

# **HIGH FREQUENCY X-RAY GENERATOR**

**Installation and Service Manual**

**03003**

Rev. V



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### Revision History

Revision	Pages Affected/Revision Description	Release Date	ECR #
A	Initial Release	6/09/06	5150
B	Added wire color code to Table 2-6	7/17/06	5202
C	Updated mAs table (Table 1-1), revised sections 1.7.1, 4.12.3 to 4.12.6 & Table 6-1	6/22/07	5605
D	Added information for 3 phase generators.	3/14/08	5913
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F	Removed Schematics from Section 11	March, 2012	7456
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H	Updated Sect. 1.8.5 with "RUN" definition.	March, 2014	8251
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# 1 PRE-INSTALLATION

## 1.1 GENERAL

This manual contains installation, calibration, acceptance and service information for the High Frequency Generators. The generator is part of a system which contains other equipment not described in this manual. To gain an understanding of the complete system, study the operator's and service manuals for all associated equipment.

## 1.2 USE OF THIS MANUAL

Throughout the manual there are indented statements which are preceded by alert words. These alert words and the following statements may direct the user in the performance of a task, or inform the user of a potentially hazardous situation. Each alert word is always used with only one specific type of information. The alert words and the information they reference are as follows.

## 1.3 SYMBOLS

1.3.1 The following is a list of symbols used throughout the manual:



### NOTE

This symbol represents Information that assists the user of the manual in the performance of a task. It may provide the user with better methods of conducting the task, or it may point out conditions that could cause the system to fail to operate properly.



### CAUTION

A CAUTION points out special procedures, or precautions, that personnel must follow to avoid *equipment damage*.



### WARNING

A WARNING identifies situations or actions that may affect patient or user safety. Disregarding a warning could result in *patient or user injury*.


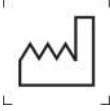











Alternating current.



Direct current.

## 1.3.2 The following is a list of symbols used on the equipment.

Symbol	Description
	Manufacturer.
	Date of manufacture.
	Model number.
	Serial number.
	This warning symbol indicates a potential hazard to operators, service personnel or equipment. It indicates a requirement to refer to the accompanying documentation for details.
	Wait at least 20 minutes after power off, before servicing the equipment.
	This symbol indicates hazards arising from dangerous voltages.
	This symbol identifies a protective earth terminal (ground).
	Follow the instructions for use. Reading the instructions for use is mandatory for a correct and safe operation of the equipment.
	Type B applied part. This symbol indicates equipment providing a particular degree of protection against electric shock, particularly regarding allowable leakage currents and reliability of the protective earth connection (if present).
	UL classified/listed device (Canada and USA).

## 1.4 PRECAUTIONS

### 1.4.1 Freight Notice to Installers

All freight is shipped FOB from the factory. This means it is the installer's responsibility to inspect the shipment for damage and proper count. Upon receipt of the merchandise, any visible damage to the cartons should immediately be examined while the shipper is present.

If the visible damage to the cartons also includes damage to the merchandise, the installer is responsible for making all claims with the shipping company.

If there is hidden damage to the merchandise, it is the installer's responsibility to discover that damage within a reasonable amount of time and contact the shipping company to make a claim.

To protect your company in the case of hidden damage it is recommended to accept freight "subject to inspection". This makes it easier to make a claim with the freight company in the event of hidden damage.

### 1.4.2 Installation Safety



#### **WARNING**

**X-RAY EQUIPMENT IS DANGEROUS TO BOTH PATIENT AND OPERATOR UNLESS MEASURES OF PROTECTION ARE STRICTLY OBSERVED**

Though this equipment is built to the highest standards of electrical and mechanical safety, the useful X-ray beam becomes a source of danger in the hands of the unauthorized or unqualified operator. Excessive exposure to x-radiation causes damage to human tissue.

Adequate precautions must be taken to prevent unauthorized or unqualified persons from operating this equipment or exposing themselves or others to radiation. Only qualified personnel should install, maintain, and operate this equipment. Only qualified service personnel should remove electrical covers.

Before operation, persons qualified and authorized to operate this equipment should be familiar with the Recommendations of the International Commission on Radiological Protection, contained in Annals Number 26 of the ICRP, and with the applicable national and local standards.

The equipment described in this manual will perform reliably when installed, maintained, and operated, in accordance with the instructions of this manual by qualified personnel. This equipment is sold with the understanding that the user assumes sole responsibility for radiation safety and that the manufacturer does not accept any responsibility for the following:

- Equipment improperly installed.
- Equipment improperly operated.
- Equipment improperly maintained or repaired.
- Equipment which has been modified or altered in any way.
- Injury or damage to patient or other personnel for any of the above causes.

We are proud of our products and are confident they will provide many years of useful and enjoyable service.



### **CAUTION**

THIS MANUAL IS FOR USE BY PERSONNEL QUALIFIED TO INSTALL, CALIBRATE, MAINTAIN AND SERVICE RADIOGRAPHIC EQUIPMENT. HAZARDOUS VOLLAGES MAY BE PRESENT, AND PERSONS UNFAMILIAR WITH SAFE OPERATING PROCEDURES SHOULD NOT ATTEMPT TO PERFORM SERVICE ON THIS DEVICE.

