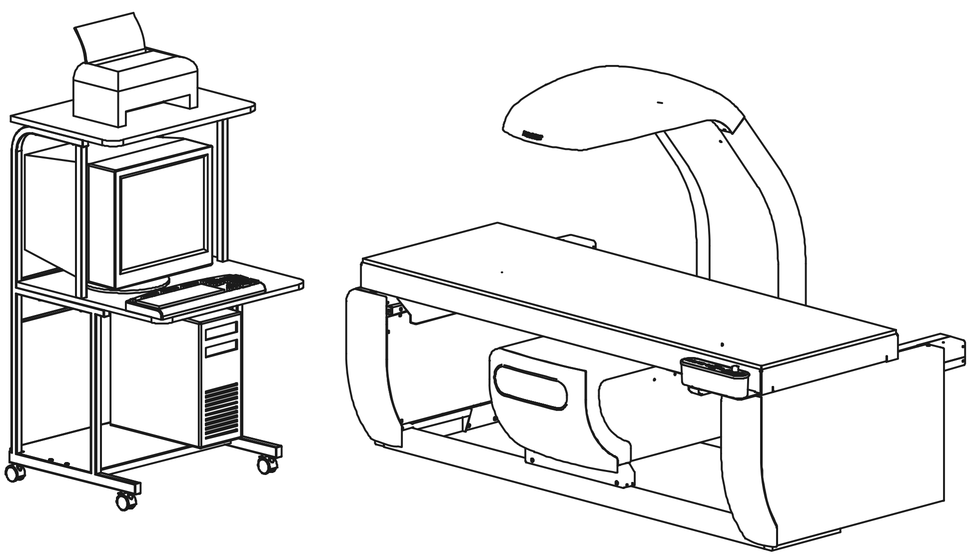
HOLOGIC®
OSTEOPOROSIS ASSESSMENT

DISCOVERY™

QDR® Series

FAN BEAM X-RAY BONE DENSITOMETER

TECHNICAL MANUAL



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Document 080-1085
Revision 008

December 2010

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Exercise proper caution when servicing the system. There are dangerous and potentially lethal voltages accessible within the Discovery system. To avoid exposure to shock hazards, the Main Circuit Breaker should be switched off, and the power cord removed, before working inside any part of the system.

The Discovery QDR Series Fan Beam X-ray Bone Densitometer produces ionizing radiation in the form of X-rays. It may be dangerous to the patient, operator or field engineer unless safe exposure factors and operating instructions are observed. To avoid unsafe exposure, do not attempt to service the equipment unless you are a Hologic, Inc., certified field engineers. Exercise proper caution when servicing the system. A dosimeter (film badge) should always be worn while on site. Dose and scatter measurements must be taken after each service call to ensure that the parameters are still within specifications.

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Printed in U.S.A.

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Section 1
INTRODUCTION

1.1 System Overview

The Hologic Discovery® X-ray Bone Densitometer (Discovery-C and -W is shown in Figure 1-1 on Page 1-2; Discovery-A and -SL is shown in Figure 1-2 on Page 1-2) estimates the bone mineral content (BMC) and bone mineral density (BMD) of selected areas of the body or of the entire skeleton. It does so using X-rays of two different energy levels. This dual-energy scheme allows soft tissue within the selected area to be subtracted out leaving only bone to be scanned and estimated.

This manual uses "Discovery" to refer to all models in the Discovery series of systems. Information presented in this manual that applies only to a particular model, or models, will be noted as such.

The patient lies face up on the table and, with the aid of a cross-hair laser, the operator positions the scanning arm over the region of interest. After entering patient data and selecting the type and size of scan desired, the operator initiates the scan with a single keystroke.

The operator is not required to select technique factors as tube current and voltage are pre-selected and fixed. Since testing is performed by fan beam method, rather than by flooding the area as in conventional radiography, the scanning time is a function of the dimensions of the area to be measured, the desired resolution, and the desired precision.

BMC results are expressed in grams of calcium hydroxyapatite and BMD is reported in grams/ cm^2 of the same compound.

In most cases, no additional shielding is necessary for patient, operator, or room. The Discovery system can be placed in any convenient non-shielded examination room. Contact your state regulatory agency for details about additional shielding requirements, if any.

The Discovery system employs a patented Automatic Internal Reference System, which continuously calibrates the machine to eliminate the effects of variations in temperature, tube flux, etc. No daily calibration is required. The daily scanning of a quality control phantom is required to provide assurance that the system is functioning correctly and to aid in the detection of any long-term drift.

The X-ray scans produced by the Discovery, and displayed on the monitor, are intended only to locate anatomical sites for measurement and to assure the operator that the machine is operating properly. They are not intended as a substitute for conventional film-based diagnostic scans.

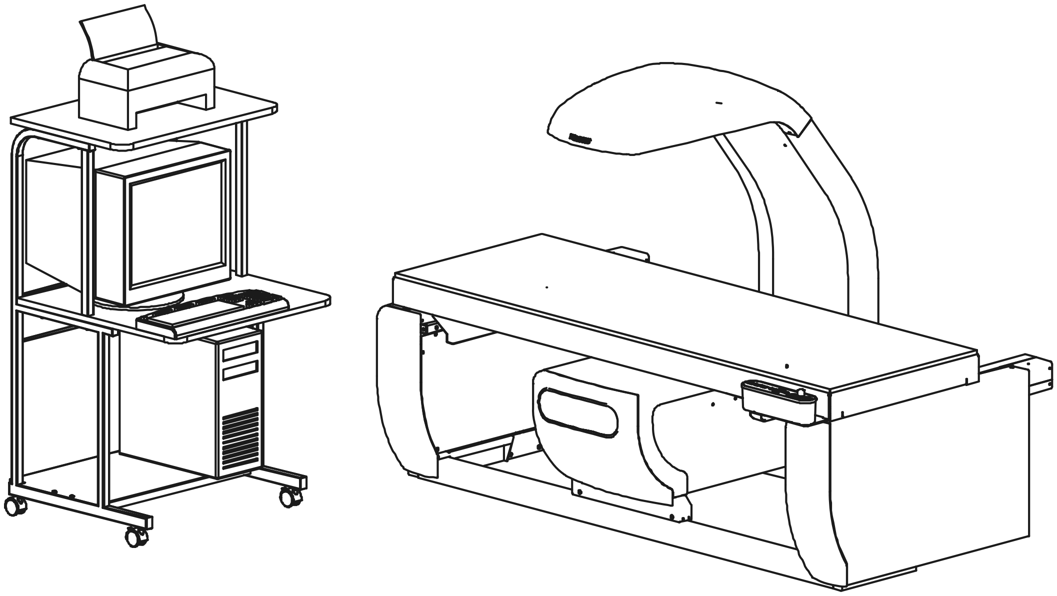


Figure 1-1. Discovery®-C and -W System

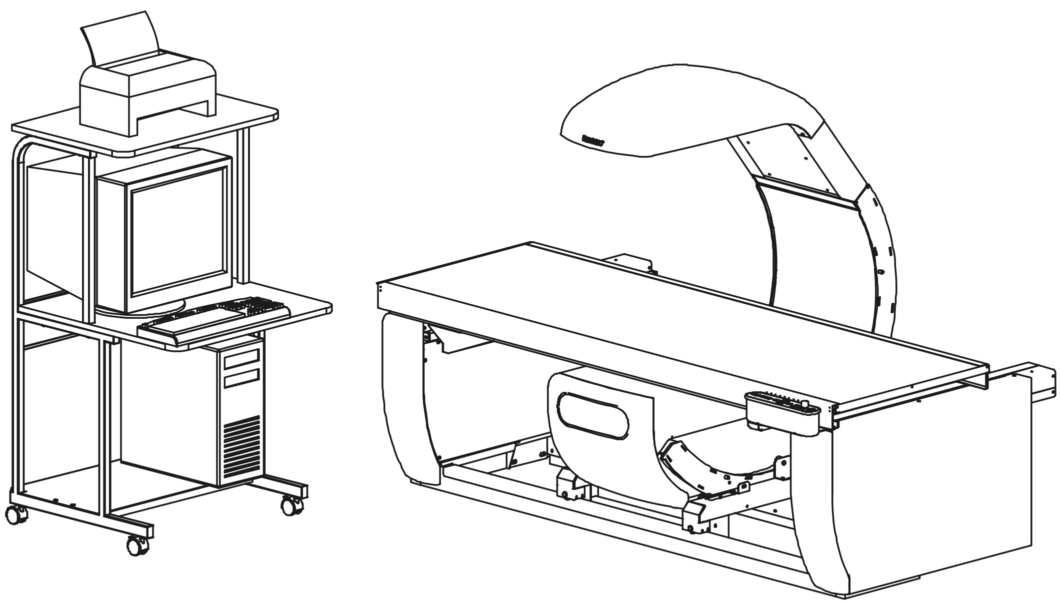


Figure 1-2. Discovery®-A and -SL System

1.1.1 X-Ray Scanning Principles

An X-ray source, consisting of a high voltage generator and X-ray tube in a common, shielded enclosure, is mounted beneath the patient on the C-Arm. It generates a narrow, tightly collimated, fan-shaped beam of X-rays which alternate, at power line frequency, between 100kVp and 140kVp. At the other end of the C-Arm, above the patient, is a crystal/solid state detector array. During a scan, the C-arm and table move, under computer control, to guide the beam over the desired scan area.

Before passing through the patient, the beam is filtered through a rotating drum in which alternating segments having radio-opacities equivalent to tissue, bone and air are located. When finally intercepted by the detector, the beam contains information about the X-ray absorbing characteristics of both the patient and the calibration materials in the filter drum. An A/D converter, fed by the detectors, supplies a complex digital signal to the computer, which uses that signal both to construct the screen display, and as the basis for its computations of BMC and BMD.

The Discovery computer algorithm is based on the principle that bone attenuates the X-ray beam differently at high and low energies. The bone mineral content of any sample point can be computed from:

$$Q = L - kH$$

where L and H are the logarithms of the sample attenuation at high (140kVp) and low (100kVp) energies, respectively. The constant k depends on the tissue attenuation characteristics of the beam. In the Discovery, k is continuously measured using the “tissue” segment in the filter wheel.

The program works in the following manner:

1. Load preliminary scan and obtain regions of interest from operator.
2. Estimate k as an average value of:

   $$k = [L_{tissue} - L_{air}] / [H_{tissue} - H_{air}]$$

   where L_{tissue} indicates a low-energy measurement with tissue-equivalent material interposed by the filter drum, and L_{air}, H_{tissue} and H_{air} are similarly defined.

Note: The subscript "air" designates the filter drum segment that is empty (i.e., contains neither bone- nor tissue-equivalent material).

3. Using this value of k, calculate Q for each point scanned using the formula given above (Q = L - kH). This array of Q values constitutes a "Q scan". Displays the Q scan.
4. Compile a histogram of the Q values. Because a large portion of the scan contains soft tissue only, this histogram will have a large peak. Choose a threshold value just above this peak, and apply that value to discriminate, point by point in the Q scan, between "bone" points (whose Q is above the threshold) and "non-bone" points (whose Q is below the threshold).

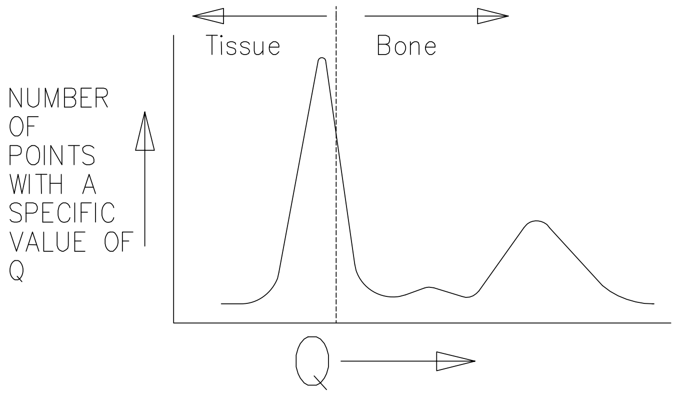


Figure 1-3. Q Scan Plot

5. Use the "non-bone" points to calculate a baseline value for each scan line. Using these points, form a new histogram and repeat steps 4 and 5 until the results converge.
6. Smooth the segment boundaries to eliminate isolated noise-generated "bone" points.
7. Display the "bone" and "non-bone" points for operator approval.
8. Determine the constant of proportionality (d_0) that relates the Q values to actual BMC (grams). This constant is determined by measuring how much Q shifts when bone-equivalent material is interposed by the filter drum.
9. Calculate the total bone mineral values by adding up the Q values for all "bone" points in each region of interest (e.g., each vertebra), and multiplying by d_0.
10. Determine the bone areas by counting the number of "bone" points in each region of interest.
11. Calculate bone mineral density as:

    BMD = BMC / area

12. Display the calculated results and print the report.

1.2 Functional Overview

This section provides block diagrams of the Discovery system along with a brief functional overview of each diagram and block. A detailed functional description along with interconnection diagrams and interconnection descriptions is provided in Section 2 of this manual.

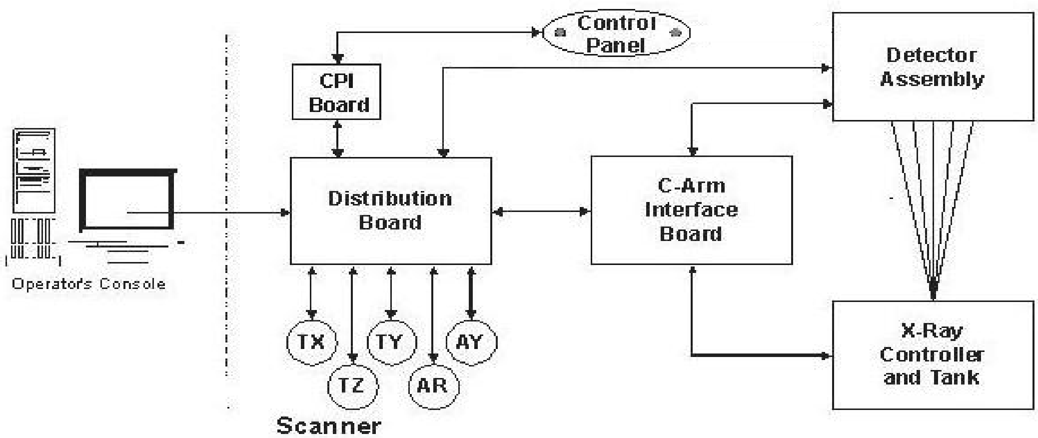


Figure 1-4. Discovery System Block Diagram

The Hologic Discovery consists of essentially three conceptual subsystems. These subsystems are the Operator's Console, Motor Control Subsystem, and C-Arm Subsystem.

The Operator's Console is the input/output subsystem of the instrument and consists of a PC running the Discovery system software under Windows XP® and the PCI Communications Controller Board manufactured by Hologic. The software communicates with the scanner sending out arm and table motion commands, X-Ray commands, and X-ray detection commands. The software also checks to see that commands have been completed and issues an appropriate error message when a command fails.

The Motor Control subsystem of the scanner is controlled by the Distribution Board. All motor movement commands are routed through the Distribution Board to the individual Motor Drivers. There is one Motor Driver for each motor: Arm Y direction (AY), Table X direction (TX), Table Y direction (TY) (A and W models only), and Arm Rotation (AR)(A and SL models only). The Distribution Board also distributes the DC power throughout the scanner. Circuit breakers for each Motor Driver can be found on the Distribution Board.

The C-Arm subsystem controls the generation and detection of X-rays. It processes the commands received from the Distribution Board and passes them to the X-Ray Controller or the Detector Assembly. The X-Ray Controller, as its name implies, controls the generation of the X-Rays by the X-Ray Source or "Tank". The X-Rays pass through the patient and are sensed by the Detector Assembly.

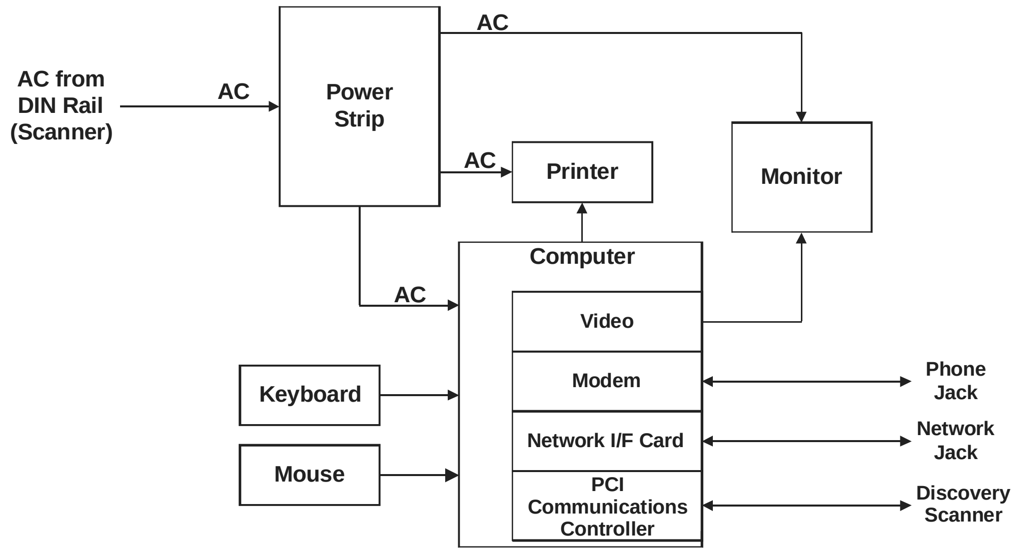


Figure 1-5. Discovery Operator's Console Block Diagram

The Discovery Operator’s Console consists of a Pentium PC on a convenient, roll-around computer cart designed specifically for the Discovery PC. AC power from the scanner is fed to the Operator’s Console via a power strip attached to the PC cart.

The Pentium PC contains the video controller board to drive the monitor and the PCI Communications Controller Board to interface the PC to the Scanner. A modem card is provided for remote communications with other PCs. A Network Interface Card (NIC) is installed to control communications with the Hologic QDRNet® or a DICOM® network. The mouse gives the operator easy control over the Windows XP-based Discovery software and the keyboard is used for data input to the Discovery software. A color inkjet printer is provided with the PC. An optional laser printer can be substituted for the inkjet printer.

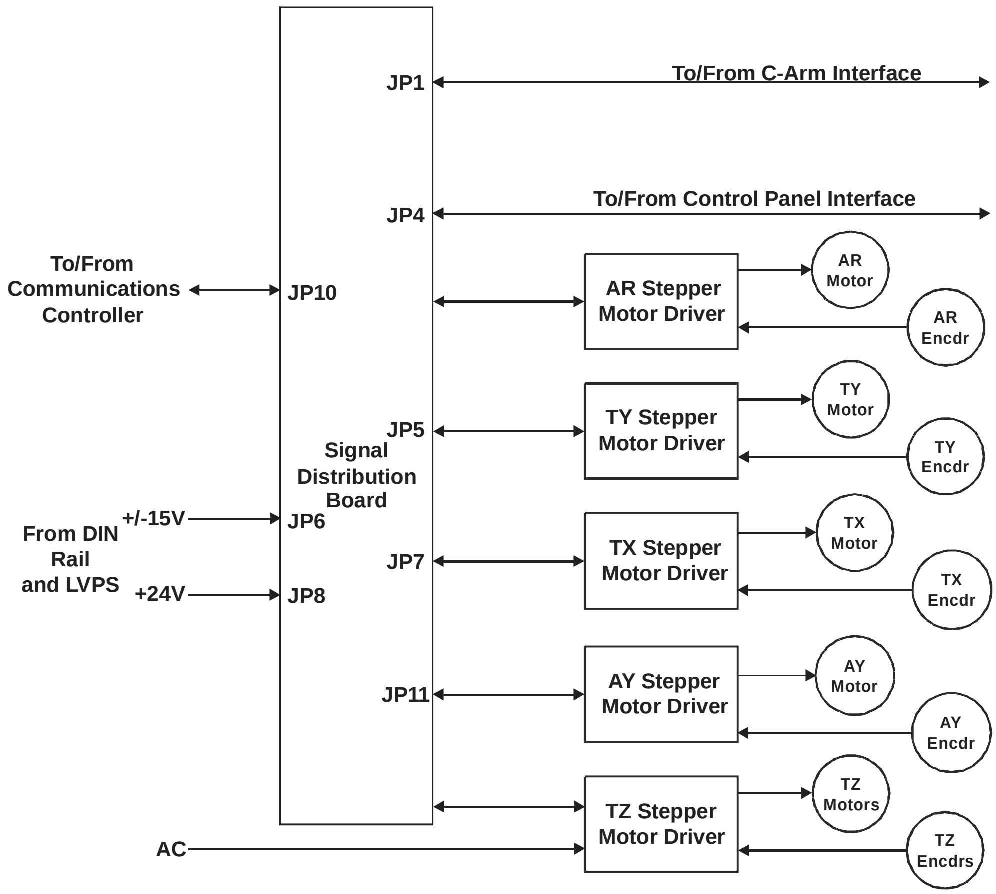


Figure 1-6.Discovery Distribution and Motor Control Block Diagram

The heart of the Discovery Scanner is the Distribution Board. This board interfaces the PC to the different subsections of the Scanner, distributes control signals to the table and C-Arm, and distributes DC power throughout the Scanner. The Distribution Board receives command inputs from the PCI Communications Controller Board in the PC and voltages from the DIN rail and Low Voltage Power Supply. Commands and voltages dealing with the generation of X-Rays or the acquisition of scan data are transferred to the C-Arm Interface Board, which controls both functions. The Distribution Board also receives Table and C-Arm motion commands from the PCI Communications Controller Board in the PC.

When a motion command is received, the Distribution Board routes the command along with a board address to the Motor Driver Boards. The addressed Motor Driver Board converts these digital commands into analog signals that are strong enough to drive the motors. A Position Encoder attached to the idler pulley moved by the motor, senses changes in the position of the arm or table. This device provides a voltage feedback to the Motor Driver Board that is translated into a motor position, which in turn, is fed back to software in the Operator’s Console PC.

The Discovery Control Panel is located at the head end of the table and communicates with the Distribution Board via the Control Panel Interface Board. The Control Panel provides the operator with a means to issue manual commands to move table and arm motors, turn power to the instrument on or off, and an indicator showing when X-rays are being generated.

The C-Arm Interface Board controls the C-Arm Subsystem. Commands to the subsystem arrive from the Distribution Board. The commands processed by the C-Arm Interface Board are sent to the Positioning Laser, the X-Ray Controller (XRC), the Aperture Motor, the Detector assembly, or the Filter Drum Assembly. The commands sent to the Positioning Laser are simple on/off commands. Commands sent to the XRC tell it when to produce X-rays, which power level of pulse to produce, and the pulse mode to be used. These commands will subsequently control the way the X-Ray Source (Tank) is driven by the XRC. Instructions to the Aperture Motor are for selecting the aperture to be used for the scan. The commands to the Filter Drum Assembly turn the Filter Drum on or off and synchronize the filter drum with the AC line waveform. The last set of command signals is sent to the Detector Assembly to synchronize the acquisition of data with the production of the X-rays from the source (Tank).

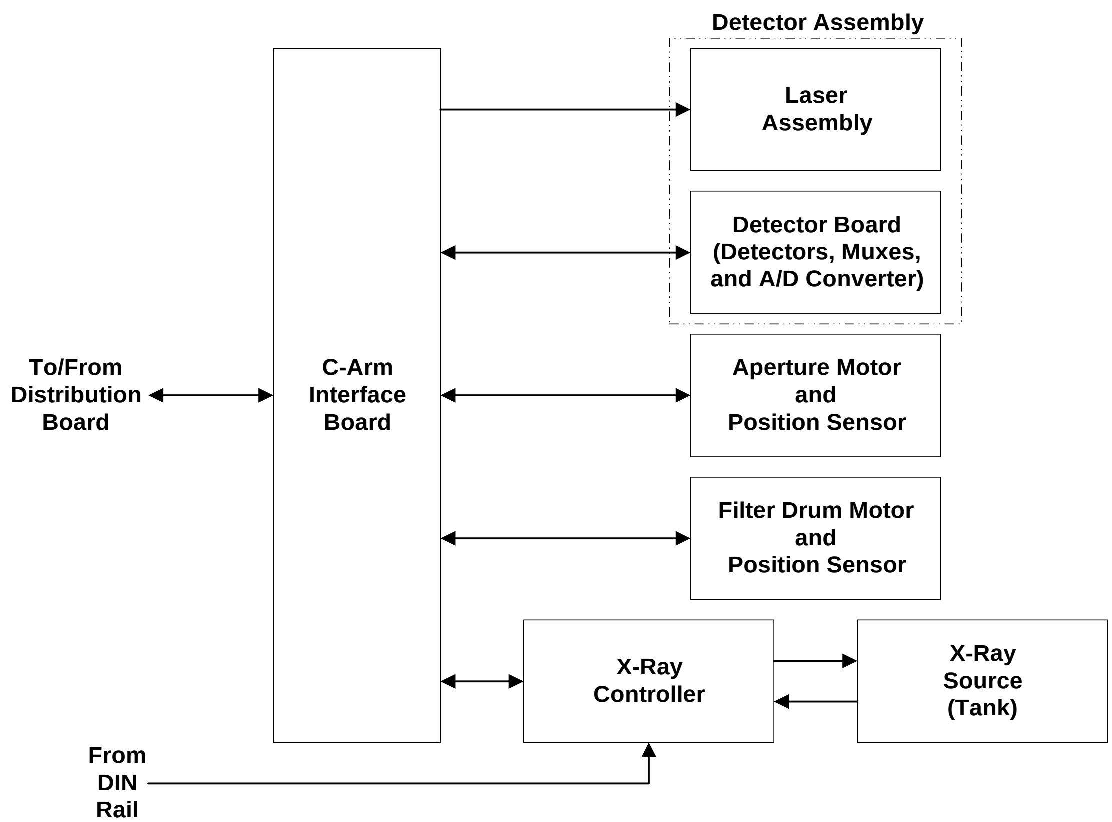


Figure 1-7. Discovery C-Arm Block Diagram

The C-Arm Interface Board collects data from most of the circuits mentioned above for transmission back to the Distribution Board and, finally, the Discovery software. The Aperture Motor Assembly sends back position information indicating which of the aperture slits is in position. The Filter Drum Assembly sends back filter and reference phase information. The XRC sends back information concerning fault conditions, beam conditions, and an AC Line signal for generating AC Line Interrupts to the software. The Detector Board sends data collected from scans back to the software through the C-Arm

Interface Board and the Distribution Board. Mathematical algorithms applied to this data produce the scans seen by the operator and to calculate the BMD, BMC, and area of the bone matter scanned.

Block	**Description**
Computer	Controls and commands all Discovery hardware modules.
PCI Communications Controller Board	Controls the flow of commands to and from the Scanner modules via the communications bus.
Distribution Board	Provides the interconnections between the Discovery Operator's Console and the Scanner and distributes DC voltages.
Control Panel	Provides switches for manually moving the C-Arm and Patient Table. Also provides Emergency Stop and Instrument On/Off switches.
TX Stepper Motor Driver	Controls the motion of the Patient Table in and out motor and monitors table position information from the encoder.
TY Stepper Motor Driver	Controls the motion of the Patient Table left to right motor and monitors table position information from the encoder (A and W only).
TZ Stepper Motor Driver	Controls the motion of the Patient Table left and right pedestal motor and monitors table position information from the string encoders (A and SL only).
AR Stepper Motor Driver	Controls the rotational motion of the C-Arm and monitors C-arm position information from the encoder (A and SL only).
AY Stepper Motor Driver	Controls the motion of the C-Arm left and right motor and monitors C-Arm position information from the encoder.
C-Arm Interface	Controls the Aperture and Filter Drum motors, generates timing and control signals for the X-Ray Controller and the Data Acquisition System, monitors the tape switches, and provides power to the Positioning Laser.
X-Ray Controller	Controls the operation of the X-ray Source.
X-Ray Source Unit	Generates the X-ray beam.
Detector Board	Converts the X-rays into electrical signals. Integrates the signals from the Solid State Detectors and converts them to a digital value in the Analog-to-Digital converter circuitry.
Control Panel	Provides the operator with a means to reposition the table, C-Arm, and to turn on the laser.
Positioning Laser	Provides a laser crosshair beam to assist in positioning the patient on the Patient Table.

1.3 Product Specifications

SPECIFICATION	MODEL	DEFINITION
Scanning Method	All	Multi-detector array, indexing table, and motorized C-arm
X-ray System	All	Switched Pulse Dual-Energy X-ray tube, operating at 100 and 140kV, 5mA avg. at 50% duty cycle, 2.5mA avg. at 25% duty cycle (30sec. maximum), Tungsten target
Detector System	A	216 multi-channel detector consisting of $CdWO_4$ scintillators coupled to silicon diodes
	SL/C/ W	128 multi-channel detector consisting of $CdWO_4$ scintillators coupled to silicon diodes
Scanning Sites	A	Lumbar spine (in AP and lateral projections), proximal femur (hip) forearm, IVA Spine, and whole body
	SL	Lumbar spine (in AP and lateral projections), proximal femur (hip), IVA Spine, and forearm
	W	Lumbar spine (in AP and decubitus lateral projections), proximal femur (hip), forearm, IVA spine (AP only) and whole body
	C	Lumbar spine (in AP and decubitus lateral projections), proximal femur (hip), forearm, and IVA spine (AP only)
Scan Region	A	1.95m (76.77 in.) x.65m (25.59 in.) maximum
	SL	96cm (38 in.) x .65m (25.59 in.) maximum
	W	1.97m (77.5 in.) x.65m (25.59 in.) maximum
	C	.96m (38 in.) x.51m (20 in.) maximum
Scatter Radiation	All	Less than 10µGy/h (1mrad/h) at 2m (79 in.) from the center of the X-ray beam for all scans
Leakage Radiation	All	The Discovery meets the requirements of 21 CFR 1020.30(k) for leakage from the X-ray source
External Shielding Requirement	All	Contact state regulatory agency.
Calibration	All	Self Calibrating using Hologic Automatic Internal Reference System. Operator calibration NOT required.

SPECIFICATION	MODEL	DEFINITION					
System Weight installed		Scanner		Console			
	A & SL	327kg	720lb	34.1kg	75lb		
	C & W	295kg	650lb				
System Weight shipping		System					
	A & SL	659kg	1450lb				
	C & W	568kg	1250lb				
Operating Temperature	All	15^{o} – 32^{o} C (59^{o} - 90^{o} F)					
Humidity	All	20 – 80% relative Humidity, non-condensing					
Storage Temperature	All	15^{o} – 32^{o} C (59^{o} - 90^{o} F)					
Humidity	All	20 – 80% relative Humidity, non-condensing					
Footprint		Length		Width		Height	
		m	inches	m	inches	m	inches
Table extended	A & W	3.02	119	1.50	59	1.42	56
Table not extended	A & W	2.02	79.5	1.22	48	1.42	56
	C & SL	2.02	79.5	1.40	55	1.42	56
Average Heat Load	ALL	1000w (3400 BTU/hr)					
Patient Table Height	A & SL	Adjustable, 71cm (28 in.) from floor when scanning in AP mode 86.4cm (34 in.) at maximum elevation					
	C & W	71cm (28 in.) +/- 25mm (1 in.)					
Positioning Laser	All	Diode laser (<1mW) cross hair, with emergency mechanical shutter					
X-Ray Collimation	All	Dual movable aperture with 0.5mm and 1.0mm slits					
Leakage Current	All	Normal <75µA		Single Fault <400µA			
Resolution	All	0.5 line pair/mm		approximately 1.0mm			

1.3.1 Exam Mode(s) Performance

Exam Type	Model	Default Scan Length (in.)	Duration(s) @ Default Length	Scan Site	Dose mGy max	*in vivo* Precision (%)
AP Spine High Def	All	8.0	163	L1, L2, L3, L4	0.20	1.0
AP Spine Array	All	8.0	82	L1, L2, L3, L4	0.20	1.0
AP Spine Fast	All	8.0	41	L1, L2, L3, L4	0.10	1.0
AP Spine Turbo	All	8.0	21	L1, L2, L3, L4	0.05	1.0
Express Scan	All	8.0	10	L1, L2, L3, L4	0.07	1.0
Decubitus Lateral Spine Fast	C & W	8.0	160	L2, L3, L4	0.40	1.0
Lat Spine High Def	A & SL	8.0	240	L1, L2, L3, L4	0.35	1.0
Lat Spine Array	A & SL	8.0	240	L1, L2, L3, L4	0.70	1.0
Lat Spine Fast	A & SL	6.0	120	L1, L2, L3, L4	0.35	1.0
Hip High Def	All	6.0	123	Femur (Total)	0.20	1.0
Hip Array	All	6.0	62	Femur (Total)	0.20	1.0
Hip Fast	All	6.0	31	Femur (Total)	0.10	1.0
Hip Turbo	All	6.0	16	Femur (Total)	0.05	1.0
Dual Hip	All	6.0	2X Scan Mode	Left & Right Femur	Selected Scan Mode	Selected Scan Mode
Whole Body	W	77.0	402	Whole Body	0.015	1.0
	A	77.0	180	Whole Body	0.01	1.0
Forearm	All	6.0	31	Forearm (Radius & Ulna) (Total)	0.10	1.0
IVA SE AP Imaging	All	16.1	10	Spine T5-L4	0.07	NA
IVA SE R/L Lateral	All	16.1	10	Spine T5-L4	0.07	NA
IVA DE R/L Imaging	All	13.6	511	Spine T5-L4	0.35	NA
Small Animal Spine and Femur	A	2/3	149	Spine & Femur	NA	NA
Small Animal Whole Body	A	12.0	122	Whole Body	NA	NA

1.3.2 Duty Cycle:

C, W and SL	IVA	12%
	All Others	50%
A	Whole Body	100%
	IVA	12%
	All Others	50%

1.3.3 Leakage Technique Factors

The leakage technique factors for all models of Discovery are the same. It is the maximum continuous current at the maximum peak potential. This is X-ray mode #3. Peak potential 100/140kVp (dual energy), current 10mA peak 25% duty cycle or 2.5mA average.

1.3.4 Minimum Beam Filtration

The minimum filtration permanently in the beam is 3.7mm Al equivalent @80kV.

1.3.5 Measured Half Value Layer (HVL) At Different Operating Potentials

Measured operating potential	Measured Half Value Layer
Discovery All	
80kV	3.7mm Al equivalent
100kV	5.0mm Al equivalent
140kV	6.5mm Al equivalent

1.3.6 Line Voltage and Maximum Line Current

Power Requirements:	All	100VAC 16A 50/60Hz, Max apparent resistance = 0.32 ohm 120VAC 14A 50/60Hz, Max apparent resistance = 0.32 ohm 230VAC 8A 50/60Hz, Max apparent resistance = 1.28 ohm

1.3.7 Technique Factors for Maximum Line Current

Peak Potential 140kVp

Tube Current 10mA peak, 50% duty factor or 5mA average.

1.3.8 Maximum Deviation

The maximum deviation from the preindication given by labeled technique factor control settings or indicators are as follows:

Peak Potential:	+/- 15%
Current:	+/- 40%
Time:	+/- 10%

1.3.9 Measurement Criteria for Technique Factors

The measurement criteria of the technique factors is as follows:

Peak Potential:	The voltage peak is measured with an oscilloscope. Voltage is a squarewave pulse. Peak is defined as the peak voltage of the 4 millisecond pulse, discounting any initial overshoot.
Current:	Current is measured with an oscilloscope on the last millisecond of the 4 millisecond pulse.
Time:	Time of each pulse is measured with an oscilloscope and defined as the time between 50% rise and fall times of the peak potential pulse. Time of the scan is measured by counting the number of AC line pulses from the start to the end. X-ray pulses are synchronous with the AC line.

Section 2
FUNCTIONAL DESCRIPTION

This section provides a detailed functional description along with interconnection diagrams and descriptions of the Hologic Discovery. Refer to Section 1 for a block diagram and a brief functional description of each block.

2.1 Computer

The Discovery Scanner is interfaced to a PCI Communications Controller Board/ISA Bus computer which controls table and C-arm movement, X-ray generation, performs all necessary calculations, and manages both the patient and QC database information.

The computer is a Pentium III-based (or higher) PC that comes equipped with floppy disk drive, hard disk drive, keyboard, mouse, 17” color monitor, and CDROM R/W for archiving scans and backups of the system database. For details pertaining to the computer and its associated components, please refer to the documentation shipped with each unit.

2.2 PCI Communications Controller Board

The PCI Communications Controller Board handles all the communications between the Computer and the Scanner C-Arm and Table assemblies. The board resides in one of the computer internal ISA slots and communicates with the computer via the computer's I/O bus. It connects to the Distribution Board in the Scanner through a 50-conductor ribbon cable. This cable contains two independent communications links (one synchronous and one asynchronous) and additional system control signals. Each signal requires a pair of conductors for differential (RS422) noise immunity.

The asynchronous link communicates with the Motor Controller Boards (TX, TY, AR, and AY), the TZ Drive Board, the C-Arm Interface Board, and the Control Panel Controller section of the Detector Board (or the Control Panel Interface on A and SL models). The synchronous link communicates with the Data Acquisition System (DAS).

2.2.1 Interface Connections

Figure 2-1 on page 2-3 describes the interconnections between the PCI Communications Controller Board and the Distribution Board. The table also identifies the connectors and their pin assignments.

Table 2-1. PCI Communications Controller Board/Distribution Board Interconnection Descriptions.

Signal Pair	**Description**	**PCI[1] Pin**	**Dist[2] Pin**
ATD+ ATD-	Asynchronous data to the Scanner.	JP1-2 JP1-27	JP10-3 JP10-4
STD+ STD-	Synchronous data to the Scanner.	JP1-28 JP1-4	JP10-6 JP10-7
STCLK+ STCLK-	Synchronous data clock from PCI Communications Controller Board to Distribution Board. Synchronizes data to the Scanner.	JP1-5 JP1-30	JP10-9 JP10-10
STFRM+ STFRM-	Synchronous data frame from PCI Communication Command Board to Distribution Board.	JP1-31 JP1-7	JP10-12 JP10-13
ARD+ ARD-	Asynchronous Data from the Scanner.	JP1-8 JJP1-33	JP10-15 JP10-16
SRD+ SRD-	Synchronous Data from the Scanner.	JP1-34 JP1-10	JP10-18 JP10-19
SRCLK+ SRCLK-	Synchronous data clock from PCI Communication Command Board to Distribution Board. Synchronizes data from the Scanner.	JP1-11 JP1-36	JP10-21 JP10-22
SRFRM+ SRFRM-	Synchronous data frame from Distribution Board to PCI Communication Command Board.	JP1-37 JP1-13	JP10-24 JP10-25
EMERGENCY_IN+ EMERGENCY_IN-	Signals an emergency condition. Generated by the C-Arm Interface Board.	JP1-14 JP1-39	JP10-27 JP10-28
ZEROX+ ZEROX-	AC line zero-crossing signal used for system wide synchronization. Generated by the C-Arm Interface Board.	JP1-40 JP1-16	JP10-30 JP10-31
INTEGRATE+ INTERGATE-	Synchronous signal for Detector Integrate period. Generated by the C-Arm Interface Board.	JP1-17 JP1-42	JP10-33 JP10-34
SYSRESET+ SYSRESET-	Resets the Scanner controllers.	JP1-20 JP1-45	JP10-39 JP10-40
EMERGENCY+ EMERGENCY-	Removes power from the Scanner motor drivers and the X-ray system	JP1-49 JP1-25	JP10-48 JP10-49

Note: 1 PCI = PCI Communication Controller Board
2 Dist = Distribution Board

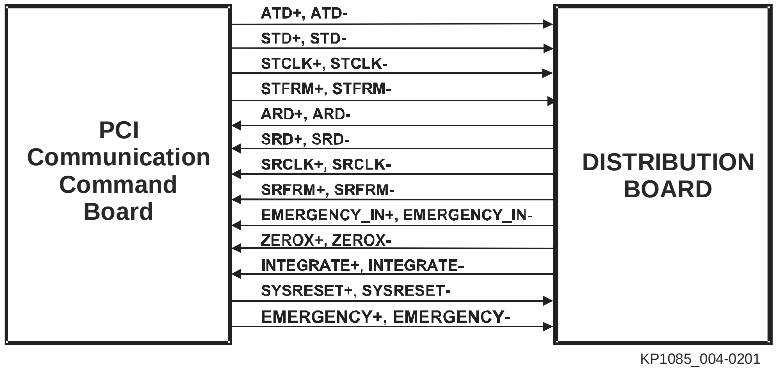


Figure 2-1. PCI Communication Command Board/Distribution Board Interconnection Diagram

2.3 Distribution Board

The Distribution Board provides interconnections between the Discovery Operator's Console (PC) and the Scanner. It passes several signal lines from the Operator's Console and power lines from the DIN rail directly to the C-Arm Interface module. It also provides buffering and individual drivers and receivers for various signal lines to and from individual Scanner modules and the PCI Communication Command Board. The Distribution Board is located in the Electronics Tray in the base of the Scanner.

One cable connects the Operator's Console (PC) communications bus to the Distribution Board. One cable connects to the Distribution Board from the DIN rail. This cable brings DC power to the Distribution Board and connects the X-Ray On and Emergency signal lines to the Power Module.

Up to eight cables connect the Distribution Board to the various Scanner boards depending on instrument model. Four cables connect to the four Motor Controller Boards (Table X, Table Y, Arm R, and Arm Y). A single cable connects to the TZ Drive Board. Two cables (one signal and one power) connect to the C-Arm Interface Board. In addition, one cable connects to the scanner Control Panel Interface Board. In the C and W models, this board is a separate section of the Detector Board. In the A and SL versions, the Control Panel Interface Board is a separate board located under the table.

The Distribution Board has provision for three jumpers that can be installed to override the EMERGENCY signal lines when troubleshooting.

2.3.1 Power

The Distribution Board receives +24 and +/-15VDC from the Multi-voltage DC Switching Power Module. The +24VDC is applied through four individual circuit breakers to the Table X, Table Y, Arm R, and Arm Y Motor Controller Boards. The +24 and +/-15VDC are passed to the C-Arm Interface Board. The +24 VDC is also reduced to +7 and +5VDC by regulators to power op-amps and analog switches located on this board. The +7VDC is passed to the Control Panel Controller Board. The +5VDC powers the digital section of the Distribution Board. The +24VDC power supply is not closely regulated and its outputs may range from +24V to +35V under normal conditions.

Note: +7VDC may measure anywhere from +6.25VDC to +7.25VDC. This is true everywhere +7VDC is shown in this manual.

Limits for +/- 15VDC

Six green LEDs indicate the status of the +28 (on QDR-4500s, +24 on Discovery), +24, +15, -15, +7 and +5VDC (ON indicates the respective voltage is present). Five red LEDs indicate the status of the five circuit breakers applying voltage to the motor drivers/ controller. ON indicates the circuit breaker has been tripped by an over-current condition.

2.3.2 Interface Connections

Figure 2-2 shows connections to/from the Distribution Board.

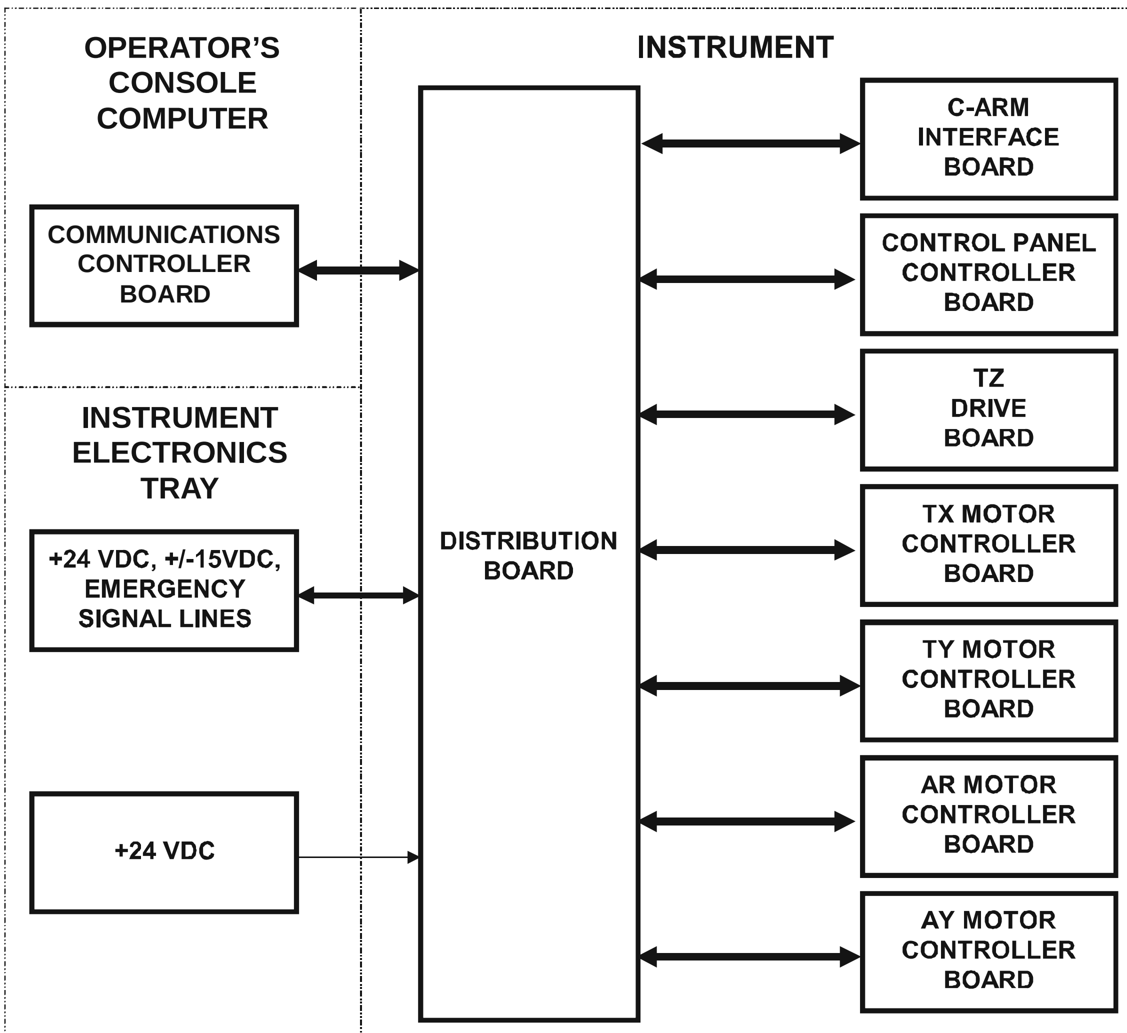


Figure 2-2. Distribution Board High Level Interconnection Diagram

2.4 Motor Controller Board

The Motor Controller Board is a microprocessor controlled power driver circuit for use with a two-coil bipolar stepper motor. It receives high-level commands through the Distribution Board from the host computer, and applies 24-volt pulses to the stepper motor windings. The Discovery uses four identical Motor Controller Boards to control and drive the Table X (Table In/Out), Table Y (Table Left/Right), C-Arm Y (C-Arm Left/Right), C-Arm R (Arm rotation, A/SL only) stepper motors. The motor windings are driven by two integrated H-bridges. These integrated circuits provide internal level conversion and power limiting. Their logic level control inputs are driven from a stepper motor control microcircuit that receives commands from the microprocessor. The control circuit senses the current in the motor windings and adjusts the duty cycle of the applied voltage in such a way as to limit the maximum motor current. The maximum value is determined by an 8-bit control word at a Digital to Analog Converter.

Each Motor Controller Board monitors the position of its respective mechanism using a voltage received from an associated Position Encoder connected to the mechanism. The Position Encoder is a precision potentiometer that divides a +/-3V reference source. The output voltage is fed to a sense amplifier in proportion to the position of the mechanism driven by the motor. The sense amplifier output is converted to digital value that provides position feedback to the microprocessor.

The Motor Controller Boards receive movement commands from the Discovery computer via the communications bus. Each Motor Controller Board contains an ID switch and four status indicators (LEDs). The ID switch is a 16-position rotary encoded switch (SW1) that is read during system initialization to determine the Motor Controller Board address for communicating with the Discovery computer. ID switch settings for the Motor Controller Boards are as follows:

Table X drive	4
Table Y drive	5
C-Arm Rotation	6
C-Arm Y drive	7

The four red status LEDs provide visual indications of motor drive power on, Stepper CPU active, motor drive direction, and motor step pulses.

The Motor Controller Board also has provision (JP2) for connecting limit switches to inhibit motor operation when the mechanism goes beyond established mechanical limits. This feature is not used in the Discovery and, therefore, no cable is connected to JP2.

2.4.1 Power

Power input to the Motor Controller Board is +24VDC. This voltage provides the motor drive power and is converted down to +5VDC for use by logic circuits on the board. The +5VDC is also converted to -5VDC. Two green LEDs provide a visual indication of the power present on the Motor Controller Board.

2.4.2 Interface Connections

Figure 2-3 shows the typical interconnections between the Distribution Board, the Motor Controller Board, the Stepper Motor, and the Position Encoder. Figure 2-1 describes the interconnections between the Distribution Board and the Motor Controller. Table 2-3 describes the interconnections between each Motor Controller and its respective stepper motor and position encoder. The tables also identify the connectors and their pin assignments.

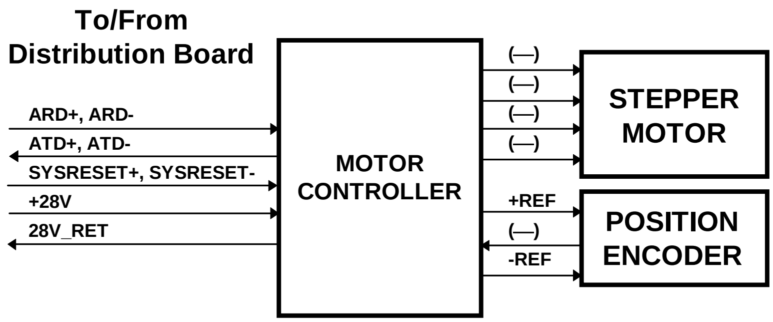


Figure 2-3. Distribution Board/Motor Controller Board Interconnection Diagram

Table 2-2. Distribution Board/Motor Controller Board Interconnection Descriptions

Signal	Description	Table X	Table Y	C-Arm Y	Pin(s)
ARD+ ARD-	Asynchronous Receive Data.	JP7	JP5	JP11	11 12
ATD+ ATD-	Asynchronous Transmit Data.	JP7	JP5	JP11	14 15
SYSRST+ SYSRST-	System Reset. Resets the Motor Controller Board.	JP7	JP5	JP11	17 18
28V 28V_RET	DC power for the Motor Controller Board.	JP7	JP5	JP11	2,3,4,5 1,6,7,8

Table 2-3. Motor Controller Board/Stepper Motor and Position Encoder Interconnection Descriptions

Signal	Description	Pin
(No label)	Motor drive signals (4).	JP5-1 - JP5-4
+REF (+3V)	Precision positive voltage to position potentiometer.	JP3-1
(No label)	Position encoder wiper return voltage.	JP3-3
-REF (-3V)	Precision negative voltage to position potentiometer.	JP3-5

2.5 TZ Drive Board (A and SL Only)

The TZ Drive Board is a microprocessor-controlled power driver circuit for the two AC pedestal motors, which raise and lower the patient table of the Discovery A and SL. This board is located in the Electronics Tray in the rear of the bottom of the Scanner base assembly.

The TZ Drive Board communicates with the PCI Board, via the Distribution Board, to drive the pedestal motors under computer control. Manual repositioning of the pedestal may be required in case of an emergency. In this case, manual control is provided through the Table switches of the Scanner's Operator Control Panel.

The TZ Drive board monitors the position of both pedestals using signals received from an associated Position Encoder connected to the respective pedestal.

2.5.1 Service Switches

The TZ Drive board contains four service switches used during replacement of a defective pedestal or Position Encoder. Table 2-4 describes these switches and their respective functions.

Caution: The TZ drive motors are designed to run at a 5% duty cycle. If the motors overheat, the built-in thermal cutouts may trip and cause the motors to stop functioning. If this occurs, you must wait about 20 minutes before functionality is restored.

The TZ drive motors are designed to run at a 5% duty cycle. If the motors overheat, the built-in thermal cutouts may trip and cause the motors to stop functioning. If this occurs, you must wait about 20 minutes before functionality is restored.

Table 2-4.TZ Drive Service Switches

Switch	Function
Mode (Normal/Service)	Determines whether the TZ Drive is in Normal or Service operation.
Direction (Up/Down)	When the TZ drive is in Service mode, determines the direction of pedestal movement (not active in normal mode).
Left	When the TZ drive is in Service mode, moves the left pedestal in the direction specified by the Direction switch (not active in normal mode).
Right	When the TZ drive is in Service mode, moves the right pedestal in the direction specified by the Direction switch (not active in normal mode).
Reset	Resets the board after manual operation. **The TZ Drive board must be reset after any manual operation.**

2.5.2 Power

Power input to the TZ Drive Board is +24VDC from the Distribution Board and 240VAC from the DIN Rail. The +24VDC powers circuitry located on this board and is reduced to

+5VDC. The +5VDC is converted to -5VDC and +/-3VDC. The +/-5VDC powers logic circuitry on this board, while the +/- 3VDC provides the reference voltage for the position sensors. Two green LEDs provide visual indication of the +24 and +5VDC status (ON indicates the respective voltage is present).

The 240VAC power is connected through control relays to the pedestal motors.

2.5.3 Interface Connections

Figure 2-4 shows the interconnections between the Distribution Board, the TZ Drive Board, the Pedestal Motors, and the Pedestal Position Encoders. Table 2-5 describes the interconnections between the Distribution Board and the TZ Drive Board. Table 2-6 describes the line voltage (240VAC, line to line) between the DIN Rail Assembly and the TZ Drive Board. Table 2-7 describes the interconnections between the TZ Drive Board and the two pedestal motors and their respective position encoders. The tables also identify the interconnection connector and pin assignments.

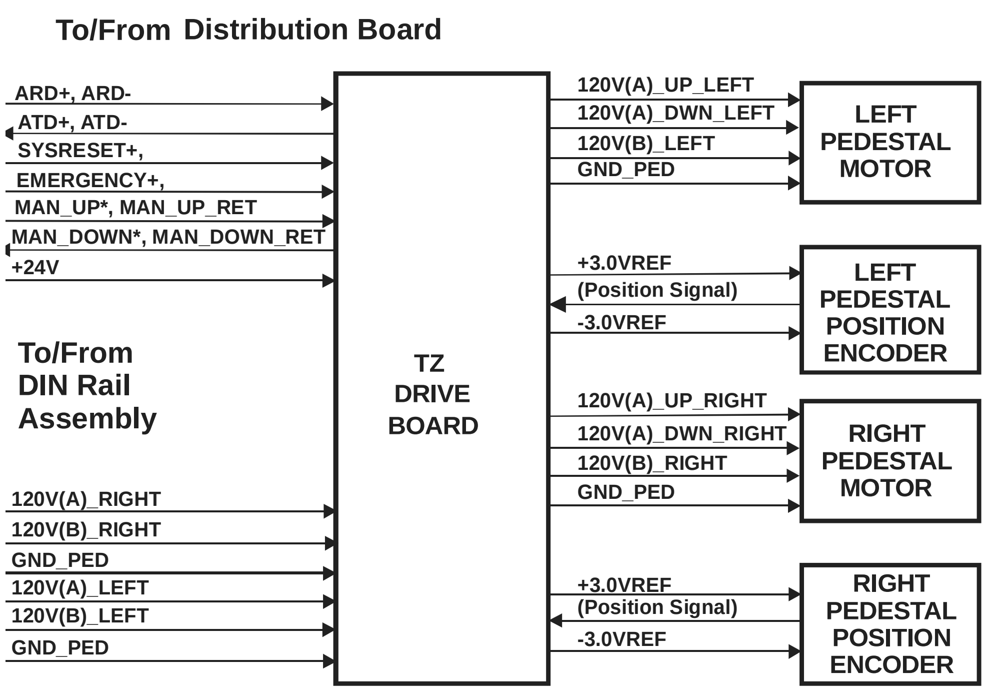


Figure 2-4. Distribution Board/TZ Drive Board Interconnection Diagram

Table 2-4 shows the interconnections between the Distribution Board, the TZ Drive Board, the Pedestal Motors, and the Pedestal Position Encoder, Table 2-5 describes the interconnections between the Distribution Board and the TZ Drive Board. Table 2-6 describes the line voltage (240VAC line to line) between the DIN Rail Assembly and the TZ Drive Board. Table 2-7 describes the interconnection between the TZ Drive Board and the two pedestal motors and their respective position encoders. The tables also identify the interconnection connectors and pin assignments.

Table 2-5. Distribution Board/TZ Drive Board Interconnection Descriptions

Signal	Description	Pin(s)
ARD+ ARD-	Asynchronous Receive Data.	JP1-11 JP1-12
ATD+ ATD-	Asynchronous Transmit Data.	JP1-14 JP1-15
SYSRST+ SYSRST-	System Reset. Resets the TZ Drive board.	JP1-17 JP1-18
EMERGENCY+ EMERGENCY-	Enables manual operation of the pedestals in the case of an emergency (under control of the Control Panel Table switch on the Patient Table).	JP1-20 JP1-21
MAN_UP* MAN_UP_RET	Raises the Patient Table in the case of an emergency.	JP1-23 JP1-24
MAN_DWN* MAN_DWN_RET	Lowers the Patient Table in the case of an emergency.	JP1-26 JP1-27
+24V	DC power for the Motor Controller board.	JP1-5, JP1-6
+6.5V	Not used.	JP1-2, JP1-3

Table 2-6. DIN Rail Assembly/TZ Drive Board Interface Descriptions

Signal	Description	Pin
120V(A)_LEFT	AC voltage (120) to drive the Left Pedestal motor.	JP6-4
120V(B)_LEFT	AC voltage (120) to drive the Left Pedestal motor.	JP6-5
120V(A)_RIGHT	AC voltage (120) to drive the Right Pedestal motor.	JP6-1
120V(B)_RIGHT	AC voltage (120) to drive the Right Pedestal motor.	JP6-2
GND_PED	Ground line to the Left/Right Pedestal motor.	JP6-3/JP6-6

Table 2-7. TZ Drive Board/Pedestal Motors and Position Encoders Interconnection Descriptions

Signal	Description	Pin
120V(A)_UP_LEFT	AC voltage to the Left Pedestal motor to move the left end of the Patient Table up.	JP5-1
120V(A)_DWN_LEFT	AC voltage to the Left Pedestal motor to move the left end of the Patient Table down.	JP5-2
120V(B)_LEFT	AC line to the Left Pedestal motor.	JP5-3
GND_PED	Ground line to the Left Pedestal motor.	JP5-4
120V(A)_UP_RIGHT	AC voltage to the Right Pedestal motor to move the right end of the Patient Table up.	JP4-1
120V(A)_DWN_RIGHT	AC voltage to the Right Pedestal motor to move the right end of the Patient Table down.	JP4-2
120V(B)_RIGHT	AC line to the Right Pedestal motor.	JP4-3
GND_PED	Ground line to the Right Pedestal motor.	JP4-4

Signal	Description	Pin
+3.0VREF	Precision positive voltage to Left/Right Pedestal position encoder potentiometer.	JP3-1/JP2-1
(Position Signal)	Left/Right pedestal position encoder wiper return voltage.	JP3-3/JP2-3
-3.0VREF	Precision negative voltage to Left/Right Pedestal position encoder potentiometer.	JP3-4/JP2-4

2.6 Control Panel Controller Board

The Control Panel Controller Board on the Discovery is a separate board under the table. Its function is to interface the Scanner Operator Control Panel to the computer allowing the software to determine the state of the Operator Control Panel switches, to define the state of the various Operator Control Panel LEDs, and to control motor movement. The board is located under the table at the head end of the scanner.

The Control Panel Controller communicates with the Operator's Console computer using the asynchronous communications signals ARD and ATD of the communications buss and the system control signals SYSRESET, XRAY_LIGHT, and EMERGENCY.

2.6.1 Power

The Control Panel Controller Board receives +7VDC from the Distribution Board. The +7 is reduced to +5VDC to power the circuitry on this board and is applied to the Operator Control Panel to power the LEDs. A green LED, on this board, provides a visual indication of the +5VDC power (ON indicates the voltage is present).

2.6.2 Interface Connections

Figure 2-5 shows the interconnections between the Distribution Board, Control Panel Controller Board, and the Operator Control Panel.

Table 2-8 describes the interconnections between the Distribution Board and the Control Panel Controller. Table 2-10 describes the interconnections between the Control Panel Controller and the Operator Control Panel. The tables also identify the connectors and their pin assignments.

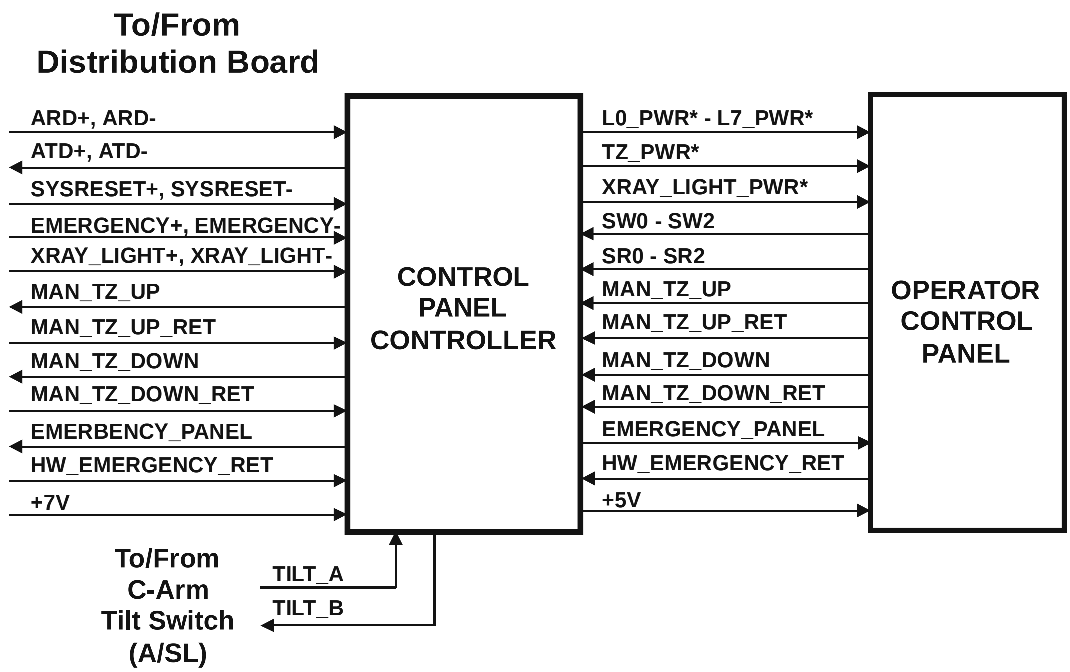


Figure 2-5. Control Panel Controller Interconnection Diagram

Table 2-8. Distribution Board/Control Panel Controller Interconnection Descriptions

Signal	Description	Pin
ARD+ ARD-	Asynchronous Receive Data from the PCI Communication Command Board via the Distribution Board.	JP2-4 JP2-5
ATD+ ATD-	Asynchronous Transmit Data to the PCI Communication Command Board via the Distribution Board	JP2-7 JP2-8
SYSRESET+ SYSRESET-	System Reset from the PCI Communication Command Board via the Distribution Board. Resets the Control Panel Controller.	JP2-10 JP2-11
EMERGENCY+ EMERGENCY-	Emergency TZ drive indicator from the PCI Communication Command Board via the Distribution Board.	JP2-13 JP2-14
XRAY_LIGHT+ XRAY_LIGHT-	X-Ray Light from the X-Ray Controller via the C-Arm Interface and Distribution Boards.	JP2-16 JP2-17
EMERGENCY_CPANEL HW_EMERGENCY_RET	State of the STOP switch and of the collision sensor. (Part of the safety daisy chain.)	JP2-19 JP2-20
+7V	DC power for the Control Panel Controller Board	JP2-2

Table 2-9. Control Panel Controller/Control Panel Interconnection Descriptions

Signal	**Description**	**CPC[1] Pin**	**CP[2] Pin**
L0_PWR*	Turns on the ENABLE switch LED.	JP6-11	JP1-11
L1_PWR*	Turns on the HOME switch LED.	JP6-12	JP1-12
L2_PWR*	Turns on the LOAD switch LED.	JP6-13	JP1-13
L3_PWR*	Turns on the TABLE switch IN/OUT LED.	JP6-14	JP1-14
L4_PWR*	Not used.	JP6-15	JP1-15
L5_PWR*	Turns on the C-ARM switch RIGHT/LEFT LED.	JP6-16	JP1-16
L6_PWR*	Not used.	JP6-17	JP1-17
L7_PWR*	Turns on the Laser LED.	JP6-18	JP1-18
XRAY_LIGHT_PWR*	Turns on the X_RAY LED	JP6-19	JP1-19
SW0	Control signal to determine the state of the C-ARM and LASER switches.	JP6-4	JP1-4
SW1	Control signal to determine the state of the TABLE IN/OUT switches.	JP6-5	JP1-5
SW2	Control signal to determine the state of the LOAD, HOME and ENABLE switches.	JP6-6	JP1-6
SR0	Returns the state of the C-ARM switch LEFT position when SW0 is active. Signals the state of the TABLE switch IN position when SW1 is active. Signals the state of the LOAD switch when SW2 is active.	JP6-1	JP1-1
SR1	Returns the state of the C-ARM switch RIGHT position when SW0 is active. Signals the state of the TABLE switch OUT position when SW1 is active. Signals the state of the HOME switch when SW2 is active.	JP6-2	JP1-2
SR2	Returns the state of the LASER and ENABLE switches when SW2 is active.	JP6-3	JP1-3
EMERGENCY_CPANEL HW_EMERGENCY_RET	Returns the state of the STOP switch. (Part of the safety daisy chain.)	JP6-23 JP6-24	JP1-23 JP1-24
+5V	Provides power for the Control Panel LEDs.	JP6-21 JP6-22	JP1-21 JP1-22

Note: 1 CPC = Control Panel Controller
2 CP = Control Panel

2.7 C-Arm Interface Board

The C-Arm Interface Board distributes DC power and signals to the Data Acquisition System (DAS) and provides control electronics for the devices located in the C-Arm assembly. It passes several signal and power lines from the Distribution Board directly to the DAS. It also provides buffering for various signal lines. The C-Arm Interface Board is located near the rear of the lower C-Arm's horizontal shelf.

Note: On the Discovery A model, the Data Acquisition System (DAS) consists of the Analog to Digital Converter, Integrator/Multiplexor, and Solid State Detector Boards. On the Discovery SL, C, and W models, a single-board, 128-Channel Detector Assembly is used.

The C-Arm Interface provides circuitry to:

- Control and monitor operation of the X-ray Controller Board. Four LEDs (two red, one green, and one yellow) on this board, provide a visual indication of the status of the X-Ray Controller and the X-ray control circuitry of this board.
- Generate timing references to the DAS and PCI Communication Command Board.
- Control power to the Positioning Laser.
- Move the Aperture stepper motor and monitor its mechanically linked position-sensing device.
- Move the stepper motor of the Reference Drum device and monitor the encoded signals returned from each drum of the device. Two green LEDs, on this board, provide a visual indication of the Reference Drum operation.
- Generate +7VDC for the DAS system

2.7.1 Continuity Daisy Chain

The C-Arm Interface Board is part of two linked chains of boards. Removing any of these boards conveys an alarm message to the host computer indicating that the electrical integrity of the system has been compromised. This message can be decoded by the host computer to detect the extent of the damage.

2.7.2 Power

The C-Arm Interface Board receives +24 and +/-15VDC from the Distribution Board. The +24VDC powers the Aperture and Reference Drum stepper motor driver circuitry. The +/-15V is passed through this board to the DAS. The +24VDC is also reduced to +5 and +7VDC. The +5VDC powers the digital section of this board and the laser while the +7VDC is applied to the DAS.

Three green LEDs, on this board, provide a visual indication of the +24 and +5VDC power (ON indicates the respective voltage is present). The third LED monitors the +28VDC used on the QDR-4500 models. On the Discovery, this voltage is actually +24VDC.

2.7.3 Interface Connections

Figure 2-6 shows the interconnections between the Distribution Board and the C-Arm Interface Board. Table 2-10 describes the interface signals and identifies the connectors and their pin assignments.

