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GE Medical Systems
HiSpeed QX/i Service Manual - General

Preface, Chapters 1 & 2
Safety & Service Desktop, Tools and Diags

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IMPORTANT PRECAUTIONS

LANGUAGE

WARNING

- **THIS SERVICE MANUAL IS AVAILABLE IN ENGLISH ONLY.**
- **IF A CUSTOMER'S SERVICE PROVIDER REQUIRES A LANGUAGE OTHER THAN ENGLISH, IT IS THE CUSTOMER'S RESPONSIBILITY TO PROVIDE TRANSLATION SERVICES.**
- **DO NOT ATTEMPT TO SERVICE THE EQUIPMENT UNLESS THIS SERVICE MANUAL HAS BEEN CONSULTED AND IS UNDERSTOOD.**
- **FAILURE TO HEED THIS WARNING MAY RESULT IN INJURY TO THE SERVICE PROVIDER, OPERATOR OR PATIENT FROM ELECTRIC SHOCK, MECHANICAL OR OTHER HAZARDS.**

AVERTISSEMENT

- **CE MANUEL DE MAINTENANCE N'EST DISPONIBLE QU'EN ANGLAIS.**
- **SI LE TECHNICIEN DU CLIENT A BESOIN DE CE MANUEL DANS UNE AUTRE LANGUE QUE L'ANGLAIS, C'EST AU CLIENT QU'IL INCOMBE DE LE FAIRE TRADUIRE.**
- **NE PAS TENTER D'INTERVENTION SUR LES éQUIPEMENTS TANT QUE LE MANUEL SERVICE N'A PAS éTé CONSULTé ET COMPRIS.**
- **LE NON-RESPECT DE CET AVERTISSEMENT PEUT ENTRAîNER CHEZ LE TECHNICIEN, L'OPéRATEUR OU LE PATIENT DES BLESSURES DUES à DES DANGERS éLECTRIQUES, MéCANIQUES OU AUTRES.**

WARNUNG

- **DIESES KUNDENDIENST-HANDBUCH EXISTIERT NUR IN ENGLISCHER SPRACHE.**
- **FALLS EIN FREMDER KUNDENDIENST EINE ANDERE SPRACHE BENöTIGT, IST ES AUFGABE DES KUNDEN FüR EINE ENTSPRECHENDE ÜBERSETZUNG ZU SORGEN.**
- **VERSUCHEN SIE NICHT, DAS GERäT ZU REPARIEREN, BEVOR DIESES KUNDENDIENST-HANDBUCH ZU RATE GEZOGEN UND VERSTANDEN WURDE.**
- **WIRD DIESE WARNUNG NICHT BEACHTET, SO KANN ES ZU VERLETZUNGEN DES KUNDENDIENSTTECHNIKERS, DES BEDIENERS ODER DES PATIENTEN DURCH ELEKTRISCHE SCHLäGE, MECHANISCHE ODER SONSTIGE GEFAHREN KOMMEN.**

AVISO

- **ESTE MANUAL DE SERVICIO SÓLO EXISTE EN INGLÉS.**
- **SI ALGÚN PROVEEDOR DE SERVICIOS AJENO A GEMS SOLICITA UN IDIOMA QUE NO SEA EL INGLÉS, ES RESPONSABILIDAD DEL CLIENTE OFRECER UN SERVICIO DE TRADUCCIÓN.**
- **NO SE DEBERÁ DAR SERVICIO TÉCNICO AL EQUIPO, SIN HABER CONSULTADO Y COMPRENDIDO ESTE MANUAL DE SERVICIO.**
- **LA NO OBSERVANCIA DEL PRESENTE AVISO PUEDE DAR LUGAR A QUE EL PROVEEDOR DE SERVICIOS, EL OPERADOR O EL PACIENTE SUFRAN LESIONES PROVOCADAS POR CAUSAS ELÉCTRICAS, MECÁNICAS O DE OTRA NATURALEZA.**

ATENÇÃO

- **ESTE MANUAL DE ASSISTÊNCIA TÉCNICA SÓ SE ENCONTRA DISPONÍVEL EM INGLÊS.**
- **SE QUALQUER OUTRO SERVIÇO DE ASSISTÊNCIA TÉCNICA, QUE NÃO A GEMS, SOLICITAR ESTES MANUAIS NOUTRO IDIOMA, É DA RESPONSABILIDADE DO CLIENTE FORNECER OS SERVIÇOS DE TRADUÇÃO.**
- **NÃO TENTE REPARAR O EQUIPAMENTO SEM TER CONSULTADO E COMPREENDIDO ESTE MANUAL DE ASSISTÊNCIA TÉCNICA.**
- **O NÃO CUMPRIMENTO DESTE AVISO PODE POR EM PERIGO A SEGURANÇA DO TÉCNICO, OPERADOR OU PACIENTE DEVIDO A' CHOQUES ELÉTRICOS, MECÂNICOS OU OUTROS.**

AVVERTENZA

- **IL PRESENTE MANUALE DI MANUTENZIONE è DISPONIBILE SOLTANTO IN INGLESE.**
- **SE UN ADDETTO ALLA MANUTENZIONE ESTERNO ALLA GEMS RICHIEDE IL MANUALE IN UNA LINGUA DIVERSA, IL CLIENTE è TENUTO A PROVVEDERE DIRETTAMENTE ALLA TRADUZIONE.**
- **SI PROCEDA ALLA MANUTENZIONE DELL'APPARECCHIATURA SOLO DOPO AVER CONSULTATO IL PRESENTE MANUALE ED AVERNE COMPRESO IL CONTENUTO.**
- **NON TENERE CONTO DELLA PRESENTE AVVERTENZA POTREBBE FAR COMPIERE OPERAZIONI DA CUI DERIVINO LESIONI ALL'ADDETTO ALLA MANUTENZIONE, ALL'UTILIZZATORE ED AL PAZIENTE PER FOLGORAZIONE ELETTRICA, PER URTI MECCANICI OD ALTRI RISCHI.**

警告

このサービスマニュアルには英語版しかありません。
ＧＥＭＳ以外でサービスを担当される業者が英語以外の言語を要求される場合、翻訳作業はその業者の責任で行うものとさせていただきます。
このサービスマニュアルを熟読し理解せずに、装置のサービスを行わないで下さい。
この警告に従わない場合、サービスを担当される方、操作員あるいは患者さんが、感電や機械的又はその他の危険により負傷する可能性があります。

注意:

本维修手册仅存有英文本。
非 GEMS 公司的维修员要求非英文本的维修手册时，
客户需自行负责翻译。
未详细阅读和完全了解本手册之前，不得进行维修。
忽略本注意事项会对维修员，操作员或病人造成触
电，机械伤害或其他伤害。

DAMAGE IN TRANSPORTATION

All packages should be closely examined at time of delivery. If damage is apparent write “Damage In Shipment” on ALL copies of the freight or express bill BEFORE delivery is accepted or “signed for” by a GE representative or hospital receiving agent. Whether noted or concealed, damage MUST be reported to the carrier immediately upon discovery, or in any event, within 14 days after receipt, and the contents and containers held for inspection by the carrier. A transportation company will not pay a claim for damage if an inspection is not requested within this 14 day period.

Call Traffic and Transportation, Milwaukee, WI (262) 785 5052 or 8*323 5052 immediately after damage is found. At this time be ready to supply name of carrier, delivery date, consignee name, freight or express bill number, item damaged and extent of damage.

Complete instructions regarding claim procedure are found in Section S of the Policy And Procedures Bulletins.

14 July 1993

CERTIFIED ELECTRICAL CONTRACTOR STATEMENT

All electrical Installations that are preliminary to positioning of the equipment at the site prepared for the equipment shall be performed by licensed electrical contractors. In addition, electrical feeds into the Power Distribution Unit shall be performed by licensed electrical contractors. Other connections between pieces of electrical equipment, calibrations and testing shall be performed by qualified GE Medical personnel. The products involved (and the accompanying electrical installations) are highly sophisticated, and special engineering competence is required. In performing all electrical work on these products, GE will use its own specially trained field engineers. All of GE’s electrical work on these products will comply with the requirements of the applicable electrical codes.

The purchaser of GE equipment shall only utilize qualified personnel (i.e., GE’s field engineers, personnel of third-party service companies with equivalent training, or licensed electricians) to perform electrical servicing on the equipment.

IMPORTANT...X-RAY PROTECTION

X-ray equipment if not properly used may cause injury. Accordingly, the instructions herein contained should be thoroughly read and understood by everyone who will use the equipment before you attempt to place this equipment in operation. The General Electric Company, Medical Systems Group, will be glad to assist and cooperate in placing this equipment in use.

Although this apparatus incorporates a high degree of protection against x-radiation other than the useful beam, no practical design of equipment can provide complete protection. Nor can any practical design compel the operator to take adequate precautions to prevent the possibility of any persons carelessly exposing themselves or others to radiation.

It is important that anyone having anything to do with x-radiation be properly trained and fully acquainted with the recommendations of the National Council on Radiation Protection and Measurements as published in NCRP Reports available from NCRP Publications, 7910 Woodmont Avenue, Room 1016, Bethesda, Maryland 20814, and of the International Commission on Radiation Protection, and take adequate steps to protect against injury.

The equipment is sold with the understanding that the General Electric Company, Medical Systems Group, its agents, and representatives have no responsibility for injury or damage which may result from improper use of the equipment.

Various protective materials and devices are available. It is urged that such materials or devices be used.

LITHIUM BATTERY CAUTIONARY STATEMENTS

CAUTION Risk of Explosion

Danger of explosion if battery is incorrectly replaced. Replace only with the same or equivalent type recommended by the manufacturer. Discard used batteries according to the manufacturer's instructions.

ATTENTION Danger d'Explosion

Il y a danger d'explosion s'il y a replacement incorrect de la batterie. Remplacer uniquement avec une batterie du même type ou d'un type recommandé par le constructeur. Mettre au rébut les batteries usagées conformément aux instructions du fabricant.

OMISSIONS & ERRORS

Customers, please contact your GE Sales or Service representatives.

GE personnel, please use the GEMS CQA Process to report all omissions, errors, and defects in this publication.

Revision History

Rev.	Date	Reason for change
0	05/17/02	Initial Release.
1	6/28/02	• Corrected 4 slice and 8 slice related information. • Corrected HiSpeed QX/i specs related information.
2	09/26/02	General Clean-up & Updates Chapter 11: Removed manual Image Analysis procedures from sections 1.4.2 & 1.5.2 Added information for Global Console - Octane2 (GOC1) CQA 1026038: Added Cradle Shimming procedure CQA 1026214: Corrected HP Anode/Cathode Inverter replacement procedure Corrected ETC, STC & OBC CPU Self-Test LED information
3	01/31/03	CQA 1029246: Removed incorrect nbsClient service documentation; replaced “List of nbsClient commands for controllers” CQA 10210552: Corrected SCSI bd identification in pciDeviceShow example CQA 10210553: Corrected DIP bd identification in pciDeviceShow example CQA10211370: Corrected Cradle Shimming Materials list. Corrected inconsistent terminology. Chapter 5: • Added information on new 8-port ethernet switch • Removed non-applicable IDE info CQA 1028489: Added procedure to verify tube temp <200ºC (to Chapter 12) Added information for NGPDU.
4	05/08/03	Added information for Global Console - Linux (GOC). Chapter 7: • Moved ESD information to (new) Appendix F • Replaced "Photodiode Control Matrix" table with Figure 7-7 "4 Slice versus 8 Slice FET Mode Assignments." • Removed Detector Replacement procedure (Refer to Direction 2335850-100, *LightSpeed Family Detector Change Procedure*) Added Appendix F - ESD Management and Device Handling. Added Appendix G - Unix & Linux Commands.
5	11/21/03	Chapter 8: Added DIP Stats Reset Procedure to Gantry Retest Matrix for HSDCD Replacement (in Table 8-33). Chapter 12: • Added wording about avoiding re-use of old bolts when changing tube. • Added Patient Safety Warning: Use correct bolts for tube replacement.
6	01/29/04	Chapter 10: Added "Gantry Enable" switch information. Also made other updates to Table 10-5, Figure 10-16, Sec. 4.3.5.1, Table 10-7. Chapter 12: Revised the tube replacement procedure (mechanical), and added "Gantry Rotation Safety Check".

Rev.	Date	Reason for change
7	07/01/05	PSR13038178:Added notice to check the hoist before starting to use the hoist Corrected "Important PreCautions".
8	04/20/07	Changes per PSR 13095642

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Preface
Publication Conventions

Purpose: This section means to inform the reader on publication conventions used. So that the reader can identify safety and general material that is considered important by it format. This includes the interpretation of computer screen text as either input or output. There are a number of specific text and paragraph styles/conventions used within this section to accomplish this task.

Please become familiar with the conventions used within this publication before proceeding.

Section 1.0
Safety & Hazard Information

1.1 Text and Character Representation

Within this publication, different paragraph and character styles have been used to indicated potential hazards. Paragraph prefixes, such as hazard, caution, danger and warning, are used to identify important safety information. Text (Hazard) styles are applied to the paragraph contents that is applicable to each specific safety statement. Words describe the type of potential hazard that may be encountered and are placed immediately before the paragraph it modifies. Safety information will normally include:

- Type of potential Hazard
- Nature of potential injury
- Causative condition
- How to avoid or correct the causative condition

EXAMPLES OF HAZARD STATEMENTS USED

A few examples are provided that have been adapted form GEMS' global document standard (2119696-100). They include paragraph prefixes and modified text styles.

⚠ **CAUTION**
Pinch Points
Loss of Data
Sharp Objects

Caution is used when a hazard exists which can or could cause minor injury to self or others if instructions are ignored. They include for example:

- **Loss of critical patient data**
- **Crush or pinch points**
- **Sharp objects**

⚠ **DANGER**
EXCESSIVE VOLTAGE
CRUSH POINT

DANGER IS USED WHEN A HAZARD EXISTS WHICH WILL CAUSE SEVERE PERSONAL INJURY OR DEATH IF INSTRUCTIONS ARE IGNORED. THEY CAN INCLUDE:

- **ELECTROCUTION**
- **CRUSHING**
- **RADIATION**

WARNING ROTATING EQUIPMENT BARE WIRES

WARNING IS USED WHEN A HAZARD EXISTS WHICH COULD OR CAN CAUSE SERIOUS PERSONAL INJURY OR DEATH IF INSTRUCTIONS ARE IGNORED. THEY CAN INCLUDE:

- Potential for shock
- Exposed wires
- Failure to Tag and lockout system power could allow for un-command motion.

NOTICE Equipment Damage Possible

Notice is used when a hazard is present that can cause property damage but has absolutely no personal injury risk**.They can include:**

- Disk drive will crash
- Internal mechanical damage, such as to the x-ray tube
- Coasting the rotor through resonance.

It's important that the reader not ignore hazard statements in this document.

1.2 Graphical Representation

Important information will always be preceded by the exclamation point contained within a triangle, as seen throughout this chapter. In addition to text, several different graphical icons (symbols) may be used to make you aware of specific types of hazards that could possibly cause harm.

ELECTRICAL

MECHANICAL

RADIATION

LASER

HEAT

PINCH

Some others make you aware of specific procedures that should be followed.

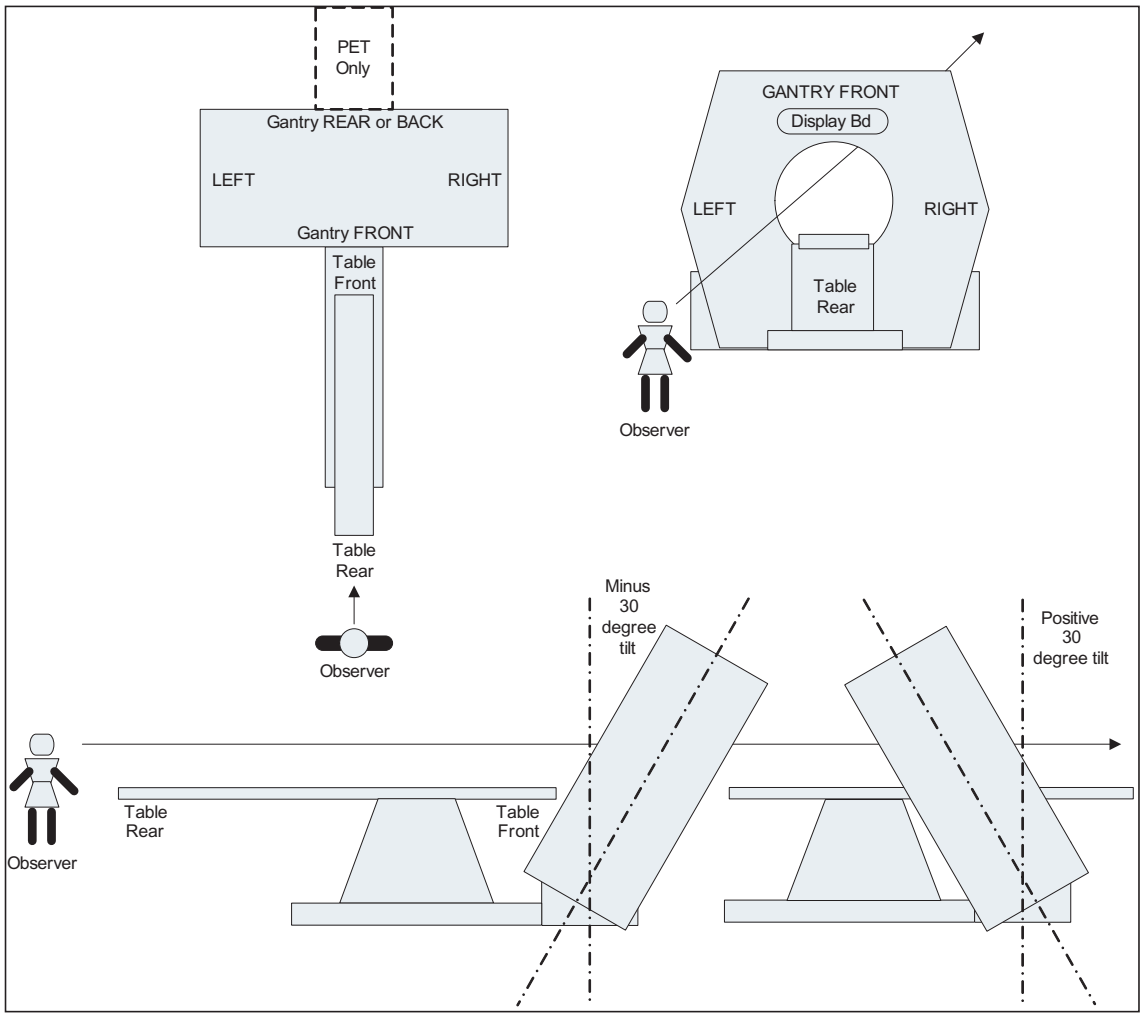
AVOID STATIC ELECTRICITY

TAG AND LOCK OUT

WEAR EYE PROTECTION

1.3 Spatial Orientation While Servicing The System

When servicing the system, spatial orientation is defined from the perspective of an observer standing at the end of the patient table looking towards the Gantry Display board, through the gantry. This orientation defines a negative or minus gantry position which places the top of the gantry leaning away from the observer. Refer to the illustration below "Service Orientation"



1.4 Service Procedure Readability, Interpretation and Clarification

This publication and its many service procedures are written at a level meant for Field personnel that have been trained and qualified to work on this system. They are not designed to be used for self directed "On The Job" training of Field Service personnel. If you have not done a specifc procedure before, it is highly recommended that you seek the supervision and expertise of your Field Leadership team. Procedures change periodically. All procedures should be read thouroughly regardless of training level and experience prior to beginning a procedure. If you do not clearly understand the steps within the procedure or how to safely proceed STOP the service action immediately and consult your Field Leadership before proceeding.

Section 2.0
Publication Conventions

2.1 General Paragraph and Character Styles

Prefixes are used to highlight important non-safety related information. Paragraph prefixes (such as Purpose, Example, Comment and Note) are used to identify important but non-safety related information. Text styles are also applied to text within each paragraph modified by the specific prefix.

EXAMPLES OF PREFIXES USED FOR GENERAL INFORMATION

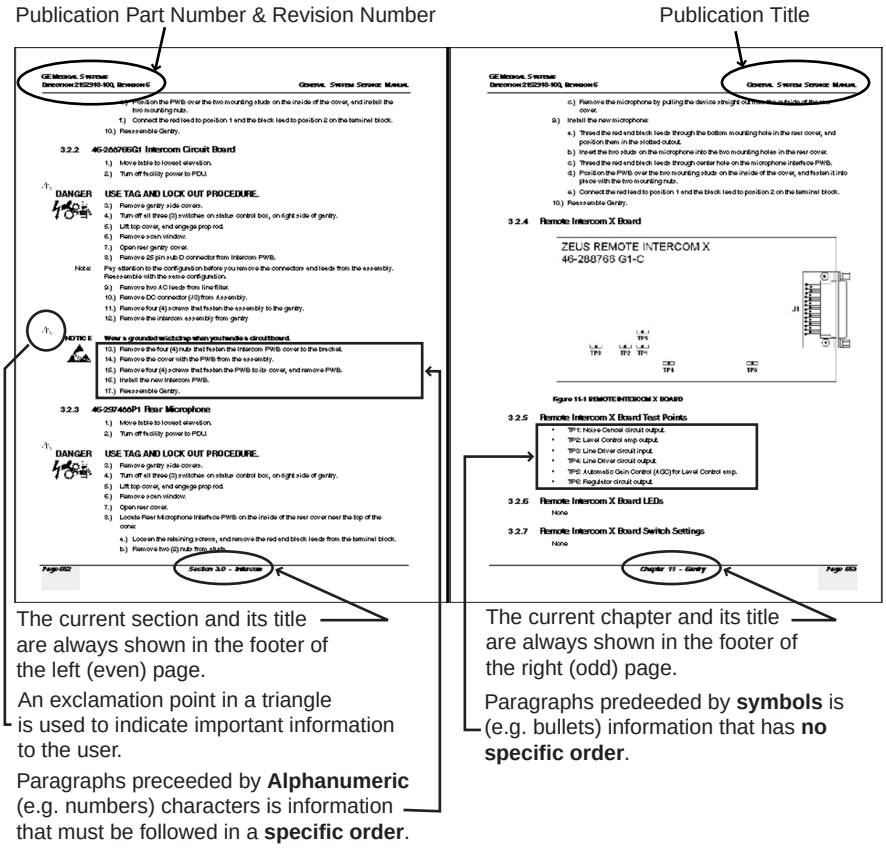
Purpose: Introduces and provides meaning as to the information contained within the chapter, section or subsection, Such as used at the beginning this chapter for example.

Note: Conveys information that should be considered important to the reader.

Example: Used to make the reader aware that the paragraph(s) that follow are examples of information possibly stated previously.

Comment: Represents "additional" information that may or may not be relevant.

2.2 Publication Page Layout



Headers and footers in this publication are designed to allow you to quickly identify your location. The document's part number and revision number appears in every header on every page. Odd numbered page footers indicate the current chapter, its title and current page number. Even page footers show the current section and its title, as well current page number.

2.3 Computer Screen Output/Input Character Styles

Within this publication different character styles are used to indicate computer input and output text. Character (input, output, and variable) styles are used and applied to the text within a paragraph so as to indicated direction. Computer screen output and input is also formatted using mono (fixed width) spaced fonts.

Example: Fixed Output

`This paragraph denotes computer screen fixed output. Its output is fixed in the sense that it does not vary from application to application.It's the most commonly used style used to indicate filenames, paths and text.`

Example: Variable Output

This paragraph denotes computer screen output that is variable. Its output varies from application to application. Variable output is sometimes found placed between greater than and lesser than operators. For example: <variable_ouput>

Example: Fixed Input

This paragraph denotes fixed input. It's typed input that will not vary from application to application. Fixed text the user is required to supply as input.

Example: Variable Input

This paragraph denotes computer input that can vary from application to application. Variable text the user is required to supply as input. Variable input sometimes is placed between greater than and lesser than operators. For example: <variable_input>. In these cases, the (<>) operators are dropped prior to input. Exceptions are noted in the text.

2.4 Buttons, Switches and Keyboard Inputs (Hard & Soft Keys)

Different character styles are used to indicate actions requiring the reader to press either a hard or soft button, switch or key. Physical hardware, such as buttons and switches, are called hard keys because they are hard wired or mechanical in nature. A keyboard or on/off switch would be a hard key. Software or computer generated buttons are called soft keys because they are software generated. Software driven menu buttons are an example of such keys. Soft and hard keys are represented differently in this publication.

Example: Hard Keys

A power switch **ON/OFF** or a keyboard key like **ENTER** is indicated by applying a character style that uses both over and under-lined bold text that is bold. This is a hard key.

Example: Soft Keys

Whereas the computer MENU button that you would click with your mouse or touch with your hand uses over and under-lined regular text. This is a soft key.

Chapter 1
General System Safety & Service

NOTICE **This section contains general safety information. Individual service procedures contain specific safety information related to the service task and take priority over this general information.**

Section 1.0
HiSpeed QX/i System Overview

1.1 Introduction

The purpose of this section is to explain the organization and data flow within the HiSpeed QX/i scanner system. The intent of this overview is to explain how the complete system works at a rather high level. Each of the following sections covers more detail. Please see the HiSpeed QX/i System Block Diagram, shown in the following figures, during this discussion.

1.2 Primary Sections of the System Block Diagram

1.) Console
2.) Gantry- Stationary
3.) Gantry- Rotating

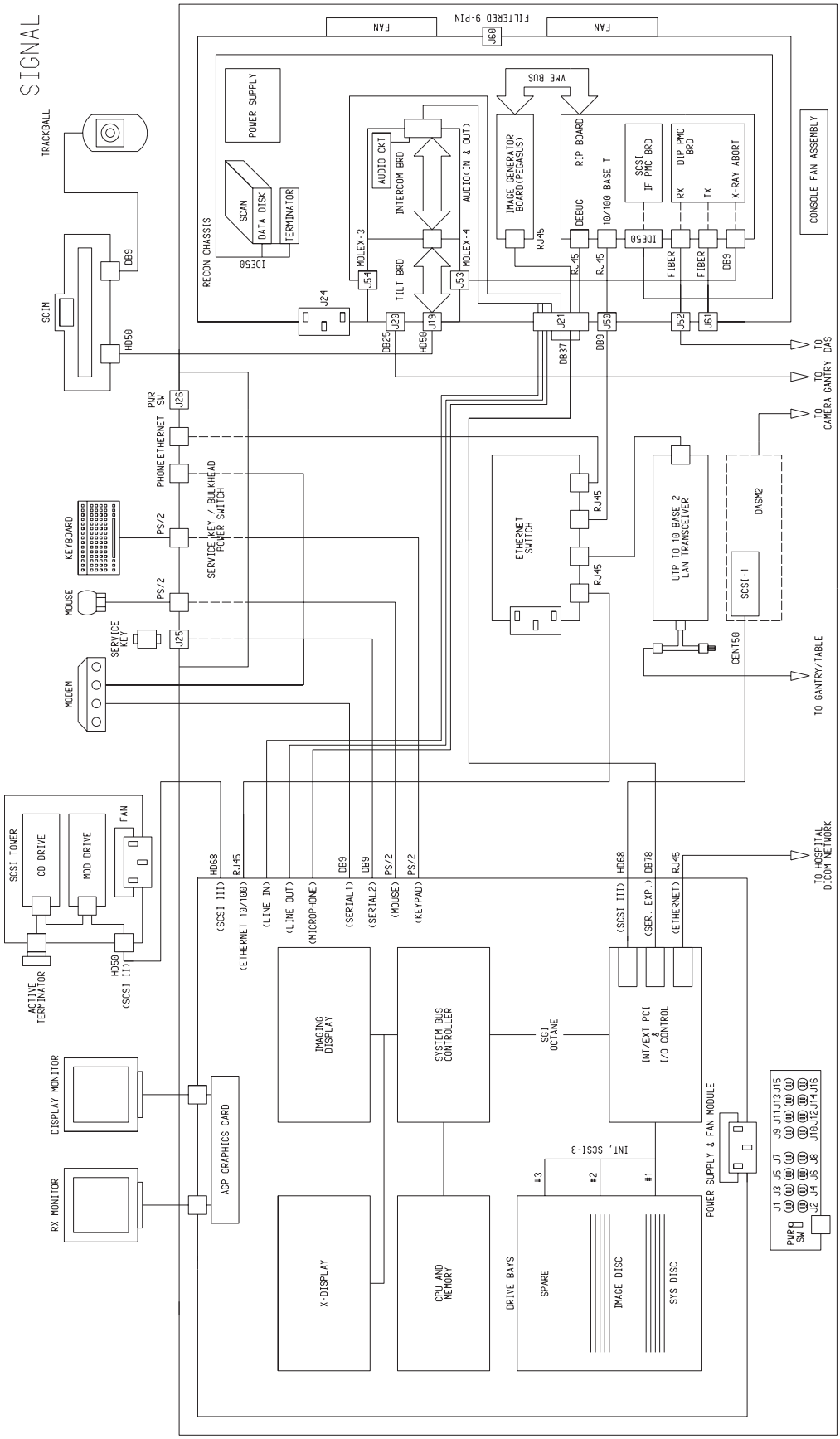


Figure 1-1 System Block Diagram (Global Console - Octane2)

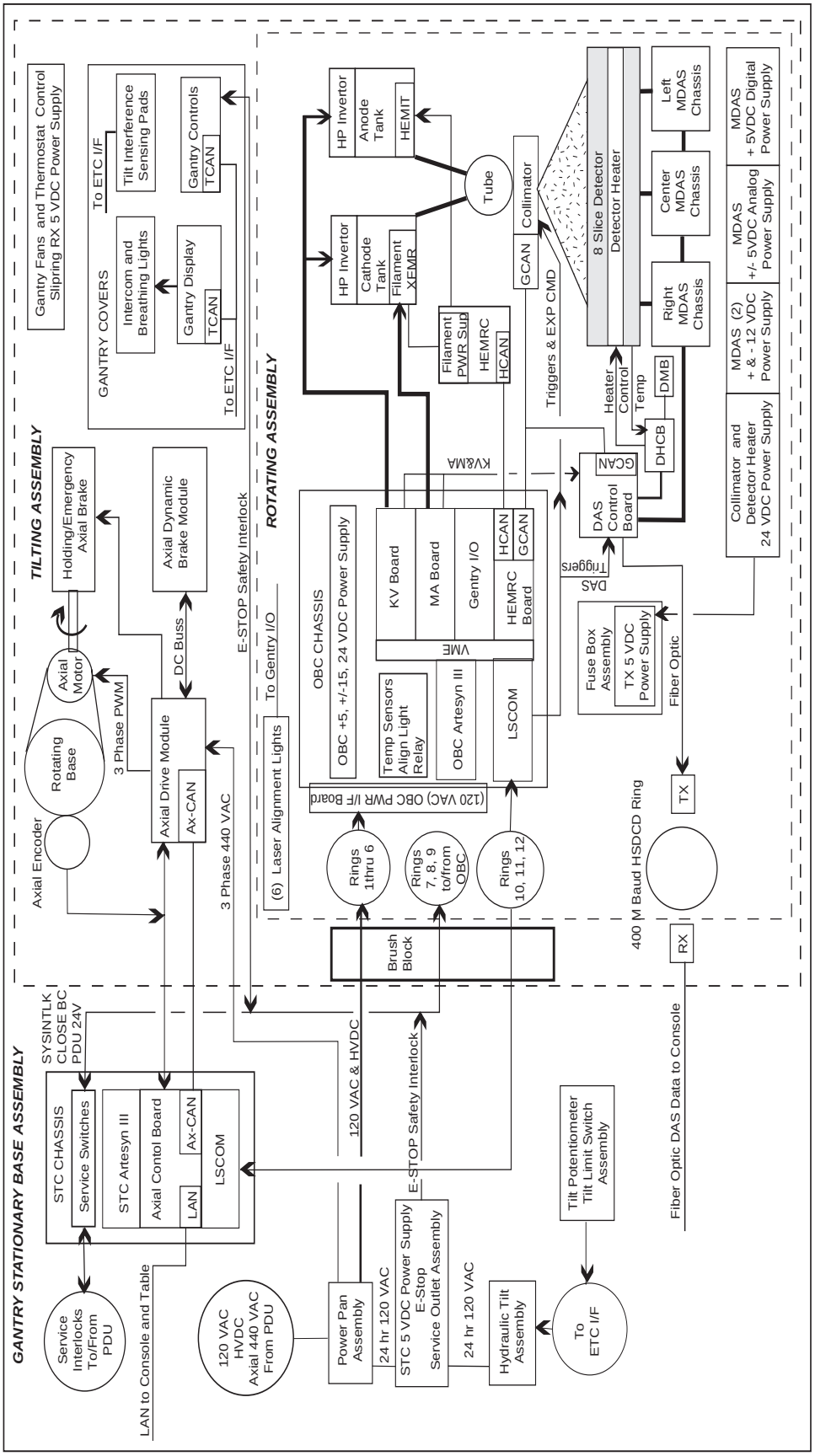


Figure 1-2 System Block Diagram (Gantry)

1.2.1 Console

For the following discussion, refer to Figure 1-1, on page 24 (GC-Oct2).

The console contains the Host computer (OC, **SGI**-Octane)—including the system **CD-ROM** and **MOD** drives—and the **ICE** Box (Image chain engine).

1.2.1.1 Host Computer

The Host computer (OC) controls and interfaces with the following hardware:

Scan CRT- This unit displays the scan parameter screens utilized by the operator to perform Scout, Axial, and Helical scans, and recon control, plus routine operator functions on the system. No images are displayed on this screen. The OC uses the Solid Impact interface board to control the display of data on the monitor.

Display CRT - Utilized to display images scanned by the system and also contains screens to allow the operator access to functions to troubleshoot the system, view the system error log, view other images or exams stored in the system, archive images, select images for filming, or functions to allow the operator to do analysis, processing and management of displayed images, and network functions. The OC utilizes the High Impact board to control the display of data on the monitor.

Mouse - Connects to the OC and is used by the operator to make selections on the display screens on either of the two display screens.

Keyboard - Allows operator to input text, IRIX or **UNIX** commands or selections required by the system software. The keyboard also contains the intercom speaker, microphone, and volume controls.

Trackball - Used by the operator to manipulate displayed images, instead of using the mouse. Allows one person to use the mouse for the system and another person to view/film images via the trackball simultaneously.

MOD & CD-ROM - The OC controls operation of the **MOD** drive and **CD-ROM** via an external **SCSI** interface. The **MOD** is used for the storing or retrieving of images using **DICOM** 3.0 format. The **MOD** can hold 4700 loss-less (JPEG compressed 512x512) image files per side, or 350 uncompressed scan data files per side. The **CD-ROM** is used primarily for the on-screen tutorial support function called “Sherlock”. This audio and video program provides support of the Exam Rx and Image Works functions for system help. This drive is also used for software load, or reading Service publications in Adobe Acrobat format.

External Connections - External connections are provided on the OC for the support of a service key, Insite, **DASM** for a laser camera operation and external **LAN** interface.

Local Disk - The OC computer operates on **SGI**’s IRIX software located on its own local disk, called the system disk. There is room for 3700 uncompressed 512x512 images. There is provision for an additional system disk that will expand image storage by 7400 uncompressed 512x512 images for a total of 11,100 images. All images are stored on this disk.

1.2.1.2 Image Chain Engine

1.) Data from the **MDAS** is applied to the **DAS** Interface Processor (**DIP**). The **DIP** board receives the serial **DAS** data, checks the serial data for correctness and applies forward error correction when required. If the scan data cannot be corrected then a scan abort condition is generated. Scan data is stored in one of two 2MB memory modules on the **DIP**. The serial data is sent to the scan data disk, for temporary storage.

2.) When sufficient data has been sent to disk, it is then sent on to the Recon Interface Processor (**RIP**) in the **ICE** box. The serial data is sent in 100 view data packets to the **RIP**, which does a checksum on the data. The **RIP** then sends the scan data to the Pegasus Image Generator board (**PEG-IG**), for scan data corrections. The **PEG-IG** performs preprocessing, calibration and scout image functions.

3.) The **PEG-IG** board then performs convolution and back-projection upon the data. When complete, the **PEG-IG** board sends the image data back to the **RIP**, where post-processing is performed to create the final image in **DICOM** 3.0 format.

4.) The **RIP** sends the completed image to the OC via the **LAN** switch. The OC then places the image on the system disk and also sends a copy to the High Impact board for image display.

1.2.2 Gantry – Stationary

For the following discussion, please refer to Figure 1-2, on page 25.

1.) The Gantry stationary control is located within the **STC** computer chassis. Within this chassis is located the **STC** computer, an axial board and the **LSCOM** board.

2.) Under **STC** control, the axial board is the interface that controls gantry rotation. The axial board connects to, and controls the operation of the Servo amplifier, which is located in the chassis assembly in front of the axial drive motor mounted to the gantry tilt assembly.

3.) When commanded by the system, the **STC** through the axial board enables the Allen Bradley servo-amp, to supply PWM voltage to the axial drive motor. The gantry can rotate speeds of 0.7, 1, 2, 3, or 4 seconds. Connected to the Gantry Rotating base assembly, on the gantry drive belt toothed interface, is an encoder. The output of the encoder is sent to both axial board and servo amplifier as feedback. The **STC** is the master. It compares the encoder feedback and the Allen Bradley servo amplifier position feedback to ensure the gantry is rotating at the correct speed.

4.) The axial board using the rotational information provided by the encoder has a specialized circuit on it that outputs two signals used by the system. These signal are **DAS** triggers and the Exposure command.

5.) **DAS** triggers are timing signals that are generated. These signals (triggers) are sent to the **MDAS**, causing the **MDAS** to go through its function to convert X-Ray information from the Detector into digital data. This data is sent to the **DIP** and the **ICE** Box to produce an image.

6.) The Exposure command is sent to the KV board in the **OBC** chassis. This signal causes the KV board to enable the High Voltage circuits of the Gantry, which in turn cause the X-Ray tube to produce X-Rays. As its name implies, the signal turns high voltage on and off, which via the X-Ray tube, turns on or off X-Rays.

7.) The Collimator Control board also receives the DAS triggers and Exposure command signals which are used in closed loop operation.

8.) A **LAN** is located on the STC CPU, which connects directly to the **VME** bus. Through this **LAN**, the **STC** receives applications firmware and interacts with the OC during the scan process.

9.) The **LSCOM** board is used to provide 2-way serial data transmission across the Gantry slip-rings. Data or commands are sent across the slip-rings between the stationary **LSCOM** under control of the **STC**, and the same for the rotating **LSCOM** board under control of the **OBC**. Data received by the stationary **LSCOM** is converted into serial data packets with **CRC** checking and send across the low resistance slip-rings to the rotating **LSCOM**. The rotating **LSCOM** receives the serial data, checks the **CRC** value, if correct the **LSCOM** then converts the data back to parallel and sends it to the **OBC**. If the transmitted **CRC** character does not check out, then the **LSCOM** boards will ask to retransmit the data. There is no error correction function provided by either the **LSCOM** boards.

10.) The **LSCOM** boards are identical and interchangeable.

11.) The **STC** computer, via the axial board, has control of the “system interlock” line. This is a relay contact located on the axial board, which is in series with the X-ray abort relay located on the **DIP** board. This provides the **STC** with a way to abort a scan in the event of a detected fault.

1.2.3 Gantry – Tilting Frame

The gantry tilting frame contains all of the rotating components discussed in the next sub-section. Other items mounted to this assembly include the Axial Drive circuitry, Slipring assembly, Intercom and gantry Display and Controls.

1.2.4 Gantry – Rotating

For the following discussion, please refer to Figure 1-2, on page 25.

1.) All of the functions located on the rotating gantry is under control of the **OBC** computer. These functions are:
   - Generation of High voltage
   - Rotor Control
   - Collimator and Filter control
   - Filament and tube current control
   - Detector
   - **DAS** Operation
   - Tube
   - Control of the HVDC buss in the **CPDU**
   - Alignment lights
   - System monitoring functions

2.) **High Voltage Control** - The system uses a High Frequency controlled High Voltage generator. The **OBC** sends to the KV board a calibration word based upon the High Voltage value selected by the operator for the specific scan prescription. The choice's are; 80, 100, 120, and 140KV. The calibration word is used to set up the KV board and output a timing signal in the range of 20KHz to 33KHz. The frequency of the signal is directly related to the KV value and tube current selected. A 20KHz provides 75KV. Moving towards 33KHz produces 40KV. This timing signal is sent out to the power inverter's. The job of the power inverter's is to control the frequency and duty cycle of the IGBTs. The HVDC is then applied to the High Voltage tank, which produces one half of the selected KV. There are two high voltage tanks, the anode and the cathode. The anode tank produces a positive bias high voltage, and the cathode tank produces a negative bias high voltage. These voltages are applied to the anode and cathode connections of the X-ray tube, so that the full selected KV value is felt across the tube. The output of each tank has a scaled feedback signal that goes to the KV board and provides a closed loop control of the KV being generated. Since there are two tanks there are two closed loops, one for the anode tank and one for the cathode tank.

3.) **Rotor control** - The x-ray tube utilizes a rotating target. The rotor control circuits are used to allow the tube rotor to be brought up to normal speed, of 8000 rpm, and when the system is finished scanning, to brake the rotor. This process uses the rotor control board within the **OBC** chassis, which connects to the High Efficiency Motor Rotor Controller module within the gantry (**HEMRC**). The **HEMRC** connects to the anode high voltage tank, to a special transformer called the **HEMIT**. The **HEMIT** makes it connection to the stator windings of the tube via the anode high voltage cable. Control signals and fault conditions are sent over a **CAN** (control area network) network (**HEMRC**-**CAN**) between the rotor controller and the **HEMRC**.

4.) **Collimator and Filter control** - The collimator unit is under control of the **OBC** via the **RCIB**-**CAN** network. The collimator uses two eccentric cams that are used to position the x-ray beam over the selected area of the detector. This in turn is based upon the selected image/ thickness by the operator. For instance if the operator selects a 4 X 1.25mm detector collimation (4 images @ slice of 1.25mm each), the final image could be in one of the following image/ thickness; 4 X 1.25mm, 2 X 2.25mm, 1 X 5mm. The filter is under software control and has two positions used at scan level, one for head scans and another for body scans. The purpose of the filter is to attenuate the X-ray beam output of the X-ray tube by filtering out soft X-ray energy and to provide more X-ray energy over the patient channels of the detector, and less X-ray energy over the non-patient channels of the detector. The collimator is basically a beam limiting device. True beam collimation is controlled by the detector. This arrangement is better known as post-patient collimation.

5.) **Filament power and Tube current control** - Provided by the MA control board. The operator can select tube current in the range of 10ma to 440ma, depending on selected kv, in 10ma

increments. At the start of a scan sequence the tube current selection is sent to the MA control board, and under control of the **OBC**, the filament will be pre-heated at low power for warm up. Then the filament is powered up to 97% of the selected tube current value until high voltage is turned on to product X-rays. Then the tube current feedback from the high voltage tanks to the MA control board will cause the tube current to be regulated to the selected value.

6.) **Detector** - New design that allows up to four (4) images to be acquired in one gantry rotation. The detector is arranged with 768 output channels. Each channel is made up of 16 cells. Each cell is 1 mm wide and 1.25 mm long. Using FET switching within the detector design the individual cells of a channel are arranged in a unique way to provide up to eight images in one data collection. The selections are:

- 4 X 1.25 mm
- 4 X 2.5 mm
- 4 X 3.75 mm
- 4 X 5 mm
- 1 x 1.25mm Single slice
- 2 x 1.25mm Thin Twin

The detector has a strip heater applied to it to maintain its temperature at approximately 32 degrees C ± 1 degree C.

7.) **MDAS** - The **MDAS** is a very high speed **A/D** converter. It takes the inputs from the detector, and converts these signals into 16 bit digital words, and sends them to the **DIP** in less than one millisecond. The **DAS** is normally triggered at a 984 Hz sample rate, this will vary based upon the requested data collection mode. The **MDAS** does the selection of the FET switches in the detector based upon operator scan selections. The **MDAS** monitors and controls the detector temperature via the Detector Heater Control board, DHCB, at 32º C ± 1º C. The **OBC** communicates to the **MDAS** over the **RCIB**-**CAN**. This connection serves as a path for commands and detector FET selection to the **MDAS** and status and fault reporting from the **MDAS**.

8.) **Tube** -The HiSpeed QX/i system uses the Performix 630 Metal-Ceramic tube. This tube is designed for exams requiring a large number of scans without pausing for tube cooling. The tube has a heat storage capacity of 6.3 MHU and a maximum power capacity of 42 KW (Option: 53.2 KW). This tube also incorporates a tube cooling design that uses serviceable air filters.

9.) **HVDC Power Supply** - Located within the **CPDU**, is the unregulated HVDC power supply. The typical bus voltage should be between 400 vdc and 700 vdc depending on the selected technique. Be aware that the voltage can rise above 700 vdc during rotor breaking. The HEMRC is designed to manage this occurrence. This HVDC is used in the system for the generation of high voltage and also by the rotor controller to accelerate and run the rotor. The **OBC** controls the normal turning on and off of this DC supply.

10.) **Alignment lights** - used by the operator for positioning patients for the starting point for scans. These lights are solid state laser type with built in diffusers.

11.) **System monitoring** - The **OBC** computer uses the Gentry I/O board to monitor scanner operation. Located on the Gentry I/O board is an **A/D** converter, through which there are many connections throughout the Gantry. The **OBC** is then able to measure items like: KV output, MA output, chassis voltages, tube temperature etc.

12.) **Slip-Rings** - there are 12 slip-rings and one HSDCD slip-ring used in the gantry. The uses of the slip-ring is as follows:

- Three slip rings are utilized for communications between the stationary and rotating **LSCOM** boards.
- Three slip-rings are used for the connection of 120 vac to power the power supplies within the gantry.
- Three slip-rings are used for what is called “System Interlock.”
- Two slip-rings are used for the connection of the HVDC.

- One ring is unused.
- One HSDCD slip-ring used only for the high speed transfer of data output from the **MDAS** to the **DIP**.

1.2.5 Table

1.) All functions that the table performs are under control of the **ETC** or table computer. Mounted on the gantry cover are control buttons that cause the table to go up/down or to move the cradle in/out, establish the landmark position, to turn on the alignment lights, or to tilt the gantry. These buttons do not control the function directly, but instead interrupts the **ETC** via the **ETC-IF** board which identifies which button was/ is pushed, and then perform the function as long as the button is depressed. The gantry controls and display use a **CAN** bus for communications. The **ETC** receives its software, scan parameters, and fault reporting over the **LAN** network located on the **ETC** controller board from the OC.

2.) **UP/Down** -By using either the gantry buttons or foot switches will cause the table to move up or down depending upon which button is pushed. The **ETC** computer, under software control, will enable the elevation amplifier, connect it to the elevation motor and thereby cause the table to move. The table will stop in its travel either by releasing the button, or because the computer has stopped the motion because of reaching a “software stop point”.

3.) **Cradle Motion** - By using gantry mounted buttons the operator can cause the cradle to move into or out of the gantry area. This is usually done for the initial positioning of a patient for a scan. By depressing the cradle move button the **ETC** will enable the cradle amplifier and connect its output to the cradle motor and cause the cradle assembly to move. The cradle will move as long as the operator holds the button down or when the computer has reached a “software stop point”. When the system is doing a scan, the **ETC** will automatically move the cradle based upon scan parameters sent to it by the OC, which is based upon values selected by the operator for the scan prescription.

4.) **Table Specifications**:
- Table can handle a 400 pound load, with a maximum load of 450 pounds with a minor shift in positional accuracy.
- Table moves from a low of 51 cm to a high of 107 cm.
- Elevation speeds are 5mm/sec and 40mm/sec
- Cradle has a range of 107cm.
- Cradle moves at a speed up to 75 cm/sec

5.) **Gantry Tilt** - By pressing gantry mounted buttons, the operator can tilt the gantry ± 30 degrees, in 0.5 degree increments. The tilt function is a hydraulic control assembly. For the tilt function the **ETC** enables the tilt relay board and connects its output to the hydraulic tilt motor, which moves the gantry at a speed of 1 degree a second. A potentiometer provides feedback to the **ETC** as tilt position. To tilt forward the hydraulic cylinders are pressurized by energizing the hydraulic pump. To tilt backward hydraulic pressure is released and gravity move the gantry.

6.) **Remote Gantry Tilt** - This is a console controlled function available only in patient scanning modes. There are two (2) touch sensor pads located on the gantry covers to ensure patient safety.

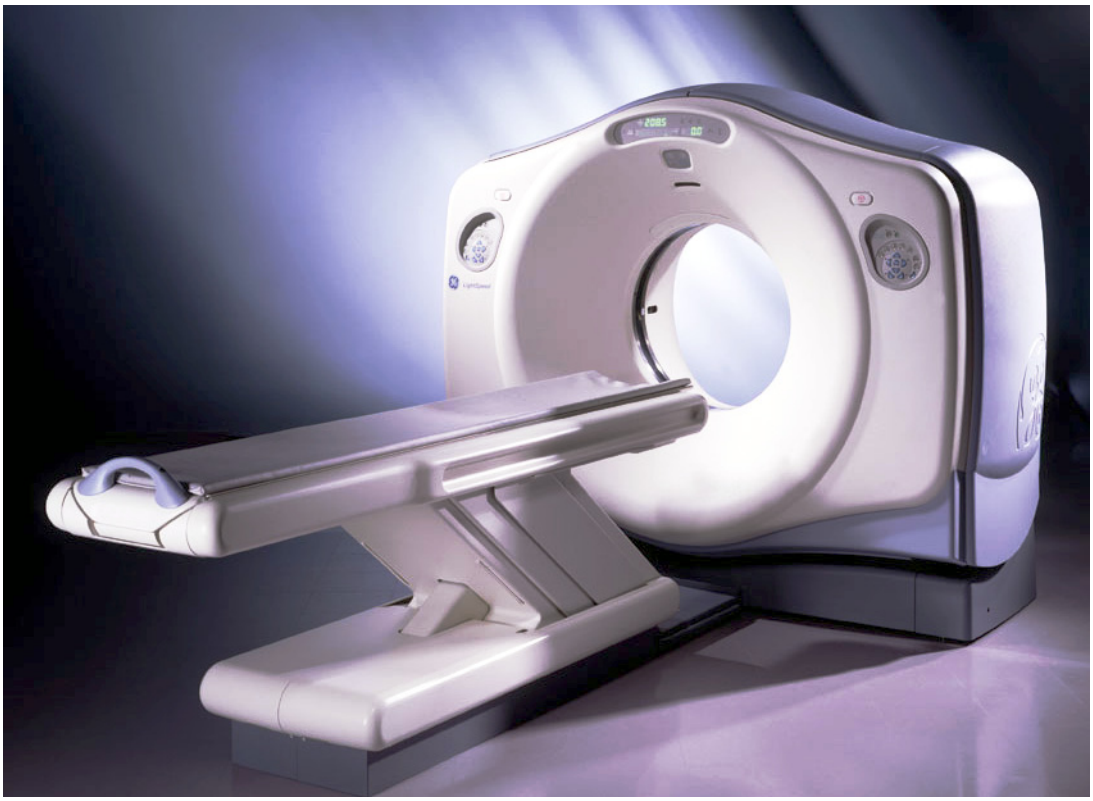
7.) **Gantry Display** - The **ETC** computer controls everything on the gantry display. The display indicates; gantry tilt, table position, cradle position, and table/ gantry limits.

Section 2.0
Safety Introduction

GE CT scanners are designed to be safely operated <u>only</u> when all system covers are in place. Removal of a cover for any reason defeats the protection they provide, and potentially exposes patients and operators to hazards. If any of the covers should become damaged, you should

contact your local GE Sales or Service representative immediately for replacement or repair. Only qualified service personnel trained in the service and operation of this scanner should remove any cover or service this equipment.

Safety features have been incorporated into the design for everyone's protection. Equipment covers remain the primary means of protection to patients, operators and service personnel. Secondary protection covers are also employed to protect service personnel.



Section 3.0
Normal System Operational Safety

This section describes operational safety (when the system covers are all in place).

3.1 Potential Hazards

Two potential hazards exist during the operation of this equipment, unless proper safety precautions are followed:

- X-Rays - Radiation generated during a patient or service scan.
- Laser Alignment Lights - Eye damage from looking directly into the alignment light beam for an extended period of time.

To prevent injury from these potential hazards, the following precautions must be taken:

- Provide proper radiation training and shielding for operators and service personnel. Check that the scan room is clear prior to scanning.
- Instruct patients and operators to refrain from looking directly into the patient alignment beams.

3.2 Safety Awareness Indicators

Numerous devices are employed throughout your system to create safety awareness.

3.2.1 Labels

Figure 1-3 Laser Light Warning & Regulatory Compliance Labels

Figure 1-4 X-Ray ICON

3.2.2 Lights & Lamps

3.2.2.1 Gantry and Console X-Ray “ON” Indicator Lamps

Both the gantry and the console have x-ray indicator displays. The system does not have an audible x-ray ON indicator, nor is it required by **FDA**. The visual indicator is illuminated when x-ray is

generated. The x-ray "ON" icon on the gantry's front cover display is shown in Figure 1-5. The same icon is on the gantry's rear cover display.

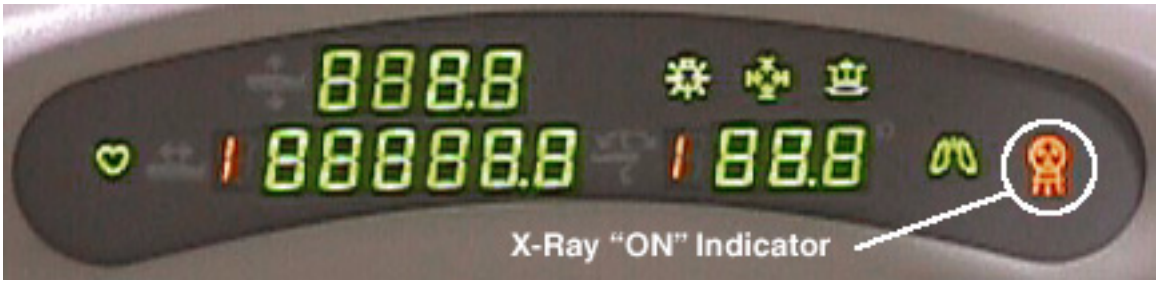


Figure 1-5 Gantry Display (Front) and X-ray "ON" Icon

A backlit x-ray "ON" indicator is located on the **SCIM**. It illuminates when x-ray is present. See Figure 1-6.

Figure 1-6 Operator Console and Gantry X-ray Exposure Warning Lights

3.2.2.2 Room Warning Light *(customer supplied)*

If a room warning light has been installed and connected to the **CT** system correctly, the room warning light will illuminate whenever X-rays are present, by default. The room warning light can also be configured to illuminate whenever high voltage is present.

See your system installation manual for wiring and configuration details.

3.3 Emergency Switches, Buttons & Locks

3.3.1 System Emergency OFF (E-OFF) Switch

The "E-OFF" switch removes all power to a **CT** system immediately. If for any reason the operator needs to remove all power supplied to the **CT** system at the main distribution panel, the E-OFF switches should be employed. Using this switch except in the case of an emergency could cause damage to hardware. Typically, one or more E-OFF switches are located in or near the operator console or gantry. KNOW THEIR LOCATIONS.

3.3.2 System Emergency Stop (E-STOP) Switches

In the unlikely event they are needed, user accessible “E-stop” (emergency stop) switches have been placed on both the console and the gantry covers. When an E-Stop circuit is engaged, it:

- brings the gantry rotation to a controlled stop.
- disables cradle power and unlatches the cradle.
- terminates high voltage and x-ray generation immediately.

Above each gantry control panel, you’ll find an emergency stop button. The E-Stop buttons are labelled with two inverted equilateral triangles inside a circle with red lettering. See Figure 1-7.

If for any reason you need to disable gantry rotation, x-ray generation and table drive functions, the E-stop switches should be employed. The E-Stop switches are momentary contacts that latch the system into the E-Stop state.

Figure 1-7 Gantry E-Stop ICON

To re-enable (remove the E-Stop condition) the system for operation again, press the reset button on any of the gantry’s control panels or at the console. See Figure 1-8.

Figure 1-8 Gantry E-Stop Reset Button

Figure 1-9 Console E-Stop Location

Do not use the scan stop buttons on the console or the gantry control panels , if it is necessary to stop gantry rotation immediately. Use the E-stop. The scan abort switch only terminates x-ray generation and does not stop gantry rotation. See Figure 1-8.

3.3.3 Table Latch and Tape Switches

Pressure sensitive “tape” switches are located on both sides of the cradle and base. The purpose of these switches is to sense obstructions during cradle movement. When activated, the switch disables cradle drive power. The cradle unlatches when cradle drive power is removed.

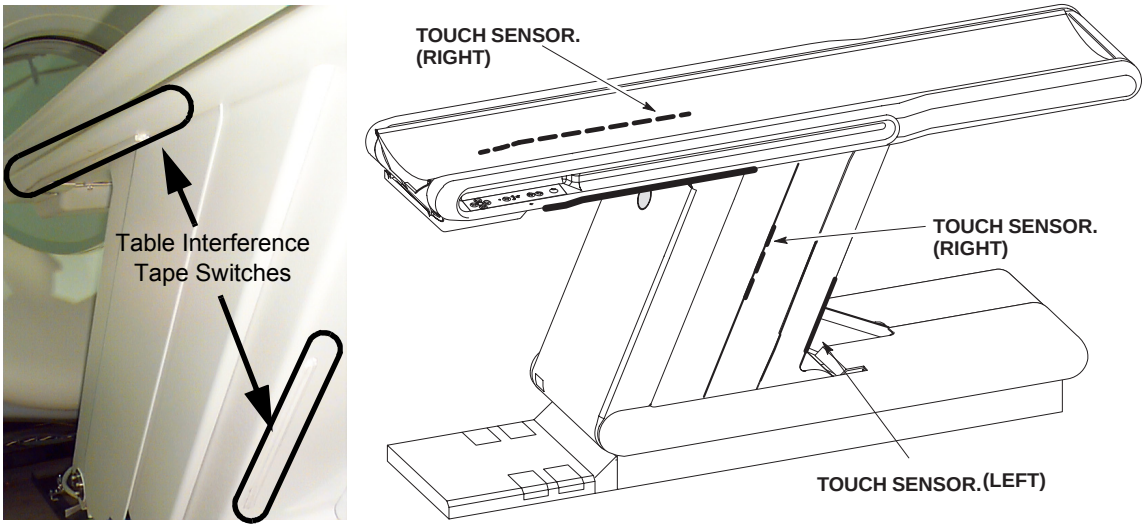


Figure 1-10 Table Tape Switches

In case of an emergency, a cradle latch button is provided on the gantry control panel. It is a toggle switch. When engaged, it unlatches the cradle, but doesn’t remove power to the cradle’s drive. To latch the cradle again, simply press the cradle latch button again.

Never use the cradle latch button to position patients. Use the cradle’s positioning buttons instead. Sudden movement of the cradle when it is unlatched can cause the system to lose track of positioning information, specially during use of an injector.

Figure 1-11 Cradle Latch Button

3.3.4 Tilt Interference Switch Pads

There are two (2) tilt interference switch pads located immediately above where the patient is positioned during scanning. They're located on both the front and rear gantry covers. When either pad is activated, remote (prescribed) tilt of the gantry is inhibited. It takes 10lbs of force (pressure) to activate either of these switches.

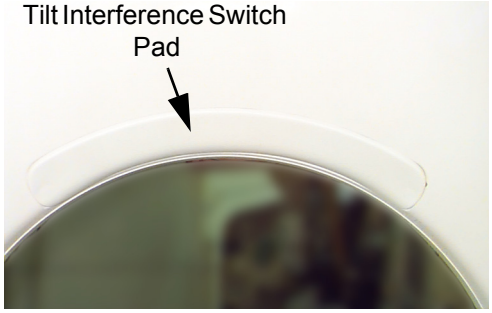


Figure 1-12 Tilt Interference Switch (front cover)

To continue tilting the gantry in the direction of the interference, the operator must manually press the tilt button. The gantry will move one half (1.2) degree each time the tilt button is depressed. Full tilt functionality is not restored until the interference has been removed.

3.3.5 Power Distribution Cover Lock

The top cover of the **PDU** locks. It should be kept locked at all times, unless being serviced. If unlocked, it is possible to remove the **PDU** covers protecting the front of the **PDU**.

Figure 1-13 PDU Lock

Section 4.0
Equipment Service

⚠ DANGER HIGH POTENTIAL FOR INJURY

EQUIPMENT SERVICE CAN ONLY BE PERFORMED SAFELY WITH THE MAIN POWER "DISCONNECT" TAGGED AND LOCKED OUT.

Follow these general rules:

- Only qualified service personnel trained in the service and operation of this scanner should perform any service on this equipment.
- Equipment fuses, switches and circuit breakers are for fire and equipment protection only. Do not rely on them to protect you against electrical shock or un-commanded equipment motion.
- Personal Protection Equipment (**PPE**) is required and must be worn.

The service switches and circuit breakers described hereafter are not to be relied on as personal protection devices. They do not replace tag and lockout of main power to ensure personal safety. Switches and breakers are intended to only inhibit particular system functions and equipment operation. They do not eliminate or remove the electrical or mechanical hazards that exist. Because hardware can fail and defeat the functionality of these devices, only Lockout/Tagout ensures protection from unattended gantry rotation and electrocution.

Personal protection equipment must always be used when performing service on this equipment. Always use **PPE** when working with hazardous chemicals or materials.

4.1 Gantry

4.1.1 Overview

With the gantry's primary covers removed, secondary covers are used to help prevent accidental contact with electrical contacts. The most electrically dangerous area in the gantry is the exposed slip ring plater. The system should be tagged and locked out whenever the gantry covers are removed.

When the gantry is rotating, the left and right sides of the gantry are where objects are most likely to be ejected, if not properly fastened. **IT IS IMPORTANT THAT ALL HARDWARE BE PROPERLY FASTENED (TORQUED) TO THEIR PROPER SPECIFICATION.**

Take the following precautions when working on, near or around the gantry:

- Never wear loose clothing or jewelry. Clothing might become entangled in the rotating assembly and jewelry can short to high voltages.
- Avoid standing near the rotating assembly when it is operational, to avoid being struck by the assembly or ejected objects. **ALWAYS TORQUE FASTENERS TO THEIR PROPER SPECIFICATION.**
- Avoid standing or kneeling near the slip ring platter. High voltages exist on the exposed rings. Always disable power to the rings by using the switches on the **STC** before performing service.
- Never put any part of your body into the gantry, unless the gantry is locked. Axial drive power must be disabled. The tilt bracket should be installed, if working on the tilt assembly.
- Avoid inhalation of slip-ring dust. Use a respirator or appropriate mask when performing service on the ring.
- Wear and use personal protection equipment.
- Tag and lockout power at the main disconnect.

Always use and follow procedures described in your service documentation, when servicing this equipment.

4.1.2 Electrical

4.1.2.1 Potential Hazards

All un-insulated electrical contacts—including the slipring—have secondary covers in place to protect service personnel from accidental contact. Removal of any secondary cover exposes service personnel to potentially deadly voltages (see Figure 1-14). All secondary covers must be in place before primary covers are installed and during routine service.

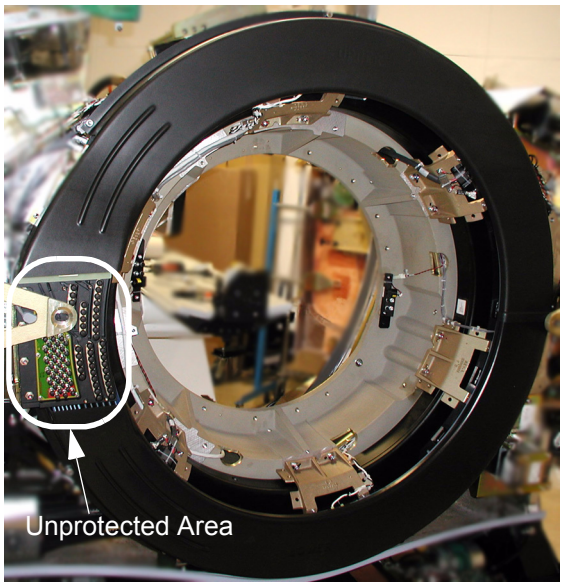


Figure 1-14 Gantry Slip Ring Platter Covers

Un-insulated high voltage areas in the brush-block area include:

- High voltage DC for X-ray generation. Only measurement equipment isolated from ground can be used to measure **HVDC** on this system. Use of grounded measurement equipment can result in serious personal injury and/or equipment damage.
- 120VAC for power supplies.

4.1.2.2 Safety Awareness Indicators

LABELS - ELECTRICAL HAZARDS

Figure 1-15 Gantry Electrical Hazard Labels

If a secondary cover can be removed and it potentially exposes a service person to an uninsulated electrical hazard, a warning label is applied to or near the secondary cover. In the gantry, voltage hazards in excess of 120VAC have been labeled. However, the 120VAC present in the gantry also is capable of causing electrocution. See Figure 1-15 for the types of labels used in the gantry.

LAMPS & LEDS

There are a number of lamps/**LED**s on the **STC** chassis backplane (see Figure 1-17) that indicate the functional state of the gantry. See Table 1-1, for a functional description.

LED #	COLOR	LABEL	DESCRIPTION
DS1	Green	C Pulse	C Pulse indicator from Axial Encoder.
DS2	Green	RST	Indicates status of the **HVDC** & gantry drives circuit in **PDU**. On steady = **HVDC** & Drives Enabled Slow Flash = E-Stop activated. **HVDC** & Drives Disabled Fast Flash = Table Tape Switch activated. Cradle, Tilt & Elevation Disabled
DS3	Yellow	AX DR ON	Indicates the Axial Drive Contactor in the **PDU** is energized.
DS4	Green	ENBL	Indicates the Axial Drive Contactor in the **PDU** is enabled.
DS5	Yellow	HVDC ON	Indicates the **HVDC** Contactor in the **PDU** is energized.
DS6	Green	ENBL	Indicates the **HVDC** Contactor in the **PDU** is enabled.
DS7	Yellow	120VAC ON	Indicates the Gantry 120Vac Contactor in the **PDU** is energized.
DS8	Green	ENBL	Indicates the Gantry 120Vac Contactor in the **PDU** is enabled.

Table 1-1 STC Lamp Descriptions

The descriptions in Table 1-1, for DS1 through DS8, apply when the associated **LED** is illuminated.

4.1.2.3 Service Outlets

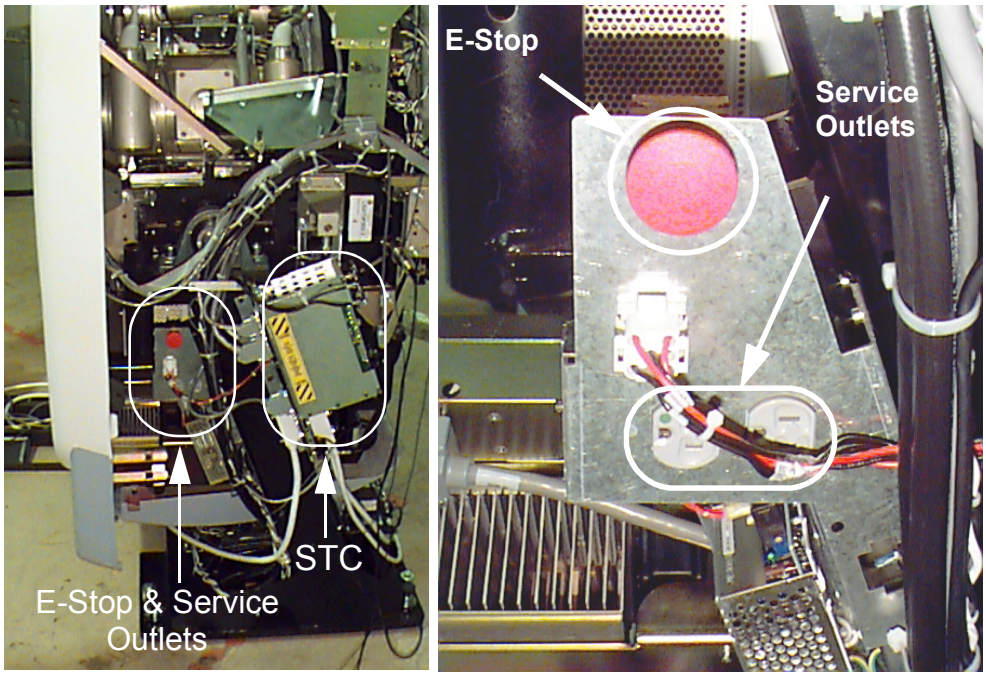


Figure 1-16 Gantry E-Stop and Service Outlets (Right Side of Gantry)

4.1.2.4 Service Switches & Circuit Breakers

A number of service switches have been provided as means of disabling hazards at particular points in the gantry, for ease of service. The gantry service switches are the:

- **STC** Service Switches
- Power Pan Circuit Breaker
- Gantry E-Stop

STC SERVICE SWITCHES

The **STC** Service switches are located at the top of the **STC**, on the backplane (see Figure 1-17). UP (enabled) is the normal operational position for these switches.

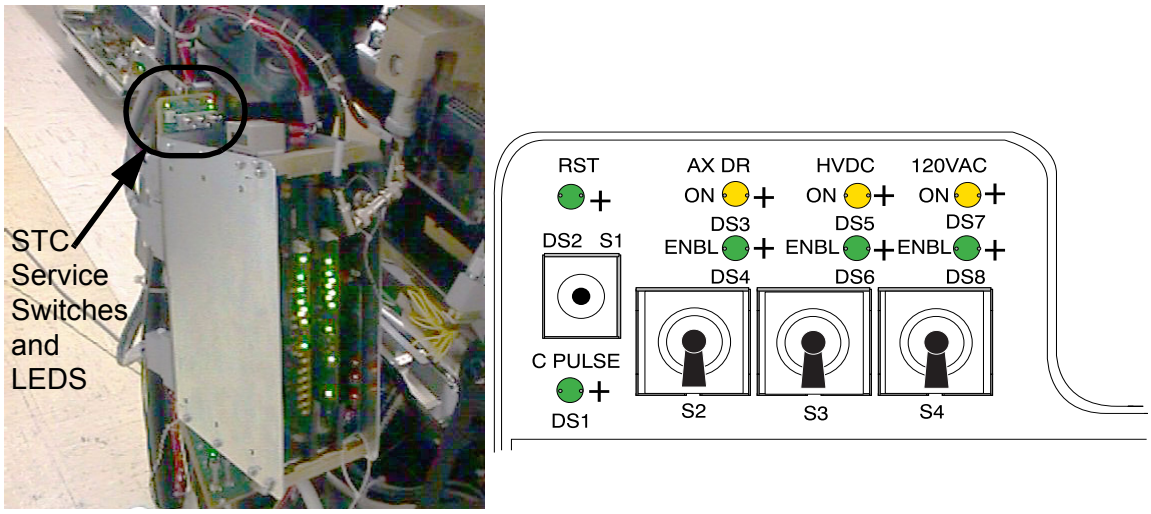


Figure 1-17 Location of STC Service Switches and LEDs (Switches shown in OFF position)

LABEL	DESCRIPTION
S1	Momentary Push button - Resets gantry drives enable circuit in **PDU**.
S2	Switch enables or disables the Axial Drive function - Default position up (enable)
S3	Switch enables or disables the **HVDC** function. Default position up (enable)
S4	Switch enables or disables Gantry 120VAC function - Default position up (enable). With S4 OFF, 120VAC to the gantry and table service outlets is controlled by CB3 in the **PDU** only.

Table 1-2 STC Service Switch Descriptions

4.1.2.5 Power Pan Circuit Breaker

The circuit breaker in the power pan, located at the rear of the gantry base, protects both t 170VDC and tilt drives (table and gantry respectively).

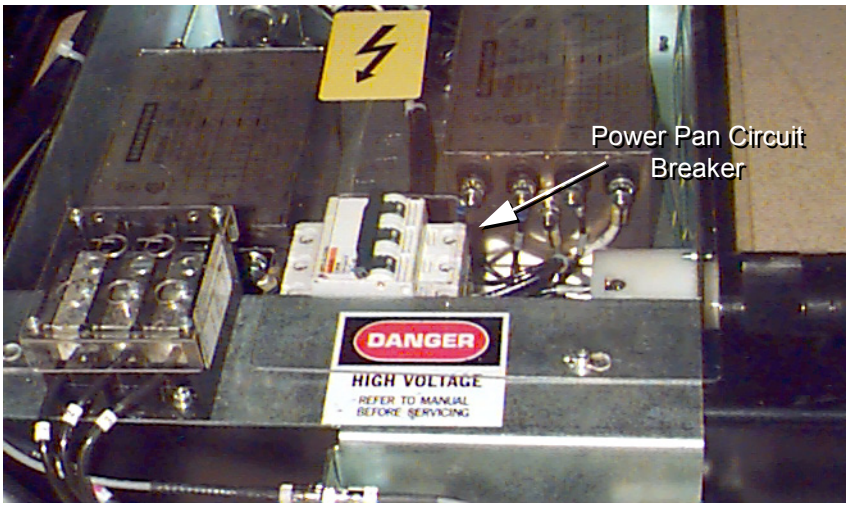


Figure 1-18 Power Pan Circuit Breaker

4.1.2.6 Gantry E-Stop

The gantry's internal E-Stop performs the same function as the E-Stops mounted to the console and the gantry covers. See Figure 1-16.

4.1.3 Mechanical

4.1.3.1 Hazards

Within the Gantry are several hazards that can cause personal injury from:

- moving assemblies (rotational and tilt)
- assembly weights (tube and covers)
- chemicals (slip ring brush dust and oils {Tube, **HV** Tank and Tilt Drive Hydraulic Oil})
- heat sources (tube)

4.1.3.2 Fastener Torque Specifications

To prevent assembly and part separations from the rotating assembly, *all fasteners must be torqued to their proper specification, using a calibrated torque wrench*. The torque specification for a fastener is specified in its associated replacement procedure. For further information on torque, including a conversion factor chart, please refer to Appendix A.

4.1.3.3 Rotational Locking Pin

To prevent un-commanded motion of the rotating assembly, the rotational locking pin must be engaged anytime the rotating assembly is serviced.

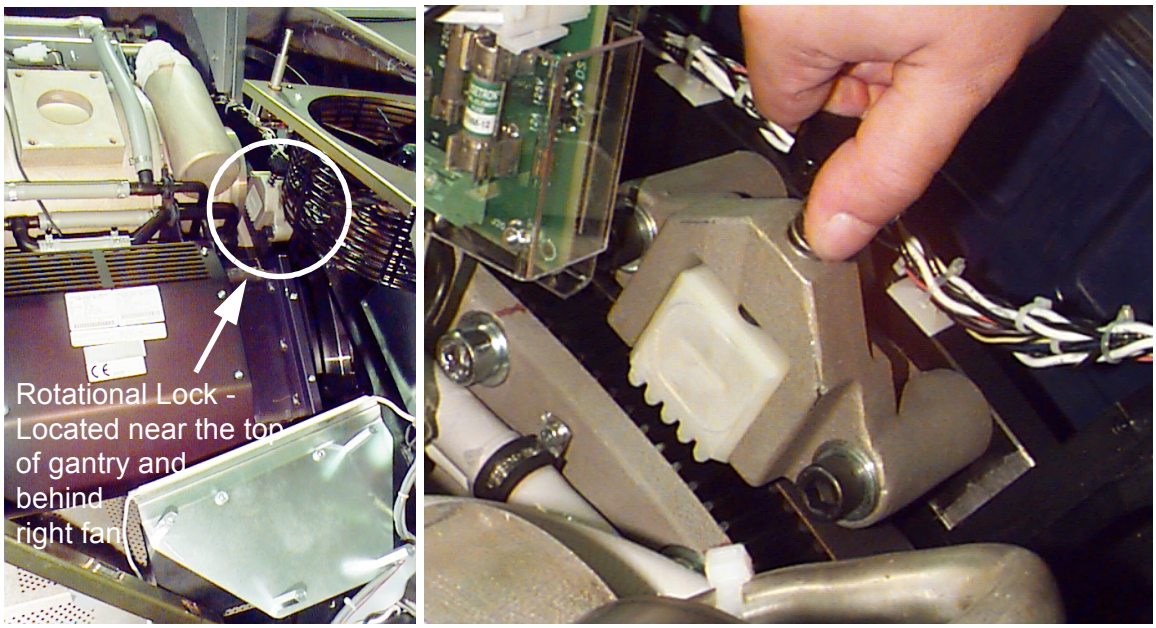


Figure 1-19 Rotational Lock Assembly

The rotational lock is located on the rear side of the gantry, near its top. It is positioned directly across from the teeth in the rotational assembly. To operate the lock:

- Turn the handle clockwise until the teeth on the lock fully engage the teeth on the rotating assembly. You can rock the rotating assembly slightly, if its necessary to align the teeth. Hand tighten until snug. Do not over tighten. Visually verify that the teeth are engaged.
- Turn the handle counter-clockwise until the teeth on the lock and the rotating assembly are fully disengaged and the teeth clear each other sufficiently.

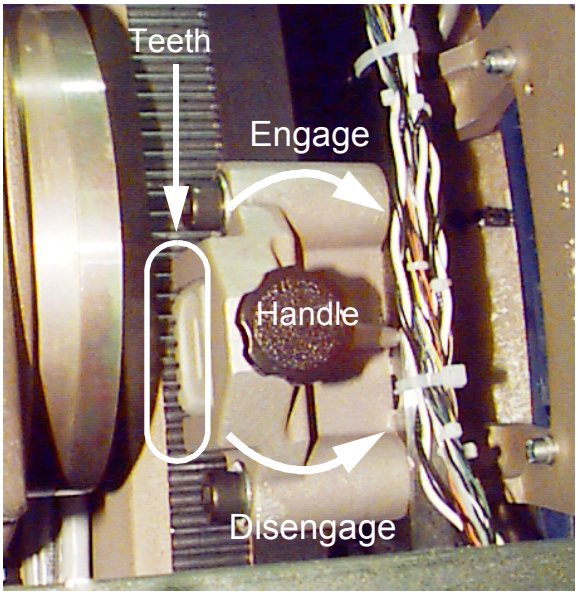


Figure 1-20 Rotational Lock Assembly Operation

4.1.3.4 Tilt Function Lock-out Using the "Locking" Brackets

WARNING **DO NOT USE THIS PROCEDURE WHEN REPLACING OR SERVICING THE TILT HYDRAULIC CYLINDERS. THE APPROPRIATE METHOD FOR SAFELY INHIBITING GANTRY MOVEMENT IS DEFINED IN THE STEPS OF THE REPLACEMENT PROCEDURE.**

This procedure would be used under the following conditions:

- If a gantry was going to be moved from one room to another during the gantry's de-installation.
- If a gantry was being permanently removed from the system.
- If another procedure specifically directs Service personnel to install these Locking Brackets to immobilize the gantry tilt function for a very specific purpose.

1.) Position the gantry at zero degrees. Start on one side.

2.) While holding the bracket in place (see Figure 1-21), secure the bracket to the stationary frame at locations 1 and 2. [Note: The two tilt brackets are identical.]

3.) Next, secure the bracket to the pivoting frame at location 3.

4.) Repeat these steps on the other side.

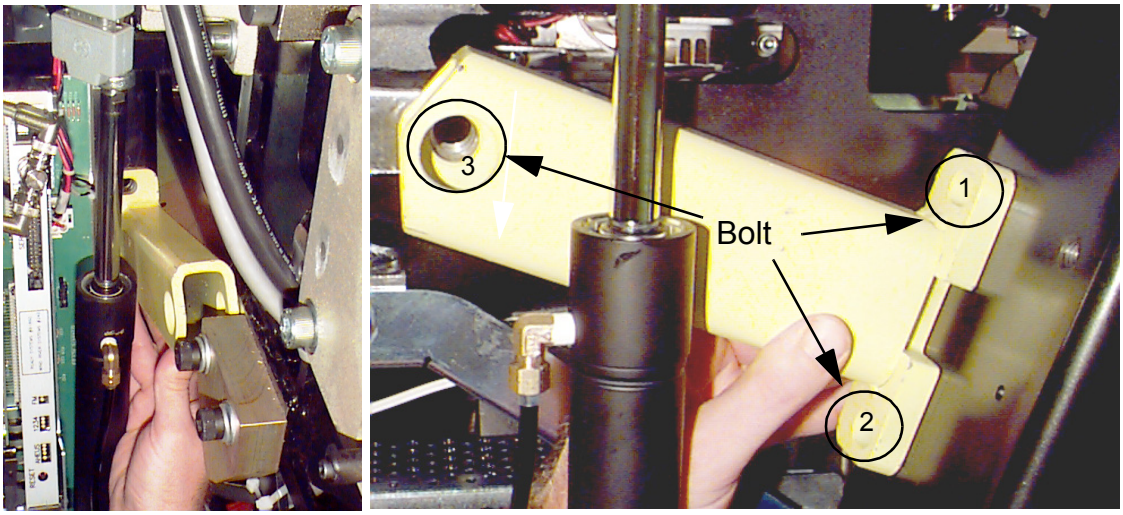


Figure 1-21 Tilt Locking Bracket (Right (STC) and Left Sides)

When the brackets and associated hardware are not being used, store them in the top compartment of the **PDU**.

5.) To remove the brackets, refer to Section 1.3 Spatial Orientation While Servicing The System:

a.) On the Left side of the gantry remove the two bolts at the base of the Locking bracket.

b.) Keep your hands and body well clear of the gantry, use a socket wrench with an extension and remove the final bolt from the rotating side of the gantry allowing the bracket to fall freely (Being held by the wrench and final bolt being removed).

c.) Carefully remove the Locking Bracket with one hand minimizing any exposure to potential pinch points.

d.) On the Right side of the gantry remove the two bolts at the base of the locking bracket.

e.) Keep your hands and body well clear of the gantry and any potential pinch points. Use a socket wrench with an extension to ONLY LOOSEN the final bolt from the rotating side of the gantry 3 full turns. There should be NO movement of the gantry when this final bolt is loosened.

f.) If even a SLIGHT gantry movement is observed and/or the bolt feels like it is binding excessively DO NOT proceed with its removal. Escalate issue, and seek Field Leadership direction immediately for instructions on how to proceed safely.

6.) If NO gantry movement is observed when the bolt was loosened, use a socket wrench with an extension to complete the final removal of the final bolt allowing the bracket to fall freely (Being held by the wrench and final bolt being removed).

7.) Carefully remove the Locking Bracket with one hand minimizing any exposure to potential pinch points.

4.1.3.5 X-Ray Tube Hoist

Whenever the x-ray tube is removed or installed, a tube hoist must be used. When the tube hoist is used, one (1) person can perform a x-ray tube change.

4.1.3.6 Front and Rear Covers Dollies

The front and rear covers have been designed to safely removed by one (1) person, using the cover dollies supplied with your system. These cover dollies must always be used, because the weight of these covers could cause injury. Both the installation manual and system manual describe how to assemble and use these devices.

4.2 Chemicals & Materials

Always wear personal protection equipment to prevent inhalation, digestion and absorption of any substance through the skin, eyes, nose or mouth.

4.2.1 Slip Ring Brush Dust and Debris

Avoid inhalation and digestion of slip-ring brush dust. The slip ring brushes are made of carbon (refer to the **MSDS** for these materials). Carbon is the conductive material used to pass power and signals to the slip ring platters. As the slip ring brushes wear, fine particles of carbon are released. This dust may become an inhalation hazard for individuals with respiratory aliments or diseases. It is recommended that a respirator be worn during service.

4.2.1.1 Cleaning Equipment

Use a **HEPA** (High Efficiency Particulate Air) vacuum cleaner to remove residual brush debris. Do not use a standard vacuum cleaner, because it cannot filter out all of the debris and will exhaust it back into the air. If a **HEPA** vacuum cleaner is not available, use alcohol soaked paper toweling to wipe surfaces clean. This method must be followed up by vacuuming with a **HEPA** vacuum, when available.

4.2.1.2 Personal Protection Equipment (PPE)

- Safety Glasses
- Neoprene or Nitrite Gloves
- Respirator (recommended)

4.2.1.3 Recommended Cleaning Procedure

DANGER **TAG AND LOCKOUT SYSTEM POWER BEFORE WORKING AROUND OR PERFORMING ANY SLIP-RING MAINTENANCE.**

To clean the slip rings, proceed as follows: Remove all existing brush debris from the brush blocks, brackets, and surrounding areas, using a **HEPA** (High Efficiency Particulate) vacuum cleaner. Use the **HEPA** vacuum cleaner to remove all brush debris that may have been deposited on the gantry base and floor during servicing. Never use rags or cloths on the slip ring and brushes.

NOTICE Potential for Equipment Damage **When cleaning the slip ring and brush area, do not touch the slip ring or the brushes with your bare fingers. Skin oil can damage the rings and brushes.**

4.2.1.4 Clean-up and Personal Hygiene

After servicing slip ring component and the area, wash your hands thoroughly with soap and water. Dispose of personal protection equipment and rags properly.

Place all materials that contain brush debris (such as the **HEPA** vacuum cleaner filter, paper toweling, gloves, and old brush assemblies) in a sealed plastic bag and return to the GE Recycling Center:

GEMS Recycling Center
% ACE Warehouse
Building #11
2200 E. College Avenue
Cudahy, WI. 53110

4.2.2 Oils (Tube, Tank and Hydraulic)

Oil resistant gloves should be worn when working with oil or performing clean-up of it. Dispose of chemicals, rags and materials in accordance with hospital and local government environmental and safety requirements.

4.2.3 Lead

Wear gloves and wash hands after handling lead. The **CT** detector uses a small amount of lead tape and a trace amount of Chromium (Cr) in its construction. The lead tape is located on the corners of the detector. Detectors can be returned to GEMS for proper disposal.

4.2.4 Heat Sources

The X-Ray tube casing, plumbing and radiator can become hot enough to cause minor burns, if not allowed to cool sufficiently. Please allow sufficient time for this equipment to cool adequately before performing any service.

4.3 Table

4.3.1 Electrical

4.3.1.1 Potential Hazards

The table base contains several lethal voltages. There are a number of points in the table where the voltages are dangerous (120 VAC and 170DC present). Theses points pose a potential electrical hazard to anyone that accidentally comes in contact with them.

4.3.1.2 Safety Awareness Indicators

A power lamp is located on the table power assembly. It is illuminated whenever power is present at the table service outlets. See Figure 1-22.

4.3.1.3 Service Outlet

A service outlet is located on the table's power assembly (see Figure 1-22). It is protected by CB3 in the **PDU**.

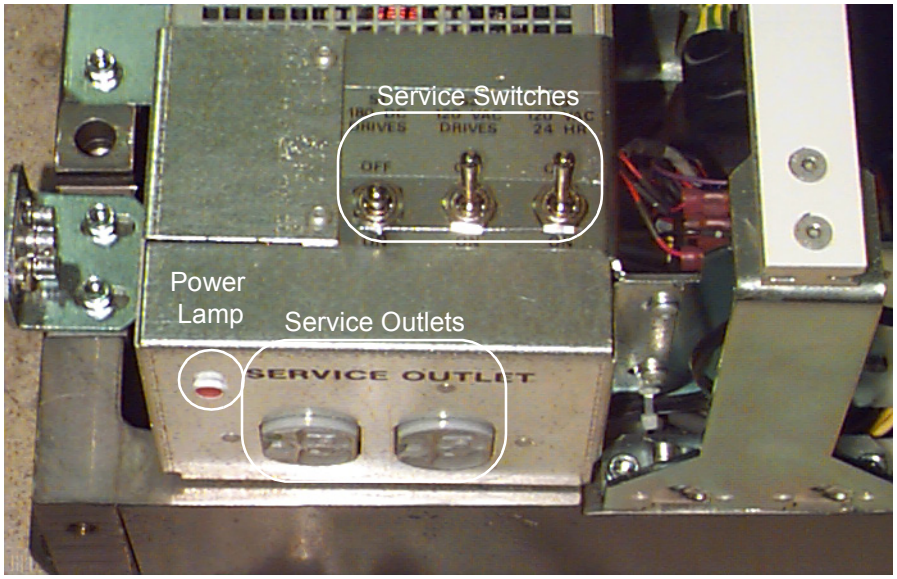
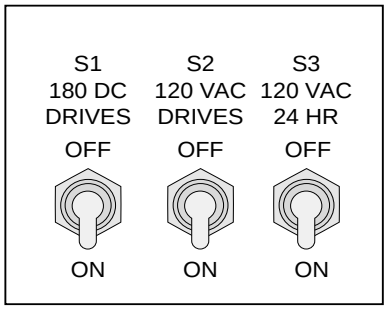


Figure 1-22 Table Service Outlet and Safety Switches

4.3.1.4 Switches

The Table Safety Service switches are located on top of the power assembly. See Figure 1-22. These switches are a subset of the 120VAC switch on the gantry.



S1 180 DC Drives - Enables/disables 170VDC Power Supplies for table elevation.

S2 120VAC Drives - Enables/disables 24V Power Supply for table cradle & elevation.

S3 120VAC 24 HR- Enables/disables 120 VAC Table Power.

Figure 1-23 Table Switches

4.3.2 Mechanical

TOUCH SENSOR (JUMPER) SERVICE JUMPER

During service, the table touch sensors must remain operable for the table to fully function. To operate the table with the covers removed, the sensors must be jumpered.

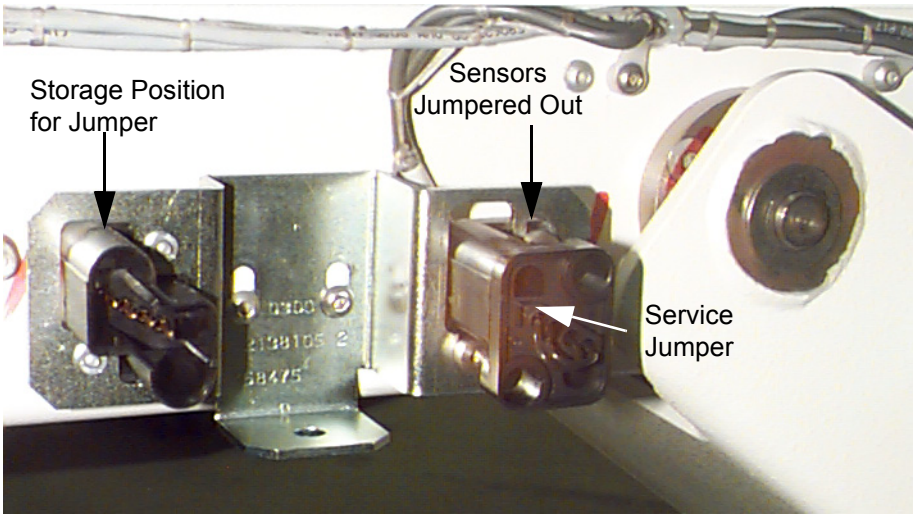


Figure 1-24 Table Touch Sensor Jumpered Out

4.3.3 Chemical

Always wear personal protection equipment that prevents inhalation, digestion and absorption through skin of chemicals.

4.4 Console

CONSOLE ON/OFF POWER SWITCH.

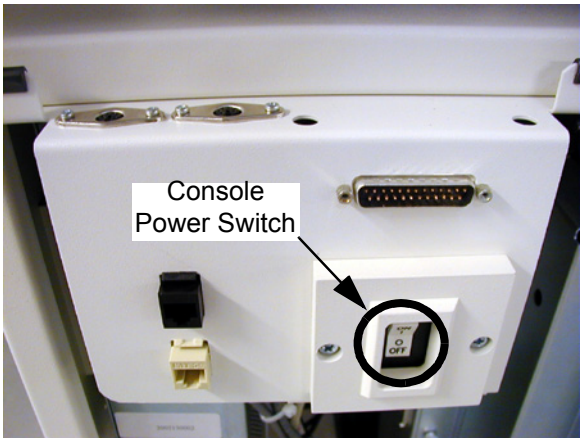


Figure 1-25 Console ON/OFF Power Switch (Global Console, front cover removed)

4.5 Compact Power Distribution Unit (CPDU)

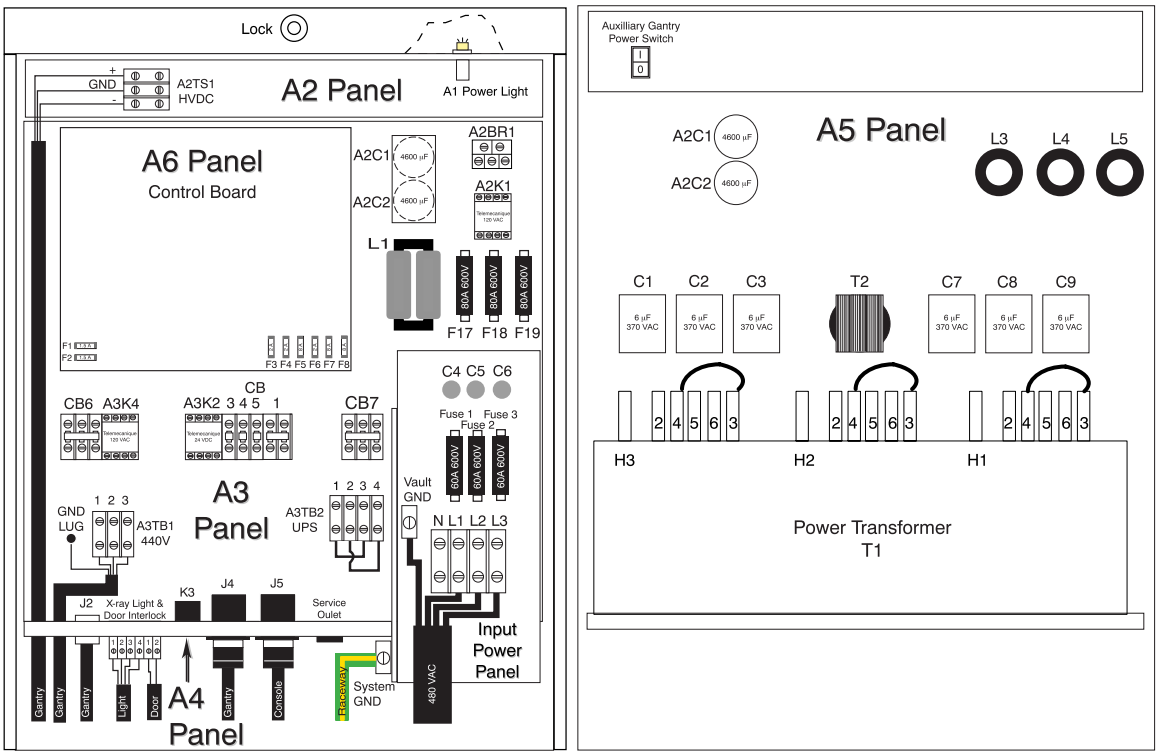


Figure 1-26 CPDU Front & Rear (exposed view)

Do not perform any work within the Power Distribution Unit (**PDU)**, unless it is de-energized. More than 100 Kilowatts of power exists in the **PDU** at various periods of time. Therefore, consider all points in the **PDU** as hazardous.

- Connect voltage measuring equipment only when power is removed and the wall power box is locked and tagged.
- Always wear safety glasses because of the high voltages that exist in the **PDU**. Components can literally explode when power is applied.

Be sure that all secondary protective covers on the PDUs are in place before the **PDU** is energized.

4.5.1 Electrical

4.5.1.1 Potential Hazards

- Axial drive power for gantry rotation (AC)
- High voltage DC for X-ray generation (floating DC)
- Distributed console, table and gantry power (AC)

4.5.1.2 Hazard Awareness Indicators

With the **PDU**'s top cover hinged open, a small power lamp is visible. When illuminated, this lamp indicates power is present within the **PDU**. See Figure 1-27.

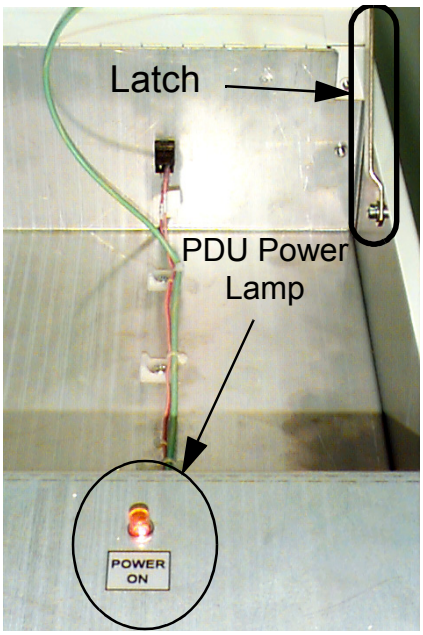


Figure 1-27 PDU Power Lamp (PDU Top Cover Opened and Latched)

4.5.1.3 Protected Service Outlets

The service outlet is protected by a circuit breaker. The outlet is located on the A4 panel. See Figure 1-26.

4.5.1.4 Circuit Breakers and Switches

CIRCUIT BREAKERS

There are three (3) groups of circuit breakers in the **PDU** used to protect various parts of the system.

CB1 - Console AC power.

CB3 - Table and Gantry AC service outlets.

CB4 - Table and Gantry AC to stationary electronics.

CB5 - Gantry rotating power, tilt power and communications.

CB6 - Main Axial drive power.

CB7 - Master 120/208VAC power (CB1, 3, 4 and 5).

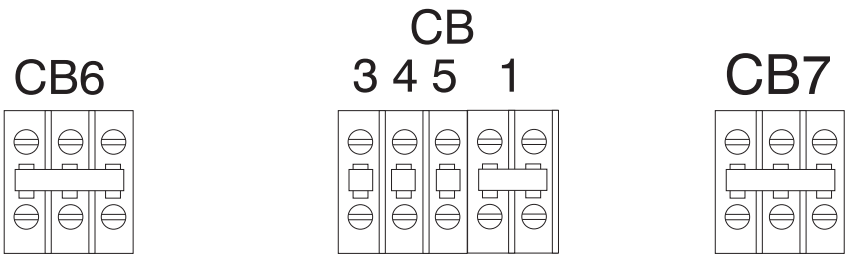


Figure 1-28 PDU Circuit Breakers

AUXILIARY GANTRY POWER SWITCH

Auxiliary gantry power switch should be left “ON” at all times. Used to disable 120VAC.

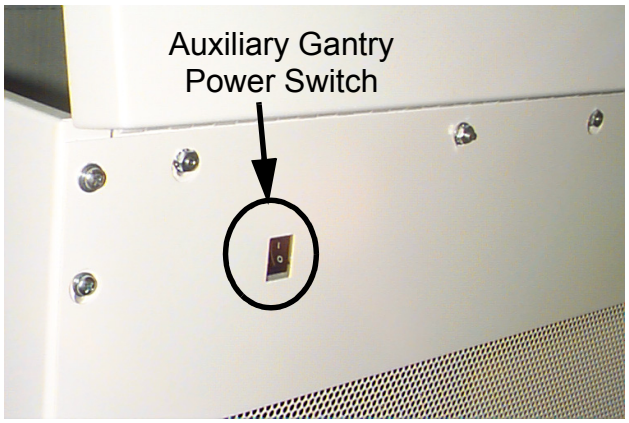


Figure 1-29 Auxiliary Gantry Power Switch (PDU Rear)

4.5.2 Mechanical

The **PDU**’s top cover employs latches on both sides to hold the cover in the open position. See Figure 1-27.

4.6 Power Distribution Unit (NGPDU)

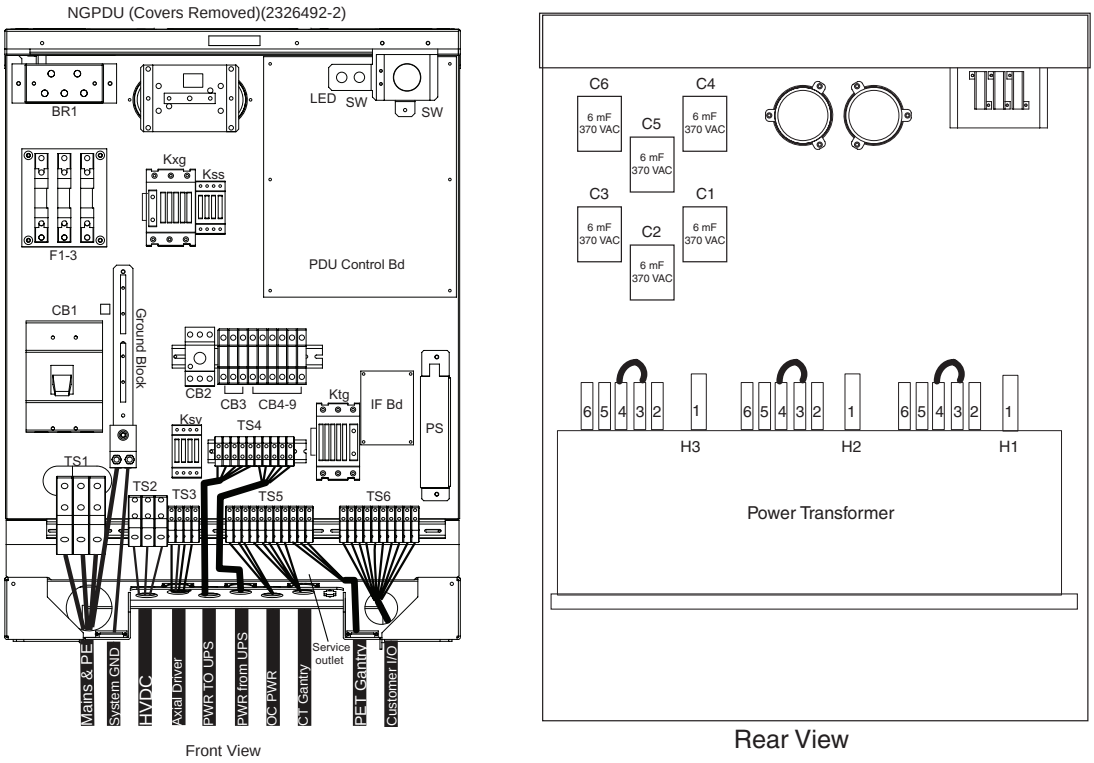


Figure 1-30 NGPDU Front & Rear (exposed view)

Do not perform any work within the **PDU**, unless it is de-energized. More than 100 Kilowatts of power exists in the **PDU** at various periods of time. Therefore, consider all points in the **PDU** as hazardous.

- Connect voltage measuring equipment only when power is removed and the wall power box is locked and tagged.
- Always wear safety glasses because of the high voltages that exist in the **PDU**. Components can literally explode when power is applied.

Be sure that all secondary protective covers on the PDUs are in place before the **PDU** is energized.

4.6.1 Electrical

4.6.1.1 Potential Hazards

- Axial drive power for gantry rotation (AC)
- High voltage DC for X-ray generation (floating DC)
- Distributed console, table and gantry power (AC)

4.6.1.2 Hazard Awareness Indicators

A small power lamp is visible on the front cover. When illuminated, this lamp indicates power is present within the **PDU**. See Figure 1-31.

Figure 1-31 PDU Power Lamp

4.6.1.3 Protected Service Outlets

The service outlet is protected by a circuit breaker. The outlet is located on the Terminal panel. See Figure 1-30.

4.6.1.4 Circuit Breakers and Switches

CIRCUIT BREAKERS

There are three (3) groups of circuit breakers in the **PDU** used to protect various parts of the system.

CB2 - Circuit Protection(Axial Drive).

CB3 - Full Winding Protection.

CB4 - CT Gantry Service Outlets.

CB5 - CT Gantry rotating loads.

CB6 - Table & CT Gantry Stationary Loads

CB7 - Operator Console

CB8 - PET Gantry

CB9 - NGPDU Control Power Supply

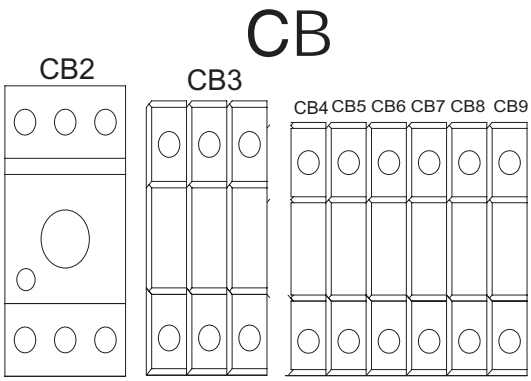


Figure 1-32 PDU Circuit Breakers

Chapter 2
Service Desktop, Tools, and Diagnostics

Section 1.0
Service Desktop

1.1 Using the Mouse

Use the mouse to access and operate diagnostics and tools from the right-hand display monitor, or open a shell and type/enter a UNIX command line. The system displays the Service Desktop Manager along the left-hand side of the right side display monitor, as shown in Figure 2-2.

Use the mouse to make screen selections on the service desktop.

Typical mousebutton functions:

- Press mousebutton one to select.
- Press mousebutton two to extend a selection.
- Press mousebutton three to access pop-up menus.

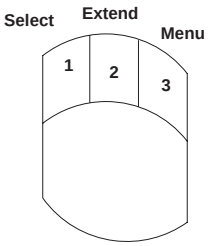


Figure 2-1 Mousebutton Definitions

1.2 Service Desktop - Main Menu (Overview)

The Service Desktop (Figure 2-2) is the entry point for all service tools and diagnostics. The desktop is designed with nine major functional menu areas each with its own purpose. These areas are:

- Error Logs - Select and review system logs (refer to section 1.9, on page 61).
- Diagnostics - Select and execute all diagnostic applications (refer to section 1.8, on page 58).
- Image Quality Tools - Image quality tools not requiring communications via firmware with the system (such as scan analysis). (Refer to section 1.10, on page 62.)
- Calibration Applications - Tools for mechanical, electrical, and imaging calibrations of the system (refer to section 1.11, on page 62).
- Configuration Applications - Save/restore system state and configuration information (refer to section 1.12, on page 63).
- Utilities - Tools useful to the field engineer while installing or servicing a system (refer to section 1.13.1, on page 64).
- Replacement Parts/Repair Procedures - Links to tools required when replacing major field replaceable units (**FRU**s). (Refer to section 1.14, on page 66.)
- Planned/Preventive/Proactive Maintenance - Information to execute a **PM** visit (refer to section 1.15, on page 66).

- Service Desktop Home Page - Icon descriptions and eventually system health status information.

Refer to the appropriate sections and pages for detailed information. References to those pages have been provided above.

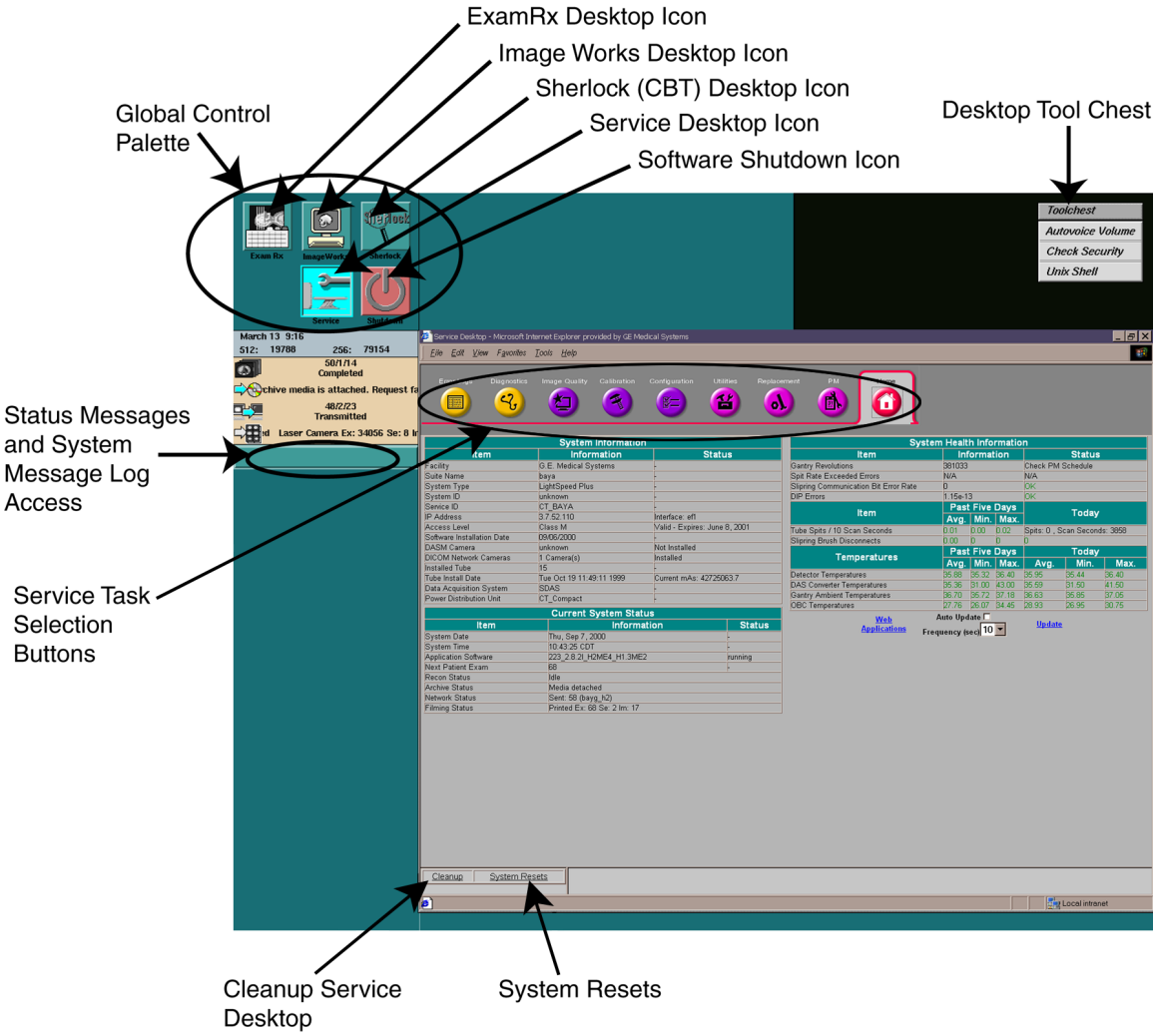


Figure 2-2 Service Desktop, Display Screen Overview

1.3 Menu Function Descriptions

The first part of this chapter briefly describes the basic service diagnostics and tools menus. The second part describes their procedures.

The product has five distinct desktops, one of which is the Service Desktop. The user may move between desktops with the touch of a button on the Global Control Palette, which is always visible on all desktops. When changing desktops, the palette below the Global Control Palette is replaced with the appropriate desktop specific Control Palette. Switching desktops does not modify the current view of a desktop. Even though it may no longer be visible, it is still in the same state as when the switch occurred.

The users of the Service Desktop have different needs than the technologists, radiologists, doctors, and other users of the system. Therefore, the functionality for the Service Desktop differs from that of the other desktops. Windows can be resized, iconified, overlapped, and scrolled. This allows for greater flexibility for the user, especially in the area of troubleshooting where access to many different functions may be needed at the same time.

1.4 Procedural User Interface

The Service Desktop contains a mixture of tools and diagnostics to be used by a Service Engineer. The main philosophy behind the user interface for the Service Desktop is to provide a **procedural** approach to servicing the scanner. All the necessary tools and diagnostics are available at the same time for the procedure at hand, whether it be troubleshooting, replacing a part, performing routine maintenance, or integrating the system for a new install.

Figure 2-3 shows the Service Desktop Service Task selection buttons. Selecting one of the buttons at the top of the window will cause a new list to be displayed in the left-hand frame of the window. In the example shown, REPLACEMENT PROCEDURES has been selected, and a general service list, containing software elements needed to perform Replacement Related Procedures, is shown.

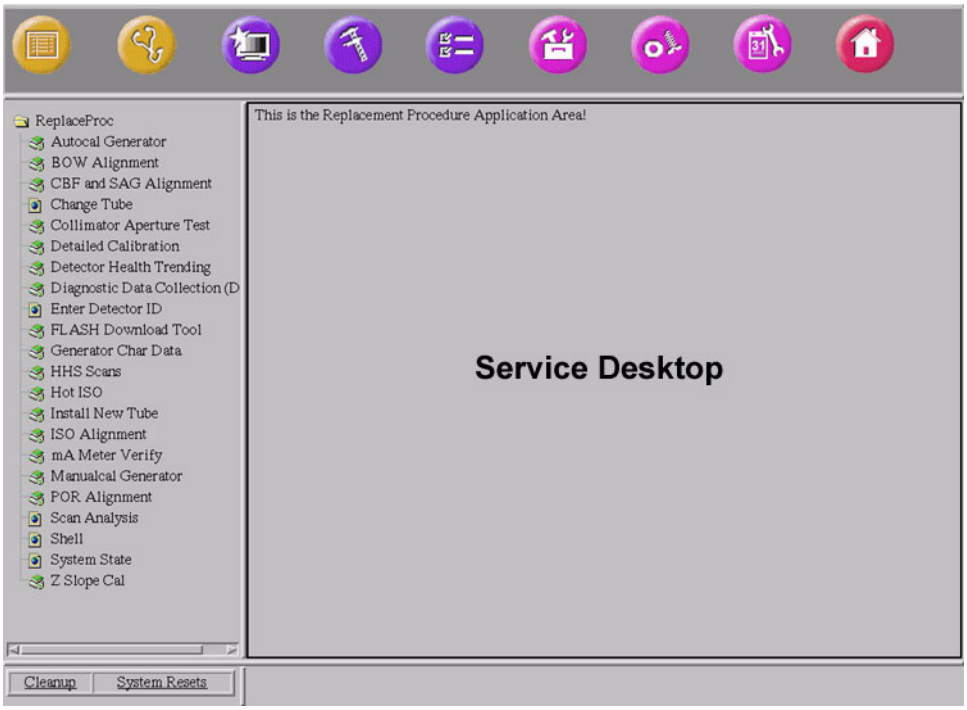


Figure 2-3 General Service Desktop Control Palette (Example)

1.5 Service Desktop Management

Change desktops by selecting the corresponding desktop icon from the Global Control Pallet (see Figure 2-2). Launch, or start each service tool or diagnostic by clicking the mouse on the tool.

The CLEANUP button on the bottom of the desktop cleans up any previously opened windows, and restores the desktop to its original state, rather than closing or dismissing each individual application visible on the Service Desktop. The CLEANUP button should be selected whenever the user is done with the Service Desktop, or whenever it is desired to return the desktops to a known state.

Figure 2-4 Desk Top Management Buttons

Note: CLEANUP reloads applications firmware

If you ran diagnostics that required diagnostic firmware, the CLEANUP button will also reload the application firmware.

The DISMISS button cleans up, then returns to the Service Desktop diagnostics menu.

The SYSTEM RESETS button displays the reset menu for various product or application firmware.

1.6 System Resets

The SYSTEM RESETS function allows the user to reset and download the scanner hardware as required, preparing the system for scanning operation. Access SYSTEM RESETS as follows:

1.) Select SYSTEM RESETS from the Service Desktop (refer to Figure 2-4). The reset applications selections include (refer to Figure 2-5):
   - SCAN - Resets and downloads all controllers in the gantry and table.
   - RECON - Resets the recon subsystem (**PEG-IG** and **RIP** boards).
   - DAS/COLL - Resets the **DAS** control and collimator control board.
   - DATA ACQUISITION - Resets the **DAS**, control, collimator control, and **DIP** boards.

2.) Select RESET from the displayed screen.

3.) Select RUN.

The status box displays the status of the selected reset.

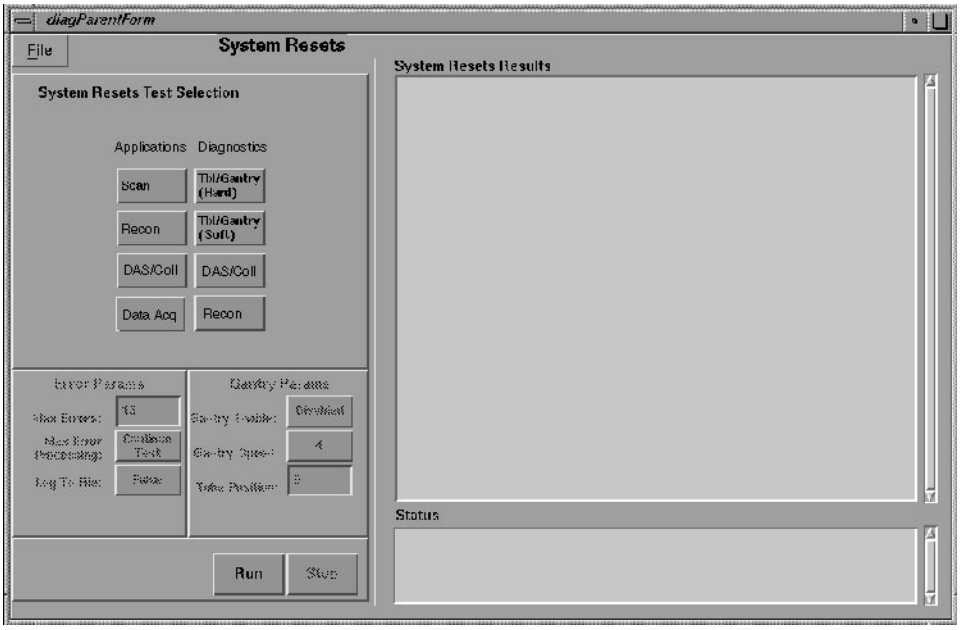


Figure 2-5 System Resets Screen

1.7 Diagnostic Graphical User Interface *(X-Windows)*

Selecting a diagnostic from the Service Desktop brings up a diagnostic **GUI**. The diagnostic interface is broken up into four different areas: specific test control, generic test control (including error parameters and gantry parameters), test results, and test status. Refer to Figure 2-6 and the descriptions that follow.

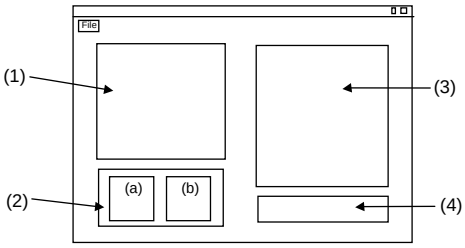


Figure 2-6 Diagnostic Graphical User Interface *(x-windows)*

Callout numbers (1, 2, a, b, 3, and 4) from Figure 2-6 include:

1.) **Specific Test Control** - Use this area for selecting a test and associated parameters.

2.) **Generic Test Control** - Use this area to control the error parameters and gantry parameters:

a.) **Error Parameters Area** - These choices are shown in every diagnostic interface (see Figure 2-7). Click on the error parameter icons to view the choices.

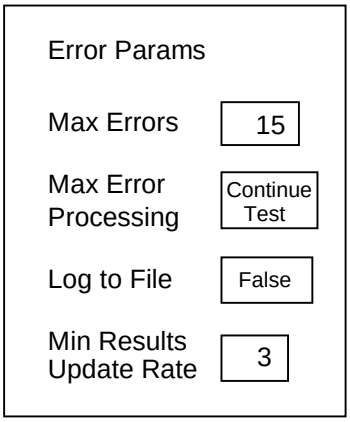


Figure 2-7 Error Parameters

Max Errors - Determines the number of errors that have to occur before processing of errors is changed. Type in any number you like.

Max Error Processing - Determines what to do when the max error count has occurred. Choices are CONTINUE THE TEST, STOP LOGGING ERRORS, and STOP THE TEST.

Log to File - Determines if the results screen should be put into a log file titled DiagSession.log. Choices are TRUE or FALSE.

Min Results Update Rate - Determines how often the results screen section should be updated. Any faster than three seconds is difficult to read.

b.) **Gantry Parameters Area** - This area defines what you want the gantry to do during a diagnostic, and is available for most tests. It is useful for reproducing errors that occur only when the gantry is rotating. Click on the gantry parameters icons to view the available choices.

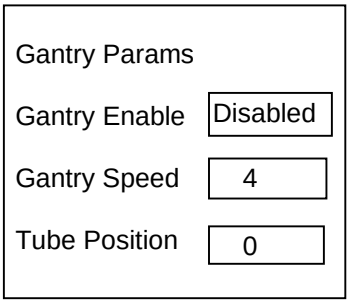


Figure 2-8 Gantry Parameters

Gantry Enable/Disable - Determines what to do with the gantry during the test. Choices include DISABLE, POSITION, and ROTATION.

Gantry Speed - Determines how fast to rotate, if rotation has been selected. Choices are 1, 2, 4, or 20 seconds per rotation.

Tube Position - Moves the tube to the position entered.

3.) **Test Results Area** - View the output results of the specific diagnostic here.

4.) **Test Status Area** - View the status messages, such as Start, Stop, and Test Aborted, here.

1.8 Diagnostics Menu - General Service

The diagnostics menu provides an alphabetical listing of the diagnostic programs available to the general class user.

1.) Click the SERVICE DESKTOP icon

to display the Service Desktop.

2.) Select the DIAGNOSTICS icon to display the system's top level diagnostics menu (refer to Figure 2-9.)

Note: With no security key installed, the General Diagnostics Menu will be displayed as described below.

- Diagnostics
  - Autocal Generator
  - Back-Up Timer Generator
  - BOW Alignment
  - {Cal Analysis}
  - CBF and SAG Alignment
  - Collimator and Filtration
  - Collimator Aperture Test
  - {Config Tracker}
  - DAS Tools
  - DD File Analysis
  - Diagnostic Data Collection
  - DIP Diagnostics
  - FLASH Download Tool
  - Generator Char Data
  - Install SMPTE from AW
  - Install New Tube
  - ISO Alignment
  - KV Loop
  - Kv & mA (X-Ray)
  - mA Meter Verify
  - Manualcal Generator
  - Mechanical Characterizatio
  - POR Alignment
  - RCIB Diagnostics
  - Rotor Control
  - Recon Data Path
  - Scan Analysis
  - Shell
  - Scan Data Path
  - Storelog
  - System State
  - Tube Usage
  - X-Ray Interlock

Figure 2-9 Diagnostics Menu (General Service Desktop)

The Menu has three types of icons:

1.) The first icon represents tools and diagnostics that require the download of diagnostic firmware to the scan control sub-system.

If a selected test finds that application firmware is loaded, and it needs diagnostic firmware, you will have to wait for diagnostic FIRMWARE DOWNLOAD to take place upon confirmation (refer to Figure 2-10).

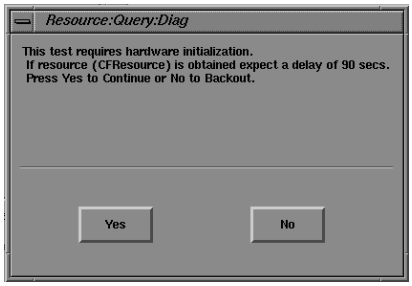


Figure 2-10 Firmware Download Query Pop-Up

2.) The second icon represents tools and diagnostics that require the download of application firmware to the scan control sub-system.

3.) The third icon represents tools and diagnostics that do not require the download of any firmware to the scan control sub-system.

A particular tool or diagnostic is executed by clicking on its icon or on the text next to the icon.

Note: Braces indicate future features

Braces surrounding a name on the menu indicate that it is a planned feature (one not yet implemented). If you select such an item, a **UNIX** shell tool will probably open.

Use the diagnostics menu to access the following tools and diagnostics:

AUTOCAL GENERATOR

Automatically updates the X-ray generator characterization files.

BACK-UP TIMER GENERATOR

Activates the exposure backup timer.

BOW ALIGNMENT

Use to check the Beam on Window (**BOW**) alignment, to ensure the x-ray beam is properly aligned to the detector window.

CAL ANALYSIS

Not yet available. Use to examine calibration information.

CBF AND SAG ALIGNMENT

Use to check the Center Body Filter (**CBF**) and System Angular Geometry (**SAG**) alignments for the focal spot, relative to the collimator and detector.

COLLIMATOR AND FILTRATION

Provides a means to command the system to move the collimator filter assembly to the various filter selections, and to move the collimator aperture assembly to the various aperture selections.

COLLIMATOR APERTURE TEST

Provides a means to perform scans and verify that the aperture selections produce a scan with the appropriate aperture thickness.

CONFIG TRACKER

Not yet available. Gathers information about the system configuration.

DAS TOOLS

Use to exercise and verify all scan data acquisition functions, such as microphonics.

DD FILE ANALYSIS

Use to view and analyze the diagnostic data files, cal, image, or scan files.

DIAGNOSTIC DATA COLLECTION (DDC)

Performs many service scanning functions and tests. Gathers system data with or without x-ray rotation.

DIP DIAGNOSTICS

Tests the **DAS** Input Processor (**DIP**) board and its functions.

FLASH DOWNLOAD TOOL

Allows downloading of FLASH (Firmware Image) to various gantry controllers (such as the **CCB**-Collimator Control Board and the **DCB**-**DAS** Control Board).

GENERATOR CHAR DATA

Use to examine the x-ray generator characterization files.

INSTALL SMPTE FROM AW

Use to install the **SMPTE** pattern and QA images so they can be displayed as a patient image.

INSTALL NEW TUBE

Updates the system resident tube information file.

ISO ALIGNMENT

Use to complete a tube ISO alignment.

KV LOOP

Tests the kV board.

KV & MA (X-RAY)

Use to perform x-ray functional tests.

MA METER VERIFY

Verifies the mA metering circuit adjustments.

MANUALCAL GENERATOR

Use to manually adjust the x-ray generation characterization files.

MECHANICAL CHARACTERIZATION

Use to set-up the mechanical characterization files.

POR ALIGNMENT

Aligns the tube plane of rotation (**POR**).

RCIB DIAGNOSTICS

Diagnostic tool that tests the Rotor Controller Interface Board (**RCIB**).

ROTOR CONTROL

Diagnostic tool that provides a functional test for the rotor controller subsystem.

RECON DATA PATH

Diagnostic tool that provides a functional test for the image reconstruction process.

SCAN ANALYSIS

Use to list/select and examine scan data.

SHELL

Opens a **UNIX** shell window where you can enter IRIX or **UNIX** commands.

SCAN DATA PATH

Diagnostic tool that provides a functional test for the scan data collection process.

STORELOG

If apps are shutdown first, it can store log files to **MOD**, then it removes those files from the system disks making more disk space available. If the host finds it needs more disk space when it boots, it will run storelog to make room.

SYSTEM STATE

Use to save and restore system configuration and calibration files to and from **MOD** media. The **MOD** saved with system state information has a **UNIX** file system that is not compatible with saving images.

⚠ **NOTICE Potential for Data Loss**

Relabeling the system state MOD as an image MOD will write a DOS filesystem on it, destroying the system state information. DO NOT save image archive data on the side containing the system state information.

TUBE USAGE

Displays x-ray tube related information for current and previous x-ray tubes.

X-RAY INTERLOCK

Tests the exposure interlocks.

1.9 Error Log Viewing Menu - General Service

The error log viewing menu provides access to information about the host hardware and the various versions of software that control the scanner. The tools and diagnostics that can be accessed from the ErrorLog menu are shown below.

Figure 2-11 ErrorLog Icon

ErrorLog
- System Error Log
- OC SYSLOG
- AW Logs
- Software History Logs
- Service Notepad
- Session Log
- Storelog
- System Browser (All features)
- Tube Usage
- Shell

Figure 2-12 ErrorLog Menu (General)

1.10 Image Quality Menu - General Service

Use the ImageQuality menu to access the tools and diagnostics shown in the figure below.

Figure 2-13 Image Quality Icon

ImageQuality
- DD File Analysis
- Install SMPTE Image
- Scan Analysis
- Shell

Figure 2-14 Image Quality Menu (General)

1.11 Calibration Applications Menu - General Service

Use the Calibration menu to access the tools and diagnostics shown in the figure below.

Figure 2-15 Calibration Applications Icon

Calibration
- BOW Alignment
- {Cal Analysis}
- CBF and SAG Alignment
- Collimator Cal
- DAS Gain Cal
- Generator Characterization
- Hot ISO Alignment
- ISO Alignment
- Mechanical Characterization
- POR Alignment
- {Z Align}

Figure 2-16 Calibration Applications Menu (General)

1.12 Configuration Applications Menu

Figure 2-17 Configuration Applications Icon

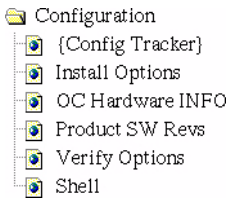


Figure 2-18 Configuration Applications Menu

Use the configuration menu to access the following tools and diagnostics:

CONFIG TRACKER

Not supported at this time.

INSTALL OPTIONS

Calls the option installation program, which allows you to load/install an option key(s) on the system via **MOD** to enable software options.

OC HARDWARE INFO

Calls the system browser preset to display OC information. Many options are available to allow you to view such things as product software revisions, disk usage, network information, and hardware configurations.

PRODUCT SOFTWARE REVS

Calls show prods to display the currently installed product software revisions.

VERIFY OPTIONS

Shows the currently installed software option keys.

SHELL

Presents a window that enables you to enter IRIX and UNIX commands, start scrips that perform a series of commands, or start programs. Press **ALT**-**F12** to exit the shell when it is no longer needed.

1.13 Utilities Menu

The Utilities Menu has three sub-menus: Install, Tools and Util. Additionally, the Utilities Menu provides the tools shown in Figure 2-20.

Figure 2-19 Utilities Icon

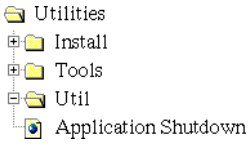


Figure 2-20 Utilities Main Menu

APPLICATION SHUTDOWN

Stops the scanning level of software, but keeps the OC responsive to IRIX/UNIX commands and GE scripts. Applications need to be shutdown to run programs such as **`reconfig`** and **`storelog`**.

1.13.1 Utilities—Install Menu - General Service

The purpose of the install menu is to provide a single access point on the service desktop to work from when integrating and testing a newly installed system prior to turn over to the user.

Use the install menu to access the tools and diagnostics shown in the figure below.

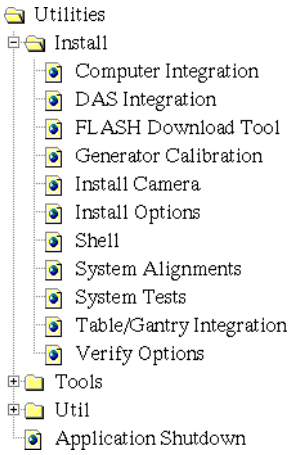


Figure 2-21 General System Installation Menu

1.13.2 Utilities—Tools Menu

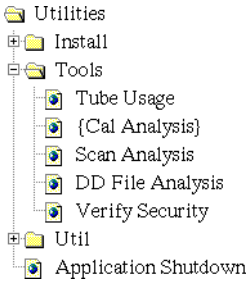


Figure 2-22 Utilities—Tools Menu

Use the tools menu to access the following tools and diagnostics:

TUBE USAGE

Shows you the x-ray tube's serial and model numbers, its meter reading, and install date.

CAL ANALYSIS

Enables you to view and analyze calibration vectors from the calibration database. This tool is not currently available. Use Scan Analysis to plot cal vectors.

SCAN ANALYSIS

Enables you to view and analyze scan data, and plot cal vectors from scan data.

DD FILE ANALYSIS

Use to view and analyze the diagnostic data files.

VERIFY SECURITY

Reports whether you have proprietary or non-proprietary access. This tool also shows the expiration date of your service key, if you have inserted one.

1.13.3 Utilities—Util Menu

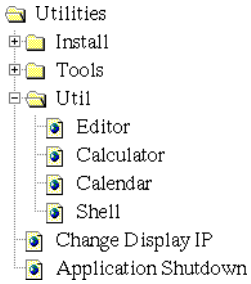


Figure 2-23 Utilities—Util Menu

Use the Util menu to access the following tools and diagnostics:

EDITOR

This opens a “JOT” text editor that enables you to access a file’s content. Selecting FILE > OPEN, opens a popup box at default location `/usr/g/bin`. The default operation is view only.

CALCULATOR

Displays a multi-function scientific calculator.

CALENDAR

Displays the current month’s calendar. (This is a perpetual calendar.)

SHELL

Presents a window that enables you to enter IRIX (OC) commands. Example: Enter: **`hinv`** to get the same information that the OC Hardware Info menu item offers.

1.14 Replacement Procedures - General Service

The Replacement Procedures selection provides access to the most frequently needed tools and diagnostics used to complete tasks associated with **FRU** part replacement.

Figure 2-24 Replacement Procedures Icon

Use the ReplaceProc menu to access the tools and diagnostics shown in the figure below.

Note: DETECTOR HEALTH TRENDING is for use by GEMS **CT** Engineering for data collection. It is not intended for field use.

- Replacement
  - Autocal Generator
  - BOW Alignment
  - CBF and SAG Alignment
  - Change Tube
  - Collimator Aperture Test
  - Detailed Calibration
  - Detector Health Trending
  - Diagnostic Data Collection (D
  - Enter Detector ID
  - FLASH Download Tool
  - Generator Char Data
  - HHS Scans
  - Hot ISO
  - Install New Tube
  - ISO Alignment
  - mA Meter Verify
  - Manualcal Generator
  - POR Alignment
  - Scan Analysis
  - Shell
  - System State
  - Z Slope Cal
  - Gantry Service Balance

Figure 2-25 General Replacement Procedures Menu

1.15 PM Information Menu - General Service

Use the **PM** menu to access the tools and diagnostics shown in the figure below.

Figure 2-26 PM Icon

- PM
  - System State
  - Storelog
  - Calendar
  - Shell

Figure 2-27 PM Menu (General)

Section 2.0
Scanner Utilities

2.1 Tube Warmup

Tube Warmup resides under the DAILY PREPARATION selection on the Exam Rx top level desktop. TUBE WARMUP includes the scans required to bring the tube to a safe operating point for patient scanning.

2.2 FastCal

Like Tube Warmup, Fast Cal is another daily preparation function. Running Fast Cal generates new Acal, Sine, and Cosine vectors used in the preprocessing stages of image reconstruction. FastCal should be run daily to maintain optimal image quality.

FASTCAL includes additional heating scans required for both AutoMaCal and Fast Calibration Scans. During FASTCAL:

DAS CONVERTER BOARD IDENTIFICATION CHECK

Upon commencing a FastCal operation, the ID's of the converter boards used by channel 762 and the z-channels (boards 47 & 48) should be checked to see if they match the converter boards that were in place when the latest **DAS** Gain Cal was performed. If there is no match, the user must be directed to perform a **DAS** Gain Cal. A button should appear that says:

```
Additional calibration scans are needed to adjust for gain changes.
After these scans are completed you must redo FastCal. After you have
read this press CONTINUE.
```

A message should be sent to the GE sys log, stating that the converter boards were swapped without redoing **DAS** Gain Cal. If converter board check fails, a **DAS** Gain Cal is required. See “DAS Gain Calibration,” on page 72.

CHECK TIME OF LAST COLLIMATOR CALIBRATIONS

Check the last time Collimator Calibration was performed. If Collimator Cal was performed within 24 hours, it is not necessary to update the Collimator Cal parameters, and the system can skip all steps pertaining to Collimator Cal.

DIRTY MYLAR WINDOW SCAN

The first scan taken, after cold tube warmup, should check to see if there is any contrast or other material on the Mylar window that will corrupt the calibration scans. Four one-second rotating scans, no tracking at this time, should be taken. The scan techniques are to be 80kvp, 20 ma, aperture 4 x 125, 4 x 250, 4 x 375, and 4 x500 respectively. If the 20 point filtered offset corrected channel 762 data vs views divided by the offset corrected view averaged value of channel 762 falls below .90 for any scan, for any row, a message must be displayed to the user and a response from the user is needed before continuing. The user should be allowed to go ahead without further action, or clean the Mylar window and repeat the blockage scan. The message should say:

```
Please check Mylar window and clean if necessary to assure proper
scanner operation.  Indicate if you want to repeat the check scan or
continue with the FastCal.
```

Send message to GE sys log.

- `Warmup1` scans raise the target temperature to greater than or equal to 500 degrees Celsius prior to AutoMaCal.
- `Warmup2` scans raise the target temperature to greater than or equal to 700 degrees Celsius for FastCal.

SWEEP SCAN

Before the first standard FastCal scan is performed, but after tube warms up, a sweep scan is taken and a Collimator Calibration is performed for that technique. There are eight sweep scans—one for each aperture and focal spot size combination. One sweep scan is performed for every FastCal executed, and therefore the entire set of Collimator Cals will be refreshed after eight FastCals are performed. Also, measure mode calculations will be made, although only the results for large spot with 4x125 or 4x500 apertures will be used.

The new Collimator Cal is compared to the old Collimator Cal in the following way:

1.) Consider the range of the ratios for the old data and pick three ratios: the two ratios 10% from either end of the range, and the ratio in the middle.

2.) Evaluate the new data at these three ratios, and compare to the values obtained with the old data.

3.) Store the new evaluated data to the history log. If the absolute values are greater than a tolerance, the entire set of eight sweep scans will be performed. A button will appear that the user must push. The message should say:

```
Additional tracking calibration scans must be  performed. After
this is completed you must restart FastCal. After reading this
message press CONTINUE.
```

4.) A message should be logged to the GE sys log that a complete Collimator Cal was retaken for all eight techniques.

MINI SCAN

After the sweep scan and calibrations have been completed and before the standard FastCal scans begin, a mini scan of 0.1 second that it is rotating and is executed with tracking on so that **DCB** computes a fresh focal spot position.

BLOCKED CHANNEL CALCULATION

During the FastCal scan, the offset corrected signals are view averaged for the inside rows (1A and 1B) for channel 762. These averaged signals are then normalized with respect to the mAs per view and the **DAS** Gain, and multiplied by a threshold value referred to as the “blocked channel threshold”. During regular scanning, the normalized signals for each view are compared to the values obtained from the FastCal scan. If the value during the patient scan is lower than the value computed during the FastCal scan, it is assumed that the corresponding row in channel 762 is blocked for the view, and tracking is put on hold.

FASTCAL SCAN

During the FastCal scans, tracking will take place. However, there will be no checking for blockage of **z** channel. Since the FastCal procedure checks for beam obstruction, there should be no blockage. The focal spot position will be computed by the **DCB**.

The flowchart in Figure 2-28 describes the sequence of actions when tube warm-up or Fast Cal is selected.

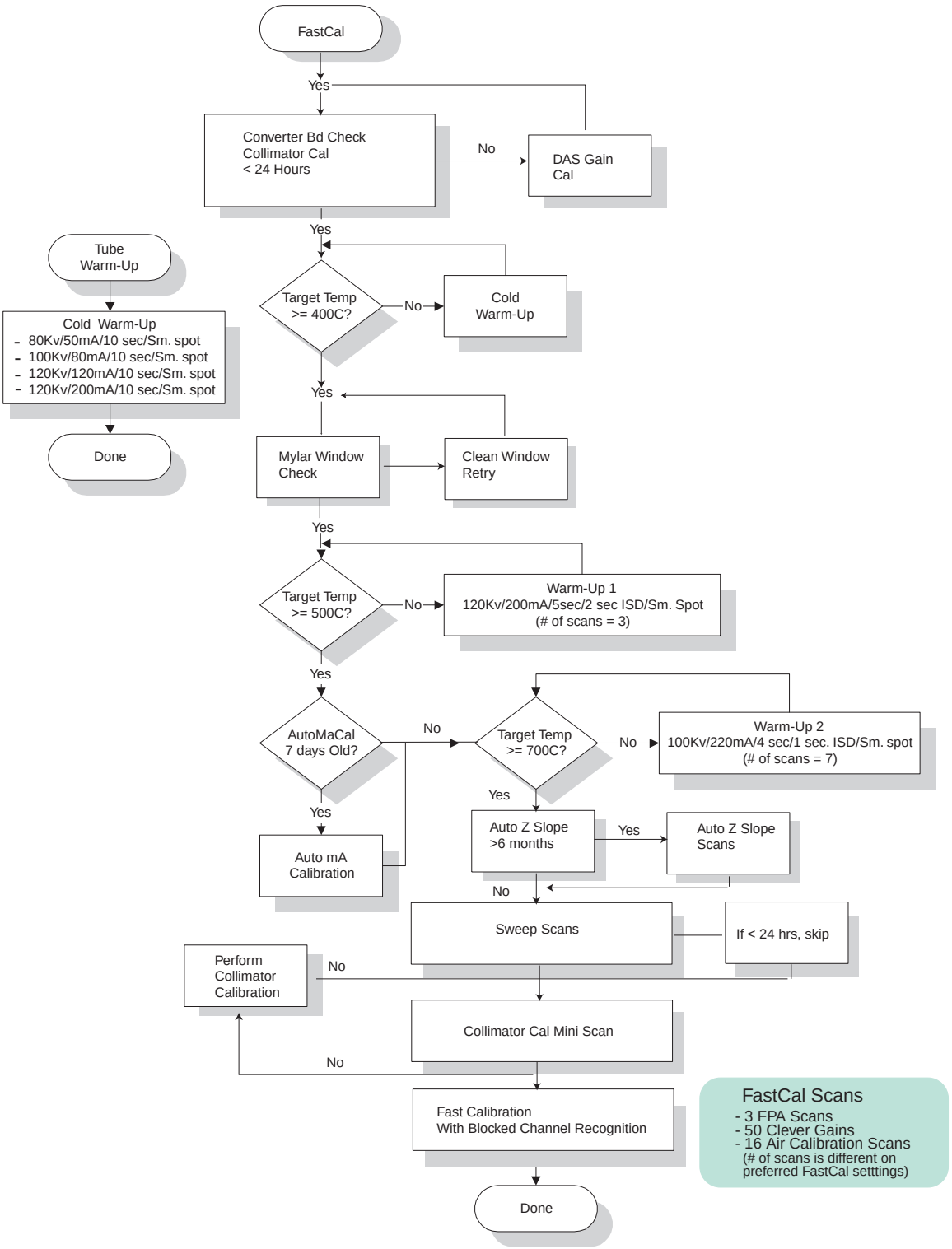


Figure 2-28 Tube Warmup and FastCal Flowchart

DAILY IQ CHECK

FastCal also performs Daily IQ Check, which compares the center 30 channels of today's FastCal vectors to yesterday's. This is done to determine whether there is any significant change that could lead to an image artifact. If the limit check fails, a message is posted to the log and to a pop-up box on the screen. The database is updated regardless of whether the check passes or fails.

The following are the two circumstances that will cause the failure:

1.) A hardware change, either after changing the detector or changing the center four **DAS** Converter cards will cause a failure message on the next FastCal.

A hardware change will cause a significant change in the calibration vectors and trip the limit check. In this case, the error message on the first FastCal after the change can generally be ignored, provided the images look good.

2.) A real change in the gain of the center channels, which could lead to an image artifact.

The possible causes are contamination on the copper filter, tube port or bowtie filter or **DAS**. Please refer to Section 3.0 - Tools and Diagnostics, for troubleshooting.

2.3 Preferred FastCal

The Preferred FastCal feature allows the site to tailor the total number of FastCal scans to what kV techniques they use when scanning patients. For example, if a site scans patients using two of the four available kVs, FastCal can be configured in **reconfig** to run with just those kV scans, thereby speeding up the total time to run FastCal by 50%.

To customize FastCal scans by kV, do the following:

1.) Shutdown applications:
   a.) If you are not already on the Service Desktop, select the SERVICE DESKTOP icon.
   b.) Select the UTILITIES icon.
   c.) Select APPLICATION SHUTDOWN.
2.) Open a UNIX SHELL from the toolchest menu on the desktop.
3.) `su -` **ENTER**
4.) Enter ***`root password`***
5.) `reconfig` **ENTER**
6.) Select PREFERENCES. Refer to Figure 2-29. Make kV choices in the "`Selected Preferred FastCal kV`" area.

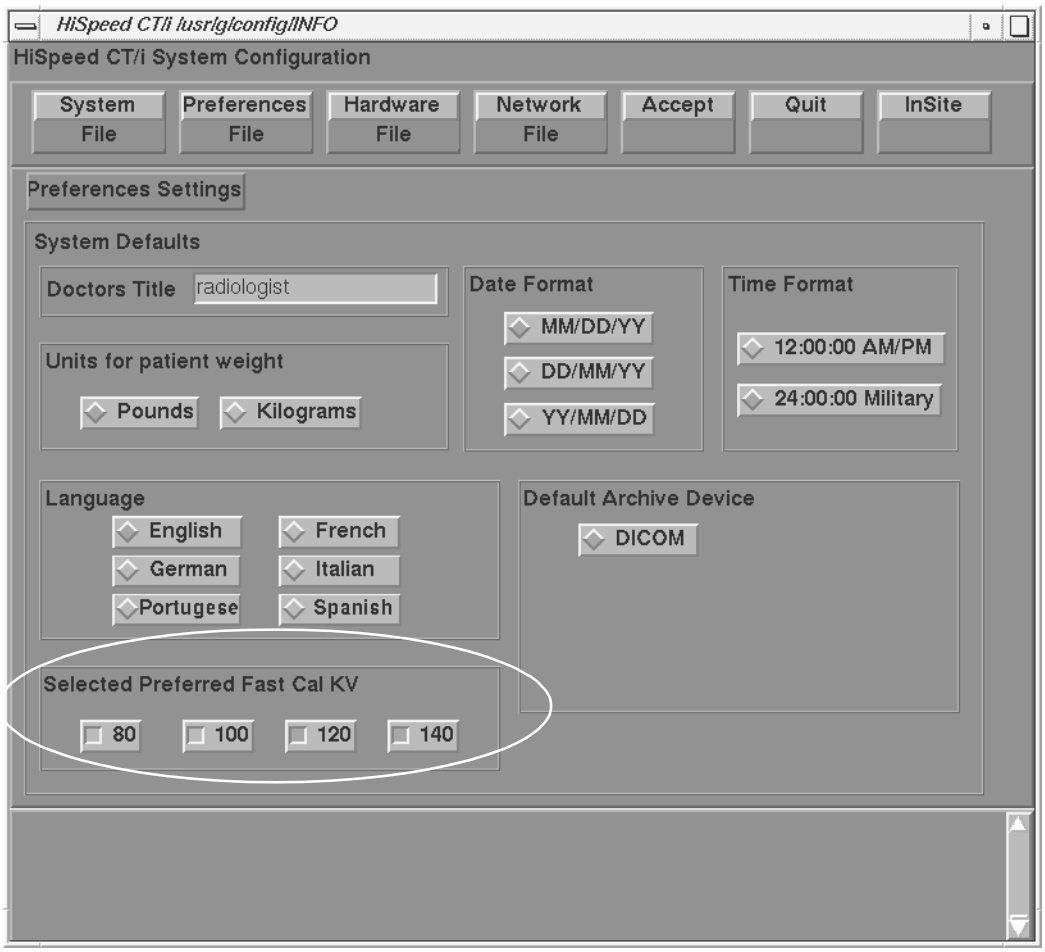


Figure 2-29 Preferences Setup Screen

A new configuration file for preferred FastCal will be created by reconfig in the `/usr/g/config` directory with file name `PreferFastCal.cfg`.

2.4 DAS Gain Calibration

1.) Enter **DAS** Gain Calibration through the Calibration menu on the Service Desktop. If you are not already on the Service Desktop, select the SERVICE DESKTOP icon.

2.) Select the CALIBRATION icon.

3.) Select DAS GAIN CALIBRATION.

4.) Before the **DAS** Gain scans are taken, a Mylar window check is done to ensure that the window is clean. Otherwise it can corrupt the tracking cals.

- If the check succeeds, the **DAS** Gain scans are taken, and the cal proceeds.
- If the check fails, a pop-up is posted asking the user to provide inputs on whether he/she wants to quit, continue, or retry the Mylar window check after cleaning the Mylar window.

The appropriate messages and pop-ups are discussed later in this section.

The Mylar window check and the corresponding state machine are also discussed in a separate section.

DAS Gain Calibration consists of 31 scans that are taken consecutively. The cal processing on the scan keys is done after all the scans are done.

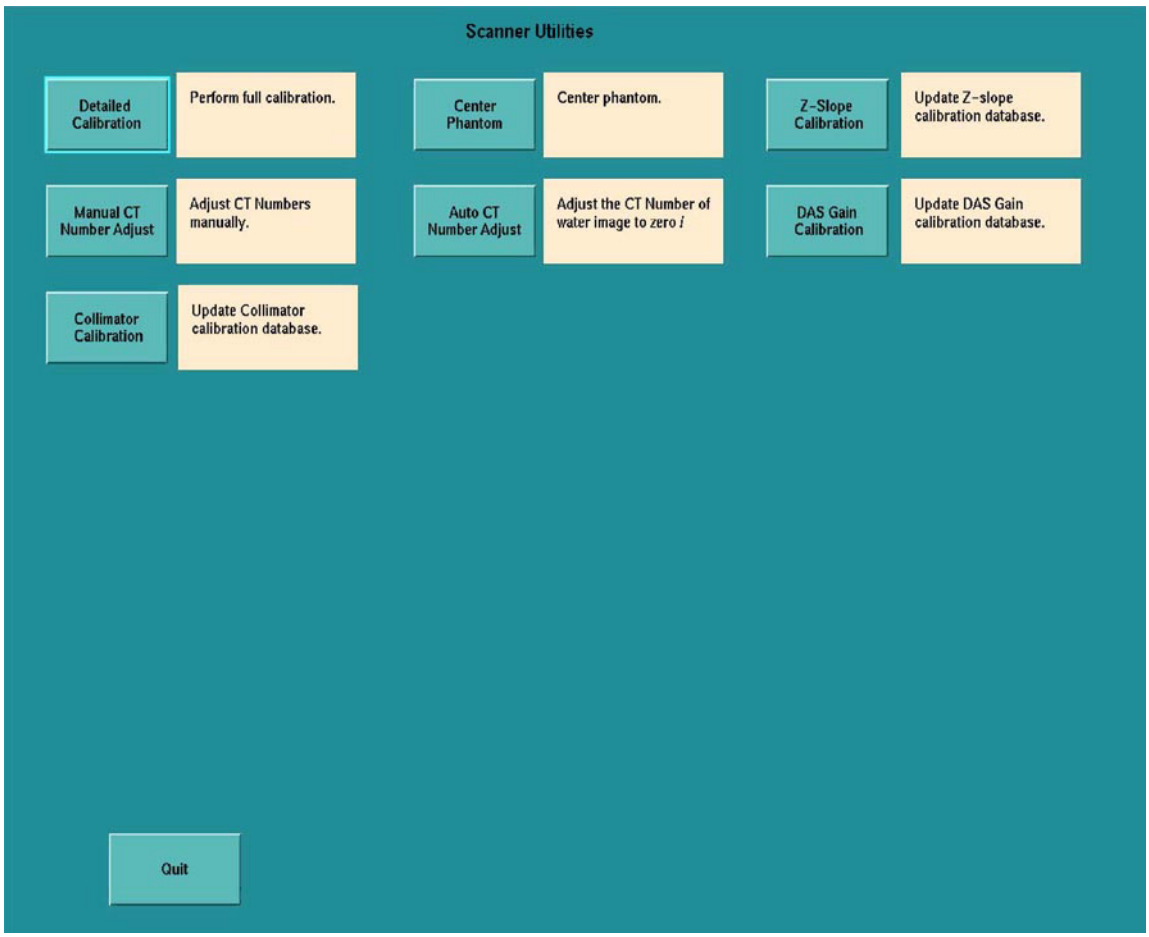


Figure 2-30 Scanner Utilities Screen

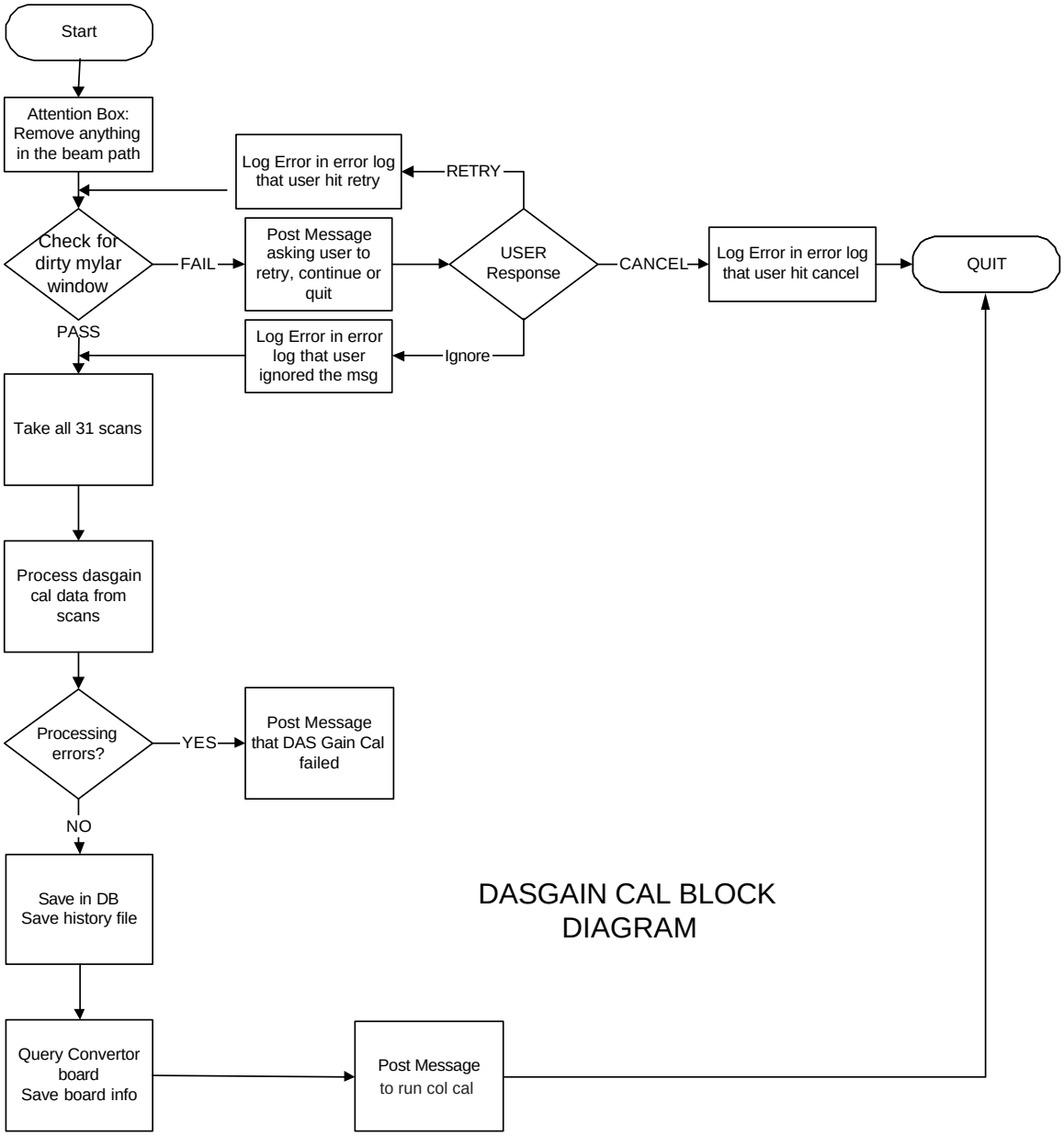


Figure 2-31 DAS Gain Cal Block Diagram

MESSAGES AND POP-UPS

Before **DAS** Gain or Collimator Cal come up, an attention box is posted asking the user to clear any obstruction in the path of the beam. Only when the user hits OK, will the cals proceed. Also after **DAS** Gain and Collimator Cals are done, each will post an attention box asking the user to run FastCal.

DAS GAIN CAL MESSAGES

Message 1: `Please remove any obstruction in the path of the beam.`

Message 2: `The user retried Mylar window check.`

Message 3: `Please check Mylar window and clean if necessary to assure proper scanner operation.`

Message 4: `User quit the tracking cal after the Mylar window check failed.`

Message 5: `User ignored the Mylar window check failure and continued with the tracking cal.`

Message 6: `DAS Gain Cal was not completed.`

MYLAR WINDOW CHECK

There is increased sensitivity with the tracking feature, if the Mylar window is dirty (refer to Figure 2-32). Therefore, a check of the Mylar window comprising four scans must be done to ensure that the Mylar window is indeed clean before the tracking cals (**DAS** Gain Cal and Collimator Cals) are performed. If the check fails and the window is found to be dirty, a message pop-up is posted that will require a user response. The user can choose to retry the Mylar window check after cleaning the window, quit, or carry on with the appropriate tracking cal anyway.

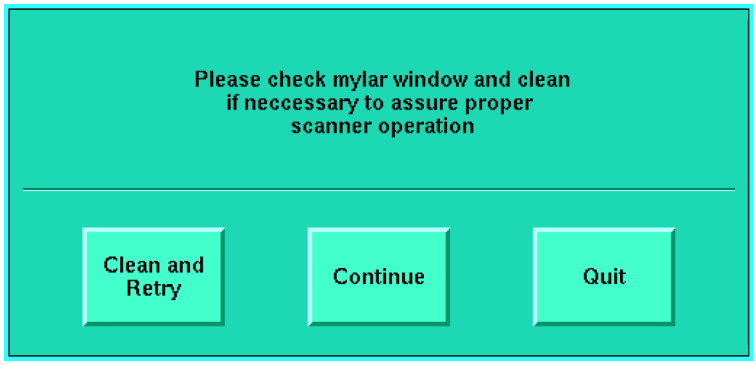


Figure 2-32 Mylar Window Check Screen

2.5 Collimator Calibration

1.) Enter Collimator Calibration through the Calibration menu on the Service Desktop. If you are not already on the Service Desktop, select the SERVICE DESKTOP icon.

2.) Select the CALIBRATION icon.

3.) Select COLLIMATOR CALIBRATION. The calibration will check for any converter boards changes for boards 47 and 48. If the board has been changed, Collimator Cal exits and posts a message informing the user to first run **DAS** Gain Cal.

4.) Collimator Cal also requires the Mylar window check before the cal can proceed to avoid corrupting the cal. If the check fails, the user can clean the Mylar window and retry or continue anyway. In either case, if the check succeeds or if the user ignores the failure and continue, the cal requires tube warm-up.

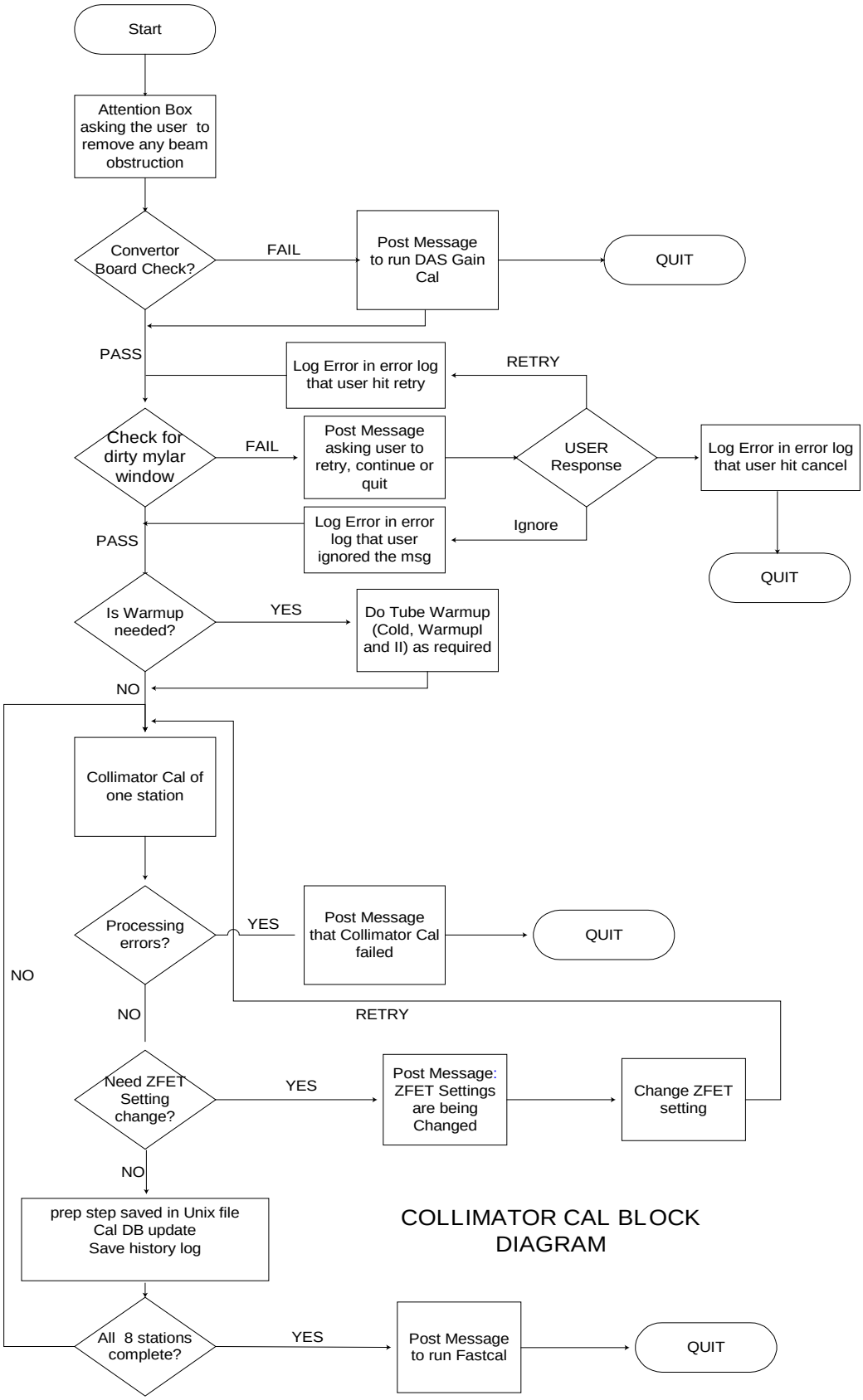


Figure 2-33 Collimator Cal Block Diagram

MESSAGES AND POP-UPS

Before **DAS** Gain or Collimator Cal come up, an attention box is posted asking the user to clear any obstruction in the path of the beam. Only when the user hits OK will the cals proceed forward. Also after **DAS** Gain and Collimator Cals are done, each will post an attention box asking the user to run FastCal.

COLLIMATOR CAL INFORMATIONAL MESSAGES

Message 1: `Please remove any obstruction in the path of the beam.`

Message 2: `Converter boards have changed. Please first run DAS Gain Cal before running Collimator Cal.`

Message 3: `Please check Mylar window and clean if necessary to assure proper scanner operation.`

Message 4: `User quit the tracking cal after the Mylar window check failed.`

Message 5 `User ignored the Mylar window check failure and continued with the tracking cal.`

Message 6: `DAS Gain Cal was not completed.`

Message 7: `Collimator Cal was not completed.`

Message 8: `The Z-FET setting was changed for this scan.`

COLLIMATOR CALIBRATION

A method has been devised of tracking the motion of the focal spot so that the collimator opening can be reduced, thus reducing dose.

With collimator tracking, the position of the collimator is no longer a fixed function of aperture and focal spot size. The two cams, which operate independently, form the sides of the collimator and must move with the motion of the focal spot. Information regarding the focal spot position is sensed through special channels called the z-channels. The information from the z-channels is translated into the position of the beam on the detector at the iso channel. The translation process depends on calibration polynomials and operating points, which are determined by the Collimator Calibration process.

DAS GAIN

This program computes the **DAS** Gain correction factors needed for the z-channel ratio (which determines the focal spot and beam position) and for channel 762 (which monitors blocking for tracking). The z-channel ratio correction is used in Collimator Calibration. There are two sets of correction factors—one for each cam.

CONVERTER BOARD CHECK

First, the ID's of the converter boards used by channel 762 and the z-channels (boards 47& 48) should be checked to see if they match the converter boards that were in place when the last **DAS** Gain Cal was performed. If there is no match, the user is directed to perform a **DAS** Gain Cal before doing Collimator Cal.

MYLAR WINDOW CHECK

Assuming the tube is warm when Collimator Cal is begun, the first scans should check if there is any contrast or other material on the Mylar window that will corrupt the calibrations. Four one-second rotating scans should be taken at 80 kvp, 20ma with aperture at 4x125, 4x250,4x375, and 4x500 respectively. If the 20 point filtered offset corrected channel 762 data vs views divided by the offset corrected view averaged value of channel 762 falls below 0.90 for any scan, for any row, a message will be displayed to the user and a response from the user is needed before continuing. The user should be allowed to go ahead without further action, clean the Mylar window and repeat the blockage scan, or quit the operation completely. The message should say:

```
Please check Mylar window and clean if necessary to assure proper
scanner operation.  Indicate if you want to repeat the check scan or
continue with the Collimator Cal, or abort Collimator Cal.
```

SWEEP SCAN

The information needed to perform calibration is obtained using sweep scans. The sweep scan is a stationary scan, with x-ray tube at 12 o'clock position, where the cam positions go through their entire range of motion in 37 incremental steps. At each step, which is a 100 views, the offset corrected view averaged data is collected for the data channels and the z-channels. This information with **DAS**, Gain is the basic information that is used to perform the calibration. Scans are only done at 120kv with the head bowtie. The time of these scans is 5.9 seconds, which allows for 37 steps at 100 views with time allowed to transition between the steps. The information from rows 2A and 1A are used to calibrate the cam on the A side while the cam on the B side uses the information from the B rows. The signals from side A should be monotonic, starting high and ending low, while the signals from side B are monotonic, starting low and ending high.

COLLIMATOR CALIBRATION

This is the major program that computes the calibration.

The outputs to the cal database are: mapping sides A & B, target position on iso channel, ratio range, and dose reduction. Some ID information that determines where the data goes is stored in the file with the other data: spot size, data channel fet, z channel fet, **DAS** Gain used, aperture size, and focal spot position. Also the ID numbers for the **DAS** Converter boards that are used by the z-channels and channel 762 need to be stored in the cal database. In measure mode, the channel positions the ratios, zratio, and dratio for both sides must be stored in addition to the other output.

The Collimator Cal needs to be done after a detector change or tube change. If a converter board change has been made, affecting the z channel or channel 762 (boards 47&48), or if the detector has been changed, the **DAS** Gain Cal should be done. Tube change does not require redoing the **DAS** Gain Cal. At the beginning of Collimator Cal, the serial numbers of the converter boards should be queried, and it should be determined if there has been a change since the last **DAS** Gain Cal was done. The software should force the user to leave collimator cal and perform **DAS** Gain Cal.

Section 3.0
Tools and Diagnostics

3.1 Log Viewer

3.1.1 Introduction

Log Viewer provides a common method to review various system files that may be useful in evaluating system performance and/or troubleshooting system problems. It replaces the System Browser at the **CT** application level of operation. The Log Viewer provides “one-stop” shopping by eliminating the need to remember complex directory structures and paths. The contents of important system files can be display using the browser’s functions and menus.

The Log Viewer is web based. It utilizes the Java language for much of its functionality and user interface. This allows for future expansion.

3.1.2 Log Viewer Startup (Applications Level)

Starting from the Service desktop Home Page Tab, select the Error Logs tab, and then select System Browser from the list of file options. See Figure 2-34. If the **CT** applications are not up, bring them up by typing `st` in the console window, and then select service desktop.

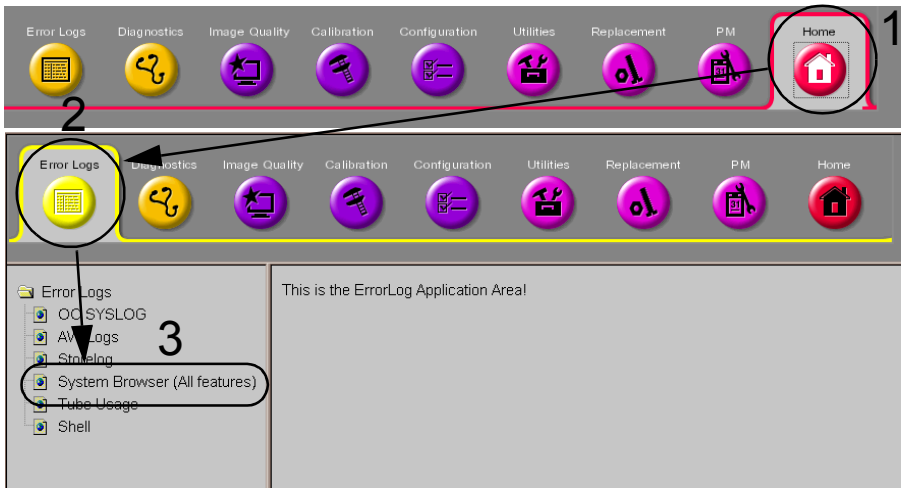


Figure 2-34 Browser Home and Error Log Tabs

Once the Log Viewer starts, a new window (**HTML** Page) is opened. By default, `gesyslog` should be selected and the logs for today should be displayed in tabular form in the display area. By default, the last messages in the `gesyslog` should be displayed

The viewer window is divided into two frames. Starting from top to bottom, they are the “selection area” and the “informational viewing area”. The selection area is used to select the log to be viewed. The informational viewing area is where the log is actually displayed.

3.1.3 Log Viewer Selections

In the browser's log selection area, the option to choose several different system logs for viewing is available.

To view a log, use the mouse, click the `Log Select` drop-down list box, and click on the log name you wish to view. Next click on SHOW LOG!. The log will be displayed in the viewing area.

The drop-down list gives you the following selections:

- GE **System Log** — `gesyslog`
- **SYSLOG OC** — The OC computer IRIX Operating System Log
- **IOS LOGS** — Application software logs for: Image Browser, Image Database Read Server, Image Database Write Server, Image Server, **DICOM** Server, Image Acquisition Server, Networking Server, Film Composer Log, Printer Server, Archive, Display, Filming.
- **Tube Usage** — Tube slice count and use information for the current and previous x-ray tubes.
- **OC Info**
- **Config Files** — OC Host Configuration File, OC Scan Hardware Configuration File
- **Scan Usage**
- **Motorola scan Corrections Computer, VxWorks Logs**

In addition to showing a log, `Histogram` VIEW and SEARCH are also available.

3.1.4 GE Message Log (`gesyslog`) Viewing

The entire `gesyslog` will be displayed, starting with the last page message first. There should be a hyperlink to the TOP of the page, when you scroll to the bottom. The PREV, FIRST and LAST links will be enabled (if the gesyslog is huge). Clicking on the TOP link displays the first few messages in log. If the PREV, FIRST, LAST links are displayed, click on them to view the next set of messages. Selecting PREV displays the previous records for the gesyslog file, if it exists. LAST takes you to the end of the log, where you should find the text "`A New gesylog file is being created`." You will find `gesyslog` located in the following pathname:

```
/usr/g/service/log/gesys_<suite name>_oc.log
```

3.1.5 SYSLOG OC

When you select SYSLOG OC and click SHOW LOG!, you can choose which specific SYSLOGS to view. Use the drop-down list box to make your selection and choose VIEW.

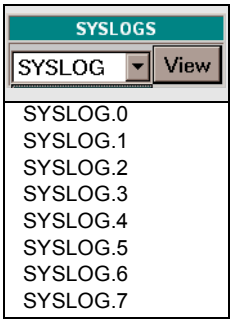


Figure 2-35 SYSLOG Drop-Down List

The SYSLOGS are found within the path `/var/adm`. If a log is present and is of size > 0 bytes, its contents will be displayed. Otherwise you will get an error message saying that the specified log-file has zero contents.

3.1.6 IOS Logs

When you select IOS LOGS and then SHOW LOG!, a new frame is opened. A pull-down in the frame lets you select which specific log file to display.

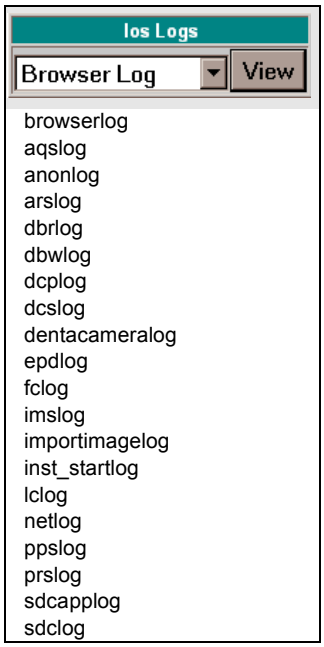


Figure 2-36 IOS Logs Drop-Down List

The **IOS** log files are created and updated by various scanner application software processes. The **IOS** Logs are normally found within the path `/export/home/sdc/logfiles`. If a log is present and is of size > 0 bytes, its contents will be displayed. Otherwise you will get an error message saying that the specified log-file has zero contents.

3.1.7 Tube Usage

When you select TUBE USAGE and then SHOW LOG!, a new frame is opened. Within the new frame is a list of tube usage files presently available for viewing. The tubes files are displayed from newest to oldest, top to bottom respectively. Three different views of information can be generated by following the hyperlink: Summary, Details, and Cumulative Statistics. See Figure 2-37.

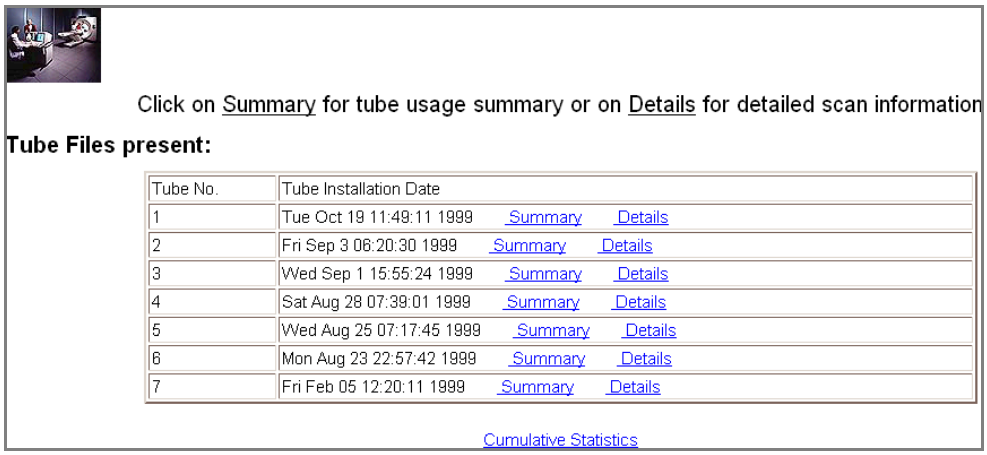


Figure 2-37 Tube Usage Screen - Example

For Tube Warranty purposes, “Warranty Effective Slices” is the correct number to report upon tube unit failure.

3.1.7.1 Tube Usage Details

The Tube Usage Details information provides identification, usage and scan information. Scan information lists the types and number of scans taken on unit being displayed. An example is provided in Figure 2-38.

HEADER INFORMATION:

Hospital Name: G.E. Medical Systems
Suite Name: CT09
Product Name: *<System Type>*
Tube serial no: 564GI5
Tube Name: 2120785
Housing serial no: 657GM7
Housing Name: 2137130-2
Installed on: Fri. Sep 3 06:20:30 1999
Last scan on: Fri. Nov 5 12:12:41 1999

TUBE USAGE

Scan Mode	Patient	Non-Patient
mAs	12898304	1188368
Number of Slices	476565	17095
Number KW Slices	811	266
KW Hours	4257.10	375.65
Scan Seconds	120150.3	9011.70000000001

SCAN INFORMATION

KV	MAMP	Scan Time (sec)	Scan Mode	Focal Spot	Usage Mode	No. of Scans	No. of Slices
80	50	0.1	CINE	SMALL	Non Patient	90	0
100	80	0.1	CINE	SMALL	Non Patient	90	0
120	120	0.1	CINE	SMALL	Non Patient	89	0
120	200	0.1	CINE	SMALL	Non Patient	266	0
120	80	2	SCOUT	SMALL	Patient	148	148
140	180	1	AXIAL	LARGE	Patient	3	12
120	200	0.8	AXIAL	SMALL	Patient	2497	9988
120	200	1	AXIAL	SMALL	Patient	3336	13344
120	400	1	AXIAL	LARGE	Patient	98	392
120	80	4	SCOUT	SMALL	Patient	558	558
120	140	1	AXIAL	SMALL	Patient	59	236

Figure 2-38 Tube Usage Detail - Example

3.1.7.2 Tube Usage Cumulative Information

The Tube Usage Cumulative Information displays the totaled tube usage information for all tubes that have been installed on the system. Refer to Figure 2-39 for an example of the display.

CUMULATIVE STATISTICS

Hospital Name: G.E. Medical Systems
Suite Name: CT01
Product Name: *<System Type>*

Scan Mode	Patient	Non-Patient
mAs	64183802	8620911.7
Number of Slices	2127256	92258
Number KW Slices	2932	1328
KW Hours	21341.91	2739.53
Scan Seconds	588763.5	53810.1999999999

Back to tube usage page.

Figure 2-39 Tube Usage Cumulative Statistics - Example

3.1.8 OC Info

When you select OC INFO and then SHOW LOG!, a new frame for `OC Info` is opened within the current window. “OC Info” executes basis IRIX commands to gather information used for display. To use, simply make a selection and select VIEW. The associated IRIX command is execute and the output is directed into the frame immediately below as **HTML** (See Table 2-1).

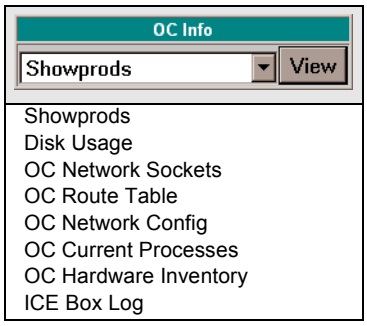


Figure 2-40 OC Info Selection (Showprods Shown)

The command results available in this area are:

OC INFO LIST ITEM	ACTION (EQUIVALENT IRIX COMMAND)
Showprods (System Software Revisions)	**showprods**
Disk Usage:	**df**
OC Network Sockets:	**netstat -ian**
OC Route Table:	**netstat -r**
OC Network Conf	**ifconfig**
OC Current Processes	**ps -aef**
OC Hardware Inventory:	**hinv**

Table 2-1 OC Info Commands

OC INFO LIST ITEM	ACTION (EQUIVALENT IRIX COMMAND)
ICE Box Log	

Table 2-1 OC Info Commands

Refer to Figure 2-41 for an example of OC Network Sockets output.

```
Name Mtu   Network     Address            Ipkts Ierrs    Opkts Oerrs  Coll
ef0  1500  192.9.220   192.9.220.1       104248     0    84909     0     0
                       224.0.0.1
                       08:00:69:13:50:11
ef1  1500  3.7.52      3.7.52.110         23636     0    20063     1  5899
                       224.0.0.1
                       08:00:69:0d:8f:1a
ppp0 1500  (pt-to-pt)  3.57.1.244          1432     1     1704     0     0
                       224.0.0.1
lo0  32992 127         127.0.0.1         253015     0   253015     0     0
```

Figure 2-41 OC Network Sockets - Example

3.1.9 Config Files

When you select CONFIG FILES and then SHOW LOG!, a new frame for `Config Files` is opened within the current window. “Config Files” executes basis IRIX commands to gather information used for display. To use, simply make a selection and select VIEW. The associated IRIX command (see Table 2-2) is execute and the output is directed into the frame immediately below as **HTML**.

The System Browser has the capability of viewing some of the routinely referenced scanner configuration files used in gathering data about the system.

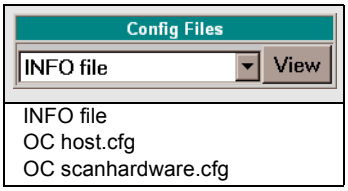


Figure 2-42 Config Files Selection (Info File Shown)

Refer to Figure 2-43 for an example of the INFO file result.

CONFIG FILES LIST ITEM	ACTION (EQUIVALENT IRIX COMMAND)
OC host.cfg	`cat /usr/g/config/host.cfg`
OC scanhardware.cfg	`cat /usr/g/config/scanhardware.cfg`
INFO file	`cat /usr/g/config/INFO`

Table 2-2 OC Info Commands

```
TZ=CST6CDT
SERVER_DISTRIBUTOR=InSite Interactive Platform
IIP_USN=0000CTBAYA
INSITE_HOME=/usr/g/insite
PERL5LIB=/usr/g/insite/lib/perl5
IIP_ProductIP=172.28.64.1
IIP_LOCALE=en
PATH=/usr/g/insite/lib:/usr/g/insite/bin:/usr/g/insite/bin:/usr/sbin:/usr/bsd:/
sbin:/usr/bin:/etc:/usr/etc:/usr/bin/X11:/usr/g/insite/ProDiags/bin:.
ERMESDIR=/usr/g/db
DBDIR=/usr/g/db
LOGDIR=/usr/g/service/log
CONFIGDIR=/usr/g/config
DD_ROOT_DIR=/usr/g/service/dd
DD_MOD_DIR=/MOD
ACCS_TIMEOUT=300000
MSD_TIMEOUT=300000
AUXCHANNEL_TIMEOUT=8000
CALMODULE_TIMEOUT=4000
MAX_VIEW_RANGE=4000
ZAXISCHANNEL_TIMEOUT=10000
HTTP_ACCEPT=*/*
HTTP_REFERER=http://3.7.52.110/ctcgi-bin/show_config.cgi
HTTP_ACCEPT_LANGUAGE=en-us
CONTENT_TYPE=application/x-www-form-urlencoded
HTTP_ACCEPT_ENCODING=gzip, deflate
HTTP_USER_AGENT=Mozilla/4.0 (compatible; MSIE 5.5; Windows NT)
HTTP_HOST=3.7.52.110
CONTENT_LENGTH=27
HTTP_CONNECTION=Keep-Alive
SERVER_SOFTWARE=Apache/1.2.6
SERVER_NAME=3.7.52.110
SERVER_PORT=80
REMOTE_HOST=3.45.112.50
REMOTE_ADDR=3.45.112.50
DOCUMENT_ROOT=/usr/g/insite/server/htdocs
SERVER_ADMIN=ii-core@med.ge.com
SCRIPT_FILENAME=/usr/g/httpd/cgi-bin/show_config.cgi
REMOTE_PORT=2000
GATEWAY_INTERFACE=CGI/1.1
SERVER_PROTOCOL=HTTP/1.1
REQUEST_METHOD=POST
QUERY_STRING=
REQUEST_URI=/ctcgi-bin/show_config.cgi
SCRIPT_NAME=/ctcgi-bin/show_config.cgi
```

Figure 2-43 INFO File - Example

3.2 Flash Download Tool

3.2.1 The Need for FLASH Version Verification and Download Tool

The control boards in the system contain a new architecture that speeds up their initialization time. Application and characterization parameters are stored in the on-board FLASH memory of the **DCB**, **CCB**, **ETC**, **STC** and **OBC** control boards, and must be the same as the files stored on disk. To ensure that these files are correct and current, a utility to validate the versions of the files (comparing Unique ID and **CRC** in FLASH with the files saved on the system disk) runs silently and automatically when the scanner hardware is reset.

The **CCB** characterization file, which uses the device's serial number for a unique ID, is handled differently than other files. The **CCB** aperture char file is specific to its accompanying collimator and is NOT part of the load from cold. Therefore, in cases when the characterization file is not on the system disk or saved in the system state, the system must upload the file from FLASH to the disk. Once uploaded to the system disk, the file can be saved to system state and downloaded back to the device, in the event the **CCB** is swapped out or replaced.

In summary, the Flash Download Tool provides the mechanism for getting the correct files uploaded from FLASH or downloaded from the system disk to FLASH as required.

3.2.2 FLASH Download Tool

The FLASH Download Tool provides the user with the following functionality:

- Query the FLASH memory and system disk to determine correctness of FLASH files.
- Download and store files to the FLASH memory when control boards are replaced.
- Upload files to the system disk as required.

The tool is in several locations on the service desktop, including the UTILITY list under INSTALL.

3.2.2.1 FLASH Download Tool User Interface

After the tool is invoked from the Service Desktop Manager, the FLASH Download Tool screen appears (refer to Figure 2-44). By default, all five nodes are selected at startup. The user selects QUERY to simply query the nodes and selects UPDATE to query, update, and then re-query the nodes. The Node, File Name, and Status are then presented to the user in the Results window whenever a query is done. The Result and Status areas in the figure below show the result of a successful query.

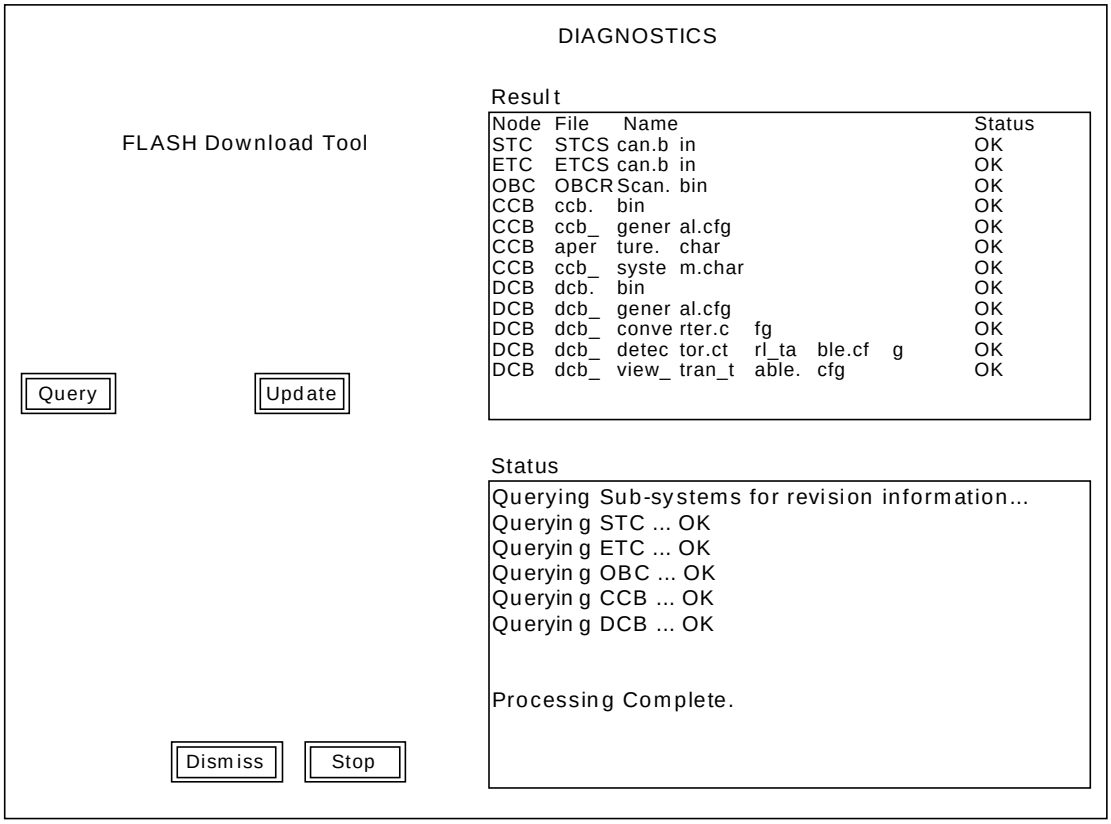


Figure 2-44 FLASH Download Tool User Interface

3.2.2.2 Button Processing

The buttons for the FLASH Download Tool shown in Figure 2-44 are described below. During a Query or an Update, all buttons are disabled except for the STOP button.

1.) Query/Update Options
   - Pressing the QUERY button will cause the FLASH Download Tool to query the nodes.
   - Pressing the UPDATE button will cause the FLASH Download Tool to update the nodes. The FLASH Download Tool will first perform a query, then update the nodes, then re-query the nodes. If the firmware is down or an ALM is updated, then the query/update sequence may be repeated.

2.) Pressing DISMISS will exit from the FLASH Download Tool.

3.) Pressing STOP will terminate the current query or update as soon as reasonable.

4.) The Node column is the name of the node, either **STC**, **ETC**, **OBC**, **CCB**, or **DCB**. The File Name column is the actual name of the file obtained from the node. The Status column indicates the status of the file, with OK indicating that no update of the file is required.

3.2.3 Serial Number Input Cases

Each collimator has a unique aperture.char file with information for its cam movement and serial number. If the collimator and **CCB** or the **CCB** only is replaced, the correct char file must be updated and stored on both the **CCB** and the system disk using the Flash Download Tool. When the **CCB** is replaced, or when the collimator with **CCB** is replaced, the following occurs:

1.) Starting up system, during hardware initialization, the `gesyslog` reports missing or invalid files and directs the user to run the Flash Download Tool.

2.) Enter Flash Download Tool and select UPDATE. The user is prompted to enter the serial number imprinted on the component for which the CHAR file is needed (refer to Figure 2-45).

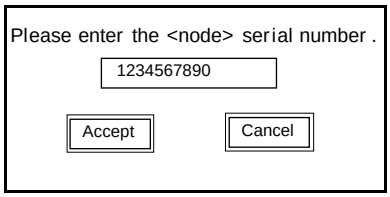


Figure 2-45 FLASH Download Tool Serial Number Window

3.) After entering the number, the FLASH Download Tool will compare the serial number entered by the user with the unique ID in the CHAR file on the system disk and on the **CCB**.

a.) **CCB Replacement Case** - The serial number entered will match the unique ID on the system disk, and the file will be downloaded to the **CCB** from the disk.

If a second pop-up to upload appears (see Figure 2-46), the number entered is not matching what is on the system Disk. There is likely a problem with the serial number that was entered. Select NO and recheck the number.

b.) **Collimator & CCB Replacement Case** - The serial number entered matches the unique ID on the collimator, (and therefore is a different ID than what is on the system disk), then an additional window (refer to Figure 2-46) appears, and the user is informed that the serial number entered requires the *upload* of a file from the **CCB** to the system disk. The user is then able to accept or refuse the file transfer.

An invalid serial number message is reported to the user in the Status window, if the number entered matches neither the unique ID on the node nor the system disk.

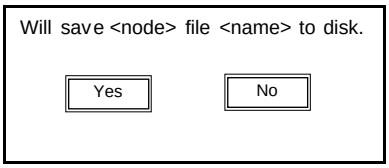


Figure 2-46 FLASH Download Tool Upload Window

After all possible uploads and downloads of files, processes similar to those in the FLASH Version Verification Utility are invoked automatically, to confirm the successful transfer of all necessary files. If the necessary files are still absent, or an error occurs, then the FLASH Download Tool Status window indicates an inoperable system condition. If successful, the tool enables scanning capabilities for the system.

System resources are taken during download and version verification to prevent scanning. The system locks out the user, if the transfer of any file is refused by exiting the tool before completing all transfers.

3.2.4 FLASH Version Verification Error Handling

The FLASH Version Verification Utility is automatically activated after a node is reset or when the system is initialized. The operation of the utility itself is invisible to the user unless an error occurs. If an error is detected by the utility, then the window shown in Figure 2-47 is displayed. An error is logged and the system is inhibited from scanning.

Figure 2-47 FLASH Version Verification Utility Window

The <attention-message> in the window shall be one of the following:

- One or more of the controllers(**ETC**/**STC**/**OBC**) or system disk contains missing or invalid files. Please run the FLASH Download Tool from the Service Desktop Manager to correct this problem.
- The collimator or system disk subsystem contains missing or invalid files. Please run the FLASH Download Tool from the Service Desktop Manager to correct this problem.
- The **DAS** subsystem or system disk contains missing or invalid files. Please run the FLASH Download Tool from the Service Desktop Manager to correct this problem.

3.2.5 Flash Download Tool Exception Handling

The error cases handled by the FLASH Download Tool are explained below in Table 2-3. Note that errors recorded by the FLASH Version Verification Utility will not be repeated in the error log. All errors will be recorded in the “GE system log”.

ERROR DESCRIPTION	ACTION
`Missing or Invalid ALM` (Application Load Module) `file on the SBC disk.` (The ALM file is the application executable file.)	An error message is reported to the error log indicating the message code of the missing file from the **SRU**. The FLASH Download Tool Status window reports a file error. The HOP or `fwmgr` lock the system scanning capabilities.
`Missing or Invalid ALM file on the FLASH memory`	An error message is reported to the error log indicating the message code of the missing file on the FLASH. The FLASH Download Tool Status window reports a file error. The FLASH Download Tool attempts to replace the file. If the file cannot be replaced, the HOP or `fwmgr` lock the system scanning capabilities.
`Missing or Invalid CHAR file on the SBC disk`	An error message is reported to the error log indicating the message code of the missing file from the **SRU**. The FLASH Download Tool Status window reports a file error. The FLASH Download Tool continues to download the next required CHAR file(s) until all possible files have been recovered. The HOP or `fwmgr` locks the system scanning capabilities.

Table 2-3 FLASH Download Tool Exception Handling

ERROR DESCRIPTION	ACTION
Missing or Invalid CHAR file on the FLASH memory	An error message is reported to the error log indicating the message code of the missing file on the FLASH. The FLASH Download Tool Status window reports a file error. The FLASH Download Tool attempts to replace the file. The FLASH Download Tool continues to download the next required CHAR file(s) until all possible files have been recovered. If the missing or invalid file could not be replaced, the HOP or `fwmgr` lock the system scanning capabilities.
Invalid **CRC** or Status received from the node	An error message is reported to the error log The HOP or `fwmgr` lock the system scanning capabilities.

Table 2-3 FLASH Download Tool Exception Handling (Continued)

3.3 Diagnostic Data Collection (DDC)

Diagnostic Data Collection is a tool that allows the user to scan and create scan files using user selectable scan types and parameters as an aid in troubleshooting and verifying the data integrity of the **DAS**/Detector subsystem.

HOW TO ACCESS DDC - GENERAL SERVICE

1.) Select DIAGNOSTICS.
2.) Select DIAGNOSTIC DATA COLLECTION.
   - Use **DDC** to collect **DAS** data with and without x-ray and/or rotation.
   - Use the Scan Analysis tool to examine collected data.

3.3.1 Scan Types and Parameters

The Diagnostic Data Collection (**DDC**) tool supports the following scan types:

1.) Static X-Ray Off.
2.) Static X-Ray On.
3.) Rotating X-Ray Off.
4.) Rotating X-Ray On.

Each scan type is presented as a selectable button on the left-hand side of the **DDC** screen. With each scan type is an associated set of scan parameters that the user will be allowed to select.

There are additional scan parameters displayed on the screen that the user will not be allowed to modify, presented as insensitive for the following reasons:

- The parameters are not required for the scan type selected.
- The parameters will not be functional until a future release.

The following table shows what scan parameters are available in each of the four scan types:

SCAN PARAMETER	STATIC X-RAY-ON	STATIC X-RAY OFF	ROTATING X-RAY-ON	ROTATING X-RAY-OFF
Run Description	X	X	X	X
Scan Time	X	X	X	X
No. of Scans	X	X	X	X

Table 2-4 Scan Parameters vs. Scan Types

SCAN PARAMETER	STATIC X-RAY-ON	STATIC X-RAY OFF	ROTATING X-RAY-ON	ROTATING X-RAY-OFF
Inter Scan Delay	X	X	X	X
Trigger Rate	X	X	X	X
Calibration Vector	X	X	X	X
Rotor		X		X
kv	X		X	
mA	X		X	
DAS Gain	X		X	
Gantry Velocity			X	X
Xray On Position			X	
Initial Start Position				X
Modulation				
Phase				
X-ray Duration				
Dly Until Xray On				
Focal Spot	X		X	
Filter	X		X	
Slice Collimation	X		X	

Table 2-4 Scan Parameters vs. Scan Types (Continued)

3.3.2 Options

For each of the scan types selected, the user may specify the following options, which are presented in the **DDC GUI** as buttons close to the bottom of the screen (refer to Figure 2-48):

1.) Auto Scan

2.) TXXT

3.3.2.1 Auto Scan

For each of the scan types selected the user may specify the auto scan option.

3.3.2.2 TXXT

TXXT (Trigger On, X-ray On, X-ray Off, Trigger Off) is an option for the Static X-Ray On and the Rotating X-Ray On scan type selections. This button will be insensitive when the Static X-Ray Off or Rotating X-Ray Off scan type is selected.

The **TXXT** button is associated with the following scan parameters:

- X-ray Duration
- Dly Until X-ray On

3.3.3 DDC Interface

The Diagnostic Data Collection Interface (Figure 2-48) consists of three main areas:

1.) Command Area

2.) Work Area

3.) Status Message Area

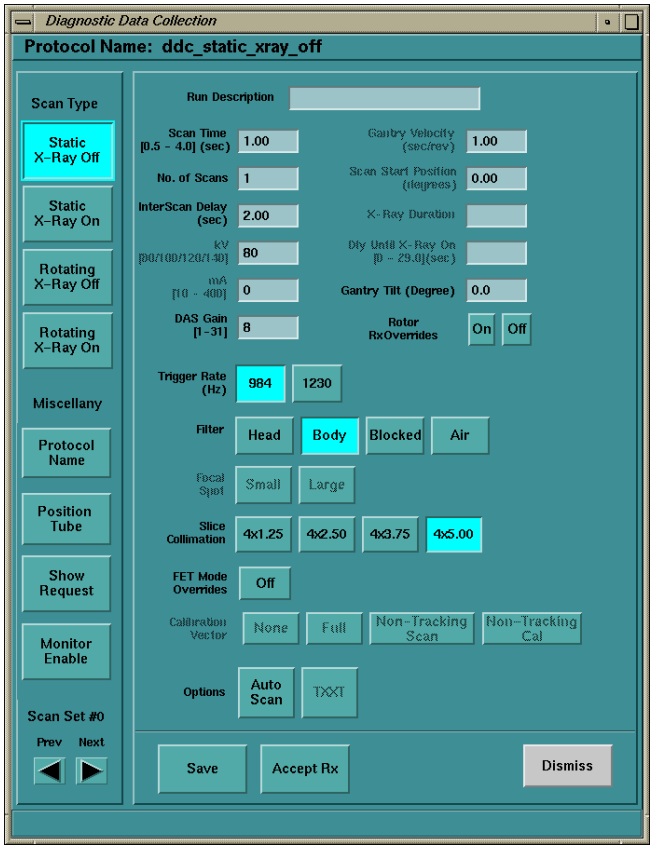


Figure 2-48 DDC Interface (example is of Static X-Ray-Off)

3.3.3.1 Command Area

The Command Area consists of a vertical palette of push buttons located on the left hand side of the screen. These include the four scan type selection buttons and two miscellaneous buttons; the Protocol Name and the Position Tube buttons.

Scan Type Buttons

The four scan type buttons, described previously in Section 3.3.1, are provided to select the scan type indicated by the button label. On selection of a scan type, the corresponding scan parameters that the user will be allowed to modify will become sensitive, and the parameters that the user will not be able to modify will become insensitive.

Protocol Name Button

When this button is selected, the Protocol Selection List pop-up window (Figure 2-49) will appear. This list contains all the available protocols on the system. When the user selects a protocol for loading, the values of the scan parameters that were stored in the protocol file will be displayed in the appropriate areas of the screen.

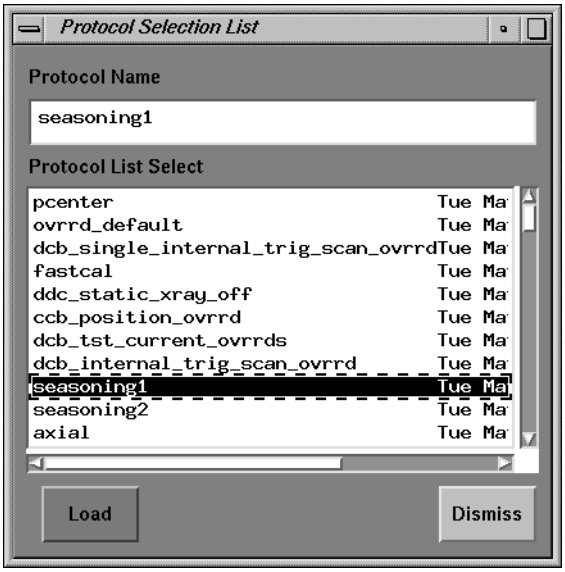


Figure 2-49 DDC Protocol List

Diagnostic Data Collection (**DDC**) Protocols are located in the following directory on the OC:

`/usr/g/protocol/service/v1.1`

Most of these protocols are used by tools and diagnostic scans. Depending on troubleshooting experience, these protocols can be selected from within **DDC**, and accepted “as is” or some of the parameters can changed for the current exam. Changes to the protocols cannot be changed and saved as well as new service protocols cannot be created.

PROTOCOL NAME	PROTOCOL USED FOR
prot.1set.scanr	For Engineering Use Only
prot.4sets.scanr	For Engineering Use Only
prot.TestDriver.scanr	For Engineering Use Only
prot.air_100.scanr	100KV Air Calibration Scans
prot.air_120.scanr	120KV Air Calibration Scans
prot.air_140.scanr	140KV Air Calibration Scans
prot.air_80.scanr	80KV Air Calibration Scans
prot.air_xtalk.scanr	Not Used
prot.aircal.scanr	Air Calibration
prot.axial.scanr	“Template” of simple Axial
prot.axial2.scanr	For Engineering Use Only
prot.bleedersetup.scanr	**HV** Bleeder set-up scans
prot.cal0.scanr	Z-Slope Cal Scans
prot.cal1.scanr	Z-Slope Cal Scans
prot.cal2.scanr	Z-Slope Cal Scans
prot.cal3.scanr	Z-Slope Cal Scans
prot.cal4.scanr	Z-Slope Cal Scans
prot.cal5.scanr	Z-Slope Cal Scans
prot.cal6.scanr	Z-Slope Cal Scans
prot.cal7.scanr	Z-Slope Cal Scans

Table 2-5 Diagnostic Data Collection (DDC) Protocols

PROTOCOL NAME	PROTOCOL USED FOR
prot.ccb_offset_ovrrd.scanr	For Engineering Use Only
prot.ccb_position_ovrrd.scanr	For Engineering Use Only
prot.ccb_test_all_ovrrds.scanr	For Engineering Use Only
prot.ccb_time_sweep_ovrrd.scanr	For Engineering Use Only
prot.ccb_trig_sweep_ovrrd.scanr	For Engineering Use Only
prot.ccb_tst_current_ovrrds.scanr	For Engineering Use Only
prot.cine.scanr	“Template” of simple Cine scan
prot.clever_gain_aircal.scanr	Clever Gain scans used during FastCal
prot.cold_warmup.scanr	Cold Tube warm-up during Calibration
prot.das_aux_channels.scanr	KV / mA Auxilary Channel Reporting in DASTools
prot.das_aux_channels2.scanr	KV / mA Auxilary Channel Reporting in DASTools
prot.das_aux_channels3.scanr	KV / mA Auxilary Channel Reporting in DASTools
prot.das_aux_channels4.scanr	KV / mA Auxilary Channel Reporting in DASTools
prot.das_dccal_absolute.scanr	Used for DCCAL Scanning in DASTools
prot.das_dccal_absolute10.scanr	Used for DCCAL Scanning in DASTools
prot.das_dccal_absolute11.scanr	Used for DCCAL Scanning in DASTools
prot.das_dccal_absolute12.scanr	Used for DCCAL Scanning in DASTools
prot.das_dccal_absolute13.scanr	Used for DCCAL Scanning in DASTools
prot.das_dccal_absolute14.scanr	Used for DCCAL Scanning in DASTools
prot.das_dccal_absolute15.scanr	Used for DCCAL Scanning in DASTools
prot.das_dccal_absolute2.scanr	Used for DCCAL Scanning in DASTools
prot.das_dccal_absolute3.scanr	Used for DCCAL Scanning in DASTools
prot.das_dccal_absolute4.scanr	Used for DCCAL Scanning in DASTools
prot.das_dccal_absolute5.scanr	Used for DCCAL Scanning in DASTools
prot.das_dccal_absolute6.scanr	Used for DCCAL Scanning in DASTools
prot.das_dccal_absolute7.scanr	Used for DCCAL Scanning in DASTools
prot.das_dccal_absolute8.scanr	Used for DCCAL Scanning in DASTools
prot.das_dccal_absolute9.scanr	Used for DCCAL Scanning in DASTools
prot.das_dcnoise.scanr	Used for DC Noise Scan in DASTools
prot.das_dcnoise_offsets.scanr	Used for DC Offset/Noise Scan in DASTools
prot.das_dcoffsets.scanr	Used for DC Offset Scan in DASTools
prot.das_drift.scanr	Used for Offset Drift Scan in DASTools
prot.das_interconnect.scanr	Used for Interconnect Test in DASTools
prot.das_interconnect10.scanr	Used for Interconnect Test in DASTools
prot.das_interconnect11.scanr	Used for Interconnect Test in DASTools
prot.das_interconnect2.scanr	Used for Interconnect Test in DASTools
prot.das_interconnect3.scanr	Used for Interconnect Test in DASTools
prot.das_interconnect4.scanr	Used for Interconnect Test in DASTools
prot.das_interconnect5.scanr	Used for Interconnect Test in DASTools

Table 2-5 Diagnostic Data Collection (DDC) Protocols (Continued)

PROTOCOL NAME	PROTOCOL USED FOR
prot.das_interconnect6.scanr	Used for Interconnect Test in DASTools
prot.das_interconnect7.scanr	Used for Interconnect Test in DASTools
prot.das_interconnect8.scanr	Used for Interconnect Test in DASTools
prot.das_interconnect9.scanr	Used for Interconnect Test in DASTools
prot.das_popmicro.scanr	Used for Pop/Noise Scans in DASTools
prot.dcb_canned_cnv_pattern_ovrrd.scanr	Scan Data Path Diagnostic Scans
prot.dcb_canned_dcb_pattern_ovrrd.scanr	Scan Data Path Diagnostic Scans
prot.dcb_cnv_autocorr_disable_ovrrd.scanr	Eng. Use only, disables Converter Bd. Auto-correction
prot.dcb_detector_ctrl_ovrrd.scanr	Eng. Use Only, Controls FET over-ride settings
prot.dcb_internal_trig_scan_ovrrd.scanr	Currently not used, Internal Trigger over-rides
prot.dcb_single_internal_trig_scan_ovrrd.scanr	Currently not used, Single Trigger over-ride
prot.dcb_test_all_ovrrds.scanr	For Engineering Use Only
prot.dcb_tst_current_ovrrds.scanr	Converter Bd. Test voltage injection over-ride
prot.dcb_view_auto_zero_chan_ovrrd.scanr	Converter Bd. Auto-zero channel over-ride
prot.ddc_axial_xray_off.scanr	Default **DDC** Axial x-ray off
prot.ddc_axial_xray_on.scanr	Default **DDC** Axial x-ray on
prot.ddc_scout_xray_off.scanr	Default **DDC** Scout x-ray off
prot.ddc_scout_xray_on.scanr	Default **DDC** Scout x-ray on
prot.ddc_static_xray_off.scanr	Default **DDC** Stationary x-ray off
prot.ddc_static_xray_on.scanr	Default **DDC** Stationary x-ray on
prot.ductwarm.scanr	Ductility warm-up scans used in Auto mA scans
prot.fpa_check.scanr	**FPA** Test Scans used during FastCal
prot.grndleakage.scanr	Ground Leakage scans during **HV** integration
prot.helical.scanr	"Template" for simple Helical scan
prot.hhs_large_spot.scanr	**HHS** Scans
prot.hhs_large_sweep.scanr	Collimator Aperture Test
prot.hhs_small_spot.scanr	**HHS** Scans
prot.hhs_small_sweep.scanr	Collimator Aperture Test
prot.hot_iso.scanr	Hot ISO Data Scans
prot.hss.scanr	Heat Soak & Seasoning Scans
prot.hssquick.scanr	Heat Soak & Seasoning Quick Scans
prot.kvtest.scanr	Not Used
prot.large_cal.scanr	Phantom Calibration
prot.medium_cal.scanr	Phantom Calibration
prot.nbt_aircal.scanr	Non-Bowtie Air Calibration
prot.ovrrd_default.scanr	Not Used
prot.p12_xtalk.scanr	Not Used
prot.p35_100.scanr	Engineering IQTB Phantom Calibration
prot.p35_120.scanr	Engineering IQTB Phantom Calibration
prot.p35_140.scanr	Engineering IQTB Phantom Calibration
prot.p35_80.scanr	Engineering IQTB Phantom Calibration
prot.p48_100.scanr	Engineering IQTB Phantom Calibration

Table 2-5 Diagnostic Data Collection (DDC) Protocols (Continued)

PROTOCOL NAME	PROTOCOL USED FOR
prot.p48_120.scanr	Engineering IQTB Phantom Calibration
prot.p48_140.scanr	Engineering IQTB Phantom Calibration
prot.p48_80.scanr	Engineering IQTB Phantom Calibration
prot.pcenter.scanr	Phantom Centering
prot.prescanma.scanr	Auto mA Calibration
prot.risefall.scanr	**HV** Integration Rise / Fall Scans
prot.rx_test_all_ovrrds.scanr	Not Used
prot.sanity_1.scanr	Internal S/W sanity testing scans
prot.sanity_2.scanr	Internal S/W sanity testing scans
prot.sanity_3.scanr	Internal S/W sanity testing scans
prot.sanity_4.scanr	Internal S/W sanity testing scans
prot.sanity_5.scanr	Internal S/W sanity testing scans
prot.sanity_6.scanr	Internal S/W sanity testing scans
prot.sanity_7.scanr	Internal S/W sanity testing scans
prot.scandp.scanr	Scan Datapath Diagnostic
prot.scantimer.scanr	Scan Timer scan
prot.scout.scanr	"Template" for simple Scout scan
prot.seasoning1.scanr	Heat Soak & Seasoning scans
prot.seasoning2.scanr	Heat Soak & Seasoning scans
prot.small_cal.scanr	Small Phantom Cal
prot.static.scanr	"Template" for simple static scan
prot.sweep.scanr	For Engineering Use Only
prot.ta_bow.scanr	Beam On Window (**BOW**) Alignment Scan
prot.ta_cbf.scanr	Center Bowtie Filter (**CBF**) Alignment scan
prot.ta_iso.scanr	ISO (cold) Alignment Air scan
prot.ta_iso_lrg.scanr	ISO (Large Spot) Alignment scan
prot.ta_iso_sml.scanr	ISO (Small Spot) Alignment scan
prot.ta_por.scanr	Plane of Rotation (**POR**) Alignment scan
prot.ta_snr.scanr	Not Used
prot.tst_all_current_ovrrds.scanr	For Engineering Use Only
prot.tst_all_ovrrds.scanr	For Engineering Use Only
prot.w20_100.scanr	Engineering IQTB Phantom Calibration
prot.w20_120.scanr	Engineering IQTB Phantom Calibration
prot.w20_140.scanr	Engineering IQTB Phantom Calibration
prot.w20_80.scanr	Engineering IQTB Phantom Calibration
prot.warmup1.scanr	Tube warm-up 1 scans during calibration
prot.warmup2.scanr	Tube warm-up 2 scans during calibration
prot.water_cal.scanr	Auto **CT** Number scans
prot.water_numbers_kv100.scanr	Manual **CT** Number Scans (100KV)
prot.water_numbers_kv120.scanr	Manual **CT** Number Scans (120KV)
prot.water_numbers_kv140.scanr	Manual **CT** Number Scans (140KV)
prot.water_numbers_kv80.scanr	Manual **CT** Number Scans (80KV)

Table 2-5 Diagnostic Data Collection (DDC) Protocols (Continued)

PROTOCOL NAME	PROTOCOL USED FOR
prot.xrayverif_4x125.scanr	Used for X-Ray verification scans in **DAS** Integration
prot.xrayverif_cal2.scanr	Used for X-Ray verification scans in **DAS** Integration
prot.xrayverif_cal4.scanr	Used for X-Ray verification scans in **DAS** Integration
prot.xrayverif_cal6.scanr	Used for X-Ray verification scans in **DAS** Integration
prot.zscal.scanr	Not Used

Table 2-5 Diagnostic Data Collection (DDC) Protocols (Continued)

Position Tube Button

When this button is selected, the Tube Position pop-up window (Figure 2-50) appears. The tube positioning function allows the user to position the tube between 0 and 360 degrees of the rotation.

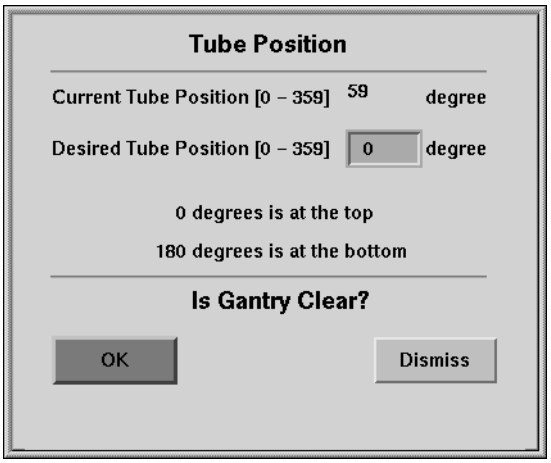


Figure 2-50 Position Tube Pop-Up Window

3.3.3.2 Work Area

All scan parameters in the fields to the right of the Command Area that may be modified, depending on the scan type and protocol selected, are displayed in the Work Area. Each scan parameter value is presented in a text field or indicated by a toggle button in a depressed state. When a value is displayed and is sensitive in a text field, a new value can be entered directly to replace the old value.

3.3.3.3 Status Message Area

Status messages will be displayed in this area at the very bottom of the **GUI** screen. The messages displayed in this area are not persistent and will disappear after a few seconds.

3.3.4 Reconstruct DDC Images

Use ReconRx screens to list/select the **DDC**-acquired data. Use ReconRx to reconstruct the **DDC**-acquired data into images.

DDC scans appear in Recon Rx List/Select when they consist of:

- Rotating X-Ray On scans
- Full rotation scans consisting of 984 views
- Scans that have a corresponding cal file

3.3.5 DDC With Tracking Off

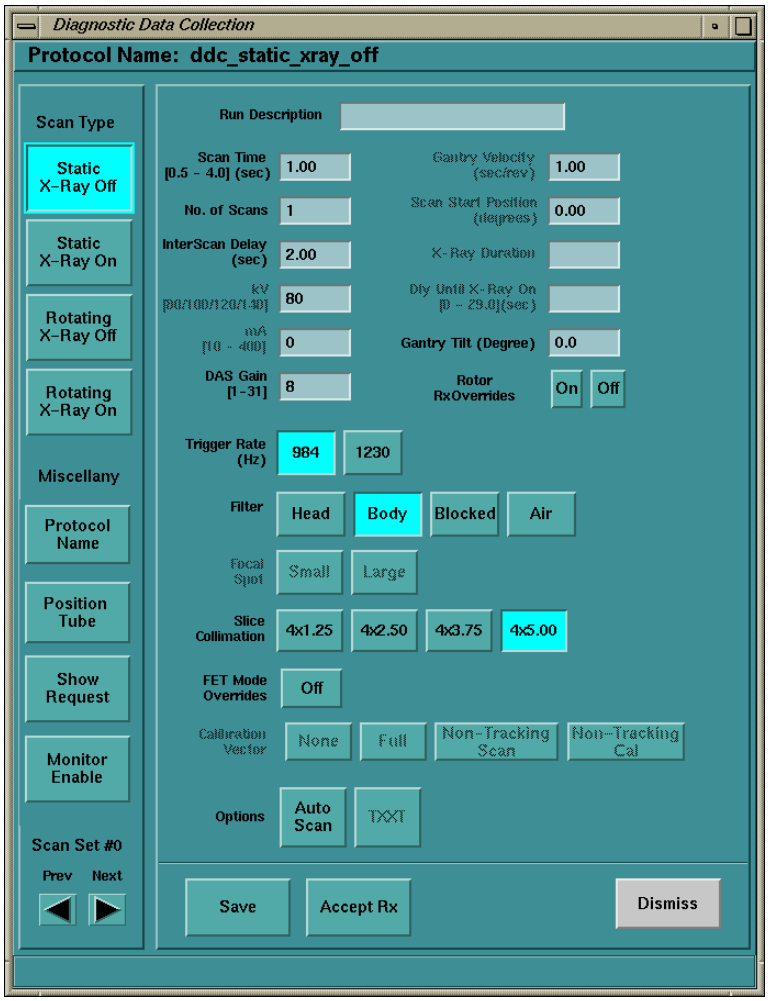


Figure 2-51 Diagnostic Data Collection Screen

To produce an image without tracking:

1.) Using **DDC**, create a non-tracking air cal. Use KV, mA, Filter, Focal Spot, and Aperture to duplicate patient scanning.

2.) Nothing should be in the beam.

3.) Select Calibration Vector Option Non-Tracking Cal. This will produce a temporary file that will be used for the air cal portion of data reconstruction.

4.) Scan.

5.) Place the phantom that you want scanned and reconstructed center in the beam.

6.) Select the exact same parameters that was used for the temporary Aircal, except for Calibration Vector option, select Non-Tracking Scan.

7.) Scan and record the exam number.

8.) Retro-Recon this exam number using Application ReCon menu options. Be sure to adjust the Field Of View (**FOV**) that matches the phantom size of **FOV** that your interested in viewing.

9.) View the images view the browser.

3.3.6 FET Mode Selection

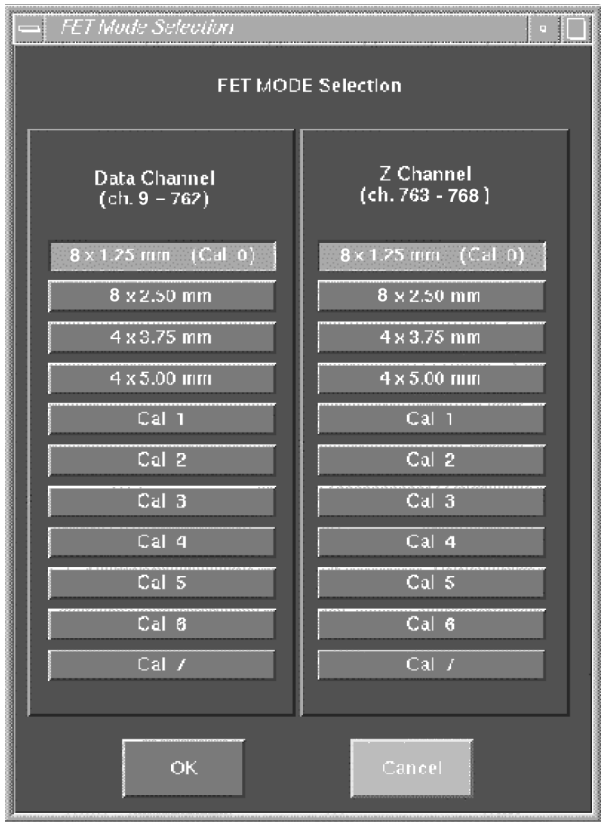


Figure 2-52 FET Mode Selection

Refer to Collimator Tracking Theory in section 4.3.18, on page 785, in Chapter 9 - X-Ray Generation, to understand FET Mode use with tracking.

3.4 Scan Data Analysis Tools (SCAN, Tracking dd, CAL)

The scan analysis feature allows users to have interactive access to scan files collected on the scanner. Scan data to be viewed can come from either patient scanning or from service mode tools such as Diagnostic Data Collection or Calibration.

Analysis is divided into three major areas of: SCAN ANALYSIS, dd FILE ANALYSIS, and CAL FILE ANALYSIS. CAL File analysis is not yet available for this system. Each major section provides a file list select interface similar to the Image Works List Select, Image Browser. Analysis List Select allows you to select the appropriate file of interest.

Any of the normal scan files may be selected for processing within Scan Analysis including Axial, Helical, and Scout scans. Once the scan data of interest is selected you can select one of several processing options, which include: Update, Scan Header, Cal Vectors, Aux Channels, Create **MSD** dd File, Plot **MSD**, Plot **VVC**, and Save Scan.

3.4.1 Definitions within Scan Analysis

dd File (Diagnostic Data File): dd files are a result file from some type of operation on the scan data file. dd files are typically some form of view summed file that may have had some specific type of processing applied to it. For example, the processing applied to the raw data to calculate the position of the pin in ISO alignment results in a temporary file that is a view summed result that could be saved as a dd file. As long as two dd files have the same number of data elements in them, the two files may be added, subtracted, multiplied, or divided with each other.

Detector Macro Row: One detector output row for each of the four 4x1.25, 4x2.5, 4x3.75, or 4x5 acquisition mode combinations for the detector. For most of the analysis functions, this provides either four selections for the detector row to be examined, or four sets of data results that correspond to the detector rows 2A, 1A, 1B, 2B. Refer to the **DAS** Architecture (section 1.1, on page 467, in Chapter 7 - Detector and DAS) for further information.

Means and Standard Deviation File (MSD): This is usually the result of combining two or more views mathematically, which results in mean values for each channel in the views and an associated standard deviation for each channel in the views. In essence all of the user selected views in a scan file are summed together, resulting in a single “master view” that contains the averaged data from all of the views. The mean values represent the average data value from the channels, and the standard deviation values represent the amount of variability for that channel’s data values across all of the views. The higher the standard deviation, the more the channel output varied from view to view.

Scan Header: This is the information contained within the scan file that identifies the specific settings in effect when that scan file was created. The scan header includes information at several levels, including: Exam, Series, and Scan. Information identifying the technique selections, scan time, acquisition mode, and many others may be found in the scan header.

Cal Vectors: Within scan analysis, the cal vectors are only those vectors contained within the scan data file at the time that the scan was taken.

Aux Channels: The auxiliary channels are data sampling “channels” in the **MDAS** that provide a way to place other data into the view besides the patient information coming from the detector. These include: Power Supply, Temperature, kV, mA, and other analog data values. These analog signals are sampled at the same rate as the patient image data and are a snapshot of those values at each view sample time.

Z-Axis Channels: These are some special purpose channels built into the detector that are used for several different special operations related to determining the x-ray beam position on the detector.

VVC (Views vs Channels): This is a way to graphically represent the data values from each channel for each view of data from the **MDAS** as a shade of grey. The display will have the views stacked vertically and the channels arranged across the display horizontally.

3.4.2 Starting Scan Analysis

Scan Analysis may be started from any of several menu locations, including: UTILITIES, TOOLS and IMAGE QUALITY.

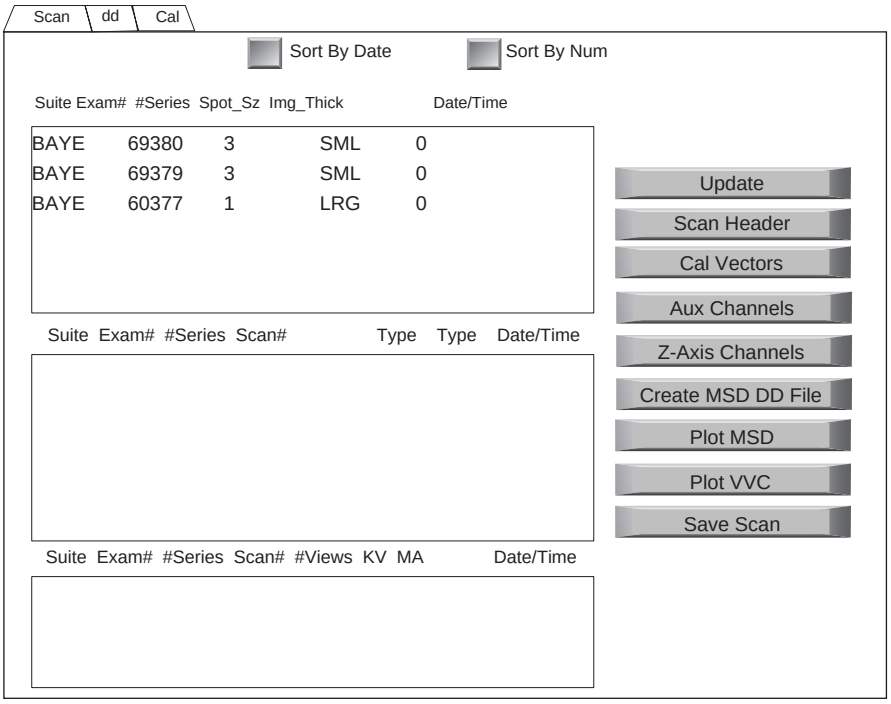


Figure 2-53 Initial Scan Analysis Screen

3.4.3 Selections in Scan Analysis

Upon starting the Scan List Select window, you can highlight an EXAM > SERIES > SCAN, and perform the desired analysis feature by pressing any of the following buttons:

3.4.3.1 UPDATE

The UPDATE selection will refresh the List Select display if new scan files have been created since the Scan Analysis Tool was started.

3.4.3.2 SCAN HEADER

The SCAN HEADER selection will open a scrolling text window that contains the header text information contained in select scan file.

3.4.3.3 CAL VECTORS

The CAL VETORS selection will open a window allowing you to select the calibration vectors *in the selected scan file* that you wish to view. After the selections are made, OK will process the data requests and display the results.

The resultant plots will be auto-scaled, and in some cases, the range of data displayed will be set automatically. This is to provide a reasonable initial view of the data. Always check the scale on the left-hand side of the plot displays. Cursor reporting of data value and channel numbers is provided.

The default selections are underlined in Table 2-6.

SCAN FILE CAL VECTORS		
Cal Header	Sin	Cos
B1	B2	B3
PCal	Acal	Misc.
XTalk	Matrix decon	ZSlope

Table 2-6 Scan File Calibration Vector Selections

3.4.3.4 AUX CHANNELS

This selection will open a window that allows you to select which of the auxiliary channels in the scan file you wish to look at, as well as the start and ending views to display. After the selections are made, OK will process the data requests and display the results.

The resultant plots will be auto-scaled, and in some cases the range of data displayed will be set automatically. This is to provide a reasonable initial view of the data. Always check the scale on the left-hand side of the plot displays. Cursor reporting of data value and view numbers is provided.

The default selections are underlined inTable 2-7.

SCAN FILE AUXILIARY CHANNELS	
Detector Heater Temperature	Negative 5 Volt Reference
MA	5 Volt Dc Power Supply
KV	Positive 5 Volt Converter
Positive 12 Volt	Digital Ground
Negative 12 Volts	Analog Ground 11
Positive 5 Volt Analog	Analog Ground 12
Negative 5 Volt Analog	Analog Ground 15
Positive 5 Volt Test Reference	Analog Ground 16

Table 2-7 Scan File Auxiliary Channel Selections

3.4.3.5 Z AXIS CHANNELS

This selection allows you to select the start and end views to display for the Z Axis Channel data. After the selections are made, OK will process the data and display the results.

3.4.3.6 CREATE MSD DD FILE

This will calculate a view averaged “super view” for the selected views and store the results in a separate file on the systems disk. The display will report the path and filename of the file just created. Once created, dd File can be viewed or compared with other files to check for specific operating characteristics.

3.4.3.7 PLOT MSD

Provides a set of view summed means and standard deviation plots of a scan file. The plotter is started to display the means vectors and the standard deviation vectors, computed across the entire scan for each detector macro row. There will be four mean and standard deviation plot sets in the display window.

After Plot **MSD** is started, a window will allow you to select:

- Start View and EndView
- View Compression: Automatic, 2 to 1, 4 to 1

- Processing steps:
  1.) Offset Correction: This processing step removes the signal bias introduced by the acquisition electronics from the scan data. This operation is performed on a channel-by-channel basis for each view.
  2.) Primary Speed Correction (afterglow): This processing applies a correction value to each channel value to reduce the effect of scintillator afterglow from the detector cells.
  3.) Reference Normalization: Makes use of unobstructed (not blocked by the patient) detector cells at the end of the detector to adjust for fluctuations in the x-ray beam and effects of aperture size and mA. In the case where the reference channels are blocked, the system uses an estimated value for the processing. The steps for reference normalizing the scan data involve:
     A.) Offset correction for the reference channels.
     B.) Dividing the offset corrected scan data by the averaged reference channels for each view.
  4.) Convolved Data: This processing step mathematically filters the channel data to remove blurring effects that would occur when the views are back-projected. The effect is to "sharpen" each channel's data value within the view. Without the convolution step, some of the x-ray attenuation data for a particular channel ends up in the channels on either side of that particular channel. Convolution puts that adjacent channel contribution back into the channel data that it should have been in to begin with.

Cursor reporting of data value and channel numbers is provided.

3.4.3.8 PLOT VVC

The PLOT VVC selection provides Views-vs-Channels display of a grey scale representation for the selected scan file. Each view of data (or summed, compressed view) is represented on the display as a horizontal line. Each pixel in the line represents the data value for a particular channel from the **DAS**.

After **VVC** is activated, a window will allow you to select:

- Row (macro row) One of: 2A, 1A, 1B, 2B
- Start View and EndView
- Start Channel and End Channel
- View Compression: Automatic, 2 to 1, 4 to 1
- Processing steps:
  1.) Offset Correction: This processing step removes from the scan data, the signal bias introduced by the acquisition electronics. This operation is performed on a channel-by-channel basis for each view.
  2.) Primary Speed Correction (afterglow): This processing applies a correction value to each channel value to reduce the effect of scintillator afterglow from the detector cells.
  3.) Reference Normalization: Makes use of unobstructed (not blocked by the patient) detector cells at the end of the detector to adjust for fluctuations in the x-ray beam and effects of aperture size and mA. In the case where the reference channels are blocked, the system uses an estimated value for the processing. The steps for reference normalizing the scan data involve:
     A.) Offset correction for the reference channels.
     B.) Dividing the offset corrected scan data by the averaged reference channels for each view.
  4.) Convolved Data: This processing step mathematically filters the channel data to remove blurring effects that would occur when the views are back-projected. The effect is to "sharpen" each channel's data value within the view. Without the convolution step, some of the x-ray attenuation data for a particular channel ends up in the channels on either side of that particular channel. Convolution puts that adjacent channel contribution back into the channel data that it should have been in to begin with.

Once displayed, the window and level for the displayed data can be changed to better see variations in the data.

CURSOR BEHAVIOR IN VVC

Cross hair cursor reporting is provided for: Data Value, **DAS** Channel, Detector Channel, and View number. The cursor is moved across the display using the mouse.

A selection box on the display allows selection of line cursors and box cursors, which allow the selection of a channel, view, or group of channels and views for plotting.

The line and box cursors can be moved around the screen to view specific areas of interest. When the mouse pointer cursor is moved over a line cursor the mouse cursor will change to a four pointer arrow. Pressing the left mouse button allows you to 'drag' the cursor across the display.

For the box cursors, the box may be dragged using the left mouse button with the mouse cursor positioned over the box. The size and shape of the box can be changed by moving the mouse cursor over the *Bottom* or *Right* edges of the box. When over the *Bottom* or *Right* edges of the box you can press the left mouse button to drag the box edge up and down or left and right.

With the channel and view cursors, the plotted data will represent all channels for a selected view or all views for a selected channel.

With the box cursors, the resulting plot will be a view summed means and standard deviation plot for the selected views and channels.

3.4.3.9 SAVE SCAN

This will save the selected scan file to a temporary disk location so that it can moved to **MOD** or transferred via ftp to another location.

3.4.4 dd File List Select Overview

dd math is a means for the user to apply mathematical operations: add, subtract, multiply, and divide to dd files, and calculate the channel-to-channel difference or ratio of means vs. standard deviation vectors of a dd file. It allows the user to specify the scaling factor for the output vector, and provides three output modes: dd file, plot, and view numbers.

dd math is part of the dd analysis user interface. Scan Analysis is used to generate dd files that may then be manipulated or examined using dd File Analysis.

3.4.4.1 dd Files Generation

There are 18 different dd file types of six orientations. The orientations are View, Channel, **RTS**, CAL, Elements, and Header.

Channel oriented means and standard deviation type dd files *are the only type* that can be created from scan data files in the Scan Analysis application.

3.4.4.2 dd Math Functions

dd math consists of the following functions:

- Add
- Subtract
- Multiply
- Divide
- Channel to Channel difference
- Ratio of means vs. standard deviation

3.4.4.3 Add, Subtract, Multiply, Divide

Applies add, subtract, multiply, and divide between vectors in two dd files. The output file is a dd file with one of the following suffixes:

- `.add`
- `.dif`
- `.mul`
- `.rat`

Operations can be performed on dd files in View orientation, Channel orientation, **RTS** orientation, and Cal orientation.

Currently, no dd type restrictions are applied to operations between dd files, as long as the dd vectors have the same number of elements. If one file has a single vector and the other file has multiple vectors, the mathematical operation will be applied multiple times using the single vector. Otherwise, the mathematical operation will be applied component-wise for the number of vectors in each file.

3.4.4.4 Channel to Channel Difference

Applies the following calculation to the data from the data set(s) in the dd files for View, **RTS** or Cal orientation:

(X2-X1), (X3-X2), (X4-X3),...,(Xn-Xn-1)

where X is the data value for each channel.

The output is channel to channel dd file with extension: `.c2c`

3.4.4.5 Ratio of Means vs. Standard Deviation

Takes a **MSD** (means and standard deviation) or **RTS** (real time statistics) type of dd file, calculates the ratio of data in the means vector (1st set) to data in standard deviation vector (2nd set). The output file is a ratio type of dd file with the extension: `.rat`

3.4.4.6 dd Math Output Mode

Three output modes are supported in dd math:

- **Plot** - Will plot the output dd vector using an on-screen vector display.
- **dd File** - Allows the user to specify the output dd file name with a full path or the file basename. If only base name is provided, the program will use the default prefix and suffix for the output file. The created dd file will be shown in the dd file list.
- **View Numbers** - View Numbers will display the dd vector numerical values on the screen, and the user can perform numerical searches in the window.

3.4.4.7 dd Analysis User Interfaces

The dd math operation panel and a set of the dd math operation buttons are part of the ddLS screen.

3.4.4.8 Functions in ddLS User Interface

The ddLS supports the following functions for various file types.

- Update
- Plot
- Save to **MOD**
- Restore From **MOD**
- dd math operations: +, -, x, /, ch2ch, Ratio
- Sort By Date or Sort by Type

The user can perform these functions, except dd math operations, by simply selecting one or more files in the list select window, and clicking the function button. The following file types are supported in the ddLS user interface.

- dd File
- Cal File
- Data File

3.4.4.9 File Operations

- **dd Math Operations** - Perform: add, subtract, multiply, divide, and channel to channel difference operations on dd files. These operations are only available for dd file types.
- **Plot** - Plots the vector(s) of the selected files in the display window for the following file types: dd Files and Cal Files
- **View #** - Prints the numerical data of the dd vector(s) to the display window(s). For image file types and scan file types, it will display the **VVC** plots of the selected files.
- **Save/Restore to/from MOD** - Saves the selected files to the **MOD** and restores all the dd files from `/MOD/ddfiles` to `/data` directory.
- **Update** - Refreshes the display in the ddLS user interface.

3.4.4.10 dd Math Operations in ddLS

The dd math operation buttons will be insensitive if no files are selected into the dd math operation panel.

The user may start dd math operation(s) by selecting the file(s) and putting them into the selection field by clicking the button FILE #1 or FILE #2. If the selected file is not a dd file, the application will not put it into the dd math operation field. A message window will pop up and ask user to select a dd file.

If only one file is selected and it is of the file type **RTS** dd file or **MSD** dd file, both CHANNEL TO CHANNEL and RATIO OF MEANS VS. STDV will become sensitive. If the selected file is not of the type **MSD** or **RTS**, only CHANNEL TO CHANNEL will become sensitive. When two dd files are selected, ADD, SUBTRACT, MULTIPLY, and DIVIDE become sensitive and CHANNEL TO CHANNEL and RATIO OF MEANS VS. STDV will be insensitive.

The user can specify the output file name when the dd file output mode is set. Otherwise a default dd file name will be provided.

The default output scaling factor is 1.0. The user can set the scaling factor to any real number.

When the dd math operation buttons are sensitive, the user can select the desired button to start the dd math operation.

3.4.5 Z-Axis Tracking

The Z-AXIS TRACKING tool is a new TAB, located within the `Analysis Tool`. The tool can be used to plot various tracking functions, using a Scan Data Set. For a scan data set, the analysis package can plot different data versus views in UN-FILTERED (the default) or FILTERED (20 pt. Boxcar) formats. Numerical information (“Max”, “Min”, “Mean”, and “Std. Dev.”) is also provided. In some plots, the numerical information provided can be used for further analysis by comparing it to a “specification” value, as an indication of a pass/fail condition. Whereas other plots are more general, and in some cases may be useful, they are typically only used for troubleshooting.

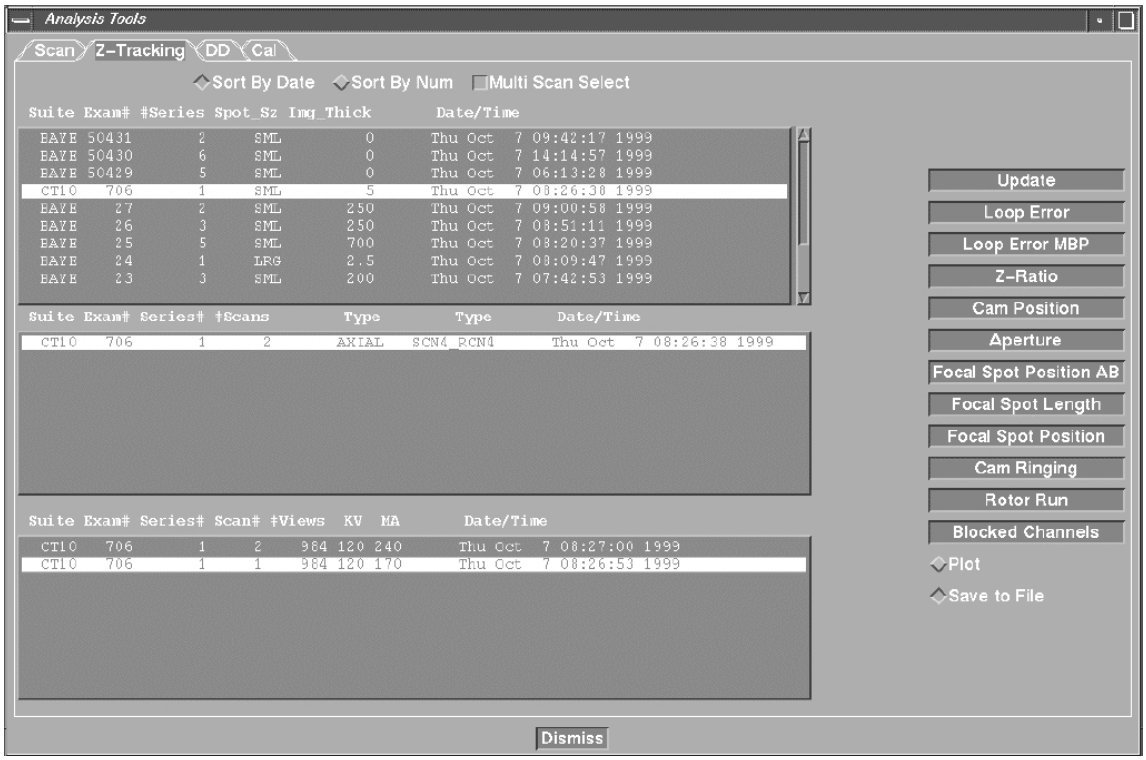


Figure 2-54 Top Level Tracking Menu

In the figures that follow, examples of “known” tracking plots are shown. Since plots vary from system to system, the examples shown should be used only as guides. Compare your system’s plots and analyze them relative to the specification shown in each figure. The plots shown are UN-FILTERED views, which is the default option when they are plotted. A `20 point boxcar` filter takes the 20 view average and then plots the data.

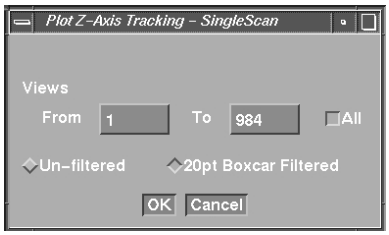


Figure 2-55 Single Scan Pop-Up Menu

A value is not considered to be out of specification unless the limit is exceeded for a sustained interval of 100 `views` or more. In the cases where specifications are not given, consider plots informational only.

3.4.5.1 LOOP ERROR

A LOOP ERROR is the difference between the calculated position of the beam minus the desired target's position (operating point) obtained during Collimator Calibration.

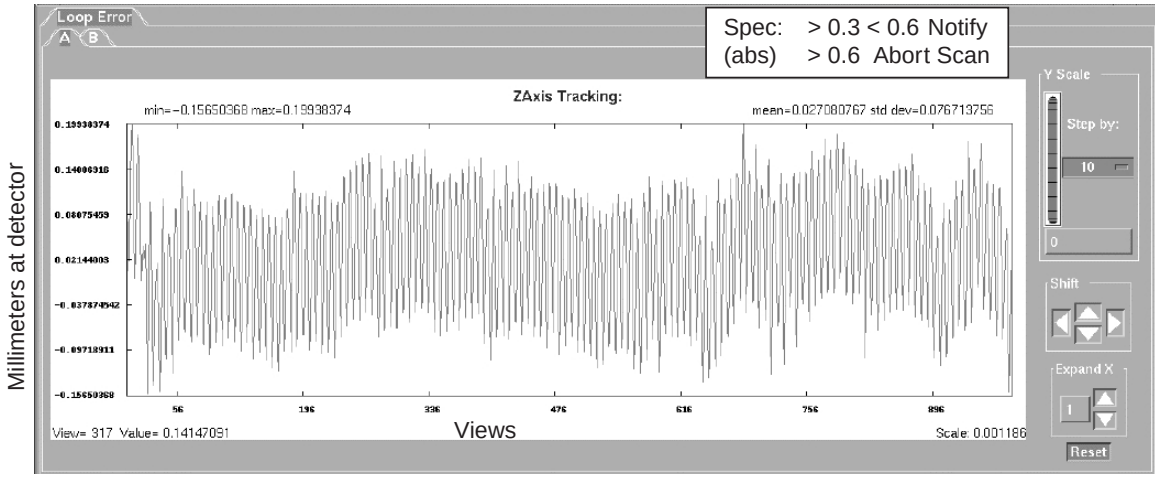


Figure 2-56 Loop Error Plot

3.4.5.2 LOOP ERROR (MBP)

A LOOP ERROR MBP (Mean Beam Position) plot is the same as the loop error plot, except that the display represents the loop error relative to the mean beam position during FASTCAL. The FASTCAL beam position is stored in the calibration database.

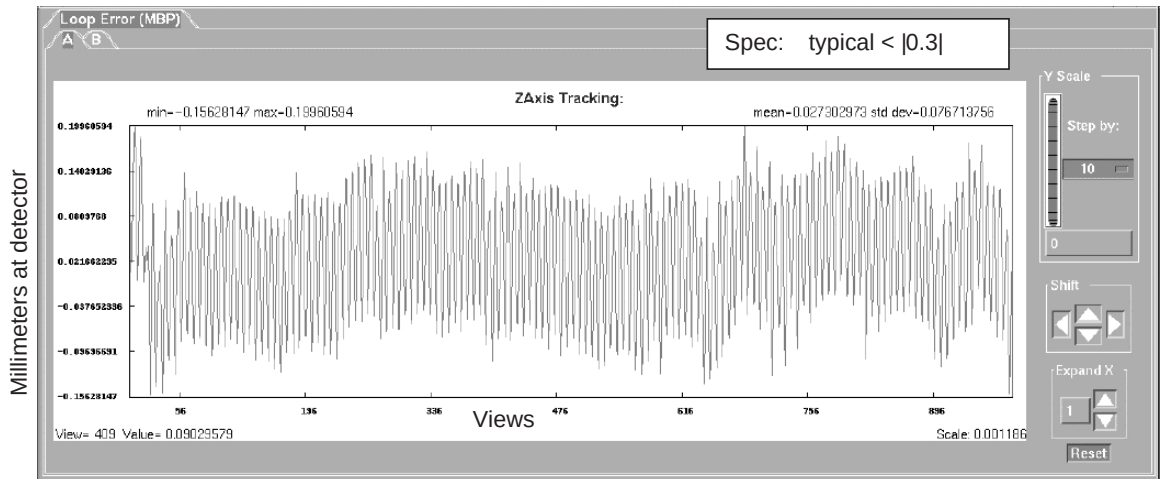


Figure 2-57 Loop Error (MBP) Plot

3.4.5.3 Z RATIO

Z-RATIO Plot computes the ratio of outer row Z-channels (Channels 763, 764, & 765 averaged) to inner row Z-channels. This is done for both the “A” and “B” sides.

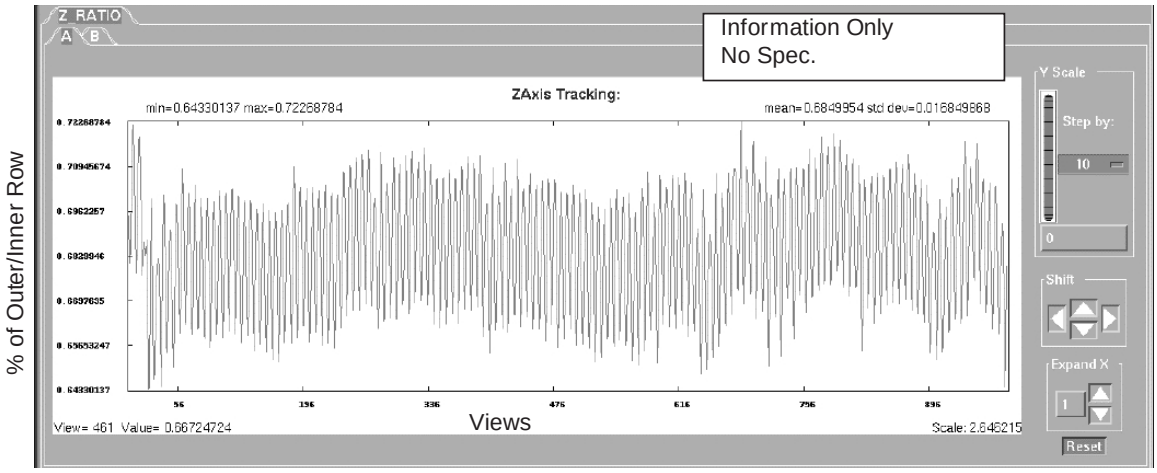


Figure 2-58 Z Ratio Plot

3.4.5.4 CAM POSITION

The CAM POSITION plot shows the CAM position during a scan from collimator opening (center-line). The absolute value of A side plus B side is the total aperture size at the collimator. Cam positions are stored in the scan file.

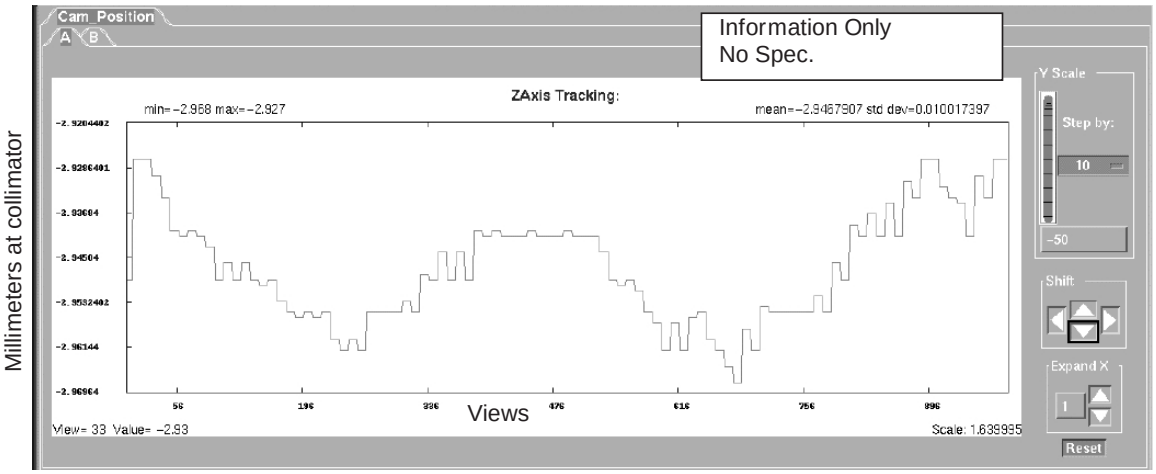


Figure 2-59 CAM Position Plot

3.4.5.5 APERTURE

APERTURE plot indicates the width of the Collimator Cam aperture in millimeters. Due to the distance magnification factor, the width at the collimator is smaller than prescribed acquisition mode, or width of the beam at the detector window.

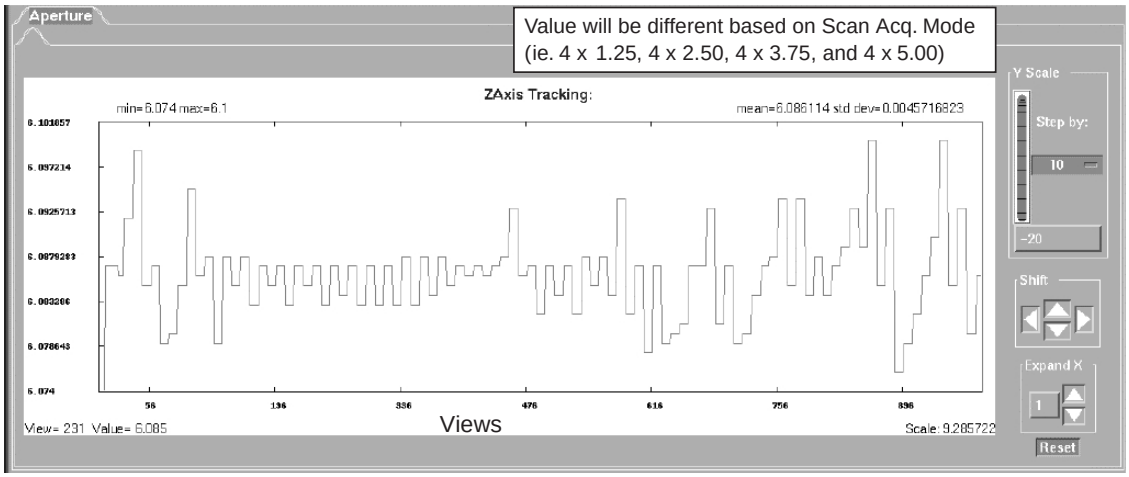


Figure 2-60 Aperture Plot

3.4.5.6 FOCAL SPOT POSITION (A/B)

FOCAL SPOT POSITION plot shows the calculated focal spot position from the centerline of either the A or B side. The vertical scale (in millimeter) represents that portion of the focal spot length. The absolute value of the A side plus the B side should equal the focal spot length (Small Spot = 0.7mm, Large Spot = 1.2mm).

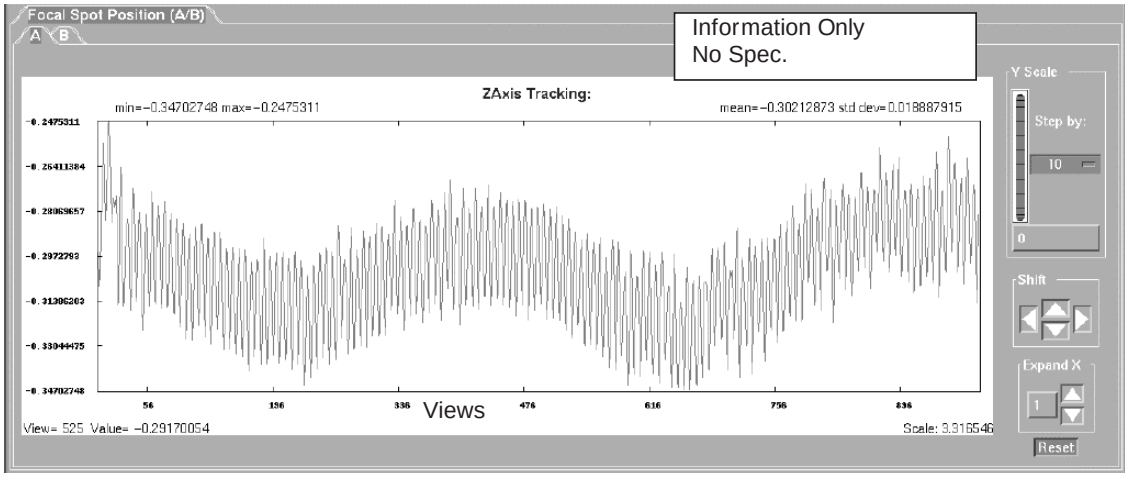


Figure 2-61 Focal Spot Position (A/B) Plot

3.4.5.7 FOCAL SPOT LENGTH

FOCAL SPOT LENGTH plot shows the calculated focal spot length. The length may change slightly due to mA, rotor wobble or gantry rotation wobble. Length is also based on the calculations, which use values from the Z-channels. Typically the small spot size is 0.7mm, and the large spot size is 1.2mm.

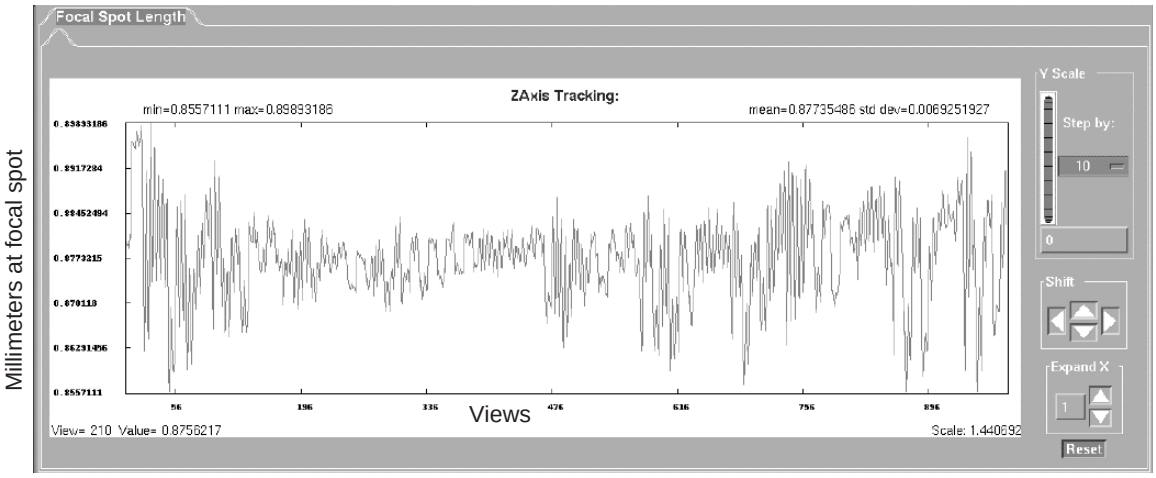


Figure 2-62 Focal Spot Length Plot

3.4.5.8 FOCAL SPOT POSITION

FOCAL SPOT POSITION plot indicates the calculated focal spot position relative to the centerline, with the center position being 0. The focal spot moves during a scan due to mA, rotor wobble, gantry rotation wobble, and because of tube (target) heat.

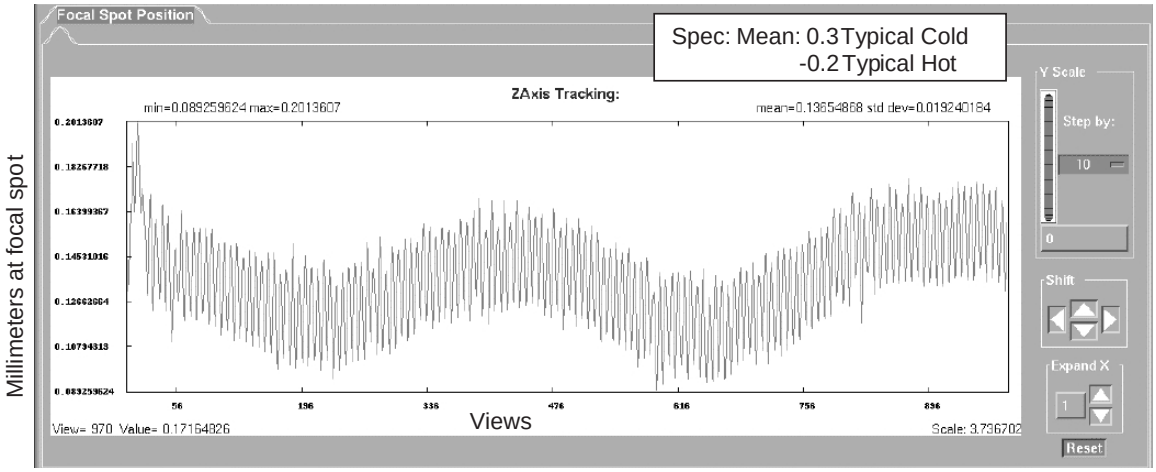


Figure 2-63 Focal Spot Position Plot

3.4.5.9 CAM RINGING

CAM RINGING provides a plot of high frequency variations, such as variations that are 180 degrees out of phase, like typical CAM ringing. A specification is not available, but typical values are less than 0.1 counts.

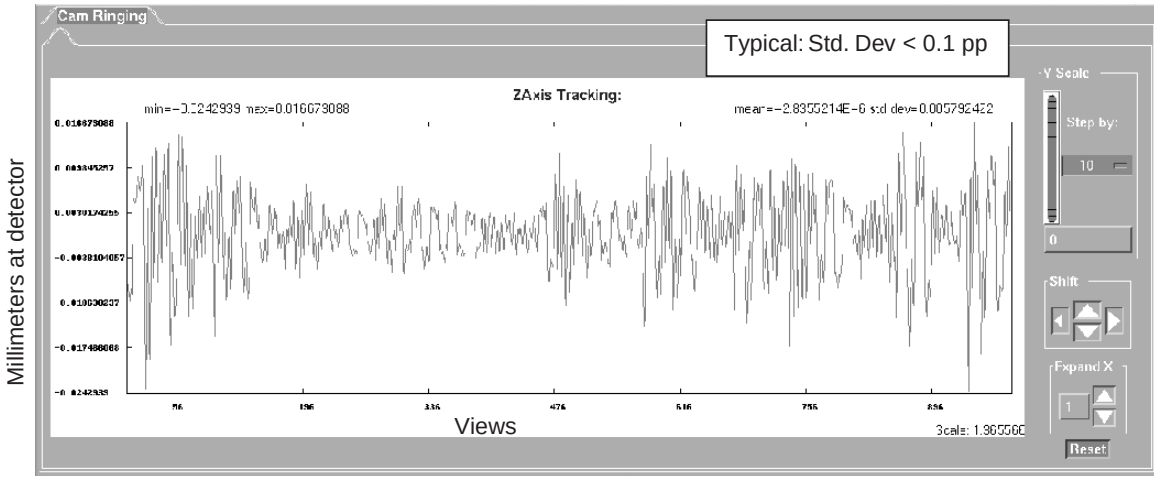


Figure 2-64 CAM Ringing Plot

3.4.5.10 ROTOR RUN

ROTOR RUN provides a plot of high frequency variations that are IN phase, such as the small periodic movement of the anode at the rotor run frequency. Typical values are less than 0.1 count values.

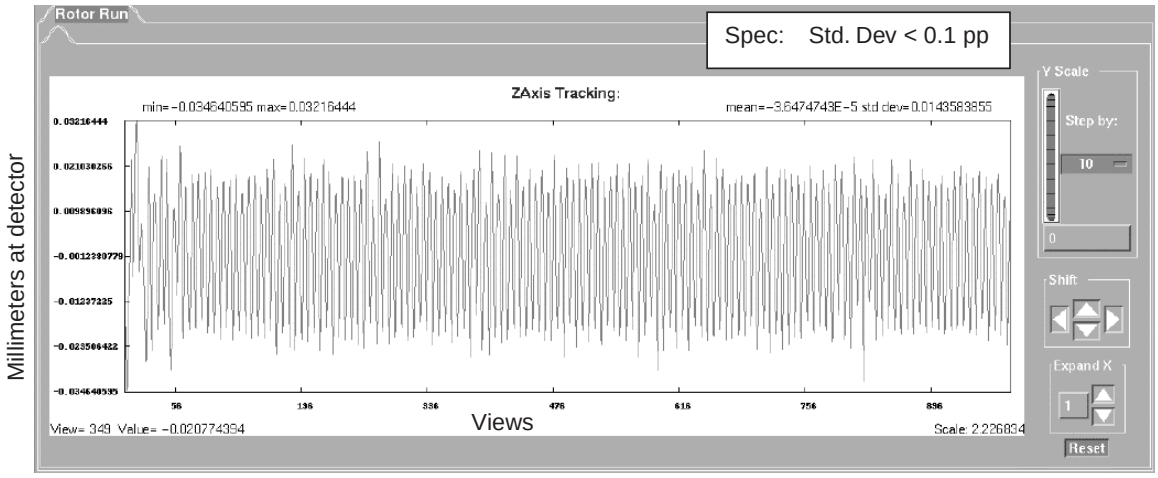


Figure 2-65 Rotor Run Plot

3.4.5.11 BLOCKED CHANNEL

A BLOCKED CHANNEL indicates that the value for **DAS** Channel 762 falls below the 10% threshold. Indicating that the channel is blocked and tracking (CAM positions) remains constant at the last known good position. This plot indicates a normal unblocked scan. Unblocked condition is indicated by a numeric value of 0. Blocked view condition is indicated by a numeric value of 1.

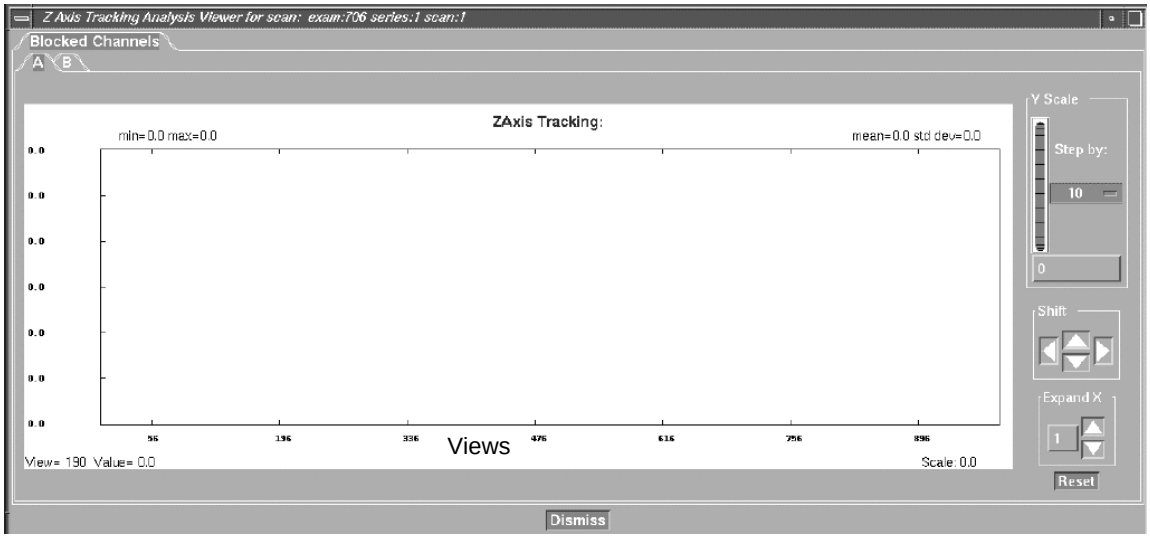


Figure 2-66 Blocked Channel Menu

3.4.5.12 MULTI-SCAN SELECT

The MULTI-SCAN SELECT option allows the user to calculate and view multiple scans. Select the MULTI-SCAN SELECT button, and then select the exams, series, or multiple scans. Once scans are selected, then select the plot that you are interested in. Due to the time it may take, based on the number of scans selected, a pop-up window may appear, to indicate the number of scans selected and the approximate time to calculate. If the time is too long, or wrong scans are selected, hit CANCEL. Once the OK button is selected, you cannot cancel processing.

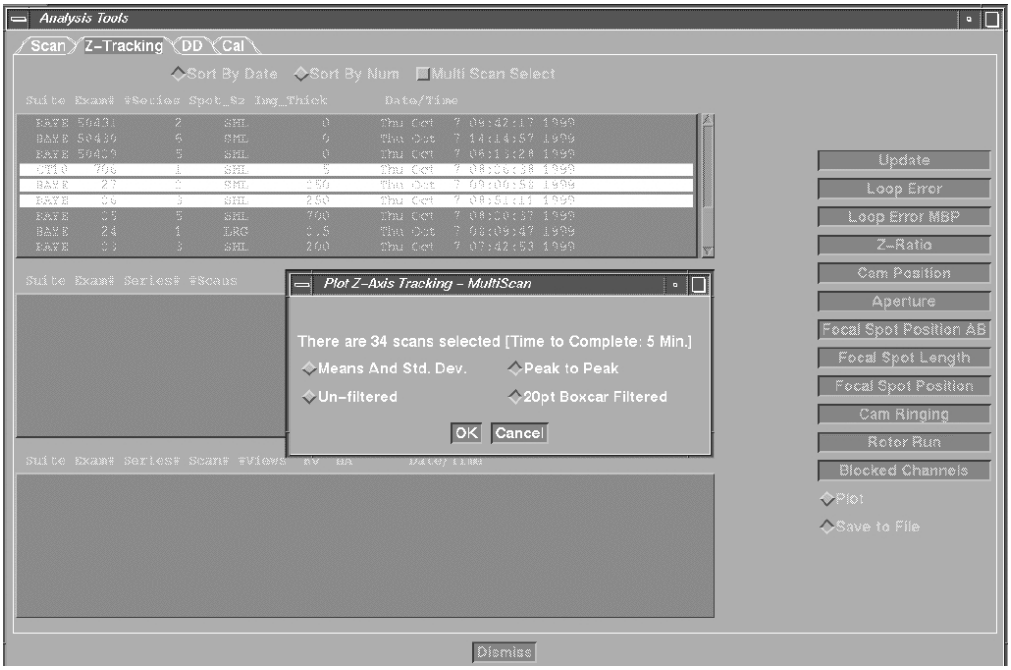


Figure 2-67 Multi-Scan Select Menu

3.4.6 Tube Spit Data Correlation Example

By using a combination of capabilities within Scan Analysis, some things just got easier.

In the past, tube spits as a source of image artifacts were frequently done by implication. The tube has been spitting lately, so the problem might be that.

With some of the new system and software capabilities, it is much easier to confirm some of these diagnosis. For example:

- **VVC** data for scan (refer to Figure 2-68). Dark horizontal lines are views with data values lower than the views immediately before and after.
- Select Channel Cursor and Plot Now (refer to Figure 2-69). Notice how the dip in the channel data corresponds to the views around 615. Next take a look at the kV and mA data.

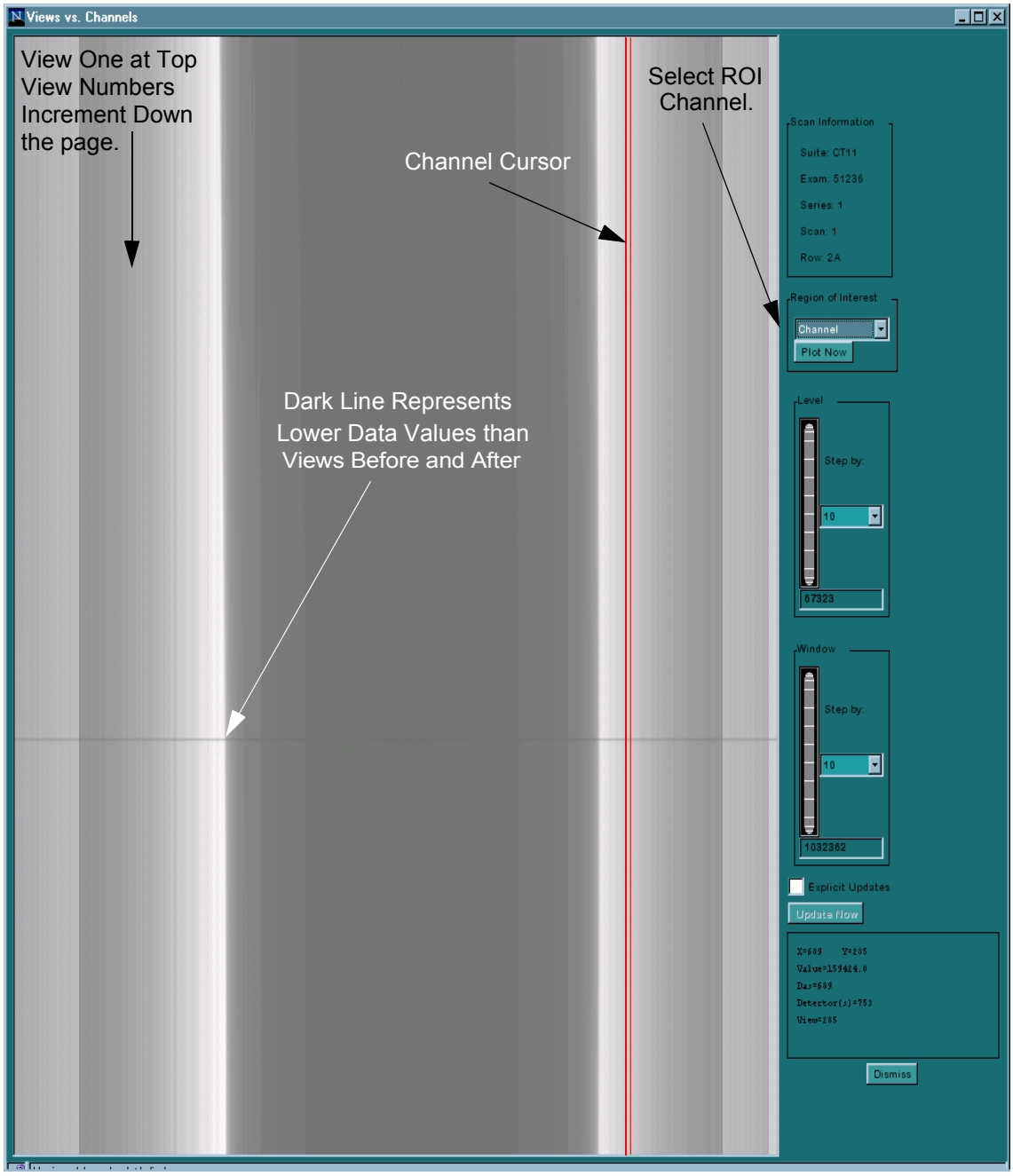


Figure 2-68 VVC Tube Spit Data Example

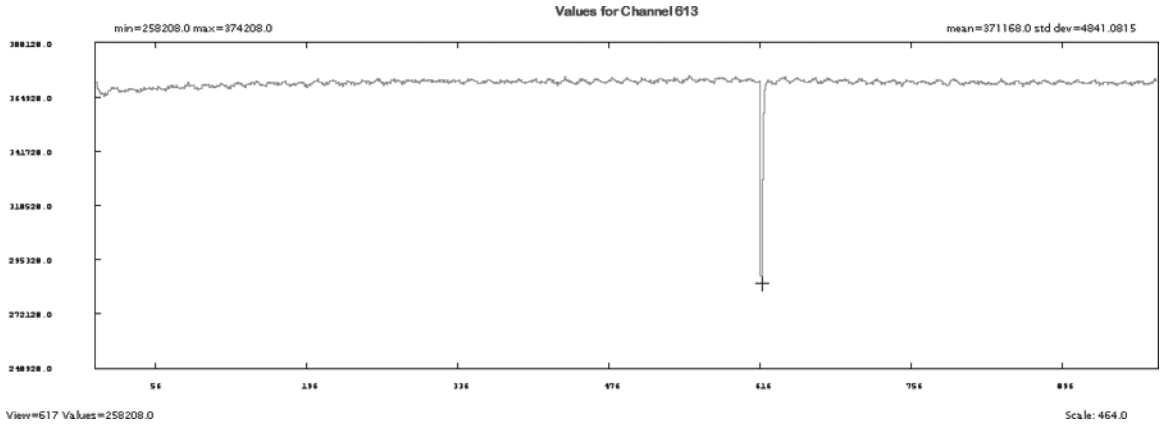


Figure 2-69 All View for one channel KV Spit Data Example

Once again the dip in the KV values reported in the view data corresponds to views around 615.

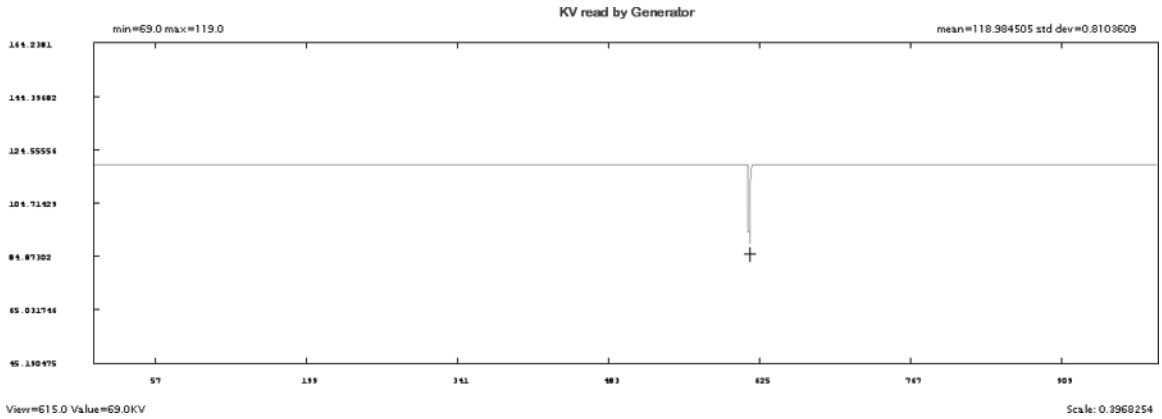


Figure 2-70 - Tube Spit Auxiliary Channel data for kV

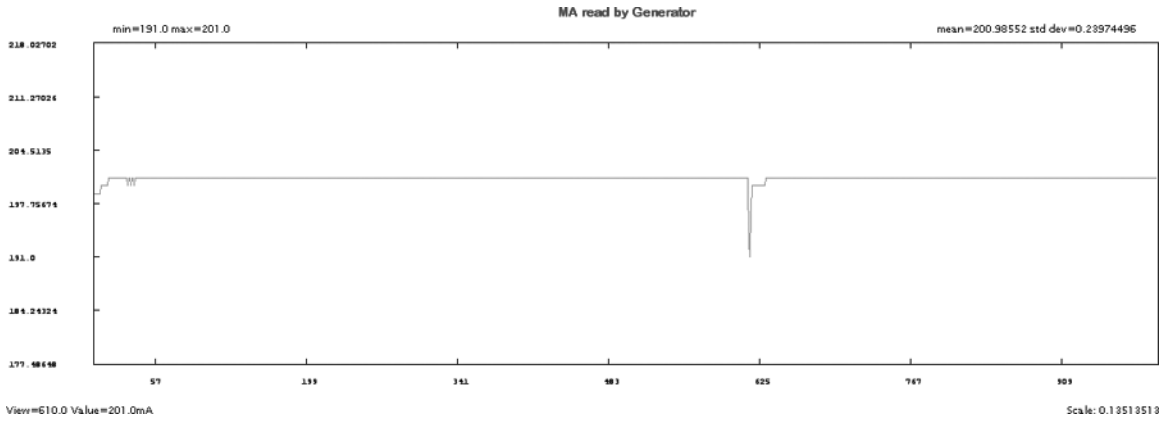


Figure 2-71 - Tube Spit Auxiliary Channel data for mA

From the previous examples, it is easy to correlate the views with suspect data from the **VVC** Display with the view by view plots for kV, mA, and Channels. Specific information to look for on the examples:

- The Min, Max, and average values for kV, mA, and channel data. This information provides a quick way to determine the scale of the information that you are viewing.
- The cursor report information provides a continuous update, depending upon the type of data that is being displayed: data values, view number, channel number.

3.4.7 Typical Examples of CAL Plots with Scan Analysis

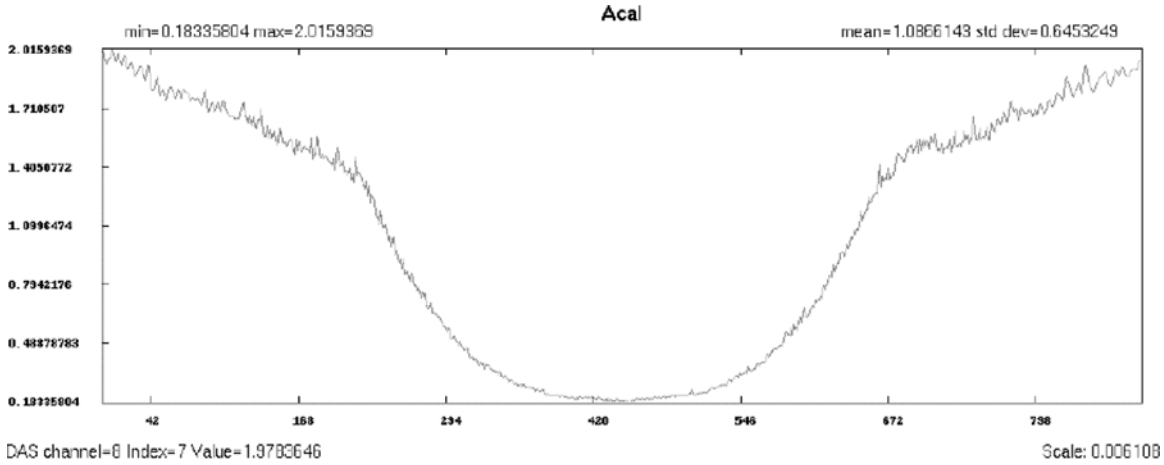


Figure 2-72 Calibration Vector Acal / Head Filter

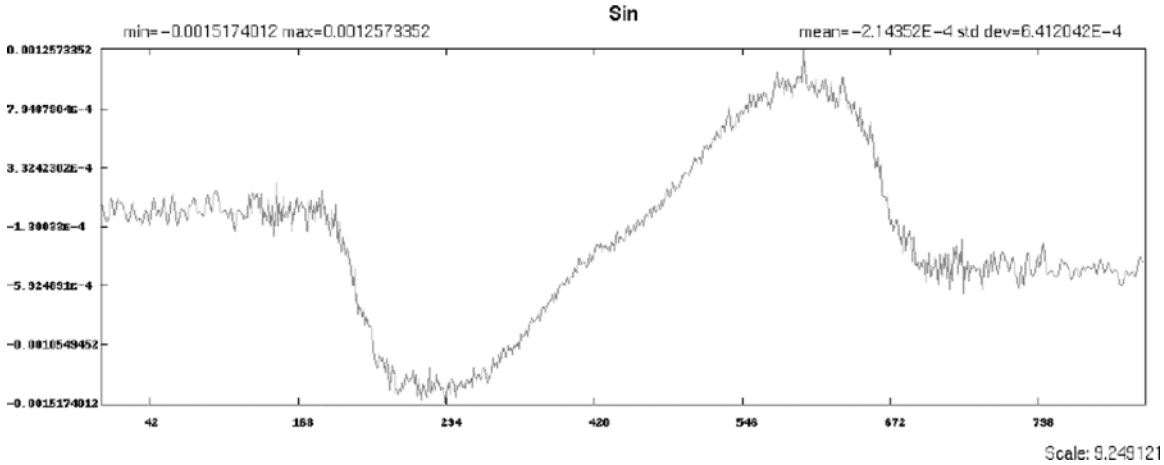


Figure 2-73 Calibration Vector Sin / Head Filter

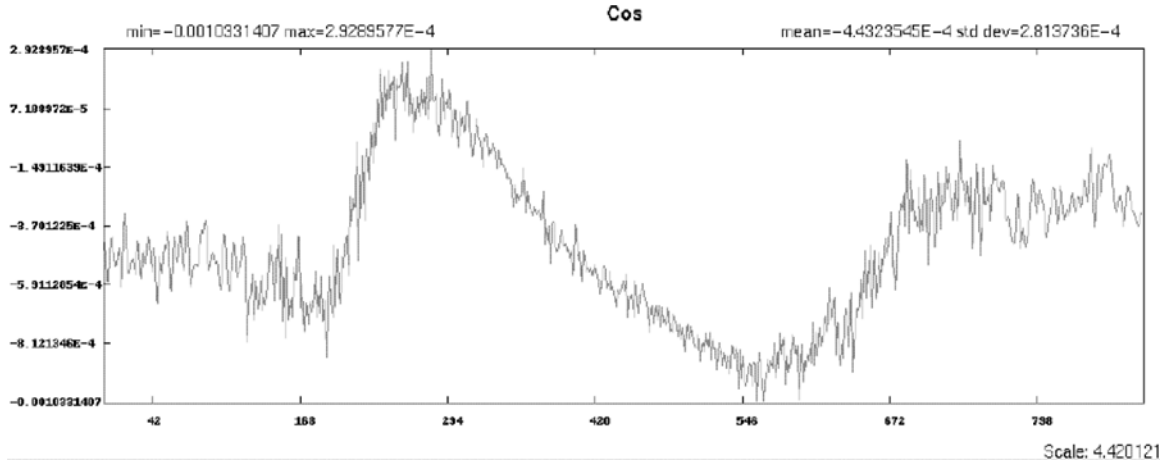


Figure 2-74 Calibration Vector Cosine / Head Filter

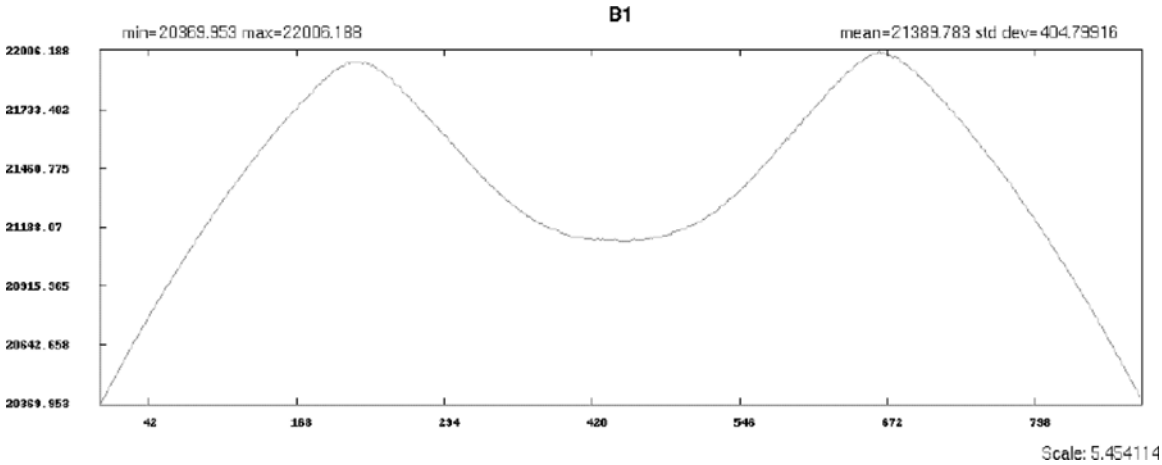


Figure 2-75 Calibration Vector "B1" / Head Filter

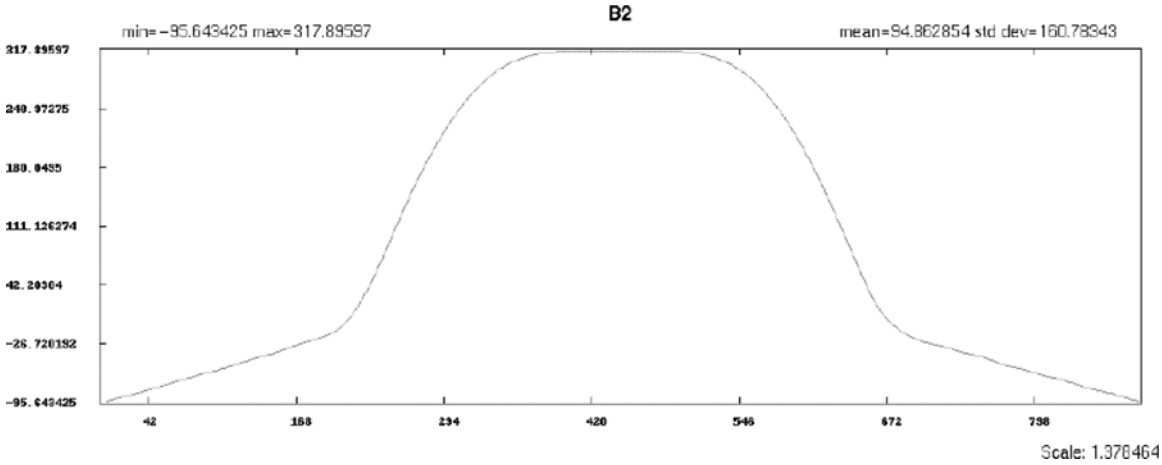


Figure 2-76 Calibration Vector "B2" / Head Filter

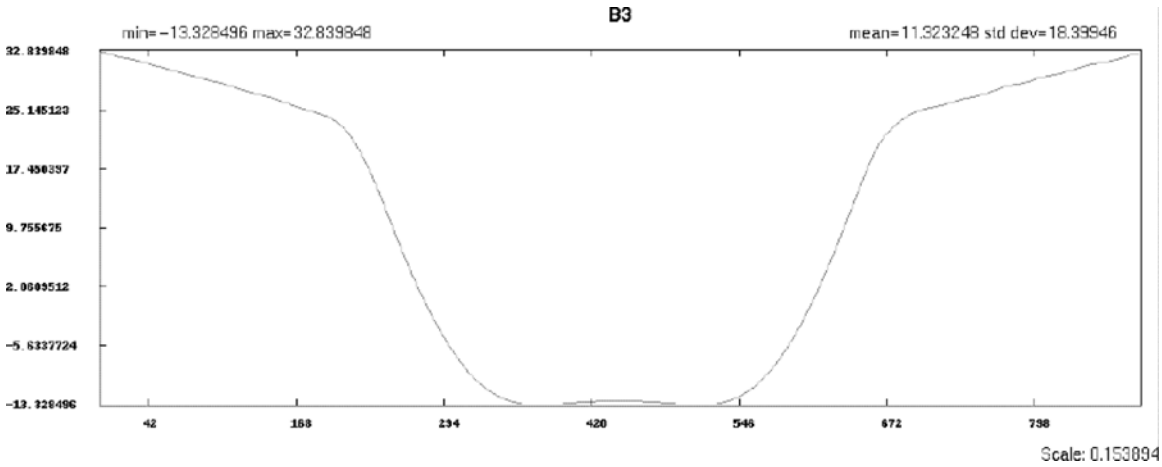


Figure 2-77 Calibration Vector "B3" / Head Filter

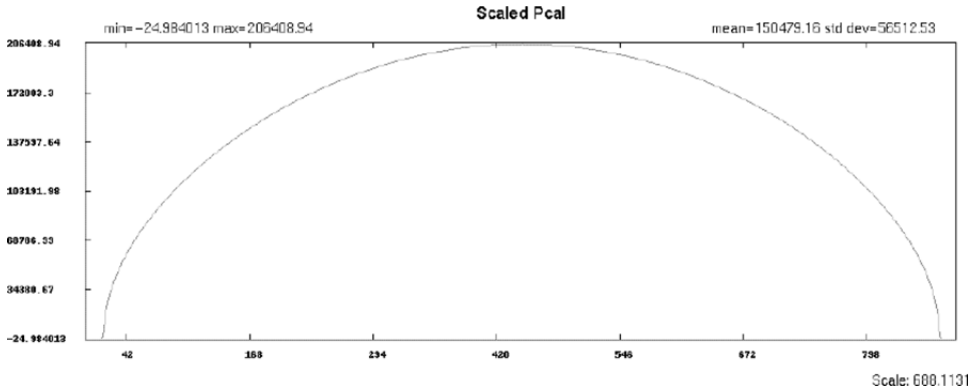


Figure 2-78 Scaled P-Cal - Head Filter

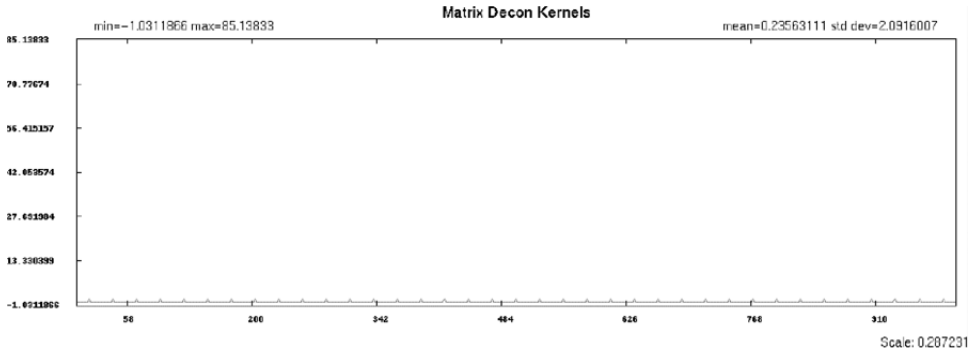


Figure 2-79 Matrix DeCon Kernels

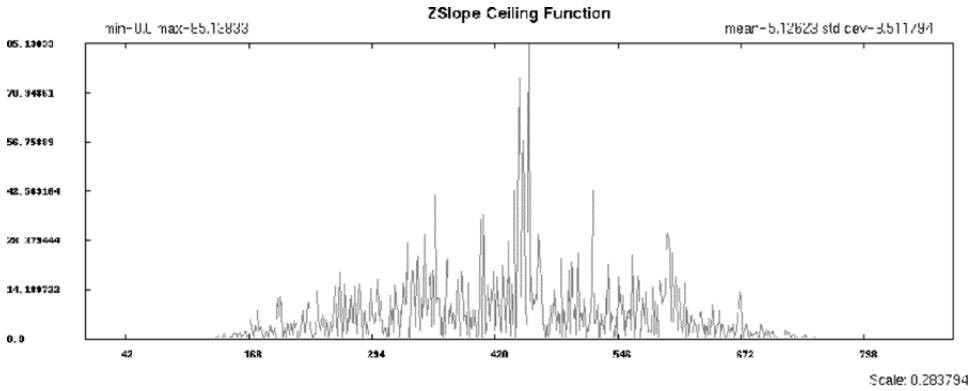


Figure 2-80 Z-Slope Cal / Ceiling Function

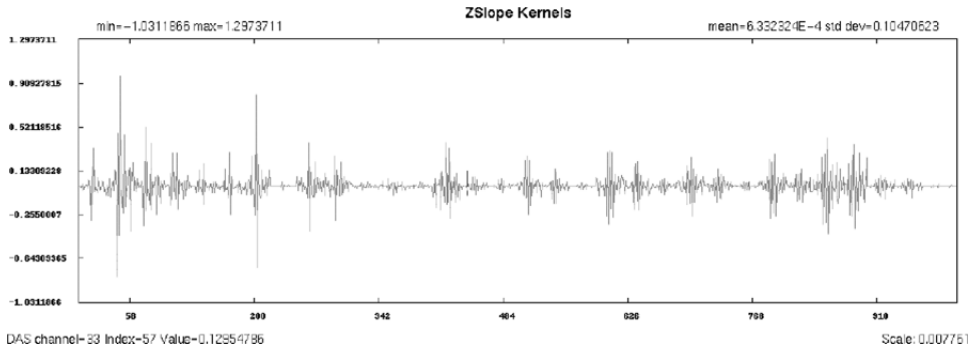


Figure 2-81 Z-Slope Cal / Z-Slope Kernels

3.5 DAS Tools

DASTool is both a tool and diagnostic used to test or exercise most or all functions of the **MDAS**, to verify the performance in both a manufacturing and field service environment. There are several sub-tests within DASTools that are specifically used during system install/integration, while other tests are used for diagnostic purposes. There is also a section called “viewers,” which allows the user to view the **DAS** architecture relative to **DAS** to Detector channel mapping, View error log, and view the test specification limits for each test.

Figure 2-82 Main DASTools Menu

Figure 2-82 shows the top level menu for DASTools. Access is through a Graphical User Interface (**GUI**) from the Service Desktop.

For most of the scanning in DASTools, **DDC** protocols are used, and the scan data is stored in standard scan data files that can be used for further review in Scan Analysis. During the scanning portion of the test, the exam, series, and scan number are displayed on the screen, as well as in the error log, if the analyzed scan data falls outside the expected values.

3.5.1 Auto Test / Manual Test

The difference between auto test and manual test is that the auto test feature runs a default number of iterations of each of the sub-tests, while the manual mode allows the user to specifically select a sub-test(s) and the number of iterations for that selection of test(s).

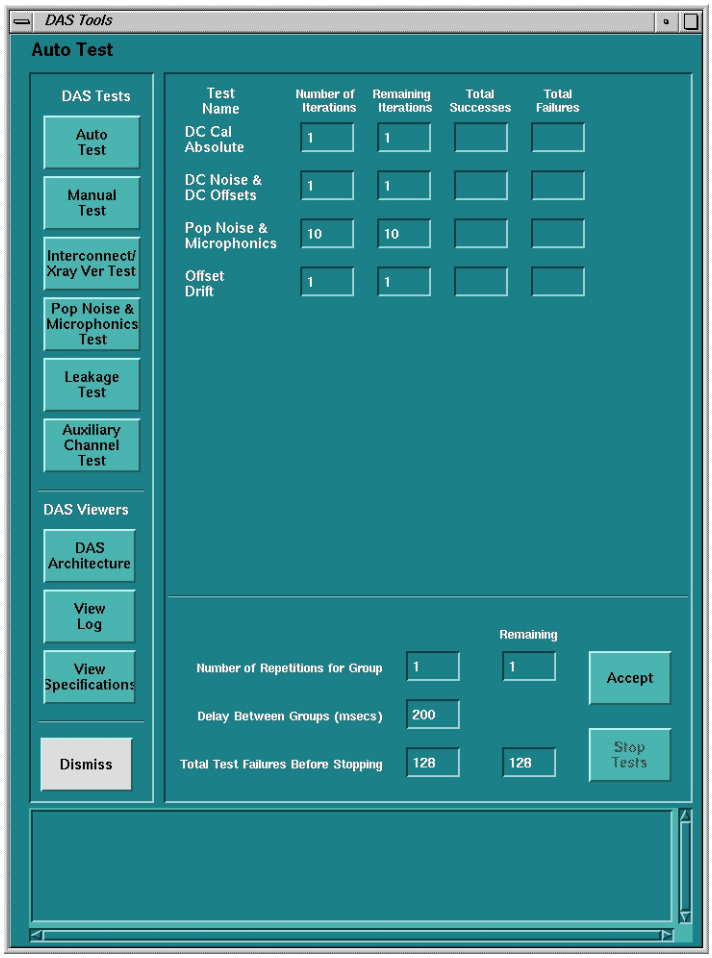


Figure 2-83 Auto Test / Manual Test

The following tests are executed during auto test:

1.) **DC CAL:** This test is performed to check the absolute linearity and absolute counts of the **DAS** using DC CAL modes using various levels, Pre-Amp gains, and **FPA** gains. There are 15 stationary **DAS** scans taken, without x-ray. Each scan is analyzed for its absolute means count. This count range is different for each scan dependent on the injected dc signal. Then the ratio of the highest count scan to each of the other scans are performed and are analyzed to a specific count range to determine the linearity of the FP amplifier.

- If DC Cal fails and the failing channels are all on one board, then most likely that particular board is suspected bad. The suggestion is to swap the board with a known good board and repeat the test.
- If the failing channels are random and occur across many boards, then the problem may be a **DAS** Control Board (**DCB**) fault, or more likely, noise getting into the **DAS**. To correct for noise, be sure that the **DAS** air plenum is securely in place and the fans are correctly mounted and orientated on the plenum. Also, check board seating, power supply noise, and cable seating on all **DAS** chassis.
- It is also possible that the diagnostic feature of this test may be bad on the board. The charging capacitors on the converter board used to input the correct diagnostic signal into

the front-end of the converter board may go bad. In this case, even if the diagnostic fails, there would be no adverse effect during patient or **DDC** scanning.

SCAN #	DAS GAIN	PROTOCOL	DESCRIPTION
1	31	DCCAL 0	Used for Offset correction on all Gain 31 scans
2	31	DCCAL 8	Tests **FPA** = 1
3	31	DCCAL 1	Tests **FPA** = 1
4	31	DCCAL 2	Tests **FPA** =8
5	31	DCCAL 3	Tests **FPA** =8
6	31	DCCAL 4	Tests **FPA** =32
7	31	DCCAL 5	Tests **FPA** =32
8	31	DCCAL 6	Tests **FPA** =128
9	31	DCCAL 7	Tests **FPA** =128
10	16	DCCAL 0	Used for Offset correction on Gain 16 Scan
11	16	DCCAL 1	Tests Pre-amp Gain capacitor
12	15	DCCAL 0	Used for Offset correction on Gain 15 Scan
13	15	DCCAL 1	Tests Pre-amp Gain capacitor
14	3	DCCAL 0	Used for Offset correction on Gain 3 Scan
15	3	DCCAL 1	Tests Pre-amp Gain capacitor

Table 2-8 DC Cal Test

2.) **Offset Drift:** A series of data collection scans, over a course of 120 seconds, and the offset means values are analyzed to measure the amount of variance over 120 seconds of scanning. There are 3 scans taken in a 4 x 5.00mm mode / Gain 31 and 3 scans in a 4 x 1.25mm mode / Gain 10 with a delay of 60 seconds between each scan. The absolute value of the Means are taken and compared.

There should be very little or no drift between the first scan of each scan mode and the scan taken 120 seconds later. The spec is ±3 counts for each channel across a 120 seconds time.

SCAN #	DAS GAIN	SCAN MODE	DESCRIPTION
1	31	4 x 5.00mm	Initial Offsets scan at specific technique
2	31	4 x 5.00mm	Offset scan after 60 second interscan
3	31	4 x 5.00mm	Offset scan after another 60 second interscan
4	10	4 x 1.25mm	Initial Offsets scan at specific technique
5	10	4 x 1.25mm	Offset scan after 60 second interscan
6	10	4 x 1.25mm	Offset scan after another 60 second interscan

Table 2-9 Offset Drift Test

Therefore, from Table 2-9 above, the difference in counts between scans 1 & 3 must be within 2 counts per channel and also the difference in counts between scans 4 & 6. Failure analysis of the drift test may be a bad converter board, but also considerations need to be taken on account of room temperature fluctuations and **DAS** warm-up time. It may be normal for this test to fail if it is executed immediately after turning on the **DAS**.

3.) **Pop/Noise & Microphonics:** A series of predefined rotating scans, w/o x-ray, and the scan data saved on disk for analysis. The scan data is then view averaged and the standard deviations are measured against a spec limit.

This test takes a series of three scans. In the auto-mode, it takes ten iterations of the series. Failure analysis of this test is dependent on test results. Pop/Noise and microphonics issues can be caused by many system related conditions. Some of the most common could be the **DAS**/Detector interface (such as elastomer connection caused by dirt, oil, debris), flex top cover clamp torque incorrect, air plenum not installed, fan orientation not correct, power supply noise, electrical connections, gantry rotation/mechanical issues, and external influences.

It is very important to look at patterns relative to **DAS**/Detector architecture, gantry rotation (azimuth position as well as velocity), and high voltage (with or without x-ray, rotor on/off).

Scan #	Gantry Rotation	X-Ray	Rotor	Acquisition Mode	DAS Gain	Scan Time/ VPS	Scan Data Saved
1	Rotating	No X-Ray	On	4 X 5.00	31	1 / 984	Raw
2	Rotating	No X-Ray	On	4 X 1.25	5	1 / 984	Raw
3	Rotating	No X-Ray	On	4 X 1.25	5	0.5 / 1640	Raw

Table 2-10 Microphonic Noise Scans

Scan #	Acquisition Mode	DAS Gain	Channel Zones / Maximum DAS Counts Spec Limits				
			1 - 64 705 - 750	65 - 224 561 - 704	225 - 560	751 - 762	763 - 768
1	4 X 5.00	31	18.0	13.0	10.0	22.0	16.0
2	4 X 1.25	5	51.0	35.0	27.0	61.0	51.0
3	4 X 1.25	5	51.0	35.0	27.0	61.0	51.0

Table 2-11 Microphonic Noise Spec Limits

4.) **Offset & Noise:** This test collects **DAS** data with zero input current (no x-ray) and the mean value of each output channel is compared to spec. Also, the standard deviation is measured against a noise spec. It involves two scans, the first in a 4 x 5.00mm mode, gain of 31 and the other in a 4 x 1.25mm mode, gain 5.

Failure analysis is similar to that of DC Cal, with the exception that there is no input test voltage applied. Depending on failed pattern, based on **DAS**/Detector architecture, the fault may be a converter board, **DAS**/Detector interface, or power supply.

Scan #	Gantry Rotation	X-Ray	Rotor	Acquisition Mode	DAS Gain	Scan Time/ VPS	Scan Data Saved
1	Stationary 0° Deg.	No X-Ray	Off	4 X 5.00	31	1 / 984	Raw
2	Stationary 0° Deg.	No X-Ray	Off	8 X 1.25	5	1 / 984	Raw

Table 2-12 Offset and Noise Scans

Scan #	Acquisition Mode	DAS Gain	Channel Zones / Maximum DAS Counts Spec Limits			
			1 - 64 705 - 750	65 - 704	751 - 762	763 - 768
1	4 X 5.00	31	2280 ±500	2280 ±500	2280 ±500	2280 ±500
2	8 X 1.25	5	2280 ±500	2280 ±500	2280 ±500	2280 ±500

Table 2-13 Offset value - Analyze “Means - Raw”

Scan #	Acquisition Mode	DAS Gain	Channel Zones / Maximum DAS Counts Spec Limits			
			1 - 100 705 - 750	101 - 704	751 - 762	763 - 768
1	4 X 5.00	31	9.5	8.5	12.0	8.5
2	4 X 1.25	5	28.0	23.0	32.0	28.0

Table 2-14 Noise value - Analyze "Standard Deviations - Raw"

3.5.2 Interconnect/X-Ray Verif Test

Both "Interconnect" and "X-Ray Verification" tests are performed (Figure 2-84). Eleven (11) scans are performed. Scans 4x1.25, CAL0, CAL1, CAL2, CAL3, CAL4, CAL5, CAL6 and CAL7 are used for the Interconnect test. Scans 4x5.00, 4x3.75, 4x2.50 and 4x1.25 are used for the X-Ray Verification tests.

Slice Thickness	DAS Gain	X-Ray	Filter	Focal Spot	Scan Time	Gantry Rotation
4 x 5.00	31	120KV/40mA	Air	Small	1 Sec. 984 views	Stationary, 0°
4 x 3.75	29	120KV/40mA	Air	Small	1 Sec. 984 views	Stationary, 0°
4 x 2.50	9	120KV/40mA	Air	Small	1 Sec. 984 views	Stationary, 0°
4 x 1.25	5	120KV/40mA	Air	Small	1 Sec. 984 views	Stationary, 0°
CAL1	5	120KV/40mA	Air	Small	1 Sec. 984 views	Stationary, 0°
CAL2	5	120KV/40mA	Air	Small	1 Sec. 984 views	Stationary, 0°
CAL3	5	120KV/40mA	Air	Small	1 Sec. 984 views	Stationary, 0°
CAL4	5	120KV/40mA	Air	Small	1 Sec. 984 views	Stationary, 0°
CAL5	5	120KV/40mA	Air	Small	1 Sec. 984 views	Stationary, 0°
CAL6	5	120KV/40mA	Air	Small	1 Sec. 984 views	Stationary, 0°
CAL7	5	120KV/40mA	Air	Small		Stationary, 0°

Table 2-15

3.5.2.1 Interconnect Test

The Interconnect Test is an automatic data collection mode to logically sequence through each switchable FET configuration, and the results compared to a known spec for each **DAS** channel. All the different FET configurations are defined with corresponding expected output values. The function of this diagnostic is to verify detector output across each row and combination of rows in respect to application slice modes. It will also help in determining if a detector is bad before removing it as a replacement.

This test will need to enable x-ray with a large aperture as to flood across all rows of the detector. Because of x-ray and optional rotation, the initiating of x-ray or mechanical movement cannot be started by InSite. The scan parameters are defined for each scan using a **DDC** protocol. There are 11 various modes across both Side A and Side B of the detector:

The output from each "scan" will be compared to each other for relative equal outputs (with some margin for cell output differences). The comparison will be each cell output for each channel to determine if a cell has no output (FET did not select) or more than expected output (FET combined more cells together than requested).

The means are to be processed and compared to specification for each row of each slice. The data is processed OFFSET CORRECTED and compared to spec for channel-to-channel spec as well as channel means. The table below indicates 8 of the 11 scans and the rows used during scanning and analysis, for the interconnect test.

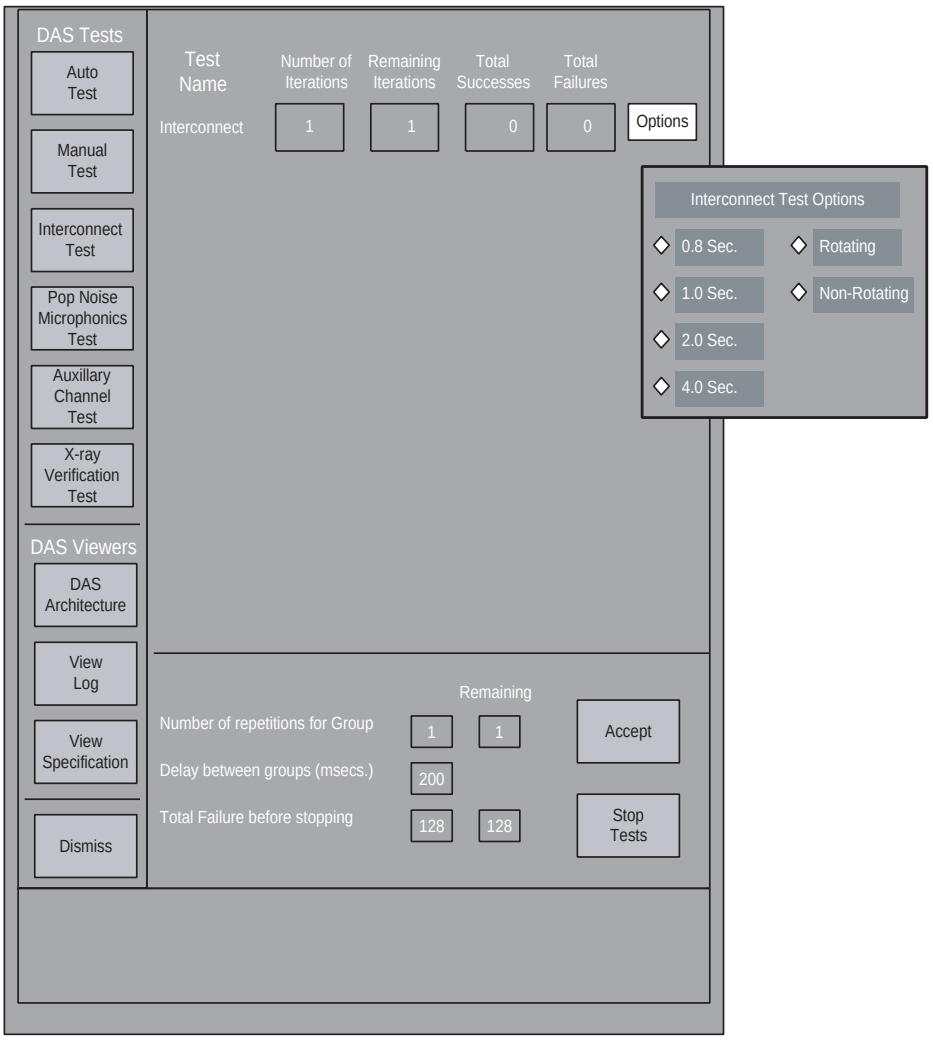


Figure 2-84 Interconnect/X-Ray Verification Test

- If failed channel follows same channel number and same row for two or more scan modes, then the error is reported, Exam/series/scan/channel/Row/Board # Housing #/Elastomer #. Suggested possible problem areas could be converter board or flex-backplane interface. Suggest swapping converter boards and re-running the test to confirm if problem follows board.
- If failed channel between two adjacent scan modes stays on the same channel, but changes rows, error is reported as a failure with Exam/series/scan/channel/Row/Board # Housing #/ Elastomer #. For single channel failure, suggested possible problem is possible detector channel FET is bad. For 32 channel pattern (same side and both rows), then possible cause is module FET set-up, check flex connection on that specific housing, elastomer. For chassis boundaries or just channels 763-768, check cabling, and **DCB** FET control lines.

Side	MODE Diode	Cal 0 (4 X 1.25)	Cal 1	Cal 2	Cal 3	Cal 4	Cal 5	Cal 6	Cal 7
B	D8							Row 2B	Row 1B
B	D7						Row 2B	Row 1B	
B	D6					Row 2B	Row 1B		
B	D5				Row 2B	Row 1B			
B	D4			Row 2B	Row 1B				
B	D3		Row 2B	Row 1B					
B	D2	Row 2B	Row 1B						
B	D1	Row 1B							Row 2B
A	D1	Row 1A							Row 2A
A	D2	Row 2A	Row 1A						
A	D3		Row 2A	Row 1A					
A	D4			Row 2A	Row 1A				
A	D5				Row 2A	Row 1A			
A	D6					Row 2A	Row 1A		
A	D7						Row 2A	Row 1A	
A	D8							Row 2A	Row 1A

Table 2-16 Interconnect Test

3.5.2.2 X-Ray Verification Test

The X-Ray Verification test evaluates the offset correct mean counts of 4x5.00, 4x3.75, 8x2.50 and 8x1.25 scans to their spec limits. If the test fails, it will report the exam, series, and scan number, along with the failing channel and row number. The scan data can also be plotted using scan analysis, to visually see the data.

Analysis of the means count is offset corrected as shown in the table below.

Slice Thickness	DAS Gain	Channel Zone 1 - 64, 705 - 750 (see note)	Channel Zone 65 - 704 (see note)	Channel Zone 751 - 762 (see note)	Channel Zone 763 - 768 (see note)
4 x 5.00	31	161K - 418.6K	83K - 215.8K	236K - 613.6K	375K - 975K
4 x 3.75	29	127.5K - 331.5K	67K - 174.2K	189K - 491.4K	412.5K - 107.25K
8 x 2.50	9	291K - 756.6K	149K - 387.4K	417.5K - 108.55K	137.5K - 357.5K
8 x 1.25	5	261K - 678.6K	136K - 353.6K	380K - 988K	252K - 655.2K
Note: Channel/Channel Variation from Mean = +20%, -40%					

Table 2-17 Analysis of Means Count

3.5.2.3 X-Ray Verification Scan - 4 x 5.00 Mode

Technique: Air Scan / 120KV / 40mA / 4 x 5.00 / 1 sec Rotating/Air Filter / Small Spot / **DAS** Gain 31

Note: This plot and specs are the same for all four rows when all four rows are connected from the detector to the **DAS**.

Data is plotted "Offset Corrected".

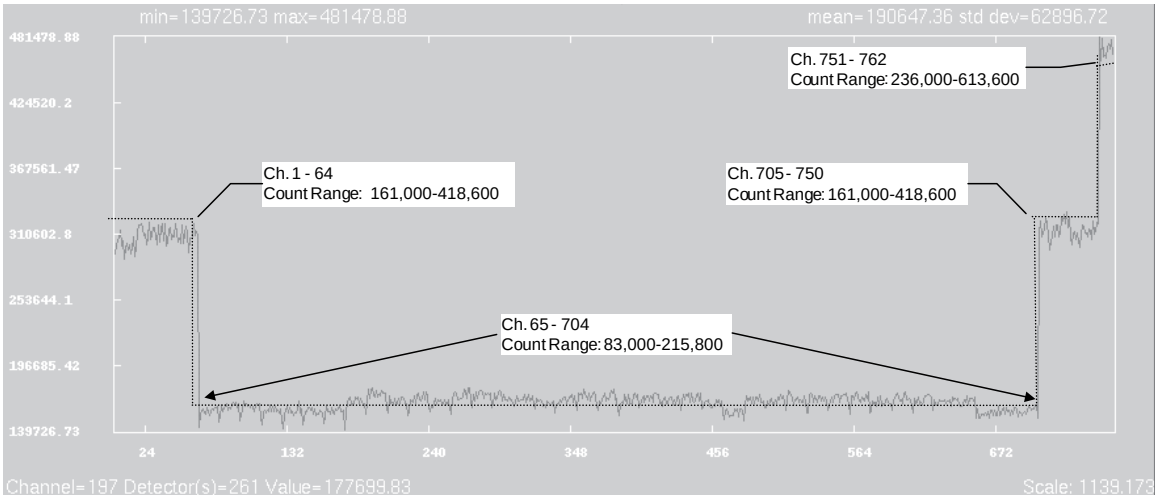


Figure 2-85 4 x 5 Spec. Limits (Means Example)

3.5.2.4 X-Ray Verification Scans - 4x5 Mode "A" Side Disconnected

*Mean plot with 'A' side of the detector physically disconnected from **DAS**.*

Technique: Air Scan / 120KV / 40mA / 4 x 5.00 / 1 sec Rotating Air Filter / Small Spot / **DAS** Gain 31

Note: This plot displays Row 1B when performing x-ray verification on the 'B'- side of the detector only with the 'A'- side flexes disconnected from the **DAS**. The sinusoidal wave pattern of the means counts is due to the capacitive charging/discharging of the unterminated 'A'- side detector diodes bleeding over to Row 1B. This is a normal plot in this detector/**DAS** configuration. Data from the disconnected 'A'- side is not specified, due to unknown results from open inputs to the **DAS**.

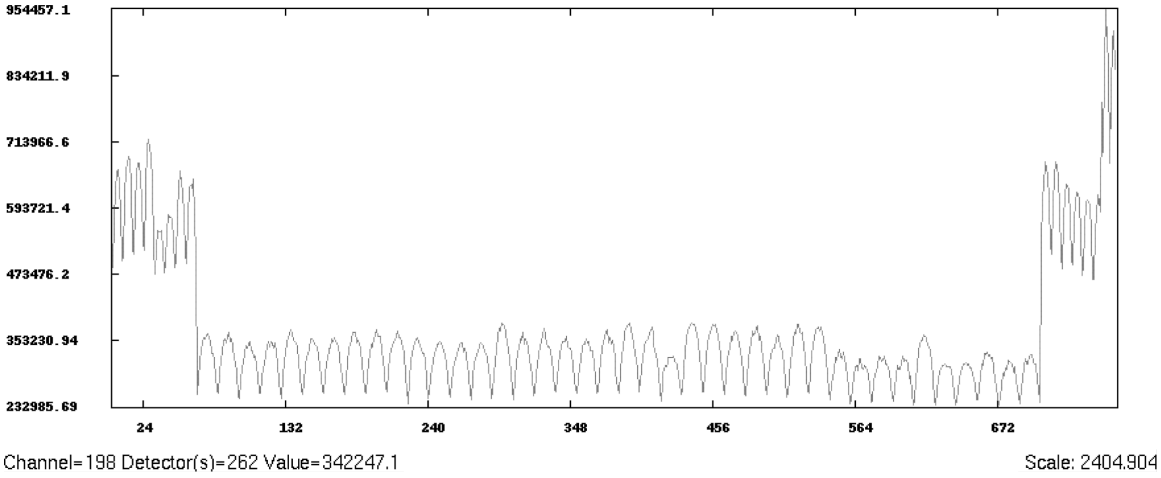


Figure 2-86 "A" side Disconnected (Means Example)

3.5.2.5 X- Ray Verification Scan - 4x1.25 Mode

Technique: Air Scan / 120KV / 40mA / 4 x 1.25 / 1 sec Rotating Air Filter / Small Spot / **DAS** Gain 5

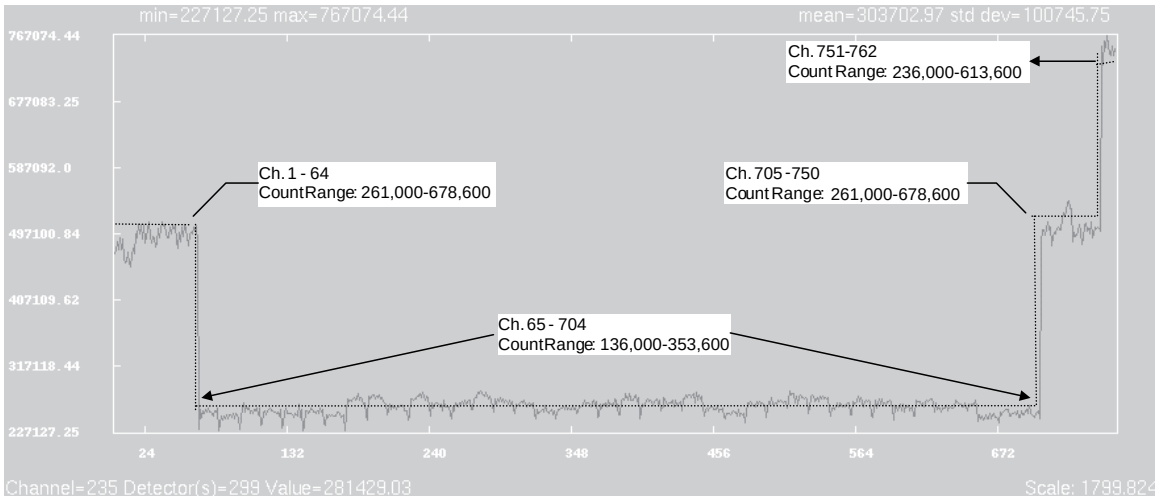


Figure 2-87 4 x 1.25 Spec. Limit (Means Example)

Note: This plot and specs are the same for all four rows when all four rows are connected from the detector to the **DAS**.

3.5.2.6 X-Ray Verification Examples

"Weak" Detector Module

Figure 2-88 shows an obvious count difference than what is expected. The channels correspond to detector module boundaries, and the detector was suspect of being bad. Do not replace the detector until further analysis has been completed.

A weak detector cell or module may or may not be a problem. The best way to determine if a detector cell or module is ok, take x-ray verification scans and analyze the channels in suspect, and compare them to the minimum and maximum expected counts range. As long as they are within the specifications, then the "weaker" cell or module is acceptable.

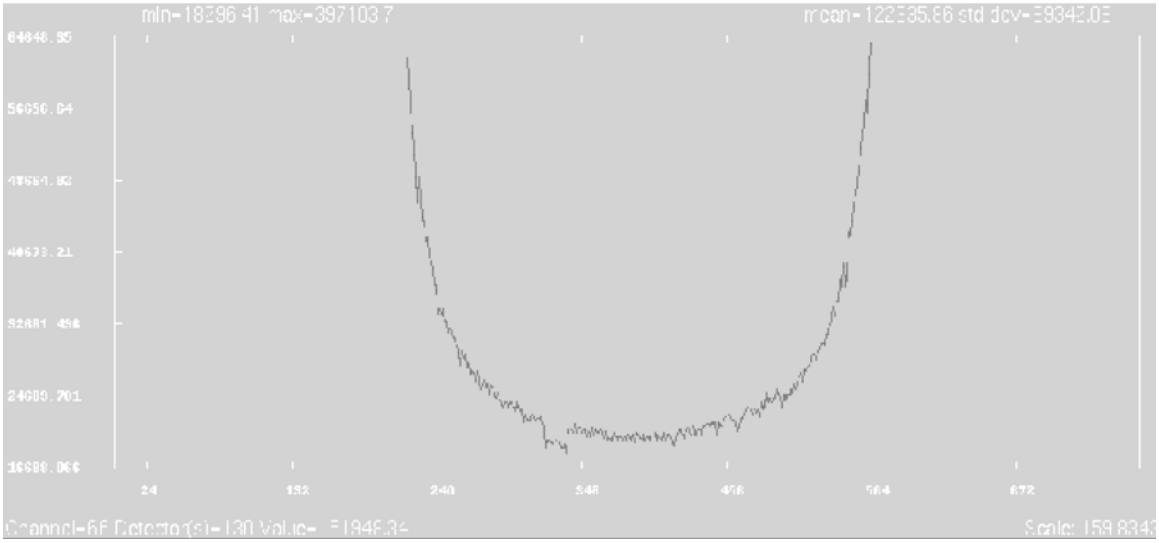


Figure 2-88 "Weak" Detector Module (Means Example)

Converter Board Pre-Amp Pattern

Figure 2-89 shows an offset means plot. The four-spike pattern is sometimes typical as a result of an individual pre-amp output either more or less than the other pre-amps on a converter board.