#### 1.4.3 General Safety

It is important that everyone associated with x-ray work is familiar with the recommendations of the Department of Health, National Bureau of Standards, and the National Council on Radiation Protection. The control of diagnostic x-ray equipment varies in detail from state to state. However, in general, all of the states adhere strictly to the established recommendations of the NCRP. Prior to operation, be sure that all personnel who are authorized to operate the x-ray system are familiar with the established regulations of the authorities named above. Also, they should be monitored to assure that they conform to the recommendations.

---

Current sources of information include:

- NCRP No 102 (Medical X-Ray, Electron Beam and Gamma-Ray Protection for Energies Up to 50 MeV)
- NCRP No 49 (Structural Shielding Design and Evaluation for Medical use of X-rays and Gamma Rays of Energies up to 10MeV).

Although x-ray radiation is hazardous, x-ray equipment does not pose any danger when it is properly used. It is the responsibility of all service and operating personnel to be properly informed on the hazards of radiation. Also, those responsible for the system must understand the safety requirements for x-ray operation. Study this manual and the manuals for each component in the system to become aware of all the safety and operational requirements.

#### 1.4.4 Manufacturer's Responsibility

Although this equipment incorporates protection against x-ray radiation other than the useful beam, practical design cannot provide complete protection. Equipment design does not compel the operator or his assistants to take adequate precautions. Nor does it prevent the possibility of improper use which results in authorized or unauthorized persons from carelessly, unwisely, or unknowingly exposing themselves or others to direct or secondary radiation. Allow only authorized, properly trained personnel to operate this equipment.

Be certain that all personnel authorized to use the equipment are aware of the danger of excessive exposure to x-ray radiation.

This equipment is sold with the understanding that the manufacturer, its agents, and representatives do not accept any responsibility for over-exposure of patients or personnel to x-ray radiation. Furthermore, the manufacturer does not accept any responsibility for over-exposure of patients or personnel to x-ray radiation generated by this equipment which is a result of poor operating techniques or procedures.

Also, no responsibility will be assumed for any machine that has not been serviced and maintained in accordance with the system technical manual, or which has been modified or tampered with in any way.

#### 1.4.5 Radiation Protection



### **WARNING**

X-Rays are dangerous to both operator and others in the vicinity unless established safe exposure procedures are strictly observed.

The useful and scattered beams can produce serious, genetic or potentially fatal bodily injuries to any persons in the surrounding area if used by an unskilled operator. Adequate precautions must always be taken to avoid exposure to the useful beam, as well as to leakage radiation from within the source housing or to scattered radiation resulting from the passage of radiation through matter.

Those authorized to operate, test, participate in or supervise the operation of the equipment must be thoroughly familiar and comply completely with the currently established safe exposure factors and procedures described in publications such as Sub-Chapter J of Title 21 of the Code of Federal Regulations, "Diagnostic x-ray Systems and their Major Components," and NCRP No 102 (Medical X-Ray, Electron Beam and Gamma-Ray Protection for Energies Up to 50 MeV) as revised or replaced in the future.

Failure to observe these warnings may cause serious, genetic or potentially fatal bodily injuries to the operator or those in the area.

Those working in the immediate area must protect themselves with lead shielding. These items would include but not necessarily be limited to goggles, thyroid shield, apron and gloves with a lead equivalency of not less than 0.5 mm.

**The best safety rule for x-ray operators is:  
“Avoid exposure to the primary beam at all times.”**

#### 1.4.6 Monitoring of Personnel

Monitoring of personnel to determine the amount of radiation to which they have been exposed provides a valuable cross-check to determine whether or not safety measures are adequate. The most effective method of determining whether or not the existing protective measures are adequate is the use of instruments to measure the exposure in rads. This measurement should be taken at all locations where the operator or any portion of his body may be during exposure.

A common method of determining whether personnel have been exposed to excessive radiation is the use of film badges. These are x-ray sensitive film enclosed in a badge which incorporates metal filters of varying degrees of transparency to x-ray radiation. Even though this device only measures the radiation which reaches the area of the body on which it is worn, it does furnish an indication of the amount of radiation received.

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## EQUIPMENT DESCRIPTION

### 1.4.7 General

The X-Ray Generator described is a high-frequency constant potential system with the following features:

- Constant potential output from a single-phase power line.
- Two-point control (kVp and mAs) in manual mode. Maximum available mA is automatically selected for minimum exposure time. User can select lower mA.
- Protection circuitry to prolong tube life and increase system performance.
- Self-diagnostic displays to inform users and service personnel of system status.
- Fully programmable anatomical technique database and LCD display screen on HF AP generators.

## 1.5 ACCURACY STATEMENT

All measurements are made in compliance with the directions of the HF Generators Service Manual in the Installation, Acceptance, and Calibration procedures sections.



Specified accuracy for kVp and mA does not include test equipment accuracy. Acceptance testing must take test equipment error into account. For additional information on the basis for the accuracy statements, refer to the Accuracy Procedure.

### 1.5.1 Exposure kVp

Output kVp within  $\pm 5\%$  of indicated kVp,  $\pm 1$  kVp. Selectable in single kVp increments.

### 1.5.2 Exposure mAs

Output mAs within  $\pm 10\%$  of indicated mAs,  $\pm 1$  mAs. Detailed mAs stations are in the operator's manual.