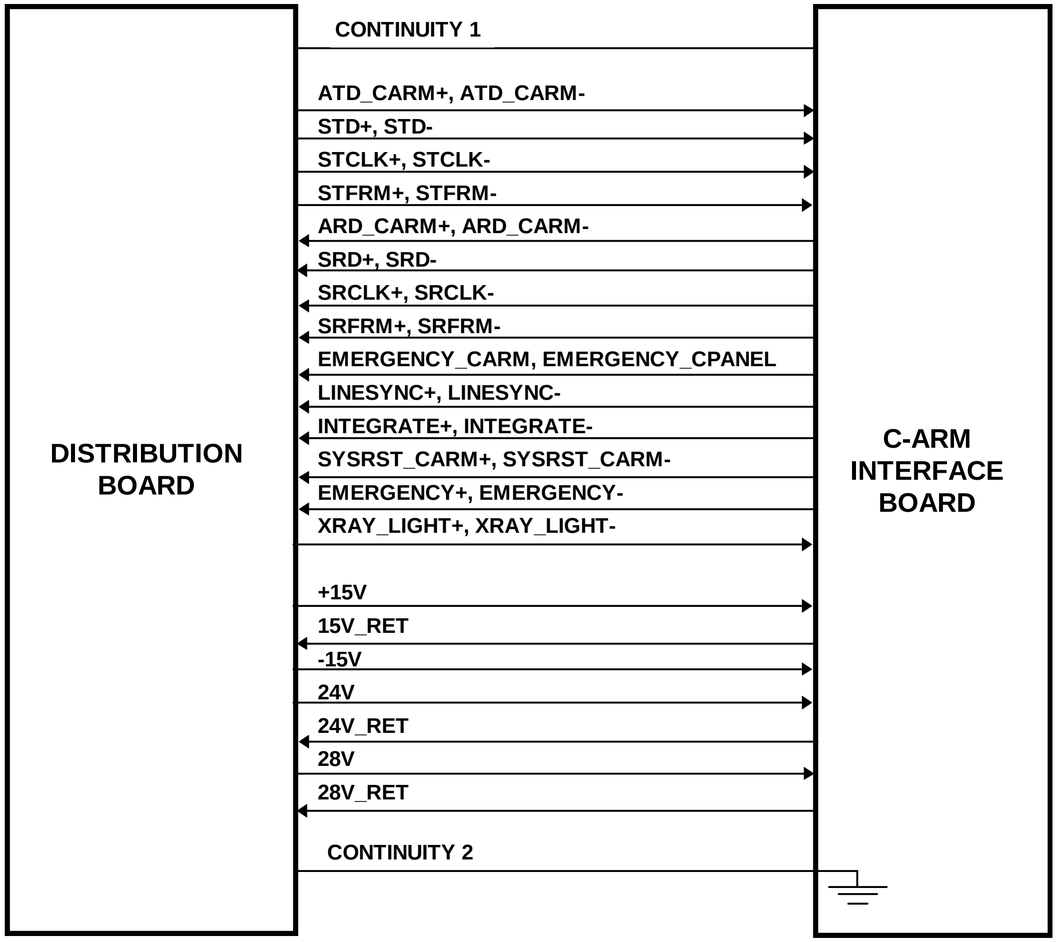


Figure 2-6. Distribution Board/C-Arm Interface Board Interconnection Diagram

Table 2-10. Distribution Board/C-Arm Interface Board Interconnection Descriptions

Signal	Description	Dist[1] Pin	C-ARM[2] Pin
ARD_CARM+ ARD_CARM-	Asynchronous data to the C-Arm Interface Board.	JP1-3 JP1-4	JP1-3 JP1-4
STD+ STD-	Synchronous data through the C-Arm Interface Board to the DAS.	JP1-6 JP1-7	JP1-6 JP1-7
STCLK+ STCLK-	Synchronizes data through the C-Arm Interface Board to the DAS.	JP1-9 JP1-10	JP1-9 JP1-10
STFRM+ STFRM-	Synchronous channel data frame from PCI Board through the Distribution Board to the DAS.	JP1-12 JP1-13	JP1-12 JP1-13
ATD_CARM+ ATD_CARM-	Asynchronous Data from the from the C-Arm Interface Board.	JP1-15 JP1-16	JP1-15 JP1-16
SRD+ SRD-	Synchronous Data through the C-Arm Interface Board from the DAS.	JP1-18 JP1-19	JP1-18 JP1-19

Signal	Description	Dist[1] Pin	C-ARM[2] Pin
SRCLK+ SRCLK-	Synchronizes data through the C-Arm Interface Board from the DAS.	JP1-21 JP1-22	JP1-21 JP1-22
SRFRM+ SRFRM-	Synchronous channel data frame through Distribution Board to PCI Communication Command Board from the DAS.	JP1-24 JP1-25	JP1-24 JP1-25
XR_ZEROX_CC+ XR_ZEROX_CC-	AC line zero-crossing signal used for system wide synchronization. Generated by the C-Arm Interface Board.	JP1-30 JP1-31	JP1-30 JP1-31
INTEGR_CC+ INTERG_CC-	Synchronous signal for Detector Integrate period. Generated by the C-Arm Interface Board.	JP1-33 JP1-34	JP1-33 JP1-34
SYSRST_CARM+ SYSRST_CARM-	Resets the C-Arm Interface Board.	JP1-39 JP1-40	JP1-39 JP1-40
EMERGENCY_CARM+ HW_EMGNCY_RET-	Removes power from the Scanner motor drivers and the X-ray system	JP1-42 JP1-43	JP1-42 JP1-43
XRAY_LIGHT+ XRAR_LIGHT-	Applies power to the AUX X-RAY light outlet on the Power Console.	JP1-48 JP1-49	JP1-48 JP1-49
CONTINUITY 1 CONTINUITY 2	Emergency shutdown daisy chain.	JP1-1 JP1-5	JP1-1 JP1-5
+15V -15V 15V_RET	Powers the Data Acquisition System.	JP4-1 JP4-3 JP4-2	JP9-1 JP9-3 JP9-2
24V 24V_RET	Generates +5VDC to power the digital section of the C-Arm Interface Board, and +7VDC for power to the Data Acquisition System.	JP4-4 JP4-5	JP9-4 JP9-5
28V 28V_RET	Powers the stepper motors and fan.	JP4-6 JP4-7	JP9-6 JP9-7

Note: 1 Dist = Distribution Board
2 C-Arm= C-Arm Interface Board

Figure 2-7 shows the boards and assemblies that connect to the C-Arm Interface Board.

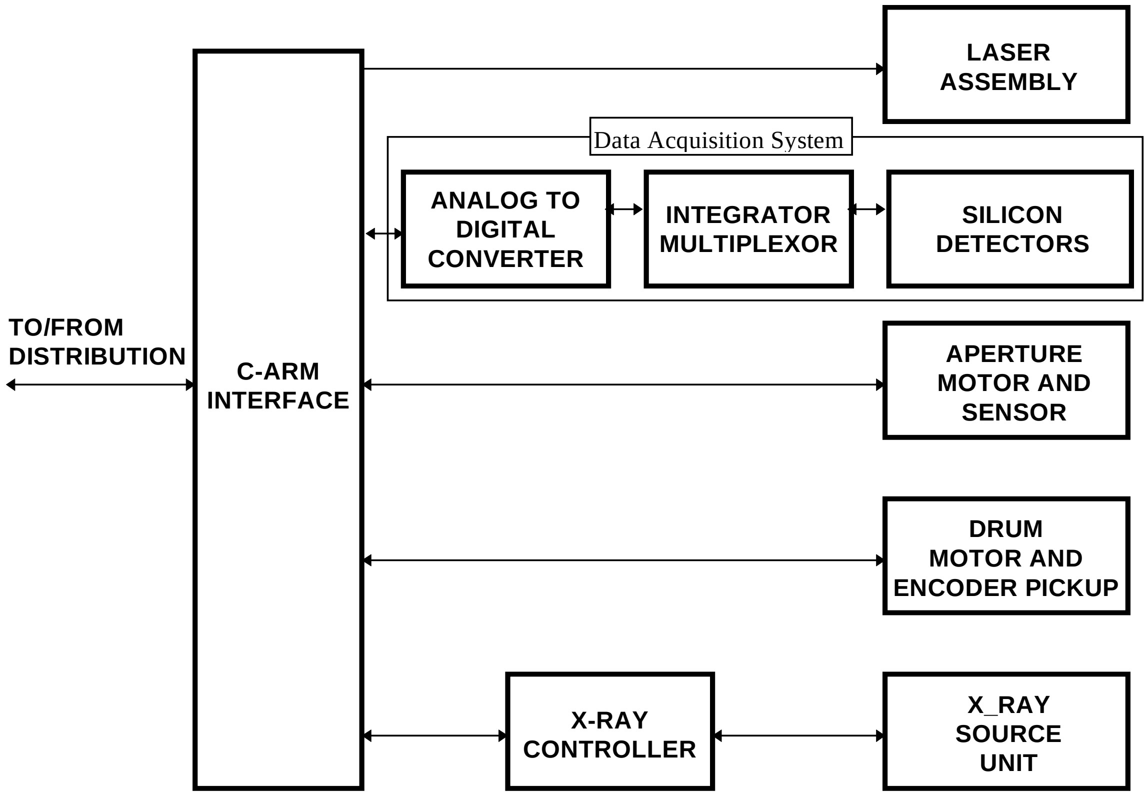


Figure 2-7. C-Arm Interface Board High Level Interconnection Diagram

2.8 X-Ray Controller Assembly (P/N 010-1273)

This assembly provides pulsed power to the primary winding of the high voltage transformer in the X-Ray Source Unit and AC power to the primary winding of the filament transformer. It consists of a single printed circuit board and several large components contained in a chassis mounted at the front of the lower C-arm, just in front of the Tank Assembly. The XRC receives split 240VAC power from the DIN Rail Power Distribution Module. It also receives command and timing data from the C-Arm Controller Board and it provides a line frequency timing signal and housekeeping and diagnostic data to the C-Arm Interface Board.

2.8.1 Interface

Figure 2-8 shows the interface connections between the C-Arm Interface Board and the X-Ray Controller Assembly. Table 2-11 describes the interface signals and identifies the connectors and their pin assignments. Note that the AC input power comes directly from the DIN Rail Power Module and connects to the X-Ray Controller Assembly.

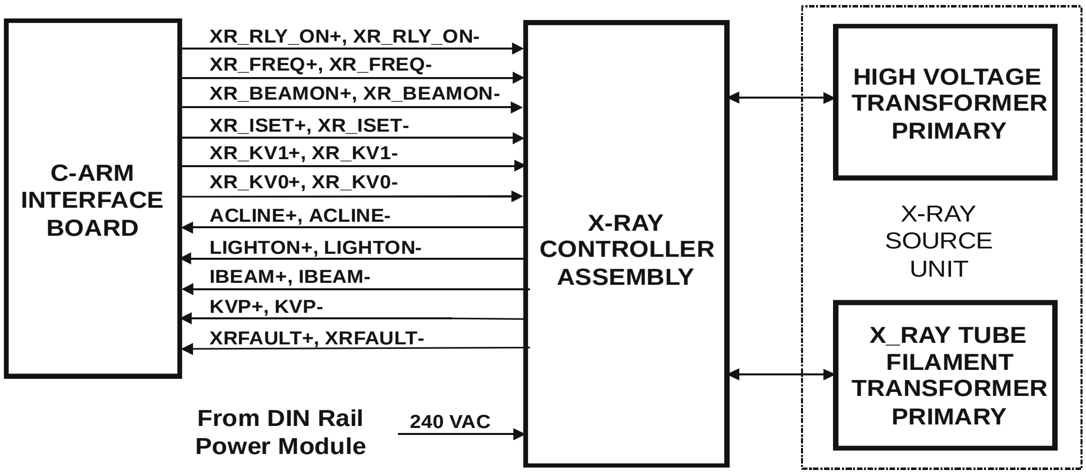


Figure 2-8. C-Arm Interface Board/X-Ray Controller Assembly Interconnection Diagram

Table 2-11. C-Arm Interface Board/X-Ray Controller Assembly Interconnection Description

Signal	Description	C-Arm Pins	I/O Logic Pins	XRC Pins
XR_RLY_ON+ XR_RLY_ON-	Allows the energy storage capacitor to be “trickle charged” before applying full power to avoid large turn-on current surges that could cause the circuit breaker to trip.	JP12-1 JP12-2	JP7-1 JP7-2	JP3-1 JP3-20
XR_FREQ+ XR_FREQ-	States whether the line frequency is 50 or 60Hz.	JP12-3 JP12-4	JP7-3 JP7-4	JP3-2 JP3-21
XR_BEAMON+ XR_BEAMON-	Controls the ON/OFF status of the X-Ray beam.	JP12-5 JP12-6	JP7-5 JP7-6	JP3-3 JP3-22
XR_ISET+ XR_ISET-	Selects the X-Ray beam current (3 or 10mA).	JP12-7 JP12-8	JP7-7 JP7-8	JP3-4 JP3-23
XR_kV1+ XR_kV1- XR_kV0+ XR_kV0-	Selects the X-Ray beam energy (80, 100, 120 or 140kVp).	JP12-9 JP12-10 JP12-11 JP12-12	JP7-9 JP7-10 JP7-11 JP7-12	JP3-5 JP3-24 JP3-6 JP3-25
ACLINE+ ACLINE-	States the phase of the power frequency.	JP12-19 JP12-20	JP7-19 JP7-20	JP3-10 JP3-29
LIGHTON+ LIGHTON-	States whether the X-Ray beam is ON/OFF. This signal controls the X-Ray ON lights of the C-Arm Control Panel, the table Control Panel, and the Operator's Console Power Module. It also controls a remote X-ray ON light through the Power Module when one is connected.	JP12-21 JP12-22	JP7-21 JP7-22	JP3-11 JP3-30

Signal	Description	C-Arm Pins	I/O Logic Pins	XRC Pins
IBEAM+ IBEAM-	Value of current pulses at the X-ray source. This is a frequency modulated diagnostic signal whose frequency is proportional to the quantity being monitored.	JP12-23 JP12-24	JP7-23 JP7-24	JP3-12 JP3-31
kVp+ kVp-	Value of voltage pulses at the X-ray source. This is a frequency modulated diagnostic signal whose frequency is proportional to the quantity being monitored.	JP12-25 JP12-26	JP7-25 JP7-26	JP3-13 JP3-32
XRFAULT+ XRFAULT-	States whether or not any fault condition exists in the X-Ray Controller Assembly.	JP12-27 JP12-28	JP7-27 JP7-28	JP3-14 JP3-33

2.8.2 X-Ray Controller Board

The X-ray Controller Board consists of five sections: Power, Timing Generator, Pulse Generator, Filament Control, and H-Bridge.

The Power section converts the split 240 VAC input to the controller into the DC voltages necessary for the board. The voltages produced in the Power section are: +5VDC (VDD – used for analog circuitry), +5VDC (VCC – used for digital circuitry), and +/- 15 VDC. The LED, D25, indicates the presence of voltage on the board.

The Timing Generator section produces the timing signals required by the control circuits. The timing is based on a half cycle of the AC waveform and is, therefore, reset at each zero crossing. An 8 MHz clock circuit provides pulses to a counter. This counter in turn provides its output count to an EPROM as its address inputs. The pulse trains produced by the EPROM are clocked into a register to clean up the signals that are then distributed to various sections of the board. The ACHIGHLOW signal produced by the timing circuits is sent to the C-Arm Interface Board where it is used to synchronize X-ray generation with the Filter Drum position.

The Pulse Generator regulates and shapes the pulses delivered to the X-ray Tank. Sense lines from the tank set the current threshold for the regulator. A reference voltage is selected and fed to one of four circuits that control the high voltage peak potential. The circuits adjust the reference voltage through four potentiometers, R55, R54, R39, and R40 that is used to establish the 80, 100, 120, and 140 KVp. The outputs of these circuits are sent to a pulse width modulator circuit to produce the control pulses to the H-Bridge. These pulses are optically coupled to the FETs in the H-Bridge.

The H-Bridge produces the actual pulses fed to the primary of the HV transformer in the X-ray tank. AC is brought to the circuit, rectified, and filtered. The H-Bridge operates as both an inverter and a pulse width modulator. The H-Bridge uses two pairs of FETs. Each pair conducts 256 times for a total pulse width of 4.096 milliseconds. Each of the FETs is individually biased with the biasing network acting as a bleeder for the large storage capacitors. The current load in the H-bridge is sensed and adjusted. The output voltage from the H-Bridge is up to 200 volts peak.

The Filament circuit is a regulator. It receives current feedback from the tank indicating the tube current. 10 volts at the feedback input is equivalent to 10 milliamps of current in the tube. The 10 volts are reduced to 5 and then fed to an A/D circuit to be converted to a digital value for use by the control circuits. The value into the A/D is sampled towards the end of the pulse where it is stable. After conversion, the digital value is fed as an address to an EPROM. If the current is correct, the output of the EPROM will be 0 volts. Anything other than 0 volts (“+” = high current, “-“= low current) will be added and accumulated in two stages forming an error integrator. This digital error number is converted back to an analog value and then used as the threshold of a comparator. The output of the comparator, through additional circuitry, adjusts the duty cycle of the modulated filament voltage.

Refer to Table 2-11 for pin assignments.

2.9 X-Ray Source Unit

The X-Ray Source (commonly referred to as the Tank assembly) consists of the X-Ray tube, the X-Ray tube filament transformer, the high voltage transformer, the high voltage rectifier circuit, and the sensing circuits that monitor the high voltage applied to the X-ray tube and the beam current.

Table 2-12 describes the interconnections between the X-Ray Controller Assembly and the X-Ray Source unit. The table also identifies the X-Ray Controller Assembly board connector and pin assignments for each interconnection signal.

Table 2-12. X-Ray Controller Assembly/X-Ray Source Unit Interface

Signal	Description	XRC Board	Controller Pin	Tank Terminal
HV_XFMR_PRI+ HV_XFMR_PRI-	High Voltage Transformer Primary	H-Bridge (JP1)	JP1-1, JP1-2 JP1-3, JP1-4	TB1-3 TB1-4
FIL_XFMR_A FIL_XFMR_B	Filament Transformer Primary	I/O & Logic (JP6)	JP2-7 JP2-8	TB1-6* TB1-9
IF+	Beam Current Sense "+"	I/O & Logic (JP6)	JP2-4	TB1-10
IF-	Beam Current Sense "-" (Chassis)	I/O & Logic (JP6)	JP2-5	TB1-7
TP1	Anode pulse monitor	I/O & Logic (JP6)	JP2-2	TB1-12
TP2	Cathode pulse monitor	I/O & Logic (JP6)	JP2-1	TB1-11

* A thermal overload protector is installed in series with the filament transformer primary winding, between TB1-6 and TB1-8.

2.10 Data Acquisition System (C, W, and SL)

The Discovery Data Acquisition System (DAS) consists of a single board that has 128 solid state (diode) detectors, the integration circuitry along with the analog-to-digital conversion circuitry, and multiplexing circuitry to select the outputs in a sequential fashion. The solid-state detectors are photodiodes with a cadmium tungstate ($CdWO_4$) crystal attached. X-rays striking the cadmium tungstate crystals are converted into photons of visible light. The diodes sense this light and convert the light into a current, which is amplified in a current to voltage converter. The converter output is applied to an integrator through analog switches. The analog switches all operate in parallel and are turned on during the X-ray pulse. These switches are turned off during the integrator hold time to prevent the introduction of integration noise into the data. The turning on and off of these switches is controlled by the **INTEGRATE** signal under control of the software. The signal from the detectors is then integrated with the final voltage obtained held in a sample/hold circuit. This voltage is sampled, in photodiode order, by the multiplexor circuitry under control of the software. The output voltage is then sent to the analog-to-digital conversion circuitry where it is changed to a digital value usable by the software. The Detector Assembly is located in the upper end of the C-arm directly above the X-ray source. There is a lead radiation shield between the detector board and the cover to stop any X-rays that may get through the detectors.

2.10.1 Solid State Detector

The Solid State Detector converts X-rays into signals that are applied to the Integrator/ Multiplexor section of the Detector Assembly board. Each Detector Assembly contains 128 high-resolution detectors. Each detector is 2mm wide at the detector. This equates to slightly less than 1mm resolution in an AP spine.

2.10.2 Integrator/Multiplexor Subsection

The Integrator/Multiplexor subsection of the Detector Assembly receives up 128 signals in parallel from the Solid State Detector Boards. This subsection integrates and stores those signals and then applies the stored signals to the Analog to Digital subsection of the Detector Assembly.

Switched signals charge integrating capacitors in this subsection during a given charging time. After the charging time, the switched signals are turned off and the charges are held on the capacitors. Each integrator is sampled, in photodiode order, by a multiplexor and the output sent to the Analog to Digital subsection. At the end of sampling, all the integrating capacitors are discharged in parallel by shorting them out with analog switches.

Each integrator has an additional input into which a test signal (**TESTLVL**) can be applied when there are no X-rays present. This test signal is used to verify the operation of the integrators and multiplexors by the SQVERIFY diagnostic program.

2.10.3 Analog To Digital Board

The Analog to Digital (ADC) subsection of the Detector Assembly converts analog signals received from the Integrator/Multiplexor subsection to a digital format.

Analog signals from the Integrator/Multiplexor subsection are applied to differential amplifiers on the ADC subsection. Outputs from the differential amplifiers are combined in a final multiplexor consisting of four analog switches. The multiplexed signals pass through a programmable gain amplifier and summing amplifier before being applied to an A/D converter. A one-volt fixed DC offset is inserted at the summing amplifier to insure that no channels ever go negative. The A/D converter converts the analog signal into 16 bit parallel data for processing by a Digital Signal Processor.

The ADC subsection uses a Motorola 56000 Digital Signal processor to generate all the control signals necessary for the Detector Assembly. This processor also provides a high-speed serial data link to the computer.

2.10.4 Power

The 128-Channel Detector Assembly receives +/-15V and +5V from the C-Arm Interface Board. The +/-15V is passed through this board to the Detector subsection. It is also regulated to +/- 12V by series regulators to power operational amplifiers and analog switches located on this board. The +/- 15V is also used to generate +/- 5V to power the analog-to-digital converter circuit. The +7V is reduced to +5V to power the digital section of this board.

2.10.5 Interface Connections

Figure 2-9 shows the interconnections between the 128-Channel Detector Assembly and the C-Arm Interface Board. Table 2-13 describes the interface signals and identifies the connectors and their pin assignments.

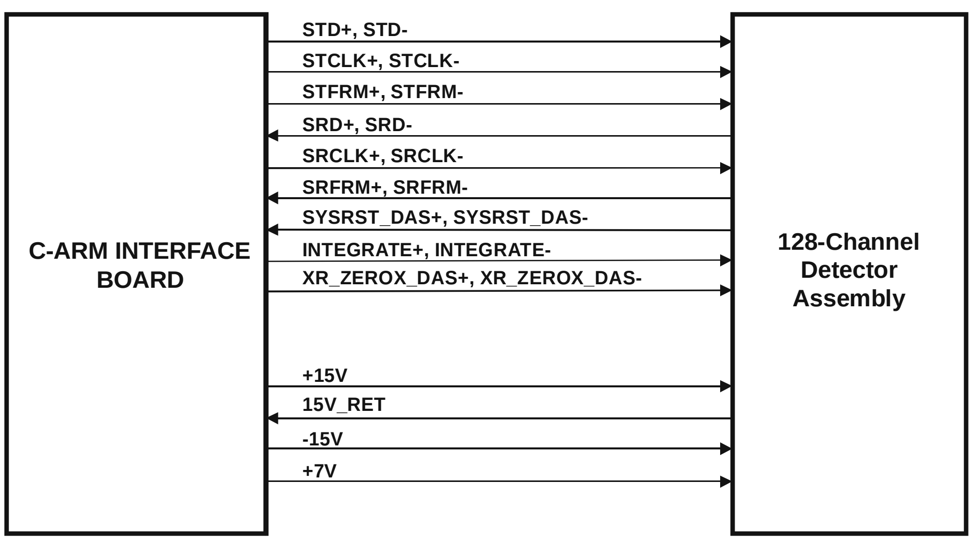


Figure 2-9. C-Arm Interface Board/128-Channel Detector Assembly Interconnection Diagram

Table 2-13. C-Arm Interface Board/128-Channel Detector Assembly Interconnection Descriptions

Signal	Description	C-Arm[1] Pin	DA[2] Pin
STD+ STD-	Synchronous data to the Analog/Digital Converter board.	JP10-3 JP10-4	P1-12 P1-13
STCLK+ STCLK-	Synchronizes data to the Analog/Digital Converter board.	JP10-6 JP10-7	P1-15 P1-16
STFRM+ STFRM-	Synchronizes DSP Communications.	JP10-9 JP10-10	P1-18 P1-19
SRD+ SRD-	Synchronous Data from the Analog/Digital board.	JP10-12 JP10-13	P1-3 P1-4
SRCLK+ SRCLK-	Synchronizes data from the Analog/Digital Converter board.	JP10-15 JP10-16	P1-6 P1-7
SRFRM+ SRFRM-	Synchronizes DSP Communications.	JP10-18 JP10-19	P1-9 P1-10
SYSRST_DAS+ SYSRST_DAS-	Resets the Analog/Digital Converter board.	JP10-21 JP10-22	P1-21 P1-22
INTEGRATE+ INTEGRATE-	Data integration signal. Generated by the C-Arm Interface Board.	JP10-24 JP10-25	P1-24 P1-25
XR_ZEROX_DAS+ XR_ZEROX_DAS-	AC line zero-crossing signal used for system wide synchronization. Generated by the C-Arm Interface Board.	JP10-27 JP10-28	P1-27 P1-28
+15V	Powers the Data Acquisition System.	JP10-32 JP10-33	P1-32 P1-33
-15V		JP10-36 JP10-37	P1-36 P1-37
15V_RET		JP10-30 JP10-31 JP10-34 JP10-35	P1-30 P1-31 P1-34 P1-35
+7V		JP10-38 JP10-39	P1-38 P1-39
CONTINUITY	Emergency shutdown daisy chain (grounded on ADC board)	JP10-1	P1-1

Notes: 1.C-Arm = C-Arm Interface Board
2.DA=128-Channel Detector Assembly

2.11 Data Acquisition System (A Model only)

The Discovery A Data Acquisition System (DAS) consists of three Solid State Detector printed circuit boards, an Integrator/Multiplexor board, and an Analog to Digital Converter (ADC) board. The Solid State Detector boards and the Integrator/Multiplexor board are physically located within the upper end of the C-arm. The detector boards mount under the Integrator/Multiplexor board and connect to the Integrator/Multiplexor board. The Integrator/Multiplexor board is contained in an electrically shielded enclosure. There is also a lead radiation shield between the detector and the integrator/multiplexor boards to stop any X-rays that might get through the detectors. The ADC board is located within the rear downward slope of the C-arm.

2.11.1 Solid State Detector

The Solid State Detector boards convert X-rays into signals that are applied to the Integrator/Multiplexor board. X-rays striking detector crystals are converted into visible light. Solid State photodiodes sense this light and convert the light into current, which is amplified in a current to voltage converter. Output from the amplifier is applied to the Integrator through analog switches. The analog switches all operate in parallel and are turned on during the X-ray pulse. These switches are turned off during the integrator hold time to prevent integrating noise into the data. The turning on and off of these switches is controlled by the **INTEGRATE** signal supplied from the Integrator/Multiplexor board. Each solid-state detector board has a capacity of 72 high-resolution detectors. This is equal to slightly less than 1mm resolution in an AP spine. The detector array contains 216 2mm detectors.

2.11.2 Power

The Solid State Detector board receives +/-15V from the Integrator/Multiplexor board. Voltage regulators, located on this board, convert this voltage to +/-12V to power the amplifiers and switches.

2.11.3 Interface Connections

Figure 2-10 shows the interconnections between the Integrator/Multiplexor board and the Solid State Detector boards. Table 2-14 describes the interface signals and identifies the interconnection connector and pin assignments.

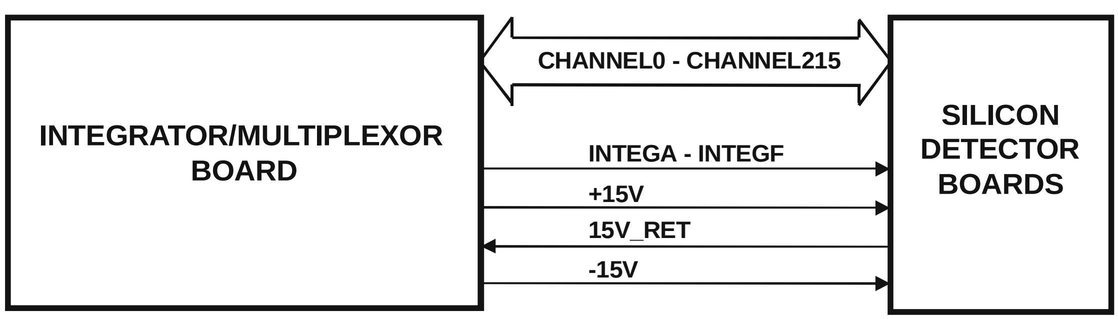


Figure 2-10. Integrator/Multiplexor Board/Solid State Detector Boards Interconnection Diagram

Table 2-14. Integrator/Multiplexor Board/Solid State Detector Boards Interconnection Descriptions

Signal	Description	I/M Pins	SD PINS
CHANNEL0 - CHANNEL215		See Note 1	See Note 2
INTEGA INTEGB INTEGC INTEGD INTEGE INTEGF		JP2-6, JP2-44 JP1-6, JP1-44 JP4-6, JP4-44 JP3-6, JP3-44 JP6-6, JP6-44 JP5-6, JP5-44	JP1-44, 6 JP2-44, 6
+15V 15V_RET -15V	Powers the amplifiers and switches of the Solid State Detector boards.	JP1-JP6-47, JP1-JP6-48 JP1-JP6-3, JP1-JP6-4, JP1-JP6-5, JP1-JP6-43, JP1-JP6-45, JP1-JP6-46, JP1-JP6-49, JP1-JP6-50 JP1-JP6-1, JP1-JP6-2	JP1/2-47, JP1/2-48 JP1/2-3, JP1/2-4, JP1/2-5, JP1/2-43, JP1/2-45, P1/2-46, JP1/2-49, JP1/2-50 JP1/2-1, JP1/ 2-2

Notes:1.Refer to schematic drawing 140-0048-SD for connector and pin assignments (cannot scope these signals).
2.Refer to schematic drawing 140-0050-SD for connector and pin assignments (cannot scope these signals).
3.Note that the CHANNEL hardware numbers are reversed from the software numbers. e.g. Hardware
CHANNEL0 = software CHANNEL215.

2.12 Integrator/Multiplexor Board

The Integrator/Multiplexor receives 216 signals in parallel from the Solid State Detector boards. The board integrates and stores those signals, and then applies the stored signals in four groups of 64 signals in parallel to the Analog to Digital board.

Switched signals from the Solid State Detector board charge integrating capacitors on this board during a given charging time. After the charging time, the switched signals are turned off and the charges are held on the capacitors. Each integrator is sampled by the multiplexor and sent to the Analog to Digital board. At the end of sampling, all the integrating capacitors are discharged in parallel by shorting them out with analog switches.

Each integrator has an additional input into which a test signal (**TESTLVL**) can be applied when there are no X-rays present. This test signal is used to verify the operation of the integrators and multiplexors when running the diagnostic program SQVERIFY.

2.12.1 Power

The Integrator/Multiplexor board receives +/-15V and +5V from the Analog to Digital board. The +/-15V is passed through this board to the Solid State Detector boards. Voltage regulators, located on this board, convert this voltage to +/-12V to power circuitry contained on this board. Analog and digital returns are kept separate.

2.12.2 Interface Connections

Figure 2-11 shows the interconnections between the Analog/Digital Converter board and the Integrator/Multiplexor board. Table 2-15 describes the interface signals and identifies the interconnection connector and pin assignments.

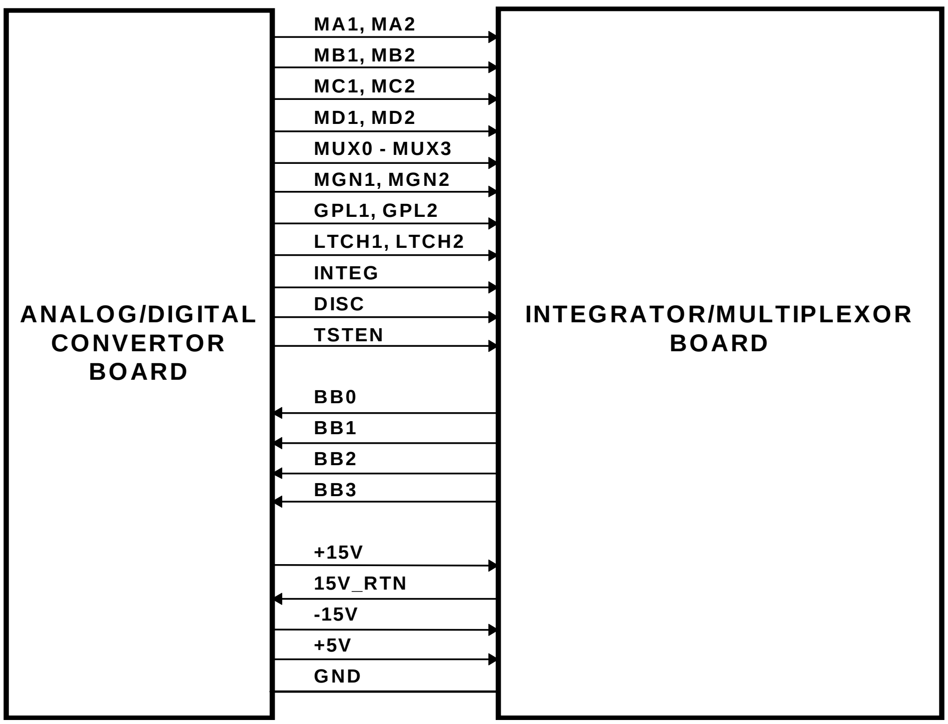


Figure 2-11. Analog Digital Converter Board/Integrator Multiplexor Board Interconnection Diagram

Table 2-15. Analog Digital Converter Board/Integrator Multiplexor Board Interconnection Diagram

Signal	Signal (see Note 1)	Description	ADC Pins	I/M PINS
MA1, MA2 MB1, MB2 MC1, MC2 MD1, MD2	IN0, IN1 IN6, IN7 IN2, IN3 IN4, IN5	Selects integrator channels to be returned to the Analog/Digital Converter.	JP4-1, JP4-3 JP4-13, JP4-15 JP4-5, JP4-7 JP4-9, JP4-11	JP7-1, JP7-3 JP7-13, JP7-15 JP7-5, JP7-7 JP7-9, JP7-11
MUX0- MUX3	IN8 IN9 IN10, IN11		JP4-17, JP4-19, JP4-21, JP4-23	JP7-17, JP7-19, JP7-21, JP7-23
GPL1, GPL2	IN14, IN15		JP4-29, JP4-31	JP7-29, JP7-31
MGN1, MGN2	IN12, IN13	Controls integrator/ multiplexor gains.	JP4-25, JP4-27	JP7-25, JP7-27
LTCH1, LTCH2	IN16	Latches control signals on Integrator/ Multiplexor.	JP4-33 JP4-37	JP7-33 JP7-37
INTEG	IN18	Controls signal integration.	JP4-35	JP7-35
DISC	IN19	Discharges the integrating capacitors.	JP4-39	JP7-39
TSTEN	IN20	Test signal used to verify the operation of the integrators and multiplexor when no X-rays are present.	JP4-41	JP7-41
BB0 BB1 BB2 BB3		Integrator signals to the Analog/Digital Converter.	JP2-2 JP2-6 JP2-10 JP2-14	JP11-2 JP11-6 JP11-10 JP11-14
+15V 15V_RET -15V		Powers the amplifiers and switches of the Integrator/ Multiplexor board and powers the Solid State Detector boards.	JP1-5 JP1-4 JP1-3	JP10-5 JP10-4 JP10-3
+5V		Powers the digital circuitry of the Integrator/ Multiplexor board.	JP1-2	JP10-2
GND			JP1-1	JP10-1

Note 1. Some signal names are labeled differently on different schematic drawings.

2.13 Analog To Digital Board (A Model Only)

The Analog to Digital (ADC) board converts analog signals received from the Integrator/Multiplexor board to a digital format. Analog signals from the Integrator/Multiplexor board are applied to differential amplifiers on the ADC board in four groups of 64 channels. Outputs from the differential amplifiers are combined in a final multiplexor consisting of four analog switches. The multiplexed signals pass through a programmable gain amplifier and summing amplifier before being applied to an A/D converter. A one-volt fixed DC offset is inserted at the summing amplifier to insure that no channels ever go negative. The A/D converter converts the analog signal into 16-bit parallel data for processing by a Digital Signal Processor.

The ADC board uses a Motorola 56000 Digital Signal processor to generate all the control signals necessary for the detector array assembly. The same software can now be used with all Discovery systems. This processor also provides a high-speed serial data link to the computer.

Note: Jumper JP5, on the ADC board, is used to select between high- and low-resolution so that the board can be used on both QDR-4500 and Discovery models. When the jumper is *in* the board is configured for *high-resolution*, when the jumper is *out* the board is configured for *low-resolution*. This jumper must always be present on Discovery A/SL models.

2.13.1 Power

The ADC board receives +/-15V and + 7V from the C-arm Interface board. The +/-15V is passed through this board to the Integrator/multiplexor board. It is also reduced to +/-12V by series regulators to power op-amplifiers and analog switches located on this board. The +/-15V also generates +/-5V to power the analog-to-digital converter circuit. The +7V is reduced to +5V to power the digital section of this board. The +5V is also passed on to the Integrator/Multiplexor board.

2.13.2 Interface Connections

Figure 2-12 shows the interconnections between the Analog/Digital Converter board and the Integrator/Multiplexor board. Table 2-16 describes the interface signals and identifies the interconnection connector and pin assignments.

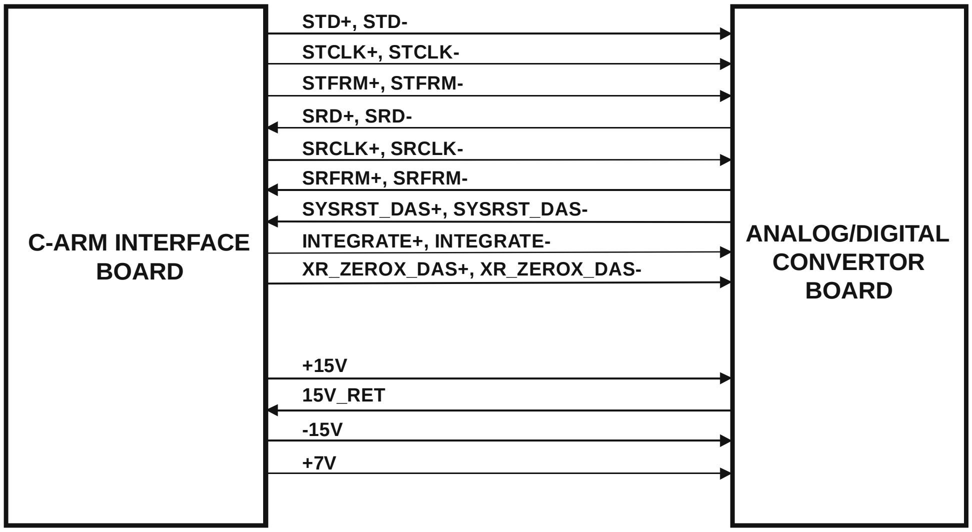


Figure 2-12. C-Arm Interface Board/Analog/Digital Converter Board Interconnection Diagram

Table 2-16. C-Arm Interface Board/Analog/Digital Converter Board Interconnection Descriptions

Signal	Description	C-Arm[1] Pin	ADC[2] Pin
STD+ STD-	Synchronous data to the Analog/Digital Converter board.	JP10-3 JP10-4	P1-12 P1-13
STCLK+ STCLK-	Synchronizes data to the Analog/Digital Converter board.	JP10-6 JP10-7	P1-15 P1-16
STFRM+ STFRM-	Synchronizes DSP Communications.	JP10-9 JP10-10	P1-18 P1-19
SRD+ SRD-	Synchronous Data from the Analog/Digital board.	JP10-12 JP10-13	P1-3 P1-4
SRCLK+ SRCLK-	Synchronizes data from the Analog/Digital Converter board.	JP10-15 JP10-16	P1-6 P1-7
SRFRM+ SRFRM-	Synchronizes DSP Communications.	JP10-18 JP10-19	P1-9 P1-10
SYSRST_DAS+ SYSRST_DAS-	Resets the Analog/Digital Converter board.	JP10-21 JP10-22	P1-21 P1-22
INTEGRATE+ INTEGRATE-	Data integration signal. Generated by the C-Arm Interface board.	JP10-24 JP10-25	P1-24 P1-25
XR_ZEROX_DAS+ XR_ZEROX_DAS-	AC line zero-crossing signal used for system wide synchronization. Generated by the C-Arm Interface board.	JP10-27 JP10-28	P1-27 P1-28

Signal	Description	C-Arm[1] Pin	ADC[2] Pin
+15V	Powers the Data Acquisition System.	JP10-32 JP10-33	P1-32 P1-33
-15V		JP10-36 JP10-37	P1-36 P1-37
15V_RET		JP10-30 JP10-31 JP10-34 JP10-35	P1-30 P1-31 P1-34 P1-35
+7V		JP10-38 JP10-39	P1-38 P1-39
CONTINUITY	Emergency shutdown daisy chain (grounded on ADC board)	JP10-1	P1-1

Notes: 1.C-Arm = C-Arm Interface board
2.ADC=Analog/Digital Converter board.

2.14 Torroid Power Module and DIN Rail

The Torroid Power Module provides the AC voltage required by the Discovery Operator's Console computer system and the Scanner. The module is located behind the pedestal at the foot end of the table and consists of a Main Power circuit breaker, a Power On indicator, and a torroid AC line input isolation transformer. The Main Power circuit breaker and the Power On indicator are located on the rear of the Pedestal enclosure. The isolation transformer is located inside the Pedestal enclosure.

AC power from the Torroid Power Module is sent to the Scanner on a four-wire cable providing split 240 volts to the DIN Rail. (Refer to Figure 3-1 and Figure 3-2 for a drawing of the C/W or A/SL versions of the DIN Rail). From the DIN Rail, unfiltered AC is fed to the line filter and, from there, distributed to various sections of the Scanner. Unfiltered AC is also fed to an AC outlet connector at the rear of the Electronics Tray. This outlet provides AC power to the Operator’s Console power strip. A second AC outlet provides unfiltered AC only while x-rays are being produced. This outlet is used in the factory to give a visual indication of x-ray production during testing.

Section 3
INSTALLATION

3.1 Pre-Installation Requirements

3.1.1 Required Tools

When installing the Discovery, a tool kit that includes the following items is required:

- Assortment of both flat-bladed and Phillips screwdrivers
- Assortment of needle-nose and diagonal cutting pliers
- Socket drivers (full set including 1/4", 3/8", 7/16", 1/2" and 3/4")
- Open-end wrenches (full set including 3/8", 7/16", 1/2", 9/16", 5/8" and 3/4") and an adjustable wrench
- Hex driver (Allen wrench) set including sizes 1/16", 5/64", 3/32", 7/64", 1/8", 9/64", 5/32" 3/16", 7/32" and 1/4"
- 24 Inch Digital Level (099-0269)
- Oscilloscope and digital multimeter
- Survey meter (Victoreen model 450P or equivalent)
- Measuring tape, approx. 3.7 meters (12 feet)
- Beam alignment tool (TLS-00080)
- X-ray test pattern (099-0715)
- Step Wedge Penetrometer (099-0716)
- Aperture Alignment Pin (099-0111)
- Aperture Alignment Block (099-0145)
- X-Ray Leakage Test Tool (099-0566)

3.1.2 Required Documentation

The following documents are required:

- The Radiation Measurement Report (CSD-0042-F07)
- Discovery Technical Manual (this manual 080-1085)
- FDA Form 2579

3.1.3 Room and Doorway Size

Use the following table to prepare for the move. Also, Figure 3-1 through Figure 3-4 for more details.

Model	Minimum Room Size	Minimum Doorway Width
SL & C	2.44m (8.0ft) x 2.44m (8.0ft)	0.77m (30.0in.)
A & W	2.44m (8.0ft) x 3.05m (10.0ft)	0.77m (30.0in.)

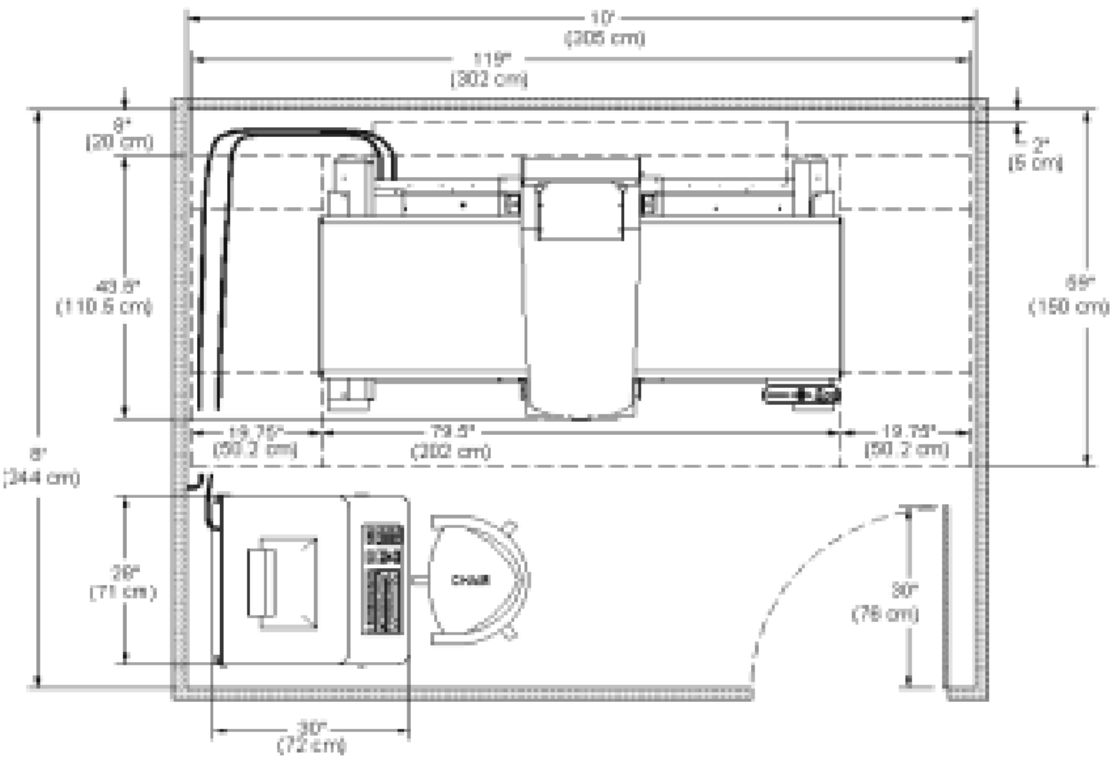


Figure 3-1. System Dimensions for Discovery-A

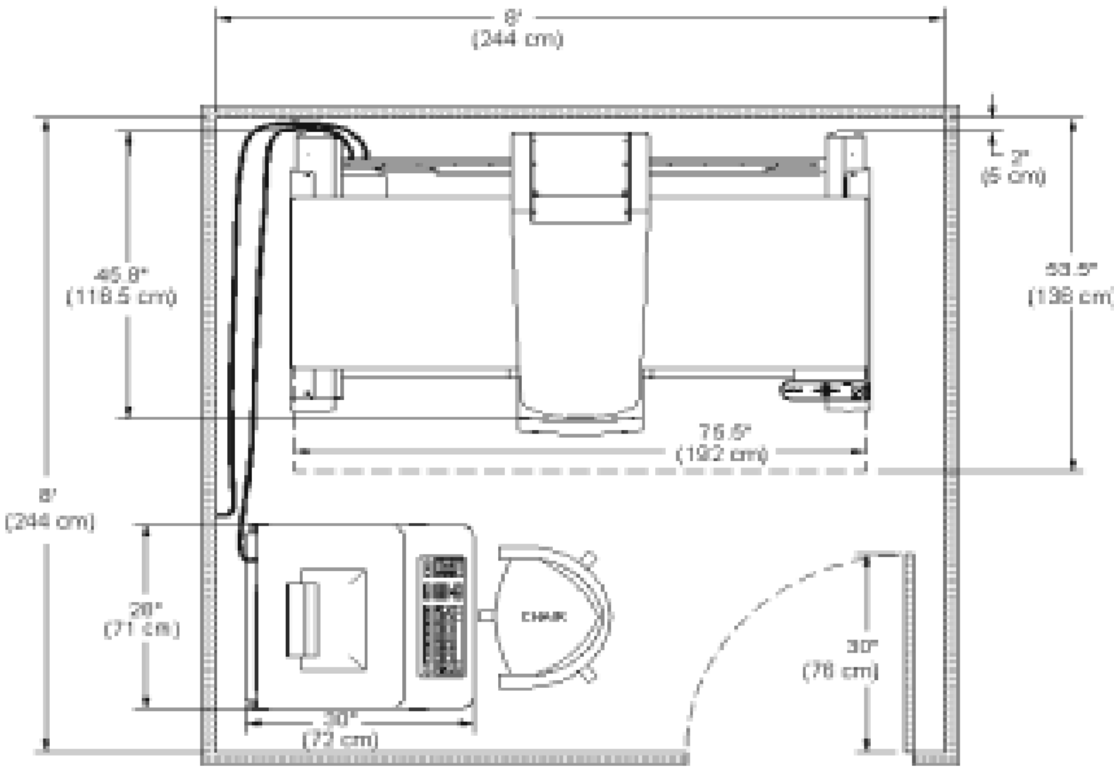


Figure 3-2. System Dimensions for Discovery-C

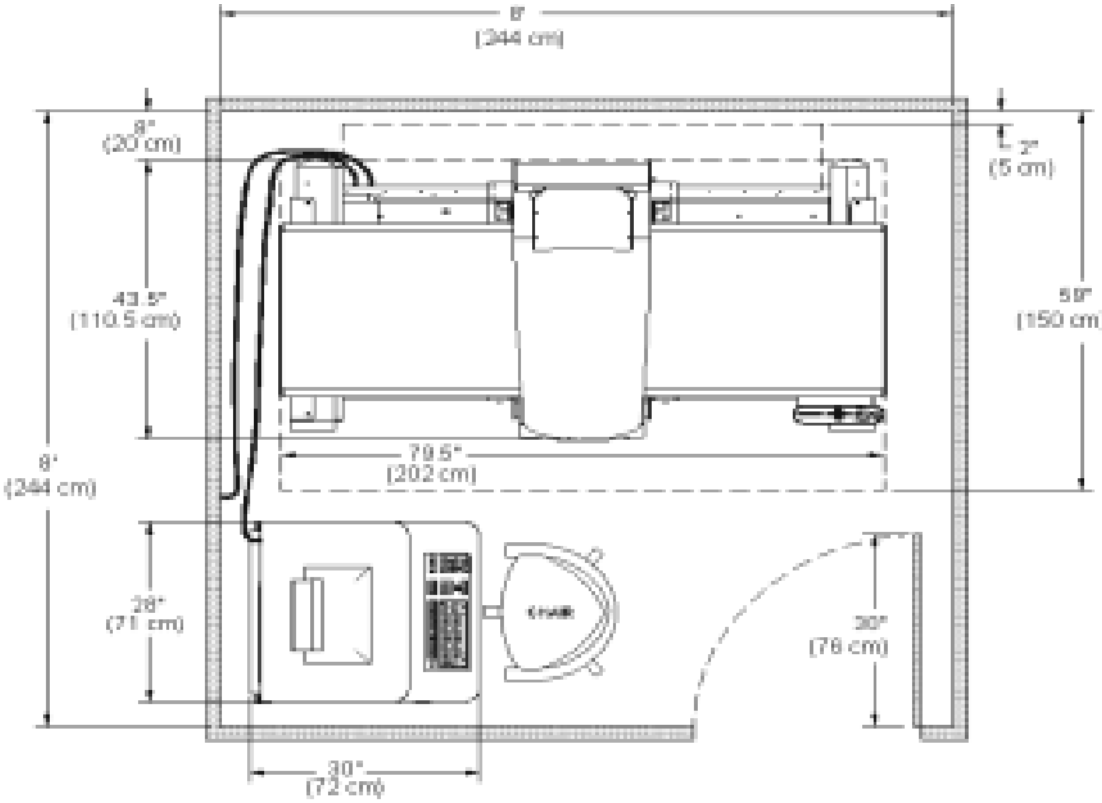


Figure 3-3. System Dimensions for Discovery-SL

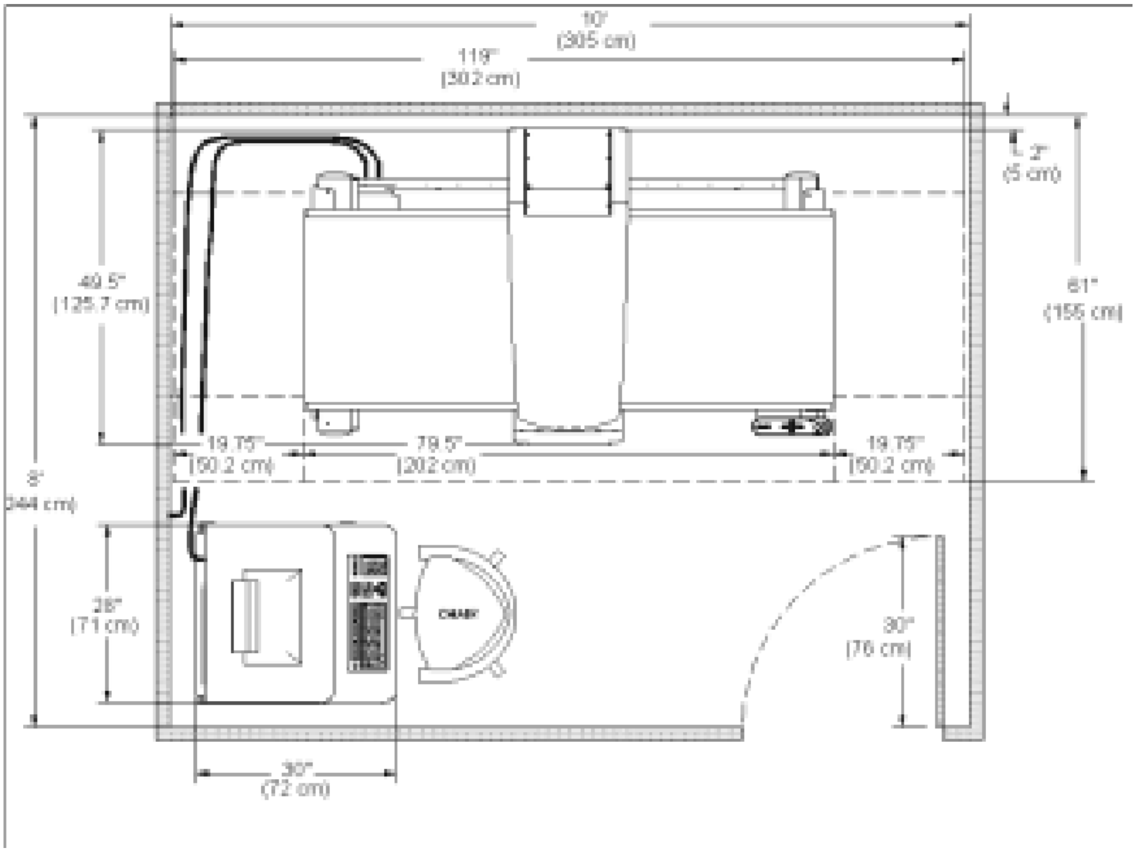


Figure 3-4. System Dimensions for Discovery-W

The Operator's Console may be up to 45ft (13.72m) away from the Scanner, but since leakage and scatter radiation levels are extremely low, it can be safely located in the same room with the Discovery itself.

3.1.4 Arrange For Help

Moving the unit to its final location requires at least two able-bodied people to direct the machine, hold doors, and lift heavy parts. The following table gives some representative weights.

	DISCOVERY-A	DISCOVERY-C	DISCOVERY-SL	DISCOVERY-W
Equipment Weight	365 kg 800 lb	295 kg 650 lb	365 kg 800 lb	295 kg 650 lb
Max. Patient Weight*	204 kg 450 lb	204 kg 450 lb	204 kg 450 lb	204 kg 450 lb
Total Weight	524 kg 1100 lb	455 kg 950 lb	524 kg 1100 lb	455 kg 950 lb
Area	1. 9 m x 1.1 m 6.3 ft x 3.5 ft	1. 9 m x 1.1 m 6.3 ft x 3.5 ft	1. 9 m x 1.1 m 6.3 ft x 3.5 ft	1. 9 m x 1.1 m 6.3 ft x 3.5 ft
Floor Loading	244 kg/m^2 49.9 lb/ft^2	215 kg/m^2 43.9 lb/ft^2	244 kg/m^2 49.9 lb/ft^2	220 kg/m^2 45 lb/ft^2

***Max. Patient Weight for systems built prior to February 2006 is 350 lb (159Kg)**

3.2 Uncrate and Move to Destination

3.2.1 Inspect For Shipping Damage

Inspect the exteriors of all crates and boxes for shipping damage. Bring any damage discovered to the attention of the customer's Shipping/Receiving department before proceeding.

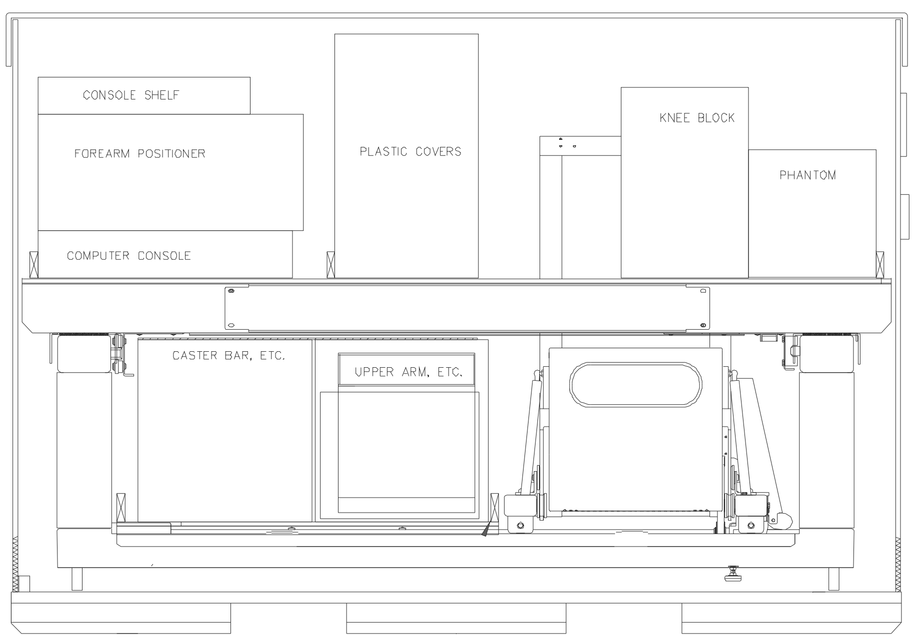


Figure 3-5. Crated Unit (Discovery A and SL)

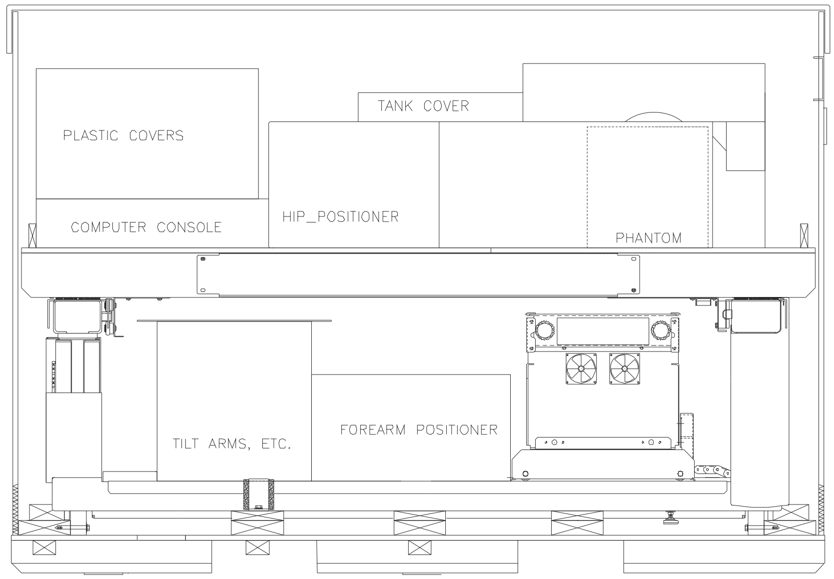


Figure 3-6. Crated Unit (Discovery C, Ci, W and Wi)

3.2.2 Uncrate Unit

Remove the unit from the crate as described below:

1. Cut the strapping that holds the packaging together.
2. Remove the cardboard cap by lifting it up and off.
3. Remove the cardboard sleeve by lifting it straight up and off. Be careful not to scratch the unit.
4. Remove the wooden table shelf and the boxes packed with the unit.

   Note: There is a metal cross brace attached to the wooden table shelf. Remove and save this cross brace as it is used later in the installation.

5. **Verify that the serial numbers on both crates and the scanner all match.**

3.2.2.1 Inspect For Hidden Shipping Damage

Open all crates and boxes, and check for signs of hidden damage. Check the ShockWatch and Tip-N’-Tell indicators for evidence of improper handling during shipment. Bring any damage discovered to the attention of the customer's Shipping/Receiving department.

3.2.3 Take Inventory

The Discovery system is shipped in two crates. Using the following checklist, take inventory of the contents of all crates and boxes, and confirm that all of the expected items have been received. Unused power cables and circuit breakers are to be returned to Hologic. Report any discrepancies to the Hologic Sales Department.

Note: Two System Backup disks are shipped with each system. One will be included with the scanner and the other shipped in the crate with the PC. Mark the one shipped with the scanner and note that if the Serial Numbers on the backup disks do not agree, the disk shipped with the scanner is the correct disk.

Installation Inventory Check List

(Quantities are one (1) each unless otherwise specified)

[ ]	Main Discovery Assembly	[ ]	Voltage Selection Kit (100/120/230)
[ ]	Printer Paper	[ ]	C-Arm Assembly
[ ]	Discovery User's Guide	[ ]	Tabletop Pad
[ ]	Computer, Mouse, and Keyboard	[ ]	Hip Positioner
[ ]	Laser or Business Inkjet Printer	[ ]	Knee (Block) Elevation Pad
[ ]	Spine Phantom	[ ]	Foot Restraint
[ ]	VGA or Flat Panel Monitor	[ ]	CDROM R/W
[ ]	Upper C-Arm Assembly	[ ]	3.5" Floppy Disks
[ ]	Discovery Console	[ ]	Miscellaneous Hardware Box
[ ]	Communication Cables	[ ]	System Backup Disks (2)
[ ]	Pedestal Covers (Left)	[ ]	C-Arm Cap and Shoulder Covers

3.2.4 Measure Path To Final Destination

Contact the department receiving the unit and request that a representative show you the room where the unit is to be installed. As you make your way from the loading dock to the room, measure all doorways and openings including any elevators on which you must travel. Look for other obstacles (thresholds, steps, sharp corners, etc.) which could cause a problem during transport. The Discovery fits through any doorway at least 30 inches (76.2cm) wide and 81inches (206cm) high, and hallways 45 inches (114cm) wide. All measurements are inside dimensions.

3.2.4.1 Short Doorway

If a Discovery must be moved through a doorway that is not at least 81" (206 cm) high, the tabletop can be removed. This allows the unit to fit through a doorway 79" (201 cm) high (inside dimension). See the instructions for removing the tabletop below.

3.2.4.2 Narrow Hallway

If a Discovery unit must be moved through a hallway that is not at least 45" (114cm) wide, the C-arm can be removed. This allows the unit to fit through a hallway 29" (74cm) wide (inside dimension). See the instructions for removing the C-arm below.

3.2.5 Remove Tabletop (If Necessary)

Note: It is not necessary to remove the tabletop if the doorway that the unit must go through is at least 81" (206 cm) high (top-to-bottom inside dimension). Removing the tabletop allows the unit to fit through a doorway 79" (201 cm) high.

The tabletop can be removed before taking the unit off the pallet. Follow the procedure below to remove the tabletop:

1. Remove the table pad and remove the right-side table rail end cover (2 Phillips screws located on the right end). This cover slides straight out the side.
2. Remove the head end pedestal covers. You will need to move the table to its extreme forward position to access the center screws on each panel.
3. Remove the two screws (Phillips) that secure the tabletop in place (located on top of the table near the rear center) and slide the table to the left, far enough to access the Table X-bearing blocks.
4. Referring to Figure 3-7, remove the right-side, front endcap (3 Phillips screws).
5. Remove the back Phillips screw from the right-side cover (of the table X-drive assembly) and slide the cover out from the front.
6. Unplug the cable to the Motor Controller board.
7. Refer to Figure 3-7. Disconnect the stainless steel cable guard (2 screws) and remove the Table X-drive attachment bracket (4 bolts and 2 nuts).
8. Remove the left rail stop (1 counter sunk screw located next to the left-side, front endcap) to allow the tabletop to be rolled off from the front.
9. Remove the 8 Allen screws (6mm) holding the table X-drive bearing blocks.
10. Remove the tabletop by carefully sliding it off the front of the unit (requires two people). **Be careful not to slide the bearing blocks off the rail.**
11. Refer to Figure 3-7. Install the right angle bracket (found in the miscellaneous hardware kit) to hold the bearing blocks and X-drive bracket in place while the scanner is moved. If this bracket is not available, tape the bearing blocks, and X-drive bracket in place.

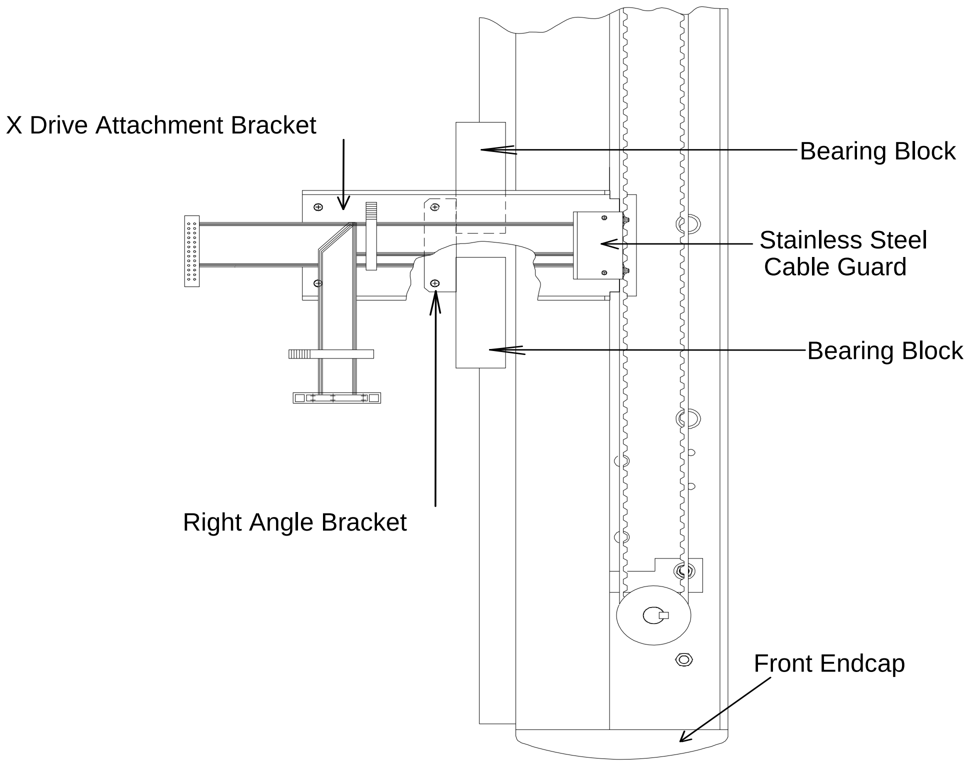


Figure 3-7. Table X Drive

3.2.6 Remove Discovery A or SL Lower C-Arm Assembly (If Necessary)

Note: It is not necessary to remove the C-arm if the hallway that the unit must go through is at least 45" (114cm) wide (side-to-side inside dimension). Removing the C-arm allows the unit to fit through a hallway 29" (74cm) wide.

The C-arm Carriage Assembly can be removed before taking the unit off the pallet. Follow the procedure below to remove the C-arm:

1. Remove the 2 carriage-to-base shipping brackets (see Figure 3-8).
2. Remove the table locking bracket located on the left side of the scanner (see Figure 3-9).
3. Move the table forward, remove the C-Arm Interface board cover, and remove the tank cover. Then move the table back.
4. Remove the X-Ray Controller Assembly (4 Phillips screws). See "X-Ray Controller Assembly" on page 5-18 for detailed removal information.
5. Remove the Tank Assembly (leave Filter Drum Assembly attached). See "Tank Assembly" on page 5-19 for detailed removal information.
6. Disconnect the cables and Nylatrac mounting hardware, and tape Nylatrac and cables in the bottom of the scanner so that they are secure.

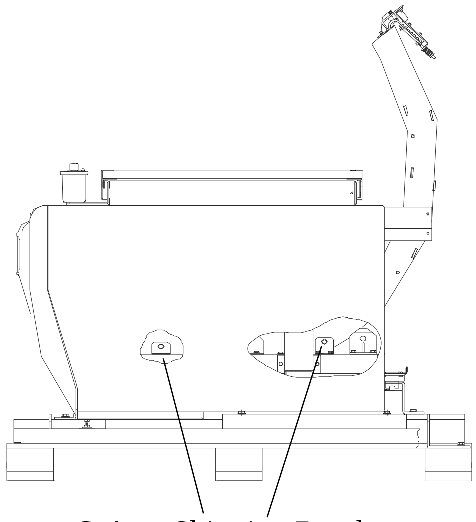


Figure 3-8. Shipping Bracket Locations (A and SL)

7. Disconnect the ribbon cable from the Arm R Motor Controller board.
8. Remove the Arm Y bearing blocks at the rear of the arm.
9. Remove the bracket that connects the C-arm to the Arm Y belt.
10. Lift the C-arm carriage up and out of the scanner unit.
11. Tape, or tie wrap, the bearing blocks to prevent them from sliding off the end of the rail.

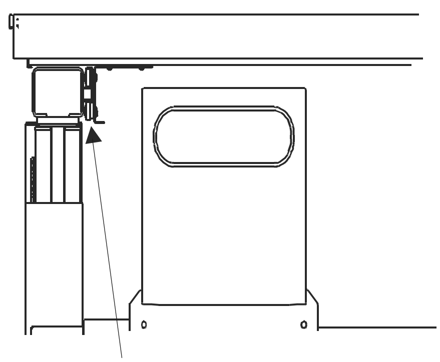


Figure 3-9. Table Locking “L” Bracket Location

3.2.7 Prepare the Tabletop for Moving (A, W,Wi)

WARNING:	Do not tilt the unit to the vertical position until the Table End Bracket is properly installed (step 4 below).

Before the Discovery can be tilted to vertical, you must slide the table to the left and clamp it so it clears the floor when the unit is tilted to vertical. To accomplish this, do the following:

1. Remove the tabletop pad.
2. Remove the three Phillips screws holding the tabletop. Two of the screws are at the left corners and one at the right back corner looking down on the tabletop.
3. Slide the tabletop to the right until it clears the table base panel.
4. Referring to Figure 3-10, adjust the Table End Stop as pictured.

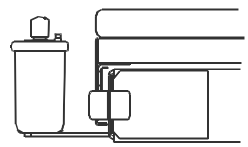


Figure 3-10. Table End Stop (Models A, W, and Wi

3.2.8 Move Unit To Destination

Follow the procedure below to move the unit:

1. Remove the four shipping brackets (Figure 3-11) as follows: <u>loosen the screws that hold the auxiliary caster bars</u> (located under each bracket), remove the lag bolts and remove the bracket. Then, re-tighten the screws that hold the auxiliary caster bar to the frame.

Bracket

Figure 3-11. Shipping Bracket

Important: The screws that hold the auxiliary caster bars must be re-tightened (Figure 3-12) to prevent the unit from dropping when moved.

Figure 3-12. Re-tighten Caster Bar Screws

2. Locate the two off-load ramps supplied with the unit. Ramps are attached to the shipping skid base (Figure 3-13).

Ramps

Figure 3-13. Off-load Ramps (as packed)

3. Install the two off-load ramps. Ramps may be installed at the end of the skid (Figure 3-14), or the side of the skid (Figure 3-15).

Figure 3-14. Ramps Installed at End of Skid

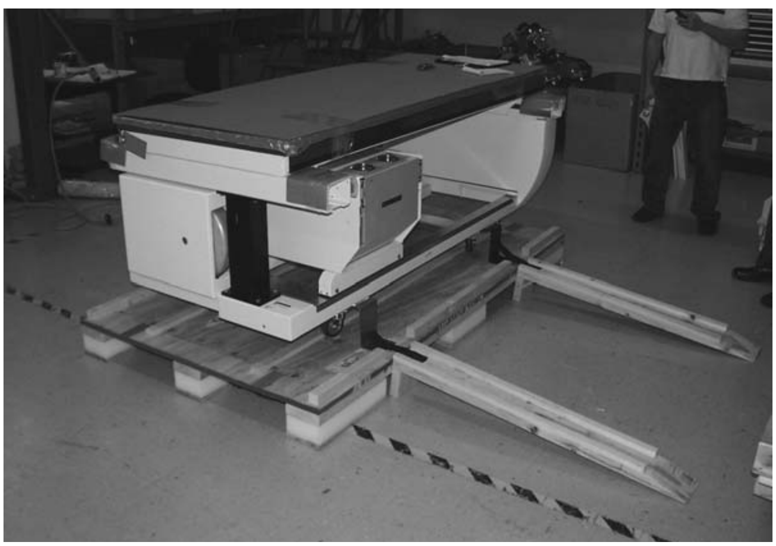


Figure 3-15. Ramps Installed at Side of Skid

4. Move the unit down the ramp and away from the skid.
5. If hallways to the destination room are wide enough to move the unit in the horizontal position, move the unit and everything that shipped with it to the destination room. Continue the install by following the procedure starting at Step 2 of *Setting Up Unit* on Page 16 of this addendum.