These spikes may or may not be normal. To check, evaluate the means counts of each spike. If the means count value is within the offset means specification, then the pre-amp (or converter board) is still good. If the means fails spec, swap boards with a known good board, verify spikes follow board, and then replace the converter board.

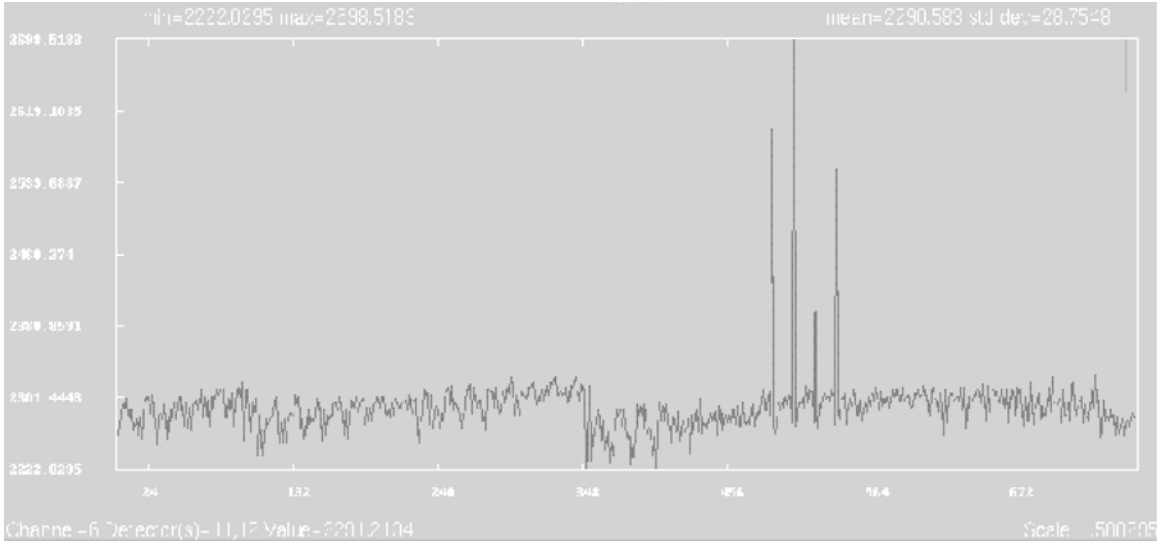


Figure 2-89 Converter Board Pre-Amp Pattern (MSD Plot showing 4 spike pattern)

3.5.3 Pop / Noise & Microphonics

A series of predefined rotating scans, w/o x-ray, and the scan data saved on disk for analysis. The scan data is then viewed averaged and the standard deviations are measured against a spec limit.

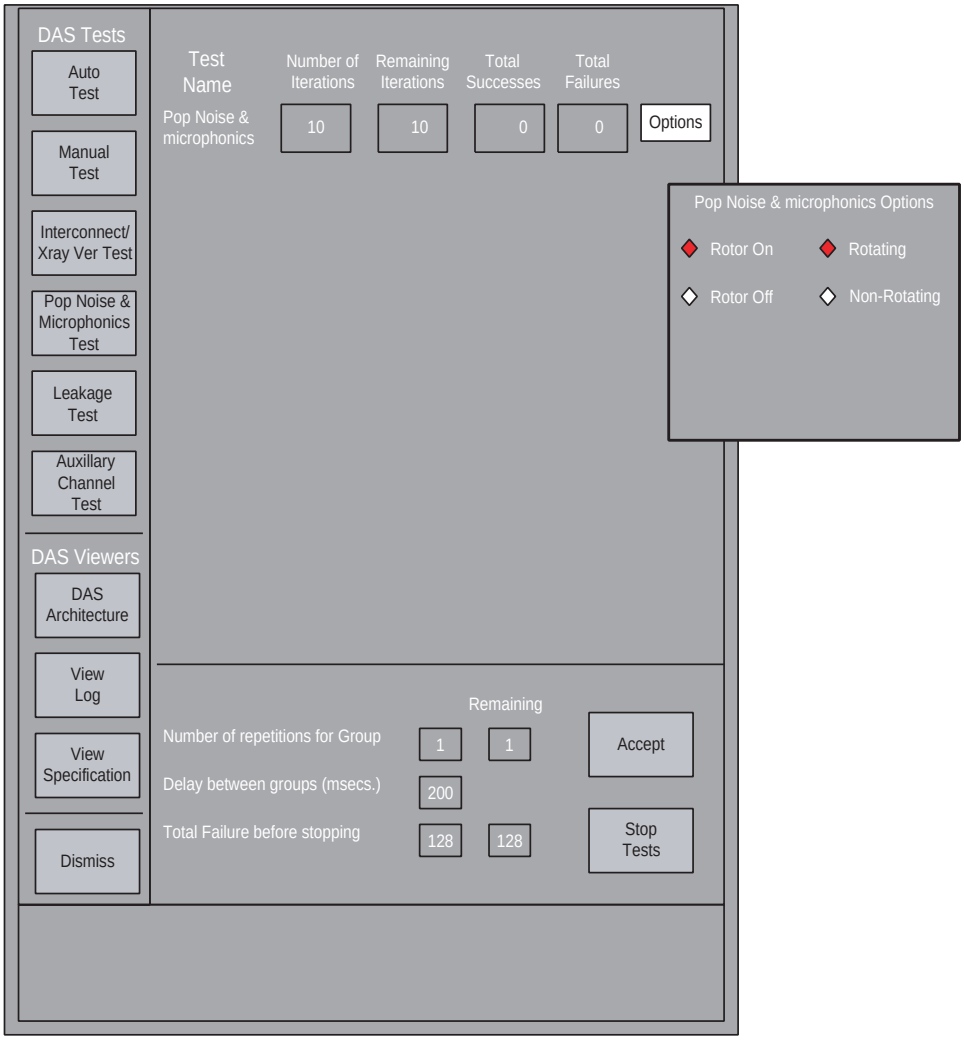


Figure 2-90 Pop Noise and Microphonics Test

This test takes a series of three scans. In the auto-mode, it takes ten iterations of the series. In the manual mode, the user has the ability to select the number of iterations as well as gantry speed and rotor selection. This helps in isolating microphonic problems caused by mechanical rotation issues, or rotor noise.

Failure analysis of this test is dependent on test results. Pop/Noise and microphonics issues can be caused by many system related conditions. Some of the most common could be the **DAS**/ Detector interface (such as elastomer connection caused by dirt, oil, debris), flex top cover clamp torque incorrect, air plenum not installed or fan orientation not correct, power supply noise, electrical connections, gantry rotation/mechanical issues, and external influences. It is very important to look at patterns relative to **DAS**/Detector architecture, gantry rotation (azimuth position as well as velocity), and high voltage (with or without x-ray, Rotor on/off).

3.5.4 Auxiliary Channel Test

The auxiliary channel test primary function is to query the **DCB** and report specific data, such as detector temperature, power supply voltage, converter board temperature, and KV/mA readings as a function of the **DCB**. With the exception of the KV/mA channel sub-test, this test uses basic

firmware routines to communicate and query the **DCB**. It does not use the Scan Acquisition process that **DDC** uses. The reason is that if the **DAS** fails power-up diagnostics, the error is reported to software and scanning is prevented, either in applications or Diagnostic Data Collection (**DDC**). This "tool" allows the user to query the **DCB** and read the supply voltages, or detector / converter board temperatures "real-time". The only exception is if the 5 vdc digital supply is so low as to not let the **DCB** function at all, or if the **DCB** cannot communicate with the **HEMRC** Controller board in the **OBC**.

THE DEFAULT

DASTools will collect data and only report the auxiliary channels to display:

CURRENT DETECTOR HEATER TEMPERATURE AND SPEC.

The detector temperature is measured by the **DCB** as is reported in one of the auxiliary channels. The reported value is in the format shown in Table 2-18.

EXPECTED	MEASURED	SPEC.	PASS/FAIL
36 deg		± 1.0	

Table 2-18 Detector Temperature Format

3.5.4.1 Power Supply Voltages

All **DAS** power supplies will be measured by the **DCB** circuitry and reported in the auxiliary channels in the form of voltages. The list of supplies are show in Table 2-19.

SUPPLY EXPECTED	MEASURED	SPEC.	PASS/FAIL
+5.0 VDC Digital		+4.75 - +5.25	
+5.0 VDC Analog		+4.75 - +5.25	
-5 VDC Analog		-4.75 - -5.25	
+12 VDC		+11.4 - +12.6	
-12 VDC		-11.4 - -12.6	
+12 VDC CAN		+11.4 - +12.6	

Table 2-19 Power Supply Voltages

3.5.4.2 DAS Converter Board Temperature

The normal operating temperature range of the **MDAS** is between 25° - 40° Celsius. If the temperature reaches 55° C, then a warning error message will be posted to the Status Area of the ExamRx Desktop and associated error message in the error log. If the temperature reaches 62° C, then the **MDAS** will report an over-temperature fault, and will prevent further scanning until the **DAS** cools and is reset.

DASTools shall query—real-time—the **DAS** converter board temperature, compare it to spec, and display test output as indicated below.

```
>>> Converter Board Temperature <<<
Converter Board 46 Temp: 27.5C Test Status:  PASSED (Expected: 26.0 to 62.0C).
Converter Board 47 Temp: 62.5C Test Status:    FAIL (Expected: 26.0 to 62.0C).
Converter Board 48 Temp: 27.5C Test Status:  PASSED (Expected: 26.0 to 62.0C).
```

3.5.4.3 KV / mA Channels

These auxiliary channels report the actual KV and mA signals as read from the generator (KV and mA control boards). Since this requires x-ray, this test will not be part of the auto-mode, but can be initiated in the manual test mode with operator intervention. The use of the Scan Enable push-button will be required to initiate x-ray. All x-ray safe guards will be in place, which would terminate x-ray in the event of a system failure, tube cooling limitations, or exposure time limitations.

The test shall take several scans at selected techniques, and the **DCB** measured KV and mA signals will be compared to the selected techniques, as well as to the system reported measured signals. If the **DCB** reported signals do not match the system reported output, then this test will fail with the following error message:

```
DCB board measured KV (or mA) differs than system measured KV (or mA) reading.
```

If the reading matches the system reported values, but is outside the system spec for selected technique, then the test should fail, but would indicate the **DCB** aux. channel is working correctly, but KV (or mA) is out of spec. Refer to **HV** set-up/Troubleshooting.

SCAN #	KV	mA	SCAN TIME	FILTER	SPOT	MODE
1	80	200	1 sec.	Blocked	Sml	Closed
2	100	100	1 sec.	Blocked	Sml	Closed
3	120	40	1 sec.	Blocked	Sml	Closed
4	140	20	1 sec.	Blocked	Sml	Closed

Table 2-20 kV / mA Channel Readings Test

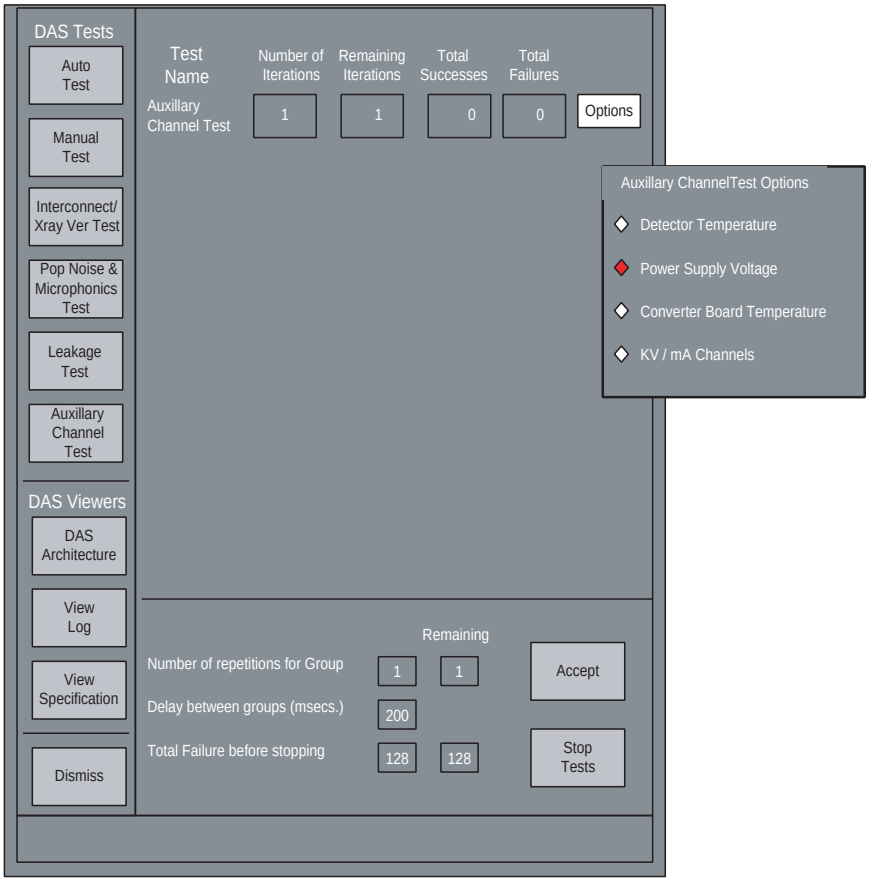


Figure 2-91 Auxiliary Channel Test

3.5.5 X-Ray Verification Test

The X-RAY VERIFICATION TEST button is no longer used, and will be changed to LEAKAGE TEST in a later release. The X-Ray Verification test is done along with the Interconnect test, when INTERCONNECT/X-RAY VERIF is selected (see "Interconnect/X-Ray Verif Test," on page 121).

3.6 X-Ray Generation Tools

Refer to Chapter 8 for: "X-Ray Tube Heat Soak and Seasoning," on page 769.

X-RAY GENERATION DIAGNOSTICS OVERVIEW

Purpose: To describe available tools for isolating problems in the **HV** subsystem.

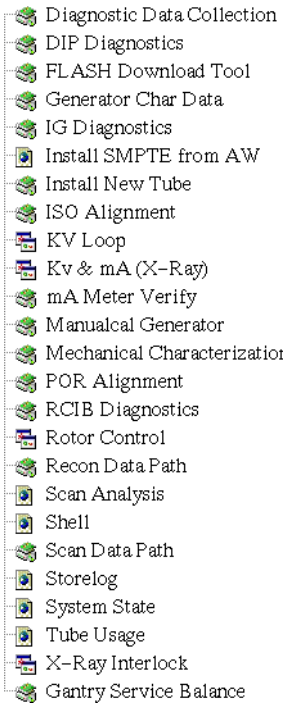


Figure 2-92 Diagnostics List

It starts at the Service Desktop Manager with the selection of DIAGNOSTICS. From there, KV, mA, Generator cal, X-Ray tests can be selected.

3.6.1 FLASH Download

The FLASH Download tool is accessed by selecting SERVICE DESKTOP -> DIAGNOSTICS -> FLASH DOWNLOAD TOOL.

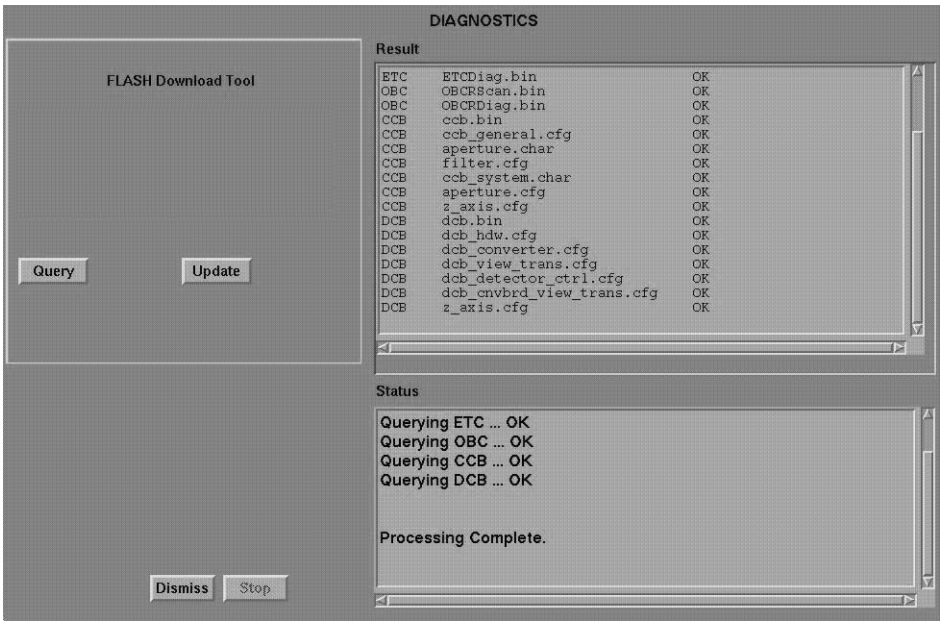


Figure 2-93 Flash Download GUI

Diagnostic Description

This utility loads the FLASH located on the **CCB**, **DCB**, **OBC**, **STC**, and **ETC** with the files stored on the system disk. This allows the nodes to initialize quickly after a reset is performed. This utility can also be used to check the nodes for the correct file versions without forcing a download.

When (to use)

1.) This tool must be used once after upgrading software or replacing the **CCB**, **DCB**, **STC**, **ETC** or **OBC**.

2.) Run tool if an attention window is brought up or an error message is logged indicating a file version mismatch was found.

What (to look for)

Verify that all files are downloaded without errors.

Notes

1.) The **OBC** must be downloaded to FLASH the **CCB** or **DCB**.

2.) Mismatches of files stored on the system disk and FLASH will prohibit scanning.

3.) Artesyn 1 boards must have both jumpers installed (20MHz).

4.) The "aperture.char" file is unique for each collimator. The numeric part of the serial number must be entered for this file to determine if an upload or download is required.

3.6.2 Collimator Functional Diagnostic Tests

The Collimator Functional Diagnostic tests are accessed from the Service Desktop by choosing Diagnostics. The “Collimator and Filtration” test selected has four sub-functional tests, which are described in the following sections.

3.6.2.1 Collimator Aperture Position Test

SERVICE DESKTOP -> DIAGNOSTICS -> COLLIMATOR AND FILTRATION TEST -> APPLICATION POSITION TEST

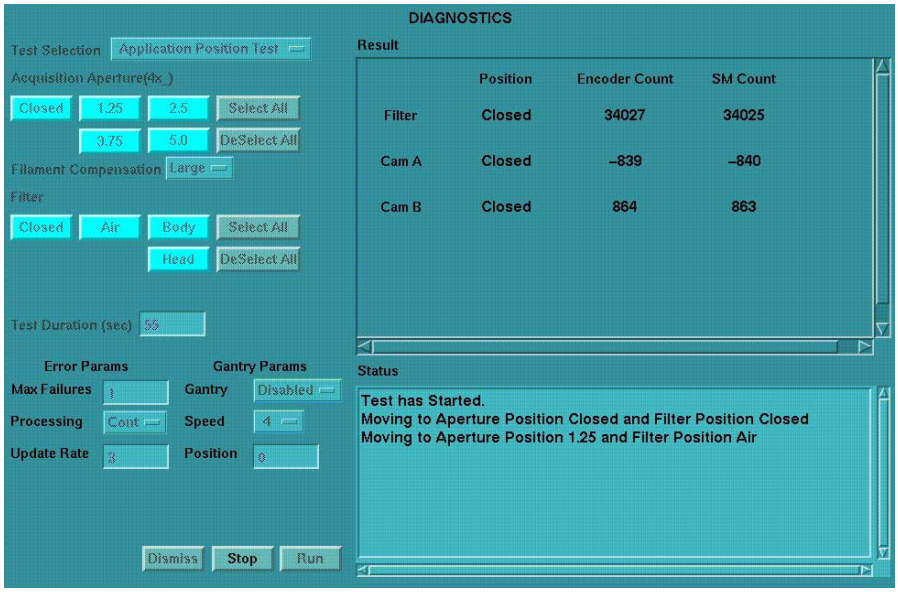


Figure 2-94 Collimator Application Test GUI

Diagnostic Description

This test continuously positions the collimator and filter to the selected position.

When (to use)

1.) Test runs in continuous modes, which help detect intermittent operating conditions.
2.) Means to visually validate the aperture and filter positions.
3.) Functional validation of the operation of the collimator.

What (to look for)

Look for highlighted fields that indicate the cam or filter did not make it to position. Check the log for additional information, when this occurs.

Notes

1.) Test can be run from application or diagnostic firmware download.
2.) Watch for finger pinch hazards.
3.) Attempt to move the filter and/or cams, when test is complete, and verify motor has a lot of holding torque.

3.6.2.2 Collimator Continuous Filter Position Test

SERVICE DESKTOP -> DIAGNOSTICS -> COLLIMATOR AND FILTRATION TEST -> CONTINUOUS FILTER POSITION TEST

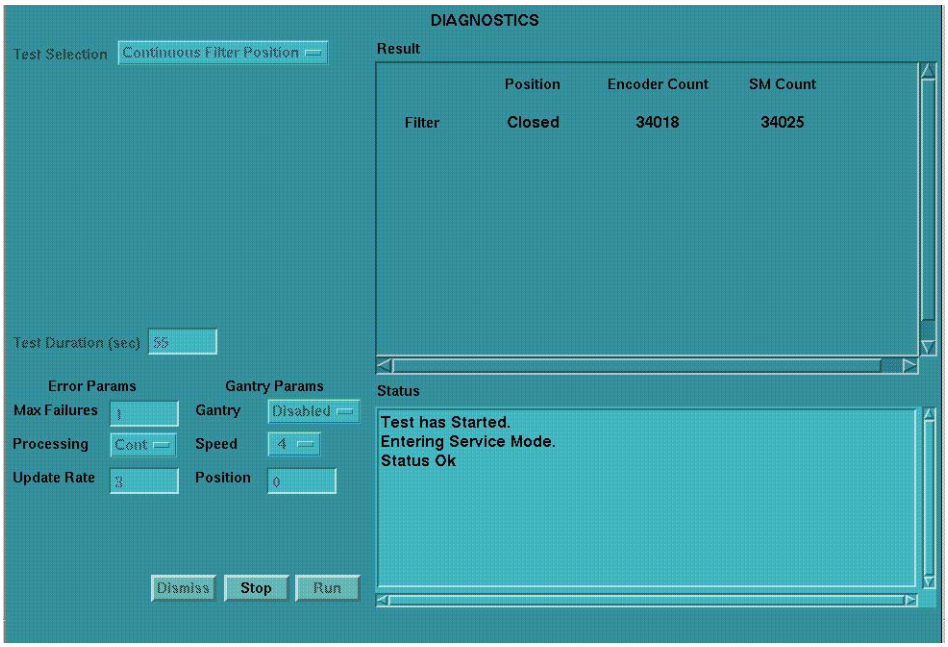


Figure 2-95 Collimator Continuous Filter Position Test GUI

Diagnostic Description

This test continuously moves the filter from one extreme to another.

When (to use)

1.) Verify no mechanical binding is present.
2.) Manual mode for signal tracing.
3.) Check for motion when errors indicate no motion sensed.

What (to look for)

If the display does not indicate changes in the encoder count, visually check the filter for motion:

1.) If filter is moving, failure is in the encode circuit.
2.) If filter is not moving, failure is in the drive circuit.

Notes

1.) Test can be run in the applications and diagnostic download.
2.) Watch for finger pinch hazards
3.) The filter drive can be divided into two functions:
   - Motor Drive (Positioning driver)
   - Encoder (Position feedback)

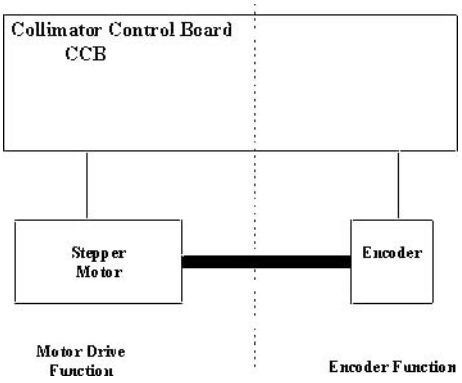


Figure 2-96 Collimator Filter Position

3.6.2.3 Collimator Continuous CAM Rotation Test

SERVICE DESKTOP -> DIAGNOSTICS ->COLLIMATOR AND FILTRATION -> CONTINUOUS CAM ROTATION TEST

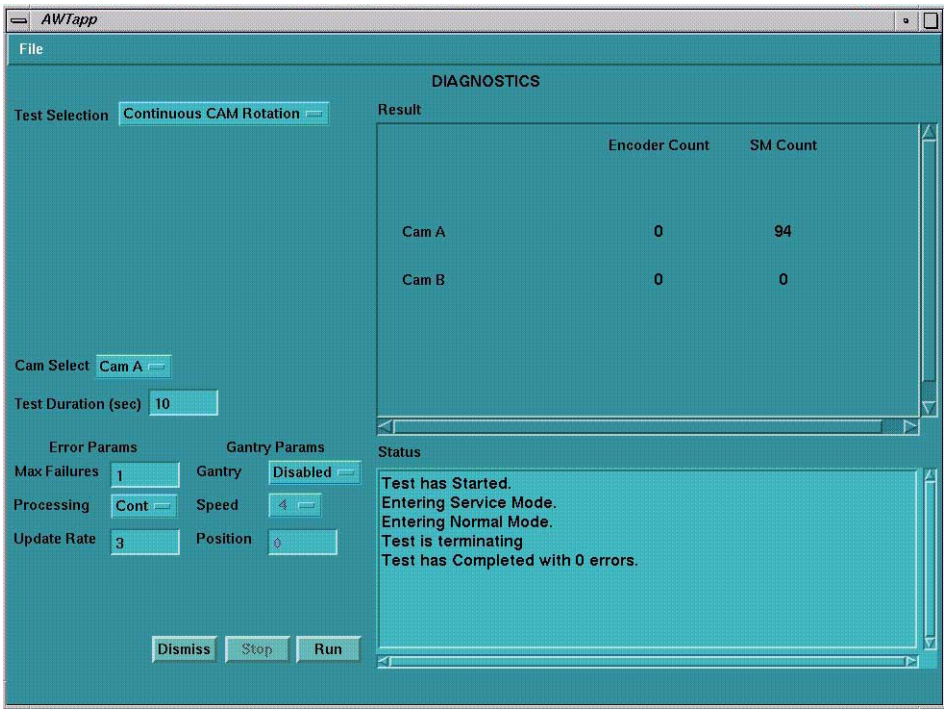


Figure 2-97 Collimator Continuous CAM Rotation Test

Diagnostic Description

This test continuously rotates the selected CAM.

When (to use)

1.) Verify no mechanical binding is present.
2.) Manual mode for signal tracing.

What (to look for)

1.) If the display does not indicate changes in the encoder count, visually check the cam for motion.

2.) Listen for mechanical vibration or binding.

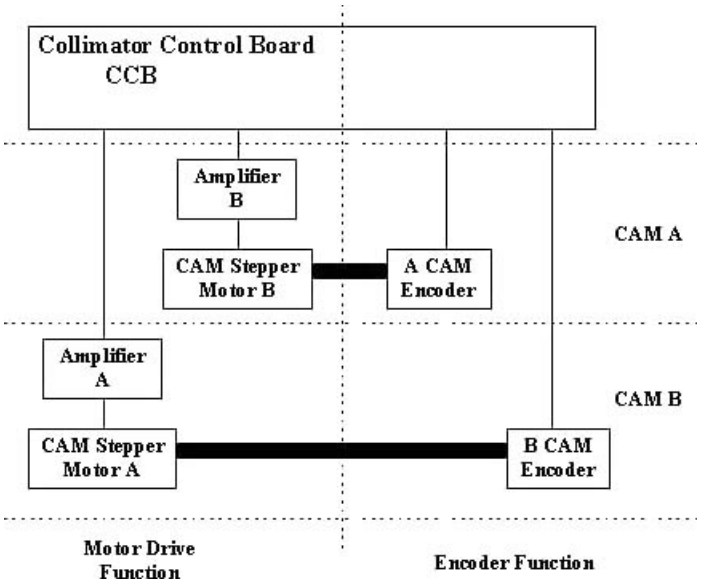


Figure 2-98 Collimator CAM Rotation

Notes

1.) Test can be run in the applications and diagnostic download.

2.) Watch for finger pinch hazards.

3.) CAM A and B circuitry is the same.

4.) CAM operation can be divided into four functions:

CAM	Function
A	Motor and Drive
A	Encoder
B	Motor and Drive
B	Encoder

3.6.2.4 Collimator Encoder Test

SERVICE DESKTOP -> DIAGNOSTICS -> COLLIMATOR AND FILTRATION -> COLLIMATOR ENCODER TEST

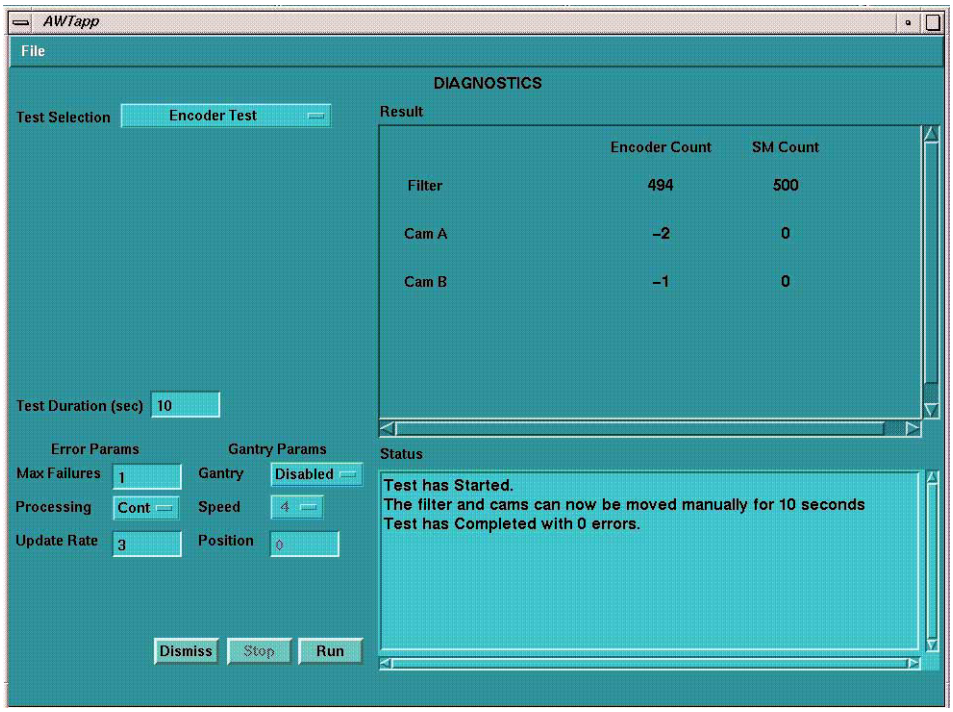


Figure 2-99 Collimator Encoder Test Screen

Diagnostic Description

Reads and displays the CAM and filter encoders while the devices are manually positioned.

When (to use)

Confirm an encoder problem with the collimator.

What (to look for)

Verify encoder reading changes once the cams or filters are moved. See below for relative encoder counts.

Notes

1.) Test can be run in the applications and diagnostic download.
2.) Watch for finger pinch hazards.
3.) Test reduces the cam holding torque to allow the cams to be rotated by hand.
4.) Cams are 2000 counts per rotation.
5.) Filter is 1000 counts per rotation.
6.) Cam encoder requires the whole collimator to be replaced.
7.) Filter encoder is a **FRU**.

3.6.3 Rotation Controller Interface Bus (RCIB) Functional Diagnostics

These diagnostics are accessed by launching Diagnostics from the Service Desktop.

3.6.3.1 Fault Line Diagnostic

SERVICE DESKTOP -> DIAGNOSTICS -> RCIB DIAGNOSTICS -> FAULT LINE

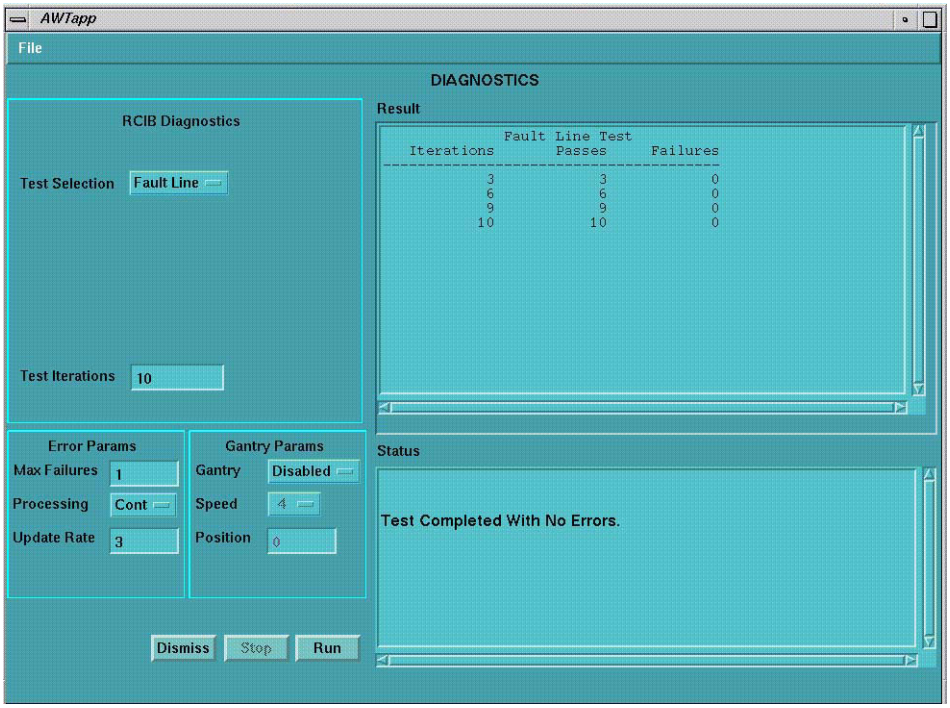


Figure 2-100 Fault Line Screen

Diagnostic Description

The Fault Line Diagnostic validates the parallel and serial fault line between the **OBC**, **DCB**, and **CCB**. Test consists of opening and closing the fault relays on each node and validating that all nodes see the fault.

When (to use)

1.) Run test to detect intermittent fault line failures.
2.) Run after fixing fault line problem to validate fix.

What (to look for)

1.) Look for any failures in the "Failures" column.
2.) Look for cable swap issues.

Notes

1.) Test can be run in the applications and diagnostic download.
2.) **OBC** must be downloaded for test to run.

3.) Test runs with diagnostic or application firmware downloads.

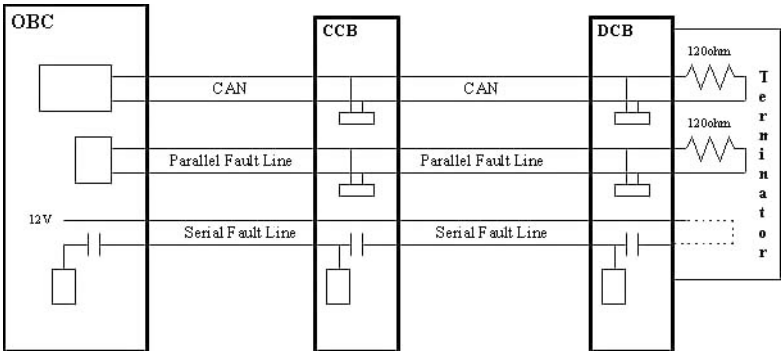


Figure 2-101 Fault Line

3.6.3.2 RCIB Ping Diagnostic

SERVICE DESKTOP -> DIAGNOSTICS -> RCIB DIAGNOSTICS -> PING

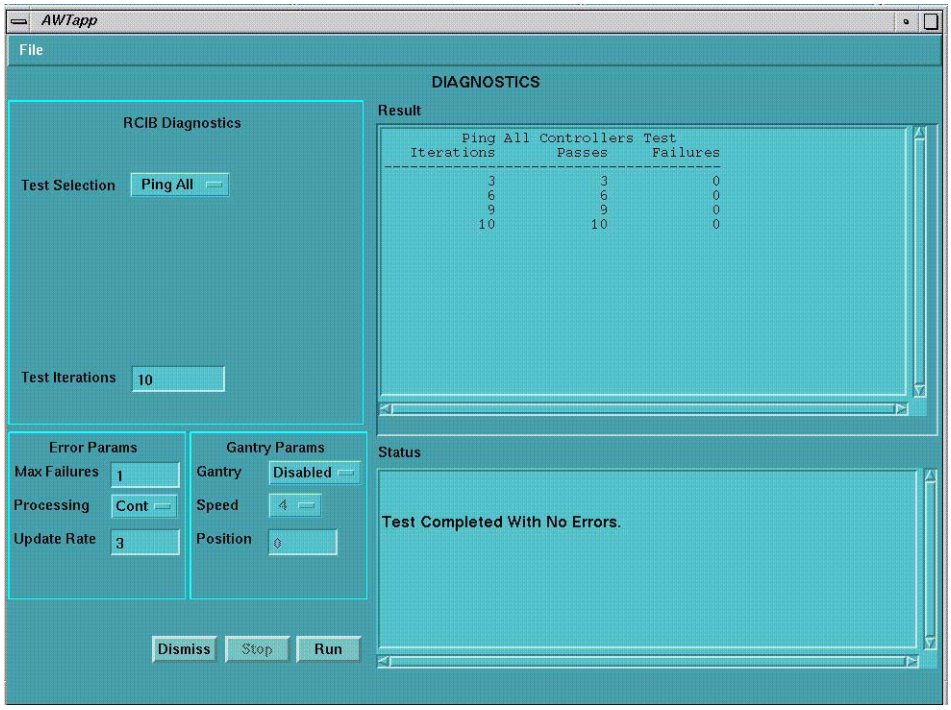


Figure 2-102 PING Screen

Diagnostic Description

The **RCIB** Ping Diagnostic sends small **CAN** packets to the selected nodes and verifies the correct response is received. This test works much the same way as a UNIX ping command.

When (to use)

1.) Run test to detect intermittent **CAN** serial line problems failures.
2.) Run after fixing **CAN** problem to validate fix.
3.) Test can be run to determine the status of the node.

What (to look for)

Look for any failures in the “Failures” column. Check error log for more information, if a problem is detected.

Notes

1.) **OBC** must be downloaded for test to run.
2.) Test can be run in the applications and diagnostic download.
3.) Test makes extensive use of slip-ring and ethernet communication lines.

3.6.4 X-Ray Functional Test

SERVICE DESKTOP -> DIAGNOSTICS -> KV & MA (X-RAY)

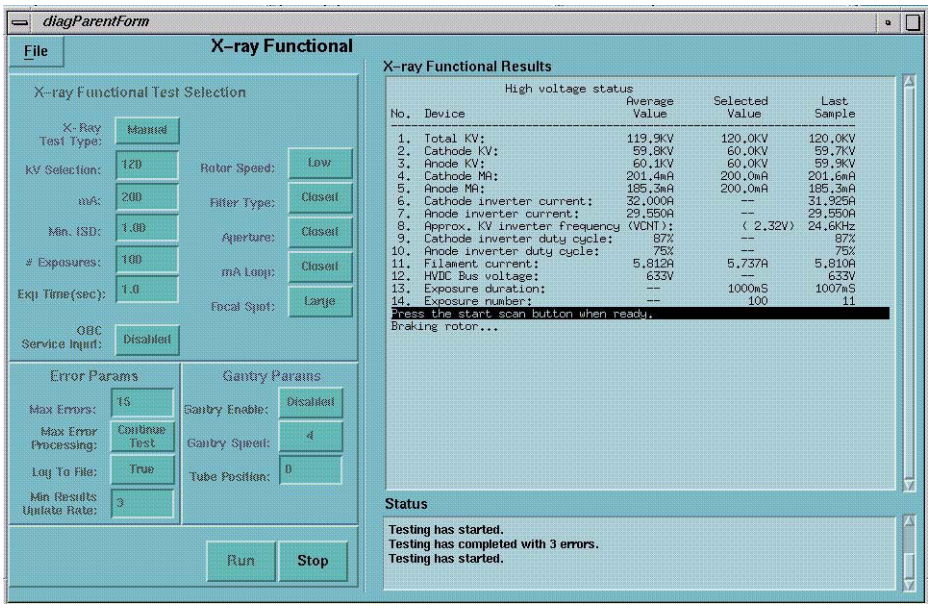


Figure 2-103 kV & mA X-ray Screen

Diagnostic Description

This diagnostic enables the collection of **HV** statistics during an x-ray exposure.

When (to use)

KV or mA errors are reported.

What (to look for)

1.) Symptom: KV out of tolerance (too low).

If one side has a low duty cycle while the other is high (25% or more difference), check the following:

a.) Check for bad light pipe: Run the fiber optic test and check the inverter with the high duty cycle for a missing trigger.

b.) Check that the IGBT connections are correct.

c.) Check for missing feedback cable in the main harness.

2.) The APPROXIMATE inverter current can be found in Figure 2-104.

3.) Verify the inverter frequency is approximately 19kHz if KV is low.
Replace the KV board if this value is closer to 30KHz

4.) See the next section for more information.

Notes

1.) There is a 180 sec. delay for **HEMRC** cooling between the start of this test to the start of another.

2.) Tube fans and pumps will remain on for 60 minutes after the test has completed.

3.) The Inverter operating frequency ranges from 19.5kHz (0.2V) to 31.5KHz (5V).

4.) Run the **HV** functional diagnostic test if over currents, shoot-through, or other types of shorts are reported.

5.) Cathode mA will always be higher than the anode mA for a Gemini tube (Metal casing). This is also true for the inverter currents.

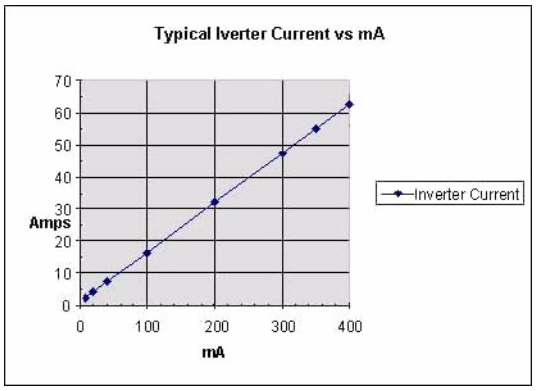


Figure 2-104 Inverter Current vs. mA

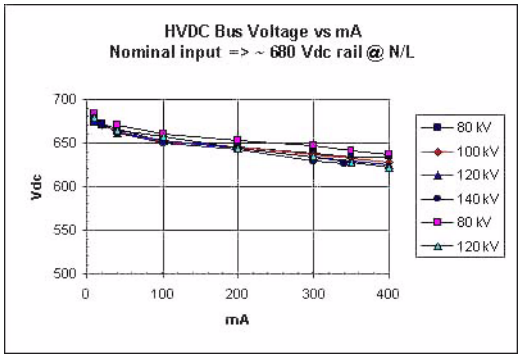


Figure 2-105 HVDC Bus Voltage vs. mA

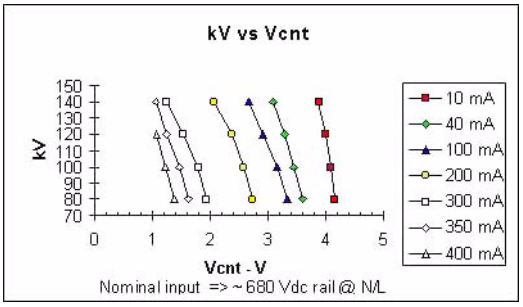


Figure 2-106 kV vs. Vent

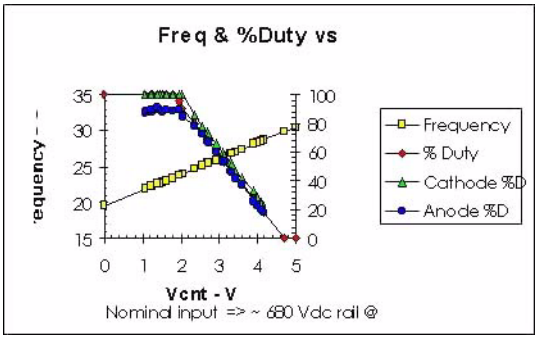


Figure 2-107 Freq and Percent (%) Duty vs. Vent

X-RAY TROUBLESHOOTING

The screen below illustrates an open IGBT. The problem was induced by pulling an anode light pipe. Note the low anode AND cathode KV values, and the high duty cycle value for the anode inverter. The anode and cathode KV's will track each other, which means the KV values reported will NOT indicate which node is failing. The key is the duty cycle. The anode is working much harder than the cathode, since one of the IGBTs is not being triggered. Also note the operating frequency. This is at the lowest value, indicating the KV control board is operating correctly to compensate for this problem.

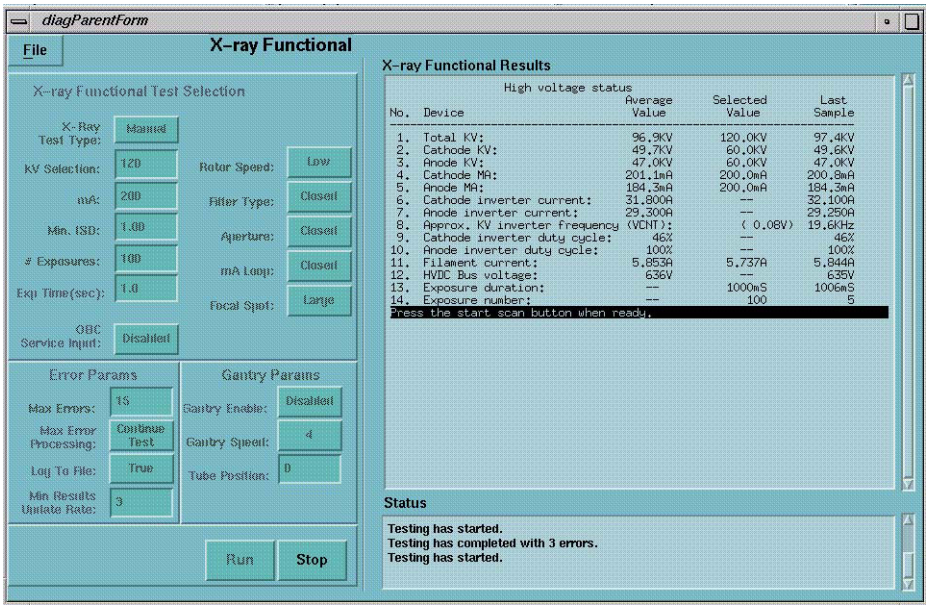


Figure 2-108 X-Ray Functional Screen

3.6.5 CAN Loop-Back Test

SERVICE DESKTOP -> DIAGNOSTICS -> ROTOR CONTROL -> CAN LOOPBACK

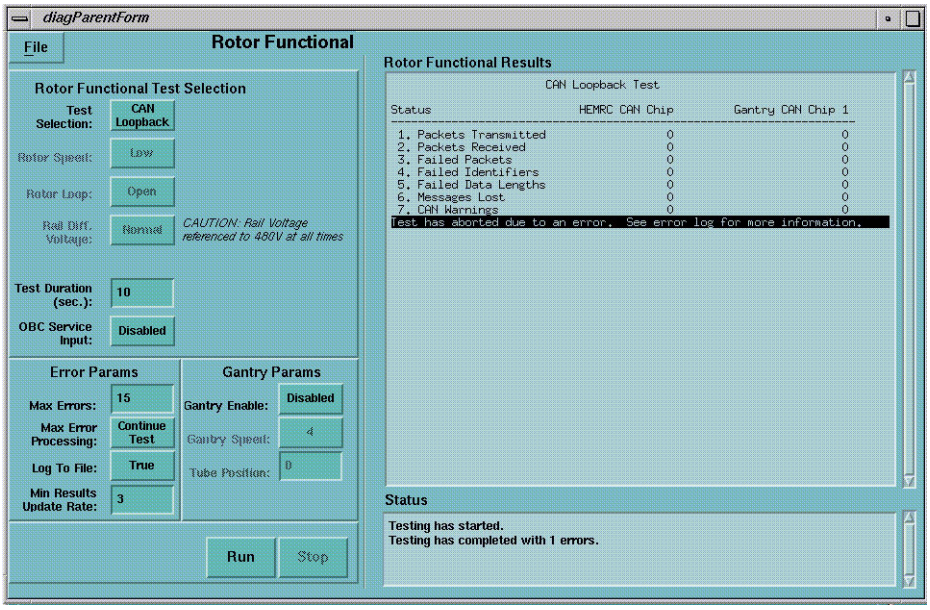


Figure 2-109 Rotor Functional Screen

Diagnostic Description

This diagnostic test loops back the **HCAN** serial line with the **GCAN** serial line. The purpose of this test is to validate the **HEMRC** Control Board **CAN** networks.

When (to use)

1.) Run test when **HCAN** communications errors are reported to the user.
2.) **HCAN** communications operate intermittently.

What (to look for)

Look for the number of failures detected. If the test passed with little or no errors, **HEMRC** control board is good. Check for bad connections, incorrect wiring, or failed **HEMRC** drive.

Notes

1.) **HCAN** communication errors are frequently due to a blown fuse on the **HEMRC** I/F board.
2.) Check the neon light on the back of the **HEMRC** drive for a power indication.
3.) The green HRX **LED** indicates the presence of **CAN** communications and 12V isolated power.
4.) **HCAN** drivers are powered by the **HEMRC** drive.
5.) Future software releases will indicate a 12V isolated power failure from a **HCAN** failure.
6.) Jumper on **HEMRC** control board must be moved to perform this test.
7.) **HEMRC** drive isolated power must be present for this test to pass.

3.6.6 Rotor Diagnostic

SERVICE DESKTOP -> DIAGNOSTICS -> ROTOR CONTROL

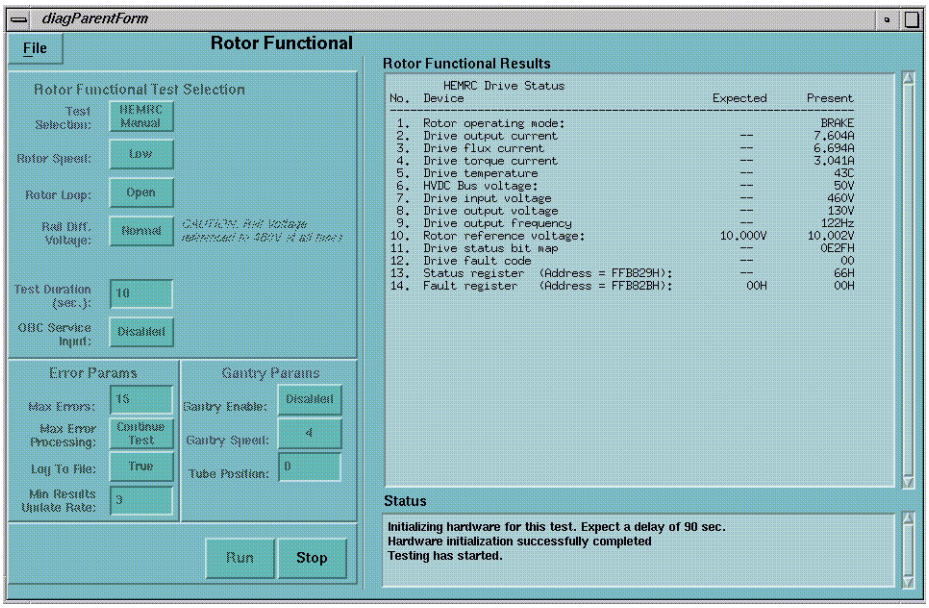


Figure 2-110 Rotor Functional Screen

Diagnostic Description

This diagnostic allows manual operation of the rotor while monitoring the operating parameters.

When (to use)

Run test after getting **HEMRC** operating errors. This does not include communication errors.

Notes

There is a 180 second delay from the start of this test to when the test can be restarted, due to a **HEMIT** heating issue.

3.6.7 kV Diagnostic

SERVICE DESKTOP -> DIAGNOSTICS -> KV LOOP -> HV MANUAL

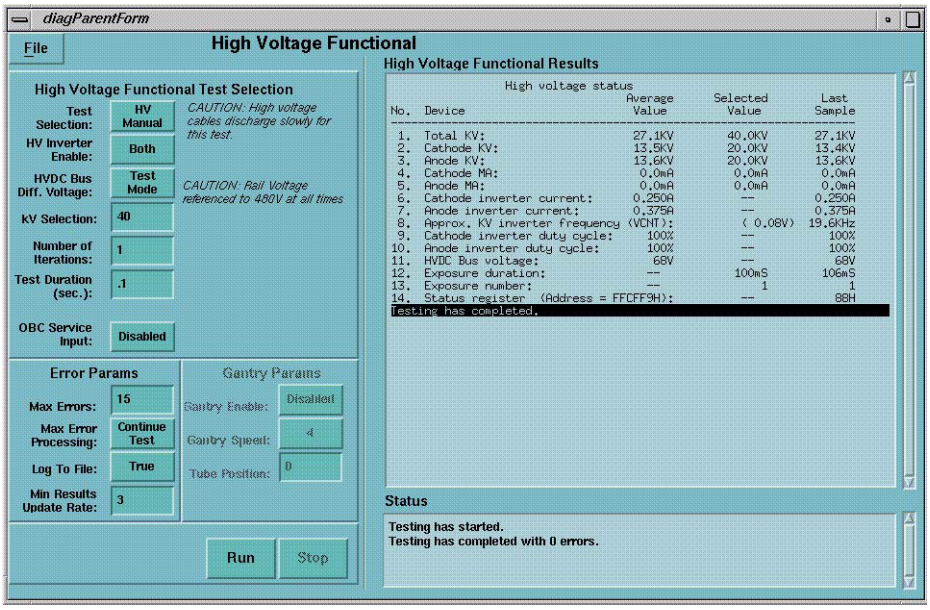


Figure 2-111 kV Diagnostic Screen

Diagnostic Description

This diagnostic operating the KV inverters without mA and at low input voltages. This test does NOT require the connection of the x-ray tube. However, if the tube is disconnected, the **HV** cables should be connected to a bleeder or disconnected at the **HV** tanks.

When (to use)

1.) This test should be run with the **HVDC** set to test mode (~75VDC) when the following errors are detected:
   - Over currents
   - Shoot-through
   - mA over currents.

2.) Run test when a shorted x-ray tube or **HV** cables are suspected.

What (to look for)

1.) Look for where the current stops with the **HVDC** set to the test mode:
   a.) Inverter currents should be less than 1 to 2 amps of current
   b.) mA should be less than 2mA

2.) High pot the tube (use bleeder) to remove the tube from the circuit and rerun the test.

Notes

1.) Use **HVDC** test mode (~75VDC) to check for shorts. KV will NOT reach the prescribed value in this mode.

2.) Normal rail voltage should only be used to test for dielectric breakdowns. Turn on one side (cathode/anode) at a time, since the bang-bang circuit was not designed for accurate KV loop control.

3.) High potting the tube is very dangerous if not done correctly, even with the **HVDC** bus set to test mode.

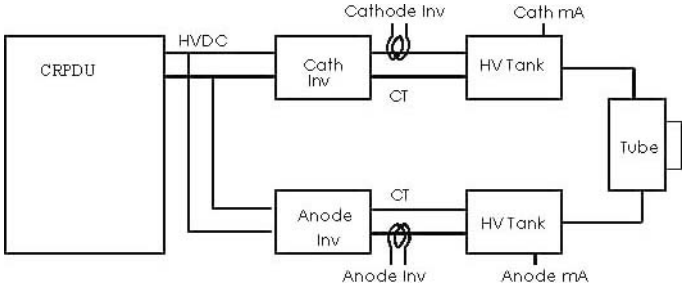


Figure 2-112 HVDC Test Setup

3.6.8 kV Fiber-Optic Test

SERVICE DESKTOP -> DIAGNOSTICS -> KV LOOP -> HV FIBER OPTICS

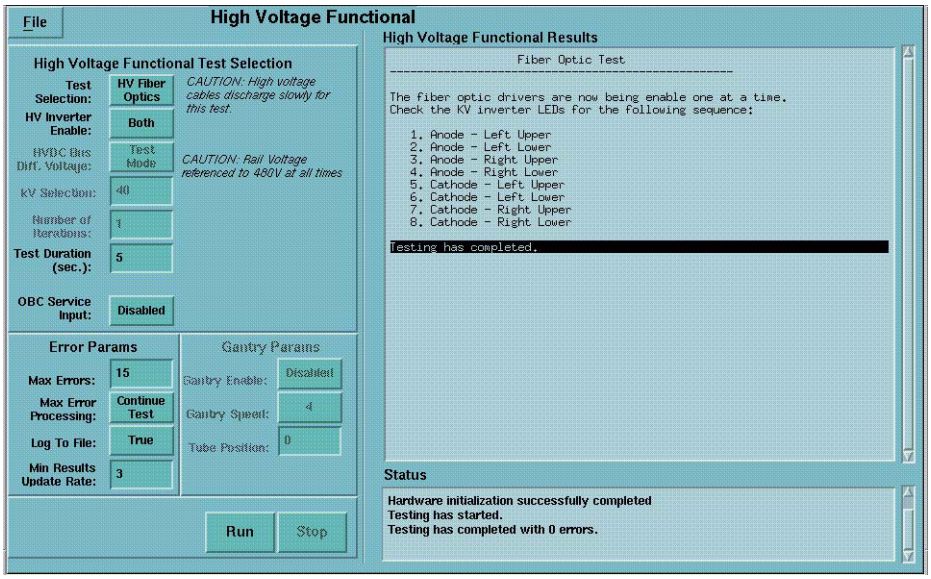


Figure 2-113 kV Fiber-Optic Screen

Diagnostic Description

This diagnostic sequentially enables the fiber optic drivers to the KV inverters.

When (to use)

1.) KV values drop as the mA increases.

2.) Suspect bad fiber-optic connection.

3.) Verification that all fiber optic connections are not miss wired.

What (to look for)

Verify **LED**s located on the KV inverters are enabled in the correct sequence.

3.6.9 Filament Diagnostic

Utilize Diagnostic Data Collection [**DDC**] to interactively select small and large filaments for troubleshooting. Errors will be captured in the system error log [gesyslog].

3.6.10 Additional Diagnostic Tests

3.6.10.1 Backup Contactor Test

Description: Test energizes the contactor for the prescribed amount of time + 2 seconds. The two second delay prevents the rail monitor from detecting false errors. Contactor operation and statuses are verified during test.

3.6.10.2 Backup Timer Test

Description: Test the exposure command, backup timer, and contactor interlock by setting the backup timer and allowing it to expire.

The following describes the order of events:

1.) The timer is downloaded with the selected test duration.
2.) Contactor is energized.
3.) The **STC** activates the exposure command.
4.) The exposure command is verified.
5.) Timer is allowed to expire.
6.) Backup contactor and timer are checked for the correct states.
7.) The test is repeated for both clock frequencies.

Timer duration is compared to system clock. Only large discrepancies are reported (>150mSec).

Total test duration is twice the selected time.

3.6.10.3 I/O Status Information Test

Description: Reads and display the gentry I/O status for operational verification. Gentry I/O status information is displayed to the user. Except for the monitoring functions, no further testing is performed.

Troubleshooting notes:

- Displays the expected and actual tube ID.
- Tube, anode tank, and cathode tank pressure statuses are displayed.
- Relay driver statuses are displayed for operational verification.

Note: This test does not display system interlock status since the interlock is kept open when not needed during diagnostic testing.

3.6.10.4 HV Meter Test

Description: KV, mA, and rail voltage values are displayed for testing meter accuracy. Test enables user to inject known voltages into the system for the purpose of meter calibration.

3.6.10.5 Tube Fan and Pump Test

Description: manual operation of the tube relay, pump, and fans. Enables tube fans and pumps for a given duration. Test has no effect if fans are already running.

3.6.10.6 Alignment Light Test

Description: manually operate the alignment lights, power supply, and driver.

- This test enables the alignment lights for a given duration.
- Test enables user to isolate between table control problems and **OBC**.

- Gantry must be at 180 degrees to view alignment lights.

3.6.10.7 Power Supply Test

Description: Read and display the **OBC** power supplies for the correct operating range. Supplies out of range are highlighted and reported to the error log.

Troubleshooting notes: The 15VDC supply is monitored after the gentry I/O 15VDC inductor causing a 0.2 - 0.3 volt error.

3.6.10.8 Thermistor Test

Description: This test displays the **OBC** temperatures and limits for a given duration. Thermistors found open are reported as such (0VDC). Temperatures found out of range are highlighted and reported to the log.

Thermistors read:

- Gantry ambient
- **OBC** ambient

3.6.10.9 Exposure Interlock Test

This test verifies the operation of the exposure interlock. The operator can loop on an error indefinitely or continue the test.

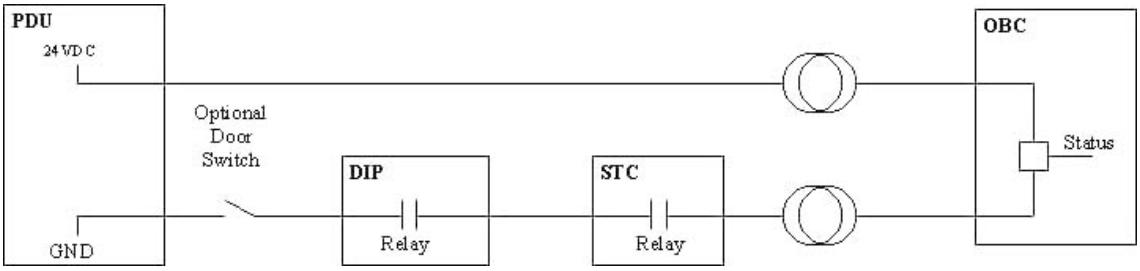


Figure 2-114 Exposure Interlock Testing

3.6.10.10 General Troubleshooting Notes

1.) Insure both jumpers are installed in the Artesyn boards for 20MHz operation.
2.) The **DCB** must have a terminator connected to the **RCIB** connection.
3.) Insure the 50 ohm inline terminator is installed at the **ETC** ethernet connection.
4.) Check the slip-ring stats, when troubleshooting **LAN** watchdog errors.

3.7 Scan Data Path (DAS Control Board to SCU)

This diagnostic will be used to test and isolate problems related to scan data generated in the **MDAS** and received at the scan data disk. It will generate known scan data from either the **DCB** or from each of the converter boards and send this data to the **DAS** interface processor board and store it on the scan data disk for analysis. The data path is shown in Figure 2-115.

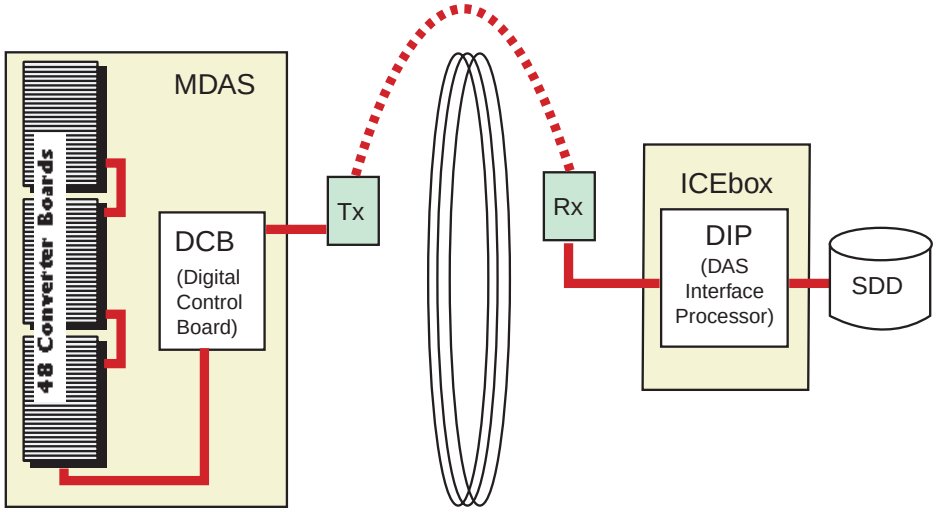


Figure 2-115 Scan Data Test Paths

The Main Diagnostic Menu selection has several options:

1.) Data Path Selection can be either from the **DCB** or converter boards (Figure 2-116).

a.) **DCB**: A known data pattern is sent from the **DCB** to the scan data disk. After the data is collected, the scan file is check summed and compared to a known checksum value. If a discrepancy is found, the test will fail. This will give an indication that the path between the **DCB** to the scan data path is bad.

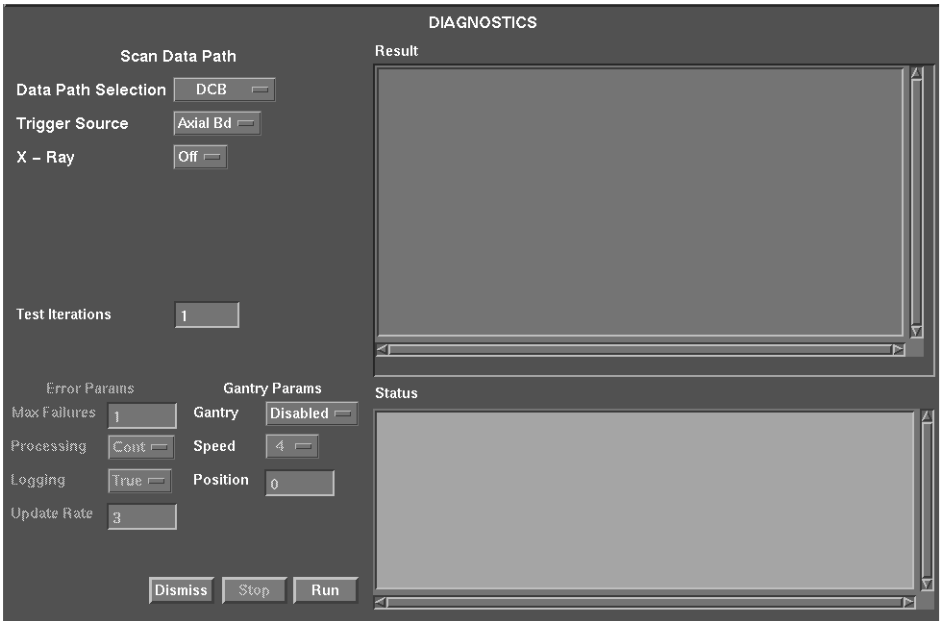


Figure 2-116 DCB Data Path Selection Screen

b.) Refer to the system error log for further details on what may be the cause. Further attempts to isolate the problem may include:

* Running **DIP** Diagnostics, with and without the loop-back cable
* Bypassing the RF slip ring by connecting the **DCB** fibre output directly to the **DIP** board.
* Running **DCB** Diagnostics
* Check **DIP** stats for **FEC** error corrections and attempts. This step should always be done, even if the test passes to see if there is a marginal error condition that **FEC** is correcting.
* Record the exam number the test uses and plot the data using Scan Analysis to look for errors. Look at ALL rows. ALL rows may not look the same. Refer to Figures 2-117, 2-118, 2-119 and 2-120, for four examples of what rows should look like.

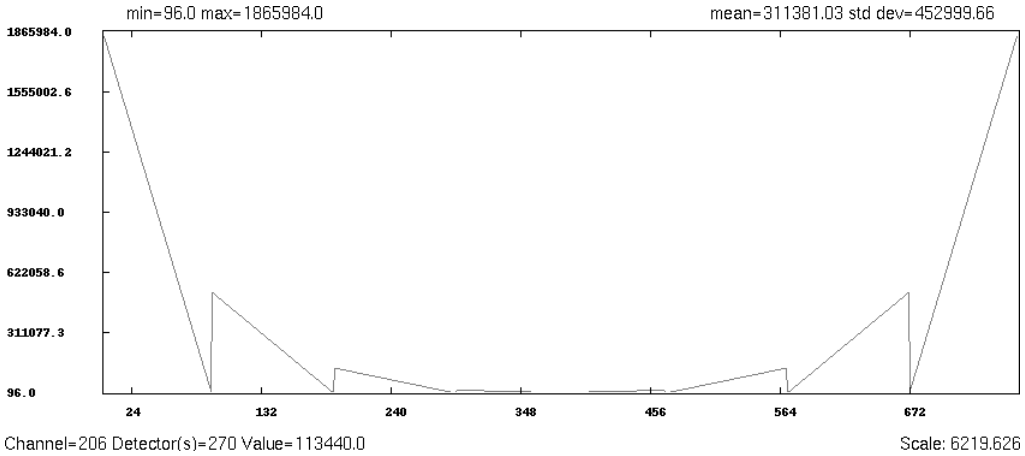


Figure 2-117 DCB Data, Means Example

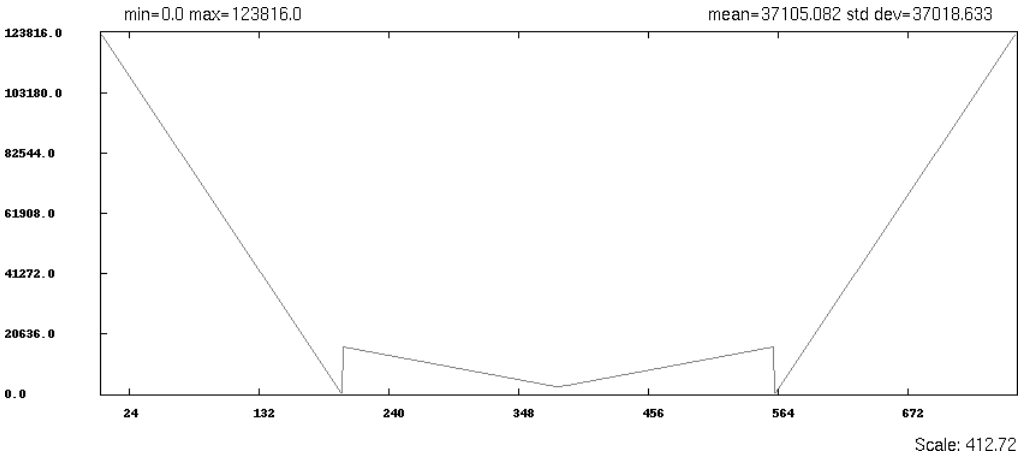


Figure 2-118 DCB Data, Means Example

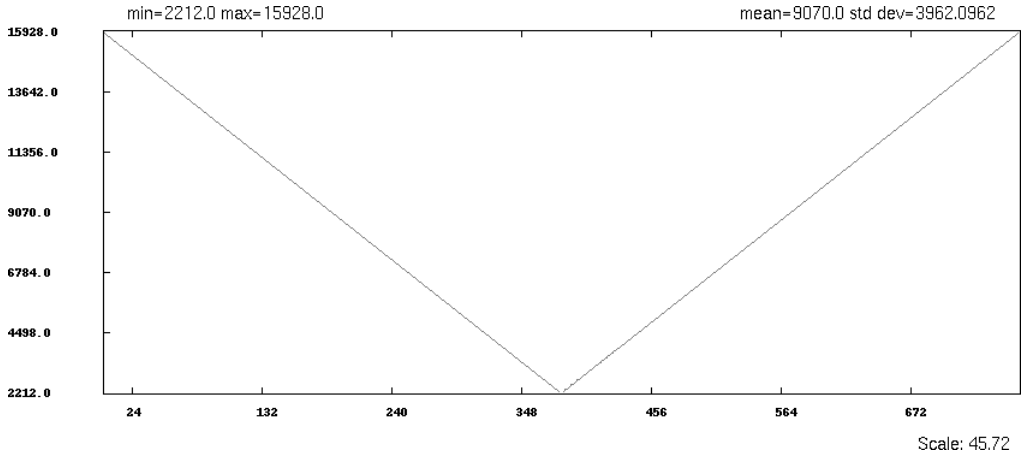


Figure 2-119 DCB Data, Means Example

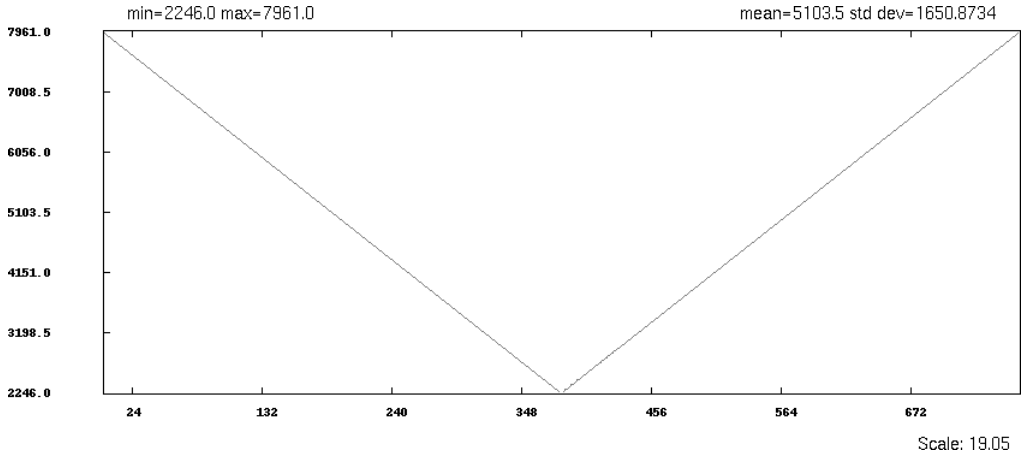


Figure 2-120 DCB Data, Means Example

c.) **Converter Boards** - A known value is input to the front-end of each of the 48 converter boards. Again, this data is sent to the scan data disk and check summed and verified for any discrepancies. Using the converter board path will help isolate if the problem is between the converter boards and the **DCB**. The reason why the **DCB** is the default option is that if the **DCB** data path fails, then most likely the converter data path will fail also. Fix the **DCB** data path first (refer to Figure 2-121).

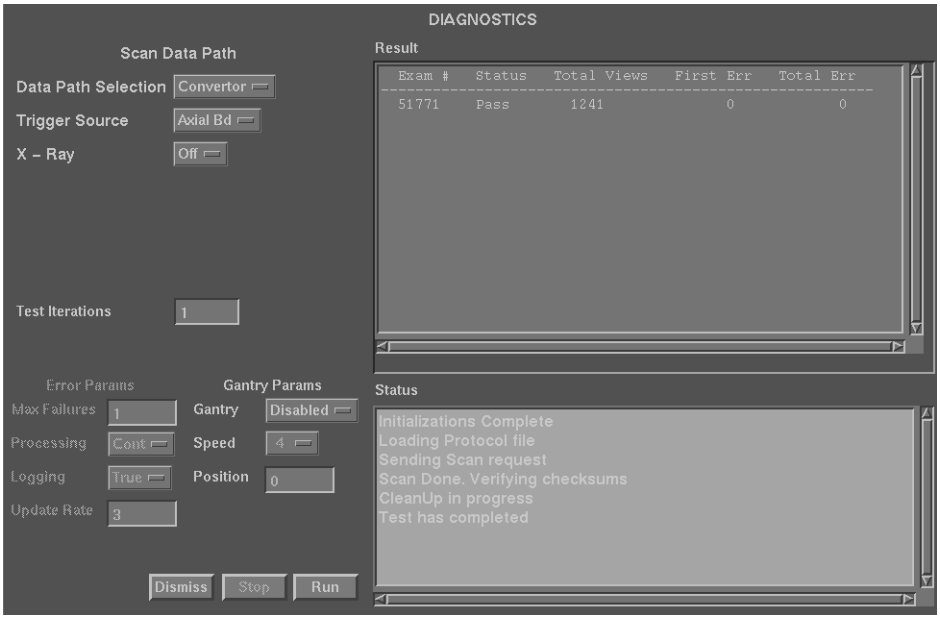


Figure 2-121 Converter Data Path Selection Screen

See Figures 2-122 through 2-125, for example row output screens.

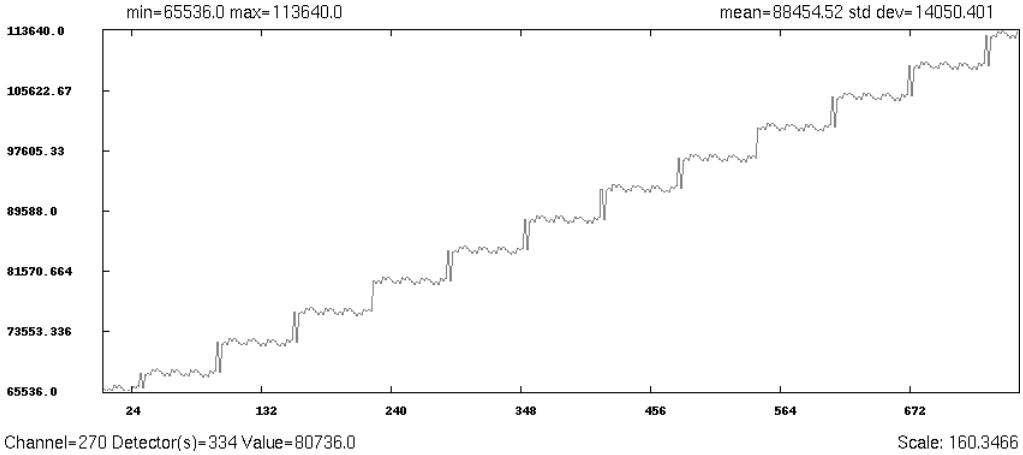


Figure 2-122 Converter Data, Means Example

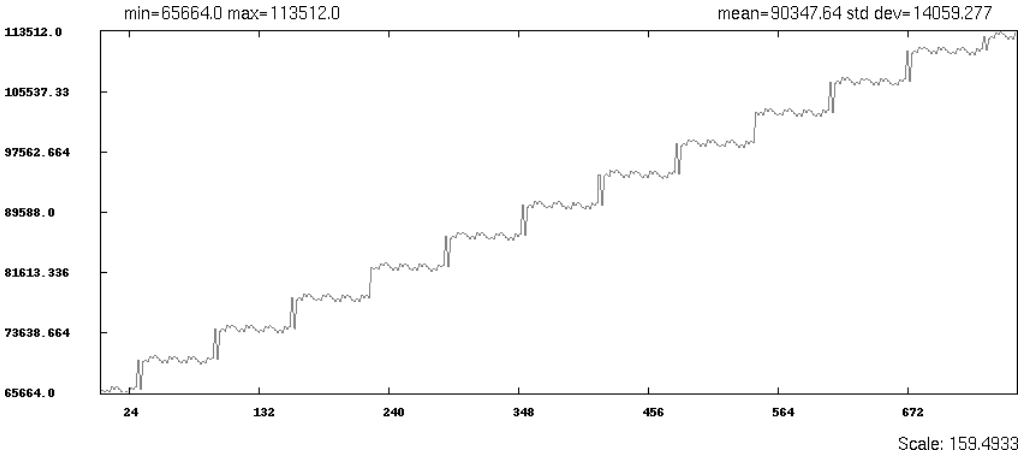


Figure 2-123 Converter Data, Means Example

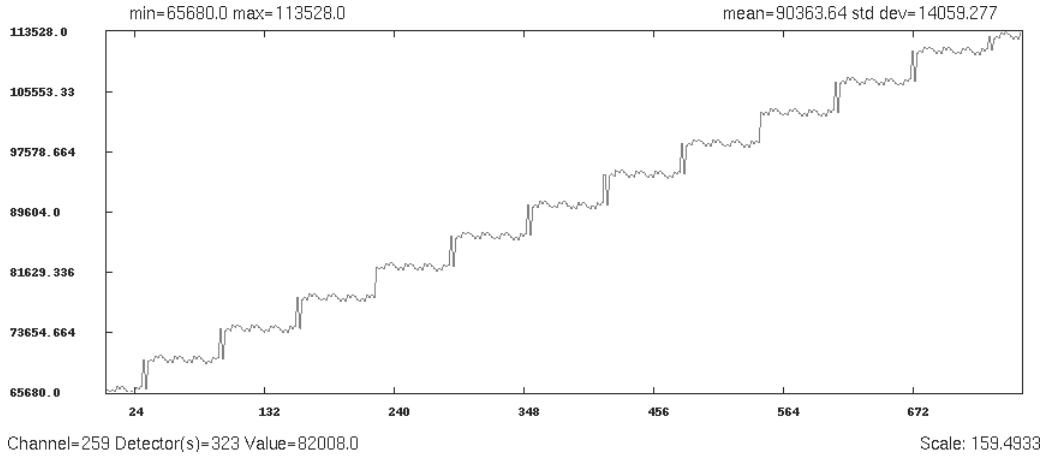


Figure 2-124 Converter Data, Means Example

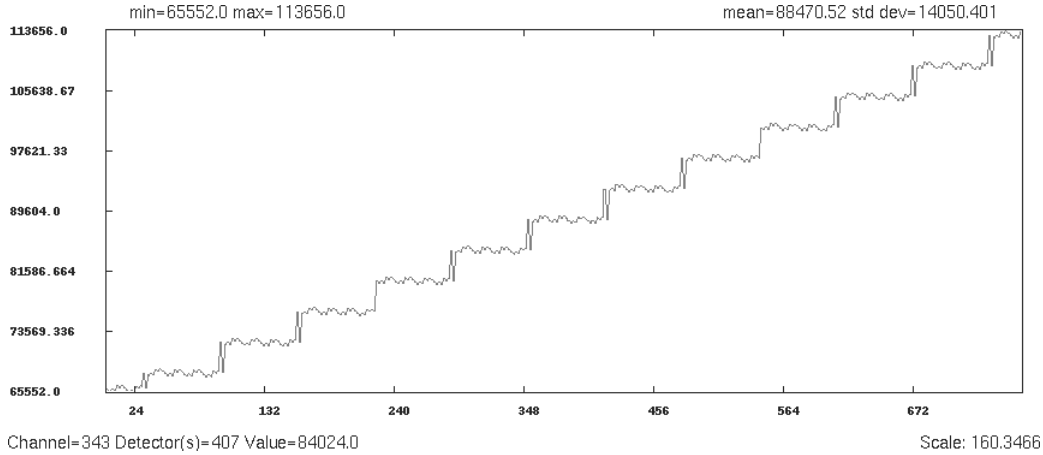


Figure 2-125 Converter Data, Means Example

2.) **Trigger Source** - Defaults to the axial board, which is the only option at this time. Future releases may include the **DCB** as an internal trigger source to help isolate trigger related faults.

3.) **X-Ray** - This option enables a low technique scan to determine if rotor and high voltage is the cause of data errors. If selected, x-ray can be initiated during data collection to flag **HV** related issues during data collection. Technique shall be kept to a minimum and follow all x-ray initialization constraints, such as techniques, scan times, and tube cooling. Default test prescription will NOT have x-ray. For testing with x-ray, scan technique shall be 80KV/20mA/1 sec/filter in closed position, and collimator at minimum opening. This option is not for use by InSite without operator initialization utilizing the Scan Push button. The default selection is No X-Ray.

4.) **Gantry Rotation** - This test is functional in a stationary gantry utilizing **DAS** internal triggers. It is functional in a rotating gantry at various gantry speeds (0.8, 1.0, & 2.0 seconds), using system generated triggers. This feature is chosen via the **GUI**, and requires the scan push-button to enable the rotation. Stationary data collection is the default option and primarily used by InSite.

3.8 Recon Data Path Test

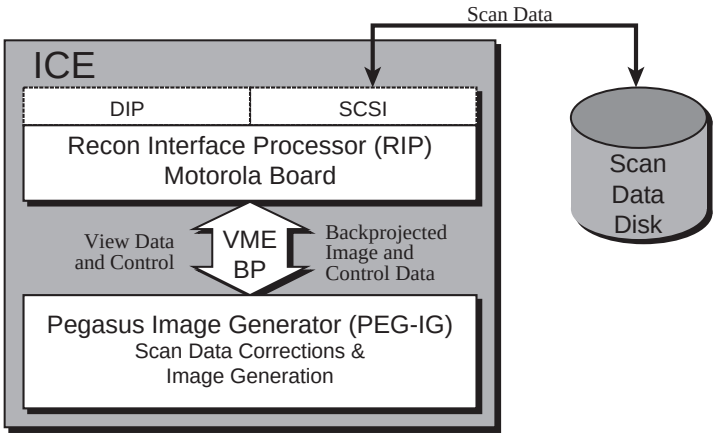


Figure 2-126 Reconstruction Data Flow Block Diagram

3.8.1 Test Description

The Recon Data Path Test validates the image reconstruction hardware and software. Testing consists of creating images from scan data loaded by the diagnostic and stored on the scan data disk and validates their checksums. Errors detected by this diagnostic should be the same as those detected during patient scanning since the same image reconstruction hardware and software is utilized in both situations. Scouts, axial and helical type images are tested. Refer to Tables 2-21 through 2-25, which list the specific scan files and images used by this test.

Images are reconstructed silently and are NOT saved or displayed. The Recon Status Area on the Service Desktop provides the status of each completed image during the test. Any failure encountered will be reported to the user and errors logged.

3.8.2 Test Initialization

3.8.2.1 Check/Load Scan Data Files

The scan database must contain the Image Generation Test scan files before testing can begin. If these files are not present, the test automatically loads the scan file from the SBC's `/usr/g/service/tools/added_tools/IMG_GEN` directory into the scan database.

3.8.2.2 Create Test Error Log

During the execution of the diagnostic, any error messages that occur will be logged under the View Failure Logs RECENT button. Errors logged under RECENT are written to the `failure.log` file in the SBC directory: `/usr/g/service/tools/added_tools/Image_Gen_Test`. The next time the diagnostic is executed, the contents of the `failure.log` file will be appended to the HISTORICAL file called `failure.log.bak` and a new `failure.log` file will be created. Note if there have been no failures during previous executions or recent executions, these logs will empty.

3.8.2.3 Read Test Protocol File

The `Img_Axial.rat`, `img_helical.rat`, and `image_scout.rat` files are read by the Recon Data Path Test at initialization. This file contains the protocols and image checksums used by the test.

3.8.3 Test Termination

The STOP button on the test main menu halts further testing and removes the shell window. The scan files used by this test remain on the disk until overwritten by another scan file.

3.8.4 Test Coverage

The hardware and software required to create images is verified by this test. The hardware includes the Scan Data Disk, Reconstruction Image Process (**RIP**) board, and the Pegasus Image Generator (**PEG-IG**) board.

3.8.4.1 Scout

Scan Protocol:Exam 19/1/1				Scan Rx			
Series	Scan Type	Phantom	SFOV	kV	mA	Time(sec.)	Range
1	scout	any	-	120	80		1500mm

Table 2-21 `img_scout.rat` Test File

3.8.4.2 Axial

Scan Protocol:Exam 19/5/1				Scan Rx			
Series	Scan Type	Phantom	SFOV	kV	mA	Time(sec.)	Range
5	axial	QA high res	small	140	200	1.0	4x5mm

Table 2-22 `img_axial.rat` Test File

Recon Protocol:

Series	Algorithms	DFOV	Targeting	IBO	Peristalic	Axial sigmaB	Series/Image
5	Soft	20	Center	Off	Off	4i	105/1-4
5	Detail	9.6	L	Off	Off	4i	105/5-8

Table 2-23 `img_axial.rat` Test File

3.8.4.3 Helical

Scan Protocol: Exam 19/7/1				Scan Rx						
Series	Scan Type	Phantom	SFOV	kV	mA	Time(s)	Range	Mode	Image Thichness	mm/ Rotation
7	Helical	QA High Res	small	140	140	0.8	4x3.75mm	Hispeed	7.5mm	22.5

Table 2-24 `img_helical.rat` Test File

Recon Protocol:

Series	Algorithms	DFOV	Targeting	IBO	Peristalic	Axial sigmaB	Heical Start	Helical Increment	Series/ Image
7	Bone	20	Center	Off	Off	2.0x	1	50% overlap	107/6-8
7	Detail	10	Center	Off	Off	1.33x	0.5	contigous	107/9-11
7	Detail	25	A/L 80%	Off	Off	1.33x	1	50% overlap	107/17-21

Table 2-25 `img_helical.rat` Test File

3.8.5 IG Test Usage

Touch the RECON DATA PATH button to bring up the Graphical User Interface, (**GUI**). The following **GUI** is displayed:

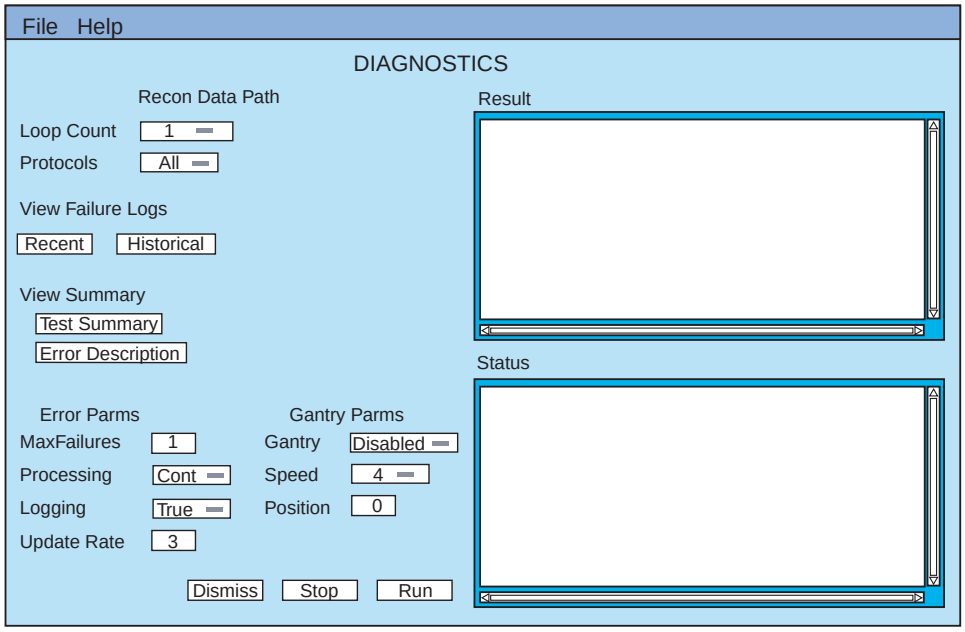


Figure 2-127 Recon Data GUI

MENU OPTIONS - "A DESCRIPTION"

RUN - Pressing RUN invokes the reconstruction of images with user selectable parameters.

LOOP COUNT - Pressing LOOP COUNT displays a pull-down menu from which you can choose a loop count of 1, 5, or continuous. This determines how many iterations of the test will be performed.

PROTOCOL - Pressing PROTOCOL displays a pull-down menu from which you can choose All, Axial, Helical, or Scout. This parameter determines which protocol to use, and consequently which images to reconstruct. Selecting All will reconstruct images using all available protocols.

ERROR DESCRIPTIONS - Upon the completion of a set of reconstructions Recon Data Path displays a summary of successes and failures (both checksum discrepancies and other reconstruction failures). More detailed information on the failures can be obtained by pressing the ERROR DESCRIPTIONS button. For additional information refer to section 3.8.6, below.

TEST SUMMARY - A summary of the most recently run tests will be displayed in the results window by pressing the TEST SUMMARY button.

```
Image Checksum Errors:      0
SDC Prep Checksum Errors    0
SDC Post Checksum Errors    0
Total Successes:            24
Total Failures              0
Press "Error Description" Button for more information
```

VIEW LOGS - Recon Data Path logs information on reconstruction failures. The results of the most recent test can be viewed by pressing the RECENT button under the VIEW LOGS heading. The historical results can be viewed by pressing the HISTORICAL button.

STOP - A test can be aborted by pressing the STOP button.

DISMISS - Pressing the DISMISS (terminate tool) button terminates the **GUI**.

RECON DATA PATH - This option executes the Image Generation Test after the number of passes are entered. A valid entry for the number of passes is from 1 to 9999. The default value is 1. Each pass takes approximately 1 minute to complete.

Note: Before executing the test, the Recon Status Box located at the top of the screen should display an "`Idle`" state. This state indicates the Image Reconstruction Process is ready to create images. Other possible states are "`Active`" and "`Shutdown`". An "`Active`" state indicates the reconstruction process is busy creating images. You should wait for these images to complete before continuing. If a "`Shutdown`" state is indicated, the Image Reconstruction Process has been halted, usually due to an error condition. Restart the process by selecting RECON MANAGEMENT and "RESTART RECON" before beginning the test.

3.8.6 Error Messages and Error Descriptions

After completing a test, pressing the TEST SUMMARY button or the RECENT button, will display a summary of the most recently run tests in the results window. If errors were encountered, the system message log and the RECENT error log should be examined after the test completes. To help determine the faulty **FRU**, select ERROR DESCRIPTIONS. A window will be displayed at the same time as the summary information, allowing the user to simultaneously view which errors were detected and what they imply. This is shown in the message below.

```
IMAGE CHECKSUM ERROR
      Possible Causes: Bad IG Board
SDC PREP CHECKSUM ERROR
      Possible Causes: Bad SDC Board
SDC POST CHECKSUM ERROR
      Possible Causes: Bad SDC Board
FAILED TO ENQUEUE
      See message log for more information
TIMEOUT WAITING FOR RECON RESPONSE
      Possible Causes:
      Queue Paused. Verify that queue is active.
      Bad RIP board
      See message log for more information
RECON REPLY ERROR
      Possible Causes:  Bad RIP Board
      See message log for more information
```

GE MEDICAL SYSTEMS

GE MEDICAL SYSTEMS-AMERICAS: FAX 262.312.7434
3000 N. GRANDVIEW BLVD., WAUKESHA, WI 53188 U.S.A.

GE MEDICAL SYSTEMS-EUROPE: FAX 33.1.40.93.33.33
PARIS, FRANCE

GE MEDICAL SYSTEMS-ASIA: FAX 65.291.7006
SINGAPOR

GE Medical Systems

gemedical.com

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Chapter 3
Operating System & Application SW/Features

Section 1.0
Overview

1.1 Host Architecture

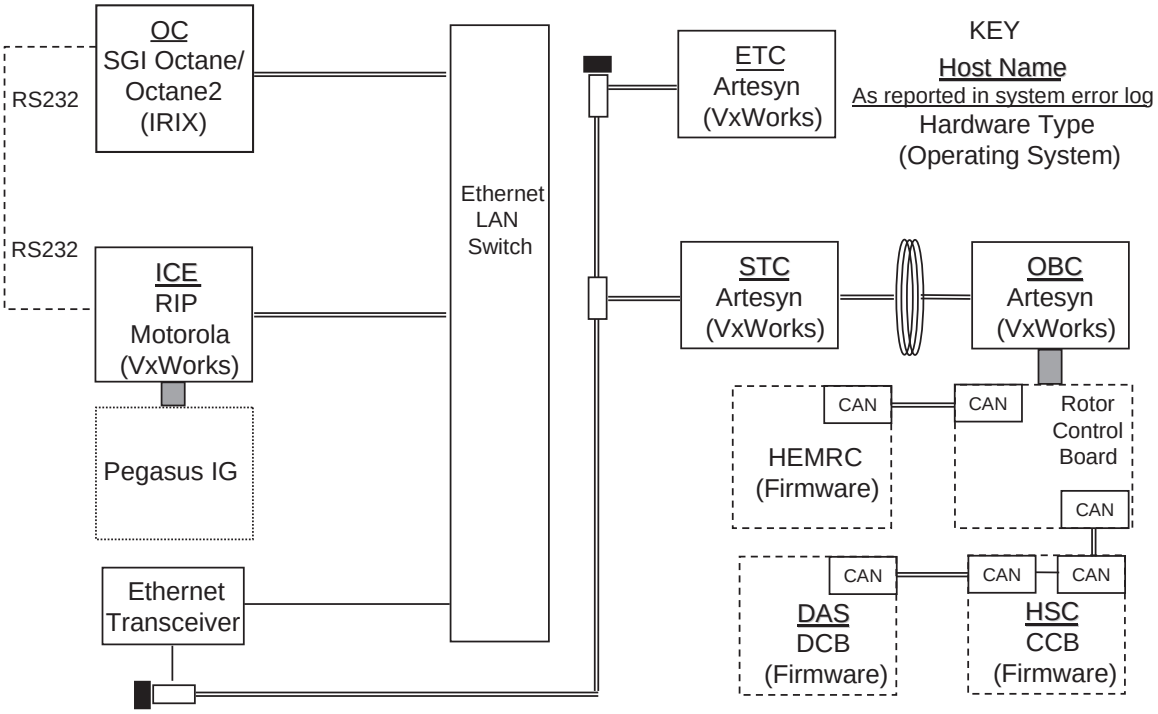

Figure 3-1 Host Architecture

Figure 3-1 shows the CT system's computers and communications paths used to control system operation. The serial, **LAN**, **CAN**, **VME** bus, and slip-ring communication paths shown are also used to distribute and bring up software during the boot-up process. Figure 3-1 also shows that several different software operating systems are used by the variety of computers in the system.

1.2 Host Operational States

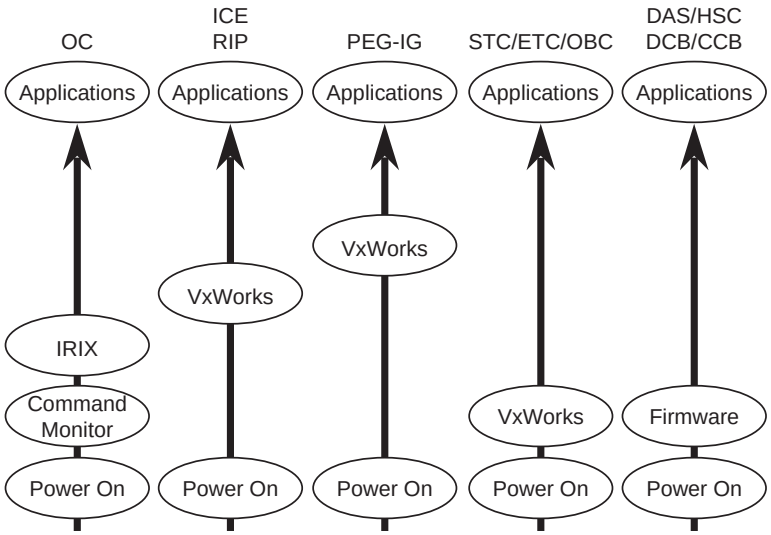

Figure 3-2 Hosts Operational states

Figure 3-2 shows that as the system is brought up from a power-off state, the computer's transition through several levels of operation to load their specific operating system and **CT** application software.

The specific levels of operation are commonly referred to as the Command Monitor, IRIX, and Applications levels from the perspective of the OC computer. Each level of operation provides different service capabilities. For service purposes, it is necessary to operate the system at each level. Procedures for changing the system level of operation as well as the service capabilities at each level are described in this chapter.

1.3 Auto Boot-up Sequence

Table 3-1 describes the software distribution and boot-up process from power-up to applications.

OC	ICE	PEGASUS IG	STC/ETC/OBC	DCB/CCB
1. Power up diagnostics	1. Power up diagnostics	1. Power up	1. Power up diagnostics	1. Power up diagnostics
2. Boot IRIX from OC disk	2. Wait for serial input activity	2. Wait for **ICE** boot-up	2. Attach **ROM** resident VxWorks. Wait for input on **LAN**	2. Wait for input on **CAN** Bus
3. Start **CT** Applications software	3. Load VxWorks and applications software via the **LAN**			
	4. Find and initialize the Pegasus **IG** Board.	3. Boot VxWorks off of **ICE**		
4. Start up Artesyn controllers via the Table/ Gantry **LAN**		4. Apps load through the **ICE**	3. Applications firmware downloaded and started	3. **OBC** initializes via **CAN** bus
Applications start-up complete				

Table 3-1 Auto Boot-up Sequence

1.4 Operating System Overview

1.4.1 Processes

UNIX allows many users with many different programs to share the **CPU** and memory. This is done by time-sharing all the resources. Every task done is a PROCESS, and every time any user starts a new task, the system starts a PROCESS and gives it a unique process ID that will identify the program. Some processes are started on power-up and run all the time. One process might start another process, which then becomes the CHILD process. The process that started the child is the PARENT process. When a program has finished its task, it must shutdown all the processes. Child processes and parent processes must be TERMINATED. This will free up all the memory and close all the files that were used by the process.

1.4.1.1 Kernel

UNIX is always running several programs in the background. The most important one, the KERNEL, is the heart of the operating system itself. It is loaded into memory on startup, and will stay in real memory all the time UNIX is running. The kernel is the “minimum system” that is needed to run any operating system. It assigns memory for each program that is running and allocates the time for each program to use the **CPU**, often refereed to as a “time slot”.

Any program or process will have the **CPU** for the maximum time of 1 second. If the process has not finished all its tasks, the kernel will swap the process out of memory and give the next process access to the **CPU**. If the active process needs data that is not directly accessible from real memory, then it will go to a WAITING state, which will signal the kernel to start another process that is ready to run. If the program itself determines it has nothing to do—that is, if it waits for another process to finish or give it some more data to work on—it will “go to sleep”. Each process and the state of each one can be listed with the `ps` command.

The kernel will also handle all input and output requests (I/O) to disc drives, printers, network and terminals. The kernel will also use parts of the disc as VIRTUAL memory. This is called the SWAP partition. When a process requests data from memory, the kernel determines if the address is REAL or VIRTUAL. In the latter case, it then needs to copy the data from disc to real memory before letting the process continue. The kernel is “custom built” for the hardware that makes up the computer. Before turning off power to the system, UNIX will have to move all the data for all the processes to disc drive and stop all active processes. This is done with the shutdown command.

Most “panic” messages on the terminal are from the kernel. If it gets a request to do something that it cannot handle, then the kernel will often just halt the system by stopping the **CPU**. A “kernel abort” message could be caused by faulty hardware or a bad program. The next time the system boots, UNIX will recognize something went wrong and if the power has not been turned off, the “bad program” will still be in memory and the system will try to copy all the data in memory and the register data to a file on the disc drive. This is the CORE file dump, and you can get a file that will take up 100 Mb or more.

1.4.1.2 Daemons

Many small programs are needed to handle utilities such as mail, printing, keeping track of the time and networking to other systems. These are commonly known as the DAEMONS. Each one can be started by the kernel, and wake up to do its task on demand. When it is finished, it will go to sleep and wait until it is needed again. Most daemons are well behaved watch dogs and will do their job without ever complaining. If they fail, then we get aborts and core files, which are quite similar to the kernel aborts. In either case, UNIX will try to inform you about what happened by sending a message to the boot terminal and enter some text in the system error log.

1.4.1.3 Processes

When the system is up and running there are many processes. Using the UNIX command **ps -ef**, a list of currently active processes can be displayed to the screen. If the system is running **CT** applications, many more active processes will be displayed. For additional information on using **ps**, see the UNIX **man** pages command (Unix & Linux Commands on page 1007). An example of the **ps -ef** command follows:

```
{ctuser@msecrp1}[12] ps -ef
UID      PID  PPID  C    STIME TTY      TIME COMD
root       0     0  0 08:38:01 ?        0:02 sched
root       1     0  0 08:38:01 ?        0:00 /etc/init
root       2     0  0 08:38:01 ?        0:00 vhand
root      76     1  0 08:38:29 ?        0:00 /usr/etc/syslogd
root     385     1  0 08:38:42 ?        0:00 /usr/bin/X11/xdm
ctuser   803     1  0 08:39:56 ?        0:01 /usr/g/bin/cupMonitor
ctuser   816   803  0 08:40:01 ?        0:00 awStart
ctuser   818   803  0 08:40:01 ?        0:02 examRxEnv dual
ctuser   917     1  0 08:40:30 ?        0:00 imserver
ctuser   919   917  0 08:40:30 ?        0:00 imserver
ctuser   960   803  0 08:40:46 ?        0:08 examRxDisplay dual
ctuser   987   803  0 08:41:42 ?        0:00 stcIf /dev/ttya5
ctuser   988   987  0 08:41:43 ?        0:00 stcIf /dev/ttya5
{ctuser@msecrp1}[13]
```

The first column (`UID`) lists the owner, or who started the process. The `PID` is the process identification number and will increment every time a new process is started. If any process is started by a “parent” process, then the `PPID` is the `PID` of that parent. This is used to control sub processes. If the parent is finished and wants to shut down, it must first take control of all “child” processes and shut each one down before the parent process can stop. The start time for each process and how long it has been running is listed in `STIME` and `TIME`. The name of each process is listed in the last column. This will often give you a good idea of what each one is doing.

From the listing above, the first process is “sched”. This is the scheduler, which manages the time sharing of the **CPU**. This is started by root and gets process `id 0`. This process is started automatically on power-up. The sched will start `/etc/init`, which starts `/usr/etc/syslogd`. This is the error logging routine. The syslogd is a daemon process that logs any errors. The “`init`” process will also start `/usr/g/bin/cupMonitor`, which is the **CT** application startup. We have four desktop applications running at the same time, and each of these is an X-Windows application. On the list above are 2 of the applications: `awStart` and `examRxDisplay`.

To terminate any process, we have the **kill** command, which is used together with the process id or the process name. The kill has some options or flags. For example, option **-15** will instruct the **kill** command to find all the child processes first and terminate each one before the parent. Only the owner of the process should terminate it. The root user can terminate any process.

When you think of how we organize directories as trees you can now see the same structure in process control. Every directory has a parent directory with one exception, the root directory. Every process has a parent process, with the exception of the scheduler. Any directory might have child directories, and any process might have child processes. Just as the root user can access any file, the root user can also control any process.

1.4.2 Environmental Paths

With so many executable commands, programming tools and utilities available, we need some common organization of the most used files. All these tools are located in different sub-directories to make it easier to upgrade or change individual components. When you type the name of a command, the shell first checks to see if it is a built-in command and if it is, then executes it. If the command name is an absolute pathname, such as `/usr/bin`, then the command is executed. If the command is neither built-in nor specified with an absolute pathname, then the shell looks in its search path for an executable program or script with the given name. The PATH string specifies which directories the shell should look in first to find the executable file for any command you have given the shell. The search path is not built into the shell. You specify this in your shell setup file. For the c-shell this is the `.cshrc` file in the user home directory. Many variables are specified in the `.cshrc`; the path is just one of them. The following is an example of a short cut to show the `.cshrc` file.

```
{ctuser@msecrp1}[2] more .cshrc
#!/bin/csh -e
umask 0
set window_choice=4Dwm
setenv GDIR /usr/g
setenv BINDIR   $GDIR/bin
set std_path = (/usr/g  /usr/g/bin  /usr/g/scripts  /sbin  /usr/sbin  /
bin  /usr/local  /usr/ucb /usr/bin  /usr/etc  /etc  /usr/bsd  /usr/atria/
bin   ~ .)
alias cp        '/bin/cp -i'
alias mv        '/bin/mv -i'
alias rm        '/bin/rm -i'
set autologout=0
set history=100

set prompt='{'$USER@`/usr/bsd/hostname`'}''[\!] '
```

We can examine some of the variables that are defined here to better understand what is available on the system. The first line "`#!/bin/csh -e`" specifies this is a c -shell. The command syntax is quite similar to the c programming language and allows scripts with if statements and so on. The line "`set std_path`" specifies which directories and in which order the shell should go through each one when it looks for any external commands. The lines that start with "`alias`" specify what options to use for each command. Any time you type `rm` on the command line, the shell will substitute with the `rm -i` (the `-i` is for interactive mode), and the system will then ask you to verify that you really want to remove the file on the command line. The intention of aliases are to make the system more user friendly. The line "`set history=100`" will tell the shell to remember the last 100 command lines you have typed. This is very helpful when you want to retype any command you have used recently. We repeat a command with the "`bang`" command (more about this later). The last line "`set prompt=`" specifies what the command line prompt should be.

Section 2.0
Boot PROM, Boot-up, and Devices

2.1 Boot Environment

2.1.1 Command Monitor

The Command (**PROM**) Monitor program controls the boot environment for all Silicon Graphics workstations. With the Command Monitor, you can boot and operate the **CPU** under controlled conditions, run the **CPU** in Command Monitor mode, and load programs like the operating system kernel or special debugging and execution versions of the kernel.

PROM stands for Programmable Read-Only Memory. Most **PROM** chips are programmed at the factory with software that 1) allows the **CPU** to boot, and 2) allows you to perform system administration and software installations. The **PROM**s are not part of your disk or operating system; they are the lowest level of access available for your system. You cannot erase or bypass them.

2.1.2 Entering the Command (PROM) Monitor

2.1.2.1 Summarized

Shutdown then restart the system, or if the system is already off, turn it on. By default, the **PROM** attempts to boot the OS when the system is powered on or reset. To prevent the boot-up and get to the command prompt monitor, press **ESC** or click the STOP FOR MAINTENANCE button. Select item 5 on the following menu:

```
System Maintenance Menu
1   Start System
2   Install System Software
3   Run Diagnostics
4   Recover System
5   Enter Command Monitor
6   Select Keyboard Layout
>
```

2.1.2.2 Procedure - Entering Command Monitor

The procedure for entering Command Monitor follows:

1.) Restart the system: If the host computer is OFF, turn it ON and proceed to Step 2. If the host computer is ON, bring it down appropriately. After a few seconds, the screen will clear and you will see a notification like the one shown in Figure 3-3. Select the RESTART button.

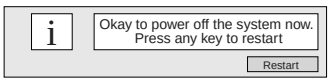

Figure 3-3 Okay to Power Off System - Notification Screen

Note: If the system is malfunctioning and a user cannot communicate with it using the mouse or keyboard, then press the reset switch on the front chassis.

2.) **Immediately** click on STOP FOR MAINTENANCE or press the **ESC** key. You only have three to five seconds to perform this action (refer to Figure 3-4).

Figure 3-4 Maintenance Option Menu

3.) The following Host Maintenance menu appears. Select item 5 in the following menu.

```
System Maintenance Menu
1   Start System
2   Install System Software
3   Run Diagnostics
4   Recover System
5   Enter Command Monitor
6   Select Keyboard Layout
```

2.1.3 Command Monitor Summary

The following commands are available at the boot **PROM** level.

COMMAND	WHAT IT DOES	SYNTAX
auto	Boots default operating system (no arguments). This has the same effect as choosing Start System from the **PROM** Monitor initial menu.	**auto**
boot	Boots the named file with the given arguments.	**boot** ***[-f][-n] pathname***
date	Displays or sets the date and time.	**date** ***[mmddhhmm[ccyy|yy][.ss]]***
exit	Leaves Command Monitor and returns to the **PROM** menu.	**exit**
help	Prints a Command Monitor command summary.	**help** ***[command] ? [command]***
hinv	Prints an inventory of known hardware on the system. Some optional boards may not be known to the **PROM** monitor.	**hinv**
init	Partially restarts the Command Monitor, noting changed environment variables.	**init**
ls	Lists files on a specified device.	**ls*devicename***
printenv	Displays the current environment variables.	**printenv** ***[env_var_list]***
printenv eaddr	Prints the Ethernet address of the built-in Ethernet controller.	**printenv eaddr**
resetenv	Resets all environment variables to default.	**resetenv**
resetpw	Resets the **PROM** password to null (no password required).	**resetpw**
setenv	Sets environment variables. Using the -p flag makes the variable setting persistent, i.e., the setting remains through reboot cycles.	**setenv** ***[-p] variable value***
single	Boots the system into single-user mode.	**single**
unsetenv	Un-sets an environment variable.	**unsetenv variable**
version	Displays Command Monitor version.	**version**

Table 3-2 Command Monitor (Command Summary)

2.1.4 Boot Environment Variables

Variables are used to tell the Host how to boot-up. These “environmental” variables are stored on the Host Computer (Octane), within **PROM**. Use the **`printenv`** command to list the current state of these variables.

The following is a typical example of these variables and their associated values. Although comments are provided (in italics), use the UNIX command **`man prom`** for additional information. Compare your default settings to those listed below.

> **`printenv`**

`AutoLoad=Yes`

Controls if the system boots automatically on reset/power cycle

`console=g`

The console variable “`g`” indicates it is connected to a graphics display

`diskless=0`

Sets the system to boot from disk

`nogfxkbd=1`

`dbaud=9600`

This is the diagnostic baud rate. It can be used to specify a baud rate other than the default when a terminal connected to serial port #1 is to be used as the console

`volume=0`

Sets the speaker volume during boot up

`sgilogo=y`

Set to y, the SGI logo shown during boot-up

`autopower=y`

The y setting allows the system to automatically power back on after an AC power failure

`netaddr=192.9.220.10`

The OC's assigned internet address. Used when booting or installing software from a remote system by Ethernet

`eadder=08:00:69:0a:27:b6`

The ethernet address of the built-in Ethernet controller. Set at factory, cannot be changed

`boottune=1`

Setting of 1 is default tune. Not supported in Octane, even though it is listed

`ConsoleOut=video( )`

Set at system startup automatically from the console variable.

`ConsoleIn=keyboard( )`

Set at system startup automatically from the console variable

`cpufreq=195 (or 225)`

processor frequency

`SystemPartition=xio(0)pci(15)scsi(0)disk(1)rdisk(0)partition(8)`

The device where the operating system loader is found

`OSLoadPartition=xio(0)pci(15)scsi(0)disk(1)rdisk(0)partition(0)`

The device partition where the core IRIX operating system is found

`OSLoadFilename=/unix`

This is the filename of the operating system kernel

`OSLoader=sash`

This is the operating system loader, which is sash for IRIX

`gfx=alive`

Enables graphics on the console

2.1.5 Keyboard Languages

If a new keyboard is not set to the site's language, press STOP FOR MAINTENANCE while the **SGI** host is booting to get its System Maintenance Menu. Then select the last item on this menu to get the *Keyboard Layout* choices. Select the desired language, like US for USA English.

KEYBOARD LAYOUT CHOICE	LANGUAGE	SUPPORTED BY CT
BE	Belgian	
DE	German	X
de_CH	Swiss German	
DK	Danish	
ES	Spanish	
FI	Finnish	
FR	French	X
fr_CH	Swiss French	
GB	Great Britain	
IT	Italian	
NO	Norwegian	
PT	Portuguese	
SE	Swedish	
US	United States	X

Table 3-3 Keyboard Choices (Language)

2.1.6 chkconfig on the OC Octane

There are a number of operating system configuration parameters (flags) that are set automatically during the **CT** application load on the OC Octane. Under normal conditions, you should never have to manually change the state of these flags. In the unlikely event of a software corruption, one can view the state of each of the flags as a part of troubleshooting, to verify they are set correctly, by running **`chkconfig`**. Also, if one of the states is found wrong, **`chkconfig`** can be used to set it back to the correct state.

Table 3-4 shows a list of the flags and the states that they should be in after the application load for the OC Octane. Enter the following to list the flags and their current states:

1.) Verify that Applications is shut down.
2.) Open a UNIX shell from the Toolchest.
3.) **`su -`** ENTER.
4.) **`chkconfig`** ENTER.

FLAG	STATE	FLAG	STATE
autoconfig_ipaddress	off	proclaim_relayagent	off
autofs	off	proclaim_server	off
automount	on	rarpd	off
change_sts	off	routed	off
desktop	on	rsvpd	off
fcagent	on	rtmond	on
fontserver	off	rwhod	off
gated	on	sar	off
impact_trace	on	savecore	on
ipaliases	on	sendmail	on
lockd	on	snetd	on
lp	on	soundscheme	off
mediad	off	timed	off
miser	off	timeslave	off
mrouted	off	verbose	off
named	off	videod	off
nds	off	visuallogin	off
network	on	vswap	off
nfs	on	windowsystem	on
noiconlogin	off	xdm	on
nostickytmp	off	yp	off*
nsd	on	ypmaster	off
pmcd	off	ypserv	off
privileges	on		
*This parameter may be on if site is running NIS (yellow pages)			

Table 3-4 OC Octane: States and Flags

NOTICE
Potential for Data Loss

Setting these flags to a wrong state can prevent the system from coming up properly. Use caution.

To manually change the state of a flag (only if it is improperly set), enter the following:

1.) **`chkconfig <flag> <state>`** ENTER (where state is on or off).
2.) **`reboot`** ENTER.

After the reboot, the flag(s) will be re-read and the change(s) made will take effect. For further details on each of the flags, look at the man page for **`chkconfig`**.

1.) **`su -`** ENTER
2.) **`man chkconfig`** ENTER

2.2 Boot-Up Sequence

2.2.1 Description of the Boot-Up Sequence

When the system is first powered on, the **PROM** runs a series of tests on the core components of the system. It then performs certain hardware initialization functions such as starting up **SCSI** hard disks, initializing graphics hardware, and clearing memory. Upon successful completion of these tasks, the **PROM** indirectly starts the operating system by invoking a bootstrap loader program called “sash”, which in turn reads the IRIX kernel from disk and transfers control to it.

2.2.2 OC (Host) - SYSLOG and Boot-up

The host computer records startup, errors and shutdown information.It recorded in a text file called `SYSLOG` that’s located in the directory `/var/adm`. The file `SYSLOG` is the most recent log. The SYSLOG files with the extension 0 through 7 are from the last eight days. In this example we have nothing for logs 4 through 7, because a software load was previously done on the 21st of the month.

Example: Listing available **SYSLOG** files

```
{ctuser@msecrp2}[4] cd /var/adm
{ctuser@msecrp2}[5] pwd
/var/adm
{ctuser@msecrp2}[6] ls -al SYSLO*
-rw-r--r--    1 root     sys         8405 Feb 25 11:18 SYSLOG
-rw-r--r--    1 root     sys          129 Feb 24 03:00 SYSLOG.0
-rw-r--r--    1 root     sys           44 Feb 23 00:00 SYSLOG.1
-rw-r--r--    1 root     sys         5596 Feb 22 12:52 SYSLOG.2
-rw-r--r--    1 root     sys         5761 Feb 21 19:18 SYSLOG.3
-rw-r--r--    1 root     sys            0 Feb 21 00:00 SYSLOG.4
-rw-r--r--    1 root     sys            0 Feb 21 00:00 SYSLOG.5
-rw-r--r--    1 root     sys            0 Feb 21 00:00 SYSLOG.6
-rw-r--r--    1 root     sys            0 Feb 21 00:00 SYSLOG.7
{ctuser@msecrp2}[6]
```

The following example shows is a typical Host (Octane) boot-up sequence. Comments have been added for clarification.

Example: Listing current **SYSLOG** file

```
{ctuser@msecrp2}[7] more SYSLOG
Jul 6 14:57 :ct unix: syslogd: restart
```

Comment: Beginning start-up of Kernel

```
Jul 6 14:57 :ct unix: IRIX Rel. 6.5 IP30 Version 05190004 System V-64 Bit
Jul 6 14:57 :ct unix: Copyright 1987-1998 Silicon Graphics, Inc.
Jul 6 14:57 :ct unix: All Rights Reserved.
Jul 6 14:57 :ct unix:
Jul 6 14:57 :ct unix:
```

*Comment: Initialize **PCI** Serial Card*

```
Jul 6 14:57 :ct unix: Digi International STS R1.10
Jul 6 14:57 :ct unix: Digi ClassicBoard PCI driver 1.1.0 configured
Jul 6 14:57 :ct unix: 0: Digi ClassicBoard 4 PCI in PCI slot 2
Jul 6 14:57 :ct unix:
```

Comment: Begin Mounting Filesystems

```
Jul 6 14:57 :ct unix: NOTICE: Start mounting filesystem: /
Jul 6 14:57 :ct unix: NOTICE:Starting XFS recovery on filesystem:
/(dev: 0/258)
Jul 6 14:57 :ct unix: NOTICE: Ending XFS recovery for filesystem:
/(/hw/node/xtalk/15/pci/0/scsi_ctlr/0/target/1/lun/0/disk/partition/0/block)
Jul 6 14:57 :ct unix:  NOTICE: Start mounting filesystem: /usr
```

```
Jul 6 14:57 :ct unix:  NOTICE: Starting XFS recovery on filesystem:/usr
(dev: 0/208)
Jul 6 14:57 :ct unix:  NOTICE: Ending XFS recovery for filesystem: /usr
(/hw/node/xtalk/15/pci/0/scsi_ctlr/0/target/1/lun/0/disk/partition/6/block)
Jul 6 14:57 :ct unix: NOTICE:
Jul 6 14:57 :ct unix: NOTICE: Ending clean XFS mount for filesystem: /usr/g
Jul 6 14:57 :ct unix: NOTICE: Start mounting filesystem: /usr2
Jul 6 14:57 :ct unix: NOTICE: Start mounting filesystem: /data
Jul 6 14:57 :ct unix: NOTICE: Start mounting filesystem: /usr/g
Jul 6 14:57 :ct unix:NOTICE: Ending clean XFS mount for filesystem:/usr2
Jul 6 14:57 :ct unix:NOTICE: Ending clean XFS mount for filesystem:/data
Jul 6 14:57 :ct unix:NOTICE: Ending clean XFS mount for filesystem:/usr/g
```

Comment: May have more image pools when or if the image space is increased.

```
Jul 6 14:57 :ct unix:NOTICE: Start mounting filesystem:
/usr/g/sdc_image_pool
/usr/g/sdc_image_pool
/usr/g/sdc_image_pool2
/usr/g/sdc_image_pool3
Jul 6 14:57 :ct unix:NOTICE: Ending clean XFS mount for filesystem:
 /usr/g/sdc_image_pool
```

Comment: Start Gateway routing daemon

```
Jul 6 14:57 5D:ct10_oc gated[209]: Start gated version 1.9.1.3
Jul 6 14:57 5D:ct10_oc gated[209]: if_init: Acting as RIP supplier to our
direct nets
Jul  6 14:57:42 5B:ct10_oc sendmail: starting
Jul  6 14:57:47 5E:ct10_oc su[704]: succeeded: console changing from root
to root
Jul  6 14:57:47 5E:ct10_oc su[704]: succeeded: console changing from root
to root
Jul  6 14:57:47 6C:ct10_oc sendmail[785]: starting daemon
(950413.SGI.8.6.12): SMTP+queueing@00:15:00
```

Comment: False Error Message: Ignore output that follows.

```
Jul  6 14:57:49 3B:ct10_oc rld[830]:   830:/usr/etc/checkmidi: rld: Fatal
Error: Cannot Successfully Map soname 'libmd.so' under any of the
filenames /usr/lib32/libmd.so:/usr/lib32/internal/libmd.so:/lib32/
libmd.so:/opt/lib32/libmd.so:/usr/lib32/libmd.so.
1:/usr/lib32/internal/libmd.so.1:/lib32/libmd.so.1:/opt/lib32/
libmd.so.1:
Jul  6 14:57:49 6D:ct10_oc dmb[827]: started
Jul  6 14:57:49 3B:ct10_oc rld[832]:   832:/usr/etc/setmididefault: rld:
Fatal Error: Cannot Successfully Map soname 'libmd.so' under any of the
filenames /usr/lib32/libmd.so:/usr/lib32/internal/libmd.so:/lib32/
libmd.so:/opt/lib32/libmd.so:/usr/lib32/libm
d.so.1:/usr/lib32/internal/libmd.so.1:/lib32/libmd.so.1:/opt/lib32/
libmd.so.1:
```

Comment: End of False Errors

```
Jul  6 14:57:49 3B:ct10_oc rld[834]: 834:/usr/etc/setmididefault: rld:
Fatal Error: Cannot Successfully Map soname 'libmd.so' under any of the
filenames /usr/lib32/libmd.so:/usr/lib32/internal/libmd.so:/lib32/
libmd.so:/opt/lib32/libmd.so:/usr/lib32/libm
d.so.1:/usr/lib32/internal/libmd.so.1:/lib32/libmd.so.1:/opt/lib32/
libmd.so.1:
```

Comment: Timeout and reset normal

```
Jul  6 14:58:12 :ct unix: ql1d4: SCSI command timeout:2 commands:0x8 0x12
Jul  6 14:58:12 :ct unix: ql1: Resetting SCSI bus.
```

Comment: Central Data Box alive

```
Jul  6 14:58:12 :ct unix: NOTICE: STS: recvcomp: stat=0x5,scsistat=0x0
Jul  6 14:58:12 :ct unix:
Jul  6 14:58:16 :ct Xsession: ctuser: login
```

Comment: Begin False Error Message

```
Jul  6 14:58:18 :ct Xsession: ctuser: UX:sh (Xsession.dt): ERROR: /usr/g/
ctuser/.desktop-ct10_oc/configchecks/autoconvert: Cannot create
Jul  6 14:58:18 :ct Xsession: ctuser: UX:sh (Xsession.dt): ERROR: /usr/g/
ctuser/.desktop-ct10_oc/configchecks/cleanupSearchbook: Cannot create
Jul  6 14:58:18 :ct Xsession: ctuser: UX:sh (Xsession.dt): ERROR: /usr/g/
ctuser/.desktop-ct10_oc/configchecks/pluginVersions: Cannot create
```

Comment: End False Error Message

```
----------
```

2.2.3 VME Chassis Boot-Up - iceConsole.log

When the **VME** chassis boots up, the Motorola powerPC (**RIP**) logs bootup and application startup communications. The output is logged to `/usr/g/service/log/iceConsole.log` file. There are two methods for viewing this log. One method is using the service desktop, another is using a Unix shell and typing commands.

The following shows a typical sequence of communications that occur of these boards, taken from the iceConsole.log file along with a brief description/interpretation of the output. At a prompt, enter the following:

Example: iceConsole.log

```
{ctuser@bayxx}[1]: cd  /usr/g/service/log
{ctuser@bayxx}[2]: more iceConsole.log
```

Comment: Begin Apps startup

```
Logfile updated Thu Mar 22 10:50:04 2001
```

"Proc_Ice" records the beginning of applications process startup in the "iceConsole log, as above.

*Comment: Reset **VME** Chassis*

```
[VxWorks Boot]: b
```

*Upon executing the "b" command from boot **PROM**, a **VME** reset takes place.*

*Comment: **VME** reset successful*

```
Copyright Motorola Inc. 1988 - 1999, All Rights Reserved
```

*First header printed after a successful **VME** reset.*

Comment: List Version &date

```
PPC1 Debugger/Diagnostics Release Version 4.5 - 09/24/99 RM01
```

Version and dates vary with release.

```
COLD Start
```

Comment: List Clock Speeds

```
Local Memory Found =08000000 (&134217728)
MPU Clock Speed =333Mhz
BUS Clock Speed =67Mhz
```

MPU speed can vary

```
Reset Vector Location  : ROM Bank B
Mezzanine Configuration: Single-MPU
Current 60X-Bus Master : MPU0
Idle MPU(s)            : NONE

L2Cache:       NONE
```

Comment: Check Memory

```
Initializing System Memory (DRAM)...          System Memory: 128MB, ECC Enabled
(ECC-Memory Detected)
```

128MB of system memory must be recognized for applications to startup.

Comment: Begin Transfer of Control

```
PPC1-Bug>rb ;v
```

*Boot **ROM** command prompt.*

```
ROMBoot about to Begin... Press <ESC> to Bypass, <SPC> to Continue
```

Comment: Check that firmware is good

```
Direct Adr: FF000000 FF000000: Searching for ROMboot Module at:  FF000000
Executing ROMboot Module "VxWorks Boot ROM" at FF000000
```

*Good Firmware found, transfer control to VxWorks Boot **ROM** now.*

Comment: VxWorks started

```
                          VxWorks System Boot

Copyright 1984-1998  Wind River Systems, Inc.
CPU: Motorola MVME2300 - MPC 604e
Version: 5.4
BSP version: 1.2/0
Creation date: Mar 20 2001, 21:12:23
```

Comment: Screen Output

Creation Date above can vary

```
[VxWorks Boot]:
```

Comment: VxWorks Boot String Executed

```
[VxWorks Boot]: $dc(0,0)oc:/usr/g/ice/bin/vxWorks.mv2300 e=192.9.220.11
b=192.9.220.12:ffffffff h=192.9.220.1 u=target tn=ice s=/usr/g/ice/bin/init.sh
```

Comment: Begin Parsed Boot string ouput

```
boot device          : dc
unit number          : 0
processor number     : 0
host name            : oc
file name            : /usr/g/ice/bin/vxWorks.mv2300
```

Comment: Kernel location specified

File `/usr/g/ice/bin/vxWorks.mv2300` is located on the host computer

```
inet on ethernet (e) : 192.9.220.11
inet on backplane (b): 192.9.220.12:ffffffff
host inet (h)        : 192.9.220.1
user (u)             : target
flags (f)            : 0x0
target name (tn)     : ice
startup script (s)   : /usr/g/ice/bin/init.sh
```

Comment: End parsed output

Comment: Begin Kernel download

```
Attached TCP/IP interface to dc0.
Attaching network interface lo0... done.
Loading... 1418644
Starting at 0x100000...
```

Comment: End Kernel download

The number of bytes loaded can vary. A loading of Zero (0) bytes indicates a possible problem.

*Comment: Configure & report **SCSI** Devices*

```
Auto-configuring SCSI bus...

ID LUN VendorID    ProductID     Rev. Type  Blocks  BlkSize pScsiPhysDev
-- --- -------- ---------------- ---- ---- -------- ------- ------------
 1  0  SEAGATE  ST318404LW       0006   0  35843670    512    0x017dda88
```

*Comment: Setup **NFS** connection on Host Computer*

```
Attached TCP/IP interface to dc unit 0
Attaching interface lo0...done
Initializing backplane net with anchor at 0x4100... done.
Backplane anchor at 0x4100... Attaching network interface sm0... done.
Creating proxy network: 192.9.220.12
Mounting NFS file systems from host oc for target ice:
```

Comment: Mount /usr/g directory

```
/usr/g
...done
```

*A good /usr/g directory **NFS** mount is important.*

Comment: Load Symbol Table

```
Loading symbol table from oc:/usr/g/ice/bin/vxWorks.mv2300.sym ...done
```

Using a rsh, load the symbol table located on the host.

Comment: Begin output from VxWorks Kernel Boot

```
 ]]]]]]]]]]]]]]]]]]]]]]]]]]]]]]]]]]]]]]]]
 ]]]]]]]]]]]]]]]]]]]]]]]]]]]]]]]]]]]]]]]
 ]]]]]]]]]]]]]]]]]]]]]]]]]]]]]]]]]]]]]]
      ]]]]]]]]]]]  ]]]]     ]]]]]]]]]]       ]]              ]]]]         (R)
 ]     ]]]]]]]]]  ]]]]]]     ]]]]]]]]       ]]              ]]]]
 ]]     ]]]]]]]  ]]]]]]]]     ]]]]]] ]     ]]                ]]]]
 ]]]     ]]]]] ]    ]]]  ]     ]]]] ]]]   ]]]]]]]]]  ]]]] ]] ]]]]  ]]   ]]]]]
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 ]]]]]     ]  ]]]]     ]]]]]      ]]]]]]]] ]]]]   ]] ]]]]    ]]]]]]]    ]]]]
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 ]]]]]]]]]]]]]]]]]]]]]]]]]]]]]]
 ]]]]]]]]]]]]]]]]]]]]]]]]]]]]]       Development System
 ]]]]]]]]]]]]]]]]]]]]]]]]]]]]
 ]]]]]]]]]]]]]]]]]]]]]]]]]]]       VxWorks version 5.4
 ]]]]]]]]]]]]]]]]]]]]]]]]]]       KERNEL: WIND version 2.5
 ]]]]]]]]]]]]]]]]]]]]]]]]]       Copyright Wind River Systems, Inc., 1984-2000

                               CPU: Motorola MVME2300 - MPC 604e.  Processor #0.
                              Memory Size: 0x2000000.  BSP version 1.2/0.
                             WDB: Ready.
```

Comment: End boot output

Comment: Begin Startup scprit

```
Executing startup script /usr/g/ice/bin/init.sh ...

rebootHookAdd mv2305_vme_reset
```

Comment: value = 0 (good)

```
value = 0 = 0x0

#
# disable automatic static constructors
#
cplusXtorSet (0);
```

Comment: value = 0 (good)

```
value = 0 = 0x0
```

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Comment: Setting Memory Options

```
#
# Don't suspend any proxy if memPartFree() invalid block
#
# 0x01 -- MEM__ALLOC_ERROR_LOG_MSG
# 0x04 -- MEM_BLOCK_ERROR_LOG_MSG
# 0x10 -- MEM_BLOCK_CHECK
memOptionsSet (0x01 | 0x10 | 0x04);
```

Comment: value = 0 (good)

```
value = 0 = 0x0

#
# Dynamically load all modules before starting code.
#

#
```

Comment: Load Apps SW Modules

```
# load application modules
#
cd "/usr/g/ice/bin";
```

Comment: value = 0 (good)

```
value = 0 = 0x0
ld < vxMonitor_pegasus.ppc
```

Comment: value = 0 (bad)

```
value = 24347656 = 0x1738408
```

An error message here means that Application SW will not likely start.

```
#
# disable scanfile debug messages
#
```

Comment: value = 0 (good)

```
_scanfile_debug = 0;
_scanfile_debug = 0x1283010: value = 0 = 0x0

#
# Add the rest of the heap before starting code,
# but after loading modules.  DO NOT LOAD ANY MODULES AFTER THIS.
#
```

Comment: value = 0 (good)

```
memPartAddToPool (memSysPartId, sysMemTop (), sysPhysMemTop () - sysMemTop ());
value = 0 = 0x0


#
# call the static constructors
#
```

Comment: value = 0 (good)

```
cplusCtors (0);
value = 0 = 0x0
```

Comment: Begin comments(#)

```
# task option defines
# VX_FP_TASK (0x0008)
#     execute with floating-point coprocessor support.
# VX_PRIVATE_ENV (0x0080)
#    include private environment support (see envLib).
# VX_NO_STACK_FILL (0x0100)
#     do not fill the stack for use by checkStack( ).
#VX_UNBREAKABLE (0x0002)
#     do not allow breakpoint debugging.
#
```

Comment: End Comments

```
# enable round-robin time slicing between equal tasks
#
```

Comment: value = 0 (good)

```
kernelTimeSlice (1);
value = 0 = 0x0
```

Comment: Sart HW watchdog timer on Motorola Bd.

```
#
# Setup the HW watchdog timer in case CPU gets so we can't reboot normally
# Task runs every 90 seconds and sets watchdog timeout to 124 seconds
taskSpawn ("watchDog", 100, 0x0008, 20000, periodRun, 90, sysHwWatchdogSet, 124,
1, 0, 0, 0);
value = 134174256 = 0x7f0xf56307ff5630 (watchDog
): sysHwWatchdogSet[
0]: timer set to #124 seconds; reset=
1
# Initialize ermes database
#
```

Comment: value = 0 (good)

```
putenv ("LOGHOST=oc");
value = 0 = 0x0
```

Comment: value = 0 (good)

```
msgHandlerInit ();
value = 0 = 0x0

#putenv("RECONMGRDEBUG=0x00001000");

#
# set the network credentials for file access
#
```

Comment: value = 0 (good)

```
nfsAuthUnixSet ("oc", 100, 100, 0, 0);
value = 0 = 0x0
```

Comment: Begin Scan Data Disk Configuration & Mount function

```
#
# configure and mount the scan disk
#
usrScsiDiskInit (1, "/raw_data");
/raw_data/  - disk check in progress ...

WARNING : dosChkLib : system clock is being set to THU MAR 22 06:32:22 2001
Value obtained from file system referenced by volume descriptor pointer: 0x7ff9ea8
The old setting was THU JAN 01 00:00:00 1970
Accepted system dates are greater than FRI JAN 01 00:00:00 1999
/raw_data/  - Volume is OK

         total # of clusters:17,503
          # of free clusters:3,762
           # of bad clusters:0
            total free space:3,762 Mb
     max contiguous free space:  1,845,493,760 bytes
                # of files:433
               # of folders:18
        total bytes in files:13,521 Mb
            # of lost chains:0
```

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```
   total bytes in lost chains:  0

volume descriptor ptr (pVolDesc):0x7ff9ea8
cache block I/O descriptor ptr (pCbio):0x7ffb520
auto disk check on mount:DOS_CHK_ONLY | DOS_CHK_VERB_1
max # of simultaneously open files:34
file descriptors in use:0
# of different files in use:0
# of descriptors for deleted files:0
# of  obsolete descriptors:0

current volume configuration:
 - volume label:NO LABEL ; (in boot sector:)
 - volume Id: 0xee220200
 - total number of sectors:35,843,670
 - bytes per sector:512
 - # of sectors per cluster:2,048
 - # of reserved sectors:32
 - FAT entry size:FAT32
 - # of sectors per FAT copy:137
 - # of FAT table copies:2
 - # of hidden sectors:0
 - first cluster is in sector #306
 - directory structure:VFAT
 - root dir start cluster:2

FAT handler information:
------------------------
 - allocation group size:2 clusters
 - free space on volume:3,944,742,912 bytes
Disk Cache, /raw_data:
Cached Block I/O Device, handle=0x7ffb520
       Description: Disk Cache - LRU
       Disk size 17 Gbytes, RAM Size 2097152 bytes
       Block size 512, heads 0, blocks/track 0, # of blocks 35843670
       partition offset 0 blocks, type Fixed, Media changed No
Total cache Blocks 3774, 0 blocks (%0) dirty
Tunable Params:
   Bypass Threshold 2, Max Dirty 254, Read Ahead 32 blocks, Sync interval 0 sec
Hit Stats: Cookie Hits 16948 Miss 272, Hash size 2221 Hits 2495 Miss 1651
   LRU Hits 2493, Misses 127, Hit Ratio %95
Write Sstats: Foreground 0, Background 0, Hidden 0, Forced 137

Subordinate Device Start:
Cached Block I/O Device, handle=0x7ffb5a8
       Description: Block Device
       Disk size 17 Gbytes, RAM Size 0 bytes
       Block size 512, heads 0, blocks/track 0, # of blocks 35843670
       partition offset 0 blocks, type Fixed, Media changed No
Subordinate Device End:
value = 0 = 0x0
```

Comment: End configuration and mounts

A value of zero is returned by the "usrScsiDiskInit" function, if successful.

```
ttsFlag = 0
ttsFlag = 0x128330c: value = 0 = 0x0
#
# Start the applications
#
```

Comment: Start VxMonitor

```
taskSpawn ("vxmonitor", 100, 0x0008, 500000, vxmonitor);
value = 132051792 = 0x7def350THU MAR 22 10:50:5
5.000 2001
```

Value can vary by SW release. VxMonitor is started to spawns and manages task on Motorola.

```
#
# put the nettask same as dataacq

#
netTaskPriority = 52;stderr i
s redirected to fd netTaskPriority15 = 0x
241f14: value = 52 = 0x34 = '4'
taskPrioritySet(taskNameToId("tNetTask"), netTaskPriority);
value = 0 = 0x0

#
# done
#
```

Comment: End Startup Script

```
Done executing startup script /usr/g/ice/bin/init.sh
```

Comment: Applications SW startup Output

```
-> num_offset_views : 512
offset_first_view : 0
offset_reuse_window : 30.000000
rebin:successfully initialized.
daGetConfigValue: dataacq.cfg, da_timeout_delta, '0'
daGetConfigValue: dataacq.cfg, da_dip_mem_and_save_size, '2048'
daGetConfigValue: dataacq.cfg, da_debug, '0x00000'
dip_execute_test_sequence: 0
dip_execute_test_sequence: 2
dip_execute_test_sequence: 5
RESTORE successfully initialized
```

Comment: Startup complete

```
*** reconmgr: GOING INTO EVENT LOOP  ****
```

Recon subsystem is now up and running.

Comment: Shutdown requested

```
-> mv2305_vme_reset
```

The above command indicates a shutdown has been requested by the host.

2.3 Attached Devices

2.3.1 Host Devices

HOST DEVICE	OCTANE	COMMENTS
serial port 1	/dev/ttym1	used for modem (with **PPP**)
----------	/dev/ttyd2	Used for Service Key
serial port 1	/dev/console	if **EPROM** configured for serial console(d)
ethernet	/ef0	Internal ethernet network for scanner operation
ethernet	/ef1	External ethernet network connection via **PCI** Card to hospital network
printer	/dev/plp	Centronics parallel printer port (NOT USED)
audio in/out		system audio and AutoVoice record/play
keyboard	/dev/keybd	PS/2 keyboard (type 3)
ice	/dev/ttydp02	**RIP** (**CPU**) Board - Serial
rhard	/dev/ttydp00	Hard reset line to Gantry - Serial
pig	/dev/ttydp01	Pegasus Board - Serial
mouse	/dev/mouse	PS/2 mouse

Table 3-5 Host Devices - Filesystem Names

2.3.2 Host High Speed Bus Devices

These are the boards used for graphics and/or communications.

Note: Graphics Head Assignment

If the board controlling the primary monitor is removed, the secondary board and monitor become the primary head by default.

Because the boards are interchangeable, this feature is useful in determining whether one board is good or possibly defective. If one of the monitors is blank or faulty, you can use the **/usr/gfx/gfxinfo** command to see which boards the host recognizes and swap their locations.

COMMAND	XIO (OCTANE)	COMMENTS
/dev/gfx	**SI** with **TRAM**	Primary head is controlled by first recognized gfx
/dev/gfx	Solid Impact	1.) Secondary head is controlled by next recognized gfx. 2.) On Octane, the **SI** board with a **TRAM** module must be installed in the top graphic board location, for proper display performance.

Table 3-6 High Speed Devices - Filesystem Names

2.3.3 Host (Octane) SCSI Devices

2.3.3.1 Host SCSI Bus Information

There are two **SCSI** buses used in the Octane host computer: **SCSI** Bus 0 and **SCSI** Bus 1.

SCSI Bus 0 contains the internal drive bays of the Octane host computer. There are NO JUMPERS on the system disk or optional disk sled assemblies. The optional disk is a customer purchased option for more image space. The system disk drive in the bottom drive bay is auto sensed as **SCSI** ID 1. The optional disk in the middle drive bay is auto sensed as **SCSI** ID 2. The top drive bay is auto sensed as **SCSI** ID 3 and is currently not used.

SCSI Bus 1 is the external **SCSI** bus from the Octane host computer. **SCSI** bus 1 contains all other **SCSI** and removable media devices. All devices on **SCSI** bus 1 have jumpers and are **SCSI-1** or **SCSI-2** 8-bit devices.

2.3.3.2 Host SCSI Device Chart

SCSI DEVICE	OCTANE	COMMENTS
System disk partition	/dev/dsk/dks0d1s*Z*	where *Z* is the partition number: *Z* = 0,1,3,5,6,7
Scan Data Disk	/dev/dsk/dks0d2sZ	where *Z* is the partition number: *Z* = 0,1,2,3 for 2nd disk
Disk	/dev/scsi/sc0d1l0	Boot/Op/Apps
Disk	/dev/scsi/sc0d2l0	Scan Data
MOD	/dev/scsi/sc1d3l0	Image archive device
CD-ROM	/dev/scsi/sc1d6l0	**LFC** and **CBT** device
DASM	/dev/scsi/sc2d1l0	/dev/dasm1 device link

Table 3-7 SCSI Devices - Filesystem Names

The general form of the **SGI SCSI** devices output listing is:

disk partition as a filesystem = /dev/dsk/dks*X*d*Y*Z
or
generalized **SCSI** device = /dev/scsi/sc*X*d*Y*Z
where:
X is the **SCSI controller channel** (0 = **SCSI** bus0, 1= **SCSI** bus 1l)
Y is the **unit number** (OC disk is unit 1, **MOD** is unit 3 and **CD-ROM** is unit 6)
Z is the **partition ID** (filesystem s0, s1, s2,...), volume (vol), or other (l0)

2.3.3.3 fx Utility

The IRIX '**fx**' **SCSI** utility can be used to test or exercise almost any **SCSI** device. It checks devices like the **MOD**, **CD-ROM**, and hard drive. It does not look for **DASM**. To non-destructively test the system disk or the optional disk, follow the example below EXACTLY until you are comfortable with '**fx**'. This utility is safe when "*used as directed*". To be sure that you don't conflict with any application software, such as Archive, shut down **CT** applications software only (using the service desktop utility), and run '**fx**' tests from any IRIX shell script as 'root'.

⚠ **NOTICE Potential For Data Loss**

THIS UTILITY IS CAPABLE OF DESTROYING ALL SOFTWARE AND DATA IMMEDIATELY ON ANY SCSI DEVICE, IF IT IS USED IN SPECIAL EXPERT MODES NOT DOCUMENTED HERE. PLEASE DO NOT EXPERIMENT WITH THIS UTILITY.

Example: Using the **FX** command

This example will READ every data block on the system disk. If there are any errors after several retries, the block in question will be remapped to a good spare sector (block), and the data will be recovered (if possible).

This example can be used to test most **SCSI** devices (not **DASM**) by using the correct ctlr# and drive# (**MOD** and **CD-ROM** require media installed). To test other drive types, run **scsistat** to identify the correct controller and drive number.

Comment: Must be root

```
{ctuser@engbay24}[1] su
Password:
```

Comment: Enter FX Utility

```
{ctuser@engbay24}[1] fx
fx version 6.4, Sep 17, 1997
```

Comment: Use default

```
fx: "device-name" = (dksc)
```

Comment: Controller #

```
fx: ctlr# = (0)
```

*Comment: Device **SCSI** ID*

```
fx: drive# = (1)
```

Comment: Use Default

```
fx: lun# = (0)
...opening dksc(0,1,0)
```

Comment: Disk Mounted

```
fx: partitions in use detected on device
fx: devname              seq owner   state
fx: /dev/rdsk/dks0d1s7    5 xfs     already in use
fx: /dev/rdsk/dks0d1s6    4 xfs     already in use
fx: /dev/rdsk/dks0d1s5    3 xfs     already in use
fx: /dev/rdsk/dks0d1s3    2 xfs     already in use
fx: /dev/rdsk/dks0d1s0    1 xfs     already in use
fx: Warning:  this disk appears to have mounted filesystems.
         Don't do anything destructive, unless you are sure
         nothing is really mounted on this disk.
...drive selftest...OK
```

Comment: Device Model

```
Scsi drive type == SGI     QUANTUM XP34550WLXY4
----- please choose one (? for help, .. to quit this menu)-----
[exi]t              [d]ebug/            [l]abel/
[b]adblock/         [exe]rcise/         [r]epartition/
```

Comment: Exercise Drive

```
fx> exe
----- please choose one (? for help, .. to quit this menu)-----
[b]utterfly           [r]andom              [st]op_on_error
[e]rrlog              [se]quential          [m]iscompares
```

Comment: Use Sequential

```
fx/exercise> se
```

Comment: Read only mode

```
fx/exercise/random: modifier = (rd-only)
```

Comment: Starting block number

```
fx/exercise/random: starting block# = (0)
```

Comment: Number of blocks to test

```
fx/exercise/random: nblocks = (8888543)
```

Comment: Number of passes to run

```
fx/exercise/random: nscans = (1)
random pass 1: scanning [0, 8888543] (8888543 blocks)
```

Comment: Percent complete

```
0%
```

*Comment: **CTRL-C** aborts*

```
(use 'CTRL-C' to stop the testing at any time)
----- please choose one (? for help, .. to quit this menu)-----
[b]utterfly           [r]andom              [st]op_on_error
[e]rrlog              [se]quential          [m]iscompares
```

Comment: Go up 1 menu level

```
fx/exercise> ..
----- please choose one (? for help, .. to quit this menu)-----
[exi]t              [d]ebug/            [l]abel/
[b]adblock/         [exe]rcise/         [r]epartition/
```

*Comment: Exit **fx** utility*

```
fx> exit
```

NOTICE Potential For Data Loss

If '**fx**' asks you to "`update the label`", always enter '**NO**'.

Section 3.0
Networking and Communications

The system has both serial and **LAN** communication lines that run between the OC (Octane) and the **ICE** (Motorola **RIP**). These communication lines coordinate scanning and recon activities across the computers. Refer to Figure 3-5 to manually check the communication lines serially and halt, reboot, or reset. Refer to Figure 3-6 to manually check the **LAN** Communications from the OC to the **ICE**, and to the **STC**, **ETC**, and **OBC** controllers.

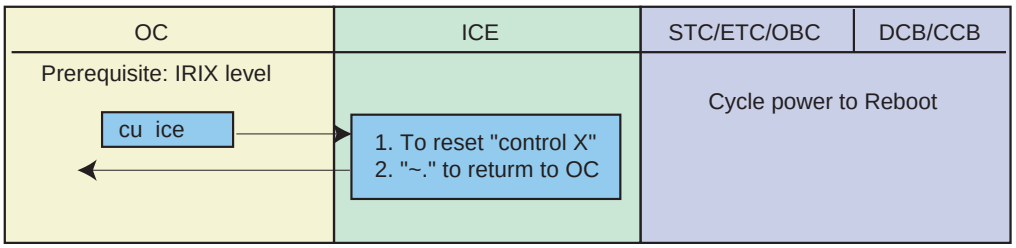

Figure 3-5 Serial Communications

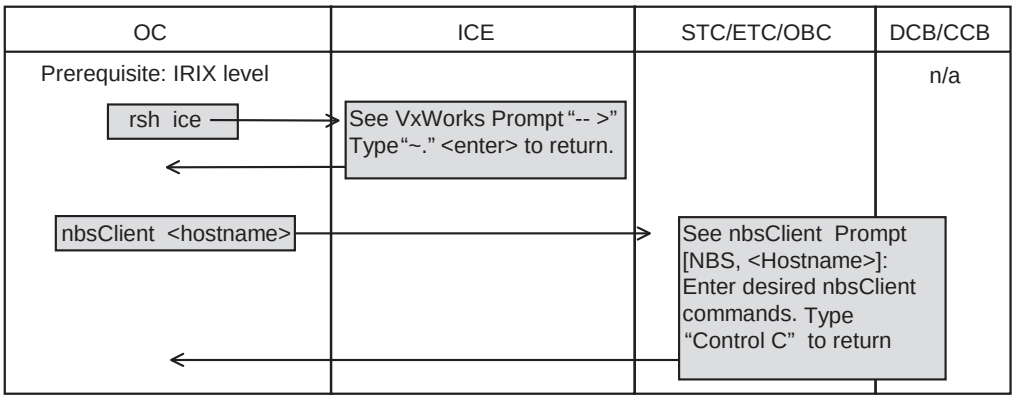

Figure 3-6 LAN Communications

3.1 Validating OC Network Connection

There are two command line executables that can be used to check OC network configuration and status: **`ifconfig`** and **`netstat`**.

3.1.1 `ifconfig` - Network interface Configuration

The command **`ifconfig`** can be used to verify that the network interface is running and is correctly configured on the system's network. The interface is defined as running when it has been probed, attached, and started by the OS (host). There are several devices that are important to host network operation. On the host side, the internal network device name is **`ef0`**. The external network device name is **`ef1`**. Use the **`ifconfig`** as follows to get configuration data about your network. At a command line on the OC, enter **`ifconfig`** followed by the device you want to inspect. Use **`ef0`** for the internal network or **`ef1`** for external network. An example of the **`ifconfig`** use follows:

Example: Check Host's internal/external networks.

```
>>ifconfig ef0
ef0:flags=1c63<UP,BROADCAST,NOTRAILERS,RUNNING,FILTMULTI,MULTICAST,CKSUM
inet 192.9.220.10 netmask 0xffffff00 broadcast 192.9.220.0
```

Comment: *IP address 192.9.220.10 is a fixed internet number assigned to the Host.*

```
>>ifconfig ef1
ef1:flags=ic63<UP,BROADCAST,NOTRAILERS,RUNNING,FILTMULI,MULTICAST,CKSUM>
inet 3.7.52.40 netmask 0xfffffc00 broadcast 3.7.55.255
```

Comment: *IP addresses (e.g. 3.7.52.40), netmask, and broadcast will depend on your own network configuration.*

3.1.2 `netstat` - Network Status

The command **`netstat`** can be used to obtain network status about your network configuration *on your system*. At a command line on the OC, enter **`netstat`** followed by the appropriate argument. Using the **`-i`** argument, you can obtain status on your system's network. Using the **`-r`** argument, you can obtain status on the devices routed by your network (such as an external suite). An example of the **`netstat`** usage initiated from the host using both arguments follows:

Example: Using the **`netstat`** command to check the network status

```
{ctuser@suite1}[1] netstat -i
Name Mtu   Network     Address      Ipkts Ierrs    Opkts Oerrs  Coll
ef0  1500  192.9.220  suite1      105044     0    46423     0     0
vd0* 4336  none       none             0     0        0     0     0
ef1  1500  3.7.52     suite1-gate 52809     0    15553     0   106
ppp0 1500  (pt-to-pt) olc-pm1          0     0        0     0     0
lo0  8304  loopback   localhost  290542     0   290542     0     0
{ctuser@suite1}[2]

>>netstat -r
Destination     Gateway         Netmask   Flags   Refs    Use  Interface
default          medctc1us                   UG      0      0    ef1
3.1.4            medctc2us    0xfffffc00     UG      0      0    ef1
3.1.20           medctc2us    0xfffffc00     UG      0      0    ef1
3.7.52           suite1-gate  0xfffffc00      U      0      6    ef1
192.9.220        suite1       0xffffff00      U     29     77    ef0
suite1           localhost                 UGHS    186     10    lo0
```

3.2 nbsClient

The nbsClient network boot server enables you to review the Scan Control Network **CPU** boards statuses and activity.

Follow the list of steps below to connect to the **STC**, **OBC**, and/or **ETC CPU** board controllers.

At the Operators Console console:

1.) Open an UNIX shell on the right-hand display.

2.) type **`nbsClient`** ***`<controller>`*** **ENTER**

`<controller>` = **stc** or **etc** or **obcr**

CNTRL+C Logs you out of the nbsClient session.

Note: The following applies to the controllers:

- You can only access the controllers for a short time before they log you out. Get the info, then press **CNTRL+C** to exit the session.
- Staying logged into the controllers for too long a period can cause errors, keep the sessions as short as possible.

```
==============================================================
List of nbsClient commands for controllers
==============================================================

Command                    Description
?                           Print this list
@                           Boot (Load and go)
 p                          Print boot params
 c                          Change boot params
 l                          Load boot file
 n                          Display Host/Routing Table
 g adrs                     Go to adrs
 d adrs[,n]                 Display memory
 m adrs                     Modify memory
 f adrs, nbytes, value      Fill memory
 e                          Print fatal exception
 a                          Print value of PC
 i                          Print Boot Revision and GIM
 r type                     Reboot, type = 'soft' or 'hard'
 s device [c]               Print[clear] SCA or R/SCOM driver statistics
 t cmd                      Run diag, cmd = led value(s) of HK tests
 u TID                      Print TCB info for specified TID
 v TID                      Summarize TCB info, TID = 0 => all
 w TID                      Summarize stack usage, TID = 0 => all
 x TID                      Print a stack trace of TID
 y                          Dump the error log
 z                          Pipe the error log to the console
 #hlp                       Display Flash Command Usage
```

Table 3-8 List of nbsClient Commands for Controllers

```
$dev(0,procnum)host:/file h=# e=# b=# g=# u=usr [pw=passwd] f=#
=============== =============
```

3.3 Networking

3.3.1 Host Network

There are two command line executables that can be used to check OC network configuration and status. They are **ifconfig** and **netstat**.

3.3.1.1 ifconfig

The command **ifconfig** can be used to verify that the network interface is running and is correctly configured on *your system only*. The interface is defined as running when it has been probed, attached and started by the OS (host). There are several devices that are important to host network operation. They are the gateway (**ef0**) and the BIT3 (**vd0**) devices. Use the **ifconfig** as follows to get configuration data about your network. At a command line on the OC, type **ifconfig** followed by the device you want to inspect—use **ef0** or **vd0**. An example of the **ifconfig** use follows:

Example: Using the **ifconfig** command to check the host network

```
>>ifconfig ef0
ef0:flags=1c63<UP,BROADCAST,NOTRAILERS,RUNNING,FILTMULTI,MULTICAST,CKSUM
inet 3.7.52.150 netmask 0xffffc00 braodcast 3.7.52.0
```

IP addresses (e.g. *3.7.52.150*) will vary and depend on your own network configuration

```
>>ifconfig vd0
vd0:flags=8e3<UP,BROADCAST,NOTRAILERS,RUNNING,NOARP,MULTICAST>
inet 192.2.100.1 netmask 0xffffc00 braodcast 192.2.100.255
```

3.3.1.2 netstat

The command **netstat** can be used to obtain network status about your network configuration *on your system*. At a command line on the OC, type **netstat** followed by the appropriate argument. Using the **-i** argument, you can obtain status on your system's network. Using the **-r** argument, you can obtain status on the devices routed by your network (such as an external suite). An example of the **netstat** usage initiated from the host using both arguments follows:

Example: Using the **netstat** command to check the network status

```
>>netstat -i
Name  Mtu   Network    Address    Ipkts    Ierrs   Opkts    Oerrs   Coll
ef0   1500  3.7.52     rhap25     655083   0       258478   1       141141
vd0   4336  192.2.100  ct01_oc0   19178    30      20406    53      0
lo0   8304  loopback   localhost  965831   0       965831   0       0

>>netstat -r
192.2.100   ct01_oc0    0xffffff00  U     83    195   vd0
```

3.3.2 Procedure to Create or Add a Static Route to the CT System

OVERVIEW

This procedure is used to turn off the routing daemon (if it is not already off), and add a default network route (static route) on a **CT** system that is part of a hospital network.

This applies to all LightSpeed software version 3.6 and above. The typical application is to connect a CT system to a network that uses a router or static routing instead of **RIP**.

PROCEDURE

It is recommended that you discuss your site's specific needs with the Network Administrator before performing this procedure. If you need assistance performing these steps, please contact the Network Support Group at the OnLine Center.

Note: Please be aware that if this procedure is performed on a system, it will need to be performed again following a software reload. Prior to performing a software reload, ensure that changes to the files addressed in this procedure are documented.

1.) Open a UNIX shell and switch user to root:

`su` - (and enter the root password)

2.) Change directory as follows:

`cd /etc/config`

3.) Create a backup copy of the static-route.options file:

`cp static-route.options static-route.options.lfc`

4.) Determine the desired static route IP address(es) from the site's Network Administration. Add these desired static routes to the static-route.options file. It is preferred to use the “jot” text editor to modify the file, as “jot” is an X-Windows screen editor with an intuitive user interface.

`jot static-route.options`

5.) Add the desired route address(es) at the end of the file, using the following syntax:

`$ROUTE $QUIET add default www.xxx.yyy.zzz` (where this is the IP Address of the default router, provided by the site)

or

`$ROUTE $QUIET add -net www.xxx.yyy.zzz` (where this is the IP Address of the network/subnetwork, provided by the site)

or

`$ROUTE $QUIET add www.xxx.yyy.zzz` (where this is the IP Address of a specific host, provided by the site)

6.) Save the changes to the static-route.options file using the FILE pulldown menu.

7.) Exit "jot".

8.) Verify the entries made to the static-route.options file by typing:

`more static-route.options`

9.) Reboot the system for the changes to take effect.

Section 4.0
Applications and Features

4.1 Accounts

The system has several accounts. The most commonly used account is "`ctuser`," which is automatically logged in on power-up. All the accounts are listed within the `/etc/passwd` file. To display the most used accounts, enter the following:

`ctuser@msecrp1}[7]` **`more /etc/passwd`**

... (This is an abbreviated list)

```
root:Q87bSMq1pevEM:0:0:Super-User:/:/bin/csh
ctuser:f8QFGFmn93MaQ:100:100:Advantage Windows Home Account:/usr/g/
ctuser:/bin/csh
genesis:f8QFGFmn93MaQ:100:100:Advantage Windows Home Account:/usr/g/
ctuser:/bin/csh
insite:osDybj5bv8LjQ:101:101:Insite Account:/usr/g/insite:/bin/csh
{ctuser@msecrp1}[8]
```

On each line there are seven fields separated by a colon (:). The first field is login name, and the second field is its encrypted password. All the fields are explained in the **`man`** page for **`passwd`**. User accounts and passwords are listed in the table below.

USER	PASSWORD
`ctuser`	**`4$apps`**
`root`	**`#bigguy`**
`genesis`	**`4$apps`** or **`genesis`**

Table 3-9 Accounts and Passwords

4.2 Program Folder

On the upper left of each monitor there is a programs folder. The programs folder includes a CONSOLE shell icon, and any UNIX shell icons that were started that have been minimized (iconified).

Console shell: The CONSOLE shell logs general output (debug type messages) from processes started during Application Startups and Shutdowns.

Figure 3-7 Program Folder

The process to move the program folder forward is as follows:

1.) **ALT** + **F3** to bring the folder forward (foreground).
2.) Double click an icon to open (processes shown as icons).
3.) Click on the (o) in the upper right corner of the shell to close.
4.) Click on the (-) in the upper left corner of the shell and select exit to dismiss.

4.3 Tool Chest

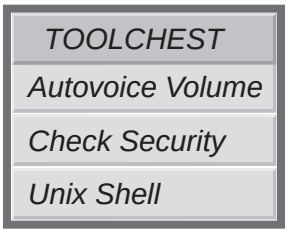

Figure 3-8 Toolchest Menu

The Toolchest menu resides in the upper right-hand corner of the desktop on both the left and right display heads. It is accessible either when the system is at IRIX level only or when Applications are up. The Toolchest has three functions: AUTOVOICE VOLUME, CHECK SECURITY, and UNIX SHELL.

AUTOVOICE VOLUME - When selected, opens up a tool for the user to adjust the volume contol for Autovoice.

CHECK SECURITY - A function used to force a read of the security key to gain access to applications appropriate for that key. This is useful when installing a key after Applications are up, rather than waiting for the system (sidney process) to read the key.

UNIX SHELL - When selected, opens up a shell tool at the OC prompt for entering commands. UNIX shells are started in a X-Window environment.

Sometimes the Toolchest is in the background. You can switch it to the foreground or background windows with the key strokes **ALT+F3**.

4.4 Verify Security

The Verify Security feature reads and reports the level of security allowed by the key that is installed or not installed. This feature also reports the date the key will expire. The Verify Security function can be used to verify the system is properly reading the key.

The VERIFY SECURITY command resides in the Service Desktop, under the UTILITIES TOOLS tab. Security can also be verified by typing: `test_check_security -v` **ENTER** within an Unix shell.

4.5 Application Start-up/Shutdown Operation

When you power-on the console, the Host Computer (Octane) runs a selftest. After a successful selftest, it boots from its own local disk. On the OC, once IRIX is up, `ctuser` will automatically log-in and begin the auto-start of application software on the OC. A pop-up window will then appear notifying the user that he or she has five seconds to abort the auto-start.

When the system's application platform is up (refer to Figure 3-9 and Figure 3-10), the **ETC**, **STC**, and **OBC** are commanded to perform a hardware reset. This takes approximately 60 seconds. Next, the Host will download firmware to the **ETC**, **STC**, and **OBC**. Finally, firmware is downloaded to the collimator and **DAS** subsystem controllers.

4.5.1 Application Screens

When applications are up and running, Scan RX is the default desktop. You can show the program's folder or the Toolchest by positioning the mouse in either of the upper corners (refer to Figure 3-9 and Figure 3-10) and then pressing **ALT+ F3**. Hold down the **ALT** key and press the **F3** key at the same time. Use **ALT+ F3** as a toggle to move icons in and out of the foreground.

Figure 3-9 Application Screen (Left Monitor Head)

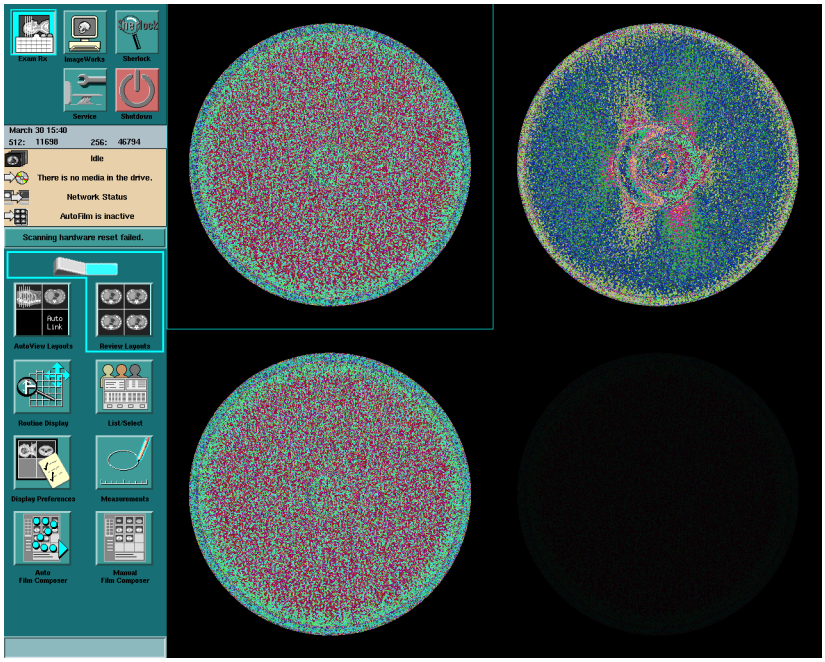

Figure 3-10 Application Screen (Right Monitor Head)

4.5.2 Applications Shutdown and Startup

4.5.2.1 Application "Only" Shutdown

To shutdown the applications platform only, and leave IRIX up on the OC, select UTILITIES and APPLICATION SHUTDOWN. This will leave you at the IRIX desktop environment. If you need to restart applications, refer to Section 4.5.2.2, on page 195. The need to shutdown applications only applies when running certain programs, such as **reconfig**.

Table 3-10 shows how applications processes in each of the subsystems are shut down as a result of selecting the softkeys (SERVICE DESKTOP > UTILITIES > APPLICATION SHUTDOWN).

STATE	OC	ICE	STC/ETC/OBC	DCB/CCB
Initial	Applications	Applications	Applications	Applications
Softkey Actions	SERVICE DESKTOP > UTILITIES > APPLICATION SHUTDOWN			
Final	IRIX	VxWorks	VxWorks	

Table 3-10 System Down Process Sequence

4.5.2.2 Application Startup (from IRIX level)

You must be at the IRIX desktop environment.

1.) From the Toolchest, select UNIX SHELL.

2.) Type **st** to start system.

Table 3-11 shows how applications processes are restarted in each of the subsystems by entering **st** in a shell.

STATE	OC	ICE	STC/ETC/OBC	DCB/CCB
Initial	IRIX	n/a		Firmware
User Action	Open a shell and type **st** **ENTER**			
Final	Apps	Apps	Apps	Apps

Table 3-11 Application Startup (from IRIX Level) Process Sequence

4.5.2.3 Halting to Boot Level (from IRIX level)

You must be at the IRIX desktop environment.

1.) From the toolchest, select UNIX SHELL.

2.) Type **sd** to halt system.

Table 3-12 shows how the operating systems in each of the subsystems are shut down by entering **sd** in a shell.

STATE	OC	ICE	STC/ETC/OBC	DCB/CCB
Initial	IRIX	n/a	VxWorks	Firmware
User Action	Open a shell> type **sd** **ENTER**			
Final	**PROM** Monitor	**PROM** Monitor		Firmware

Table 3-12 Halt to Boot (from IRIX Level) Process Sequence

4.5.2.4 Preventing Automatic Shutdown During Startup

Applications software can be prevented from automatically shutting down the system, if an error occurs during startup. If applications software encounters an unrecoverable error during startup, it attempts to recover. However, sometimes the error is so severe that software must terminate and shut down the system. Thus preventing the use of tools to isolate the failure.

The procedure that follows can be used to prevent automatic shutdown.

1.) Before the system startups **CT** applications software, the following popup confirmation box is displayed.

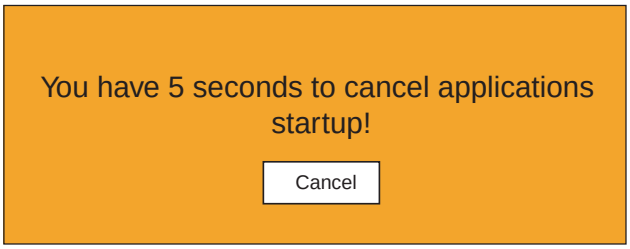

Figure 3-11 Cancel Applications Startup Screen

Using the mouse, left click the CANCEL button within 5 seconds of the window being displayed

2.) Immediately after clicking Cancel, the following popup message box appears.

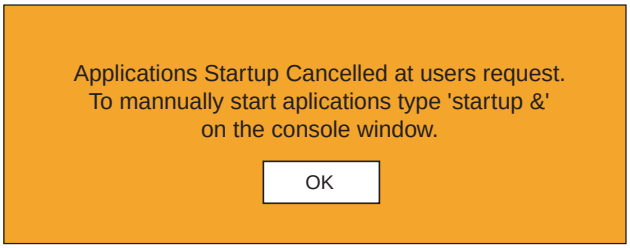

Figure 3-12 Applications Startup Cancelled Acknowledgement Screen

Using the mouse, left click the OK button.

3.) From the `TOOLCHEST`, use the mouse and left click on the UNIX SHELL button.

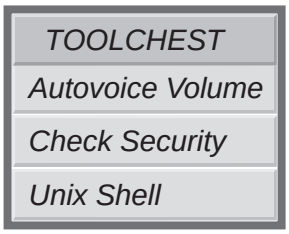

Figure 3-13 ToolChest

4.) At the prompt, in the Unix Shell, type: **`setenv NOHOSTSHUTDOWN`** **ENTER**

The above command prevents the applications startup process from shutting down if an error is encountered.

5.) Now start applications software by typing: **`startup &`** **ENTER**

Applications software will startup and not terminate if an error is encountered.

4.5.3 System Shutdown and Restart

4.5.3.1 Shutdown to Boot Prom Level (from applications)

NOTICE
Potential for loss of data

Because of the way in which the operating system software makes use of disk caching, follow the recommended shutdown procedure to give the system a chance to write any information in the cache buffers to the disk before you turn OFF power.

Use the following procedure to minimize the chance that the system leaves any files in a bad state.

1.) Select SHUTDOWN on the right head to stop scanner applications and OS software (refer to Figure 3-14).

Figure 3-14 Shutdown Button

A script starts that synchronizes the operating system file structure, and halts the operating system on the OC host computer. Table 3-13 shows the final state of each of the subsystems after selecting SHUTDOWN.

STATE	OC	ICE	STC/ETC/OBC	DCB/CCB
Initial	Apps	Apps	Apps	Apps
User Action	Select SHUTDOWN			
Final	**PROM** Monitor	**PROM** Monitor	VxWorks	

Table 3-13 System Shutdown (from applications) Process Sequence

2.) You may power off the console power switch when you see the message in Figure 3-15.

3.) You can turn off the System Mains Disconnect to remove all system power.

4.5.3.2 Restarting from a System Shutdown

Click RESTART using the mouse to bring up the operating system and applications. If you have just powered up the system, this will happen automatically. You will have an opportunity (five seconds) to stop applications autostart and remain at the IRIX desktop level.

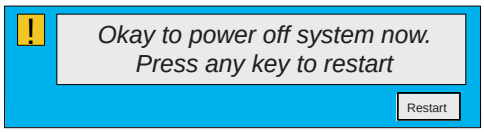

Figure 3-15 Power Off Message

4.6 Magneto-Optical Disk (MOD)

MODs labeled (formatted) for storing images have a DOS-like structure. **MOD**s formatted for software have a UNIX structure. There are some DOS MODE commands in `/usr/g/bin` to help you view and copy files between the Image Archive media and the system. The size of DICOMDIR indicates how much space images are taking on the **MOD**. You must use Image Works to DETACH, then do another **`dmls`** in a shell to see an updated size.

`dmls`	list files of current directory
`dmcd` ***`<path>`***	change to the directory identified by path
`dmcat props`	show content of the file props, which tells you the properties of that media
`dmcat stat`	show content of the file stat, which shows last time media was used
`dmcpin -b` ***`<dosname> <unixname>`***	copy file on media to the system

4.7 User Informational Tools

CBT SOFTWARE HARD DISK SPACE REQUIREMENTS

Computer Based Training (**CBT**) software is provided with the system to assist the operator. By using the **CBT** and operator reference manual, users can quickly obtain the necessary skills to operate this **CT** scanner in an efficient and effective manner.

During installation, the **CBT** makes safe, minor changes to the system disk. The **CBT** creates/modifies user information files (e.g., for bookmarks). To do this, the **CBT** software requires predefined hard disk area and an IRIX path name to access it. The following directory is added:

`/usr/g/cbt`

This directory contains the necessary **CBT** startup files and executables. This directory is also used and should be used to store the **CBT** bookmarks as necessary.

Section 5.0
Procedures and Adjustments

5.1 Setting Date and Time

If the timezone is wrong, you must run **reconfig** on the OC to select the correct one.

1.) On the Service Desktop, select **Utilities –> Shutdown Applications**.

2.) Open a UNIX Shell and become <root> in the OC window.

3.) Enter: **su**

Enter the super user (root) password, default password is **#bigguy**)

4.) Enter: **setdate**

You will now be presented with a series of date questions. Enter time specific values.

```
The month is ? <MM>
The day is ? <DD>
The hour is ? <HH>
The minute is ? <mm>
The year is ? <YYYY>
```

MM is month (01–12), ***DD*** is day (01–31), ***HH*** is hour (00–23), ***mm*** is minutes (0–59), ***YYYY*** is the year. Verify that both the OC is set to the desired time and date.

5.) Close the shell by typing: **exit**

6.) Type:**st** to restart application software.

5.2 Screen Saver Setup

You can turn the screen saver on or off, and select the screen saver that appears for the current session. To do so, open a UNIX shell and type: **ssaver**

The **SGI GUI** for doing this will open.

5.3 Mouse Adjustment

You can adjust the acceleration and click speed of the mouse and switch operation of the buttons. To do so, open a UNIX shell and type: **mouse**

The **SGI GUI** for doing this will open.

5.4 Running storelog

Storelog is run when there is insufficient disk space on the OC disk to bring up the system to Applications Level. During Applications startup, the diskmanagement process checks for adequate disk space; if there is insufficient space, **`storelog`** will come up automatically in a shell prompting the user. The threshold level for the OC that prompts the need for **`storelog`** is when the partitions approach 97-98% full.

Storelog is a tool that recovers system disk space by removing files not essential to the operation of the system. Storelog provides an option to save the files, (core, log, data) to **MOD** prior to removing them from the system disks. Removing these “system log” files does not add image space, but should allow the applications to startup.

The storelog tool can be run standalone in a UNIX shell by simply typing **`storelog`**, or from the Service Desktop select ERRORLOG, and choose STORELOG.

5.5 Running sprsnap

The use of the sprsnap is primarily intended for debugging. The purpose of the tool is to capture the state of the system prior to the system crash. This includes core files, log files and configuration files. To initiate the program, open a UNIX shell and type the following:

> **`sprsnap`**

A series of questions will appear. Save the files to **MOD**.

In addition to saving system information, sprsnap removes core files.

FILES SPRSNAP SAVES

Comment: Core files from the OC

`/usr/g/service/log/core*`
`/usr/g/bin/core*`
`/usr/tmp/core*`

Comment: UNIX kernel core files from the OC

`/var/adm/crash/*`
`/usr/g/service/log` from the OC
`/var/adm/*SYSLOG*` files from the OC

`/var/adm/install*`

Comment: Install log files from the OC

`/usr/g/ctuser/logfiles/sdclog`

Comment: SDC log files from the OC

Comment: ScanRx info files from the OC

`/usr/g/service/log/exam*.protocol`
`/usr/g/service/log/exam*.scan.request`
`/usr/g/service/log/gesys_`uname -n`.log`

`/usr/g/queue`

Comment: Miscellaneous information such as disk space, process status and showprod in Queue directory.

Comment: Scan files

`/usr/g/data_management/ex*/ex*_hdr`

Comment: SDC log from the OC

`/usr/g/ctuser/logfiles/sdclog`

Comment: Miscellaneous files from OC

`/usr/g/service/log/*.timers`
`/usr/g/bin/*.timers*`

`/usr/g/en_US/app_defaults/archive/SCSI.fol`
`/usr/g/en_US/app_defaults/devices/camera.dev`

```
/usr/g/config/INFO
/usr/g/config/dataacq.cfg
/usr/g/config/dataacq.init
/usr/g/config/scan_file_mgr.cfg
/usr/g/config/scan_disk_io.cfg
/usr/g/config/scanfilemgr.init
```

5.6 Initializing a Maxoptics MOD

If you have a **MOD** upon which you want to put system files, this is different from image files. You prepare the **MOD** by making a file system on it. System State and DD File Analysis will detect this condition and prepare the **MOD** in the drive for you. To prep a system **MOD** under other circumstances, open a UNIX shell and type: **`mkfsMOD`** (formatting takes about 3-5 min).

Note: **mkfsMOD** will not work on **DICOM** image and options **MOD**s.

5.7 Saving System State

To save the system configuration information, characterization, calibration, protocols, etc. to a System State **MOD**, perform the following tasks:

1.) Bring the system up if it is not already up.
2.) Insert the System State **MOD**.
3.) Click on the SERVICE DESKTOP.
4.) Click on the PROACTIVE/PREVENTIVE/PLANNED MAINTENANCE icon.
5.) Click on SYSTEM STATE.
6.) Click on ALL. This will highlight Cals, Characterization, Reconfig Info, etc.
7.) Click on SAVE.
    The save will take a few minutes. Review the output for errors or missing files; the scroll bar on the right works only when the tool isn't busy performing some task, it may take a little while. If you see any missing files or failures, then refer to the note below.
8.) Click on DISMISS.

5.8 Saving and Restoring Scan Files

Saving scan files to **MOD** requires that the media first be formatted for a UNIX filesystem. Refer to Section 5.6 for formatting the **MOD**. Saving scan file function reads the scan files from the Scan Data Disk and lists them in the **GUI** for choosing. Saving scanfiles onto the **MOD** puts the scan files in the following directory path on the **MOD**: `/MOD/service_mod_data/SFfiles`. The scan files are saved as an `iq.<suiteid>.exam.series.scan` file, (referred to as a `.iq` file) in the `Sfiles` directory.

Restoring scan files function reads the **MOD** directory path: `/MOD/service_mod_data/Sfiles` and presents the files in a list/select **GUI** for restoring. Restoring the scan files takes a copy of `.iq` file on **MOD** and puts it into the scandata disk partition.

Both the Save and Restore Scan files functions reside under RECON MGMT on the top level ExamRx Desktop.

5.8.1 Saving Scan Files to MOD

Perform the following steps for Saving scanfiles to **MOD**:

1.) Place a formatted **MOD** in the drive.

2.) Bring up Recon Management main menu: Select RECONMGMT.
3.) Select SAVE SCAN DATA.
4.) Click on the Exam, Series, Scan file(s) desired.
5.) Select SAVE SELECTED FILES.
6.) When the save operation is complete, a pop-up reports "`xx scanfiles saved`"—select OK.
7.) Select QUIT.

5.8.2 Restoring Scanfiles from MOD

Perform the following steps for Restoring scan files from **MOD**.

1.) Place the **MOD** into the drive.
2.) Bring up Recon Management main menu: Select RECONMGNT.
3.) Select RESTORE SCAN DATA.
4.) Click on the Exam, Series, Scan file(s) desired to be restored.
5.) Select RESTORE SELECTED SCAN FILES.
6.) When the restore operation is complete, a pop-up comes up reporting '`xx scanfiles restored`'—select OK.
7.) Select QUIT.

5.9 Reserve/Release Scan Data

The reserve function allows you to prevent the overwriting of scan data files. The files can then be selected at a later time for future storage and reconstruction. Otherwise, eventually all of the scan data files will be overwritten with new scan data. The release function unreserves any scanfiles previously reserved, freeing that scan file to be overwritten.

5.9.1 Reserving Scan Files

Perform the following steps for Reserving scan files:

1.) From the top level ExamRx Desktop, select RECONMGMT.
2.) Select RESERVE SCAN DATA.
3.) A list of exam/series/scans currently unreserved is presented.
4.) Click on the Exam/Series/Scan(s) desired to be reserved, then select RESERVE SELECTED SCANFILES.
5.) Operation is complete when a pop-up stating "`xx scanfile reserved`" comes up. Select OK.
6.) Select QUIT.

5.9.2 Releasing Scan Files

Perform the following steps for Releasing scan files:

1.) From the top level ExamRx Desktop, select RECONMGMT.
2.) Select RELEASE SCAN DATA.
3.) A list of exam/series/scans currently reserved is presented.
4.) Click on the Exam/Series/Scan(s) desired to be released, then select RELEASE SELECTED SCANFILES.
5.) Operation is complete when a pop-up stating '`xx scanfile released`' comes up. Select OK.
6.) Select QUIT.

Chapter 4
Camera

Section 1.0
Theory

1.1 DASM (Data Acquisition System Manager)

A **DASM** may be used as the interface between the host computer and the laser camera. The current **CT** system is capable of using either an “analog” or a “digital” **DASM** to perform this function.

1.1.1 Analog DASM

The “analog” **DASM** attaches to the host **SCSI** bus and emulates a **SCSI** disk drive in function. It accepts high-level commands and 512 x 512 image data from the host via the **SCSI** bus and sends images and control commands to the laser camera via the camera’s video input and RS-422 serial interface.

The “analog” **DASM** contains 4 Mbytes of on-board Data Memory, which appears to the host as a **SCSI** disk drive responding to the **SCSI** Common Command Set. Data Memory is used for image storage as well as for host command and status handshaking. The host application makes command, status and image transfers by accessing **DASM** Data Memory through the **SCSI** bus.

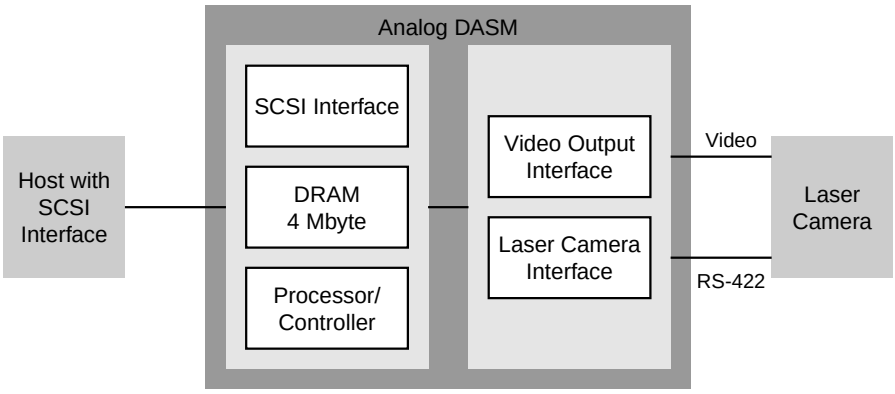

Figure 4-1 Analog DASM

1.1.2 Digital DASM

The “digital” **DASM** connects the host’s **SCSI** port to the laser camera’s control and image data ports. It attaches to the laser imager using separate data and control cables from the Digital Data Output and Camera Control Interface of the **DASM** to the corresponding inputs of the laser imager.

The Digital Data Output of the digital **DASM** conforms to all laser camera copper connections. The **DASM**’s Digital Data Output has RS-485 line drivers and receivers and can be connected up to 250 feet from the laser imager, if the proper cabling is used. This distance can be extended up to 1,000 feet with a **SCSI** to fiber optic converter.

The **DASM**’s digital control output accommodates standard RS-232 and RS-422 serial port connections to the laser imager. Digital control can be used at up to 9600 baud.

1.2 DICOM

Note: The following section contains a general description of the functions supported by **DICOM** on the GEMS scanner.

1.2.1 Storage

The Service Class User (**SCU**) sends image data and the Service Class Provider (**SCP**) receives image data. The image data is formatted into Objects such as **CT**, MR, Secondary Capture (SC), CR, X-ray RF, X-ray US, NM, etc. See Figure 4-2.

- **GE Application**: MR Signa 5.4 Manual Send - User initiates the transfer of image (or series/ study of images) from the Signa to an Advantage. The Signa may also send to a non-GE device.
- **GE Application**: **CT** System Auto Transfer - Automatically transfers images to the Advantage Windows at scan. Again, it may also send images to a non-GE device.

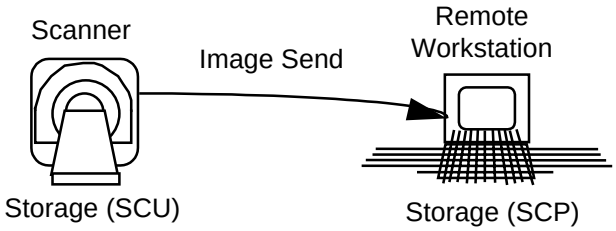

Figure 4-2 DICOM Storage

1.2.2 Query Retrieve (Q/R)

Allows a system to query another system for a list of available images (query). Also allows a system to request another system to send images (retrieve). The **SCU** initiates the queries and retrieval, and the **SCP** responds to queries with a list of available data, as well as responding to the retrieval request by sending images. See Figure 4-3.

GE Application: Pull Query - The Advantage Review-Diagnostic (**ARD**) user requests a list of images from the scanner. The **ARD** requests the scanner to send some of these images to the **ARD** and the scanner sends the images using the Service Class.

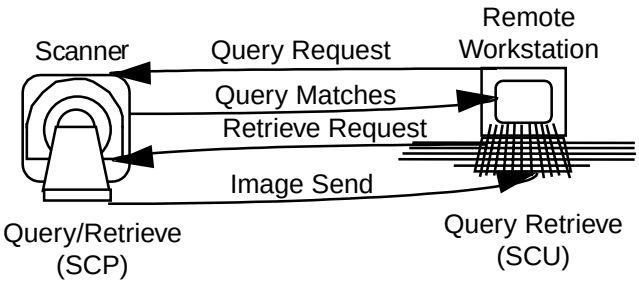

Figure 4-3 DICOM Query/Retrieve

1.2.3 Modality Worklist Management

Allows a scanner (**SCU**) to obtain patient requested procedure information for scheduled examinations from Information Management System (**IMS**). Often called the **DICOM** interface, however the scanner will generally not be connected directly to **HIS**/ **RIS** but to an **IMS**, which in turn will be connected to the **HIS**/ **RIS**. See Figure 4-4.

GE Application - A worklist is presented to the technician who simply selects the scheduled patient from the list rather than manually entering the patient demographics information. Saves typing time and avoids typing errors. Automates scheduling and information flow.

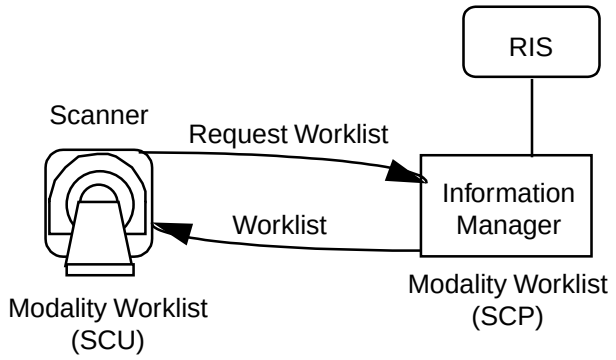

Figure 4-4 DICOM Modality Worklist Management

1.2.4 Study Component Management

Allows a modality (**SCU**) to keep an Imaging Information Management System (**IMS**) updated on the progress and completion of an examination. The associated series of form a Study Component whose actual content and status is transmitted to the Information Management system (**SCP**). See Figure 4-5.

GE Application - Quality management in the imaging process, automatic inputs to billing, and timely triggering of post acquisition (post processing, interpretation, ICU, etc.) events.

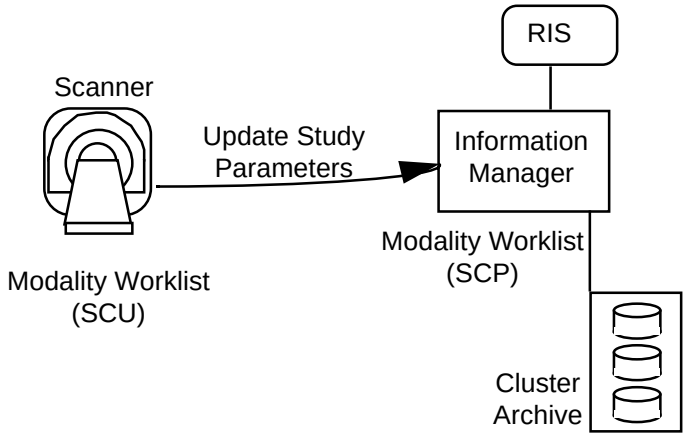

Figure 4-5 DICOM Study Component Management

1.2.5 Storage Commitment

Allows modalities (**SCU**) to relinquish archiving responsibility to an external device (e.g., network archive) acting as a Service Class Provider (**SCP**). The Storage Service Class is used in conjunction with the Commitment Service Class to transfer the images to the storage device(s). See Figure 4-6.

GE Application - (Primary Archive Node) Frees up disk space on the scanner without extensive manual archiving. Function needed on a scanner to safely work with a network manager.

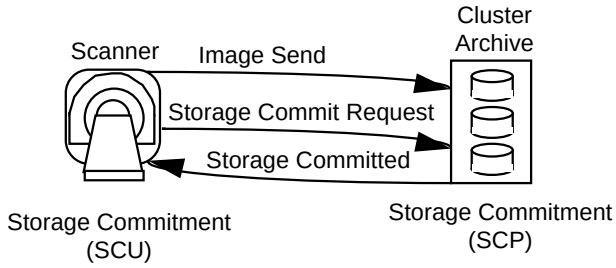

Figure 4-6 DICOM Storage Commitment

1.2.6 Results Management

Allows the radiologist reports to be retrieved by the Service Class User (**SCU**). See Figure 4-7.

GE Application: Reports may be viewed with the patient's images when retrieved from an Information System.

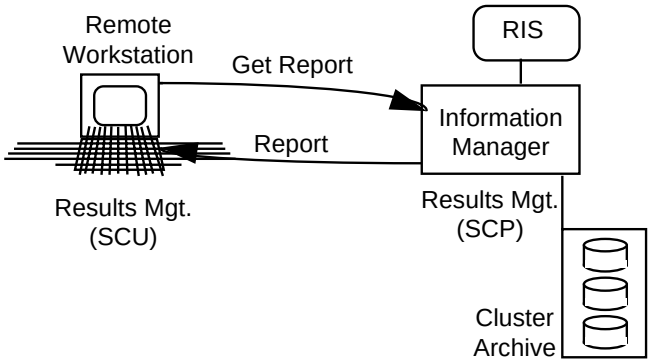

Figure 4-7 DICOM Results Management

1.2.7 Basic Print Management

Allows a workstation or scanner to send images to a printer for hard copy output. For example, a workstation (**SCU**) sends images to a laser camera (**SCP**) to be copied on film. This network interface permits workstations to share one camera interface, which can reside anywhere on the network. See Figure 4-8.

Note: Camera manufacturers are just beginning to offer **DICOM** products. Currently, no GE products support this feature.

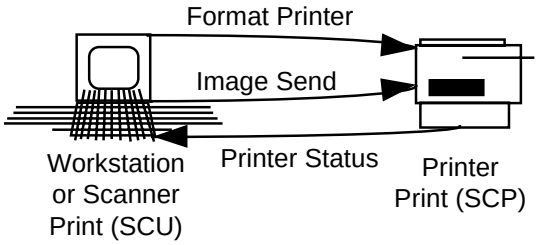

Figure 4-8 DICOM Basic Print Management

1.2.8 1.3 GB MOD Media

Standardizes the physical media (Magneto Optical Disk holding 1. 3 Billion bytes of data) and the logical format in which images are stored on the archive media. A device supporting the Media Interchange Service Class may support the following roles:

- File-Set Creator (FSC) to initialize a new piece of media and write a number of images
- File-Set Reader (FSR) to read the imaging directory and selected images stored on a media
- File-Set Updater (FSU) to read and update the imaging directory as well as images on the media

1.2.9 640 MB CD-R Media

Standardizes the physical media (Recordable Compact Disk holding 640 Million bytes of data) and the logical format in which images are stored on the archive media. A device supporting the Media Interchange Service Class may support one or more of the roles defined above.

1.2.10 Verification

Allows any system to send a test message to another system to verify the network connection.

1.2.11 Glossary of DICOM Terms

CONFIGURATION

The **DICOM** Print Configuration Information field is controlled by the Camera Manufacturer. It is typically used to set information on the Look-up Table to be used to convert the inputted digital image data to the hardcopy film output (since the range of valid data for the input may not match the range for the output data); however, it is not limited to this purpose. The string field is defined by the Camera Manufacturer and is currently up to 1024 bytes. The value is equivalent to working the contrast on a image monitor.

DENSITY

Density is a film term that represents the pixel value at a particular point on the film. Empty Density is the pixel representation of a blank image frame on a film. Border Density is the pixel representation of the area outside of the image frames on the film. Minimum Density is the minimum pixel representation to be used within an image, while Maximum Density is the maximum pixel representation to be used within an image. The last two values are equivalent to working the brightness on a image monitor. The range and effect of the last two density parameters are Camera Manufacturer dependent.

DICOM

Acronym for Digital Imaging and Communication in Medicine. This standard is a detailed specification for transferring medical images and related information between computers.

MAGNIFICATION TYPE

Images from the scanner are digitized at a low resolution and are then printed at a higher resolution. To accomplish this, images are interpolated prior to being printed. A number of techniques may be used to perform the image interpolation. The most common techniques are:

- Replication: This is the simplest method of interpolation (zero order interpolation). In this case adjacent data is used to calculate the fill data. The resultant images are typically extremely blocky and contain jagged edges.
- Bilinear: Also known as first order (linear) interpolation, this technique consists of fitting straight lines through adjacent data points to determine intermediate points. The resultant images are somewhat blurred.
- Cubic: Third order (cubic) interpolation is usually the favored technique. There are a large number of possible formulations for cubic interpolation. Each differs by the coefficients used in the process. The Camera Manufacturers use a second parameter called a Smoothing Type to set the coefficients. The implementation of the coefficient is Camera Manufacturer dependent. The cubic interpolation presents the smoothest version of interpolation when compared to replication or bilinear interpolation.

SERVICE CLASS

Represents a specific application feature by defining a set of related **SOP** classes (**DICOM** Print).

SMOOTHING TYPE

A value used in conjunction with the Magnification Type. It is only relevant when the magnification type is set to Cubic. Smoothing is used to set the coefficients for the formulation of the interpolation. The valid values and meaning of the Smoothing Type parameter are controlled by the **DICOM** Print Manufacturer. For example, Imation expects a smoothing factor of 0 to 15, while Agfa expects a smoothing factor of VR type 0, or falling within the range of 100 to 299.

SCP

Acronym for **Service Class Provider**. This is the Service Class server. (In the case of **DICOM** Print, this is the **DICOM** Print Camera.)

SCU

Acronym for **Service Class User**. This is the Service Class client. (In the case of **DICOM** Print, this is the GE scanner.)

SOP

Acronym for **Service Object Pair**. This term is used in **DICOM** to specify the capabilities of a **DICOM** entity. The entity is defined by the union of the Information Object Definition (IOD) (e.g., **CT** image) and the **DICOM** Message Service Element (DIMSE) Services (e.g., store).

Section 2.0 Setup

2.1 Overview

The system supports either **DASM** Laser or network **DICOM** Print type cameras. Configuring the system for camera and its parameters is done from the SERVICE DESKTOP, UTILITIES menu, INSTALL submenu, and selecting INSTALL CAMERA.

Once set up, the parameters must be saved.

2.2 Filming Image Quality

Note: It is important that the camera limits are clearly understood from the camera manufacturer's Conformance Statement. Work closely with the Camera Field Engineer when setting up min and max density and configuration.

The parameters that directly affect Filming Image Quality in the camera.dev file are:

- set minDensity
- set maxDensity
- set smoothType - Used only when Mag type is set to Cubic.
- set configuration - This value sets the min & max density curve range. Camera manufacturer dependent.

DENSITY SETUP TIPS WITH BLUE FILM TYPE

The starting min and max density settings vary by camera and film type, and configuration settings.

Note: If the configuration is set to 200, and maxDensity 300, films will be quite dark. Bottomline is the higher the density and config LUT, the darker the film.

See Table 4-1 for some suggested settings for the AGFA camera. **For other camera models, refer to the camera manufacturer's conformance statement and consult with the camera FE.**

CAMERA TYPE	MEDIA TYPE	FILM TYPE	SUGGESTED STARTING	
			MINIMUM DENSITY	MAXIMUM DENSITY
AGFA Drystar 2000	Blue Film	TS Blue Base Low Speed High Density	17	185
AGFA Drystar 2000	Blue Film	TS Blue Base Fast Speed Normal Density	18	229
AGFA Drystar 2000	Blue Film	DT Blue Base Normal Speed High Density	24	300
AGFA Drystar 2000	Clear Film	TS Clear Base Low Speed High Density	5	173
AGFA Drystar 2000	Clear Film	TS Clear Base Fast Speed Normal Density	6	217
AGFA Drystar 3000	Blue Film	DT Blue Base Normal Density	23	300
AGFA Drystar 3000	Clear Film	DT Clear Base Normal Density	6	300

Table 4-1 Density Values

RECOMMENDATIONS

1.) If the Hospital already has the camera in use in laser mode, make sure you use these values as the start point. You may want to take a number of films before you change out the hardware and use them for comparison afterwards.

2.) Set up the **DICOM** Print Camera, and use the initial starting point. Set up to look as good as the camera FE and GE **CT** FE can make it.

3.) Assume that before the **DICOM** Print install is complete, the films have been approved by the appropriate Hospital Staff. This means some time (up to 4 hours) must be allocated for the Camera FE, **CT** FE and site to work together. If it is possible, the camera manufacturer can create a film with multiple contrasts for the Doctors to pick from.

2.3 DASM

A **DASM** Laser Camera is a camera connected to the **CT** system through a **DASM** (either Analog or Digital). The **CT** System connects to the **DASM** via the Host Computer **SCSI** Bus, and provides either Analog Video (Analog **DASM**) or Digital Video (Digital **DASM**) and control & command signals to the Laser Camera. Figure 4-9, below, shows an example of the required configuration parameters for a **DASM** Laser Camera.

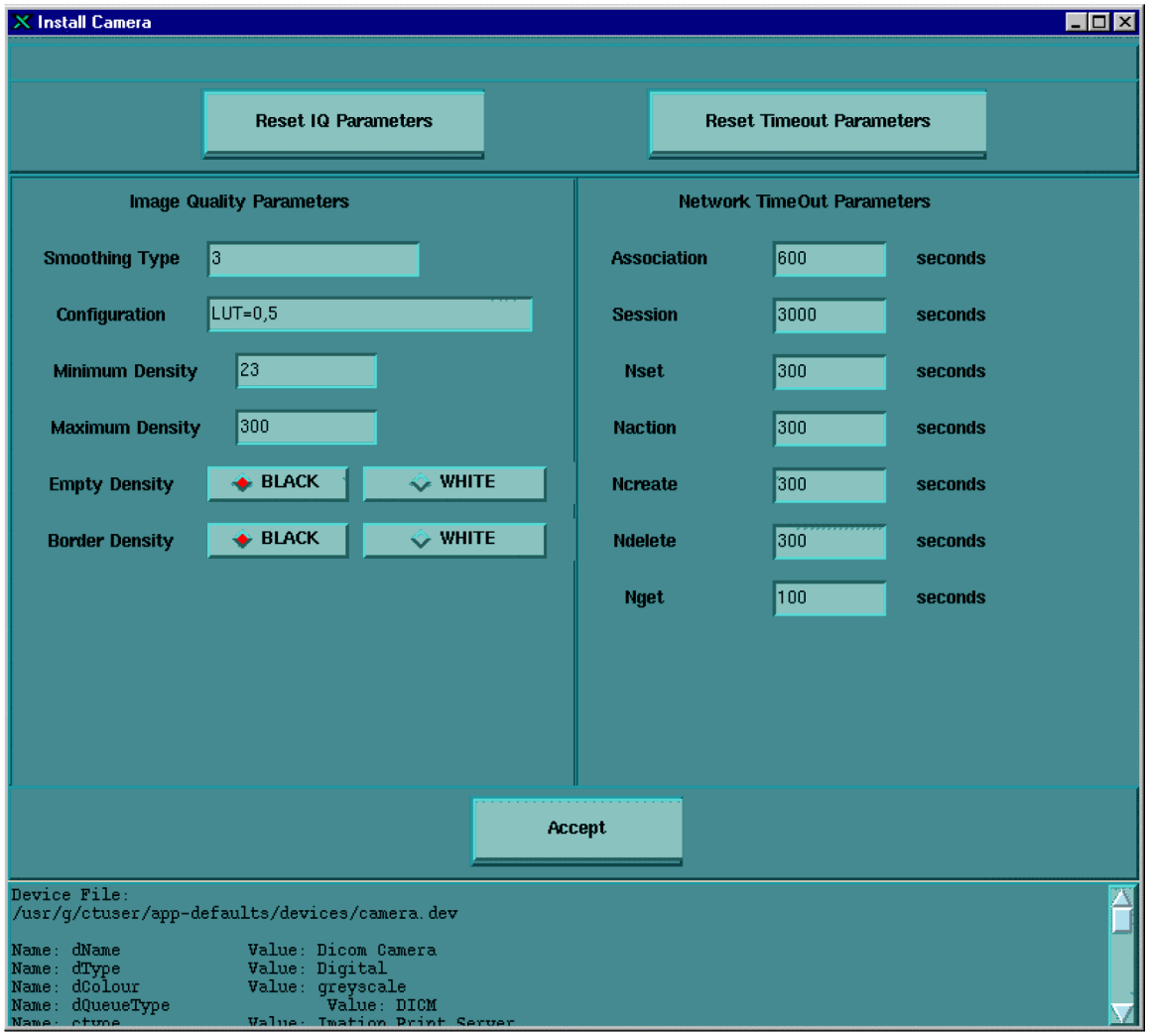

Figure 4-9 DASM Laser Camera Install Screen

1.) The **Laser Camera Type** should be selected first as this will preset all of the other parameters, with the exception of the **DASM** and Film. It is a good idea to verify the preset information, as camera models do change over time.

2.) Select the **DASM Interface**, either **Analog** or **Digital**, that matches your physical **DASM** type.

3.) Two **Options** are available with a Laser Camera: **Slides** and **Zoom**. Setting this option allows the option to be enabled or disabled at the application level. However, before selecting **Slides** or **Zoom**, be sure that the customer's camera supports these options.

4.) Camera manufacturers provide two Film resolution options for cameras. The **Smooth** resolution blurs the image, while the **Sharp** resolution makes the image "pixelly".

Recommended camera settings are as follow:

Kodak: Smooth

Dupont/Sterling: Smooth

3M/Imation: Sharp

Agfa: Sharp

If images on film are “too pixelly”, chances are that the film has been set to “sharp” — change the setting to “smooth.” The converse also applies.

2.4 DICOM

2.4.1 Applications Setup

A **DICOM** Print Camera is a network camera that has a hostname and IP Address connected on the Hospital Network (Ethernet Connection) from the scanner. The scanner uses **TCP/IP** network protocol to communicate and send **DICOM** Images in packets to the Camera for filming. Refer to Section 2.3.3.6 for a glossary of terms and definitions associated with **DICOM** Print. Figure 4-10 is an example of the required configuration parameters for a **DICOM** Print Camera:

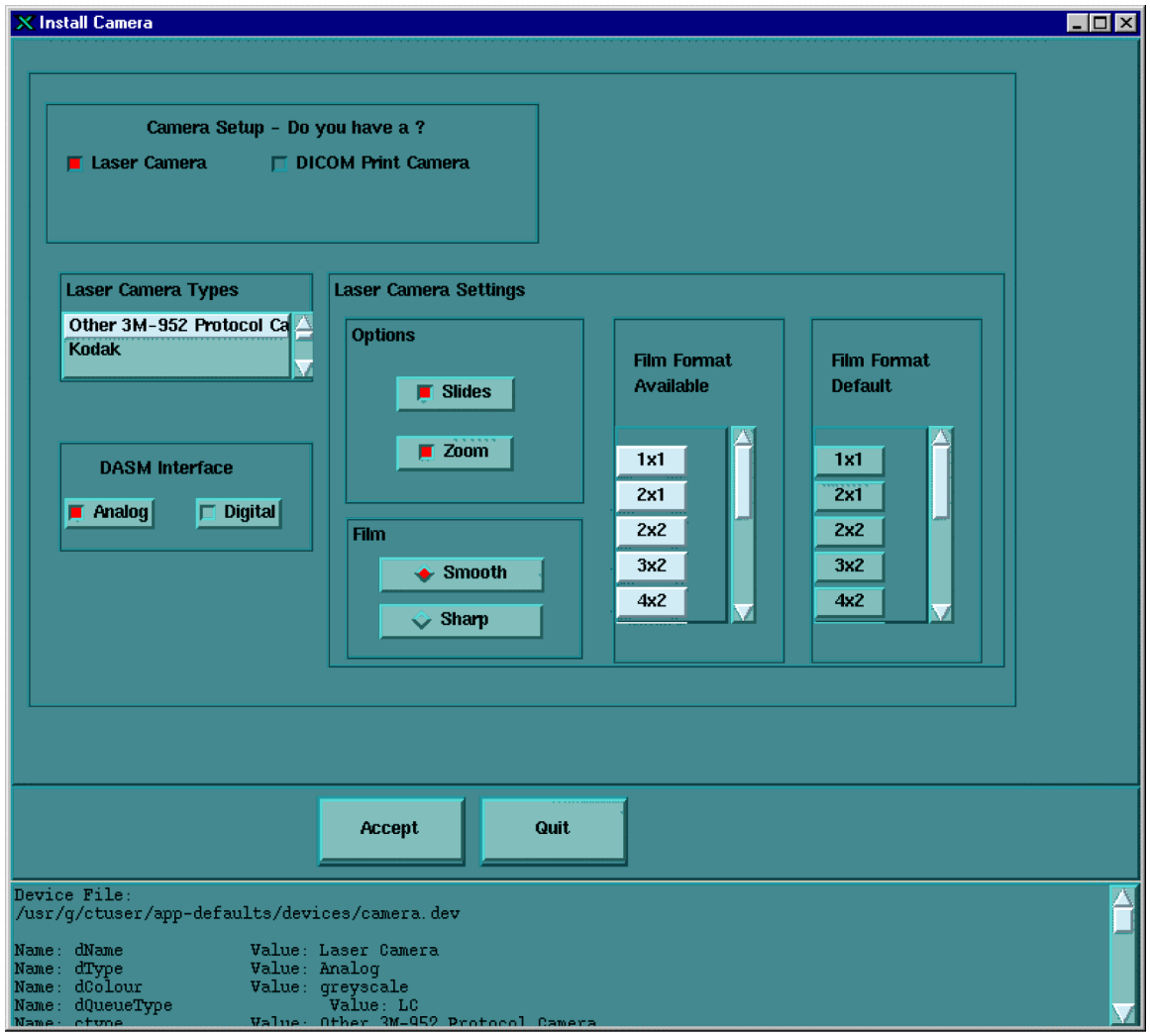

Figure 4-10 DICOM Print Camera Install Screen

1.) The **DICOM Print Camera Type** should be selected first, as this will preset all of the other parameters, with the exception of the Network Parameters. It is a good idea to verify the preset

information, as camera models do change over time.

Note: Selection of a different camera type will also clear the Image Quality parameters, as these are camera manufacturer dependent.

2.) Set up the **Network Parameters**

Note: To determine the correct **DICOM** Camera Network parameters (IP Address, Hostname, **AE** Title, Port Number, and Comments) contact the Hospital's Network Administrator.

- **IP Address** - **DICOM** Print Server IP Address as defined by the network.
- **Host Name** - **DICOM** Print Server host name as defined by the network.
- **Application Title** - **DICOM** Print Server Application Entity Title as defined by the server.
- **TCP/IP Listen Port** - **DICOM** Print Server **TCP/IP** Listen Port as defined by the server.
- **Comments** - (Optional) Comments to be used by the **DICOM** Print Server.

3.) **Destination** selects the final location for the film output, either **Magazine** or **Processor**.

4.) **Orientation** selects the film orientation; currently only the **Portrait** option is supported.

5.) **Medium Type** selects the type of film to be used, either **Blue Film** or **Clear Film**.

6.) The **Magnification Type** parameter selects the algorithm used to interpolate pixels to provide the necessary film resolution. This parameter should be set in conjunction with the camera manufacturer to make the best possible image. The settings are:

- **None** - No interpolation. This option is not supported by all camera vendors.
- **Replicate** - Adjacent pixels are interpolated, which results in images described as "pixelly". This algorithm is not usually preferred.
- **Bilinear** - A first order interpolation of pixels is used, which results in images described as blurred. This algorithm is not usually preferred.
- **Cubic** - A third order interpolation is used with a large number of possible formulations. Camera manufacturers define parameters, called smoothing type, to set coefficients used in the algorithm. Implementation of these coefficients is camera manufacturer dependent.

7.) The valid **Film Formats** are determined by the camera manufacturer (for example, IMATION does not support 4x6, 2x4, or 1x2; AGFA does not support 2x4). Also note that the **DICOM** Print convention is to designate film formats by column x row (e.g., 12-on-1 film is 3x4).

The Network Parameters entered in the Camera Installation **GUI** (including Camera Hostname, IP Address, **AE** Title, Port Number, and Comment) are written to **`/usr/g/ctuser/Prefs/SdCPHosts`** file on the OC.

The settings information entered in the Camera Installation **GUI** is written to **`/usr/g/ctuser/app-defaults/devices/camera.dev`** file on the OC.

A second screen, Figure 4-11, with image quality and timeout information parameters for filming sessions, comes up after selecting ACCEPT. Figure 4-11, below, is an example of the required image quality and timeout parameters for a **DICOM** Print Camera:

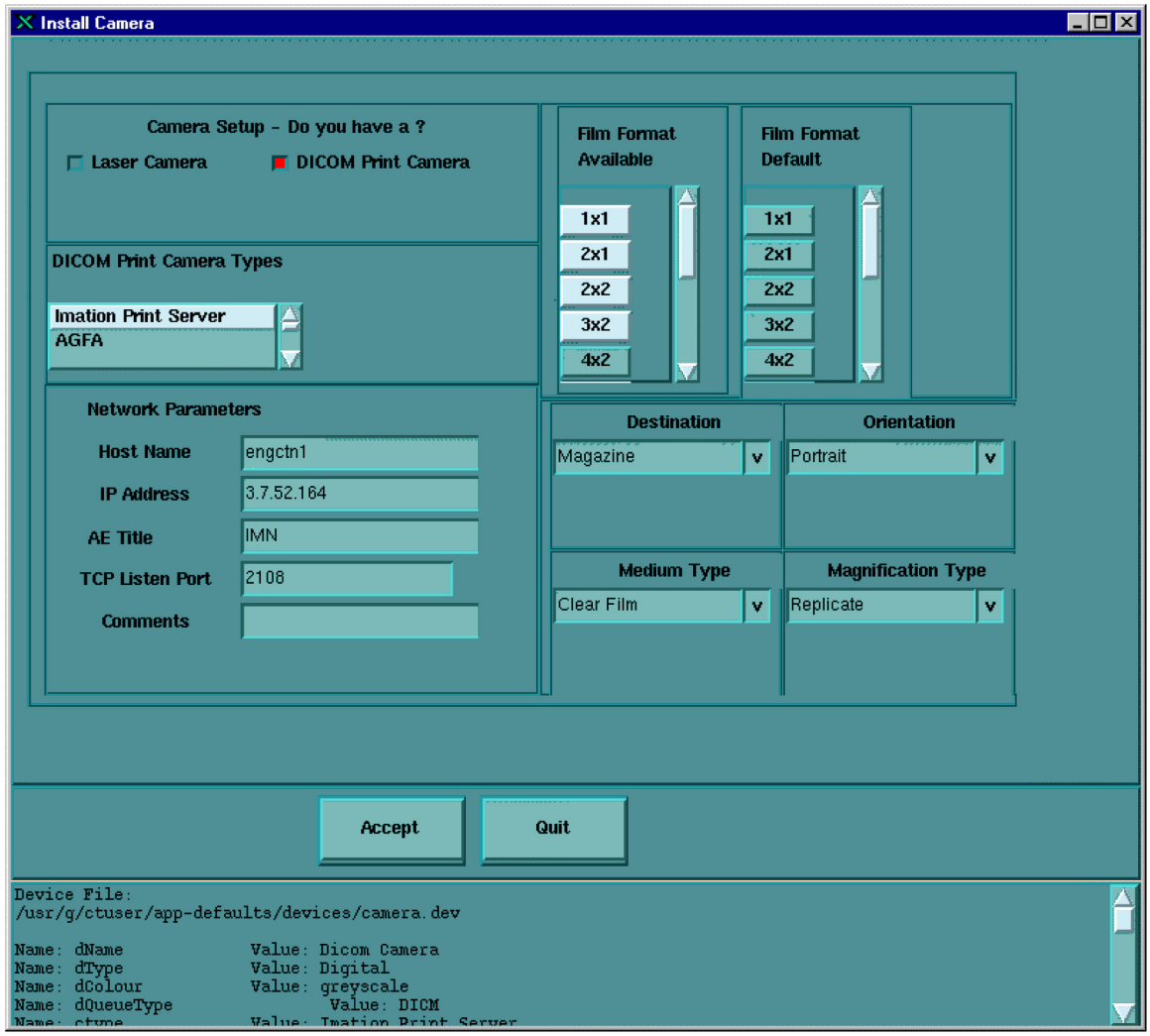

Figure 4-11 DICOM Print Camera Image Quality & Timeout Settings

The image quality parameters are saved on the OC in:

`/usr/g/ctuser/app-defaults/devices.camera.dev` file.

The timeout parameters are saved on the OC in:

`/usr/g/ctuser/app-defaults/print/dprint.cfg` file.

Note: To determine the correct camera settings, contact the Camera Service representative, and review the Camera Manufacturer's **DICOM** Conformance Statement. A detailed **DICOM** Conformance Statement is available through your GEMS service representative. You may need to refer to a copy of this document as you are working with the camera manufacturer's representative, to correctly set up the **DICOM** Print Camera settings.

2.4.2 Network Setup

2.4.2.1 Configuring the DICOM Network

Use the Gateway Host name for the Application Entity (**AE**) Title, the Gateway IP number for the **DICOM** Address and Port 104 for the scanner.

The **DICOM** configuration is set in `/usr/g/config/WLdcm.cfg`

`WLdcm` means Work List Server (software) for **DICOM**. Unsuccessful transfers are logged to the GE Error Log from WLServer. The most recent WLrsp.binx file with the biggest number in `/usr/g/config` is usually the one that failed to transfer.

2.4.2.2 Adding Stations to Network

1.) Select Network from Image Works
2.) Go to Select Remote Host from the pull down menu.
3.) Select Add.
4.) Enter the IP address, station name, network protocol you want to use.
5.) Save.

2.4.2.3 DICOM Port Number

- Genesis stations (HiLight, HiSpeed): 104
- Non-Genesis stations: 4006

This lo0 entry also must be present in file `/etc/hosts` or the network will not work.

```
127.0.0.1   localhost
```

2.5 Save System State

Once the camera is set up, the settings stored in the configuration files (camera.dev, sdCPHosts, and dprint.cfg) must be saved. Save these parameters to the System State **MOD**. Run SYSTEM STATE, and select CAMERA PREFERENCES and SAVE. For details on the save system state procedure, see Saving System State on page 201.

Section 3.0 Troubleshooting

3.1 Check Hardware

Check the camera hardware for errors. See the appropriate section of the Console chapter for details.

1.) Check the printer for paper jam or other malfunction.
2.) Check the physical connections between components.
3.) Run hardware diagnostics, as appropriate:
   - **`hinv`**
   - **`showdasm`** (**DASM** only)
   - **`scsistat`**
   - **`ping`** (**DICOM** only)

3.2 Check Error Logs

3.2.1 Filming Error and Status logs

During Laser Camera Print filming, the system writes to two camera logfiles, l`clog` and `prslog`. When a print job starts, the Laser Camera status information is logged to `~ctuser/logfiles/lclog`. The print job information is logged to `~ctuser/logfiles/prslog`.

---

lclog

Location

OC: `/usr/g/ctuser/logfiles/lclog`

Description

This logfile contains Laser Camera print filming sequence and Printer status information for the most recent print session job. Each time a new print job is performed, the status information for that latest job will overwrite the previous one.

3.2.2 prslog

Location

OC: `/usr/g/ctuser/logfiles/prslog`

Description

This is a running history log of print server initializations and shutdowns, and print jobs that are started and completed.

3.3 Troubleshooting DICOM Print Camera Problems

LOG OF ERROR AND FILMING STATUS

During **DICOM** Print filming, the system writes to two camera logfiles, `dcplog` and `prslog`. When a print job starts, the dicom information is logged to `~ctuser/logfiles/dcplog`. The print job information is logged to `~ctuser/logfiles/prslog`. The called **AE** title/host/IP/port number is taken from `~ctuser/Prefs/SdCPHosts` file.

3.3.1 dcplog

This logfile contains dicom print filming sequence and Printer status information for the most recent print session job. Each time a new print job is performed, the status information for that latest job will overwrite the previous one.

1.) Printer Status Area in the dcplog report

The Printer Status area in the log report will either be NORMAL, WARNING, or FAILURE. In the event of a WARNING or FAILURE, the Status Info field attempted to identify the root cause.

NORMAL - print job was successful, no problems.

WARNING - one of three conditions can happen:

a.) The job aborts and the status info field indicates SUPPLY FULL, RECEIVER FULL, or FILM JAM. (See part 3 below for FILM JAM example.**)**

b.) The job continues and Warning is posted to the operator if Status Info field reports SUPPLY LOW.

c.) The job continues and a Warning is *not posted to the operator, but the message is put in dcplog file.*

Note: What gets reported is dependent upon the camera type and the camera server's ability to report it.

FAILURE - the print job has aborted; see Status Info field for more information.

2.) Dcplog example of a print job leading up to a Film Jam:

```
{ctuser@engbayXX}[17] cd /usr/g/ctusr/logfiles
{ctuser@engbayXX}[18] more dcplog
_[40;1H_[K# DICOM print_scu pid: 5463
print_scu -aIMN -hcamera -c1 -f1x1_fid -p/usr/g/ctuser/film/
img21a0017f -d/usr/g/ctuser/app-defaults/devices/camera.dev
dcm_bind: AETitle = engbay26_DCP
map_app_title: title IMN host camera ip-addr 3.7.52.164 port 2104
EstablishAssoc: DCM_OPEN_REQ Action success
EstablishAssoc: OPEN_CONF received
Starting the print session
NgetService: Event Received : DCM_NGET_END
NgetService: Event Received : DCM_DATA
```

PRINTER STATUS	
SOP uid	
Instance uid	
Printer Status	**WARNING** ←
status info	FILM JAM ←
printer_name	advt
manufacturer	AGFA
model	ADVT
device serial number	123456
software version	Version 2.0
Warning	Media jam. **Failed during the print session, status -1. Job stopped here.**
CloseAssoc	DCM_CLOSE_REQ Action Success

Table 4-2 Printer FILM JAM

3.) Known error reported from Nget with Imation Cameras that should not be troubleshot:

The prslog reports:

```
MESSAGE from Process 2059 >> Wed Aug 19 10:03:48 1998  [PRSserver]>
Print job started
Message from Process 2060 >> NgetService: N-GET response received with
failure/warning Status
Message from Process 2060 >> AETitle: IMN_PrintServer
Message from Process 2060 >> Print Session successfully completed
```

The dcplog reports:

```
NgetService: N-GET response received with failure/warning Status ¨the
known error.
```

PRINTER STATUS	
SOP uid	:
Instance uid	
Printer status	NORMAL
status info	
printer_name	IMN_LaserImager
manufacturer	Imation
model	M8700
device serial number	
software version	1.5b4
AETitle	IMN_PrintServer

Table 4-3 Imation Print Report

What Imation supports:

Imation supports the following six elements/attributes:

```
> (0x21100010, CS, ”NORMAL”)  # Printer Status OK
> (0x21100020, CS, ””)  # Printer Status Info OK
> (0x21100030, LO, ”IMN_LaserImager”)  # Printer Name OK
> (0x00080070, LO, ”Imation”)  # Manufacturer OK
>  (0x00081090, LO, ”M8700”)  # Manufacturer’s Model Name OK
>  (0x00181020, LO, ”1.5b4”)  # Software Versions OK
```

The Bug:

Nget is requesting status from these three additional elements that are not supported:

```
>  (0x00181000, LO, ””)  # Device Serial Number
>  (0x00181200, DA, ””)  # Date of Last Calibration
>  (0x00181201, TM, ””)  # Time of Last Calibration
```

The Fix:

Instruct Camera FE to disable the above three elements that are not supported.

4.) Communication and Network Error Troubleshooting

The most common types of network errors that can occur with **DICOM** Print are a:

- **DCM** Networkerror and
- **DCM** Protocol error.

DCM Network errors:

Successful network communications to the camera are dependent on a correctly configured IP Address and Port Number. Any errors associated with the network will be logged as a "**DCM** Network Error" in the "type" field in the dcplog report, as shown in the example below. Use ping and snoop to discover the root cause, covered in the troubleshooting steps below.

Example: **DCM** Network Error

Example of dcplog with a DCM Network Error:

```
{ctuser@engbayXX}[3] cd /usr/g/ctusr/logfiles
{ctuser@engbayXX}[4] more dcplog
_[40;1H_[K# DICOM print_scu pid: 5498
print_scu -aIMN -hcamera -c1 -f1x1_fid -p/usr/g/ctuser/film/
img22a0017f -d/usr/g/ctuser/app-defaults/devices/camera.dev
dcm_bind: AETitle = engbay26_DCP
map_app_title: title IMN host camera ip-addr 3.7.52.164 port 2104
EstablishAssoc: DCM_OPEN_REQ Action success
```

Errors logged beyond this point of failure may be a result of this Error:

***DCM** kernel lower level error:*

```
type = 508 -- DCM network error    ¨ ERROR
code = 114 -- lost transport connection
ul_code = 52, reason = 0, source = 0, reject = 0
filename = kernel/D_assoc.c  line = 3051
Failed to contact printer, status 114
```

Steps for troubleshooting a DCM Network Error:

a.) Verify correct IP Address and Port Number are correct in the Install Camera **GUI**.

Note: If the IP Address and Port Number are correct, the remote application (camera server) may not be running.

b.) Verify Applications restarted after running Install Camera from Service Desktop Utilities.

c.) Verify on the OC in /usr/g/ctuser/SdCPHosts the IP Address and Port Number are correct. Enter the following:

```
ctuser@bayXX}[2] cd  /usr/g/ctuser/Prefs
ctuser@bayXX}[3] cat SdCPHosts
3.7.52.164camera IMN2106ctn display
```

d.) Ping to the camera's IP address, and check for packet loss. A successful ping indicates a good physical connection and IP Address. Port number can still be bad; proceed to next step.

Example of successful ping:

```
{ctuser@engbayXX}[5] ping 3.7.52.164
PING 3.7.52.164 (3.7.52.164): 56 data bytes
64 bytes from 3.7.52.164: icmp_seq=0 ttl=255 time=0.927 ms
64 bytes from 3.7.52.164: icmp_seq=1 ttl=255 time=1.079 ms
64 bytes from 3.7.52.164: icmp_seq=2 ttl=255 time=1.090 ms
64 bytes from 3.7.52.164: icmp_seq=3 ttl=255 time=1.070 ms
64 bytes from 3.7.52.164: icmp_seq=4 ttl=255 time=1.048 ms
64 bytes from 3.7.52.164: icmp_seq=5 ttl=255 time=1.073 ms
64 bytes from 3.7.52.164: icmp_seq=6 ttl=255 time=1.199 ms
----3.7.52.164 PING Statistics----
7 packets transmitted, 7 packets received, 0% packet loss
round-trip min/avg/max = 0.927/1.069/1.199 ms
```

e.) If you are unable to successfully ping the camera, use the snoop tool to monitor what is going on with communication packets during a print job. Snoop will read the number of

responses from the server while attempting to do a print job. In Example A below, there is only one summary line being reported, (one outbound), and NO inbound response indicating the remote camera host (engctnl) cannot be reached. Refer to Snoop on page 222 for snoop and its usage.

Example:
Example A:

snoop -SVta 3.7.52.164 ←where **3.7.52.164** in this case is the camera ***<IP address>***

Using device ef0 (promiscuous mode)

```
14:46:19.250400engbay26 -> engctn1length:58  ETHER Type=0800 (IP),
size = 58 bytes
14:46:19.250400engbay26 -> engctn1length:58  IP D=3.7.52.164
S=3.7.52.151 LEN=44, ID=57050
14:46:19.250400engbay26 -> engctn1length:58  TCP D=2106 S=1192 Syn
Seq=1001039841 Len=0 Win=16384
```

f.) If there are only two summary lines, (Example B below) one outbound and one inbound, this indicates that we can successfully ping the remote camera host, (IP Address is good) but the remote application is either not running (i.e. the machine is up, the application that acts as the print server is not running), or the wrong port number is being used. Refer to Snoop on page 222 for snoop and its usage.

Example B:

snoop -SVta 3.7.52.164 ← where 3.7.52.164 in this case is the camera <IP address>

Using device ef0 (promiscuous mode)

```
14:46:19.250400  engbay26 -> engctn1length:58  ETHER Type=0800
(IP), size = 58 bytes
14:46:19.250400  engbay26 -> engctn1 length:58  IP  D=3.7.52.164
S=3.7.52.151 LEN=44, ID=57050
14:46:19.250400  engbay26 -> engctn1length:58  TCP D=2106 S=1192
Syn Seq=1001039841 Len=0 Win=16384
_________________________________
14:46:19.251971  engctn1 -> engbay26length:60  ETHER Type=0800
(IP), size = 60 bytes
14:46:19.251971  engctn1 -> engbay26length:60  IP  D=3.7.52.151
S=3.7.52.164 LEN=40, ID=10027
14:46:19.251971  engctn1 -> engbay26length:60  TCP D=1192 S=2106
Rst Ack=1001039842 Win=0
```

Example C below shows what would be logged in the dcplog with incorrect port number problem. This is really a tcp initialization error, attempting to open an association, the remote host is up and running but the port number is wrong. Note: this same error can also be caused by the remote application (camera server) not running.

Example C:

```
{ctuser@engbayXX}[17] cd /usr/g/ctusr/logfiles
{ctuser@engbayXX}[18] more dcplog
# DICOM print_scu pid: 2523
print_scu -aIMN -hengctn1 -c1 -f1x1_fid -p./1on1 -d./camera.dev
dcm_bind: AETitle = engbay26_DCP
map_app_title: title IMN host engctn1 ip-addr 3.7.52.164 port 2106
EstablishAssoc: DCM_OPEN_REQ Action success
Errors logged beyond this point of failure may be a result of this
Error:
DCM kernel lower level error:
type = 508 -- DCM network error ¨ ERROR
```

```
code = 114 -- lost transport connection
ul_code = 52, reason = 0, source = 0, reject = 0
filename = kernel/D_assoc.c  line = 3051
Failed to contact printer, status 114
```

DCM Protocol Error

A **DCM** Protocol Error indicates a problem with calling parameters when trying to open an association. They can be caused by having an incorrect **AE** Title configuration. The errors reported by a print server are only as good as the dicom implementation of that server. The Imation server will accept any called **AE** title. The Kodak mlp190 will accept any called **AE** title. The AGFA however, requires the **AE** to match. The following are examples of what will be reported in the dcplog, with an incorrect **AE** Title on an AGFA system (Example D), and what snoop is reporting (Example E).

Example D:

```
cd /usr/g/ctuser/logfiles
more dcplog
print_scu -aIMN1 -hengctn1 -c1 -f1x1_fid -p./1on1 -d./camera.dev
# DICOM print_scu pid: 2492
print_scu -aIMN1 -hengctn1 -c1 -f1x1_fid -p./1on1 -d./camera.dev
dcm_bind: AETitle = engbay26_DCP
map_app_title: title IMN1 host engctn1 ip-addr 3.7.52.164 port 2106
EstablishAssoc: DCM_OPEN_REQ Action success
Errors logged beyond this point of failure may be a result of this
Error:
DCM kernel lower level error:
type = 507 -- DCM Protocol error  ERROR
code = 166 -- invalid PDU parameter value
ul_code = 37, reason = 0, source = 0, reject = 0
filename = kernel/D_assoc.c  line = 3051
DCM kernel lower level error:
type = 503 -- DCM Kernel integrity errors
code = 136 -- error with the dicom upper layer
ul_code = 22, reason = 0, source = 0, reject = 0
filename = kernel/D_assoc.c  line = 500
Fatal DCM error: 136
dcm_deinit: Kernel Deinit Failed
Failed to contact printer, status 166
```

EXAMPLE E:

The number of packets, outbound and inbound with length of ~60 and ~500 indicates that the remote application is running, but it is not allowing the **SCU** (Service Class User, i.e. the OC) to open an association. This also indicates the IP Address and Port Number is correct.

engbay26 2# **snoop -SVta *<camera IP address>***

Using device ef0 (promiscuous mode)

```
15:10:36.357083    engbay26 -> engctn1     length:   58  ETHER Type=0800
(IP), size = 58 bytes
15:10:36.357083    engbay26 -> engctn1     length:   58  IP  D=3.7.52.164
S=3.7.52.151 LEN=44, ID=59135
```

```
15:10:36.357083    engbay26 -> engctn1     length:   58  TCP D=2106 S=1209
Syn Seq=1188358241 Len=0 Win=16384
_____________________________________
15:10:36.358280     engctn1 -> engbay26    length:   60  ETHER Type=0800
(IP), size = 60 bytes
15:10:36.358280     engctn1 -> engbay26    length:   60  IP  D=3.7.52.151
S=3.7.52.164 LEN=44, ID=37125
15:10:36.358280     engctn1 -> engbay26    length:   60  TCP D=1209 S=2106
Syn Ack=1188358242 Seq=1847802416 Len=0 Win=8760
_____________________________________
15:10:36.358390    engbay26 -> engctn1     length:   54  ETHER Type=0800
(IP), size = 54 bytes
15:10:36.358390    engbay26 -> engctn1     length:   54  IP  D=3.7.52.164
S=3.7.52.151 LEN=40, ID=59137
15:10:36.358390   engbay26 -> engctn1    length:  54  TCP D=2106 S=1209
Ack=1847802417 Seq=1188358242 Len=0 Win=16060
_____________________________________
15:10:36.361533    engbay26 -> engctn1     length:  456  ETHER Type=0800
(IP), size = 456 bytes
15:10:36.361533    engbay26 -> engctn1     length:  456  IP  D=3.7.52.164
S=3.7.52.151 LEN=442, ID=59138
15:10:36.361533   engbay26 -> engctn1    length:  456  TCP D=2106 S=1209
Ack=1847802417 Seq=1188358242 Len=402 Win=16060
_____________________________________
15:10:36.412509     engctn1 -> engbay26    length:   60  ETHER Type=0800
(IP), size = 60 bytes
15:10:36.412509     engctn1 -> engbay26    length:   60  IP  D=3.7.52.151
S=3.7.52.164 LEN=40, ID=37126
15:10:36.412509    engctn1 -> engbay26   length:  60  TCP D=1209 S=2106
Ack=1188358644 Seq=1847802417 Len=0 Win=8760
_____________________________________
15:10:36.424127     engctn1 -> engbay26    length:   64  ETHER Type=0800
(IP), size = 64 bytes
15:10:36.424127     engctn1 -> engbay26    length:   64  IP  D=3.7.52.151
S=3.7.52.164 LEN=50, ID=37127
15:10:36.424127    engctn1 -> engbay26   length:  64  TCP D=1209 S=2106
Ack=1188358644 Seq=1847802417 Len=10 Win=8760
_____________________________________
15:10:36.424376    engbay26 -> engctn1     length:   64  ETHER Type=0800
(IP), size = 64 bytes
15:10:36.424376    engbay26 -> engctn1     length:   64  IP  D=3.7.52.164
S=3.7.52.151 LEN=50, ID=59141
15:10:36.424376   engbay26 -> engctn1    length:  64  TCP D=2106 S=1209
Ack=1847802427 Seq=1188358644 Len=10 Win=16060
_____________________________________
15:10:36.428902     engctn1 -> engbay26    length:   60  ETHER Type=0800
(IP), size = 60 bytes
15:10:36.428902     engctn1 -> engbay26    length:   60  IP  D=3.7.52.151
S=3.7.52.164 LEN=40, ID=37128
15:10:36.428902     engctn1 -> engbay26    length:   60  TCP D=1209 S=2106
Fin Ack=1188358654 Seq=1847802427 Len=0 Win=8760
_____________________________________
15:10:36.428975    engbay26 -> engctn1     length:   54  ETHER Type=0800
(IP), size = 54 bytes
15:10:36.428975    engbay26 -> engctn1     length:   54  IP  D=3.7.52.164
S=3.7.52.151 LEN=40, ID=59143
15:10:36.428975   engbay26 -> engctn1    length:  54  TCP D=2106 S=1209
Ack=1847802428 Seq=1188358654 Len=0 Win=16060
```

Note: If the **AE** title is correct, the server may have a security feature that requires that the local host be registered on the remote host.

Image Packet Transfer, Output From `snoop`

This is an excerpt from a snoop output representing actual image packets, (length ~1514), being transferred to the camera:

```
12:19:58.436211    engbay26 -> engctn1     length: 1514  ETHER Type=0800
(IP), size = 1514 bytes
12:19:58.436211    engbay26 -> engctn1     length: 1514  IP  D=3.7.52.164
S=3.7.52.151 LEN=1500, ID=38793
12:19:58.436211   engbay26 -> engctn1    length: 1514  TCP D=2106 S=1511
Ack=3095191028 Seq=1815234494 Len=1460 Win=16060

12:19:58.436256    engbay26 -> engctn1     length: 1514  ETHER Type=0800
(IP), size = 1514 bytes
12:19:58.436256    engbay26 -> engctn1     length: 1514  IP  D=3.7.52.164
S=3.7.52.151 LEN=1500, ID=38794
12:19:58.436256   engbay26 -> engctn1    length: 1514  TCP D=2106 S=1511
Ack=3095191028 Seq=1815235954 Len=1460 Win=1606
```

3.3.2 Snoop

Snoop (`snoop`) is the troubleshooting tool that monitors all the communication and image packets inbound and outbound to the camera during a print job (depending on switch settings). The packet size length is important in understanding what is being transferred. A length size of < 500 indicates requests and responses between the scanner and the print server. These are from the NGET (printer status), and NCREATE (film session and film box). A series of packet lengths of about 1500 indicates an image transfer in progress. This applies to both dicom print and dicom send.

STEP	COMMENT
1. Open up a Unix shell	From Desktop, select Unix Shell
2. Become root.	**`su -`**
3. Start the snoop session in the shell and set it up to display outgoing and incoming packets.	**`snoop -SVta <camera ip address>`**
4. Send a **DICOM** Print job to the camera	In ImageWorks desktop, display an image and drag/drop the image into the film composer and Print it.
5. Observe the output packets of data being sent and received.	Length sizes < 500 = communication request between the scanner and the print server. Length sizes ~1500 = the image packet size being sent.

Table 4-4 Steps for Starting a Snoop Session

The following examples show common uses of snoop. See Number 3, below, for a description of snoop usage and switch descriptions. Typical use examples:

1.) How to display outgoing and in-going packets:

```
{ctuser@bayXX}[3] su  -
password
bayxx 1#  snoop -SVta  <camera ip address>
Using device ef0 (promiscuous mode)
```

```
15:00:18.606959     engbay26 -> engctn1      length:   58  ETHER
Type=0800 (IP), size = 58 bytes
15:00:18.606959     engbay26 -> engctn1      length:   58  IP
D=3.7.52.164 S=3.7.52.151 LEN=44, ID=59593
15:00:18.606959    engbay26 -> engctn1     length:   58  TCP D=2104
S=3565 Syn Seq=1295817451 Len=0 Win=16384
15:00:18.608481      engctn1 -> engbay26     length:   60  ETHER
Type=0800 (IP), size = 60 bytes
15:00:18.608481      engctn1 -> engbay26     length:   60  IP
D=3.7.52.151 S=3.7.52.164 LEN=40, ID=33153
15:00:18.608481     engctn1 -> engbay26    length:   60  TCP D=3565
S=2104 Rst Ack=1295817452 Win=0
```

2.) How to display incoming packets only:

```
{ctuser@bayXX}[3] su -
password
bayxx 1# snoop -SPVta  <camera ip address>
Using device ef0 (promiscuous mode)
14:58:54.506391      engctn1 -> engbay26     length:   60  ETHER
Type=0800 (IP), size = 60 bytes
14:58:54.506391      engctn1 -> engbay26     length:   60  IP
D=3.7.52.151 S=3.7.52.164 LEN=40, ID=14589
14:58:54.506391     engctn1 -> engbay26    length:   60  TCP D=3563
S=2104 Rst Ack=1285065404 Win=0
```

3.) Usage for snoop:

```
[ -a ]   # Listen to packets on audio
[ -d device ]# settable to le?, ie?, bf?, tr?
[ -s snaplen ]# Truncate packets
[ -c count ]# Quit after count packets
[ -P ]   # Turn OFF promiscuous mode
[ -D ]   # Report dropped packets
[ -S ]   # Report packet size
[ -i file ]# Read previously captured packets
[ -o file ]# Capture packets in file
[ -n file ]# Load addr-to-name table from file
[ -N ]   # Create addr-to-name table
[ -t  r|a|d ]# Time: Relative, Absolute or Delta
[ -v ]   # Verbose packet display
[ -V ]   # Show all summary lines
[ -p first[,last] ]# Select packet(s) to display
[ -x offset[,length] ]# Hex dump from offset for length
[ -C ]   # Print packet filter code
```

For additional information, refer to the manual page for snoop. To do so, open a Unix shell, and enter the following:

```
su  -
password
man snoop
```

3.4 Sample Logs

3.4.1 `lclog` - laser camera log

```
Successful Camera Initialization
User_Msg... CODE----> 301
#301fname = /usr/g/ctuser/film/img41a000QY
arg_copies = 1arg_format = 4x3_fidddasm952 interface was
loaded...Set_Vendor_Bits...LcSyscall: cmd 30
scsisleep duration=100000000nsLcgetResponse: ready 1
Set_12_Line_Border pass...
LcSyscall: cmd a4
LcgetResponse: ready 1
Clear_Alarm...LcSyscall: cmd 85
LcgetResponse: ready 1
Request_Status Called...LcSyscall: cmd 96
LcgetResponse: ready 1
LcSysrep: resp ``STA,1,RDY''
LcSysrep(RQS): status160->STA,1,RDY
LcSysrep: RDYLcSysrep():ALM 1,log_msg: code = 1 (logged_error = 0)
LcSyscall: cmd 82
LcgetResponse: ready 1
LcSysrep: resp ``PAS''
LcSysrep(ALI): status160->PAS
Allocate_Device OK
opening data file /usr/g/ctuser/film/img41a000QYSet_Greyscale...
LcSyscall: cmd a5
LcgetResponse: ready 1
      Start of Print Job
STATISTICS*************START PRINTING FILM****************/usr/g/ctuser/
film/img41a000QYLcSyscall: cmd 90
LcgetResponse: ready 1
LcSysrep: resp ``PAS''
LcSysrep(MAT): status160->PAS
LcSyscall: cmd a3
LcgetResponse: ready 1
LcSysrep: resp ``PAS''
LcSysrep(LUT): status160->PAS
LcSyscall: cmd 9f
LcgetResponse: ready 1
LcSysrep: resp ``PAS''
LcSysrep(WIM): status160->PAS
Lc_clear_all:CMI...LcSyscall: cmd 86
LcgetResponse: ready 1
LcSysrep: resp ``PAS''
LcSysrep(CLR): status160->PAS
      Start of Image Acquisition Process
lc_load_and_acquire: img->image_sx=512lc_load_and_acquire: img-
>image_sy=512lc_load_and_acquire: img->image_psize=0.000000main : zoomd =
0, zoomh = 0
set_zoomd : ...set_zoomf...loading file /usr/g/ctuser/film/
img41a000QYxxL952_vdbSetFormat pass...format = 12 zoom = 0.000000
```

```
set_zoomd : ...set_zoomf...L952_vdbSetFormat leavingOLD SYTLE IMAGE
ACQUISITION, NO RING BUFFERINGentering rbL952_lcamStore: fname = /usr/g/
ctuser/film/img41a000QY, num_imgs=12, hdrlen =632entering
rbL952_lcamStore: image_sx = 512,image_sy =512, image_deep=
8rbL952_lcamStore: nbchuncks = loop_var = 16 nblocks= 512 image_size
=262144ACQUIRE IMAGE... Image_ID = 1
LcSyscall: cmd 84
LcgetResponse: ready 0
LcgetResponse: ready 1
LcSysrep: resp ``PAS''
LcSysrep(AQU): status160->PAS
ACQUIRE IMAGE... Image_ID = 2
```

Comment: *The above 6 steps are repeated for each succeeding Image Acquisition. Image acquisition completed, begin Printing*

```
LcSysrep(AQU): status160->PAS
L952_vdbPrint: format = 12 print_copies = 1Define_Zone: format =
12set_zoomd : ...set_zoomf...xxDefine_Zone: format = 12 nb_zone = 4
nb_image_line 3xxDefine_Zone: set_zoomd = 0.000000 , set_zoomf =
0.000000scan_ssparam = dd
xxDefine_Zone scanned ssparam = ddxxDefine_Zone: images_id[0] =
1xxDefine_Zone: images_id[1] = 2xxDefine_Zone: images_id[2] =
3Request_Status Called...LcSyscall: cmd 96
LcgetResponse: ready 1
LcSysrep: resp ``STA,1,RDY''
LcSysrep(RQS): status160->STA,1,RDY
LcSysrep: RDYLcSysrep():ALM 1,log_msg: code = 1 (logged_error = 0)
LcSyscall: cmd 8b
LcgetResponse: ready 1
LcSysrep: resp ``PAS''
LcSysrep(DZO): status160->PAS
xxDefine_Zone scanned ssparam = ddxxDefine_Zone: images_id[0] =
5xxDefine_Zone: images_id[1] = 6xxDefine_Zone: images_id[2] =
7Request_Status Called...LcSyscall: cmd 96
LcgetResponse: ready 1
LcSysrep: resp ``STA,1,RDY''
LcSysrep(RQS): status160->STA,1,RDY
LcSysrep: RDYLcSysrep():ALM 1,log_msg: code = 1 (logged_error = 0)
LcSyscall: cmd 8b
LcgetResponse: ready 1
LcSysrep: resp ``PAS''
LcSysrep(DZO): status160->PAS
xxDefine_Zone scanned ssparam = ddxxDefine_Zone: images_id[0] =
9xxDefine_Zone: images_id[1] = 10xxDefine_Zone: images_id[2] =
11Request_Status Called...LcSyscall: cmd 96
LcgetResponse: ready 1
LcSysrep: resp ``STA,1,RDY''
LcSysrep(RQS): status160->STA,1,RDY
LcSysrep: RDYLcSysrep():ALM 1,log_msg: code = 1 (logged_error = 0)
LcSyscall: cmd 8b
LcgetResponse: ready 1
LcSysrep: resp ``PAS''
LcSysrep(DZO): status160->PAS
```

```
xxDefine_Zone scanned ssparam = ddxxDefine_Zone: images_id[0] =
13xxDefine_Zone: images_id[1] = 14xxDefine_Zone: images_id[2] =
15Request_Status Called...LcSyscall: cmd 96
LcgetResponse: ready 1
LcSysrep: resp ``STA,1,RDY''
LcSysrep(RQS): status160->STA,1,RDY
LcSysrep: RDYLcSysrep():ALM 1,log_msg: code = 1 (logged_error = 0)
LcSyscall: cmd 8b
LcgetResponse: ready 1
LcSysrep: resp ``PAS''
LcSysrep(DZO): status160->PAS
Lc_set_up_to_print call...nbcopies= 1LcSyscall: cmd 9a
LcgetResponse: ready 1
LcSysrep: resp ``STC''
LcSysrep(STP): status160->STC
LcSysrep(STP): STC OK...
EXPOSE...
LcSyscall: cmd 8d
LcgetResponse: ready 1
LcSysrep: resp ``PTC''
LcSysrep(EXP): status160->PTC
camscan: (17:75 to 8b)  0x72 EXP 0xd  0x6 EOE 0xd & 0xa  0xb  0xc PTC 0xd
& 0xa  0xb  0xc  0xa
camscan: dcr's 1
LcSysrep(EXP): DCR...print_copies = 0User_Msg... CODE----> 353
#353
```

Comment: *End of Print Job*

```
STATISTICS:******END OF THIS JOB /usr/g/ctuser/film/img41a000QY Ready To
Print new*******Release_Device...LcSyscall: cmd 95
LcgetResponse: ready 1
User_Msg... CODE----> 350
#350
```

3.4.2 `dcplog` - dicom print log

dcplog Sample Output of a Successful 1on1 Film Job.

Note: The output is broken up into sections with key film session actions in bold, and an explanation indented and in italics. The dcplog includes the use of these acronyms in the following example:

SCP = Service Class Provider: The camera, a receiver of images.

SCU = Service Class User: The OC scanner, has ability to send images

calling AE title

dcm_bind: AETitle = engbay26_DCP

called **AE** title - hostname - IP address port number of printer

map_app_title: title IMN host engctn1 ip-addr 3.7.52.164 port 2104

Print **SCU** (on the OC) requests an association with print **SCP** (print server at camera) using the IP address, port number and **AE** title. The **SCU** proposes abstract syntaxes (in this case print service class) along with transfer syntaxes used for each syntax and **PDU** transfer rate.

EstablishAssoc: DCM_OPEN_REQ Action success

The Print **SCP** responds with an association acceptance. If the association has been accepted, the Dicom parameters (host, IP, **AE**, port correctly configured):

EstablishAssoc: OPEN_CONF received

The **SCU** sends an NGET request to the **SCP** for printer status:

Starting the print session

The **SCP** returns an NGET response status and printer status to the **SCU**:

Note:
- IF the **SCP** returns a NORMAL status to the **SCU**, the job continues.
- If the **SCP** returns an ERROR status to the **SCU**, the print job will fail.
- If the **SCP** returns a WARNING status, the job may fail or continue depending on status info. See table for list of supported status.

NgetService: Event Received: DCM_NGET_END

NgetService: Event Received: DCM_DATA

PRINTER STATUS	
SOP uid	
Instance uid	
Printer status	NORMAL
status info	
printer_name	advt
manufacturer	AGFA
model	ADVT
device serial number	123456
software version	Version 2.0
AETitle	IMN

Table 4-5 Printer Events

*The **SCU** sends an NCREATE request to the **SCP** to create the film session. The Film session presentation consists of copies, priority of job, medium type, and film destination:*

```
NcreateService: NCREATE BEG Action Success
NcreateService: DCM DATA Action Success
NcreateService: Waiting for Event
NcreateService: Event received: DCM_RETURN_BUFF
NcreateService: Waiting for Event
```

*The **SCP** returns Ncreate RSP status to **SCU** along with instance uid for film session:*

```
NcreateService: Event received: DCM_NCREATE_END
NcreateService: Status is : 0
film session instance uid 1.3.51.1
film session instance uid 1.3.51.1
filmbox ref sop uid 1.3.51.1
```

*The **SCU** sends NCreate RQ to the **SCP** to create the film box. The presentation includes film format, orientation, magnification, film size:*

```
NcreateService: NCREATE BEG Action Success
NcreateService: DCM DATA Action Success
NcreateService: Waiting for Event
```

*The **SCP** returns NCREATE RSP status to the **SCU** along with referenced sop instance uid for film box and referenced **SOP** instance uids for each image box:*

```
NcreateService: Event received: DCM_RETURN_BUFF
NcreateService: Waiting for Event
```

```
NcreateService: Event received: DCM_NCREATE_END
NcreateService: Waiting for Event
NcreateService: Event received: DCM_DATA
filmbox instance uid 1.3.51.1.1
```

***SCU** sends NSET RQ to the **SCP** to set the image box. The presentation includes instance uid, image position on the film, number of Rows, Columns, Bits, and image pixel data:*

```
NsetService: Event Received: DCM_RETURN_BUFF
```

***SCP** returns NSET RSP status to the **SCU** along with affected sop instance uid for image box:*

```
NsetService: Event Received: DCM_NSET_END
Image Attributes set
```

*The **SCU** and **SCP** repeat the NSET RQ and NSET RSP for the image boxes until all images have been sent to the **SCP**. When all images have been sent, the **SCU**, it sends NACTION RQ to the **SCP** to print the film box with instance uid generated during the NCREATE. The **SCP** returns NACTION RSP to print the film:*

```
NactionService: Event received: DCM_NACTION_END
NactionService: Event received: DCM_DATA
parse_data_set returned status 0x0
Film Box sent to printer N - Action
```

*The **SCU** sends NDELETE RQ to the **SCP** to delete the film box with instance uid generated during the NCREATE. **SCP** returns NDELETE RSP to delete the film box and returns the sop Instance of the film job:*

```
NdeleteService: Event Received : DCM_NDELETE_END
Film box instance deleted
ref SOP C uid 1.2.840.10008.5.1.1.14
ref SOP I uid 1.3.51.1.1.1.1
Print Session successfully completed
```

*The **SCU** sends RELEASE RQ to the **SCP** to release the association:*

```
req close assoc
CloseAssoc: DCM_CLOSE_REQ Action Success
```

*The **SCP** returns RELEASE RP to release association:*