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## 1.6 COMPATIBILITY STATEMENT

These X-ray generators are compatible with the following equipment:

### 1.6.1 X-RAY TUBES:

- Toshiba E7239 (1.0 x 2.0 mm FS)
- Toshiba E7242 (0.6 x 1.5 mm FS)
- Toshiba E7252 (0.6 x 1.2 mm FS)
- Toshiba E7254 (0.6 x 1.2 mm FS)
- Toshiba E7255 (0.6 x 1.2 mm FS)
- Toshiba E7884 (0.6 x 1.2 mm FS)
- Toshiba E7886 (0.7 x 1.3 mm FS)
- Varian RAD 8 (1.0 x 2.0 mm FS)
- Varian RAD 13 (1.0 x 2.0 mm FS)
- Varian RAD 14 (0.6 x 1.2 mm FS)
- Varian RAD 21 (0.6 x 1.2 mm FS)
- Varian RAD 44 (1.0 x 2.0 mm FS)
- Varian RAD 56 (0.6 x 1.0 mm FS)
- Varian RAD 60 (0.6 x 1.2 mm FS)
- Varian RAD 68 (1.0 x 2.0 mm FS)
- Varian RAD 74 (0.6 x 1.5 mm FS)
- Expansion of the compatible tubes list is possible as need dictates

### 1.6.2 COLLIMATORS:

- Summit G800
- Summit D800
- Progeny MC150
- Progeny Linear II
- Progeny Linear IV
- Ralco R108
- Ralco R221
- Ralco R225
- Collimare CML-125
- Collimare CML-150
- Expansion of the compatible collimators list is possible as need dictates

1.6.3 AEC Radiation Detectors: An integrated AEC option is available to allow interfacing with Ion Chambers manufactured by Advanced Instrument Development (Melrose Park, Illinois) & Solid State Radiation Measuring Chambers manufactured by Claymount (Netherlands):

- AID ICX 1153
- AID ICX 1192
- AID ICX 1159
- Claymount SSMC 617 Chamber with SSMC 1001 Pre-Amp
- Expansion of the compatible Ion chambers list is possible as need dictates

1.6.4 BUCKYS (all 110 – 125 Vac):

- Summit J500
- Midwest 7440
- Midwest 1436
- Liebel 8000
- Liebel 9000
- Progeny True Speed Bucky
- US X-ray Bucky 1JU 2020
- Expansion of the compatible bucky list is possible as need dictates

## 1.7 SPECIFICATIONS

### 1.7.1 Duty Cycle

The duty cycle is continuous for radiographic use. However, operation should be limited to the capacity of the x-ray tube.

### 1.7.2 Maximum Outputs

The maximum power ratings for the HF Generators are listed in Table 1-1. The maximum line currents are listed in Table 1-2 and Table 1-3.

**Table 1-1: Maximum Power Rating**

<b>FACTOR</b>	<b>Single Phase Generator</b>	<b>Three Phase Generator</b>
kVp	125 kVp	125 kVp
mA	300 mA (500 mA Optional)	500 mA
Power	20/30/42 kW	30/40/42/50/52 kW

### 1.7.3 Maximum Momentary Line Current

Complete power requirements are shown in Table 1-2 and Table 1-3 below.

**Table 1-2: Maximum Line Current for Single Phase Generators**

<b>LINE VOLTAGE</b> (50 / 60 Hertz)	<b>LINE CURRENT</b>		
	<b>20kW*</b>	<b>30kW</b>	<b>42kW*</b>
208 VAC	138 A	231 A	346 A
220 VAC	131 A	218 A	327 A
240 VAC	120 A	200 A	300 A
277 VAC	104 A	173 A	260 A

\* Key Code board is required.

**Table 1-3: Maximum Line Current for Three Phase Generators**

<b>LINE VOLTAGE</b> (50 / 60 Hertz)	<b>LINE CURRENT</b>		
	<b>30kW</b>	<b>40/42kW*</b>	<b>50/52kW*</b>
208 VAC	133 A	200 A	250 A
220 VAC	126 A	189 A	236 A
240 VAC	115 A	173 A	216 A
380 VAC	73 A	109 A	137 A
416 VAC	67 A	100 A	125 A
440 VAC	63 A	94 A	118 A
480 VAC	58 A	87 A	108 A

\* Key Code Board is required.

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#### 1.7.4 Technique Factors That Constitute Maximum Line Current

For 20kW (300mA) generators:

Maximum line current will occur during exposures of 66 kVp, 300 mA.

For 30kW (300mA) generators:

Maximum line current will occur during exposures of 100 kVp, 300 mA.

For 30kW (500mA) generators:

Maximum line current will occur during exposures of 60 kVp, 500 mA.

For 40kW generators:

Maximum line current will occur during exposures of 80 kVp, 500 mA.

For 42kW generators:

Maximum line current will occur during exposures of 84 kVp, 500 mA.

For 50kW generators:

Maximum line current will occur during exposures of 100 kVp, 500 mA.

For 52kW generators:

Maximum line current will occur during exposures of 104 kVp, 500 mA.