   If the unit must be placed in the vertical position continue with the procedure below.

3.2.8.1 Stand Unit on End (if necessary)

1. Attach the caster bars and cross brace located in the separate shipping box (Figure 3-16).

WARNING:	Cross brace must be installed before tipping the unit on its end.

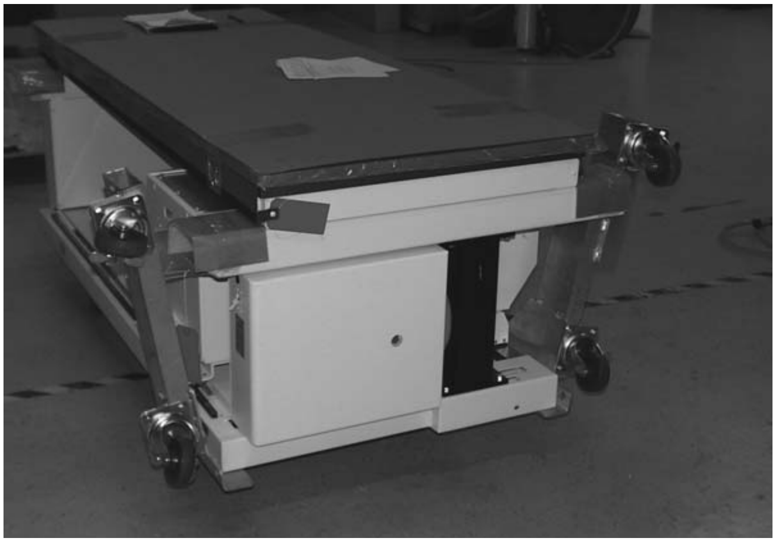


Figure 3-16. Caster Bars Installed

2. With two people, tip the unit on end, Figure 3-17 and Figure 3-18 (cardboard, or equivalent, can be used to protect the floor).

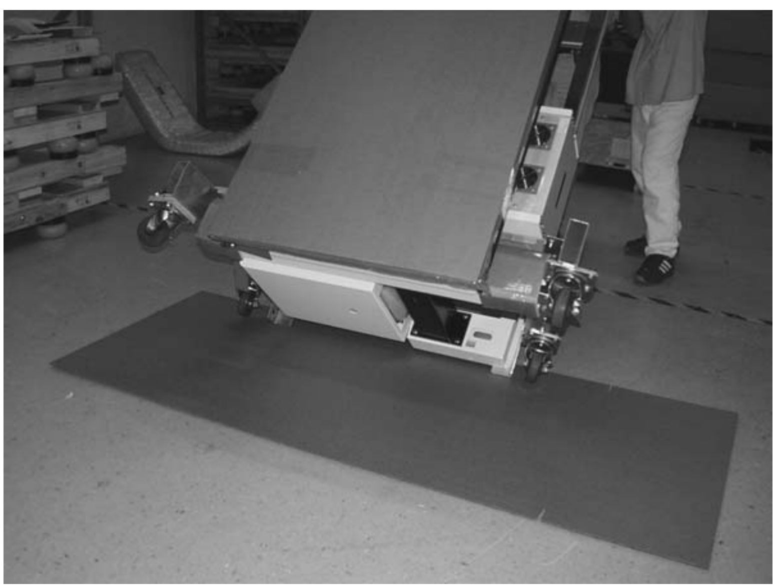


Figure 3-17. Tipping Unit on End

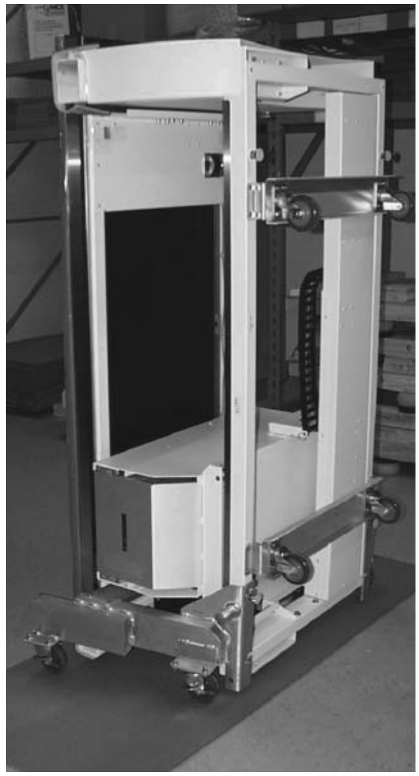


Figure 3-18. Unit in Vertical Position

3. Remove the auxiliary caster bars.
4. Move the unit and everything that shipped with it to the destination room.

3.2.9 Set Up the Unit

Follow the procedure below to set up the unit:

1. Carefully tilt the unit down.

WARNING:	The unit will feel heavier when putting it down than it felt when tipping it up. This is because the pivot point is different. For safety purposes it is recommended that two people are used to tilt the unit down.

2. Remove the caster bars and cross brace. Position the unit in its final location in the room.
3. Level the unit.
4. Remove the 2 carriage-to-base shipping brackets (Figure 3-19).
5. **Discovery A, W & Wi -** Remove the table end stop (Figure 3-10).
6. Remove the table locking bracket located on the left rear side of the scanner (Figure 3-9).

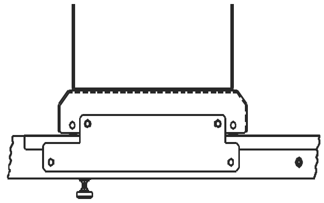


Figure 3-19. Carriage to Base Brackets

3.2.9.1 Install Discovery C-Arm (C, Ci, W and Wi)

Follow the procedure below to install a Discovery C-arm assembly:

1. Carefully place the C-arm on the bottom bolts. Tilt the arm back slightly and slip the cables through the openings and then tilt the arm forward until the front bolts are in place.
2. Put 7/16" nuts and washers on all 4 bolts and tighten.
3. Install the cables.
4. Install the Control Panel and T-beam end caps.
5. Using a digital level insure that the scanner is level (front to back and left to right).

3.2.9.2 Install Discovery Upper C-Arm (A and SL)

Follow the procedure below to install a Discovery A or Discovery SL upper C-arm assembly:

WARNING:	Do not remove C-arm shipping brackets (Figure 3-20) until done.

1. Refer to Figure 3-20. Reposition the belt tensioning mechanism. The belt tensioning mechanism is turned around to facilitate shipping and moving the assembly (the shipping bracket is not used after the mechanism is repositioned).
2. Remove the back C-arm cover (2 Phillips screws).
3. Remove the two 1/2" bolts that lock the upper C-arm in place (left in place during shipment).
4. Remove the screws for the C-arm shoulder cover (left in place during shipment).
5. Remove the two C-arm retaining brackets (to allow upper C-arm to be set in place).
6. Remove the cover from the upper C-arm.
7. Install the upper C-arm onto the lower C-arm (tilt the front of the upper C-arm up to slide it in place).
8. Install the retaining brackets.

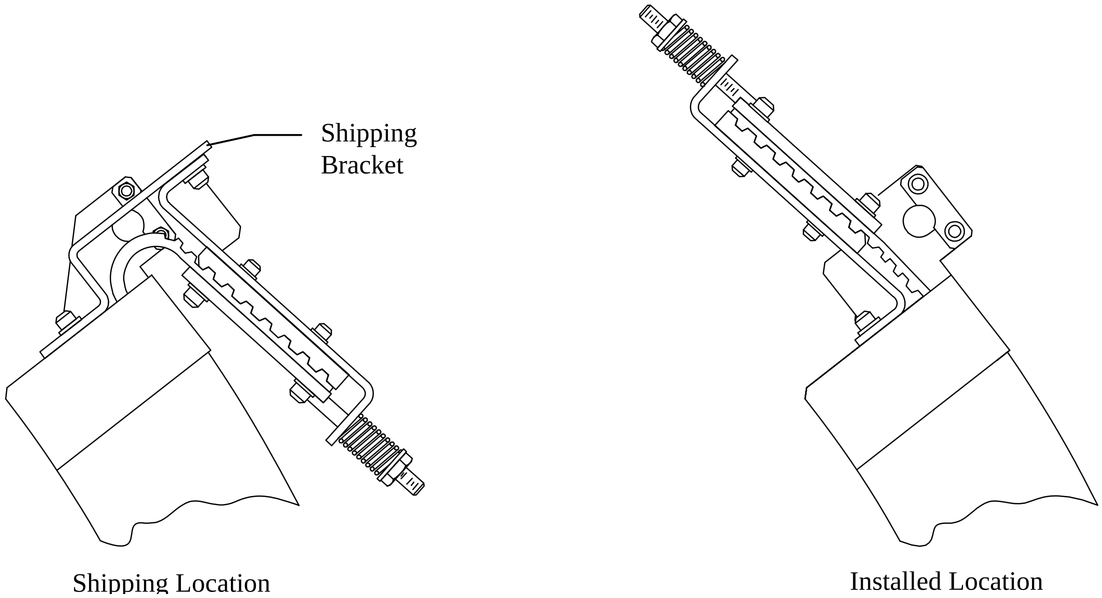


Figure 3-20. Repositioning the Belt Tensioning Mechanism

9. Install the two 1/2" bolts.
10. Remove the C-arm top cover.
11. Install the counter-weights (shipped in carton with casters) into the upper C-arm.
12. Connect the two cables from the upper C-arm to the lower C-arm.
13. Install the 1/2" x 13" trim plate that mounts (on the front) between the upper and lower C-arm (make sure trim plate is aligned to front of C-Arm).
14. Remove the four C-arm shipping brackets (see Figure 3-20). Save these brackets, they are needed if the tank is ever removed.
15. Level the scanner left to right.
16. Level the system front to back: be sure the scanner table top is level 0° ±0.0° front to rear at both the head and foot ends. **Failure to level A and SL models will result in TZ, and other, positioning tolerance errors when attempting to acquire whole body, lateral, or IVA scans.**

3.3 Install the System

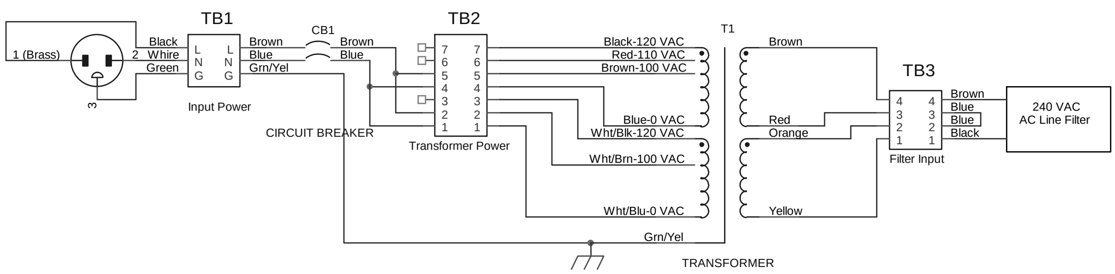
3.3.1 Install Cables

Follow the procedure below to cable the system:

1. Locate the box shipped with the system containing the Voltage Selection Kit that includes the AC Input cable, Main Circuit Breaker, jumpers wires, and mounting hardware.
2. Confirm that you have the proper kit for the site's AC voltage (100/120/230VAC).

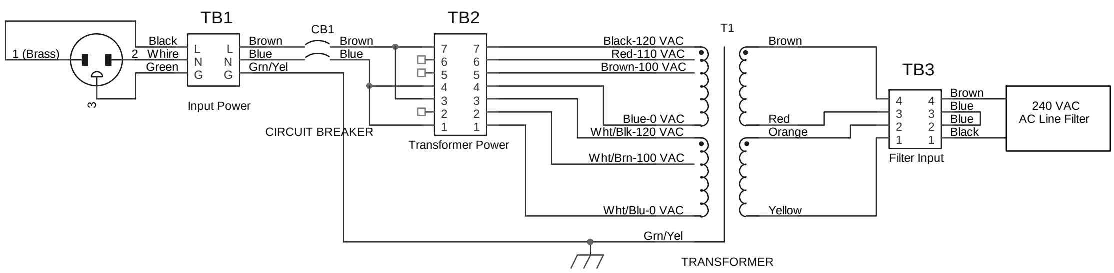
3. Measure the voltage between ground and neutral at the wall outlet that will be used for the system. If it is more than TBD mV call Hologic Technical Support before continuing.
4. Remove foot end cover on the Electronics Tray (on the left side facing the machine) and the cover of the Torroid Assembly.
5. Remove the AC input cable from the kit, install the strain relief, and route the cable though bottom of the Torroid Assembly.
6. Screw the strain relief into the bushing at the bottom of the Torroid Assembly and fix the cable to the exposed stud using the cable clamp and NyLock nut provided in the kit.

100 VAC OPTION



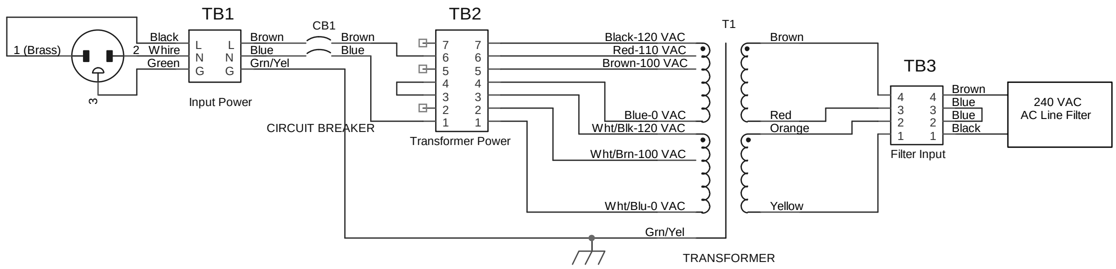
Circuit Breaker = 310-0018 (20 Amp, 2 Pole)
Power Cable = 180-0626

120 VAC OPTION



Circuit Breaker = 310-0053 (15 Amp, 2 Pole)
Power Cable = 180-0621

230 VAC OPTION



Circuit Breaker = 310-0006 (7.5 Amp, 2 Pole)
Power Cable = 180-0622

7. Attach the ground wire to the grounding lug using the hardware provided. Attach the neutral and phase wires to TB1.
8. Install the circuit breaker from the voltage kit into the hole in the rear of the Toroid Assembly using the screws provided in the kit
9. Attach the two wires (brown and blue) from TB1 to the Line terminals (top terminals) on the circuit breaker.
10. Attach the two wires (brown and blue) from TB2 to the Load terminals (bottom terminals) on the circuit breaker.
11. Use the jumpers provided to configure the terminal block as shown in the tables below.

120 VAC 50/60 Hz	Wire	From	To
	Blue	Circuit Breaker - Load	Pin 1 – TB2
	Brown	Circuit Breaker – Load	Pin 7 – TB2
	Blue Jumper	Pin 1 – TB2	Pin 4 – TB2
	Brown Jumper	Pin 3 – TB2	Pin 7 – TB2

230 VAC 50/60 Hz	Wire	From	To
	Blue	Circuit Breaker - Load	Pin 1 – TB2
	Brown	Circuit Breaker – Load	Pin 6 – TB2
	Brown Jumper	Pin 3 – TB2	Pin 4 – TB2

	Wire	From	To
100 VAC 50/60 Hz	Blue	Circuit Breaker - Load	Pin 1 – TB2
	Brown	Circuit Breaker – Load	Pin 5 – TB2
	Blue Jumper	Pin 1 – TB2	Pin 4 – TB2
	Brown Jumper	Pin 2 – TB2	Pin 5 – TB2

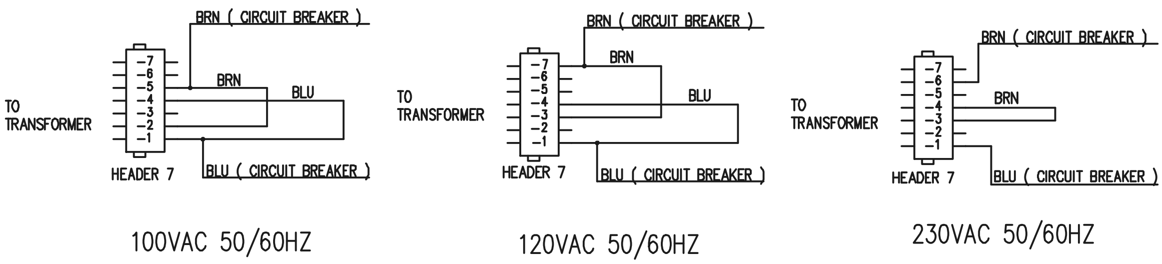


Figure 3-21. Isolation Transformer Input Taps

12. Confirm that the secondary side taps are set up as shown in the diagram in Figure 3-21. These diagrams can also be found on the inside of the Torroid Assembly Cover.

    Note: The terminology "Header 7" used on Figure 3-21, and on the inside of the Torroid Assembly Cover, comes from the schematic for the assembly (it is a 7-pin terminal block "header"). The tables above refer to the same terminal block as TB2 (the designation on the assembly drawing).

13. Replace the cover of the Torroid Assembly.
14. Route the Operator Console AC Supply Cable through the cable clamp block on the rear of the Scanner.
15. Attach the Console Power Cord to the top power receptacle. The bottom power receptacle is used in the manufacturing process to power a light when X-rays are on. The bottom receptacle can be used to power an external x-ray on annunciator lamp at the customer site (if required by local regulations).
16. Route the Operator Console Communications Cable through the cable clamp block on the rear of the Scanner.

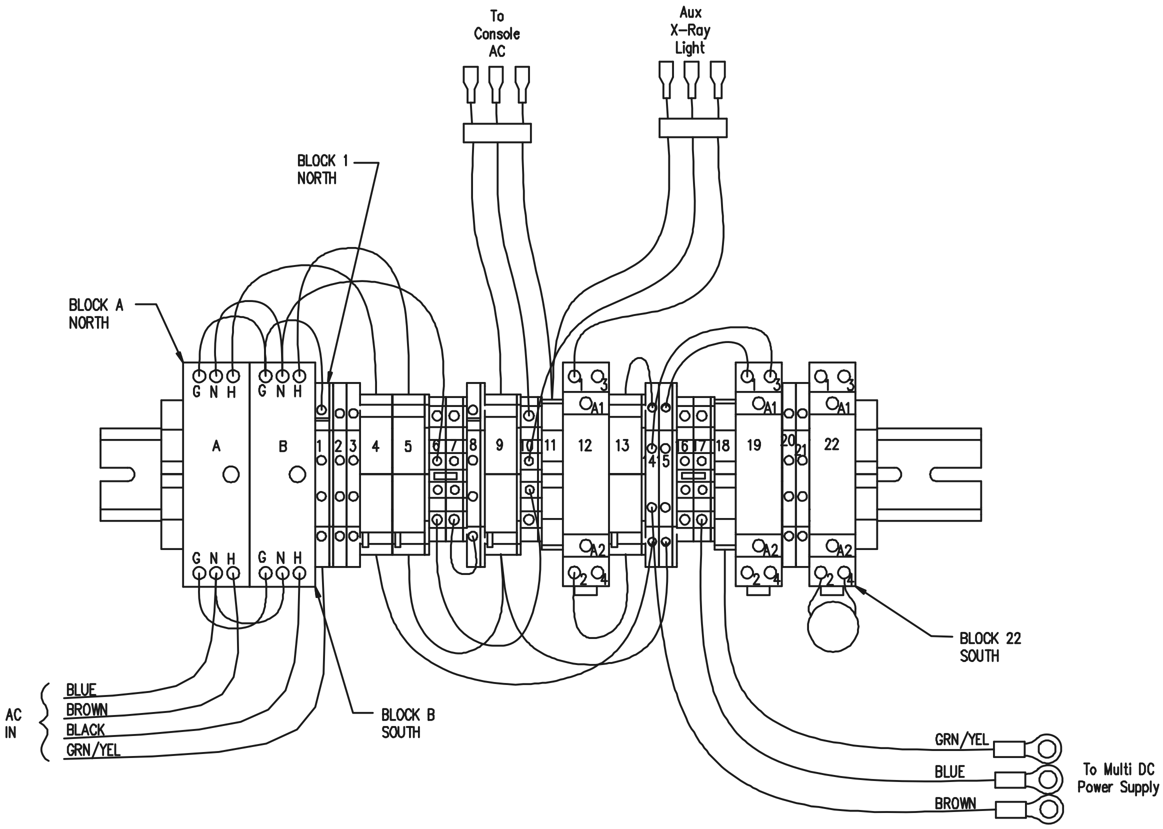


Figure 3-22. DISCOVERY-C and W DIN Rail AC Input/Output Wiring Diagram

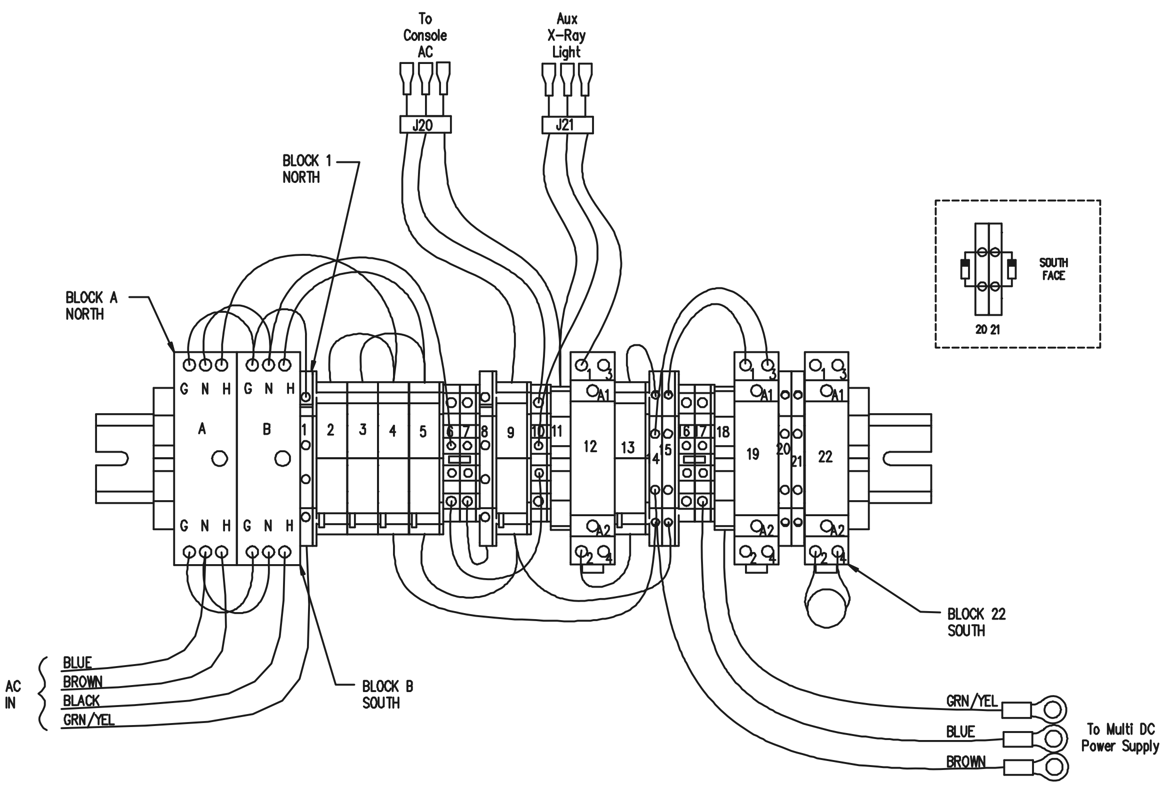


Figure 3-23. Discovery-A and SL DIN Rail AC Input/Output Wiring Diagram

17. Attach the Communications Cable to JP10 on the Distribution Board and the ground strap to the grounding stud.
18. Attach the other end of the Communications Cable to the PCI Communications Controller Board connector at the rear of the PC.
19. Plug the Operator Console AC Supply Cable to the Power Strip male connector.

SAFETY PRECAUTIONS

There are a number of safety precautions that MUST be observed when servicing the Discovery systems.

HIGH VOLTAGE: Voltage levels that can injure or be fatal are present through the Discovery systems. The line voltage (100, 120, 230 volts) is supplied to the Torroid Assembly and the scanner. The X-ray source unit contains 140kV as well as other AC and DC voltages. The pedestal motors use 230 volts regardless of the line voltage. Use caution when checking, calibrating, and troubleshooting. Always trip the main breaker when replacing components.

X-RADIATION: Service personnel are required to wear a dosimeter. Do not leave the system unattended in X-RAY SURVEY (SURVEY mode).

ESD PRECAUTIONS: To prevent damage due to ESD (Electrostatic Discharge), you must take precautions when handling components. Remove any charge from your body by wearing an approved and properly grounded wrist strap. Keep PCBs in their ESD protective bag until you are ready to install them. Treat defective PCBs as new to prevent any additional damage.

3.3.2 Check Power Line Voltage

Hologic specifies that the Discovery be powered from a dedicated power line.

Power Requirements for all Discovery models:	100VAC 16A 50/60Hz, Max apparent resistance = 0.32 ohm 120VAC 14A 50/60Hz, Max apparent resistance = 0.32 ohm 230VAC 8A 50/60Hz, Max apparent resistance = 1.28 ohm

3.3.2.1 Measure Line Voltage

Before plugging in the Discovery, measure the voltage (neutral to phase) with an AC voltmeter at the outlet from which the unit will draw power. The measured voltage must be within ± 10% of the voltage shown on the power label (located where the power cord attaches to the Torroid Power Module). The Discovery Torroid Assembly is a step up/step down isolation transformer, which can be re-strapped to accommodate other input voltages. See Figure 3-21 for the most common configurations of the isolation transformer.

There are two standards for conductor color-coding. The North American standard specifies the BLACK conductor as LINE and the WHITE as NEUTRAL, while the International standard defines the BROWN conductor as LINE and the BLUE as NEUTRAL.

Note: Be sure to change the label if you re-strap the transformer.

Note: Enter this information into the Radiation Measurement Report (see example on page 3-70).

3.3.2.2 Measure Isolation Transformer Secondary Voltage

After plugging in the instrument and switching on the main breaker and instrument power on the Control Panel, measure the voltage at the power strip located at the rear of the Operator's Console with a digital voltmeter set to measure AC volts.

Note: The voltage should be between 110 VAC and 130 VAC. If the voltage is out of this range, recheck the voltage at the wall outlet, and the strapping of the isolation transformer as shown in Figure 3-21.

3.3.3 Install Computer

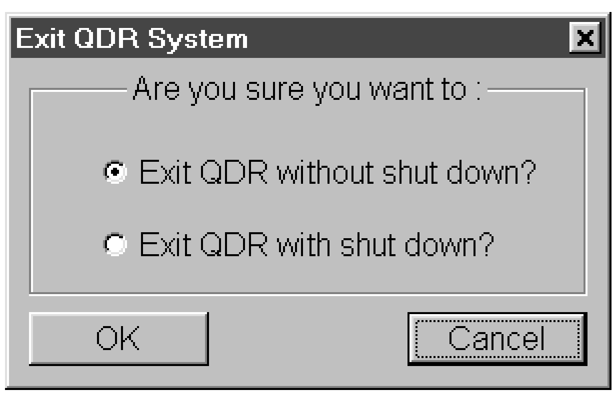
Follow the procedure below to install the computer:

1. Set up the computer cart using the enclosed instructions. Place the computer, keyboard, monitor, and printer on the cart.
2. Install computer system and power cables.
3. Turn on the computer and confirm that all options shipped with the instrument or listed on the sales order have been installed.

3.3.4 Start QDR Software in Service Mode

Follow the procedure below to cable the system:

1. Log on to Windows XP as **Field Service** using the last 6 digits of the RTX Run-time serial number as the password. (If this is the first time the computer is being powered on, the password will be **password**.)
2. Exit the Discovery software by clicking the **Exit** button and selecting the **Exit QDR without shut down?** option and then clicking the **OK** button.



3. Click the **Start** button on the desktop and then select **Search For Files or Folders...**
4. In the Search Results window, select **All files and folders**, type **service** in the **All or part of the file name:** edit box, and then click on the **Search** button.

5. The software now searches for **SERVICE**. A list in the right panel will show you the files found. In the list, click the "service" item shown in **C:\QDR\Utilities** and drag it to the desktop. Close the Search window and then double-click the Service icon on the desktop. The software will now be restarted in service mode.

3.3.5 Check Table Alignment

To check the table alignment, perform the following procedure:

1. Using a measuring tape, and referring to Figure 3-24, check the following:
   - Distance from the edge of the table to the back of both T-rails ("A" dimension).
   - Distance between the T-rails (front and rear).
   - Gap from the edge of the table bracket (left side) to the rail.
2. Record all the measurements.
3. Facing the front of the Discovery, gently push the foot end (left side) of the table. The table should move away from, and then back, to its original position.
4. Check the "A" dimension and the bracket-to-guide rail gap again. Compare them to their original values.
5. If all the measurements are within specification, the table is properly aligned. If the measurements are not within specification, go to the Aligning Table section below.

3.3.5.1 Table Alignment Procedure

After you have taken the measurements in the Checking Table Alignment section, use the procedures below to align the table. Note that if both the "A" dimension and the bracket-to-guide rail gap are out of specification, you should recheck the measurements after performing the first adjustment.

3.3.5.2 Table Edge to T-Rail ("A" Dimension) Adjustment

To change the "A" dimension, do the following:

1. Remove the outer and inner covers from the right pedestal.
2. Loosen the four bolts fastening the top of the pedestal and the four bolts fastening the bottom of the pedestal (see Figure 3-25).
3. Adjust the table so the "A" dimension is within the specification.
4. Tighten the bolts and check the table alignment again.

If the alignment is within the specification, replace the pedestal covers. If you still note a change in the "A" dimension, continue with the following steps.

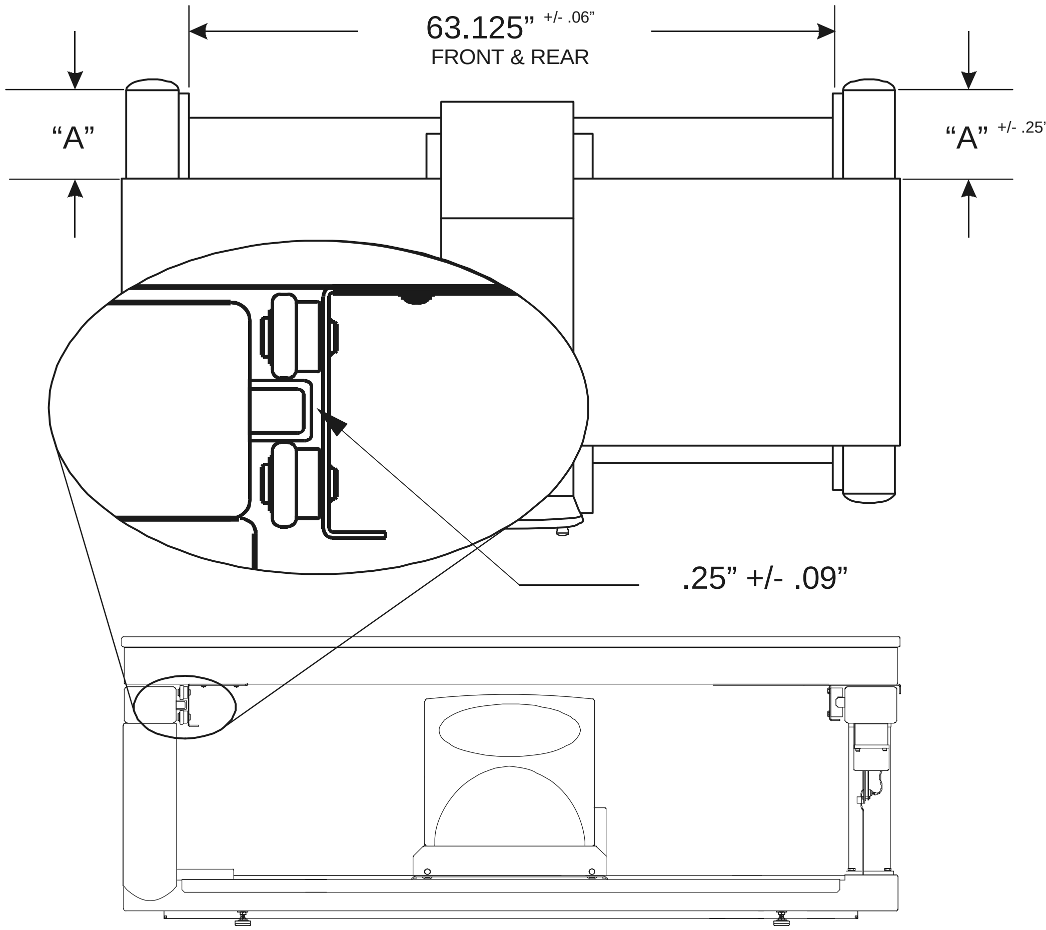


Figure 3-24. Table Alignment

(Not drawn to scale)

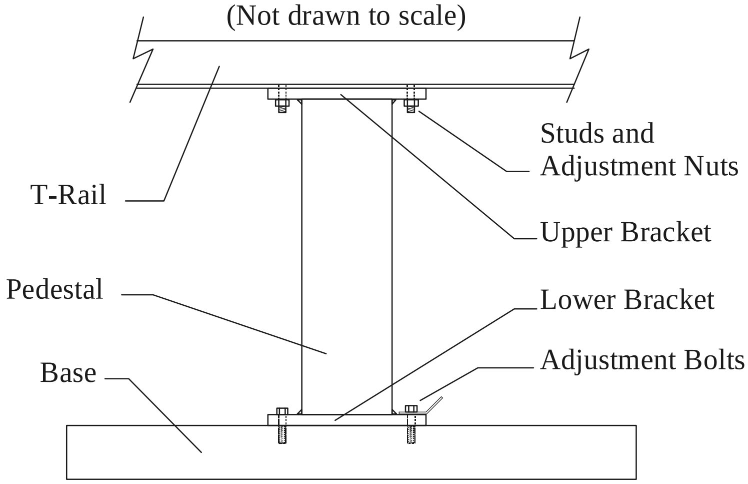


Figure 3-25. Pedestal (covers removed)

5. Make sure the upper and lower brackets are securely fastened to the upper and lower frames.

Note: Even if the brackets are secured to the frames, they may not be securely fastened to the pedestal. If not, remove the table to access the screws that secure the brackets to the pedestal. Refer to Remove Tabletop on page 3-9 for table removal procedures.

If the screws are loose, apply a small amount of Loctite to the threads and tighten the screws.

The upper and lower brackets are attached to the pedestal with four, 6mm flat-head Allen screws. While the table is off, it is a good idea to remove the pedestal to make sure that these screws are tight as well.

To change the “A” dimension, do the following:

6. Mount the pedestal to the lower frame. Do not tighten the bolts until the alignment has been completed.
7. Install the table and check its alignment. Make the necessary adjustments, then tighten the upper and lower bolts.
8. Install the pedestal covers that were removed in Step 1.

3.3.5.3 Front to Back T-Rail and Table Edge/Rail Gap Adjustment

To adjust the front-to-back T-Rail dimensions and table edge-to-rail gap, perform the following procedure:

1. Remove the outer and inner covers from the left pedestal.
2. Loosen the four bolts fastening the top of the pedestal and the four bolts fastening the bottom of the pedestal.

   Note: Before adjusting the distance between the rails, make sure the upper and lower brackets are securely fastened to the pedestal. Refer to Steps 3 -5 of the previous (Aligning Table) section and then go to the next step.

3. Adjust the distance between the T-rails and the table edge-to-rail gap and tighten the bolts.
4. Install the pedestal covers that were removed in Step 1.

3.3.6 Perform C-Arm Parallelism Adjustment (A and SL systems only)

1. Using a digital level and with the Tank cover removed, measure the angle across the tank and from back to front on the Tank. Record the angles.
2. Remove the upper C-Arm covers and repeat the measurements on the upper C-Arm assembly. Again record the angles.
3. If the angles measured on the tank vary by more than 0.0 degrees from those found on the C-Arm, do the following.
4. Rotate the C-Arm until the center of gravity for the upper C-Arm is over the lower C-Arm (approximately 60 degrees rotated).
5. Loosen eight 1/4" bolts (4 on each side).

6. Move the C-arm until it is parallel to the tank using the digital level to measure the angles.

3.4 Calibrate and Test the System

3.4.1 Check Tube kV Peak Potential

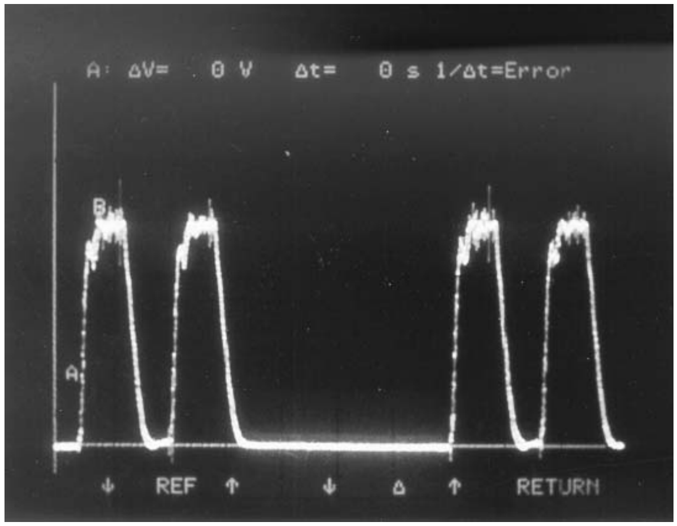
WARNING:	X-rays are generated during this procedure. Keep hands, head and other body parts out of beam.

Proper operation of the Discovery requires that the X-ray tube generate X-ray pulses of 80kVp, 100kVp, 120kVp, and 140kVp, all ± 10%. The peak potential check must be performed at installation time and whenever the X-ray source or X-ray controller is repaired or replaced. Because it would be very dangerous to directly monitor the kVp potentials, there is a 10,000 to 1 voltage divider circuit inside the High Voltage Power Supply/Source (HVPS/S). By monitoring this divided voltage, one can determine the peak potentials being impressed on the X-ray Tube. The monitoring can be done on the terminal strip on top of the X-ray Source.

WARNING:	Although the test voltage is low, there are elevated voltages near and around the test points.

1. Remove the tank cover (2 Phillips screws).
   Set up the scope as follows:
   Channel 1:2V/div (0.2V/div if using x10 probes)
   Channel 2:2V/div (0.2V/div if using x10 probes)
   Time base:5.0ms/div
   Trigger on line (positive slope)
   Set Vertical Mode to Add
   Invert Channel 2.
   Connect Channel 1 to TB1-PIN 12 (on the tank)
   Connect Channel 2 to TB1-PIN 11 (on the tank)
2. Ground both channels and move the trace to the bottom of the screen. Remove the grounds and go to DC coupling.
3. Instrument power, computer power, and the X-ray enable key should all be on.
4. Start the X-Ray Survey Utility by selecting **Utilities|Service Utilities|X-Ray Survey** (see “X-Ray Survey” on page 9-1 for information on the utility).
5. Change **X-Ray Mode** to 4 and **Aperture** to 7. (**Note:** On Ci and Wi systems, the Aperture parameter is set to a default value of -1 by the system software. Do not change this value on Ci and Wi systems.)
6. Click **X-Rays (F2)** to turn X-Rays on.
7. Observe the oscilloscope. You should see a trace similar to Figure 3-17, approximately 4ms pulses with a peak amplitude of 8V (ignore the overshoot, measure after it settles out). This corresponds to 80kVp inside the tank.

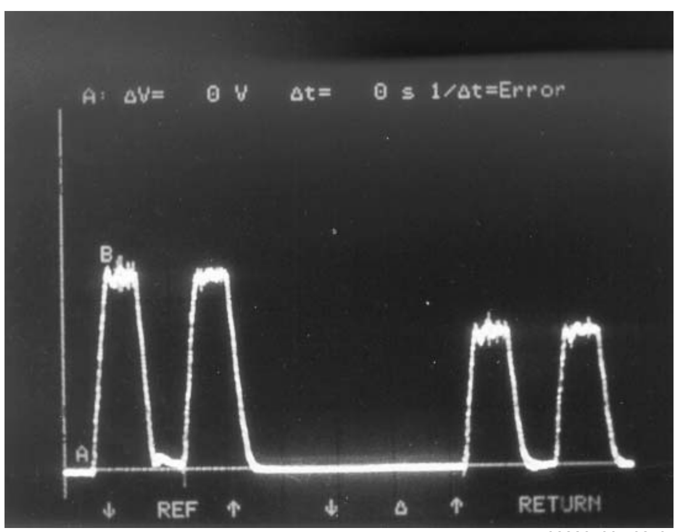
8. Click **X-Rays (F2)** to turn X-Rays off.
9. Change the **X-ray Mode** to 3.



AW-00336_001-0318

Figure 3-17. Peak Potential Mode 4

10. Click **X-Rays (F2)** to turn X-Rays on.
11. Observe the oscilloscope. You should see a trace similar to Figure 3-18, alternating pulses, approximately 4ms in duration, with a peak amplitude of 14V and 10V respectively (corresponding to 140kVp and 100kVp inside the tank).



AW-00336_001-0319

Figure 3-18. Peak Potential Mode 3

If the scope trace seen is not as shown in either Figure 3-17 or Figure 3-18, the system may have insufficient AC power, a faulty X-ray Controller, or defective Tank.

Note: Enter this information into Enter this information into the Radiation Measurement Report (see example on page 3-70).

3.4.2 Check Tube Current

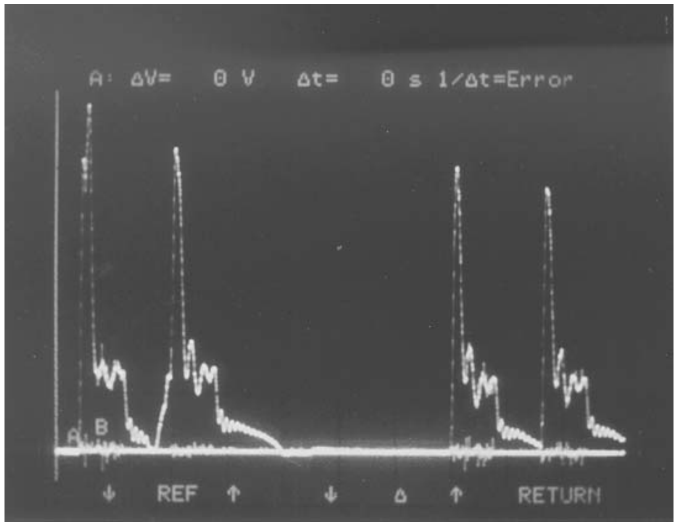
WARNING:	X-rays are generated during this procedure. Keep hands, head and other body parts out of beam.

Follow the procedure below to check X-ray tube current. Monitoring tube current is done on the barrier strip on top of the X-ray source.

WARNING:	Although the test voltage is low, there are elevated voltages near and around the test points.

1. If the tank cover is not off, remove it (2 Phillips screws).
2. Set up the scope as follows:
   Channel 1:2V/div (0.2V/div if using x10 probes)
   Channel 2:2V/div (0.2V/div if using x10 probes)
   Time base:5.0ms/div
   Trigger on Line (positive slope)
   Set Vertical Mode to Add
   Invert Channel 2.
   Connect Channel 1 to TB1-PIN 10 (on the tank)
   Connect Channel 2 to TB1-PIN 7 (on the tank)
3. Ground both channels and move the trace to the bottom of the screen. Remove the grounds and go to DC Coupling.
4. Instrument power, computer power, and the X-ray enable key should all be on.
5. Start the X-Ray Survey Utility by selecting **Utilities|Service Utilities|X-Ray Survey** (see “X-Ray Survey” on page 9-1 for information on the utility).
6. Change **X-ray Mode** to1 and **Aperture** to 7. (**Note:** On Ci and Wi systems, the Aperture parameter is set to a default value of -1 by the system software. Do not change this value on Ci and Wi systems.)
7. Click **X-Rays (F2)** to turn X-Rays on.
8. Observe the oscilloscope. You should see a trace similar to Figure 3-19, approximately 4ms pulses with a peak amplitude of 3V (ignore the overshoot and measure current on the back, after it settles out). This corresponds to 3ma ± 35% tube current.
9. Click **X-Rays (F2)** to turn X-Rays off..

   Note: Enter this information into the Radiation Measurement Report (see example on page 3-70).
10. Change **X-ray Mode** to 3.

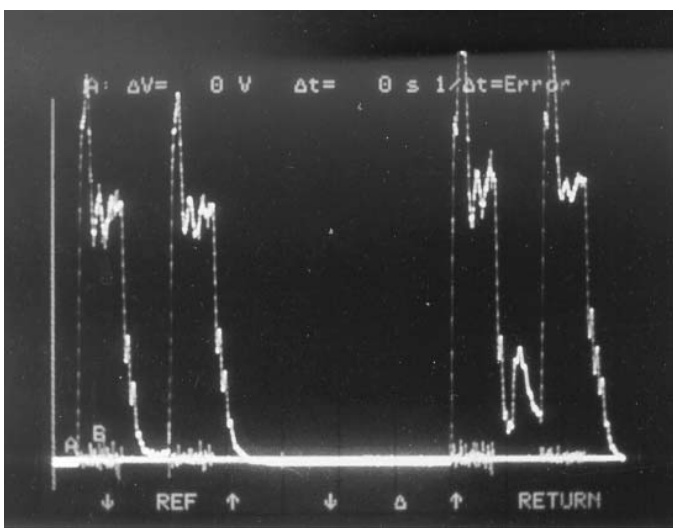


AW-00336_001-0320

Figure 3-19. Tube Current Mode 1

11. Click **X-Rays (F2)** to turn X-Rays on.
12. Observe the oscilloscope. You should see a trace similar to Figure 3-20, approximately 4ms pulses with a peak amplitude of 10V (ignore the overshoot and measure current on the back, after it settles out). This corresponds to 10mA ± 35% tube current.

If the scope trace seen is not as shown in either Figure 3-19 or Figure 3-20, the system may have insufficient AC power, a faulty X-ray Controller, or a defective Tank.



AW-00336_001-0321

Figure 3-20. Tube Current Mode 3

Note: Enter this information into the Radiation Measurement Report (see example on page 3-70).

3.4.3 Adjust Belt Tension

3.4.3.1 Check Belt Tension

Check for proper tension on the AR, TX and TY motor drive belts. Perform the tension adjustment for any belt that is loose.

3.4.3.2 Adjust Arm R Belt Tension

1. Loosen the belt tension block (two 1/4" bolts).
2. Adjust the tension nut so that the spring is compressed to 7/8" from the inside of one washer to the inside of the other washer.
3. Tighten the tension block bolts.

3.4.3.3 Adjust Table X Belt Tension

1. At the encoder end of the belt, loosen the tension spring and tensioning nut.
2. Tighten the tension nut so that the spring is compressed to 7/8 inch. The bracket cutout can be used as a measuring guide (the inside of the washer should be flush with the bracket cut).
3. Tighten the two mounting bolts holding the tension block.

3.4.3.4 Adjust Table Y Belt Tension

1. At the encoder end of the belt, loosen the 2 bolts holding the tension block.
2. Install the tension spring and tensioning nut.
3. Tighten the tension nut so that the spring is compressed to 7/8 inch. The bracket cutout can be used as a measuring guide (the inside of the washer should be flush with the bracket cut).
4. Tighten the two mounting bolts holding the tension block.

3.4.3.5 Adjust C-Arm Y Belt Tension

1. Move the C-Arm to the center of the table.

CAUTION:	Do not move the C-arm or the table more than 1"/second with the power off.

2. Turn off the Discovery computer power and main circuit breaker on the rear of the foot end pedestal.
3. Remove the Electronics Tray covers.
4. Loosen the two mounting bolts holding the belt tension block.
5. Adjust the tension nut so that the spring is compressed to 7/8 inch.
6. Tighten the two mounting bolts holding the tension block.

3.4.4 Calibrate Motors

The SQDRIVER program provides a CALIBRATE command for each of the motors (AY, AR, TY, TX, and TZ) to calibrate the encoder readback and determine the limits of motion. These values are loaded into the SQDRIVER.INI file.

Note: Calibrate motors in the following order: TZ, AY, TY, TX, and AR.

Use the following table to determine which calibration procedures you need to perform on a given Discovery model.

	Perform the calibration procedures if indicated (*) in order from left to right.				
Model	**TZ**	**AY**	**TY**	**TX**	**AR**
A	*	*	*	*	*
SL	*	*	N/A	*	*
W	N/A	*	*	*	N/A
Wi	N/A	*	*	*	N/A
C	N/A	*	N/A	*	N/A
Ci	N/A	*	N/A	*	N.A

Each motor (except TZ) requires the corresponding protocol calibration file in the PROTOCOL sub-directory (e.g., for MOTOR$AY, the calibration protocol is MOTOR_AY.PRO).

To perform the calibration procedure:

1. From the Discovery Main Menu screen, select **Utilities|Service Utilities|SQDRIVER** (you must be in Service Mode).
2. At the **CARM$$$$>** prompt, type **MOTOR$XX<Enter>**, where **XX** equals TZ, AY, TY, TX, or AR depending on which motor you are calibrating.

3.4.4.1 MOTOR$TZ (Discovery A and SL only)

1. Select the TZ motor device driver by typing: **MOTOR$TZ<Enter>**.
2. At the **MOTOR$TZ**> prompt, type: **CALIBRATE<Enter>**.

   The program sends the calibration command to the TZ microprocessor and waits twenty seconds for table motion to complete. During this time, the TZ microprocessor moves the table pedestals to their top mechanical limit and then back down to their lower mechanical limit. You are then asked the following:

   Mark the current height of the table and press the <Enter> key to move the table to the topmost position. Then measure the distance that the table moved in centimeters.

3. Measure the distance moved using the bottom edge of the top pedestal cover and the floor. The system displays:

Total Distance Moved By Pedestal [20.0 cm]?

4. Type **xx.x<Enter>** where xx.x = the distance you measured. It should be 20.0 cm (7 inch). If the distance is not 20.0 cm, type the actual measurement. **The distance measurement affects system results.**

5. Press **<Enter>**. The system then displays the following:

   Are Sure Total Distance Moved By Pedestal Is xx.x cm. [Y/N]?

   The xx.x equals the measurement you typed in above. If you type N, the system redisplays the second message and you should retype the distance you measured. If you typed Y, the system displays the following:

   Update Driver INI-File [Y/N] ?

6. Type **Y<Enter>**.

   The SQDRIVER program then reads the calibration parameters from the TZ microprocessor and prompts:

   ```
   set_table_calibration=368,3227,382,3237
   calibrate_position=10,1000,1000,713,50000,382,382,3237
   pos_limit_position=200210
   neg_limit_position=0
   Update Driver INI-File [Y/N] ?
   ```

   For information about calibration parameters, see “Calibration Parameters TZ” on page 3-34.

7. If the position limits are within specifications, Type **Y<Enter>** to accept the calibration values.

   If the position limits are not within specifications, Type **N<Enter>** and adjust the Linear Rotary String (Encoder). See Adjustment on page 5-15 for details.

8. Calibrate the TZ motor lower left and lower right encoder positions to a range of 250 - 300 and a difference of no more than ± 5 between the two encoders. Setting the TZ encoders to a number outside this range may introduce other errors. Unlike the encoders for the table and arm motions, the encoders for TZ are not adjustable in real time. You must make a trial adjustment and then rerun the calibration to update the values on the display screen.

   The measured distance traveled for motor TZ must be very accurate as well. The distance traveled should be 20.0 cm ±0.1 cm. Always use this specification whenever performing TZ motor calibrations.

   Report any systems that do not conform to the TZ specifications to Technical Support.

3.4.4.1.1 Calibration Parameters TZ

The four values for **set_table_calibration** are, respectively, the left pedestal lower and upper encoder limits and the right pedestal lower and upper encoder limits. The two lower limits should be *close* to each other, as should the two upper limits. The eight **calibrate_position** fields are:

1) **10** (Tolerance). The ± position tolerance, in encoder ticks, for absolute moves. Although the TZ microprocessor does its own absolute moves, not the AT device driver, this field is used by state machine programs to determine whether the TZ position is within tolerance and should be ten (10).

2,3) **1000,1000** (NumberOfSteps,StepDistance). The number of motors steps corresponding to the step distance in microns. These two fields are only used for stepping motors, not for the DC table motors, and should always be 1000,1000.

4,5) **819,50000** (NumberOfTicks,TickDistance). The number of encoder ticks corresponding to the tick distance in microns. The table encoder calibration is fixed and should always be 819 encoder counts per 50,000 microns.

6) **500** (EncoderOffset). The value subtracted from the encoder readback to set the origin of motion. The origin of TZ motion is the lower right pedestal, so this field should be the same as the third field in the **set_table_calibration** line (above).

7,8) **500,3494** (NegLimit,PosLimit). The encoder readings for the negative (downward) and positive (upward) mechanical stops. In normal operation, the TZ microprocessor uses the right pedestal readings for closed loop control so these two fields should be the same as the last two fields in the **set_table_calibration** line (above).

The **pos_limit_position** and the **neg_limit_position** are the limits of motion, in microns, in the positive and negative direction

Note: The *PosLimitOffset* and *NegLimitOffset* entries in the *[TzMotor]* section of the *SQDRIVER.INI* file determine the motion limits relative to the mechanical stops. If these entries are not present, or are zero, the motion limits are set to the mechanical limits, as in the above example.

3.4.4.2 MOTOR$AY

To perform the calibration procedure:

1. Select the AY motor device driver by typing: **MOTOR$AY<Enter>**
2. At the **MOTOR$AY>** prompt in SQDRIVER, type: **CALIBRATE<Enter>**

   The program prompts:

   > **Press <Enter> when the AY motor reaches the LEFT mechanical limit.**
   >
   > **Press <ESC> to stop calibration.**

3. The program moves the AY motor to the left. When AY hits the left mechanical stop the first time press **<Esc>**.
4. Check the position value. It must be 3750±5. Adjust if necessary.

   If out of range, loosen the coupling setscrew and manually rotate the encoder until the readback is 3750±5 (i.e., in the range 3745-3755) and then tighten the coupling setscrew.

5. Repeat the calibration procedure above but now, when AY hits the left mechanical stop, press **<Enter>**.

   The program then starts AY moving to the right and prompts:

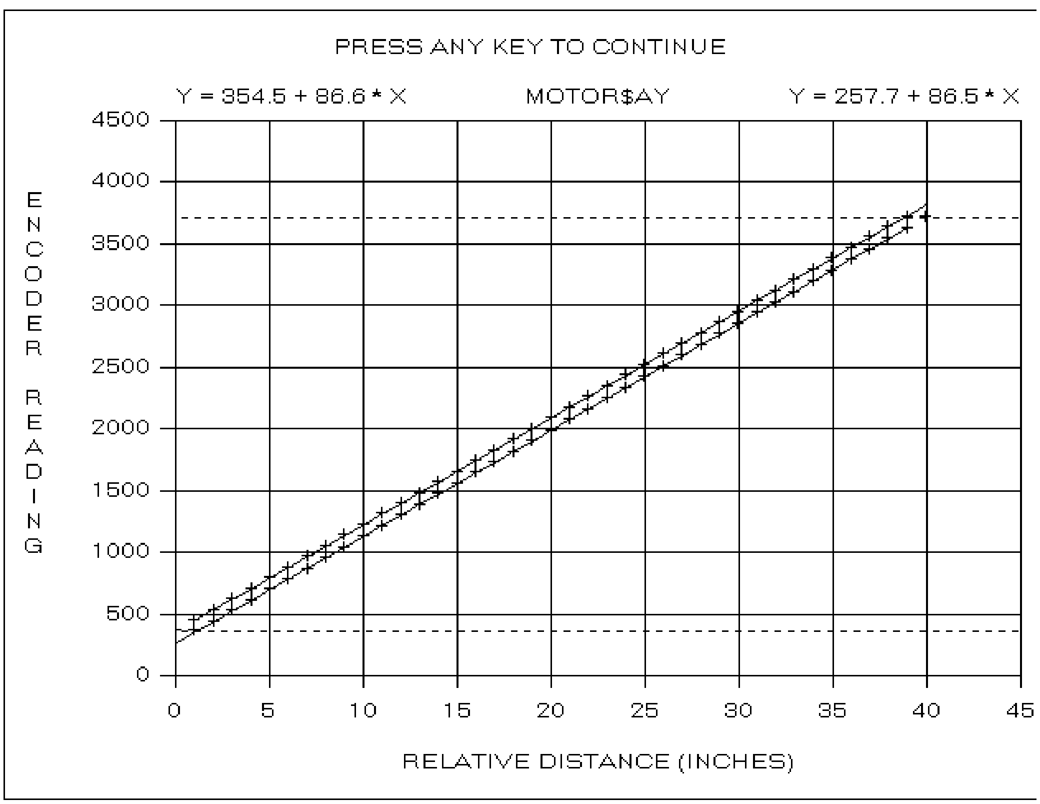
Press <Enter> when the AY motor reaches the RIGHT mechanical limit.Press <ESC> to stop calibration.

6. When AY hits the right mechanical stop, press **<Enter>**.

   The program then switches to graphics mode and draws the Encoder Vs Distance calibration grid. It steps the AY motor to the left in one inch increments until the motor hits the left mechanical stop, and then steps the AY motor to the right in one inch increments until the motor hits the right mechanical stop. The program plots the encoder data during the scan (in raw encoder units, 0-4095).

   Note: Press **<Esc>** anytime during the scan to abort the calibration procedure.

   When the calibration scan completes, the program computes the linear fit for both the positive and negative motion. The linear fit parameters are displayed at the top left and top right of the plot in the form Y = Intercept + Slope * X. The two slopes (e.g., 86.6 and 86.5) should be within 0.3 of each other.



The program displays the positive and negative limits as horizontal dashed lines.

Note: The *PosLimitOffset* and *NegLimitOffset* entries in the *[AyMotor]* section of the *SQDRIVER.INI* file determine the motion limits relative to the mechanical stops. If these entries are not present, or are zero, the motion limits are set to the mechanical limits).

The program then changes the plot title to **PRESS ANY KEY TO CONTINUE**.

7. Press the **<Enter>** key and the program prompts.

```
motor_direction=1
calibrate_position=1,2288,41187,209,61339,363,363,3750
pos_limit_position=984946
neg_limit_position=0
Update Driver INI-File [Y/N] ?
```

For information about calibration parameters, see “Calibration Parameters AY” on page 3-37.

8. Type **Y<Enter>** to accept the calibration values or **N<Enter>** to reject them.

3.4.4.2.1 Calibration Parameters AY

The **motor_direction** field determines whether the positive step direction is the *reverse* of the direction of increasing encoder values ('0' if the direction is *not* reversed, '1' if it is). This value is set from the corresponding parameter in the MOTOR_AY.PRO file and is a constant for each motor (i.e., the direction of increasing encoder values must agree with the system coordinates and the positive step direction is set by the wiring harness for the stepper motor).

The eight **calibrate_position** fields are:

1) **1** (Tolerance). The ± position tolerance, in encoder ticks, for absolute moves. The calibration program sets this field to the value found in the corresponding **calibrate_position** field in the MOTOR_AY.PRO file.

2,3) **2288,41187** (NumberOfSteps,StepDistance). The number of motors steps corresponding to the step distance in microns. The ratio of these two numbers determines the step size (41187/2288 ≅ 18 microns). The calibration program sets these fields to the values found in the corresponding **calibrate_position** fields in the MOTOR_AY.PRO file. Since these values are a property of the mechanical design of the system, they should never change.

4,5) **209,61339** (NumberOfTicks,TickDistance). The number of encoder ticks corresponding to the tick distance in microns. Again, it is the ratio of these two numbers (61339/209 ≅ 293 microns) that determines the encoder calibration. These numbers will generally change from calibration to calibration (although the ratio should remain approximately the same).

6) **363** (EncoderOffset). The value subtracted from the encoder readback to set the origin of motion. The origin of AY motion is the extreme right mechanical stop, so this value should be the same as the first field below.

7,8) **363,3719** (NegLimit,PosLimit). The encoder readings for the negative (right) and positive (left) mechanical stops.

The **pos_limit_position** and the **neg_limit_position** are the limits of motion, in microns, in the positive and negative direction.

Note: The *PosLimitOffset* and *NegLimitOffset* entries in the *[AyMotor]* section of the *SQDRIVER.INI* file determine the motion limits relative to the mechanical stops. If these entries are not present, or are zero, the motion limits are set to the mechanical limits, as in the above example).

Note: The last calibration scan data is saved in the file MOTOR_AY.DAT. You can reanalyze the data–e.g., after editing *SQDRIVER.INI* by typing the command **CALIBRATE @MOTOR_AY.DAT** at the **MOTOR$AY>** prompt in SQDRIVER.

3.4.4.3 MOTOR$TY (A, W and Wi models only)

1. Select the TY motor device driver by typing: **MOTOR$TY<Enter>**
2. At the **MOTOR$TY**> prompt in SQDRIVER, type: **CALIBRATE<Enter**>

   The program starts TY moving to the left and prompts:

   > **Press <Enter> when the TY motor reaches the LEFT mechanical limit.**
   >
   > **Press <ESC> to stop calibration.**

3. The program moves the TY motor to the left. When TY hits the left mechanical stop the first time press <**Esc**>.
4. Check the position value. It must be 3750±5. Adjust if necessary.

   If out of range, loosen the coupling setscrew and manually rotate the encoder until the readback is 3750±5 (i.e., in the range 3745-3755) and then tighten the coupling setscrew.

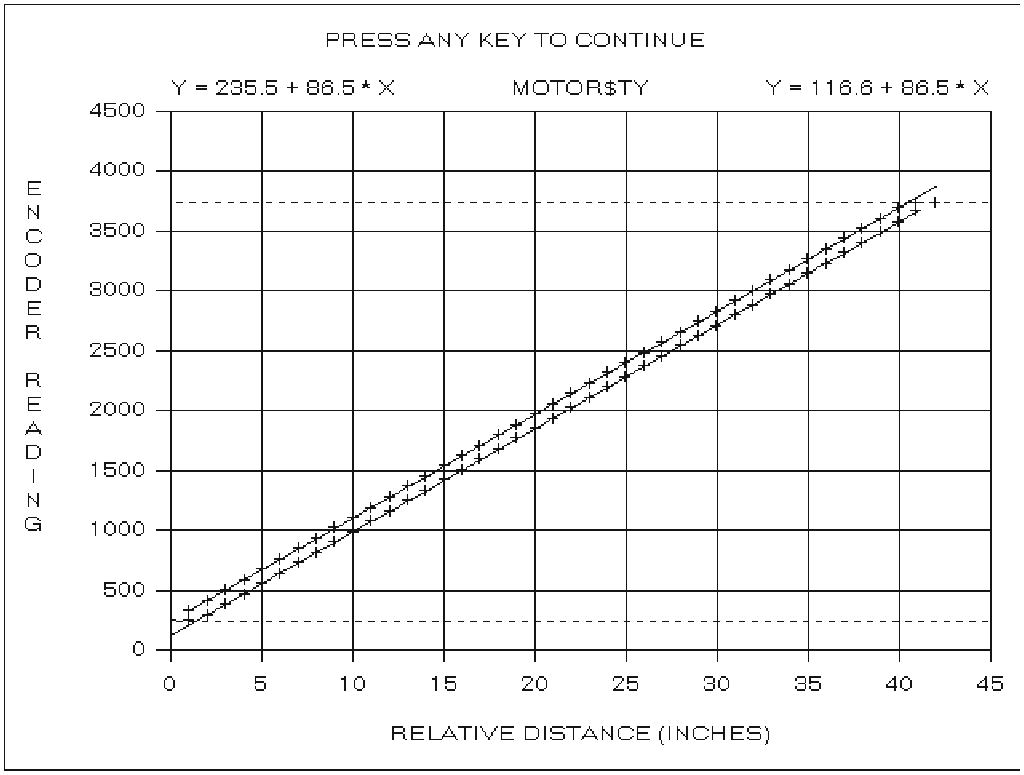
5. Repeat the calibration procedure above but now, when TY hits the left mechanical stop, press **<Enter>**.

   The program then starts TY moving to the right and prompts:

   > **Press <Enter> when the TY motor reaches the RIGHT mechanical limit.**
   >
   > **Press <ESC> to stop calibration.**

   When TY hits the right mechanical stop, press **<Enter>**. The program then switches to graphics mode and draws the Encoder Vs Distance calibration grid. It steps the TY motor to the left in one inch increments until the motor hits the left mechanical stop, and then steps the TY motor to the right in one inch increments until the motor hits the right mechanical stop. The program plots the encoder data during the scan (in raw encoder units, 0-4095).

Note: Press **<Esc>** anytime during the scan to abort the calibration procedure.



When the calibration scan completes, the program computes the linear fit for both the positive and negative motion. The linear fit parameters are displayed at the top left and top right of the plot in the form Y = Intercept + Slope * X. The two slopes (e.g., 86.5 and 85.6) should be within 0.3 of each other.

When the calibration scan completes, the program computes the linear fit for both the positive and negative motion. The linear fit parameters are displayed at the top left and top right of the plot in the form Y = Intercept + Slope * X. The two slopes (e.g., 86.5 and 85.6) should be within 0.3 of each other.

The program displays the positive and negative limits as horizontal dashed lines.

Note: The *PosLimitOffset* and *NegLimitOffset* entries in the *[TyMotor]* section of the *SQDRIVER.INI* file determine the motion limits relative to the mechanical stops. If these entries are not present, or are zero, the motion limits are set to the mechanical limits.

The program then changes the plot title to **PRESS ANY KEY TO CONTINUE**.

6. Press the **<Enter>** key and the program prompts.

> **motor_direction=0**
>
> **calibrate_position=1,2287,27446,154,45219,238,238,3742**
>
> **pos_limit_position=1028879**
>
> **neg_limit_position=0**
>
> **Update Driver INI-File [Y/N] ?**

Note: The last calibration scan data is saved in the file MOTOR_TY.DAT. You can reanalyze the data–e.g., after editing *SQDRIVER.INI*–by typing the command **CALIBRATE @MOTOR_TY.DAT** at the **MOTOR$TY>** prompt in SQDRIVER.

3.4.4.4 MOTOR$TX

1. Select the TX motor device driver by typing: **MOTOR$TX<Enter>**
2. At the MOTOR$TX> prompt in SQDRIVER, type: **CALIBRATE<Enter>**

   The program prompts:

   > **Press <ESC> to stop calibration.**

   The program moves the TY (W only) and AY motors to their center positions and prompts:

   > **Use the Table IN / OUT switch to move the C-Arm to 0 degrees.**
   >
   > **Press <Enter> when the C-Arm is positioned.**
   >
   > **Press <ESC> to stop calibration.**

   This message displays on all systems. On only A and SL systems, you must use a digital level to set the C-arm to 0º $\pm$0º. On other systems, ignore the message.

3. Press **<Enter>** and the program prompts:

   > **Press <Enter> when the TX motor reaches the OUTER mechanical limit.**
   >
   > **Press <ESC> to stop calibration.**

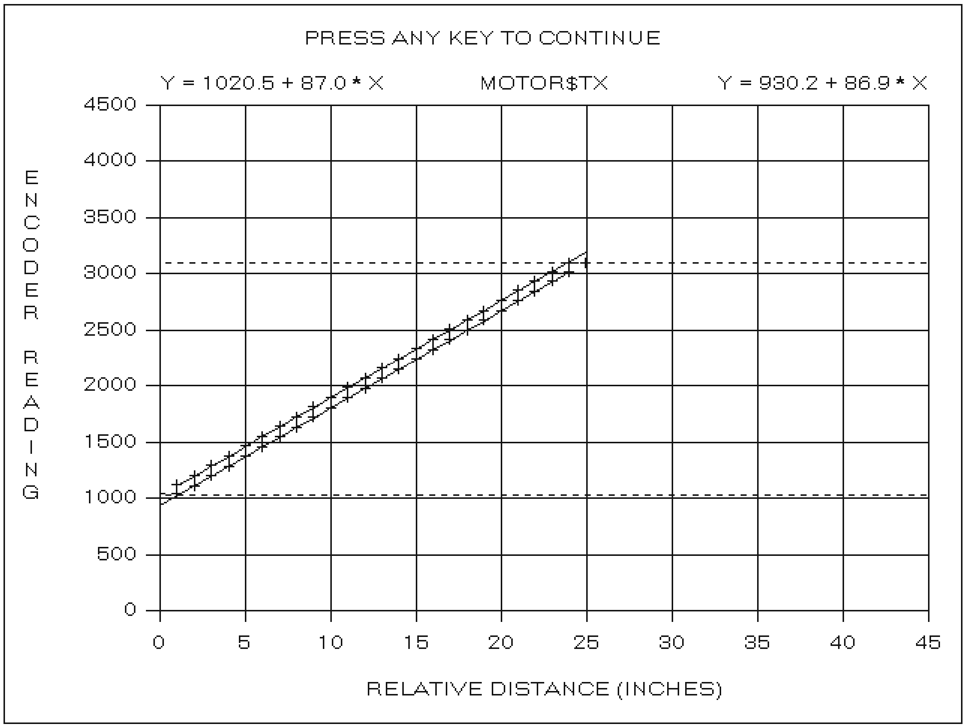
4. The program moves the table to the front. When TX hits the outer mechanical stop for the first time press **<Esc>**.
5. Check the position value. It must be 1000±5. Adjust if necessary.

   If out of range, loosen the coupling setscrew and manually rotate the encoder until the readback is 1000±5 (i.e., in the range 995-1005) and then tighten the coupling setscrew.

6. Repeat the calibration procedure above but now, when TX hits the outer mechanical stop, press **<Enter>**.

The program switches to graphics mode and draws the Encoder Vs Distance calibration grid. It steps the TX motor in by 1" increments until the inner mechanical stop is hit. The program plots the encoder data during the scan (in raw encoder units, 0-4095).

Press **<Esc>** at anytime during the scan to terminate the calibration procedure.



When the calibration completes, the program computes the linear fit for both the positive and negative motion. The line for parameters are displayed at the top left and top right of the plot in the form Y = Intercept + Slope * X. The two slopes (87.0 and 86.9 in the example below) should be within 0.3 of each other.

The program displays the positive and negative limits as horizontal dashed lines.

Note: The *PosLimitOffset* and *NegLimitOffset* entries in the *[TxMotor]* section of the *SQDRIVER.INI* file determine the motion limits relative to the mechanical stops. If these entries are not present, or are zero, the motion limits are set to the mechanical limits.

7. The program then changes the plot title to **PRESS ANY KEY TO CONTINUE**. Press the **<Enter>** key and the program prompts:

```
motor_direction=1
calibrate_position=1,2287,27446,43,12563,1026,1026,3096
pos_limit_position=604777
neg_limit_position=0
Update Driver INI-File [Y/N] ?
```

The **motor_direction**, **calibrate_position**, **pos_limit_position** and **neg_limit_position** fields have the same interpretation as discussed under MOTOR$AY.

8. Type **Y<Enter>** to accept the calibration values or **N<Enter>** to reject them.

Note: The last calibration scan data is saved in the file MOTOR_TX.DAT. You can reanalyze the data–e.g., after editing *SQDRIVER.INI*–by typing the command **CALIBRATE @MOTOR_TX.DAT** at the **MOTOR$TX>** prompt in SQDRIVER.