```
close accepted
```

3.4.3 `prslog` - printer server log

LOCATION	DESCRIPTION
OC: `/usr/g/ctuser/logfiles/prslog`	This is a running history log of print server initializations and shutdowns, and print jobs are started and completed.
Example prslog output	
Successful print server initialization:	
`MESSAGE from Process 1639>> Tue Aug 18 13:10:38 1998`	`[Server]> initialization in progress for port PRSserver`
`MESSAGE from Process 1639>> Tue Aug 18 13:10:38 1998`	`[Server]> ...initialization completed for port PRSserver`
`MESSAGE from Process 1674>> Tue Aug 18 13:11:02 1998`	`[PRSserver]> Hello, I'm the print server, still alive on host engbay13`

Table 4-6 prslog Output

LOCATION	DESCRIPTION
Successful print jobs running:	
MESSAGE from Process 1799>> Tue Aug 18 13:15:56 1998	[PRSserver]> Print job started
MESSAGE from Process 1799>> Tue Aug 18 13:16:21 1998	Printed Ex: 1472 Se: 103 Im: 1
MESSAGE from Process 1799>> Tue Aug 18 13:16:21 1998	[PRSserver]> Completed print job: Ex: 1472 Se: 103 Im: 1
MESSAGE from Process 1817>> Tue Aug 18 13:16:50 1998	[PRSserver]> Print job started
MESSAGE from Process 1817>> Tue Aug 18 13:17:16 1998	Printed Ex: 1472 Se: 103 Im: 25
MESSAGE from Process 1817>> Tue Aug 18 13:17:16 1998	[PRSserver]> Completed print job: Ex: 1472 Se: 103 Im: 25
MESSAGE from Process 1825>> Tue Aug 18 13:17:41 1998	[PRSserver]> Print job started
MESSAGE from Process 1825>> Tue Aug 18 13:18:06 1998	Printed Ex: 1472 Se: 103 Im: 49
MESSAGE from Process 1825>> Tue Aug 18 13:18:06 1998	[PRSserver]> Completed print job: Ex: 1472 Se: 103 Im: 49
MESSAGE from Process 1831>> Tue Aug 18 13:18:33 1998	[PRSserver]> Print job started
MESSAGE from Process 1831>> Tue Aug 18 13:18:59 1998	Printed Ex: 1472 Se: 103 Im: 73
MESSAGE from Process 1831>> Tue Aug 18 13:18:59 1998	[PRSserver]> Completed print job: Ex: 1472 Se: 103 Im: 73
Print server shutdown from Applications being brought down:	
MESSAGE from Process 1639>> Tue Aug 18 14:48:34 1998	[Server]> Caught signal : 2
MESSAGE from Process 1674>> Tue Aug 18 14:48:35 1998	[Server]> Caught signal : 2.
MESSAGE from Process 1639>> Tue Aug 18 14:48:41 1998	[Server]> terminated
Successful print server initialization:	
MESSAGE from Process 1598>> Tue Aug 18 14:53:43 1998	[Server]> initialization in progress for port PRSserver
MESSAGE from Process 1598>> Tue Aug 18 14:53:43 1998	[Server]> ...initialization completed for port PRSserver
MESSAGE from Process 1636>> Tue Aug 18 14:54:09 1998	[PRSserver]> Hello, I'm the print server, still alive on host engbay13
MESSAGE from Process 1902>> Tue Aug 18 15:15:40 1998	[PRSserver]> Print job started
MESSAGE from Process 1902>> Tue Aug 18 15:16:06 1998	Printed Ex: 1476 Se: 2 Im: 1
MESSAGE from Process 1902>> Tue Aug 18 15:16:06 1998	[PRSserver]> Completed print job: Ex: 1476 Se: 2 Im: 1
MESSAGE from Process 1926>> Tue Aug 18 15:17:10 1998	[PRSserver]> Print job started
MESSAGE from Process 1926>> Tue Aug 18 15:17:35 1998	Printed Ex: 1476 Se: 2 Im: 16
MESSAGE from Process 1926>> Tue Aug 18 15:17:35 1998	[PRSserver]> Completed print job: Ex: 1476 Se: 2 Im: 16

Table 4-6 prslog Output (Continued)

3.4.4 `camera.dev` (AGFA DICOM Print Camera)

Enter the following:

1.) {ctuser@bayXX}[5] **`cd /usr/g/ctuser/app-defaults/devices`**

2.) {ctuser@bayXX}[6] **`cat camera.dev`**

`camera.dev` CONTENTS LISTING	DESCRIPTION
`set dName {Dicom Camera}`	Sets the name that appears in manual composer and scanRx autofilm setup
`set dType digital`	Refers to 1 of {postscript, analogue, or digital}. For **DICOM** the dType is set to digital.
`set dQueueType DICM`	Refers to the Job type; can be {LP=postscript, LC=laser camera, or DICM} for **DICOM** print cameras.
`set ctype {Imation Print Server}`	**DICOM** camera type selected during Camera Installation
`set dQueueName dicom`	Sets the name that appears in the Filming Queue
`set defaultFormat  4x3_fid`	Default format for manual composer selected during Camera Installation
`set dHostName agfacamera`	Hostname of the print server entered during Camera Installation
`set dAppTitle DRYSTAR`	**AE** title of the print server entered during Camera Installation
`set medType BLUE`	Medium type selected during Camera Installation - can be one of BLUE FILM, CLEAR FILM, or PAPER - this element is sent during NCREATE of the Film Session.
`set destination MAGAZINE`	The destination for printed film selected in during Camera Installation. Can be one of MAGAZINE, PROCESSOR - this element is sent during NCREATE of the Film Session.
`set filmOrientation PORTRAIT`	The Orientation of image boxes on film selected during Camera Installation can be one of LANDSCAPE or PORTRAIT - this element is sent during NCREATE of the Film Box.
`set magType CUBIC`	The magnification of film selected during Camera Installation. Can be one of REPLICATE, BILINEAR, CUBIC, or NONE - this element is sent during NCREATE of the Film Box.

Table 4-7 camera.dev contents listing

camera.dev CONTENTS LISTING	DESCRIPTION
set minDensity 5 set maxDensity 300 set borderDensity BLACK set emptyDensity BLACK set smoothType 140 set configuration PERCEPTION_LUT=200	These elements are sent during the NCREATE of the Film Box and will set the following values: • sets minimum Optical Density - film and camera type dependent. • sets Maximum Optical Density - film and camera type dependent. • sets border density • sets empty image density • sets the smoothing type when magType is set to CUBIC • sets configuration info. This value differs for all camera vendors who typically define the LUT for contrast.
pformat 1x1_fid pformat 2x1_fid pformat 2x2_fid pformat 3x2_fid pformat 3x3_fid pformat 4x3_fid pformat 5x3_fid pformat 4x4_fid pformat 5x4_fid	Manual film composer and auto film formats Note: **DICOM** defines film format as column vs. row, as opposed to GE's Laser film format definition of row vs. column.

Table 4-7 camera.dev contents listing (Continued)

3.4.5 SdCPHosts (DICOM Print only)

Enter the following:

1.) {ctuser@bayXX}[2] **cd /usr/g/ctuser/Prefs** ENTER
2.) {ctuser@bayXX}[3] **cat SdCPHosts** ENTER

SdCPHosts CONTENTS LISTING EXAMPLE	DESCRIPTION
3.7.52.164	The IP address of the camera, entered during Camera Installation
camera	The hostname of the camera, entered during Camera Installation
PRINTSCP	The **AE** (Applications Entity) Title, entered during Camera Installation
2106	The **TCP** Listen Port number, entered during Camera Installation
ctn display	A comment entered in the network comment field of Camera Installation.

Table 4-8 SdCPHosts contents listing example

GE MEDICAL SYSTEMS

GE MEDICAL SYSTEMS-AMERICAS: FAX 262.312.7434
3000 N. GRANDVIEW BLVD., WAUKESHA, WI 53188 U.S.A.

GE MEDICAL SYSTEMS-EUROPE: FAX 33.1.40.93.33.33
PARIS, FRANCE

GE MEDICAL SYSTEMS-ASIA: FAX 65.291.7006
SINGAPOR

GE Medical Systems

gemedical.com

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GE Medical Systems
HiSpeed QX/i Service Manual - General

Chapters 5 & 6
Console & Table

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Chapter 5
Console

Section 1.0
Theory

1.1 Console Varieties

The HiSpeed QX/i CT scanners are equipped with one of two varieties of Console:

- Global Console - Linux (GC-Linux)
- Global Console - Octane2 (GC-Octane2)

Though functionally identical, these two generations of operator's console differ in physical layout (see Figure 5-1, on page 246 and Figure 5-4, on page 249). The most significant changes from the GC-Octane2 Console to the GC-Linux console are:

- Replacement of the IRIX OS-based SGI Workstation (Octane2) with a Linux OS-based Workstation.
- Replacement of the MOD as an archive device with a DVD-RAM drive.

1.2 Console Overview

The console is divided into two functional subsystems, one is called the Host and the other the Scan Reconstruction Unit (**SRU**). The Host subsystem consists of the following hardware:

- Host computer
- Mouse, keyboard, trackball & monitors
- System disks
- **MOD** drive (housed in SCSI tower, on Global Console - Linux)
- **CD-ROM** drive
- Network devices (switches and converters)
- Serial I/O (input/output)
- DVD-RAM (Global Console - Linux only), housed in SCSI tower

The Scan Reconstruction Unit (**SRU**) subsystem consists of the following hardware:

- **ICE** box
- Pegasus Image Generator
- Motorola Computer
- **DIP**
- Scan Data Disk

Communications between these functional subsystems occur via network and serial connections. Communications between the host and **SRU** take place primarily using network channel. Using the network channel allows sharing of resources on the host disk by the **SRU** (client). Serial communications are used for the downloading and "flashing" memory (**PROM**) in the **SRU**.

Table 5-1 lists the key components covered in this chapter, as well as their acronyms.

COMMON NAME	ALIAS/ ACRONYM	COMMON NAME	ALIAS/ ACRONYM
Linux OS Computer, Octane2 Computer, Octane Computer,	Host Computer	**VME** Chassis/enclosure and Boards	**ICE** Box
DAS Interface Processor	**DIP**	Recon Interface Processor (Motorola Board)	**RIP**
Pegasus Image Generator	**PIG**, **PEG-IG**	Scan Recon Computer	**SRU**
Scan Data Disk	**SDD**	Small Computer System Interface	**SCSI**
System Control Interface Module	**SCIM**	Data Acquisition System Manager	**DASM**

Table 5-1 Naming Conventions

1.2.1 Global Console - Linux (GC-Linux)

1.2.1.1 Physical Organization

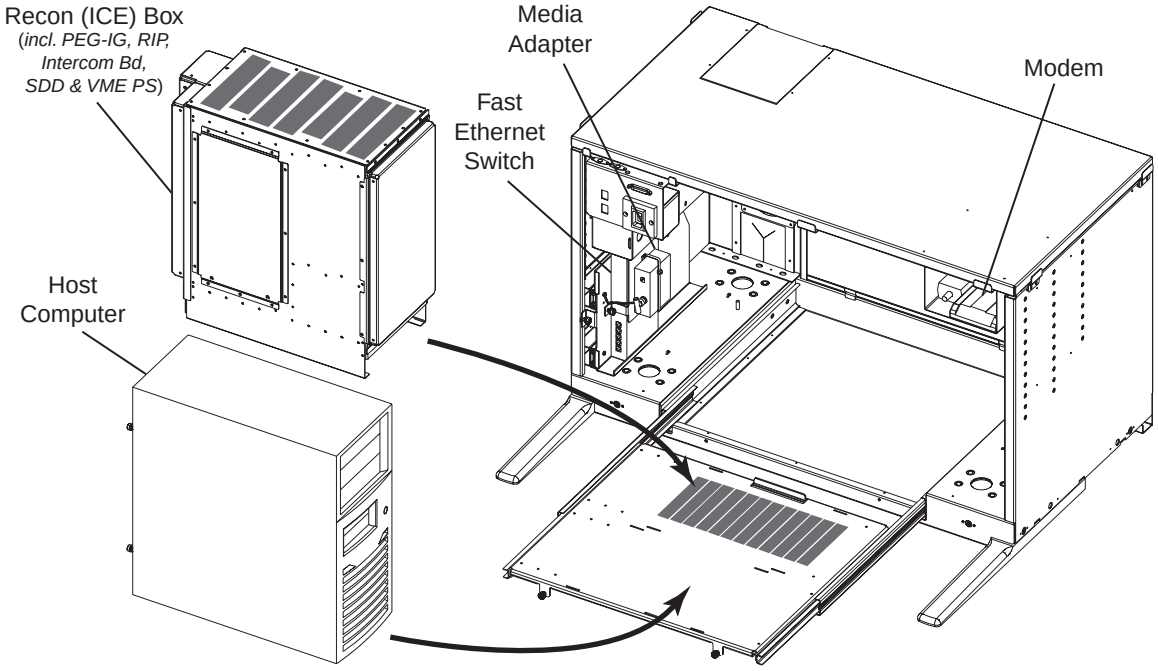


Figure 5-1 Locations of Key Console Components (Global Console - Linux)

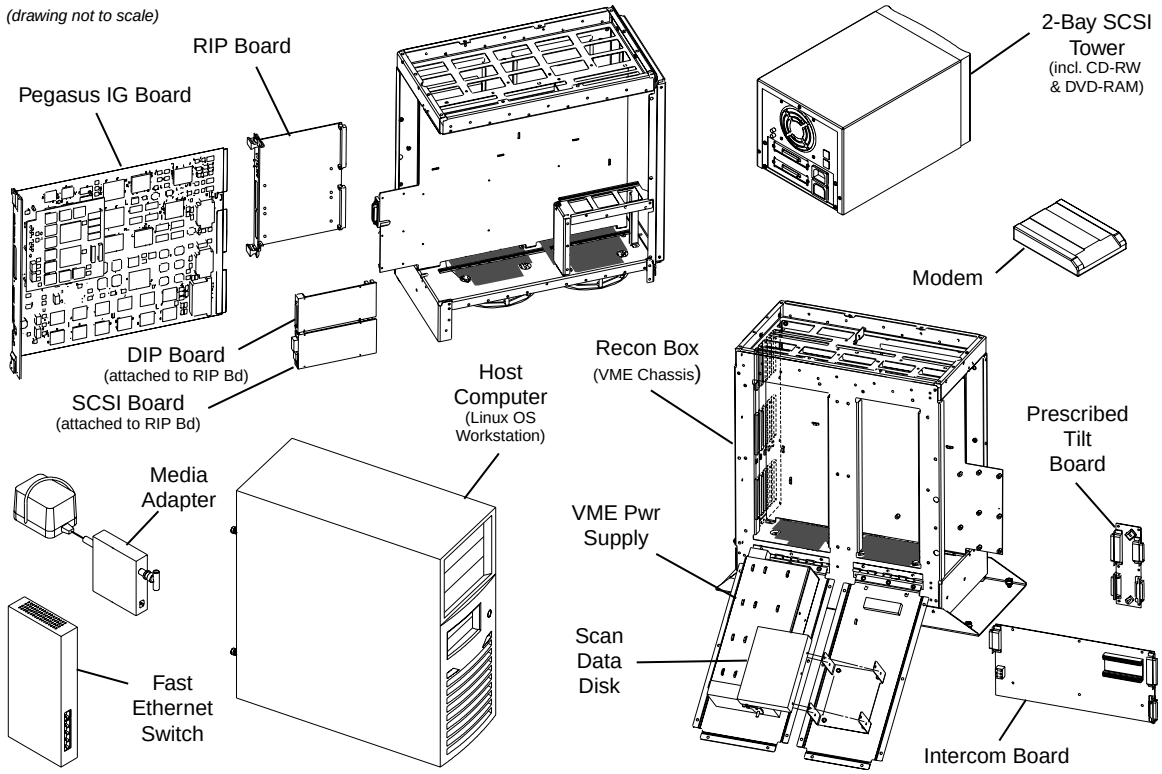


Figure 5-2 Key Console Components (Global Console - Linux)

1.2.1.2 Block Diagram

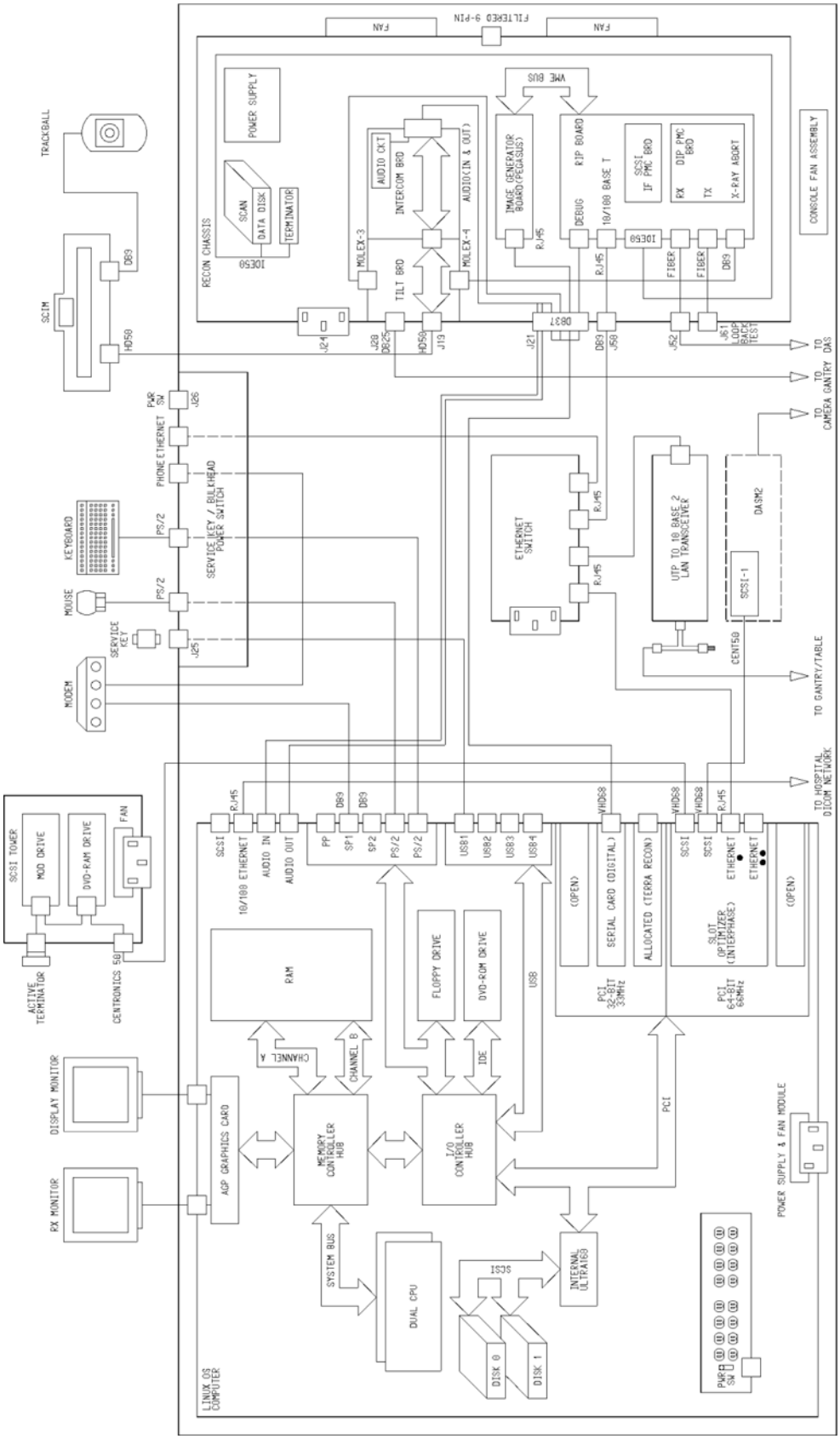


Figure 5-3 Block Diagram for Global Console - Linux

1.2.2 Global Console - Octane2 (GC-Oct2)

1.2.2.1 Physical Organization

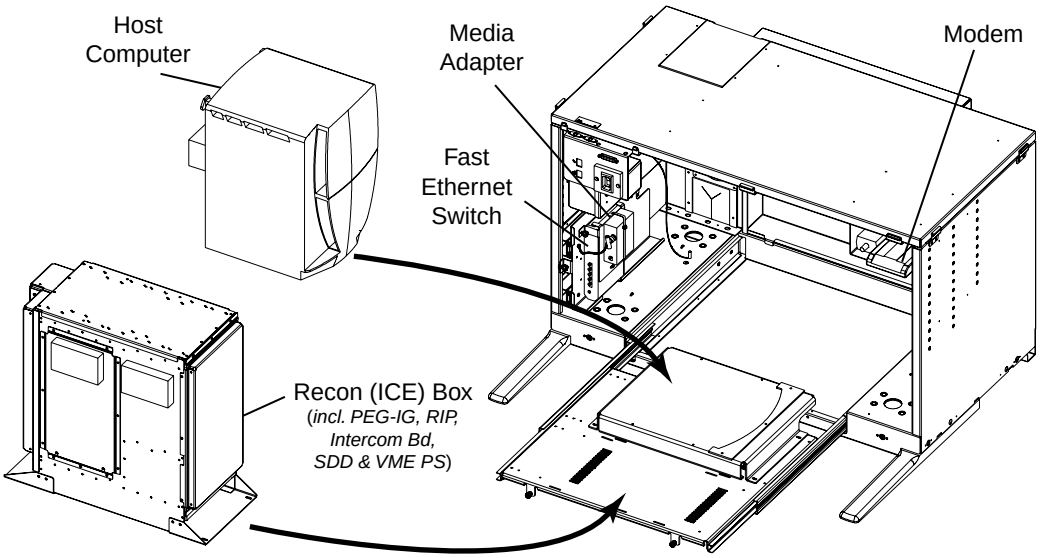


Figure 5-4 Locations of Key Console Components (Global Console - Octane2)

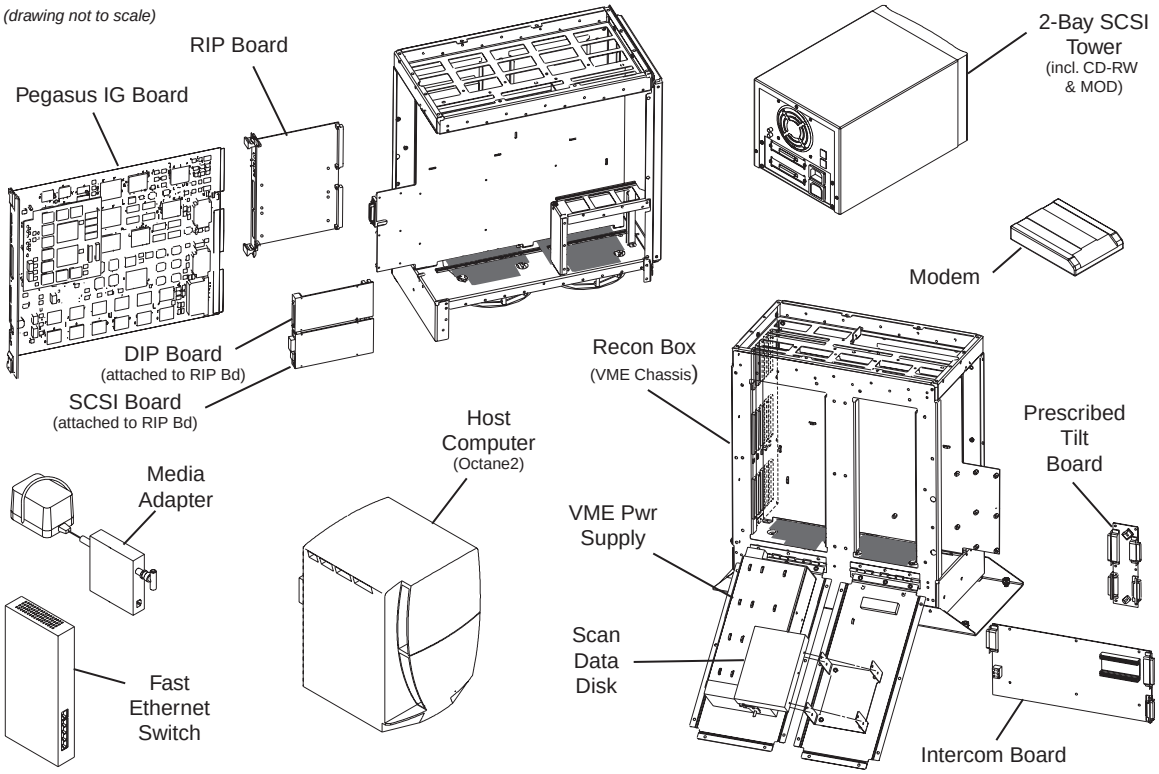


Figure 5-5 Key Console Components (Global Console - Octane2)

1.2.2.2 Block Diagram

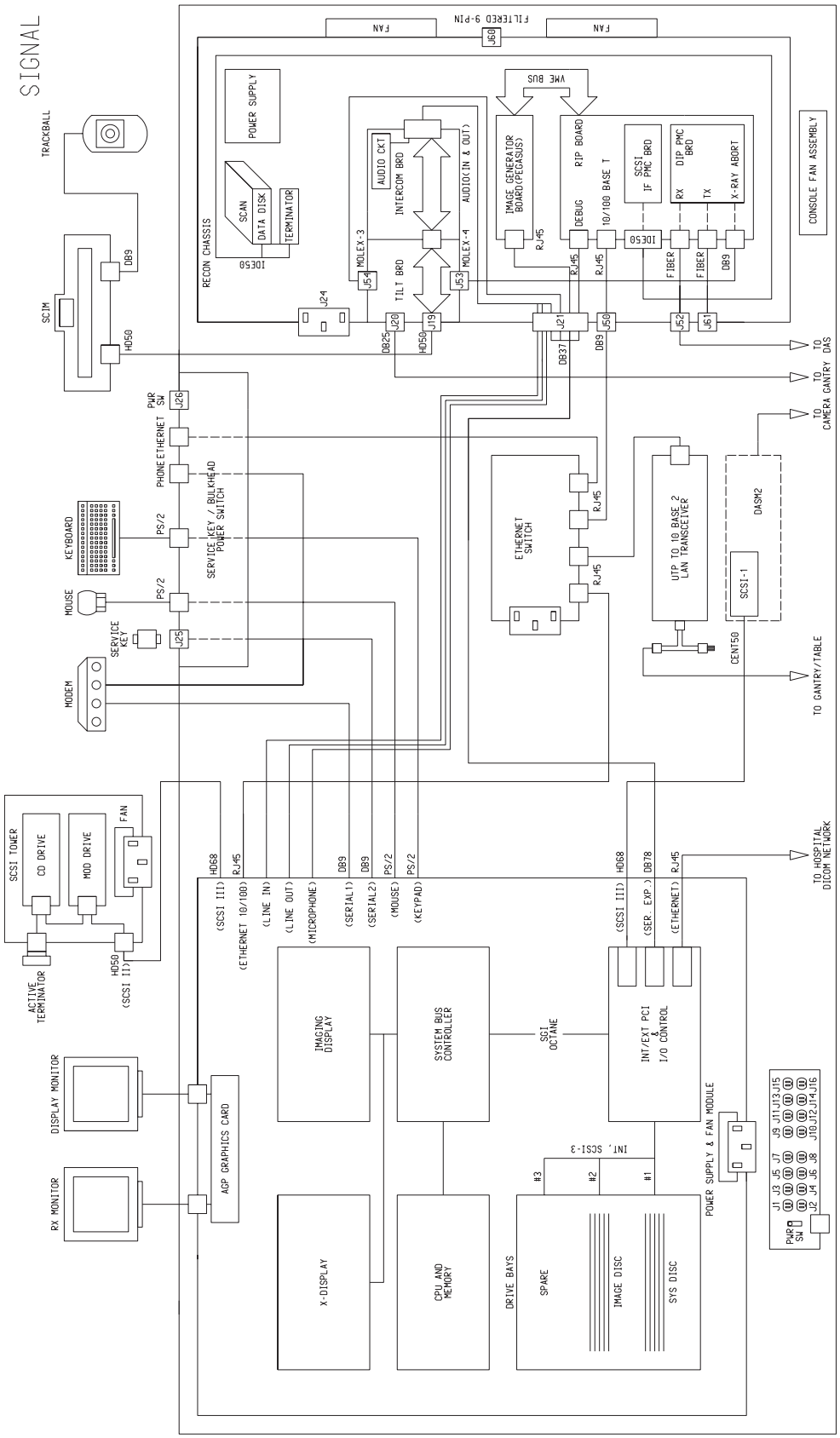


Figure 5-6 Block Diagram for Global Console - Octane2

1.3 Host Subsystem

1.3.1 System Control Interface Module (SCIM)

The **SCIM** provides the Scan Control (Start Scan, Pause Scan, Stop Scan, Move To Scan, Stop Move, Prescribed Tilt and Emergency Stop) and Intercom (Patient, Operator and Auto Voice) functionality. The **SCIM** also provides a visual X-Ray On indicator for exposures.

The **SCIM** is connected to J19 (refer to appropriate console block diagram, for location of J19). The physical interface is a 1.8 meter 50 conductor cable with micro HD 50 male connectors at each end. This interface cable provides both DC power (+5, +12V and -12V) and communication (RS-422) signals using discrete paths.

Upon power-up, the **SCIM** performs a self test of its internal processor and memory. Upon passing all self tests, all **LED**s illuminate for two seconds and then turn off. If any of the self tests fail, the **LED** On/Off sequence does not occur.

The microprocessor within the **SCIM** monitors the communication path to the Host computer for requests, and the state of the keys on the **SCIM**. Any time a key state change is detected, communications is sent to the host computer.

Overlays are used to identify **SCIM** functionality. **SCIM** overlays are available for different **SCIM** configurations and in several different languages.

The **SCIM** is spill resistant but not spill proof. It has been designed to withstand an accidental spill of liquids into the enclosure. Such as coffee or soft drinks. An elastomer within the **SCIM** routes spilled liquids to drain holes on the underside of the unit. Over-current protection has also been incorporated into the **SCIM**, in the event liquid does reach internal electronic components. Allow the **SCIM** to drain and dry, if liquids enter the enclosure.

There are NO serviceable parts within the **SCIM**, the keyboard or cable.

1.3.2 Video Display Monitors - CRT

This product uses energy efficient (1 Watt deep sleep mode) conventional Cathode Ray Tube (**CRT**) computer monitors. Both monitors' **CRT**s used in this **CT** scanner are manufactured by the Sony Corporation. Each features a flat faced trinitron tube with a viewable area of 19.8 inches and a dot pitch of 0.24mm. The **CRT** has a 39% face plate transmission and an AR/AS coating. The monitors support a full set of user definable settings. Color temperature (9300K, 6500K, 5000K) is selectable via a nine language on-screen display (OSD).

Figure 5-7 Display Monitors

1.3.2.1 Signal Input Parameter

- Horizontal 30-121 kHz
- Vertical: 48-160 HZ
- Input connector:HD 15 D-Sub
- Video: Analog RGB, 0.700Vp-p, positive, 75 OHM
- Sync: Separate HD/VD, TTL Polarity Free or External Composite, TTL Polarity Free

1.3.2.2 Power Specifications

- 100-120/220-240 VAC; 50/60Hz (Auto Sensing)
- Meets EPA Energy Star, VESA DPMS & NUTEK 803299

1.3.2.3 Agency Approvals

- Safety: UL, EN60950 (TUV, GS Mark)
- Marking: CE
- **EMI**: FCC Class B, IC B, CISPR22B, VCCI Level II
- X-Ray: DHHS, DNHW, PTB
- Human factor: MPR2, ZH1/618, ISO 9241-3 & 8, TCO-99

1.3.2.4 Mechanical Specifications

- 491mm x 498mm x 478mm (HxWxD) - Tilt swivel included
- 32 kg (70.4 lbs)

1.3.2.5 Timing Characteristics and Video Levels

The following tables define the video signal timing for the image and operator display video outputs. Both channels are 1280 x 1024 RGB color at 72HZ, 1 Volt peak-to-peak video at 75 ohms.

DISPLAY MONITOR - VIDEO CHARACTERISTICS	
Parameter	72 Hz
Active Pixel Format	1280 x 1024
Field/Frame	non-interlaced
Refresh Rate	72.239 Hz
Pixel Clock Freq, Period	129.25 MHz, 7.737 ns

Table 5-2 Display Monitor Video Characteristics & Timing

VIDEO OUTPUT	VIDEO LEVEL	SYNC LEVEL	BLANKING LEVEL
Red	0.714 Vp-p	none	0.054 volts
Blue	0.714 Vp-p	none	0.054 volts
Green	0.714 Vp-p	0.286 volts	0.054 volts

Table 5-3 DASM Red/Green/Blue Output Level Specifications

1.3.2.6 Splitting Video Signals

Use only a high quality video signal splitter, in a GE CT approved configuration. See the *Installation Manual* that came with your system, for further details on the appropriate use of video splitters.

If the display signal is used to drive multiple monitors, only use a commercial, high quality splitter (i.e., Black Box Corp. #RGBSplit-2, or Inline Corp. #IN3012). You should also use high quality (low loss) 75 ohm video cables. Splitters are also available from GEMS (B7530RC).

1.3.3 LCD Monitor

1.3.3.1 Overview

The 1850X is a high performance 18.1” LCD (Liquid Crystal Display) monitor capable of over displaying 16 million colors. It is manufactured by NEC™ and “Ambix” Technology, which is a dual input technology allowing both analog and digital inputs off of one connector.

The monitor is setup and configured for use through using its on-board menu system (OSM). Please see Section 2.1.2, on page 287 for help using the OSM. For further information on this monitor, consult the NEC website: ***http://www.necmitsubishi.com.***

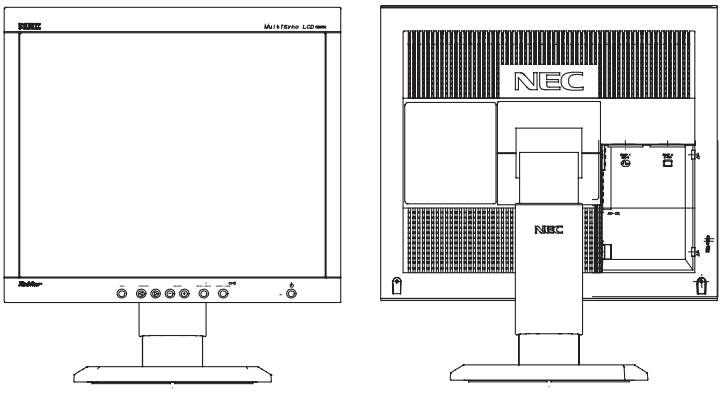


Figure 5-8 LCD Monitor (NEC 1850x)

1.3.3.2 Description

LCD: a-Si active matrix thin-film-transistor (TFT)

Effective display size:(Landscape) 14.14”(H) x 11.31”(V) / 359.04mm(H) x 287.232mm(V)
18.1” / 46cm diagonal

Viewing angle:Up 85 deg. / down 85 deg. / right 85 deg. / left 85 deg. (Typical)

Net Weight (Excluding stand):12.1lbs / 5.5Kg

Total Power Consumption:65 watts (typical) in “ON” mode and less than 3 watts in power saving mode.

Operating Environment:Temperature+41 to +95 deg.F / +5 to +35 deg.C
Humidity 30% to 80%
Altitude 0 to 10,000 Feet / 3,048m

1.3.4 Host Computer - Linux Workstation

The Global Console - Linux uses an HP xw8000 Workstation (see Figure 5-9), running Linux OS, as the Host Computer. This workstation contains no field servicable parts. For specific product information, please refer to the manufacturer’s web site, at: ***http://www.hp.com***.

Figure 5-9 Hewlett Packard (HP) Workstation xw8000

1.3.5 Host Computer - Octane/Octane2

1.3.5.1 Overview - Hardware Features

The Host Computer is a Silicon Graphics Inc. (**SGI**) computer. Two versions of this computer can be used in this product: Octane or Octane2. Physically, they appear the same, except the Octane2 has blue covers (the original Octane has teal). Some key performance and service features include:

- A “slide-out” System Module, which contains the **CPU**(s)/bricks
- R12K Single or Dual (Direct-3D Option) brick processor
- Peripheral Device Support through an integrated chassis.
  - **PCI** expansion bay for three 32 or 64-bit wide **PCI** devices
  - Three 3.5-inch Ultra **SCSI** drive bays
- 512MB’s (non-D3D) or 1.5GB (D3D) upgrade-able **DIMM** Memory
- Powerful graphics subsystem that supports dual [head] monitors. Octane2 uses a V12 graphics XIO card/subsystem, with dual channel display (**DCD**) daughter card.
- A Unique System ID module (NIC Chip) containing system Ethernet number (which gets imprinted on option **MOD**s)
- A slide-out Power Supply
- Dual 9GB, high speed (10k rpm), Small Computer System Interface (**SCSI**) disk drives. Slide-out internal hard drives with slot dependent **SCSI** IDs. The bottom slot being assigned **SCSI** ID1, the one above **SCSI** ID2, and the top slot for **SCSI** ID3, if installed.

Figure 5-10 Octane2 Host Computer

Figure 5-11 Octane (original) Host Computer

For additional information on Silicon Graphic’s Octane or Octane2 computer, please visit the manufacturer’s web site at ***http://www.sgi.com***.

1.3.5.2 System Module

The Silicon Graphics Octane/Octane2 workstation is powered by the 64-bit MIPS R12000A processor, with out-of-order execution, large flexible caches, and superscalar design. It features:

- R12KS-360 (single) or R12KS-400 (dual) MHz Processor(s)
- 4-way superscalar, 64-bit architecture
- Out-of-order instruction execution
- 5 separate execution units
- MIPS 4 instruction set
- 32KB two-way set-associative on-chip instruction cache
- 2MB fast L2 (secondary) cache

1.3.5.3 Peripheral Component Interconnect (PCI) Support

The host contains a Peripheral Component Interconnect (**PCI**) expansion chassis, which is connected to the main crossbar/crossbow bus within the Octane, and is capable of communicating at 266 MB per second. This bus is used to communicate with the Hospital's Ethernet network using a 10/100BT second ethernet **PCI** card. In addition, the **PCI** chassis contains a **SCSI** and serial.

PCI card cage contains 3 **PCI**-64 slots (2 full-height and 1 half-height) for either **PCI**-32 or **PCI**-64 cards. This card cage is inserted into the back of the Octane/Octane2 system.

The host computer configures the devices in the card cage during boot-up. The IRIX operating system assigns and configures at boot-up those devices it recognizes. Support for devices is either built into the kernel (e.g., **SCSI** support) or added later as device drivers (software). Device drivers (e.g., Serial expander **PCI** card) are added and loaded outside of the kernel.

The **SGI** Part Number is **PCI**-CARDCAGE

Figure 5-12 PCI Support Module

Fast Ethernet (100Base-TX) Adapter

The fast ethernet adapter provides a second 10/100Base-T port for the host computer. It is a one-port card that auto-negotiates between Fast Ethernet and Ethernet. The card also provides half and full duplex and auto-negotiates between the two. The port supports Category 5 unshielded twisted pair (**UTP**) wiring via an RJ45 connector. In addition to providing the additional Fast Ethernet port, the card also has one mouse and keyboard port. The **SGI** Part Number is **PCI**-FE-TX-MK

Figure 5-13 Fast Ethernet (100Base-TX) Adapter

SCSI PCI Card

This card fits into the **PCI** card cage. This single-ported card supports transfer rates up to 40Mb/S and can handle up to 6,000 I/Os per second, depending on system configuration and I/O transfer size. This **PCI SCSI** card supports active termination and has a 68-pin, high-density **SCSI** connector. The card is backward compatible with **SCSI** 1 and **SCSI** 2 devices. The **SGI** Part Number is **PCI**-**SCSI**-Q-SE-1P.

Serial Expansion PCI Card - Digi ClassicBoard

The Digi ClassicBoard is a high-performance 32 bit serial communications card. Manufactured by Digi International, it's available in multiple output port configurations. The card used in this product supports communication to 4 serial ports, through a DB78 connector. Internally, the board supports auto configuration of all **PCI** interrupts and speeds up to 460.8 Kbps. There are no user selectable jumpers or switches, and it occupies one slot in the host computer's **PCI** card cage.

Figure 5-14 Digi ClassicBoard Serial Port Expander Card

The board communicates electrically to the host (**SGI**) computer using the **PCI** bus. Software drivers designed for the board are loaded during OS/Apps installation and used to control and establish communications between hardware.

The Digi ClassicBoard is not manufactured for or distributed by **SGI**. For additional product information, visit Digi International's WEB site at ***http://www.digi.com.***

1.3.5.4 Dual In-line Memory Modules (DIMM)

The Octane host computer uses **DIMM** (Dual In-line Memory Module) memory. Octane's system memory is made up of **DIMM**s that use synchronous **DRAM** (**SDRAM**) technology—the fastest memory currently available. Each **DIMM** fills one of two slots in a bank. Memory must always be added in increments of two. A non-direct 3D system has one (1) pair of **DIMM**s, totalling 512MB of memory installed. A system with direct 3D (dual processor) has 1.5 GB (1536MB) system memory and three (3) pairs of **DIMM**s installed. **DIMM**s must always be of the same type and density throughout the system module.

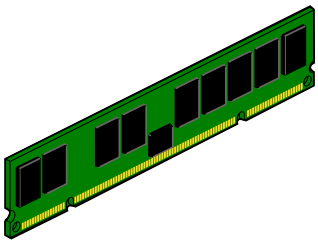


Figure 5-15 DIMM Memory

1.3.5.5 Octane2 Graphics Subsystem

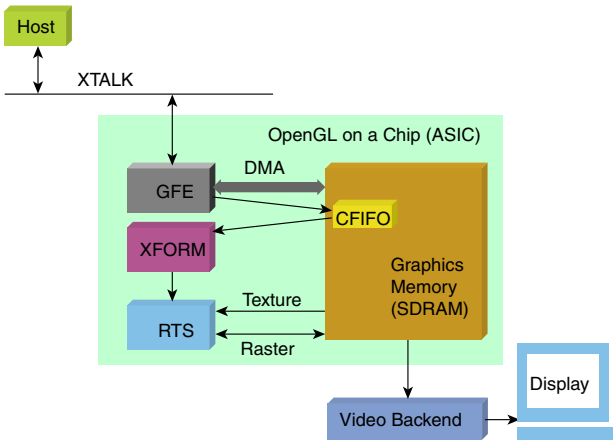
The Octane2 graphics subsystem differs from that found in the original Octane. It features a a V12 graphics XIO card/subsystem, with dual channel display (**DCD**) daughter card.

VPRO (V12) Graphics Card

OVERVIEW

Figure 5-16 V12 Graphics Subsystem (w/o DCD card)

The VPro (V12) is a high performance XIO graphics subsystem. It contains two primary **ASIC**s: one for transformation and rasterization, and another for back end –video that goes to the DACs. Utilizing a **ASIC** containing OpenGL; transformation, lighting, texturing, clipping, and the image pipeline management is handle efficiently. The OpenGL **ASIC** interfaces to the display back end chip via a dedicated onboard bus and to the rest of the system via a 16-bit 800MB-per-second bidirectional XTALK interface. See Figure 5-17.



CFIFO: Deep command **FIFO** to buffer command streams
GFE: Graphics front end to process OpenGL graphics instructions
XFORM: Transform engine
RTS: Rasterization, texture, and shading engine

Figure 5-17 VPro (V12) Block Diagram (shown w/o DCD card)

The graphics subsystem utilizes a large and highly configurable memory for display. All buffers, texture memory and CFIFO memory are allocated from a single large graphics memory pool, as shown in Figure 5-18. Unlike the graphics subsystem used in Octane, texture memory is contained on the V12 graphics card. No additional texture memory card is required.

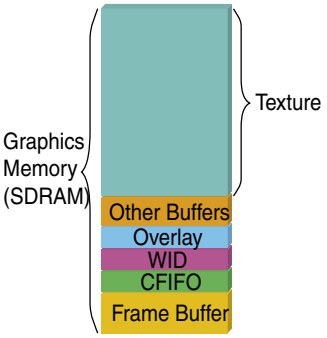


Figure 5-18 VPro (V12) Graphic Memory Organization

FEATURES

- Up to 128MB graphics memory including 104MB texture memory capacity.
- Hardware acceleration of OpenGL® 1.2 core features and imaging extensions.
- Hardware-accelerated specular shading.
- Advanced texture management with asynchronous texture download capability.
- 48-bit (12-bit per component) RGBA.
- 96-bit hardware-accelerated accumulation buffer for depth of field, full-scene anti-aliasing, motion blurs, and other effects.
- Perspective-correct textures and colors.
- High-performance hardware clipping.
- No user serviceable parts, jumpers or switches.

Dual Channel Display (DCD) Card

The Dual Channel Display (**DCD**) card is a daughter card that attaches to the V12 graphics card. With the **DCD**, the viewing area is expanded across two monitors. With the **DCD** installed, the left and right monitors are connected to it two output connectors. The output connector on the V12 is not connected/used when using the **DCD** card.

Figure 5-19 Dual Channel Display (DCD) Card

1.3.5.6 Small Computer System (Integral) Interface

The host contains three **SCSI** interfaces. Two of the interfaces are integrated into the computer's main system boards and the other is an add-on card found in the **PCI** card cage. Together, these **SCSI** interfaces talk to devices both inside and outside the computer's chassis.

The Hard disk drives internal to the computer's chassis are driven by one of the integral **SCSI** controllers. Another integral **SCSI** controller talks to the external **CD-ROM** and **MOD** devices. The third controller, in the **PCI** card cage, talks any attached **SCSI** device (i.e, **DASM**).

`Controller 0: ->` **SCSI** card for **SGI** Internal Hard Disk Drives

`Controller 1: ->` **SCSI** card for **CD-ROM** and **MOD**

`Controller 2: ->` **SCSI** card for **DASM**

SCSI device IDs are position dependent inside the computer's drive bay. Device ID zero (0) is assigned to the integral **SCSI** `controller 0` itself. During boot, the computer attempts to boot the OS from **SCSI** device ID 1 on `controller 0.` **SCSI** device ID 1 is assigned to the drive in the lowest slot of the computer's internal drive bay. Thus, it's important to keep the internal disk oriented correctly. The boot drive must always be keep in the lowest slot.

1.3.6 SCSI Tower (Global Console only)

The two bay **SCSI** tower used with the Global Console - Octane2 contains a **DVD-ROM** drive and a **MOD** (**M**agneto-**O**ptical **D**isk) drive. On the Global Console - Linux, the SCSI tower contains a **DVD-RAM** drive and a **MOD** drive.

Figure 5-20 SCSI 2-bay tower, rear view

1.3.7 DVD-RAM

The Global Console - Linux uses a **DVD-RAM** (Digital Versatile Disc - Random Access Memory) drive for saving system state – a function performed by the MOD on previous consoles. The DVD-RAM drive is physically located in the SCSI tower, which sits on the console table top. Figure 5-21 shows a DVD-RAM disk (cartridge style) in the drawer of the DVD-RAM drive.

Figure 5-21 DVD-RAM drive (Global Console - Linux)

There are several different types of recordable DVDs available in today's market, including:

- DVD-R (allows one-time recording)
- DVD-RW (allows more than 100 cycles of recording and erasing)
- DVD-RAM (allows more than 100,000 cycles of recording and erasing)
- DVD+R (allows one-time recording)
- DVD+RW (allows multiple cycles of recording and erasing)

The DVD-R/RW and DVD-RAM formats have been ratified by the DVD forum, whereas the DVD+R/RW formats have not. More importantly, these formats are not 100% compatible with one another, and a DVD of one format may not work in a different format drive. The utmost care must be taken to ensure that only DVD-RAM type disks are used with the available DVD-RAM drive.

DVD-RAMs have a maximum data storage capacity of 4.7 GB. This provides nearly seven times the data storage capacity of a CD-R, which has a 700 MB limit, and nearly four times the capacity of the MOD disks, which have a maximum data capacity of 1.2 GB.

DVD-RAMs are the only DVDs that come in a cartridge and as a bare disc (The Global Console - Linux uses cartridge style DVDs). They are NOT readable by standard DVD-ROM drives. They can only be read by compatible DVD-RAM compatible drives.

1.3.8 Magneto Optical Drive (MOD) - MaxOptix T5-2600, Sony SMO-F551-SD

1.3.8.1 Overview

Figure 5-22 Sony SMO-F551-SD MODs

MOD drives are a combination of magnetic (magneto) and laser (optical) technologies. They are used to record data on read/write removable disks. High performance with reading speeds up to 4.6MB/sec can be realized.The **MOD** drive is a 5.25" half height format drive without an external enclosure, as shown in Figure 5-22.

Each removable **MOD** disk holds all of the image data. This versatile format allows desktop users to read and write data files, just like a high capacity hard disk, with the major added benefit of keeping a separate disk for each project or client.

Key system benefits include:

- user's files can be more easily organized
- unlimited capacity - add another disk when one gets full
- disks can be used easily for reliable archive back-ups
- transfer large amounts of data is simple & reliable
- secure sites can easily lock up their data at night

The drive also support a "write-once" format disk providing the ultimate in data security - once data is written, it cannot be altered.

1.3.8.2 Features

Reliability

Since the disks are read and written with a non-contact optical head, there is never a head crash like hard disk drives. The disks are made of high strength poly carbonate plastic, the same material as “bullet-proof” glass. The data layer is kept safe between a sandwich of poly carbonate. Also the disks are rated for more than 50 year data storage life, far longer than hard disks and magnetic tape.

Immunity to Stray Magnetic Fields

A **MOD** disk isn't affected by stray magnetic fields because data is written with a combination of laser and magnetic power - without this combination, data cannot be altered.

Support for Worldwide Standards

The Maxoptix & Sony optical disks and drives comply with the ISO (International Standards Organization) standards. Compliance with these standards assures that any ISO disk can be used with anyone's ISO drive. This feature:

- Eliminates reliance on single source suppliers
- Guards against premature obsolescence
- Enables users to exchange data and disks with greatest confidence of compatibility

The Maxoptix T5-2600MO drive (not shown) supports four industry standard formats: 650MB, 1.0GB, 1.2GB, and 2.3GB, however the Applications Software only allows storage of images to either the 1.2 or 2.3GB disks.

The Sony SMO-F551-SD (shown in Figure 5-22) is compatible with the following 5 ¼” (130 mm) Magneto Optical Disks:

Compatibility		Type	Description		ISO Standard
Read	Write				
		8x R/W	5.2GB	2048 bytes/sector	ISO/IEC 15286
		8x R/W	4.8GB	1024 bytes/sector	
		8x R/W	4.1GB	512 bytes/sector	
		8x WO	5.2GB	2048 bytes/sector	
		8x WO	4.8GB	1024 bytes/sector	
		8x WO	4.1GB	512 bytes/sector	
		4x R/W	2.6GB	1024 bytes/sector	ISO/IEC 14517
		4x R/W	2.3GB	512 bytes/sector	
		4x WO	2.6GB	1024 bytes/sector	
		4x WO	2.3GB	512 bytes/sector	
		4x DOW	2.6GB	1024 bytes/sector	
		4x DOW	2.3GB	512 bytes/sector	
		2x R/W	1.3GB	1024 bytes/sector	ISO/IEC 13549
		2x R/W	1.2GB	512 bytes/sector	
		2x WO	1.3GB	1024 bytes/sector	
		2x WO	1.2GB	512 bytes/sector	
		1x R/W	650MB	1024 bytes/sector	ISO/IEC 10089
		1x R/W	594MB	512 bytes/sector	
		1x WO	650MB	1024 bytes/sector	ISO/IEC 11560
		1x WO	594MB	512 bytes/sector	

W/R : Rewritable, WO : Write-Once, DOW : Direct Overwrite

Table 5-4 Sony MOD (SMO-F551-SD) compatible media

Minimal Maintenance

Because the data on an **MOD** is well protected under the disk's near-indestructible poly carbonate surface, it isn't affected by contamination, except for a periodic head cleaning every few years.

1.3.8.3 Operating System Recognition of MOD Drive

The operating system must see an operational drive during boot up to include the driver support for the **MOD**. The entries in `/hw/scsi/` and `/hw/rdsk` are created during boot-up and **MOD** permissions are defined in the `/etc/ioperms` file. Initially the permission for the **MOD** is only read and write for 'root'. Therefore device setup is done by 'root'.

The script `~/install/install.mod` calls `~/install/install.ars` which calls `~/bin/scsistat` program.

`~/install/install.mod`	Takes care for the needs of the high level parts of system = `~/.SdCrc`
`~/install/install.ars`	Takes care of `/etc/ioperms`, `~/app-defaults/archive/SCSI.fol` and `~/Prefs/SdCArchiveDevice`. The data that feeds this task comes from `~/bin/scsistat`.
`~/bin/scsistat`	Loops through **SCSI** device ports from 0 to 63 to locate devices. Device 12 is controller 1 target 4 (8*1+4=12). This is an important tool for **SCSI** bus and device testing. This program is a "super-process" so that probing all **SCSI** ports can be done by mortals. `scsistat` performs a **SCSI** "INQUIRY" command to the devices. Repeated execution of this program can help to get the attention of a non-responsive device.

1.3.8.4 GEMS MOD Disk Media

GE Medical Systems supports Optical Media Recording technology for image archive. Because of technology evolution, a number of different Application Data Formats (**ADF**s) used across different scanners. As a result, each **ADF** is associated with a specific physical media. The following charts shows these **ADF** profiles.

ADFNAME	DRIVE MFG.	TYPE	MEDIA	ISO #	FILE SYSTEM	LOGICAL FORMAT
"GWORM"	PIONEER	**WORM**	DEC502	10089 "B"	DOROFILE	GENESIS
"GMOD"	PIONEER	MO	DEC702	10089 "B"	ODRP	GENESIS
"GMOD2"	Maxoptix	MO	1.2GB (512)	13549	ODRP	GENESIS
"GMOD4"	Maxoptix	MO	2.3GB (512)	14517	ODRP	GENESIS
"DMOD"	Maxoptix	MO	1.2GB (512)	13549	DOS "FAT"	**DICOM**
"DMOD2"	Maxoptix	MO	2.3GB (512)	14517	DOS "FAT"	**DICOM**
"YMOD"	PIONEER	MO	DEC702	10089 "B"	KPAR	YMS
"HYMOD"	HITACHI	MO	650MB (1024)	Private	KPAR	YMS
"HYMOD2"	Maxoptix	MO	2.6GB (1024)	14517	KPAR	YMS

Table 5-5 MOD Application Data Formats (ADF)

DEFINITIONS

ADFName

A name of the standard "profile" associated with the total Application Data Format for the media including the media, the file system format, and the logical data encoding format.

Drive Mfg.

The name of the primary vendor of the drive and the media used in the **ADF** profile.

Type

The fundamental recording technology of the physical media. **WORM** – Write Once Read Many – is an ablative technique that burns pits into the surface of the media to cause a loss of reflectivity. **WORM** media can only be written once and not reused. **MOD** is Magneto Optic use heat of the laser to change the curie point of the magnetic domain so that a magnet can change the angle of the reflectivity of the media. **MOD** can be reused by reLABELing.

Media

This is a vendor ID number of the media that identifies the physical media. There are five different physical media standards that have been used in the GEMS products. Though there are five physical media, they are supported by two specific and independent drives. The PIONEER uses a “sampled servo” recording format and the other drives use a “tracking servo” with the latter being the winner in the standard’s acceptance competition.

ISO #

The International Standards Organization (ISO) standard specification of the physical media.

File System

There is commonly a storage of data into a dataset that has a “name” and a length and a location on the media. The File system is a defined way in which the properties of a “dataset” is recorded on the media so that the “dataset” (file) can be listed and selected. There are four different file systems used by GEMS systems.

Logical Format

This is the data encoding of the internal stored datasets (files).

1.3.9 Console Intercom Board (2167014)

The Intercom board provides two functions: 1) voice messaging and control, and 2) communications feed-through.

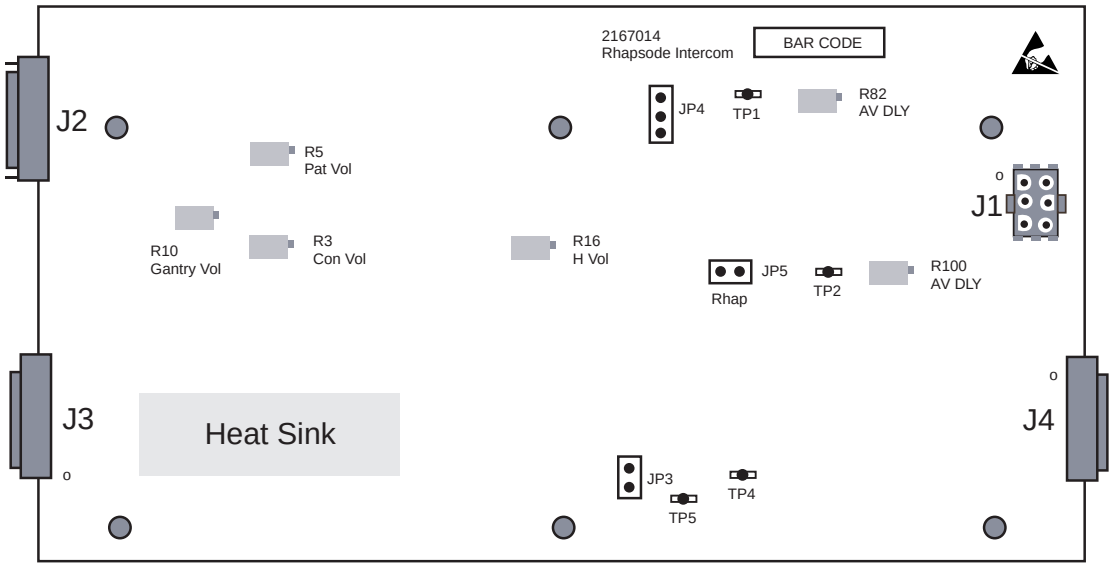


Figure 5-23 Console Intercom Board (2167014) Physical Layout

1.3.9.1 Autovoice Theory of Operation

Autovoice messages are sent simultaneously to the gantry and table speakers and the console speaker, except when the talk button is depressed. The gantry microphone is disabled during autovoice. The user at the operator’s console is always able to talk to the patient via the intercom. The

patient on the table can hear the operator at the console when the operator depresses the talk button. The autovoice message is disconnected when the talk button is depressed.

The user at the operator's console is always able to hear the patient on the table through the intercom, even at the lowest volume setting, except when the talk button is depressed or while autovoice is being played. A volume control knob is provided at the console to regulate the sound volume of Autovoice messages played back to the gantry or table. The autovoice volume at the console is controlled by a graphical user interface tool on the computer screen. In addition, two other volume control knobs for the intercom system shall be provided to adjust sound level for the speakers at the gantry/table and the console.

Computer based training (**CBT**) audio playback is available at the console only. Volume is controlled on screen. **CBT** audio cannot be played if the talk button is depressed or when autovoice is playing.

Gantry Microphone Input

Patient voice signals from the Gantry Intercom circuit are supplied to the Console Intercom board, using differential line driver amplifiers. This helps eliminate common mode noise, which may be induced in the interconnection cables. To complete the signal to noise improvement process, the differential voice signals are received by a differential input amplifier that discriminates against any common mode signal.

Two sections of module U14 are used for impedance matching to the inputs at J3-11 and J3-30, and for establishing a local ground reference. Module U8 is the differential amplifier that provides conversion from differential mode to single ended mode. Module U8 provides more than 70 dB of differential to common mode signal discrimination. A third section of U14 provides a gain of 2.2 and impedance matching to drive the High side of the console 5k ohm volume control potentiometer through J2-11.

AutoVoice Right

AutoVoice signals at J4-3 are processed by three sections of U17, with unity gain to drive TP2 and the switching matrix.

AutoVoice Left

AutoVoice signals at J4-2 are processed by three sections of U18, with unity gain to drive the High side of the 5k ohm AutoVoice volume control through J2-5 as signal AVVOLPOT. A section of U11 provides a gain of 3.2 as signal AV_VOL.

The AV_VOL signal is fed into an active peak detector circuit formed by two sections of U11. The discharge time constant is adjusted by potentiometer R100. The resulting DC voltage is amplified by a third section of U11 to produce the "No Signal" = –5VDC, or the "600mv Signal" = +5VDC, control signal found at TP3. The DC signal is shifted by U7 to provide 5 volt drive for NOR gate U9, which provides a Low signal OC_CNTL to the switching logic.

Console Microphone Pre-Amplifier

Voice signals from the Operator Console microphone are brought to the input of module U2 through J2-14, J2-15 and J2-16. The signal amplitude at J2-15 is multiplied by ten in amplifier U2 at Pin 8, for input to U13. Microphone Pre-amplifier U13 provides variable signal gain and compression to reduce variation in patient volume as the console operator moves around the console microphone.

Another section of U2 provides impedance matching at Pin 14, to drive the 5k ohm Patient Volume Control through J2-8. A third section of U2 provides impedance matching at Pin 7 for driving Balanced line driver U3 with output on pins on 1 and 8. VR1 is a +5 volt voltage regulator that determines the break point for signal compression in U13.

Power Amplifier

Signals coming from the volume control wipers are switched by U16 and appear as inputs to the power amplifier section formed by U15 and U12. TP4 is connected to the output of U15 pin 1 and provides an opportunity to monitor the voice signals being sent from the patient. TP5 is connected to the output of U15 pin 7 and provides an opportunity to monitor the voice signals coming from the console. Both of these signals are imposed on the input terminals of power amplifier chip U12.

Signal OCSPK from U2 pin 4 drives the console speaker through J2-17. Signal PSPK from U12 pin 6 drives the patient speaker through J2-12.

Power Supply

Power for the board is obtained through connector J1. J1 pins 2 and 3 are connected to Analog ground. Pin 1 is connected to Logic ground. Pin 4 supplies +12 vdc. Pin 5 supplies + 5 vdc. Pin 6 supplies –12 vdc. Module U1 is a voltage regulator that derives + 6 vdc, for Microphone bias, from the +12 vdc supply.

1.3.9.2 “Point to Point” Feed-Through

Connectors J2, J3 and J4 provide for interconnection of a number of circuits that have little or no functional relationship to the intercom feature. These interconnection paths from connector to connector are continuous conductors that can be checked by continuity measurement.

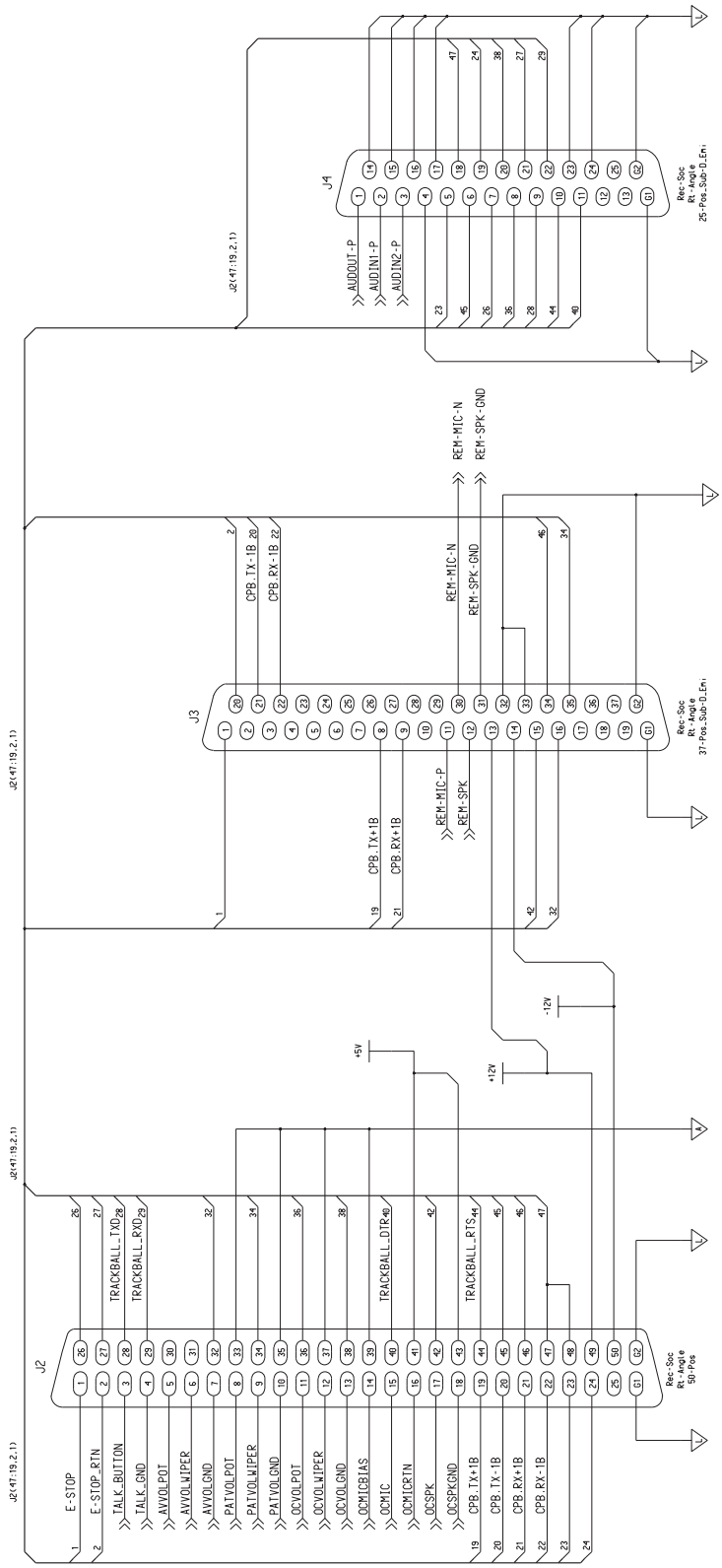


Figure 5-24 Intercom Board - Schematic

1.3.10 Media Adapter (AT-MC15, Allied Telesyn)

For additional product information, see Allied Telesyn. web site at ***www.alliedtelesyn.com***

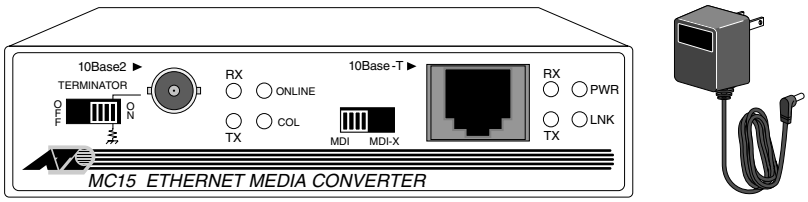


Figure 5-25 AT-MC15 (Allied Telesyn)

1.3.10.1 Overview

The AT-MC15 (Figure 5-25) is a thin-net/twisted pair converter providing a 10Base-2 BNC connection. It converts Ethernet signals from twisted pair cable to thin-net cable and vice versa. An external power supply serves as its power source.

1.3.10.2 Power Requirements

The AT-MC15 draws power from a wall-mount type AC-DC power adapter, which attaches at AT-15's DC jack. TUV/UL/CSA compliant, the AC power adapter supplies an unregulated output of 12 VDC at 1A. The power required for the AT-MC15 is 12Vdc, 500 mA.

1.3.11 Fast Ethernet Switch (AT-FS708 or AT-FS705, Allied Telesyn)

For additional product information, see Allied Telesyn web site at ***www.alliedtelesyn.com.***

1.3.11.1 AT-FS708

The AT-FS708 (Figure 5-27) is a twisted pair eight-port, Fast Ethernet switch. It has seven auto-negotiable 10BaseT/100 Base-TX ports with a total bandwidth of 800 Mbps. Port 8 can be used as a MDI or MDI-X port for simple connection (via straight-through cable) to other hubs or switches. The AT-FS708 series is fully compliant with **IEEE** 802.3u standards for 100 Mbps baseband networks.

Figure 5-26 AT-FS708 Front Panel

1.3.11.2 AT-FS705

The AT-FS705 (Figure 5-27) is a twisted pair five-port, Fast Ethernet switch. It has five auto-negotiable 10BaseT/100 Base-TX ports. Port 5 can be used as a MDI or MDIX port for simple connection to other hubs and switches. The AT-FS705 series are fully compliant with **IEEE** 802.3u standards for 100 Mbps baseband networks.

Figure 5-27 AT-FS705 Front Panel

1.3.11.3 Power Requirements

The AT-FS708 and AT-FS705 series switches use internal switching power supplies with 100 to 120 VAC, 50/60 Hz input rating. Maximum power consumption is 50W.

1.3.12 Data Acquisition System Manager (DASM) Video

1.3.12.1 DASM Timing Characteristics

ANALOG DASM VIDEO TIMING CHARACTERISTIC	60 HZ	50 HZ
pixel frequency:	24.192 Mhz	24.192 Mhz
pixel period:	41.336 nsec	41.336 nsec
horiz line freq:	33.6 Khz	33.6 Khz
horiz line width:	720 pixels	720 pixels
horiz active:	544 pixels	544 pixels
horiz blanking:	176 pixels	176 pixels
horiz front porch:	26 pixels	26 pixels
horiz sync:	76 pixels	76 pixels
horiz back porch:	74 pixels	74 pixels
vert frame freq:	60 Hz	50 Hz
vert frame time:	560 lines	672 lines
vert active:	524 lines	524 lines
vert blanking:	36 lines	148 lines
vert sync:	3 lines	3 lines
vert back porch:	30 lines	86 lines
vert front porch:	3 lines	59 lines
scanning format:	non-interlaced	non-interlaced

Table 5-6 Analog DASM Video Timing Specifications

1.3.12.2 DASM Display Formats

ANALOG DASM VIDEO DISPLAY FORMAT	
visible field:	544 pixels by 524 lines
image field:	512 pixels by 512 lines
grayscale field:	32 pixels by 16 level gray bar on left side of image
grayscale:	software selectable on/off
grayscale off value:	0 (black)
initial grayscale:	255 (white) at upper left corner
border field:	12 lines at bottom of visible field
border field value:	any 8-bit value, software programmable

Table 5-7 Analog DASM Video Display Formats

1.3.12.3 DASM Serial Ports

ANALOG DASM HOST COMMUNICATIONS/CONTROL SERIAL PORT (ANALOG INTERFACE ONLY)	
interface:	RS422
25D conn pinout:	pin 8 (RX+), pin 21 (RX-), pin 9 (TX+), pin 22 (TX-), pin 7 (GND)
baud rate:	1200 baud
word length:	8 bit, 1 start bit, 1 stop bit
parity:	even
type:	asynchronous

Table 5-8 Analog DASM Host Communications/Control Ports

Note: The digital **DASM**/**LCAM** serial control is standard RS232 on pins 2, 3, and 7. Some cameras may require a NULL MODEM cable and/or adapter.

1.3.12.4 Filming Interface Specifications (Video & Serial)

Analog DASM VIDEO OUTPUT

ANALOG DASM VIDEO OUTPUT (MEASURED INTO 75 OHMS AT BNC OUTPUT)	
amplitude:	1 volt peak-to-peak
video:	0.643V ±10%
setup:	0.071V ±10%
sync:	0.286V ±10%
DAC resolution:	8 bits
diff linearity:	± 1 LSB max
glitch area:	80 picovolt-seconds max, for any step size
rise/fall times:	> 10 nsec, 10%–90%
FS settling time:	7.5 nsec typical to 1 LSB
transfer func:	guaranteed monotonic
noise level:	> 5.0 millivolt peak-to-peak, combined sync/async noise
DC offset:	± 1VDC referenced to ground

Table 5-9 DASM Video Output Specifications

Analog DASM PIXEL CLOCK OUTPUT

ANALOG DASM PIXEL CLOCK OUTPUT	
logic family:	F series TTL
output low level:	0.8VDC max
output high level:	2.0VDC min
output period:	41.336 nsecs ±10%
transition times:	10 nsec max, 10%-90%

Table 5-10 Analog DASM Pixel Clock Output

1.4 Scan Reconstruction Unit Theory

The Scan Reconstruction Unit (**SRU**) consists of the following components:

Scan Data Disk (**SDD**)	The **SDD** is the raw **DAS** data save media and can hold 1,000 8-slice rotations of data.
Reconstruction Interface Processor (**RIP**)	The **RIP** is responsible for coordinating the save operation and moving the data from the **DIP** to the scan data disk.
DAS Interface Processor (**DIP**)	The **DIP** is responsible for receiving data from Slip Ring Communications (**SRC**), decoding the **FEC CRC** and buffering it for saving by the **RIP**.
Pegasus Image Generator (**PEG-IG**)	The **PEG-IG** is responsible for correcting and calibrating the **DAS** data (after it has been saved onto the **SDD**), and then making an image from the corrected view data.

For **SRU** component interconnection information, see the Console block diagram (page 248 for GC-Linux, page 250).

1.4.1 Scan Reconstruction Unit Overview

1.4.1.1 X-ray Abort

The **DAS** Interface Processor (**DIP**) contains a 24V X-ray Abort relay. This normally open relay must be closed to enable X-ray exposure. If the **SRU** detects that it is unable to save uncorrupted scan data to non-volatile memory, then it will open the X-ray Abort relay, halting any further X-ray exposure. See Figure 5-6, on page 250.

1.4.1.2 Scan Data Flow

DATA TRANSFER	984 HZ	1405 HZ	1968 HZ
DAS Interface	61.40 Mb/s	87.67 Mb/s	122.80 Mb/s
Scan Data Save	6.14 Mb/s	8.77 Mb/s	12.28 Mb/s

Table 5-11 Scan Data Flow Rates

The Forward Error Correction (**FEC**) algorithm implemented in **DIP** hardware will add an additional 10% to the scan data rates. All data received through the **DAS** Interface must be saved in non-volatile memory. One super view size (including header) is 6,240 bytes.

1.4.1.3 Scan Data Capacity

System requirement 2000 rotations:

- 984 Vws/Rot x 4 Rows/Vw x 768 Ch/Row x 2 B/Ch = 6.05MB / Rot - Scan Data
- 984 Vws/Rot x 24 Wds/Hdr x 4 B/Wd = 94.5 KB / Rot - Header
- 2000 Rotations x 6.14 MB / Rotation = 12.28 GB.
- Scan Data Disk is currently an 18GB capacity disk, and holds only the Scan Data (views).
- OC host computer holds Scan Header Data.

1.4.1.4 Reconstruction Data Flow

DATA TRANSFER	3.0 SECONDS
Scan Data Restore	3.0 MB/s
Prep to **FBP** to Image Pull	2.34 MB/s

Table 5-12 Reconstruction Data Flow Rates

1.4.1.5 Reconstruction Performance

Time-to-First-Image reconstruction time, T1st, is measured from the point the software function, **DIP** Control, receives the first “Data Available” interrupt from **DIP** hardware, to the point where the software function, Image Create, pulls the reconstructed image from the **PEG-IG** board.

T1st assumes the following functional flow.

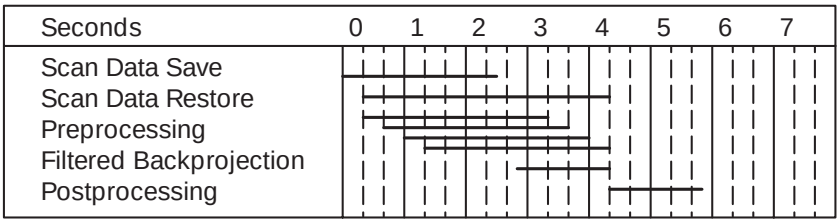


Figure 5-28 Time to first Image (assuming 0% overhead)

Preliminary study of Helical Reconstruction processing estimates that the time to first image including overhead is 7 seconds. Case study features 3:1 pitch, 2x Z-over-sampling, 3.0 second recon, and continuous images. The system requirement measured from start scan button pushed until image displayed is 10 sec. for helical and 6 sec. for axial scans.

Image-to-Image reconstruction time, TImg, is measured from the point where the software function, Image Create, pulls a reconstructed image from the **PEG-IG** board to the point where Image Create pulls the next reconstructed image from the **PEG-IG** board.

TImg assumes the following functional flow.

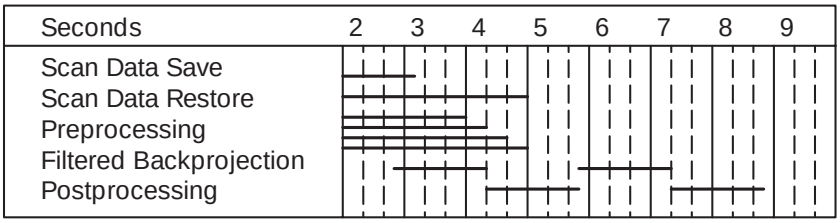


Figure 5-29 Image to Image Time (assuming 0% overhead)

TImg assumes Filtered Backprojection (**FBP**) and Postprocessing are the determining functions. **FBP** takes approximately 1.60 sec. and Postprocessing is 0.70 sec., i.e. total time = 2.30 Seconds. IBO adds 0.80 sec. to Postprocessing.

1.4.1.6 Preprocessing

Preprocessing is performed on the **PEG-IG** Board. The data is received from the **RIP** and **DAS** interface processor Board.

1.4.1.7 Filtered Backprojection (1.60 Seconds)

Convolution operates on projections the same way: 8 **DSP**s filter 8 projections simultaneously. However, the filter time is approximately 13ms. per iteration. Thus, the total filter time is approximately 123 x 13ms = 1.60 seconds.

Backprojection hardware operates simultaneously on 8 projections per pixel scan. The time to backproject these 8 projections is 5.24ms. per 5122 image or 1.31ms. per 2562 image. The image backprojection time is based on number of views divided by 8 and multiplied by the respective pixel scan time. For example: 984 projections P 8 = 123 iterations x 5.24ms = 0.64 seconds for 5122 images.

Backprojection hardware is operating on projections n through n+7. Convolution is operating on projections n+8 though n+15. The filtered backprojection time is based on the longer of these two functions.

1.4.1.8 Postprocessing (0.7 Seconds)

Ring-fix takes 500ms, and clip, scale, and round take 200ms to complete.

1.4.2 Scan Reconstruction Unit Hardware Theory

The **SRU** has three inter-bus connections and one external control signal: 1) **MDAS** (via RF Slip Ring), 2) **UIF** Sub-system (Host Computer), 3) Scan Control, and 4) X-ray Abort (to **PDU**).

The **MDAS**-**SRU** connection utilizes TAXI transmitted from the **DAS** Control Board (**DCB**) and received by **SRU**'s **DIP** Card. The Host-**SRU** connection utilizes Ethernet-**TCP** via 100BaseTX. The **SRU**-Scan connection (3) utilizes Ethernet-**UDP** via 10Base2. X-ray Abort (4) is a 24V, normally-open relay that controls the X-Ray ON function. See Figure 5-6, on page 250.

There are four major intra-bus connections: 1) **PMC** - **PCI** Mezzanine Card, 2) Ultra **SCSI** - Small Computer System Interface, 3) 100BaseTX-Ethernet, and 4) **VME** - Versa Modulo Euro-card. These bus structures must support data and control flow for a 4 row, 0.7 second scanner and scalable to support 0.5 second scanning.

There are two logical sections to the console chassis. One section contains the Host Computer with System Disk, Ethernet and Serial Interfaces, and the Scan Data Disk. The other section contains a **VME** Backplane, Recon Interface Processor with piggy-backed **PMC** Scan Data **SCSI** Interface and **PMC DIP** Interface boards, and Pegasus Image Generator Board. The entire **VME** Chassis is commonly termed the Image Chain Engine (**ICE**).

The Host Computer performs functions for scan control, and the **RIP** performs functions for recon control, and scan data acquisition. The **PEG-IG**, under the control of the **RIP**, performs functions for preprocessing, filtered backprojection, iterative bone option, and postprocessing. The Host Computer–**VME** connection utilizes Ethernet-**TCP** via 100BaseTX.

Recon Interface Processor (RIP) - or Motorola POWER-PC Computer performs Recon Control functions. It is the central "hub" for all logical connections between sub-systems in the **ICE**. Its processor is RISC and contains adequate memory to support Control and Image Chain functions. It connects to the scan data disk and performs the Scan Data Save and Restore functions. The **RIP** can communicate with the rest of the **ICE** through the **VME** Backplane, and with the OC Host Computer through its 100BaseTX-Ethernet Interface.

Scan Data Disk (DD or SDD) serves as a buffer for the Image Chain's data flow architecture and a temporary storage facility for the scan data required for reconstruction (header data for the scans is stored on the OC Host's disks). This disk sub-unit must support 4 row, 0.7 second scanning, i.e. 8.61 MB/s Scan Data Save and 2.60 MB/s Scan Data Restore and be scalable to support 4 row, 0.5 second scanning, i.e. 12.06 MB/s Scan Data Save and 2.60 MB/s Scan Data Restore. Save and Restore operations must be partitioned or interleaved to minimize Time to First Image (T1st) and allow scan and recon simultaneity.

LAN Switch & HUB interconnect two 100BaseTX and one 10Base2 Ethernet ports. The ethernet switch isolates the 100Mb/s transmissions from the 10Mb/s transmissions. The ethernet hub converts **UTP** to thin coax media for communication with the Gantry.

DAS Interface Processor (DIP) is a bus medium translator. It guarantees a continuous flow of **DAS** data from the 125Mb/s TAXI to the 132MB/s **PMC**-bus. This board connects directly to the **RIP** as a **PCI**-**PMC** Card. It has adequate data buffers to support the Scan Data Save operation. Forward Error Correction will be applied to the data stream to increase the errors/bit rate to approximately 10-14. The **DIP** will count the occurrences of forward error corrected scan data during an exposure. If Scan Data cannot be corrected, then an abort condition exists. The **RIP** software will record the **FEC** correction count on a per scan basis. Its TAXI design can be easily upgraded to support 175Mb/s transfer rate (i.e., 4 row, 0.5 second scanning). The **DIP** also contains the 24V normally-open relay that contributes to the X-ray On function.

Pegasus Image Generator (PEG-IG) performs **Scan Data Correction**. The **Scan Data Correction** portion of the **PEG-IG** performs the Image Chain's preprocessing, calibration, and scout imaging functions. It receives Scan Data from the **RIP** and transmits Projection Data and Scout Images to the board's Image Generator.

Pegasus Image Generator performs the Image Chain's Filtered Backprojection and Postprocessing (including Iterative Bone Option, IBO) functions. It receives Projection Data from the **RIP** and transmits Scout, Axial, Cine, or Helical Images to the **RIP** for transfer to the OC Host.

POWER SUPPLY

The following chart identifies power requirements of the external power supply used for the Scan Data Disks and the **VME** Chassis:

EXTERNAL POWER REQUIREMENTS	+ 3 VOLTS	+ 5 VOLTS	- 12 VOLTS	+ 12 VOLTS
Scan Data Disks		1.0 A	3.6 A	
Recon Interface Processor	+	4.0A +	0 mA +	0 mA +
Pegasus Image Generator		12.0 A		500 mA
Total = 134.2 Watts		17.0 A	3.6 A	0.5 A

Table 5-13 Scan Reconstruction Unit Power Supply Requirements

Note: Up to 15 Watts additional power may be drawn by the two **PMC** cards (**DIP** and **SCSI**) attached to the **RIP** Board.

Care must be taken to provide the proper in-rush current necessary to accelerate the disk drive motors to specified RPMs.

1.4.3 Scan Data Disk Assembly

SEAGATE P/N »	ST318452LW	
Formatted capacity:	18.4 Gbytes	
Max. data blocks:	35,843,670 (222EE56h)	
Cylinders and heads (user accessible):	18,497 / 4 heads	
Disc rotation:	15k rpm	
Operating voltages:	+5V	+12V
Typical operating current:	0.88A	0.79A

Table 5-14 Scan Data Disk Drive Characteristics

1.4.4 Recon Interface Processor (RIP) - Motorola Board

The Motorola POWER-PC based processor board used in the current generation of CT systems performs the function of Reconstruction Interface Processing. The board (MVME2308) utilizes a 333 MHz MPC 604R PPC processor, contains 128 Mbytes of main memory, and has both a **SCSI PMC** daughter-card and a **DIP PMC** daughter-card.

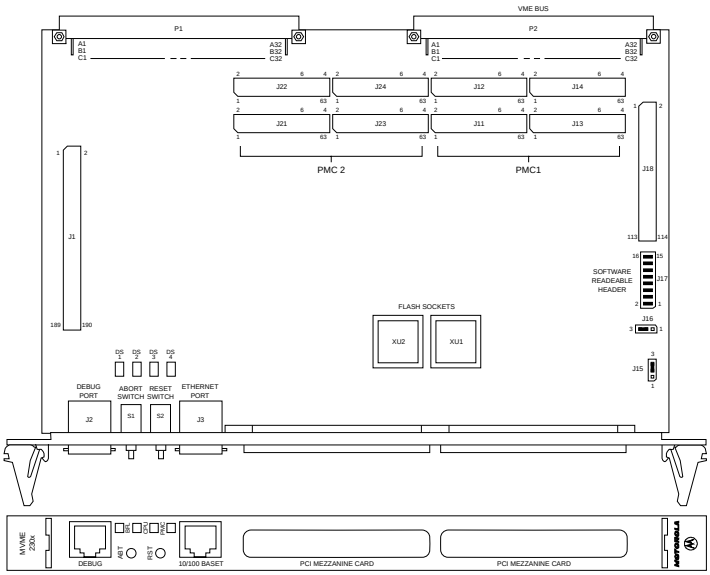


Figure 5-30 Recon Interface Processor Board Layout

The MVME230x is a **VME** processor module equipped with a PowerPC 604 microprocessor. Features include:

- Ethernet and debug ports
- Boot **ROM**
- Flash memory
- **DRAM**
- Interface for two **PCI** Mezzanine Cards (**PMC**s)

Four standard buses are supported:

- PowerPC Processor Bus
- ISA Bus
- **PCI** Local Bus
- VMEbus

The MVME230x interfaces to the VMEbus via the P1 and P2 connectors. It also draws +5V, +12V, and -12V power from the VMEbus backplane through these connectors. The +3.3V power, used for the **PCI** bridge chip and possibly for the **PMC** mezzanine, is derived onboard from the +5V power.

Two RJ45 connectors on the front panel provide the interface to 10/100Base-T Ethernet, and to a debug serial port.

Items that can be configured manually on the MVME230x include:

- Flash memory bank A/bank B reset vector (J15)
- VMEbus system controller selection header (J16)
- General-purpose software-readable header (J17)

The MVME230x has been factory tested and is shipped with the configurations described in the following sections. The MVME230x factory-installed debug monitor, PPCBug, operates with those factory settings.

1.4.5 PMC SCSI Card - SBS Technologies (2265396)

The **PMC**-UltraSCSI Card provides a high performance UltraWide **SCSI** (Fast-40) adapter solution for a **PMC** carrier board in **VME**-based systems. It is an ideal module for disk, tape, **CD-ROM** or other storage media and **SCSI** peripheral applications. The module supports single-ended or differential signaling for asynchronous or synchronous **SCSI** operations. Flexible physical I/O access is available via a 68-pin **SCSI**-III front panel connector or the **PMC** back panel P4 connector.

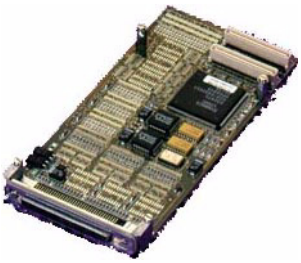


Figure 5-31 PMC-UltraSCSI Card (SBS Technologies)

The **PMC**-UltraSCSI features the LSI Logic SYM53C875 UltraWide **SCSI** (Fast-40) controller, with **SCSI** SCRIPTS processor support. It allows bus transfer rates up to 40 MB/sec synchronous across a 16-bit bus. In addition, 4KB of on-chip static **RAM** is available for **SCSI** SCRIPTS instruction storage to control the **SCSI** device.

The **PMC**-UltraSCSI supports **DMA** with 536 bytes of **FIFO**. The **FIFO** has burst length of up to 128 transfers to allow maximum bandwidth. Interrupt is supported via **PCI** pin INTA#. VxWorks, LynxOS, and Windows NT device drivers are available for the **PMC**-UltraSCSI (single-ended signaling only). The module is compliant with standard single-wide **PMC** specifications **IEEE** P1386.1 and **PCI** Specifications.

KEY FEATURES

- Supports UltraSCSI (Fast-20), **SCSI**-I, **SCSI**-II, and **SCSI**-III
- Features LSI Logic SYM53C875 **SCSI** controller
- Synchronous **SCSI** data rates up to 40 Mbytes/sec, asynchronous up to 20 Mbytes/sec
- Front-panel or back-panel I/O access (via order options)
- Single-ended or differential **SCSI** bus support (via order options)

Support for VxWorks, LynxOS, and Windows NT (single-ended only)

1.4.6 DAS Interface Processor (DIP)

1.4.6.1 Overview

The **DIP** is the main interface between the **DAS** and the **SRU** Subsystem. It receives high-speed serial data from the slip ring, buffers it, and sends an interrupt to Scan Data Save process in the **RIP**. The **RIP** then saves data to the Scan Data Disk (**SDD**). The interface between Scan Data Acquisition and the **SRU** is drawn at the serial interface of the **DIP**. The **DIP** board is a plug-in mezzanine adapter card, with a **PCI**-standard interface, to the **RIP** board.

The **DIP** board also contains the **SRU** portion of a “wired and” interface to the scan abort relay. Access to the relay is achieved via a registered write on the **PCI** bus, via the **RIP** board.

The **DIP** board also contains the **SRU** input to the RHARD reset interface to the scan control hardware in the **STC**, **ETC**, and **OBC**. Access to the relay is achieved via a registered write on the **PCI** bus, via the **RIP** board.

There’s no built-in self test on the **DIP** Board. The **DIP** board does provide data loopback capability in diagnostics.

Inputs

FROM SLIP RING

High-speed serial data, on fiber optic media, received via a connector on the faceplate of the **DIP** board. Data can be either:

- Offset Data Views prior to scan start and containing a Forward Error Correction (**FEC**) **CRC**
- Scan Data Views after scan start and containing a Forward Error Correction (**FEC**) **CRC**

FROM RIP, VIA THE PCI BUS

- **PCI** board configuration control, via a set of configuration registers
- **PCI** board base address, via a set of configuration registers
- Data transfer configuration, via a register set
- X-ray Abort line control, via a command register
- RHARD line control, via a command register

Outputs

TO RIP

- Interrupts when a configurable amount of **DAS** data is buffered and ready for saving OR when one of several data integrity errors has occurred. Per the **PCI** Spec v2.1, the **DIP** only uses INTA_N in the **PCI** bus.
- A block of **DAS** data, via Direct Memory Access (**DMA**) memory read

TO PDU

Wired “AND” relay connection for X-ray abort

TO SCAN CONTROL HARDWARE

RHARD relay connection for resetting the scan control hardware

1.4.6.2 Data Paths

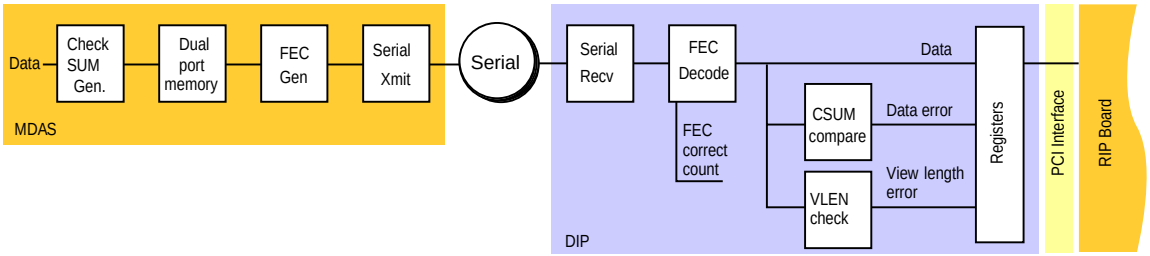


Figure 5-32 DAS/DIP Data Path

SRC Data Path

The Scan Data Interface to the **DAS** scan data buffers is the primary **DAS** data path, within the **DIP**. The data path is 16-bits wide and is timed off of the serial data receive clock, running at 16.667 MHz. Therefore, the bandwidth is 33.33 Mbytes/sec. Of this, only 25 Mbytes/sec. (including **FEC**) are used.

When reading and writing in burst mode, the **SDRAM** bus is capable of transferring eight 32-bit data words at 66.6676 MHz in 15 clock cycles. This provides a bandwidth of 142 MB/s. The **SDRAM** bus provides a margin of 43 MB/s when it is being fully utilized by the Serial and **PCI** Interfaces.

PCI Data Path

This **PCI** Data Path connects the **RIP**'s **PCI** interface with the **SDRAM** Data Buffers. The data bus is 32 bits wide while the address bus is only 24 bits. All functions on the bus appear as a memory map, with respect to the **RIP**. All transactions are 32-bits long word-wide timed off of the **PCI** board clock, running at 33 MHz. Therefore, the bandwidth of the bus is 132 Mbytes / second in burst mode. However, the **DIP** is only capable of transferring a 32-bit long word of data every two clock cycles in burst mode. Therefore, the bandwidth limit on the **DIP** is 66 Mbytes / second.

1.4.6.3 Interfaces

Scan Abort Line

The abort line interface is the gateway for the **SRU** subsystem to abort scanning in the event of a fatal error condition that cannot be terminated through normal scan control communication messages. Error conditions can include **CPU** failures, communication failures, and **DAS** data errors. A relay that normally forms a closed loop with the **PDU** is connected to a male, 9-pin, Sub-miniature D connector on the **DIP** faceplate. The relay opens to abort a scan. The interface is designed to be safe upon reset. This means that the relay is normally open and must be closed by writing a logical "1" to the **DIP** command register before X-rays can be turned on. Abort line status is available to the **RIP** via the **DIP** status register. See Figure 5-33.

RHARD

The RHARD interface is the gateway for the **SRU** subsystem to reset the scan control hardware (**STC**, **ETC**, and **OBC**) in the event of a controller lockup error condition that cannot be reset through normal scan control communication messages. A relay that normally forms a closed loop with the **STC** and **ETC** is connected to the same male, 9-pin, Sub-miniature D connector on the **DIP** faceplate as the Abort Line Interface above. The relay opens to reset the scan control hardware. Reset relay status is available to the **RIP** via the **DIP** status register. See Figure 5-33.

Scan Data Interface

The Scan Data Interface function is responsible for the following: (See Figure 5-33)

- Controlling the Transmit function. Transmit only occurs when diagnostic mode is active.
  - Reading the Test Data **FIFO**, when non-empty
  - Setting up the data to be transmitted to the Transmit function and creating the write enable
- Controlling the Loopback function. Loopback mode can only be enabled when diagnostic mode is active.
- Controlling the Receive function.
  - Detecting an incoming data byte stream and reading it from the Receive function
  - Checking byte parity errors and feeding those errors back into **FEC** for increased error detection and correction
  - Detecting modem violations and **FEC CRC** errors from the Receive function
  - De-multiplexing the incoming byte stream into 32-bit words
  - Checking the header for data type and magic number to recognize view length errors. There are two magic numbers, one for an offset views and one for scan data views. The upper 16-bits of the first word of each view is compared to the values written into the BMR. If there is a match, the lower 16-bits are considered the length of the view and are loaded into a counter. When the counter expires, it is assumed to be at the start of the next view

and the word is checked again. If there is not a match, a view length error is assumed.

- Controlling the **DAS** Buffer Crossbar and writing **DAS** data words to the **DAS** Data Buffer
- Making interrupt requests to the **PCI** Interface function

PCI Interface

The **DIP** is considered a target-only **PCI** board. All registers and buffers on the **DIP** are mapped into memory Unix memory space. Registers and buffers can be accessed through programmed I/O by the **CPU** or through **DMA** by any device on the **PCI** bus. **PCI** I/O space accesses are not allowed. All registers and buffers are accessed with 32-bit transfer only and both single and burst mode transfers are supported.

The **PCI** Interface function is responsible for controlling the **PCI** bus transactions:

- Providing board level plug-n-play and configuration
- Providing address decodes for all board registers and memory devices
- Providing transaction sequencing for all access modes
- Providing system interrupt capability for reporting all error conditions

1.4.6.4 DIP Board Processing

The **DIP** acts as the main interface between the **DAS** and the **SRU** Subsystem. It is responsible for receiving data from the slip ring, buffering it, and sending an interrupt to Scan Data Save to have it save to the Scan Data Disk (**SDD**). The interface between Scan Data Acquisition and the **SRU** is drawn at the interface of the **DIP**. The **DIP** board is a mezzanine adapter card, with a **PCI**-standard interface, to the **RIP** board. See Figure 5-33 for a block diagram of the **DIP** PWA.

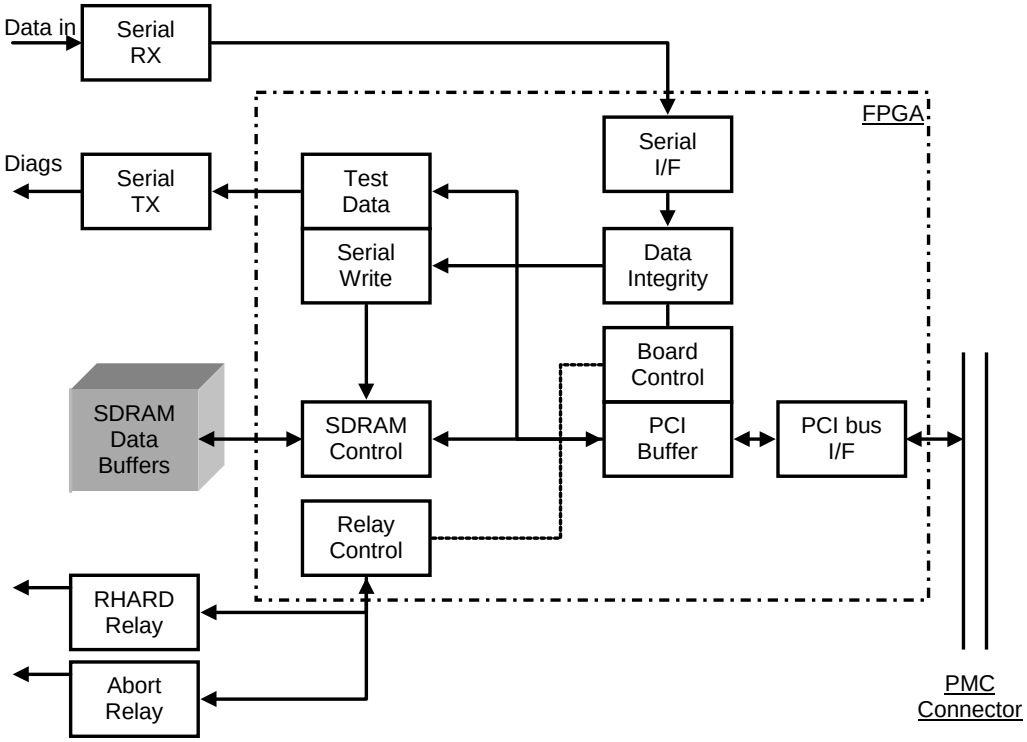


Figure 5-33 DIP Block Diagram

The only processing that is performed on the **DIP** is data integrity checking. Each view record, sent by the **DAS** contains the following information:

- Header, with a Unique (Magic) ID

- Channel Data
- Checksum of the header and the channel data

SETUP

The **RIP** sets up the **DAS** data buffer transfer size, in words, in the **DIP** command register. This transfer size is the number of 32-bit words -1 that will be written into one of the two **DAS** Data Buffers before the **DIP** will interrupt the **RIP**.

The **RIP** sets up the **DIP** magic number register for both the offset and scan views, but only sets the enable bit for the offset views.

The **RIP** sets up the **DIP** command register to enable **FEC** and data receive and waits for interrupts from the **DIP** indicating that there are buffers of offset data ready for save.

OFFSET VIEWS

The first buffers of data to be written are offset views. Once enough offset data has been written to a **DAS** data buffer to equal the **DAS** buffer transfer size, the **DIP** will switch the Scan Data Buffer crossbar to the other buffer and interrupt the **RIP**.

The **DIP** ISR on the **RIP** will read the **DIP** interrupt status register, see that the interrupt was for a buffer ready, kick off the transfer, and wait for completion. A resource on the **RIP** will then perform **PCI** 32-bit memory access reads of the Scan Data Buffer until the block has been transferred. When the **RIP** gets the completion message, it will set the transfer complete bit in the **DIP** command register.

The **RIP** will then wait for the next interrupt to repeat the process until all offset data blocks, except for the last, have been transferred.

The last offset view to be sent from the **DAS** has a flag in the Unique ID word of the header indicating that this will be the last offset to be sent. This indicates to the **DIP** that the last **DAS** data buffer will be a partial buffer. When the **DIP** has written this last partial buffer, it will interrupt the **RIP** with a different bit set in the **DIP** interrupt status register. The **DIP** ISR that reads the **DIP** interrupt status register will detect this and perform a read of the BSR to determine the size of the last transfer. It will then setup the last transfer and kick off the transfer.

When offsets are complete, the **RIP** sets up the magic number register to disable offset views and enable scan views.

SCAN VIEWS

The process for collecting scan data views is identical to collecting offset data views

1.4.6.5 Power Requirements

The **DIP** uses 2 of the available power supplies provided by the **PCI** backplane. Power dissipation on the **DIP** for each supplied used is shown in Table 5-15.

ELEMENT	MAXIMUM POWER
+5V	2 watts
+3.3V	7 watts
+12V	Not Used
-12V	Not Used

Table 5-15 DIP Power Requirements

1.4.7 Pegasus Image Generator (PEG-IG) Board Theory

Refer to the Pegasus schematic (2216467SCH) for this section.

Figure 5-34 is the block diagram of the Pegasus board.

The Pegasus Assembly is a complex circuit board that converts raw image data into a viewable image. There are thirteen microprocessors, as well as twelve custom **ASIC**s that all work in parallel to perform this task. The following is a short description of each major section of the board.

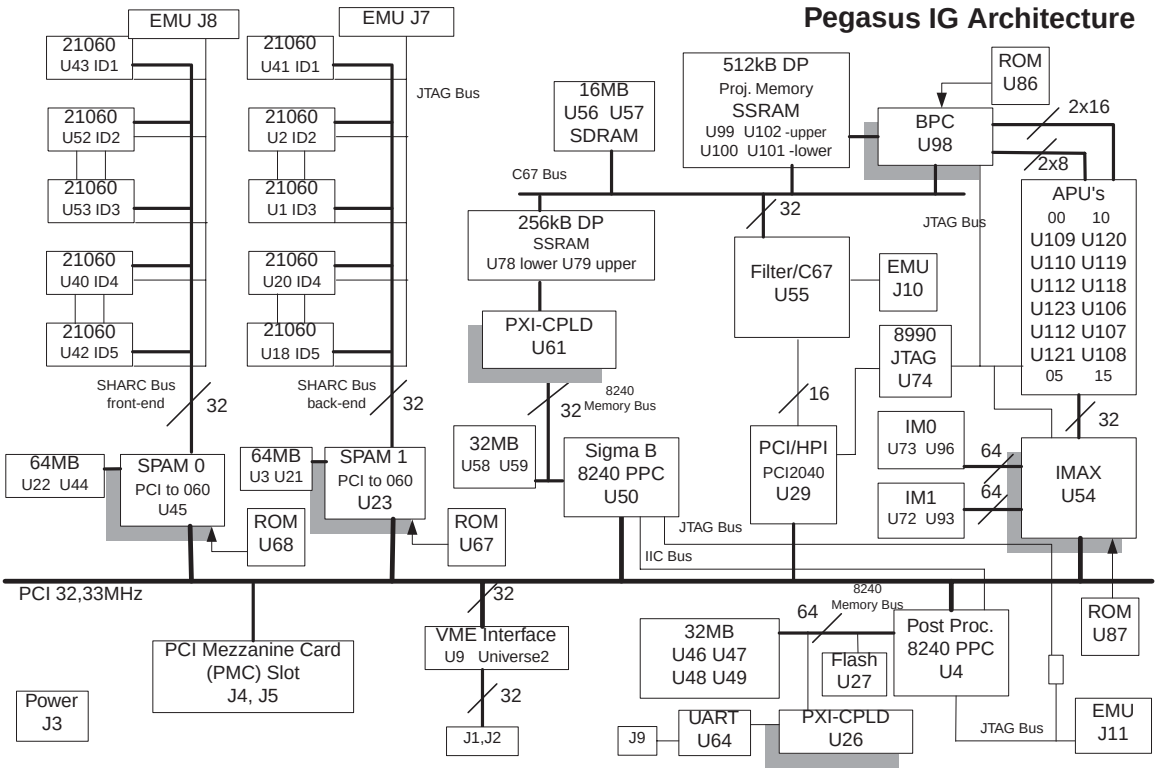


Figure 5-34 Pegasus Image Generator Board Block Diagram

1.4.7.1 Power Supply Overview

The Pegasus board gets all its power from the **VME** 5V supply. There are three local power regulators (page 11 of the schematics) that supply 1.9V, 2.6V, and 3.3V power for the board. The comparators on page 11 are for the purpose of power sequencing. Specifications for the TI and Motorola microprocessors requires that, to prevent damage to the processor, the 3.3V supply may only come up after the core voltage is up (1.9V and 2.6V), and must come down before the core voltage comes down.

There are three power supply **LED**s near the center backplane connector:

DS14 - Goes on when the 5V power is up.

DS15 - Goes on when the on-board 2.6V regulator is up.

DS16 - Goes on when the on-board 1.9V regulator is up.

These **LED**s only give an approximate indication of the power status, i.e. they do not indicate whether or not the supply is out of tolerance.

1.4.7.2 VME Interface

The Pegasus board uses a Tundra Universe II chip for the **VME** interface (located on pages 26-32 of the schematics). This chip is a “single chip” **VME** interface solution, with the exception of the discrete buffers needed between the Universe and the **VME** bus connectors.

In addition to providing a generic **VME** interface, the board's master **PCI** hardware reset is also driven from the Universe chip.

1.4.8 Scan Reconstruction Unit Cabling

1.4.8.1 Power and Ground

The **LAN** electronics contain their own power supplies and receive 110VAC power from the Console **PDU**. The Scan Data Disks and the **VME** backplane receive their +5VDC and +12VDC power from a power supply that – in the H3 console – is shared with the "User Drive Assembly" of the console. In the Global Consoles, this power supply is mounted on one of the two "flip-down" doors on the side of the Recon box, and supplies power to all components within the box.

1.4.8.2 DAS Data Receive

Connects the **HSDCD** slip ring receiver to the console **DIP** Board, via 62.5/125 um fiber-optic cable. The transmitted data is serially encoded using CIMT format per the HDMP 1032/1034 chip specifications. The maximum data rate is 350 Mbaud.

1.4.8.3 X-ray Abort

Connects the Power Distribution Unit (**PDU**) to the **DIP** Board via a cable with DB9 Connectors; the typical application is 35m. The **DIP** design uses a 4-pin Mate-n-Loc connector (Table 5-36, on page 315, shows the pin definitions). The sense pins are shorted when a cable is present, resulting in a logic "HI." If the cable is disconnected, the resulting logic level is "LO." This state can be read by the host computer via the Status or Interrupt Registers.

This four pin format must be converted to mate with a 9-pin Sub-D AMP205204-4 connector before leaving the console. This connector adaptor can be placed on the console's bulkhead.
See Table 5-36, on page 315.

1.4.8.4 Serial Port

There is one serial port connection. It is between the Host Computer and the **RIP**. The Host connector is of type RJ45. The **RIP** connector is of type RJ45. They comply with the RS232 specification. These ports function as a backup connection to the **RIP** in the event that the processor unit does not properly initialize (Boot Link). It is also dedicated to performing Scan and Recon inter-processor communications during system operation.

1.4.8.5 Ethernet Switch

All external and internal Ethernet connections between the **SRU** and Scan Control components must be made through an Ethernet Switch. This switch isolates the 100Mb/s traffic of the Host Computer and **RIP** board from the 10Mb/s traffic between the Host and Patient Handling Sub-system (PHS). These connections to the switch use Category 5 Un-shielded Twisted Pair (**UTP**) cable with RJ45 connectors. The 10Mb/s media is converted from 10BaseT to 10Base2 before leaving the console.

1.4.8.6 Ethernet

Connects the Scan Control Subsystems (10Base2) to the OC Host Computer (10BaseT). The media conversion takes place in the console via a powered converter. The cable from the Ethernet switch to the Ethernet converter is a Category 5 Un-shielded Twisted Pair (**UTP**) cable; maximum length 6m. The cable from the powered transceiver to the Scan Control Subsystems is Thin Coax. The typical application is 35m.

1.4.8.7 Fast Ethernet

Connects the **UIF** Host Computer, and Image Chain Engine (**ICE**) using a Category 5 Un-shielded Twisted Pair (**UTP**) cable. The connection to the **RIP** is a standard 100BaseTX Ethernet (RJ45). Maximum length 6m.

1.4.8.8 External SCSI

Connects **RIP** to (1) Scan Data Disk using high density 68 pin cable as defined by the ANSI **SCSI**-3 (Wide Ultra **SCSI**) Standard for 16bit - 40MB/s buses. Maximum length 0.75m.

1.4.8.9 Technical Specifications

Serial

Table 5-16 shows cable pin-out assignments for the serial ports.

PIN	ASSIGNMENT	DESCRIPTION
1	DCD	Data Carrier Detect
2	RD	Receive Data
3	TD	Transmit Data
4	DTR	Data Terminal Ready
5	SG	Signal Ground
6	DSR	Data Set Ready
7	RTS	Request to Send
8	CTS	Clear to Send
9	RI	Ring Indicator

Table 5-16 Serial Port Pinout Assignments

Ethernet 10-Base T/100-Base T

Table 5-17 shows the cable pinout assignments for the Ethernet 10-Base T/100-Base T port.

PIN	ASSIGNMENT
1	TRANSMIT+
2	TRANSMIT–
3	RECEIVE+
4	(Reserved)
5	(Reserved)
6	RECEIVE–
7	(Reserved)
8	(Reserved)

Table 5-17 Ethernet 10-BASE T/100-Base T Port Pinout Assignments

SCSI

Table 5-18 shows the cable pinout assignments for the **SCSI** port.

PIN	ASSIGNMENT	PIN	ASSIGNMENT
1	GROUND	35	-DB(12)
2	GROUND	36	-DB(13)
3	GROUND	37	-DB(14)
4	GROUND	38	-DB(15)
5	GROUND	39	-DB(P1)
6	GROUND	40	-DB(0)
7	GROUND	41	-DB(1)
8	GROUND	42	-DB(2)
9	GROUND	43	-DB(3)
10	GROUND	44	-DB(4)
11	GROUND	45	-DB(5)
12	GROUND	46	-DB(6)
13	GROUND	47	-DB(7)
14	GROUND	48	-DB(P)
15	GROUND	49	GROUND
16	GROUND	50	GROUND
17	TERMPWR	51	TERMPWR
18	TERMPWR	52	TERMPWR
19	OPEN	53	OPEN
20	GROUND	54	GROUND
21	GROUND	55	-ATN
22	GROUND	56	GROUND
23	GROUND	57	-BSY
24	GROUND	58	-ACK
25	GROUND	59	-RST
26	GROUND	60	-MSG
27	GROUND	61 -SEL	28
GROUND	62	-C/D	29
GROUND	63	-REQ	30
GROUND	64	-I/O	31
GROUND	65	-DB(8)	32
GROUND	66	-DB(9)	33
GROUND	67	-DB(10)	34
GROUND	68	-DB(11)	

Table 5-18 SCSI Port Pinout Assignments

Section 2.0
Jumpers, Switches, Adjustments, LEDs & Connections

2.1 Host Subsystem

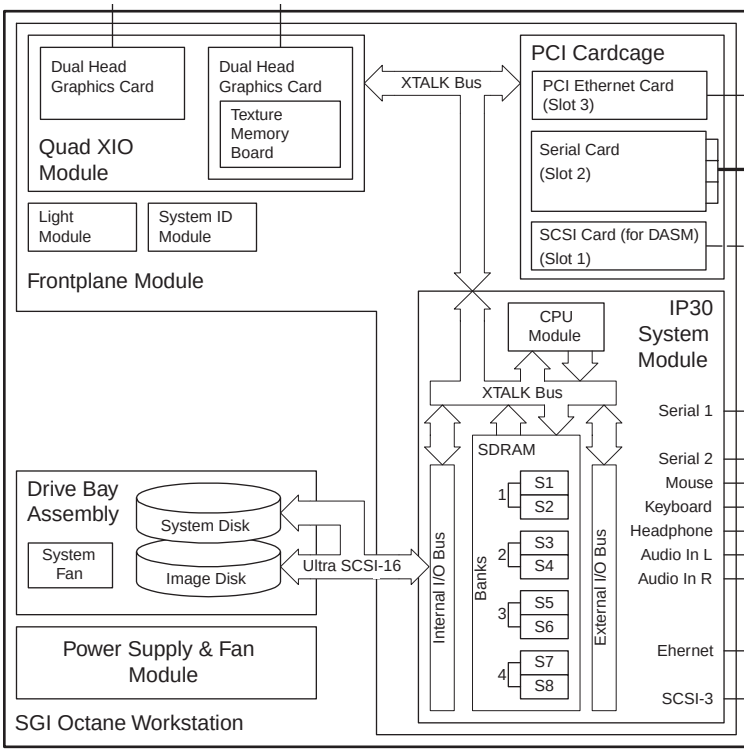


Figure 5-35 Host (Octane) Computer Block Diagram

2.1.1 Video Monitors - CRT

2.1.1.1 Connections

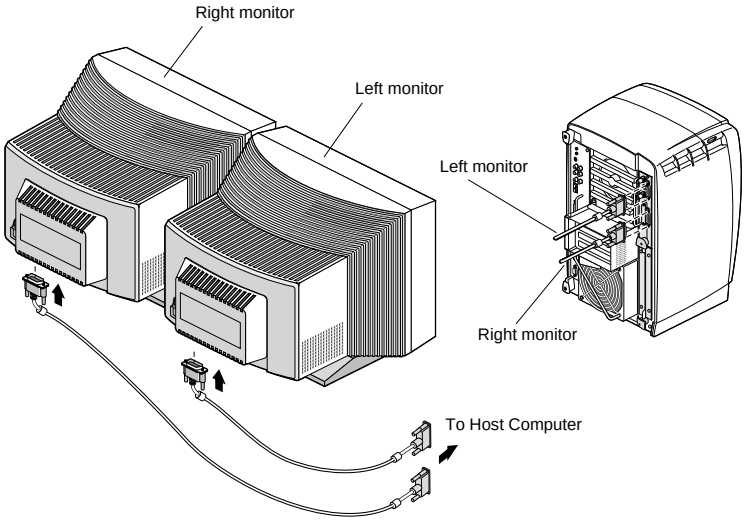


Figure 5-36 Video Monitor Connection to the Host Computer (Octane shown)

2.1.1.2 Controls

Overview

The light output from all color monitors is lower than the output from black and white monitors. For this reason, you need to be very careful when setting up the monitor brightness and contrast. Initially, the systems are set to factory defaults, but these can be adjusted. Refer to the “Installation Manual” for details on how to adjust the Brightness and Contrast for these monitors.

The technologist may perceive that the image on the monitor is “softer” than the image on the film, (i.e. they like the film, but they would like the image on the monitor to look like their film in terms of contrast and brightness). By now, you’ve probably guessed that due to the light output of the color monitor, you need to make the adjustment for Brightness and Contrast so that the technologist can see anatomical structure (window width) at the right amount of brightness (window level).

You can type < `confidence` > in a Unix shell, then select the monitor icon to have the host help you make some adjustments to the monitor.

Sony Trinitron Artifacts (Horizontal Lines)

Due to the Sony Trinitron picture tube design used in the Display Monitors, an artifact on the display is seen as two equal distance horizontal lines.

- This artifact will NOT appear on films.
- This artifact is NOT in the image, but rather is a function of the design of the monitor.

Front Controls

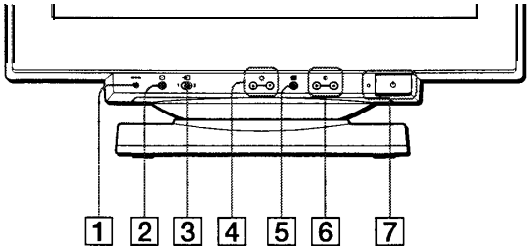


Figure 5-37 Monitor Front Parts and Controls

ITEM	DESCRIPTION
1	**Reset Button** This button resets the adjustments to the factory settings.
2	**ASC (auto sizing and centering) Button** This button automatically adjusts the size and centering of the picture. Note: Do not use the ASC function, as it does not work properly with **SGI** video output.
3	**Input Switch** This switch selects the INPUT 1 (video input 1 connector) or INPUT 2 (video input 2 connector) video input signal.
4	**Brightness Buttons** These buttons display the Brightness/Contrast menu and function as the ⏶/⏷ buttons when selecting menu items.

Table 5-19 Front Parts and Controls

ITEM	DESCRIPTION
5	**Menu Button** This button displays the main menu.
6	**Contrast Buttons** These buttons display the Brightness/Contrast menu and function as the ⊂/⊃ buttons when selecting menu items.
7	**Power Switch and Indicator** This button turns the monitor on and off. The power indicator lights up in green when the monitor is turned on, and either flashes in green and orange, or lights up in orange when the monitor is in power saving mode.

Table 5-19 Front Parts and Controls (Continued)

Rear Controls

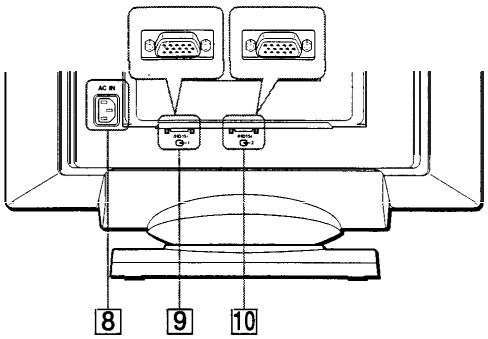


Figure 5-38 Monitor Rear Parts and Controls

ITEM	DESCRIPTION
8	**AC IN Connector** This connector provides AC power to the monitor.
9	**Video Input 1 Connector** This connector inputs RGB video signals (0.700 Vp-p, positive) and sync signals.
10	**Video Input 2 Connector** This connector inputs RGB video signals (0.700 Vp-p, positive) and sync signals.

Table 5-20 Rear Parts and Controls

2.1.1.3 Video Input Connector

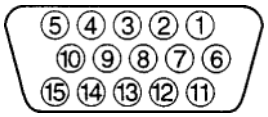


Figure 5-39 Monitor Video Pin Connector

ITEM	DESCRIPTION	ITEM	DESCRIPTION
1	Red	9	DDC + 5V
2	Green (Sync on Green)	10	Ground
3	Blue	11	ID (Ground)

Table 5-21 Monitor Video Pin Connector Assignments

ITEM	DESCRIPTION	ITEM	DESCRIPTION
4	ID (Ground)	12	Bi-Directional Data (SDA)
5	DDC (Display Data Channel) Ground	13	Horizontal Sync
6	Red Ground	14	Vertical Sync
7	Green Ground	15	Data Clock (SDL)
8	Blue Ground		

Table 5-21 Monitor Video Pin Connector Assignments(Continued)

2.1.2 Video Monitors - LCD

2.1.2.1 Connections

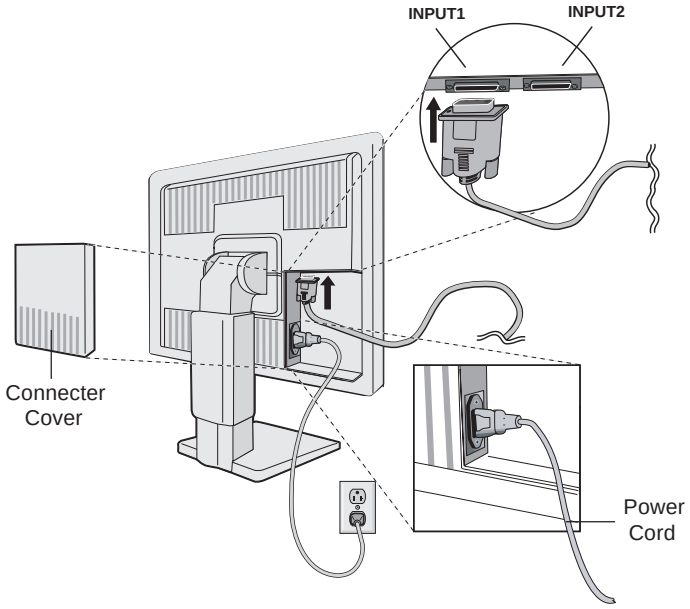


Figure 5-40 LCD Monitor Connections

VIDEOSIGNAL / DDC 1: Monitor rear side DVI-I (analog & digital)
VIDEOSIGNAL / DDC 2: Monitor rear side 15-pin D-Sub *(according to PC 99)*

Input signal connector: HD D-sub (15Pin) Connector

PIN - ASSIGNMENT OF 15-PIN D-SUB:					
1	Red Video	6	Red Ground	11	Monitor Ground
2	Green Video	7	Green Ground	12	DDC-Serial Data
3	Blue Video	8	Blue Ground	13	H-Sync.
4	No Connection	9	+5V input *)	14	V-Sync.
5	DDC-Return	10	Logic Ground	15	DDC-Serial Clock

* In case the power of the PC unit is switched off and the power of the monitor is switched on, no voltage may occur at pin 9.

Table 5-22 LCD Monitor - HD D-Sub Connector Pin-Out

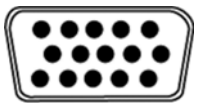


Figure 5-41 LCD Monitor - HD D-Sub Connector Pin-Out

Input signal connector: DVI Connector

PIN – ASSIGNMENT OF DVI CONNECTOR					
1	TX2-	9	TX1-	17	TX0-
2	TX2+	10	TX1+	18	TX0+
3	Shield (TX2 / TX4)	11	Shield (TX1 / TX3)	19	Shield (TX0 / TX5)
4	TX4-	12	TX3-	20	TX5-
5	TX4+	13	TX3+	21	TX5+
6	DDC-Serial Clock	14	+5V power *)	22	Shield (TXC)
7	DDC-Serial Data	15	Ground (H/V sync)	23	TXC-
8	V-Sync. (analog)	16	Hot plug detect	24	TXC+
C1	Red Video (analog)	C2	Green Video (analog)	C3	Blue Video (analog)
C4	H-Sync. (analog)	C5	Ground (analog)	--	--

* In case the power of the PC unit is switched off and the power of the monitor is switched on, no voltage may occur at pin 14.

Table 5-23 LCD Monitor - DVI Connector Pin-Out

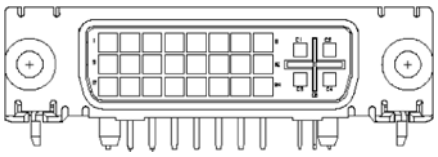


Figure 5-42 LCD Monitor - DVI Connector Pin-Out

2.1.2.2 Monitor Positioning

Raise and Lower Monitor Screen

To raise or lower screen, place hands on side of the monitor and lift or lower to the desired height. See Figure 5-43.

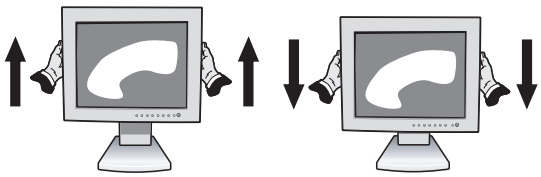


Figure 5-43 Raise or Lower LCD Monitor Screen

Tilt and Swivel

Grasp both sides of the monitor screen with your hands and adjust the tilt and swivel as desired.

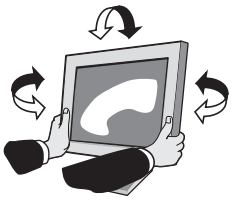


Figure 5-44 LCD Monitor Tilt and Swivel

Remove Monitor Stand for Mounting

To prepare the monitor for alternate mounting purposes:

1.) Disconnect all cables.

2.) Place hands on each side of the monitor and lift up to the highest position.

3.) Place monitor face down on a non-abrasive surface. (Place the screen on a 2-inch platform so that the stand is parallel with the surface.) Refer to Figure 5-45.

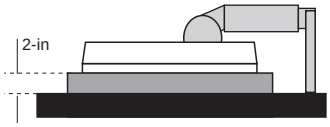


Figure 5-45 Place LCD monitor face down

4.) Remove the stand cover by sliding the top/bottom pieces off the stand. Remove the 4 screws connecting the monitor to the stand and lift off the stand assembly. The monitor is now ready for mounting in an alternate manner. Refer to Figure 5-46.

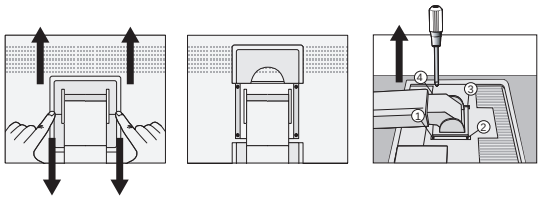


Figure 5-46 Remove stand from monitor

5.) Reverse this process to reattach stand.

Note: Use only VESA-compatible alternative mounting method.

NOTICE **Please use the attached screws (4 pcs) when mounting. To fulfil the safety requirements the monitor must be mounted to an arm which guaranties the necessary stability under consideration of the weight of the monitor. The LCD monitor shall only be used with an approved arm (e.g. GS mark).**

2.1.2.3 Controls

On-Screen Manager

OSM™ (On-Screen Manager) control buttons on the front of the monitor function as follows:

To access OSM menu, press any of the control buttons (◄, ►, –, +).

To change DVI/D-SUB signal input, press the NEXT button.

To rotate OSM between Landscape and Portrait modes, press the RESET button.

Note: OSM must be closed in order to change signal input and rotate.

	Menu
EXIT	Exits the OSM controls. Exits to the OSM main menu.
CONTROL ◄/►	Moves the highlighted area left/right to select control menus. Moves the highlighted area up/down to select one of the controls.
ADJUST – / +	Moves the bar left/right to increase or decrease the adjustment. Active Auto Adjust function. Enter the Sub Menu.
NEXT	Moves the highlighted area of main menu right to select one of the controls.
RESET	Resets the highlighted control menu to the factory setting. Resets the highlighted control to the factory setting.

Note: When RESET is pressed in the main and sub-menu, a warning window will appear allowing you to cancel the RESET function by pressing the EXIT button.

Brightness/Contrast Controls

BRIGHTNESS

Adjusts the overall image and background screen brightness.

CONTRAST

Adjusts the image brightness in relation to the background.

AUTO **AUTO ADJUST** (Analog input only)

Adjusts the image displayed for non-standard video inputs.

Auto Adjust (Analog input only)

AUTO Automatically adjusts the Image Position and H.Size settings and Fine settings.

Position Controls (Analog input only)

LEFT / RIGHT

Controls Horizontal Image Position within the display area of the LCD.

DOWN / UP

Controls Vertical Image Position within the display area of the LCD.

H. SIZE

Adjusts the horizontal size by increasing or decreasing this setting.

FINE

Improves focus, clarity and image stability by increasing or decreasing this setting.

AccuColor® Control Systems

AccuColor® Control Systems: Six color presets select the desired color setting (sRGB and NATIVE color presets are standard and cannot be changed). Color temperature increases or decreases, in each preset. **R, Y, G, C, B, M, S**: Increases or decreases Red, Yellow, Green, Cyan, Blue, Magenta and Saturation depending upon which is selected. The change in color will appear on screen and the direction (increase or decrease) will be shown by the color bars.
NATIVE: Original color presented by the LCD panel that is unadjustable.

sRGB: sRGB mode dramatically improves the color fidelity in the desktop environment by a single standard RGB color space. With this color supported environment, the operator could easily and confidently communicate color without further color management overhead in the most common situations.

Tools 1

SMOOTHING: Select one of three image sharpness settings. This function is only valid when the expanded display function (expansion function) is on.

TEXT MODE: Use this to display text clearly.

NORMAL MODE: This sharpness is between TEXT and GRAPHIC MODE.

GRAPHIC MODE: This mode is suited for images and photographs.

EXPANSION MODE: Sets the zoom method.

FULL: The image is expanded to 1280 x 1024,regardless of the resolution.

ASPECT: The image is expanded without changing the aspect ratio.

OFF: The image is not expanded.

CUSTOM (DIGITAL INPUT & RESOLUTION OF 1280x1024 ONLY): Select one of seven expansion rates.In this mode the resolution may be low and there may be blank areas.This mode is for use with special video cards.

VIDEO DETECT: Selects method of video detection when more than one computer is connected.

FIRST DETECT: The video input has to be switched to “FIRST DETECT” mode. When current video input signal is not present, then the monitor searches for a video signal from the other video input port.If the video signal is present in the other port, then the monitor switches the video source input port to the new found video source automatically. The monitor will not look for other video signals while the current video source is present.

LAST DETECT: The video input has to be switched to the “LAST DETECT” mode. When the monitor is displaying a signal from the current source and a new secondary source is supplied to the monitor, then the monitor will automatically switch to the new video source. When current video input signal is not present, then the monitor searches for a video signal from the other video input port. If the video signal is present in the other port, then the monitor switches the video source input port to the new found video source automatically.

NONE: The Monitor will not search the other video input port unless the monitor is turned on.

DVI SELECTION: This function selects the DVI input mode. When the DVI selection has been changed, you must restart your computer.

DIGITAL: DVI digital input is available.

ANALOG: DVI analog input is available.

Tools 2

LANGUAGE: OSM™ control menus are available in seven languages.

OSM POSITION: You can choose where you would like the OSM control image to appear on your screen. Selecting OSM Location allows you to manually adjust the position of the OSM control menu left, right, down or up.

OSM TURN OFF: The OSM control menu will stay on as long as it is use. In the OSM Turn Off submenu, you can select how long the monitor waits after the last touch of a button to shut off the OSM control menu. The preset choices are 10,20,30,45,60 and 120 seconds.

OSM LOCK OUT: This control completely locks out access to all OSM control functions. When attempting to activate OSM controls while in the Lock Out mode, a screen will appear indicating the OSM controls are locked out. To activate the OSM Lock Out function, press ◄,then ► and hold down simultaneously. To de-activate the OSM Lock Out, press ◄, then ► and hold down simultaneously.

xy **RESOLUTION NOTIFIER**: This optimal resolution is 1280x1024. If ON is selected, a message will appear on the screen after 30 seconds, notifying you that the resolution is not at 1280x1024.

FACTORY PRESET: Selecting Factory Preset allows you to reset all OSM control settings back to the factory settings. The RESET button will need to be held down for several seconds to take effect. Individual settings can be reset by highlighting the control to be reset and pressing the RESET button.

Information

MODE **DISPLAY MODE**: Provides information about the current resolution display and technical data including the preset timing being used and the horizontal and vertical frequencies.

Increases or decreases the current resolution. (Analog input only)

MONITOR INFO: Indicates the model and serial numbers of your monitor.

OSM™ Warning: OSM Warning menus disappear with Exit button.

NO SIGNAL: Gives a warning when there is no signal present. After power is turned on or when there is a change of input signal or video is inactive, the No Signal window will appear.

RESOLUTION NOTIFIER: Gives a warning of use with optimized resolution. After power is turned on or when there is a change of input signal or the video signal doesn't have proper resolution, the Resolution Notifier window will open. This function can be disabled in the TOOL menu.

OUT OF RANGE: This function gives a recommendation of the optimized resolution and refresh rate. After the power is turned on or there is a change of input signal or the video signal doesn't have proper timing, the Out Of Range menu will appear.

CHECK CABLE: This function will advise you to check all Video Inputs on the monitor and computer to make sure they are properly connected.

NOTE: If "ⓘ CHANGE DVI SELECTION" is displayed switch to DVI SELECTION.

2.1.3 Host Computer - Linux Workstation

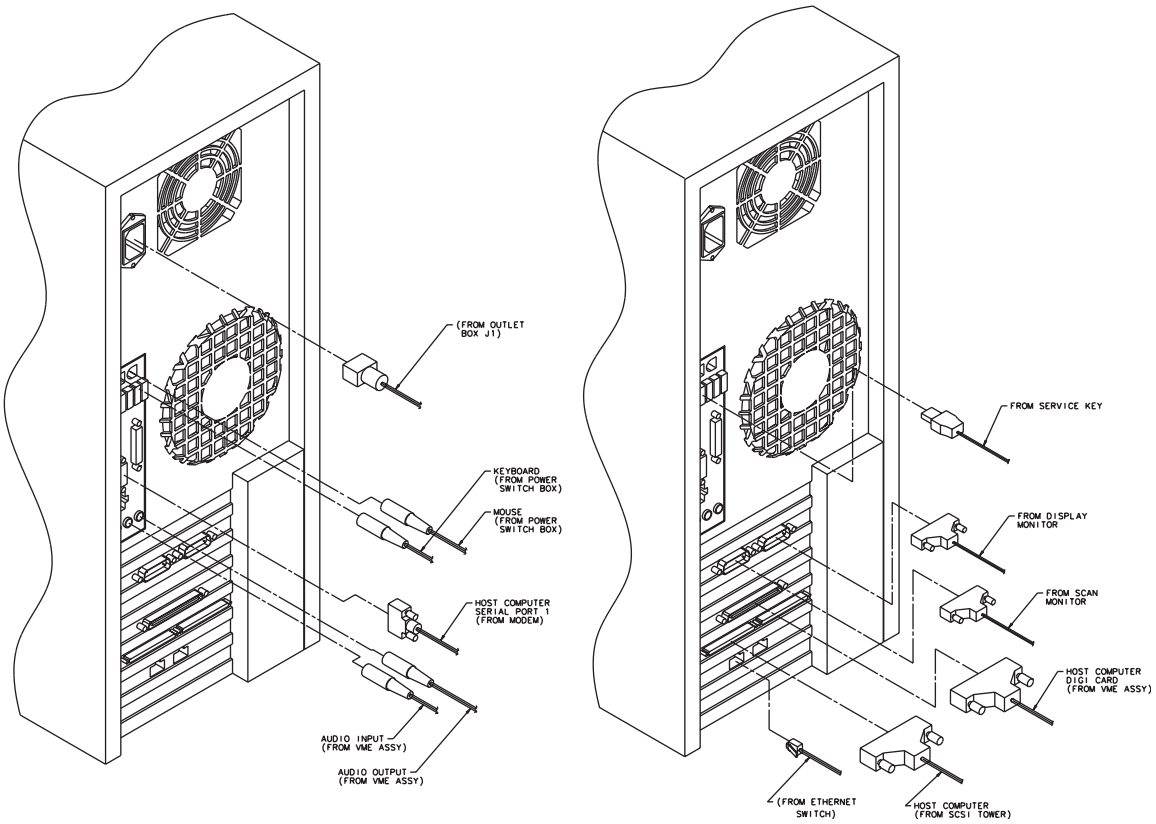


Figure 5-47 Connections on Rear of HP xw8000 (GC-Linux only)

2.1.4 Host Computer - Octane/Octane2

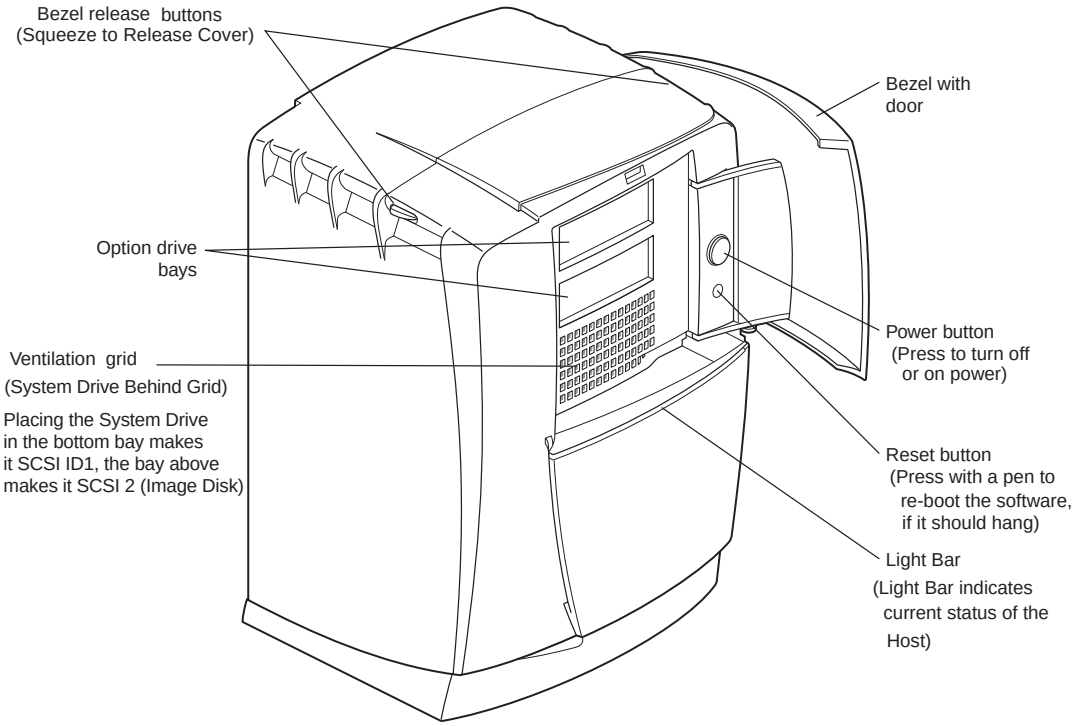


Figure 5-48 Front View of Octane Computer (Octane2 similar)

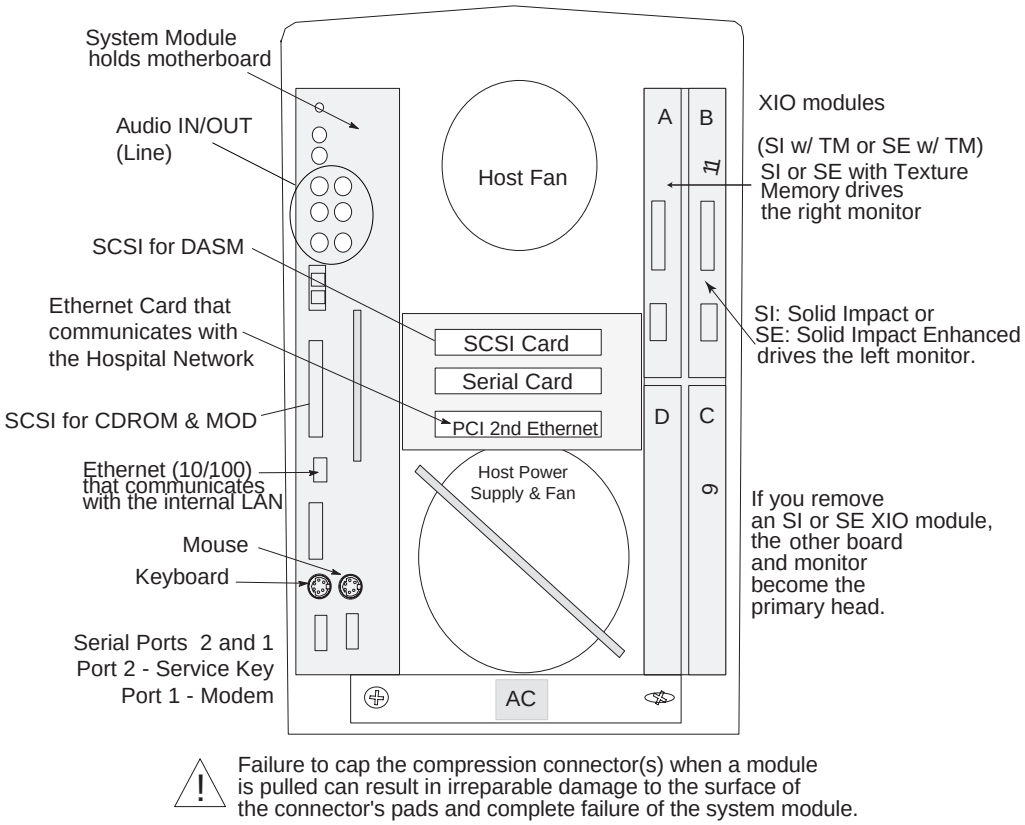


Figure 5-49 Rear View of Host Octane Computer (Octane2 varies)

2.1.4.1 Octane2 Graphics Subsystem

VPRO (V12) Graphics Card

Table 5-24 shows the V12 graphics board port pinout assignments for a 20” monitor.

PIN	ASSIGNMENT
A1	Red signal, analog
A2	Green signal, analog
A3	Blue signal, analog
1	Monitor ID bit 3, TTL
2	Monitor ID bit 0, TTL
3	Composite Sync (active low), TTL
4	Horizontal Sync (active high), TTL
5	Vertical Sync (active high), TTL
6	Monitor ID bit 1, TTL
7	Monitor ID bit 2, TTL
8	Ground
9	Ground
10	Ground

Table 5-24 20-inch Monitor Port Pinout Assignment

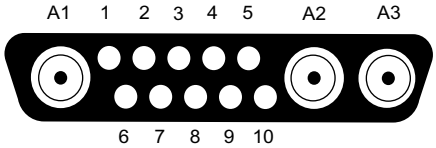


Figure 5-50 V12 Graphics Board Monitor Port

The 13W3 cover should be screwed in place when the V12's monitor port is not in use. Such as when using the **DCD** card. With the cover in place, unwanted **EMI** is eliminated.

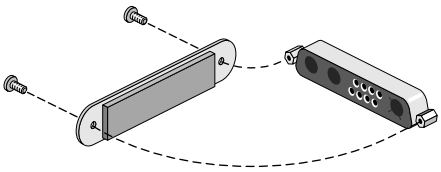


Figure 5-51 V12 Graphics Card 13W3 Cover

Dual Channel Display (DCD) Card

Table 5-25 shows the **DCD** board port pinout assignments for a 20" monitor

PIN	ASSIGNMENT	PIN	ASSIGNMENT	PIN	ASSIGNMENT
1	T.M.D.S. Data2-	9	T.M.D.S. Data1-	17	T.M.D.S. Data0-
2	T.M.D.S. Data2+	10	T.M.D.S. Data1+	18	T.M.D.S. Data0+
3	T.M.D.S. Data2/4 Shield	11	T.M.D.S. Data1/3 Shield	19	T.M.D.S. Data0/5 Shield
4	T.M.D.S. Data4-	12	T.M.D.S. Data3-	20	T.M.D.S. Data5-
5	T.M.D.S. Data4+	13	T.M.D.S. Data3+	21	T.M.D.S. Data5+
6	DDC Clock	14	+5V Power	22	T.M.D.S. Clock Shield
7	DDC Data	15	Ground *(return for +5V, HSync, and VSync)*	23	T.M.D.S. Clock +
8	Analog Vertical Sync	16	Hot Plug Detect	24	T.M.D.S. Clock-
C1	Analog Red	C2	Analog Green	C3	Analog Blue
C4	Analog Horizontal Sync	C5	Analog Ground *(analog R, G, and B return)*		

Table 5-25 DCD Board Pinout Assignments

2.1.4.2 PCI Support: SCSI PCI Card

SCSI CONNECTOR PINOUT

Signal Name	Pin Number	Pin Number	Signal Name
Ground	1	35	-DB(12)
Ground	2	36	-DB(13)
Ground	3	37	-DB(14)
Ground	4	38	-DB(15)
Ground	5	39	-DPARH
Ground	6	40	-D0
Ground	7	41	-D1
Ground	8	42	-D2
Ground	9	43	-D3
Ground	10	44	-D4
Ground	11	45	-D5
Ground	12	46	-D6
Ground	13	47	-D7
Ground	14	48	-DPAR
Ground	15	49	Ground
Ground	16	50	Ground
TERMPWR	17	51	TERMPWR
TERMPWR	18	52	TERMPWR
Reserved	19	53	Reserved
Ground	20	54	Ground
Ground	21	55	-ATN
Ground	22	56	Ground
Ground	23	57	-BSY
Ground	24	58	-ACK
Ground	25	59	-RST
Ground	26	60	-MSG
Ground	27	61	-SEL
Ground	28	62	-C/D
Ground	29	63	-REQ
Ground	30	64	-I/O
Ground	31	65	-DB(8)
Ground	32	66	-DB(9)
Ground	33	67	-DB(10)
Ground	34	68	-DB(11)

Table 5-26 Single-Ended Ultra SCSI PCI Card Connector Pinout

2.1.4.3 PCI Support: Serial PCI Card - Digi ClassicBoard

STANDARD/TRADITIONAL - DB25 PINOUT

EIA-232 SIGNAL	DB-25	EIA-232 SIGNAL	DB-25
RI	22	RxD	3
DSR	6	SG**	7
RTS	4	CTS	5
GND*	1	DTR	20
TxD	2	DCD	8

Table 5-27 Standard/Traditional - DB25 Pinout

DIGI INTERNATIONAL CLASSICBOARD - DB78M PINOUT

DB78 PIN	Signal Name	Equivalent DB25 PIN	DB78 PIN	Signal Name	Equivalent DB25 PIN
1	DTR8	8-20	40	TxD5	5-2
2	TxD6	6-2	41	RTS6	6-4
3	DTR6	6-20	42	DSR6	6-6
4	CTS6	6-5	43	DCD5	5-8
5	DSR5	5-6	44	RI5	5-22
6	DCD8	8-8	45	CTS8	8-5
7	RI8	8-22	46	RxD7	7-3
8	RxD6	6-3	47	RI7	7-22
9	CTS7	7-5	48	DCD7	7-8
10	TxD4	4-2	49	DTR1	1-20
11	TxD3	3-2	50	TxD2	2-2
12	RTS3	3-4	51	RTS1	1-4
13	DTR3	3-20	52	DTR4	4-20
14	RTS4	4-4	53	CTS2	2-5
15	RI2	2-22	54	DSR1	1-6
16	CTS1	1-5	55	RxD1	1-3
17	RxD2	2-3	56	RxD4	4-3
18	DCD4	4-8	57	CTS4	4-5
19	RI4	4-22	58	DSR3	3-6
20	RI3	3-22	59	CTS3	3-5
21	RTS5	5-4	60	RTS8	8-4
22	DTR5	5-20	61	DTR7	7-20
23	DCD6	6-8	62	RTS7	7-4
24	RI6	6-22	63	TxD7	7-2
25	CTS5	5-5	64	TxD8	8-2
26	DSR8	8-6	65	----	
27	RxD8	8-3	66	----	
28	RxD5	5-3	67	----	
29	DSR7	7-6	68	GND1	1-7
30	TxD1	1-2	69	GND2	2-7
31	RTS2	2-4	70	GND3	3-7
32	DTR2	2-20	71	GND4	4-7
33	DCD2	2-8	72	GND5	5-7
34	DSR2	2-6	73	GND6	6-7
35	DCD1	1-8	74	GND7	7-7
36	RI1	1-22	75	GND8	8-7
37	RxD3	3-3	76	----	
38	DSR4	4-6	77	----	
39	DCD3	3-8	78	----	

Table 5-28 DB78M PINOUT to equivalent DB25 PINOUT Map

2.1.5 CD-ROM Drive - Teac CD-532S

2.1.5.1 GE Specific Jumper Settings

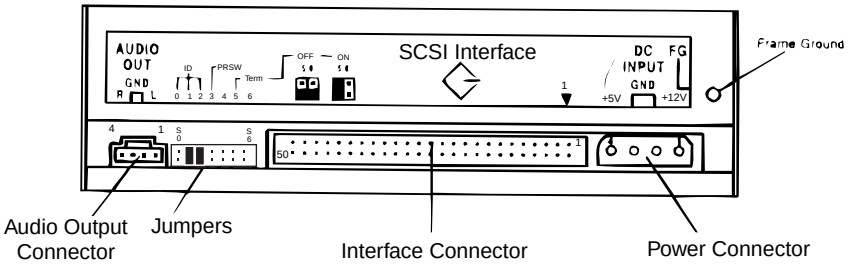


Figure 5-52 GE Specific Jumper Settings

2.1.5.2 Jumper Description

1.) S0, S1 and S2 jumpers determine the **SCSI** ID number.

SCSI ID	S0	S1	S2
0	OFF	OFF	OFF
1	ON	OFF	OFF
2	OFF	ON	OFF
3	ON	ON	OFF
4	OFF	OFF	ON
5	ON	OFF	ON
6	OFF	ON	ON
7	ON	ON	ON

Table 5-29 Strap Jumper Settings

Figure 5-53 CD-ROM Jumper Block

2.) S3: Parity Check
- Strap jumper ON — The drive does NOT perform parity check.
- Strap jumper OFF — The drive performs parity check.

3.) S4: Logical Block Size
- Strap jumper ON — The drive operates at 512 bytes per logical block.
- Strap jumper OFF — The drive operates at 2048 bytes per logical block.

4.) S5: Terminator
- Strap jumper ON — Terminator is activated.
- Strap jumper OFF — Terminator is NOT activated.

5.) S6: Factory
Reserved for Factory Use Only (always OFF)

2.1.6 Magneto Optical Disk (MOD) Drive - MaxOptix T5-2600 (2260734-2)

2.1.6.1 GE Specific Switches and Jumpers

The location of the jumpers on T5-2600 is shown here. There is a single 40-pin Berg connector on the T5 Model, and a 24 pin Berg connector and a mini-dip switch pack on the T5 Star Model.

Note: 'ON' refers to the on position as indicated on the dip-switch bank. 'ON' is equivalent to being closed or having a jumper installed.

The Drive is configured with a **SCSI** ID of 3. Refer to Figure 5-54 to help identify the pin numbers. Jumpers should be as follows:

1 - 2 ON

3 - 4 ON The first three jumper settings make a **SCSI** ID of 3.

5 - 6 OFF

7 - 8 ON This Enables Write Verify

All Other Pins - OFF - No jumpers

SW1 **DIP** Switch Settings - All 1 - 8 positions should be OFF

2.1.6.2 Jumper Descriptions

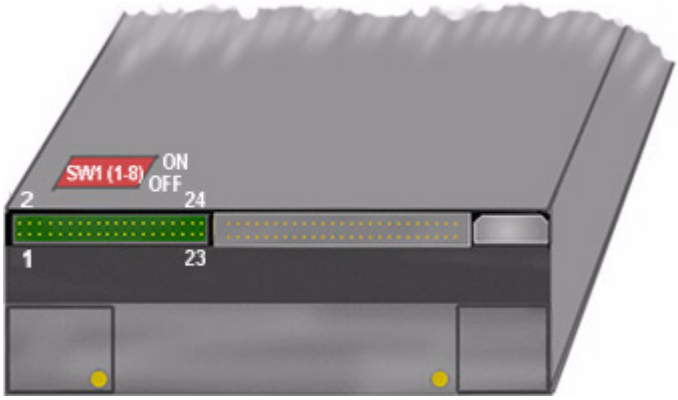


Figure 5-54 MOD Drive (Maxoptix T5-2600 Star)

PIN NUMBER	DESCRIPTION	DEFAULT	FUNCTION
1 & 2	**SCSI** ID bit zero	installed	enable
3 & 4	**SCSI** ID bit one	installed	enable
5 & 6	**SCSI** ID bit two	removed	disable
7 & 8	Write with verify	installed	enable
9 & 10	Active termination	removed	disable
11 & 12	Drive supplied term power	removed	disable
13 & 14	**SCSI** bus supplied term power	removed	disable
15	AC eject	Jukebox operation	Reserved
16	**LED** pipe	Jukebox operation	Reserved
17	PwrDnReq	Jukebox operation	Reserved
18	PwrDnAck	Jukebox operation	Reserved
19	AC error	Jukebox operation	Reserved

Table 5-30 Functional Switch Connector Pin Assignments

PIN NUMBER	DESCRIPTION	DEFAULT	FUNCTION
20	Cart in drive	Jukebox operation	Reserved
21	AC reset	Jukebox operation	Reserved
22	Cart loaded	Jukebox operation	Reserved
23	GND	Jukebox operation	Reserved
24	Stand alone/AC	Jukebox operation	Reserved

Table 5-30 Functional Switch Connector Pin Assignments

SWITCH NUMBER	DESCRIPTION	DEFAULT
SW1-1	DEC MVAX Mode	Off
SW1-2	Disable Auto Spin Up	Off
SW1-3	Disable **SCSI** Bus Parity	Off
SW1-4	Enable Apple Mode	Off
SW1-5	Disable Removable Media	Off
SW1-6	Disable Optical Device	Off
SW1-7	Disable Write Cache	Off
SW1-8	Disable Read Cache	Off

Table 5-31 Configuration Switch Settings (SW1)

2.1.7 Magneto-Optical Disk (MOD) Drive - Sony SMO-F551-SD

2.1.7.1 GE Specific Jumper Settings

GE specific settings for the Sony SMO-F551-SD **MOD** drive are shown in Figure 5-55. See Table 5-32 for descriptions of the Functional Switch connectors.

Figure 5-55 Sony MOD drive functional switch - GE specific settings

2.1.7.2 Jumper Descriptions

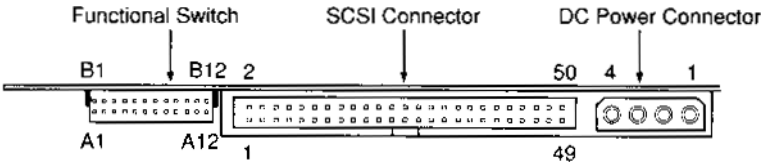


Figure 5-56 Sony SMO-F551-SD (MOD) drive connectors (rear view)

A1	**SCSI** ID2	B1	GND
A2	**SCSI** ID1	B2	GND
A3	**SCSI** ID0	B3	GND
A4	Disable **SCSI** Parity	B4	GND
A5	Disable Write Cache	B5*	Reserved
A6	Disable AUto Spin-up	B6*	Reserved
A7	Force Verify for Write command	B7*	Reserved
A8	Disable Manual Eject	B8*	Reserved
A9	Enable Fast **SCSI**	B9*	Reserved
A10	Device Type	B10*	Reserved
A11	Enable Termination	B11	GND
A12	Terminator Power	B12	Terminator Power Source

* This pin is NOT directly connected to the GND. Do not use this pin as GND. SMO-F551-SD drives the signal to GND level depending on the functional switch setting. Otherwise, the signal is not driven to GND level.

Table 5-32 Functional Switch Connector Pin Assignments (Sony MOD)

2.1.8 Prescribed Tilt Board (2269601)

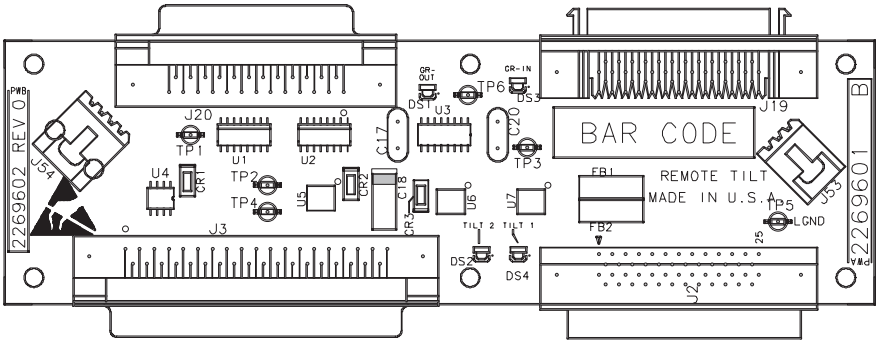


Figure 5-57 Prescribed Tilt Board (2269601) Physical Layout

2.1.9 Console Intercom Board (2167014)

2.1.9.1 GE Specific Settings

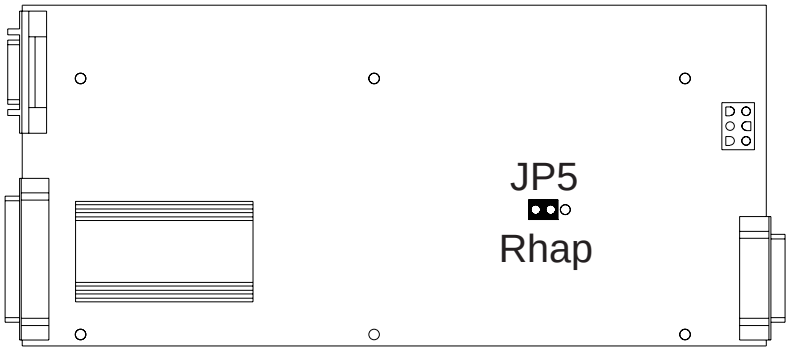


Figure 5-58 Console Intercom Board - GE Specific Settings

2.1.9.2 Software Settings (Autovoice Control)

See Figure 5-59 for the normal (default) settings of the software audio panel. This audio panel is displayed on the right-head monitor, in the upper left-hand corner when Applications is down.

To adjust the Gantry Speaker volume, adjust the right volume thumb wheel while autovoice is playing, and check the volume for the gantry speaker.

To adjust the Console Speaker Volume, bring up the Autovoice volume control audio panel.

- Select the OPTIONS pull-down menu.
- Select OUTPUT SLIDERS INDEPENDENT.
- Adjust the RIGHT Channel volume only (Analog Out)—this is the only volume control.
- The LEFT Channel must be kept locked at the maximum.
- The Analog In settings will affect the level of Autovoice record, and if you desire, you can click on the METER selection box to view the recording levels.
- DO NOT turn on the MONITOR selection, as it will cause immediate and uncontrollable feedback.
- Select FILE - SAVE when you have finished, to retain your settings.

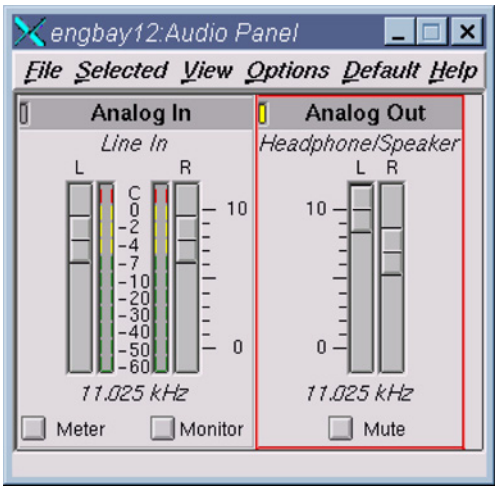


Figure 5-59 Autovoice Control Audio Panel

2.1.10 Media Adapter (AT-MC15, Allied Telesyn)

2.1.10.1 GE Specific Switch Settings

1.) Termination switch is set to **OFF** and BNC "Tee" adapter with 50 ohm termination plug attached to 10 Base 2 connector.

2.) MDI switch set to **MDI** position

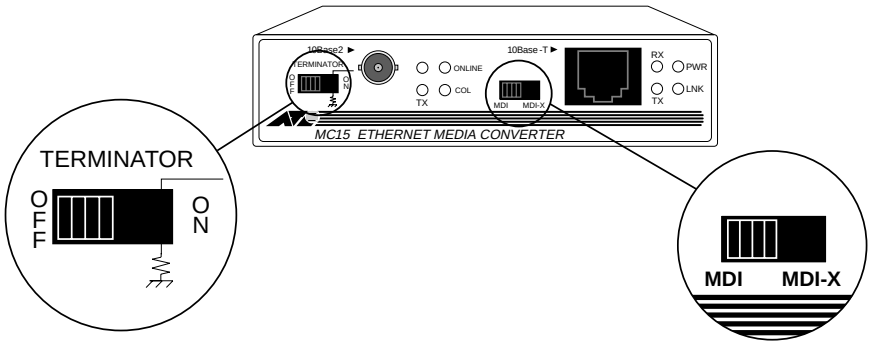


Figure 5-60 GE Specific AT-MC15 Switch Settings

2.1.10.2 LEDs

Status **LED**s are located on the front panel next to each port. See Figure 5-61. Each **LED** is described in the table below (Table 5-33).

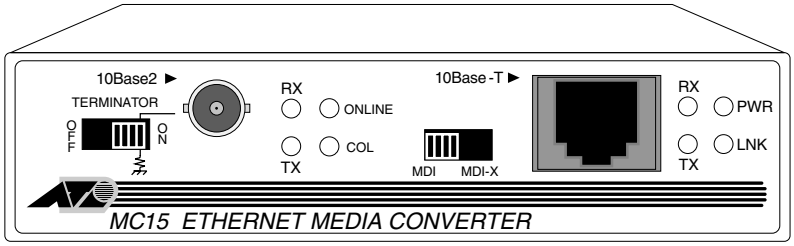


Figure 5-61 AT-MC15 (Allied Telesyn)

LED	DESCRIPTION
PWR	Indicates power is applied
LNK	Indicates link is established
TX (right)	Indicates data is being transmitted
RX (right)	Indicates valid data is being received
TX (left)	Indicates data is being transmitted on the BNC port
RX (left)	Indicates valid data is being received on the BNC port
ONLINE	Indicates the BNC port is connected to an active 10Base-2 segment
COL	Indicates the BNC port is sensing a collision signal

Table 5-33 AT-MC15 LEDs

2.1.11 Series Fast Ethernet Switch (AT-FS708 or AT-FS705, Allied Telesyn)

For additional product information, see Allied Telesyn web site at ***www.alliedtelesyn.com.***

2.1.11.1 Overview

All connectors and **LED**s are located on the front panel.

Figure 5-62 AT-FS708 Front Panel

Figure 5-63 AT-FS705 Front Panel

2.1.11.2 Cables and Connections

Table 5-34 lists connectors and defines their function.

SWITCH	CONNECTOR	FUNCTION
AT-FS708	Ports 1 through 8 are 10/100Base-TX connectors (RJ45)	Connecting to a high performance workstation, server, or hub.
AT-FS705	Ports 1 through 5 are 10/100Base-TX connectors (RJ45)	Connecting to a high performance workstation, server, or hub.

Table 5-34 Connector Types on Switches

Only use the cables supplied with the system. Category 5e cables must be used with 100Base-TX connections. Using any other category for a 100Base-TX connection can result in high error rates. If voice-quality cables are used in a 100Base-TX network system, data movement can be slow, collision-prone or non-existent. In addition, interface **LED**s will usually indicate a valid link in such cases.

2.1.11.3 LEDs

Figures 5-64 and 5-65 illustrate the front panel **LED**s; Table 5-35 lists and defines these **LED**s.

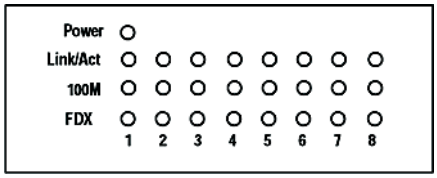


Figure 5-64 Front Panel LEDs (AT-FS708)

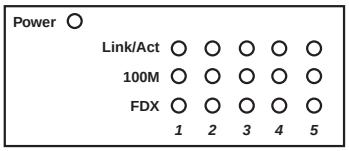


Figure 5-65 Front Panel LEDs (AT-FS705)

LEDS	COLOR	DESCRIPTION
Power (switch)	Green	**ON** indicates that the switch is receiving power. **OFF** indicates that there is no power to the switch.
LINK/ACT (port)	Green	**ON** indicates a valid physical link on the port. **Blinking** indicates data is being transmitted. **OFF** means no link.
100M (port)	Green	**ON** means the bandwidth is 100 Mbps. **OFF** means the bandwidth is 10 Mbps.
FDX (port)	Green	**ON** indicates full-duplex mode. **OFF** indicates half-duplex mode.

Table 5-35 LED Status

2.1.11.4 Power Requirements

The AT-FS708 and AT-FS705 series switches use internal switching power supplies, with 100 to 120 VAC, 50/60 Hz input rating. Maximum power consumption is 50W.

2.1.12 Data Acquisition System Manager (DASM)

2.1.12.1 GE Specific Jumper Settings

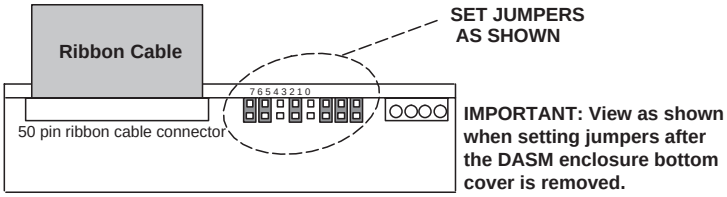


Figure 5-66 DASM Jumpers

2.1.12.2 GE Specific SCSI Settings

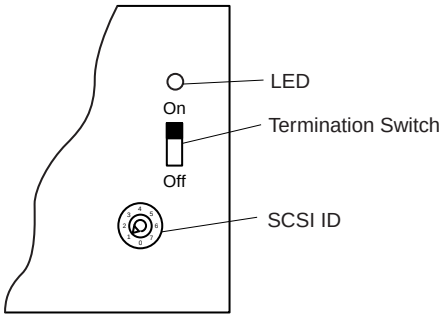


Figure 5-67 DASM Bottom, Showing SCSI Settings

2.1.12.3 DASM/LCAM Host Control Serial Link (Digital DASM Only)

RS232 serial host control interface, 25-pin D-type connector

- pin 2 (TX)
- pin 3 (RX)
- pin 7 (GND)

A null modem cable may be required (reverses pins 2–3) between some cameras.

- baud rate = 1200
- start bits = 1
- stop bits =1
- parity = even
- end of message = CR
- protocol = ACK/NACK (3M M952)

2.1.12.4 DASM LEDs

DASM green **LED**s viewed from front of **DASM** and air vents at bottom. The “RDY” and “XFR” **LED**s only exist on the analog VDB **DASM**.

```
-----------------------------------------
          o RDY
               o XFR
                         o    o    o    o
                        PWR  CPU  SCSI PIF
-----------------------------------------
DASM air inlet vents
-----------------------------------------
```

- PWR - on whenever **DASM** power applied (+5VDC)
- CPU - flashes idle heartbeat at 1 CPS or indicates **CPU** activity
- **SCSI** - flashes when OC and **DASM** communicate over the SCSIbus
- PIF - flashes when the **DASM** and camera communicate over the serial port
- RDY - analog VDB only, indicates an image is ready to be “grabbed” by the camera video/ analog input port
- XFR - analog VDB only, indicates an image is being “grabbed” by the camera video/analog input port

2.1.12.5 DASM/LCAM Image Data Interface

RS422/RS485 8-bit digital image data interface, 37-pin D-type connector (3M M952 defacto industry standard digital interface).

- pixels: 512
- lines: 512
- bits/pixel: 8
- protocol: 3M M952

The gray scale reference bar option at the left of the filmed images is *NOT* supported by the digital filming interface.

2.2 Scan Reconstruction Unit (ICEbox)

2.2.1 Scan Data Disk Assembly

If you have a need for further information, please visit Seagate's WEB site at www.seagate.com

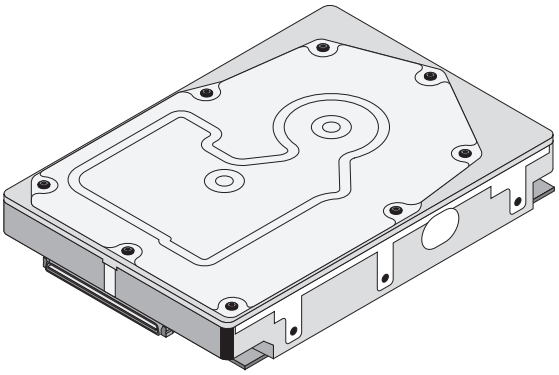


Figure 5-68 Scan Data Disk Drive (Seagate P/N ST318452)

2.2.1.1 Electrostatic Discharge and Protection for Disk Drives

NOTICE **Removal of circuit boards by personnel not performing depot repair will damage components.**

All drive electronic assemblies are sensitive to static electricity, due to the electrostatically sensitive devices used within the drive circuitry. Although some devices such as metal-oxide semiconductors are extremely sensitive, all semiconductors, as well as some resistors and capacitors, may be damaged or degraded by exposure to static electricity.

2.2.1.2 GE Specific Jumper Settings

Please set your **SCSI** Disk as shown in Figure 5-69.

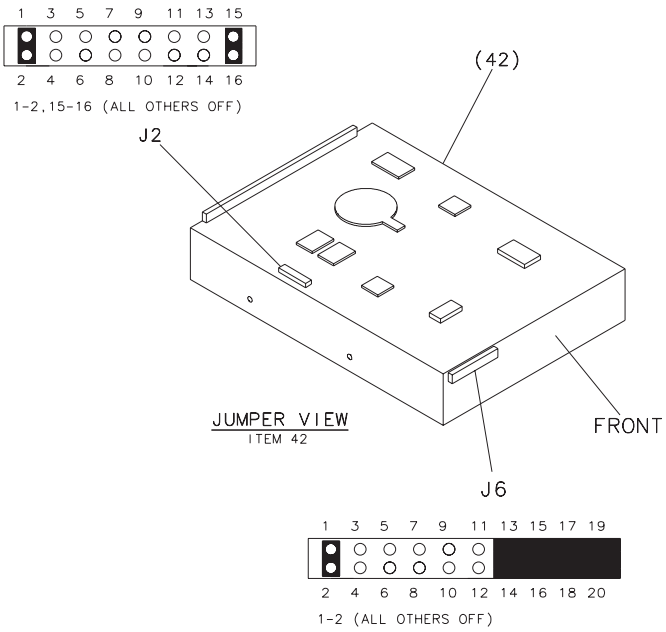


Figure 5-69 Scan Data Disk – GE Specific Settings

2.2.1.3 Jumpers

SCSI ID

The scan data drive must be configured as shown in Figure 5-69. The following information is provided for reference only.

Figure 5-70 shows a view of the drive's ID select jumper connectors (at left) and the drive's J5-auxiliary jumper connector (at right). Both J5-auxiliary and J6 have pins for selecting drive ID and for connecting a remote **LED** cable. Only one or the other should be used, although using both at the same time will not damage the drive.

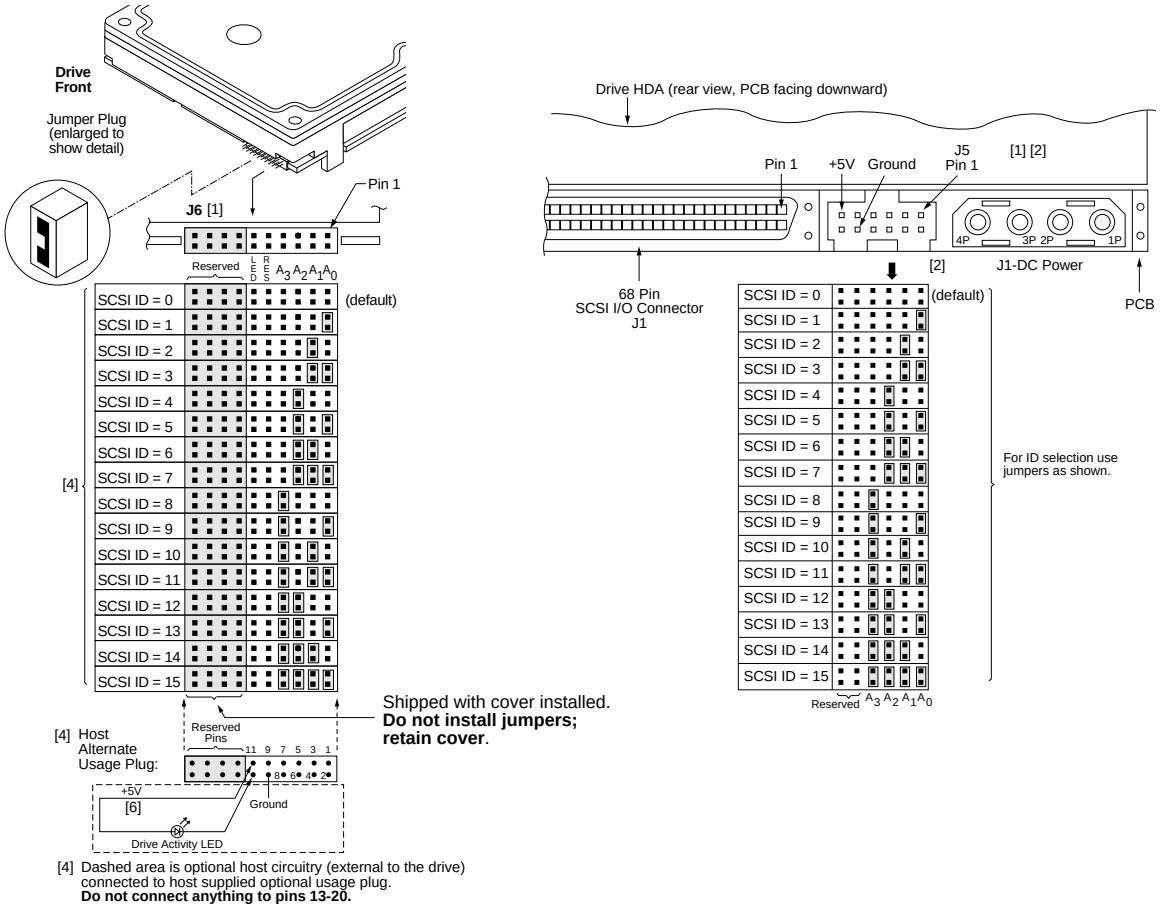


Figure 5-70 Scan Data Disk – SCSI Jumpers

Options (J2) Jumpers

Figures 5-71 and 5-72 show the option select jumper headers.

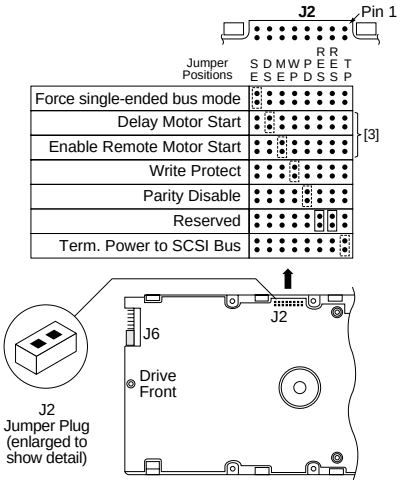


Figure 5-71 Scan Data Disk (J2 Header) Option Jumpers- ST318451

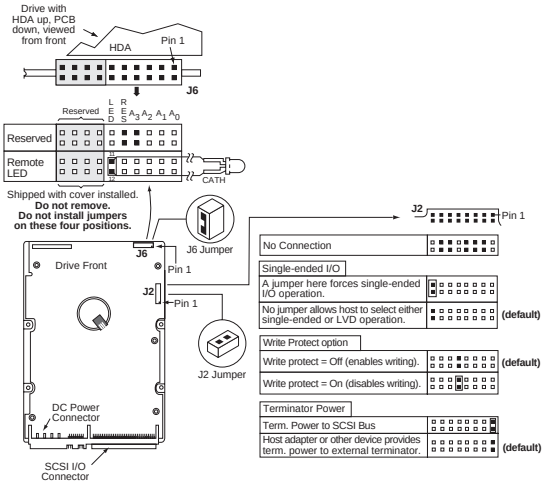


Figure 5-72 Scan Data Disk (J2 Header) Option Jumpers- ST318452 (rt)

Drive Termination (General Overview)

ST318451LW and ST318452LW drives do not have internal terminators or any other way of adding internal termination to the drive. External termination is required.

The example in Figure 5-73 shows an internal hard disc at one end of the **SCSI** bus with the **SCSI** controller at the other end (both are terminated). The bottom example shows two additional **SCSI** devices connected externally—this means the **SCSI** controller is no longer on the end of the **SCSI** chain and should not be terminated.

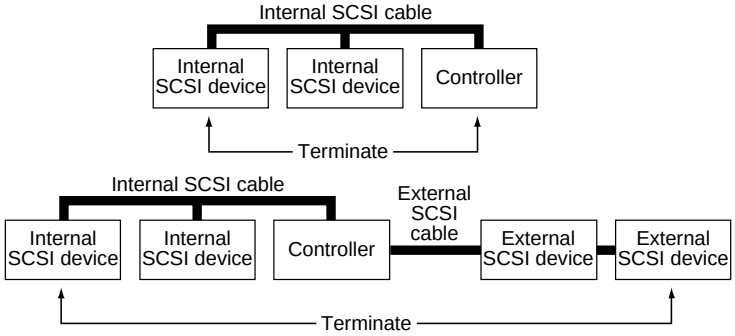
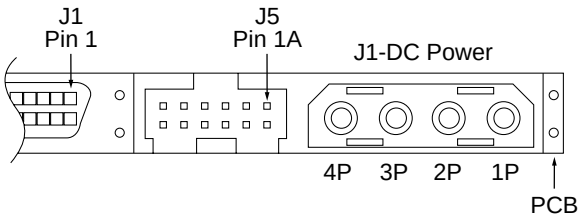


Figure 5-73 Typical SCSI bus Termination

Power Connections



Pin	Power
1P	+12V
2P	+12V ret
3P	+ 5V ret
4P	+ 5V

Figure 5-74 DC power connector

2.2.2 VME Power Supply

The figure below shows the terminal connections, adjustment potentiometers, and specifications for the power supply.

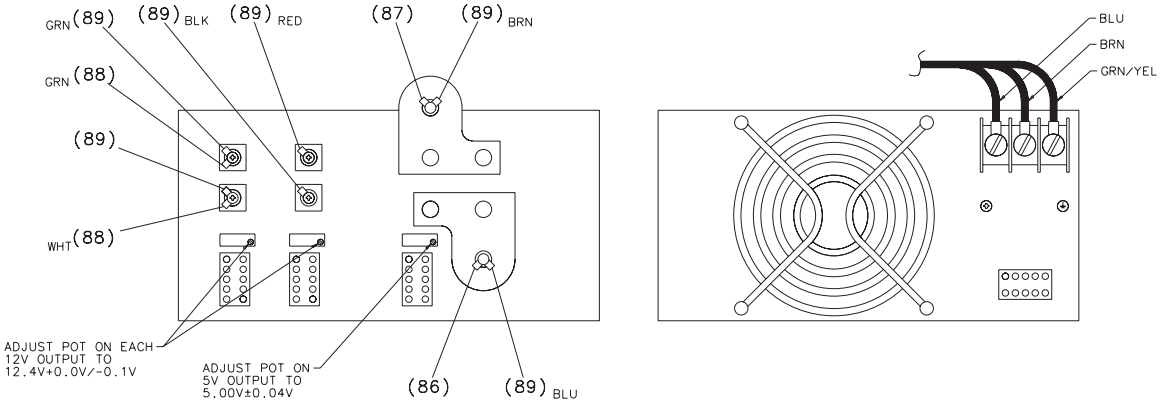


Figure 5-75 VME Power Supply Terminals & Adjustments (Astec)

2.2.3 VME Backplane

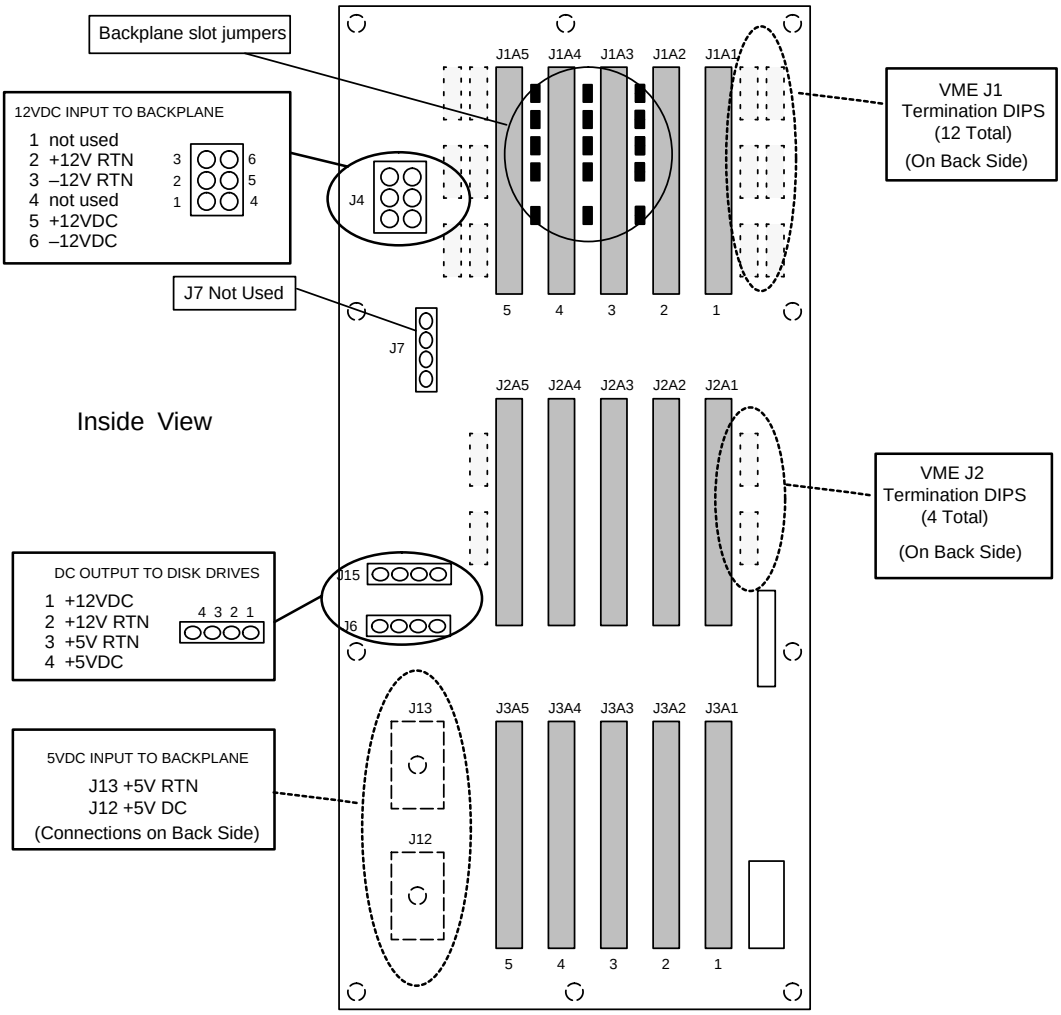


Figure 5-76 Scan Recon Chassis VME Backplane, Inside View

2.2.4 Recon Interface Processor (RIP) - Motorola Board

2.2.4.1 Switches

There are two switches (ABT and RST) and four **LED** (light-emitting diode) status indicators (BFL, **CPU**, **PMC** (two)) located on the MVME230x front panel. See Figure 5-77, on page 313.

ABT (S1)

When activated by software, the Abort switch, ABT, can generate an interrupt signal from the base board to the processor at a user-programmable level. The interrupt is normally used to abort program execution and return control to the debugger firmware located in the MVME230x Flash memory. The interrupt signal reaches the processor module via ISA bus interrupt line IRQ8*. The signal is also available from the general purpose I/O port, which allows software to poll the Abort switch after an IRQ8* interrupt and verify that it has been pressed.

The interrupter connected to the ABT switch is an edge-sensitive circuit, filtered to remove switch bounce.

RST (S2)

The Reset switch, RST, resets all onboard devices and causes HRESET* to be asserted in the MPC604. It also drives a SYSRESET* signal, if the MVME230x processor module is the system controller.

The Universe **ASIC** includes both a global and a local reset driver. When the Universe operates as the VMEbus system controller, the reset driver provides a global system reset by asserting the VMEbus signal SYSRESET*. A SYSRESET* signal may be generated by the RESET switch, a power-up reset, a watchdog time-out, or by a control bit in the Miscellaneous Control Register (MISC_CTL) in the Universe **ASIC**. SYSRESET* remains asserted for at least 200 ms, as required by the VMEbus specification.

Similarly, the Universe **ASIC** supplies an input signal and a control bit to initiate a local reset operation. By setting a control bit, software can maintain a board in a reset state, disabling a faulty board from participating in normal system operation. The local reset driver is enabled even when the Universe **ASIC** is not system controller. Local resets may be generated by the RST switch, a power-up reset, a watchdog time-out, a VMEbus SYSRESET*, or a control bit in the MISC_CTL register.

2.2.4.2 Status Indicators

There are four **LED** (light-emitting diode) status indicators located on the MVME230x front panel. BFL, **CPU**, PMC2, and PMC1. See Figure 5-77.

BFL (DS1) - The *yellow* BFL **LED** indicates board failure; lights when the BRDFAIL* signal line is active.

CPU (DS2) - The *green* CPU **LED** indicates **CPU** activity; lights when the DBB* (Data Bus Busy) signal line on the processor bus is active.

PMC (DS3) - The top *green* PMC **LED** indicates **PCI** activity; lights when the **PCI** bus grant to PMC2 signal line on the **PCI** bus is active. This indicates that a **PMC** installed on slot 2 is active.

PMC (DS4) - The bottom green **PMC LED** indicates **PCI** activity; lights when the **PCI** bus grant to PMC1 signal line on the **PCI** bus is active. This indicates that a **PMC** installed on slot 1 is active.

2.2.4.3 10/100 BASE-T Port

The RJ45 port on the front panel of the MVME230x labeled 10/100 BASE-T supplies the Ethernet **LAN** 10Base-T/100Base-TX interface, implemented with a DEC 21140/21143 device.

2.2.4.4 RIP - Motorola Board - GE Specific Settings

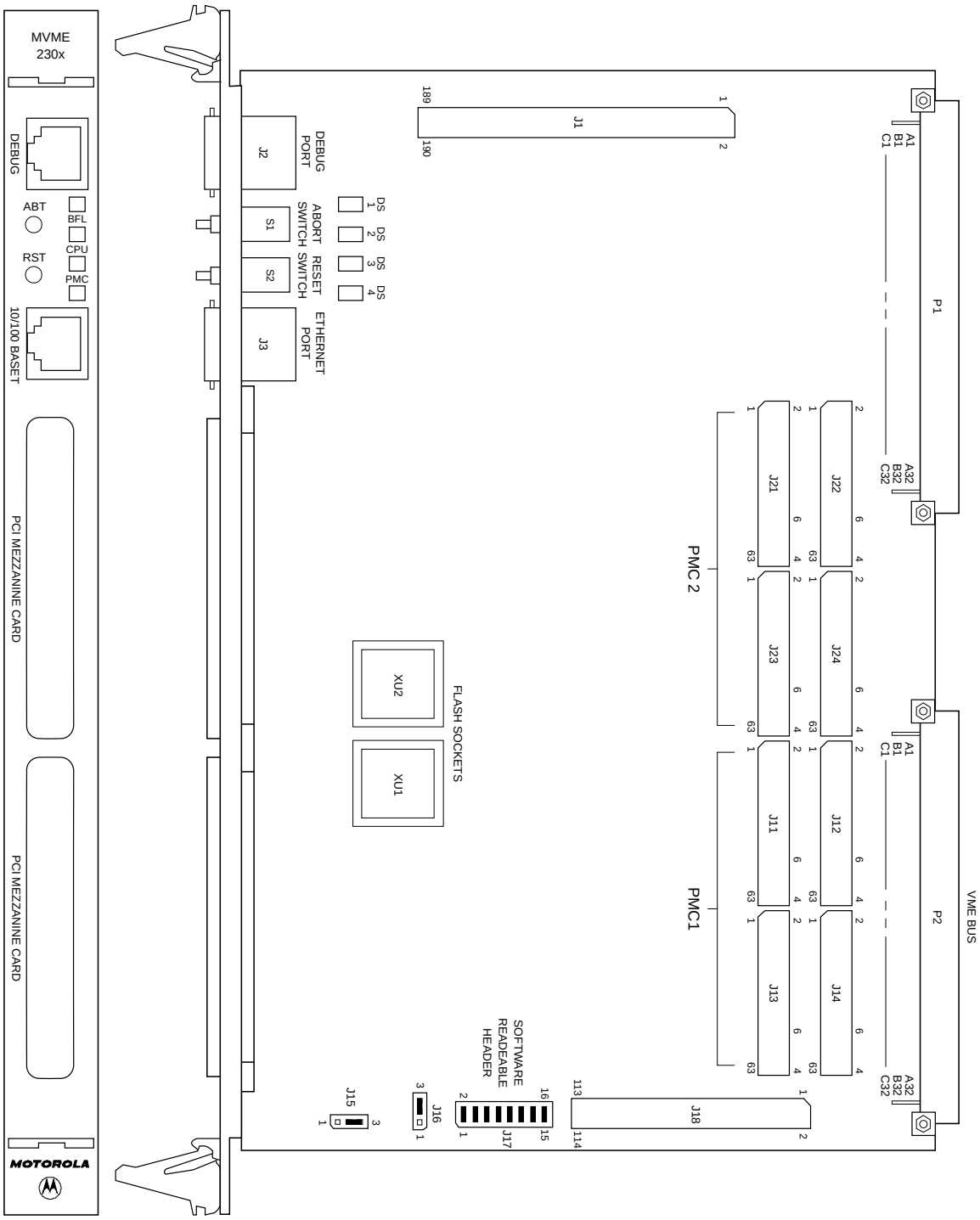


Figure 5-77 RIP - Motorola Board - GE Specific Settings

2.2.5 SCSI "PMC" Card (2265396) - SBS Technologies

GE SPECIFIC SETTINGS

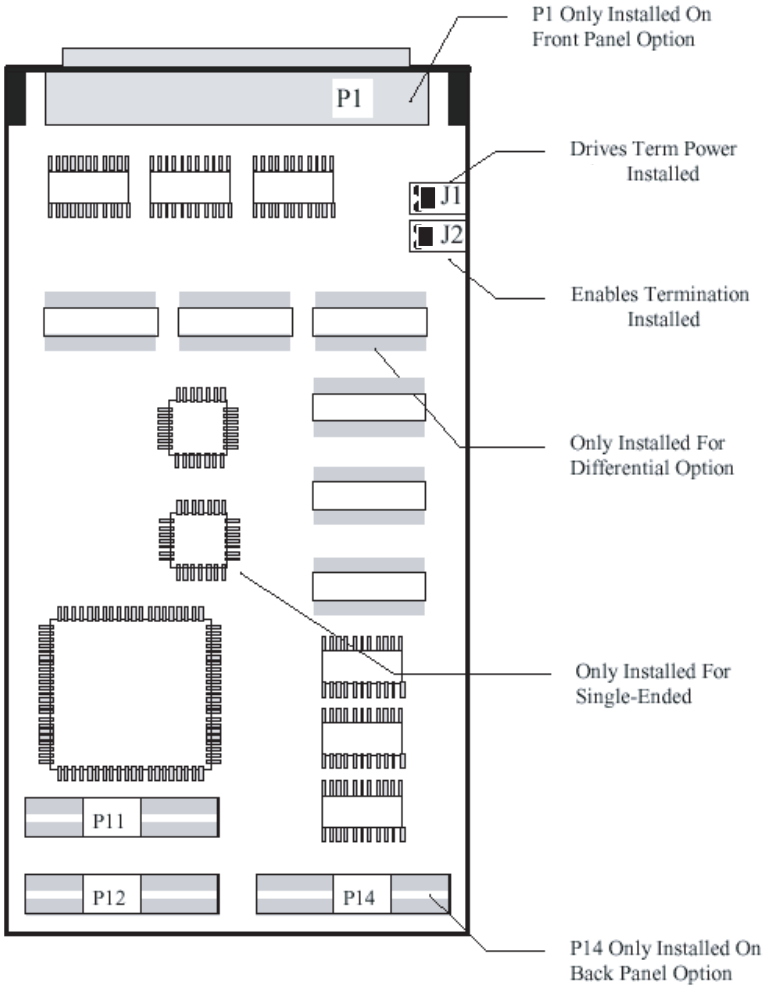


Figure 5-78 PMC SCSI Board - GE Specific Settings

2.2.6 DIP "PMC" Board

2.2.6.1 Jumpers and Switches

There are no jumpers, switches or pots that either the customer or service will operate.

2.2.6.2 LEDs

There is one **LED** on the **DIP**. It illuminates when the **PCI** Bus is activating the FRAME signal. This signal is active on all **PCI** cycles.

2.2.6.3 Connections

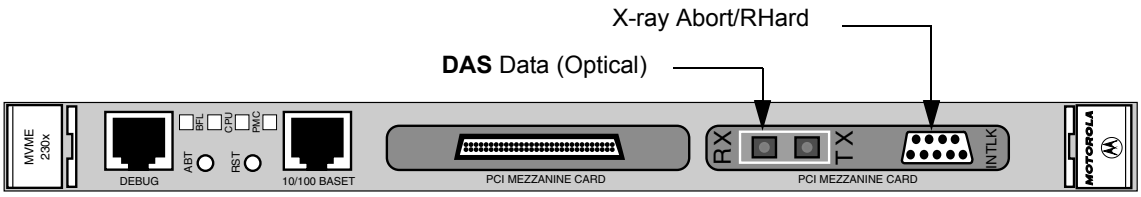


Figure 5-79 DIP Board External Cable Connections

GLASS FIBER OPTIC CABLE CONNECTION

For the slip ring interface (**DAS** Data) and data loopback.

Note: Orientation of RX and TX connectors

The optical cable connection is made to the RX port, which is located above the TX port as viewed from the front of the unit.

EDGE CONNECTORS

Two **PMC**-compliant 64-pin card edge connectors for the 32-bit **PCI** interface, as well as VCC and LGND.

X-RAY ABORT AND RHARD INTERFACE

The X-ray Abort and RHARD interface is a male, 9-pin Subminiature-D connector that is accessible from the front face of the **DIP**. Two of the pins are dedicated to the relay contacts for X-ray Abort, two for the RHARD, and two are dedicated to a read of cable status. See table below for pinout.

PIN NUMBER	SIGNAL NAME	PIN NUMBER	SIGNAL NAME
1	ABORT IN	2	Not connected
3	ABORT OUT	4	Not connected
5	Cable Read OUT	6	RHARD OUT
7	Not connected	8	RHARD IN
9	Cable Read IN		

Table 5-36 DIP Board's X-ray Abort and RHard Pinouts

2.2.7 Pegasus Image Generator (PEG-IG)

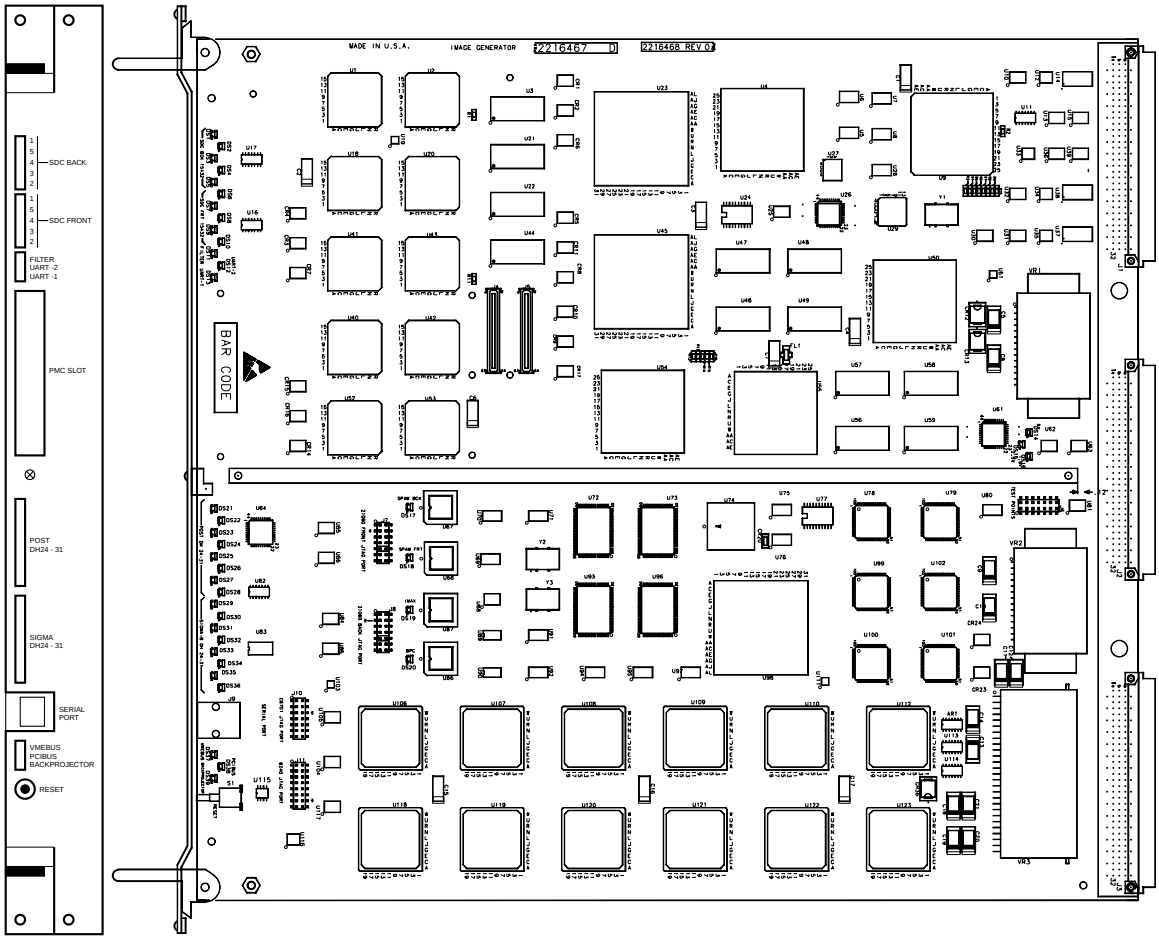


Figure 5-80 Pegasus Image Generator (PEG-IG) Board

2.2.7.1 LEDs

The Diagnostic **LED**s can be visually inspected to assist in monitoring the various functions. Refer to Figure 5-80, on page 316, for **LED** locations.

DS17, DS18, DS19, and DS20 signify when the Xilinx **FPGA**s have completed their programming phase and are in application mode. (These should all go “on” about a half-second after power-up or board RESET).

DS12 and DS13 are user programmable via a register located in the UART serial port interface. (Currently not used during Diagnostics)

DS14, DS15, and DS16 indicate power supply status:

DS14 - 5.0 Volt Supply is “up”

DS15 - 2.6 Volt Supply is “up”

DS16 - 1.9 Volt Supply is “up”

DS7-11 are user programmable via the FLAG(3) pin of the ADSP-21060 processor located in SDC-VW Processing Front-end. (These will blink during the “collision test” diagnostic).

DS1, DS2, DS3, DS4, and DS5 are user programmable via the FLAG(3) pin of the ADSP-21060 processor located in SDC-VW Processing Back-end. (These will blink during the “collision test” diagnostic).

DS11 is user programmable via the Timer-1 Out pin of the TMS320C6701 located in Filter Processing. (Currently not used during Diagnostics)

DS21-28 are user programmable via data bits 24-31 of the Post Processor.

Here are the functions of these **LED**s during **ROM**-based diagnostics:

(Top) DS31 - (Unused)
DS30 - (Unused)
DS29 - **APU LED**. Blinks when the **APU** diags are running.
DS28 - C67 **LED**. Blinks when the C67 diags are running.
DS27 - IMAX **LED**. Blinks when the IMAX diags are running.
DS26 - SPAM1 **LED**. Blinks when the SPAM1 diags are running.
DS25 - SPAM0 **LED**. Blinks when the SPAM0 diags are running.
(Bottom) DS24 - VxWorks Heartbeat **LED**. Blinks when VxWorks is running.

During System tests, DS24 is the heartbeat **LED** for VxWorks.

DS29-36 are user programmable via data bits 24-31 of the Sigma_B Processor.

Here are the functions of these **LED**s during **ROM**-based diagnostics:

(Top) DS31 - (Unused)
DS30 - (Unused)
DS29 - (Unused)
DS28 - (Unused)
DS27 - (Unused)
DS26 -. (Unused)
DS25 - Dual Port **LED**. Blinks when the Dual Port Diag is running.
(Bottom) DS24 - VxWorks Heartbeat **LED**. Blinks when VxWorks is running.

During System tests, DS24 is the heartbeat **LED** for VxWorks.

DS39 is active whenever the Image Memory's **DMA** Controller is active. (Blinks during IMAX and **APU** diagnostics)

DS38 is active whenever **PCI** data transfers are taking place.

DS37 is active whenever **VME** data transfers are taking place.

2.2.7.2 PEG-IG Jumpers

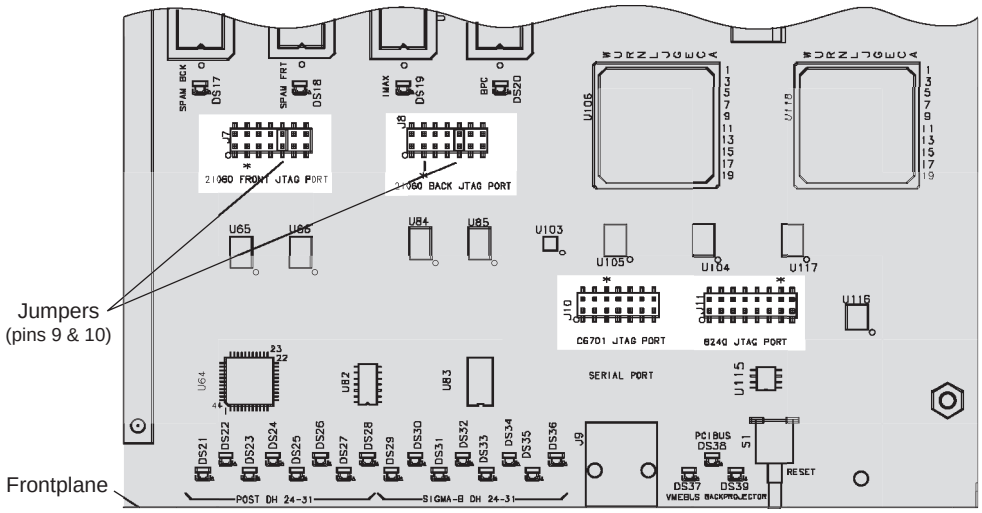


Figure 5-81 Pegasus Image Generator (PEG-IG) Board

Section 3.0
Replacement Procedures, Global Consoles

3.1 Host Hardware, Global Console (Octane2 and Linux)

3.1.1 Console Covers

3.1.1.1 Side Covers

Removal Procedure

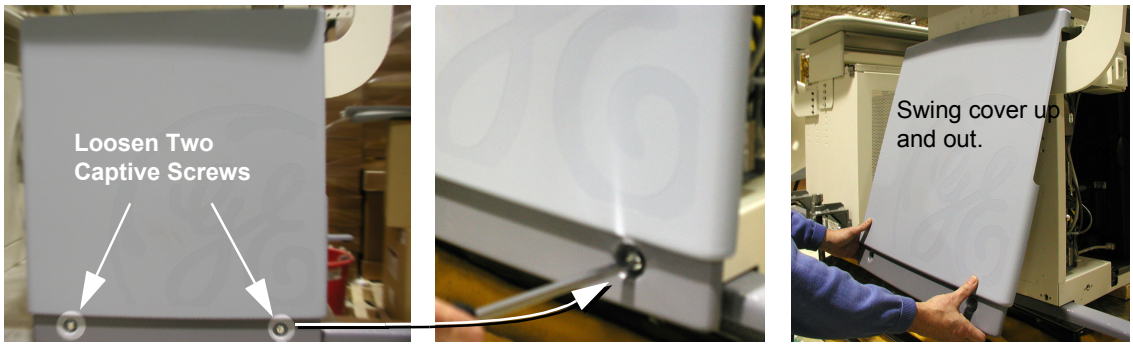


Figure 5-82 Side Cover Removal - Global Console

1.) Loosen the two captive screws at the bottom of the side cover.
2.) Rotate the bottom of the cover up and out.
3.) Lift cover off of cover hangers (see Figure 5-83, below)

Figure 5-83 Side Cover Hanger - Global Console

Installation Procedure

1.) Engage side cover on cover hangers.
2.) Swing cover into position.
3.) Tighten the two captive screws at the bottom of the side cover.

3.1.1.2 Front Cover

Removal Procedure

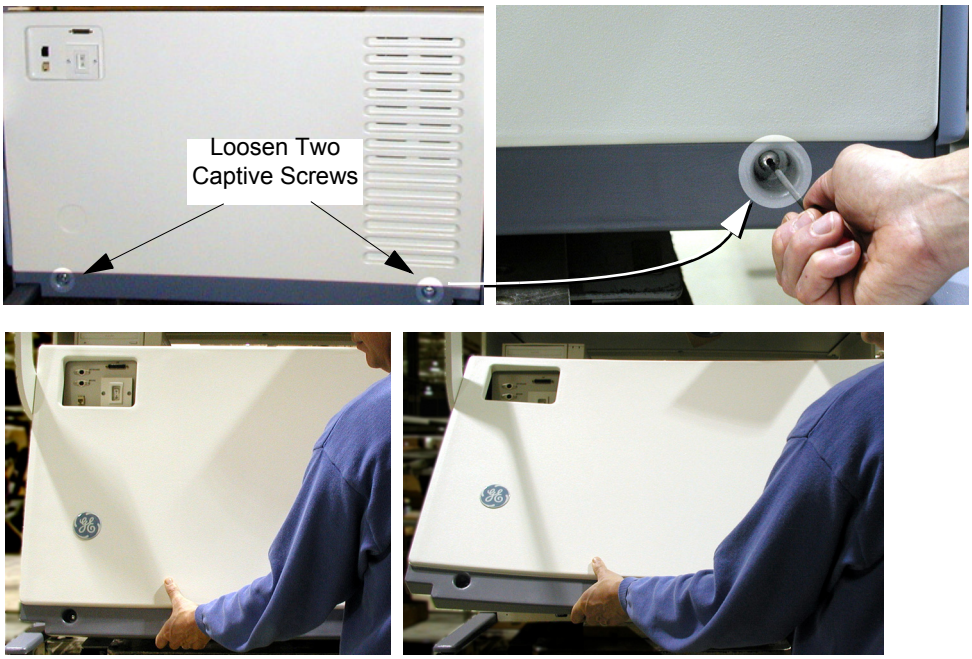


Figure 5-84 Front Cover Removal - Global Consoles

1.) From the service desktop, shut down the system
2.) Turn off console power.
3.) Loosen two captive screws at bottom of console.
4.) Rotate bottom of cover outward and upward until it may be lifted free of the console at the top.

Installation Procedure

1.) Engage top of cover with top front of console.
2.) Swing cover down, into place.
3.) Tighten two captive screws at bottom of console.

3.1.1.3 Rear Cover

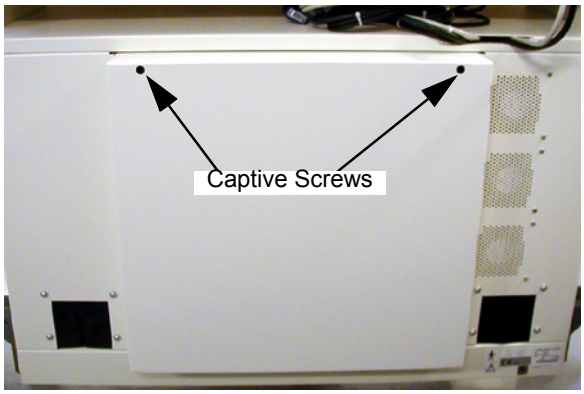


Figure 5-85 Rear Cover, Global Consoles

1.) Loosen two captive screws at top of rear cover.
2.) Tilt cover backward, so top moves away from console.
3.) Lift cover away, so that tabs disengage from bottom lip of opening.
4.) To reinstall, reverse the previous steps.

3.1.2 SCIM/Keyboard

3.1.2.1 SCIM/Keyboard Removal

1.) From the service desktop, shut down the system, then turn off console power.
2.) Remove the existing keyboard cable from the left-hand port on the top of the console front bulkhead.

3.1.2.2 SCIM/Keyboard Installation

CONNECTING THE KEYBOARD, TRACKBALL, AND MOUSE

1.) Route the keyboard cables under the **SCIM**, as shown in Figure 5-86 and Figure 5-87.

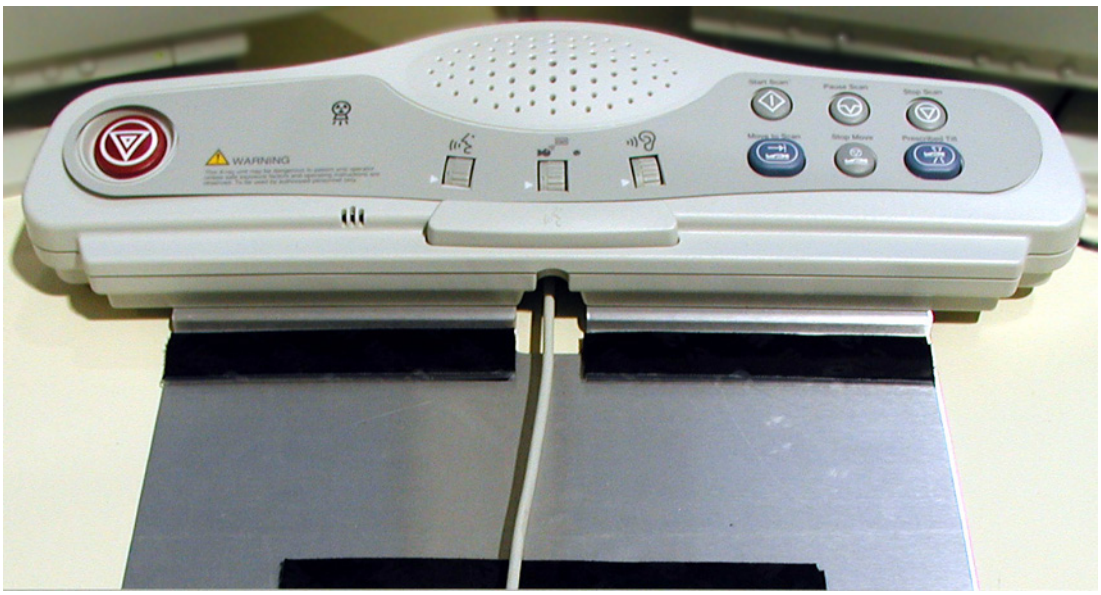


Figure 5-86 SCIM with keyboard cable routed through cable opening

Figure 5-87 SCIM bottom, showing cables and keyboard mounting bracket.

2.) Connect the mouse and keyboard cables to the proper ports (mouse on right, keyboard at left) on the console front bulkhead.

3.) Route the trackball cable and connect it directly to the **SCIM**.

4.) The **SCIM** cable is run under the monitor table top, through the slot at the rear of the console, and connected to J19 on the recon box front bulkhead.

Note: To replace the SCIM cable, the console front cover must be removed. See "Front Cover," on page 319, for details.

5.) Select and install the proper overlay for your system: (1) with Tilt or (2) without tilt.

6.) The keyboard should attach to the **SCIM** using the supplied Velcro strip and fit snugly against the **SCIM** when finished, as shown in Figure 5-88.

Figure 5-88 SCIM connected to the keyboard with the US English tilt overlay installed.

7.) Check all cable connections. Turn on console power and check that the console boots without errors. At the application level, complete functional checks of the keyboard and **SCIM**. Set voice controls and listening volumes to appropriate levels.

3.1.3 Keyboard Table Top

Figure 5-89 Keyboard Table Top Removal

1.) Locate the latches at either end of the underside of the keyboard table top.
2.) Pull latches inward (toward center of table top) until pins have cleared the bracket holes.
3.) Lift table top off of brackets, and set aside.
4.) To reinstall the table top, reverse the previous steps, making certain to properly align the latch pins with the appropriate bracket holes.

CAUTION **The protruding brackets may be a potential source of injury, while working around the console. Protective “boots” may be made out of bubble wrap or other suitable material, and placed over the ends of the exposed brackets. An example is shown in the figure below.**

Figure 5-90 Protective "boot" covers exposed console bracket

3.1.4 Linux Workstation

3.1.4.1 Replacement Overview

The Linux Workstation (HP workstation xw8000) is a FRU 1, and has no replaceable parts within its chassis. The procedure for replacing this computer is a four step process:

1.) Save system state to DVD, and shut down system.
2.) Disconnect and remove the problem computer from the Global Console.
3.) Connect replacement computer into the system.
4.) Load software (see the *Software Load Procedures* manual for details) and restart system.

3.1.4.2 Detailed Replacement Procedure

NOTICE Save System State

Before replacing the Linux workstation, make certain to Save System State to DVD (if possible). See "Saving System State," on page 201.

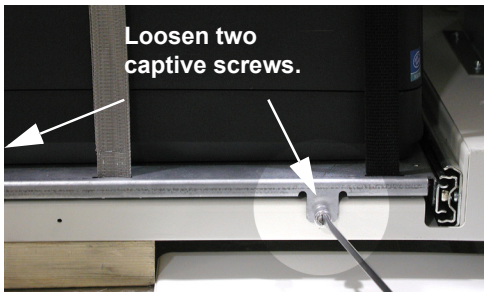
Remove Defective Computer

1.) From the service desktop, shut down the system.

WARNING

POTENTIAL FOR PERSONAL INJURY OR DEATH BY ELECTRIC SHOCK. TO AVOID RISK OF ELECTRIC SHOCK, FOLLOW PROPER LOCKOUT/TAGOUT PROCEDURES.

2.) Tag and lockout system power.
3.) Turn off console power.
4.) Remove the console's front cover. (See "Front Cover," on page 319.)
5.) Loosen the two captive screws and use the strap to pull out the console tray.



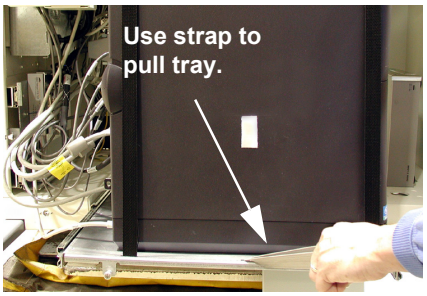


Figure 5-91 Console Slide Out Tray (GC-Linux)

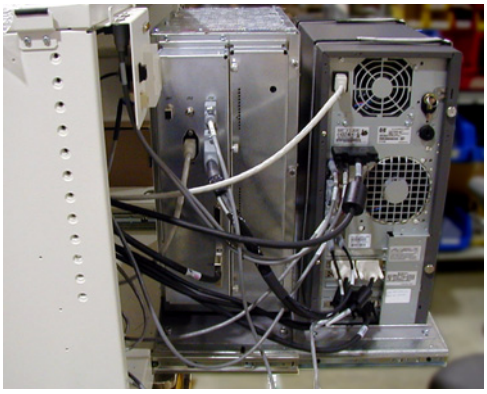


Figure 5-92 Console Tray in Its Extended Position (GC-Linux)

6.) Disconnect the cables attached to the back of the computer.

7.) Remove the velcro straps from the computer, and lift the computer off of the tray.

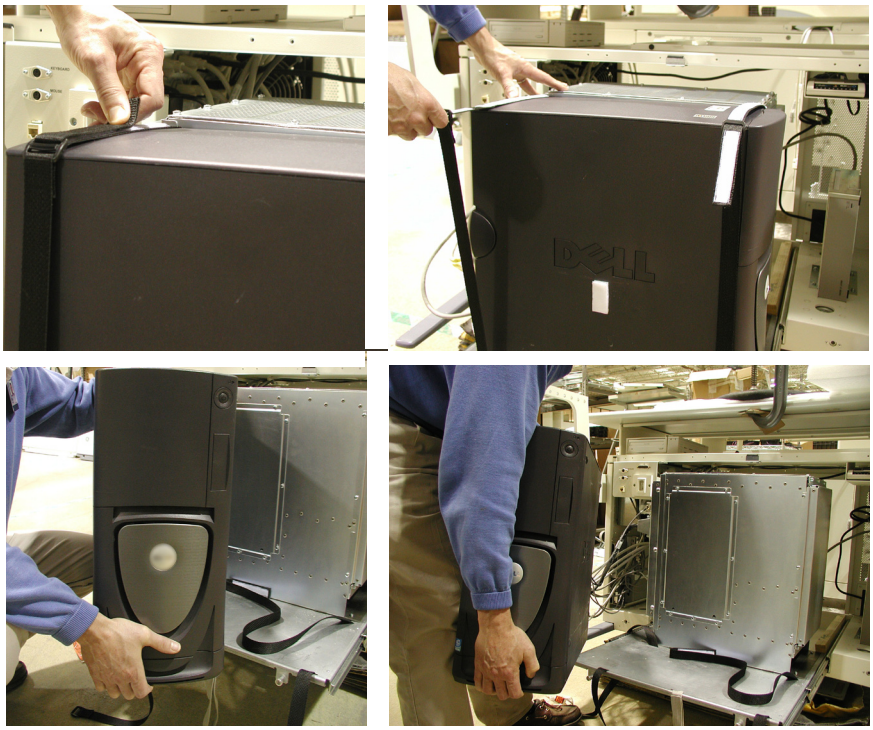


Figure 5-93 Removing Computer from Tray (GC-Linux)

NOTICE
Potential for Data Loss

It may be necessary to swap hard drives between the old and new workstations, to retain the customer's image data. If such action is necessary, perform the "Optional Hard Drive Swap," on page 325**.**

Install Replacement Computer in Console

1.) Place computer on computer tray – with front of computer at right.

2.) Replace velcro straps.

3.) Reconnect cables to rear of computer. Ty-rap as necessary.

Install Computer Software & Restart

1.) Restore power to the console and install software onto the replacement computer. Refer to the *Software Load Procedures* manual for detailed instructions.
2.) Slide the console tray into place and secure with the two captive screws.
3.) Install console's front cover.
   a.) Lift the cover and engage the top edge of the cover with the top lip of the console.
   b.) Slowly swing the cover downward until in place.
   c.) Tighten two captive screws at bottom of console to secure cover.

3.1.4.3 Optional Hard Drive Swap

NOTICE Potential for Equipment Damage

Perform this procedure ONLY IF NECESSARY to retain customer image data. There are no FRUs within the HP xw8000 computer, and no other components should be removed. Disturbing any other components within the HP chassis could result in equipment damage, which will void any warranty.

NOTICE

To prevent damage to components within the HP xw8000 chassis, observe the following ESD precautions:

- **Work on a static-free mat.**
- **Wear a static strap to ensure that any accumulated electrostatic charge is discharged from your body to ground.**
- **Create a common ground for the equipment you are working on by connecting the static-free mat, static strap and peripheral units to that piece of equipment.**

Remove the Side Cover & Front Bezel

With ALL cables removed from both the old and new workstations, perform the following steps:

1.) Unlock the cover on the side of the old workstation.
   The cover keys are attached to the back panel of the system.
2.) Pull out on the latch to release the cover.
3.) Tilt the cover open, then lift it off.

Figure 5-94 Opening the Side Cover

4.) Remove the front bezel, by gently lifting the three plastic tabs on the left side of the bezel.

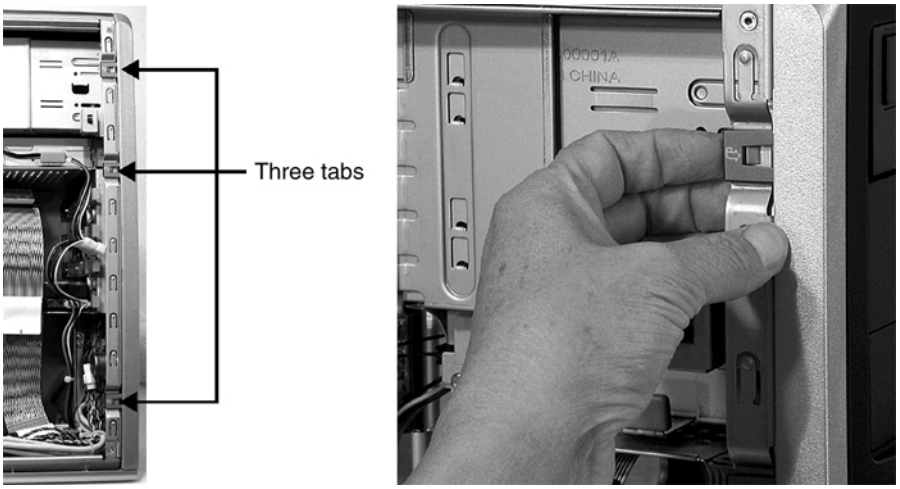


Figure 5-95 Front Bezel Tabs

5.) Rotate the bezel off the workstation chassis.

6.) Repeat the above procedure, to open the new workstation.

Remove the Hard Drives

NOTICE
Do NOT mix IDE & SCSI drives

Your workstation has either IDE or SCSI hard drives (both types can not be installed in the same system). Do NOT attempt to interchange IDE and SCSI drives. You can connect either:

- **One to five SCSI drives using the integrated SCSI controller, *OR***
- **One or two IDE drives using the integrated IDE controller**

1.) Place the workstation on its side with the system board facing up.

2.) Remove the power and data (IDE or SCSI) cables from the drive.

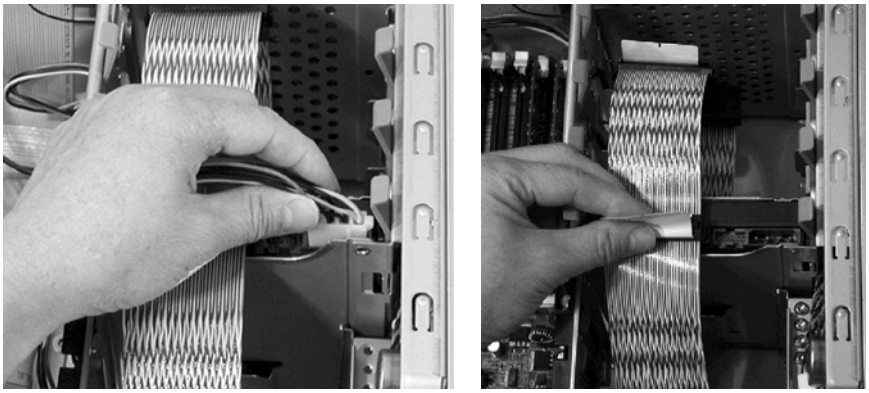


Figure 5-96 Hard Drive Cables - Left: Power Cable; Right: Data Cable (SCSI)

3.) Place your fingers on the colored release clips on the sides of the drive, and squeeze inward. Pull gently just enough to release the drive rail latches.

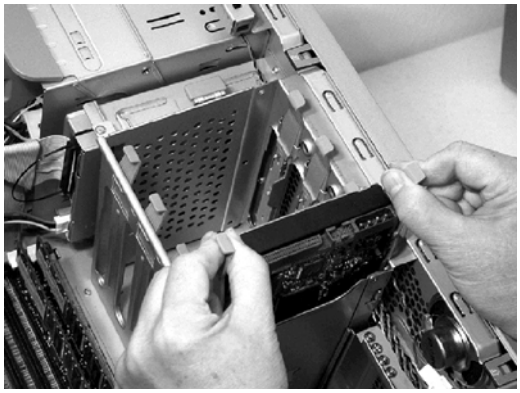


Figure 5-97 Hard Drive Rails

NOTICE **The drive rails are not screwed on to the drive. Do not hold the drive by the rails when it is not installed in a drive bay, because you could drop and damage the drive.**

4.) Grasp the hard drive with your hand and pull out.

5.) Place the hard drive (with rails attached) on a static mat.

6.) Repeat the above procedures on the new workstation, to extract its hard-drive.

Install the Hard Drives

NOTICE **Hold onto the hard drive — NOT the rails — when handling the drive.**

1.) Insert the old drive (with the image data) into the bay of the new workstation. Load the drives in the order shown in Figure 5-98 (IDE) or Figure 5-99 (SCSI):

a.) For IDE drives, insert the first drive into bay 2 (second from bottom), and the second drive into bay 3 (third from bottom). Press down gently until the drive snaps into place.

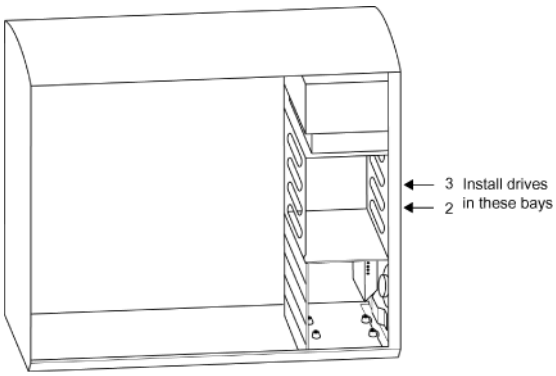


Figure 5-98 IDE Drive Loading Order

b.) For SCSI drives 1 through 4, insert the drive into the next available bay, loading the drives in the order shown below. Press down gently until the drive snaps into place.

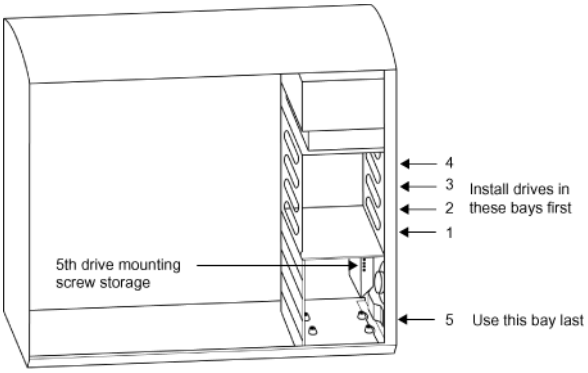


Figure 5-99 SCSI Drive Loading Order

c.) For SCSI drive 5:

* Remove the three drive screws from the storage in the system chassis (Figure 5-99).
* Insert the drive.
* Install the screws, attaching the drive directly to the bottom floor of the workstation. No drive rails are used.

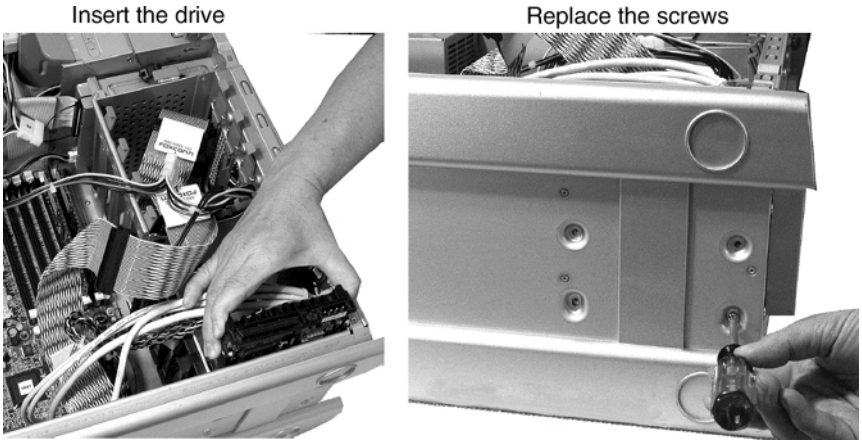


Figure 5-100 Installing a fifth SCSI drive

2.) Connect the drive cables:

a.) Connect the power cable to the hard drive (see Figure 5-96, on page 326).

b.) For IDE drives, connect the IDE cable to the drive.

Note: If your workstations (both old and new) have IDE hard drives, the system has two IDE cables. Connect the primary IDE connector to the hard drives. The secondary IDE connector is for optical drives. Make sure you connect them properly.

c.) For SCSI drives, connect the SCSI cable to the drive. Do NOT change the jumper settings on your old drive.

3.) Repeat steps 1 and 2, to place the NEW drive into the OLD workstation.

Note: The old workstation must have the new drive installed, when it is returned.

Replace the Side Cover and Front Bezel

1.) Ensure that all internal cables are properly connected and safely routed in the new workstation.

2.) Replace the front bezel:

a.) Align the plastic quarter rounds on the inside of the bezel with the sheet metal sockets on the right side of the chassis.

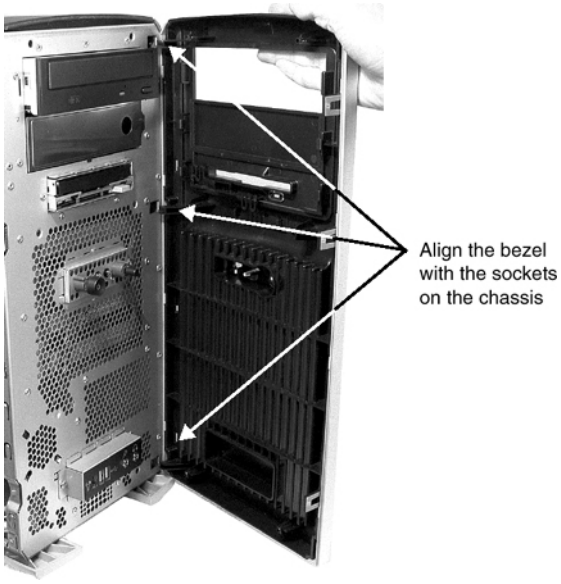


Figure 5-101 Bezel Alignment

b.) Rotate the bezel into position and verify that the plastic tabs on the left side of the bezel click into position on the workstation chassis. The bezel should be flush against the workstation.

3.) Lower the cover onto the chassis (aligning the guide rail on the bottom inside edge of the cover with the bottom edge of the workstation chassis).

Figure 5-102 Aligning and Closing the Cover

4.) Close the cover.

5.) Lock the cover using the key provided.

6.) Repeat the above procedure, to close and lock the old workstation, with the new (empty) drive installed.

3.1.5 Octane2 Computer

3.1.5.1 Before You Begin

The Octane2 computer field replaceable unit (**FRU**) is shipped configured to reuse components from the computer it replaces. The computer is shipped minus the following components:

- Disk Drives
- **PCI** Module and **PCI** boards
- Memory Modules
- System ID Module

You will remove these components from the computer being replaced and re-install them in your replacement computer. All of the above components are also available as individual **FRU**s.

Avoiding Equipment Damage and Personal Injury

Avoid damage to components and personal injury by taking the following precautions:

- Do not touch or clean the compression connector.
- Place the protective cap over the compression connector, if available.
- Lay all modules and board on antistatic surfaces only.
- Place all modules and board in antistatic bags.
- Wear a grounded **ESD** wrist strap in good working order.
- Maintain a clean work environment.
- Tag and lockout power.
- Wait five minutes after power is off before you continue. Let the system module cool.

Disk Drives

Disk drives are packaged in special carriers and require no assembly or disassembly. The primary system drive is placed in the bottom bay and the (image) disk in the middle drive bay. No jumpers are required because the computer's hardware automatically assigns **SCSI** IDs.

The ID Module

The system ID module is unique to your **CT** system. The System ID Module contains the computer's unique "Ethernet Address" number. If you loose the ID module, all of the Software Options you have installed will not be available for use. System software is locked to this unique ID during installation.

3.1.5.2 Octane2 Replacement Process

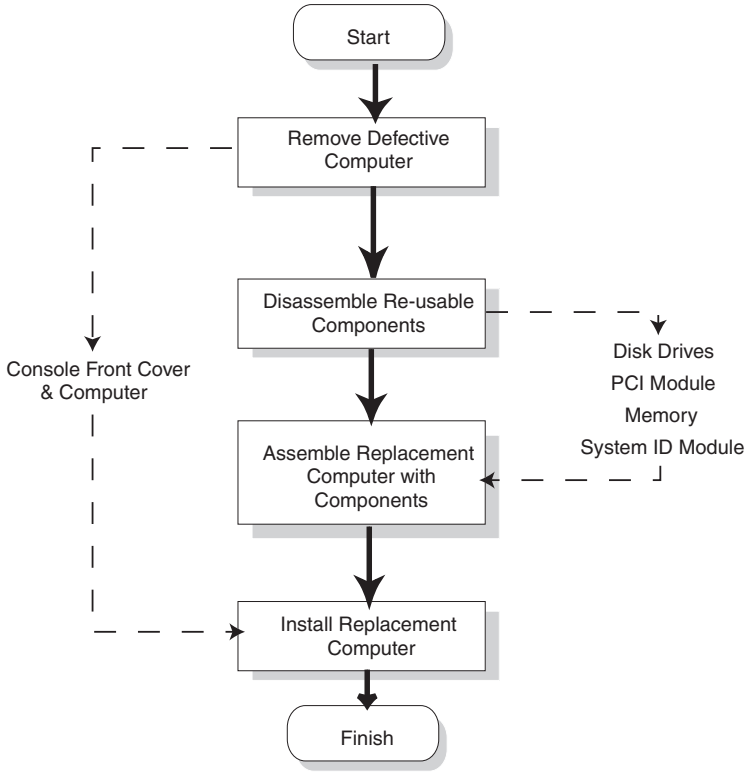


Figure 5-103 Replacement Process

NOTICE
Potential for Equipment Damage

Electronic devices are extremely sensitive to ESD damage. Always do the following:

- **Wear a grounded ESD wrist strap.**
- **Place parts on antistatic surfaces.**
- **Transport parts in antistatic bags.**

Remove Defective Computer

1.) From the service desktop, shut down the system.
2.) Tag and lockout system power.
3.) Turn off console power.
4.) Remove the console's front cover, using a Phillips head screwdriver (see "Front Cover," on page 319, for details).
5.) Loosen two captive screws and pull out computer tray.
6.) Remove the recon box:
    a.) Disconnect the cables attached to the front of the recon box
    b.) Remove the brackets that hold the recon box in place
    c.) Move the recon box out of the way, setting it on a clean and stable surface
7.) Disconnect the cables attached to the back of the computer.
8.) Lift the computer out and place on a stable and clean work surface.

Disassemble Reusable Components

DISK DRIVES

1.) Remove the front bezel (cover) from the computer. Press both bezel release buttons simultaneously to release the cover.
2.) Tilt the bezel toward you and lift up to remove.
3.) Grasp a drive handle and lift it to a horizontal position.

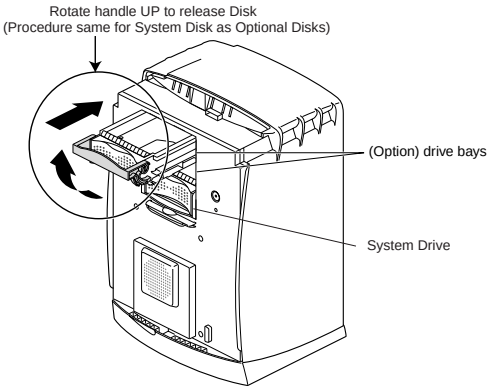


Figure 5-104 Removing & installing Disk Drives

4.) Applying gentle and steady pressure, pull out the drives.
5.) Place each drive on an antistatic surface or in an approved antistatic bag.
6.) Re-install the front cover.

PCI MODULE

1.) Loosen the two captive screws (see Figure 5-105).
2.) Pull out the release lever along the bottom of the module (see Figure 5-105).

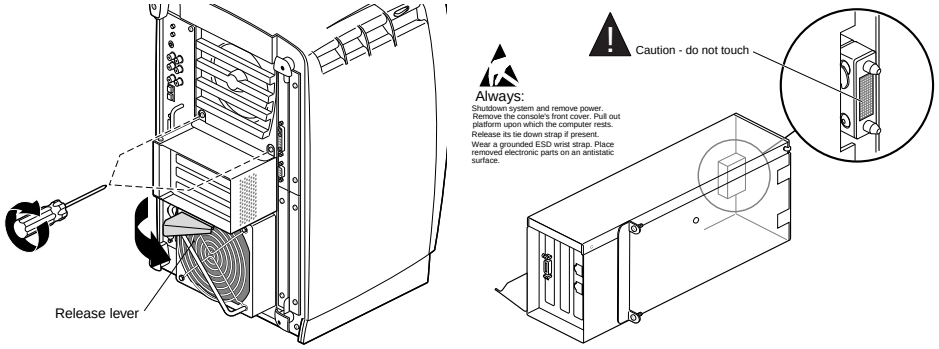


Figure 5-105 Removing the PCI Module

3.) Slide out the module, taking care not to allow the compression connector to touch anything. Cap the compression connector, once the module is resting on an antistatic surface.

MEMORY

CAUTION Potential for Personal Injury

Allow computer components to cool. Wait 5 min. after power off before handling components.

1.) Remove the system module.

a.) Loosen the captive screw in each sliding handle.

b.) Pull both handles at the same time until they are fully extended (Figure 5-106).

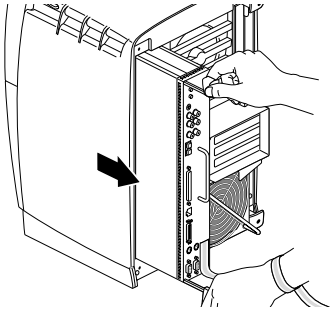


Figure 5-106 System Module

c.) Grasp the module handle with your left hand and place your right hand against the top of the computer's back. Pull out the module without allowing the delicate connectors on its back edge to touch anything.

d.) Place the system module on an antistatic surface, component side up.

2.) Remove the memory modules.

a.) Locate and unlatch the memory on the System Module. Press down on the latch, near the end of each **DIMM** socket (Figure 5-107). The **DIMM**s will partially eject from the socket.

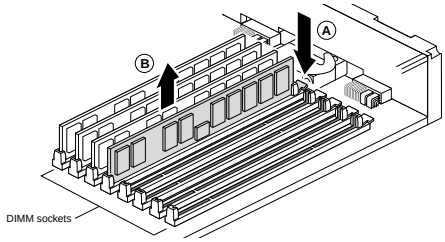


Figure 5-107 DIMM Removal & Installation

b.) Remove the memory modules and place in an antistatic environment.

ID MODULE

With patience, the ID module can be extracted from the frontplane without damage to either. If this process proves too difficult, follow the process outlined in Section 3.3.7, on page 351.

1.) Visually locate the ID module. It's on the frontplane near the top, as viewed looking into the slot vacated by the System Module. It is a small silver disk, held in by a metal retaining clip.

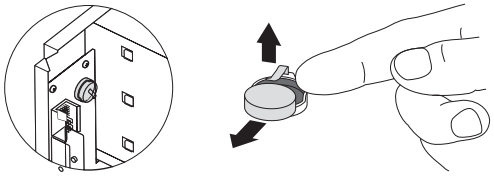


Figure 5-108 System ID Module

2.) With one hand, reach inside the computer and use your fingers to extract the ID module.

Assemble Replacement Computer with Components

NOTICE Potential for equipment damage

Do not use excessive force to install any component. Excessive force can result in component failure. Be patient and use only gentle but firm pressure.

ID MODULE

1.) Remove the system module from the replacement computer.
   a.) Loosen the captive screw in each sliding handle.
   b.) Pull both handles at the same time until they are fully extended.
   c.) Pull out the system module.
   d.) Place the system module on an antistatic surface component side up.
2.) Install ID Module into replacement computer
   a.) With one hand, reach inside the replacement computer and use your fingers to insert the ID module.
   b.) Visually inspect the ID module and make sure it is securely in place.

MEMORY

1.) Install Memory Modules
   a.) Insert the **DIMM**s into their sockets on the new system module. You'll hear a click when they are latched. Notice how the latch on the end of the socket moves up when they're seated properly. ***DIMM**s are notched on the bottom so that they cannot be inserted incorrectly.* See Figure 5-109.

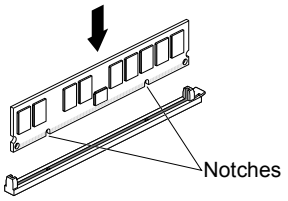


Figure 5-109 Inserting Memory Modules

   b.) Verify that both sockets in a bank are populated. **DIMM**s must be installed in pairs. See Figure 5-110.

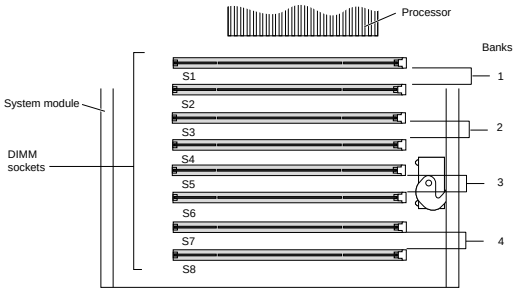


Figure 5-110 DIMM Socket and Bank Identifications

2.) Install System Module back into replacement computer
   a.) Grasp the module and push inwards, without allowing the delicate connectors on its back edge to touch anything.
   b.) With the module inserted, push both handles in at the same time until they are fully seated.

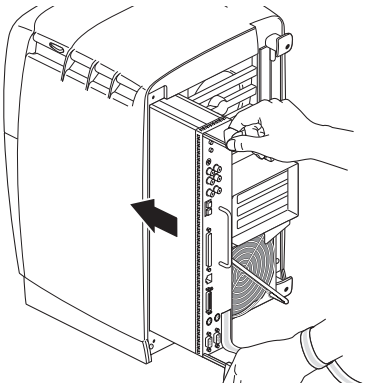


Figure 5-111 System Module

c.) Tighten the captive screw in each sliding handle.

PCI MODULE

1.) Slide the **PCI** module in the replacement computer. Do not to allow the compression connector to touch anything (be sure to remove compression cap before inserting).

2.) Push the release lever in to close (latch). (See Figure 5-112 for location of lever.)

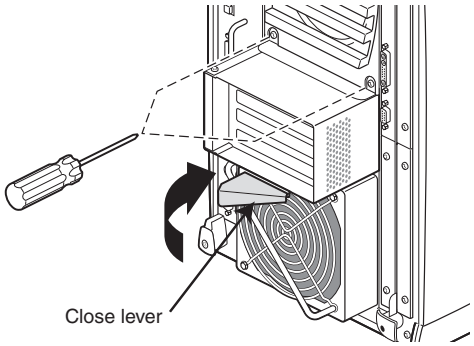


Figure 5-112 PCI Module Installation

3.) Tighten the two captive screws (Figure 5-112).

DISK DRIVES

1.) Remove the replacement computer front bezel (cover). Press both bezel release buttons simultaneously to release the cover.

2.) Tilt the bezel toward you and lift up to remove.

3.) Grasp a drive handle and lift it to a horizontal position.

4.) Applying gentle and steady pressure, push the drives into place.

5.) Rotate the drive handle to the vertical position to lock the drive in place.

6.) Re-install the front bezel.

Install Replacement Computer in Console

1.) Place computer on computer tray.

2.) Reconnect cables.

3.) Reinstall recon box, making certain to reattach all cables.

4.) Slide tray in, and secure with captive screws.

5.) Reinstall console's front cover, using a Phillips screwdriver. Refer to "Front Cover," on page 319, for details.
6.) Turn on system power.
7.) Turn on console power switch to start-up computer.

3.1.5.3 Octane2 512 Memory

For memory replacement, please refer to "DIMM Memory," on page 345.

3.1.5.4 Octane2 9GB Disk Drive

For hard disk replacement, please refer to "Internal Hard Drives," on page 343.

3.1.5.5 Octane2 PCI Card Cage Assembly

For **PCI** card cage replacement, please refer to "PCI Expansion Card Module," on page 350.

3.1.6 Magneto Optical Disk (MOD)

System software options are deployed through a special **MOD**. If you happen to lose that **MOD**, please contact your OLC representative, who will contact the proper **CT** Manufacturing personnel to procure a new options **MOD**. If the Host **System ID module** (small disk inside the Frontplane Module) for a Global Console-Octane2 is replaced, a new options **MOD** is required (the GC-Linux has no system ID module).

3.2 Scan Reconstruction Unit (ICE Box), Global Consoles

3.2.1 Access to the SRU's Interior

The following procedures describe what must be done in order to access the RIP board (including SCSI and DIP boards) or PEG-IG board in the Global Consoles.

3.2.1.1 Slide Out Console Tray

1.) Shutdown application and operating system software.
2.) Power down the console using the power switch located on the front cover.

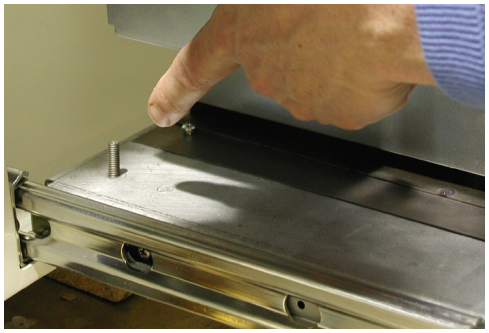
WARNING

POTENTIAL FOR PERSONAL INJURY OR DEATH BY ELECTRIC SHOCK. TO AVOID RISK OF ELECTRIC SHOCK, FOLLOW PROPER LOCKOUT/TAGOUT PROCEDURES.

3.) Tag and lockout the main system power, at the main disconnect.
4.) Remove all items (keyboard, trackball, etc.) from the keyboard table top.
5.) Remove the keyboard table top, and set aside (see Section 3.1.3, on page 322).
6.) Using a 4mm hex wrench, release the cover latches and remove the console front cover.
7.) Loosen the two captive screws and use strap to pull out the console tray.

NOTICE
Use ESD ground lug when working in ICE box.

A ground lug is located at the rear left corner of the tray. It should be used as a grounding point for ESD wrist-straps, when working inside the VME recon (ICE) box. See the photo below.



8.) **GC-LINUX ONLY:**
Remove the velcro straps from the computer, and set the computer out of the way (refer to Figure 5-93, on page 324). Disconnect cables as necessary.

3.2.1.2 ICE Box Components

To gain access to:

- **PEG-IG board**, remove the right front cover from the **VME** chassis.

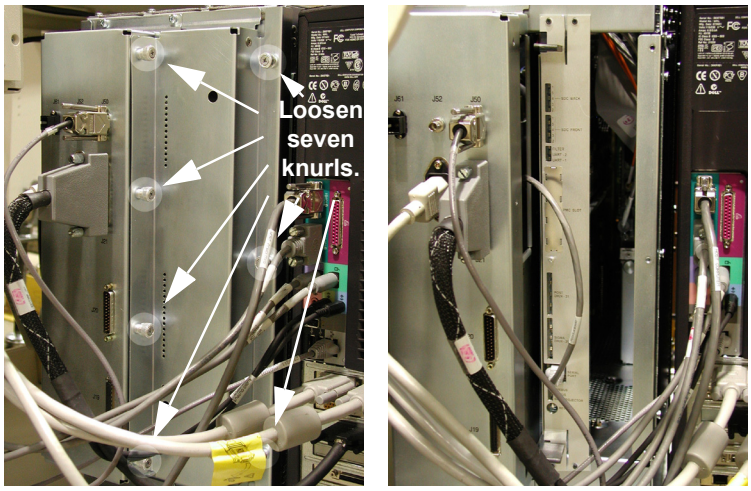


Figure 5-113 ICE Box Right Front Cover Removal (GC-Linux pictured)

- **RIP (Motorola) board**, remove the right side panel from the **VME** chassis.

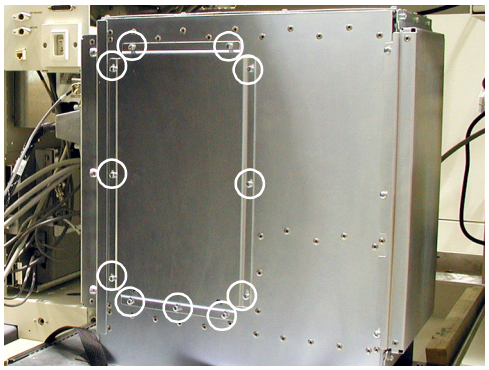


Figure 5-114 Remove 11 screws, to remove the ICE box right side panel

- **Intercom board**, remove the right front cover from the **VME** chassis (see Figure 5-113), then remove the left front bulkhead, disconnecting cables as necessary.
- **Prescribed tilt board**, remove the right front cover from the **VME** chassis (see Figure 5-113), then remove the left front bulkhead, disconnecting cables as necessary.
- **Scan Data Disk**:

1.) Remove the entire recon chassis from its brackets.

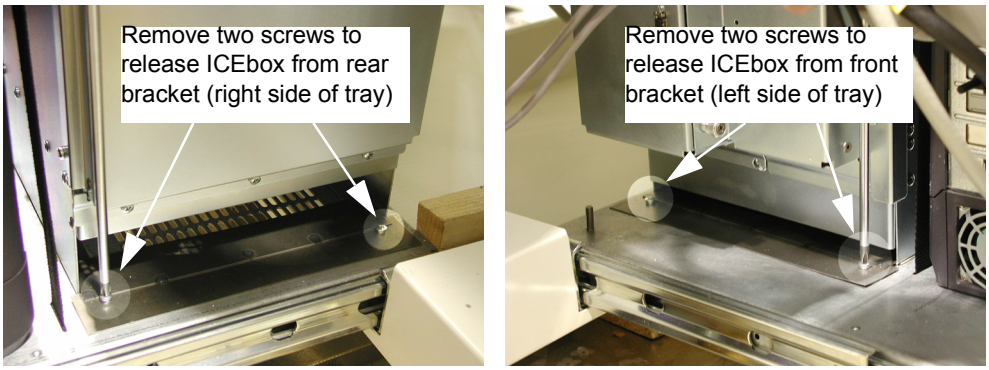


Figure 5-115 Remove recon chassis (ICE box) from its brackets (GC-Linux shown)

2.) Rotate the chassis so that the left side is accessible (remove cables as necessary)

NOTICE **Scan Data Disk is mounted on flip down door. Hold onto the door while removing the last screw, so that it does not drop inadvertently.**

3.) Carefully open the front flip-down door (**SDD** is mounted on door).

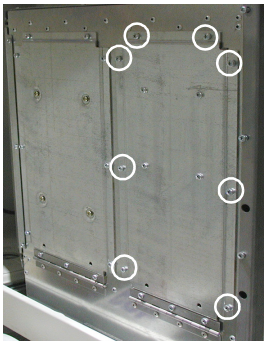


Figure 5-116 Remove eight screws on front door to access SDD

- **VME Power Supply**

1.) Remove the entire recon chassis from its brackets

2.) Rotate the chassis so that the left side is accessible (remove cables as necessary)

NOTICE **VME power supply is mounted on flip down door. Hold onto the door while removing the last screw, so that it does not drop inadvertently.**

3.) Carefully open the rear flip-down door (power supply is mounted on door)

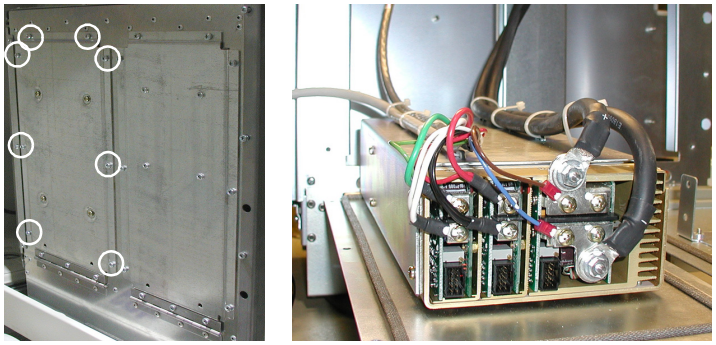


Figure 5-117 Remove eight screws on rear door to access power supply

3.2.2 Reconstruction Interface Processor (RIP) Board

The **RIP** Board has two **PCI** Mezzanine Cards (**PMC**s), piggybacked on the board (see Figure 5-118). These two **PMC**s are the SBS **SCSI** Controller Card and the GE **DIP** Card.

The connectors for the **PMC**s are very fragile, and must be treated gently. Be especially careful when removing or installing a **PMC**, so that you do not damage the connectors.

3.2.2.1 RIP Board Flash Procedure

Once the **RIP** Board has been replaced, the flash **ROM** on it must be programmed to work in the CT system. This procedure is normally executed as a part of the Config/Reconfig procedure (during or after a Load From Cold). However, it is not necessary to perform a Load From Cold, or even a Reconfig, if all you have done is replace the **RIP** Board.

3.2.2.2 DIP "PMC" Board Replacement

NOTICE **The DIP board is a static sensitive device. Good ESD practices should be followed.**

The **DIP** is mounted on top of **RIP** board, which is located in the **VME** (**ICE** Box) chassis of the console. It necessary to remove the **RIP** board to replace the **DIP** Board.

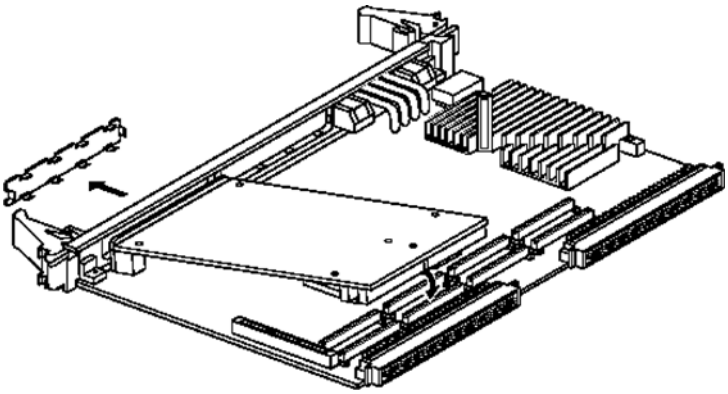
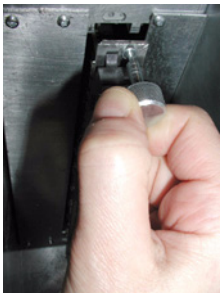


Figure 5-118 DIP Board Installation

1.) Gain access to the ICE box (see "Access to the SRU's Interior," on page 336).
2.) Remove the cables connected to **RIP** board.
3.) Disconnect the optical cable from the port optical connector labeled RX.

4.) Loosen the thumb screws (knurl nuts) so that the **RIP** card can be removed.



5.) Gently but firmly, grasp the **RIP** board by it handles and pull it loose and towards you.

Figure 5-119 RIP Board Handles

6.) Immediately place the **RIP** board in a anti-static bag or onto a static free work surface.

7.) To remove the **DIP** from the **RIP** Board, do the following:
*(It's not necessary to remove any standoffs from the **RIP** to remove the **DIP** Board.)*

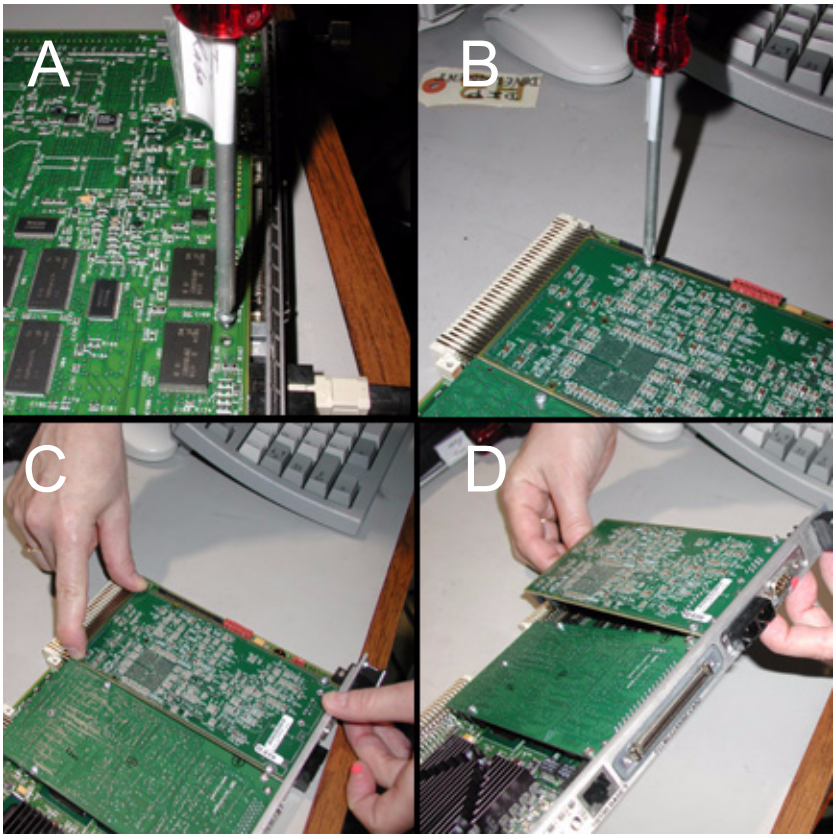


Figure 5-120 DIP Board Removal and Installation

a.) On the bottom of the **RIP** board assembly, remove the two (2) screws nearest the face plate that attach the **DIP** to the **RIP**. These screws thread into the **DIP** board's edge connectors. See Figure 5-120, A.

b.) On the top side of the **RIP** board, remove the two (2) screws nearest the edge connector retaining the **DIP**. It's not necessary to remove the stand-offs. See Figure 5-120, B.

c.) Gently pull the **DIP** and **RIP** board apart, where they are attached by the **PCI**/**PMC** edge connector. See Figure 5-120, C.

d.) Lift the **DIP** board out. Figure 5-120, D. Place into a anti-static bag immediately.

8.) To install a **DIP** board, do the following:

a.) Rotate the **DIP** into position and gently but firmly press down on the **PCI**/**PMC** edge connector to seat. See Figure 5-120, D then C.

b.) Re-install all of the removed screws. See Figure 5-120, B then A.

9.) Gently but firmly, re-install the **RIP** board assembly into its **VME** card cage slot and secure with thumb screws.

10.) Attach cables to **RIP**, **SCSI** and **DIP** boards and reassemble console.

11.) Remove lockouts and power up console.

3.2.3 Pegasus Image Generator (PEG-IG) Board

1.) Gain access to the ICE box (see "Access to the SRU's Interior," on page 336).

2.) Disconnect the serial cable from the faceplate of the Pegasus **IG** board.

3.) Remove the four (4) 2mm allen head screws that hold the **PEG-IG** circuit board in place.

NOTICE **Wear a grounded ESD wrist strap. Place removed electronic parts on an anti-static surface.**

4.) Remove the old **PEG-IG** board from the card cage and place it into a static bag.

5.) Remove the new **PEG-IG** board from its static bag, and inspect the board.

a.) Verify that it has only two (2) jumpers installed as follows (see Figure 5-81, on page 317):

* J7: positions 9 and 10
* J8: positions 9 and 10

b.) Verify that the board's connectors are free from foreign objects and that no pins are bent.

6.) Install the four (4) allen head screws and two (2) nylon flat washers on the **PEG-IG** board faceplate. The washers should be used for the mounting holes on the "tabs" at the left of the faceplate.

7.) Place the new circuit board into the card cage and tighten the four (4) allen head screws to properly secure the board.

8.) Reattach the serial cable to the serial port on the **PEG-IG** board's faceplate.

9.) Reassemble the console, reversing steps used earlier. Be certain to reattach any cables removed for access.

10.) Reapply power, bring the system back up, and run the appropriate diagnostic tests.

3.2.4 VME Power Supply

On a Global Console (GC-Oct2 or GC-Linux), the VME power supply is located within the Recon box. See Section 3.2.1 (beginning on page 336), for instructions on how to gain access to the VME power supply.

TERMINAL	# OF WIRES	WIRE COLOR
+ 5 VDC	2	1 lg black & 1 brown
5 VDC return	2	1 lg black & 1 blue
1 (+)	2	red
3 (–)	2	black
5 (+)	3	green
6 (–)	3	white

Table 5-37 Power Supply Terminal Identification

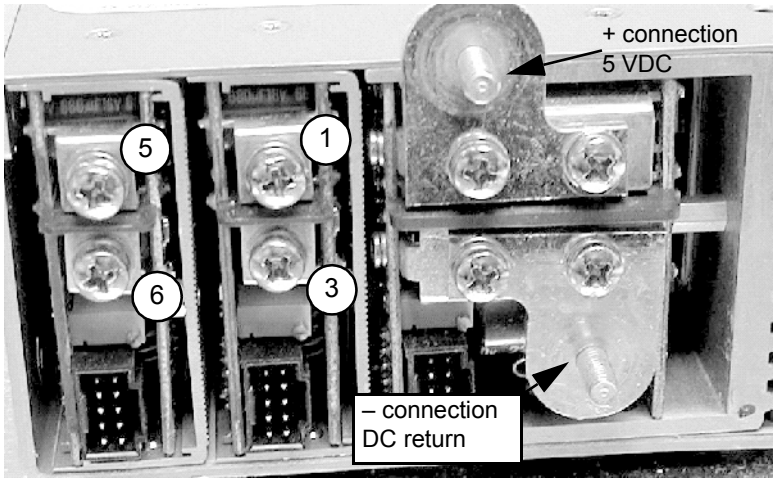


Figure 5-121 Power Supply Terminals

Note: Verify leads and colors on your console power supply before removing them from the existing Power One supply.

TERMINAL	COLOR	# WIRES
N	BLUE	1
~	BROWN	1
GND	GREEN	1

Table 5-38 AC Connections for VME power supply

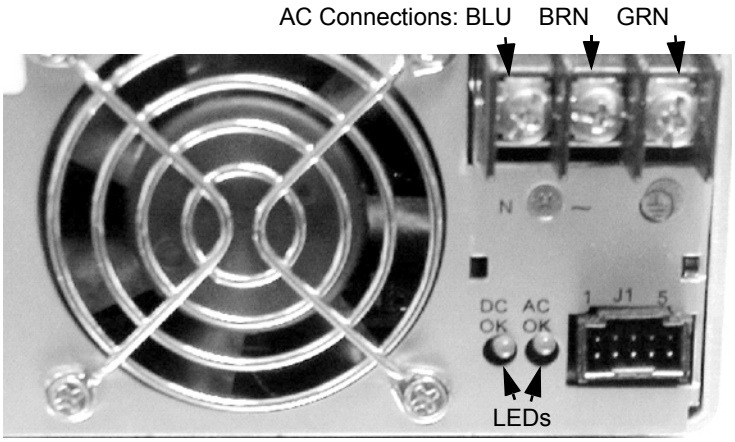


Figure 5-122 Front view of VME power supply

3.3 Additional Procedures for Octane2

Note: The Octane2 is itself a FRU. Parts within the Octane2 should not normally be replaced, in and of themselves. The procedures in this section should be used only as reference when "swapping out" drives, memory and system ID modules, when replacing an Octane2 FRU.

3.3.1 Internal Hard Drives

Hard drives come in a special carrier and require no assembly or disassembly. *Place the primary system drive in the bottom bay* on the front of the computer. The second system (image) disk is placed in the middle drive bay. The host's hardware automatically assigns **SCSI** IDs. The primary disk (lowest one) is assigned **SCSI** ID 1 (`dks0d1sN`*)*. The one inserted above and in the middle of the drive bay then becomes **SCSI** ID 2 (`dks0d2sN`*)*.

Note: Do not use the top slot. Currently, the top slot in the drive bay is not used.

PROCEDURE

1.) Shutdown console power.
2.) Remove the console's front cover. Pull out platform upon on which the computer rests and release any tie-down strap if present.
3.) Remove the locking bar (if found).

NOTICE **You must wear a grounded ESD wrist strap. Place removed electronic parts on or in an anti-static surface.**

CAUTION **Wait five minutes after power is off before you continue. Let it cool.**

4.) Press both bezel release buttons on front upper sides.
5.) Tilt the cover forward and lift to remove it.
6.) Lift the drive's handle to the horizontal position and *gently* slide it into the bay. *Pushing a drive in with too much force can damage it. Seat the drive carefully but firmly.*

7.) When it is flush with the chassis, rotate the handle down to lock it in place.

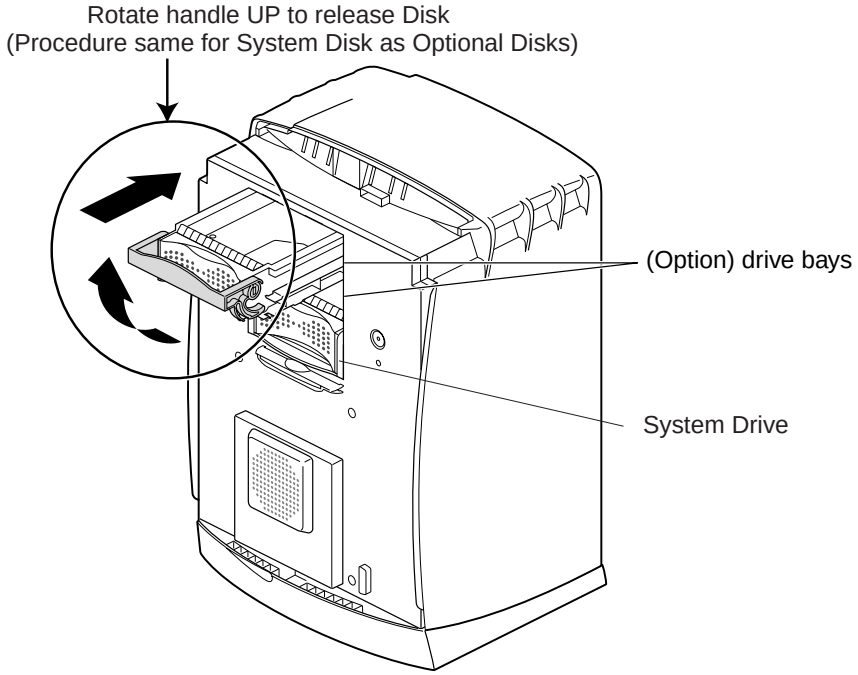


Figure 5-123 Host (Octane) System Drive

8.) If needed, remove the plastic panel for a new bay if adding a disk. Keep it in case it is needed later. Snap a saved panel to the cover if you permanently remove a hard drive from a bay. *This insures proper air flow. Do not remove a drive unless you have a replacement or a cover for the bay.*

9.) Re-power the system, press STOP FOR MAINTENANCE, and use **`hinv`** to verify that the host recognizes the hard drive(s).

3.3.2 System Module

NOTICE **Wear a grounded ESD wrist strap. Place removed electronic parts on or in an antistatic surface.**

CAUTION **Wait five minutes after the power is off before you continue. Let it cool.**

1.) Shutdown the system and remove power.

2.) Remove the console's front cover. Pull out the platform upon which the computer rests. Release its tie-down strap (if present).

3.) Remove the locking bar (if applicable).

4.) Loosen the captive screw in the sliding handles on the top and bottom.

5.) Pull both handles at the same time until they are fully extended.

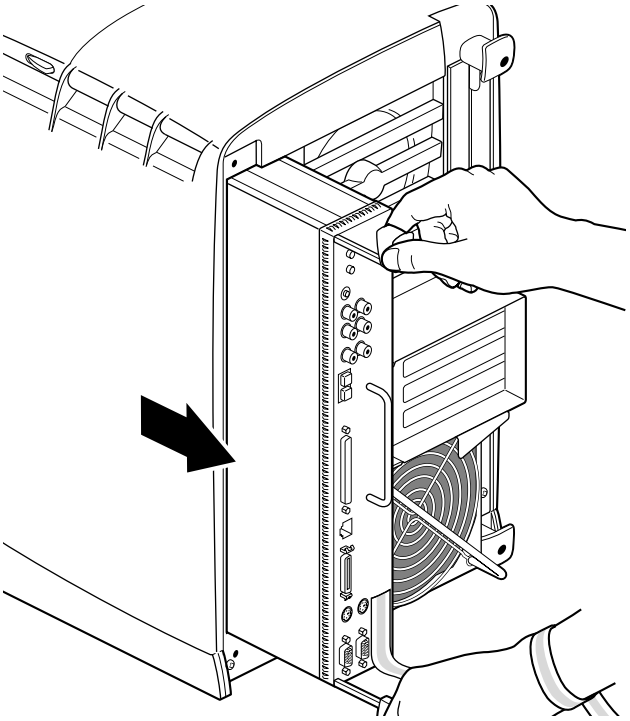


Figure 5-124 Removing the System Module

6.) Grasp the module handle with your left hand and place your right hand against the top of the computer's back. Pull the module out without allowing the delicate connectors on its back edge to touch anything.

7.) Place the system module on an antistatic surface with the component side up.

8.) Place a cap on each compression connector.

9.) To replace the system module, perform the above steps in reverse order.

10.) You may need to set/reset boot environment variables. See "Boot Environment Variables," on page 172, for details.

3.3.3 DIMM Memory

Populating Memory

The Octane/Octane2 workstation has four **DIMM** banks with two **DIMM** sockets in each of the banks. Before you install the two 1 GB **DIMM**s, review the following information:

- Bank 1 (sockets 1 and 2) must always be filled.
- The highest density **DIMM**s must be installed in Bank 1, while lower density **DIMM**s must be installed in the remaining banks by order of their size (highest density first).
- Banks must be filled sequentially; when Bank 1 is full, fill Bank 2. Do not skip banks.
- Each bank must be empty, or contain two **DIMM**s, one in each of the two sockets.
- Capacity refers to the number of megabytes or gigabytes of memory in a **DIMM**: 32, 64, 128, or 256 MB, and so on, or 1 GB.
  - Minimum memory capacity is 64 MB (2 x 32 MB **DIMM**).
  - Maximum memory capacity is 1.5 GB (6 x 256 MB **DIMM**).
  - Minimum memory configuration is 64 MB in a bank (2 x 32 MB **DIMM**).

- Maximum configuration is 2 GB in a bank (2 x 1 GB **DIMM**).

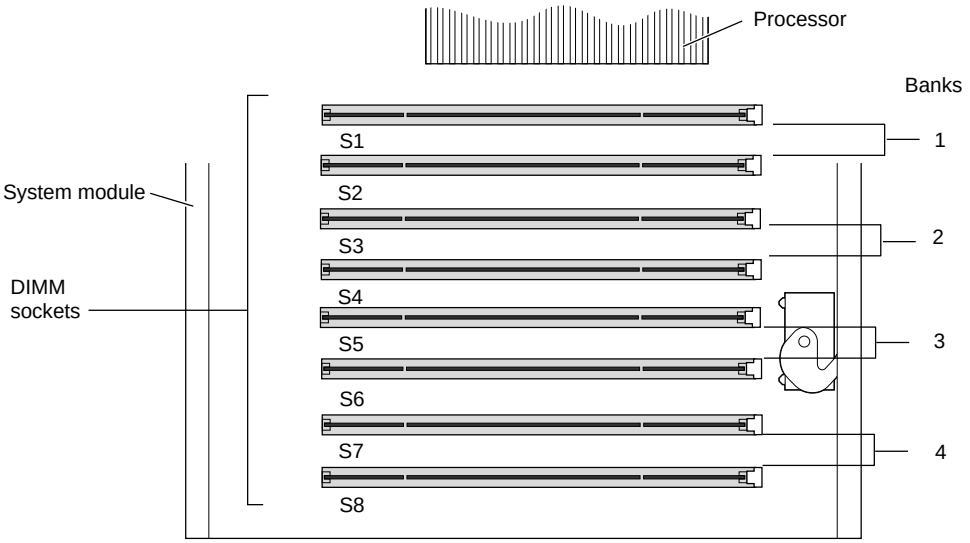


Figure 5-125 (Octane) Host - DIMM Socket and Bank Identifications

GE Specific Memory Configurations

OCTANE 1

BANK 1		BANK2		BANK3		BANK4	
S1	S2	S3	S4	S5	S6	S7	S8
256	256	Empty	Empty	Empty	Empty	Empty	Empty
128	128	128	128	Empty	Empty	Empty	Empty
128	128	64	64	64	64	Empty	Empty

Table 5-39 Octane 1, without D3D, 512MB Total

BANK 1		BANK2		BANK3		BANK4	
S1	S2	S3	S4	S5	S6	S7	S8
256	256	256	256	256	256	Empty	Empty
256	256	256	256	128	128	128	128

Table 5-40 Octane 1, with D3D, 1.5GB Total

OCTANE 2

BANK 1		BANK2		BANK3		BANK4	
S1	S2	S3	S4	S5	S6	S7	S8
256	256	256	256	256	256	Empty	Empty

Table 5-41 Octane 2, with and without D3D, 1.5 GB Total

Procedure

NOTICE

Avoid Touching Bristles

- **Memory modules are extremely sensitive to static electricity. Use an ESD wrist strap and handle with care.**
- **Be aware that the heat sinks inside the computer become very HOT.**
- **DIMMs are located near a very delicate compression connector. Be extremely careful not to touch the compression connector's gold bristles. Always use the compression connector protective cap.**

To install or remove memory, you must power off the console, wait 5 minutes to allow the heat sinks to cool, and attach a wrist strap. Then remove the system module. Then return to these instructions.

1.) Locate the **DIMM**s you want to remove or replace.

As shown in Figure 5-126, press down on the latch at (A), near the end of the **DIMM** socket. The **DIMM** partially ejects from the socket. It can then be removed (B, in Figure 5-126).

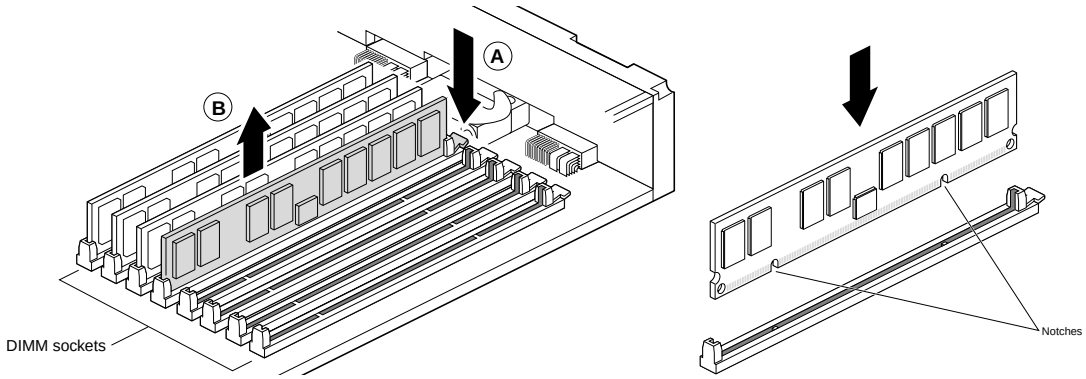


Figure 5-126 Host (Octane) DIMM Removal & Installation

2.) Insert the replacement **DIMM** into the socket, gently but firmly. You hear a click as it is seated, and the latch on the end of the socket moves up. **DIMM**s are notched on the bottom so that they cannot be inserted incorrectly. See Figure 5-126.

3.) Check to be sure both sockets in the bank are full. **DIMM**s must be installed in pairs.You have finished installing memory and are ready to replace the system module.

Common Mistakes

- **DIMM Sockets not populated correctly** - Both sockets in a **DIMM** bank must be either empty or populated. If you are removing one **DIMM** and not replacing it immediately, also remove the other **DIMM** in the bank and replace it when you install a new **DIMM**.
- **DIMM not seated properly** - Before replacing a memory module, check that all are seated correctly in their slots. Memory is installed correctly when it is vertical and perpendicular to the motherboard, and the latches on the both sides fit snugly around it. If the memory module appears to be leaning, wear an **ESD** wrist strap and push it into a vertical position.
- I**ncorrect memory combinations** - The first bank has two **DIMM**s that are exactly the same. The second bank, if used, has two **DIMM**s that are exactly the same, and so on for each

succeeding bank. See Table 5-42, below, for additional information about **DIMM** identification.

DIMM MANUFACTURER - MEMORY CAPACITY	MANUFACTURER PART NUMBER	OTHER CODING (E.G., LABEL COLOR)	COMMENTS
SGI - 32MB	9940069	Yellow	Never used on 3.X
Dataram - 32MB	60056	n/a	Never used on 3.X
SGI - 64MB	9940084 9470178	Blue Green	Used on standard 3-D Option only
Dataram - 64MB	62614	n/a	Used on standard 3-D Option only
SGI - 128MB	9470168	Brown*	Standard Memory
SGI - 128MB	9010020	Brown**	Standard Memory
Dataram - 128MB	62615	n/a	Standard Memory
SGI - 256MB	9010021	White***	Standard/Direct-3D
Dataram - 256MB	62621	High Profile	Direct-3D Option
Dataram - 256MB	62649	Low Profile	Direct-3D Option

* 2K Refresh **DIMM**s, must be used as a matched pair in a bank, typically used in the original IP-30 System Module (**SGI** P/N 030-0887-003).

** 4K Refresh **DIMM**s, must be used as a matched pair in a bank, and will only function in an enhanced IP-30 System Module (**SGI** P/N 030-1467-001).

*** 4K Refresh **DIMM**s, must be used as a matched pair in a bank, and will only function in an enhanced IP-30 System Module (**SGI** P/N 030-1467-001).

Table 5-42 DIMM Identification

3.3.4 Octane (Original): Graphics Subsystem - XIO Module

Before removing a graphics board or **TMRAM**, you must power off the OCTANE workstation, wait 5 minutes for the heat sinks to cool, attach a wrist strap, and not allow the compression connectors to touch anything. Test for heat before touching any of the parts.

Removing the XIO Module

1.) Bring down the system.

2.) Power off console

3.) Remove the console's front cover. Pull out platform upon which the computer rests. Release its tie-down strap, if present.

4.) Remove the locking bar (if applicable).

5.) Unplug the Octane power cord.

CAUTION

The heat sinks on the XIO boards become very hot. Wait 5 minutes after powering off the OCTANE workstation before you remove the XIO module. Test before touching any of the XIO boards.

6.) Remove all the cables from the XIO module.

NOTICE

The components inside the OCTANE workstation are extremely sensitive to static electricity; you must wear the wrist strap while replacing parts inside the workstation.

7.) When you remove the XIO module, the compression connectors on the back of the XIO module (XIO boards) are accessible and easily damaged. All XIO graphics boards have compression connectors, and most XIO option boards do.

NOTICE
Avoid Damage

The compression connectors on each XIO board are very delicate and easily damaged. Do not touch or bump the gold bristled pad.

8.) Loosen the two captive screws in the XIO module handles with a Phillips screwdriver until the screws are disconnected from the chassis.

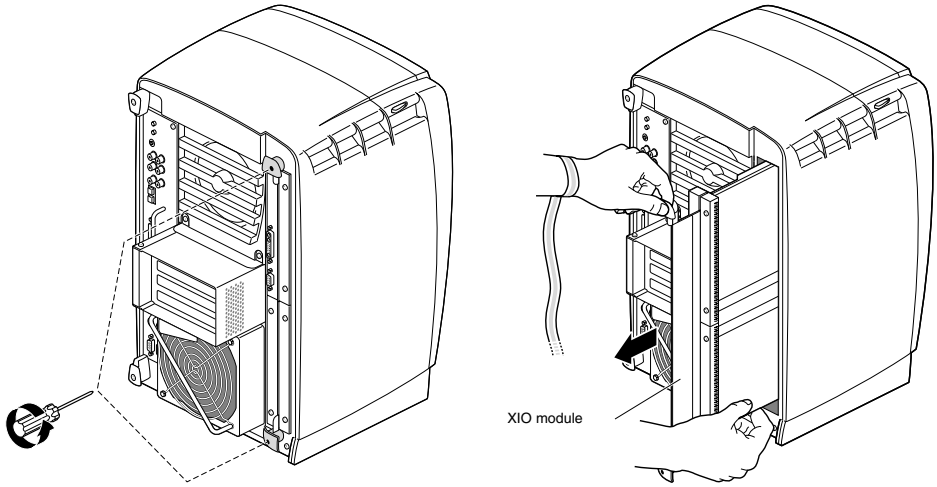


Figure 5-127 Removing the XIO Module

9.) Grasp the handles and pull until the XIO module protrudes about an inch from the chassis. The handles and XIO module move out about one inch before the I/O panels move.

10.) Continue to pull on the handles until the XIO module releases from the workstation. Grasp the XIO module along its length, and support the base of the module with your hand as you remove it from the chassis.

11.) The handle area protrudes when the XIO module is out of the chassis. When protruding, the identification slots for the XIO boards, D and A, B and C, are visible.

Note: Do not push on the handle area after you have removed the XIO module. The XIO module locks to the workstation only if the handle area is protruding.

12.) Place the XIO module on a flat, antistatic surface.

Installing the XIO Module

NOTICE **Please observe the following:**

- **Place the XIO module with the graphics boards facing toward the inside of the workstation. The boards may be damaged if placed the other way.**
- **Wear an antistatic wrist strap.**

1.) Slide the XIO module into the guides on the top and bottom of the workstation.

2.) Before you insert the XIO module, make sure the handle portion protrudes in a locked position from the I/O panels. If the handles are flush with the I/O panels, the XIO module will stop during insertion. Pull out the handles until the sliding portion of the XIO module is rigid, then continue inserting the XIO module into the chassis.

3.) Grasp the handle area while supporting the XIO module, and slide the module into the chassis.

4.) Use the handles to push the XIO module into a locked position. (The I/O panels are nearly flush

with the workstation when properly inserted, however, there is a slight variation in the depth of the boards.)

5.) Tighten the captive screws in the handles.

6.) Remove the wrist strap.

7.) Reconnect all XIO cables to the XIO module.

3.3.5 PCI Expansion Card Module

1.) Shutdown system and remove power.

2.) Remove the console's front cover. Pull out the platform upon which the computer rests. Release its tie-down strap, if present.

NOTICE **Wear a grounded ESD wrist strap. Place removed electronic parts on an anti-static surface.**

3.) Remove any cables from the **PCI** module.

4.) Loosen the two captive screws (see Figure 5-128).

5.) Pull out the release lever along the bottom of the module (see Figure 5-128).

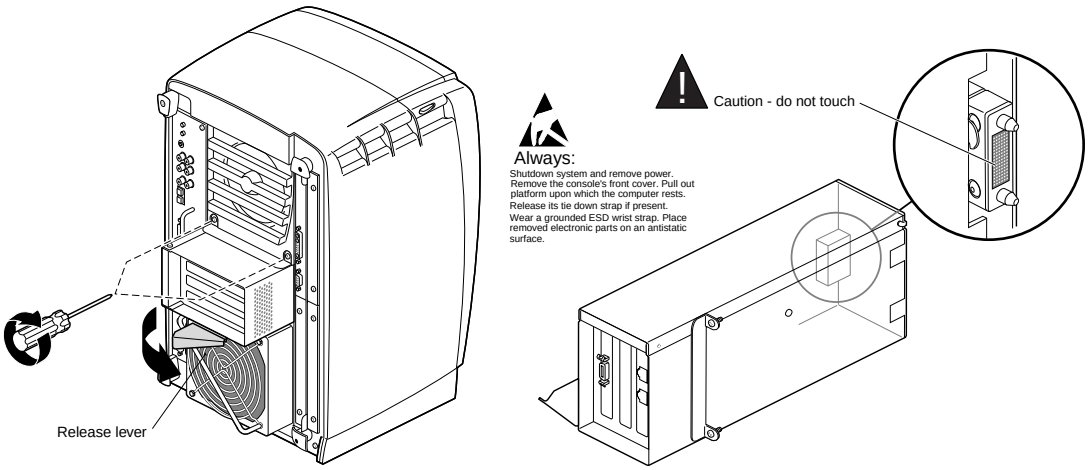


Figure 5-128 (Octane) Host - Removing the PCI Module

6.) Slide out the module, taking care not to allow the compression connector to touch anything. Cap the compression connector, once the module is resting on an antistatic surface.

3.3.6 Octane Power Supply

1.) Shutdown system and remove power.

2.) Remove the console's front cover. Pull out platform upon which the computer rests. Release its tie-down strap, if present.

3.) **Remove the PCI module** (refer to page 350).

NOTICE **Wear a grounded ESD wrist strap. Place removed module on an antistatic surface.**

Note: The power supply is grounded while its power cord is plugged in. Just have power off to the console.

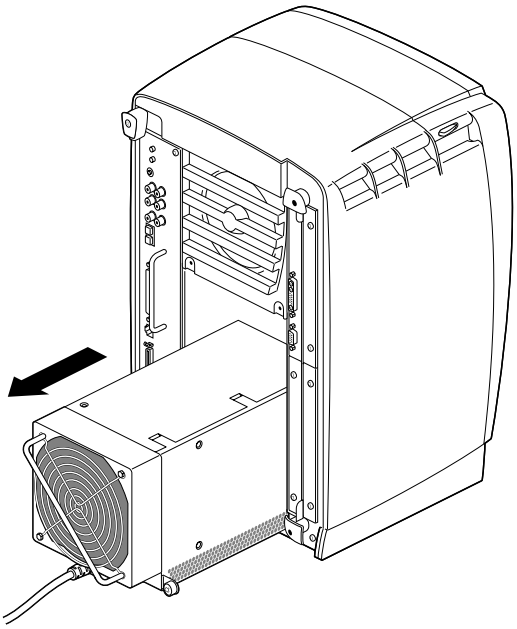


Figure 5-129 Octane Power Supply

4.) Use a phillips screwdriver to loosen the two captive screws at the base of the power supply module.
5.) Grasp the handle, pull it out, then unplug the power cord.
6.) Reverse these steps to reinstall.

3.3.7 Octane Frontplane Module

Follow this procedure to replace the **System ID Module**, the **Fan Module** or the **Frontplane Module**.

Note: Save your ID Module

If the Frontplane Module is replaced, move the System ID Module from the old unit to the new. See Figure 5-130. The new front plane module does not come with a system ID module.

1.) Shutdown system and remove power.
2.) Remove the console's front cover. Pull out platform upon which the computer rests. Release its tie-down strap if present.

NOTICE **Wear a grounded ESD wrist strap. Place removed electronic parts on an antistatic surface.**

3.) Remove the System Module. Refer to page 344.
4.) Remove the XIO Module. Refer to page 348.
5.) Remove the **PCI** Module. Refer to page 350.
6.) Remove the Octane Power Supply. Refer to page 350.
7.) Squeeze both buttons on upper front sides of Octane computer, then tilt forward and lift to remove its front cover.
8.) Remove all Octane Disk Drives. Refer to page 343.
9.) Remove the Light Module. Squeeze both top and bottom wings of the light together at both ends, gently and evenly pull straight out.
10.) Loosen the six (6) captive screws that hold the frontplane module to the chassis. Refer to Figure 5-130, below.
11.) Place your hand inside the drive bay and lift the module from the base.

12.) Place it face down on an antistatic surface. Avoid touching any components.

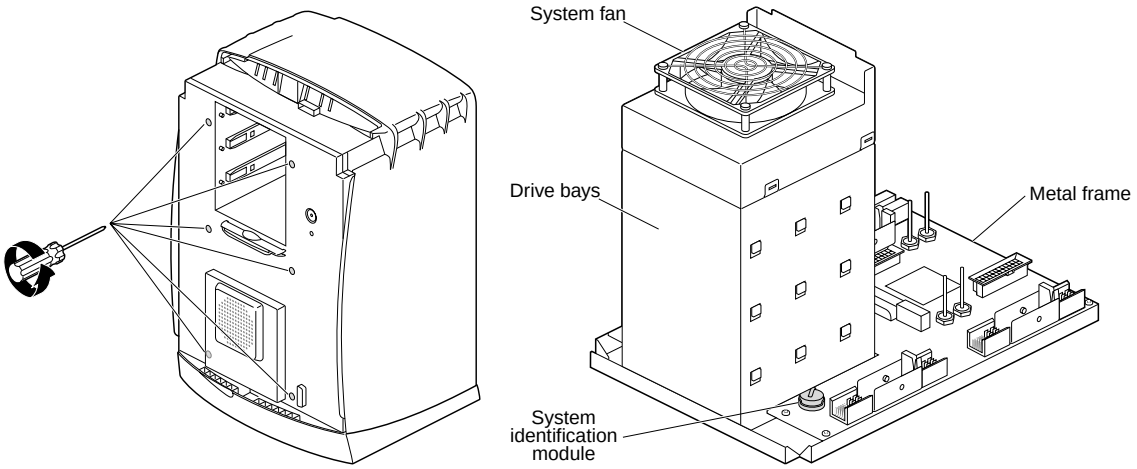


Figure 5-130 Removing the Frontplane Module from the Chassis

Now you can replace the System ID module or the Fan. The **System ID Module** holds the pre-programmed Ethernet address for the Octane computer. It is a small circular disk held by a metal retaining clip next to the drive bay. If the System ID module is changed, all software options (**MOD**s) will have to be re-ordered, as the Options **MOD**(s) is fingerprinted to the Host Ethernet address at first installation.

Power Supply Fan

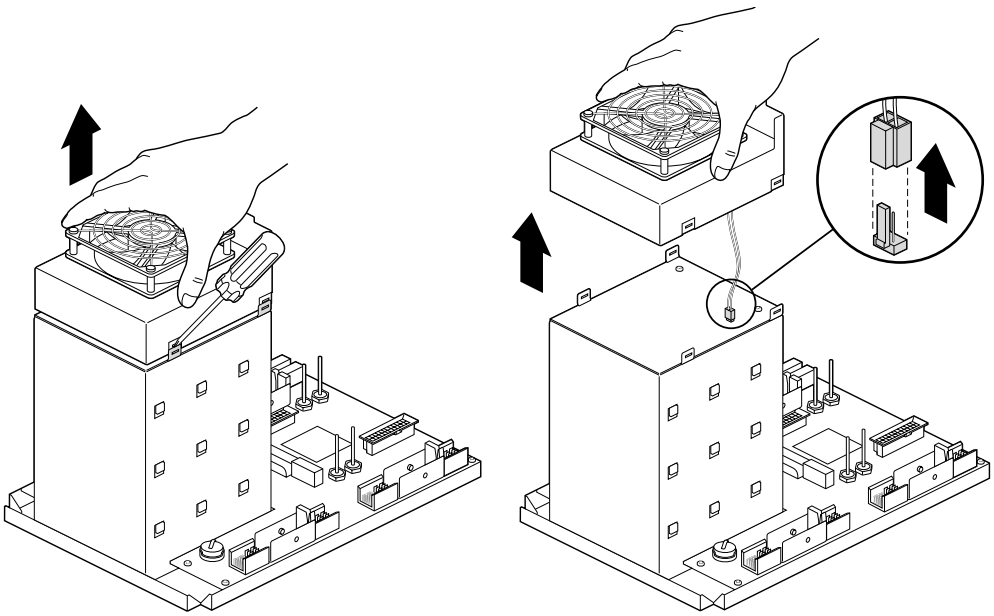


Figure 5-131 Releasing the PS Fan

13.) Use a flat headed screwdriver to separate the four tabs holding the fan module to the back of the drive bay.

14.) Disconnect the power connector under the fan

System Identification Module

Remove the system identification module only when replacing the frontplane module.

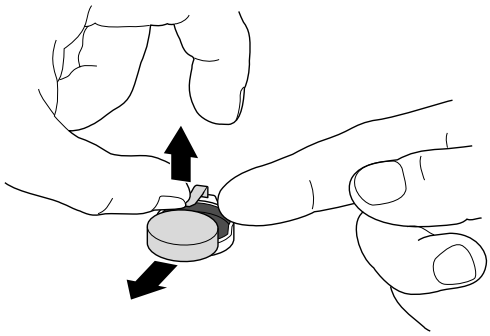


Figure 5-132 Removing the System ID Module

1.) Remove the system identification module.
   a.) Lift up on the metal retaining clip.
   b.) Slide the system identification module to the side and out.
2.) Place the system identification module on the new frontplane.
   a.) Lift up on the retaining clip.
   b.) Slide the system identification module under the clip.

Note: The System ID Module contains the host Ethernet Address number. If you replace this item, all of your Software Options (which are fingerprinted to this number) will be unavailable. You will have to order a new Options **MOD**(s) to restore option software, in this case.

Section 4.0 Troubleshooting

4.1 Host Subsystem

4.1.1 Host Computer - Linux Workstation

4.1.1.1 Solving Hardware Problems

Workstation Does Not Start Properly

DISPLAY IS BLANK

If your display is blank after you turn on your Workstation, check that:

- The Workstation and monitor are turned on. (The power lights should be illuminated.)
- Both the Workstation and monitor power cords are firmly connected and plugged in.
- The outlet power is functioning.
- The monitor is firmly connected to the graphics card connection.
- The monitor's contrast and brightness settings are set correctly.

A POST ERROR MESSAGE IS DISPLAYED

The Power-on-Self-Test (POST) can detect both an error and a change to the configuration. In either case, a code and short description is displayed. Depending on the message, one or more choices are displayed:

- Press **F1** to ignore the message and continue.
- Press **F2** to run the Setup program and correct a system configuration error.
- Press **ENTER** to see more details about the message. After viewing these details, you are returned to the original POST display screen.

Keyboard Doesn't Work

If your keyboard does not work as expected:

- Ensure that all the keyboard cables are firmly connected.
- Ensure the keyboard is connected to the keyboard connector rather than the mouse connector on the rear panel of the Workstation.
- Ensure you are using a PS2 keyboard rather than a USB keyboard.
- Replace the keyboard with a known working unit to ensure the keyboard itself is not defective.

Monitor Doesn't Work

If the display is blank, refer to "Display is Blank," on page 354.

If the display works properly during the Power-on-Self-Test (POST), but goes blank when Applications start, the display settings in the operating system may not be compatible with your monitor.

Mouse Doesn't Work

If your mouse does not work as expected:

- Ensure that the mouse cable is firmly connected.
- Ensure that the mouse is connected to the mouse connector rather than the keyboard connector on the rear panel of your Workstation.
- Ensure you are using the correct driver. You can download the latest driver from the HP web site (***www.hp.com/workstations/support***).
- Clean the mouse ball with a dry, lint-free cloth if the cursor moves sporadically.
- Replace the mouse with a known working unit to ensure the mouse itself is not defective.

4.1.1.2 Understanding the Diag LEDs

The Diag LEDs on the front panel of the Workstation can help you identify specific problems with your Workstation:

- During system start up, all four LEDs are green.
- If no problems are detected during start up, all four LEDs turn off.
- If a problem is detected, one or more of the LEDs changes color.

If an error is detected (one or more of the LEDs changes color), see Table 5-43 for brief list of combinations that you may see when you initially set up your system.

The LED patterns are defined by:

- R = Red
- Y = Yellow
- G = Green
- ● = Off

If any of the errors listed in Table 5-43 occur, replace the HP Computer.

PATTERN	ERROR
RRYY	Fatal internal processor error (#IERR).
RYY●	No memory detected.
RYYY	Corrupted memory.
YR●●	BIOS is in crisis recovery mode.
YYR●	3.3v circuitry error.
GR●●	BIOS recovery complete.
GYR●	1.8V power circuitry error.
GGRY	Battery voltage error. Battery may be at the end of its life.
●YRY	12V power circuitry error.
●YRG	2.5 RDRAM power circuitry error.
(R = Red, Y = Yellow, G = Green, ● = Off)	

Table 5-43 Diag LED Patterns

4.1.1.3 Using e-DiagTools for Hardware Problems

Note: Run e-DiagTools before contacting the OLC for help. e-DiagTools gives you information your OLC engineer needs.

Use e-DiagTools to diagnose hardware-related problems on your HP Workstation. If any of the Diag LEDs on the front panel of your Workstation are on, go to "Understanding the Diag LEDs," on page 355, before attempting to use e-DiagTools.

4.1.2 Host Computer - Octane/Octane2

4.1.2.1 Overview: Diagnosing Host Computer Hardware Problems

There are number of ways that Octane hardware problems can be identified and diagnosed. These range from a hardware inventory, to diagnostic testing, to a simple command line executable.

POWER-ON TESTS

Power-On tests run automatically whenever the host computer is powered-on or reset. They test the motherboard, memory modules and graphics boards. Fault notification is done through light bar **LED** codes and Error Messages in the OC `/var/adm/SYSLOG`, or on the console monitor (**CRT**).

HARDWARE INVENTORY

Using the **`hinv`** software command, a listing of the hardware devices that the host computer can communicate with or not communicate with is displayed.

4.1.2.2 Power-On Tests

Power-Up Sequence - Overview

The computer follows a sequential power-up process. After power to the computer is applied, the lightbar on the front of the computer turns Red. While the motherboard is running its power-up self-test, the bar remains RED.

When the bar first lights, during power-on, the monitor displays `running power-on diagnostics` on screen.

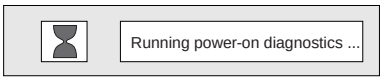


Figure 5-133 Power-on Diagnostics Notifier

After all of the power-on tests have passed, the light bar turns white, and the `Starting Up the System` pop-up window appears. This is when you can access **SGI** diagnostics and its host command line. Press the **ESC** key or click on the STOP FOR MAINTENANCE box if you want to access the firmware based tools.

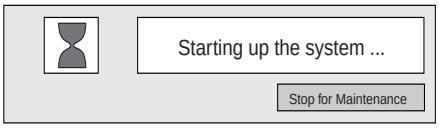


Figure 5-134 Starting up the system notifier

If you don't interrupt, after a few seconds the “System Is Coming Up” pop-up will appear.

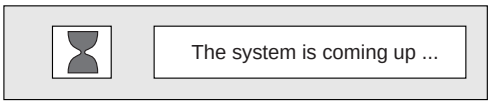


Figure 5-135 The System is coming up notifier

Light Bar LEDs

The light bar **LED**s on the front of the Octane computer provide useful diagnostic information. If a problem occurs during computer initialization, the Octane computer will report it using these **LED**s.

In this section, failure symptoms are described, as well as their possible causes and remedies.

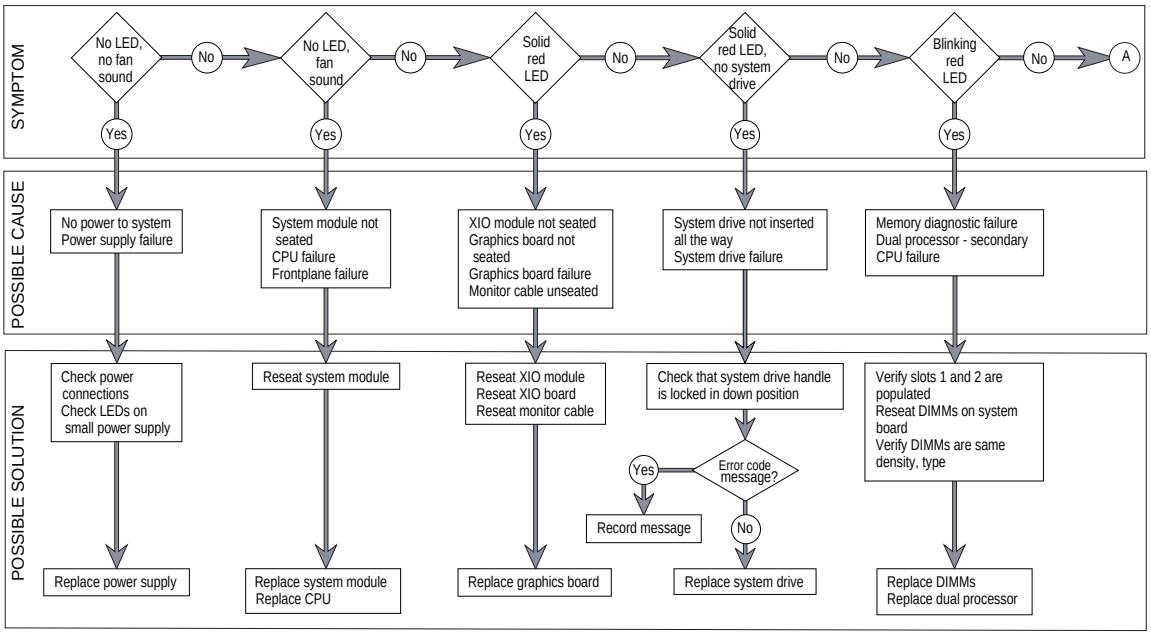


Figure 5-136 Interpreting the Light Bar LEDs (part 1 of 3)

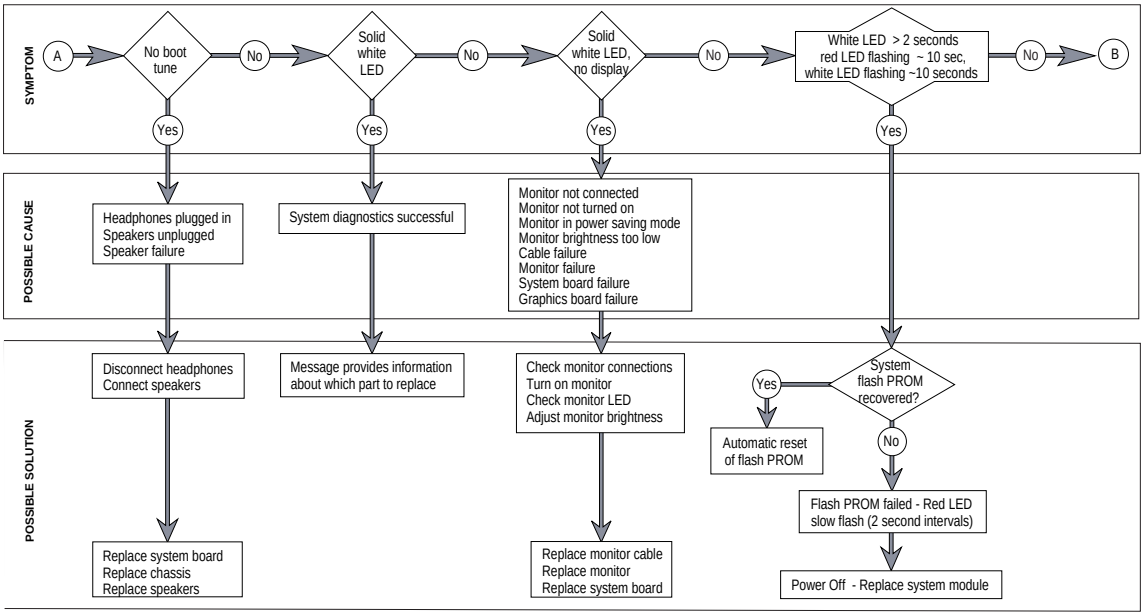


Figure 5-137 Interpreting the Light Bar LEDs (part 2 of 3)

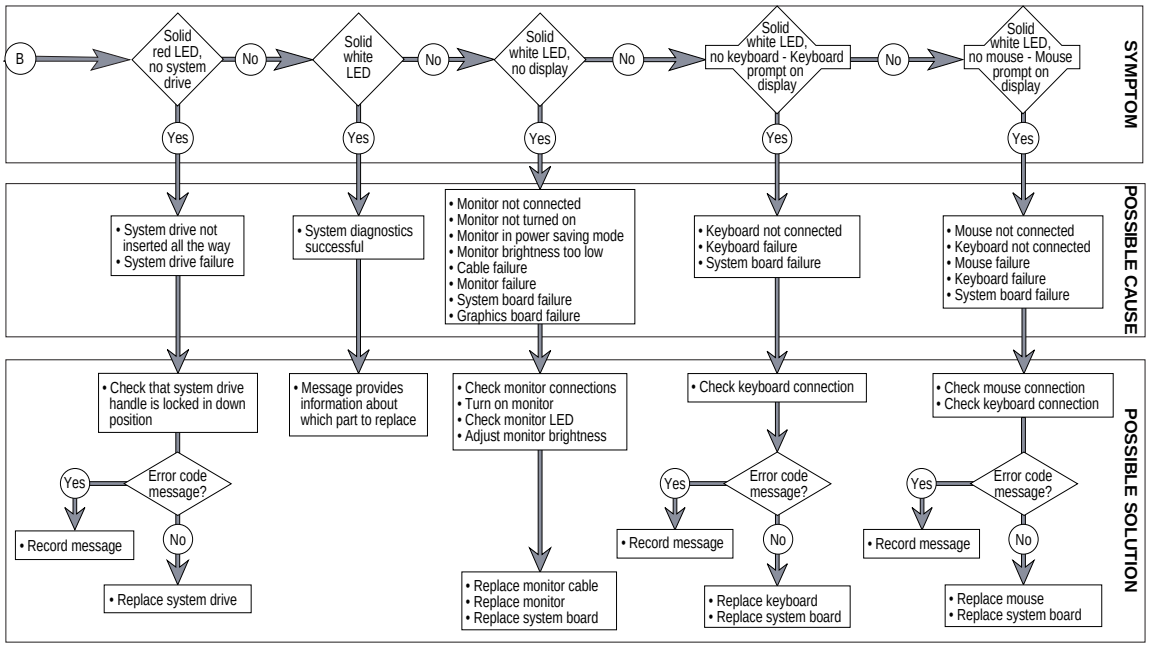


Figure 5-138 Interpreting the Light Bar LEDs (part 3 of 3)

CPOP Connector LEDs

Located immediately behind the lower right front cover are seven (7) green **LED**s. These **LED**s are visible with the front cover removed by looking through the holes located in the lower front right of the chassis (see Figure 5-139). The **LED**s you will see are attached to the back of the front plane circuit board, as viewed through the holes in the lower right area of the chassis next to the DB15 connector. There are 2 columns: 1 column consisting of 4 **LED**s and another with 3 **LED**s. They are depicted in Table 5-44 and Table 5-45 that way.

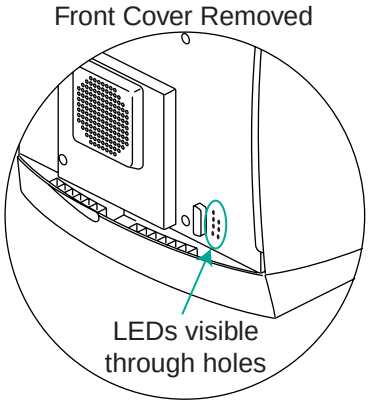


Figure 5-139 CPOP Connector LEDs

DESCRIPTION	COLUMN 1	COLUMN 2	DESCRIPTION
Base IO	OFF		
Quad A	OFF	OFF	**PCI**
Quad C	OFF	OFF	Quad B
Quad D	OFF	OFF	Heart

Table 5-44 CPOP Connector LEDs - Generic Application

DESCRIPTION	COLUMN 1	COLUMN 2	DESCRIPTION
System Module	ON		
Quad A (**SI** w/ TM)	ON	ON	**PCI** Chassis
Quad C (None in this scanner)	OFF	OFF	Quad B (None in this scanner)
Quad D (**SI**)	ON	ON	Heart **ASIC**

Table 5-45 CPOP Connector LEDs - CT Product Specific Application

The purpose of these **LED**s is NOT “diagnostic” in nature—these **LED**s simply indicate whether the XIO modules are properly seated and have been detected by hardware. In the case of the Heart **ASIC**, the **LED** is a “status OK” indicator.

Brief descriptions of these 7 green **LED**s follow:

Base IO	Main System Module is seated/detected OK
Quad A	Top left XIO quad module is seated/detected OK
Quad C	Lower right XIO quad module is seated/detected OK
Quad D	Lower left XIO quad module is seated/detected OK
PCI	**PCI** chassis/**ASIC** seated/detected OK
Quad B	Top right XIO quad module seated/detected OK
Heart	Heart memory control **ASIC** on System Module status OK

Computer Panics

Panics are un-recoverable errors caused by a computer hardware failures. The symptom includes a Panic error message, computer hangs, and the need to re-boot.

The key to troubleshooting `PANIC` errors is understanding the error message. In most cases, the message will state the symptom. Such as `WIDGET_ERR`, as shown in Figure 5-140 for example. `WIDGET_ERR` is not the cause but the symptom. To localize, look for a hardware device that is reporting the error.

Figure 5-140 Example Panic Error Message

In Figure 5-140, the error screen indicates an unexpected interrupt being reported by the `Heart`. The “Heart” is an **ASIC** on the Octane IP30 motherboard. Therefore the IP30 is experiencing problems. Another **SGI** hardware acronym that can show up is `Xbow`. Xbow stands for crossbow. It’s the XIO **ASIC** on the Octane frontplane. It interconnects the IP30, XIO graphics, and the **PCI** module. These are the two most commonly encountered hardware acronyms.

4.1.2.3 Host (Octane) Hardware Inventory “`hinv`”

Every time the system boots, it will log what hardware was found. You can read this log with the **`hinv`** command, and verify the software is able to talk with the hardware you expected. If, because of a bad memory module, the system finds less memory than is installed, then IRIX will use more of the virtual memory in the swap space (this will require more swapping to the disc drive and slow down the software). The error log will show no entry about missing memory. IRIX will identify each disc drive connected to the **SCSI** controller, but the **DASM** is not a known device for IRIX, so it is labeled as a disc drive.

The following example shows the use of and output from the **`hinv`** command. Comments have been added for clarification.

Example: ’hinv’ command

```
{ctuser@ct10_oc}[10] hinv
```

```
1 300 MHZ IP30 Processor
```

*The line above identifies the system as having a standard single 300Mhz Processor Module “**CPU** brick,” which is plugged into the Octane IP30 System Module.*

```
CPU: MIPS R12000 Processor Chip Revision: 2.3
FPU: MIPS R12010 Floating Point Chip Revision: 0.0
```

MIPS R12000 Microprocessor IC (inside the PM) is identified in the first line above. The MIPS R12010 Floating Point coprocessor IC (inside the PM) is identified in the next line. Revision levels may change over time. You should not become alarmed if yours is different.

```
Main memory size: 1536 Mbytes
```

*Standard Main Memory configuration is identified in the line above. The Octane computer utilizes Dual Inline Memory Modules (**DIMM**) using Error Correction Code (ECC). The Octane IP30 has eight **DIMM** connectors, arranged in four banks of two. They are labeled S1 through S8. **DIMM**s*

must be installed in like-pairs into connectors S1-S2, S3-S4, S5-S6, and S7-S8. (2 x 64MB) ***DIMM****s are normally in connectors S1 and S2. (2 x 64MB)* ***DIMM****s are normally in connectors S3 and S4.*

```
Instruction cache size: 32 Kbytes
Data cache size: 32 Kbytes
```

*In the above two lines, the MIPS R12K primary instruction cache & data cache memory inside the R12K microprocessor in the PM (****CPU*** *brick) is identified.*

```
Secondary unified instruction/data cache size: 2 Mbyte
```

*Secondary cache memory inside the PM (****CPU*** *brick) and its size are reported in the above line.*

```
Integral SCSI controller 0: Version QL1040B (rev. 2), single ended
```

SCSI *Bus 0 (internal* ***SCSI*** *controller 0, internal devices)*

```
Disk drive: unit 1 on SCSI controller 0
```

System Disk 1

```
Disk drive: unit 2 on SCSI controller 0
```

System Disk 2

```
Integral SCSI controller 1: Version QL1040B (rev. 2), single ended
```

SCSI *Bus 1 (internal* ***SCSI*** *controller 1, external devices)*

```
Optical disk: unit 3 on SCSI controller 1
```

MOD *Drive*

```
CDROM: unit 6 on SCSI controller 1
```

CD-ROM *Drive*

```
Integral SCSI controller 2: Version QL1040B (rev. 2), single ended
```

SCSI *Bus 2 (internal* ***PCI SCSI*** *controller 1, external devices -* ***DASM****)*

```
Disk device: unit 1 on SCSI controller 2
```

DASM *- Controller 2 is visible only if the Device connected is powered-on and connected*

```
IOC3 serial port: tty1
```

The next line is the 9-pin D-type native serial port #1 on the IP30. RS232 device /dev/ttym1 for remote boot or ***PPP*** *connections. This is also the Octane primary console port via device /dev/ttyd1 (can be used for laptop control via firmware command).*

```
IOC3 serial port: tty2
```

This is the Octane's 9-pin D-type native serial port #2 on the IP30. Used for Service Key and is linked to /dev/servkey.

```
IOC3 parallel port: plp1
```

The next line shows the Octane's native Centronics parallel port on the IP30 which is not used.

```
Graphics board: ESI with texture option
```

Driving Right Display Head

```
Graphics board: ESI
```

Driving Left Display Head

```
Integral Fast Ethernet: ef0, version 1, pci 2
```

The internal network interface is shown on the line above. This is the FAST ethernet (100 megabit/sec) device mode of the Octane IP30 native 10/100 megabit (auto-sensing) ethernet chip.

```
Fast Ethernet: ef1, version 1, pci 3
```

***PCI** network card for external network interface.*

```
Iris Audio Processor: version RAD revision 12.0, number 1
```

The line above shows the Octane IP30 native audio processor chip. It is used this for recording and playing Autovoice digital audio files.

```
PCI card, bus 0, slot 2, Vendor 0x114f, Device 0x4
```

***PCI** network card for external network interface*

4.1.2.4 Confidence Tests

Confidence Tests is a group of tests that can be run with applications up. They are useful in determining whether peripheral devices such as the keyboard, monitor, mouse, and **CD-ROM** drive are operating correctly.

The confidence tests are IRIX supplied diagnostics for testing items such as the mouse, keyboard, monitors, audio subsystem, and external **SCSI** devices. To invoke on the OC, enter "**`confidence`**" at a UNIX prompt. A window will pop up containing an icon for each testable device present. Clicking on that icon will invoke the diagnostic that will test that device. Below the icon window is a status window that displays information such as which devices are present and which are not. Tests can be run individually, or multiple tests can be selected. To select more than one test, choose the pull down menu "DEVICES" from the menu bar, and click on the box of each desired test.

Audio Test

Choosing the audio confidence test pops up a window, giving the user the choice of running an output or input audio test. When the output button is pressed, a voice replies with the message: "*This is the audio confidence test.*" If you hear this message, the test is successful.

CD-ROM Test

To run the **CD-ROM** confidence test, insert a **CD** into the **CD-ROM** drive, and click on the CD-ROM confidence test icon. Test pass and fail information is printed to the confidence test status window.

Keyboard Test

Choosing the keyboard confidence test brings up a picture of a keyboard. As the user presses the keys on the real keyboard, the keys on the picture are highlighted. This test can be used to verify that individual keys on the keyboard are working properly. To dismiss this test, press the **LEFT MOUSE BUTTON**.

Monitor Test

When the monitor confidence test is chosen, the screen becomes black, and a blue menu appears in the center. Clicking with the mouse on different menu items results in different patterns being displayed on the monitor. This test can be used to help verify that the monitor is working properly. The monitor on which the confidence tests are invoked is the monitor that will be tested by this confidence test. To dismiss this test, choose the exit option from the menu.

Mouse Test

When the mouse confidence test is chosen, the image on the screen is replaced by a gray background and an image of a mouse. The movement of this image duplicates the movement of the real mouse. Clicking on the **LEFT**, **RIGHT**, or **MIDDLE** mouse buttons causes the corresponding button on the image to be highlighted. This diagnostic can be used to verify that the mouse is working properly. Pressing the **ESC** key on the keyboard dismisses the mouse test.

4.1.2.5 Peripheral Component Interconnect (PCI) Support

Fast Ethernet (100Base-TX) Adapter - SGI

DEVICE RECOGNITION

The objective of this test is to verify that the hardware is detected by the operating system.

1.) Open a UNIX shell.
2.) At the prompt, type: **`hinv | grep Ethernet`**
3.) The following line must appear: `Integral Fast Ethernet: ef0, version 1, pci 2`
If no Ethernet board appears, your operating system doesn't recognize the hardware.

SCSI PCI Card - SGI

In the unlikely event you encounter a problem, the following checks can be preformed to help isolate the source of the failure. The checks are simple. First, verify the hardware is recognized. Next verify that its software driver is loaded into memory correctly. Finally, make sure the device is mapped properly by the operating system to the device.

DEVICE RECOGNITION

The objective of this test is to verify that the hardware is detected by the operating system.

1.) Open a UNIX shell.
2.) Check that the **SCSI** card is recognized, by using the **`hinv`** command.
   a.) At the prompt, type: **`hinv | grep Integral`**
```
Integral SCSI controller 0: Version QL1040B (rev. 2), single ended
Integral SCSI controller 1: Version QL1040B (rev. 2), single ended
Integral SCSI controller 2: Version QL1040B (rev. 2), single ended
Integral Fast Ethernet: ef0, version 1, pci 2
```
   a.) Inspect the output and verify that `Controller 2` is listed.
```
Integral SCSI controller 2: Version QL1040B (rev. 2), single ended
```

SOFTWARE DRIVER

Software driver support for **SCSI** cards is embedded automatically in the IRIX OS kernel and cannot be viewed. If defective, none of the **SCSI** devices will operate.

OPERATING SYSTEM MAPPING

The objective of this test is to verify that the **SCSI** card is mapped to a device. If no device (i.e. **DASM**) is attached to the **PCI SCSI** card's external connector, that **PCI SCSI** card is not listed in the **`scsistat`** output listing.

1.) Open a UNIX shell.

Note: **DASM** must be attached and "ON" to check **PCI SCSI** Card

2.) At the prompt, type: **scsistat**

```
Device 0 1  Disk      SGI      IBM DNES-309170Y FW Rev: SA30
Device 0 2  Disk      SGI      IBM DNES-309170Y FW Rev: SA30
Device 1 3  Optical   Maxoptix T5-2600          FW Rev: H4.2
Device 1 6  CD-ROM    TEAC     CD-ROM CD-532S   FW Rev: 1.0A
Device 2 1  Disk      CDA      DASM-VDB         FW Rev: 3.0A
```

3.) Inspect the screen output and verify that the **DASM** is recognized.

```
Device 2 1  Disk      CDA      DASM-VDB         FW Rev: 3.0A
```

4.) If "`Device 2 1`" is not listed:

a.) Verify that a device is connected to the **SCSI** card and is turned "ON".

b.) Verify that all other devices in the **PCI** chassis operate correctly.

* If all other cards in the **PCI** work, the **SCSI** card or attached device may be defective.
* If other devices do not work, the frontplane or **PCI** card cage may be defective.

Serial Expansion PCI Card - Digi ClassicBoard

The following checks can be preformed to help isolate the source of a **PCI** serial card failure. The checks are simple. First, verify the hardware is recognized. Next verify that its software driver is loaded into memory correctly. Finally, make sure the device is mapped properly by the operating system to the device.

DEVICE RECOGNITION

The objective of this test is to verify that the hardware is detected by the operating system.

1.) Open an Unix shell.

2.) Check that the Serial hardware is recognized, by using the **hinv** command.

a.) At the prompt, type: **hinv | grep PCI**

b.) If the Serial card is detected, you will see the following **PCI** card listed:

```
PCI card, bus 0, slot 2, Vendor 0x114f, Device 0x4
```

Verify the vendor ID for the serial card listed is `0x114f`

3.) If the Serial expansion **PCI** card is not listed, verify that other devices in the **PCI** chassis operate correctly.

- If other devices work, the serial card is possibly defective.
- If other devices do not work, the frontplane or **PCI** card cage may be defective.

SOFTWARE DRIVER

The objective of this test is to verify that the software driver for the Serial card is loaded in memory.

1.) Open a UNIX shell.

2.) At the prompt, type: **showprods | grep cdp**

3.) Verify you see the following:

if you have installed version 1.0 serial software drivers.

```
I cdp              03/09/2001 Digi ClassicBoard PCI Adapters
I cdp.man          03/09/2001 Digi ClassicBoard PCI Documentation
I cdp.man.relnotes 03/09/2001 Digi ClassicBoard PCI ReleaseNotes
I cdp.sw           03/09/2001 Digi ClassicBoard PCI Software
I cdp.sw.base      03/09/2001 Digi ClassicBoard PCI Base Software
```

You should see the following, if you have installed version 1.1 serial software drivers.

```
I cdpci              03/09/2001 Digi ClassicBoard PCI Adapters
I cdpci.man          03/09/2001 Digi ClassicBoard PCI Documentation
I cdpci.man.relnotes 03/09/2001 Digi ClassicBoard PCI ReleaseNotes
I cdpci.sw           03/09/2001 Digi ClassicBoard PCI Software
I cdpci.sw.base      03/09/2001 Digi ClassicBoard PCI Base Software
```

4.) If the Serial driver is not listed, see the software installation procedure on how to load the serial drivers.

OPERATING SYSTEM MAPPING

The objective of this test is to verify that the Serial devices are properly mapped to a device, by inspecting the `/etc/uucp/Devices` file.

1.) Open a UNIX shell.

2.) At the prompt, type: **`cd /etc/uucp`**

3.) Now type: **`tail -5 Devices`**

The **`tail`** command lists the last 5 lines in the ASCII file called `Devices`.

```
# Serial line connection for the sbc
ICE ttydp02 - 9600 direct
rhard ttydp00 - 9600 direct
pig ttydp01 - 57600 direct
ACU /dev/ttyf1 null 38400 212 x MultiTech
```

4.) Inspect the output. If the serial card is mapped correctly, you will see the serial devices connected. Such as `ICE`, `rhard`, `pig` and `ACU` hardware.

5.) If one or more of the devices is not listed, do the following:

a.) If no Serial device is listed, see the software installation procedure on how to load the serial drivers.

b.) If one is missing:

1.) Recheck the operational status of the missing subsystem containing the device.

2.) Check for a defective connection between the serial card and the subsystem.

4.1.2.6 DIMM Memory

Checking for Faults

DIMM errors appear in the OC error log file, SYSLOG, located in the directory `/var/adm/`. Hard (unrecoverable) memory errors will cause an **SGI** operating system (Irix) PANIC. Usually, a PANIC message will be posted to a screen window and logged in /var/adm/SYSLOG. The offending module will be identified by its socket number.

A boot-up failure message indicating "`PANIC: CPU parity error interrupt`" may mean there is a bad module in the first bank. If the system will not re-boot after a hard memory error `PANIC`, it is probably because the **Octane host needs the first memory bank to be in good working in order for boot up**. To eliminate this possibility, swap all modules in the first bank with those in the second. For the Octane host, this means swap the modules in S3 and S4 with those in S1 and S2 (see Figure 5-141, on page 366). Before doing this, check that all **DIMM**s are correctly seated in their slots.

To view only the critical host errors, open a shell and type:

`sysmon /var/adm/SYSLOG` for today's entries *or* **`/var/adm/SYSLOG.0`** for yesterday's

Or, from the Service Desktop, select ERROR LOGS and SYSTEM BROWSER, then select SYSLOG OC from the View pull-down menu, select the SYSLOG you wish to view in the Option box, and press VIEW FILE to view the entire syslog.

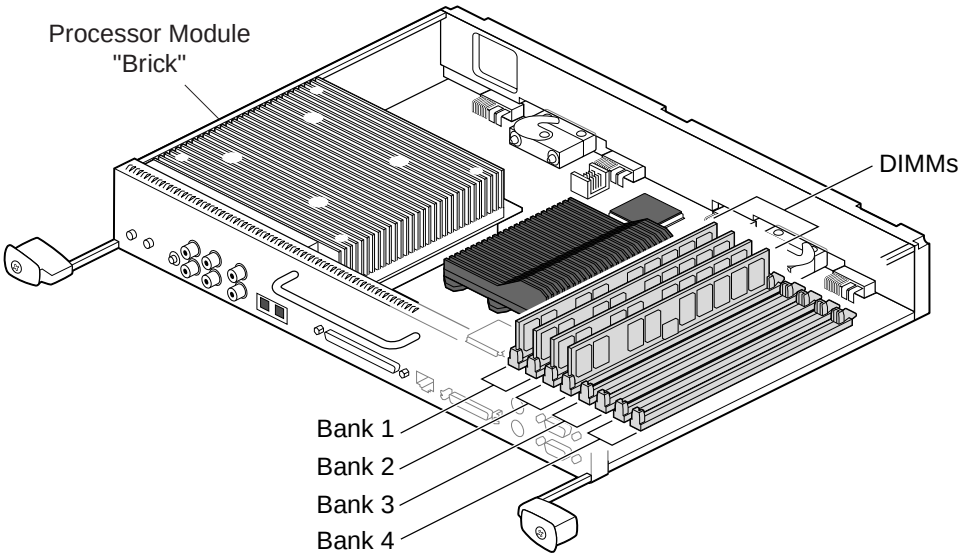


Figure 5-141 Octane System Module

To do a more complete test, interrupt **ESC** boot-up, Enter Command Monitor and type:

`ide memtest`

Memory Identification

SGI Part # 9940069 (YELLOW LABEL)

32MB **DIMM**—a pair makes 64MB

GEMS part # =2169940-51 pair

SGI Part # 9940084 (BLUE LABEL) or 9470178 (GREEN LABEL)

64MB **DIMM**—a pair makes 128MB

GEMS part # = 2169940-61 pair

SGI Part # 9470168 (BROWN)

28MB **DIMM** 2K REFRESH—a pair makes 256MB

GEMS part # = 2169940-411 pair

SGI Part #9010020 (BROWN)

128MB **DIMM** 4K REFRESH—a pair makes 256MB

GEMS part # = 2169940-411 pair

Note: The “4k refresh” **DIMM**s can only be used in the newer “Enhanced IP30”, which is GEMS part # 2169940-45 (**SGI** #030-1467-001). These 4k refresh **DIMM**s cannot be used in the older Octane IP30, which is GEMS part #2169940-13 (**SGI** #030-0887-003). Use the IRIX 'hinv -mvv' command, or read the IP30 label to determine the IP30 version you have.

SGI Part # 9470223 (RED)

256MB **DIMM** 4K REFRESH—a pair makes 512MB

GEMS part # = 2169940-TBD1 pair

DATARAM Part # 60056 (no color code)

32MB **DIMM**—a pair makes 64MB

GEMS part # - 21998061 pair

DATARAM Part # 62614 (no color code)

64MB **DIMM**—a pair makes 128MB

GEMS part # - 2199806-21 pair

DATARAM Part # 62615 (no color code)

128MB **DIMM**—a pair makes 256MB

GEMS part # - 2199806-51 pair

DATARAM Part #_____ (no color code)

256MB **DIMM**—a pair makes 512MB

GEMS part # - 2199806-61 pair

4.1.2.7 Octane2 Graphics Subsystem

Common Problems

SYMPTOM	POSSIBLE CAUSE
V12 or Display Option Board does not appear in `hinv`.	Either the board is installed incorrectly, or it is defective. Make sure the board is correctly seated. If re-seating the board does not solve the problem, the board may be defective.
Same image appears on both monitors.	Timing mode is set to single channel.
Monitors are blank.	Remove the 13W3 cover from the VPro Graphics Board monitor port and connect a monitor to this port. Enter `hinv` in a UNIX shell to see if the system recognizes the board. If the system does not recognize the board, it may not be seated properly or it may be defective. If re-seating the board does not solve the problem, the board may be defective.
In single channel modes, one monitor displays the image correctly, but the other monitor's image is bad.	The board is probably defective.
The images on both monitors alternate between the correct image and noise, a constant color, or a badly flickering image.	The board is probably defective.
In dual channel mode, two superimposed flickering images appear on a monitor connected to the VPro Graphics Board monitor port.	Currently, the VPro Graphics Board monitor port is not disabled in dual channel mode. If you connect a monitor to the VPro Graphics Board monitor port in dual channel mode, the monitor displays alternating images from the left and right channels.

Table 5-46 V12 and DCD Common Problems

Operating System Hardware Recognition

1.) Open a UNIX shell.

2.) At the prompt, type: **`hinv | grep Graphics`**

3.) The following line must appear: `Graphics board: V12`

If no graphics board appears, your operating system doesn't recognize the hardware. You will not be able to communicate correctly with the graphics subsystem.

Operating System Compatibility

To function correctly, the V12 graphics card requires IRIX Version 6.5.10 or later. If for some reason after you installed software your graphics doesn't work, perform the following check.

1.) In a command line window, enter **`uname -R`**

2.) Verify the installation of IRIX 6.5.10 or later.

Hardware Compatibility

PROM

To function correctly, the V12 graphics card requires a **PROM** revision of 4.5 or later. There are two methods for checking version:

METHOD 1:

1.) While the system is booting, press the **ESC** key. The **PROM** menu appears.

2.) Choose ENTER COMMAND MONITOR in the **PROM** menu. The Command line interface screen appears.

3.) Enter version and verify the following:

`SGI version 6.5 Rev 4.5 IP30`, where `4.5` or later is the correct **PROM** revision for the V12 board.

METHOD 2:

You can also verify your **PROM** revision by typing **`flash -V`** in a UNIX shell, if your system is running IRIX 6.5.10 or later.

FRONTPLANE "XBOW"

The V12 graphics board must have a frontplane "xbow" revision of 1.4 or later. The xbow is an **ASIC** device located on the frontplane. There are two methods for checking revision.

METHOD 1:

1.) Shut down your system.

2.) Restart your system.

3.) While the system is booting, press the **ESC** key. The **PROM** menu appears.

4.) Choose ENTER COMMAND MONITOR in the **PROM** menu. The Command line interface screen appears.

5.) Enter System.

Xbow (rev 1.4 or later) should appear under Chips/NICs.

If Xbow (rev 1.3 or earlier) appears, the frontplane is incompatible with V12 graphics board.

METHOD 2:

If your system is running IRIX 6.5.10 or later, you can also verify this information as follows:

1.) Open a Unix shell.

2.) Enter **`hinv`** to display the hardware inventory list.

`Xbow ASIC: Revision 1.4` should appear in the list.

If `Xbow ASIC: Revision 1.3` or earlier appears, the frontplane is incompatible with V12 graphics board.

POWER SUPPLY

1.) Check your power supply by entering **`hinv -m`** in a command line window. The hardware inventory list appears, as shown in the example in Figure 5-142.

2.) The part number for `PWR.SPPLY.ER` must be: `060-0035-00x`, where `x` = `1` or higher, as shown in the example in Figure 5-142.

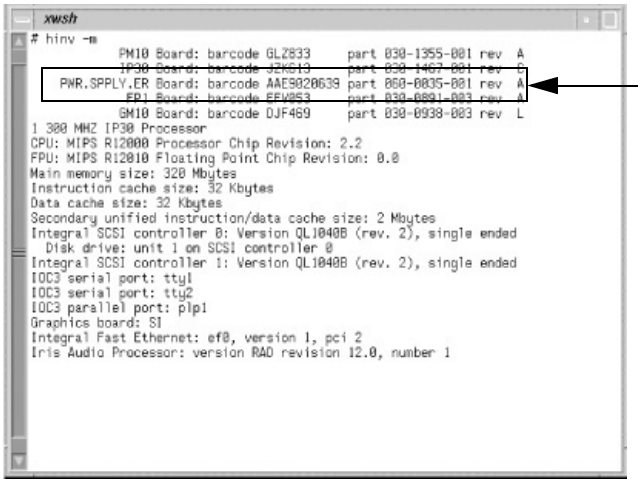


Figure 5-142 Power Supply Version

3.) If the above part number, in Figure 5-142, is not displayed for `PWR.SPPLY.ER`, your power supply is incompatible with the V12 graphics card.

4.1.2.8 Octane (Original) Graphics Subsystem

SI (Solid Impact) or SE (Solid Impact Enhanced)

The Octane graphics board that controls the primary “head,” (the monitor normally on the right) is in slot A. It is called **SI** (or **SE**) with Texture Memory or IMPACTSR with 4 **TRAM**s.

You can troubleshoot these boards by trying the secondary board in the primary slot, but at least one of the two must be installed in the primary slot and working to boot the system. The **SI** (or **SE**) with Texture Memory must be in Slot A to run the scanner applications.

Octane Graphics System Hardware

To view those components of the graphics system that the **SGI** host currently sees, enter this command in a shell: **`/usr/gfx/gfxinfo`** You should see something that looks similar to the following example (example shown is with **SE** Graphics boards):

Example: "gfxinfo" command

```
Graphics board 0 is "IMPACTSR" graphics.
    Managed (":0.1") 1280x1024
    Product ID 0x2, 1 GE, 1 RE, 4 TRAMs
```

```
    MGRAS revision 4, RA revision 0
    HQ rev B, GE12 rev A, RE4 rev C, PP1 rev H,
    VC3 rev A, CMAP rev F, Heart rev F
    unknown, assuming 19" monitor (id 0xf)
    Channel 0:
    Origin = (0,0)
    Video Output: 1280 pixels, 1024 lines, 72.24Hz (1280x1024_72)
Graphics board 1 is "IMPACTSR" graphics.
    Managed (":0.0") 1280x1024
    Product ID 0x2, 1 GE, 1 RE, 0 TRAMs
    MGRAS revision 4, RA revision 0
    HQ rev B, GE12 rev A, RE4 rev C, PP1 rev H,
    VC3 rev A, CMAP rev F, Heart rev F
    unknown, assuming 19" monitor (id 0xf)
    Channel 0:
    Origin = (0,0)
    Video Output: 1280 pixels, 1024 lines, 72.24Hz (1280x1024_72)
```

4.1.2.9 SCSI (Integral) Interface

DEVICE RECOGNITION

The objective of this test is to verify that the integral **SCSI** controllers are detected by the operating system.

1.) Open a UNIX shell.

2.) Check that the integral **SCSI** controllers are recognized, by using the **`hinv`** command.

a.) At the prompt, type: **`hinv | grep Integral`**

```
Integral SCSI controller 0: Version QL1040B (rev. 2), single ended
Integral SCSI controller 1: Version QL1040B (rev. 2), single ended
Integral SCSI controller 2: Version QL1040B (rev. 2), single ended
Integral Fast Ethernet: ef0, version 1, pci 2
```

b.) Inspect the output and verify that `Controller 0` and `1` are listed.

```
Integral SCSI controller 0: Version QL1040B (rev. 2), single ended
Integral SCSI controller 1: Version QL1040B (rev. 2), single ended
```

SOFTWARE DRIVER

Software driver support for **SCSI** cards is embedded automatically in the IRIX OS kernel and cannot be viewed. If defective, none of the **SCSI** devices on any controller will operate.

OPERATING SYSTEM MAPPING

The objective of this test is to verify that the **SCSI** card is mapped to a device. If no device (i.e. **DASM**) is attached to the **PCI SCSI** card's external connector, that **PCI SCSI** card is not listed in the **`scsistat`** output listing.

1.) Open a UNIX shell.

Note: **DASM** must be attached and "ON" to check **PCI SCSI** Card

2.) At the prompt, type: **`scsistat`**

```
Device 0 1  Disk      SGI      IBM DNES-309170Y FW Rev: SA30
Device 0 2  Disk      SGI      IBM DNES-309170Y FW Rev: SA30
Device 1 3  Optical   Maxoptix T5-2600          FW Rev: H4.2
Device 1 6  CD-ROM    TEAC     CD-ROM CD-532S   FW Rev: 1.0A
```

```
Device 2 1  Disk      CDA      DASM-VDB         FW Rev: 3.0A
```

3.) Inspect the screen output and verify that the Disk, Optical and **CD-ROM** drives are recognized.

```
Device 0 1  Disk      SGI      IBM DNES-309170Y FW Rev: SA30
Device 0 2  Disk      SGI      IBM DNES-309170Y FW Rev: SA30
Device 1 3  Optical   Maxoptix T5-2600          FW Rev: H4.2
Device 1 6  CD-ROM    TEAC     CD-ROM CD-532S   FW Rev: 1.0A
```

4.) If a `Device` is not listed: *(FW rev./ver. can vary)*

a.) Verify that a **SCSI** device is connected to the **SCSI** connector and is turned “ON”.

b.) Verify that all other devices attached to that **SCSI** connector operate correctly.

* If all other devices on the **SCSI** bus work, the **SCSI** card or attached device may be defective.
* If other devices do not work, the frontplane or system module may be defective.

4.1.3 Magneto Optical Disk (MOD)

In the unlikely event you encounter a problem, the following quick checks can be preformed to help isolate the source of the failure or remedy the situation.

4.1.3.1 Common Problems

MOD Will Not Archive

When the **MOD** will not archive, use the following flowchart to help isolate the problem.

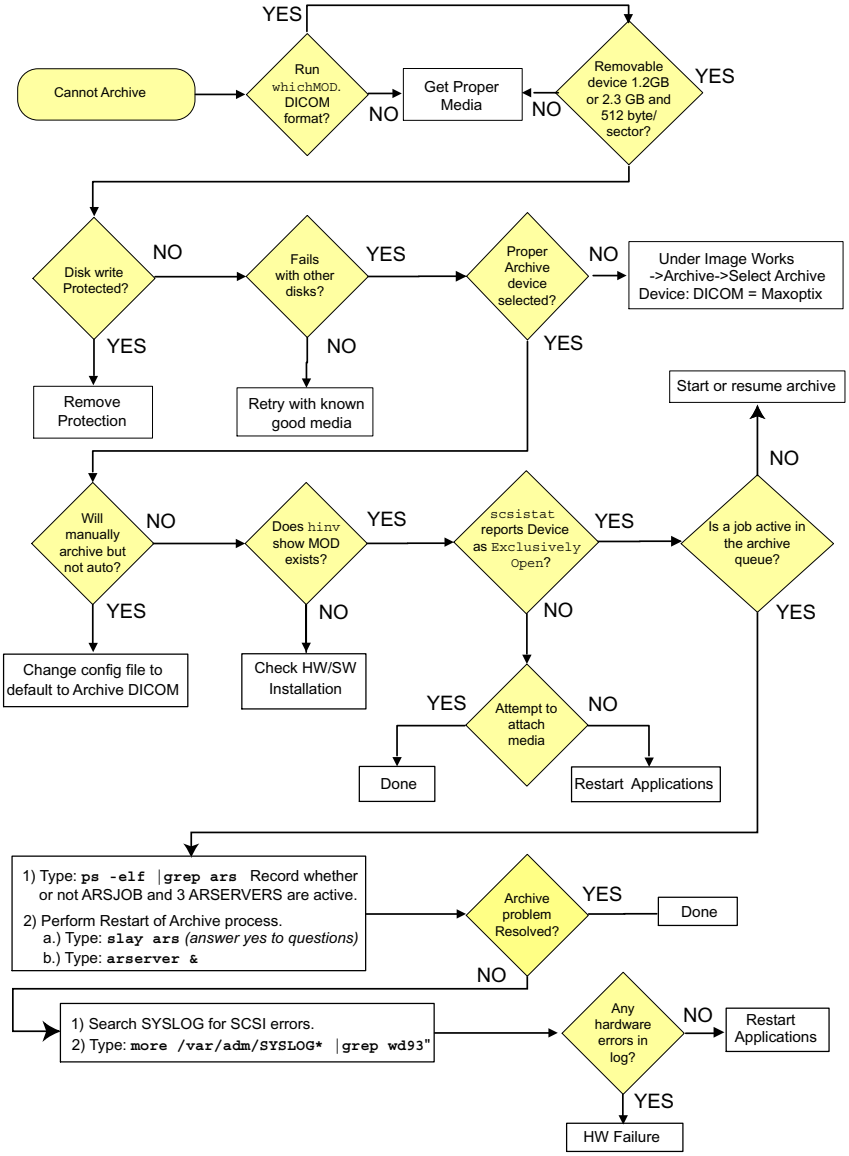


Figure 5-143 Troubleshooting Archive Problems

Verifying the HW/SW Installation

First, verify the **SCSI** hardware is recognized. Next, make sure the **SCSI** device is mapped properly by the operating system. When **SCSI** hardware is detected and mapped, software support is automatically loaded during boot.

To check that the above has been done, do the following by using pipe (`|`), **`grep`** and **`tail`** UNIX commands:

1.) Open an Unix shell.

2.) Check that the **MOD**'s **SCSI** card is recognized, by using the **`hinv`** command.

a.) At the prompt, type: **`hinv | grep Integral`**

You'll output similar to the following.

```
Integral SCSI controller 0: Version QL1040B (rev. 2), single ended
Integral SCSI controller 1: Version QL1040B (rev. 2), single ended
Integral SCSI controller 2: Version QL1040B (rev. 2), single ended
Integral Fast Ethernet: ef0, version 1, pci 2
```

Note: Controller 2 depends on HW configuration

Depending on your system's hardware configuration, you may only see 2 controllers listed. For example, systems without a Pegasus **IG** board see only controllers 0 and 1.

b.) Inspect the screen output and verify that all integral controllers are recognized.

3.) Use the **`scsistat`** command to list attached **SCSI** devices recognized by the OS. If the **MOD** is listed, operating system support for the **MOD** has been installed during console boot-up.

Note: **MOD** must be attached and turned "ON"

a.) At the prompt, type: **`scsistat`**

```
Device 0 1  Disk      SGI      IBM DNES-309170Y FW Rev: SA30
Device 0 2  Disk      SGI      IBM DNES-309170Y FW Rev: SA30
Device 1 3  Optical   Maxoptix T5-2600          FW Rev: H4.2
Device 1 6  CD-ROM    TEAC     CD-ROM CD-532S   FW Rev: 1.0A
Device 2 1  Disk      CDA      DASM-VDB         FW Rev: 3.0A
```

b.) Inspect the screen output and verify that **MOD** (`Optical`) is recognized

4.) If either of the previous fails:

a.) Recheck your results by cycling power off and then on, and then re-booting the console. Run the above checks again.

b.) If `SCSI controller 1`is not listed in the output of the **`hinv`** command:

* Check all **SCSI** and power connections.
* Replace the IP30 board

c.) If `SCSI controller 1` is listed but no `optical` device is listed by **`scsistat`**, replace the **MOD**.

Disk Fails to Eject

Any number of situations can cause **MOD** disk to become locked and not eject from the **MOD** drive. They can include the drive being locked by a software process and not being released. For example, the operator fails to terminate an archive function properly.

The most common problem is a dirty **MOD** drive mechanism. If the **MOD** disk fails to eject repeatedly and its not caused by operator error or locked processes, it's suggested that the **MOD** be replaced. The **MOD** has no user serviceable parts and cannot be cleaned without disassembly.

To release a disk that is locked, the following steps should be followed:

1.) Open an Unix shell and become superuser.

Type: **`su -`**

Type **`#bigguy`** as the password.

2.) Determine the type of **MOD** disk in the drive. Type the following command: **`whichMOD`**

3.) If you receive the message `this is a GE DICOM Image Archive Disk`, do the following:

a.) Within an UNIX shell, type the following command: **`scsistat`**

```
Device 0 1  Disk      SGI      IBM DPSS-309170M FW Rev: S96A
Device 0 2  Disk      SGI      IBM DPSS-309170M FW Rev: S96A
Device 1 3  Unknown   EXCLUSIVELY_OPEN
Device 1 6  CD-ROM    TEAC     CD-ROM CD-532S   FW Rev: 1.0A
```

b.) Inspect the **scsistat** listing.

1.) `device 1 3` is listed as `EXCLUSIVELY_OPEN.` You must do the following to detach it before you can eject the media:

i.) Pause the Archive Queue

ii.) Detach the Media

iii.) Press the **EJECT** button on the **MOD** and remove the disk.

iv.) When the **MOD** ejects, you are finished.

2.) If `Device 1 3 Optical Maxoptix T5-2600 FW Rev: H4.2` is displayed, do the following:

i.) Release the **MOD** by typing **eject /dev/scsi/sc1d3l0**

ii.) Press the **EJECT** button on the **MOD** and remove the disk.

iii.) Shutdown and restart **CT** applications

4.) If you receive the message `this is a GE SYSTEM STATE Disk`, do the following:

a.) Within an UNIX shell, type the following command: **unmountMOD**

b.) Press the **EJECT** button on the **MOD** and remove the disk.

5.) If any of the above procedures fail to eject the **MOD** disk, do one of the following:

a.) Force a **SCSI** bus reset.

1.) As super user, type **scsiha -r 1**

This resets **SCSI** *controller 1, as shown in the scsistat output.*

2.) Press the **EJECT** button on the **MOD** and remove the disk.

3.) Shutdown and restart **CT** applications

b.) Force an extraordinary 'unlock', of the **MOD** media to kill processes using the **MOD**.

1.) As super user, type **lockmod -f**

2.) Press the **EJECT** button on the **MOD** and remove the disk.

3.) Shutdown and restart **CT** applications

c.) If a forced unlock fails: shutdown the system, re-boot and remove the **MOD** disk.

Read Failures

Using the **readmod** command, a read of each sector on the media is done. The **readmod** command verifies reads can be done at the simplest level. When defects are detected, cross checking between two different **MOD** disks is suggested, to determine whether the **MOD** drive or the disk is defective.

It may be possible to recover a defective **MOD** disk. Defective disks may be cleaned using cleaners designed for **CD-ROM** disk surfaces. Be careful not to scratch the surface, or the **MOD** disk will need to be replaced.

Defective **MOD** drives must be replaced. Because the drive requires disassembly, cleaning of the optical drive mechanism in the field is not possible.

To test the basic read capability of the drive and media, use the following procedure:

1.) Open an Unix shell and become superuser.

Type: **su -**

Type **#bigguy** as the password.

2.) Load a blank/spare **MOD** disk into the drive.

3.) At the prompt type **`readmod`**

The reading will start at sector 0 and include 30000 sectors by default (no options selected).

4.) Inspect the output. If there are defective sectors on the medium, these will be reported during the read operation. Defective sectors will be reported with syndrome `####03` while "blank sectors" will be reported as `####08`. *Defects are BAD*.

Write Failures

NOTICE Potential for Data Loss

The zapdmod command can write data to the sectors on an MOD and therefore destroy the contents of that medium. Make sure the MOD being used has only expendable data. As a precaution, the program requires "-do" command line switch to activate the write operations.

Use the **`zapdmod`** command to write data to every sector on the medium. The program is used to perform 'write' operations to every or "select" sectors on a medium to see that it can receive data at the simplest level. The original intent was to provide the ability to erase the first 30000 sectors of a medium so that it looked like a fresh medium. This is much like a media format preparation.

When defects are detected, cross checking between two different **MOD** disks is suggested. To determine whether the **MOD** drive or disk is defective.

It may be possible to recover a defective **MOD** disk. Defective disks may be cleaned using cleaners designed for cleaning **CD-ROM** disk surfaces. Be careful not to scratch the surface. Else, the **MOD** disk must be replaced.

Defective **MOD** drives must be replaced. Because the drive requires disassembly, cleaning of the optical drive mechanism in the field is not possible.

To test the basic read capability of the drive and media, use the following procedure:

1.) Open an Unix shell and become superuser.

Type: **`su -`**

Type **`#bigguy`** as the password.

2.) Load a expendable **MOD** disk into the drive.

3.) At the prompt type **`zapdmod -do`**

To activate the write mode, you must include a **`-do`** command line switch. The write starts at sector 0 and includes 30000 sectors by default (no switches selected). The writes will be performed in blocks of 64 sectors by default.

4.) Inspect the output.

4.1.3.2 Diagnostic Tools

The following commands can be used to interrogate and test the **SCSI** bus, MO drive and its disk. They must be executed as superuser (root).

---

scsistat

Usage: **`scsistat [-h|-c|-i|-v|-V|-dl|-d #]`** ***`[scsi id(s) to check]`***

`scsistat` with no argument prints out the firmware information for each device on the **SCSI** bus. Alternatively, one may specify any number of devices to be checked on the command line.

`-c #` Perform a configuration check of each specified device.

`-dl` Dump the defective sector list if media in drive.

`-d #` Takes the lower 2 bits of the number and sets the internal debug entry, to increase diagnosis.

-h Causes this message to be printed.

-i Dump the contents of the 'inquiry' packet.

-V Have `scsistat` print it's current version number.

---

scsiha

Usage: **scsiha [-r]*<scsi bus number | full name of the scsi bus vertex>***

scsiha is used primarily to reset the **SCSI** bus through a **SCSI** controller. Controller 0 is attached to the local (OS and application disks) **SCSI** disks used for host computer operation. It's suggested that you do not attempt to reset controller 0 with **CT** application running. Controller 1 is attached to the external **SCSI** devices such as the **MOD** and **CD-ROM**. If you have a Controller 2, it's normally attached to the **DASM**.

-r Used to reset adapter and/or **SCSI** bus

---

lockmod

Usage: **lockmod [-h] [-l] [-f] [-V] *[<devicename>]***

With no arguments, the program unlocks the ***<devicename>*** media.

-I Locks the media into ***<devicename>*** and maintains persistent ownership until a '**lockmod**' command causes release. The process is persistent on a '**lockmod -l**' command making the media inaccessible to other process requests. Upon '**lockmod**' command, the persistent process will release media ownership and the media will become accessible. A FORCE unlock ability is available. Use advisedly. This is an abnormal release method.

-f Forces an extraordinary 'unlock', if the media must be released for some exceptional reason. This will not release a '**lockmod -l**' command locked media.

The default ***<devicename>*** is '**DMOD**'.

---

readmod

NOTICE
Potential for Data Loss if -do switch used

Usage: **readmod [-f devicename] [-k] [-L] \ [-v] [-R [-do]] [-b <blocks>] [-c <count>] [-s <start>] *[-o <filename>]***

This programs reads a range of media and optionally stores the data into an output file that can be used by **zapmod** or **zapdmod**. **devicename** can be PIONEER, DMOD, 0.6GB, 1.2GB, 2.3GB. The '**readmod**' default is 'DMOD'.

-b *<blocks>* The number of blocks to read as a group. The default is 64.

-c *<count>* The total number of blocks to read. The default is 30000.

-s *<start>* The starting block number of the media range to read. The default is 0. The starting sector is defined by **-s ####** and the count by **-c ####** options. The count will limit itself to maximum sectors on media if the limit is exceeded.

-i *<dirpath>* This is used to search a media for JPEG images. The ***<dirpath>*** is the location to receive the images found.

-k Switch tells the programs to "keep going" if there is a fault.

-L Look for `END_BLOCK_ID` to find rollfwd file.

-m	Measure the percentage of the disk written.
-n	Do NOT report BLANK SECTOR occurrences.
-o *<filename>*	This is the destination filename for the data. Used to store the read data into the UNIX file system file
-C	Report all sector addresses in cluster relative notation.
-R	The **-R** switch add a little DOS knowledge about the “boot sector” and about the Archive media LABELs. Performs a ROOT dir recovery process on **DICOM** media. The '-do' switch is needed to effect a change. *Don’t use the -do switch to write to the media.*

---

zapdmod

Usage: **zapdmod [-f devicename] [-do] \ [-b <blocks>] [-c <count>] [-s <start>] [-t] [-r] [-v] \ [-l] | *[-i <filename>]* | *[-fill <val>]***

This program writes zero data or fill options to the media range. devicename can be PIONEER, DMOD, 0.6GB, 1.2GB, 2.3GB. The 'zapdmod' default is 'DMOD'. The 'zapmod' default is 'PIONEER'.

-do	To activate the write mode, you must include a **-do** command line switch. Required to actually overwrite the first <count> blocks of the medium with selected fill data.
-b *<blocks>*	The number of blocks to write as a group. The writes will be performed in blocks of 64 sectors by default. **-b ###** changes
-c *<count>*	The total number of blocks to overwrite. The default is 30000.
-s *<start>*	The starting block number of the media range to overwrite. The default is 0. The starting sector is defined by **-s ####** and the count by **-c ####**. The count will limit itself to maximum media sectors if the medium size limit is exceeded.
-fill *<val>*	The data value used to fill the block. The default is 0. MAX val is 255.
-i *<filename>*	The ***<filename>*** contains the data to be written. The **-i *<filename>*** will use a UNIX file system file as the data to be written. The length must agree with the requested blocking factor size. The blocking factor is 64 sectors or the ***<count>*** whichever is less. Use **readmod -o** … to make the file.
-l	This will fill each sector with a flat dataset starting with 0 through 255, then ramp datasets.
-t	Test the range of sectors requested with write and read and compare byte for byte. Switch tells the program to write, then read, and compare the data
-r	Use a random sector selection in the range of sectors. The coverage using random selection is about 43. The random pattern is different every time.

4.1.3.3 Filesystem Tools

The following commands can be used to interrogate and modify the filesystem, DOS files and **DICOM** files located on a **MOD** disk.

DOS/FAT Filesystem Commands

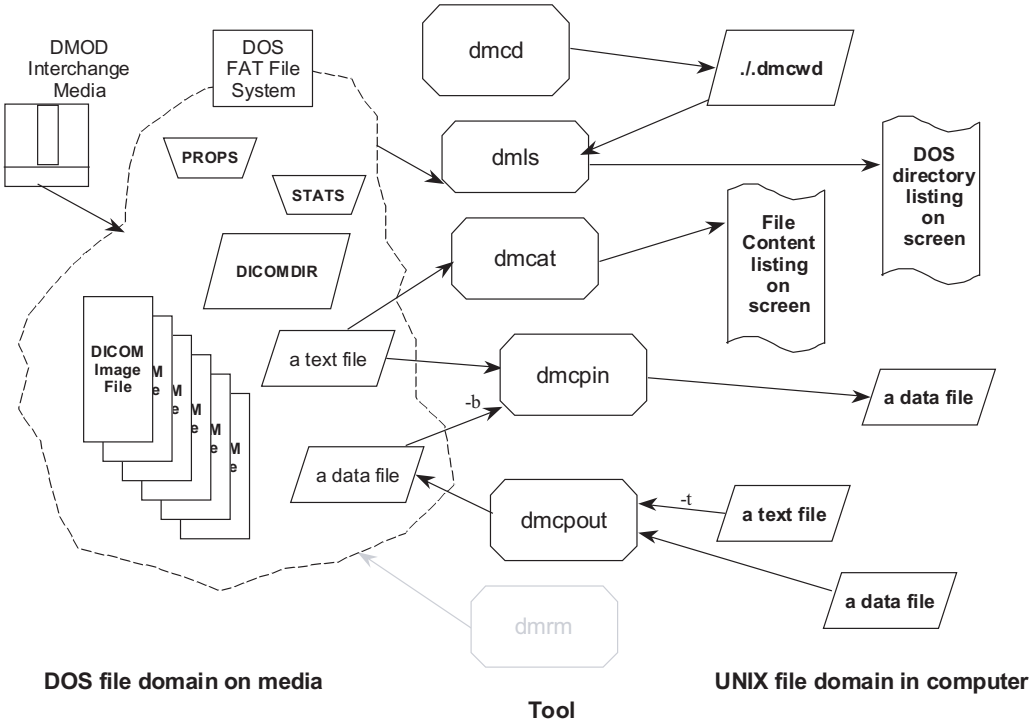


Figure 5-144 DOS/FAT Filesystem Commands - Graphical Overview

DMCD

Usage: **`dmcd [-v] <filename>`**

Performs a “change directory” in the DOS filesystem of the **MOD** media.

DMLS

Usage: **`dmls [-v] [-f devicename] path`**

Performs a “list of file” in the current DOS directory on the **MOD** media.

DMCAT

Usage: **`dmcat [-f devicename] <filename>`**

Performs a “cat of file contents” of a file on the **MOD** media.

DMCPIN

Usage: **`dmcpin [-b] [-d] [-D #] [-f devicename] file destpath`**

Performs a “copy of a file” from DOS filesystem to UNIX filesystem.

DMCPOUT

Usage: **`dmcpout [-t] [-f devicename] file file ... destpath`**

Performs a “copy of files” from the UNIX filesystem to DOS filesystem.

DMRM

Usage: **`dmrm [-f devicename] path`**

Performs a “remove file” from the DOS filesystem on the **MOD** media.

DICOM Filesystem Commands

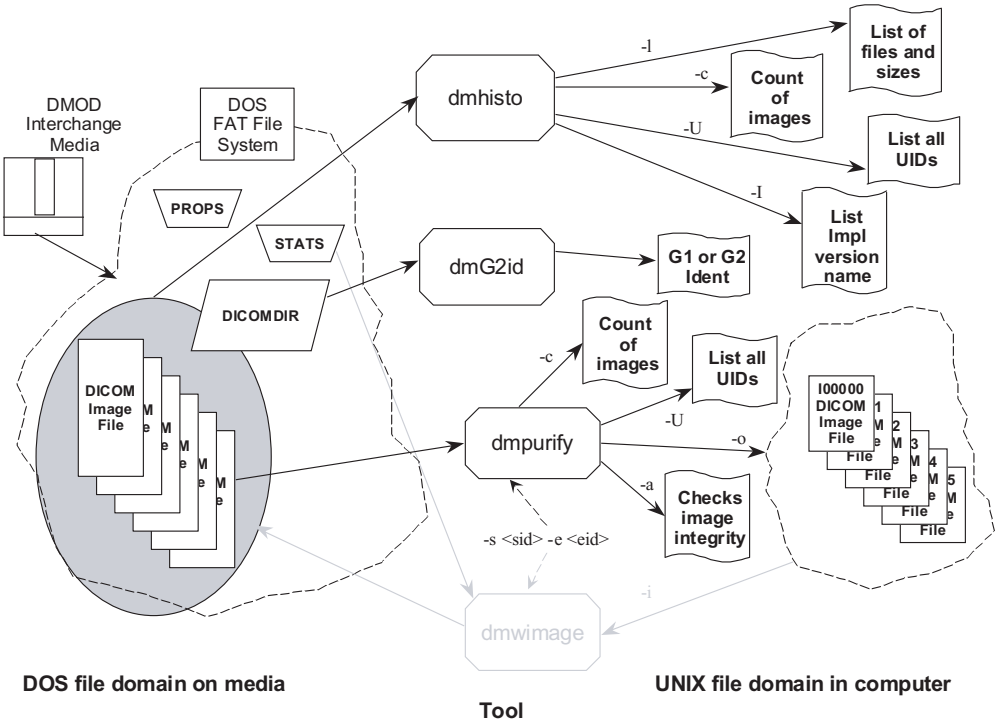


Figure 5-145 DICOM Filesystem Commands - Graphical Overview

dmhisto

Usage: **`dmhito [-c] [-s <binsize>] [-d <debugDMOD>] [-t] [-v] [[-f] <device_id>`**

This program looks at a GEMS **DICOM MOD** and outputs a histogram of file sizes on the media in 1KB per bin. Each bin is a quantity of files.]

-c output the total file count along with the histogram info

-6 output the 6 sigma detailed sizes

-l output the detailed long list of files and sizes

-s sets bin size - default is 1024 resulting in a KB histo chart

-d sets the debugDMOD value - default is 0

device_id default is 'DMOD'

-t turns on some timing information

-v turns on increases the verbosity of the output

dmG2id

Usage: **dmG2id [-d <debugDMOD>] [-c] {-v} *[-f <device_id>***

This program looks at a GEMS **DICOM MOD** and locates the DICOMDIR and searches for the Frame of Reference entry in the file. This FoR only occurs in the Generation 2 **DICOM MOD** and it is the KEY that keeps a G2 media from mounting to a G1 system.]

-D Selects a virtual device name. DMOD is default

-f Selects disk filename.

-d Sets the debugDMOD value - default is 0. `device_id` default is 'DMOD'

-v Increases the verbosity of the output (multiple allowed).

- The verbose of 1 will report record category counts
- The verbose of 2 will report the images that are G2.

-c Reports the number of times FoR was found in DICOMDIR

dmpurify

Usage: **dmpurify [-d <debugDMOD>] [-f <device_id>] [-c] {-v|-U} \ [-s <sfid> [-e <efid>]] [[-g] [-r] -o <output_dir>] \ [[-m] [-a] [-do]**

This program looks at a GEMS **DICOM MOD** and scans that disk for images that have Multiple Fragments. Each of the MFI images can be converted to a Single Fragment image by this routine.]

-d Sets the debugDMOD value - default is 0

Device_id default is 'DMOD'

-f Selects a virtual device name. DMOD is default

-c Reports the number of files and size stats

-v Increases the verbosity of the output (multiple allowed). The -v is used to simply scan the media for MFI's.

-U Don't look for MFIs but simply report UIDs. (g2e2, g2e3, g2e10, g2e12, g8e16, g10e10, g20eD, g20eE, g8e18, g20E52)

-s Sets the starting file identifier number (0=default)

-e Sets the ending file identifier number (lastUsed=default)

-g Grab each file from the media and place it in the output receiver directory defined with -o. This disables end of image testing and allows for the recovery of short images.

-r Use the 'real' file index for the grabbed file (0=default)

-o Output the images that were found on media to this directory pathname as sequentially numbered files.

-a Search for **DICOM** encoding problems in g18e20 and g18e22 tags

-m Search for multi-fragment images (original program purpose)

-do Is required to actually fix the problems and write the results to **MOD**. IF you don't understand, DON'T '-do' IT.

4.1.4 Autovoice/Intercom

4.1.4.1 Autovoice/Intercom Volume

Some of the processing for AutoVoice comes from the host's motherboard. If there is an autovoice problem, you may want to interrupt system boot up **ESC**, Enter Command Monitor, then type:

```
ide audiofield
```

to run diagnostics on the host's audio hardware.

4.1.4.2 Intercom Volume Verification

To adjust the Gantry Speaker volume, adjust the left-most volume thumb-wheel on the keyboard assembly while speaking into the console microphone.

To adjust the Console Speaker volume, adjust the center volume thumb-wheel on the keyboard assembly while speaking into the Gantry microphone.

4.1.4.3 Autovoice Volume Verification

To adjust the Gantry Speaker volume, adjust the right volume thumb-wheel on the keyboard assembly while autovoice is playing, and check the volume for the gantry speaker.

See Figure 5-146, for the normal (default) settings of the software audio panel. This audio panel is displayed on the right-head monitor, in the upper left-hand corner, when Applications is down.

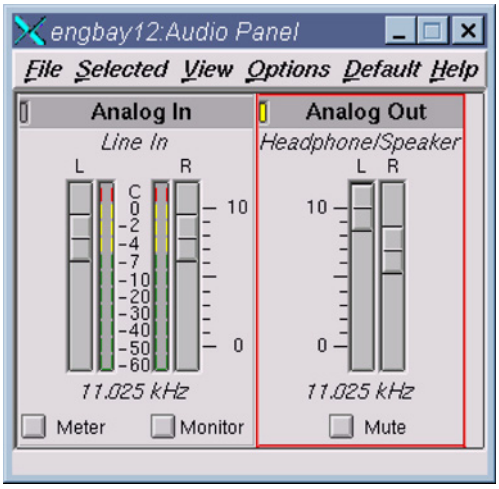


Figure 5-146 Autovoice Control Audio Panel

To adjust the Console Speaker Volume, bring up the Autovoice volume control audio panel.

- Select the OPTIONS pull-down menu.
- Select OUTPUT SLIDERS INDEPENDENT.
- Adjust the RIGHT Channel volume only (Analog Out) — this is the only volume control.
- The LEFT Channel must be kept locked at the maximum.
- The Analog In settings will affect the level of Autovoice record, and if you desire, you can click on the METER selection box to view the recording levels.
- DO NOT turn on the MONITOR selection, as it will cause immediate uncontrollable feedback.
- Select FILE - SAVE when you have finished, to retain your settings.

4.1.5 Console Intercom Board (2167014)

4.1.5.1 Functional Test

Preset Potentiometers

- R3 Max (25 turns) CW,< 10 ohms between pot pins 1 and 3
- R5 Max (25 turns) CW,< 10 ohms between pot pins 1 and 3
- R10 Max (25 turns) CW,< 10 ohms between pot pins 1 and 3
- R100 Set to 150K ohms between pot pins 1 and 3

Power Supply Currents

- +5 vdc supply Less than 1 ma
- +12 vdc supply 120 ma ± 20 ma
- –12 vdc supply 100 ma ± 20 ma

Supply Voltages

- +5 vdc supply ± 0.2 vdc (Across CR3)
- +12 vdc supply ± 0.6 vdc (Across CR2)
- –12 vdc supply ± 0.6 vdc (Across CR1)
- +6 vdc regulator ± 0.4 vdc (Across CR1)
- +5 vdc regulator ± 0.4 vdc (Across CR34)

Logic Tests

The following table shows the operation of the “Talk Button” logic with all ac signal sources removed.

PUSH-BUTTON	J2-3	U9-4 (AV_CNTL)	U4-6 (CON_CNTL)	U9-1 (OC_CNTL)
Open	High	High	Low	High
Close	Low	Low	High	Low

Table 5-47 Talk Logic (2167014) on the intercom Board

AutoVoice Sensing

This test confirms the action of a signal level sensing circuit. The test starts with no signal on J4-2. The DC voltage on TP 3 should be more negative than –5 vdc. The voltage on U9-pin 1 should exceed +3.5 vdc.

Supply a 600 mv ± 10% peak to peak, 1000 Hz sine wave to J4-2 (Auto Voice Left). The DC voltage on TP 3 should exceed +5vdc. The voltage on U9-pin 1 should be less than +0.25 vdc. Reduce signal level to 240mv± 10% peak to peak. J4-2 will change to negative in 2 ± 0.5 seconds.

Gain Tests

The following gain tests are achieved by supplying a 1000 Hz, 100 mv peak to peak sine wave at the specified input with respect to analog ground. Output voltages are measured at the specified connector pin.

- J3-11 (Gantry Microphone Pre-Amplifier) to J2-11 gain = 2.1 ± 10%
- J3-30 (Gantry Microphone Pre-Amplifier) to J2-11 gain = 2.1 ± 10%
- J4-2 (Auto Voice Left to Volume Control) J2-5 Gain = 1 ± 10%
- J4-3 (Auto Voice Right) Gain to TP 2 = 1 ± 10%
- J4-3 (AutoVoice Right) to TP 4 gain =.9 ± 10%, when AV_CNTL is High
- J4-3 (AutoVoice Right) to J2-17 gain = 25 ± 10%, when AV_CNTL is High
- J2-6 (AVVOL.WIPER) to TP 5 gain = 6 ± 10%, when AV_CNTL is High
- J2-9 (PATVOL.WIPER) to TP 5 gain = 10 ± 10%, when CON_CNTL is High
- J2-12 (Patient volume control) to TP 4 gain =.33 ± 10%, when OC_CNTL is High
- J2-12 (Patient volume control) to J2-17 gain = 10 ± 10%, when OC_CNTL is High
- Adjust Potentiometer R3 to Max CCW position.
- J2-12 (Patient volume control) to J2-17 gain = 3.3 ± 10%, when OC_CNTL is High

High Gain Tests

The following gain tests are achieved by supplying a 1000 Hz, 10 mv peak to peak sine wave at the specified input.

- J2-9 (PATVOL.WIPER) to J3-12 gain = 300 ± 10%, when CON_CNTL is High
- J2-6 (AVVOL.WIPER) to J3-12 gain = 190 ± 10%, when AV_CNTL is High
- Adjust Potentiometer R5 to Max CCW position.
- J2-6 (AVVOL.WIPER) to J3-12 gain = 60 ± 10%, when AV_CNTL is High

ALC Test

- Supply a 10 mv peak to peak, 1000 Hz sine wave to J2-15. J2-15 to J2-8 gain = 7.5 ± 20%.
- Supply a 100 mv peak to peak, 1000 Hz sine wave to J2-15. J2-15 to J2-8 gain = 1.5 ± 20%.

4.1.5.2 Potentiometer Settings

• R3	2.k ohms	Console Max Volume
• R5	1.5k ohms	Gantry Max Volume
• R10	500 ohms	Gantry Min. Volume
• R100	150k ohms	AutoVoice Detect delay

4.1.6 Host Media Adapter - CTP100T Coax to 10BASE-T

4.1.6.1 Troubleshooting - Using LANVIEW

The CTP100T adapter uses Cabletron System's built-in visual diagnostic and status monitoring system, LANVIEW. LANVIEW **LED**s are more effective than a network monitor because networking personnel can quickly scan the **LED**s to diagnose network problems and determine which node or segment is faulty.

The following discusses the function and purpose of each CTP100T LANVIEW **LED** shown below.

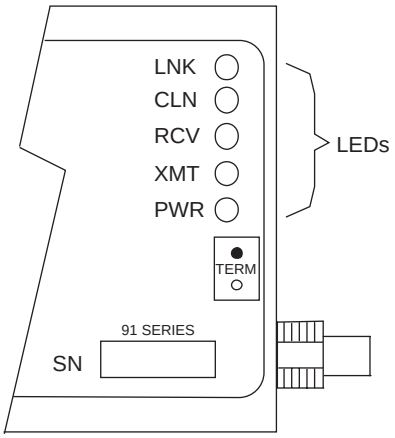


Figure 5-147 LANVIEW LEDs

4.1.6.2 Link OK (LNK) LED

When this green **LED** is ON, a link has been established between the CTP100T adapter and the device at the other end of the twisted pair segment. It remains on as long as the link is maintained.

If no data has been sent for 16 ms, a positive link test pulse of 100 ns is sent onto the transmit link of the twisted pair cable. The link pulses are received by the CTP100T adapter and checked to determine if they are occurring at the correct rate, polarity and pulse shape. If no pulses are received or the pulses are not correct, the transceiver enters the Link Fail State and the **LED** goes off. The CTP100T adapter will not receive or transmit data until the link is restored by receiving a correct link test pulse or a valid packet. If the polarity is reversed on the twisted pair segment receive link, the Link **LED** flashes, indicating that this condition exists. The segment should be removed from the module and the wiring corrected.

4.1.6.3 Collision Present (CLN) LED

This red **LED** flashes when the CTP100T adapter detects a collision condition. The frequency of the flashes may increase as network activity increases, since more collisions are likely to occur. The flash of the **LED** is pulse-stretched for viewing effect. A solid light indicates a jabber condition.

4.1.6.4 Receive (RCV) LED

This yellow **LED** flashes when the CTP100T adapter receives a data packet from the coaxial segment and transmits it on the twisted pair segment. The flash of the **LED** is pulse-stretched for viewing effect. The **LED** flashes when there is traffic on the segment, even if the data is not intended for the devices attached to the twisted pair segment on the other side of the CTP100T adapter.

4.1.6.5 Transmit (XMT) LED

This green **LED** flashes when a data packet is transmitted on the thin-net coaxial segment by the device connected to the CTP100T RJ45 port. The **LED**'s flash is pulse-stretched for viewing effect.

4.1.6.6 Power (PWR) LED

This green **LED** is ON when the CTP100T adapter is receiving power from the external (wall) transformer.

4.1.7 Fast Ethernet Switch - AT-FS705 Series Switch

4.1.7.1 Connectivity Testing

Perform the following steps to test for a valid connection and to confirm correct network operation.

1.) Connect Port 1 and Port 2 of a single switch to two nodes or workstations, and turn on the switch power supply by connecting the AC power cord.

2.) Wait approximately 1-3 seconds for the auto-negotiation process to complete after power-on or after the cables are reconnected.

3.) Check to make sure the Link and other activity **LED**s of both Port 1 and Port 2 are lit.

4.) After confirming that Port 1 and Port 2 are operational, reconnect one of the nodes/ workstations to another port, then repeat this communications test with the switch's remaining ports. Verify the connection in each port by checking the Link and other activity **LED**s.

Note: When testing the cascade port (Port 5), make sure you connect to the proper jack (MDI or MDI-X) according to the type of device you are connecting to the port.

4.1.7.2 Is the Unit Receiving Power?

Check the power (PWR) **LED** on the front of the switch. This green **LED** should be lit.

If the power **LED** is not on, check both ends of the AC power cord. Make sure the power cord is plugged into a functioning outlet and that it is properly inserted into the switch's power connector on the back of the unit.

Note: There is no "power" switch on the AT-FS705 series switches. If the power cord is properly connected, the switch should be receiving power.

4.1.7.3 Is the Link/Activity LED Lit?

The Link **LED** on the front of the switch lights when a proper connection is established. If this **LED** is not lit, check for the problems listed below, and make corrections as necessary.

1.) Problem: The cable has been cut, damaged, or is the wrong type of cable.

Solution: Try making the connection with a different cable. Be sure you are using an undamaged cable of the correct type.

2.) Problem: Connected equipment is not turned on or not operating properly.

Solution: Check connected equipment (computer, another switch, etc.) and turn on power.

3.) Problem: For Port 5, the device is connected to the wrong jack (MDI/MDI-X).

Solution:

a.) When cascading two switches, the unit using the cascade port (Port 5) should use the MDI jack, while the other unit should use its MDI-X jack.

b.) When Port 5 of the switch is not connected to another switch but is used to connect to a workstation or other equipment, you should use the MDI-X jack.

4.) Problem: There is data loss between the switch and one of the attached network nodes.

Solution:

a.) Make sure that the distance between the switch and the connected network device is no greater than 100 meters.

b.) Make sure you are using Category 5 cable.

4.1.8 DASM

4.1.8.1 DASM Diagnostics

```
diagnostic(s): (OC) hinv, scsistat, showdasm, clrsp, rqs, rsp
error log(s): (OC)
```

The **DASM** runs a power up **self-test** as well as an idle test loop (heartbeat) when on. See the manual that comes with all **DASM**s for more info on **LED** error status and heartbeat indications. When the **DASM** is failing, its middle two **LED**s flash an error code, after all **LED**s are momentarily flashed ON.

There is an application utility called **`showdasm`** that can be run from any shell to check basic communications with the **DASM** by retrieving its configuration. Note however that while there are active filming jobs, **`showdasm`** *will fail* with an “open failure” because the **DASM** device is opened exclusively by the filming print filter/manager.

A **SCSIbus0 reset popup ALERT** message is a clear indication of a physical **DASM** problem/failure. This SCSIbus0 channel is dedicated to the **DASM**. The components in this chain include:

- **DASM**
- **SCSI** cable (**SGI** carrier to **DASM**)
- **SCSI** terminator module (on **DASM**)
- **LED**/switch/**SCSI** PWA inside **SGI** carrier
- SCSIbus0 ribbon cable inside **SGI** carrier
- Ribbon-to-IP22 PWA inside **SGI** carrier
- IP22 motherboard (contains **SCSI** controller/termination)

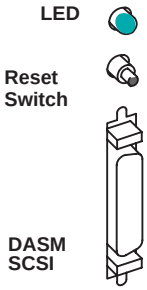


Figure 5-148 DASM LED, Reset Switch and SCSI Connector

Sometimes after a filming and/or **SCSIbus problem**/error, the **DASM** device can be confused and/or out of synchronization with the host **SCSI** driver and/or platform **DASM** manager. Usually a second or third attempt at running **`showdasm`** will re-synchronize **SCSI** communications.

While the **Analog DASM** is in its idle test/loop or when an image has been sent to the **DASM**, the Video Output should have either a continuously changing pattern or the last image sent. This may be checked for the Analog **DASM** by connecting a short piece of coaxial cable from the **DASM** Analog Video Output connector to the Green Video input on one of the display monitors, after disconnecting the MG Video Input cables.

WHERE FILMING ERRORS ARE LOCATED

To investigate a filming problem, look at the following logs:

`/usr/g/service/log/gessy*.log`

`/var/adm/SYSLOG*`

`/usr/g/ctuser/logfiles/prslog`

4.1.8.2 DASM LEDs

Make sure the **DASM** power is applied (green power **LED**) and that the **DASM** power-up self-test completes successfully (flashing green **CPU LED** indicates idle heartbeat).

On analog VDB **DASM** only, the “RDY” and “XFR” **LED**s should toggle back and forth when filming is running. This toggling indicates that film sheet images are being output by the **DASM** (“RDY”) and then captured by the camera video/analog input port (“XFR”).

4.1.8.3 Checking DASM SCSIbus Connection & Basic DASM Operation

A.) Use **`hinv`** to check that the **DASM** was present at the last OC boot-up. The **DASM** looks like a disk drive to the Irix OS.

DASM LINE FROM `hinv` OUTPUT:

```
(other output)
Disk drive: unit 1 on SCSI controller 1
(other output)
```

B.) Use **`scsistat`** to perform a “live” SCSIbus probe for the **DASM** device. Analog VDB and digital **LCAM** are shown separately, and the **DASM** firmware revisions should be as shown.

ANALOG VDB LINE FROM `scsistat` OUTPUT:

```
(other output)
Device 1 1  Disk     CDA      DASM-VDB         FW Rev: 1.0e
(other output)
```

DIGITAL LCAM LINE FROM `scsistat` OUTPUT:

```
(other output)
Device 0 1  Disk      ANALOGIC DASM-LCAM-3M     FW Rev: 1.3
(other output)
```

C.) Use **`showdasm`** to perform an extended inquiry from the **DASM** device. You must be 'root' with `ctuser` environment, as shown below, and the filming queue MUST be empty or fully paused or the **`showdasm`** will fail.

```
{ctuser@rhapby18}[1] showdasm
Could not initialize_scsi status = ffffffff
{ctuser@rhapby18}[2] su ENTER
Password:
```

```
{ctuser@rhapby18}[1] showdasm
Vendor: CDA  Device: DASM-VDB
Pif software rev: 1.0e  Krnl_rev: 2.1j
DRAM size: 1MB  SRAM size: 32KB I/O blocks: 2048  block size: 512
SCSI ID: 1   CMDBLK addr: 200000 Baud: 1200  RS232 ctl reg: hex 8e
Eprom checksum: hex 0038f90f       Internal checksum: hex 0038f770
RS232 Disabled DBUG Disabled           Power-on RAM tests Disabled
{ctuser@rhapby18}[2]
```

Any SCSIbus or device related errors will be logged to the shell window you're using, the OC console shell window, and will also be saved in the OC `/var/adm/SYSLOG*` Irix system log. The **DASM** device is `/dev/dasm1`, which is linked to `/dev/scsi/sc1d1l0` (Octane).

If the above functions work, the **DASM** power, SCSIbus connections, and the host side **DASM** operation are all working properly. If not, you may have a problem with 'reconfig' (camera option, **DASM** type, etc.), **SCSI** cabling, or the **DASM** (it's usually NOT the **DASM**). Make sure

you '**su**' from the '`ctuser`' shell and that the filming queue is empty or fully paused or the **scsistat** will show `EXCLUSIVELY OPEN` for the **DASM** line, and the **showdasm** will fail to open the **DASM** device, due to incorrect device permissions and environment variables.

4.1.8.4 DASM Status File

The **LCAM** Status file is used for ALARMS, ERRORS and other messages from the laser camera. Here are the error codes from `lc_msg_data.h`:

```
/*.......................str.................,num,sev*/
/* Status codes */
  ""                                          ,0,0,
  "1 Camera Is Ready"                         ,1,0,
  "2 Acquiring an image"                      ,2,0,
  "3 Opening the magazines"                   ,3,0,
  "4 Removing a film from supply magazine"    ,4,0,
  "5 Moving film to exposure area"            ,5,0,
  "6 Exposing film (no other operations can be performed)",6,0,
  "7 Closing the magazines"                   ,7,0,
  "8 Moving film to film processor"           ,8,0,
  "9 Unassigned status code"                  ,9,0,
/* Recoverable Alarm codes */
  "10 Supply Magazine Empty"          ,PRS_MEDIA_SUPPLY_EMPTY,ERR_FATAL,
  "11 Receive Magazine Full"          ,PRS_MEDIA_RECEIVE_FULL,ERR_FATAL,
  "12 Supply Magazine Full"           ,PRS_MEDIA_SUPPLY_MISSING,ERR_FATAL,
  "13 Receive Magazine Missing"       ,PRS_MEDIA_RECEIVE_MISSING,ERR_FATAL,
  "14 Supply Drawer Open"             ,PRS_MEDIA_SUPPLY_OPEN,ERR_FATAL,
  "15 Receive Drawer Open"            ,PRS_MEDIA_RECEIVE_OPEN,ERR_FATAL,
  "16 Top Cover Open"                 ,PRS_TOP_COVER_OPEN,ERR_FATAL,
  "17 Film Processor Not Ready"       ,PRS_FILM_PROCESSOR_NOT_READY,ERR_FATAL,
  "18 Docking Unit Not Ready"         ,PRS_DOCKING_UNIT_NOT_READY,ERR_FATAL,
  "19 Unassigned alarm detected"      ,PRS_UNDEFINED_ALARM_CODE_19,ERR_FATAL,
  "20 Film Transport Error..."        ,PRS_FIRST_FEED_ERROR,ERR_FATAL,
  "92 Camera Interface On Line ?"     ,PRS_CAMERA_MMU_NO_RESPONSE,ERR_FATAL,
  "99 MMU timer started (952)"        ,99,0,
/* Status codes */
  "200 Camera Interface On Line ?"            ,PRS_DASM_COMM_ERROR,ERR_FATAL,
  "201 Can't allocate camera after 15 mn Trying...",PRS_PRINTER_BUSY_TIMEOUT,0,
  "202 Your Film Was Queued Trying To Allocate Camera...",PRS_FILM_QUEUED,0,
  "203 Film Low..."                           ,PRS_MEDIA_SUPPLY_LOW,0,
  "204 Print Paused..."                       ,PRS_PRINT_PAUSED,0,
  "207 Camera Is busy at This Time Print Paused...Restart",PRS_PRINTER_BUSY,0,
 "208 Can't Process Print Request at This Time Print Paused...Restart"
,PRS_BAD_PARAM,ERR_FATAL,
  "209 Time_out Print ...Restart"             ,PRS_PRINT_CYCLE_TIMEOUT,0,
  "210 Failed acquire "                       ,PRS_FAILED_ACQUIRE,ERR_FATAL,
  "212 Unsupported Format"                    ,212,0,
  "301 OK"                                    ,PRS_STATUS_OK,0,
  "Unknown Error returned"                    ,LAST_LC_MSG,0
```

4.2 SRU - H3 & GC-Oct2 Consoles

4.2.1 Reconstruction Interface Processor (RIP)

4.2.1.1 Diagnostic Tests Overview

The Reconstruction Interface Processor (**RIP**), or Motorola Board, has built-in diagnostic routines that are executed by running either of two executable diagnostic scripts. These scripts are `diags` and `fulldiags`, and are called from a UNIX Shell window.

The `diags` test is a short board level diagnostic test (approximately 1 minute), and the `fulldiags` test is a longer test that performs more extensive, lower level testing of the board's **RAM** and VME3 channels (approximately 6 minutes). These executable scripts are located in the `/usr/g/ice/bin` directory of the OC - Octane.

Starting the diagnostic will reboot the Motorola Board into a diagnostics mode. When the tests are completed, the script will automatically return to the Octane `ctuser` prompt at the `/usr/g/ice/bin` directory level.

Note: Because the **RIP** Board is rebooted when these tests are launched, you must shut down Applications before running either of these tests.

4.2.1.2 Diagnostic Test Execution

Perform the following steps to launch either the short or long Motorola diagnostic tests:

1.) Perform an Application Shutdown.
   a.) Click on the SERVICE DESKTOP.
   b.) Click on the UTILITIES icon.
   c.) Click on APPLICATION SHUTDOWN.
2.) Open a UNIX Shell.
3.) Change directory to `/usr/g/ice/bin`.
   At the ctuser prompt, type:
   `cd /usr/g/ice/bin` **ENTER**
4.) Launch either the short or long **RIP** diagnostic test.
   At the ctuser prompt, type:
   `ice diags` **ENTER**
   or
   `ice fulldiags` **ENTER**
   Each test starts **RIP** diagnostic testing at the **VME** `PPC1-Diag>` prompt level. Verify that all tests listed result in either a `PASSED` or `BYPASS` indication. The `diags` test takes approximately 1 minute to complete, and the `fulldiags` test takes approximately 6 minutes to complete. When the test routines complete, the routines automatically return the system to the ctuser prompt at the `/usr/g/ice/bin` directory.
5.) Close the Shell.
   At the ctuser prompt, type:
   `exit` **ENTER**
6.) Restart Applications.
   At the ctuser prompt, type:
   `st` **ENTER**

4.2.2 Scan Data Disk and SCSI Controller (Disk Subsystem)

4.2.2.1 Diagnostic Testing Overview

The disk subsystem should work correctly, if it passes the tests described in the sections that follow. Three simple questions are answered:

1.) Is the disk subsystem hardware recognized by the **RIP** "**CPU**"?

2.) Does the **RIP**'s operating system ("Vx Works") recognize the hardware as a disk subsystem?

3.) Can data be reliably written and read from the disk subsystem?

Because of the tight linkage between a **SCSI** controller and a single disk drive, the tools used to identify and resolve problems are similar.

Note: Before executing any of the VxWorks software commands, it's highly recommended that **CT** applications be shutdown. There is a potential for **CT** Applications to become inoperable as a result of the system commands you execute, thus requiring a restart anyway.

4.2.2.2 Recognition of SCSI Controller Hardware by the RIP Board

Verify the **RIP** board is able to identify the existence of the **SCSI** card. Perform the following steps to verify that the **SCSI** Board is being recognized by the Operating System:

1.) Shutdown Applications:

a.) Click on the SERVICE DESKTOP.

b.) Click on the UTILITIES icon.

c.) Click on APPLICATION SHUTDOWN.

2.) Connect to **ICE** Box (**RIP** Board), using one of the following methods.

Serial Connection:

a.) Open a Unix shell (as `ctuser)`

b.) Type the following at the command prompt: **`ice stop start connect`** **ENTER**

Network Connection:

a.) Open a Unix shell and become root: **`su -`** **ENTER**

b.) Enter password: **`#bigguy`** **ENTER**

c.) Remote login into **ICE** box: **`rlogin ice`** **ENTER**

3.) Execute the VxWorks command to view the **PCI** Devices information:

`-> pciDeviceShow` **ENTER**

The system will provide a text output page similar to the following:

```
-> pciDeviceShow
Scanning function 0 of each PCI device on bus 0
Using configuration mechanism 1
bus       device    function  vendorID  deviceID  class
00000000  00000000  00000000  00001057  00004801  00060000
00000000  0000000b  00000000  000010ad  00000565  00060100
00000000  0000000d  00000000  000010e3  00000000  00068000
00000000  0000000e  00000000  00001011  00000009  00020000
00000000  00000010  00000000  00001000  0000000f  00010000
00000000  00000011  00000000  00000001  00000001  00ff0000  <-- SCSI bd
value = 0 = 0x0
```

In the above example, the line of information in the printout (as marked) identifies the **SCSI** Board, and shows that it is properly recognized by VxWorks

4.) Exit VxWorks and return to the Octane ctuser prompt. At the VxWorks prompt, type the following to end a serial connection: **`~.`** **ENTER**

5.) The **SCSI** controller must be listed above in order to be recognized by the **RIP** board. If not, you most likely have a defective **SCSI** controller or **PCI** interface (**RIP** board). If recognized, proceed to next check (Section 4.2.2.3).

4.2.2.3 Recognition of SCSI Disk Subsystem by the Operating System

The operating system must see the existence of a **SCSI** disk drive, before software support is loaded. Perform the following steps to verify that the **SCSI** Board and disk properly recognized.

1.) Shutdown Applications:
   a.) Click on the SERVICE DESKTOP.
   b.) Click on the UTILITIES icon.
   c.) Click on APPLICATION SHUTDOWN.

2.) Connect to **ICE** Box (**RIP** Board), using one of the following methods.

   SERIAL CONNECTION:

   a.) Open a Unix shell (as `ctuser`)
   b.) Type the following at the command prompt: **`ice stop start connect`** **ENTER**

   NETWORK CONNECTION:

   a.) Open a Unix shell and become root: **`su -`** **ENTER**
   b.) Enter password: **`#bigguy`** **ENTER**
   c.) Remote login into **ICE** box: **`rlogin ice`** **ENTER**

3.) Execute the following VxWorks command to list **SCSI** devices recognized by the operating system:

   `-> scsiShow` **ENTER**

   The system will provide a text output page similar to the following, depending on the make and model of disk drive recognized. *A disk drive must be listed, regardless of make and model.*

SEAGATE ST318404LW MODELS:

```
ID LUN VendorID    ProductID      Rev. Type  Blocks  BlkSize pScsiPhysDev
-- --- -------- ---------------- ---- ---- -------- ------- ------------
 1  0  SEAGATE  ST318404LW       0002   0  35843670    512    0x017dda88
value = 0 = 0x0
```

SEAGATE ST318451LW MODELS:

```
ID LUN VendorID    ProductID      Rev. Type  Blocks  BlkSize pScsiPhysDev
-- --- -------- ---------------- ---- ---- -------- ------- ------------
 1  0  SEAGATE  ST318451LW       0003   0  35843671    512    0x01bddb18
value = 0 = 0x0
```

4.) Inspect the output of the **`scsiShow`** command. Is a disk drive listed in the output? If no, the **SCSI** controller, cable or disk drive may be defective. You must correct this problem before proceeding. If listed, proceed to next check (Section 4.2.2.5)

5.) Exit VxWorks and return to the Octane ctuser prompt. At the VxWorks prompt, type the following to end a serial connection: **`~.`** **ENTER**

4.2.2.4 Recognition of the Disk File system by the Operating System

There must be a file system on the disk drive. The file system on the disk is created during a software load. A file system must exist for **CT** applications to operate correctly. In the following check, you will very the existence of that file system.

1.) Shutdown Applications:
   a.) Click on the SERVICE DESKTOP.
   b.) Click on the UTILITIES icon.
   c.) Click on APPLICATION SHUTDOWN.

2.) Connect to **ICE** Box (**RIP** Board), using one of the following methods.

   SERIAL CONNECTION:
   a.) Open a Unix shell (as `ctuser`)
   b.) Type the following at the command prompt: **`ice stop start connect`** **ENTER**

   NETWORK CONNECTION:
   a.) Open a Unix shell and become root: **`su -`** **ENTER**
   b.) Enter password: **`#bigguy`** **ENTER**
   c.) Remote login into **ICE** box: **`rlogin ice`** **ENTER**

3.) Execute the following VxWorks command to preform a listing of the directory `raw_data`:
   `-> ls "/raw_data"` **ENTER** (*remember to include the quotes)*

4.) You should get a listing of the directory `raw_data`, if it exists.