## 1.7.5 Power Line Requirements

The line currents given in Table 1-2 and Table 1-3 are the momentary line currents during an exposure. This is not the recommended circuit breaker rating. The recommended supply power requirements are:

<b>Building Distribution Transformer (Min Ratings)</b>		
Gen kW	1PH	3PH
<b>20</b>	37.5kVA	-
<b>30</b>	60kVA	3x20kVA
<b>40/42</b>	75kVA	3x25kVA
<b>50/52</b>	-	3x37.5kVA

<b>Line Determination Chart</b>			
VAC	RANGE	VAC	Range
<b>208</b>	202 to 214	<b>380</b>	361 to 398
<b>220</b>	215 to 229	<b>416</b>	399 to 428
<b>240</b>	230 to 250	<b>440</b>	429 to 460
<b>277</b>	251 to 290	<b>480</b>	461 to 504

<b>Recommended minimum line AWG of power and earth wires</b>													
Copper wire only, Maximum voltage drop 5% @ maximum exposure load													
<b>Generator Type</b>				Length between the building's main incoming electrical panel and the service disconnect switch in the X-ray room									
PH	VAC	KW	mA	25ft	50ft	75ft	100ft	125ft	150ft	175ft	200ft	250ft	300ft
<b>1</b>	<b>208-277</b>	<b>20</b>	<b>300</b>	8	4	3	2	1	0	00	00	000	0000
<b>1</b>	<b>208-277</b>	<b>30</b>	<b>300</b>	6	4	2	1	0	00	000	000	0000	250 <sup>1</sup>
<b>1</b>	<b>208-277</b>	<b>30</b>	<b>500</b>	4	2	0	00	000	0000	0000	250 <sup>1</sup>	350 <sup>1</sup>	350 <sup>1</sup>
<b>1</b>	<b>208-277</b>	<b>40/42</b>	<b>500</b>	4	2	0	00	000	0000	250 <sup>1</sup>	250 <sup>1</sup>	350 <sup>1</sup>	400 <sup>1</sup>
<b>3</b>	<b>208-250</b>	<b>30</b>	<b>500</b>	8	4	3	2	1	0	0	00	000	0000
<b>3</b>	<b>208-250</b>	<b>40/42</b>	<b>500</b>	6	4	3	1	0	0	00	000	0000	0000
<b>3</b>	<b>208-250</b>	<b>50/52</b>	<b>500</b>	6	4	2	1	0	00	00	000	0000	250 <sup>1</sup>
<b>3</b>	<b>380-480</b>	<b>30</b>	<b>500</b>	10	8	6	4	4	4	3	2	1	1
<b>3</b>	<b>380-480</b>	<b>40/42</b>	<b>500</b>	10	8	6	4	4	3	3	2	1	0
<b>3</b>	<b>380-480</b>	<b>50/52</b>	<b>500</b>	10	6	4	4	3	2	2	1	0	00

**Note 1:** MCM (Thousand Circular Mils)

<b>Minimum Disconnect Switch per NEC</b>					
(Maximum Momentary Current/2)					
<b>Generator Type</b>					
PH	VAC	20kW	30kW	40/42kW	50/52kW
<b>1</b>	<b>208</b>	70 A	115 A	175 A	-
<b>1</b>	<b>220</b>	65 A	110 A	165 A	-
<b>1</b>	<b>240</b>	60 A	100 A	150 A	-
<b>1</b>	<b>277</b>	60 A	90 A	130 A	-
<b>3</b>	<b>208</b>	-	70 A	100 A	125 A
<b>3</b>	<b>220</b>	-	65 A	95 A	120 A
<b>3</b>	<b>240</b>	-	60 A	90 A	110 A
<b>3</b>	<b>380</b>	-	35 A	55 A	70 A
<b>3</b>	<b>416</b>	-	35 A	50 A	65 A
<b>3</b>	<b>440</b>	-	35 A	50 A	60 A
<b>3</b>	<b>480</b>	-	35 A	45 A	55 A

---

1.7.6 Collimator Power

24 VAC, 7 A  $\sim$ , 50/60 Hz

(Switched, for momentary use, should not be used for more than 5 minutes.)

1.7.7 Electric Locks Power

24 VDC, 4 A  $\overline{\text{---}}$  (Continuous), or 24 VDC, 5 A  $\overline{\text{---}}$  (65% duty cycle)

1.7.8 X-ray Tube Rotor/Stator Power

240 VAC, 7 A  $\sim$ , 50/60 Hz

(Switched, for momentary use, should not be used for more than 5 minutes.)

1.7.9 Estimated Heat Output

609 BTU/hour

1.7.10 Estimated Electrical Energy Consumption

132 Watts for 8 hours per day

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## 1.8 ENVIRONMENTAL REQUIREMENTS

### 1.8.1 Environmental Conditions for Use

- Temperatures ranges 50°F (10°C) to 104°F (40°C)
- Relative Humidity Range 30% to 75%
- Atmosphere pressure range: 20.67 inHg (700hPa) to 31.30 inHg (1060hPa)

### 1.8.2 Environmental Conditions for Transport and Storage

- Temperatures ranges -40°F (-40°C) to 158°F (70°C)
- Relative Humidity Range 10% to 90%
- Atmosphere pressure range: 14.67 inHg (500hPa) to 31.30 inHg (1060hPa)

### 1.8.3 Information regarding potential EMC interference and advice for avoidance

- Mains power quality should be that of a typical commercial or hospital environment
- Power frequency magnetic fields should be at levels characteristic of a typical location in a commercial or hospital environment

## 1.9 APPLICABLE STANDARDS

This X-ray generator complies with the following regulatory and design standards:

- FDA 21 CFR Subchapter J (for human applications only)
- UL 60601-1
- CAN/CSA-C22.2 No.601.1
- X-RAY EQUIPMENT IEC 60601-2-7
- Degree of protection against harmful ingress of water: IPXO/Ordinary.
- Degree of protection against electric shock: Class I, Type B Applied Parts.