3.4.4.5 MOTOR$AR (Discovery A and SL)

1. Confirm that the table is level front-to-back. Do this by removing the table pad. Place the digital level on the table at the foot end and read the value on the level. It must be 0º degrees ±0.0º degrees. Move the level to the head of the table. Confirm that the level is still at 0.0º degrees. Adjust the leveling feet as necessary to obtain this result. **Failure to perform this step will result in positioning tolerance errors on whole body, lateral, and IVA scans.**
2. Select the AR motor device driver by typing: **MOTOR$AR<Enter>**
3. At the **MOTOR$AR>** prompt, type: **CALIBRATE<Enter>**

The program prompts:

Press <ESC> to stop calibration.

The program moves the TY and AY motors to their center positions, then moves the TZ motor to its topmost position and prompts:

Use the Table IN / OUT switch to move the C-Arm to 0 degrees.
Press <Enter> when the C-Arm is positioned.
Press <ESC> to stop calibration.

4. Remove the C-arm Tank cover.
5. Place the digital level on the top of the tank assembly (*not on the top of the C-arm*) and use the Table IN/OUT switch on the operator panel to move the C-arm until it is 0º ±0.0º
6. Remove the level.
7. Press **<Enter>**.

The program prompts:

Press <ESC> to stop calibration.

The program moves the TZ table to its top most position and moves the TX table inwards until it almost touches the C-arm. It rotates the C-arm by 2 degrees to obtain an initial estimate of the encoder calibration and then prompts:

Press <Enter> when the AR motor reaches the AP mechanical limit.
Press <ESC> to stop calibration.

The program rotates the C-arm counter clockwise (i.e., the tank assembly moves away from the front of the machine). When the C-arm hits the AP mechanical limit the first time, press **<ESC>**.

8. Check the position value. It must be 250±5. Adjust if necessary.

   If out of range, loosen the coupling setscrew and manually rotate the encoder until the readback is 250±5 (i.e., in the range 245-255) and then tighten the coupling setscrew.

9. Before repeating the calibration procedure, rotate the C-arm back to approximately 0º by:

   Typing the command: **MOVE_REL 1470<Enter>**.

10. Repeat the calibration procedure above but now, when AY hits the left mechanical stop, press **<Enter>**.

Press <ESC> to stop calibration. Press <Enter> when the AR motor reaches the AP mechanical limit.

Wait until the rotation completes and then repeat the calibration procedure above but now, when the C-arm hits the AP mechanical stop,

11. Press **<Enter>**.

The program prompts:

Press <ESC> to stop calibration.

and moves the C-arm back to the approximate 0° position. The program then prompts:

Use the Table IN / OUT switch to move the C-Arm to 0 degrees.
Press <Enter> when the C-Arm is positioned.
Press <ESC> to stop calibration.

Place a level on top of the X-ray tank assembly (***not*** the top of the C-arm) and use the Table IN/OUT switch on the operator panel to move the C-arm until it is 0º ±0.1º. Remove the level, wait until the rotation completes, and then repeat the calibration procedure above but now, when the C-arm hits the AP mechanical stop,

12. Press **<Enter>**.

    The program prompts:

Press <ESC> to stop calibration.

    and moves the C-arm back to the approximate 0° position. The program then prompts:

Use the Table IN / OUT switch to move the C-Arm to 0 degrees.
Press <Enter> when the C-Arm is positioned.
Press <ESC> to stop calibration.

    Place a level on top of the X-ray tank assembly (***not*** the top of the C-arm) and use the Table IN/OUT switch on the operator panel to move the C-arm until it is 0º ±0.1º. Remove the level and then

13. Press **<ENTER>**.

    The program prompts:

Press <ESC> to stop calibration.

    and moves the C-arm and the X-table together until the C-arm is at approximately 83°. It then changes the prompt to:

Press <Enter> when the AR motor reaches the lateral mechanical limit.
Press <ESC> to stop calibration.

    and begins rotating the C-arm clockwise (i.e., the tank assembly moves toward the front of the machine). When the C-arm hits the LATERAL mechanical limit,

14. Press **<ENTER>**.

    The program prompts:

Press <ESC> to stop calibration.

    and moves the C-arm back to the approximate 83° position. The program then prompts:

Use the Table IN / OUT switch to move the C-Arm to 83 degrees.
Press <Enter> when the C-Arm is positioned.
Press <ESC> to stop calibration.

15. Place the digital level on top of the X-ray tank assembly and use the Table IN/OUT switch on the operator panel to move the C-arm until it is at 83°±0.1º (do ***not*** make this measurement with the cosmetic covering on the tank assembly).

16. Remove the level and then press **<Enter>**.

The program prompts:

Press <ESC> to stop calibration.

and moves the C-arm and the X-table back to their initial 0° positions.

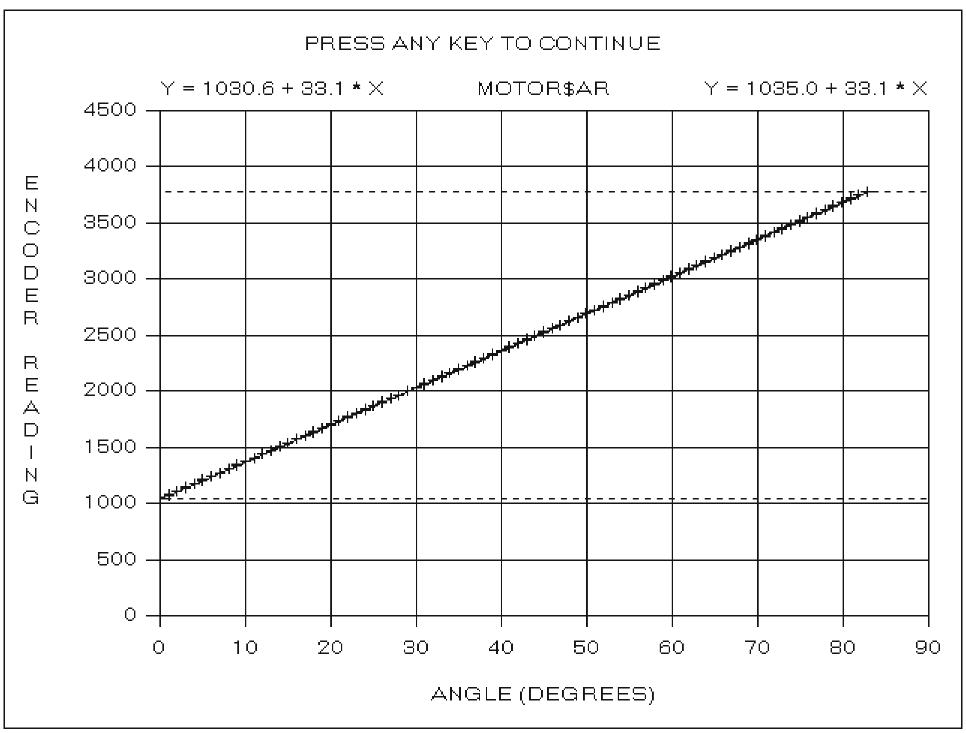
The program then switches to graphics mode and draws the Encoder Vs. Angle calibration grid. It steps the AR motor clockwise in 1° increments until the motor reaches the 83° position and then steps the AR motor counter clockwise in 1° increments until the motor return to approximately 0°. The program plots the encoder data during the scan (in raw encoder units, 0-4095).

Note:Press **<ESC>** anytime during the scan to abort the calibration procedure.

When the calibration scan completes, the program computes the linear fits to the positive and negative rotation. The linear fit parameters are displayed at the top left and top right of the plot in the form Y = Intercept + Slope * X. The two slope values should be within 0.1 of each other.

The program displays the positive and negative limits as horizontal dashed lines

Note: The *PosLimitOffset* and *NegLimitOffset* entries in the *[ArMotor]* section of the *SQDRIVER.INI* file determine the motion limits relative to the mechanical stops. If these entries are not present, or are zero, the motion limits are set to the mechanical limits.



The program then changes the plot title to:

PRESS ANY KEY TO CONTINUE

17. Press the **<Enter>** key and the program prompts:

```
motor_direction=0
calibrate_position=1,50771,5601,2747,4980,1035,265,3831
pos_limit_position=5069
neg_limit_position=-1395
              Update Driver INI-File [Y/N] ?
```

For information about calibration parameters, see “Calibration Parameters” on page 3-46.

18. Type **Y<Enter>** to accept the calibration values or **N<Enter>** to reject them.
19. Exit SQDRIVER by typing exit and clicking Return.

3.4.4.5.1 Calibration Parameters

The **motor_direction** field determines whether the positive step direction is the *reverse* of the direction of increasing encoder values ('0' if the direction is *not* reversed, '1' if it is). This value is set from the corresponding parameter in the MOTOR_AR.PRO file and is a constant for each motor (i.e., the direction of increasing encoder values must agree with the system coordinates and the positive step direction is set by the wiring harness for the stepper motor).

The eight **calibrate_position** fields are:

1) **1** (Tolerance). The ± position tolerance, in encoder ticks, for absolute moves. The calibration program sets this field to the value found in the corresponding **calibrate_position** field in the MOTOR_AR.PRO file.

2,3) **50771,5601** (NumberOfSteps,StepDistance). The number of motors steps corresponding to the step distance in minutes of rotation. The ratio of these two numbers determines the step size. The calibration program calculates these fields based on the measurements of the 0° and 83° positions.

4,5) **2747,4980** (NumberOfTicks,TickDistance). The number of encoder ticks corresponding to the tick distance in minutes of rotation. Again, it is the ratio of these two numbers that determines the encoder calibration. These numbers will generally change from calibration to calibration (although the ratio should remain approximately the same).

6) **1035** (EncoderOffset). The value subtracted from the encoder readback to set the origin of motion. The origin of AR motion is the 0° position, so this value is the encoder reading at 0°.

7,8) **265,3831** (NegLimit,PosLimit). The encoder readings for the negative (counter clockwise, or AP) and positive (clockwise, or LATERAL) mechanical stops.

The **pos_limit_position** and the **neg_limit_position** are the limits of motion, in minutes of rotation, in the clockwise and the counter clockwise direction

Note: The *PosLimitOffset* and *NegLimitOffset* entries in the *[ArMotor]* section of the *SQDRIVER.INI* file determine the motion limits relative to the mechanical stops. If these entries are not present, or are zero, the motion limits are set to the mechanical limits, as in the above example.

Note: The last calibration scan data is saved in the file **MOTOR_AR.DAT**. You can re analyze the data–e.g., after editing *SQDRIVER.INI*–by typing the command **CALIBRATE @MOTOR_AR.DAT<Enter>** at the MOTOR$AR> prompt in SQDRIVER.

3.4.5 X-Ray Beam Alignment

WARNING:	X-rays are generated during this procedure. Keep hands, head and other body parts out of beam.

It is crucial that the X-ray beam be precisely aligned with the detector array because improper alignment will directly affect the repeatability (coefficient of variation, or CV) of the Discovery. Therefore, this alignment must be verified at the time of installation or whenever any work is performed that may affect it.

To check beam alignment:

Insert the alignment fixture (see the following three figures) into the detector opening.

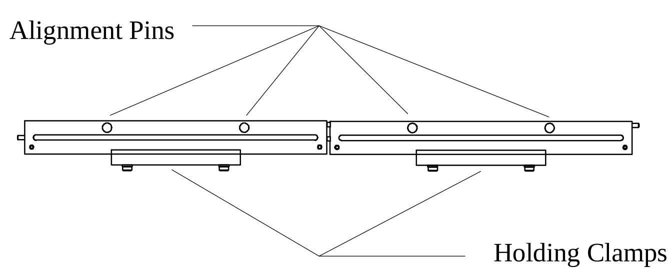
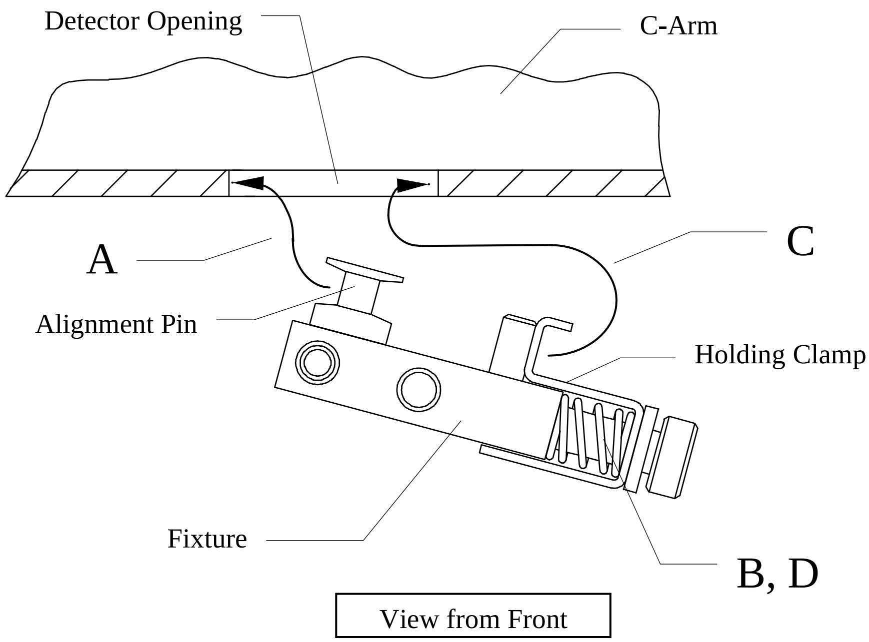


Figure 3-21. X-Ray Alignment Fixture (TLS-00080)



Step A. Insert the left side of the Alignment Fixture into the left side of the Detector Opening so that the vertical edges of the four Alignment Pins are secure.

Step B. Compress the Holding Clamps.

Step C. Raise the right side of the Alignment Fixture into the Detector Opening.

Step D. Release the Holding Clamps.

Note: If the Alignment Fixture is inserted with the Alignment Pins on the right, the procedure works equally well.

Figure 3-22. Inserting The X-Ray Alignment Fixture

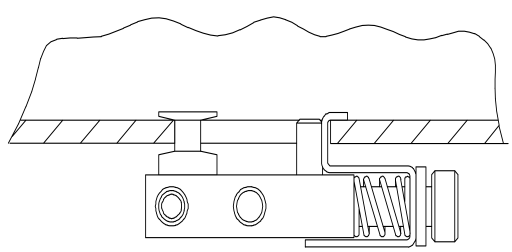


Figure 3-23. The Alignment Fixture Properly Installed

To perform beam alignment:

1. Start the X-Ray Survey Utility by selecting **Utilities|Service Utilities|X-Ray Survey** (see “X-Ray Survey” on page 9-1 for information on the utility).
2. Set **Aperture** to 10 (set **Aperture** to -1 for Ci and Wi models), **Hi gain** to 2, **Lo gain** to 1 and **X-ray Mode** to 3**.**

3. Place the Aperture Alignment Pin through the hole in the Aperture Plate. It should drop straight through and into the alignment hole in the Filter Drum Assembly base plate and be perpendicular to the Aperture Plate. If it is not perform steps 4 through 7. Otherwise, proceed to step 8.
4. Hit the **<Esc>** key to return to the Discovery Main screen.
5. From the Discovery Main Menu screen, select **Utilities|Service Utilities|SQDRIVER**.
6. At the **CARM$$$$**> prompt, type **move_aper_rel +100** (to move the Aperture Plate right) or **move_aper_rel –100** (to the move Aperture Plate left) until the Alignment Pin is both vertical and perpendicular to the Aperture Plate. (Place the block on the base plate next to the pin and compare the pin to the vertical surface of the block to see if the pin is perpendicular).
7. Type **exit <Enter>** to return to the Discovery Main Screen.
8. Start the X-Ray Survey Utility by selecting **Utilities|Service Utilities|X-Ray Survey** (see “X-Ray Survey” on page 9-1 for information on the utility).
9. Do not change the **Aperture** setting, the **Hi gain** setting (set to 2), the **Lo gain** setting (set to 1) or the **X-ray mode** setting (set to 3).
10. For **Display**, click **Graph/**
11. Click **X-ray (F2)** to turn on x-rays.

The correct display should show a flat graph with an amplitude of approximately 5.5 volts with the alignment fixture installed (approximately 6.5 volts with alignment fixture removed. volts. If thebeam alignment is not correct, perform the following procedure.

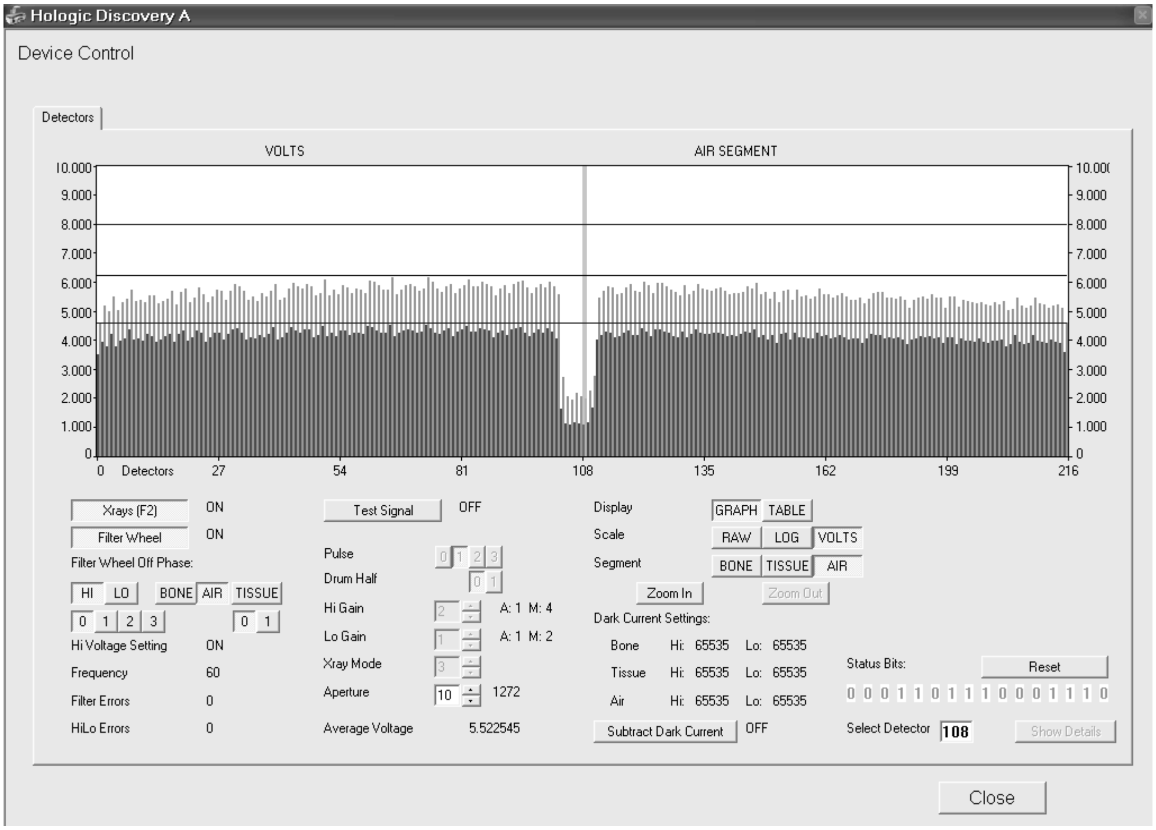


Figure 3-24

12. Set the machine in the Center Table position.

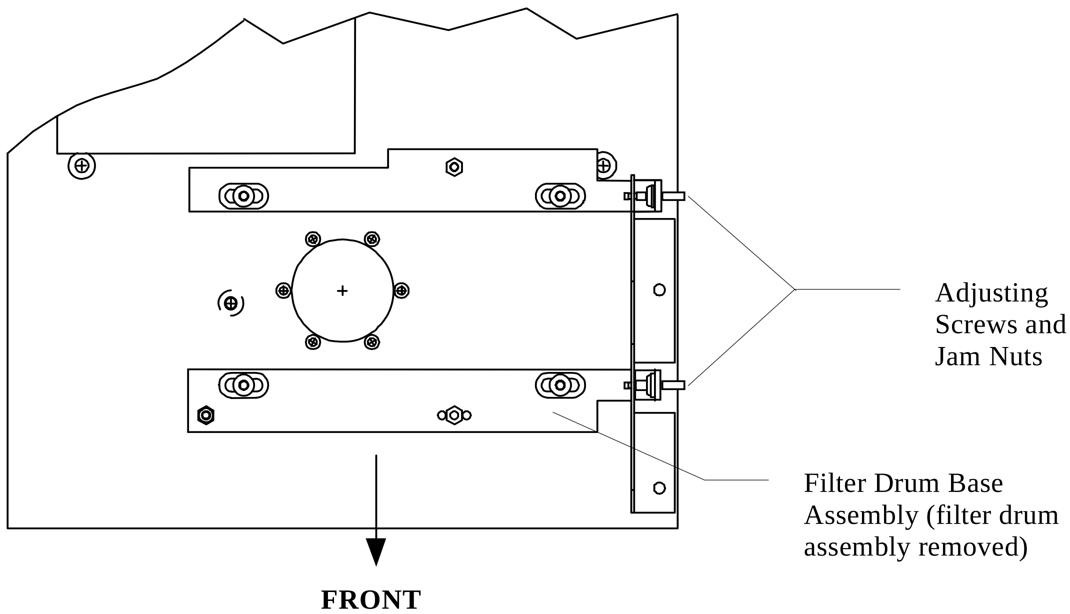


Figure 3-25. Filter Drum Adjustments - Top View

13. At the Filter Drum assembly, loosen the jam nuts and insert Allen wrenches (3/32") in both Filter Drum Allen alignment screws. (Figure 3-25 above shows the locations of alignment screws and jam nuts.) Ensure that the Filter Drum is running.
14. Start the X-Ray Survey Utility by selecting **Utilities|Service Utilities|X-Ray Survey** (see “X-Ray Survey” on page 9-1 for information on the utility).
15. Set **Aperture** to 10 (set **Aperture** to -1 for Ci and Wi models), **Hi gain** to 2, **Lo gain** to 1 and **X-ray mode** to 3
16. For **Display**, click **Graph**.
17. For **Segment,** click **Air**.
18. Click **X-ray (F2)** to turn on x-rays.

The next 5 steps adjust the beam side to side.

WARNING:	The X-rays are on. Keep body parts out of the beam.

1. Move the **front** Filter Drum alignment screw until the X-ray signal reaches maximum voltage.

   Note: The last direction turned should be clockwise to eliminate backlash when the jam nuts are tightened. The plot should show peak amplitude.

2. Move the **rear** Filter Drum alignment screw until the X-ray signal reaches maximum voltage.

   Note: The last direction turned should be clockwise to eliminate backlash when the jam nuts are tightened. The plot should show peak amplitude.

3. Finger tighten the jam nuts on both Filter Drum alignment screws, then gently snug them with a small wrench (use of excessive force will change the beam alignment). After the jam nuts are snug, re-check the graph for proper beam alignment.

   Note: The X-rays should still show peak amplitude.

4. Turn off the X-rays using the **<F2>** key.
5. Remove the alignment test fixture from the C-arm.

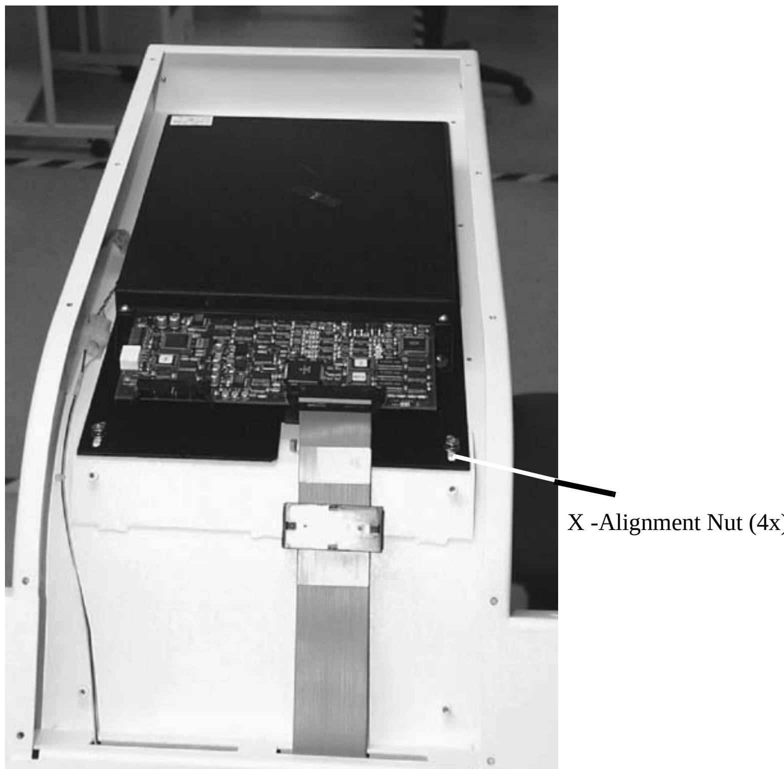


Figure 3-26. Array Assembly - Top View, Partial

The next six steps adjust the beam front to back.

1. At the Array assembly, loosen the four X-alignment nuts located at the corners of the assembly (see Figure 3-26 above).
2. Turn on the X-rays with the **<F1>** key.
3. For a **Discovery A only**, adjust the array assembly so that detectors 0 and 215 are equal.
4. For **Discovery C, Ci, W, Wi, and SL** models, adjust the array assembly so that detectors 44 and 171 are equal. You will have to exit this routine, remove the alignment pin, run the Aperture Calibration procedure (**Note:** aperture calibration cannot be run on Ci and Wi models), and then return to X-Ray Survey. When you enter X-Ray Survey do not change this **Aperture** setting (set to 7; -1 on Ci and Wi models), the **Hi gain** setting (set to 2), the **Lo gain** setting (set to 1) or the **X-ray mode** setting (set to 3).
5. For **Display**, click **Graph**.
6. Click **X-ray (F2)** to turn x-rays on.
7. Follow the procedure in step 3 while checking detectors number 44 and 171 to check for the fall off of x-rays.
8. Tighten the four X-ray Detector Assembly alignment nuts.
9. Click **X-ray (F2)** to turn x-rays off.
10. Remove the block and pin (Discovery A Only).
11. Click **Close** to exit X-Ray Survey.
12. Reboot the PC to return to the Discovery software.

3.4.6 Calibrate Aperture (Cannot be run on Ci and Wi models)

It is crucial that the X-ray beam be precisely aligned with the detector, as improper alignment directly affects the repeatability (coefficient of variation, or CV) of the Discovery.

Note: If the table cannot be moved from the Control Panel, it may be necessary to go to the **Utilities|Emergency Motion** menu selection in the Discovery Software.

This procedure locates the exact positions of each aperture (slit) in motor steps and saves those values in the HARDWARE.INI file. X-rays are produced during this procedure.

1. Center the table using the **Center Table** button on the Control Panel.
2. Remove all objects from the table.
3. From the Discovery Main screen, select **Utilities|Service Utilities|SQDRIVER**.

4. At the **CARM$$$$>** prompt, type **CALIBRATE<Enter>** (be patient, this procedure takes several minutes to start).

3.4.7 Check Laser Positioning Offset

Center the table and arm using Center Table button on the Control Panel or the **Utilities| AP Reposition** feature in the software.

1. Turn on the laser and set the point of a sharp metal object to the right of, and at a 45º angle to, the crosshair.
2. At the Discovery Main Menu screen, click the **Perform Exam** button, create a test patient biography, and select AP Lumbar as the scan type.
3. Uncheck the Use Default Scan Mode check box and click **Next**.
4. Start the scan.
5. After scan starts and you can see the object, click the **Reposition Scan** button.
6. Using the mouse, move the image so that the tip of the object is horizontally in the center and touching the bottom edge of the scan area.
7. Click the **Restart Scan** button and let the arm reposition.
8. At the **Start Scan** screen, click the **Cancel** button.
9. Turn on the laser. Locate the 3 laser adjustment screws (small Phillips) under the C-arm. Adjust these screws to tilt the assembly until the laser crosshair is on the tip of the pointed object.
10. Run another scan to check your adjustments.

3.5 A/D Gain Control Adjustment

An A/D gain adjustment potentiometer ensures that all systems have the same input to the A/D converter regardless of slight variations in X-ray flux. The location of the potentiometer depends on the system configuration:

- On systems with a separate A/D Converter board, the adjustment is the only potentiometer on the A/D Converter board.
- On systems without a separate A/D Converter board, the adjustment is the only potentiometer on the X-Ray Detector assembly.

Caution: Any adjustment of this potentiometer affects the QC highs and lows. You must run detector flattening after adjusting the A/D gain. **DO NOT ADJUST THE A/D GAIN UNLESS ABSOLUTELY NECESSARY AS DEFINED BY "Check and Verify the A/D Gain" on page 3-54.**

3.5.1 Check and Verify the A/D Gain

1. Install all system covers that are normally in the X-ray beam.
2. Install the table pad onto the table.

3. Start the QDR/APEX software in Service mode.
4. On the QDR/APEX main screen, select **Utilities|Service Utilities|X-Ray Survey**.
5. Set **Pulse** to 1, press <ALT><P>.
6. Set
    a. Hi Gains to **2.**
    b. Lo Gains to **1**.
    c. X-ray Mode to **3**.
    d. Aperture to **7**.
5. Press **<Enter>**.
6. Display the X-Ray Survey bar graph, press <Ctrl><Page Down>.
7. Observe Hi Air, press <Alt><S>.
8. Turn on X-rays, press <F1>.
9. Verify that the average X-ray signal level is 6.25V and that all detectors are within the 4.5V to 8.5V range. If these conditions are met, the procedure is complete. Do not adjust the A/D gain.

    If these conditions are not met, continue to “Adjust the A/D Gain” on page 3-55.

3.5.2 Adjust the A/D Gain

Caution: Do not adjust the A/D gain unless absolutely necessary as defined by **“Check and Verify the A/D Gain” on page 3-54**.

1. Adjust the A/D gain potentiometer to achieve an average X-ray signal of 6.25V.
2. Check that all detectors are within a range of 4.5V to 8.5V.
3. Perform the Detector Flattening procedure described in “Perform Detector Flattening ” on page 3-55.

3.5.3 Perform Detector Flattening

WARNING:	X-rays are generated during this procedure. Keep hands, head and other body parts out of beam.

This procedure flattens the X-ray beam for each scan mode and finds the metal edge of the table.

Note: All covers, table mat, etc., normally in the X-ray path, MUST be on the Scanner before running Beam Flattening.

1. Restart the Discovery software in service mode (if not already). Press the **Center Table** button and turn on the laser.
2. If you are using an Anthropomorphic Spine Phantom (resembles vertebral bodies, Part Number 030-1967), place the phantom on end (vertical) with the spinal

processes pointing towards the head end of the table. The laser crosshair should be 1.5 inch in from the left end and centered. (Some phantoms will have a target hole, if not, use a ruler).

If you are using a DXA Quality Control Phantom (aluminum representation of vertebral bodies that does not resemble real bone, Part Number ASY-01564), place the phantom on end with the flattening target facing up. Orient the phantom so the metal edge is to the right (head end) and tissue to the left (foot end) as viewed from the front of the table. Align the phantom flattening target to the laser crosshair.

3. Start the X-Ray Survey Utility by selecting **Utilities/Service Utilities/X-Ray Survey** (see “X-Ray Survey” on page 9-1 for information on the utility).
4. Set **Pulse** to 1, **High gain** to 2, **Low gain** to 1, **X-ray Mode** to 3 and **Aperture** to 7.
5. For **Display**, click **Graph**.
6. Click **X-Rays (F2)** to turn X-Rays on.
7. Check that phantom covers the whole beam. This is critical. If phantom does not cover the whole beam, move it until it does. Keep the phantom as straight as possible.
8. Turn off X-rays with the **<F2>** key and press **<Esc>** to exit X-Ray Survey. Reboot the PC, logon as Field Service, and restart the software in Service Mode to return to Discovery Main Menu screen.
9. Select **Utilities|Service Utilities|Detector Flattening**. Click the Continue button. This procedure can takes about 10 minutes on a C or W model and 55 minutes on an A or SL.
10. When flattening is complete, run a QC scan and cancel adding it to the QC plot.
11. Use the Scan File Plot utility to check X-ray beam flatness of the QC scan performed in Step 10.

3.5.4 Perform Lateral Alignment Test (A and SL)

WARNING:	X-rays are generated during this procedure. Keep hands, head and other body parts out of beam.

Note: This procedure applies to A and SL systems only. Use this procedure to verify lateral alignment.

This procedure verifies lateral alignment.

1. On the control panel press Center to move the table and C-Arm to the center position.
2. On the control panel press Laser on the control panel to turn the laser light on.
3. Place the spine phantom on the table top with its laser target towards the left (foot end) and the vertebrae to the right (head end).

4. Align the phantom so that the laser crosshair is on the phantom laster target. Using the laser as a guide, adjust the phantom to be parallel to the table edges (just like when performing a QC scan).
5. On the APEX/QDR main screen, select Perform Exam.
6. Create a test patient biography.
7. Select OK at patient Confirmation Screen.
8. On the Select Scan Type screen select AP/Lateral Pair. Uncheck Use Default Scan Mode and click Next.
9. Select Array and click Next.
10. On the Select Lateral Scan Mode screen select Array and click Next.
11. Verify the alignment of the spine phantom to the laser.
12. Change Scan Length to 6.0 inches and click Start Scan to perform the AP scan.
13. When scan has finished, select Spine as the analysis method, and click Next.
14. Analyze the scan, and click Start Position. At the bottom of screen verify that the centerline angle is $\pm$ 2 degrees. If OK, go to the next step. If not OK, restart the procedure (go back to Step 1), being careful to align the phantom properly to the laser.
15. If you are using an Anthropomorphic Spine Phantom (resembles vertebral bodies, Part Number 030-1967), skip this step.

    If you are using a DXA Quality Control Phantom (aluminum representations of vertebral bodies, Part Number ASY-01564), place 2 sheets of paper along the left and right edges of the phantom as shown in Figure 3-27.

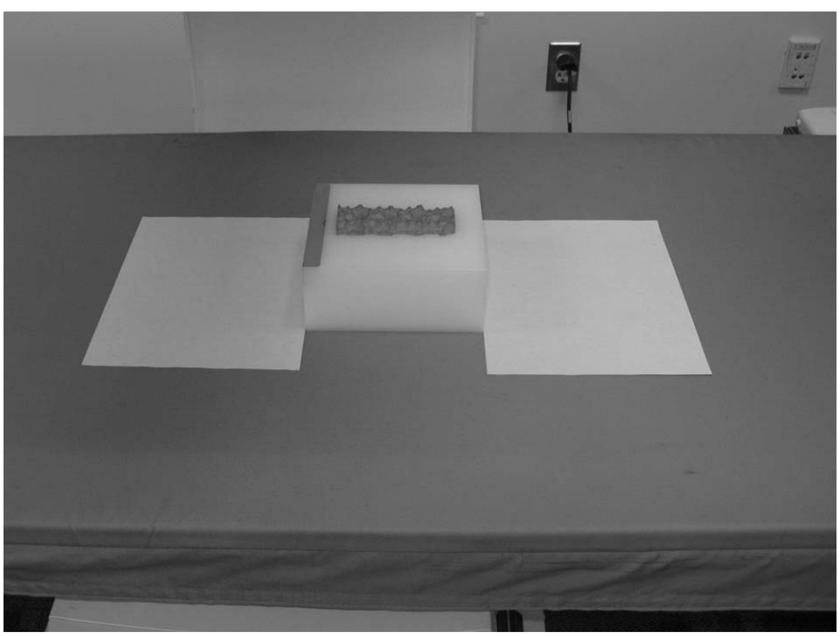


Figure 3-27.

Next, rotate the phantom "bone" segments towards the front of the scanner as shown in Figure 3-28. Be careful to keep the phantom left and right edges parallel to the sheets of paper.

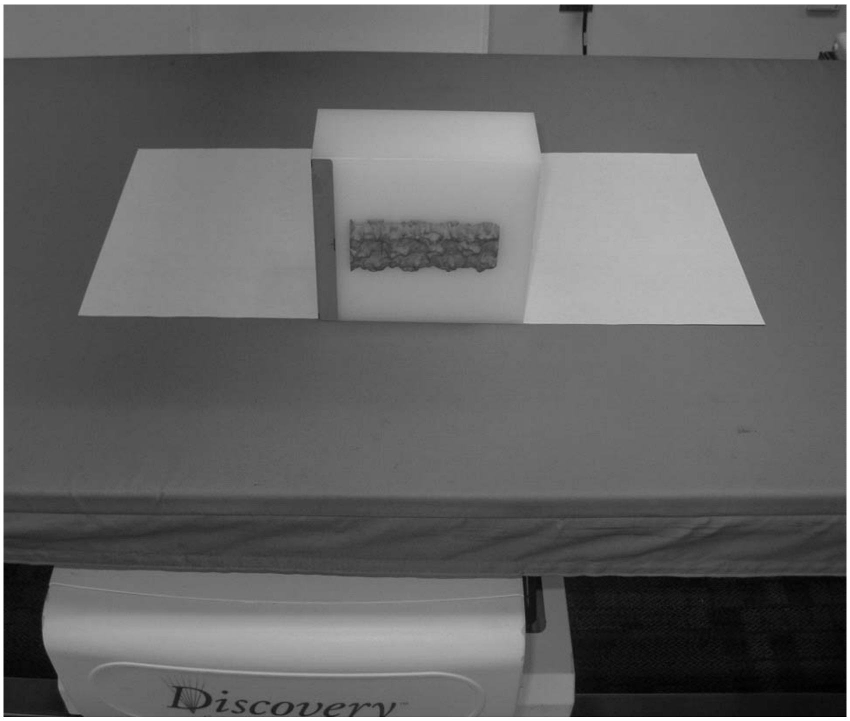


Figure 3-28.

16. Click close, and then hold the Enable Lateral switch on the control panel to move the system to the lateral position.
17. Click Start Scan to perform the lateral scan.
18. When the scan has finished, press and hold the Enable Lateral switch to return the system to AP position.
19. Analyze the lateral scan (refer to User Guide for instructions if necessary). When done, click Close.
20. At the Exit Analysis screen select Report. Print a report of the procedure just performed, and include the report in the paperwork being returned to Hologic.

3.5.5 Check HVPS/S (Tank) For Radiation Leakage

For regulatory and safety reasons, the High Voltage Power Supply/Source (HVPS/S) must be checked for radiation leakage at the time of installation or whenever the HVPS/S is repaired or replaced.

3.5.5.1 Principles

Radiation leakage from the HVPS/S results from a defect in the lead liner of the tank or its cover. If there is a hole in the lead liner, the resulting leakage will produce a pencil beam of X-rays. If there is a crack in the lead liner, the resulting leakage will produce a fan beam. In either case, the initial survey must be taken close to and almost touching the tank with the survey meter probe. If a leak is found, the meter indicates a spike in the reading. If this occurs, you must then move the probe one-meter (approx. 40”) along the beam from that spot to determine if the leakage is within acceptable levels.

The Victoreen 450P has a response time of:

Range	Time
0-4mR/h	3.3 seconds
0-40mR/h	4.5 seconds

3.5.5.2 Performing the Leakage Test Procedure

1. Remove the tank cover and set the X-ray leakage test shield (099-0566) over the aperture slot.

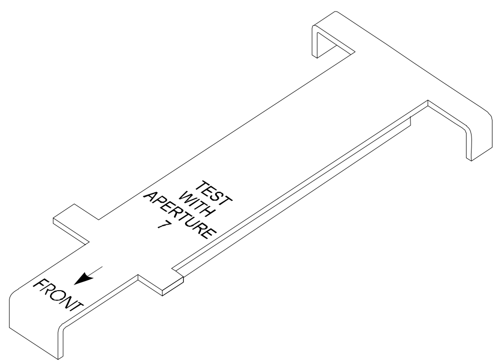


Figure 3-29. Leakage Test Shield (099-0566)

2. Start the Utility by selecting **Utilities|Service Utilities|X-Ray Survey** (see “X-Ray Survey” on page 9-1 for information on the utility).
3. Change **X-Ray Mode** to 3 and **Aperture** to 7 to lock in the changes.

3.5.5.3 Initial Leakage Survey

WARNING:	X-rays are generated during this procedure. Keep hands, head and other body parts out of beam.

1. Turn on X-rays by pressing the **<F1>** key.
2. Slowly move the meter probe (Victoreen Model 450P or equivalent) about all accessible surfaces (see table above for meter response times) to detect any leaks.
3. If a leak is detected (a spike in the reading), measure a point at a one meter (approx. 40”) distance from the leak and insure that the reading is 10µGy/h (1.0mrad/h) or less.

3.5.5.4 Final Leakage Survey

WARNING:	X-rays are generated during this procedure. Keep hands, head and other body parts out of beam.

1. Position the survey meter one meter (approx. 40”) from the tank and move it all around the outside of the instrument.
2. The reading must be 10µGy/h (1.0mrad/h) or less. Record the highest reading in the service report.
3. Press the **<F2>** key to turn off X-rays, remove the tool, and replace the tank cover.

Note: Enter this information into the Radiation Measurement Report (see example on page 3-70).

3.5.6 Calibrate For Area, BMD And BMC

Calibration for Area, BMD, and BMC is accomplished in 3 stages:

a. Array Scan Thickness Measurement & Calibration
b. Calibration of Area and BMC for Array Scan Modes
c. Adding Array AP scans to the QC database

Follow the procedure, in order, and exactly as shown, for each stage of the calibration.

Note: If the Discovery being installed is to replace an existing QDR pencil beam or hybrid pencil/fan beam system, then a cross-calibration must first be performed to ensure that any longitudinal studies begun on the QDR being removed can safely be continued on the new Discovery. *Perform the cross-calibration before de-installing the existing QDR.* (Refer to QDR 1000-4500 Upgrade Procedure, 080-0767 for complete instructions.)

Note: If this customer site includes two or more fan beam systems or if this Discovery is replacing an older fan beam system (model QDR 4500 or Delphi), perform the cross calibration procedure contained in Technical Bulletin TB-00123 before de-installing the older system.To ensure stability, the instrument must be completely powered up for a minimum of *30 minutes* prior to running any of the following tests. Also, because the tabletop pad will have a slight affect on the test results, all scans *must* be performed with it in place.

WARNING:	X-rays are produced during most of these tests. Keep hands, head and other body parts out of the X-ray beam path. The tester should also be wearing an approved radiation dosimetry badge.

3.5.7 Scan Thickness Measurement & Calibration (C and W)

1. Press the Center Table button.
2. Turn on the laser.
3. With the laser on, place the phantom so that the laser dot is on the centerline of the phantom, 1/2" from the left end, shining on the phantom target. The sides of the phantom should be aligned parallel to the table, using a ruler if necessary.
4. Be sure the spine phantom has been entered in the patient database in the form of "Spine Phantom #*nnnn*" (where *nnnn* is the number of the phantom) so that the QC plot program can identify it properly.
5. From the Discovery Main Menu screen, select **Perform Exam**, select the **Spine Phantom**, and click the **OK** button at Patient Information dialog box.
6. Select **AP Lumbar Spine**, uncheck default scan check box, and click the **Next>** button.
7. Select **Array**, click the **Next>** button, set the scan length to **6** inches, and start the scan.
8. Analyze the scan and click the **Close** button to exit the Analysis screen.
9. Start the Field Service Calibration program by selecting **Utilities|Service Utilities|Field Service Calibration** from the Discovery Main Menu screen.
10. Select the Spine Highs/Lows for Array Spine phantom option to automatically calculate the new thickness indicators for array spine.
11. Select the Spine Phantom scanned in step 6 from the list of Analyzed Scans and click the **Next** button. Click the **Continue** button on the Successfully Calculated message box.
12. Click on the Temp Write button and click the Continue button on the Successfully Wrote message box. Exit Field Service Calibration.

3.5.8 Scan Thickness Measurement & Calibration (A and SL)

1. From the QDR For Windows perform exam button, select the spine phantom to be used for checking the array scan modes. This should be the one shipped with the machine.

   Note: Be sure the spine phantom has been entered in the patient database in the form of "Spine Phantom #nnn" (where nnn is the number of the phantom) so that the QC plot program can identify it properly.

2. Center the table, place the phantom on the table and set up a exam using the AP/Lateral setup, uncheck the use default scan mode box, click next, select Array scan mode for the AP component and Fast Array for the Lateral component. The sides of the phantom should be aligned parallel to the table, using a ruler if necessary.
3. Press and hold Enable until the arm and table move into position. Recheck phantom alignment with laser, and click continue.

   Note: Do not move the arm or table, otherwise the test will have to be started over.
4. Change the scan length to 6 inches, and click start scan to begin the AP component.
5. When scan has finished, select Spine as the analysis method, and click **Next**.
6. Analyze the scan, and click start position. Check at bottom of screen that the centerline angle is + or - 2 Degrees.
7. Click close, and then hold the enable button to lateral position.
8. Click Start Scan to perform Lateral component.
9. Press and hold the Enable switch to return to AP position.
10. Analyze scan (refer to user guide for Lateral analysis) and close the screen.
11. Click exit to close the Exit Analysis screen.
12. Restart QDR for Windows software in service mode (if not already). From the QDR Main window, select Utilities, Service Utilities, Field Service Calibration.
13. Select Highs/Lows for Array Spine Phantom
14. Select the AP scan just performed and click next
15. Click continue on the Calculated highs and lows page.
16. Select Highs/Lows for Array Lateral Phantom.
17. Click continue on the Calculated highs and lows page.
18. Click Temp Write to write temporary results and click continue to exit the write dialog box.

3.5.9 Calibration of Area and BMC, for Array Scan Modes

After the machine has been calibrated for thickness measurement in the array mode, it must be calibrated for the array AREA and BMC measurements.

1. Restart the Discovery software in service mode (if not already). Center the table. From the Discovery Main Menu screen, select **Utilities|Service Utilities|AP Reposition**. Return to the menu and select **Utilities|Service Utilities|Auto Scan**.
2. Select the Spine Phantom.

3. Click **OK** at Patient Confirmation dialog box.
4. Select AP Lumbar Scan Type, input **20** for number of scans, uncheck Use Default, and click the **Next** button.
5. Select Array and click the **Next** button.
6. Analyze the first scan manually. Note the scan #. Click the **Close** button to exit analysis.
7. From the Discovery Main Menu screen, select **Utilities|Service Utilities|Auto Analyze**.
8. Click on unanalyzed Scans and select the 19 scans, click on **Compare** radio button and then click the **next** button.
9. Now, select the scan analyzed in step 6 and click the **next** button.
10. The 19 scans will now be compared with the analyzed scan.
11. From the Discovery Main Menu screen, select **Utilities|Service Utilities|Field Service Calibration**.
12. Click the **ACF/BCF** button. Select the 20 scans, click **next**, and then click **Continue** at the Successfully Calculated dialog box.
13. At the Field Service Calibration dialog box, click the **Write** button to write the values to ARRC.TXT file. Click the **Continue** button to return to the Discovery Main Menu screen.
14. Print ARRC.TXT file by using these steps:
    - Press the **<Ctrl><Esc>** keys to bring up the WindowsXP Taskbar.
    - Select **Find**
    - Select **Files or Folders**
    - Type **ARCC.TXT** in the **Named:** edit box.
    - Click **Find Now** or simply hit the **<Enter>** key.
    - Right click on the first ARRC.TXT entry in the list presented to you and select **Print** from the menu. (You want the ARRC.TXT entry in the QDR\DATA directory NOT the QDR\DATA\LRTEMP directory.)
15. Verify ACF=ACFL=ACFT and BCF=BCFL=BCFT in ARRC.TXT.

3.5.10 RECALYZE and Add Array AP Scans to the QC Database

Once the unit has been calibrated, AP scans must be re-analyzed and added to the QC database.

After the machine has been calibrated for thickness measurement in the array mode, it must be calibrated for the array AREA and BMC measurements.

1. From the Discovery Main Menu screen, select **Utilities|Service Utilities|Auto Analyze**.

2. Select Analyzed scans, click **RECALYZE**, and select the 20 scans just acquired and click the **Next** button.
3. The scans will now be recalculated to the new calibration.
4. Highlight the scans from the Excluded list and click the **Include Scans** button and then the **Finish** button. (Selection is easier if you click Scan Date bar above the list. This will order the scans by date and time).From the Discovery Main Menu screen, select **QC|QC Data Management|Select Scans**.
5. Select the **QC|QC Data Management|Plot** option from the Discovery Main Menu Screen to generate an AREA, BMC, and BMD plot for each array mode. Verify that the QC plots include the factory scans and the scans just performed.
6. Ensure that all scans fall between the two, dotted limit lines.
7. Print the BMD, BMC, Area HiAir and LoAir plots. Include the printed plots with the other paperwork being returned to Hologic.

Note: For more details on performing the QC setup and producing QC plots, refer to the Discovery User's Guide.

3.5.11 Install Software Options

Install, configure, and test all software options purchased by the customer as defined by the Sales Order except for the HL7 option (installation of HL7 is a customer responsibility). This includes but is not limited to DICOM and a local copy of Physician's Viewer on the Discovery system.

3.5.12 Test Scan Modes

WARNING:	X-rays are generated during this procedure. Keep hands, head and other body parts out of beam.

Perform at least one scan in each of the scan modes to verify that machine is fully functional in all modes of operation. Verify that there are no electrical or mechanical problems during each scan mode.

[ ] Perform an AP Spine Array, Fast Array, and Express (Ci and Wi only) scan.

[ ] Perform a Left Hip Array, Fast Array, and Express (Ci and Wi only) scan.

[ ] Perform a Whole Body scan (A, W, and Wi only).

[ ] Perform a Forearm scan.

[ ] Perform the IVA Scan QC Procedure described below.

3.5.12.1 Performing the IVA Scan QC Procedure

The ability of the Discovery to produce high quality images must be tested:

- at the time of installation
- after the repair of any parts associated with the generation or detection of x-rays

Each service engineer has been provided with an 11-step aluminum phantom (Step Wedge Penetrometer, P/N 099-0716) for checking image contrast and a line-pair phantom (X-ray Test Pattern, P/N 099-0715) for verifying scan resolution.

Checking the quality of the IVA scans requires three scans:

- single-energy AP
- single-energy lateral
- dual-energy AP

To perform an IVA scan QC, do the following:

1. Press the Center Table button to center the table.
2. Press the Laser button to turn the laser ON. If the laser goes off during the alignment process just press the Laser button again to turn the laser ON.
3. Place the x-ray Step Wedge Phantom (P/N 099-0716) on the table approximately an inch to the right of the crosshair. Center the laser line approximately through the center of the Step Wedge.
4. The Step Wedge Phantom should be placed with its thickest end to the left (foot end) and its thinnest end on the right with its edges parallel to the table.
5. **Skip steps 6 through 8 for Models Ci and Wi.**
6. The X-ray Test Pattern Phantom (P/N 099-0715) should be aligned approximately an inch to the right of the Step Wedge Phantom.
7. The x-ray test pattern should be placed on the table with the lines the Test Pattern Phantom perpendicular to the motion of the C-arm during scanning. The laser line should pass through the center of the x-ray Test Pattern Phantom. The 1.8 and 0.6 test patterns should be farthest from the Step Wedge Phantom. The 0.6 test pattern should be nearest to the front of the table.
8. Depress the **Laser** button on the C-Arm to turn OFF the laser.
9. Click the **Perform Exam** button at the Discovery Main Screen.
10. Select the IVA Test as the patient. If this name is not present, then click the **New patient** button. Enter **IVA Test** as the new patient last name. Leave the first name and initials blank and then click the **OK** button.
11. Click the name **IVA Test** from the patient names. Click the **OK** button.
12. In **Patient Confirmation** Screen, click the **OK** button.
13. At the Select Scan Type screen, select IVA Imaging.
14. Uncheck the Use default scan mode check box and then click the **Next>>** button.
15. Select **SE AP Image** then click the **Next>>** button.
16. Select **None** then click the **Next>>** button.
17. From the **Scan Parameters** screen set the scan length to **10.0** inches.

18. Click the **Start Scan** button to run a single-energy **AP scan**.
19. From the **Hologic Analyze** screen, perform the next 3 steps.

    Note: Intensity may be adjusted to visualize scan.
20. Count the **12** steps associated with the Step Wedge Phantom.
    The number of steps visible on the Step Phantom should be 11 and 1 more for the table.
21. **Skip this step on models Ci and Wi.** By clicking the **+** sign to increase the magnification and using the scroll bar to examine the x-ray test pattern image on the screen, you should be able to see **three lines** for the **0.8 test pattern image**.
22. When completed, click the **Cancel** button.

3.5.13 Finish Assembling Unit

Dress all cables at the rear of the console with nylon tie wraps. Take the time to replace any covers or enclosures that may have been previously removed. Check that all of the machine's safety features (ground wires, emergency stop, etc.) are in place and working properly. Finally, clean the machine and remove any unwanted packing materials from the room.

3.5.14 Measure X-Ray Dose To Patient

WARNING:	X-rays are generated during this procedure. Keep hands, head and other body parts out of beam.

A radiation dose measurement must be performed at installation time, and should be done routinely whenever the machine is serviced. This test requires the use of a Victoreen Model 450P or equivalent measuring device set to measure dose over time (mR/Hr).

Note: The dose measurements must be done with the machine fully assembled *<u>and the table mat in place</u>*.

1. Place the meter in the center of the table approximately ½ inch to the right of the laser crosshair.
2. Click the **Perform Exam** button, create a test patient biography, and select the **Array spine** scan.
3. Set scan length for 9.5 inches and click the **Start scan** button.
4. The meter is now scanned.
5. Observe the scan to verify that the entire chamber of the meter is included in the scan.
6. Record the result from the meter.

    Note: The array spine scan dose should be less than 200µGy (20mrad).
7. Record the highest reading in the service report.

Note: Enter this information into the Radiation Measurement Report (see example on page 3-70).

3.5.15 Measure X-Ray Scatter From Phantom

WARNING:	X-rays are generated during this procedure. Keep hands, head and other body parts out of beam.

A radiation scatter measurement must be performed at the time of installation. You must use a survey-type radiation meter (Victoreen 450P or equivalent).

Perform the following:

1. Center the table and C-arm
2. Place the spine phantom in the center of the table and align using the laser.
3. Start an AP Spine scan.
4. Using the **<Esc>** key, stop the scan when it is between the two middle vertebrae.
5. Start the X-Ray Survey Utility by selecting **Utilities|Service Utilities|X-Ray Survey** (see “X-Ray Survey” on page 9-1 for information on the utility).
6. Using the survey meter, measure the scatter radiation at a distance of 2 meters from the phantom on a horizontal plane all around the unit. Move the meter slowly (refer to the Victoreen response table on page 3-59).

   Note: If you cannot measure the scatter radiation at a distance of 2 meters because of space restrictions, you can measure at 1 meter and divide the result by 4. This reading must be less than 10µGy/h (1.0mrad/h) at 2 meters (approx. 80 in.) in array AP scan mode.

7. Record the highest reading in the service report and then turn off X-rays by clicking on **X-ray (F2)**.

Note: Enter this information into the Radiation Measurement Report (see example on page 3-70).

3.5.16 Perform QC

Once the machine has been fully assembled and calibrated, at least one QC scan should be performed.

- Perform the daily QC procedure and enter the scan into the QC database.

3.5.17 Run Reproducibility Test

Reproducibility is the ability of the scanner unit to perform consecutive scans while keeping the amount of radiation for each scan consistent. Instrument reproducibility is tested by running 10 consecutive scans of the spine phantom shipped with the unit. You must then plot the results of the High Air and Low Air measurements for these scans and insure that the coefficient of variation for absolute radiation is less than 4%. The plot screen does not readily display the coefficient of variation for absolute radiation.

You must use the formula:

coefficient of variation for absolute radiation = standard deviation (SD) x.0028

Therefore:

If…	Then…
the Standard Deviation (SD) for both High Air (HiA) and Low Air (LoA) is less than or equal to 14,	the coefficient of variation for absolute radiation is less than 4%.

To do this:

1. If necessary, restart the Discovery software in Service Mode.
2. Perform 10 array spine scans (using **Utilities|Service Utilities|Autoscan** from the Discovery Main Menu screen).
3. Analyze the first scan manually.
4. Include the analyzed Scans into the QC database. On the APEX main screen, select **QC>QC data Management>Select Scans.** In the Excluded Scans pane, select (highlight) the ten scans just analyzed and click Include Scans. Click OK when done.
5. Put the results in the QC database (if you have not already done so).
6. From the Discovery Main Menu, select **QC|QC Data Management|Plot**. Use a start and end date that will only select the scans that you have just completed.
7. Select QC Parameter to Plot, HiA, and Plot.
8. Plot the data for the 10 scans in step 1.
9. Assure that the SD is 3 or less.
10. Repeat for "LoA" by repeating steps 4-7. This result must also be 3 or less.

Note: Enter this information into the Radiation Measurement Report (see example on page 3-70).

3.5.18 Table Top Radiographic Uniformity (A, W and Wi)

This procedure verifies proper X-Ray beam alignment and the uniformity of the X-Ray transparency of entire tabletop (for Discovery A, W and Wi models).

1. If necessary, restart the Discovery software in Service Mode.
2. Type **WBAIRQC** in the Patient Biography. Enter the serial number of the unit in the Patient ID field.

   Make sure that only the pad is on the table. Clear the table of anything else.

3. Perform one Whole Body *air* scan (a scan with nothing on the table). Do NOT interrupt the scan for any reason. When the scan completes, select **Exit Exam**. Do not analyze the scan that was just performed.
4. From the Discovery Main Menu screen, select **Utilities|Service Utilities|Table Top Radiographic Uniformity**.
5. Select the Whole Body scan and click the **Next>** button.
6. Table Top Radiographic Uniformity results tabs are now displayed. Select the **Low Air** Tab.

11. **If the Global Stats S.D. (2) is less than 2.0, the instrument is properly aligned**.

    If the Global Stats S.D. is greater than or equal to 2.0, then the machine is not aligned properly. Check the following:

    - If the image appears "streaky" or "banded", check for loose wires or other debris between the table and the tank.
    - Check the Aperture Calibration (see page 3-53).
    - Check AC Line voltage.
    - Check +/- 15V Power Supply
    - Check Detector Flattening on page 3-55.
    - Re-run daily QC (see the *Discovery User's Guide).*

    Print a copy of the test results and inlcude it with the other paperwork being returned to Hologic.

    After realignment, repeat the Table Top Radiographic Uniformity test. If the global S.D. is less than 2.0, you are done. If the global S.D. if equal or greater than 2.0, print a copy of the test results and include it with the other paperwork being returned to Hologic.

    If the global is equal to or greater than 2.0, the non-uniformity may be attributed to the table itself. If so, continue with this procedure. Make sure that the machine has body composition loaded. If it does, then follow the appropriate procedure below.

3.5.19 Instruments using Body Composition Analysis (BCA)

Instruments performing BCA must have a global S.D. of less than 2.0. If the realignment and recalibration procedures above have been performed and an S.D. of less than 2.0 cannot be obtained, then the tabletop must be replaced.

Note: Archive the air scans you have acquired and either e-mail or ship them to a Technical Support Specialist at Hologic headquarters for final evaluation.

3.5.20 Instruments using BMD Whole Body Analysis

Instruments using only BMD Whole Body measurements can tolerate a larger S.D. If the global S.D. is less than 3.0, you are done. If the S.D. is equal to or greater than 3.0, the tabletop must be replaced.

Note: Archive the air scans you have acquired and either e-mail or ship them to a Technical Support Specialist at Hologic headquarters for final evaluation.

Note: If the customer is upgrading to the Body Composition Analysis option, you must follow the procedure and meet the requirements in “Run Reproducibility Test” on page 3-67.

3.6 The Radiation Measurement Report

After installation, the field engineer must fill out the Radiation Measurement Report (CSD-0042-F07) and keep this information on file.

Section 4
ALIGNMENT AND CALIBRATION

4.1 Check Table Alignment

To check the table alignment, perform the following procedure:

1. Using a measuring tape, and referring to Figure 4-1, check the following:
   - Distance from the edge of the table to the back of both T-rails (“A” dimension).
   - Distance between the T-rails (front and rear).
   - Gap from the edge of the table bracket (left side) to the rail.
2. Record all the measurements.
3. Facing the front of the Discovery, gently push the foot end (left side) of the table. The table should move away from, and then back, to its original position.
4. Check the “A” dimension and the bracket-to-guide rail gap again. Compare them to their original values.
5. If all the measurements are within specification, the table is properly aligned. If the measurements are not within specification, go to the Aligning Table section below.

4.2 Align the Table

After you have taken the measurements in the Checking Table Alignment section, use the procedures below to align the table. Note that if both the “A” dimension and the bracket-to-guide rail gap are out of specification, you should recheck the measurements after performing the first adjustment.

4.2.1 Table Edge to T-Rail (“A” Dimension) Adjustment

To change the “A” dimension, do the following:

1. Remove the outer and inner covers from the right pedestal.
2. Loosen the four bolts fastening the top of the pedestal and the four bolts fastening the bottom of the pedestal (see Figure 4-2).
3. Adjust the table so the “A” dimension is within the specification.
4. Tighten the bolts and check the table alignment again.

If the alignment is within the specification, replace the pedestal covers. If you still note a change in the “A” dimension, continue with the following steps.

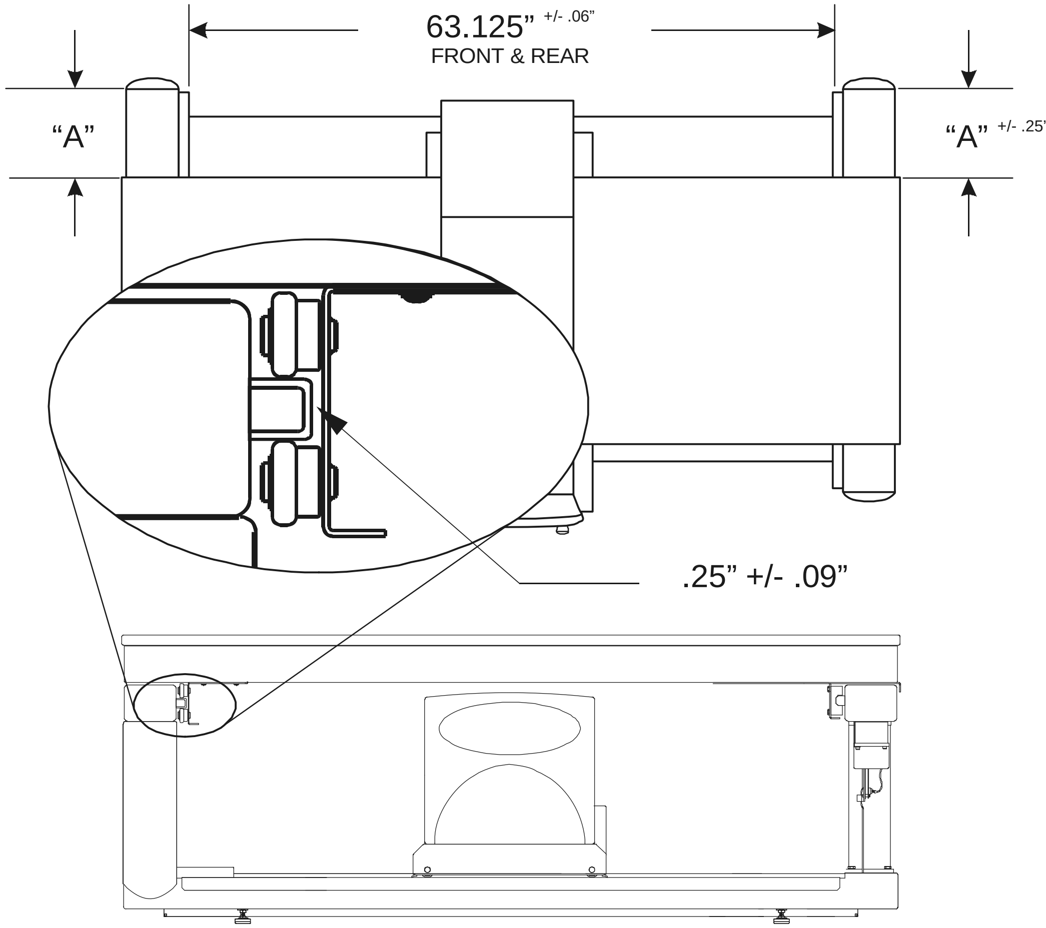


Figure 4-1. Table Alignment

(Not drawn to scale)

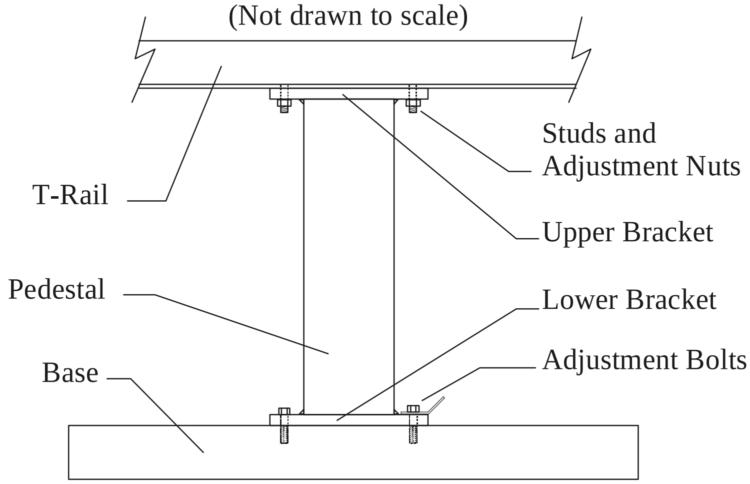


Figure 4-2. Pedestal (covers removed)

5. Make sure the upper and lower brackets are securely fastened to the upper and lower frames.

Note: Even if the brackets are secured to the frames, they may not be securely fastened to the pedestal. If not, remove the table to access the screws that secure the brackets to the pedestal. Refer to Remove Tabletop on page 3-9 for table removal procedures.

If the screws are loose, apply a small amount of Loctite to the threads and tighten the screws.

The upper and lower brackets are attached to the pedestal with four, 6mm flat-head Allen screws. While the table is off, it is a good idea to remove the pedestal to make sure that these screws are tight as well.

To change the "A" dimension, do the following:

6. Mount the pedestal to the lower frame. Do not tighten the bolts until the alignment has been completed.
7. Install the table and check its alignment. Make the necessary adjustments, then tighten the upper and lower bolts.
8. Install the pedestal covers that were removed in Step 1.

4.2.2 Front to Back T-Rail and Table Edge/Rail Gap Adjustment

To adjust the front-to-back T-Rail dimensions and table edge-to-rail gap, perform the following procedure:

1. Remove the outer and inner covers from the left pedestal.
2. Loosen the four bolts fastening the top of the pedestal and the four bolts fastening the bottom of the pedestal.

   Note: Before adjusting the distance between the rails, make sure the upper and lower brackets are securely fastened to the pedestal. Refer to Steps 3 -5 of the previous (Aligning Table) section and then go to the next step.

3. Adjust the distance between the T-rails and the table edge-to-rail gap and tighten the bolts.
4. Install the pedestal covers that were removed in Step 1.

4.3 C-Arm Parallelism Adjustment

1. Using a digital level and with the Tank cover removed, measure the angle across the tank and from back to front on the Tank. Record the angles.
2. Remove the upper C-Arm covers and repeat the measurements on the upper C-Arm assembly. Again record the angles.
3. If the angles measured on the tank vary by more than 0.0 degrees from those found on the C-Arm, do the following.
4. Rotate the C-Arm until the center of gravity for the upper C-Arm is over the lower C-Arm (approximately 60 degrees rotated).

5. Loosen eight 1/4" bolts (4 on each side).
6. Move the C-arm until it is parallel to the tank using the digital level to measure the angles.

4.4 X-Ray Beam Alignment

It is crucial that the X-ray beam be precisely aligned with the detector array because improper alignment will directly affect the repeatability (coefficient of variation, or CV) of the Discovery. Therefore, this alignment must be verified at the time of installation or whenever any work is performed that may affect it.

To check beam alignment:

WARNING:	X-rays are being generated during this procedure. Keep hands, head and other body parts out of beam.

Insert the alignment fixture (see the following three figures) into the detector opening.

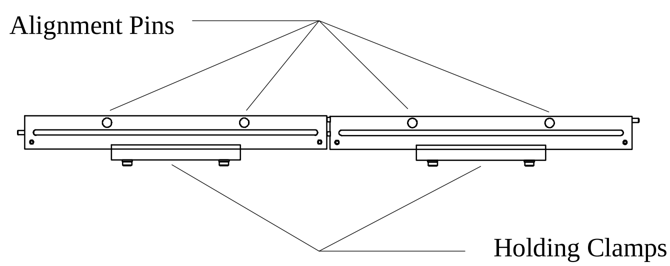
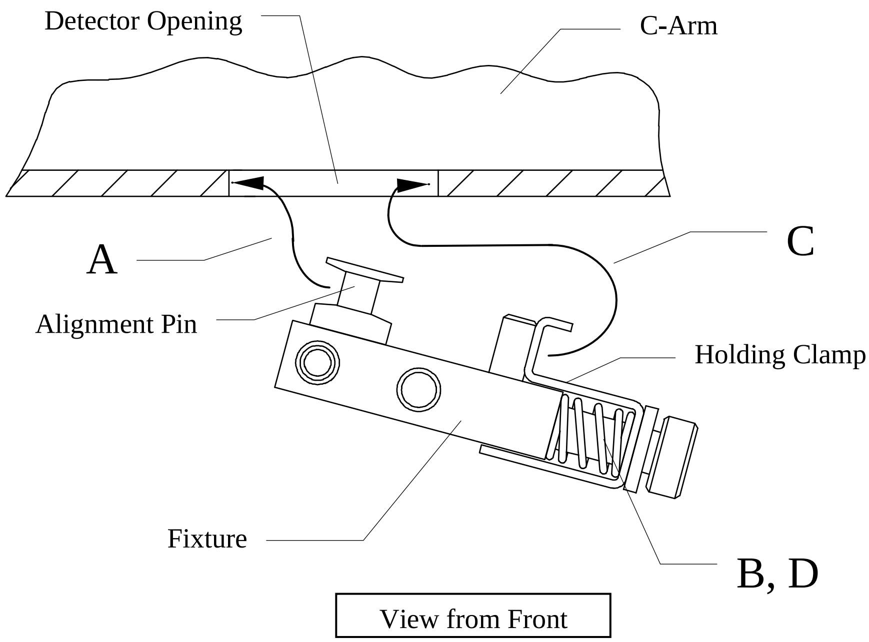


Figure 4-3. X-Ray Alignment Fixture (TLS-00080)



Step A. Insert the left side of the Alignment Fixture into the left side of the Detector Opening so that the vertical edges of the four Alignment Pins are secure.

Step B. Compress the Holding Clamps.

Step C. Raise the right side of the Alignment Fixture into the Detector Opening.

Step D. Release the Holding Clamps.

Note: If the Alignment Fixture is inserted with the Alignment Pins on the right, the procedure works equally well.