```
/raw_data/info_file
/raw_data/recovery
/raw_data/ex163.CT18.1003803242.952008
/raw_data/ex171.CT18.1003832725.458539
```

5.) Inspect the screen output.
   - If the "**`ls`**" command lists the contents of the `raw_data` directory, you're done and everything is okay. Proceed to the next check (Section 4.2.2.5)
   - If you receive `file not found` or some other error message, the directory is defective.

4.2.2.5 Testing for Reliable Disk Subsystem Operation

To test the reliability of the disk subsystem (**RIP** Board, **SCSI** Controller, and Scan Data Disk), preform the following test:

1.) Shutdown Applications:
   a.) Click on the SERVICE DESKTOP.
   b.) Click on the UTILITIES icon.
   c.) Click on APPLICATION SHUTDOWN.

2.) Open a UNIX Shell.

3.) Serial connect to the VxWorks prompt.
   At the Octane ctuser prompt, type:
   `ice stop start connect` **ENTER**

4.) Launch the Scan Data Disk test:
   `->` **`test_high_speed`** **ENTER**
   The system will proceed to transfer data to and from the Scan Data Disk. If any errors are detected, they will be displayed on the terminal screen. If the test runs to completion without error, you can be assured that the Scan Data Disk, **SCSI** Controller, and **RIP** Board are

capable of performing acceptably well to handle the scan data save and restore operations that are utilized during normal scanning.

5.) Exit VxWorks and return to the Octane ctuser prompt. At the VxWorks prompt, type:

-> **~. ENTER**

4.2.3 PMC DIP Board

4.2.3.1 System Op. Errors Commonly Associated with the DIP Bd

The **RIP** board is a common place for san data acquisition system errors to be logged and reported. Scan data acquisition errors are reported to the **RIP**, using interrupts, real-time. This section attempts to sort out those failures so that the failing subsystem can be correctly identified.

Failures can occur almost anywhere along the scan data acquisition chain, including the **DIP** and **RIP** board. Error detection and correction schemes built into slip ring communications (**SRC**) are the first level of defense. To prevent lost/missing and/or corrupt data from being processed.

The first step is to identify the failing subsystem. Failures common to the **SRC** subsystem are **FEC** errors, serial data modem violations and view length errors. If you receive any of these errors, the **SRC** subsystem should be thoroughly checkout first. If you receive data checksum or parity errors error messages, then the **DIP** and **RIP** board (**ICE** box subsystem) should be thoroughly tested.

Common SRC Errors

FORWARD ERROR CORRECTION (FEC) ERROR

FEC protects the integrity of the link between the **DAS DCB** and the **DIP**. Without any form of error correction, the system bit error rate is 10-12. This translates to a data error every one week of scanning. With **FEC**, the not correctable failure rate is reduced to 10-15 or a data error every 6 years. Therefore **FEC** virtually eliminates the possibility of a data error between the **DCB** and the **DIP**. In addition, the **FEC** on board the **DIP** will maintain a running count in the board status register, per scan, of the number of corrected bit errors. This register is readable from the **RIP** and can be used to maintain statistics and indicate potential problems.

SERIAL DATA MODEM VIOLATION

A SERIAL DATA modem violation is a very basic failure of the communication link, indicating that the link has broken.

VIEW LENGTH ERROR

A view length error is another very basic failure of the communication link, indicating lost data and that the link has been broken.

Common PCI Interface Errors

SRC errors indicate problems with the **DAS** to **DIP** communication link, not the **DIP** or the **DIP** to **RIP** interface. Since the **PCI** bus link in the **ICE** box is orders of magnitude more reliable than the **SRC** path, error correction is not used. However, error detection is used with the **RIP**'s **PCI** interface to the **DIP** board. The following errors indicates a detection problem in either the **DIP** or the **RIP** board.

DATA CHECKSUM ERROR

A checksum for each view is generated by the **DCB** (in the **DAS**) and stored in the view data. View data is stored on the scan data disk by the **DIP** and **RIP**. The checksum is tested when view data is restored from disk. Any failure that generates a checksum error should have also generated one

of the above mentioned **SRC** errors. If not, the error could have only occurred on the **DIP** board or during the transfer of data from the **DIP** to the **RIP**.

PARITY ERROR

The **PCI** interface uses parity error detection. A parity bit is generated for each scan data word transmitted across the **PCI** interface between the **DIP** and the **RIP**. Hardware on board the **RIP** checks parity and produces an abort condition when an error is detected. A parity error can only occur during the transfer of data from the **DIP** to the **RIP**.

Common DIP Board Errors

To isolate the **DIP** from the **RIP** board as the failing, the following should be done:

1.) **View the system error log**. **FEC**, serial data modem, or view length errors indicate a **DAS** to **DIP** error, not a **DIP** failure. **PCI** parity errors indicate a **DIP** to **RIP** error. Data checksum errors indicate a **DIP**, **RIP** or possibly a scan data disk error.

2.) **Run DIP BLDs**. These tests will run known data patterns through the **DIP** at full data rates, indicating problems on board the **DIP** or the **DIP** to **RIP** interface.

3.) **Run the system data path tests**. These tests will run known data patterns from the **DAS** to the **RIP**, through the **DIP** at full data rates. By monitoring the system error log as mentioned above, more information can be gathered to determine the failing **FRU**.

4.2.3.2 Diagnostic Tests Overview

If the **DIP** and **RIP** boards are to work correctly, they must be able to communicate reliably. Three simple questions must be answered first:

1.) Is the **DIP** board recognized by the **RIP** "**CPU**"?

2.) Can data be transferred from the **DIP** to the **RIP** board reliably?

3.) Is data received reliably from the slipring?

4.2.3.3 Recognition of DIP Board by the RIP

Performing the following steps to determine whether the **RIP** Board (VxWorks) sees the existence of the **DIP** Board through the **PCI** interface.

1.) Shutdown Applications:

   a.) Click on the SERVICE DESKTOP.

   b.) Click on the UTILITIES icon.

   c.) Click on APPLICATION SHUTDOWN.

2.) Open a UNIX Shell.

3.) Serial connect to the VxWorks prompt.

   At the Octane ctuser prompt, type:

   `ice stop start connect` **ENTER**

4.) Execute the VxWorks command to view the **PCI** Devices information:

   `-> pciDeviceShow` **ENTER**

5.) Inspect the screen output. Verify the **DIP** board is recognized by the **RIP** through its **PCI** interface.

```
Scanning function 0 of each PCI device on bus 0
Using configuration mechanism 1
bus       device    function  vendorID  deviceID  class
00000000  00000000  00000000  00001057  00004801  00060000
00000000  0000000b  00000000  000010ad  00000565  00060100
00000000  0000000d  00000000  000010e3  00000000  00068000
00000000  0000000e  00000000  00001011  00000009  00020000
00000000  00000010  00000000  00001000  0000000f  00010000   <-- DIP bd
00000000  00000011  00000000  00000001  00000001  00ff0000
value = 0 = 0x0
```

In the above example, the last line of information in the printout (as marked) identifies the **DIP** Board, and shows that it is properly recognized by VxWorks

6.) Exit VxWorks and return to the Octane ctuser prompt. At the VxWorks prompt, type:
`-> ~.` **ENTER**

4.2.3.4 Testing DIP Board Functionality (DIP Diagnostics)

Diagnostics for the **DIP** board are located on the Service Desktop, under the Diagnostics Menu. There are two types of test selections available (quick and extensive), and two sources of data (internal loopback and external loopback).

If you wish to perform the external loopback tests, you will need to loop back data between the fiber-optic jacks (J2 and J3) on the **DIP** board. A suggested cable for this purpose is the fiber-optic cable used to connect the **DCB** to the slip ring transmitter. (Fiber-optic Cable Part Number is 2293408.)

1.) Click on the SERVICE DESKTOP.
2.) Click on the DIAGNOSTICS icon.
3.) Click on DIP DIAGNOSTICS.

A diagnostic **GUI** will appear on the console that will allow you to select the testing mode and the loopback mode. See Figure 5-149. If you select “external” for the loopback mode, a separate window will pop-up, reminding you of the need to install an external fiber-optic jumper.

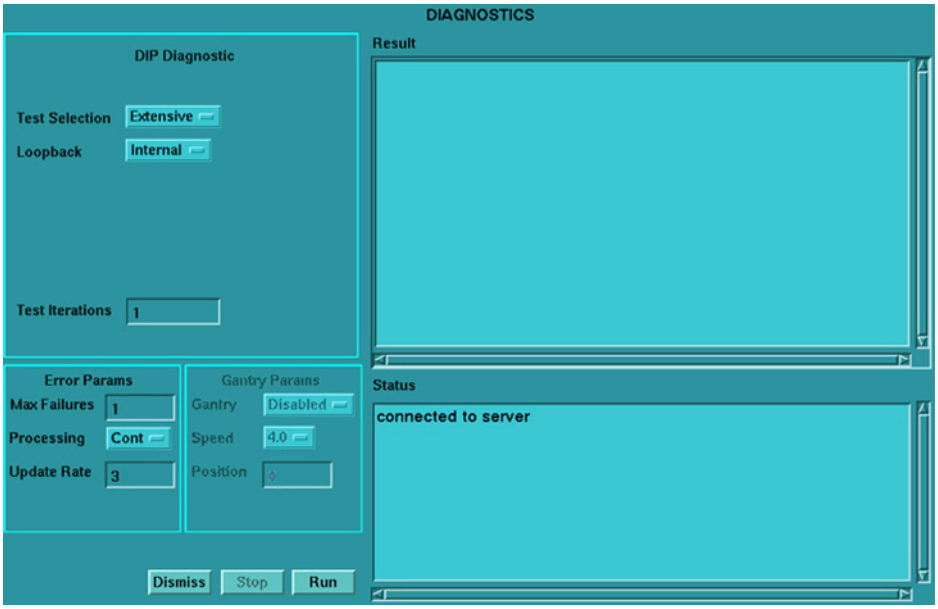


Figure 5-149 DIP Diagnostics GUI

4.2.4 Pegasus Image Generator Board (PEG-IG, PIG)

4.2.4.1 Diagnostic Overview

There are two (2) levels of Pegasus diagnostics:

- **Low level board diagnostics** - run from the service browser with applications shutdown. Used to test the functionality of the Pegasus board specifically.
- **High level Recon Data Path tests** - run from the service desktop at applications level. Tests the ability of the Pegasus board to communicate and operate with the rest of the system.

4.2.4.2 Low Level Board Diagnostics

TEST PROCEDURE

1.) On the `Service Desktop` page, click UTILITIES (circular button at the top menu bar), then click `Application Shutdown` in the left menu column. Wait for the "`Attention`" window to disappear and then open a shell. Within that shell, execute the following command to start the service browser (See Figure 5-150):

> **`service_browser`** **ENTER**

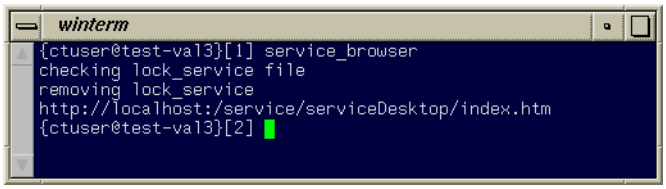


Figure 5-150 Initiating the Service browser

2.) With the service browser displayed, select the `Diagnostics` TAB (See Figure 5-151).

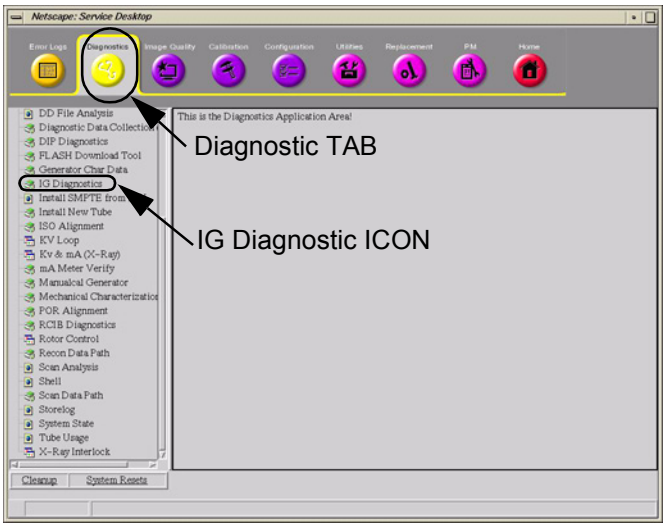


Figure 5-151 Service Browser - Diagnostic TAB

3.) Within the Diagnostic TAB, select the `IG Diagnostic` ICON in the file list menu on the left, by clicking on it. The **IG** Board level Diagnostic screen appears. (See Figure 5-152)

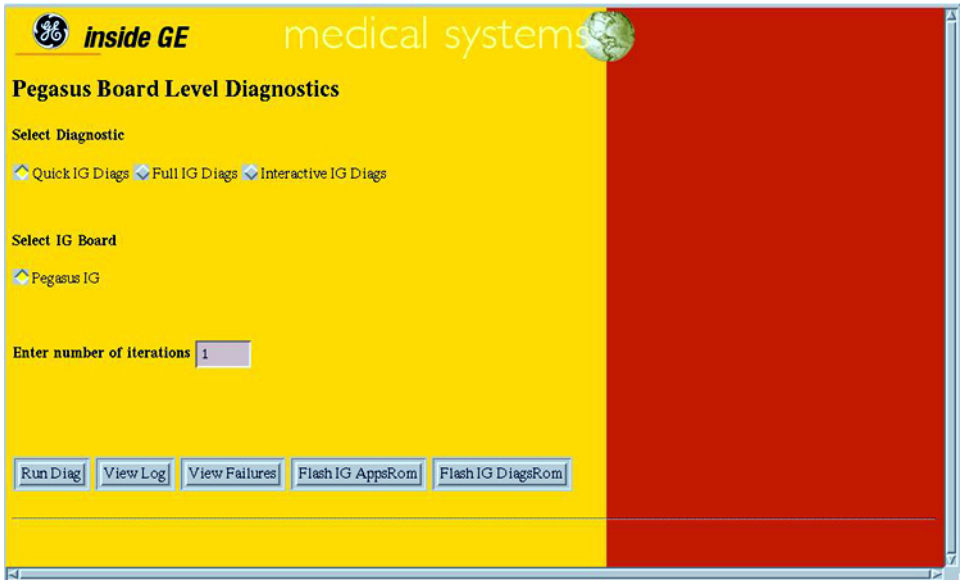


Figure 5-152 IG Board Level Diagnostic Screen

4.) Select either `Quick IG Diags` or `Full IG Diags` and `Enter number of iterations`.

5.) Select RUN DIAG. A shell window will open and the results of each test is displayed on-screen. See Figure 5-154 and Figure 5-155. When testing has completed, close the shell window before attempting to run any other tests.

6.) To exit testing, close all diagnostic windows. See Figure 5-157.

4.2.4.3 Tool Errors & Usage

Tool Errors

On rare occasions, diagnostic tests may fail to execute or an error message will be displayed. Pre-form the following

1.) Close all open shell windows created by executing RUN DIAG. Diagnostics will not run with multiple windows opened by Run Diag.

2.) Shutdown console, restart and then re-run **IG** Diagnostics. On rare occasions, run diags cannot allocate the OS system resources necessary to execute diagnostics. When this occurs, you will see multiple `PTY` (pseudo TTY) errors reported.

None of the items identified above are related to the operation of the **PEG-IG** board. They're only related to the operation of the diagnostic tool itself.

Tool Usage

RUN DIAG is used to initiate the diagnostics chosen. Select RUN DIAG to begin test execution according to the parameters selected. First, select the diagnostic. Next, select the **IG** Board to be tested, Finally, enter the number of test iterations (1 is the default) desired.

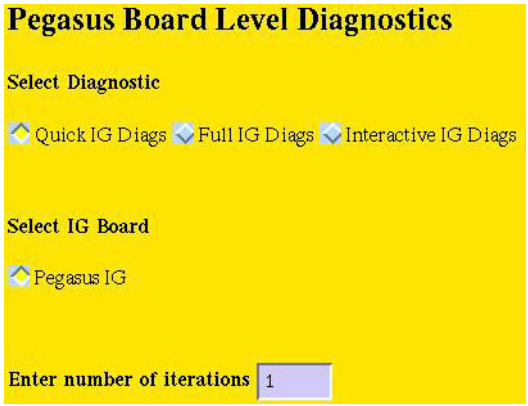


Figure 5-153 Board Level Diagnostic Parameters

A new window is displayed (spawned) with output from the test selected displayed.

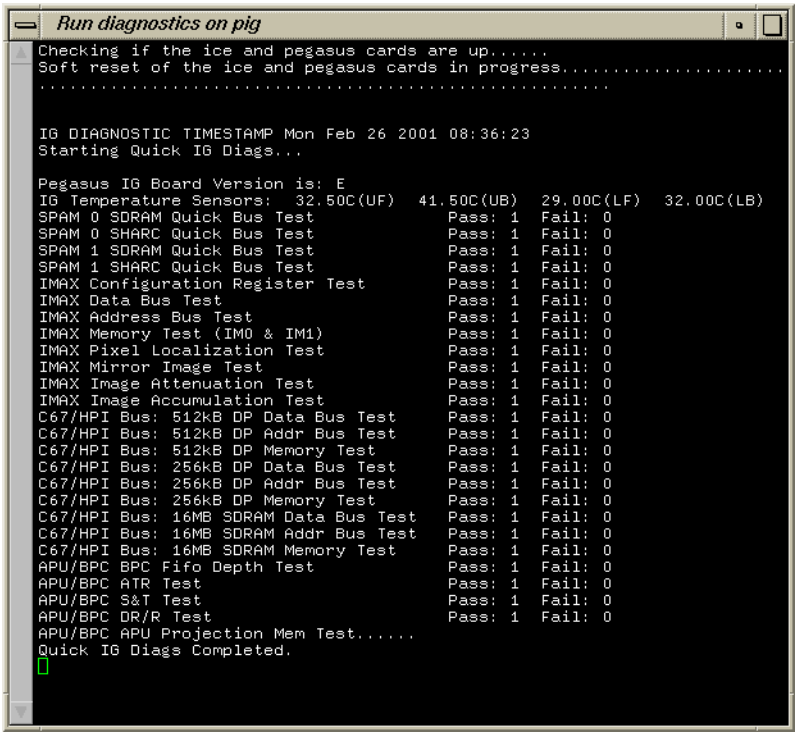


Figure 5-154 Quick Diags Screen

```
Run diagnostics on pig
Checking if the ice and pegasus cards are up...
IG DIAGNOSTIC TIMESTAMP Mon Feb 26 2001 08:27:47
Starting Full IG Diags...

Pegasus IG Board Version is: E
IG Temperature Sensors:  32.00C(UF)  42.00C(UB)  28.50C(LF)  30.50C(LB)
SPAM 0 SDRAM Quick Bus Test            Pass: 1  Fail: 0
SPAM 0 SHARC Quick Bus Test            Pass: 1  Fail: 0
SPAM 0 SHARC Host Bus Memory Test      Pass: 1  Fail: 0
SPAM 0 SDRAM Memory Test............   Pass: 1  Fail: 0
SPAM 0 PowerPC Collision Tests         Pass: 1  Fail: 0
SPAM 0 SHARCs Collision Tests          Pass: 1  Fail: 0
SPAM 1 SDRAM Quick Bus Test            Pass: 1  Fail: 0
SPAM 1 SHARC Quick Bus Test            Pass: 1  Fail: 0
SPAM 1 SHARC Host Bus Memory Test      Pass: 1  Fail: 0
SPAM 1 SDRAM Memory Test............   Pass: 1  Fail: 0
SPAM 1 PowerPC Collision Tests         Pass: 1  Fail: 0
SPAM 1 SHARCs Collision Tests          Pass: 1  Fail: 0
IMAX Configuration Register Test       Pass: 1  Fail: 0
IMAX Data Bus Test                     Pass: 1  Fail: 0
IMAX Address Bus Test                  Pass: 1  Fail: 0
IMAX Memory Test (IM0 & IM1)           Pass: 1  Fail: 0
IMAX Pixel Localization Test           Pass: 1  Fail: 0
IMAX Mirror Image Test                 Pass: 1  Fail: 0
IMAX Image Attenuation Test            Pass: 1  Fail: 0
IMAX Image Accumulation Test           Pass: 1  Fail: 0
C67/HPI Bus: 512kB DP Data Bus Test    Pass: 1  Fail: 0
C67/HPI Bus: 512kB DP Addr Bus Test    Pass: 1  Fail: 0
C67/HPI Bus: 512kB DP Memory Test      Pass: 1  Fail: 0
C67/HPI Bus: 256kB DP Data Bus Test    Pass: 1  Fail: 0
C67/HPI Bus: 256kB DP Addr Bus Test    Pass: 1  Fail: 0
C67/HPI Bus: 256kB DP Memory Test      Pass: 1  Fail: 0
C67/HPI Bus: 16MB SDRAM Data Bus Test  Pass: 1  Fail: 0
C67/HPI Bus: 16MB SDRAM Addr Bus Test  Pass: 1  Fail: 0
C67/HPI Bus: 16MB SDRAM Memory Test    Pass: 1  Fail: 0
APU/BPC BPC Fifo Depth Test            Pass: 1  Fail: 0
APU/BPC ATR Test                       Pass: 1  Fail: 0
APU/BPC S&T Test                       Pass: 1  Fail: 0
APU/BPC DR/R Test                      Pass: 1  Fail: 0
APU/BPC APU Projection Mem Test......  Pass: 1  Fail: 0
APU/BPC Circular Dual Port Test        Pass: 1  Fail: 0
APU/BPC Apu Pipeline Test              Pass: 1  Fail: 0
APU/BPC Homogeneity Test............   Pass: 1  Fail: 0
APU/BPC Individual Apu Test............
Full IG Diags Completed.
```

Figure 5-155 Full Diags Screen

```
Run diagnostics on pig
Checking if the ice and pegasus cards are up....
Soft reset of the ice and pegasus cards in progress.............................
.....................................


IG DIAGNOSTIC TIMESTAMP Mon Feb 26 2001 08:43:52

-> menu

********* Pegasus Main Menu *********
0. Exit Menu

1. Print Pegasus Version
2. Print Pegasus Temperatures

3. SPAM Menu
4. IMAX Menu
5. C67 Menu
6. APU Menu

7. Quick Diags
8. Full Diags

Enter Choice: 1

Pegasus IG Board Version is: E


********* Pegasus Main Menu *********
0. Exit Menu

1. Print Pegasus Version
2. Print Pegasus Temperatures

3. SPAM Menu
4. IMAX Menu
5. C67 Menu
6. APU Menu

7. Quick Diags
8. Full Diags

Enter Choice: 2

IG Temperature Sensors:  32.50C(UF)  41.50C(UB)  28.50C(LF)  32.50C(LB)