- Equipment not suitable for use with flammable anesthetic mixture with air or with oxygen or nitrous oxide.

While most Summit X-ray Generators are UL Classified, some are not. UL Classified X-ray Generators will display a UL Classified label on the rear surface of the X-ray Generator's Power Module. To determine if an X-ray Generator is UL Classified, please examine the rear surface of the Power Module looking for the UL mark as shown below:



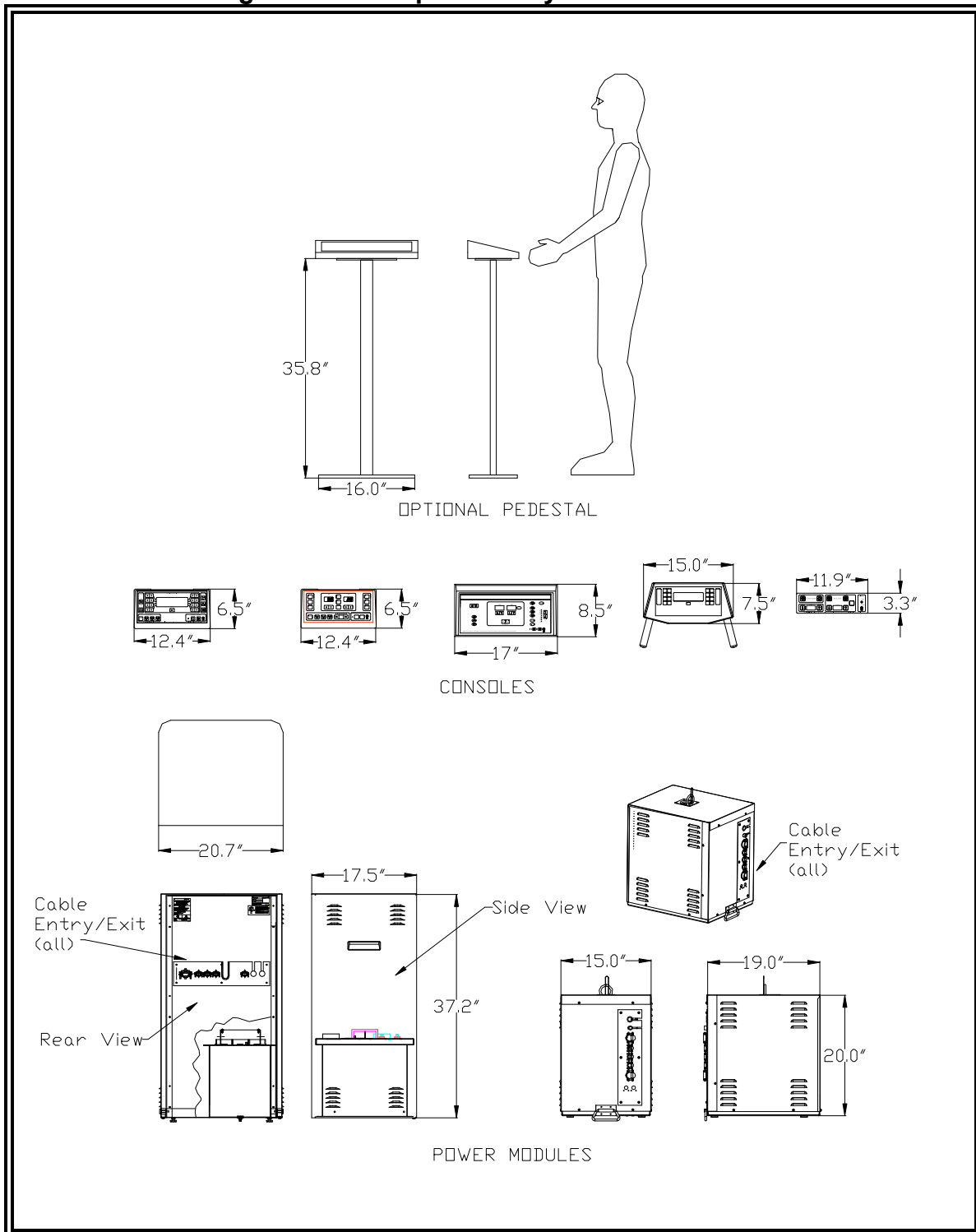
## 1.10 CONDUIT FOR COMMUNICATION CABLE

If the two communication cables between the Power Module and Operator's Console are to be run through conduit, the minimum conduit size is **1-1/2"** internal diameter due to the non-removable DB9 connectors on the ends of the cables.

## 1.11 SPACE REQUIREMENTS

Figure 1-1 shows the physical dimension and cable access points of the Power Module, the High Voltage Transformer, and the Operator's Console.