Figure 4-4. Inserting The X-Ray Alignment Fixture

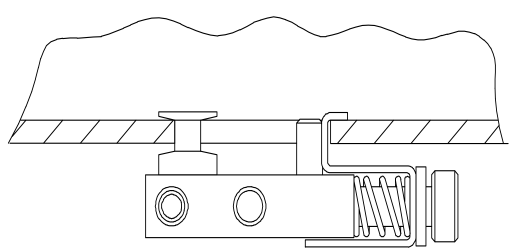
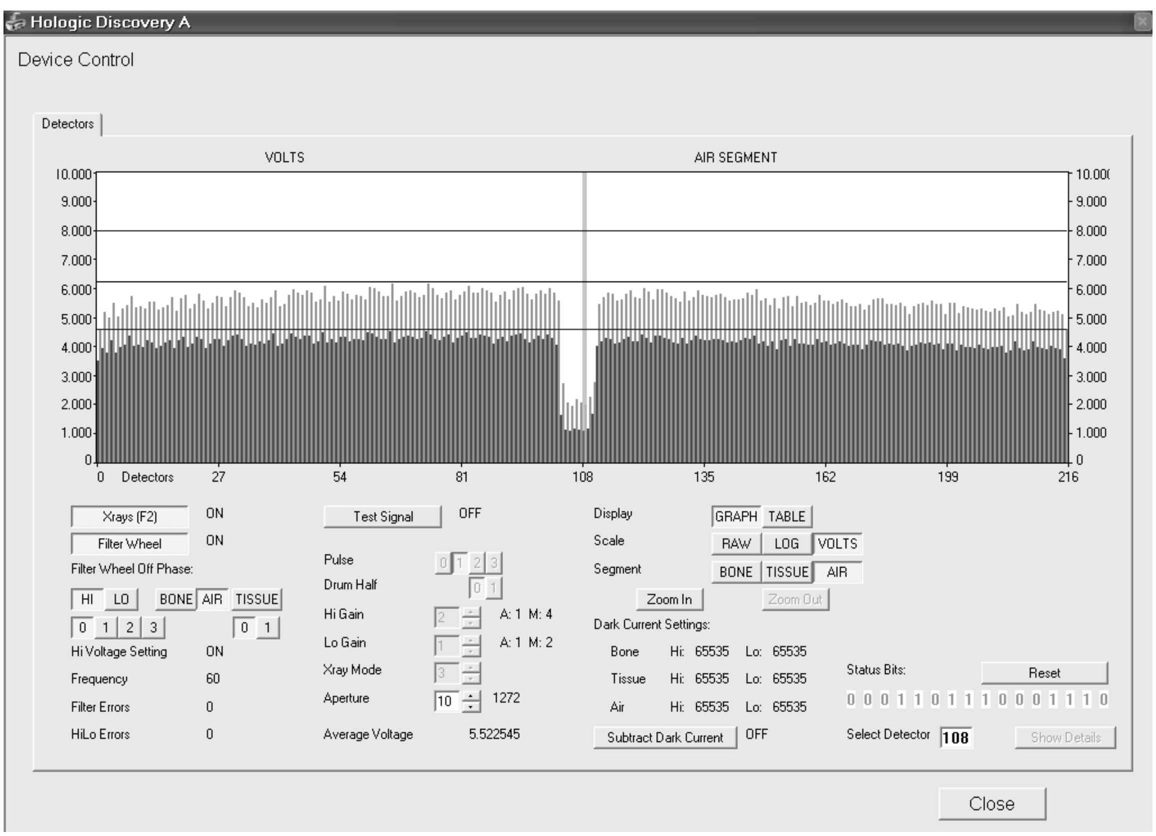


Figure 4-5. The Alignment Fixture Properly Installed

1. Start the X-Ray Survey Utility by selecting **Utilities|Service Utilities|X-Ray Survey** (see “X-Ray Survey” on page 9-1 for information on the utility).
2. Set **Aperture** to 10, **Hi gain** to 2, **Lo gain** to 1 and **X-ray Mode** to 3**.**
3. Place the Aperture Alignment Pin through the hole in the Aperture Plate. It should drop straight through and into the alignment hole in the Filter Drum Assembly base plate and be perpendicular to the Aperture Plate. If it is not perform steps 4 through 7. Otherwise, proceed to step 8.

4. Hit the **<Esc>** key to return to the Discovery Main screen.
5. From the Discovery Main Menu screen, select **Utilities|Service Utilities|SQDRIVER**.
6. At the **CARM$$$$>** prompt, type **move_aper_rel +100** (to move the Aperture Plate right) or **move_aper_rel –100** (to the move Aperture Plate left) until the Alignment Pin is both vertical and perpendicular to the Aperture Plate. (Place the block on the base plate next to the pin and compare the pin to the vertical surface of the block to see if the pin is perpendicular).
7. Type **exit <Enter>** to return to the Discovery Main Screen.
8. Start the X-Ray Survey Utility by selecting **Utilities|Service Utilities|X-Ray Survey** (see “X-Ray Survey” on page 9-1 for information on the utility).
9. Do not change this **Aperture** setting (set to 10), the **Hi gain** setting (set to 2), the **Lo gain** setting (set to 1) or the **X-ray mode** setting (set to 3).
10. For **Display**, click **Graph/**
11. Click **X-ray (F2)** to turn on x-rays.

The correct display should show a flat graph with an amplitude of approximately 5.5 volts with alignment fixture installed (approximately 6.5 volts with alignment fixture removed). If the beam alignment is not correct, perform the following beam alignment procedure.



To perform beam alignment:

1. Set the machine in the Center Table position.

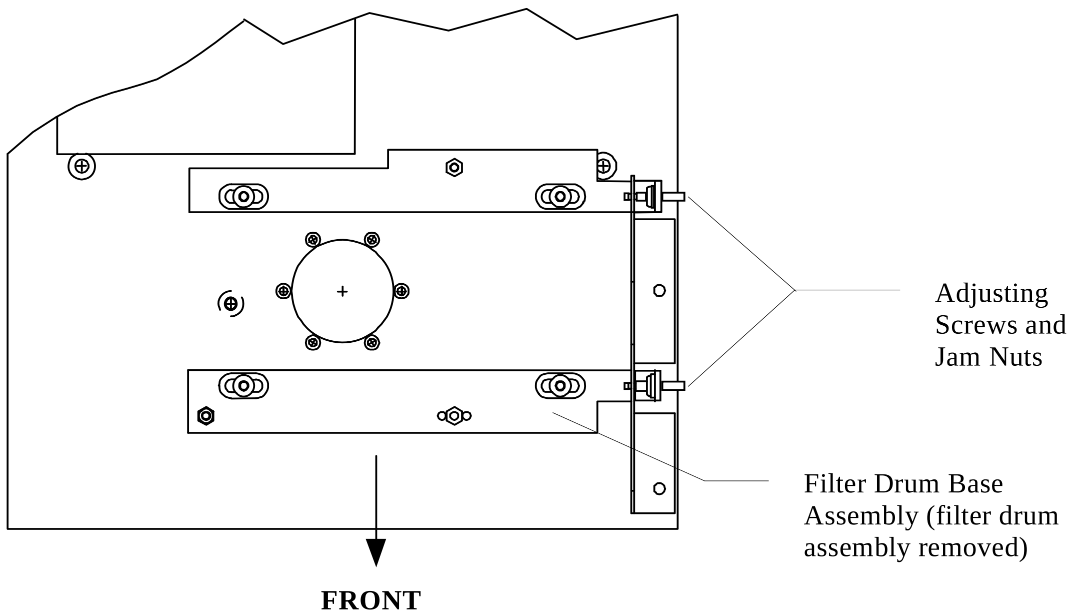


Figure 4-6. Filter Drum Adjustments - Top View

2. At the Filter Drum assembly, loosen the jam nuts and insert Allen wrenches (3/32") in both Filter Drum Allen alignment screws. (Figure 4-6 above shows the locations of alignment screws and jam nuts.) Ensure that the Filter Drum is running.
3. Start the X-Ray Survey Utility by selecting **Utilities|Service Utilities|X-Ray Survey** (see “X-Ray Survey” on page 9-1 for information on the utility).
4. Set **Hi gain** to 2, **Lo gain** to 1 and **X-ray mode** to 3
5. For **Display**, click **Graph**.
6. For **Segment,** click **Air**.
7. Click **X-ray (F2)** to turn on x-rays.

   The next 5 steps adjust the beam side to side.

WARNING:	The X-rays are on. Keep body parts out of the beam.

8. Move the **front** Filter Drum alignment screw until the X-ray signal reaches maximum voltage.

   Note: The last direction turned should be clockwise to eliminate backlash when the jam nuts are tightened. The plot should show peak amplitude.

9. Move the **rear** Filter Drum alignment screw until the X-ray signal reaches maximum voltage.

Note: The last direction turned should be clockwise to eliminate backlash when the jam nuts are tightened. The plot should show peak amplitude.

10. Tighten the jam nuts on both Filter Drum alignment screws.

Note: The X-rays should still show peak amplitude.

11. Turn off the X-rays using the **<F2>** key.
12. Remove the alignment test fixture.

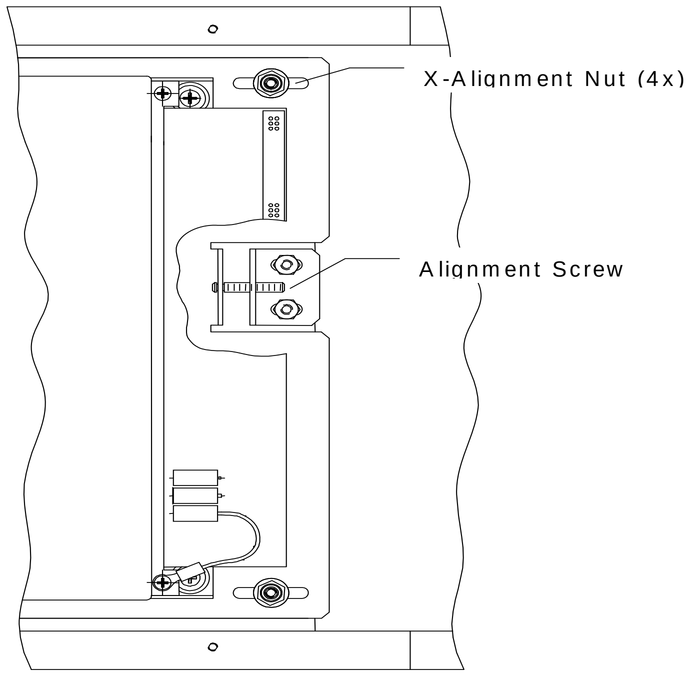


Figure 4-7. Array Assembly - Top View, Partial

The next six steps adjust the beam front to back.

13. At the Array assembly, loosen the four X-alignment nuts (see Figure 4-7 above).
14. Turn on the X-rays with the **<F1>** key.
15. For a **Discovery A only**, adjust the array X-alignment screw in one direction until the trace drops off (the signal on the end detectors of the array will drop off). Then, count the turns while moving it in the other direction until the trace falls off on the detector on the other end of the array. Set the adjustment in the middle by turning the screw back half the number of turns counted.
16. For **Discovery C, Ci, W, Wi, and SL** models, detectors 44 through 171 will be turned on. You will have to exit this routine, remove the alignment pin, run the Aperture Calibration procedure (Aperture Calibration cannot be run on Ci and Wi), and then return to X-Ray Survey. When you enter X-Ray Survey do not change this **Aperture** setting (set to 7), the **Hi gain** setting (set to 2), the **Lo gain** setting (set to 1) or the **X-ray mode** setting (set to 3).
17. For **Display**, click **Graph**.
18. Click **X-ray (F2)** to turn x-rays on.

19. Follow the procedure in step 3 while checking detectors number 44 and 171 to check for the fall off of x-rays.
20. Tighten the four array X-alignment nuts.
21. Click **X-ray (F2)** to turn x-rays off.
22. Remove the block and pin (Discovery A Only).
23. Click **Close** to exit X-Ray Survey.
24. Reboot the PC to return to the Discovery software.

4.5 Aperture Calibration

Note: Aperture Calibration cannot be run on Ci and Wi)

This procedure locates the exact starting positions of each aperture (slit) in motor steps and the center of each slit.

1. Center the table.
2. From the Discovery Main Menu screen, select **Utilities|Service Utilities|SQDRIVER**.
3. At the **CARM$$$$>** prompt type **CALIBRATE<Enter>** (Note that this procedure takes approximately 2 – 3 minutes to start and 10 minutes to complete).

4.6 Motor Calibration

The SQDRIVER program provides a CALIBRATE command for each of the motors (AY, AR, TY, TX, and TZ) to calibrate the encoder readback and determine the limits of motion.

Use the following table to determine which calibration procedures you need to perform on a given Discovery model.

	Perform the calibration procedures if indicated (*) in order from left to right.				
Model	**TZ**	**AY**	**TY**	**TX**	**AR**
A	*	*	*	*	*
SL	*	*	N/A	*	*
W	N/A	*	*	*	N/A
Wi	N/A	*	*	*	N/A
C	N/A	*	N/A	*	N/A
Ci	N/A	*	N/A	*	N.A

Each motor (except TZ) requires the corresponding protocol calibration file in the PROTOCOL sub-directory (e.g., for MOTOR$AY, the calibration protocol is MOTOR_AY.PRO).

To perform the calibration procedure:

1. From the Discovery Main Menu screen, select **Utilities|Service Utilities|SQDRIVER** (you must be in Service Mode).
2. At the **CARM$$$$>** prompt, type **MOTOR$XX<Enter>**, where **XX** equals TZ, AY, TY, TX, or AR depending on which motor you are calibrating.

4.6.0.1 MOTOR$TZ (Discovery A and SL only)

1. Select the TZ motor device driver by typing: **MOTOR$TZ<Enter>**.
2. At the **MOTOR$TZ**> prompt, type: **CALIBRATE<Enter>**.

   The program sends the calibration command to the TZ microprocessor and waits twenty seconds for table motion to complete. During this time, the TZ microprocessor moves the table pedestals to their top mechanical limit and then back down to their lower mechanical limit. You are then asked the following:

```
Mark the current height of the table and press the <Enter>
key to move the table to the topmost position. Then measure
the distance that the table moved in centimeters.
```

3. Measure the distance moved using the bottom edge of the top pedestal cover and the floor. The system displays:

Total Distance Moved By Pedestal [20.0 cm]?

Type **xx.x<Enter>** where xx.x = the distance you measured. It should be 20.0 cm (7 inch). If the distance is not 20.0 cm, type the actual measurement. **The distance measurement affects system results.**

4. Press **<Enter>**. The system then displays the following:

   Are Sure Total Distance Moved By Pedestal Is xx.x cm. [Y/N]?

   The xx.x equals the measurement you typed in above. If you type N, the system redisplays the second message and you should retype the distance you measured. If you typed Y, the system displays the following:

   Update Driver INI-File [Y/N] ?

5. Type **Y<Enter>**.

   The SQDRIVER program then reads the calibration parameters from the TZ microprocessor and prompts:

   ```
   set_table_calibration=368,3227,382,3237
   calibrate_position=10,1000,1000,713,50000,382,382,3237
   pos_limit_position=200210
   neg_limit_position=0
                Update Driver INI-File [Y/N] ?
   ```

   For information about calibration parameters, see “Calibration Parameters” on page 4-11.

6. If the position limits are within specifications, Type **Y<Enter>** to accept the calibration values.

   If the position limits are not within specifications, Type **N<Enter>** and adjust the Linear Rotary String (Encoder). See Adjustment on page 5-15 for details.

7. Calibrate the TZ motor lower left and lower right encoder positions to a range of 250 - 300 and a difference of no more than ± 5 between the two encoders. Setting the TZ encoders to a number outside this range may introduce other errors. Unlike the encoders for the table and arm motions, the encoders for TZ are not adjustable in real time. You must make a trial adjustment and then rerun the calibration to update the values on the display screen.

   The measured distance traveled for motor TZ must be very accurate as well. The distance traveled should be 20.0 cm ±0.1 cm. Always use this specification whenever performing TZ motor calibrations.

   Report any systems that do not conform to the TZ specifications to Technical Support.

4.6.0.1.1 Calibration Parameters

The four values for **set_table_calibration** are, respectively, the left pedestal lower and upper encoder limits and the right pedestal lower and upper encoder limits. The two lower limits should be *close* to each other, as should the two upper limits. The eight **calibrate_position** fields are:

1) **10** (Tolerance). The ± position tolerance, in encoder ticks, for absolute moves. Although the TZ microprocessor does its own absolute moves, not the AT device driver, this field is used by state machine programs to determine whether the TZ position is within tolerance and should be ten (10).

2,3) **1000,1000** (NumberOfSteps,StepDistance). The number of motors steps corresponding to the step distance in microns. These two fields are only used for stepping motors, not for the DC table motors, and should always be 1000,1000.

4,5) **819,50000** (NumberOfTicks,TickDistance). The number of encoder ticks corresponding to the tick distance in microns. The table encoder calibration is fixed and should always be 819 encoder counts per 50,000 microns.

6) **500** (EncoderOffset). The value subtracted from the encoder readback to set the origin of motion. The origin of TZ motion is the lower right pedestal, so this field should be the same as the third field in the **set_table_calibration** line (above).

7,8) **500,3494** (NegLimit,PosLimit). The encoder readings for the negative (downward) and positive (upward) mechanical stops. In normal operation, the TZ microprocessor uses the right pedestal readings for closed loop control so these two fields should be the same as the last two fields in the **set_table_calibration** line (above).

The **pos_limit_position** and the **neg_limit_position** are the limits of motion, in microns, in the positive and negative direction

Note: The *PosLimitOffset* and *NegLimitOffset* entries in the *[TzMotor]* section of the *SQDRIVER.INI* file determine the motion limits relative to the mechanical stops. If these entries are not present, or are zero, the motion limits are set to the mechanical limits, as in the above example.

4.6.0.2 MOTOR$AY

If you have to replace the encoder, before beginning this procedure, loosen the set screws that secure the encoder coupling to the pulley shaft.

To perform the calibration procedure:

1. Select the AY motor device driver by typing: **MOTOR$AY<Enter>**
2. At the **MOTOR$AY>** prompt in SQDRIVER, type: **CALIBRATE<Enter>**

   The program prompts:

Press <Enter> when the AY motor reaches the LEFT mechanical limit. **Press <ESC> to stop calibration.**

3. The program moves the AY motor to the left. When AY hits the left mechanical stop the first time press **<Esc>**.
4. Check the position value. It must be 3750±5. Adjust if necessary.

If out of range, loosen the coupling setscrew and manually rotate the encoder until the readback is 3750±5 (i.e., in the range 3745-3755) and then tighten the coupling setscrew.

5. Repeat the calibration procedure above but now, when AY hits the left mechanical stop, press **<Enter>**.

   The program then starts AY moving to the right and prompts:

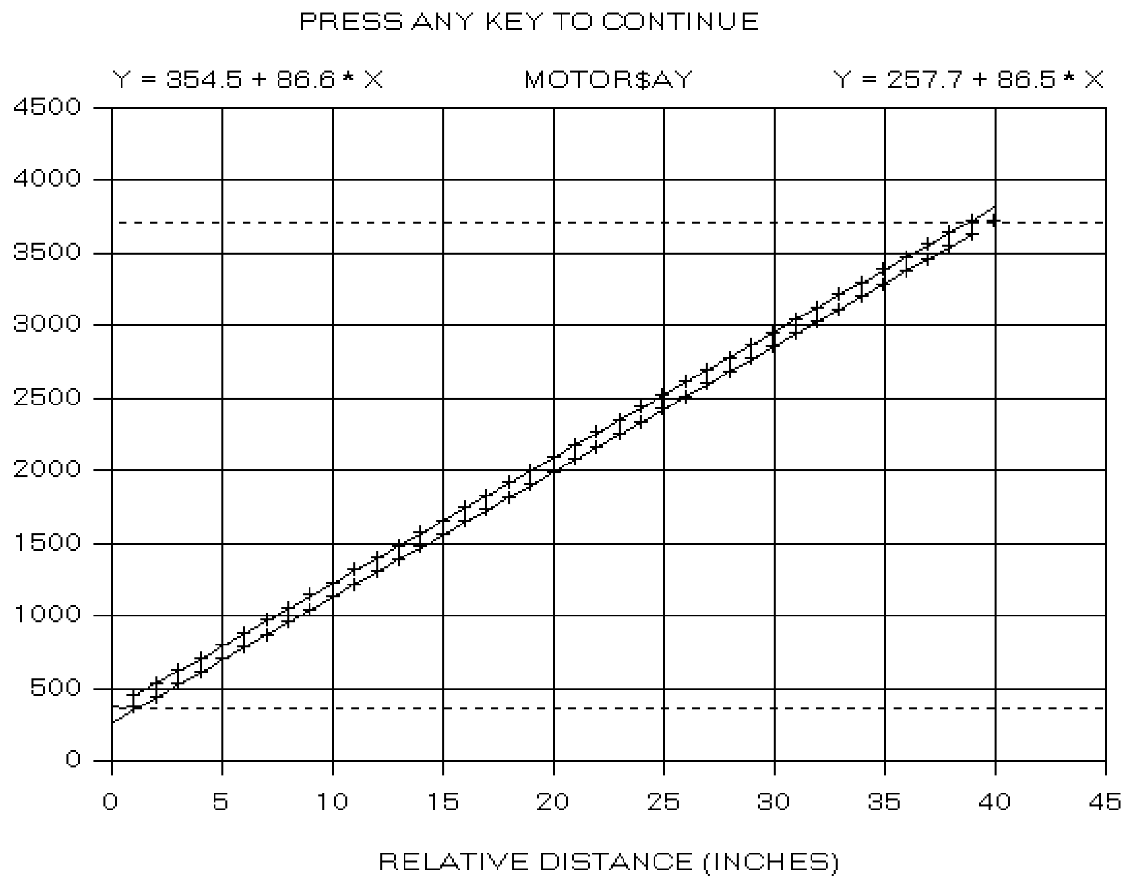
   Press <Enter> when the AY motor reaches the RIGHT mechanical limit.
   Press <ESC> to stop calibration.

6. When AY hits the right mechanical stop, press **<Enter>**.

   The program then switches to graphics mode and draws the Encoder Vs Distance calibration grid. It steps the AY motor to the left in one inch increments until the motor hits the left mechanical stop, and then steps the AY motor to the right in one inch increments until the motor hits the right mechanical stop. The program plots the encoder data during the scan (in raw encoder units, 0-4095).

   Note: Press **<Esc>** anytime during the scan to abort the calibration procedure.

   When the calibration scan completes, the program computes the linear fit for both the positive and negative motion. The linear fit parameters are displayed at the top left and top right of the plot in the form Y = Intercept + Slope * X. The two slopes (e.g., 86.6 and 86.5) should be within 0.3 of each other.



The program displays the positive and negative limits as horizontal dashed lines.

Note: The *PosLimitOffset* and *NegLimitOffset* entries in the *[AyMotor]* section of the *SQDRIVER.INI* file determine the motion limits relative to the mechanical stops. If these entries are not present, or are zero, the motion limits are set to the mechanical limits).

The program then changes the plot title to **PRESS ANY KEY TO CONTINUE**.

7. Press the **<Enter>** key and the program prompts.

motor_direction=1

calibrate_position=1,2288,41187,209,61339,363,363,3750

pos_limit_position=984946

neg_limit_position=0

Update Driver INI-File [Y/N] ?

For information about calibration parameters, see “Calibration Parameters” on page 4-11.

8. If the position limits are within specifications, Type **Y<Enter>** to accept the calibration values.

4.6.0.2.1 Calibration Parameters

The **motor_direction** field determines whether the positive step direction is the *reverse* of the direction of increasing encoder values ('0' if the direction is *not* reversed, '1' if it is). This value is set from the corresponding parameter in the MOTOR_AY.PRO file and is a constant for each motor (i.e., the direction of increasing encoder values must agree with the system coordinates and the positive step direction is set by the wiring harness for the stepper motor).

The eight **calibrate_position** fields are:

1) **1** (Tolerance). The ± position tolerance, in encoder ticks, for absolute moves. The calibration program sets this field to the value found in the corresponding **calibrate_position** field in the MOTOR_AY.PRO file.

2,3) **2288,41187** (NumberOfSteps,StepDistance). The number of motors steps corresponding to the step distance in microns. The ratio of these two numbers determines the step size (41187/2288 ≅ 18 microns). The calibration program sets these fields to the values found in the corresponding **calibrate_position** fields in the MOTOR_AY.PRO file. Since these values are a property of the mechanical design of the system, they should never change.

4,5) **209,61339** (NumberOfTicks,TickDistance). The number of encoder ticks corresponding to the tick distance in microns. Again, it is the ratio of these two numbers (61339/209 ≅ 293 microns) that determines the encoder calibration. These numbers will generally change from calibration to calibration (although the ratio should remain approximately the same).

6) **363** (EncoderOffset). The value subtracted from the encoder readback to set the origin of motion. The origin of AY motion is the extreme right mechanical stop, so this value should be the same as the first field below.

7,8) **363,3719** (NegLimit,PosLimit). The encoder readings for the negative (right) and positive (left) mechanical stops.

The **pos_limit_position** and the **neg_limit_position** are the limits of motion, in microns, in the positive and negative direction.

Note: The *PosLimitOffset* and *NegLimitOffset* entries in the *[AyMotor]* section of the *SQDRIVER.INI* file determine the motion limits relative to the mechanical stops. If these entries are not present, or are zero, the motion limits are set to the mechanical limits, as in the above example).

Note: The last calibration scan data is saved in the file MOTOR_AY.DAT. You can reanalyze the data–e.g., after editing *SQDRIVER.INI* by typing the command **CALIBRATE @MOTOR_AY.DAT** at the **MOTOR$AY>** prompt in SQDRIVER.

4.6.0.3 MOTOR$TY (A, W and Wi models only)

If you have replaced the TY Encoder, before beginning this procedure, loosen the set screws that secure the encoder coupling to the pulley shaft. If you are performing the initial installation of the instrument, this is unnecessary.

1. Select the TY motor device driver by typing: **MOTOR$TY<Enter>**
2. At the **MOTOR$TY**> prompt in SQDRIVER, type: **CALIBRATE<Enter**>

   The program starts TY moving to the left and prompts:

Press <Enter> when the TY motor reaches the LEFT mechanical limit.
Press <ESC> to stop calibration.

3. The program moves the TY motor to the left. When TY hits the left mechanical stop the first time press <**Esc**>.
4. Check the position value. It must be 3750±5. Adjust if necessary.

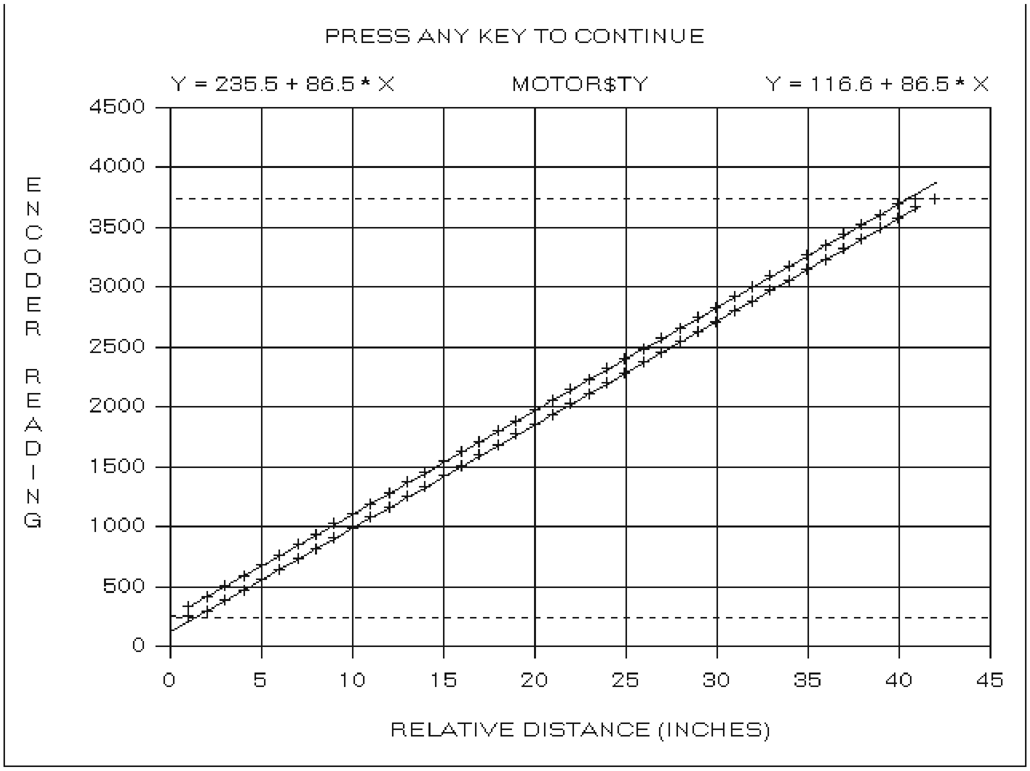
   If out of range, loosen the coupling setscrew and manually rotate the encoder until the readback is 3750±5 (i.e., in the range 3745-3755) and then tighten the coupling setscrew.
5. Repeat the calibration procedure above but now, when TY hits the left mechanical stop, press **<Enter>**.

   The program then starts TY moving to the right and prompts:

Press <Enter> when the TY motor reaches the RIGHT mechanical limit.
Press <ESC> to stop calibration.

   When TY hits the right mechanical stop, press **<Enter>**. The program then switches to graphics mode and draws the Encoder Vs Distance calibration grid. It steps the TY motor to the left in one inch increments until the motor hits the left mechanical stop, and then steps the TY motor to the right in one inch increments until the motor hits the right mechanical stop. The program plots the encoder data during the scan (in raw encoder units, 0-4095).

   Note: Press **<Esc>** anytime during the scan to abort the calibration procedure.



When the calibration scan completes, the program computes the linear fit for both the positive and negative motion. The linear fit parameters are displayed at the top left and top right of the plot in the form Y = Intercept + Slope * X. The two slopes (e.g., 86.5 and 85.6) should be within 0.3 of each other.

When the calibration scan completes, the program computes the linear fit for both the positive and negative motion. The linear fir parameters are displayed at the top left and top right of the plot in the form Y = Intercept + Slope * X. The two slopes (e.g., 86.5 and 85.6) should be within 0.3 of each other.

The program displays the positive and negative limits as horizontal dashed lines.

Note: The *PosLimitOffset* and *NegLimitOffset* entries in the *[TyMotor]* section of the *SQDRIVER.INI* file determine the motion limits relative to the mechanical stops. If these entries are not present, or are zero, the motion limits are set to the mechanical limits.

6. The program then changes the plot title to **PRESS ANY KEY TO CONTINUE**. Press the **<Enter>** key and the program prompts.

motor_direction=0

calibrate_position=1,2287,27446,154,45219,238,238,3742

pos_limit_position=1028879

neg_limit_position=0

Update Driver INI-File [Y/N] ?

Note: The last calibration scan data is saved in the file MOTOR_TY.DAT. You can reanalyze the data–e.g., after editing *SQDRIVER.INI*–by typing the command **CALIBRATE @MOTOR_TY.DAT** at the **MOTOR$TY**> prompt in SQDRIVER.

4.6.0.4 MOTOR$TX

If you have replaced the encoder, before beginning this procedure, loosen the set screws that secure the encoder coupling to the pulley shaft and make sure that the tank assembly is not under the operator console. For normal installations, this is unnecessary.

1. Select the TX motor device driver by typing: **MOTOR$TX<Enter>**
2. At the MOTOR$TX> prompt in SQDRIVER, type: **CALIBRATE<Enter>**

   The program prompts:.

Press <ESC> to stop calibration.

   The program moves the TY (W only) and AY motors to their center positions and prompts:.

Use the Table IN / OUT switch to move the C-Arm to 0 degrees.
Press <Enter> when the C-Arm is positioned.
Press <ESC> to stop calibration.

   The above message is always displayed when calibrating MOTOR$TX. This is the normal message for a QDR-4500. The message was not changed for DISCOVERY systems.

3. Press **<Enter>** and the program prompts:

Press <Enter> when the TX motor reaches the OUTER mechanical limit.
Press <ESC> to stop calibration.

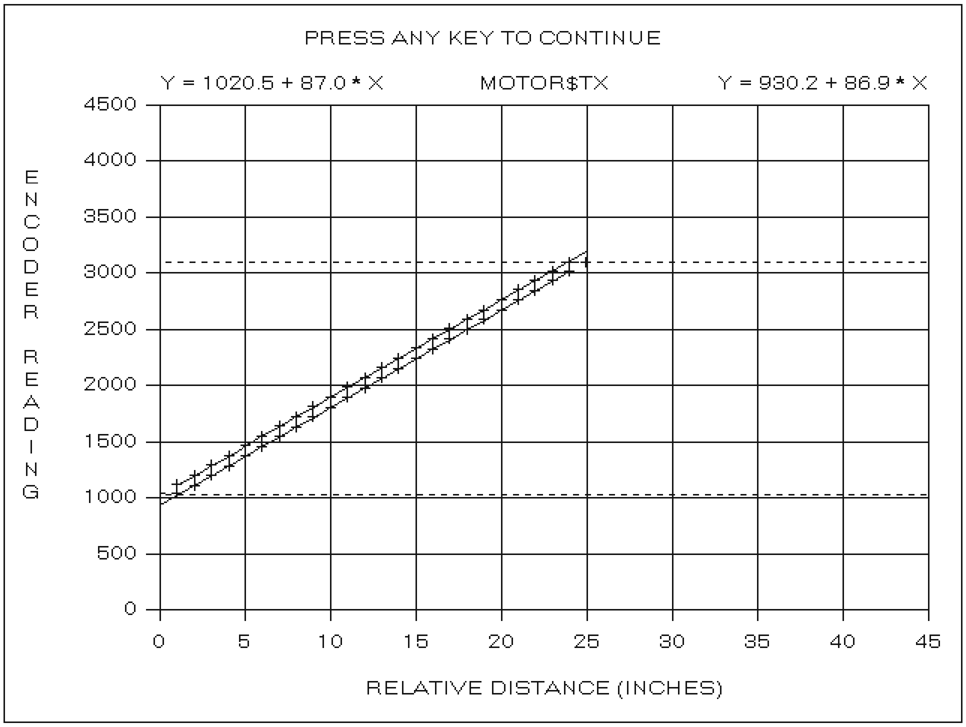
4. The program moves the TX motor to the left. When TX hits the left mechanical stop the first time press <**Esc**>.
5. Check the position value. It must be 1000±5. Adjust if necessary.

   If out of range, loosen the coupling setscrew and manually rotate the encoder until the readback is 1000±5 (i.e., in the range 995-1005) and then tighten the coupling setscrew.

6. Repeat the calibration procedure above but now, when AY hits the left mechanical stop, press **<Enter>**.

   The program switches to graphics mode and draws the Encoder Vs Distance calibration grid. It steps the TX motor in by 1" increments until the inner mechanical stop is hit. The program plots the encoder data during the scan (in raw encoder units, 0-4095).

7. Press **<Esc>** at anytime during the scan to terminate the calibration procedure.



When the calibration completes, the program computes the linear fit for both the positive and negative motion. The line for parameters are displayed at the top left and top right of the plot in the form Y = Intercept + Slope * X. The two slopes (87.0 and 86.9 in the example below) should be within 0.3 of each other.

The program displays the positive and negative limits as horizontal dashed lines.

Note: The *PosLimitOffset* and *NegLimitOffset* entries in the *[TxMotor]* section of the *SQDRIVER.INI* file determine the motion limits relative to the mechanical stops. If these entries are not present, or are zero, the motion limits are set to the mechanical limits.

The program then changes the plot title to **PRESS ANY KEY TO CONTINUE**.

8. Press the **<Enter>** key and the program prompts:

motor_direction=1

calibrate_position=1,2287,27446,43,12563,1026,1026,3096

pos_limit_position=604777

neg_limit_position=0

Update Driver INI-File [Y/N] ?

The **motor_direction**, **calibrate_position**, **pos_limit_position** and **neg_limit_position** fields have the same interpretation as discussed under MOTOR$AY.

9. Type **Y<Enter>** to accept the calibration values or **N<Enter>** to reject them.

Note: The last calibration scan data is saved in the file MOTOR_TX.DAT. You can reanalyze the data–e.g., after editing *SQDRIVER.INI*–by typing the command **CALIBRATE @MOTOR_TX.DAT** at the **MOTOR$TX>** prompt in SQDRIVER.

4.6.0.5 MOTOR$AR (Discovery A and SL)

If you have replaced the encoder, before beginning this procedure, loosen the set screws that secure the encoder coupling to the pulley shaft. If this is an initial installation, this is unnecessary.

1. Confirm that the table is level front-to-back. Do this by removing the table pad. Place the digital level on the table at the foot end and read the value on the level. It must be 0º degrees ±0.0º degrees. Move the level to the head of the table. Confirm that the level is still at 0.0º degrees. Adjust the leveling feet as necessary to obtain this result. **Failure to perform this step will result in positioning tolerance errors on whole body, lateral, and IVA scans.**
2. Select the AR motor device driver by typing: **MOTOR$AR<Enter>**
3. At the **MOTOR$AR>** prompt, type: **CALIBRATE<Enter>**

   The program prompts:

Press <ESC> to stop calibration.

   The program moves the TY and AY motors to their center positions, then moves the TZ motor to its topmost position and prompts:

Use the Table IN / OUT switch to move the C-Arm to 0 degrees.
Press <Enter> when the C-Arm is positioned.
Press <ESC> to stop calibration.

4. Remove the C-arm Tank cover.
5. Place the digital level on the top of the tank assembly (*not on the top of the C-arm*) and use the Table IN/OUT switch on the operator panel to move the C-arm until it is 0º ±0.0º
6. Remove the level.
7. Press **<Enter>**.

   The program prompts:

Press <ESC> to stop calibration.

The program moves the TZ table to its top most position and moves the TX table inwards until it almost touches the C-arm. It rotates the C-arm by 2 degrees to obtain an initial estimate of the encoder calibration and then prompts:

Press <Enter> when the AR motor reaches the AP mechanical limit. **Press <ESC> to stop calibration.**

8. The program rotates the C-arm counter clockwise (i.e., the tank assembly moves away from the front of the machine). When the C-arm hits the AP mechanical limit the first time, press **<ESC>**.Check the position value. It must be 250±5. Adjust if necessary.

   If out of range, loosen the coupling setscrew and manually rotate the encoder until the readback is 250±5 (i.e., in the range 245-255) and then tighten the coupling setscrew.

9. Before repeating the calibration procedure, rotate the C-arm back to approximately 0º by:

   Typing the command: **MOVE_REL 1470<Enter>**.

10. Repeat the calibration procedure above but now, when AY hits the left mechanical stop, press **<Enter>**.

Press <ESC> to stop calibration. Press <Enter> when the AR motor reaches the AP mechanical limit.

    Wait until the rotation completes and then repeat the calibration procedure above but now, when the C-arm hits the AP mechanical stop,

11. Press **<Enter>**

    The program prompts:

Press <ESC> to stop calibration.

    and moves the C-arm back to the approximate 0° position. The program then prompts:

Use the Table IN / OUT switch to move the C-Arm to 0 degrees. **Press <Enter> when the C-Arm is positioned.** **Press <ESC> to stop calibration.**

    Place a level on top of the X-ray tank assembly (***not*** the top of the C-arm) and use the Table IN/OUT switch on the operator panel to move the C-arm until it is 0º ±0.1º. Remove the level, wait until the rotation completes, and then repeat the calibration procedure above but now, when the C-arm hits the AP mechanical stop,

12. Press **<Enter>**

The program prompts:

Press <ESC> to stop calibration.

and moves the C-arm back to the approximate 0° position. The program then prompts:

Use the Table IN / OUT switch to move the C-Arm to 0 degrees.

Press <Enter> when the C-Arm is positioned.

Press <ESC> to stop calibration.

Place a level on top of the X-ray tank assembly (***not*** the top of the C-arm) and use the Table IN/OUT switch on the operator panel to move the C-arm until it is 0º ±0.1º. Remove the level and then

13. Press **<ENTER>**

The program prompts:

Press <ESC> to stop calibration.

and moves the C-arm and the X-table together until the C-arm is at approximately 83°. It then changes the prompt to:

Press <Enter> when the AR motor reaches the LATERAL mechanical limit.

Press <ESC> to stop calibration.

and begins rotating the C-arm clockwise (i.e., the tank assembly moves toward the front of the machine). When the C-arm hits the LATERAL mechanical limit,

14. Press **<ENTER>**

The program prompts:

Press <ESC> to stop calibration.

and moves the C-arm back to the approximate 83° position. The program then prompts:

Use the Table IN / OUT switch to move the C-Arm to 83 degrees.

Press <Enter> when the C-Arm is positioned.

Press <ESC> to stop calibration.

15. Place the digital level on top of the X-ray tank assembly and use the Table IN/OUT switch on the operator panel to move the C-arm until it is at 83°±0.1º (do ***not*** make this measurement with the cosmetic covering on the tank assembly).
16. Remove the level and then press **<Enter>**

The program prompts:

Press <ESC> to stop calibration.

and moves the C-arm and the X-table back to their initial 0° positions.

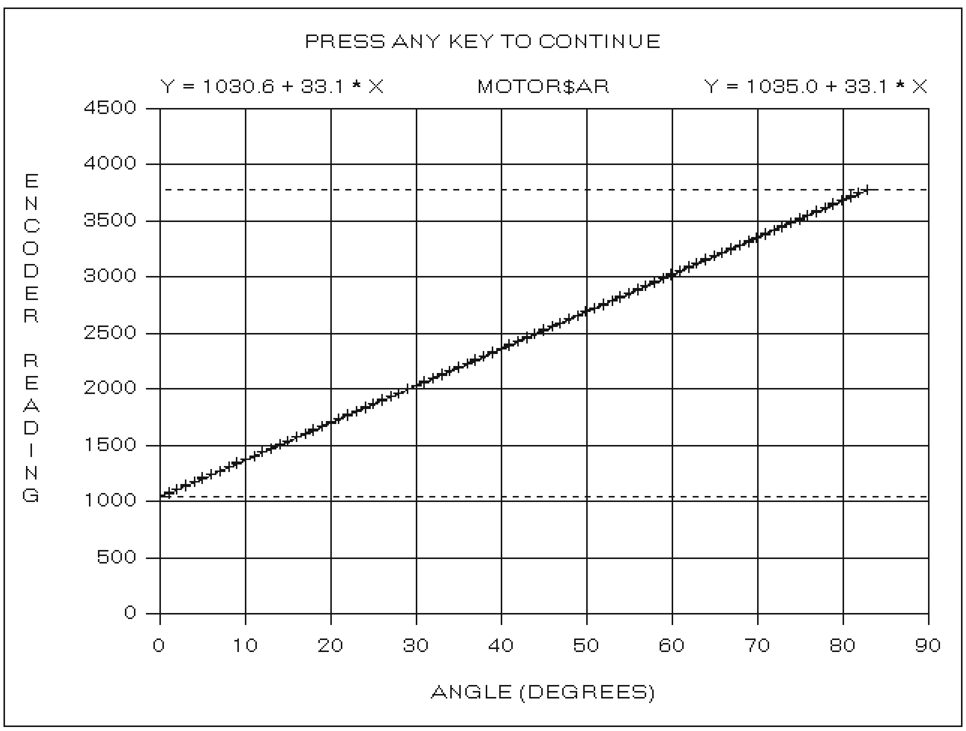
The program then switches to graphics mode and draws the Encoder Vs. Angle calibration grid. It steps the AR motor clockwise in 1° increments until the motor reaches the 83° position and then steps the AR motor counter clockwise in 1° increments until the motor return to approximately 0°. The program plots the encoder data during the scan (in raw encoder units, 0-4095).

Note: Press **<ESC>** anytime during the scan to abort the calibration procedure.

When the calibration scan completes, the program computes the linear fits to the positive and negative rotation. The linear fit parameters are displayed at the top left and top right of the plot in the form Y = Intercept + Slope * X. The two slope values should be within 0.1 of each other.

The program displays the positive and negative limits as horizontal dashed lines

Note: The *PosLimitOffset* and *NegLimitOffset* entries in the *[ArMotor]* section of the *SQDRIVER.INI* file determine the motion limits relative to the mechanical stops. If these entries are not present, or are zero, the motion limits are set to the mechanical limits.



The program then changes the plot title to:

PRESS ANY KEY TO CONTINUE

17. Press the **<Enter>** key and the program prompts:

```
motor_direction=0
calibrate_position=1,50771,5601,2747,4980,1035,265,3831
pos_limit_position=5069
neg_limit_position=-1395
Update Driver INI-File [Y/N] ?
```

For information about calibration parameters, see "Calibration Parameters" on page 4-25.

18. Type **Y<Enter>** to accept the calibration values or **N<Enter>** to reject them.
19. Exit SQDRIVER by typing exit and clicking Return.

4.6.0.5.1 Calibration Parameters

The **motor_direction** field determines whether the positive step direction is the *reverse* of the direction of increasing encoder values ('0' if the direction is *not* reversed, '1' if it is). This value is set from the corresponding parameter in the MOTOR_AR.PRO file and is a constant for each motor (i.e., the direction of increasing encoder values must agree with the system coordinates and the positive step direction is set by the wiring harness for the stepper motor).

The eight **calibrate_position** fields are:

1) **1** (Tolerance). The ± position tolerance, in encoder ticks, for absolute moves. The calibration program sets this field to the value found in the corresponding **calibrate_position** field in the MOTOR_AR.PRO file.

2,3) **50771,5601** (NumberOfSteps,StepDistance). The number of motors steps corresponding to the step distance in minutes of rotation. The ratio of these two numbers determines the step size. The calibration program calculates these fields based on the measurements of the 0° and 83° positions.

4,5) **2747,4980** (NumberOfTicks,TickDistance). The number of encoder ticks corresponding to the tick distance in minutes of rotation. Again, it is the ratio of these two numbers that determines the encoder calibration. These numbers will generally change from calibration to calibration (although the ratio should remain approximately the same).

6) **1035** (EncoderOffset). The value subtracted from the encoder readback to set the origin of motion. The origin of AR motion is the 0° position, so this value is the encoder reading at 0°.

7,8) **265,3831** (NegLimit,PosLimit). The encoder readings for the negative (counter clockwise, or AP) and positive (clockwise, or LATERAL) mechanical stops.

The **pos_limit_position** and the **neg_limit_position** are the limits of motion, in minutes of rotation, in the clockwise and the counter clockwise direction

Note: The *PosLimitOffset* and *NegLimitOffset* entries in the *[ArMotor]* section of the *SQDRIVER.INI* file determine the motion limits relative to the mechanical stops. If these entries are not present, or are zero, the motion limits are set to the mechanical limits, as in the above example.

Note: The last calibration scan data is saved in the file **MOTOR_AR.DAT**. You can re analyze the data–e.g., after editing *SQDRIVER.INI*–by typing the command **CALIBRATE @MOTOR_AR.DAT<Enter>** at the MOTOR$AR> prompt in SQDRIVER.

4.7 Laser Positioning Offset Adjustment

The laser of the Discovery is used to correctly position the C-Arm over the patient. Improper adjustment can cause improper detector flattening and may force the operator to reposition the scan more frequently than necessary.

1. Center the table, turn on the laser, and set the point of a sharp metallic object on the crosshair
2. At the QDR Main Menu screen, click the **Perform Exam** button, create a test patient biography, and select **AP Lumbar** as the scan type. (DO NOT use the spine phantom biography as a patient.) Uncheck the **Use Default Scan Mode** check box and click **Next**. Select **Array Mode** and click **Next**.
3. Click the **Start Scan** button.
4. After scan starts and you can see the metallic object, click the **Reposition Scan** button.
5. Using the mouse, move the image so that the tip of the metallic object is in the horizontal center of the scan area and touching the bottom edge of the scan area.
6. Click the **Restart Scan** button and let the arm reposition.
7. At the **Start Scan** screen, click the **Cancel** button.
8. Turn on the laser.
9. Locate the 3 laser adjustment screws (small Phillips) under the C-arm. Adjust these screws to tilt the assembly until the laser crosshair is on the tip of the pointed object.
10. Run another scan to check your adjustments.

4.8 A/D Gain Control Adjustment

An A/D gain adjustment potentiometer ensures that all systems have the same input to the A/D converter regardless of slight variations in X-ray flux. The location of the potentiometer depends on the system configuration:

- On systems with a separate A/D Converter board, the adjustment is the only potentiometer on the A/D Converter board.

- On systems without a separate A/D Converter board, the adjustment is the only potentiometer on the X-Ray Detector assembly.

Caution: Any adjustment of this potentiometer affects the QC highs and lows. You must run detector flattening after adjusting the A/D gain. **DO NOT ADJUST THE A/D GAIN UNLESS ABSOLUTELY NECESSARY AS DEFINED BY “Check and Verify the A/D Gain” on page 4-27.**

4.8.1 Check and Verify the A/D Gain

1. Install all system covers that are normally in the X-ray beam.
2. Install the table pad onto the table.
3. Start the QDR/APEX software in Service mode.
4. On the QDR/APEX main screen, select **Utilities|Service Utilities|X-Ray Survey**.
5. Set **Pulse** to 1, press <ALT><P>.
6. Set
   a. Hi Gains to **2.**
   b. Lo Gains to **1**.
   c. X-ray Mode to **3**.
   d. Aperture to **7**.
5. Press **<Enter>**.
6. Display the X-Ray Survey bar graph, press <Ctrl><Page Down>.
7. Observe Hi Air, press <Alt><S>.
8. Turn on X-rays, press <F1>.
9. Verify that the average X-ray signal level is 6.25V and that all detectors are within the 4.5V to 8.5V range. If these conditions are met, the procedure is complete. Do not adjust the A/D gain.

   If these conditions are not met, continue to “Adjust the A/D Gain” on page 4-27.

4.8.2 Adjust the A/D Gain

Caution: Do not adjust the A/D gain unless absolutely necessary as defined by **“Check and Verify the A/D Gain” on page 4-27**.

1. Adjust the A/D gain potentiometer to achieve an average X-ray signal of 6.25V.
2. Check that all detectors are within a range of 4.5V to 8.5V.
3. Perform the Detector Flattening procedure described in “Detector Flattening ” on page 4-29.

4.9 Filter Drum Encoder Alignment

1. Attach Ch1 probe to SEGMENT test point (TP3) on the C-Arm Interface board.
2. Attach Ch2 probe to BRASS test point (TP2) on the C-Arm Interface board.
3. Connect probe to ground.
4. Go to X-Ray Survey and turn on the Filter Drum motor.
5. As the filter drum motor turns on and rotates look on the C-Arm Interface board.
   a. The yellow “Index” LED blinks (on then off) as the Index mark passes the optical interrupter.
   b. Verify the green “Top of Drum” and “Brass on Top” LED (D8) blink as the drum spins.
   c. The green “AC Lock” LED (D7) lights (steady, not blinking) after a few revolutions of the drum.
6. Measure from the rising edge of the BRASS to the rising edge of the SEGMENT (it does not matter which edge leads). The time measured must be less than 500 µs (500 µs = 0.5 ms). See Figure 4-8 and Figure 4-9.

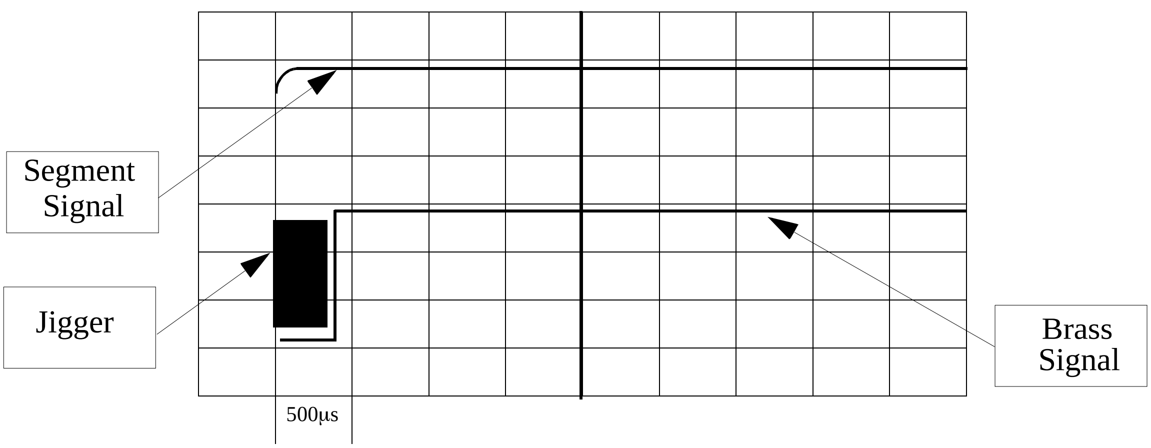


Figure 4-8 Trigger on CH1

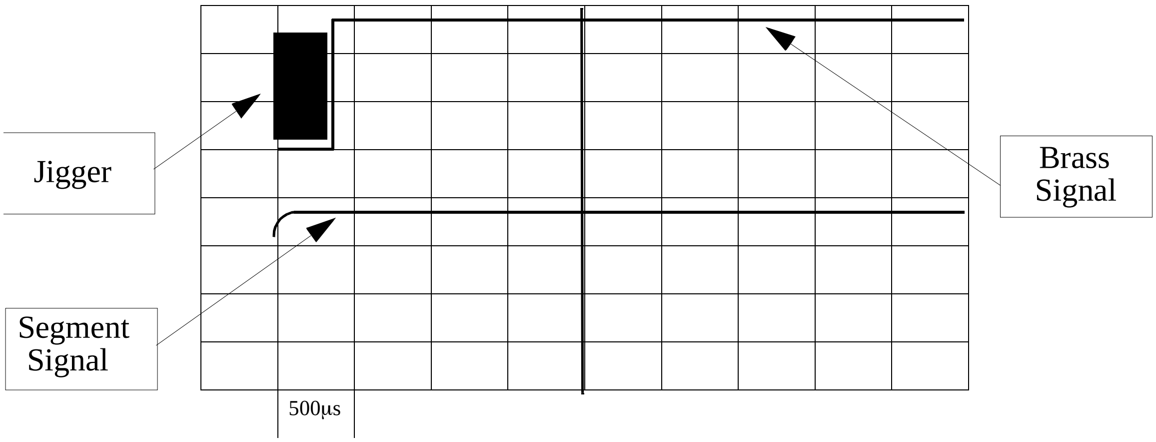


Figure 4-9 Trigger on CH2

4.10 Detector Flattening

WARNING:	X-rays are being generated during this procedure. Keep hands, head and other body parts out of beam.

This procedure flattens the X-ray beam for each scan mode and finds the metal edge of the table.

Note: All covers, table mat, etc., normally in the X-ray path, MUST be on the Scanner before running Beam Flattening.

1. Restart the Discovery software in service mode (if not already). Press the **Center Table** button and turn on the laser.
2. If you are using an Anthropomorphic Spine Phantom (resembles vertebral bodies, Part Number 030-1967), place the phantom on end (vertical) with the spinal processes pointing towards the head end of the table. The laser crosshair should be 1.5 inch in from the left end and centered. (Some phantoms will have a target hole, if not, use a ruler).

   If you are using a DXA Quality Control Phantom (aluminum representation of vertebral bodies, Part Number ASY-01564), place the phantom on its end with the flattening target facing up. Orient the phantom so the metal edge is to the right (head end) and tissue to the left (foot end) as viewed from the front of the table. Align the phantom flattening target to the laser crosshair.
3. Start the X-Ray Survey Utility by selecting **Utilities/Service Utilities/X-Ray Survey** (see “X-Ray Survey” on page 9-1 for information on the utility).
4. Set **Pulse** to 1, **High gain** to 2, **Low gain** to 1, **X-ray Mode** to 3 and **Aperture** to 7.
5. For **Display**, click **Graph**.
6. Click **X-Rays (F2)** to turn X-Rays on.

7. Check that phantom covers the whole beam. This is critical. If phantom does not cover the whole beam, move it until it does. Keep the phantom as straight as possible.
8. Turn off X-rays with the **<F2>** key and press **<Esc>** to exit X-Ray Survey. Reboot the PC, logon as Field Service, and restart the software in Service Mode to return to Discovery Main Menu screen.
9. Select **Utilities|Service Utilities|Detector Flattening**. Click the Continue button. This procedure can takes about 10 minutes on a C or W model and 50 minutes on an A or SL.
10. When flattening is complete, run a QC scan and cancel adding it to the QC plot.
11. Use the Scan File Plot utility to check X-ray beam flatness of the QC scan performed in Step 10.

4.11 Lateral Alignment Test (QDR 4500A and SL)

This procedure applies to A and SL systems only. Use this procedure to verify lateral alignment.

This procedure verifies lateral alignment.

1. On the control panel press Center to move the table and C-Arm to the center position.
2. On the control panel press Laser on the control panel to turn the laser light on.
3. Place the spine phantom on the table top with its laser target towards the left (foot end) and the vertebrae to the right (head end).
4. Align the phantom so that the laser crosshair is on the phantom laster target. Using the laser as a guide, adjust the phantom to be parallel to the table edges (just like when performing a QC scan).
5. On the APEX/QDR main screen, select Perform Exam.
6. Create a test patient biography.
7. Select OK at patient Confirmation Screen.
8. On the Select Scan Type screen select AP/Lateral Pair. Uncheck Use Default Scan Mode and click Next.
9. Select Array and click next.
10. On the Select Lateral Scan Mode screen select Array and click Next.
11. Verify the alignment of the spine phantom to the laser.
12. Change Scan Length to 6.0 inches and click Start Scan to perform the AP scan.
13. When scan has finished, select Spine as the analysis method, and click Next.

14. Analyze the scan, and click Start Position. At the bottom of screen verify that the centerline angle is ± 2 degrees. If OK, go to the next step. If not OK, restart the procedure (go back to Step 1), being careful to align the phantom properly to the laser.

15. If you are using an Anthropomorphic Spine Phantom (looks like actual bones, Part Number 030-1967), skip this step.

If you are using a DXA Quality Control Phantom (does not look like actual bones, Part Number ASY-01564), place 2 sheets of paper along the left and right edges of the phantom as shown in Figure 4-10.

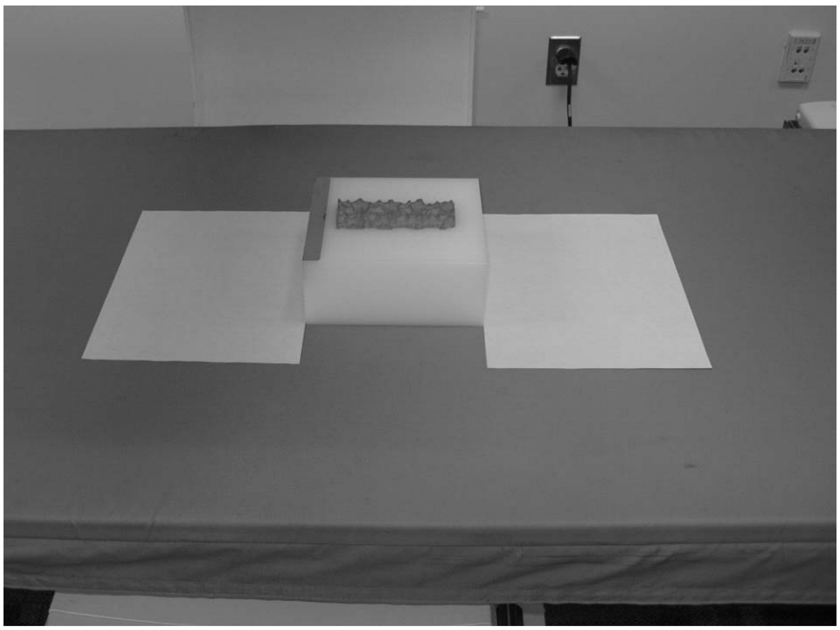


Figure 4-10.

Next, rotate the phantom "bone" segments towards the front of the scanner as shown in Figure 4-11. Be careful to keep the phantom left and right edges parallel to the sheets of paper.

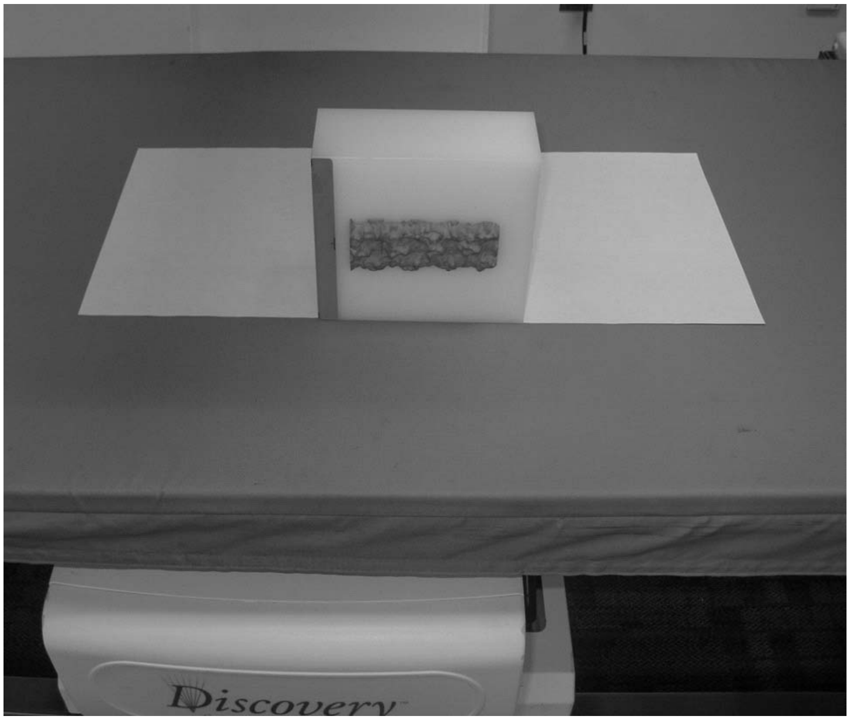


Figure 4-11.

16. Click close, and then hold the Enable Lateral switch on the control panel to move the system to the lateral position.
17. Click Start Scan to perform the lateral scan.
18. When the scan has finished, press and hold the Enable Lateral switch to return the system to AP position.
19. Analyze the lateral scan (refer to User Guide for instructions if necessary). When done, click Close.
20. At the Exit Analysis screen select Report. Print a report of the procedure just performed, and include the report in the paperwork being returned to Hologic.

4.12 Table Top Radiographic Uniformity

This procedure verifies proper X-ray beam alignment (for Discovery A and W):

1. Restart the Discovery software in service mode (if not already).
2. Type **WBAIRQC** in the Patient Biography. Enter the serial number of the unit in the Patient ID field.

   Make sure that only the pad is on the table. Clear the table of anything else.

3. Perform one Whole Body *air* scan (a scan with nothing on the table). Do NOT interrupt the scan for any reason. Select **Exit Exam** when complete. Do not analyze the scan you just performed.
4. From the Discovery Main Menu screen, select **Utilities|Service Utilities|Table Top Radiographic Uniformity**.
5. Select the Whole Body scan and click the **Next>** button.
6. Table Top Radiographic Uniformity results tabs are now displayed. Select the **Low Air** Tab.
7. **If the Global Stats S.D. (2) is less than 2.0, the instrument is properly aligned**. Print a copy of the test results and include it with the other paperwork being returned to Hologic.

If the Global Stats S.D. is greater than or equal to 2.0, then the machine is not aligned properly. Check the following:

- If the image appears "streaky" or "banded", check for loose wires or other debris between the table and the tank.
- Check the "Aperture Calibration " on page 4-9.
- Check AC Line voltage.
- Check +/- 15V Power Supply
- Check "Detector Flattening " on page 4-29.
- Re-run daily QC (see the *Discovery User's Guide).*

After realignment, repeat the Table Top Radiographic Uniformity test. If the global S.D. is less than 2.0, print a copy of the test results and include it with the other paperwork being returned to Hologic.

If the global S.D. if equal or greater than 2.0, the non-uniformity may be attributed to the table itself. If so, continue with this procedure. Make sure that the machine has body composition loaded. If it does, then follow the appropriate procedure in 4.12.1 or 4.12.2.

4.12.1 Instruments using Body Composition Analysis (BCA)

Instrument performing BCA must have a global S.D. of less than 2.0. If the realignment and recalibration procedures above have been performed and an S.D. of less than 2.0 cannot be obtained, then the tabletop must be replaced.

Note: Archive the airscans you have acquired and either e-mail or FEDEX them to a Technical Support Specialist at Hologic headquarters for final evaluation.

4.12.2 Instruments using BMD Whole Body Analysis

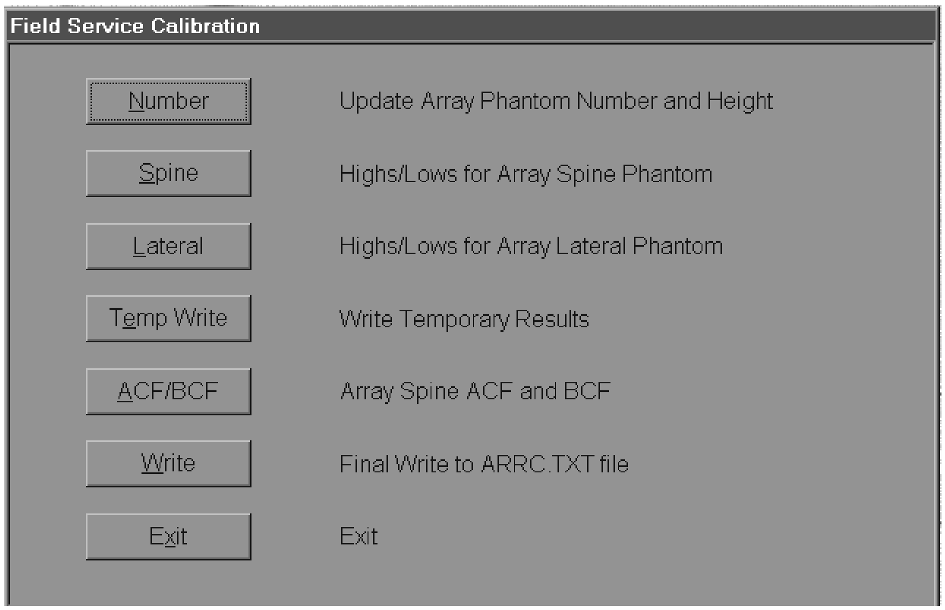
Instruments using only BMD Whole Body measurements can tolerate a larger S.D. If the global S.D. is less than 3.0, then you are done. If the S.D. is equal or greater then 3.0, then the tabletop must be replaced.

Note: Archive the airscans you have acquired and either e-mail or FEDEX them to a Technical Support Specialist at Hologic headquarters for final evaluation.

Note: If the customer is upgrading to the Body Composition Analysis option, you must follow the procedure and meet the requirements in 4.12.1.

4.13 Check Phantom values

1. From the Discovery Main Menu screen, select **Utilities|Service Utilities|Field Service Calibration**.
2. Click the **Number** button.



3. Compare values displayed with actual values printed on the phantom. If there is a discrepancy, check to make sure you have the phantom that shipped with the unit. Check with Hologic Technical Support if needed.

4.14 Area, BMD, and BMC Calibration

Calibration for Area, BMD, and BMC is accomplished in 3 stages:

a. Array Scan Thickness Measurement & Calibration
b. Calibration of Area and BMC for Array Scan Modes
c. Adding Array AP scans to the QC database

Follow the procedure, in order, and exactly as shown, for each stage of the calibration.

Note: If the Discovery being installed is to replace an existing QDR (model 2000*plus*, 2000, 1500, 1000*plus*, 1000 or 1000/W), then a cross-calibration must first be performed to ensure that any longitudinal studies begun on the QDR being removed can safely be continued on the new Discovery. *Perform the cross-calibration before de-installing the existing QDR.* (Refer to QDR 1000-4500 Upgrade Procedure, 080-0767 for complete instructions.)

Note: To ensure stability, the instrument must be completely powered up for a minimum of *30 minutes* prior to running any of the following tests. Also, because the tabletop pad will have a slight affect on the test results, all scans *must* be performed with it in place.

WARNING:	X-rays are produced during most of these tests. Keep hands, head and other body parts out of the X-ray beam path. The tester should also be wearing an approved radiation dosimetry badge.

4.14.1 Scan Thickness Measurement & Calibration (C and W)

1. Press the Center Table button.
2. Turn on the laser.
3. With the laser on, place the phantom so that the laser dot is on the centerline of the phantom, 1/2" from the left end, shining on the phantom target. The sides of the phantom should be aligned parallel to the table, using a ruler if necessary.
4. Be sure the spine phantom has been entered in the patient database in the form of "Spine Phantom #*nnnn*" (where *nnnn* is the number of the phantom) so that the QC plot program can identify it properly.
5. From the Discovery Main Menu screen, select **Perform Exam**, select the **Spine Phantom**, and click the **OK** button at Patient Information dialog box.
6. Select **AP Lumbar Spine**, uncheck default scan check box, and click the **Next>** button.
7. Select **Array**, click the **Next>** button, set the scan length to **6** inches, and start the scan.
8. Analyze the scan and click the **Close** button to exit the Analysis screen.
9. Start the Field Service Calibration program by selecting **Utilities|Service Utilities|Field Service Calibration** from the Discovery Main Menu screen.
10. Select the Spine Highs/Lows for Array Spine phantom option to automatically calculate the new thickness indicators for array spine.
11. Select the Spine Phantom scanned in step 6 from the list of Analyzed Scans and click the **Next** button. Click the **Continue** button on the Successfully Calculated message box.
12. Click on the Temp Write button and click the Continue button on the Successfully Wrote message box. Exit Field Service Calibration.

4.14.2 Scan Thickness Measurement & Calibration (A and SL)

1. From the QDR For Windows perform exam button, select the spine phantom to be used for checking the array scan modes. This should be the one shipped with the machine.

   Note: Be sure the spine phantom has been entered in the patient database in the form of "Spine Phantom #nnn" (where nnn is the number of the phantom) so that the QC plot program can identify it properly.

2. Center the table, place the phantom on the table and set up a exam using the AP/ Lateral setup, uncheck the use default scan mode box, click next, select Array scan mode for the AP component and Fast Array for the Lateral component. The sides of the phantom should be aligned parallel to the table, using a ruler if necessary.
3. Press and hold Enable until the arm and table move into position. Recheck phantom alignment with laser, and click **Continue**.

   Note: Do not move the arm or table, otherwise the test will have to be started over.

4. Change the scan length to 6 inches, and click start scan to begin the AP component.
5. When scan has finished, select Spine as the analysis method, and click **Next**.
6. Analyze the scan, and click start position. Check at bottom of screen that the centerline angle is + or - 2 Degrees.
7. Click close, and then hold the enable button to lateral position.
8. Click Start Scan to perform Lateral component.
9. Press and hold the Enable switch to return to AP position.
10. Analyze scan (refer to user guide for Lateral analysis) and close the screen.
11. Click exit to close the Exit Analysis screen.
12. Restart QDR for Windows software in service mode (if not already). From the QDR Main window, select Utilities, Service Utilities, Field Service Calibration.
13. Select Highs/Lows for Array Spine Phantom
14. Select the AP scan just performed and click **Next.**
15. Click continue on the Calculated highs and lows page.
16. Select Highs/Lows for Array Lateral Phantom.
17. Click continue on the Calculated highs and lows page.
18. Click Temp Write to write temporary results and click continue to exit the write dialog box.

4.14.3 Calibration of Area and BMC, for Array Scan Modes

After the machine has been calibrated for thickness measurement in the array mode, it must be calibrated for the array AREA and BMC measurements.