********* Pegasus Main Menu *********
0. Exit Menu

1. Print Pegasus Version
2. Print Pegasus Temperatures

3. SPAM Menu
4. IMAX Menu
5. C67 Menu
6. APU Menu

7. Quick Diags
8. Full Diags

Enter Choice:
```

Figure 5-156 Interactive Diags Screen

Always close the test window after testing has completed. Double-click the square box in the upper left corner of the window with the minus sign.

Close Window
(double-click)

Figure 5-157 Close Window ICON

VIEW LOG displays the entire contents of the `pig.log`, located in `/usr/g/service/log` directory. The PIG.LOG cannot be viewed using the system browser tool located in the service desktop.

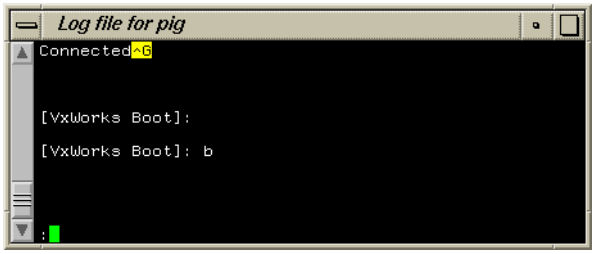


Figure 5-158 View Log Screen

VIEW FAILURES displays all the **IG** failures recorded in the `pig.log.` Located in `/usr/g/service/log` directory.

Figure 5-159 View Failures Screen

FLASH IG APPSROM & FLASH IG DIAGSROM is only use when instructed. Designed for manufacturing use only.

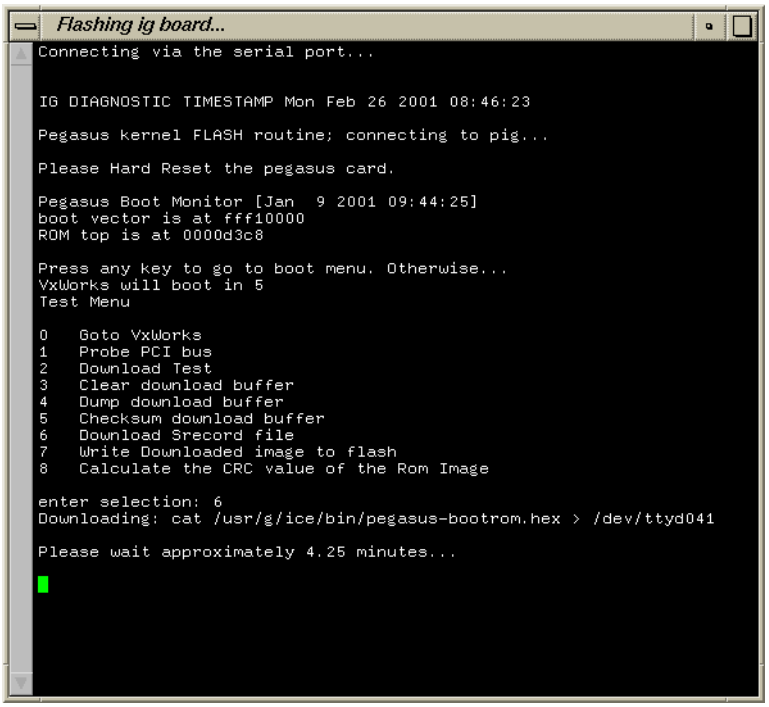


Figure 5-160 Flash IG AppsRom Screen

Figure 5-161 Flash IG DiagsRom Screen

4.2.4.4 Recon Data Path Test

CT Scanner applications must be up and running. If not, click on APPLICATION STARTUP, in the upper right corner of the screen. It takes about 3 minutes for applications to start. Applications are up when the a dialog window says that you need to run *fastcal*. Click OK.

1.) Go to the Service Desktop and select the `Diagnostics` TAB (See Figure 5-151).

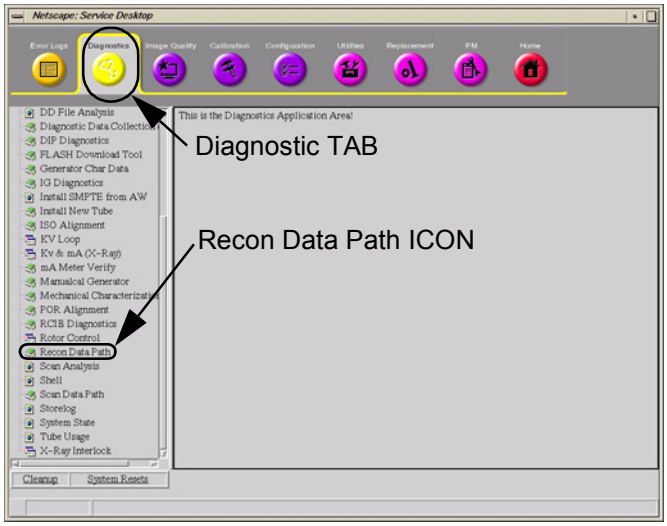


Figure 5-162 Diagnostic TAB Screen

2.) In the menu column on the left side of the Service Desktop page, click RECON DATA PATH icon (toward the bottom of the list). This brings up the Auto Recon page (10-15 sec. to appear).

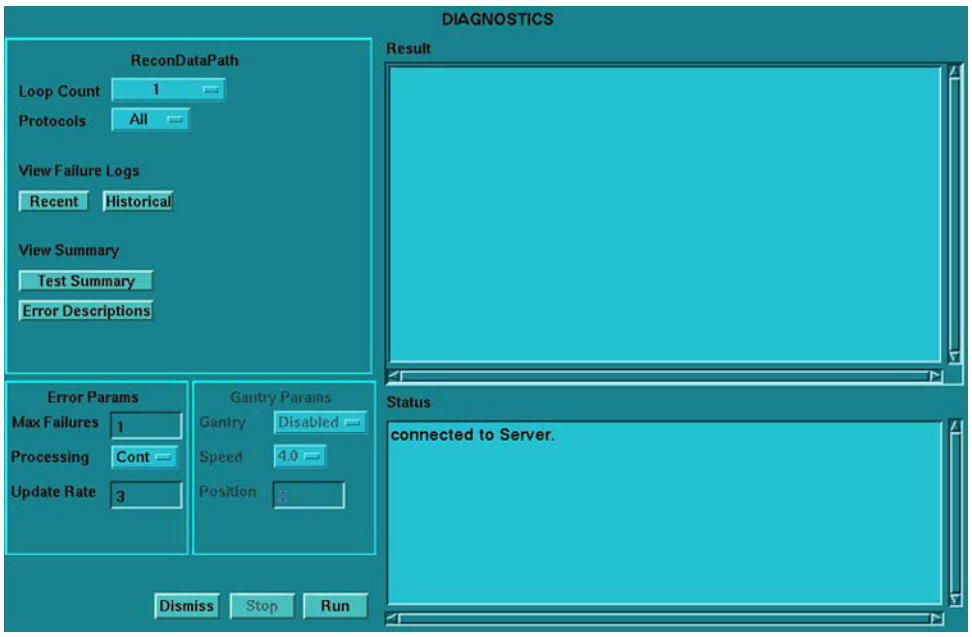


Figure 5-163 Recon Data Path Diagnostic Screen

3.) When the `Recon Data Path` page comes up, select a `loop count` of: 5, select ALL tests, then click RUN. This runs five loops of all tests; each loop generates 20 images, for a total of 100 images. This test checks the image output by comparing checksums of each image. *(takes about 4 minutes to run)*.

4.) When complete, click DISMISS.

4.2.5 SDC (Scan Data Corrections) Diagnostics

There is a tty vendor diagnostic available to test the **SDC** portion of the **PEG-IG** board called **`rundmc`**. The executable is located on the SBC in `/usr/g/bin`. Invoking the diagnostic will reboot vxWorks to a diagnostics mode on the Motorola (**RIP**) Board. Exiting the diagnostic does not reboot vxWorks back to Applications.

Restarting Applications, '**`st`**' will reboot vxWorks to the applications recon state.

Note: Because vxWorks is rebooted upon execution of this diagnostic, Applications must be shutdown before running diagnostics on the **SDC** portion of the **PEG-IG** board.

Perform the following steps to execute the diagnostic:

1.) From the Service Desktop select UTILITIES.
2.) Select APPLICATION SHUTDOWN.
3.) Open a UNIX Shell and enter the following commands:

> **`cd /usr/g/bin`**

> **`rundmc`**

4.) Menu Option [2] displays the main menu. Execute tests in verbose mode. Select **ENTER**.
5.) Enter your desired loop count; the default is [1] then select **ENTER**.
6.) vxWorks re-booting messages appear on the screen and the board level tests will appear as they are run. The tests for a single pass complete within a few minutes.
7.) When tests are complete, results with number of passes and failures is displayed.
8.) **ENTER** returns you to the Main Menu.
9.) If desired, select **`4`** to view the log.
10.) If desired, select **`5`** to view the help menu.
11.) Select **`6`** to Exit.
12.) Return to the OC prompt and startup Applications by entering "**`st`**". Applications startup will re-initialize vxWorks.

Chapter 6
Table

Section 1.0
Table Theory

The functions performed by the electronics within the table include:

- Control of Gantry tilt
- Table elevation
- Table cradle longitudinal drives

Please refer to Figure 6-1, below, and Figure 6-2, on page 407, as reference for the table theory.

Patient positioning is done manually through the gantry mounted operator controls. The drives provide horizontal and vertical positioning of the patient. Longitudinal motion of the cradle provides horizontal positioning through the scan plane. During scanning modes, longitudinal position is controlled by the **ETC** computer and control board. Longitudinal motion can also be controlled with console pushbuttons used to advance the patient to the next scan position. An additional feature is Prescribed Remote Tilt functionality.

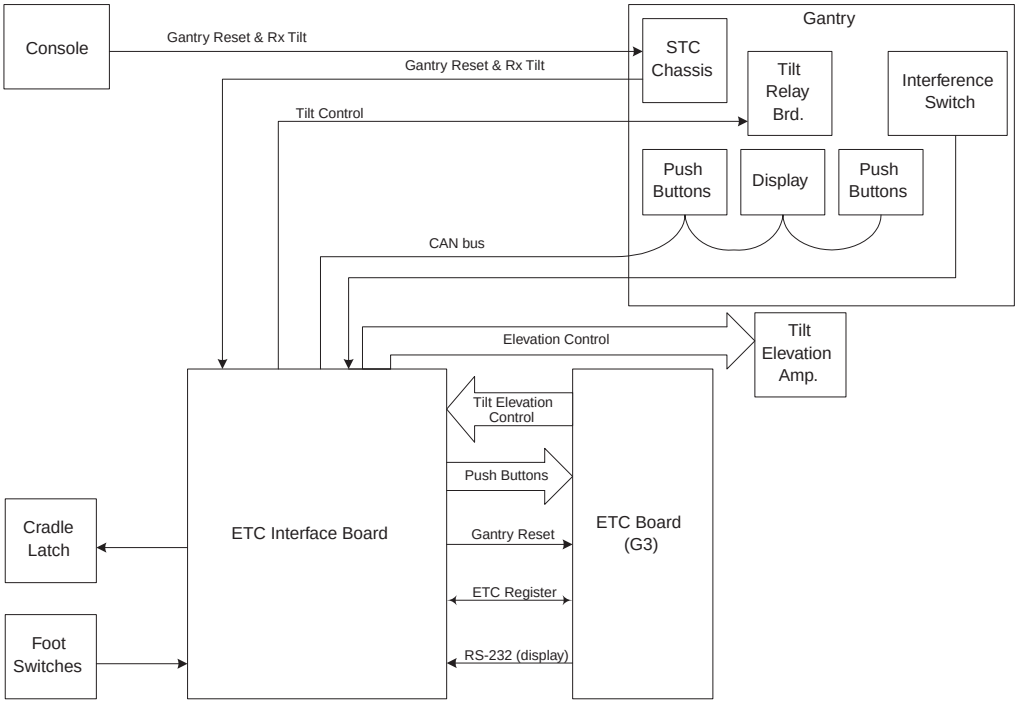


Figure 6-1 Table Block Diagram

1.1 Elevation/Tilt Operation

Control of this closed loop drive system is provided by the **ETC** computer, control and interface boards. Interlocks and enables are set by a table/gantry interference matrix and firmware. The drive amplifier is supplied with 170vdc and creates a three-phase half-wave rectified drive voltage that is pulse

width modulated at a switching frequency of 17 khz. The resulting output is supplied through enable and motor select relays to the table elevation drive motor. The control circuit has no adjustments.

Elevation feedback is provided by a 6:1 geared encoder and is converted to elevation information by the **ETC** control board firmware. The encoder turns one complete revolution over the entire table elevation range. Control signals are routed via the **ETC-IF** board, where the signal enabling elevation is intercepted and another enable is created so that the interface board can also disable elevation if the interference sensor is in fault or interference is detected. Tilt control signals, forward and backward, are decoded and routed to the tilt relay board via the **ETC-IF**. Tilt position feedback is provided by a 5-turn potentiometer.

WARNING **TABLE ELEVATION UTILIZE GAS SPRINGS TO ASSIST IN ELEVATION MOTION. GANTRY TILT USES HYDRAULIC CONTROL SYSTEM FOR GANTRY MOTION. ALWAYS FOLLOW THE DOCUMENTED REPLACEMENT PROCEDURES FOR COMPONENTS WITHIN THESE DRIVES SYSTEMS TO AVOID INJURY DURING THE REPLACEMENT OF THESE COMPONENTS.**

1.2 Cradle Operation

Control of this closed loop drive system is provided by a single chip motion controller, located on the **ETC** control board. The controller sets velocity, direction, acceleration, and position. The drive amplifier is supplied with 24vdc and creates a three-phase half-wave rectified drive voltage that is pulse width modulated at a switching frequency of 17 khz. The resulting output is supplied through an enable relay to the cradle drive motor. The motor turns a drive roller at the front of the table that the cradle rests on, thus causing the cradle to move.

Direction and speed feedback is supplied by an encoder and a 10-turn potentiometer driven by a cable and spool assembly attached to the cradle mounting hardware. The cradle encoder outputs approximately 10 pulses per mm of cradle movement and makes 8 full revolutions over the full cradle range. The potentiometer determines which of the 8 revolutions the encoder is in. A tachometer is used for additional stabilization of the control loop. There are no adjustments for this control loop.

1.2.1 Auto Move Correction

Once a patient landmark has been set, changing the table elevation by using the gantry mounted pushbuttons will result in the cradle moving in or out so that the position of the cradle in the gantry opening and patient landmark remain unchanged. This auto move correction does not occur if the elevation is changed with the foot switches or if a landmark has not been set.

1.2.2 Cradle Latch Control

Depressing the gantry mounted operator control cradle release switch will cause the cradle to float freely. This allows the operator to pull the cradle and patient back to the foot end latch position, in case of a patient emergency. Depressing the cradle release switch again will cause the drive to engage and enable the cradle to be driven away from the latched position.

1.3 Emergency Off Interface

The table provides an interface between the gantry mounted operator emergency off control and reset switches and the Power distribution unit. If an emergency off switch is depressed, table elevation, cradle longitudinal, gantry axial, **HV** primary supply, and gantry tilt drives are disabled and the reset light will begin flashing at a slow frequency. Depressing the reset switch will once again enable the drives.

1.4 LAN Communications

Firmware sends position and other status information through this interface to the System Host Control.

1.5 Gantry Display

The Gantry Display Board is centered on top of the Gantry, directly above the table opening. It is controlled via a **CAN** network, located on the **ETC-IF** (Enhanced Table Controller Interface) circuit board.

1.6 Table Sync Generation

Table Sync Generation is used to inform the axial controller that the table has reached the start of scan position for scout scans.

1.7 CAN Network

The **CAN** network is the communications interface for the gantry display and control panels. The network supports four (4) control panels: two (2) each on front and rear gantry covers. The **CAN** requires the gantry display and one (1) control panel for successful initialization. Upon power-up the **ETC-IF** tests communications to the gantry display and controllers. Faults are reported as node failures.

Additionally, a watchdog circuit disables out-going pushbutton signals, from the **ETC-IF** board, if the microprocessor gets hung up. The watchdog needs to be reset every 150 ms. See Figure 6-2.

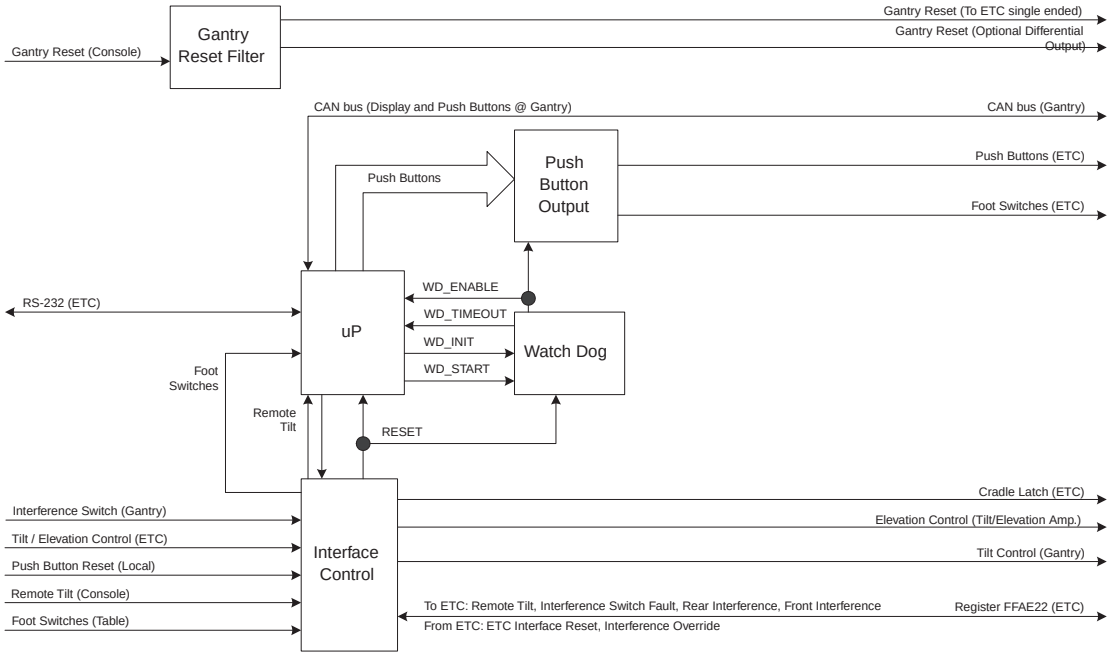


Figure 6-2 ETC-IF Functional Block Diagram

1.8 Switch Monitoring

1.8.1 Elevation and Cradle Limit Switches

Elevation switches are magnetic reed switches located at the top and bottom of the elevation linear actuator assembly. Cradle limit switches are mechanical switches located at either extreme end of cradle movement. Firmware ensures that these extreme positions are never achieved. The limit positions can be achieved during the characterization process or firmware/hardware failure.

1.8.2 Patient Interference Switches

Tape switches are located at positions where it is possible for patient extremity injury during positioning. If any of these switches are depressed, cradle longitudinal, table elevation, and gantry tilt drives are disabled and the gantry operator control panel reset light will flash at a fast frequency. Removing the table side covers will activate this circuitry as well. A jumper plug is provided under the side covers, to enable the drive circuits for service purposes. Depressing the gantry operator control reset switch will once again enable these drives.

1.8.3 Gantry Mounted Interference Touch Panels

Sensors are mounted on the front and rear of the gantry. When a sensor is not pressed, the impedance is 20 kOhms. When a sensor is pressed, the resistance becomes near Zero (0) Ohms. This signal will be decoded on the **ETC-IF** board, first to indicate that the maximum impedance of the sensor is 40 kOhms (fault condition). Second that the sensor is not a short circuit (interference condition). This is done for both front and rear sensors. If there is interference or a fault condition, both elevation and tilt will be disabled.

A green **LED** will indicate that the sensor is not shorted. A yellow **LED** will indicate that the sensor has more than 40k Ohms of resistance.

1.8.4 Gantry Mounted Operator Programmable Control Switches

The Gantry side pushbuttons are located on each side of the gantry. They give the operator manual control of the of drive operations for Patient Positioning and are monitored by the table **ETC** board via the **ETC-IF CAN** network.

1.8.5 Gantry Tilt / Table Elevation Interference Matrix Switches

Used as a safety back-up for a firmware controlled matrix that ensures that the table cradle and gantry never touch each other and any gantry angle, table elevation, or cradle position.

1.8.6 Remote Tilt Switches

These switches are located at the console **SCIM** keyboard. The function is Prescribed Remote Tilt, which means that these switches will only tilt the gantry to the prescribed RX position. This feature enhances the productivity of the technologist as they can more easily position the gantry between groups or series prescriptions. For patient safety, the Gantry Mounted Interference Touch Panels will disable gantry motion if any contact is sensed on the surface of these panels.

1.8.7 Elevation Foot Switches

The foot switches (up and down) come into the **ETC-IF** board at J8 directly from the foot pedals. The switches have inverse logic dual path input. When either enable for the foot switch is pressed, the enable (active low) line is sent to the microprocessor. When the up pedal is active, the up signal will be high into the processor. When the down pedal is active, the down signal will be high into the processor.

1.9 Gantry and Table Controls Functionality

1.9.1 Overview

The Gantry User Interface consists of a Gantry Display, Gantry Push buttons, and **ETC-IF** Controller (located on the **ETC** Interface Board). Each of these new components incorporate a Motorola 6808AZ60 microprocessor. Figure 6-3 illustrates the overall design of the Smart Controls.

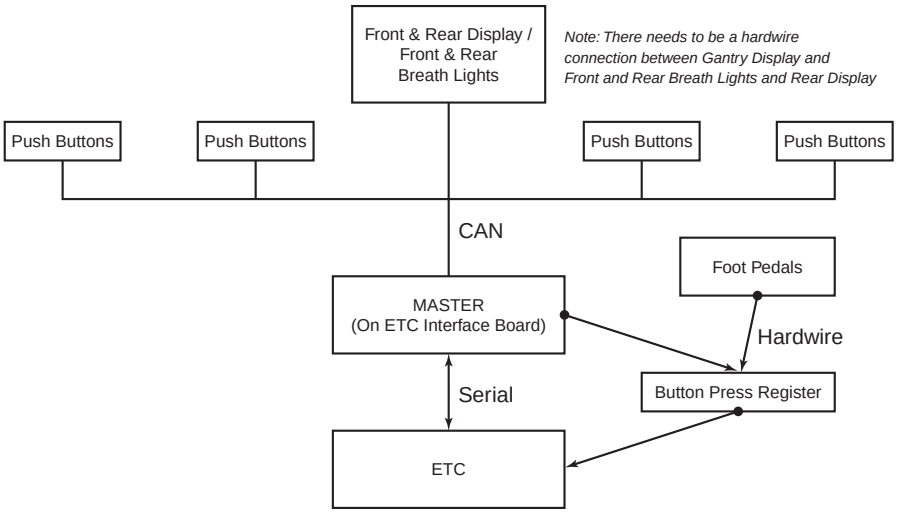


Figure 6-3 Gantry User Interface Design Block Diagram

1.9.2 Theory of Operation

The Smart Controls system is designed with the **ETC-IF** Controller as the interface between the **ETC** and the Gantry elements. The **ETC-IF** controller is a slave to the **ETC** and the Gantry components are slaves to the **ETC-IF** Controller

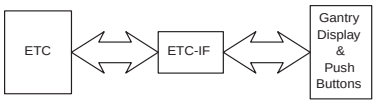


Figure 6-4 Smart Controls Design Block Diagram

Code Organization

The code on all three types of controllers consists of boot code and application code (both residing in Flash Memory). The boot code is always the first to be invoked on a reset. The boot code checks for valid application code through the calculation of a checksum, and if it is found, the application code is started. If not, then the boot code jumps to the boot application loop. The boot application loop has only one purpose, and that is to download code to flash memory.

Common Application Functions

Several functions are common between the three controllers. These functions are:

- Self Tests
- Processor Initialization
- Communication
- Downloading Code
- Firmware Revision and Board Revision Reporting

- Diagnostic **LED**s
- Diagnostic Switches

Power-On Self Tests

At the time of power-up or reset, the micro-controller performs two self tests:

- **RAM** Check: The micro-controller searches all **RAM** locations for any possible errors.
- Code Corruption Test: A checksum check is performed on the application code to ensure code integrity.

1.9.3 General Design Information

The Gantry User Interface Network could include the following nodes, in the following quantities:

- **ETC-IF** (1)
- Push Buttons (5)
- Display (1)

1.9.3.1 Communications Protocol

Startup/Initialization

1.) Gantry Control

When any Node is reset or powered-up, it begins sending the Gantry Control “I'm Alive” message to the **ETC-IF** on a periodic basis (every 500 ms). Once the **ETC-IF** receives that message, it responds by broadcasting the Assign ID message to all Control nodes, in which a specific board number, serial number and node ID is embedded. Each Control node checks the message, and if it has its own board number and serial number, then it assigns that node ID to itself. The node, once it receives the command, acknowledges it with an ACK and stop sending the “I'm Alive” message. If more than one node has the same board number and serial number, the **ETC-IF** logs an error message, but allows them to operate.

2.) Gantry Display

When the display is reset or powered-up, it begins sending the Gantry Display “I'm Alive” message on a periodic basis (every 500 ms) to the **ETC-IF**. Once the **ETC-IF** receives that message, it responds with the “Stop Alive Message” command that informs the Gantry Display node that its presence has been detected by the **ETC-IF**. The node, once it receives the command, acknowledges it with an ACK and stop sending the “I'm Alive” message.

3.) Safety

The Gantry Pushbuttons and Display contain safety critical elements (start scan capability, X-ray On indicator) that require safety to be a major consideration in the **CAN** network design.

4.) CAN Messages

CAN messages are protected against corruption using several methods. First, a quadruple 8-bit filter algorithm is used by the **CPU** to register only the messages that are anticipated by that Node. Second, a sequence number is embedded in all messages and is checked by the **ETC-IF** (to make sure that new sequence numbers are sent) as it receives messages from the nodes to guard against **CAN** reflections. Finally, a checksum is used in critical messages (such as button presses) to further validate their content.

5.) Display Indicators

The Display indicators are validated by using an associated checksum on the packet to be sent to the Display Node. The Display Node verifies the checksum prior to setting the requested indicators and responds to the **ETC-IF** to acknowledge the receipt of the message.

6.) Reset Line

A Reset line is available for the **ETC-IF** to set, if it deems that one or more of the nodes must be reset to correct a problem.

7.) Display Messages

Display Messages must be acknowledged by the node that receives them, whether it is the Pushbutton Node or the Display Node. This is imperative to ensure that node has at least received the message correctly and verified it.

8.) Protocol Definition

The **CAN** protocol that is used is the **CAN** 2.0B(extended) protocol, which defines a packet as a 29 bit header and a 0-8 byte long message.

9.) Node IDs and Object IDs

Node IDs are assigned to nodes either on startup from the **ETC-IF**, or by default in its code as follows:

- **ETC-IF** -> node ID 0
- Display -> node ID 1
- Controls -> node ID's 2-6

Object IDs are set as follows:

- **ETC-IF** ->0
- Control ->1
- Display -> 2

Note: If the Node ID or Device ID are not used in the message header, they are to be defaulted to 0xF.

1.9.3.2 Communication

The controllers are initialized to operate using both the **SCI** port and the **CAN** port.

SCI

The **SCI** port operates at 9600 Baud Rate, using an RS232 driver.

CAN

The **CAN** port operates at 250K Baud Rate. Each of the nodes initialize its acceptance filters based on its device ID and node ID.

SPI

The **SPI** port is a synchronous serial communication port. This port is used to communicate to an **EEPROM** resident on the board.

1.9.3.3 Firmware and Board Revision Reporting

Each microprocessor is able to report its firmware number, firmware revision, board number, board revision, and board serial number. The firmware number and revision number are embedded in the firmware code. The board number, revision and serial number are read through the **SPI** port from an **EEPROM** located on the board.

1.9.3.4 Diagnostic LEDs

Each node has four firmware controllable **LED**s, operating differently during application code and boot code.

Application Code

- **LED** 0: Error Code -> This **LED** blinks an error code, if an error exists. The tens digit blinks at 2Hz and the ones digit blinks at 5Hz.
- **LED** 1: HeartBeat -> This **LED** blinks at 2Hz, as long as the firmware is running correctly.
- **LED** 2: Connected (for control and display) -> This **LED** is on solid, as long as the watchdog message between the **ETC-IF** and the node is not in violation.
- **LED** 2: Button Pressed (for **ETC-IF**) -> This **LED** is on solid, whenever the **ETC-IF** is putting out a bitMask to the **ETC** with a button pressed.
- **LED** 3: StartProcessing -> This **LED** is on solid from the point that the Begin Processing Packet is received until a reset occurs.

Boot Code

- **LED** 0: Invalid SREC -> This **LED** is on solid from the point that an invalid packet is received until a valid written packet is received.
- **LED** 1: HeartBeat -> This **LED** blinks at 5Hz as long as boot is running and not downloading code. The **LED** blinks at 3Hz, if the code is writing to FLASH.
- **LED** 2: Data Verification Failure -> This **LED** is on solid from the point that a packet is not verified in FLASH correctly until a reset occurs.
- **LED** 3: Checksum Error-> This **LED** is on solid from the point that an invalid checksum on an SREC packet is detected until a reset occurs.

1.9.3.5 Diagnostic Switches

Each node has four firmware readable diagnostic switches, operating as follows:

SWITCH NUMBER	DISPLAY FUNCTION	CONTROLS FUNCTION	ETC-IF FUNCTION
0	No function	No function	DO NOT USE
1	No function	No function	DO NOT USE
2	No function	Enable Button code display test	No function
3	Enable Display Test	Enable Display Test	No function

Table 6-1 ETC-I/F, Gantry Display, Gantry Control Panel Switches

1.9.4 Functional Description

The following described functions are related to some **CAN** or **SCI** port communication.

1.9.4.1 Code States

Application Code has three states: Init, Normal and Shutdown. All application code starts in Init mode, during which all startup initialization occurs. The transition to normal state occurs once the **ETC-IF** receives the “Begin Processing” Message and sends it on to the nodes. A node will enter the shutdown state once commanded to do so by the **ETC-IF** for being in a faulty state, such as too many resets in a short period of time.

1.9.4.2 ETC-IF

Overview

The **ETC-IF** has the main function of controlling the Smart Control components and interfacing between the **ETC** and the components. The **ETC-IF** is able to connect to 5 button nodes and 1 display node at one time.

Note: Some system error messages refer to "**TNC**." **TNC** stands for "Table Network Control" and refers to the **ETC-IF**.

Pushbutton Reporting

The **ETC-IF** reports the status of the pushbuttons to the **ETC** board. This is accomplished via a periodic message that is received from the pushbutton nodes. The **ETC-IF** has a wake up cycle (50 ms) triggered by the TIM module. When waking up, the **ETC-IF** checks for the Altera Time Out Bit, then checks the Button Status Database for any pressed buttons. The **ETC-IF** further checks the button pressed for possible illegal combinations. The **ETC-IF** then checks for the Foot Pedal inputs and the Remote Tilt input and again verifies that no illegal combinations exist. Finally, the **ETC-IF** outputs the final bitMask to the **ETC**. If any illegal combinations are detected, or more than one node has a pressed button, then the **ETC-IF** sets the bitMask to the default state. The following flow chart (Figure 6-5) further explains the process.

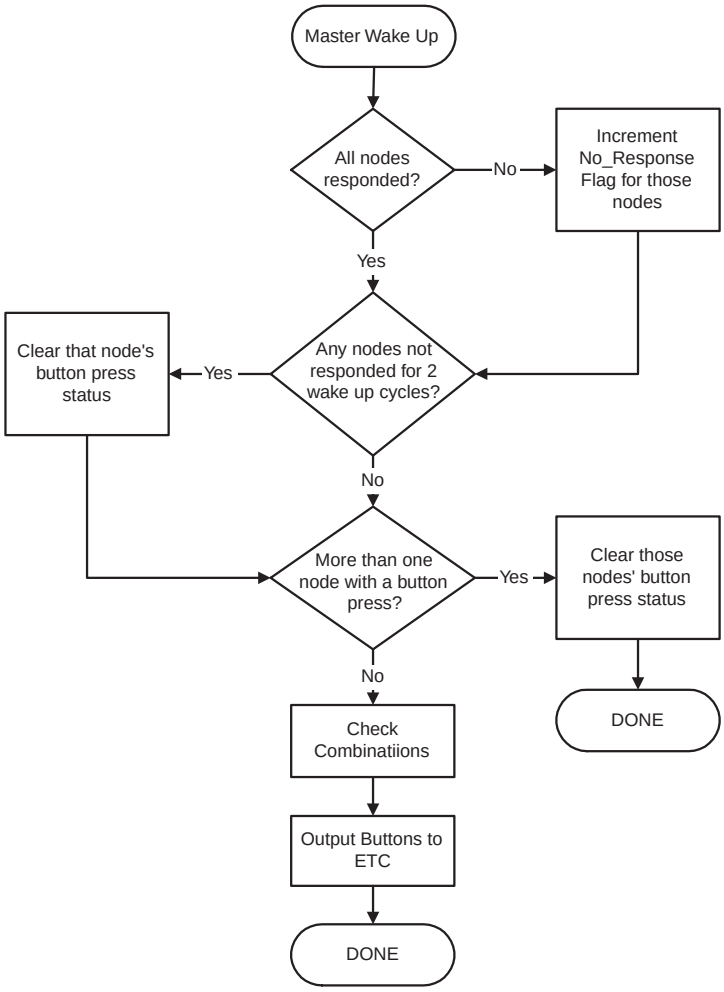


Figure 6-5 Pushbutton Reporting Flow Diagram

Node Watchdog

The **ETC-IF** acts as a watchdog for the nodes (display and pushbutton) at a 150 ms rate. The **ETC-IF** sends out a watchdog message and expects a reply from each node confirming its receipt of the message. If any node fails to respond five (5) consecutive times, the **ETC-IF** considers it not alive, sets the appropriate fault bit to the **ETC** in the status query response, and updates its status in the node alive database.

Display Messages

The **ETC-IF** is also responsible for commanding the display and pushbutton nodes to display information. The **ETC-IF** is prompted to do so by the **ETC** via the serial line, at which point the **ETC-IF** commands the appropriate node (pushbutton or display) to display the required information. The **ETC-IF** waits for either an acknowledge from that node or a time-out, and then responds to the **ETC** with either an ACK or a NACK.

Revision Query

The **ETC-IF** accepts a revision query from the **ETC**. The revision query is a sequenced event that operates as follows:

1.) **ETC** sends revision query command.
2.) **ETC-IF** responds with its own revision information.
3.) **ETC** sends revision query command.
4.) **ETC-IF** queries the first alive node in its database for its information and responds to the **ETC** with the information.
5.) **ETC** loops on sending the revision query command and receiving the information.
6.) When done with all the nodes, the **ETC-IF** responds with a message code informing the **ETC** that all revision queries are done.

Status Query

A status query is responded to with the following information:

1.) Status of the **ETC-IF**
2.) Number of alive nodes
3.) Number of connected nodes
4.) Fault Status of the Network

Node Database

The **ETC-IF** keeps a database of all nodes that were at one time connected. This database contains the following information:

1.) Node ID
2.) Serial Number
3.) Board Number
4.) Alive Status
5.) Number of failing Watchdogs
6.) Number of Recent Resets
7.) Last Received **CAN** message Sequence Number

Expected Response Database

The **ETC-IF** keeps a database to track the message expected to be received by it and the required actions. This database is required due to the single-threaded nature of the code. This database holds the following information:

1.) Message Code to be received
2.) Node ID to send the message
3.) Time Out Counter
4.) Ack to the **ETC** Required (Boolean)
5.) Number of Entries in the Database

Button Status Database

The **ETC-IF** keeps a database to track the status of all the button nodes. This database keeps the following information:

1.) Last Received Button Pressed Status
2.) Button Pressed (Boolean)
3.) Input Accepted (Boolean)

Error Status Database

The **ETC-IF** keeps a database of any errors that may occur. These errors have to be queried and acknowledged by the **ETC** before they are removed. The **ETC-IF** logs the following errors:

1.) Message Time Out
2.) Too many nodes connected to the Network
3.) Possible Duplicate Node ID Scenario
4.) Node Fails the Watchdog
5.) Node Has Stuck Button
6.) Self Test failure
7.) Node Shutdown
8.) Altera Watchdog Timeout
9.) Pushbutton Time-out on Updating the **ETC-IF**
10.) 1Message Checksum Failure
11.) Invalid Command Received
12.) **CAN** errors
13.) Serial Errors
14.) **EEPROM** Read/Write Errors
15.) Spurious Interrupts
16.) Maximum Reset By one Node Surpassed
17.) Foot Pedals Stuck
18.) Invalid Reset Reasons
19.) Remote Tilt Input Stuck

1.9.5 Display

The main function of the Display is to update its displays based on the commands received from the **ETC-IF**.

1.9.5.1 Display Specific Functions

Self Test

The Display node runs a display self test on any reset. It sets all of its **LED**s ON (including the Breath Lights and Rear Display). It then cycles through the flashing of each of the elements for two seconds each. Once through this cycle twice, it sets all the **LED**s ON and stops the pattern. It also stops when receiving the “Begin Processing” command from the **ETC-IF**.

Setting Displays

The Display node incorporates the use of five 32-bit shift registers to set the displays. In order to change any of the displays, the microprocessor translates the required data into bits and then shifts it to the correct shift register. Once the data is sent to the shift register, the processor enables the register, at which point it moves the data to the display segments. The shift registers are designated as below:

Register 0: Indicators, Breath Lights, and X-display

Register 1: Tilt

Register 2: Elevation

Register 3: Cradle 3 MSD

Register 4: Cradle 4 LSD

The Display Node wakes up every 50 ms and updates all of the display registers with the latest Bit Maps. The Display node also controls the blinking of any displays.

Display Faults

The Display is determined to be in a fault state on one of two conditions: when it fails the watchdog, or when it reports a self-test error. If the display node is in a fault state due to a watchdog failure, the node reconnects to the network, once it receives another watchdog message and responds to it. In the meantime, the node displays “ERR” as a visual indication of the problem. If the node experiences a self-test error, it displays “OFF” and shuts itself down due to its unreliability.

1.9.5.2 Pushbuttons

The Pushbutton node has the main task of reporting button presses to the **ETC-IF**, as well as setting its displays based on commands from the **ETC-IF**.

Setting Displays

The Pushbutton node incorporates the use of a 32-bit shift register to set its displays. In order to change any of the displays, the microprocessor translates the required data into bits and then stores it in a global variable. Every 50 ms, the node updates the shift register with the latest information. The Button node also controls the blinking of any displays on its node.

Self Test

The Pushbutton node checks for any stuck buttons at the time of any reset. If a stuck button is detected, it is deemed invalid by that node and will not be reported to the **ETC-IF** as a pushed button until the next time the self-test is performed and the button passes.

Sending Button Status

The Pushbutton node has a wake-up every 30ms to examine and send button press status. It performs according to the flow chart shown in Figure 6-6.

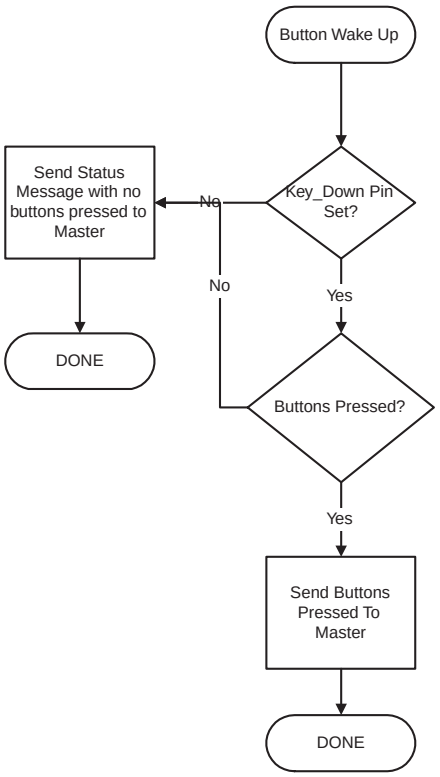


Figure 6-6 Button Status Flow Diagram

Pushbutton Faults

A Pushbutton node is determined to be in a fault state in the following cases:

1.) Times out on a watchdog.
2.) Fails to report its button status for two consecutive **TNC** wake up cycles.
3.) Reports a self-test failure.
4.) Reset 5 times within one minute.

In case 1, the node displays “ERR” as a visual indication of the problem and tries to reconnect. In case 2, the node's button status is not accepted until it correctly responds to 5 consecutive cycles. In case 3, the node displays “OFF” and shuts itself down. In case 4, the node is commanded to be shut down by the **TNC**.

1.9.6 Gantry Display Indicator Lights and Numeric Displays

Figure 6-7 Gantry Display Panel

- **Interference** - Indicator - **ETC CPU** uses the interference matrix to determine this and controls the light accordingly.
- **Cradle Latch** - Indicator - Indicates the load home condition.
- **Alignment Light** - Indicator comes on when the alignment light button is pressed.
- **X-Ray "On" Indicator** - Indicates the KV at the x-ray tube is greater than 10 KV.
- **Cradle Unlatched** - Indicator - **ETC** turns this on when cradle unlatch was pressed or when emergency off button is activated.
- **Cardiac Gate Indicator** - Indicates the Cardiac Gating hardware is connected.
- **Respirator Indicator** - Indicates the Respirator hardware is connected.
- **Longitudinal** - Numerical Display - Continuously updated as table moves. Resolution is 0.5 mm relative to landmark. Display is blank if landmark is not established or cradle reference has been lost.
- **Elevation** - Numerical Display - Continuously updated as table moves. Resolution is 0.5mm, measured from ISO center. Display is blank until reference is found or lost.
- **Gantry Tilt** - Numerical Display - Continuously updated as gantry moves. Resolution is 0.5 degrees.

1.9.7 Gantry Mounted Control Panels

Figure 6-8 Gantry Mounted Control Panels

- Press to raise the table in slow speed.
- Press to lower the table in slow speed.
- Press to drive the cradle toward the gantry in slow speed.
- Press to drive the cradle away from the gantry in slow speed.
- Press and hold the center button at the same time to increase cradle and elevation speed by a factor of 2.
- Press to restore the gantry and table to the Home position. The gantry returns to the 0_ Tilt position, while the cradle drives all the way out of the gantry. After the gantry and cradle reach their home positions, the table lowers to the minimum height.
- Press to tilt the top of the gantry toward the table.
- Press to tilt the top of the gantry away from the table.

  Within ScanRx, a tilt to RX is required, one of the two tilt **LED**s will flash, indicating which button to press. Holding the button down will move the tilt to the prescribed angle, then the **LED** will turn off. If the tilt is moved off of the correct angle, then the correct **LED** will start flashing again.
- Press to turn ON the internal and external laser alignment lights.
  - Will cause gantry motion for correct rotational position as necessary.
  - Read the laser warning labels on the gantry.
  - Warn your patients to close their eyes before you turn on these potentially blinding lights.
- Press again to turn OFF the alignment lights.
- Press to designate the anatomy directly under the internal lights as the 0.0 mm scan location.The alignment lights intersect at the three dimensional isocenter. (Dim the scan room lights to improve alignment laser visibility.)
- Press to designate the anatomy directly under the external lights as the 240.0 mm scan location. After you prescribe the scan and initiate the scan sequence, the system prompts you to press the Advance to Scan button to move the cradle into position for the first scan.
- Press to latch or unlatch the cradle.
- Pressing the Reset Drives button when its **LED** is flashing will reset the drives. When the **LED** is solid, it will do nothing. If the **LED** is not on, then it is disconnected.
- Press and hold the Range Button will cycle through the allowable motion ranges on the gantry display.
- Pressing the Demo Button cycles through four steps of breath lights demonstration:
  - Flash Breath Light.
  - Hold Breath On w/ 30 sec. showing.

- 30 Second countdown on display.
- Breath Light on.

- Timer Display: The Timer displays the Prep Countdown, ISD Countdown and IGD Countdown. It also gives feedback for errors on the control panel by either flashing “ERR” (stuck button) or leaving “ERR” ON solid (loss of communications) or OFF (board is disconnected from Network and the **ETC-IF** board needs to be reset).
- Pressing the Stop Scan button at any time that a scan is prescribed will stop the scan. When its **LED** is on, X-rays are being emitted.
- Pressing the Start Scan button when its **LED** is flashing will start the prescribed scan sequence. If its **LED** is solid, the button functions as a resume button.

WARNING **USE OF THE START/STOP BUTTON ON THE GANTRY CONTROL CAN RESULT IN X-RAY EXPOSURE OF THE OPERATOR AS WELL AS THE PATIENT. KNOWLEDGE OF THIS FEATURE’S FUNCTIONALITY IS IMPERATIVE.**

1.9.7.1 Gantry Mounted Control Start/Stop Button Functionality

The Start and Stop exposure buttons function as follows:

1.) New Patient ScanRX Prescription is entered and accepted.
2.) Technician enters scan room and attends patient.
3.) Technician observes Delay time on Control Panel Timer Display and Start Scan **LED** flashing.
4.) Technician presses Start Scan button. Delay timer countdown begins.
5.) Technician presses Stop Scan button for any reason.
   a.) Timer Display goes blank.
   b.) Start Scan **LED** becomes Solid ON (Resume Mode)
6.) Technician now presses Start Scan button.
   a.) Start Scan **LED** begins flashing (Start Scan Mode)
   b.) Timer Display is still blank.

   IF THE START SCAN BUTTON IS PRESSED A SECOND TIME, XRAY EXPOSURE IS INITIATED.
7.) Technician should exit scan room and initiate exposure by pressing the flashing Start Scan on the console.

1.9.7.2 Table Elevation Foot Switch Functionality

When pressed continuously, the Table Elevation Foot Switch Pedal closest to the table will return the Cradle to the Home position, and then lower the table to minimum elevation.

When pressed continuously, the Elevation Foot Switch Pedal closest to the Gantry will elevate the table to approximately 180 on the Gantry Display, and then Advance the cradle to 100 mm.

These are values programmed related to table characterization. Future plans are to allow these values to be programmed explicitly within each Protocol.

Section 2.0
Procedures and Adjustments

2.1 Cradle Shimming

2.1.1 Tools

Straight Edge

2.1.2 Materials

Quantities are as needed to complete the task:

P/N	DESCRIPTION
46-196354P4 (or 2265863-2 for LCC)	0.015" (0.40mm) Shim
46-196354P1 (or 2265863 for LCC)	0.030" (0.80mm) Shim

Table 6-2 Cradle Shimming Materials

2.1.3 Overview

Cradle shimming is a function performed by manufacturing during the table assembly process. The purpose is to ensure that when the cradle is bolted to its carriage, the cradle bottom surface is in good contact with the pivoting pair of cradle drive rollers.

The two most common problems being resolved are that the free end of the cradle is:

1.) “Pointing” upward, so that the cradle does not get enough traction with the cradle drive rollers, or

2.) Being forced downward into the cradle drive rollers, which can cause the carriage to bind on the rails.

2.1.4 Procedure

1.) Refer to “Cradle Assembly,” on page 434 for cradle removal instructions. Remove the cradle and right, upper side cover.

2.) Release the carriage from the home latch, and slowly move the carriage all the way toward the cradle drive.

Note: Do not release the carriage. The encoder assembly will be damaged during the rapid unwind of the encoder cable spool.

3.) The carriage rides on two sets of rollers on the rails. The top set of rollers is engaged when the cradle is not cantilevered, that is, when most of the patient weight rests between the carriage and cradle drive. The bottom set of rollers is engaged when it is cantilevered, that is, when most of the patient weight is hanging beyond the cradle drive.

With the carriage close to the cradle drive, wedge the carriage upward so that it is resting against the bottom rollers on the bottom surface of the rails.

4.) Lay a straight edge across the two cradle drive rollers and the cradle-mounting surface of the carriage. By pivoting the cradle drive, you should be able to get the straight edge to touch both rollers and the carriage.

5.) Any gaps between the straight edge and the carriage are the points that need to be shimmed. Place shims as appropriate to fill these gaps. Locations for shims are, as needed, at each of the six cradle mounts on the carriage.

6.) Double stick tape (46-170106P1) may be used to aid in holding the shims in place to ease reassembly and later disassembly.

2.2 Elevation Characterization

1.) Remove upper right and lower right table covers.

2.) Locate the small L-shaped measurement block, stored on top of the bigger measurement block.

   a.) Remove the small L-shaped measurement block from its storage position.

   b.) Install it in its characterization position, at the right rear of the table.

   c.) Move the measurement plate, on the right side of table, to the **out** position.

   d.) Tighten the mounting screws for both plates.

3.) If you are not on the Service Desktop, click on the SERVICE DESKTOP icon.

4.) Click on the CALIBRATION icon.

5.) Select MECHANICAL CHARACTERIZATION**.**

6.) Select TABLE ELEVATION**.**

7.) Follow the Elevation Characterization instructions displayed on the screen. *Important - Take care to measure the exact elevation distances. Incorrect measurement results in Elevation Characterization failure*.

   Refer to Figure 6-9. Measure the elevation distance as vertically as possible. Measure between the bottom surface of each measurement block and the center of the rear leg upper pivot pin.

8.) Return the measurement plates to the storage position.

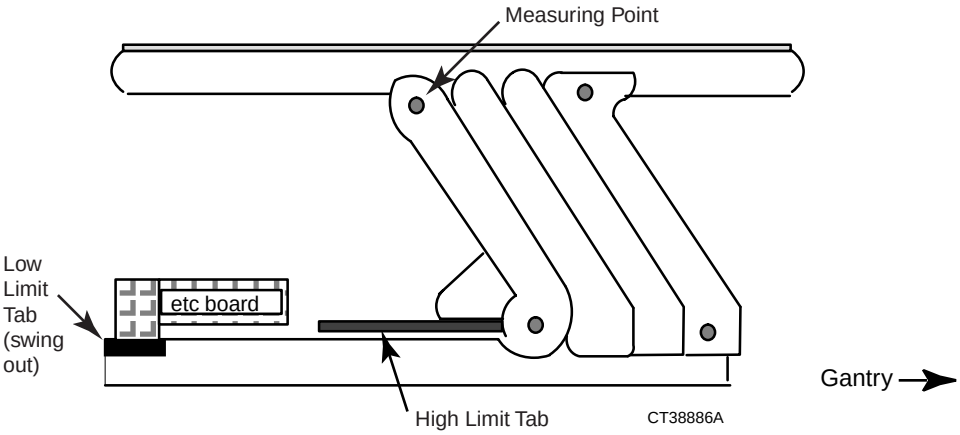


Figure 6-9 Measure Elevation Distance

2.3 ETC Board

Refer to Figure 6-10, below, for sections 2.3.1 through 2.3.3.

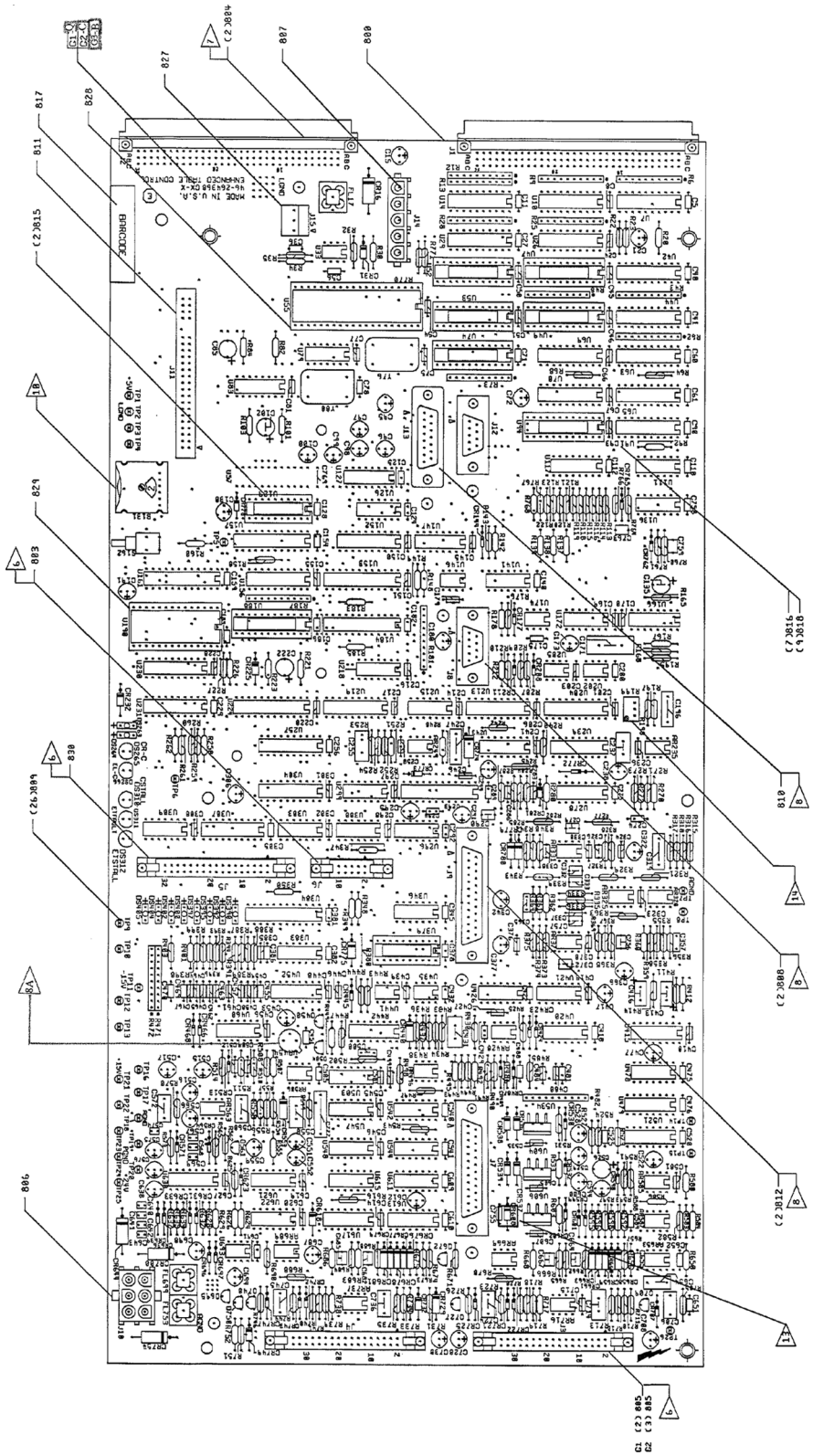


Figure 6-10 ETC Board Layout

2.3.1 ETC Board Test Points

TP1 +5V: (Digital +5 volts) Power Supply Test Point

TP2 LGND: (Digital LGND) Power Supply Test Point

TP3: (Digital ±12 volts) RS232 Table XMIT

TP4: (Digital ±12 volts) RS232 Table REC

TP5: (Digital +5 volts) Spare

TP6: (Digital 0 – 5 volts) Long Encoder CH C

TP7 AGND: (Analog) AGND Power Supply Test Point

TP8: (Analog ±15 volts) Cradle Tach (relatively noisy signal) Gain = 75 mm/sec = 6.3 volts at TP

TP9: (Digital 0 – 5 volts) Long Encoder CH B

TP10: (Digital 0 – 5 volts) Long Encoder CH A

TP11 –15v: (Analog –15 volts) Power Supply Test PointTP12: (Analog 0 – 10 volts) Elev/Tilt Pulse Width Modulation (PWM) Control, (controls AR689 pulse width) Gain =5 uSec pulse Width/volt command

TP13: (Analog +10 volts) +10 Reference

TP14: (Analog 0 – 15 volts) Cradle Current Integrator (averages out pulses from AR653) Wider pulses = more amp current = higher signal

TP15 –15V: (Analog 0 – 15 volts) Elev/Tilt Current Integrator (averages out pulses from AR563) Wider pulses = more amp current = higher signal.

TP16: (Analog 0 – 10 volts) Cradle Pulse Width Modulation (PWM) Control (controls AR669 pulse width) Gain = 5 uSec pulse Width/volt command Analog Signal

TP17: (Digital 0 – 15 volts) Cradle Pulse Width Modulation (PWM) sets output (v) of power amp. Volts out = Pulse width (uSec) * 24 / 56

TP18 AGND: (Analog Ground) Power Supply Test Point

TP19: (Analog ±15 volts) Elev/Tilt Motor Voltage Feedback (Filtered map pulse width modulation signal, fc = 39 cps, gain TP19/amp voltage =.05v/v)

TP20: (Digital 0 – 15 volts) Trigger SYNCH Signal PWM trigger for power amps (17.72 KHz)

TP21 +15V: (Analog +15 volts) Power Supply Test Point

TP22: (Digital 0 – 5 volts) Elev/Tilt Command Direction (+5V = Up/Forward)

TP23: (Digital 0 – 15 volts) Elev/Tilt PWM (sets output (v) of power amp. volts out = pw (uSec) * 160 /56)

TP24 PGND: (Analog Physical Ground) Power Supply Test Point

TP25 +24V: (Analog +24 volts) Power Supply Test Point

TP26: (Analog ±15 volts) Cradle motor voltage Feedback (filtered amp pwm signal), FC = 64 CPS Gain (TP26/amp voltage) = 0.41v/v

2.3.2 ETC Board LEDs

DS263 CR–A: Cradle Encoder A–pulse active

DS264 CR–B: Cradle Encoder B–pulse active

DS265 CR–C: Cradle Encoder C–pulse active

DS266 EL–C: Elevation Encoder C–pulse active

DS310 CSTALL: Cradle stalled when on

DS311 ETFAULT: Elevation/Tilt Amp fault elevation or tilt drive shorted when on

DS312 ETSTALL: Elevation/Tilt Amp stall or tilt drive stalled when on

2.3.3 ETC Board Switch Settings

S162: Reset

S131 Diagnostic: Set to **F**. Note this switch is checked during power up but is not used.

2.4 ETC CPU (Artesyn III) - GE Specific Settings

See Figure 6-11 for the following discussion of the **ETC** board. For the **OBC CPU** see Section 3.19, on page 774, and for the **STC CPU**, see Section 2.15, on page 602.

2.4.1 ETC CPU (Artesyn) Board Layout

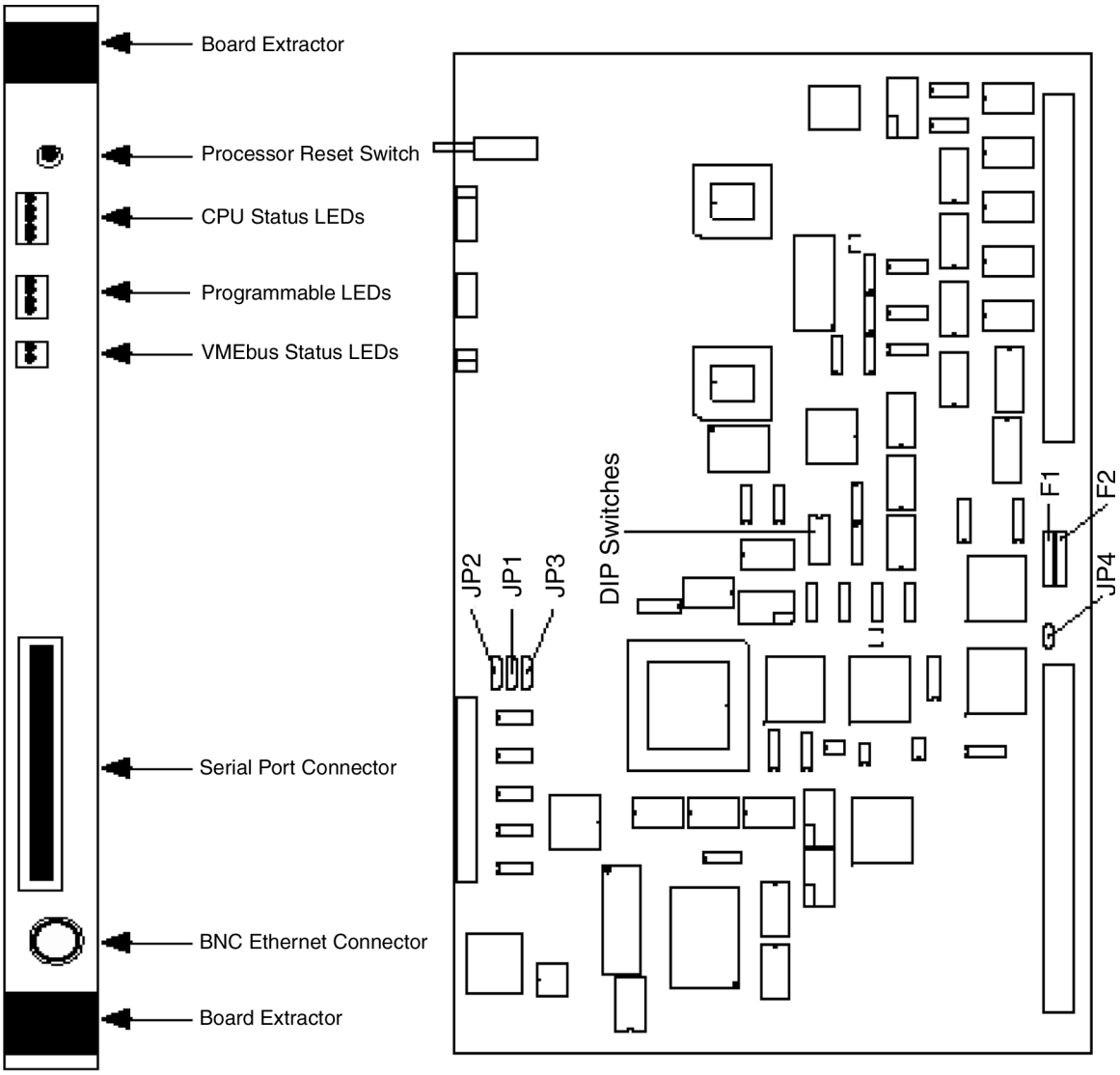


Figure 6-11 ETC CPU (Artesyn) Board Layout

2.4.2 CPU Board Jumpers

JUMPER	FUNCTION	GE CONFIGURATION	COMMENTS
JP1	Port A RI/DCD	J1:1-2	
JP2	Port B RI/DCD	J2:2-3	
JP3	RS-232 Handshaking	J3:1-2	
JP4	Watchdog Enable	removed	Watchdog Disable

Table 6-3 ETC CPU (Artesyn III) Board Jumper Settings

2.4.3 DIP Switch Settings

See board (Figure 6-11, on page 425).

SWITCH NUMBER	CONFIGURATION		FUNCTION	COMMENTS
1	OFF	OPEN	**ETC** node	Selects board for **ETC** Chassis
2	OFF	OPEN	**ETC** node	Selects board for **ETC** Chassis
3	OFF	OPEN	Primary Nodes	selects primary nodes
4	OFF	OPEN	n/a	Not applicable
5	ON	CLOSED	nbsClient view	View logs via nbsClient/**LAN**
6	OFF	OPEN	n/a	Not applicable
7	ON	CLOSED	**EPROM** Boot	Power-Up view **EPROM** Boot
8	OFF	OPEN	Test Disable	Self Test Mode disabled

Table 6-4 ETC CPU (Artesyn III) Board DIP Switch Settings

2.4.4 Power-Up Self Test

The **CPU** board will undergo a Power-Up Self Test, which lasts approximately 18 seconds. After the proper setting of the **EPROM**s, **DIP** switches and board jumpers, the **CPU** board will be placed into a **VME** chassis. A properly terminated Thin-net cable must be attached to the board's BNC connector. This cable is necessary for the Ethernet self tests to complete successfully. No other boards need to be present.

Upon power-up, the self test begins. The **LED** display is at the value 'E' and the test will perform the instruction Set and **EPROM** Checksum Test. When the test is done, the **LED** value will proceed to the next descending value, 'D', and will perform the **RAM** verification test. In the same manner, when this test is done, the **LED** value will proceed to 'C', then 'B', then 'A' and finally to '9'. After the test at '9', the self test is done.

When the test is completed, the **LED** values displayed will indicate if any tests have failed. If a failure is detected, the **EPROM**s, **DIP**-switch settings, Ethernet cable, and board jumpers should be rechecked to ensure proper setup. Then the self test should be rerun. The board must pass the test before shipment. See Figure 6-11, above, for location of the **LED**s.

LED # 1234	LED HEX	LED ASSIGNMENT	DURATION
xxxo	E	Instruction Set and **EPROM** Checksum Test	1 second
xxox	D	**RAM** Verification	13 seconds
xxoo	C	CIO Unit Test	0.3 seconds
xoxx	B	Internal Loop Back	1 second
oxox	A	External Loop Back	1 second
oxxo	9	Transmit Test	1 second
x = on o = off			

Table 6-5 ETC CPU (Artesyn III) Board Power Up LEDS

2.4.5 Power Up Self Test Results

On Power-up, the ETC controller displays the results of its self tests. Power must remain off to a controller for at least 60SEC or Self-test may not be run or results may be inaccurate. This is because the dynamic RAM retains the CPON information. In this event, power-up tests are bypassed and the results of the last power-up test are displayed on LEDs.

1 2 3 4	HEX	LED ASSIGNMENT
• • • •	F	Not Available - - Do Not Use for a test
• • • o	E	Artesyn (see Table 6-7 for details)
• • o •	D	Artesyn (see Table 6-7 for details)
• • o o	C	Artesyn (see Table 6-7 for details)
• o • •	B	VME/LAN (see Table 6-8 for details)
• o • o	A	VME/LAN (see Table 6-8 for details)
• o o •	9	VME/LAN (see Table 6-8 for details)
o • o o	4	spare for GE future use
o o • •	3	spare for GE future use
o o • o	2	spare for GE future use
o o o •	1	spare for GE future use
o o o o	0	Not Available - - Do Not Use for a test
• = LED ON, o = LED OFF, 1 = LED MSB, 4 = LED LSB		

Table 6-6 ETC Self-Test LED Outputs

2.4.5.1 ETC, STC & OBC (Artesyn) Tests

FUNCTION	LEDS	DESCRIPTION
Initialization	(F: • • • •)	Setup interrupt vectors & CIO
Failure	(E: • • • o)	CPU HALTS
Processor/PROM Checksum	(E: • • • o)	68000 Instruction set check (ram used) ROM Verified using CRC16 based polynomial
Failure	(E: • • • o)	CPU HALTS
Ram Verification -	(D: • • o •)	Each word of memory R/W 16 times
Failure	(E: • • • o)	CPU HALTS
CIO Verification	(C: • • o o)	Checks interrupts, timers, counters (no VME)
Failure	(E: • • • o)	CPU HALTS
• = “on” o = “off”		

Table 6-7 Artesyn Board Related LED Readouts

At this point the type of node (ETC, STC or OBCR) determines the tests that are run.

2.4.5.2 ETC - VME/LAN Tests

FUNCTION	LEDS	DESCRIPTION
LAN controller tests	(B: • o • •)	Checks module present, controller & internal loops
Failure	(B: • o • •)	Flashes, possibly with other failures
LAN External loop-back	(A: • o • o)	Checks wire/ termination
Failure	(A: • o • o)	Flashes, possibly with other failures
TDR test	(9: • o o •)	Checks wire/ termination
Failure	(9: • o o •)	Flashes, possibly with other failures
• = “on” o = “off”		

Table 6-8 ETC VME & LAN Related LED Readouts

2.5 ETC-IF Board

2.5.1 Power Supply Voltage Requirements

The **ETC** Interface board +5Vdc voltage margin will be:

Idle: 4.62Vdc - 5.50Vdc (7.6% -> +10.0%)

Active: 4.62Vdc - 5.50Vdc (7.6% -> +10.0%)

2.5.2 Diagnostic Jumpers

Four jumpers for diagnostics will be on board. They will be pulled up to VCC. When the jumper is installed, they will be shorted to ground.

Diag0 and Diag1 will be used to support remote tilt operation. No jumpers should be placed on the header for Diag0 and Diag1.

Diag2 and Diag3 are spare and will be used by firmware.

2.5.3 Reset and Power-Up Requirements

Power-up

All flip-flops will go to their default states and the cradle-latch relay will be in the latched state. Also sends reset through the **CAN** bus.

ETC initiated reset

This will reset everything except FFAE22 register and the cradle-latch state.

Pushbutton reset

The same as the power-up reset, except that the cradle-latch state is maintained.

Gantry reset

This reset does not reset the interface board. It is sent to the **CPU** card on the **ETC** board.

Applications requirement

Applications firmware must be updated once, using Flash Download procedures.

2.6 Gantry Display, Gantry Control Panel, ETC-IF Switches

DIAGNOSTIC SWITCHES

Each node will have four firmware readable diagnostic switches, operating as follows:

SWITCH NUMBER	DISPLAY FUNCTION	CONTROLS FUNCTION	ETC-IF FUNCTION
0	No function	No function	DO NOT USE
1	No function	No function	DO NOT USE
2	No function	Enable Button code display test	No function
3	Enable Display Test	Enable Display Test	No function

Table 6-9 ETC-IF, Gantry Display, Gantry Control Panel Switches

Section 3.0
Table Replacement Procedures

3.1 Gantry Display and Controls

Refer to "Display," on page 654.

3.2 AC/DC Power Switch Replacement

1.) Raise the table to maximum height.
2.) Turn off the Table breaker in the **PDU**, to remove power from the entire table.
3.) Remove the left base covers.
4.) Locate the Power Assembly:
   a.) Remove the screws from the outlet cover.
   b.) Move the cover aside, to gain access to the power switches.
   c.) Loosen the nut that fastens the defective power switch to the plate.
   d.) Remove the switch from the plate

Note: Pay attention to the location of the wires on the defective switch, before you remove them. Restore the wires to their original configuration on the replacement switch.

5.) Loosen the screw terminals, and remove the wires from the defective switch.
6.) Transfer the wires to the same location on the replacement switch.
7.) Reassemble the Table, and replace the covers.
8.) Turn on the Table breaker in the **PDU** to restore power.

3.3 Actuator Cover

1.) Raise the table to maximum height.
2.) Remove the Base Covers, the right Table Side Covers and right Side Panels.
3.) Locate the Actuator cover:
   a.) Remove both of the clips that fasten the spring pin to the actuator cover.
   b.) Slide out the pin, to release the spring.
   c.) Remove the two screws that fasten the cover hinge to the U-bracket.
   d.) Remove the Actuator cover from the table.
4.) When you install the actuator cover:
   a.) Center the cover in the rear leg opening.
   b.) Tighten the hinge screws
   c.) Seat the spring in the notch on the spring pin.
5.) Reassemble the Table, and replace the covers.

3.4 Actuator Limit Switch

1.) Raise the table to maximum height.
2.) Turn off the Table breaker in the **PDU**, to remove power from the entire table.
3.) Remove the Base Covers.

4.) Remove the Actuator Cover, if you plan to replace or adjust the Upper Limit Switch. (Refer to Section 3.3, on page 430.)

5.) Remove the wires from the switch.

6.) To remove the Upper Limit Switch:

a.) Loosen the screw that fastens the switch in place.

b.) Slide the switch up, along the actuator until free.

c.) Remove the wires from the terminals

7.) To remove the Lower Limit Switch:

a.) Remove the screw and two washers from the switch.

b.) The nut plate is trapped, but may slide down the actuator.

c.) Remove the wires from the terminals

8.) To install either limit switch:

a.) Slide the switch into place on the actuator.

b.) Connect the wires to the W and C terminals.

c.) Do not tighten the screw until you adjust the switch position.

9.) To adjust the Upper Limit Switch:

a.) Locate the calibration plate, on the right side of the base frame.

b.) Loosen the two Cal plate screws.

c.) Move the plate to its horizontal position, and tighten the screws.

d.) Restore power, and elevate the table until the distance between the bottom of the Cal plate, at the UPPER LIMIT SWITCH position, and the center mark on the upper rear leg pivot pin equals 33.62 ±0.03 inches.

e.) Remove power, and attach a continuity device to the W and C terminals.

f.) Loosen the clamping screw on the upper limit switch.

g.) Slide the switch upward until at least 1 of the magnet tubes appears below the switch.

h.) Slowly slide the switch downward until the switch opens, then tighten the screw.

10.) To adjust the Lower Limit Switch:

a.) Locate the calibration bar on the right rear corner of the base frame.

b.) Remove the Cal bar from its storage position.

c.) Reposition the bar in the storage hole, to make it parallel to the rear surface of the base frame, then tighten the screw.

d.) Restore power, and elevate the table until the distance between the bottom outer edge of the Cal bar and the center mark on the upper rear leg pivot pin equals 14.53 ±0.03 inches.

e.) Remove power, and attach a continuity device to the W and C terminals.

f.) Loosen the clamping screw on the switch, and slide the switch downward as far as possible.

g.) Slowly slide the switch upward, until the switch opens, then tighten the screw.

11.) Return the calibration plate and bar to their storage positions.

12.) Reassemble the Table, and replace the covers.

13.) Turn on the Table breaker in the **PDU** to restore power.

3.5 Actuator Magnet Rod

1.) Raise the table to maximum height.

2.) Turn off the Table breaker in the **PDU**, to remove power from the entire table.

3.) Remove the Base Covers, the right Side Panels and the Actuator Cover.

Refer to "Actuator Cover," on page 430.

4.) Remove the two nuts that fasten the Magnet Rod to its plate at the upper end of the actuator.

5.) Slide the Magnet Rod out of the actuator.

6.) Replace the Magnet Rod, and adjust the Upper and Lower Actuator switches.

Note: Because magnet strengths vary, follow the procedure that starts on page 430, to adjust both Actuator Limit Switches.

7.) Reassemble the Table, and replace the covers.

8.) Turn on the Table breaker in the **PDU** to restore power.

3.6 Table Elevation Actuator

WARNING PREVENT INJURY TO YOURSELF OR OTHERS. IF THE GAS SPRINGS CANNOT SUPPORT THE WEIGHT OF THE TABLE, THE TABLE COULD FALL. PLACE A SUPPORT BAR BETWEEN THE Z-CHANNEL AND FLOOR, OR ENLIST THE AID OF A SECOND PERSON TO MONITOR THE TABLE.

1.) Raise the table to maximum height.

Note: Remove all objects from the cradle before proceeding.

2.) Turn off the Table breaker in the **PDU**, to remove power from the entire table.

3.) Remove the Base Covers, the right Side Panels and the Actuator Cover.

4.) Remove the Actuator Cover U-bracket.

Follow the Actuator Cover removal procedure, on page 430.

5.) Disconnect the motor wires and ground strap.

6.) Cut the Ty-Raps, and remove the clamp that fastens the limit switch wires to the Actuator.

7.) The gas springs keep the Actuator under tension, even when you raise the table to maximum height. To remove tension from the Actuator:

- Raise the table past its upper height limit with a power supply, or by manually turning the hex drive on the end of the motor.
- Raise the table to fully extend the gas springs, while the lower gas spring remains at the back of the slot in the lower mounting block.

8.) Loosen and remove the lock nut from the upper Actuator mounting pin.

If you cannot easily remove the upper Actuator mounting pin, return to the previous step, and raise the table to remove the gas spring tension.

Note: Important: Loosen both actuator mounting pins before you remove either one.

9.) Pay attention to the positions of the two bumper washers and spacer when you remove them.

10.) Retract the Actuator with the power supply, or the hex drive, but do not let the Actuator fall when the rod end clears the upper mounting block.

Note: Do not over-shorten the Actuator.

11.) Remove, and keep, the E-ring from the lower mounting pin.

12.) Slide the pin out.

13.) Lift and remove the Actuator from the table.

14.) When you install the Actuator:

a.) Coat the lower pin with a thin layer of Molykote grease.

b.) Take care to install the E-ring correctly.

c.) Place one bumper washer on either side of the rod end of the Upper Mounting Pin.

- On the right side, the bumper washer fits over the shoulder on the hex-side of the pin.
- On the left side, the spacer fits inside the bumper washer, and spaces the rod end away from the mounting clevis.

d.) Torque the lock nut to 40 ft-lbs.

15.) Connect the motor wires to the corresponding terminals.

16.) Connect the wires to the corresponding W and C terminals of each switch.

17.) Ty-Rap the limit switch harness in place.

18.) Adjust the Upper and Lower Actuator Limit Switches.

The Actuator adjustment procedure begins on page 430.

19.) Reassemble the Actuator Cover.

Refer to Actuator Cover, Section 3.3, on page 430.

20.) Reassemble the Table, and replace the covers.

21.) If necessary, turn on the Table breaker in the **PDU** to restore power.

3.7 Cradle Drive Belt

1.) Raise the table to maximum height.

2.) Turn off the Table breaker in the **PDU**, to remove power from the entire table.

3.) Remove the Cradle Drive Assembly, and set it on a work surface.

Cradle Drive Assembly procedure begins on page 435.

4.) Remove the belt from the pulleys:

a.) Loosen the four screws that fasten the motor in place.

b.) Slide the motor toward the drive roller, to remove tension from the belt.

c.) Remove the belt.

5.) After you install the new belt:

a.) Slide the motor away from the drive roller, until the belt deflects 0.050/0.060 inches with 4 to 6 ounces applied at its mid-span.

b.) Tighten the four screws, to fasten the motor, with tension on the belt.

6.) Replace the Cradle Drive Assembly.

7.) Reassemble the Table, and replace the covers.

8.) Turn on the Table breaker in the **PDU** to restore power.

3.8 Elevation Encoder Belt

1.) Raise the table to maximum height.

2.) Turn off the Table breaker in the **PDU**, to remove power from the entire table.

3.) Remove the Base Covers and left Side Panels.

4.) Remove the elevation encoder belt from the sprockets:

a.) Loosen the two screws that fasten the Elevation Encoder Assembly to the base.

b.) Slide the encoder assembly toward the large sprocket, to remove tension from the encoder belt.

c.) Remove the belt.

5.) After you install the new belt:

a.) Align the splice on the belt with the mark on the large sprocket.

b.) Slide the Elevation Encoder Assembly away from the large sprocket, until the belt deflects 0.250 inches with 32 – 35 oz. applied at its mid-span.

c.) Tighten both screws, to fasten the encoder assembly in place, with tension on the belt.

6.) Loosen the coupler screw, and adjust the Encoder Table Elevation C-pulse.
- Encoder Table Elevation procedure begins on page 437.
- The C-Pulse adjustment procedure begins on page 437.

7.) Loosen and adjust the switch cam.
Table Interference Matrix Switch procedure begins on page 441.

8.) Reassemble the Table, and replace the covers.

9.) If necessary, turn on the Table breaker in the **PDU** to restore power.

3.9 50 Ohm BNC Feed-Through Connector

1.) Locate the Feed-Through connector near the SCA-**LAN** PWB, on the table **ETC** PWB.

2.) Rotate the knurled rings to remove, and install the BNC Feed-Through Connector.

3.) Use care to route the cables and BNC connectors out of harms way.

3.10 Cal Pin

There are two procedures: one with the Cal pin and one without.

1.) Use the Cal Pin to lock the cradle/carriage into position, at specific locations.
- Remove the right Table Side Covers, and Cradle Drive Cover, to access the Cal pin.
- Store the Cal pin in the bottom of the right z-channel, beneath the Cradle Drive Cover.

2.) The following procedures use the Cal pin:
- Home Switch: starts on page 440.
- Home Latch Assembly: starts on page 441.
- Longitudinal Encoder Assembly: starts on page 443.
- Longitudinal Limit Switch: starts on page 445.
- Longitudinal Encoder Pot Assembly: starts on page 445.

3.11 Cradle Assembly

1.) Raise the table to maximum height.

2.) Drive the Cradle/carriage to the latched, home position, before you try to remove the assembly.
An unlatched Cradle/carriage assembly could quickly move toward the gantry, and damage the longitudinal encoder assembly.

3.) Remove, and keep, the six plug buttons that cover the cradle bolt holes.

4.) Loosen and remove the six screws located beneath the plug buttons.

5.) Lift the Cradle upward, to remove the assembly from the table.

6.) To install the Cradle:
a.) Position the rear end of the Cradle over the carriage.
b.) Align the holes in the cradle to the threads in the carriage.
c.) Start, but do not tighten, all six screws.
d.) Look through the gantry bore at the end of table.
e.) Laterally position the Cradle on the drive rollers, until the same gap exists between the sloped sides of the Cradle and the guide rollers.
f.) Tighten the six screws to 13 ft-lbs.

g.) Replace the plug buttons.

7.) Make sure the cradle/carriage does not rest against the latch.

3.12 Cradle Drive Amplifier

1.) Raise the table to maximum height.
2.) Turn off the Table breaker in the **PDU**, to remove power from the entire table.
3.) Remove the left Base Covers.
4.) Loosen the captive screws (or remove the four screws) that fasten the servo amp cover in place.
5.) Remove the servo amp cover and set aside.
6.) Locate the Cradle Drive Amplifier, toward the outside of the table:
    a.) Detach all of the wire connectors.
    b.) Remove the seven screws that fasten the Amp to its mounting bracket.
7.) Remove and replace the defective Cradle Drive Amplifier.
8.) Reassemble the Table, and replace the covers.
9.) Turn on the Table breaker in the **PDU** to restore power.

3.13 Cradle Drive Assembly

1.) Raise the table to maximum height.
2.) Turn off the Table breaker in the **PDU**, to remove power from the entire table.
3.) Remove the right Table Side Covers.
4.) Latch the carriage, and remove the Cradle Assembly.
    Cradle Assembly procedure begins on page 434.
5.) Loosen the two captive screws, and remove the Cradle Drive Cover.
    a.) Disconnect the ground strap from the Z-Channel.
    b.) Unplug the J21 wire connector from the left side.
    c.) Unplug the J18 wire connectors from the right side.

Note: An unlatched Cradle/carriage assembly could quickly move toward the gantry and damage the longitudinal encoder assembly.

6.) Move the carriage toward the gantry:
    a.) Hold the carriage in place with one hand.
    b.) Manually unlatch the carriage with the other hand.
    c.) Slowly move the carriage toward the gantry, until it meets the bumper stop.
7.) Remove the Cradle Drive Assembly:
    a.) Tilt the front roller of the Cradle Drive downward.
    b.) Lift the entire assembly up, then backward, and then down.
    c.) Gently remove the assembly from the bottom of the table.

Note: Take care not to disturb the Longitudinal Encoder cable.

8.) After you reassemble the Cradle Drive:
    a.) Center the Cradle between the guide rollers.
    b.) Torque the six screws to 13 ft-lbs.
    Cradle Assembly procedure begins on page 434.
9.) Reassemble the Table, and replace the covers.

10.) Turn on the Table breaker in the **PDU** to restore power.

3.14 Elevation Encoder Assembly

1.) Raise the table to maximum height.
2.) Turn off the Table breaker in the **PDU**, to remove power from the entire table.
3.) Remove the Base Covers, and the left Side Panels.
4.) Locate the table harness at the rear of the **ETC** mounting panel:
    a.) Disconnect the J15 Encoder cable from the table harness.
    b.) Cut the Ty-Raps, to free the cable.
5.) Remove the two screws that fasten the Elevation Encoder Assembly to the table base.
6.) Slide the Assembly toward the large sprocket, to relieve belt tension.
7.) Remove the belt from the encoder assembly.
8.) Remove the defective Encoder Assembly from the table.
9.) Install the replacement Elevation Encoder Assembly:
    a.) Replace the belt
    b.) Slide the Elevation Encoder Assembly away from the large sprocket, until the belt deflects 0.250" with 32 – 35 oz. applied at its mid-span.
    c.) Tighten both screws, to fasten the encoder assembly in place, with tension on the belt.
10.) Adjust the encoder C-Pulse position.
    - Encoder Table Elevation (C-pulse) procedure begins on page 437.
    - The C-Pulse adjustment procedure begins on page 437.
11.) Adjust the Table Interference Matrix Switch.
    Interference Matrix Switch procedure begins on page 441.
12.) Characterize the elevation axis. The Mechanical Characterization procedure begins on page 422.
13.) Reassemble the Table, and replace the covers.
14.) Turn on the Table breaker in the **PDU** to restore power.

3.15 Elevation/Tilt Amplifier

1.) Raise the table to maximum height.
2.) Turn off the Table breaker in the **PDU**, to remove power from the entire table.
3.) Remove the left Base Covers.
4.) Loosen the captive screws (or remove the four screws) that fasten the servo amp cover in place.
5.) Remove the servo amp cover and set it aside.
6.) Locate the Elevation/Tilt Amplifier, toward the inside of the table.
    a.) Detach all of the wire connectors.
    b.) Remove the seven screws that fasten the Amp to its mounting bracket.
7.) Remove and replace the defective Elevation/Tilt Amplifier.
8.) Reassemble the Table, and replace the covers.
9.) Turn on the Table breaker in the **PDU** to restore power.

3.16 Table Elevation Encoder

1.) Raise the table to maximum height.
2.) Turn off the Table breaker in the **PDU**, to remove power from the entire table.
3.) Remove the Base Covers and the left Side Panels.
4.) Locate the table harness at the rear of the **ETC** mounting panel:
    a.) Disconnect the J15 Encoder cable from the table harness.
    b.) Cut the Ty-Raps, to free the cable.
5.) Locate the Elevation Encoder Assembly:
    a.) Loosen the screw on the encoder-side of the flexible coupling.
    b.) Loosen the two set screws that fasten the thumb wheel to the encoder shaft.
6.) Remove the encoder assembly:
    a.) Locate the three servo clamps that fasten the encoder to the mounting block.
    b.) Turn each servo clamp 1/2 turn ccw.
    c.) Pull the encoder away from the block.
    d.) Slide the thumb wheel and the spacer off the shaft.
    e.) Remove the encoder from the table.
7.) Install the replacement encoder assembly:
    a.) Place the spacer on the Encoder shaft.
    b.) Insert the shaft through the block and thumb wheel.
    c.) Firmly seat the encoder in the block.
    d.) Let the Encoder cable hang down (±45 degrees) while you tighten the three servo clamps.
    e.) Press the thumb-wheel against the spacer and the Encoder, while you tighten the two set screws in the thumb-wheel.
8.) C-Pulse Adjustment:
    a.) Locate the Calibration plate, on the right side of the base frame.
    b.) Loosen the two screws on the Cal plate, move the plate to its horizontal position, then tighten the screws.
    c.) Turn on the Table breaker in the **PDU** to restore power.
    d.) Restore table power, and elevate the table until the distance between the bottom of the Cal plate, at the C-pulse position, and the center mark on the upper rear leg pivot pin equals 27.52 ± 0.01 inches.
    e.) Turn the thumb-wheel to rotate the encoder shaft and light the C-Pulse **LED** on the **ETC** PWB.
    f.) Tighten the flexible coupler screw to clamp the Encoder shaft in the C-Pulse position.
    g.) Verify the C-Pulse **LED** remains lit.
    h.) Return the Cal plate to its storage position.
9.) Reassemble the Table, and replace the covers.

3.17 ETC Board

3.17.1 Required Tools

- Phillips #2 screwdriver
- Flatblade screwdriver
- 5/64” Hex Key
- **ESD** Wristband

3.17.2 Procedure Detail

NOTICE **Prevent permanent damage to the static-sensitive boards. Attach the anti-static wrist strap to your wrist and to a bare metal grounding point on the table before you continue.**

1.) Remove table base cover.
2.) Power off the table by flipping the three (3) switches opposite the **ETC** assembly.
3.) Use a flat-blade screwdriver to loosen the 2 screws that fasten the cover over the **ETC** Board.
4.) Use a flat-blade screwdriver to remove the screw on the floor of the table control area that allows the assembly to pivot.
5.) Pivot the assembly.
6.) Disconnect all connections to the Interface Board.
7.) Use a flat-blade screwdriver to remove 4 copper colored screws that secure Interface Board.
8.) Use a hex key to remove the three (3) screws that fix Interface Board above **ETC** Board.
9.) Lift off interface board.
10.) Disconnect all cables to **ETC** and Artesyn.
11.) Use a hex key to remove the eight (8) screws that hold the **ETC** Board.
12.) Use a hex key to remove the one (1) screw that holds the Artesyn Board.
13.) Remove the **ETC** and Artesyn Boards as one, and then separate the two boards.
14.) Connect the new **ETC** and Artesyn Boards.
15.) Install the new **ETC** and Artesyn Boards as one.
16.) Reassemble the table.

3.18 ETC-IF Board

3.18.1 Required Tools

- Phillips #2 screwdriver
- Flatblade screwdriver
- 5/64” Hex Key
- **ESD** Wristband

3.18.2 Procedure Details

NOTICE **Prevent permanent damage to the static-sensitive boards. Attach the anti-static wrist strap to your wrist and to a bare metal grounding point on the table before you continue.**

1.) Remove table base cover.
2.) Power off the table by flipping the 3 switches opposite the **ETC** assembly.
3.) Use a flat-blade screwdriver to loosen the 2 screws that fasten cover over the **ETC** Board.

4.) Use a flat-blade screwdriver to remove the screw on the floor of the table control area that allows the assembly to pivot.
5.) Pivot the assembly.
6.) DIsconnect all connections to the Interface Board.
7.) Use a flat-blade screwdriver to remove 4 copper colored screws that secure Interface Board.
8.) Use a hex key to remove 3 screws that fix Interface Board above **ETC** Board.
9.) Lift off interface board.
10.) Install the new board, replace screws and reconnect cabling.
11.) Pivot **ETC** assembly and secure in operational position.
12.) Restore power to table, and perform Flash Download to load applications firmware.
13.) Verify hardware reset, gantry display and motion controls are fully functional.
14.) Install **ETC** assembly cover.
15.) Reassemble table

3.19 ETC Fan

1.) Raise the table to maximum height.
2.) Turn off the Table breaker in the **PDU**, to remove power from the entire table.
3.) Remove the Base Covers.
4.) Unplug the Fan connector.
5.) Pay attention to the position of the Fan connector (lower left corner) and the direction of air flow (toward the **CPU** PWA).
6.) Remove three (3) screws that fasten the Fan to the power assembly bracket.
7.) Remove the two (2) screws that fasten the guard to the defective Fan.
8.) When you install the replacement Fan, position it with the connector in the lower left corner and the air flow indicator pointing toward the **CPU** PWA.
9.) Turn on the Table breaker in the **PDU** to restore power.
10.) Reassemble the Table, and replace the covers.

3.20 Servo Amp Fuse

1.) Raise the table to maximum height.
2.) Turn off the Table breaker in the **PDU**, to remove power from the entire table.
3.) Remove the left Base Covers.
4.) Loosen the captive screws (or remove the four screws) that fasten the servo amp cover in place.
5.) Remove the servo amp cover, and set aside.
6.) Remove the plastic fuse cover, if present.
7.) Remove the defective fuse from its holder.
8.) Install the new fuse.
9.) Reassemble the Table, and replace the covers.
10.) Turn on the Table breaker in the **PDU** to restore power.

3.21 Gas Spring Replacement

1.) Raise the table to maximum height.
2.) Turn off the Table breaker in the **PDU**, to remove power from the entire table.

Note: Important - Remove all objects from the cradle.

3.) Remove the Base Covers and the right Side Panels.
4.) The gas springs keep the Actuator under tension, even when you raise the table to maximum height. To remove tension from the Actuator:
   - Raise the table past its upper height limit with a power supply, or by manually turning the hex drive on the end of the motor.
   - Raise the table to fully extend the gas springs, while the lower gas spring remains at the back of the slot in the lower mounting block.
5.) Loosen and remove the lock nut from the upper Actuator mounting pin.

   If you cannot easily remove the upper Actuator mounting pin, return to the previous step, and raise the table to remove the gas spring tension.

Note: Important - Loosen both actuator mounting pins before you remove either one.

6.) Remove the E-Rings from the top and bottom Gas Spring mounting pins.
7.) Remove the pins from their mounting blocks.
8.) Remove both Gas Springs.

⚠ WARNING DISPOSE OF GAS SPRINGS PROPERLY

DO NOT THROW DEFECTIVE GAS SPRINGS IN THE TRASH. COMPACTING A PRESSURIZED GAS SPRING MAY CAUSE IT TO EXPLODE. RETURN BOTH GAS SPRINGS TO:

GEMS RECYCLING CENTER, ACE WAREHOUSE
ATTN.: PAUL NEUMILLER
2200 E. COLLEGE AVE. BLDG. 11
CUDAHY, WI, 53110

9.) When you install the replacement Gas Springs:
   a.) Position the Gas Spring pressure chambers UP, or closest to the front table leg.
   b.) Take care to install the E-ring correctly.
10.) Reassemble the Table, and replace the covers.
11.) Turn on the Table breaker in the **PDU** to restore power.

3.22 Home Position Switch

1.) Raise the table to maximum height.
2.) Turn off the Table breaker in the **PDU**, to remove power from the entire table.
3.) Remove the right Table Side Covers and Cradle Drive Cover, to access the Cal pin.
4.) Install and tighten the Cal pin to about one-half inch from the home position, to hold the carriage in place.

Note: Pay attention to the location of the wires on the defective switch, before you remove them. Restore the wires to their original configuration on the replacement switch.

5.) Disconnect the wires from the Home Position switch terminals.
6.) Remove the nut that fastens the switch in place.
7.) Remove the defective switch from its bracket.

8.) Install the replacement switch.

Make sure you connect the wires to the COM and N.O. terminals.

9.) Adjust the position of the switch in the bracket:

a.) Loosen the two nuts that fasten the bracket in place.

b.) Move the bracket until the switch actuates when the carriage reaches 0.50 ±0.03 inches from the Home Position.

10.) Return the Cal pin to its storage position.

11.) Reassemble the Table, and replace the covers.

12.) Turn on the Table breaker in the **PDU** to restore power.

3.23 Home Latch Assembly

1.) Raise the table to maximum height.

2.) Turn off the Table breaker in the **PDU**, to remove power from the entire table.

3.) Remove the right Table Side Covers and Cradle Drive Cover, to access the Cal pin.

4.) Install and tighten the Cal pin in the home position, to hold the carriage in place.

5.) Remove the Cradle Assembly and the right side Rail Cover.

Cradle Assembly procedure begins on page 434.

6.) Disconnect the harness at the terminal strip.

7.) Remove the four screws that fasten the Latch Assembly to the z-channel.

8.) Remove the defective Latch assembly.

9.) Install the replacement Latch Assembly, but do not tighten the four screws.

10.) Adjust the position of the entire Latch Assembly in its slots:

a.) Adjust the Latch assembly until the distance between the carriage latch block and the forward edge of the latch bar opening equals 0.050 ±0.005 inches.

b.) Maintain this distance while you tighten the four screws.

c.) Adjust the set screw in the latch clevis block, until the outer edge of the latch bar overlaps the outer edge of the carriage latch block by 0.050 ±0.00 inches.

d.) Maintain this distance while you tighten the jam nut.

11.) Make sure the solenoid plunger bottoms out:

a.) Adjust the position of the solenoid bracket, until the clearance between the outer edge of the latch bar and the outer edge of the carriage latch block equals 0.050 ±0.005 inches.

b.) Maintain this distance while you tighten the two screws.

12.) Adjust the position of the spring bracket, until the spring has 0.125 inches pre-load, when the latch bar rests against the set screw.

Maintain this distance while you tighten the two screws.

13.) Install the Cradle.

Cradle Assembly procedure begins on page 434.

14.) Return the Cal pin to its storage position.

15.) Reassemble the Table, and replace the covers.

16.) Turn on the Table breaker in the **PDU** to restore power.

3.24 Interference Matrix Switch

1.) Raise the table to maximum height.

2.) Remove the left Base Covers.

3.) Turn off the Table breaker in the **PDU**, to remove power from the entire table.
4.) Remove the Servo Amp Assembly.
5.) Remove the two screws that fasten the interference switches to the bracket.

Note: Pay attention to the location of the wires on the defective switch, before you remove them. Restore the wires to their original configuration on the replacement switch.

6.) Detach the wires from the terminals of the defective switch.
7.) Remove the defective switch and install the replacement switch.
8.) Fasten the switches to the bracket, but do NOT tighten the screws.
9.) Adjust the switch-to-cam clearance:
    a.) Position the switches until the roller lever comes in contact with the switch housing.
    b.) Adjust the switch position until a 0.035/0.045 inch gap exists between the roller and the outside cam surface.
    c.) Maintain this distance while you tighten the two screws.
10.) Turn on the Table breaker in the **PDU** to restore power.
11.) Adjust the actuation point:
    a.) Locate the Cal plate, on the right side of the base frame.
    b.) Loosen the two Cal plate screws, move the plate to the horizontal position, then tighten the Cal plate screws.
    c.) Elevate the table until the distance between the bottom of the Cal plate (at the INT. MTX SWITCH S2 position) and the center mark on the upper rear leg pivot pin equals 26.03 ±0.03 inches.
12.) Adjust the cam:
    a.) Loosen the cam clamping screw.
    b.) Rotate the cam until switch S2 (closest to center of the table) rides on the outside surface of the cam.
    c.) Turn the cam CW (seen from the left side of the table) until S2 actuates.
    d.) Tighten the cam clamping screw, and verify the setting.
13.) Reassemble the Table, and replace the covers.

3.25 Intercom Speaker

1.) Raise the table to maximum height.
2.) Turn off the Table breaker in the **PDU**, to remove power from the entire table.
3.) Remove the right Side Panels.
4.) Remove the two nuts that fasten the speaker cover to the speaker.
5.) Remove the two nuts that fasten the Speaker and grill in place.
6.) Remove the defective speaker, and install the replacement speaker.
7.) Reassemble the Table, and replace the covers.
8.) Turn on the Table breaker in the **PDU** to restore power.

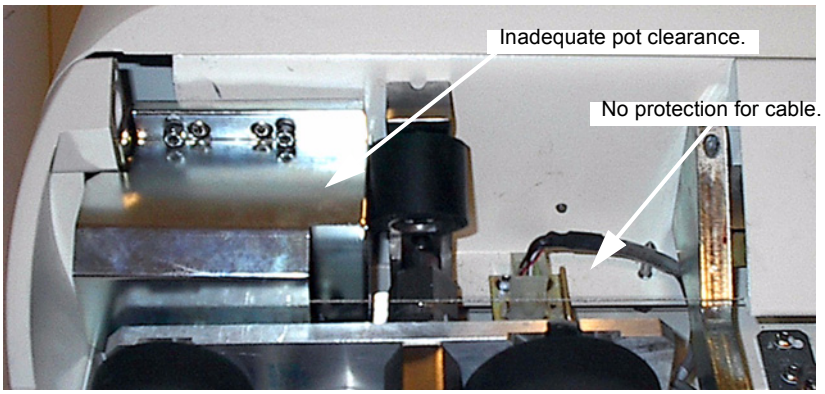
3.26 Tape Switch Jumper Plug

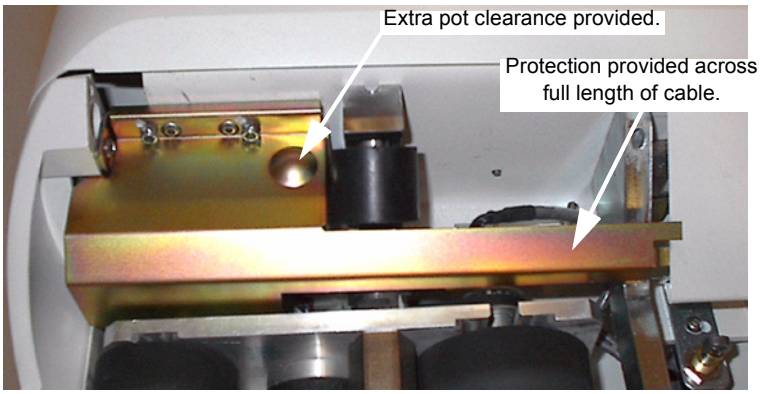
Use the Jumper Plug to simulate the presence of a Side Cover Tape Switch, when you remove the corresponding cover from the table.

- Refer to the Table Side Covers procedures.
- The Table Side Cover descriptions begin on page 447.

3.27 Leg Tape Switch

1.) Raise the table to maximum height.
2.) Turn off the Table breaker in the **PDU**, to remove power from the entire table.
3.) Remove the right Side Panels.
4.) Disconnect the Tape Switch from the harness.
5.) Remove the Tape Switch and the adhesive from the rear leg.
6.) Thoroughly clean the mounting surface with alcohol.
7.) Remove the protective strip from the adhesive, and press the switch firmly in place.
8.) Replace the Side Panels.
9.) Turn on the Table breaker in the **PDU** to restore power.
10.) Test the Tape Switch for proper operation.





3.28 Longitudinal Encoder Assembly

1.) Raise the table to maximum height.
2.) Turn off the Table breaker in the **PDU**, to remove power from the entire table.
3.) Remove the right Table Side Covers and Cradle Drive Cover to access the Cal pin.
4.) Remove the Cradle Assembly and the right side Rail Cover.
Cradle Assembly procedure begins on page 434.
5.) Remove the two lock nuts that fasten the Longitudinal Encoder Assembly Cover in place.
6.) Remove the two screws that fasten the Front End Cover in place.
7.) Grasp the carriage with one hand, while you manually unlatch the carriage with the other hand.
8.) Slowly move the carriage assembly toward the gantry, until it rests against the bumper stop.

NOTICE **Letting go of the Cradle/carriage assembly before it rests against the bumper stop could damage the longitudinal encoder assembly.**

9.) Loosen the clamp that fastens the pot sprocket to the pot shaft.

10.) Detach the stranded steel cable from the carriage:

a.) Firmly hold the eyelet on the encoder cable.

b.) Remove the shoulder screw and spacer from the carriage.

NOTICE **Maintain at least 2 pounds of tension on the cable. If you release tension and allow the cable spool to unwind, you will damage the encoder assembly.**

11.) Remove one turn of cable pre-load:

a.) Slowly pull the cable by the eyelet until it reaches the first hex spacer on the encoder asm.

b.) Fasten the eyelet to the hex spacer with a ty-rap, to maintain the initial three turns of pre-load on the spool.

12.) Locate the right z-channel:

a.) Unplug the encoder J16 connector from the table harness.

b.) Unplug the pot connection at J17.

13.) Remove the two screws that fasten the Encoder Assembly to the table.

14.) Remove the defective Longitudinal Encoder Assembly.

15.) When you install the replacement Encoder Assembly:

a.) Make sure the cable maintains the initial three turns of pre-load on the spool.

Factory replacement assemblies arrive with the initial three turns of pre-load applied and the eyelet anchored to the hex spacer.

b.) Do not tighten the pot sprocket clamp at this time.

c.) Connect J16 and J17.

d.) Fasten the cable to the carriage with the shoulder screw and spacer.

e.) Slowly move the carriage to the home position, then install and tighten the Cal pin, to fasten the carriage in place.

16.) Turn on the Table breaker in the **PDU** to restore power.

NOTICE **You will damage the pot if you turn it past the zero VDC position.**

17.) Adjust the pot:

a.) Attach a DVM to terminals #2 and #1 (GND) of the pot.

b.) Turn the pot shaft with a small screwdriver, until the DVM displays 0.80 ±0.01 VDC.

c.) Maintain the voltage display, while you tighten the pot clamp.

d.) Do not remove the DVM at this time.

18.) Adjust the C-Pulse:

a.) Loosen the clamp that fastens the cable spool to the encoder shaft.

b.) Turn the encoder thumb-wheel to light the C-pulse **LED** on the **ETC** PWA.

c.) Tighten the clamp, and verify the C-pulse **LED** remains lit.

19.) Check for increase in pot voltage:

a.) Hold the carriage assembly in position with one hand, while you remove the Cal pin with the other hand.

b.) Continue to hold on to the carriage assembly, while you manually release the Home position latch.

c.) Watch the DVM display, while you slowly move the carriage toward the gantry.

d.) The pot voltage should increase as the carriage moves toward the gantry.

⚠ **NOTICE** **You will damage the pot if you turn it past the zero VDC position.**

20.) Characterize the longitudinal axis.

21.) Store the Cal pin, reassemble the Table, and replace the covers.

3.29 Longitudinal Limit Switch

1.) Raise the table to maximum height.

2.) Turn off the Table breaker in the **PDU**, to remove power from the entire table.

3.) Remove the Cradle Drive Cover.

Note: Pay attention to the location of the wires on the defective switch, before you remove them. Restore the wires to their original configuration on the replacement switch.

4.) Disconnect the wires from the limit switch terminals.

5.) Remove the nut that fastens the switch in place.

6.) Remove the defective switch from its bracket.

7.) Install the replacement switch.

Make sure you connect the wires to the COM and N.O. terminals.

8.) Adjust the position of the switch in the bracket with the two nuts, so that it actuates when the cradle/carriage is at its maximum travel position, as determined by the Cal pin.

9.) Return the Cal pin to its storage position. Refit the Side Cover and Cradle Drive Cover.

10.) Reassemble the Table, and replace the covers.

11.) Turn on the Table breaker in the **PDU** to restore power.

12.) Adjust the position of the switch in the bracket:

a.) Loosen the two nuts that fasten the bracket in place

b.) Move the Cradle/carriage assembly to the maximum travel position, and fasten into position with the Cal pin.

c.) Move the bracket until the switch actuates with the carriage in the maximum travel position.

13.) Return the Cal pin to its storage position.

14.) Reassemble the Table, and replace the covers.

15.) Turn on the Table breaker in the **PDU** to restore power.

3.30 Longitudinal Encoder Pot Assembly

1.) Raise the table to maximum height.

2.) Remove the Cradle Drive Cover.

3.) Install the Cal pin at the home position, then remove the Cradle Assembly.

Cradle Assembly procedure begins on page 434.

4.) Turn off the Table breaker in the **PDU**, to remove power from the entire table.

5.) Remove the two lock nuts that fasten the Longitudinal Encoder Assembly Cover in place.

6.) Remove the two screws that fasten the Front End Cover in place.

7.) Remove the pot assembly:

a.) Loosen the clamp that fastens the pot sprocket to the pot shaft.

b.) Disconnect the Pot Assembly from the table harness, at J17.

c.) Loosen the two servo clamps.
d.) Slide the defective Pot Assembly downward, and off the sprocket.
e.) Take care not to lose the plastic spacer on the pot shaft.

8.) After you install the replacement Pot Assembly:
a.) Make sure the sprocket comes in contact with the plastic spacer.
b.) Attach a DVM to terminals #2 and #1 (GND) of the pot.
c.) Turn the pot shaft with a small screwdriver, until the DVM displays 0.80 ±0.01 VDC.
d.) Maintain the voltage display, while you tighten the pot clamp.

9.) Return the Cal pin to its storage position.
10.) Reassemble the Table, and replace the covers.
11.) Turn on the Table breaker in the **PDU** to restore power.

3.31 Quad Output Power Supply

1.) Raise the table to maximum height.
2.) Turn off the Table breaker in the **PDU**, to remove power from the entire table.

Note: Pay attention to the location of the wires on the defective supply, before you remove them. Restore the wires to their original configuration on the replacement supply.

3.) Remove the Table Drive Power Supply:
a.) Locate the Quad Output PS (lower power supply).
b.) Disconnect the power input and out wires from the terminals.
c.) Locate and remove the 2 screws that fasten the Quad Output PS to the right side of the Power Assembly main bracket.
d.) Slide the defective power supply out of the assembly.

4.) Install the replacement Quad Output PS.
5.) Reassemble the Table, and replace the covers.
6.) Turn on the Table breaker in the **PDU** to restore power.

3.32 Elevation and Cradle Amplifier Relay

1.) Raise the table to maximum height.
2.) Turn off the Table breaker in the **PDU**, to remove power from the entire table.
3.) Remove the left Base Covers.
4.) Loosen the captive screws (or remove the 4 screws) that fasten the servo amp cover in place.
5.) Remove the servo amp cover, and set aside.
6.) Slide the wire retainer to the side, and pull the defective relay from its socket.
7.) Install the replacement relay.
8.) Reassemble the Table, and replace the covers.
9.) Turn on the Table breaker in the **PDU** to restore power.

3.33 Right Base Cover

1.) Raise the table to maximum height.
2.) Turn each of four captive Dzus fasteners one-quarter turn CCW, to release the cover.
3.) Turn each of four captive Dzus fasteners one-quarter turn CW, to fasten the cover.

The screwdriver slot in the fastener appears horizontal when successfully engaged.

3.34 Table Side Cover (Left or Right)

1.) Raise the table to maximum height.
2.) Turn each of two Dzus fasteners one-quarter turn CCW, and remove, to release the cover.
3.) Tip the bottom of the cover outward slightly, then lift the cover upward to clear the four pins in the z-channel.
4.) If you plan to use any of the table drives:
    a.) Remove the Tape Switch Jumper Plug from its storage position.
    b.) Plug the Tape Switch Jumper into the harness connector.
5.) When you install the Side Cover:
    a.) Return the jumper plug to its storage position.
    b.) The screwdriver slot in the fastener aligns with the Side Cover when you successfully engage the fastener.
6.) Test the Side Cover Tape Switch operation.
7.) Reassemble the Table, and replace the covers.

3.35 Table Side Panels (Right or Left Rear, Right or Left Front)

1.) Raise the table to maximum height.
2.) Remove the Table Base Covers and Table Side Covers.

Note: Pay attention to the orientation of the ground strap terminal, before you remove it. Orient the terminal in the same direction when you replace it.

3.) Remove the ground strap connection from the z-channel.
4.) Each panel has two flat-head screws that fasten the Pivot Tube to its bracket.
    Remove, and keep, the flat-head screws.
5.) When you install the Side Panel, make sure the pivot points move without interference. If the pivot points cannot move freely:
    a.) Loosen the two screws that fasten the upper mounting bracket in place.
    b.) Slide the bracket in its slots, until the side panel pivot points move freely.
6.) Reassemble the Table and replace the covers.

3.36 Table Drive Power Supply

1.) Raise the table to maximum height.
2.) Turn off the Table breaker in the **PDU**, to remove power from the entire table.
3.) Remove the Base Covers.
4.) Remove the power supply hold down bracket.
5.) Remove the screws attaching the outlet cover and move the cover aside to gain access to the power supplies.
6.) The Table Drive PS is the upper power supply. Disconnect the wires from both ends of the power supply.
7.) Remove the upper two attaching screws from the right side of the Power Assembly main bracket attaching the Table Drive PS, and slide the power supply out.
8.) To install the Table Drive PS, reverse above steps, making sure to connect the wires correctly.

9.) Refit the Base Covers.
10.) Reassemble the Table, and replace the covers.
11.) Turn on the Table breaker in the **PDU** to restore power.

3.37 Table Side Cover Tape Switch

1.) Raise the table to maximum height.
2.) Turn off the Table breaker in the **PDU**, to remove power from the entire table.
3.) Remove the Table Side Covers.
4.) Remove the two shoulder screws that fasten the connector to the bracket in the Side Cover.
5.) Remove the terminals from the connector.
6.) Cut the Ty-Raps that fasten the Tape Switch wire to the four brackets.
7.) Remove the Tape Switch.
8.) When you install the replacement Tape Switch:
    a.) Orient the shorter wires toward the connector bracket, when you route the wires through the holes in the cover.
    b.) Slide the tape switch into the channel.
    c.) Do not remove the protective strip from the adhesive.
    d.) Replace the side cover.
9.) Turn on the Table breaker in the **PDU** to restore power.
10.) Test the Tape Switch operation.

Section 4.0
Retest Matrix

REPLACEMENT VERIFICATION AND RETEST

TABLE COMPONENTS	TASK	VERIFICATION TEST
DC Power Supply (±15 volt, +24 volt)	Measure loaded voltages	Perform System Scanning Test, see page 668.
DC Drive Power Supply (+24 volt)	Measure loaded voltages	1.) Confirm full cradle travel and Gantry tilt capability. 2.) Perform System Scanning Test, see page 668.
Longitudinal (Cradle) Pot Assembly (page 445) Encoder cable	Replace, Install or Adjust (page 445)	1.) Remove the Pot (page 445) 2.) Install the Pot (page 445) 3.) Check Pot Voltage (pages 443 & 445) 4.) Perform System Scanning Test, see page 668.
Longitudinal (Cradle) Encoder	Replace, Install or Adjust (page 443)	1.) Remove the Encoder. (443) 2.) Install the Encoder. (443) 3.) Adjust C-Pulse. (443) 4.) Check Pot Voltage (pages 443 & 445) 5.) Perform System Scanning Test, see page 668.
Cradle Drive Amplifier	Replace faulty board, (see page 435)	Perform System Scanning Test, see page 668.
Cradle Assembly	Replace cradle (page 434)	Perform System Scanning Test, see page 668. Repeat with maximum weight
Cradle Drive Assembly	Replace Cradle Drive Assembly (page 435)	1.) Characterize cradle 2.) Perform System Scanning Test, see page 668.
Elevation Encoder or Timing Belt	1.) Replace Elevation Encoder (page 436) 2.) Set C-Pulse (page 437)	1.) Characterize Elevation 2.) Perform System Scanning Test, see page 668.
Actuator (Elevation) Limit Switch	Replace, Install or Adjust (page 430)	1.) Characterize Elevation 2.) Perform System Scanning Test, see page 668.
Table Elevation Actuator	Replace, Install (page 432)	1.) Characterize Elevation 2.) Perform System Scanning Test, see page 668.

Table 6-10 Table Component Replacement Verification

TABLE COMPONENTS	TASK	VERIFICATION TEST
ETC board	Replace, install faulty board (page 438)	1.) Check Characterization Limits (for tilt and table elevation interference) 2.) Perform System Scanning Test, see page 668.
ETC-IF board	Replace, install faulty board (page 438)	1.) Verify gantry controls initialize correctly. 2.) Exercise Elevation, Cradle and Tilt functions
DC Power Supply (+170 Volt)	Measure unloaded and loaded voltages (supply located on the base of table).	Exercise elevation function.
Interference Matrix Switch (Elevation Limit Switches)	Replace, install faulty switch (page 441)	1.) Check Characterization Limits (for tilt and table elevation interference) 2.) Perform System Scanning Test, see page 668.
Gas Springs	Replace, install both Springs (page 440)	1.) Clean excess oil from springs, and exercise table elevation full range with maximum load. 2.) Perform System Scanning Test, see page 668.
Home Latch Assembly	Replace, Install assembly (page 441)	1.) Verify Cradle latches and unlatches. 2.) Perform System Scanning Test, see page 668.
Table Side Cover Tape Switch	Replace, Install Assembly (page 448)	1.) Emergency Stop Check 2.) Perform System Scanning Test, see page 668.
Leg Tape Switches	Replace, Install faulty switch (page 443)	1.) Emergency Stop Check 2.) Perform System Scanning Test, see page 668.
Left or Right Top Cover	Replacement or removal during installation (page 447)	1.) Emergency Stop Check 2.) Perform System Scanning Test, see page 668.
Left or Right Side Panel	Replacement or removal during installation (page 447)	1.) Emergency Stop Check 2.) Perform System Scanning Test, see page 668.
ETC Artesyn Board	Replace, Install faulty board	1.) Verify **ETC** Node **DIP** switch 2.) Perform System Scanning Test, see page 668.

Table 6-10 Table Component Replacement Verification (Continued)

Section 5.0
Troubleshooting - Table Velocity Errors

5.1 Problem

Occasionally, **CT** scanner owners have reported cradle velocity errors.This occurs while driving into the gantry, and with the cradle loaded down by a patient. There have also been reports of a potentiometer to encoder correlation error, but this error is more likely caused by a problem with the longitudinal encoder assembly, specifically the pot. or pot. drive belt and sprockets.

The most likely cause for the velocity error is an out-of-adjustment clutch on the cradle drive assembly. This clutch is adjusted to slip when a force of 36–39 pounds is exerted horizontally on the cradle while driving into the gantry. When the clutch slips, the velocity of the cradle will be far enough out of normal range to trigger an error, which stops the drive. Ideally, this would not occur within the normal operating range of less than 36 pounds. However, when the clutch is out of adjustment, it will slip at lower drive forces that are within the normal range of operation. A one–direction roller-clutch, inside the clutch assembly, prevents any slipping when driving out of the gantry.

Although traction problems between the drive roller and cradle could exist, they are unlikely due to the rough bottom surface of the cradle, and due to the weight of the patient maintaining the contact between the cradle and roller. Another unlikely cause would be roller smoothness; the harder cradle surface is intentionally molded with a rough surface, which slightly distorts the roller's softer rubber surface, creating the high coefficient of friction. Generally, traction problems only occur when there is no patient weight to keep the cradle in contact with the roller. In this case, the shimming between the cradle and the carriage should be reviewed.

5.2 Solution

During the manufacturing of the clutch friction discs, a burr on the inside diameter of the disc (which relaxes after a period of time) was created, causing the clutch to go out of adjustment after leaving the factory. One of two courses of action can be followed, depending on the amount of time available for repair, availability of new parts, and availability of a force gauge:

- The existing clutch can be adjusted. This is the quickest procedure, since it does not require the cradle drive to be removed from the table. However, this is a two-person procedure, and requires a force gauge. Also, since the burrs have not been removed, the adjustment may not be maintained for a long period of time.
- The clutch can be disassembled, the burrs removed, and the clutch then reassembled and adjusted. This is the most time consuming procedure, but does not require a new clutch. However, this is a two-person procedure, and requires a force gauge and cradle drive removal.

5.3 Tools Required

5.3.1 Clutch Adjustment

- Push force gauge, 0-50# or 0-100# (P/N 46-308109P2)
- 5/64” and 1/8” hex key wrenches
- 1 1/4” open-end wrench or channel-lock pliers with this capacity
- Loctite 242

5.3.2 Clutch Repair

- Push force gauge, 0-50# or 0-100#
- 5/64” and 1/8” hex key wrenches

- 1-1/4” open-end wrench or channel-lock pliers with this capacity.
- Loctite 242
- Sandpaper, 220 grit

5.4 Procedures

Figure 6-12 is provided as a reference drawing for the clutch assembly. Please review Figure 6-12 to familiarize yourself with the various parts of the clutch assembly before beginning any procedure.

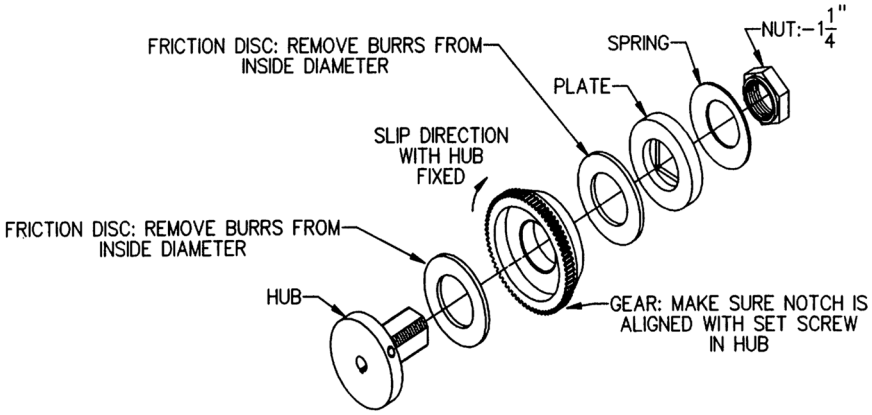


Figure 6-12 Table Clutch Assembly

5.4.1 Clutch Adjustment

1.) Place at least 100# on the cradle, toward the gantry end.

2.) Remove the cradle drive cover from the bottom of the table.

3.) Locate the clutch on the left end of the drive roller. Loosen the two set screws securing the 11/4” hex nut with the 5/64” hex wrench. If necessary, release and move the cradle to rotate the drive roller and clutch, to gain access to the set screws.

4.) Position the cradle about 3 feet from home. Tighten the hex nut a small amount (1/4 flat), and then measure the driving force into the gantry with the force gauge. Drive the cradle with the table-side controls at the fast speed, while the FE reaches through the gantry with the force gauge pushing on the end of the cradle. Push hard enough for the clutch to slip, and note the reading on the gauge. Insure that the drive roller is stationary (i.e., not slipping on the cradle bottom), and that the end of the clutch (i.e., hex nut) is rotating when the measurement is taken. If the roller is slipping on the cradle, then add more weight to the cradle.

5.) For proper adjustment, the gauge reading should be as close to 40# as possible, but must **not** exceed 40#. An ideal range is 36-39#. Repeat step 4 until the correct force is measured. Loctite and tighten the set screws and verify the reading again.

6.) A check must now be made to see if the cradle releasing solenoid and gear rack are properly adjusted. Removing the cradle will make this check easier to perform and more accurate. Follow the procedure in Section 3.11, on page 434, for removing the cradle.

When the solenoid is energized, the gear rack is engaged in the clutch gear and allows the cradle to be driven. The engagement of the rack in the gear must not have any backlash, nor can the solenoid plunger be excessively extended out of the solenoid body. When correctly set, the solenoid plunger will be within 0.010" of bottoming-out in the body, when there is no backlash at the rack/gear interface.

Adjust the solenoid bracket so that the plunger is bottomed when the solenoid is energized, and then move the bracket forward (toward the gantry) until there is no backlash between the rack and gear, as checked at four, 90 degree apart, positions on the gear. The solenoid should

be energized so that all the looseness is removed from the linkage; if energizing is not possible, be sure to push on the plunger itself (not the pin or link) when checking the adjustment.

7.) Refit the cradle drive cover.

5.4.2 Clutch Repair

1.) Follow the procedures in Sections 3.12 and 3.13 for removing the cradle drive from the table.

2.) Locate the clutch on the left end of the drive roller. Loosen the two set screws securing the 11/4” hex nut with the 5/64” hex wrench. Remove the hex nut from the clutch, along with the spring washer, hub plate, friction washer, gear with one-way bearing, and the second friction washer. Do not remove the clutch hub itself.

3.) Inspect the inside diameter of both friction washers for burrs. Remove any burrs with the sandpaper. Clean the dust and particles from the washers and then reassemble in reverse order; hand tighten the hex nut. Note that the friction washers are centered by the roller clutch that is pressed into the gear.

4.) Refit the cradle drive assembly according to the procedures in Sections 3.12 and 3.13.

5.) Position the cradle about 3 feet from home. Tighten the hex nut a small amount (1/4 flat), and then measure the driving force into the gantry with the force gauge. Drive the cradle with the table-side controls at the fast speed, while the FE reaches through the gantry with the force gauge pushing on the end of the cradle. Push hard enough for the clutch to slip, and note the reading on the gauge. Insure that the drive roller is stationary (i.e., not slipping on the cradle bottom), and that the end of the clutch (i.e., hex nut) is rotating when the measurement is taken. If the roller is slipping on the cradle, then add more weight to the cradle.

6.) For proper adjustment, the gauge reading should be as close to 40# as possible, but must **not** exceed 40#. An ideal range is 36-39#. Repeat Step 4) until the correct force is measured. Loctite and tighten the set screws and verify the reading again.

7.) A check must now be made to see if the cradle releasing solenoid and gear rack are properly adjusted. Removing the cradle will make this check easier to perform and more accurate. Follow the procedure in Section 3.11, on page 434, for removing the cradle.

When the solenoid is energized, the gear rack is engaged in the clutch gear and allows the cradle to be driven. The engagement of the rack in the gear must not have any backlash, nor can the solenoid plunger be excessively extended out of the solenoid body. When correctly set, the solenoid plunger will be within 0.010" of bottoming-out in the body, when there is no backlash at the rack/gear interface.

Adjust the solenoid bracket so that the plunger is bottomed when the solenoid is energized, and then move the bracket forward (toward the gantry) until there is no backlash between the rack and gear, as checked at four, 90 degree apart, positions on the gear. The solenoid should be energized so that all the looseness is removed from the linkage; if energizing is not possible, be sure to push on the plunger itself (not the pin or link) when checking the adjustment.

8.) Refit the cradle drive cover.

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GE MEDICAL SYSTEMS-AMERICAS: FAX 262.312.7434
3000 N. GRANDVIEW BLVD., WAUKESHA, WI 53188 U.S.A.

GE MEDICAL SYSTEMS-EUROPE: FAX 33.1.40.93.33.33
PARIS, FRANCE

GE MEDICAL SYSTEMS-ASIA: FAX 65.291.7006
SINGAPOR

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Chapters 7 & 8
Detector/DAS & Gantry

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Chapter 7
Detector and DAS

Section 1.0
Theory

Note: 4 Slice and 8 Slice

4 Slice on HiSpeed QX/i and 8 Slice

The HiSpeed QX/i system can operate in the 4 slice data collections per rotation mode, and is not capable of operating in the 8 slice per rotation mode. However, the Detector and MDAS themselves used on HiSpeed QX/i are designed to operate also in the 8 slice mode. The sections that follow contain the descriptions, figures, and tables related to 8 slice to help you understand the Detector and DAS in their inherent functions.
Refer to "4 Slice versus 8 Slice Configuration," on page 504 for more information.

1.1 Detector

The primary function of the Detector is to convert X-ray photons into electrical current, which is sent to the Data Acquisition System (**DAS**) for signal amplification and analog to digital conversion, before being sent to the Scan Recon Unit for image reconstruction.

The x-rays pass through the patient (or object being scanned) and are attenuated by the density of material. The remaining energy of x-rays pass through to the detector. The detector is composed of tungsten collimator plates, to differentiate the signals to individual channels, and tungsten wires, to differentiate to individual cells of a channel.

Once the x-ray beam is collimated into cells/channels, the photons hit the scintillator pack, which causes it to emit light. The scintillator pack is made up of cast material and a GE exclusive material called Lumex. Lumex is an efficient x-ray absorbtion to light output material, with low afterglow characteristics. The light from the scintillator pack is then picked up by a photodiode array. The photodiode array converts the emitted light into an electric current, which is then passed through to the **DAS**. The current strength is dependent on the amount of x-ray energy absorbed into the Lumex, which corresponds to the light energy output. There is a photodiode output from each detector cell.

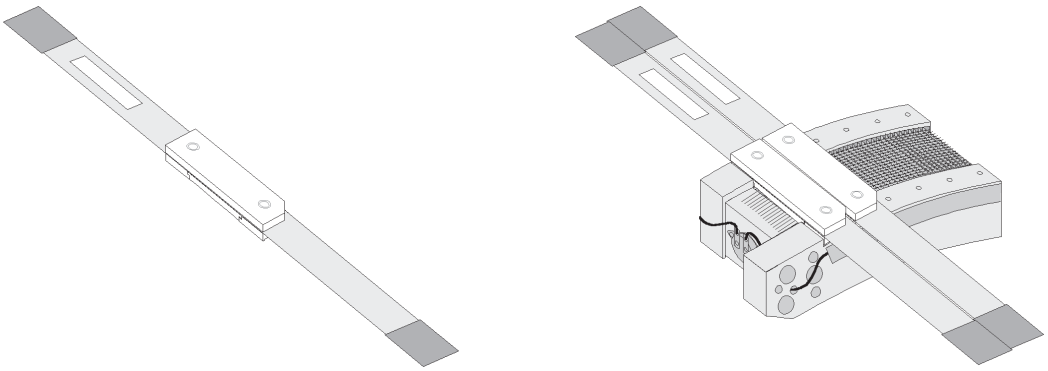


Figure 7-1 Detector Modules

The detector assembly used on this system houses 57 **Detector Modules** (Figure 7-1). Each module has two sides—an **A-side** and a **B-side** (refer to Figure 7-3)—with eight (8) diodes or **cells**

per **channel** per **side**. Cells are labeled **D1** through **D8**, for a total of 16 cells per channel (both A and B sides). There are 16 channels per module.

Each module uses two **flex** connections to the Data Acquisition System (**DAS**). The flex connectors cannot be removed from the module. The flex end is connected to the **DAS** via a **twin elastomer**, with 128 signal lines, 18 FET control lines, 1 mechanical ground and 1 signal ground.

The individual modules have separate mechanical and signal grounds. The module mechanical ground is isolated from the detector housing. The detector housing is a mechanical connection to the gantry mounting plate, and is also an electrical connection. The photodiode control circuitry also has an electrical ground (FET logic ground DGND) and a FET bias. The FET bias was designed to allow a +1V bias to be applied to the FET to reduce or eliminate leakage. This line is connected to electrical ground (FET logic ground DGND).

Detector module temperature is regulated by the electrical resistance heater and the thermistor shown in Figure 7-2. The heater and thermistor are incorporated into the detector assembly. The overall mass of the assembled detector system ranges between 14 and 16 Kg.

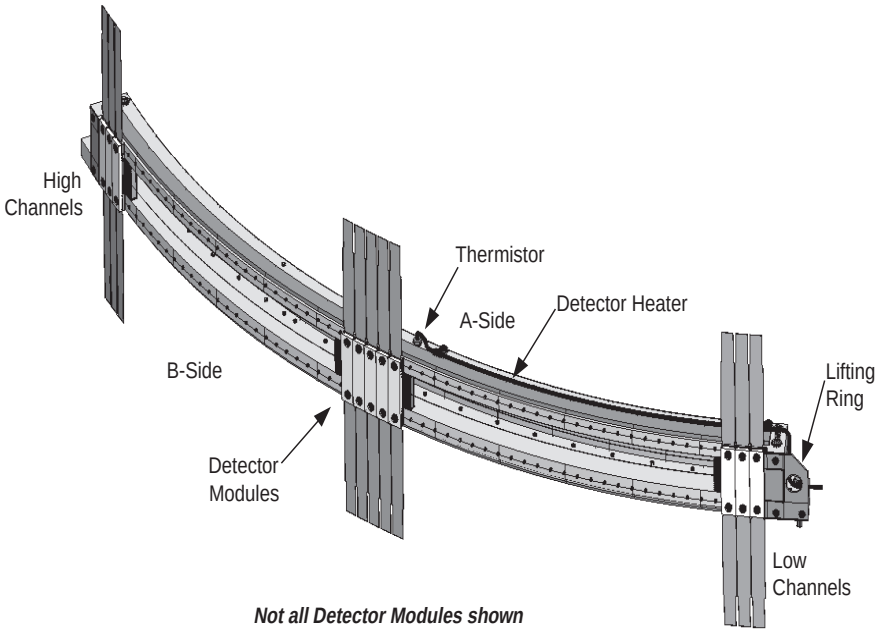


Figure 7-2 Detector Layout

1.1.1 Detector Module

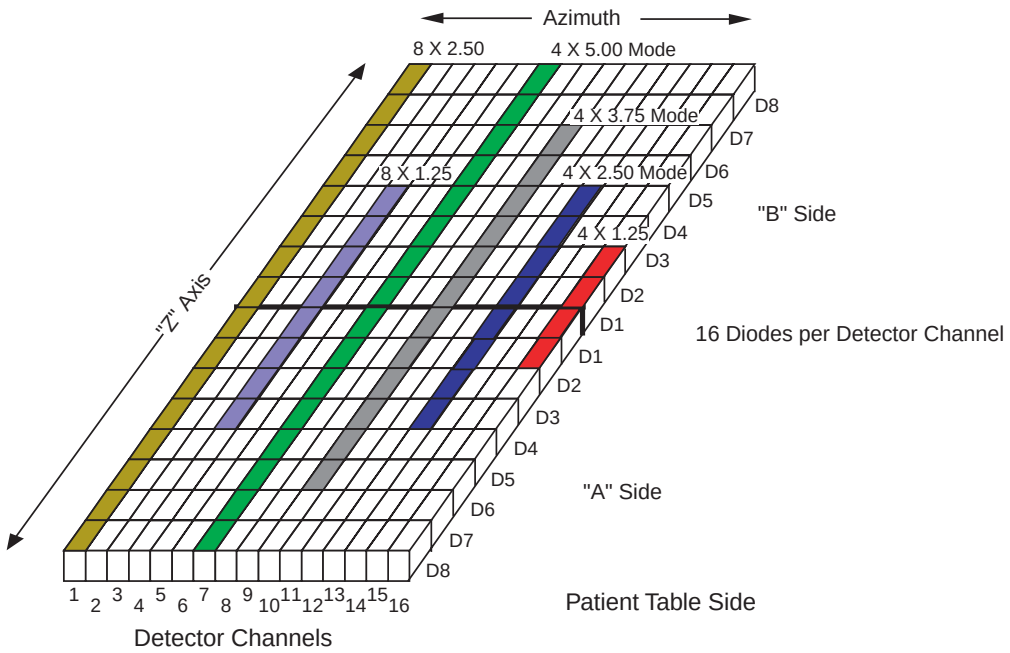


Figure 7-3 Detector Module

Detector Module: A detector module consists of 16 detector channels.

Detector Channel*:* A detector channel consists of 16 diodes arranged in the “Z” direction. In total, there are 912 detector channels on a detector. A single channel is 1mm in length, in the azimuthal direction. A detector channel is sometimes referred to as a **Detector Column**.

Detector Row*:* A row of 16 cells across all detector channels designated by Diode Number AND Side. (Ex. Detector Row D2, Side “A”).

Note: A Detector Row is *not* the same as a **Scan Slice**. A detector row is 1.25mm wide (Z-Direction).

Cell*:* A cell is a single photodiode, and is 1/16 of a Detector Channel. In other words, there are 16 cells, or diodes, per Detector Channel.

Side A/B*:* There are 2 “sides” to a Detector, Side “A” and Side “B”. The sides divide the Detector width in half, with 8 Rows per side. Side “A” is closer to the front of the Gantry (or Table side) and Side “B” is toward the back of the Gantry.

1.1.2 Z-Axis Cell Summation

The detector is segmented into cells in the Z dimension. Post–patient collimation is provided by the segmentation of the detector cells, not by a separate post–patient collimator (see Figure 7-4). The post–patient collimation, along with summation of cells in the Z direction by the detector FET array, determines the Z–axis slice thickness of the scan data.

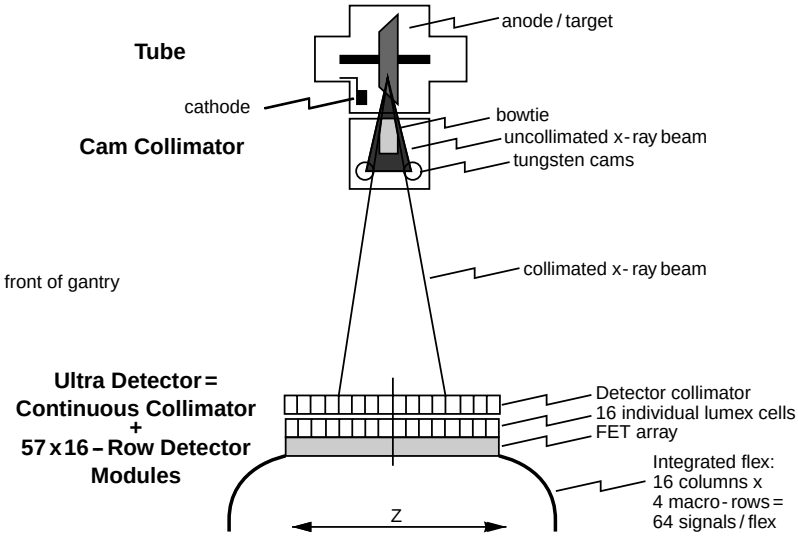


Figure 7-4 Detector Theory - X-Ray Collimation

The Z dimension extent of each cell is 1.25mm at ISO center. Cells are summed in Z to produce a **macro cell**. For eight-slice modes, one or two cells may be summed to form the macro cell. For four-slice modes, one, two, three or four cells may be summed.

All macro cells in the same Z plane form a **macro row**. A macro row is the detector row or combination of rows that is used to generate a post-collimation slice thickness. A macro row consisting of a single cell in each column produces scan data with a thickness of 1.25mm at ISO center. A macro row consisting of 4 summed cells in each column produces scan data with a thickness of 5.0mm at ISO center. There can be up to 8 macro rows, labeled 4A, 3A, 2A, 1A, 1B, 2B, 3B and 4B.

Each flex transmits 4 macro cells to the **DAS** per column x 16 columns per detector module = 64 data channels per flex.

1.1.3 Post Collimation: Z-Axis Beam Profile Considerations

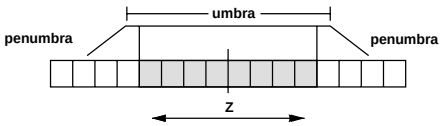


Figure 7-5 Z-axis X-ray Beam Profile, 4 x 2.5mm Detector Configuration

The collimated beam has a Z–axis profile that consists of the umbra (essentially flat) and the penumbra (sloped) (see Figure 7-5, highly idealized). In order to avoid image artifacts, the system must always operate with the umbra region completely covering the detector cells contributing to the selected macro rows. During gantry rotation, the position of the beam moves a small amount in the Z direction, due to various mechanical sags in the gantry, tube, collimator, etc. To ensure that the detector cells are completely covered by the umbra region, the Z dimension extent of the umbra is increased so that the detector is covered regardless of Z–axis beam motion (see Figure 7-5). Detector reference cells are used to estimate the actual position of the x-ray beam on the detector, and real-time feedback is provided to the collimator to compensate for beam motion.

1.1.4 Detector FET Control

The Detector FETs (Field Effect Transistors) are used as switches to combine detector rows, to achieve the prescribed slice thickness. These FETs are physically located in the detector assembly.

NOTICE **FETs are EXTREMELY ESD SENSITIVE. ALWAYS use ESD precautions when handling the Detector or Detector flexes. A bad FET will require the entire Detector to be replaced.**

After a Scan prescription is entered at the Host Computer, the Scan Rx parameters are sent to the appropriate controllers. For slice thickness, the parameters are sent to both the Collimator control board, to select the proper Collimator CAM positions, and the **DAS** Control Board (**DCB**), to select the macro row width.

There are three (3) sets of FET Control lines driven by the **DCB**. Each set consists of six (6) lines used as a binary value that gets decoded in the Detector and finally controls Detector Diode selection. The three (3) sets of FET Control are described in Table 7-1.

FET	DESCRIPTION	CHANNELS
Low Z	FET control lines for low z-reference channels	**DAS** Channels 1 - 8
Data	FET control lines for data channels	**DAS** Channels 9 - 762
High Z	FET control lines for z-reference channels. [Z-Axis tracking.]	High Z-Ref Channels 763 - 768

Table 7-1 FET Control Matrix

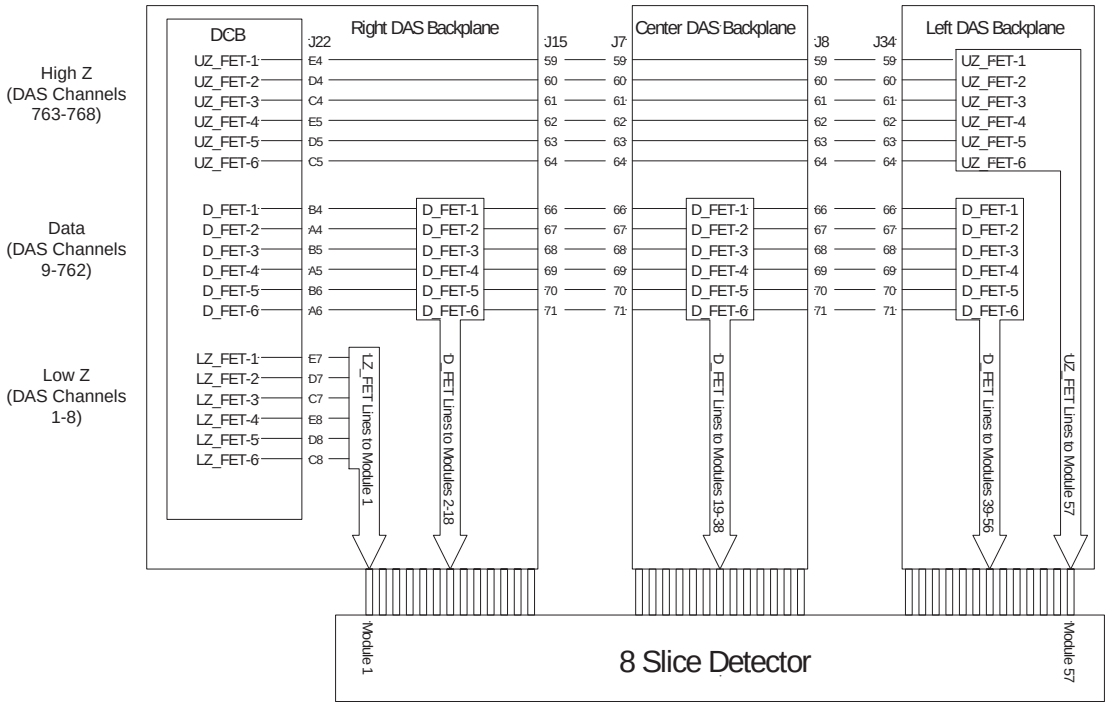


Figure 7-6 FET Control Interconnect

The **DCB** uses five quad SPST analog switches, which are used to drive the FET_BUS. See Figure 7-7.

For an illustration of the LEDs, please refer to Figure 7-41, on page 516.

Normal data modes with Z-chan same as H1.x																4-slice configuration									
A8 (D8)	A7 (D7)	A6 (D6)	A5 (D5)	A4 (D4)	A3 (D3)	A2 (D2)	A1 (D1)	B1 (D1)	B2 (D2)	B3 (D3)	B4 (D4)	B5 (D5)	B6 (D6)	B7 (D7)	B8 (D8)	Slice mode	FET mode	Detector Mode name	Protocol Mode name	FET 1 LED	FET 2 LED	FET 3 LED	FET 4 LED	FET 5 LED	FET 6 LED
2	1													1	2	Z-chan	45	4Cal6	Cal6	OFF	ON	OFF	OFF	ON	OFF
2	2	2	2	1	1	1	1	1	1	1	1	2	2	2	2	4x5.00	36	4x5.00	4x5.00	ON	ON	OFF	ON	ON	OFF
	2	1											1	2		Z-chan	44	4Cal5	Cal5	ON	ON	OFF	OFF	ON	OFF
		2	2	2	1	1	1	1	1	1	2	2	2			4x3.75	35	4x3.75	4x3.75	OFF	OFF	ON	ON	ON	OFF
			2	1							1	2				Z-chan	42	4Cal3	Cal3	ON	OFF	ON	OFF	ON	OFF
				2	2	1	1	1	1	2	2					4x2.50	34	4x2.50	4x2.50	ON	OFF	ON	ON	ON	OFF
				2	2	1	1	1	1	2	2					Z-chan	34	4x2.50	4x2.50	ON	OFF	ON	ON	ON	OFF
						2	1	1	2							4x1.25	33	4x1.25	4x1.25	OFF	ON	ON	ON	ON	OFF
						2	1	1	2							Z-chan	33	4x1.25	4x1.25	OFF	ON	ON	ON	ON	OFF
						2	1	1	2							1x1.25	33	4x1.25	4x1.25	OFF	ON	ON	ON	ON	OFF
						2	1	1	2							Z-chan	33	4x1.25	4x1.25	OFF	ON	ON	ON	ON	OFF
						2	1	1	2							Thin twin	33	4x1.25	4x1.25	OFF	ON	ON	ON	ON	OFF

Normal data modes with Z-chan same as H1.x																8-slice configuration									
A8 (D8)	A7 (D7)	A6 (D6)	A5 (D5)	A4 (D4)	A3 (D3)	A2 (D2)	A1 (D1)	B1 (D1)	B2 (D2)	B3 (D3)	B4 (D4)	B5 (D5)	B6 (D6)	B7 (D7)	B8 (D8)	Slice mode	FET mode	Detector Mode name	Protocol Mode name	FET 1 LED	FET 2 LED	FET 3 LED	FET 4 LED	FET 5 LED	FET 6 LED
2	1					4	3	3	4					1	2	Z-chan	17	8Cal6	Cal6	OFF	ON	ON	ON	OFF	ON
2	2	2	2	1	1	1	1	1	1	1	1	2	2	2	2	4x5.00	8	4x5.00	4x5.00	ON	ON	ON	OFF	ON	ON
3	2	1					4	4					1	2	3	Z-chan	16	8Cal5	Cal5	ON	ON	ON	ON	OFF	ON
		2	2	2	1	1	1	1	1	1	2	2	2			4x3.75	7	4x3.75	4x3.75	OFF	OFF	OFF	ON	ON	ON
	4	3	2	1							1	2	3	4		Z-chan	14	8Cal3	Cal3	ON	OFF	OFF	OFF	ON	ON
				2	2	1	1	1	1	2	2					4x2.50	6	4x2.50	4x2.50	ON	OFF	OFF	ON	ON	ON
				2	2	1	1	1	1	2	2					Z-chan	6	4x2.50	4x2.50	ON	OFF	OFF	ON	ON	ON
						2	1	1	2							4x1.25	5	4x1.25	4x1.25	OFF	ON	OFF	ON	ON	ON
	4	3	2	1							1	2	3	4		Z-chan	14	8Cal3	Cal3	ON	OFF	OFF	OFF	ON	ON
				4	3	2	1	1	2	3	4					8x1.25	0	8x1.25	8x1.25	ON	ON	ON	ON	ON	ON
2	1					4	3	3	4					1	2	Z-chan	17	8Cal6	Cal6	OFF	ON	ON	ON	OFF	ON
4	4	3	3	2	2	1	1	1	1	2	2	3	3	4	4	8x2.50	1	8x2.50	8x2.50	OFF	ON	ON	ON	ON	ON
						2	1	1	2							Z-chan	5	4x1.25	4x1.25	OFF	ON	OFF	ON	ON	ON
						2	1	1	2							1x1.25	5	4x1.25	4x1.25	OFF	ON	OFF	ON	ON	ON
						2	1	1	2							Z-chan	5	4x1.25	4x1.25	OFF	ON	OFF	ON	ON	ON
						2	1	1	2							Thin twin	5	4x1.25	4x1.25	OFF	ON	OFF	ON	ON	ON

Figure 7-7 4 Slice versus 8 Slice FET Mode Assignments

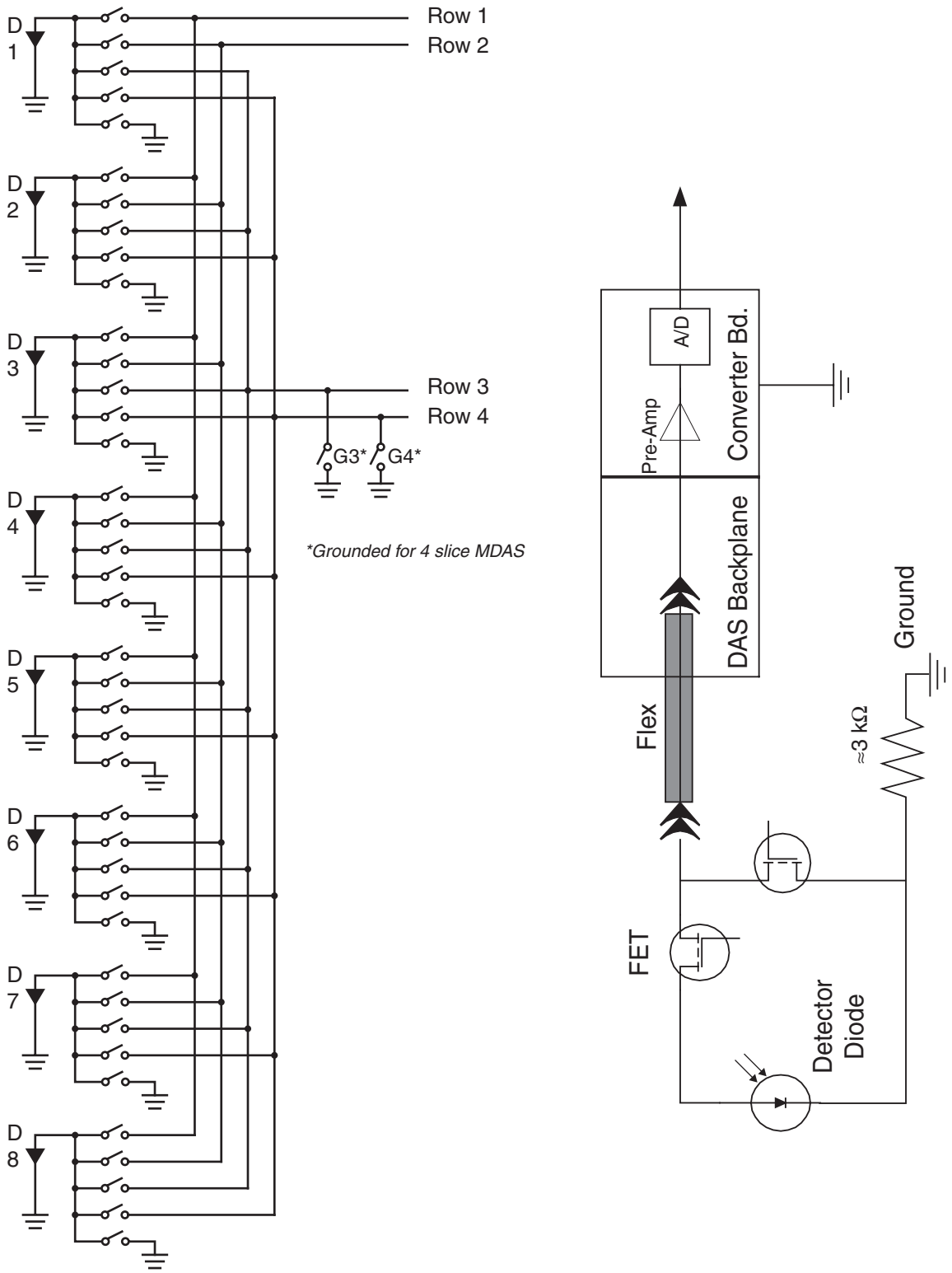


Figure 7-8 MDAS FET Array Arrangement (only one side is shown)

1.1.5 Detector Output Bus to DAS Data Flow

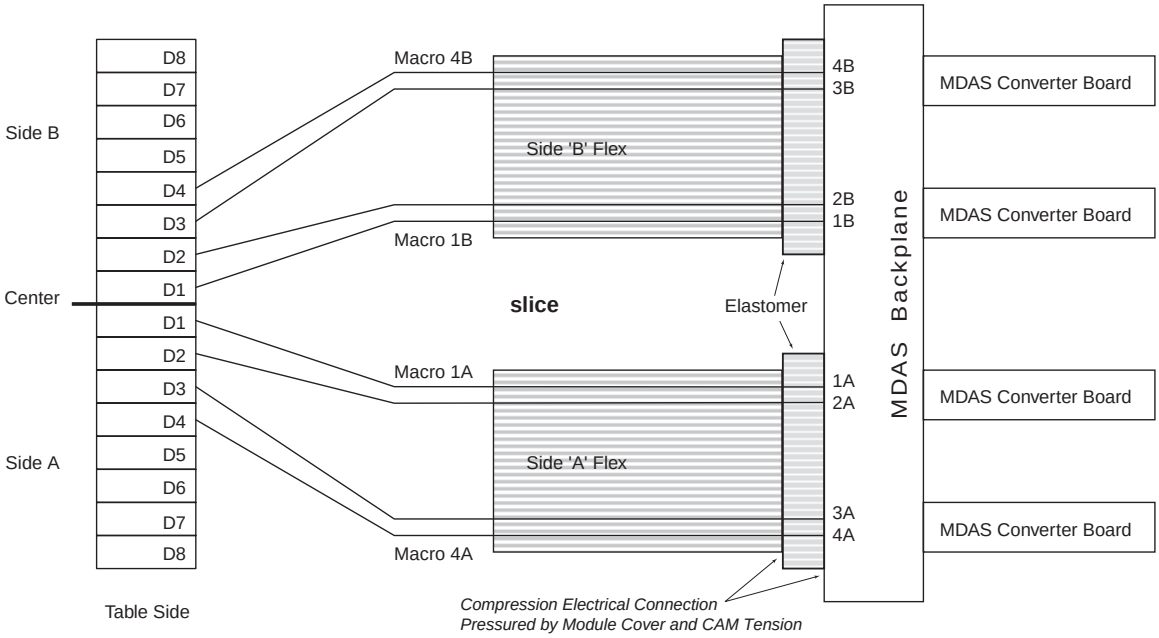


Figure 7-9 8 x 1.25mm Slice

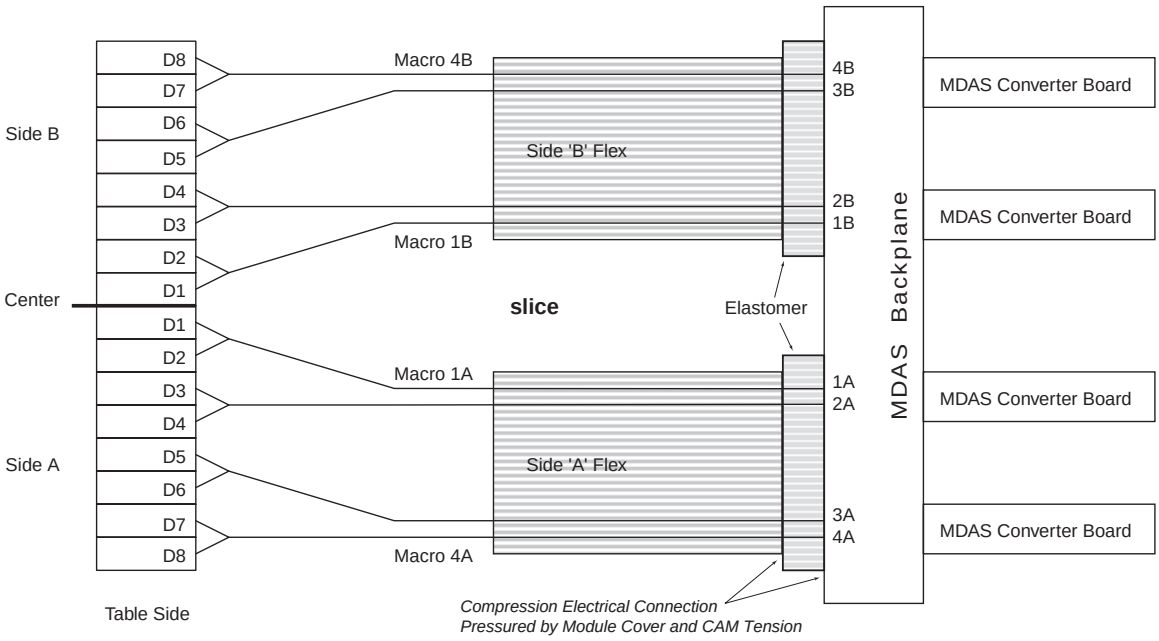


Figure 7-10 8 x 2.50mm

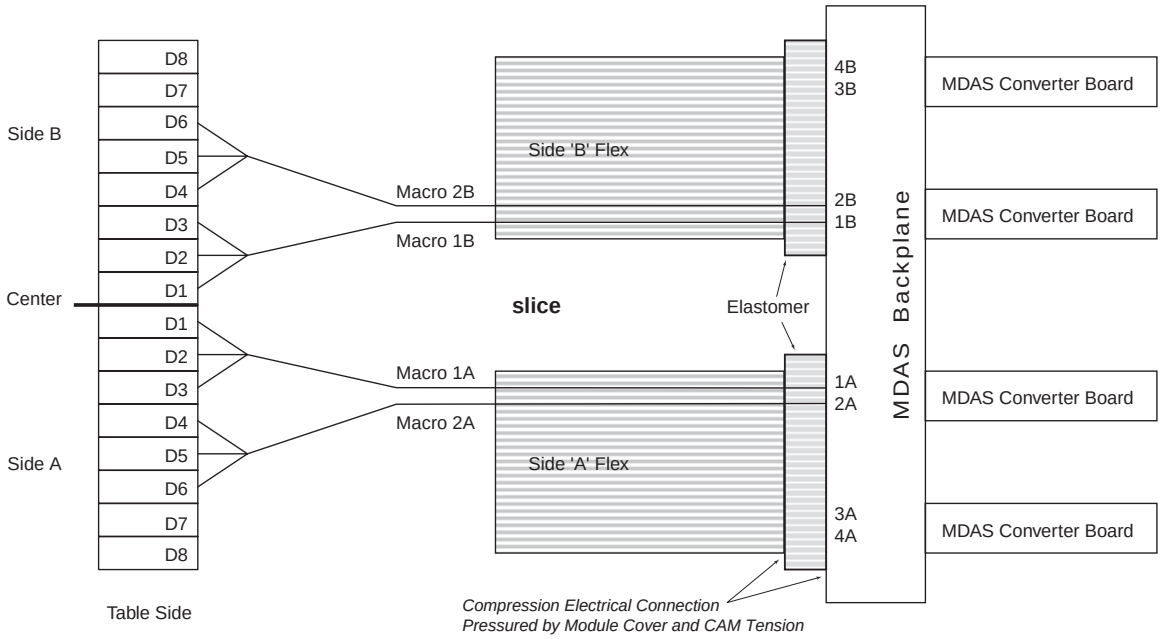


Figure 7-11 4 x 3.75 mm

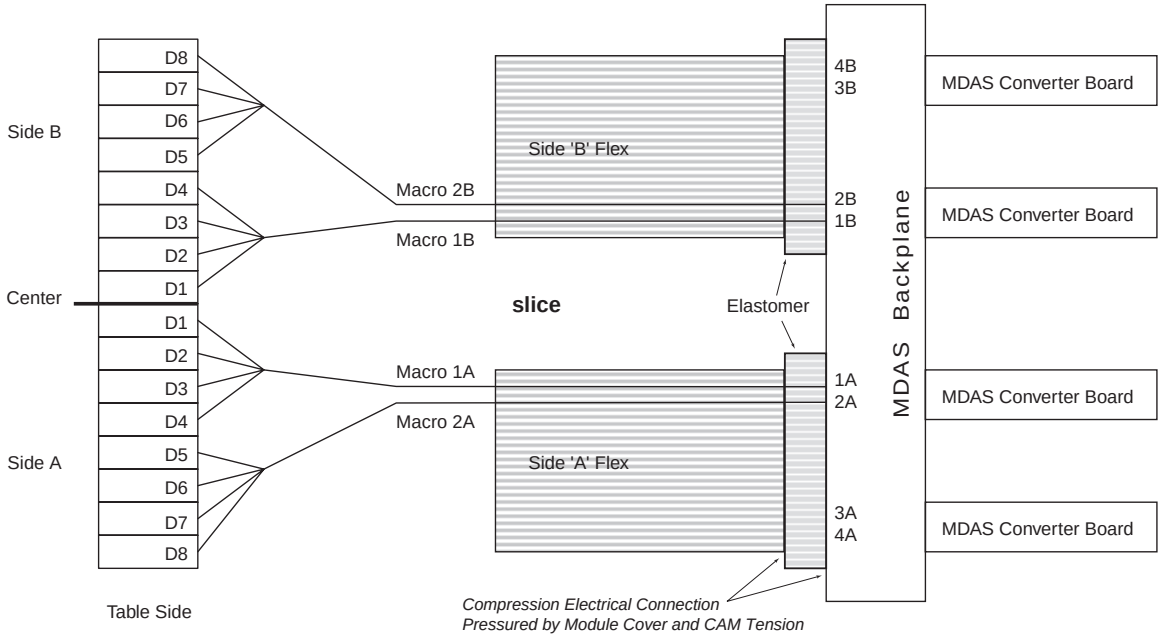


Figure 7-12 4 x 5.00 mm

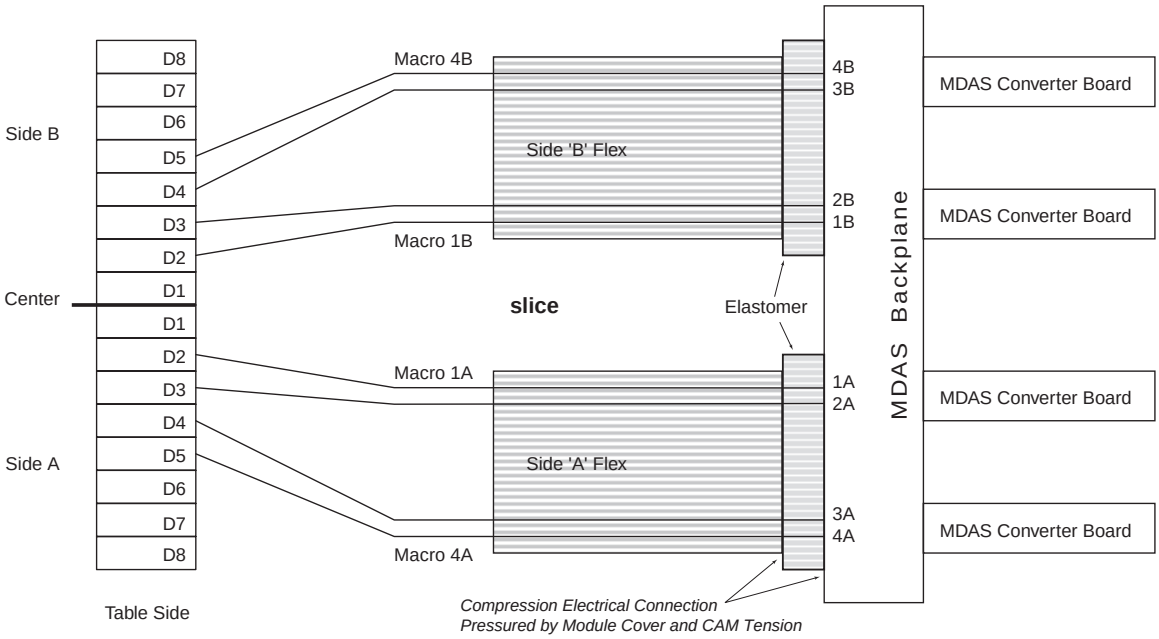


Figure 7-13 8CAL1

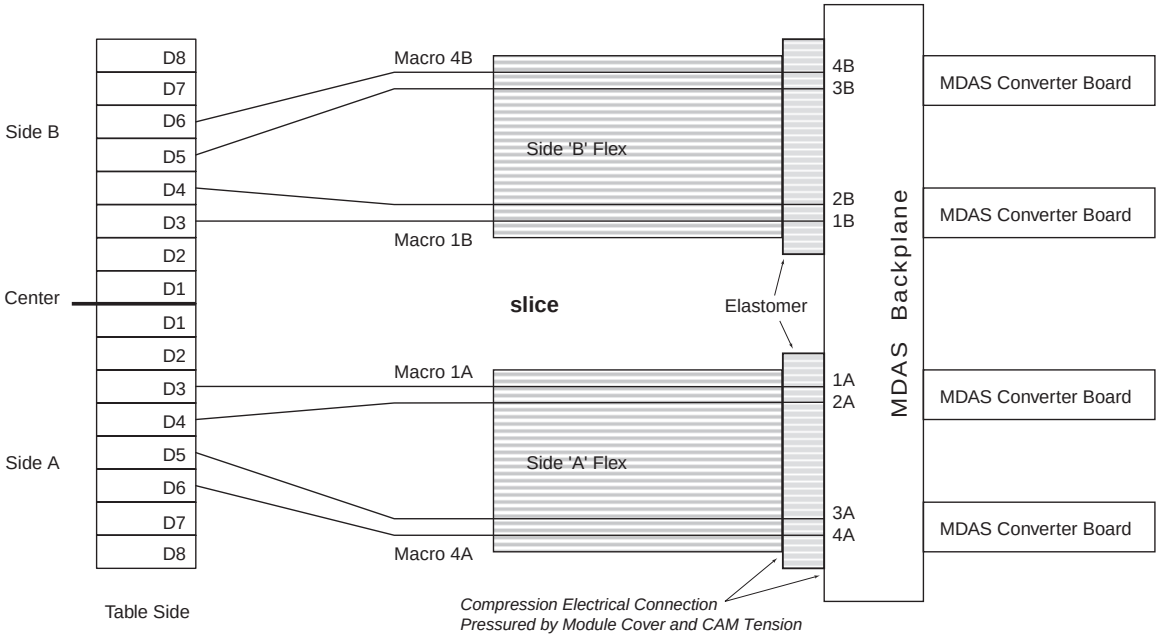


Figure 7-14 8CAL2

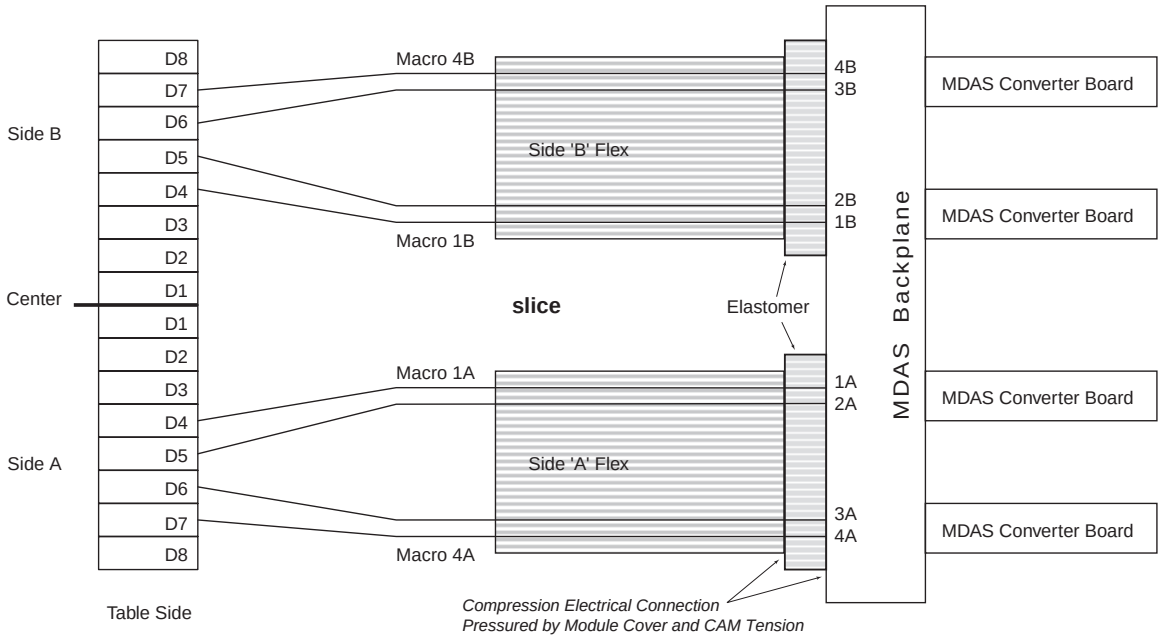


Figure 7-15 8CAL3

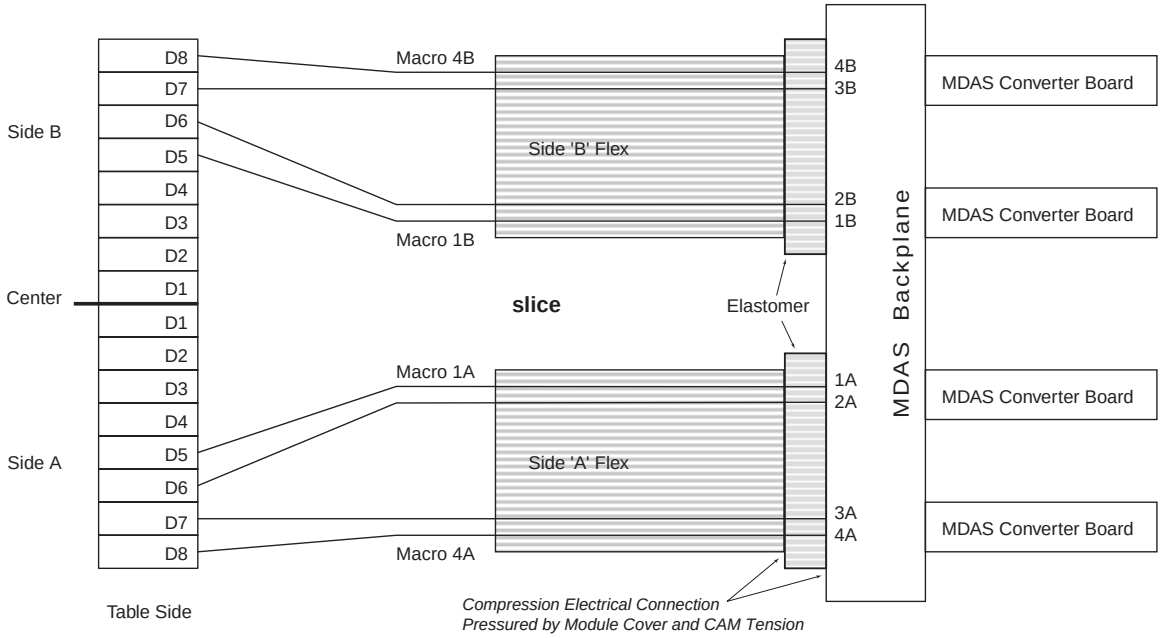


Figure 7-16 8CAL4

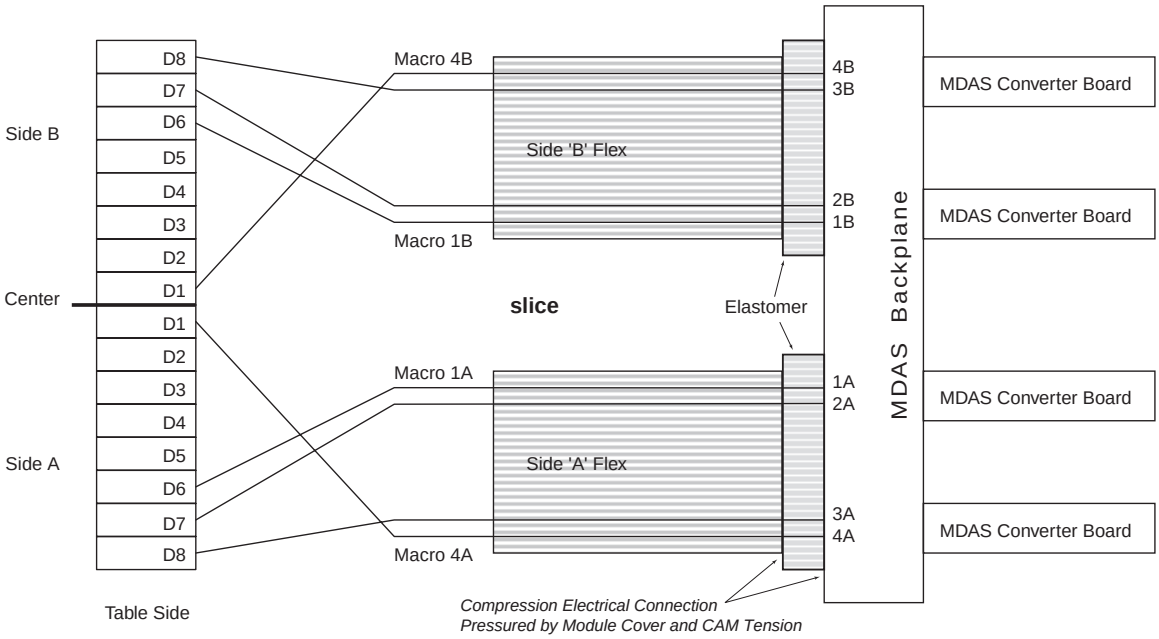


Figure 7-17 8CAL5

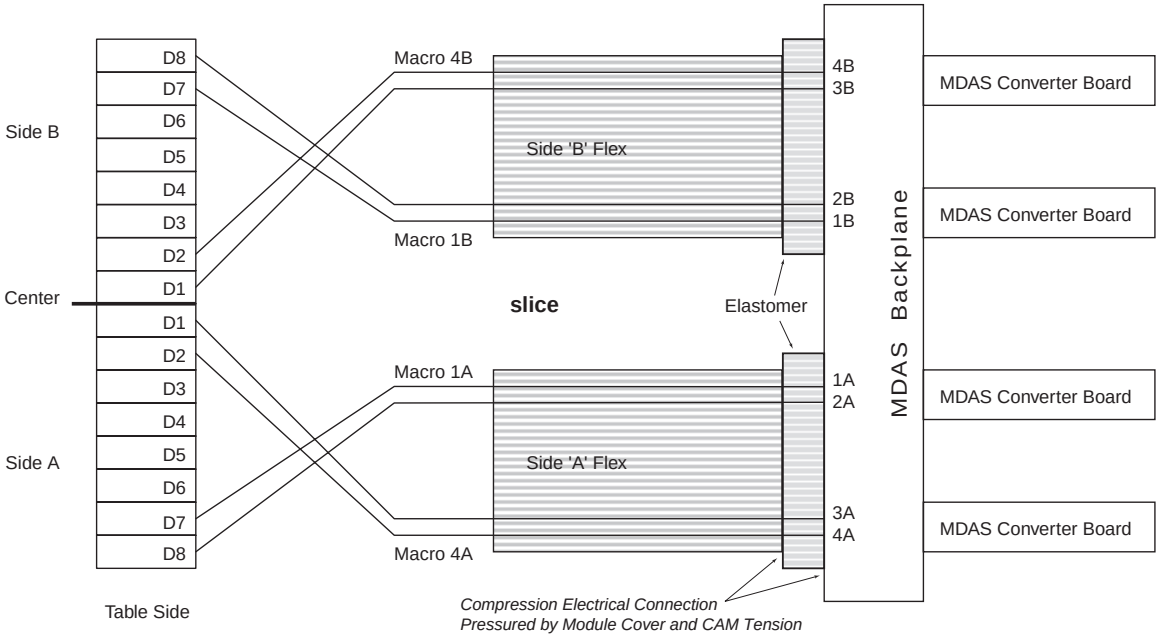


Figure 7-18 8CAL6

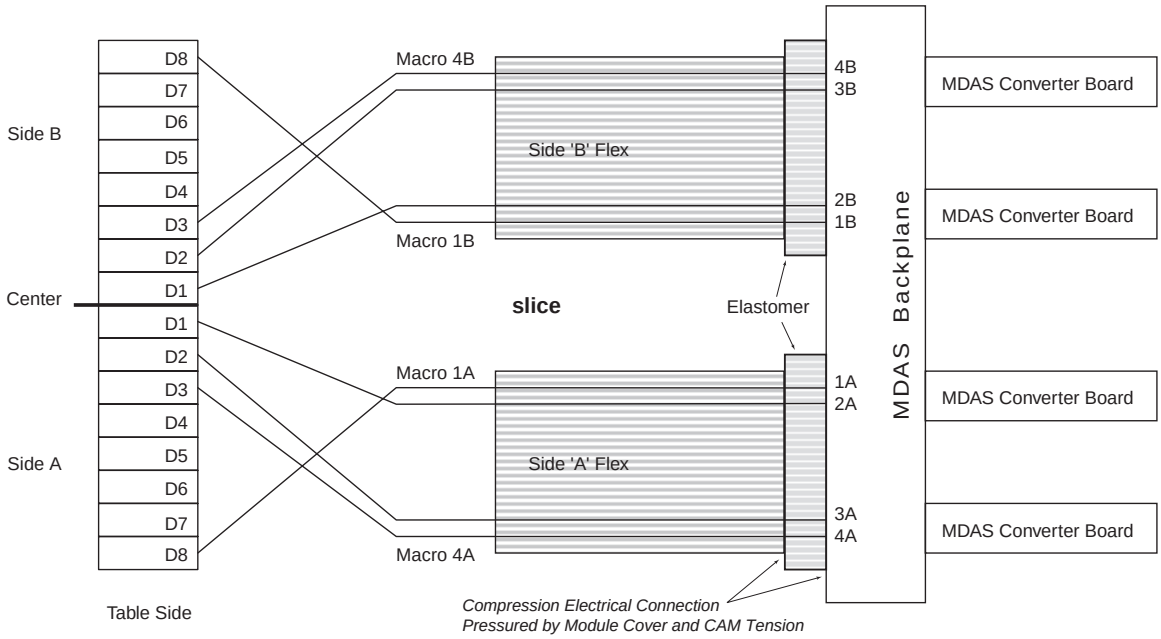


Figure 7-19 8CAL7

1.1.6 Detector Cell to Output Channel Organization

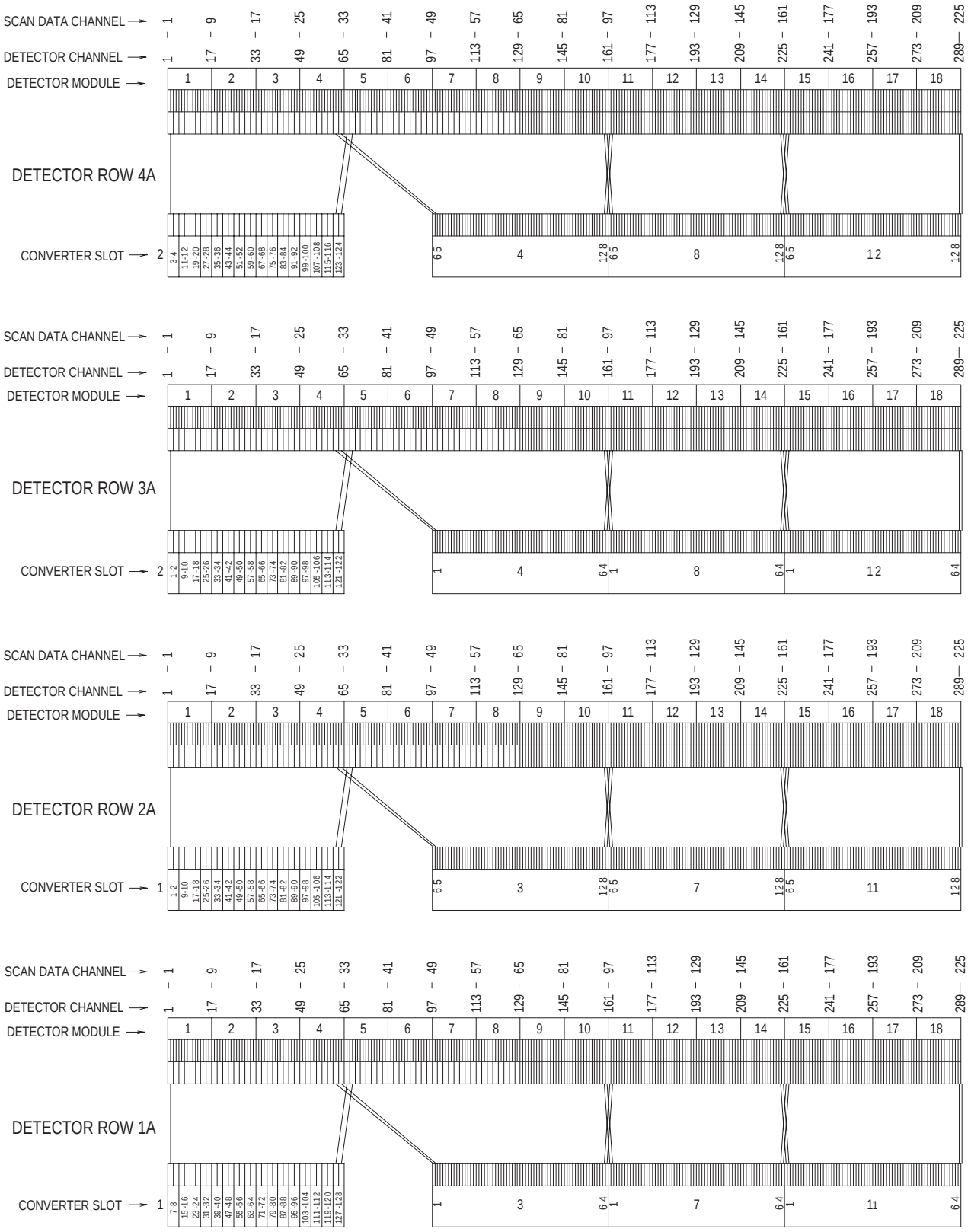


Figure 7-20 MDAS Right Backplane Detector-to-DAS Map, Rows 1A, 2A, 3A & 4A

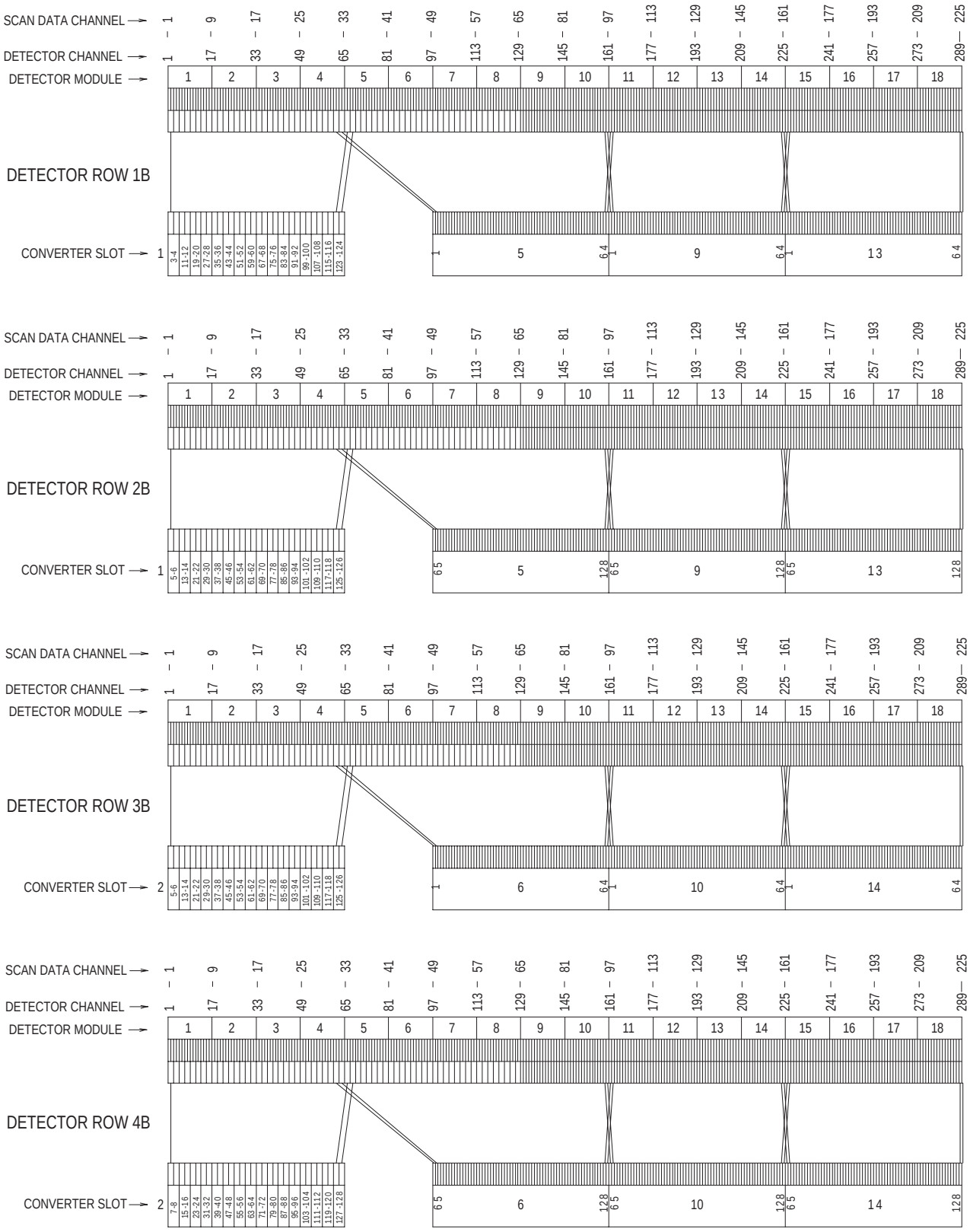


Figure 7-21 MDAS Right Backplane Detector-to-DAS Map, Rows 1B, 2B, 3B & 4B

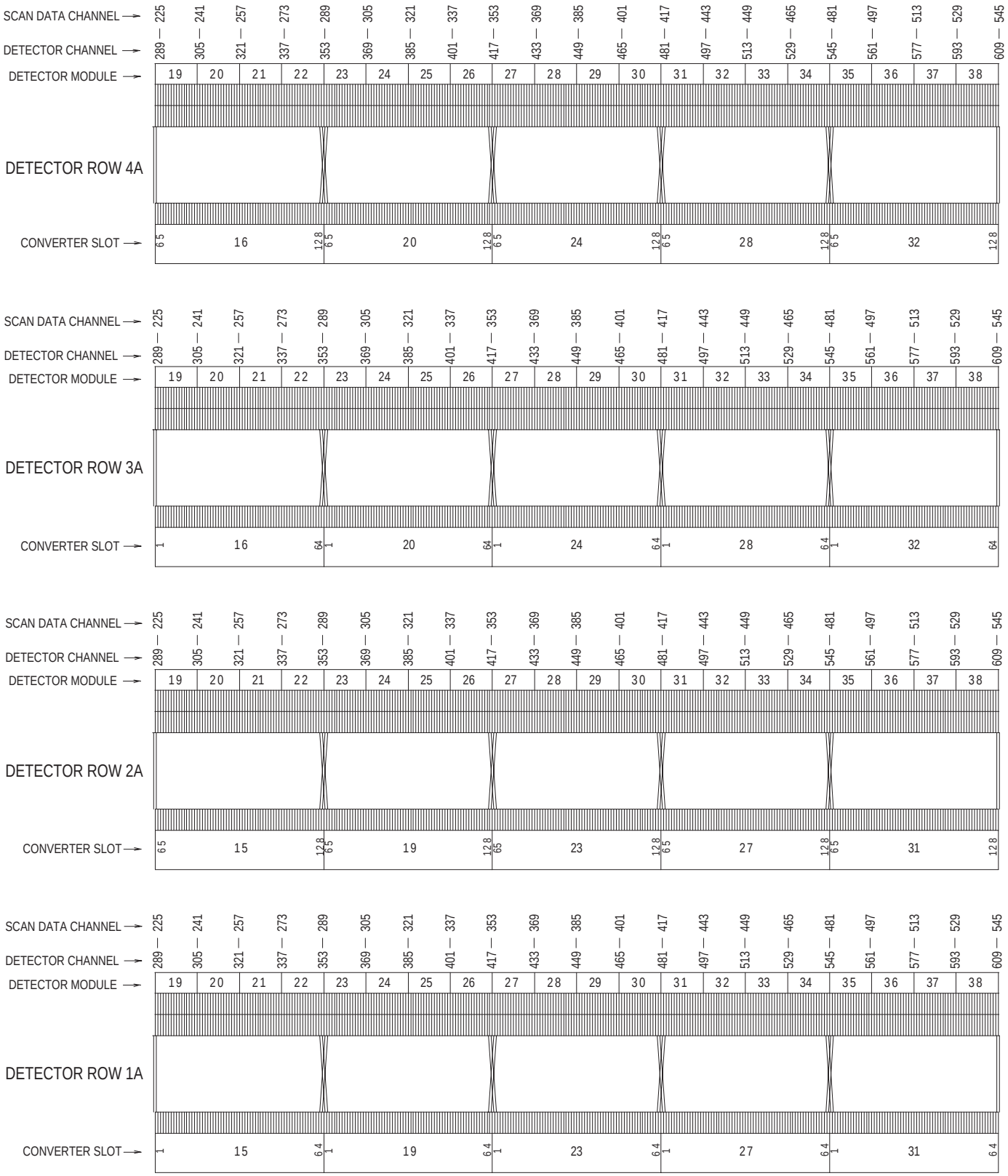


Figure 7-22 MDAS Center Backplane Detector-to-DAS Map, Rows 4A, 3A, 2A & 1A

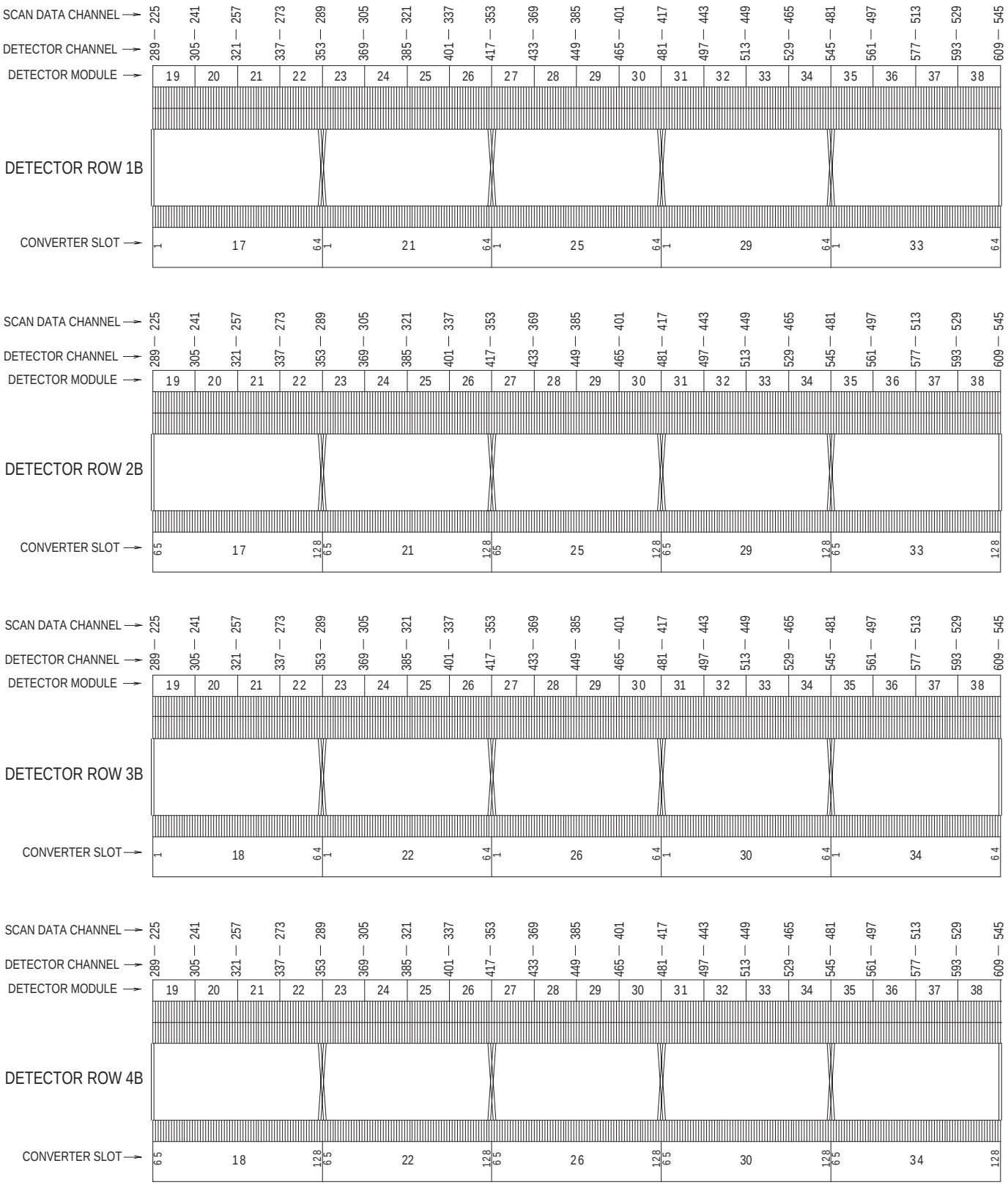


Figure 7-23 MDAS Center Backplane Detector-to-DAS Map, Rows 1B, 2B, 3B & 4B

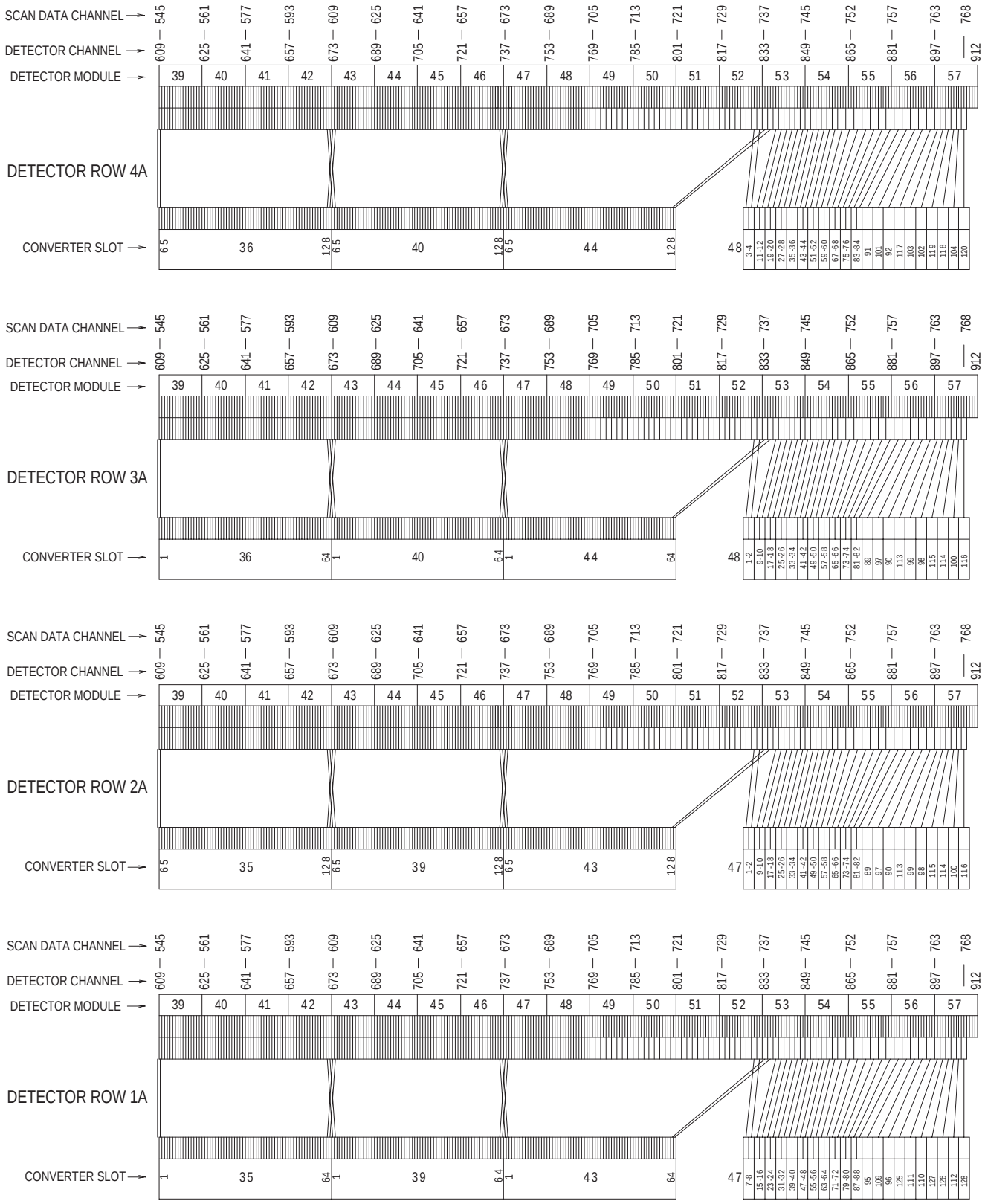


Figure 7-24 MDAS Left Backplane Detector-to-DAS Map, Rows 4A, 3A, 2A & 1A

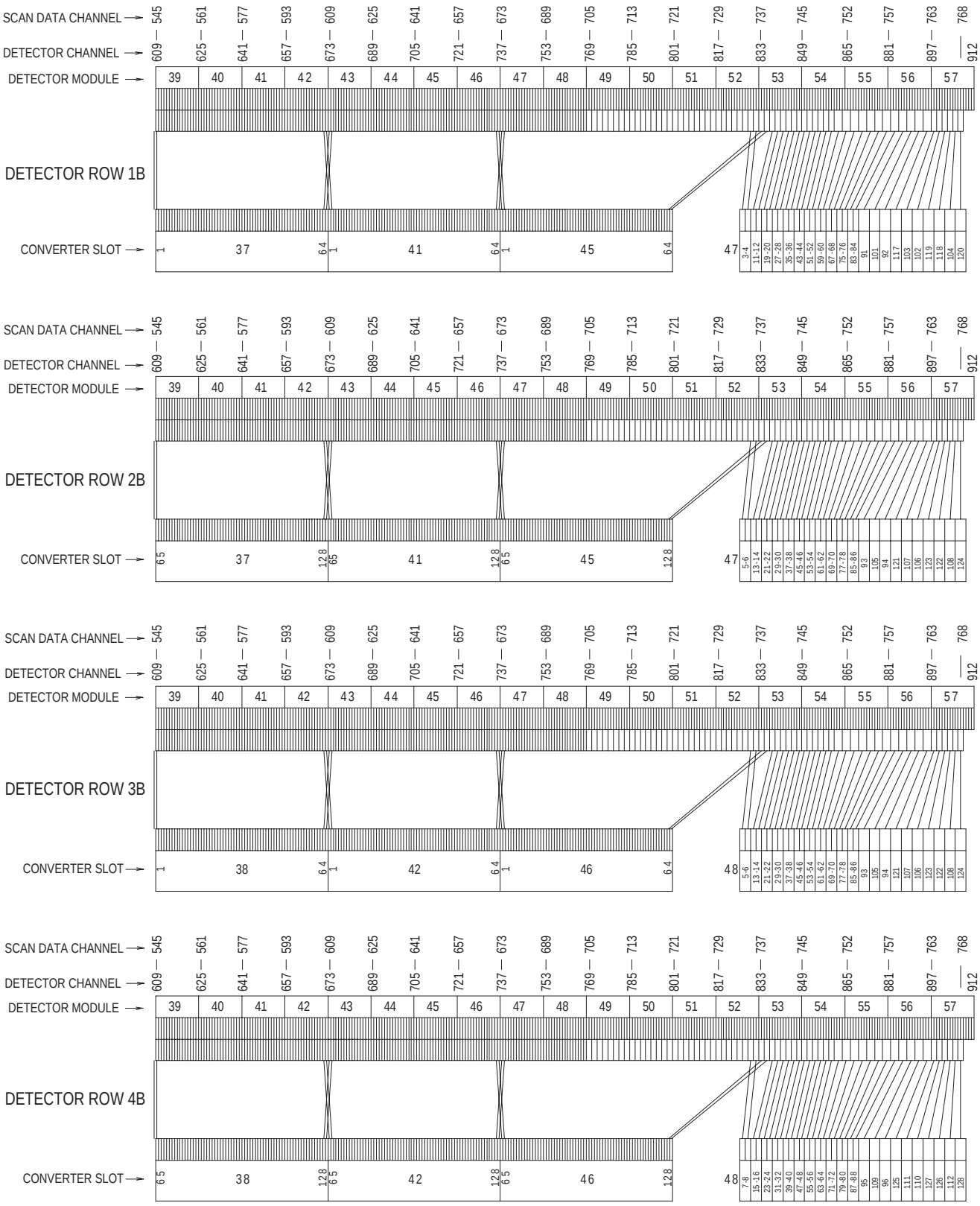


Figure 7-25 MDAS Left Backplane Detector-to-DAS Map, Rows 1B, 2B, 3B & 4B

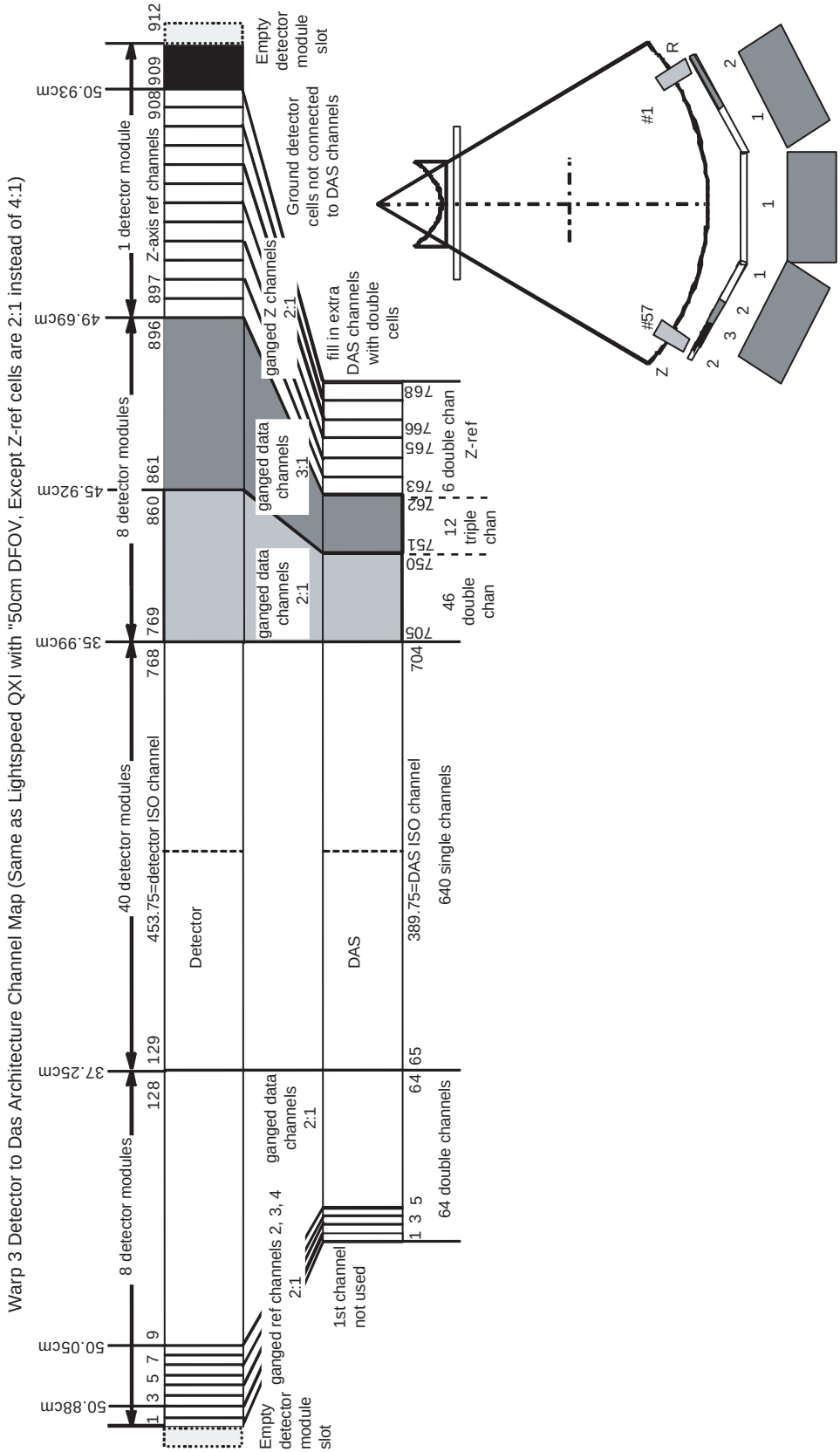


Figure 7-26 DCS to MDAS Architecture Map

1.1.7 Detector Memory Board (DMB)

This part is located behind the Right **DAS** Chassis next to the power supply assemblies. The **DMB** is used to store non-volatile information such as the Detector Memory Board Revision, which heater/cooler zones are enabled, and on/off temperature set limits to name a few. **DMB** Memory is divided basically into sections - static memory and dynamic memory. Before a Write to the dynamic portion of On-Detector Memory is performed, a Write to the On-Board Memory is performed first. By writing to the On-Board **EEPROM** first, this will ensure that the Dynamic portion of On-Detector Memory has a mirror backup located in On-Board Memory. Dynamic data calculated and collected by the **DHCB** will be written to the **DMB** Memory in this way once per hour. When reading from the Dynamic portion of **DMB** Memory, there is no need to copy the data to the **DHCB** Memory since it was placed there during the Write operation.

The Static portion of **DMB** Memory is written to the **DHCB** Memory once per day.

A Background task will execute once a day to compare the contents of both the static and dynamic portions of the **DHCB** Memory with the **DMB** Memory to test for **DMB** Memory corruption.

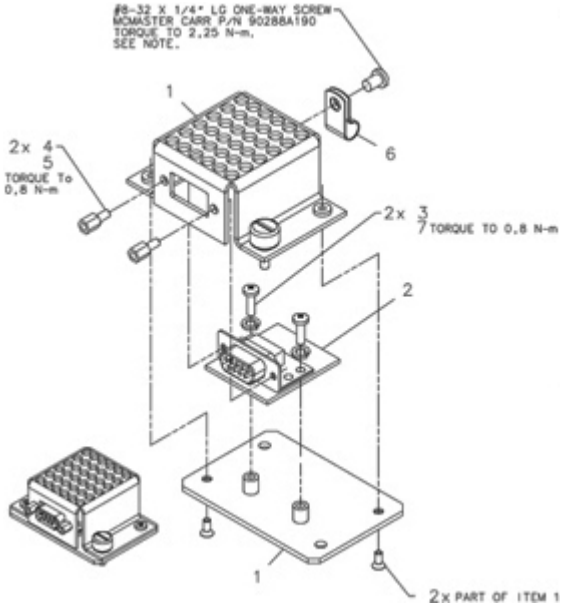


Figure 7-27 Detector Memory Board

DMB Failures

If the **DMB** module fails the **DHCB** will sense this and default to a single zone heater mode. Errors will be posted in the gesys_host.log file indicating the **DMB** needs to be replaced.

The **DMB** module can be replaced if necessary. In this event the new **DMB**, item 2 in Figure 7-27, will have blank Static and Dynamic memory. The **DHCB** will recognize this upon power up and write to the new **DMB** module, all pertinent configuration data. Note, histories and detector serial number will be lost.

1.1.8 Detector Heater Control Board (DHCB)

In order to obtain consistent and accurate results, the detector must be kept at a constant temperature. The detector temperature is maintained by hardware circuits on the Detector Heater Control Board (**DHCB**). The heater is supplied power by the **DHCB**, while the **DHCB** gets power from the external 24V power supply. This differs from LightSpeed and LightSpeed Plus, where the detector heater control and power were supplied by the **DCB**.

The **DHCB** monitors detector temperature via a thermistor embedded in the external rail of the detector. Hardware circuits on the analog section of the **DHCB** convert thermistor resistance into a

digital value that represents the detector temperature. These digital values are kept in a register on the **DHCB**, and temperature values are averaged over 10 samples. The output is then compared with upper and lower limits. When the temperature value goes below the lower limit, the **DHCB** enables the heater power supply via a HTR_ON signal. When the temperature value goes above the upper limit, the **DHCB** turns the heater power off. In this way, the **DHCB** can keep the detector at a constant temperature.

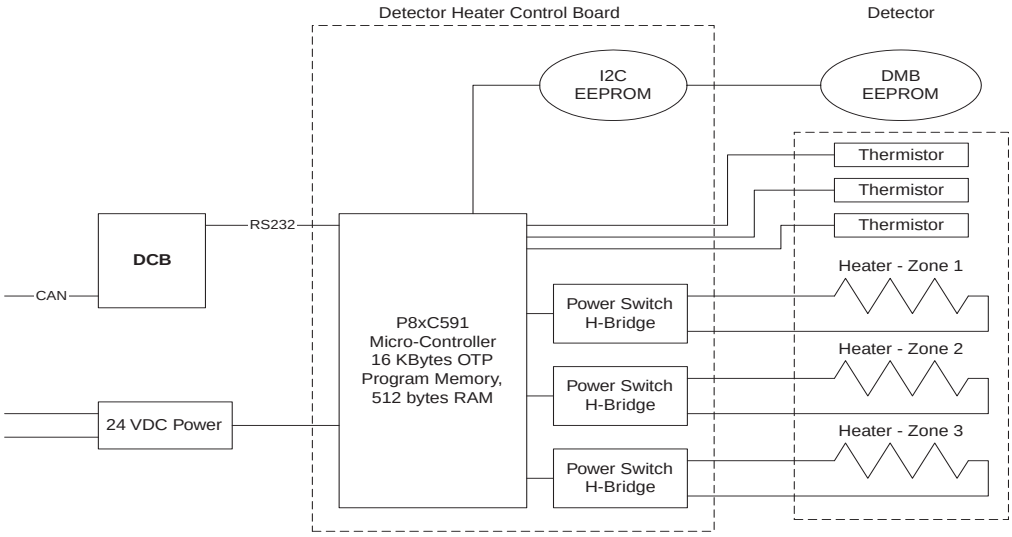


Figure 7-28 Detector Heater Control

The modules in the detector system are maintained at a temperature of 36 ± 0.3 degrees C (module to module variation) and to 36 ± 0.05 degree C (near thermistor).

The primary function, provided by the 8xC591 microcontroller, is to perform basic control and monitor of temperature in three zones of the Warp 3 detector and report status, faults and errors to the system via the **DCB**. Currently only the center zone, which spans the entire length of the detector, is employed in the product design. Zones 1 and 3 are available for future design expansion.

1.1.8.1 Basic DHCB Functions

The 8xC591 microcontroller is responsible for providing the following functions:

- Power-On Self-Test
- Board Initialization
- Communication
- **DMB EEPROM** Access
- **DHCB EEPROM** Access
- Fault Detection and reporting
- Firmware Revision reporting

1.1.8.2 Power-On Self-Test

At the time of power-on or board reset, the microcontroller will perform 2 tests.

- The microcontroller's **RAM** will be checked for proper operation by writing and reading back various patterns.
- A checksum verification of the application firmware will be performed. If either of these tests fail the converter card application firmware can not be executed. To indicate this failure the **LED** will flash rapidly at a 5 Hz rate. This **LED** will continue to flash until communication with the **DCB** is established.

If either of the 2 tests fails, the FW will disable all heater outputs.

1.1.8.3 Initialization

After power-up or rest, the microcontroller's firmware will perform its initialization functions that are partitioned into 5 tasks - hardware initialization, **DMB** memory validation, communication, parameter, and **CPU** Watchdog initialization.

1.1.8.4 Communication Initialization

The **DCB** establishes communication with the **DHCB** via the RS232 communication interface. The Communication link is a Master (**DCB**) / Slave (**DHCB**) configuration. Therefore, the **DCB** initiates all communication and the **DHCB** simply responds.

1.1.8.5 On-Detector & On-Board Temp. Control Table Memory Validation

Upon initialization, the temperature control tables in both the **DMB** and **DHCB** are accessed and their respective checksums are validated. If either table fails its checksum test, the appropriate error bits are masked into the **DHCB**.

1.1.8.6 Status and Fault Handling

The general philosophy of status and fault handling is that when a change in status or fault occurs, the associated Status/error flag is set. When the **DCB** queries the **DHCB**, the status/error bit mask is sent to the **DCB** and depending on the type of error, the appropriate action is then taken.

Each **DHCB** condition/fault is represented in a status/error bit map.

Status/Error Flags

The following are Status/Error Flags. The **LED** will flash per the table below (i.e., if we have a **DHCB EEPROM**, the **LED** will flash twice, then pause off, then repeat).

STATUS/ERROR CODE	NUMBER OF FLASHES	DESCRIPTION
0x0000	None	No Error
0x0001	1	General Error.
0x0002	2	I2C Error
0x0004	3	**EEPROM** Readback Verify Error
0x0008	4	On-Detector **EEPROM** Error
0x0010	5	On-Board **EEPROM** Error
0x0020	6	Spare-1 Error
0x0040	7	Spare-2 Error
0x0080	8	Spare-3 Error
0x0100	9	Serial Rec Timeout Error
0x0200	10	Sensor and/or Control Abort Fault
0x0400	11	**DHCB** Mfg. Identification Table in **EEPROM** is invalid
0x0800	12	Temperature Control Table in **EEPROM** is invalid
0x1000	13	I2C ADC Failure
0x2000	14	Clock Loss Logic Error
0x4000	15	**DHCB** is in Service Mode
0x8000	16	Reset Occurred

Table 7-2 DHCB Error Code and LED Display

1.2 MDAS

1.2.1 Block Diagram

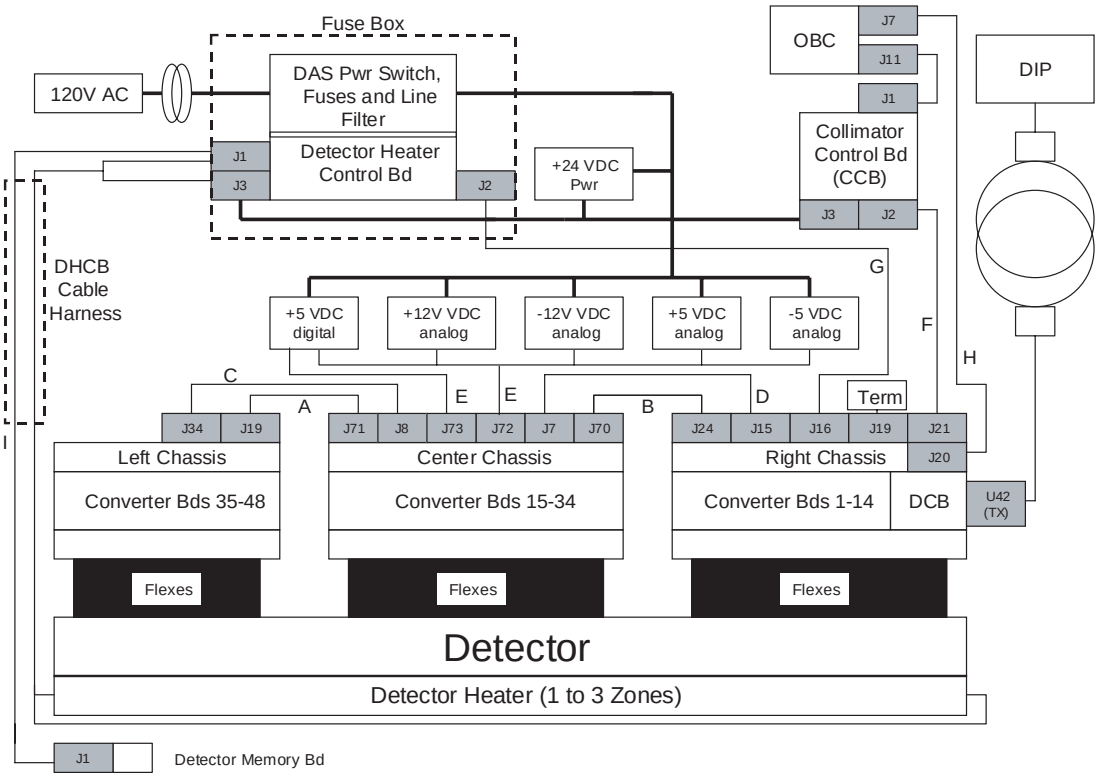


Figure 7-29 MDAS Block Diagram

1.2.2 Data Flow — Serial Data Stream

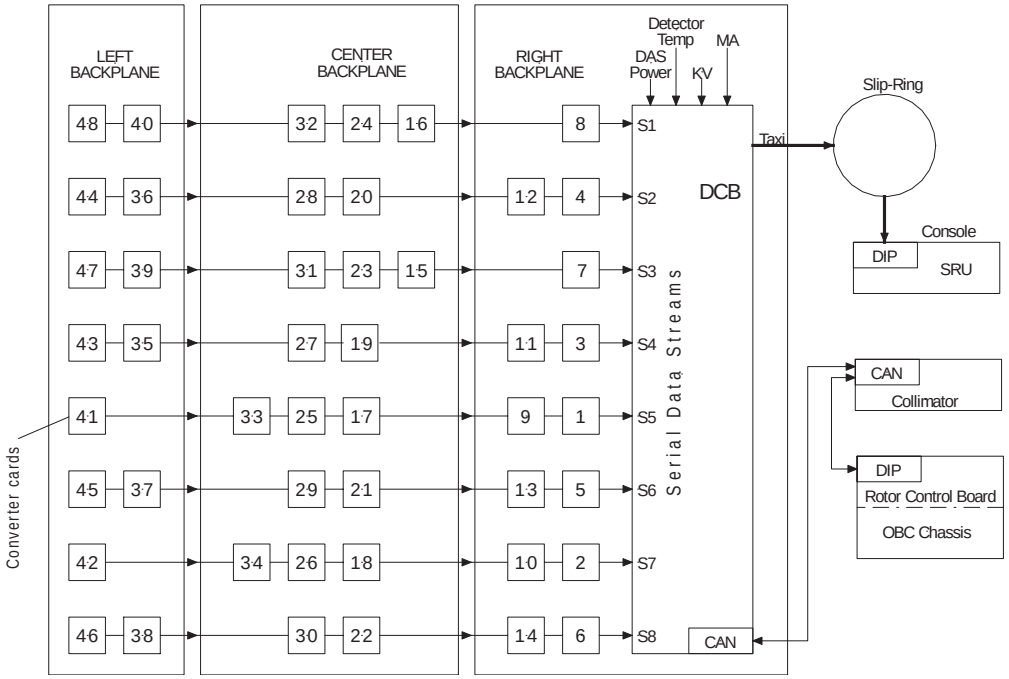


Figure 7-30 Data Flow — Serial Data Stream

1.2.3 Converter Boards

1.2.3.1 Block Diagram

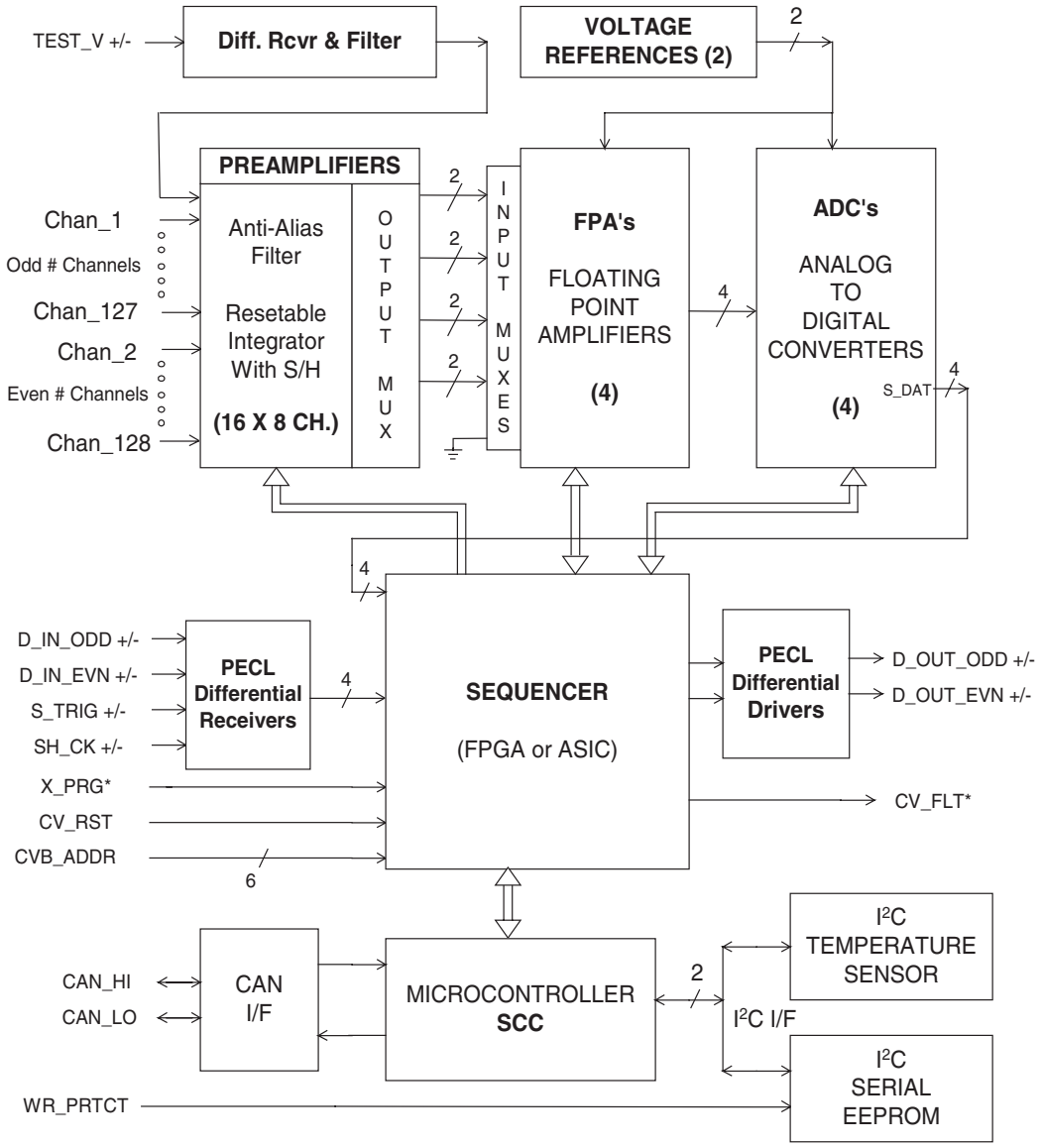


Figure 7-31 Converter Board Block Diagram

1.2.3.2 Signal Interfaces

X-Ray Detector Output Signals

- The smallest element of the detector matrix is a detector cell. The detector cell, as presented to the **DAS**, is a zero-biased photodiode whose current output (photo-current I_p) is proportional to the incident x-ray flux.

  A simple electrical circuit model for the x-ray detector cell is a current source in parallel with a capacitor (C_s, photodiode shunt capacitance) and a resistor (R_s, photodiode shunt resistance). One end of the three element parallel combination is connected to a **DAS** input signal channel, and the other end is connected to electrical circuit ground.

- Some applications include the connection of multiple cells (in parallel) to a single **DAS** preamplifier channel. The output of such interconnected cells is referred to as a **macro cell**.

  If an application includes cells that are not connected to a preamplifier input, such cells are connected to electrical ground by the FET array. These ground cells present a FET off impedance to the **DAS**. With respect to noise specifications and offset drift specifications, this off impedance is assumed to be greater than 1 gigohm, under all operating conditions.
- The minimum expected resistance, typical expected capacitance and maximum expected input capacitance, seen by the Converter Board from the detector and backplane for the various slice widths or number of pixels, are as follow:

# OF CELLS	SLICE WIDTH	R_S (MIN)	C_S (TYP)	C_S (MAX)
1	1.25 mm	260 MΩ	83 pfd	102 pfd
2	2.50 mm	153 MΩ	107 pfd	131 pfd
3	3.75 mm	109 MΩ	130 pfd	161 pfd
4	5.00 mm	84.5 MΩ	152 pfd	190 pfd

  The capacitance values listed in the table above represent the worst case for the signal lines on the backplane. Maximum capacitance values are the 4.5 Sigma limits, and assume a 10% standard deviation of the mean value for each of the elements making up the total capacitance.

  The capacitance values listed above do not include the input capacitance generated on the Converter board by the input signal traces. Typical or Mean capacitance for the longest input signal lines on the Converter Board is expected to be 15 pfd or less.
- For most **DAS** channels, the detector cell is one 1 mm long in the azimuthal direction. However, some cell outputs (e.g., high-Z channels) are electrically connected in either pairs or triplets in the azimuthal direction to effectively form 2 mm and 3 mm long cells. Cells so connected are termed **ganged cells**. Because of the different source impedance associated with these cells, **DAS** performance is affected or degraded. However, the Converter Board preamplifier circuit is designed to be stable with the ganged source impedance cells.
- The Converter boards receive the detector output signal on the same backplane connector as the rest of the **DAS** control and power connections. The backplane connector is defined in 2.3.2 - Converter Board Backplane Connector, beginning on page 514.
- The maximum DC offset applied by the Converter Board on the photodiode is within ± 2.0 mVDC, with no current from the detector (x-ray off).

  The maximum DC offset applied by the Converter Board on the photodiode is between +3.5/ -2.0 mVDC, with full scale current (1.14 µA) from the detector.

Data Acquisition

The converter card is externally controlled by the following signals:

- S_TRIG (Differential, view trigger signal). The nominal frequency range of this signal is 500 Hz to 1640 Hz continuous. It is synchronized with the SH_CK signal, defined below. S_TRIG is used by the Converter Board to initiate a data acquisition timing cycle for all channels on the Converter Board.
- SH_CK is a differential pair input signal that is used with S_TRIG to generate all data acquisition timing signals for the Converter Board. It is the clock used to shift data off the Converter Board to the Digital Control Board, and is free running. Anticipated frequency of this clock is 16 MHZ.
- CV_RST (Converter Board Reset) is a high level active signal that is activated by the **DCB** (**DAS** Control Board). It is a semi-hard reset for the Converter Board. This signal resets the on-board microcontroller and initializes all registers in the on-board **FPGA**/**ASIC** Sequencer to a fixed, known set of values. The On-Board microcontroller can then modify the registers.

The microcontroller sets up the board registers in response to commands received via the Controller Area Network (**CAN**) bus interface.

- CAN_HI & CAN_LO (Differential, bidirectional Signal Pair) are used to implement the physical interface for the **CAN** control bus on the Converter Board.
- CV_FLT* (Converter Fault Not). This is an open collector or open drain (wired-OR) output signal from the converter board(s). It is activated by the converter board microcontroller whenever it detects a variety of different fault conditions on the converter board. The signal is received and processed by the **DCB** (**DAS** Control Board). It is anticipated that the **DCB** will poll the converter board via the **CAN** bus, to determine which board pulled the “CV_FLT” signal line low.
- TEST_V (Analog Differential Test Voltage) is a voltage that is generated by the **DCB** that is used to test the Converter Board during **MDAS** self-test. The TEST_V is used to simulate a variable signal level from the detector.
- ADDR 5:0 (Board Address) is a 6 line input bus that is used by the board to determine its **CAN** bus address. These inputs are hard wired with unique addresses on the **MDAS** backplane for each of the Converter Board slots.
- X_PRG* (**FPGA** Reconfigure Not) is a normally high edge-sensitive logic signal that can be momentarily held low and then released, to re-initiate the power-up configuration of the on-board **FPGA** Sequencer.
- WR_PRTCT (**EEPROM** Write Protect) is an active high logic signal that can be used to provide hardware protect of the **EEPROM** contents on Converter board populated with **EEPROM**s with this feature.

Data Interface

The Converter Board functions in a data chain. Each board accepts serial data from the previous board, inserts its own data and retransmits the data downstream to the next Converter board or the **DCB**. The data bit time is equal to the period of the SH_CK input signal.

- D_IN_OD (input data for odd numbered channels) is a differential signal pair for receiving data from the next upstream Converter board.
- D_IN_EVN (input data from even numbered channels) is a differential signal pair for receiving data from the next upstream Converter board.
- D_OUT_OD (output data for odd numbered channels) is a differential signal for transmitting data to the next downstream Converter board or **DCB**.
- D_OUT_EVN (output data for even numbered channels) is a differential signal for transmitting data to the next downstream Converter board or **DCB**.
- The serial data from each converter board is part of a six converter board data chain (see Figure 7-30, on page 490).

1.2.3.3 Power Requirements

The converter board uses the following power supply voltages: +5 volt digital, +5 volt analog, –5 volt analog, +12 volt analog, and –12 volt analog.

CHARACTERISTICS	+5V ANALOG	-5V ANALOG	+12V ANALOG	-12V ANALOG	+5V DIGITAL
Supply current (typical)	0.15 A	0.15 A	0.17 A	0.13 A	0.52 A
Voltage tolerance	±5%	±5%	±5%	±5%	±5%
Max. peak-to-peak noise & ripple[1]	5.0 mV	5.0 mV	5.0 mV	5.0 mV	5.0 mV
Max. RMS noise & ripple[2]	150 µV	150 µV	-	-	-
Max. line regulation, 10% line voltage change	±0.05%	±0.05%	±0.05%	±0.05%	±0.05%
Max. load regulation, 50% load change	±0.05%	±0.05%	±0.05%	±0.05%	±0.05%
Output transient response, max. recovery to within 1% of initial setpoint, w/ 50% load change	50 µsec	50 µsec	50 µsec	50 µsec	50 µsec
Max. temperature coefficient	0.03%/°C	0.03%/°C	0.03%/°C	0.03%/°C	0.03%/°C
Min. adjustment range	±5%	±5%	±5%	±5%	±5%
Overvoltage limitation	6.0 VDC		26.4 VDC between +/- Supply rails & ±15 V to Analog Gnd		6.9 VDC

1) As measured in 20 MHz bandwidth
2) In 0.1 Hz to 5 kHz bandwidth

Table 7-3 DC Power Requirements

1.2.3.4 Board Status LED

The converter board gives a visual indication of an error condition. There is a **LED** on each converter board that will flash several times during the power-up diagnostics. The **LED** should remain off if the diagnostics were successful. If the self-tests fail, then the **LED** for the failing converter board will flash a sequence code to indicate the type of error detected:

ERROR CODE	LED FLASHES	DESCRIPTION
0x0000	0	No Error
0x0001	1	General Error
0x0002	2	Pre-Amp Error
0x0004	3	**EEPROM** Write/Read Error
0x0008	4	Register Access Error
0x0010	5	**CAN** Communication Error
0x0020	6	Temperature Error
0x0040	7	I^2C Protocol Error
0x0080	8	Invalid **CAN** address received from Xilinx
0x0100	9	Host detected an error
0x0800	12	Card Identification Table Error
0x1000	13	Trim Table Error
0x2000	14	Config Table Error
0x4000	15	Fault Line is Asserted
0x8000	16	Reset Occurred

Table 7-4 Converter Board LED Error Codes

The converter board status **LED** also flashes during **CAN** communications. Error definitions follow:

General Error

This is a general error notification, for miscellaneous errors that may occur on the converter board.

Pre-Amp Error

This fault occurs when there is a failure modifying the state of the pre-amps. This can occur when:

- A request is made to put the pre-amps into standby.
- A request is made to calibrate the **A/D**s.
- A request is made to put the pre-amps into offset trim state.

EEPROM Error

Every write to the **EEPROM** is verified by a read-back. The **EEPROM** error indicates that this verification failed.

Register Access Error

A register access fault can occur only during the read-back verify phase of a register write command and can occur on either the register address write or on the register data write commands.

At each write of a converter board register, a read-back verify will be done on both the address register and data register to verify that the data was written properly. A fault will occur when the read-back does not compare to what was written.

The fault that is generated is determined by the source of the register write command. If the register write is commanded by the microcontroller during board initialization or mainline processing, the register fault status bit will be set and the board fault line activated. The firmware will continue normal operation so that it can be interrogated by the **DCB**.

The other source of register write commands comes from the **DCB** through **CAN** communication. When a register write is commanded, the register will be written and read-back verified before sending the ACK or NACK back to the controller. When there is a fault, a NACK will be sent, the register access fault bit will be set in the status register and communication will be terminated. The firmware will then continue processing normally. The board fault line will not be activated in this instance, since the controller knows there is an error and which converter card is at fault. There will be no error detection of attempts to write to read-only registers or register address out of range. This will allow for future Xilinx register additions or changes without any firmware changes.

CAN Bus Error

A **CAN** Bus fault occurs when the **CAN** controller goes into a Bus Error condition. This condition may or may not be transient. In either case, the fault line will be activated. If it is a hard failure, the **DCB** will not be able to communicate with the converter card. The only indication of this failure is given via the card's **LED**.

Temperature Fault

The firmware has detected an under/over temperature condition. The fault line will be activated.

I2C Error

This error is generated if any part of an i2c transaction fails.

Invalid CAN Address

This error occurs when the **CAN** address read from the **FPGA** is invalid (<1 and >64). This can occur if the **FPGA** did not initialize correctly. Since the address in invalid, no communication with this card can occur, so the only indication of this failure will be through the **LED**.

Host Detected Error

This error bit is reserved for the Host. It allows the host to signal an error condition by flashing the **LED** with this code. This can be useful if the Host detected an error from a specific card. For

example, if the Host detects a parity error from a card, it can signal that card to flash the **LED** so the service technician can easily identify the failing card.

Config Table Error

There are actually three bits associated with config table errors. Each bit represents one of the configuration tables. The respective bit for each config table will be set, if the table contains an invalid checksum.

Fault Line Asserted

This bit indicates that the converter card is holding the fault line in an asserted state. The fault line is asserted when the converter card encounters an error.

Reset Occurred

This bit indicates that the converter card has been reset. *This bit is automatically cleared on the first State Query command received from the Host.*

1.2.4 DAS Control Board (DCB)

The **DCB** performs the function of controlling the 3.x **DAS**. It has interfaces with:

- the **OBC** for receiving setup instruction and reporting error and status,
- the converter cards for setting them up for a scan and receiving channel data,
- the detector for controlling FET switch positions and heater state (if **DHCB** not present),
- the **DHCB** for monitoring the detector temperature control function,
- the X-ray generation subsystem for monitoring kV and mA, and
- the slip-ring communication subsystem for outputting **DAS** data to the **SRU**.

1.2.4.1 Block Diagram

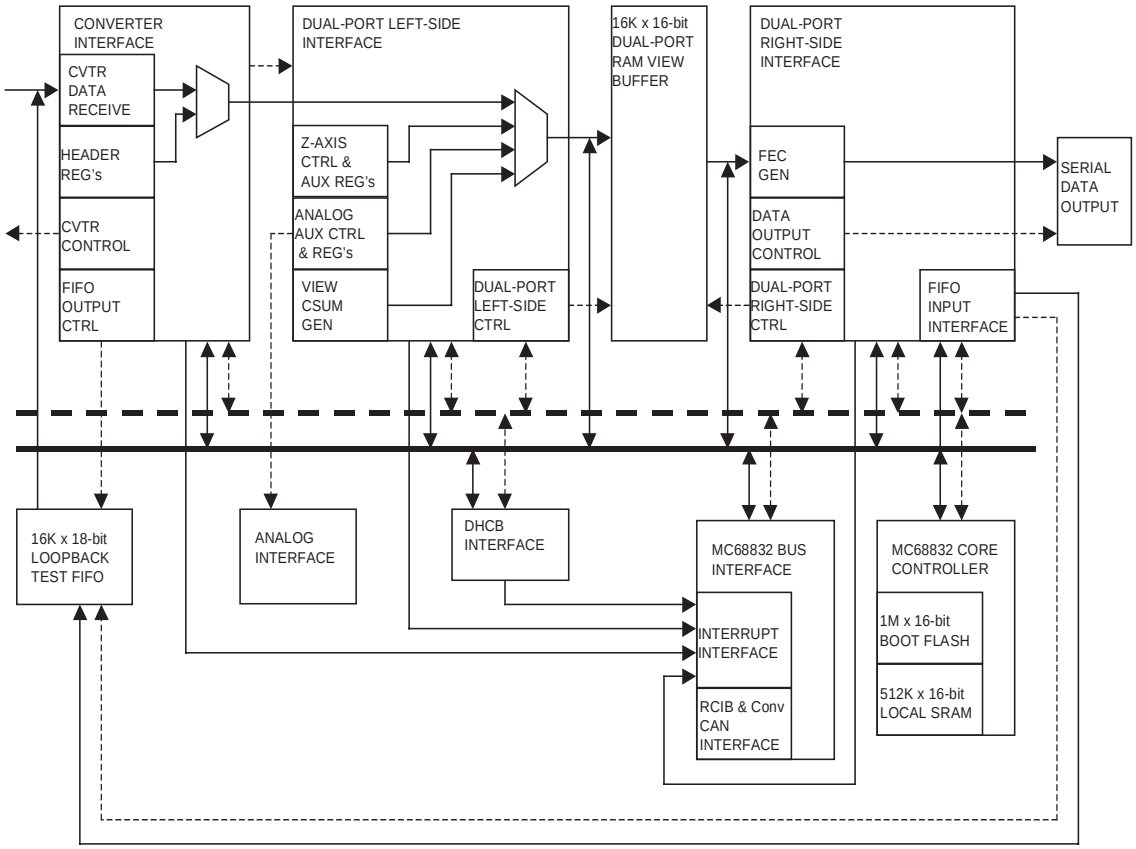


Figure 7-32 DCB Block Diagram

1.2.4.2 Theory of Operation

The **DCB** is the main control board for the Millennium Data Acquisition System (**MDAS**). It handles all the data streams from the converter cards, and packages this data into a single high speed serial data stream. Specifically, it performs the following functions:

- Interfaces with the On-board Controller (**OBC**) for Rx reception and scan completion, via the **RCIB CAN** interface.
- Sets up and controls the converter cards, via the **CAN** interface.
- Receives triggers and starts acquisitions with the converter cards.
- Performs serial-to-parallel conversion on data streams from the converter cards, does parity checking on the data, and runs it through a translation table for view data ordering.
- Adds Forward Error Correction (**FEC**) to the channel data and sends it across the slip-ring to the Image Chain Engine (**ICE**) via the high speed serial interface.
- Detects jitter and time-outs in the view trigger signal.
- Monitors the detector temperature, via the **DHCB**.
- Monitors the power supply voltages to make sure they are within the software programmable limits.
- Acquires the KV and mA values for each scan.
- Controls the FET switch array in the detector to change the number and thickness of scan slices.
- Monitors the **MDAS** system for various faults.

1.2.4.3 Inputs

- From Converter Boards, eight (8) serial data streams consisting of even and odd channels
- From On-board Controller (**OBC**):
  - Input View Triggers
  - KV & mA analog signals
  - **CAN** Bus communication for scan prescription information
  - Fault Signal
- From **DHCB**: Data containing detector temperature

1.2.4.4 Outputs

- To Converter Boards:
  - Shift clock
  - Trigger Signal
  - Control information via the **CAN** communication bus
  - Outer Row Serial Data Streams, for a 4 slice system
  - Reset signal
  - Analog test voltage
- To On-board Controller (**OBC**):
  - Output View Triggers
  - **CAN** Bus communication for scan complete or error information
  - Fault Signal
- To Detector:
  - FET Control signals
  - Heater relay control (DHCB) (controls heater power supply, which drives the detector heater)
- To Slip-ring [and then on to the Scan Reconstruction Unit (**SRU**)]: High speed data stream containing the view data with embedded **FEC** and **CRC**.

1.2.4.5 Error Codes

DCB (& CCB) BOOT OR START-UP ERRORS	ERROR CODE
Boot **RAM** Test Failure	12
Boot **RAM** copy of application code failed	13
Boot Code **CRC** Failure	14
Application **CRC** Failure	15
Boot Application **CRC** Failure	16
Application code size invalid	17
Boot Application code size is invalid	18

Table 7-5 DCB (& CCB) Boot/Start-up Errors

DCB (& CCB) APPLICATION ERRORS	ERROR CODE
Application Initialization Errors	
Unable to create controller heartbeat task	20
Unable to initialize the serial interface	21
Unable to init command execution and decode	22
An error was detected using the **SCI** Driver	23
Unable to init S/W watchdog refresh task	24
Unable to initialize idle task	25
Controller communication Init failed	26
Unable to create memory pool	27
Unable to init programmable Interrupt time	28
Serial Driver is unable to est. pend for read	29
Application Run-time Errors	
Unable to make S/W init required by applications	40
Unable to make MCU init required by applications	41
Unable to silence interrupts	42
Applications hardware failed self-test	43
Unable to create interrupt handlers	44
Unable to initialize hardware	45
Unable to create inter-task communication objects	46
Unable to create application tasks	47
Unable to initialize due to configuration data	48
Unable to initialize due to characterization data	49
Unable to initialize the error logger	50
Unable to initialize the tracer	51
Unable to create error logger task	52
Unable to create tracer task	53
Unable to create Platform task	54

Table 7-6 DCB (& CCB) Application Errors

1.2.4.6 Functional Description

Clock Overview

E_TRIG (External Trigger)

This is the trigger input clock that occurs at up to 1968 Hz in an 8-slice mode. A rising edge tells the **DCB** to begin sampling another “view” of data from the converter cards.

SHCK_2X (Double Frequency Shift Clock)

This is the main 32 MHz synchronous clock that is used as the raw clock for all converter interface functions. The clock is divided by 2 in the **DCB** control **FPGA** (into SHCK_1X) and is used to move and manipulate the converter stream data until it gets into the left side of the dual port **RAM**. In addition, the **DCB** has the ability to generate a 40 MHz synchronous clock (SHCK_2X) by changing a registered select line to the programmable clock generator. This provides a 20 MHz shift clock (SHCK_1X) for 1968 Hz, 8-slice scanning capability. See the Compatibility Note in the CAN_CLK description below.

DATAOUT_CLK_RAW (Raw Serial Data Clock)

This is a 33.33 MHz clock that goes to the **DCB** control **FPGA** where it is divided by 2 (into DATAOUT_CLK). This 16.67 MHz clock is used for **FEC** generation on the data that comes out of the right side of the dual port **RAM**. It also serves as the base clock for the serial data interface.

M68332_CLK_RAW (Raw MC68332 Clock)

This is a 50 MHz clock and is divided by 2 in the **DCB** control **FPGA** (into M68332_CLK) to get the 25 MHz clock used to run the 68332 processor.

M68332_CLK (Clock input to MC68332)

This is a 25 MHz clock driven by the **DCB** control **FPGA** that is used as a clock for the 68332 processor.

M68332_CLKOUT (Clock output from MC68332)

This is a 25 MHz clock driven by the MC68332 and sent back to the **DCB** control **FPGA**. It is used to control all bus accesses and functionality within the control **FPGA**.

CAN_CLK (Raw CAN Clock)

This is a 32 MHz clock which is divided by 2 in the **DCB** control **FPGA** to generate the 16 MHz clocks used to run the **RCIB** and Converter **CAN** interfaces. This clock is tied directly to the selectable SHCK_2X within the clock generator chip.

Note: **Compatibility Note:** In order to scan in a system with a 1968 Hz trigger rate, the CAN_CLK and SHCK_2X must be de-coupled. The **CAN** controller firmware is written based on a 16 MHz **CAN** interface clock, which is the maximum frequency for the **CAN** controllers. De-coupling the two clocks requires that the **CAN** interface clock be set to 12.5 MHz and derived from M68332_CLK_RAW. Additionally, this change in clock frequency requires modification of the **CAN** controller timing in the **DCB** firmware.

AD_CLK (Analog to Digital Clock)

This is a 1.6 MHz clock from the **DCB** control **FPGA** that is used for the **A/D** converter chip on board the **DCB**. It is derived by dividing SHCK_1X clock by 10. The AD_CLK can be turned on or off by software control.

WATCHDOG_CLK

This is a 1.0 MHz clock that is a buffered version of the clock used by the programmable clock generator to create the SHCK_2X, DATAOUT_CLK_RAW, M68332_CLK_RAW, and UART_CLK clock signals. This clock is monitored by the watchdog circuitry to detect and report clock instability.

UART_CLK (UART Clock for interface to DHCB)

This is a 6.25 MHz clock that is divided by 20 in the baud rate generator of the UART to create a 312.5 kHz baud rate clock. This clock operates at 16 times the transmit and receive clock rates (19.2 kHz) with 1.73% error.

Core Controller

The Core Controller forms the basic computing element on the **DCB**. It is made up of the following elements:

Motorola 68332 microprocessor

- 1 MByte of FLASH memory
- 1 MByte of **SRAM**
- Intel 82527 **CAN** communications interface
- Diagnostic **LED**s
- Appropriate reset circuitry

The Core Controller uses the features of the 68332 microprocessor, such as the RS-232 interface, interrupt controller, and flexible chip select mechanism.

Bus Interface

The MC68332 Bus Interface is responsible for interrupt control, **CAN** control, **SRAM** control, FLASH control, and other miscellaneous control functions.

Converter Board Interface

The Converter Board Interface is responsible for the following functions:

- It performs scan control sequencing. It takes the external trigger input, widens it, and drives the Converter trigger and **DCB** trigger signals.
- It generates all of the signals sent to the converter board during a scan and for receiving **DAS** channel data.
- It receives serial data from the converter boards.
- It provides converter stream parity generation and checking. Parity is computed on each word of each stream received from the converter board. When a parity error occurs, this function will save the converter board and stream that contained the first parity error and interrupt the firmware running on the MC68332. The firmware has the option of aborting the scan (current implementation) or performing other processing when a parity error occurs.
- It provides loop-back **FIFO** control logic for reading data out of the loop-back **FIFO**. This is useful for diagnostic purposes, where data from the loop-back **FIFO** is routed into the bit shuffler to test the data path for the Converter Board data streams.
- It provides a diagnostic mode for filling a view with a known value.
- It provides a diagnostic mode for receiving channel data from the Diagnostic Loopback **FIFO** instead of the converter boards.
- It provides a diagnostic mode for generating a single internal trigger or a series of them at a programmable frequency. The resolution of the internal trigger generation logic is 4 SH_CK periods, or 250 nS and the range of trigger periods, since the register controlling this frequency is 16-bits, is 250 nS to about 16.4 mS.

1.2.5 MDAS Backplanes

The backplane used on **MDAS** is separated into three sections: Right, Center and Left. The three backplane boards are connected via a ribbon cable, with a 80–pin connector on each board.

Right Backplane

The Right backplane contains connectors for Converter boards 1 through 14. The pinout of these connectors is defined in Section 2.3.1, beginning on page 508.

FET **LED**s are located on the Right Backplane (see "LEDs," beginning on page 516).

Center Backplane

The Center backplane contains connectors for converter boards 15 through 34. The pinout of these connectors is defined in Section 2.3.1, beginning on page 508.

Test Points are available on the Center Backplane to measure Power Supply voltages (see Table 7-16, on page 516).

Left Backplane

The Left backplane contains connectors for converter boards 35 through 48. The pinout of these connectors is defined in Section 2.3.1, beginning on page 508.

1.2.6 Elastomers

The **twin elastomer** is a conductor that consists of two rows of metal filaments embedded in a core of silicon rubber. The solid rubber core is placed between layers of soft silicone rubber.

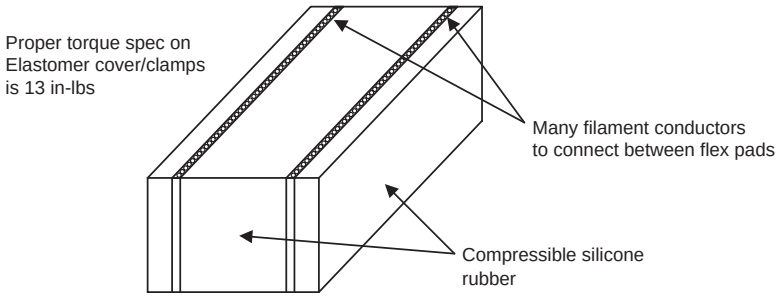


Figure 7-33 Twin Elastomer

The brass filaments are gold plated to be especially resilient. They are treated to spring and can be repeatedly compressed.

The Elastomers are used to make an electrical connection between the Detector flexes and **MDAS** backplane. Since the output of the Detector is a very low current signal, the connection must be clean from debris and oil, as well as exhibiting proper compression. This compression is made by correct torque of the Flex housing cover and clamp. The torque specification is 13 in-lbs (1.47 N-m).

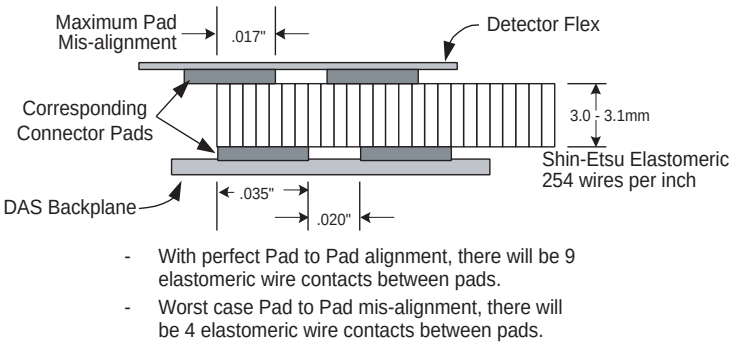


Figure 7-34 Elastomeric Pad Spacing

1.2.7 Detector and MDAS Channel Mapping (Partial)

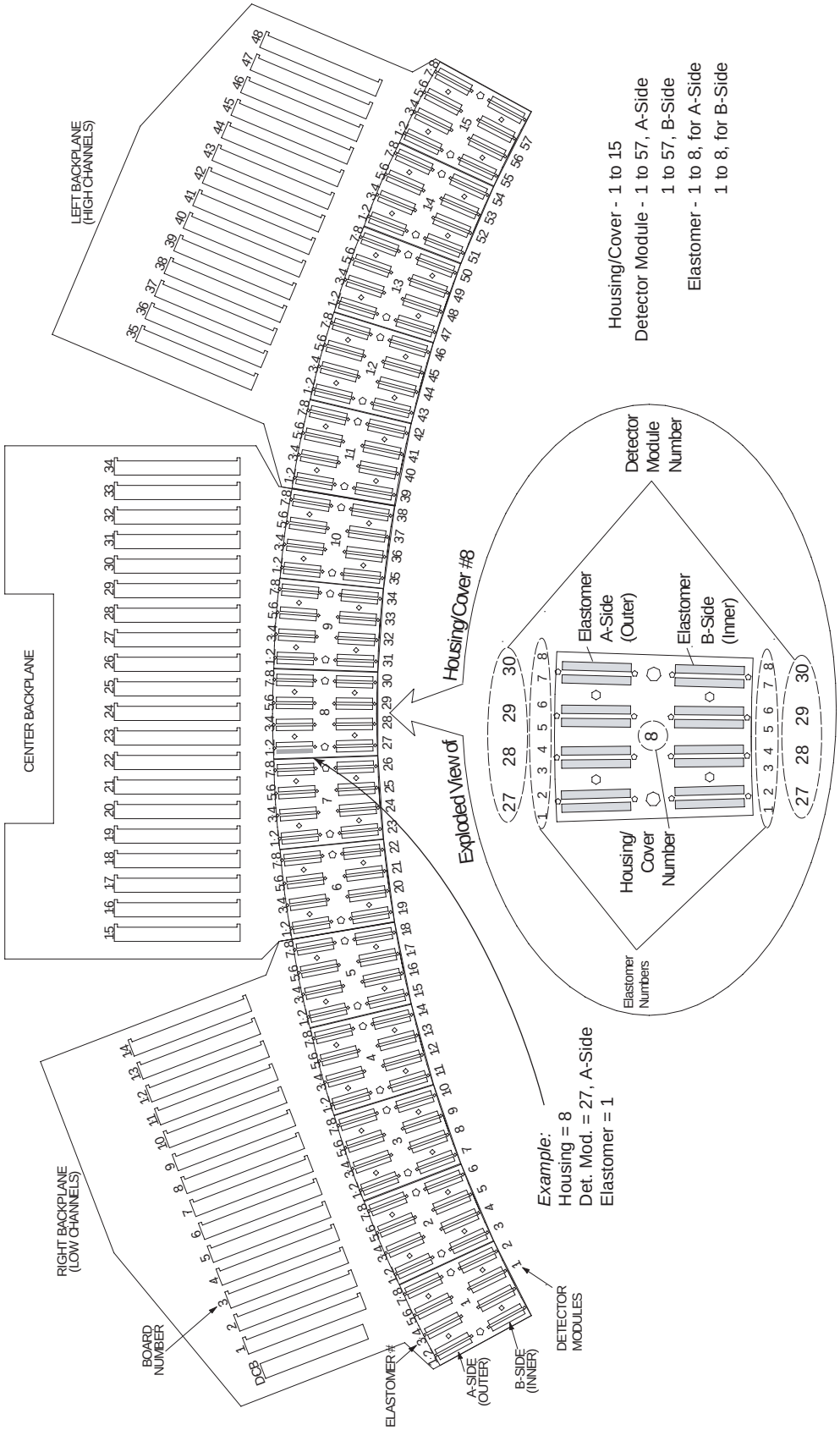


Figure 7-35 Detector/DAS Hardware Architecture Map

1.2.8 DCB Monitoring

1.2.8.1 Hardware

An **A/D** converter is used to measure the following. It has 16 bits of resolution. The measurements are updated at 1408Hz minimum.

- kV and mA levels from the **OBC**/Generator
- All **MDAS** power supply levels
- Test analog voltage generated by a 12bit **DAC**
- Detector temperature thermistor reading

1.2.8.2 Firmware

The major component of the sub-system monitoring block is an **A/D** converter that continuously gathers data and writes this data into the Auxiliary channels area of the data header.

Approximately every 250mS, firmware will poll the auxiliary channels that contain **DAS** power supply voltages and will test the voltages to the margins. If a supply is found to be outside of its margin, a warning message is to be logged into the error log.

Whenever a **DAS** Rx message is received, firmware will poll detector temperature and will test the temperature against the following limits:

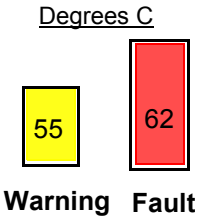
- If the detector temperature is over 36.5 degrees C, issue a warning message and allow scanning to continue.
- If the detector temperature is under 35.5 degrees C, issue a warning message and allow scanning to continue.

1.2.9 Power-On and Warm-Up/DAS Temperature Characteristics

The maximum required elapsed time from power-on to full specified **DAS** performance is one (1) hour. Time to meet full specified **DAS** performance is computed on the basis of two minutes warm-up per minute since power was last on, or 1 hour, whichever is less. However, under no conditions where the power has been temporarily turned off, shall the required warm-up (to meet full performance specification) be less than five (5) minutes.

Each Converter board has its own temperature sensor that is constantly monitored:

- If the temperature reaches 55 degrees C, then a **Warning Error** message will be posted to the Status Area of the ExamRx Desktop and associated Error Message in the error log.
- **If the temperature reaches 62 degrees C, then the MDAS will report an Over-Temperature Fault and will prevent further scanning until the DAS cools and is reset.**



Conditions that lead to **MDAS** over-temperature faults include:

- Room Environment/Temperature
- **MDAS** cooling fans not working or Air Plenum not installed
- **MDAS** filters are dirty
- Gantry fans not working properly

1.2.10 MDAS Power-Up Diagnostics

Whenever power is turned on to the **DAS** or a **DAS** Reset is performed, the **DAS** runs a series of Power-Up diagnostics. The sequence of tests is as follows.

DAS / DCB BOOT SEQUENCE AFTER POWER-ON OR RESET

1.) MCU Initialization
2.) **RAM** Test
3.) Boot Flash **CRC** Test
4.) Application **CRC**/size Test
5.) Load the code into **RAM** (Application code from Flash)
6.) Start the Application code

Once Application code is booted successfully in the **DCB**, then the **DCB** establishes itself with the **OBC** and the **DAS** Converter boards in the following sequence of initialization and tests:

1.) Platform Software and Hardware Driver initialization.
2.) **DCB** Hardware self-tests.
3.) Initialize Application Hardware and communication tasks.
4.) Initializes Converter boards, 2 boards at a time, and does this 6 times. This is when the Converter board **LED**s flash several short times in sequence from board 1 through 48. The Converter board initialization consists of:
   - Converter board access (Read/writes)
   - Initialization
   - Reading of **EEPROM**
   - Set of Temperature sensors
   - Setting of Offset Trim
   - Calibration
   - Fault line test
5.) When all the converter boards are initialized, the **DCB** performs the following tasks:
   - Updates configure Tracker and version verification data
   - Reads Converter board temperature tests
   - Runs a quick data path test (2 views worth of data)
6.) Ready to Interface with **OBC**.

In an error condition, the error is reported to the **DCB**, if possible (depending on the type of fault). The **DCB** then relays the information to the **OBC**, and finally to the system error log. If the **DCB** is at fault and cannot communicate with the **OBC**, then a **DAS** Communication Error is logged.

1.3 4 Slice versus 8 Slice Configuration

The HiSpeed QX/i system can operate 4 slice per rotation, data collections mode, whereas, the Detector and MDAS are capable of operating 4 slice or 8 slice per rotation.

The previous theory sub sections describe an 8 slice configuration system. The functions of the DCB, Converters, DHCB, DMB and Detector are the same in both configurations. The set points, impedances and specifications are also the same for both configurations.

From a hardware perspective the main difference is in the MDAS. The 4 slice configuration uses a depopulated MDAS. This means that all EVEN slots are empty. Only ODD numbered slots contain converter boards. Data collection is still performed in the same manner using only the odd converter card slot assignments. Reference Figure 7-30, on page 490.

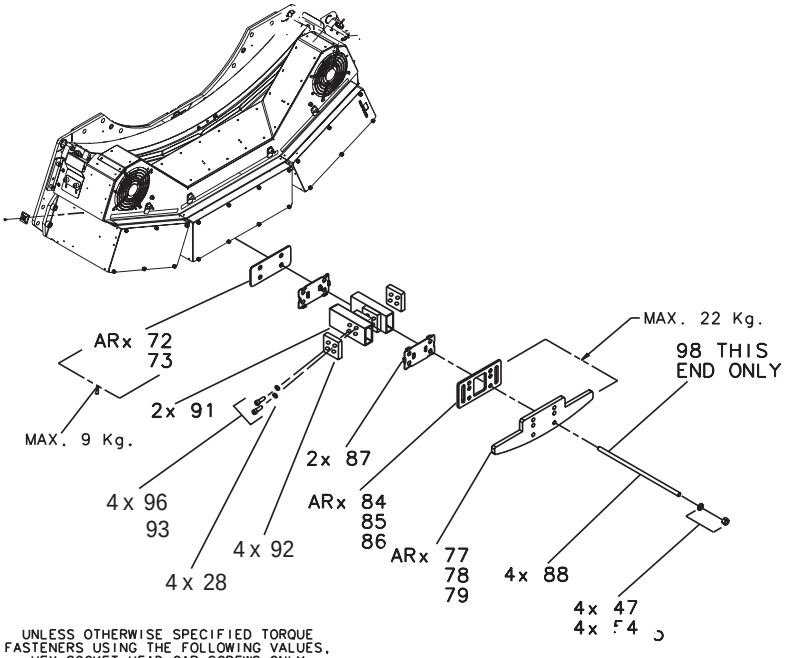
Since the even converter slots are empty, to maintain signal integrity, rows 3 and 4 of the detector FET matrix are grounded under DCB control. Reference Figure 7-8, on page 473.

As the detector FET enable lines employed are different in the 4 slice mode versus the 8 slice mode, this results in only 4 macro row capability, 2A, 1A, 1B, 2B. Reference Figure 7-37, on page 506 for FET mode and macro row comparisons.

These configuration differences require that a unique full Detailed Calibration be performed for 4 slice versus 8 slice mode operations. This is necessary since different macro cell combinations are used. There are less calibration stations in the 4 slice configuration.

An additional hardware difference is related to gantry balance. Since the 4 slice MDAS configuration contains only 24 converter cards, additional weight has been added at the factory. These weights are located above the center DAS chassis. There are 4 individual weights mounted on the aluminum spacer tubing. These weights have 4 slice stamped onto them. These weights are used only in the 4 slice configuration.

2291276-2 HELIOS 3 ROTATING BASE (4 SLICE) ASM ONLY



UNLESS OTHERWISE SPECIFIED TORQUE FASTENERS USING THE FOLLOWING VALUES, HEX SOCKET HEAD CAP SCREWS ONLY VALUES ARE BASE ON ENGAGING LIKE MATERIALS OR HAVING TWO DIAMETERS OF BOLT ENGAGEMENT

FASTENER SIZE	TORQUE
M3	1 Nm
M4	2.3 Nm
M6	7.9 Nm
M10	38.4 Nm
M12	66.4 Nm
M16	160 Nm

Item 96 Screw Hexagon Socket 4MM
Item 93 Loctite 242
Item 92 Weight, MDAS 4 Slice Only Balance
Item 28 Washer, Lock Spring 4.1 MM 7.6MM Spring Steel
Item 54 Nut Hexagon 12 MM
Item 47 Washer, Lock Spring 12.2 MM 21.1 MM

Figure 7-36 4 Slice Balance Weights Location

Normal data modes with Z-chan same as H1.x																4-slice configuration									
A8 (D8)	A7 (D7)	A6 (D6)	A5 (D5)	A4 (D4)	A3 (D3)	A2 (D2)	A1 (D1)	B1 (D1)	B2 (D2)	B3 (D3)	B4 (D4)	B5 (D5)	B6 (D6)	B7 (D7)	B8 (D8)	Slice mode	FET mode	Detector Mode name	Protocol Mode name	FET 1 LED	FET 2 LED	FET 3 LED	FET 4 LED	FET 5 LED	FET 6 LED
2	1													1	2	Z-chan	45	4Cal6	Cal6	OFF	ON	OFF	OFF	ON	OFF
2	2	2	2	1	1	1	1	1	1	1	1	2	2	2	2	4x5.00	36	4x5.00	4x5.00	ON	ON	OFF	ON	ON	OFF
	2	1											1	2		Z-chan	44	4Cal5	Cal5	ON	ON	OFF	OFF	ON	OFF
		2	2	2	1	1	1	1	1	1	2	2	2			4x3.75	35	4x3.75	4x3.75	OFF	OFF	ON	ON	ON	OFF
			2	1							1	2				Z-chan	42	4Cal3	Cal3	ON	OFF	ON	OFF	ON	OFF
				2	2	1	1	1	1	2	2					4x2.50	34	4x2.50	4x2.50	ON	OFF	ON	ON	ON	OFF
				2	2	1	1	1	1	2	2					Z-chan	34	4x2.50	4x2.50	ON	OFF	ON	ON	ON	OFF
						2	1	1	2							4x1.25	33	4x1.25	4x1.25	OFF	ON	ON	ON	ON	OFF
						2	1	1	2							Z-chan	33	4x1.25	4x1.25	OFF	ON	ON	ON	ON	OFF
						2	1	1	2							1x1.25	33	4x1.25	4x1.25	OFF	ON	ON	ON	ON	OFF
						2	1	1	2							Z-chan	33	4x1.25	4x1.25	OFF	ON	ON	ON	ON	OFF
						2	1	1	2							Thin twin	33	4x1.25	4x1.25	OFF	ON	ON	ON	ON	OFF

Normal data modes with Z-chan same as H1.x																8-slice configuration									
A8 (D8)	A7 (D7)	A6 (D6)	A5 (D5)	A4 (D4)	A3 (D3)	A2 (D2)	A1 (D1)	B1 (D1)	B2 (D2)	B3 (D3)	B4 (D4)	B5 (D5)	B6 (D6)	B7 (D7)	B8 (D8)	Slice mode	FET mode	Detector Mode name	Protocol Mode name	FET 1 LED	FET 2 LED	FET 3 LED	FET 4 LED	FET 5 LED	FET 6 LED
2	1					4	3	3	4					1	2	Z-chan	17	8Cal6	Cal6	OFF	ON	ON	ON	OFF	ON
2	2	2	2	1	1	1	1	1	1	1	1	2	2	2	2	4x5.00	8	4x5.00	4x5.00	ON	ON	ON	OFF	ON	ON
3	2	1					4	4					1	2	3	Z-chan	16	8Cal5	Cal5	ON	ON	ON	ON	OFF	ON
		2	2	2	1	1	1	1	1	1	2	2	2			4x3.75	7	4x3.75	4x3.75	OFF	OFF	OFF	ON	ON	ON
	4	3	2	1							1	2	3	4		Z-chan	14	8Cal3	Cal3	ON	OFF	OFF	OFF	ON	ON
				2	2	1	1	1	1	2	2					4x2.50	6	4x2.50	4x2.50	ON	OFF	OFF	ON	ON	ON
				2	2	1	1	1	1	2	2					Z-chan	6	4x2.50	4x2.50	ON	OFF	OFF	ON	ON	ON
						2	1	1	2							4x1.25	5	4x1.25	4x1.25	OFF	ON	OFF	ON	ON	ON
	4	3	2	1							1	2	3	4		Z-chan	14	8Cal3	Cal3	ON	OFF	OFF	OFF	ON	ON
				4	3	2	1	1	2	3	4					8x1.25	0	8x1.25	8x1.25	ON	ON	ON	ON	ON	ON
2	1					4	3	3	4					1	2	Z-chan	17	8Cal6	Cal6	OFF	ON	ON	ON	OFF	ON
4	4	3	3	2	2	1	1	1	1	2	2	3	3	4	4	8x2.50	1	8x2.50	8x2.50	OFF	ON	ON	ON	ON	ON
						2	1	1	2							Z-chan	5	4x1.25	4x1.25	OFF	ON	OFF	ON	ON	ON
						2	1	1	2							1x1.25	5	4x1.25	4x1.25	OFF	ON	OFF	ON	ON	ON
						2	1	1	2							Z-chan	5	4x1.25	4x1.25	OFF	ON	OFF	ON	ON	ON
						2	1	1	2							Thin twin	5	4x1.25	4x1.25	OFF	ON	OFF	ON	ON	ON

Figure 7-37 4 Slice versus 8 Slice FET Mode Assignments

Section 2.0
Jumpers, Switches, Adjustments, LEDs & Connections

2.1 Detector Heater Power Supply

Refer to "Collimator/Detector Heater Power Supply," on page 742.

2.2 Detector Flexes

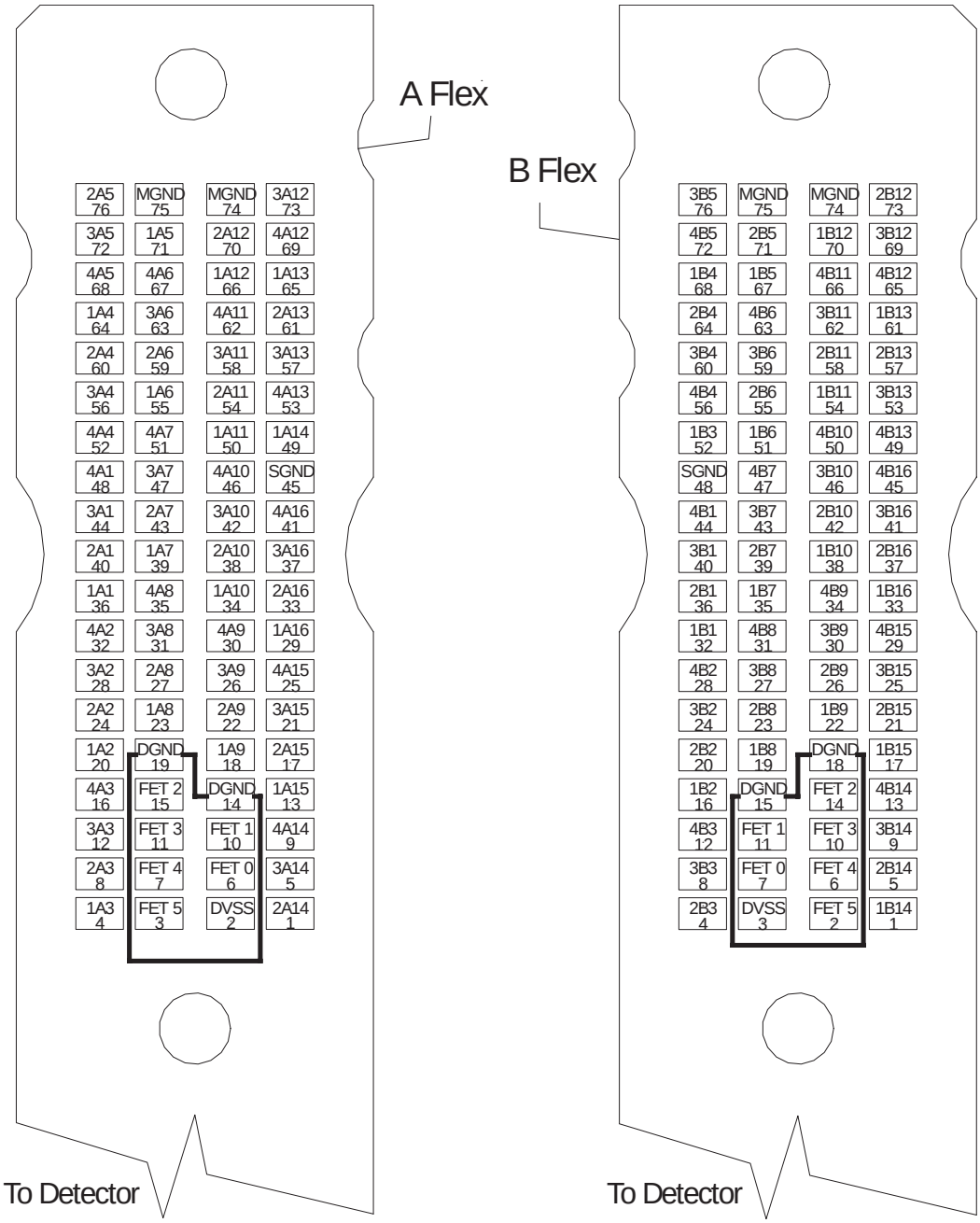


Figure 7-38 Pin Connections (DAS at 12 o'clock)

2.3 DAS

2.3.1 External Interface Pinouts

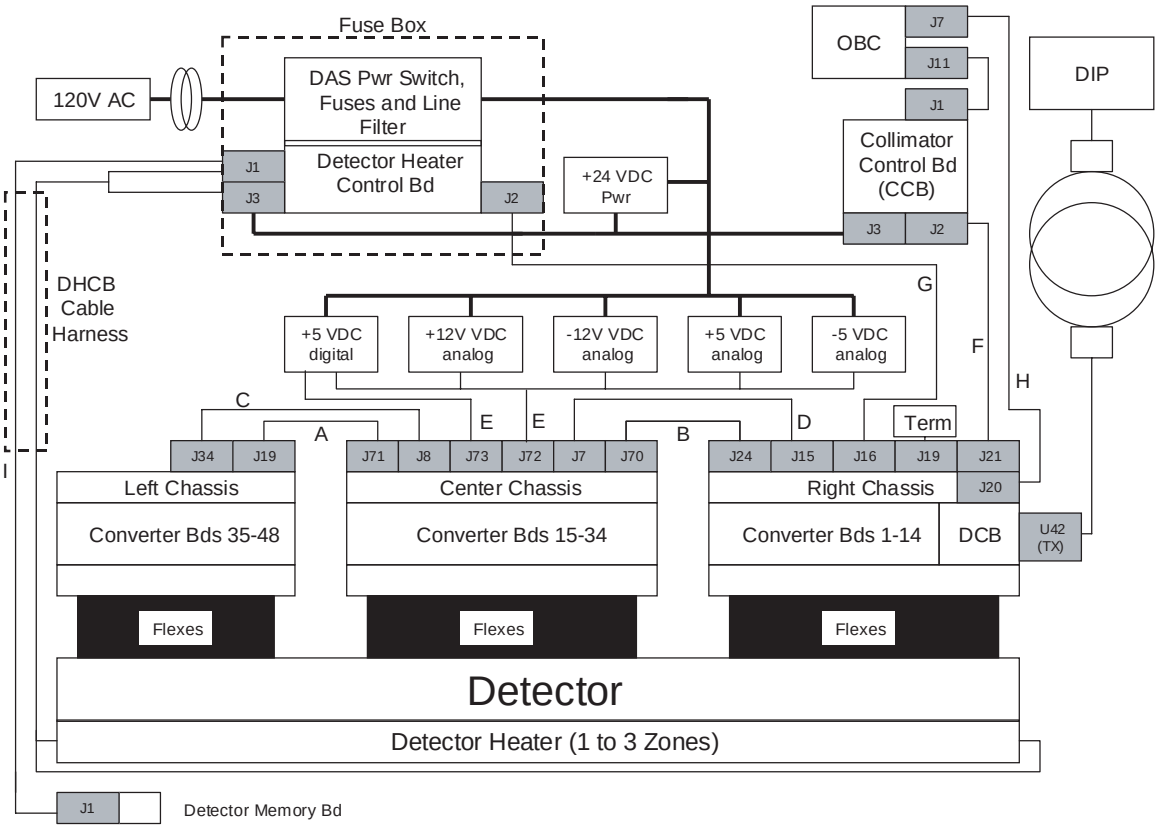


Figure 7-39 MDAS Interface Pinout Block Diagram

Note: Letters next to Interconnect Cables represents further detailed descriptions in following pages.

2.3.1.1 Cable A

MDAS Power Cable between Center (J71) and Left **MDAS** Chassis (J19)

CENTER CHASSIS CONNECTOR - PIN #	COLOR	DESCRIPTION	LEFT DAS CHASSIS CONNECTOR - PIN #
J71 - 1	Red	+5VDC Digital	J19 - 1
J71 - 2	Green	Digital Ground	J19 - 2
J71 - 3	Orange	+5VDC Analog	J19 - 3
J71 - 4	Brown	5V Analog Ground	J19 - 4
J71 - 5	Yellow	-5VDC Analog	J19 - 5
J71 - 6	Blue	+12VDC Analog	J19 - 6
J71 - 7	Black	12V Analog Ground	J19 - 7
J71 - 8	White	-12VDC Analog	J19 - 8

Table 7-7 Cable A - MDAS Power Cable

2.3.1.2 Cable B

MDAS Power Cable between Center (J70) and Right **MDAS** Chassis (J24)

CENTER CHASSIS CONNECTOR - PIN #	COLOR	DESCRIPTION	RIGHT CHASSIS CONNECTOR - PIN #
J70 - 1	Red	+5VDC Digital	J24 - 1
J70 - 2	Green	Digital Ground	J24 - 2
J70 - 3	Orange	+5VDC Analog	J24 - 3
J70 - 4	Brown	5V Analog Ground	J24 - 4
J70 - 5	Yellow	-5VDC Analog	J24 - 5
J70 - 6	Blue	+12VDC Analog	J24 - 6
J70 - 7	Black	12V Analog Ground	J24 - 7
J70 - 8	White	-12VDC Analog	J24 - 8

Table 7-8 Cable B - MDAS Power Cable

2.3.1.3 Cables C & D

DAS Data Cables between Left **DAS** Chassis, Center **DAS** Chassis and Right **DAS** Chassis.

SIGNAL NAME	LEFT DAS CONNECTOR-PIN #	CENTER DAS CONNECTOR-PIN #		RIGHT DAS CONNECTOR-PIN #
LGND	J34-1	J8-1	J7-1	J15-1
RDT_SS1_OD+	J34-2	J8-2	J7-2	J15-2
RDT_SS1_OD-	J34-3	J8-3	J7-3	J15-3
RDT_SS1_EV+	J34-4	J8-4	J7-4	J15-4
RDT_SS1_EV-	J34-5	J8-5	J7-5	J15-5
RDT_SS2_OD+	J34-6	J8-6	J7-6	J15-6
RDT_SS2_OD-	J34-7	J8-7	J7-7	J15-7
RDT_SS2_EV+	J34-8	J8-8	J7-8	J15-8
RDT_SS2_EV-	J34-9	J8-9	J7-9	J15-9
RDT_SS3_OD+	J34-10	J8-10	J7-10	J15-10
RDT_SS3_OD-	J34-11	J8-11	J7-11	J15-11
RDT_SS3_EV+	J34-12	J8-12	J7-12	J15-12
RDT_SS3_EV-	J34-13	J8-13	J7-13	J15-13
RDT_SS4_OD+	J34-14	J8-14	J7-14	J15-14
RDT_SS4_OD-	J34-15	J8-15	J7-15	J15-15
RDT_SS4_EV+	J34-16	J8-16	J7-16	J15-16
RDT_SS4_EV-	J34-17	J8-17	J7-17	J15-17
RDT_SS5_OD+	J34-18	J8-18	J7-18	J15-18
RDT_SS5_OD-	J34-19	J8-19	J7-19	J15-19
RDT_SS5_EV+	J34-20	J8-20	J7-20	J15-20
RDT_SS5_EV-	J34-21	J8-21	J7-21	J15-21
RDT_SS6_OD+	J34-22	J8-22	J7-22	J15-22
RDT_SS6_OD-	J34-23	J8-23	J7-23	J15-23

Table 7-9 DAS Data Cables

SIGNAL NAME	LEFT DAS CONNECTOR-PIN #	CENTER DAS CONNECTOR-PIN #		RIGHT DAS CONNECTOR-PIN #
RDT_SS6_EV+	J34-24	J8-24	J7-24	J15-24
RDT_SS6_EV-	J34-25	J8-25	J7-25	J15-25
RDT_SS7_OD+	J34-26	J8-26	J7-26	J15-26
RDT_SS7_OD-	J34-27	J8-27	J7-27	J15-27
RDT_SS7_EV+	J34-28	J8-28	J7-28	J15-28
RDT_SS7_EV-	J34-29	J8-29	J7-29	J15-29
RDT_SS8_OD+	J34-30	J8-30	J7-30	J15-30
RDT_SS8_OD-	J34-31	J8-31	J7-31	J15-31
RDT_SS8_EV+	J34-32	J8-32	J7-32	J15-32
RDT_SS8_EV-	J34-33	J8-33	J7-33	J15-33
LGND	J34-34	J8-34	J7-34	J15-34
CAN_BUS_SHIELD	J34-35	J8-35	J7-35	J15-35
CVTR_CAN_BUS+	J34-36	J8-36	J7-36	J15-36
CVTR_CAN_BUS-	J34-37	J8-37	J7-37	J15-37
CAN_BUS_SHIELD	J34-38	J8-38	J7-38	J15-38
LGND	J34-39	J8-39	J7-39	J15-39
LGND	J34-40	J8-40	J7-40	J15-40
CVTR_SHCK+	J34-41	J8-41	J7-41	J15-41
CVRT_SHCK+	J34-42	J8-42	J7-42	J15-42
CVTR_SHCK-	J34-43	J8-43	J7-43	J15-43
CVTR_SHCK-	J34-44	J8-44	J7-44	J15-44
CVTR_S_TRIG+	J34-45	J8-45	J7-45	J15-45
CVTR_S_TRIG+	J34-46	J8-46	J7-46	J15-46
CVTR_S_TRIG-	J34-47	J8-47	J7-47	J15-47
CVTR_S_TRIG-	J34-48	J8-48	J7-48	J15-48
LGND	J34-49	J8-49	J7-49	J15-49
CVTR_FLT*	J34-50	J8-50	J7-50	J15-50
CVTR_RST	J34-51	J8-51	J7-51	J15-51
CVTR_XPRG*	J34-52	J8-52	J7-52	J15-52
LGND	J34-53	J8-53	J7-53	J15-53
CVTR_WR_PRTCT	J34-54	J8-54	J7-54	J15-54
SPARE	J34-55	J8-55	J7-55	J15-55
SPARE	J34-56	J8-56	J7-56	J15-56
LGND	J34-57	J8-57	J7-57	J15-57
AGND	J34-58	J8-58	J7-58	J15-58
UZ_FET-1	J34-59	J8-59	J7-59	J15-59
UZ_FET-2	J34-60	J8-60	J7-60	J15-60
UZ_FET-3	J34-61	J8-61	J7-61	J15-61
UZ_FET-4	J34-62	J8-62	J7-62	J15-62

Table 7-9 DAS Data Cables (Continued)

SIGNAL NAME	LEFT DAS CONNECTOR-PIN #	CENTER DAS CONNECTOR-PIN #		RIGHT DAS CONNECTOR-PIN #
UZ_FET-5	J34-63	J8-63	J7-63	J15-63
UZ_FET-6	J34-64	J8-64	J7-64	J15-64
AGND	J34-65	J8-65	J7-65	J15-65
D_FET-1	J34-66	J8-66	J7-66	J15-66
D_FET-2	J34-67	J8-67	J7-67	J15-67
D_FET-3	J34-68	J8-68	J7-68	J15-68
D_FET-4	J34-69	J8-69	J7-69	J15-69
D_FET-5	J34-70	J8-70	J7-70	J15-70
D_FET-6	J34-71	J8-71	J7-71	J15-71
AGND	J34-72	J8-72	J7-72	J15-72
N/C	J34-73	J8-73	J7-73	J15-73
N/C	J34-74	J8-74	J7-74	J15-74
AGND	J34-75	J8-75	J7-75	J15-75
AGND	J34-76	J8-76	J7-76	J15-76
TEST_V+	J34-77	J8-77	J7-77	J15-77
TEST_V-	J34-78	J8-78	J7-78	J15-78
AGND	J34-79	J8-79	J7-79	J15-79
AGND	J34-80	J8-80	J7-80	J15-80

Table 7-9 DAS Data Cables (Continued)

2.3.1.4 Cable E

MDAS Power Harness from **MDAS** Power Supplies to Center **MDAS** Chassis (J72 & J73)

CENTER CHASSIS CONNECTOR - PIN #	COLOR	DESCRIPTION	DAS POWER SUPPLIES CONNECTOR - PIN #
J72 - 1	Red	+5VDC Digital	Large 5VDC Supply (+OUT)
J72 - 2	Green	Digital Ground	Large 5VDC Supply (- COM)
J72 - 3	Orange	+5VDC Analog	Small 5VDC Supply (+5VDC)
J72 - 4	Brown Brown	5V Analog Ground	Small 5VDC Supply (+5V Rtn) Small 5VDC Supply (-5V Rtn)
J72 - 5	Yellow	-5VDC Analog	Small 5VDC Supply (-5VDC)
J72 - 6	Black	+12VDC Analog	Middle 12VDC Supply (+OUT)
J72 - 7	Black White	12V Analog Ground	12VDC Supply (+12V Rtn) 12VDC Supply (-12V Rtn)
J72 - 8	White	-12VDC Analog	Lower 12VDC Supply (-OUT)
		+ 5VDC Digital Power Supply Sense Leads	
J73 - 1	Black	+ 5VDC Digital Power Supply Sense Leads	5VDC Supply
J73 - 2	White	+ 5VDC Digital Power Supply Sense Leads	5VDC Supply

Table 7-10 Cable E - MDAS Power Harness

2.3.1.5 Cable F

MDAS Cable from Collimator (J2) to **DAS CAN** (J21).

COLLIMATOR BACK-PLANE PIN #	COLOR	DESCRIPTION	DAS CAN PIN #
J2-1	Black	12V RTN	J21-1
J2-2	Black	**GCAN** H	J21-2
J2-3	Black	**GCAN** FLT P	J21-3
J2-4	Black	**GCAN** RST P	J21-4
J2-5	Black	EXP CMND P	J21-5
J2-6	Black	Not Used	J21-6
J2-7	Black	Trig P	J21-7
J2-8	Green/Black	GRND	J21-8
J2-9	Red	+12V ISO	J21-9
J2-10	White	**GCAN** L	J21-10
J2-11	Green	**GCAN** FLT N	J21-11
J2-12	Blue	**GCAN** FLT N	J21-12
J2-13	Yellow	EXP CMND N	J21-13
J2-14	Brown	Not Used	J21-14
J2-15	Orange	Trig N	J21-15

Table 7-11 Cable F - Collimator to DAS CAN Cable

2.3.1.6 Cable G

MDAS Cable (RS-232) between **DCB** (J16) and **DHCB** (J2)

DCB CONNECTOR PIN #	COLOR	DESCRIPTION	DHCB CONNECTOR PIN #
J16-1	Black	**DCB** to **DHCB** TXD	J2-1
J16-2	Black	**DCB** to **DHCB** RXD	J2-2
J16-3	Black	**DCB** to **DHCB** TXD	J2-3
J16-4	Black	**DHCB** Sense A	J2-4
J16-5	Green/Black	**DHCB** GND	J2-5
J16-6	Red	**DHCB** Neg V	J2-6
J16-7	White	N/C	J2-7
J16-8	Green	**DHCB** Sense B	J2-8
J16-9	Blue	N/C	J2-9

Table 7-12 Cable G - DCB/DHCB RS-232

2.3.1.7 Cable H

Analog Interface Cable from Right **DAS** Chassis (J20) to **OBC** (J7). The Analog Interface Cable is used for monitoring the KV & MA analog control voltages.

DCB CONNECTOR - PIN #	COLOR	SIGNAL NAME	DESCRIPTION	OBC BACKPLANE CONNECTOR - PIN #
J20 - 3	Black	KV_MEA+	KV Signal Input (pos)	J7-2
J20 - 4	Black	MA_MEA+	MA Signal Input (pos)	J7-5
J20 - 7	Red	KV_MEA-	KV Signal Input (neg)	J7-1
J20 - 9	White	MA_MEA-	MA Signal Input (neg)	J7-4

Table 7-13 Cable H - Analog Interface Cable

2.3.1.8 Cable I

MDAS Cable, DET/**DHCB** (J1,J3)/**DMB** (J1)/Collimator (J3)

FROM CONNECTOR PIN #	COLOR	DESCRIPTION	TO CONNECTOR PIN #
DHCB J1-1	White/Blue	Left Thermistor A	Left Detector-4
DHCB J1-2	White/Blue	Center Thermistor A	Right Detector-4
DHCB J1-3	White/Blue	Right Thermistor A	Right Detector-7
DHCB J1-4	Red	DMB_SDA	DMB J1-1
DHCB J1-5	White	DMB_SCL	DMB J1-2
DHCB J1-6	Green	DMB_WP	DMB J1-3
DHCB J1-7	Blue	VCC_LOGIC	DMB J1-4
DHCB J1-8	Green/Black	LOGIC GND	DMB J1-5
DHCB J1-9	Blue/White	Left Thermistor B	Left Detector-5
DHCB J1-10	Blue/White	Center Thermistor B	Right Detector-5
DHCB J1-11	Blue/White	Right Thermistor B	Right Detector-8
DHCB J1-12	Black	Logic Ground	DMB J1-6
DHCB J1-13	Black	Logic Ground	DMB J1-7
DHCB J1-14	Black	Logic Ground	DMB J1-8
DHCB J1-15	Black	Logic Ground	DMB J1-9
DHCB J3-4	Red	Center Heater A	Right Detector-1
DHCB J3-1	Black	Center Heater B	Right Detector-2
DHCB J3-3	Red	Right Heater A	Right Detector-10
DHCB J3-8	Black	Right Heater B	Right Detector-11
DHCB J3-7	Red	Left Heater A	Detector Left-1
DHCB J3-2	Black	Left Heater B	Detector Left-2
DHCB J3-9	Red	24V Input Power	24V PS-2
DHCB J3-5	Black	24V Input Ground	24V PS-1
24V PS	Black	+24V RTN	Collimator J3-2
24V PS	Red	+24V	Collimator J3-1

Table 7-14 Cable I - DHCB/DET/DMB/Collimator Cable

2.3.2 Converter Board Backplane Connector

The Converter Board uses a 192 (4 x 48) pin, right-angle gold-plated connector.

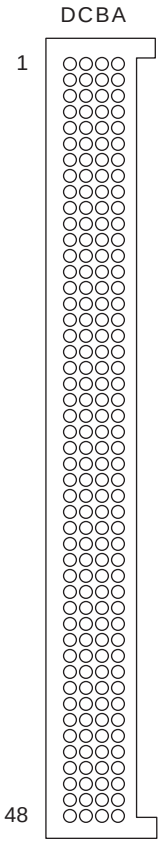


Figure 7-40 Converter board backplane connector (viewed with DAS at 12 o'clock)

Pin assignments are shown in Table 7-15

ROW PIN NO.	COL A SIGNAL NAME	COL B SIGNAL NAME	COL C SIGNAL NAME	COL D SIGNAL NAME
1	LGND	+5V_L	LGND	+5V_L
2	LGND	D_OUT_OD-	CVB_ADDR_5	D_OUT_EVN-
3	D_IN_OD-	D_OUT_OD+	D_IN_EVN-	D_OUT_EVN+
4	D_IN_OD+	CV_RST	D-IN_EVN+	LGND
5	LGND	CV_FLT*	CVB_ADDR_4	X_PRG*
6	S_TRIG-	+5V_L	CAN_LO	CAN_HI
7	S_TRIG+	LGND	CVB_ADDR_3	LGND
8	LGND	SH_CK-	LGND	CVB_ADDR_2
9	LGND	SH_CK+	LGND	CVB_ADDR_1
10	WT_PRTCT	LGND	CVB_ADDR_0	AGND
11	+5V_A	AGND	-5V_A	TEST_V-
12	+5V_A	AGND	-5V_A	TEST_V+
13	AGND	AGNE	AGND	SGND

Table 7-15 Converter Board Connector Pin Assignments

ROW PIN NO.	COL A SIGNAL NAME	COL B SIGNAL NAME	COL C SIGNAL NAME	COL D SIGNAL NAME
14	CHAN112	CHAN108	CHAN104	CHAN100
15	CHAN128	CHAN124	CHAN120	CHAN116
16	CHAN110	CHAN106	CHAN102	CHAN98
17	CHAN126	CHAN122	CHAN118	CHAN114
18	CHAN80	CHAN76	CHAN72	CHAN68
19	CHAN96	CAHN92	CHAN88	CHAN84
20	CHAN78	CHAN74	CHAN70	CHAN66
21	CHAN94	CHAN90	CHAN86	CHAN82
22	CHAN48	CHAN44	CHAN40	CHAN36
23	CHAN64	CHAN60	CHAN56	CHAN52
24	CHAN46	CHAN42	CHAN38	CHAN34
25	CHAN62	CHAN58	CHAN54	CHAN50
26	CHAN16	CHAN12	CHAN8	CHAN4
27	CHAN32	CHAN28	CHAN24	CHAN20
28	CHAN14	CHAN10	CHAN6	CHAN2
29	CHAN30	CHAN26	CHAN22	CHAN18
30	AGND	AGND	AGND	SGND
31	CHAN111	CHAN107	CHAN103	CHAN99
32	CHAN127	CHAN123	CHAN119	CHAN115
33	CHAN109	CHAN105	CHAN101	CHAN97
34	CHAN125	CHAN121	CHAN117	CHAN113
35	CHAN79	CHAN75	CHAN71	CHAN67
36	CHAN95	CHAN91	CHAN87	CHAN83
37	CHAN77	CHAN73	CHAN69	CHAN65
38	CHAN93	CHAN89	CHAN85	CHAN81
39	CHAN47	CHAN43	CHAN39	CHAN35
40	CHAN63	CHAN59	CHAN55	CHAN51
41	CHAN45	CHAN41	CHAN37	CHAN33
42	CHAN61	CHAN57	CHAN53	CHAN49
43	CHAN15	CHAN11	CHAN7	CHAN3
44	CHAN31	CHAN27	CHAN23	CHAN19
45	CHAN13	CHAN9	CHAN5	CHAN1
46	CHAN29	CHAN25	CHAN21	CHAN17
47	AGND	AGND	AGND	SGND
48	-12V_A	-12V_A	+12V_A	+12V_A

Table 7-15 Converter Board Connector Pin Assignments (Continued)

2.3.3 DAS Backplanes

2.3.3.1 LEDs

MDAS LEDs are located on the Right Backplane.

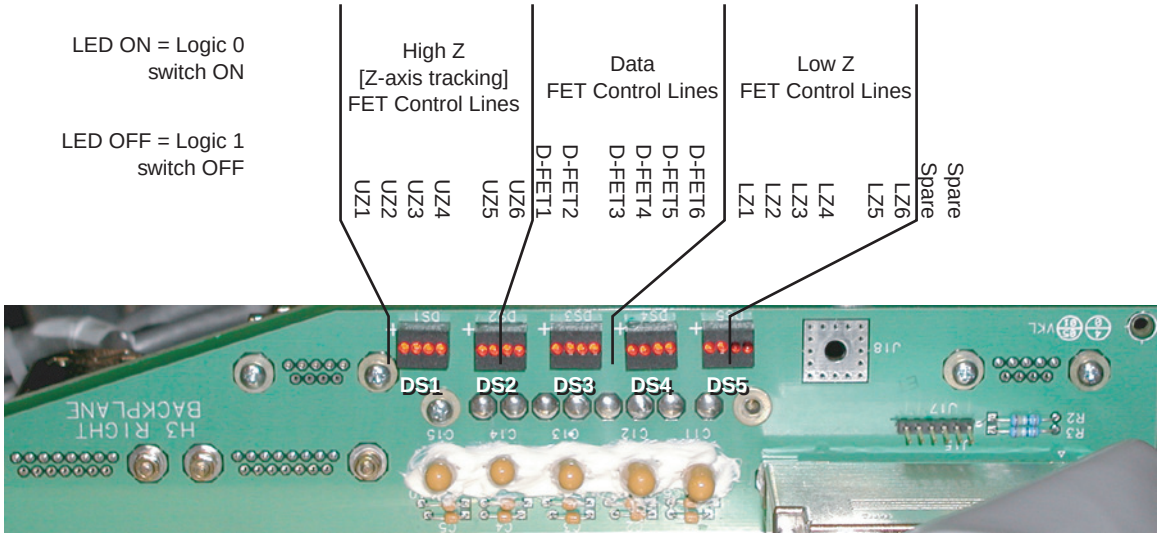


Figure 7-41 MDAS LEDs (as viewed with DAS at 12 o'clock)

2.3.3.2 Power Supply Test Points

Test Points are available on the Center Backplane to measure Power Supply voltages.

TEST POINT	DESCRIPTION	SPECIFICATIONS
TP1	+12 VDC Analog wrt AGND	+12 VDC ± 0.6 VDC
TP2	-12 VDC Analog wrt AGND	+12 VDC ± 0.6 VDC
TP3	+5 VDC Analog wrt AGND	+5 VDC ± 0.25 VDC
TP4	-5 VDC Analog wrt AGND	+5 VDC ± 0.25 VDC
TP5	AGND (Analog Ground)	
TP6	LGND (Logic Ground)	
TP7	+5 VDC Digital wrt LGND	

Table 7-16 Backplane Voltage Test Points

2.3.4 DAS Control Board (DCB)

2.3.4.1 Board Layout

The **MDAS DCB** differs from the SDAS **DCB** physically in that it is packaged in the right **MDAS** chassis with the Converter boards. This eliminates a number of cables and connectors. There are only two connectors on the **MDAS DCB** for normal operation: An optical cable connector for high speed serial data transmission to the slip ring and a backplane connector for data and control signals to/from the Converter cards, signals from the Generator, RS232 interface to the Detector Heater Control Board (**DHCB**).

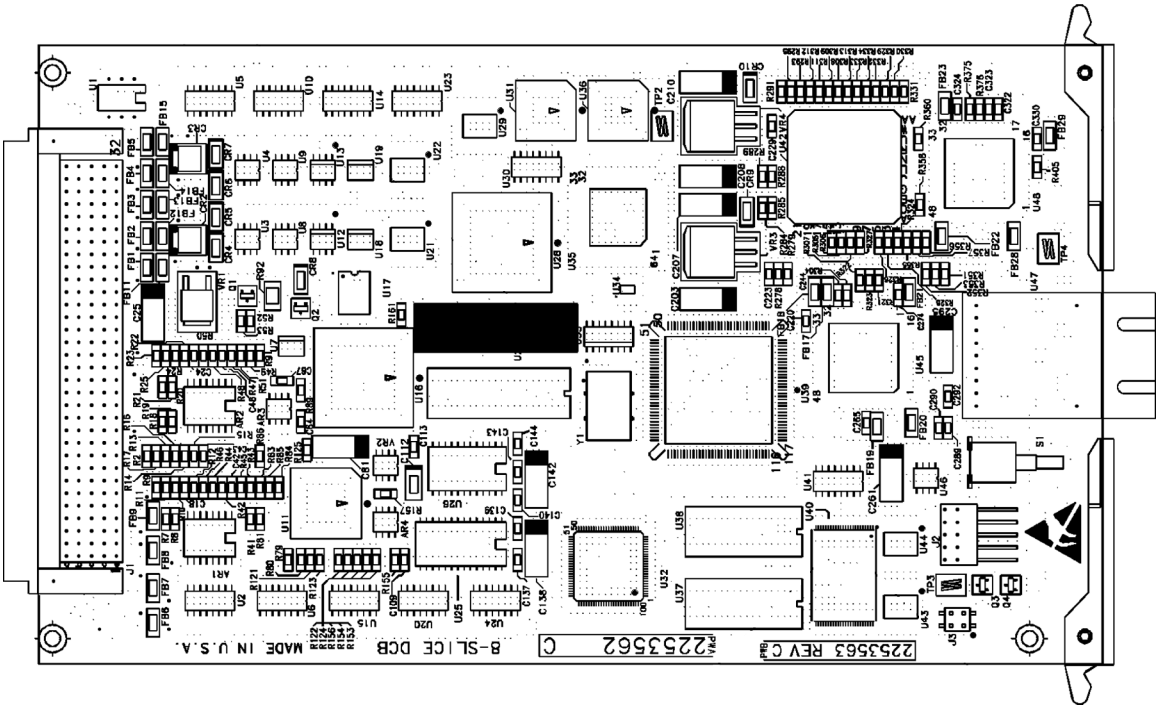


Figure 7-42 DAS Control Board Layout

ITEM	DESCRIPTION
S1	**DCB** Board Reset switch
J9	Fiber Optic, High Speed Serial **DAS** Data Out
TP1	+5 VDC Digital
TP2	Digital Ground

Table 7-17 DAS Control Board - Switch. Connector & Test Point Descriptions

Pushbutton Reset

The pushbutton reset, S1, initiates a hard reset to all the board logic. This initializes all the hardware to a known state, and causes the Core 68332 processor to reboot. The X1 - X4 **FPGA**s, however, are only reconfigured from serial **EPROM** at board power-up.

Test Points

The **DCB** Has the following test points:

- *TP1*: +5V Digital Power
- *TP2*: Digital Ground

Jumpers

The **DCB** has two jumpers, in a straight, 4-pin male, 0.1-inch spacing, header-type connector. The factory configuration for each jumper is OUT. The normal Applications Mode is both jumpers OUT. These jumpers are located on the **DCB** and are accessible only when the **DCB** is out of the **MDAS**

chassis or the cover for the right chassis is off. The pinout for the jumper block is shown in Table 7-18.

PIN SET	JUMPER IN	JUMPER OUT	DEFINITION
1-2	Boots the loader	Boots the Application	When this jumper is IN, the RS-232 serial port on J3 is enabled at 19.2 kBaud, allowing interactive debugging with a dumb terminal or PC
3-4	Test Mode	Application Mode	When this jumper is IN, the **FPGA**'s outputs are tri-stated for in-circuit test purposes

Table 7-18 Test Jumper Block Pinout

2.3.4.2 LEDs

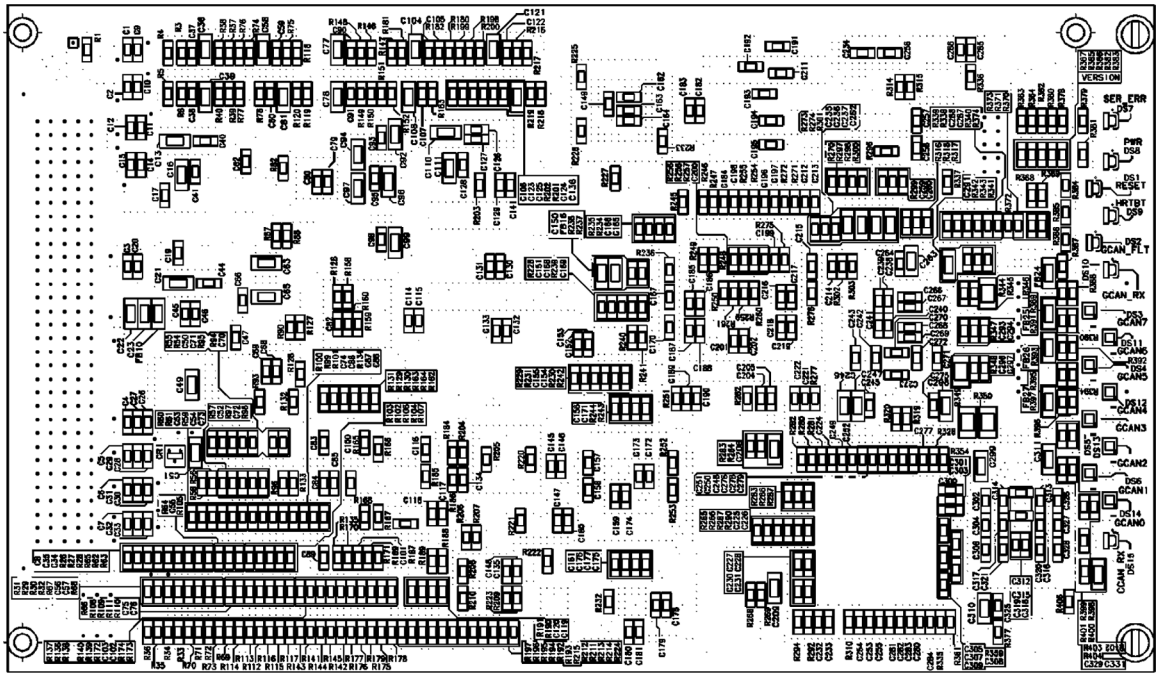


Figure 7-43 DAS Control Board Layout - Reverse side, showing LEDs (at right)

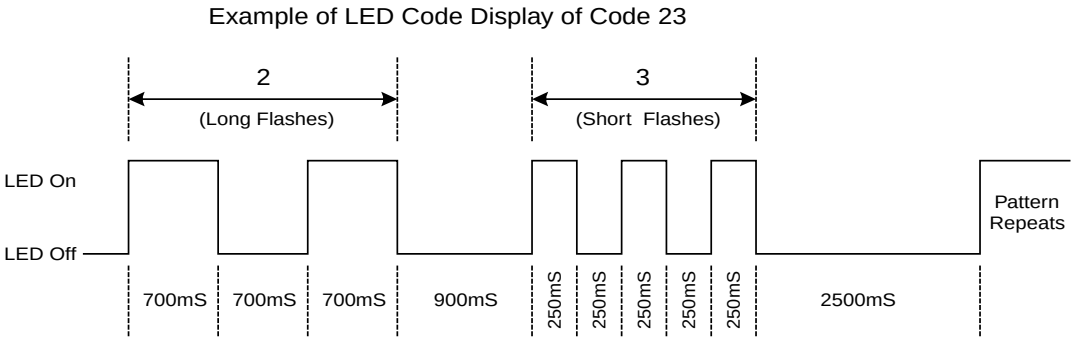


Figure 7-44 Pulse Sequence Example

LED	DESCRIPTION	NORMAL STATUS
Serial Data Output Error	This Green **LED** will be on in the case of a Taxi link error. [Monitors Diagnostic Fiber Optic Receive Port.]	On during Applications
Power	This Green **LED** should remain ON at all times, if proper +5VDC is applied to the Controller board.	On
Reset	This **LED** comes on when the board is reset and will turn Off after a successful reset.	Off
Heartbeat	This **LED** will Flash a Error code if the micro-Controller Unit (MCU) fails boot-up. All other **CAN LED**s will be turned ON. Refer to Boot-Up Error Code Table and Example of Pulse sequence display.	Flashing at 1 sec. interval
RCIB CAN Fault	Represents the current or "Real" state of the fault line. If ON, the Fault Line is asserted. **LED** color is Yellow.	Off
CAN Rx	This **LED** flashes during data receive on the **CAN** bus.	Off
CAN 7	This **LED** will flash a error code sequence if a fault is detected while the **DCB** is running applications. Refer to Application Fault Error Code Table and Example of Pulse sequence display.	Off
CAN 6	**LED** ON: **DCB** is connected to **OBC** **LED** OFF: **DCB** is not connected to **OBC**	On
CAN 5	**LED** ON: F/W thinks Fault line is asserted. Check **GCAN LED** for "Real" state of fault line. **LED** OFF: F/W thinks Fault line is Not asserted	Off
CAN 4	**LED** ON: F/W sends command to prep or monitor Fault Line. Check **GCAN LED** for "Real" state of fault line. **LED** OFF: Fault line NOT Set	On
CAN 3	**LED** ON: **DCB** in Shutdown **LED** OFF: Not in Shutdown	Off
CAN 2	**LED** ON: In collection of Scan Views **LED** OFF: Not in Scan View collection	Off
CAN 1	**LED** ON: In collection of Offsets **LED** OFF: Not in Offset collection	Off
CAN 0	**LED** ON: Trigger seen for View / Offsets **LED** OFF: No Triggers detected	Off

Table 7-19 DCB LED Descriptions

2.3.4.3 Detector Heater Control Board (DHCB)

Reference "Detector Heater Control Board (DHCB)," on page 487.

2.3.4.4 Backplane Connector Pinout

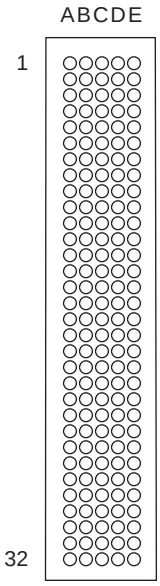


Figure 7-45 DCB backplane connector (viewed with DAS at 12 o'clock)

ROW	COLUMN E	COLUMN D	COLUMN C	COLUMN B	COLUMN A
1	+12VA	+12VA	AGND	-12VA	-12VA
2	+5VA	+5VA	-5VA	-5VA	-5VA
3	AGND	AGND	AGND	AGND	AGND
4	FET_BUS(1) UZ_FET(1)	FET_BUS(2) UZ_FET(2)	FET_BUS(3) UZ_FET(3)	FET_BUS(7) UZ_FET(4)	FET_BUS(8) UZ_FET(5)
5	FET_BUS(4) UZ_FET(6)	FET_BUS(5) D_FET(1)	FET_BUS(6) D_FET(2)	FET_BUS(9) D_FET(3)	FET_BUS(10) D_FET(4)
6	AGND	AGND	AGND	FET_BUS(11) D_FET(5)	FET_BUS(12) D_FET(6)
7	FET_BUS(13) LZ_FET(1)	FET_BUS(14) LZ_FET(2)	FET_BUS(15) LZ_FET(3)	AGND	AGND
8	FET_BUS(16) LZ_FET(4)	FET_BUS(17) LZ_FET(5)	FET_BUS(18) LZ_FET(6)	AGND	TEST_V_BUS(1) TEST_V-
9	AGND	AGND	AGND	AGND	TEST_V_BUS(2) TEST_V+
10	GEN_DET_THERM(0) KV_MEA-	GEN_DET_THERM(2) MA_MEA-	GEN_DET_THERM(4) DETHTRT_1-	DHCB_DETECT(0) DHCB_DETECT_-	N/C
			(if DHCB present) N/C	(if no DHCB present) N/C	
11	GEN_DET_THERM(1) KV_MEA+	GEN_DET_THERM(3) MA_MEA+	GEN_DET_THERM(5) DETHTRT_1+ (if DHCB present) N/C	DHCB_DETECT(1) DHCB_DETECT_+ (if no DHCB present) N/C	DHCB_RS232(4) DHCB_RS232_LGND (if no DHCB present) N/C
12	AGND	AGND	AGND	AGND	AGND
13	LGND	LGND	LGND	LGND	LGND
14	VCC	VCC	VCC	VCC	VCC
15	LGND	LGND	LGND	VCC	VCC
16	CVTR_CAN(1) CVTR_CAN_BUS+	CVTR_CAN(2) CVTR_CAN_BUS-	LGND	M68332_RS232(1) RS232_TXD	M68332_RS232(2) RS232_RXD

Table 7-20 DCB Backplane Connector Pinout

ROW	COLUMN E	COLUMN D	COLUMN C	COLUMN B	COLUMN A
17	LGND	LGND	ISO_GND	+12V_CAN	+12V_CAN
18	M68332_HOST(0) RCIB_CAN_BUS+	M68332_HOST(2) RCIB_FLT_BUS+	M68332_HOST(6) RCIB_CAN_RST+	M68332_HOST(8) EXP_CMD+	M68332_HOST(10) E_TRIG+
19	M68332_HOST(1) RCIB_CAN_BUS-	M68332_HOST(3) RCIB_FLT_BUS-	M68332_HOST(7) RCIB_CAN_RST-	M68332_HOST(9) EXP_CMD-	M68332_HOST(11) E_TRIG-
20	M68332_HOST(4) RCIB_CAN_PSOK_OUT	M68332_HOST(5) RCIB_CAN_PSOK_IN	ISO_GND	LGND	LGND
21	ISO_GND	ISO_GND	DHTR_ON(1) DTHTR_RLY_ (if DHCB present) N/C	DHCB_RS232(1) DHCB_RS232_TXD (if no DHCB present) N/C	DHCB_RS232(2) DHCB_RS232_RXD (if no DHCB present) N/C
22	LGND	LGND	DHTR_ON(2) DTHTR_RTN_1 (if DHCB present) N/C	DHCB_RS232(3) DHCB_RS232_TXD_RTN (if no DHCB present) N/C	N/C
23	CVTR_VCC	CVTR_CTRL (1) CVTR_SHCK+	CVTR_CTRL (3) CVTR_S_TRIG+	CVTR_CTRL (5) CVTR_RST	CVTR_CTRL (7) CVTR_X_PRG_n
24	LGND	CVTR_CTRL (2) CVTR_SHCK-	CVTR_CTRL (4) CVTR_S_TRIG-	CVTR_CTRL (6) CVTR_FLT_RAW_n	CVTR_CTRL (8) CVTR_WR_PRTCT
25	CVTR_ROWS (1) RDT_SS1_EV+	LGND	LGND	LGND	LGND
26	CVTR_ROWS (2) RDT_SS1_EV-	CVTR_ROWS (9) RDT_SS3_EV+	CVTR_ROWS (15) RDT_SS4_OD+	CVTR_ROWS (21) RDT_SS6_EV+	CVTR_ROWS (27) RDT_SS7_OD+
27	CVTR_ROWS (3) RDT_SS1_OD+	CVTR_ROWS (10) RDT_SS3_EV-	CVTR_ROWS (16) RST_SS4_OD-	CVTR_ROWS (22) RDT_SS6_EV-	CVTR_ROWS (28) RDT_SS7_OD-
28	CVTR_ROWS (4) RDT_SS1_OD-	CVTR_ROWS (11) RDT_SS3_OD+	CVTR_ROWS (17) RDT_SS5_EV+	CVTR_ROWS (23) RDT_SS6_OD+	CVTR_ROWS (29) RDT_SS8_EV+
29	CVTR_ROWS (5) RDT_SS2_EV+	CVTR_ROWS (12) RDT_SS3_OD-	CVTR_ROWS (18) RDT_SS5_EV-	CVTR_ROWS (24) RDT_SS6_OD-	CVTR_ROWS (30) RDT_SS8_EV-
30	CVTR_ROWS (6) RDT_SS2_EV-	CVTR_ROWS (13) RDT_SS4_EV+	CVTR_ROWS (19) RDT_SS5_OD+	CVTR_ROWS (25) RDT_SS7_EV+	CVTR_ROWS (31) RDT_SS8_OD+
31	CVTR_ROWS (7) RDT_SS2_OD+	CVTR_ROWS (14) RDT_SS4_EV-	CVTR_ROWS (20) RST_SS5_OD-	CVTR_ROWS (26) RDT_SS7_EV-	CVTR_ROWS (32) RDT_SS8_OD-
32	CVTR_ROWS (8) RST_SS2_OD-	LGND	LGND	LGND	LGND

Table 7-20 DCB Backplane Connector Pinout (Continued)

2.4 DAS Power Supply Adjustments

Refer to "DAS Power Supplies (2225212-2 ±5 vdc, 2225217 (2) 12 vdc)," on page 579.

2.5 MDAS - Flex Housing and Clamping

When installing Detector Flexes to the **MDAS** backplane, it is very important to exercise all **ESD** precautions. Use of a ground wrist strap and finger cots is required, when handling the Detector Flexes.

Remove the Detector **ESD** Boots from 4 Detector flexes at a time.

Clean with alcohol pads to remove any dirt, debris or oils from electrical contacts.

Note: Alcohol prep pads and "lint free" pads can leave fibers on the cleaned surfaces. Inspect thoroughly to remove any fibers that may have been deposited.

Install 4 flexes on the Housing and install the housing cover.

While holding the housing cover in place, install 2 clamp plates and torque the clamp plates to 13 in-lbs (1.47 N-m). This is an extremely critical torque spec. Too little, the electrical connection will not be good and produce intermittent opens, noise, or popping. Too much and you risk breaking the screw.

There have been tolerance stack-up measurements to determine the appropriate amount of compression to the elastomer to provide a reliable connection.

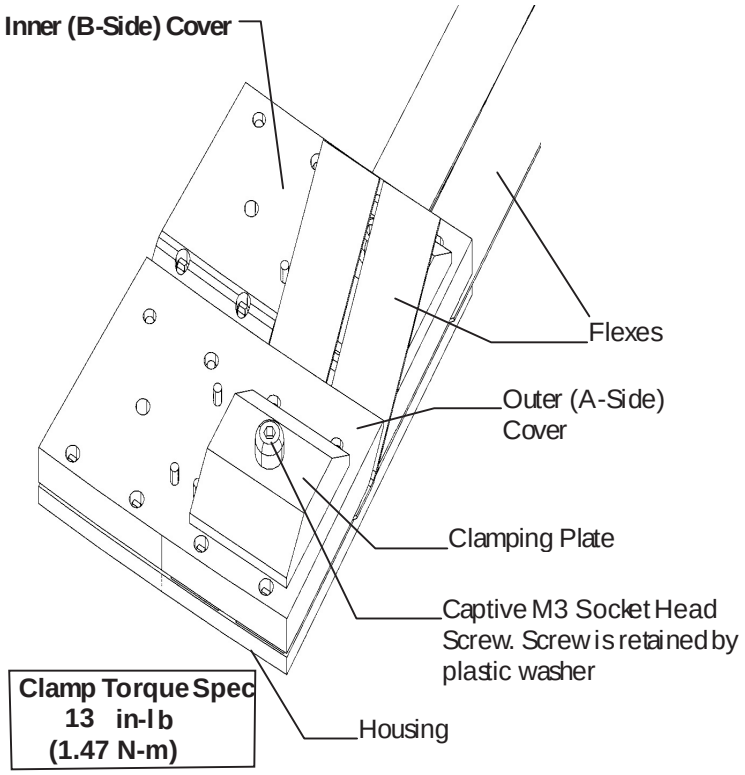


Figure 7-46 Flex Housing and Clamping

2.5.1 MDAS General Cleaning

OBJECTIVE OF PROCEDURE

The **DAS** air plenum and filters have accumulated dust. This can restrict airflow leading to converter card over-temp errors and/or dust/dirt contamination of the chassis interior components.

PROCEDURE DETAILS

1.) Accumulate Cleaning Materials.

NOTICE **Failure to use the ESD nozzle and proper ESD grounding will generate a static charge of DAS components up to 12,000 volts.**

- Compressed Air: Air must be manufactured for cleaning electronic devices and does not contain any class I or II cleaning chemicals. Propellant is 2-Tetrafluoroethane. Use of a **ESD** nozzle is required.
- Vacuum: It is suggested to use the following vacuum:
  * **ESD** Type Vacuum Cleaner (120VAC)
  * **ESD** Type Vacuum Cleaner (220/240VAC)
- Filters and accessories:
  * Vacuum Cleaner: Anti-Static Dusting Brush
  * **ESD** Type Vacuum Cleaner Filter, (10 per box)
- **ESD** Materials (Wrist strap, mat, etc.)
- **ESD** Board bags (Optional, obtain locally)
- High Output Ionizing Fan (Optional. Refer to Appendix F - ESD Management and Device Handling for instructions on use.)

2.) Take a DC Noise baseline scan using DASTools Manual test.
- This is to establish the **DAS'** current noise characteristics. Do not troubleshoot any noise failures until after the cleaning. The cleaning may “fix” some noise issues.
- Since this procedure requires the removal and handling of the Converter boards, it may induce problems. The baseline scans will be repeated after cleaning to verify **DAS** performance, however it may be important to know if the cleaning caused problems or if the **DAS** had characteristics spikes, humps before the cleaning. This information will help determine if troubleshooting or further **DAS** integration is necessary.

3.) Turn Off **DAS** Power Supplies

4.) Remove the Air Plenum (Fan Cover)

5.) Remove front chassis cover to gain access to boards.

6.) Clean one chassis at a time. Manually rotate the Gantry so that the **DAS** is at the 90 degree position. Clean the Right Chassis (or top chassis) first.

7.) Remove all the circuit cards from the chassis in sequence.
- Each board should be placed in an **ESD** bag or on an **ESD** mat.
- The order of the boards must be noted so that when the boards are re-installed, they are in the same location as original. This way, only FastCal will need to be performed. If the boards are not in the same location, Full Air and Phantom Calibrations will be required, including **DAS** Gain and collimator Cals.
- Cleaning the Chassis:

NOTICE **When using compressed air, do not invert the can as this will cause liquid to come out. Testing has shown that this can cause a large static charge to develop where the spray hits.**

  * Using the compressed air, blow air from the inner diameter of the chassis. At the

same time, use the vacuum on the outside of the chassis to "catch" the dirt/dust. This will also help avoid the dirt/dust from blowing around.

  * Blow air around the connectors, corners of chassis, and chassis holes. Visually inspect, and manually remove any debris that is not blown out.

- Cleaning the Converter Boards:
  * Make sure you are fully grounded using your **ESD** strap.
  * Hold one board at time, and blow compressed air across the board, removing the dirt/dust that may have accumulated between component pins, etc.

    It is highly recommended that an **ESD** nozzle be used, as it will prevent **ESD** damage to circuit board components.
  * After the board is cleaned, use the ionizing fan to remove any built up charges on the board; then re-install the board in its original location. Failure to do this may cause phantom calibrations to be re-done.
  * Repeat steps until all chassis and boards are cleaned and installed.
  * Turn the **DAS** on and let it warm-up. It takes 2 minutes of warm-up time for every minute the **DAS** was turned off, up to 1 hour. The **DAS** can be warming up while the Air Plenum is being cleaned.
- Cleaning the Air Plenum.
  * Blow or vacuum off the dirt/dust from the inside of the Air Plenum, as well as from the cooling fan blades and fan guards. Remove each air filter and thoroughly vacuum to remove the accumulated dust. If you use water to rinse the filters after vacuuming, make sure the filters are completely dry before re-inserting them into the air plenum.
  * Hint: Some Field Engineers have a set of spare filters on site.
  * Re-install the Air Plenum.
- Verify all covers are installed, and complete the following tests within DASTools:
  * 1 iteration of DC Means / Noise
  * 1 iteration of microphonics / pop

  All tests must pass. If not, troubleshoot and correct the failures.
- 3.7.7 Complete a FastCal and verify Image Quality by scanning the 48cm phantom using the Service Protocol: "Image Series 48cm" and image specifications.

Scan Type	Phantom	Kv	mA	SFOV	Thickness	Scan Time	Start/End Locations	# of Scans
Axial	48 cm	120	340	Large	5 mm (4i)	1.0 Sec.	I7.5/S7.5	4

Table 7-21 Service Protocol

Exam/Series/ image	AvXc	AvXo	AvXo - AvXc	Avg. Std. Dev.	Comments
1, 5, 9, 13					
2, 6, 10, 14					
3, 7, 11, 15					
4, 6, 12, 16					
Specs	---	---	±8.5	<40.0	

Table 7-22 Image Series Data

Box Size:45 x 45 pixels

Center Coordinates: 256, 256

Outside Coordinates: 256, 60452, 256256, 45260, 256

2.5.2 MDAS Converter Card Cleaning and De-Ionizing Procedure

OBJECTIVE OF THE PROCEDURE

The following procedure should be followed when **DAS** Converter boards and/or chassis need cleaning, or Converter boards are replaced for microphonics or noise resulting in image artifacts (rings, bands, streaks and smudges).

TOOLS REQUIRED

1.) Static Wrist Strap and cord
2.) Lint free Towels.
3.) Amax Contact, and Circuit Cleaner
4.) **DAS**/DET Interface Kit
Contains rubber gloves, static nozzle for use with compressed air, and static bags needed by this procedure.
5.) Aero Duster
6.) Screwdriver (flat) size # 6
7.) High Output Ionizing Fan (Refer to Appendix F - ESD Management and Device Handling for instructions on use.)

WARNING **ROTATING GANTRY CAN CAUSE SEVERE INJURY OR DEATH. MAKE SURE GANTRY IS PROPERLY DE-ENERGIZED AND LOCKED WHILE PERFORMING THIS SERVICE. FOLLOW THE GANTRY SAFETY INSTRUCTIONS IN CHAPTER 1 OF THE SYSTEM SERVICE MANUAL.**

CAUTION **Store Amax Cleaner at Site with MSDS document. Do not store in the company car. Use spray as directed in this procedure. Safety glasses and finger cots must be worn when using the spray.**

EYE PROTECTION

NOTICE **Do not clean the elastomers with AMAX spray. The elastomers absorb liquid. The manufacturer does not recommend trying to clean elastomers.**

NOTICE **Mishandling can easily damage converter cards. Handle only on the sides and only with proper ESD protection. Do not touch the connector, any board components, or circuit traces. Fingerprints are resistive circuit elements at low detector signal levels. Cards should always be placed in a Static Bag when not in the DAS.**

NOTICE **When using compressed air, do not invert the can as this will cause liquid to come out. testing has shown that this can cause a large static charge to develop where the spray hits.**

NOTICE **Failure to use the ESD nozzle and proper ESD grounding will generate a static charge of DAS components up to 12,000 volts.**

PROCEDURE

Take DC Noise baseline scan using DASTools Manual test (use default settings) to establish the current noise characteristics of **DAS**. Do not troubleshoot any noise failures until after the cleaning.

1.) Use Scan Analysis and plot the means and standard deviations for all rows to find channels that violate the noise specification. Refer to Chapter 11 - Image Quality for the acceptable noise values The Channel Map tool can be used to determine which channel(s) is (are) noisy and the card location.

2.) Lock out system power (See System Service Manual, Chapter 1).

3.) Open Gantry and shut off 550V, axial drive, and **DAS** power.

4.) All protective **ESD** materials should be in place (i.e. wrist straps and grounded mats for laying out converter cards; ionizing fan set up at far end of the patient table).

5.) Rotate and lock the gantry so that the **DAS** Chassis that you are working with is vertical, so that run off from the Spray cleaner does not get into the elastomer housings. See Figure 7-47.

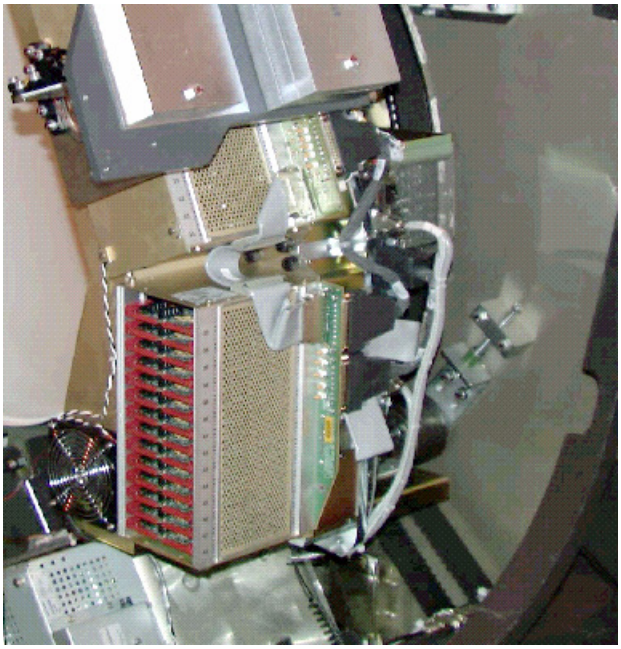


Figure 7-47 Proper Positioning of DAS Chassis for Cleaning

6.) Use the #6 screwdriver to remove the cover of the **DAS** chassis that has the suspected bad card(s).

7.) Remove the suspected noisy Converter card(s) and place it (them) in static free bags. Also remove the neighboring cards to the “bad” card and place them in static free bags. Mark down the slot positions of all removed cards so they can be put back in the same slots after cleaning.

8.) At this point, examine the **DAS** for dust. If there is dust in the **DAS**, perform the inspection and cleaning procedure as prescribed in the “MDAS General Cleaning,” on page 523. If there are still noisy channels after completing the **DAS** Cleaning procedure, repeat this cleaning procedure starting from step 1. If there was not any dust inside the **DAS**, continue with this procedure.

9.) Install the static free nozzle on the Aero Duster can and spray off the backplane connector from which the cards were removed. Use the static free nozzle every time the compressed air is used in this procedure.

10.) Position “lint free” towels between the chassis and the flex housings. This will prevent any excess cleaner from entering any parts not needing cleaning. See Figure 7-48.

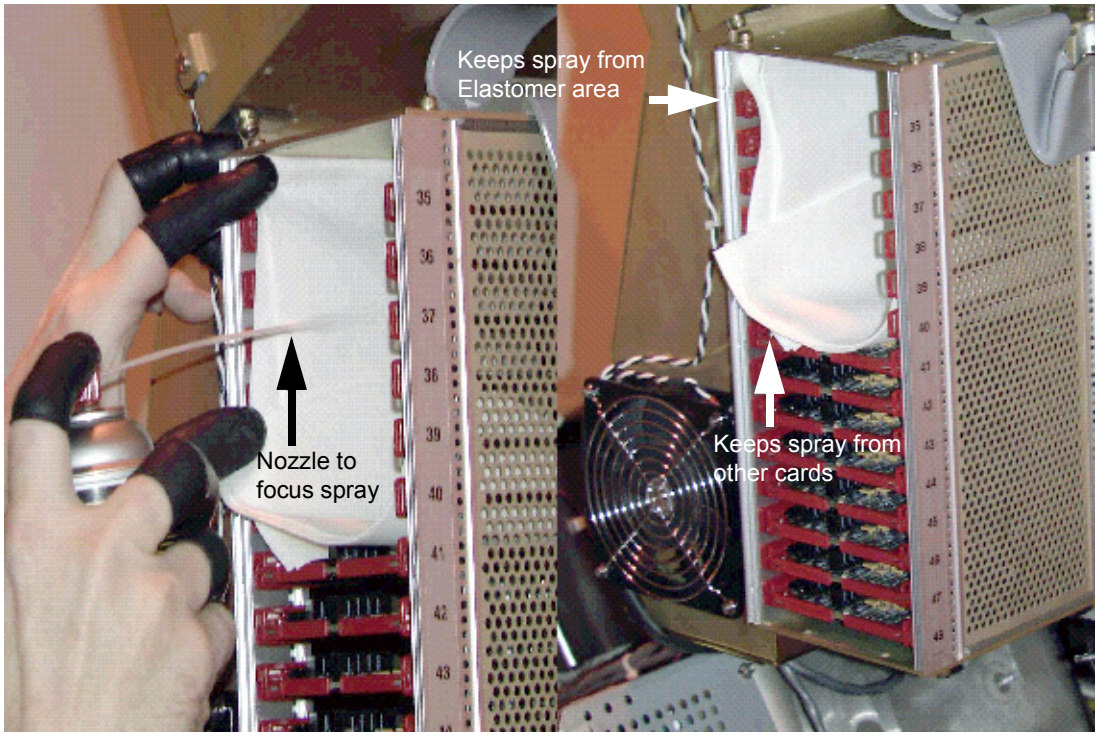


Figure 7-48 Proper placement of "lint-free" towels

11.) Use the Amax Contact Cleaner spray with the plastic tube to focus the spray to clean the backplane connectors of the suspected “bad” card location. Apply only enough to wet the entire backplane connector(s). Amax Contact Cleaner dries extremely fast. Do not spray directly on the detector or elastomers.

12.) Let the backplane dry for 2 minutes. Do not spray air in the chassis to dry the cleaner.

13.) Remove the Converter cards (see Figure 7-49) one at a time from their static bags and spray the connector (see Figure 7-50) with it facing down. Spray the outside of the connector shroud on all sides and also spray inside the pin housing. (Give it a good soaking). Allow the card to air dry. Do not use the compressed air to dry it.

14.) To clean the card components, hold the card sideways (see Figure 7-49) and spray from top to bottom. Direct spray away from edge connector. Allow card to air dry. Do not use compressed to dry it.

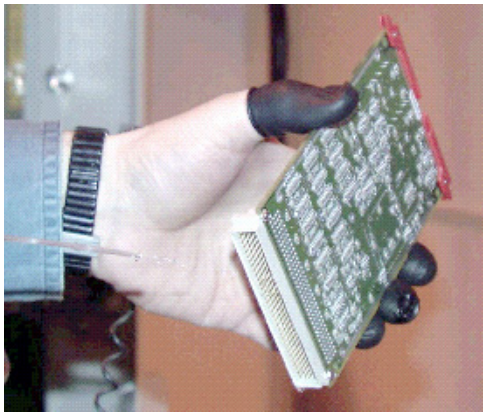


Figure 7-49 Proper method for handling converter cards

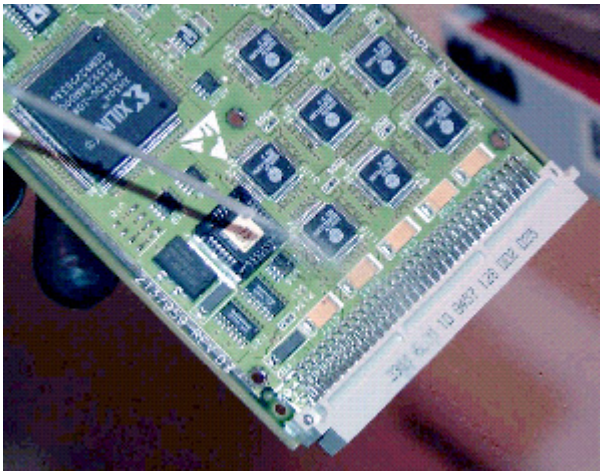


Figure 7-50 Spraying "off" the connectors

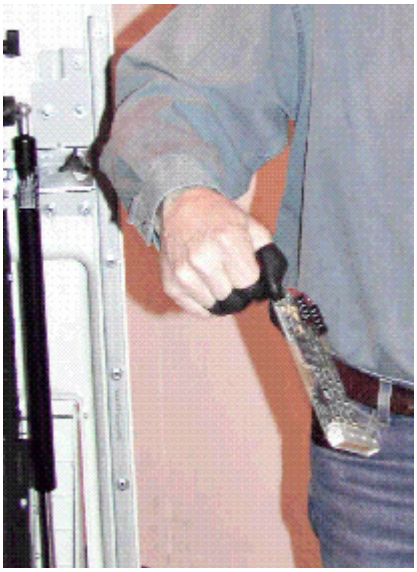


Figure 7-51 Allow the cleaner to run off the converter card completely

15.) Use the ionizing fan on the empty chassis and on clean coverter cards before re-insertion into the chassis.

16.) Reinstall cards in the same slots from which they were taken.

Turn the **DAS** ON and let it warm up. It takes two (2) minutes of warm-up time for every minute the **DAS** was turned OFF, up to one (1) hour.

Verify all covers are installed, turn on **DAS** power and complete the following tests within DASTools.

- 1 iteration of DC Means/Noise
- 1 iteration of microphonics/pop

All tests must pass. If not, troubleshoot and correct the failures.

Section 3.0
Replacement Procedures

3.1 Detector Memory Board (DMB)

3.1.1 Required Tools

- Flat-blade screwdriver
- Phillips # 1 screwdriver
- 2 mm, 3 mm. hex key
- 3/16 inch nut-driver (AMP HD Connector Tool or Xcelite nut-driver)
- **ESD** Wrist Band

3.1.2 Procedure Details

1.) Remove right side cover.
2.) Turn off all 3 switches (Axial Drive, **HVDC**, 120VAC) on the **STC** backplane.
3.) Disconnect cable connection from **DMB** assembly.
4.) Loosen thumbscrews with the flat-blade screwdriver and remove assembly from mounting bracket.

NOTICE **Assembly is permanently attached to the detector. Do not pull on the cord. You will damage the detector, resulting in complete detector replacement.**

5.) Remove the HD Connector Screw locks with the 3/16” nut-driver.
6.) Remove two (2) 2.5 mm hex screws from the under side of the assembly.
7.) Remove the two (2) Phillips screws holding the module to the base.
8.) Install new module in reverse order.

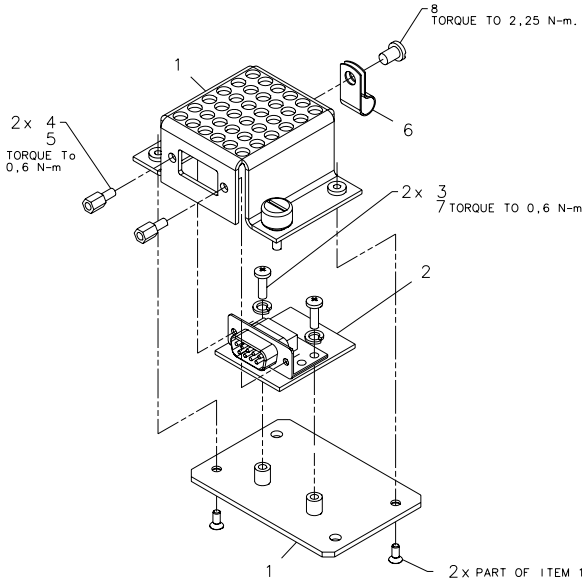


Figure 7-52 Detector Memory Board Replacement

3.2 Detector Replacement

Refer to Direction 2335850-100, "LightSpeed Family Detector Change Procedure" – shipped with the replacement detector – for detailed detector replacement procedures.

3.3 MDAS

3.3.1 Accessing the MDAS Assembly

DANGER **POTENTIAL FOR ELECTROCUTION OR SHOCK. HAZARDOUS VOLTAGES ARE PRESENT IN THE GANTRY, EVEN WITH ALL STC SERVICE SWITCHES "OFF". SERVICING OF THE MDAS SHOULD BE PERFORMED BY QUALIFIED PERSONNEL ONLY.**

1.) Remove gantry right side cover, and turn OFF all three (3) service switches on the **STC** backplane (see removal procedure, on page 613).

2.) Continue to open the gantry, by removing the following:
- Mylar scan window (page 628)
- Left side cover (page 613)
- Top covers (page 616)
- Front cover (page 616)

3.) Rotate gantry so that the **DAS** assembly is at the 12:00 position.

WARNING **POTENTIAL FOR PERSONAL INJURY. USE THE ROTATIONAL LOCK TO PREVENT UNCOMMANDED MOVEMENT OF THE GANTRY.**

4.) Lock the gantry in position, using the rotational lock (see "Rotational Locking Pin," on page 42).

5.) Put on wrist strap and use **ESD** precautions.
Jack locations for grounding the wrist strap are near the left and right chassis mounting screws.

3.3.2 Converter Board(s)

3.3.2.1 Board Removal

NOTICE **Follow ALL Electro-Static Discharge procedures. Always use ESD Wrist Strap and grounding cords. The use of a ground Monitor is suggested.**

1.) Move the table cradle to the home position, and lower the table to its lowest elevation.

2.) Remove gantry covers, shut OFF power, and lock the gantry in position, per "Accessing the MDAS Assembly," above.

3.) Put on wrist strap and use **ESD** precautions.

4.) Remove appropriate chassis cover.
- When working in the Right chassis, the fiber-optic cable must first be removed from the Transmit ("TX") port (see Figure 7-53).
- Left and Right chassis have 6 captive screws.
- Center chassis has 8 captive screws.

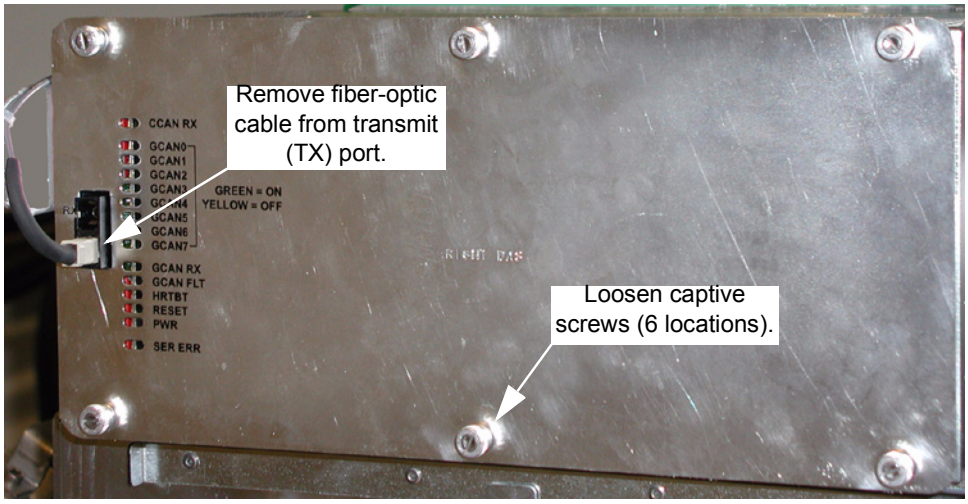


Figure 7-53 Right DAS Chassis

5.) Slide Converter board out of chassis.

a.) Lift both red ejection tabs and the board will disengage from backplane connection.

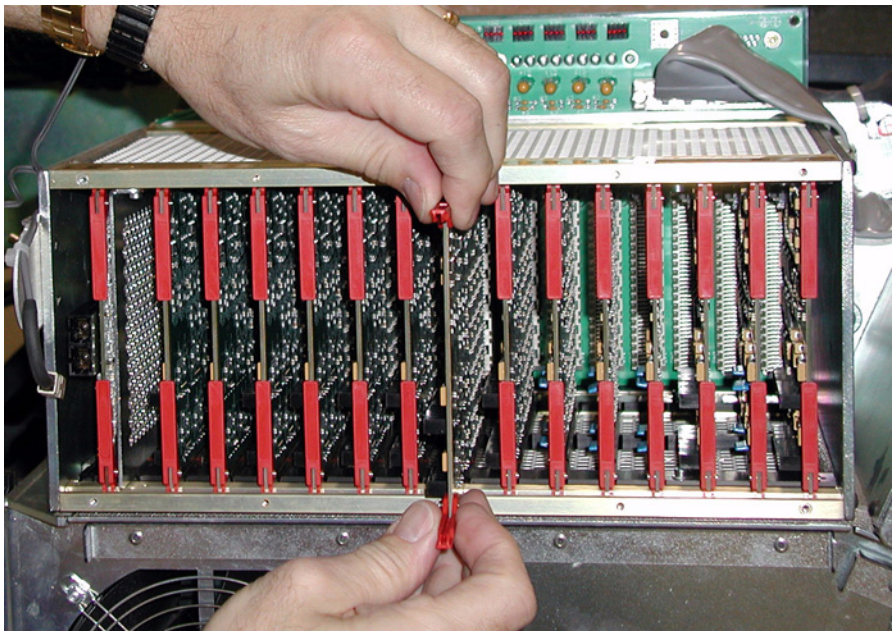


Figure 7-54 Use ejector tabs to remove converter cards from chassis

b.) Continue sliding board straight out and place into anti-static bag.

3.3.2.2 Board Installation

NOTICE **Follow ALL Electro-Static Discharge procedures. Always use ESD Wrist Strap and grounding cords. The use of a ground Monitor is suggested.**

1.) Remove New Converter Board from anti-static bag.

2.) Align Converter board edges to card guides in Chassis.

3.) Slide the board into the chassis until Red ejector tabs align with the card guides.

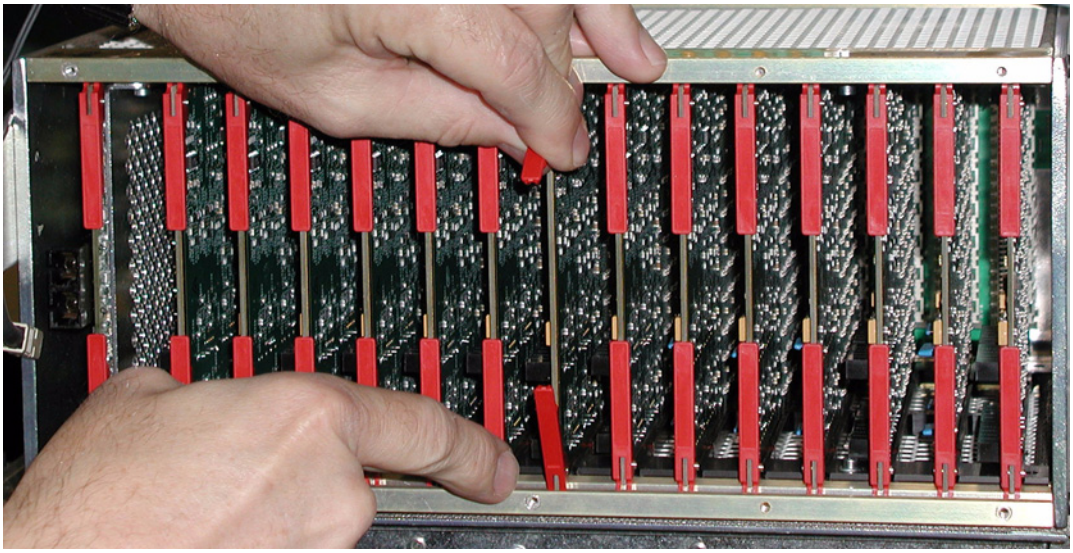


Figure 7-55 Position card so that ejector tabs fit into channel

4.) Fold the Red tabs over to push board into place. Press in on tabs to fully seat card into the backplane connector—the card should move inward an additional millimeter (approximately).

NOTICE
Card must be fully seated.

Failure to fully seat a converter card into DAS backplane may result in the failure of all 128 channels in that converter card.

5.) Turn the Gantry 120V power ON, and verify no failures during power-up self-tests, via **DCB LED** status or System error log.

6.) Reinstall Converter board chassis cover by first engaging all screws, and then tightening.

If replacing cards in the right **DAS** chassis, reconnect the fiber-optic cable to the transmit (TX) port (see Figure 7-53, on page 531).

7.) If applications software is up, perform a **DAS** Reset from the Reset Menu.

8.) Depending on the fault, let the board warm-up five (5) minutes to verify it fixed the problem, but at least 1 hour before DASTools, FastCal, or Image Quality scans. A cold board may fail Offset Drift or Pop Noise until it is in normal operating temperature ranges.

9.) Turn on Axial and 550VDC switches (on **STC** backplane).

10.) Disengage rotational lock.

11.) Verify proper functionality:

a.) Run at least 10 passes of Scan Data Path Diagnostic from Converter Boards.

b.) Run 1 pass of DASTools.

c.) Run FastCal, if less than 5 cards replaced.

d.) Run full FastCal and Phantom Cal, if more than 5 cards replaced or if I/Q fails due to replaced boards.

Note: Upon running FastCal the first time, Daily IQ check may fail, and can generally be ignored, provided the images look good. See "Daily IQ Check," on page 70.

e.) Take 10 I/Q scans of the 48cm phantom.

f.) Verify fault or reason to replace the board now passes.

12.) Reassemble gantry covers.

3.3.3 DAS Control Board (DCB)

3.3.3.1 Board Removal

NOTICE **Follow ALL Electro-Static Discharge procedures. Always use ESD Wrist Strap and grounding cords. The use of a ground Monitor is suggested**

1.) Remove gantry covers, shut OFF power, and lock the gantry in position, per "Accessing the MDAS Assembly," on page 530.

2.) Put on wrist strap and use **ESD** precautions.

3.) Remove the right **DAS** chassis cover (see Figure 7-53, on page 531):

   a.) Disconnect the fiber-optic cable from the Transmit (TX) port.

   b.) Loosen the six (6) captive screws that hold the cover in place.

4.) Eject the **DCB**, using the red ejector tabs (identical to converter card removal; see Figure 7-54, on page 531).

5.) Slide **DCB** out of chassis and place into anti-static bag.

3.3.3.2 Board Installation

NOTICE **Follow ALL Electro-Static Discharge procedures. Always use ESD Wrist Strap and grounding cords. The use of a ground Monitor is suggested.**

1.) Remove New **DAS** Control Board from anti-static bag.

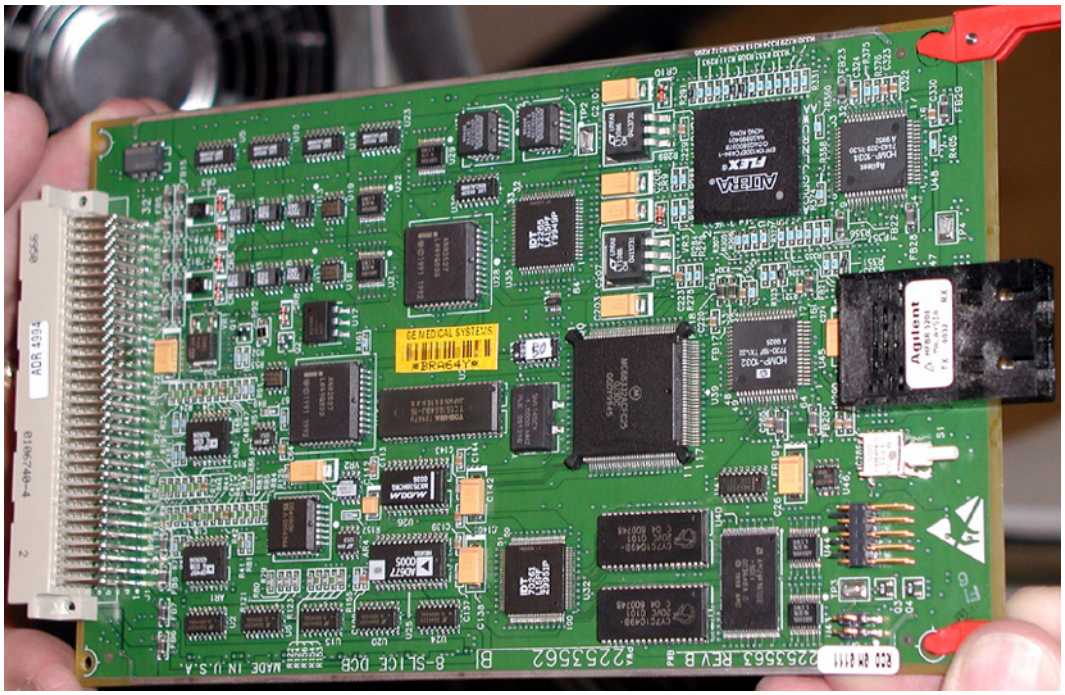


Figure 7-56 DAS Control Board

2.) Verify proper Jumper configuration:

   a.) JP1; No Jumpers for normal operation.

   b.) JP2; No Jumpers for normal operation.

3.) Insert new board into chassis:
   a.) Align **DCB** edges to card guides in Chassis.
   b.) Slide the board into the chassis until Red ejector tabs align with the card guides (see Figure 7-55, on page 532).
   c.) Fold the Red tabs over to push board into place.
4.) Turn the Gantry 120V power ON (**STC** backplane switch), and verify **DCB** Power **LED** is illuminated.
5.) Turn on the Axial and 550VDC switches, on the **STC** backplane.
6.) Disengage rotational lock.
7.) If applications software is up, perform a **DAS** Reset from the Reset Menu.

Note: It may be necessary to FLASH the new **DCB**.

8.) Verify proper functionality:
   a.) Run at least10 passes of Scan Data Path Diagnostic.
   b.) Take 10 I/Q scans of the 48cm phantom.
   c.) Verify fault or reason to replace the board now passes.
9.) Reassemble gantry covers.

3.3.4 DAS Air Plenum Removal & Installation

3.3.4.1 Overview

The **DAS** Air Plenum must be removed in order to perform the following replacement procedures:

- "Elastomers," on page 535
- "DAS Backplane (Left, Center or Right)," on page 536
- "Cooling Fans," on page 545

3.3.4.2 Plenum Removal

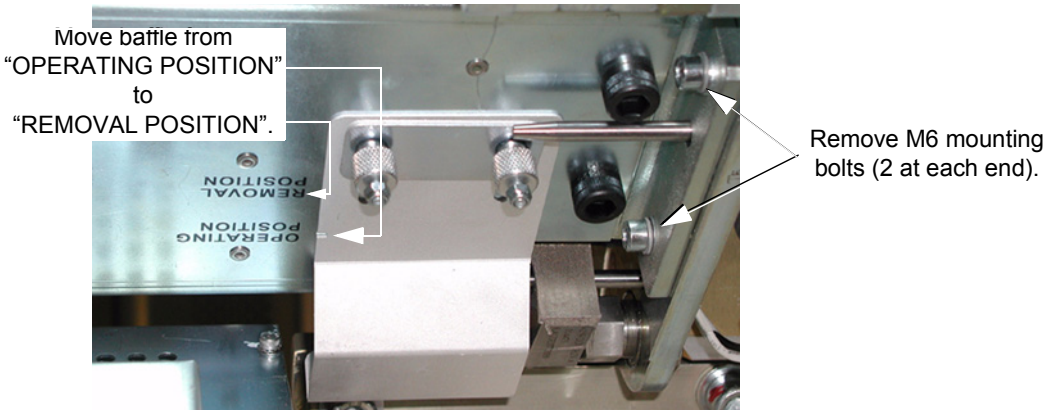


Figure 7-57 DAS Air Plenum: Baffle & Mounting Bolts

1.) Remove gantry covers, shut OFF power, and lock the gantry in position, per "Accessing the MDAS Assembly," on page 530.
2.) Disconnect Fan AC power at Connector J22.
3.) Set air baffles on either end of the duct to the "Removal Position" (see Figure 7-57):
   a.) Loosen knurl nuts
   b.) Slide baffle into position
   c.) Hand tighten knurl nuts

4.) Remove four (4) M6 mounting bolts (2 at each end). See Figure 7-57.
5.) Carefully slide the plenum towards the front, without catching wires or Detector flexes.
6.) Set the plenum aside, on a clean surface.
7.) Continue with replacement procedures.

3.3.4.3 Plenum Installation

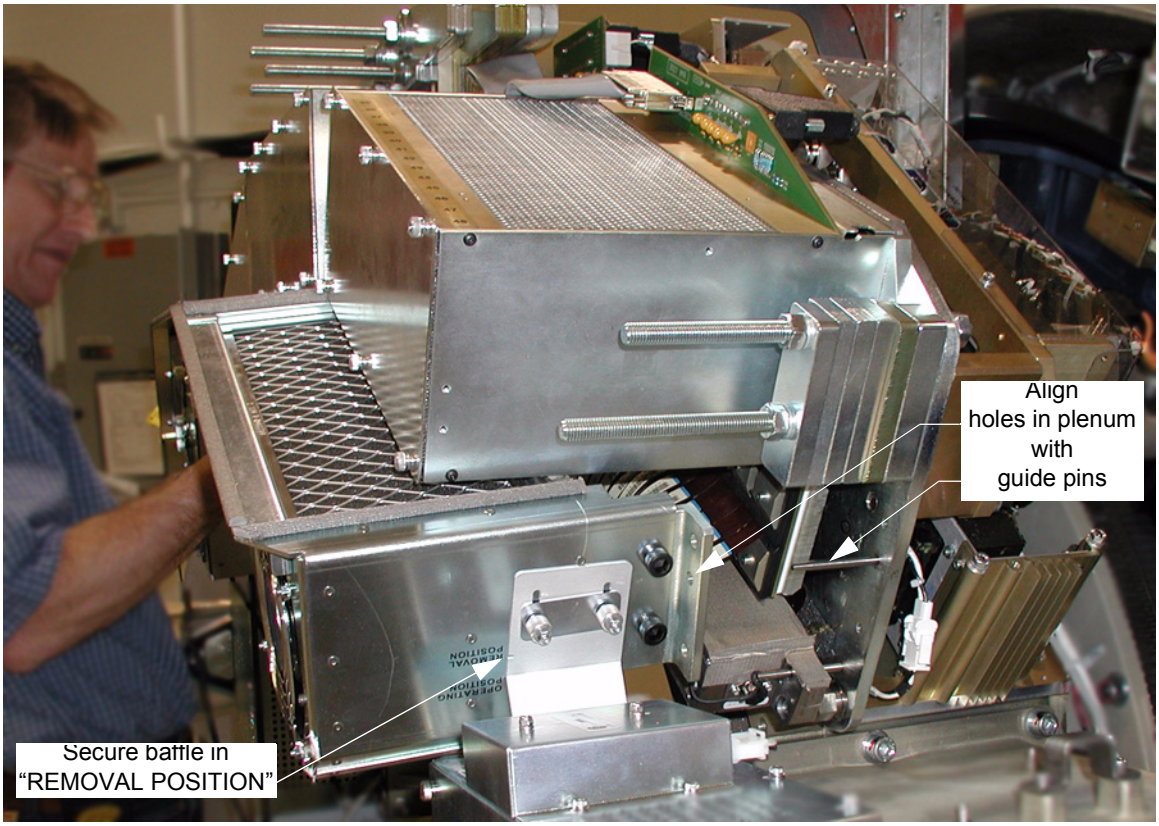


Figure 7-58 DAS Air Plenum Installation

1.) Ensure that baffles are secured in "REMOVAL POSITION".
2.) Lift plenum into place, and align guide holes with guide pins.
3.) Slide plenum onto guide pins.
4.) Fasten plenum securely into place, using the four (4) M6 mounting bolts and four lock washers. Torque to 7.9 N-m (69.9 in-lbs).
5.) Return baffles to the "OPERATING POSITION".
6.) Connect Fan AC power at Connector J22.

3.3.5 Elastomers

NOTICE **Ensure that you are properly grounded by using the appropriate ESD wrist strap and cord connected to a good ground point in the Gantry.**

1.) Remove gantry covers, shut OFF power, and lock the gantry in position, and remove the **DAS** air plenum, per "Accessing the MDAS Assembly," on page 530 and "DAS Air Plenum Removal & Installation," on page 534.
2.) Put on wrist strap and use good **ESD** precautions. Wear Finger Cots, and follow good Detector Handling practices.

3.) Remove appropriate Flex housing outer cover by removing the housing Cover clamps.
- A-side flexes must be removed to gain access to B-side flexes. To increase access space to the B-side, carefully bend the detached A-Side flex straight out towards the front of the gantry, so that it is perpendicular to the Detector window.
- Each cover holds four (4) flex cables in place.
- There are 2 clamps per cover. Each clamp is held by a 3mm captive hex cap screw. Use a 2.5mm Hex screwdriver bit to remove each clamp and cover.
- Keep A-side and B-Side covers separate, as they are not interchangeable.

NOTICE Elastomers may become dislodged.

Elastomers can potentially FALL OUT of housings, while flexes are being removed. Exercise caution.

4.) Place an anti-static Detector Flex Boot on each exposed flex.

5.) Carefully remove the questionable elastomer from its seating.

6.) Insert the new elastomer so that the gold contact lines face outward.

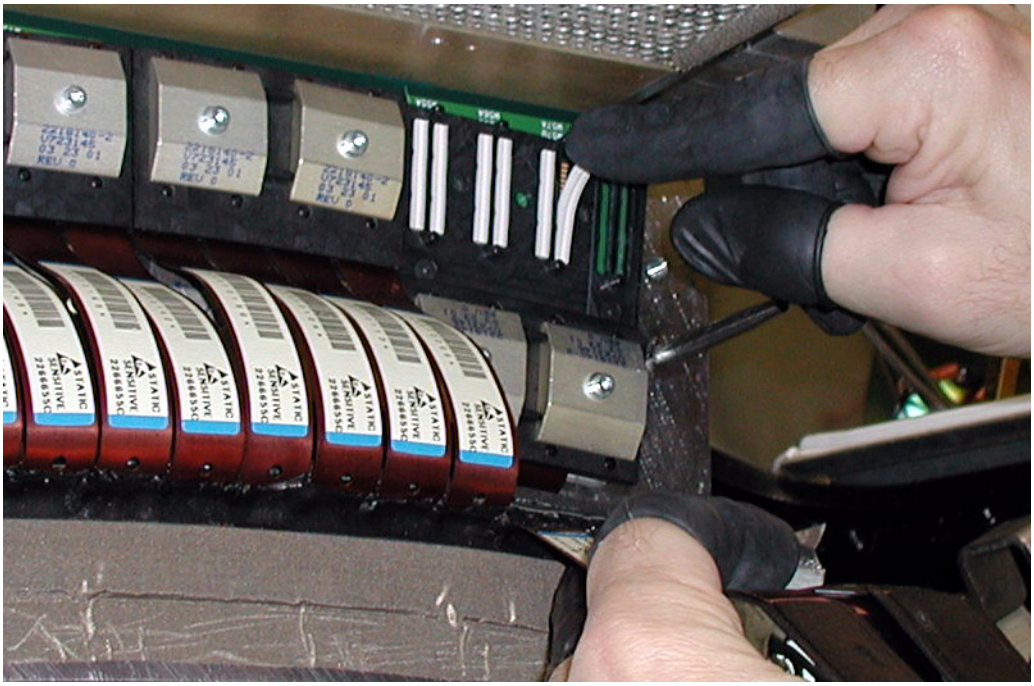


Figure 7-59 "A-Side" Elastomer Installation

7.) Remove anti-static boots from flexes, and ensure that flex ends are clean. Clean with approved Alcohol pads, where required.

8.) Replace flex covers (B-Side first), and torque clamps to 13 in-lb (1.47 N-m).

9.) When complete, replace plenum, per "Plenum Installation," on page 535.

10.) Remove rotational lock, restore power and reassemble gantry covers.

3.3.6 DAS Backplane (Left, Center or Right)

3.3.6.1 Chassis Removal (Left, Center or Right)

NOTICE **Ensure that you are properly grounded by using the appropriate ESD wrist strap and cord connected to a good ground point in the Gantry.**

1.) Remove gantry covers, shut OFF power, and lock the gantry in position, and remove the **DAS** air plenum, per "Accessing the MDAS Assembly," on page 530 and "DAS Air Plenum Removal & Installation," on page 534.

2.) Put on wrist strap and use good **ESD** precautions.

3.) Using Detector Handling precautions (verify use of **ESD** strap, grounding and Finger Cots), disconnect Detector flexes from the appropriate backplane.

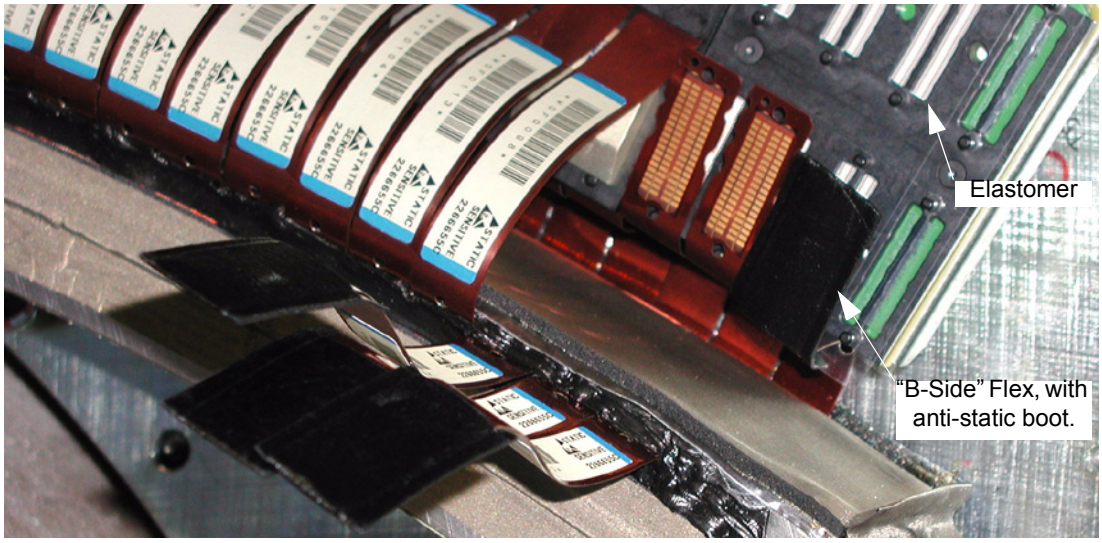


Figure 7-60 Flex cables, with anti-static boots

a.) Remove Flex housing outer (A-Side) covers by removing the housing Cover clamps.
   * Left chassis: covers 11 - 15
   * Center chassis: covers 6 - 10
   * Right chassis: covers 1 - 5

   There are 2 clamps per cover. Each clamp is held on by a 3mm captive hex cap screw. Use a 2.5mm Hex screwdriver bit to remove each clamp and cover.

b.) Carefully remove each flex from the backplane and bend each A-Side Flex straight out towards the front, so that it is perpendicular to the Detector window. This is to gain more access to the B-Side.

c.) Place an Anti-static Detector Flex Boot on each flex.

d.) Remove all Inner (B-Side) Clamps, covers, and flexes, using the same procedure as the A-Side. Place anti-static boots on flexes.

e.) Set the covers aside and keep them separated from the Inner (B-Side) covers. A-side covers are different from B-Side covers.

4.) Disconnect the appropriate power cables:
   - Left chassis: J19, Power cable between Center and Left Chassis
   - Center chassis:
     * J70, Power cable between Center and Right Chassis.
     * J71, Power cable between Center and Left Chassis.
     * J72, Power Cable between Center Chassis and Power Supplies
     * J73, Power Sense Cable
   - Right chassis: J24, power cable between center and right chassis

5.) Disconnect the appropriate data cables:
   - Left chassis: J18, Data cable between Center and Left Chassis

- Center chassis:
  * J8, Data cable between Center and Left Chassis.
  * J7, Data cable between Center and Right Chassis.
- Right chassis:
  * J15, data cable between center and right chassis
  * J16, data cable between right chassis and **DHCB**
  * J21, **CAN** cable between right chassis and collimator
  * J20, data cable between right chassis and **OBC**
  * TX port, fiber optic cable between right chassis and slip-ring

6.) Remove weights as necessary for removal of chassis.

NOTICE **Weights must be replaced in the exact sequence and positioning as from which they are removed. Gantry rotation will be adversely affected by improper balancing.**

7.) Remove four (4) large 10mm cap screws holding the chassis to the **DAS** mounting blocks, while holding on to the chassis. When the last cap screw is removed, remove the chassis from the Gantry and place on an **ESD** pad (to protect converter cards).

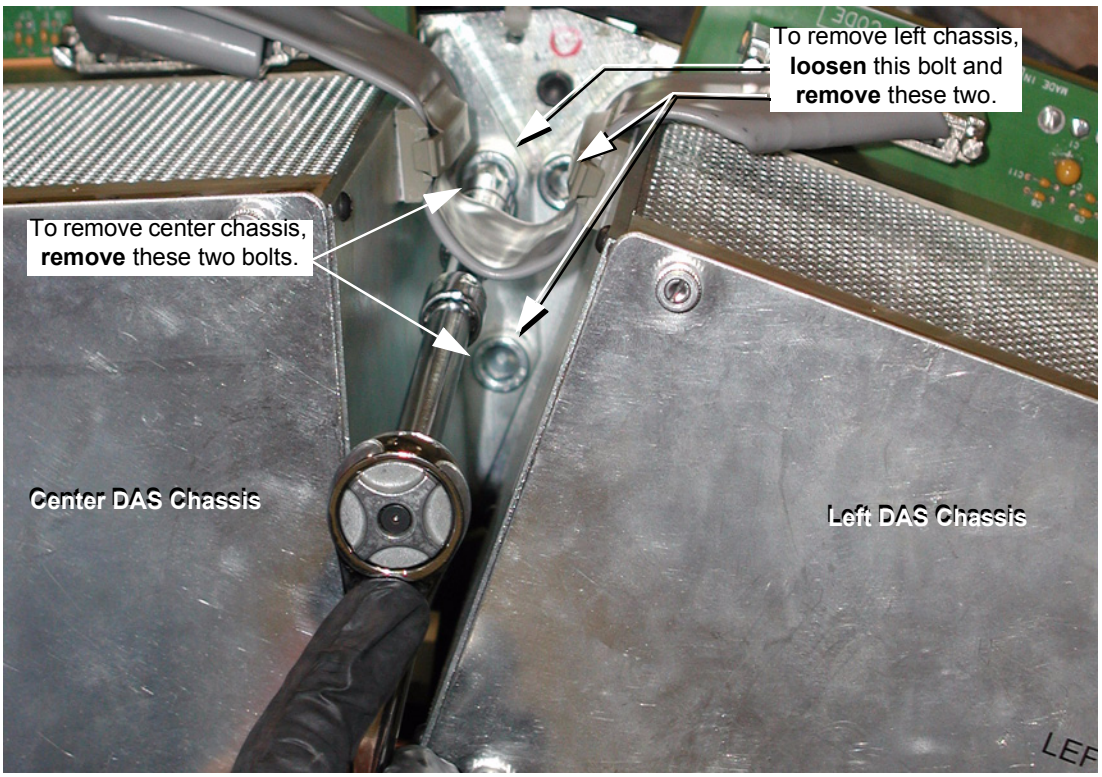


Figure 7-61 DAS Chassis mounting bolts, between left and center chassis

- The center chassis shares one bolt each with the left and right chassis.
- When removing the left or right chassis, the second bolt on the shared side of the center chassis must be **loosened** slightly.
- Be careful not to damage detector flexes.

3.3.6.2 Chassis Installation (Left, Center or Right)

NOTICE **Ensure that you are properly grounded by using the appropriate ESD wrist strap and cord connected to a good ground point in the Gantry.**

1.) Carefully place the **DAS** Chassis in position. Use special care:
   - Do not smash or otherwise damage Detector flexes
   - Keep Detector Flex Boots in place
   - Ensure that ALL Detector flexes are in front of backplane

2.) Secure by using four (4) large 12mm Cap screws, with Loctite 271 applied to each of the screw's threads. Torque each chassis mounting screw to 30 ft.-lbs (40.68 N-m).

   When replacing the left or right chassis, be sure to also tighten the center chassis bolt that was loosened for removal.

3.) Connect the appropriate power cables:
   - Left chassis: J19, Power cable between Center and Left Chassis
   - Center chassis:
     * J70, Power cable between Center and Right Chassis.
     * J71, Power cable between Center and Left Chassis.
     * J72, Power Cable between Center Chassis and Power Supplies
     * J73, Power Sense Cable
   - Right chassis: J24, power cable between center and right chassis

4.) Connect Data Cables
   - Left chassis: J18, Data cable between Center and Left Chassis
   - Center chassis:
     * J8, Data cable between Center and Left Chassis.
     * J7, Data cable between Center and Right Chassis.
   - Right chassis:
     * J15, data cable between center and right chassis
     * J16, data cable between right chassis and **DHCB**
     * J21, **CAN** cable between right chassis and collimator
     * J20, data cable between right chassis and **OBC**
     * TX port, fiber optic cable between right chassis and slip-ring

5.) If applicable, transfer the Converter boards from the replaced chassis to the new chassis.
   a.) Confirm **ESD** practices
   b.) Remove Chassis board cover
   c.) Remove 1 board at a time and transfer each board from the original chassis to the new chassis in the same board slot location.

6.) Install Detector flexes (B-Side)
   a.) Confirm **ESD** and Detector flex handling practices. Use **ESD** Wrist strap and Finger Cots.
   b.) Remove retainer that is covering housing and holding Elastomers in place.
   c.) Verify all Elastomers are in their slots in the housings and are free from debris (spray with air).
   d.) Remove Flex Boot and visually inspect each flex before installing for debris. Clean with approved Alcohol pads where required.
   e.) Install Inner row (B-Side) flexes first.
   f.) Install 4 flexes over appropriate housing slots and install cover and clamps to hold flexes in place. Torque each clamp cap screw to 13 in-lbs (1.47 N-m) no more, no less.

7.) B-Side Checkout
   a.) Keep Axial switch Off, but turn on Gantry 120VAC and 550VDC switches.
   b.) Do NOT Rotate Gantry because the A-Side Detector flexes are not connected.
   c.) Turn on **DAS** Power switch
   d.) Verify Converter board power-up diagnostics passed, via NO Board **LED**s remain on.
   e.) From the Operators console, perform a Hardware Reset
   f.) Perform **DAS** / Detector Integration to verify B-Side connections
   g.) When the B-Side is okay, install Outer row (A-Side) flexes.
8.) Install Detector flexes (A-Side)
   a.) Turn OFF the **DAS** Power Switch and 550VDC Switch
   b.) Remove Flex Boot and visually inspect each flex for debris before installing (spray with air). Clean with approved Alcohol pads where required.
   c.) Install 4 flexes over appropriate housing slots and install cover and clamps to hold flexes in place. Torque each clamp cap screw to 13 in-lbs (1.47 N-m) no more, no less.
   d.) Turn **DAS** and Gantry Power switches ON
   e.) Perform **DAS** / Detector Integration
9.) If applicable, install chassis board cover.
   If the right chassis was replaced, reattach the fiber-optic cable to the transmit (TX) port.
10.) Install plenum, per "Plenum Installation," on page 535.
11.) Return weights to their original sequence and position (if applicable).
12.) Disengage rotational lock.
13.) Restore power.
14.) See Retest Matrix for tests after replacing a **DAS** Chassis.
15.) Install / Close all covers.

3.3.6.3 Retest Matrix

1.) **DAS** Detector Integration
   a.) X-Ray Verification
   b.) Microphonics
   c.) Pop/Noise
2.) Air Cal
3.) Image Quality Checks
4.) Save State

3.3.7 DAS Power Supplies

There are several power supplies for the **MDAS**, including: -5VDC analog, +5VDC analog, 5VDC digital, -12VDC, +12VDC and 24VDC. To gain access to any of these, perform the following:

DANGER **POTENTIAL FOR ELECTROCUTION OR SHOCK. HAZARDOUS VOLTAGES ARE PRESENT IN THE GANTRY, EVEN WITH ALL STC SERVICE SWITCHES "OFF". SERVICING OF THE MDAS SHOULD BE PERFORMED BY QUALIFIED PERSONNEL ONLY.**

1.) Remove gantry right side cover, and turn OFF all three (3) service switches on the **STC** backplane (see removal procedure, on page 613).
2.) Remove the gantry left side cover (procedure is on page 613).
3.) Remove the gantry top covers (procedure is on page 616).
4.) Rotate gantry so that the **DAS** assembly is in a position where the power supply can be easily accessed. This could be anywhere between the 9 o'clock and 3 o'clock positions, depending on which power supply is to be replaced and the availability of a stepping stool (to work from the top of the gantry).

WARNING **POTENTIAL FOR PERSONAL INJURY. USE THE ROTATIONAL LOCK TO PREVENT UNCOMMANDED MOVEMENT OF THE GANTRY.**

5.) Lock the gantry in position, using the rotational lock (see "Rotational Locking Pin," on page 42).

3.3.7.1 -5VDC Power Supply

The -5 volt DC power supply is located behind the center **DAS** chassis, attached to the casting.

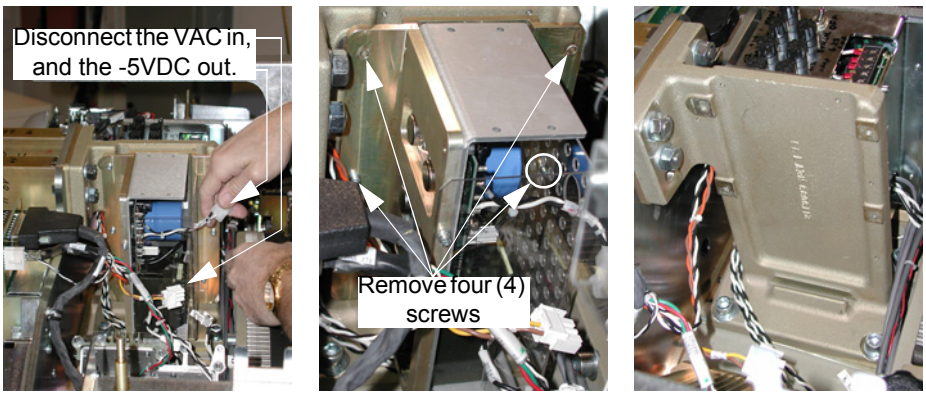


Figure 7-62 Remove the power supply from the Gantry

1.) Disconnect the supply power (2 pin, 120VAC) and supply output (3 pin, -5VDC) connectors.
2.) Remove the four (4) 4mm hex head screws that are used to mount the power supply to the cast metal bracket. Remove the power supply assembly from the gantry.

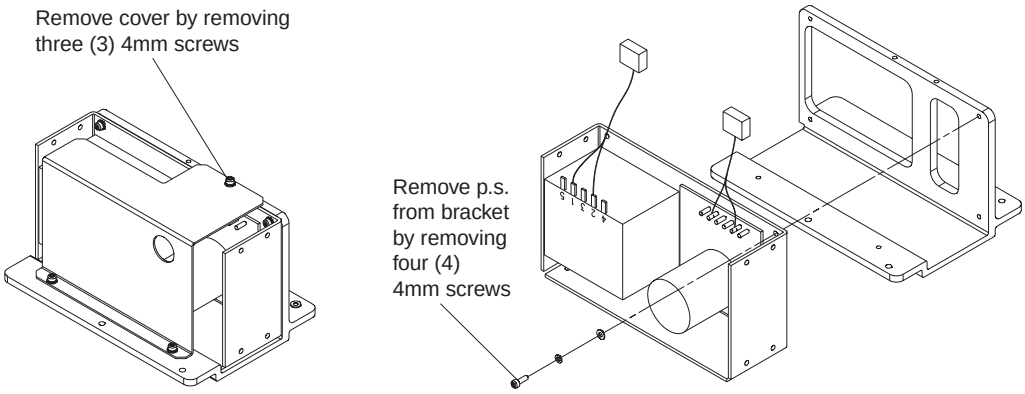


Figure 7-63 Remove the power supply from its mounting bracket

3.) Remove the power supply's clear plastic cover, by removing the three (3) 4mm hex screws. Retain the cover, screws, three (3) washers and three (3) lock washers.

4.) Remove the power supply from its mounting bracket, by removing the four (4) 4mm hex screws, four (4) washers and four (4) lock washers. Retain the hardware.

5.) Mount the new power supply on its bracket, using the 4mm hex screws, washers and lock washers. Torque the screws to 1.4 N-m (12.39 in-lbs).

6.) Reattach the clear plastic cover. Torque the 4mm hex screws to 0.7 N-m (6.2 in-lbs).

7.) Mount the power supply assembly on the gantry, using 4mm hex screws and loctite 271.

8.) Reconnect the supply output and supply power.

9.) Restore power to the gantry and verify power supply output voltage (see Table 7-16, on page 516). Adjust supply output, if necessary.

10.) Reassemble the gantry covers.

3.3.7.2 +5VDC Power Supply

The +5 volt DC analog power supply is located behind the right **DAS** chassis.

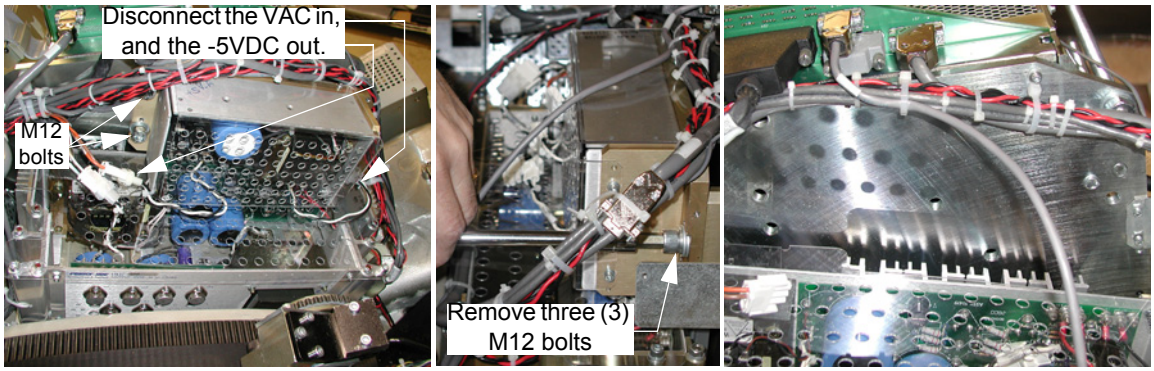


Figure 7-64 Remove the power supply from the Gantry

1.) Disconnect the supply power (2 pin, 120VAC) and supply output (3 pin, -5VDC) connectors.

2.) Remove the three (3) 12mm hex head bolts that secure the power supply to the gantry. [Two bolts are located at one end of the power supply assembly, and the third is at the other end.] Lift the power supply assembly out of the gantry.

3.) Remove the plastic cover by removing four (4) each: 4mm hex screws, washers and lock washers.

4.) Remove the power supply from the bracket by removing the six (6) 4mm hex screws, six (6) washers and six (6) lock washers.

5.) Attach the new power supply to the bracket, using 4mm hex screws, washers and lock

washers. Torque the screws to 1.5 N-m (13.28 in-lbs).

6.) Attach the plastic cover to the assembly, using 4mm screws, washers and lock washers. Torque the screws to 0.7 N-m (6.2 in-lbs).

7.) Reattach the completed power supply assembly to the gantry, using the three bolts and lock washers. Torque the bolts to 66 N-m (48.68 ft-lbs).

8.) Reconnect the supply output and supply power.

9.) Restore power to the gantry and verify power supply output voltage (see Table 7-16, on page 516). Adjust supply output, if necessary.

10.) Reassemble the gantry covers.

3.3.7.3 -12VDC Power Supply

The -12 VDC power supply is located behind the left **DAS** chassis, along with the +5VDC logic power supply.

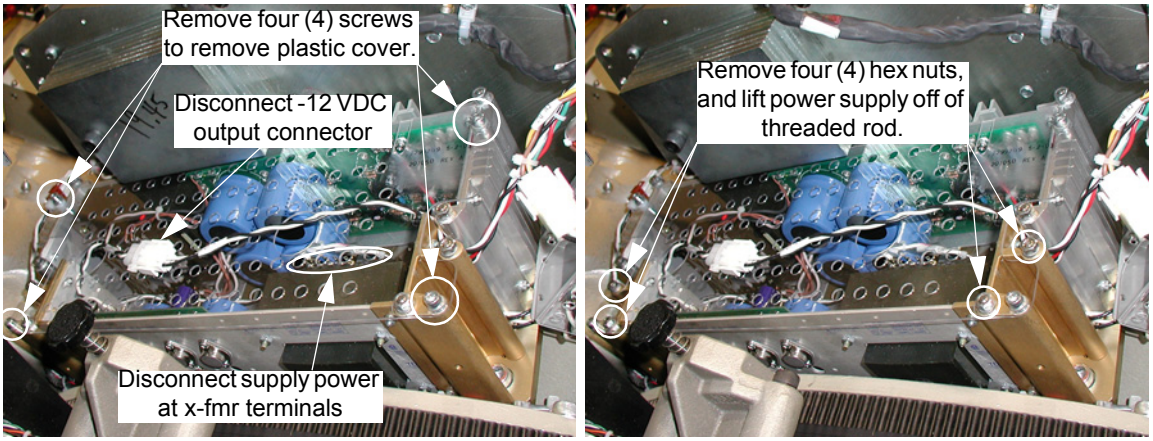


Figure 7-65 -12VDC Power Supply Removal

1.) Disconnect the -12VDC output connector from the power supply.

2.) Remove four (4) each 6mm hex screws, washers and lock washers, to remove the clear plastic cover from the left power supply assembly.

3.) Disconnect the AC supply power at the transformer terminals.

4.) Remove the four (4) 6mm hex nuts, four (4) washers and four (4) lock washers that hold the power supply in place.

5.) Lift the power supply assembly off of the threaded rod.

6.) Slide the new power supply onto the threaded rod, and secure with the 6mm hex nuts, washers and lock washers. Torque to 7.9 N-m (69.92 in-lbs).

7.) Reconnect the AC supply power to the transformer terminals.

8.) Replace the clear plastic cover, using 6mm hex screws, washers and lock washers. Torque screws to 7.9 N-m (69.92 in-lbs).

9.) Reconnect the supply output connector.

10.) Restore power to the gantry and verify power supply output voltage (see Table 7-16, on page 516). Adjust supply output, if necessary.

11.) Reassemble the gantry covers.

3.3.7.4 +12VDC Power Supply

The +12 volt DC power supply is located behind the right **DAS** chassis, along with the +24V power supply. Replacement of this supply is virtually identical to that for the -12V supply. For details, see the -12VDC Power Supply procedure, above (3.3.7.3).

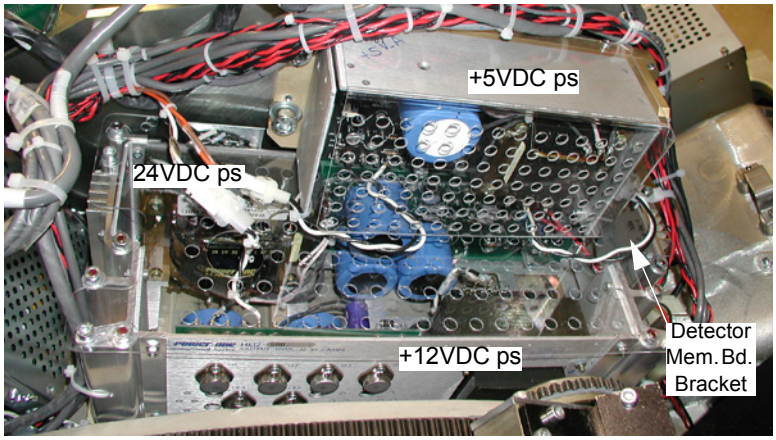


Figure 7-66 Location of +12VDC Power Supply

3.3.7.5 +24VDC Power Supply

The +24 volt DC power supply is located behind the right **DAS** chassis, along with the +12V power supply (see Figure 7-66, above). Replacement of this supply is virtually identical to that for the -12V supply (3.3.7.3), with the following exceptions:

- The +5VDC power supply assembly must first be removed (see 3.3.7.2, on page 542)
- The Detector Memory Board Bracket may need to be removed (see Figure 7-66)

Note: IMPORTANT: When replacing the power supply, be sure to reinstall the Detector Memory Board Bracket (if removed), in addition to the +5VDC power supply assembly. Make sure that the +5VDC assembly mounting screws are torqued to specification, 66 N-m (48.68 ft-lbs), and both its supply power and output connectors are reassembled.

3.3.7.6 +5VDC Logic Power Supply

The +5 volt DC logic power supply is located behind the left **DAS** chassis, along with the -12VDC power supply. Replacement of this supply is virtually identical to that for the -12V supply (3.3.7.3), with the following exception: Gantry Balance Weights must be removed before the power supply can be removed.

NOTICE **Weights MUST be replaced in the same order in which they are removed. Gantry rotation will be adversely affected by improper balancing.**

Apply Loctite 271 to the threads, and torque the M12 mounting bolts to 66N-m (48.68 ft-lbs).

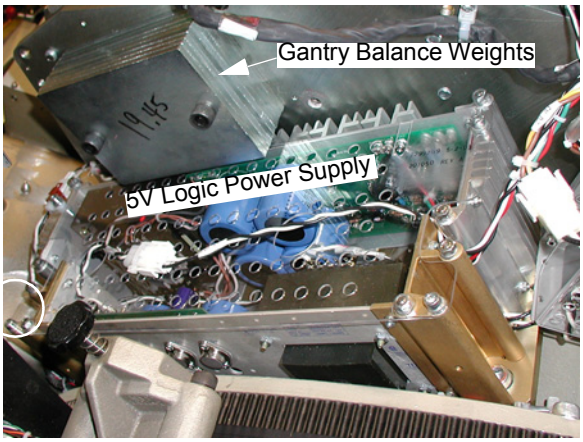


Figure 7-67 Location of 5V Logic Power Supply

3.3.8 Cooling Fans

1.) Remove gantry covers, shut OFF power, lock the gantry in position, and remove the **DAS** air plenum, per "Accessing the MDAS Assembly," on page 530 and "DAS Air Plenum Removal & Installation," on page 534.

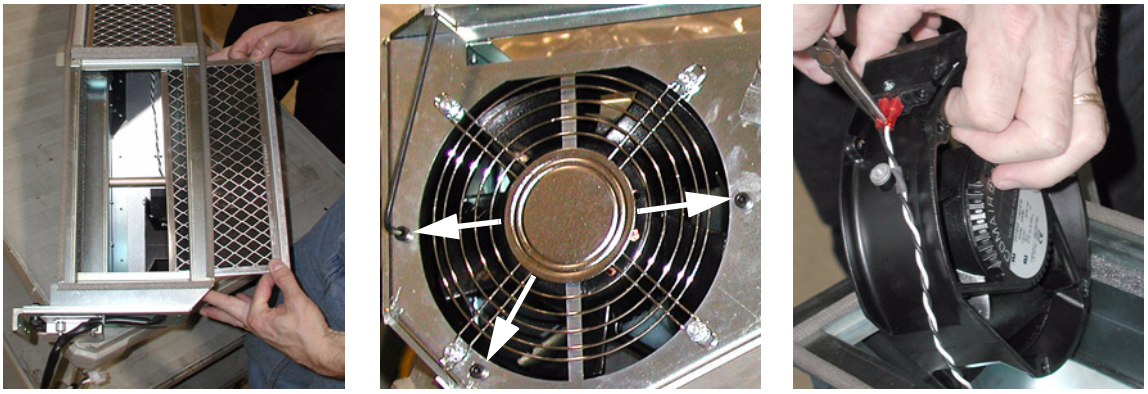


Figure 7-68 Remove filter, remove 3 screws, remove push-on connectors

2.) Loosen the thumbscrew that holds the filter above the fan that is to be replaced, and remove the filter from the plenum.

3.) Remove the three (3) 3mm Hex screws and three (3) hex nuts that hold the fan in place.

Note: It is not necessary to remove the finger guard.

4.) Remove fan from plenum interior. If the support tube interferes with removal, then remove the bolt that holds the tube in place, and remove the tube.

5.) Unplug the two (2) push-on terminals. Needle-nose pliers can be used for this process.

6.) Connect push-on terminals to new fan, and place fan in plenum with airflow indicator pointing inward. Orient fan so that all three mounting holes align properly.

7.) Reattach fan to plenum, using the three (3) 3mm hex screws and hex nuts. Reinstall support tube, if applicable.

8.) Inspect filter for dirt. Clean with a vacuum (or soap and water), if necessary, and reinstall. Secure the filter with the bracket and thumbscrew.

9.) Reinstall plenum, per "Plenum Installation," on page 535.

10.) When **DAS** servicing is complete, disengage rotational lock, restore power, and replace gantry covers.

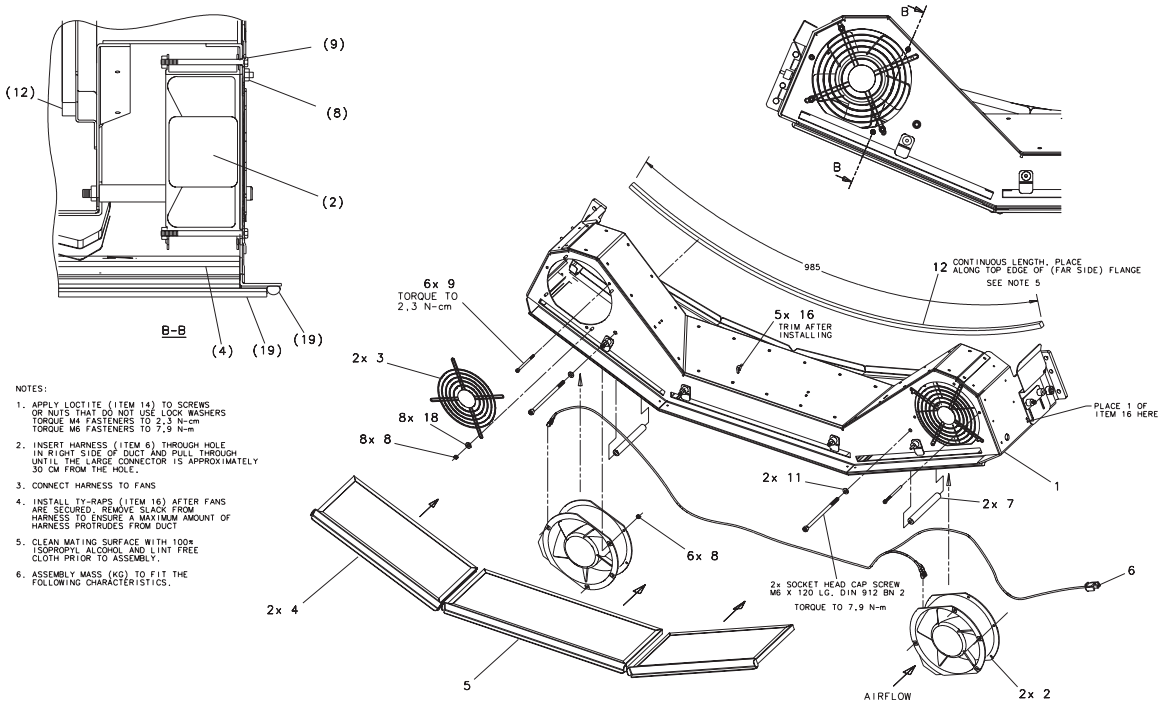


Figure 7-69 DAS Air Plenum Assembly

3.3.9 Detector Heater Control Board (DHCB)

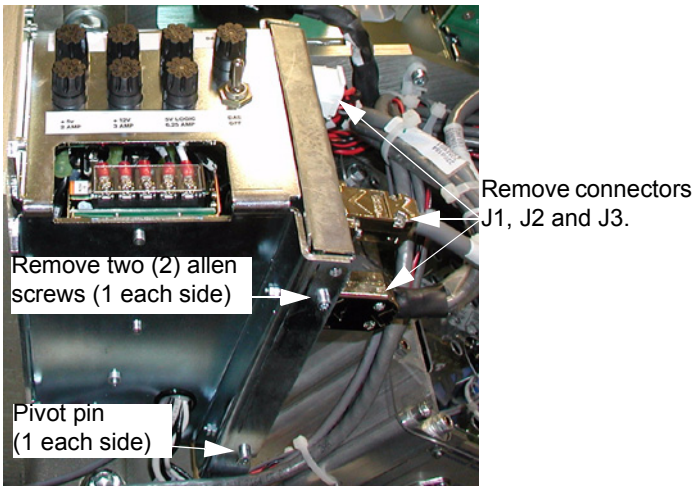


Figure 7-70 DAS fuse box assembly, with DHCB attached

1.) Remove the right gantry cover, and turn off the **HVDC** and 120VAC service switches on the **STC** backplane (see removal procedure, on page 613).
2.) Remove both top gantry covers (see removal procedure, on page 616).
3.) Rotate gantry until the fuse box assembly is within reach.
4.) Turn off the Axial Drive switch on the **STC** backplane.
5.) Remove connectors J1, J2 and J3.
6.) Remove 2 top allen screws (one front, one back)
7.) Drop unit down, and swing out on lower pivot pins.
8.) Slip pivot pins on new **DHCB** assembly into their slots, and rotate assembly into place.
9.) Replace two allen screws on top of unit.
10.) Reconnect J1, J2 and J3.
11.) Return all three service switches to their ON positions, and reassemble the gantry covers.

3.3.10 Detector Thermistor

3.3.10.1 Required Parts

QTY	PART NUMBER	PART NAME
1	2147197	Detector Thermistor Probe
2	511A59OP274	Amp Mate n Lok Male Pins
1	90300-1-E	AMP Universal Mate-N-Lok Pin Crimper Tool
1	2214897	**EMC** Tape (enough to cover thermistor wire along Detector)
1	458994	Amp Universal Mate-N-Lok Pin Pusher (Extractor)
3-4		Small Ty-raps

Table 7-23 Required Parts

3.3.10.2 Retest Matrix

- One hour warm-up
- Verify detector temperature is 36 degrees Celsius
- FastCal
- IQ Check

3.3.10.3 Procedure Details

1.) Verify that you have all the parts/tools required.
2.) Turn off 120VAC Gantry Power.
3.) Disconnect Detector Cable at J3.
4.) Remove Thermistor wires/pins from J3 connector. These are the Red and Black wires. Note their location within the connector. Use Pin extract tool.

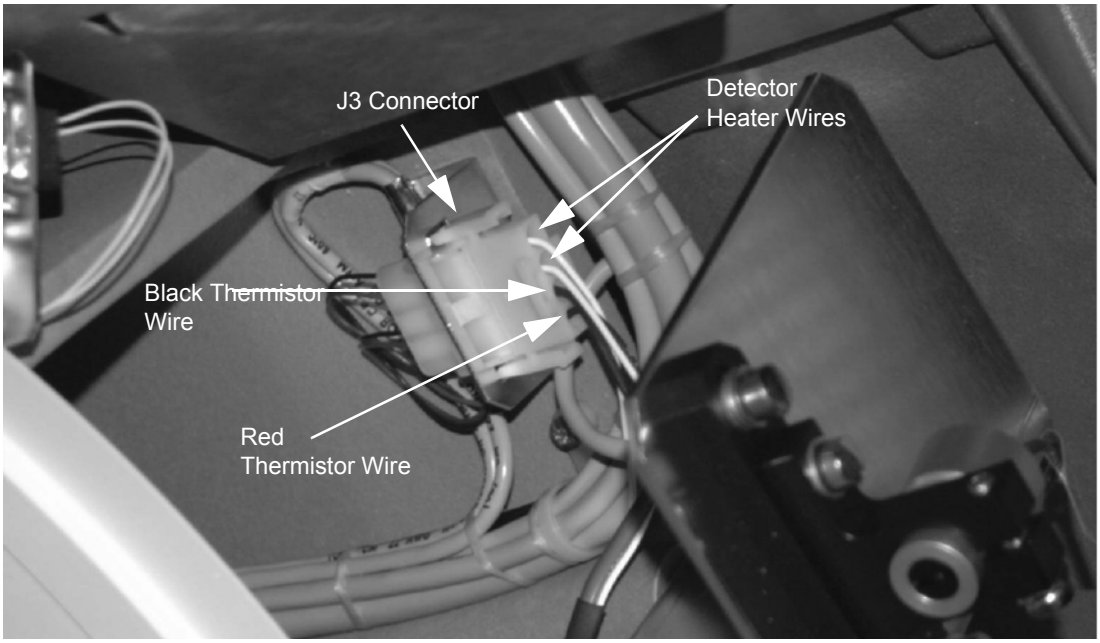


Figure 7-71 J3 connector, showing thermistor wires

5.) Verify correct old Thermistor wires, then cut the old Thermistor cable close to where the Thermistor cable and Detector Heater cables are joined in the shrink-wrap sleeve. Do NOT cut the Detector Heater wires.

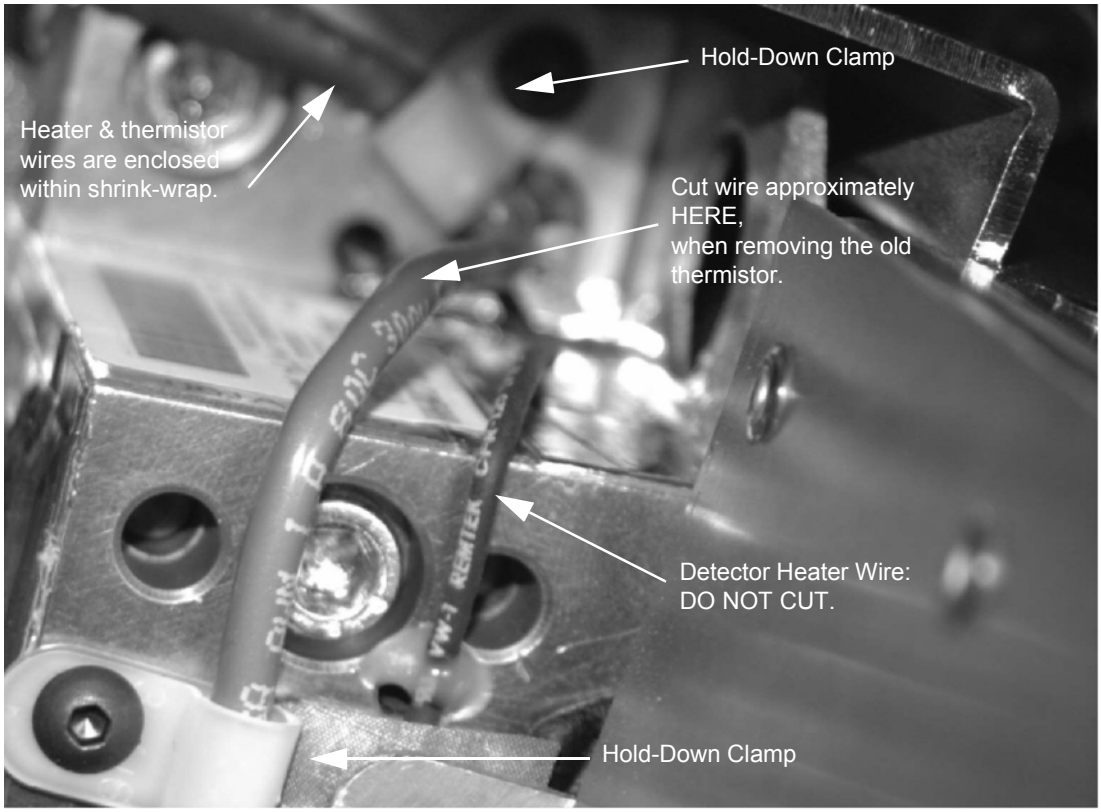


Figure 7-72 Approximate location for cutting thermistor wire

6.) Unscrew the Thermistor wire “Hold-down clamps”. There are two (2): one is near the end of the detector, the other is near the Thermistor.

7.) Carefully peel back the **EMC** tape covering the Thermistor wire so the wire is free.

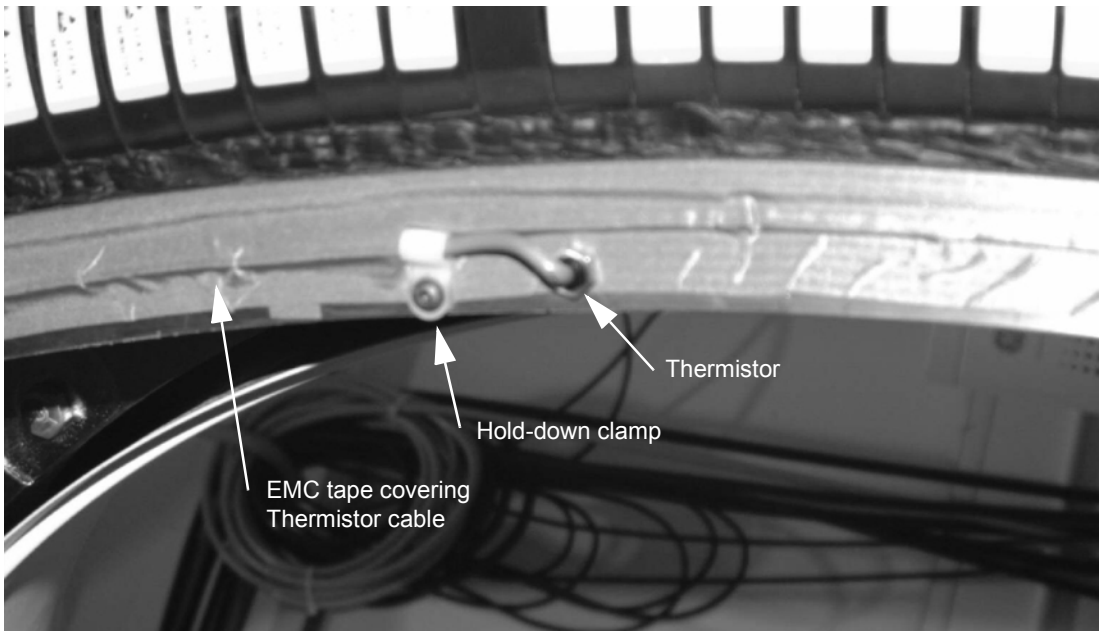


Figure 7-73 Remove old thermistor

8.) Unscrew and remove the Thermistor using a 9mm open-end wrench.

NOTICE **Make sure no dirt or debris gets into the detector through the open hole.**

9.) Make sure the new Thermistor is clean before installing (No lint, dirt, debris, etc.)

10.) Screw in the new Thermistor until snug. Use finger pressure on wrench. Do not over-tighten. The metal Thermistor housing is only a shell. The wire should be free so it does not get twisted.

11.) Route the wire along the detector side just like the old wire, against the inner radius of the Heater element.

12.) Use **EMC** tape or Conductive tape to cover the wire.

13.) Secure the wire with the 2 “Hold-down” wire clamps. Make sure the wire is properly positioned at the Thermistor so it doesn't interfere with the **DAS** Fan Air Plenum, and that the wire isn't too tight, creating a sharp bend at the detector. It should also not be so loose as to get caught or rub on anything during rotation.

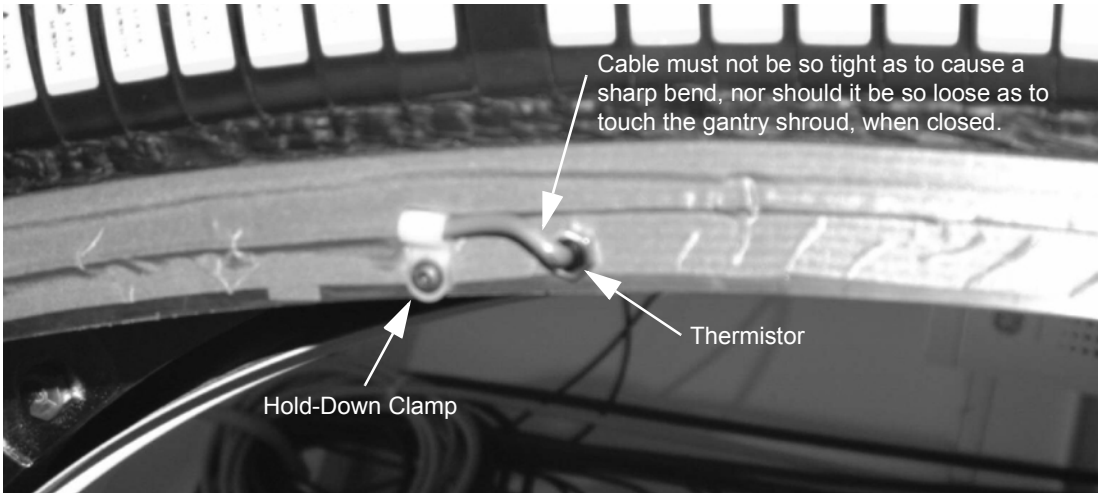


Figure 7-74 Route new thermistor cable

14.) Route the wire along side the Shrink-wrapped cable going to J3. Ty-rap the new cable to the outside of the shrink-wrapped cable.

15.) Install the pins of the wire into the J3 connector.

16.) Connect J3 and confirm that any excess wire is secure and out of the way.

17.) Test the system. Take several scans for a couple of hours so that you are satisfied that the problem has been corrected.

18.) Wait at least one (1) hour with power ON for the Detector to warm up. Then perform FastCal.

Chapter 8
Gantry

Section 1.0
Theory

1.1 Functions of the Stationary Gantry

FRU	FUNCTION
STC Computer	Axial board control **LSCOM** board control **LAN** communications to System Host Control
Axial Board	Scan Start/stop control Operator Hard key monitor X-ray light control **DAS** trigger generation Gantry axial speed and position control Axial speed/position monitoring
LSCOM Board	Slip ring communications to/from rotating gantry

Table 8-1 Stationary Gantry FRU versus Function

DAS and **HV** subsystems are located in other sections of this manual.

1.1.1 Communication Subsystem Theory

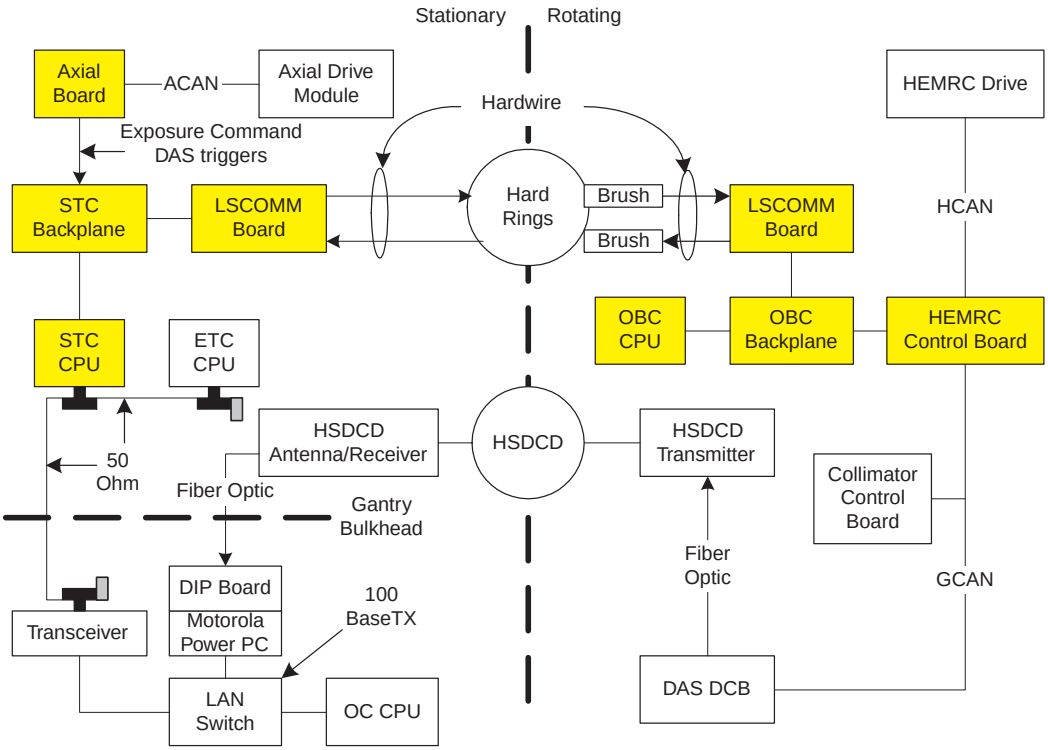


Figure 8-1 Communication Block Diagram

Communications between the OC and Table/Gantry computers are performed by a **LAN** connection and hard-wired slip-rings. Scan data from the **DAS** is transferred across the **HSDCD** (High Speed Data Capacitive Device) ring to the **DIP** board in the console. The **DAS** data transfer rate is 333 Mbaud. The 10base2 thin net 50 ohm **LAN** cable provides the communication path between the OC computer in the console, the **ETC** in the table, and the **STC** in the stationary gantry. The hard slip rings allow the bidirectional transfer of data between the **STC** and the rotating components, including the **OBC**. The control rings transfer data at 2.5 Mbaud.

The system utilizes one **HSDCD** ring and 11 hard wired slip rings. Five rings provide AC and DC power and ground; three provide interlock signals for the **HV** subsystem; and three provide the communication path between the stationary and rotating components. Only the three communication rings will be discussed here.

DANGER **EXTREME CAUTION IS NECESSARY WHEN WORKING IN THE SLIP RING AREA, AS BOTH HV DC PRIMARY AND 120 VAC ARE PRESENT AND EXPOSED ON THE RING.**

The hard slip rings communication connection acts as a sub-network between the **STC** and **OBC**, but also carries the specific **DAS** trigger and Exposure Command signals multiplexed within the data stream. Control and status information travels in both directions across the rotating interface along 2 high speed serial links utilizing 3 rings, one inbound and one outbound, both using an isolated ring as signal reference. This provides for excellent noise immunity. Brushes ride on the conductive ring material to provide signal connection to the stationary components, and screws inserted into the back of each ring provide the connection for the rotating components. Serial link control and signal multiplexing/de-multiplexing is provided by 2 common **LSCOM** boards. **LED**s located on these boards indicate communication status of the data paths.

Scan Data travels from the rotating side to the stationary side and ultimately to the reconstruction subsystem through the **HSDCD** ring. This contact-less path begins at the **HSDCD** transmitter on the ro-

tating structure. The stationary pickup is an antenna and receiver coupled together. The **HSDCD** ring and antenna form two plates of a capacitor. The transmitter input and receiver output are fiber-optic connections. Forward error correction is used in this path to ensure extremely high data reliability.

1.1.2 Axial Motion & Control

The Axial II Control Board is responsible for interfacing the axial drive control firmware of the gantry Stationary Controller (**STC**) microprocessor. The hardware involved in the axial servo drive consists of the Axial II Control Board, the Axial Motor Drive, the Axial Motor, Axial Motor Dynamic Brake Assembly, Axial Encoder, Axial Drive Belt and Axial Home Flag. See Figure 8-2.

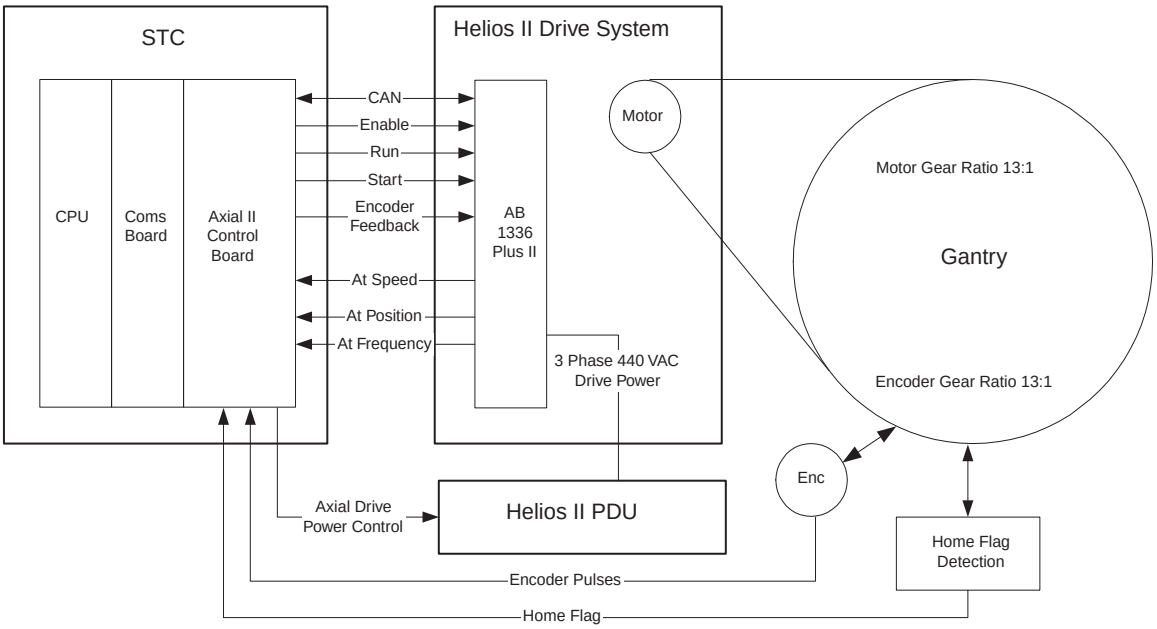


Figure 8-2 Axial Control Block Diagram

The Axial Drive Power Contactor in the **PDU** controls the 3 phase, 440 VAC input of the Axial Motor Drive Module. There are interlocks in the power contactor control for an Axial Enable/Disable switch located on the **STC** chassis backplane.

The Axial Motor Drive module is supplied with enable, speed, brake and direction information from the Axial II Control Board. The Axial Motor Drive monitors the axial speed and direction internally, as well as receiving axial encoder feedback from the Axial II board for fine speed control. The combination of internal and external control allows the drive module to modulate the frequency of the AC output, allowing the gantry to rotate at a maximum speed of 0.5 seconds per revolution in the clockwise direction. Note, the drive module will not drive in a counter-clockwise direction under normal control.

The Axial Motor is an AC induction type. The axial brake engages the motor shaft and is meant as a static brake to hold the gantry still once it has been positioned by the axial drive.

The motor is coupled to the rotating bearing with a belt, with a gear ratio of 13 motor rotations to 1 gantry bearing rotation. An optical “slip-flag” detector senses a metal flag that rotates through it once every bearing revolution. The slip-flag information is used for axial coincidence as a position reference and over-speed sensing.

The encoder is directly coupled to the rotating bearing next to the Axial Drive Belt. It is interfaced with a direct contact gear as weighted assembly with a 13 to 1 gear ratio, the same as the axial motor to rotating bearing. This arrangement allows for simplified transfer functions for speed control and more accurate positioning of **DAS** trigger generation versus motor mounted encoder packaging. The axial encoder is an incremental encoder and provides 2048 counts per encoder rotation. The information from the encoder is decoded on the Axial board and used for gantry position and

speed control as well as **DAS** trigger generation. The **STC** firmware verifies the Axial II board's encoder counts to be 106496 ± 3 counts per gantry revolution referenced to home coincidence.

The axial dynamic brake assembly is used to dissipate energy originating from the induction motor. Axial braking is accomplished by reducing the frequency applied to the motor leads to a level lower than the current operating point of the motor windings. This is termed negative slip. Negative slip generates electrical field resistance or negative torque within the windings. At the same time the motor windings generate voltage raising the motor lead voltage. This excess voltage is dissipated by the dynamic braking module via load resistors and chopper circuit control via the AXDC bus. This means that 440 VAC is always applied to the Axial Motor Drive module to both accelerate and decelerate the gantry. Loss of this voltage will result in the gantry coasting to stop—this can take more than a minute.

Scan start/stop and Autovoice control are implemented using switches on the console keyboard assembly. A hard-key processor on the keyboard assembly is hard-wired to the axial board via a UART serial link. The hard-key processor monitors the status of the "Start Scan" and "Stop Scan" switches on the keyboard assembly. Upon closure of the Start Scan switch contacts, the hard-key processor sends a "start scan" message to the **STC** via the axial board, indicating that the scan should start. This communications link is also used to signal the start of Autovoice messages.

DANGER **DISABLE THE AXIAL DRIVE MECHANISM BEFORE SERVICING THE GANTRY INTERIOR.**

- **THE AXIAL DRIVE ENABLE STATUS LED, DS4, ON THE STC CHASSIS BACKPLANE INDICATES STATUS OF THE AXIAL POWER CONTROL CIRCUIT ONLY, NOT THE STATE OF THE AXIAL POWER CONTACTOR.**
- **A FAILURE IN THE POWER CONTACTOR COULD ENABLE AXIAL MOTOR DRIVE AND CAUSE UN-COMMANDED MOTION.**
- **WHENEVER SERVICING THE ROTATING ASSEMBLY, LOCK THE GANTRY USING THE LOCKING MECHANISM.**

1.1.2.1 Axial Motor Drive (AMD Assembly)

The **AMD** Assembly consists of an Interface Board, AC Drive, Dynamic Brake Assembly, harnesses and 2 power sources. Figure 8-3 shows a block diagram of the **AMD** assembly.

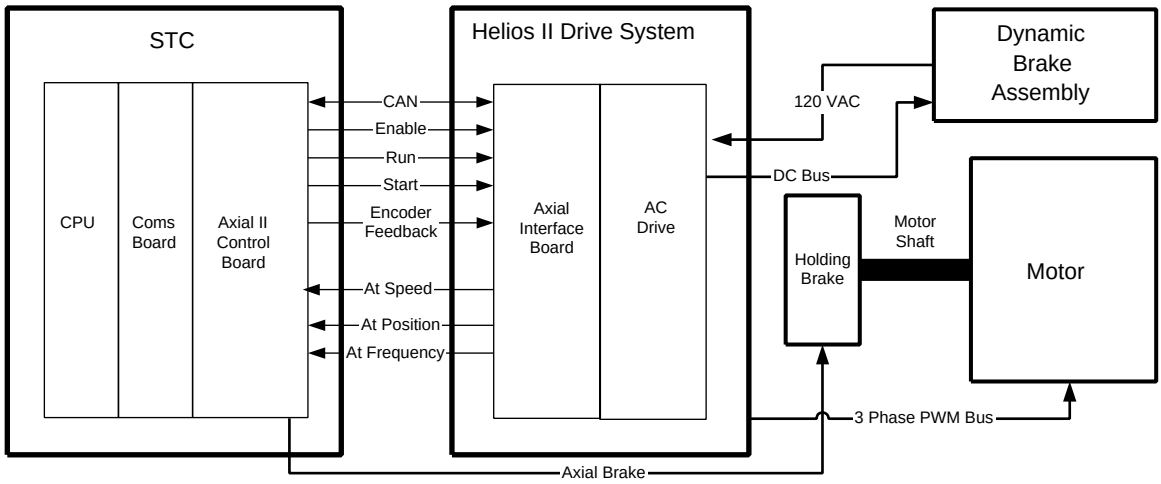


Figure 8-3 AMD Hardware Block Diagram

1.1.2.2 General Axial Drive Function

The Axial Motor Drive (**AMD**) provides three phase power to the Axial AC motor. In addition to the Axial II Control Board, the axial motor requires an external Axial Dynamic Brake Module. The **AMD** is a 2 part integrated device, Axial Interface board (**AIF**) and AC Drive. The axial firmware controls the acceleration, run, and deceleration cycles of the axial motor. The axial control firmware resides in the **STC CPU** and sends drive instructions to the Axial II Control Board (**ACB**).

The **ACB** communicates with the AC Drive through the (**AIF**), located on the **AMD** assembly. The **AMD** interprets the instructions and configures itself to execute the commands. The **AMD** has its own self contained firmware. The drive converts 3 phase 440 VAC input power to three phase Axial **HEM** (High Efficiency Motor Drive) power. This motor drive power is applied directly to the Axial Motor for acceleration, run and braking functions.

Refer to Figure 8-3. Control signals travel from the **STC** Axial II Control Board to the **AMD** through the Axial Interface harness. The **AIF** routes the signals to the AC Drive.

1.1.3 Axial II Control Board – Theory of Operation

The Axial Control board (**ACB**), located in the **STC** chassis, uses the **VME** bus to communicate with the **STC CPU**. The **ACB** uses a **CAN** (Controller Area Network) serial interface, called the **ACAN** (AXIAL **CAN**), and discrete signals to communicate with the **AMD**. Figure 8-4, on page 556, shows the discrete control signals. The **ACAN** interface and discrete control signals enter the **AIF** for control of the AC Drive.

The **AMD** supplies isolated 12V power (1.2A capability) to the **ACAN** and Fault circuitry.

Fault detectors and fault status feedback from the **ACAN** monitor hardware operation. The **AMD** notifies the **ACB** when it detects a fault, or a monitored value falls out of tolerance.

1.1.3.1 VME Interface

The **VME** interface contains the logic to perform address and data latching, address decoding, and **VME** handshaking, according to timing specified in PAL documentation, 2147462PDL. All signals pass through the standard **VME** connector, J1.

Of the seven interrupts defined for the **VME** bus, the **ACB** uses level 1, level 2, level 4 and level 5. Other boards on the **STC** also use the level 1 interrupt, which is wire OR-ed on the backplane.

- **IRQ1**: Interrupt level 1 indicates an over-speed condition. This can be reset by firmware and function retried.
- **IRQ2**: The **ACB** uses Interrupt level 2 during **ACAN** communications.
- **IRQ4**: Interrupt level 4 is a normal operating indication the **ACB** uses for state or positive edge transitions.
  - Axial Power COntactor >State Change
  - Exposure Command> Positive edge detect
  - Option Box (Cardiac R Pulse) > Positive edge detect
  - Zero Trigger (Scan End) > Positive Edge Detect
  - Home Flag> Positive edge detect
  - Axial Sample timer (25 msec timer for speed control)> Positive edge
  - Table Sync (Used to synchronize scout and Helical Scans with cradle motion)> Positive edge detect.
  - Smart View foot switch> State transition
  - Gantry contact (Gantry tape switches)> Positive edge detect
  - Axial Motor Drive (Faults; AT_SPEED, AT_FREQ, AT_POS)> State transition.
  - Extra Inputs (Undefined Spares)> State transition
  - I2C interrupts (**ACB** mounted temp sense, communications) > STATE TRANSITIONS
- **IRQ5**: The **ACB** uses interrupt level 5 for console pushbutton, serial communications.

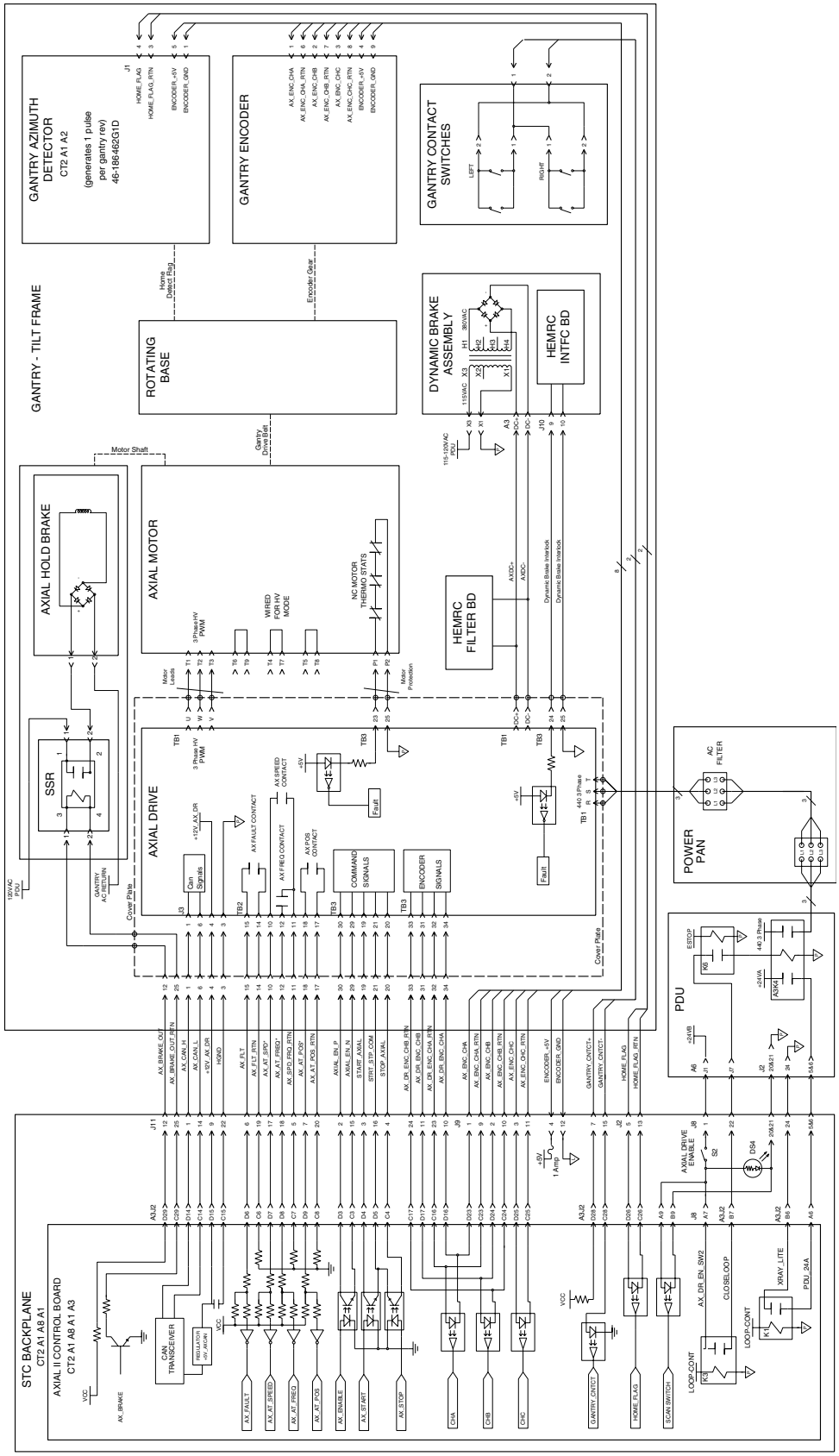


Figure 8-4 Hardwire Control Signals, Functional Interconnect

1.1.3.2 Command I/O

In normal operation, the **STC CPU** sends state commands through the command registers located at address 0xFFAC00 to 0xFFAFFF. This includes Diagnostic testing and status reporting.

1.1.3.3 Reset Pushbutton

The **ACB** contains a manual board reset pushbutton, S1. Pushing the on-board reset has the same effect as receiving a SYSRST from the **VME**.

1.1.3.4 Clocks

Y1, Y2, Y3, and Y4 on the **ACB** generate 16MHz, 12MHz, 40Mhz, and 3.6864Mhz clocks respectively. Y1 is used for AX_CAN communications. Y4 is used for console pushbutton communications from the **SCIM**.

1.1.4 Axial Controller Interface Bus (ACIB) Theory

The ACIB is the umbilical cord that links the Axial Motor Drive to the Axial II Control Board. This link consists of the signals listed below. Each signal is a differential pair for noise immunity.

- Isolated 12VDC is generated by the **HEMRC** Control Board that powers the Controller Area Network (**CAN**) Drivers.
- Axial Enable is available to the **AMD** to determine when gantry rotation begins and ends.
- **CAN** Serial Line is used for the transmission of control signals. It must be terminated by a 120 ohm resistor at the beginning and end of the cable. This particular **CAN** line is referenced as the Axial **CAN** (**ACAN**) bus.
- Fault Line is the primary means to inform the Axial II Control Board of a fault. The fault line is asserted by the **AMD** under the following conditions:
  - The Controller is reset
  - A Fault is detected by the controller

Reset is asserted by the **STC** when it becomes desirable to reset the **AMD**. The **ACB** resets the **AMD** via a command register or during an **STC** reset.

1.1.4.1 Axial CAN (AX_CAN)

The **ACB** uses the 82527 **CAN** protocol controller (U45) and **CAN** bus interface circuitry to communicate with the **AMD** Assembly. This is a bidirectional serial link. The 82527 interrupts the Altera controller (**FPGA**) with the AX_DRIVE_COMM* signal to indicate a status change of the 82527. The 82527 communicates with the Altera (**FPGA**) directly via AXADDR and DATA buses on the **ACB**. The 82527 uses the 16MHz clock for timing. The board AXRESET* signal resets the 82527.

U26 and U24 optically isolate the AX_CAN bus from the **ACB** board circuitry. U28, the **CAN** transceiver chip, resides on the isolated side of the **CAN** interface. The optically isolated side of the AX_CAN receives power from an isolated 12 volt, 125 mA supply located on the **AMD**. VR1 regulates this 12 volt supply down to 5 volts (+5V_AXCAN). This isolated 5 volt supply provides power to the isolated side of the AX_CAN interface. The AX_CAN output signals are AX_CAN_H and AX_CAN_L. R339 provides the required **CAN** bus termination for the Axial II Control Board end of the AX_CAN bus.

DS12 illuminates whenever U26 receives data over the AX_CAN bus.

1.1.4.2 ACB to AMD Interface Overview

The communications between the **ACB** and **AMD** consist of:

- Bidirectional **CAN** serial communications bus: a 125 Kbaud bidirectional serial link, used to convey commands and status information.
- AX_Fault signal from the **AMD** to **ACB**.

- AX_AT-SPD* signal from the **AMD** to the **ACB**.
- AX_AT_FREQ* signal from the **AMD** to the **ACB**.
- AX_AT_POS* signal from the **AMD** to the **ACB**.
- AX_EN_P, AX_EN_N signal from the **ACB** to the **AMD**
- AX_ENC_CHA/CHB signals from the **ACB** to the **AMD**
- Three-wire start-stop signal

The opto-isolated Enable, Start, and Stop signals from the **ACB** to the **AMD** provide a contact closure as an input to the **AMD**. The Enable contacts close electrically to enable the **AMD**, the Start contacts close electrically to start the **AMD**, and the Stop contacts close electrically to enable the **AMD** to run and open electrically to stop the **AMD**. The Enable, Start, and Stop opto-isolators carry 10mA with less than a 3V drop when closed, and withstand 5V when the contacts open.

The fault signal from the **AMD** to the **ACB** consists of the AX_FLT and AX_FLT_RTN signal wires. The circuit uses drives with a normally-open fault contact. If either the fault signal wires open electrically, the **ACB** generates a fault condition. If the AX_SPD_FRQ_RTN signal wire opens during operation, the system can report either AX_AT_SPD or AX_AT_FREQ errors.

The AX_AT_SPD*, AX_AT_FREQ* AND AX_AT_POS* are active low or NO FAULT conditions during normal axial operations. These signals should be high with the gantry rotation idle. The AX_FLT is a normally low signal. If this signal goes high, then the AX_FAULT_CONTACTS in the **AMD** have opened and you have a fault.

If the motor is at or above Frequency for the phase it is currently in, then AT SPEED will be satisfied and closes. AT SPEED will then open when the phase changes transition, and waits for the motor to be at or above Frequency again for this next phase, then will close if the motor reaches Frequency. This will continue throughout the entire rotation cycle, Accel, Run, and Brake. It is key to know that the **AMD** module will try to drive the motor to the correct speed, and if it cannot attain the speed requested, the current will max out at a specific level and not drive any higher, the result will be that the motor could not make it to the correct frequency in the allotted time for that phase, and the AT SPEED fault will be seen.

1.1.4.3 AMD Stop and Start

The discrete start and stop signals to the **AMD** are opto-coupled logic signals. The STOP_AXIAL signal must equal a logic high for the **AMD** to start acceleration, continue acceleration or run. The logic high STOP_AXIAL signal creates a low impedance between the STOP_AXIAL and STRT_STP_COM output signals, which permits the **AMD** to accelerate or run.

When the START_AXIAL signal goes to a logic high (causing a low impedance between the START_AXIAL and STRT_STP_COM outputs) and the STOP_AXIAL signal equals a logic high, the **AMD** begins to accelerate (if it hasn't already done so). Once acceleration begins, the **AMD** continues to advance along its acceleration profile, or continues to run, regardless of the logic condition of the START_AXIAL signal. The **AMD** begins to decelerate (if it is running) whenever the STOP_AXIAL signal goes to a logic low.

1.1.4.4 AXDC Bus Voltage Monitoring

This function is performed within the **AMD** module. Errors are reported to the Axial II Control Board.

1.1.4.5 CAN Error Detection

CAN implements five error detection mechanisms: three at the message level and two at the bit level.

Note: **CAN** will retry up to 128 times before logging an error.

The following mechanisms are at the message level:

- **Cyclic Redundancy Checks (CRC) -** Every transmitted message contains a 15 bit Cyclic Redundancy Check (**CRC**) code. The **CRC** is computed by the transmitter and is based on the message content. All receivers that accept the message perform a similar calculation and flag any errors.

- **Frame Checks -** There are certain predefined bit values that must be transmitted at certain points within any **CAN** Message Frame. If a receiver detects an invalid bit in one of these positions, a Form Error (sometimes also known as For at Error) will be flagged.
- **Acknowledgement Error Checks -** If a transmitter determines that a message has not been acknowledged, then an ACK Error is flagged.

The following mechanisms are at the bit level:

- **Bit Monitoring -** Any transmitter automatically monitors and compares the actual bit level on the bus with the level that it transmitted. If the two are not the same, then a bit error is flagged.
- **Bit Stuffing - CAN** uses a technique known as bit stuffing as a check on communication integrity. After five consecutive identical bit levels have been transmitted, the transmitter will automatically inject (stuff) a bit of the opposite polarity into the bit stream. Receivers of the message will automatically delete (de-stuff) such bits before processing the message in any way. Because of the bit stuffing rule, if any receiving node detects six consecutive bits of the same level, a stuff error is flagged.

1.1.5 Axial Motor Drive – Theory of Operation

1.1.5.1 Axial Motor Drive (AMD)

The Axial Motor Drive is a customized version of a commercially available Allen-Bradley Model 1336 Plus II variable frequency AC motor drive. It contains its own microprocessor, power supplies and a three-phase full bridge inverter. The **AMD** communicates with the Axial II Control Board through a **CAN** (Controller Area Network) serial bus.

1.1.5.2 Jumper Settings for the Axial Motor Drive

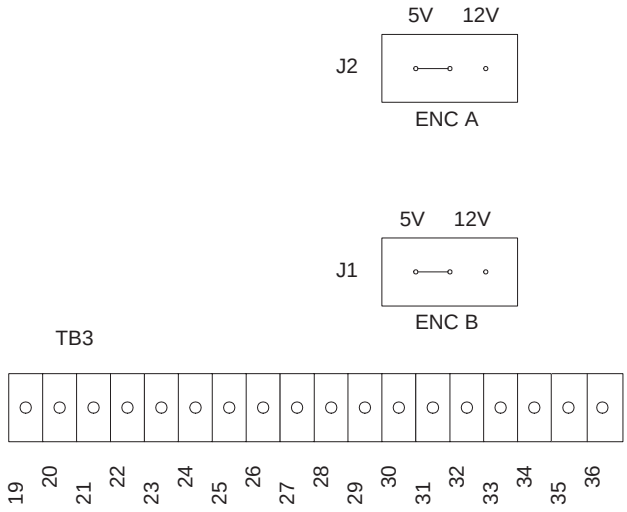


Figure 8-5 Axial Motor Drive Encoder Board Jumpers

The **AMD** Encoder board jumpers J1 and J2 should be set for 5V.

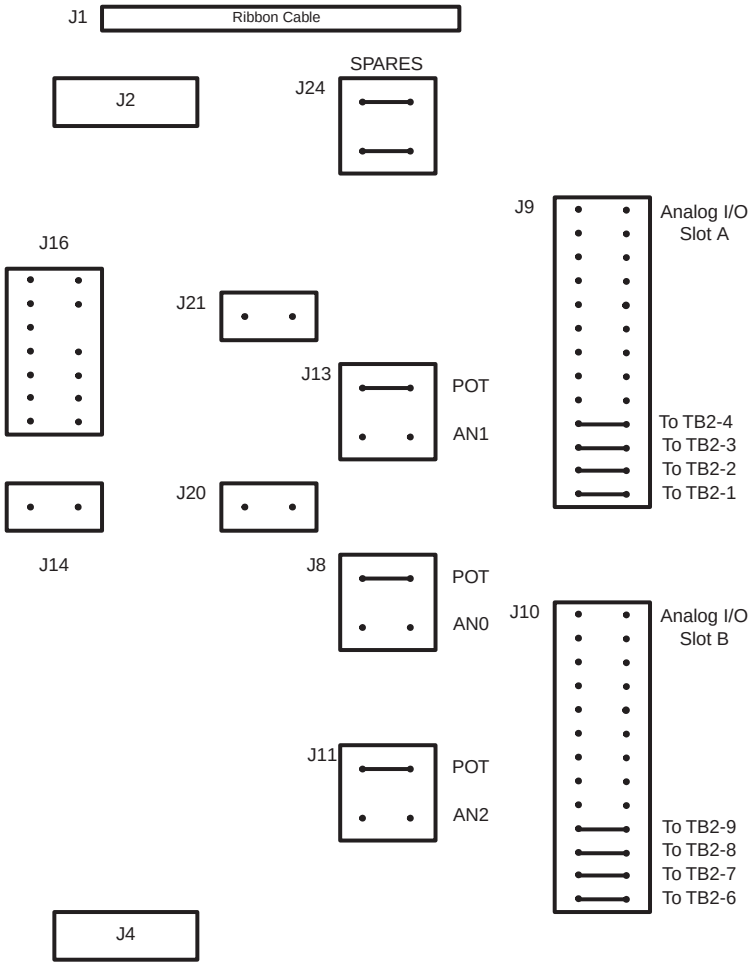


Figure 8-6 Axial Motor Drive Control Board Jumpers

The **AMD** Control board jumpers are all factory default settings. See Figure 8-6 for specifics.

1.1.6 Axial Control Error Messages

The Axial II Control Board receives certain detected error conditions, generally related to communication or functional interfaces to the **AMD**. Many of these messages contain variable fields. The general description has been provided for clarity.

ERROR CODE CLASS 260006500	MESSAGE TEXT Drive error messages are posted as 260006500. In the body of the error log entry the fault code will be posted in the format of FXX
F01	Undefined Fault. This fault code is undefined and may indicate a defective Drive. Retry operation. If problems persist contact the factory for instructions.
F02	Auxiliary Fault. The interlock between the Chopper Control circuit on the axial I/F Board and the Drive is open. Possible Chopper Control fault or connections to the I/F board. Also check the fuse on the chopper resistor pan.
F03	Power Loss Fault. The Drive internal DC bus remained low for >500mS. Possible low voltage condition on 480 VAC in gantry or power interruption. Also may indicate excessive run or braking power required due to sluggish Motor.
F04	Undervoltage Fault. The Drive internal DC bus voltage dropped below 325V. Possible low voltage condition on 480 VAC in gantry or power interruption. Also, may indicate excessive run or braking power required due to sluggish Motor.
F05	Overvoltage Fault. The Drive internal DC bus voltage has exceeded 810V. Possible failure of axial I/F Board Chopper Control or excessive motor regeneration from AXMotor during braking.
F06	Motor Stall Fault. The Drive output current has exceeded 12.6A for > 4 seconds. Possible Motor frozen bearing or shorted Motor winding. Defective Motor and/or cabling.
F07	Overload Fault. The Drive output current has exceeded 9.7A for an extended time. Possible Motor sticky bearing or shorted Motor winding. Also, possible defective Motor and/or cabling.
F08	Overtemp Fault. The Drive heatsink temperature has exceeded 90C (195F). Check for blocked or dirty heat sink fins. Also check if the gantry ambient temperature has exceeded 40C (104F).
F09	Open Pot Fault. Potentiometer speed control is not used in this system. This fault code indicates a possible corrupted configuration parameter, defective Drive or Control Board. Retry operation.
F10	Serial Fault. This fault code indicates a possible corrupted configur-ation parameter, defective Drive or Control Board. Retry Operation.
F11	Op Error Fault. This fault code indicates a possible corrupted config-uration parameter, defective Drive or Control Board. Retry Operation.
F12	Overcurrent Fault. Check for a short circuit at the drive output or excessive load conditions at the motor.
F13	Ground Fault. Check the motor and external wiring to the drive output terminals for a grounded condition.
F14	Option Error. This fault code is undefined and may indicate a defective Drive. Retry operation. If problems persist contact the factory for instructions.
F15	Motor Thermistor. System detected and open or short in the Motor Thermistor. Retry Check connections to thermistor and motor heat.
F16	Bipolar directional fault detected by the axial drive.
F17	C167 Watchdog. Internal Drive Fault. Perform Reset of the Drive. If the problem. Retry is frequent the Drives main control board is suspect replace drive.
F18	Hardware Trap. Internal Drive Fault. Perform Reset of the Drive. If the problem. Retry is frequent the Drives main control board is suspect replace drive.
F19	Precharge Fault. This fault code indicates a possible hardware failure in the Drive. Retry operation. If problems persist, replace the Drive.
F20	The load loss detect is set to enabled and the drive output torque current was below the load loss level for a time period greater then the load loss time.

Table 8-2 Axial Control Error Messages

ERROR CODE CLASS 260006500	MESSAGE TEXT Drive error messages are posted as 260006500. In the body of the error log entry the fault code will be posted in the format of FXX
F21	Undefined Fault. This fault code is undefined and may indicate a defective Drive. Retry operation. If problems persist contact the factory for instructions.
F22	DSP Reset Fault. Power up has occurred with an open Stop_AX2 or closed Start_AX2* signal. Check Control Board and wiring between Drive and **STC**.
F23	Loop Overrun Fault. This fault code indicates a possible hardware failure in the Drive. Retry operation. If problems persist, replace the Drive.
F24	Motor Mode Fault. This fault code indicates a possible hardware failure in the Drive. Retry operation. If problems persist, replace the Drive.
F25	Undefined Fault. This fault code is undefined and may indicate a defective Drive. Retry operation. If problems persist contact the factory for instructions.
F26	Power Mode Fault. This fault code indicates a possible hardware failure in the Drive. Retry operation. If problems persist, replace the Drive.
F27	DSP Comm Fault. Internal Drive Fault. Perform Reset of the Drive. If the problem. Retry is frequent the Drives main control board is suspect replace drive.
F28	DSP Timeout Fault. Internal Drive Fault. Perform Reset of the Drive. If the problem. Retry is frequent the Drives main control board is suspect replace drive.
F29	Hertz Error Fault. This fault code indicates an operating frequency parameter was out of range. Possible corrupted configuration parameter, defective Drive or Control Board. Retry Operation.
F30	Hertz Select Fault. This fault code indicates an operating frequency parameter was out of range. Possible corrupted configuration parameter, defective Drive or Control Board. Retry Operation.
F31	DSP Queue Fault. Internal Drive Fault. Perform Reset of the Drive. If the problem. Retry is frequent the Drives main control board is suspect replace drive.
F32	EEprom Fault. This fault code indicates a possible hardware failure in the Drive. Retry operation. If problems persist, replace the Drive.
F33	Max Retries Fault. The Drive unsuccessfully tried to reset a fault. See message(s) above for original problem.
F34	Prm Access Flt. Verify that the [Run Boost] parameter is less than or equal to the [Start Boost] parameter.
F35	Negative Slope Fault. This fault code indicates a Volts / Hertz programming error. Possible corrupted configuration parameter, defective Drive or Control Board. Retry Operation.
F36	Diag C Lim Fault. Check programming of [Cur Lim Trip En] parameter. Check for excess load, improper DC boost setting, DC brake volts set too high or other causes of excess current.
F37	P Jump Error Fault
F38	Phase U Fault\n\ A phase to ground short has been detected in the U phase. Check the wiring\n\ between the drive and Motor. Check Motor for grounded primary winding.
F39	Phase V Fault. A phase to ground short has been detected in the V phase. Check the wiring between the drive and Motor. Check Motor for grounded primary winding.
F40	Phase W Fault. A phase to ground short has been detected in the W phase. Check the wiring between the drive and Motor. Check Motor for grounded primary winding.
F41	UV Short Fault. A phase to phase short has been detected between the U & V phases. Check the wiring between the drive and Motor. Check Motor for shorted primary.
F42	UW Short Fault. A phase to phase short has been detected between the U & W phases. Check the wiring between the drive and Motor. Check Motor for shorted primary.
F43	VW Short Fault. A phase to phase short has been detected between the V & W phases. Check the wiring between the drive and Motor. Check Motor for shorted primary.

Table 8-2 Axial Control Error Messages (Continued)

ERROR CODE CLASS 260006500	MESSAGE TEXT Drive error messages are posted as 260006500. In the body of the error log entry the fault code will be posted in the format of FXX
F44	Undefined Fault. This fault code is undefined and may indicate a defective Drive. Retry operation. If problems persist contact the factory for instructions.
F45	Undefined Fault. This fault code is undefined and may indicate a defective Drive. Retry operation. If problems persist contact the factory for instructions.
F46	Power Test Fault. This fault code indicates a possible hardware failure in the Drive. Check all connections to the Power/Driver Board. Retry operation. If problems persist, replace the Drive.
F47	Transistor Saturation Fault. This fault code indicates a possible hardware failure in the Drive. Retry operation. If problems persist, replace the Drive.
F48	Reprogram Fault. Reset the **STC** or cycle power to the drive.
F49	Undefined Fault. This fault code is undefined and may indicate a defective Drive. Retry operation. If problems persist contact the factory for instructions.
F50	Poles Calc Fault
F51	Background 10ms Over. This fault code indicates a possible hardware failure in the Drive. Retry operation. If problems persist, replace the Drive.
F52	Foreground 10ms Over. This fault code indicates a possible hardware failure in the Drive. Retry operation. If problems persist, replace the Drive.
F53	EE Init Read. This fault code indicates a possible hardware failure in the Drive. Retry operation. If problems persist, replace the Drive.
F54	EE Init Value. This fault code indicates a possible hardware failure in the Drive. Retry operation. If problems persist, replace the Drive.
F55	Temp Sense Open. This fault code indicates a possible hardware failure in the Drive. Retry operation. If problems persist, replace the Drive.
F56	Precharge Open. This fault code indicates a possible hardware failure in the Drive. Retry operation. If problems persist, replace the Drive.
F57	Ground Warning. Check the Motor and external wiring to the drive output terminals for a grounded condition.
F58	Blown Fuse Fault. This fault code indicates a possible hardware failure in the Drive. Retry operation. If problems persist, replace the Drive.
F59	Undefined Fault. This fault code is undefined and may indicate a defective Drive. Retry operation. If problems persist contact the factory for instructions.
F60	Encoder Loss. This indicates that the axial drive can not sense the axial encoder. Possible causes are:Encoder, cabling, unplugged Axial II Control Board or improper axial drive encoder jumper setting.
F61	Mult Prog Input. Multiple functions selected may indicate a defective Drive. Retry More than one function has been programed reset hardware.
F62	III Prog Input. Multiple functions selected may indicate a defective Drive. Retry Config file or Drive Eprom may be corrupt reset hardware.
F63	Shear Pin Fault. Output Amps exceeds program limits Check Axial hardware and belt. Retry Look for slippage in Axial drive hardware or Axial Drive Belt.
F64	Power Overload. This fault code is undefined and may indicate a defective Drive. Retry operation. If problems persist contact the factory for instructions.
F65	Adapter Frequency Error. This fault code indicates an operating frequency parameter was out of range. Possible corrupted configuration parameter, defective Drive or Control Board. Retry Operation.
F66	EEprom Checksum Fault. This fault code indicates a possible hardware failure in the Drive. Retry operation. If problems persist, replace the Drive.
F67	Sync Loss Fault. This fault code is undefined and may indicate a defective Drive. Retry operation. If problems persist contact the factory for instructions.

Table 8-2 Axial Control Error Messages (Continued)

ERROR CODE CLASS 260006500	MESSAGE TEXT Drive error messages are posted as 260006500. In the body of the error log entry the fault code will be posted in the format of FXX
F68	ROM or RAM Loss Fault. Internal power-up tests did not execute properly. Check Language Module. Retry operation. If problems persist, replace the Drive.
F69	Open Output Fault. An undercurrent condition has been detected in one or more of the Drive output wires. Check the wiring between the drive and the Motor. Check the Motor for an open primary winding.
F70	Phase Unbalance Fault. An imbalance between Drive output phase currents has been detected. Check the wiring between the drive and the Motor.

Table 8-2 Axial Control Error Messages (Continued)

1.1.7 Axial Dynamic Brake Assembly

This assembly provides logic and control power for the **AMD** when the Axial Power Contactor is open. During gantry deceleration, excess **AMD** AXDC bus power is dissipated through chopper load resistors.

The Axial Dynamic Brake Assembly is a modified **HEMRC** circuit. All components are identical, but configured differently. The following theory describes the Axial Applications only.

The following reference information comes from the **HEMRC** Interface Board Test Specification, 2145832TST. Refer to the 2145832TST document for any updated information, or for more complete discussion of the Interface Board functions.

Chopper Control

DANGER **THE CHOPPER CONTROL CIRCUIT ON THE INTERFACE BOARD IS REFERENCED TO THE AXDC – RAIL AT ALL TIMES. THIS IS A POTENTIALLY LETHAL VOLTAGE SOURCE. DO NOT CONNECT TO GROUND.**

The Interface board Chopper circuit helps dissipate excess energy in the Axial Motor Drive's internal AXDC bus. The Chopper circuit is always active in this application. As the motor decelerates, it acts as a generator, which converts some of the kinetic energy to current. The Axial Motor Drive channels this current into its internal AXDC bus, which causes the voltage on the bus to rise. If the bus voltage exceeds 810V, the drive will disable itself and abort the braking process. When the braking process aborts, the gantry coasts to a stop. The chopper circuit limits the bus voltage to approximately 750V to prevent the gantry from coasting.

The Axial Motor Drive's AXDC voltage powers the circuit at J7 of the **HEMRC** board. Two 7500 ohm 40W chassis mounted dropping resistors, connected at J4 & J5, limit the power supply current to <50 mA. CR4 regulates the nominal 15V to power the Chopper Control circuit. **LED** DS3 illuminates to indicate the presence of circuit power.

Since the chopper is always enabled, the open collector of AR1-1 floats, which in turn enables the operation of comparator circuit of AR1-2. The voltage sensed at J7-1 is scaled and compared to a fixed 5V reference provided by VR1. When the bus voltage exceeds 750V, AR1-2 goes high, driving Q3 and turning on IGBT Q1. An external 100 ohm, 1000W shunt resistor is connected through a fuse (AXDC+ and J7-5) to the collector of Q1. When Q1 turns on, this shunt resistor is applied to the AXDC bus and discharges the excess energy. When the voltage falls below 700V, AR1-2 goes low and driver transistor Q2 turns off Q1, which disconnects the shunt resistor.

The AR1-13 circuit detects the on state of Q1. Normally, Q1 stays on for a few milliseconds at a time. If it stays on too long, Q1 can damage the shunt resistor. Therefore, when the collector of Q1 goes low for more than ~1ms, AR1-13 floats high to release the RC timer of R26 & C10. If this condition lasts for more than ~130ms, AR1-14 goes high, which generates a fault condition.

Pins 4 & 5 of J8 are normally jumpered together so the normal low state of AR1-14 turns “on” the normally open solid-state relay U2, and closes its output “contact”. The output of U2 passes through J10-9 & 10 to the Axial Motor Drive. When this circuit opens, the drive detects an error condition and aborts all operation. It also notifies the system of an auxiliary drive fault.

The detected fault also turns on Q4, to generate a pulse from T1 at J8-1 & 3, which fires the gate of an external SCR. The SCR is connected between an 8 ohm tap on the shunt resistor and the AXDC-. When the SCR fires, the surge current blows the chopper’s input fuse and isolates the fault from the AXDC bus supply.

1.1.7.1 Filter Board

The filter board adds differential mode and common mode capacitance to the Axial Motor Drive internal AXDC bus, to reduce the electrical noise created by the switching IGBTs. This board is required for **EMI**/**EMC** compatibility.

1.1.7.2 Chopper Resistor Assembly

The chopper resistor assembly provides a high power dissipation load to the **AMD** bus, if required during axial braking. The chopper resistor configuration resembles the shunt regulator. The Interface Board contains the actual chopper switching element (an IGBT).

When the axial induction motor brakes, it can momentarily generate a current. When this happens, the **AMD** converts some of the rotational energy to electrical energy and returns it to the internal AXDC bus causing a rise in the bus voltage. If the AXDC bus voltage exceeds ~750V, the chopper IGBT turns on and discharges the excess energy through resistors A4R1 & A4R2. The IGBT turns off when the voltage drops below ~700V. This process continues as long as necessary to keep the bus voltage below ~750V. Normally this action occurs for less than 5 seconds during the brake cycle. At all other times the IGBT remains off and essentially “disconnects” the resistors from the bus. The intermittent duty cycles permits the use of resistors with a much lower power rating than a continuous duty cycle would require.

Because the circuit uses the intermittent duty rated resistors A4R1 & A4R2, it contains fuse A4F1 to isolate the resistors from the bus in the event of a control failure. If a fault occurs, A4SCR1 fires and crowbars the bus. The anode of A4SCR1 connects to a tap on resistor A4R1, nominally set to 8 ohms from the fused end. When the SCR fires, the high current load it creates causes fuse A4F1 to open and disconnect the resistor assembly from the bus, to isolate the fault.

1.1.7.3 Step-Up Transformer

500VA isolation transformer, T1, is configured as a nominal 115:380 V step-up transformer. T1 provides the 24 hour power to the **AMD** that is needed to maintain communication with the **ACB**. Diodes inside the **AMD** rectify the ~380VAC to create a nominal 500 VDC bus (no load, with 120 VAC input). DC to DC converters inside the drive develop power for its internal logic from this bus. T1 should normally never provide power for axial braking.

1.1.7.4 Bridge Rectifier

Bridge Rectifier CR1 connects in series between the T1 step-up transformer and the **AMD** AXDC bus as the logic and control power source for the drive. The drive internal bus voltage always equals the greater of either the braking voltage or the T1 voltage.

1.1.7.5 Dropping Resistors

Chassis mounted dropping resistors R4 & R5 limit the chopper circuit power supply current derived from the **AMD** AXDC bus to <50 mA. The Chopper Control supply is referenced to the AXDC bus return, NOT to ground. NEVER reference this voltage to ground.

DANGER

THE CHOPPER CONTROL CIRCUIT ON THE INTERFACE BOARD IS REFERENCED TO THE AMD AXDC BUS AT ALL TIMES. THIS IS A POTENTIALLY LETHAL VOLTAGE SOURCE. DO NOT CONNECT TO GROUND.

VARIOUS COMPONENTS, INCLUDING THE CHOPPER RESISTOR ASSEMBLY AND HEMRC INTERFACE BOARD, ARE REFERENCED TO THE AXIAL MOTOR DRIVE AXDC BUS AT ALL TIMES. THIS IS A POTENTIALLY LETHAL VOLTAGE SOURCE. DO NOT CONNECT TO GROUND.

THE HEMRC INTERFACE BOARD CONTAINS NO TEST POINTS. ALL ACTIVE CIRCUITRY IS HIGH IMPEDANCE AND TIED TO HAZARDOUS VOLTAGES. DO NOT PROBE.

A4R1 & A4R2 TAP ADJUSTMENTS

Verify/Align the connection tabs and hardware of the chopper resistors A4R1 and A4R2 so they clear any sheet metal by at least 0.5in.

Adjust the tap band on chopper resistor A4R1 to 8 ohms ± 0.5 ohms, with respect to the end connected to fuse A4F1.

The tap band on chopper resistor A4R2 is not used, but you still must secure the band in place to prevent dielectric failure to the adjacent sheet metal. To minimize confusion, adjust the tap band to 8 ± 0.5 ohms, with respect to the end connected to A2J7-5.

1.1.8 X-Ray Light Control

The axial board provides a set of relay contacts, K1, to control a relay in the **PDU**. The **PDU** relay closes a set of contacts that drive the site X–ray ON Light. The relay contacts are closed (x–ray light turned on) whenever the Axial II Control Board commands X–rays to the **OBC**. The axial board must drive a 24V 100mA **LED** mounted in the rear of the Gantry. This light, separate from the Gantry display, will indicate the presence of the axial board's x–ray command and will coincide with the **PDU** x–ray ON light signal. The light is controlled by firmware rather than hardware so that it can be coordinated with actual x–ray state and not just the x–ray exposure command. **STC** firmware receives notification via the communication slip rings from the **OBC** when x–rays turn on and off.

1.1.9 DAS Triggers

The Axial II Control Board generates **DAS** triggers for all data collection modes. Refer to Table 8-3). The **DAS** trigger signal uses inputs from gantry encoder, table, and x–ray command circuitry to coordinate the **DAS** trigger signal with gantry and table motion. The **DAS** trigger function produces both offset triggers for **DAS** offset characterization and view triggers for actual scan data acquisition.

The trigger circuitry supports 4 scan modes: static, scout, axial, and helical. The modes and offset or view triggers output are selected by firmware. Firmware sets up the hardware by pre–programming the modes and parameters before the triggers are actually generated.

Scout and helical modes require a sync pulse from the table to coordinate the start of triggers. Scout scans use a fixed clock input reference to generate the triggers. Static mode also uses a fixed clock reference. Helical and axial use the gantry encoder signal as a reference to generate triggers.

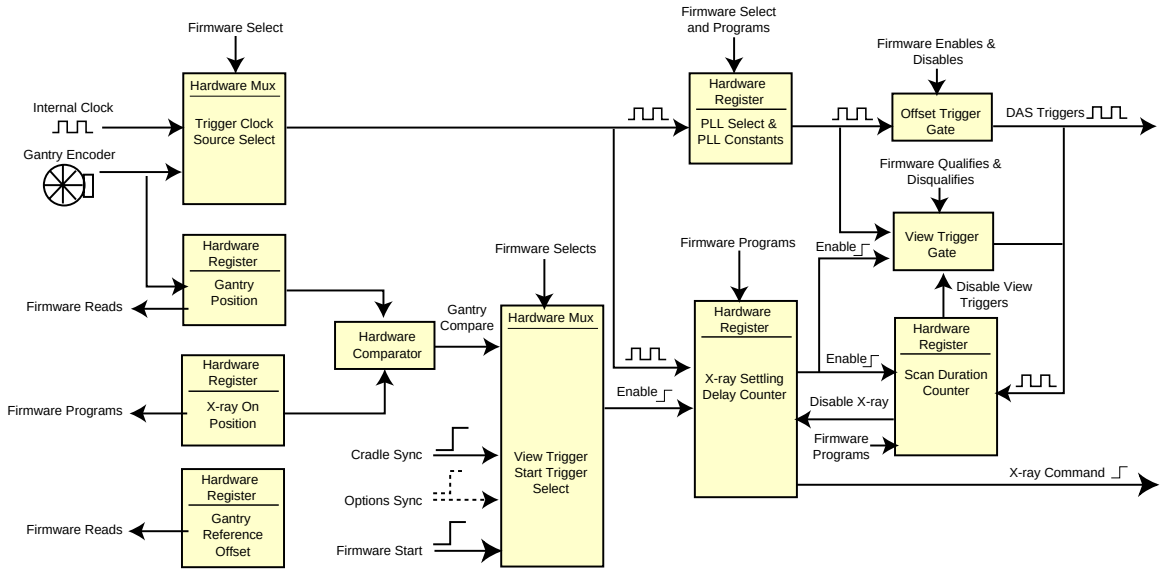


Figure 8-7 Triggers Block Diagram

The **DAS** trigger counter controls the duration of the scan by counting the number of **DAS** triggers generated by the **ACB**. When the programmed number of triggers is received, the zero triggers signal is asserted, causing exposure command to deactivate, trigger generation to deactivate and firmware to be interrupted by a maskable interrupt on **VME** IRQ4.

To allow for variable length scans, such as required by the **CT** Smartview option, four counters make up the **DAS** trigger counter circuit: pre-trigger, minimum triggers, maximum triggers and cycle triggers. Note that if the respective counter is programmed to zero, then the output is active. When the pre-trigger counter expires, the other counters begin counting. This allows for a fixed number of triggers to be generated outside of the control of the other counters. The minimum counter inhibits the zero trigger signal until at least a minimum number of triggers in addition to pre-triggers has been generated. The maximum counter asserts zero trig when the maximum number of triggers in addition to pre-triggers has been generated. The cycle counter, in conjunction with a bit programmable via the **VME**, can be used to force the system to collect an integer number of triggers in addition to pretriggers. The cycle counter allows for the acquisition of a variable number of “sectors” during scanning.

Speed control is achieved by using the Axial encoder input in two places: the **STC** and the **AMD** via the **ACB**. The **AMD** uses the encoder feedback to close its control loop and regulate speed. The **STC** uses the encoder feedback and compares it to the AT SPEED feedback from the **AMD**. The **AMD** status is polled every 25 msec. A speed fault will occur if 5 consecutive samples are out of tolerance. The speed regulation is ± 3% of commanded velocity.

SCAN SPEED (SEC)	VIEWS PER GANTRY ROTATION	SLIPRING BANDWIDTH (MBAUD)
Scout	Variable	Variable
0.7	980	117
1.0	984	83
2.0	1968	83
3.0	2952	83
4.0	3936	83

Table 8-3 Scan Speeds, # of Views and Slipring Bandwidth

1.2 Axial Control *(Major Function)*

1.2.1 Axial Power Contactor Interlock (Minor Function)

The Axial Power Contactor minor function controls the 440 VAC input to the Axial Motor Drive. The Axial Power Contactor is an AC rated contactor that connects or disconnects the 3-phase 440 VAC. This function also provides status monitoring and reporting of the power contactor. There is an interlock in the power contactor control for the Axial Enable/Disable switch on the **STC** chassis backplane.

DANGER **DISABLE THE AXIAL DRIVE MECHANISM BEFORE SERVICING THE GANTRY INTERIOR. THE AXIAL LOOP CONTACTOR STATUS LED ON THE STC CHASSIS BACKPLANE INDICATES THE STATUS OF THE AXIAL POWER CONTROL CIRCUIT ONLY, NOT THE STATE OF THE AXIAL POWER CONTACTOR. A FAILURE IN THE POWER CONTACTOR COULD LEAVE 440 VAC CONNECTED TO THE AXIAL MOTOR DRIVE AT ALL TIMES.**

1.2.1.1 Axial Power Contactor Circuit

The base requirements for this circuit to function are: Power to the **PDU**, DRIVEON enabled, and Axial drive switch enabled on the **STC** chassis backplane. At this point the firmware is needed to close the Axial Drive Power Contactor. This means the scan hardware needs to be downloaded successfully. The Axial II Control Board, Altera (**FPGA**), now contains the necessary firmware. When the **FPGA** receives a valid request to rotate the gantry, the LOOPCONT signal is generated. This signal energizes the K3 relay on the Axial board. The following sequence then occurs.

The 24V-B from the **PDU** relay board goes through the Axial drive enable switch, S2, on the **STC** chassis backplane. At this point 24V-B becomes AX_DR_EN_SW/SW2. When Axial board relay K3 closes, AX_DR_EN_SW/SW2 becomes CLOSELOOP as it leaves the Axial board. The CLOSELOOP signal goes to the **PDU** Relay bd, K6. This in turn energizes K13, on the **PDU** relay bd, generating the LOOPHI command. LOOPHI energizes A3K4, which closes and provides 3-phase 440 VAC power to the Axial Motor Drive.

Note: 440 VAC will be present at the Axial Motor Drive under normal conditions. Remember that this is firmware controlled. Also the Axial Drive Enable Switch on the **STC** backplane will disable/enable the Axial Drive Power Contactor independent of firmware control. A second hardware reset is not required.

1.2.1.2 Axial Power Contactor Read Back Circuit

When the Axial Power Contactor is energized, it closes a set of N.O. contacts that permits the application of +24V through the Axial Power Contactor relay contacts, back to the Gantry. The signal LOOP-CONT-CLOSED enters the Axial Board at J2A3 and flows into an opto-isolator. The opto-isolator converts the 24 VDC LOOP_CONT signal to 5 volt logic and is sent to the Altera (**FPGA**). Also the green **LED** LPC (DS13) illuminates.

LOOP-CONT-CLOSED_RTN is actually PGND from the **PDU**. This is a differential circuit.

1.2.1.3 Axial Brake Circuit

The Altera generates the AXBRAKE command based upon the scan type and firmware request. A 5 VDC signal called AX_BRAKE_OUT is routed to the SSR (Solid State Relay) mounted on the Axial motor. This signal is always present. The Altera generates the control signal AXBRAKE, which provides a return path for AX_BRAKE_OUT_RTN. This allows current to flow through the SSR, which energizes the coil of the holding brake assembly. When the SSR is energized, its contacts close and apply 120 VAC to the Axial Holding Brake assembly. The Axial Holding Brake is now released. With no power applied, the holding brake is engaged.

Note: The axial brake is released when the Axial Drive Enable Switch is in the “disable” position. This allows the gantry to be rotated by hand without fighting the friction of the brake.

1.2.1.4 Remote Axial C-Pulse Indicator Circuit

The Axial II Control Board receives the “C” pulse from the encoder at J2D25 (AX_ENC_CHC) and J2C25 (AX_ENC_CHC_RTN). This signal is opto-isolated and becomes CHC. A green **LED** DS2 (CHC) lights when a “C” pulse is received. CHC is processed and becomes CH_C*. This CH_C* signal provides the return path for REMOTE_C_L. REMOTE_C_H is the 5 VDC source used to illuminate the “C” pulse **LED** on the **STC** backplane. The “C” pulse **LED** located on the left fan assembly is also driven by this circuit.

1.2.2 Axial Servo Control Loop (Minor Function)

The hardware involved in the axial servo drive consists of the Axial II Control Board, Axial Motor Drive, Axial Motor, Axial Motor Brake, Axial Encoder, Axial Drive Belt and Axial Home Flag.

The Axial Motor is an induction motor. The axial brake engages the motor shaft and is meant as a static brake to hold the gantry still once it has been positioned by the axial drive. The brake's friction is not sufficient to hold the gantry still against the full accelerating force of the motor and amplifier. Should the brake fail while the gantry is in motion, the gantry will continue to rotate until halted by firmware. The brake cannot hold the gantry still while the tube or inverters are being changed. When servicing the rotating base, the gantry should be locked using the locking block mechanism.

The axial brake is released when the Axial Drive Enable Switch is in the “disable” position. This allows the gantry to be rotated by hand without fighting the friction of the brake.

The encoder is directly coupled to the rotating bearing. It is an incremental encoder and provides 2048 counts per rotation. The quadrature information from the encoder is decoded on the Axial board and used for gantry position and speed control as well as **DAS** trigger generation.

The motor is coupled to the rotating bearing with a steel reinforced Kevlar belt, with a gear ratio of 13 motor rotations to 1 gantry bearing rotation.

1.3 HSDCD (High Speed Data Capacitive Device) Slip Ring Architecture

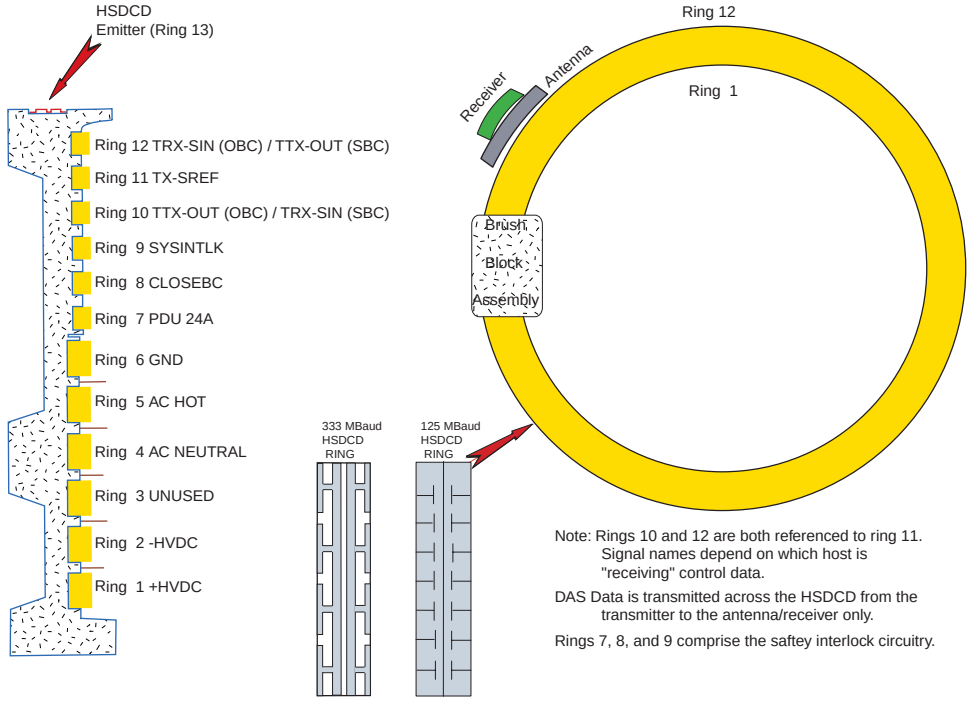


Figure 8-8 High Speed Data Capacitive Device (HSDCD) Slip Ring Architecture

1.3.1 HSDCD Communications

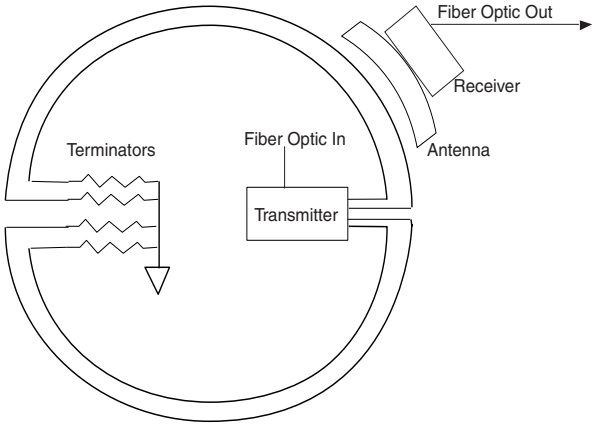


Figure 8-9 HSDCD Slip Ring Communications

1.3.1.1 HSDCD Modulation

DAS data received by the transmitter is converted into **HSDCD** (High Speed Data Capacitive Device) differential signalling. The transmitter converts its input to differential signals on the ring itself. The antenna is capacitively coupled to the ring and passes the differential signal to the receiver. The receiver converts and amplifies the differential signal to the original transmitter data input format.

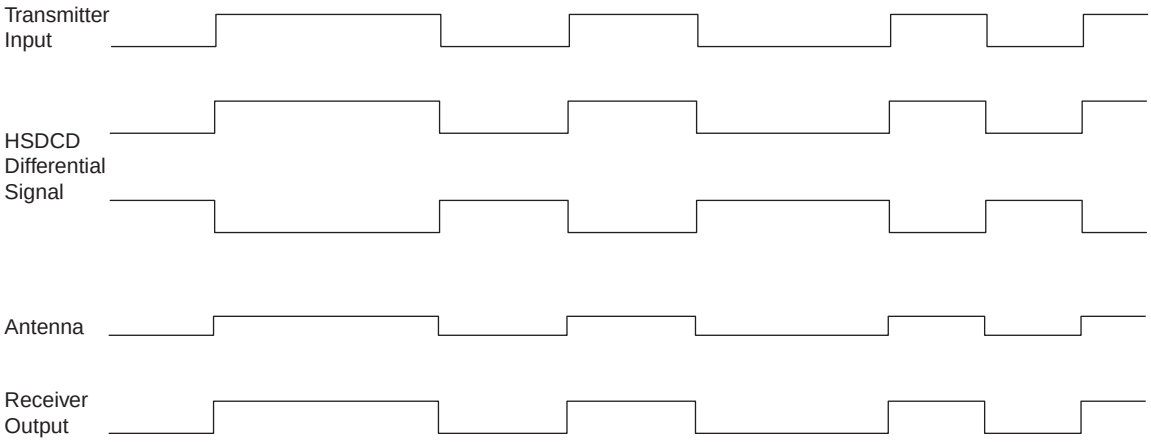


Figure 8-10 HSDCD Modulation

1.3.1.2 Data Rate

Serial Taxi **DAS** Data is transmitted at a rate of333 MBaud. Each bit cell is 3 nanoseconds wide. Each word consists of 16 bits within 20 bit encoding, so each byte cell is 30 nanoseconds wide.

1.3.1.3 HSDCD Transmitter

The function of the transmitter is to take **DAS** data from its fiber-optic input port and send this signal out on transmitting antenna structure.

1.3.1.4 HSDCD Ring

The **HSDCD** section of the slip ring is actually made up of a circuit board material that has two traces that run its entire circumference to carry the differential signal. This is called the emitter. It also has

a ground plane underneath. The dimensions of the board are controlled to maintain a low trace impedance. This cross sectional shows its construction.

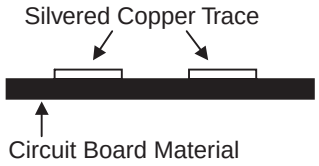


Figure 8-11 HSDCD Ring

At the end of each strip, opposite the end fed by the transmitter, each trace is terminated with a 16 ohm surface mount resistor to the ground plane. Each board strip feeds one half of the ring with the **HSDCD** signal.

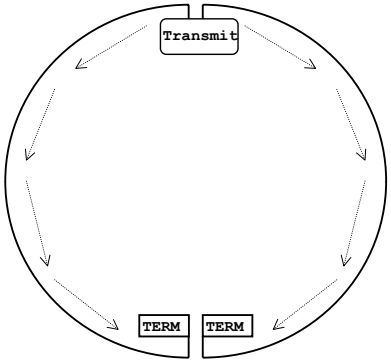


Figure 8-12 HSDCD Ring Termination

1.3.1.5 HSDCD Antenna

The purpose of the **HSDCD** antenna is to pick up the differential signal from the traces on the ring. The pickup face of the antenna, which is positioned 1.41 mm (0.60 inches) height (use alignment tool 2245483) away from the ring traces, has two traces the same width and spacing as the traces on the ring, and each one acts like one plate of a capacitor. Hence, the signals are capacitive coupled from the ring to the antenna.

1.3.1.6 HSDCD Receiver

The purpose of the **HSDCD** receiver is to amplify the transmitted data signal from the **HSDCD** antenna to a usable level and convert it back into fiber-optic **DAS** taxi data.

1.3.1.7 Communication Error Rates

Errors are caused by any noise that enters the **HSDCD** system within its pass band. Communication error rates are measured by how many errors occur in N number of bits. This is called the Bit Error Rate (BERR). The **HSDCD** system has been designed to produce 0 or 1 bad bits in 10E12 bits. Note that this is exclusive of forward error correction that enhances BERR to 0 or 1 errors in 10E14 bits. Under normal system operation, this would translate into one scan abort in five years due to **DAS** data channel errors. The system BERR performance can be monitored through the Dip Stats selection under the service menu. This tells you:

- When the DipStats file was created or reset to zero
- When the stats were last updated (end of last exam)
- How many data bytes were transmitted since file creation (or reset)
- How many offset bytes were transmitted since file creation (or reset)
- How many taxi violations occurred since file creation (or reset)

- How many successful forward error corrections (**FEC**) occurred since file creation (or reset)
- How many scan aborts (unsuccessful **FEC**) occurred since file creation (or reset)

BERR can be calculated by the following:

E Number of Errors = Number of Scan Aborts

NO Number of offset bits = Number of offset bytes X 10

ND Number of Data bits = Number of data bytes X10

BERR = E / (NO + ND)

1.3.2 HSDCD Service Indicators

1.3.2.1 HSDCD Transmitter

The transmitter has two **LED**s. The green **LED** is on for power and the yellow is on for data. The yellow data **LED** is normally on in both system idle or active data collection.

1.3.2.2 HSDCD Receiver

The receiver has two **LED**s. The green **LED** is on for power and the yellow is on for data. The yellow data **LED** is normally on in both system idle or active data collection.

1.3.2.3 HSDCD Antenna

The **HSDCD** antenna has no indicators.

1.3.2.4 Brush Tip Wear Indicators

Each individual brush has an arrow stamped into one side of the tip material. Brushes should be replaced when worn to the tip of the arrow.

1.4 Gantry Tilt

Gantry tilt is achieved by means of a hydraulic pump and 2 hydraulic cylinders. Control signals are received from the **ETC-IF** board. The Tilt Relay board can operate in 2 modes: system control or manual. Under system control, the tilt relay board receives tilt enable, forward and backward control signals. These signals energize either the pump motor or tilt solenoids. Under manual control, power is received from the **STC** power circuit, and motion is controlled manually by switch S2. Switch S1 determines system or manual control.

Gantry forward tilt requires the energizing of the pump motor. The pump increases the fluid pressure in the system, resulting in the extension of the cylinder pistons, and the gantry tilts forward.

Gantry backward tilt requires the energizing of the two (2) tilt backward solenoids. This relieves fluid pressure, and the weight of the gantry compresses the cylinder pistons. This is true for all gantry angles. Reference Figure 8-13.

Speed control for both forward and backward motion is set by adjusting separate restrictor valves for 1 second per degree of motion.

The hydraulic system has a pressure relief bypass valve, which is factory set to 50 kgf/cm squared. This hydraulic system is also self bleeding.

Tilt limits are set at ± 30 degrees. Angle position is monitored via feedback of the tilt potentiometer. The feedback is sent to the table electronics, where it is digitized for gantry tilt display and prescribed remote tilt position control.

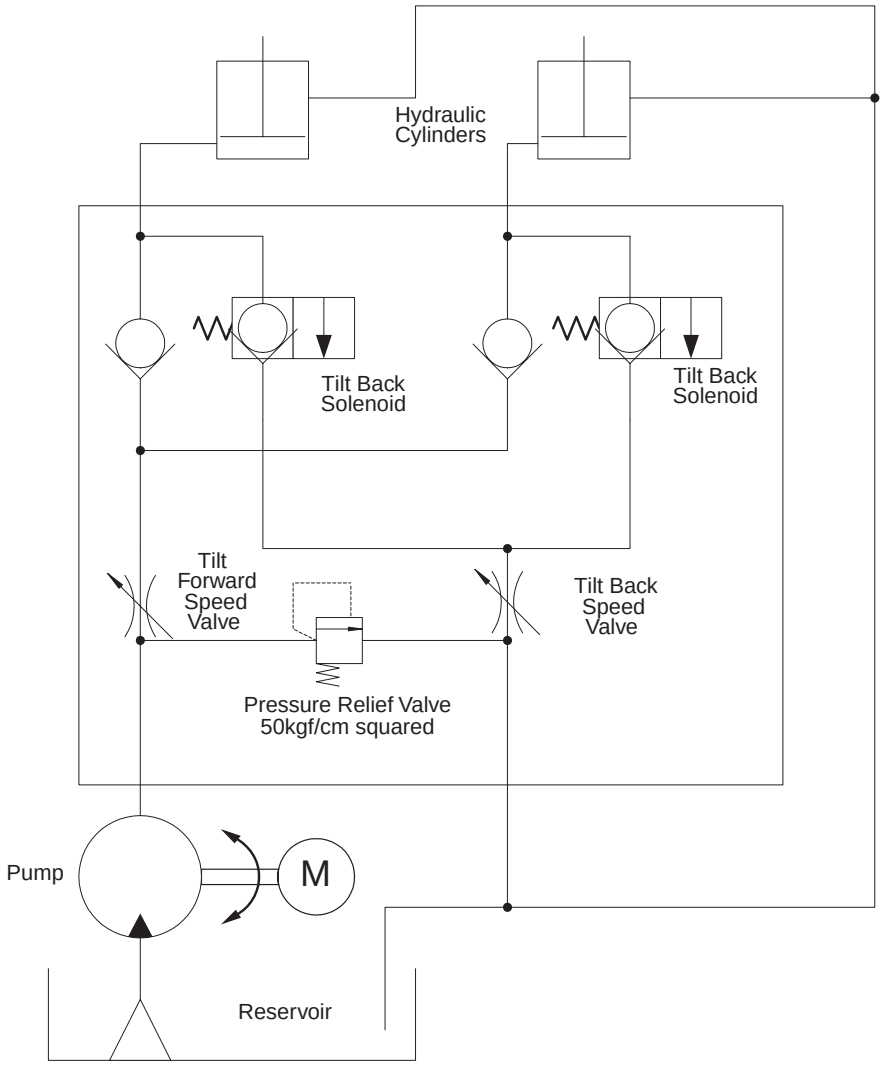


Figure 8-13 Gantry Hydraulic Tilt Functional Block Diagram

1.5 Gantry Service Balance

Gantry service balance is achieved by use of a service **GUI** tool, accessed from a variety of locations, from the common service desktop. This balance procedure is used for the Static (or X) Balance only. Dynamic (or Z) Balance is performed during manufacturing, and is not possible in the field.

WARNING **GANTRY BALANCE MUST BE CHECKED FOR ANY COMPONENTS REPLACED ON OR REMOVED FROM THE ROTATING ASSEMBLY.**

Why? > Large changes in “X” have small effects on “Z” motion.

Where? > Where any part is replaced on the Rotating Gantry Assembly.

When? > After every rotating gantry part replacement.

Measurements of Gantry motion:

- Motion > kg-m, kilograms per meter
- Amplitude > kg-m, kilograms per meter
- Phase Angle > Degrees, 0 to 360

How is Gantry Imbalance Detected?

- X motion is a 1 hertz signal per 360 degrees of gantry rotation.
- The amplitude of this signal determines the percent of imbalance.
- The phase angle determines where trim weight needs to be added to achieve desired gantry balance.

The Axial drive subsystem is the heart of Field Gantry Balance.

The Axial Encoder output is the source of data for calculations.

Firmware controls axial open loop rotation and data calculations.

Calculation results are reported using an arbitrary scale.

- Balanced > 0 to 180 counts, GREEN
- Marginally Balanced > 180 to 240 counts, YELLOW
- Not Balanced > 240 or greater count, RED

The gantry service balance procedure consists of four steps, and requires new balance trim weights, as described below:

- Balance Check > Evaluate current Gantry Balance state.
- Create Baseline > Remove “Trim Weights” and calculate Gantry Imbalance.
- Reference Weights > Add “8” Full Side weights and calculate “known” Gantry Imbalance amplitude and phase angle. Report recommended “Trim Weights” and locations to achieve gantry balance.
- Balance Verification > Same as Balance Check.
- Side Weight “Full and Half” > Mounted at 125 and 235 degree rotating gantry locations.
- Round Weights > Mounted at 84 and 276 degree rotating gantry locations.
- Wedge and Wedge Adder Weights > Mounted at 60 and 308 degree rotating gantry locations.

PROBABILITY OF IMBALANCE IN THE FIELD

FRU Replacement Examples

- Tube Change > 0.1 per 1000
- Tube and **HV** Tank > 3 per 1000

Risks of False Results

- Axial hardware component failures
  - Axial Encoder
  - Axial Circuit Board
  - Axial Drive Assembly
- Incorrect Reference Weight Placement
- Incorrect torque of Trim Weight Fasteners

Risk of Severe Gantry Damage

- Incorrect installation of Full Side Weights at 125 or 235 degree locations.
- Using Threaded Rods to manually rotate the gantry.
- Incorrect torque of Trim Weight Fasteners.

Section 2.0
Procedures and Adjustments

2.1 Power Supply Checks

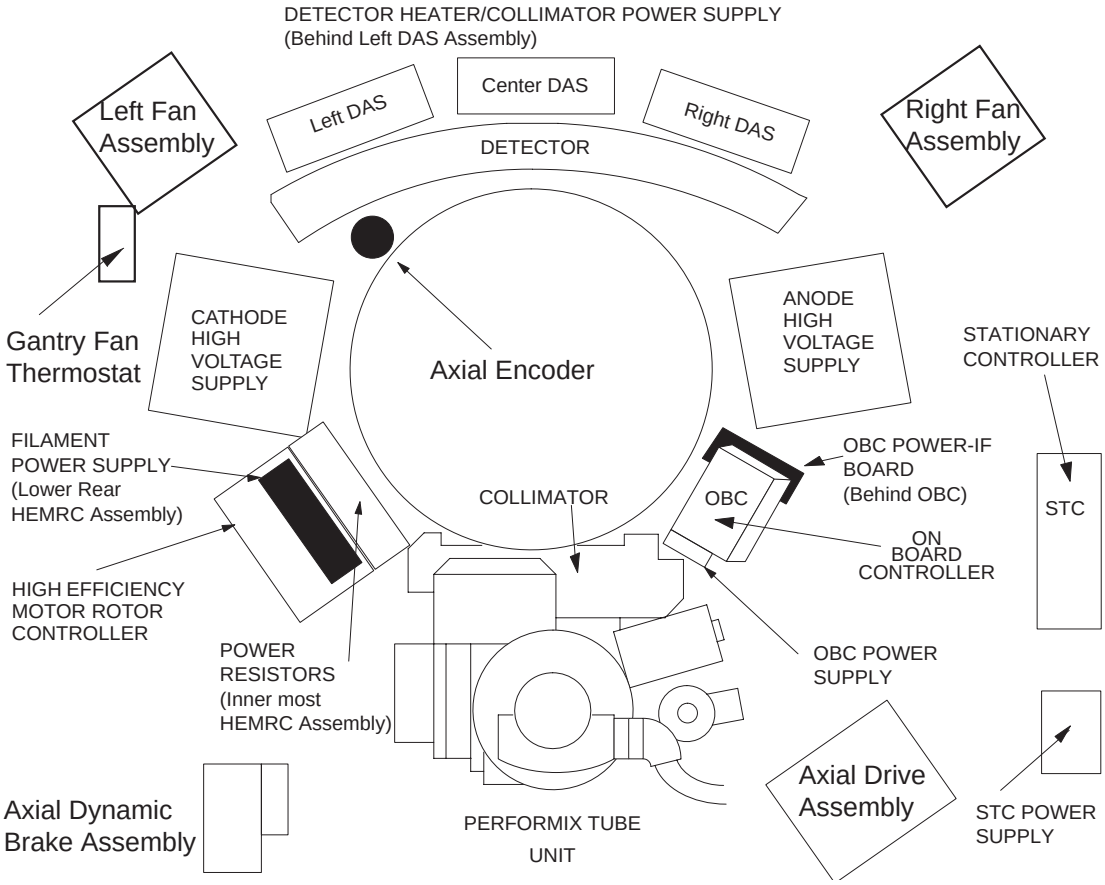


Figure 8-14 GANTRY POWER SUPPLIES WITH A PERFORMIX TUBE

2.1.1 STC Power Supplies

1.) Turn OFF the axial drive enable and **HVDC** enable switches on the **STC** chassis.
2.) Turn ON gantry 120VAC enable switch on the **STC** chassis.
3.) Use a DVM to verify the **STC** power supply voltages at the following test points on the Axial bd:

AXIAL BOARD TEST POINTS	SPECIFICATIONS	SOURCE
TP12 (VCC) WRT TP9 (GND)	+5vdc (±0.25V)	**STC** Power Supply
TP10 (3V3) WRT TP9 (GND)	+3.3vdc (±0.05V)	Axial Board (No Adjustment)
TP3 (12V) WRT TP3 (HGND)	+12vdc (±0.25V)	Axial Motor Drive (No Adjustment)
TP2 (5V CAN) WRT TP1 (HGND)	+5vdc (±0.25V)	Axial Board (No Adjustment)
WRT means “With Respect To”		

Table 8-4 STC Power Supply Test Points

FUSE	VALUE	DESCRIPTION
F1	1 amp	5Vdc to external Axial Encoder & Home Flag assemblies
F2	1 amp	5Vdc to external Cardiac Interface assemblies.

Table 8-5 STC Backplane Fuses

SWITCH #	LABEL	DESCRIPTION
S1	S1	Momentary PB, resets gantry drives enable circuit in **PDU**.
S2	S2	Toggle switch enables Axial Drive.
S3	S3	Toggle switch enables **HVDC**
S4	S4	Toggle switch enables Gantry 120Vac

Table 8-6 STC Switches

LED	COLOR	LABEL	DESCRIPTION
DS1	Green	C Pulse	C Pulse indicator from Axial Encoder.
DS2	Green	RST	Indicates status of the **HVDC** & gantry drives circuit in the **PDU**: On steady = **HVDC** & Drives Enabled Slow Flash = E-Stop activated. **HVDC** & Drives Disabled Fast Flash = Table Tape Switch activated. Cradle, Tilt & Elevation Disabled
DS3	Yellow	AX DR ON	Indicates the Axial Drive Contactor in the **PDU** is energized.
DS4	Green	ENBL	Indicates the Axial Drive Contactor in the **PDU** is enabled.
DS5	Yellow	HVDC ON	Indicates the **HVDC** Contactor in the **PDU** is energized.
DS6	Green	ENBL	Indicates the **HVDC** Contactor in the **PDU** is enabled.
DS7	Yellow	120VAC ON	Indicates the Gantry 120Vac Contactor in the **PDU** is energized.
DS8	Green	ENBL	Indicates the Gantry 120Vac Contactor in the **PDU** is enabled.
DS9	Green	ENC PWR	Indicates fuse, F1, which feeds the Axial Encoder is OK.
DS10	Green	HHC PWR	Indicates fuse, F2, which feeds the Cardiac Interface is OK.
DS11	Green	ETC PWR	Indicates 5Vdc from the **ETC**, which feeds Hand-Held Control is OK.

Table 8-7 STC LEDs

TP #	COLOR	LABEL	DESCRIPTION
TP1	Yel	TRX-SIN	Communication signals inbound to **STC** from Slip Ring 10.
TP2	Blk	TX-SREF	(Isolated) Communication signals reference from/to Slip Ring 11.
TP3	Yel	TTX-SOUT	Communication signals outbound from **STC** to Slip Ring 12

Table 8-8 STC Test Points

2.1.2 OBC Power Supplies

Turn OFF the Axial Enable and **HVDC** switches on the **STC** backplane.

NON-ADJUSTABLE SUPPLIES	ADJUSTABLE SUPPLIES
OBC +24	**ETC**,**OBC**, +5, ±15
Table (Display, Emergency Stop) +24	Table (Cradle Drive, Relays) +24
Filament Supply +30	Data Communication +12
Tilt/Elevation +170	**DAS** +5, ±5
	Collimator/Detector Heater +24

Table 8-9 OBC and Table Power Supplies

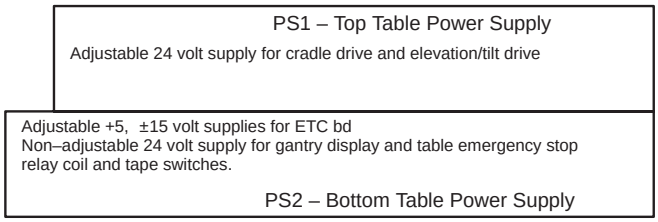


Figure 8-15 Table Power Supplies (Left View)

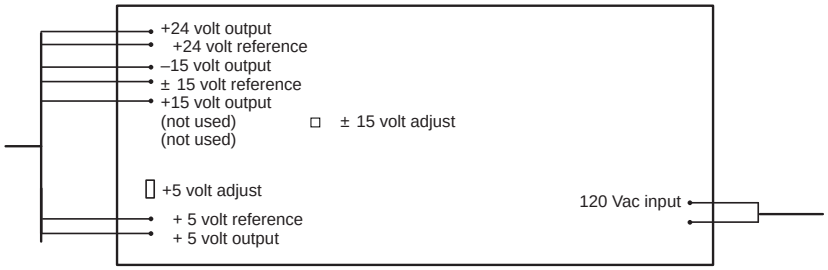


Figure 8-16 OBC and Bottom Table Power Supplies (Top View)

TEST POINT	SPECIFICATION
Gentry I/O bd **TP 3** Ref **TP 4**	5 vdc ± 0.25 vdc
Gentry I/O bd **TP 6 (+15**) **TP 7 (-15**) Ref **TP 5**	±15 vdc ± 0.25 vdc
Gentry I/O **TP 11** Ref **TP 17**	24 vdc ± 2.0 vdc

Table 8-10 OBC Power Supply Test Points and Specifications

SW #	LABEL	DESCRIPTION
S1	Lights Laser	Laser alignment light control ON/AUTO.

Table 8-11 OBC Backplane Switches

LED #	COLOR	LABEL	DESCRIPTION
DS1	Yellow	DS1	Indicates laser alignment light power supply is ON.

Table 8-12 OBC Backplane LEDs

RELAY #	LABEL	DESCRIPTION
K78	K78	Filament selection relay. De-energized => Large Focal Spot Selected. Energized => Small Focal Spot Selected.

Table 8-13 OBC Backplane Relays

TP #	COLOR	LABEL	DESCRIPTION
TP1	Yellow	TRX-SIN	Communication signals inbound to **OBC** from Slip Ring 12.
TP2	Black	TX-SREF	(Isolated) Communication signals reference from/to Slip Ring 11.
TP3	Yellow	TTX-SOUT	Communication signals outbound from **OBC** to Slip Ring 10.

Table 8-14 OBC Backplane Test Points

2.1.3 OBC Power Interface Board

Turn OFF the axial drive enable and **HVDC** enable switches on the **STC** chassis.

- The primary function of the **OBC** PWR I/F is to provide a single, 120 VAC power distribution point on the rotating gantry for the X-Ray Generation Subsystem.
- The second function of the board is to provide a convenient location for fusing the various subsystem circuits. In this way the major pieces of the XRGEN subsystem have been grouped logically, while adequately protecting the harnessing from faults.
- The third function is to provide “Open Fuse Detection” for the Tube fan & pump circuit. A small voltage sensing circuit monitors the level at the load end of F3. If fuse F3 should open, the optically coupled solid state relay, U1, will interrupt the XRT pressure switch signal to the Gentry I/O board. This will cause an immediate scan abort and prevent additional energy from being dumped into the XRT.
- For personnel protection, adhesive insulating pads are applied to the back of the **OBC** PWR I/F board to protect service personnel from accidentally contacting live component leads.
- The **OBC** PWR I/F contains devices that can be damaged by **ESD**. This damage may not be immediately apparent, but may show up in the future as degraded operational performance. Therefore, these components should never be handled by anyone who is not wearing a properly grounded **ESD** prevention wrist strap. Careful attention to **ESD** packaging and handling procedures are required, to insure long term reliability of this assembly.

FUSE #	RATING	DESCRIPTION
F1	8A, MDA	Protects 120 VAC to the **OBC** and Inverters.
F2	15A, MDA	Protects 120 VAC to the **HEMRC** Assembly.
F3	12A, FNM	Protects 120 VAC to the X-Ray Tube Assembly.
		Note: All fuses are specified with slow-blow characteristics.

Table 8-15 OBC Power Interface Board Fuses

LED #	COLOR	LABEL	DESCRIPTION
DS1	Green	DS1	Indicates 120 VAC is present on the board.

Table 8-16 OBC Power Interface Board LEDS

CONNECTOR	VALUE	COMMENTS
J8-1 & 2	120 VAC (Line)	Input externally protected to 30A maximum.
J8-3 & 4	0 VAC (Grounded Neutral)	

Table 8-17 OBC Power Interface 120 VAC Distribution

There are no Switches or Test Points on this board.

2.1.4 DAS Power Supplies (2225212-2 ±5 vdc, 2225217 (2) 12 vdc)

Test Points are available on the Center Backplane to measure Power Supply voltages.

TEST POINT	DESCRIPTION	SPECIFICATIONS
TP1	+12 VDC Analog wrt AGND	+12 vdc ± 0.6 vdc
TP2	-12 VDC Analog wrt AGND	-12 vdc ± 0.6 vdc
TP3	+5 VDC Analog wrt AGND	+5 vdc ± 0.25 vdc
TP4	-5 VDC Analog wrt AGND	-5 vdc ± 0.25 vdc
TP5	LGND (Logic Ground)	
TP6	AGND (Analog Ground)	
TP7	+5 VDC Digital wrt LGND	

Table 8-18 Backplane Voltage Test Points

2.1.5 Fuse Box Power Distribution

FUSE #	RATING	DESCRIPTION
DAS Power	15 Amp 250V MDA	**DAS** AC Input Power
24 VDC	6 amp 250V 3AG Fast	Detector Heater
-12 VDC	3 amp 250V 3AG Slo-Blo	**DAS** Power
+12 VDC	3 amp 250V 3AG Slo-Blo	**DAS** Power
-5 VDC	2 amp 250V 3AG Slo-Blo	**DAS** Power
+5 VDC	2 amp 250V 3AG Slo-Blo	**DAS** Power
5 VDC Logic	6.25 amp 250V 3AG Slo-Blo	**DAS** Power
Power Switch	SPST 15 Amp @ 125 VAC	**DAS** Power Switch

Table 8-19 DAS Power and Fuse box Specifications

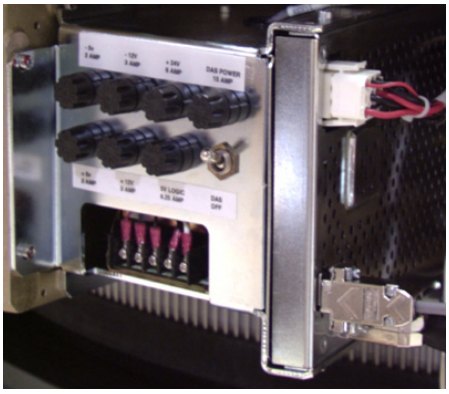


Figure 8-17 DAS Power and Fuse box Assembly

2.2 Axial Motion Checks

2.2.1 Axial Encoder Check

Turn the Gantry by hand until it passes through the Axial Home Flag. Verify:

- Axial board CHA and CHB **LED**s toggle.
- Axial board CHC **LED** toggles on and off once while home **LED** is illuminated.
- Also verify the “C Pulse” **LED** on the **STC** Backplane illuminates with the CHC **LED**.

2.2.2 Axial Home Flag Check

Turn the Gantry by hand until the Axial Home Flag approaches the sensor. Verify:

- Flag passes through sensor without making contact.
- Flag is centered in sensor window top to bottom.
- With flag in sensor window, verify DS5 (Home) **LED** on Axial board illuminates.
- Perform Axial Encoder Check, page 580.

2.2.3 Axial Brake Check

Toggle the axial drive enable switch on the **STC** backplane. Listen to the brake; it should energize and de-energize.

Note: The brake may not toggle if the system underwent a hardware reset since the last time you turned on gantry AC power. If the brake doesn’t toggle, use the 120 VAC enable switch on the **STC** backplane to turn gantry 120 VAC power off, then on. Then toggle the axial drive enable switch on the **STC** backplane. You should now hear the brake as it energizes and de-energizes.

Make sure:

- When you turn off the axial drive enable, the switch pilot light turns off and the brake releases. (You can easily rotate the Gantry by hand.)
- When you turn on the axial drive enable switch, the switch pilot light turns ON and the brake energizes.

Turn on all three switches on the **STC** backplane.

2.2.4 Axial Dynamic Brake Fuses

FUSE#	VALUE	DESCRIPTION
F1	20A, 700Vdc	Not Used
F2	20A, 700Vdc	Not Used
F3	3A, 250Vdc	Not Used
F4	8A, 350VAC Slo-Blo	Not Used
F5	8A, 350VAC Slo-Blo	Not Used
A4 F1	10A, 700Vdc	DCIN+ to Chopper Resistor Assembly

Table 8-20 Axial Dynamic Brake Fuses

2.2.5 Axial Control Functional

Perform gantry rotational testing using Axial Functional Diagnostic. Service Desktop>Diagnostics>Axial Control>Axial Functional.

1.) Perform one (1) pass each "Open Loop Rotation" at each scan speed. Verify no errors.
2.) Perform one (1) pass each "Closed Loop Rotation" at each scan speed. Verify no errors.
3.) Perform several passes of "Goto Position" choosing different angles. Verify no errors.

2.3 Resetting the C-Pulse

1.) Turn off the axial drive and the **HVDC** switches located on the **STC** backplane.

2.) Rotate the gantry until the middle of the home plate is in the center of the opto-sensor window. Verify that the DS3 **LED** on the axial board lights up. Notice that when the gantry is rotated, **LED**s DS7 and DS6 flash. The DS3 **LED** should only light up when the home plate is in the opto-sensor window.

3.) Once the DS3 **LED** is on, rotate the gantry ± 1 degree. Verify that the DS2 **LED** lights up. Notice that the DS2 **LED** might not stay on but rather just flash. The key is to stop rotating the gantry as soon as the DS2 **LED** flashes. If the DS2 **LED** flashes or lights up, you have coincided with the c-pulse, otherwise follow the additional step.

If the DS2 **LED** does not flash or light up, verify that the home plate is in the center of the opto-sensor, and lift as well as rotate the encoder gear assembly until DS2 lights up.

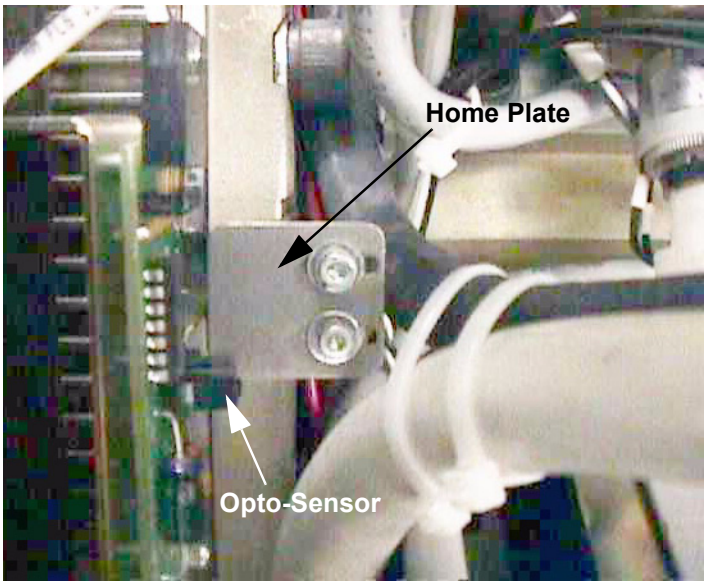


Figure 8-18 Home Plate Passing Through Opto-Sensor Window

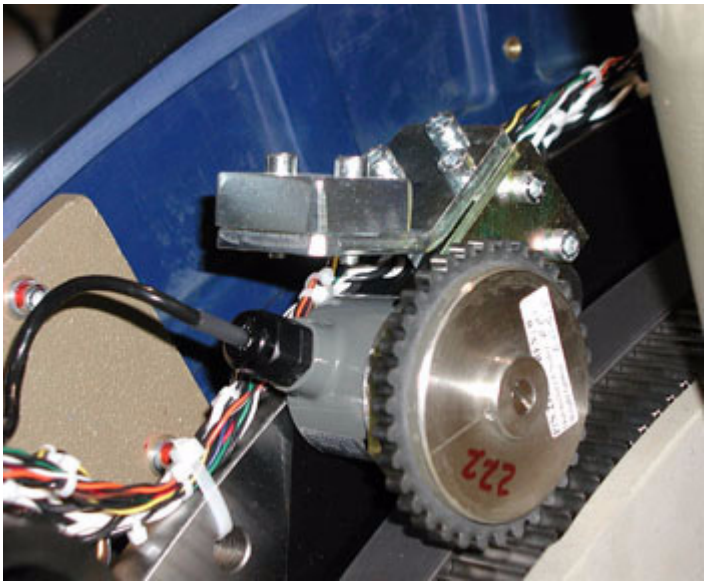


Figure 8-19 Encoder

2.4 Tilt Pot Assembly

Tilt angle accuracy is achieved by using potentiometer feedback and three reference points. Characterization is performed by reading the potentiometer voltage feedback at each of these three points. This method creates a slope characterization file that is accurate, independent of the gantry leveling procedure performed during installation. (See the installation manual for details on gantry leveling.) For this reason, unique precise tilt angle values are written on the tilt label for your system. Reference Figure 8-20. This method allows manufacturing to measure and record precise tilt angle values using an inclinometer. The manufacturing process first takes a relative reading creating an offset, and then absolute readings are used with offset correction. The result is actual tilt angles during normal system operation.

CAUTION **DO NOT ATTEMPT TO ADJUST THE 150 TOOTH PULLEY. THIS IS FACTORY SET. DISTURBING THIS PULLEY WILL RESULT IN INVALID TILT LABEL VALUES AND INACCURATE APPLICATION TILT ANGLES. CARE SHOULD ALSO BE USED TO PREVENT DAMAGING THE LEGIBILITY OF THE TILT LABEL.**

2.4.1 Tilt Pot and Belt Adjustment

The tilt pot is a 5 turn, 5k ohm potentiometer. The adjustment of this potentiometer can be confusing. The procedure is based upon a relative tilt value as opposed to an absolute or real value. It is very important that this procedure be followed carefully.

CAUTION **DO NOT USE THE GANTRY DISPLAY TO DETERMINE TILT ANGLE. YOU MUST USE THE SCRIBE MARKS ON THE 150 TOOTH PULLEY TO SET CORRECT TILT ANGLE FOR POTENTIOMETER ADJUSTMENT.**

1.) Tilt gantry to middle reference position. Refer to Figure 8-20.

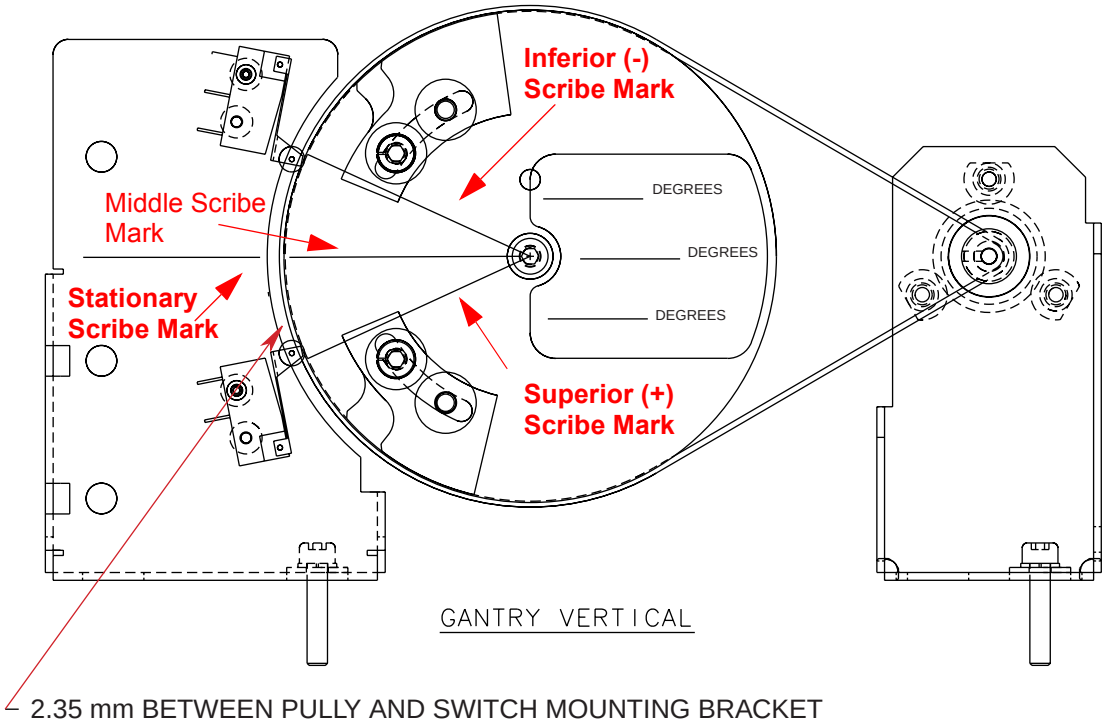


Figure 8-20 Tilt Pot Adjustment Diagram

2.) For coarse adjustment, loosen tilt pot mounting bracket and relieve tension on the timing belt.

3.) Connect DVM minus lead to **CCW** (center post) of the potentiometer and DVM plus to **S** (closest outside post) of the potentiometer.

4.) Rotate small pulley until the DVM reads 5 vdc.

5.) Restore belt tension with the tilt pot mounting bracket and secure.

6.) For final adjustment, loosen tilt pot clamps and rotate the body of the pot until the DVM reads 5.0 ± 0.1 vdc.

7.) Tighten pot clamps and verify DVM reading.

Refer to Figure 8-21 for the following steps:

8.) Loosen both screws holding the Tilt Pot Bracket.

9.) Ensure that the belt's edge is parallel to the Large Pulley.

10.) Tension the belt by applying a force of 0.56 N (.1258 lbs, 57.1 grams) to the Tilt Pot Bracket.

11.) While the belt is in tension, torque the two screws to 7.9 Nm (68.97 in.-lbs).

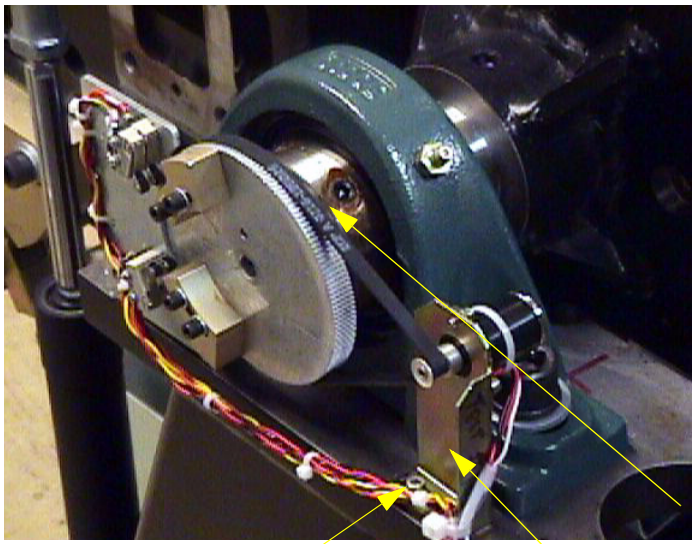


Figure 8-21 Tilt Pot Belt Tension Adjustment

Note: Although **CT** Engineering has indicated a “recommended” tension of 57.1 grams as optimal, the *exact* amount of force is not critical to proper system function. Measurement methods for this can be as specific as the use of a force gauge, or as general as a light tug, using one finger.

Tool suggestions:

1.) Locally acquired Force Gauge that measures in the 1 to 8 ounce range.

Example: Economy Linear Tension & Compression Gauge 8 oz X 220 G Cap, 0.25 oz X 5 G Grad, 14" Lg $69.11 Each (Part #2115T11), available from McMaster-Carr Supply Company.

2.) One finger with light force applied to the bracket.

2.4.2 Tilt Limit/Interference Adjustments

Tilt limit and interference is sensed using micro-switches to provide feedback in a faulted state. These switches are not activated during normal operation. Firmware control stops tilt motion prior to these switches being activated. A faulted state will prevent further tilt motion in that direction. Tilt is functional in the opposite direction to clear the faulted state.

Tilt interference limits are minus (-) 22.00 degrees and plus (+) 19.00 degrees.

Tilt limits are ± 30.00 degrees.

The interference matrix is dependent upon table elevation and cradle position.

ADJUSTMENT PROCEDURE

1.) Launch Tilt Characterization: SERVICE DESKTOP > SYSTEM INTEGRATION > CHARACTERIZATION > TILT CHARACTERIZATION

CAUTION **Do not accept and save any values during this procedure. You will corrupt your tilt characterization. This program disables firmware control and allows the user to tilt the gantry under hardware control to actuate the switches for adjustment and verification purposes.**

2.) Elevate the table slightly above middle height. Press and hold the limits pushbutton. Verify that S22 and I22 alternate on the gantry display tilt window. Adjust elevation height as necessary.

3.) Release limit pushbutton and tilt gantry back to minus (-) 22.50 degrees. This will be seen on the gantry display cradle window.

4.) Remove Back Limit Cam and adjust Back Interference Cam to actuate the Back Tilt Interference Switch. (Use a DVM set to DC volts to monitor the switch activation). See Figure 8-22.

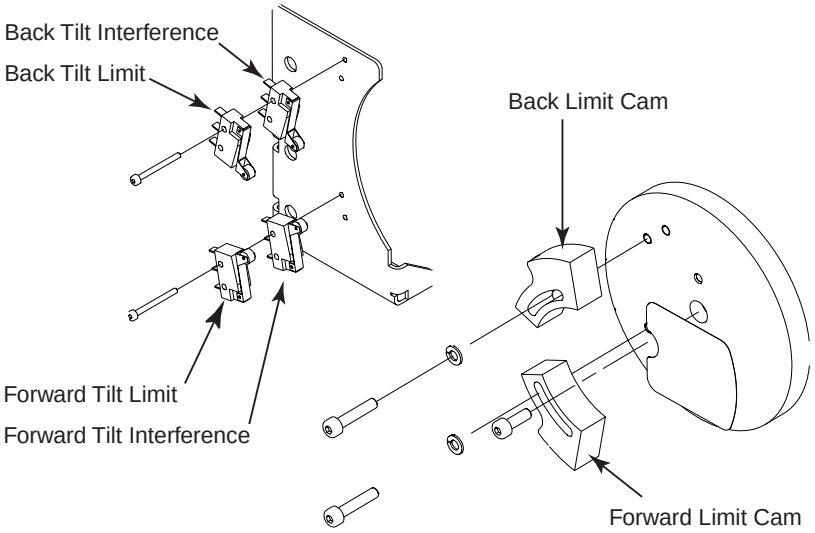


Figure 8-22 Tilt Limit/Interference Cam Adjustment

5.) Tilt gantry forward and then back again. Verify the tilt stops between minus (-) 22.50 and minus (-) 22.60 degrees as shown on the gantry display cradle window.

6.) Tilt gantry forward to plus (+) 19.50 degrees as shown on the gantry display cradle window.

7.) Remove the Forward Limit Cam and adjust the Forward Interference Cam position to just actuate the Forward Tilt Interference Switch. (Use a DVM set to DC volts to monitor the switch activation). Reference Figure 8-22.

8.) Tilt gantry back and then forward again. Verify the tilt stops between plus (+) 19.50 and plus (+) 19.60 degrees as shown on the gantry display cradle window.

9.) Elevate the table to maximum height. Press and hold the limits pushbutton. Verify that S30 and I30 alternate on the gantry display tilt window.

10.) Tilt gantry forward to plus (+) 30.25 degrees as shown on the gantry display cradle window.

11.) Install the Forward Limit Cam and adjust position to just actuate the Forward Tilt Limit Switch. (Use a DVM set to DC volts to monitor the switch activation). Refer to Figure 8-22.

12.) Tilt gantry back and then forward. Verify the tilt stops between plus (+) 30.25 and plus (+) 30.35 degrees as shown on the gantry display cradle window.

13.) Tilt gantry back to minus (-) 30.25 degrees.

14.) Install Back Limit Cam and adjust to actuate Back Tilt Limit switch. (Use a DVM set to DC volts to monitor the switch activation). Refer to Figure 8-22.

15.) Tilt gantry forward and then back again. Verify the tilt stops between minus (-) 30.25 and minus (-) 30.35 degrees as shown on the gantry display cradle window.

16.) Tilt the Gantry through both Forward and Backward tilt range. Verify the gantry stops at both angles as specified above.

17.) Proceed through the Tilt Characterization screens and exit **WITHOUT SAVING**. It is not necessary to tilt the gantry as instructed. Ignore all reported values.

18.) Exercise the tilt function under firmware control, and verify that the Interference and Limit Switches are not activated during normal operation. Use the DVM as above for each switch. Notice the gantry display will show tilt with 1 decimal point in the tilt window.

2.5 Hydraulic Tilt Motor Assembly

This assembly has two basic elements, fluid level and speed control.

2.5.1 Tilt Speed Adjustment Procedure

1.) Remove rear gantry base covers.

2.) Using a stop watch or suitable time piece adjust for one (1) degree per second motion.

CAUTION **Adjustments are very sensitive. Improper speed adjustments will result in overspeed error generation.**

Note: Tilt speed will vary based upon hydraulic fluid temperature. Adjustments should be made at normal scan room temperature settings.

3.) From zero (0) degrees tilt, press and hold the tilt forward button, until gantry display reads S25. Observe tilt speed using time piece.

4.) Press and hold backward tilt button, until gantry display reads I25. Observe tilt speed using time piece.

5.) Adjust forward speed control valve for one (1) degree per second motion. See Figure 8-23.

6.) Adjust backward speed control valve for one (1) degree per second motion. See Figure 8-23.

7.) Repeat steps 3 through 6 until tilt speed for both directions is correct.

8.) Now tilt the gantry forward to S30. Observe the S25 to S30 speed. Do this several times. If a noticeable difference is observed, then check the hydraulic fluid levels.

Note: This is a self bleeding system. Trapped air can cause slowed or limited tilt range. Exercising the full range of motion several times should purge any trapped air from the hydraulic system.

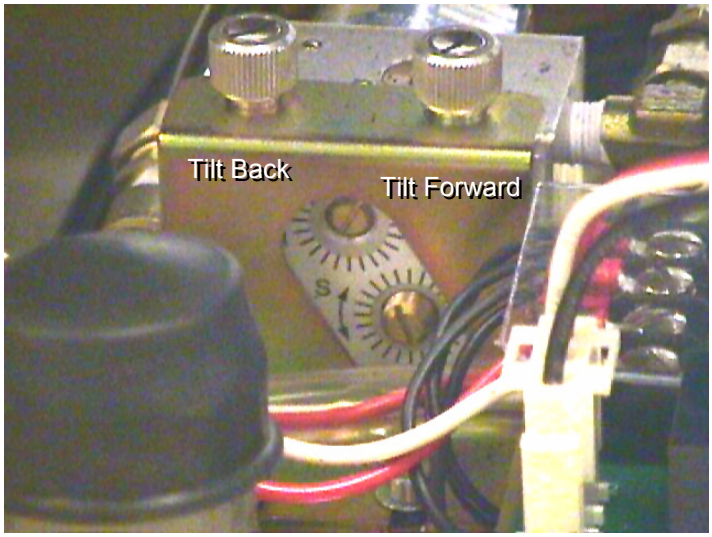


Figure 8-23 Tilt Speed Adjustment Screws

2.5.2 Hydraulic Fluid Check and Fill Procedure

REQUIRED TOOLS

- 5 mm Hex key
- Hydraulic fluid (P/N 2227239)
- Teflon Tape

CAUTION **ALWAYS CHECK AND FILL THE HYDRAULIC TILT ASSEMBLY WITH THE GANTRY TILTED FULL BACKWARDS. FAILURE TO DO THIS WILL RESULT IN HYDRAULIC FLUID SPILLS VIA THE OVERFLOW TUBE WHEN THE SYSTEM IS PRESURIZED.**

1.) Remove the rear gantry base covers.
2.) Tilt the gantry forward and backward the full range of motion several times. It is important that the pump be warm to the touch.
3.) When the pump is warm to the touch, tilt the gantry back 30 degrees.
4.) Remove the forward 6 mm cap screw (without the vent tubing).
5.) Use the 5 mm hex key as a dip stick.
Clean the hex key with alcohol to remove any grease or other contaminants.
6.) The fluid level should be just below the fill port (about 15 mm on your dip stick). Reference Figure 8-24.

Figure 8-24 Tilt Fluid Level Measuring Device

7.) To fill the unit a flexible hose on suitable squeeze bottle is recommended.
8.) Use paper towels to catch any overflow.
9.) Clean the threads of the cap and wrap 2 full turns with new teflon tape.
10.) Reassemble gantry.

Note: This Hydraulic system is not permanently sealed. It is normal to see RED coloring around the teflon tape of the threaded joints. The difference between a “seep” and a “leak” is a puddle.

2.6 Mechanical Characterization - Gantry Tilt

Select TILT and CHARACTERIZE in sequence, then follow the Tilt Characterization instructions displayed on the monitor screen. (See Figure 8-25.)

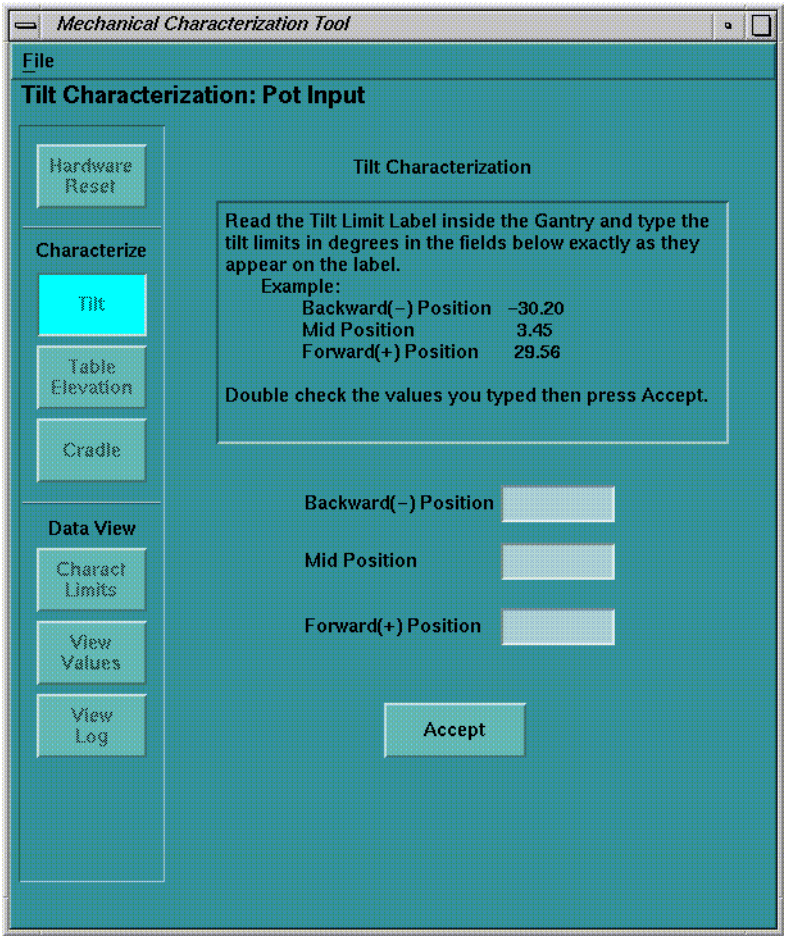


Figure 8-25 Gantry Tilt Characterization

2.7 Alignment Lights Visual Checks

DANGER **VERIFY THAT ALL PERSONNEL ARE CLEAR OF THE SYSTEM, AND THE GANTRY ROTATES FREELY TO 180 DEGREES.**

1.) Press the alignment light button on the gantry-mounted table controls, to position the gantry.
2.) Press the alignment light button on the gantry-mounted table controls again to turn the lights OFF.
3.) Turn OFF the axial drive enable and **HVDC** enable switches, on the **STC** backplane.
4.) Use the switch on the **OBC** backplane to manually turn on the alignment lights, (table side, upper left corner, labeled “Lights Laser”). Note, DS1 next to “Lights Laser” switch will illuminate.

WARNING **WHEN OPERATING THE ALIGNMENT LIGHTS, NEVER STARE AT THE LASER BEAMS, AS THEY CAN CAUSE PERMANENT EYE DAMAGE.**

LASER LIGHT

2.7.1 Internal Axial Lights

Place a sheet of plain white paper over the output port of each light and verify that the two lines of laser light coincide with each other.

Do not try to adjust the internal axial lasers on the **CT** system to shine “down” on the collimator.

2.7.2 External Axial to Internal Axial Distance

Raise the table to its highest elevation. Extend the cradle until both the internal and external laser lights shine on the cradle. Place a metric rule on the right edge of the cradle, and measure the distance from the internal axial laser line to the external axial line generated by each laser. Verify this distance equals 240.0 mm ±1.0mm. Place the rule on the left edge of the cradle and measure again.

Extend the cradle until both internal and external laser lines shine on it. Lower the table to the interference limit. Verify the 240.0 mm ±1.0mm distance between the internal and external lights, on both edges of the cradle, as above.

2.7.3 Coronal Lights

Place a sheet of plain white paper at the left side of the patient opening, in front of the coronal laser light. Verify that the two coronal lines coincide with each other. Check the right side in the same way.

Place the paper in the center of the Gantry opening, and use a level to verify that the coronal lines are horizontal.

2.7.4 Alignment Light Visibility

H.H.S. requirements state that lights used to define the tomographic plane must be visible under ambient light conditions, up to 500 lux. To verify:

1.) Turn the scan room lights on to their brightest normal level. Do not add localized spot lights to increase the brightness level.

2.) Raise the table to its highest position, advance the cradle into the gantry, and turn on the alignment lights.

3.) Center the back of your hand over the cradle, and hold it in the alignment light. Make sure you can see the external axial alignment lights on your hand. You only have to see the axial lights, not the sagittal or coronal lights.

4.) Repeat the procedure with the internal axial lights.

If you cannot see the external or internal axial lights under the conditions described above, obtain a DIGAPHOT model #3300 or 3303 light meter; measure the ambient light intensity at the cradle surface at the external and internal alignment light locations.

Note: Foot-candles x 10.76 = lux.

If the light reading(s) exceeds 500 lux, reduce the room lighting to the 500 lux level, and repeat steps 3 and 4. If the light meter readings equal 500 lux or less, replace the laser light(s) and/or their power supplies.

2.8 Alignment Light Adjustment Procedure

2.8.1 Required Tools

- Long Phillips #2 screwdriver
- 1 large washer 0.5 ID, 1.5 OD
- Masking Tape
- Torpedo Level
- Large 48 cm Phantom
- 5 mm Hex key

2.8.2 Procedure Details

1.) Remove gantry side, top front and back covers.
2.) Remove cradle pad and associated accessories.
3.) Place Large Phantom on end of cradle so it extends 2 inches beyond the cradle end.
4.) Verify phantom is level front to back and side to side.
5.) Assemble washer and screwdriver and secure to phantom as shown in Figure 8-26.

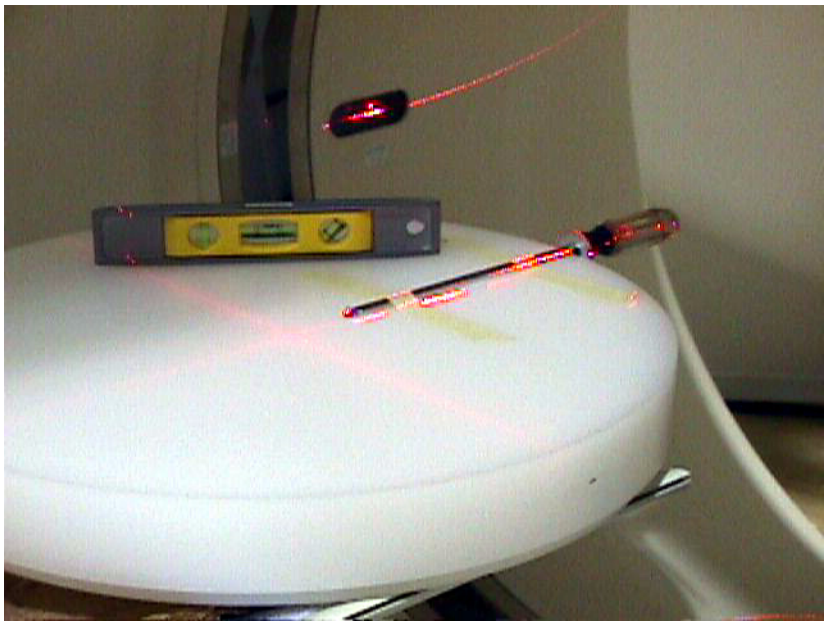


Figure 8-26 Internal and External Laser Alignment Jig Setup

DANGER **VERIFY THAT ALL PERSONNEL ARE CLEAR OF THE SYSTEM, AND THE GANTRY ROTATES FREELY TO 180 DEGREES.**

6.) Turn on laser lights using gantry control panel.
7.) Adjust jig position such that:
- Internal lasers shine on the washer's edge center
- Sagittal and Coronal lasers shine on the center of the screwdriver shaft

Note: Chose either the left or right side of the jig as a reference for this procedure.

8.) Select New Patient, Baby, 20.1 Service Generic Scan, Create New Series, Scout.

SCOUT	SCAN TYPE	START LOC.	END LOC.	KV	MA	SCOUT PLANE
1	Scout	S 50	I 50	120	80	90
2	Scout	S 50	I 50	120	80	0

Table 8-21 Laser Align Generic Service Scan Scout Protocol

9.) Confirm and Scan.
10.) Image Works, Browser Select Exam, Series, Image.
11.) Select Format one over one (lower left)

Note: Both scout should now be displayed. Adjust the window and level setting so you can see the outline of the screwdriver handle. Click in a viewport to activate it, and select Grid.

The washer and screwdriver shaft need to be centered under the zero (0) grid lines. Both washer and screwdriver should also be parallel to the associated grid lines. See Figure 8-27.

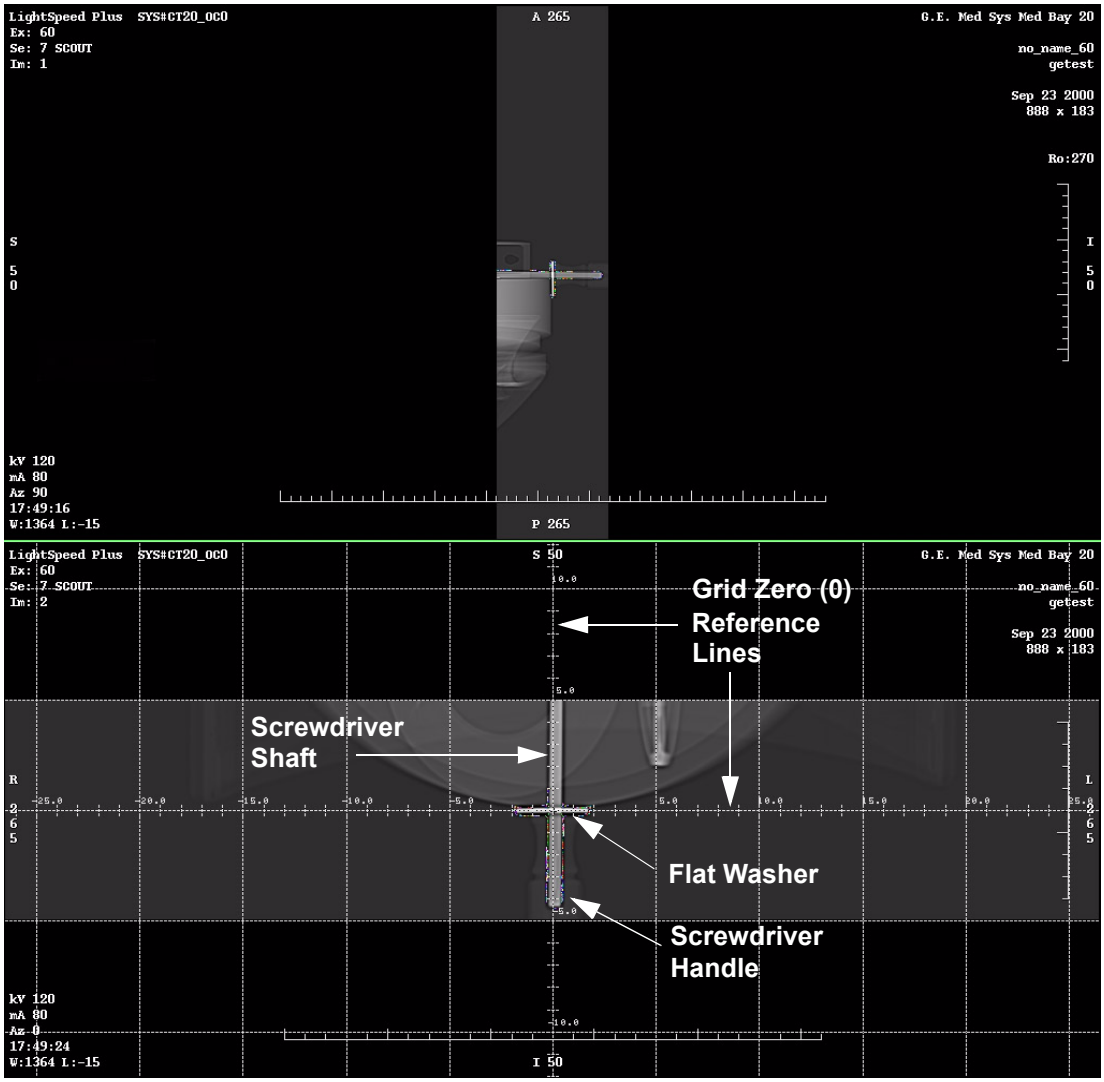


Figure 8-27 Aligning the Laser Adjustment Jig to ISO Center and the Z-Axis

12.) Write down the error delta from the Zero (0) grid lines to the center of the screwdriver shaft and washer edge. Use measure distance if desired.

13.) Position the jig exactly the error delta using gantry controls. **DO NOT MOVE THE PHANTOM.**

Note: Changing Elevation will post an error window. Ignore this and proceed.

14.) Select Repeat Series and scan.

15.) Repeat steps 8 through 14 until jig reference points are centered under the grid zero (0) lines.

⚠ **CAUTION** **Once the jig is aligned to ISO Center and the Z-Axis, do not disturb it. If it is disturbed you will need to start over.**

16.) Press the Internal Landmark button to zero the cradle position display.

DANGER **VERIFY THAT ALL PERSONNEL ARE CLEAR OF THE SYSTEM, AND THE GANTRY ROTATES FREELY TO 180 DEGREES.**

17.) Press the Alignment Lights button.

DANGER **NEVER SERVICE THE GANTRY WITH THE AXIAL DRIVE ENABLED. UNEXPECTED GANTRY ROTATION CAN RESULT IN SERIOUS INJURY OR DEATH.**

18.) Turn off Axial Enable switch on the **STC** backplane.

19.) Adjust the Reference Internal Laser chosen in step 7 to shine on the washer's edge center. Reference Figure 8-28.

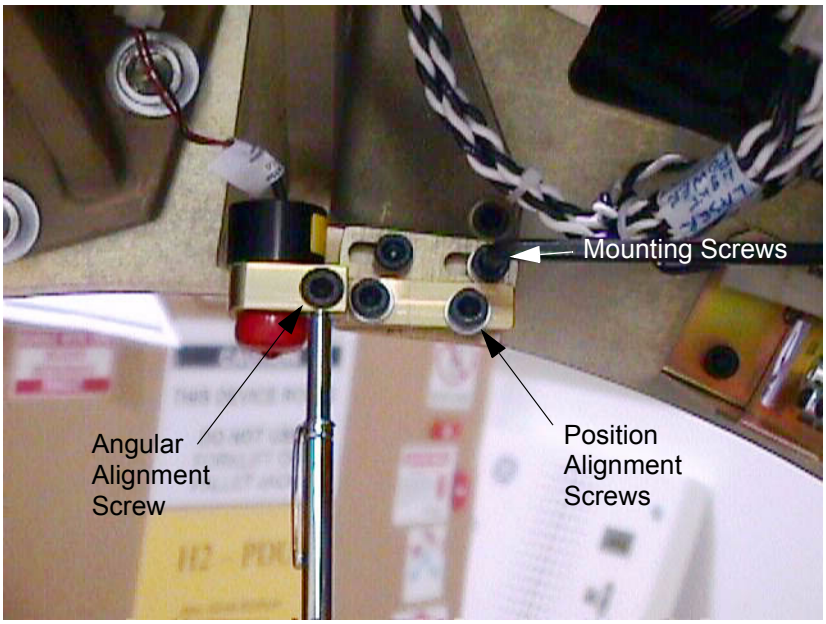


Figure 8-28 Laser Adjustment Screws

Note: Properly adjusted Lasers will bisect the output port of the other 2 Internal lasers.

20.) Adjust the Sagittal and Coronal lasers so they shine on the screwdriver shaft at ISO Center. Set Coronal lasers as level as possible and Sagittal laser as parallel to the cradle as possible. Tracking adjustments will be performed in later steps.

21.) Move the cradle out of the gantry to 240 mm position, using the gantry control panel.

22.) Adjust the Reference External Laser to shine on the washer's edge center.

Note: Properly adjusted Lasers will bisect the output port of the other External laser.

23.) After Reference Lasers have been adjusted, raise and lower the table, and verify both the External and Internal lasers track the washer's edge center.

CAUTION **If vertical angle adjustment is necessary, make sure you center the jig at ISO Center before you adjust the Internal or External reference lasers.**

24.) Repeat steps 19 through 23 as needed.

25.) Remove the screwdriver jig without disturbing the phantom.

26.) Now that the reference lasers have been set, use a piece of notebook paper to adjust the other Internal and External lasers to coincide with the reference lasers. Refer to "Alignment Lights

Visual Checks," on page 588.

27.) Place another object, such as a full contrast bottle or unopened soda can, on the phantom. Attach masking tape and position the object at ISO Center using the laser lights. Refer to Figure 8-29.

28.) Using a pen, carefully mark the laser intersection points on the masking tape. Once set, DO NOT DISTURB THE JIG.

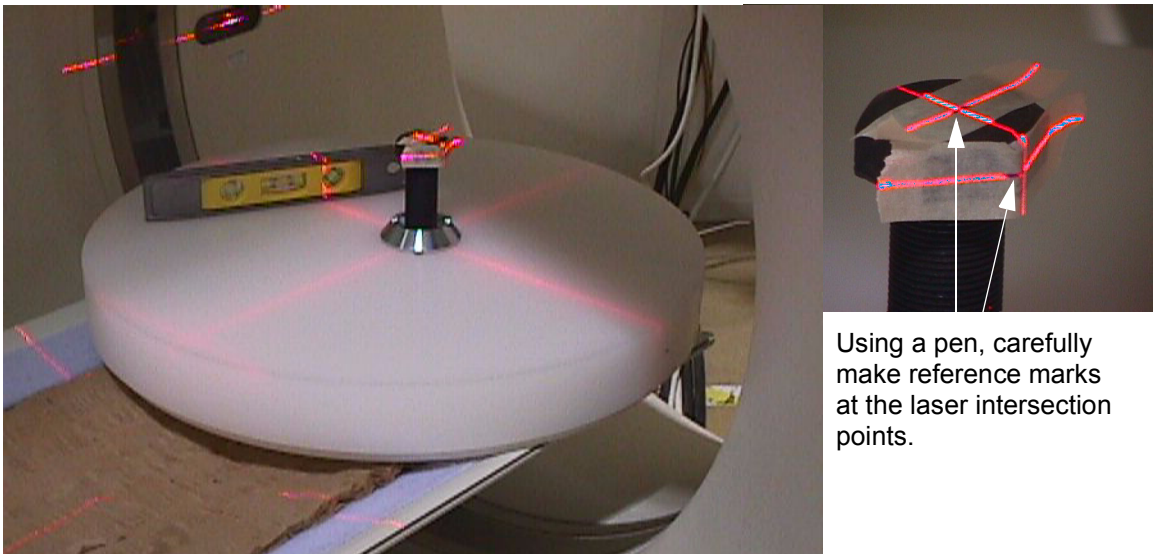


Figure 8-29 Sagittal and Coronal Laser Alignment Jig Setup

29.) Using the gantry control panel, move the cradle out of the gantry to 240 mm. Verify the Sagittal and Coronal laser lights track your pen marks.

CAUTION **If Sagittal or Coronal angle adjustment is necessary, make these adjustments one at a time, and verify the laser tracks from Internal to External landmarks before making the next adjustment. If the jig is disturbed, reposition the jig at ISO Center to reestablish your reference. Verify both Sagittal and Coronal lasers shine on the pen marks at ISO Center before proceeding. The loss of reference will require repeating steps 5 – 15 and 25 – 29. This would be necessary to ensure accuracy.**

30.) The last adjustment is the un-referenced Coronal laser to the Reference Coronal laser chosen in step 7. Refer to "Alignment Lights Visual Checks," on page 588.

31.) Assemble the gantry.

2.9 Scan Window Alignment

NOTICE Potential for Equipment Damage. **The cones of the front and rear gantry covers must be aligned within specification to ensure proper scan window fit. If the scan window is not fit properly, fluids can get into the collimator, causing permanent damage.**

COLLIMATOR AND COVER DIFFERENCE

1.) With the front and rear covers secured in place and scan window removed, rotate the collimator to the 3 o'clock position.

2.) Using an appropriate (calipers or steel ruler), measure the distance (*d*) in millimeters (mm) from the collimator's surface to the metal scan window rim, on both the front and rear covers. Record measurements. See Figure 8-30.

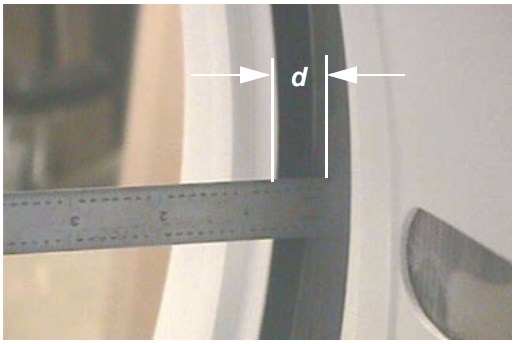


Figure 8-30 Collimator Cover Gap Distance

3.) If the difference $|d_f - d_r|$ between the front (f) and rear (r) measurements is greater than 3 mm, one of the cover must be shifted appropriate direction. On the cover that gives you the most adjustment, lightly loosen the screws securing each mounting plate. Slide the plates in the direction that will give you the appropriate shift and re-secure screws. See Figure 8-31.

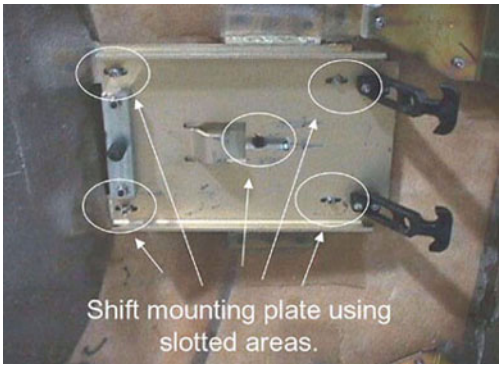


Figure 8-31 Gantry Cover Mounting Plate and Screws

For example, if the distance between the collimator and the front cover is 1.5 mm and the distance between the collimator and rear cover is 10.5mm, then the difference is 5mm. The front cover must be shifted right at least 2mm. This means that mounting bracket on the front cover must shifted at least 2mm left.

4.) Repeat steps 2 and 3 until the difference between the two measurements is less than 3mm.

5.) Rotate the collimator to the 9 o'clock position.

6.) Repeat steps 2 through 4. Verify that a difference of less than 3 mm is obtainable with the collimator positioned at the 9 o'clock position.

SCAN WINDOW GAP

7.) Measure the distance (D) between front and rear covers of the scan window rims. Measure the distance between the two covers at the bottom of the cone. See Figure 8-32.

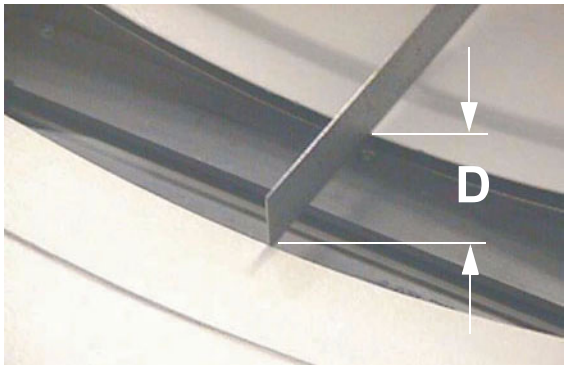


Figure 8-32 Scan Window Gap Distance

8.) If the spacing is the spacing is greater than 57 mm, bring the covers together using the bolts located on the end of each cover latch. See Figure 8-33.

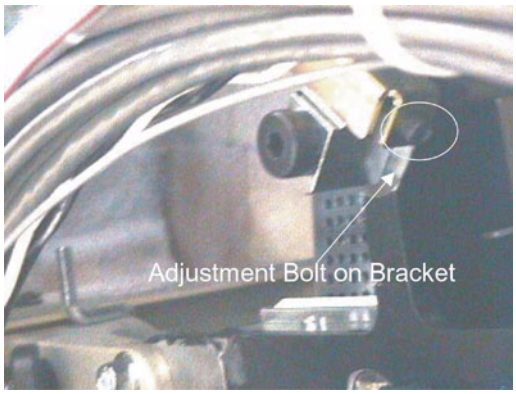


Figure 8-33 Cover Bracket Adjust Bolt Location

9.) Repeat steps 7 and 8 until the spacing is less than 57mm.

VISUAL INSPECTION

10.) Install the scan window and check that the scan window is not raised higher than the front or rear cover at any location on the circle and that the window is not wrinkled. See Figure 8-34.

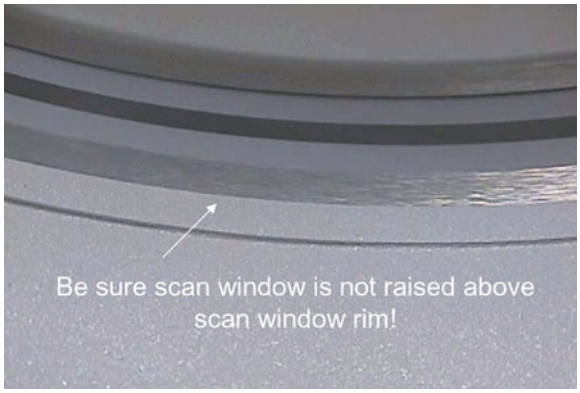


Figure 8-34 Correct Scan Window Alignment

2.10 Gantry Display Test

1.) Turn ON the gantry 120 VAC Enable Switch on the **STC** backplane.
2.) Make sure the gantry display goes through the power-up self-test. The display continues to cycle through its self-test until it completes the hardware reset and download.
3.) TURN ON “X-RAY DRIVES” power by pressing the RESET button on the gantry control panel.

2.11 Common Slip Ring Checks

2.11.1 Visual Checks

- Ensure cable connections are securely fastened.
- Terminator boards mounted correctly with correct screws.
- Fiber-optic cables connected and locked.
- Damaged components/ring/brushes.

2.11.2 Power and Grounding Checks

- Ground screws on ring # 6.
- Frame bonding ground on unused ring # 3.
- Ground and filter connections on back side of platter.
- Harness shield ground connections.

2.11.3 Basic Theory of Operation of LSCOM Boards

3-wire serial communication:

- Inbound
- Outbound
- Reference

2.11.3.1 Violations

A violation is created in one of three ways:

- An invalid command is received.
- The 2 command/data bits do not match for a byte.
- The parity bit is not correct.

2.11.3.2 Brush Disconnects

The serial communication is +5V to –5V during normal operation. If the line is disconnected or if the brushes are bouncing then the serial line will be at 0V compared to the reference line. The three types of disconnects indicate different times for the line at 0V.

(75ns < short < 200ns < medium < 4.4us < long)

2.12 Service Actions

2.12.1 Why Clean with Alcohol or Sand with Cratex Crayons

1.) Communication failures (TAXI Link Failures) after vacuuming failed.

2.) Cratex sanding is for mechanical damage to the ring **ONLY** (e.g. pits and arc marks).

2.12.2 Alcohol Clean

Alcohol cleaning should be done as a corrective (repair) action only. Alcohol cleaning is not a **PM** action and should only be done if necessary, and only AFTER vacuuming the slip ring and gantry has not corrected the problem.

1.) Vacuum ring per **PM** procedure.

2.) Check baseline.

3.) Remove brush block (the alcohol will contaminate the brushes). Refer to "Slipring Brush Block," on page 646 for the proper removal procedure.

4.) Use specified alcohol (46-183039p1) and allow to AIR DRY for 15 min. DO NOT use the alcohol prep pads found in hospitals. They are often not PURE alcohol, and can contaminate the slip ring and brushes.

5.) Reinstall the removed components. Refer to "Slipring Brush Block," on page 646. The proper replacement procedure is critical to the life of the slip ring components.

Note: Only Use GE Approved Alcohol 46-183039P1.

2.12.3 Cratex

CAUTION **Cratex should be used to fix pit and arc marks only.**

Note: Smoothing out the track surfaces is a time consuming task and if not done properly and completely will result in either permanent damage or will cause another arc. Do it right the first time. Removing the "clogged" end of the cratex stick with a coarse file will help speed up the process of smoothing out pitted areas. Reference "Inspection Criteria," on page 597 before proceeding.

1.) Remove Brush Block Assembly before using Cratex. See "Slipring Brush Block," on page 646.

2.) Using a Cratex fine abrasive stick (46-297961P2), attempt to smooth out the pitted area or areas with deposits on the slip ring. Do not attempt to clean areas larger than 2 centimeters at one time. ONLY use Cratex on the ring that is in need of repair. If an area is still not smooth, use Cratex medium abrasive stick (46-297961P1). After using the medium, repeat procedure with the fine.

3.) When done with the Cratex sticks, it is very important to remove ALL traces of abrasive with a thorough alcohol cleaning.

4.) Replace the brush block assembly. Refer to "Slipring Brush Block," on page 646. The proper replacement procedure is critical to the life of the slip ring components.

2.12.4 Inspection Criteria

A normal ring will have a "patina" of brush material on the surface of the brass ring. This patina is about 3 mils thick and is self renewing. This is the natural lubricant and completely normal. Do not attempt to remove this, as future problems will arise and create a cycle of repeating failures on excess dust production.

Micro spots are acceptable provided they do not exceed the following specifications, and their forms contain no burrs and depths no greater than D1, D2. Reference Figure 8-35.

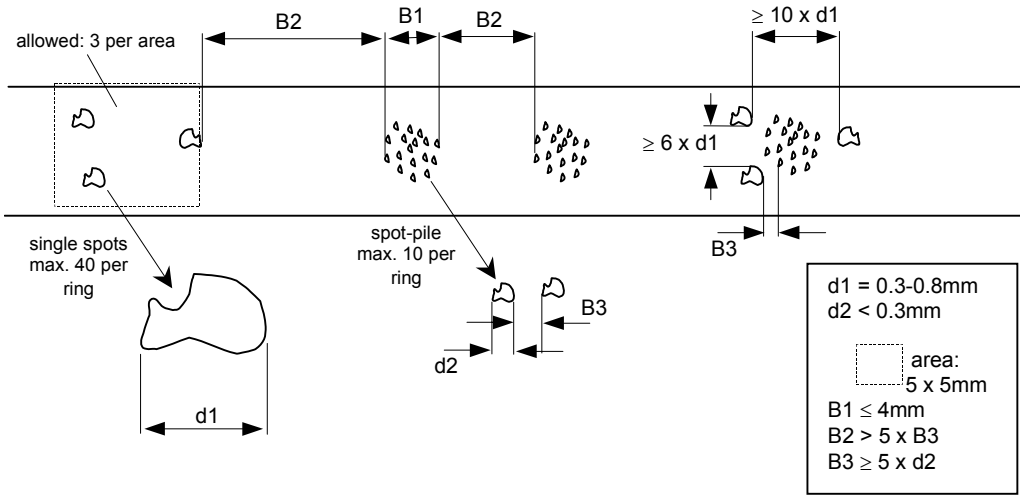


Figure 8-35 Slipring Inspection Criteria

2.12.5 Removal/Installation/Replacement

Refer to Section 3.0 - Replacement Procedures. The proper replacement procedure is critical to the life of the slip ring components.

2.13 S/A HSDCD Slip Ring Adjustments

2.13.1 333 MBaud HSDCD Slipring Receiver Adjustment Procedure

This document describes the steps necessary to properly replace and adjust the position of the **HSDCD** antenna above the emitter traces on the rotating slip ring. Accurate placement of the **HSDCD** antenna is important to achieve the optimal data transfer performance and to avoid contact between the ring and the stationary antenna. The optimal position of the **HSDCD** antenna above the emitter traces on the ring is 1.41 mm height (.060 inches), and centered.

Under normal circumstances, the position of the **HSDCD** antenna should never need adjustment. Only adjust if there are indications of interference. Under no circumstances should the **HSDCD** antenna be allowed to contact the rotating components.

DANGER **ELECTRIC SHOCK. MAY CAUSE SERIOUS INJURY OR DEATH. UNLESS DISABLED, HIGH VOLTAGES ARE PRESENT ON THE SLIP RING. POWER ON THE SLIP RING INCLUDES 120VAC AND 750VDC.**

1.) Disable power to the gantry. Lock out and Tag.
2.) Remove mylar window, side, top and rear gantry covers.
3.) Make sure the **HSDCD** has no power applied - there should be no **LED**s on.
4.) Loosen the axial adjustment screws and the radial adjustment screw for the **HSDCD** antenna.
5.) The **HSDCD** antenna should now be loose above the emitter. Insert the **HSDCD** adjustment tool between the **HSDCD** antenna and the emitter traces on the ring. The tool should fit snugly. The desired result is to space the **HSDCD** antenna above the emitter, at a height of 1.41 mm (.060 inches) above the emitter.
6.) Tighten the radial screws. Press slightly on the top of the **HSDCD** antenna as the adjustment screws are tightened. Reference Figure 8-36.
7.) Carefully slide the adjustment tool from between the **HSDCD** antenna and the emitter.
8.) Using the alignment sights at each end of the **HSDCD** antenna, center it above the center trace on the emitter PCB. Reference Figure 8-36.

9.) While holding the position of the **HSDCD** antenna, tighten the axial alignment screws.

10.) Adjust the Axial Thumbscrews to just contact the Antenna assembly. This is the axial position preset for future reference.

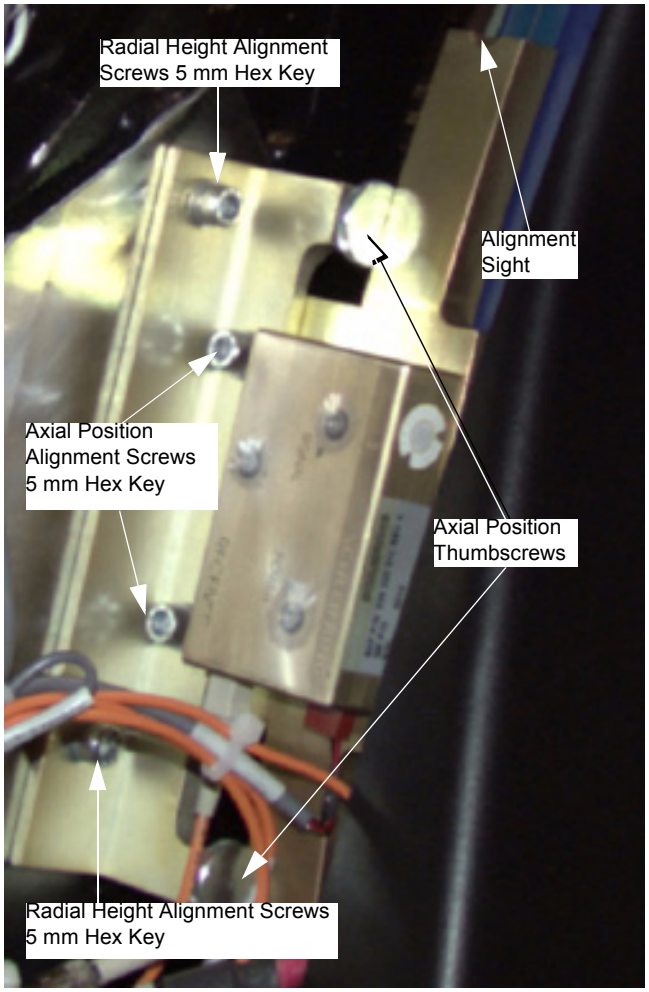


Figure 8-36 333 MBaud HSDCD Receiver

NOTICE
Potential for Ring Damage

Do not rotate the gantry with the adjustment tool installed. Damage to the delicate PCB traces will result. There is no method to repair ring boards in the field - a ring swap would be necessary.

11.) Inspect the air-gap between the **HSDCD** antenna and the ring as the gantry rotates. It may be necessary to disable the gantry brake to rotate the gantry more easily. Look for clearances between the emitter and the **HSDCD** antenna. While rotating the ring, check that the emitter trace is aligned with the **HSDCD**. During rotation, no parts of the **HSDCD** antenna should contact the emitter surface.

- The stationary and rotating components must never touch, even with the gantry tilted.
- The run-out of the platter slip ring traces should not exceed 0.83 mm axially, and 0.81 mm radially.
- Especially check clearances near the emitter solder and PCB connections.
- The **HSDCD** receiver has two **LED**s. One **LED** indicates power is applied to the **HSDCD** and the other indicates the **HSDCD** is transmitting a signal.

12.) Restore power to the system. Verify proper operation by running verification scans. Verification procedure should consist of:
   - Observe diagnostic "**DIP** Stats" information. Before starting, log raw ring error count, **FEC** correct-able counts, and the date/time of the last file update.
   - Run 5 stationary and 50 rotational scans with x-ray. The technique is not important. It is important to exit the exam, because this triggers the "**DIP** Stats" update.
   - Observe diagnostic "**DIP** Stats" information. There should be no additional raw **HSDCD** ring errors or **FEC** correctable events.

13.) Replace the gantry covers and secure. Re-install the mylar window.

2.13.2 S/A HSDCD Rotating Transmitter Power Measurements

1.) Locate the **HSDCD** Transmitter Power supply inside the Fuse Box Assembly.

2.) Measure the DC voltage on the wires leading to the **HSDCD** Transmitter. The specification is +15 volts DC ± 2.0 volts. Use indicator **LED**s to ensure proper operation.

2.13.3 S/A HSDCD Stationary Receiver Power Measurements

1.) Locate the **HSDCD** Receiver Power supply on the rear of the right fan assembly

2.) Measure the DC voltage on the wires leading to the **HSDCD** Receiver. The specification is +15 volts DC, ± 2.0 volts. Use indicator **LED**s to ensure proper operation.

2.14 Gantry Thermostat

The gantry thermostat is a self contained Electronic Thermostat Control Unit.

Figure 8-37 Gantry Temperature Fan Control Thermostat

ELECTRONIC THERMOSTAT CONTROL SETUP PROCEDURE

CAUTION Potential for artifacts

This is not a recording device. Failure to use the correct settings can result in artifacts due to incorrect detector temperature deltas.

1.) Press the **SET** key once to access the Fahrenheit/Celsius mode. The display will show the

current status., either F for degrees or C for degrees Celsius. Then press either the **UP** or **DOWN** arrow keys to toggle between the F or C designation.

2.) Press the **SET** key again to access the setpoint. The LCD will display the current setpoint and S1 annunciator will be blinking to indicate that the control is in the setpoint mode. Press either **UP** or **DOWN** arrow keys to adjust the setpoint to the desired temperature.

3.) Press the **SE**t key again to access the differential. The LCD will display the current differential and the DIF 1 annunciator be blinking to indicate that the control is in the differential mode. Press either **UP** or **DOWN** arrow keys to adjust the differential setting.

4.) Press the **SET** key again to access the cooling or heating mode. The LCD will display the current mode either C1 for cooling or H1 for heating. Press either **UP** or **DOWN** arrow keys to toggle the setting.

5.) Press the **SET** key and programming is complete.

STEP	DESCRIPTION	GE DISPLAY SETTING
1	Fahrenheit or Celsius	C
2	Setpoint Temperature	26
3	Differential Temperature	2
4	Cooling or Heating Mode	C1

Table 8-22 Thermostat Settings

Comment: *The Electronic Thermostat Control will automatically end programming if no key has been pressed for a period of 30 seconds. Any settings that have been input to the control will be accepted at that point.*

All control settings are retained in non-volatile memory, if power to the Electronic Thermostat Control is interrupted for any reason. Re-programming is not necessary after power outages or disconnects unless different control settings are required.

The Electronic Thermostat Control is provided with a lockout switch to prevent tampering by unauthorized personnel. When placed in the lock position, the keypad is disabled and no changes can be made. When placed in the unlock position, the keypad will function normally.

To access the lockout switch, disconnect the power supply and open the control. The switch is located on the inside cover about 50.8 mm above the bottom. To disable the keypad, slide the **SWITCH** to the left lock position. To enable the keypad, slide the **SWITCH** to the right unlock position. All Electronic Thermostat Controls are shipped with this switch in the unlock position. The settings shown in Table 8-22 are programmed at the factory during system staging.

2.15 STC CPU (Artesyn III) - GE Specific Settings

For **OBC CPU**, see "OBC CPU (Artesyn III) - GE Specific Settings," on page 774. For **ETC CPU**, see "ETC CPU (Artesyn III) - GE Specific Settings," on page 425.

2.15.1 STC CPU (Artesyn III) Board Layout

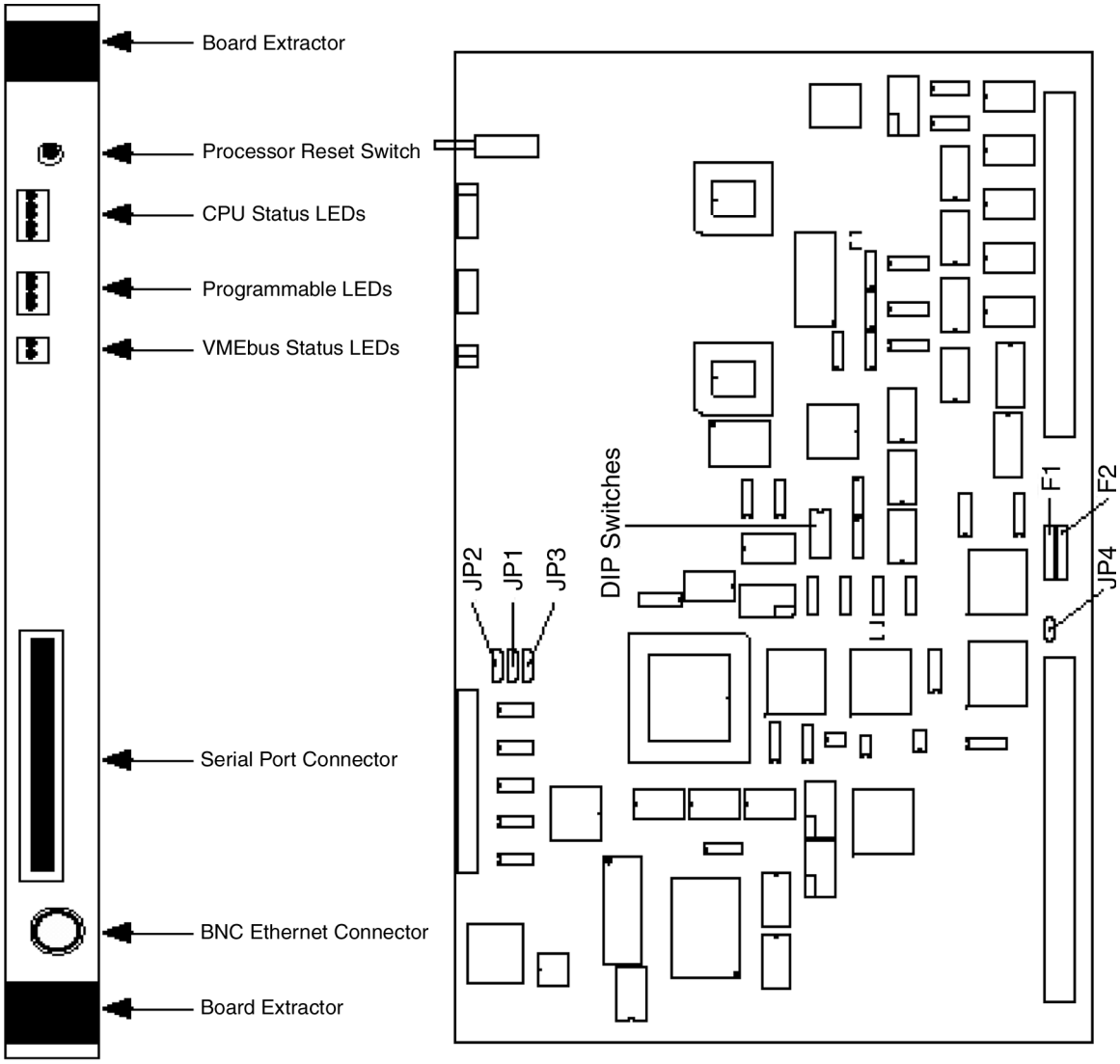


Figure 8-38 STC CPU (Artesyn III) Board Layout

2.15.2 CPU Board Jumpers

JUMPER	FUNCTION	GE CONFIGURATION	COMMENTS
JP1	Port A RI/DCD	J1:1-2	
JP2	Port B RI/DCD	J2:2-3	
JP3	RS-232 Handshaking	J3:1-2	
JP4	Watchdog Enable	removed	Watchdog Disable

Table 8-23 STC CPU (Artesyn III) Board Jumper Settings

2.15.3 DIP Switch Settings

See board (Figure 8-38, above).

SWITCH NUMBER	CONFIGURATION		FUNCTION	COMMENTS
1	ON	CLOSED	**STC** node	Selects board for **STC** Chassis
2	ON	CLOSED	**STC** node	Selects board for **STC** Chassis
3	OFF	OPEN	Primary Nodes	selects primary nodes
4	OFF	OPEN	n/a	Not applicable
5	ON	CLOSED	nbsClient view	View logs via nbsClient/**LAN**
6	OFF	OPEN	n/a	Not applicable
7	ON	CLOSED	**EPROM** Boot	Power Up view **EPROM** Boot
8	OFF	OPEN	Test Disable	Self Test Mode disabled

Table 8-24 STC CPU (Artesyn III) Board DIP Switch Settings

2.15.4 Power-Up Self-Test

The **CPU** board will undergo a Power-Up Self-Test that lasts approximately 18 seconds. After the proper setting of the **EPROM**s, **DIP** switches and board jumpers, the **CPU** board will be placed into a **VME** chassis. A properly terminated Thin-net cable must be attached to the board's BNC connector. This cable is necessary for the Ethernet self tests to complete successfully. The **LSCOM** board must be present for the successful completion of the Power-Up Self-Test.

Upon power-up, the self test begins, the **LED** display is at the value 'E' and the test will perform the instruction Set and **EPROM** Checksum Test. When the test is done, the **LED** value will proceed to the next descending value, 'D', and will perform the **RAM** verification test. In the same manner, when this test is done, the **LED** value will proceed to 'C', then 'B', then 'A' and finally to '9'. After the test at '9', the self test is now done.

When the test is completed, the **LED** values displayed will indicate if any tests have failed. If a failure is detected, the **EPROM**s, **DIP**-switch settings, Ethernet cable, and the board jumpers should be rechecked to ensure proper setup. Then the self test should be rerun. The board must pass the test before shipment. See Figure 8-38 for location of these **LED**s.

LED # 1234	LED HEX	LED ASSIGNMENT	DURATION
xxxo	E	Instruction Set and **EPROM** Checksum Test	1 second
xxox	D	**RAM** Verification	13 seconds
xxoo	C	CIO Unit Test	0.3 seconds
xoxx	B	Internal Loop Back	1 second
oxox	A	External Loop Back	1 second
oxxo	9	Transmit Test	1 second
x = on o = off			

Table 8-25 STC CPU (Artesyn III) Board Power Up LEDs

2.15.5 Power-Up Self-Test Results

On Power-up, the STC controller displays the results of its self tests. Power must remain off to a controller for at least 60SEC or Self-test may not be run or results may be inaccurate. This is because the dynamic ram retains the CPON information. In this event, power-up tests are bypassed and the results of the last power-up test is displayed on LEDs.

1 2 3 4	HEX	LED ASSIGNMENT
• • • •	F	Not Available - - Do Not Use for a test
• • • o	E	Artesyn (see Table 8-27 for details)
• • o •	D	Artesyn (see Table 8-27 for details)
• • o o	C	Artesyn (see Table 8-27 for details)
• o • •	B	VME/LAN (see Table 8-28 for details)
• o • o	A	VME/LAN (see Table 8-28 for details)
• o o •	9	VME/LAN (see Table 8-28 for details)
• o o o	8	LSCOM (see Table 8-29 for details)
o • • •	7	LSCOM (see Table 8-29 for details)
o • • o	6	LSCOM (see Table 8-29 for details)
o • o o	4	spare for GE future use
o o • •	3	spare for GE future use
o o • o	2	spare for GE future use
o o o •	1	spare for GE future use
o o o o	0	Not Available - - Do Not Use for a test
• = LED ON, o = LED OFF, 1 = LED MSB, 4 = LED LSB		

Table 8-26 STC Self-Test LED Outputs

2.15.5.1 ETC, STC & OBC (Artesyn) Tests

FUNCTION	LEDS	DESCRIPTION
Initialization	(F: • • • •)	Setup interrupt vectors & CIO
Failure	(E: • • • o)	CPU HALTS
Processor/PROM Checksum	(E: • • • o)	68000 Instruction set check (RAM used) ROM Verified using CRC16 based polynomial
Failure	(E: • • • o)	CPU HALTS
Ram Verification -	(D: • • o •)	Each word of memory R/W 16 times
Failure	(E: • • • o)	CPU HALTS
CIO Verification	(C: • • o o)	Checks interrupts, timers, counters (no VME)
Failure	(E: • • • o)	CPU HALTS
• = “on” o = “off”		

Table 8-27 Artesyn Board Related LED Readouts

At this point the type of node (ETC, STC or OBCR) determines the tests that are run.

2.15.5.2 STC - VME/LAN Tests

FUNCTION	LEDS	DESCRIPTION
LAN controller tests	(B: • o • •)	Checks module present, controller & internal loops
Failure	(B: • o • •)	Flashes, possibly with other failures
LAN External loop-back	(A: • o • o)	Checks wire/ termination
Failure	(A: • o • o)	Flashes, possibly with other failures
TDR test	(9: • o o •)	Checks wire/ termination
Failure	(9: • o o •)	Flashes, possibly with other failures
• = “on” o = “off”		

Table 8-28 STC VME/LAN Related LED Readouts

2.15.5.3 LSCOM/Communications Test

FUNCTION	LEDS	DESCRIPTION
Module Present test	(8: • o o o)	Checks for Presence of TAXI
Failure	(8: • o o o)	Flashes, possibly with other failures
VME FIFO test	(7: o • • •)	Checks VME path using loop-back
Failure	(7: • o o o)	Flashes, possibly with other failures
AP FIFO test	(6: o • • o)	Checks DAS path using loop-back
Failure	(6: • o o o)	Flashes, possibly with other failures
• = “on” o = “off”		

Table 8-29 LSCOM/Communications Related LED Readouts

2.16 Remote Intercom Board

The intercom board has R19 preset to 5.5k ohm and R10 preset to 1.25k ohm. No adjustments are normally needed. Verify these values are set correctly by using a multi-meter to measure test points TP1 & TP2 (yellow), for R10, and TP3 & TP4 (red), for R19.

1.) At the console set the **SCIM** patient volume control to its midway point. You should not hear anything in the background when no one is speaking. If someone is talking at the gantry, the intercom should be activated.

2.) Next rotate the gantry at 0.5 sec. The intercom system will come on briefly while the system is accelerating but should shut off once it reaches the 0.5 sec speed.

3.) Verify the system will come on when someone is laying on the table and speaking into the microphone while the system is rotating at 0.5 seconds.

4.) If steps 2 and 3 are working correctly and you can hear the patient clearly there is no need to make any adjustments.

5.) If the intercom system comes on when the patient is talking but you are unable to hear the person clearly adjust R19 on the intercom board. Increase the resistance by 1K at a time until you can hear the person clearly. This will increase the sensitivity of ALC also.

6.) If the system comes on and stays on or if it comes on and off intermittently when rotating at 0.5 seconds you will need to adjust the R10 potentiometer on the intercom board in the gantry.

7.) Increase the resistance by 100 ohms at a time and repeat steps 1 through 6. Continue this process until the intercom system stays off when no one is talking, is activated when someone

is speaking and the patient can be heard clearly.

Note: R19 is used to control the overall signal gain. Decrease the R19 value to decrease gain. Increase the R19 value to increase the gain (G). The gain is calculated by:

$$1 + R19(kohm) = G$$

R10 combined with R19 is used to control the sensitivity of Automatic Level Control (ALC). If the console speaker turns on frequently without patient speaking during 0.5 sec rotation increase the R10 value to desensitize ALC until the speaker turns off during gantry rotation without patient speaking. If patient has to yell to activate ALC, decrease the R10 resistance to increase sensitivity. The sensitivity (S) is calculated by:

$$\frac{1 + R19(kohm)}{1 + \left(\frac{0.1}{R10(kohm)}\right)} = S$$

2.17 Gantry Service Balance

WARNING **GANTRY BALANCE MUST BE CHECKED FOR ANY COMPONENTS REPLACED ON OR REMOVED FROM THE ROTATING ASSEMBLY.**

2.17.1 Prerequisites

Gantry balance can be *checked* without removing covers. Gantry balance *adjustments* require front and possibly rear gantry cover removal.

DANGER **FAILURE TO TORQUE TRIM WEIGHT FASTENING HARDWARE WILL RESULT IN DAMAGING PROJECTILE EVENTS. THIS WILL RESULT IN SEVERE EQUIPMENT DAMAGE AND POSSIBLE PERSONAL INJURY.**

2.17.2 Procedure

WARNING **DO NOT USE THREADED RODS TO ROTATE GANTRY.**

2.17.2.1 GUI Access

- Diagnostic Data Collection
- DIP Diagnostics
- FLASH Download Tool
- Generator Char Data
- IG Diagnostics
- Install SMPTE from AW
- Install New Tube
- ISO Alignment
- KV Loop
- Kv & mA (X-Ray)
- mA Meter Verify
- Manualcal Generator
- Mechanical Characterizatio
- POR Alignment
- RCIB Diagnostics
- Rotor Control
- Recon Data Path
- Scan Analysis
- Shell
- Scan Data Path
- Storelog
- System State
- Tube Usage
- X-Ray Interlock
- Gantry Service Balance
- Replacement
  - Autocal Generator
  - BOW Alignment
  - CBF and SAG Alignment
  - Change Tube
  - Collimator Aperture Test
  - Detailed Calibration
  - Detector Health Trending
  - Diagnostic Data Collection (D
  - Enter Detector ID
  - FLASH Download Tool
  - Generator Char Data
  - HHS Scans
  - Hot ISO
  - Install New Tube
  - ISO Alignment
  - mA Meter Verify
  - Manualcal Generator
  - POR Alignment
  - Scan Analysis
  - Shell
  - System State
  - Z Slope Cal
  - Gantry Service Balance

Figure 8-39 General Access

2.17.2.2 GUI Screens

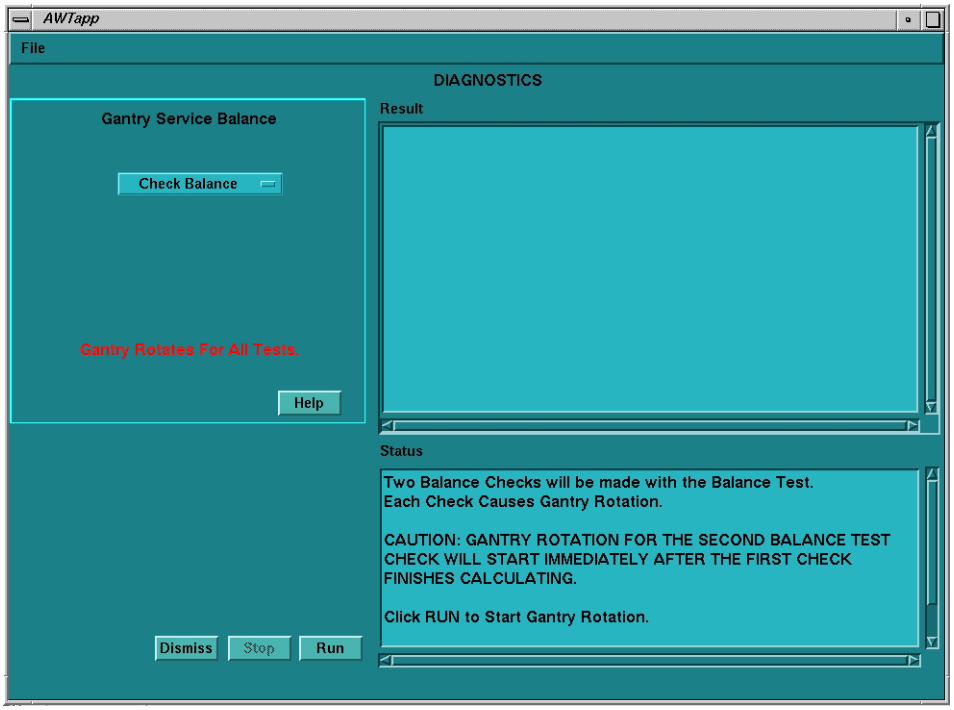


Figure 8-40 Gantry Balance Tool Opening Screen

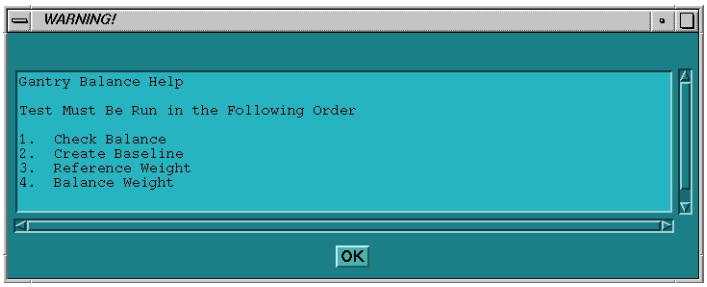


Figure 8-41 Gantry Balance Help Screen

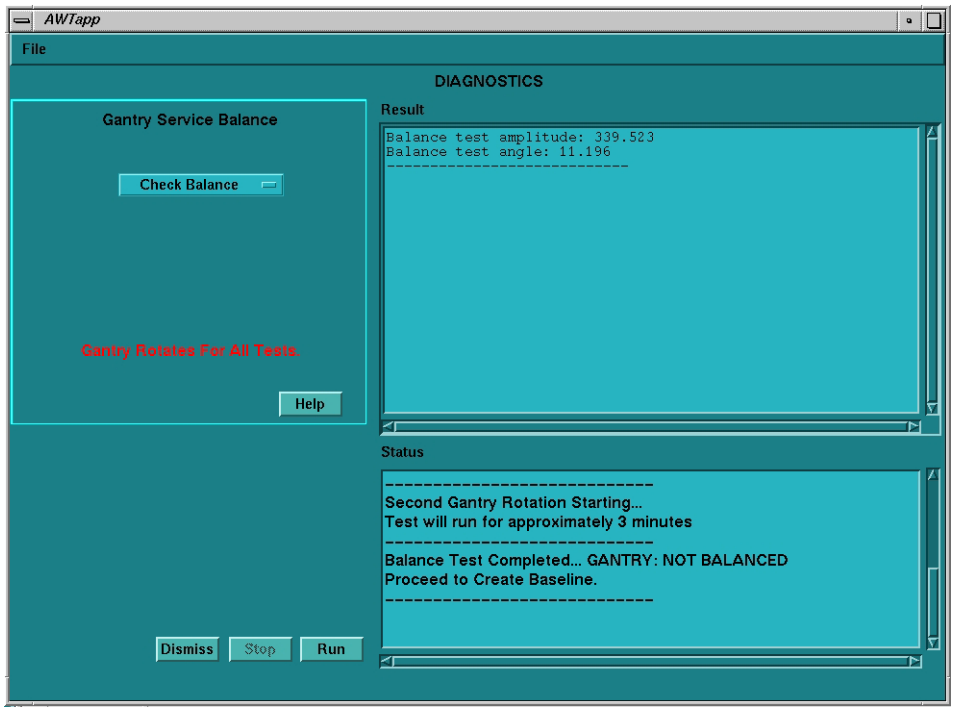


Figure 8-42 Check Balance Results

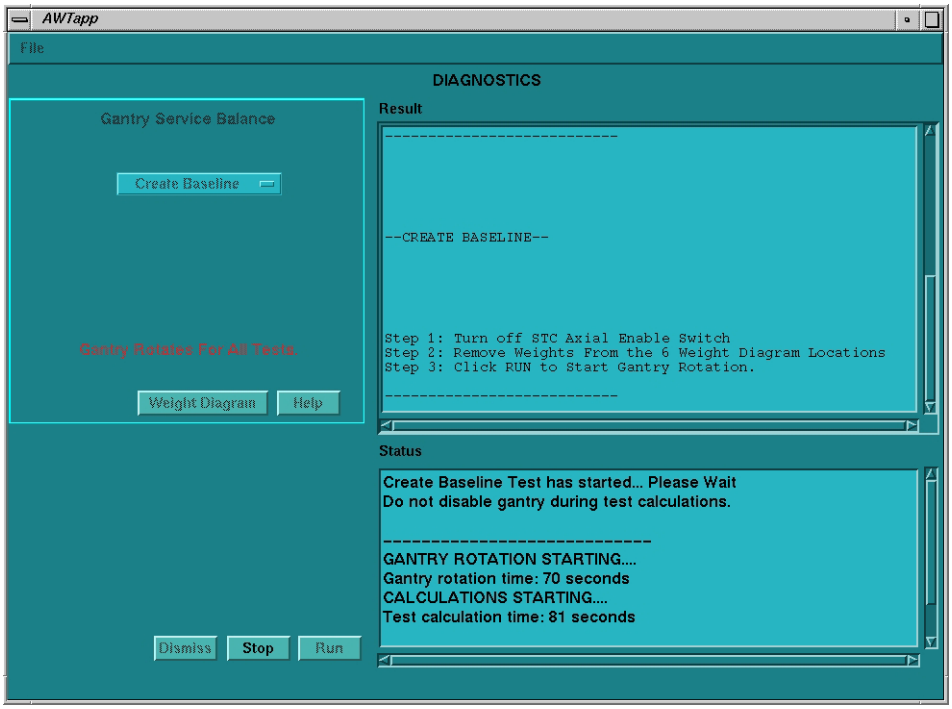


Figure 8-43 Create Baseline Instructions

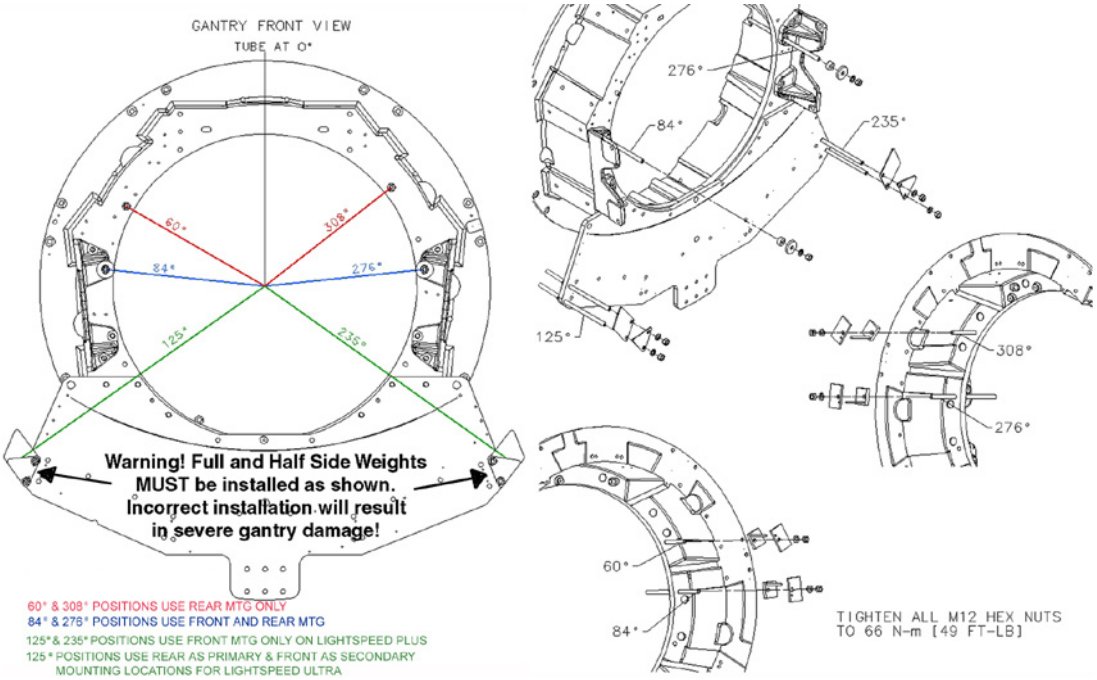


Figure 8-44 Weight Diagram

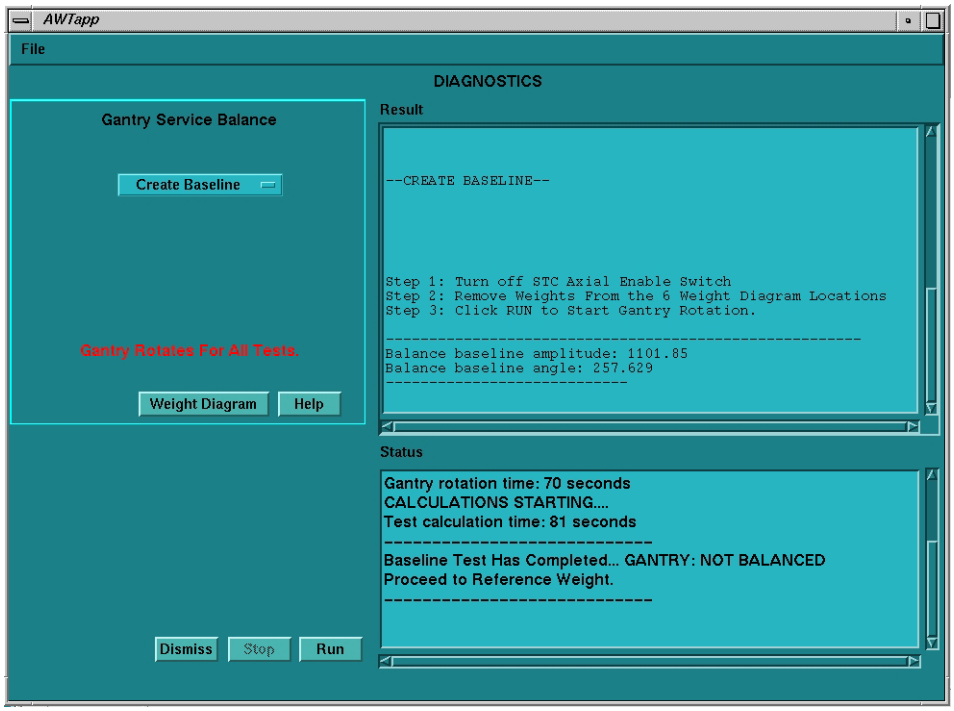


Figure 8-45 Create Baseline Results

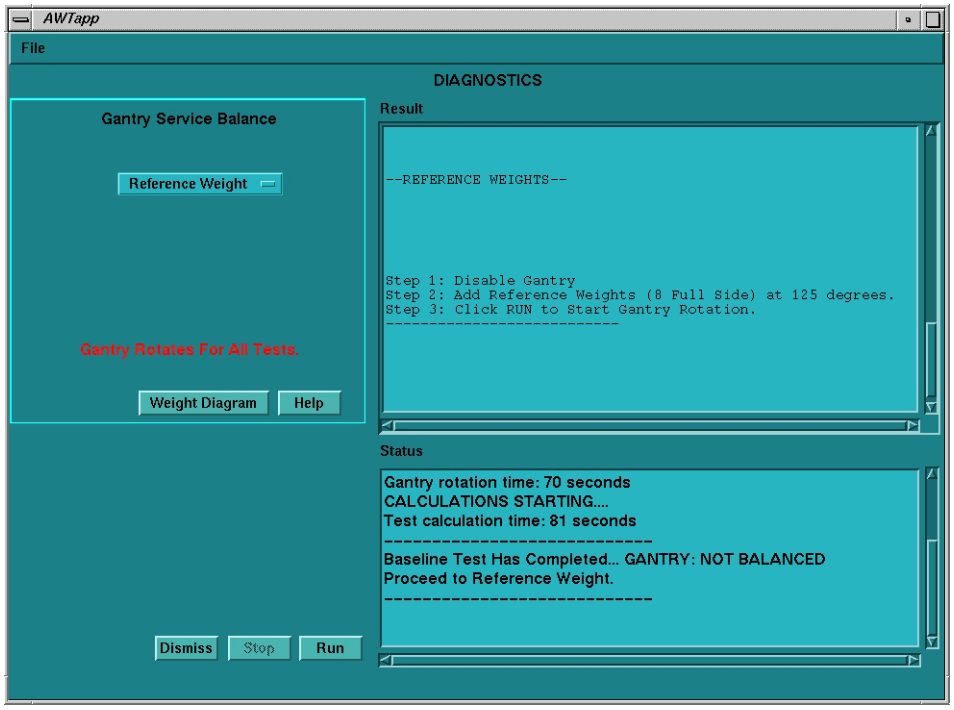


Figure 8-46 Reference Weight Instructions

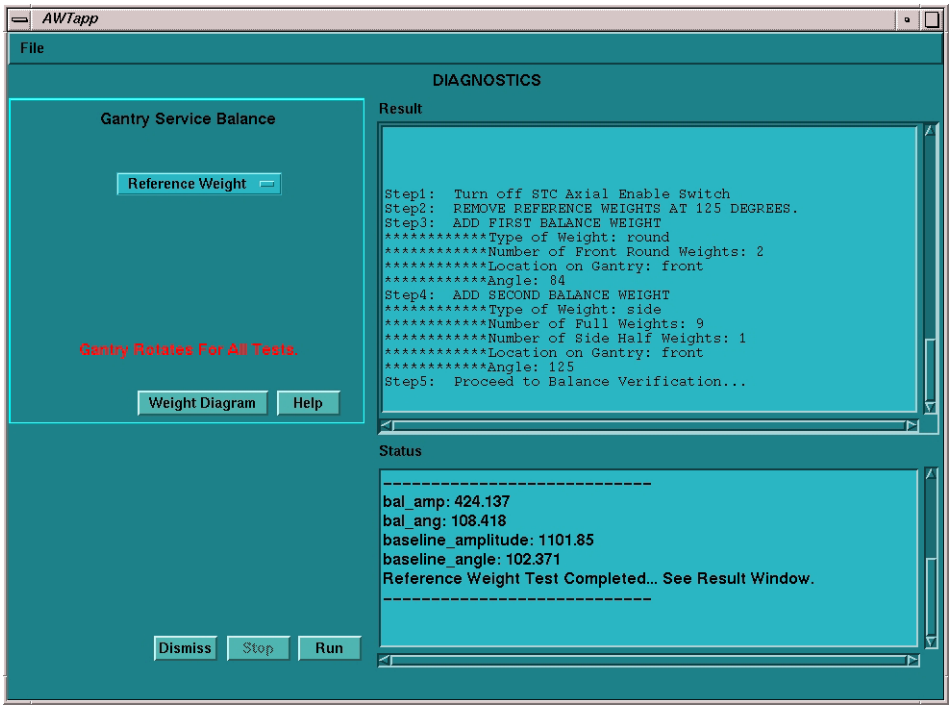


Figure 8-47 Calculated trim weight values and locations

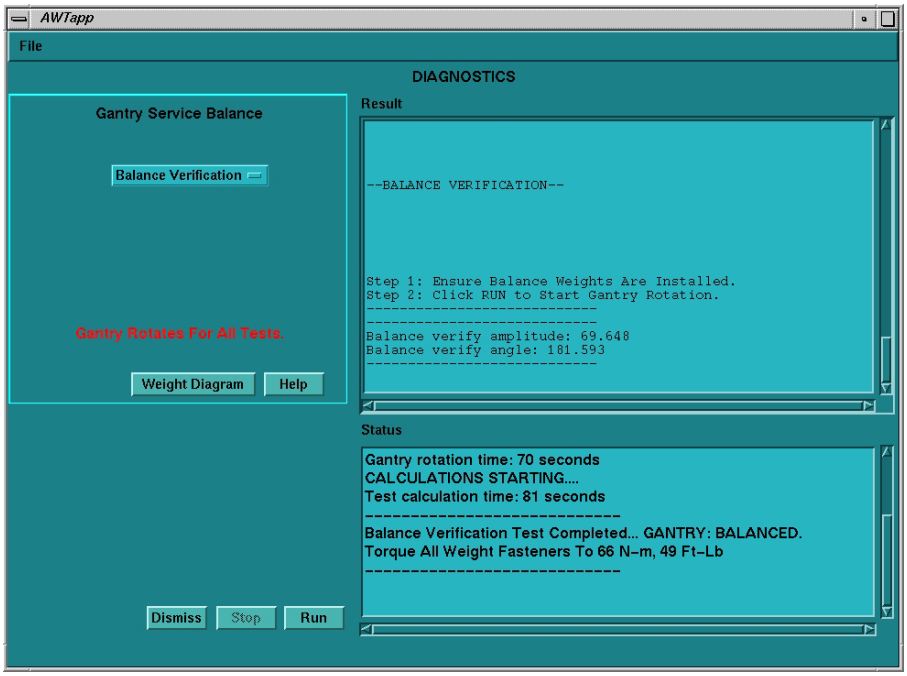


Figure 8-48 Balance Verification Successful Screen

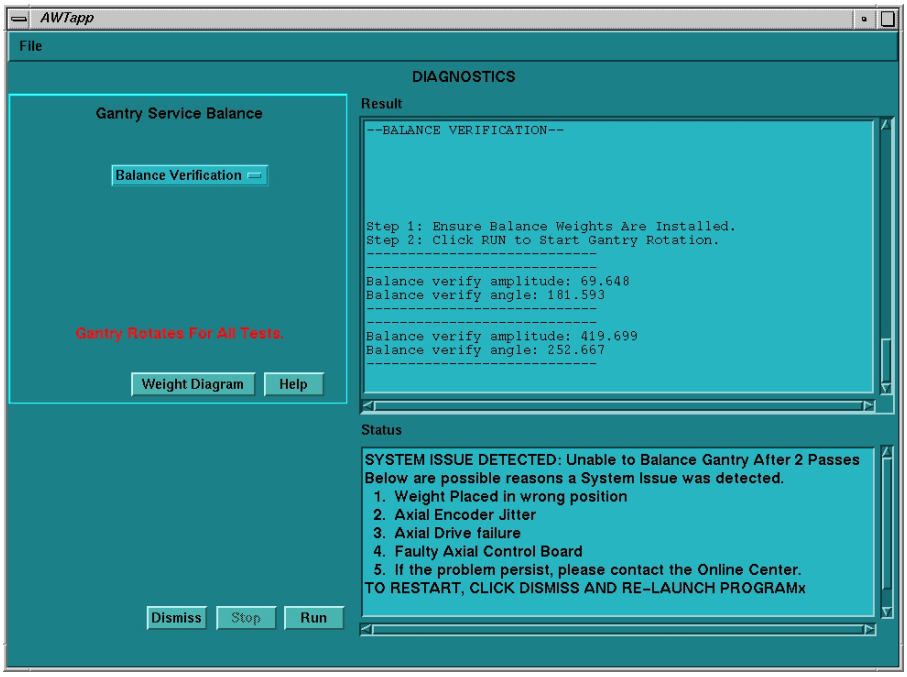


Figure 8-49 Balance Verification Failure Screen

GENERAL COMMENTS

This program is written to follow a specific path without deviation. Various generic error screens are presented to assist you to identify common mistakes, such as “Failure to energize axial enable switch between steps”. In the event of a System Issue Detected failure, the program directs you to investigate most likely items of failure. Those items must be repaired before the program can be successfully completed.

Section 3.0
Replacement Procedures

3.1 Covers

3.1.1 Side Covers

Before beginning this procedure, please read the safety information in "Gantry," on page 37.

3.1.1.1 Side Cover Removal

1.) Lower table to home (lowest) position.

CAUTION Potential for injury if covers removed and power is left "ON".

Always remove the right side cover first, and turn "OFF" power at the STC.

2.) Use an 8mm Hex wrench to unlatch the side cover from the front cover. See Figure 8-50.

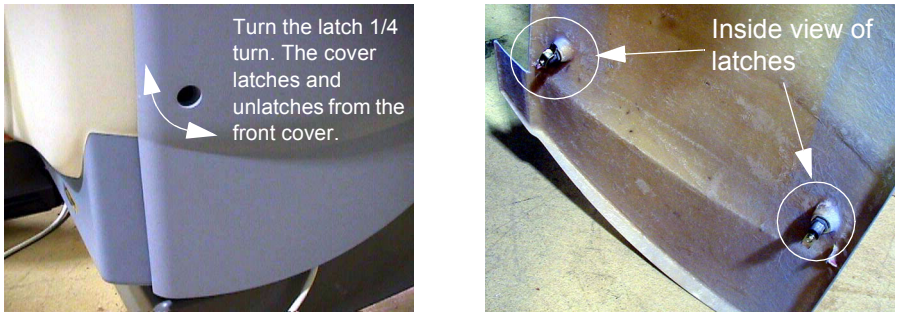


Figure 8-50 Side Cover Latches

3.) Remove the right side cover by lifting it upward to release the two (2) latches, located on the top edge of the cover. Once removed, the **STC** backplane should be exposed.

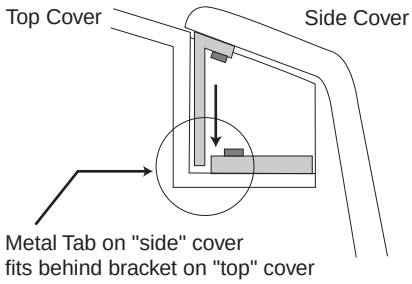


Figure 8-51 Side and Top Cover Clasp

4.) Turn off all three (3) power switches on the **STC** backplane.

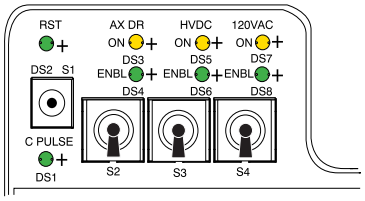


Figure 8-52 STC Power Switches

5.) Repeat steps 1-3 for the left side cover.

3.1.1.2 Side Cover Installation

1.) To install a side cover, place it over the top cover and let the two (2) side cover latches slide behind the metal tabs, located on the top cover. See Figure 8-51.
2.) Use Hex wrench to secure the side cover to front cover by turning the bolts a quarter turn. See Figure 8-50.

3.1.2 Tilt Regulatory Covers

Before beginning this procedure, please read the safety information in "Gantry," on page 37.

CAUTION **Before you remove the tilt regulatory covers, make sure the axial drive is disabled (see Figure 8-52).**

Note: While it *is* possible to remove these covers without removing the front cover first, removal of the front cover does make the process easier and eliminates the need to tilt the gantry to gain access for the right side.

3.1.2.1 Right Side Tilt Regulatory Cover Removal

1.) Remove gantry side covers.
2.) Turn off axial drive enable.
3.) Tilt gantry backward to around -5.0 degrees.
4.) Disconnect the lower right front cover brace from the gantry front cover.
5.) Using a 6 mm ball-end hex wrench, remove four screws securing the cover to the gantry frame.
6.) Tilt gantry forward to around +18.5 degrees.
7.) Referring to Figure 8-53, carefully slide the panel out of position through the rear of the gantry.
8.) Reconnect the right lower gantry front cover latch

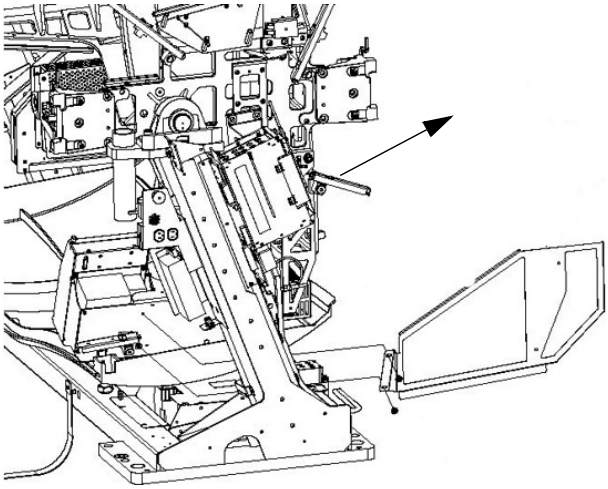


Figure 8-53 Right Side Tilt Regulatory Cover Removal

3.1.2.2 Right Side Tilt Regulatory Cover Installation

1.) Turn off axial drive enable.
2.) Tilt gantry forward to around +18.5 degrees.
3.) Referring to Figure 8-54, carefully slide panel into position from the rear of the gantry.
4.) Tilt gantry backward to around -5.0 degrees.
5.) Disconnect right lower gantry front cover latch.
6.) Loosely fasten two front screws, two lock washers, and two washers to the holes at the front

edge of the panel (see Figure 8-54).

7.) Loosely fasten two rear screws, two lock washers, and washers to the new holes at the rear of the panel (see Figure 8-54).

8.) Assure that the clearance indicated in Figure 8-54 (1 cm) is met before final tightening of the four screws.

9.) Tighten screws.

10.) Reconnect right lower gantry front cover latch.

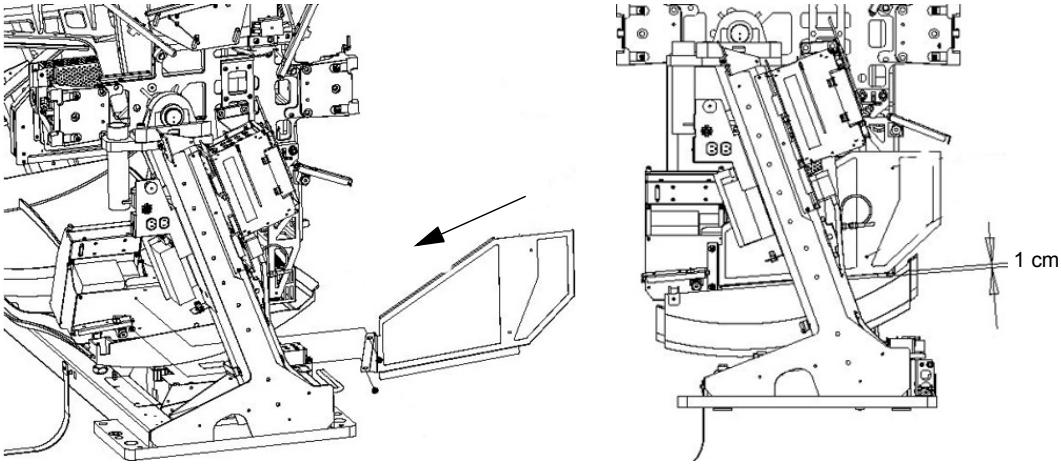


Figure 8-54 Right Side Tilt Regulatory Cover Installation

3.1.2.3 Left Side Tilt Regulatory Cover Removal

1.) Verify axial drive is turned off.

2.) Tilt gantry to 0 degrees.

3.) As shown in Figure 8-55, remove the four screws, four lock washers, and four washers fastening the cover to the gantry **HEMRC** cover and the front cover angle.

4.) Remove the cover by sliding it through the rear of the gantry.

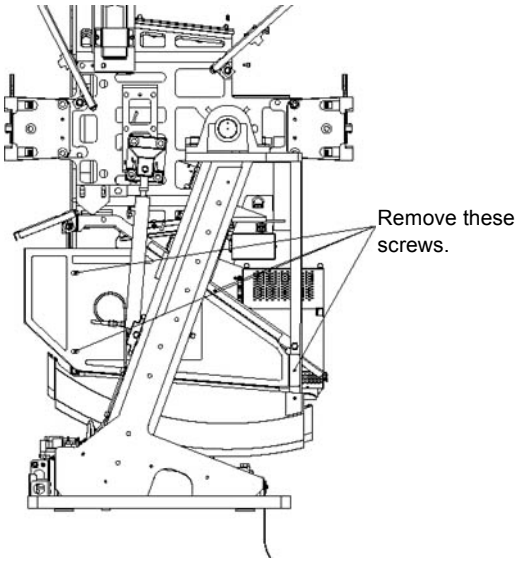


Figure 8-55 Left Side Tilt Regulatory Cover Removal

3.1.2.4 Left Side Tilt Regulatory Cover Installation

Simply reverse the installation procedure to reinstall the cover.

3.1.3 Top Covers

Before beginning this procedure, please read the safety information in "Gantry," on page 37.

CAUTION **Before you remove top covers, always make sure the three (3) power switches have been turned off. (See Figure 8-52.)**

3.1.3.1 Top Cover Removal

1.) Remove the associated side cover if you have not already removed it.
2.) Take the end of the top cover nearest to the side cover and tilt upwards.
3.) Slide the cover down 75 millimeters. This allows the cover's tab to disengage from the mounting bracket. See Figure 8-56.
4.) Lift the cover clear and repeat the above steps for the other cover.

3.1.3.2 Top Cover Installation

The top cover consists of two (2) pieces. Install the front and rear gantry covers, if not already installed. See Section 3.1.4, on page 616, and Section 3.1.5, on page 627.

1.) Take one of the top covers and align the tabs on the cover with its associated bracket. Lift and slide the cover into place. Position the cover to fully engage the fan interlock switch.

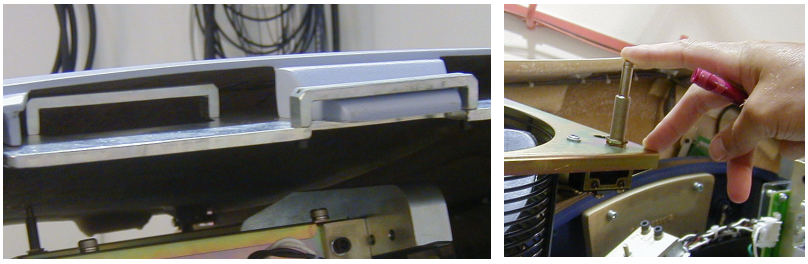


Figure 8-56 Top cover tabs and bracket, plus fan interlock switch.

2.) Take the other top cover and align the tabs on the cover with its associated bracket. Lift and slide the cover into place, while being sure to engage the fan interlock switch.

3.1.4 Front Cover

Before beginning this procedure, please read the safety information in "Gantry," on page 37.

NOTICE Potential for front and rear cover damage. **Front and rear cover removal and installation can be safely accomplished by (1) person using the dollies provided with the system. Failure to use these dollies will significantly increase the likelihood of damage to the covers. Do not lean covers against walls.**

3.1.4.1 Original Front Cover Dolly Setup

The front cover dollies are a folding design for easy storage. This design is stable and assembly/disassembly can be done in 30 second

DANGER **DO NOT USE DOLLIES ON UNEVEN SURFACES SUCH AS STEPS OR ELEVATOR THRESHOLDS. THE DOLLIES ARE DESIGNED TO BE USED ON FLAT LEVEL FLOORS WITHIN THE SCANNING SUITE ONLY. MISUSE CAN RESULT IN PERSONAL INJURY OR DAMAGE TO COVERS OR OTHER FACILITY ITEMS.**

WARNING **ROTATING ARMS ON THE STAND ARE SUPPOSED TO BE STIFF. IF THEY FALL FREELY, TIGHTEN THE TENSIONING NUTS. LOOSE ROTATING ARMS WILL REDUCE THE STABILITY OF THE DOLLIES WHEN SUPPORTING THE FRONT COVER. DO NOT LUBRICATE.**

Note: Rotating arms are shown in the inverted or upside down position for clarity.

1.) Arrange Dolly sections for assembly. The base and stand can be assembled only one way. Refer to Figure 8-57.
   - The stand has a large stud and 3 smaller studs that engage the base assembly.
   - The large stud provides stability.
   - The three small studs engage the base arms preventing them from folding under if accidentally tipped.
   - The Locking pin engages the 4th base arm and prevents accidental separation when assembled.

Figure 8-57 Front Cover Dolly base and stand disassembled

2.) Unfold the base as shown in Figure 8-57 and place on flat surface.

3.) Install Stand in base, insert base locking pin, unfold stand top and secure with palm screw. Ensure additional safety bracket and washer are installed. Reference Figure 8-58.

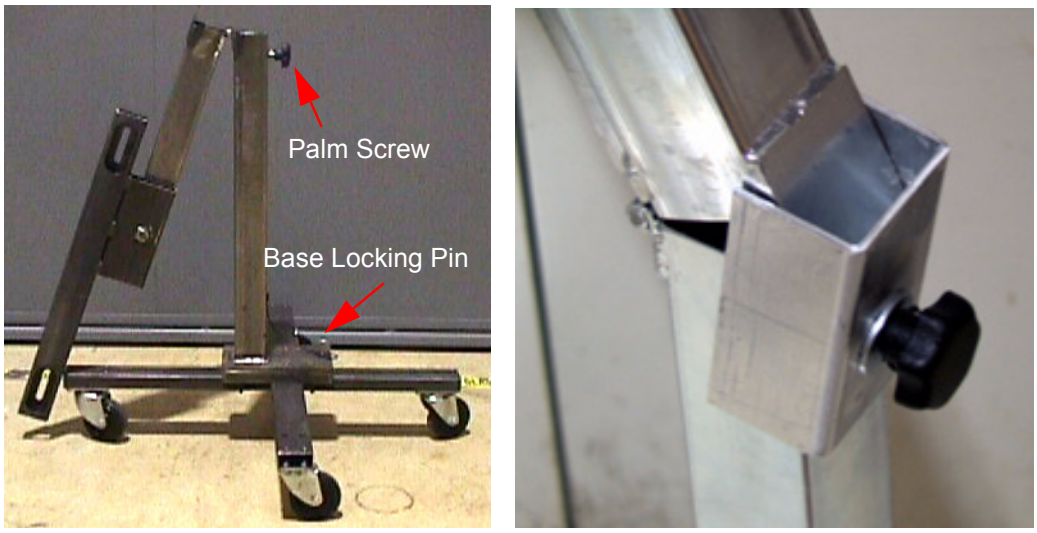


Figure 8-58 Front Cover Dolly Stand and Base with additional Safety Bracket

4.) Assemble second dolly. Both look similar as in Figure 8-59. However the stand portion of the dollies are side specific. The “Right” dolly has the locking pin for cover rotation. The “Left” dolly does not have a cover rotation locking pin.

- Both dolly stands should have an “R” or an “L” indicating right or left.
- The base assemblies are interchangeable.

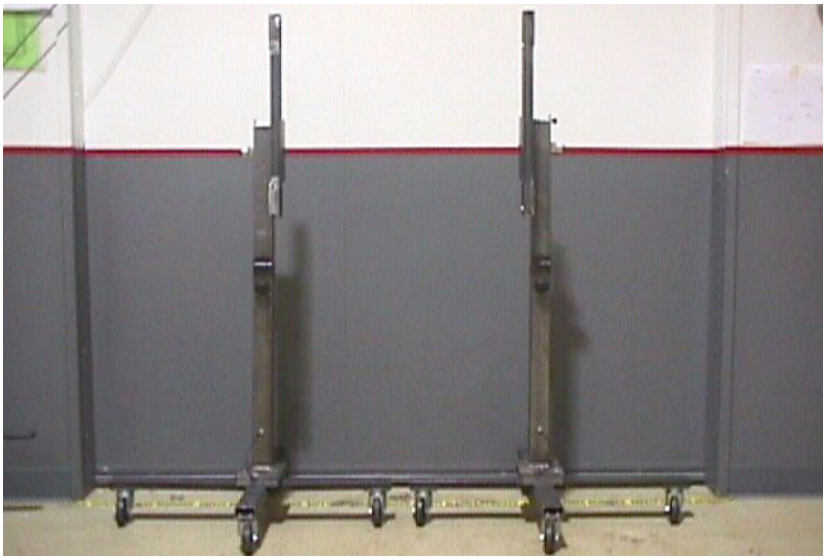


Figure 8-59 Front Cover left and Right Fully Assembled

3.1.4.2 Redesigned Front Cover Dolly Setup

The Front Cover Dollies were redesigned for cost reduction and potential safety concerns. The new Front Cover Dollies can be ordered as replacements for the original design.

DANGER **DO NOT USE DOLLIES ON UNEVEN SURFACES SUCH AS STEPS OR ELEVATOR THRESHOLDS. THE DOLLIES ARE DESIGNED TO BE USED ON FLAT LEVEL FLOORS WITHIN THE SCANNING SUITE ONLY. MISUSE CAN RESULT IN PERSONAL INJURY OR DAMAGE TO COVERS OR OTHER FACILITY ITEMS.**

WARNING **ROTATING ARMS ON THE STAND ARE SUPPOSED TO BE STIFF. IF THEY FALL FREELY, TIGHTEN THE TENSIONING NUTS. LOOSE ROTATING ARMS WILL REDUCE THE STABILITY OF THE DOLLIES WHEN SUPPORTING THE FRONT COVER. DO NOT LUBRICATE.**

1.) Arrange Dolly sections for assembly. The base and post can be assembled only one way. Refer to Figure 8-60 and Figure 8-61.

- The base uses two (2) palm screws to clamp the four (4) legs in the open or usage mode.
- The base also uses the same palm screws to prevent the legs from falling in storage mode.
- The top post can be inserted in either base and is keyed for proper engagement.
- The top post locking pin prevents the sections from separating during usage.

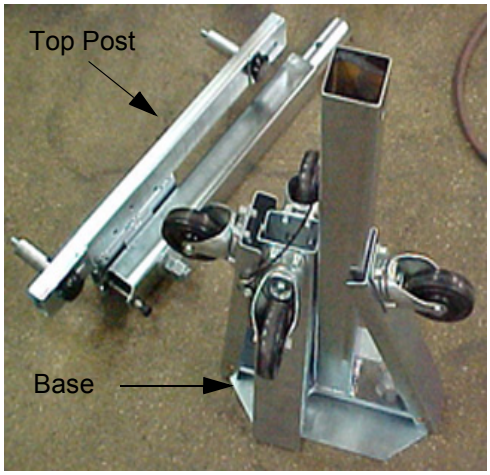


Figure 8-60 Redesigned Front Cover Dolly in Storage Mode

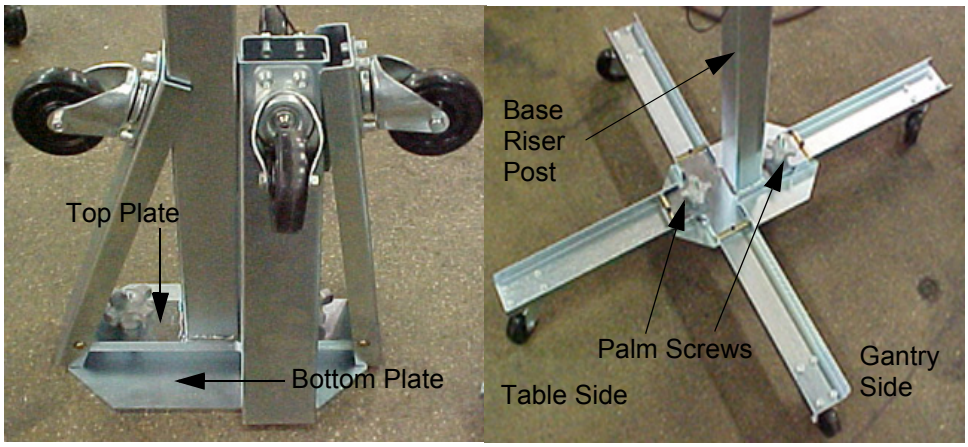


Figure 8-61 Redesigned Front Cover Dolly Base Assembly

2.) Unfold the base legs by loosening both palm screws to the top of their travel.

3.) Carefully unfold the legs so that the castors touch the floor.

4.) Tighten the palm screws to clamp the legs between the base top and bottom plates.

Note: Lifting the base by the riser post while leaving the castors on the floor will ease palm screw tightening. Reference Figure 8-61.

WARNING **ENSURE BOTH PALM SCREWS ARE TIGHTENED SECURELY AND THE LEGS ARE CLAMPED TIGHTLY BETWEEN THE BASE TOP AND BOTTOM PLATES. FAILURE TO DO SO WILL RESULT IN INSTABILITY DURING FRONT COVER HANDLING.**

5.) Insert top post into the base riser post. Align the key for complete engagement.

6.) Insert top post locking pin to secure both top and bottom sections.

7.) Reverse above steps to disassemble.

Note: For base storage only one (1) palm screw needs to be tightened. This will engage the bottom base plate and the leg ends preventing the legs from unfolding during transport and storage.

3.1.4.3 Removal

Before beginning this procedure, please read the safety information in "Gantry," on page 37.

1.) Position the table at its lowest position.

2.) Remove gantry side and top covers, if you have not already done so. See Section 3.1.1, on page 613. Make sure that the three (3) power switches have been turned off. See Figure 8-52.

3.) Assemble the front cover dolly.

a.) Tighten the two (2) shoulder bolts to the gantry securely. This will make cover installation easier. See Figure 8-62.

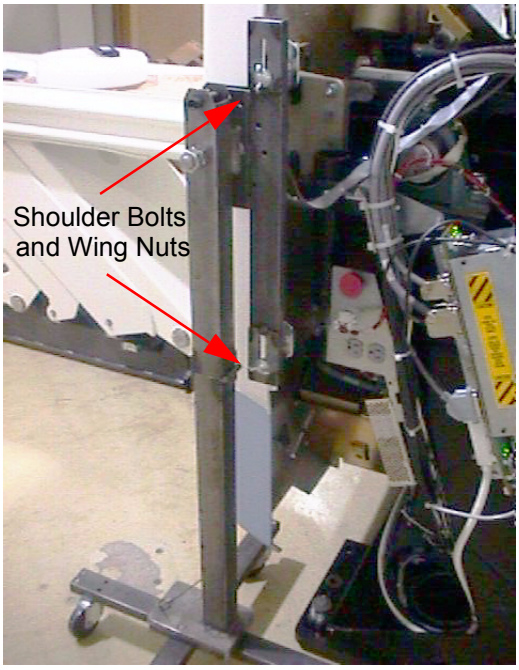


Figure 8-62 Front Side Dolly

b.) Attach side dolly to the shoulder bolts and secure assembly with two (2) wing nuts.

c.) Repeat steps a and b to assemble the other side dolly.

4.) Detach front cover J3 and J2 and front cover BKHD J1 cables.

5.) Remove front cover

a.) Disengage upper and lower cantrell brackets on both sides of the cover.

1.) Using steady but firm pressure, lift each of the lower cantrell brackets from their associated retainers. See Figure 8-63.

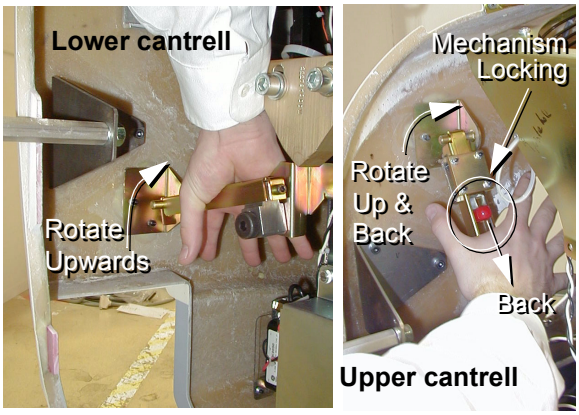


Figure 8-63 Releasing cover brackets

2.) Disengage the locking mechanism on the upper cantrell brackets by using your thumb to slide the trigger (red lever) back. This will release the locking mechanism and allow the cantrell to be rotated upwards with steady and firm pressure.

b.) Disengage the rubber retaining straps on both sides. You may find it helpful to lift “up” on the cover to align the stud while attaching the rubber retaining straps.

c.) Also lift and rotate cover locking arm to unlocked position.

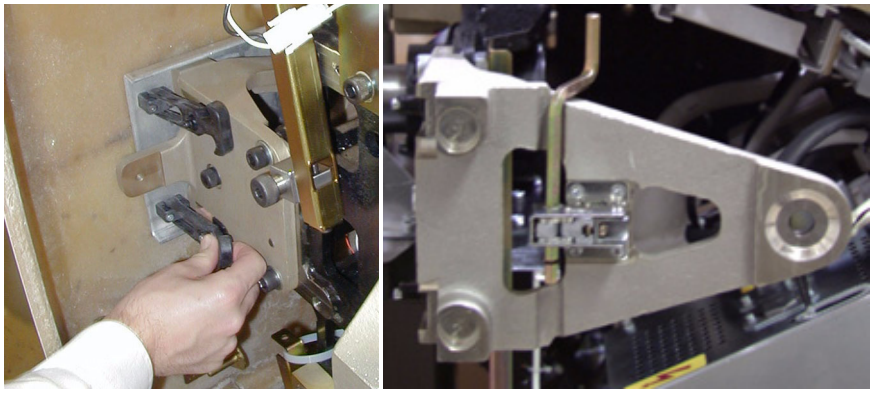


Figure 8-64 Rubber retaining straps and Cover Locking mechanism

6.) Rotate front cover away from gantry.

a.) Move front cover away from gantry, leaving space (about 5 feet) between cover and gantry.

b.) Pull the locking pin and rotate front cover away from gantry. Place locking pin in one of the side dolly perforations. See Figure 8-65.

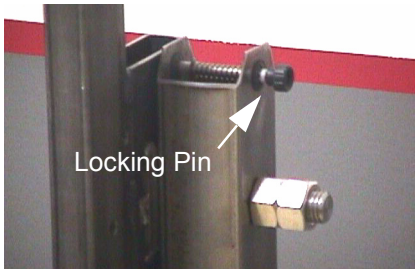
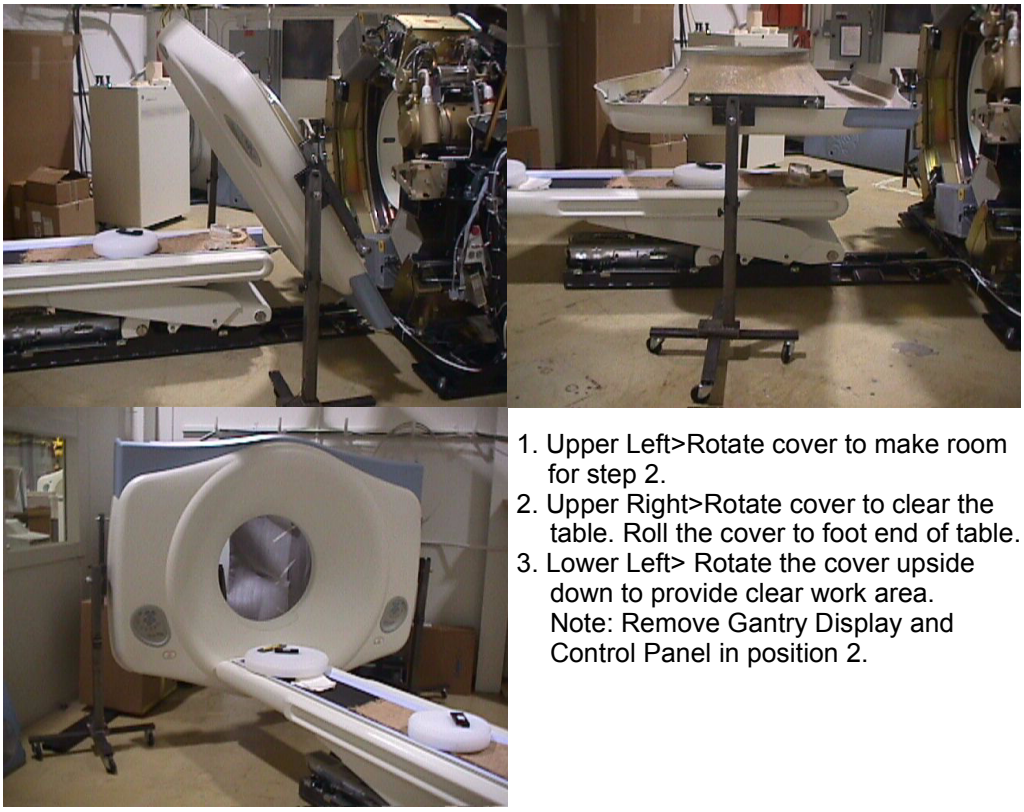


Figure 8-65 releasing Front Cover Dolly Hinge



1. Upper Left>Rotate cover to make room for step 2.
2. Upper Right>Rotate cover to clear the table. Roll the cover to foot end of table.
3. Lower Left> Rotate the cover upside down to provide clear work area.
   Note: Remove Gantry Display and Control Panel in position 2.

Figure 8-66 Front Cover Removal Sequence

7.) Rotate the cover horizontally and move it back and over the table to a safe location. Once in a safe location, you may over-rotate the cover full vertically but upside down.

8.) Remove the gantry display and one (1) of the cover's control assemblies, and place them into the service positions.

a.) Remove the gantry display and place it into its service position.

* The gantry display is held in place with (5) thumb screws. Use a flat-blade screwdriver to remove the Display. Reference Figure 8-67.
* Mount the Display on the Right Gantry Fan.
* There are (2) mounting methods. Both use the cables connected to the REAR GANTRY COVER.
* DIsconnect the cabling at the right rear gantry cover. Only (1) cable will connect to the Gantry Display.
* Position "A" - use one of the display T-hook to hang in the "T" slot on the side of the right Gantry Fan Assembly. Reference Figure 8-68.
* Position "B" - place the Display in the cradle across the top of the right Gantry Fan Assembly. Use thumb-screw to secure display on right side. Reference Figure 8-69.

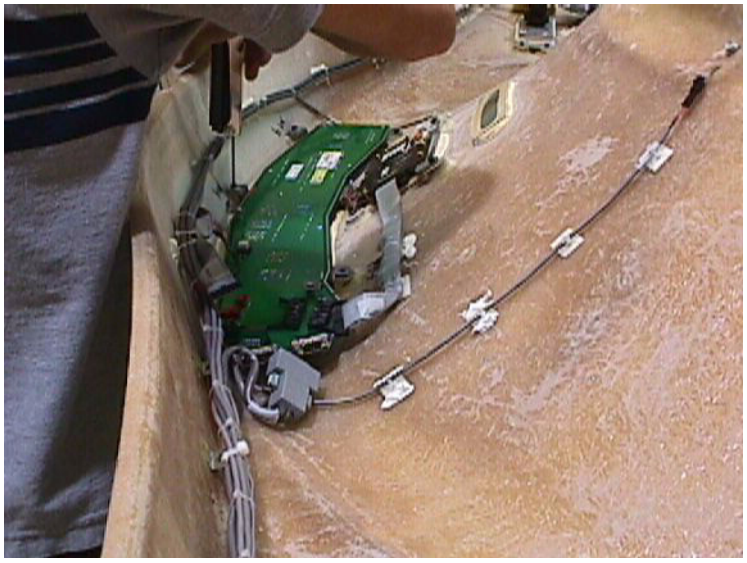


Figure 8-67 Gantry Display Removal

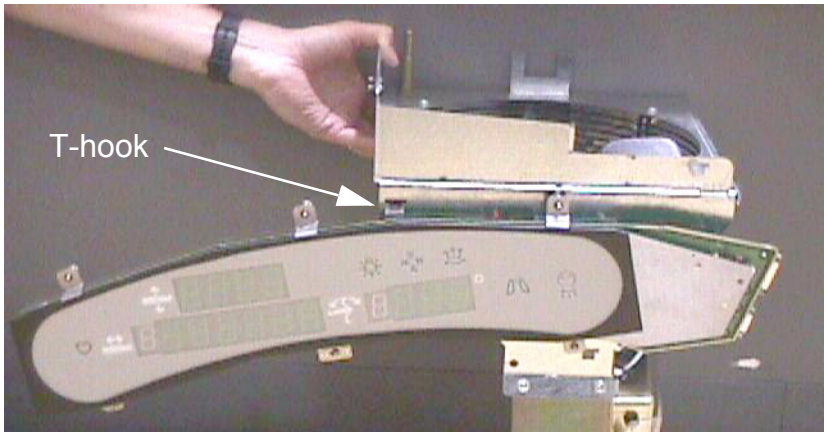


Figure 8-68 Gantry Display Service Mounting Location "A"

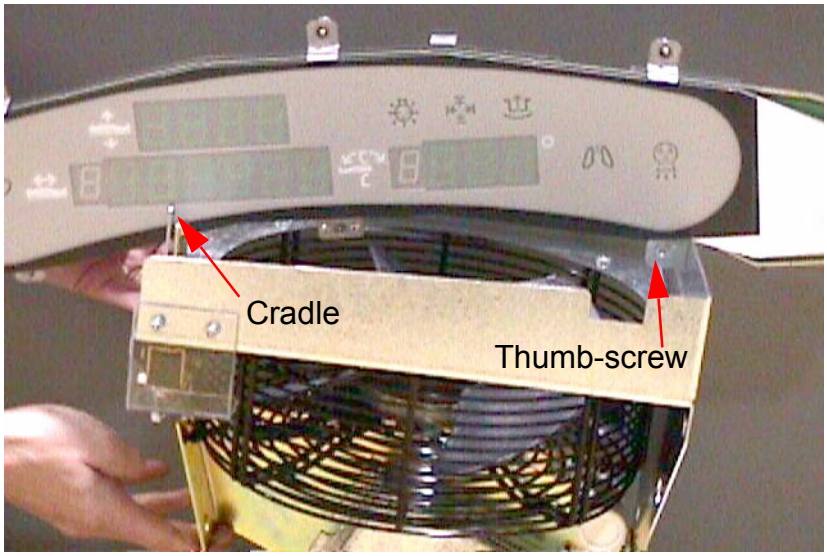


Figure 8-69 Gantry Display Service Mounting Location "B"

b.) Remove a gantry control and place it into its service position.

1.) Press on each ball stud until the panel is released. Keep one hand on the control panel at all times to prevent it from dropping to the floor.

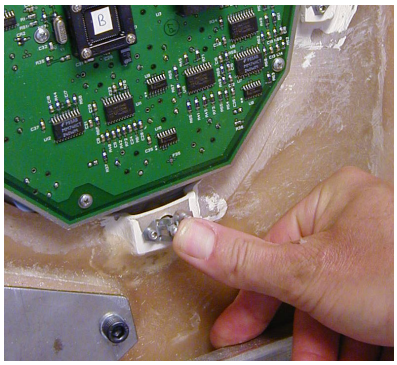


Figure 8-70 Gantry control panel removal

2.) Align the ball studs with their associated receivers and snap into place.

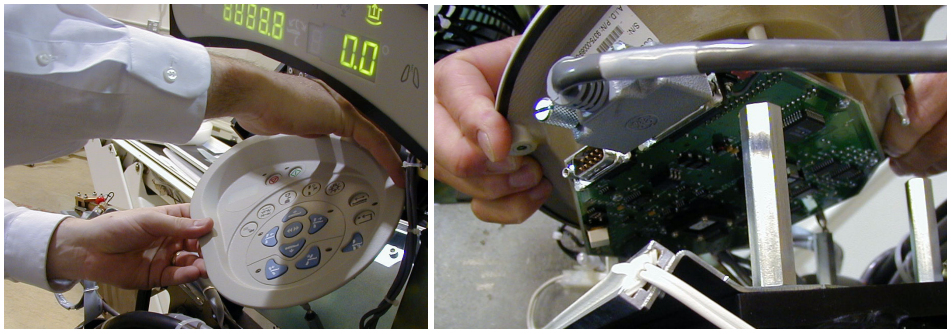


Figure 8-71 Control panel service position

3.) Connect cable to terminator located on the cantrell arm. Reference Figure 8-72.

Note: There are 3 cables, each of which is unique. The ribbon cable is not used in the Service configuration. The other 2 cables will only fit in the terminator or the control panel, not both.

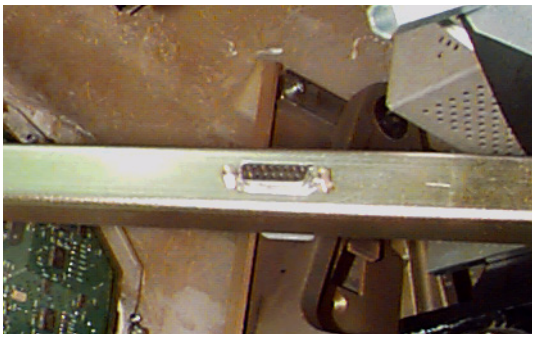


Figure 8-72 Gantry Service Mode Cable Terminator

3.1.4.4 Installation

1.) Remove the gantry display and control assembly from their service positions and reattach them to the gantry cover.
   a.) Disconnect cables from Display and Gantry Control Panels.
   b.) Install Gantry Display in front cover. Secure the 5 thumbscrews. With a flat-blade screwdriver, gently tighten past finger-tight.
   c.) Install the gantry control panel, making sure the ball studs are secure within the receivers.
   d.) Reattach cables.
2.) Rotate gantry back to its vertical position.

NOTICE Potential for front cover damage.

When you rotate the gantry back to its vertical position, make sure not to scratch the front cover with the edge of the table cradle.

3.) Attach the front cover.
   a.) Align the studs on both sides of the front cover with each associated receiver. Receiver is located on the gantry frame.

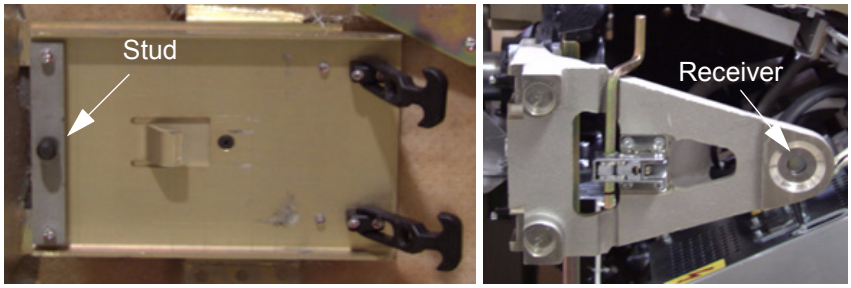


Figure 8-73 Cover stud and Mounting bracket receiver

   b.) Insert the stud on one side into its associated receiver and attach the rubber retaining straps.Then insert the stud on the other side into its associated receiver and attach its rubber retaining straps.

   You may find it helpful to lift "up" on the cover to align the stud while attaching the rubber retaining straps.
4.) Reattach upper and lower cantrell brackets on both sides.
   a.) Remove upper Cantrell brackets from service position and rotate them into position over their associated retaining pins. See Figure 8-74.

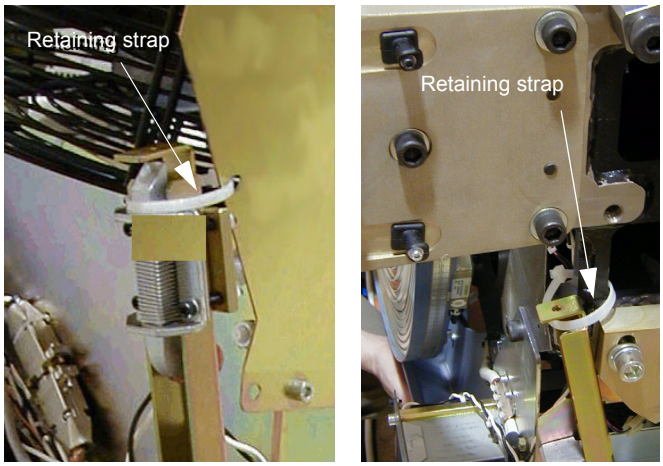


Figure 8-74 Service position of upper and lower cantrell brackets.

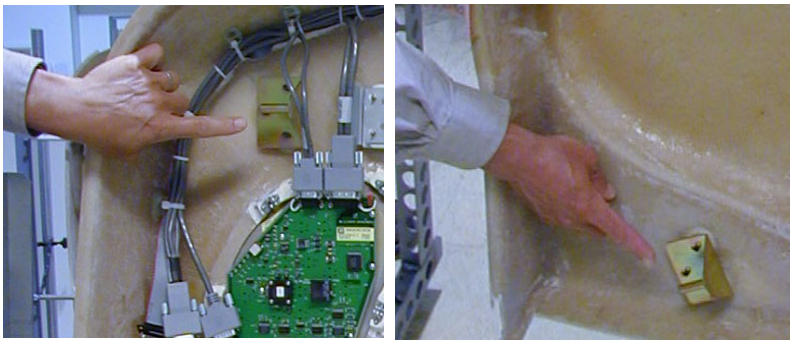


Figure 8-75 Cover retaining pins (top and bottom)

Press down firmly on the bracket and snap it into place. The locking mechanism on each upper bracket should lock the bracket securely into place. Do this on both sides. See Figure 8-76.

Figure 8-76 Locking the cover brackets into place.

b.) Remove lower cantrell brackets from service position (see Figure 8-74), and rotate them into position over their associated retaining pins. Press down firmly on the bracket and snap it into place. See Figure 8-76.

Note: Mis-adjustment of the cantrell brackets can cause misalignment of the top and side covers. The upper and lower cantrell brackets do not require adjustment during normal use.

5.) Remove dolly, disassemble and store safely away for later use.

6.) Reattach cables to cover.

3.1.5 Rear Cover

3.1.5.1 Removal

1.) Assemble the rear cover dolly.

a.) Tighten the two (2) shoulder bolts to the rear cover.

Figure 8-77 One side of the Rear cover dolly

b.) Fit side dolly through the shoulder bolts and secure assembly with two (2) wing nuts. See Figure 8-77

c.) Repeat steps a and b for the other side dolly.

CAUTION Potential for injury if covers removed and power is left "ON".

2.) Disconnect cables on the right side of the rear cover.

3.) Remove rear cover.

a.) Disengage upper and lower cantrell brackets on both sides of the rear cover.

1.) Using steady but firm pressure, lift each of the lower cantrell brackets from their associated retainers. See Figure 8-63.

2.) Disengage the locking mechanism on the upper cantrell brackets by using your thumb to slide the trigger (red lever) back. This will release the locking mechanism and allow the cantrell to be rotated upwards with steady and firm pressure.

b.) Disengage the rubber retaining straps on both sides.

3.1.5.2 Installation

1.) Position cover in back of gantry

2.) Attach the rear cover

a.) Align the studs on both sides of the rear cover with the receivers located on the gantry frame.

b.) Insert the stud on one side into its associated receiver and attach the rubber retaining straps.Then insert the stud on the other side into its associated receiver and attach its rubber retaining straps.

Note: You may find it helpful to lift "up" on the cover to align the stud while attaching the rubber retaining straps.

3.) Reattach upper and lower cantrell brackets on both sides.

a.) Remove upper cantrell brackets from service position and rotate them into position over their associated retaining pins. Press down firmly on the bracket and snap it into place. The locking mechanism on each upper bracket should lock the bracket securely into place. Do this on both sides.

b.) Remove lower cantrell brackets from service position and rotate them into position over their associated retaining pins. Press down firmly on the bracket and snap it into place.

Note: Adjustment of the cantrell brackets can cause misalignment of the top and side covers. The upper and lower cantrell brackets do not require adjust during normal use.

4.) Remove dolly, disassemble and store safely away.

5.) Reattach cables to cover.

6.) Reinstall the mylar (scan) window. Carefully, bend the scan window and place it into the channel (groove) provided in the covers.

Figure 8-78 Installing the mylar window

3.1.6 Scan Window

3.1.6.1 Remove Scan Window

1.) Grab the window at the top and pull firmly downward.

2.) Continue to pull until the top of the scan window makes contact with the bottom portion of the scan window.

3.) Hold the top and bottom portions of the scan window together, grasp both sides of the scan window, move them together and lightly pull upward, until you can free the window from between the front and rear covers.

Figure 8-79 Scan Window Removal

3.1.6.2 Install Scan Window

NOTICE Potential for Equipment Damage.

The cones of the front and rear gantry covers must be aligned within specification to ensure proper scan window fit. If the scan window is not fit properly, fluids can get in to the collimator causing permanent damage. See "Scan Window Alignment," on page 593**.**

1.) Install the front and rear covers.

2.) Deform the scan window, as shown in Figure 8-80, and nest the scan window at the bottom of the opening between the front and rear covers, (Figure 8-81) with the rivets in the 6 o'clock installation position. Remember the rivets must be in the 12 o'clock position when the mylar window is fully installed.

3.) After you complete the initial seating of scan window, let the window slowly unfold, and work both sides of the window into position, starting at the bottom and finishing at the top.

4.) Make sure you position the window with the rivets at the 12 o'clock position, and the mylar window slit at either the 3 or 9 o'clock position.

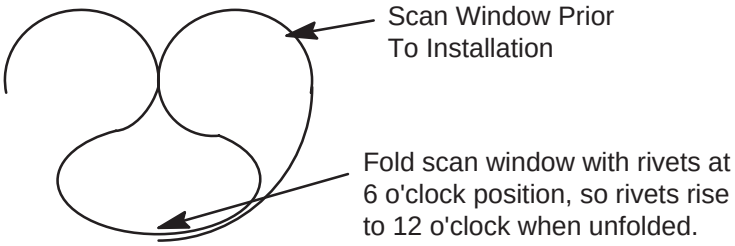


Figure 8-80 Install Scan Window

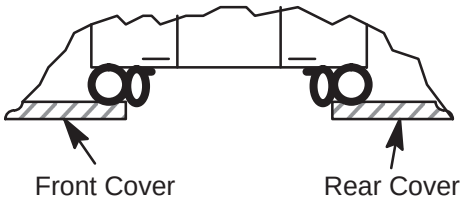


Figure 8-81 Scan Window Nested Between Front and Rear Cover

3.2 Axial

3.2.1 Axial Drive Motor Assembly

3.2.1.1 Required Tools

- 6mm, 10mm, 8mm hex keys
- 12 inch extension for 6mm hex key
- Hoist and 2 flexible lifting straps

3.2.1.2 Procedure Details

1.) Remove the right and back covers and lower slipring cover.

2.) Remove the tilting gantry bottom cover.

3.) Turn off all 3 switches (Axial Drive, **HVDC**, 120VAC) on the **STC** backplane. Remove all system power at the Main Disconnect panel and use proper Lockout/Tagout procedures.

DANGER **LETHAL VOLTAGES ARE PRESENT WITHIN THIS ASSEMBLY. ALWAYS REMOVE POWER BEFORE ATTEMPTING TO REMOVE ANY COVERS. SEVERE INJURY OR DEATH CAN RESULT.**

4.) Rotate the tube to the 3:00 position.

5.) Disconnect the Control and Dynamic Brake cabling at the Axial Drive Module. Reference "Axial Drive Module," on page 631.

6.) Remove the Drive Gear cover.

7.) Using the 6mm hex key and the 12 inch extension, fully loosen the elongated hex screw to loosen the drive belt.

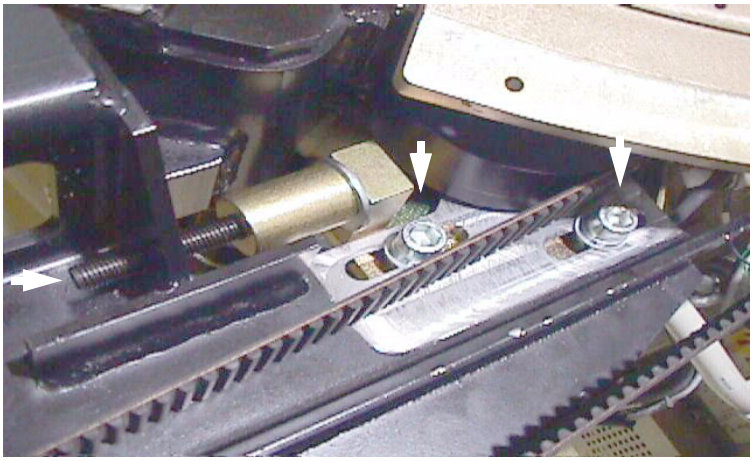
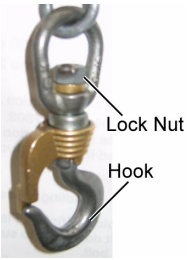


Figure 8-82 To loosen drive belt, loosen 2 screws and the long hex screw

8.) Remove the drive belt from the drive gear. Take care to not disturb the teeth engagement along the rotating assembly.

9.) Using a 10mm hex key, loosen 2 screws that will loosen drive belt.

WARNING



IF THE HOIST IS USED WITH THE LOCK NUT OF THE HOOK LOOSE, THE MOTOR MIGHT BE DROPPED FROM THE HOIST, WITH THE RESULT THAT A SERVICE PERSONNEL MIGHT BE SERIOUSLY INJURED. CHECK IF THE LOCK NUT OF THE HOOK IS LOOSENED FIRST BEFORE STARTING TO USE THE HOIST. IF LOOSENED, DO NOT USE THE HOIST THEN ORDER THE NEW HOIST.

10.) Assemble hoist and use it to support the motor.

WARNING **MAKE SURE THE MOTOR IS SUPPORTED WITH A HOIST.**

11.) Loosen 4 hex screws to release motor and remove ground cable.

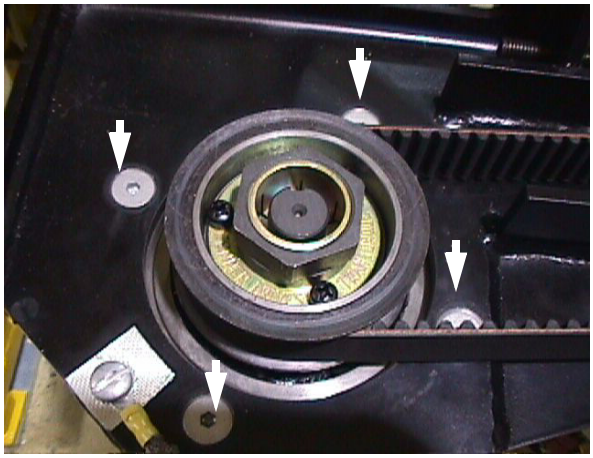


Figure 8-83 Removing the 4 hex screws will release motor

12.) Replace motor and secure it in place.
13.) Install the drive belt on the drive gear and tension belt. Reference "Belt Removal and Installation," on page 636.
14.) Connect cabling to Axial Drive module. Reference "Axial Drive Module," on page 631.
15.) Reassemble gantry.

3.2.2 Axial Drive Module

3.2.2.1 Required Tools

- Screwdriver flat-blade
- Screwdriver Phillips #1 and #2
- 4 MM Hex Key

3.2.2.2 Procedure Details

1.) Remove gantry side, top and front covers.
2.) Turn off all 3 switches (Axial Drive, **HVDC**, 120VAC) on the **STC** backplane. Remove all system power at the Main Disconnect panel and use proper Lockout/Tagout procedures.

DANGER **LETHAL VOLTAGES ARE PRESENT WITHIN THIS ASSEMBLY. ALWAYS REMOVE POWER BEFORE ATTEMPTING TO REMOVE ANY COVERS. SEVERE INJURY OR DEATH CAN RESULT.**

3.) Rotate the tube to the 3:00 position.
4.) Remove Axial Drive Module (**ADM**) cover by loosening the 4 thumb screws.
5.) Using the flat-blade screwdriver, carefully loosen and fully remove the lock nut from the electrical connector. Push the lock nut and male threads along the cables clear of the **ADM** housing assembly. Do not attempt to remove these from the cables. This will allow cable removal later.
6.) Disconnect the control cable from the outside bottom of the **ADM** assembly.
7.) Disconnect the 3 phase VAC power connections at TB1 R, S, T. Write down colors for later reference.
8.) Disconnect the output PWM cable to the motor at TB1 U, W, V. Write down colors for later reference.
9.) Disconnect the Axial Dynamic Brake cable connections at TB1 DC+, DC- and TB3 24, 25. Write down colors for later reference.

10.) Disconnect the molex connection at the holding brake relay.

11.) Carefully remove the cables from the **ADM** cover using the slots provided. Carefully cut and remove ty-raps as needed.

12.) Remove the six (6) M6 screws using the 4mm hex key. Four (4) screws are on the bottom and two (2) are on the sides. This will separate the **ADM** assembly, including the two (2) trapezoid shaped support brackets, from the main support bracket.

13.) Verify the two (2) jumpers are in the 5V encoder position on the new **ADM** assembly. Reference Figure 8-5, on page 559.

14.) Assemble in reverse order. Remember to replace all removed ty-raps.

15.) Restore system power, turn ON **STC** service switches and verify **LED**s are illuminated on **ADM**.

16.) Reassemble gantry.

3.2.3 Axial Drive Holding Brake

3.2.3.1 Required Tools

9/16 socket wrench

3.2.3.2 Procedure Details

1.) Remove all gantry covers. (Front cover removal not needed for this procedure.)
2.) Turn off all three (3) switches (Axial Drive, **HVDC**, 120VAC) on the **STC** backplane.

DANGER VERIFY 120 VAC IS NOT PRESENT AT HOLDING BRAKE RELAY.

3.) Engage indexer lock to prevent unexpected gantry rotation.
4.) Disconnect 2 MOLEX connections to holding brake relay.
5.) Remove three (3) bolts that secure BRAKE motor to MOTOR.
6.) Slide assembly off shaft.
7.) Check the collar alignment on the NEW Holding Brake before installing on motor shaft. The hexagonal opening should be centered to insure there are no grinding noises from the brake when in operation.
8.) If the Hexagonal opening is not centered perform steps 9, 10 and 11.

DANGER 120 VAC IS PRESENT AT HOLDING BRAKE RELAY.

9.) Connect 2 Molex connectors to New Holding Brake while it is not attached to the motor shaft. This will release the brake.
10.) Center the Hexagonal opening with respect to the circular shaft opening.
11.) Remove the 2 Molex connections. The brake will engage when power is remove.
12.) Install new brake.
13.) Reassemble gantry.

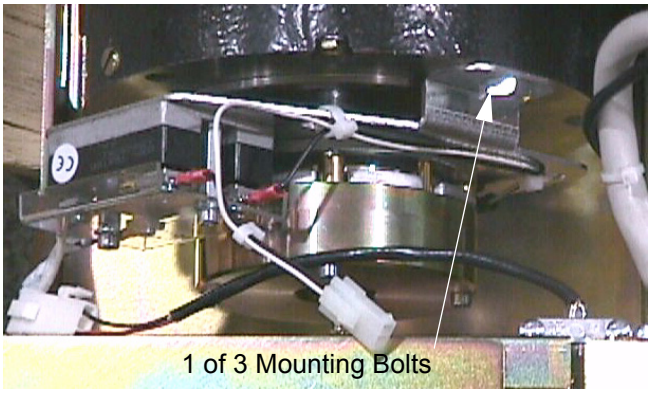


Figure 8-84 Axial Holding brake

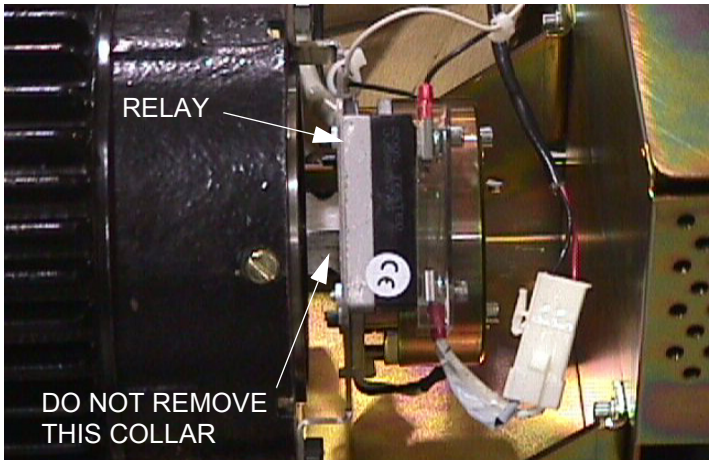


Figure 8-85 Axial Holding Brake Relay

3.2.4 Axial Dynamic Braking Module

This procedure describes the proper method for safe access to the components of this assembly. Always use proper service practices in **ESD**, power control, and assembly/disassembly procedures. Verify all connections are correct and tightened prior power application.

3.2.4.1 Required Tools

- Phillips #2 screwdriver
- Flat-blade screwdriver
- 3 MM. Hex Key

3.2.4.2 Procedure Details

1.) Move table to its lowest elevation.

2.) Remove right and left side covers. Rear cover removal is optional.

3.) Tilt gantry forward to allow sufficient clearance for assembly cover removal.

4.) Turn off all 3 switches (Axial Drive, **HVDC**, 120VAC) on the **STC** backplane. Remove all system power at the Main Disconnect panel and use proper Lockout/Tagout procedures.

DANGER

LETHAL VOLTAGES PRESENT WITHIN THIS ASSEMBLY. ALWAYS REMOVE POWER BEFORE ATTEMPTING TO REMOVE ANY COVERS. SEVERE INJURY OR DEATH CAN RESULT.

5.) Loosen 4 slot binder screws located on the side metal cover.

6.) Carefully remove side metal cover.

Once the side metal cover has been removed, the **HEMRC-IF** board and Chopper circuit components will be exposed.

The chopper load resistors are located behind the **HEMRC-IF** mounting panel.

7.) Remove the screws and chopper load resistor cover as necessary.

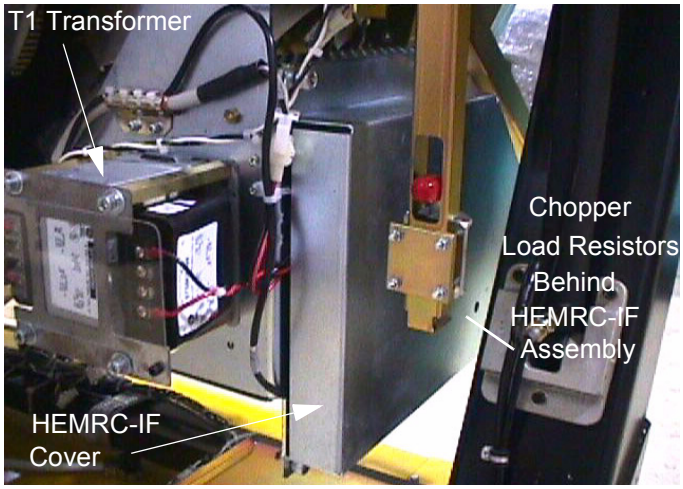


Figure 8-86 Axial Dynamic Brake Assembly

8.) Replace failed components.
9.) Replace covers and reassemble gantry.

3.2.5 Home Flag and Sensor Board Assembly

3.2.5.1 Required Tools

- **ESD** wrist-band
- 2.5mm, 5mm hex keys

3.2.5.2 Procedure Details

1.) Move table to its lowest elevation.
2.) Remove right and left covers.
3.) Turn off all 3 switches (Axial Drive, **HVDC**, 120VAC) on the **STC** backplane.
4.) Locate the home flag by rotating gantry. Replace if any damage is visible.
5.) Locate the Home Flag Sensor assembly, refer to Figure 8-87.
6.) Disconnect the harness.
7.) Remove the M6 screws attaching the bracket to the frame.

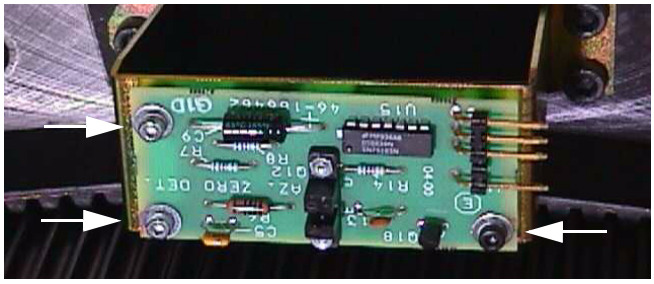


Figure 8-87 Home Flag Sensor Assembly

8.) Replace Sensor Assembly and Home Flag as necessary.
9.) Slowly rotate gantry by hand and adjust flag position to pass through the center of the opto-sensor on the sensor board. Make sure the flag is parallel to the opto-sensor.
10.) Perform "Resetting the C-Pulse," on page 581.
11.) Reassemble gantry.

3.2.6 Axial Encoder Assembly

3.2.6.1 Required Tools

- 8 mm hex key
- Flat-blade screwdriver, thin

3.2.6.2 Procedure Details

1.) Remove gantry side and top covers.
2.) Tilt gantry back to 30 degrees.
3.) Turn off all 3 switches (Axial Drive, **HVDC**, 120VAC) on the **STC** backplane.
4.) Disconnect the Encoder DB 9 pin connect from the gantry harness.
5.) Carefully cut ty-raps as necessary.
6.) Using the 8 mm hex key, remove the shoulder screw on which the encoder assembly pivots.
7.) Install in reverse order.
8.) Perform "Resetting the C-Pulse," on page 581 in Procedures and Adjustments.

3.2.7 Belt Removal and Installation

3.2.7.1 Required Tools

- 12 inch extension for hex key
- 10mm, 8mm 6mm, 5mm hex keys

3.2.7.2 Procedure Details

1.) REMOVAL

a.) Remove the gantry covers (reference "Covers," on page 613) and lower slipring cover.

b.) Turn off all 3 switches (Axial Drive, **HVDC**, 120VAC) on the **STC** backplane. Remove all system power at the Main Disconnect panel and use proper Lockout/Tagout procedures.

c.) Remove the Home Flag assembly to prevent damage. Reference "Home Flag and Sensor Board Assembly," on page 635.

d.) Remove the Axial Encoder to prevent damage to the encoder gear teeth. Reference "Axial Encoder Assembly," on page 636.

e.) Disconnect power connector to **OBC** power distribution board.

f.) Remove the **HEMRC** cover.

g.) Rotate the tube to the 3:00 position. Do not engage the rotational lock.

h.) Loosen the two (2) M12 screws with the 10mm hex key. Reference Figure 8-82, on page 630.

i.) Using the 6mm hex key and the 12 inch extension, fully loosen the elongated hex screw to remove the drive belt from the drive gear. Reference Figure 8-82, on page 630.

j.) Remove the drive belt from the drive gear.

Note: To remove the drive belt requires no slack around the rotating assembly. You will need every millimeter of length to clear the corner of the **HEMRC**. This is very tight, but it can be done, as shown in Figure 8-88.

k.) Work the belt toward the table on the rotating assembly. Keep all slack at the tube side of the gantry.

CAUTION **Use caution around the OBC to prevent damage to the OBC Power-I/F board. Patience is the key.**

l.) Work the belt around and behind the **OBC** to provide enough length to cross the tube.

m.) Work the belt between the **HEMRC** and the tube radiator.

n.) Once belt is over the hose, work belt around cathode end of the tube and radiator. You need to get in front of the tube to clear the corner of the **HEMRC**.

o.) Once the belt is past the tube, carefully gather all the slack to clear the **HEMRC** corner.

p.) When the **HEMRC** is cleared, then carefully work the belt around the rest of the rotating gantry, completing the removal process.

2.) INSTALLATION

a.) Install the belt using the removal steps, 1k through 1p, in reverse order.

b.) Connect the power connector to the **OBC** Power-I/F board.

c.) Install the home flag, axial encoder and the **HEMRC** cover.

d.) Slide the belt over the main drive gear and align it towards the back of the rotating assembly teeth. Check both top and bottom.

e.) Work the belt through the pulley tensioner assembly and place on motor drive gear.

f.) Tighten the elongated hex screw using a 6mm hex key and a 12 inch extension. Apply enough tension so the washer can be rotated with your fingers.

g.) Rotate gantry by hand several times and check tension. Make sure the belt does not slip off tensioning pulley and is tracking correctly toward the rear of the gantry. Repeat step 2g as needed.

h.) Correct tension is achieved when the washer can be turned by finger, with some difficulty.

i.) Tighten the two (2) M12 screws to 30 Ft-lbs. This locks the tensioner assembly.

j.) Install the home flag assembly. Reference "Axial Home Flag Check," on page 580.

k.) Install the axial encoder and adjust. Reference "Resetting the C-Pulse," on page 581.

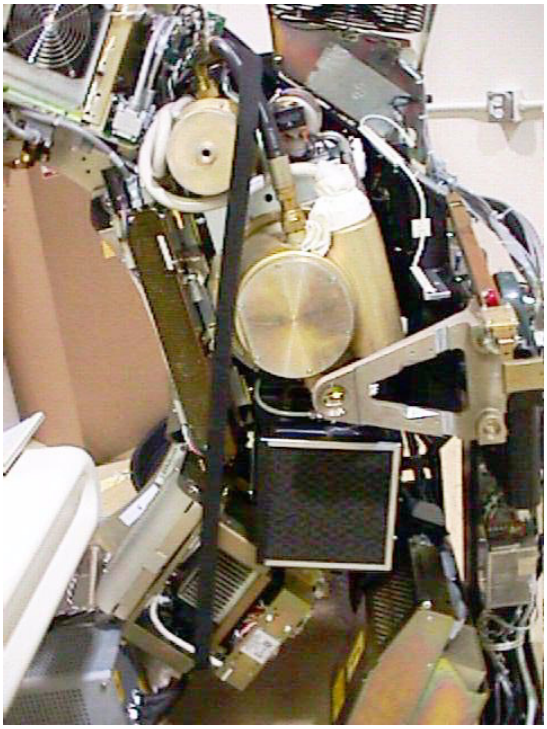


Figure 8-88 Axial Drive Belt Installation/Removal Critical Path

3.3 STC

3.3.1 STC Boards

3.3.1.1 Required Tools

- **ESD** wrist-band
- Phillips #2 screwdriver, if replacing the Artesyn-3 board

3.3.1.2 Procedure Details

1.) Remove right side cover.
2.) Turn off all 3 switches (Axial Drive, **HVDC**, 120VAC) on the **STC** backplane.

THE FOLLOWING PROCEDURE IS FOR THE ARTESYN-3 BOARD:

1.) Unplug serial and ethernet cables.
2.) Loosen top and bottom fasteners with a Phillips #2 screwdriver.
3.) Pull Artesyn board out using black plastic tabs located on top and bottom of the board.
4.) Install new Artesyn board and reassemble gantry.
5.) Retest matrix.

THE FOLLOWING PROCEDURE IS FOR THE LSCOM & AXIAL BOARDS:

1.) Turn off all the 3 switches (Axial Drive, **HVDC**, 120VAC) on the **STC** backplane.
2.) Pull two latches to release the board.
3.) Remove the defective board.
4.) Install the new board. Secure the newly installed board using the two latches.
5.) Retest matrix.

3.3.2 STC Backplane

3.3.2.1 Required Tools

- Phillips #2
- Flathead
- **ESD** Wristband
- 5 mm. hex key
- 3 mm. hex key

3.3.2.2 Procedure Details

1.) Remove all gantry covers. (Front cover removal is unnecessary for this procedure)
2.) Completely shutdown power. (A1, Lockout/Tagout)
3.) Disconnect all control harness cabling.
4.) Remove **STC**
5.) Unscrew ty-rap that secures cabling with hex key.
6.) Remove circuit boards.
7.) Remove hex screws from base assembly and 3 screws behind the tilt riser.
8.) Carefully pivot **STC** backwards and slide assembly out.
9.) Remove 3 hex screws that secure chassis to backplane.

10.) Remove chassis.
11.) Install new **STC** Backplane.
12.) Install in reverse order.
13.) Perform retest matrix.

3.3.3 STC Power Supply

3.3.3.1 Required Tools

- Phillips #2 screwdriver
- Flat-blade screwdriver
- 3 mm. hex key
- **ESD** Wrist Band

3.3.3.2 Procedure Details

1.) Remove right side cover.
2.) Turn off all 3 switches (Axial Drive, **HVDC**, 120VAC) on the **STC** backplane.
3.) Remove plastic safety cover.
4.) Disconnect 4 cables that connect to power supply
5.) Remove 4 hex screws.
6.) Remove **STC** Power Supply.
7.) Install new Power Supply.
8.) Reference adjustment procedures, "STC Power Supplies," on page 575.

3.3.4 E-Stop Button

1.) Remove right side cover.
2.) Remove front cover.
3.) Turn off all 3 switches (Axial Drive, **HVDC**, 120VAC) on the **STC** backplane.
4.) Loosen two screws to remove 2 cables.
5.) Loosen 4 hex screws that fasten the emergency stop button to the cover.
6.) Replace the emergency stop button and reconnect cables.
7.) Reassemble gantry.

3.3.5 STC AC Filter

3.3.5.1 Required Tools

- Phillips #2 short screwdriver
- Flat-blade screwdriver
- 3 mm. Hex Key
- 8 mm. socket wrench
- 9/32 socket wrench
- **ESD** Wrist Band

3.3.5.2 Procedure Details

1.) Remove right side cover.
2.) Remove plastic safety cover.

3.) Disconnect 4 cables that connect to power supply
4.) Remove 3 hex screws.
5.) Remove **STC** Power Supply.
6.) Use socket wrench to remove 4 nuts on top and bottom of AC Filter.
7.) Use socket wrench to remove 2 nuts on top and bottom of AC Filter.
8.) Remove **STC** AC Filter.
9.) Install new **STC** AC Filter.
10.) Reference adjustment procedures.

3.4 Slip Ring

3.4.1 Slipring Platter

3.4.1.1 Required Tools

- Phillips #1 and #2 screwdriver
- Flat-blade screwdriver
- 5 mm, 8 mm, 10 mm Hex Key
- Side Cutter pliers
- Ty-Raps Medium, Long
- **ESD** Wrist Band
- Magnetic mount Dial Indicator with 2 adjustable arms

3.4.1.2 Procedure Details

1.) Remove all gantry covers.
2.) Remove slipring safety covers.
3.) Tilt Gantry forward to +30 degrees.
4.) Completely shutdown system power. (A1, Lockout/Tagout)
5.) Remove rear cover mounting brackets, both sides. Three (3) 12mm bolts on each mount.
6.) Remove brush block and ty-rap the brush block to the stationary member out of harms way. You can remove the brush block assembly entirely if you choose.
7.) Remove all wiring ty-raps on the ring inside diameter.
   - Write down all filter and cabling connections.
   - Write down ty-rap locations and sizes.

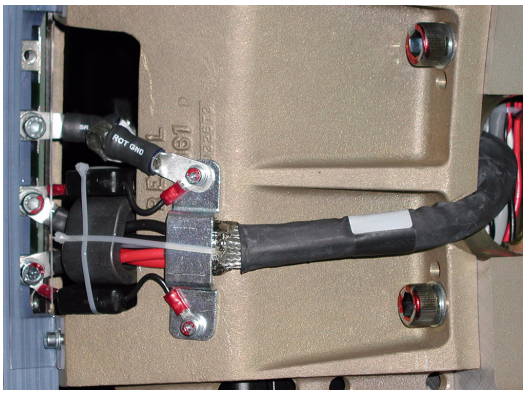


Figure 8-89 Slipring Filter

8.) Disconnect all cables from slipring.

9.) Remove antenna bracket with antenna assembly.

WARNING **FOLLOW THIS PROCEDURE EXACTLY. DO NOT TAKE SHORT CUTS. BOTH AXIAL AND RADIAL RUNOUT AS WELL AS GANTRY BALANCE ARE AT STAKE.**

10.) Rotate gantry so signal PCB is in 12 o'clock position. This puts the tube at 12 o'clock also.

11.) Engage axial rotating lock to prevent gantry rotation.

12.) Mark slipring, slipring cast mounting brackets, and rotating casting with numbers 1 through 6.
- Start at 12 o'clock and write "1" on all three surfaces.
- Continue clockwise with the next mount with number 2. Do this for all remaining mounts.
- This will ensure everything will be installed in the same locations.

13.) Open new slipring box.
- Place top cover on the floor foam side up.
- Flip the new slipring over in the box, so that brass is face down.
- Install the signal PCB.

14.) On the gantry, remove all twelve (12) 12mm bolts securing the cast mounting brackets to the rotating casting.

Leave the bolts at the 12 o'clock position for last.

15.) After removing last bolts, carefully remove slipring and cast mounting bracket assembly.

DANGER **THE SLIPRING AND CAST MOUNTING BRACKETS WEIGH ABOUT 150 LB (68 KG). 3 PEOPLE MINIMUM ARE NEEDED TO REMOVE THIS ASSEMBLY.**

Remember there are 3 mounts with pins, so pull ring straight off. Use a flat-blade screwdriver to separate the brackets from the rotating casting if necessary.

16.) Place the old ring, brass side down, on top of foam cover.

Align the signal PCB with the replacement ring to simplify the transfer of the cast mounting brackets to the new slipring.

NOTICE **INSPECT ALL INTERFACES FOR BURRS, DEBRIS OR OTHER IMPERFECTIONS. THESE ITEMS CAN RESULT IN RUNOUT FAILURES, REQUIRING A REPEAT OF THIS ENTIRE PROCEDURE.**

17.) Transfer each of the cast mounting brackets one at a time. Ensure these brackets are installed in the same position from old to new slipring.

a.) Place cast mounting bracket number 1 on the new slipring aligning 6mm pin in slot.

There are four holes that attach the cast mounting bracket to the slipring. The hole diagonal from the pin is 6.2mm. The other three are 7mm. The 6.2mm hole and 6mm pin are to help you align the ring.

b.) Place the 6mm bolt in the 6.2mm hole and align over slipring insert.

c.) Gently pull or push the cast mounting bracket radially out (away from ISO). Use the pin slot as the stop and the 6.2mm hole for alignment.

d.) Tighten the 6mm bolt until the lock washer starts to compress. Just tighten (snug) enough so that bolts are engaged.

e.) Then install the other three 6mm bolts and snug until they are engaged.

Once the slipring is installed, torque all of the bolts to 6 N-m (53 in-lbs or 4.45 ft-lbs).

18.) Repeat steps 17 for all six (6) cast mounting brackets.

19.) Align new slipring and cast mounting brackets with the rotating casting.
- Ensure marked numbers are aligned, 1 to 1, 2 to 2 etc.

- Align guide pins with holes on each of the three (3) cast mounting brackets to rotating base.
- Push until seated. Maintain pressure against the ring & hand tighten all 12 mm bolts.

20.) Release axial rotational lock.
Rotate gantry by hand as needed to ease access to slipring mounting bolts.

21.) Final torquing. Reference "Slipring Platter Torque Pattern," on page 642.
Start with the three (3) pinned cast mounting brackets.

22.) Start with bracket location # 1 and torque the two (2) 12 mm bolts to 68 N-m (49 ft-lbs).

23.) Repeat step 21 for cast mounting bracket # 2 through # 6 in order.

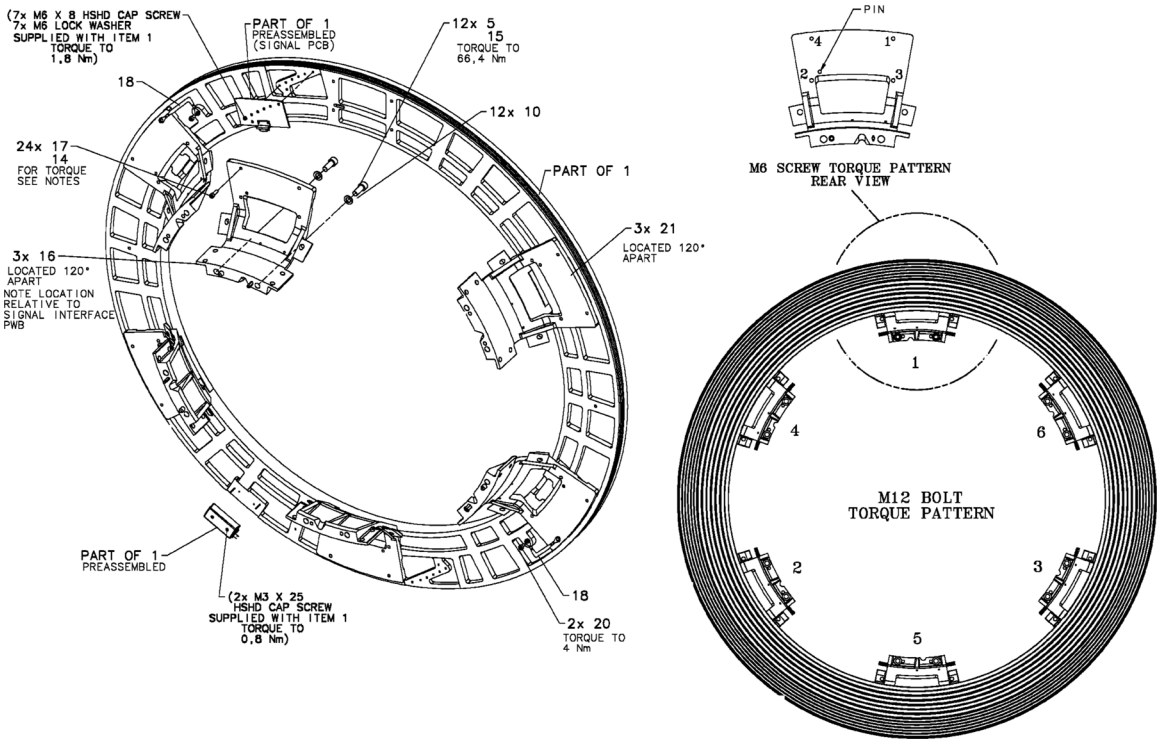


Figure 8-90 Slipring Platter Torque Pattern

24.) Start with bracket location # 1 and torque the four (4) 6mm bolts in order 1, 2, 3, 4. Reference Figure 8-90. Torque to 6 N-m (53 in-lbs or 4.45 ft-lbs).

25.) Repeat step 24 for location # 2 through # 6 in order.

26.) Connect the filters, wiring harnesses and ground clamps to the slipring.

27.) Mount and adjust the Dial Indicator so that the plunger tip rides on the Blue edge of the **HSDCD** ring.

28.) Rotate the gantry by hand and measure the Radial Runout.
- Radial runout should not exceed .0319 inches (32 mils, 0.81 mm).
- Reference "Radial Runout Adjustment," on page 643 if out of specification.

29.) Adjust the Dial Indicator and place the plunger tip directly on the brass surface of ring 12.

30.) Rotate the gantry by hand and measure the Axial Runout.
- Axial runout should not exceed .0327 inches (33 mils, 0.83 mm).
- Reference "Axial Runout Adjustment," on page 643 if out of specification.

31.) Secure all rotating harnesses with ty-raps as observed at start of this procedure (Figure 8-89).

32.) Install Antenna/Receiver assembly. Reference "333 MBaud HSDCD Slipring Receiver Adjustment Procedure," on page 598.

33.) Install brush block assembly. Reference "Slipring Brush Block," on page 646.

34.) Install slipring safety covers.
35.) Restore power to system.
36.) Refer to "Retest Matrix for Slipring Components," on page 671.

Radial Runout Adjustment

DANGER **PROPERLY SHUT DOWN THE SYSTEM, AND FOLLOW LOCKOUT/TAGOUT PROCEDURES.**

1.) Identify the "High" and "Low" physical locations on the slipring.
2.) With the gantry tilted forward + 30 degrees, place the "High" location at 12 o' clock.
3.) Loosen—do not remove—the four (4) 6 mm bolts at the cast mounting bracket to slipring interface.
4.) Loosen—do not remove—the four (4) 12 mm bolts on each of the six (6) cast mounting brackets.
5.) Physically lift/push/pull the ring to release binding tension.
At + 30 degree tilt, gravity effects are minimized.
6.) Re-torque bolts per steps 20 through 24 of section 3.4.1 - Slipring Platter "Procedure Details," on page 640. Tightening sequences must be followed for desired results.

Axial Runout Adjustment

DANGER **PROPERLY SHUT DOWN THE SYSTEM, AND FOLLOW LOCKOUT/TAGOUT PROCEDURES.**

1.) Identify the "High" and "Low" physical locations on the slipring.
2.) With the gantry tilted forward + 30 degrees, place the "Low" location at 6 o' clock.
3.) Loosen—do not remove—the four (4) 6 mm bolts at the cast mounting bracket to slipring interface.
4.) Loosen—do not remove—the four (4) 12 mm bolts on each of the six (6) cast mounting brackets.
5.) Physically lift/push/pull the ring to release binding tension.
At + 30 degree tilt, gravity effects are minimized.
6.) Re-torque bolts per steps 20 through 24 of section 3.4.1 - Slipring Platter "Procedure Details," on page 640. Tightening sequences must be followed for desired results.

NOTICE **If readings are still out of specification continue with step 7.**

7.) Inspect the one (1) or two (2) closest cast mounting brackets for proper seating at both the slipring and rotating casting interfaces.
- All bolts should be properly torqued.
- No gaps greater than .005 inches (0.127 mm) at any interface edge.

8.) Correct any "High" gaps greater than .005 inches (0.127 mm) at any interface edge.
9.) Recheck both Radial and Axial runout.
10.) Using standard notebook paper (0.003 inches (0.076 mm) thick nominal) make shims for one (1) or two (2) mounting locations on either side of the "Low" location.
A single sheet folded in half when compressed will be 0.005 inches (0.127 mm) nominal.
11.) Remove the four (4) 6 mm bolts at the cast mounting bracket to slipring interface.
12.) Slide shim between the slipring and cast mounting bracket to block the two (2) outside diameter holes.
13.) Carefully puncture, remove, trim and reinstall shim.

14.) Install the 6 mm bolts and torque per step 24 of section 3.4.1 - Slipring Platter "Procedure Details," on page 640.

15.) Repeat this procedure as needed.

Notes:

- **IF YOU NEED TO SHIM MORE THAN TWO (2) LOCATIONS, THERE IS SOMETHING ELSE WRONG.**
- **REMOVE AND DISASSEMBLE THE SLIPRING ASSEMBLY, PER** "Slipring Platter," on page 640**.**
- **INSPECT ALL CONTACT POINTS FOR BURRS, DEBRIS OR OTHER OBSTRUCTIONS CAUSING RUNOUT FAILURES.**

3.4.2 Slipring Receiver

3.4.2.1 Required Tools

- **ESD** wrist-band
- 2.5mm hex key

3.4.2.2 Procedure Details

1.) Move table to its lowest elevation.

2.) Remove rear gantry cover.

3.) Turn off all 3 switches (Axial Drive, **HVDC**, 120VAC) on the **STC** backplane A1 and follow Lockout/Tagout procedures.

4.) Remove J1 and J2 cables.

5.) Remove hex screws holding the receiver to the antenna.

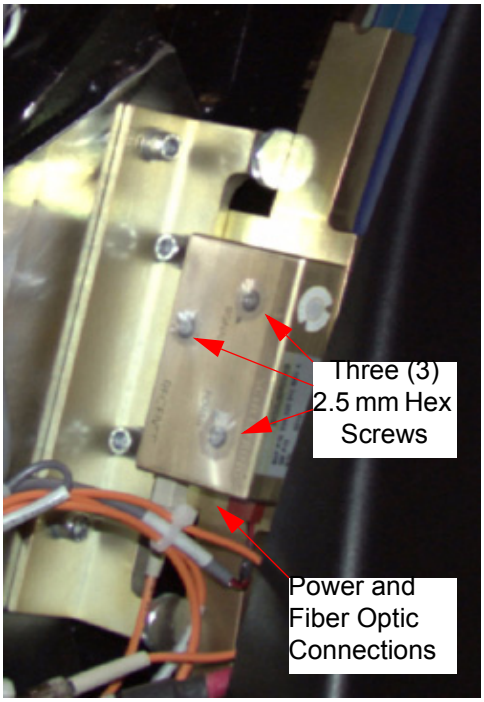


Figure 8-91 333 MBaud Slipring Receiver

6.) Replace receiver.

7.) Verify antenna gap and alignment adjustments.

8.) Refer to "Slip Ring Component Replacement Verification," on page 671.

3.4.3 Slipring Transmitter

3.4.3.1 Required Tools

- **ESD** wrist-band
- 2.5mm hex key

3.4.3.2 Procedure Details

1.) Move table to its lowest elevation.
2.) Remove rear gantry cover.
3.) Turn off all 3 switches (Axial Drive, **HVDC**, 120VAC) on the **STC** backplane, A1 and follow Lockout/Tagout procedures.
4.) The transmitter is located on the back of the slipring. Locate it by rotating gantry.

CAUTION Slip Ring Contamination Possible

Be careful to not contaminate slipring or signal.

5.) Remove J1 and J3 cables.
6.) Using a 2.5mm hex key, remove screws holding the transmitter to the slipring.

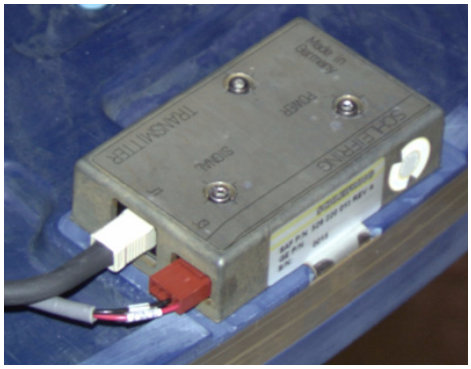


Figure 8-92 333 MBaud Slipring Transmitter

7.) Replace transmitter.
8.) Refer to "Slip Ring Component Replacement Verification," on page 671.

3.4.4 Slipring Power Supply Assembly

3.4.4.1 Required Tool

2.5mm hex socket

3.4.4.2 Procedure Details

1.) Remove rear cover and right side cover.
2.) Turn off all 3 switches (Axial Drive, **HVDC**, 120VAC) on the **STC** backplane. Follow Lockout/Tagout procedures.
3.) Using the hex socket, remove 2 cap screws from the back side of supply located on the rear right fan assembly.
4.) Remove safety plate.
5.) Disconnect wiring.
6.) Replace the slipring power supply assembly.
7.) ****Adjustment Procedures****

3.4.5 Slipring Brush Block

3.4.5.1 Required Tools

- Flat-blade screwdriver
- 5 mm, 10mm Hex Key

3.4.5.2 Procedure Details

1.) Move table to its lowest elevation.

1.) Remove side, top and rear gantry covers.

2.) Turn off all 3 switches (Axial Drive, **HVDC**, 120VAC) on the **STC** backplane.

3.) Remove Rear Gantry cover support bracket.

4.) Remove Slipring covers.

5.) Disconnect all connections to Brush block.

6.) Remove (4) 6mm cap screws that secure brush block assembly to gantry.

7.) Carefully remove brush block.

8.) Inspect each brush tip for wear. Each tip will have a triangle stamped on one side. When the brush wears to the point of the triangle the brush must be replaced.

CAUTION Brush Contamination Possible

Do not touch brushes with your fingers. The skin oils will contaminate the brush and reduce usable life and potentially create future failures.

9.) Remove individual brushes from the block as necessary by unscrewing brush cap and extracting brush.

Note: Since brushes are spring-loaded to ensure constant contact with the slipring during operation, when the block is removed, the springs will relax causing brushes to bound outwards.

If brush is to be re-used make sure you install it in the same orientation as removed. The brush was seated/conditioned in that position.

NOTICE Brush Tip Damage Possible

Brush tips are extremely brittle. Do not apply sideways force as they will break. Any brush that has been damaged in this fashion must be replaced.

10.) Carefully install brush block by exerting even pressure perpendicular to the ring surface.

11.) Secure brush block with the (4) 6 mm cap screws. Do not tighten yet.

12.) Carefully push brush block against the position adjustment set screws in the mounting bracket.

13.) Remove (3) brushes total, (2) brushes from the inside **HVDC** ring top and bottom and (1) brush from ring 10 bottom (2nd from the outside). Remember the orientation for later installation.

14.) Use a flashlight to verify block position is adjusted so the brushes ride in the center of their tracks.

15.) Torque (4) 6 mm cap screws to 5.5 N-m (48.7 in-lbs or 4 ft-lbs).

16.) Reassemble gantry.

17.) Refer to "Slip Ring Component Replacement Verification," on page 671.

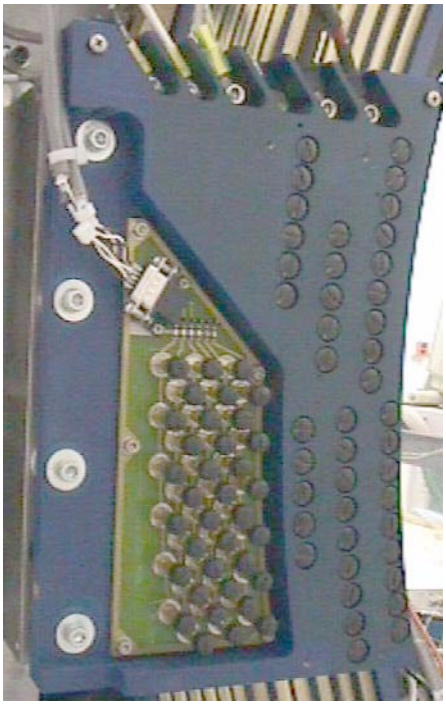


Figure 8-93 Slipring Brush Block Assembly

3.5 Tilt

3.5.1 Tilt Relay Board

3.5.1.1 Required Tools

- **ESD** wrist-band
- Phillips #2 short and flat blade screwdriver

3.5.1.2 Procedure Details

1.) Remove right and base covers.
2.) Turn off all 3 switches (Axial Drive, **HVDC**, 120VAC) on the **STC** backplane.
3.) Tilt gantry back 20 degrees.

⚠ **CAUTION** **Wear a grounded wrist strap when you handle a circuit board.**

4.) Use a short #2 phillips screwdriver to loosen the 4 screws that fasten plastic cover to the Tilt Relay Board.
5.) Remove J2 and J3 connectors.
6.) Loosen 4 screws that secure the 4 cables to the relay board.
7.) Loosen 8 screws to release the Tilt Relay board.
8.) Install new Tilt Relay board and reassemble gantry.
9.) Retest Matrix

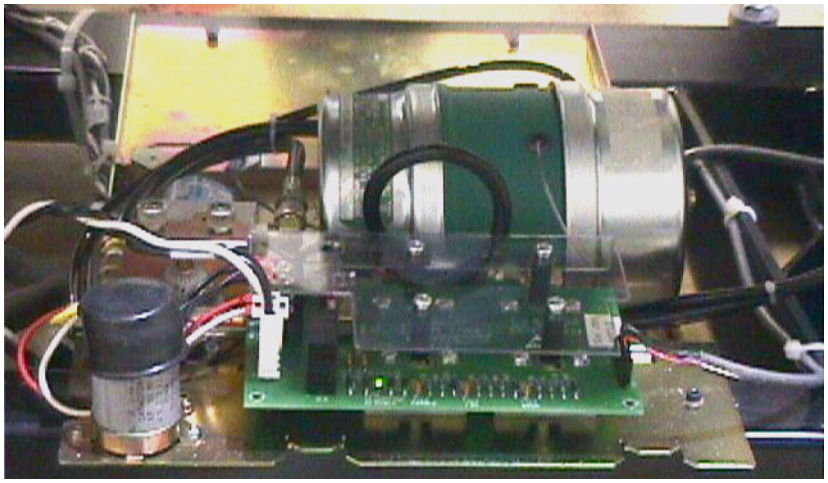


Figure 8-94 Tilt Relay Board

3.5.2 Hydraulic Tilt Motor Assembly

3.5.2.1 Required Tools

- 2.5mm, 5mm, 10mm hex key
- Flat-blade screwdriver
- Phillips #1 and #2 screwdriver
- Hydraulic oil (2227239)
- Oil absorption material/spill kit, as defined by HAZMAT processes and procedures
- Paper towels

3.5.2.2 Procedure Details

DANGER **DANGER: CRUSH HAZARD. THIS SERVICE PROCEDURE REQUIRES THE GANTRY TO BE TILTED ALL THE WAY BACK IN ITS MINUS 30 DEGREE POSTION AND PLACED ON ITS MECHANICAL STOPS.**

DANGER **DANGER: CRUSH HAZARD. NEVER INTENTIONALLY INTRODUCE AIR INTO THE HYDRAULIC SYSTEM.**

DANGER **DANGER CRUSH HAZARD. NEVER EXTEND THE HYDRAULIC PISTONS BY HAND. DOING SO WILL CAUSE INSUFFICENT HYDRAULIC PRESSURE IN THE SYSTEM WHEN TILT FUNCTION IS RESTORED.**

DANGER **DANGER: CRUSH HAZARD. THE NEWLY REPLACED HYDRAULIC CYLINDERS MAY NOT BE UNDER FULL HYDRAULIC PRESSURE. THIS MAY RESULT IN THE GANTRY TILTING SUDDENLY OR ERRATICALLY WHEN THE GANTRY IS MOVED FOR THE FIRST TIME, PAST THE ZERO DEGREE (FULLY UPRIGHT) POSITION. REMAIN CLEAR OF THE GANTRY UPON INITIAL STARTUP AFTER THE HYDRAULIC TILT ASSEMBLY REPLACEMENT.**

DANGER **ELECTROCUTION HAZARD. 120 VAC IS PRESENT AT THE TILT RELAY BOARD. TURNING OFF THE STC SERVICE SWITCHES WILL NOT REMOVE THIS POWER.**

Note: for an accurate description of spatial orientation with regards the proper servicing of this product refer to "Spatial Orientation While Servicing The System," on page 19.

1.) Remove gantry side and any base covers to gain access to the gantry tilt hydraulic assembly located in the base of the gantry.

2.) To proceed:

a.) If the gantry tilt function allows, use the controls on the gantry to drive the gantry to the minus 30-degree (All the way back) position. Refer to Figure 8-95 for a side view and exact location of the gantry.

i.) On the Tilt Control board located on the Tilt Motor control board located in the gantry base near the Tilt motor:

* Locate and place the Service Switch in the "Service" Position.
* Use the Manual Tilt drive switch on the Tilt Control Board to drive the gantry to the mechanical stops.

b.) If the gantry tilt function is not operational, use the service switch on the gantry control board to drive the gantry to the minus 30-degree (All the way back) position. Refer to Figure 8-95 for a side view and exact location of the gantry.

i.) On the Tilt Control board located on the Tilt Motor control board located in the gantry base near the Tilt motor:

* Locate and place the Service Switch in the "Service" Position.
* Use the Manual Tilt drive switch on the Tilt Control board to drive the gantry to the mechanical stops.

Note: When you are standing at the back of the table facing the Gantry Display Board, looking through the gantry, the top of the gantry must be tilted away from you, (All the way back). Refer to Figure 8-95 for a side view and exact location of the gantry.

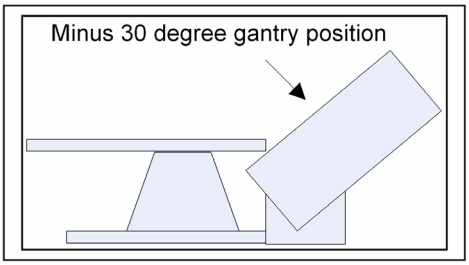


Figure 8-95 Gantry in Tilt Hydraulic Service Position

3.) Once the gantry is in the correct position disable the gantry tilt function, High voltage and

120VAC on the Service Switch Panel.

4.) Shutdown system software and turn off the console power switch under the console table top.

5.) Remove all system power at the main disconnect (A1) panel. Perform proper Lockout/Tagout power control procedures.

6.) While viewing the gantry from the rear, the gantry tilt hydraulic assembly is located inside the right gantry base assembly of the gantry. Label the wires located on the gantry tilt Control board for later assembly.

7.) While viewing the gantry from the rear, disconnect the three-phase power plug at the side of the gantry power pan, located inside the left side of the gantry base assembly.

8.) Remove the rear screws securing the gantry tilt hydraulic assembly to the gantry base frame.

9.) Loosen the front screws securing the gantry tilt hydraulic assembly. Their complete removal is not necessary.

10.) Disconnect and remove the cables connections and wires at the terminal on the Tilt Control Board.

11.) Identify all tie wraps and fasteners securing the hydraulic lines to the gantry frame and Take note of the routing of these hydraulic lines.

12.) Remove any fasteners and tie wraps securing the hydraulic lines to the gantry base frame and hydraulic cylinder. Be careful not to puncture or kink any of the hydraulic lines.

13.) While viewing the gantry from the rear, the STC Assembly will be on the left, to proceed, it may be easier to remove the STC Assembly by removing the 3 screws securing it to the Gantry Frame. No cable removal should be necessary from the STC.

14.) While viewing the gantry from the rear, loosen 4 hex socket caps at the top of the left hydraulic cylinder mount bracket, and 3 screws of the mount bracket at the bottom of the left hydraulic cylinder. Keep your hands clear of potential gantry pinch points at all times.

15.) Remove the left hydraulic cylinder and its lines from the gantry base.

16.) Carefully install the new left hydraulic cylinder in place. Make sure the lines are properly routed along the gantry frame. Do not tie wrap them in place at this time.

17.) While viewing the gantry from the rear, loosen 4 hex socket caps at the top of the right hydraulic cylinder mount bracket, and 3 screws of the mount bracket at the bottom of the right hydraulic cylinder. Keep your hands clear of potential gantry pinch points at all times.

18.) Remove the right hydraulic cylinder and its lines from the gantry base.

19.) Completely remove the gantry tilt hydraulic pump assembly from the gantry base.

20.) To proceed, inspect the replacement gantry tilt hydraulic unit and hydraulic cylinders for any damage in shipment. There should be no leaking oil and no residual oil in the shipping crate. The hydraulic pistons should be full compressed into their cylinders. (Do not extend the pistons by hand).

   a.) If you suspect that the replacement unit is not in proper condition for installation or appears damaged in any way stop the replacement process and escalate by calling Field Leadership for further direction.

   b.) If you do not see any damage remove the replacement unit from its shipping crate being careful not to kink the hydraulic lines.

21.) Move the replacement unit to the back of the gantry.

22.) Install the gantry Tilt Motor Assembly into the base. Secure the gantry Tilt Motor Assembly with its four screws.

23.) Install the right hydraulic cylinder.

24.) Loosely secure all hydraulic lines with tie wraps. Do not tighten the tie-wraps at this time. Make sure to leave approximately 1 inch (2.5cm) of slack on both left and right cylinder lines to prevent hose damage during forward tilt.

25.) Attach all wires and cables removed from the gantry tilt control board.

26.) While viewing the gantry from the rear, torque the M12 screws for the upper left cylinder mount

bracket to 66.4 N-m (49 ft-lbs).

27.) While viewing the gantry from the rear, torque the M12 screws for the upper right cylinder bracket to 66.4 N-m (49 ft-lbs).

28.) If the STC Assembly was removed, re-attach the STC Assembly to the gantry frame. If any tie wraps were removed from the cables, re-install new ones.

29.) Remove Lockout/Tagout following all Lockout/tagout procedures to restore main power.

DANGER

DANGER: CRUSH HAZARD. THE NEWLY REPLACED HYDRAULIC CYLINDERS MAY NOT BE UNDER FULL HYDRAULIC PRESSURE. THIS MAY RESULT IN THE GANTRY TILTING SUDDENLY OR ERRATICALLY IF THE GANTRY IS MOVED PAST THE ZERO DEGREE (FULLY UPRIGHT) POSITION. REMAIN CLEAR OF THE GANTRY UPON INITIAL STARTUP AFTER THE HYDRAULIC TILT ASSEMBLY REPLACEMENT. NEVER INTENTIONALLY INTRODUCE AIR INTO THE HYDRAULIC SYSTEM.

DANGER

ELECTROCUTION HAZARD. 120 VAC IS PRESENT AT THE TILT RELAY BOARD. TURNING OFF THE STC SERVICE SWITCHES WILL NOT REMOVE THIS POWER.

30.) Enable the gantry tilt function, High voltage and 120VAC at the Service Switch Panel.

31.) While viewing the gantry from the rear, locate the tilt Control Board on the replacement tilt hydraulic assembly.

32.) On the Service Switch Panel, set the Service Switch to the “Service” position.

33.) Use the manual tilt switch to drive the gantry off of its stops approximately 1 inch (2.5cm).

34.) On the Service Switch Panel, set the Service Switch to the “Normal” position.

35.) Turn on the Console using the power switch under the console table top. The system software should automatically boot the system up to full operation.

36.) To proceed:

a.) If another Field Engineer is available on site have one person stand behind and clear of the gantry while observing the hydraulic lines and gantry motion during the first tilt. If another Field Engineer is not present proceed to step b of step 36.

i.) Have the other person stand at the side of the gantry (clear of tilt motion) and use one of the Operators control panels on the front of the gantry to tilt the gantry forward using the tilt feature to tilt the gantry to the -10 degree position for first time and stop.

ii.) Check the hydraulic lines periodically to ensure that there is enough slack to accommodate further tilting.
NOTE: It may be possible for the gantry to move erratically when it passes through the zero degree (Fully Upright) position the first time and its weight becomes supported by the new hydraulic system.

iii.) While staying clear of the gantry, (Stand at its side) use one of the Operators control panels on the front of the gantry to continue tilting the gantry forward to the zero degree (Fully upright) position and stop. During the tilt the observer should stop the tilt if he/she observes any problem with the hydraulic lines or the gantry encounters any obstructions.

iv.) While staying clear of the gantry, (Stand at its side) use one of the Operators control panels on the front of the gantry to continue tilting the gantry forward to the + 10 degree position and stop.

v.) Check the hydraulic lines for proper slack and gantry in general for any other obstructions.

vi.) While staying clear of the gantry, (Stand at its side) use one of the Operators control

panels on the front of the gantry to continue tilting the gantry forward to the +30 degree position where it should come to a complete stop.

vii.) At this time tighten the tie wraps holding the hydraulic lines.

b.) If another Field Engineer is not available to observe the gantry tilt for the first time periodically stop titling the gantry and check the gantry movement for obstructions and slack in the hydraulic lines.

i.) Stand at the side of the gantry (clear of tilt motion) and use one of the Operators control panels on the front of the gantry to tilt the gantry forward using the tilt feature to tilt the gantry to the -20 degree position for first time and stop.

ii.) Check the hydraulic lines to ensure that there is enough slack to accommodate further tilting.

iii.) Stand at the side of the gantry (clear of tilt motion) and use one of the Operators control panels on the front of the gantry to tilt the gantry forward using the tilt feature to tilt the gantry to the -10 degree position for first time and stop.

iv.) Check the hydraulic lines to ensure that there is enough slack to accommodate further tilting.

NOTE: It may be possible for the gantry to move erratically when it passes through the zero degree (Fully Upright) position the first time and its weight becomes supported by the new hydraulic system.

v.) While staying clear of the gantry, (Stand at its side) use one of the Operators control panels on the front of the gantry to continue tilting the gantry forward to the zero degree (Fully upright) position and stop.

vi.) Check the hydraulic lines to ensure that there is enough slack to accommodate further tilting.

vii.) While staying clear of the gantry, (Stand at its side) use one of the Operators control panels on the front of the gantry to continue tilting the gantry forward to the + 10 degree position and stop. Be prepared for possible erratic tilt motion during this step.

viii.)At the + 10 degree position check the hydraulic lines for proper slack and gantry in general for any other obstructions.

ix.) While staying clear of the gantry, (Stand at its side) use one of the Operators control panels on the front of the gantry to continue tilting the gantry forward to the +30 degree position where it should come to a complete stop.

c.) At this time tighten up the tie wraps by hand holding the hydraulic lines.

37.) While viewing the gantry from the rear, torque the M6 screws for the lower left cylinder mount bracket to 7.9 N-m (5.8 ft-lbs).

38.) While viewing the gantry from the rear, torque the M6 screws for the lower right cylinder bracket to 7.9 N-m (5.8 ft-lbs).

39.) While viewing the gantry from the rear, locate the tilt Control Board on the replacement tilt hydraulic assembly.

40.) On the Service Switch Panel, set the Service Switch to the “Service” position to test the manual tilt function under the full weight of the gantry.

41.) Use the manual tilt switch to drive the gantry to the zero degree (Fully Upright) position and stop.

42.) On the Service Switch Panel, set the Service Switch to the “Normal” position.

43.) While staying clear of the gantry, (Stand at its side) use one of the Operators control panels on the front of the gantry to resume tilting the gantry, exercising the new tilt hydraulic assembly completely through its full range of motion.

44.) Exercise the tilt function at least 6 full cycles (-30 to +30) to purge any air from the hydraulic system.

45.) Place the gantry at its zero degree (Fully upright) position and stop.
46.) When the tilt pump is warm to the touch make final speed adjustments.
47.) Refer to "Tilt Speed Adjustment Procedure," on page 586.
48.) Reassemble gantry by replacing any covers removed.
49.) Refer to "Clean-up and Personal Hygiene," on page 45, for proper disposal of contaminated materials.

3.5.3 Tilt Pot Assembly

3.5.3.1 Required Tools

- Phillips #2 screwdriver
- Flat-blade screwdriver
- 3/32 Hex Key
- 3 mm hex key
- 5 mm hex

3.5.3.2 Tilt Potentiometer Procedure Details

Reference Figure 8-96.

1.) Remove gantry side covers.
2.) Turn off all 3 switches (Axial Drive, **HVDC**, 120VAC) on the **STC** backplane.
3.) Remove 3 hex screws that secure tilt pot cover and remove.
4.) Loosen the 2 hex screws that tension the belt.
5.) Remove belt off the small pulley.
6.) Disconnect tilt pot connector.
7.) Cut ty-raps as necessary.
8.) Remove hex screws that secure tilt pot.
9.) Remove tilt pot assembly.
10.) Install new tilt pot assembly and adjust per "Tilt Pot and Belt Adjustment," on page 582.
11.) Reassemble gantry.

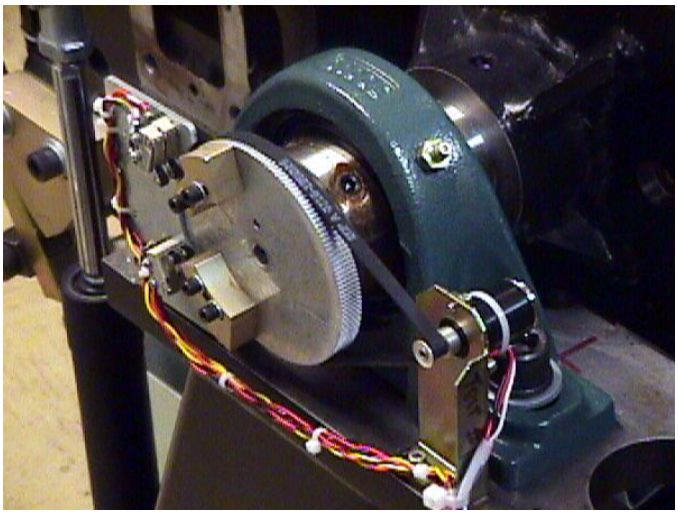


Figure 8-96 Gantry Tilt Pot Assembly 2178677

3.5.3.3 Tilt Interference and Limit Switches

3.5.3.4 Required Tools

- Phillips #2 screwdriver
- Flat-blade screwdriver
- 3/32 Hex Key
- 3 mm hex key
- 5 mm hex

3.5.3.5 Tilt Interference/Limit Switches Procedure Details

Reference Figure 8-96.

1.) Remove gantry side covers.
2.) Turn off all 3 switches (Axial Drive, **HVDC**, 120VAC) on the **STC** backplane.
3.) Remove 4 slotted screws to loosen the dual-switch bodies.
4.) Disconnect outside switch. (Black and white wires in top and bottom locations.)
5.) Disconnect inside switch. (Yellow and red wires in top and bottom locations.)
6.) Disconnect molex connector to replace harness.
7.) Cut ty-raps as necessary.
8.) Install new switch assembly and adjust per "Tilt Limit/Interference Adjustments," on page 583.
9.) Reassemble gantry.

3.6 Fuse Box Switch Assembly

3.6.1 Required Tools

- Phillips #2
- Flathead
- 10 MM. hex key

3.6.2 Procedure Details

1.) Remove all gantry covers.
2.) Rotate Fuse Box Assembly to 10 o'clock.
3.) Remove 2 hex screws that secure Fuse Box Assembly.
4.) Slide fuse box up so that washers fit through aperture on fuse box, and then release the fuse box.
5.) Cut any necessary ty-raps.
6.) Disconnect all associated terminals and cables.

3.7 Display

3.7.1 Display Assembly

1.) Remove right side cover.
2.) Remove front cover.
3.) Turn off all 3 switches (Axial Drive, **HVDC**, 120VAC) on the **STC** backplane.
4.) Remove 4 cables.
5.) Loosen 6 screws that fasten the display assembly to the cover.

6.) Replace the display assembly panel and reconnect cables.
7.) Reassemble gantry.

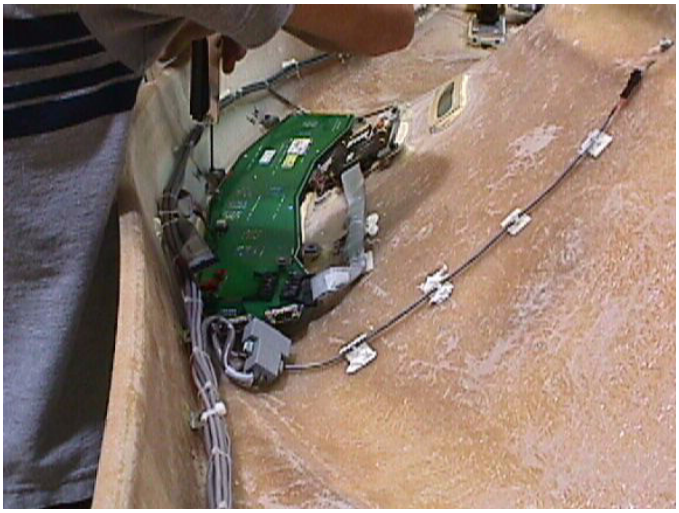


Figure 8-97 Display Removal

3.7.2 Control/Scan Start Panel

1.) Remove right side cover.
2.) Remove front cover.
3.) Turn off all 3 switches (Axial Drive, **HVDC**, 120VAC) on the **STC** backplane.
4.) Disconnect J1 and left control cables.
5.) Loosen 5 screws that fasten the start panel to the cover.
6.) Replace control panel and reconnect J1 and left control cables.
7.) Reassemble gantry.

3.7.3 Breathing Light Assembly

1.) Remove gantry side and top covers.
2.) Turn off all 3 switches (Axial Drive, **HVDC**, 120VAC) on the **STC** backplane.
3.) Remove gantry front or rear cover as needed.
4.) Remove 2 cables.
5.) Loosen 4 screws that fasten the breathing light assembly to the cover.
6.) Replace the breathing light assembly panel and reconnect cable.
7.) Reassemble gantry.

Figure 8-98 Gantry Breathing Light Assembly

3.7.4 Gantry Cover Touch Pad

3.7.4.1 Required Tools

Socket wrench

3.7.4.2 Procedure Details

1.) Remove side, top, and front covers.
2.) Turn off all 3 switches (Axial Drive, **HVDC**, 120VAC) on the **STC** backplane.
3.) Disconnect touch strip cable.
4.) Remove 2 nuts that secure touch pad to outside of gantry.
5.) Install new touch pad.
6.) Reassemble gantry.

3.8 Intercom

3.8.1 Intercom Board

3.8.1.1 Required Tools

- **ESD** Wrist-Band
- Phillips #1 screwdriver
- Quarter inch ratchet
- 6 inch extension
- 7mm socket

3.8.1.2 Procedure Details

1.) Remove right side cover.
2.) Turn off all 3 switches (Axial Drive, **HVDC**, 120VAC) on the **STC** backplane.
3.) Use the quarter inch ratchet to loosen but not remove the 2 lower nuts and washers.

Note: Be careful not to lose the nuts and washers. Also notice that the flat washer is installed first, then the lock washer and then the nut.

4.) Remove 2 upper nuts and washers.
5.) Disconnect control cable.
6.) Remove 4 screws that secure intercom board.
7.) Reinstall intercom board in reverse order. Verify that J2 jumper is in auto position.
8.) In steps c) and d), be sure to torque to 9 inch pounds for rotational force integrity.
9.) ***Retest Matrix****

3.8.2 Remote Intercom X Board

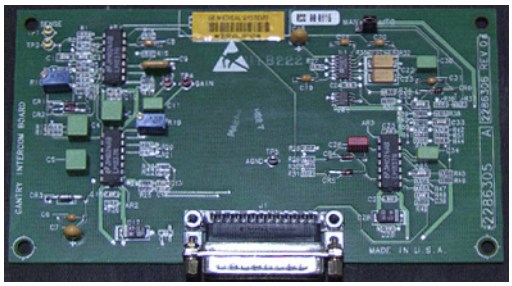


Figure 8-99 Remote Intercom X Board - Obsolete (no adjustments)

3.8.3 Remote Intercom X Board Test Points

- Reference "Remote Intercom Board," on page 605 for test point and adjustments.

- J2 AGC control Normal setting is Auto.

3.9 Laser

3.9.1 Laser Lights

3.9.1.1 Required Tools

5mm hex key

3.9.1.2 Procedure Details

1.) Remove gantry covers.
2.) Turn off all 3 switches (Axial Drive, **HVDC**, 120VAC) on the **STC** backplane.
3.) Disconnect the electrical connection to the defective laser assembly
4.) Loosen laser clamp nut.
5.) Attempt to remove the laser from clamp using the 5mm hex key. If additional clearance is needed, loosen 2 mounting screws NOT alignment screws. Remove mounting bracket IF necessary.

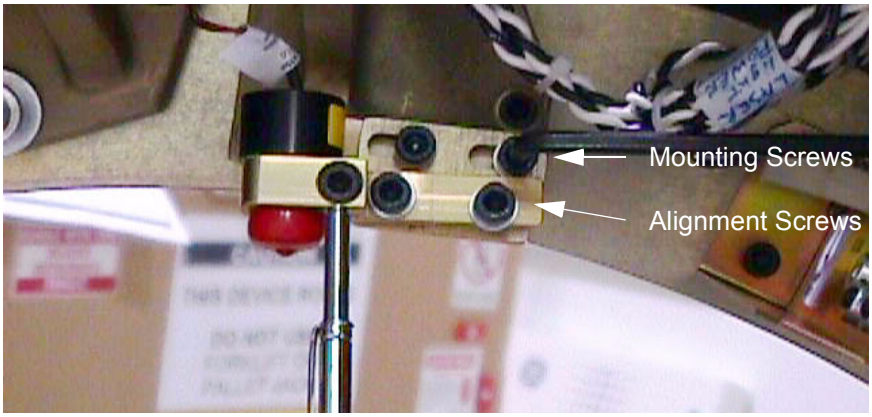


Figure 8-100 Laser Mount Assembly

3.9.2 Coronal Laser Assembly

1.) Move table to its lowest elevation.
2.) Remove right and back covers.
3.) Turn off all 3 switches (Axial Drive, **HVDC**, 120VAC) on the **STC** backplane.
4.) Disconnect the electrical connection to the defective laser assembly
5.) Loosen 2 hex screws holding laser assembly in place.
6.) Replace the defective laser assembly.
7.) Reconnect electrical connection to new laser assembly.
8.) Align laser light.
9.) Reassemble gantry.

3.9.3 Internal Laser Assembly

1.) Move table to its lowest elevation.
2.) Remove right and back covers.
3.) Turn off all 3 switches (Axial Drive, **HVDC**, 120VAC) on the **STC** backplane.
4.) Disconnect the electrical connection to the defective laser assembly

5.) Loosen 2 screws holding laser assembly in place.
6.) Replace the defective laser assembly.
7.) Reconnect electrical connection to new laser assembly.
8.) Align laser light.
9.) Reassemble gantry.

3.9.4 Sagittal/External Laser Mount

1.) Move table to its lowest elevation.
2.) Remove right and back covers.
3.) Turn off all 3 switches (Axial Drive, **HVDC**, 120VAC) on the **STC** backplane.
4.) Disconnect the electrical connection to the defective laser assembly
5.) Loosen 4 hex screws holding laser assembly in place.
6.) Replace the defective laser assembly.
7.) Reconnect electrical connection to new laser assembly.
8.) Align laser light.
9.) Reassemble gantry.

3.10 Cooling Fan

3.10.1 Cooling Fan - Left/Right

3.10.1.1 Required Tools

- 3mm hex key
- 1/2 hex socket cap.

3.10.1.2 Procedure Details

1.) Remove right and left covers.
2.) Turn off all 3 switches (Axial Drive, **HVDC**, 120VAC) on the **STC** backplane.
3.) Unplug the cable connecting the fan to the rest of the assembly.
4.) Remove the four (4) 4mm cap screws.
5.) Remove the hex nut that fastens capacitor to the assembly.
6.) Replace fan and capacitor.
7.) Turn on all 3 switches (Axial Drive, **HVDC**, 120VAC) on the **STC** backplane.
8.) Carefully depress fan cover switch and verify fan operation.

Note: Left fan is thermostatically controlled.

9.) Reassemble gantry.

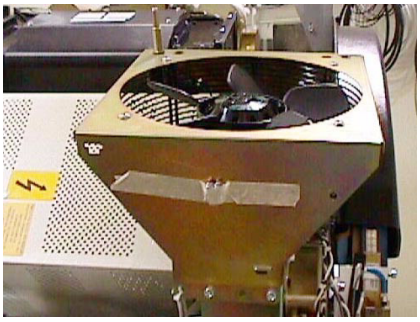


Figure 8-101 Fan Assembly

3.10.2 Fan Switch

3.10.2.1 Required Tools

5/16 socket

3.10.2.2 Procedure Details

1.) Remove rear cover and right side cover.

2.) Turn off all 3 switches (Axial Drive, **HVDC**, 120VAC) on the **STC** backplane. Follow Lockout/Tagout procedures.

Note: The Plunger height is adjusted at factory.

3.) Remove two (2) nuts. Remove screws carefully to avoid dropping screws.

4.) Disconnect 2 connections (normally open and common).

5.) Replace switch and reassemble.

6.) Depress switch plunger and fan should start.

Note: Left fan is thermostatically controlled.

3.11 OBC

3.11.1 OBC Circuit Boards

- KV Board
- MA Board
- **HEMRC** Control Board
- GENTRY I/O
- ARTESYN III (**CPU**)
- **LSCOM** Board

Note: Please refer to the most recent *llustrated Parts List* (or *Schematics Manual*) for CB part numbers.

3.11.1.1 Required Tools

- **ESD** wrist-band
- Flat-blade screwdriver
- Phillips #2 screwdriver, if replacing the Artesyn-III board

Before beginning this procedure, please read the safety information in "Gantry," on page 37.

3.11.1.2 Procedure Details

1.) Remove the right gantry side cover.

2.) Turn **OFF** all 3 switches (Axial Drive, **HVDC**, 120 VAC) on the **STC** backplane.
3.) Remove right top gantry cover.
4.) Position **OBC** at the 2:00 o'clock position
5.) Put on grounding wrist strap.
6.) Loosen the 8 captive screws, and remove the **OBC** Front Cover.

THE FOLLOWING PROCEDURE IS FOR THE ARTESYN-III BOARD:

1.) Unplug serial and ethernet cables.
2.) Loosen top and bottom fasteners with a Phillips #2 screwdriver.
3.) Pull Artesyn board out using black plastic tabs located on top and bottom of the board.
4.) Place the board in an Anti-Static bag.
5.) Install the new board.
6.) Install **OBC** Cover. Torque to 2 N-m (17.7 in-lbs).

THE FOLLOWING PROCEDURE IS FOR THE GENTRY I/O, HEMRC, KV, MA, AND LSCOM BOARDS.

1.) Remove the right gantry side cover.
2.) Turn **OFF** all 3 switches (Axial Drive, **HVDC**, 120 VAC) on the **STC** backplane.
3.) Remove right top gantry cover.
4.) Position **OBC** at the 2:00 o'clock position
5.) Put on grounding wrist strap.
6.) Loosen the 8 captive screws, and remove the **OBC** Front Cover.
7.) Pull two latches to release the board.
8.) Place the board in an Anti-Static bag.
9.) Install the new board. Secure the newly installed board using the two latches.
10.) Install **OBC** Cover. Torque to 2 N-m (17.7 in-lbs).

3.11.2 OBC Power Supply

3.11.2.1 Required Tools

- Flat-blade screwdriver
- Phillips #2 screwdriver
- 3 mm, 5 mm Hex key sockets

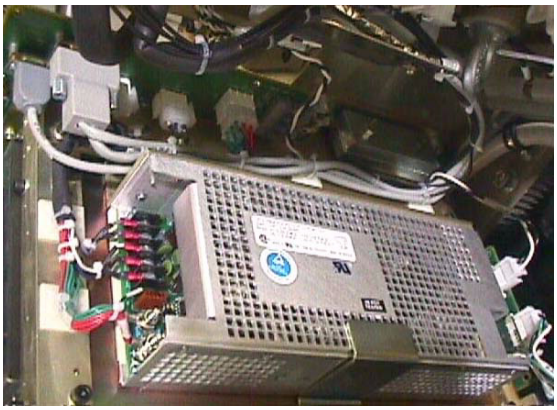
3.11.2.2 Procedure Details

DANGER USE PROPER LOCKOUT/TAGOUT PROCEDURES.

1.) Move table to its lowest elevation.
2.) Remove right side and top covers.
3.) Turn **OFF** all 3 switches (Axial Drive, **HVDC**, 120 VAC) on the **STC** backplane.
4.) Position **OBC** at 3:00 o'clock.
5.) Remove the 4 mm cap screw and washer securing the front mounting bracket.
6.) Remove mounting bracket.
7.) Remove the 4 mm cap screws and washers that secure AC plastic shield.
8.) Remove plastic shield.

9.) Disconnect input/output (IO) wiring from power supply strips.
Write wiring down for reassembly.
10.) Remove (2) 6 mm cap screws and washers on rear gold mounting bracket.
11.) Remove power supply and gold bracket from **OBC** assembly.
12.) Remove (3) Phillips screws that secure mounting bracket to the power supply.
13.) Remove mounting bracket.
14.) Reassemble assembly in reverse order.
- Torque the 6 mm cap screws and washers to 7.9 N-m (5.8 ft-lbs).
- Torque the 4 mm cap screws to 2.3 N-m (20.35 in-lbs).

15.) Restore power and verify per adjustment procedure.
16.) Refer to "OBC Power Supplies," on page 577.



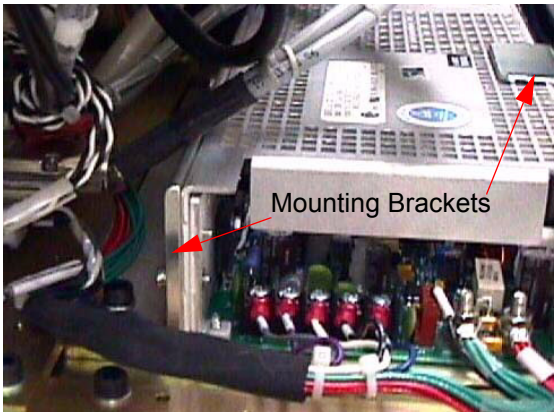


Figure 8-102 OBC Power Supply and Mounting Brackets

3.11.3 OBC Backplane

3.11.3.1 Required Tools

- Phillips #2 screwdriver
- Flat-blade screwdriver
- 3 mm, 5 mm, 10 mm Hex key socket
- Loctite 242 (46-170686P2)

3.11.3.2 Procedure Details

1.) Move table to its lowest elevation.
2.) Remove side, top and front gantry covers.
3.) Turn **OFF** all 3 switches (Axial Drive, **HVDC**, 120 VAC) on the **STC** backplane.
4.) Remove power at main disconnect (A1) panel. Use proper Lockout/Tagout procedures.
5.) Position **OBC** at 2:00 o'clock.
6.) Engage gantry rotational lock.
7.) Remove 4 mm cap screws (including washers) at the front of the mounting bracket.
8.) Remove mounting bracket.
9.) Remove 4 mm cap screws that secure AC plastic shield.
10.) Remove plastic shield.
11.) Disconnect input/output (IO) wiring from power supply strips.
12.) Cut ty-rap mounts as necessary.

Note: Pay close attention to routing of cables as you cut theses ty-raps.

13.) Disconnect all power connections at **OBC** Power I/F board.
14.) Disconnect J11, J16, and J17 connectors from backplane.
15.) Cut any necessary ty-raps.
16.) Remove all circuit boards.
17.) Remove (4) M12 cap screws securing chassis to rotating base casting.
18.) Carefully lift chassis off gantry.
19.) Place **OBC** on flat table back plane facing up.
20.) Remove (12) 4 mm cap screws securing backplane to the chassis.

NOTICE **This includes the flat and lock washer on each of the screws. These washers are important to the grounding integrity of the backplane.**

21.) Remove backplane.
22.) Install new backplane. Torque (12) 4 mm cap screws and washers to 2.3 N-m (20.35 in-lbs).
23.) Install Chassis on gantry. Apply Loctite 242, and torque (4) M12 cap screws to 66.4 N-m (49 ft-lbs).

Note: Make sure all harnesses are routed and secured in the same fashion prior to disassembly.

24.) Complete re-assembly.
25.) Torque 4 mm cap screws (dry) to 2.3 N-m (20.35 in-lbs).
26.) Torque 6 mm cap screws (dry) to 7.9 N-m (5.8 ft-lbs).
27.) Torque **OBC** Cover to 2 N-m (17.7 in-lbs).

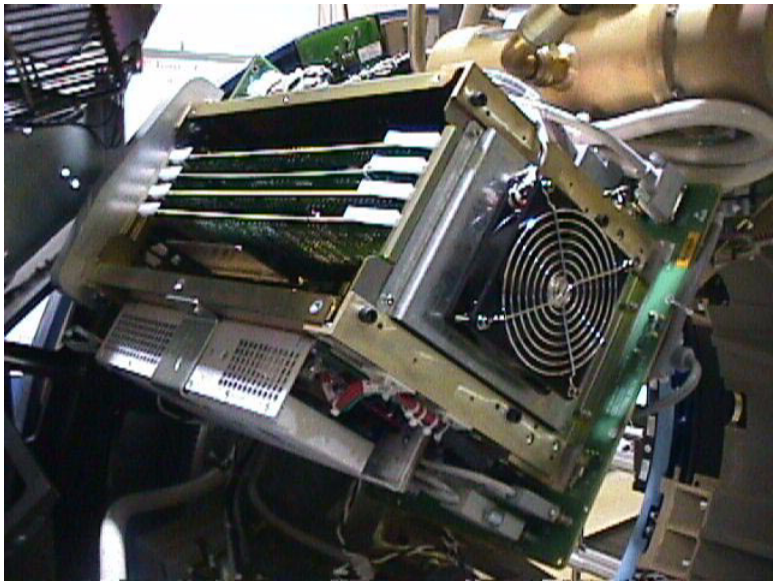


Figure 8-103 OBC Chassis at 10 O'Clock

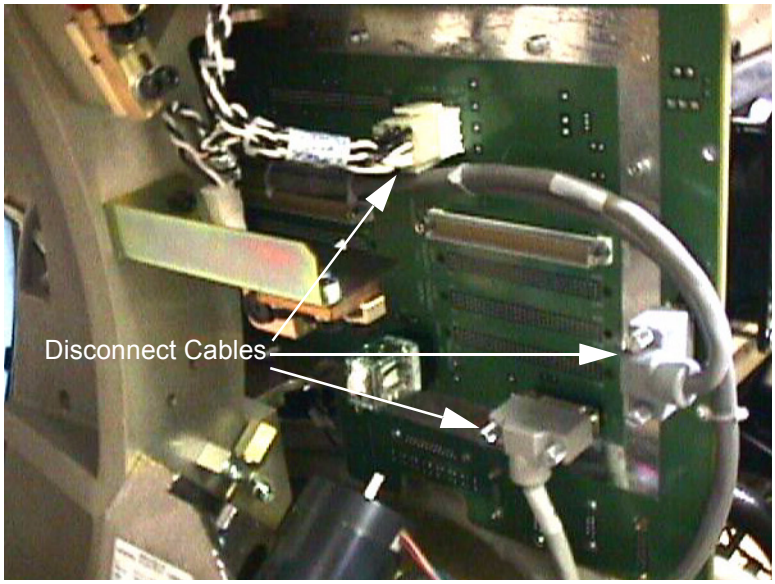


Figure 8-104 OBC Backplane Cabling

3.11.4 OBC Power I/F

3.11.4.1 Required Tools

- Phillips #2 screwdriver
- Flat-blade screwdriver
- Metric Hex Key Set

3.11.4.2 Procedure Details

1.) Remove all gantry covers. (Front cover removal is unnecessary for this procedure)
2.) Completely shutdown power. (A1, Lockout/Tagout)
3.) Position **OBC** at 3:00.
4.) Use to remove cap screws that secures AC plastic shield.
5.) Remove plastic shield.
6.) Remove fuse from fuse holder.
7.) Install new fuse.
8.) Reassemble assembly in reverse order.
9.) Restore power and verify per adjustment procedure.

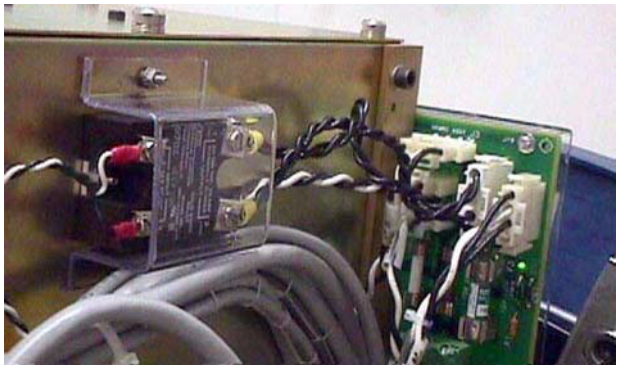


Figure 8-105 OBC Power I/F Board and Tube Fan Pump Relay

3.11.5 OBC Thermistor

3.11.5.1 Required Tools

- Flat-blade screwdriver
- 3 mm Hex key socket
- 3/16” open end wrench

3.11.5.2 Procedure Details

DANGER USE PROPER LOCKOUT/TAGOUT PROCEDURES.

1.) Move table to its lowest elevation.
2.) Remove right side and top covers.
3.) Tilt Gantry forward to 30 Degrees. (For easier access)
4.) Turn **OFF** Axial Enable and **HVDC** on the **STC** backplane.
5.) Position **OBC** at 2 o’clock. (**OBC** boards will be removed).
6.) Remove power at main disconnect (A1) panel. Use proper Lockout/Tagout procedures.

NOTICE **Use proper ESD procedures when handling circuit boards.**

7.) Remove **OBC** cover and all circuit boards.
8.) Disconnect all **OBC** Power I/F connections.
9.) Remove the (4) 4 mm cap screws and washers securing the **OBC** Power I/F board.
10.) Remove the (3) 4 mm cap screws securing the **CPU** mounting bracket.
11.) Disconnect the thermistor harness from internal backplane J9.
12.) Cut ty-raps and carefully unscrew the thermistor from the bracket.
13.) Install new thermistor and secure with very small ty-raps.
14.) Install internal J9 backplane connector and mount **CPU** bracket with (3) 4 mm cap screws finger tight.
15.) Carefully insert **LSCOM** board and seat in backplane connectors. This will align the **CPU** bracket.
16.) Tighten the (3) 4 mm cap screws for the **CPU** bracket.
17.) Remove the **LSCOM** board.
18.) Install the **OBC** Power I/F board. Tighten (4) 4mm cap screws and washers.
19.) Complete **OBC** assembly.
20.) Apply power at main disconnect (A1) panel. Use proper Lockout/Tagout procedures.
21.) Turn **ON** **HVDC** and 120 VAC on the **STC** backplane. Verify no smoke or arching.
22.) Perform hardware reset.
23.) Assemble gantry.
24.) No specific retest procedures.

3.11.6 OBC Ambient Thermistor (Tube Fan Pump Relay Control Harness)

- Phillips #2 screwdriver
- Flat-blade screwdriver
- 3 MM. Hex Key

3.11.6.1 Procedure Details

DANGER **USE PROPER LOCKOUT/TAGOUT PROCEDURES.**

1.) Move table to its lowest elevation.
2.) Remove right side and top covers.
3.) Turn **OFF** all 3 switches (Axial Drive, **HVDC**, 120 VAC) on the **STC** backplane.
4.) Position **OBC** at 2:00 o'clock.
5.) Remove (2) 4 mm cap screws that secure safety cover over tube fan/pump and relay.
6.) Disconnect cable J15 on **OBC** backplane.
7.) Cut the 3 mounting ty-raps.
8.) Disconnect the black and white wires from terminal 3 and 4. The terminal 3 wire is white and the terminal 4 wire is black.
9.) Remove harness.
10.) Remove J15 connector.
11.) Remove ambient thermistor assembly.

NOTICE **Make sure new thermistor is mounted in the same position as the original.**

12.) Install new ambient thermistor assembly.

3.11.7 OBC Fan

3.11.7.1 Required Tools

- Flat-blade screwdriver
- 3 mm Hex key socket

3.11.7.2 Procedure Details

DANGER USE PROPER LOCKOUT/TAGOUT PROCEDURES

1.) Move table to its lowest elevation.
2.) Remove right side and top covers.
3.) Tilt Gantry backward to 30 Degrees. (For easier access)
4.) Turn **OFF** all 3 switches (Axial Drive, **HVDC**, 120 VAC) on the **STC** backplane.
5.) Position **OBC** at 2:00 o'clock.
6.) Engage gantry rotational lock.
7.) Disconnect Power Cord from Fan.
8.) Remove (4) 4 mm cap screws that fasten Fan and Grill in place.
9.) Transfer grill to new fan, if necessary, and install new Fan.
10.) Reassemble Gantry.
11.) Turn **ON** 120 VAC on the **STC** backplane. Verify Fan is operational.
12.) Assemble gantry.
13.) No specific retest procedures.

3.11.8 OBC Chassis Assembly

Reference 3.11.3 - OBC Backplane.

3.12 Thermostat Assembly

3.12.1 Required Tools

- Phillips #2
- Flathead
- 5 MM. hex key

3.12.2 Procedure Details

1.) Remove Left side cover.
2.) Remove 2 hex screws that secure assembly to gantry.
3.) Disconnect power from thermostat.
4.) Remove thermostat.
5.) Install new thermostat.

Note: When installing new thermostat, synchronize settings from old thermostat with new thermostat.

Figure 8-106 Gantry Ambient Temperature Fan Control Thermostat

3.13 Gantry Rotation Interference Touch Strip

1.) Remove side, top, and front covers.
2.) Turn off all 3 switches (Axial Drive, **HVDC**, 120VAC) on the **STC** backplane.
3.) Disconnect touch strip cable.
4.) Remove gantry rotation touch strip.
5.) Install new gantry rotation touch strip.

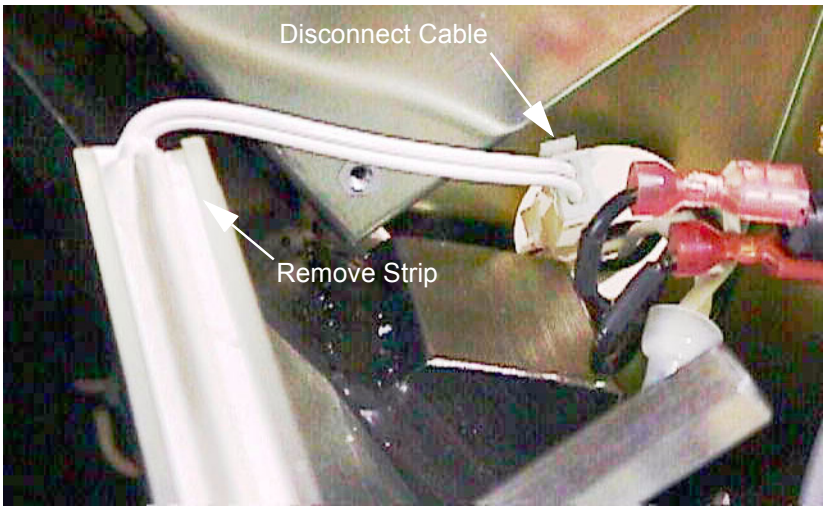


Figure 8-107 Gantry Rotation Interference Touch Strips

Section 4.0
Retest Matrix

4.1 System Scanning Test

Use the System Scanning Test to verify hardware functionality. Review images for visible artifacts, and review the message log for unacceptable errors.

1.) Place the QA phantom on the cradle.
- Drive the table to an elevation of 100.
- Align the reference line on the phantom with the internal laser lights.

NOTICE Avoid Detector Damage

Never scan above 50 mA without first placing a phantom in the field of view. Levels in excess of 50 mA can cause temporary radiation damage to the detector that lasts several hours. If you acquire image series cals with a radiation damaged detector, the cals may cause artifacts in subsequent image series scans.

2.) Manually select the scan parameters in Table 8-30.

Scan Type	kV	mA	SFOV	Thickness	Scan Time	Start Location	End Location	Tilt/Pitch
Scout	120	40	-	-	-	S200	I800	0°, HQ
Scout	120	40	-	-	-	S200	I800	90°, HS
Cine	120	50	Large	4x5	30sec	S0	S0	1.0, HQ
Axial	120	50	Large	4x5	1.0sec	S0	S0	I30, HS
Axial	120	50	Large	4x1.25	1.0sec	S0	S0	S30, HQ
Helical	120	50	Large	4x1.25	30sec	S70	I75	HS

Table 8-30 System Scanning Test scan parameters

3.) Complete the scans.

4.2 OBC Component Replacement Verification

NOTICE **Please perform the retests listed below when you replace or adjust these parts.**

OBC SYSTEM COMPONENT	TASK	VERIFICATION TESTS
Artesyn III (**CPU**) board	Replacement, "OBC Circuit Boards," on page 659.	Successful Hardware reset. System Scanning Test on page 668.
LSCOM board	Replacement, "OBC Circuit Boards," on page 659. •	1.) Hardware Reset using console gantry reset (Hardwire). 2.) Acquire 10 scouts: (120kV/ 40mA., 1000mm table movement) 3.) Acquire 100 axials: (120kV/ 80mA., 0.5 sec. Scan) 4.) Acquire 1 helical: (120kV/ 40mA., 30 sec. Scan) 5.) Acquire 10 axial scans: (120kV/ 400mA., 4 sec. Scan) 6.) Verify NO increase in Link errors
Gentry I/O board	Replacement, "OBC Circuit Boards," on page 659.	1.) Verify mA meter 2.) Verify kV meter 3.) kV and mA verification 4.) Exposure time accuracy 5.) System Scanning Test, see page 668. 6.) X-Ray Functional Test
OBC Backplane	Replacement, "OBC Backplane," on page 661. Check empty chassis power supplies, all slots "OBC Power Supplies," on page 577.	1.) Verify mA meter 2.) Verify kV meter 3.) Auto mA Cal 4.) System Scanning Test, see page 668.
OBC Thermistor	Replacement, "OBC Thermistor," on page 664.	None
OBC Fan	Replacement, "OBC Fan," on page 666.	None
OBC Ambient Thermistor	Replacement, "OBC Ambient Thermistor (Tube Fan Pump Relay Control Harness)," on page 665.	None

Table 8-31 OBC Component Retest Matrix

4.3 STC Component Replacement Verification

NOTICE **Please perform the retests listed below when you replace or adjust these parts**.

COMMUNICATION FRU	TASK	VERIFICATION TEST
Artesyn **CPU** Board	Replacement, "STC Boards," on page 638	System Scanning Test on page 668.
LSCOM	Replacement, "STC Boards," on page 638, to replace **LSCOM** in **OBC** refer to "OBC Circuit Boards," on page 659. •	1.) Hardware Reset using console gantry reset (Hardwire). 2.) Acquire 10 scouts: (120kV/ 40mA., 1000mm table movement) 3.) Acquire 100 axials: (120kV/ 80mA., 0.5 sec. Scan) 4.) Acquire 1 helical: (120kV/ 40mA., 30 sec. Scan), 5.) Acquire 10 axial scans: (120kV/ 400mA., 4 sec. Scan) 6.) Verify NO increase in Link errors
Axial Board	Replacement, "STC Boards," on page 638	Exposure time accuracy and System Scanning Test on page 668.
STC Backplane	Check empty chassis power supplies – all slots.	System Scanning Test on page 668.

Table 8-32 Retest Matrix for LSCOM Communication FRU

4.4 Slip Ring Component Replacement Verification

NOTICE **Please perform the retests listed below when you replace or adjust these parts**.

COMMUNICATION FRU	TASK	VERIFICATION TEST
Slip Ring Assembly	Replacement "Slipring Platter," on page 640.	1.) Hardware Reset using console gantry reset (Hardwire). 2.) Acquire 10 scouts: (120kV/40mA, 1000mm table movement) 3.) Acquire 100 axials: (120kV/80mA, 0.5 sec. Scan) 4.) Acquire 1 helical: (120kV/40mA, 30 sec. Scan), 5.) Acquire 10 axial scans: (120kV/ 400mA, 4 sec. Scan) 6.) Verify NO increase in **LSCOM** errors. 7.) Verify NO increase in corrected or uncorrected **FEC** errors
Brush Tips and Brush Block	Replacement and Alignment, "Slipring Brush Block," on page 646.	1.) Hardware Reset using console gantry reset (Hardwire). 2.) Acquire 10 scouts: (120kV/40mA, 1000mm table movement) 3.) Acquire 100 axials: (120kV/80mA, 0.5 sec. Scan) 4.) Acquire 1 helical: (120kV/40mA, 30 sec. Scan), 5.) Acquire 10 axial scans: (120kV/ 400mA, 4 sec. Scan) 6.) Verify NO increase in **LSCOM** errors.
HSDCD Electronics (Transmitter or Receiver)	Replacement, "Slipring Transmitter," on page 645, to replace **HSDCD** receiver refer to page "Slipring Receiver," on page 644.	1.) Hardware Reset 2.) Acquire 10 scouts: (120kV/40mA, 1000mm table movement) 3.) Acquire 100 axials: (120kV/80mA, 0.5 sec. Scan) 4.) Acquire 1 helical: (120kV/40mA, 30 sec. Scan), 5.) Acquire 10 axial scans: (120kV/ 400mA, 4 sec. Scan) 6.) Verify NO increase in corrected or uncorrected **FEC** errors

Table 8-33 Retest Matrix for Slipring Components

4.5 Intercom Component Replacement Verification

NOTICE **Please perform the retests listed below when you replace or adjust these parts**.

GANTRY FRU	TASK	VERIFICATION TEST
Microphone	Replacement, "Breathing Light Assembly," on page 655.	Verify patient can be heard at the console.
Intercom Board	Replacement, "Intercom Board," on page 656.	Play canned AUTOVOICE messages.

Table 8-34 Retest Matrix for Gantry Intercom Components

4.6 Axial Component Replacement Verification

NOTICE **Please perform the retests listed below when you replace or adjust these parts**.

GANTRY FRU	TASK	VERIFICATION TEST
Axial Motor Drive	Replacement, "Axial Drive Module," on page 631.	Axial Control Functional, page 580. System Scanning Test, page 668.
Drive Belt	Replacement, "Belt Removal and Installation," on page 636. To set C-Pulse, Axial Home Flag physical position, "Resetting the C-Pulse," on page 581.	Run Microphonics, a test under **DAS** Tools, found under Trouble Shoot. System Scanning Test, page 668.
Axial Encoder	Replacement, "Axial Encoder Assembly," on page 636. Adjustment, "Resetting the C-Pulse," on page 581.	Axial Encoder Check, page 580. Axial Control Functional, page 580. System Scanning Test, page 668.
Home Flag	Replacement, "Home Flag and Sensor Board Assembly," on page 635. To set C-Pulse, Axial Home Flag physical position refer to "Resetting the C-Pulse," on page 581.	Axial Home Flag Check, page 580.
Axial Brake	Replacement, "Axial Drive Holding Brake," on page 633. Axial Brake check. on "Axial Brake Check," on page 580.	Axial Brake Check, page 580. Exercise alignment lights, and acquire several 1 second scans.
Axial Dynamic Brake Module	To verify gantry does not coast to a stop.	Perform one (1) 0.5 sec scan. Verify gantry stops in less than 10 seconds. Axial Control Functional, page 580.

Table 8-35 Retest Matrix for Gantry Axial Drive Components

4.7 Power Components Replacement Verification

NOTICE **Please perform the retests listed below when you replace or adjust these parts.**

GANTRY FRU	TASK	VERIFICATION TEST
DAS DC Power Supply (+12 V)	Measure unloaded and loaded voltages, "DAS Power Supplies (2225212-2 ±5 vdc, 2225217 (2) 12 vdc)," on page 579.	System Scanning Test, page 668.
Collimator/ Detector Power Supply	Measure unloaded and loaded voltages, "Collimator/Detector Heater Power Supply," on page 742.	System Scanning Test, page 668 **DAS** Tools – Aux channel test to confirm 34 degrees C.
STC DC Power Supply +5 volt	Replacement, "STC Power Supply," on page 639. Measure unloaded and loaded voltages "STC Power Supplies," on page 575.	System Scanning Test, page 668.
OBC DC Power Supply (+5 volt,± 15 volt, +24 volt)	Replacement, "OBC Power Supply," on page 660. Measure unloaded and loaded voltages. "OBC Power Supplies," on page 577.	System Scanning Test, page 668.

Table 8-36 Retest Matrix for Gantry Power Supplies

4.8 Tilt Component Replacement Verification

NOTICE **Please perform the retests listed below when you replace or adjust these parts.**

GANTRY FRU	TASK	VERIFICATION TEST
Hydraulic Tilt Assembly	Replacement, "Hydraulic Tilt Motor Assembly," on page 648. Adjustment, "Tilt Speed Adjustment Procedure," on page 586. Fluid level check, "Hydraulic Fluid Check and Fill Procedure," on page 587	Verify full range of tilt operation.
Tilt Relay bd	Replacement, "Tilt Relay Board," on page 647.	Verify full range of tilt operation.
Tilt Pot	Replacement, "Tilt Potentiometer Procedure Details," on page 653. Tilt Characterization, "Mechanical Characterization - Gantry Tilt," on page 588.	Verify full range of tilt operation.
Tilt switches	Replacement, "Tilt Interference and Limit Switches," on page 654. Adjustment, "Tilt Limit/Interference Adjustments," on page 583.	Verify full range of tilt operation.

Table 8-37 Retest Matrix for Gantry Tilt Components

4.9 Laser Component Replacement Verification

NOTICE **Please perform the retests listed below when you replace or adjust these parts.**

GANTRY FRU	TASK	VERIFICATION TEST
Laser Lights	Replacement, "Laser Lights," on page 657. Adjustment, "Alignment Light Adjustment Procedure," on page 589.	Verify Laser, "Alignment Lights Visual Checks," on page 588.

Table 8-38 Retest Matrix for Gantry Components

4.10 Display Component Replacement Verification

NOTICE **Please perform the retests listed below when you replace or adjust these parts.**

GANTRY FRU	TASK	VERIFICATION TEST
Gantry Display Assembly	Replacement, "Display Assembly," on page 654.	Verify self test and counts change for table up/down, in/out and gantry tilt.
Breathing Lights	Replacement, "Breathing Light Assembly," on page 655.	Verify patient can be heard at the console. Test using Breath Display button on gantry control panel.

Table 8-39 Retest Matrix for Gantry Components

4.11 Safety Component Replacement Verification

NOTICE **Please perform the retests listed below when you replace or adjust these parts.**

GANTRY FRU	TASK	VERIFICATION TEST
Axial Enable Interlock	Replacement, "STC Backplane," on page 638.	Test Axial Enable by exercising alignment lights. They won't come on if axial functions are inoperable.

Table 8-40 Retest Matrix for Gantry Components

4.12 Gantry Miscellaneous Component Replacement Verification

NOTICE **Please perform the retests listed below when you replace or adjust these parts.**

GANTRY FRU	TASK	VERIFICATION TEST
Mylar Window	To replace, see "Scan Window," on page 628.	Perform (10) slices at 10mm aperture.

Table 8-41 Retest Matrix for Gantry Components

GE MEDICAL SYSTEMS

GE MEDICAL SYSTEMS-AMERICAS: FAX 262.312.7434
3000 N. GRANDVIEW BLVD., WAUKESHA, WI 53188 U.S.A.

GE MEDICAL SYSTEMS-EUROPE: FAX 33.1.40.93.33.33
PARIS, FRANCE

GE MEDICAL SYSTEMS-ASIA: FAX 65.291.7006
SINGAPOR

GE Medical Systems

gemedical.com

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GE Medical Systems
HiSpeed QX/i Service Manual - General

Chapters 9 & 10
X-Ray Generation & PDU

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Chapter 9
X-Ray Generation

Section 1.0
Introduction

The High Voltage subsystem for the current scanner is the same basic subsystem introduced in the HSA product line. The High Voltage subsystem has undergone several quality improvements throughout the **CT** product development. This evolution is HSA, HSARP, CTI, Lightspeed families.

The Theory Section has been provided basically intact as its basic content is unchanged. Please note that references to older style boards are still true with the current configuration. Specific items—such as legacy specific tables, screens or examples—have been removed.

The current CT scanner supports the following **OBC** (On Board Controller) circuit boards:

- KV Board - 2143147
- MA Board - 2154834
- **HEMRC** Control Board - 2179860
- GENTRY I/O 46-288512G1
- ARTESYN III (**CPU**) - 2224296-3
- **LSCOM** Board - 2233488

Section 2.0
Theory

2.1 kV Troubleshooting Theory

2.1.1 Reported vs. Actual Tube kV

The kV (and mA) reported to the software, which includes the reported kV to the console, does not have to be what is actually across the x-ray tube. The kV reported to the software does not have to be what is seen by the bleeder.

Reported kV comes from the Anode and Cathode kV Test points on the kV Control Bd. Because of kV closed loop regulation, this test point (on a normally operating scanner) should never be different from “SELECTED VALUE” (± 2.999%). This is the node that the loop uses to regulate. Because the gain of the electronic monitoring devices between the x-ray tube and this test point may not be 1, the kV reported here **IS NOT THE ACTUAL kV SEEN ACROSS THE X-RAY TUBE.** It is what the system **THINKS** is the actual tube voltage. The purpose of kV gain adjustment is to get a gain of one between x-ray tube and TP10.

Note: It is uncommon, but possible to get the kV gain pots out of adjustment as much as ± 15kV.

The purpose of the kV Feedback Gain Pot is to ensure a gain of one in the feedback circuit. A gain of one will ensure that the voltage across the x-ray tube (and bleeder) is what gets reported to the kV Feedback Test Point. The closed loop regulates to these test points, if these test points are wrong the system will change inverter current to compensate for the wrong kV.

Improperly adjusted kV Gain Pots can result in the kV being off as much as ±30kV total from what the system (software) thinks is across the tube. This means that the system is cooling for 120kV, and actual kV across the tube can be as high as 150kV. Tube life would be very low with this scenario.

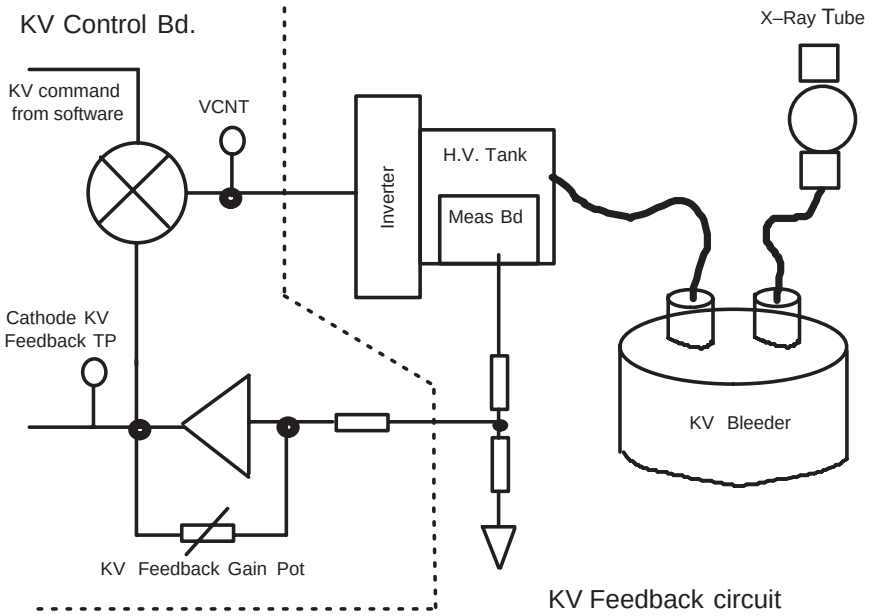


Figure 9-1 Why Reported kV may not be the Actual kV Across the Tube

EXAMPLE: kV Feedback Gain Pot is adjusted for a gain of.90. A kV command of 100 kV is received (50kV anode, 50kV cathode). With 50kV across kV Bleeder (as read with the scope), and a gain of 0.90 the kV Test Point will only see 45kV. The error mux will command a higher inverter current until kV Test Point is 50kV. HOWEVER the kV across the bleeder (x-ray tube) is really 55.5kV.

Tweaking the kV Gain Pot for a gain closer to one will cause the error mux to reduce the inverter current, therefore compensating for the kV Test Point. The kV Gain Pots are adjusted correctly when the kV across the bleeder is the same as the kV Test Points.

2.1.2 kV Gain Pot Adjustment

2.1.2.1 Purpose of This Information

To reinforce that the kV feedback test points DO NOT reflect actual kV across the tube. The purpose of the kV gain pot is to ensure that there is a gain of 1 (one) between the tube kV measurement (meas bd) and tube kV reporting (kV test points.)

The reason that kV test points (on a normally operating system) will never be different than commanded, is that this is the node the closed loop uses to regulate the kV. If this test point is wrong the system will change inverter current to compensate. It takes milliseconds to do this, therefore it looks like these test points never change.

Another reason for this documentation is to emphasize how far off the kV gain pots can be adjusted and the system still think that the kV across the tube is what the cooling algorithm thinks it is.

2.1.2.2 Definitions

Definitions for columns labelled in Table 9-1:

Turns cw - The kV gain pot was turned fully ccw, then turned clockwise one turn at a time.

Bleeder - kV bleeder installed in system. This is actual kV across the tube.

Kvan and Kvca - anode and cathode test points on the kV control board.

Note: One turn cw (from fully ccw) will bring the gain closer to one, resulting in the bleeder voltage come up closer to the test point. This is true up until 15 turns when the gain is less than one. Now the actual kV across the tube is GREATER THAN the test points (measurement gain less than one).

2.1.2.3 Summary

A properly adjusted kV gain pot should be in the neighborhood of about 15 turns.

Example: kV FEEDBACK POT Values

ANODE			CATHODE		
FULLY CCW (starting pt)			FULLY CCW (starting pt)		
TURNS CW	BLEEDER	KVAN	TURNS CW	BLEEDER	KVCA
2	44.854	5.9823	2	45.036	6.0004
3	45.751	5.9095	3	45.438	6.0192
4	47.008	5.9711	4	46.473	6.0306
5	48.266	5.9639	5	47.47	6.0232
6	49.543	5.9631	6	48.576	6.0274
7	50.614	5.9601	7	49.731	6.0244
8	51.613	5.9493	8	50.84	6.0235
9	52.615	5.9554	9	51.835	6.0238
10	53.705	5.9445	10	52.749	6.0327
11	54.883	5.9449	11	54.065	6.0235
12	56.103	5.9442	12	55.337	6.0241
13	57.32	5.9361	13	56.49	6.0225
14	58.315	5.9324	14	57.861	6.0207
15	59.532	5.931	15	58.917	6.0309
16	60.527	5.9238	16	60.06	6.0192
17	60.763	5.9081	17	61.354	6.0263
18	62.041	5.9359	18	62.695	6.0324
19	63.041	5.9328	19	63.68	6.0213
20	64.108	5.9361	20	65.114	6.0253
21	65.136	5.9479	21	66.429	6.0213
22	66.118	5.955	22	67.334	6.0327
23	67.122	5.9636	23	68.731	6.0293
24	68.134	5.9706	24	69.827	6.0303
25	69.164	5.986	25	70.917	6.0238
26	70.081	5.9981	26	71.974	6.0275
27	71.157	5.9385	27	73.147	6.0297
28	72.092	5.9854	28	74.256	6.0235
29	73.171	5.9808	29	74.961	6.0241
30	74.155	5.9801	30	75.041	6.0244

Table 9-1 Typical kV Feedback Pot Values

2.1.3 SW & HW Tools Available for Troubleshooting

2.1.3.1 Diagnostics

kV & mA (X-Ray) Results Screen on the Troubleshoot menu is the ****Primary tool** for kV related problems other than Overcurrents or Shoot-thrus. Overcurrents or Shoot-thrus will terminate scans, resulting in no data collection also **OBC BLD**s

2.1.3.2 Tools

Schematics Manual

- kV Control Bd. (Newer Style Bd.) Schematics 2143147SCH
- kV Inverter Gate Driver Bd. Schematics 46-264662-S
- kV Inverter Capacitor Bd. and Schematics 46-264664-S
- **OBC** Backplane list
- Gantry Rotating Member Block Diagram
- Gantry_Rotating_Interconnect
- X-Ray Tube 120 VAC

Equipment

- Bleeder
- Bleeder/O'Scope combination can cause aliasing with the bleeder kV signal, resulting in kV ripple as high as 20kV.
- Multi-meter
- Oscilloscope

2.1.4 Explanation of kV/mA Results Screen

This is an example of a results screen from a 120kV, 200mA, 10 second scan. (This example is from a "**newer style**"—i.e., 46-321198—kV Control board, with 550vdc DCRGS.)

HIGH VOLTAGE STATUS				
NO.	DEVICE	AVERAGE VALUE	SELECTED VALUE	LAST SAMPLE
1.	Total kV:	119.4 kV	120.0 kV	119.4 kV
2.	Cathode kV:	59.7 kV	60.0 kV	59.7 kV
3.	Anode kV:	60.1 kV	60.0 kV	60.1 kV
4.	Cathode mA:	193.7 mA	200 mA	193.7 mA
5.	Anode mA:	193.7 mA	200 mA	193.7 mA
6.	Cathode inverter current:	30.7 A	–	30.7 A
7.	Anode inverter current:	30.7 A	–	30.7 A
8.	Approx. kV inverter frequency(VCNT):		(1.6V)	xx.x KHz
9.	Cathode inverter duty cycle:	100%	–	100%
10.	Anode inverter duty cycle:	83%	–	83%
11.	Rail voltage:	540 V	550 V	540 V
12.	Exposure duration:	–	10000 mS	10001 mA
13.	Exposure number:	–	1	1

Table 9-2 kV/mA Results Screen - 46-321198 kV Control bd.

Definitions of Column Headings:

AVERAGE VALUE: The average taken over the duration of the scan (see Exposure Duration).

SELECTED VALUE: The value prescribed by the user, or the value required to perform the scan.

LAST SAMPLE: The last value read during an ACTIVE exposure.

1. Total kV Explanation:	119.4kV	120.0kV	119.4kV

On the 46-321198G1-F board this signal comes from TP11. It is an op-amp sum of Anode kV (TP9) and Cathode kV (TP10). Because of kV closed loop regulation, this test point (on a normally operating scanner) should never be different from “SELECTED VALUE” (± 2.999%). **DO NOT TROUBLESHOOT “Total kV” low** (or high). Instead troubleshoot either the anode or the cathode being low (or high), they are the inputs to this value.

“Total kV” gets reported to the software through the Gentry I/O and **OBC** Backplane.

2. Cathode kV Explanation:	59.7kV	60.0kV	59.7kV

On the 46-321198G1-F board this signal comes from TP10. Because of kV closed loop regulation, this test point (on a normally operating scanner) should never be different from “SELECTED VALUE” (± 2.999%). This is the node that the loop uses to regulate. Because the gain of the electronic monitoring devices between the x-ray tube and this test point may not be 1, the kV reported here **IS NOT THE ACTUAL kV SEEN ACROSS THE X-RAY TUBE.** It is what the system **THINKS** is the actual tube voltage. The purpose of kV gain adjustment is to get a gain of one between x-ray tube and TP10.

Note: It is uncommon, but possible to get the kV gain pots out of adjustment as much as ± 15kV.

Inverter current is commanded by (VCNT). Compare these three readings (cathode kV, Cathode inverter current and (VCNT)) and troubleshoot. Nominal values are attached.

3. Anode kV Explanation	60.1kV	60.0kV	60.1kV

On the 46-321198G1-F board this signal comes from TP9. Because of kV closed loop regulation, this test point (on a normally operating scanner) should never be different from “SELECTED VALUE” (± 2.999%). This is the node that the loop uses to regulate. Because the gain of the electronic monitoring devices between the x-ray tube and this test point may not be 1, the kV reported here **IS NOT THE ACTUAL kV SEEN ACROSS THE X-RAY TUBE.** It is what the system **THINKS** is the actual tube voltage. The purpose of kV gain adjustment is to get a gain of one between x-ray tube and TP9.

Note: It is uncommon, but possible to get the kV gain pots out of adjustment as much as ± 15kV.

Inverter current is commanded by (VCNT). Compare these three readings (Anode kV, Anode inverter current and (VCNT)) and troubleshoot. Nominal values are attached.

4. Cathode mA Explanation:	193.7mA	200.0mA	193.7mA

This value comes from the mA Control Bd. 2154834 TP4, through the backplane and Gentry I/O bd. Since the cathode is in series with the anode, TP4 should be the same value as the anode mA. The scale is 1v/100mA.

In closed loop mode TP4 should be commanded mA. In open loop mode the value should be less (whatever is in GenCalSeed). TP4 is actually the cathode high voltage tank secondary amperage, the x-ray tube is the load for the secondary. mA Meter Verification verifies that the measurement electronics have a gain of one and that reported mA is actual mA.

Cathode high voltage tank secondary amperage (and x-ray tube mA) is the direct result of filament heating, for improper mA include filament function while troubleshooting. If mA is out of tolerance (3%), check kV values for large errors, verify mA metering, and run the Filament Functional test. BLDs can help also.

If cathode and anode mA are different, suspect mA measurement electronics (use mA Meter Test), or suspect a shattered x-ray tube insert shorting out the filament (cathode) or the anode.

5. Anode mA Explanation 193.7mA 200.0mA 193.7mA

This value comes from the mA Control Bd. 2154834 TP10, through the backplane and Gentry I/O bd. Since the anode is in series with the cathode, TP10 should be the same value as the cathode mA. The scale is 1v/100mA.

In closed loop mode TP10 should be commanded mA. In open loop mode the value should be less (whatever is in GenCalSeed). TP10 is actually the anode high voltage tank secondary amperage, the x-ray tube is the load for the secondary. mA Meter Verification verifies that the measurement electronics have a gain of one and that reported mA is actual mA.

Anode high voltage tank secondary amperage (and x-ray tube mA) is the direct result of filament heating, for improper mA include filament function while troubleshooting. If mA is out of tolerance (3%), check kV values for large errors, verify mA metering, and run the Filament Functional test. BLDs can help also.

6. Cathode Inverter Current Explanation: 30.7A – 30.7A

This value comes from the kV Control Bd. 46-321198G1-F TP21, through the backplane and Gentry I/O bd. The scaling is 25A/volt. Values over 8 amps will result in an overcurrent error. Locate the “OVERCURRENT” toroid/transformer. This toroid monitors the current leaving the inverter and going to the tank primary.

7. Anode Inverter Current Explanation: 30.7A – 30.7A

This value comes from the kV Control Bd. 46-321198G1-F TP20, through the backplane and Gentry I/O bd. The scaling is 25A/volt. Values over 8 amps will result in an overcurrent error. Locate the “OVERCURRENT” toroid/transformer. This toroid monitors the current leaving the inverter and going to the tank primary.

8. Approx. kV Inverter Frequency (VCNT) Explanation: (1.60V) xx.xKHz

This value comes from the kV Control Bd. 46-321198G1-F TP24, through the backplane and Gentry I/O bd. This is the input voltage to the voltage controlled oscillator. the operating range is from 0-5v, which will give a frequency range of 19.5khz to 31.5khz.

A (VCNT) of 0.2v is a command for a lower frequency, a lower frequency will allow more current through the primary resulting in more kV output. To summarize, a (VCNT) 0f 0.2v is max current command, should have max inverter current, should have max kV.

A (VCNT) of 5v (or more) is a command for a higher frequency, a higher frequency will allow less current through the primary resulting in less kV output. To summarize, a (VCNT) 0f 4.99v is min current command, should have min inverter current, should have min kV.

(VCNT) is an composite signal generated from the difference between kV command and kV feedback. This error signal is also an input into (VCNT).

Compare these three readings (cathode kV, Cathode inverter current and (VCNT)) and troubleshoot. Nominal values are attached.

9. Cathode Inverter Duty Cycle Explanation: 100% – 100%

This value comes from the kV Control Bd. 46-321198G1-F TP23, through the backplane and Gentry I/O bd. The system uses duty cycle to regulate at the lower mAs more than it uses frequency. At the higher mAs the system uses frequency to regulate more than it uses duty cycle. Compare the cathode duty cycle to the anode duty cycle.

10. Anode Inverter Duty Cycle Explanation:	**83%**	**–**	**83%**

This value comes from the kV Control Bd. 46-321198G1-F TP22, through the backplane and Gentry I/O bd. The system uses duty cycle to regulate at the lower mAs more than it uses frequency. At the higher mAs the system uses frequency to regulate more than it uses duty cycle. Compare the cathode duty cycle to the anode duty cycle.

Note: The following statement is only true for the older KV board 46-321064G1 and inverters tuned to 19.1 Khz and 18.6 Khz. The anode duty cycle should never reach 100% and rarely gets past 95%. At 95% and at a max (VCNT) command, the system is out of energy, therefore you should only see these percentages at 140kv, 340ma. When the system is out of energy, the kv will start caving in. Also at mAs higher than 100ma, the anode duty cycle should never exceed the cathode duty cycle.

IF THIS SCENARIO HAPPENS, the system is running out of energy. Most likely due to an IGBT not firing.

FOR KV BOARDS OTHER THAN 46-321064G1: The duty cycle can achieve 100% on either the cathode or anode inverter. This should be considered normal operation for the new inverters.

Exposure Duration, Number, and Status Register Explanation:			
Exposure duration:	–	10000mS	10001mS
Exposure number:	–	1	1
Status register (Address = FFCFF9H):		–	8FH

2.1.5 Tube Spit Explanation

2.1.5.1 How does the system determine when a tube spit happens?

When a fast fall time is detected on the kV waveshape.

Tubes spit all of the time. A pessimist might even say that if a tube doesn't spit, there is something wrong with it. The question is, "When do we stop scanning because of tube spits?" The answer is, "when spits affect image quality or could cause equipment damage."

The kV Control Bd. monitors the kV via the kV feedback test points. A tube spit will cause the kV drop at a very fast rate. An integrator circuit on the kV Control Bd. monitors the kV feedback, whenever this integrator detects this fast fall time (an integrator has little impedance to fast frequencies), it is considered a tube spit. The kV Control Bd. will then turn off x-rays for approximately 100ms to allow the x-ray tube to recover.

2.1.5.2 Why is scanning stopped after 32 spits have been detected?

The answer is image quality.

It has been determined that more than 32 spits per scan second may affect image quality, therefore the system will stop scanning when the system has counted more than 32 spits per scan second.

On the older style kV Control Bd. (46-321064), scanning will abort when 32 spits occur in a rolling 1 second window, for a net rate of 27.1 to 40.7 spits/sec.

On the newer style kV Control Bd. (2143147), scanning will abort when 9 spits occur in a rolling 0.26 second window for a net rate of 34.3 spits/sec.

Overcurrents and Shoot-Thrus protect the system against damage. Spit detection is not used to protect the system against damage.

2.1.6 Bleeder Ripple/Oscilloscope Aliasing

The current bleeder in use today was designed for line frequency type generators and has a band width of 720hz. The high voltage subsystem operates at approximately 19.khz to 31khz. The problem is, if you connect a scope probe directly to the bleeder, it has a tendency to amplify high frequency ripple. The bleeder requires the cable capacitance to roll off the high end properly. Also, there are actually a couple different bleeders out there under the same model #. They were never

intended to deal with signals above 720 Hz (for line frequency machines). As a result the high frequency response is unreliable.

This is not to say avoid using the present bleeder for measuring high voltage. The Bleeder is what GEMS uses for measuring high volt. HOWEVER when using the bleeder it is very difficult deter mine what is real ripple and what is aliasing.

Refer to the waveshapes in Section 2.1.7 for examples of normal bleeder waveshapes.

2.1.7 kV Reference Material

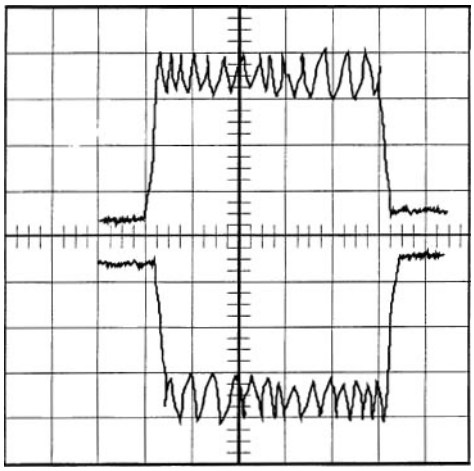


Figure 9-2 kV Ripple @ 0.2 second scope trace

- A:20V=0.2S B:20V=0.2S
- 140KV 340ma Bleeder (slow sweep)
- This is a normal picture.

This is a good example of the scope aliasing the inverter ripple. NOTE: that the ripple can be as high as 20kV per side. Although aliasing will indicate something at higher frequencies, it is not a true waveform.

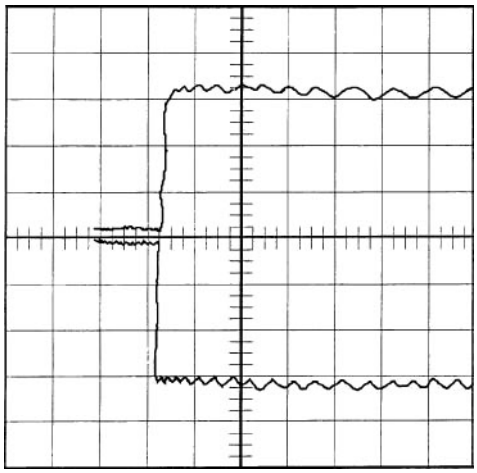


Figure 9-3 kV Ripple @ 0.1 second scope trace

- A:20V=0.1S B:20V=0.1S
- 140KV 340ma Bleeder (slow sweep)
- This is a normal picture.

This is a good example of the scope aliasing the inverter ripple. This picture is the same picture as is in the previous section, the only difference is the scope time base. NOTE: that the ripple can be as high as 20kV per side. Although aliasing will indicate some thing at higher frequencies, it is not a true waveform.

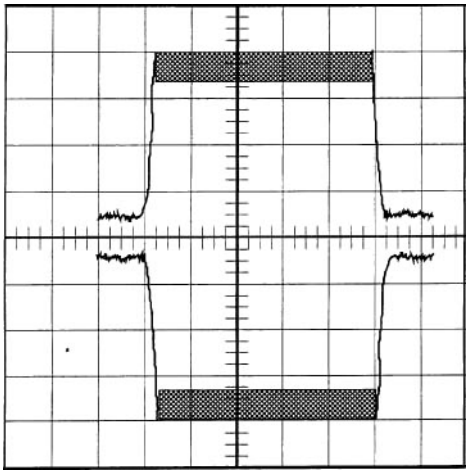


Figure 9-4 kV Ripple @ 0.2 sec. scope trace w/scope in “peak or “envelope” mode

- A:20V=0.2S B:20V=0.2S
- 140KV 340ma Bleeder (slow sweep)
- This is a normal picture, w/scope in “peak” or “envelope” mode.

This is a good example of the scope aliasing the inverter ripple. Note that the ripple can be as high as 20kV per side. Although aliasing will indicate something at higher frequencies, it is not a true waveform.

RESULTS SCREEN VALUES FOR:

kV Control Bd. (2143147)

- with a Compact **PDU** (unregulated **HVDC**)
- with a PERFORMIX tube
- at Nominal Line Voltage

2.2 mA Troubleshooting Theory

2.2.1 mA Loop Theory

2.2.2 mA Meter Verification Theory

The purpose of mA Meter Verification is to ensure that the mA Measurement Electronics has a gain of one between actual tube current and reporting to the firmware. This firmware value would then be reported to the console.

The method outlined in various GEMS documents is to install an ISO compliant, calibrated ammeter across two test points. This meter effectively shorts out a 680ohm resistor. The next step is to install a 62ohm resistor from one side of the ammeter to the mA test point (TP5) on the measurement Bd.

TP5 is a voltage representation of tube current. This voltage is feed to the mA Control Bd. in the **OBC** and the resultant mA is fed to the firmware and can be read from a mA test point. This is where the gain of one is needed, between the Measurement Bd. TP5 and the mA Control Bd. mA Test Point.

When $\overline{\text{ACCEPT}}$ is touched on the console screen and after a time delay Q1 is turned on (+)15vdc (0r -15vdc) is applied through the ammeter (not the shorted out 680ohm resistor), through the

68ohm resistor to TP5. 15vdc over 62ohm comes out to 242mA, add in the other resistances in the measurement circuit an it comes out to be about 140mA to 200mA.

It really doesn't matter what the actual mA is, all that matters is that the console reading (firmware value from the mA Test Points) MATCHES what the ISO compliant, calibrated ammeter says.

2.2.3 SW and HW Tools Available for Troubleshooting

2.2.3.1 Schematics

- mA/Filament Control Bd. Schematics 2154834SCH
- **OBC** Backplane list
- Gantry Rotating Member Block Diagram
- Gantry_Rotating_Interconnect
- X-Ray Tube 120 VAC

2.2.3.2 Equipment

- Multi-meter
- Oscilloscope

2.2.4 Explanation of Cathode & Anode mA Results Screen

Cathode mA:	**193.7mA**	**200.0mA**	**193.7mA**

This value comes from the mA Control Bd. 2154834 TP4, through the backplane and Gentry I/O bd. Since the cathode is in series with the anode, TP4 should be the same value as the TP10 (anode mA, they are in series). The scale is 1v/100mA.

In closed loop mode TP4 should be commanded mA. In open loop mode the value should be less (whatever is in GenCalSeed). TP4 is actually the cathode high voltage tank secondary amperage, the x-ray tube is the load for the secondary. mA Meter Verification verifies that the measurement electronics have a gain of one and that reported mA is actual mA.

Cathode high voltage tank secondary amperage (and x-ray tube mA) is the direct result of filament heating, for improper mA include filament function while troubleshooting. If mA is out of tolerance (3%), check kV values for large errors, verify mA metering, and run the Filament Functional test. BLDs can help also.

If cathode and anode mA are different, suspect mA measurement electronics (use mA Meter Test), or suspect a shattered x-ray tube insert shorting out the filament (cathode) or the anode.

Anode mA:	**193.7mA**	**200.0mA**	**193.7mA**

This value comes from the mA Control Bd. 2154834 TP10, through the backplane and Gentry I/O bd. Since the cathode is in series with the anode, TP10 should be the same value as the TP4 (cathode mA, they are in series). The scale is 1v/100mA.

In closed loop mode TP10 should be commanded mA. In open loop mode the value should be less (whatever is in GenCalSeed). TP10 is actually the anode high voltage tank secondary amperage, the x-ray tube is the load for the secondary. mA Meter Verification verifies that the measurement electronics have a gain of one and that reported mA is actual mA.

Anode high voltage tank secondary amperage (and x-ray tube mA) is the direct result of filament heating, for improper mA include filament function while troubleshooting. If mA is out of tolerance (3%), check kV values for large errors, verify mA metering, and run the Filament Functional test. BLDs can help also.

If cathode and anode mA are different, suspect mA measurement electronics (use mA Meter Test), or suspect a shattered x-ray tube insert shorting out the filament (cathode) or the anode.

2.2.5 Reference Material

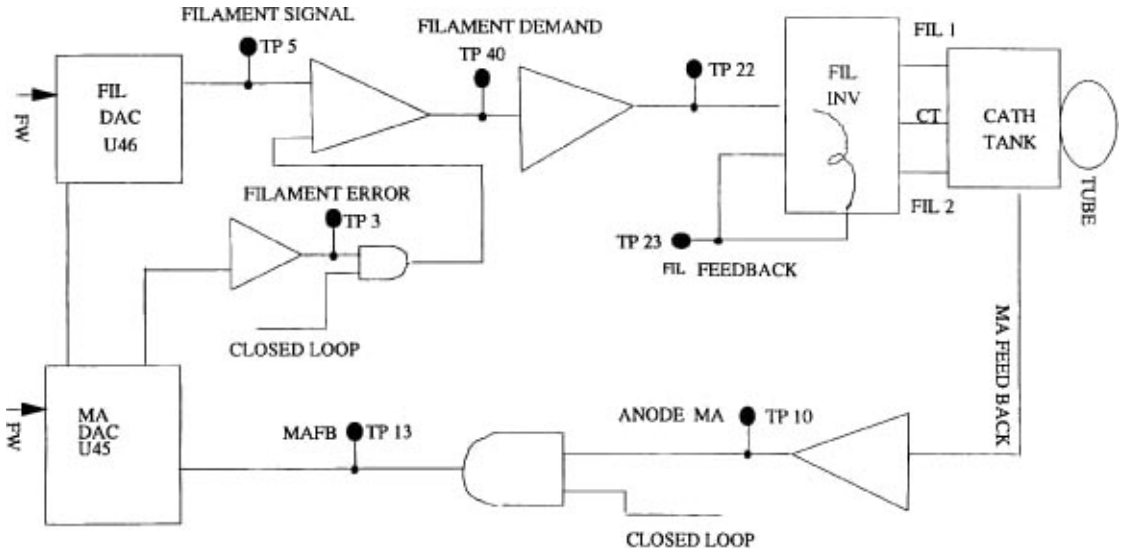


Figure 9-5 Simplified schematic

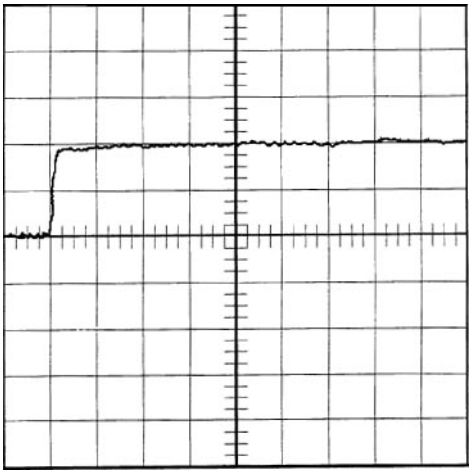


Figure 9-6 Normal mA waveshape for 80kV, 100mA.

- Channel A:0.5 v Board: mA Control 2154834 scope: TEK 224
- Vert: 0.5v Horz:5mS TP 10 to TP 2
- 80KV 100mA CLOSED LOOP mA TP10 (anma) to TP2 (sgnd)

This is a picture of the mA feedback read off of the mA Control Bd, with **CLOSED LOOP** mA selected. There should not be a great difference between CLOSED LOOP mA and OPEN LOOP mA. IF there is, it indicates that CLOSED LOOP is trying to make up for a problem, investigate for root cause.

Anode and cathode mAs are in series. Therefore anode and cathode mA waveshapes are duplicates.

Comment: *If not, either Ohm's law has been redefined for series circuits, or there is a problem. Verify for a measurement problem first.*

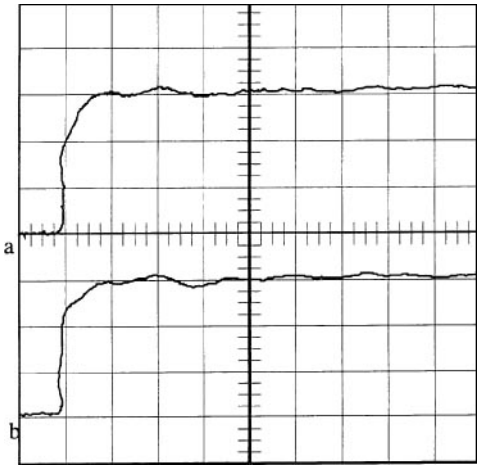


Figure 9-7 Normal mA waveshape for 80kV, 320mA.

- Channel A: 1v=5mS Board: mA control 2154834 scope:TEK 244 B:1v=5mS Vert:1v Horz:5mS.
- Ch 1 (a)= 80KV 320mA CLOSED LOOP mA TP10 (ANMA) to TP2 (sgnd)
- Ch 2 (b)= 80KV 320mA CLOSED LOOP mA TP4 (CAMA) to TP2 (sgnd)

This is a picture of the mA feedback read off of the mA control bd.

There should not be a great difference between CLOSED LOOP mA and Open loop mA. If there is, it indicates that CLOSED LOOP is trying to make up for a problem, investigate for root cause.

Anode and cathode mAs are in series. Therefore anode and cathode mA waveshapes are duplicates. If not, either Ohm's law has been redefined for series circuits, or there is a problem. [I would verify for a measurement problem first.]

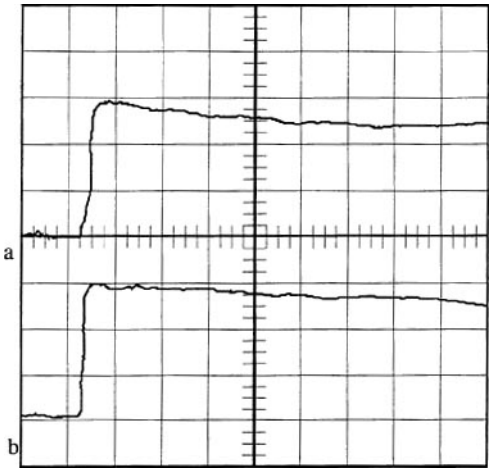


Figure 9-8 Normal mA waveshape for 80kV, 320mA OPEN LOOP MODE

- channel a:1v=50mS Board scpoe:TEK 224
- b:1v=50mS mA control Vert:1v
- 2154834 Horz: 50mS
- ch1 (a) =80KV 320mA OPEN LOOP mA TP10 (anma) to TP2 (sgnd)
- ch2 (b) =80KV 320mA OPEN LOOP mA TP4 (cama) to Tp2 (sgnd)

In open Loop Mode, there is a possibility of exceeding 400mA. DO NOT RUN the mA HIGHER THAN 350mA IN OPEN LOOP MODE. Exceeding 400mA WILL DAMAGE the H.V. subsystem.

This is a picture of the mA feedback read off of the mA Control Bd, with OPEN LOOP mode selected.

Compare this picture with CLOSED LOOP mA at the same technique. Note that in OPEN LOOP mode the mA is not regulated to a perfect 320 mA.

There should not be a great difference between CLOSED LOOP mA and OPEN LOOP mA. If there is, it indicates that CLOSED LOOP is trying to make up for a problem. Investigate for root cause.

2.3 HEMRC Theory

2.3.1 HEMRC Functions Theory

2.3.1.1 Performix Tube Theory of Operation

The Performix Tube uses a three-phase stator, which requires a **HEMRC** (High Efficiency Motor Rotor Controller) assembly and **HEMRC** Control board instead of the CTVRC Control board and assembly.

2.3.1.2 HEMRC Control Board (HCB)

The **HEMRC** Control board, (2179860) resides in slot A2 of the **OBC**. The **HEMRC** Control board performs three main functions. It provides:

- The interface between the **OBC** and the **HEMRC**

  Figure 9-11, on page 702, shows a Functional Interconnect for the hardwire control signals.
- **HVDC** Bus voltage monitoring
- A **CAN (Controller Area Network)** interface between the **OBC** and future subsystems

See Section 2.3.2, for **HEMRC** Control board Theory of Operation.

2.3.1.3 HEMRC Assembly

The **HEMRC** Assembly contains an Interface Board, AC Drive, Chopper Resistor Assembly, harness and assorted power supplies. The **HEMRC** Assembly also contains the Detector Heater, Collimator and Filament Power Supplies, which operate in the same manner as their HSA (CTVRC) counterparts.

The **HEMRC** Assembly replaces the CTVRC Assembly in systems that use the Performix tube.

Figure 9-9 shows a block diagram of the **HEMRC** assembly.

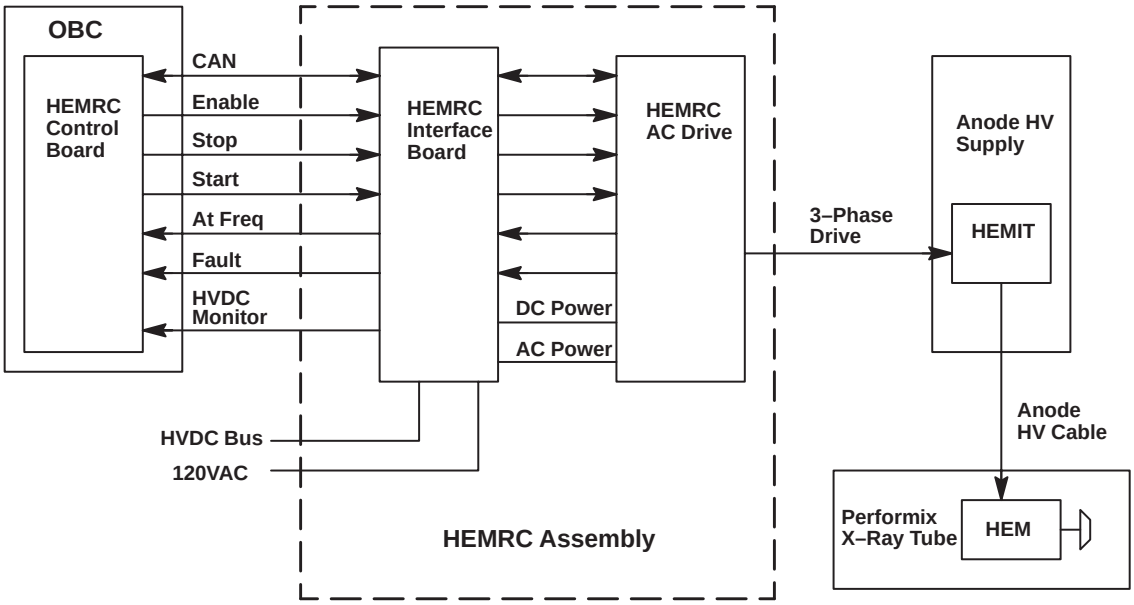


Figure 9-9 HEMRC Hardware Block Diagram

2.3.1.4 General HEMRC Function

The Rotor Control function provides three phase power to the rotating anode of the Performix x-ray tube. In addition to the **HEMRC** Control board, the Performix tube requires a **HEMRC** AC Drive, **HEMRC** Interface board, **HEMIT** (High Efficiency Motor Isolation Transformer), and controlling firmware. The rotor control firmware controls the acceleration, run, and deceleration cycles of the rotating anode. The rotor control firmware resides on the **OBC CPU** board and communicates directly with the **HEMRC** Control board (**HCB**), in slot A2. The **HEMRC** Control board communicates with the **HEMRC** AC Drive through the **HEMRC** Interface board (**HIF**), located on the **HEMRC** assembly. The drive converts input power to three phase anode **HEM** (High Efficiency Motor Drive). This motor drive power passes through the **HEMIT**, located in the Anode High Voltage Transformer, before it reaches the **HEM** in the Performix Tube.

Refer to Figure 9-10. Control signals travel from the **HCB** to the **HEMRC** through the gantry harness. The **HEMRC** Interface Board routes the signals to the **HEMRC** AC Drive. The **HEMRC** AC Drive sends Stator power through a low voltage, shielded stator cable to the **HEMIT**. The **HEMIT** provides 1:1 **HV** isolation and couples the stator power to the Performix tube through the Anode High Voltage cable.

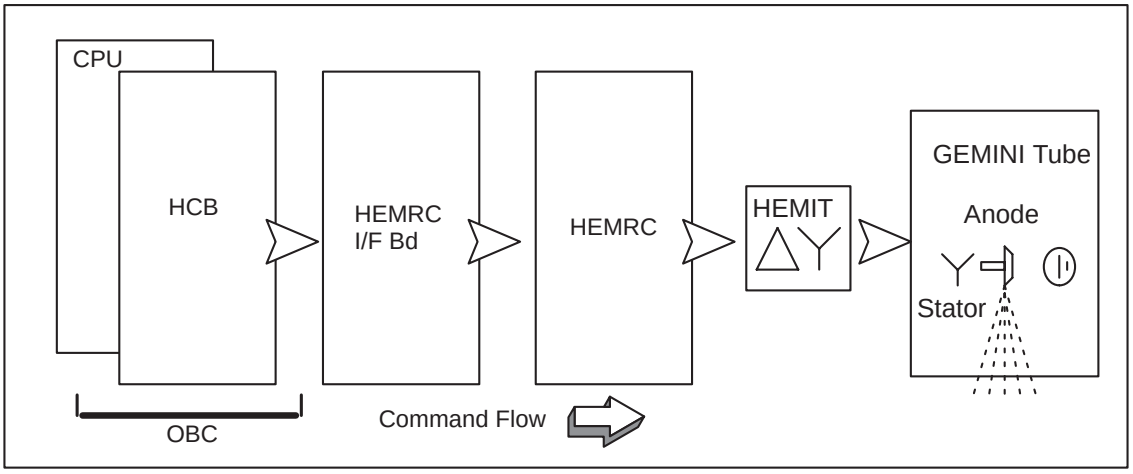


Figure 9-10 HEMRC Functional Command Flow Diagram

2.3.2 HEMRC Control Board – Theory of Operation

The **HEMRC** Control board (**HCB**), located in slot A2 of the **OBC**, uses the **VME** bus to communicate with the **OBC CPU**. The **HCB** uses a **CAN** (Controller Area Network) serial interface, called the **HCAN** (**HEMRC CAN**), and discrete signals to communicate with the **HEMRC**. Figure 9-11, on page 702 shows the discrete control signals. The **CAN** interface and discrete control signals enter the **HIF** (**HEMRC** Interface) for distribution to the **HEMRC**. The **HIF** also provides an analog feedback voltage to the **HEMRC** Control board in proportion to the voltage on the **CT HVDC** bus.

The **HCB** also contains a separate **CAN** serial interface, called the **GCAN** (Gantry **CAN**), and discrete control signals to communicate with other subsystems in the **CT** gantry subsystem. The **HCB** communicates with the **HIF** and gantry subsystems through shielded cables from the J3 connector of the **HEMRC** Control board.

Both the **HEMRC CAN** and the Gantry **CAN** originate in the **HCB**. The **HCB** supplies isolated 12V power (1.2A capability) and Fault circuitry to the **GCAN**, and accommodates up to six (6) **CAN** nodes (future) on the network.

Fault detectors and fault status feedback from the **HEMRC** and Gantry **CAN** based subsystems (if used) monitor hardware operation. The **HCB** notifies the **CPU** when it detects a fault, or a monitored value falls out of tolerance.

2.3.2.1 VME Interface

The **VME** interface contains the logic to perform address and data latching, address decoding, and **VME** handshaking, according to timing specified in PAL documentation, 2147462PDL. All signals pass through the standard **VME** connector, J1.

Of the seven interrupts defined for the **VME** bus, the **HCB** uses level 1, level 2, and level 4 interrupts. Other boards on the **OBC** also use the level 1 interrupt, which is wire OR-ed on the backplane.

- **IRQ1**: Interrupt level 1 indicates the presence of a hard failure. A fault signal from the **HEMRC** or the HIV (High Voltage DC Bus Over voltage signal) generates a level 1 interrupt. Firmware can mask a **HEMRC** fault with the HEMRC_FLT_EN signal, to prevent **HCB** tie ups.
- **IRQ2**: The **HCB** uses Interrupt level 2 during **HCAN** and **GCAN** communications.
- **IRQ4**: Interrupt level 4 indicates the occurrence of a transition a state change or the presence of a Gantry **CAN** fault. Firmware can mask the **GCAN** fault.

2.3.2.2 Command I/O

In normal operation, the **OBC CPU** sends state commands through the command registers located at address FFB821H and FFB823H. The **OBC CPU** also uses the command register located at FFB823H to provide Board Level Diagnostic (**BLD**) features.

The registers located at FFB829H, FFB82BH, and FFB82DH report Status.

Section 2.3.2.16, on page 708, contains the Command Register assignments.

2.3.2.3 Reset Pushbutton

The **HCB** contains a manual board reset pushbutton. Pushing the on-board reset does not have the same effect as receiving a RACKRST or SYSRST from the **VME**. The RACKRST and SYSRST also reset the **GCAN**.

2.3.2.4 Clocks

U2, U3, and U4 on the **HCB** generate 244Hz and 15.26Hz clocks from the 16MHz clock. The **HVDC** Bus monitoring circuit uses the 244Hz clock and the **HEMRC CAN** Interface circuit uses the 15.26 Hz clock.

2.3.2.5 Voltage Reference

The Voltage Reference circuitry produces a test reference voltage used to test the **HVDC** Bus monitoring circuit during board level diagnostic (**BLD**) tests.

2.3.2.6 HEMRC CAN (HCAN)

The **HCB** uses the 82527 **CAN** protocol controller (U54) and **CAN** bus interface circuitry to communicate with the **HEMRC** Assembly. The **HCB** communicates with the **OBC CPU** through the address and data bus, R_W*, and HEMRC_CAN_CS* signals. The 82527 communicates with the **HEMRC** through the **HCAN** bus interface, connected to the TX0 and RX0 pins. The 82527 interrupts the **OBC CPU** with the HEMRC_CAN_IRQ* signal to indicate a status change of the 82527. The HEMRC_CAN_IRQ* generates a level 2 interrupt to the **OBC CPU** through the status register located at FFB82DH, bit 0.

The 82527 uses the 16MHz clock for timing. The board RESET* signal resets the 82527.

U66 and U67 optically isolate the **HEMRC CAN** bus from the **HEMRC** Control board circuitry. U77, the **CAN** transceiver chip, resides on the isolated side of the **CAN** interface. The optically isolated side of the **HEMRC CAN** receives power from an isolated 12 volt, 125 mA supply located on the **HEMRC**. VR3 regulates this 12 volt supply down to 5 volts. This isolated 5 volt supply provides power to the isolated side of the **HEMRC CAN** interface. The **HEMRC CAN** output signals are HCH and HCL. R94 provides the required **CAN** bus termination for the **HEMRC** Control board end of the **HEMRC CAN** bus.

DS8 illuminates whenever the 82C250 receives data over the **HEMRC CAN** bus.

2.3.2.7 OBC to HEMRC Interface Overview

The communications between the **OBC** and **HEMRC** consist of:

- Bi-directional **CAN** serial communications bus: a 125 Kbaud bidirectional serial link, used to convey commands and status information between the **HEMRC** and **OBC**
- Fault signal from the **HEMRC** to **OBC**
- At-speed signal from the **HEMRC** to the **OBC**
- Enable signal from the **OBC** to the **HEMRC**
- Three-wire start-stop signal

The opto-isolated Enable, Start, and Stop signals from the **OBC** to the **HEMRC** provide a contact closure as an input to the **HEMRC** (Figure 9-11). The Enable contacts close electrically to enable the **HEMRC**, the Start contacts close electrically to start the **HEMRC**, and the Stop contacts close electrically to enable the **HEMRC** to run and open electrically to stop the **HEMRC**. The Enable, Start, and Stop opto-isolators carry 10mA with less than a 3V drop when closed, and withstand 5V when the contacts open.

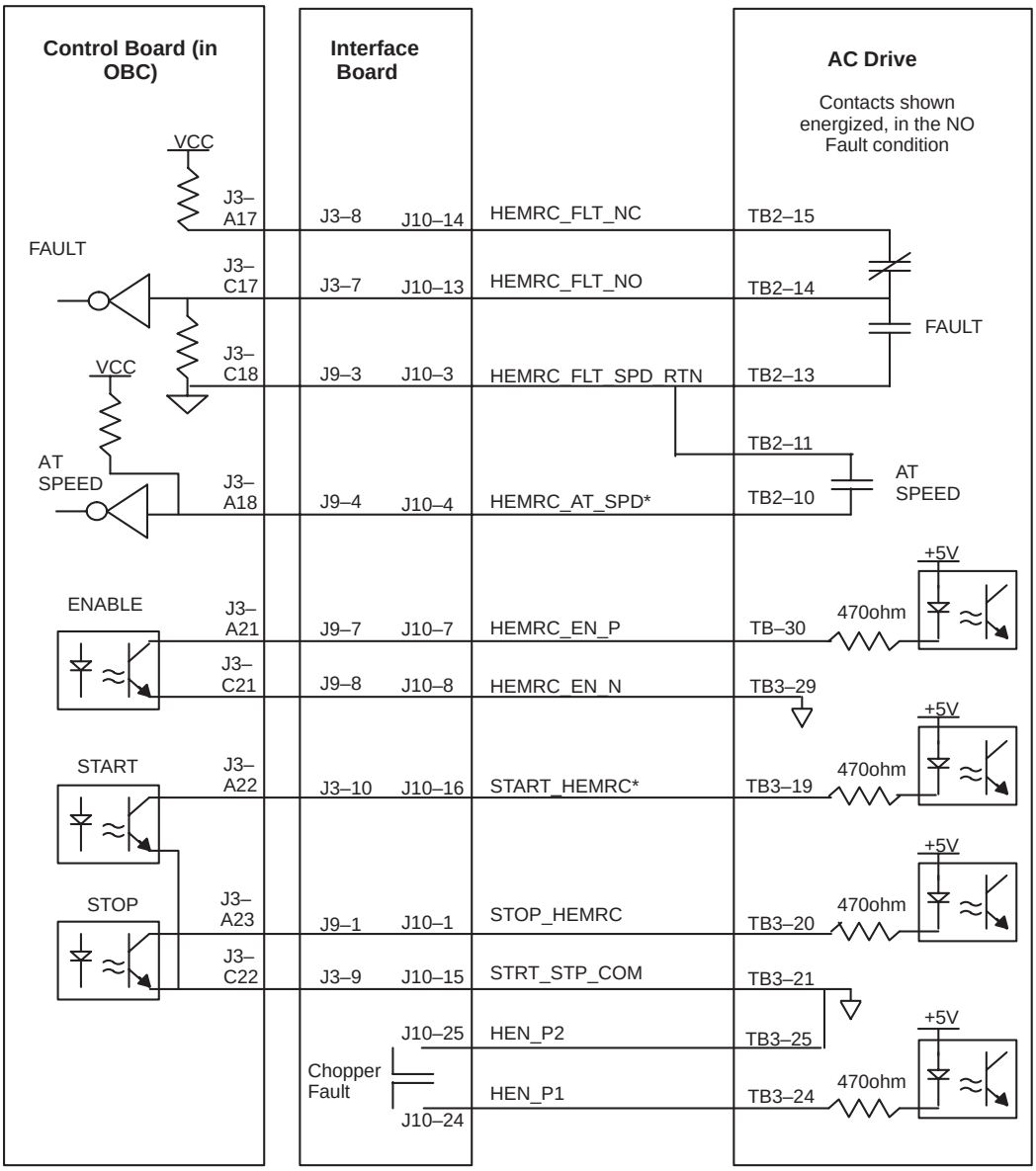


Figure 9-11 Hardwire Control Signals, Functional Interconnect

The fault signal from the **HEMRC** to the **OBC** consists of the HEMRC_FLT_NC, HEMRC_FLT_NO, and HEMRC_FLT_SPD_RTN signal wires. Figure 9-11 contains a block diagram of the connections between the **HCB** and **HEMRC**. Refer to the schematics for actual component values. Use the components in Figure 9-11 for functional reference only. The circuit uses drives with a normally-open fault contact. If either the HEMRC_FLT_NC signal wires or HEMRC_FLT_NO signal wires open electrically, the **HCB** generates a fault condition. If the HEMRC_FLT_SPD_RTN signal wires open while the HEMRC_FLT_NC and HEMRC_FLT_NO signal wires are connected, the **HCB** does NOT sense a **HEMRC** fault condition. The HEMRC_FLT_SPD_RTN connects to chassis ground to provide a redundant signal return path for the fault signal. In addition, if the HEMRC_FLT_SPD_RTN wire opens, the **HCB** will not sense an at-speed condition, which indicates the x-ray tube anode failed to reach a safe speed to allow x-ray exposure.

The **HEMRC** fault feedback circuit uses three signals from the **HEMRC** (fed back through the **HEMRC** Interface board), HEMRC_FLT_NC, HEMRC_FLT_NO, and HEMRC_FLT_SPD_RTN. Under a no-fault operating condition, the HEMRC_FLT_NC and HEMRC_FLT_NO signals connect electrically, and the HEMRC_FLT_NO and HEMRC_FLT_SPD_RTN signals do not connect electrically, which creates a logic high signal to the input of U17 pin 1, that indicates a no-fault condition. During a fault condition, no electrical connection exists between the HEMRC_FLT_NC and HEMRC_FLT_NO signals, and the HEMRC_FLT_NO and HEMRC_FLT_SPD_RTN signals connect electrically to create a logic low to the input of U15 pin 1, which indicates a fault condition.

If the rotor is at or above Frequency for the phase it is currently in, then AT SPEED will be satisfied and closes. AT SPEED will then Open when the Phase changes transition, and waits for the rotor to be at or above Frequency again for this next phase, then will close if the rotor reaches Frequency. This will continue throughout the entire rotor cycle, Accel, Run, and Brake. It is key to know that the A/B drive will try to drive the rotor to the correct speed, and if it can not attain the speed requested, the current will max out at a specific level and not drive any higher, the result will be that the rotor could not make it to the correct frequency in the allotted time for that phase, and the AT SPEED fault will be seen.

2.3.2.8 Fault Circuitry

This feedback uses three signals to allow a broken wire to be detected as a fault condition. If the HEMRC_FLT_NC wire breaks, the input to U15 pin 1 goes low to indicate a fault condition (regardless of the integrity of the two remaining signals). If the HEMRC_FLT_NO wire breaks, the input to U15 pin 1 goes low to indicate a fault condition (regardless of the integrity of the two remaining signals). If the HEMRC_FLT_SPD_RTN signal wire breaks, the drive uses the remaining HEMRC_FLT_NC and HEMRC_FLT_NO signals to indicate a fault condition. With the three signal design, no possible combination of broken wires could prevent the detection of a **HEMRC** fault condition.

In a fault condition, U17 pin 2 goes to a logic high, which clears the D flip-flop U20 and causes U20 pin 12 to go high and indicate a fault with the signal HEMRC_FLT. During a fault condition, U41 pin 10 goes to a logic low, which combines with the ROT_EN signal to disable the **HEMRC**.

When the fault clears, the FLTRST signal resets the HEMRC_FLT.

Under a no-fault condition, the **HEMRC** enables when the ROT_EN signal and the output U41 pin 10 (no fault) go to a logic high, creating a low impedance between the HEMRC_EN_P and HEMRC_EN_N output signals, which turns the opto-isolator U73 “ON”.

The HEMRC_EN_P and HEMRC_EN_N output signals pass through the **HEMRC** Interface board on route to the **HEMRC**. The center of schematic sheet eight contains the **HEMRC** at-speed indication circuit. When the **HEMRC** reaches its programmed speed, it closes a contact between the HEMRC_AT _SPD* and HEMRC_FLT_SPD_RTN signals, to create a logic high to U17 pin 4. The next clock pulse clocks this signal into D flip-flop U6, which sends the AT_SPEED signal to a logic high to generate a momentary pulse on the STAT_CHG signal, which in turn sends a level 4 interrupt to the **OBC CPU**.

Because D flip-flop U6 receives a 15.26Hz clock pulse, the **OBC CPU** has enough time to respond to the level 4 interrupt and read the status of the **HEMRC** Control board before the status changes again. This clocking scheme also prevents the generation of simultaneous interrupts. The

HEMRC_AT_SPD* signal combines with the INTLK* signal to prevent x-ray exposure from occurring before the **HEMRC** reaches its pre-programmed speed. The EXPEN signal must equal a logic high before x-ray exposure can occur.

2.3.2.9 HEMRC Stop and Start

The discrete start and stop signals to the **HEMRC** are opto-coupled logic signals. The HEMRC_STOP* signal must equal a logic high for the **HEMRC** to start acceleration, continue acceleration or run. The logic high HEMRC_STOP* signal creates a low impedance between the STOP_HEMRC and STRT_STP_COM output signals, which permits the **HEMRC** to accelerate or run.

When the HEMRC_START signal goes to a logic high (causing a low impedance between the START_HEMRC* and STRT_STP_COM outputs) and the HEMRC_STOP* signal equals a logic high, the **HEMRC** begins to accelerate (if it hasn't already done so). Once acceleration begins, the **HEMRC** continue to advance along its acceleration profile, or continues to run, regardless of the logic condition of the HEMRC_START signal. The **HEMRC** begins to decelerate (if it is running) whenever the HEMRC_STOP* signal goes to a logic low.

2.3.2.10 Gantry CAN

The **HEMRC** circuitry supports the use of the 82527 **CAN** protocol controllers (U53 and U62) and **CAN** bus interface circuitry to communicate with the **CAN** based gantry subsystems. The Gantry **CAN** interface uses two **CAN** protocol controllers on the **CAN** bus. The 82527s communicate with the **OBC CPU** through the address and data bus, R_W*, GCAN1_CAN_CS*, and GCAN2_CAN_CS* signals. The 82527s communicate with the gantry subsystems through the **CAN** bus interface, connected to the TX0 and RX0 pins. A status change of the 82527 **CAN** causes the GCAN1_IRQ* and GCAN1_IRQ* signals to generate a level 2 interrupt to the **OBC CPU**, visible at status register location FFB82DH.

The 82527s use the 16MHz clock for timing. The board RESET* signal resets the 82527s.

U62, U63, U54, and U65 optically isolate the Gantry **CAN** (**GCAN**) bus from the **HEMRC** Control board (**HCB**) circuitry. The **CAN** transceiver chips, U74 and U75, on the isolated side of the **CAN** interface, receive power from an isolated five volt supply produced by DC-DC converter U82 on the **HEMRC** Control board. The **GCAN** output signals are GCH and GCL. R103 provides the required **CAN** bus termination for the **HEMRC** Control board end of the gantry **CAN** bus when you connect GCR to GCH with the jumper plug on J4 and J5.

When the **HEMRC** Control board transmits on the gantry **CAN** bus, DS5 (G1TX) or DS6 (G2TX) illuminates to indicate transmission activity. During reception, DS7 (GRX) illuminates.

The discrete signals for the Gantry **CAN** interface are GCAN_RST, GCAN_FLT and FAULT2. When GCAN_RESET goes to a logic high, it uses RS485 transceiver (DS3695) U79 to drive GCAN_RST_P high and GCAN_RST_N low.

The Gantry **CAN** fault feedback circuitry consists of two parts.

- The primary system uses the 82C250 **CAN** transceiver U72. When a fault condition exists on one of the gantry **CAN** subsystems, GCAN_FLT_P goes high relative to GCAN_FLT_N, and Rxd and Txd equal a logic zero. This condition causes a logic high on the GCAN_FLT signal, which in turn generates a level 4 interrupt whenever the GCAN_FLT_EN signal equals a logic high. DS4 (GFLT) illuminates whenever a gantry **CAN** fault condition exists.
- The second fault uses a loop through signal of the GCAN_+12V_ISO signal through other modules. This signal enters the **HCB** at J2-A8 (FAULT_SENSE). If this signal goes low for any reason, the FAULT2 and GCAN_FLT signals go to a logic high. The firmware can also break the loop-through line by driving DRV_GCAN_FLT* to a logic zero, which creates a GCAN_FLT and FAULT2 signal that firmware can readback.

The GCAN_FLTRST signal resets both kinds of **CAN** faults. At 3.0 mS must elapse between the release of a Driven **GCAN** Fault (DRV_GCAN_FLT*) and the Gantry **CAN** Fault Reset (GCAN_FLTRST), to allow time for the solid state relay to switch.

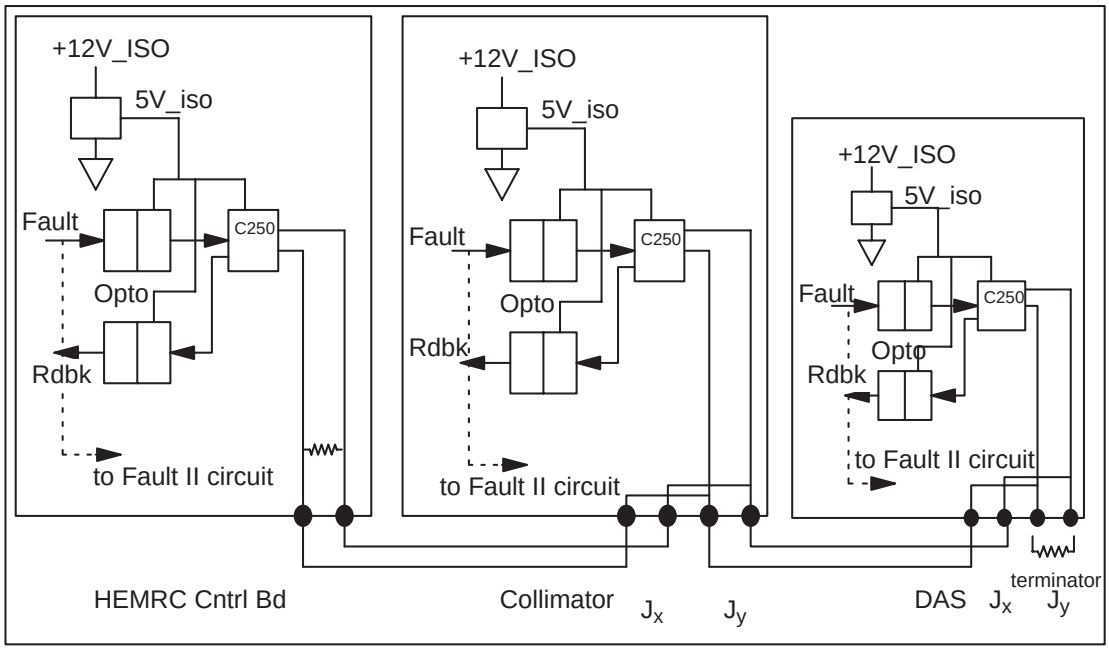


Figure 9-12 GCAN Bus Primary Fault Signal Path

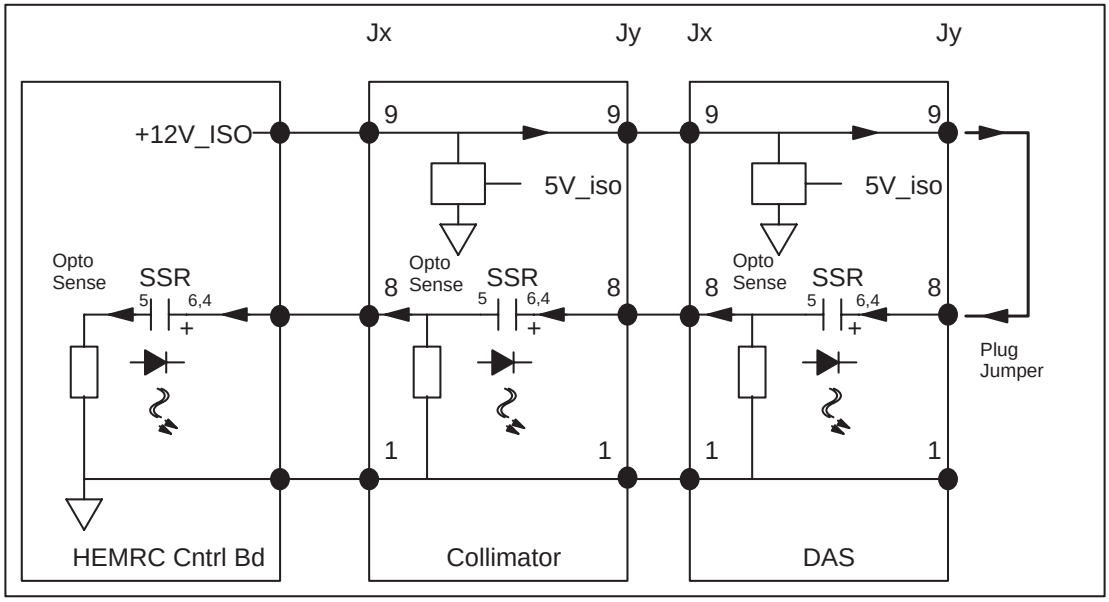


Figure 9-13 GCAN Bus Secondary Fault Signal Path

2.3.2.11 DC Bus Voltage Monitoring

The system uses the **HCB** to monitor the **HVDC** Bus that feeds the **HEMRC**. The **HEMRC** Interface board provides the **HVDC** Bus feedback to the **HEMRC** Control board (**HCB**).

The differential amplifier AR4 senses the feedback voltage. The **HEMRC** Interface board contains the one megohm of the input impedance. Resistor networks R147 & R148 and R143 & R144 limit the common mode voltage injected at the op-amp. You can monitor the voltage at “DCV” (TP 9); scaled 100V/V. The MUX periodically sends this value to the **CPU** for it to read.

The circuit compares this voltage to a fixed ~470V limit, and samples the result at a 244 Hz rate. Whenever the result changes state, it generates a level 4 interrupt to signal the **CPU** that the bus is responding to commands &/or faults. The **CPU** can then take appropriate action.

The voltage also passes through a filter with an approximately 20 millisecond time constant, for comparison to an upper limit. Jumper JP1, selects the upper limit. Position “A” selects an upper limit of ~670V for use by systems with a DCRGS **PDU**. Position “B” sets the upper limit to ~800V, for use by systems with an unregulated **HVDC** Supply in their **PDU**. The position of jumper JP1 produces a signal, DCR*, which the **CPU** reads at address FFB829H.

If a failure of the **HVDC** Supply occurs, the circuit exceeds the upper voltage limit, and generates an abort. This condition produces a level 1 interrupt, described in the following MUX_IRQ section.

2.3.2.12 MUX_IRQ

The MUX_IRQ function consists of an analog multiplexer, used to feed the **HVDC** Bus voltage feedback signal and test reference voltage back to the **OBC** through RC_MUX and the IRQ generation circuits.

You can monitor the multiplexer output at test point “MUX” (TP3). VR2 and AR3 generate the +10V and -10V reference voltages. The **CPU** reads the value of the +10V reference through the multiplexer. The **CPU** detects scaling errors in the system by comparing its value to an external reference.

Two fault conditions, High DC Bus Voltage and **HEMRC** Fault, generate a level 1 interrupt. Firmware can use the HEMRC_FLT_EN signal to mask the HEMRC_FLT signal. The firmware masks the interrupt during powerup reset conditions.

A High DC Bus Voltage fault generates a “KILLBC*” signal that immediately disables the back-up contactor supplying the inverter power. This fault may indicate a loss of control in the DC bus regulator, and the existence of a potential hazard.

When it receives a level 1 interrupt, the **CPU** interrogates the board status registers to determine what fault occurred, then it disables the **HEMRC** and resets the interrupt and fault latches while it posts error messages.

Three state transition conditions generate a level 4 interrupt:

- STAT_CHG
- VCHG
- **GCAN** Fault Firmware can use GCAN_FLT_EN to mask GCAN_FLT

When it receives a level 4 interrupt, the **CPU** interrogates the board status registers to determine the appropriate action.

A status change in one of the **CAN** protocol controller devices generates a level 2 interrupt. The HEMRC_CAN_IRQ*, GCAN1_IRQ*, and GCAN2_IRQ* signals indicate a status change in the corresponding **CAN** protocol control device.

When it receives a level 2 interrupt, the **CPU** interrogates the register at location FFB82DH to determine the appropriate action.

2.3.2.13 CAN Loopback

When you place the four position shorting plug in the J5 position, it connects the **HEMRC CAN** to the external **HEMRC CAN** bus and the Gantry **CAN** to the external **GCAN** bus. When you install the connector, the NORMAL signal equals a logic “1”. Register location 0FFB829 contains the status information.

Move the connector to the J4 position to place the **HEMRC** Control board in diagnostic **CAN** mode. This mode connects **HEMRC CAN** bus output to the **GCAN** bus on the **HEMRC** Control board, and disconnects the external HERMC **CAN** bus from the circuit board while leaving the **GCAN** externally connected. This mode permits the readback of the **HEMRC CAN** bus output by the Gantry **CAN** bus and the readback of the Gantry **CAN** bus output by the **HEMRC CAN**. The NOT_NORMAL signal equals a logic “1” when you place the connector in the J4 position. Register location 0FFB829 contains the status information.

The opto-coupler across the HEMRC_ISO_+12V provides readback to the firmware to assist in troubleshooting an error in the **CAN** readback circuitry. The firmware only senses the presence or absence of the voltage; it tell whether the voltage falls inside or outside the tolerance.

2.3.2.14 CAN Error Detection

CAN implements five error detection mechanisms; three at the message level, and two at the bit level.

Note: **CAN** will retry up to 128 times before logging an error.

The following mechanisms are at the message level:

- **Cyclic Redundancy Checks (CRC) -** Every transmitted message contains a 15 bit Cyclic Redundancy Check (**CRC**) code. The **CRC** is computed by the transmitter and is based on the message content. All receivers that accept the message perform a similar calculation and flag any errors.
- **Frame Checks -** There are certain predefined bit values that must be transmitted at certain points within any **CAN** Message Frame. if a receiver detects an invalid bit in one of these positions a Form Error (sometimes also known as For at Error) will be flagged.
- **Acknowledgement Error Checks -** If a transmitter determines that a message has not been acknowledged, then an ACK Error is flagged.

The following mechanisms are at the bit level:

- **Bit Monitoring -** Any transmitter automatically monitors and compares the actual bit level on the bus with the level that it transmitted. If the two are not the same, then a bit error is flagged.
- **Bit Stuffing - CAN** uses a technique known as bit stuffing as a check on communication integrity. After five consecutive identical bit levels have been transmitted, the transmitter will automatically inject (stuff) a bit of the opposite polarity into the bit stream. Receivers of the message will automatically delete (de-stuff) such bits before processing the message in any way. Because of the bit stuffing rule, if any receiving node detects six consecutive bits of the same level, a stuff error is flagged.

2.3.2.15 Control Area Networks

There are two very different and unique **CAN** networks on the current CT Systems.

- **RCIB GCAN**: Network between the **OBC** and the Collimator Control Bd and **DAS** Control Bd. **GCAN** is a 1 MegaBaud bus with point to point protocol, and transfers 8 Bytes at a time.
- **HEMRC HCAN**: Network between the **OBC** and the Allen Bradley **HEMRC** AC Drive. **HCAN** is a 125KBaud bus with Master/Slave protocol and transfers 8 Bytes at a time. (Currently used **HCAN** protocol is Allen Bradley proprietary.)

The **RCIB** is the umbilical cord that links the controllers to the system. This link consists of the signals listed below. Each signal is a differential pair for noise immunity.

RCIB BLOCK

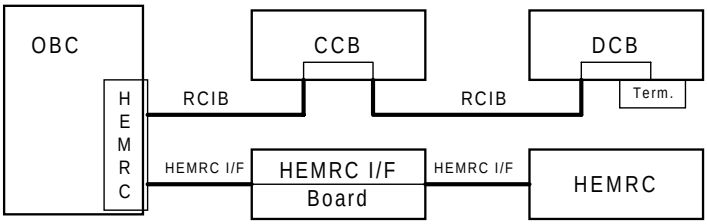


Figure 9-14 Controller Hardware Interface

- Isolated 12VDC is generated by the **HEMRC** Control Board, which powers the Controller Area Network **GCAN Drivers only**.
- Isolated 12VDC for **HCAN** is generated by the **HEMRC** AC DRIVE, which powers the Controller Area Network **HCAN Drivers only**.
- Exposure Command is available to the controllers to determine when x-ray generation begins and ends.
- Triggers are used as the system clock by the controllers. The **DAS** Control Board (**DCB**)

triggers the data collection each time this line is asserted.

- **CAN** Serial Line is used for the transmission of control signals. It must be terminated by a 120 Ohm resister at the beginning and end of the cable. This particular **CAN** line is referenced as the Gantry **CAN** (**GCAN**) bus to distinguish it from the **HEMRC** (**HCAN**) bus.
- Fault Line is the primary means to inform the **OBC** of a fault. The fault line is asserted by the Controllers under the following conditions:
  - The Controller is reset.
  - A Fault is detected by the controller.
- Reset Line is asserted by the **OBC** when it becomes desirable to reset the Controllers. No other controller has the capability to assert this line except for the **OBC** that is not affected by this signal. The **OBC** resets this line via a command register or during an **OBC** reset.
- Interlock line verifies the **RCIB** cable is connected to all controllers.

2.3.2.16 Memory Maps

ADDRESS	READ/ WRITE	BIT(S)	FUNCTION/ SIGNAL NAME	DESCRIPTION
FFB801	R	All	Insite Info	Board #, character “?” and digit 1 Value = F2H.
FFB803	R	All	Insite Info	Board #, digits 2&3. Value = 17H.
FFB805	R	All	Insite Info	Board #, digits 4&5. Value = 98H.
FFB807	R	All	Insite Info	Board #, digits 6&7. Value = 60H
FFB809	R	All	Insite Info	Board Group #. Value = 01H
FFB80B	R	All	Insite Info	Board Version letter. Example: Value = 42H, ASCII code for “B”. Refer to assembly drawing for specific version information.
FFB80D through FFB81F				Not used.

Table 9-3 Memory Map of Insite Registers

ADDRESS	READ/ WRITE	BIT(S)	FUNCTION/ SIGNAL NAME	DESCRIPTION
FFB821	R/W	7	ROT_EN	A “1” turns the **HEMRC** control on.
		6	GCAN_RST	Setting this bit to a “1” initiates a reset of the peripherals on the Gantry **CAN** bus.
		5	INTLK*	Setting this bit to a “1” disables the broken wire interlock to the EXPEN signal. Intended as a diagnostic tool only.
		4	not used	
		3	MUXENA	Analog MUX Selection. MUXENA = “1” selects the analog MUX. MUXENA = “0” is not used but is provided for firm ware compatibility with previous circuit boards and for possible expansion of MUX channels.

Table 9-4 Memory Map of Command Registers

ADDRESS	READ/ WRITE	BIT(S)	FUNCTION/ SIGNAL NAME	DESCRIPTION
		2,1,0	2,1,0	MUXENA concatenated with bits 2,1,0 form the MUX address space. Only the portion of the address space with MUXENA = “1” is used. Bits 2,1,0 select the channel with in the MUX. The four bit concatenated MUX address space and associated signals are listed below. Code — Signal Selected x0H — MUXENA = “0”, not used x1H — MUXENA = “0”, not used x2H — MUXENA = “0”, not used x3H — MUXENA = “0”, not used x4H — MUXENA = “0”, not used x5H — MUXENA = “0”, not used x6H — MUXENA = “0”, not used x7H — MUXENA = “0”, not used x8H — DC rail monitor voltage. Scale: 100 V/V x9H — Signal Ground. 0 V xAH — Signal Ground. 0 V xBH — TESTREF analog voltage. **DAC** output used to test **HVDC** bus feedback circuitry. Scale: 1V/V. xCH — Signal Ground. 0 V xDH — Signal Ground. 0 V xEH — Signal Ground. 0 V xFH — +10 V Reference. Scale: 0.5 V/V

Table 9-4 Memory Map of Command Registers (Continued)

ADDRESS	READ/ WRITE	BIT(S)	FUNCTION/ SIGNAL NAME	DESCRIPTION
FFB823	R/W	7	not used	
		6	HVDC_MON_TST	A “1” injects 98.6% of the TESTREF **DAC** (B825) output into the **HVDC** bus monitor.
		5	not used	
		4	DRV_GCAN_FLT*	A low creates a **GCAN** Fault.
		3	HEMRC_FLT_EN	A “0” disables the HEMRC_FLT signal from generating a level 1 interrupt. A “1” allows the HEMRC_FLT to generate a level 1 interrupt. The status of HEMRC_FLT can be read at status register (B829) regardless of the state of HEMRC_FLT_EN.

Table 9-5 Memory Map of Diagnostic Command Register

ADDRESS	READ/ WRITE	BIT(S)	FUNCTION/ SIGNAL NAME	DESCRIPTION
		2	GCAN_FLT_EN	A “0” disables the GCAN_FLT gantry **CAN** fault signal from generating a level 4 interrupt. A “1” allows the GCAN_FLT to generate a level 4 interrupt. The status of GCAN_FLT can be read at status register (B829) regard less of the state of GCAN_FLT_EN.
		1	HEMRC_STOP*	A “0” commands the **HEMRC** to decelerate. A “1” is required to allow the drive to accelerate or run.
		0	HEMRC_START	A “1” commands the **HEMRC** to accelerate. HEMRC_STOP* must be a “1” for acceleration. This bit does not need to be maintained at “1” to keep the **HEMRC** running.

Table 9-5 Memory Map of Diagnostic Command Register (Continued)

Note: Command Register FFB823 is intended for diagnostic use only. Application code must set all bits to “0” before turning the **HEMRC** on.

ADDRESS	READ/ WRITE	BIT(S)	FUNCTION/ SIGNAL NAME	DESCRIPTION
FFB825	W	All	**DAC** “A” Data	TESTREF voltage command. 00H - FFH corresponds to: 0V – +10V.
FFB827	W	All	not used but available for **DAC** “B” Data expansion	

Table 9-6 Memory Map of DAC Command Registers

ADDRESS	READ/ WRITE	BIT(S)	FUNCTION/ SIGNAL NAME	DESCRIPTION
FFB829	R	7	FAULT 2	A “1” indicates that the loop back signal has been broken somewhere in the system.
		6	AT_SPEED	A “1” indicates the **HEMRC** is at or above programmed speed.
		5	DCR*	A “1” indicates jumper JP1 is in the Unregulated **HVDC** Supply selection state. This changes the limits for the **HVDC** Bus Overvoltage detector.
		4	GCAN_FLT	A “1” indicates a fault on one or more of the gantry **CAN** based devices.
		3	ROTINT4	A “1” indicates the **HEMRC** Control board has issued a level 4 interrupt.
		2	LOV	A “1” indicates the DC Rail is less than 450V. This bit is continuously updated every 4 msec. A change of state generates a level 4 interrupt.

Table 9-7 Memory Map of Status Register and GCAN Fault Reset

ADDRESS	READ/ WRITE	BIT(S)	FUNCTION/ SIGNAL NAME	DESCRIPTION
		1	NORMAL	A “1” indicates that the **CAN** mode connector is in the normal **CAN** mode location. This is required for **CAN** communication to the **HEMRC** and any other **CAN** based subsystems on the gantry.
		0	NOT_NORMAL	A “1” indicates that the **CAN** mode connector is in the diagnostic **CAN** mode location. In this position, **CAN** communications are looped back between the **HEMRC CAN** network and the Gantry **CAN** network.
FFB829	W	N/A	GCAN_FLTRST	A write to this address causes the gantry **CAN** fault signal to be reset provided a fault condition no longer exists. Any data value can be used for this write.

Table 9-7 Memory Map of Status Register and GCAN Fault Reset (Continued)

ADDRESS	R/W	BIT(S)	FUNCTION/ SIGNAL NAME	DESCRIPTION
FFB82B	R	7	HIV	A latched “1” indicates an overvoltage was sensed on the **HVDC** Bus. (if JP1=“A”, DCV > 670 V else if JP1=“B”, DCV > 800V.) This generates a level 1 interrupt and disables the **HEMRC** and back-up contactor.
		6	not used	
		5	not used	
		4	not used	
		3	not used	
		2	not used	
		1	HEMRC_12V_ FLT	A “0” indicates that the HEMRC_ISO_+12V is non-zero. It does not guarantee that it is at +12V.
		0	HEMRC_FLT	A “1” indicates a fault condition exists on the **HEMRC**. This is latched on the **HEMRC**.
FFB82B	W	N/A		A write to this address will clear all the above latched status flags, provided the originating fault has cleared.
FFB82D	W	N/A		A write to this address will clear the level 4 interrupt re quest latch.
FFB82F	W	N/A		A write to this address will clear the level 1 interrupt re quest latch.

Table 9-8 Memory Map of Status Register and Fault Reset

ADDRESS	R/W	BIT(S)	FUNCTION/ SIGNAL NAME	DESCRIPTION
FFB82D	R	7	not used	
		6	not used	
		5	not used	
		4	not used	
		3	not used	
		2	GCAN2_IRQ*	A “0” indicates the Gantry **CAN** protocol controller #2 (82527) is requesting interrupt service.
		1	GCAN1_IRQ*	A “0” indicates the Gantry **CAN** protocol controller #1 (82527) is requesting interrupt service.
		0	HEMRC_CAN_IRQ*	A “0” indicates the **HEMRC CAN** protocol controller (82527) is requesting interrupt service.
FFB82D	W	N/A		A write to this address will clear the level 4 interrupt re quest latch.

Table 9-9 Memory Map of CAN Interrupt Status Register and IRQ4 Reset

ADDRESS	R/W	BIT(S)	FUNCTION/ SIGNAL NAME	DESCRIPTION
FFB82F	W	N/A		A write to this address clears the level 1 interrupt request latch.

Table 9-10 Memory Map of IRQ1 Reset

PIN NUMBER	ROW A – SIGNAL NAME	ROW B – SIGNAL NAME	ROW C – SIGNAL NAME
1	D00	BBSY*	D08
2	D01	BCLR*	D09
3	D02	ACFAIL*	D10
4	D03	BG0IN*	D11
5	D04	BG0OUT*	D12
6	D05	BG1IN*	D13
7	D06	BG1OUT*	D14
8	D07	BG2IN*	D15
9	LGND	BG2OUT*	LGND
10	SYSCLK	BG3IN*	SYSFAIL*
11	LGND	BG3OUT*	BERR*
12	DS1*	BR0*	SYSRESET*
13	DS0*	BR1*	LWORD*

Table 9-11 Pin Assignments J1/P1 Connector – VME Bus Interface

PIN NUMBER	ROW A – SIGNAL NAME	ROW B – SIGNAL NAME	ROW C – SIGNAL NAME
14	WRITE*	BR2*	AM5
15	LGND	BR3*	A23
16	DTACK*	AM0	A22
17	LGND	AM1	A21
18	AS*	AM2	A20
19	LGND	AM3	A19
20	IACK*	LGND	A18
21	IACKIN*	SERCLK	A17
22	IACKOUT*	SERDAT*	A16
23	AM4	LGND	A15
24	A07	IRQ7*	A14
25	A06	IRQ6*	A13
26	A05	IRQ5*	A12
27	A04	IRQ4*	A11
28	A03	IRQ3*	A10
29	A02	IRQ2*	A09
30	A01	IRQ1*	A08
31	-12V	+5VSTDBY	+12V
32	+5V	+5V	+5V

Table 9-11 Pin Assignments J1/P1 Connector – VME Bus Interface (Continued)

PIN NUMBER	ROW A – SIGNAL NAME	ROW B – SIGNAL NAME	ROW C – SIGNAL NAME
1	+5LED	+5V	+5V
2	LGND	LGND	LGND
3		<RESERVED>	RACKRST*
4			
5			
6			
7			
8			
9			
10			
11			
12	LGND	LGND	LGND
13	+5V	+5V	+5V
14			
15			
16			

Table 9-12 J2/P2 Connector – Interboard Connections

PIN NUMBER	ROW A – SIGNAL NAME	ROW B – SIGNAL NAME	ROW C – SIGNAL NAME
17			
18			RC-MUX
19			KILLBC*
20			EXPEN
21	EXPCMD		
22	LGND	LGND	LGND
23			VREF
24			DCV
25			
26	SGND	SGND	SGND
27	+15V	+15V	+15V
28	SGND	SGND	SGND
29	-15V	-15V	-15V
30	SGND	SGND	SGND
31	LGND	LGND	LGND
32	+5V	+5V	+5V

Table 9-12 J2/P2 Connector – Interboard Connections (Continued)

PIN NUMBER	ROW A – SIGNAL NAME	ROW B – SIGNAL NAME	ROW C – SIGNAL NAME
1			
2			
3			
4	GCAN_+12V_ISO		IGND
5	GCAN_H	OPEN	GCAN_L
6	Connected to Pins B and C via backplane	Connected to Pin A via back plane	Connected to Pin A via back plane
7			
8	FAULT_SENSE	Connected to Pin A via back plane	Connected to Pin A via back plane
9	GCAN_FLT_P	OPEN	GCAN_FLT_N
10	OPEN	OPEN	OPEN
11	DAS_TRIG+		DAS_TRIG-
12			
13			
14	GCAN_RST_N		GCAN_RST_P
15	EXP_CMND_N		EXP_CMND_P
16	TRIG_N		TRIG_P
17	HEMRC_FLT_NC		HEMRC_FLT_NO

Table 9-13 J3/P3 Connector - External Connections

PIN NUMBER	ROW A – SIGNAL NAME	ROW B – SIGNAL NAME	ROW C – SIGNAL NAME
18	HEMRC_AT_SPD*		HEMRC_FLT_SPD_RTN
19			
20	HEMRC_CAN_H		HEMRC_CAN_L
21	HEMRC_EN_P		HEMRC_EN_N
22	START_HEMRC*		STRT_STP_COM
23	STOP_HEMRC		
24	DCRV-		DCRVM-
25	HEMRC_ISO_+12V		HEMRC_ISO_RTN
26			
27			
28			
29	PGND	PGND	PGND
30	+24V	+24V	+24V
31	+24V	+24V	+24V
32	PGND	PGND	PGND

Table 9-13 J3/P3 Connector - External Connections (Continued)

2.3.3 HEMRC Error Messages & Fault Codes

2.3.3.1 Error Messages

The **HEMRC** Control function within the **OBC** may detect certain error conditions, generally related to communication or functional interfaces to the AC Drive. Many of these messages contain variable fields. (In the following listing of possible error messages a `%d` represents a numeric value, `%b` represents a variable text string, and `%xh` represents a data value.)

MESSAGE NUMBER	MESSAGE TEXT
185500	`HEMRC CAN chip interrupt can not be cleared. Disabling CAN chip. Interrupt code:%d Disable code:%d`
185501	`HEMRC CAN Bus error. HEMRC serial communications are down.`
185502	`Software error detected while waiting for HEMRC semaphore. HEMRC message not sent.`
185503	`Software error detected while pending on event flags. CAN message request not processed. VRTX error:%d`
185504	`Software error: Timeout waiting for free HEMRC CAN Buffer. HEMRC message not sent.`
185505	`Could not send HEMRC message in the allotted time. HEMRC serial link is down. Possible causes: HEMRC CAN jumper, HEMRC fuse, interconnects, CAN devices,... Retries used:%d`
185506	`Invalid response received when sending HEMRC message. HEMRC message not sent. Retries used:%d`

Table 9-14 HEMRC Error Messages

MESSAGE NUMBER	MESSAGE TEXT
185507	Software error: Invalid response received from CAN ISR. HEMRC message not sent. ISR response code:*%d*
185508	Software error: Invalid packet sent to HEMRC. HEMRC error response code:*%d* Service=*%d* Class=*%d* Instance=*%d* Attribute=*%d* Data=*%d*
185509	Software error: Invalid parameter. HEMRC message not sent.
185510	Software error: Parameter mismatch. The parameter value read from the HEMRC does not match the value written. Parameter number: *%d* Expected value: *%d* Actual value: *%d*
185511	HEMRC fault could not be reset.
185512	The HEMRC CAN communications initialization failed.
185513	The rotor configuration file may be incompatible with the present HEMRC firmware version. Rotor operation may be impaired. HEMRC Firmware version: *%d.%02d*
185514	The rotor configuration file may be incompatible with the present HEMRC drive type. Rotor operation may be impaired. HEMRC drive type: *%d*
185515	*%b* error: Reset state found active.
185516	HEMRC CAN chip
185517	Gantry CAN chip #1
185518	Gantry CAN chip #2
185519	Hardware error: *%b* control line as read from the HEMRC Control Board in unexpected state*%d*, expected state*%d*.
185520	Hardware error:*%b* control line as read from the HEMRC Drive was found in unexpected state*%d*, expected state*%d*.
185521	"Enable"
185522	"Start"
185523	"Run/Stop"
185524	The HEMRC is not running after being enabled. Unknown source of failure. HEMRC status: *0x%06x*
185525	Software error detected while waiting for HEMRC semaphore. CAN loopback test not run. VRTX error:*%d*
185526	HEMRC CAN Bus Error. An abnormal number of errors have occurred on the HEMRC CAN bus. Check diagnostic jumper on HEMRC board and wire connections.
185527	CAN Loopback Test Aborted. Message Transmit Error Message was not transmitted successfully from*%b* to*%b*. TxOk signal did not go high.
185528	CAN Loopback Test Aborted. Message Receive Error Message sent from*%b* was not successfully received by*%b*. New Data signal did not go high.
185529	CAN Loopback Test Aborted.*%b* received message successfully, but did not generate interrupt.

Table 9-14 HEMRC Error Messages (Continued)

MESSAGE NUMBER	MESSAGE TEXT
185530	CAN Loopback Test Identifier Error. *%d* of the transmissions from *%b* to *%b* resulted in conflicting message Identifiers.
185531	CAN Loopback Test Data Length Code Error. *%d* of the transmissions from *%b* to *%b* resulted in conflicting values for the data length code segment of the Message Configuration Register.
185532	CAN Loopback Test Message Lost Error. Lost *%d* of the messages transmitted from *%b* to *%b*.
185533	CAN Loopback Test Error. *%d* of the bytes transmitted from *%b* to *%b* contained an error.
185534	CAN Loopback Test Error. *%d* messages transmitted by *%b*, but *%b* only received *%d* messages.
185535	CAN Loopback Test Error. *%d* packets sent from *%b* to *%b* contained errors.
185536	Firmware Error: Unable to install interrupt handler.
185537	CAN Bus Error. An abnormal number of errors have occurred on the CAN bus. Error detected by *%b*.
185538	Firmware Error: Bus Fault Flag is set, but none of the CAN chips are bus off.
185539	Firmware Error: Unable to post HEMRC message semaphore.
185540	Firmware Error: Bad interrupt code found in interrupt register during loopback test. Interrupt Code: *%d*
185541	Hardware Error: Interrupts are occurring but there are no interrupt codes in any of the CAN chip interrupt registers.
185542	CAN Warning Status. An abnormal number of errors have occurred on the CAN bus. Error detected by *%b*. Status Register Value: *%xh*
185543	Hardware Error: *%b* chip interrupt cannot be cleared. Disabling chip. Interrupt Code: *%d*
185544	Error: The loopback test found the first error while sending a message from *%b* to *%b*. Expected Value: *%d* Actual Value: *%d*
185545	Hardware Error: Message Object 15 generated an interrupt, but Interrupt Pending was not set.
185546	The HEMRC is not running after being disabled. HEMRC status: *0x%06x*
185547	Hardware error: The At Frequency line from the HEMRC is stuck high. HEMRC Control Board latch address: 0xFFB829 Bit: D6 HEMRC status: OFF
185548	The HEMRC operating frequency is below the minimum value. Actual frequency: *%d.%03d* Minimum frequency limit: *%d.%03d* At Frequency signal: *%b* Expected: *%b* Rotor State = *%b*
185549	The At Frequency signal does not agree with the drive output frequency. Possible causes: Interconnection, HEMRC drive, HEMRC control board. Drive freq: *%d.%03d* Minimum freq. limit: *%d.%03d* At Frequency signal: *%b* Expected: *%b* Rotor State = *%b*
185550	Active
185551	Inactive

Table 9-14 HEMRC Error Messages (Continued)

MESSAGE NUMBER	MESSAGE TEXT
185552	The CAN test jumper on the HEMRC Control Board is in the wrong position for this test. Place the jumper in the diagnostic position and rerun test. HEMRC address: 0xFFB829 Bit: D0
185553	The HEMRC drive detected a Line Loss. This occurs when the input power to the drive falls below 85% of the nominal Bus voltage. Possible causes: x-ray tube stator, HEM-IT, HEMRC power supply,... Alarm status: *%xH*
185554	The HEMRC drive is being re-initialized due to the detection of error *F%d*. Status: *%d* (1=OK)
185555	The CAN test jumper on the HEMRC Control Board is in the DIAGNOSTIC position. Place jumper in the NORMAL mode in order to scan.
185556	The CAN test jumper on the HEMRC Control Board is missing. Place jumper in the NORMAL mode in order to scan.
219800	The HEMRC AC Drive reported fault code: Fxx (Where xx equals the number in the following table.)

Table 9-14 HEMRC Error Messages (Continued)

2.3.3.2 Fault Codes

The **HEMRC** AC Drive contains an independent microprocessor controller. When the drive detects a fault, it sends a Fault Code to the **HCB**/**OBC**. The **OBC**, in turn, posts an error message in the log. Unfortunately, the **OBC** logs all AC Drive error messages as # 219800. However, the body of the message contains the actual Fault Code in the first line, as shown in Table 9-15.

Subsequent lines in the message contain unique description, based on the actual Fault Code.

FXX	FAULT	DESCRIPTION
1	Undefined Fault	This fault code is undefined and may indicate a defective Drive. Retry operation. If problems persist, contact the factory for instructions.
2	Auxiliary Fault	The interlock between the Chopper Control circuit on the **HEMRC** I/F Board and the Drive is open. Possible Chopper Control fault or connections to the I/F board. Also check the fuse on the chopper resistor pan.
3	Power Loss Fault	The Drive internal DC bus remained low for >500mS. Possible low voltage condition on 120 VAC in gantry or power interruption. Also may indicate excessive run or braking power required due to sluggish tube.
4	Undervoltage Fault	The Drive internal DC bus voltage dropped below 325V. Possible low voltage condition on 120 VAC in gantry or power interruption. Also, may indicate excessive run or braking power required due to sluggish tube.
5	Overvoltage Fault	The Drive internal DC bus voltage has exceeded 810V. Possible failure of **HEMRC** I/F Board Chopper Control or excessive motor regeneration from x-ray tube during braking.
6	Motor Stall Fault	The Drive output current has exceeded 12.6A for > 4 seconds. Possible x-ray tube frozen bearing or shorted stator or Anode **HV** cable. Also, possible defective **HEMIT** and/or stator cable.

Table 9-15 HEMRC Fault Codes for the 219800 Error Message

FXX	FAULT	DESCRIPTION
7	Overload Fault	The Drive output current has exceeded 9.7A for an extended time. Possible x-ray tube sticky bearing or shorted stator or Anode **HV** cable. Also, possible defective **HEMIT** and/or stator cable.
8	Overtemp Fault	The Drive heatsink temperature has exceeded 90C (195F). Check for blocked or dirty heat sink fins. Also check if the gantry ambient temperature has exceeded 40C (104F).
9	Open Pot Fault	Potentiometer speed control is not used in this system. This fault code indicates a possible corrupted configuration parameter, defective Drive or Control Board. Retry operation.
10	Serial Fault	This fault code indicates a possible corrupted configuration parameter, defective Drive or Control Board. Retry Operation.
11	Op Error Fault	This fault code indicates a possible corrupted configuration parameter, defective Drive or Control Board. Retry Operation.
12	Overcurrent Fault	Check for a short circuit at the drive output or excessive load conditions at the motor.
13	Ground Fault	Check the motor and external wiring to the drive output terminals for a grounded condition.
14 to 18	Undefined Fault	This fault code is undefined and may indicate a defective Drive. Retry operation. If problems persist contact the factory for instructions.
19	Precharge Fault	This fault code indicates a possible hardware failure in the Drive. Retry operation. If problems persist, replace the Drive.
20 21	Undefined Fault	This fault code is undefined and may indicate a defective Drive. Retry operation. If problems persist contact the factory for instructions.
22	Drive Fault Reset	Power up has occurred with an open Stop_HEMRC or closed Start_HEMRC* signal. Check Control Board and wiring between Drive and **OBC**.
23	Loop Overrun Fault	This fault code indicates a possible hardware failure in the Drive. Retry operation. If problems persist, replace the Drive.
24	Motor Mode Fault	This fault code indicates a possible hardware failure in the Drive. Retry operation. If problems persist, replace the Drive.
25	Undefined Fault	This fault code is undefined and may indicate a defective Drive. Retry operation. If problems persist contact the factory for instructions.
26	Power Mode Fault	This fault code indicates a possible hardware failure in the Drive. Retry operation. If problems persist, replace the Drive.
27	Undefined Fault	This fault code is undefined and may indicate a defective Drive. Retry operation. If problems persist, contact the factory for instructions.
28	Timeout Fault	This fault code indicates a possible hardware failure in the Drive. Retry operation. If problems persist, replace the Drive.
29	Hertz Error Fault	This fault code indicates an operating frequency parameter was out of range. Possible corrupted configuration parameter, defective Drive or Control Board. Retry Operation.

Table 9-15 HEMRC Fault Codes for the 219800 Error Message (Continued)

FXX	FAULT	DESCRIPTION
30	Hertz Select Fault	This fault code indicates an operating frequency parameter was out of range. Possible corrupted configuration parameter, defective Drive or Control Board. Retry Operation.
31	Timeout Fault	This fault code indicates a possible hardware failure in the Drive. Retry operation. If problems persist, replace the Drive.
32	**EEPROM** Fault	This fault code indicates a possible hardware failure in the Drive. Retry operation. If problems persist, replace the Drive.
33	Max Retries Fault	The Drive unsuccessfully tried to reset a fault. See message(s) above for original problem.
34	Run Boost Fault	Verify that the [Run Boost] parameter is less than or equal to the [Start Boost] parameter.
35	Negative Slope Fault	This fault code indicates a Volts/Hertz programming error. Possible corrupted configuration parameter, defective Drive or Control Board. Retry Operation.
36	Diag C Lim Fault	Check programming of [Cur Lim Trip En] parameter. Check for excess load, im proper DC boost setting, DC brake volts set too high or other causes of excess current.
37	P Jump Error Fault	
38	Phase U Fault	A phase to ground short has been detected in the U phase. Check the wiring between the drive and **HEMIT**. Check **HEMIT** for grounded primary winding.
39	Phase V Fault	A phase to ground short has been detected in the V phase. Check the wiring between the drive and **HEMIT**. Check **HEMIT** for grounded primary winding.
40	Phase W Fault	A phase to ground short has been detected in the W phase. Check the wiring between the drive and **HEMIT**. Check **HEMIT** for grounded primary winding.
41	UV Short Fault	A phase to phase short has been detected between the U & V phases. Check the wiring between the drive and **HEMIT**. Check **HEMIT** for shorted primary.
42	UW Short Fault	A phase to phase short has been detected between the U & W phases. Check the wiring between the drive and **HEMIT**. Check **HEMIT** for shorted primary.
43	VW Short Fault	A phase to phase short has been detected between the V & W phases. Check the wiring between the drive and **HEMIT**. Check **HEMIT** for shorted primary.
44 45	Undefined Fault	This fault code is undefined and may indicate a defective Drive. Retry operation. If problems persist contact the factory for instructions.
46	Power Test Fault	This fault code indicates a possible hardware failure in the Drive. Check all connections to the Power/Driver Board. Retry operation. If problems persist, re place the Drive.
47	Transistor Saturation Fault	This fault code indicates a possible hardware failure in the Drive. Retry operation. If problems persist, replace the Drive.
48	Reprogram Fault	Reset the **OBC** or cycle power to the drive.

Table 9-15 HEMRC Fault Codes for the 219800 Error Message (Continued)

FXX	FAULT	DESCRIPTION
49	Undefined Fault	This fault code is undefined and may indicate a defective Drive. Retry operation. If problems persist contact the factory for instructions.
50	Poles Calc Fault	
51	Background 10ms Over	This fault code indicates a possible hardware failure in the Drive. Retry operation. If problems persist, replace the Drive.
52	Foreground 10ms Over	This fault code indicates a possible hardware failure in the Drive. Retry operation. If problems persist, replace the Drive.
53	EE Init Read	This fault code indicates a possible hardware failure in the Drive. Retry operation. If problems persist, replace the Drive.
54	EE Init Value	This fault code indicates a possible hardware failure in the Drive. Retry operation. If problems persist, replace the Drive.
55	Temp Sense Open	This fault code indicates a possible hardware failure in the Drive. Retry operation. If problems persist, replace the Drive.
56	Precharge Open	This fault code indicates a possible hardware failure in the Drive. Retry operation. If problems persist, replace the Drive.
57	Ground Warning	Check the **HEMIT** and external wiring to the drive output terminals for a grounded condition.
58	Blown Fuse Fault	This fault code indicates a possible hardware failure in the Drive. Retry operation. If problems persist, replace the Drive.
59 to 64	Undefined Fault	This fault code is undefined and may indicate a defective Drive. Retry operation. If problems persist contact the factory for instructions.
65	Adapter Frequency Error	This fault code indicates an operating frequency parameter was out of range. Possible corrupted configuration parameter, defective Drive or Control Board. Retry Operation.
66	**EEPROM** Checksum Fault	This fault code indicates a possible hardware failure in the Drive. Retry operation. If problems persist, replace the Drive.
67	Undefined Fault	This fault code is undefined and may indicate a defective Drive. Retry operation. If problems persist contact the factory for instructions.
68	**ROM** or **RAM** Loss Fault	Internal power-up tests did not execute properly. Check Language Module. Retry operation. If problems persist, replace the Drive.
69 70	Undefined Fault	This fault code is undefined and may indicate a defective Drive. Retry operation. If problems persist contact the factory for instructions.

Table 9-15 HEMRC Fault Codes for the 219800 Error Message (Continued)

2.3.3.3 Precautions

ESD can damage devices on the **HEMRC** Control board. This damage may not be immediately apparent, but may show up in the future as degraded operational performance. Never handle this board unless you are wearing a properly grounded **ESD** prevention wrist strap. Pay careful attention to **ESD** packaging and handling procedures to insure the long term reliability of this assembly.

2.3.3.4 Default Jumper Configuration

The default configuration for shipment: JP1= “A” and jumper plug in J5 (Normal **CAN** Mode). Secure the jumper plug to the header with a ty-rap. (See assembly drawing for details).

2.3.4 HEMRC Assembly – Theory of Operation

2.3.4.1 HEMRC AC Drive

The **HEMRC** AC Drive is a customized version of a commercially available Allen-Bradley Model 1336 variable frequency AC motor drive. It contains its own microprocessor, power supplies and a three phase full bridge inverter. The AC Drive communicates with the **OBC CPU** through a **CAN** (Controller Area Network) serial bus.

Note: Through special arrangement with Allen-Bradley, the AC Drive uses a derivative of their PROPRIETARY protocol for maximum communication speed and efficiency.

The **OBC**/**HCB** firmware controls all sequence operations of the drive. The drive's internal **CPU** controls lower level detail functions and fault protection. The **HCB** uses discrete signals, in addition to the **CAN**, to control the drive. These signals include Enable, Start, Stop, At Speed, and fault signals. The AC Drive provides an isolated 12V supply to the **HCB**, to power the opto-isolators.

During normal operation the AC Drive outputs a 3-phase voltage produced by variable pulse width switching of the drive's IGBT inverter. The peak voltage of this output equals either the **HVDC** (High Voltage DC) bus voltage or the rectified 380V from transformer T1 (described in Section 2.3.4.5, on page 725), whichever is greater. However, independent of bus voltage, the drive uses PWM switching to maintain the commanded RMS 3-phase output voltage and frequency. The **HCB** firmware modifies the commands to the drive as required to supply the current needed for acceleration, run and deceleration of the x-ray tube.

JUMPER SETTINGS FOR THE AC DRIVE INSIDE THE HEMRC

When installing the **HEMRC** AC Drive review the following jumper settings.

JP1	Open
JP2	Installed

There are spare jumpers located near the Allen-Bradley Language Module.

2.3.4.2 HEMRC Interface Board

The following reference information comes from the **HEMRC** Interface Board Test Specification, 2145832TST. Refer to the 2145832TST document for any updated information, or for more complete discussion of the Interface Board functions.

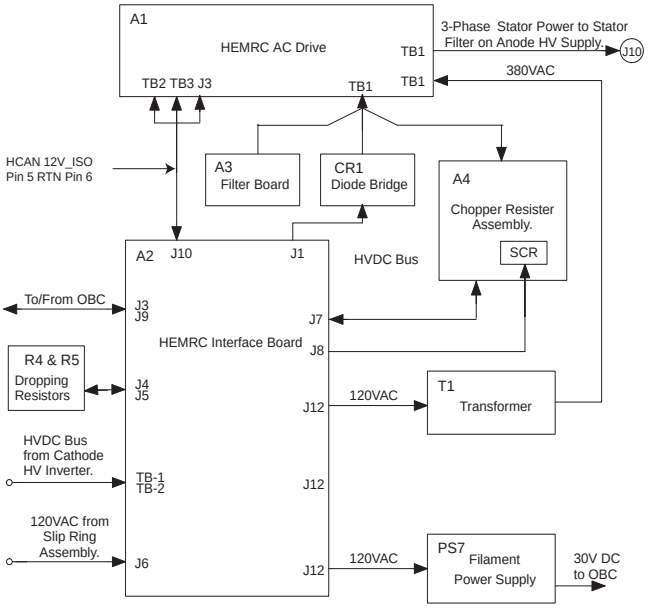


Figure 9-15 HEMRC Assembly Block Diagram

Wiring Harness

These signal lines, originally used for the **OBC** wire list, have been reassigned in the **HEMRC** control. Table 9-16 lists signal names corresponding to the **OBC** wire list and the **HEMRC** control.

OBC WIRE LIST	PERFORMIX TUBE SYSTEM				
WIRE LIST SIGNAL NAME	HEMRC CONTROL BOARD J3-	NEW SIGNAL NAME	HEMRC I/F BD INPUT CONN.	HEMRC I/F BD OUTPUT CONN.	HEMRC AC DRIVE I/O CONN.
LLEDL	A17	HEMRC_FLT_NC	J3-8	J10-14	TB2-15
ULEDL	C17	HEMRC_FLT_NO	J3-7	J10-13	TB2-14
LLEDR	A18	HEMRC_AT_SPD*	J9-4	J10-4	TB2-10
ULEDR	C18	HEMRC_FLT_SPD_RTN	J9-3	J10-3	TB2-11 & 13
STI1_L	A20	HEMRC_CAN_H	J3-4	J10-12	J3-1
STI2_L	C20	HEMRC_CAN_L	J3-3	J10-11	J3-6
LDI1_L	A22	START_HEMRC*	J3-10	J10-16	TB3-19
LDI2_L	C22	STRT_STP_COM	J3-9	J10-15	TB3-21
STI1_R	A21	HEMRC_EN_P	J9-7	J10-7	TB3-30
STI2_R	C21	HEMRC_EN_N	J9-8	J10-8	TB3-29
LDI1_R	A23	STOP_HEMRC	J9-1	J10-1	TB3-20
LDI2_R	C23		J9-2	J10-2	
DCRVM+	A25	HEMRC_ISO_+12V	J9-5	J10-5	J3-4
DCRV+	C25	HEMRC_ISO_RTN	J9-6	J10-6	J3-3
DCRV-	A24	DCRV-	J3-6		
DCRVM-	C24	DCRVM-	J3-5		
		HEN_P1		J10-9	TB3-24
		HEN_P2		J10-10	TB3-25

Table 9-16 OBC Wire List to HEMRC Control Signal Name Translation

HVDC Sensing

HVDC enters the board at TB1 & TB2, passes through fuses F1 & F2 and outputs to the AC Drive at J1. Fuses F1 & F2 provide isolation between the **HVDC** bus and the AC Drive in the event of a component failure. **LED** DS1 illuminates to indicate the presence of voltage.

The **HEMRC** Interface Board provides the **HVDC** Bus monitor input. The resistors R1 through R5 form the input network of a differential amplifier circuit, located on the **HEMRC** Control Board. The output of this network drives a set of fault detectors read by the **OBC CPU** to monitor bus status.

R6 through R10, along with CR1 & U1, form a threshold detector circuit. U1, an optically coupled, normally closed, solid-state relay enables the chopper regulator when the **HVDC** bus voltage falls below 500V. U1 switches (nominally) between 500 and 550 volts.

Capacitors C1, C2, & C3 provide common mode and differential mode **EMI** filtering.

Chopper Control

DANGER **THE CHOPPER CONTROL CIRCUIT ON THE INTERFACE BOARD IS REFERENCED TO THE DC–RAIL AT ALL TIMES. THIS IS A POTENTIALLY LETHAL VOLTAGE SOURCE. DO NOT CONNECT TO GROUND.**

The Interface board Chopper circuit helps to dissipate excess energy in the AC Drive's internal DC bus. During braking of the x-ray tube rotor, the system **HVDC** bus turns off, which in turn directs U1 to enable the chopper. As the tube decelerates, its motor acts as a generator, which converts some of the kinetic energy to current. The AC Drive channels this current into its internal DC bus, causing the voltage on the bus to rise. If the bus voltage exceeds 810V, the drive disables itself and aborts the braking process. When the braking process aborts, the rotor coasts to a stop. The chopper limits the bus voltage to approximately 750V to prevent the tube from coasting.

The AC Drive's DC voltage powers the circuit at J7. Two 7500 ohm 40W chassis mounted dropping resistors, connected at J4 & J5, limit the power supply current to <50 mA. CR4 regulates the nominal 15V to power the Chopper Control circuit. **LED** DS3 lights to indicate the presence of circuit power.

When U1 enables the chopper, the open collector of AR1-1 floats, which in turn enables the operation of comparator circuit of AR1-2. The voltage sensed at J7-1 is scaled and compared to a fixed 5V reference provided by VR1. When the bus voltage exceeds 750V, AR1-2 goes high, driving Q3 and turning on IGBT Q1. An external 100 ohm, 1000W shunt resistor is connected through a fuse (DC+ and J7-5) to the collector of Q1. When Q1 turns on, this shunt resistor is applied to the DC bus and discharges the excess energy. When the voltage falls below 700V, AR1-2 goes low and driver transistor Q2 turns off Q1, disconnecting the shunt resistor.

The AR1-13 circuit detects the on state of Q1. Normally, Q1 stays on for a few milliseconds at a time. If it stays on too long, Q1 can damage the shunt resistor. Therefore, when the collector of Q1 goes low for more than ~1ms, AR1-13 floats high to release the RC timer of R26 & C10. If this condition lasts for more than ~130ms, AR1-14 goes high, which generates a fault condition.

Pins 4 & 5 of J8 are normally jumpered together so the normal low state of AR1-14 turns "on" the normally open solid-state relay U2, and closes its output "contact". The output of U2 passes through J10-9 & 10 to the AC Drive. When this circuit opens, the drive detects an error condition and aborts all operation. It also notifies the system of the fault.

The detected fault also turns on Q4, to generate a pulse from T1 at J8-1 & 3, which fires the gate of an external SCR. The SCR is connected between an 8 ohm tap on the shunt resistor and the DC-. When the SCR fires, the surge current blows the chopper's input fuse and isolates the fault from the **HVDC** bus supply.

AC Distribution

120 VAC enters the board at J6 and illuminates **LED** DS2. Fuse F3 feeds the collimator power supply through J12-1, and fuse F4 feeds the filament power supply through J12-3. Fuse F5 feeds the isolation transformer, which supplies standby & braking power through J12-5 to the **HEMRC** AC Drive.

2.3.4.3 Filter Board

The filter board adds differential mode and common mode capacitance to the AC Drive internal DC bus to reduce the electrical noise created by the switching IGBTs. This board is required for **EMI**/ **EMC** compatibility.

2.3.4.4 Chopper Resistor Assembly

The chopper resistor assembly provides a high power dissipation load to the AC Drive bus, if required during x-ray rotor braking. The chopper resistor configuration resembles the shunt regulator. The Interface Board contains the actual chopper switching element (an IGBT).

When the x-ray tube induction motor brakes, it can momentarily generate a current. When this happens, the AC Drive converts some of the rotational energy to electrical energy and returns it to the internal DC bus causing a rise in the bus voltage. If the DC bus voltage exceeds ~750V, the chopper IGBT turns on and discharges the excess energy through resistors A4R1 & A4R2. The IGBT turns off when the voltage drops below ~700V. This process continues as long as necessary to keep the bus voltage below ~750V. Normally this action occurs for less than 5 seconds during the brake cycle. At all other times the IGBT remains off and essentially “disconnects” the resistors from the bus. The intermittent duty cycles permits the use of resistors with a much lower power rating than a continuous duty cycle would require.

Because the circuit uses the intermittent duty rated resistors A4R1 & A4R2, it contains fuse A4F1 to isolate the resistors from the bus, in the event of a control failure. If a fault occurs, A4SCR1 fires and crowbars the bus. The anode of A4SCR1 connects to a tap on resistor A4R1, nominally set to 8 ohms from the fused end. When the SCR fires, the high current load it creates causes fuse A4F1 to open and disconnect the resistor assembly from the bus, to isolate the fault.

2.3.4.5 Step-Up Transformer

500VA isolation transformer, T1, is configured as a nominal 115:380 V step-up transformer. T1 provides the 24 hour power to the AC Drive, needed to maintain communication with the **HCB**/**OBC**. Diodes inside the AC Drive rectify the ~380Vac create a nominal 500 VDC bus (no load, with 120 VAC input). DC to DC converters inside the drive develop power for its internal logic from this bus. During extended periods of running the rotor, the system main **HVDC** bus turns off, and T1 becomes the course of continuing power for the Drive. T1 always provides the power during rotor braking.

2.3.4.6 Bridge Rectifier

Bridge Rectifier CR1 connects in series between the system main **HVDC** and the AC Drive internal bus to provide an alternate power source for the drive. The drive internal bus voltage always equals the greater of either the main **HVDC** or the T1 voltage.

Because the drive bus remains energized at all times, but the main **HVDC** bus only energizes during rotor acceleration, exposures and 1 minute hold-up times, CR1 isolates the main **HVDC** bus from the drive’s internal bus. CR1 prevents the drive bus from feeding back to the main **HVDC** bus and accidently energizing the gantry slip rings and **PDU**.

2.3.4.7 Dropping Resistors

Chassis mounted dropping resistors R4 & R5 provide the power supply from the AC Drive internal bus to the Chopper Control on the Interface Board. The Chopper Control supply is referenced to the **HVDC** bus return, NOT to ground. NEVER reference this voltage to ground.

DANGER **THE CHOPPER CONTROL CIRCUIT ON THE INTERFACE BOARD IS REFERENCED TO THE DC – RAIL AT ALL TIMES. THIS IS A POTENTIALLY LETHAL VOLTAGE SOURCE. DO NOT CONNECT TO GROUND.**

2.3.4.8 Connectors

The **HEMRC** Assembly has many connections to the CT system. Unless otherwise indicated, for ease of installation and field upgrade of existing systems, these connections use Mate-N-Lok connectors. Connector designations follow the labelling conventions used in the previous system configurations. Many of the external connections are made directly to sub-components on the assembly and use that sub-component's location identifier in its label.

The following sections group the connections into External Connections and Internal Connections.

External Connections

CATHODE INVERTER

PIN#	SIGNAL	DESCRIPTION
1	HVDC-	HVDC- from Cathode Inverter **EMC** Filter

Table 9-17 TB1 – From Cathode Inverter (10-32 stud)

PIN#	SIGNAL	DESCRIPTION
1	HVDC+	HVDC+ from Cathode Inverter **EMC** Filter

Table 9-18 TB2 – From Cathode Inverter (10-32 stud)

HEMRC

PIN#	SIGNAL	DESCRIPTION
1	—	No Connection
2	—	No Connection
3	HEMRC_CAN_L	Bidirectional **CAN** data line (low)
4	HEMRC_CAN_H	Bidirectional **CAN** data line (high)
5	DCRVM-	HVDC+ Rail Voltage Monitor to control board
6	DCRV-	HVDC- Rail Voltage Monitor to control board
7	HEMRC_FLT_N O	Normally open fault signal to control board
8	HEMRC_FLT_NC	Normally closed fault signal to control board
9	STRT_STP_CO M	Common return for START_HEMRC* and STOP_HEMRC signals from the control board
10	START_HEMRC*	Start command from the control board

Table 9-19 J3 – To/From HEMRC Control Board in the OBC

SLIP RING

PIN#	SIGNAL	DESCRIPTION
1	120 VAC	120 VAC from the gantry slip ring
2	0VAC	AC Neutral from the gantry slip ring
3	—	No Connection

Table 9-20 J6 – From 120 VAC Slip Rings

HEMRC CONTROL BOARD

PIN#	SIGNAL	DESCRIPTION
1	STOP_HEMRC	Stop command from the control board
2	spare	Unused
3	HEMRC_FLT_SPD_RTN	Common return for _FLT_ and HEMRC_AT_SPD* signals to the control board
4	HEMRC_AT_SPD*	At speed signal to the control board
5	HEMRC_ISO_+12V	AC Drive 12V power supply to the control board
6	HEMRC_ISO_RTN	Return for the 12V power supply to the control board
7	HEMRC_EN_P	High side of enable signal from the control board
8	HEMRC_EN_N	Low side of enable signal from the control board
9	—	No Connection
10	—	No Connection

Table 9-21 J9 – To/From HEMRC Control Board in the OBC

FILAMENT

PIN#	SIGNAL	DESCRIPTION
Push-On	30VDC	30 VDC positive to mA Control Board in the **OBC**
Ring Term	30VRTN	30 VDC return to mA Control Board in the **OBC**

Table 9-22 (No Connector) – Output from Filament Power Supply

STATOR

PIN#	SIGNAL	DESCRIPTION
1	BLK	Phase 2 to Stator Filter on Anode **HV** Supply
2	WHT	Phase 1 to Stator Filter on Anode **HV** Supply
3	GRN	Phase 3 to Stator Filter on Anode **HV** Supply
4	SHLD	Cable Shield to Stator Filter on Anode **HV** Supply

Table 9-23 Stator Cable Output to Stator Filter (& HEMIT)

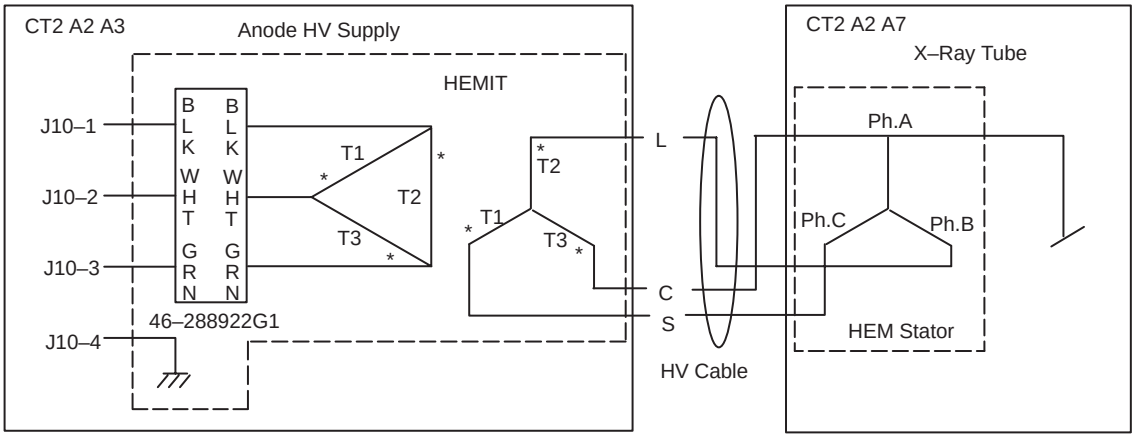


Figure 9-16 HEMIT Wiring Diagram

RESISTANCE READINGS FOR HEMIT

Input
- J10-1 to 2 Approx 1.2 Ohms
- J10-2 to 3 Approx 1.2 Ohms
- J10-1 to 3 Approx 1.2 Ohms

Output
- L to C Approx 1.2 Ohms
- S to C Approx 1.2 Ohms
- L to S Approx 1.3 Ohms

RESISTANCE READING AT THE TUBE WELLS

Cathode
- L to C Approx 0.2 Ohms
- S to C Approx 0.2 Ohms
- L to S Approx 0.3 Ohms

Anode
- L to C Approx 2.3 Ohms
- S to C Approx 2.3 Ohms
- L to S Approx 2.3 Ohms

Note: At no time should you read any continuity to ground. Readings are approximates, variability in meter leads and measurement methods should be taken into consideration.

Internal Connections

HEMRC

TERMINAL	SIGNAL	DESCRIPTION
S	H4	380 VAC input from transformer, T1
T	H1	380 VAC return from transformer, T1
DC+	DC+	Bidirectional DC bus connection from CR1+, Filter Board, and Chopper Resistor Assembly
DC-	DC-	Bidirectional DC bus connection from CR1-, Filter Board, and Chopper Resistor Assembly
U	BLK	Phase 2 to Stator Filter on Anode **HV** Supply
V	WHT	Phase 1 to Stator Filter on Anode **HV** Supply
W	GRN	Phase 3 to Stator Filter on Anode **HV** Supply

Table 9-24 A1 TB1 – HEMRC AC Drive Power Connections, A1

“TO” HEMRC INTERFACE BOARD

TERMINAL	SIGNAL	DESCRIPTION
10	HEMRC_AT_SPD*	At speed signal to the **OBC** via I/F Board
11	HEMRC_FLT_SPD_RTN	Common return for _FLT_ and HEMRC_AT_SPD*
signals to the **OBC** via I/F Board	13	HEMRC_FLT_SPD_RTN
Jumper to terminal 11	14	HEMRC_FLT_NO

Table 9-25 A1 TB2 – To HEMRC Interface Board, A2

TERMINAL	SIGNAL	DESCRIPTION
Normally open fault signal to the **OBC** via I/F Board	15	HEMRC_FLT_NC
Normally closed fault signal to the **OBC** via I/F Board		

Table 9-25 A1 TB2 – To HEMRC Interface Board, A2 (Continued)

"FROM" HEMRC INTERFACE BOARD

TERMINAL	SIGNAL	DESCRIPTION
19	START_HEMRC*	Start command from the **OBC** via I/F Board
20	STOP_HEMRC	Stop command from the **OBC** via I/F Board
21	STRT_STP_COM	Common return for START_HEMRC* and STOP_HEMRC signals from the **OBC** via I/F Board
24	HEN_P1	High side of auxiliary enable from the I/F Board
25	HEN_P2	Low side of auxiliary enable from the I/F Board
29	HEMRC_EN_N	Low side of enable signal from the **OBC** via I/F Board
30	HEMRC_EN_P	High side of enable signal from the **OBC** via I/F Board

Table 9-26 TB3 – From HEMRC Interface Board

"TO/FROM" HEMRC INTERFACE BOARD

PIN#	SIGNAL	DESCRIPTION
1	HEMRC_CAN_H	Bidirectional **CAN** data line (high) to the **OBC** via I/F Board
3	HEMRC_ISO_RTN	Return for the 12V power supply to the **OBC** via I/F Board
4	HEMRC_ISO_+12V	AC Drive 12V power supply to the **OBC** via I/F Board
6	HEMRC_CAN_L	Bidirectional **CAN** data line (low) to the **OBC** via I/F Board

Table 9-27 J3 -– To/From HEMRC Interface Board

DIODE BRIDGE

PIN#	SIGNAL	DESCRIPTION
1	HVDC	Fused HVDC+ to bridge diode
2	HVDC	Fused HVDC+ to bridge diode
3	—	No connection
4	—	No connection
5	HVDC_RTN	Fused HVDC- to bridge diode
6	HVDC_RTN	Fused HVDC- to bridge diode

Table 9-28 J1 - To chassis mounted Diode Bridge, CR1

RESISTOR R4

PIN#	SIGNAL	DESCRIPTION
1	none	One end of dropping resistor R1
2 to 9	—	No connection
10	none	Other end of dropping resistor R1

Table 9-29 J4 – To Resistor, R4

RESISTOR R5

PIN#	SIGNAL	DESCRIPTION
1	none	One end of dropping resistor R2
2 to 9	—	No connection
10	none	Other end of dropping resistor R2

Table 9-30 J5 – To Resistor, R5

"TO/FROM" CHOPPER RESISTOR ASSEMBLY

PIN#	SIGNAL	DESCRIPTION
1	DCOUT+	AC Drive internal DC+
2	—	No connection
3	DCFUSED	Fused AC Drive internal DC+
4	—	No connection
5	CHOP_R	Chopper power resistor assembly
6	—	No connection
7	—	No connection
8	DCOUT-	AC Drive internal DC-

Table 9-31 J7 - To/From Chopper Resistor Assembly

"TO SCR" CHOPPER RESISTOR ASSEMBLY

PIN#	SIGNAL	DESCRIPTION
1	GATE	To Gate of SCR
2	—	No connection
3	GATE_RTN	To auxiliary Cathode of SCR
4	none	Interlock loopback to J8-5
5	none	Interlock loopback to J8-4

Table 9-32 J8 - To SCR on Chopper Resistor Assembly SCR1

HEMRC AC DRIVE

PIN#	SIGNAL	DESCRIPTION
1	STOP_HEMRC	Stop command to the AC drive
2	spare	Unused
3	HEMRC_FLT_SPD_RTN	Common return for _FLT_ and HEMRC_AT_SPD* signals from the AC drive
4	HEMRC_AT_SPD*	At speed signal from the AC drive
5	HEMRC_ISO_+12V	AC Drive 12V power supply from the AC drive
6	HEMRC_ISO_RTN	Return for the 12V power supply from the AC drive
7	HEMRC_EN_P	High side of enable signal to the AC drive
8	HEMRC_EN_N	Low side of enable signal to the AC drive
9	HEN_P1	High side of auxiliary enable to AC drive
10	HEN_P2	Low side of auxiliary enable to AC drive
11	HEMRC_CAN_L	Bidirectional **CAN** data line (low)
12	HEMRC_CAN_H	Bidirectional **CAN** data line (high)
13	HEMRC_FLT_NO	Normally open fault signal from the AC drive
14	HEMRC_FLT_NC	Normally closed fault signal from the AC drive
15	STRT_STP_COM	Common return for START_HEMRC* and STOP_HEMRC signals to the AC drive
16	START_HEMRC*	Start command to the AC drive
17	—	No connection
18	—	No connection
19	—	No connection
20	—	No connection

Table 9-33 J10 – To/From HEMRC AC Drive

POWER SUPPLIES

PIN#	SIGNAL	DESCRIPTION
3	Fil_120	Fused 120 VAC to filament power supply, PS7
4	Fil_0	0Vac to filament power supply
5	Xform_120	(X3) Fused 120 VAC to Isolation Transformer, T1
6	0VAC	(X1) 0Vac to Isolation Transformer

Table 9-34 J12 - To Power Supplies

2.3.4.9 Test Points, LEDs, Fuses & Tap Adjustments

DANGER

VARIOUS COMPONENTS, INCLUDING THE CHOPPER RESISTOR ASSEMBLY AND HEMRC INTERFACE BOARD, ARE REFERENCED TO THE HEMRC AC DRIVE DC BUS AT ALL TIMES. THIS IS A POTENTIALLY LETHAL VOLTAGE SOURCE. DO NOT CONNECT TO GROUND.

THE HEMRC INTERFACE BOARD CONTAINS NO TEST POINTS. ALL ACTIVE CIRCUITRY IS HIGH IMPEDANCE AND TIED TO HAZARDOUS VOLTAGES. DO NOT PROBE.

HERMC LEDS

LED	COLOR	DESCRIPTION
A1 A1 DS1	Red	Fault condition detected by AC Drive
DS1	Yellow	Power applied to AC Drive
DS1	Yellow	HVDC bus energized
DS2	Green	120 VAC applied to the Interface board
DS3	Yellow	AC Drive DC+ and DC- energized
DS4	Red	Fault detected in the Chopper Control

Table 9-35 HERMC LEDs

HEMRC FUSES

FUSE#	VALUE	DESCRIPTION
F1	20A, 700Vdc	HVDC- to **HEMRC** AC Drive
F2	20A, 700Vdc	HVDC+ to **HEMRC** AC Drive
F3	3A, 250Vdc	Not used
F4	8A, 350Vac Slo-Blo	120 VAC to Filament power supply
F5	8A, 350Vac Slo-Blo	120 VAC to **HEMRC** AC Drive Isolation Transformer
A4 F1	10A, 700Vdc	DCIN+ to Chopper Resistor Assembly
PS5 F1	10A, 32V	Not Used
PS7 F1	15A, 250V	Fused DC to mA Board in the **OBC**

Table 9-36 HERMC Fuses

A4R1 & A4R2 TAP ADJUSTMENTS

Verify/Align the connection tabs and hardware of the chopper resistors A4R1 and A4R2 so they clear any sheet metal by at least 0.5in.

Adjust the tap band on chopper resistor A4R1 to 8 ohms, ± 0.5 ohms, with respect to the end connected to fuse A4F1.

The tap band on chopper resistor A4R2 is not used, but you still must secure the band in place to prevent dielectric failure to the adjacent sheet metal. To minimize confusion, adjust the tap band to 8 ohms, ± 0.5 ohms, with respect to the end connected to A2J7-5.

2.4 mA Control Board

The 2154834 mA Board is managed by the Cathode mA. This change is required for compatibility with the Performix X-Ray Tube.

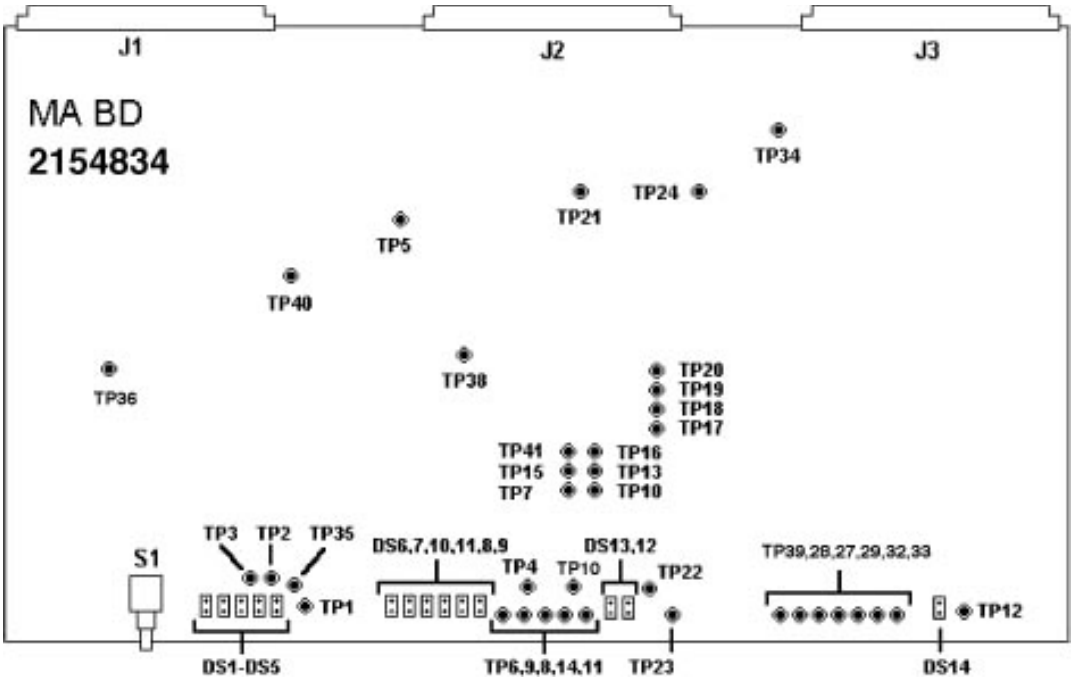


Figure 9-17 2154834, HEMRC mA Board

2.4.1 mA Board LEDs

DS1: (GRN) CLOOP	mA Loop is Closed
DS2: (GRN) INVEN	Inverter is Enabled
DS3: (RED) ANO	Anode OverCurrent Fault Detected in mA Monitoring
DS5: (RED) CAO	Cathode OverCurrent Fault Detected in mA Monitoring
DS6: (RED) FIL FLT	Filament Inverter Fault Detected (includes Inverter Fault Filament Undercurrent, Filament Overcurrent Open Filament and Shorted Filament)
DS7: (RED) INV FLT	Inverter Fault Detected
DS8: (RED) FIL UC	Filament Undercurrent Fault Detected
DS9: (RED) OFIL	Open Filament Fault Detected
DS10: (RED) SH FIL	Shorted Filament Fault Detected
DS11: (RED) FIL OC	Filament Overcurrent Fault Detected
DS12: (RED) IFLT	Filament Inverter Fault Detected (same as DS5 except on Inverter section of board)
DS13: (GRN) SMSP	Small Focal Spot is Selected
DS14: (GRN) INV ON	Inverter is On

2.4.2 mA Board Test Points

TP1: +5 V	+5 V Reference Supply
TP2: SGND	Signal ground
TP3: FERR	Filament Error output from AR3, P7 (0.5 Volt/Amp)
TP4: CAMA	Cathode **HV** supply mA feedback (1 Volt/100mA)
TP5: FSIG	Filament Demand output from AR7, P1 (1 Volt/Amp)
TP6: LGND	Logic Ground
TP7: -10REF	-10 V Reference Supply
TP8: ACAL1	Put an Ammeter between ACAL1 and CCAL2 as part of anode meter cals (200 mA scale)
TP9: CCAL1	Put an Ammeter between CCAL1 and CCAL2 as part of cathode meter cals (200 mA scale)
TP10: ANMA	Anode **HV** supply mA feedback (1 Volt/100mA)
TP11: ACAL2	Put an Ammeter between ACAL1 and ACAL2 as part of anode meter cals (200 mA scale)
TP12: FSHG	
TP13: MAFB	mA feedback into multiplying **DAC** U44, P17
TP14: CCAL2	Put an Ammeter between CCAL1 and CCAL2 as part of cathode meter cals (200 mA scale)
TP16: +24 V	+24 V Supply
TP20: FILSH	Filament Short Signal
TP21: +30 V	+30 V Reference Supply
TP22: FCMD	Filament Command output from AR12, P1 (1 Volt/Amp)
TP23: FCUR	Filament Feedback into PWM U67, P1 (1 Volt/Amp)
TP24: +15 V	+15 V Reference Supply
TP27: FIL CT	Filament Waveform into the Center Tap of the Filament Transformer
TP28: PD	Switching Interval Waveform from the PWM
TP29: FIL2	Filament Inverter Q12 drain Voltage
TP31: FGND	GND Tied to End of Guard Band
TP32: FIL1	Filament Inverter Q14 Drain Voltage
TP33: FSH	Filament Current – DC Level
TP35: +5LED	+5 V **LED** Chassis Supply
TP36: +5 V	+5 V Chassis Supply
TP37: -15V	-15 V Reference Supply
TP38: +15AV	+15 V Reference Supply
TP39: FD	Tie this Test Point high to disable fault generation
TP40: FDMD	Filament Demand
TP41: MAMUX	mA MUX Selection Output
TP42: FGND	GND Tied to End of Guard Band

2.4.3 mA Board Switch Settings

S1: RESET - Manual reset for the board

2.5 HEMRC Control Board

The **HEMRC** Control Board (High Efficiency Motor Rotor Control), performs three main functions. It provides an interface between the **OBC** and the **HEMRC**, **HVDC** Bus voltage monitoring, and a **CAN** interface between the **OBC** and future subsystems.

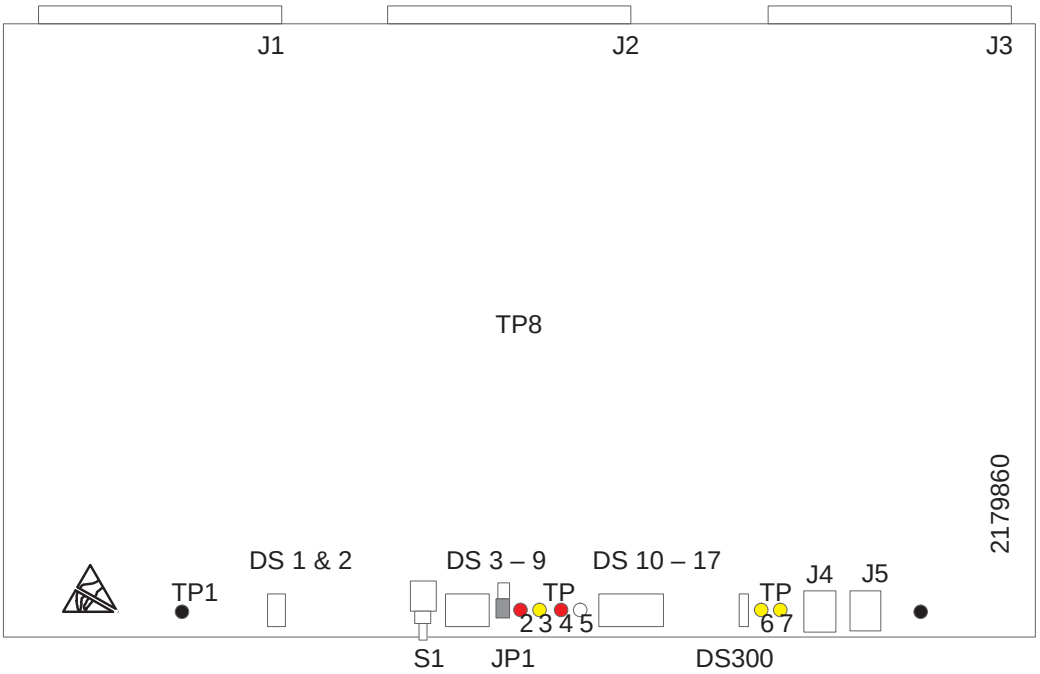


Figure 9-18 2179860 HEMRC Board

2.5.1 HEMRC Board Test Points

TP1: (BLK) LGND	Logic ground
TP2: (RED) +5V	+5 V supply voltage
TP3: (YEL) MUX	Analog signal as selected by the muxes
TP4: (RED) +15V	+15 V supply voltage
TP5: (WHT) -15V	-15 V supply voltage
TP6: (YEL) +10V	+10 V Reference
TP7: (YEL) DCV	DC rail monitor voltage. Scale: 100 V/V
TP8: (BLK) SGND	Signal ground

2.5.2 HEMRC Board LEDs

DS1: (YEL) LORPM	Indicates **HEMRC** output frequency is below programmed threshold
DS2: (YEL) LOV	Indicates the DC Rail is less than 470 V.
DS3: (RED) HIV	Indicates a DC Rail overvoltage (> 670 V) detected.
DS4: (RED) GFLT	Indicates a fault on a Gantry **CAN** based subsystem.
DS5: (GRN) G1TX	Indicates Gantry **CAN** 1 is transmitting.
DS6: (GRN) G2TX	Indicates Gantry **CAN** 2 is transmitting.
DS7: (GRN) GRX	Indicates **GCAN** is receiving.
DS8: (GRN) HRX	Indicates **HEMRC CAN** is receiving.
DS9: (RED) HFLT	General. Function defined by firmware.
DS10: (GRN)	General. Function defined by firmware.
DS11: (GRN)	General. Function defined by firmware.
DS12: (GRN)	General. Function defined by firmware.
DS13: (GRN)	General. Function defined by firmware.
DS14: (GRN)	General. Function defined by firmware.
DS15: (GRN)	General. Function defined by firmware.
DS16: (GRN)	General. Function defined by firmware.
DS17: (GRN)	General. Function defined by firmware.
DS300: (GRN) G12V	Indicates that GCAN_+12V_ISO is present.

2.5.3 HEMRC Board Jumper Setting (JP1)

The maximum output of the **PDU** can be determined by the **OBC** by reading the location of this jumper. This jumper location indicates whether or not the **PDU** has a DCRGS.

JUMPER POSITION

A = Selects voltage limits for systems with a DCRGS. (This is the default shipping position).

B = Selects voltage limits for systems with an Unregulated **HVDC** Supply. This is the proper position for use with the CT scanner.

2.5.4 HEMRC Board Jumper Plug

The jumper plug is a four position “shorting” plug that is installed in either the J4 or J5 **CAN** loopback connector. This jumper plug location selects whether the unit is in the normal or diagnostic **CAN** mode.

JUMPER PLUG

J5 = (Normal) Selects normal **CAN** operation where the **HEMRC CAN** and Gantry **CAN** are connected to their respective **CAN** networks. (This is the default shipping position).

J4 = (Loopback) Selects diagnostic **CAN** mode where the **HEMRC CAN** and Gantry **CAN** networks are connected together.

2.5.5 HEMRC Board Switch Function

S1: RESET Resets all command, fault and interrupt latches on this board, and also creates a GCAN_RESET signal that is sent to downstream controllers via the control interface bus connections.

2.6 HEMRC Interface Board

The **HEMRC** (High Efficiency Motor Rotor Control) Interface Board provides a transition point for terminating existing gantry harness connections at J3 and J9. The board also provides the input means for the system to monitor the **HVDC** Bus and AC distribution.

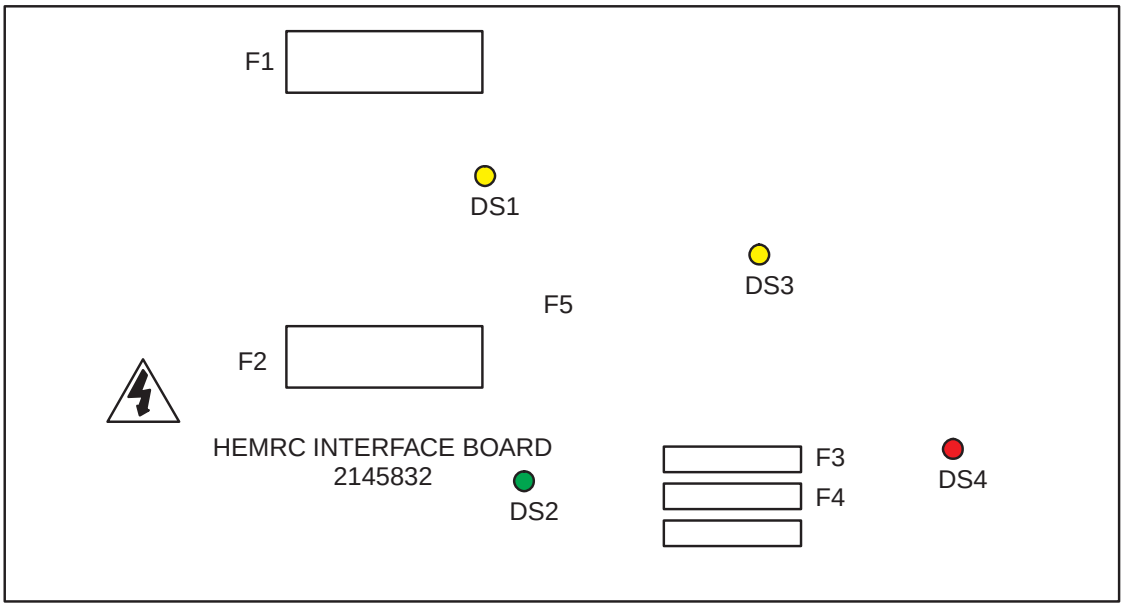


Figure 9-19 2145832 HEMRC Interface Board

2.6.1 HEMRC Interface Board Test Points

CAUTION Potential for Electrical Shock

There are no test points on this board. All active circuitry is high impedance and tied to hazardous voltages. It must not be probed.

The Chopper Control circuit is referenced to the DC- rail at all times. This is a potentially lethal voltage source. DO NOT connect to ground.

2.6.2 HEMRC Interface Board LEDs

DS1: (YEL)	Indicates the HVDC- to **HEMRC** AC Drive.
DS2: (GRN)	Indicates 120 VAC is applied to the board.
DS3: (YEL)	Indicates the AC Drive DC+ and DC- are energized.
DS4: (RED)	Indicates a fault was detected in the Chopper Control.

2.6.3 HEMRC Interface Board Fuses

F1: (20A, 700 VDC)	HVDC- to **HEMRC** AC Drive.
F2: (20A, 700 VDC)	HVDC+ to **HEMRC** AC Drive.
F3: (3A, 250 VAC)	Not Used.
F4: (8A, 250 VAC slo-blo)	120 VAC to Filament power supply.
F5: (8A, 250 VAC slo-blo)	120 VAC to **HEMRC** AC Drive Isolation Transformer.

2.7 kV Control Board

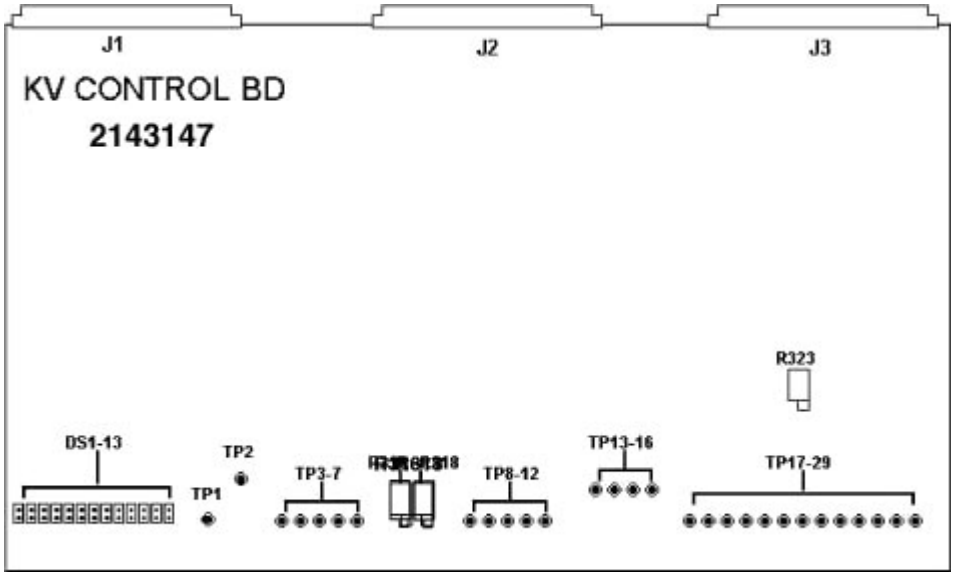


Figure 9-20 2143147 kV Control Board

2.7.1 kV Control Board Test Points

TP1 HVON	Indicates the kV feedback equals or exceeds 75% of command.
TP2 +5V	+5V (VCC) logic power.
TP3 LGND	Logic ground.
TP4 TRIG	A “1” indicates the selected inverter(s) is (are) turned on.
TP5 EXCM	Indicates an exposure command is being received from **LSCOM** bd.
TP6 EXEN	Indicates exposures are not disabled by the CTVRC, I/O or mA bds.
TP7 SPIT	Indicates a spit has been detected and recovery is in process.
TP8 KVCM	kV command. Scale: 15kV/V.
TP9 ANKV	Anode kV feedback. Scale: 10 kV/V.
TP10 CAKV	Cathode kV feedback. Scale 10kV/V.
TP11 KVTB	Total kV feedback. Scale 20 kV/V.
TP12 SGND	Signal ground
TP13 MUX	Analog MUX output as selected by firmware.
TP14 +10V	+10V reference.
TP15 -15V	-15V supply voltage.
TP16 +15V	+15V supply voltage.
TP17 KVERR	Integrated kV error signal.
TP18 PCNT	Average inverter duty cycle. Scale: 12%/V - 10%.
TP19 SGND	Signal ground.
TP20 ANOC	Anode inverter current. Scale: 25 A/V.
TP21 CAOC	Cathode inverter current. Scale: 25 A/V.
TP22 APH	Anode inverter duty cycle. Scale: 20%/V - 100%.

TP23 CPH	Cathode inverter duty cycle. Scale: 200% - 20%/V.
TP24 VCNT	Frequency control voltage. Scale: 19.5 kHz + 2.2kHz/V.
TP25 LGND	Logic ground.
TP26 SAW	Sawtooth (5 to 10V) at double the inverter frequency, nominally 39 to 61 kHz.
TP27 FREQ	5V square wave at double the inverter frequency.
TP28 APLSA	“1” indicates an “ON” pulse of the anode inverter.
TP2 CPLSA	“1” indicates an “ON” pulse of the cathode inverter.

2.7.2 kV Control Board LEDs

DS1 SPRT	Indicates the maximum spit rate has been exceeded.
DS2 GFLT	Indicates a “GO” fault has occurred.
DS3 ANST	Indicates an anode shoot-through has occurred.
DS4 CAST	Indicates a cathode shoot-through has occurred.
DS5 ANOC	Indicates an anode overcurrent has occurred.
DS6 CAOC	Indicates a cathode overcurrent has occurred.
DS7 ANOV	Indicates an anode overvoltage has occurred.
DS8 CAOV	Indicates a cathode overvoltage has occurred.
DS9 AINT	Indicates the anode inverter interlock is open.
DS10 CINT	Indicates the cathode inverter interlock is open.
DS11 OVRV	Indicates the kV feedback has exceeded the upper limit of the load regulator. May be ignored if on after power up or hardware reset.
DS12 HVND	Indicates anode and/or cathode kV feedback signals exceed 10 kV.
DS13 INON	Indicates the selected inverter(s) is (are) turned on.

2.7.3 kV Control Board Switch Settings

S1: InSite readable dip switch set for the ASCII equivalent of the board assembly version.

2.7.4 kV Control Board Adjustments

R316 CAKV	Adjusts the gain of the cathode kV feedback. Factory adjusted for unity gain. Field adjusted during **HV** PS cal procedure. Range: approximately ±20%.
R318 ANKV	Adjusts the gain of the anode kV feedback. Factory adjusted for unity gain. Field adjusted during **HV** PS cal procedure. Range: approximately ±20%.
R323 (FREQ)	Factory adjusted for minimum frequency of 39.0 kHz ±1.0 kHz at TP27 (FREQ) with TP24 (VCNT) set to 0V. Should not require field adjustment.

2.8 Gentry I/O Board

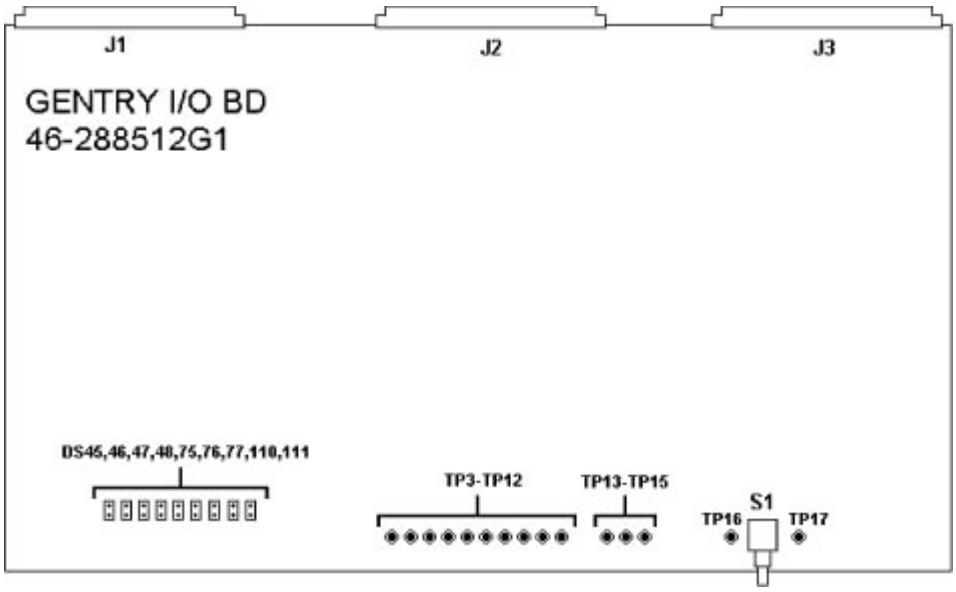


Figure 9-21 46-288512G1 Gentry I/O Board

2.8.1 Gentry I/O Board Test Points

TP3: +5V	TP8: +12V	TP13: SOUT
TP4: LGND	TP9: -12V	TP14: -SIN
TP5: SGND	TP10: +10V	TP15: SRTN
TP6: +15V	TP11: +24V	TP16: +SIN
TP7: -15V	TP12: A/DIN	TP17: PGND

2.8.2 Gentry I/O Board LEDs

DS45: ECMD INTR	DS76: ADC CMPLT
DS46: BCTR INTR	DS77: BTMR EXP
DS47: DTHTR INTR	DS110: TPRLY ON
DS48: BCTR CLS	DS111: INTR CLS
DS75: AXLTS ON	

2.8.3 Gentry I/O Board Switch Settings

S1: Reset

2.9 Interface Measurement Board

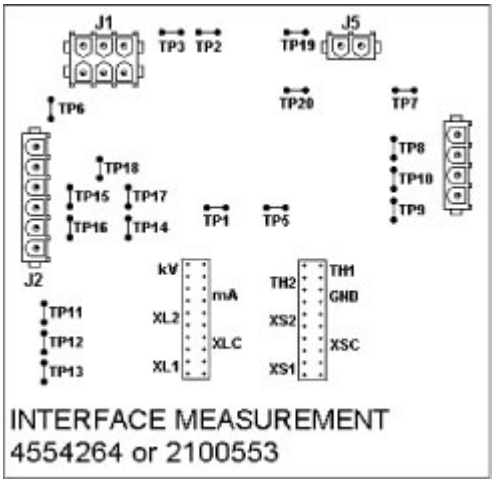


Figure 9-22 Interface Measurement Board

INTERFACE MEASUREMENT BOARD TEST POINTS

TP1 KV	Sensed kV signal - Scale 10 kV/V
TP2 KV	kV signal to **OBC**
TP3 KV GND	kV return signal to **OBC**
TP4	
TP5 MA	Sensed kV signal - Scale 100 kV/V
TP6 MA GND	mA return signal to **OBC**
TP7 PS1	Pressure Switch 1
TP8 PS2	Pressure Switch 2
TP9 TH1	Thermistor 1 (not used)
TP10 TH2	Thermistor 2 (not used)
TP11 XS2	Small Filament 2
TP12 XSC	Small Filament Common
TP13 XS1	Small Filament 1
TP14 XL2	Large Filament 2
TP15 XLC	Large Filament Common
TP16 XL1	Large Filament 1
TP17 MAout	mA signal to **OBC**
TP18 GND	Tank ground
TP19 kV	Sensed kV signal - Scale 10 kV/V
TP20 GND	Tank ground

See “X-Ray Generation,” on page 687.

Section 3.0
Procedures and Adjustments

3.1 Collimator/Detector Heater Power Supply

TEST POINTS	SPECIFICATIONS
Across output lugs on power supply	24 VDC ± 1 VDC

Table 9-37 Detector Heater Power Supply

ADJUSTMENT PROCEDURE

DANGER **USE PROPER LOCKOUT/TAGOUT PROCEDURES.**

1.) Remove gantry side covers and top covers.
2.) Turn **OFF** Axial Drive and **HVDC** on the **STC** backplane.
3.) Rotate gantry until Collimator/Detector Power assembly reaches the 2 o'clock position.
4.) Engage gantry rotational lock.
5.) Remove four (4) nuts on Filament Power assembly safety cover and remove cover.
6.) Collimator P.S. output checks:
   - Connect positive voltmeter lead to +OUT terminal on power supply.
   - Connect negative voltmeter lead to -OUT terminal on power supply.
   - Turn voltage adjustment pot to adjust the output voltage to 24 ± 1 VDC.
7.) Reassemble Gantry.

3.2 Collimator Fuse 6 Amp

Located on the Fuse box assembly. Use good service procedures.

3.3 Filament Power Supply

TEST POINTS	SPECIFICATIONS
Across Fuse and chassis on **HEMRC** Assembly	+28 VDC to +37 VDC

Table 9-38 Filament Power Supply

There are no adjustments for this power supply.

CHECK PROCEDURE

CAUTION Potential for Electrical Shock

When Gantry 120 VAC is energized, 440 VAC is present in the HEMRC assembly. All active circuitry is high impedance and tied to hazardous voltages.

The Chopper Control circuit is referenced to the DC- rail at all times. This is a potentially lethal voltage source. DO NOT connect to ground.

1.) Remove gantry side covers and top covers.

2.) Turn **OFF** all 3 switches (Axial Drive, **HVDC** 120 VAC) on the **STC** backplane.
3.) Rotate gantry until **HEMRC** assembly reaches the 2 o'clock position.
4.) Engage gantry rotational lock.
5.) Remove **HEMRC** cover.
6.) Connect DVM + plus lead to fuse terminal located at **HEMRC** 2nd tier left rear next to T1 transformer. Connect DVM - minus lead to **HEMRC** chassis.
7.) Turn 120 VAC switch **ON** at the **STC** backplane.
8.) Verify voltage.
9.) Turn 120 VAC switch **OFF** at the **STC** backplane.
10.) Remove DVM connections and reassemble gantry.

3.4 A4R1 & A4R2 Tap Adjustments

⚠ **CAUTION Potential for Electrical Shock**

When Gantry 120 VAC is energized there is 440 VOLTS present in the HEMRC assembly. All active circuitry is high impedance and tied to hazardous voltages.

The Chopper Control circuit is referenced to the DC- rail at all times. This is a potentially lethal voltage source. DO NOT connect to ground.

Perform All Adjustments using proper Lockout/Tagout Procedures.

1.) Remove gantry side covers and top covers.
2.) Turn **OFF** all 3 switches (Axial Drive, **HVDC** 120 VAC) on the **STC** backplane.
3.) Rotate gantry until **HEMRC** assembly reaches the 2 o'clock position.
4.) Engage gantry rotational lock.
5.) Remove **HEMRC** Resistor cover.
6.) Verify/Align the connection tabs and hardware of the chopper resistors A4R1 and A4R2 so they clear any sheet metal by at least 0.5in.
7.) Adjust the tap band on chopper resistor A4R1 to 8 ohms, ± 0.5 ohms, with respect to the end connected to fuse A4F1.
8.) The tap band on chopper resistor A4R2 is not used, but you still must secure the band in place to prevent dielectric failure to the adjacent sheet metal. To minimize confusion, adjust the tap band to 8 ohms, ± 0.5 ohms, with respect to the end connected to A2J7-5.
9.) Replace cover and reassemble gantry.

3.5 Access HV Maintenance through Service Desktop

1.) Select SERVICE DESKTOP.
2.) Select CALIBRATION.
3.) Select GENERATOR CHARACTERIZATION.

3.6 Generator Characterization

Use the Generator Characterization Program to update the "small spot" and "large spot" characterization files, to provide a starting point for the closed loop mode of the generator. This iterative process requires several scans at a different KV/MA/spot size. It calculates corrections, repeats the scan until the results fall within tolerance, then updates the characterization file.

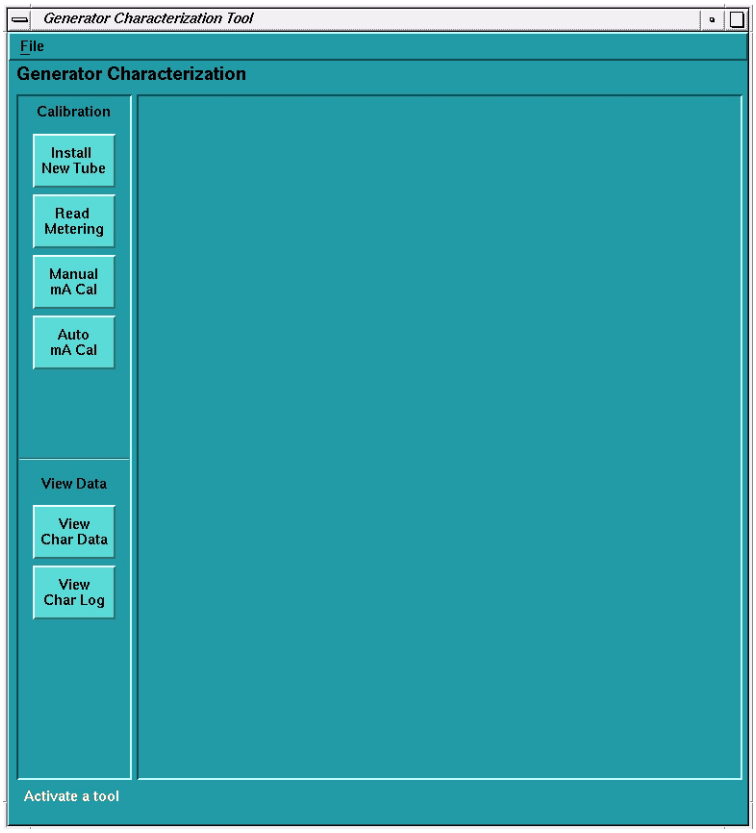


Figure 9-23 Generator Characterization Menu Screen

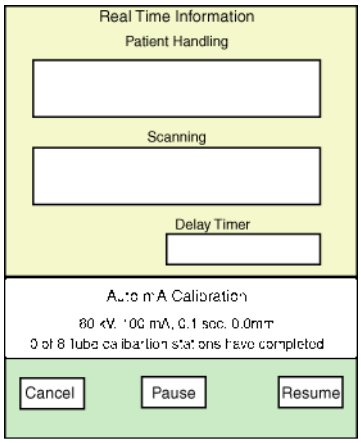


Figure 9-24 Auto mA Calibration Status Screen

3.7 X-Ray Generation / Collimation and Filtration

3.7.1 CAM A/B Amplifier Checkout Procedure

OBJECTIVE

Verify that the CAM A/B Amplifier is functional.

REFERENCES

Schematics - Collimator Control Board

Before beginning this procedure, please read the safety information in "Gantry," on page 37.

PROCEDURE SUMMARY

1.) Check the power supply to AMP.
2.) Swap cables with the other AMP.
3.) Select SERVICE DESKTOP.
4.) Select DIAGNOSTICS.
5.) Select COLLIMATOR AND FILTRATION.
6.) Exercise the CAM A/B and verify no test failures. Reference Figure 9-25.

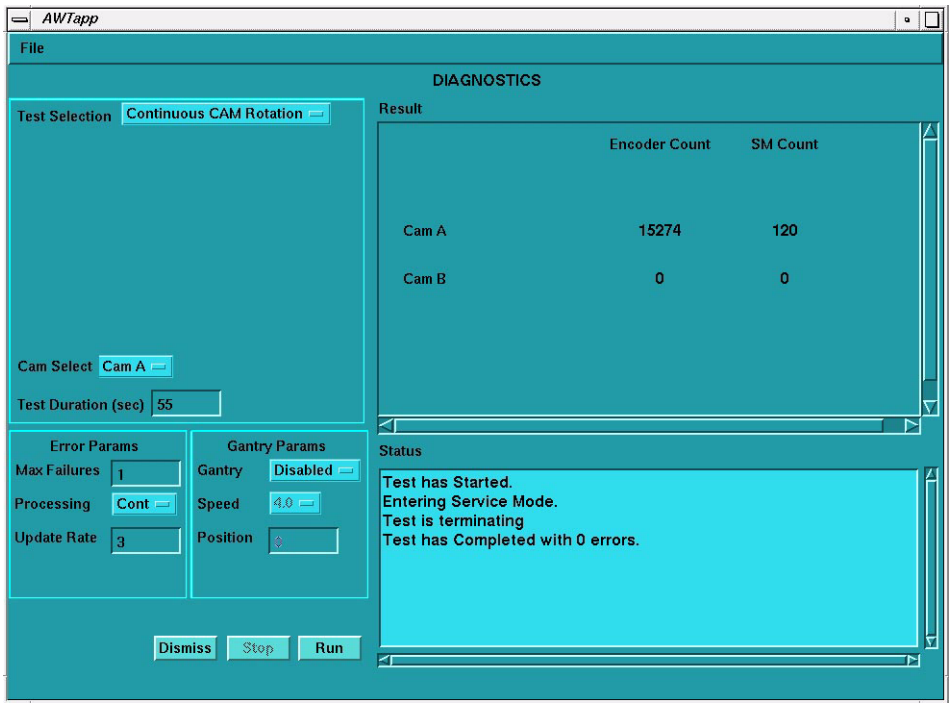


Figure 9-25 Collimator CAM Continuous Rotation Test

3.7.2 CAM A/B Encoder Checkout Procedure

OBJECTIVE

Verify that the CAM A/B Encoder is functional.

REFERENCES

Schematics - Collimator Control Board

Before beginning this procedure, please read the safety information in "Gantry," on page 37.

PROCEDURE SUMMARY

1.) Select SERVICE DESKTOP.
2.) Select DIAGNOSTICS.
3.) Select COLLIMATOR AND FILTRATION.
4.) Turn **OFF** the Axial Enable switch on the **STC** backplane.
5.) Engage gantry rotational lock.

DANGER **USE PROPER LOCKOUT/TAGOUT PROCEDURES TO PREVENT UNEXPECTED GANTRY MOTION.**

6.) Exercise the CAM A/B encoders and verify no test failures. Reference Figure 9-26.

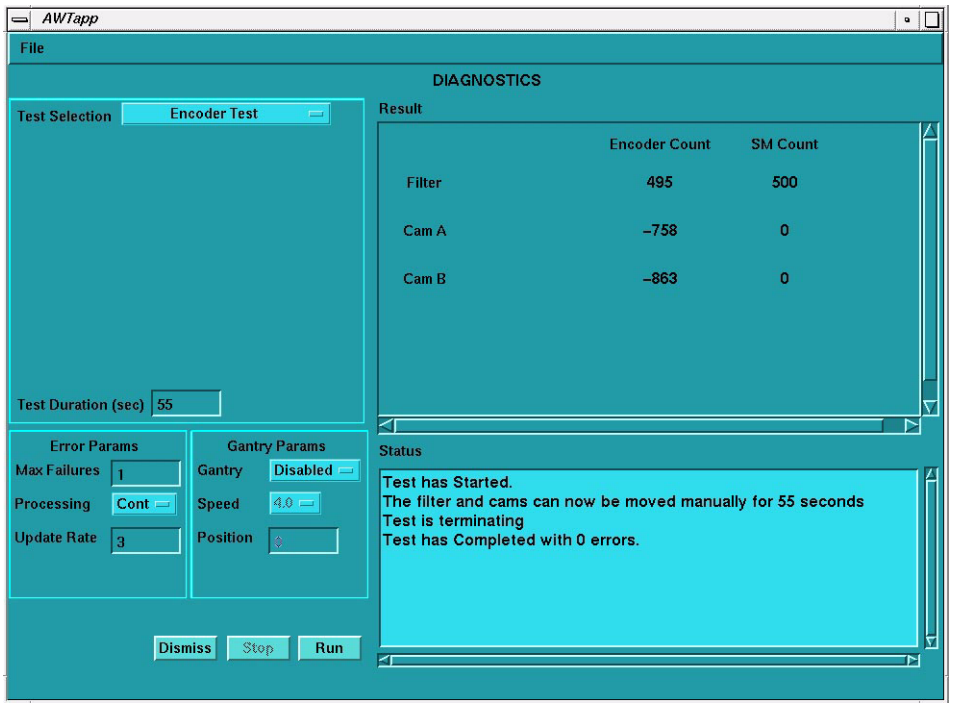


Figure 9-26 Collimator CAM A/B Manual Encoder Test

3.7.3 CAM A/B Motor Checkout Procedure

OBJECTIVE

Verify that the CAM A/B Motor is functional.

REFERENCES

Schematics - Collimator Control Board

Before beginning this procedure, please read the safety information in "Gantry," on page 37.

PROCEDURE SUMMARY

1.) Ohm CAM A (or CAM B) motor windings.
2.) Swap CAM drive harness with other CAM.
3.) Perform "CAM A/B Encoder Checkout Procedure," on page 746.

3.7.4 Collimator Control Board Checkout Procedure

OBJECTIVE

Verify that the Collimator Control (**CCB**) is functional.

REFERENCES

Schematics - Collimator Control Board

Before beginning this procedure, please read the safety information in "Gantry," on page 37.

PROCEDURE SUMMARY

1.) Verify correct "Flash" firmware is downloaded.
2.) Select SERVICE DESKTOP.
3.) Select DIAGNOSTICS.
4.) Select COLLIMATOR AND FILTRATION.
5.) Exercise the Application Position Test and verify no test failures. Reference Figure 9-27.

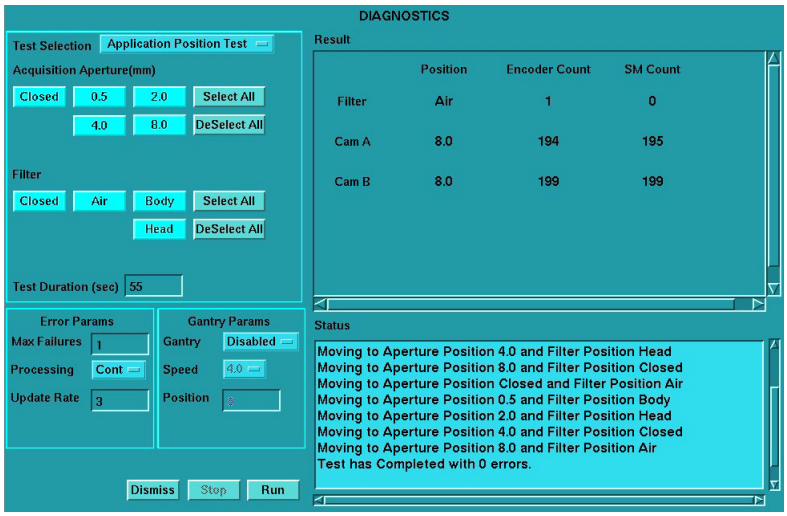


Figure 9-27 Collimator Applications Position Test

3.7.5 Characterization Software Procedure

OBJECTIVE

1.) Verify that the Characterization Software is functional.
2.) **FRU**s Involved - **MOD** / **CD** containing the most recent “System State”.
3.) Perform Flash Download if necessary.

Before beginning this procedure, please read the safety information in “Gantry,” on page 37.

PROCEDURE SUMMARY

1.) Select SERVICE DESKTOP.
2.) Select UTILITIES.
3.) Select INSTALL.
4.) Select FLASH DOWNLOAD TOOL.
5.) Select QUERY.
6.) Select UPDATE if necessary. Reference Figure 9-28.

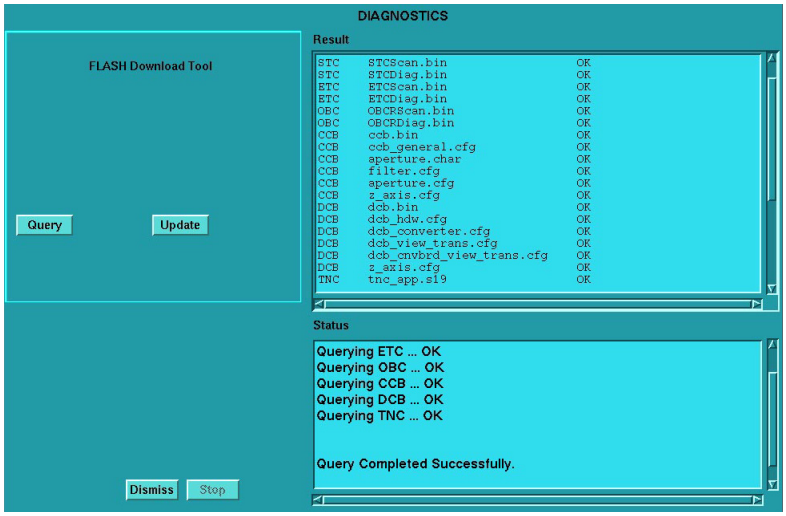


Figure 9-28 Flash Download Tool

3.7.6 Filter Amplifier Checkout Procedure

OBJECTIVE

Verify that the Filter Amplifier is functional.

REFERENCES

Schematics - Collimator Control Board

Before beginning this procedure, please read the safety information in “Gantry,” on page 37.

PROCEDURE SUMMARY

Reference “Collimator Control Board Checkout Procedure,” on page 747, for diagnostics details.

3.7.7 Filter Encoder Checkout Procedure

OBJECTIVE

Verify that the Filter Encoder is functional.

REFERENCE

Schematics - Collimator Control Board

Before beginning this procedure, please read the safety information in "Gantry," on page 37.

PROCEDURE SUMMARY

Reference "Collimator Control Board Checkout Procedure," on page 747, for diagnostics details.

3.7.8 Filter Home Switch Checkout Procedure

OBJECTIVE

Verify that the Filter Home Switch is functional.

REFERENCES

Schematics - Collimator Control Board

Before beginning this procedure, please read the safety information in "Gantry," on page 37.

PROCEDURE SUMMARY

Reference "Collimator Control Board Checkout Procedure," on page 747, for diagnostics details.

3.7.9 Filter Drive/Motor Checkout Procedure

OBJECTIVE

Verify that the Filter Drive/Motor is functional.

REFERENCES

Schematics - Collimator Control Board

Before beginning this procedure, please read the safety information in "Gantry," on page 37.

PROCEDURE SUMMARY

Reference "Collimator Control Board Checkout Procedure," on page 747, for diagnostics details.

3.7.10 Procedure for Determining State of Rotor Operation

OBJECTIVE

1.) Determine the phase of Rotor operation during which an error is generated.

2.) Reference Document:
2145832SCH Schematic - HEMRC_IF, HVDC_Sense, Chopper_Cntl, AC_Dist, **HCB**

3.) The **HEMRC** Rotor has 9 phases of operation. There are 3 accel phases, 2 Run phases, 3 Brake phases, and idle. The 3 accel phases and the 1st run phase use **HVDC**. The rest of the phases use 120 VAC stepped up to 380VAC by T1. A graphical interpretation of the 9 Phases is shown in Figure 9-29.

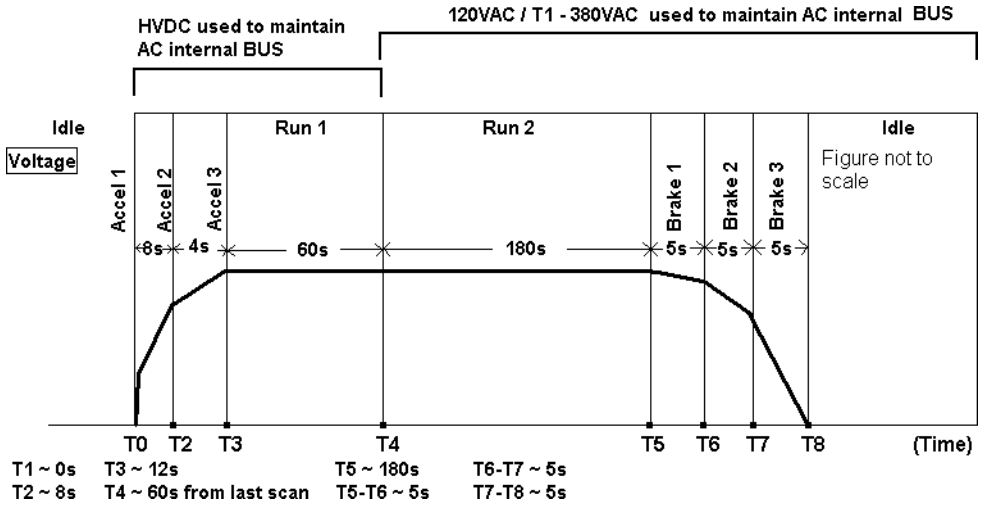


Figure 9-29 9 Phases of Rotor Operation

Before beginning this procedure, please read the safety information in "Gantry," on page 37.

PROCEDURE SUMMARY

The best way to determine the phase is to understand which part of the scan cycle the rotor is in. This can be done by listening to tube accel, run and Brake noises coming from the tube:

- Tube will accelerate when commanded by diagnostics.(A.K.A. "Rotor Prep")
- Tube will accelerate when "Accept Rx" is checked.(A.K.A. "Rotor Prep")
- Tube will brake ≈ 180s after last slice or after last diag request.

3.7.11 HEMRC Rotor Functional Results for Normally Operating System

OBJECTIVE

1.) Give the user examples of Normal Operating Results for the Rotor Control.
2.) Reference Documents: Schematic - HEMRC_IF, HVDC_Sense, Chopper_Cntl, AC_Dist, **HCB**.
3.) Select DIAGNOSTICS.
4.) Select ROTOR CONTROL.
5.) **FRU**s Involved:
   - **HEMRC** Interface Board - **HIF** (All phases)
   - **HEMRC** AC DRIVE (All phases)
   - Fuses F1, F2 on interface Bd (would produce a Primary Error of "NO **HVDC**")
   - **HVDC** BUS (1st 4 Phases)
   - 120 VAC from Slip Ring Assembly (last 4 Phases)
   - T1 transformer (last 4 Phases)
   - Bridge rectifier - CR1 (1st 4 Phases)

Before beginning this procedure, please read the safety information in "Gantry," on page 37.

PROCEDURE SUMMARY (THEORY/BACKGROUND)

1.) The **HEMRC** rotor has 9 phases of operation. 3 Accel phases, 2 Run phases, 3 Brake Phases, and idle. The 3 Accel and the 1st run phase use **HVDC**, the rest of the phases use 120 VAC stepped up to 380VAC by T1.

2.) Run the XRAY Generation / Rotor control Diags with “Test Selection: **HEMRC** Manual”.

3.) You should be able to observe the following Parameters in the “Test Window”:

- Rotor Op Mode
- Drive Output Current
- Drive Flux Current
- Drive Torque Current
- Drive Temperature
- **HVDC** Bus Voltage
- Drive Input Voltage
- Drive Output Voltage
- Drive Output Frequency
- Rotor Ref Voltage
- Drive Status Bit Map
- Drive Fault Code
- Status Register
- Fault Register

NORMAL RESULTS WITH UNREGULATED HVDC

Mode	Accel	Accel	Accel	Accel	Accel	Accel	Accel	Accel	Accel	Accel	Accel	Run	Run	Run	Run	Run	Run	Run	Brake	Brake	Brake	Brake	Brake	Brake	Brake	Brake
Output Current	0	8.478	10.86	11.96	12.24	11.59	12	11.71	11.6	7.483	2.31	2.17	2.07	2.3	2.24	2.19	4.214	5.268	6.033	7.516	7.446	7.412	6.193
Flux Current	0	0.818	2.963	4.616	5.732	6.298	6.304	6.394	5.732	3.933	2.59	2.11	1.74	1.49	1.3	0.9	1.157	2.211	3.521	4.819	5.605	7.049	6.015
Torque Current	0	1.576	4.811	6.987	8.334	8.927	9.483	9.635	9.969	9.719	6.2	4.2	2.98	2.37	2.1	2.01	2.34	2.967	2.75	2.951	3.302	2.976	4.112
DriveTemp	42	42	42	42	42	42	42	42	42	42	42	42	42	42	42	42	42	42	42	42	42	42	42
HVDC Bus	540	541	541	540	540	542	540	541	540	542	541	541	541	541	542	542	273	85	29	11	4	1	1
Input Volt	544	538	535	537	537	537	538	537	539	543	550	566	545	545	546	542	487	601	639	634	553	481	473
Output Volt	0	56	87	112	126	142	185	232	319	106	100	99	99	99	99	99	200	200	200	236	208	100	22
Output Freq	0	50	77	99	111	126	155	194	274	297	280	280	280	280	280	280	274	258	24	221	195	100	21
Ref Volt	9.998	10	9.998	9.998	9.998	9.998	9.998	9.998	9.998	9.998	10	10	10	10	10	10	9.998	9.998	9.998	9.998	9.998	9.998	9.998
Status Bit	0E0C H	0E1F H	0E5F H	0E5F H	0E5F H	0E5F H	0E5F H	0E5F H	0E5F H	0E2F H	0F0F H	0F0F H	0F0F H	0F0F H	0F0F H	0F0F H	0E2F H	0E2F H	0E2F H	0E2F H	02EF H	0E2F H	0E2F H
Drive Fault	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Status Reg	02H	02H	02H	02H	02H	02H	02H	02H	02H	42H	42H	42H	42H	42H	42H	42H	46H	46H	46H	46H	46H	46H	46H
Fault Reg	00H	00H	00H	00H	00H	00H	00H	00H	00H	00H	00H	00H	00H	00H	00H	00H	00H	00H	00H	00H	00H	00H	00H

Figure 9-30 Results with CRPDU Unregulated HVDC

3.8 Frequency Sweeps – Tanks

3.8.1 Errors

Artifacts, **CT** Number Drifts, Shoot-through, Overcurrents, and mA problems.

3.8.2 Theory

By supplying a sinewave to the primary of the tank and varying the frequency, the impedance of the primary can be observed by measuring the RMS voltage dropped across the primary.

Note: This test only checks the tuned portion of the tanks. If this test reveals a bad tank, the tank is most likely the problem. However, if this test doesn't reveal a bad tank it doesn't absolve the tank, it only reduces the probability of the tank being the problem.

GENERAL GUIDELINES

- A good tank should show a linear rise with frequency with a peak between 40K to 100K HZ.
- A tank with shorted **HV** rectifiers or capacitors will show a peak between 2K to 20K HZ.
- A tank with a resistive failure such as carbonized insulation will show very low voltage with no well defined peak.

TOOLS

1.) BK 3001 Audio Generator, or equivalent.
2.) Meter to measure RMS voltage to 150 kHz.

FRU'S INVOLVED

Anode and Cathode Tank.

3.8.3 Summary

1.) Set up testing devices.
2.) Remove P1 and P2 wires from tank.
3.) Connect testing devices to tank.
4.) Frequency Sweep the tank using the Audio Generator.
5.) Determine disposition of tank.

Before beginning this procedure, please read the safety information in "Gantry," on page 37.

3.8.4 Procedure Details

1.) Setup meter and Audio Generator
   - Set volt meter to AC Volts.
   - Set up Audio Generator (BK3001): Leads in output jack, Range to X100, waveform to sinewave, attenuation to 0.
   - Connect leads of Audio Generator to meter and adjust amplitude knob to achieve voltage between 1 to 5 volts.
2.) Remove P1 and P2 leads from the High Voltage Tank.
3.) Connect both the BK 3001 and the RMS Meter from P1 to P2 studs.
4.) Sweep the frequency from 2KHz to 150KHz, while monitoring the RMS voltage. Write down each value for reference.
5.) For a good High Voltage Tank, a peak measurement should occur between 40KHz to 100KHz (see Table 9-39). The absence of a peak, or the occurrence of a peak at a frequency other

than 40KHz to 100KHz indicates a High Voltage Supply failure. If the RMS measurements fluctuate at the higher frequencies (i.e., 2-10 volt drift), this tank is also bad. This should be noticeable on the High Voltage waveform at high techniques or it will show as artifacts on patient scans. Replace Tank if it fails to peak within 40kHz to 100kHz,or if the voltage across the RMS meter fluctuates while frequency is stable.

6.) End of procedure.

FREQUENCY SETTINGS ON AUDIO GENERATOR (KHZ)	TANK (MV) SAMPLE VALUES FOR BAD TANK	TANK (MV) SAMPLE VALUES FOR BAD TANK	TANK (MV) SAMPLE VALUES FOR GOOD TANK
2.0	100	55	55
2.8	150	66	66
3.2	175	70	70
4.2	250	81	81
5.0	350	89	89
6.4	750	101	101
7.5	1000	110	110
8	1000	113	113
10	600	129	129
12	340	138	138
15	220	154	154
18	160	159	159
20	130	201	201
28	80	174	174
32	60	167	167
42	30	225	225
50	20	324	324
64	30	578	578
75	50	517	517
80	60	Unstable Voltage	476
100	80	Unstable Voltage	260
120	100	Unstable Voltage	174
150	140	Unstable Voltage	124

Table 9-39 Frequency / Voltage Tank Settings

3.9 Verify kV Meter

This section describes the calibration check of system internal kV metering circuits.

1.) Select READ METERING.

2.) Select RUN to start the test. During the test, the firmware reads the metering circuits in the OFF state, then reads the metering circuits in the ON state, and finally reports the readings to the display.

3.) Compare the data in the “Delta” column on the Read Meter screen (Figure 9-4) to the data in the “Limit” column.

Note: “Delta” = DVM - A/D

CIRCUIT “OFF”	CIRCUIT “ON”
Anode kV = 0 ± 0.5	Anode kV = 50 ± 7.5
Cathode kV = 0 ± 0.5	Cathode kV = 50 ± 7.5
Total kV = 0 ± 0.5	Total kV = 100 ± 15.0

Table 9-40 Generator Characterization Test Specifications

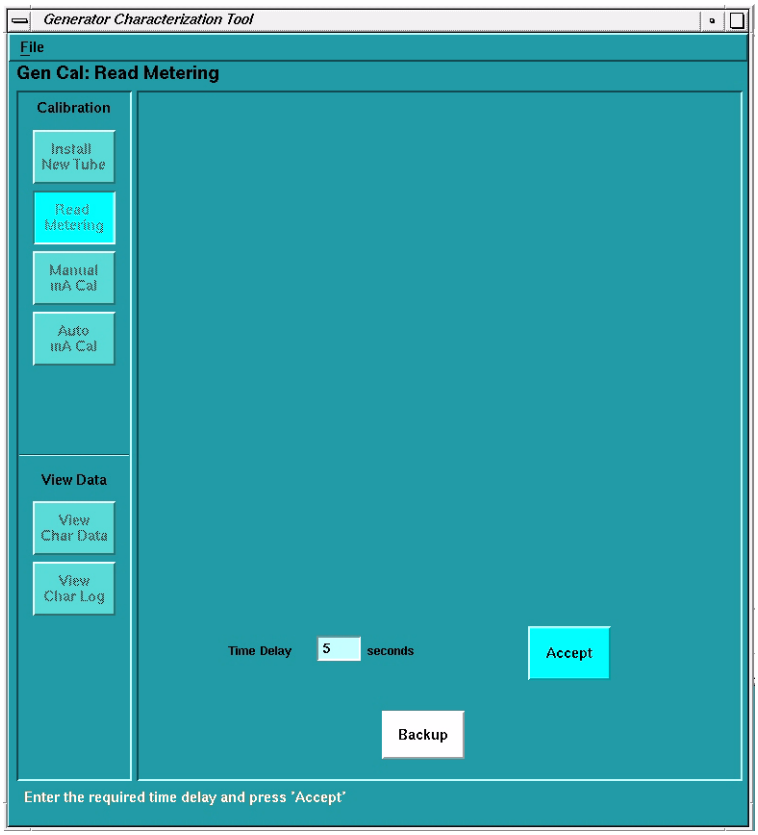


Figure 9-31 Read Metering Screen

3.10 Verify mA Meter

3.10.1 Summary

This section describes the calibration and checks system internal mA metering circuits.

1.) Launch Diagnostics.

2.) Set-up test equipment

Before beginning this procedure, please read the safety information in "Gantry," on page 37.

3.10.2 Procedure Details

1.) Inside the Gantry:

a.) Switch OFF the **HVDC ENABLE** on **STC** backplane.

b.) Switch OFF the **AXIAL DRIVE ENABLE** on **STC** backplane.

c.) Rotate the Anode tank to the 2 o'clock position.

d.) Engage gantry rotational lock.

2.) Select SERVICE DESKTOP.

3.) Select CALIBRATION.

4.) Select GENERATOR CHARACTERIZATION.

5.) Select READ METERING.

Note: On the display, enter a time delay in seconds, to provide enough time to walk from the console to the DVM, and record the reading. The test will not begin until this time delay expires.

Once it begins, the test enables the meter circuit for only 4 seconds.

6.) Use a DVM as an mA meter; connect it to the hardware on the anode side:

a.) Connect the black lead to TP8 (ACAL1) on the mA board.

b.) Connect the red lead to TP11 (ACAL2) on the mA board.

7.) On the Display, select the ACCEPT button.

8.) Record the displayed, and measured, Anode mA values for "Circuit OFF" and "Circuit ON".

Note: Your system has the test wire to TP5 included in the harness, the Cathode side should read approximately 19 mA during "Circuit On".

9.) Disconnect the test equipment from the Anode side, if used.

Note: When you exit Generator Characterization, this test may generate