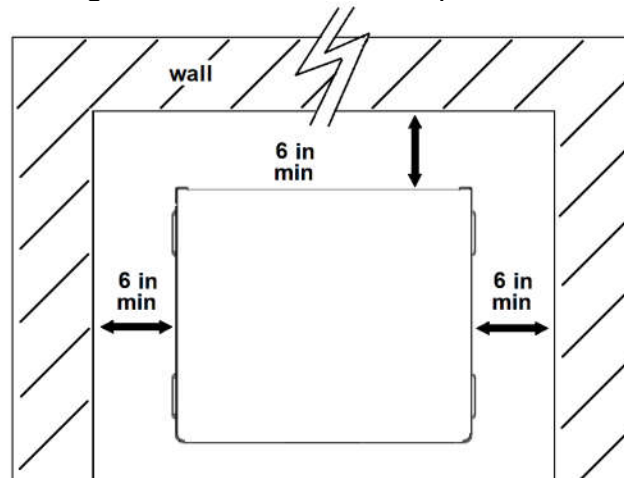
Figure 1-1: Component Physical Dimensions



## 1.12 LOCATING AND MOUNTING THE STAND-ALONE GENERATOR

### Clearance:

Refer to local building codes for additional requirements.



### Securing to Floor:

If local building codes require securing the equipment, it is up to the installer to provide appropriate hold down brackets as approved by the local codes. If necessary, the four mounting feet can be removed and the 4 x 1/4-20 threaded holes re-purposed as installer deems appropriate.

### Installation Location and Generator Sounds:

It is common to place the X-ray generator with the user console in the operator room or behind the operator shielded barrier. This helps to reduce the patient discomfort that comes from hearing the normal generator sounds that occur during exposure.

If the generator must be placed in the same room as the patient, then the installer should consider additional sound preventative measures:

- Move the generator as far away from the patient (wallstand and table) as possible.
- Add sound absorption materials to the room (ex. carpeting, acoustic wall/ceiling tiles).
- Surround the generator with sound absorption materials (ex. cubicle wall dividers).
- Make sure the appropriate wire sizes are used for the incoming line. If the wires are undersized additional noise will come from the walls (due to the undersized wires rattling during exposure).

Train the operator about generator noise:

- Assure the end user that this is normal and safe.
- Notify the end user that in general, by the time the patient hears, processes, and responds to the sound, the x-ray is over. The radiograph is not affected.
- The end user can always notify the patient that the generator will make sounds.

---

## 2 INSTALLATION

### 2.1 INTRODUCTION

This section describes procedures necessary for the installation of the following units:

- Operator's Console
- High Voltage Transformer
- Power Module
- Connections to ancillary devices common to an X-ray room

This material is presented in sequence to facilitate an orderly and safe installation. Complete calibration procedures are presented later.

### 2.2 INSTALLATION ITEMS AND TEST EQUIPMENT

#### 2.2.1 Test Equipment

The following test equipment is required for the installation:

- Digital Multi-meter with RMS measurement capability such as a Fluke 87 or equivalent.
- Kvp measurement device. A high voltage divider such as a Machlett Dynalyzer.
- mA/mAs measurement device.
- A dosimeter for linearity and reproducibility such as a Keithley model or equivalent.
- A digital dual trace storage oscilloscope with pause and trigger features for waveform shape such as a Tektronix 210 or equivalent.

The following miscellaneous items are required or may prove useful for the installation:

- Silicone Insulating Grease - DC4 vapor-proofing compound or equivalent.
- Alcohol
- Standard Hand Tools
- Victoreen mAs meter or equivalent
- Keithley Non-invasive kVp meter or equivalent

## 2.3 PRELIMINARY ROOM INSPECTION

Prior to beginning installation, inspect the x-ray room to verify compliance with specifications for the following:

- Incoming Line
- Service Disconnect
- Lead Shielding per local code
- Conduit
- Space Requirements

## 2.4 UNPACKING

Upon receipt of the x-ray generator and associated equipment, inspect all shipping containers for signs of damage. If damage is found, notify the carrier or his agent immediately. When the equipment is unpacked, inspect all pieces for visible damage. If any damaged parts are detected, repair or order replacements to prevent unnecessary delay in installation.

Before beginning the installation, verify the following:

- All internal connections and fasteners are secure
- All internal wiring is secure

## 2.5 COMPONENT ACCESS

### 2.5.1 Access to Operator's Console PCBA

Access to the Operator's Console PCBA is achieved by removing the screws from the bottom of the Console Enclosure. The electronics are contained in the top section of the console.

### 2.5.2 Access to Power Module

Access to the Power Module is achieved by removing the power module cover. The cover is held down by screws as illustrated in Figure 2-1 and Figure 2-2.