1. Restart the Discovery software in service mode (if not already). Center the table. From the Discovery Main Menu screen, select **Utilities|Service Utilities|AP Reposition**. Return to the menu and select **Utilities|Service Utilities|Auto Scan**.
2. Select the Spine Phantom.
3. Click **OK** at Patient Confirmation dialog box.
4. Select AP Lumbar Scan Type, input **20** for number of scans, uncheck Use Default, and click the **Next** button.
5. Select Array and click the **Next** button.
6. Analyze the first scan manually. Note the scan #. Click the **Close** button to exit analysis.
7. From the Discovery Main Menu screen, select **Utilities|Service Utilities|Auto Analyze**.
8. Click on unanalyzed Scans and select the 19 scans, click on **Compare** radio button and then click the **next** button.
9. Now, select the scan analyzed in step 6 and click the **next** button.
10. The 19 scans will now be compared with the analyzed scan.
11. From the Discovery Main Menu screen, select **Utilities|Service Utilities|Field Service Calibration**.
12. Click the **ACF/BCF** button. Select the 20 scans, click **next**, and then click **Continue** at the Successfully Calculated dialog box.
13. At the Field Service Calibration dialog box, click the **Write** button to write the values to ARRC.TXT file. Click the **Continue** button to return to the Discovery Main Menu screen.
14. Print ARRC.TXT file by using these steps:
    - Press the **<Ctrl><Esc>** keys to bring up the WindowsXP Taskbar.
    - Select **Find**
    - Select **Files or Folders**
    - Type **ARCC.TXT** in the **Named:** edit box.
    - Click **Find Now** or simply hit the **<Enter>** key.
    - Right click on the first ARRC.TXT entry in the list presented to you and select **Print** from the menu. (You want the ARRC.TXT entry in the QDR\DATA directory NOT the QDR\DATA\LRTEMP directory.)
15. Verify ACF=ACFL=ACFT and BCF=BCFL=BCFT in ARRC.TXT.

4.14.4 RECALYZE and Add Array AP Scans to the QC Database

Once the unit has been calibrated, AP scans must be re-analyzed and added to the QC database.

After the machine has been calibrated for thickness measurement in the array mode, it must be calibrated for the array AREA and BMC measurements.

1. From the Discovery Main Menu screen, select **Utilities|Service Utilities|Auto Analyze**.
2. Select Analyzed scans, click **RECALYZE**, and select the 20 scans just acquired and click the **Next** button.
3. . The scans will now be recalculated to the new calibration.
4. Highlight the scans from the Excluded list and click the **Include Scans** button and then the **Finish** button. (Selection is easier if you click Scan Date bar above the list. This will order the scans by date and time).From the Discovery Main Menu screen, select **QC|QC Data Management|Select Scans**.
5. From the Discovery Main Menu, select the **QC|QC Data Management|Plot** to create plots for BMD, BMC, AREA, HiAir, and LoAir plot for each array mode. Verify that the QC plots inlcude QC scans from at least the last two years.
6. Ensure that all scans fall between the two, dotted limit lines.
7. Print the BMD, BMC, Area, HiAir, and LoAir plots. Include them with the other paperwork being returned to Hologic.

Note: For more details on performing the QC setup and producing QC plots, refer to the Discovery User's Guide.

Sample HARDWARE.INI (Calibration) File

HARDWARE.INI Variables	Set by…	Descriptions
[Version]		.INI File Section Name
HardwareModel=14	Factory	Discovery model (C=20, W=21, A=23, SL=22).
[Laser]		
LaserYOffset=-38100	Factory	Laser Offset Value
[TxMotor]		
PosLimitPosition=409575	Factory	Positive limit in microns (= 16 1/8 inches)
SpineInitPos=208000	Factory	TX center position in microns (= 8.18 inches)
MaxSpinePos=233400	Factory	+ Limit for spine placement
MinSpinePos=182600	Factory	- Limit for spine placement
PatientUnloadPos=0	Factory	Table position for unloading patients
APLatDiff=376200	Factory	AP/Lateral Difference
MaxTrackOffset=25400	Factory	

LocalMotionMax=465000	Factory	Max table position using Control Panel
LocalMotionMin=0	Factory	Min table position using Control Panel
LocalMotionHomePos=208000	Factory	X Center table position using Control Panel
ScanPosTolerance=25400		+/- Tolerance for Scan X Position (1 in)
[TyMotor]		
SpineInitPos=503175	Factory	TX center position in microns (= 8.18 inches)
FlatPos=503175	Factory	TX position for Detector Flattening
LocalMotionPos=503175	Factory	Y Center table position using Control Panel
ScanPosTolerance=25400	Factory	+/- Tolerance for Scan Y Position (1 in)
[TzMotor]		
SpineInitPos=500	Factory	TZ Start Position (AP)
LatInitPos=98425	Factory	TZ Start Position (LAT)
LocalMotionPos=500	Factory	TZ Center Positioning Control Panel
PatientUnloadPos=500	Factory	Patient Unload Position
ScanPosTolerance=3175	Factory	+/- Tolerance for TZ
[AyMotor]		
SpineInitPos=460000	Factory	C-Arm scan start position
FlatPos=510000	Factory	Detector flattening start position
FlatMoveDist=25400	Factory	Detector flattening move distance
LocalMotionHomePos=460000	Factory	Center C-Arm position
YTiltOffset=-127000	Factory	
TBarStartPos=152400	Factory	Tissue BAR Start Position
[ArMotor]		
SpineInitPos=500	Factory	Spine Initial Position
LateralInitPos=4980	Factory	Lateral initial Position
ScanPosTolerance=60	Factory	+/- Tolerance for Scanning
LocalMotionMax=60	Factory	Not Max Talerance for Center
LocalMotionMin=-60	Factory	Min Center Position Tolerance
[Gain]		Collimator & gain selection
SpineHiGain=3,3	Factory	
SpineLoGain=3,3	Factory	
SpineHiGain=6,3	Factory	
SpineLoGain=6,2	Factory	
SpineHiGain=7,2	Factory	
SpineLoGain=7,1	Factory	
SpineHiGain=8,1	Factory	

SpineLoGain=8,0	Factory	
SpineHiGain=10,2	Factory	
SpineLoGain=10,1	Factory	
DecubHiGain=3,3	Factory	
DecubLoGain=3,3	Factory	
HipHiGain=6,3	Factory	
HipLoGain=6,2	Factory	
HipHiGain=7,2	Factory	
HipLoGain=7,1	Factory	
IVAHiGain=6,1	Factory	
IVALoGain=6,1	Factory	
[Flattening]		
DailyFlatFile=FLT721NA.DCL	Automatic	
[Aperture]		Size Parameters: Number, Length, Width
Size=0, 2.510, 0.04	Factory	
Size=1, 2.510, 0.04	Factory	
Size=2, 2.510, 0.04	Factory	
Size=3, 2.510, 0.04	Factory	
Size=4, 2.510, 0.04	Factory	
Size=5, 2.510, 0.04	Factory	
Size=6, 2.400, 0.04	Factory	
Size=7, 2.400, 0.02	Factory	
Size=8, 2.510, 0.04	Factory	
Size=9, 2.510, 0.04	Factory	
Size=10, 2.510, 0.04	Factory	
Size=11, 2.510, 0.04	Factory	
Size=12, 2.510, 0.04	Factory	
Size=13, 2.510, 0.04	Factory	
Tolerance=10		+/- Tolerance to center of aperture
Slot=0, 4439	Factory	Number and distance to center of aperture
Slot=1, 4139	Factory	
Slot=2, 3679	Factory	
Slot=3, 3464	Factory	
Slot=4, 3099	Factory	
Slot=5, 2904	Factory	
Slot=6, 2524	Factory	

Slot=7, 2329	Factory	
Slot=8, 1919	Factory	
Slot=9, 1704	Factory	
Slot=10, 1324	Factory	
Slot=11, 1109	Factory	
Slot=12, 649	Factory	
Slot=13, 349	Factory	
SlotOff=0, 3909	Factory	Number and Position “Off Aperture”
SlotOff=1, 3909	Factory	
SlotOff=2, 3281	Factory	
SlotOff=3, 3281	Factory	
SlotOff=4, 2714	Factory	
SlotOff=5, 2714	Factory	
SlotOff=6, 2124	Factory	
SlotOff=7, 2124	Factory	
SlotOff=8, 1514	Factory	
SlotOff=9, 1514	Factory	
SlotOff=10, 879	Factory	
SlotOff=11, 879	Factory	
SlotOff=12, 174	Factory	
SlotOff=13, 174	Factory	
[Attenuator]		
Tolerance=15	Factory	+/- Tolerance for Attenuator Blocks
Block=0,4038	Factory	Attenuator Block Number and Distance
Block=1,3809	Factory	
Block=2,3559	Factory	
Block=3,3309	Factory	
Block=4,3059	Factory	
Block=5,2809	Factory	
Block=6,2559	Factory	
Block=7,2309	Factory	
Block=8,2059	Factory	
Block=9,1809	Factory	
Block=10,1559	Factory	
Block=11,1309	Factory	
Block=12,1059	Factory	

Block=13,809	Factory	
Block=14,559	Factory	
Block=15,309	Factory	
[HeatUnits]		
BDelay=30	Factory	Boot Up Delay
MaxVHU=70000	Factory	Maximum Vinnie Heat Units
CoolRate=250	Factory	Cooling Rate of VHU
Vhus1=90	Factory	X-Ray Mode 1
Vhus2=250	Factory	X-Ray Mode 2
Vhus3=300	Factory	X-Ray Mode 3
Vhus4=120	Factory	X-Ray Mode 4
Vhus5=90	Factory	X-Ray Mode 5
Vhus6=2100	Factory	X-Ray Mode 6
Vhus7=700	Factory	X-Ray Mode 7
Vhus8=1000	Factory	X-Ray Mode 8

Sample ARRC.TXT (Array Calibration) File

ARRC.TXT Variables	**Set by…**	**Descriptions**
USE = 0	Factory	A variable used by the software to determine what parameters to use for scatter correction. It can be set to one of four possible values (0, 1, 2, or 3) but should always be set to 0.
Q4 = 0.651 1.013 1.461	Factory	These numbers are used for all array modes. The numbers are determined by measuring a three-step (thin, medium, and thick) block phantom at the factory.
Q4_HAT = 0.617 0.980 1.445	Factory	Similar to Q4, except the measurements are taken on the Step phantom with extra absorber material placed on top of it.
T4 = 2.628	Factory	Thickness (height in inches) of the block phantom.
T4_HAT = 7.00	Factory	Thickness (height in inches) of the block phantom with extra absorber.
DELTA0 = 0.493	Factory	Thickness of tissue segment in the filter wheel.
T0_N = 6.85	Fact. or F.S.	Overall height of the phantom (in inches) shipped with the Discovery. (Varies with each phantom.)
HIA_N = 1305.39	Automatic	Hi Air,
LOA_N = 1622.56	Automatic	Low Air,
HIT_N = 1389.09	Automatic	Hi Tissue, and

LOT_N = 1718.52	Automatic	Low Tissue attenuations values in "raw A/D" numbers. These values are used to determine the thickness of a patient being scanned in an AP array scan mode. They are updated whenever a spine array scan is added to the QC database (i.e. the daily array QC scan) or in FSCAL.
ACF = 1.021550	Fact. or F.S.	Area Correction Factor for AP Spine and Hip scans
BCF = 1.005450	Fact. or F.S.	Bone Correction Factor for AP Spine and Hip scans
SFF = 1.083600 1.095000	Factory	Spine Fan Factors
LFF = 0.943000 0.954000	Factory	Lateral Fan Factors
HFF = 1.077300 1.120000 1.077300 1.120000 1.077300 1.120000 1.077300 1.120000	Factory	Hip Fan Factors Multiplication factors for BCF & ACF array scans. These values are the same on all Discovery models.

ARRC.TXT Variables	**Set by…**	**Descriptions**
T0_NL = 6.00	Factory	Width of the phantom shipped with the discovery. This value is the same for all phantoms.
HIA_NL = 0.00	Automatic	Hi Air - Lateral
LOA_NL = 0.00	Automatic	Lo Air - Lateral
HIT_NL = 0.00	Automatic	Hi Tissue - Lateral
LOT_NL = 0.00	Automatic	Lo Tissue - Lateral
ACFL = 1.021550	Fact. or F.S.	Area Correction Factor for Lateral scans.
BCFL = 1.005450	Fact. or F.S.	Bone Correction Factor for Lateral scans.
HIA_NF = 1319.16	Factory	Hi Air,
LOA_NF = 1634.86	Factory	Low Air,
HIT_NF = 1402.73	Factory	Hi Tissue, and
LOT_NF = 1730.71	Factory	Low Tissue attenuations values in "raw A/D" numbers. Factory values for AP array scans. Used as reference for the software to determine if the Hi/Low values are out of factory range.
HIA_NLF = 0.00	Factory	Hi Air
LOA_NLF = 0.00	Factory	Lo Air
Not used in the DISCOVERY	Factory	Hi Tissue
LOT_NLF = 0.00	Factory	Lo Tissue
QC_HILO_MIN = 50.0	Factory	Day-to-day drift check warning message limit.
QC_HILO_MAX = 100.0	Factory	Day-to-day drift check error message limit.

QC_HILO_FACT_MAX = 200.0	Factory	Long-term drift check warning message limit.
QC_HILO_FACT_MIN = 100.0	Factory	Long-term drift check error message limit.
UPDATED = 06/20/94 12:00:00	Automatic	Date and time the ARRC.TXT file was last updated.
UPDATED_N =	Automatic	Date Last Updated - Normal
UPDATED_NL =	Automatic	Date Last Updated - Lateral

ARRC.TXT Variables	**Set by…**	**Descriptions**
QDR_SERIAL_NB = 80015	Factory	Serial number of the Discovery.
ARRAY_PHANTOM_NB = 1922	Fact. or F.S.	Serial number of the phantom shipped with the instrument.
ARRC_SEQUENCE_NB = 001	Automatic	Sequential number of the last ARRC.TXT file.
ACFT = 1.021550	Fact. or F.S.	Area Correction Factor for Turbo scans.
BCFT = 1.005450	Fact. or F.S.	Bone Correction Factor for Turbo scans.
SFFT = 1.083600 1.095000	Factory	Spine Fan Factors Turbo mode correction factors.
HFFT = 1.042700 1.102800 1.042700 1.102800 1.042700 1.102800 1.042700 1.102800	Factory	Hip Fan Factors Turbo mode. Multiplication factors for BCF & ACF in turbo scan modes. These values are the same on all Discoverys.
VERSION_NB = 005 3/27/95		Fan Factor Version # (same for all)
WBINTACF = 1.000		Whole Body Fan Factor Area
WBINTBCF = 1.131		Whole Body Fan Factor BMC
AWBAREA = 0.975		Whole Body Fan Factor Area
AWBBMC = 1.020		Whole Body Fan Factor BMC
AWBLEAN = 0.962		Body Composition Fan Factor lean
AWBWT = 1.01		Body Composition Total Mass
FOREAREA = 1.0		Forearm Fan Factor Area
FOREBMC = 1.0		Forearm Fan Factor BMC
HWVERSION = 14		System Hardware Descriptor
PCAL_STEP_NB = 5		PCAL Step Phantom

Section 5
REMOVE AND REPLACE PROCEDURES

This section describes how to remove and replace the Field Replaceable Units (FRUs) in the Discovery. To safely perform a FRU removal or replacement, take care to follow the procedure precisely as written.

Note: Whenever a component in the x-ray path is replaced, you must recalibrate and rerun QC.

5.1 Recommended Tools

Tool	Size/Type
Hex driver	3/32"
Hex driver or wrench	5/32"
Nut driver	1/4"
Nut driver	3/8 inch
Nut driver	5/16"
Nut driver	7/16"
Screwdriver	Narrow slotted
Screwdriver	Phillips head
Screwdriver	Slotted
Wrench	3/8 inch

ESD PRECAUTIONS: To prevent damage due to ESD (Electrostatic Discharge), you must take precautions when handling components. Remove any charge from your body by wearing an approved and properly grounded wrist strap. Keep PCBs in their ESD protective bag until you are ready to install them. Treat defective PCBs as new to prevent any additional damage.

5.2 Electronics Tray FRUS

This section describes how to remove and replace the FRUs in the Electronics Tray/Carriage Drive area of the Discovery (see Figure 5-1). To remove any of the FRUs in the Electronics Tray assembly, remove the 6 Phillips retaining screws and remove the cover. Next, remove the nut that holds the ground wire to the cover ground lug.

5.2.1 Electronics Tray Printed Circuit Boards

To remove and replace the Distribution Board, Din Rail Assembly, Low Voltage Power Supply, TZ Drive Board (A & SL only), or AY Drive Board refer to Figure 5-1 and follow the procedure below:

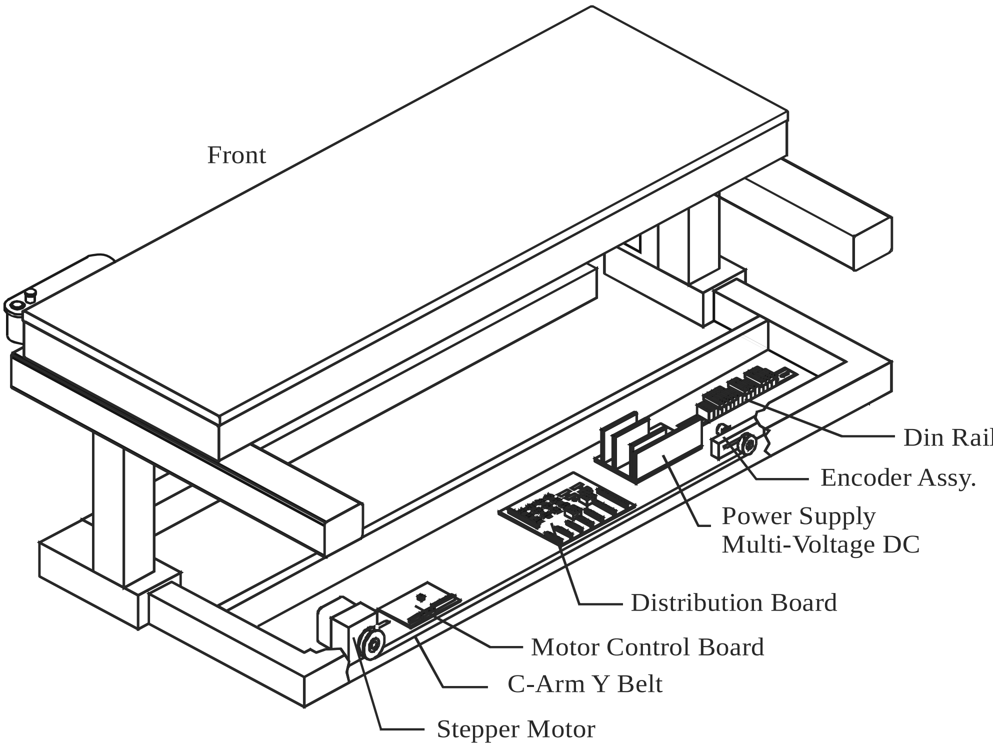


Figure 5-1. Electronic Tray FRUs

1. Move the C-arm all the way to the right.
2. Shut down the computer and then turn off the main circuit breaker on the foot end pedestal.
3. Remove the cable covers and unplug the cables on the board to be replaced.
4. To remove the board, unscrew the Phillips screws holding the board.

   Note: Some boards have standoffs and/or plastic hold-down snaps.
5. To replace the board reverse the steps.
6. Restore the motor cable shield.

   Note: When replacing the AY Motor Controller board, make sure that you set the ID switch to 7. When replacing the TZ Drive board, make sure that you set the Normal/Service switch to the Normal position.

C-Arm Y Belt

To remove and replace the C-arm Y-Belt, refer to Figure 5-1 and follow the procedure below:

1. Move the C-arm to the center of the table.
2. Shut down the computer and then turn off the main circuit breaker on the foot end pedestal.
3. At the encoder end of the belt, loosen the 2 bolts holding the tension block, remove the tensioning nut, and remove and replace the belt.
4. Install the tension spring and tensioning nut.
5. Tighten the tension nut so that the spring compresses to 7/8 inch. The bracket cut-out can be used as a measuring guide (the inside of the washer should be flush with the bracket cut).
6. Tighten the two mounting bolts holding the tension block.
7. Restore power, boot the computer and login as Service.
8. Perform the procedure in “MOTOR$AY” on page 3-35.

5.2.2 C-Arm Y Motor or Gearcase

To remove and replace the C-arm Y-Motor or Gearcase, refer to Figure 5-1 and follow the procedure below:

1. Move the C-arm to the center of the table.
2. Shut down the computer and then turn off the main circuit breaker on the foot end pedestal.
3. At the encoder end of the belt, loosen the 2 bolts holding the tension block, remove the tensioning nut and remove the belt.
4. At the motor end of the belt, remove the cable cover and unplug the motor cable from the Motor Controller Board.
5. Remove the four Allen bolts, and nuts, holding the motor and gearcase.

   Note: The two bottom nuts are accessible with a ratchet wrench and extension.
6. Remove the motor first, then the gearcase.
7. If replacing the gearcase, install the pulley from the old gearcase on the new gearcase.
8. Replace the motor and gear case assembly making sure to align the gasket correctly. Snug the Allen bolts, but do not over tighten.
9. Install the belt on both pulleys.
10. At the encoder end of the belt, install the tension spring and tensioning nut.
11. Tighten the tension nut so that the spring compresses to 7/8 inch. The bracket cut-out can be used as a measuring guide (the inside of the washer should be flush with the bracket cut).
12. Tighten the two mounting bolts holding the tension block.

13. Restore the cable shield and ground strap terminations.
14. Restore power, boot the computer and login as Service.
15. Perform the procedure in “MOTOR$AY” on page 3-35.

5.2.3 C-Arm Y Encoder

To remove and replace the Encoder, refer to Figure 5-1 and follow the procedure below:

1. Before removing power from the Discovery, remove both cable covers, unhook the center cable hold-down clip and free the encoder cable without unplugging it.
2. Move the C-arm towards the center of the Scanner (so the encoder is accessible).
3. Shut down the computer and then turn off the main circuit breaker on the foot end pedestal.
4. Unplug the encoder from the Motor Controller Board and pull out the cable.
5. Remove the coupling hardware holding the encoder to the belt drive.
6. Remove the encoder from the bracket assembly.
7. Replace the encoder on the bracket, install the coupling but do not tighten the screws.
8. Restore power, boot the computer and login as Service.
9. Perform the procedure in “MOTOR$AY” on page 3-35.

   Note: When starting this procedure, make sure the encoder coupling setscrew **is not** tightened.

5.3 Table Y FRUs (A, W and Wi Only)

This section describes how to remove and replace the FRUs associated with the Table Y motion of the Discovery (see Figure 5-2).

1. Before removing power from the Discovery, move the table to the far left using the Motor Control Pad. The Motor Control Pad can be accessed from the Discovery Main Menu screen by choosing **Utilities|Emergency Motion**.
2. Shut down the computer and then turn off the main circuit breaker on the foot end pedestal.
3. Remove 2 screws from the right table rail end cover, and slide the cover off from the end.

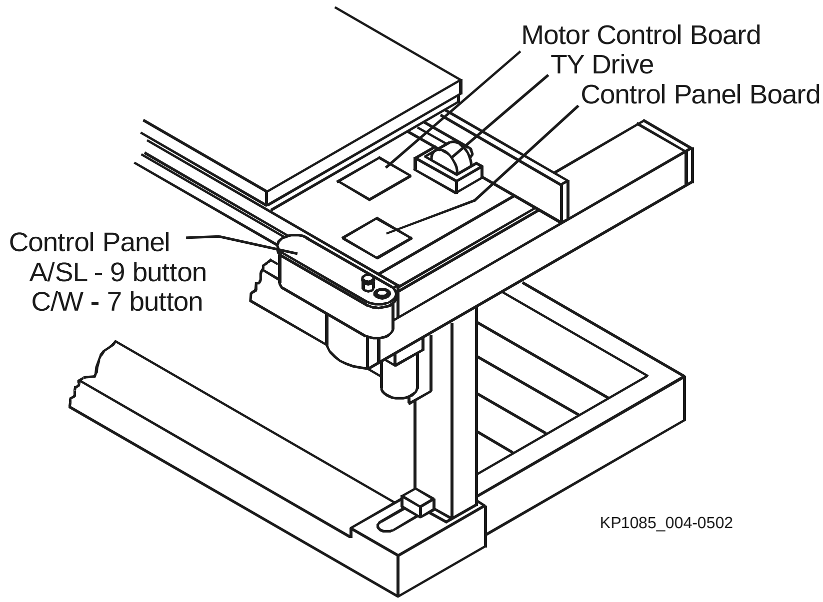


Figure 5-2. Table Y FRUs (C and W Models only)

5.3.1 Control Panel (All models)

To remove and replace the Control Panel refer to Figure 5-2 and follow the procedure below:

1. Shut down the computer and then turn off the main circuit breaker on the foot end pedestal.
2. Remove 3 screws located under the Control Panel box.
3. Unplug the cable and ground strap (from the Control Panel to the Control Panel board) on the Control Panel board and remove the panel.
4. To replace the Control Panel reverse the steps.

5.3.2 PCBs Under Right-Side of the Table

To remove and replace the boards under the table (TY Motor Controller Board or Control Panel Controller Board), refer to Figure 5-2 and follow the procedure below:

1. Unplug the cables on the board to be replaced.
2. To remove the board, unscrew the Phillips screws holding the board

   Note: Some boards have standoffs and/or plastic hold-down snaps.
3. To replace the board, reverse the steps.

   Note: When replacing the TY Motor Controller board, ensure that the ID switch is set to 5.

5.3.3 Table Y Belt

To remove and replace the Table Y-Belt, refer to Figure 5-2 and Figure 5-3 and follow the procedure below:

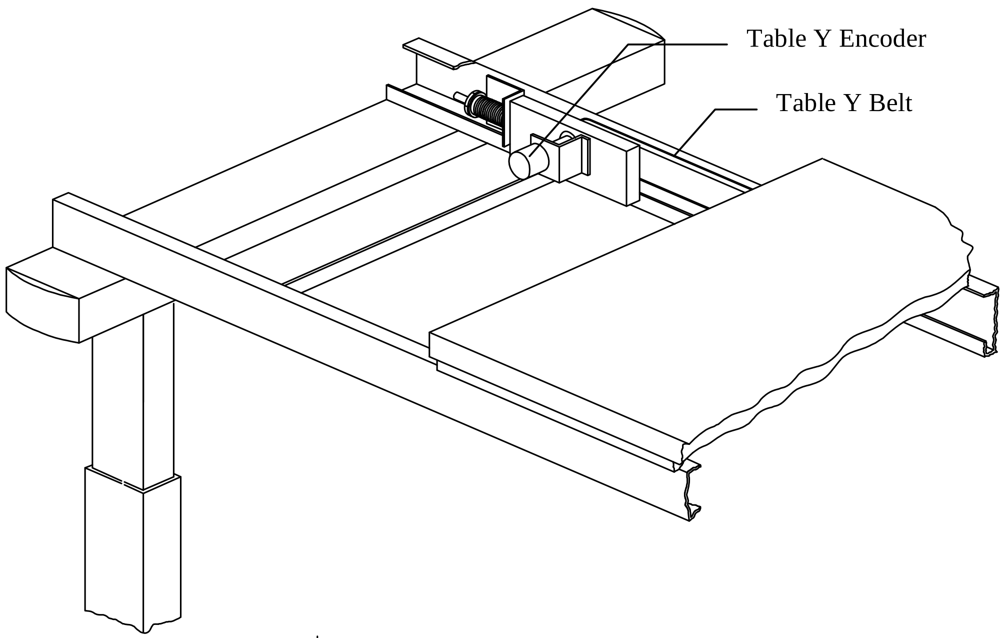


Figure 5-3.Foot End Table Y FRUs

1. Center the table and remove the two screws that secure the tabletop in place.
2. Shut down the computer and then turn off the main circuit breaker on the foot end pedestal.
3. Pull the tabletop to the left far enough to remove the right table rail end cover, and remove the cover. Mark this as the right cover so that it is not confused later with the left cover (they are not interchangeable).
4. Pull the tabletop to the right far enough to remove the left table rail end cover, and remove the cover. Mark this as the left cover so that it is not confused later with the right cover (they are not interchangeable).
5. At the encoder end of the belt, loosen the 2 bolts holding the tension block, remove the tensioning nut, and remove and replace the belt.
6. Install the tension spring and tensioning nut.
7. Tighten the tension nut so that the spring is compressed to 7/8 inch. The bracket cutout can be used as a measuring guide (the inside of the washer should be flush with the bracket cut).
8. Tighten the two mounting bolts holding the tension block.
9. Restore power, boot the computer and login as Service.

10. Perform the procedure in “MOTOR$TY (A, W and Wi models only)” on page 3-38.

    Note: When starting this procedure, make sure the encoder coupling setscrew **is not** tightened.

5.3.4 Table Y Motor or Gearcase

To remove and replace the Table Y Motor or Gearcase, refer to Figure 5-2 and Figure 5-3, perform the steps for removing the belt described above, and continue with this procedure. Perform the following:

1. Remove the Table Y Belt as described above.
2. Unplug the motor cable from the Motor Controller Board.
3. Remove the four Allen bolts, and nuts, holding the motor and gearcase.
4. Remove the motor and the gearcase.
5. If replacing the gearcase, install the pulley from the old gearcase on the new gearcase.
6. Replace the motor and gear case assembly making sure to align the gasket correctly. Snug the Allen bolts but don’t over tighten.
7. Install the belt on both pulleys.
8. At the encoder end of the belt, install the tension spring and tensioning nut.
9. Tighten the tension nut so that the spring is compressed to 7/8 inch. The bracket cutout can be used as a measuring guide (the inside of the washer should be flush with the bracket cut).
10. Tighten the two mounting bolts holding the tension block.
11. Restore power, boot the computer and login as Service.
12. Perform the procedure in “MOTOR$TY (A, W and Wi models only)” on page 3-38.

Note: When starting this procedure, make sure the encoder coupling setscrew **is not** tightened.

5.3.5 Table Y Encoder

To remove and replace the Table Y Encoder, refer to Figure 5-2 and Figure 5-3 and follow the procedure below:

1. Center the table and remove the two screws that secure the tabletop in place.
2. Shut down the computer and then turn off the main circuit breaker on the foot end pedestal.

3. Pull the tabletop to the left far enough to remove the right table rail end cover, and remove the cover. Mark this as the right cover so that it is not confused later with the left cover (they are not interchangeable).
4. Pull the tabletop to the right far enough to remove the left table rail end cover, and remove the cover. Mark this as the left cover so that it is not confused later with the right cover (they are not interchangeable).
5. Unplug the encoder from the Motor Controller Board and pull out the cable.
6. Remove the coupling holding the encoder to the belt drive.
7. Remove the encoder from the bracket assembly.
8. Replace the encoder on the bracket, install the coupling but do not tighten the screws.
9. Restore power, boot the computer and login as Service.
10. Perform the MOTOR$TY calibration procedure on page 3-38.

Note: When starting this procedure, make sure the encoder coupling setscrew **is not** tightened.

5.4 Table X FRUS

This section describes how to remove and replace the FRUs associated with Table X motion of the Discovery (see Figure 5-4).

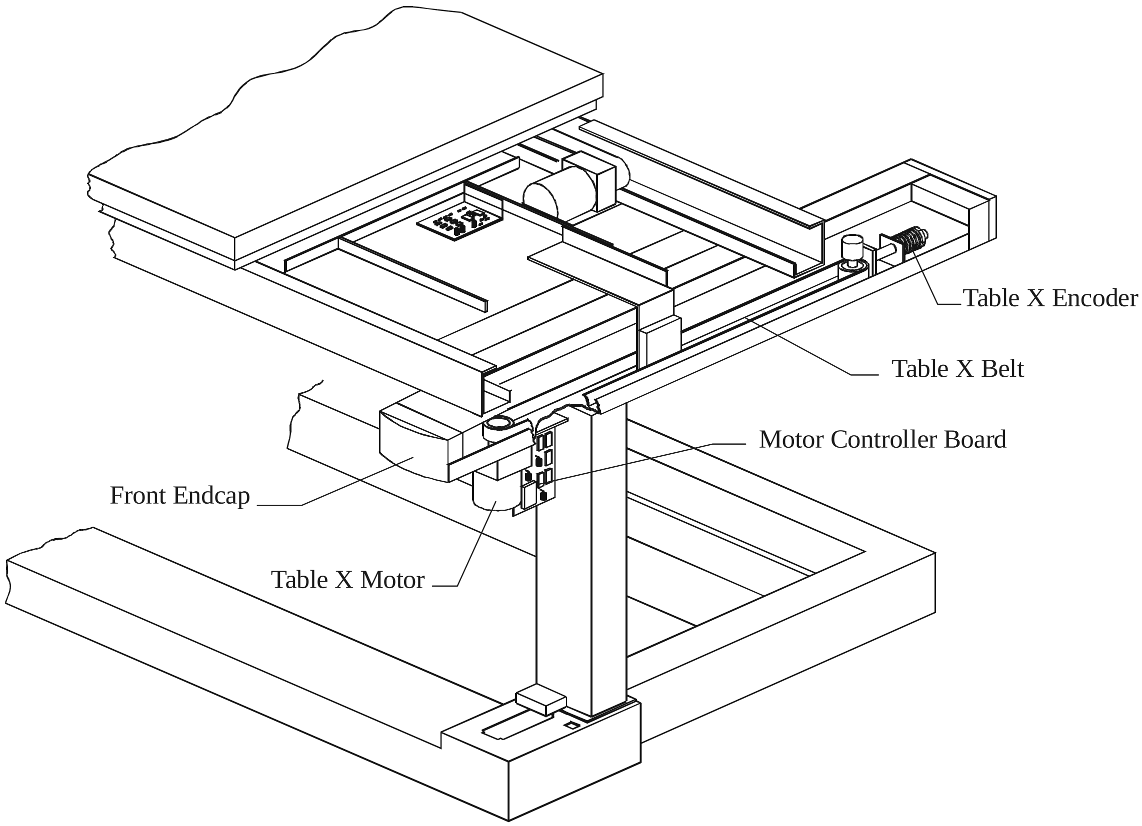


Figure 5-4. Table X FRUs

5.4.1 Table X Motor Controller PCB

To remove and replace the TX Motor Controller board, refer to Figure 5-4 and follow the procedure below:

1. Before removing power from the Discovery, move the table up as far as it will go.
2. Remove 6 flat head Phillips screws from the upper pedestal cover and remove the cover.
3. Shut down the computer and then turn off the main circuit breaker on the foot end pedestal.
4. Unplug the cables on the TX Motor Controller board.
5. To remove the board, unscrew the Phillips screws holding the board.
6. To replace the board reverse the steps.
7. Restore the motor cable shield.

Note: When replacing the TX Motor Controller board, ensure that the ID switch is set to 4.

5.4.2 Table X Belt

To remove and replace the Table X Belt located within the X Table Drive Assembly, refer to Figure 5-4 and follow the procedure below:

1. Before removing power from the Discovery, move the table to the far left using the Motor Control Pad. The Motor Control Pad can be accessed from the Discovery Main Menu screen by choosing Utilities|Emergency Motion.
2. Shut down the computer and then turn off the main circuit breaker on the foot end pedestal.
3. Remove 2 screws from the right table rail end cover, and slide the cover off from the end.
4. Remove the front endcap from the table X drive assembly (3 Phillips screws).
5. Remove the back Phillips screw from the right side cover (of the table X drive assembly) and slide the cover out from the front. This provides access to the belt.
6. At the encoder end of the belt, loosen the 2 bolts holding the tension block, remove the tensioning nut, and remove and replace the belt.
7. Install the tension spring and tensioning nut.
8. Tighten the tension nut so that the spring is compressed to 7/8 inch. The bracket cutout can be used as a measuring guide (the inside of the washer should be flush with the bracket cut).
9. Tighten the two mounting bolts holding the tension block.
10. Restore power, boot the computer and login as Service.
11. Perform the MOTOR$TX calibration procedure on page 3-40.

    Note: When starting the MOTOR$TX calibration procedure, make sure the coupling setscrew **is not** tightened.

5.4.3 Table X Motor or Gearcase

To remove and replace the Table X Motor or Gearcase, refer to Figure 5-4 and follow the procedure below:

1. Remove the Table X Belt as described above.
2. Remove 5 flat head Phillips screws from the upper pedestal cover and remove the cover.
3. Unplug the motor cable from the Motor Controller Board.
4. Remove the four Allen bolts, and nuts, holding the motor and gearcase.
5. Remove the motor and the gearcase.
6. If replacing the gearcase, install the pulley from the old gearcase on the new gearcase.

7. Replace the motor and gear case assembly making sure to align the gasket correctly. Snug the Allen bolts but don't over tighten.
8. Install the belt on both pulleys.
9. At the encoder end of the belt, loosen the two bolts holding the tension block and install the tension spring and tensioning nut.
10. Tighten the tension nut so that the spring is compressed to 7/8 inch. The bracket cutout can be used as a measuring guide (the inside of the washer should be flush with the bracket cut).
11. Tighten the two mounting bolts holding the tension block.
12. Restore the cable shield and ground strap terminations.
13. Restore power, boot the computer and login as Service.
14. Perform the procedure in "MOTOR$TX" on page 3-40.

    Note: When starting the MOTOR$TX calibration procedure, make sure the coupling setscrew **is not** tightened.

5.4.4 Table X Encoder

To remove and replace the Table X Encoder located within the X Table Drive Assembly, refer to Figure 5-4 and follow the procedure below:

1. Before removing power from the Discovery, move the table to the far left using the Motor Control Pad. The Motor Control Pad can be accessed from the Discovery Main Menu screen by choosing Utilities|Emergency Motion.
2. Shut down the computer and then turn off the main circuit breaker on the foot end pedestal.
3. Remove 2 screws from the right table rail end cover, and slide the cover off the end.
4. Remove the front endcap from the X table drive assembly. The cover is held on with 2 hex screws.
5. Remove 6 Phillips screws from the right side cover (of the X table drive assembly) and slide the cover out from the front. This provides access to the encoder and belt.
6. Remove 5 flat head Phillips screws from the upper pedestal cover and remove the cover. This provides access to the Motor Controller Board.
7. Unplug the encoder from the Motor Controller Board and pull out the cable.
8. Remove the coupling holding the encoder to the belt drive.
9. Remove the encoder from the bracket assembly.
10. Replace the encoder on the bracket, install the coupling but do not tighten the screws.

11. Restore power, boot the computer and login as Service.
12. Perform the procedure in “MOTOR$TX” on page 3-40.

    Note: When starting the MOTOR$TX calibration procedure, make sure the encoder coupling setscrew **is not** tightened.

5.5 Table Z FRUs (A and SL only)

This section describes how to remove and replace the FRUs associated with Table Z (up and down) motion of the Discovery (see Figure 5-5).

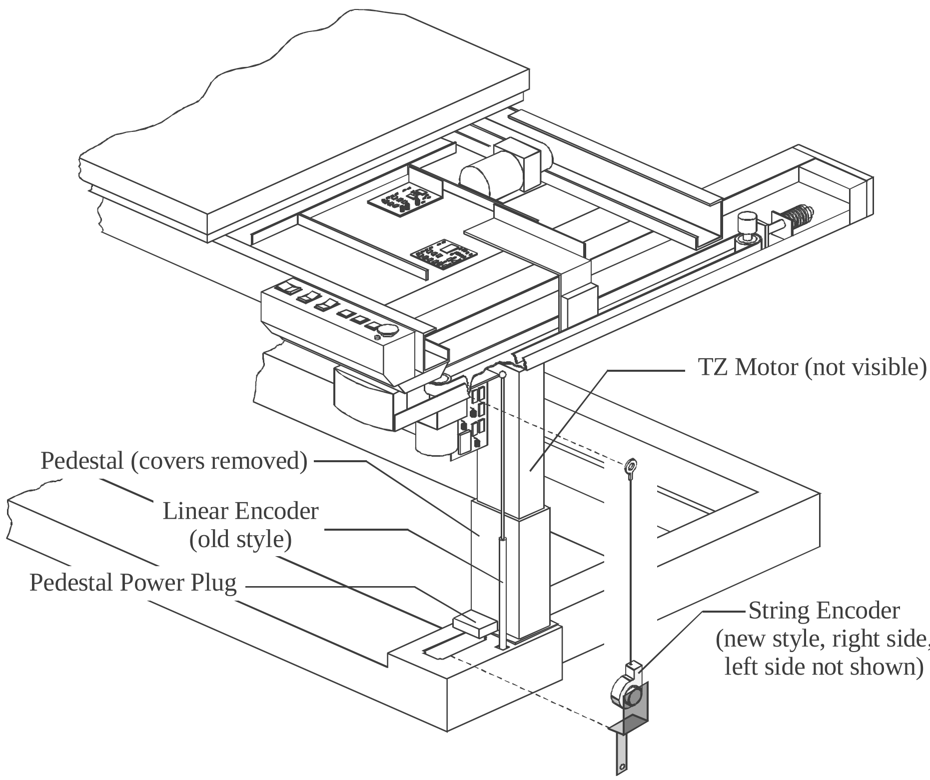


Figure 5-5. Table Z FRUs

5.5.1 Pedestal

To remove and replace either pedestal, refer to Figure 5-6 and follow the procedure below. The procedure requires two pieces of 2 x 4 lumber, approximately 3 feet long, and two pieces of foam padding.

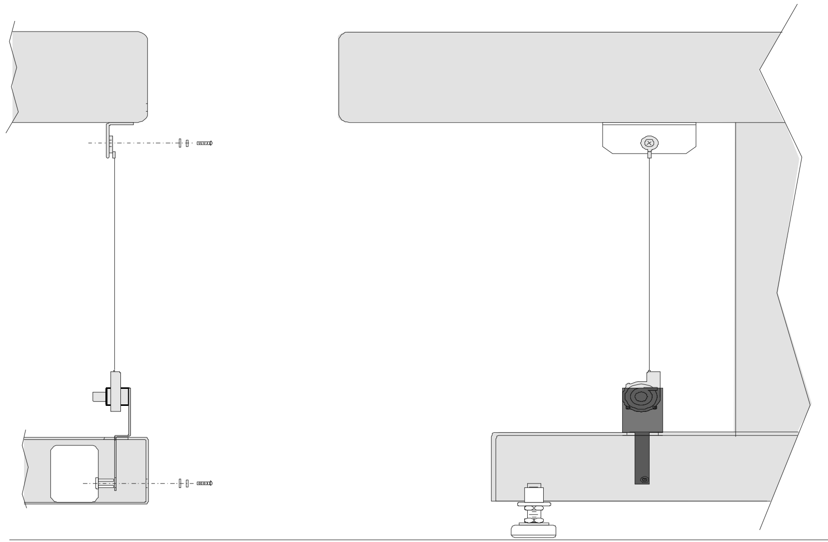


Figure 5-6. Installing the Rotary String Encoder

1. Remove the Electronics Tray covers.
2. Remove 6 flat head Phillips screws from the upper pedestal cover and remove the cover.
3. Remove 5 flat head Phillips screws from the lower pedestal cover and remove the cover.
4. Move the C-arm towards the pedestal to be replaced, but ensure that the service switches on the TZ Motor Controller board are accessible.
5. Place two 2 x 4s on end, on top of the tank. The 2 x 4s should be oriented front to back, on the tank, to support the table. Place foam padding between the 2 x 4s and the table to protect the tape safety switch.
6. Push in the Emergency Stop switch.
7. On the TZ Motor Controller board, set the Normal/Service switch to Service and set the Direction switch to Down.
8. Press the left and right switches together until the table just rests on the 2 x 4s.
9. Remove the top bolts on the pedestal (9/16”). The cosmetic bracket will come off.

   Note: If removing the left pedestal, the left T-rail will become loose. Be careful not to drop this T-rail.

10. Press the appropriate pedestal switch on the TZ Motor Controller board to lower the pedestal completely.
11. Remove the pedestal power plug, the lower four pedestal bolts, and remove the pedestal.

12. Remove the end plates from the old pedestal and install on the new pedestal being careful to maintain their orientation (6mm Allen screws). Apply a small amount of Loctite when installing the screws.
13. Replace the pedestal and install the pedestal lower bolts, but leave them loose for now.
14. Replace the power plug.
15. On the TZ Motor Controller board, set the Direction switch to Up.
16. Press the appropriate pedestal switch on the TZ Motor Controller board to raise the pedestal until it just touches the T-rail.
17. Install the cosmetic bracket and upper pedestal bolts leaving the bolts loose for now.
18. Using the switches on the TZ Motor Controller board, raise both pedestals and remove the 2 x 4s and foam.
19. Measure from the inside of one T-rail to the inside of the other. It must be 65 inches at both the front and back. If it is not, move the pedestal until the measurements are correct.
20. Tighten the lower and upper pedestal bolts.
21. On the TZ Motor Controller board, set the Direction switch to Down.
22. Using the switches on the TZ Motor Controller board, lower both pedestals all the way down.
23. On the TZ Motor Controller board, set the Service switch to Normal and press Reset (large black button).
24. Login as Service and perform the MOTOR$TZ calibration by selecting **Utilities|Service Utilities|SQDRIVER** from the Discovery Main Menu screen (you must be in Service Mode). At the **CARM$$$>** prompt, type **MOTOR$TZ <Enter>**

Refer to the MOTOR$TZ calibration procedure on page 3-33 for details.

25. After the calibration process completes, replace all covers.

5.5.2 The Linear Rotary String (Encoder)

5.5.2.1 Installation

When replacing one of these encoders, make certain you have the correct part.

	Part Number
Right Encoder	030-2417
Left Encoder	030-2867

Refer to Figure 5-5 and Figure 5-6 and follow the procedure below:

1. Remove the electronics tray covers.
2. Push in the Emergency Stop Switch then press and hold the Table Up Switch to move the table all the way up.

WARNING:	Shut down the computer and then turn off the main circuit breaker on the foot end pedestal.

3. Remove 6 flat head Phillips screws from the upper pedestal cover and remove the cover.
4. Remove 5 flat head Phillips screws from the lower pedestal cover and remove the cover.
5. Remove the linear encoder top screw (Phillips).
6. Remove the linear encoder bottom screw (access to the bottom Phillips screw is through the frame hole).
7. Unplug the linear encoder cable from the TZ Drive board and snake the cable out..

WARNING:	Do not allow the string to snap back into the encoder after being extended. This can permanently damage the unit.

8. Route the new encoder cable through the path of the old encoder and plug it into the TZ Drive board.
9. Install the rotary encoder at the bottom using the screw and two washers provided.

   Note: The bracket must sit on the top surface of the base frame before tightening.
10. Replace the linear encoder top screw by extending the string and fastening to the top using screw and washers provided.
11. Turn on the instrument power, boot the computer and login as Service.
12. Perform the MOTOR$TZ calibration by selecting **Utilities|Service Utilities|SQDRIVER** from the Discovery Main Menu screen (you must be in Service Mode). At the **CARM$$$>** prompt, type **MOTOR$TZ <Enter>**

    Refer to “MOTOR$TZ (Discovery A and SL only)” on page 3-33 for details.
13. When calibration and adjustment is done, replace the pedestal covers.

5.5.2.2 Adjustment

Use this section only when the pedestals are not within the 20 counts specified.

1. Type Y<Enter>.

   A screen similar to the following appears.

DeviceState	E_OK
PedestalMode	OPERATIONAL

Table Status	OK	
Left Pedestal	AT_TARGET	
Right Pedestal	AT_TARGET	
Position	199649	
PosLimitPosition	199930	
NegLimitPosition	0	
LowerLeft	384	
UpperLeft	3235	
LowerRight	383	Adjust the Right String
UpperRight	3234	Encoder center hub until
PositionAverage	8	EncoderPosition
DriverVersion	8.02	equals UpperLeft.
DeviceVersion	2.30	
EncoderPosition	3230	
EncoderNegLimit	383	
EncoderPosLimit	3234	
A384;3235;383;3234		

2. Loosen the three screws on the inner side of the right encoder just enough to allow the center hub to turn.
3. Adjust the encoder by rotating the center hub until the 'Encoder Position' count value on the monitor matches the 'Upper Left' count value.
4. Secure the three adjustment screws on the face of the encoder.
5. Return to Step 2 of the "MOTOR$TZ (Discovery A and SL only)" on page 3-33 to recalibrate at the new encoder setting.

Note: Upon recalibration, the 'Upper Right' and 'Upper Left' count values should become virtually equal. If the 'Lower Left' and 'Lower Right' count values differ by more than 20 counts, readjust the encoder by rotating the center hub until the 'Encoder Position' count value equals the 'Upper Left' count value ± half of the lower count difference. Secure the three adjustment screws on the face of the encoder Return to Step 2 of the MOTOR$TZ calibration procedure on page 3-33 to recalibrate at the new encoder setting.

5.6 Lower C-Arm FRUS

This section describes how to remove and replace the C-arm Interface Board, X-Ray Controller (XRC), Tank, and Filter Drum Assemblies located on the lower C-arm (see Figure 5-7), and Arm rotation FRUs (A & SL only).

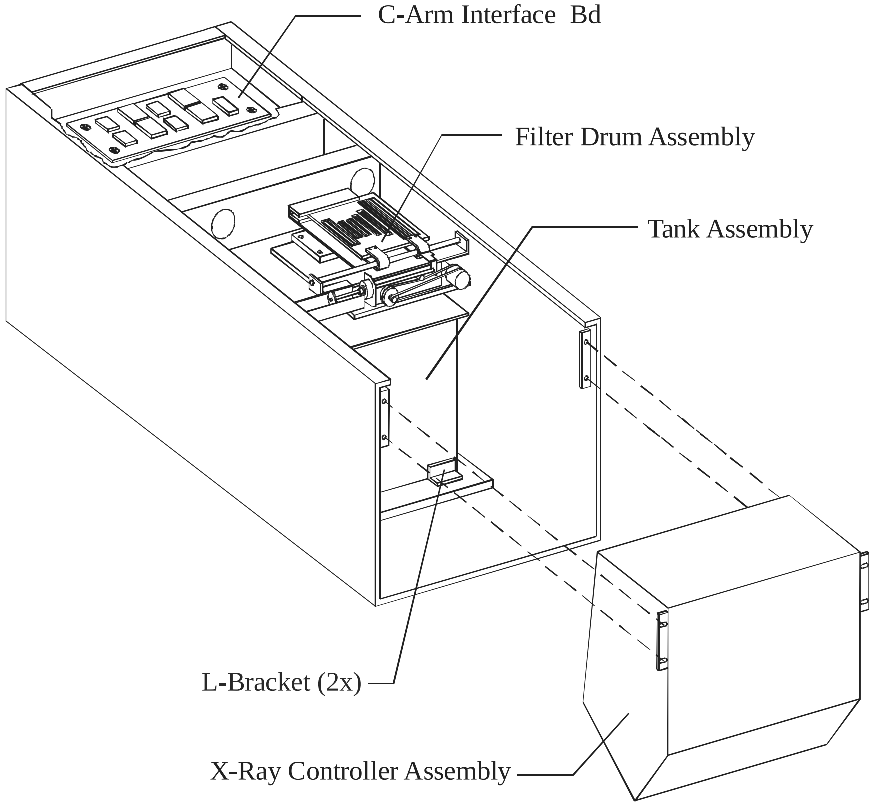


Figure 5-7. Lower C-Arm FRUs

5.6.1 C-Arm Interface Board

To remove and replace the C-Arm Interface Board, refer to Figure 5-7 and follow the procedure below:

1. With the C-arm in the center of the table, use the Control Panel to move the table out as far as it will go, for easier access to the cover screws.
2. Shut down the computer and then turn off the main circuit breaker on the foot end pedestal.
3. Remove the lower C-arm cover, then remove the rear tank cover (covers the C-arm Interface board).
4. Unplug all cables to the C-Arm Interface Board.
5. Remove 4 Phillips screws and remove the board.
6. To replace the C-Arm Interface Board reverse the steps.
7. Restore power, boot the computer and login as Service.
8. Perform “Test Scan Modes” on page 3-64.

5.6.2 X-Ray Controller Assembly

To remove and replace the X-Ray Controller (XRC), refer to Figure 5-22 and do the following:

1. Using the Control Panel, move the table in for easier access to the XRC.
2. Shut down the computer and then turn off the main circuit breaker on the foot end pedestal.
3. Remove the lower C-arm cover by removing 2 Phillips screws and sliding it out from the front.
4. Remove the 4 Phillips screws holding the XRC (see Figure 5-7
5. Pull the XRC forward far enough to access the cables.
6. Unplug all of the cables and remove the XRC by pulling it out.
7. To replace the XRC reverse the steps.
8. Restore power, boot the computer and login as Service.
9. Perform “Area, BMD, and BMC Calibration” on page 4-34.
10. Log out of Service and login as User.
11. Perform “Test Scan Modes” on page 3-64.

5.6.3 Filter Drum Assembly

To remove and replace the Filter Drum Assembly, refer to Figure 5-7 and do the following:

1. Using the Control Panel, move the table in as far as it will go and center the C-arm for easier access to the Filter Drum Assembly.
2. Start the X-Ray Survey Utility by selecting **Utilities|Service Utilities|X-Ray Survey** (see “X-Ray Survey” on page 9-1 for information on the utility).
3. Set **Aperture** to **7**.
4. Shut down the computer and then turn off the main circuit breaker on the foot end pedestal.
5. Remove the lower C-arm cover by removing 2 Phillips screws and sliding it out from the front. Also, remove the bottom cover.
6. Remove the 4 Phillips screws holding the XRC (see Figure 5-7).
7. Pull the XRC forward far enough for access to the Filter Drum (it is not necessary to remove the XRC cables.
8. Remove the rear tank cover (covers the C-arm Interface board).
9. Unplug the 2 Filter Drum cables from the C-arm Interface board.
10. Remove 3 hex head screws (3/32 inch Allen screws).

11. Remove the Filter Drum by lifting it up (while tilting it slightly forward) and out.
12. Replace the 3 hex head screws. Ensure that the curved spring washers are placed (curved downward) so that the washer compresses when the screw is tightened.
13. Replace the cables.
14. Replace the screws in the XRC assembly.
15. Restore power, boot the computer and login as Service.
16. Perform “X-Ray Beam Alignment ” on page 4-4.
17. Perform “Aperture Calibration ” on page 4-9.
18. Perform “A/D Gain Control Adjustment” on page 4-26.
19. Replace all covers that were removed.
20. Perform “Detector Flattening ” on page 4-29.

5.6.4 Tank Assembly

To remove and replace the Tank Assembly, refer to Figure 5-7 and Figure 5-8 and follow the procedure below:

WARNING:	Because of the weight of the tank (about 200lbs), 2 people are required to safely remove and replace the tank.

1. Using the Control Panel, move the table in as far as it will go for easier access.
2. Start the X-Ray Survey Utility by selecting **Utilities|Service Utilities|X-Ray Survey** (see “X-Ray Survey” on page 9-1 for information on the utility).
3. Set **Aperture** to 7.
4. Shut down the computer and then turn off the main circuit breaker on the foot end pedestal.
5. Remove the lower C-arm cover by removing 2 Phillips screws and sliding it out from the front.
6. Remove the XRC (see procedure above).
7. Remove the Filter Drum Assembly (see procedure above).
8. For A and SL models only: Lock the C-arm in place by securing the shipping brackets on each side of the arm.

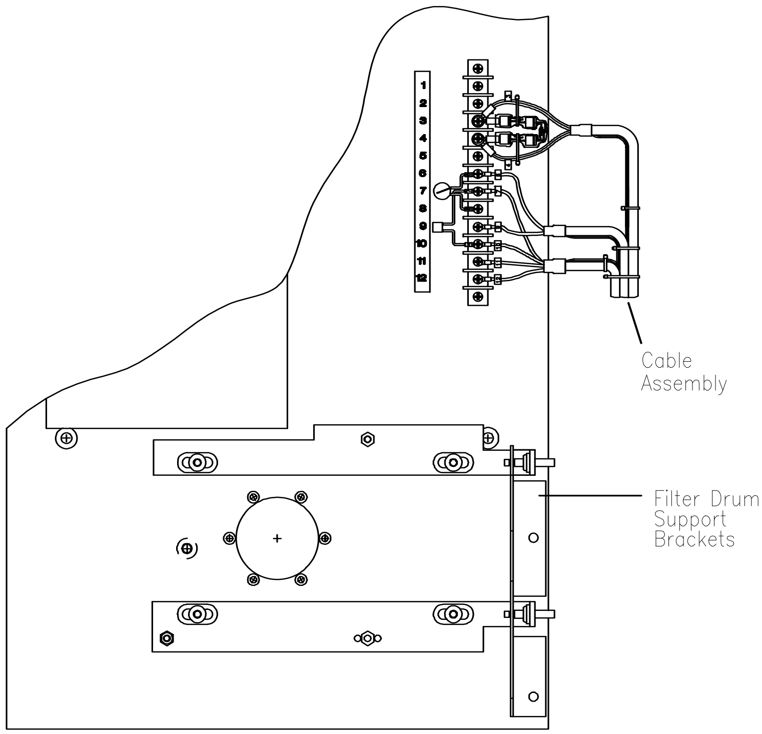


Figure 5-8. Top View of Tank

9. Remove the two L-brackets from the front of the tank that holds the tank to the C-arm (7/16 inch).
10. Carefully slide the tank out of the C-arm onto a pallet (requires 2 people).
11. Remove the old tank from the tank tray, and install the new tank on the tray.
12. Remove the cable assembly from the old tank and install it on the new tank (see Figure 5-8).
13. Remove the Filter Drum support brackets from the old tank and install on the new tank (see Figure 5-8).
14. Slide the tank tray, with tank installed, back in place in the C-arm and replace the L-brackets.
15. Remove the 2 shipping brackets on each side of the C-arm.
16. Replace the Filter Drum Assembly.
17. Replace the X-ray Controller Assembly.
18. Be sure to reconnect the cable shield and ground strap terminals.
19. Before turning on the Scanner, check the tank cable connections to ensure that they are correct.
20. Restore power, boot the computer and login as Service.

21. Starting with the “Check Tube kV Peak Potential” on page 3-28, perform all the procedures in that section in order, with the exception of the Calibrate Motors and Check Laser Positioning Offset procedures.

5.6.5 Arm R FRUS (A and SL only)

This section describes how to remove and replace the Arm R (Rotate) FRUs located on the right side of the lower C-arm (see Figure 5-9 and Figure 5-8).

Before removing power from the Discovery, move the C-arm towards the middle-left side of the table to allow working room. Use the Motor Control Pad. The Motor Control Pad can be accessed from the Discovery main screen by choosing **Utilities|Emergency Motion**.

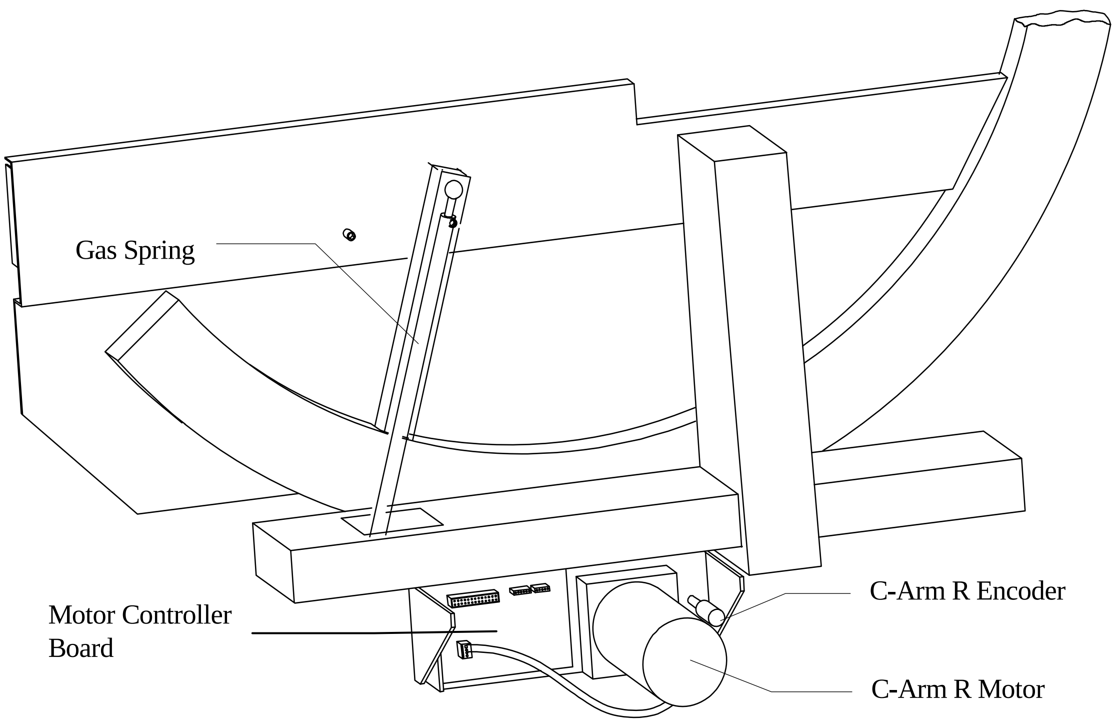


Figure 5-9. C-Arm R FRUs (Outside View)

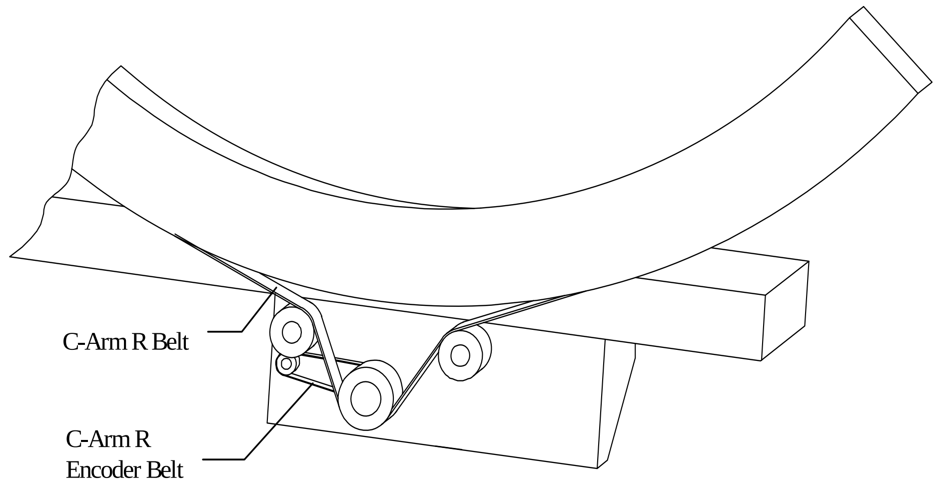


Figure 5-10. C-Arm R FRUs (Inside View)

5.6.6 Motor Controller Board

To remove and replace the Motor Controller Board refer to Figure 5-9 and follow the procedure below:

1. Remove the motor cover plate by removing 2 (Phillips) screws.
2. Shut down the computer and then turn off the main circuit breaker on the foot end pedestal.
3. Unplug the cables and unscrew the Phillips screws holding the board.
4. To replace the board reverse the steps.

   Note: When replacing the AR Motor Controller board, ensure that the ID switch is set to 6.

5.6.7 Arm R Belt

To remove and replace the Arm R Belt refer to Figure 5-9 and Figure 5-10, and follow the procedure below:

1. Shut down the computer and then turn off the main circuit breaker on the foot end pedestal.
2. Remove the tank covers.
3. Remove the X-ray controller assembly (to gain access to the front belt clamp).
4. Remove the rear C-arm shoulder cover.

   Note: Take care not to move the C-arm during the remainder of this procedure.

5. Remove the belt tension nut, and remove the rear belt clamp (four 5/16" bolts).
6. Remove the belt from the motor pulleys. Access the pulleys from the left side of the Scanner looking under the C-arm (see Figure 5-10).

7. Remove the belt from the front belt clamp (four Phillips screws).
8. Install the new belt in reverse order, front belt clamp first, then over the pulleys, and then to the rear belt clamp.
9. Tighten both belt clamps.
10. Loosen the belt tension block (two 1/4" bolts).
11. Install the tension nut and adjust to 7/8" from the inside of one washer to the inside of the other washer.
12. Tighten the tension block bolts.
13. Restore power, boot the computer and login as Service.
14. Perform the procedure in “MOTOR$AR (Discovery A and SL)” on page 3-42.

5.6.8 Arm R Motor, Gearcase, Encoder or Encoder Belt

To remove and replace the Arm R Motor refer to Figure 5-9 and Figure 5-10, and follow the procedure below:

1. Shut down the computer and then turn off the main circuit breaker on the foot end pedestal.
2. Remove the rear C-arm shoulder cover and the arm R motor cover plate.
3. At the rear of the C-arm, remove the belt bracket (2 bolts) while leaving the belt attached. This provides enough slack to remove the belt from the motor pulleys.
4. Remove the belt from the motor pulleys. Access the pulleys from the left side of the Scanner looking under the C-arm (see Figure 5-10).
5. Remove the arm R encoder cable.
6. Remove the Motor Controller board ribbon cable and snake the cable through the access hole.
7. Remove the entire arm R motor assembly bracket with motor, board, and encoder (four 7/16" bolts).
8. Remove the encoder and pulley assembly (2 Phillips screws) and the encoder belt.
9. If replacing the motor or gearcase, remove the four Allen bolts, and nuts, holding them. If replacing the gearcase, install the pulley from the old gearcase on the new gearcase. Then, replace the motor and gear case assembly making sure to align the gasket correctly. Snug the Allen bolts but don’t over tighten.
10. If replacing the encoder, loosen the coupling setscrew and remove the encoder from the bracket assembly. Then, replace the encoder on the bracket but do not tighten the coupling setscrew yet.
11. Replace the arm R motor assembly bracket with motor, board, and encoder (four 7/16" bolts).

12. Replace the cables and replace the belt on the motor pulleys. Be sure to restore the cable shield and ground strap terminations.
13. Replace the belt bracket and loosen the belt tension block (two 1/4" bolts).
14. Adjust the tension nut so that the spring is compressed to 7/8" from the inside of one washer to the inside of the other washer.
15. Tighten the tension block bolts.
16. Restore power, boot the computer and login as Service.
17. Perform the procedure in “MOTOR$AR (Discovery A and SL)” on page 3-42.

    Note: When starting the MOTOR$AR calibration procedure, make sure the coupling setscrew **is not** tightened.

5.6.9 Gas Spring

It is not necessary to remove any covers to remove and replace either Gas Spring. Refer to Figure 5-9 and follow the procedure below:

1. Using Emergency Motion, rotate the C-Arm to the Lateral position.
2. Remove the retaining clip from the top of the gas spring and remove the spring from the stud.
3. Remove the nut that holds the lower stud in place.
4. Remove the stud and spring together.
5. Prior to installing the new spring, lubricate the ball studs at both ends with white lithium grease.
6. Put the lower stud on the new spring and attach the retaining clip.
7. Install the top of the spring to the top stud and replace the retaining clip.

5.7 Upper C-Arm FRUS

This section describes how to remove and replace the Detector Assembly, ADC Board (A Only), Control Panel, and Laser Assembly located on the upper C-arm. It also describes the procedure for replacing a failing 64 Channel Detector Assembly (010-1653) with a 64 Channel Detector Assembly (ASY-00271) on Ci and Wi units.

5.7.1 Detector Assembly A, SL, W, C Systems

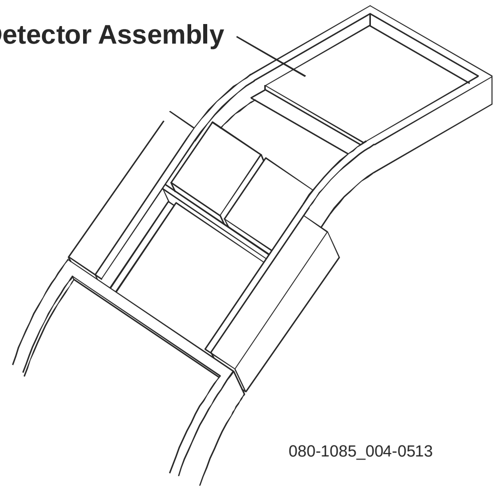


Figure 5-11. Detector Assembly Mounting

To remove and replace the Detector Assembly (refer to Figure 5-11) and follow the procedure below:

1. Shut down the computer and then turn off the main circuit breaker on the foot end pedestal.
2. Unplug the cables and remove the screws on the detector assembly and remove it from the system.
3. Install the new detector assembly using the screws and cables removed in the previous step.
4. Turn on the Discovery power, boot the computer and login as Service.
5. Perform the X-Ray Beam Alignment procedure on page 4-4.
6. Perform the A/D Gain Control Adjustment on page 4-21.
7. Perform the ìLaser Positioning Offset Adjustment on page 4-21.
8. Replace any covers that were removed and perform ìDetector Flattening on page 4-22.
9. Perform the Field Service Calibration procedure.
10. Perform a System Backup.
11. Perform a System Recover. Verify that the System Backup recovers without error.
12. Verify proper system operation.

5.7.2 Detector Assembly C1 and Wi Systems

Early versions of Discovery Ci and Wi systems used detector assembly 010-1653. This assembly is no longer available and has been replaced by detector assembly ASY-00271. The following procedure explains how to remove the old detector assembly and replace it with the new detector assembly. If your system already has the new ASY-00271 detector assembly, use the removal/replacement procedure in Section 5.7.1.

Remove the 010-1653 Detector Assembly

To remove the 010-1653 Detector Assembly, refer to Figure 5-12 and follow the procedure below:

1. Shut down the computer and then turn off the main circuit breaker on the foot end pedestal.
2. Unplug the 180-0292 laser cable connector.
3. Remove the cables and the screws on the existing Detector Assembly (010-1653) and remove the assembly.
4. Remove the cables and the screws on the existing ADC Board (140-0087) and remove the board.

Note: The 180-0185 and 180-0189 ribbon cables on the ADC Board will not be reused. Also, the four 6-32x.25 screws (200-0356) securing the ADC board will not be reused.

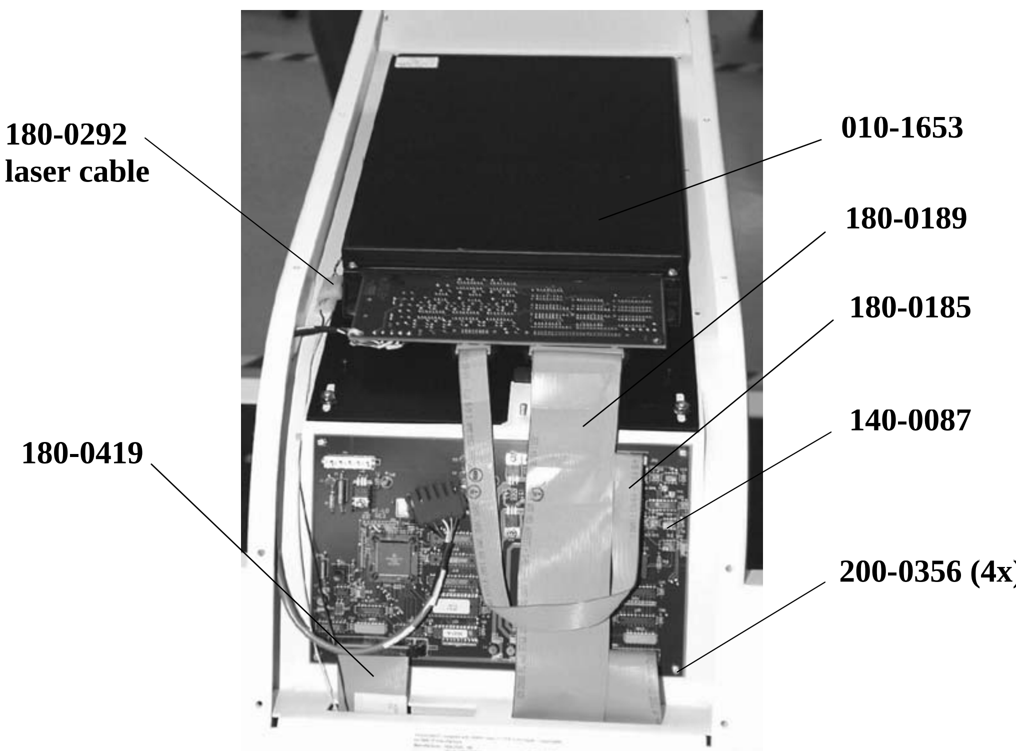


Figure 5-12. Detector Assembly 010-1653

Install the ASY-00271 Detector Assembly

1. Install the ASY-00271 Detector Assembly (see Figure 5-13) in place of the 010-1653 using the screws removed in Step 3.
2. Connect the 180-0292 laser cable.
3. Re-route the 180-0419 ribbon cable and install it on P1 of the ASY-00271.
4. Install the 370-0056 clamp-on ferrite core over the 180-0419 ribbon cable.
5. Turn on the Discovery power, boot the computer and login as Service.
6. Perform "X-Ray Beam Alignment " on page 4-4.
7. Perform "A/D Gain Control Adjustment" on page 4-26.
8. Perform "Laser Positioning Offset Adjustment" on page 4-26.
9. Replace any covers that were removed and perform "Detector Flattening " on page 4-29.
10. Perform the Field Service Calibration procedure.