```
kV board tube spit counter = x error messages.
```

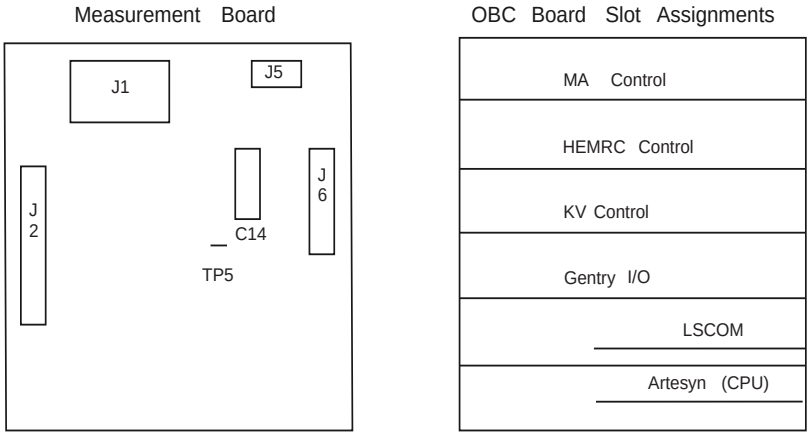


Figure 9-32 Tank Measurement Board

10.) Use a DVM as an mA meter:

a.) Connect the black lead to TP9 (CCAL1) on the mA board.

b.) Connect the red lead to TP14 (CCAL2) on the mA board.

11.) On the Display, Select the ACCEPT button.

12.) Record the displayed, and measured, Cathode mA values for “Circuit OFF” and “Circuit ON”.

Note: Your system has the test wire to TP5 included in the harness, the Anode side should read approximately 20mA during “Circuit On”.

13.) Disconnect the test equipment from the Cathode side if used.

Note: When you exit Generator Characterization, this test may generate

```
kV board tube spit counter = x error messages.
```


3.11 Set Calseed Values

3.11.1 Summary

This procedure creates the slope intercept relationship. The software needs to determine the power demands to achieve desired mA versus the loading effect of the tube.

Before beginning this procedure, please read the safety information in “Gantry,” on page 37.

3.11.2 Procedure Details

Use the following sequence to run a partial Install New Tube. Use this procedure to set the calseed values on a new system.

1.) Select UTIITIES.

2.) Select DIAGNOSTICS.

3.) Select INSTALL NEW TUBE.

4.) The system prompts you to verify the tube type.

5.) Verify the number corresponds to your tube type, answer **Y** (yes) or **N** (no):

SOFTWARE TOKEN	HOUSING #	INSERT #
12-MX_135CT	46-274800G1	46-274600G1
13-MX_165CT	46-309500G2	46-309300G1
14-MX_165CT_I	46-309500G2	46-309300G2
15-MX_200CT	2137130-2	2120785

Table 9-41 Software Tokens for Various Tube Housings & Inserts (CalSeed)

6.) Press START SCAN when it illuminates.

The system automatically runs the program and updates the display:

```
- seed filament current shift scans -
```

Note: ABORT the program after the seed filament current shift scans and before the ductility warm-up.

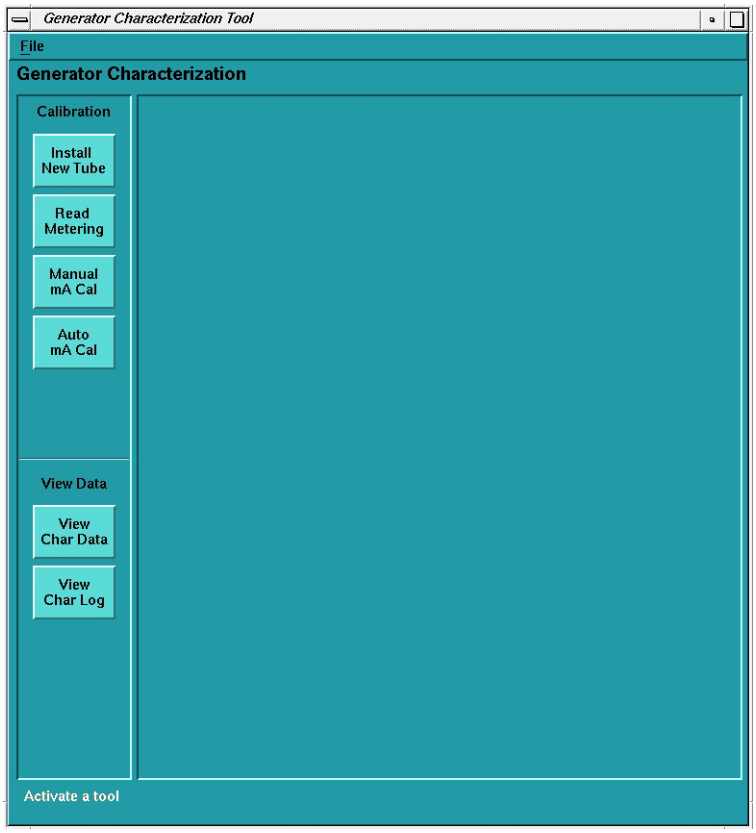


Figure 9-33 Generator Characterization Screen

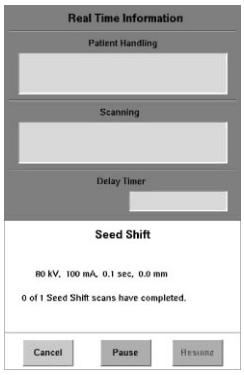


Figure 9-34 Seed Shift Real TIme Information Screen

3.12 KV Gain Pots Adjustment

Before beginning this procedure, please read the safety information in "Gantry," on page 37.

3.12.1 Install HV Divider

1.) Inside the Gantry on the **STC** backplane:

a.) Switch OFF the **HVDC ENABLE**.

b.) Switch OFF the **AXIAL DRIVE ENABLE**.

c.) Rotate the Tube to the 3 o'clock position

d.) Engage gantry rotational lock.

e.) Switch OFF the **120 VAC GANTRY POWER**.

f.) Install the **HV** Divider between Tube and Tanks.

Note: Place the **HV** Divider on a table or tube hoist, so the cables reach the tube.

2.) Add a ground wire (minimum size of AWG 12) from Tube ground to bleeder ground. Refer to Figure 9-35.

CAUTION Potential Electrical Hazard

Performix tube unit MUST be grounded to the gantry during testing.

3.) Switch ON the **120 VAC GANTRY POWER**.

4.) Switch ON the **HVDC ENABLE**.

5.) Press the button, on the gantry control panel, turning ON the drives power.

Note: If the gantry covers are removed press the **RESET BUTTON** on the **STC** backplane to turn ON Drives power.

6.) Reset the hardware.

NOTICE Potential for tube damage

Incorrect installation of anode and cathode HV cables can destroy the Performix tube unit.

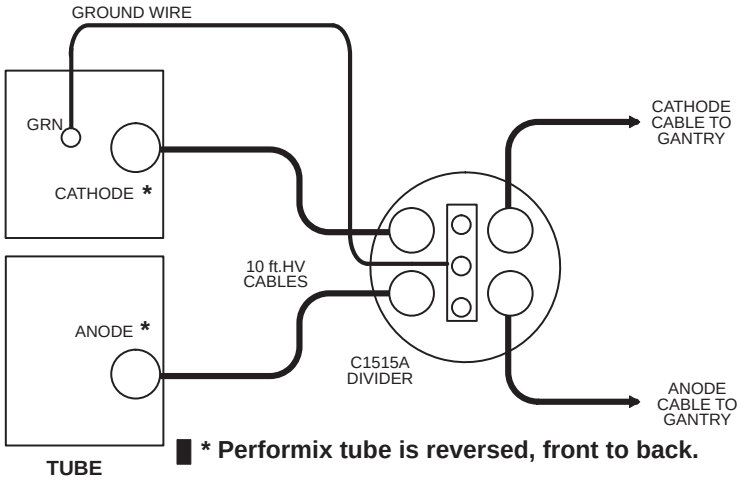


Figure 9-35 HV Divider Installation

3.12.2 Set Up Instrumentation

Use an oscilloscope with 10X probes

1.) Use the Gantry Service Outlet to provide 120 VAC power for the scope. This will reduce noise on the scope waveform.

2.) Connect **channel one** to the **anode** output of the divider. Connect the scope ground to bleeder ground.

3.) Connect **channel two** to the **cathode** output of the divider. Connect the scope ground to bleeder ground.

Note: In order to minimize bleeder-induced ripple on the kV waveform, connect a 30 foot Belden shielded twisted pair cable between the scope probes and the bleeder.

4.) Trigger channel one, positive, DC couple, trigger mode normal.

5.) Channel one and two, 10v/div, time base 200ms.

6.) Invert Channel two.

3.12.3 Calibrate the Cathode

1.) Select SERVICE DESKTOP.

2.) Select REPLACEMENT.

3.) Select DIAGNOSTIC DATA COLLECTION (DDC).

4.) Select PROTOCOL NAME.

5.) Select BLEEDER SETUP and LOAD.

6.) Verify/Set-up the following **DDC** parameters:

- STATIC X-RAY ON	Interscan Delay **2.00**
- **1 SECOND**	**DAS** Gain **31**
- **1 SCAN**	Gantry Tilt **0.0**
- FOCAL SPOT LARGE	Trigger Rate 984
- **100 KV**	Filter BLOCKED
- **50 MA**	Calibration Vector NONE
- MONITOR ENABLE	

7.) Select ACCEPT RX. The Computer Displayed reading specification for the Cathode kV and Anode kV equals 50 ± 0.5 kV.

Note: If you use scope cursors to window the trace, position the Left Vertical Cursor to the Right of the Rising Edge of the waveform. Position the Right Vertical Cursor to the Left of the Falling Edge of the Waveform.

8.) Adjust the Cathode pot on the kV board, until the scope reading for the Cathode kV, and the displayed reading for the Cathode kV in the message log, fall within ±0.5kV of each other.

9.) Use the pot, labeled CAKV, R316, on the kV board, to adjust the scope reading.

- CCW decreases the scope kV.
- CW increases the scope kV.
- 1/2 turn equals approximately 0.5 kV.

10.) Record the results on **FORM 4879**.

3.12.4 Calibrate the Anode

1.) Select SERVICE DESKTOP.
2.) Select REPLACEMENT.
3.) Select DIAGNOSTIC DATA COLLECTION (DDC).
4.) Select PROTOCOL NAME.
5.) Select BLEEDER SETUP and LOAD.
6.) Verify/Set-up the following **DDC** parameters:

- STATIC X-RAY ON	Interscan Delay **2.00**
- **1 SECOND**	**DAS** Gain **31**
- **1 SCAN**	Gantry Tilt **0.0**
- FOCAL SPOT LARGE	Trigger Rate 984
- **100 KV**	Filter BLOCKED
- **50 MA**	Calibration Vector NONE
- MONITOR ENABLE	

7.) Select ACCEPT RX. The Computer Displayed reading specification for the Cathode kV and Anode kV is 50 +/– 0.5 kV.

Note: If you use scope cursors to window the trace, position the Left Vertical Cursor to the Right of the Rising Edge of the waveform. Position the Right Vertical Cursor to the Left of the Falling Edge of the Waveform.

8.) Adjust the Anode pot on the kV board, until the scope reading for the Anode kV, and the displayed reading for the Anode kV in the message log, fall within ±0.5kV of each other.
9.) Use the pot, labeled ANKV, R318, on the kV board, to adjust the scope reading.
   - CCW decreases the scope kV.
   - CW increases the scope kV
   - 1/2 turn is approximately 0.5 kV.
10.) Record the results on **FORM 4879**.

3.12.5 Measure Total kV

1.) Select SERVICE DESKTOP.
2.) Select REPLACEMENT.
3.) Select DIAGNOSTIC DATA COLLECTION (DDC).
4.) Select PROTOCOL NAME.
5.) Select BLEEDER SETUP and LOAD.
6.) Verify/Set-up the following **DDC** parameters:

- STATIC X-RAY ON	Interscan Delay **2.00**
- **1 SECOND**	**DAS** Gain **31**
- **1 SCAN**	Gantry Tilt **0.0**
- FOCAL SPOT LARGE	Trigger Rate 984
- **100 KV**	Filter BLOCKED
- **50 MA**	Calibration Vector NONE
- MONITOR ENABLE	

7.) Change the oscilloscope to add ch.1 and ch.2, to read total kV from the **HV** divider.
8.) Channel one and two, 20v/div, time base 200ms, trigger channel. one, positive.
9.) Select ACCEPT RX.
10.) Record the scope reading, and the Average. kV displayed in the message log, in **FORM 4879**.

11.) Display the Generator Characterization menu.

12.) Toggle the soft-key MONITOR ENABLE **OFF**, so the message log no longer displays kV and mA readings.

3.12.6 Install New Tube Program

Use this program to complete Auto mA Cal on a new tube. *Run this program only on a new tube.*

Refer to Figure 9-5

1.) Select SERVICE DESKTOP.

2.) Select CALIBRATION.

3.) Select GENERATOR CHARACTERIZATION.

4.) Select the INSTALL NEW TUBE.

Note: The system automatically warms up the tube.

5.) The system prompts you with the tube type. Verify the number corresponds to your tube type; answer **Y** or **N**.

SOFTWARE TOKEN	HOUSING NUMBER	INSERT NUMBER
12-MX_135CT	46-274800G1	46-274600G1
13-MX_165CT	46-309500G2	46-309300G1
14-MX_165CT_I	46-309500G2	46-309300G2
15-MX_200CT	2137130-2	2120785

Table 9-42 Tube Type Table (SW tokens for various Housings and Inserts)

6.) Press **START SCAN** when it flashes, to automatically run the program and update the display:

```
seed filament current shift scans
```

3.12.7 Auto mA Calibration

Run this program when you replace the X-Ray tube, or the system requires recalibration.

1.) Select SERVICE DESKTOP.

2.) Select CALIBRATION.

3.) Select GENERATOR CHARACTERIZATION.

4.) Select AUTO MA CAL.

Note: The software automatically warms up the tube.

5.) Press **START SCAN** when it flashes, to automatically run the program and update the display:

```
- Ductility warm-up -
- Auto mA Cal -
```

6.) The system displays the final filament currents on the screen.

3.12.8 KV Rise and Fall Times

1.) In the **OBC**, connect a scope to the KV board.
   - Channel 1: Exposure Command EXCM, TP5. Scope ground to LGND, TP3, 2v/div
   - Channel 2: Total kV KVTB, TP11. (At this test point KV = 20KV per volt.) Scope ground to AGND SGND, TP12, 1v/div

2.) Set the Scope Time base to 200 usec.
   Positive or Negative trigger as required.

3.) Select DIAGNOSTIC DATA COLLECTION (DDC).

4.) Select PROTOCOL NAME.

5.) Select RISEFALL and LOAD.

TECHNIQUE		RISE		FALL	
kV	mA	**Record** Delay ms	Limit	**Record** Delay ms	Limit
80	400		0 +1.9 ms	Test not required.	N/A
140	40	Test not required.	N/A		-0 +0.5 ms

Table 9-43 kV Rise and Fall Time Record Table

Note: See Figure 9-36 and Figure 9-37, for measurement clarification.

3.12.8.1 Measure Rise Time

1.) Verify/Set-up the following **DDC** parameters:
   - STATIC X-RAY ON — Interscan Delay **2.00**
   - **1 SECOND** — **DAS** Gain **31**
   - **1 SCAN** — Gantry Tilt **0.0**
   - FOCAL SPOT LARGE — Trigger Rate 984
   - **80 KV** — Filter BLOCKED
   - **400 MA** — Calibration Vector NONE

Note: Measure rise time only on the 80kV/400mA scan.

2.) Select ACCEPT RX.

3.) Select PAUSE after the start of scan, to prevent the scope from displaying the fall time.

4.) After you record the rise time, select the RESUME to initiate the fall time scan.

5.) Record the delay between the rise of the EXCM signal, and the 75% threshold crossing of the **selected kV** (on **FORM 4879**).
   - Do not include the waveform overshoot.
   - The 75% point for 80kV equals 60kV

Note: Refer to Figure 9-36 for measurement clarification.

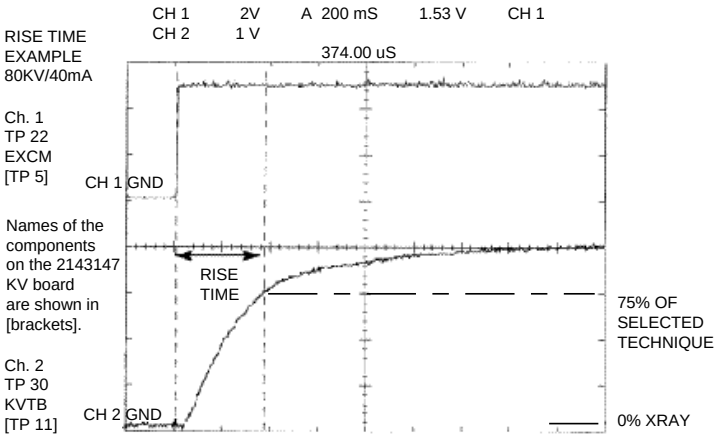


Figure 9-36 Rise Time Measurement

Note: The 75% point for:

- 80kV equals 60kV
- 100kV equals 75kV
- 120kV equals 90kV
- 140kV equals 105kV

3.12.8.2 Measure Fall Time

1.) Verify/Set-up the following **DDC** parameters:

- STATIC X-RAY ON	Interscan Delay **2.00**
- **1 SECOND**	**DAS** Gain **31**
- **1 SCAN**	Gantry Tilt **0.0**
- FOCAL SPOT LARGE	Trigger Rate 984
- **140 KV**	Filter BLOCKED
- **40 MA**	Calibration Vector NONE

Note: Measure fall time only on the 140kV/40mA scan.

2.) Record the delay between the fall of the EXCM signal, and the 75% threshold crossing of the **selected kV** (on **FORM 4879**).

- Do not include the waveform overshoot.
- The 75% point for 140kV equals 105kV

Leave the scope connected for the next test.

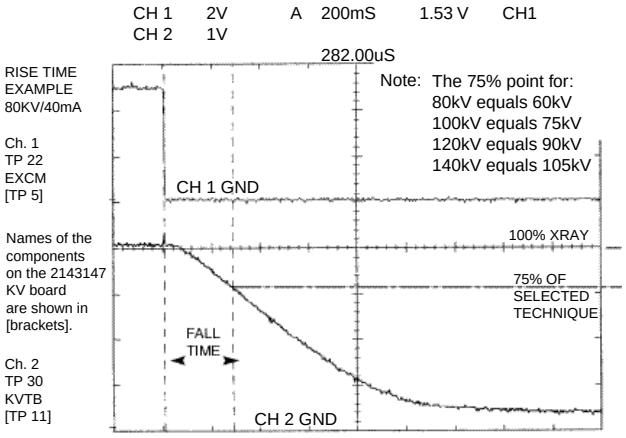


Figure 9-37 Fall Time Measurement

3.12.9 Verify Internal Scan Timer

1.) Select DIAGNOSTIC DATA COLLECTION (DDC).
2.) Select PROTOCOL NAME.
3.) Select SCANTIMER and LOAD.
4.) Toggle the softkey MONITOR ENABLE to **ON**, to display the scan time in the message log.
5.) In the **OBC**, connect a scope to the kV board, as follows:
   a.) Channel 1, Exposure Command (EXCM, TP22). Scope ground to TP3, 2v/div
   b.) Channel 2, Total kV, TP11. Scope ground to SIG, TP12, 1v/div
   c.) Set the Scope Time base to 200msec, positive trigger.
6.) Verify/Set-up the following **DDC** parameters:

- STATIC X-RAY ON	Interscan Delay **2.00**
- **1 SECOND**	**DAS** Gain **31**
- **1 SCAN**	Gantry Tilt **0.0**
- FOCAL SPOT LARGE	Trigger Rate 984
- **100 KV**	Filter BLOCKED
- **40 MA**	Calibration Vector NONE

7.) Record the measured scan time from the oscilloscope and the displayed scan time from the message log. Spec limits are as follows:

Note: Scope Exposure Duration = 0.96 to 1.04 s.
Displayed Exposure Duration = 0.99 to 1.02 s.

8.) Toggle the softkey MONITOR ENABLE **OFF**, to stop the scan time display in the message log.
   Failure to turn the MONITOR ENABLE **OFF** results in the system message log filling with exposure information.
9.) Disconnect the scope from the kV board.
10.) Replace the **OBC** cover**.**

3.13 Tube Usage Statistics

The System Browser is used to display information about the currently installed tube as well as previously installed tubes. The Tube Usage viewer provides three different levels of information viewing for Tube Usage: Summary, Details, and Cumulative.

Note: For Tube Warranty purposes ‘Warranty Effective Slices’ is the correct number to report upon tube unit failure.

Figure 9-38 shows an example of the Tube Usage Screen. This screen allows you to select Summary, Details or Cumulative Statistics. If previous tubes had been installed on this example system, the other tubes would be listed in the Option window by descending install date.

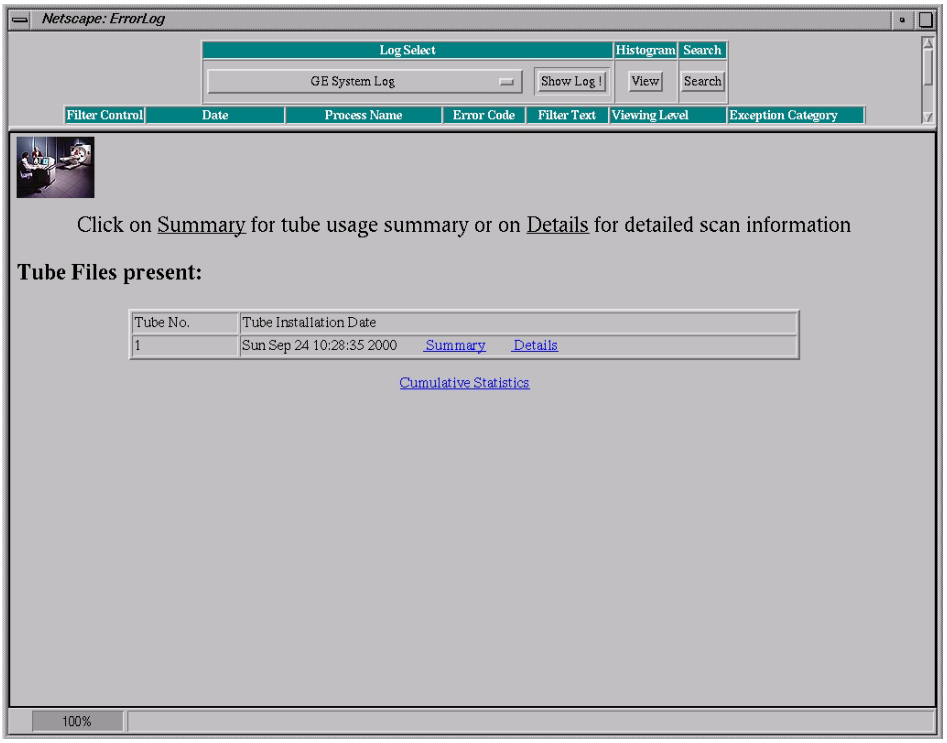


Figure 9-38 Tube Usage Screen

3.13.1 Tube Usage Details Information

The Tube Usage Details information identifies the selected Tube Unit and Site Information plus details on the types and number of scans taken on that tube unit. Refer to Figures 9-39 and 9-40 for examples of the display.

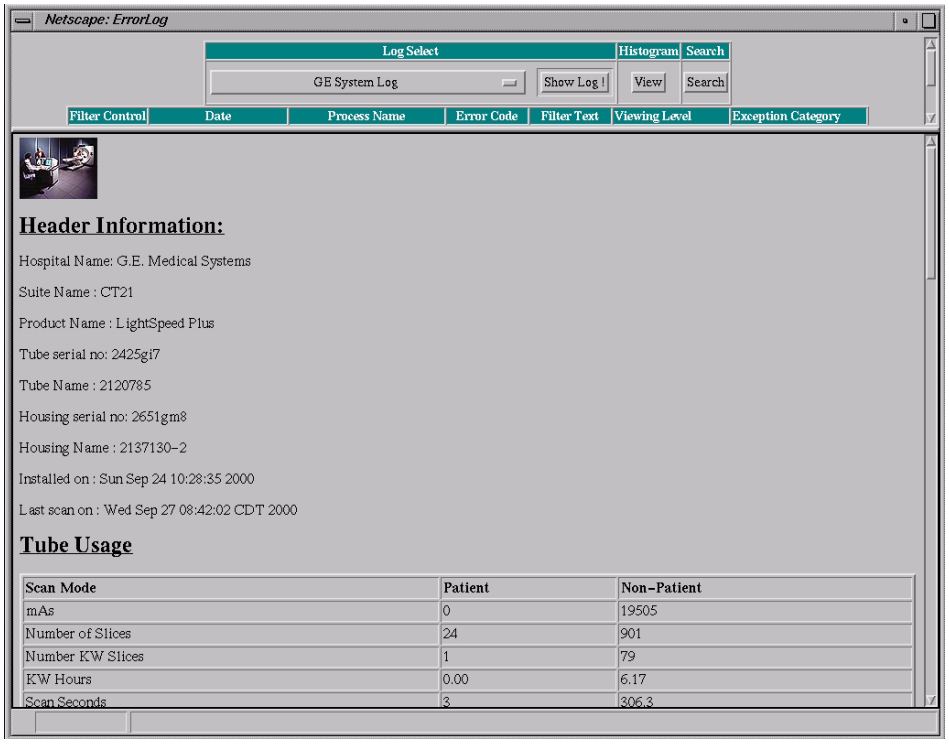


Figure 9-39 Tube Usage Detail Example

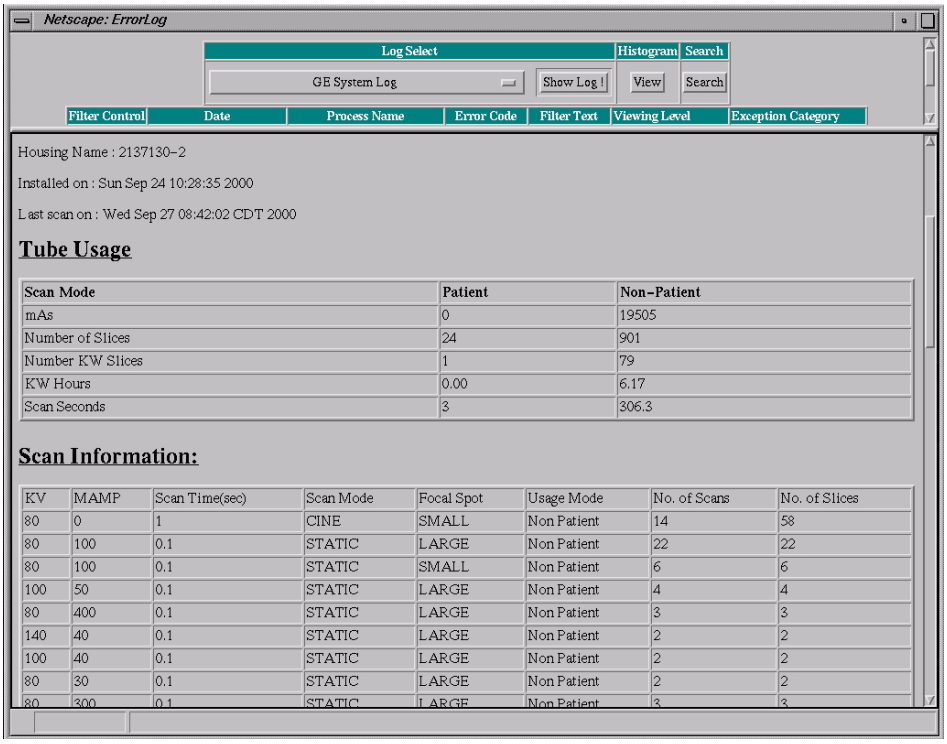


Figure 9-40 Tube Usage Details Screen showing partial Scan Information

3.13.2 Tube Usage Cumulative Information

The Tube Usage Cumulative Information displays the totaled tube usage information for all tubes that have been installed on the system. Refer to Figure 9-41 for an example of the display.

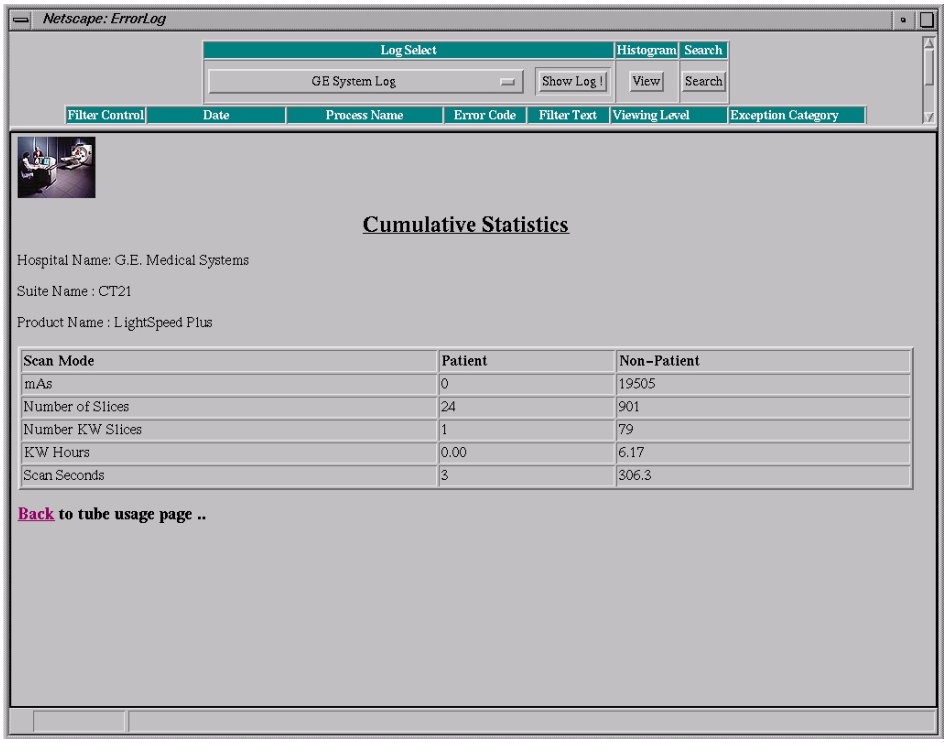


Figure 9-41 Tube Usage Cumulative Example.

3.14 Change Tube (New Tube) Program

New Tube prepares the system to store tube usage statistics, for trend analysis and tube warranty purposes. Before beginning this procedure, please read the safety information in "Gantry," on page 37.

1.) Select REPLACEMENT.
2.) Select CHANGETUBE.
3.) Refer to the list in Table 9-44, and type/enter the failure code for the defective tube in the "Tube Unit Failure Code" field on the screen.

failcode **ENTER**

FAILURE CODE	FAILURE CODE
AI: Image Artifact	OH: Other-Housing Related
BG: Broken Glass	OL: Generator Overload
CA: Casing Arcing	OR: Other-Rotor Related
CB: Casing Bubbles/Particles Seen	PF: Overheat/Pump Failure
CL: Casing Oil Leak	PT: Pulled Tube (No Failure)
GS: Grid Short	RF: Frozen Rotor
OC: Other-Cathode Related	RN: Noisy Rotor
OE: Tube Loss Due to Failure Elsewhere	SD: Shipping Damage/Error
OF: Open Filament	SS: Stator Open/Stator Short
OG: Arcing	XL: Low X-Ray Output

Table 9-44 Tube Failure Codes

4.) Refer to the Tube Housing; type/enter the new Tube's Insert Serial Number in the appropriate field on the screen.

Insert Serial Number

5.) Refer to the Tube Housing; type/enter the new Tube's Housing Serial Number in the appropriate field on the screen.

Housing Serial Number

6.) Click OK to accept these changes. (Refer to Figure 9-42.)

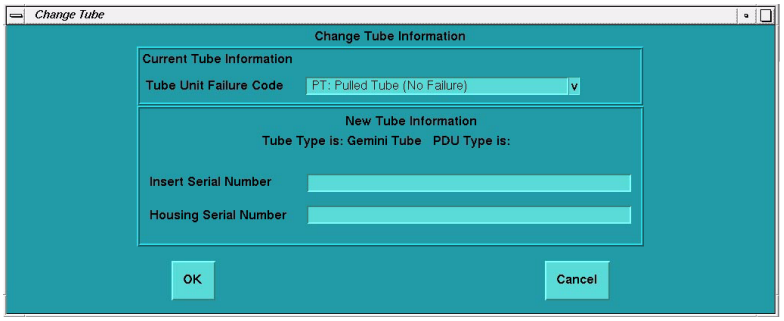


Figure 9-42 Change Tube Screen

3.15 X-Ray Tube Heat Soak and Seasoning

3.15.1 Heat Soak and Seasoning Overview

The Heat Soak and Seasoning program drives the scanner to perform a set of scans, which when taken in the proper sequence and with the correct time intervals between scans can extend the life of **CT** tubes. This program is run by service personnel whenever deemed necessary through observing the number of tubespits during actual scan operations. The entire protocol consists of three phases that will be executed in sequence.

This program seasons a new tube by first performing a tube heat soak. This process is done to remove any undissolved gases in order to minimize the occurrence of mA overloads.

After the heat soak, a high voltage stability test (Seasoning) is performed to verify that the tube is stable. Real time feedback of high voltage stability is provided to the user in order to determine if the current technique scans must be repeated. Because some of the scans used in this procedure are not used in normal patient scanning, special calibration scans are needed to determine the parameters needed to make these scans.

The Heat Soak and Seasoning procedure can be thought of as a series of alternating calibrations and scans. The particular sequence and parameters differ with the tube's type. In some cases, tube cooling delays need to be determined so that scans can be completed without need for extra cooling delays.

3.15.2 Tube Warmup

The Tube warmup phase of the Tube Heat Soak and Seasoning procedure raises the temperature of the tube slowly in order to prepare it for the high power scans that will follow. This phase is very important to minimize target damage when it is suddenly subjected to high energy input.

3.15.3 Heat Soak

New tubes may have undissolved gases that could render the tube unusable due to excessive arcing. The purpose of the heat soak phase is to redissolve gases in the tube at high temperatures in order to minimize the occurrence of current overloads. (i.e. tube spits).

The Heat Soak procedure consists of three sub-phases, which are: Heat input, Anode Soak and casing Soak. The Heat input and Anode Soak scans are performed in a dynamic series so that additional tube cooling is not necessary during the two sub-phases.

- Heat Input

  This phase heats the target up to maximum heat storage. This heats the target and other parts of the tube to maximum temperature for proper de-gassing. At the same time, the tube "getter", a chemical that absorbs gases, is heated up to its activation temperature to absorb the gases in the tube.
- Anode Soak

  This phase maintains the target at maximum heat storage and maximum temperature to continue the de-gassing and absorption of gases by the getter.
- Casing Soak

  In this phase, the tube unit is heated up to the casing heat storage limit. This heats the oil to a point where gases can be reabsorbed by the oil.

3.15.4 High Voltage Seasoning

High Voltage seasoning eradicates any small micron sized particles that may be in the tube insert. Left in the tube, these particles can become charged and thus, cause arcing. In addition, this segment can be used as troubleshooting tool by the service person to verify that tube operation is stable prior to customer use.

Interruptions during the automated scans are allowed only during the Seasoning phase. if interrupted, scanning can be resumed from the previous scanning station till completion. The state entered on an interruption is called the manual mode.

3.15.5 Heat Soak and Seasoning Procedure

1.) Select REPLACEMENT.
2.) Select DDC.
3.) Select LOAD PROTOCOL.
4.) Refer to Table 9-45, and load each protocol individually.

Tube Heat Soak and Seasoning Protocols

The Tube Heat Soak and Seasoning protocol for the MX_200CT tube (Performix) is given below. Refer to Performix tube replacement procedures. All scans are done with the tube's large focal spot. The scan time and interscan delays specified in the protocols listed must be rigidly enforced.

The execution of the scans listed must follow certain rules. The tube warm up stage is optional depending on the temperature of the tube. The next five scan groups (Heat Input to Casing Soak 2) must be executed without interruptions (if possible). If the protocol is stopped during this period, it is recommended that this entire group of protocols be executed again. During Seasoning, execution may be stopped at the operator's discretion and can be either resumed or started once again from the previous scan group.

MX_200CT Protocol	Scan Group	kV	mA	# of Scans	ISD (sec.)	Scan Time (sec.)	Pre Group Delay (sec.)	Static / Rotate (4.0sec)
warmup1	1	120	200	3	2	5		R
warmup2	1	100	220	7	1	4		R
hss_heat_1	1	80	100	15	2	2	2	R
	2	80	300	24	2	3	2	R
hss_heat_2	1	100	320	17	5	3	2	R
hss_soak	1	100	320	10	3	1	2	R
	2	100	270	90	16	2	60	R
hss_season1	1	100	50	10	5	1	5	R
hss_season2	1	100	50	5	5	1	5	R
hss_season3	1	100	50	5	5	1	5	R
hss_season4	1	120	50	5	5	1	5	R
hss_season5	1	130	50	5	5	1	5	R
hss_season6	1	135	50	5	5	1	5	R
hss_season7	1	140	50	10	5	1	5	R
hss_season8	1	145	50	10	5	1	5	R
hss_season9	1	150	50	15	5	1	5	R

Table 9-45 MX_200CT HEAT SOAK AND SEASONING PROTOCOL

3.15.6 Hot ISO

Hot ISO is a software procedure that does not require any physical adjustment. It is a set of calculations used to improve image quality due to focal spot movement as the tube is heated.

Hot ISO requires that the tube be heated to near maximum capacity so that the total drift of the focal spot can be measured. Heat Soak and Seasoning (**HSS**) heats up the new tube to near maximum storage for tube Seasoning. ISO scans are added between the heating scans and the season scans of the **HSS** feature with minimal impact on both tube change time and **HSS**.

The ISO values that result from Hot ISO requires four new fields in ScanHardware.cfg (two to store the drift values of each of the spots (small & large) and two to store the ISO values of the cold spots (small & large). These values will also have to be stored in the INFO file for Save/Restore of system state.

3.16 Exposure Backup Timer Functional Test

Use this test to verify the backup timer operation (i.e., timer activates, timer counts down to zero and backup contactor de-energizes).

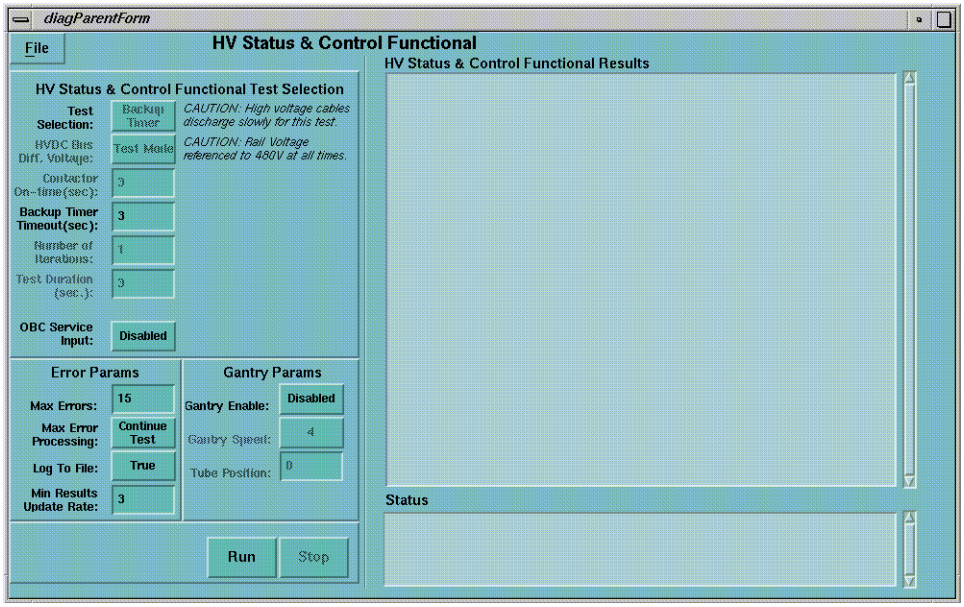


Figure 9-43 Backup Timer Diagnostic Screen

The Gentry I/O Board contains the backup timer. The software loads the scan time +5% into the backup counter before the start of exposure. The extra 5% gives the backup contactor time to energize. The backup timer begins counting down when the system detects the **HV** ON or Exposure Command. If either of these conditions persist after the timer counts down to zero, it sends a level 1 interrupt to the **CPU** and disables the backup contactor.

The read and write verification requires the operation of the clock and clock select circuits. This diagnostic tests both the 488.28 Hz and 1953 Hz clocks. The diagnostic simulates an exposure, and verifies that the circuit generates a backup timer interrupt.

The system posts a test status message to the screen while it runs the corresponding test.

The Backup Timer Timeout defaults to three seconds, which should provide enough time to verify operation of the backup timer.

1.) Select DIAGNOSTICS.
2.) Select BACK-UP TIMER GENERATOR.
3.) Select RUN.

- The results window indicates the progress of the test, and not the state of the hardware.
- The screen information updates one line at a time, as each step completes.
- If a failure occurs, the system posts an inverted video error message indicating a test abort after the failing step.

3.17 X-Ray Interlock Functional Test

This function tests the ability of the X-Ray interlock to disable an exposure. The test opens and closes the **STC** and **DIP** Board interlock relays and verifies the state of the Gentry I/O interlock sensor. In the event of a fault, the test allows the user to loop on this condition indefinitely, for troubleshooting purposes.

1.) Select DIAGNOSTICS.

2.) Select X-RAY INTERLOCK.

Note: When making selections:

- You may select other tests from this screen by clicking mousebutton one on the test selection softkey, or by clicking mousebutton three over the test selection softkey to display the following pop-up selection menu.
- When you select Run, the system checks the scan subsystem for resident firmware. If the system does not detect the firmware, it posts a message to inform you that it needs to download firmware. It prompts you to select YES to download the firmware.

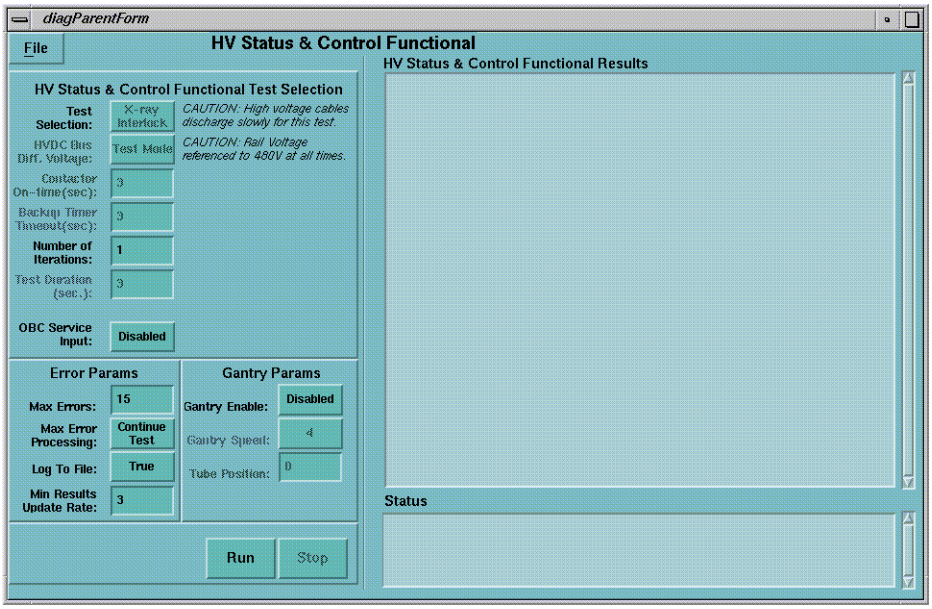


Figure 9-44 X-Ray Interlock Functional Test results example

3.18 X-Ray Exposure Manual Test

Before beginning this procedure, please read the safety information in "Gantry," on page 37.

1.) Select DIAGNOSTICS.

2.) Select KV & MA (X-RAY).

It assumes your baseline is accurate. Test this baseline with a bleeder at least once a year.

Figure 9-45 shows the **X-Ray Functional Test screen**. Input ranges are:

- **KV:** 60 to 140KV in 1KV steps
- **mA:** 40 to 400mA in 1mA steps (10 to 440 mA with Performix tube and CRPDU)
- **Duration:** 1.0 to 10 Seconds in 0.1 second steps
- **Iterations:** 1 to 100
- **ISD:** 1 to 60 Seconds in 1 second steps

Select RUN and wait for the Scan Start button on the console keypad to illuminate. Press the Scan Start button, when lit, to initiate the scan.

The X-Ray Functional Test Results screen output consists of **HV** statistics. The data displayed was taken 1007ms into the exposure and was posted to the screen. ("_" indicates an unknown value.)

- *Average:* the average value taken over the duration of the exposure.
- *Selected:* the value prescribed by the user.
- *Last Sample:* the last value read before the screen updated. The Last Sample exposure duration displays the data collection time, **in milliseconds, from the start of exposure**.

Data displayed in the Last Sample column represents the last sample of **HV** statistics taken on or before 1007 milliseconds after the start of the exposure.

Figure 9-45 represents the screen at the end of the exposure. You can tell the exposure has ended because the Last Sample exposure duration equals or exceeds the Selected exposure duration value.

Note: Backup timer determines exposure duration

The backup timer determines the exposure duration. This timer stops counting after the system removes the Exposure Command and **HV** ON status, which means the last exposure could have occurred later than indicated.

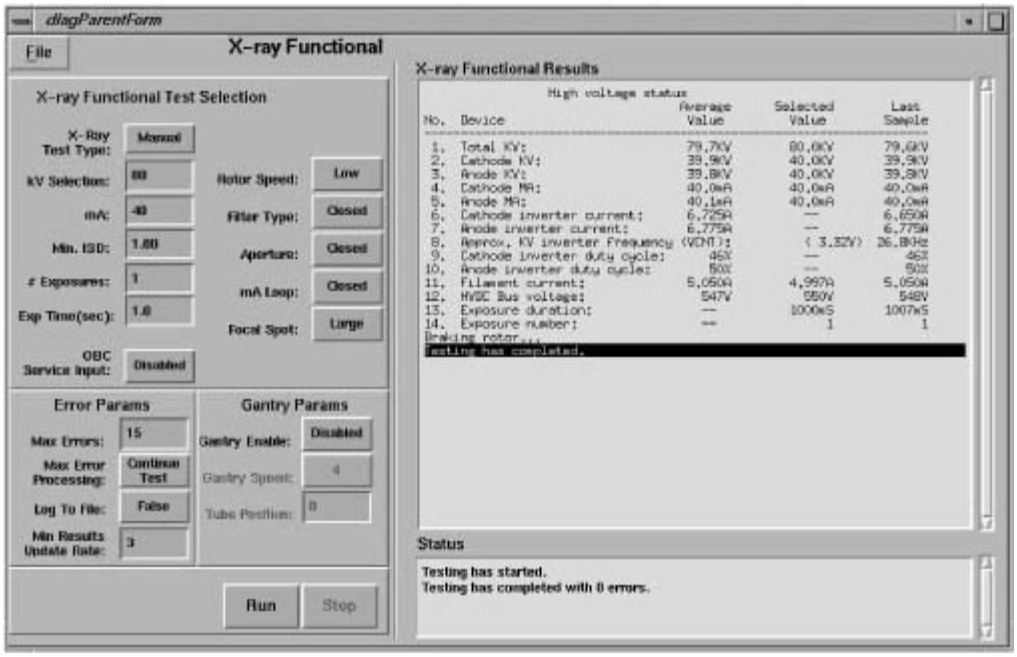


Figure 9-45 X-Ray Functional Test Results Example

3.19 OBC CPU (Artesyn III) - GE Specific Settings

For **STC CPU** see Chapter 8, Section 2.15, on page 602, and for **ETC CPU** see Chapter 6, Section 2.4, on page 425.

3.19.1 OBC CPU (Artesyn III) Board Layout

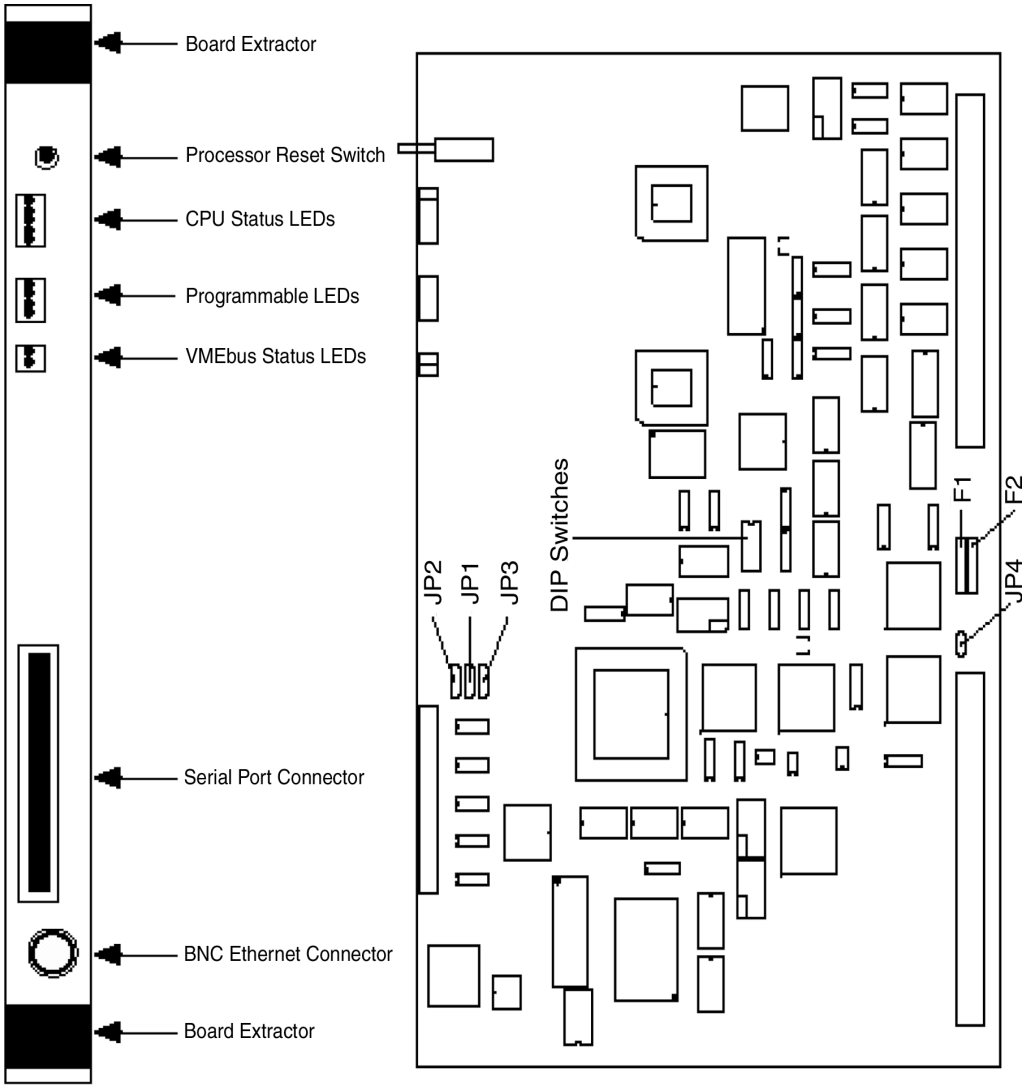


Figure 9-46 OBC CPU (Artesyn) Board Layout

3.19.2 CPU Board Jumpers

JUMPER	FUNCTION	GE CONFIGURATION	COMMENTS
JP1	Port A RI/DCD	J1:1-2	
JP2	Port B RI/DCD	J2:2-3	
JP3	RS-232 Handshaking	J3:1-2	
JP4	Watchdog Enable	removed	Watchdog Disable

Table 9-46 OBC CPU (Artesyn III) Board Jumper Settings

3.19.3 DIP Switch Settings

See board (Figure 9-46, above).

SWITCH NUMBER	CONFIGURATION		FUNCTION	COMMENTS
1	OFF	OPEN	**OBC** node	Selects board for **OBC** Chassis
2	ON	CLOSED	**OBC** node	Selects board for **OBC** Chassis
3	OFF	OPEN	Primary Nodes	selects primary nodes
4	OFF	OPEN	n/a	Not applicable
5	ON	CLOSED	nbsClient view	View logs via nbsClient/**LAN**
6	OFF	OPEN	n/a	Not applicable
7	ON	CLOSED	**EPROM** Boot	Power Up view **EPROM** Boot
8	OFF	OPEN	Test Disable	Self Test Mode disabled

Table 9-47 OBC CPU (Artesyn) Board DIP Switch Settings

3.19.4 Power-Up Self-Test

The **CPU** board will undergo a Power-Up Self-Test that lasts approximately 18 seconds. After the proper setting of the **EPROM**s, DIP switches and board jumpers, the **CPU** board will be placed into a **VME** chassis. The **LSCOM** board must be present for the successful completion of the Power-Up Self-Test.

Upon power up, the self test begins, the **LED** display is at the value ‘E’ and the test will perform the instruction Set and **EPROM** Checksum Test. When the test is done, the **LED** value will proceed to the next descending value, ‘D’, and will perform the **RAM** verification test. In the same manner, when this test is done, the **LED** value will proceed to ‘C’, then ‘B’, then ‘A’ and finally to ‘9’. After the test at ‘9’, the self test is now done.

When the test is completed, the **LED** values displayed will indicate if any tests have failed. Reference Table 9-48. If a failure is detected the **EPROM**s, dip-switch settings, Ethernet cable, and the board jumpers should be re-checked to ensure proper setup. Then the self test should be re-run. The board must pass the test before shipment. See Figure 9-46, for location of these **LED**s.

LED # 1234	LED HEX	LED ASSIGNMENT	DURATION
xxxo	E	Instruction Set and **EPROM** Checksum Test	1 second
xxox	D	**RAM** Verification	13 seconds
xxoo	C	CIO Unit Test	0.3 seconds
xoxx	B	Internal Loop Back	1 second
oxox	A	External Loop Back	1 second
oxxo	9	Transmit Test	1 second
x = on o = off			

Table 9-48 OBC CPU (Artesyn III) Board Power Up LEDS

3.19.5 Power-Up Self-Test Results

On Power-up, the **OBC** controller displays the results of its self tests. Power must remain off to a controller for at least 60SEC or Self-test may not be run or results may be inaccurate. This is because the dynamic ram retains the CPON information. In this event, power-up tests are bypassed and the results of the last. power-up test displayed on **LED**s.

1 2 3 4	HEX	LED ASSIGNMENT
• • • •	F	Not Available - - Do Not Use for a test
• • • o	E	Artesyn (see Table 9-50 for details)
• • o •	D	Artesyn (see Table 9-50 for details)
• • o o	C	Artesyn (see Table 9-50 for details)
• o o o	8	LSCOM (see Table 9-51 for details)
o • • •	7	LSCOM (see Table 9-51 for details)
o • • o	6	LSCOM (see Table 9-51 for details)
o • o o	4	spare for GE future use
o o • •	3	spare for GE future use
o o • o	2	spare for GE future use
o o o •	1	spare for GE future use
o o o o	0	Not Available - - Do Not Use for a test
• = LED ON, o = LED OFF, 1 = LED MSB, 4 = LED LSB		

Table 9-49 OBC Self-Test LED Outputs

3.19.5.1 ETC, STC & OBC (Artesyn) Tests

FUNCTION	LEDS	DESCRIPTION
Initialization	(F: • • • •)	Setup interrupt vectors & CIO
Failure	(E: • • • o)	CPU HALTS
Processor/PROM Checksum	(E: • • • o)	68000 Instruction set check (ram used) ROM Verified using CRC16 based polynomial
Failure	(E: • • • o)	CPU HALTS
Ram Verification -	(D: • • o •)	Each word of memory R/W 16 times
Failure	(E: • • • o)	CPU HALTS
CIO Verification	(C: • • o o)	Checks interrupts, timers, counters (no VME)
Failure	(E: • • • o)	CPU HALTS
• = “on” o = “off”		

Table 9-50 Artesyn Board Related LED Readouts

At this point the type of node (ETC, STC or OBCR) determines the tests that are run.

3.19.5.2 OBC (OBCR) - LSCOM/Communications Test

FUNCTION	LEDS	DESCRIPTION
Module Present test	(8: • o o o)	Checks for Presence of TAXI
Failure	(8: • o o o)	Flashes, possibly with other failures
VME FIFO test	(7: o • • •)	Checks VME path using loop-back
Failure	(7: • o o o)	Flashes, possibly with other failures
DAS FIFO test	(6: o • • o)	Checks DAS path using loop-back
Failure	(6: • o o o)	Flashes, possibly with other failures
• = “on” o = “off”		

Table 9-51 OBCR LSCOM/Communications Related LED Readouts

3.20 OBC Backplane

A manual Laser Light test switch resides on this board. The Filament relay is on the back side of this board. Reference Figure 9-47.

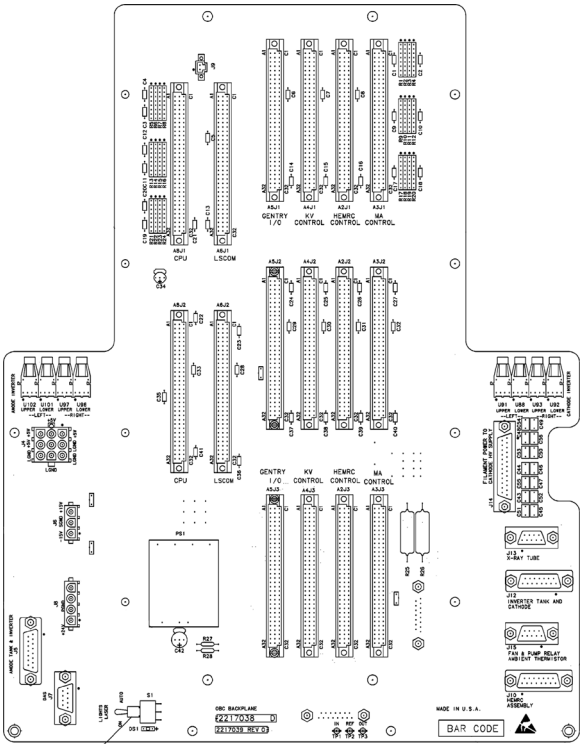


Figure 9-47 OBC Backplane Laser Test Switch

3.21 OBC Power Interface

This board provides power distribution for the **OBC** and **HV** subsystem, and includes several fuses (Figure 9-48 and Table 9-52). The board also contains a circuit that monitors the Tube Fan and Pumps, and reports any sensed failures, including open fuse detection. See the schematics for circuit details.

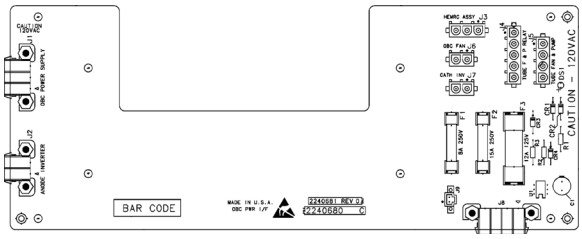


Figure 9-48 OBC Power Interface Board Fuse Locations

FUSE #1	VALUE	DESCRIPTION
F1	8A, 250v	Cathode, Anode Inverter, **OBC** Fan and **OBC** power supply.
F2	15A, 250v	**HEMRC** Assembly.
F3	12A, 125v	Tube Fan and Pumps.

Table 9-52 OBC Power Interface Fuses

Section 4.0
Collimator Theory of Operation

The mechanics of the collimator are controlled by firmware. The Collimator Control Board (**CCB**) is the interface between the firmware and the mechanics. The basic function of the collimator is to set the x-ray beam width at the patient and provide filtering of the beam for the proper “hardness”.

4.1 Collimator Control Board (CCB)

This Collimator Control Board has five major functions:

1.) The Core Controller for processing and control.
2.) Communications using the Controller Area Network (**CAN**) Interface with Fault & Reset signals.
3.) CAM positioning.
4.) Filter positioning.
5.) Voltage regulation and referencing.

4.1.1 Major Function List

Table 9-53 lists the major functions of the **CCB**.

1.Core controller	9. Gantry **CAN** function
2.CPU332	10.**LED** function
3.Clock and Clock Loss circuitry	11.Exposure Command
4.Reset Bus	12.Trigger Clock
5.TPU and CAM drives	13.System Fault
6.RS232	14.**GCAN** RESET
7.Power Up Configuration	15.CAM drive
8.FLASH and **RAM**	16.Filter Drive

Table 9-53 Major Function List of CCB

4.1.2 Location of Parts

Figure 9-49 shows the location of parts on the **CCB**.

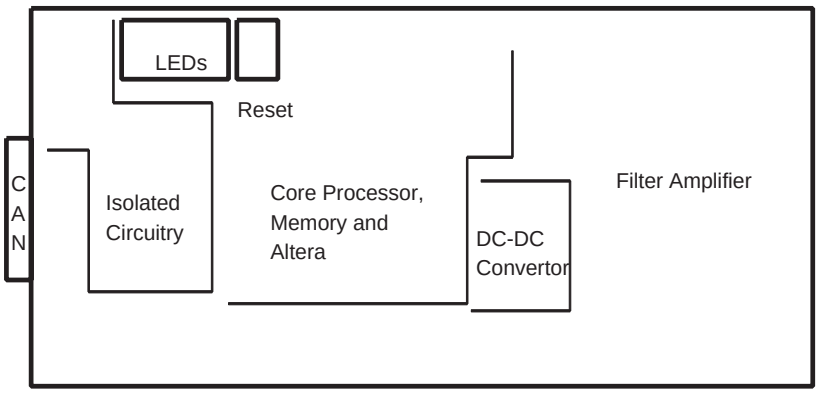


Figure 9-49 Location of Parts (CCB)

4.2 Core Controller

The “Core controller” shares functionality with the controller section of the Data Acquisition Control Board (**DCB**). The core section consists of the processor, clock and clock processing, RS232 circuitry, Flash memory and **RAM**.

4.2.1 CPU332

This comes with a 16 MHz clock and the Standard TPU (Time Processor Unit) with enhanced PPWA (Period/Pulse-Width Accumulator). The TPU is essentially a dedicated processor for time related functions.

4.2.2 Clock and Clock Loss Circuitry

The processor clock is derived off a 32.000MHz crystal oscillator, which is divided down to 16 Hz, which is fed into the processor. The clock runs through the processor and exits the chip at the CLKOUT pin before feeding the rest of the board. If the clock stops for over 9.9 mS, the missing pulse detector will pull the reset bus line low and set the clock loss bit in the Altera. This bit can only be reset by firmware command (or power cycling).

4.2.3 Reset Bus

There is one central Reset line on the **CCB**. This central line connects the **CPU**, the pushbutton reset, the external **GCAN** reset, the Background Debugging Mode connection, the Altera, and the 82527 **CAN** controller.

The external **GCAN** reset is applied by commanding GCAN_RST_P high relative to GCAN_RST_N. This puts the board into reset.

4.2.4 CPU Signal Buffering/ Conditioning

The **CPU** does not interface directly to any external devices. It buffers the signals through HCT244 devices. The following are inputs from external devices:

The CAM and Filter encoder signals are buffered inputs to the TPU as are the filter home switch and the **DAS** trigger signal. The Filter C pulse and the filter home switch are combined to form the filter home signal. The TPU is set up to decode the quadrature of the encoders and provides a 16 bit counter for each axis position.

The filter home switch contacts and the filter encoder C pulse are also buffered to the DATA bus through the “INREG” register (U24). That is the only register outside of the Altera used for data.

Outputs from the TPU are for the CAM and filter drives and these are buffered out through an HCT244.

4.2.5 TPU and CAM Drives

The TPU has a stepper motor control algorithm that is used for the CAM drives. The firmware sets of the TPU with the acceleration and deceleration rates and the step rate. When it sets the desired position the TPU takes care of the actual move. It is set up now for half step commands to the Vexta 5 phase stepper driver at a rate of 2000 steps per second for a standard aperture move.

4.2.6 RS232

The RS232 link is on the board purely for development reasons.

4.2.7 Power-Up Configuration

The Data3, Data9 are held low on reset to configure the 68332. Data3 low on reset release configures the /CS6 pin to be ADDR19 so we can access 1 MB of memory. Data9 low on release of reset turns the IRQ[7:1] lines into PortF outputs. Holding MODCLK low configures the 68332 to use an external clock source.

4.2.8 FLASH and RAM

The memory for the **CCB** consists of 8 Mbit (1 Mbyte) of 120 nS FLASH and the same amount of 55 nS **RAM**. The FLASH interfaces directly to the 68332. The **RAM** does not. The **DCB** uses the the same boot firmware. ADDR0 is not used on the memory. The read/write decode from the Altera handles the byte selection.

4.3 Gantry Controller Area Network (CAN)

A **CAN** (Controller Area Network) is used to communicate with the **HEMRC** Control Board (**HCB**) or the **DAS**. This is a serial link with a protocol and hardware interface. As part of our **CAN** physical connection we include application specific signals such as: **GCAN** (Gantry **CAN**) fault, Fault2, Exposure Command, Triggers and **GCAN** Reset.

4.3.1 CAN Function

The **CAN** controller chip is an Intel 82527. Firmware writes and reads from this chip to send and receive messages via the **CAN**. When pin 2 of the HCPL7101 is high, the output (pin 6) is high. The outputs (pins 6 and 7) of the 82C250 will be floating. This is the “recessive” bus state on the network. A logic zero from the 82527 will result in GCH (Gantry Can High) being pulled to high and GCL (Gantry Can Low) being pulled low.

4.3.2 LED Function

The 82527 has two ports on it: one is used as the data bus interface to the rest of the board; the other is used to light **LED**s. The function of these **LED**s are defined by firmware.

4.3.3 Exposure Command

The exposure command signal comes from the **HCB** and is opto-coupled into the collimator control board. When `Exposure_Command_P` is high relative to `Exposure_Command_N`, the exposure command signal output of the opto-coupler is high. This signal goes into the Altera device and where the state of the signal is latched and an interrupt to the processor is created.

4.3.4 Trigger Clock

This signal also comes from the **HCB** and is buffered through an HCT244 and sent to the TPU in the 68332.

4.3.5 System Fault

The **CCB** has three methods of telling the system it has a fault: by the **CAN** bus, the fault line driven by the **CAN** driver, and by the serial Fault2 line. When the firmware senses a fault, it writes to the Altera to create a GCAN_FLT_TX signal. This signal drives an isolated 82C250 **CAN** interface chip and opens a solid state relay. The relay opens the loopback line that runs from the **HCB**, through the Collimator, through the **DAS**, back through the Collimator and the **HCB**. These boards will detect an open and react to the fault. Both the **GCAN** FLT and the FAULT2 readback signals go to the Altera where they create an interrupt and are latched for reading by the firmware.

4.3.6 GCAN Reset

This signal comes from the **HCB** and is opto-coupled into the collimator control board. When GCAN_RST_P is high relative to GCAN_RST_N, the GCAN_RST* signal output of the opto-coupler is low. This then creates a board Reset just as pushing the Reset pushbutton would do.

4.3.7 CAM Drive

The CAM drive function consists of the clockwise and counterclockwise pulse commands to the stepper motor driver, encoder feedback, the driver disable signal and the driver current cutback inhibit signal. The clockwise and counter-clockwise pulses are derived in the Altera from quadrature pulses created by the TPU in the 68332. The rate of these is under firmware control. The TPU also decodes the encoder signals to keep track of the count and direction of movement.

Two control signals from the 68332 are for controlling the behavior of the Vexta, 5 phase stepping motor driver. Essentially the 68332 writes to a register to set the signals CURR_HOLD and CAM_OFF_OUT.

When CURR_HOLD is high, it turns on FET Q35 and prevents the stepping motor driver from automatically decreasing its drive to the motor. Normally the current gets cut back by half after a move because it is not needed for acceleration and movement.

When the CAM_OFF_OUT signal goes high, it turns on a FET Q36, which turns off the stepping motor driver and allows the CAMS to “freewheel”.

4.3.8 Filter Drive

The filter driver is a basic H-bridge with high side current sensing for each phase. Sensing the high side allows protection for output shorts to ground. The stepping signals come from the TPU and decoded by the Altera to sequence the high and low FET drive signals.

4.3.9 Current Limit

The current limit circuitry is the same for both phases. An instrumentation amplifier with high common mode rejection senses the current through an effective 0.25 ohm resistance. The output of the amplifier is then fed into two comparators. One comparator is for pulse to pulse current limiting and the other is the short circuit latch comparator. For pulse to pulse current limit, the voltage regulators are divided down to create a reference voltage. This reference is fed into the comparator and when the output from the sensed current exceeds the reference, the comparator switches and shuts off a latch, which turns off the top FET. This cycles at a 15 kHz rate because of the clock into the latch.

4.3.10 Short Circuit Function

The short circuit protection circuitry uses the same concept as the pulse to pulse limit except on a short, the rate of rise of the current is so fast that the current sensed can rise to just over 10 A. This is limited by the 6.8 uH inductor on the board and the reverse recovery charge of the lower FET's parasitic diode. As the current passes the short circuit reference voltage, a comparator switches in a latch that cuts off drive to the top FETs. Only firmware can reset this latch so current stays off after a short until firmware commands otherwise.

4.3.11 Current Cut Back

The Current Cut back function drops the current to the filter. This keeps the motor from unnecessarily dissipating power when it is not moving. The firmware can command this, which then turns on Q5. When Q5 is on, it drops the pulse to pulse current reference.

4.3.12 Basic H-Bridge Function

The H-bridge uses two high side gate driver chips per phase. These create floating voltages to drive the top FETs without transformers or optical circuitry. The resistor - diode combinations around the inverters which feed the gate driver chips and the gates of the FETs are set up to prevent "shoot through" or simultaneous conduction. This is prevented by turning on the FETs slow and turning them off fast. The SD signal into the ir2110 devices disables drive until a command occurs. Holding SD high disables the driver.

4.3.13 Filter Home Switch

The filter home switch tells the **CCB** when the filter is physically positioned “at home” of course. It does this by feeding back the normally open and normally closed contact signals, which can be read at register U24 (Address 0x800000/1 in the memory map). When at home, the normally open switch is closed and the normally closed switch is closed.

4.3.14 Voltage Regulators and Reference Voltages

The voltage regulators create voltages for the FET gate drivers (12V), and the instrumentation amp (± 8V). The 8V signal is for the pulse to pulse and short circuit currents.

4.3.15 Altera Functionality

The Altera functionality is covered in the Programmable Device Logic (PDL) specification 2208487PDL.

4.3.16 I/O Bit Map

With the exception of the INREG register (Address 0x800000), the input and output registers are in the Altera.

Output Register

Writing a logic one to bit one of the output register will reset the Fault interrupt regardless of the source of the interrupt. The interrupt is generated on the leading edge of the fault signals. There are two fault signals, one is from the **CAN** (controller area network) and this can also be commanded by firmware on the **CCB**. The fault signal is created by a break in the loopback wire of the **CAN** connectors. This second fault path is what is referred to as Fault2 on both the **HEMRC** Control Board and the Collimator Control Board.

BIT	ADDRESS FFA009 WRITE ONLY	OUTPUT REGISTER LOW CONDITION	HIGH CONDITION
0	Fault Interrupt Reset	No Action	Clears Fault Interrupt
1			
2			
3			
4			
5			
6			
7			

Table 9-54 Collimator Output Registers

Z-Axis Tracking Timer

Within the Altera chip there is a timer-counter function. One function provides 125 kHz for the quadrature decode functions and 15.6 kHz to the filter amplifier circuitry on the **CCB**. Both these clocks are derived from the 16 MHz crystal derived clock.

For the Z-Axis function there is a 14 bit “up” counter with a clock of 3906 Hz derived from the 16 MHz system clock. The timer function comes from the ability to load a digital comparator that compare the value loaded by firmware against the value of the counter. Firmware is given the capability of asynchronously loading the counter, clearing the counter and masking the interrupt that is generated when the compare and count value match.

There are 3 control signals that configure this function:

CONTROL	ADDRESS	DESCRIPTION
`cntctlwr`	FFA00A	Clocks in the control bits that configure the counter.
`cntlo_wr`	FFA00B	Clocks in the low byte of the 14 bit compare word.
`cnthi_wr`	FFA00C	Clocks in the high byte of the 14 bit compare word

`cnctlwr` is generated by a WRITE to address FFA00A
`cntlo_wr` is generated by a WRITE to address FFA00B
`cnthi_wr` is generated by a WRITE to address FFA00C

Figure 9-50 Collimator Z-Axis Control Signals

The interrupt is generated when the count matches the compare value.

Collimator Register

The collimator register is used for collimator specific functions. It allows the firmware to command and readback status on the filter drive amplifier currents and also allows the firmware to shut down the collimator cam drives.

4.3.17 Z-Axis Tracking Overview

- The purpose of tracking is to follow the focal spot so that the system can keep the umbra of the beam on the detector to **reduce dose** and still avoid artifacts.
- Dose reduction is approx. 40% less in the 4 x 1.25mm mode and 25% less in the 4 x 5.00 mode.
- Z-Axis tracking is needed because the focal spot moves in Z due to thermal changes in the tube, and in mechanical forces during Gantry rotation and tilt.
- Z-Axis tracking involves the X-Ray Tube Focal Spot, Collimator, Detector, **DAS**, **DCB**, **CCB**, and **RCIB**/**GCAN** Communication Networks.

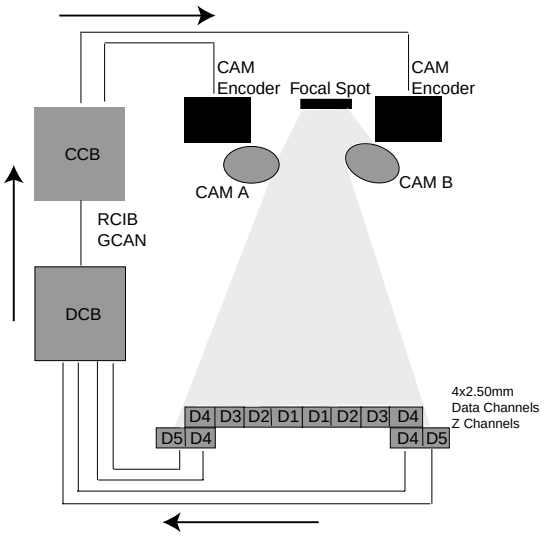


Figure 9-51 Typical Tracking Feedback Loop

4.3.18 Collimator Tracking Control Loop Theory

The purpose of tracking is to follow the focal spot so that we can keep the uniform X-ray of the narrowest possible beam on the detector to reduce dose and still avoid artifacts.The focal spot moves in Z due to thermal changes in the tube and a mechanical forces during gantry rotation and tilt angle. Each cam is basically an independent system.

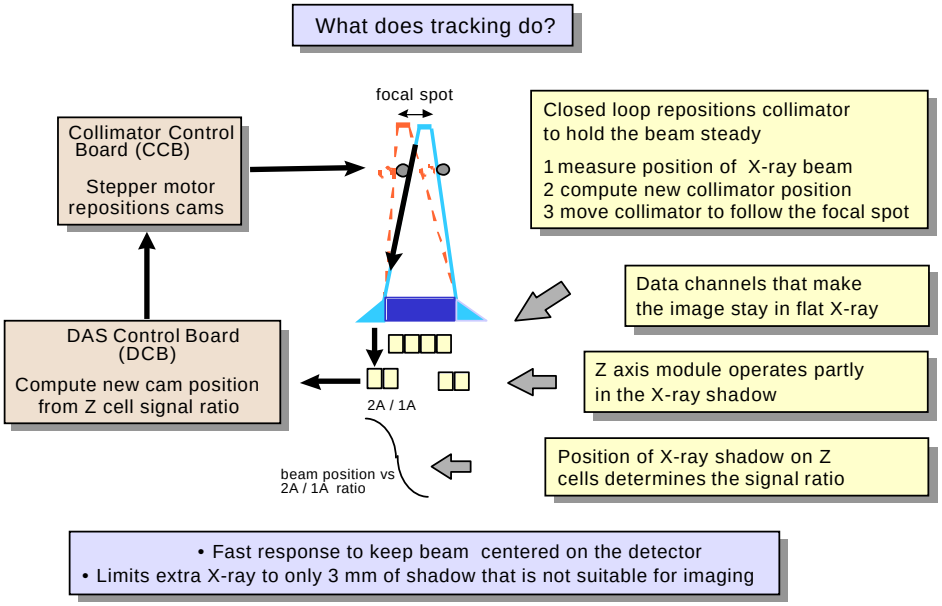


Figure 9-52 Tracking Diagram

1.) Select a safe operating point at the edges of the detector (target beam position at isocenter).

2.) Sample X-ray beam position every view and adjust collimator CAM positions every 20 ms. to keep the beam at the ISO center channel operating point.

   a.) Compute Z ratio for each side of the Z module (outer row)/ (inner row). (Channels 763, 764, 765, 766, 767 & 768.)

   b.) Convert the ratio to a beam position at the Z module.

   c.) Compute the focal spot position given the beam position on the Z module, the cam position for the Z module, and geometric magnification factors at the Z module.

   d.) Compute the new cam position for the isocenter channel given the focal spot position and geometric magnification factors for the isocenter channel. During views when portions of the patient, patient table, IV line etc. block the Z module, the beam position measurement can not be used.

   e.) We will compare **DAS** data channel 762 (data channel adjacent to the Z module) to an expected signal as a function of the measured mA, **DAS** gain, and trigger period. The Z module is blocked if either inner row is less than 0.9 times the expected value. During a blocked condition, the cams will hold constant at the last unblocked position.

      - Transient conditions during a tube spit do not require special action.

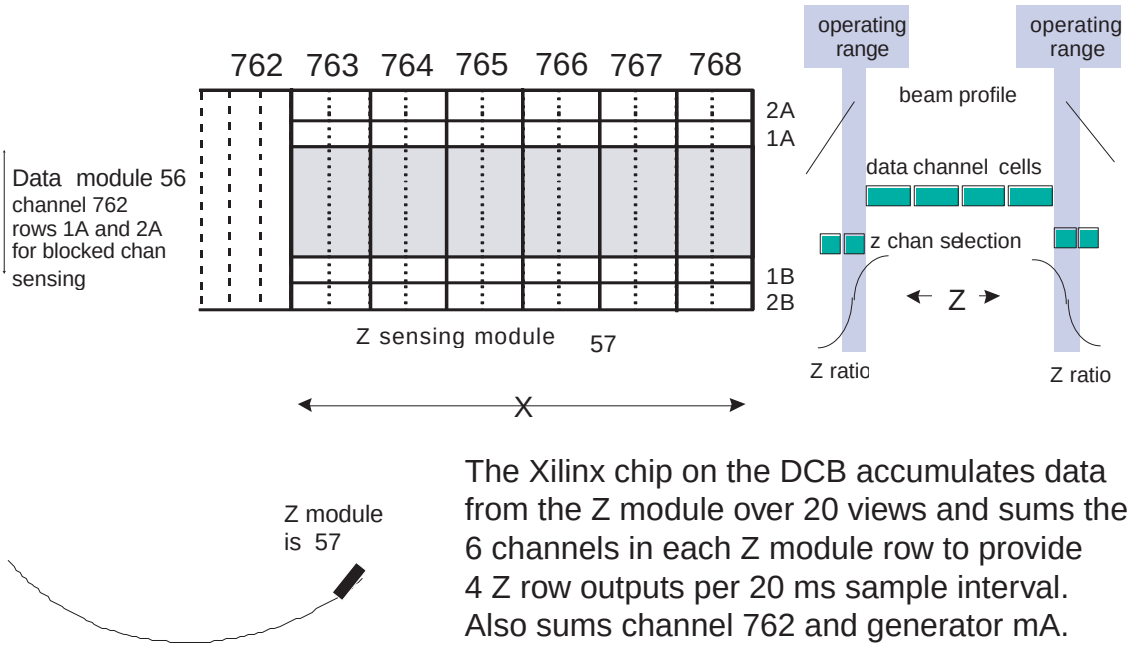
   f.) Measure the beam position and readjust the collimator approximately every 20 ms.

3.) Scan aborts will occur when the following conditions exist.

   a.) Beam position on detector, non-blocked z-chnls condition, is out of tolerance by +/- 0.4 mm of desired position for more than 100 mSec.

   b.) Signal Corruption of chnls 762 through 768, where zero or negative values (counts) are detected for more than 200 mSec OR generator mA feedback to **DCB** is less than 4 mA for more than 200 mSec.

   c.) Focal spot length error for more than 4000 mSec



The Xilinx chip on the DCB accumulates data from the Z module over 20 views and sums the 6 channels in each Z module row to provide 4 Z row outputs per 20 ms sample interval. Also sums channel 762 and generator mA.

Figure 9-53 Z Sensing Module

Note: Z module cells can be switched independently of the data channels to provide the optimum tracking zratio.

4.3.19 Tracking Loop Variables

4.3.19.1 Blocked Channel Check: 762

The x-ray signal output of **DAS** Channel 762 is characterized during FASTCAL (Air Scan with No beam obstructions). During patient scanning, if the x-ray signal on **DAS** channel 762 falls below 10% of the signal characterized during FASTCAL, then it is considered “blocked” and the collimator CAMS will hold constant at the last “un-blocked” position.

4.3.19.2 Z-Channels

- The Z-Channels are **DAS** channels 763, 764, 765, 766, 767 & 768.
- Each **DAS** Z-channel is a combination of 2 detector channels in the X direction.
- Z-Channels have a different Detector Row selection than Data channels. This is selected by the Z-FET control lines.
- Beam position is determined by the following equation:

$$R = \frac{\text{OuterRow}}{\text{InnerRow}} \times \text{DASGainCalCorrectionRatio}$$

The R value is then transformed into a 4th degree polynomial to find the Z-Axis Beam position, which determines beam width at detector (mmd) and focal spot length (mmf).

mmd = millimeters at detector

mmf = focal spot length in millimeters.

Note: Errors are reported by the system in umd (micrometers at detector) or umf, due to computational accuracy.

```
OVERRIDES: value = {
   RX_OVERRIDES: value = 0xa
   FILAMENT_I: value =   0.0000
   ANODE_DAC: value = 0x0
   CATHODE_DAC: value = 0x0
   ROTORSPEED: value = ROTOR_SPEED_HIGH
   XRAY_DELAY_SEC: value =   0.0000
   XRAY_DURATION_SEC: value =   1.0000
   DCB_OVERRIDES: value = 0x20
```

*Puts the **DCB** into over-ride mode so FET control can be selected.*

```
   CANNEDDCBPATTERNSELECTION: value = 0x0
   CANNEDCNVPATTERNSELECTION: value = 0x0
   AUTOCORRECTIONDISABLEMASK: value = 0x0
   INNERCHANNELCONTROL: value = 0x3
```

*Controls the Center **DAS** Chassis FET configuration*

```
   OUTERCHANNELCONTROL: value = 0x3
```

*Controls the Right and Left **DAS** Chassis' FET configuration*

```
   ZCHANNELCONTROL: value = 0x9
```

Controls the Z-Channel FET configuration (Channels 763, 764, 765, 766, 767 & 768)

```
   INJECTEDDCVOLTAGE: value = 0x0
   CCB_OVERRIDES: value = 0x2
```

Puts the collimator Control Board in over-ride mode

```
   COLLIMATORWIDTH: value = 0x22c4
```

Keeps the collimator Cams wide open to flood the Detector

Normal data modes with Z-chan same as H1.x																8-slice configuration									
A8 (D8)	A7 (D7)	A6 (D6)	A5 (D5)	A4 (D4)	A3 (D3)	A2 (D2)	A1 (D1)	B1 (D1)	B2 (D2)	B3 (D3)	B4 (D4)	B5 (D5)	B6 (D6)	B7 (D7)	B8 (D8)	Slice mode	FET mode	Detector Mode name	Protocol Mode name	FET 1 LED	FET 2 LED	FET 3 LED	FET 4 LED	FET 5 LED	FET 6 LED
2	1					4	3	3	4					1	2	Z-chan	17	8Cal6	Cal6	OFF	ON	ON	ON	OFF	ON
2	2	2	2	1	1	1	1	1	1	1	1	2	2	2	2	4x5.00	8	4x5.00	4x5.00	ON	ON	ON	OFF	ON	ON
3	2	1					4	4					1	2	3	Z-chan	16	8Cal5	Cal5	ON	ON	ON	ON	OFF	ON
		2	2	2	1	1	1	1	1	1	2	2	2			4x3.75	7	4x3.75	4x3.75	OFF	OFF	OFF	ON	ON	ON
	4	3	2	1							1	2	3	4		Z-chan	14	8Cal3	Cal3	ON	OFF	OFF	OFF	ON	ON
				2	2	1	1	1	1	2	2					4x2.50	6	4x2.50	4x2.50	ON	OFF	OFF	ON	ON	ON
				2	2	1	1	1	1	2	2					Z-chan	6	4x2.50	4x2.50	ON	OFF	OFF	ON	ON	ON
						2	1	1	2							4x1.25	5	4x1.25	4x1.25	OFF	ON	OFF	ON	ON	ON
	4	3	2	1							1	2	3	4		Z-chan	14	8Cal3	Cal3	ON	OFF	OFF	OFF	ON	ON
				4	3	2	1	1	2	3	4					8x1.25	0	8x1.25	8x1.25	ON	ON	ON	ON	ON	ON
2	1					4	3	3	4					1	2	Z-chan	17	8Cal6	Cal6	OFF	ON	ON	ON	OFF	ON
4	4	3	3	2	2	1	1	1	1	2	2	3	3	4	4	8x2.50	1	8x2.50	8x2.50	OFF	ON	ON	ON	ON	ON
						2	1	1	2							Z-chan	5	4x1.25	4x1.25	OFF	ON	OFF	ON	ON	ON
						2	1	1	2							1x1.25	5	4x1.25	4x1.25	OFF	ON	OFF	ON	ON	ON
						2	1	1	2							Z-chan	5	4x1.25	4x1.25	OFF	ON	OFF	ON	ON	ON
						2	1	1	2							Thin twin	5	4x1.25	4x1.25	OFF	ON	OFF	ON	ON	ON

Figure 9-54 FET modes for Data and Z Channels - 8 Slice Only

Normal data modes with Z-chan same as H1.x															4-slice configuration											
A8 (D8)	A7 (D7)	A6 (D6)	A5 (D5)	A4 (D4)	A3 (D3)	A2 (D2)	A1 (D1)	B1 (D1)	B2 (D2)	B3 (D3)	B4 (D4)	B5 (D5)	B6 (D6)	B7 (D7)	B8 (D8)	Slice mode	FET mode	Detector Mode name	Protocol Mode name	FET 1 LED	FET 2 LED	FET 3 LED	FET 4 LED	FET 5 LED	FET 6 LED
2	1													1	2	Z-chan	45	4Cal6	Cal6	OFF	ON	OFF	OFF	ON	OFF
2	2	2	2	1	1	1	1	1	1	1	1	2	2	2	2	4x5.00	36	4x5.00	4x5.00	ON	ON	OFF	ON	ON	OFF
	2	1											1	2		Z-chan	44	4Cal5	Cal5	ON	ON	OFF	OFF	ON	OFF
		2	2	2	1	1	1	1	1	1	2	2	2			4x3.75	35	4x3.75	4x3.75	OFF	OFF	ON	ON	ON	OFF
			2	1							1	2				Z-chan	42	4Cal3	Cal3	ON	OFF	ON	OFF	ON	OFF
				2	2	1	1	1	1	2	2					4x2.50	34	4x2.50	4x2.50	ON	OFF	ON	ON	ON	OFF
				2	2	1	1	1	1	2	2					Z-chan	34	4x2.50	4x2.50	ON	OFF	ON	ON	ON	OFF
						2	1	1	2							4x1.25	33	4x1.25	4x1.25	OFF	ON	ON	ON	ON	OFF
						2	1	1	2							Z-chan	33	4x1.25	4x1.25	OFF	ON	ON	ON	ON	OFF
						2	1	1	2							1x1.25	33	4x1.25	4x1.25	OFF	ON	ON	ON	ON	OFF
						2	1	1	2							Z-chan	33	4x1.25	4x1.25	OFF	ON	ON	ON	ON	OFF
						2	1	1	2							Thin twin	33	4x1.25	4x1.25	OFF	ON	ON	ON	ON	OFF

Figure 9-55 FET modes for Data and Z Channels - 4 Slice Only

4.3.19.3 Focal Spot Length Check

During some conditions the Z module measurement can be corrupted due to a transient undetected blockage or due to a tracking loop malfunction. These conditions can be detected, identified by the **DCB** firmware, and reported to the gesyslog.

The focal spot length is computed on each sample interval from the measured Z and Cam positions.

- If Z measurements from each side are both valid, then the computed focal spot length should be close to the expected focal spot length from FastCal.
- If the computed focal spot length is not within tolerance of the focal spot length determined during Fast Cal then the control loop will hold the current cam positions.
- If the inconsistent length condition continues for more than 400 msec without a normal blocked channel indication from channel 762, then the loop is assumed to be malfunctioning and the scan is aborted.

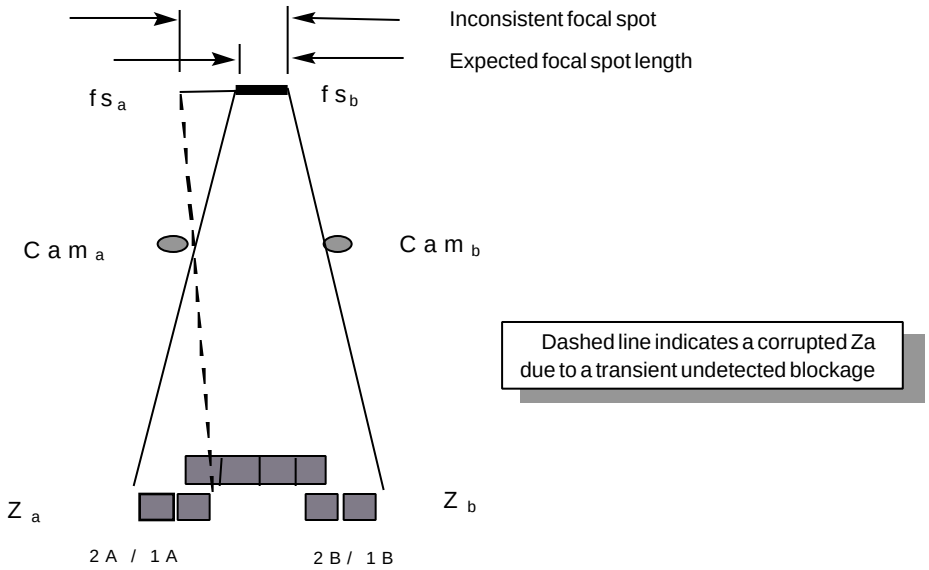


Figure 9-56 Focal Spot Length Check

4.3.20 Special Tracking Characterizations

4.3.20.1 Mylar Window Check

- Takes 4 scans (1 scan at each Patient Acquisition Mode). If a 20 view average of channel 762 falls below .95 of the expected value, then an error prompt informs the user to check and clean the Mylar window.
- Scans are taken without tracking and the collimator fully open to flood all detector rows.
- Technique is 80KV / 20mA / 1 Sec. / Air Filter
- Mylar window check is completed before **DAS** Gain Cal, Collimator Cal, and FASTCAL.

  For more information, see "Dirty Mylar Window Scan," on page 67.
- Characterizes the differences in **DAS** Gain (gain ranges 1-31) for **DAS** channels 762 (used for blocked channel detection) and Z-Channels (763, 764, 765, 766, 767 & 768).
- The differences are a result of Pre-Amp Gain Capacitor tolerances on converter boards 47 and 48.
- The serial numbers of converter boards 47 and 48 are queried and stored during **DAS** Gain Cal. Collimator Cal and FASTCAL query the **DAS** and compare the serial numbers since the last time **DAS** Gain Cal was completed.
- A **DAS** Gain Cal is required whenever **DAS** Converter boards 47 or 48 are swapped or changed.

DESCRIPTION

DAS Gain calibration is required to support Z axis tracking. The ratio formed by the Z modules that is used as the basis for beam positioning is effected by the **DAS** gain selection. Capacitor tolerances on the **DAS** converter cards can change the ratio causing a beam position error. To avoid this error we measure the outer to inner row gain variation to develop a Z ratio correction factor for each gain selection.

DAS Gain Cal also determines a gain independent blocked channel threshold for the inner rows of **DAS** channel 762 for the tracking firmware. This gain factor is used to scale the gain normalized blocked channel scale factor to the proper level in the tracking firmware.

The **DAS** Gain cal flowchart is shown below. Before **DAS** Gain scans are taken, a mylar window check is done to ensure that the window is clean. Otherwise it can corrupt the tracking cals.

If the check succeeds, the **DAS** gain scans are taken and the cal proceeds forward. If the check fails, a pop-up is posted asking the user to provide inputs on whether they want to quit, continue anyway or retry the mylar window check after cleaning the mylar window.

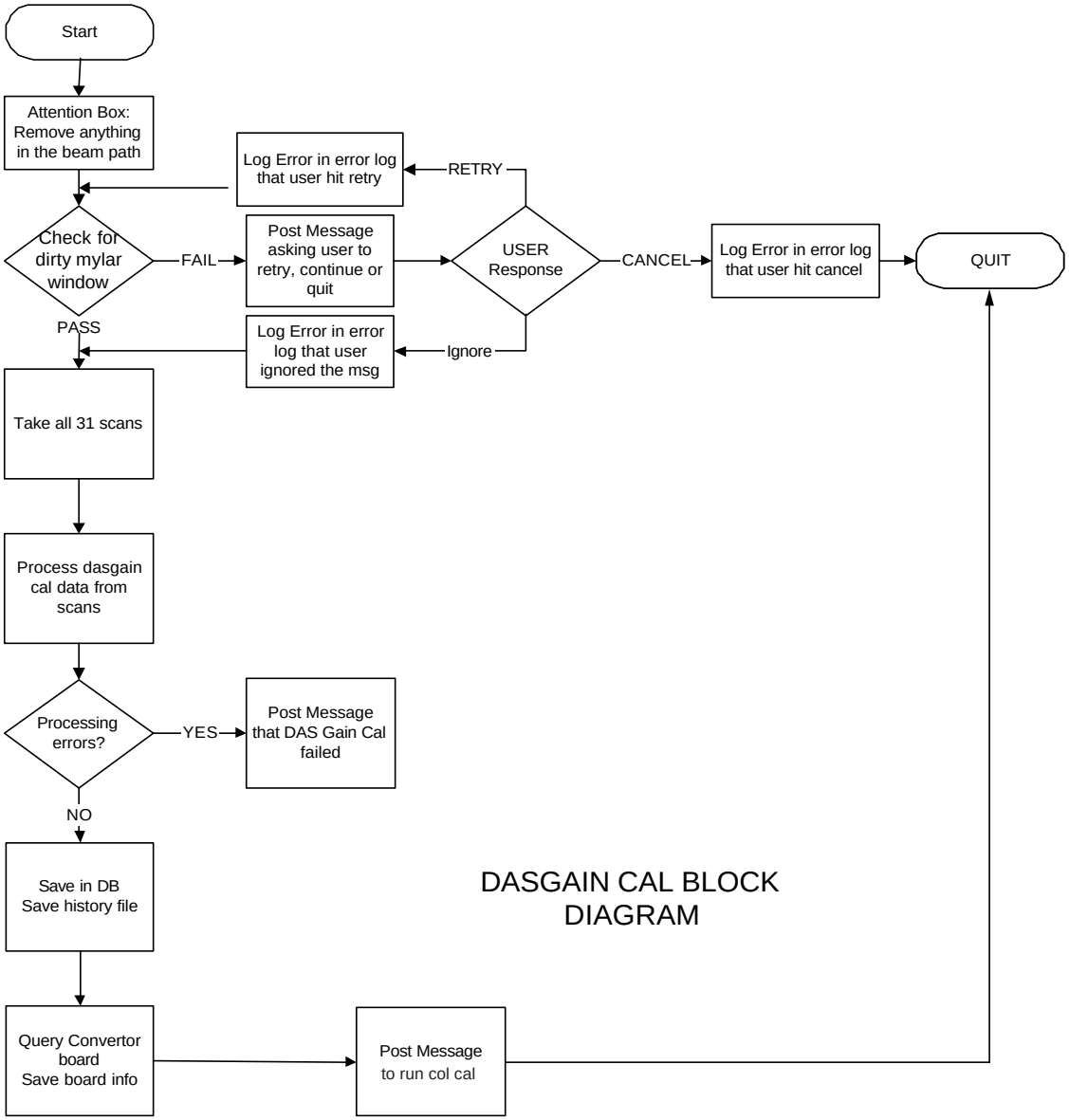


Figure 9-57 DAS Gain Cal Block Diagram

DAS GAIN CAL SCANS

- **DAS** Gain Calibration consists of 31 scans that are taken consecutively.
  Stationary / 120KV / 20mA / 0.3 Sec / Air / Gain 1
  through
  Stationary / 120KV / 20mA / 0.3 Sec / Air / Gain 31
- Processing is completed after all scans are completed.
- Total time is approximately 4 minutes.
- **DAS** Gain Cal takes 31 scans to collect signal data for all **DAS** channels at each of the 31 **DAS** gain settings using the **DAS** Gain protocol file.

4.3.20.2 Collimator Cal

Characterizes the beam position based on x-ray signal vs. collimator encoder position.

Eight Air scans taken using the following techniques:

LARGE SPOT		SMALL SPOT		NOMINAL COLLIMATOR WIDTH
120KV/300mA		120KV/150mA		
1	4 x 1.25mm	5	4 x 1.25mm	2100
2	4 x 2.50mm	6	4 x 2.50mm	2900
3	4 x 3.75mm	7	4 x 3.75mm	4470
4	4 x 5.00mm	8	4 x 5.00mm	5960
9	1 x 1.25 mm	10	1 x 1.25 mm	2100
		11	Thin Twin	1400

Table 9-55 Air Scans

- All scans with z-tracking off
- Scan time is 5.9 seconds
- Thin Twin is 6.5 seconds
- Stationary Scans

- Offset from Nominal: ±900 cts.
- #of views: 100 at each step
- Step size: 50 cts.
- # of steps: 37

FASTCAL completes 1 Collimator Cal (Sweep) Scan each time FASTCAL is run. This results in all eleven of the scans in Table 9-55 getting updated after FASTCAL is run eleven times.

4.3.21 Diagnostics Related to Z-Axis Tracking

- Collimator Aperture Test. See "Collimator Functional Diagnostic Tests," on page 132.
- **DAS** Tools. See "DAS Tools," on page 117.
- Interconnect Test. See "Interconnect Test," on page 121.
- Tracking Analysis. See "Scan Data Analysis Tools (SCAN, Tracking dd, CAL)," on page 97.
- Diagnostic Data Collection. See "Diagnostic Data Collection (DDC)," on page 88.
  - FET Over-ride mode
  - Create and apply non-tracking Cal and **DDC** Scan

Z-AXIS ERROR CODES

Many of these messages contain variable fields for which some text or values will be substituted.

ERROR CODE	ERROR CODE TEXT	LOG LEVEL	HOST
260007445	"%SUNABLE TO NOTIFY Z-AXIS STATE MACHINE OF EVENT.\N\ ERROR CODE %D RECEIVED."	log	myhost>
260007446	"Z-AXIS CONFIGURATION TABLE"	log	myhost>
260007447	"%STHE DCB Z-AXIS HARDWARE FAILED TO GENERATE AN INTERRUPT DURING THE SELF TEST.\N\ POSSIBLE DCB Z AXIS TRACKING HARDWARE FAILURE."	log	myhost>
260007448	"%STHE DCB Z-AXIS HARDWARE GENERATED AN UNEXPECTED INTERRUPT DURING THE SELF TEST.\N\ POSSIBLE DCB Z AXIS TRACKING HARDWARE FAILURE."	log	myhost>
260007449	"DCB Z AXIS CIRCUITRY TEST"	log	myhost>
260007450	"%STHE BEAM TRACKING ALGORIHTM ENCOUNTERED A DIVISION BY ZERO."	log	myhost>
260007451	"%STHE PRESCRIBED SCAN HAS NOT BEEN CALIBRATED FOR BEAM TRACKING.\N\ DATA SETTING: %D Z SETTING: %D"	log	myhost>
260007452	"%SA BEAM TRACKING FEEDBACK MESSAGE CONTAINED AN INVALID MOVE SEQUENCE NUMBER.\N\ THIS INDICATES A Z-AXIS MOVE WAS POTENTIALLY SKIPPED.\N\ UPDATE SEQ #: %D\N\ EXPECTED SEQ #: %D"	log	myhost>
260007453	"%STWO OR MORE TRACKING MESSAGES ARE OUTSTANDING FROM THE COLLIMATOR.\N\ CURRENT SEQUENCE #: %D"	log	myhost>
260007454	"%SBEAM TRACKING CALCULATED A FOCAL SPOT SIZE THAT HAS EXCEEDED THE WARNING TOLERANCE.\N\ TOLERANCE : %6D UMF\N\ CACLULATED SIZE: %6D UMF\N\ NOMINAL SIZE : %6D UMF"	log	myhost>
260007455	"%SBEAM TRACKING CALCULATED A FOCAL SPOT SIZE THAT HAS EXCEEDED THE ABORT TOLERANCE.\N\ TOLERANCE : %6D UMF\N\ CACLULATED SIZE: %6D UMF\N\ NOMINAL SIZE : %6D UMF"	log	myhost>
260007456	"%SBEAM TRACKING CONTROL LOOP ERROR EXCEEDED THE WARNING TOLERANCE.\N\ TOLERANCE : %6D UMD\N\ CONTROL ERROR : %6D UMD\N\ BEAM SIDE : %B"	log	myhost>
260007457	"%SBEAM TRACKING CONTROL LOOP ERROR EXCEEDED THE ABORT TOLERANCE.\N\ TOLERANCE : %6D UMD\N\ CONTROL ERROR : %6D UMD\N\ BEAM SIDE : %B"	log	myhost>
260007458	“A SIDE”	log	myhost
260007459	“B SIDE”	log	myhost
260007460	"%SSCAN ABORT -- BEAM TRACKING DETECTED SIGNAL CORRUPTION.\V\ MA LEVEL: %LD\V\ Z CHANNELS : %LD, %LD, %LD, %LD\V\ OFFSET VECTOR: %LD, %LD, %LD, %LD"	log	myhost

Table 9-56 Z-AXIS Tracking Error Codes

Section 5.0
Replacement Procedures

5.1 Collimator Replacement Procedures

5.1.1 Filter Assembly

5.1.1.1 Required Tools

- 3 mm Hex key sockets
- Phillips #2 screwdriver

Before beginning this procedure, please read the safety information in "Gantry," on page 37.

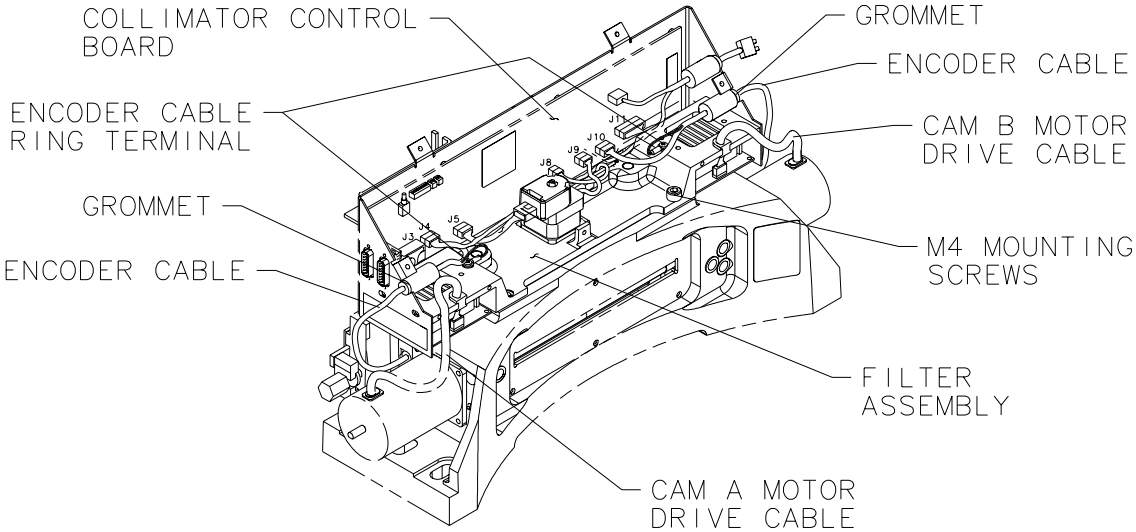


Figure 9-58 Filter Assembly Replacement

Conversion Factor: 1 N-m = 1.356 ft-lb

5.1.1.2 Procedure Details

1.) Remove the gantry side, top and front cover.
2.) Turn **OFF** all 3 switches (Axial Drive, **HVDC**, 120 VAC) on the **STC** backplane.
3.) Position a drop cloth below the Collimator to collect any hardware that might be dropped.
4.) Follow the procedure for removing the Collimator Control Board.
5.) Follow the procedure for removing the Cam Motor Driver Modules.
6.) Remove driver covers on motor mount assembly and set aside.
7.) Remove the CAM A & B encoder cable ring terminals & washers.
8.) Return the screws & washers to their original location after removing the ring terminals.
9.) Slide the grommet on the CAM A & B encoder cables out of the frame mount to fully disconnect the encoder cables from the frame.
10.) Remove the Filter PWB Mount Bracket by removing the six pan head M4 mounting screws and set aside.
11.) Remove the four hex socket M4 frame mounting screws.

Note: Do not damage the fragile aluminum, graphite & copper filter assembly that extends into the Collimator frame during the Filter removal or new Filter installation.

12.) Lift the filter asm. from the steel Collimator frame and set to the side.
13.) Remove the new Filter Asm. from the shipping box.
14.) Seat the new Filter Asm. on the Collimator alignment pins.
15.) Place the old Filter Asm. in to the shipping box.
16.) On the new Filter Asm., insert the four hex socket M4 frame mounting screws and torque to 3 ± 0.3 N-m.
17.) Replace the Filter PWB Mount Bracket by installing all six pan head screws loosely, then tighten and torque to 3 ± 0.3 N-m.
18.) Follow the procedure for re-connecting the Cam Motor Driver Modules.
19.) Replace the driver covers on motor mount asm.
20.) Follow the procedure for re-connecting the Collimator Control Board.
21.) Remove the screw & washer for the ring terminals & use to secure the CAM A & B ring terminals & tighten.
22.) Replace the top cover of the Collimator using the five pan head mounting screws with spring washers and tighten.

Note: Ensure the Cam Driver Leads are outside of the cover.

23.) Remove the drop cloth and follow the procedures for closing the gantry.

5.1.2 Collimator Control Board (CCB)

5.1.2.1 Required Tools

- **ESD** Kit
- 3 mm Hex key
- Phillips #2 screwdriver

Before beginning this procedure, please read the safety information in "Gantry," on page 37.

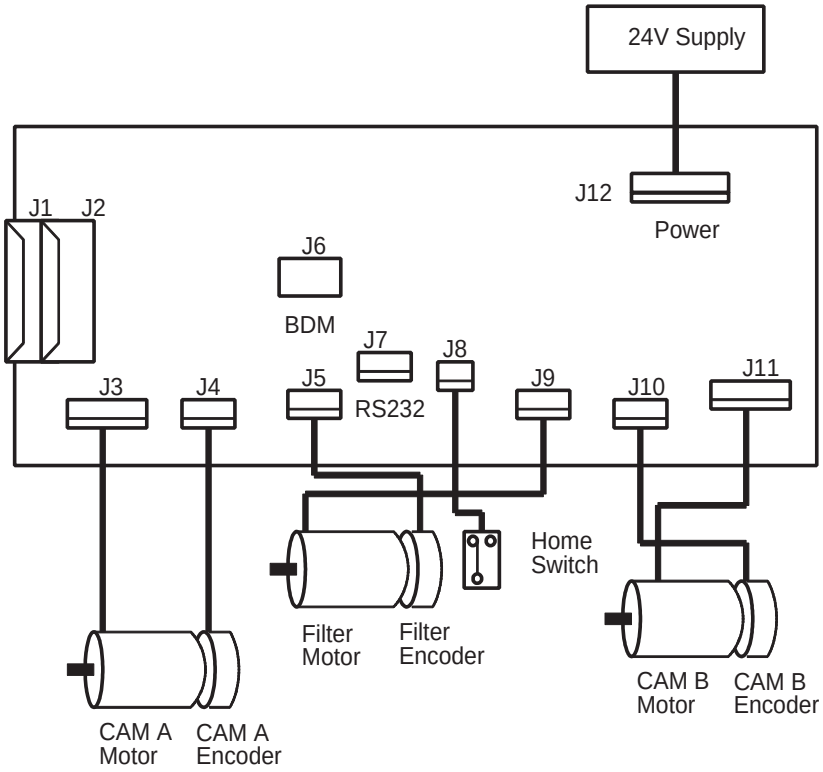


Figure 9-59 Collimator Control Board (CCB) Replacement

5.1.2.2 Procedure Details

NOTICE **The CCB is static sensitive. Please follow proper static handling procedures.**

1.) Remove the gantry side, top and front cover.
2.) Turn **OFF** all 3 switches (Axial Drive, **HVDC**, 120 VAC) on the **STC** backplane.
3.) Position the gantry with the XRT at six-o'clock.
4.) Remove the top cover from the Collimator by removing the five pan head M4 mounting screws that have spring washers.
5.) Disconnect the power cable at connector J12, on the lower side on the Collimator.
6.) Disconnect the two 15 pin D **CAN** bus connections, J1 and J2, on the upper side of the Collimator.
7.) Remove the four **CAN** bus connection jackscrews with flat washers & lock washers.
8.) Disconnect the CAM A(J4) & B(J10) encoder cables.
9.) Disconnect all of the remaining cables as shown in the illustration.
10.) Remove the six pan head M4 mounting screws.
11.) Remove the replacement **CCB** from it's shipping container.
12.) Place the new **CCB** on the Collimator.
13.) Place the old **CCB** in the shipping container.
14.) Install the six pan head screws loosely to hold board in place.
15.) Install & tighten the four **CAN** bus connection jackscrews.
16.) Tighten the six pan head screws.
17.) Re-connect the power cable at connector J12, on the Collimator lower end.
18.) Re-connect the two 15 pin D **CAN** bus connections, J1 and J2, on the upper side of the Collimator.
19.) Re-connect the CAM A(J4) & B(J10) encoder cables.
20.) Re-connect the remaining cables as shown in the illustration.
21.) Enter replacement procedures software menu.
22.) Enter Collimator.
23.) Access Flash Download Tool and follow the procedure to flash the characterization file onto the **CCB**.

Note: **CCB** PWA is static sensitive and is to be loaded with Collimator characterization file specific to frame assembly and linked to the manufacturer's serial number.

24.) Replace the top cover of the Collimator using the five pan head mounting screws with spring washers and tighten.

5.1.3 Cam Motor Driver Module

5.1.3.1 Required Tools

- 2. 5mm, 3 mm Hex key sockets
- Phillips #2 screwdriver

Before beginning this procedure, please read the safety information in "Gantry," on page 37.

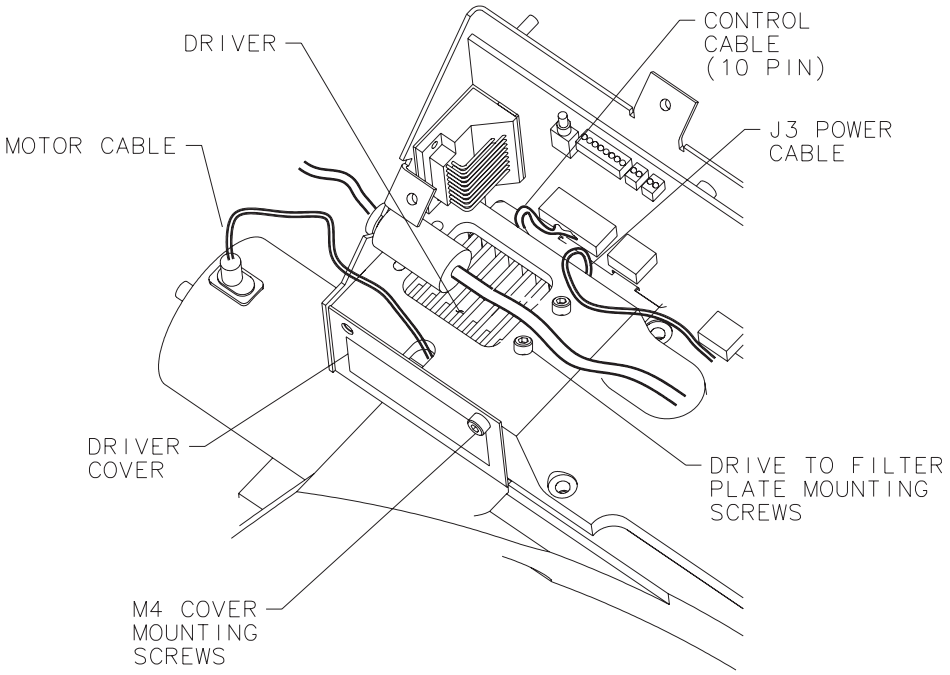


Figure 9-60 Cam Motor Driver Replacement

Conversion Factor: 1 N-m = 1.356 ft-lb

5.1.3.2 Procedure Details

1.) Remove the gantry side, top and front cover.
2.) Turn **OFF** all 3 switches (Axial Drive, **HVDC**, 120 VAC) on the **STC** backplane.
3.) Position the gantry with the XRT at six-o'clock.
4.) Remove the top cover from the Collimator by removing the five pan head M4 mounting screws that have spring washers.
5.) Remove the driver cover on motor mount assembly by removing two pan head M4 screws with washers.
6.) Disconnect the three wire J3 power connector at the rear of the module.
7.) Disconnect the ten pin amp control cable at the rear of the module.
8.) Disconnect the drive to motor cable connection.
9.) Remove the four head cap screws 3 mm cap screws holding the drive to the filter top plate.
10.) Remove the cam motor driver module & place in container for return.
11.) Install new cam motor driver module with the four pan cap screws.
12.) Torque pan cap screws to 1.2 ± 0.1 N-m.
13.) Connect the drive to motor cable.
14.) Connect the six wire motor phase drive connector.
15.) Connect the J3 power connector.
16.) Install the driver cover on motor mount asm. ensuring that the two tabs engage with the slots in the filter PWB Bracket.
17.) Tighten the two pan head M4 screws with spring washers.
18.) Replace the top cover of the Collimator using the five pan head mounting screws with spring washers and tighten.

5.1.4 Collimator Assembly

5.1.4.1 Required Tools

- Spanner Wrench
- Hoist
- Tube Change Bracket
- 10 mm Hex key sockets

5.1.4.2 Procedure Details

Before beginning this procedure, please read the safety information in "Gantry," on page 37.

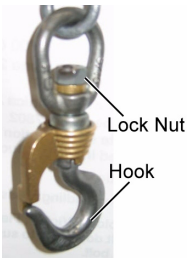
Conversion Factor: 1 N-m = 1.356 ft-lb

NOTICE Potential For Equipment Damage **DO NOT lift the Collimator by the Motors.**

1.) Move table to its lowest elevation.
2.) Remove all covers.
3.) Position the tube at 3 o'clock.
4.) Turn **OFF** all 3 switches (Axial Drive, **HVDC**, 120 VAC) on the **STC** backplane.
5.) Engage gantry rotational lock.

DANGER **LOCK GANTRY TO AVOID INJURY DUE TO UNEXPECTED ROTATION.**

WARNING



IF THE HOIST IS USED WITH THE LOCK NUT OF THE HOOK LOOSE, THE COLLIMATOR MIGHT BE DROPPED FROM THE HOIST, WITH THE RESULT THAT A SERVICE PERSONNEL MIGHT BE SERIOUSLY INJURED. CHECK IF THE LOCK NUT OF THE HOOK IS LOOSENED FIRST BEFORE STARTING TO USE THE HOIST. IF LOOSENED, DO NOT USE THE HOIST THEN ORDER THE NEW HOIST.

6.) Connect and secure hoist and tube change bracket to the tube.
7.) Remove high voltage cables from cathode and anode using spanner wrench.
8.) Remove the tube (see tube removal procedure).

CAUTION **Be careful to keep tube and oil droplets away from contaminating the slipring.**

9.) Disconnect connectors J2, J3 and J11 from collimator.
10.) Remove collimator by removing the two (2) bolts from the top and two (2) bolts from the bottom and 2 bolts from the rear of the collimator using 10 mm Hex key sockets.
11.) Install new collimator by replacing the six (6) bolts removed in above step.
12.) Secure the tube back in place.
13.) Replace high voltage cables back using spanner wrench.

Note: If oil needs to be topped off, be careful of spills. Do not use any part of the gantry as a shelf to rest oil on.

14.) Reassemble gantry.

5.1.5 Cam Drive Motor and Flex Coupling

5.1.5.1 Required Tools

- 3 mm, 4 mm Hex key sockets
- 3/32 Hex key
- Phillips #2 screwdriver
- Flat-blade screwdriver
- Loctite 242

Before beginning this procedure, please read the safety information in "Gantry," on page 37.

Conversion Factor: 1 N-m = 1.356 ft-lb

5.1.5.2 Procedure Details

1.) Remove the gantry side, top and front cover.
2.) Turn **OFF** all 3 switches (Axial Drive, **HVDC**, 120 VAC) on the **STC** backplane.
3.) Position the gantry with the XRT at six-o'clock.
4.) Remove the top cover from the Collimator by removing the five pan head M4 mounting screws that have spring washers.
5.) Remove the three red cap/plugs from the Collimator front surface (on side which motor will be removed).
6.) Remove the driver cover on motor mount assembly by removing the two pan head M4 screws with spring washers.
7.) Disconnect the connector between motor drive and motor.
8.) Use a flashlight aimed through the cap/plug holes to see the set screw in the coupler.
9.) Rotate the motor until the screw is visible and can be loosened on the flexible motor coupler.
10.) Loosen the flexible coupling hex screw.
11.) Remove the four hex socket M4 screws holding the motor to the Motor Mount Plate.
12.) Remove the motor from the collimator housing.
13.) Remove the flex coupling.

Note: At this point replace the failed coupling or motor and proceed.

14.) Install the flex coupling. Place a small drop of Loctite 242 on setscrew threads. Torque to 1.5 ± 0.15 N-m.
15.) Install the new motor and tighten the four hex socket screws to 3 ±0.3 N-m.
16.) Tighten the flexible motor coupling screw. Torque to 1.5 ± 0.15 N-m.
17.) Connect the connector between motor drive and motor.
18.) Install the driver cover on motor mount asm. insuring that the two tabs engage with the slots in the filter PWB Bracket.
19.) Tighten the two pan head M4 screws with spring washers.
20.) Replace the top cover of the Collimator using the five pan head mounting screws with spring washers and tighten.
21.) Install the three cap/plugs after all hardware has been torqued.

5.1.6 Cam Encoder Harness

5.1.6.1 Required Tools

- 3 mm, 4 mm Hex key sockets
- 3/32 Hex key

- Phillips #2 screwdriver
- Flat-blade screwdriver

Before beginning this procedure, please read the safety information in "Gantry," on page 37.

Conversion Factor: 1 N-m = 1.356 ft-lb

5.1.6.2 Procedure Details

1.) Remove the gantry side, top and front cover.
2.) Turn **OFF** all 3 switches (Axial Drive, **HVDC**, 120 VAC) on the **STC** backplane.
3.) Position the gantry with the XRT at six-o'clock.
4.) Remove the top cover from the Collimator by removing the five pan head M4 mounting screws that have spring washers.
5.) Remove the three red cap/plugs.
6.) Remove the driver cover on motor mount assembly by removing the two pan head M4 screws with spring washers.
7.) Disconnect the connector between motor drive and motor.
8.) Disconnect the ground shield lead.
9.) Use a flashlight aimed through the cap/plug holes to see the screw in the coupler.
10.) Rotate the motor until the screw is visible and can be loosened on the flexible motor coupler.
11.) Loosen the flexible motor coupling screw.
12.) Take out the four hexagon socket M4 screws holding the motor to the Motor Mount Plate.
13.) Remove the motor.
14.) Remove the four countersunk M6 cap screws for the Motor Mount Plate.
15.) Remove the Motor Mount Plate.
16.) Disconnect the harness.
17.) Unplug harness from encoder by depressing locking mechanism and pulling out.
18.) Remove the screw for the harness shield ground lead.
19.) The harness can now be removed and placed in container for return.
20.) Install the new harness and ensure it is locked in position.
21.) Tighten the screw for the harness shield ground lead.
22.) Connect the harness.
23.) Install the motor mount plate.
24.) Torque the four countersunk 6x12mm cap screws to 17 ± 1.5 N-m.
25.) Install motor & tighten the four hexagon socket screws to 3 ±0.3 N-m.
26.) Tighten the flexible motor coupling screw to 1.5 ±0.15 N-m.
27.) Connect the ground shield lead.
28.) Connect the connector between motor drive and motor.
29.) Install the driver cover on motor mount asm. ensuring that the two tabs engage with the slots in the filter PWB Bracket.
30.) Tighten the two pan head M4 screws with spring washers.
31.) Replace the top cover of the Collimator using the five pan head mounting screws with spring washers and tighten.
32.) Install the three cap/plugs after all hardware has been torqued.

5.1.7 Secondary Aperture

5.1.7.1 Required Tools

2 mm Hex key

Before beginning this procedure, please read the safety information in "Gantry," on page 37.

Conversion Factor: 1 N-m = 1.356 ft-lb

5.1.7.2 Procedure Details

1.) Remove the gantry side, top and front cover.
2.) Turn **OFF** all 3 switches (Axial Drive, **HVDC**, 120 VAC) on the **STC** backplane.
3.) Position the gantry with the XRT at six-o'clock.
4.) Remove the six countersunk M2.5 flat head mounting screws.
5.) Remove the secondary aperture and place in shipping container for return.
Be careful not to damage the collimator output window.
6.) Install the new secondary aperture ensuring not to damage any of the interior edges due to the critical nature of x-ray filtering.
7.) Tighten the six flat head screws using Loctite 242 10CC.

5.1.8 Primary Aperture

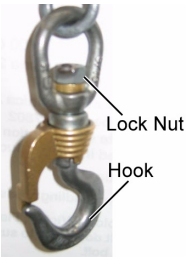
5.1.8.1 Required Tools

- 2 mm, 4 mm, 10 mm Hex key
- 4 mm socket
- Phillips #2 screwdriver
- Tube hoist and boom
- Spanner wrench

Before beginning this procedure, please read the safety information in "Gantry," on page 37.

Conversion Factor: 1 N-m = 1.356 ft-lb

WARNING



IF THE HOIST IS USED WITH THE LOCK NUT OF THE HOOK LOOSE, THE APERTURE MIGHT BE DROPPED FROM THE HOIST, WITH THE RESULT THAT A SERVICE PERSONNEL MIGHT BE SERIOUSLY INJURED. CHECK IF THE LOCK NUT OF THE HOOK IS LOOSENED FIRST BEFORE STARTING TO USE THE HOIST. IF LOOSENED, DO NOT USE THE HOIST THEN ORDER THE NEW HOIST.

5.1.8.2 Procedure Details

1.) Remove the gantry side, top and front cover.
2.) Turn **OFF** all 3 switches (Axial Drive, **HVDC**, 120 VAC) on the **STC** backplane.
3.) Position the gantry with the XRT at six-o'clock.
4.) Remove the four hexagon socket M4 screws for the X-Axis Tube Gauge Mount Bracket.
5.) Remove the X-Axis Tube Gauge Mount Bracket.
6.) Follow the procedure for removal of the Collimator Assembly.
7.) Remove the two M5 slotted head shoulder screws for the Interposer Plate.

8.) Remove the Interposer Plate with Interposer Adjuster Block attached.
9.) Remove eight countersunk M2.5 flat head screws to remove the primary aperture.
10.) Remove the aperture and place in the container for shipment.
11.) Install the new primary aperture ensuring not to damage any of the interior edges due to the critical nature of x-ray filtering.
12.) Apply Loctite 242 to the eight flat head screws and tighten.
13.) Apply Loctite 242 to the two shoulder screws and mount the Interposer Plate tightening the screws.
14.) Apply Loctite 242 to the four socket screws and mount the X-Axis Tube Gauge Mount Bracket tightening the screws.
15.) Follow the procedure for mounting the Collimator on the gantry.

5.1.9 Power Harness

5.1.9.1 Required Tools

Phillips #2 screwdriver

Before beginning this procedure, please read the safety information in "Gantry," on page 37.

Conversion Factor: 1 N-m = 1.356 ft-lb

5.1.9.2 Procedure Details

1.) Remove the gantry side, top and front cover.
2.) Turn **OFF** all 3 switches (Axial Drive, **HVDC**, 120 VAC) on the **STC** backplane.
3.) Position the gantry with the XRT at six-o'clock.
4.) Remove the top cover from the Collimator by removing the five pan head 4x8mm mounting screws with spring washers.
5.) Cut the ty-raps holding down the Power Harness.
6.) Disconnect the Cam A motor drive power connector.
7.) Disconnect the Cam B motor drive power connector.
8.) Disconnect J12 from **CCB**.
9.) Remove Power Harness and place in packaging to return.
10.) Place the new Power Harness on the frame.
11.) Connect J12 to the **CCB**.
12.) Connect the Cam A motor drive power connector.
13.) Connect the Cam B motor drive power connector.
14.) Ty-Rap the Power Harness.
15.) Replace the top cover of the Collimator using the five pan head mounting screws with spring washers and tighten.

5.1.10 FRU 2's Not Requiring Procedures

Before beginning this procedure, please read the safety information in "Gantry," on page 37.

The following **FRU**s do not have replacement procedures because of the simplistic nature of removal.

DESCRIPTION	FRU CODE
Cap plug, 46-230644P10	Yes
CCB Cover, 2286438	Yes
Driver Harness, 2125241	Yes
Filter Encoder Harness, 2126849	Yes
Filter Switch Harness, 2126848	Yes
CCB Jackscrew, 46-221417P1	Yes, see "Collimator Control Board (CCB)," on page 795.
Interposer Plate, 2243925	Yes
Adjuster Screw, 2120094	Yes
Window, 2214248	Yes, see "Secondary Aperture," on page 801.

Table 9-57 FRU's Not Requiring Procedures

5.2 Transformer Tank Measurement Board

5.2.1 Required Tools

- Phillips #2screwdriver
- Flat-blade screwdriver

Before beginning this procedure, please read the safety information in "Gantry," on page 37.

5.2.2 Procedure Details

1.) Position table to lowest elevation.
2.) Turn **OFF** facility power to **PDU**.

DANGER USE PROPER LOCKOUT/TAGOUT PROCEDURES.

3.) Remove, and set aside, both gantry side covers.
4.) Turn **OFF** all 3 switches on the status control box on right side of Gantry.
5.) Lift top cover, and engage prop rod.
6.) Remove Scan window.
7.) Open front cover.
8.) Rotate Measurement Board to 3:00 position.
9.) Unplug connectors J1, J2, J5, and J6
10.) Remove 6 screws and washers that fasten measurement board to High Voltage Supply.
11.) Carefully pry measurement board off High Voltage Tank.
12.) Replace Measurement Board.

Note: Carefully align connector pins from Interface Measurement Board to Round Interface Board on High Voltage Supply.

13.) Reassemble Gantry.
14.) Refer to Retest Verification Table at the end of this chapter.

5.3 High Voltage Tank (Anode)

5.3.1 Required Tools

- Hoist
- 10 mm Ball Hex key to 3/8” drive sockets
- 19 mm socket or box wrench
- 5/16, 1/2, 9/16 inch sockets or box wrenches
- Paper Towels

Before beginning this procedure, please read the safety information in “Gantry,” on page 37.

5.3.2 Procedure Details

DANGER **USE PROPER LOCKOUT/TAGOUT PROCEDURES.**

1.) Move table to its lowest elevation.
2.) Remove side, top and front gantry covers.
3.) Turn **OFF** all 3 switches (Axial Drive, **HVDC**, 120 VAC) on the **STC** backplane.
4.) Remove power at main disconnect (A1) panel. Use proper Lockout/Tagout procedures.
5.) Remove the 3 M12 cap screws that will release the support bracket near the **STC** assembly.

Note: Lower rear “3rd” M12 screw may not be installed. This is normal.

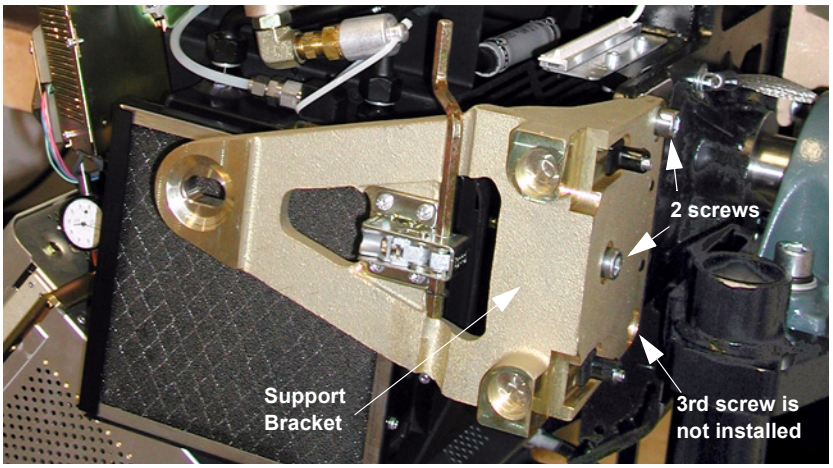


Figure 9-61 Gantry cover support bracket and screws

6.) Rotate gantry to locate the high voltage tank about 9 o’clock.
7.) Engage gantry rotational lock.

DANGER **ENSURE GANTRY ROTATIONAL LOCK IS FULLY ENGAGED TO PREVENT UNEXPECTED GANTRY MOTION.**

8.) Use the spanner wrench to remove the high voltage cable connector from the high voltage transformer tank.
   - Ground the ends of the H.V. cable to the Gantry frame, to ensure no voltage exists at the end of the cable.
   - Use rags or paper towels to wipe excess oil from the High Voltage Cable Connector and tank well.
   - Stuff the tank wells with paper towels to absorb any oil.

9.) Remove cables J1, J2 and J6 from the measurement PWB.

WARNING **OBSERVE THE POSITION OF THE CABLES AND TY-RAPS FOR LATER INSTALLATION. IT IS CRITICAL TO PREVENT DAMAGE TO THE SYSTEM DURING NORMAL GANTRY ROTATION. 14 G'S OF FORCE ARE FELT AT 0.5 SECOND ROTATIONAL SPEED.**

10.) Remove four screws fastening the cover to the inverter assembly and remove cover.

11.) Measure voltage on the two large capacitors to verify 0 volts.

12.) Disconnect J1 connector from the bottom of the inverter assembly.

13.) Disconnect J6 connector from gate driver PWB.

14.) Carefully disconnect four fiber optic cables from gate driver board, making note of where the Ty-rap is for routing the cable back in its original position.

Note: Optic cables must not come in contact with Green Resistors on the Inverter; contact with the resistors can result in a melting of the optic cables.

15.) Verify **HVDC** rail or 120 VAC is not present.

16.) Disconnect **HVDC** cable from capacitor PWB.

17.) Cut Ty-raps from side plate of inverter.

18.) Remove all cables from the Inverter by removing cable restraint at the top of the inverter.

19.) Remove two (2) inverter output leads from H.V. Transformer Tank locations P1 and P2.

20.) Disengage gantry rotational lock.

CAUTION **Be careful not to damage any of the loose cables while you rotate the gantry to position the tank for removal.**

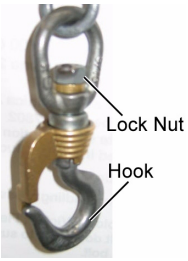
21.) Carefully rotate the gantry clockwise to the 2 o'clock position.

22.) Engage gantry rotational lock.

DANGER **ENSURE GANTRY ROTATIONAL LOCK IS FULLY ENGAGED TO PREVENT UNEXPECTED GANTRY MOTION.**

23.) Remove the four (4) 3/8 bolts from the inverter baseplate, that fasten the inverter assembly to the H.V. Transformer Tank.

WARNING



IF THE HOIST IS USED WITH THE LOCK NUT OF THE HOOK LOOSE, THE HV TANK MIGHT BE DROPPED FROM THE HOIST, WITH THE RESULT THAT A SERVICE PERSONNEL MIGHT BE SERIOUSLY INJURED. CHECK IF THE LOCK NUT OF THE HOOK IS LOOSENED FIRST BEFORE STARTING TO USE THE HOIST. IF LOOSENED, DO NOT USE THE HOIST THEN ORDER THE NEW HOIST.

24.) Remove the inverter assembly from the gantry:
- Attach the hoist to the boom arm in the gantry.
- Attach the hoist lifting chain to the lifting bracket on the transformer tank bottom.
- Remove slack from the hoist chain.

25.) Remove the four (4) M12 screws that fasten transformer tank to the rotating base.

26.) Use the hoist to lower the transformer tank to the floor.

27.) Install the new transformer tank.

Note: Install four (6) M12 tank mounting bolts, and torque to 66.4 Nm.
The 2 bolts with nuts need to be torqued at the cap screw not the nut.

28.) Mount the inverter to the **HV** tank. Torque the four (4) 3/8 inch bolts to 20 ft-lbs.
29.) Remove the host and boom.
30.) Disengage gantry rotational lock.
31.) Rotate the gantry counterclockwise to the 9 o'clock position.
32.) Engage gantry rotational lock.
33.) Reassemble all cabling and secure with ty-raps as observed in step 9 through19.

WARNING **ENSURE CABLES ARE PROPERLY SECURED. IT IS CRITICAL TO PREVENT DAMAGE TO THE SYSTEM DURING NORMAL GANTRY ROTATION. 14 G'S OF FORCE ARE FELT AT 0.5 SECOND ROTATIONAL SPEED.**

34.) Before you install the **HV** Cable Connector, add 20 cc of dielectric oil to the **HV** Connector well in the **HV** Transformer Tank.
35.) Align the cable terminal orienting key with the notch in the receptacle.
36.) Slowly insert the cable, to engage the connector pins, and seat the cable in the well.
- Tighten the cable locking ring.
- Rotate the cable strain relief for a clean cable dress.
- Use the spanner wrench to tighten the locking ring.
- Use a torque wrench to tighten the locking ring to 11.1 ft.–lbs (153 kg-cm).0

NOTICE **Do not over tighten the locking ring. Over tightening can deform the cable plug sealing surfaces, break the oil seal between receptacle and housing, twist the receptacle, and disrupt internal wiring.**

- Back off on the cable locking ring without disturbing the cable plug.
- Re–tighten the locking ring, and torque to 7.1 ft-lbs (98 kg-cm).

Note: Use the spanner wrench with a torque wrench when you tighten the high–voltage cables on the tube unit.

IF YOU GET OIL ON YOUR HANDS, WASH THEM NOW

37.) Carefully wipe up all excess oil.
38.) Secure **HV** Cables using Large Ty-Raps as shown in Figure 9-64, on page 813.
39.) Reassemble Gantry.
40.) Refer to Retest Verification Table at the end of this chapter.

5.4 High Voltage Tank (Cathode)

5.4.1 Required Tools

- Hoist
- 10 mm Ball Hex key to 3/8" drive sockets
- 19 mm socket or box wrench
- 5/16, 1/2, 9/16 inch sockets or box wrenches
- Paper towels

Before beginning this procedure, please read the safety information in "Gantry," on page 37.

5.4.2 Procedure Details

DANGER **USE PROPER LOCKOUT/TAGOUT PROCEDURES.**

1.) Move table to its lowest elevation.
2.) Remove side, top and front gantry covers.
3.) Turn **OFF** all 3 switches (Axial Drive, **HVDC**, 120 VAC) on the **STC** backplane.
4.) Remove power at main disconnect (A1) panel. Use proper Lockout/Tagout procedures.
5.) Remove the 3 M12 cap screws that will release the support bracket near the **STC** assembly. Reference Figure 9-61, on page 804.
6.) Rotate gantry until the Cathode **HV** transformer tank reaches the 3 o'clock position.
7.) Engage gantry rotational lock.

DANGER **ENSURE GANTRY ROTATIONAL LOCK IS FULLY ENGAGED TO PREVENT UNEXPECTED GANTRY MOTION.**

8.) Use the spanner wrench to remove the high voltage cable connector from the high voltage transformer tank.
   - Ground the ends of the H.V. cable to the Gantry frame, to ensure no voltage exists at the end of the cable.
   - Use rags or paper towels to wipe excess oil from the High Voltage Cable Connector and tank well.
9.) Remove cables J1, J2 and J6 from the measurement PWB.

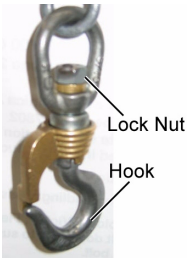
CAUTION **Observe the position of the cables and ty-raps for later installation. It is critical to prevent damage to the system during normal gantry rotation. 14 G's of force are felt at 0.5 second rotational speed.**

10.) Remove four screws fastening the cover to the inverter assembly
   Remove cover.
11.) Measure voltage on the two large capacitors to verify 0 volts.
12.) Disconnect J1 connector from the bottom of the inverter assembly.
13.) Disconnect J6 connector from gate driver PWB.
14.) Carefully disconnect four fiber optic cables from gate driver board, making note of where the Ty-Rap is for routing the cable back in it's original position.

Note: Optic cables must not come in contact with Green Resistors on the Inverter; contact with the resistors can result in a melting of the optic cables.

15.) Verify **HVDC** rail or 120 VAC is not present.
16.) Disconnect **HVDC** cable from capacitor PWB.
17.) Cut Ty-raps from side plate of inverter.
18.) Remove all cables from the Inverter by removing cable restraint at the top of the inverter.
19.) Remove two (2) inverter output leads from H.V. Transformer Tank locations P1 and P2.
20.) Remove the four (4) 3/8 bolts from the inverter baseplate, that fasten the inverter assembly to the H.V. Transformer Tank.

WARNING



IF THE HOIST IS USED WITH THE LOCK NUT OF THE HOOK LOOSE, THE HV TANK MIGHT BE DROPPED FROM THE HOIST, WITH THE RESULT THAT A SERVICE PERSONNEL MIGHT BE SERIOUSLY INJURED. CHECK IF THE LOCK NUT OF THE HOOK IS LOOSENED FIRST BEFORE STARTING TO USE THE HOIST. IF LOOSENED, DO NOT USE THE HOIST THEN ORDER THE NEW HOIST.

21.) Remove the inverter assembly from the gantry:
- Attach the hoist to the boom arm in the gantry.
- Attach the hoist lifting chain to the eyebolt on the transformer tank.
- Remove slack from the hoist chain.

22.) Remove the four (4) bolts that fasten transformer tank to the rotating base.

23.) Use the hoist to lower the transformer tank to the floor.

24.) Install the new transformer tank.

Note: Install four (4) M12 tank mounting bolts, and torque to 66.4 Nm.
The 2 bolts with nuts need to be torqued at the cap screw not the nut.

25.) Mount the inverter to the **HV** tank. Torque the four (4) 3/8 inch bolts to 20 ft-lbs.

26.) Remove the host and boom.

27.) Reassemble all cabling and secure with ty-raps as observed in step 9 through19.

CAUTION **Ensure cables are properly secured. It is critical to prevent damage to the system during normal gantry rotation. 14 G's of force are felt at 0.5 second rotational speed.**

28.) Before you install the **HV** Cable Connector, add 20 cc of dielectric oil to the **HV** Connector well in the **HV** Transformer Tank.

29.) Align the cable terminal orienting key with the notch in the receptacle.

30.) Slowly insert the cable, to engage the connector pins, and seat the cable in the well.
- Tighten the cable locking ring.
- Rotate the cable strain relief for a clean cable dress.
- Use the spanner wrench to tighten the locking ring.
- Use a torque wrench to tighten the locking ring to 11.1 ft.–lbs (153 kg-cm).

NOTICE **Do not over-tighten the locking ring. Over tightening can deform the cable plug sealing surfaces, break the oil seal between receptacle and housing, twist the receptacle, and disrupt internal wiring.**

- Back off on the cable locking ring without disturbing the cable plug.
- Re–tighten the locking ring, and torque to 7.1 ft-lbs (98 kg-cm).

Note: Use the spanner wrench with a torque wrench when you tighten the high–voltage cables on the tube unit.

IF YOU GET OIL ON YOUR HANDS, WASH THEM NOW

31.) Carefully wipe up all excess oil.

32.) Secure **HV** Cables using Large Ty-Raps as shown in Figure 9-64, on page 813.

33.) Reassemble Gantry.

34.) Refer to Retest Verification Table at the end of this chapter.

5.5 HP Anode/Cathode Inverter

5.5.1 Required Tools

- 5/16, 1/2, 9/16 inch sockets or box wrenches
- Flat-blade screwdriver
- Loctite 242

Before beginning this procedure, please read the safety information in "Gantry," on page 37.

5.5.2 Procedure Details

DANGER USE PROPER LOCKOUT/TAGOUT PROCEDURES.

1.) Move table to its lowest elevation.
2.) Remove side, top and front gantry covers.
3.) Turn **OFF** all 3 switches (Axial Drive, **HVDC**, 120 VAC) on the **STC** backplane.
4.) Remove power at main disconnect (A1) panel. Use proper Lockout/Tagout procedures.
5.) Position Gantry with the tube at the 12 o'clock position.
6.) Engage gantry rotational lock.
7.) Remove four screws fastening cover to inverter assembly, and remove cover.
8.) Measure voltage on the two large capacitors to verify 0 volts.
9.) Disconnect J1 connector from the bottom of the inverter assembly.
10.) Disconnect J6 connector from gate driver PWB.
11.) Carefully disconnect four fiber optic cables from gate driver board, making note of where the Ty-rap is for routing the cable back in it's original position.

Note: Optic cables must not come in contact with Green Resistors on the Inverter; contact with the resistors can result in a melting of the optic cables.

12.) Disconnect **HVDC** cable from capacitor PWB.
13.) Remove all cables from the Inverter by removing cable restraint at the top of the inverter.
14.) Remove two inverter output leads from Transformer Tank locations P1 and P2.
15.) Remove four (4) 3/8 bolts from inverter baseplate, which fastens inverter assembly to H.V. Transformer Tank.
16.) Remove inverter assembly from gantry.
17.) Install new inverter assembly.

Note: Use Loctite 242, and torque the four (4) 3/8 tank mounting bolts to 20 ft-lbs.

18.) Reassemble Gantry.
19.) Refer to Retest Verification Table at the end of this chapter.

Figure 9-62 HP Inverter

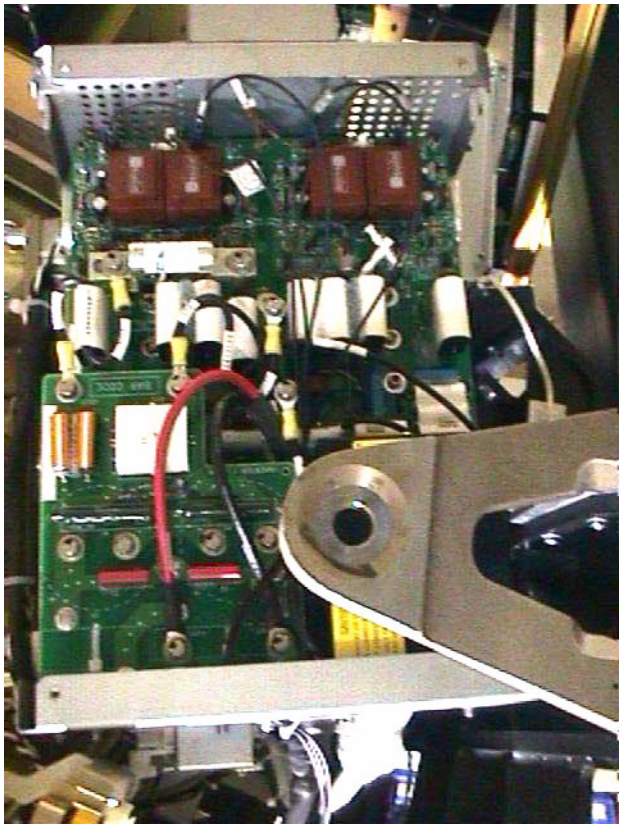


Figure 9-63 HP Inverter, Cover removed

5.6 HV Cables

5.6.1 Required Tools

- Spanner wrench
- 3 mm Hex key
- Large ty-raps 46-208758P5
- Transformer oil
- Paper towels

Before beginning this procedure, please read the safety information in "Gantry," on page 37.

5.6.2 Procedure Details

DANGER **USE PROPER LOCKOUT/TAGOUT PROCEDURES.**

Removal

1.) Move table to its lowest elevation.
2.) Remove side gantry covers and rear base covers.
3.) Turn **OFF** all 3 switches (Axial Drive, **HVDC**, 120 VAC) on the **STC** backplane.
4.) Remove top gantry covers.
5.) Position tube at 3:00 o'clock position
6.) Remove power at main disconnect (A1) panel. Use proper Lockout/Tagout procedures.
7.) Remove ty-raps securing the **HV** cables.
8.) Using spanner wrench remove **HV** candlestick from tube well.
   - Ground the end of the cable to the Gantry Frame to verify no voltage.
   - Wipe excess oil with paper towels.
   - Cover tube well.
9.) Rotate Gantry until the tube reaches the 12 o'clock position.
   Position **HV** cable toward front of gantry.
10.) Use the spanner wrench to remove the candlestick at the **HV** tank.
   - Wipe excess oil with paper towels.
   - Cover the **HV** tank well.
11.) Place the tilt relay board in the manual mode.
12.) Restore power at main disconnect (A1) panel. Use proper Lockout/Tagout procedures.
13.) Manually tilt gantry backward to 30 degrees.

Note: Tilting the gantry is optional. This provides for easier access to the cable clamps while standing at the rear of the gantry.

14.) Remove power at main disconnect (A1) panel. Use proper Lockout/Tagout procedures.
15.) For the Cathode cable;
   - Cut ty-raps at rear of **HEMRC** assembly.
   - Remove 2 cable clamps behind tube attached to the rotating base casting.
16.) For the Anode Cable;
   - Carefully cut ty-raps securing the rotating harness to the **HV** cable.
   - Remove the 2 cable clamps on both sides of the **OBC** assembly attached to the rotating base casting.
17.) Carefully remove the cable from the Gantry.

Installation

CAUTION **Always start at the hv tank. Excess slack in the hv cables can result in system damage. Ensure cables are properly secured. It is critical to prevent damage to the system during normal gantry rotation. 14 G's of force are felt at 0.5 second rotational speed.**

1.) Insert the **HV** Cable candlestick into the **HV** tank well. No oil yet.
2.) Loosely tighten the cable in the well.
3.) For the Cathode cable;
   - Route the cable behind the **HEMRC** assembly.
   - Loosely ty-rap cable to the **HEMRC** frame at 2 points.
   - Verify the **HV** cable can be removed from the **HV** tank. **USE THE ABSOLUTE MINIMUM AMOUNT OF CABLE SLACK**.
   - Secure the ty-raps.
   - Install the cable clamps as originally oriented behind the tube.
4.) For the Anode cable;
   - Route the cable behind the **OBC** assembly.
   - Install the cable clamp near the stamped "-" on the rotating base casting.
   - Verify the **HV** cable can be removed from the **HV** tank. **USE THE ABSOLUTE MINIMUM AMOUNT OF CABLE SLACK**.
   - Install the second cable clamp between the tube and the **OBC** assembly on the rotating base casting.
5.) Remove the candlestick from the **HV** tank well.
6.) Restore power to the main (A1) panel. Do not turn on the **STC** backplane switches.
7.) Manually tilt the gantry to zero degrees.
8.) Remove power at main disconnect (A1) panel. Use proper Lockout/Tagout procedures.
9.) Add 20 ml (0.7 oz) of dielectric oil to the well of the **HV** transformer tank.
10.) Align the cable terminal orienting key with the notch in the receptacle.
11.) Slowly insert the cable, to engage the connector pins, and seat the cable in the well.
   - Tighten the cable locking ring.
   - Rotate the cable strain relief for a clean cable dress.
   - Use the spanner wrench to tighten the locking ring.
   - Use a torque wrench to tighten the locking ring to 11.1 ft.–lbs (153 kg-cm).

NOTICE **Do not over tighten the locking ring. Over tightening can deform the cable plug sealing surfaces, break the oil seal between receptacle and housing, twist the receptacle, and disrupt internal wiring.**

- Back off on the cable locking ring without disturbing the cable plug.
- Re–tighten the locking ring, and torque to 7.1 ft-lbs (98 kg-cm).

Note: Use the spanner wrench with a torque wrench when you tighten the high–voltage cables on the tube unit.

IF YOU GET OIL ON YOUR HANDS, WASH THEM NOW

12.) Carefully wipe up all excess oil.
13.) Rotate tube to the 3:00 o'clock position.
14.) Secure **HV** Cables using Large Ty-Raps as shown in Figure 9-64.
15.) Add 20 ml (0.7 oz.) of dielectric oil to the **HV** connector well of the x-ray tube.

16.) Align the cable terminal orienting key with the notch in the receptacle.

17.) Slowly insert the cable, to engage the connector pins, and seat the cable in the well.

- Tighten the cable locking ring.
- Rotate the cable strain relief for a clean cable dress.
- Use the spanner wrench to tighten the locking ring.
- Use a torque wrench to tighten the locking ring to 11.1 ft.–lbs (153 kg-cm).

NOTICE **Do not over tighten the locking ring. Over tightening can deform the cable plug sealing surfaces, break the oil seal between receptacle and housing, twist the receptacle, and disrupt internal wiring.**

- Back off on the cable locking ring without disturbing the cable plug.
- Re–tighten the locking ring, and torque to 7.1 ft-lbs (98 kg-cm).

Note: Use the spanner wrench with a torque wrench when you tighten the high–voltage cables on the tube unit.

IF YOU GET OIL ON YOUR HANDS, WASH THEM NOW

18.) Carefully wipe up all excess oil.

19.) Place tilt relay board back to normal mode.

20.) Restore power at main disconnect (A1) panel.

21.) Turn **ON** the 120 VAC at the **STC** backplane.

22.) Manually rotate the gantry and verify there are no obstructions.

23.) Turn **ON** the Axial Enable and **HVDC** on the **STC** backplane.

24.) Rotate the Gantry at a speed of 1 Revolution per second, for several revolutions.

25.) Rotate the Gantry at a speed of 0.5 Revolution per second, for several revolutions.

26.) Check the tube and transformer tank wells for oil leaks.

27.) Reassemble Gantry.

28.) Refer to Retest Verification Table at the end of this chapter.

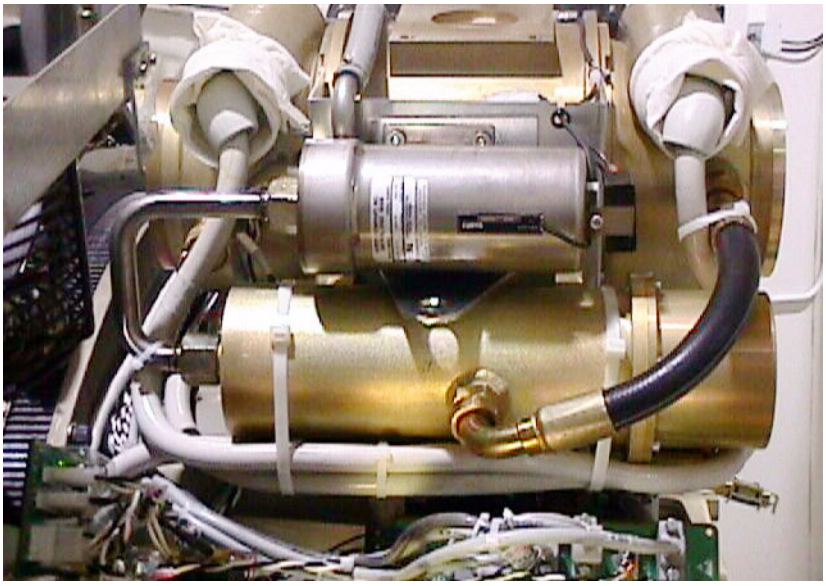


Figure 9-64 HV Cable Routing

5.7 HEMRC

5.7.1 Filament Power Supply

5.7.1.1 Required Tools

- 10 mm open end/box wrench
- 3 mm, 5 mm Hex key sockets
- 7 mm, 10 mm and 9/16”socket
- Flathead screwdriver
- Phillips #2 screwdriver
- Ty-raps 7.5 inch 46-208758P3

Before beginning this procedure, please read the safety information in “Gantry,” on page 37.

5.7.1.2 Procedure Details

DANGER **USE PROPER LOCKOUT/TAGOUT PROCEDURES.**

Removal

1.) Move table to its lowest elevation.
2.) Remove side, top and front gantry covers.
3.) Turn **OFF** all 3 switches (Axial Drive, **HVDC**, 120 VAC) on the **STC** backplane.
4.) Remove power at main disconnect (A1) panel. Use proper Lockout/Tagout procedures.
5.) Position **HEMRC** at 1 o’clock to clear fan obstruction.
6.) Remove **HEMRC** cover.
7.) Disconnect all connectors from **HEMRC** Interface board.
8.) Disconnect **HVDC** Power Cable from HVDC+ and HVDC- lugs (3/8” brass nuts).
9.) Disconnect **HVDC** cable ground bracket, cut choke ty-raps and set cable aside.
10.) Remove (6) 4 mm cap screws and washers and remove **HEMRC** Interface board.
11.) Cut ty-raps to Cathode High Voltage Cable.
12.) Position cable behind **HEMRC** assembly.
13.) Remove the J15 DB 9 connector on the left side of the T1 transformer.
14.) Remove J3/J9 **CAN** communication cable shield ground bracket. (7 mm nuts and washer).
15.) Remove (2) 10 mm nuts and washers securing **HEMRC** Filter mounting bracket. Set aside bracket.
16.) Remove (4) 10 mm nuts and washers to remove top-tier mounting bracket and remove bracket.
17.) Remove wires at Allen Bradley amplifier R, S.
Flip the Safety cover up by lifting on the black left and right tabs.
18.) Remove wires X1, X3 and H1, H4 from T1 transformer.
19.) Disconnect connections to **HEMRC** Drive. DC+, DC-.
20.) Disconnect FWB+ (Orange) and FWB- (Purple) at the Full wave Diode bridge on the **HEMRC** Filter bracket.
Remove ty-raps from chopper harness choke. (DC+, DC- cable)
21.) Disconnect stator cable shield ground bracket and ground wire from the **HEMRC** filter board.
(2) 7 mm nuts and 1, 4 mm cap screw with washer.
22.) Disconnect Stator black T1 wire (U), the white T2V wire (V), and the green T3W wire (W).

23.) Set **HEMRC** Filter bracket aside
24.) Disconnect SCR1-1 SCR1-2, SCR1-3 wires.
25.) Disconnect Filament power supply wires from fuse next to T1 transformer. Feed them through the grommet into the bottom-tier.
26.) Remove the T1 transformer.
    a.) Remove (4) 6 mm cap screws.
    b.) Remove (4) 9/16” standoffs.
27.) Remove the (4) 7 mm nuts securing the Allen Bradley amplifier.
28.) Remove the amplifier and set aside.
29.) Free the chopper harness from the quick release wire guides.
30.) Carefully thread the chopper power harness through the mid-tier plate to the white J7 connector. Do not attempt to force the connector through the hole. It will not fit.
31.) Remove remaining (2) 10 mm nuts and washers for mid-tier plate.
32.) Remove the (2) 10 mm nuts on the bottom center support brace.
33.) Carefully lift and flip the mid-tier plate and rest it on the **HV** tank next to the **HEMRC** assembly.
34.) Remove the (3) 4 mm cap screws from both sides rear air diverter on bottom plate.

CAUTION **This is sharp spring steel.**

35.) Remove the (4) 10 mm nuts and washers using the box wrench. (2 are beneath the transformer.)
36.) Remove filament power supply.

Installation

1.) Install new filament power supply. Torque (4) 10 mm nuts and washers to 5.9 Nm.
2.) Install spring steel air diverters. Torque 3 per side, 4 mm cap screws to 5.9 Nm.
3.) Install mid-tier plate.
    - Torque 2 bottom center brace, 10 mm nuts to 5.9 Nm.
    - Torque 2 center mid-tier plate, 10 mm nuts and washers to 5.9 Nm.
4.) Carefully work chopper power harness back out to mid-tier.
5.) Secure chopper harness in quick clip wire guides.
6.) Install T1 transformer. Torque 9/16” standoffs and (4) 6mm cap screws and washers to 5.9 Nm.
    - Remember the top spacer plate.
    - X1 and X3 terminals are tank side.
7.) Install Allen Bradley amplifier. Torque (4) 7 mm nuts to 1.7 Nm.
8.) Connect the SCR1-1, SCR1-2, SCR1-3 and Filament power supply fuse wires.
9.) Connect the FWB+ (Orange) and FWB- (Purple) wires to the Full wave Diode bridge.
    - Make sure you get the polarity correct.
    - Make sure you ty-rap the FWB choke to the bracket TY-RAP LOCK INSIDE.
    - Make sure you connect the Stator ground to the **HEMRC** filter board. (4 mm cap screw).
10.) Connect the Stator cable shield ground bracket to the **HEMRC** Filter Bracket. Torque to 1.7 Nm.
11.) Connect the DC+, DC- lead from the filter board and Chopper harness to the amplifier.
12.) Connect the Stator black T1 wire (U), the white T2V wire (V), and the green T3W wire (W).
13.) Connect the T1 transformer X1, X3 and H1, H4 wires. (X3 and H4 is toward the rear).
14.) Connect the T1 transformer R and S wires to the Allen Bradley amp.
15.) Install the top-tier bracket. Torque the (4) 10 mm nuts and washers to 5.9 Nm.

16.) Install the J15 DB 9 connector. Make sure to tighten the finger screws.
17.) Secure the **HV** cable to the rear of the **HEMRC** assembly.
18.) Install the **HEMRC** Interface board. Torque (6) 4 mm cap screws and washers to 1.7 Nm.
19.) Connect all **HEMRC** connectors.
20.) Secure the J3/J9 **CAN** communications cable shield ground. Torque (2) 7 mm nuts and washers to 1.7 Nm.
21.) Route **HVDC** cable loop under top-tier bracket. Secure **HVDC** cable shield ground. Torque (2) 7 mm nuts and washers to 1.7 Nm.
22.) Secure **HVDC** choke to left side top-tier support bracket with 2 ty-raps.
This should be flat against the bracket to not interfere with the cover.
23.) Install **HEMRC** cover. Tighten 1/4 turn past seated finger tight.
24.) Apply power at main disconnect (A1) panel. Use proper Lockout/Tagout procedures.
25.) Turn **ON** **HVDC** and 120 VAC on the **STC** backplane. Verify no smoke or arching.
26.) Perform hardware reset.
27.) Assemble gantry.
28.) Refer to Retest Verification Table at the end of this chapter.

5.7.2 HEMRC Fuse Replacement

46-170021P104 (10 amp.) Located on the **HEMRC** bottom-tier right front side.
46-170021P43 (3 amp.) Located on the **HEMRC** Interface Board**.**
46-170021P15 (8 amp.) Located on the **HEMRC** Interface Board**.**
46-170021P101 (20 amp.) Located on the **HEMRC** Interface Board**.**

5.7.2.1 Required Tools

- Flat-blade screwdriver
- Digital Volt Meter (DVM)

Before beginning this procedure, please read the safety information in “Gantry,” on page 37.

5.7.2.2 Procedure Details

DANGER USE PROPER LOCKOUT/TAGOUT PROCEDURES.

1.) Move table to its lowest elevation.
2.) Remove side, top and front gantry covers.
3.) Turn **OFF** all 3 switches (Axial Drive, **HVDC**, 120 VAC) on the **STC** backplane.
4.) Remove power at main disconnect (A1) panel. Use proper Lockout/Tagout procedures.
5.) Position **HEMRC** at 1 o’clock to clear fan obstruction.
6.) Remove **HEMRC** cover.
7.) Using a DVM measure both sides of all fuses to chassis ground. Verify zero (0) volts.
8.) Remove fuse and confirm that it has opened.
9.) Replace fuse.
10.) Replace **HEMRC** cover and secure 1/4 turn past seated finger tight.
11.) Apply power at main disconnect (A1) panel. Use proper Lockout/Tagout procedures.
12.) Turn **ON** **HVDC** and 120 VAC on the **STC** backplane. Verify no smoke or arching.
13.) Assemble gantry covers.
14.) Refer to Retest Verification Table at the end of this chapter.

5.7.3 Fuse Block on the HEMRC Resistor Panel Asm

5.7.3.1 Required Tools

- Flat-blade screwdriver
- Digital Volt Meter (DVM)
- 3 mm Hex key sockets

Before beginning this procedure, please read the safety information in "Gantry," on page 37.

5.7.3.2 Procedure Details

DANGER USE PROPER LOCKOUT/TAGOUT PROCEDURES.

1.) Move table to its lowest elevation.
2.) Remove side, top and front gantry covers.
3.) Turn **OFF** all 3 switches (Axial Drive, **HVDC**, 120 VAC) on the **STC** backplane.
4.) Remove power at main disconnect (A1) panel. Use proper Lockout/Tagout procedures.
5.) Position **HEMRC** at 1 o'clock to clear fan obstruction.
6.) Remove **HEMRC** cover.
7.) Using a DVM measure both sides of all fuses to chassis ground. Verify zero (0) volts.
8.) Remove 10 amp fuse. from fuse holder on bottom-tier front right side.
9.) Disconnect wires from fuse holder.
10.) Remove two (2) 4 mm cap screws attaching fuse holder.
11.) Remove and replace fuse holder. Torque 2 4 mm cap screws to 1.7 Nm.
12.) Replace leads removed in step 9.
13.) Replace 10 Amp fuse.
14.) Replace **HEMRC** cover and secure 1/4 turn past seated finger tight.
15.) Apply power at main disconnect (A1) panel. Use proper Lockout/Tagout procedures.
16.) Turn **ON** **HVDC** and 120 VAC on the **STC** backplane. Verify no smoke or arching.
17.) Assemble gantry covers.
18.) Refer to Retest Verification Table at the end of this chapter.

5.7.4 HEMRC Dropping Resistors

5.7.4.1 Required Tools

- Flat-blade screwdriver
- Digital Volt Meter (DVM)
- 7 mm socket

Before beginning this procedure, please read the safety information in "Gantry," on page 37.

5.7.4.2 Procedure Details

DANGER USE PROPER LOCKOUT/TAGOUT PROCEDURES.

1.) Move table to its lowest elevation.
2.) Remove side, top and front gantry covers.
3.) Turn **OFF** all 3 switches (Axial Drive, **HVDC**, 120 VAC) on the **STC** backplane.

4.) Remove power at main disconnect (A1) panel. Use proper Lockout/Tagout procedures.
5.) Position **HEMRC** at 1 o'clock to clear fan obstruction.
6.) Remove **HEMRC** cover.
7.) Using a DVM measure both sides of all fuses to chassis ground. Verify zero (0) volts.
8.) Remove ty-raps and disconnect from **HEMRC** Interface board J4/J5 connectors.
9.) Remove 2 per resistor, 7 mm cap screws.
10.) Replace resistor. Torque 7 mm cap screws to 1.7 Nm
11.) Connect to **HEMRC** interface board.
12.) Ty-rap wires as originally found.
13.) Replace **HEMRC** cover and secure 1/4 turn past seated finger tight.
14.) Apply power at main disconnect (A1) panel. Use proper Lockout/Tagout procedures.
15.) Turn **ON** **HVDC** and 120 VAC on the **STC** backplane. Verify no smoke or arching.
16.) Assemble gantry covers.
17.) Refer to Retest Verification Table at the end of this chapter.

5.7.5 HEMRC Braking Resistors

5.7.5.1 Required Tools

- Flat-blade screwdriver
- Digital Volt Meter (DVM)
- 3 mm, 5 mm Hex key sockets
- 10 mm box wrench

Before beginning this procedure, please read the safety information in "Gantry," on page 37.

5.7.5.2 Procedure Details

DANGER USE PROPER LOCKOUT/TAGOUT PROCEDURES.

1.) Move table to its lowest elevation.
2.) Remove side, top and front gantry covers.
3.) Turn **OFF** all 3 switches (Axial Drive, **HVDC**, 120 VAC) on the **STC** backplane.
4.) Remove power at main disconnect (A1) panel. Use proper Lockout/Tagout procedures.
5.) Position **HEMRC** at 6 o'clock.
6.) Remove (2) 4 mm cap screws and washers.
Cover under the **HEMRC** Assembly closest to ISO Center.
7.) Using a DVM measure both sides of the resistors to chassis ground. Verify zero (0) volts.
8.) Remove electrical connection from defective resistor.
- Write down wiring connections and hardware arrangement.
- Do not drop the hardware into the **HEMRC** assembly

9.) For both resistors perform the following:
- Remove 6 mm lock nut and star lock washer.
- Remove 6 mm tensioning nut.
- Loosen, do not remove, the (2) 10 mm nuts to separate the resistor mounting covers.
- Slide the covers apart. Note the original position.
- Carefully retract long bolt to pivot the failed resistor up out of the assembly.
- Catch the insulating washers.

10.) Replace failed resistor.

11.) Loosely install the tensioning nut on both long bolts.
12.) Carefully position resistors and insulating washers while you slide the mounting covers together. Make sure the covers engage properly.
13.) Snug the tensioning bolts finger tight to hold the mounting covers together.
14.) Position the mounting covers as identified in step 9. Torque both 6 mm nuts to 5.9 Nm.
15.) Rotate the resistors so that the connectors are parallel to the **HEMRC** assembly to prevent electrical arcing or shorts.
16.) Torque the tensioning nut to 5.9 Nm.
17.) Install the star lock washer and 6 mm lock nut. Torque to 5.9 Nm.
18.) Replace electrical connections to resistor.
    - Careful not to drop hardware into **HEMRC** assembly.
    - Orient hardware as identified in step 8.
19.) Replace **HEMRC** resistor cover. Torque (2) 4 mm cap screws and washers to 5.9 Nm
20.) Apply power at main disconnect (A1) panel. Use proper Lockout/Tagout procedures.
21.) Turn **ON** **HVDC** and 120 VAC on the **STC** backplane. Verify no smoke or arching.
22.) Assemble gantry covers.
23.) Refer to Retest Verification Table at the end of this chapter.

5.7.6 HEMRC Interface Board

5.7.6.1 Required Tools

- Flat-blade screwdriver
- Digital Volt Meter (DVM)
- 3 mm Hex key sockets

Before beginning this procedure, please read the safety information in "Gantry," on page 37.

5.7.6.2 Procedure Details

DANGER USE PROPER LOCKOUT/TAGOUT PROCEDURES.

1.) Move table to its lowest elevation.
2.) Remove side, top and front gantry covers.
3.) Turn **OFF** all 3 switches (Axial Drive, **HVDC**, 120 VAC) on the **STC** backplane.
4.) Remove power at main disconnect (A1) panel. Use proper Lockout/Tagout procedures.
5.) Position **HEMRC** at 1 o'clock to clear fan obstruction.
6.) Remove **HEMRC** cover.
7.) Using a DVM measure both sides of all fuses to chassis ground. Verify zero (0) volts.
8.) Remove electrical cable connections from the interface board.
9.) Remove (6) 4 mm cap screws and washers.
10.) Replace **HEMRC** interface board. Torque (6) 4 mm cap screws and washers to 1.7 Nm.
11.) Reinstall cable connections to interface board.
12.) Replace **HEMRC** cover and secure 1/4 turn past seated finger tight.
13.) Apply power at main disconnect (A1) panel. Use proper Lockout/Tagout procedures.
14.) Turn **ON** **HVDC** and 120 VAC on the **STC** backplane. Verify no smoke or arching.
15.) Assemble gantry covers.
16.) Refer to Retest Verification Table at the end of this chapter.

5.7.7 HEMRC Step-up (T1) Transformer

5.7.7.1 Required Tools

- 3 mm, 5 mm Hex key sockets
- 10 mm and 9/16”socket
- Flathead screwdriver
- Phillips #2 screwdriver
- Ty-raps 7.5 inch 46-208758P3

Before beginning this procedure, please read the safety information in “Gantry,” on page 37.

5.7.7.2 Procedure Details

DANGER **USE PROPER LOCKOUT/TAGOUT PROCEDURES.**

Removal

1.) Move table to its lowest elevation.
2.) Remove side, top and front gantry covers.
3.) Turn **OFF** all 3 switches (Axial Drive, **HVDC**, 120 VAC) on the **STC** backplane.
4.) Remove power at main disconnect (A1) panel. Use proper Lockout/Tagout procedures.
5.) Position **HEMRC** at 1 o’clock to clear fan obstruction.
6.) Remove **HEMRC** cover.
7.) Disconnect all connectors from **HEMRC** Interface board.
8.) Disconnect **HVDC** Power Cable from HVDC+ and HVDC- lugs (3/8” brass nuts).
9.) Disconnect **HVDC** cable ground bracket, cut choke ty-raps and set cable aside.
10.) Remove (6) 4 mm cap screws and washers and remove **HEMRC** Interface board.
11.) Remove J3/J9 **CAN** communication cable shield ground bracket. (7 mm nuts and washer).
12.) Remove (4) 10 mm nuts and washers to remove top-tier mounting bracket and remove bracket.
13.) Remove wires X1, X3 and H1, H4 from T1 transformer.
14.) Remove the T1 transformer.
    a.) Remove (4) 6 mm cap screws.
    b.) Remove (4) 9/16” standoffs.

Installation

1.) Install T1 transformer. Torque 9/16” standoffs and (4) 6mm cap screws and washers to 5.9 Nm.
    - Remember the top spacer plate.
    - X1 and X3 terminals are tank side.
2.) Connect the T1 transformer X1, X3 and H1, H4 wires. (X3 and H4 is toward the rear).
3.) Install the top-tier bracket. Torque the (4) 10 mm nuts and washers to 5.9 Nm.
4.) Install the **HEMRC** Interface board. Torque (6) 4 mm cap screws and washers to 1.7 Nm.
5.) Connect all **HEMRC** connectors.
6.) Secure the J3/J9 **CAN** communications cable shield ground. Torque (2) 7 mm nuts and washers to 1.7 Nm.
7.) Route **HVDC** cable loop under top-tier bracket. Secure **HVDC** cable shield ground. Torque (2)

7 mm nuts and washers to 1.7 Nm.

8.) Secure **HVDC** choke to left side top-tier support bracket with 2 ty-raps. This should be flat against the bracket to not interfere with the cover.
9.) Install **HEMRC** cover. Tighten 1/4 turn past seated finger tight.
10.) Apply power at main disconnect (A1) panel. Use proper Lockout/Tagout procedures.
11.) Turn **ON** **HVDC** and 120 VAC on the **STC** backplane. Verify no smoke or arching.
12.) Perform hardware reset.
13.) Assemble gantry.
14.) Refer to Retest Verification Table at the end of this chapter.

5.7.8 SCR Module

5.7.8.1 Required Tools

- Flat-blade screwdriver
- Digital Volt Meter (DVM)
- 3 mm Hex key sockets
- Thermal compound (46-170212P1)

Before beginning this procedure, please read the safety information in "Gantry," on page 37.

5.7.8.2 Procedure Details

DANGER USE PROPER LOCKOUT/TAGOUT PROCEDURES.

1.) Move table to its lowest elevation.
2.) Remove side, top and front gantry covers.
3.) Turn **OFF** all 3 switches (Axial Drive, **HVDC**, 120 VAC) on the **STC** backplane.
4.) Remove power at main disconnect (A1) panel. Use proper Lockout/Tagout procedures.
5.) Position **HEMRC** at 1 o'clock to clear fan obstruction.
6.) Remove **HEMRC** cover.
7.) Using a DVM measure both sides of all fuses to chassis ground. Verify zero (0) volts.
8.) Note and record position of three (3) wires (Red, Pur and Wht) attached to SCR.
9.) Note and record position of two (2) wires (Blk and Wht) attached to SCR.
10.) Note and record position of SCR terminals.
11.) Remove leads identified in steps 8 and 9.
12.) Remove two (2) 4 mm cap screws.
13.) Clean SCR mounting surface on resistor mounting panel, using a dry tissue to remove thermal compound.
14.) Prepare new SCR by coating the mounting surface with thermal compound (46-170212P1).
15.) Mount SCR in position recorded in step 10. Torque (2) 4 mm cap screws to 1.7 Nm.
16.) Replace leads removed in steps 8 and 9.
17.) Install **HEMRC** cover. Tighten 1/4 turn past seated finger tight.
18.) Apply power at main disconnect (A1) panel. Use proper Lockout/Tagout procedures.
19.) Turn **ON** **HVDC** and 120 VAC on the **STC** backplane. Verify no smoke or arching.
20.) Perform hardware reset.
21.) Assemble gantry.
22.) Refer to Retest Verification Table at the end of this chapter.

5.7.9 Bridge Rectifier

5.7.9.1 Required Tools

- Flat-blade screwdriver
- Digital Volt Meter (DVM)
- 3 mm Hex key sockets
- Thermal compound (46-170212P1)

Before beginning this procedure, please read the safety information in "Gantry," on page 37.

5.7.9.2 Procedure Details

DANGER USE PROPER LOCKOUT/TAGOUT PROCEDURES.

1.) Move table to its lowest elevation.
2.) Remove side, top and front gantry covers.
3.) Turn **OFF** all 3 switches (Axial Drive, **HVDC**, 120 VAC) on the **STC** backplane.
4.) Remove power at main disconnect (A1) panel. Use proper Lockout/Tagout procedures.
5.) Position **HEMRC** at 1 o'clock to clear fan obstruction.
6.) Remove **HEMRC** cover.
7.) Using a DVM measure both sides of all fuses to chassis ground. Verify zero (0) volts.
8.) Note and record position of bridge rectifier terminals and polarity mark.
9.) Note and record the position of four (4) leads connected to bridge rectifier. (Red, Blk, Pur and Orn)
10.) Remove the four leads from bridge rectifier.
11.) Remove 7 mm hex nut and washers holding the bridge rectifier to the **HEMRC** mounting plate.
12.) Remove bridge rectifier.
13.) Clean bridge rectifier mounting surface on mounting plate, using a dry tissue to remove thermal compound.
14.) Prepare new bridge rectifier by coating mounting surface with thermal compound (46-170212 P1).
15.) Mount bridge rectifier as recorded in step 8. Torque 7 mm hex nut and washers 1.7 Nm.
16.) Replace leads removed in step 10 as noted in step 9.
17.) Install **HEMRC** cover. Tighten 1/4 turn past seated finger tight.
18.) Apply power at main disconnect (A1) panel. Use proper Lockout/Tagout procedures.
19.) Turn **ON** **HVDC** and 120 VAC on the **STC** backplane. Verify no smoke or arching.
20.) Perform hardware reset.
21.) Assemble gantry.
22.) Refer to Retest Verification Table at the end of this chapter.

5.7.10 HEMRC Filter Board

5.7.10.1 Required Tools

- Flat-blade screwdriver
- Phillips #2 screwdriver
- Digital Volt Meter (DVM)
- 3 mm Hex key sockets

Before beginning this procedure, please read the safety information in "Gantry," on page 37.

5.7.10.2 Procedure Details

DANGER USE PROPER LOCKOUT/TAGOUT PROCEDURES.

1.) Move table to its lowest elevation.
2.) Remove side, top and front gantry covers.
3.) Turn **OFF** all 3 switches (Axial Drive, **HVDC**, 120 VAC) on the **STC** backplane.
4.) Remove power at main disconnect (A1) panel. Use proper Lockout/Tagout procedures.
5.) Position **HEMRC** at 1 o'clock to clear fan obstruction.
6.) Remove **HEMRC** cover.
7.) Using a DVM measure both sides of all fuses to chassis ground. Verify zero (0) volts.
8.) Engage gantry rotational lock.
9.) Remove five (5) bolts fastening cover to **HEMRC** assembly and remove cover.
10.) Remove the (2) 6 mm nuts and washers securing the **HEMRC** Filter bracket.
11.) Remove the DC+ and DC- wire from the Allen Bradley amplifier.
12.) Remove the (4) 4 mm cap screws and washers securing the filter board.
13.) Install the new filter board. Torque the (4) 4 mm cap screws to 1.7 Nm.
Remember to install the Stator ground wire.
14.) Connect the DC+ and DC- wire to the Allen Bradley amplifier.
15.) Install the **HEMRC** Filter bracket. Torque the (2) 6 mm nuts to 5.9 Nm.
16.) Install **HEMRC** cover. Tighten 1/4 turn past seated finger tight.
17.) Apply power at main disconnect (A1) panel. Use proper Lockout/Tagout procedures.
18.) Turn **ON** **HVDC** and 120 VAC on the **STC** backplane. Verify no smoke or arching.
19.) Perform hardware reset.
20.) Assemble gantry.
21.) Refer to Retest Verification Table at the end of this chapter.

5.7.11 HEMRC AC Drive Replacement

5.7.11.1 Required Tools

- 3 mm, 7 mm, 10 mm Hex key sockets
- Flathead screwdriver
- Phillips #2 screwdriver
- Ty-raps 7.5 inch 46-208758P3

Before beginning this procedure, please read the safety information in "Gantry," on page 37.

5.7.11.2 Procedure Details

DANGER **USE PROPER LOCKOUT/TAGOUT PROCEDURES.**

Removal

1.) Move table to its lowest elevation.
2.) Remove side, top and front gantry covers.
3.) Turn **OFF** all 3 switches (Axial Drive, **HVDC**, 120 VAC) on the **STC** backplane.
4.) Remove power at main disconnect (A1) panel. Use proper Lockout/Tagout procedures.
5.) Position **HEMRC** at 1 o'clock to clear fan obstruction.
6.) Remove **HEMRC** cover.
7.) Disconnect all connectors from **HEMRC** Interface board.
8.) Disconnect **HVDC** Power Cable from HVDC+ and HVDC- lugs (3/8" brass nuts).
9.) Disconnect **HVDC** cable ground bracket, cut choke ty-raps and set cable aside.
10.) Remove (6) 4 mm cap screws and washers and remove **HEMRC** Interface board.
11.) Remove J3/J9 **CAN** communication cable shield ground bracket. (7 mm nuts and washer).
12.) Remove (2) 10 mm nuts and washers securing **HEMRC** Filter mounting bracket. Set aside bracket.
13.) Remove (4) 10 mm nuts and washers to remove top-tier mounting bracket, and remove bracket.
14.) Remove wires at Allen Bradley R, S. Flip the Safety cover up by lifting on the black left and right tabs.
15.) Disconnect connections to **HEMRC** Drive. DC+, DC-.
16.) Disconnect Stator black T1 wire (U), the white T2V wire (V), and the green T3W wire (W).
17.) Remove the (4) 7 mm nuts securing the Allen Bradley amplifier.
18.) Remove the amplifier and set aside.

Installation

1.) Install Allen Bradley amplifier. Torque (4) 7 mm nuts to 1.7 Nm.
2.) Connect the DC+, DC- lead from the filter board and Chopper harness to the amplifier.
3.) Connect the Stator black T1 wire (U), the white T2V wire (V), and the green T3W wire (W).
4.) Connect the T1 transformer R and S wires to the Allen Bradley amp.
5.) Install the top-tier bracket. Torque the (4) 10 mm nuts and washers to 5.9 Nm.
6.) Install the **HEMRC** Interface board. Torque (6) 4 mm cap screws and washers to 1.7 Nm.
7.) Connect all **HEMRC** connectors.
8.) Secure the J3/J9 **CAN** communications cable shield ground. Torque (2) 7 mm nuts and washers to 1.7 Nm.
9.) Route **HVDC** cable loop under top-tier bracket. Secure **HVDC** cable shield ground. Torque (2) 7 mm nuts and washers to 1.7 Nm.
10.) Secure **HVDC** choke to left side top-tier support bracket with 2 ty-raps. This should be flat against the bracket to not interfere with the cover.
11.) Install **HEMRC** cover. Tighten 1/4 turn past seated finger tight.
12.) Apply power at main disconnect (A1) panel. Use proper Lockout/Tagout procedures.
13.) Turn **ON** **HVDC** and 120 VAC on the **STC** backplane. Verify no smoke or arching.
14.) Perform hardware reset.
15.) Assemble gantry.
16.) Refer to Retest Verification Table at the end of this chapter.

5.7.12 Tube Fan/Pump Relay

5.7.12.1 Required Tools

- Phillips #2 screwdriver
- Flat-blade screwdriver
- 3 MM. Hex Key

Before beginning this procedure, please read the safety information in "Gantry," on page 37.

5.7.12.2 Procedure Details

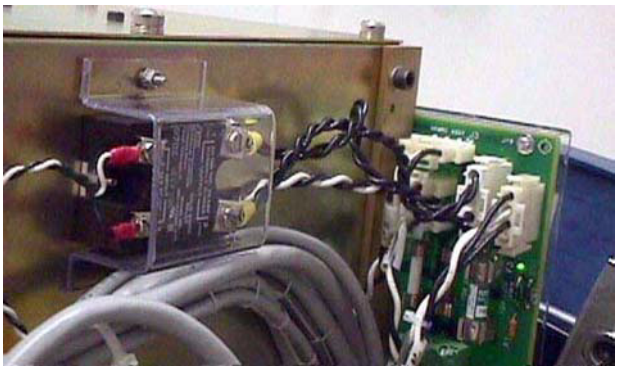


Figure 9-65 OBC Tube Fan/Pump Relay

DANGER USE PROPER LOCKOUT/TAGOUT PROCEDURES.

1.) Move table to its lowest elevation.
2.) Remove right side and top covers.
3.) Turn **OFF** all 3 switches (Axial Drive, **HVDC**, 120 VAC) on the **STC** backplane.
4.) Position **OBC** at 2 o'clock.
5.) Remove (2) 4 mm cap screws that secure safety cover over tube fan/pump relay.
6.) Remove the (4) wires from the relay.
Write down the wiring and relay orientation for later assembly.
7.) Remove (2) 4 mm cap screws and washers.
8.) Install new relay and safety cover. Torque 4 mm cap screws to 2.3 Nm.
9.) Restore power.
10.) Verify no errors in system log and tube fan is operating.
11.) Reassemble gantry.

5.7.13 OBC Filament Relay

5.7.13.1 Required Tools

Flat-blade screwdriver

Before beginning this procedure, please read the safety information in "Gantry," on page 37.

5.7.13.2 Procedure Details

1.) Move table to its lowest elevation.
2.) Remove side, top and front gantry covers.
3.) Turn **OFF** all 3 switches (Axial Drive, **HVDC**, 120 VAC) on the **STC** backplane.

4.) Position **OBC** at 2:00 o'clock. Reference Figure 9-66.

5.) Carefully remove the Filament relay retaining clip on the **OBC** backplane. Observe how the clip is mounted for later assembly.

6.) Remove Filament Relay.

7.) Install new relay and make sure retaining clip is properly installed.

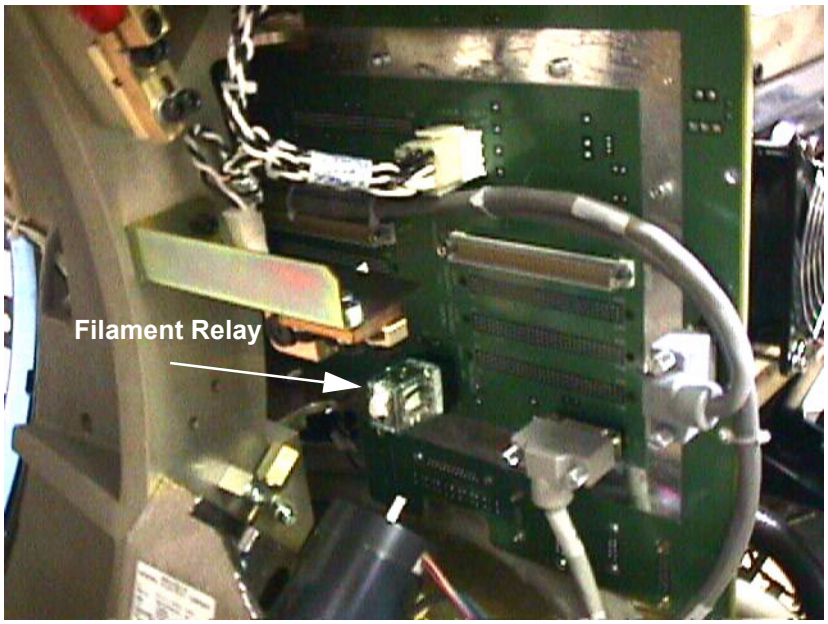


Figure 9-66 OBC Backplane Filament Relay

Section 6.0
Retest Matrix: High Voltage Replacement Verification

NOTICE **Please perform the retests listed below when you replace or adjust a high voltage part.**

HV SYSTEM COMPONENTS	TASK	VERIFICATION TEST
Tube	Pull and complete tube data for old tube and install new tube. See Table 9-44, on page 768.	Verify mA meter, new Auto mA Cal (Seed Shift only), (10) slices of micro phonics, Alignments, calibrate **HV** Tank Feed back, kV meter*, heat soak and season the tube, verify mA and kV, QCal, Cals, "N" number check, then do image series.
HEMRC Filament power Supply	Replacement, "HEMRC," on page 814.	Auto mA Cal, verify kV and mA, and "System Scanning Test," on page 668.
HEMRC FUSES	Replacement, "HEMRC Fuse Replacement," on page 816.	"System Scanning Test," on page 668.
HEMRC Fuse Block	Replacement, "Fuse Block on the HEMRC Resistor Panel Asm," on page 817.	"System Scanning Test," on page 668.
HEMRC Dropping Resistors	Replacement, "HEMRC Dropping Resistors," on page 817.	"System Scanning Test," on page 668.
HEMRC Braking Resistors	Replacement, "HEMRC Braking Resistors," on page 818.	"System Scanning Test," on page 668.
HEMRC Interface Board	Replacement, "HEMRC Interface Board," on page 819.	"System Scanning Test," on page 668.
HEMRC Step-up T1 Transformer	Replacement, "HEMRC Step-up (T1) Transformer," on page 820.	"System Scanning Test," on page 668.
HEMRC SCR Module	Replacement, "SCR Module," on page 821.	"System Scanning Test," on page 668.
HEMRC Bridge Rectifier	Replacement, "Bridge Rectifier," on page 822.	"System Scanning Test," on page 668.
HEMRC Filter Board	Replacement, "HEMRC Filter Board," on page 823.	"System Scanning Test," on page 668.
HEMRC AC Drive	Replacement, "HEMRC AC Drive Replacement," on page 823.	"System Scanning Test," on page 668.
HV Cable	Replacement, "HV Cables," on page 811.	"Auto mA Calibration," on page 762.

Table 9-58 High Voltage System Retest Matrix

HV SYSTEM COMPONENTS	TASK	VERIFICATION TEST
HV Tank (Anode or Cathode)	Replacement, "High Voltage Tank (Anode)," on page 804.	"KV Gain Pots Adjustment," on page 759. "Verify kV Meter," on page 755. "Verify mA Meter," on page 756. "Auto mA Calibration," on page 762. "KV Rise and Fall Times," on page 763. "System Scanning Test," on page 668.
HV Inverter (Anode or Cathode)	Replacement, "HP Anode/ Cathode Inverter," on page 809.	"Verify kV Meter," on page 755. "Verify mA Meter," on page 756. "Auto mA Calibration," on page 762. "System Scanning Test," on page 668.
Measurement Board	Replacement, "Transformer Tank Measurement Board," on page 803.	"KV Gain Pots Adjustment," on page 759. "Verify kV Meter," on page 755. "Verify mA Meter," on page 756. "Auto mA Calibration," on page 762. "KV Rise and Fall Times," on page 763. "System Scanning Test," on page 668.
Filament Relay	Replacement, "OBC Filament Relay," on page 825.	"Auto mA Calibration," on page 762. "System Scanning Test," on page 668.
Tube Cooling Relay	Replacement, "Tube Fan/ Pump Relay," on page 825.	• Plane of Rotation (**POR**). • X-Ray Beam on Window (**BOW**) • Isocenter • Center Body Filter (**CBF**) and **SAG**
mA Board	Replacement, "OBC Circuit Boards," on page 659.	"Verify mA Meter," on page 756. "Verify kV Meter," on page 755. "Auto mA Calibration," on page 762. Exposure Time Accuracy, and "System Scanning Test," on page 668.
kV Board	Replacement, "OBC Circuit Boards," on page 659.	"Verify kV Meter," on page 755. "Verify mA Meter," on page 756. "KV Gain Pots Adjustment," on page 759. "Auto mA Calibration," on page 762. "KV Rise and Fall Times," on page 763. "System Scanning Test," on page 668.
HEMRC Control Board	Replacement, "OBC Circuit Boards," on page 659.	Select kV & mA under Troubleshoot; refer to information that begins on page 690. "System Scanning Test," on page 668.
Collimator Assembly	Replacement, "Collimator Assembly," on page 798.	"Characterization Software Procedure," on page 748, Complete Tube alignments, Collimator Calibration, Detailed Phantom Calibrations and Perform IQ test Chapter 10.

Table 9-58 High Voltage System Retest Matrix (Continued)

HV SYSTEM COMPONENTS	TASK	VERIFICATION TEST
Collimator Control Board	Replacement, "Collimator Control Board (CCB)," on page 795.	"Characterization Software Procedure," on page 748 and Collimator calibration.
Collimator/ Detector Heater Power Supply	Adjustment, "Collimator/ Detector Heater Power Supply," on page 742.	Adjust for a reading of 24 volts ± 1.0 volts at the -out and + out terminals
Collimator Filter	Replacement, "Filter Assembly," on page 794.	Perform **CBF** adjustments in Chapter 11, Perform IQ test Chapter 10
Collimator CAM Motor Drive Module	Replacement, "Cam Motor Driver Module," on page 796.	Perform "CAM A/B Amplifier Checkout Procedure," on page 745.
Collimator CAM Drive Motor	Replacement, "Cam Drive Motor and Flex Coupling," on page 799.	Perform "CAM A/B Motor Checkout Procedure," on page 747.
Collimator Encoder Harness	Replacement, "Cam Encoder Harness," on page 799.	Perform "CAM A/B Encoder Checkout Procedure," on page 746.
Collimator Secondary Aperture	Replacement, "Secondary Aperture," on page 801.	Perform **CBF** adjustments in Chapter 11, Perform IQ test Chapter 10
Collimator Primary Aperture	Replacement, "Primary Aperture," on page 801.	Complete Tube alignments, Detailed Phantom Calibrations and Perform IQ test Chapter 10.
Collimator Power Harness	Replacement, "Power Harness," on page 802.	Perform Collimator Functional Tests starting with "CAM A/B Amplifier Checkout Procedure," on page 745.

Table 9-58 High Voltage System Retest Matrix (Continued)

Chapter 10
Power Distribution Unit

Section 1.0
Overview

The **PDU** provides a single location to connect input power for the entire **CT** system. Its function is to provide the following features to the System:

- Compensation means for a wide range of input voltages via tap selection
- Provide required system AC power from a single source
- Provide High Voltage DC power for x-ray generation
- Provide power for gantry axial rotation
- Provide a means for emergency shutdown of all x-ray and drives power circuits
- Provide system AC power circuit protection
- Provide an interface for an external **UPS** connection
- Meet the requirements of IEC601 for both radiated and conducted emissions

The **PDU** is designed to comply with United States Federal Regulations and the European Medical Device Directive. It bears the certification marks of a United States National Recognized Test Laboratory with Canadian deviation or a Canadian certified test house. Each unit is identified as being in compliance by being labeled with the official mark(s) of each respective agency.

Section 2.0
PDU Varieties

There are two distinct varities of Power Distribution Unit (PDU) that may be shipped with the CT Scanner. These varieties are the CPDU (Compact PDU) and the NGPDU.

- The CPDU is described in Section 3.0.
- The NGPDU is described in Section 4.0.

Section 3.0
CPDU

3.1 CPDU Physical Description

3.1.1 Mechanical Enclosure

The enclosure has a front, back and top access covers. The top cover is hinged at the rear and is provided with a lock to prevent unauthorized access. The top cover is provided with supports, such that it will remain in the open position safely without service personnel assistance. Two captive fasteners at the top and two guide pins at the bottom hold the front cover in place. The front cover weighs less than 25 lbs.

A single full-width Lexan safety shield is provided under the front cover. It extends ½" below the top front edge of the assembly to the bottom of all **HVDC** Supply components, including the **PDU** Control Board. There's a cutout in the lower left corner of the shield to provide access to the low voltage portion of the **PDU** Control Board.

The rear cover is held in place by twelve 10-32 machine screws. To maintain a good high frequency ground between internal subassemblies, all internal metal surfaces are solidly grounded to each other.

The enclosure is painted Mist Gray (GEMS Gray #1).

3.1.2 Component Locations

The main input transformer is located in the rear accessible chamber near the bottom of the cabinet, allowing enough room for cable access beneath. For ease of installation and serviceability the remaining components for the **HVDC** Supply and AC Power Distribution are located on the vertical dividing panel behind the front cover. Refer to Table 10-1 below, for general component information. Items numbers in table appear in circles of Figure 10-1.

ITEM	NAME / DESCRIPTION
1	8A, 250V, Slow-Blow Fuse
2	2A, 250V, Slow-Blow Fuse
3	1.5A, 250V, Fuse
4	80A, 600V, Semiconductor Fuse
5	60A, 600V, Dual Element Fuse
6	6uF, 370Vac Capacitor
7	20A, 3P, 4W Receptacle NEMA Type L14-20R-Flange Mount
8	0.025uF, 480V, 100A, Feed-through Capacitor
9	Transformer 2113764-26
10	2133533-2 1.2 mH, 140 A, DC Inductor
11	4600 μF, 450 V, Capacitor
12	32/50A Contactor, 120Vac, 60Hz Coil
13	Warning light control Relay
14	Front Cover
15	110A, 1600V Diode Bridge
16	**PDU** Control Board
17	18/35A Contactor, 24Vdc Coil

Table 10-1 Major Components

ITEM	NAME / DESCRIPTION
18	30A, 4P, 5W Receptacle NEMA Type L21-30R-Flange Mount
19	15A, 1P Circuit Breaker
20	30A, 1P Circuit Breaker
21	15A, 2P Circuit Breaker 10A, 3P Circuit Breaker
22	15A, 3P Circuit Breaker
23	30A, 3P Circuit Breaker

Table 10-1 Major Components

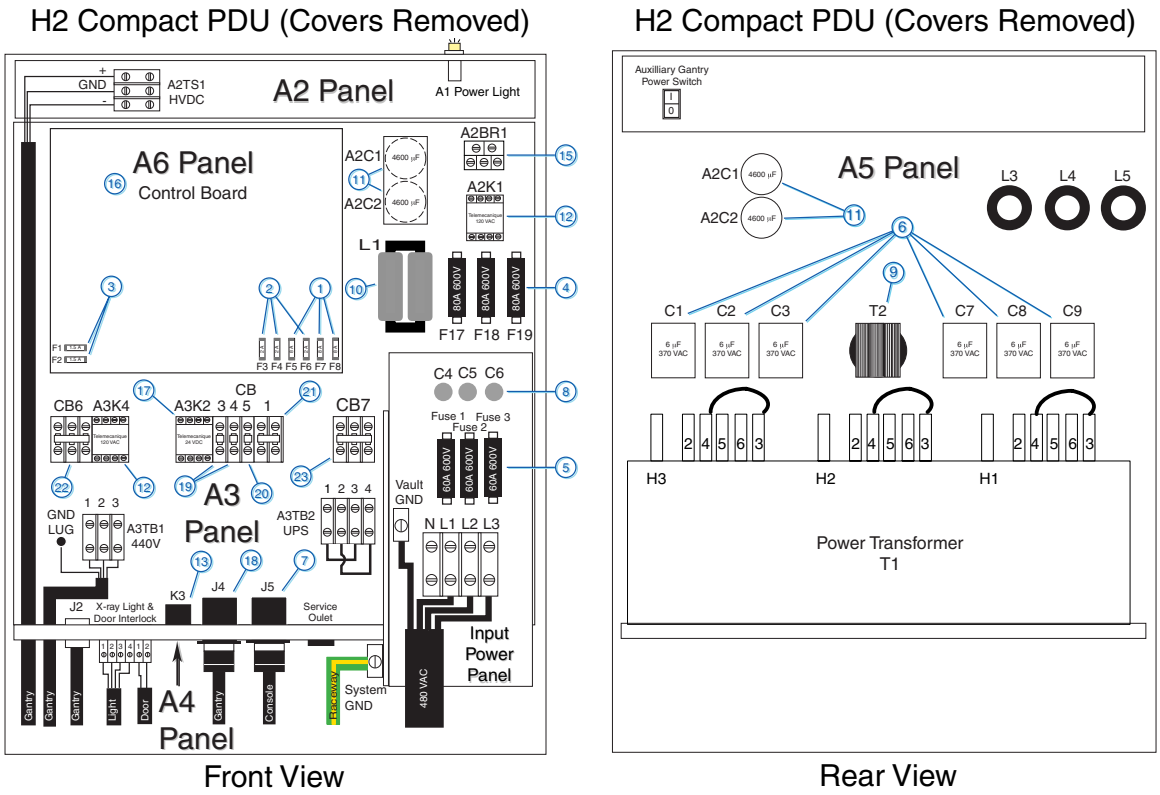


Figure 10-1 Component/Physical Layout

3.1.3 Product Labeling

3.1.3.1 Rating Plate

The **PDU** has a rating plate permanently attached to the rear edge of the top cover. It contains the following information:

Manufactured for GE Medical Systems
Milwaukee, Wisconsin
by (Vendor Name)

Power Distribution Unit
Model No. 2269902 / (Vendor model #)
Serial No. _____

Input Voltage: 3 ~ 380 // 480 V
Line Frequency: 50 / 60 Hz
Input Power:
Momentary 90 kVA @ 0.85 PF
Continuous 20 kVA

Weight 640 lbs. (291 kg.)
Date Code: _____ Made in USA
(appropriate test house markings, e.g., UL, ETL, CSA or eq.)

3.1.3.2 Auxiliary Rating Plate

For ease of service identification, an auxiliary rating plate is also located inside the unit, under the top cover. It includes the GEMS model number and unit serial number.

3.2 CPDU Service Overview

3.2.1 Replacement Parts / Interchangeability

All replacement parts required for servicing the **PDU** are directly interchangeable without need of any re-adjustment. Circuit boards and sub-assemblies are given unique part numbers and revisions are completely backward compatible.

3.2.2 Service Tools

The **PDU** is designed so no special service tools are required. The assembly can be serviced with standard off-the-shelf service tools.

3.3 CDPU Electrical Specifications

3.3.1 Primary Input Power

The input power terminals accommodate #4 to #1/0 (fine strand) wire sizes. Ferrules are provided for the maximum wire capacity allowed. Input line fuses rated 60A per phase are used to protect the system. Dual element, time delay motor starting fuses are used.

The primary input power terminations & fuses are mounted in a dedicated enclosure within the **PDU**. Bulkhead mounted, low inductance, feed through filter capacitors are connected in series with each of the three primary lines on the load side of the primary fuses. The capacitance of each device is 0.025μF to ground.

3.3.2 Input Filtering

Low inductance, AC filter capacitors rated for mains connection are installed in a floating wye configuration on the three primary lines, on the load side of the fuses. Each capacitor is rated at 6.0 μF.

3.3.3 Input Transformer

The main input transformer is an indoor style, multiple winding, 3-phase isolation transformer. It has an open frame, varnish impregnated core & coil construction. It is suitable for continuous duty without requiring forced air-cooling. The insulation system used is UL, CSA, & IEC recognized for 180C (Class H) or better, and each transformer is labeled accordingly.

3.3.3.1 Magnetic Circuit

The magnetic circuit is designed for nominal 50/60 Hz operation (47 to 63 Hz limits). It accommodates a daily variation of ±10% input voltage, (i.e., 110% input voltage doesn't cause excessive exciting current and core losses). Under worst case conditions, the transformer's peak inrush current is less than 1000A when properly connected and energized at 380 V, 50 Hz.

3.3.3.2 Primary

All power for the **CT** System passes through the primary winding of the input transformer. It is protected by the primary input fuses described above.

The primary winding is designed for delta connection. Voltage selection taps are provided on each phase to accommodate 20 volt steps over the input voltage range of 380 to 480 V. All leads are brought out to a panel for external voltage selection. Leads are designated as follows:

System Voltage:	380	400	420	440	460	480	
Lead Connections:	2-6	2-5	2-4	3-6	3-5	3-4	
Ex. Phase A" "	S	2	3	4	5	6	F
(Tap voltage from "S"	0	180	240	240	260	280	480)

Figure 10-2 Compact PDU Primary taps

At shipment, the primary taps are set to the 480 volt connection.

3.3.3.3 Secondary #1 (designated as the "X" winding)

Secondary #1 is a 208Y/120V wye connected power winding. The phase leads are labeled X1, X2, and X3. The neutral, labeled X0, is isolated and brought out for external connection to ground.

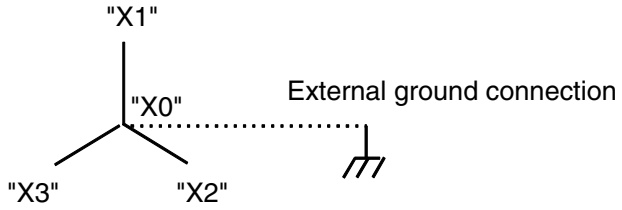


Figure 10-3 Secondary "X" Winding Configuration

The full winding feeds general-purpose power to the **CT** system. The winding is protected at 30A per phase with a three-pole, 30A circuit breaker labeled CB7.

3.3.3.4 Secondary #2 (designated as the “Y” winding)

Secondary #2 is a 494Y/285V wye connected power winding. The phase leads are labeled Y1, Y2, and Y3. The neutral, labeled Y0, is isolated and brought out for external connection to ground.

This winding contains three (3) normally closed thermal cutout switches, one securely embedded in each phase coil. These switches are set to open at a nominal temperature of 180C. When actuated, they generate an over-temperature fault on the **PDU** Control Board and disable the **HVDC** output.

Taps are provided on each phase (labeled Y4, Y5, and Y6) to provide a 440Y/254V, wye connected source. These taps are used to power the gantry axial drive.

In addition, a second set of taps is provided on each phase (labeled Y7, Y8, and Y9) to provide a 52Y/30V, wye connected source. These taps are used for intermittent service diagnostic tests only, and their load is mutually exclusive of all other loads on this winding.

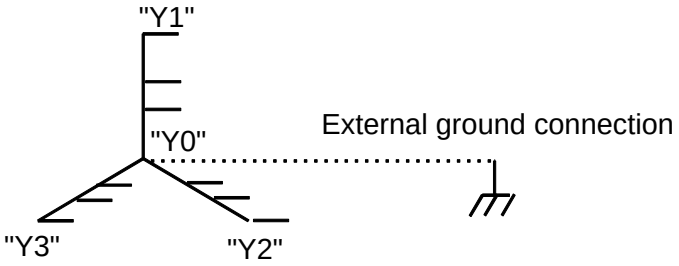


Figure 10-4 Secondary “Y” Winding

The #2 secondary winding provides x-ray & drives power to the system. The full winding powers the **HVDC** supply. This is a six-pulse unregulated DC supply, which feeds the X-Ray source. The output of the full winding is protected by 80A semiconductor fuses, F17, F18 and F19. Winding protection is accomplished electronically by the load control circuitry for both short-circuit and thermal overloads.

The 440Y/254V taps feed an external Variable Speed AC Motor Drive. These taps are protected at 15A per phase with a three-pole, 15A circuit breaker, labeled CB6.

As mentioned above, the second set of taps providing a 52Y/30V, wye connected source are used for intermittent service diagnostics only. These taps provide an alternate source for the unregulated DC supply normally fed by the full winding. They are protected electronically by the DC supply circuitry, and no fusing is provided.

3.3.3.5 Shields

Full width electrostatic shields are provided between the primary and secondary windings. Each shield is grounded to the core and frame. (The lead position and attachment method minimizes shield impedance to high frequency noise signals.)

3.3.4 AC Power Distribution

A general overview of the AC Power Distribution of the **CT** system is shown in the diagram below.

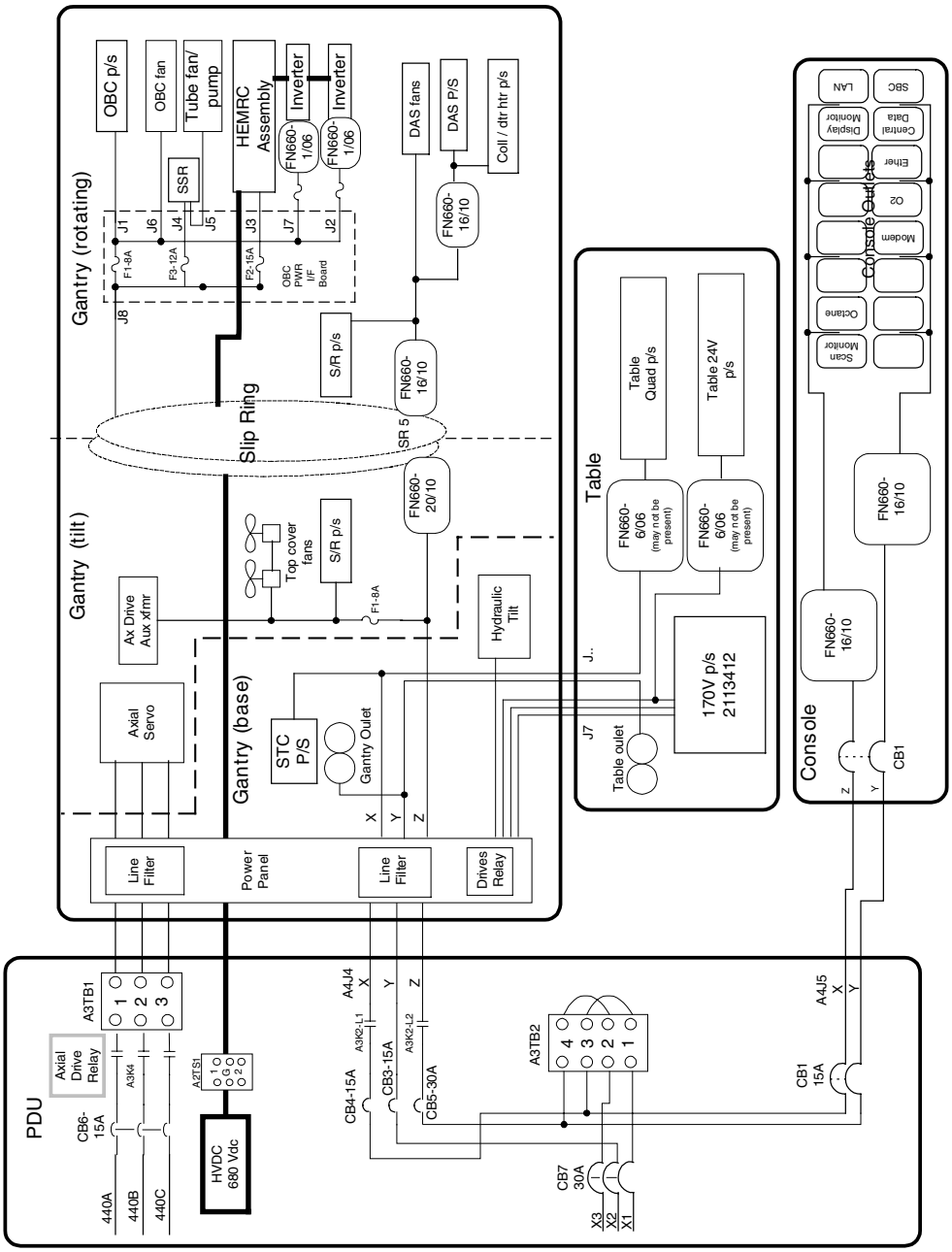


Figure 10-5 AC Power Distribution

3.3.5 General Purpose 120/208V AC Power Distribution

3.3.5.1 Full Winding Protection

The **PDU** Isolation Transformer, Secondary #1, supplies low voltage AC subsystem power. It is protected at 30A per phase with a three-pole, 30A circuit breaker. The full winding protection breaker is labeled CB7.

3.3.5.2 UPS Interface

Phases A & C on the load side of CB7 is wired to terminals 1 & 2 of a four-position terminal block, labeled A3TB2. Jumpers connect terminals 1 to 3 and 2 to 4, with the **PDU** loads connected to the outputs of terminals 3 & 4. These jumpers are removed whenever an *optional* **UPS** is used with the system.

3.3.5.3 Circuit Protection

AC power is distributed to the **CT** System via four (4) separate branch circuits. These branches are protected by individual circuit breakers as follows:

BREAKER	RATING	POLES	PHASE	LOAD DESCRIPTION
CB1	15A	2	A, C	Console via J5-X, J5-Y
CB3	15A	1	B	Table* & Gantry Service Outlets via J4-Y, also **PDU** Service Outlet
CB4	15A	1	A	Table 24Hr power & Gantry Stationary Loads via A3K2-L1 & J4-X
CB5	30A	1	C	Gantry Rotating Loads via A3K2-L2 and J4-Z
*Table service outlet is limited to 10 amperes.				

Table 10-2 Circuit Breaker

3.3.5.4 AC Power Output Connections

The output connectors for AC power distribution to external subsystems shall be as follows:

SUBSYSTEM	PDU CONNECTOR TYPE
Gantry	30A, 4P, 5W Receptacle, NEMA Type L21-30R-Flange Mount. Labeled “J4 GANTRY”
Console	20A, 3P, 4W Receptacle, NEMA Type L14-20R-Flange Mount. Labeled “J5 Console”

Table 10-3 AC Output Connectors

3.3.6 High Voltage DC Power Supply

3.3.6.1 Electrical Requirements

The **HVDC** power supply is an unregulated, six pulse DC power source that feeds the high voltage subsystem used to generate x-rays. The output voltage of this supply ranges between a maximum of 750VDC (No Load) and a minimum of 500VDC (Full Load). The full load current capacity of this supply is 100ADC.

3.3.6.2 Circuit Protection

The input to the **HVDC** Supply is the 3-phase, 494V output from the transformer secondary #2 as previously described. Each phase of this winding is protected by an 80 AMP semiconductor fuse.

3.3.6.3 Construction / Description

The load side of the fuses is connected to a three-pole contactor. The operating voltage of the coil is115 VAC 50/60Hz. The contactor has an auxiliary switch with a single pole, normally open contact used for sensing the status of the device. The load side of the contactor is connected to the input of a 3 phase, full wave bridge rectifier. The bridge rectifier is mounted to an aluminum heat sink,

approximately 2” X 6” X 1/4”. Thermal compound is used between the heat sink and rectifier and between the heat sink and chassis mounting surface.

The DC output of the bridge rectifier is filtered with an L-C network composed of a 1.2mH series inductor, and two 4600uf, 450 volt electrolytic capacitors. The capacitors are connected in series and across the output leads of the inductor.

3.3.6.4 Output Terminations

Output leads from the capacitors are terminated in a three position terminal strip. This terminal strip is labeled “A2TS1”. It is mounted horizontally on the vertical surface above the **PDU** Control Board. The terminal strip positions are labeled: Top “TS1-1 (+)”, Center “GND” and Bottom “TS1-2 (-)”. A Lexan cover is provided over the terminal strip to prevent service personnel from accidentally contacting live parts.

The internal wiring is connected to the right side of the terminal strip, leaving the left side open for field installation of the system cable. A cable clamp is provided at the transformer bulkhead, which is used for strain relief and termination of the shield of the field installed cable.

3.3.7 Axial Drive Circuit

3.3.7.1 Electrical Requirements

The 440V taps of secondary #2 are used to power an external variable speed AC motor drive used for axial rotation of the gantry. The drive uses a conventional three-phase full wave bridge rectifier input circuit. This produces strong 5th & 7th harmonic currents typical of 6-pulse rectification. The maximum load under gantry acceleration conditions is 15A.

3.3.7.2 Circuit Protection

The circuit is protected at 15A per phase with a three-pole, 15A circuit breaker, labeled CB6.

3.3.7.3 Axial Drive Contactor

The CB6 circuit breaker feeds a three-pole contactor, labeled A3K4. The contactor’s 115 VAC coil is controlled externally by the **CT** system. Auxiliary contacts on the contactor provide status feedback information to the system.

3.3.7.4 Output Terminations

Output leads from the A3K4 contactor terminate in a three position terminal strip. This terminal strip is labeled “A3TB1”. It is mounted on the vertical surface below the contactor. A Lexan cover is provided over the terminal strip to prevent service personnel accidentally contacting live parts.

The internal wiring is connected to the top of the terminal strip, leaving the bottom open for field installation of the system cable. A cable clamp is provided at the transformer bulkhead, which is used for strain relief and termination of the shield of the field installed cable. In addition, a 10-32 ground stud is provided in the vertical panel left of the A3TB1 terminal strip.

3.3.8 Control Signals

The **PDU** provides all power to the **CT** system. A **PDU** Control Board is located within the unit and provides for proper sequencing of the sub-system power, servo system, and x-ray backup contactor when commanded by the system. To facilitate control, the **PDU** Control Board contains a low voltage limited energy (LVLE) 24Vdc power supply, which provides the necessary communication power to the system. The output voltage of this supply is 24 VDC, +6 / -4 volts for all conditions of line and load.

3.3.8.1 Subsystem Signal List

The following is a list of **PDU** Control Signals, that are accessible by means of a 37 position, female subminiature D type receptacle connector located in the output bulkhead at the bottom of the enclosure. This connector is labeled A4J2.

PIN #	SIGNAL NAME	FUNCTIONAL DESCRIPTION
1	PDU_24B	+24Vdc output to Gantry E-Stop Control circuits.
2	PDU_24B	+24Vdc output to Gantry E-Stop Control circuits.
3	LP_CONT_CLSD	Switched +24Vdc output indicating contactor A3K4 is closed.
4	HV_MODE	Current limited +15Vdc output for **HV** Mode circuit in gantry.
5	PDU_24A	+24Vdc output to Gantry X-Ray Control circuits.
6	PDU_24A	+24Vdc output to Gantry X-Ray Control circuits.
7	LITESHI	+24Vdc signal to indicate the status of the x-ray and drive power enable. Three states are possible: • Lamp on steady indicates x-rays and all drives enabled. • Lamp flashing rapidly indicates all table motion and gantry tilt disabled • Lamp flashing slowly indicates all drives and x-rays disabled.
8	FOUR	Switched 24Vdc input from E-Stop push button control loop.
9	ONE	Switched +24Vdc output to E-Stop/Gantry reset push buttons.
10	TBLOFF	Switched +24Vdc output to table tape switch circuit.
11	DRIVEON	Switched +24Vdc output to gantry to enable elevation, tilt & cradle drives contactors.
12	120_RDBK	Switched +24Vdc output indicating contactor A3K2 is closed.
13	BU_CONT_CLSD	Switched +24Vdc output indicating contactor A2K1 is closed.
14	MAN_HVDC	Switched +24Vdc output to gantry to command **HVDC** on.
15	MAINS_UV+	Current limited +15Vdc output for Mains Under-voltage circuit in Gantry.
16	N/C	no connection
17	N/C	no connection
18	DRRDBKRN	Contact closure w.r.t. pin 37 indicating the drives relays are commanded “on”.
19	GND	Redundant chassis ground connection for cable shield.
20	PDU_PGND	Signal Ground return for 24Vdc circuits to/from gantry.
21	PDU_PGND	Signal Ground return for 24Vdc circuits to/from gantry.
22	CLOSELOOP	+24VDC input signal to close the Axial Drive contactor, A3K4.
23	HV_MODE_RTN	Switched +15Vdc HV_MODE signal from gantry.
24	XRAYLITE	+24VDC input signal to close the Hospital Room Light relay, A4K3.
25	EXP_INTLK	Exposure Interlock loop to PGND via Room Door Interlock at A4TS1-5 & 6.
26	LITESRTN	Signal Ground return for LITESHI circuit from gantry.
27	ESTP_SRC	+24Vdc output to Gantry E-Stop Control circuits.
28	DRIVON	Switched +24Vdc input from E-Stop/Gantry reset push buttons.

Table 10-4 Subsystem Signal List

PIN #	SIGNAL NAME	FUNCTIONAL DESCRIPTION
29	TABLEOFF	Switched +24Vdc input from table tape switch circuit.
30	DRVRTN	Signal Ground return for DRIVEON circuit from gantry
31	GANTRY_PWR	+24VDC input signal to close the Gantry Power Contactor, A3K2.
32	BUCONT	+24VDC input signal to close the Backup Contactor, A2K1.
33	N/C	no connection
34	MAINS_UV-	Switched low-side output for mains under voltage circuit.
35	N/C	no connection
36	N/C	no connection
37	DRRDBK	Contact closure w.r.t. pin 18 indicating the drives relays are commanded “on”.

Table 10-4 Subsystem Signal List (Continued)

3.3.8.2 Room Warning Light & Door Interlock Connections

A six position terminal block, labeled A4TS1, is provided in the output bulkhead at the bottom of the enclosure. This terminal block has compression type terminals approved for use with bare or stranded wire and suitable for a wire size range of 22 to 10AWG.

Terminals 1 through 4 are used for connection of an external hospital room warning light as described below. Terminals 5 & 6 are used for connection of a room door interlock switch in the system x-ray enable circuit.

- EXTERNAL XRAY WARNING LIGHT - Positions 1 and 3 of the terminal block is connected across a normally open set of relay contacts rated at 250 VAC, 20 Amps. The relay is labeled A4K3.
- Positions 2 and 4 of the terminal block is jumpered together with a series RC network having a resistance of 100 ohms, a capacitance of 0.5 uF and a voltage rating of 250 VAC.
- The terminal block shall be labeled as follows:
  - Positions 1 and 2, “INPUT POWER”.
  - Positions 3 and 4, “LOAD”.

  In addition, the following label appears near the terminal block:

CAUTION Potential for electrical shock

TURNING OFF POWER TO THE PDU MAY NOT REMOVE POWER TO THIS TERMINAL BLOCK. VERIFY REMOVAL OF POWER WITH AN APPROPRIATE MEASURING DEVICE BEFORE SERVICING. INPUT VOLTAGE NOT TO EXCEED 30VAC.

- ROOM DOOR INTERLOCK - Positions 5 & 6 of the terminal block provide for a Room Door interlock in the X-Ray Exposure control of the system. Terminal 5 is connected to the EXP_INTLK signal at A4J2-25. Terminal 6 is connected to PGND at A6J7-30 on the **PDU** Control Board.
- These terminals are labeled “DOOR INTERLOCK SW”. Each unit is shipped with a jumper installed between pins 5 & 6 (by default).

3.3.8.3 Auxiliary Gantry Power Switch

An auxiliary gantry power switch is mounted on the right rear surface of the enclosure. The switch is connected to the 24Vdc control circuit of contactor A3K2, in series with the “GANTRY_PWR” signal at A4J2-31. “UP” is “ON”, and is the default position.

3.4 CPDU Drawings

3.4.1 Gantry Power Control

When the 120VAC ON signal is received at the GANTRY_PWR connection, given the auxiliary power switch is closed, relay coil A6K8 is energized and its contacts close. This relay completes the circuit to the coil of A3K2, which in turn completes the 120VAC circuit to the gantry and table. See Figure 10-6. Stationary gantry and table power is protected by CB4 and gantry rotating power by CB5.

Table and gantry service outlet power is unaffected by 120VAC ON signal and can only be disabled by its associated circuit breaker CB3. Note that CB3, CB4 and CB5 are slaves to master circuit breaker CB7. Table service outlet is limited to 10 amperes.

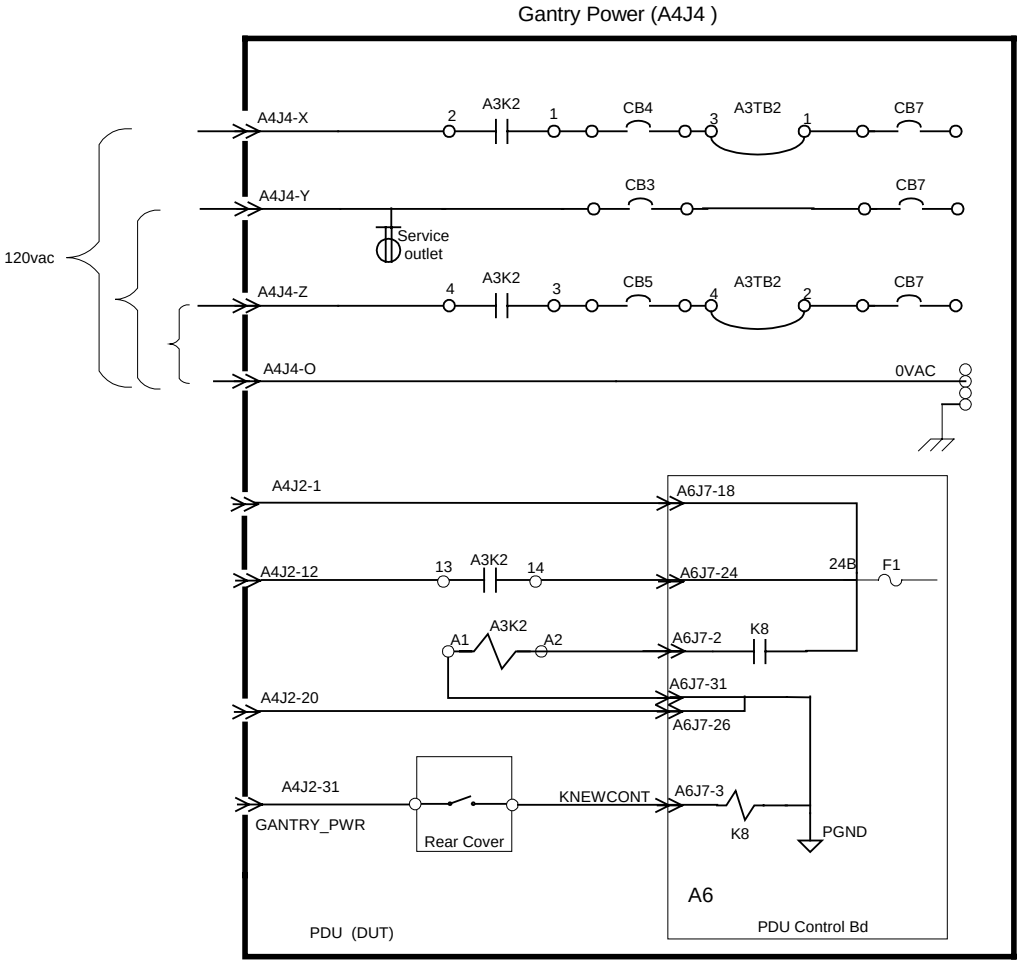


Figure 10-6 Gantry Power Control

3.4.2 Axial Drive Power Control

Axial Drive Power is controlled by relay A3K4 and is protected by circuit breaker CB6. When the **PDU** control board senses an e-stop condition, coil A6K6 (e-stop) locks out operation of relay coil A6K13, which prevents activation of the relay A3K4.

Axial Drive Power and Feedback

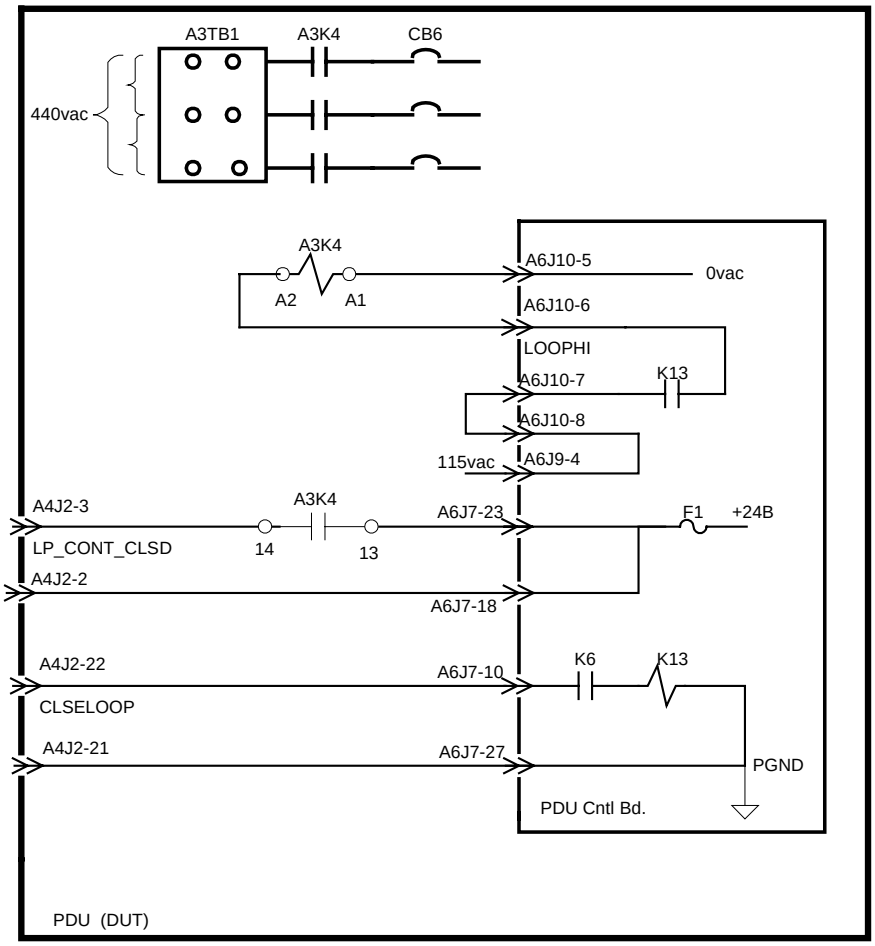


Figure 10-7 Axial Drive Power Control

3.4.3 HVDC Supply Control

When the BUCONT signal is received and the connection between HV_MODE and HV_MODE_RTN is made, the **HVDC** supply will produce output. When the coils K12 and K11 are energized, the coil A2K1 is energized. The contacts on A2K1 close and supply power to the **HVDC** supply. This operation can be inhibited by the **PDU** control board “E-stop” circuit, through relay contacts A3K2. See Figure 10-8.

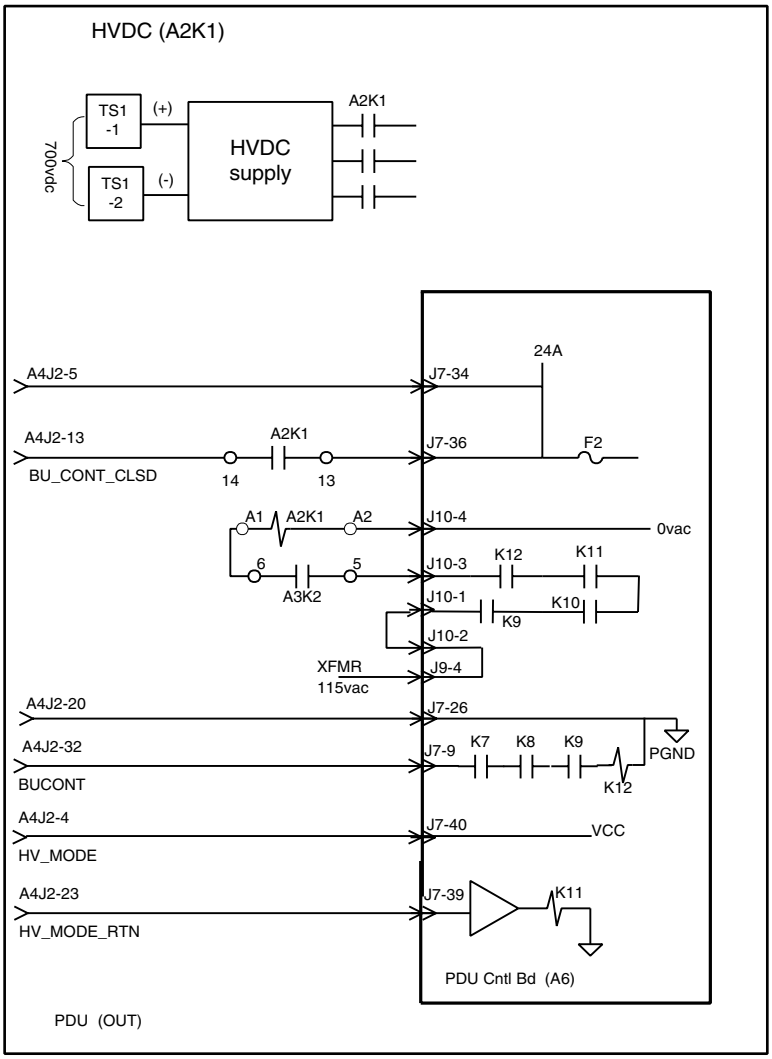


Figure 10-8 HVDC Supply Control

3.4.4 Console Power Control

120VAC Power for the console is derived from two legs of 208VAC. Console power is protected by circuit breaker CB1. CB1 is a slave to CB7.

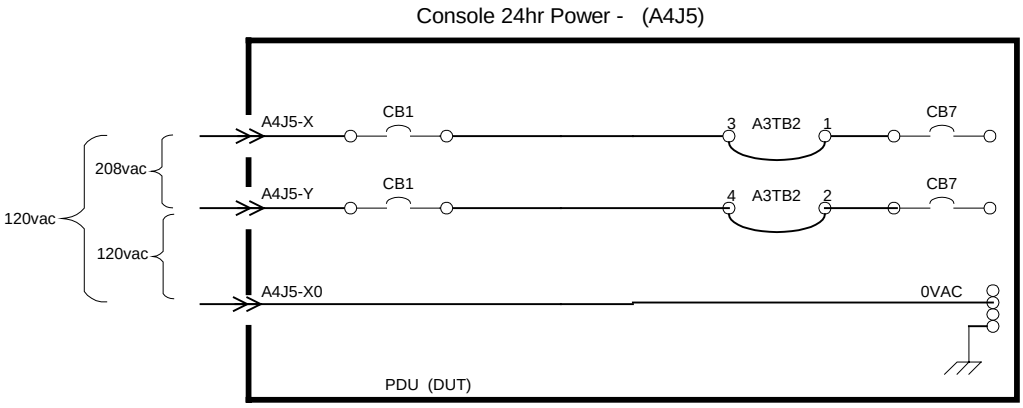


Figure 10-9 Console Power Control

3.4.5 Room Light Control

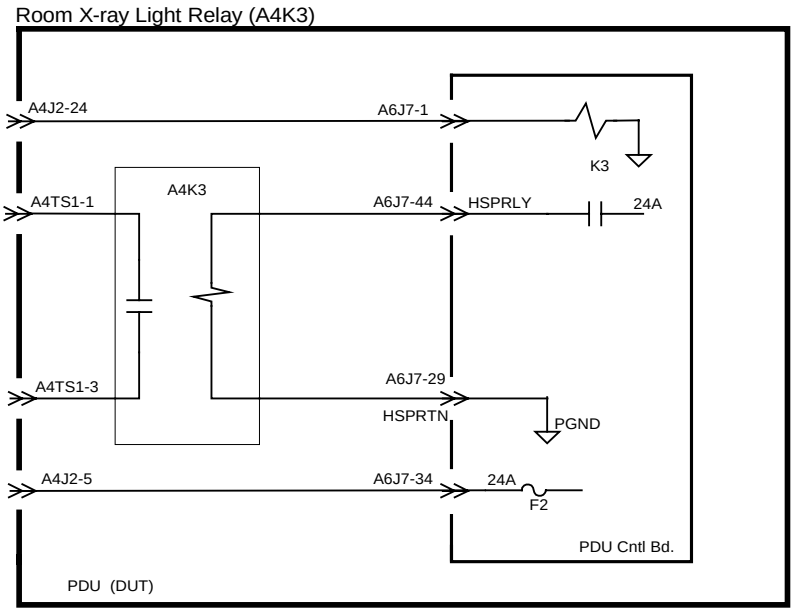


Figure 10-10 Room Light Control

3.4.6 E-Stop/Drives Control

For the following discussion, see Figure 10-11.

NORMAL STATE

With the E-stops and tape sensors in normal state, a connection is made between ESTP_SRC and FOUR, and between TBLOFF and TABLEOFF respectively. In this condition, the reset and drives enable lamps are illuminated steadily, the reset light being controlled by the connection between LITESHI and LITESRTN, the drives light by DRIVEON and DRVRTN connections.

TAPE SENSOR

When a table tape sensor is activated, the connection between TBLOFF and TABLEOFF is opened. This situation opens the circuit between DRIVEON and DRVRTN, and turns the drive enable lamp off. The blinking circuit now pulses the reset lamp slowly to indicate the condition.

E-STOP

When an E-stop switch is activated, the connection between ESTP_SRC and FOUR is opened. This situation opens the circuit between DRIVEON and DRVRTN, and turns off the drive enable lamp. The blinking circuit now pulses the reset lamp fast, to indicate the e-stop condition, through the connection LITESHI and LITESRTN.

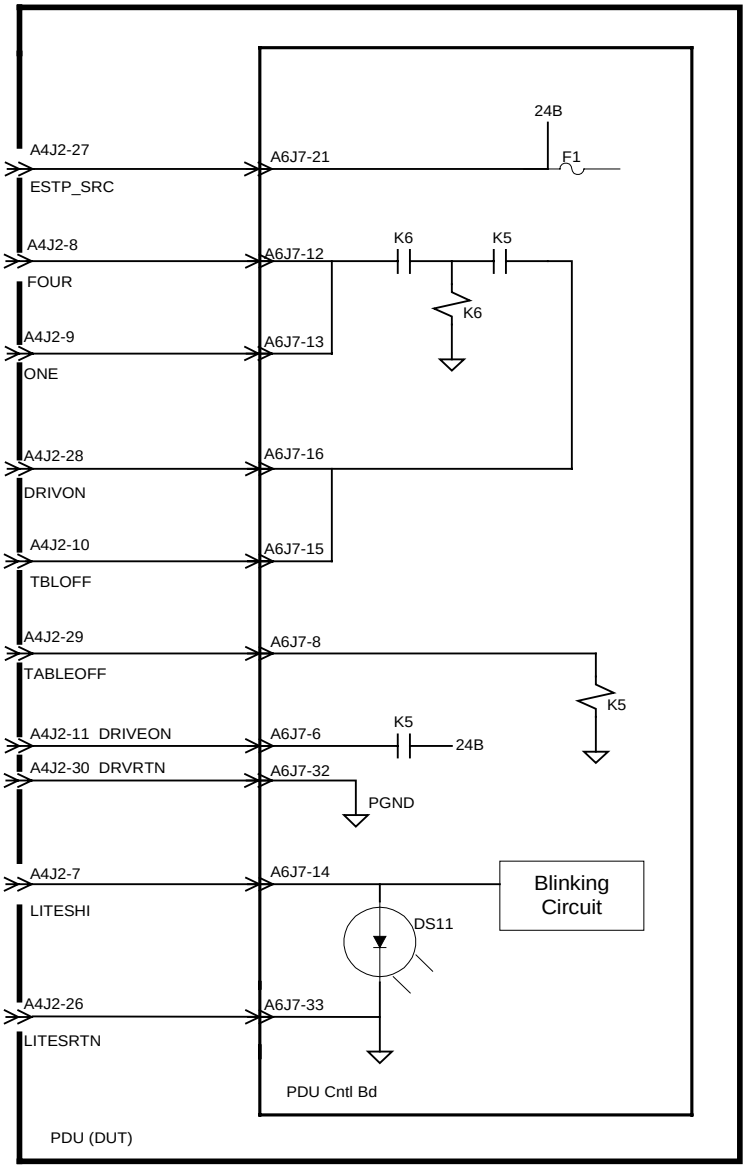


Figure 10-11 E-Stop/Drives Control

Section 4.0
NGPDU

While in the stand-by mode, the NGPDU does not generate sound levels in excess of 50dbA, when measured at a distance of one meter from the nearest cabinet surface, in any direction.

4.1 NGPDU Physical Description

4.1.1 Mechanical Enclosure

The enclosure has a front, rear and top access covers. The top cover is installed on the frame with a captive fastener in the middle of front edge. The front cover weighs less than 22 lbs (10 kg).

A single full-width Lexan safety shield is provided under the front cover. It extends ½" below the top front edge of the assembly to the bottom of all **HVDC** Supply components, including the **PDU** Control Board.

The rear cover is held in place by two captive fasteners. To maintain a good high frequency ground between internal subassemblies, all internal metal surfaces are solidly grounded to each other.

The enclosure is painted Mist Gray (GEMS Gray #1).

4.1.2 Component Locations

The main input transformer is located in the rear accessible chamber near the bottom of the cabinet, allowing enough room for cable access beneath. For ease of installation and serviceability the remaining components for the **HVDC** Supply and AC Power Distribution are located on the vertical dividing panel behind the front cover. Refer to Table 10-5 below, for general component information. Items numbers in table appear in circles of Figure 10-1.

ITEM	PART NO.	NAME / DESCRIPTION	COMMENTS
2	2326492-2	NGPDU assemble 2	For HiSpeed QX/i, non-stockable
3	2354578	Front Cover	
4	2354579	Side Cover	
5	2354580	Rear Cover	
6	2354581	Top Cover	
7	2334820	PDU Control Board	
8	2356067	PDU IF Board	IF Bd
9	2351483	110A CB ASSY	CB1
10	2351484	15A Breaker	CB2
11	2384770	32A Breaker	CB3
12	2351486	10A Breaker	CB4
14	2295544	16A Breaker	CB6
15	2295545	20A Breaker	CB7
16	2295543	32A Breaker	CB5, CB8
17	2295546	4A Breaker	CB9
18	2351488	100A Contactor	Kxg
19	2351489	50A Contactor	Ktg

Table 10-5 Major Components

ITEM	PART NO.	NAME / DESCRIPTION	COMMENTS
20	2351490	18-32A Contactor	Ksv
21	2351491	14-25A Contactor	Kss
23	2351493	100A Fuse	F1-3
24	2113764-3	6uf / 370Vac Capacitor	C1-6
25	2351494	4600uf / 450V Capacitor	C7, C8
26	2351495	Diode Bridge	BR1
27	2201229-2	Power Supply	PS
28	2391041	Resistor Assy	R
29	2202215-2	Emergency Switch	SW
30	2286488	LED Assy	LED
31	2396924	Gantry Enable Swtch	SW including LED

Table 10-5 Major Components

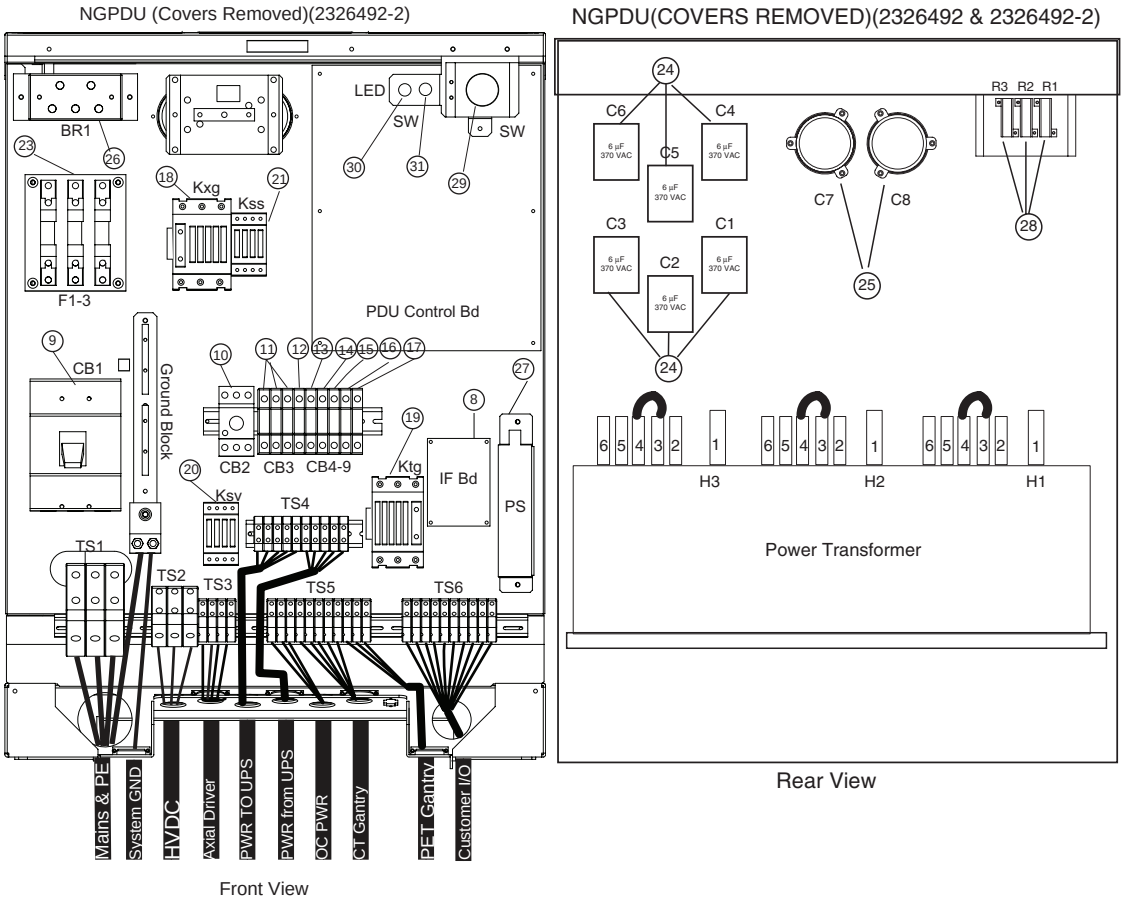


Figure 10-12 Component/Physical Layout

4.1.3 Product Labeling

4.1.3.1 Rating Plate

The **PDU** has a rating plate permanently attached to the rear cover, near the top edge and approximately centered on the cabinet. It contains the following information:

For Model 2326492-2:

Manufactured for

GE Medical Systems

by (Vendor Name)
Made in (Country of origin)

Power Distribution Unit
Model No. 2326492-2 / (Vendor model # if different)
Serial No. _____

Input Voltage: 3 ~ 200 // 240, 380 // 480 V
Line Frequency: 50 / 60 Hz
Input Power:
Momentary 90 kVA @ 0.85 PF
Continuous 20kVA

Weight 770 lbs. (350 kg.)
Mfg Date : _____
(appropriate test house markings, e.g., UL, ETL, CSA or eq.)

4.1.3.2 Auxiliary Rating Plate

For ease of service identification, an auxiliary rating plate is also located inside the unit, in a visible location when servicing the unit from the front. It includes the GEMS model number and unit serial number.

4.2 NGPDU Service Overview

4.2.1 Replacement Parts / Interchangeability

All replacement parts required for servicing the **PDU** are directly interchangeable without need of any re-adjustment. Circuit boards and sub-assemblies are given unique part numbers and revisions are completely backward compatible. Any changes to form, fit, or function which affect interchangeability shall require the assignment of a unique part number.

4.2.2 Service Tools

The **PDU** is designed so no special service tools are required. The assembly can be serviced with standard service tools.

4.3 NGDPU Electrical Specifications

4.3.1 Primary Input Power

The input power terminals accommodate #4 to #1/0 (fine strand) wire sizes. Ferrules are provided for the maximum wire capacity allowed. Input line fuses rated 100A per phase are used to protect the system. Dual element, time delay motor starting fuses are used.

The primary input power terminations & fuses are mounted in a dedicated enclosure within the **PDU**. Bulkhead mounted, low inductance, feed through filter capacitors are connected in series with

each of the three primary lines on the load side of the primary fuses. The capacitance of each device is 0.025µF to ground.

4.3.2 Input Filtering

Low inductance, AC filter capacitors rated for mains connection are installed in a floating wye configuration on the three primary lines, on the load side of the fuses. Each capacitor is rated at 6.0 µF.

4.3.3 Input Transformer

The main input transformer is an indoor style, multiple winding, 3-phase isolation transformer. It has an open frame, varnish impregnated core & coil construction. It is suitable for continuous duty without requiring forced air-cooling. The insulation system used is UL, CSA, & IEC recognized for 180C (Class H) or better, and each transformer is labeled accordingly.

4.3.3.1 Magnetic Circuit

The magnetic circuit is designed for nominal 50/60 Hz operation (47 to 63 Hz limits). It accommodates a daily variation of ±10% input voltage, (i.e., 110% input voltage doesn't cause excessive exciting current and core losses). Under worst case conditions, the transformer's peak inrush current is less than 1000A when properly connected and energized at 380 V, 50 Hz.

4.3.3.2 Primary

All power for the **CT** System passes through the primary winding of the input transformer. It is protected by the primary input fuses described above.

The primary winding is designed for delta connection. Voltage selection taps are provided on each phase to accommodate 20 volt steps over the input voltage range of 380 to 480 V. All leads are brought out to a panel for external voltage selection. Leads are designated as follows:

Ex. Phase "A"	(S)7	6	5	4	3	2	1(F)
(Tap Voltage from "S"	0	200	220	240	240	300	480)
System Voltage:	380	400	420	440	460	480	
Lead Connections:	2-6	2-5	2-4	3-6	3-5	3-4	

Figure 10-13 Compact PDU Primary taps

The gap in the winding between sections is located at the electrical middle of the winding, i.e., 240vac from the "S" end. This feature allows the use of an alternate connection pattern for 200/220/240 volt input. In this configuration the PDU maximum momentary input rating is limited to 90kVa. **(Note: This connection is used with the 2326492-2 assembly only.)**

The connection options are:

System Voltage:	200	220	240
Lead Connections:	1-6	1-5	1-4

This winding contains three normally closed thermal cutout switches, one securely embedded in each phase coil. These switches are set to open at a nominal temperature of 150C. They are capable of interrupting 120 Vac, 1 A, contactor coil power.

At shipment, the primary taps are set to the 480 volt connection.

4.3.3.3 Secondary #1 (designated as the "X" winding)

Secondary #1 is a 208Y/120V wye connected power winding. The phase leads are labeled X1, X2, and X3. The neutral, labeled X0, is isolated and brought out for external connection to ground.

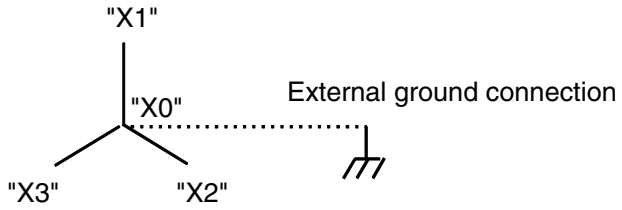


Figure 10-14 Secondary "X" Winding Configuration

The full winding feeds general-purpose power to the **CT** system. The winding is protected at 40A per phase with a three-pole, 40A circuit breaker labeled CB3.

4.3.3.4 Secondary #2 (designated as the "Y" winding)

Transformer for Model 2326492-2 (86 turns total):

Secondary #2 is a nominal 494Y/283V wye connected power winding. The phase leads are labeled Y1, Y2, and Y3. The neutral, labeled Y0, is isolated and brought out for external connection to ground.

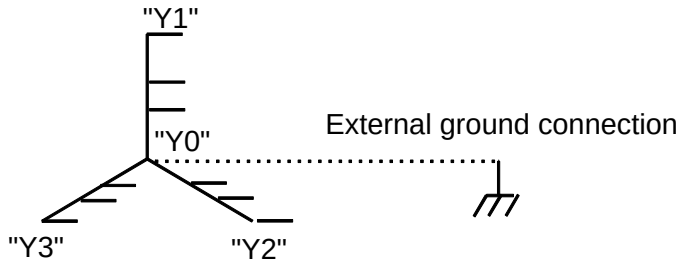


Figure 10-15 Secondary "Y" Winding

The #2 secondary winding provides x-ray & drives power to the system. The full winding powers the HVDC supply. This is a six-pulse unregulated DC supply, which feeds the X-Ray source. As such, the output current is rich in the non-triplen odd harmonics. In particular, it contains ~35% 5_{th} and ~15% 7_{th} harmonic with additional higher harmonics being substantially lower magnitude.

The 440Y/254V taps feed an external Variable Speed AC Motor Drive. Assuming an 8% duty cycle, this drive produces an effective load current of 4.6A per phase. These taps are to be protected at 15A per phase with a three-pole, 16A circuit breaker, labeled CB2.

4.3.3.5 Shields

Full width electrostatic shields are provided between the primary and secondary windings. These are made from 0.005" copper or aluminum foil, with a minimum 0.5" insulated overlap. Each shield is grounded to the core and frame with green leads as short as practicable. (The lead position and attachment method minimizes shield impedance to high frequency noise signals.)

4.3.4 AC Power Distribution

A general overview of the AC Power Distribution of the **CT** system is shown in the diagram below.

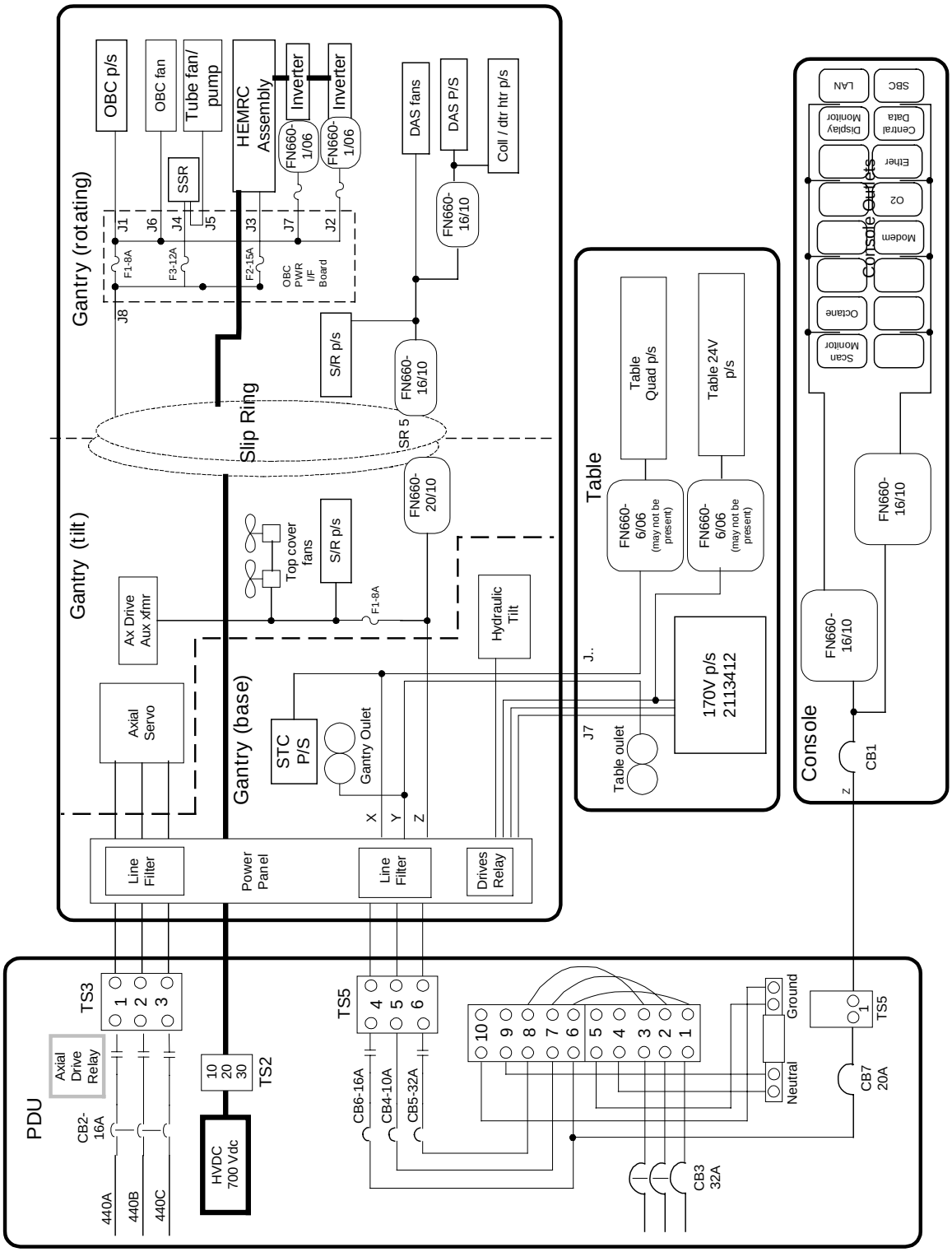


Figure 10-16 AC Power Distribution

4.3.5 General Purpose 120/208V AC Power Distribution

4.3.5.1 Full Winding Protection

The **PDU** Isolation Transformer, Secondary #1, supplies low voltage AC subsystem power. It is protected at 32A per phase with a three-pole, 32A circuit breaker. The full winding protection breaker is labeled CB3.

4.3.5.2 UPS Interface

A 10 position terminal strip, labeled TS4, is provided in the bulkhead for connection of an optional partial system UPS. This terminal block has compression type terminals approved for use with bare or stranded wire and is suitable for wire size 8AWG (8.5 mm^2).

Terminals TS4-1 through TS4-5 provide output power connection to the optional UPS. Terminals TS4-6 through TS4-10 provide the power connections back to the NGPDU from the UPS. Connections are as follows:

TERMINAL NUMBER	SIGNAL NAME	FUNCTIONAL DESCRIPTION
1	CB3-A	Phase A, 120VAC power to UPS
2	CB3-B	Phase B, 120VAC power to UPS
3	CB3-C	Phase C, 120VAC power to UPS
4	0VAC	Neutral (0VAC) to UPS
5	GND	Safety ground (G/Y) wire to UPS
6	UPS-A	Phase A, 120VAC power from UPS
7	UPS-B	Phase B, 120VAC power from UPS
8	UPS-C	Phase C, 120VAC power from UPS
9	0VAC	Neutral (0VAC) from UPS
10	GNDC	Safety ground (G/Y) wire from UPS

Table 10-6 UPS Connection

Jumpers shall connect terminals 1 to 6, 2 to 7, and 3 to 8 with the PDU loads connected to the outputs of terminals 6, 7, & 8. These jumpers will be removed in the field whenever an optional UPS is used with the system.

4.3.5.3 Circuit Protection

AC power is distributed to the **CT** System via seven (7) separate branch circuits. These branches are protected by individual circuit breakers as follows:

BREAKER	RATING	POLES	PHASE	LOAD DESCRIPTION
CB2	16A	3	A B C	Axial Drive
CB4	10A	1	B	CT Gantry Service Outlets
CB5*	32A	1	C	CT Gantry Rotating Loads
CB6	16A	1	A	Table & CT Gantry Stationary Loads
CB7	20A	1	A	Operator Console
CB8	30A	1	B	PET Gantry
CB9	4A	1	A	NGPDU Control Power Supply
*Table service outlet is limited to 10 amperes.				

Table 10-7 Circuit Breaker

4.3.5.4 AC Power Output Connections

The output connectors for AC power distribution to external subsystems shall be as follows:

SUBSYSTEM	PDU CONNECTOR TYPE
Gantry	40A / 15A, 3P, 5W Phonix UK16N labeled TS5-4 to 8. (30A, 1P, 3W Phonix UK16N labeled TS5-9 to 11 for PET Gantry)
Console	20A, 1P, 3W Phonix UK16N labeled TS5-1 to 3.

Table 10-8 AC Output Connectors

4.3.6 High Voltage DC Power Supply

4.3.6.1 Electrical Requirements

The **HVDC** power supply is an unregulated, six pulse DC power source that feeds the high voltage subsystem used to generate x-rays. For model 2326492 the output voltage of this supply ranges between a maximum of 740VDC (No Load) and a minimum of 480VDC (minimum sag at a maximum step load of 225ADC). For model 2326492-2 the output voltage of this supply ranges between a maximum of 760VDC (No Load) and a minimum of 525VDC (minimum sag at a maximum step load of 100ADC).

4.3.6.2 Circuit Protection

The input to the **HVDC** Supply is the 3-phase, output from the transformer secondary #2 as previously described. Each phase of this winding is protected by semiconductor fuse, labeled F1, F2, F3. Fuse sizes are indicated below.

For model 2326492-2: F1, F2, F3 = 100 Amp, 660VAC

4.3.6.3 Construction / Description

The load side of the fuses is connected to a three-pole contactor, Kxg, having an AC1 rating of 100 Amps. The load side of the contactor is connected to the input of a 3 phase, full wave bridge rectifier / capacitor filter circuit. An auxiliary contactor, Kss, in series with a 20 ohms / phase resistive soft-start circuit is connected in parallel with the main contacts of Kxg.

EMC FILTER CAPACITORS - C4, C5, C6

Low inductance, AC filter capacitors rated for mains connection are installed in a grounded wye configuration on the load side of Kxg. Each capacitor is rated 6.0 uF and has a minimum operating voltage rating of 330 VAC with a surge voltage rating of at least 2KV. If metal can style capacitors are used, their cans are solidly grounded to chassis metal and they are suitable for 330 VAC line to ground operation.

BRIDGE RECTIFIER - BR1

A 3-phase, full wave bridge rectifier rated 200 Amp, 1600V is used. The bridge rectifier is mounted to an aluminum heat sink, approximately 2°± X 6°± X 1/4°±. Aluminum Association Type 1100- F or equivalent aluminum is used. Thermal compound is used between the heat sink and rectifier and between the heat sink and chassis-mounting surface in accordance with the bridge manufacturer's specification.

HVDC Filter Capacitor(s)

The DC output of the bridge rectifier is filtered with two 4600uf, 450 volt electrolytic capacitors connected in series across the output terminals of the bridge. A discharge resistor network for each capacitor is included on the pdu control board.

4.3.6.4 Output Terminations - TS2

HVDC output leads from the capacitors terminate in a three position terminal block, labeled “ TS2”. In addition to the cable ground connection, a cable clamp is provided at the NGPDU bulkhead, which is used for strain relief and 360. termination of the shield of the field installed cable.

TERMINAL NUMBER	SIGNAL NAME	FUNCTIONAL DESCRIPTION
1	"+"	HVDC to CT gantry.
2	GND	Auxiliary safety ground (G/Y) wire to CT gantry.
3	"-"	HVDC Return to CT gantry.

Table 10-9 TS2 Terminal Block

4.3.7 Axial Drive Circuit

4.3.7.1 Electrical Requirements

The 440V taps of secondary #2 are used to power an external variable speed AC motor drive used for axial rotation of the gantry. The drive uses a conventional three-phase full wave bridge rectifier input circuit. This produces strong 5th & 7th harmonic currents typical of 6-pulse rectification. The maximum load under gantry acceleration conditions is 15A.

4.3.7.2 Circuit Protection

The circuit is protected at 15A per phase with a three-pole, 16A circuit breaker, labeled CB6.

4.3.7.3 Axial Drive Contactor

The CB6 circuit breaker feeds a three-pole contactor, labeled Ktg. The contactor’s 120VAC coil is controlled externally by the **CT** system. Auxiliary contacts on the contactor provide status feedback information to the system.

4.3.7.4 Output Terminations

Output leads from the Ksv contactor terminate in a four position terminal block, labeled TS3. In addition to the cable ground connection, a cable clamp is provided at the NGPDU bulkhead, which is used for strain relief and 360. termination of the shield of the field installed cable.

TERMINAL NUMBER	SIGNAL NAME	FUNCTIONAL DESCRIPTION
1	Ksv - 440A	Phase A, 440Vac power to Axial Drive.
2	Ksv - 440B	Phase B, 440Vac power to Axial Drive.
3	Ksv - 440C	Phase C, 440Vac power to Axial Drive.
4	GND	Auxiliary safety ground (G / Y) wire to Axial Drive.

Table 10-10 TS3 Terminal Block

4.3.8 Control Signals

The **PDU** provides all power to the **CT** system. A **PDU** Control Board is located within the unit and provides for proper sequencing of the sub-system power, servo system, and x-ray backup contactor when commanded by the system. To facilitate control, the **PDU** Control Board contains a low voltage limited energy (LVLE) 24Vdc power supply, which provides the necessary communication power to the system. The output voltage of this supply is 24 VDC, ±3 volts for all conditions of line and load.

4.3.8.1 Subsystem Signal List

For model 2326492-2:

The following is a list of **PDU** Control Signals that are accessible by means of a 37 position, female sub-miniature D type receptacle connector located in the output bulkhead. This connector is labeled J2.

PIN #	SIGNAL NAME	FUNCTIONAL DESCRIPTION
1	+24B	+24Vdc output to Gantry E-Stop Control circuits.
2	+24B	+24Vdc output to Gantry E-Stop Control circuits.
3	LP CONT CLSSD	Switched +24Vdc output indicating contactor Ksv is closed.
4	HVMODE	Current limited +15Vdc output for **HV** Mode circuit in gantry.
5	+24A	+24Vdc output to Gantry X-Ray Control circuits.
6	+24A	+24Vdc output to Gantry X-Ray Control circuits.
7	LITESHI	+24Vdc signal to indicate the status of the x-ray and drive power enable. Three states are possible: • Lamp on steady indicates x-rays and all drives enabled. • Lamp flashing rapidly indicates all table motion and gantry tilt disabled • Lamp flashing slowly indicates all drives and x-rays disabled.
8	FOUR	Switched 24Vdc input from E-Stop push button control loop.
9	ONE	Switched +24Vdc output to E-Stop/Gantry reset push buttons.
10	TBLOFF	Switched +24Vdc output to table tape switch circuit.
11	DRIVEON	Switched +24Vdc output to gantry to enable elevation, tilt & cradle drives contactors.
12	120_RDBK	Switched +24Vdc output indicating contactor Ktg is closed.
13	BU_CONT_CLSD	Switched +24Vdc output indicating contactor Kxg is closed.
14	MAN_HVDC	Switched +24Vdc output to gantry to command **HVDC** on.
15	MAINS_UV+	Current limited +15Vdc output for Mains Under-voltage circuit in Gantry.
16	N/C	no connection
17	N/C	no connection
18	DRRDBKRN	Contact closure w.r.t. pin 37 indicating the drives relays are commanded “on”.
19	GND	Redundant chassis ground connection for cable shield.
20	PDU_PGND	Signal Ground return for 24Vdc circuits to/from gantry.
21	PDU_PGND	Signal Ground return for 24Vdc circuits to/from gantry.
22	CLOSELOOP	+24VDC input signal to close the Axial Drive contactor, Ksv.
23	HV_MODE_RTN	Switched +15Vdc HV_MODE signal from gantry.
24	XRAYLITE	+24VDC input signal to close the Hospital Room Light relay, KD6.
25	EXP_INTLK	Exposure Interlock loop to PGND via Room Door Interlock at TS6-.
26	LITESRTN	Signal Ground return for LITESHI circuit from gantry.
27	ESTP_SRC	+24Vdc output to Gantry E-Stop Control circuits.
28	DRIVON	Switched +24Vdc input from E-Stop/Gantry reset push buttons.
29	TABLEOFF	Switched +24Vdc input from table tape switch circuit.
30	DRVRTN	Signal Ground return for DRIVEON circuit from gantry

Table 10-11 Subsystem Signal List

PIN #	SIGNAL NAME	FUNCTIONAL DESCRIPTION
31	GANTRY_PWR	+24VDC input signal to close the Gantry Power Contactor, Ktg.
32	BUCONT	+24VDC input signal to close the Backup Contactor, Kxg.
33	SYSLITE	+24VDC input signal to close the SYSTEM_ON light
34	MAINS_UV-	Switched low-side output for mains under voltage circuit.
35	N/C	no connection
36	N/C	no connection
37	DRRDBK	Contact closure w.r.t. pin 18 indicating the drives relays are commanded “on”.

Table 10-11 Subsystem Signal List

4.3.8.2 Room Warning Light & Door Interlock Connections

A ten position terminal block, labeled **TS6**, is provided in the output bulkhead for connection of the customer room warning lights and door interlock. This terminal block has compression type terminals approved for use with bare or stranded wire and shall be suitable for a wire size range of 14 to 10AWG (2.25 to 5.5 mm^2).

Terminals 1 through 8 are used for connection of external hospital room warning lights as described below. Terminals 9 & 10 are used for connection of a room door interlock switch in the system x-ray enable circuit.

- **EXTERNAL "XRAY ON" LIGHT** - A normally open relay contact rated 125 VAC, 10 Amps is connected between Positions 3 & 4 of the terminal block.
- **EXTERNAL "SYSTEM ON" LIGHT (Currently this function is not yet available)** - A normally open relay contact rated 125 VAC, 10 Amps is connected between Positions 5 & 6 of the terminal block.
- **EXTERNAL "GENERATOR READY" LIGHT** - A normally open relay contact rated 125 VAC, 10 Amps is connected between Positions 7 & 8 of the terminal block.
- Positions 2, 4, 6 and 8 of the terminal block are jumpered together. Series RC networks having a resistance of 470 ohms, a capacitance of 0.47 uF and a voltage rating of 250 VAC, are connected across terminal block positions 3 & 4, 5 & 6, and 7 & 8 on the Control Board.
- The terminal block is labeled as follows:

Positions 1 and 2, "LVAC INPUT".

Positions 3 and 4, "X-RAY LIGHT ".

Positions 5 and 6, " SYS-ON LIGHT".(Not yet Available)

Positions 7 and 8, " READY LIGHT".

In addition, the following information appears near the terminal block:

CAUTION Potential for electrical shock

TURNING OFF POWER TO THE PDU MAY NOT REMOVE POWER TO THIS TERMINAL BLOCK. VERIFY REMOVAL OF POWER WITH AN APPROPRIATE MEASURING DEVICE BEFORE SERVICING. INPUT VOLTAGE NOT TO EXCEED 30VAC.

- **ROOM DOOR INTERLOCK** - Positions 9 & 10 of the terminal block provide for a Room Door interlock in the X-Ray Exposure control of the system. Terminal 9 is to be connected to the EXP_INTLK signal (J1-17) and terminal 10 is to be connected to PDU_PGND on the PDU Control Board.
- These terminals are clearly labeled "DOOR INTLK SW".
- At shipment from the factory, each NGPDU has a 14 AWG (2.25 mm2) jumper wire installed between terminals 9 & 10.

4.4 NGPDU Drawings

4.4.1 Gantry Power Control

When the 120VAC ON signal is received at the GANTRY_PWR connection, given the auxiliary power switch is closed, relay coil KD2 is energized and its contacts close. This relay completes the circuit to the coil of Ktg, which in turn completes the 120VAC circuit to the gantry and table. See Figure 10-6. Stationary gantry and table power is protected by CB6 and gantry rotating power by CB5.

Table and gantry service outlet power is unaffected by 120VAC ON signal and can only be disabled by its associated circuit breaker CB4. Note that CB4, CB5 and CB6 are slaves to master circuit breaker CB3. Table service outlet is limited to 10 amperes.

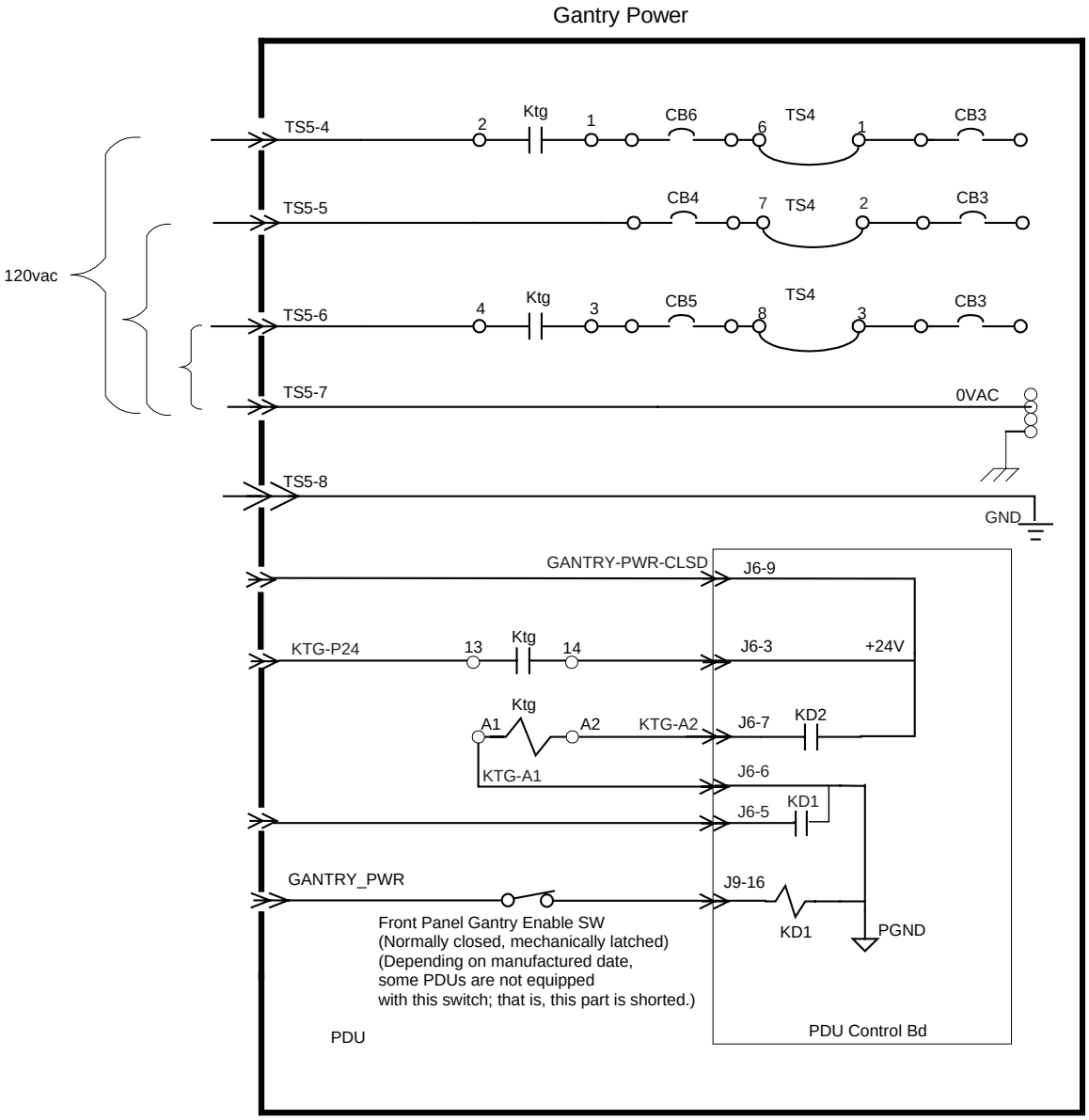


Figure 10-17 Gantry Power Control

4.4.2 Axial Drive Power Control

Axial Drive Power is controlled by relay Ksv and is protected by circuit breaker CB6. When the **PDU** control board senses an e-stop condition, NGPDU is disconnected with Gantry_PWR_CLSD loop, which prevents activation of the relay Ksv.

Axial Drive Power and Feedback

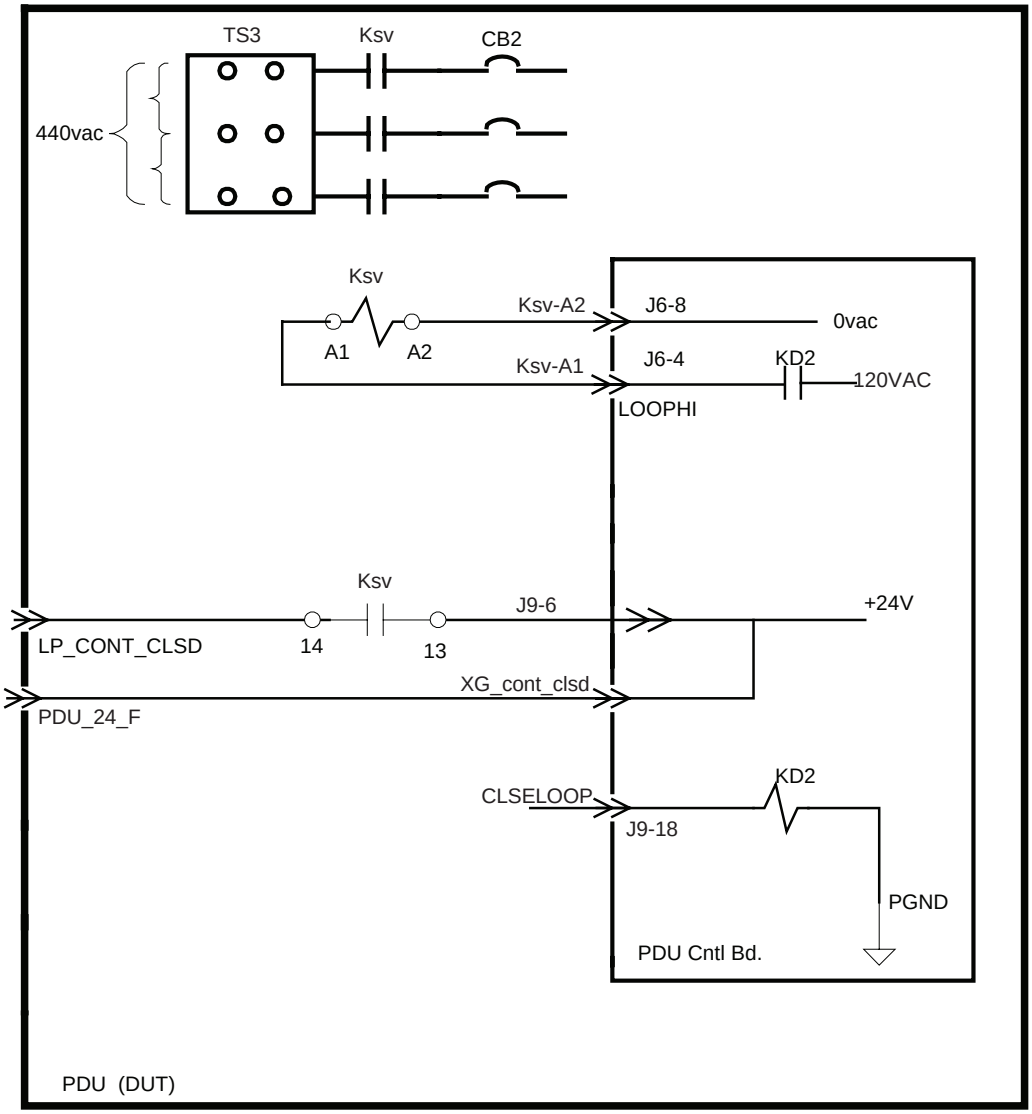


Figure 10-18 Axial Drive Power Control

4.4.3 HVDC Supply Control

When the BUCONT signal is received and the connection between HV_MODE and HV_MODE_RTN is made, the **HVDC** supply will produce output. When the coils KD4 is energized, the coil Kxg is energized. The contacts on Kxg close and supply power to the **HVDC** supply. This operation can be inhibited by the **PDU** control board “E-stop” circuit, through relay contacts Ktg. See Figure 10-8.

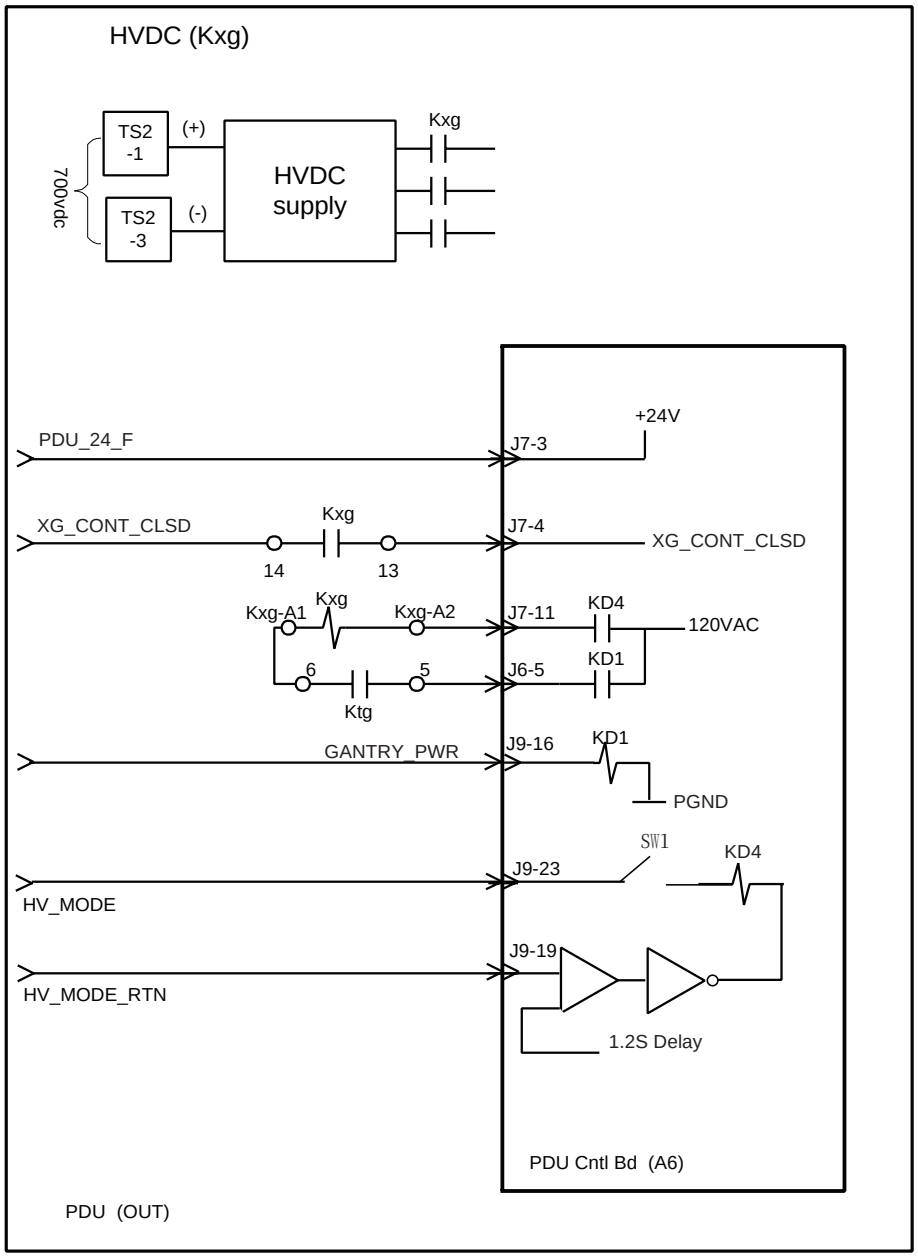


Figure 10-19 HVDC Supply Control

4.4.4 Console Power Control

120VAC Power for the console is derived from two legs of 208VAC. Console power is protected by circuit breaker CB7. CB7 is a slave to CB3.

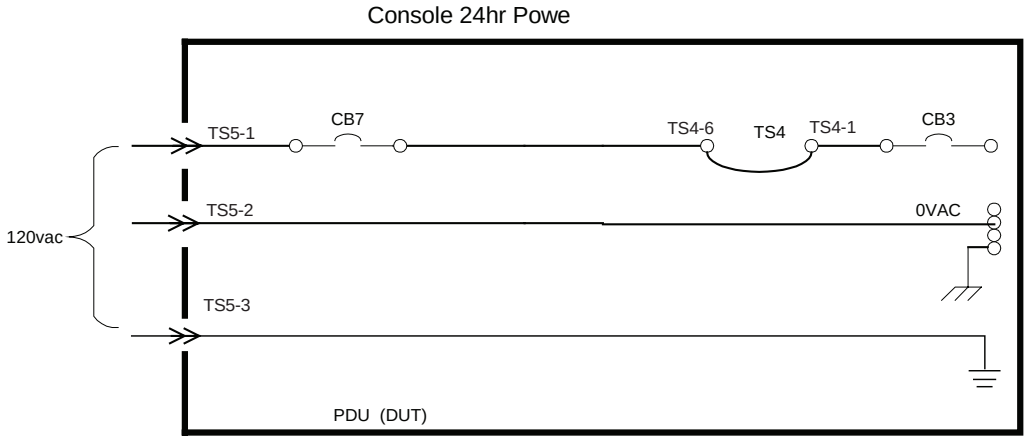


Figure 10-20 Console Power Control

4.4.5 Room Light Control

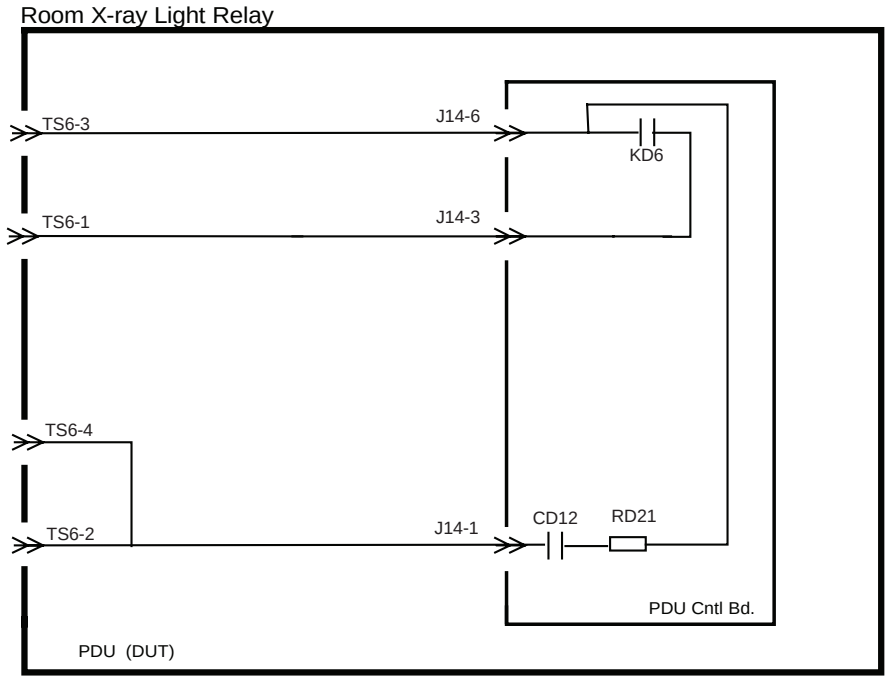


Figure 10-21 Room Light Control

4.4.6 E-Stop/Drives Control

For the following discussion, see Figure 10-22.

NORMAL STATE

With the E-stops and tape sensors in normal state, a connection is made between ESTP_SRC and FOUR, and between TBLOFF and TABLEOFF respectively. In this condition, the reset and drives enable lamps are illuminated steadily, the reset light being controlled by the connection between LITESHI and LITESRTN, the drives light by DRIVEON and DRVRTN connections.

TAPE SENSOR

When a table tape sensor is activated, the connection between TBLOFF and TABLEOFF is opened. This situation opens the circuit between DRIVEON and DRVRTN, and turns the drive enable lamp off. The blinking circuit now pulses the reset lamp slowly to indicate the condition.

E-STOP

When an E-stop switch is activated, the connection between ESTP_SRC and FOUR is opened. This situation opens the circuit between DRIVEON and DRVRTN, and turns off the drive enable lamp. The blinking circuit now pulses the reset lamp fast, to indicate the e-stop condition, through the connection LITESHI and LITESRTN.

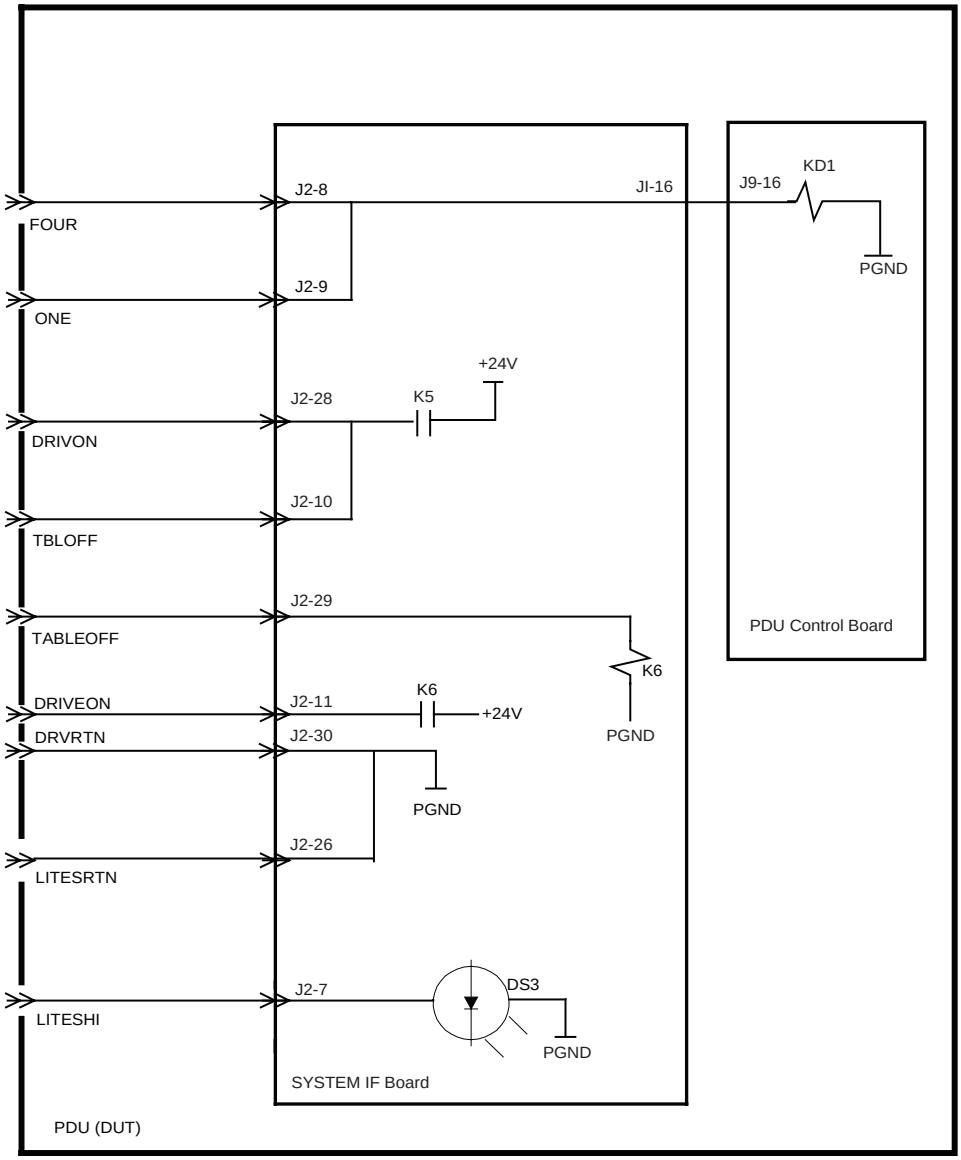
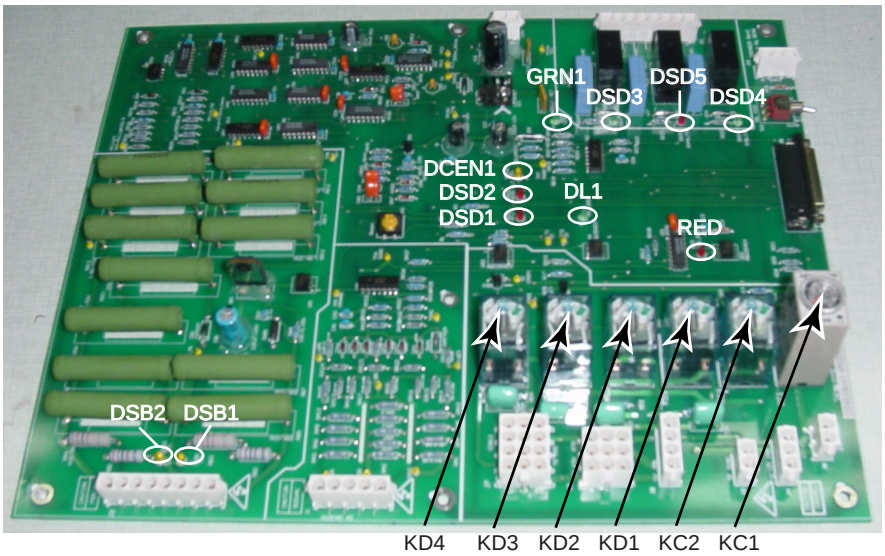


Figure 10-22 E-Stop/Drives Control

4.5 NGPDU LEDs

There are 17 LEDs on the PDU Control Board. See the below illustration:



The ON / OFF status of these LEDs are explained in the below table:

LED on Control Board		Description		Error
ID	NAME	ON	OFF	
DSD1	Voltage Fault	It's for HVDC - If the differential buss voltage exceeds 500Vdc within the first 200mS after turning on the PDU Control board, control board shall detect and latch a VFLT condition and shall issue a "VFLT". i.e. DSD1 light.	If the contactors Kxg and/ or Kss are closed, the control board should not have this issue. i.e. DSD1 OFF.	DSD1 LED ON (RED)
DSD2	BUSS Fault	It's for HVDC - If the differential buss voltage does not exceed 200Vdc within the first 200mS after turning on the PDU Control board, control board shall detect and latch a BS_FLT condition and shall issue a "BUSS_FLT". i.e. DSD2 light.	If the contactors Kxg and/ or Kss are closed, the control board shall open them, i.e. DSD2 OFF.	DSD2 LED ON (RED)
DSD3	RDY light	This is the "Generator Ready" Light. NGPDU provides isolated terminals KD7 for customer Room Light connections.	This means the "Generator is not ready.".	DSD3 LED OFF (GREEN)
DSD4	X-ray light	From the Gantry to close the "X-Ray ON" Light . NGPDU provides isolated terminals KD7 for customer Room Light connections.	This means the X-ray shouldn't be ON from Gantry signal.	DSD4 LED OFF (GREEN)

Table 10-12 LED Description

LED on Control Board		Description		Error
ID	NAME	ON	OFF	
DSD5	SYS light	Input signal from the Gantry to close the"System ON" Light relay. NGPDU provides isolated terminals KD5 for customer Room Light connections.	System OFF	DSD5 LED OFF (GREEN)
DSB1	HV-	Has HVDC-	No HVDC-	DSB1 LED OFF (YELLOW)
DSB2	HV+	Has HVDC+	No HVDC+	DSB2 LED OFF (YELLOW)
DCEN1	DC Enable	If the contactors Kxg and/or Kss are not closed, and there is no issue, DCEN1 is on.	If the contactor Kxg and/or Kss are closed, and there is no issue, DCEN1 is off.	DCEN1 LED OFF(Green)
GRN1	Voltage +24V	24VDC green status indicator lamp - it will be ON whenever the NGPDU is energized.	24VDC green status indicateor lamp --it will be OFF whenever ther NGPDU is powered off.	GRN1 LED OFF (Green)
DL1	Phase Loss	A phase undervoltage / open fuse detection circuit on the PDU Control board. If the voltage w.r.t. ground on any one or more phases drops below 185Vac (~70% of the normal), DL1 light.	If contactors Kxg and/or Kss (described above) are closed, no phase loss issue.	DL1 LED ON (RED)
RED	Interlock Open	This is +24Vdc output signal to Gantry that indicates the customer room door interlock is open. This signal automatically resets and dynamically tracks the status of the interlock circuit.	It means no interlock happens.	nterlock LED ON (RED)
KC1	Relay LED	Over temperature protect status	Not over temperature protect or less than 30s	LED ON(RED)
KC2	Relay LED	Over temperature protect status	Not over temperature protect	LED ON(RED)
KD1	Relay LED	Ktg Power ON	Ktg Power OFF	LED OFF (Green)
KD2	Relay LED	ksv Power ON	Ksv Power OFF	LED OFF (Green)
KD3	Relay LED	Kss Power ON	Kss Power OFF	LED OFF (Green)
KD4	Relay LED	Kxg Power ON	Kxg Power OFF	LED OFF (Green)

Table 10-12 LED Description (Continued)

GE MEDICAL SYSTEMS

GE MEDICAL SYSTEMS-AMERICAS: FAX 262.312.7434
3000 N. GRANDVIEW BLVD., WAUKESHA, WI 53188 U.S.A.

GE MEDICAL SYSTEMS-EUROPE: FAX 33.1.40.93.33.33
PARIS, FRANCE

GE MEDICAL SYSTEMS-ASIA: FAX 65.291.7006
SINGAPOR

GE Medical Systems

gemedical.com

Technical Publication

Direction 2340897-100
Revision 08

Book 6 of 6

Pages 867 - 1068

GE Medical Systems
HiSpeed QX/i Service Manual - General

Chapters 11 & 12 - Image Quality & Tube Replace, Appendices, Glossary & Index

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Chapter 11
Image Quality

Section 1.0
Image Series

1.1 Scan Protocol

The person who acquires the image series has the responsibility to review the images, and verify they meet the specifications listed on data sheets. Responsibilities also include means and standard deviation measurements, and keeping a record of failures that occur during the image series.

Unless otherwise stated, use the following scan parameters during the image series acquisition:

- Scan **FOV** equal to display **FOV** (Field of View)
- 512x512 matrix size

Note: **Consider *any* image series scan that does not meet specifications as failing.**

For means and standard deviations, 90% of the slices must pass. Any failure on a particular technique requires at least ten additional slices to evaluate effectively.

Systems with metal-free cradles have a phantom holder with a perpendicular adjustment (Z-axis) knob on it. **Each time you change phantoms,** make sure you use a bubble level, and the Z-axis knob on the phantom holder, to level the phantom.

1.2 Data Recording: Means and Standard Deviation

Any failure on a particular technique requires at least a ten additional slices to evaluate effectively. For means and standard deviations, 90% of the slices must pass.

- Record means to two decimal places, and round to the nearest one-tenth, (one decimal place) when you compare the resulting values to the spec.
- Record standard deviations to two decimal places, then round off to one decimal place, to compare it to the spec.
- Average standard deviations: Use two decimal places to average the values, then round off to one place.

Before you record the means and standard deviations, check the image data sheets to determine whether to average the means and standard deviations, or record them slice by slice. Make sure you record all the required image data on the **HHS** data sheets.

1.3 Term Definitions

Xc - Mean **CT** number for the specified center coordinates of the phantom image.

AvXc - Average Mean **CT** number for the center of the phantom image: Average the mean **CT** value for all specified center coordinates of all slices in an exam.

Xo - Mean **CT** number for the outside of the phantom image: Average the mean **CT** value for all specified outside coordinates of one slice.

AvXo - Average outside mean **CT** number for the number of slices in an exam.

AvSDc - Average image noise about the center image coordinate (measured as the standard deviation) of all slices in an exam.

AvSDo - Average image noise (standard deviation) for the outside of a phantom: Average of all outside coordinates of all the slices in an exam.

1.4 48cm Phantom Image Series Image Performance Verification

1.4.1 Acquiring the 48cm Phantom Image Series

1.) Mount the Phantom Holder on the head-end of the table.
2.) Mount the 48cm Phantom on the Phantom Holder.
3.) Align, level, & center the 48cm Phantom.
- Align phantom using the internal laser lights.
- Level phantom using bubble level and the Z Axis knob on the Phantom Holder.
- Center phantom using the CENTER PHANTOM utility in the left head SCANNER UTILITIES selection and the X and Y Axis knobs on the Phantom Holder.

4.) Set up the system to scan a four scan, 16 image, 48cm Phantom image series.

MANUAL SCAN PROTOCOL SETUP

Refer to Table 11-1 and set-up an Axial scan with the parameters as shown.

Series Description	Scan Type	Start Loc.	End Loc.	Total # of Images	Thick Speed	Interval (mm)	Gantry Tilt	SFOV	kV	mA	Total Exposure Time	DFOV (cm)	Recon Type
48 Lg Series 1	Axial Full 1.0 sec.	I7.50	S7.50	16	5.0 4i	0.00	S0.0	Large	120	340	4.0 sec.	50.0	Std

Table 11-1 48cm Phantom Image Series Scan Parameters

AUTO SCAN PROTOCOL SETUP

a.) On the Exam Rx desktop, select NEW PATIENT.
b.) Type the following entries in the two listed `Patient Information` fields:
Patient ID: `Service`
Name:`48cm Phantom Image Series`
c.) From the Protocol display, click on the infant box.
d.) On the infant display window, click on the area below the infant's right foot to display the `Miscellaneous` menu.
e.) Click on the 20:10 IMAGE SERIES 48 CM button.
f.) Select the first series (`Series Description` filed should display `48cm Lg Series 1`)

5.) Set internal Landmark.
6.) Acquire a four-scan, 16 image, 48 cm Phantom image series.

1.4.2 Brightness Uniformity and Noise

1.4.2.1 Specifications

Each Row (2A, 1A, 1B, and 2B) of the series *must* pass 48cm Brightness Uniformity and Noise (for the first series scan parameters) specifications:

- AvXo - AvXc: < +/- 8.5
- AvSDo: < 70.0

1.4.2.2 Recommended Failure Recovery

A.) Perform DETAILED CAL.

B.) Perform AUTO CT# ADJUST.

C.) Repeat this procedure to verify 48cm Phantom Image Performance.

1.5 20cm QA Phantom Image Series Image Performance Verification

1.5.1 Acquiring the 20cm QA Phantom Image Series

1.) Mount the Phantom Holder on the head-end of the table.

2.) Mount the 20cm QA Phantom on the Phantom Holder.

3.) Align, level, & center the 20cm QA Phantom.

- Align the etched line (QA#1 position) on phantom using the internal laser lights.
- Level phantom using bubble level and the Z Axis knob on the Phantom Holder.
- Center phantom using the CENTER PHANTOM procedure in the left head SCANNER UTILITIES selection and the X and Y Axis knobs on the Phantom Holder.

4.) Set up the system to scan the QA#1, QA#2, and QA#3 positions on the 20cm QA Phantom.

MANUAL SCAN PROTOCOL SETUP

Refer to Table 11-2 and set-up an Axial scan with the parameters shown

Series Description	Scan Type	Start Loc.	End Loc.	Total # of Images	Thick Speed	Interval (mm)	Tilt	SFOV	kV	mA	Total Exposure Time	DFOV (cm)	Recon Type
QA#1	Axial Full 1.0 sec.	I5.00	S5.00	4	10.0 2i	0.00	S0.0	Small	120	260	2.0 sec.	25.0	Std
Recon 2: Q	Recon #2 of Series #1–4 images											15.0	Bone
QA#2	Axial Full 1.0 sec.	S40.00	S50.00	8	10.0 2i	0.00	S0.0	Small	120	260	4.0 sec.	25.0	Std
QA#3	Axial Full 1.0 sec.	S55.00	S65.00	8	10.0 2i	0.00	S0.0	Small	120	260	4.0 sec.	25.0	Std

Table 11-2 20cm QA Phantom Image Series Scan Parameters

AUTO SCAN PROTOCOL SETUP

a.) On the Exam Rx desktop, select NEW PATIENT.

b.) Type the following entries in the listed `Patient Information` following fields:

* `Patient ID:`**`Service`**
* `Name:`**`20cm QA#3 Phantom Image Series`**

c.) From the Protocol display, click on the infant box.

d.) On the Infant display window, click on the area below the infant's right foot to display the `Miscellaneous` menu.

e.) Click on the 20:12 IMAGE SERIES QA button.

f.) When the scan prescription appears on the left monitor, select the 1st series.

5.) Set internal Landmark.

6.) Acquire the QA#1, QA#2 and QA#3 positions of the 20cm QA Phantom.

1.5.2 High Contrast Spatial Resolution

1.5.2.1 Specifications

Each image of the series must pass 20cm QA#1 High Contrast Spatial Resolution parameter (Contrast Scale, Four-Image MTF Average and Visible Line Pair (for the first and second series scan parameters) specifications:

- Contrast Scale: 110.0 to 130.0
- MTF Average: 0.65 to 1.0
- Visible Lines: B, C, D, E, F

1.5.2.2 Recommended Failure Recovery

A.) Check Phantom Alignment (leveling is critical) and repeat this scanning and High Contrast Spatial Resolution Performance Test.

B.) Perform Alignment Procedures (POR Alignment, BOW Alignment, CBF/SAG Alignment, ISO Alignment, and Hot ISO Alignment), perform Full Calibration (Detailed Calibration and Auto CT# Adjust, and repeat this scanning and High Contrast Spatial Resolution Performance Test.

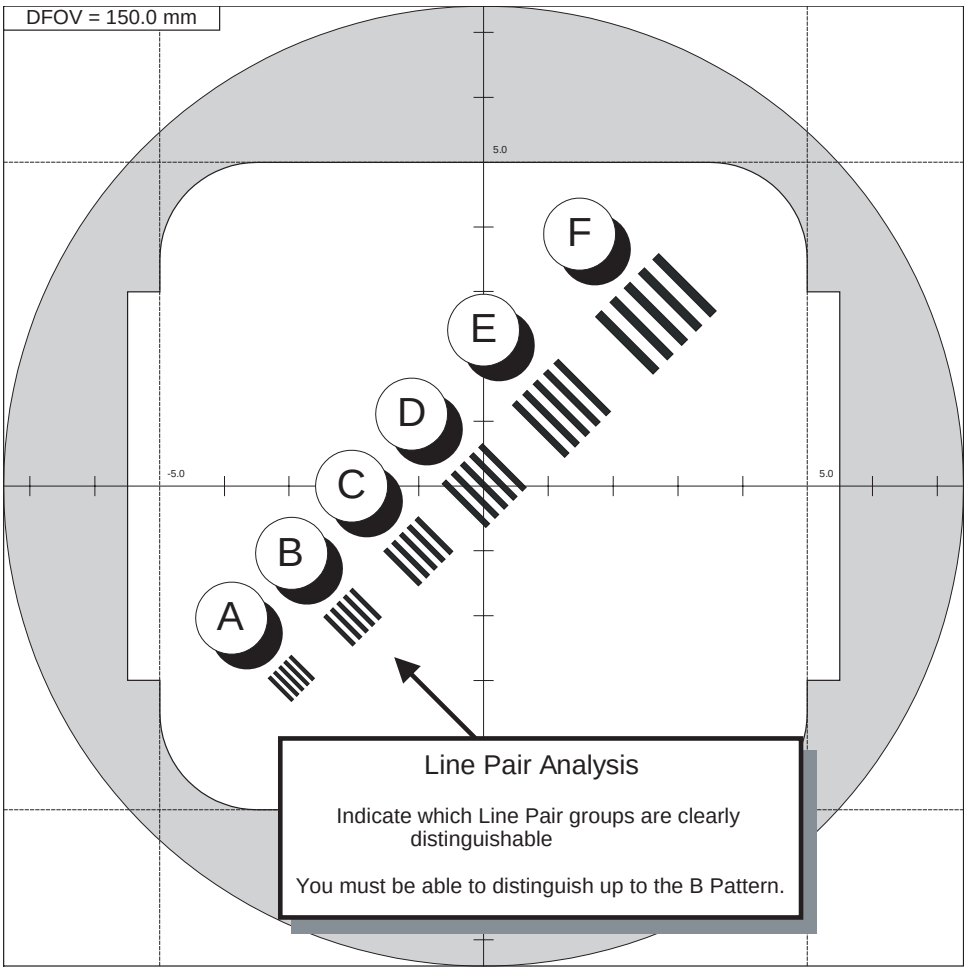


Figure 11-1 20cm QA#1 Phantom High Contrast Spatial Resolution (Visible Line Verification)

1.5.3 Low Contrast Detectability

1.5.3.1 Image Performance Verification

1.) Select the third 20cm QA Phantom image series (QA#2 Holes) from the exam acquired in the previous section.

   a.) From the Global Control Palette, click on the IMAGE WORKS Desktop.

   b.) From the Image Works Desktop, select the IMAGE WORKS BROWSER window.

   c.) Select the exam and the third series acquired in the previous section.

   d.) Select the VIEWER button on the Image Works Browser window. Set up the viewer window for four-image viewing.

2.) Build a 10 mm x 100 mm reference ROI Box using the Image Works Viewer tools.

   a.) Click on the grid button to place a grid on the first image.

   b.) Click on the MEASURE button and select the box ROI icon.

   c.) Adjust the size of the ROI box to be a rectangle of approximately 10 mm x 50 mm (500 mm2) box.

   If required, magnify the image to adjust to proper dimensions. See Figure 11-2 for additional ROI size and placement information.

3.) Collect Mean values for two reference ROI Box positions on four (1st, 3rd, 5th, and 7th) of the eight 20cm QA#2 Phantom images.

   If required, magnify the image to adjust to proper dimensions. See Figure 11-2 for additional ROI placement information.

   a.) Adjust the Window setting of the image to 20 by simultaneously holding the center mouse button down while dragging the cursor to the left. Adjust level for a viewable image as shown in Figure 11-2.

   b.) Position the reference ROI Box built in step 2 on the Plexiglas portion of the QA#2 phantom image without touching the water portion or the hole pattern. See Figure 11-2.

   c.) Type **`prop a`** in the Image Works Accelerator Line followed by <Return> to propagate Box # 1 ROI (size and position) on the remaining images in the series.

   d.) Click on the MEASURE button and select the box ROI icon to display Box # 2. The system places an ROI box labeled # 2 at the center of the image with the exact same dimensions as Box # 1.

   e.) Reposition Box # 2 over the water portion of the QA#1 phantom image and directly above Box # 1 (Box # 2 position in Figure 11-2).

   f.) Type **`prop a`** in the Image Works Accelerator Line followed by <Return> to propagate Box # 2 ROI (size and position) on the remaining images.

   g.) Record the Mean values of the 1st, 3rd, 5th, and 7th images in the series for each of the two box positions in Table 8.

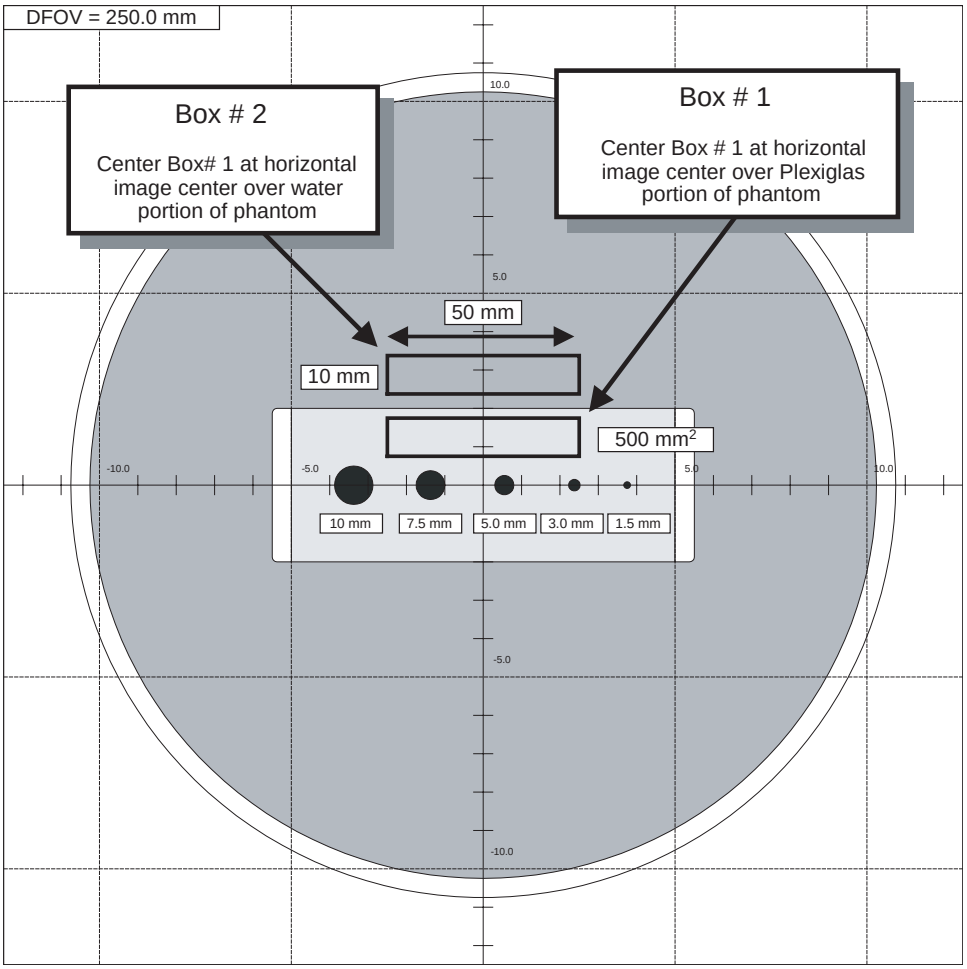


Figure 11-2 20cm QA#2 Phantom Low Contrast Detectability - Building and Placing Reference ROI Boxes

Image	Visible Holes Viewable at Window 20	Box 1 Means (Plexiglas)	Box 2 Means (Water)	Contrast Factor (Box 1 Means – Box 2 Means)	Comments
1					
3					
5					
7					
Specifications	**See Table 11-4**	**n/a**	**n/a**	**2.0 to 12.0**	**n/a**

Table 11-3 20cm QA#2 Phantom Low Contrast Detectability Image Performance Worksheet #1

4.) View the 1st, 3rd, 5th, and 7th images of the QA#2 Holes Series, record the number of visible holes in Table 11-3, and verify each image meets specifications.

a.) While viewing the 1st, 3rd, 5th, and 7th images, indicate in Table 11-3 the number of holes that can be visually distinguished. See Figure 11-2.

b.) Verify Visible Hole visual check meets specifications listed in Table 11-4 for the calculated Contrast Factor and record in the HHS Record Tables.

Contrast Factor Range (Box 1 Means – Box 2 Means)	Visible Number of Holes		Smallest Visible Hole Size
	Lower Limit*	Upper Limit*	
2.00 to 3.99	2	5	7.5mm
4.00 to 7.99	3	5	5.0mm
8.00 to 12.00	4	5	3.0mm
*Required number of visible holes depends on the contrast factor.			

Table 11-4 20cm QA#2 Phantom Visible Hole Specifications

1.5.3.2 Failure Recovery

Specifications

At least two out of the four images of the series must pass the 20cm QA#2 Low Contrast Detectability parameter (Visible Hole Size for a calculated Contrast Factor) for the third series scan parameters specifications.

Recommended Recovery

A.) Check Phantom Alignment (leveling is critical) and repeat this scanning and High Contrast Spatial Resolution Performance Test.

B.) Perform Alignment Procedures (POR Alignment, BOW Alignment, CBF/SAG Alignment, ISO Alignment, and Hot ISO Alignment), perform Full Calibration (Detailed Calibration and Auto CT# Adjust, and repeat this scanning and Low Contrast Detectability Performance Test.

1.5.4 QA#3 Phantom Brightness Uniformity and CT#

1.5.4.1 Performance Verification

1.) Select the fourth 20cm QA#3 Phantom exam acquired in the previous section.
   a.) From the Global Control Palette, click on the IMAGE WORKS Desktop.
   b.) From the Image Works Desktop, select the IMAGE WORKS BROWSER window.
   c.) Select the exam and fourth (QA#3) series acquired in the previous section.
   d.) Select the VIEWER button on the Image Works Browser window. Set up the viewer window for four-image viewing.

2.) Build a 31 x 31 pixel reference ROI Box using the Image Works Viewer tools.
   a.) Click on the grid button to place a grid on the first image.
   b.) Click on the MEASURE button and select the box ROI icon.
   c.) Adjust the size of the ROI box to be a square 15 mm x 15 mm (225 mm2) box. Tolerance: 15 mm +/- 1 mm (196 mm2 to 256 mm2).

   If required, magnify the image to adjust to proper dimensions. See Figure 11-3 for additional ROI size and placement information.

3.) Collect Mean values for five reference ROI Box positions on the eight 20cm QA#3 Phantom images.

   If required, magnify the image to adjust to proper dimensions. See Figure 11-3 for additional ROI placement information.

   a.) Position the reference ROI Box built in step 2 directly over the center of the image using

the grid cross-hairs as a guide.

b.) Type **`prop a`** in the Image Works Accelerator Line followed by <Return> to propagate Box # 1 ROI (size and position) on the remaining images in the series.

c.) Click on the MEASURE button and select the box ROI icon to display Box # 2. The system places an ROI box labeled # 2 at the center of the image with the exact same dimensions as Box # 1.

d.) Reposition Box # 2 to the left center portion on the first image.

e.) Type **`prop a`** in the Image Works Accelerator Line followed by <Return> to propagate Box # 2 ROI (size and position) on the remaining images.

f.) Record the Mean values of the eight images in the series for each of the five box positions in Table 11-5.

Each image can only display text for the mean, standard deviation, and box area for three images at a time. To view the data for a particular box, select the box on the image and the system displays the data for the box number selected.

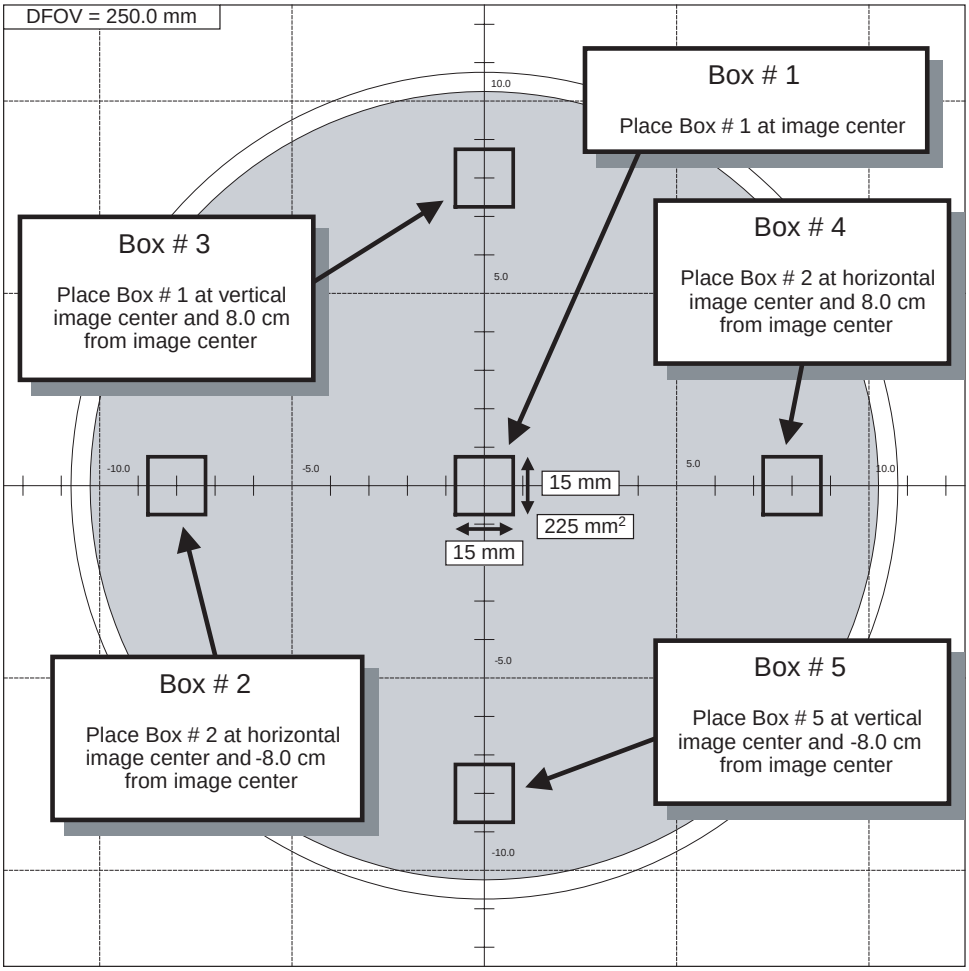


Figure 11-3 20cm QA#3 Phantom Brightness Uniformity & CT# Measurement - Building And Placing Reference ROI Boxes

Image	Box 1 (Center)	Box 2 (Left Center)		Box 3 (Top Center)		Box 4 (Right Center)		Box 5 (Bottom Center)		Outside Boxes Avg	
	Means (Xc)	Means	Std dev	Means	Std dev	Means	Std dev	Means	Std dev	Means (AvXo)	Std dev (AvSDo)
1			n/a		n/a		n/a		n/a		n/a
2			n/a		n/a		n/a		n/a		n/a
3			n/a		n/a		n/a		n/a		n/a
4			n/a		n/a		n/a		n/a		n/a
5			n/a		n/a		n/a		n/a		n/a
6			n/a		n/a		n/a		n/a		n/a
7			n/a		n/a		n/a		n/a		n/a
8			n/a		n/a		n/a		n/a		n/a

Table 11-5 20cm QA#3 Phantom CT# Brightness Uniformity & CT# Image Performance Worksheet

Box Size = 196 mm2 to 256 mm2
15 mm (+/- 1 mm) x 15 mm (+/- 1 mm)
31 (+/- 2 pixels) x 31 (+/- 2 pixels)

Box Positions: Box 1 = 0 mm x 0 mm
Box 2 = 0 mm x -80 mm
Box 3 = 80 mm x 0 mm
Box 4 = 0 mm x 80 mm
Box 5 = -80 mm x 0 mm

Row	Images	Center Box Means (AvXc)	Outer Boxes Means Averages (AvXo)	Outer Boxes Means Averages minus Center Box Means (AvXo - AvXc)	Outer Boxes Standard Deviation Averages (AvSDo)	Comments
2A1A	1, 3, 5, 7				n/a	
1B2B	2, 4, 6, 8				n/a	
Specifications		**0.0 ± 3.0**	**n/a**	**<± 3.0**	**n/a**	

Table 11-6 48cm Phantom CT# Brightness Uniformity & Noise Row Performance Worksheet

4.) Calculate the Brightness Uniformity and CT# values for each image in the series, record values in Table 11-6, and compare to specifications.

a.) Calculate and record the average means values (AvXo) for the four outside Boxes (Boxes 2 through 5) for each of the images and record in Table 11-5.

b.) Calculate and record the average center box (Box 1) means values (AvXc) for each row (2A1A: Images 1, 3, 5, and 7; 1B2B: Images 2, 4, 6, 8) in Table 11-6.

c.) Calculate and record the average outside boxes (Box 2 through 5) means values (AvXo) for each row (2A1A: Images 1, 3, 5, and 7; 1B2B: Images 2, 4, 6, 8) in Table 11-6.

d.) Calculate the Brightness Uniformity (AvXo - AvXc) value for each row and record in Table 11-6.

e.) Verify Brightness Uniformity (AvXo - AvXc) value and the average CT# value (AvXc) for each row meets specifications listed in Table 11-6.

f.) Record the 20cm QA#3 Phantom Brightness Uniformity (AvXo - AvXc) value and average CT# value (AvXc) for each row in the HHS Record Tables.

1.5.4.2 Failure Recovery

Specifications

Each Row (2A1A, 1B2B) of the series must pass 20cm QA#3 Phantom Brightness Uniformity and average CT# specifications:

- AvXo - AvXc: < +/- 3.0
- AvXc: < +/- 3.0

Recommended Recovery

A.) Perform DETAILED CAL.

B.) Perform AUTO CT# ADJUST.

C.) Repeat this procedure to verify 20cm QA#3 Phantom Image Performance.

1.5.5 QA#3 Phantom Noise

1.5.5.1 Performance Verification

1.) Select the fourth 20cm QA#3 Phantom exam acquired in the previous section.

a.) From the Global Control Palette, click on the IMAGE WORKS Desktop.

b.) From the Image Works Desktop, select the IMAGE WORKS BROWSER window.

c.) Select the exam and fourth (QA#3) series acquired in the previous section.

d.) Select the VIEWER button on the Image Works Browser window. Set up the viewer window for four-image viewing.

2.) Build a 51 x 51 pixel reference ROI Box using the Image Works Viewer tools.

a.) Click on the grid button to place a grid on the first image.

b.) Click on the MEASURE button and select the box ROI icon.

c.) Adjust the size of the ROI box to be a square 25 mm x 25 mm (625 mm2) box. Tolerance: 25 mm +/- 1 mm (576 mm2 to 676 mm2).

If required, magnify the image to adjust to proper dimensions. See Figure 11-4 for additional ROI size and placement information.

3.) Collect Standard Deviation values for the single reference ROI Box position on the eight 20cm QA#3 Phantom images.

If required, magnify the image to adjust to proper dimensions. See Figure 11-4 for additional ROI placement information.

a.) Position the reference ROI Box built in step 2 directly over the center of the image using the grid cross-hairs as a guide.

b.) Type **`prop a`** in the Image Works Accelerator Line followed by <Return> to propagate Box # 1 ROI (size and position) on the remaining images in the series.

c.) Record the Standard Deviation values of the eight images in the series for centered box position in Table 11-7.

4.) Calculate the average Noise values for each image in the series, record values in Table 11-7, and compare to specifications.

a.) Calculate and record the average Noise values (AvSDc) for the inside Boxes for each of the two rows (2A1A and 1B2B) and record in Table 11-7.

b.) Verify Noise (AvSDc) values for each row meets specifications listed in Table 11-7.

c.) Record the 20cm QA#3 Phantom Noise (AvSDc) for each row in the HHS Record Tables.

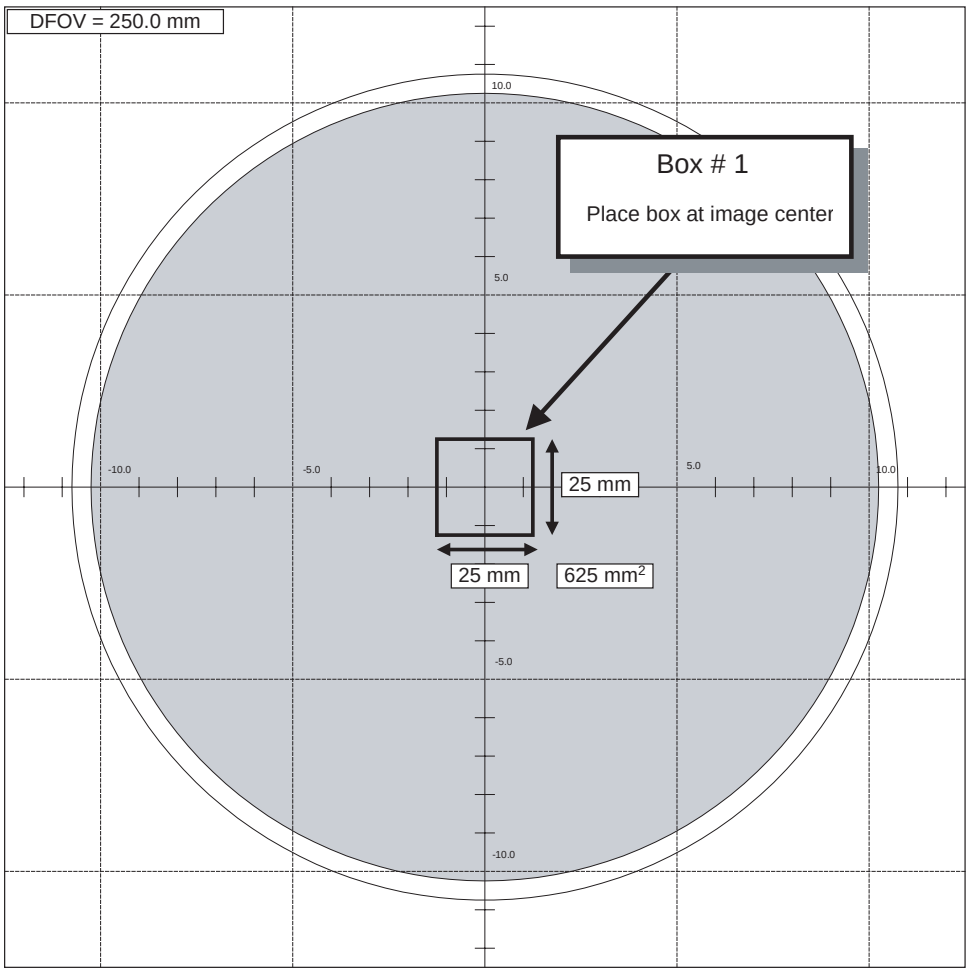


Figure 11-4 20cm QA#3 Noise Measurement - Building And Placing Reference ROI Box

Image	Row	Box 1 Std Dev (SDc)	Average Std Dev (AvSDc)	AvSDc Specifications		Comments
				Systems with less than 5000 scans	Systems with more than 5000 scans	
1	2A1A			3.2 ± 0.3	3.2 ± 0.4	
3						
5						
7						
2	1B2B					
4						
6						
8						

Table 11-7 20cm QA#3 Phantom Noise Performance Worksheet

Box Size = 576 mm2 to 676 mm2
25 mm (+/- 1 mm) x 25 mm (+/- 1 mm)
51 (+/- 2 pixels) x 51 (+/- 2 pixels)

Box Position: Box 1 = 0 mm x 0 mm

1.5.5.2 Failure Recovery

Specifications

Each Row (2A1A, 1B2B) of the series must pass 20cm QA#3 Phantom Noise specifications shown in Table 11-7.

Recommended Recovery

A.) Perform DETAILED CAL.

B.) Perform AUTO CT# ADJUST.

C.) Repeat this procedure to verify 20cm QA#3 Phantom Image Performance.

Section 2.0
Image Quality

2.1 Rings in an Axial Image

Using the Example shown in Figure 11-5, there is a obvious ring in the first image within the group of 4 images. During an Axial series, it is important to know certain parameters about the Scan Prescription. See Table 11-8

SCAN (RX) PRESCRIPTION		COMMENTS
Scan Type	Axial	In a Axial mode, there are several options relative to scanning and displaying images, either 4 x i, or 2 x I (where i = thickness) In a 4 x i mode, images are created from the rows used as indicated by slice thickness. *This mode should always be used to troubleshoot Detector / **DAS** related artifacts.* In a 2 x i mode Recon actually combines 2 rows of data to produce a thicker slice.
Scan Type	Helical	Images are created using data from all Rows used during data acquisition. (The actual rows being dependent on slice thickness) The amount of data used to reconstruct a image from a row, or row weighting is dependent on table speed.
Head First	Head First	Image 1 consists of the Data in Row 2A Image 2 consists of the Data in Row 1A Image 3 consists of the Data in Row 1B Image 4 consists of the Data in Row 2B
Feet First	Feet First	Image 1 consists of the Data in Row 2B Image 2 consists of the Data in Row 1B Image 3 consists of the Data in Row 1A Image 4 consists of the Data in Row 2A
Slice Thickness	4 x 1.25	Uses 4 Center rows of the Detector (D2, D1, D1, D2)
	4 x 2.50	Uses 8 Center rows of the Detector (D4+D3, D2+D1, D1+D2, D3+D4)
	4 x 3.75	Uses 12 Center rows of the Detector (D6+D5+D4, D3+D2+D1, ….)
	4 x 5.00	Uses 16 rows of the Detector(D8+D7+D6+D5, D4+D3+D2+D1,…)
	1 x 1.25	Uses 1 Center row of the Detector (A side D1)
	Thin Twin	Uses 2 Center rows of the Detector (D1, D1)
Technique	KV vs. Slice Thickness	The **DAS** Converter boards have 31 pre-amp gains that are selected by selected technique. These gains are not User selectable, however it is important to know if a Artifact only appears at the same pre-amp gain. The pre-amp gain used can be found within the scan header by using Scan Analysis.
Focal Spot Size	Small vs. Large	Technique dependent small spot ≤ 24KW, Large spot > 24KW
Calibration Used	Small vs. Large	Needed to know if artifact may be caused by cal vectors

Table 11-8 Troubleshooting a Ring in an Axial Image

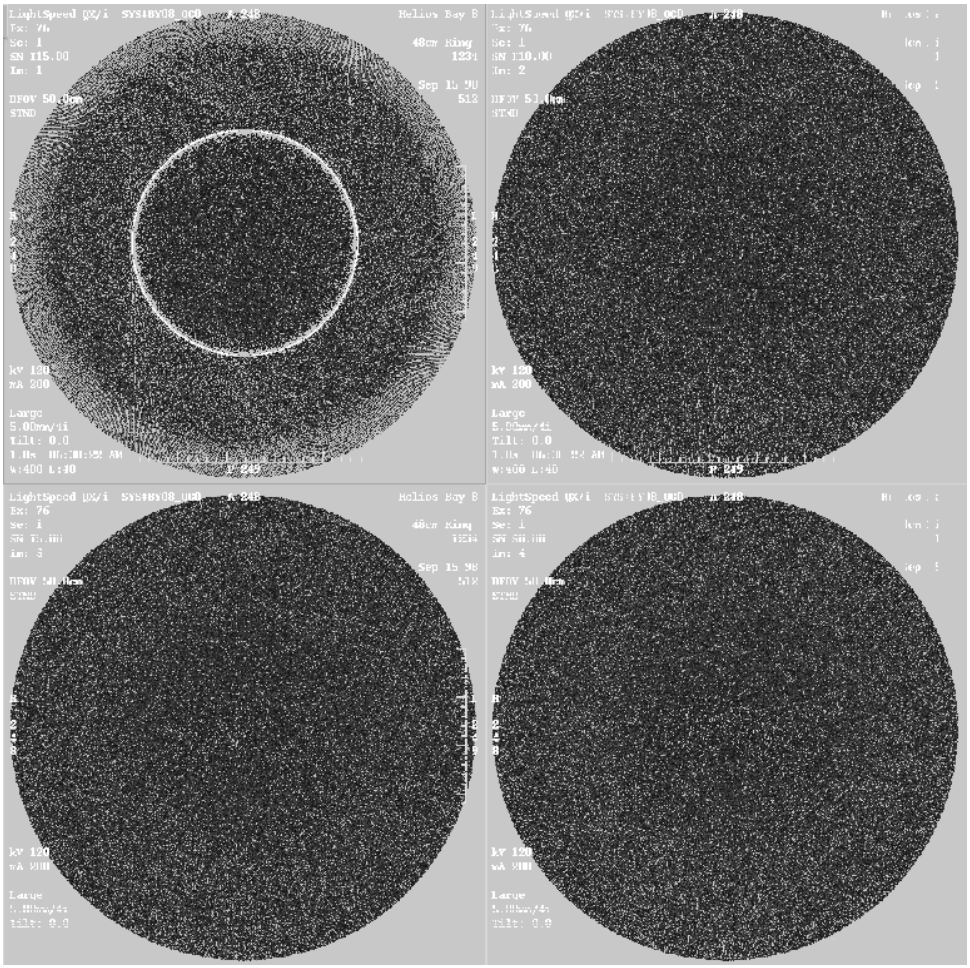


Figure 11-5 Example of Bad Channel in Axial Image Series

Looking at the Example in Figure 11-5, just by knowing the scan series was using Axial 4 x 5.00 Mode and was done Head first (Annotation of image vs. Table position), it can be determined that the Ring is probably in Row 2A of the Scanfile.

To confirm this, use Scan Analysis and plot the Means & Standard Deviations (**MSD**) of the selected Exam, Series, and Scan Number. From the Service Desktop:

1.) Select UTILITIES.

2.) Select TOOLS.

3.) Select SCAN ANALYSIS.

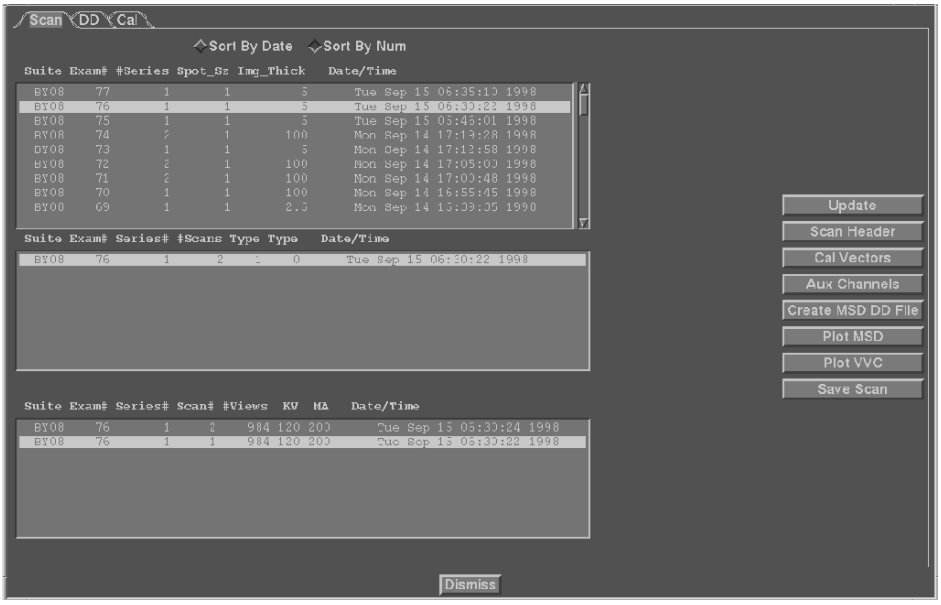


Figure 11-6 Scan Analysis GUI

Select an EXAM NUMBER, SERIES, and SCAN NUMBER. Remember that 1 scan, in a 4 x i mode, is made up of 4 Data sets (or rows), which produces 4 images. In the example, images 1 through 4 are created from scan 1. Once the scan is highlighted, select PLOT MSD.

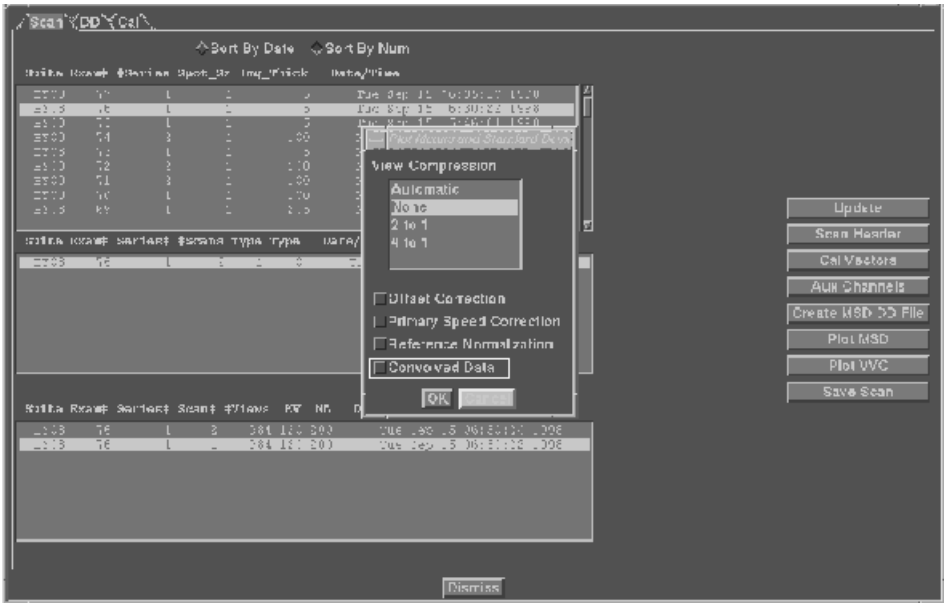


Figure 11-7 Plot MSD GUI

Leave the view compression defaulted to NONE, but choose CONVOLVED DATA, which will identify a ring type artifact better in the resultant plot. Select OK.

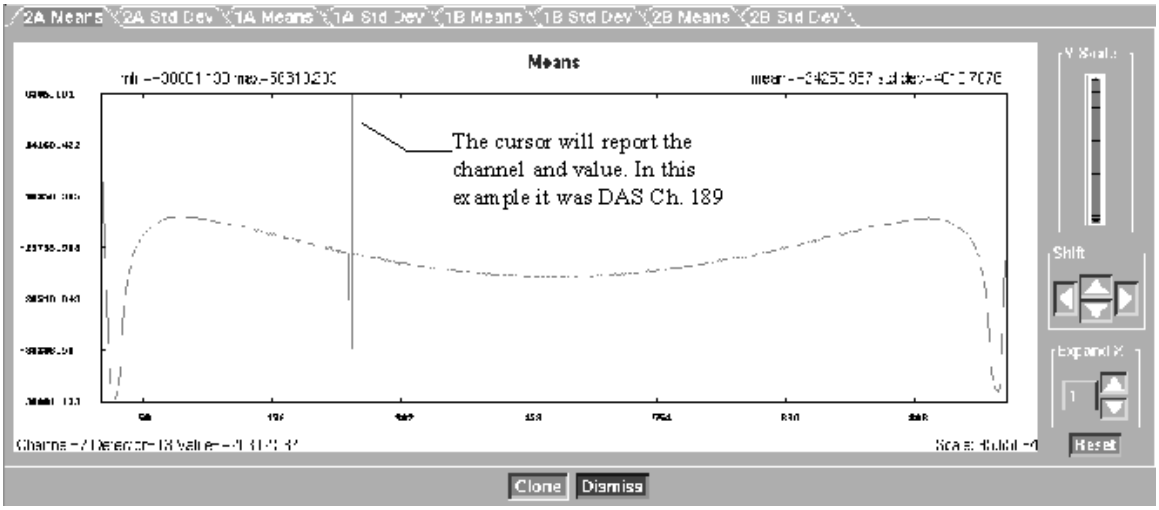


Figure 11-8 Scan Analysis (2A) Means & Standard Deviation GUI

The Scan Analysis Tool will first plot Row 2A. Any of the 4 rows of Means and Standard Deviations can be viewed by selecting the appropriate tabs (see Figure 11-8). Select the tab that indicates the row where the ring is expected based on your initial observations. It maybe necessary to adjust the level to find a spike in the data or view other rows. Look for any abnormal spikes.

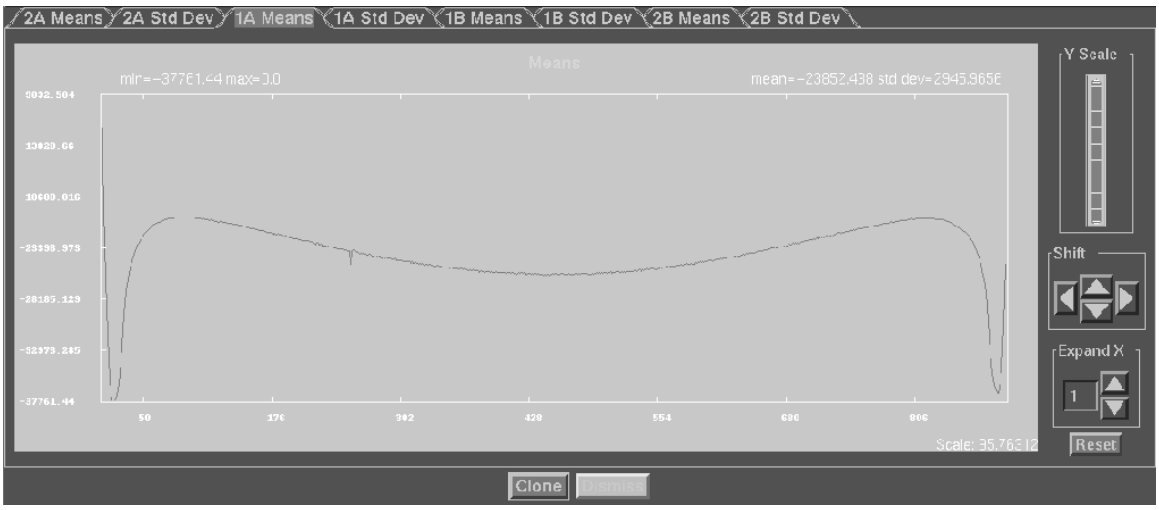


Figure 11-9 Scan Analysis (1A) Means & St. Dev. GUI

In Row 2A (see Figure 11-8), the ring is apparent. Notice the large spike in the data on channel 189. Row 1A (see Figure 11-9) has a small spike on channel 189 that is a result of capacitive discharge from row 2b channel 189. The small spike can be ignored. It is a product of the major spike on row 2B. Rows 1B and 2B look good. See Figures 11-10 and 11-11.

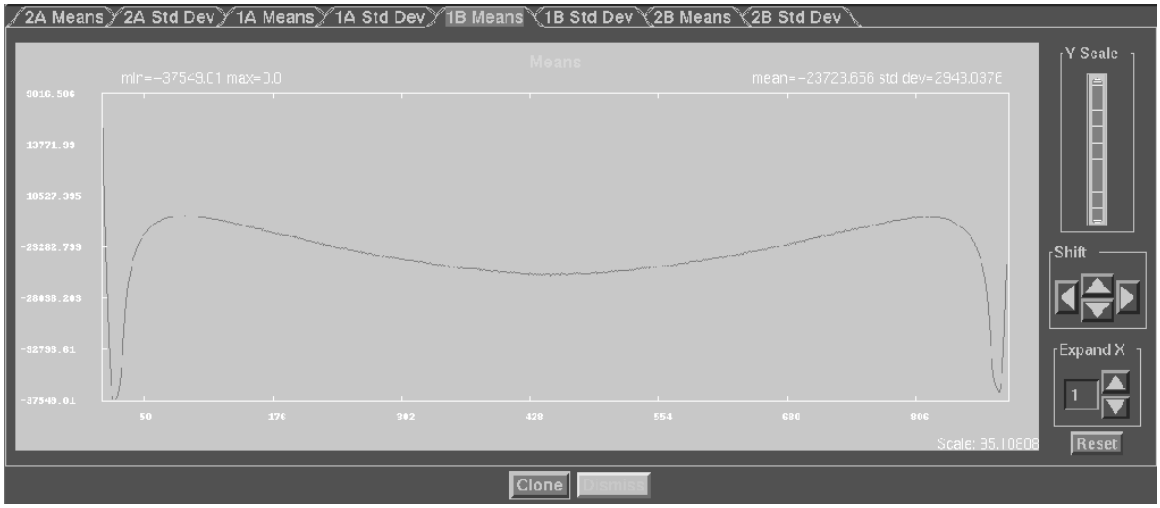


Figure 11-10 Scan Analysis (1B) Means & St. Dev. GUI

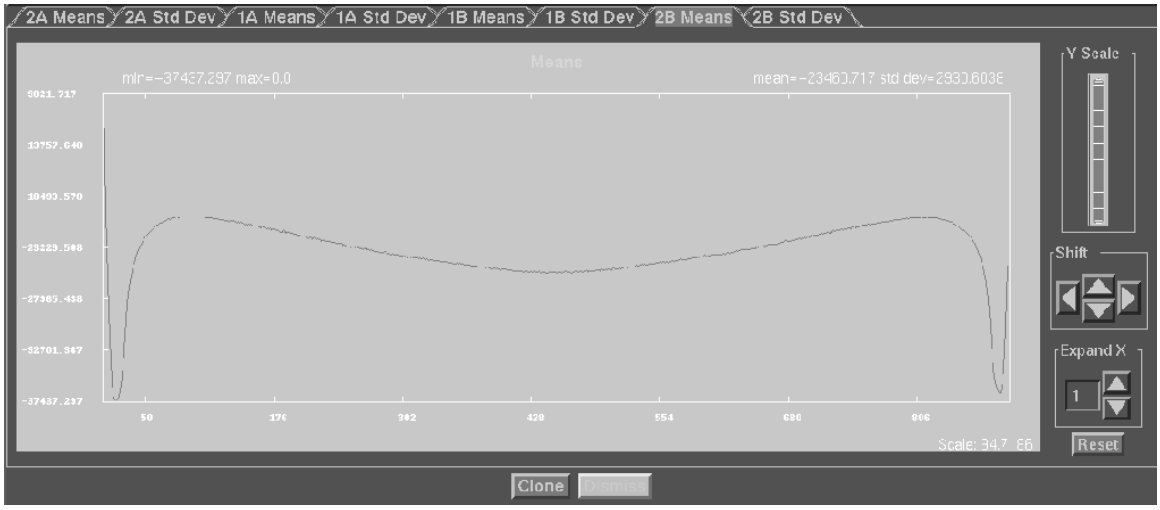


Figure 11-11 Scan Analysis (2A) Means & St. Dev. GUI

Now the Ring has been verified. It is in Row 2B and is on **DAS** Channel 189.

From within Scan Analysis, Cal vectors can be plotted to see if the bad **DAS** channel is present.

Determine if the ring is caused by a particular acquisition mode by scanning a phantom using different modes or slice thickness'. The example was scanned in a 4 x 5.00 mode and the ring appeared on Row 2A, therefore, the Detector rows or diodes used were D8+D7+D6+D5. They produce row 2A. If another scan was taken at 4 x 1.25 mode, then the first image, or row 2A data would be acquired from Detector row D2. If the ring is a hard failure (consistent every time) and if after changing slice thickness the ring does away, the ring may have been caused by a suspect detector. *Perform further detector verification before replacing a detector*. If the ring is still present, the problem could still be the detector, but may be a **DAS** board or elastomer interface connection.

By using the DAS / DETECTOR Architecture Tool, found in the pull-down menu under FILE, select the tool. A TTY window appears and prompts for a Detector Row and **DAS** Channel. The program will display the associated **DAS** Converter board, Detector channel, module number, elastomer number, and other important information.Find the associated **DAS** converter board number. If you have multiple rings, look for patterns (Converter Bd, Row, etc.).

If **DAS** is Suspect, swap filter Cards and repeat Scan & Analyze. When swapping cards make sure you swap with a card 4 slots away, slot 12 with slot 16 for example. This ensures the data from FET multiplexing is not on the same card.

1.) If bad channel follows bd. replace the bd.

2.) If bad channel stays at same location, problem area could be:

   a.) **DAS** Backplane

   b.) **DAS** Backplane to Elastomeric connection point

   c.) Elastomeric to Detector Flex connection point

      1.) Bad Detector (Replace)

      2.) Bad Flex (part of detector, replace Detector)

      3.) Bad Flex to Detector connection point (part of detector, replace Detector)

      4.) Bad Detector Channel (part of detector, replace Detector

      5.) Bad Detector Cell (part of detector, replace Detector)

Troubleshoot Ring Artifacts in a Helical series by duplicating the problem in a Axial Mode. If the Helical data is used to troubleshoot, the bad data can be in any row since all 8 rows of data can be used to produce a Helical image and the number of views to produce a helical image are weighted differently based on table speed and pitch.

Note that the Helical images are a result of the same bad **DAS** Channel as the Above Axial example. The hard ring in the Axial example appears as partial arcs in the Helical images.

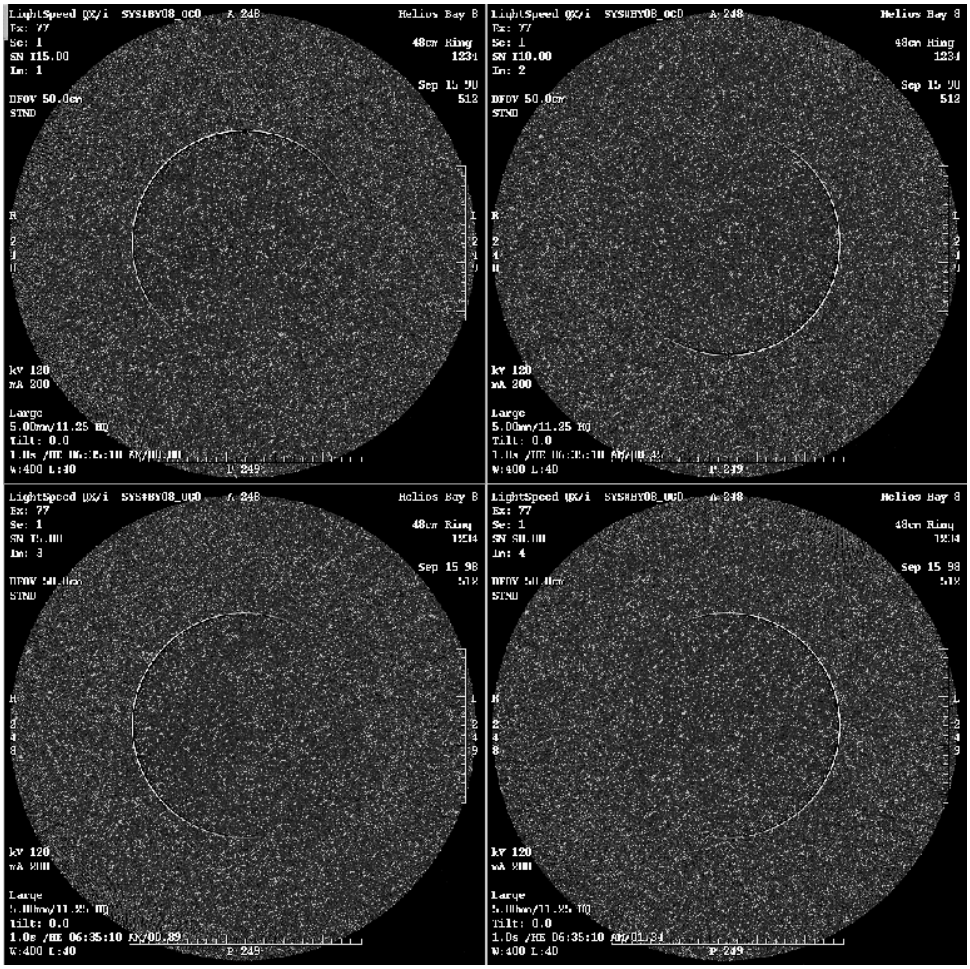


Figure 11-12 Example of Bad Channel in Helical Image Series

2.2 Image Quality Characteristics & Testing Procedures

2.2.1 What to Check for IQ

HiSpeed QX/i uses 16 rows of detectors with 4 rows of output, which produces up to four images at one rotation. HiSpeed QX/i also utilizes data from all selected rows in helical reconstruction by using different weighting schemes to produce better quality helical images. HiSpeed QX/i is also designed to perform longer helical scans at lower mAs. Because of the differences, when checking the image quality (IQ), we need to pay an attention to those artifacts/appearance that are unique to the HiSpeed QX/i scanner. The following are some of the examples:

1.) Ring/band artifacts may appear as partial or non-uniform ring/band in helical images. When this happens, axial scans may need to be taken to localize the bad **DAS** channel(s) or detectors.

2.) If artifacts happen in images of one of the outer rows, it may indicate a misalignment of beam in Z-direction (**BOW**). Again, axial scans may need to be taken to further isolate the problems if the problems happened in the helical images.

3.) HiSpeed QX/i uses 16 detectors that cover more space in Z-direction than CT/i. When using thicker slice configurations (5mm/4i), axial images made by the two outer rows are more susceptible to cone beam artifact (an example of a cone beam artifact is shading off a rib into the liver). Also, the use of peristaltic correction can increase the cone beam effect. In general, the use of thinner slice configurations reduces cone beam artifact. Also, helical mode will help reduce cone beam artifact, with HQ mode having less cone beam artifact that HS mode.

Specifically, the IQ checks may include the following:

1.) Alignment
   a.) **MTF** with GE Performance phantom, both axial and helical images, comparing with spec.
   b.) Aliasing test, both cold and hot.
   c.) Z-Beam motion.

2.) Noise/Artifacts
   a.) Noise measurement with 20 cm water phantom, comparing with spec.
   b.) Cone beam artifact.

3.) Microphonics - Check image quality (lack of rings, streak and/or center artifacts).

4.) Clever **DAS** Gain - Confirm that the **DAS** gains used in the patient scans match those in the cals.

5.) **CT** Number Uniformity - Check both water and poly phantoms' **CT** number uniformity, comparing with spec.

2.2.2 How to Check Image Quality

For artifact definitions and numerical measurements, see Installation Manual. For Image Troubleshooting, see Installation Manual. However, if artifacts happened in helical images, take axial scans to further isolate the problems.

2.2.2.1 Alignment

A.) **MTF** - Values should be similar to those of CT/i.

- Phantom: GE performance phantom (if available). The wire section of the GE performance phantom is not thick enough to have 2 10mm thick images. Two scans need to be done to verify both sides (2A1A and 1B2B) of the detector.
- Data Collection:
   1.) Center the phantom in x-y direction.
   2.) Landmark (in z-direction) at the center of the wire.

3.) Take scans per Table 11-9.

Cal	kV/mA	Slice thickness	Scan mode/time	Recon FOV / alg	Scan plane	# of scans	Tilt	Images analyzed
small	120/440	10mm/2i	Ax/0.8sec	25cm/std. 10cm/edge	S0 - S10	2	0	@S0
small	120/440	10mm/2i	Ax/0.8sec	25cm/std. 10cm/edge	I10 - S0	2	0	@S0
small	120/130	10mm/2i	Ax/2.0sec	25cm/std. 10cm/edge	S0 - S10	2	0	@S0
small	120/130	10mm/2i	Ax/2.0sec	25cm/std. 10cm/edge	I10 - S0	2	0	@S0
small	120/440	5mm/ 7.5mm/ sec	HQ 1sec	25cm/std. 10cm/edge	I5 - S5	4	0	@S0

Table 11-9 Alignment Scan Settings

- Data Analysis: Use the “Image Resolution” button in the “Image Analysis” tool kit to measure system **MTF**, compare with spec. Use images at S0.

B.) Aliasing - Check ISO alignment, and check if hot ISO was executed correctly.

- Phantom: GE QA phantom, section No. 1.
- Data Collection:

1.) Fastcal 120 kV, head bowtie.
2.) Let tube cool 30 minutes after last fastcal or scanning.
3.) Center the GE QA phantom and take scans per Table 11-10.
4.) Take heating scans using the protocol for QOEC tube heating.
5.) Take scans in (4) again.

Cal	kV/mA	Slice thickness	Scan mode/time	Recon FOV / alg	Scan plane	# of scans	Tilt	Images analyzed
small	120/200	2.5mm/4i	Ax/1sec	12.8cm/bone	I3.8 - S3.7	1	0	all
small	120/210	2.5mm/4i	Ax/1sec	12.8cm/bone	I3.8 - S3.7	1	0	all

Table 11-10 Aliasing Scan Settings

- Data Analysis: Inspect images visually. Both cold and hot tube images should be lack of aliasing artifacts.

C.) Z-Beam Motion - If artifacts happened in one of the outer rows, it may suggest that the **BOW** is not aligned correctly.

- Phantom: GE QA Phantom
- Data Collection:

1.) Fastcal 120kV, head Bowtie
2.) Let tube cool 1 hour after last fastcal or scanning

3.) Center the QA phantom water section, take scans per Table 11-11.

Cal	kV/mA	Slice thickness	Scan mode/time	Recon FOV / alg	Scan plane	# of scans	Tilt	Images analyzed
small	120/200	5mm/4I	Ax/1sec	25cm/std.	I7.5 - S7.5	1	0	all
small	120/100	5mm/4I	Ax/4sec	25cm/std.	I7.5 - S7.5	1	0	all
small	120/200	1.25mm/4I	Ax/1sec	25cm/std.	I1.9 - S1.8	1	0	all
small	120/100	1.25mm/4I	Ax/4sec	25cm/std.	I1.9 - S1.8	1	0	all

Table 11-11 Beam Motion Scan Settings

4.) Scan a series of 30 scans at 4sec with 4sec ISD per Table 11-12.

Cal	kV/mA	Slice thickness	Scan mode/time	Recon FOV / alg	Scan plane	# of scans	Tilt	Images analyzed
small	120/200	5mm/4i	Ax/4sec	25cm/std.	I7.5 - S7.5	30	0	None

Table 11-12 Scan Settings (4sec ISD)

5.) Repeat scans in (4) again.

Data Analysis: Check images visually, pay attention to the two outer rows. No failing ring and/or band artifacts should occur

2.2.2.2 Noise

Image noise should meet the spec.

- Phantom: GE QA phantom.
- Data Collection:

1.) Fastcal, 120kV, Head Bowtie.

2.) Center the QA phantom water section, and take scans per Table 11-13.

Cal	kV/mA	Slice thickness	Scan mode/time	Recon FOV / alg	Scan plane	# of scans	Tilt	Images analyzed
small	120/260	10mm/2i	Ax/1sec	25cm/std.	I5 - S5	1	0	all
small	120/190	10mm/ 15mm/sec	HE-HQ 1sec	25cm/std.	I10 - S10	2	0	@S0

Table 11-13 Noise Scan Settings

Data Analysis: Place **ROI** in the center and measure image noise (standard deviation). The spec is 2.7 < Stdv < 3.3 for both axial and helical scans at the above techniques with peristaltic off.

2.2.2.3 Cone Beam Artifact

An example of a cone beam artifact would be shading off a rib into the liver. The greater the cone angle (slice thickness in Z-direction), the more severe the cone beam artifact. Cone beam artifact is typically more pronounced in the images from the two outer rows, where the **POR** is not as accurate as in the inner rows, especially when using thicker slices. Images obtained using thinner slice configurations should improve image quality in terms of cone beam artifact. Helical reconstruction uses all selected row outputs to minimize cone beam artifacts.

2.2.2.4 Clever DAS Gain

A multiple **DAS** gain scheme is used to reduce the low signal image noise. For body bowtie, scan techniques (kV/Collimation/Spot Size) are further divided into different mA ranges based on the

detector collimation. For example, for the technique of 120kV/bbt/4x500/LS we have three different mA ranges:

- 210 - 240 mA (gain 17)
- 250 - 300 mA (gain 21)
- 310 - 440 mA (gain 31).

Artifacts (ring, band and center spot) may be caused by a failure of a **DAS** channel at one of the gains but not all of them (i.e., an image artifact at a certain mA range but not others). Run **DAS** check to identify or exclude **DAS** problems.

140KV/380MA	MA BREAK POINT (MA RANGE)	DAS GAIN	BOWTIE OVR FACTOR AR ISO
4x500	380 (250 - 380)	31	1.19 (lockout @320mA)
4x500	240 (180 - 240)	24	0.97
4x375	380 (250 - 380)	29	0.95
4x375	240 (180 - 240)	18	0.96
4x250	380 (250 - 380)	19	0.96
4x250	240 (180 - 240)	13	0.92
4x125	380 (180 - 380)	10	0.94

Table 11-14 DAS Gains, Body Filter, Large Spot (140kV/380mA)

120KV/440MA	MA BREAK POINT (MA RANGE)	DAS GAIN	BOWTIE OVR FACTOR AR ISO
4x500	440 (310 - 440)	31	0.96
4x500	300 (250 - 300)	21	0.96
4x500	240 (210 - 240)	17	0.94
4x375	440 (310 - 440)	24	0.94
4x375	300 (250 - 300)	16	0.95
4x375	240 (210 - 240)	13	0.97
4x250	440 (310 - 440)	16	0.92
4x250	300 (210 - 300)	11	0.94
4x125	440 (280 - 440)	8	0.96
4x125	270 (210 - 270)	5	0.95

Table 11-15 DAS Gains, Body Filter, Large Spot (120kV/440mA)

100KV/420MA	MA BREAK POINT (MA RANGE)	DAS GAIN	BOWTIE OVR FACTOR AR ISO
4x500	420 (250 - 420)	19	0.95
4x375	420 (250 - 420)	15	0.94
4x250	420 (250 - 420)	10	0.94
4x125	420 (250 - 420)	5	0.93

Table 11-16 DAS Gains, Body Filter, Large Spot (100kV/420mA)

80KV/400MA	MA BREAK POINT (MA RANGE)	DAS GAIN	BOWTIE OVR FACTOR AR ISO
4x500	400 (310 - 400)	9	0.98
4x375	400 (310 - 400)	7	0.96
4x250	400 (310 - 400)	5	0.90
4x125	400 (310 - 400)	3	0.73

Table 11-17 DAS Gains, Body Filter, Large Spot (80kV/400mA)

140KV/170MA	MA BREAK POINT (MA RANGE)	DAS GAIN	BOWTIE OVR FACTOR AR ISO
4x500	170 (130 - 170)	17	0.95
4x500	120 (10 - 120)	13	0.91
4x375	170 (120 - 170)	13	0.97
4x375	110 (10 - 110)	9	0.91
4x250	170 (120 - 170)	9	0.94
4x250	110 (10 - 110)	6	0.91
4x125	170 (10 - 170)	5	0.85

Table 11-18 DAS Gains, Body Filter, Small Spot (140kV/170mA)

120KV/200MA	MA BREAK POINT (MA RANGE)	DAS GAIN	BOWTIE OVR FACTOR AR ISO
4x500	200 (150 - 200)	14	0.98
4x500	140 (90 - 140)	10	0.96
4x500	80 (10 - 80)	6	0.92
4x375	200 (170 - 200)	11	0.96
4x375	160 (100 -160)	9	0.94
4x375	90 (10 - 90)	5	0.96
4x250	200 (170 -200)	8	0.87
4x250	160 (10 - 160)	6	0.93
4x125	200 (10 - 200)	4	0.88

Table 11-19 DAS Gains, Body Filter, Small Spot (120kV/200mA)

100KV/240MA	MA BREAK POINT (MA RANGE)	DAS GAIN	BOWTIE OVR FACTOR AR ISO
4x500	240 (10 - 240)	11	0.92
4x375	240 (10 - 240)	8	0.96
4x250	240 (10 - 240)	6	0.86
4x125	240 (10 - 240)	3	0.85

Table 11-20 DAS Gains, Body Filter, Small Spot (100kV/240mA)

80KV/300MA	MA BREAK POINT (MA RANGE)	DAS GAIN	BOWTIE OVR FACTOR AR ISO
4x500	300 (240 - 300)	7	0.87
4x500	230 (10 - 230)	5	0.94
4x375	300 (10 - 300)	5	0.90
4x250	300 (10 - 300)	4	0.76
4x125	300 (10 - 300)	3	0.48

Table 11-21 DAS Gains, Body Filter, Small Spot (80kV/300mA)

2.2.2.5 Microphonics

Scan phantom at low signal level to test insensitivity of the **DAS**, Detector, and interconnect system to noise generated by vibration sources. Sources of vibration could be gantry rotation, tube rotor, fans pumps, dust in DAS etc.

- Phantom: 48cm Poly phantom
- Data collection:
  1.) Fastcal, 120 kV, Body Bowtie
  2.) Center 48cm poly phantom, and take scans per Table 11-22.

Cal	kV/mA	Slice thickness	Scan mode/time	Recon FOV / alg	Scan plane	# of scans	Tilt	Images analyzed
large	120/200	5mm/4i	Ax/1sec	48cm/std	I1.9 - S1.8	30	0	all

Table 11-22 Microphonics Scan Settings

- Data Analysis: Images should have no visible rings/bands, streak and center artifacts

2.2.2.6 CT Number Uniformity

- Phantom: 5 inch water, GE QA, 35cm Poly and 48 Poly phantoms.
- Data Collection: Perform 1X series scans.
- Data Analysis: Use the “Series Means” button in the “Image Analysis” tool kit to analyze the **CT** number uniformity.

2.3 Artifacts Caused by Collimator Grease

Image Artifacts have been generated and reported on some CT systems due to the contamination of the bowtie and the primary copper filter. This contamination is from the lubricating grease used on the filter positioning drive screw assembly.

The following information may apply in general to all 46-296300G5, 2214768, 2214768-2 and 2214768-3 Collimators.

2.3.1 Inspection Process

The inspection takes less than 5 minutes. It consists of simply examining the Copper primary filter.

2.3.1.1 Required Tool

Bright Flashlight

2.3.1.2 General Inspection Procedure

1.) Remove Mylar Scan Window
2.) Launch Diagnostic Data Collection, DDC, from the Service Desktop.
   a.) Select DIAGNOSTICS.
   b.) Select DIAGNOSTIC DATA COLLECTION.
   c.) Select POSITION TUBE.
   d.) Enter `180` and execute.
   e.) Select STATIC X-RAY OFF.
      i.) `Filter` AIR.
      ii.) `Slice Collimation` ***`Largest Aperture`***, 4 x 5.00 for example.
   f.) Select ACCEPT RX.
3.) Using a flashlight, inspect the primary copper filter by looking down into the collimator output port. See Figure 11-13.

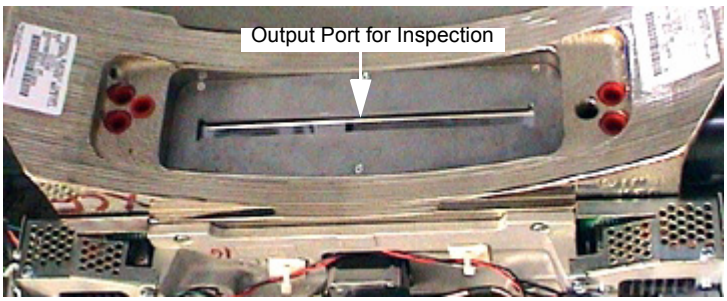


Figure 11-13 Collimator Output Port

Comment: *The copper filter should be clean, dent and scratch free. Discoloration is acceptable.*

Figure 11-14 Extremely Contaminated Copper Filter

If contamination is visible, proceed to Cleaning Process, below.

2.3.2 Cleaning Process

This procedure details the steps necessary to remove the contamination without removing the X-Ray Tube. The entire process will take approximately 3 hours. Tube/Collimator Alignments do not need to be performed. If you wish, you can check the alignments after completing the cleaning process. Any adjustments will require a complete Detailed Phantom Calibration.

Note: If you are at this step during a tube change you must perform a complete Tube Alignment and Detailed Phantom Calibration.

⚠ **NOTICE** **Do not check tube alignments if contamination is present. You will get false results. Perform Tube Alignment checks only after the contamination has been removed.**

2.3.2.1 Required Tools

- 3 mm Hex key for 3/8” drive
- Phillips #0 screwdriver
- Phillips #2 screwdriver
- Vacuum Cleaner or Tape
- Field Torque Wrench Kit 46-268445G1
- ESD Kit 2220482
- Aero Duster Spray 2226685
- Collimator Cleaning Kit 2339299

  Collimator Cleaning Kit contains the following items:
  - Aero Duster Spray System 2335064
  - Alcohol Pads 46-183039P1
  - 91% pure Alcohol 46-183000P164
  - Cleaning Swabs 2339300
  - Loctite 242 10CC 46-170686P2
  - Service Note T-1449 2339305-100

2.3.2.2 Cleaning Procedure Flowchart

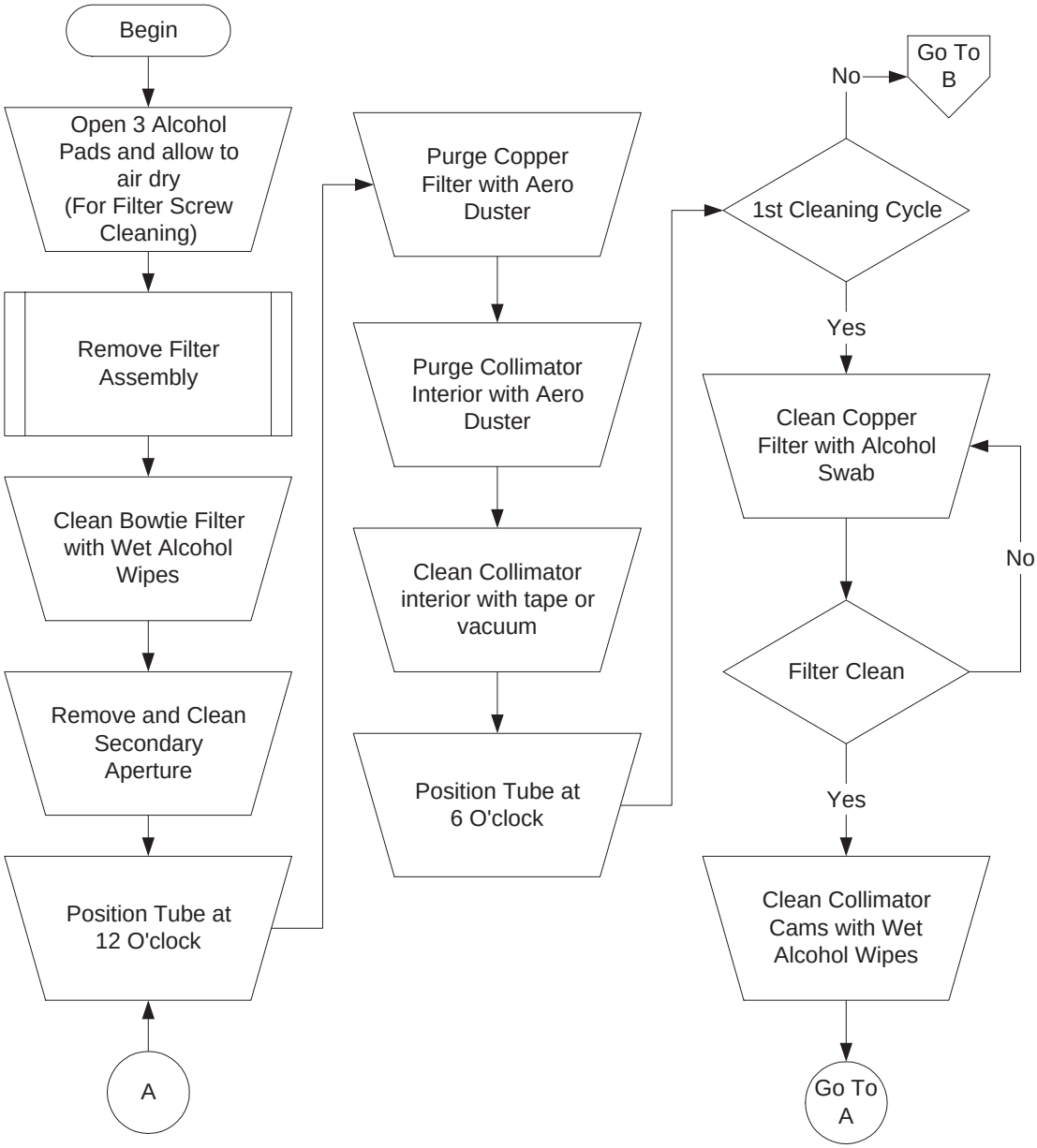


Figure 11-15 Clean Process Flowchart

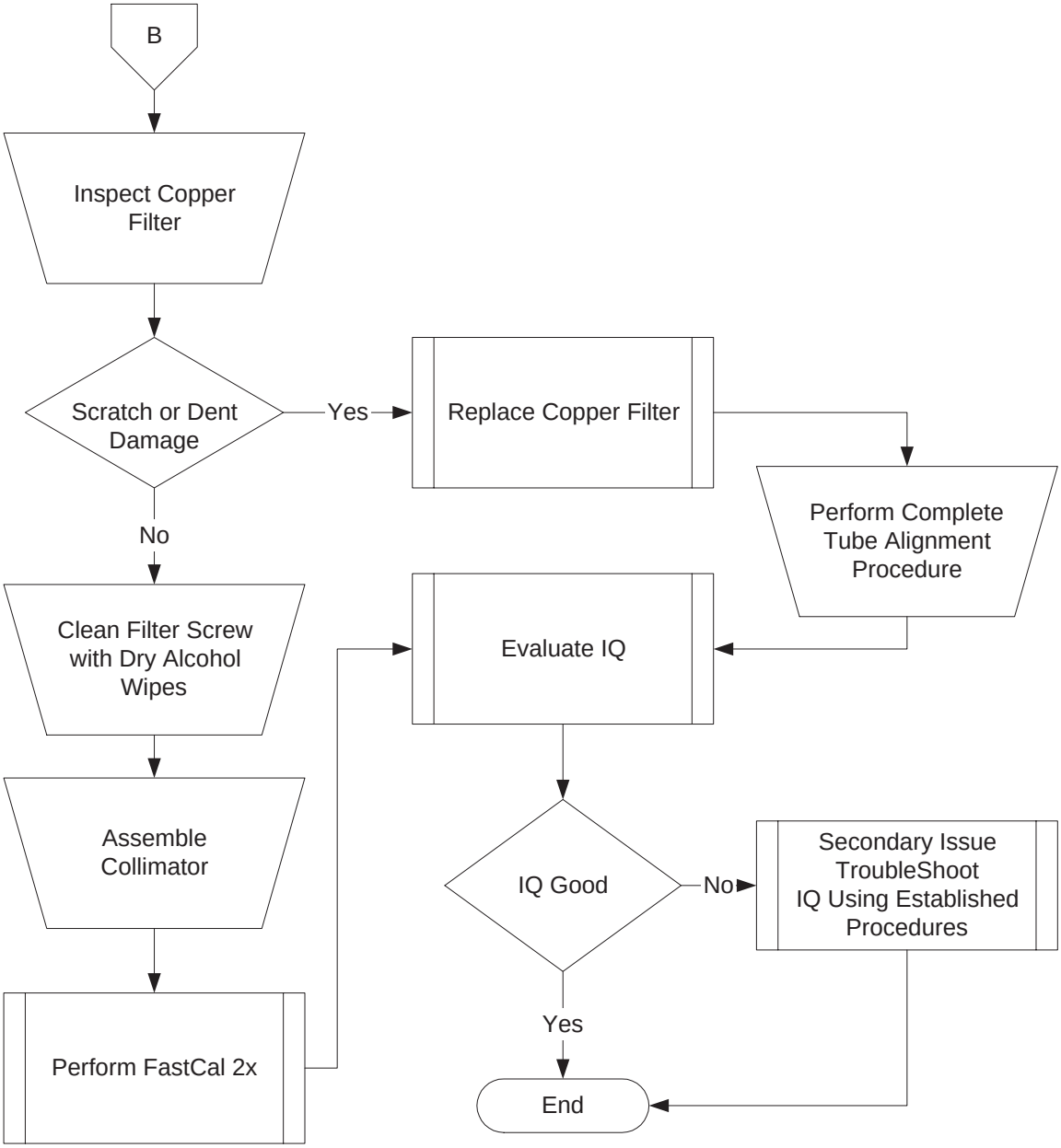


Figure 11-16 Collimator Cleaning Flowchart (continued)

2.3.2.3 Cleaning Procedure Details

1.) Remove the Gantry Covers as needed.

WARNING **RISK OF ELECTRICAL SHOCK. FOLLOW PROPER LOCKOUT/TAGOUT PROCEDURES.**

2.) Perform Gantry Power Lockout/Tagout procedures.

3.) Open three (3) Lint Free Alcohol Pads, unfold and allow to air dry.

4.) Position the gantry with the Collimator at six-o'clock.

5.) Remove Collimator Filter Assembly (see "Filter Assembly," on page 794, for further details).

6.) Clean Bowtie Filter with fresh, wet alcohol pads.
Clean until pads are no longer soiled.

7.) Remove Secondary Aperture and Output Window. See Figure 11-17.
- Take care not to lose the six (6) screws.
- Take care not to damage or nick the lead aperture.

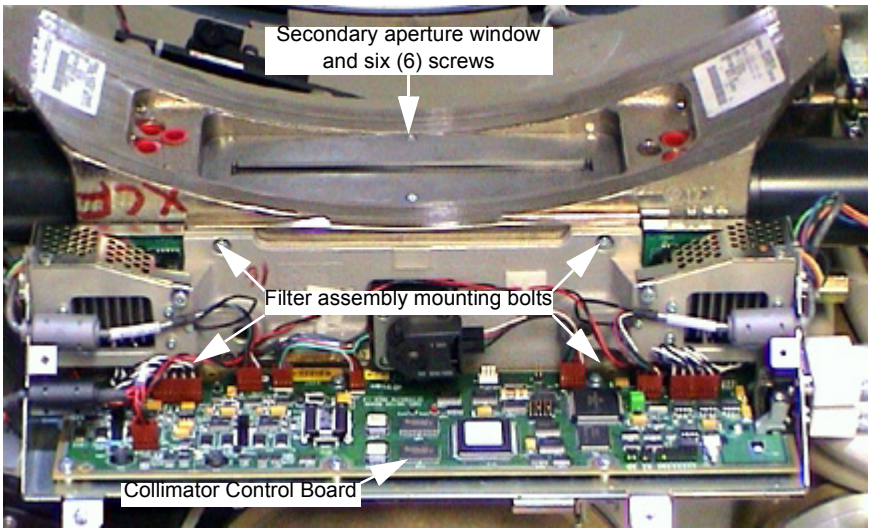


Figure 11-17 Collimator Assembly

a.) Use fresh, wet alcohol pads to clean the window and output port.

b.) Inspect output port and carefully remove any metal or lead that protrudes into the x-ray beam path.

8.) Rotate gantry so collimator is at 6 o'clock. See Figure 11-18.

a.) Using the Aero Duster and nozzle, blow out debris from the Copper Filter chamber.

b.) Using the Aero Duster and nozzle, blow out debris from the Collimator Interior.

c.) Clean collimator interior with vacuum cleaner or tape to remove any attached grease to metal particles.

⚠ **NOTICE Potential equipment damage**

Do not use the metal end of the vacuum hose. This can scratch the collimator cams. Use non-metallic accessories supplied with the vacuum cleaner.

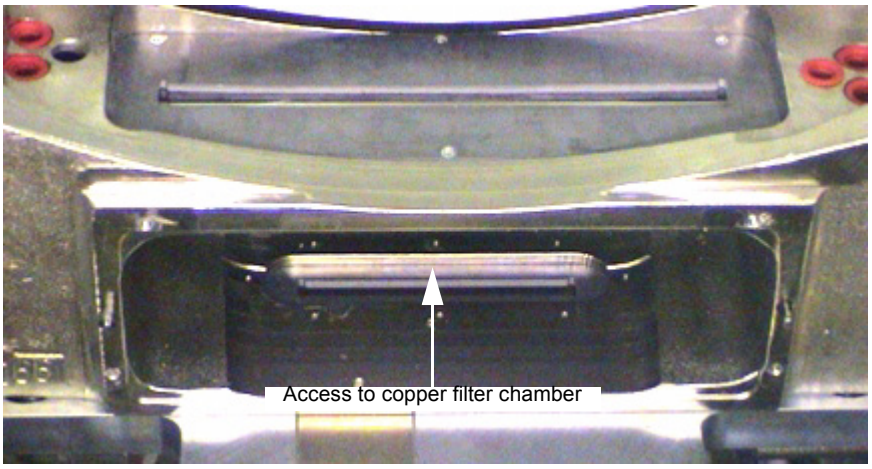


Figure 11-18 Cleaning Collimator Interior

9.) Rotate gantry so collimator is at 12 o'clock and repeat step 8 cleaning.

10.) Rotate gantry so collimator is at 6 o'clock and repeat step 8 cleaning.
This is to ensure all loose particles are removed from Copper Filter Chamber.

11.) Use clean swab, wet with alcohol, to clean the Copper Filter. See Figure 11-19.

a.) Cut swab to 7.5 cm length (3 inches).

b.) Wet lint-free foam head with alcohol. Squeeze excess alcohol from head.

NOTICE Potential equipment damage

Too much alcohol can dissolve glue that secures lead lining in place. This type of damage will result in intermittent artifacts and require collimator replacement.

c.) Carefully insert swab into copper filter chamber, and wipe filter clean.

NOTICE Potential equipment damage

Use extreme to care not dent or scratch the copper filter. Such damage will require replacement of the copper filter, resulting in a complete tube change procedure.

d.) Remove swab and inspect copper filter. Repeat with clean swabs as necessary until clean.

Figure 11-19 Swabs, Pure Alcohol and Alcohol Pads

12.) Using fresh, wet alcohol pads, clean the Collimator Cams.
Rotate the Cams using the motor shaft on each side of the collimator.

NOTICE Potential equipment damage

Use care to not scratch or bend the cams. Do not allow cams to contact each other while rotating by hand. Damage can result in tracking errors or excessive patient dose. This would require collimator replacement.

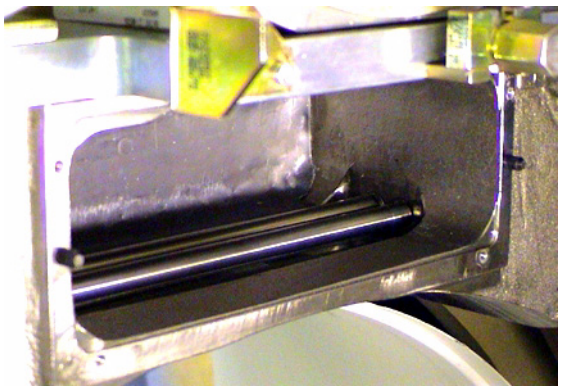


Figure 11-20 Cleaning Collimator Cams

13.) Using the dry lint free alcohol pads from step 3, clean the Bowtie Filter assembly positioning screw. See Figure 11-21.

a.) Remove only excess grease from the drive nut.

* Remove only accumulated grease that may dislodge.
* The grease should lightly coat the screw thread, not fill it.

b.) Position the filter using a flat blade screwdriver.

NOTICE Potential equipment damage

Do not remove filter off of the positioning drive screw.
Do not crush home switch with filter assembly.
Either action will require replacement of the Filter Assembly.

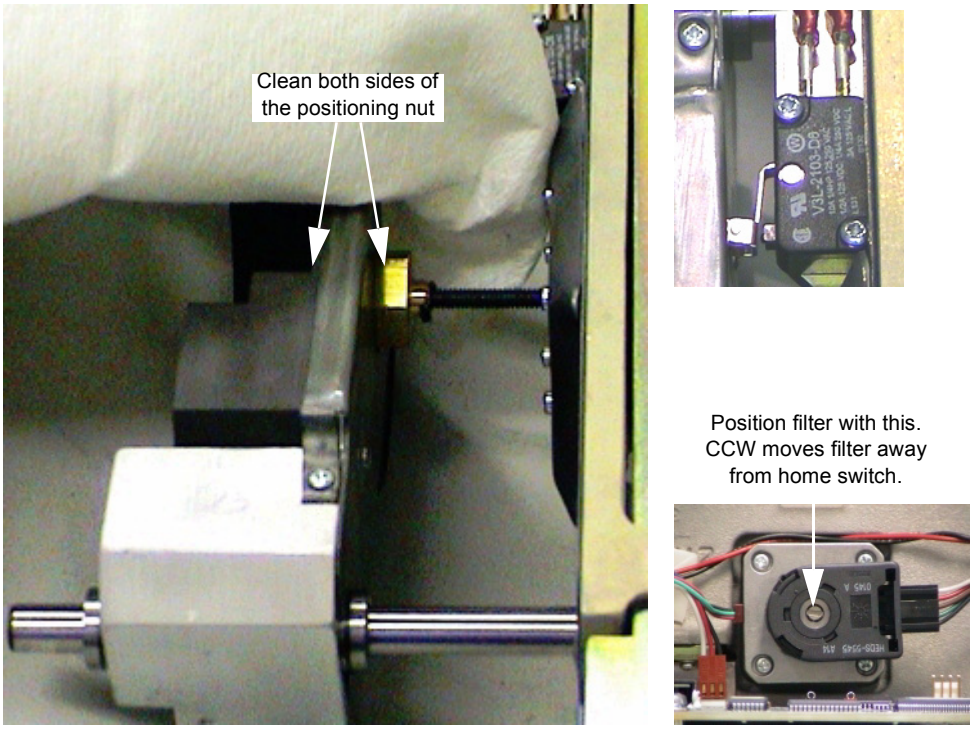


Figure 11-21 Filter Position Screw

14.) Assemble collimator. (Refer to Collimator Filter Assembly replacement procedure, starting on page 794, for details.)

a.) Four (4) Filter Assembly bolts. Torque to 3 ± 0.3 N-m (26.5 lbf-in).

b.) Six (6) Secondary Aperture screws.
Use Loctite 242. Take care not to damage the lead window.

15.) Restore gantry power and perform a hardware reset.

2.3.3 IQ Evaluation

NOTICE **Allow DAS and Detector to warm up for 1 hour.**

1.) Perform Fastcal, twice.
2.) Perform IQ or 1x Image Series, per Section 4.0 of this chapter (beginning on page 917).
3.) Evaluate Image Quality and ensure system meets specifications both numerical and visually. Perform Ct Number Adjustment if necessary.

2.3.4 Additional Information

Image Quality Testing may fail for one or more of the following reasons:

- Tube Alignments were performed with contamination present.
  - Check and adjust tube alignments as necessary.
  - Perform Detailed Phantom Calibrations and CT Number Adjustment.
- Detailed Calibrations were performed with contamination present.

  Reload Phantom Calibrations from Saved State and perform Fastcal twice or perform Detailed Phantom Calibrations and CT Number Adjustment.
- Beam Obstruction may be present on Tube Output Port or chamber between Tube and Copper Filter.

  Remove Tube and Inspect this area for beam obstructions. Clean or replace parts as needed.
- Component failure within the Image Chain in addition to the collimator contamination.

  Troubleshoot accordingly.

Section 3.0
Detector Artifact Specification

3.1 Scope

The purpose of this section is to specify image artifact tolerances and measurement criteria for those artifacts seen in test phantoms that otherwise pass the Image Performance Specification but contain visually objectionable artifacts.

3.2 Constraints

The system must meet all the conditional requirements and applicable performance document requirements, as called out in the Image Performance Specification. Each row of the detector must pass on its own right. Protocols must be consistent so that you do not confuse the rows. Scans should be done in the head first orientation from I to S. This ensures that if images are displayed 4 at a time, row 2a will be in the upper left hand corner, row 1a in upper right, row 1b in lower left, and row 2b in lower right.

3.3 Application

This document applies to those images obtained while performing scans in accordance with the applicable image performance specification. Unless otherwise specified, all artifact criteria contained in this section shall apply to standard algorithm 512x512 image reconstructions.

EXCEPTIONS

The following phantoms are excluded from the artifact requirements, because they are designed to test specific performance parameters, and are not representative of anatomy:

- QA phantom - High contrast resolution bar pattern section.
- QA phantom - Low contrast resolution hole pattern section.

3.4 System Artifacts

3.4.1 Band

DEFINITION

Dark or light circles or arcs concentric with the axis of rotation. Bands are defined as being 3 pixels wide or wider, but may have poorly defined edges. Width is the main distinguishing feature between bands and rings.

SPECIFICATION APPLICATION

Band specs apply to all Standard reconstruction images. They are evaluated by the following:

$$|\overline{X}_b - \overline{X}_r| \leq T$$

where:

$\overline{X}_b$ is the mean value of the band measured as an arc of no less than 3 pixels in width and no less than 51 pixels area,

$\overline{X}_r$ is the mean value of a reference area measured as the mean value of two arcs measured on either side of the band—each arc shall be no less than 51 pixels in area—and

T is the threshold value for the phantom as defined in “threshold values” section.

MEASUREMENT METHOD

The preferred method of measurement is using the "IABAND" program. Measurement is to be performed on the most intense part of the band. The band measurement should be the entire width of the band.

When near the center or edge of an image, one **ROI** value may be used to define $\overline{X}_r$. If this is done, the reference area should be at least 102 pixels. Measurements may be taken at any radius and at any angle.

THRESHOLD VALUES

A band is considered a failure for any value greater than the following over the indicated radius:

PHANTOM	4X500	4X375	4X250	4X125	RADIUS
48/L	8.0	8.0	8.0	8.0	0 - 23.5 cm
35/L	2.5	2.5	2.5	2.5	0 - 14.0 cm
35/L	3.5	3.5	3.5	3.5	14.0 - 15.0 cm
35/L	12	12	12	12	> 15.0 cm
20/S	2.8	n/a	2.8	2.8	0 - 8.5 cm
5/S, 65° Slope, BIS, WEQ/WEQ	2.3	2.3	2.3	2.3	0 - 2.0 cm
5/S, 65° Slope, BIS, WEQ/WEQ	2.6	2.6	2.6	2.6	2.0 - 5.1 cm
Note: When using the IA band program, be sure to ignore the outer reference area if its outside 15.0 cm					

Table 11-23 Threshold Values - Band Specifications

Note: When using the IA band program, be sure to ignore the outer reference area if outside of 15.0 cm.

Addendum: For 35/L, if beyond 15.0cm the band is greater than 3.5 counts, scan 4 slices of the muscle fat phantom at the 35/L technique. The phantom must be off centered such that portions of both the muscle and fat regions will be located at the radius of the band in question. Use an ISD of 1 second (or 5 seconds) so that the start angle will vary by 90 degrees from scan to scan. If there is no banding visible at the same radius as the 35/L banding, the 35/L scans are considered to be passing.

For 20/S, if beyond 8.5cm the band is greater than 2.8 counts, scan 4 slices of 25cm phantom on small cal at the same technique that the 20cm was failing. The band should be less than 4 counts on the 25cm phantom.

ALTERNATIVE MEASUREMENT METHOD

Since all bands are not created equal, this method should be used for unusually wide bands, unusually narrow bands, bands that are surrounded by bands of opposing colors, or other cases where the IA band program will give unpredictable results. It can also be used to pass 48cm, 35cm, and 25cm/L images that fail the IA band program.

An alternative to the IA band program that can be performed in the standard display program and allows extra flexibility for the regions of interest is to define the band area or reference area by depositing cursors (circular to outline the inner and outer boundaries of the area, and line cursors to define the upper and lower (or left and right) boundaries of the area. Circular cursors shall be centered at the center of reconstruction. Line cursors shall cross at the center of the reconstruction

circle. The reference area(s) shall be bounded by the same line cursors as the band area. All other requirements of section 4.1 remain as previously stated.

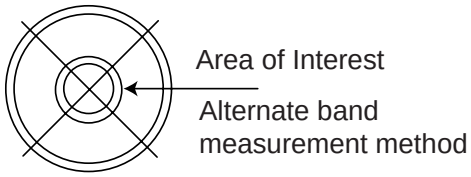


Figure 11-22 Alternative Band Measurement

FAILURE RATE

80% of all slices within a run must meet this specification.

3.4.2 Center Smudge

DEFINITION

Dark or light area of 169 pixels (13 x 13 box) near the center of scan **FOV** having poorly defined edges. The reference area around the smudge is measured by the **ROI** of a 41 x 41 ellipse and does not include the smudge area.

SPECIFICATION APPLICATION

Smudge specs shall apply to Standard reconstruction images as specified in the “threshold values” section. It shall be evaluated by the following:

$$\left|AV\{\bar{X}_s - \bar{X}_r\}\right| \le T_s$$

where:

$\bar{X}_s$ is the mean value of the smudge area,

$\bar{X}_r$ is the mean value of a 41 x 41 ellipse and excludes the smudge area,

$AV\{\}$ is the Average Threshold value for a minimum of 4 slices on a given row, and

T_s is the threshold value.

MEASUREMENT METHOD

Perform the measurement of the smudge area by depositing a centered circular cursor directly over the most intense portion of the smudge, place the crosshair inside the smudge area and do an **ROI**. Perform the measurement of the reference area by depositing a circular cursor positioned such that its center coincides with the center of the smudge area, then placing the crosshair cursor inside the reference but outside of the smudge area, do an **ROI**.

- Smudge cursor size = 13 x 13 ellipse
- Reference cursor size = 41 x 41 ellipse.

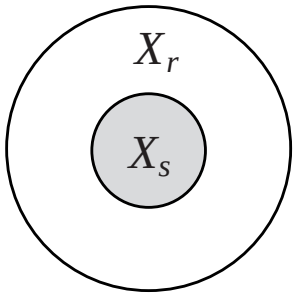


Figure 11-23 Center Smudge Measurement

THRESHOLD VALUES

Smudge specs shall be evaluated using the following threshold values:

PHANTOM	4X500	4X375	4X250	4X125
48/L	14.0	14.0	14.0	14.0
35/L	2.2	2.2	2.2	4.0
20/S	2.2	2.2	2.2	4.0
20/L	3.0	3.0	3.0	4.0
5/S, 65° Slope, BIS, WEQ/WEQ	3.5	3.5	3.5	4.0

Table 11-24 Threshold Values - Smudge Specifications

ALTERNATIVE MEASUREMENT METHOD

Use the Image Analysis smudge program.

3.4.3 Center Artifact

DEFINITION

A sharply defined small area (usually the center 4 pixels) having mean pixel values that differ more than a threshold value (see below) from the reference area. The average of a four pixel box that includes at least one of the four center pixels must be greater than the specified threshold value to be considered a failure.

SPECIFICATION APPLICATION

The average of the 4 center pixels or the average of any four pixel box that includes any of the four center pixels must be more than 3.5 x σ_r (σ_r = the standard deviation) limits to be considered a center artifact. See thresh old values section.

MEASUREMENT METHOD

Reference area shall be a 41 x 41 pixel box at the center of the image. $\bar{X}_r$ is the mean of the box, and σ_r is the standard deviation of the same box. $\bar{X}_a$ is the mean of any 4 pixel box that includes one or more of the center 4 pixels.

THRESHOLD VALUES

Each of the 4 pixel boxes that includes any one or more of the 4 center pixels must have a mean value, AVXr, within the following limits:

	4X5.00	4X3.75	4X2.50	4X1.25	1X1.25	2X0.63
35/L	$\bar{X}_r \pm 3.5\sigma_r$	n/a	$\bar{X}_r \pm 3.5\sigma_r$	$\bar{X}_r \pm 3.5\sigma_r$	$\bar{X}_r \pm 3.5\sigma_r$	$\bar{X}_r \pm 7.0\sigma_r$
20/S & 20/L	$\bar{X}_r \pm 3.5\sigma_r$	n/a	$\bar{X}_r \pm 3.5\sigma_r$	$\bar{X}_r \pm 3.5\sigma_r$	$\bar{X}_r \pm 3.5\sigma_r$	$\bar{X}_r \pm 7.0\sigma_r$

Table 11-25 Threshold Values - Center Artifact

where:

$\bar{X}_r$ is the mean value of the 41 x 41 pixel box and

σ_r is the standard deviation of the 41 x 41 pixel box.

AVXr is the average of Xr of a minimum of 4 images from the same detector row.

This specification does not apply to phantom and cals not noted in the table above.

ALTERNATIVE MEASUREMENT METHOD

Use the Image Analysis center artifact program.

3.4.4 Rings - 48cm Phantoms

DEFINITION

- A dark or light circle or arc approximately 3 or less pixels in width. Rings are typically one pixel wide.
- 48/L images: the ring must be greater than or equal to 30 degrees of ARC and have a minimum diameter of no smaller than 1 cm. The ring must also be repeatable at the same radius and image quadrant.

SPECIFICATION APPLICATION

This specification applies to standard reconstruction 48cm and 42cm phantoms.

MEASUREMENT METHOD

Measure the ring using **ROI** by placing two elliptical arcs surrounding the ring and taking care to include only pixels that are on the ring. The image may be magnified to accommodate this measurement. Next, measure the background mean **CT** number of the non-magnified image by using a 2cm x 2cm box **ROI** directly centered about the ring or partial ring.

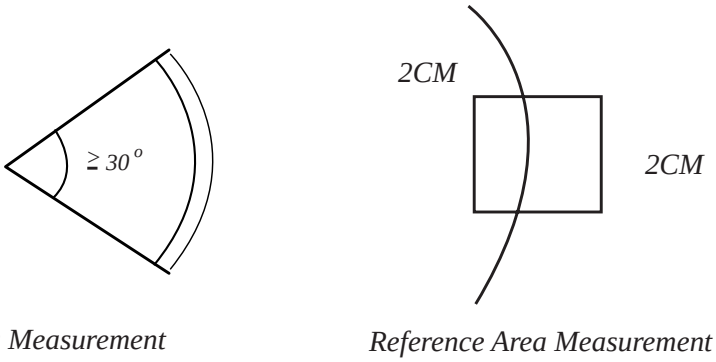


Figure 11-24 Ring Measurement - 48cm and 42cm phantoms

THRESHOLD VALUES

$$|\bar{X}_r - \bar{X}_a| \leq T$$

where:

$\bar{X}_r$ is the mean pixel value of the ring, and

$\bar{X}_a$ is the mean pixel value of a 2cm x 2cm reference area, and

T is the threshold value for failure as shown in the table below.

	4X5.00	4X3.75	4X2.50	4X1.25	1X1.25	2X0.63
48/L	36.0	36.0	n/a	n/a	n/a	n/a
42/L	15.0	15.0	n/a	n/a	n/a	n/a

Table 11-26 Threshold Values Failure Specifications (Part 1)

ALTERNATIVE MEASUREMENT METHOD

Use the Image Analysis ring program, adding 20% to the failure threshold.

FAILURE RATE

80% of all slices within 10 contiguous slices.

3.4.5 Rings - All Other Phantoms

DEFINITION

A dark or light circle or partially closed circle approximately 3 or less pixels in width. Rings are typically one pixel in width.

SPECIFICATION APPLICATION

All images.

MEASUREMENT METHOD

Measure the ring using **ROI** by placing two elliptical arcs surrounding the ring and taking care to include only pixels that are on the ring. The image may be magnified to accommodate this measurement. Next, measure the background mean **CT** number of the normal or magnified image by using a 2cm x 2cm box **ROI** directly centered about the ring or partial ring.

Note:
- For 5" images with tight rings located about the center 4 pixels, magnify the image to fill the whole display screen, then apply the method and criteria described in this section.
- On bone detail images, the ring must be $\geq 180°$ arc.

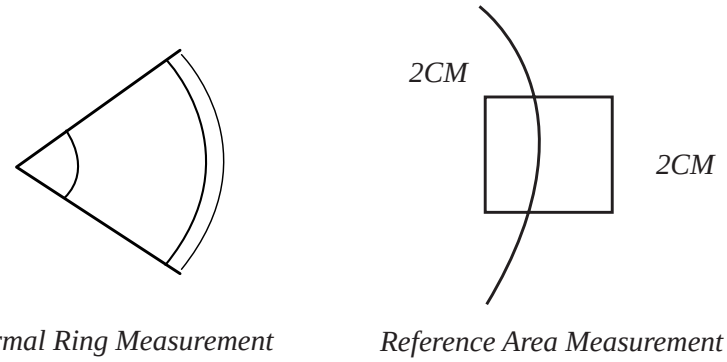


Figure 11-25 Ring Measurement - All other phantoms

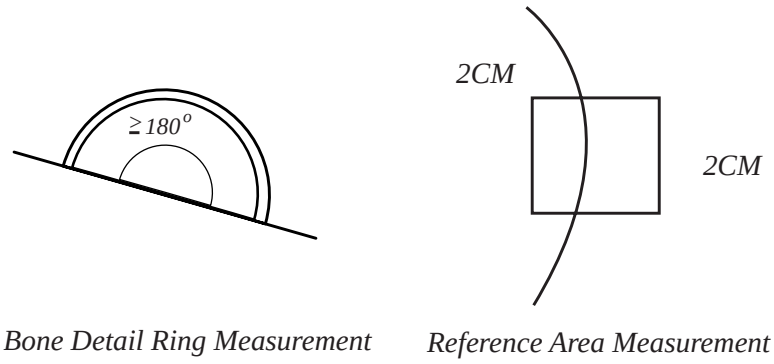


Figure 11-26 Bone Detail Ring Measurement

THRESHOLD VALUES

$$|\overline{X}_r - \overline{X}_a| \leq T$$

where:

$\overline{X}_r$ is the mean pixel value of the ring, and

$\overline{X}_a$ is the mean pixel value of a 2cm x 2cm reference area, and

T is the threshold value for failure as shown in the table below:

PHANTOM	4X5.00	4X3.75	4X2.50	4X1.25	1X1.25	4X1.25
35/L	4.8	4.8	4.8	n/a	n/a	n/a
25/S	4.0	n/a	4.0	4.0	n/a	n/a
20/S	4.8	4.8	4.8	4.8	4.8	9.6
5"/S	4.8	4.8	4.8	4.8	n/a	n/a
65° Slope, BIS, WEQ/WEQ	4.8	4.8	4.8	4.8	n/a	n/a

Table 11-27 Threshold Values Failure Specifications (Part 2)

ALTERNATIVE MEASUREMENT METHOD

Comment: Reference Only

For reference; may not be available.

Use the Image Analysis ring program, adding 20% to the failure threshold.

FAILURE RATE

No greater than one in 250 slices on a given calibration.

3.4.6 Streaks

DEFINITION

Straight dark or light lines across the images, 3 or less pixels in width. Streaks may be any length.

SPECIFICATION APPLICATION

Streak specs apply to all images.

MEASUREMENT METHOD

Outline the streak by depositing a line cursor on either side of the streak, and bound the ends by depositing a cursor on them. Use **ROI** inside the streak area. If necessary, magnify the image to accomplish the measurement.

THRESHOLD VALUES

$$|\overline{X}_s - \overline{X}_r| \leq 4.0 \text{ counts}$$

where:

$\overline{X}_s$ is the mean value of the streak, and

$\overline{X}_r$ is the mean value of a 41 x 41 pixel reference area, and

ALTERNATIVE MEASUREMENT METHOD

Use the Streak program in Image Analysis.

FAILURE RATE

No more than 1 failing streak out of 50 images.

3.4.7 Clump

DEFINITION

Small light or dark areas at the center of the scan **FOV**. These must be 3 or more contiguous failing pixels within the center 9x9 pixels. All 3 of the pixels must be on the positive or negative side of the specification to considered a failure.

SPECIFICATION APPLICATION

This specification applies to all 48/L phantom scans.

MEASUREMENT METHOD

Center a 41 x 41 pixel box and determine the mean and standard deviation. Perform a cursor report on a 9x9 pixel box at the center of the image. Search for three or more contiguous pixels that are outside of the limits.

THRESHOLD VALUES

Each pixel in a 9x9 box at the center of the image must be within the following limits:

	4X5.00	4X3.75	4X2.50	4X1.25
48/L	$\bar{X}_r \pm 3.0\sigma$	$\bar{X}_r \pm 3.0\sigma$	n/a	n/a

Table 11-28 Threshold Values - Clump

where:

$\bar{X}_r$ is the mean value of the 41 x 41 pixel box and

σ_r is the standard deviation of the 41 x 41 pixel box.

ALTERNATIVE MEASUREMENT METHOD

Use the Image Analysis clump program, making sure to use the proper sigma factor.

FAILURE RATE

80% of all slices within a run must meet this specification.

3.4.8 Center Spot

DEFINITION

Dark or light area near the center of the scan **FOV** having no defined edges and consisting of up to 25 pixels.

SPECIFICATION APPLICATION

Phantoms: 5", 65º Slope, BIS, and WEQ/WEQ.

MEASUREMENT METHOD

Measure the reference area with a centered 21 x 21 pixel box. Keeping a 5 x 5 box within a centered and deposited 9x9 box (so that the center pixel is always included), search for the 5x5 box with the largest mean value difference from the reference area.

THRESHOLD VALUES

This specifications applied in two parts as follows:

1.) Center spot - The difference in mean values shall be:

$|\overline{X}_s - \overline{X}_r| \leq 3.2$ for 120Kv/10mm and 5mm scans.

$|\overline{X}_s - \overline{X}_r| \leq 3.5$ for 100Kv, 140kV/10mm and 5mm scans, and 80 kV scans.

2.) Max pixel (for white spots only) - A spot is white if it is greater than the surrounding area by:

For 5mm and 10m

$|\overline{X}_s - \overline{X}_r| > 1.5$ for 120 kVp.

$|\overline{X}_s - \overline{X}_r| \geq 1.8$ for 140 kVp, 100kVp.

If the spot is white, the maximum allowable pixel value within the 5x5 box shall be less than a 4 count difference from the reference area.

For 1mm

$|\overline{X}_s - \overline{X}_r| \geq 2.4$ for 120 kVp.

$|\overline{X}_s - \overline{X}_r| \geq 2.9$ for 100 kV, 140kV.

Max pix value = 6.4

ALTERNATIVE MEASUREMENT METHOD

Use the Image Analysis center spot program.

FAILURE RATE

90% of all slices within a run must meet this specification.

3.5 Clinical Acceptability – Visually Objectionable Artifacts

3.5.1 Artifacts Described within this Document

A system that has a visual artifact described in this document that passes its respective specification shall be considered to be clinically acceptable within the nominal service interval.

3.5.2 Artifacts *Not* Described within this Document

A system that has a visual artifact that does not meet the descriptions of artifacts described in section 4 and determined to be objectionable by Quality Control, shall be brought to the attention of Systems Engineering in order to determine the nature of the artifact. If the system meets the engineering specification and the problem can not be rectified, then Systems Engineering, **CT** Manufacturing, and **CT** Applications will jointly take measure to determine the clinical implications of the artifact.

Section 4.0
1X Image Series Outline

Phantom	kVp	mA	Slice	Time	# rot	# img	CT #	Noise	Unif	MTF	LCD	Ring	Band	Streak	Smudge	Clump	CA
48 Poly	120	340	4x5(4i)	1	4	16	NA	<50	±8.5	NA		*	*	*	*	*	NA
	120	200	4x5(4i)	0.8	4	16	NA	<70	±8.5	NA		*	*	*	*	*	NA
	120	400	4x1.25(4i)	2	4	16	NA	<50	±8.5	NA		*	*	*	*	*	NA
GE	120	440	4x5(2i)	0.8	4	4	NA	NA	NA	*		NA	NA	NA	NA	NA	NA
Perfor	120	130	4x5(2i)	2	4	4	NA	NA	NA	*		NA	NA	NA	NA	NA	NA
	120	40	4x5(2i)	0.8	4	4	NA	NA	NA	*		NA	NA	NA	NA	NA	NA
0.8 sec	120	440	5mm 7.5Q	HE	4	4	NA	NA	NA	*		NA	NA	NA	NA	NA	NA
GE QA	120	260	4x5(2i)	1	4	4	NA	NA	NA	*		NA	NA	NA	NA	NA	NA
	120	260	4x5(2i)	1	4	4	NA	NA	NA	NA	*	NA	NA	NA	NA	NA	NA
	120	260	4x5(2i)	1	4	8	±3.0	<0.3 3	±3.0	NA	NA	*	*	*	*	NA	*
	120	200	4x1.25(4i)	2	4	16	±3.0	NA	±3.0	NA	NA	*	*	*	*		
	120	400	4x5(4i)	2	4	16	±3.0	NA	±3.0	NA	NA	*	*	*	*	NA	*
	120	400	4x1.25(4i)	1	4	16	±3.0	NA	±3.0	NA	NA	*	*	*	*	NA	*
lrg SFOV	120	260	4x5(4i)	1	4	16	±6.0	NA	±4.0	NA	NA	*	*	*	*	NA	*
																NA	*
35 Poly	120	400	4x5(4i)	1	4	16	NA	NA	±4.0	NA	NA	*	*	*	*		
	120	200	4x3.75(4i)	3	4	16	NA	<10	±3.0	NA	NA	*	*	*	*	NA	NA
	140	300	4x2.5(4i)	2	4	16	NA	<10	±3.0	NA	NA	*	*	*	*	NA	NA
	120	300	4x1.25(4i)	2	4	16	NA	<17	±3.0	NA	NA	*	*	*	*	NA	NA
																NA	NA
5”	120	240	4x5 (4i)	2	4	16	±5.0	NA	± 4.0	NA	NA	*	*	*	*		
Water	100	200	4x5(4i)	2	4	16	±5.0	NA	±4.0	NA	NA	*	*	*	*	NA	*
	120	240	4x1.25(4i)	4	4	16	±5.0	NA	±4.0	NA	NA	*	*	*	*	NA	*
	80	170	4x5(4i)	4	4	16	±5.0	NA	±4.0	NA	NA	*	*	*	*	NA	*
	140	120	4x5 (4i)	4	4	16	±5.0	NA	±4.0	NA	NA	*	*	*	*	NA	*
35cm	120	300	4x2.5(4i)	2	4	16	± 5.0	<25	± 3.0	NA	NA	NA	NA	NA	NA	NA	NA

Note: NA - not applicable
* - see following page for detailed specification

Table 11-29 1X Image Series Outline

ARTIFACT	48CM POLY PHANTOM SPECS	GE QA	35CM POLY	5" WATER
Rings	± 36 cts; 5 mm images only	± 4.8 cts	± 4.8 cts	± 4.8
Clump	< 3.0 sigma; 5 mm images only			
Streaks	± 4.0 cts	± 4.0 cts	± 4.0 cts	± 4.0
Bands	± 8.0 cts (0 to 23.5 cm)	± 2.8 cts (0 to 8.5 cm)	2.5 cts (0-14 cm) 3.5 cts (14-15.8 cm)	2.3 cts (0-2 cm) 2.6 cts (2-5.2 cm)
Smudge	± 14 cts;1.25 mm images only.	± 2.2 cts	2.2 cts	± 3.5 cts
Center Artifact		± 3.5 sigma	± 3.5	

Table 11-30 48 cm Poly Phantom Specs

GE PERFORMANCE PHANTOM

- **MTF**
  - Small Spot (< 200mA)
    - Standard Algo.
    - 3.8 lp/cm @ 50% Modulation
    - 6.5 lp/cm @ 10% Modulation
  - Large Spot (> 200mA)
    - Standard Algo.
    - 3.8 lp/cm @ 50% Modulation
    - 6.2 lp/cm @ 10% Modulation
- **MTF**
  - Small Spot (< 200mA)
    - Edge Algo.
    - 8.5 lp/cm @ 50% Modulation
    - 13.0 lp/cm @ 10% Modulation
  - Large Spot (> 200mA)
    - Edge Algo.
    - 7.9 lp/cm @ 50% Modulation
    - 12.1 lp/cm @ 10% Modulation

GE QA PHANTOM

MTF

- Standard Algo.
- **MTF** 0.65 - 1.0
- Contrast Scale 110 to 130

LCD	CONTRAST FACTOR	# OF HOLES VISIBLE
	2.0 to 3.99	at least 2
	4.0 to 7.99	at least 3
	8.0 to 12.0	at least 4

Table 11-31 GE QA Phantom - LCD

5” WATER PHANTOM

Center Spot

- Max Pixel + 4.0 cts 5mm
  6.4 cts 1.25mm
- Center Spot 5mm only ± 3.2 @ 120kV
  ± 3.5 @ 100, and 140kV

Chapter 12
Tube Replacement

Purpose: This chapter covers the replacement procedure for X-ray tubes. See Figure 12-1 for an overview of this process. The sections within this chapter explain this process.

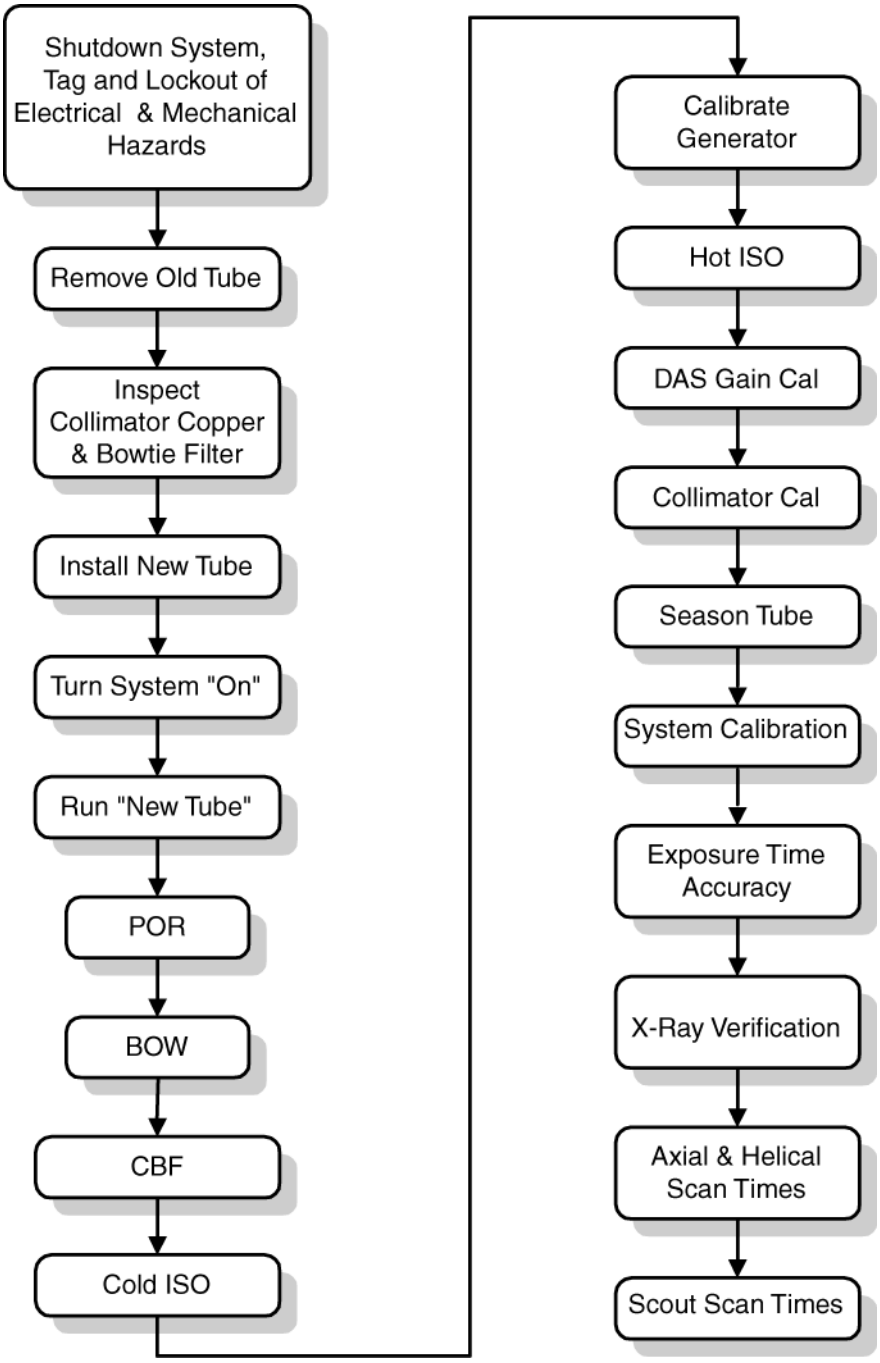


Figure 12-1 Basic Tube Replacement Flow

Section 1.0
Remove Old Tube

Before beginning this procedure, please read the safety information.

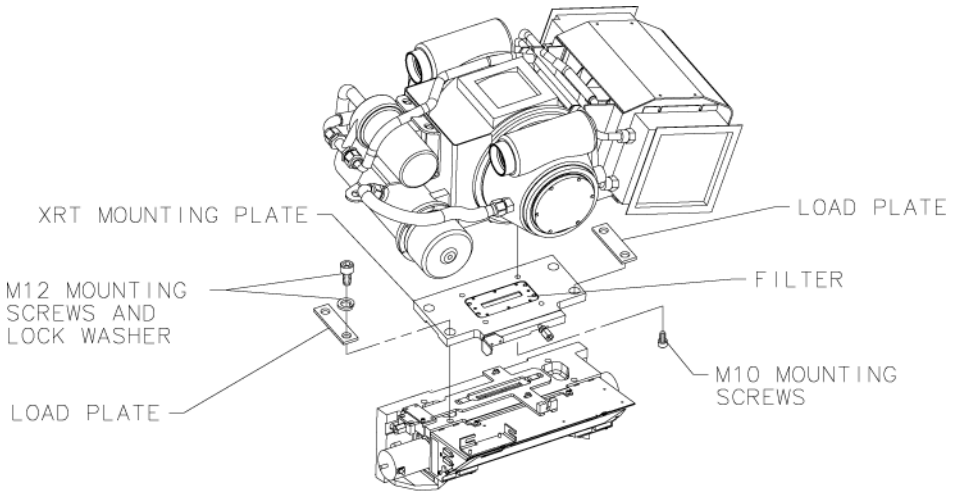


Figure 12-2 Tube Removal Diagram

WARNING **FOLLOW LOCKOUT/TAGOUT PROCEDURES FOR POWER & ROTATIONAL HAZARDS.**

Make sure you engage the locking mechanism before you remove the tube. Failure to lock the gantry could result in injury, should the gantry suddenly move and strike you.

1.) Remove, and set aside, both gantry side covers, top covers, front and rear covers.

2.) Remove the M12 screws from the right front gantry cover mounting bracket, remove and set aside the bracket. See Figure 12-3.

Note: It might be necessary to tilt the gantry back to remove the third bolt, which is not normally installed. Remember to tilt the gantry back to zero degrees.

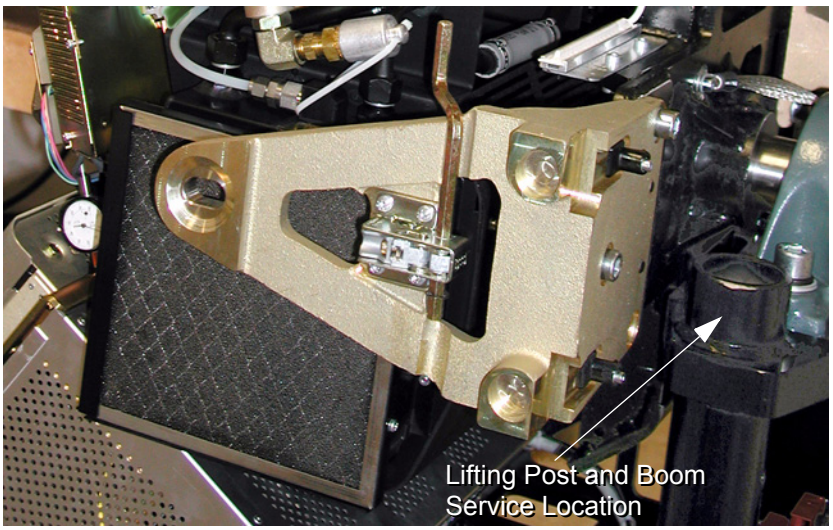


Figure 12-3 Right Front Gantry Cover Mounting Bracket

3.) Turn off facility power to **PDU** and lockout/tagout.

4.) Turn off the **AXIAL DRIVE ENABLE** and **HVDC ENABLE** switches on the **STC** backplane.

Note: It may be easier to loosen the M12 tube mounting bolts with the tube at about the 2 o'clock position before locking the tube at the 3 o'clock position. Simply loosen the tube mounting bolts one half (½) turn. Do not remove the bolts yet.

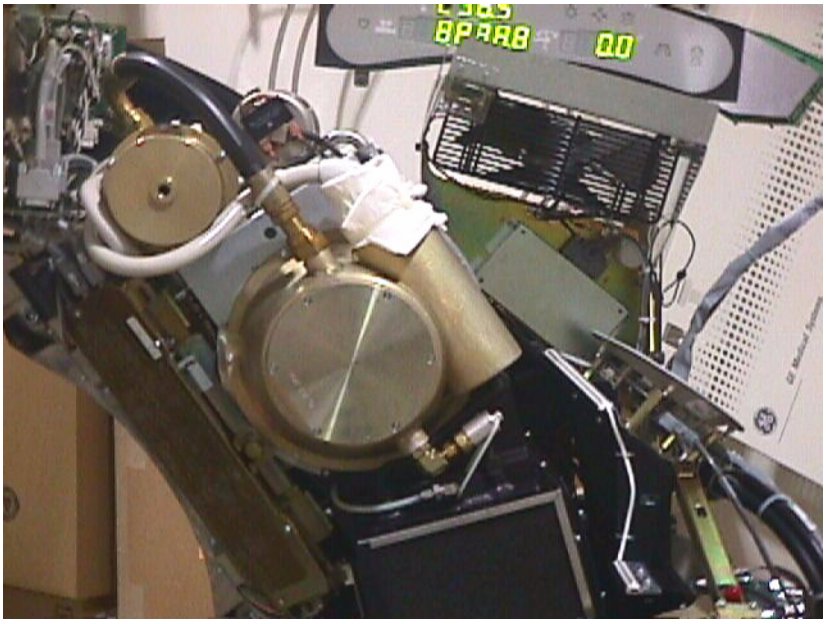


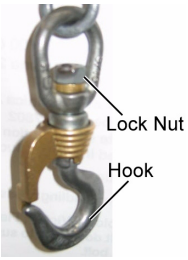
Figure 12-4 Tube Angle to Loosen and Torque M12 Screws

5.) Rotate the Gantry until the failed tube unit reaches the 3 o'clock position.

⚠ **CAUTION** **Make sure the tube is at 90 degrees so the tube hangs at the correct engagement angle for removal and installation.**

6.) Engage rotational lock. Check that the gantry is securely locked by attempting to rotate the gantry by hand.

⚠ **WARNING**



IF THE HOIST IS USED WITH THE LOCK NUT OF THE HOOK LOOSE, THE X-RAY TUBE MIGHT BE DROPPED FROM THE HOIST, WITH THE RESULT THAT A SERVICE PERSONNEL MIGHT BE SERIOUSLY INJURED. CHECK IF THE LOCK NUT OF THE HOOK IS LOOSENED FIRST BEFORE STARTING TO USE THE HOIST. IF LOOSENED, DO NOT USE THE HOIST THEN ORDER THE NEW HOIST.

7.) Insert the lifting post, boom and chain hoist. Reference Figure 12-3.

8.) Disconnect the 12 pin tube I.D. system cable, from the top of the tube unit.

9.) Disconnect the 4 pin mate-n-lock pump and fan power system cable

10.) Disconnect the ground strap from the top of the tube unit

11.) Remove the anode and the cathode cable:

- Carefully cut ty-raps securing **HV** cables. Note **HV** cable routing.
- Loosen each cable's locking ring with the spanner wrench.
- Pull each cable terminal out of its receptacle.
- Ground the end of the cables to the Gantry frame.

- Wipe up any oil that drips from the cable terminal.
- Use paper towels to soak up any oil in the wells.

CAUTION **Remove the mounting bars in the following (lower/upper) order to lessen the risk of injury to your hand. Keep one hand under the bolt and pressure plate while unfastening it. This is to prevent them from falling into the fan that is attached to the tube.**

Note: It may be easier to tape the socket to the extension. This will prevent the socket from being dislodged on the tube radiator assembly

12.) The XRT is attached to the Collimator with a Tube Mount Bracket Assembly (P/N 2128696). Remove the mounting plate & XRT from the Collimator by removing the four M12 (P/N 46-328416P24) cap screws and lock washers, and two load plates (P/N 2120104), with a hex socket driver. With your hand, reach behind the radiator to the screws from either side of the XRT center section while removing the bolts with two 12-inch extensions (24 inch length) on a ratchet. **Throw these M12 bolts and washers away, as they should not be reused.**

13.) Carefully swing the tube clear of the gantry.

Note: Be careful not to damage the fragile copper filter or lead shield in the mounting plate for the next step.

NOTICE Potential for IQ artifacts **When removing the mounting plate from the tube, be careful with the Copper Filter. It should be free of debris, scratches and dust. Particles create artifacts in the image by affecting the attenuation properties of the copper filter.**

14.) Remove the mounting plate by removing the four M10 (P/N 46-328416P20) hex head screws. **Throw these bolts and washers away, as they should not be reused.**

15.) **Inspect the copper filter**. The primary copper filter is easily examined, since the primary copper filter assembly is removed with the tube. The copper filter should be clean, dent and scratch free:

- If contamination is visible (see Figure 12-5), clean or replace the copper filter.
- If scratches or dust are visible, the copper filter must be replaced.
- Discoloration is acceptable.

Figure 12-5 Extremely Contaminated Copper Filter

16.) **Inspect the Bowtie Filter**. It is possible that the Bowtie Filter is contaminated and the Primary Copper Filter is not contaminated.

Note: Perform this inspection before installing the new tube unit. Also look at the tube side of the copper filter when you are swapping the interposer plate. Remove any debris found before installing the interposer plate on the new tube unit.

The following tools are required for this inspection procedure:

- Phillips #2 Screwdriver
- Flat blade Screwdriver
- Bright Flashlight

Inspect the Bowtie Filter as follows:

a.) Remove the Collimator Control Board Sheet Metal Cover. See Figure 12-6.

Figure 12-6 Collimator Control Board Cover

WARNING

DO NOT ATTEMPT TO MOVE THE FILTER WITH POWER ON.

b.) With power removed from the gantry, use a flat blade screwdriver and position the bowtie filter assembly so it is visible through the input port or tube side of the collimator assembly.

* CCW will move the filter into the beam. See Figure 12-7.
* Do not move the filter back to the home position.

NOTICE
Potential for equipment damage

Do not force the filter if it feels stuck. Damage to the limit switch can result.

Do not move the filter more than necessary for inspection. The filter can fall off the drive screw.

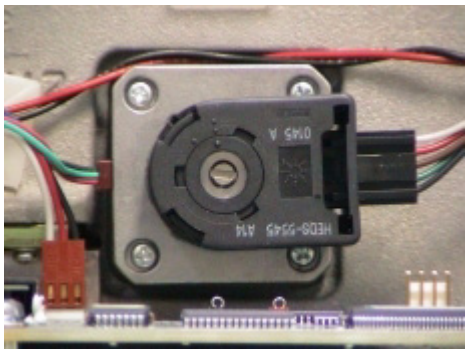


Figure 12-7 Filter Position Adjuster

c.) Using a flashlight, inspect the bowtie filter for contamination.
Look through the input port or tube side of the collimator.
If contamination is visible, clean or replace the filter assembly.

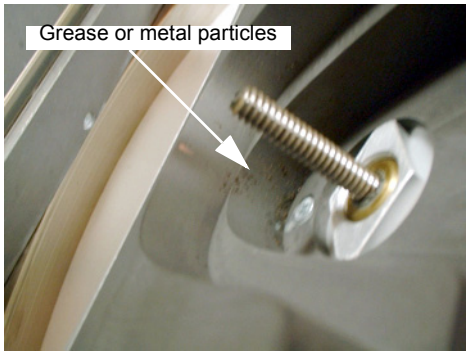


Figure 12-8 Contaminated Bowtie Filter

Section 2.0
Install New Tube

WARNING **SEVERE INJURY POSSIBLE.**
TUBE CAN SEPARATE FROM GANTRY, IF NOT TORQUED CORRECTLY.
ALWAYS USE PROPER TORQUE ON ALL FASTENERS.

WARNING **FOLLOW LOCKOUT/TAGOUT PROCEDURES FOR POWER & ROTATIONAL HAZARDS.**

1.) Allow the tube unit to warm to room temperature before you install it.

NOTICE
Potential for IQ artifacts

When attaching the mounting plate on the tube, be careful with the Copper Filter. It should be free of debris, scratches and dust. Particles affect the attenuation properties of the copper filter, resulting in artifacts in the image.

2.) Attach the mounting plate from the old tube using new M10 x 25mm bolts provided with the tube. **Do NOT use Loctite**.
- Finger tighten all four (4) bolts
- Torque all four (4) bolts to the following specification:

15 ft-lbs	**20 N-m**	**180 in-lbs**	**210 kg-cm**

This seats each bolt, enabling you to visually ensure that the mounting holes are not stripped while applying final torque.

WARNING **SEVERE INJURY POSSIBLE.**
IF YOU TURN THE TORQUE WRENCH MORE THAN 90º (¼ TURN) WHILE APPLYING FINAL TORQUE, THE MOUNTING THREADS ARE STRIPPED.
DO NOT USE THIS TUBE.

Apply final torque on all four bolts:

30 ft-lbs	**41 N-m**	**360 in-lbs**	**420 kg-cm**

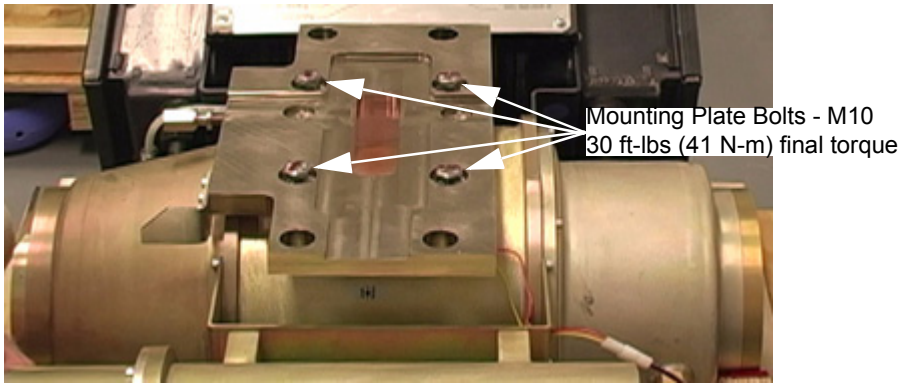


Figure 9 - Tube and Mounting Plate

CAUTION
Potential for IQ artifacts

When attaching the mounting plate on the tube, be careful with the Copper Filter. It should be free of debris, scratches and dust. Particles create artifacts in the image. Use a lint free wipe to clean, if needed.

3.) Re-check facility power and make sure it is off.

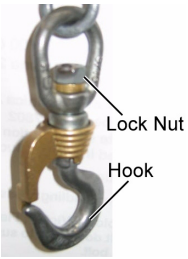
WARNING

SEVERE INJURY TO PATIENT COULD OCCUR.

USING THE WRONG BOLTS COULD PLACE STRESS ON BOLTS, CAUSING TUBE TO SEPARATE FROM GANTRY.

USE PROPER BOLTS.

WARNING



IF THE HOIST IS USED WITH THE LOCK NUT OF THE HOOK LOOSE, THE X-RAY TUBE MIGHT BE DROPPED FROM THE HOIST, WITH THE RESULT THAT A SERVICE PERSONNEL MIGHT BE SERIOUSLY INJURED. CHECK IF THE LOCK NUT OF THE HOOK IS LOOSENED FIRST BEFORE STARTING TO USE THE HOIST. IF LOOSENED, DO NOT USE THE HOIST THEN ORDER THE NEW HOIST.

4.) Use the hoist to lift the new tube unit:

a.) Position the tube on the gantry: The “crosses” on the mounting plate and on the collimator should fit in perfectly when the tube is aligned properly.

Note:

* To ease installation, fasten the top pressure plate to the rotating structure first. Then attach the bottom pressure plate.
* Use new bolts and washers from tube crate. Make sure to select the proper bolts. There are instructions in the crate, and on the tube itself.

b.) Fasten the lower and upper and pressure plates to the rotating structure with the M12 (50 mm) bolts, and torque to

49 ft.-lbs	**66 N-m**	**590 in-lbs**	**680 kg-cm**

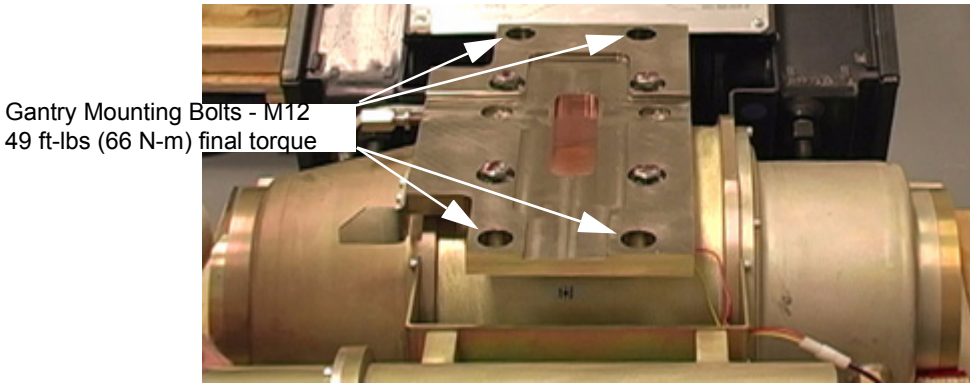


Figure 10 - Tube and Mounting Plate

5.) Attach the tube I.D. cable to the 12 pin mate–N–Lock connector on top of the tube.
6.) Attach the tube pump and fan power cable to the 4 pin mate–N–Lock connector.
7.) Fasten the grounding strap to the 1/4–20 ground stud on top of the tube unit.
8.) Remove the plastic cap plug from each cable receptacle on the tube unit.

Note: Take care not to lose the rubber quad rings for the High Voltage cables.

9.) Lightly wet the new rubber quad ring with transformer oil (917).
10.) Return the quad ring to its slot at the top of the receptacle retaining ring.
11.) Pour transformer oil (917) into the receptacle to a depth of 10 mm (0.375 in).

NOTICE **Incorrectly routed or secured HV cables will result in damage to the HV cables and/or other parts of the gantry.**

12.) Be sure to route the **HV** cable as shown in Figure 12-11.

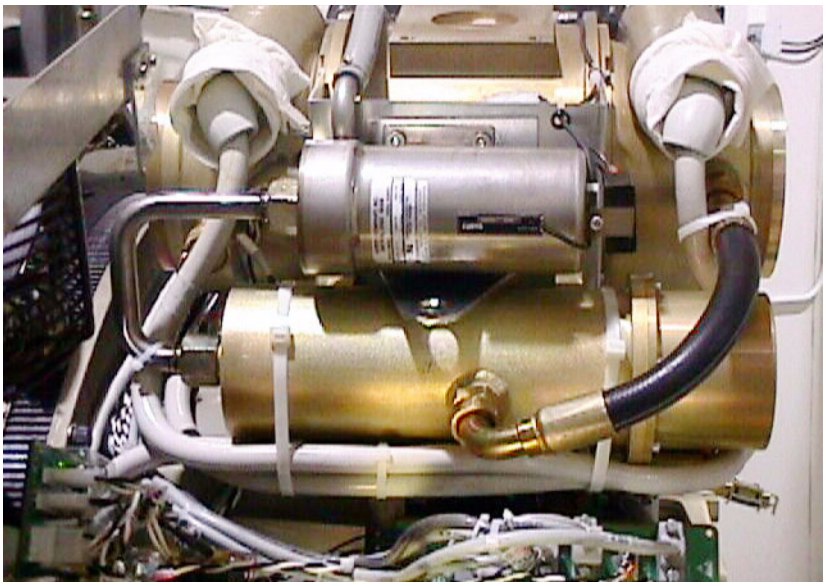


Figure 12-11 HV Cables Properly Routed and Secured

13.) Align the cable terminal orienting key with the notch in the receptacle.
14.) Slowly insert the cable, to engage the connector pins, and seat the cable in the well.
- Tighten the cable locking ring.
- Rotate the cable strain relief for a clean cable dress.

NOTICE **Do not over tighten the locking ring. Over tightening can deform the cable plug sealing surfaces, break the oil seal between receptacle and housing, twist the receptacle, and disrupt internal wiring.**

- Use the spanner wrench to tighten the locking ring until oil does not leak, when gantry rotates.

Note: Use the spanner wrench with a torque wrench when you tighten the high–voltage cables on the tube unit.

CAUTION **IF YOU GET OIL ON YOUR HANDS, WASH THEM NOW**

15.) Carefully wipe up all excess oil.
16.) Secure **HV** Cables using Large Ty-Raps, as shown in Figure 12-11.
17.) Disconnect hoist from tube and boom.
18.) Remove the post and boom from the gantry. Reference Figure 12-3, on page 920.
19.) Check for oil leaks:
- Wrap rags or paper towels around the cable horns, and tape them into place.
- Manually rotate the tube to the 6 o'clock position.
- Return the tube to the 3 o'clock position
- Remove the toweling and wipe up all excess oil.
- Wipe off the cable horns, locking rings and strain reliefs with an alcohol-dampened rag.
- Repeat with a dry rag.
- Wrap the cable strain reliefs and locking rings with a single layer of absorbent paper tissue. You can use two inch wide strips cut from a paper napkin.
- Wrap the bottom edge of the paper around the top end of the cable horn, and tape it in place.
- Extend the top edge of the paper over the top of the locking ring, and tape it to the plastic cable strain relief.
- Remove paper after leak check.

20.) Install the right gantry front cover bracket. Reference Figure 12-3, on page 920.
21.) Restore system power at the main disconnect panel.
22.) Turn on gantry **120 VAC**, **HVDC POWER** and **AXIAL DRIVE ENABLE** at the **STC** backplane. Wait at least 10 minutes to warm up the filament.
23.) After restart of software, begin entering the new tube information.
24.) Select SERVICE DESKTOP.
25.) Select CALIBRATION.
26.) Select GENERATOR CALIBRATION.
27.) Select INSTALL NEW TUBE.
28.) Verify tube types match before proceeding.

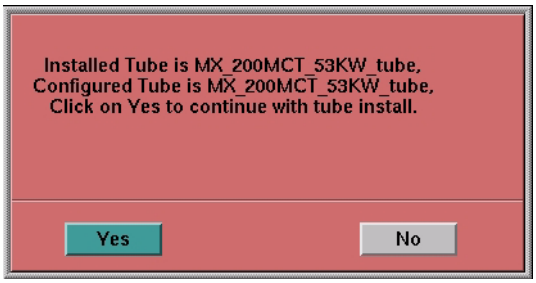


Figure 12-12 Install New Tube Configuration Check

Section 3.0
Plane of Rotation (POR)

3.1 Overview

The purpose of Plane of Rotation measurement/alignment is to put the X-ray tube in the correct physical relationship to the detector and verify it. This is normally only necessary when the X-ray tube has been replaced or moved.

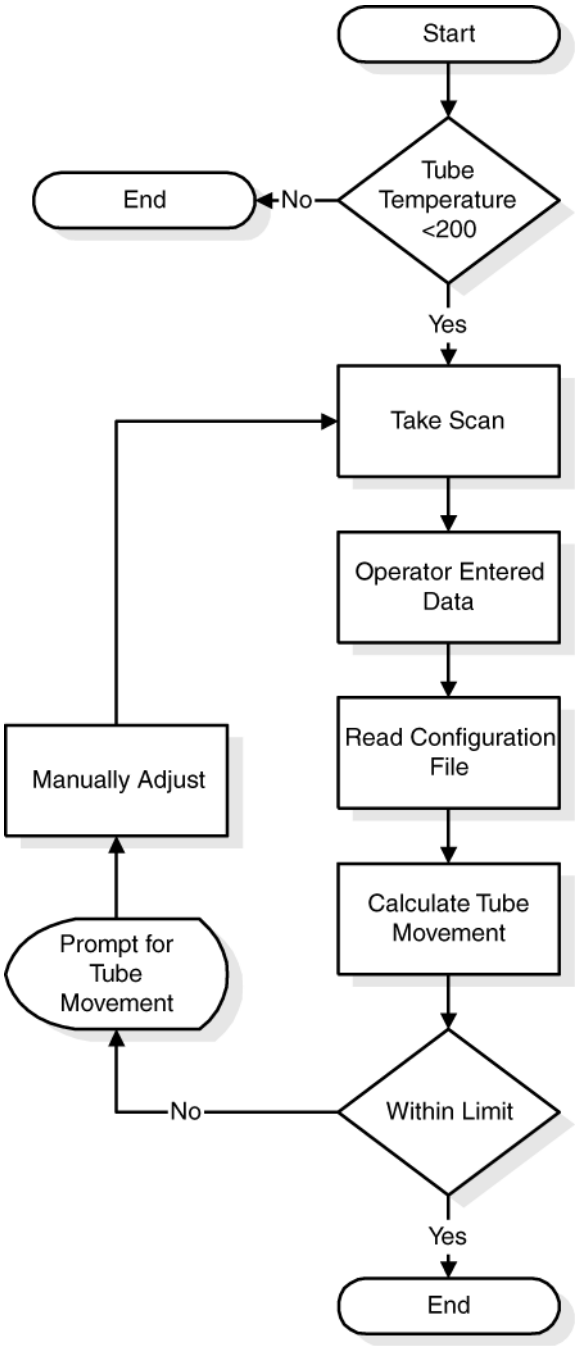


Figure 12-13 POR Procedural Flow

3.2 Tools Required

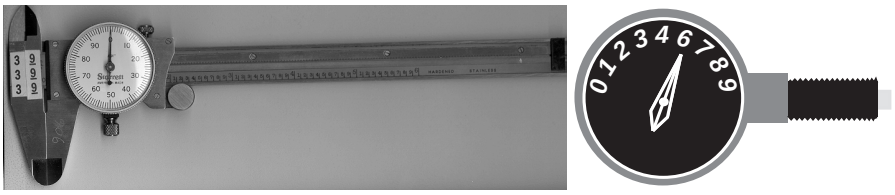


Figure 12-14 Vernier Caliper & Dial Gauge Indicator

- Calibrated Vernier Caliper (millimeters or inches)
- Dial gauge Indicator (millimeters or inches)
- Type 52 Polaroid Film (see Figure 12-17, on page 931)
- Type 52 Polaroid Film Developer

3.3 Procedure

3.3.1 Verify Tube Temperature < 200º C

1.) Click DAILY PREP
2.) Click TUBE WARM-UP
3.) Click ACCEPT in pop-up window
4.) Click PAUSE
5.) Click CANCEL (Do not QUIT Daily Prep)

NOTICE **Do not start X-ray exposures. Starting tube warm-up will result in additional tube cooling wait times.**

6.) Open system error log (`gesys_suite.log`)
7.) Click LAST PAGE

Look for this type of entry:

This entry is created when Pause is clicked.