Figure 2-1: Compact Power Module Panel Screws

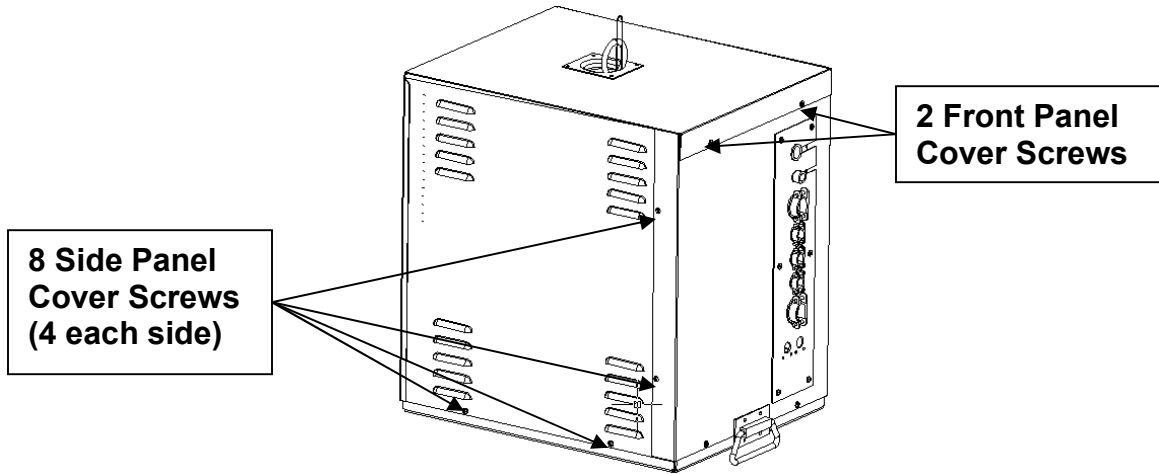
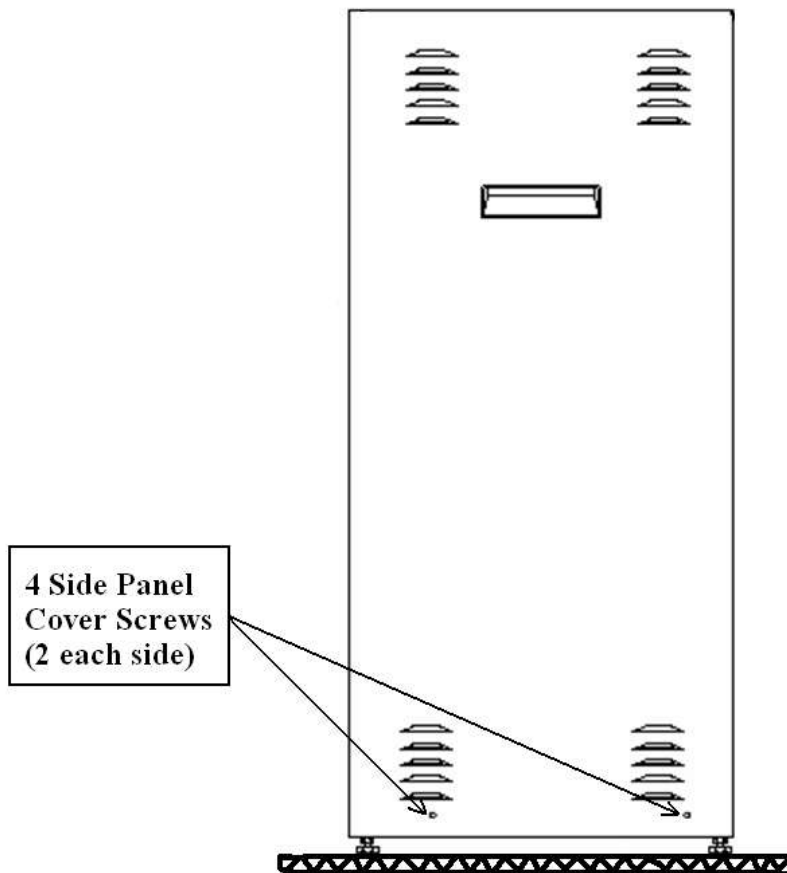


Figure 2-2: Tall Power Module Panel Screws



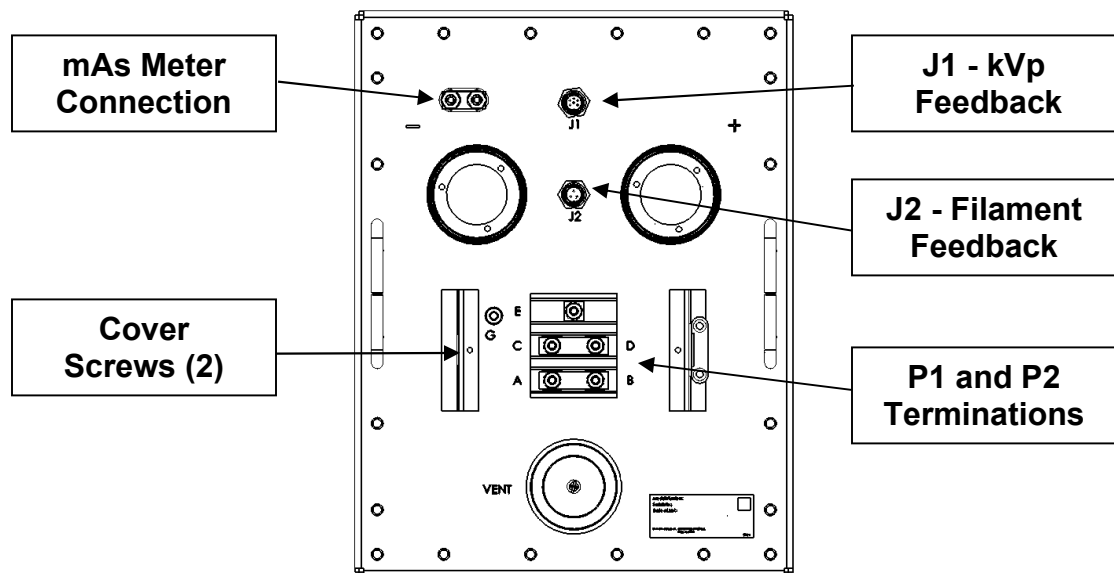
### 2.5.3 Access to the High Voltage Transformer

Terminal connections for wires “P1”, “P2” and “GND” can be accessed by removing the two screws at the terminal cover on top of the unit. Cathode is left, anode is right. mAs meter connection is on the left behind the cathode as well.