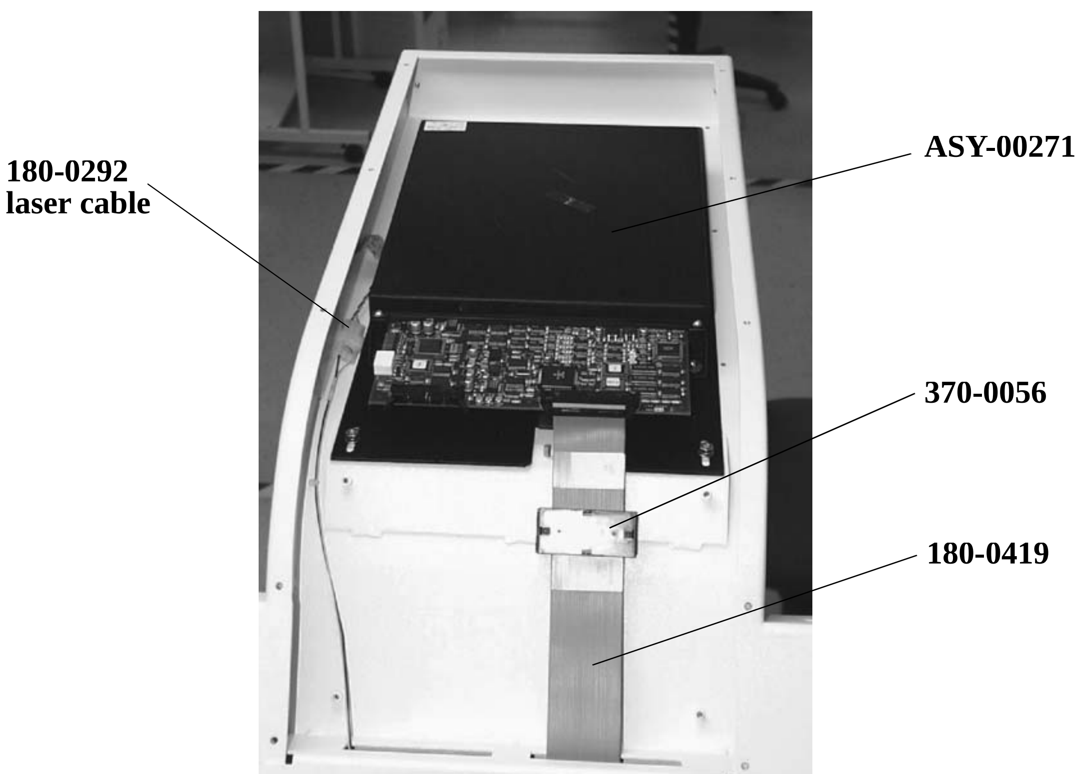


Figure 5-13. Detector Assembly ASY-00271

11. Perform a System Backup.
12. Perform a System Recover. Verify that the System Backup recovers without error.
13. Verify proper system operation.

5.7.3 Laser Assembly

To remove and replace the Laser, or Laser Assembly, refer to Figure 5-11 and Figure 5-14 and follow the procedure below:

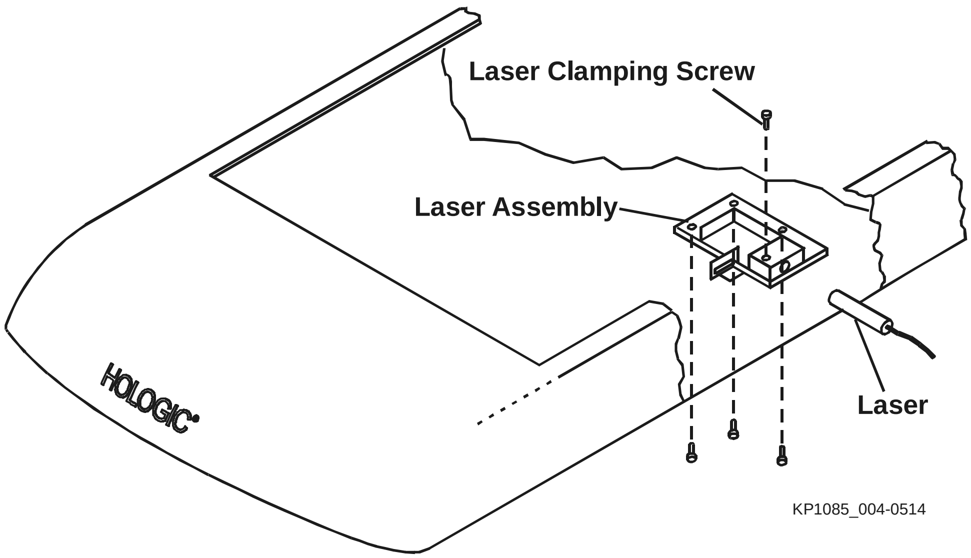


Figure 5-14. Laser Assembly

1. Shut down the computer and then turn off the main circuit breaker on the foot end pedestal.
2. Remove the top C-arm cover.
3. Remove the cables at the Detector Assembly.
4. Remove the 4 bolts holding the Detector Assembly (on rubber grommets) to the C-arm (see Figure 5-11).
5. Remove the Detector Assembly.
6. To replace the laser only, loosen the laser clamping screw. To replace the laser assembly, remove the three mounting screws.
7. Restore power, boot the computer and login as User.
8. To adjust the laser, loosen the laser clamping screw, turn the laser on and rotate it until the correct alignment is seen.
9. Perform “Laser Positioning Offset Adjustment” on page 4-26.

5.7.4 Analog to Digital Converter Board (A Model only)

To remove and replace the Analog to Digital Converter (ADC) Board refer to Figure 5-15 and follow the procedure below:

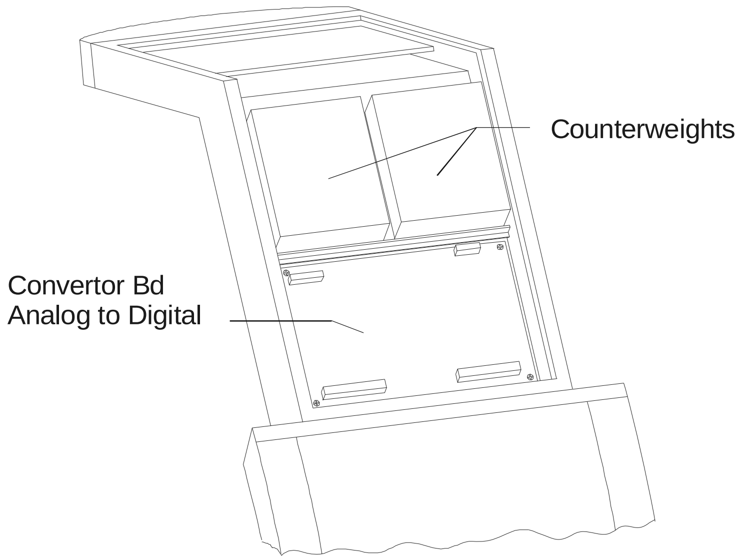


Figure 5-15. Rear C-Arm FRUs

1. The C-arm should be in the AP position.
2. Shut down the computer and then turn off the main circuit breaker on the foot end pedestal.
3. Remove the C-arm covers.
4. Unplug the cables on the ADC board.
5. Remove 4 Phillips screws, and remove the ADC board.
6. To replace the ADC board reverse the steps.
7. Restore power, boot the computer and login as Service.
8. Perform “A/D Gain Control Adjustment” on page 4-26.
9. Replace any covers that were removed.
10. Perform “Detector Flattening ” on page 4-29.

5.8 Aperture Assembly FRUS

This section describes how to remove and replace the FRUs on the Aperture Assembly.

5.8.1 Aperture Stepper Motor

To remove and replace the Aperture Stepper Motor (320-0041), refer to Figure 5-16 and follow the procedure below:

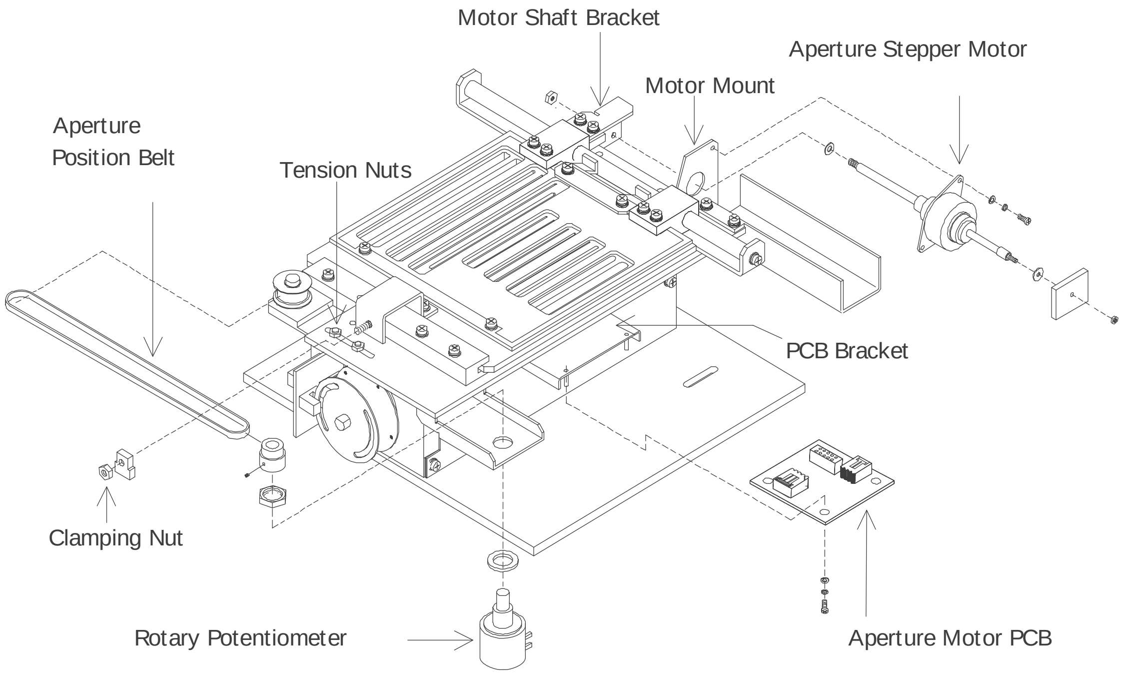


Figure 5-16. Aperture Assembly FRUs

1. Shut down the computer and then turn off the main circuit breaker on the foot end pedestal.
2. Unplug the motor cable.
3. Remove the 2 Phillips screws from the motor shaft bracket.
4. Remove the motor mount (2 Phillips screws) and remove the motor assembly.
5. Remove the motor from the motor mount, and remove the end lock nut and flat washer. Transfer the dampening pad to the new motor.
6. Reverse the steps above to install the new motor.
7. Turn on the Discovery power, boot the computer and login as Service.
8. Perform “Aperture Calibration ” on page 4-9.

5.8.2 Aperture Motor PCB

To remove and replace the Aperture Motor PCB (140-0068), refer to Figure 5-16 and follow the procedure below:

1. Shut down the computer and then turn off the main circuit breaker on the foot end pedestal.
2. Remove the 2 Phillips screws from the motor shaft bracket.
3. Move the aperture back far enough to expose the screws that hold the PCB bracket.
4. Remove the 2 PCB bracket screws.
5. Unplug the cables and install the new PCB on the bracket.
6. Reverse the steps above to complete the installation of the new Aperture Motor PCB assembly.
7. Turn on the Discovery power, boot the computer and login as Service.
8. Perform the “Aperture Calibration ” on page 4-9.

5.8.3 Aperture Position Belt

To remove and replace the Aperture Position Belt (255-0032), refer to Figure 5-16 below:

1. Shut down the computer and then turn off the main circuit breaker on the foot end pedestal.
2. Loosen the 2 belt tension nuts and the belt clamping nut.
3. Remove and replace the belt (ensure the belt is under the pem stud).
4. Tension the belt moderately tight (remove slack), and tighten the belt tension nuts.
5. Remove the 2 Phillips screws from the motor shaft bracket.
6. Rotate the belt pulley fully clockwise, then turn the pulley back 3/4 turn counter clockwise (3/4 turn of the potentiometer pulley, not the idler pulley).
7. Move the aperture towards the potentiometer until it stops.
8. Tighten the belt clamping nut (do not over tighten).
9. Move the aperture back until the motor shaft bracket screw holes line up.
10. Install the 2 Phillips screws holding the motor shaft bracket.
11. Turn on the Discovery power, boot the computer and login as Service.
12. Perform “Aperture Calibration ” on page 4-9.

5.8.4 Rotary Potentiometer

To remove and replace the Rotary Potentiometer (included in the cable assembly 180-0267), refer to Figure 5-16 and follow the procedure below:

1. Shut down the computer and then turn off the main circuit breaker on the foot end pedestal.
2. Remove the Aperture Position Belt (refer to the procedure above).
3. Remove the potentiometer pulley.
4. Remove and replace the potentiometer (face wires towards the Aperture Motor PCB).
5. Replace the potentiometer pulley (pulley goes all the way down on the shaft).
6. Refer to the Aperture Position Belt procedure and replace the belt.
7. Turn on the Discovery power, boot the computer and login as Service.
8. Perform “Aperture Calibration ” on page 4-9.

5.9 Drum Assembly FRUS

This section describes how to remove and replace the FRUs on the Drum Assembly.

5.9.1 Drum Encoder PCB

To remove and replace the Drum Encoder PCB (140-0089), refer to Figure 5-16, Figure 5-17 and Figure 5-18 and follow the procedure below:

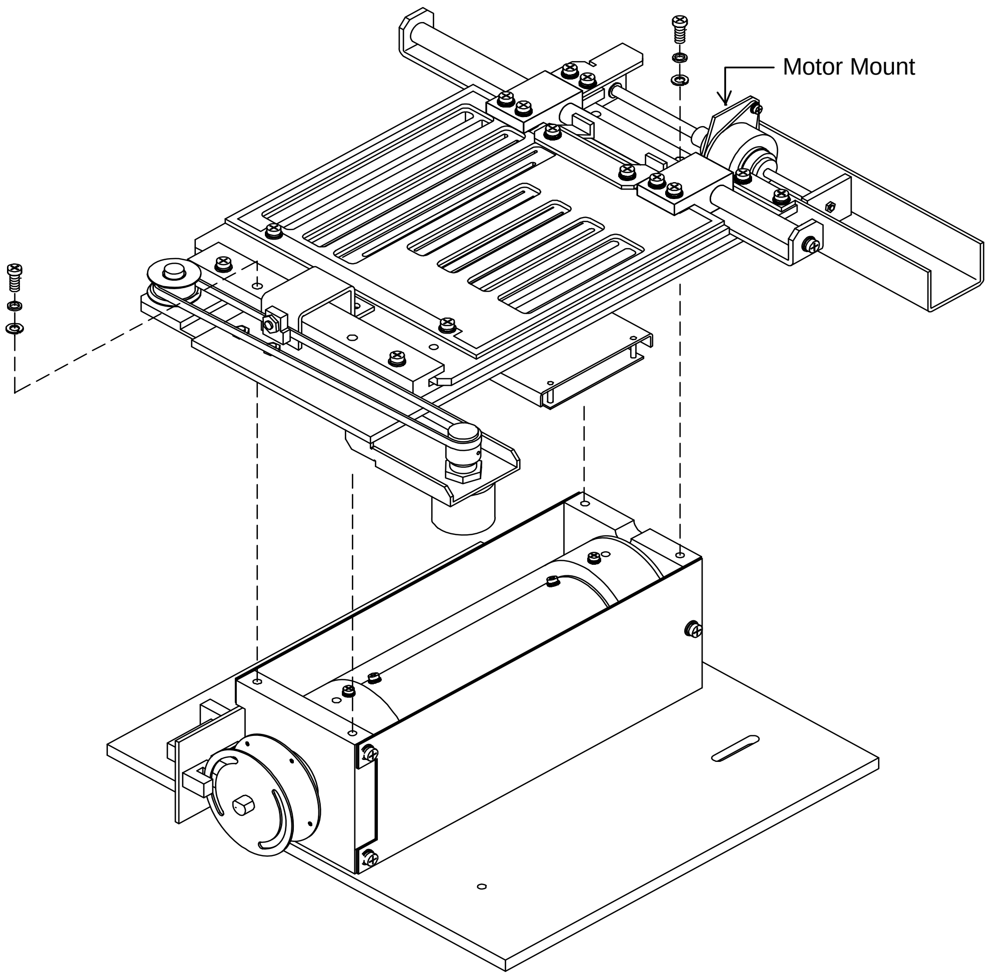


Figure 5-17. Aperture Assembly Removal

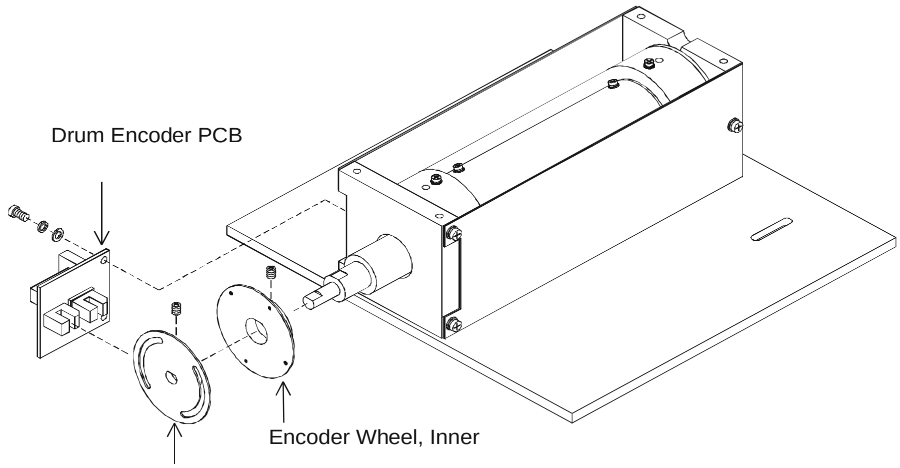


Figure 5-18. Rear Drum Assembly FRIS

1. Shut down the computer and then turn off the main circuit breaker on the foot end pedestal.
2. Remove the Aperture Assembly by removing 4 Phillips screws that secure the assembly, and 2 Phillips screws that secure the aperture motor mount, to the drum end plates.
3. Unplug the PCB cable.
4. Remove and replace the PCB (ensure that the encoder wheels are not touching the sensors.
5. Attach Ch1 probe to SEGMENT test point (TP3) on the C-Arm Interface board.
6. Attach Ch2 probe to BRASS test point (TP2) on the C-Arm Interface board.
7. Connect probe to ground.
8. Go to X-Ray Survey and turn on the Filter Drum motor.
9. As the filter drum motor turns on and rotates look on the C-Arm Interface board.
    a. The yellow “Index” LED blinks (on then off) as the Index mark passes the optical interrupter.
    b. Verify the green “Top of Drum” and “Brass on Top” LED (D8) blink as the drum spins.
    c. The green “AC Lock” LED (D7) lights (steady, not blinking) after a few revolutions of the drum.
10. Measure from the rising edge of the BRASS to the rising edge of the SEGMENT (it does not matter which edge leads). The time measured must be less than 500 µs (500 µs = 0.5 ms). See Figure 5-19 and Figure 5-20.

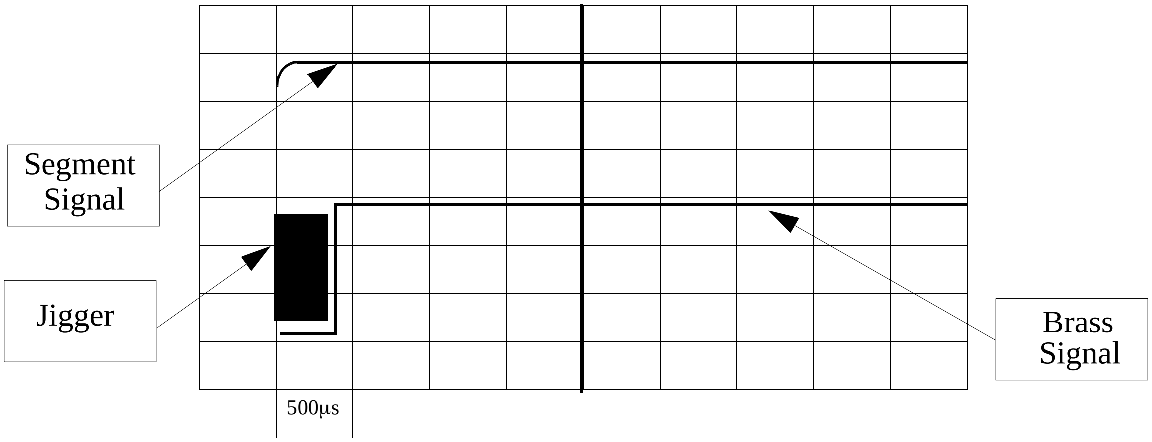


Figure 5-19 Trigger on CH1

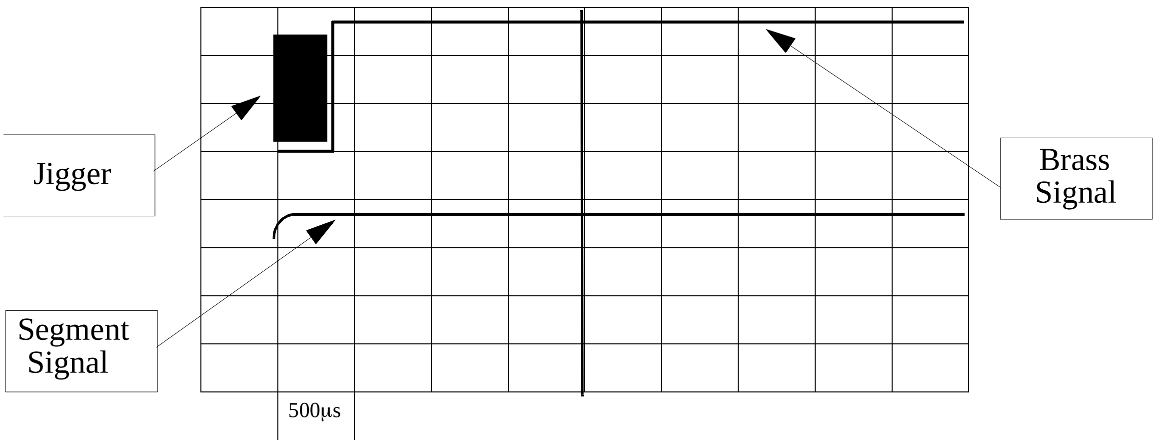


Figure 5-20 Trigger on CH2

11. If timing is out of specification, (no steady LOC LED) loosen the two encoder board mounting screws, and adjust the PCB up or down to get timing in specifications. When timing is in specifications, retighten the PCB mounting screws and recheck timing. If necessary, readjust the timing. The LOC LED must be solid on and steady.
12. Replace the Aperture Assembly.

5.9.2 Drum Belts

To remove and replace either Drum Belt (130 teeth or 150 teeth), refer to Figure 5-18 and follow the procedure below:

1. Push the Emergency Stop button.
2. Remove the Aperture Assembly by removing 4 Phillips screws that secure the assembly, and 2 Phillips screws that secure the aperture motor mount, to the drum end plates (refer to Figure 5-16).

3. Loosen the 2 drum motor mount screws, the idler screw and the outer pulley set screw. Remove the belts.
4. Install the Filter Drum Alignment Pin (099-0110), small end first, through the slotted holes and into the small hole at the base plate. If the pin is installed properly, the drum will not rotate.
5. Install the 150 tooth belt on the back pulley (ensure the belt is positioned under the idler).
6. Install the 130 tooth belt on the front pulley.
7. Tighten the 2 drum motor mount screws (the motor mount is spring loaded to seek proper tension).
8. Tighten the idler screw (the idler is spring loaded to seek proper tension).
9. Tighten the outer pulley set screw.
10. Remove the Filter Drum Alignment Pin.
11. Pull the Emergency Stop button.

5.9.3 Stepper Motor Assembly

To remove and replace the Stepper Motor Assembly, refer to Figure 5-18 and follow the procedure below:

1. Shut down the computer and then turn off the main circuit breaker on the foot end pedestal.
2. Remove the Aperture Assembly.
3. Remove the drum belts (see procedure above).
4. Remove the stepper motor pulley.
5. Remove and replace the motor (4 flathead Phillips screws).
6. Replace the pulley, use Loctite 222 (540-0100) on the set screw.
7. Refer to the Drum Belts procedure above and replace the belts.

5.9.4 Drum Bearings

To remove and replace the drum bearings, refer to Figure 5-21 and Figure 5-22 and follow the procedure below:

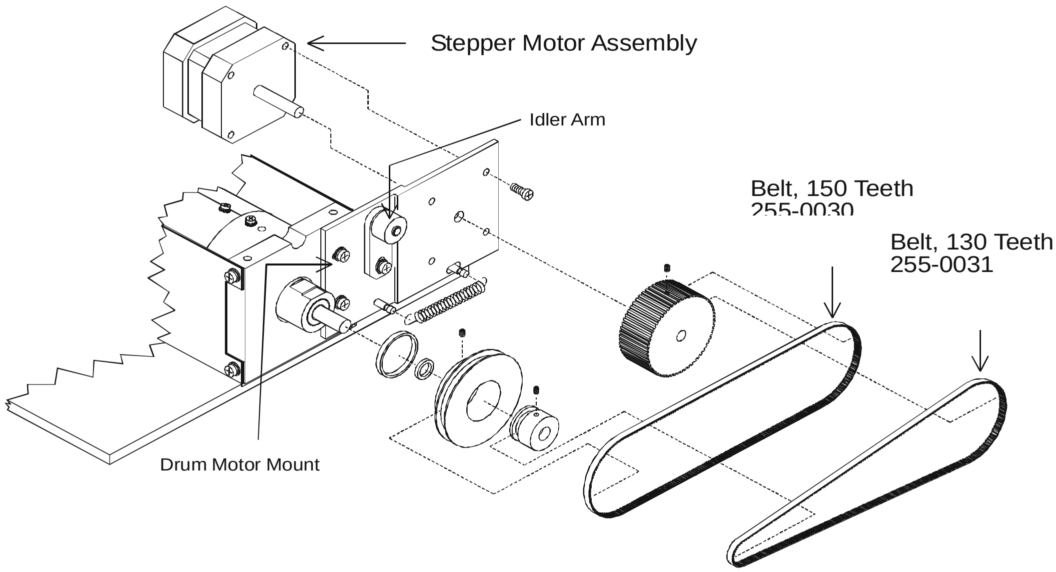


Figure 5-21. Front Drum Assembly FRUs

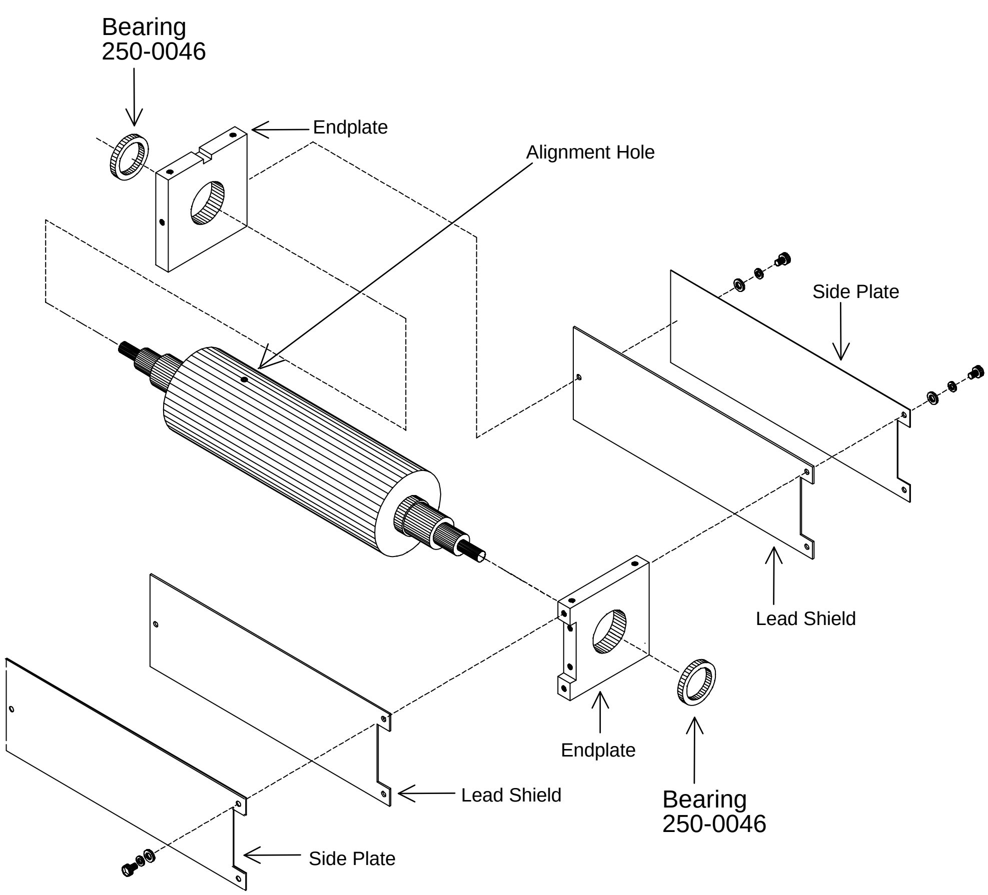


Figure 5-22. Drum Bearings

1. Remove the aperture assembly and drum belts (see procedures above).
2. Remove the 2 drum motor mount screws (see Figure 5-18)

3. Remove 6 screws from underneath the drum assembly base plate (4 screws hold the end plates and 2 screws hold the motor mount spring tensioner block).
4. Remove the side plates and lead shields (3 Phillips screws on each side).
5. Remove the drum encoder PCB and both encoder wheels.
6. Remove both drum belt pulleys.
7. Remove the drum from the endplates.
8. Remove one drum endcap (4 Phillips screws) and remove the inner drum.
9. Replace the bearings.
10. Reassemble the drum and replace (and tighten) the screws in the endcap.

    Note: When replacing the end cap ensure that the flats on each side of the drum shaft are facing the same way (this happens where the two side-by-side holes line up).

11. Replace the 2 endplates. The endplate with the cutout (for the PCB) goes on the drum end *away* from the alignment hole (see Figure 5-21).
12. Replace the lead shields and side plates (6 screws).
13. Align the 2 endplates onto the holes on the recessed area on the base plate. Orient the front endplate towards the 2 slotted holes. Orient the rear endplate on the opposite set of holes and position so that the endplate side with cutout (for PCB) is facing the "C" cutout of the base plate. Replace the 4 flat washers, split locks, and 4-40 x 3/8 screws that secure the endplates.
14. Insert the Drum Spacing Fixture (099-0296) between the endcap and the front endplate. Push the filter drum against the fixture to center it between the two blocks. Do not remove the fixture at this time.
15. Install the spacers and pulleys at the front endplate (see Figure 5-18). Ensure that the pulley set screws line up with the flat, and use Loctite 222 on set screws. Press the filter drum against the fixture, and the pulley against the endplate, while tightening the set screw.

Note: Leave the outer pulley set screw loose until belts are installed.

16. Remove the Drum Spacing Fixture.
17. Replace the inner encoder wheel (see Figure 5-17). Press (squeeze together) the drum and encoder wheel against the endplate and tighten the set screw (use Loctite 222).
18. Replace the outer encoder wheel.
19. Replace the drum encoder PCB. Ensure that the encoder wheels do not contact the sensors.
20. Replace the stepper motor assembly (2 screws on the motor mount, and 2 screws on the base plate). Leave the motor mount screws loose for now.
21. Replace the drum belts (see the Drum Belts procedure).
22. Tighten outer pulley set screw after belts are installed.
23. Refer to the Aperture Assembly procedure and install the aperture assembly.

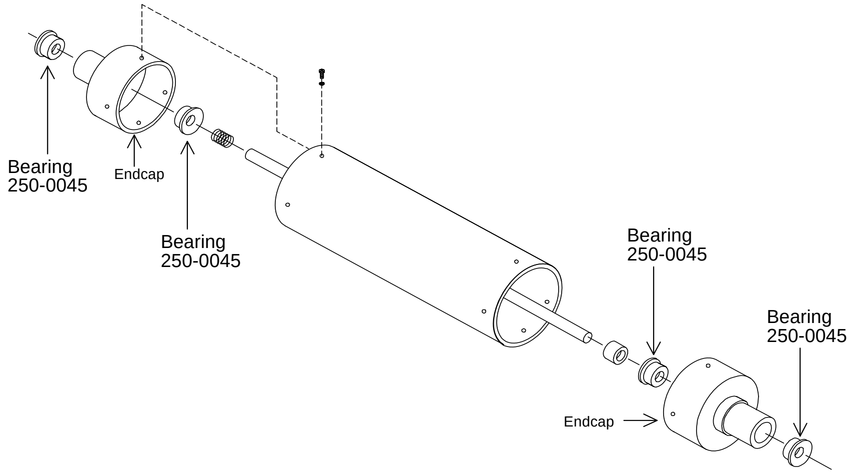


Figure 5-23. Drum Inner Bearings

5.10 Replacing EMI Cables

EMI cables are ribbon cables modified with braided shielding and ground lugs. When replacing, be sure each ground lug is fastened to a ground connection, usually to the ground plane of the PCB at that end. Use a star washer between the ground lug and the ground plane. Be sure the ground lug does not short out any component on the PCB.

When dressing the cables, be sure the braided shield does not come in contact with any electrical component or voltage source.

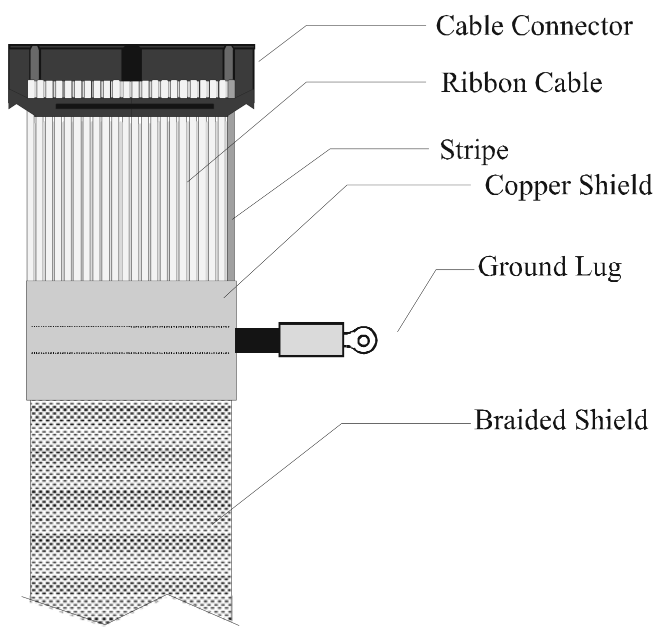


Figure 5-24. The EMI Compliance Cable

5.11 FRU Lists

The following tables provide the information necessary to identify and order the correct FRU.

Please note:

- The tables are listed by Figure, and then by Cable, Miscellaneous, Mobile, and then Special Tools.
- The "Used On" column indicates which Discovery model(s) the Part Number is used; "All" indicates all Discovery models.

Table 5-1. Electronics Tray FRUs (Figure 5-1)

Part Number	Description	Used On
010-0792	Stepper Motor (AY Drive Motor)	All
100-0060	Power Supply, 24V +/-15V	All
140-0049	TZ Control Board	
140-0085	Motor Control Board	A and SL
140-0086	Distribution Board	All
180-0239	Cable, AY Encoder	All
180-0423	Cable, Arm YY Drive, Shielded	C and W
180-0426	Cable, Arm YY Drive, Shielded	A and SL
255-0038	AY Drive Belt	All
310-0006	Circuit Breaker, 7.5 Amp	All
310-0053	Circuit Breaker, 15 Amp	All
310-0018	Circuit Breaker, 20 Amp	All
310-0014	Fuse, 10 Amp	All
310-0044	Fuse, 6 Amp	All
310-0086	Fuse, 8 Amp	All
325-0004	Gearcase 50:1	All

Table 5-2. Table Y FRUS (Figure 5-2)

Part Number	Description	Used On
010-0792	Drive Motor (TY Drive Motor)	A and W
140-0085	Motor Control Board	A and W
180-0241	Cable, TY Encoder	A and W
180-0426	Cable, Table YY Shielded	A and W
255-0033	TY Drive Belt	A and W
325-0004	Gearcase 50:1	A and W

Table 5-3. Table X FRUs (Figure 5-4)

Part Number	Description	Used On
010-0792	Drive Motor (TX Drive Motor)	All
140-0085	Motor Control Board	All
180-0240	Cable, TX Encoder	All
180-0422	Cable, Table XX Drive Shielded	All
255-0021	TX Drive Belt	All
325-0005	Gearcase 30:1	All

Table 5-4. Lower C-Arm FRUs (Figure 5-7)

Part Number	Description	Used On
010-0575	X-ray Tank	All
010-1547	Aperture/Filter Drum Assembly	Ci, Wi
010-1549	Aperture/Filter Drum Assembly	C, W, SL, A
ASY-000409	Assy, 10ma X-Ray Controller	All
140-0090	C-arm Interface Board	All

Table 5-5. Upper C-Arm FRUs (Figure 5-9 and Figure 5-10)

Part Number	Description	Used On
010-0682	Assy, Crosshair Laser Block	All
030-3171	Control Panel, Discovery, 7 Button	C and W
030-3127	Control Panel, Discovery, 9 Button	A and SL
465-0042	Switch, Pushbutton w/LED Pnl	All
465-0043	Switch, Emergency Stop Anti-Rotate	All
ASY-01374	128 Channel Assy 56303	C, W, SL
010-1606	Assy, Discovery Det 216 Chan 2mm	A
010-1653	64 Channel Detector Assembly	Ci, Wi
ASY-00271	64 Channel Detector Assembly	Newer Ci, Wi and replacement for 010-1653 on older Ci, Wi
140-0087	A/D Converter PCB	Ci/Wi with 010-1653 detector

Table 5-6. Computer and Isolation Module

Part Number	Description	Used On
PWR-100-DISCRY	Kit, Power, Discovery, 100V	All
PWR-120-DISCRY	Kit, Power, Discovery, 120V	All
PWR-230-DISCRY	Kit, Power, Discovery, 230V	All
010-1559	Assembly, Torroid	All
120-0049	Monitor, 17" SVGA	All
120-0152	Mouse, P/S	All
120-0161	Keyboard, P/S	All
010-1545	Discovery Computer w/XP	All

Table 5-7. Internal Computer Assemblies

Part Number	Description	Used On
120-0208	5.2 GB Magneto-Optical Drive	All
120-0135	PCI SCSI Interface Board	All
120-0116	Hard Drive, 20GB minimum	All
120-0017	3.5”, 1.44MB Floppy Drive	All
120-0241	CD-R/W Drive	All
120-0154	Network Card, PCI Communication Command Board	All
140-0124	PCI Communications Controller PCB	All
180-0136	SCSI Cable, Internal	All
129-0159	MODEM PCI	All

Table 5-8. Aperture Assembly FRUs (Figure 5-16)

Part Number	Description	Used On
140-0068	Aperture Motor PCB	All
180-0267	Cable, Aperture Motor Signal	All
255-0032	Aperture Position Belt	All
320-0041	Aperture Stepper Motor	All

Table 5-9. Front Drum Assembly FRUs (Figure 5-21)

Part Number	Description	Used On
010-0627	Filter Drum Stepper Motor Assembly	All
140-0089	Drum Encoder Assembly	All
255-0030	Drum Wheel Belt 150 Teeth (Inboard)	All
255-0031	Drum Wheel Belt 130 Teeth (Outboard)	All

Table 5-10. Drum Bearings (Figure 5-22)

Part Number	Description	Used On
250-0045	Drum Inner Bearing	All
250-0046	Drum Outer Bearing	All

Table 5-11. Cables

Part Number	Description	Used On
180-0213	Cable, Fan, X-Ray Controller	All
180-0328	Cable, X-Ray Signal	All
180-0529	Cable, C-arm Sig Discovery	A and SL
180-0344	Cable, Tank Drive	All
180-0416	Cable, X-Ray Power	C and W
180-0526	Cable, X-Ray Power	A and SL
180-0417	Cable, Safety Switch	All
180-0533	Cable, Operator Panel	All
180-0531	Cable, AR Drive	A and SL
180-0419	Cable, DAS Communication	All
180-0420	Cable, C-Arm Signal	All
180-0421	Cable, C-Arm Power	All
180-0422	Cable, Table XX Drive	C and W
180-0532	Cable, Table X Drive	A and SL
180-0423	Cable, Arm YY Drive	C and W
180-0426	Cable, Table YY Drive	W
189-0543	Cable, Arm YY Drive	A and SL
180-0530	Cable, C-arm Pwr	A and SL
180-0292	Cable, Laser Pwr	All
180-0534	Cable, Table Z Drive	A and SL
180-0527	Cable, Ped Right	A and SL
180-0528	Cable, Ped Left	A and SL
180-0185	Cable, A/D Analog Data	A and older Ci/Wi with 010-1653 detector
180-0189	Cable, A/D Digital Data	A and older Ci/Wi with 010-1653 detector
180-0190	Cable, Power Multipleer	A and older Ci/Wi with 010-1653 detector
190-0619	Cable, TZ Power	A and SL

Table 5-12. Miscellaneous

Part Number	Description	Used On
010-1578	Cable Kit, Discovery C & W	C and W
010-1556	Cable Kit, Discovery A & SL	A and SL

Table 5-13. Mobile

Part Number	Description	Used On
010-0980	ASSY, L'KG PIN Y CARR, MOBILE	A and SL
010-0981	ASSY, L'KG PIN C-ARM MOBILE	A and SL
010-0993	ASSY,CARR L'KG PIN,MOBILE	C&W

Table 5-14. Special Tools

Part Number	Description	Used On
099-0110	Filter Drum Alignment Pin	All
099-0111	Aperture Alignment Pin	All
099-0145	Aperture Alignment Block	All
099-0264	Communications Controller Board Loopback Plug	All
099-0269	24 Inch Digital Level	All
099-0566	X-ray Leakage Test Tool	All
099-0715	X-ray Test Pattern	All
099-0716	Step Wedge Penetrometer	All
180-0287	Tape Switch Eliminator Jumper	All
TLS-00080	X-ray Fan Beam Alignment tool	All

Section 6
FAULT ISOLATION

This section provides information to help identify the source of a problem in the Discovery system. The three general categories are:

Problem...	**Refer to the section titled...**	**On page...**
Dead system, or power problem	Power Problems	6-1
Scanner motion problem	Motion Problems	6-2
Computer display problem	Display Problems	6-5

6.1 Before Starting

Before starting, make sure the software configuration is compatible with the scanner.

6.2 Software Configuration

To check the software revision and loaded options, from the Discovery Main Screen, select **Utilities|System Configuration**. On the System Configuration screen, you will find a drop-down list box labeled "Software:" By dropping down this list, you will be shown the release version of the Discovery software and all loaded options. The release version should be at a minimum level of 12.0.

6.3 Hardware Configuration

When troubleshooting, it is sometimes helpful to observe the indicators available on the PCBs and other FRUs. Many components of the system have LEDs indicating the presence of necessary voltages and the state of some signals. Section 8 is helpful in locating these LEDs and observing the state of the system.

6.4 Power Problems

Table 6-1. **Power Component Locations**

Component...	**Where…**
Main circuit breaker	Rear of foot end pedestal
Power switch	Control panel
LED’s for DC voltages	Distribution Board and most driver and control PCBs
Emergency stop switches and circuits	Control panel
Computer power and operation	Computer console power strip

The following suggestions apply to a Discovery system exhibiting a power problem:

If...	**Check...**	**Refer to...**
System "dead"	Main breaker left pedestal Emergency Stop or Instrument On/Off switch on Control Panel	*Check Power Line Voltage* heading, Section 3 Check fuses
Main power suspect	Check AC input voltage Power cable to the Torroid Assembly	*Power Module* heading, Section 2
Suspected Power Module problem	Check AC Voltage at Scanner DIN Rail	*Power Module FRU s* heading, Section 5
Suspected DC power supply problem	Check LED's on Distribution Board for all DC voltages (lit if present)	Check fuses
24V LED not lit	All tape switches and connectors (tape sw reads 120W when open Emergency Stop Switch and associated circuitry Computer is off Hologic software running (check error log)	Check fuses Distribution board, Figure 5-1
System does not start up	System properly configured (see "Before Starting" on page 6-1 Before starting, make sure the software configuration is compatible with the scanner. Emergency Stop switch in "On" (Out) position	
Console does not power up	Main circuit breaker, power strip	

Also...

Problem...	**Possible cause...**	**Corrective action...**
Laser does not turn on	Safety feature if system thinks C-arm is at head of table	Restart in Service mode From **Service Utilities**, run **SQDRIVER** At **CARM$$$$>** prompt, type **LASER_SAFTY 0 <Enter>** Exit from **SQDRIVER** Reboot the computer

6.5 Motion Problems

Motion problems are failures related to movement of the table and/or C-arm. In most (but not all) cases, an error message accompanies Discovery motion problems. Therefore, it is good troubleshooting practice to check the error log (C:\ERRLOG.DAT file) for occurrences of motion related problems. The following suggestions apply to a Discovery system that exhibits a motion problem.

Start by identifying the bad axis (if it is not obvious). Ask the operator for symptoms and check the error log. See Figure 6-1 for possible motion directions.

Table 6-2. Motion Component Locations

	Refer to the Figure Below		
	ARM-Y	**TX**	**TY**
Drive Belt	Figure 5-1		Figure 5-1, Figure 5-2
Drive Motor	Figure 5-1		Figure 5-2
Driver Board	Figure 5-1	Figure 5-1	Figure 5-1
Encoder	Figure 5-1		
Motor Controller Board	Figure 5-1		FigureFigure 5-2 5-2
Distribution Board	Figure 5-1		
Operator Control Panel	Figure 5-2		
Control Panel PCB	Figure 5-2		
Computer			
PCI Communications Controller Board			

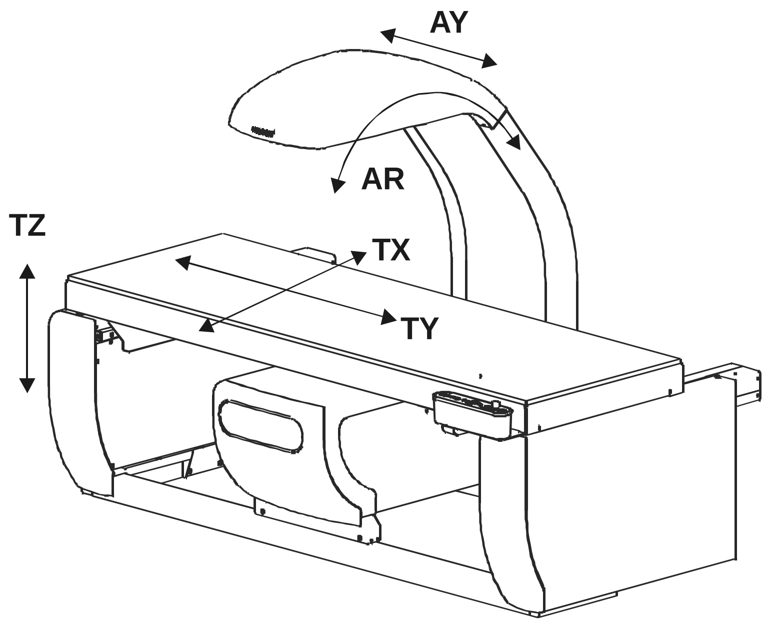


Figure 6-1. Scanner Motion Directions|

Table 6-3. Motion Component Locations

	Refer to the Figure 6-1				
	ARM-Y	**ARM-R**	**TX**	**TY**	**TZ**
Drive Belt	Figure 5-1			Figure 5-2	
Drive Motor	Figure 5-1			Figure 5-2	
Driver Board	Figure 5-1				
Encoder	Figure 5-1				
Encoder Belt					

Motor Controller Board	Figure 5-1			Figure 5-2	
Distribution Board	Figure 5-1				
Oper Cntrl Panel	Figure 5-2				
Control Panel PCB	Figure 5-2				
Computer					
PC Communications Controller Board					

Table 6-4. TX, TY, TZ, AR, AY

Check...	Refer to...
Belt	*Motor Controller Board* heading,
Encoder coupling	Figure 5-1, Figure 5-2, , , ,
Motor controller board	Section 8, *PCB SUMMARY INFORMATION*
Motor/gear case for the motor subsystem in question	
TY (on A & W models only)	
Left and right end panels on table for proper installation. This may cause problems if reversed. (Left 030-1376, right 030-1838).	

CAUTION:	Running any motor subsystem to its limit (in either direction) does not damage the motor. However, if the motor encoder is not properly calibrated, it may be damaged.

Table 6-5. TX, TY, AY

To...	Run...	Refer to...
Perform simple table and C-arm movements	Motor Control Pad (computer motion control)	The Discovery Main Menu, select: Utility Emergency Motion
Perform precise table and C-arm movements	SQDRIVER	*Motor Calibration* heading, and *Motor$XX* (for the specific motor), Section 4
Monitor all motion parameters		
Troubleshoot problems encountered initiating motion from the Operator's Control Panel		*Control Panel* heading, Section 2
Run the hardware checker	Hardware checker	SQVERIFY

6.6 Control Panel Problems

If a Control Panel problem is suspected, or if control panel functions are not responding, use the SQVERIFY program to help isolate the problem. From Discovery Main Menu, select **Utilities|Service Utilities|SQVERIFY**. Select the **Panel** test function and run all subtests.

6.7 Display Problems

Display problems can be grouped into four general categories: vertical stripe, horizontal stripe, noise (dots, speckles, etc.), and no display.

Table 6-6. Display Component Locations

Component	**See...**
Detector Boards	Figure 5-11
Aperture Assembly	
C-Arm Interface Board	Figure 5-7
Filter Drum Assembly	
Filter Drum Assembly (X-Ray Beam Alignment)	Page 4-4
Detector Assembly (X-Ray Beam Alignment)	Page 4-4
Printer (if quality is bad on printout or no bone displayed).	
X-Ray Tank and X-Ray Controller	Figure 5-7
Collimator	Figure 5-7

6.7.1 Vertical Stripe

This type of display problem is most likely related to the detector subsystem. The following suggestions apply to a Discovery system that exhibits a vertical stripe in the display:

Check...	**Refer to...**
Detectors	Check for signal strength and noise in graphic mode of X-Ray Survey (see “X-Ray Survey” on page 9-1)
Narrow vertical stripe - bad detector	*Data Acquisition System* heading, Section 2, for block diagrams and interconnection charts or run the DAS tests in SQVERIFY.
Foreign matter (especially metallic) anywhere in the X-ray beam path in the aperture slit, collimator cup, etc.	
Also...	
Run the hardware checker	SQVERIFY

6.7.2 Horizontal Stripe

This type of display problem is most likely related to the line voltage, bad cables, or X-ray subsystem. The following suggestions apply to a Discovery system that exhibits a horizontal stripe in the display:

Check...	**Refer to...**
Line voltage/Power ground	see “Check Tube kV Peak Potential” on page 3-28
Tube kV Peak Potential	see “Check Tube kV Peak Potential” on page 3-28
Tube Current	see “Check Tube Current ” on page 3-30
Filter drum turning	
Filter drum belt	
Green LEDs on C-Arm Interface	Figure 5-7, Section 8
Banding–variations in horizontal stripe intensity, usually spread across display.	X-ray controller, Figure 5-7
Also...	
Run the hardware checker	see “SQVERIFY” on page 9-10

6.7.3 Noise

The term "noise" is used here to describe any flaw, or irregularity in the display (dots, specks, uneven lines, etc.) or similar problem. The following suggestions apply to a Discovery system that exhibits noise in the display:

Check...	Refer to...
Tube kV peak potential	see “Check Tube kV Peak Potential” on page 3-28
Tube current	see “Check Tube Current ” on page 3-30
X-ray beam alignment	see “X-Ray Beam Alignment ” on page 4-4
Signal strength and noise	see “X-Ray Survey” on page 9-1
Aperture position and aperture belt	see “Aperture Calibration ” on page 4-9
Filter Drum is turning	Figure 5-16
Filter Drum belt	Figure 5-21
Green LED’s on C-Arm Interface board	Figure 5-7, Section 8
Aperture plate assembly, first precollimator, second precollimator and collimator for specs of lead and other deformities.	Figure 5-17
Also...	
Run the hardware checker	see “SQVERIFY” on page 9-10

6.7.4 No Display

The term "no display" is used here to describe:

- no scan display
- completely white screen
- completely dark screen
- “blotchy” or “grainy” display

This type of display problem is usually related to the detector subsystem or the X-ray subsystem.

The following suggestions apply to a Discovery system that exhibits no scan display:

Check...	Refer to...
Tube kV peak potential	see “Check Tube kV Peak Potential” on page 3-28
Tube current	see “Check Tube Current ” on page 3-30
X-ray production	see “Field Service Preventive Maintenance” on page 7-1
Signal strength and noise	see “X-Ray Survey” on page 9-1
Filter Drum is turning	Figure 5-6, Figure 5-18 through Figure 5-23
Filter Drum belt	Figure 5-18, Figure 5-23
Green LED’s on C-Arm Interface board	Figure 5-6, Section 8

No display may indicate a bad Detector Assembly	see "Data Acquisition System (C, W, and SL) " on page 2-20
Check aperture position and aperture belt	see "Aperture Calibration " on page 4-9
Also...	
Run the hardware checker	see "SQVERIFY" on page 9-10

6.8 Targeting/Laser Problems

If...	**Check...**	**Refer to...**
Object being scanned appears	Detector array. It may be too far forward or back inside the upper arm assembly.	Figure 5-11
to the left or right	Laser alignment	Page 4-26
of the scan window	**Run...** Detector Flattening	Page 4-29

6.9 Data Communications Problems

Data communications problems occur between the computer and the scanner. Refer to the following table:

Error messages usually include the keywords:	**Check the:**
Message Packet Sent Received	Digital Signal Processor. If IC is not seated properly, replace the board. Data, power, and ribbon cables for proper seating. Device states in the SQDRIVER for errors. If a device is stated as "E_TIMEOUT", it is suspect.

6.10 Area/BMD/BMC/CV Specification Problems

If...	Possible cause		Refer to...
X-ray beam misaligned	X-ray beam alignment on aperture 7. Signal output level should not rise or fall by a significant margin.		page 4-4
X-ray beam quality problems	Measure X-ray peak potential and tube current waveforms. Make sure they are both stable and within specs. Check X-Ray Survey bar graph for shifting or “dancing” X-rays. If so, test X-Ray Controller. Check A/C line for stability (voltage and frequency).		Page 3-30, Page 4-4
Mechanical frame problems	Check motor drive belts for excessive play. Ensure all hardware on the arm, frame, and drives are secure and clear of moving assemblies (C-arm, etc.)		Page7-1
Mechanical motor drive problems	Check for loose assemblies:	Detector Assembly X-ray Tank X-ray Controller Aperture Assembly	Figure 5-8 Figure 5-6 Figure 5-18 Figure 5-18
	The bone and/or tissue segments in the filter drum may be defective or out of spec. If so, replace and restart system testing.		Figure 5-18 through Figure 5-24

6.11 X-Ray Problems

The following lists some common X-ray problems and some suggested solutions. Refer to Section Two *Functional Description* for more information on the X-Ray subsystem.

6.11.1 No X-Rays

If...	Check...	Refer to...
X-Ray (24VDC LED) on Distribution Board is not lit	X-ray Enable LED on Control Panel and Distribution Board should be on	
“NO A/C Line Interrupts” message at start-up	Interlock inhibit 24VDC from LVPS, power distribution X-ray Controller interlock switch Computer problems (CommCon) Defective Control Panel I/F XRC Power Cable/Connector problems	Figure 5-1, Figure 5-2. Figure 5-14. Figure 5-16

6.12 X-Ray Alignment Problems

6.12.1 X-Ray beam does not align properly

If the X-ray beam does not align properly per the procedure, follow these suggestions.

1. Try to align the X-ray beam to the drop-off points per the alignment procedure. Recheck the position of aperture 10 with the alignment block and pin. If the

block and pin line up, the alignment brackets need to be repositioned. (Check captive screws and jam nuts.)

2. If you align the X-ray beam to both drop-off points but the range is narrow, (on aperture 10 you should have 3-8 turns of the hex driver) the collimator cup and/or the pre-collimator disk on the X-ray tank may be misaligned.

   Using glow paper, assure that the X-ray beam is hitting the front and back on the detector array equally. If not, this may indicate that the X-ray tube has shifted within the letharge. Perform further verification before replacing the X-ray tank.

3. If the aperture and detector array window are aligned, remove the aperture assembly and inspect the cup and disk. Look for any debris or lead fragments. When replacing the cup and disk, align the apertures as closely as possible to the detector array window.

6.12.2 System Fails X-Ray Beam Alignment Verification

Align the X-ray beam and recalibrate the aperture. If this fails, inspect the aperture assembly for any loose hardware or excessive play in the aperture plate. Check the aperture assembly encoder’s belt tension. Tension should be set to 2.5 lbs. If the belt is too tight, it may cause encoder readback errors and cause the calibration program to fail.

6.13 Detector Flattening Problems

6.13.1 System Consistently Fails the Detector Flattening Procedure

1. Check for loose, misaligned, or defective Aperture Assembly, Collimator Cup, or Pre-collimator Disk. (Refer to X-ray Alignment Problems above.)
2. If the X-rays are unstable or “dancing”, monitor the X-rays on the X-RAY SURVEY bar graph screen for any amplitude shifting of the defective signal display.
3. If shifting is taking place, check/replace the X-ray Controller Assembly and X-ray Tank connections. Check the X-ray peak potential and tube current waveforms and monitor for waveform distortion. This may indicate a defective interconnection cable, X-ray Tank, or power supply.
4. Check output signal level. You may have to reset the ADC gain level.
5. Check for bad detectors in the Detector Assembly. Run the DAS test in SQVERIFY.
6. Check the Filter Drum to see that it is installed correctly. Check the segment readback values in X-Ray Survey with X-rays ON.
7. Check for lead fragments in the X-ray beam. Inspect the Collimator Cup, disk, and Aperture Assembly.

8. If a failure occurs during a whole body, recheck the TX motor cal files. The X-rays may be hitting the table edge. Make sure the drives are operating normally. Examine the Detector Flattening scans for any unusual indications using **Utilities|Scan File Plot** and selecting the WBAIRQC scan. If an error message is displayed, go to “Detector Flattening ” on page 4-29.

6.14 Laser Problems

WARNING:	The laser beam can cause serious retinal damage if focused directly into the eye. Be sure to turn the laser OFF when visually inspecting the shutter and aperture.

When troubleshooting the laser, refer to the following:

Make sure...	**Refer to...**
Shutter is open and not obstructing the beam	Page 5-29, Figure 5-14
Motor drives have been calibrated	Pages 3-33 to 3-42

If...	**Suggestions**
Laser does not turn on	(Software is inhibiting laser when table head is near the laser) Move the C-arm to the center of the table and retry. Do the following: 1. Check black and yellow wires from the C-arm Interface PCB to the underside of the Detector Assembly. 2. Shut off instrument power (Emergency Stop Switch on Control Panel). 3. Disconnect laser power connector. 4. Connect a DVM to the plug coming from the Detector Assembly. 5. Turn laser power on. 6. Check connector for +5VDC. Check C-arm Interface Board, Distribution Board, all cables. Check computer. At installation only, type “laser_safety=0” in SQDRIVER and reboot. Check AY motor calibration file. If data is corrupt or uncalibrated, laser may not turn on, despite position of C-arm.

Laser crosshair beam is defective	Check laser block assembly mirrors for breaks, cracks, or misalignment Check that shutter is open Check that aperture is unobstructed Loosen the securing screw to adjust the laser to perpendicular (see Figure 5-10)
Laser does not turn off	Check laser button on Control Panel Check control panel laser switch at **PANEL** tests in SQVERIFY Check for bad: C-arm Interface Board Distribution Board Interconnect cable Computer assembly

6.15 Oil leakage

If the tank assembly is leaking oil, you may have to tighten the screws on the tank cover. It is important that you tighten the screws using the proper torque specifications and the proper sequence.

6.15.1 The Torque Specifications

The torque settings are listed in the following table:

Location	**Torque Specifications**	**Set wrench to…**
Lexan Cup	10-12 in-lb	11 in-lb
Bladder Gasket	10-12 in-lb	11 in-lb
Transformer Seal	70 in-lb	70 in-lb
Tank Cover Gasket	36-40 in-lb	38 in-lb

6.15.2 Tank Top Cover Components and Screw Location

The following figure shows the Tank Top Cover and the locations of the seals:

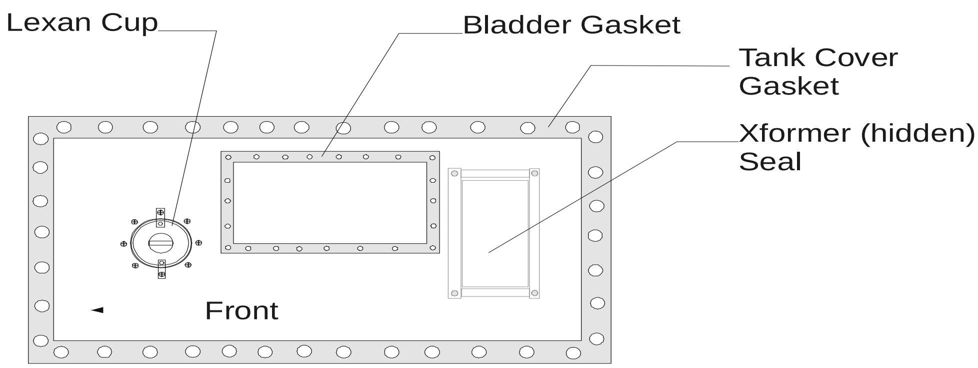
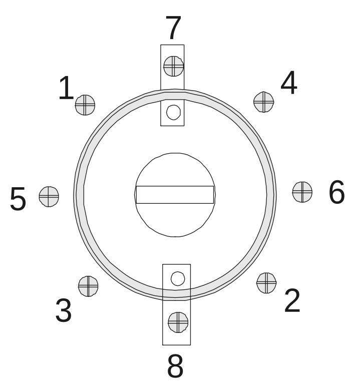


Figure 6-2. Tank Assembly Top view

6.15.3 Tightening the Lexan Cup Screws

Tighten the Lexan Cup seals in the following order using the torque settings in the above table:



Lexan Cup Screw Tightening Order
Figure 6-3.

6.15.4 Tightening the Bladder Gasket Screws

Using the torque settings in the table above and referring to the figure below, tighten the Bladder Gasket screws as follows:

1. Tighten screw #1, then #2, then #3, and then #4.
2. After screw #4, continue around the edge of the gasket in a clockwise direction, tightening alternate screws, until returning to #4.
3. Continue around the edge of the gasket in a clockwise direction, tightening all the remaining screws.

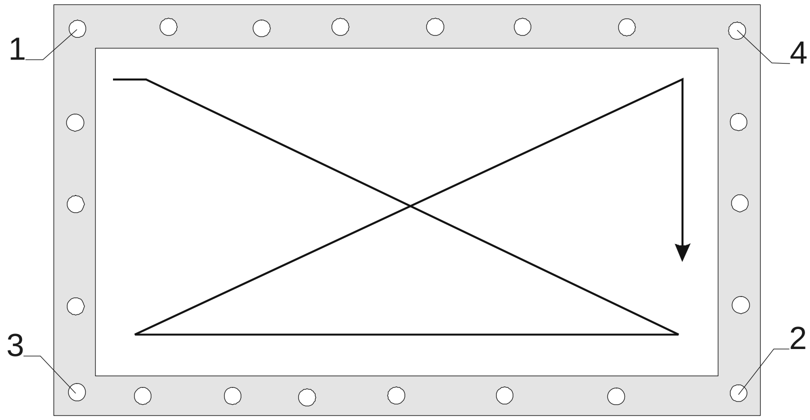


Figure 6-4. Bladder Gasket Screws

6.15.5 Tightening the Transformer Seal Screws

Tighten the Transformer Seal screws using the torque settings in the table above and the sequence in the figure below.

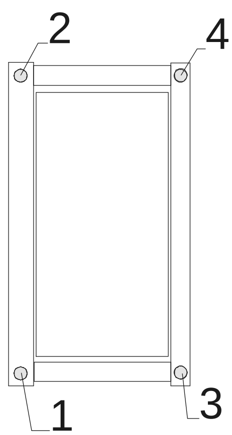


Figure 6-5. Transformer Screws

6.15.6 Tightening the Tank Cover Gasket Screws

Refer to the figure below and the torque settings in the table above and tighten the Tank Cover Gasket screws as follows:

1. Tighten screws #1 through #6 in the sequence as indicated.
2. Starting at the screw next to screw #6, move in a clockwise direction and tighten alternate screws.
3. Repeat this pattern in a clockwise direction and tighten all remaining screws.

Note: The three Tank Cover Gasket screws at the rear of the tank and shown below are the most critical locations for oil leaks. Always check these screws if a leak is suspected.

4. **Important: Do not remove screws located on the tank.** There are no field replaceable units or required adjustments inside the tank, so there is no reason to loosen or remove any screws on the tank.

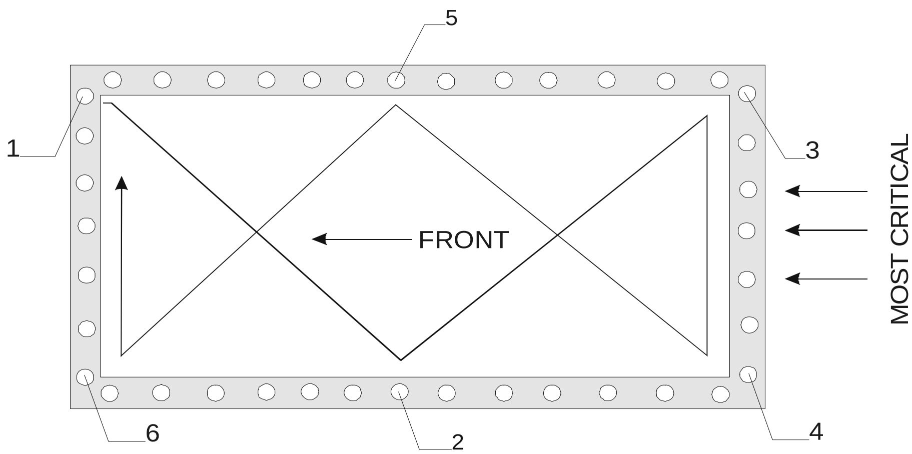


Figure 6-6. Tank Cover Gasket

6.16 Miscellaneous Problems

Problem...	**Symptom...**	**Solution...**
Detector	X-Ray Survey bar graph is ramped, or it appears as 3 or 4 separate ramped sections.	Replace the Detector Assembly
X-ray lamp	Turns on with X-rays off	Replace the Distribution Board
System	Fails HI-Pot test	Check all ground connections Make sure ground wire terminals are secure Check crimped terminals
Hi voltage transformer	Buzzing sound from X-ray tank assembly	Check torque on transformer bolts
System	No power	Check Emergency Stop Switch Check main power cord Check Torroid Assembly circuit breaker Check AC input voltage

Section 7
PREVENTIVE MAINTENANCE

This section lists the procedures that should be performed by trained service personnel at least once per year, and preferably at six-month intervals.

NOTICE
The Discovery system meets applicable FDA radiation performance standards through its useful and expected life provided no components or parts are removed from the system and no unauthorized adjustment or unauthorized replacement of certified components is perform

7.1 Customer Preventive Maintenance

Hologic requires that the customer run a daily QC scan of the spine phantom supplied with the Discovery, and add that scan to the QC database. If the CV of the database exceeds 0.8% the customer is asked to inform Hologic Field Service.

The customer is further advised to perform a weekly backup of the patient database (Backup) and archive QC scans along with their patient scans.

No other regular maintenance activity is recommended or required of the customer.

7.2 Field Service Preventive Maintenance

Hologic recommends that the following procedures be performed by trained service personnel at least once per year and preferably at six-month intervals:

[ ] Perform an Archive of all scans and a System Backup.

[ ] Exit QDR without shutdown, then delete all temporary files (.tmp) on the hard drive.

[ ] In the QDR software, run RECONCILE to compact the database.

[ ] Check the QC database for any problems (e.g. drift, etc.).

[ ] Check ERRLOG.DAT and ERROR.LOG

[ ] Check X-ray tube voltage and current as described in the *INSTALLATION* section of this manual. With X-rays on acquire screen captures of the X-Ray Survey bar graph screen with the X-ray beam alignment tool installed and with the alignment tool removed. Print both screen captures and include with the other paperwork being returned to Hologic.

[ ] Measure scatter, leakage, and patient dose as described in the *INSTALLATION* section of this manual.

[ ] Check X-ray beam alignment as described in the *ALIGNMENT AND CALIBRATION* section of this manual.

[ ] On A and W system models, perform the Table Top Radiographic Uniformity test. Print a copy of the test results and include it with the other paperwork being returned to Hologic.

[ ] Run 10 spine scans and check calibration (do not recalibrate unless necessary).

[ ] Print copies of the baseline phantom scan, recent phantom scan, and the results of scan averaging for the 10 spine scans in the previous step. Compare these printouts with those from the last PM for possible problems, and send the printouts to Hologic to be kept with the service records for this system.

[ ] From the Discovery Main Menu, select **QC|QC Data Management|Plot**. Setup the QC Plot to include QC scans from at least the last wo years. Display and print a copy of the BMD, BMC, Area, HiAir, and LoAir plots to be included in the paperwork being returned to Hologic.

[ ] During a scan, verify that pressing the red Emergency STOP switch *immediately* stops all C-Arm motion, table motion, and X-ray production. X-ray production should be monitored by a Victoreen 450P or equivalent.

[ ] Test all tape switches. The tape switches are located along the length of the front and back of the table, and mounted on the frame under the table. Verify that pressing a tape switch *immediately* stops all C-Arm motion, table motion, and X-ray production. X-ray production should be monitored by a Victoreen 450P or equivalent.

Note: The front (table) tape switch is disabled until the C-arm is at 0°, so this switch should be checked with the C-arm at a position greater than 30°.

[ ] Replace (if necessary) and adjust the motor drive belts as follows:

Note: Detailed instructions for drive belt replacement and adjustments can be found in the *REMOVE AND REPLACE* section of this manual.