```
bay57   dailyPrepRx
StateMachineEventNotify.c   418
Tube temperature before Cold Tube Warmup is 315.15 degrees Celsius.
```

This entry is created when Cancel is clicked.

```
bay57   dailyPrepRx
StateMachineEventNotify.c   411
Tube temperature after Cold Tube Warmup is 312.89 degrees Celsius.
```

Start Tube Alignments when 200.00 degrees Celsius is reported.

```
bay57   dailyPrepRx
StateMachineEventNotify.c   418
Tube temperature before Cold Tube Warmup is 200.00 degrees Celsius.
```

8.) Repeat steps 3 through 5 as necessary to generate updates in the `gesyslog`.
9.) Click QUIT to exit Daily Prep, when tube temperature shows 200.00 Celsius.

3.3.2 For Tube Change Only

Wait 90 minutes if the new tube had more than 25 Kilo Joules of energy input, [KV x mA x Sec ÷ 1000] within the last 30 minutes prior to the start of system alignments.

Note: If a tube heat soak has been performed you must wait a minimum of 6 hours before system alignments can be performed.

3.3.3 Start the POR Software

Note: Make sure the tube is cold before alignments.

1.) Select SERVICE DESKTOP.
2.) Select CALIBRATION.
3.) Select POR ALIGNMENT

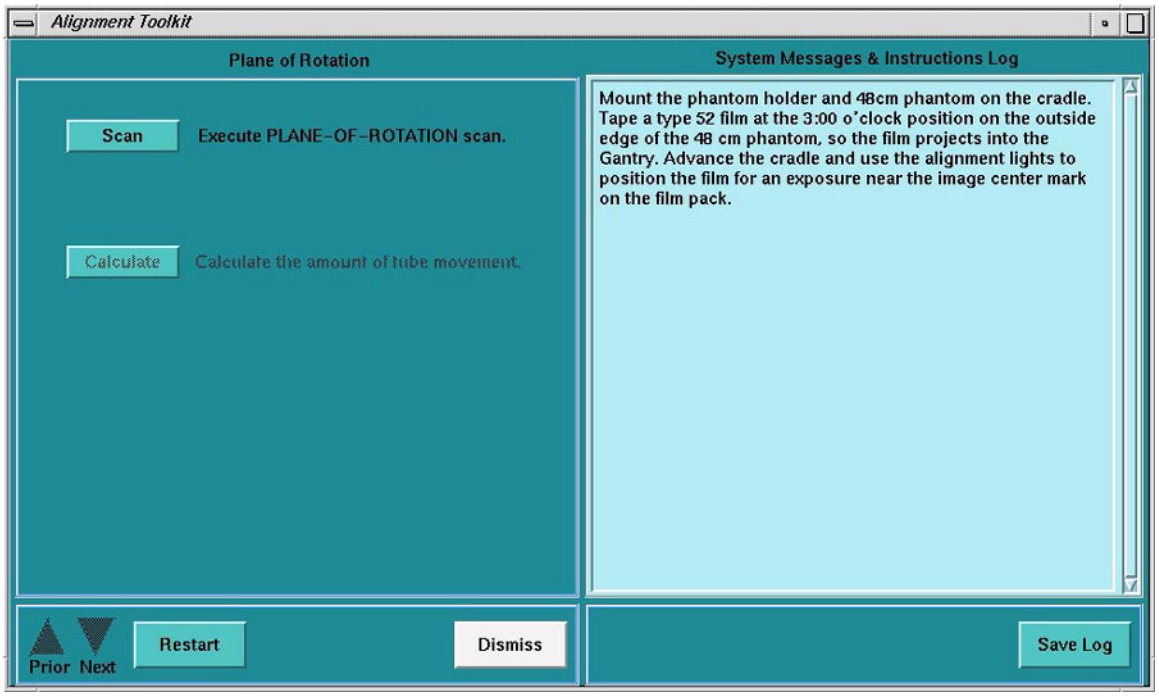


Figure 12-15 Plane Of Rotation Alignment Screen

3.3.4 Measure Tube Alignment

1.) Mount the Dial Indicator onto the Collimator / Tube Assembly as shown Figure 12-16. *Make sure you zero the dial indicator, when it is securely in place*.

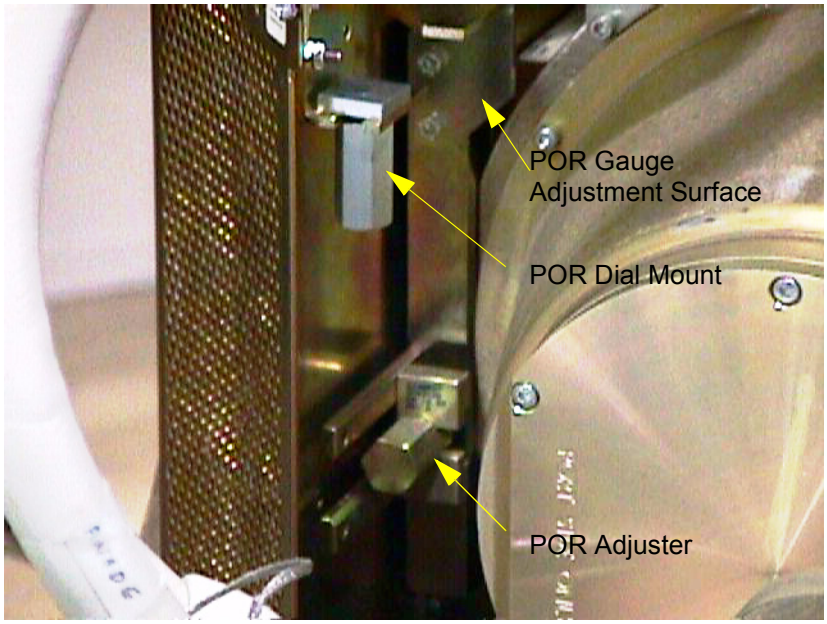


Figure 12-16 POR Gauge Mount and Adjuster.

2.) Loosen the (4) M-12 bolts that secure the tube. (½ turn out - and no more - is all that's necessary.)

3.) Get the system's phantom holder and its 48cm phantom onto it.

4.) Attach (1) "*Polaroid type 52*" film on the outside edge of the 48cm phantom, at the 3 o'clock position.

Note: Only the film should be projecting into the Gantry bore when complete. The phantom is used only to position and hold the film in the gantry bore, Figure 12-19.

Orient the side of the film side marked "**This side toward lens"** towards iso center, see Figure 12-17. When exposed and developed later, the film will show the alignment of the x-ray beam with respect to the table, as viewed from the X-Ray tube in the 3 o'clock position.

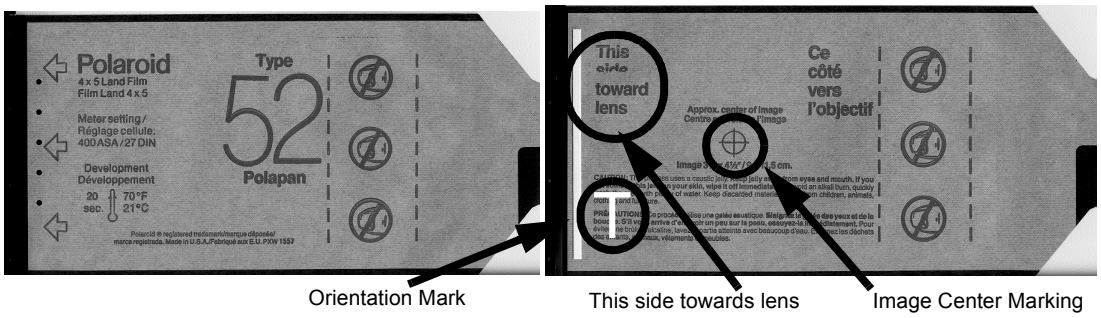


Figure 12-17 Polaroid Film, Type 52

5.) Advance the cradle and rotate the phantom if necessary, while using the alignment lights, to position the film's center marking on the alignment light marks.

6.) Take a scan.

7.) Remove the exposed film and immediately mark the outside of the film nearest the table. For example, use a pen and print the letter "T" on the film nearest the table, Figure 12-17. Go and develop the exposed film. After the film is developed, transfer the table marking to the film itself while keeping the orientation correct, Figure 12-19.

8.) Verify that:

- The film's narrow (white beam) slit lies within (between) the wider (gray) X-Ray slit.
- The film's edges in both Z direction are equally well defined by the exit slit of the collimator. The edges of the narrow beam should be much sharper than the wide beam. If a difference in edge definition exists, check for gross Z misalignment. (*Mis-alignment of the slit in the tube's collimator adapter is a common cause of fuzzy film edges.*)

9.) Refer to Figures 12-18 and 12-19 during the following instructions. Use a Vernier Calipers to measure the width of the 2 wider (dark gray) slits. They're the dark gray slits that extend past the edges of the narrower (off-white) slit and to the blackest part of the film.

a.) Take 3 measurements to obtain an average value for X_F. X_f is the side of the film closest to the table. Using the same film measurement tool, take (1) X_f measurement at the top of the film, another near the middle and another near the bottom. Add these (3) X_f distances together and divide this sum by 3 or "n". *Where,*

$$X_F = (X_{f1} + X_{f2} + X_{f3})/(n)$$

Note: It is important that you take multiple measurements. The more measurements you take, the more accurate the measurement. There is less likelihood of a measurement error and you will increase the accuracy of the alignment.

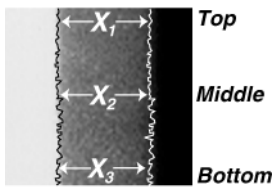


Figure 12-18 XF and XR measurement points

b.) Now take 3 measurements to obtain an average value for X_R. Take (1) X_R measurement at the top of the film, another near the middle and another near the bottom of the film. Add these 3 values together and divide the sum by 3 to obtain an average for X_R.

$$X_R = (X_{r1} + X_{r2} + X_{r3})/(n)$$

c.) Use the values obtained for X_F (front distance) and X_R (rear distance) in the calculation that follows.

10.) Click on the **CALCULATE** button, Figure 12-15, on page 930. Enter the values for X_F and X_R obtained in the steps above. The software will do the distance calculation.

The specification limits are 0.059 - 0.082 inches or 1.50 - 2.083 millimeters.

11.) Check the results.

- If the tube is out of specification, move the tube as indicated by the program. If adjustment is necessary, clockwise rotation (in) of adjustment bolt moves the tube towards the table side. Repeat Steps 3 through 11 again if you have moved the tube, to check accuracy of adjustment. See Figure 12-19 for more details.
- If the tube is within specification, tighten the four (4) M-12 Bolts bolts on the tube and torque them to 49 ft-lbs (66.4 Nm) and you're done.

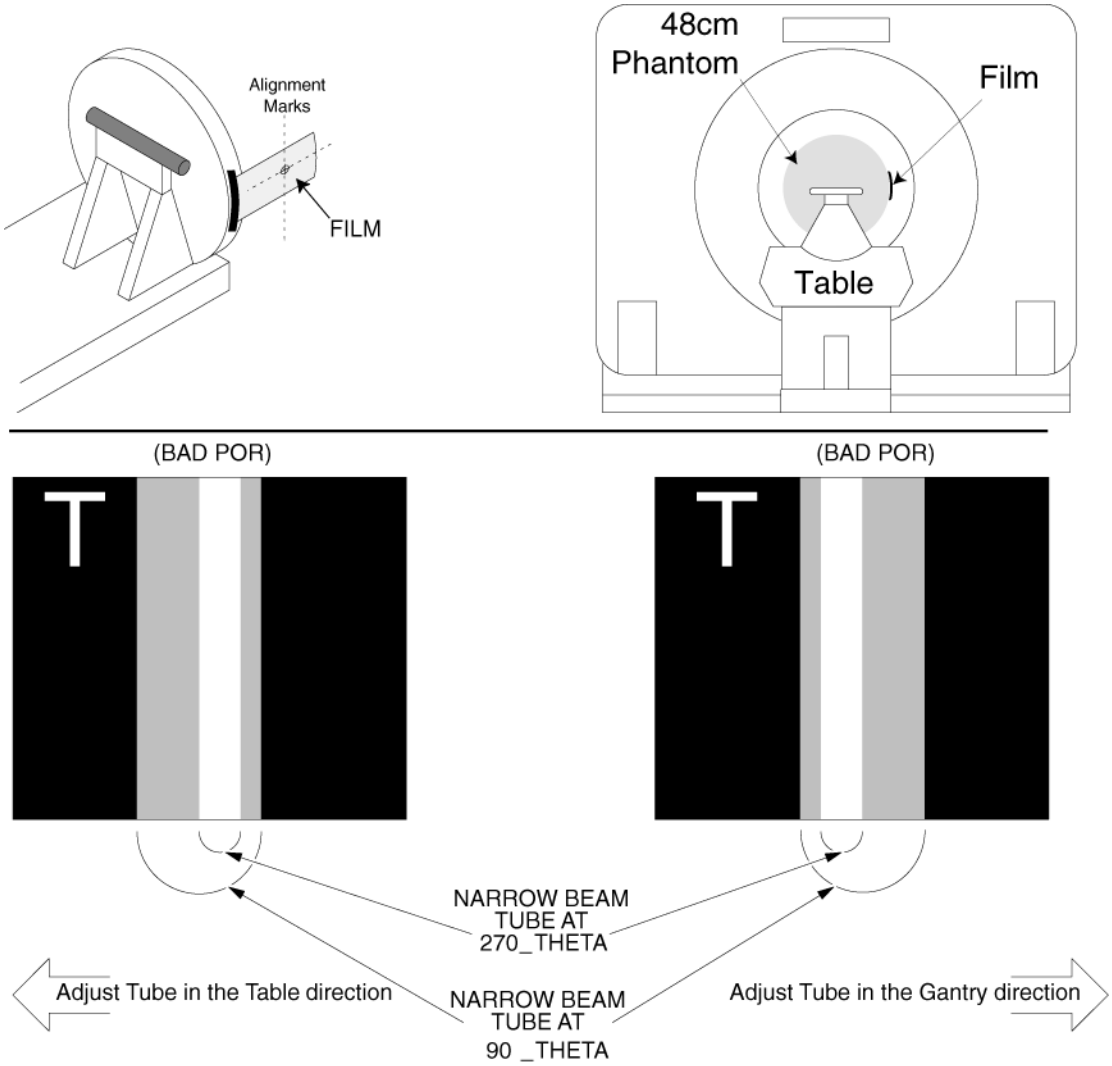


Figure 12-19 Plane of Rotation Film Interpretation

Section 4.0
Beam on Window Alignment (BOW)

Purpose: The objective is to put the Detector in the correct position, assuming the tube is already in the correct position. This makes sure the X-ray Flux does not miss the Detector.

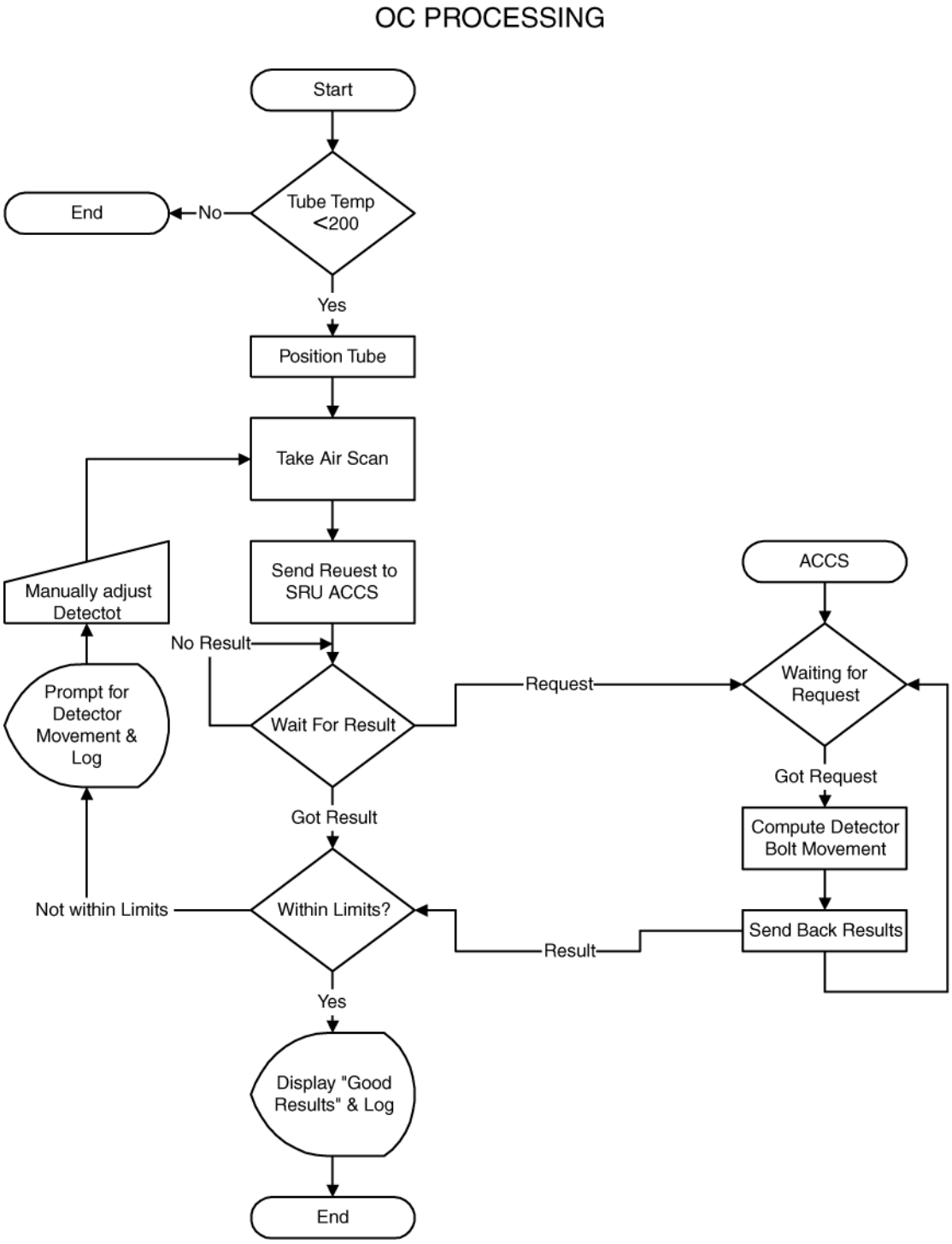


Figure 12-20 BOW Alignment Process Flow

4.1 Verify Tube Temperature < 200º C

1.) Click DAILY PREP
2.) Click TUBE WARM-UP
3.) Click ACCEPT in pop-up window
4.) Click PAUSE
5.) Click CANCEL (Do not QUIT Daily Prep)

⚠ **NOTICE** **Do not start X-ray exposures. Starting tube warm-up will result in additional tube cooling wait times.**

6.) Open system error log (`gesys_suite.log`)
7.) Click LAST PAGE

Look for this type of entry:

This entry is created when Pause is clicked.

```
bay57   dailyPrepRx
StateMachineEventNotify.c   418
Tube temperature before Cold Tube Warmup is 315.15 degrees Celsius.
```

This entry is created when Cancel is clicked.

```
bay57   dailyPrepRx
StateMachineEventNotify.c   411
Tube temperature after Cold Tube Warmup is 312.89 degrees Celsius.
```

Start Tube Alignments when 200.00 degrees Celsius is reported.

```
bay57   dailyPrepRx
StateMachineEventNotify.c   418
Tube temperature before Cold Tube Warmup is 200.00 degrees Celsius.
```

8.) Repeat steps 3 through 5 as necessary to generate updates in the `gesyslog`.
9.) Click QUIT to exit Daily Prep, when tube temperature shows 200.00 Celsius.

4.2 For Tube Change Only

Wait 90 minutes if the new tube had more than 25 Kilo Joules of energy input, [KV x mA x Sec ÷ 1000] within the last 30 minutes prior to the start of system alignments.

Note: If a tube heat soak has been performed you must wait a minimum of 6 hours before system alignments can be performed.

4.3 Accessing the Software

1.) Select SERVICE DESKTOP.
2.) Select CALIBRATION.
3.) Select BOW ALIGNMENT

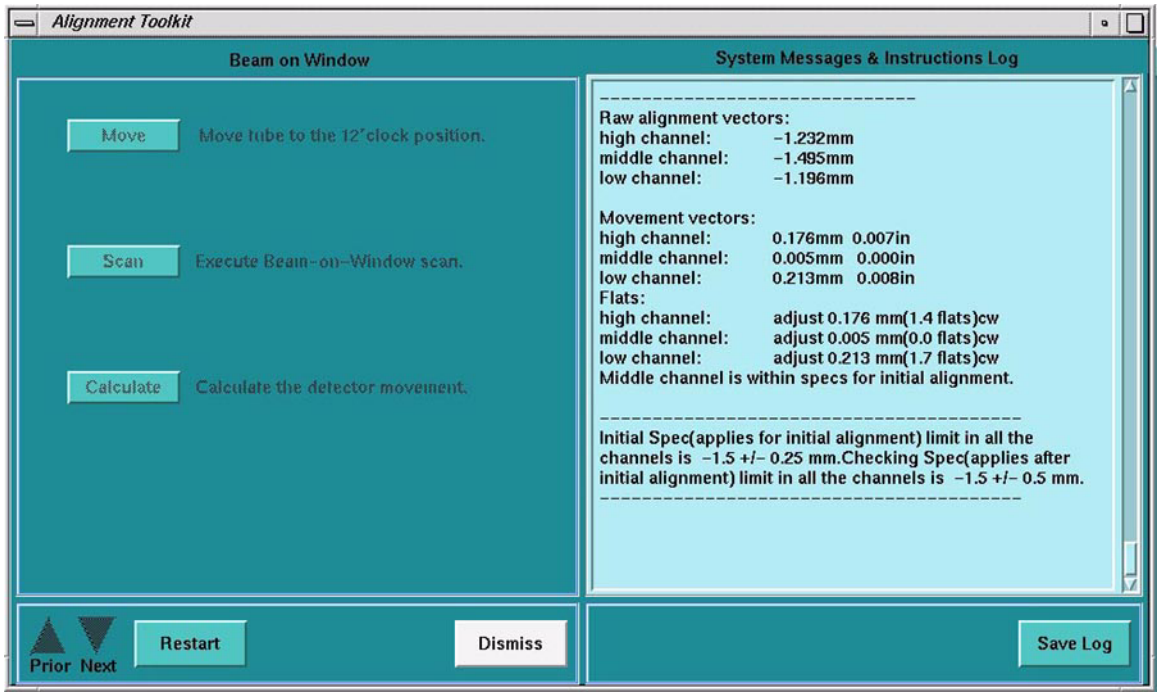


Figure 12-21 Screen Shot for Beam on Window Alignment

4.4 Adjustment Procedure

1.) Select MOVE to send the tube to the 12 o'clock position.
2.) Acquire a Beam on Window Scan.
3.) Select CALCULATE and make adjustments as indicated by the program.
4.) Remove the rear gantry cover if necessary.
5.) Refer to Figure 12-22. Loosen the M-6 caphead screws, located at each end of the detector (total of two caphead screws).
6.) Loosen the middle nut (jam nut) with a 10 mm wrench. Make adjustments as requested by software.
7.) Acquire a Beam on Window Scan, then select CALCULATE.
8.) If the adjustments pass the calculation, proceed to step 9, otherwise return to step 2.
9.) Tighten all three screws. (Torque to 120 inch-lbs, 13.5 Newton Meters).

Note: The specs for **BOW** are checked by the software. If an adjustment is needed for the first **BOW** scan, make adjustments per procedure. In the verification scan, the spec is different than the software version because the tube is warm. The spec is -1.5 ± 0.5mm.

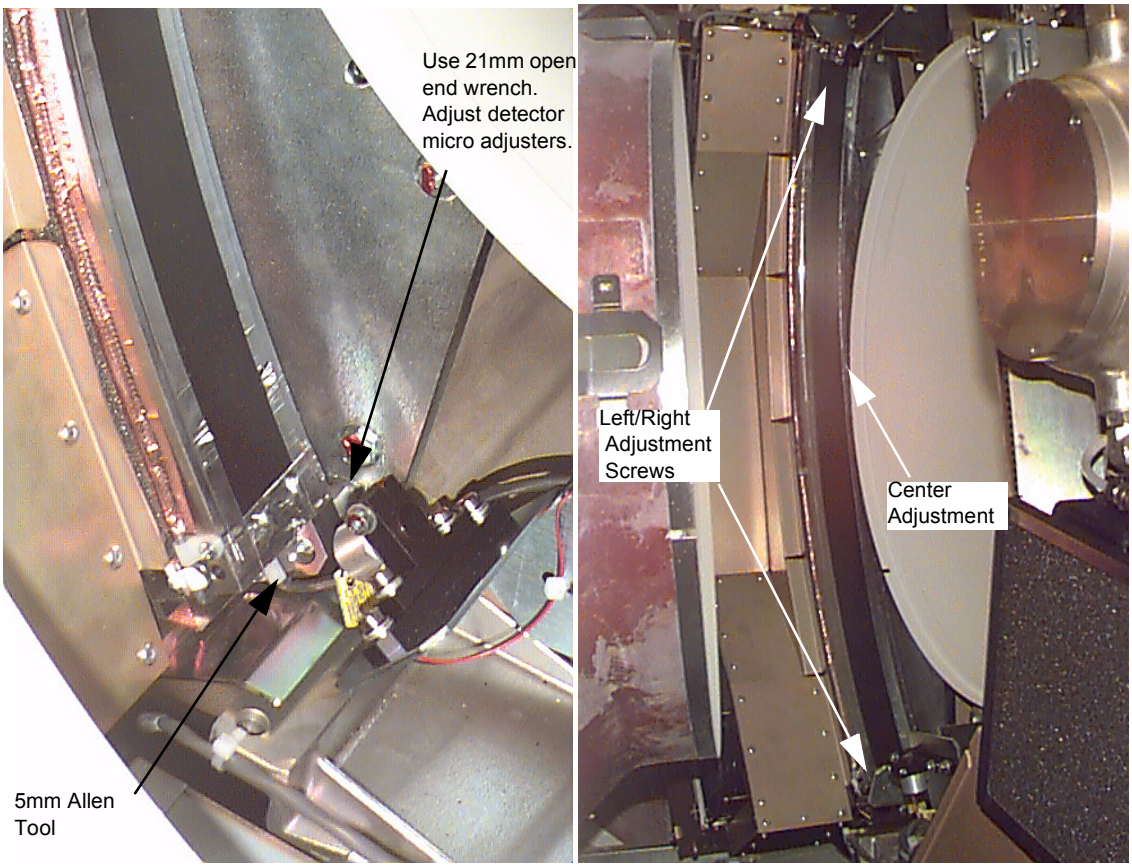


Figure 12-22 Detector Cap-head Screws

Note: CW (clockwise) turns move the detector toward the mounting plate. CCW (counter-clockwise) turns move the detector away from the mounting plate. Right=Low Chnl, Center=Medium Chnl, Left=High Chnl.

Section 5.0
CBF / SAG Alignment Process

Purpose: **CBF**/**SAG** Alignment ensures the focal spot is accurate, the bowtie filter is centered and center of rotation is in a straight line.

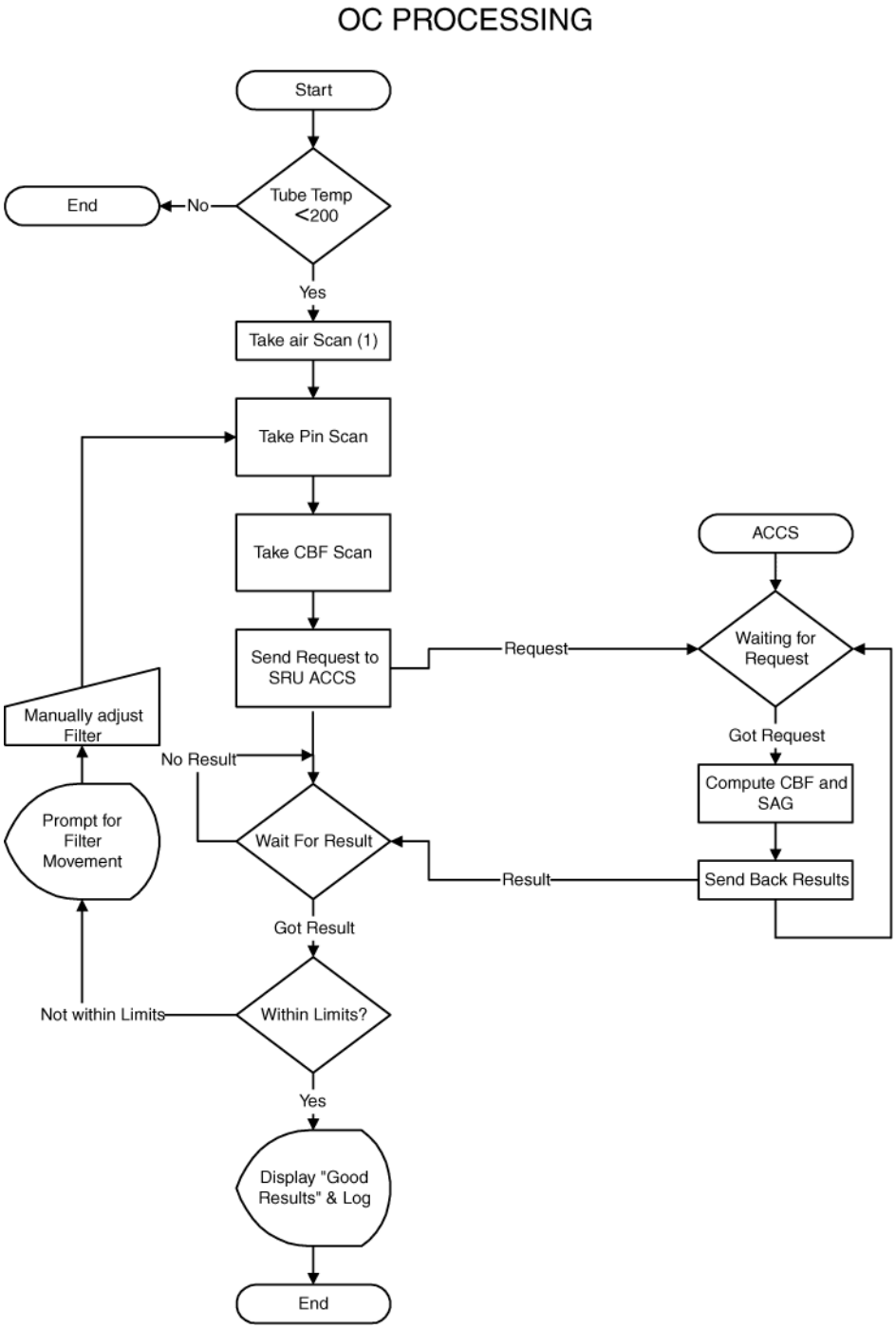


Figure 12-23 CBF Procedural Flow

5.1 Verify Tube Temperature < 200º C

1.) Click DAILY PREP
2.) Click TUBE WARM-UP
3.) Click ACCEPT in pop-up window
4.) Click PAUSE
5.) Click CANCEL (Do not QUIT Daily Prep)

⚠ **NOTICE** **Do not start X-ray exposures. Starting tube warm-up will result in additional tube cooling wait times.**

6.) Open system error log (`gesys_suite.log`)
7.) Click LAST PAGE

Look for this type of entry:

This entry is created when Pause is clicked.

```
bay57   dailyPrepRx
StateMachineEventNotify.c   418
Tube temperature before Cold Tube Warmup is 315.15 degrees Celsius.
```

This entry is created when Cancel is clicked.

```
bay57   dailyPrepRx
StateMachineEventNotify.c   411
Tube temperature after Cold Tube Warmup is 312.89 degrees Celsius.
```

Start Tube Alignments when 200.00 degrees Celsius is reported.

```
bay57   dailyPrepRx
StateMachineEventNotify.c   418
Tube temperature before Cold Tube Warmup is 200.00 degrees Celsius.
```

8.) Repeat steps 3 through 5 as necessary to generate updates in the `gesyslog`.
9.) Click QUIT to exit Daily Prep, when tube temperature shows 200.00 Celsius.

5.2 For Tube Change Only

Wait 90 minutes if the new tube had more than 25 Kilo Joules of energy input, [KV x mA x Sec ÷ 1000] within the last 30 minutes prior to the start of system alignments.

Note: If a tube heat soak has been performed you must wait a minimum of 6 hours before system alignments can be performed.

5.3 Accessing the Software

1.) Select SERVICE DESKTOP.
2.) Select CALIBRATION.
3.) Select CBF AND SAG ALIGNMENT

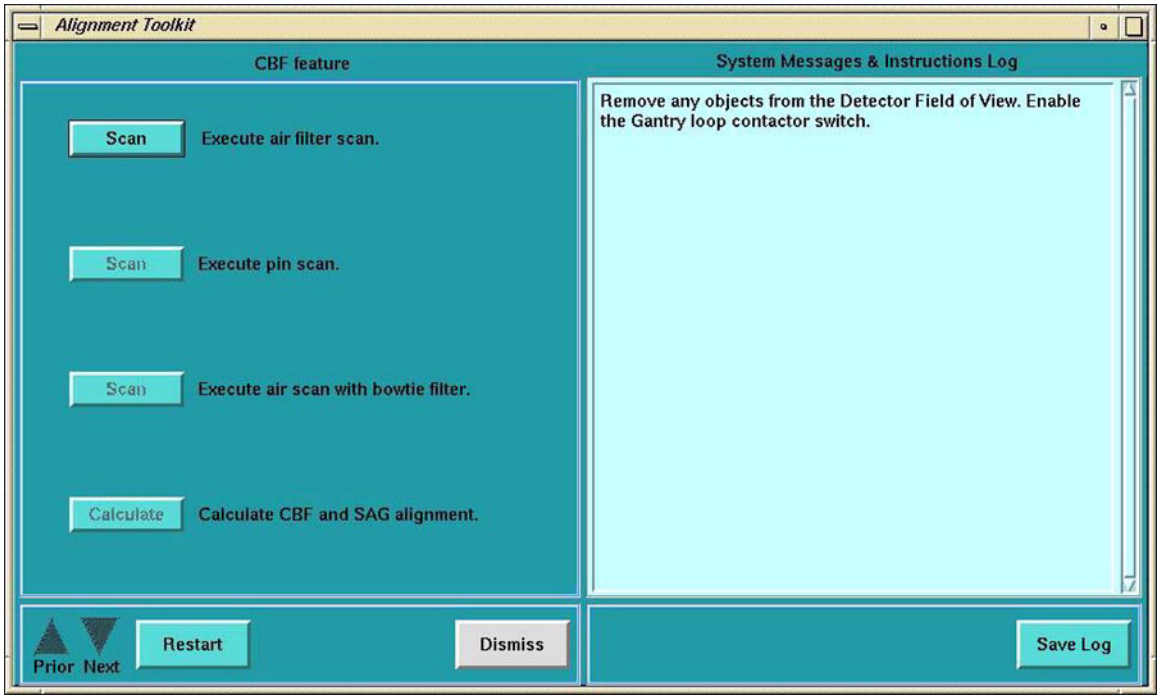


Figure 12-24 CBF / SAG Alignment Program Screen

5.4 Adjustment Procedure

1.) Click on the **SCAN** button to execute air filter scan.
2.) Place the 1/8 inch screw driver on the phantom holder (should be pointing into the Z direction).
3.) Execute pin scan.
4.) Execute air scan with bow-tie filter.
5.) Click on the **CALCULATE** button to calculate the **CBF** and **SAG** alignment.
6.) Mount indicator onto the **HEMRC** (Figure 12-25). *Make sure that you zero the Dial Indicator.*

Figure 12-25 CBF Dial Indicator

7.) Loosen the six (6) M12 collimator cap screws. Four (4) cap screws are on the front side of the collimator. (One cap screw is behind the cable connections. Use a swivel adapter for ratchet wrench.) **Two (2) cap are screws on the rear (through the rotating base casting)**.

Reference Figure 12-26.

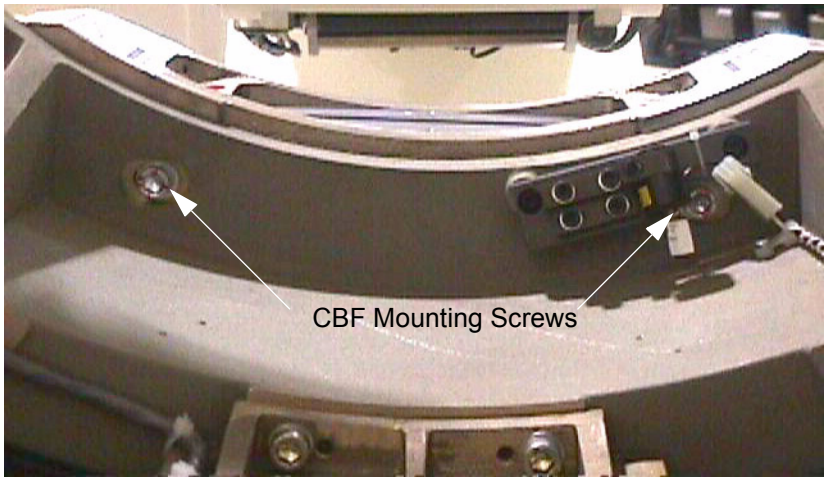


Figure 12-26 Collimator CBF Rear Mounting Screws

8.) Adjust the Collimator as indicated by the results of the calculation. (Ignore the negative sign in front of the adjustments.)
9.) Tighten the Collimator.
10.) Rescan and calculate.
11.) Proceed to the next step if the adjustment is within limit, otherwise jump to step 7.
12.) Torque all six (6) M12 cap screws to 49 ft/lbs (66.4 Nm)

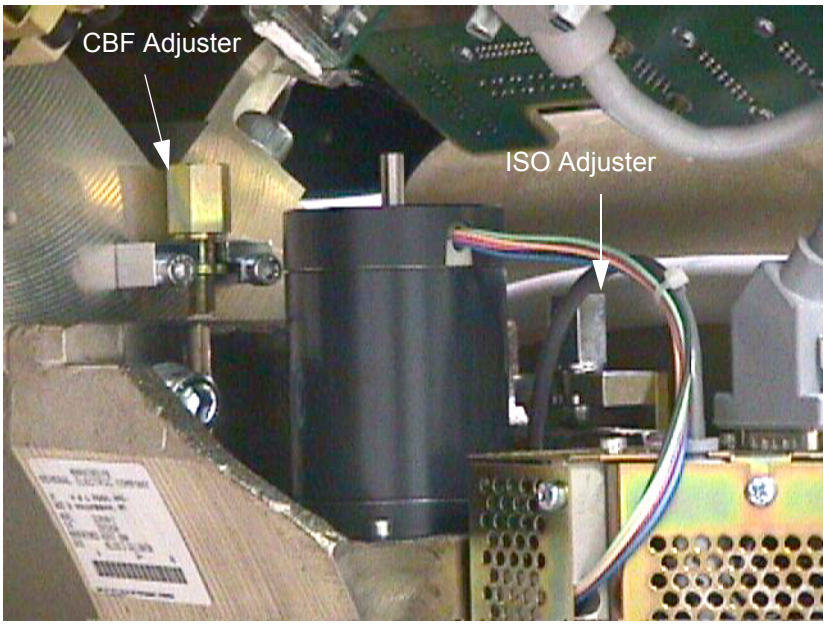


Figure 12-27 CBF Adjuster Location

Section 6.0
ISO Alignment

Cold ISO Alignment is done before the tube is heated by Generator calibrations. Hot ISO is done later. For details on Hot ISO, see HOT ISO Alignment on page 957.

6.1 Verify Tube Temperature < 200º C

1.) Click DAILY PREP
2.) Click TUBE WARM-UP
3.) Click ACCEPT in pop-up window
4.) Click PAUSE
5.) Click CANCEL (Do not QUIT Daily Prep)

NOTICE **Do not start X-ray exposures. Starting tube warm-up will result in additional tube cooling wait times.**

6.) Open system error log (`gesys_suite.log`)
7.) Click LAST PAGE

Look for this type of entry:

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Tube temperature before Cold Tube Warmup is 315.15 degrees Celsius.
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This entry is created when Cancel is clicked.

```
bay57   dailyPrepRx
StateMachineEventNotify.c   411
Tube temperature after Cold Tube Warmup is 312.89 degrees Celsius.
```

Start Tube Alignments when 200.00 degrees Celsius is reported.

```
bay57   dailyPrepRx
StateMachineEventNotify.c   418
Tube temperature before Cold Tube Warmup is 200.00 degrees Celsius.
```

8.) Repeat steps 3 through 5 as necessary to generate updates in the `gesyslog`.
9.) Click QUIT to exit Daily Prep, when tube temperature shows 200.00 Celsius.

6.2 For Tube Change Only

Wait 90 minutes if the new tube had more than 25 Kilo Joules of energy input, [KV x mA x Sec ÷ 1000] within the last 30 minutes prior to the start of system alignments.

Note: If a tube heat soak has been performed you must wait a minimum of 6 hours before system alignments can be performed.

6.3 Overview

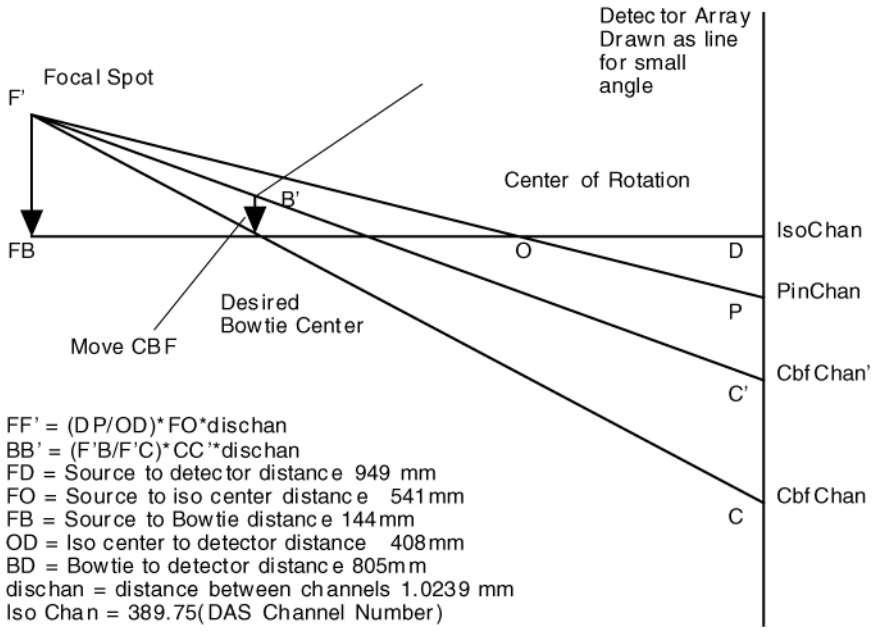


Figure 12-28 Geometry for CBF/ISO Adjustment

The geometry of ISO alignment is shown in Figure 12-28. The following computational software are required for ISO alignment:

1.) Centroid calculation program as used by CT/I.

2.) ISO and **CBF** computation.

The scans required for ISO are the following:

A.) Air scans:

1.) 80 kV/40 mA/ 4x500 FET Setting/4x500 aperture /4 sec/small spot/air filter/ rotating

2.) 80 kV/40 mA/ 4x500 FET Setting/4x500 aperture/4 sec/large spot/air filter/ rotating

B.) Pin scans:

3.) 80 kV/40 mA/ 4x500 FET Setting/4x500 aperture/4 sec/small spot/air filter/ rotating

4.) 80 kV/40 mA/ 4x500 FET Setting/4x500 aperture/4 sec/large pot/air filter/ rotating.

For all above ISO/**CBF** scans, **DAS** gain should be set to its default level for that technique. After the scans are taken, the following computational steps should be carried out:

1.) Normalize scan data 3 & 4 using air scans 1 and 2 respectively.

2.) Compute centroid using data from scans 3 and 4 and average over all rows.

3.) Average the two numbers obtained in step 2 for large and small spots. This is our average centroid value.

4.) If the average value is at **DAS** Channel 389.75 ±.02 channels, the adjustment is done. Else move the tube by the following: move = (average value - IsoChan) *dischan* (FO/OD) mm

- Where: IsoChan = 389.75
- Dischan = channel to channel distance 1.0239 mm
- FO = source to iso center distance 541 mm
- OD = Iso center to detector distance 408 mm

Take scans 3 and 4 and repeat centroid computation. Please note that if the computed ISO channel is out more than 1 channel, all four scans must be taken for each successive iteration.

Please note that the ISO values for small and large focal spots must be saved for use by the reconstruction process.

6.4 Accessing the Software

1.) Select SERVICE DESKTOP.
2.) Select CALIBRATION.
3.) Select ISO ALIGNMENT

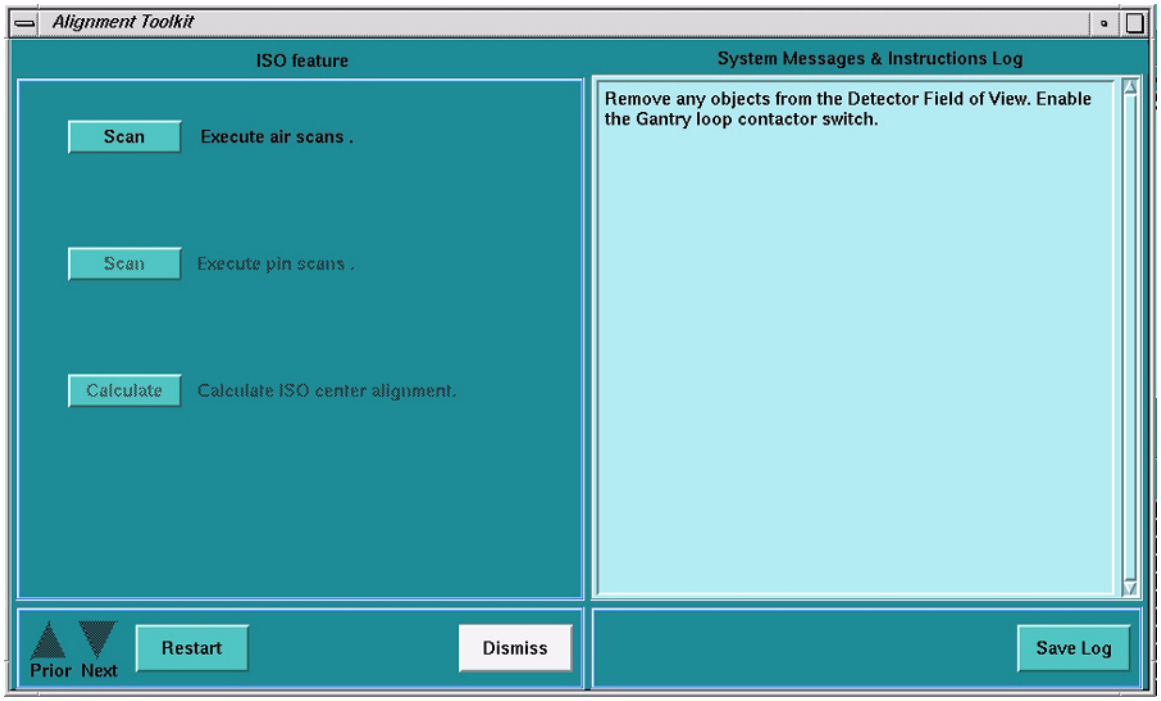


Figure 12-29 ISO Alignment Menu

6.5 ISO Adjustment Procedure

1.) Execute Air scan (small spot).
2.) Execute Air scan (large spot).
3.) Place the 1/8 inch screw driver on the phantom holder (should be pointing into the Z direction).
4.) Execute pin scan (small spot).
5.) Execute pin scan (large spot).
6.) **CALCULATE** ISO center alignment.
7.) Mount the dial indicator on the tube assembly. (Figure 12-30.) Make sure that you zero it.

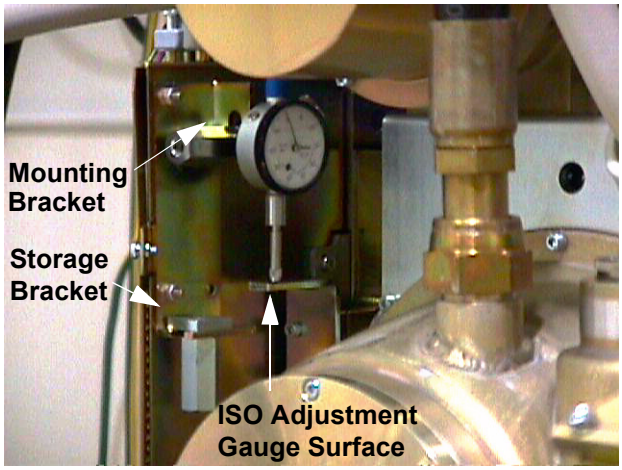


Figure 12-30 ISO Dial Gauge Mounting Location

8.) Loosen the 4 M-12 bolts on the tube assembly.

9.) Adjust the tube UP / DOWN as indicated by the calculation. The adjustment bolt is located on the top of the tube - Please see Figure 12-31.

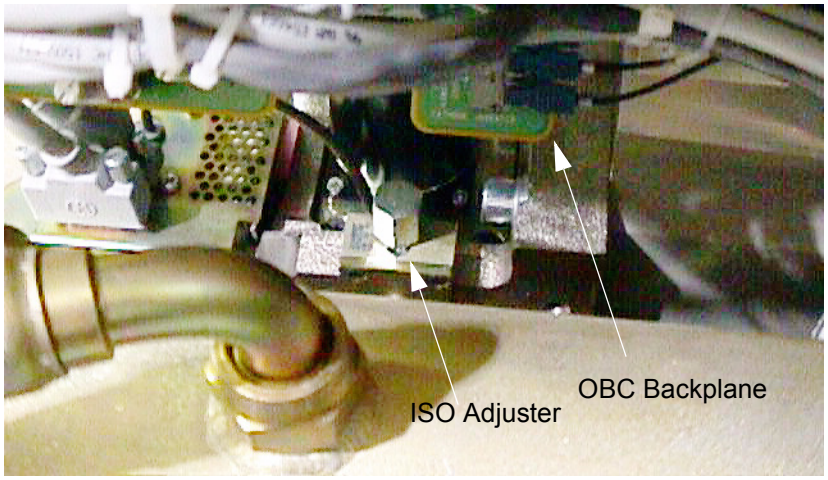


Figure 12-31 ISO Alignment Adjuster

10.) Tighten the four (4) M12 bolts and verify dial gauge still reads the correct adjustment value.

11.) Repeat steps 1 through 6.

12.) If the adjustments are within limit proceed to the next step, otherwise go to step 9.

13.) Tighten the four (4) M12 bolts. Torque to 49 ft-lbs (66.4 Nm).

14.) Wait 15 minutes, then recheck BOW to verify that the Beam-on-Window values are within the drift spec of -1.5mm ±0.5mm.

- If BOW is within spec, DO NOT adjust anything
- If BOW is out of spec, alignments must be done, starting with POR and ending with BOW recheck.

Section 7.0
Calibration - High Voltage

7.1 Access HV Maintenance through Service Desktop

1.) Select SERVICE DESKTOP.
2.) Select CALIBRATION.
3.) Select GENERATOR CHARACTERIZATION.

7.2 Generator Characterization

Use the Generator Characterization Program to update the “small spot” and “large spot” characterization files, to provide a starting point for the closed loop mode of the generator. This iterative process requires several scans at a different KV/MA/spot size. It calculates corrections, repeats the scan until the results fall within tolerance, then updates the characterization file.

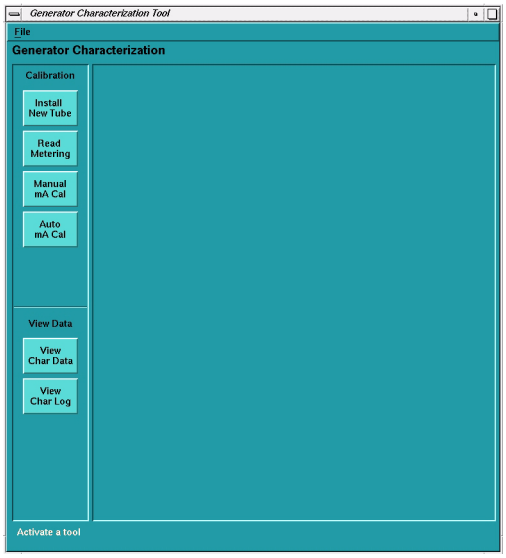


Figure 12-32 Generator Characterization Menu Screen

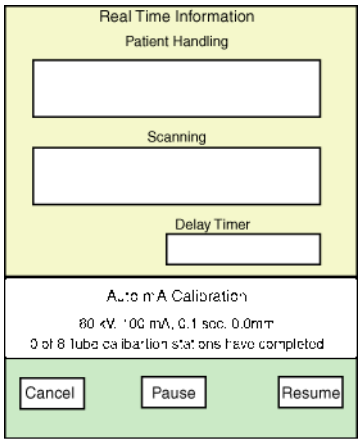


Figure 12-33 Auto mA Calibration Status Screen

7.3 Verify kV Meter

This section describes the calibration check of system internal kV metering circuits.

1.) Select READ METERING.

2.) Select RUN to start the test. During the test, the firmware reads the metering circuits in the OFF state, then reads the metering circuits in the ON state, and finally reports the readings to the display.

3.) Compare the data in the “Delta” column on the Read Meter screen (Figure 9-4) to the data in the “Limit” column.

Note: “Delta” = DVM - A/D

CIRCUIT “OFF”	CIRCUIT “ON”
Anode kV = 0 ± 0.5	Anode kV = 50 ± 7.5
Cathode kV = 0 ± 0.5	Cathode kV = 50 ± 7.5
Total kV = 0 ± 0.5	Total kV = 100 ± 15.0

Table 12-1 Generator Characterization Test Specifications

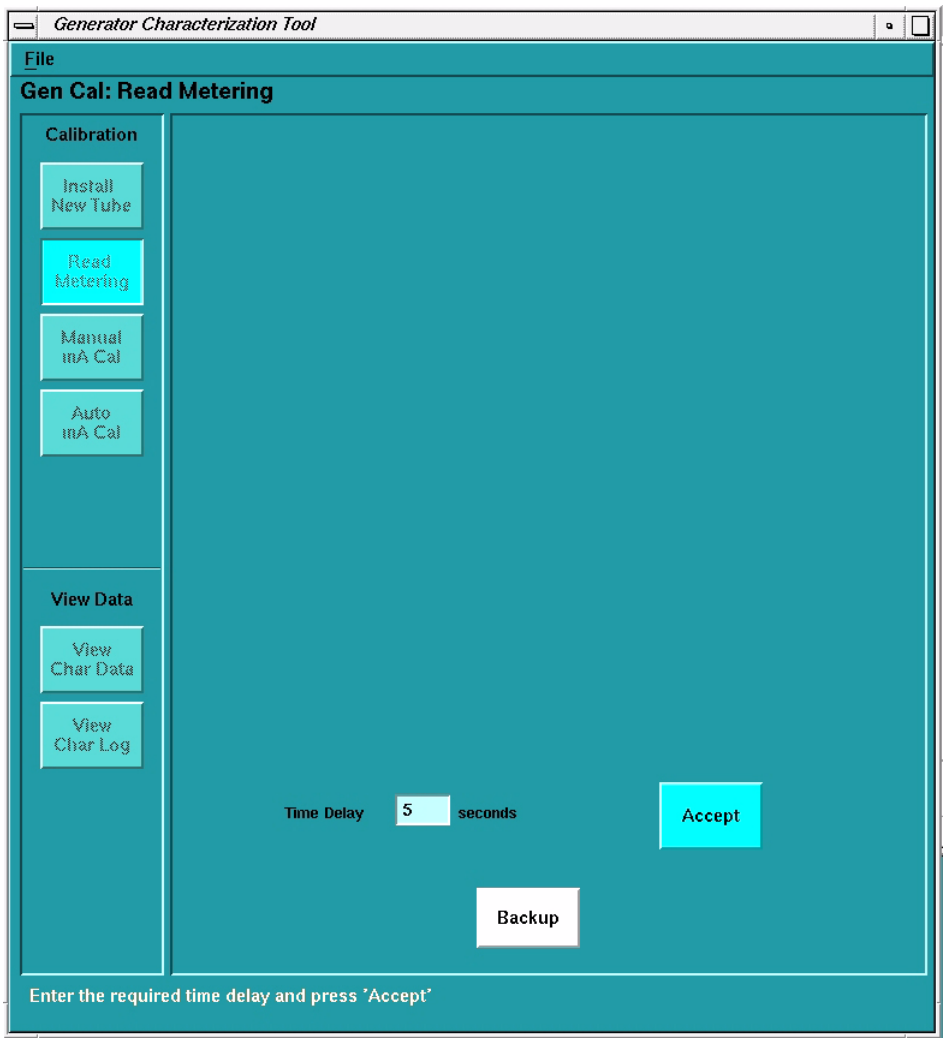


Figure 12-34 Read Metering Screen

7.4 Verify mA Meter

WARNING **WHEN SERVICING THE GANTRY:**

- **NEVER PUT ANY BODY PART INTO THE GANTRY WITHOUT FIRST DISABLING THE AXIAL DRIVE AND RE-VERIFYING (CHECK TWICE) THAT IT IS DISABLED.**
- **ENSURE THAT THE DRIVE STATUS LED (Figure 12-35) IS NOT LIT. DO NOT SERVICE THE GANTRY IF THIS LED IS ON.**

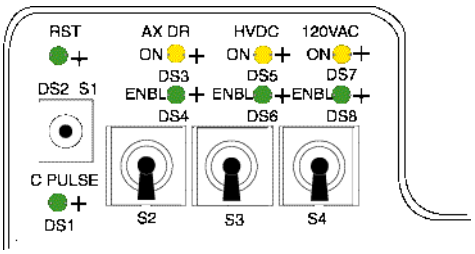


Figure 12-35 STC Backplane Service Switches

This section describes the calibration check system internal mA metering circuits.

1.) Inside the Gantry:
   a.) Switch OFF the **HVDC ENABLE** on **STC** backplane.
   b.) Switch OFF the **AXIAL DRIVE ENABLE** on **STC** backplane.
   c.) Rotate the Anode tank to the 2 o'clock position.
   d.) Engage the gantry rotational lock.
2.) Select SERVICE DESKTOP.
3.) Select CALIBRATION.
4.) Select GENERATOR CHARACTERIZATION.
5.) Select READ METERING.

Note: On the display, enter a time delay in seconds, to provide enough time to walk from the console to the DVM, and record the reading. The test will not begin until this time delay expires.

Once it begins, the test enables the meter circuit for only 4 seconds.

6.) Use a DVM as an mA meter; connect it to the hardware on the anode side:
   a.) Connect the black lead to TP8 (ACAL1) on the mA board.
   b.) Connect the red lead to TP11 (ACAL2) on the mA board.

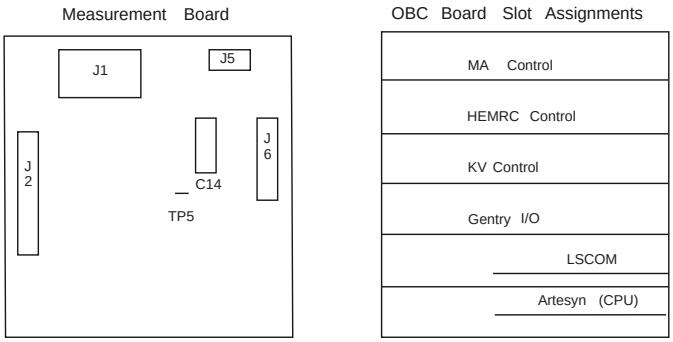


Figure 12-36 Tank Measurement Board

7.) On the Display, select the ACCEPT button.

8.) Record the displayed, and measured, Anode mA values for “Circuit OFF” and “Circuit ON”.

Note: Your system has the test wire to TP5 included in the harness, the Cathode side should read approximately 19 mA during “Circuit On”.

9.) Disconnect the test equipment from the Anode side, if used.

Note: When you exit Generator Characterization, this test may generate

`kV board tube spit counter = x error messages.`

10.) Use a DVM as an mA meter:

a.) Connect the black lead to TP9 (CCAL1) on the mA board.

b.) Connect the red lead to TP14 (CCAL2) on the mA board.

11.) On the Display, Select the ACCEPT button.

12.) Record the displayed, and measured, Cathode mA values for “Circuit OFF” and “Circuit ON”.

Note: Your system has the test wire to TP5 included in the harness, the Anode side should read approximately 20mA during “Circuit On”.

13.) Disconnect the test equipment from the Cathode side if used.

Note: When you exit Generator Characterization, this test may generate

`kV board tube spit counter = x error messages.`

7.5 KV Gain Pots Adjustment

7.5.1 Install HV Divider

1.) Inside the Gantry on the **STC** backplane:

a.) Switch OFF the **HVDC ENABLE**.

b.) Switch OFF the **AXIAL DRIVE ENABLE**.

c.) Rotate the Tube to the 3 o’clock position

d.) Engage the gantry rotational lock.

e.) Switch OFF the **120 VAC GANTRY POWER**.

f.) Install the **HV** Divider between Tube and Tanks.

Note: Place the **HV** Divider on a table or tube hoist, so the cables reach the tube.

2.) Add a ground wire (minimum size of AWG 12) from Tube ground to bleeder ground. Refer to Figure 12-37.

CAUTION Potential Electrical Hazard

Performix tube unit MUST be grounded to the gantry during testing.

3.) Switch ON the **120 VAC GANTRY POWER**.

4.) Switch ON the **HVDC ENABLE**.

5.) Press the button, on the gantry control panel, turning ON the drives power.

Note: If the gantry covers are removed press the **RESET BUTTON** on the **STC** backplane to turn ON Drives power.

6.) Reset the hardware.

NOTICE Potential for tube damage

Incorrect installation of anode and cathode HV cables can destroy the Performix tube unit.

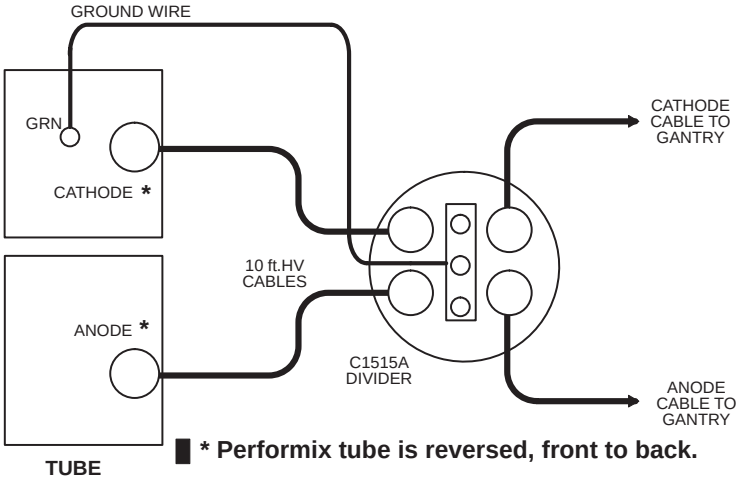


Figure 12-37 HV Divider Installation

7.5.2 Set Up Instrumentation

Use an oscilloscope with 10X probes

1.) Use the Gantry Service Outlet to provide 120 Vac power for the scope. This will reduce noise on the scope waveform.

2.) Connect **channel one** to the **anode** output of the divider. Connect the scope ground to bleeder ground.

3.) Connect **channel two** to the **cathode** output of the divider. Connect the scope ground to bleeder ground.

Note: In order to minimize bleeder-induced ripple on the kV waveform, connect a 30 foot Belden shielded twisted pair cable between the scope probes and the bleeder.

4.) Trigger channel one, positive, DC couple, trigger mode normal.

5.) Channel one and two, 10v/div, time base 200ms.

6.) Invert Channel two.

7.5.3 Calibrate the Cathode

1.) Select SERVICE DESKTOP.

2.) Select REPLACEMENT.

3.) Select DIAGNOSTIC DATA COLLECTION (DDC).

4.) Select PROTOCOL NAME.

5.) Select BLEEDER SETUP and LOAD.

6.) Verify/Set-up the following **DDC** parameters:

- STATIC X-RAY ON	Interscan Delay **2.00**
- **1 SECOND**	**DAS** Gain **31**
- **1 SCAN**	Gantry Tilt **0.0**
- FOCAL SPOT LARGE	Trigger Rate 984
- **100 KV**	Filter BLOCKED
- **50 MA**	Calibration Vector NONE
- MONITOR ENABLE	

7.) Select ACCEPT RX. The Computer Displayed reading specification for the Cathode kV and Anode kV equals 50 ± 0.5 kV.

Note: If you use scope cursors to window the trace, position the Left Vertical Cursor to the Right of the Rising Edge of the waveform. Position the Right Vertical Cursor to the Left of the Falling Edge of the Waveform.

8.) Adjust the Cathode pot on the kV board, until the scope reading for the Cathode kV, and the displayed reading for the Cathode kV in the message log, fall within ±0.5kV of each other.

9.) Use the pot, labeled CAKV, R316, on the kV board, to adjust the scope reading.
- CCW decreases the scope kV.
- CW increases the scope kV.
- 1/2 turn equals approximately 0.5 kV.

10.) Record the results on **FORM 4879**.

7.5.4 Calibrate the Anode

1.) Select SERVICE DESKTOP.
2.) Select REPLACEMENT.
3.) Select DIAGNOSTIC DATA COLLECTION (DDC).
4.) Select PROTOCOL NAME.
5.) Select BLEEDER SETUP and LOAD.
6.) Verify/Set-up the following **DDC** parameters:

- STATIC X-RAY ON	Interscan Delay **2.00**
- **1 SECOND**	**DAS** Gain **31**
- **1 SCAN**	Gantry Tilt **0.0**
- FOCAL SPOT LARGE	Trigger Rate 984
- **100 KV**	Filter BLOCKED
- **50 MA**	Calibration Vector NONE
- MONITOR ENABLE	

7.) Select ACCEPT RX. The Computer Displayed reading specification for the Cathode kV and Anode kV is 50 ± 0.5 kV.

Note: If you use scope cursors to window the trace, position the Left Vertical Cursor to the Right of the Rising Edge of the waveform. Position the Right Vertical Cursor to the Left of the Falling Edge of the Waveform.

8.) Adjust the Anode pot on the kV board, until the scope reading for the Anode kV, and the displayed reading for the Anode kV in the message log, fall within ±0.5kV of each other.

9.) Use the pot, labeled ANKV, R318, on the kV board, to adjust the scope reading.
- CCW decreases the scope kV.
- CW increases the scope kV
- 1/2 turn is approximately 0.5 kV.

10.) Record the results on **FORM 4879**.

7.5.5 Measure Total kV

1.) Select SERVICE DESKTOP.
2.) Select REPLACEMENT.
3.) Select DIAGNOSTIC DATA COLLECTION (DDC).
4.) Select PROTOCOL NAME.
5.) Select BLEEDER SETUP and LOAD.
6.) Verify/Set-up the following **DDC** parameters:

- STATIC X-RAY ON	Interscan Delay **2.00**

- **1 SECOND** — **DAS** Gain **31**
- **1 SCAN** — Gantry Tilt **0.0**
- FOCAL SPOT LARGE — Trigger Rate 984
- **100 KV** — Filter BLOCKED
- **50 MA** — Calibration Vector NONE
- MONITOR ENABLE

7.) Change the oscilloscope to add ch.1 and ch.2, to read total kV from the **HV** divider.

8.) Channel one and two, 20v/div, time base 200ms, trigger channel. one, positive.

9.) Select ACCEPT RX.

10.) Record the scope reading, and the Average. kV displayed in the message log, in **FORM 4879**.

11.) Display the Generator Characterization menu.

12.) Toggle the soft-key MONITOR ENABLE **OFF**, so the message log no longer displays kV and mA readings.

7.5.6 Verify kV Meter

Use this procedure to verify the calibration of the internal kV metering circuits.

1.) Select SERVICE DESKTOP.

2.) Select CALIBRATION.

3.) Select GENERATOR CHARACTERIZATION.

4.) Select READ METERING.

5.) Select ACCEPT.

- The test begins after the time delay expires.
- Once the test begins, the software enables the meter circuit for 4 seconds.

6.) Record the displayed Anode kV, Cathode kV and Total kV values in the **FORM 4879** “Circuit OFF” and “Circuit ON” table.

7.) Select BACKUP.

7.5.7 Remove the External HV Divider

1.) Press the button, on the gantry control panel, turning **OFF** the drives power.

Note: If the gantry covers are removed, proceed to step 2.

2.) Inside the Gantry on the **STC** backplane:

a.) Switch OFF the **HVDC ENABLE**.

b.) Switch OFF the **AXIAL DRIVE ENABLE**.

c.) Switch OFF the **120 VAC GANTRY POWER**.

d.) Remove the **HV** Divider between the Tube and Tanks (Figure 12-37, on page 950).

e.) Reconnect the **HV** cables for normal operation.

NOTICE **Incorrect installation of anode and cathode HV cables can destroy the Performix tube.**

f.) Re-apply paper toweling around tube locking ring to absorb excess oil.

g.) Disengage the gantry rotational lock.

a.) Switch ON the **HVDC ENABLE**.

b.) Switch ON the **AXIAL DRIVE ENABLE**.

c.) Switch ON the **120 VAC GANTRY POWER**.

3.) Press the button, on the gantry control panel, turning ON the drives power.

Note: If the gantry covers are removed, press the **RESET BUTTON** on the **STC** backplane to turn ON Drives power.

4.) Reset the hardware.

7.5.8 Install New Tube Program

Use this program to complete Auto mA Cal on a new tube. *Run this program only on a new tube.* Refer to Figure 9-5.

1.) Select SERVICE DESKTOP.
2.) Select CALIBRATION.
3.) Select GENERATOR CHARACTERIZATION.
4.) Select the INSTALL NEW TUBE.

Note: The system automatically warms up the tube.

5.) The system prompts you with the tube type. Verify the number corresponds to your tube type; answer **Y** or **N**.

SOFTWARE TOKEN	HOUSING NUMBER	INSERT NUMBER
12-MX_135CT	46-274800G1	46-274600G1
13-MX_165CT	46-309500G2	46-309300G1
14-MX_165CT_I	46-309500G2	46-309300G2
15-MX_200CT	2137130-2	2120785

Table 12-2 Tube Type Table (SW tokens for various Housings and Inserts)

6.) Press **START SCAN** when it flashes, to automatically run the program and update the display:

```
seed filament current shift scans
```

7.5.9 Auto mA Calibration

Run this program when you replace the X-Ray tube, or the system requires re-calibration.

1.) Select SERVICE DESKTOP.
2.) Select CALIBRATION.
3.) Select GENERATOR CHARACTERIZATION.
4.) Select AUTO MA CAL.

Note: The software automatically warms up the tube.

5.) Press **START SCAN** when it flashes, to automatically run the program and update the display:

```
– Ductility warm-up -
– Auto mA Cal -
```

6.) The system displays the final filament currents on the screen.

7.5.10 KV Rise and Fall Times

1.) In the **OBC**, connect a scope to the KV board.
   - Channel 1: Exposure Command EXCM, TP5. Scope ground to LGND, TP3, 2v/div
   - Channel 2: Total kV KVTB, TP11. (At this test point KV = 20KV per volt.) Scope ground to AGND SGND, TP12, 1v/div

2.) Set the Scope Time base to 200 usec.
   Positive or Negative trigger as required.

3.) Select DIAGNOSTIC DATA COLLECTION (DDC).

4.) Select PROTOCOL NAME.

5.) Select RISEFALL and LOAD.

TECHNIQUE		RISE		FALL	
kV	mA	**Record** Delay ms	Limit	**Record** Delay ms	Limit
80	400		0 +1.9 ms	Test not required.	N/A
140	40	Test not required.	N/A		-0 +0.5 ms

Table 12-3 kV Rise and Fall Time Record Table

Note: See Figure 12-38 and Figure 12-39, for measurement clarification.

7.5.11 Measure Rise Time

1.) Verify/Set-up the following **DDC** parameters:
   - STATIC X-RAY ON — Interscan Delay **2.00**
   - **1 SECOND** — **DAS** Gain **31**
   - **1 SCAN** — Gantry Tilt **0.0**
   - FOCAL SPOT LARGE — Trigger Rate 984
   - **80 KV** — Filter BLOCKED
   - **400 MA** — Calibration Vector NONE

Note: Measure rise time only on the 80kV/400mA scan.

2.) Select ACCEPT RX.

3.) Select PAUSE after the start of scan, to prevent the scope from displaying the fall time.

4.) After you record the rise time, select the RESUME to initiate the fall time scan.

5.) Record the delay between the rise of the EXCM signal, and the 75% threshold crossing of the **selected kV** (on **FORM 4879**).
   - Do not include the waveform overshoot.
   - The 75% point for 80kV equals 60kV.

Note: Refer to Figure 12-38 for measurement clarification.

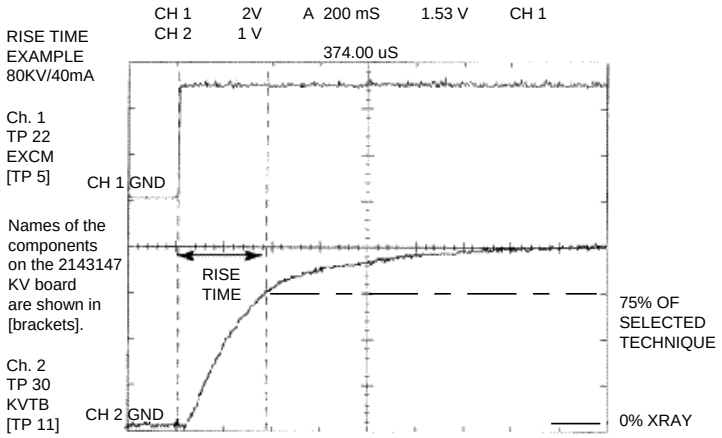


Figure 12-38 Rise Time Measurement

Note: The 75% point for:

- 80kV equals 60kV
- 100kV equals 75kV
- 120kV equals 90kV
- 140kV equals 105kV

7.5.12 Measure Fall Time

1.) Verify/Set-up the following **DDC** parameters:

- STATIC X-RAY ON	Interscan Delay **2.00**
- **1 SECOND**	**DAS** Gain **31**
- **1 SCAN**	Gantry Tilt **0.0**
- FOCAL SPOT LARGE	Trigger Rate 984
- **140 KV**	Filter BLOCKED
- **40 MA**	Calibration Vector NONE

Note: Measure fall time only on the 140kV/40mA scan.

2.) Record the delay between the fall of the EXCM signal, and the 75% threshold crossing of the **selected kV** (on **FORM 4879**).

- Do not include the waveform overshoot.
- The 75% point for 140kV equals 105kV

Leave the scope connected for the next test.

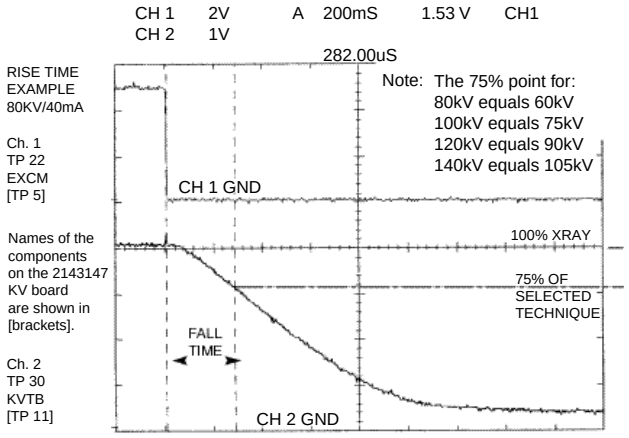


Figure 12-39 Fall Time Measurement

7.5.13 Verify Internal Scan Timer

1.) Select DIAGNOSTIC DATA COLLECTION (DDC).
2.) Select PROTOCOL NAME.
3.) Select SCANTIMER and LOAD.
4.) Toggle the softkey MONITOR ENABLE to **ON**, to display the scan time in the message log.
5.) In the **OBC**, connect a scope to the kV board, as follows:
   a.) Channel 1, Exposure Command (EXCM, TP22). Scope ground to TP3, 2v/div
   b.) Channel 2, Total kV, TP11. Scope ground to SIG, TP12, 1v/div
   c.) Set the Scope Time base to 200msec, positive trigger.
6.) Verify/Set-up the following **DDC** parameters:

- STATIC X-RAY ON	Interscan Delay **2.00**
- **1 SECOND**	**DAS** Gain **31**
- **1 SCAN**	Gantry Tilt **0.0**
- FOCAL SPOT LARGE	Trigger Rate 984
- **100 KV**	Filter BLOCKED
- **40 MA**	Calibration Vector NONE

7.) Record the measured scan time from the oscilloscope and the displayed scan time from the message log. Spec limits are as follows:

Note: Scope Exposure Duration = 0.96 to 1.04 s.
Displayed Exposure Duration = 0.99 to 1.02 s.

8.) Toggle the softkey MONITOR ENABLE **OFF**, to stop the scan time display in the message log.
   Failure to turn the MONITOR ENABLE **OFF** results in the system message log filling with exposure information.
9.) Disconnect the scope from the kV board.
10.) Replace the **OBC** cover**.**

Section 8.0
HOT ISO Alignment

8.1 Accessing the Software

1.) Select SERVICE DESKTOP.
2.) Select CALIBRATION.
3.) Select HOT ISO ALIGNMENT.

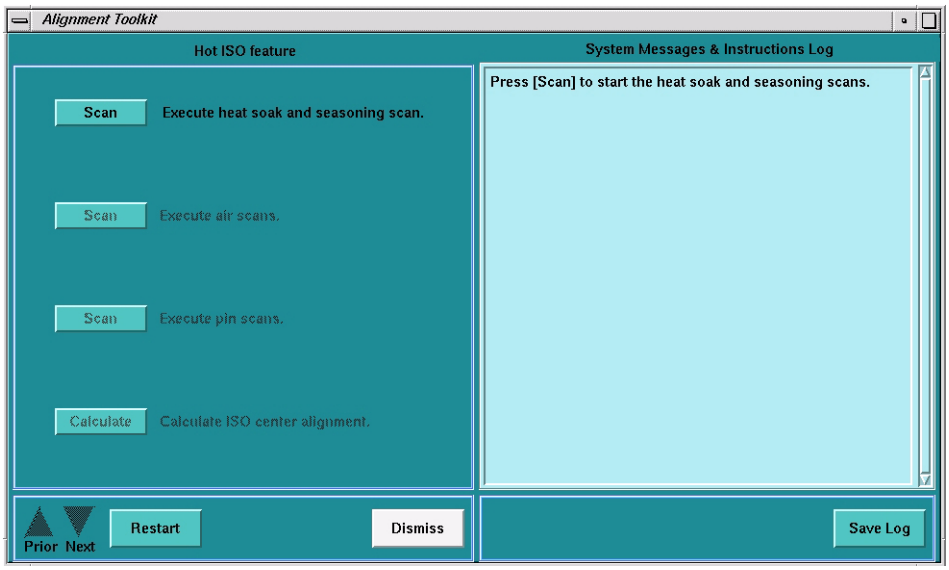


Figure 12-40 HOT ISO Screen

8.2 Adjustment Procedure

1.) Execute the Heat Soak and Seasoning scan.
2.) Execute Air Scan (small spot).
3.) Execute Air Scan (large spot).
4.) Place the 1/8 inch screw driver on the phantom holder (should be pointing into the Z direction).
5.) Execute Pin Scan (small spot).
6.) Execute Pin Scan (Large spot)
7.) Calculate correction factor with Calculate button.

Note: No movement of the tube is required. This is a software correction done automatically.

Section 9.0
DAS Gain Calibration

1.) Perform **DAS** Gain Calibration by selecting the function from Scanner Utilities (**left head**).
2.) Select SCANNER UTILITIES, and Select DAS GAIN CALIBRATION.
3.) Ensure that there is nothing in the x-ray beam and continue.
4.) The system will now perform a Mylar window check and provide the appropriate messages if the window should need cleaning.
5.) Upon completion of the Mylar window scans the system will now take 31 scans and save the results in the Calibration Data Base. The system will provide the appropriate messages if the calibration should fail.

Section 10.0
Collimator Calibration

1.) Perform Collimator Calibration by selecting the function from Scanner Utilities (**left head**).
2.) Select SCANNER UTILITIES, and Select COLLIMATOR GAIN CALIBRATION.
3.) Ensure that there is nothing in the x-ray beam and continue.
4.) The system will now perform a Mylar window check if needed and provide the appropriate messages if the window should need cleaning.
5.) Upon completion of the Mylar window scans the system will now take 8 scans and save the results in the Calibration Data Base. The system will provide the appropriate messages if the calibration should fail.

Section 11.0
Calibration Process

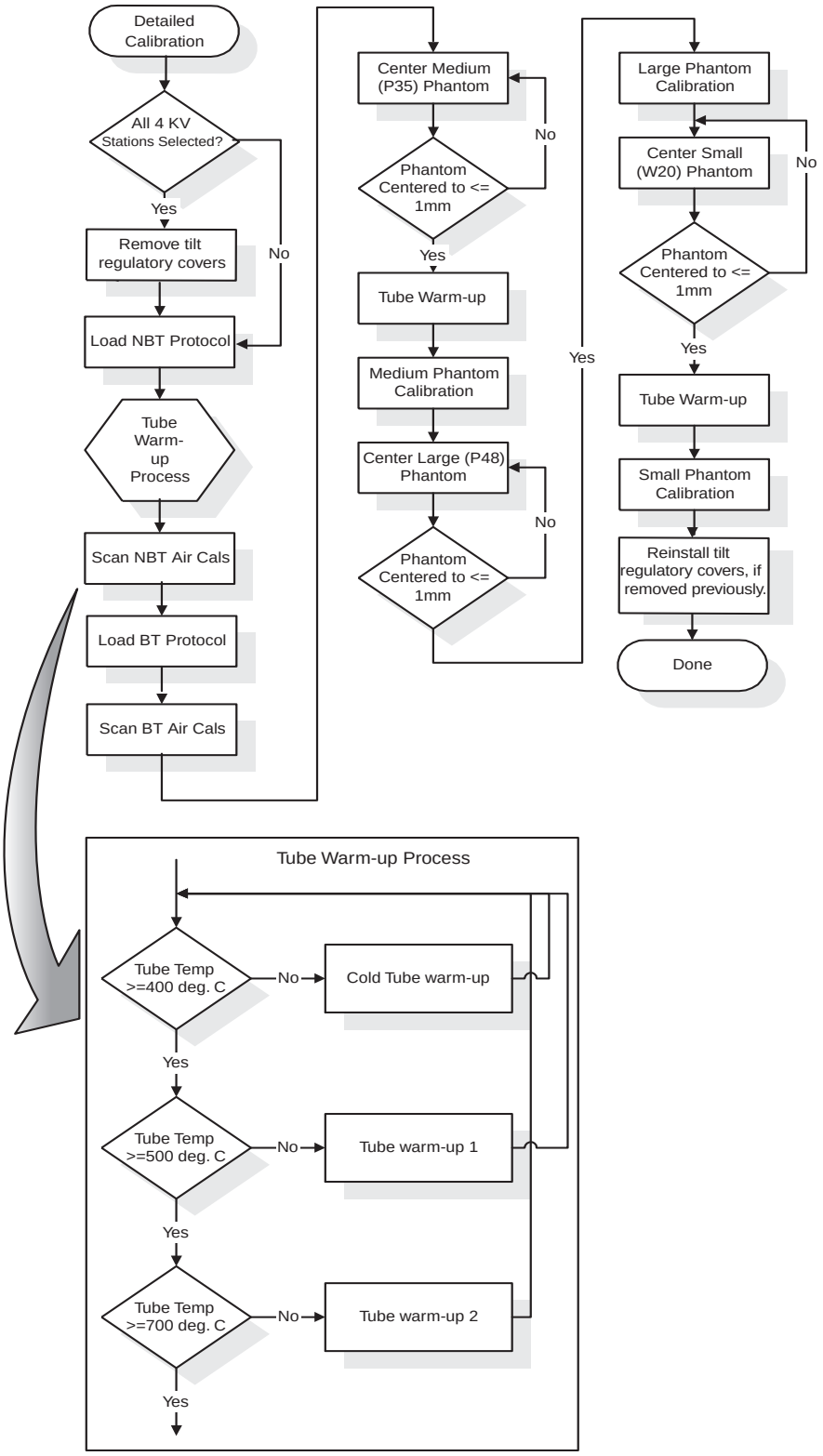


Figure 12-41 Calibration Flowchart: Non-Bow-tie, Bow-tie and Phantom Centering

1.) System performs gantry balance check. If this test does not pass, it is not recommended that you perform calibrations until the balance issue is resolved.

NOTICE **Detailed calibrations generate significant heat in the gantry. If all four (4) KV stations are to be calibrated, you must remove the two tilt regulatory covers, located on the lower right and left sides of the gantry behind the side covers.**

If the covers are not removed, a detector over-temperature condition will occur that will result in the premature termination of the calibration process. This will result in two hours of wasted time and a complete restart of the calibration procedure.

2.) If all four (4) KV stations are selected for calibration, remove tilt regulatory covers (see Tilt Regulatory Covers on page 614). Up to three (3) KV stations may be calibrated without removing the covers.

3.) Bring up the main menu: It is represented as an icon located on the bottom of the screen labeled as “Scanner Utilities”. Click the on-screen SCANNER UTILITIES button (**left head**).

4.) The Main menu consists of the following three button selections:

- Detailed Calibration - Brings up the Detailed Calibration screen.
- Adjust **CT** Number - Not implemented at this time
- Quit - Exits the application

5.) Detailed Calibration menu (refer to Figure 12-42)

Click the on-screen button DETAILED CALIBRATION. The Detailed Calibration screen consists of several rows of toggle buttons that can be selected to build the desired techniques needed to perform detailed calibration processing. These buttons are located on the top left area of the screen.

- kV toggle button selections: 80 kV, 100 kV, 120 kV, and 140 kV.
- **SFOV** toggle button selections: Small/Head and Large/Body
- Slice Collimation toggle button selections: 4x1.25, 4x2.50, 4x3.75, and 4x5.00.
- Focal Spot toggle button selections: Small and Large.

Comment: *The defaults select all techniques and aperture settings. The customer has the option to select specific kVs that are used most often. It is preferred to calibrate all kV stations. All aperture settings must be calibrated or they cannot be used for scanning.*

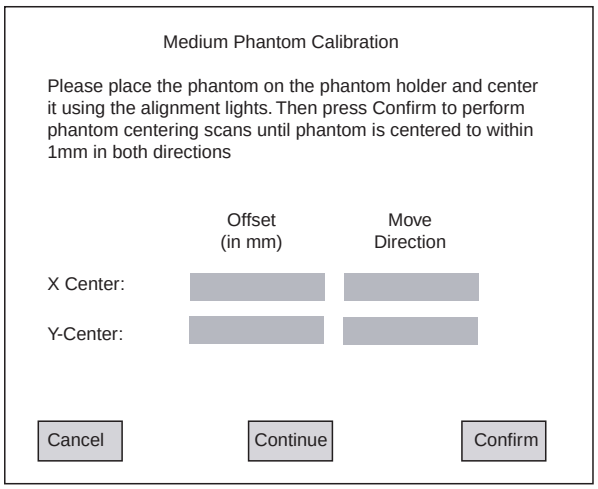


Figure 12-42 Phantom Centering & Calibration Screen

Note: There is also an option to perform new non-bow-tie air calibrations whether data from previous non-bow-tie calibrations exist in the CAL database or not. New non-bow-tie air calibration data can be created by selecting the option button labeled as “Acquire Non-Bow-tie Air Scans” on

the **GUI**. If this button is not selected, then the application performs a series of checks to determine whether non-Bow-tie air scans are necessary. Click the on-screen button CONFIRM.

6.) Activation (Scan List) Screen

Initially, the scrolled window on this screen displays a list of all scans that are performed for one of the following processes:

- Tube Warm up processing: Cold Warm up, Warm up 1, or Warm up 2
- Non-Bow-tie Air Calibration processing
- Bow-tie Air Calibration processing

The Activation screen title changes dynamically to indicate which process is currently running.

If for any reason a problem is detected, the current scan and processing aborts and the last scan be reacquired. When a problem is detected, the Activation screen's "Pause" button becomes a "Resume" button, scanning and processing of the current scan is aborted, and an error message may be displayed on the log.

At this point, selecting the "resume" button is recommended to re-acquire the last scan in order to continue the detailed calibrations. This logic is implemented for all air and phantom scanning and processing.

7.) Phantom Centering and Calibration Screen (Figure 12-42)

This screen is displayed automatically after the air calibrations complete successfully. For each Phantom there are two functions that must be accomplished on this level of processing: phantom centering and phantom calibrations. Medium, Large and Small phantom centering and calibrations are accomplished respectively using this **GUI** window.

NOTICE
Centering time must not exceed 10 min.

There is a requirement that the phantom centering process may not exceed a total of 10 minutes to complete. If the process ever exceeds this time limit, detailed calibrations cannot continue and must be aborted.

FOLLOW THESE STEPS:

a.) Place the correct size phantom on the phantom holder of the Gantry.

b.) Align the phantom manually on the gantry by using the alignment lights as a guide.

c.) On the small water phantom, make sure the alignment lights are centered on the water section. The black markers on the phantom are centered on the resolution section and the center of the water section is 60mm (2-3/8 inches) in front of the markers.

d.) Select the CONFIRM button to calculate the accuracy of the alignment. A list of scans needed for phantom centering is displayed and executed. When this process completes, the Activation screen disappears and the x and y coordinate values are displayed in the "Offset" fields provided for the "X-Center" and "Y-Center" rows. These fields are located directly below the instructions field.

e.) If either x or y coordinate value is greater than 1mm, repeat steps 2 and 3 until both values are less than or equal to 1 mm. The values in the field "Move Directions" indicate where to move the phantom on the gantry to help in aligning the phantom more accurately.

f.) Once x and y coordinates are less than or equal to 1mm, the phantom is centered and ready to be calibrated. Select the "Continue" button to begin calibrations.

g.) The "Cancel" button may be selected at any time while scanning is not in progress. This brings down the window and re-displays the Detailed Calibration screen.

Note: As soon as the CONTINUE button is selected, the application checks the X-ray tube temperature to determine whether the tube needs to be warmed up before scanning can begin.

8.) If removed in step 2, reinstall the tilt regulatory covers (see Tilt Regulatory Covers on page 614).

Section 12.0
Gantry Rotation Safety Check

This test proves that the scanner is safe to rotate at maximum rotation speed.

WARNING **CRUSH HAZARD.**

EQUIPMENT COULD EJECT FROM GANTRY.

ENSURE THAT NO PERSONNEL ARE IN THE SAME ROOM/AREA AS THE GANTRY, PRIOR TO AND DURING THIS SCAN.

Use DDC to Rotate the Gantry for 10 minutes, at the fastest allowed gantry speed.

CT SYSTEM TYPE	MAX GANTRY ROTATION (SERVICE)
LightSpeed Pro16	0.5 sec/rev
LightSpeed RT	0.5 sec/rev
LightSpeed 16	0.5 sec/rev
LightSpeed Ultra	0.5 sec/rev
LightSpeed Plus	0.5 sec/rev
LightSpeed QX/i	0.8 sec/rev
HiSpeed QX/i	0.5 sec/rev
HiSpeed CT/i	0.8 sec/rev
HiSpeed NX/i, ZX/i	0.8 sec/rev

Table 10: CT Systems and their fastest (service) allowable gantry speeds

1.) Launch Diagnostic Data Collection (DDC) Utility:
   a.) Open the Common Service Desktop
   b.) Click on the DIAGNOSITICS Icon
   c.) Click on the DATA ACQUISITION Folder
   d.) Click on the DIAGNOSTIC DATA COLLECTION Menu Item
2.) Prepare System for DDC Scan. Refer to Figure 12-43.
   a.) Select ROTATING X-RAY OFF
   b.) Type: **120** in `Scan Time (sec)` field
   c.) Type: **0.5** (or fastest allowed speed for your system in service mode) in the `Gantry Velocity (sec/rev)` field.
   d.) `No of Scans` = **5**. This will result in 10 minutes of rotation.
   e.) Verify other settings, as shown.
   f.) Click on ACCEPT RX button, to send scan request to firmware

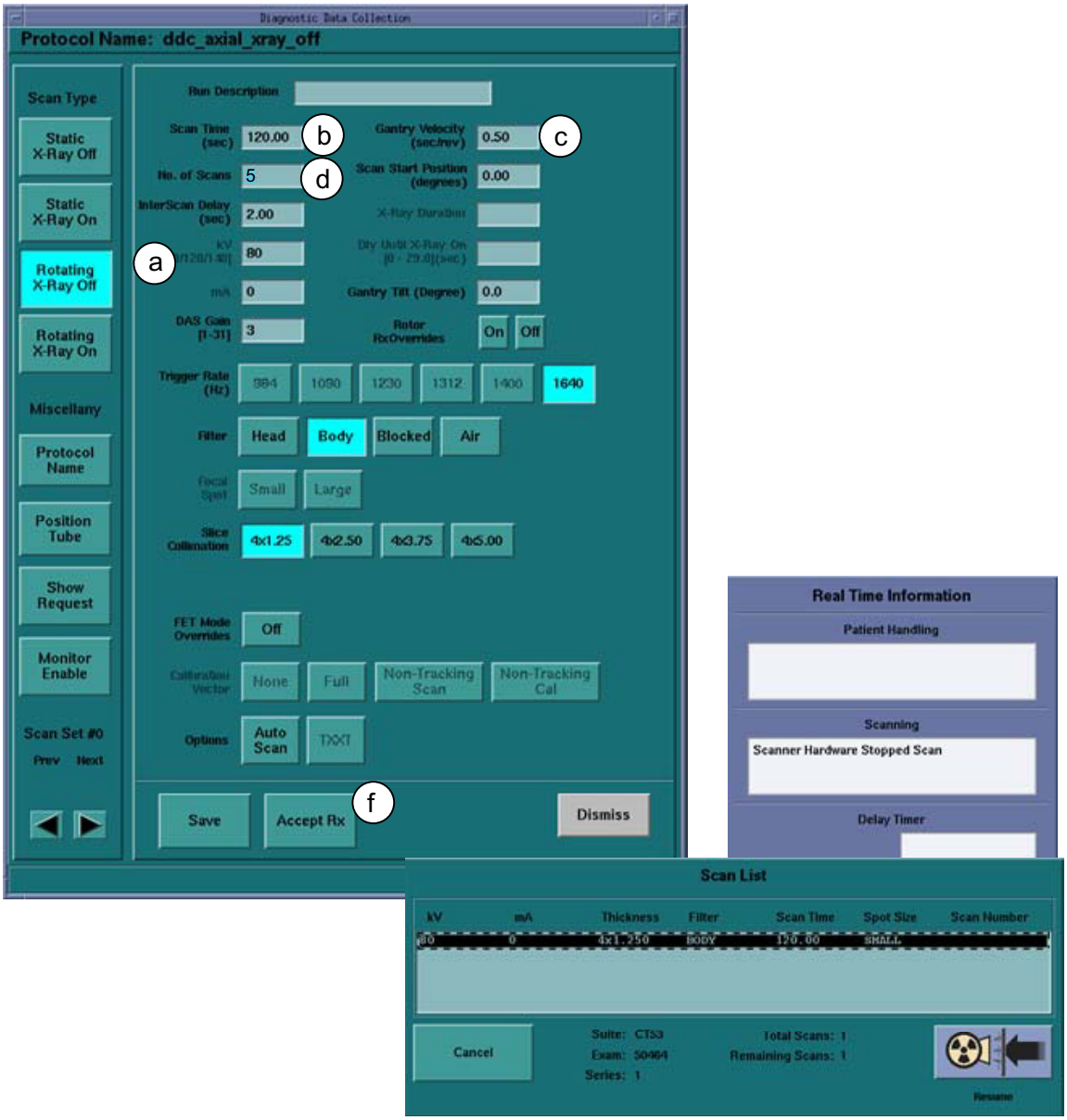


Figure 12-43 DDC Tool

The Utility:

- Displays the Scan List GUI and the Real Time Information window.
- After a few seconds, it starts flashing the **SCAN** button on the console.

3.) Press the Scan button on the Console, to start the DDC Scan. When complete, the DDC Utility dismisses the Scan List GUI and the Real Time Information window.

Section 13.0
Exposure Time Accuracy

Begin at the top level Service Screens, and execute the following sequence of soft-keys:

1.) Select SERVICE DESKTOP.
2.) Select DIAGNOSTICS.
3.) Select DIAGNOSTIC DATA COLLECTION (DDC).
4.) Select MONITOR ENABLE, to display scan times in the message log.
5.) Change to the EXAMRX Desktop.
6.) Select NEW PATIENT and prescribe the following scans.

Section 14.0
Scout Scan Times

Use examrx to take scout scans with the following distances. (Total of six scans.)

1.) Distance in mm: **20, 25, 30, 40, 150, 300, 480**
2.) Use **120KV** and **40MA**
3.) Record the scan time, displayed in the message log, on the **HHS** data sheet.

Section 15.0
Axial and Helical Scan Times

15.1 Axial Scans

Use normal applications (new patient) to acquire Axial Scans with the following parameters:

1.) Use **120KV** and **40MA**
2.) Use the following scan time and **FOV**

SELECTED TIME	FOV
0.6 sec	small **FOV**
0.6 sec	large **FOV**
1.0 sec	large **FOV**
2.0 sec	large **FOV**
3.0 sec	large **FOV**
4.0 sec	large **FOV**

Table 12-4 Axial Scan Times and FOVs

15.2 Helical Scans

Use normal applications (NEW PATIENT) to acquire Helical Scans with the following parameters:

1.) Use **120KV** and **40MA**
2.) Use **10MM** Scan Thickness
3.) Use the following scan time and location

SELECTED TIME	SCAN LOCATION
15.0 sec	S70-170
28.0 sec	S135-I135
30.0 sec	S145-I145

Table 12-5 Helical Scan Times and FOVs

4.) When you complete the scan time tests, switch back to the SERVICE DESKTOP to display the Diagnostic Data Collection screen, and toggle the MONITOR ENABLE **OFF**. Otherwise, the message log fills with kV, mA and scan statistics.

Section 16.0
X-Ray Verification

Note: Refer to Chapter 2, Section 3.5.2 - Interconnect/X-Ray Verif Test for details on X-Ray Verification.

1.) Select SERVICE DESKTOP.
2.) Select DIAGNOSTICS.
3.) Select DAS TOOLS.
4.) Select X-RAY VERIFICATION.
5.) Run tests and record results in Form 4879 upon successful completion.

Appendix A
Torque

Section 1.0
Recommended Torque Wrench Practices

1.) Never use a torque wrench to loosen a tightened fastener.
Permanent damage of the internal mechanism can occur due to excessive strain.

2.) Always approach the specified torque slowly. This is not a speed wrench.

   a.) Hand location is important. Position one hand at the axis of rotation and one hand on the tool handle. This give the user stability and accurate torque repeatability.

   b.) Always approach the desired torque evenly and slowly. If the desired torque is 66 N-m on 4 bolts, then tighten each bolt 50 to 70% of desired value. Then set the wrench to the required torque and tighten slowly until the wrench “Just Clicks”.

3.) Always release the tension on the torque wrench to prevent “spring set” on adjustable or “clicker” type torque wrenches. This will ensure correct torque settings throughout the range of the tool.

4.) Always allow the tool to reach room temperature.

   - Spring tension is the basis of “Clicker” type torque wrenches.
   - A spring’s tension changes with temperature.

5.) Calibrate the tool on a regular schedule.
Follow established local calibration processes.

6.) Do not drop or shock the tool.
Internal damage can occur. Calibration should be performed to ensure accuracy.

7.) Do not attempt to straighten a bent “Beam” or non adjustable wrench. Replace it.

8.) Never use a “Universal Joint” with a torque wrench.
The angle of the universal joint can change the torque value by more than 50%.

9.) Always use the torque wrench with a 90 degree angle whenever possible.

   a.) Figure A-3 illustrates the effects not being perpendicular.

   b.) The 25 degree tilt is the physical limit of a Bondhus Ball End Hex key.

   c.) Use the specified torque value for the HV tank mounting fasteners. Do not attempt to calculate the sin angle correction.

   There is less than 2% error for up to 10 degrees of tilt from the desired angle.

   d.) Minimize the angle as much as possible.

10.) Always clean fastener threads to reduce friction.
Fasteners should thread easily using finger pressure.

   a.) Replace fasteners or clean threads using a tap or die, compressed air, brass brush.

   b.) Never use a tap to clean thread inserts. It will damage them requiring replacement.

11.) Never lubricate a fastener unless specifically instructed.
Loctite is considered in the design. It must be used when specified.

12.) Replace Nylon nuts if they are finger loose.

13.) **ALL FASTENERS HAVE A TORQUE REQUIREMENT.** DEFAULT TABLES SHOULD BE USED **ONLY** IF THE SERVICE DOCUMENTATION DOES NOT SPECIFY A TORQUE VALUE.

Section 2.0
General Torque Cross Reference

Table A-1 and Table A-2 are provided as default references only. Use the appropriate replacement procedure to verify the correct torque requirement for each specific fastener.

Note: The *Illustrated Parts List* contains Engineering drawings that should also be used as a reference. These drawings call out specific instructions as notations, where needed.

NOTICE **Use Table A-1 and Table A-2 only as a last resort. If the Service documentation does not contain specific torque values, the default values can then be assumed to apply.**

All Fasteners use either "flat and lock washers" or loctite. These items must be used as specified.

FASTENER SIZE	TOOL SIZE HEX KEY	TOOL SIZE SOCKET	TORQUE IN N-M	TORQUE IN LBF-FT	TORQUE IN LBF-IN
M3	2.5 mm	5.5 mm	1	-	8.9
M4	3 mm	7 mm	2.3	1.7	20.4
M6	5 mm	10 mm	7.9	5.8	70
M8	6 mm	13 mm	19	14	168
M10	8 mm	16 mm	38.4	28.3	-
M12	10 mm	18 mm	66.4	48.9	-
M16	14 mm	24 mm	160	117.8	-

Table A-1 Default Torque Values as Specified by GEMS CT for Lightspeed Plus and Forward

FASTENER SIZE	TORQUE IN STEEL	TORQUE IN ALUMINUM	TOOL SIZE HEX KEY	TOOL SIZE SOCKET
3/8 - 16	25 +/- 2 Lbf-Ft 33.9 +/- 2.7 N-m	20 +/- 2 Lbf-Ft 27.1 +/- 2.7 N-m	5/16	9/16
1/4 - 20	8 +/- 1 Lbf- Ft 10.85 +/- 1.36 N-m	5 +/- 0.5 Lbf-Ft 6.8 +/- 0.7 N-m	3/16	7/16
8 - 32	20 +/- 2 Lbf-In 2.26 +/- 0.23 N-m	15 +/- 2 Lbf-In 1.7 +/- 0.23 N-m	9/64	5/16

Table A-2 Default Torque Values as Specified by GEMS CT for Lightspeed QXI and Previous

Many service operations on this CT scanner require a torque wrench. The use of a torque wrench may appear complicated because there are several standards and metrics. Using conversion factors and the conversion chart below can simplify that task.

First, only use a calibrated torque wrench. Use a torque wrench that is on a Calibration schedule and is approved by GEMS-AM Service. The kit that can be used that is on a regular Calibration schedule is kit number 46-268445G1. This torque wrench kit has wrenches that measure inch pounds and foot pounds.

Second, make any necessary conversions for the torque wrench you are using.The units of measure are typically marked on most torque wrenches. To make conversions to Kgcm and Newton meters, use the following conversion table, or calculate using conversion factors.

Kilogram Centimeter (Kgcm)	Inch lbs (in-lbs)	Foot lbs (Ft-lbs)	Newton Meters (Nm)
1	0.868	-	-
2	1.74	-	-
3	2.6	-	-
4	3.5	-	-
5	4.3	-	-
6	5.2	-	-
7	6.1	-	-
8	6.9	-	-
9	7.8	-	-
10	8.7	-	0.98
20	17.4	1.4	1.96
30	26.0	2.2	2.94
40	34.7	2.9	3.92
50	43.4	3.6	4.90
60	52.0	4.3	5.88
70	60.8	5	6.86
80	69.4	5.8	7.85
90	78.1	6.5	8.83
100	86.8	7.2	9.81
200	173.6	14.5	19.61
300	260.4	21.7	29.42
400	347.2	28.9	39.23

Table A-3 Torque Conversion Cross Reference

TORQUE CONVERSION FACTORS

- To convert Kgcm to foot-lbs, multiply Kgcm by 0.07233
- To convert Kgcm to inch-lbs, multiply Kgcm by 0.8679
- To convert Kgcm to N-m, multiply Kgcm by 0.0981
- To convert N-m to inch-lbs, multiply N-m by 8.8508
- To convert N-m to foot-lbs, multiply N-m by 0.73756
- To convert foot-lbs to N-m, multiply lbf-ft by 1.3558
- To convert inch-lbs to N-m, multiply lbf-in by 0.11298

Section 3.0
Torque Formula

T = R x F x sin (angle)

Where: T = Torque in N-m

R = Distance from axis of rotation

F = Force Applied

Sin(90) = 1

From this formula we can see that it is necessary to apply the force at a 90 degree angle to the axis of rotation to achieve accurate fastener torque. This same principle can be applied when using accessories with the torque wrench. See Figure A-1 and Figure A-2.

Note: The length of a standard square drive extension has no effect on torque since it is along the axis of rotation. See Figure A-3.

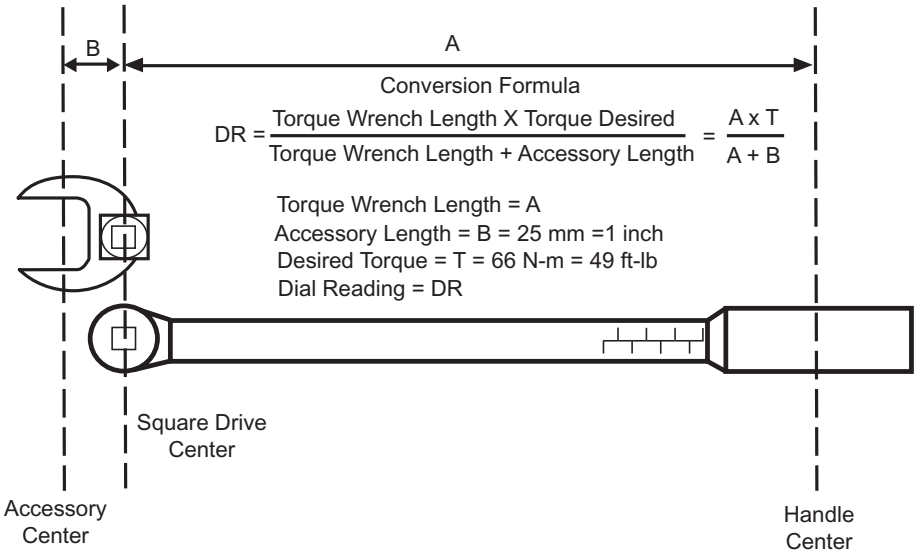


Figure A-1 Formula to adjust for Straight Line Accessory

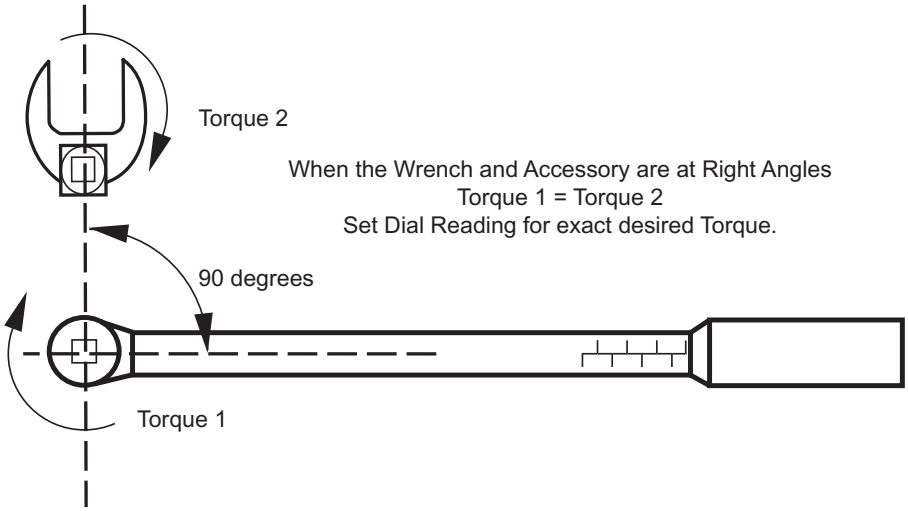


Figure A-2 Formula for 90 Degree Accessory Usage

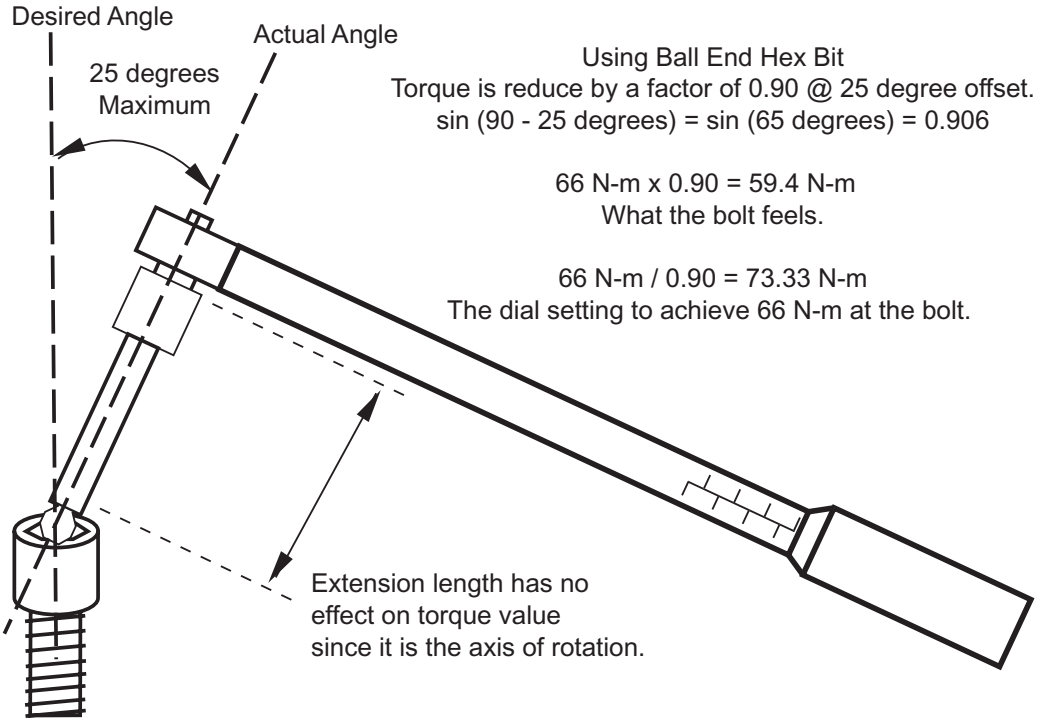


Figure A-3 Formula when not at 90 Degree to Axis of Rotation

Section 4.0
Torque Wrench Accuracy

It needs to be clearly understood that “torque” is an indirect measure of tension or “preload force”. The components of a bolted joint can be defined as,

- Preload force (Fp), bolt stretch.
- Tension force (Ft), resistance of bolted materials.
- Clamping force (Fc), difference of preload and tension forces.
- Shear force (Fs), sideways or sliding force of bolted materials.

Therefore, Fc = Fp - Ft

With shear force, a properly designed and tightened joint, the friction between the bolted materials absorbs the stress and the bolt itself feels little to no load.

There are other factors that need to be considered as well. Fastener material has a large effect on torque versus preload force. Lubricants can also significantly change the effects of torque versus preload force. Anti-seize compounds can reduce the needed torque up to 20%.

In short, torque measurement is an economical method of achieving a properly tensioned joint. Other methods are available, but training needs and tool expense increase.

CT Engineering has taken into account the variability of using torque wrenches. The design standard applied is a safety factor of 8 on all fasteners, after the “G Force” load is calculated for each component. This is to ensure clamping force is maintained without exceeding the strength of the fastener.

Various studies have been performed on the effectiveness of torque wrench accuracy. The following conclusions have been made.

PRELOAD MEASURING METHOD	ACTUAL PRELOAD FORCE ERROR
“Feeling”	> 35%
Torque Wrench	+/- 25%
Angle Torquing	+/- 15%
Indicating Washer	+/- 10%
Fastener Elongation	+/- 5%
Strain Gauge	+/- 1%

Table A-4 Torque Method Accuracy

As demonstrated in Table A-4, not using a torque wrench is the worst case event.

The “Feeling” method also changes with the tool. A ¼” drive “feels” different than a ½” drive.

Appendix B
Hardware Cross-Reference

SOCKET HEAD CAP AND THREAD PITCH	HEX KEY SIZE NOMINAL	HEX HEAD CAP AND THREAD PITCH	SOCKET WRENCH SIZE NOMINAL
M1.6 x 0.35	1.5mm	N/A	N/A
M2 x 0.4	1.5mm	N/A	N/A
M2.5 x 0.45	2.0mm	N/A	N/A
M3 x 0.5	2.5mm	N/A	N/A
M4 x 0.7	3.0mm	N/A	N/A
M5 x 0.8	4.0mm	M5 x 0.8	8.0mm
M6 x 1.0	5.0mm	M6 x 1.0	10.0mm
M8 x 1.25	6.0mm	M8 x 1.25	13.0mm
M10 x 1.5	8.0mm	M10 x 1.5	16.0mm
M12 x 1.75	10.0mm	M12 x 1.75	18.0mm
M14 x 2.0	12.0mm	M14 x 2.0	21.0mm
M16 x 2.0	14.0mm	M16 x 2.0	24.0mm
M20 x 2.5	17.0mm	M20 x 2.5	30.0mm
M24 x 3.0	19.0mm	M24 x 3.0	36.0mm
M30 x 3.5	22.0mm	M30 x 3.5	46.0mm
M36 x 4.0	27.0mm	M36 x 4.0	55.0mm
M42 x 4.5	32.0mm	M42 x 4.5	65.0mm
M48 x 5.0	36.0mm	M48 x 5.0	75.0mm

Table B-1 American Standard Metric Hex/Socket Head Cap Screws to Tool Cross Reference

Appendix C
Installation of FlexTrial Options

Section 1.0
Description

FlexTrial is a trial program offering GE Medical Systems customers a chance to "try before they buy" purchase option software. It helps customers evaluate application software—with no financial obligation or risk.

Option keys are automatically activated for 30 days through an automated web-based download procedure. For sites that can not be accessed remotely, a key can be sent to a local GE employee, via e-mail or file download, and configured on the system manually.

Section 2.0
Information Required to Order FlexTrial Options

Before any FlexTrial option can be ordered, two pieces of information must be obtained from the system. If this information is not obtained, the request will be invalid.

1.) System ID. This is the system ID used when problem calls are placed for the system (i.e., Cares or Must). This identifies the means by which the service organizations uniquely identify the system.

2.) The system's unique Host ID. To find this ID number: at the Computer Console, go to the SERVICE DESKTOP and select SHELL. At the system prompt, type the following:

`check_config` **ENTER**

The system will respond with a number up to 10 digits (e.g., `1234567890`). This is the system's unique Host ID number. No two **SGI** computers have the same number.

Section 3.0
Requesting an Option FlexTrial

To request a software option FlexTrial:

On the internet, call up the GE Medical Systems URL (http://www.gemedicalsystems.com) and select the community tab, or contact your local Software Sales Representative.

- In the Americas, contact GEMS Direct at 1-800-886-0815.
- In Europe, contact GEMSE Direct at 00 800 CALL GEMS (00 800 2255 4367);
  Northern Europe local +44 1753 874 881;
  Iberian Peninsula +34 91 375 4584;
  France +33 1 49 93 22 46;
  Central Europe +49 69 95 30 72 23;
  Italy +39 02 754 19 681
- In Asia, contact James Tan at +65-97 36 82 43
- or your local Service Sales Specialist.

The Software Sales Representative will verify system compatibility and forward the customer a FlexTrial agreement confirming their interest in the software for a limited trial of 30 days.

Time will expire for the software option at the completion of the 30 day period.

Section 4.0
Configuration for Systems with Remote Connection

Once connectivity of the system is established and successful download of the required key(s) has been achieved, the process requires no intervention by local GE personnel. The option key will be shown in the options list, but an application shutdown and startup, as prompted by the system, is required for the option to be enabled.

Section 5.0
Configuration for Systems without Remote Connection

A number string that represents the software license key will be generated. This key is valid for only 30 days. Once the key has been generated, it can be e-mailed, FTP'd to GLOBE, or sent to an address designated by the Software Sales Representative at the time the request was placed.

Note: Once a FlexTrial Key is generated, it will work for 30 days only. Any delay in manually configuring the key to the customer site will shorten the time the customer has to try the feature.

If you are to receive a license Key for a site, your e-mail will receive a new message with the subject line, "`License Key File for SysID:XXXX`". `XXXX` will be the system ID used when ordering the FlexTrial. Open the message and scroll to the bottom of the message to find the activation key(s). See Figure C-1.

```
#-----------------------------------------------------------------------------
#License strings will be added below in the created package
#-----------------------------------------------------------------------------
sprep99 flextrial 30 277a05aca21101312f672196
smartprep flextrial 30 18048594ac1101312f670668
```

Flex Trial keys

Figure C-1 FlexTrial keystring is the last 24 character string at the bottom

Figure C-1 shows two keys that have been sent. The number of keys depends on how many were ordered.

Once the keys are received, to activate, do the following at the system computer:

1.) Go into the **Service Desktop/ Utilities/ Install Options/ Start**.

2.) The ***Software Options*** window will be displayed. Select INSTALL. The window titled ***Select Mechanism*** will appear.

3.) From the ***Select Mechanism*** window, select FLEX TRIAL. The ***Enter String*** window will appear.

4.) In the ***Enter String*** window, enter the 24-digit character license string, and select ACCEPT. The ***Software Options*** window will then be displayed.

5.) From the ***Software Options*** window, select QUIT. The ***Options*** window will then be displayed.

6.) In the ***Options*** window, select OK.

7.) Restart the applications software, or shutdown and reboot the system by selecting the SHUTDOWN icon.

Section 6.0
Permanent Download Key Installation (Future Capability)

To permanently install a purchased permanent option with a downloaded option key, follow the procedure below.

1.) Go into the **Service Desktop/ Utilities/ Install Options/ Start**.
2.) The ***Software Options*** window will come up. Select INSTALL. The window titled ***Select Mechanism*** will be displayed.
3.) From the ***Select Mechanism*** window, select PERMANENT. The ***Select Device*** window will then be displayed.
4.) From the ***Select Device*** window, select MANUAL. The ***Enter String*** window will then appear.
5.) In the ***Enter String*** window, enter the 24-digit character license string, and select ACCEPT. The ***Software Options*** window will then be displayed.
6.) From the ***Software Options*** window, select QUIT. The ***Options*** window will then be displayed.
7.) In the ***Options*** window, select OK.
8.) Restart the applications software or shutdown and reboot the system by selecting the SHUTDOWN icon.

Section 7.0
De-Install a FlexTrial Option

Should there be a need to de-install a FlexTrial option before its 30 day expiration period, follow the procedure below:

1.) Go into the **Service Desktop/ Utilities/ Install Options/ Start**.
2.) The ***Software Options*** window will come up. Select the option(s) to be de-installed and select REMOVE. The ***SW Options Error*** window will then be displayed.
3.) From the ***SW Options Error*** window, select OK to permanently remove the option. The ***Software Options*** window will then be displayed.
4.) From the ***Software Options*** window, select QUIT. The ***Options*** window will be displayed.
5.) In the ***Options*** window, select OK.
6.) Restart the applications software or shutdown and reboot the system by selecting the SHUTDOWN icon.

Appendix D
FORM 4879 (Data Record)

NOTICE
Potential for Data Loss and/ or Equipment Damage

To prevent potential data loss, please do the following:

- **Record data collected from procedures into Form F4879 if directed, located in this chapter.**
- **Only use the Installation manual that arrives with your system for installation. Any other revisions of this manual may not exactly match your system.**

Section 1.0
Site History

SYSTEM HISTORY

Where Installed _____

City _____ State _____

Customer's Telephone Number _____ Room No._____

System I.D. No._____

Operator's Console (Master Control)

Model Number _____ Serial Number _____

System Gantry

Model Number _____ Serial Number_____

Dates of Tests _____ Performed by _____

Table D-1 Data Record

TEST EQUIPMENT HISTORY

Test Equipment Used (If Applicable)				
Name	**Manufacturer**	**Model Number**	**Serial Number**	**Calib. Due**
HV Bleeder				
Oscilloscope				
DMM				

Table D-2 Test Equipment Used

COMPONENT TRACEABILITY

The Component Locator Installation Report has been completed and sent to the Product Locator File.

Certified Component Changes				
Equipment	**Model Number**	**Serial Number**	**Install Date**	**Exp. Ctr. Reading**
Old Tube Casing				
Old Tube Insert				
New Tube Casing				
New Tube Insert				
Old Detector				
New Detector				
Old Collimator				
New Collimator				
Old Anode Tank				
New Anode Tank				
Old Cathode Tank				
New Cathode Tank				

Table D-3 Certified Component Changes

Section 2.0
System Tests

Inst.	Tube	P.M.
Det.	Col.	HV Tank

After installing a system, or repairing or replacing one of the subsystems listed in Table D-3 on page 980, complete the required system tests, and fill out the corresponding portions of Form 4879. If the device name appears in the table, run the corresponding test and fill in the values. If the name is blacked out, you don't have to fill in that portion of the form.

MA METER VERIFICATION - HHS REQUIREMENT

Initials:_____

Inst.	Tube	P.M.
Det.	Col.	HV Tank

Circuit ON		
	A/D	Range
Anode mA		15 - 25
Cathode mA		15 - 25
DVM - A/D = Delta Compare Delta to Limits		

Table D-4 mA Meter Verification (Table 1)

MA METER VERIFICATION - HHS REQUIREMENT

Initials:_____

Inst.	Tube	P.M.
Det.	Col.	HV Tank

Circuit OFF					Circuit ON				
	DVM	A/D	Delta	Limits +/-		DVM	A/D	Delta	Limits+/-
Anode KV	0.0	*	*	0.5	Anode KV	50.0	*	*	7.5
Cathode KV	0.0	*	*	0.5	Cathode KV	50.0	*	*	7.5
Total KV	0.0	*	*	0.5	Total KV	100.0	*	*	15.0
DVM - A/D = Delta Compare Delta to Limits * Ignore these values at this time.									

Table D-5 mA Meter Verification (Table 2)

Circuit OFF					Circuit ON				
Anode mA				0.5	Anode mA				4.5
Cathode mA				0.5	Cathode mA				4.5

DVM - A/D = Delta Compare Delta to Limits
* Ignore these values at this time.

Table D-5 mA Meter Verification (Table 2)

NEW TUBE SEED SHIFT - HHS REQUIREMENT

Initials:_____ ☐ Check box when complete

Inst.	Tube	P.M.
Det.	Col.	HV Tank

SIGNAL TO NOISE TEST (X-RAY VERIFICATION)

Initials:_____ ☐ Check box when complete

Inst.	Tube	P.M.
Det.	Col.	HV Tank

TUBE Z-AXIS ALIGNMENT (FORMERLY TUBE PLANE OF ROTATION (POR)

☐ Check box when complete

Inst.	Tube	P.M.
Det.	Col.	HV Tank

Z-Align Used:Adjusted In Specification. (Go to Detector Z-Axis, step A),

-**OR**-

Tube Plane of Rotation (**POR**) using Film. XF - XR = 1.8mm ±0.3mm

BEAM ON WINDOW

☐ Check box when complete

Inst.	Tube	P.M.
Det.	Col.	HV Tank

1.) If you used Z-Align **(Future)** for the Z-Axis Alignment, no additional adjustment is necessary

-**OR**-

Run **BOW** on a cold tube. If you have to check **BOW** after completing the system alignments, let at least three hours elapse from the last scan, to let the tube completely cool.

- The channel should equal -1.5mm ±0.25mm on initial checks.
- The channel should equal -1.5mm±0.50mm on verification checks.
- This program computes the position of the detector in three places: Right, Center and Left

2.) Record the displayed position values in the following table:.

Right/Low	Center/Medium	Left/High

Table D-6 Beam On Window

ISOCENTER

☐ Check box when complete

Inst.	Tube	P.M.
Det.	Col.	HV Tank

Average of Large and Small Focal Spots. Spec: 389.75 ±0.02 channels

CENTER BODY FILTER (CBF)

☐ Check box when complete

Inst.	Tube	P.M.
Det.	Col.	HV Tank

Adjust **CBF** Value. Spec: Target Value ±0.2 channels

COLLIMATOR APERTURE CHECK - HHS REQUIREMENT

Initials:_____ ☐ Check box when complete

Inst.	Tube	P.M.
Det.	Col.	HV Tank

Aperture	Center	Spec - Center only
Small		3.783 ±5%
Large		5.9 ±5%

Table D-7 Collimator Aperture Check

VERIFICATION OF HV TANK FEEDBACK RESISTORS - HHS REQUIREMENT

(Formerly Calibration of HV Tank Feedback Resistors)

Initials:_____

Inst.	Tube	P.M.
Det.	Col.	HV Tank

Use KV Test (Only if KV test baseline available) and fill in the chart: Verification of total kV.

Nominal kV	Expected	Measured	% Deviation ±1%
100			

Table D-8 KV Test

-**OR**-

Use the HV Divider and Oscilloscope

ANODE AND CATHODE

Technique	Anode Divider	Displayed Anode KV	Delta KV	Limits ± KV
100/50L				0.5

Table D-9 Anode Test

Technique	Cathode Divider	Displayed Cathode KV	Delta KV	Limits ± KV
100/50L				0.5

Table D-10 Cathode Test

Anode Divider - Displayed Anode = delta KV

Cathode Divider - Displayed Cathode = delta KV

Compare delta KVs to limits. Anode and Cathode computer displayed readings have a limit of 50.0 ± 0.5 KV.

TOTAL KV

Technique	Cathode and Anode Divider	Displayed Total KV	Delta KV	Limits ± KV
100/50L				1.5

Table D-11 Cathode & Anode Test

(Cathode & Anode Divider) - Displayed Total KV = delta KV, Compare delta kV to limits

KV METER VERIFICATION

Circuit OFF					Circuit ON				
	DVM	A/D	Delta	Limits ±		DVM	A/D	Delta	Limits ±
Anode KV	0.0			0.5	Anode KV	50.0			7.5
Cathode KV	0.0			0.5	Cathode KV	50.0			7.5
Total KV	0.0			0.5	Total KV	100.0			15.0
Anode mA	*	*	*	0.5	Anode mA	*	*	*	4.5
Cathode mA	*	*	*	0.5	Cathode mA	*	*	*	4.5
* Ignore these values at this time.									

Table D-12 KV Meter Verification

DVM - A/D = Delta, Compare Delta to Limits.

AUTO MA CAL

☐ Check box when complete

Inst.	Tube	P.M.
Det.	Col.	HV Tank

The MX200 tube uses a metal/ceramic frame, which means some electrons hit the target and actually bounce off, and are then captured by the frame. This causes a frame current, which results in an anode mA measurement of slightly less than the cathode mA, typically 5 to 10% less. Because the cathode mA is the true indicator of radiation output, the CT system controls cathode mA rather than anode mA.

KV AND MA VERIFICATION DATA SHEET HHS REQUIREMENT

Initials:_____

Inst.	Tube	P.M.
Det.	Col.	HV Tank

Data sheet complete and meets specification (attach print out/film from system if available).

SMALL FOCAL SPOT TECHNIQUE											
		At 5ms		Spec Limits	Cathode		Anode			Spec Limits for	
KV	mA	KV	mA	for mA at 5ms	KV	mA	KV	mA	Tota l KV	Total KV	Cathode mA
80	40			34-44						78.4-81.6	36.2-43.8
	70			59-77						78.4-81.6	65.6-74.4
	100			85-110						78.4-81.6	95.0-105
	150			128-165						78.4-81.6	144-156
	200			170-220						78.4-81.6	193-207
	300			255-330						78.4-81.6	291-309
100	40			34-44						98-102	36.2-43.8
	70			59-77						98-102	65.6-74.4
	100			85-110						98-102	95.0-105
	150			128-165						98-102	144-156
	200			170-220						98-102	193-207
	240			204-264						98-102	232.2-247.8
120	40			34-44						117.6-122.4	36.2-43.8
	70			59-77						117.6-122.4	65.6-74.4
	100			85-110						117.6-122.4	95.0-105
	150			128-165						117.6-122.4	114-156
	200			170-220						117.6-122.4	193-207
140	40			34-44						137.2-142.8	36.2-43.8
	70			59-77						137.2-142.8	65.6-74.4
	100			85-110						137.2-142.8	95.0-105
	130			110-143						137.2-142.8	124.4-135.6
	170			144-187						137.2-142.8	163.6-176.4

Table D-13 Small Focal Spot Technique

KV AND MA VERIFICATION DATA SHEET HHS REQUIREMENT

Initials:_____

Inst.	Tube	P.M.
Det.	Col.	HV Tank

Data sheet complete and meets specification (attach print out/film from system if available).

LARGE FOCAL SPOT TECHNIQUE											
		At 5ms		Spec Limits	Cathode		Anode			Spec Limits for	
KV	mA	KV	mA	for mA at 5ms	KV	mA	KV	mA	Total KV	Total KV	Cathode mA
80	40			34-44						78.4-81.6	36.2-43.8
	70			59-77						78.4-81.6	65.6-74.4
	100			85-110						78.4-81.6	95.0-105
	200			170-220						78.4-81.6	193-207
	300			255-330						78.4-81.6	291-309
	400			340-440						78.4-81.6	389-411
100	40			34-44						98-102	36.2-43.8
	70			59-77						98-102	65.6-74.4
	100			85-110						98-102	95.0-105
	200			170-220						98-102	193-207
	300			255-330						98-102	291-309
	420			357-462						98-102	408-432
120	40			34-44						117.6-122.4	36.2-43.8
	70			59-77						117.6-122.4	65.6-74.4
	100			85-110						117.6-122.4	95.0-105
	200			170-220						117.6-122.4	193-207
	300			255-330						117.6-122.4	291-309
	400			340-440						117.6-122.4	389-411
140	40			34-44						137.2-142.8	36.2-43.8
	70			59-77						137.2-142.8	65.6-74.4
	100			85-110						137.2-142.8	95.0-105
	200			170-220						137.2-142.8	193-207
	300			255-330						137.2-142.8	291-309
	340			289-374						137.2-142.8	330.2-349.8

Table D-14 Large Focal Spot Technique

RISE AND FALL TIMES - HHS REQUIREMENT

Initials:_____

Inst.	Tube	P.M.
Det.	Col.	HV Tank

Technique					
KV	**mA**	**Rise Delay ms**	**Limit**	**Fall Delay ms**	**Limit**
80	400		0 +1.9ms	Not Applicable	
140	40	Not Applicable			0 +2ms

Table D-15 Rise and Fall Times

VERIFICATION OF INTERNAL SCAN TIMER - HHS REQUIREMENT

Initials:_____

Inst.	Tube	P.M.
Det.	Col.	HV Tank

Technique					
KV	**mA**	**Oscilloscope Exposure Duration**	**Limit**	**Displayed Exposure Duration**	**Limit**
100	40		0.96-1.04 sec		0.99-1.02 sec

Table D-16 Verification of Internal Scan Timer

EXPOSURE TIME ACCURACY - HHS REQUIREMENT

Initials:_____

Inst.	Tube	P.M.
Det.	Col.	HV Tank

SCOUT SCANS

Technique Distance	Displayed Exposure Duration	Limit
50 mm		0.56 - 0.60
150 mm		1.52 - 1.64
600 mm		5.84 - 6.32

Table D-17 Scout Scans

AXIAL SCANS

Technique Time	Displayed Exposure Duration	Limit
0.8 or fastest scan		0.768 - 0.832
1.0		0.960 - 1.04
2.0		1.92 - 2.08

Table D-18 Axial Scans

HELICAL SCAN

Technique Duration	Displayed Exposure Duration	Limit
30.1 sec (5 mm image, 15 mm HQ mode)		28.9 - 31.3

Table D-19 Helical Scans

OPERATOR INDICATORS - HHS REQUIREMENT

Initials:_____

Inst.	Tube	P.M.
Det.	Col.	HV Tank

X-Ray Indicators on Front and Back of Gantry Illuminate During X-Ray

X-RAY BEAM LOCATION - HHS REQUIREMENT

Initials:_____

Inst.	Tube	P.M.
Det.	Col.	HV Tank

TOMO PLANE INDICATION ACCURACY

Refer to the system service manual, and verify that the relationship of the alignment lights to the x-ray beam meets compliance.

- Internal Lights (1mm)

- External Lights (1mm)
- All alignment lights remain visible with room lights at maximum settings.

IMAGE CALIBRATION

☐ Check box when complete

Inst.	Tube	P.M.
Det.	Col.	HV Tank

Detailed Calibrations completed and CT N Number adjustment completed. The Number of Phantom Cals vary with site-specific scanning protocols.

IMAGE QUALITY CHECK - HHS REQUIREMENT

Initials:_____

Inst.	Tube	P.M.
Det.	Col.	HV Tank

48CM POLY PHANTOM

48cm/L Scan parameters: 5mm (4i)/ 340mA /1 sec/16 Images

Exam/Series/ Image	AvXc	AvXo	AvXo - AvXc	AvSDo	Comments	Scan Tech Signature/ Date
__/__ / 1, 5, 9, 13						
2, 6, 10, 14						
3, 7, 11, 15						
4, 8, 12, 16						
SPECS	- - -	- - -	±8.5	<40.0	- - -	- - -

Table D-20 48cm Poly Phantom

*If your AvSDo fails, check to make sure you did not scan this technique at 1mm.

Box Size: 45 x 45 pixels

Center Coordinates: 256, 256

Outside Coordinates: 256, 60 452, 256256, 45260, 256

Image Acceptance/Date: _____

Certified Image Reviewer:_____

ARTIFACT LIMITS:

Rings:	**Smudge:**
48/L; 30 to 36 counts	48/L; 6.8 counts
1.25mm	1.25mm; 12.0 counts
Table D-21 Artifact Limits	
Band:	Streaks:
8.0 counts	4.0 counts
Band Radius:	Center Artifact:
0 to 23.5cm	N/A
Clump:	**Center Artifact:**
48/L; 3.0 SIGMA	1.25mm; 14.0 counts
1.25mm; N/A	
Center Spot: N/A	

IMAGE QUALITY CHECK - HHS REQUIREMENT

Initials:_____

Inst.	Tube	P.M.
Det.	Col.	HV Tank

20CM QA#1 PHANTOM

QA#1 scan parameters: S/10mm (2i)/120kV/260mA/1 sec/4 images. Use this scan data for Bone Retro. Record data on **Form 4879**.

Exam/Series/ Image	MTF	MTF 2 slice avg.	Contrast Scale	Comments/ Artifacts	Scan Tech Signature/ Date
____/____ /1		MTF1 + MTF3 ÷ 2 =			
3					
2		MTF2 + MTF4 ÷ 2 =			
4					
SPECS	- - -	0.65 to 1.0	110.0 to 130.0	- - -	- - -

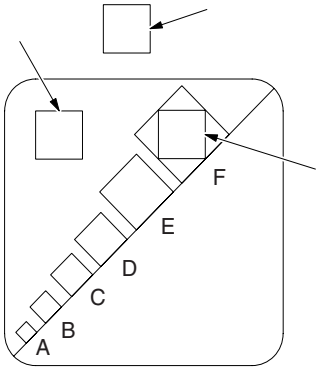
Table D-22 QA#1 Data (Prospective Images)

QA#1 scan parameters: S/10mm (2i)/120KV/260mA/1 sec/4 images Bone Retro/Display **FOV** = 15cm Record data on **Form 4879**

Exam/Series/Image	Line Patterns Visible	Comments/Artifacts	Scan Tech Signature/ Date
_____/_____/1			
2			
3			
4			
SPECS	B, C, D, E, F	- - -	- - -

Table D-23 QA#1 Data (Retrospective Images)

Box Size: 17 x 17 pixels



Contrast Scale = mean of B–mean of C.

SD = SD of ROI Box over F slits.

SD = (SD + SC) /2

Modulation = _____

MTF = 2.2 (Modulation/Contrast Scale)

IMAGE QUALITY CHECK - HHS REQUIREMENT

Initials:_____

Inst.	Tube	P.M.
Det.	Col.	HV Tank

20CM QA#2 PHANTOM

QA#2 scan parameters: S/10mm (2i)/120KV/260mA/1 sec/Peristaltic OFF

Scan from S40.0 to S50.0 - Record results on **Form 4879**

Exam/Series/ Image at location S40.0	Visible Hole View w/ Window 20	Contrast Factor	Comments/ Artifacts	Scan Tech Signature/ Date
_____/_____/1				
3				
5				
7				
SPECS	See Table, below	2.0 to 12.0	- - -	- - -

Table D-24 QA#2 Data (Part 1)

Box size: 49 x 9 pixels

Contrast Factor	Visible Number of Holes: Lower Limit*	Visible Number of Holes: Upper Limit*	Smallest Visible Hole: Size
2.00 to 3.99	2	5	7.5mm
4.00 to 7.99	3	5	5.0mm
8.00 to 12.00	4	5	3.0mm

Table D-25 QA#2 Data (Part 2)

*Required number of visible holes depends on the contrast factor.

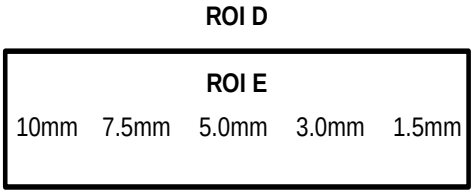
2 out of the 4 scans taken must meet this specification.

Image Acceptance/Date: _____

Certified Image Reviewer:_____

FOR REFERENCE ONLY:

Use the manual method for calculating Contrast Factor.



ROI D 49 X 9 pixels x=256, y=200
ROI E 49 X 9 pixels x= 256, y=235
Contrast Factor = Mean E – Mean D

IMAGE QUALITY CHECK - HHS REQUIREMENT

Initials:_____

Inst.	Tube	P.M.
Det.	Col.	HV Tank

20CM QA#3 PHANTOM

QA#3 scan parameters: S/10mm 2i/120KV/260mA/1 sec/8 Images

Scan from S55.0 to S65.0

Record data on **Form 4879.**

Exam/Series/ Image	AVXc 4 scan avg.	Std Dev 4 scan avg.	AvXo - AvXc	Comments/ Artifacts	Scan Tech Signature/ Date
____/____ / 1,3,5,7					
2,4,6,8					
SPECS	0 ±3.0	2.6 to 3.4	±3.0	- - -	- - -

Table D-26 QA#3 Data

Note: **The average value of each row in TableD-26 must meet the specifications technique listed at the bottom of the corresponding column.**

Box Size: 31 x 31 pixels at Coordinate (256, 256)

Center Coordinates: (256, 256)

Outside Coordinates: (256, 95), (417, 257), (256, 417), (95, 256)

Visually Inspect images for rings and bands

Visual results acceptable?.Yes: ☐

Artifact Limits:

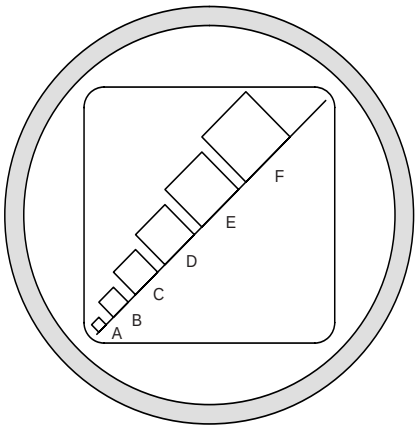
- **Rings:** 4.0/4.8 cts
- **Band:** 2.8 cts
- **Band Radius:** 0-8.5 cm
- **Clump:** N/A
- **Center Spot:** N/A
- **Center Artifact:** 3.5 Std. Dev.
- **Smudge:** 2.2 counts 1mm; 4.0 counts
- **Streaks:** 4.0 cts

Image Acceptance/Date: _____

Certified Image Reviewer:_____

UNUSUAL ALIASING, OTHER ARTIFACTS

Inst.	Tube	P.M.
Det.	Col.	HV Tank



Visual inspection for unusual aliasing, and other artifacts. Visual results acceptable? Yes: ☐

CT NUMBER CHECK

Inst.	Tube	P.M.
Det.	Col.	HV Tank

All CT N numbers for all calibrated techniques fall within 0 ±1.5 HU. All Values 0±1.5 HU? Yes: ☐

HEAT SOAK/SEASONING

☐ Check box when complete

Inst.	Tube	P.M.
Det.	Col.	HV Tank

COLLIMATOR CHANGE

- Required test data - Z axis detector alignment Polaroid
- Immediately submit Form 2579

Appendix E
Console Hardware Compatibility

Section 1.0
Recon CPU

Table E-1, below, can be used to help identify which model recon CPU — a.k.a. Power PC (PPC), RIP board or Motorola board — is used on which LightSpeed family console.

GE Part #	Motorola Part #	Used On Console Part #	(J15) Jumper Settings	(J16) Jumper Setting	Memory Size	Description
2207232* 2197234* 2197234-3	MVME2306	2180551	2-3	2-3	32MB	LS (QX/i) Octane I w/ O2 and H1.1 SW
2197234-4	MVME2306	2180551	2-3	2-3	32MB	LS (QX/i) Octane I w/ O2 and H1.2 SW
2197234-2	MVME2308	2180551-2	2-3	2-3	128MB	LS (QX/i) Octane I w/o O2
2197234-2	MVME2300	2266832 2266832-2	2-3	2-3	128MB	LS Plus with Octane I
2197234-2	MVME2300	2304732 2304732-2	2-3	2-3	128MB	LS Plus with Octane II
2197234-2	MVME2300	2266832-3 2266832-4	2-3	2-3	128MB	LS 3.X with Octane I
2197234-2	MVME2300	2304732-3 2304732-4	2-3	2-3	128MB	LS 3.X with Octane II
2197234-2	MVME2300	2341104	2-3	2-3	128MB	HS QX/i with Octane II
* Obsolete product						

Table E-1 Recon CPU & Console Compatibility Matrix

Section 2.0
DIP Board

Table E-2, below, can be used to help identify which model DIP board is used on which LightSpeed family console.

GE Part #	Used On Console Part #	Description
2160800	2180551	QX/i with Octane I w/ O2 and H1.1 (DIP Board found in O2 computer)
2160800	2180551	QX/i with Octane I w/ O2 and H1.2 (DIP Board found in O2 computer)
2216666	2180551-2	QX/i with Octane I w/o O2
2245261	2266832 2266832-2	Plus with Octane I
2245261	2304732 2304732-2	Plus with Octane II
2259530	2266832-3 2266832-4	LS 3.X with Octane I
2259530	2304732-3 2304732-4	LS 3.X with Octane II
2259530	2341104	HS QX/i with Octane II

Table E-2 DIP Board and Console Compatibility Matrix

Appendix F
ESD Management and Device Handling

Section 1.0
Electrostatic Discharge and Proper Device Handling

The circuit boards and disk drives for this system contain densely populated electronic components that are expensive and electrically sensitive. An electrostatic discharge (**ESD**) between 100 and 1000 V may damage a component. This is substantially less than the 3000 V discharge needed to feel any static. An **ESD** may cause an immediate failure, or it may weaken components to produce future, intermittent problems.

Always use the **ESD** strap pro-actively. Put circuit boards inside an anti-static bag or approved container before it is handled by a non-grounded person, moved from the grounded (**ESD** safe) area, or stored. Always place the board top side up on a flat surface when it is unmounted. Never handle the part outside its anti-static container unless the surrounding surfaces and you are grounded. Discharge the outside of the container before transferring the part.

PRO-ACTIVE ACTION	PROCEDURE
Turn power OFF	Turn power OFF before you touch, insert or remove parts containing electronic components.
Use wrist strap	Unless you are working near a live 30 V or more circuit, ground your wrist to the specially designed ground plug on the unit before you touch any parts. This includes connecting cables to a drive, board, device, or bulkhead. While wearing your strap, test it with a specially designed meter. If it fails, it may be due to dry skin; apply lotion to your wrist and test again. Throw away any strap that is more than three months old.
Don't let anything other than your grounded hand touch the electronic **FRU**	Do not let your sleeve, tie, pen, Styrofoam cup, plastic manual binder or clothing touch the circuit board or disk drive. Wearing cotton clothes and shoes with rubber-like soles may lessen how much **ESD** you generate walking across the room. Working in a room where relative humidity is under 20% can generate electrostatic voltages of 7000 to 35,000 Volts. However it only takes 100 V to destroy an **EEPROM**.
Use proper handling	Handle circuit boards, disk drives, or any electronic part as little as possible. Place them on an anti-static workbench pad or in a grounded static dissipative bag. Do not stack components. Store circuit boards in an anti-static container. Pink, blue, or clear poly bags do NOT give protection from external sources of **ESD**. Instead, a grounded anti-static box may be used as a static free work surface.
Treat failed parts the same as good ones	Don't add to the expense, complication and future un-reliability of a part by allowing it to be repeatedly zapped. Treat failed parts with proper **ESD** handling.

Table F-1 Actions that Reduce the Chances of ESD damage

PRO-ACTIVE ACTION	PROCEDURE
Use a special vacuum	Only use a vacuum of the type that prevents electrostatic buildup.
Use Ionizing Fan	The ionizing fan reduces the amount of charge built up in an area. The fan can be turned on and pointed in a general direction to keep an area from becoming statically charged. The fan can also be pointed at a single location to eliminate charge on that piece of equipment. Allow air to flow for at least six (6) seconds, for charge to dissipate.

Table F-1 Actions that Reduce the Chances of ESD damage (Continued)

Section 2.0
ESD Management Process

ESD MANAGEMENT TOOLS

GEMS CT has evaluated current ESD process and recommends the following items be utilized to aid in the prevention of materials damage due to ESD events.

1.) Anti-Static kit
   - Work Station Monitor
   - Wrist Strap
   - 20 foot grounding cord
   - Anti-static mat (Field Supplied)
2.) Aero Duster Air Spray System
3.) Aero Duster Spray (Field Supplied)
4.) High Output Ionizing Fan
5.) ESD Smock
6.) Safe Skin Nitrile Gloves
7.) Amax Contact and Circuit Board Cleaner (Field Supplied)
8.) ESD Flex Boots (4 and 8 Slice Detectors)
9.) Elastomer Tweezers (4 and 8 Slice Detectors)
10.) Elastomer Removal Pick (4 and 8 Slice Detectors)
11.) Spare Elastomers w/container (4 and 8 Slice Detectors)
12.) Alcohol Pads 91% (4 and 8 Slice Detectors)
13.) 16 Slice ESD Boots (16 Slice Detectors)

PROCESS DIFFERENCES

1.) Nitrile Gloves replace Finger Cots.
   a.) Finger cots can leave black particles on surfaces.
   b.) Incorrect dressing of finger cots results in skin oils contamination.
2.) Aero Duster Spray System replaces Metal Tube used for Canned Air.
   Can spray angle is critical. No Liquid Spray allowed. New Aero Duster Spray System provides user the flexibility of access to components while the Aero Duster can remains upright.
3.) High Output Ionizing Fan
   Applies physics laws to dissipate charge on insulating materials.

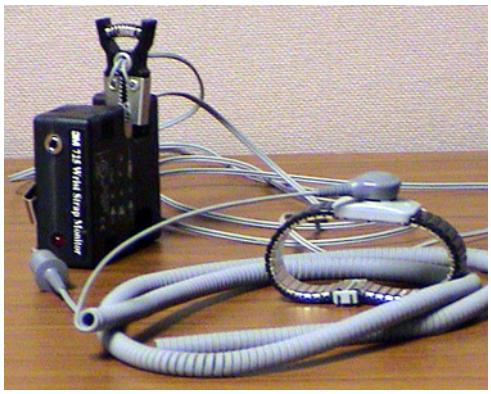


Figure F-1 ESD Workstation Monitor and Wrist Strap

- Monitor requires a 9 volt battery.
- Monitor will “Beep” when you are not properly grounded.
- Wrist strap must contact your skin. Do not place on top of clothing or Nitrile gloves.

Figure F-2 DAS/Detector Interface Tools

- ESD Flex Boot Covers to protect detector from ESD damage
- Alcohol wipes to clean flex leads prior to installation on the DAS/Detector Interface (DDIF).
- Plastic tweezers and pick to remove and install elastomers.
- Aero Duster attachment to remove debris from the DDIF assembly.

Figure F-3 ESD Nitrile Glove

Use Nitrile gloves to prevent skin oil contamination. DO NOT use any other type of glove.

Figure F-4 Full Length Smock

Use an ESD smock to prevent static discharge from your clothing. The wrist strap will not remove static charge from your clothing. The ESD smock will not remove charge from you clothing, it is a barrier to prevent ESD damage.

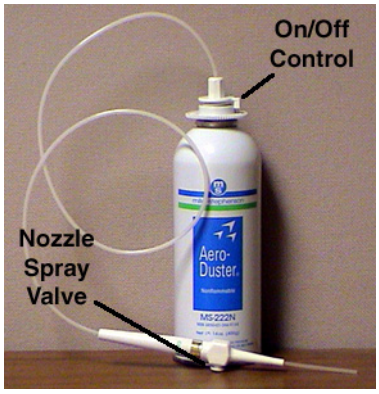


Figure F-5 Aero Duster and Spray System Attachment

- Remove the standard Aero Duster trigger.
- Rotate Aero Duster Attachment to the OFF position.
- Snap onto top of Aero Duster can. (Set attachment to OFF position before removal)

Figure F-6 Ionizing Fan

Section 3.0
Service ESD Tool Usage

⚠ **NOTICE** **When using aero duster to remove debris, do not allow liquid to contact any components. The evaporation of this liquid will generate static charge resulting in microphonic noise or ESD damage.**

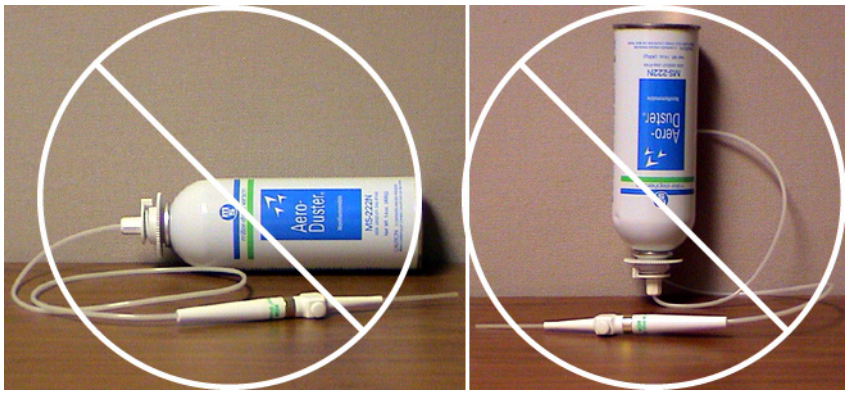


Figure F-7 Wrong Angles will generate Liquid Spray

- Do not use Aero Duster Spray as shown in Figure F-7. This will create a liquid stream which will charge the surface as it evaporates.
- Always hold can upright as in Figure F-5 and clear the hose attachment by spraying away from any surface. Do this to ensure no liquid is discharged.
- Liquid discharge can be seen as a mist at the output of the nozzle and a frosting on surfaces.
- You want to HEAR the spray, NOT see it.

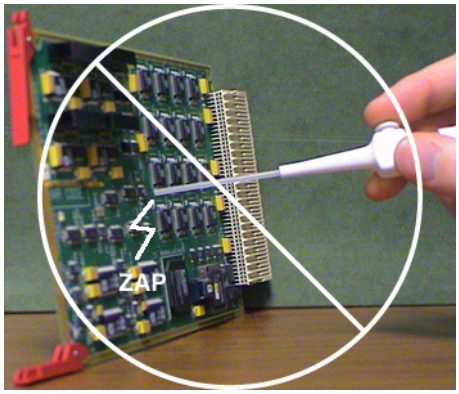


Figure F-8 Incorrect Aero Duster Nozzle Use

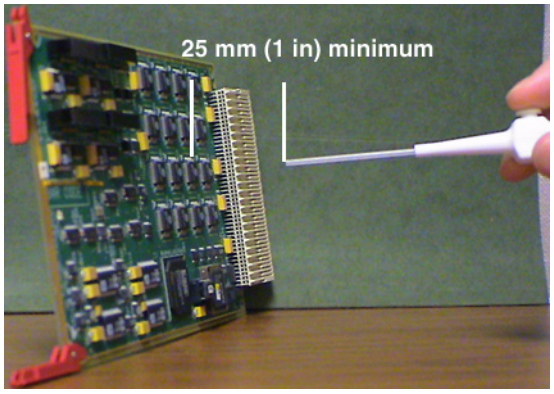


Figure F-9 Proper Aero Duster Nozzle Use

- Never touch the tip of the nozzle to any surface. The tip can be charged in excess of 10,000 volts. This can result in severe ESD damage and/or microphonics noise.
- Charge on the nozzle tip will not be transferred by the flow of gaseous spray. Maintain at least 25 mm or 1 inch from any surface.
- Always clear the nozzle, away from surfaces, of any potential liquid spray.

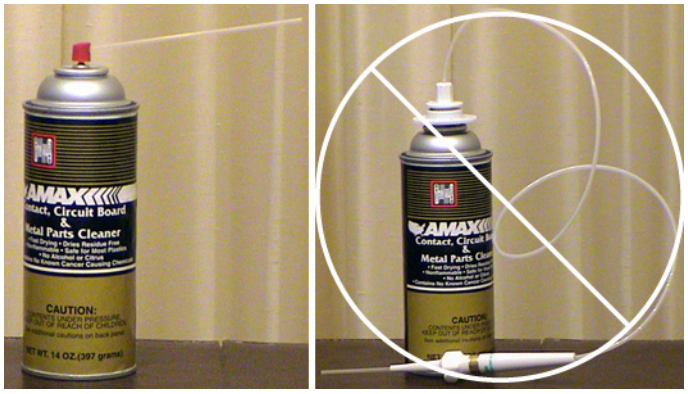


Figure F-10 Amax Cleaner Correct and Incorrect Usage

- Amax Contact and Circuit board cleaner can be used to dissipate static charge.
- Amax Contact Cleaner should not be used on the elastomers. The elastomers will absorb the liquid preventing proper evaporation. The result will be microphonics noise and artifacts.
- Do not attach the Aero Duster attachment to any other chemicals.

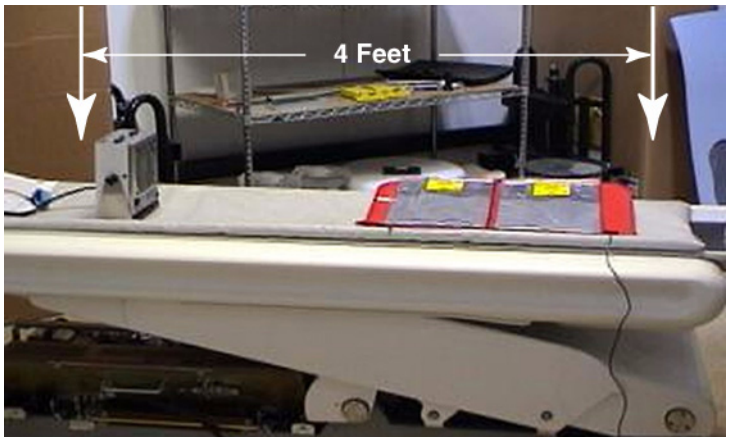


Figure F-11 Preparing your work area

- Place the static mat near the end of the cradle. Connect the ground lead to the Threaded Rod for the Gantry Balance Trim Weights on either side of the DAS.
- Place the Ionizing Fan on the cradle blowing across the static mat. Set the fan speed to high. The effective coverage of the fan is less than 6 feet.
- Use the table service outlet to power the Ionizing Fan.

Figure F-12 Using the Ionizing Fan to dissipate charge at the DDIF

- The Ionizing Fan is to be used to dissipate built up charges.
- It takes about six seconds for the fan to dissipate any charge.
- Slowly direct the air flow from the fan across the affected area. Make several passes over the area.
- There are no visual or physical indications to show effectiveness in this process.
- The fan will be most useful when dealing with the detector and DAS, but can be used on other components as well.

Appendix G
Unix & Linux Commands

Section 1.0
Unix Commands

1.1 Essentials

logout	use this command when you are done, always
Help	Gives a brief overview of where to go for help

1.2 Files and Directories

cd	change directory
pwd	print working directory (the directory you are in)
mkdir	make a new directory
ls	list files
ls -a	Lists all files in the directory, including hidden files. A hidden file is one whose name starts with a period (.)
cp	copy a file
less	view a text file
cat	prints the contents of a file on the screen
More	Display the contents of a file, pausing between each screen full. Type more file
control-D	Pressing the control key and the d key at the same time interrupts programs and returns you to the prompt

1.3 System Status

date	displays the current date and time
du	displays amount of disk space in 512byte blocks ('du -s' gives the summary for a directory)
quota -v	displays disk limits and amount currently in use
ps	display running processes ('ps -ef | grep username' gives all the processes owned by a particular user)
who	display who is on and where they are on from
uptime	display time, number of users, and load averages
whoami	Displays user logged on to the system and directories
chkconfig	

1.4 Networking

telnet	open a remote session with host
rlogin	open a remote session with host
ftp	File Transfer Protocol: send and receive files between machines
ping	check to make sure a remote machine is reachable

1.5 Editors and Text Processors

vi	Visual Editor
grep	searches a file for a pattern

Section 2.0 Linux Commands

2.1 Essentials

logout	use this command when you are done, always
Help	Gives a brief overview of where to go for help
/	root directory
./	current directory
./command_name	run a command in the current directory when the current directory is not on the path
../	parent directory
~	home directory

2.2 Files and Directories

cd	change directory
pwd	print working directory - the directory where you are
mkdir	make a new directory
ls	list files
ls -a	Lists all files in the directory, including hidden files. A hidden file is one whose name starts with a period (.).
cp	copy a file
less	view a text file
cat	prints the contents of a file on the screen
More	Display the contents of a file, pausing between each screen full. Type more file
control-D	Pressing the control key and the d key at the same time interrupts programs and returns you to the prompt

2.3 System Status

date	displays the current date and time
top	a program to see how your memory and CPU are holding up
-	displays disk limits and amount currently in use
ps	display running processes ('ps -ef | grep username' gives all the processes owned by a particular user)
w	display who is on and where they are on from
tail	follow a file as it grows
cfdisk	similar to fdisk, but menu-driven
chkconfig	Query or update system services/daemons for different run levels
df	displays capacity and free capacity on different physical devices such as hard drive partitions that are mounted on the file system. Gives free space in blocks.
du	displays information on disk usage.
du / -bh | less	display detailed disk usage for each subdirectory starting at root

2.4 Networking

telnet	open a remote session with host
rlogin	open a remote session with host
ftp	File Transfer Protocol: send and receive files between machines
ping	check to make sure a remote machine is reachable

2.5 Editors and Text Processors

emacs	Visual Editor.
Pico	Visual editor
grep	searches a file for a pattern

Section 3.0
Using Linux Commands

3.1 Navigation

3.1.1 cd

The `cd` command changes directories. It's a very common navigation command that you'll end up using, just like you might have done in MS-DOS.

You must put a space between `cd` and the "`..`" or else it won't work; Linux doesn't see the two dots as an extension to the cd command, but rather a different command altogether.

3.1.2 ls

The `ls` letters stand for list. It basically works the same way as the dir command in DOS. Only being a Unix command, you can do more with it.

Typing **ls** will give you a listing of all the files in the current directory. If you're new to Linux, chances are that the directories you are commonly in will be empty, and after the **ls** command is run, you aren't given any information and will just be returned to the command prompt (the shell).

There are “hidden” files in Linux, too. Their file names start with a dot, and doing a normal **ls** won't show them in a directory. Many configuration files start with a dot on their file names because they would only get in the way of users who would like to see more commonly used items. To view hidden files, use the **-a** flag with the **ls** command, i.e. **ls -a**.

To view more information about the files in a directory, use the **-l** flag with **ls**. It will show the file permissions as well as the file size, which are probably what are the most useful things to know about files.

You might occasionally want to have a listing of all the subdirectories, also. A simple **-R** flag will do, so you could look upon **ls -R** as a rough equivalent of the **dir /s** command in MS-DOS.

You can put flags together, so to view all the files in a directory, show their permissions/size, and view all the files that way through the subdirectories, you could type **ls -laR**.

3.1.3 pwd

This command simply shows what directory you're in at the moment. It stands for “Print Working Directory”. It's useful for scripting in case you might ever want to refer to your current directory.

3.2 Editing

The basic syntax to invoke these text editors is the same. Type the name of the editor followed by the file you want to edit, separated by a space in between. Non-existent files will be blank. Blank files will be blank as well.

3.2.1 emacs

To use GNU Emacs (or its counterpart, XEmacs), there are really only two commands you need to know. While you're editing a certain file with emacs or xemacs, you can save it with the **CTRL-X CTRL-S** keystrokes. Then to exit, type **CTRL-X CTRL-C**.

3.2.2 pico

The instructions for using pico are located on the screen. You save the file by using the **CTRL-O** keystroke (for write-out) and exit with **CTRL-X**.

3.2.3 vim

Most modern distributions include **vim**, derived from the infamously arcane Unix editor, **vi**.

Using **vim** is different in that there are several modes in which you use it. To do actual editing of the files, press **ESC** **i** (both separately). Then to save it, press **ESC** **: w**. Escape, the colon, and “w” should be keyed in one after the other. Finally, to quit, type **ESC** **: q**. The same rules apply as in previous vim commands.

You can use “w” and “q” at the same time to enable yourself to write to the file and then quit right afterwards. Just press **ESC** **: w q**.

If you don't have **vim** installed, try **vi** instead.

3.3 Monitoring Your System

3.3.1 tail

The program **tail** allows you to follow a file as it is growing. It is often used to follow `/var/log/` messages, by typing **tail -f /var/log/messages**. Of course, you can use anything else,

including the other logs in `/var/log/`. Another file you may want to keep an eye out for is `/var/log/secure`.

If you want to leave that running all the time, I recommend having some sort of terminal program in X, logged in as `root` through `su`.

Another program you may want to look at is **`head`**. It monitors the top of the file specified, instead of the bottom.

3.3.2 top

This program shows a lot of stuff that goes on with your system. In the program, you can type:

`M` for memory usage information

`P` for CPU information

`q` to quit

3.3.3 w

Typing **`w`** will tell you who is logged in. This can be helpful if you're the only one who uses your computer and you see someone logged in that's not supposed to be.

Another alternative is **`who`**.

3.4 Shutting Down and Rebooting

To shut down your system, type **`shutdown -h now`**, which tells the shutdown program to begin system halt immediately. You can also tell it to halt the system at a later time, but you'll have to consult the shutdown manual page for that (man shutdown).

To do a reboot, you can either type **`reboot`** or **`shutdown -r`**. You can also use the famous **CTRL-ALT-DELETE** combination to reboot, which you might already be familiar with.

Shutting down and restarting properly (as described above) will prevent your file system from being damaged. File system damage is the most obvious of the consequences, but there are probably other things out there as well. The point is, shut down your system properly.

There are (rare) cases in which the machine might lock up entirely, and prevent you from being able to access a command prompt. Only then will your last resort be to do a forced reboot (just pressing the restart button on the case).

Section 4.0
Reference Books

4.1 Unix

> **LEARNING THE VI EDITOR** - a book to teach you how to use the standard text editor for all Unix systems.

> **LEARNING UNIX OPERATING SYSTEM** -- by Jerry D. Peek

> **ESSENTIAL REFERENCE FOR ANY LINUX NEWBIE :-)**: A list by Jacob Weiskoff,

4.2 Linux

> **LEARNING THE VI EDITOR** - a book to teach you how to use the standard text editor for all Unix systems.

> **LEARNING GNU EMACS** - another book on another powerful text editor. It's good especially if you program or simply prefer Emacs.

> **LEARNING RED HAT LINUX, 2ND EDITION**, by Bill McCarty (Paperback)

> **SAMS TEACH YOURSELF LINUX PROGRAMMING IN 24 HOURS (COMPLETE LEARNING EDITION)**, by Warren Gay (Editor), Tony Zhang (Editor)

> **RED HAT LINUX 7 FOR DUMMIES**

Glossary

TERM	MEANING
* (asterisk)	Indicates a signal is active, true, valid, asserted when at or switching to its low value (active low).
10-BASE2 or 5 or T 100-BASE T	A 10BASE connection can transfer data between networked computers at up to 10 Mbps. 10Base2 is thin coaxial and segments must be no longer than 185 m (607 ft). 10Base5 is thick coaxial and segments must be no longer than 500 m (1640 ft). 10BaseT is twisted pair wiring; use Category 5 or better. The Octane can support 100BASE T which transfers at 100 Mbps.
140 SPECint92	The computer industry has developed a standard measure of integer, floating point, and other system performance to better compare actual system performance under real conditions, unlike the older MIPS or MEGAFLOPS ratings. The SPECint92 is a standard measurement of integer performance across various computing systems.
A/D, ADC	**A**nalog to **D**igital **C**onverters are used to convert analog electrical signals to digital quantities.
ACAN	**A**xial **CAN**.
ACB	**A**xial **C**ontrol **B**oard.
ADF	**A**pplication **D**ata **F**ormat.
ADM	**A**xial **D**rive **M**odule.
AE Title	**A**pplication **E**ntity is the **DICOM** name for a machine with a **DICOM** purpose on a network. The site's network administrator assigns a specific title to each application entity. You must carefully enter this information with the same capitalization as it is given to you.
AIF	**A**xial **I**nter**F**ace.
AiM	**A**pplication **i**ntegration **M**echanism is a simple mechanism to enable new modules to share data and messages with older modules. The idea is to limit the interactions between the to-be-integrated application and the “integrated” ones. It is proposed as an efficient way to add new applications to the SdC platform, such as an existing *Advantage Windows* system. The design paradigm of AiM is referred to as weakly coupled design.
Air Cals	Air Calibration. This calibration is a series of scans that are taken of only air. The images are reconstructed and the **CT** numbers adjusted to give a number of -1000 for each pixel.
ALARA	**A**s **L**ow **A**s **R**easonably **A**chievable. ALARA is a safety reminder to use the least power necessary to get a diagnostically useful image.
ALM	**A**pplication **L**oad **M**odule.
AMD	**A**xial **M**otor **D**rive.
API	**A**pplication **P**rogramming **I**nterface is the network software libraries or subroutines from which an application writer can call upon for various services.
APU	**A**ttenuation **P**ipeline **U**nit.
ARD	**A**dvantage **R**eview **D**iagnostic
ARP	**A**ddress **R**esolution **P**rotocol is a network protocol that maps ethernet addresses to IP ones.
ASIC	**A**pplication **S**pecific **I**ntegrated **C**ircuit.
AUI	**A**ttachment **U**nit **I**nterface. An **IEEE** 802.3 connecting the Media Access Unit (MAU) to the networked device. It also refers to the connector that attaches the host port to an AUI cable.
AWW	**A**dvantage **W**indows **W**orkstation is a stand alone image work station. The system is Sun Computer based and the software was developed in France.
AX-CAN	**AX**ial **CAN**

TERM	MEANING
axial resolution	The ability to distinguish between two tissue interfaces along the sound beam. Echoes less than a pulse width apart will not be resolvable; they will blend in the image. Pulse width and beam width determine this quality.
back projection	Mathematically summing and averaging all the data for a given pixel from every **CT** view during acquisition. The recon processor creates three dimensional voxels in two dimensions which eventually become the display image pixels. Given a filtered projection, this term refers to the process of smearing the projection back across an image matrix.
Balum	RF impedance matching device.
bandwidth	The frequency range that contains the significant ultrasound content. It also describes the amount of data that a circuit or network can handle.
BDM	**B**ackground **D**ebug **M**odule.
BLD	**B**oard **L**evel **D**iagnostic
BOW	**B**eam **O**n **W**indow is the alignment of the X-Ray beam to the window on the detector.
BPC	**B**ack **P**rojector **C**ontroller.
bps	**b**its **p**er **s**econd
bulkhead	The bulkhead refers to a panel where peripherals, laptops, modems, network can be connected.
bus	A parallel communications pathway composed of a group of wires, or of traces on a board or within a chip. The same bus can be used for different signals when tristate ICs are used because those not needed can be turned off; their output is changed to high impedance.
byte	A byte is eight bits numbered 0 through 7, bit 0 is the least significant bit (LSB). A byte is the smallest unit stored by a computer. Its location has one unique address. The **VME** standard divides all locations into four groups that share the same last two digits, 00, 01, 10, 11, in their address.
Cam A, Cam B	Cams A & B are used to pre-patient collimate the x-ray beam.
CAN	**C**ontroller **A**rea **N**etwork
cat	UNIX command used to create or print files on the screen or to a file or device
CBF	**C**enter **B**ody **F**ilter This is the alignment of the focal spot of the X-Ray tube to the center of the body filter in the collimator. This is the left/right alignment when looking at the gantry from the table.
CBT	**C**omputer **B**ased **T**raining.
CC	**C**ontrol **C**ommunications
CCB	**C**ollimator **C**ontrol **B**oard - Provides the electrical control to position the bowtie filter and the collimator Cams.
CCITT	**C**onsultative **C**ommittee for **I**nternational **T**elephone and **T**elegraph is an organization that sets worldwide voice and data communications standards.
CD-R	**C**ompact **D**isk - **R**ecordable. Write once compact disk.
CD-ROM	**C**ompact **D**isk **R**ead **O**nly **M**emory is an off-the-shelf 4X **CD-ROM** drive. It is used to load software and play the Sherlock Operator's Manual.
CD-RW	**C**ompact **D**isk - **Re-Writable**. Re-recordable compact disk.
CF	**C**ommunications **F**acility
CGI	**C**ommon **G**ateway **I**nterface is an API developed for the Internet. A CGI could convert a WORD 6.0 document into a web page (**HTML**) or return user input on a web form to a WWW server or enable a computer to access the Internet through a firewall.
client	The computer or application that uses computer services provided by another computer or application. Each can then be optimized for their task.

TERM	MEANING
CMOS	**C**omplementary **M**etal **O**xide **S**emiconductors are densely populated Integrated Circuits (ICs). They tend to need less power than TTL ICs. Nominal operating levels are 0 - 0.8 V for Low and 3.4 - 5 V for High. TTL compatible CMOS recognizes 2.4 V as High. CMOS chips are readily damaged by **ESD**.
Collimator Mounting Plate	Mounting plate to fasten collimator to the rotating base.
control bus	A control bus carries signals used to initiate memory and data I/O operations.
CPDU	**C**ompact **P**ower **D**istribution **U**nit. The **CPDU** is a cabinet used to supply power to the entire **CT** system. It was originally called the **CRPDU**, and is often referred to simply as the **PDU**.
CPU	**C**entral **P**rocessing **U**nit.
CQA	**C**ustomer **Q**uality **A**ssurance is a report by a customer to complain about the quality of a GE Medical Systems product. Strict procedures are followed to resolve the complaint to the customer's and government's satisfaction.
CRC	**C**yclic **R**edundancy **C**heck
cron	A cron is a UNIX process that runs at regular intervals when the system is not busy with higher priority tasks. Looking for scheduled patient data on the network is a cron task.
CRT	**C**athode **R**ay **T**ube. Video monitors made from **CRT**s are sometimes referred to as **CRT**s.
CT	**C**omputed **T**omography.
CTS	**C**lear **T**o **S**end. Serial control signal from the DCE.
CUP	**C**ommon **U**nix **P**latform is a foundational software library that **CT** and MR share. CUP monitor is used to control the most fundamental processes like the startup and shutdown of the scanner.
DA, **DAC**	**D**igital to **A**nalog **C**onverter.
daemon	A daemon is a UNIX background software process. The routing daemon maintains a routing table or database used to select the appropriate network interface when transmitting packets. This routing table contains a single entry for each route to a specific network or host.
DAS	**D**ata **A**cquisition **S**ystem. The **DAS** is used to collect the data from the detector, convert it to digital, and send it to the Front End Processor.
DAS Channel	There are 768 **DAS** channels per slice. Only 765 are connected to the detector channels. Outer channels from the detector are ganged or paralleled on the **DAS** backplane, therefore fewer **DAS** channels per slice than detectors.
DAS Count	Approximately 0.5 PPM (parts per million) of full scale. Equals one LSB (least significant bit) of **DAS** data word with largest **FPA** gain, i.e. exponent bits equal to 00 binary.
DAS Gain	**DAS** gain is actually preamp gain. It is a gain code defining the size of the integration capacitance. **DAS** gain is proportional to the inverse of the capacitance or gain code. **DAS** gain is set prior to scan. Lower gain code means less full scale signal, but better **DAS** electronic noise performance.
DASM	**D**ata **A**cquisition **S**ystem **M**anager. The **DASM** is the interface to a camera for filming the images. The **DASM** takes a single image and transmits it digitally or in analog form, depending on the type of **DASM**.
DAT	Signal abbreviation for Data. The **VME** Data bus transfers are bidirectional because the Master Controller may command either a Read or Write. Other data buses are one directional and carry a circuit board's output to its destination(s). The Vector Parameter bus, aka Scan Control bus, and the I and Q Data buses are the other major DAT buses.
datagram	The smallest unit of network data
DCB	**D**AS **C**ontrol **B**oard. Controls **DAS** functions including sending digital **DAS** data to RF slip ring, and receipt and status back to the rest of the system.

TERM	MEANING
DCD	**D**ata **C**arrier **D**etect. Serial control signal from the DCE.
DCD	**D**ual **C**hannel **D**isplay.
DCE	**D**ata **C**ommunication **E**quipment is an EIA term that refers to a digital device designed to emulate or provide a transmission connection, such as a modem. RS-232 signals move in one prescribed direction relative to the DCE or DTE.
DCM	**D**ICOM **C**ommand **M**anager. The **DCM** is software that provides the Application Programming Interfaces (APIs) that implement **DICOM** tasks. A **DICOM** task initializes the **DCM** kernel on the AK server which will communicate with the remote **DICOM** station using **DCM** APIs.
DDC	**D**iagnostic **D**ata **C**ollection.
Detector Cell	The detector cell is the smallest element of the detector, consisting of a single photodiode. There are 912 detector cells per row. A detector cell is approximately 1 mm in the azimuthal direction by 1.25 mm in the Z direction, right on the scintillator.
Detector Channel	A detector channel consists of 16 photodiodes arranged in the “Z” direction. There are 16 channels per detector module. In total, there are 912 detector channels on a detector. A single channel is 1mm in width, in the azimuthal direction. A detector channel is sometimes referred to as a **Detector Column**.
Detector FETs	**F**ield **E**ffect **T**ransistors are used to select the photodiode combination of detector rows for post collimation slice thickness. The FETs are physically located on the detector assembly, but are controlled by the **DCB** (**DAS** Control Board).
Detector Module	A group of 16 detector channels, each channel divided into 16 cells (also called a Pack).
DHCB	**D**etector **H**eater **C**ontrol **B**oard.
DICOM	**D**igital **I**maging and **CO**mmunication in **M**edicine. **DICOM** is a computer file and protocol standard used by the medical imaging industry. It enables the transfer of data between various medical scanners and devices, regardless of manufacturer. The ACR (American College of Radiology) and NEMA (National Electrical Manufacturers Association, diagnostic imaging vendors) are working together to help make this evolving standard a reality. It is designed with PACs, Ethernet, networking type applications in mind so that information can be shared across electronic networks linking many kinds of computers. The practical emphasis has been on medical device manufacturers to conform so that their patient data from one particular modality are readable by computers, workstations, printers, medical scanning devices from many vendors. A **DICOM** task will initialize the **DCM** kernel on the AK server which will communicate with the remote **DICOM** client station using **DCM** APIs.
DIMM	**D**ual **I**n-line **M**emory **M**odule.
DIP	**D**AS **I**nterface **P**rocessor. The **DIP** takes raw scan data from the slip ring and writes it to disk
DIP Switch	**D**ual **I**n-line **P**in Switch. Small electrical switches, commonly packaged in blocks of eight and used on printed circuit boards.
DMA	**D**irect **M**emory **A**ccess provides fast transfers between circuit board memory and its destination. The **DMA** controller relieves the **CPU** of managing I/O operations between **RAM** and disk or **A/D** devices. It is used to transfer completed axial images from the **SRC** to the OC.
DMB	**D**etector **M**emory **B**oard.
DNS	**D**omain **N**ame **S**ervice is a software protocol that translates Internet location names which are easier to remember to their IP addresses.
domain	The domain name identifies the machine/computer on a network.

TERM	MEANING
DOS MODE	**MOD**s labeled (formatted) for storing images have a DOS like structure. **MOD**s formatted for software have a UNIX structure. There are some DOS MODE commands in /usr/g/bin to help you view and copy files between the Image Archive media and the system. The size of DICOMDIR indicates how much space images are taking on the **MOD**. You must use Image Works to DETACH it then do another dmls in a shell to see an updated size.
DRAM	**D**ynamic **R**andom **A**ccess **M**emory
DSP	**D**igital **S**ignal **P**rocessor is an integrated circuit (IC) that performs special function digital calculations.
DSR	**D**ata **S**et **R**eady. Serial control signal from the DCE.
DTE	**D**ata **T**erminal **E**quipment is an EIA term that refers to a digital device designed or configured to provide data, such as a computer or peripheral. RS-232 signals move in one prescribed direction relative to the DCE or DTE.
DTR	**D**ata **T**erminal **R**eady. Serial control signal from the DTE.
DVD	**D**igital **V**ersatile **D**isk. DVDs are optical media, similar to CDs, but capable of holding up to 4.7GB of data on a single sided, single layer disk.
DVD-RAM	**D**igital **V**ersatile **D**isk - **R**andom **A**ccess **M**emory. Recordable DVD.
ECL	**E**mitter **C**oupled **L**ogic. ECL is a family of ICs used for high-speed signal transfer applications. It is faster than TTL. It requires voltages of -5 and -2 V which are labeled 5VN and 2VN. ECL differential signals are parallel terminated.
EEPROM	**E**lectronically **E**rasable **P**rogrammable **R**ead **O**nly **M**emory. The program stored in an **EEPROM** chip may be electronically erased. Consequently, **EEPROM**s are highly susceptible to **ESD**.
EFS	**E**xtent **F**ile **S**ystem. EFS was used on R3.5 and earlier for **SGI** IRIX OC disks. Starting with R3.6, the OC disk uses the XFS system.
EIA	**E**lectronic **I**ndustries **A**ssociation is a US government department that provides the latest electronic related standards for engineers and manufacturers.
Elastomer	Rubber-like conductor of electricity.
EMC	**E**lectro **M**agnetic **C**ompatibility describes an electronic device that resists other and curbs its own electromagnetic influence.
EMI	**E**lectro-**M**agnetic **I**nterference.
EPROM	**E**rasable **P**rogrammable **R**ead **O**nly **M**emory uses ultraviolet light through a window on the chip to erase it.
ESD	**E**lectro**S**tatic **D**ischarge. Always use a known working (tested) wrist strap grounded to the unit before you touch any part with electronic components. There are several special grounding plugs on the frame for this. It is highlighted with a yellow icon label. Place the removed part in an anti-static bag or on a grounded pad. Protect it from further damage.
ETC	**E**nhanced **T**able **C**ontroller manages table/cradle movement and gantry tilt.
ethernet	Ethernet describes a hardware protocol for transferring data on a local area network (**LAN**). Ethernet cable can be coaxial, twisted pair or fiber optic.
Ethernet Address	Every system on an Ethernet network must have a unique Ethernet address. The physical Ethernet address of your system is the unique number assigned to the Ethernet board in the host. This unique number is assigned to the manufacturer of your Ethernet hardware by the **IEEE** (formerly by Xerox, one of the original developers of Ethernet). This is not to be confused with the IP address, which can be set arbitrarily.
Ethernet Switch	Connects the OC, **ICE** box, and gantry controllers together on the internal network.
FBP	**F**iltered **B**ack **P**rojection.
FEC	**F**orward **E**rror **C**orrection.

TERM	MEANING
FES	**F**ast **E**thernet **S**witch
FIFO	**F**irst **I**n, **F**irst **O**ut. A memory device in which the first piece of data stored in the buffer is the first removed; can be used as a buffer to align outputs.
firewall	A firewall is a computer that prevents unauthorized access to the network upon which it resides. A correctly configured internal computer can reach outside the firewall. See 'proxy.'
FOV	**F**ield **O**f **V**iew
FPA	**F**loating **P**oint **A**mplifier. Auto-ranging gain stage between preamp and Analog to Digital converter on converter board. Gain from **FPA** is used to generate exponent portion of **DAS** data word.
FPGA	**F**ield **P**rogrammable **G**ate **A**rray is a standardized **ASIC**. It's a digital component that is designed and programmed to perform a specialized board function.
FPR	**F**ield **P**roblem **R**eport is a means to formally report a potential safety or regulatory problem to headquarters.
FRU	**F**ield **R**eplaceable **U**nit. A GE Acronym for items which can be replaced by field personnel.
ftp	**F**ile **T**ransfer **P**rotocol is a **TCP/IP** standard that is used to move files between computers on a network. It is particularly needed between dissimilar computers. It also describes Internet sites that use this protocol. Popular Web browsers and PC applications eliminate the need for you to know the FTP commands by simplifying the interface. They can usually be listed with the `help' command. `ls -lt' will list and sort with details all remote files at remote location. `cd xyz' will change remote directory to xyz. `lcd abc' will change your local directory to abc. `put nnnn' will put local file nnnn onto the remote computer. `get xxxx' will get remote file xxxx; it will copy it to your current local directory. `bye' to exit.
gateway	A gateway is a program or computer that handles moving data from one network to another. It often refers to communications between different kinds of networks. It handles client input and output for the server. The Gateway Host Name is also the **AE** Title.
GCAN	**G**antry **CAN**
Gentry I/O	Generator / Gantry I/O is located in the On Board Computer Chassis. It performs miscellaneous gantry and generator functions.
GND	Ground is used both as a signal reference and a power return path.
GSB	**G**antry **S**ervice **B**ox. Located on the right side of the gantry. It can be used to turn off Gantry 24 hour power, the Axial Drive and the HVDC voltage. LEDs indicate status of each function.
GUI	**G**raphical **U**ser **I**nterface
HAS*	**H**igh **A**ddress **S**trobe indicates that the eight most significant bits (23:16) of an address will be transferred. Address Strobe, AS*, transfers the first 16 bits (15:0). Used to transfer **VME** data.
HCAN	**H**EMRC **CAN** bus on **HEMRC** control board
HCB	**H**EMRC **C**ontrol **B**oard
Helical Acquisition Modes	• hi Speed mode, AKA 6 to 1 pitch (table travels 6 macro rows per rotation) • hiQ mode, AKA 3 to 1 pitch (table travels 3 macro rows per rotation).
HEM	**H**igh **E**fficiency **M**otor drive.
HEMIT	**H**igh **E**fficiency **M**otor **I**solation **T**ransformer.
HEMRC	**H**igh **E**fficiency **M**otor **R**otor **C**ontroller. Device used to accelerate and rotate the x-ray tube anode.
HEMRC-IF	**HEMRC** **I**nter**f**ace
HEPA	**H**igh **E**fficiency **P**articulate **A**ir.
HHCS	**H**ex **H**ead **C**ap **S**crew

TERM	MEANING
HIF	**H**EMRC **I**nter**F**ace board.
HIS	**H**ospital **I**nformation **S**ystem describes a computer system that retrieves and stores patient personal data and their diagnostic images on a network.
HPRF	**H**igh **P**ulse **R**epetition **F**requency allows higher velocities to be detected without causing aliasing artifacts. The system invokes this when operating in PW Doppler Mode and the velocity scale or sample volume gate depth exceeds certain limits. When HPRF is active, multiple sample volume gates appear along the Doppler mode cursor. Doppler information from all gates is added together and displayed as one spectrum. The main gate is slightly larger.
HSC	**H**elios **S**mart **C**ollimator
HSDCD	**H**igh **S**peed **D**ata **C**apacitive **D**evice.
HSHC	**H**ex **S**ocket **H**ead **C**ap screw
HSS	**H**eat **S**oak and **S**easoning.
HSSD	**HiS**peed **S**can Data **D**isk is used for saving raw data as it comes from the **DAS**.
HTML	**H**yper**T**ext **M**arkup **L**anguage is an Internet standard that decrees how a web page should be tagged in order to display information as intended or to go to another place on the Internet or to start a particular function. **HTML** is evolving. It is readable by both computers and people.
HTTP	**H**yper**T**ext **T**ransfer **P**rotocol is an information serving protocol that helps make the Internet possible because it is generic, stateless and object oriented means to transfer files.
HV	**H**igh **V**oltage.
HVDC	**H**igh **V**oltage **DC** (Direct Current).
hypertext	Hypertext describes the kind of information that the Internet supplies; beside text, there are sounds, voice recordings, maps, pictures, animations, videos, 3D simulations, live interactive games and conversations, links to other information sources.
ICD	**I**nspection **C**ertification **D**ocument arrives with new equipment. It is used to prove the unit was tested. A SHIPMENT and INSTALLATION card accompany it. They are submitted to headquarters upon those events to track the location of the unit.
ICE, **ICE** Box	**I**mage **C**hain **E**ngine. Preprocesses scan data and backprojects data into image. Includes PowerPC (**RIP**) and **PEG-IG** board.
ICMP	**ICMP** is the error and control message protocol used by the Internet protocol family. It is used by the kernel to handle and report errors in protocol processing. It may also be accessed through a `raw socket' for network monitoring and diagnostic functions. **ICMP** is used internally by the protocol code for various purposes including routing, fault isolation, and congestion control. Receipt of an **ICMP** redirect message will add a new entry in the routing table or modify an existing one. **ICMP** messages are routinely sent by the protocol code.
IDE	**I**nteractive **D**iagnostic **E**nvironment.
IF or I/F	**I**nter**f**ace. An interface is a circuit needed to connect either two different devices or families of circuits. It solves a problem. An interface may prepare and protect circuits; it may decode, deliver, translate signals.
I-FETs	Inside FETS; refers to FET control lines that are aligned with **DAS** center backplane.
IG	**I**mage **G**enerator
IMS	**I**nformation **M**anagement **S**ystem.
Insite Modem	Data communication device.
InterNIC	The Internic provides the primary directory and IP address registration services for the American part of the Internet.

TERM	MEANING
IP	**I**nternet **P**rotocol. IP describes globally used computer communications applications like ping, telnet, and ftp. These are not specific to Ultrasound or GE Medical Systems. IP is the internetwork datagram delivery protocol that is central to the Internet protocol family. Programs may use IP through higher-level protocols such as the Transmission Control Protocol (**TCP**) or the User Datagram Protocol (**UDP**), or may interface directly using a ``raw socket.'' `pings' have an IP and **ICMP** header.
IP Address	Every computer on the Internet has a unique IP Address consisting of four 8 bit integers (bytes) separated by dots. Each part can be number from 0 to 255. One portion identifies the host and another the network. That portion can be from one to three contiguous parts. IP Address allocation is managed by a central authority.
IPC	**I**nter **P**rocess **C**ommunication. IPC is the exchange of data between two software processes, either within the same computer or over a network. It implies a protocol that guarantees a response to a request. Examples are Unix sockets, RISC OS' messages and Microsoft Windows' DDE
IRIX	IRIX is a UNIX-based operating system from Silicon Graphics (**SGI**) that is used in its computer systems from desktop to supercomputer. It is an enhanced version of UNIX System V Release 4. IRIX integrates the X Window system with OpenGL, creating the first real-time 3-D X environment.
ISDN	**I**ntegrated **S**ervices **D**igital **N**etwork is a telecommunication media that US phone companies are beginning to offer. It transfers data through existing phone lines five time faster than V.32bis modems. It is already in use in Europe.
ISO Alignment	ISO Alignment is the alignment of the focal spot of the tube to the center channel of the detector. This alignment is left/right when viewing the gantry from the table.
ISR	**I**nterrupt **S**ervice **R**outines are needed in a real-time (**VME**) system to notify, respond, or process new conditions then get out of the way of the next interrupt. It resets a device, starts a task, reads or writes data, tells the **CPU** of a user request, a software error, a hardware fault.
kernel	Describes the portion of a computerized machine that controls it. Sometimes it means the hardware, the Central Processing Unit (**CPU**), that controls all the Input/Output (I/O) and coordinates the operation of all hardware; sometimes it means the software that does this. Since it involves both, one cannot do its job without the other, kernel really means the controlling hardware and software.
Keyboard	Input device.
LAN	**L**ocal **A**rea **N**etwork. A network for transferring data or images that is confined to a small area. Usually within the same building.
lateral resolution	Lateral resolution is the ability to distinguish between two echoes at the same distance from the probe. Narrower beams have better lateral resolution.
LFC	**L**oad **F**rom **C**old. “Cold” Software Load Procedure.
LIFO	**L**ast **I**n, **F**irst **O**ut.
LSB	**L**east **S**ignificant **B**it. Bus names include the number of signals that comprise that bus. The number that appears after the colon is the LSB of that bus. The following example has eight signal lines. EXAMPLE: BUSNAME(7:0)
LSD	**L**ocal **S**CSI **D**isk. 450MB hard disk used to hold the UNIX and scan recon software for the Single Board Computer. Located in the console.
LUT	**L**ook-**U**p **T**able is memory under **VME** control that quickly adjusts parameters for a specific system control or performs a mathematical function via mapping.
malloc errors	This is a fatal situation for software; if it could not correctly allocate memory space for an operation, the system cannot continue.

TERM	MEANING
MBD	**M**odem **B**ack **D**oor offers another way for InSite to access the scanner when the **PPP** connection does not work.
MBP	**M**ean **B**eam **P**osition.
MDAS	**M**illennium **D**ata **A**cquisition **S**ystem. **MDAS** allows 4-slice or 8-slice operation (SDAS, by comparison, allowed only 4-slices to be recorded with each rotation of the gantry). An 8-slice MDAS is used with the LightSpeed Ultra CT Scanner; a 4-slice MDAS is used with the LightSpeed Plus, LightSpeed QX/i and HiSpeed QX/i CT Scanners.
MDAS converter board	Converts analog detector signal to digital data. 64channels, 8 pre-amps, 2 **A/D**s per board. 48 boards per **MDAS**.
mean	The arithmetic average of all values in a set.
Mechanical Index	Mechanical Index is represented by MI on the display and is related to cavitational bioeffects. As acoustic waves pass through tissue, they cause it to expand and contract. This expansion may cause gas bubbles to form. It is considered not dangerous with equipment that is operating and used properly. Mechanical Index is derived from measured Peak Rarefactional Pressure (Pr) and the probe's frequency. The risk for cavitation is greatest in B mode.
memory map	Each component on a board has its own unique address in the **VME** memory map. Each BE board has a range of **VME** addresses assigned to it. The boards reside in the **VME** memory map in two different areas: the short I/O space and the extended memory space.
MFM	**M**essage **F**ormat **M**anager. MFM is the AKSERVER (software) component that translates data to **DICOM** format so that it can be sent to another **DICOM** device on the network.
MI	**M**echanical **I**ndex is a measure of acoustic output.
MNP	**M**icrocom **N**etworking **P**rotocol compresses uncompressed files as they are transferred through a modem.
MOD	**M**agneto **O**ptical **D**isk. **MOD** is a storage device that can be recycled. It's used to store system software, files and images.
modem	Device used to transmit digital information across phone lines. It is an abbreviation for Modulator-Demodulator.
mouse	Input device.
MSB	**M**ost **S**ignificant **B**it. Bus names include the number of signals that comprise that bus. The number that appears before the colon is the MSB of that bus. The following example has eight signal lines.
MSD	**M**eans and **S**tandard **D**eviation
MSDS	**M**aterial **S**afety **D**ata **S**heet
MTM	**M**essage **T**ransfer **M**anager. A **DICOM** term.
MTU	**M**aximum **T**ransmission **U**nit. Internet datagrams can be fragmented and reassembled during their transmission. If the datagram is larger than the maximum transmission unit of the network, it is fragmented on output.
MUX	Multiplexer selects one of multiple inputs to be routed to one output.
mv	UNIX command to move a file to another location or to rename it.
Name	For the network configuration, the **DICOM** Archive or Print application's name must be entered exactly as the site's network administrator has named the **DICOM** device, so that all software on the network can properly recognize it. One device can have more than one **DICOM** application so there can be more than one Name and **AE** Title associated with any particular **DICOM** computer.
NC	**N**o **C**onnection describes an electrical interface.

TERM	MEANING
NDIS	**N**etwork **D**evice **I**nterface **S**pecification describes 3Com and Microsoft drivers needed to make **TCP/IP** networking happen.
Net Mask	A Net Mask is an IP Address filter that eliminates communication/noise from network devices of no interest to your machine
Netscape	Software that displays electronic words, sounds, pictures, that have been put in htm, **HTML**, gif, mpeg format, meaning it adheres to the http protocol.
Network Interface	Connection from local unit to network.
Network Protocol	Makes use of a Point to Point Protocol (**PPP**) to communicate with the OnLine Centers. The **PPP** allows standard **TCP/IP** connectivity tools to be used as if the modem connection where part of a **TCP/IP** based network. Multiple levels of access security are used to insure that unauthorized users cannot access the system. For **PPP** to work correctly, a unique IP address must be assigned to either the modem or to the **SGI** computer gateway.
Network Type Support	100BASE T describes the speed and hardware that can be used to connect computers. The Indigo2 supports either AUI or 10BASE T. It does not support 100BASE T. The Octane however supports 10BASE T and 100BASE T depending on what it senses when it boots. **SGI** configuration settings for networking are in file `/etc/inetd.conf`. To reset the network when applications are down: enter**: KILLALL -V -HUP INETD**
NFS	**N**etwork **F**ile **S**ystem describes a computer system that can use or supply other computer systems even if they are dissimilar. **NFS** consists of client (user) and server (supplier) systems. An **NFS** server can export local directories for remote clients to use. A **NFS** client can then use those remote files. Filesystem describes filesystems that are exported from one host and mounted on other hosts across a network. **NFS** enables you to access files and directories located on remote systems on the network as if they were located on your local system. **NFS** filesystems are available by using optional **NFS** software. **NFS** to external systems should be not be used to safeguard the scanner's privacy. This is set by the reconfig or **LFC** procedure. The nfs property on the host is set by the **`chkconfig nfs on`** command.
NIS	**N**etwork **I**nformation **S**ervices is an **NFS** service that supports distributed databases for maintaining administrative files for the network, like passwords, host addresses. Network Information Services (NIS) provides a centralized database of information about systems on the network. This service can be used to look up the hostname or IP address of a particular system on the network. Turn on NIS only if the site's network administrator tells you it is necessary and provides you with an NIS domain name. Insert the Install Software CD, enter mountMOD, start the rinstall command, select CONFIG, NETWORK, ADVANCED OPTIONS.
NVRAM	**N**on **V**olatile **R**andom **A**ccess **M**emory is used to hold important system info.
OBC	**O**n **B**oard **C**omputer. The **OBC** is the **CPU** that is on the rotating frame. It is used to monitor and control the components on the rotating frame.
OBCR	**O**n **B**oard **C**omputer (**R**emote) Same as the **OBC**. Used when pinging the **OBC**.
OC	**O**perator’s **C**onsole. Consists of Octane **CPU**, hard drives & two 21" **CRT**s (Cathode Ray Tube).
OC	**O**perator's Console **C**omputer is the Silicon Graphics Computer.
Octane	Host computer (**SGI**)
OE	**O**utput **E**nable signal
O-FETs	**O**utside **FETs**. Refers to FET control lines that are aligned with two outer **DAS** backplanes. Excludes the Z-Fets.
packet	A packet is a group of binary digits representing data and control which is sent in a well defined format over a network.
Partition	A *disk partition* can be used as a file system, a logical volume, or raw disk space.

TERM	MEANING
P-Cal	**P**hantom **Cal**. The phantoms are made of water (**CT#** 0) or teflon (**CT#** ~100). Large medium and small phantoms are scanned and the images generated. Then an adjustment is made to give each pixel the correct **CT#**. This is applied to all images scanned.
PCI	**P**eripheral **C**omponent **I**nterconnect.
PCI-FE	Serial expansion device
PDU	**P**ower **D**istribution **U**nit. Shortened acronym for “Compact Power Distribution Unit (**CPDU**)”
PDU	**P**rotocol **D**ata **U**nit is a packet.
PEG-IG, **PIG**	**PEG**asus **I**mage **G**enerator Board. Image backprojection board (**VME** based).
ping	A UNIX command used to check whether another device on the network is on or reachable.
PLD	**P**rogrammable **L**ogic **D**evice is also an **ASIC**.
PM	**P**lanned (or **P**eriodic) **M**aintenance.
PMC	**P**CI **M**ezzanine **C**ard.
POR	**P**lane **O**f **R**otation. This is the physical alignment of the focal spot of the tube with the aperture of the collimator. The alignment is towards or away from the table.
Port	For network configuration, enter the number that the administrator has assigned for the **DICOM** application.
POSIX	**P**ortable **O**perating **S**ystem **I**nterface for UNI**X**. POSIX is an **IEEE** standard that defines the language interface between application programs and the UNIX operating system. Adherence to the standard ensures compatibility when programs are moved from one UNIX computer to another. POSIX is primarily composed of features from UNIX System V and BSD UNIX.
PPE	**P**ersonal **P**rotection **E**quipment.
PPP	**P**oint to **P**oint **P**rotocol enables a computer to access a network with a telephone, a fast modem and a service provider.
Preamp (preamplifier)	8-channel custom **ASIC** on the converter board that integrates the current signal from the detector. Also serves as anti-aliasing filter before analog to digital conversion of the signal from the detectors.
PROM	**P**rogrammable **R**ead **O**nly **M**emory is programmed by burning fusible links inside the chip. Once burned, they cannot be changed.
protocol	A recipe of software, parameters and settings that will enable two computers to communicate.
proxy	A network proxy enables a computer user to communicate across a firewall of an intranet whose access from the outside world is guarded by that firewall. Business employees need to configure their web browser software proxies for various protocols used to access Internet information is various ways, http being the most common. Home users who have an independent service provider do not need or use proxies.
Radial Alignment	Radial Alignment This is the alignment of the detector so that both ends are equidistant from the focal spot of the tube.
RAM	**R**andom **A**ccess **M**emory
RCIB	**R**otating **C**ontroller **I**nterface **B**us. The **CAN** bus and control lines from the **HCB** (**HEMRC** Control Board) to the **CCB** and **DCB** on the rotating side of the gantry.
RCOM	**R**otating **COM**munications
reconfig	A shell started program with a **GUI** that changes system parameters. To start Reconfig, Shutdown Applications (on Utilities Service Menu), become su at root, enter: reconfig. Make required timezone, operation, site preferences, network, hardware configuration changes with the **GUI**. To restart Applications, select YES to reboot prompt or enter: st&

TERM	MEANING
Ref-Channels (Reference channels)	**DAS** channels 1 through 3 on each slice. Used to normalize **DAS** data to x-ray source intensity; consequently should be outside patient anatomy.
register	A digital, electronic device for temporary storage of a value.
Removable Media Drives	Disk drives in which the media can be removed. For example: **MOD**s, floppy disks and CD-ROMs
repeater	A network repeater is a device to connect two or more devices to a subnet; the last port on a repeater can be used to connect multiple hubs. A repeater conditions the signal and with the hub port can extend the physical distance between devices. This is important because there are limits to how far a cable length can be effective.
REQ	Request signal
RF Ring	Communication channel to passes raw image data from the rotating side of the gantry (**MDAS**) to the stationary side.
RF Shoe	Picks up the RF signal from the RF ring.
RI	**R**ing **I**ndicator is a serial control signal from the DCE.
RIP	**R**econ **I**nterface **P**rocessor. The Power PC single board computer (**VME** based).
RIS	**R**adiology **I**nformation **S**ystem describes a computer system that retrieves and stores patient personal data and their diagnostic images on a network. Some of these **RIS** systems are compatible with the **CT** system. When the host application called Worklist Server, or WLServer, conforms with the **RIS**, then that patient data can be shared across the network.
ROI	**R**egion **O**f **I**nterest
ROM	**R**ead **O**nly **M**emory.
router	A router is a device that determines what path network traffic will take to reach its destination. It extends a local area network (**LAN**) to create a larger inter-network. It uses the routing information inside the data and the criteria programmed into it to make decisions on how to most efficiently route the data.
routine	A specialized software program or module. This system uses Activity Manager and Delivery routines.
Routing Table	A file that identifies network interfaces; it details the names and IP addresses of all the routers and gateways in the network.
RS-232	Electronic Industries Association (EIA) standard for serial data transmission that prescribes signals by voltage level and pin location.
RS-422	EIA standard for the serial exchange of digital data between two pieces of electronic equipment that uses a balanced, or differential, interface. It uses relative differences between a positive and negative signal without reference to a common ground. This enables greater speed and immunity to noise or **EMI**.
RTS	**R**eal **T**ime **S**tatistics.
RTS	**R**equest **T**o **S**end. Serial control signal from the DTE.
RxD	Received Data. Serial data from the DCE to the DTE. It is input to the host from a peripheral or modem.
SAG	**S**ystem **A**ngular **G**eometry.
SARQ	**S**tationary **A**utomatic **R**etry **Q**uery. Small board used in transmitting data across the slip rings to the rotating part of the gantry. It generates an ECC error code used to verify data integrity. It is located in the **STC** chassis.

TERM	MEANING
sash	**S**tand-**a**lone **sh**ell can be started from the **SGI** command monitor prompt, reached by interrupting the system boot and selecting “5”. Sash can be used to find and load files and devices, files outside the reach of the command monitor, the **SGI PROM**, meaning files in IRIX or Unix.
SCIM	**S**ystem **C**ontrol **I**nterface **M**odule
SCOM	**S**tationary **COM**munications.
SCP	**S**ervice **C**lass **P**rovider describes a **DICOM** task/device that allows other devices on the network to query the **SCP** for images or data. A **SCP** task listens on the specified port for the Application Entities (**AE**) that it has been configured to hear. **SCP** is like a server.
SCSI	**S**mall **C**omputer **S**ystem **I**nterface is a peripheral interface standard commonly used for hard disk drives and some printers to speed up data transfer.
SCU	**S**can **C**ontrol **U**nit is a term for the chassis that contains the **RIP** and **PEG-IG** boards. The boards reconstruct scan data into image files.
SCU	**S**ervice **C**lass **U**ser describes a **DICOM** task/device that uses another unit on the network to store or print images or get patient information so that the technologist does not have to key it in. **SCU** is like a client
SdC	**S**tation **d**e **C**onsultation. French name for the Advantage Windows workstation.
SDC	**S**can **D**ata **C**orrections are performed by the **PEG-IG** board.
SDD	**S**can **D**ata **D**isk. Hard drive that holds scan data. It replaced the HSD (High Speed Disk).
SDD	**S**oftware **D**esign **D**ocument
SDM	**S**ervice **D**esktop **M**anager. Graphical User interface used to access service related tools and functions.
SDRAM	**S**ynchronous **D**ynamic **R**andom **A**ccess **M**emory.
SE	**S**olid Impact **E**nhanced. Graphics board used with the SGI Octane computer.
semaphore	A software object that handles device reservations for tasks.
server	A server is a computer system or application that provides the programs and disk space that a client computer or application possibly somewhere else on the network uses. The communication link between a server and client is called a socket.
SFOV	**S**can **F**ield **O**f **V**iew
SG	**S**ignal **G**round
SGI	**S**ilicon **G**raphics **I**ncorporated Company makes the Silicon Graphics Computer (ergo, “**SGI** computer”).
SI	**S**olid **I**mpact. Graphics board used with the SGI Octane computer.
SMPTE	**S**ociety of **M**otion **P**icture and **T**elevision **E**ngineers.
socket	The software structure that enables a communication link between any two network computer processes, like a server and client, is called a socket. You need an IP address and a port to establish a socket. The verb 'bind' is often used in connection to socket.
Software Level - Application	Applications Level is the software level where the scanner specific software has been initialized and the system could be used to: scan, archive, display, film, etc.
Software Level - Boot	Boot level is where no software is running other than what can be run out of **CPU** firmware. This was often referred to as `**PROM** Monitor' or `Boot Prompt' or Single User Mode.
Software Level - Operating (Irix)	Operating is the software level in between `Boot Level' and `Applications Level'. This is often referred to as the Operating System level. The system will normally start and login as user `ctuser' leaving the User Interface ready for selection of Irix and Unix Commands or start-up of the Scanner Applications Software.

TERM	MEANING
SOP	**S**ervice **O**bject **P**air. A **DICOM** software term. Server Object Pair is Service Class User plus Service Class Provider. Client/Server
SRC	**S**lip **R**ing **C**ommunications.
SRU	**S**can **R**econstruction **U**nit
STC	**ST**ationary **C**omputer used to monitor **ETC** and **OBC** status. Controls communications between the **ETC** and **OBC**. Also monitors the axial rotation of the gantry.
STP	**S**hielded **T**wisted **P**air
subnet	A subnet is a group of connected computers or hosts. The network portion of their IP addresses would match, but the host portion would be unique.
System State	Program available on Service **PM** menu that enables you to save and restore protocols, calibration, configuration, Auto Voice, Display Preferences, and characterization of the Table, Gantry, and InSite features. This should be done with a Max Optics **MOD**. Mark this **MOD** so that no one will use it for Image Archive. The LABEL instruction under that feature will reformat your System State **MOD** into a DOS MODE format, destroying it.
task	The smallest complete unit of software. A task can use and wait for system resources without explicit concern for other tasks.
TCP	**T**ransmission **C**ontrol **P**rotocol (software) assumes the datagram service it is layered above is unreliable. A checksum over all data helps **TCP** implement reliability. Using a window-based flow control mechanism that makes use of positive acknowledgments, sequence numbers, and a retransmission strategy, **TCP** can usually recover when datagrams are damaged, delayed, duplicated or delivered out of order by the underlying communication medium. If the local **TCP** receives no acknowledgments from its peer for a period of time, as would be the case if the remote machine crashed, the connection is closed and an error is returned to the user. If the remote machine reboots or otherwise loses state information about a **TCP** connection, the connection is aborted and an error is returned to the user.
TCP/IP	**T**ransmission **C**ontrol **P**rotocol/**I**nternet **P**rotocol is a common standard for transferring data across the Internet.
telnet	Telnet is another **TCP/IP** standard. Telnet is a protocol that enables your computer to logon to a remote computer and query that computer for its information or use its programs. Download its instructions and read offline so as not to prevent others from access. Logoff using that computer's commands. If you cannot figure what that is, try [Ctl + Esc]. Telnet can also be used as an adjective to describe Internet sites where this protocol is used.
Termination	Termination is required at both ends of a **SCSI** bus.
TNC	**T**able **N**etwork **C**ontroller. Another name for the **ETC-IF**.
TRAM	**T**exture **R**andom **A**ccess **M**emory on the MG1,0 and MG1,1 boards used to perform pixel interpolations and hold same image data.
tristate	Describes electronic device whose output may be HIGH, LOW, or high impedance meaning not driven This makes it possible to use the same bus for different purposes. It also is used as a verb to mean to disconnect the unused circuitry by making it's connection high impedance.
TTL	**T**ransistor to **T**ransistor **L**ogic is low with voltage levels from 0 to 0.8 V, and high at levels of 2.4 to 5 V. This is also called Vcc, digital logic, and 5V.
Tube Mounting Plate	Mounting plate between tube and collimator.
TxD	Transmitted Data. Serial data from the DTE to DCE. It is serial data from the host to a peripheral or modem.
TXXT	**T**rigger On, **X**-Ray On, **X**-Ray Off, **T**rigger Off
UDP *or* udp	**U**ser **D**atagram **P**rotocol. **UDP** is a network term.
UID	**U**nique **ID**entifier

TERM	MEANING
UPS	Un-interruptible Power **S**upply.
URL	**U**niform **R**esource **L**ocator is a way to define a resource location on a network. It describes the type of service (http, ftp, or telnet, and its exact location by network, if different, its directory and its file name. Format: protocol://computer[:port]/path/filename Example: http://www.gemedicalsystems.com
UTP	**U**n-shielded **T**wisted **P**air
V.32	A CCITT standard for 4800 and 9600 baud modem communications. V.32 modems transfer data at 9600 bps, unless phone line quality is poor. Until it improves, the modem transfers at 4800 bps.
V.32bis	A CCITT standard for modem communications that extends the V.32 connection rate range in the following steps: 4800, 7200, 9600, 12 k, and 14.4 k bps. These modems fall back one speed at a time as phone line quality worsens, or up one as it improves.
V.34	A CCITT standard for modem communications that extends the V.32 connection rate to 28.8 k bps. With data compression, this rate can theoretically go to 115.2 kbps but the condition of most phone company links prevents that from happening. This standard was previously known as V.Fast and V32terbo.
V.42	A CCITT standard for modem communication that improves throughput by correcting errors and compressing data
V.Everything	A CCITT standard for modem communications that improves throughput by adapting to the modem to which it connects and using optimal protocols.
VLSI	Very **L**arge **S**cale **I**ntegration of electronic circuits on one chip.
VME	**V**ersa **M**odulo **E**urocard
VME ASIC	The **RIP CPU** has a master **ASIC** that implements the VMEbus interface standard. It contains a **DMA** controller, local and global interrupt handlers, and the VMEbus R/W logic. The other boards have a slave **VME** Interface **ASIC** to communicate with that master **ASIC**.
VME_ADR	31 lines of three state driven, one directional signals that identify the devices that will receive or place data on the bus. All devices are memory mapped.
VME_AM	**VME A**ddress **M**odifier. A VMEbus signal that broadcasts information about the address during the address load cycle such as whether it is short (16 bits), standard (24), or extended (32 bits long). It can be used to identify a sequential transfer which is not to be interrupted until the entire data block is transferred. Six lines are reserved for this purpose.
VME_AS*	**A**ddress **S**trobe is a three state driven signal whose falling edge indicates the master has placed a stable, valid address and modifier onto the bus.
VME_BERR*	**VMEb**us **Err**or is generated by any slave board if the data size is wrong or an error occurred in a transfer; it is generated by the **CPU** bus timer if a data transfer fails to occur.
VME_DAT	Thirty-two lines of three state driven bidirectional data used to transfer information between the **CPU** and the other boards on the VMEbus.
VME_DS0* or 1	**D**ata **S**trobe is a high current, three state VMEbus signal driven by the **VME** host and interrupt handlers.
VME_DTACK*	**D**ata **T**ransfer **ACK**nowledge signal is driven low by a slave or interrupter. When asserted, it tells the device it has placed the requested data on the bus.
VME_IACK*	**I**nterrupt **ACK**nowledgment is accomplished by a **VME** daisy chain. IACK jumpers should be open or removed if there is a board in its associated Back End slot. One must be installed to continue the interrupt path if there is no board in a slot.

TERM	MEANING
VME_IRQ0n*	**I**nterrupt **Re**quests (see also **ISR**). These seven lines are monitored by the MVME166 for signals from the other boards that indicate that an I/O process is waiting, that no device responded to a command, that a voltage or output is wrong. The highest numbered request line has the highest priority. Software assigns the priorities and what appropriate routine should be implemented.
VME_LWORD*	**L**ong **WORD** select is a three state VMEbus address signal driven low by the **VME** host and used with ADR01, DS0*, DS1* to indicate a 32-bit data transfer.
VME_SYSRESET*	A control signal that resets every board. This happens when the unit is powered ON, or the RESET switch on the **CPU** is pressed.
VMEbus	VersaModule Eurocard bus; an **IEEE** backplane standard that prescribes how data transfers will be managed. The VMEbus can handle 8, 16, and 32 bit transfers. It has multiprocessing and interrupt capability. The maximum data transfer rate is 40 MB/sec.
VVC	**V**iews **V**ersus **C**hannels
WORM	**W**rite **O**nce, **R**ead **M**any.
X Window	X Window is a windowing system developed at MIT, which runs under all major operating systems.
XCR	Ethernet Converter - 10BaseT to 10Base2
xfs	Starting with R3.6, the host uses the XFS filesystem rather than EFS. XFS uses database journaling technology to provide high reliability and rapid recovery. Recovery after a system crash is completed within a few seconds, without the use of a filesystem checker such as the fsck command. Recovery time is independent of filesystem size. XFS is designed to be a very high performance filesystem. Under certain conditions, throughput exceeds 100 MB per second.
Y/C	An abbreviation for a composite video signal that carries color, sync and brightness information. The Y portion – called luminance – carries the sync and brightness and can be used for black and white as well as color video. The C signal – called chrominance or chroma – carries color information, and synchronizes with the horizontal frequency.
Z-Alignment	After changing a tube, both the **BOW** (beam on window) and **POR** (plane of rotation) need to be done. Since the collimator & detector have not changed position, the X-Ray tube only needs to be adjusted toward or away from the table. (Assumes the collimator & detector are in the correct position.) The Z-Align can do this with one adjustment instead of two.
Z-CHANNELS	**DAS** channels 763 through 765 in each slice. Used to control “Z” direction centering of beam on detector via the collimator. Have special detector FET control lines, to select outer detector cells.

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GE MEDICAL SYSTEMS

GE MEDICAL SYSTEMS-AMERICAS: FAX 262.312.7434
3000 N. GRANDVIEW BLVD., WAUKESHA, WI 53188 U.S.A.

GE MEDICAL SYSTEMS-EUROPE: FAX 33.1.40.93.33.33
PARIS, FRANCE

GE MEDICAL SYSTEMS-ASIA: FAX 65.291.7006
SINGAPOR