[ ] For each drive belt (C-Arm Y, C-Arm R, Table X, and Table Y) perform the following:

- Loosen the 2 mounting bolts holding the tension block.
- Tighten the tension nut so that the spring is compressed to 7/8 inch. The bracket cutout can be used as a measuring guide (the inside of the washer should be flush with the bracket cut). For the AR tension spring, adjust to 7/8" from the inside of one washer to the inside of the other.
- Tighten the two mounting bolts holding each drive belt's tension block.

Note: It is not necessary to perform the MOTOR calibration procedures after tensioning the motor drive belts.

[ ] Ensure that all cable connections are tight.

[ ] Run CHECKDISK on the C drive. This utility program can be started by clicking on **start|Run…**, then typing **CHKDSK**, and then clicking the **OK** button. **DO NOT run Scandisk on any Archive media.**

[ ] Run Disk Defragmenter to and compact and re-order the files on the computer's hard disk. This utility program can be started by clicking on **Start|Run…**, then typing **DEFRAG**, and then clicking the **OK** button.

[ ] Run a computer virus checker (any major brand that is current for latest virus types).

[ ] Clean the fan filters, paying special attention to the computer fan filter.

[ ] Clean all exterior metal surfaces and wipe off the rails.

[ ] Clean the monitor screen, keyboard, and mouse ball rollers.

[ ] Clean the inkjet printer rollers and ink cartridge electrical contacts with isopropyl alcohol.

7.2.1 Guide Rail and Bearing Maintenance

On all Discovery models, a guide rail and two guide bearings (AY) are located at the lower back of the C-arm. Another guide rail and two guide bearings (TX) are located on the right side running front to back just below the table. (See Figure 7-1).

1. Clean the AY and the TX guide rails using a dry, clean cloth.

   Note: DO NOT use solvents such as alcohol or WD-40. If a solvent is needed to remove dirt and/or gum buildup on the rail, be sure to thoroughly dry the rail before moving the bearings. The solvent may harm the bearing grease.

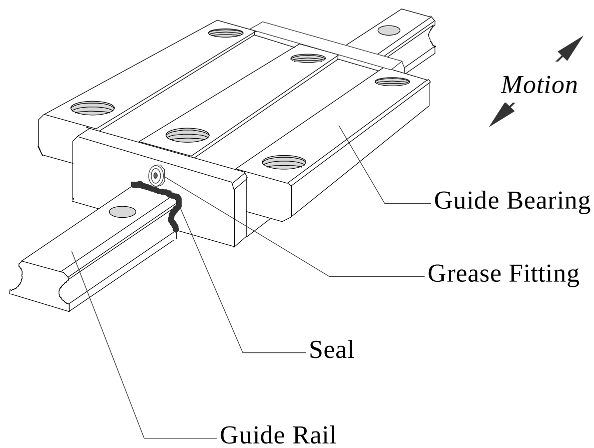


Figure 7-1. Guide Bearing and Rail

2. Grease the guide bearings.

Note: The bearings must be greased every 100km (62mi) of travel, depending on usage. This may range between one and two years. The following table lists more information about the grease to be used.

Generic	**Brand Names**	**Manufacturer**
EP-2 Lithium soap-based grease	Beacon 325	ESSO
	Alvania Grease RA	Shell
	Mobilux Grease No. 2	Mobil
	Isoflex Super LDS 18	Kluber

Consult Hologic Field Service for more information on obtaining the proper tools, material, and procedure.

Section 8

PCB SUMMARY INFORMATION

Distribution Board								
LED’s1		**Signal**	**Voltage Source**		**Jumpers**			**Refer to...**
D1	On	+7VDC	Int	Voltage Reg.	JP1 (panel)		Out	
D3[2]	Off	TZ Drive	-	-	JP2 (dist)		Out	
D5	On	+5VDC	Int	Voltage Reg.	JP3 (C-arm)		Out	
D7	On	+28VDC	Int	Low Voltage Power Supply	**Circuit Breakers**			Figure 5-1
D9	On	+15VDC	Int	Low Voltage Power Supply	CB	Drive	Normally	
D10	On	-15VDC	Int	Low Voltage Power Supply	1	TZ	In A&SL	
-	-	+24VDC	Int	Low Voltage Power Supply	2	TY	In	
D11[2]	Off	TY DRIVE			3	TX	In	
D12[2]	Off	TX DRIVE			4	AR	In A&SL	
D13[2]	Off	AR DRIVE			5	AY	In	
D14[2]	Off	AY DRIVE						
Notes:	Voltage indicators = green; motor drive status = red If red led is on, there is a failure in the PCB. The CB should be tripped.							

PCI Communications Command Board		
Jumpers		**Refer to...**
JP1 (IRQ) at 10	In	
JP2 (IRQ)	Out	Figure 5-17
JP3 (IREQA)	Out	
JP4 (IREQB)	In	
JP5 (E-OUT) at C	In	

Stepper Motor Controller								
Signal		**Signal**	**Source**		**Jumpers and Switches**		**Refer to...**
D3	On	+24VDC	Ext	Signal Dist.	W1 (SYSRESET)	In	
D6	On	+5VDC	Int.	Voltage Reg.			
-	-	-5VDC	Int.	Voltage Reg.			
D7 (4 LED pack)							
MEN	On	**Note:** All 4 LED's are On					
CPU	Flash	solid when the selected					
DIR	Off	motor drive is engaged.					
STEP	Off					Set to...	
		Stepper motor (AR)			SW1	6	Figure 5-9
		Stepper motor (AY			SW1	7	Figure 5-1
		Stepper motor (TX)			SW1	4	Figure 5-3
		Stepper motor (TY)			SW1	5	Figure 5-2

TZ Drive (A and SL Only)							
LEDs		**Voltage / Signal**	**Source**		**Jumpers**		**Refer To...**
D11	On	+5VDC	Int.	Voltage Reg.	JP7 (NORMAL)	In	
D12	On	+24VDC	Ext.	Signal Dist.	JP8 (TEST)	Out	Figure 5-1
D8	Flash	STATUS (4 LED group)	-	-	NORMAL/ SERVICE	NORM	
-	-	-5VDC	Int.	Voltage Reg.	UP/DOWN SERVICE	N/A	
-	-	+3VDC	Int.	Voltage Reg.			
-	-	-3VDC	Int.	Voltage Reg.			
-	-	240VAC	Ext.	Power Cons.	JP6	Left Ped. (pin 4 to 5) Right Ped. (pin 1 to 2)	

128-Channel Detector Assembly (C, W and SL Models only)								
LED's		**Voltage**	**Voltage Source**		**Jumpers**		**Refer to...**
D4	On	+12VDC	Int.	Voltage Reg.	J1 (Run/Test)	In	
D5	On	-12VDC	Int.	Voltage Reg.	J2 (Run/Test)	In	
D6	On	VCC	Int.	Voltage Reg.			
D7	On	+5VDC	Int.	Voltage Reg.			
U14 (LED display) Flickers "1" on bootup, then lock on "2".							
Potentiometer		R18 (A/D GAIN CNTRL) See procedure in Section 4.					Page 4-26

Detector Array Assembly (A Model only)			
Source		**Source**	**Refer To...**
+15VDC	Ext.	ADC PCB	
-15VDC	Ext.	ADC PCB	Figure 5-8
+5VDC	Ext.	ADC PCB	
+12VDC	Int.	Voltage Reg.	
-12VDC	Int.	Voltage Reg.	

ADC (A Model only)							
LEDs		**Voltage**	**Voltage Source**		**Jumpers**		**Refer to...**
D1	On	VCC	Int.	Voltage Reg.	JP3 (GROUND)	Out	
D2	On	+5VDC	Int.	Voltage Reg.	JP5 (HI/LO RES)		
D3	On	+12VDC	Int.	Voltage Reg.	A	In	
D4	On	-12VDC	Int.	Voltage Reg.			Figure 5-11
D5	On	-5VDC	Int.	Voltage Reg.			
-	-	+7VDC	Ext	C-Arm Int. Bd.			
-	-	+/-15VDC	Ext	C-Arm Int. Bd.			
U14 (LED display) Flickers "1" on bootup, then lock on "2".							
Potentiometer		P3 (A/D GAIN CNTRL) See procedure in Section 4.					Page 4-26

C-Arm Interface								
LED's		**Signal**	**Voltage Source**		**Jumpers**			**Refer to...**
D1	On	+28VDC	Ext	Signal Dist.	JP7	DRUM	Out	
D3	On	+24VDC	Ext	Signal Dist.	JP8	MAIN	Out	
D6	On	+5VDC	Int.	Voltage Reg.	W1, W2	NORMAL(1-2) TEST (2-3)	In	
-	-	+7VDC	Int.	Voltage Reg.	W3	SYS-RESET	In	
-	-	+15VDC	Ext	Signal Dist.	W4	TEST-MODE	Out	
-	-	-15VDC	Ext	Signal Dist.	W5	Safety switches	In	
Drum					JP15	Redundant for		
D7	On	LOCKED				W5 may be Out if W5 is In		Figure 5-6
D8	Flash-ing	DRUM AT TOP						
X-Ray								
D9	Off	X-RAY CPU ERROR						
D10	Off	X-RAY ENABLE						
D11	On	X-RAY CPU OK						
D12	Off	X-RAY FAULT						

Section 9
SOFTWARE TOOLS

The Discovery system software includes software tools to troubleshoot the system. They are:

- X-Ray Survey Tool Disk
- SQDRIVER
- SQVERIFY
- Emergency Motion (SQKEYPAD)

9.1 X-Ray Survey

The X-Ray Survey is a 32-bit utility that tests the functions of X-Ray generation and detection for the system. This utility is used by Hologic manufacturing and service engineers only.

9.1.1 Invoking X-Ray Survey

1. Log on as the Field Service and start the QDR Software in Service mode.
2. Click **Utility** > **Service Utilities** > **X-Ray Survey** and the X-Ray Survey utility screen will appear (see Figure 9-1).

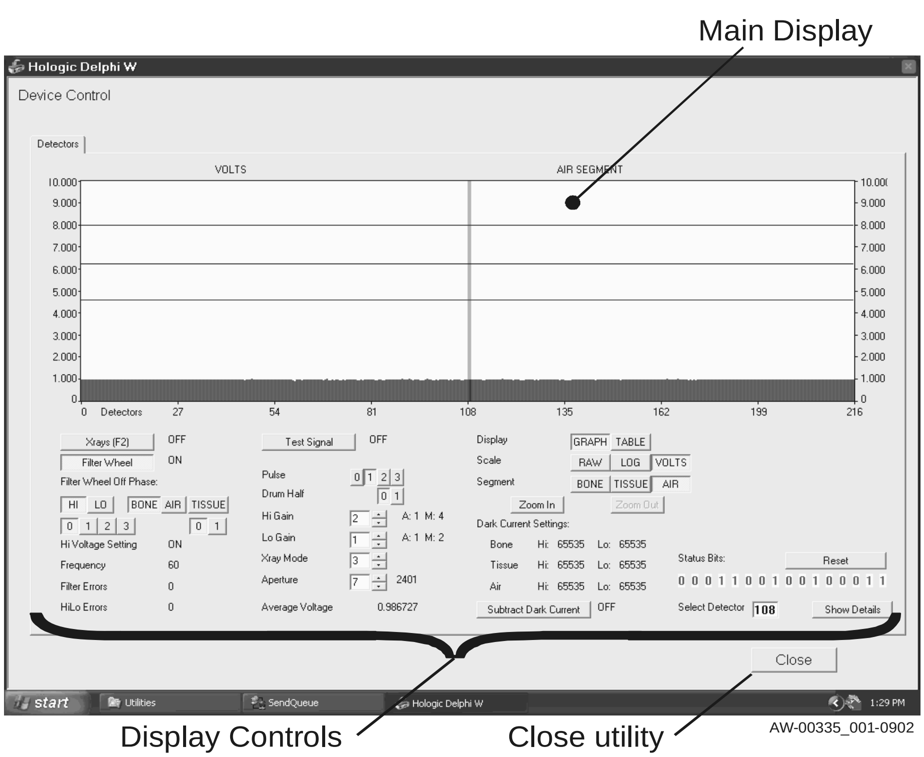


Figure 9-1. The Main Display Controls

The utility screen is broken into three parts:

1. The Main Display shows either a bar-graph or numeric fields for each detector depending on which **Display** button is selected.
2. The Display Controls that affect the data shown in the main display. Not all controls are used by the field engineer.
3. The **Close** button which exits the utility.

9.1.2 The Main Display

The Main Display provides data in two forms depending upon which display button is selected.

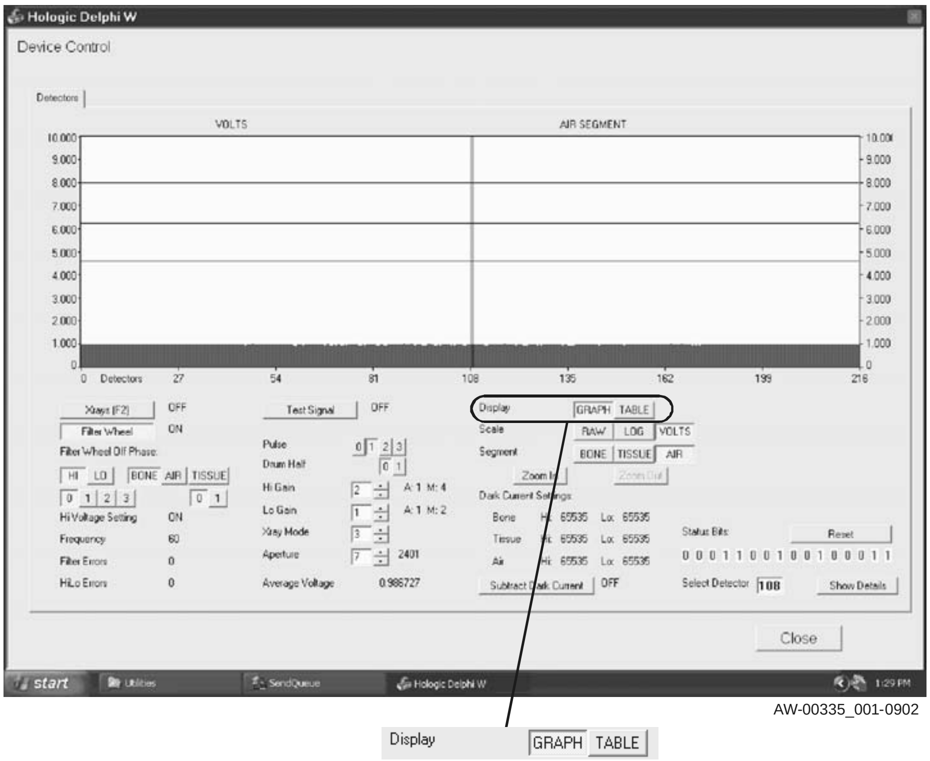


Figure 9-2. The Main Display Controls

When the **Graph** button is active and the system is producing X-Rays, the data is presented in a bar graph (see Figure 9-3). Scale markings on the bottom of the graph indicate detector numbers. Scale markings aling the sides indicate the numeric value of the column height. A label alone the left half of the graph indicates which numeric value for the column is being displayed (for field engineering purposes this will always be Volts). A label above the right half of the graph indicates which drum segment is being displayed (for feild engineering purpose this will always be Air Segment). The bar grapg shaded green is the hi voltage, the bar graph shaded brown is lo voltage.

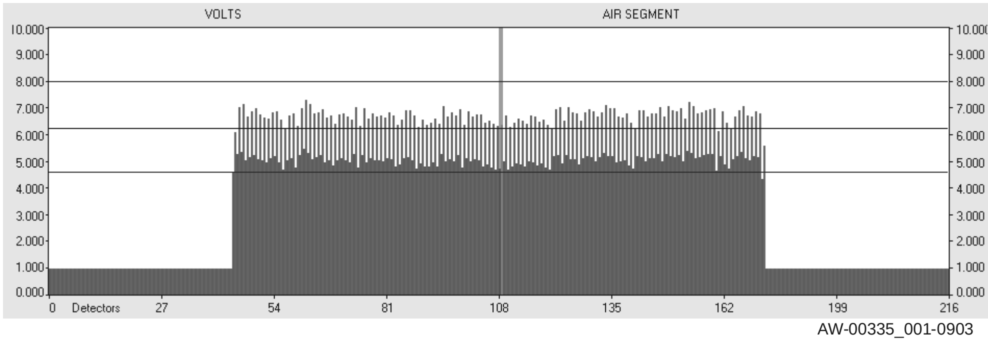


Figure 9-3. X-Ray Data as a Bar Graph

When the Table button is active and the system is producing X-Rays, numeric data is preserved (see Figure 9-3). A label above the left half of the graph indicates which value is being displayed (for field engineering purpose this will always be Volts). The display has a vertical scroll bar on the right because only a sixth of the data for all of the detectors is showing at one time.

VOLTS

Det	HiBone	LoBone	HiTiss	LoTiss	HiAir	LoAir	Det	HiBone	LoBone	HiTiss	LoTiss	HiAir	LoAir
0	0.9873	0.9868	0.9871	0.9870	0.9866	0.9868	108	4.5940	2.9068	5.2164	3.8352	6.3023	4.7541
1	0.9866	0.9870	0.9866	0.9874	0.9868	0.9870	109	4.8775	3.0504	5.5142	4.0497	6.6705	5.0092
2	0.9870	0.9871	0.9868	0.9873	0.9868	0.9866	110	4.5315	2.8821	5.1557	3.7827	6.2382	4.6867
3	0.9871	0.9874	0.9870	0.9870	0.9868	0.9866	111	4.6593	2.9419	5.2683	3.8769	6.4106	4.8223
4	0.9873	0.9874	0.9868	0.9868	0.9865	0.9874	112	4.7286	2.9795	5.3881	3.9594	6.5748	4.9297
5	0.9871	0.9873	0.9868	0.9871	0.9866	0.9870	113	4.7218	2.9769	5.3701	3.9452	6.5142	4.8956
6	0.9876	0.9870	0.9868	0.9871	0.9868	0.9868	114	4.6621	2.9331	5.2781	3.8758	6.3891	4.8112
7	0.9871	0.9868	0.9871	0.9874	0.9868	0.9866	115	4.8371	3.0277	5.4984	4.0230	6.6435	4.9960
8	0.9871	0.9871	0.9866	0.9868	0.9871	0.9865	116	4.8209	3.0155	5.4618	4.0230	6.6505	4.9882
9	0.9866	0.9868	0.9871	0.9868	0.9870	0.9866	117	4.6694	2.9636	5.3062	3.9135	6.4443	4.8365
10	0.9871	0.9868	0.9866	0.9868	0.9862	0.9870	118	4.7143	2.9831	5.3451	3.9448	6.4994	4.9065
11	0.9866	0.9866	0.9865	0.9868	0.9866	0.9863	119	4.5945	2.8945	5.2049	3.8154	6.2756	4.7382
12	0.9868	0.9870	0.9865	0.9868	0.9863	0.9871	120	4.5115	2.8629	5.1020	3.7787	6.2164	4.7054
13	0.9866	0.9865	0.9870	0.9866	0.9865	0.9865	121	5.0088	3.1420	5.6872	4.1855	6.9201	5.2317
14	0.9876	0.9871	0.9870	0.9873	0.9873	0.9871	122	5.0372	3.1768	5.7111	4.2257	6.9633	5.2790
15	0.9879	0.9880	0.9877	0.9882	0.9876	0.9874	123	4.6746	2.9699	5.3095	3.9577	6.4886	4.9206
16	0.9880	0.9877	0.9874	0.9874	0.9877	0.9876	124	5.0350	3.1580	5.7432	4.2133	6.9938	5.2476
17	0.9880	0.9880	0.9877	0.9877	0.9877	0.9876	125	4.9287	3.0898	5.5879	4.1051	6.8188	5.1318

AW-00335_001-0904

Figure 9-4. X-Ray Data as a Raw Data

9.1.3 The Display Controls

9.1.3.1 The Display Controls

The Display Controls can be broken into four functional areas:

- Controls starting with **Xrays (F2)** OFF/ON
- Controls starting with **Test Signals**
- Controls starting with **Display**
- Controls starting with **Status Bits**

9.1.3.2 Controls starting with Xrays

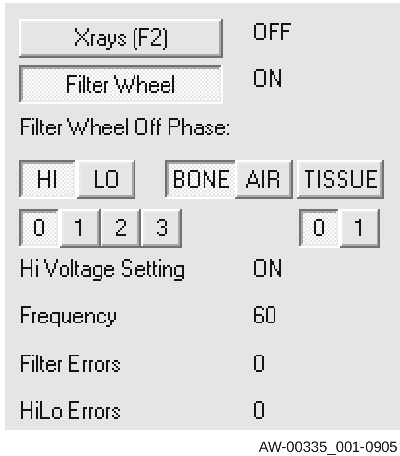


Figure 9-5. Controls Starting with Xray

These controls include:

9.1.3.2.1 Xrays (F2) button OFF/ON.

The default setting of this button is OFF. Clicking this button will produce X-Rays from the system. Keyboard F2 can also be used (toggles Xrays ON and OFF). When **Xrays** are ON warning lights on the scanner will go on and the Main Display will look like either Figure 9-3 or Figure 9-4 depending on the setting of the **Display** button (see below). When the **Xray (F2)** button is ON the **Filter Wheel** button is grayed out and cannot be used.

WARNING: While the Xray button is ON the system is producing X-Rays, take proper precautions.

9.1.3.2.2 Filter Wheel button OFF/ON.

The default for this button is OFF. The Field Engineer will not use the Filter Wheel button and it should always remain OFF. This deals with testing the system in different mode.

Note: The next set of controls have the label Filter Wheel Off Phase which indicates the state of the Filter Wheel. These controls (HI/LO, BONE/AIR/TISSUE, 0/1/2/3 and 0/1) indicate where the Filter Wheel will stop when it is not moving.

*9.1.3.2.3 **HI/LO** buttons.*

The default for these buttons is **HI**. The Field Engineer will not use the **HI/LO** buttons and they should always remain the default.

*9.1.3.2.4 **BONE/AIR/TISSUE** buttons.*

The default for these buttons is **BONE**. The Field Engineer will not use the **BONE/AIR/TISSUE** buttons and they should always remain the default.

*9.1.3.2.5 **0/1/2/3** buttons.*

The default for these buttons is **0**. The Field Engineer will not use the **0/1/2/3** buttons and they should always remain the default.

*9.1.3.2.6 **0/1** buttons.*

The default for these buttons is **0**. The Field Engineer will not use the **0/1** buttons and they should always remain the default.

Label Information

This area also provides information on the **Hi Voltage Setting** (either ON or OFF), **Frequency**, **Filter Errors** and **HiLo Errors**.

9.1.3.3 Controls starting with Test Signals

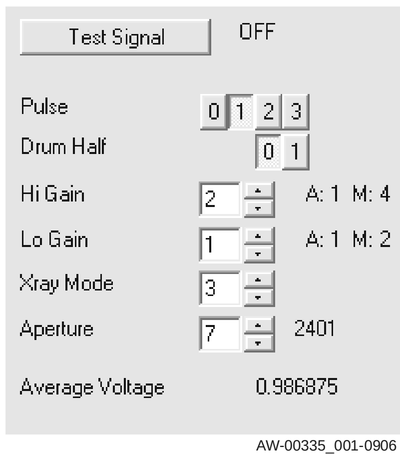


Figure 9-6. Controls starting with Test Signals

These controls include:

9.1.3.3.1 Test Signal button OFF/ON.

The default setting of this button is OFF. When this button is ON a test signal is sent to all of the detectors. Activity will be shown on the main display (see Figure 9-3 or Figure 9-4).

9.1.3.3.2 Pulse 0/1/2/3.

The default setting of this button is **1.** This indicates what data is displayed and not what the scanner is doing. The Field Engineer will not use the Pulse **0/1/2/3** buttons and they should always remain the default.

9.1.3.3.3 Drum Half 0/1.

The default setting for this button is **0**. This indicates what data is displayed and not what the scanner is doing. The Field Engineer will not use the Pulse **0/1** buttons and they should always remain the default.

9.1.3.3.4 Hi Gain.

This is a spinner control with a range of 0 to 11. Changing **Hi Gain** changes the displayed detector values for the Hi portions of the current segment. The associated actual gain values are shown in the following table.

Gain Code	A/D Gain	MUX Gain	Total Gain
0	1	2	1
1	1	2	2
2	1	4	4
3	1	8	8
4	2	1	2
5	2	2	4
6	2	4	8
7	2	8	16
8	4	1	4
9	4	2	8
10	4	4	16
11	4	8	32

9.1.3.3.5 Lo Gain.

This is a spinner control with a range of 0 to 11. Changing Lo Gain changes the displayed detector values for the Lo portions of the current segment. The associated actual gain values are shown in the above table.

9.1.3.3.6 Xray Mode.

This is a spinner control with a range of 0 to 8. The default mode is 3. This control determines the voltage, current and duty cycle for the x-ray generator. Most scans use X-ray Mode 3, Whole Body uses 3 and IVA (single energy) uses 6. The following table shows the full set of defined X-ray modes.

X-Ray Mode	Pulse Cycle	Peak Ma	Average Ma	High KV	Low Kv
0	0	--	--	--	--
1	50%	3	0.75	140	100
2	50%	10	2.5	--	100
3	50%	10		240	100
4	50%	3	0.75	--	80
5	50%	3	0.75	140	80
6	100%	10	5.0	140	--
7	50%	10	2.5	140	--
8	100%	10	5.0	--	100

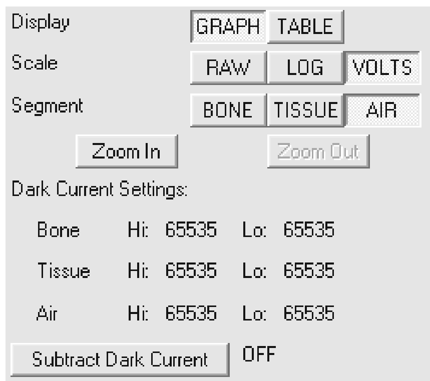
9.1.3.3.7 Aperture.

This is a spinner control with a range of 0 to 13. This controls the slit through which the X-rays pass to limit the dimensions of the X-ray beam. This control allows the selection of a specific aperture in the system and can be used to test aperture movement.

9.1.3.3.8 Average Voltage

This displays the average voltage across all detectors for the Hi Air segment

9.1.3.4 Controls starting with Display



AW-00335_001-0907

Figure 9-7. Controls starting with Display

9.1.3.4.1 Display

This has two buttons: **GRAPH** and **TABLE**. This controls what is seen on the Main Display. In **GRAPH** the Main Display shows as a bar graph (see Figure 9-3) with scale markings on the left side according to how Scale is set (see below). It shows the lo (brown tinted) and the hi (green tinted) voltages. In **TABLE** the Main Display shows the data from the detectors as numeric data.

9.1.3.4.2 Scale

This has three buttons: RAW, LOG and VOLTS. The Default is VOLTS. The Field Engineer will not use RAW or LOG and the button should always remain the default (VOLTS). This control sets up the scale markings on the Main Display when the Display is set to GRAPH and changes the units for the numeric value when the TABLE is displayed.

9.1.3.4.3 Segment

This has three buttons: BONE, TISSUE and AIR. The default is AIR. This controls the data segment that are displayed in the GRASPH. The Field Engineer will not use either BONE or TISSUE and the button should always remain the default (AIR).

9.1.3.4.4 Zoom In and Zoom Out.

By default, the GARAPH is displayed at minimum resolution When either function reaches it maximum the button will be grayed out. Zoom In increases the resolution, meaning that less of the total data range is displayed on the graph but differences in bar heights are magnified. The horizontal scale isn't affected and all detectors are displayed regardless of the zoom value. Zoom Out will reverse what Zoom In has done.

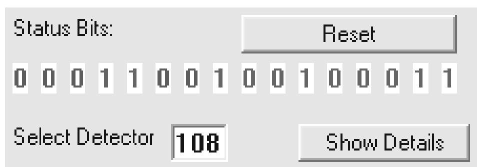
9.1.3.4.5 Data Current Settings

This reports the Hi and Lo settings of the dark current for Bone, Tissue and Air.

9.1.3.4.6 Subtract Dark Current OFF/ON

The default for this button is OFF. Dark voltage is a residual reading for any equipment that has current. Hologic allows 1 volt to compensate for dark current (see Figure 9-3). Clicking on this button will remove the dark voltage from the Main Display bar graph. The Field Engineer will not use Subtract Dark Current and it should always remain the default.

9.1.3.5 Controls starting with Status Bits



AW-00335_001-0908

Figure 9-8. Controls starting with Status Bits

9.1.3.5.1 Status Bits

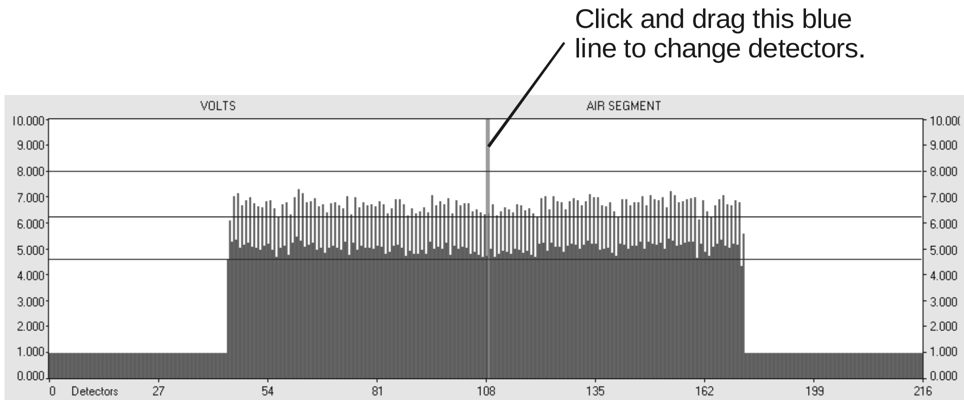
Detector values come back from the scanner as sixteen bit numbers, traveling through some parts of the hardware on sixteen separate wires. The Status Bits field displays the most recent value for each bit, and color-codes whether that bit has ever changed. Red bits have not been changed, green bits have. The Reset button sets all the bits to red.

9.1.3.5.2 Reset

The Reset button re-starts the process of computing the means and standard deviations for each filter-segment. It resets the number of samples to zero. It also resets the bits in the Status Bits display.

9.1.3.5.3 Select Detector

This is an edit box that displays specific data about the selected detector. Select Detector has a default of 108 (the middle of the bar graph as shown in Figure 9-3). This displays both the currently selected detector (number) and allows a new detector to be selected by insert a number in the edit box. A new detector can also be selected by dragging the vertical blue line on the Main Display bar graph (see Figure 9-9). The number displayed in the edit box will be automatically updated to reflect the line position.



AW-00335_001-0909

Figure 9-9.Moving the Detector

9.1.3.5.4 Show Details

Show Details defaults to off. When clicked, a small window pops up containing detailed information about one detector, in tabular form (see Figure 9-10). This information includes the current (most recent) value, mean value, standard deviation and number of samples (values used to calculate the mean and standard deviation) for each of the six filter-segments. The pop-up window can be dragged wherever the user wants and remains until Show Details is actively released.

Data for Detector 108:

	Volts	N	Mean	StdDev	CV%
Hi Bone	* 0.9647	20	0.9643	0.0003	0.0000
Lo Bone	* 0.9592	9	0.9592	0.0002	0.0000
Hi Tissue	* 0.9642	23	2.1726	2.3444	0.0165
Lo Tissue	* 0.9592	24	1.7210	1.5171	0.0135
Hi Air	* 0.9638	22	0.9642	0.0003	0.0000
Lo Air	* 0.9595	13	1.3313	1.3417	0.0154

Figure 9-10. Show Details Window

9.2 SQDRIVER

The SQDRIVER program is accessed from the Discovery Main Menu by selecting **Utilities|Service Utilities|SQDRIVER**. This program is used to calibrate the motors and can be used as an effect tool for troubleshooting motor movement problems.

9.3 SQVERIFY

The SQVERIFY program is accessed from the Discovery Main Menu by selecting **Utilities|Service Utilities|SQVERIFY**. This program is a diagnostic program, which can be used to perform a series of low-level tests of system components. Refer to the SQCHECK User Manual (080-0707) for detailed explanations of its use.

9.4 SQKEYPAD

The SQKEYPAD program is accessed from the Discovery Main Menu by selecting **Utilities|Emergency Motion**. This program provides the Field Service Engineer with a method for moving all motors even in conditions where a detected software error condition would normally prevent any movement of the motors. This program can be used as a quick means of checking most motor control functions.

Section A
ERROR MESSAGES

For any system error there may be one, or more, messages. Messages shown in the *Error Message List* section below may be the first message, or a subsequent message.
All messages, for each system error, are saved in the ERRLOG file.

In the following *Error Message List*, error messages are in alphabetical order (by first line of their message text).

In some cases a message identifier is also provided [in brackets].

The error messages covered in this section may indicate a hardware, or software, error. For hardware errors a suggested action is provided.

In most cases, software errors are “software checks” that are used during the software development process. During normal operation, these messages should never appear. If they do, and a suggested action is not provided, call Hologic Technical Support. Include as much information as possible about what was being done at the time the error occurred (including all messages for that error, LOCUS field, message identifier, etc.).

NOTE:
Depending on the software running on the unit additional error messages may be available that are not described in this appendix.

Error Message List

ERROR MESSAGE	HARDWARE /SOFTWARE ERROR	LOCUS	COMMENT/ACTION
Address in the response message did not match the address in the sent message. [E_ADDRESS_MISMATCH_I]			
			Action: This message should be reported to Hologic Technical Support. Include as much information as possible about the scan.
Analysis aborted. d0= ___ below acceptable limit			
	Hardware or Software		d0 is found to be below zero, which is not possible if there are X-rays reaching the detector. Action: This message should be reported to Hologic Technical Support. Include as much information as possible about the scan.
Arm and table are in danger of colliding! [E_COLLISION_IMMINENT_I]			Comment: The C/C has calculated that the C-arm and table are within 1/4". Action: If the C-arm and table are really within this distance, the problem is with the application (or operator) that moved them so close. If they are not, then either the calibration information for the system is wrong or the mechanical stops for the table and C-arm have moved. One or more of the motors may have stopped short of the actual mechanical stop during calibration. Verify that the positive limit positions for each motor correspond to the published specs for the model. To recover from this, select the **Utility** option from the main menu and then select the **emergency Motion** option from the sub-menu. By holding down the **Enable** button on the operator control panel, you can use the keypad to move the table and C-arm away from each other.

ERROR MESSAGE	HARDWARE /SOFTWARE ERROR	LOCUS	COMMENT/ACTION
Bad checksum in message. [E_BAD_BLOCK_I]			Comment: The checksum calculated by the C/C for a message did not match the one in the message packet. Action: Either the driver is incorrectly configured, one or more devices are jumpered to the debug mode, there is a hardware problem on the communication link (cable or connectors) or one of more of the DSP chips in the C/C or DAS board is not properly seated. Verify that the DEVICE=C:\MENU\MAPIDEV.SYS line in CONFIG.SYS has the options /OVERLAP=0 and /HANDSHAKE=1. Check each stepper motor board and verify that its address is correctly set. Verify that the TZ motor board **does not** have the debug jumper installed. Verify that the communications cable is installed and properly secured on the back of the C/C board. If the problem persists, it may be because one (or both) of the DSP chips on the C/C or DAS board is not properly seated in the PGA socket. Try "massaging" the DSP chip on the C/C board **and** the one on the DAS board. If the problem changes (gets worse or better) when you do so, replace the appropriate board. If the problem persists, place all devices in emulation mode (e.g., by turning off instrument power and booting in the workstation mode). Disconnect all devices except the C-arm from the communications link. Turn off C-arm emulation. If there are no problems, proceed to re-connect each device and take it out of emulation until the offending device is found. Replace the appropriate board.
BoundaryLine Internal Software Error	Software		This message should be reported to Hologic Technical Support. Include as much information as possible about what you were doing at the time.
Cannot generate bad detector map, too many bad detectors			Action: One or more detectors is bad. See instructions for running hardware checking program.
Cannot obtain results of scan ________ of __________	Software		Comment: For some reason, the system was unable to obtain the results of a scan that was selected for normals plotting. Action: This message should be reported to Hologic Technical Support.
Can't open a window	Software		Action: Ensure that **only** Hologic software is installed on the computer. If so, report this message to Hologic Technical Support. Include as much information as possible about what you were doing at the time.

ERROR MESSAGE	HARDWARE /SOFTWARE ERROR	LOCUS	COMMENT/ACTION
Carm Unable to position device within specified tolerance	Hardware		Comment: There is a problem with the aperture mechanism. Action: Check the aperture assembly. Test the aperture positioning with the SUSQ program.
Corrupted Scan Data Detected	Software		This message should be reported to Hologic Technical Support. Include as much information as possible about what you were doing at the time.
Could not find file extension in	Software		This message should be reported to Hologic Technical Support. Include as much information as possible about what you were doing at the time.
Couldn't write the new record	Hardware or Software		Comment: The system was unable to write a reference curve that was entered or edited. Action: Check that the hard drive is not full. That is, check the message "Room for __ scans" in the status window and ensure that it does not say zero. If it is full, then archive and delete one or more scans and try again. If the hard drive is not full, then you have either a hard drive failure or a corrupt reference curve database.
db_File error __ ..... **or** **db_VISTA error __ .....**	Software		Any message that begins this way should be reported to Hologic Technical Support. Include as much information as possible about what you were doing at the time.
Device already in use by foreground task [E_LOCKOUT_I]		MAPI	Comment: The MAPI driver was already opened by another application when the driver attempted to go ON_LINE (i.e., the driver requires exclusive access to the MAPI driver). Action: Report this error to Hologic Technical Support.

ERROR MESSAGE	HARDWARE /SOFTWARE ERROR	LOCUS	COMMENT/ACTION
		STATE	Comments: 1. An application attempted to load or execute a state machine when one was already running, or an application attempted to execute a state machine while one or more devices were still executing a command, or an attempt to abort the currently executing state machine failed. 2. Whenever an application issues a device command and the state machine is executing a state machine protocol. Action: Report these errors to Hologic Technical Support.
		MOTOR_xx	Comment: An application attempted to modify stepper motor parameters while the motor was moving (acceleration distance/type, first/final rates, position average, etc.), or an application issued a MOVE_ABS while a MOVE_REL was in progress (or vice versa). Action: Report this error to Hologic Technical Support.
		C-Arm	Comments: 1. An application attempted to control the laser positioning light when it was under local control or an application attempted to turn on the laser while the C-arm and table were within the laser safety distance of each other. Action: Be sure the table and C-arm are properly positioned before starting a scan. If the problem persists, report this error to Hologic Technical Support. 2. An application attempted to issue another move command to the aperture shuttle while it was still moving. Action: The aperture may not be calibrated and an application attempted to move it to a calibrated position. The aperture shuttle on the C-arm may be jammed and the driver is still attempting to position it in response to a previous MOVE_ABS command. Visually inspect the aperture shuttle and use the MOVE_REL command to verify that the shuttle is moving. If it is not, fix the mechanical or electrical problem with the aperture shuttle and then recalibrate the aperture.

ERROR MESSAGE	HARDWARE /SOFTWARE ERROR	LOCUS	COMMENT/ACTION
		Motor_TZ	Comment: The TZ system is in service mode; the pedestals are moving and an application attempts to move them in the opposite direction; or the TZ system is performing a calibration. Action: Verify that the TZ board service mode switch is in the off position. Note: If you change the service mode switch position on the TZ board, you must reset the TZ microprocessor before the new switch position takes affect. Otherwise, report this error to Hologic Technical Support.
Device has not been configured [E_NOT_CONFIGURED_I]			Comment: Invalid motor calibration data has been sent to the driver (e.g., one or more of the motor calibration parameters–number of steps, step distance, number of ticks or tick distance–is less than or zero). Action: Verify that the system has been properly calibrated and the normal Hologic system startup procedure has been followed (i.e., reboot the machine and if the problem persists, recalibrate the motor).
Device is in emulation mode [E_EMULATE_I			Comment: The device is in emulation mode. This is not an error but a report of the device driver internal state. Some QDR 4500 models normally run with emulation enabled for the devices that are not installed (e.g., the 4500W does not support the AR device). Action: None.
Device not ready to perform requested action [E_NOT_READY_I			
		STATE	Comment: An application attempted to execute a state machine but the state machine is not ready to execute because one or more of the necessary data structures has not been downloaded (program or task table). Action: Report this error to Hologic Technical Support.

ERROR MESSAGE	HARDWARE /SOFTWARE ERROR	LOCUS	COMMENT/ACTION
		C-Arm	Comment: Attempt to turn on X-rays when either the filter drum is not yet locked (if it is on) or the initial 30-second X-ray delay after startup has not elapsed. Reported as the device state if the C-arm is reset. Reported as command error for any IS_xxx command executed from an application (as opposed to executing from a state machine). Action: Wait until the filter drum synchronizes to the A/C line and until the high voltage relay in the X-ray controller is turned on (30 seconds after the system starts).
		Motor_xx	Reported as command error for any IS_xxx command executed from an application (as opposed to executing from a state machine). Reported as device state if the motor is reset. Action: Determine why the motor was reset (e.g., power line brown out).
		Motor_TZ	Reported as command error for any move command until valid calibration information has been downloaded. Reported as command error for any IS_xxx command executed from an application (as opposed to executing from a state machine). Action: Verify that the TZ driver has been calibrated and that the correct Hologic system startup procedure has been followed (i.e., reboot the system and if the problem persists, recalibrate the TZ motor)
Device time-out waiting for requested action [E_TIME_OUT_I]			Comment: For everything except the state machine, indicates that a message was sent to the device and a response was not received within 150ms. Action: Follow the procedure under "BAD CHECKSUM IN MESSAGE." for isolating the failed device and replace or repair it. Comment: For the state machine, indicates that one of the self-limiting commands has timed out or that the state machine continued executing into the next cycle. Action: Report this error to Hologic Technical Support.

ERROR MESSAGE	HARDWARE /SOFTWARE ERROR	LOCUS	COMMENT/ACTION
Driver is not installed [E_NOT_INSTALLED_I]			Comment: Returned in response to the ON_LINE command to indicate that the MAPI driver is not installed in the system. Action: Verify that the line DEVICE=C:\MENU\MAPIDEV.SYS is in the system CONFIG.SYS file, that the correct interrupt level (IRQ) and I/O base address are specified and that the file C:\MENU\MAPIDEV.SYS is installed on the system.
Driver is off line [E_OFF_LINE_I]			Comment: Returned by any driver whenever a command is written to the driver and the system is OFF_LINE. Action: Put the driver back on line.
Driver missed a hardware interrupt [E_MISSED_INTERRUPT_I]			Comment: The filter drum or the X-ray hi/lo monitor is enabled in the C-arm driver and the driver detected a dropped message from the C-arm microprocessor (indicated by a mismatch in the message sequence field). Action: Verify that no other software, TSR or operating system is running while you do a scan (e.g., do not run a scan with while connected to a network or attempt to run a scan under Windows). This may also be due to a communications error between the AT and the C-arm. Follow the procedure under "BAD CHECKSUM IN MESSAGE." to diagnose I/O errors.
Emergency stop active [E_EMERGENCY_STOP_I]			Comment: The system emergency stop is active, either because the operator has pressed the emergency stop button, one of the emergency stop strips has been touched, or because the C/C has calculated that the C-arm and the table are within 1/10" of each other. Action: If the emergency stop button on the operator panel is down (on), pull it up. Verify that nothing is touching the emergency stop strips on the table. If the C-arm and table are within 1/10", the problem is with the application (or operator) that moved them so close. If they are not, see the discussion about E_COLLISION_IMMINENT_I. If both E_COLLISION_IMMINENT_I and E_EMERGENCY_STOP_I are active, the only way to recover is to manually push the table and C-arm away from each other and then follow the recovery procedure under E_COLLISION_IMMINENT_I.
End of file			Action: This could occur at the start of a lateral scan if the currently selected scan is not an analyzed companion AP scan.

ERROR MESSAGE	HARDWARE /SOFTWARE ERROR	LOCUS	COMMENT/ACTION
Error closing optical file ________________ **Error flushing optical file _______________** **Error writing optical record ____________**	Hardware		There is a problem writing an optical file. Either the medium is full, or there is a hardware malfunction. Action: Check for disk full. Go to DOS, type DIR D: and check for free space. If the disk is not full, call Hologic Technical Support.
Error copying file _________	Hardware		There was an error copying the named file. Action: Verify that there was space on the target drive. Check the "Room for .. " message in the status window. Run appropriate diagnostics.
Error creating file ______________ _________________	Hardware or Software		There is a problem creating a new file (which may be on your hard drive, your diskette, or your optical). Either the medium is full, or there is a hardware error. Action: First determine which disk drive is involved. The filename should start with a drive letter, followed by a colon. Drive A: is diskette, C: is hard drive, and D: is the optical. Check for disk full. For diskette, simply try a different diskette and see if the problem goes away. For hard drive, check the "Room for ___" message in the status window. For optical, type DIR D:. If the disk is not full, run appropriate diagnostics.
Error initializing graphics module.			Action: This can be caused by not enough available memory or an incorrect graphics adapter. Verify that **only** Hologic software is installed on the system and that the graphics adapter has not been modified.
Error in region of interest structure	Software		Action: This message should be reported to Hologic Technical Support. Include as much information as possible about what you were doing at the time.
Error opening the flattening input file **Error reading flattening configuration record**			Action: Disk error or missing software. Check operation of hard disk, and check consistency of system software with CHEKPART.
Error reading flattening factor record			Action: Most likely cause is no flattening done for given scan mode. Re-run BIGFLAT.

ERROR MESSAGE	HARDWARE /SOFTWARE ERROR	LOCUS	COMMENT/ACTION
Error reading flattening records			Action: Disk error or missing software. Check operation of hard disk, and check consistency of system software with CHEKPART.
Error reading Optical drive: ____________ **Error reading file _______ : __________**	Hardware		There was a disk problem while reading a file. Action: Run appropriate diagnostics.
Error reading reference attenuation record			Action: Flattening may not have been done for this scan mode. Re-run BIGFLAT.
Failure at file ________ line ______ **file extension doesn't start with 'P' in ...**	Software		These messages should be reported to Hologic Technical Support. Include as much information as possible about what you were doing at the time.
flattening records are not initialized			Action: Disk error or missing software. Check operation of hard disk, and check consistency of system software with CHEKPART.
Garbled Optical File	Software		The optical file that you are attempting to restore scans from seems to be clobbered. Action: Run diagnostics on the optical drive. If this error recurs, report it to Hologic Technical Support.
GetDKernel Internal Software Error **GetKernel Internal Software Error**	Software		These messages should be reported to Hologic Technical Support. Include as much information as possible about what you were doing at the time.

ERROR MESSAGE	HARDWARE /SOFTWARE ERROR	LOCUS	COMMENT/ACTION
Histogram Overflow in datahist **Histogram Smoothing Error** **Illegal Context Record Type** **Illegal high value in qgen** **Inconsistent d0 limits in rsattencalc** **Indeterminate or bad data for attenuation curves** **Indeterminate Data For k Calculation** **Insufficient Data To Determine k/delta0**	Software		These messages should be reported to Hologic Technical Support. Include as much information as possible about what you were doing at the time.
Internal Buffer Size Exceeded	Software		This message should be reported to Hologic Technical Support. Include as much information as possible about what you were doing at the time.
Internal device request queue full [E_QUEUE_FULL_I]			Comment: The common buffer area for storing system sounds is full. Action: Run CHEKPART to verify system software is correctly installed. Reduce the size of one or more of the tunes or tune files you used to specify the system sounds.

ERROR MESSAGE	HARDWARE /SOFTWARE ERROR	LOCUS	COMMENT/ACTION
Internal driver error [E_INTERNAL_ERROR_I]			Comment: If returned in response to an ON_LINE command, indicates that the MAPI device driver is not properly installed in the system. Action: Verify that the line DEVICE=C:\MENU\MAPIDEV.SYS is in the system CONFIG.SYS file, that the interrupt level (IRQ) and I/O base address are correctly set and that the file C:\MENU|MAPIDEV.SYS is installed on the system. Comment: If returned in response to a XRAY_ON_PHASE, XRAY_SEQUENCE, or PULSE_PER_SEG command to the C-arm device, indicates that the currently selected X-ray mode is invalid. Action: Report this to Hologic Technical Support. Comment: If reported as the device status for the C-arm, it indicates an unrecognized response from the C-arm micro. Action: This may be due to a communications error between the AT and the C-arm. Follow the procedure under "BAD CHECKSUM IN MESSAGE." to diagnose I/O errors. Comment: If reported as the abort code for the state machine, it indicates that the internal driver event queue was full when the state machine attempted to issue the system-wide abort code for state machine termination. Action: Report this error to Hologic Technical Support.
Internal Error:..... **Internal Software Error: ......**	Software		Any message that begins this way should be reported to Hologic Technical Support. Include as much information as possible about what you were doing at the time.
Internal stack error [E_STACK_ERROR_I]			Comment: Returned by the state machine driver to indicate that the local stack for a task has overflowed or underflowed. Action: Report this problem to Hologic.
Invalid ...	Software		In general, any message that begins with the word "Invalid" should be reported to Hologic Technical Support. Include as much information as possible about what you were doing at the time. See the following "Invalid..." errors for more information.

ERROR MESSAGE	HARDWARE /SOFTWARE ERROR	LOCUS	COMMENT/ACTION
Invalid address for message packet [E_INVALID_ADDR_I]			Comment: The address of a message packet was invalid. The MAPI driver keeps an address table that maps each byte address to its respective communications link (SSI, SCI or C/C). The selected address was not assigned to any link and therefore was not recognized by the MAPI driver. Action: Report this error to Hologic Technical Support.
Invalid flattening data [E_INVALID_FLAT_DATA_S]			Comment: The most likely cause is that the signal for one or more of the detectors is higher than allowed. Action: One or more detectors is bad. See instructions for running hardware checking program.
Invalid identification file.			Action: QDR 4500 ID file C:\SQUID.DAT is not valid. Call Hologic Technical Support.
Invalid machine type in ARRC.TXT.			Action: This is not an error if the machine is not yet calibrated.
Invalid mode for device driver [E_INVALID_MODE_I]		C-arm	Comment: Returned by the C-arm if an application attempts to change the X-ray mode when X-rays are already on. Action: Report this error to Hologic Technical Support.

ERROR MESSAGE	HARDWARE /SOFTWARE ERROR	LOCUS	COMMENT/ACTION
		State	Comment: Returned as the device state if the C-arm microprocessor returned an unrecognized response to the fast query. Action: This may be due to a communications error between the AT and the C-arm. Follow the procedure under "BAD CHECKSUM IN MESSAGE." to diagnose I/O errors. Otherwise, report this error to Hologic Technical Support. Comment: For the state machine driver, this error indicates that either the protocol attempted to execute a command that is not supported; that an instruction that requires a register reference did not provide one; or, more commonly, an attempt was made to access the external data buffers and they were either not available or were still being using by the application. Action: If you are running any program other than standard Hologic software, remove it and retry the scan (e.g., do not run a scan while connected to a network or attempt to run a scan under Windows). Otherwise, report this error to Hologic Technical Support.
		Motor_xx	Comment: For a stepper motor, the application attempted to move a motor in the opposite direction in which it is currently moving (i.e., a motor's motion can be extended in the same direction as the current motion but it cannot reverse motion). Action: Report this error to Hologic Technical Support.
Invalid parameter(s) [E_INVALID_PARAM_I]			Comment: The value of the parameter associated with a device command was out of range. Action: Report the application in error to Hologic Technical Support.
Invalid serial number in ARRC.TXT.			Action: This is not an error if the machine is not yet calibrated.
Invalid serial number in environ.bat file.			Action: Machine serial number is not valid. Call Hologic Technical Support.
Invalid values in bad detector map			Action: See instructions for running hardware checking program.

ERROR MESSAGE	HARDWARE /SOFTWARE ERROR	LOCUS	COMMENT/ACTION
I/O Error	Hardware or Software		There was an error reading or writing a disk drive. The message should identify the drive and say something about the nature of the error. Action: If this is an "out of space" error, verify that there is room on the target drive. Check the "Room for ..." message in the status window. Otherwise, run appropriate diagnostics on the disk and controller; if the problem involves diskette (Drive A:), try a different diskette.
Limit Exceeded:	Software		Any message that begins this way should be reported to Hologic Technical Support. Include as much information as possible about what you were doing at the time.
Local motion active [E_LOCAL_MOTION_I]			Comment: An application has attempted to enable or disable local motion when one or more motors were still moving. This is also the abort code reported by the state machine when a protocol is aborted to start the local motion state machine. Action: When moving the system using the operator control panel, wait until all motion stops before starting an application that requires motor movement (e.g., the scan program).
Machine serial number is not valid.			Action: QDR 4500 ID file C:\SQUID.DAT is not valid. Call Hologic Technical Support.
Machine type in configuration files is inconsistent.			Action: QDR 4500 ID file C:\SQUID.DAT is not valid. Call Hologic Technical Support.
Machine type is not valid.			Action: QDR 4500 ID file C:\SQUID.DAT is not valid. Call Hologic Technical Support.
Memory allocation error.			Action: Verify that **only** Hologic software is installed on the system.
Message packet canceled [E_CANCELED_I]			Comment: The message packet was canceled before the response was received. This is not an error but merely records the current state of a message packet. The driver normally cancels all outstanding message packets when it goes off line. Action: None.

ERROR MESSAGE	HARDWARE /SOFTWARE ERROR	LOCUS	COMMENT/ACTION
Message packet not sent yet to the C/C [E_WAITING_I]			Comment: Indicates that the message has been queued up in the MAPI's buffers for transmission but has not yet been sent. Reported as the Carm device status if the fast query message was not sent before the beginning of the next A/C line cycle. Action: Because the driver must communicate with the C-arm every A/C line cycle, and because all other devices share the communications link, any device that causes an I/O error (e.g., a timeout) generally causes this error in the C-arm. The first thing to do is to determine if the problem is really with the C-arm or with another device in the system. Place all devices in emulation mode (e.g., by turning off instrument power and booting up in the workstation mode). Then, first take the C-arm out of emulation. If it reports no errors, then proceed to take each one of the other devices out of emulation mode until the one in error is found. Also see the discussion under "BAD CHECKSUM IN MESSAGE." for diagnosing I/O errors.
Message packet sent and waiting for response [E_SENT_I]			Comment: The message has been sent but the response has not yet been received. Reported as the C-arm device status if the fast query response for a cycle is not received before the next cycle. Action: See the discussion of the associated error E_WAITING_I.
Missing ARRC.TXT file.			Action: Check that ARRC.TXT exists in C:\XCDATA. If it does, re-boot to ensure that the system is correctly initialized. If not, restore ARRC.TXT from a dbarchive backup.
Missing tissue bar initialization file	Software		The file that contains the calibration information for the tissue bar is missing or has not been installed. Action: Install the tissue bar initialization software that comes with the tissue bar.

ERROR MESSAGE	HARDWARE /SOFTWARE ERROR	LOCUS	COMMENT/ACTION
Motor direction has reversed during stepping [E_MOTION_REVERSED_I]			Comment: Whenever a motor is moving, the driver checks its position every three seconds. If the motor direction at each of these check intervals is not in the correct direction, the driver stops motion and returns this error. Motion reversal is primarily due to the stepper motor cutting out because of a thermal overload and usually occurs on the AY motor. In most cases, a mechanical problem (loose belt, loose encoder coupling, etc.) causes this problem. In some cases, a bad encoder and in fewer cases, a bad drive board causes this problem. Action: Wait a few minutes for the motor to cool down and re-try the scan. Check the drive belt tension. Check the encoder coupling setscrew. If the problem is not corrected, replace the drive board. If these steps fail, replace the encoder motor. The procedure for these operations can be found in the *Remove and Replace* section of this manual. If the problem persists, contact Hologic Technical Support.
Motor is at a limit [E_LIMIT_POSITION_I]			Comment: An application tried to move the motor beyond the limit position (i.e., the motor need not necessarily be **at** a limit). Action: Be sure that the table and C-arm are at the correct starting position before starting a scan. Verify that the range of motion (positive limit position) of the motors (AR, AY, TX, TY and TZ) are correct for the QDR model. Also see the discussion under E_COLLISION_IMMINENT_I.
Motor power has been turned off because the arm and table have collided! [E_COLLISION_STOP_I]			Action: To proceed, select emergency Motion on the Utility menu. Then push the table away from the arm. To restart the system, select retry by pressing the <ENTER> key.
No A/C line interrupts! [E_WORKSTATION_BOOT_I]			Action: Check that instrument power is on. When the problem is corrected, press <Enter> to continue. If you want to leave instrument power off, press <ESC> to boot in the workstation mode. In this mode, you can not do any scans even if you turn instrument power back on. This massage can occur if the Emergency Stop switch is pushed in. Refer to the *“NO A/C Line Interrupts” message at start-up on page 6-9*.
No motion detected while motor stepping [E_NO_MOTION_I]			

ERROR MESSAGE	HARDWARE /SOFTWARE ERROR	LOCUS	COMMENT/ACTION
	Hardware		The QDR is equipped with motion detectors which detect actual motion in the X, Y and C-arm rotation motors. This message occurs when one of these motors was commanded to move and no motion was detected. Action: Check for loose belt couplers, tighten set screws A/R. Check for coupler hitting bearing block, move coupler A/R. Check motion encoder, replace if defective. Check Motor & Drive board, replace if defective. Check stepper translator, replace if defective.
		MOTOR$xx	Whenever a motor is moving, the driver checks its position every three seconds and stops stepping if the incremental positions at these check intervals do not match the motion parameters (final rate) to within approximately 50%. Action: Determine why the motor is not moving (check motor coupling, drive belt, and encoder shaft coupling).
		MOTOR$TZ	The device state reported whenever the TZ firmware reports a pedestal timeout during a move command. Action: See the discussion of the TZ drive's E_TOLERANCE_I error.
No data for attenuation curves	Software		This message should be reported to Hologic Technical Support. Include as much information as possible about what you were doing at the time.
Not enough memory	Software		Ensure that **only** Hologic software is installed on the computer. If so, this message should be reported to Hologic Technical Support. Include as much information as possible about what you were doing at the time.
Old Whole Body Context Type	Software		This message should be reported to Hologic Technical Support. Include as much information as possible about what you were doing at the time.
Operator terminated action [E_OPERATOR_I]			Action: None.
Out of memory	Software		Ensure that **only** Hologic software is installed on the computer. If so, this message should be reported to Hologic Technical Support. Include as much information as possible about what you were doing at the time.

ERROR MESSAGE	HARDWARE /SOFTWARE ERROR	LOCUS	COMMENT/ACTION
Overflow calculating flattening or daily factors			Action: Most likely cause is saturation of one or more detectors during the flattening procedure.
Parameter size is invalid [E_INVALID_SIZE_I]			Comment: The device state reported by the C-arm if the response to a fast query is not a minimum length to encompass all necessary information. Action: This may be due to a communications error between the AT and the C-arm. Follow the procedure under "BAD CHECKSUM IN MESSAGE." to diagnose I/O errors.
Parameter size is too large for driver [E_TOO_LONG_I]			Comment: For the state machine, indicates that a reference was made beyond the machine limits (e.g., a register reference that exceeded the number of registers; a jump to a location beyond the end of the state machine; etc.). For all other devices, indicates that the message response from the remote micro overflowed the internal buffers and was partially lost. Action: For the state machine, report this error to Hologic Technical Support. For other devices, this error may indicate a problem on the communications bus. Follow the procedure under "BAD CHECKSUM IN MESSAGE." for isolating I/O errors.
Patient File Record __ Too Small **Patient File Record __ Too Large**	Hardware or Software		These messages indicate problems performing I/O operations (usually to the hard drive, but possibly to diskette or optical). Action: Ensure that there is adequate space on the hard drive (Check the "Room for ..." message in the status window. You should always leave room for 1 or 2 scans). There may be a disk problem; appropriate diagnostics should be run. If you are unable to find a hardware problem, the message should be reported to Hologic Technical Support. Include as much information as possible about what you were doing at the time.
PGLINE: ...	Software		Any message that begins this way should be reported to Hologic Technical Support. Include as much information as possible about what you were doing at the time.
Remote device did not echo command [E_NAK_I]			Comment: Whenever the first byte in a message response does not match the command character. Action: This is probably a communications error between the AT and the microprocessor. Follow the procedure under "BAD CHECKSUM IN MESSAGE." to diagnose I/O errors.

ERROR MESSAGE	HARDWARE /SOFTWARE ERROR	LOCUS	COMMENT/ACTION
ROI Limit Error	Software		This message should be reported to Hologic Technical Support. Include as much information as possible about what you were doing at the time.
Scan File Record __ Too Small (__) **Scan File Record __ Too Large (__)** **Scan has 0 points or lines**	Hardware		These messages indicate problems performing I/O operations (usually to the hard drive, but possibly to diskette or optical). Action: Ensure that there is adequate space on the hard drive (Check the "Room for ..." message in the status window. You should always leave room for 1 or 2 scans). There may be a disk problem; appropriate diagnostics should be run. If you are unable to find a hardware problem, the message should be reported to Hologic Technical Support. Include as much information as possible about what you were doing at the time.
Software Error	Software		Any message that begins this way should be reported to Hologic Technical Support. Include as much information as possible about what you were doing at the time.
Starting phase Out of Range	Software		This message should be reported to Hologic Technical Support. Include as much information as possible about what you were doing at the time.
Test failed - absolute max or min limit exceeded			Action: One or more detectors is bad. See instructions for running hardware checking program.
Test failed - maximum SD exceeded			Action: Detectors are not seeing a uniform beam. Check all hardware having to do with X-ray generation or detection.
Test failed - mean exceeds limits			Action: X-ray beam at edges is not consistent with beam at center. Check X-ray beam alignment.

The analyze data file either did not exist or did not contain any valid entries			
	Software		The software was not correctly installed (No ANALYZE.DAT file). This might also be due to a hardware problem with the hard disk drive. Action: Notify Hologic Technical Support.
There are no files available to restore (*Optical* restore)			

ERROR MESSAGE	HARDWARE /SOFTWARE ERROR	LOCUS	COMMENT/ACTION
	User or Software		When restoring files from optical ("Optical" on main menu), you selected an archive that contains no scans. Action: Report this problem to Hologic Technical Support.
There are no records in the Normals Curve database.			
	Software		The reference curve database appears to be totally empty. This condition should never occur in normal operations. Action: The Hologic software may not have been installed correctly.
The X-ray controller is not generating A/C line interrupts [E_NO_TIMER_INTERRUPT_I]			
	Hardware		The X-ray Controller assembly generates an interrupt every 1/120 of a second (60HZ line) or every 1/100 of a second (50Hz line). The PC clock generates 18 interrupts a second (regardless of line frequency). If two clock ticks occur with NO Motor & Drive board interrupts between them, then this message is produced. Action: Report this error to Hologic Technical Support. Include as much information as possible about what you were doing at the time. Refer to the *"NO A/C Line Interrupts" message at start-up on page 6-9*.
Truncated Patient Record ...	Hardware or Software		This message indicate problems performing I/O operations (usually to the hard drive, but possibly to diskette or optical). Action: Ensure that there is adequate space on the hard drive (Check the "Room for ..." message in the status window. You should always leave room for 1 or 2 scans). There may be a disk problem; appropriate diagnostics should be run. If you are unable to find a hardware problem, the message should be reported to Hologic Technical Support. Include as much information as possible about what you were doing at the time.
***device:* Unable To Allocate Resources**			
	Software		This message should be reported to Hologic Technical Support. Include as much information as possible about what you were doing at the time.

ERROR MESSAGE	HARDWARE /SOFTWARE ERROR	LOCUS	COMMENT/ACTION
Unable to Allocate Space for Environment **Unable to Restore Environment** **Unable to Calculate Line-By-Line d0's**	Software		These messages should be reported to Hologic Technical Support. Include as much information as possible about what you were doing at the time
Unable to determine power line frequency	Hardware		The C-Arm was unable to measure line frequency interval. Action: Check function of the C-Arm. Check stability of A/C line frequency.
Unable to format diskette	Hardware or Software		This usually means that you attempted to format a diskette that was defective. Action: Try a different diskette. If this message occurs repeatedly, and with more than one diskette, it may mean a hardware problem with a diskette drive or the controller board. (In some computers, the controller circuitry is on the motherboard; if this circuitry is defective, the entire computer must be replaced.)
Unable to normalize line sums	Software		This message should be reported to Hologic Technical Support. Include as much information as possible about what you were doing at the time.

ERROR MESSAGE	HARDWARE /SOFTWARE ERROR	LOCUS	COMMENT/ACTION
Unable to find file **Unable to Find Line by Line d0's** **Unable to Find Previous Analysis Results** **Unable to Open Tissue Calibration File ________** **Unable to open temporary file ________** **Unable to open temporary Q-File** **Unable to Position File to HALO Record** **Unable to Position Data File** **Unable to Position File: ________** **Unable to Position Patient File** **Unable to Position Patient File Past Record __** **Unable to Position Patient File To End** **Unable to Position Scan File Past Record __ (__)** **Unable to Position Q-Data File** **Unable to Read Data File** **Unable to Read File: ________** **Unable to Read Line by Line d0's** **Unable to Read Previous Analysis Results** **Unable to Rewind Q-File** **Unable to Rewind File: ________** **Unable to Read BMD Image Frame** **Unable to Read HALO Frame Header** **Unable to Read Q-Data File** **Unable to Write to Q-Image File**			
	Hardware or Software		These messages indicate problems performing I/O operations (usually to the hard drive, but possibly to diskette or optical). Action: Ensure that there is adequate space on the hard drive (Check the "Room for ..." message in the status window. You should always leave room for 1 or 2 scans). There may be a disk problem; appropriate diagnostics should be run. If you are unable to find a hardware problem, the message should be reported to Hologic Technical Support. Include as much information as possible about what you were doing at the time.

ERROR MESSAGE	HARDWARE /SOFTWARE ERROR	LOCUS	COMMENT/ACTION
Unable to position device within specified tolerance [E_TOLERANCE_I]			Comment: For the stepping motors, the aperture shuttle or the TZ drive, indicates that the requested position could not be obtained within the specified device tolerance. Action: For the TZ drive (table pedestals), check the firmware version. If it is not 2.30 or higher, replace the TZ EPROM with the latest version. If the problem persists (or if the firmware version was already 2.30 or higher), it may be caused by a thermal overload in the DC motors. Our experience has been that they cannot run at much more than a 5% duty cycle. You can check whether it is a firmware or hardware problem by engaging the emergency stop button on the operator's panel. Then use the table up switch to move the table. If it does not move, wait at least twenty (20) minutes and try again. If it moves after 20 minutes, it was a thermal overload. If it does not move, call Hologic Field Service. Action: For one of the stepping motors (AR, AY, TX or TY), either the motor has not been properly calibrated, the motor is binding, or the drive belt is too loose. Action: For the aperture shuttle (LOCUS CARM), either the apertures have not been calibrated or the mechanism is binding. Visually inspect the aperture shuttle and use the MOVE_REL command to verity that the shuttle is moving without binding. If it does not move or binds, fix the electrical or mechanical problem with the shuttle. If it does move, recalibrate the shuttle.
Unable to open a window	Software		Ensure that **only** Hologic software is installed on the computer. If so, this message should be reported to Hologic Technical Support. Include as much information as possible about what you were doing at the time.
Unable to restore scan. If the System Disk is full Delete Archived scans and try again.			
	User or Software		The system was unable to restore one or more scans. Action: This usually means that the hard drive is full. Check the "Room for ..." message in the status window. If the disk is **not** full, then this indicates a hard drive problem.

ERROR MESSAGE	HARDWARE /SOFTWARE ERROR	LOCUS	COMMENT/ACTION
Unexpected message from remote device [E_UNEXPECTED_RESPONSE_I]			Comment: The first character in a fast query response was not the fast query command ("?"). Action: Follow the procedure under "BAD CHECKSUM IN MESSAGE." for isolating communications bus I/O errors.
Unknown ROI type in DrawROI	Software		These messages should be reported to Hologic Technical Support. Include as much information as possible about what you were doing at the time.
***device:* Unrecognized Command Code**			
	Software		This message should be reported to Hologic Technical Support. Include as much information as possible about what you were doing at the time.
Unrecognized device command [E_UNKNOWN_COMMAND_I]			Comment: Returned by all devices in response to an unrecognized command. Action: Report this error to Hologic Technical Support. Include as much information as possible about what you were doing at the time.
Unsolicited message from C/C [E_UNSOLICITED_MESSAGE_I]			Action: Report this error to Hologic Technical Support. Include as much information as possible about what you were doing at the time.
X-ray controller is not generating A/C line interrupts [E_NO_TIMER_INTERRUPT_I]			
		DAS	A request was made to read the a/d's and there was no system line frequency interrupts (required to synchronize DAS with C-arm).
		Global	The system was on-line and another on-line command was issued but there were still no timer interrupts. Action: Check that the Instrument Power switch and the X-Ray Enable key are on. Also, see the discussion of E_INTERLOCK_INHIBIT_I, E_EMERGENCY_STOP_I and E_COLLISION_IMMINENT_I. Refer to the *“NO A/C Line Interrupts” message at start-up on page 6-9*.

ERROR MESSAGE	HARDWARE /SOFTWARE ERROR	LOCUS	COMMENT/ACTION
X-ray controller is not generating system timing interrupts [E_INTERLOCK_INHIBIT_I]			
			Comment: There have been at least two consecutive system clock ticks (approximately 1/10 second) without any A/C line frequency interrupts from the X-ray controller. Action: Verify that the X-ray controller current fuse on the operator console is not "popped". If it is, push it in. If it continues to pop, repair or replace the X-ray tank. The E_EMERGENCY_STOP_I error also turns off power to the X-ray controller and thus disables the A/C line interrupts. Follow the procedure under E_EMERGENCY_STOP_I to clear this condition first. Refer to the *"NO A/C Line Interrupts" message at start-up on page 6-9*.
X-ray firing order is out of sequence [E_XRAY_SEQUENCE_I]			Comment: The X-ray pulse level reading from the C-arm did not match the expected level (i.e., the C-arm driver has a "template" for each X-ray pulsing mode and if the actual pulse level does not match the template for the given X-ray mode, it generates this error). Action: If the filter drum and X-ray generator are out of sync, it is often difficult to determine which is at fault. Verify that the filter drum is synchronized with the A/C line and that the X-ray modes are correctly defined in SQDRIVER.INI. The set screw and/or the belts on the filter drum assembly may need adjustment (in addition to the two drum pickoff segments). To aid in diagnosing the problem, disable the filter drum and X-ray hi/lo monitors in SQDRIVER.EXE (remember to re-enable them before you leave the program). Another problem that may occur is that the X-ray filament thermal overload has tripped. To check this, turn on X-rays in SQDRIVER.EXE and verify that the **XraySignalLevel** readback is changing (and does not read zero). If it reads as zero, wait 2-3 minutes for the thermal overload condition to clear itself and then try again. To see if the X-rays are pulsing properly, turn off the filter drum and then turn on X-rays.

ERROR MESSAGE	HARDWARE /SOFTWARE ERROR	LOCUS	COMMENT/ACTION
X-ray signal level (hi/lo) did not match the filter drum position [E_XRAY_PHASE_I]			
			Comment: If the filter drum monitor is enabled and the filter drum is on, this error indicates that the filter drum wheel readback did not match the expected value (i.e., there must be six segment readbacks, there must be eight pulses within each segment and the first four pulses in each segment are required to be brass and the second four are required to be air). Action: See the discussion under E_XRAY_SEQUENCE_I.