**Figure 2-3: HV Transformer**



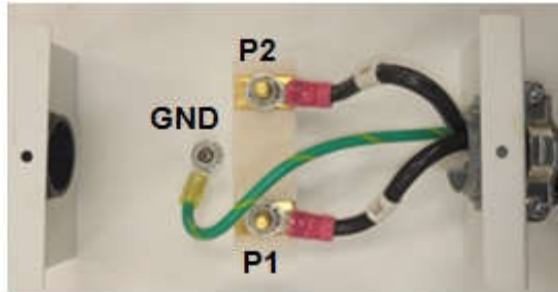
**Figure 2-4: Sample HV Transformer Connections**



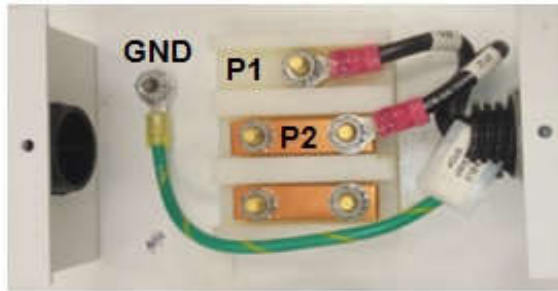
There is no access to the interior of the High Voltage Transformer. This is a sealed unit and opening it in the field without guidance by Technical Support will void the factory warranty.

Follow connection instructions for wires “P1” & “P2” (based on AC Line Voltage measured at fuses F1 & F2) as described below:

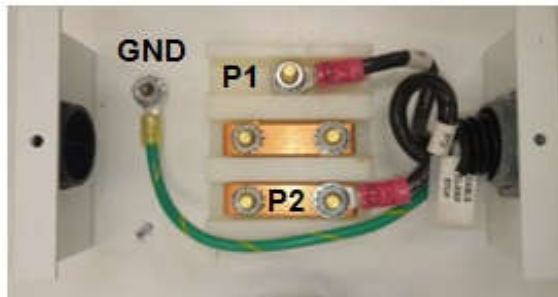
**K904-00**  
240  
(208-285VAC)



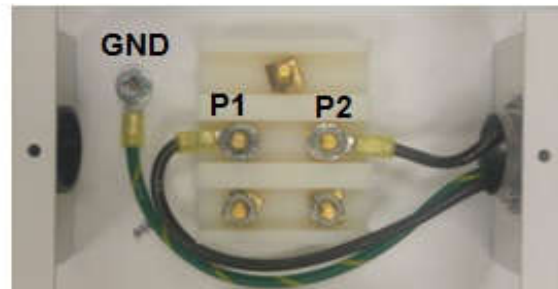
**K904-01**  
208/220  
(202-229VAC)



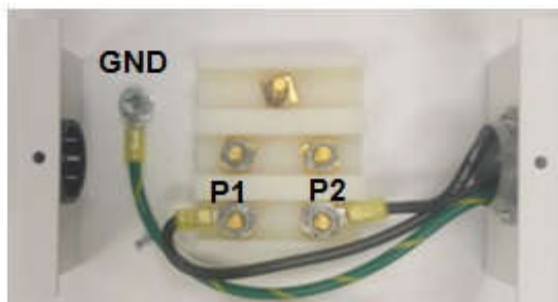
**K904-01**  
240/277  
(230-290VAC)



**K904-02**  
380/416  
(361-428VAC)



**K904-02**  
440/480  
(429-504VAC)

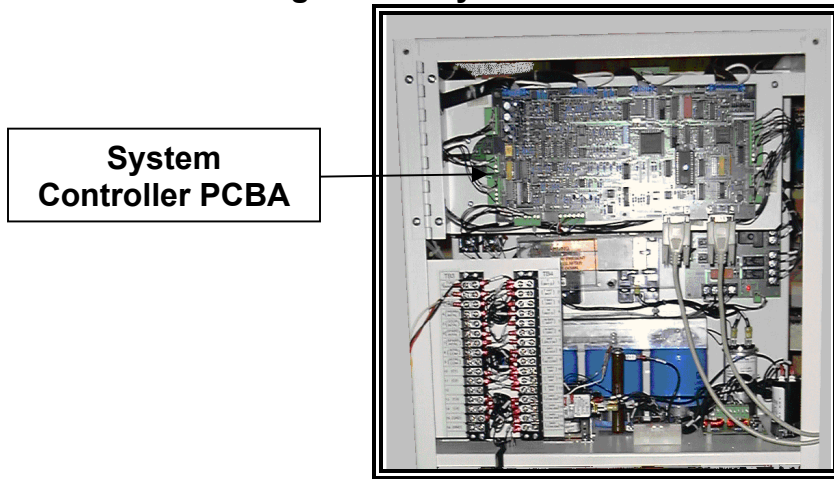


2.6 CIRCUIT BOARD IDENTIFICATION

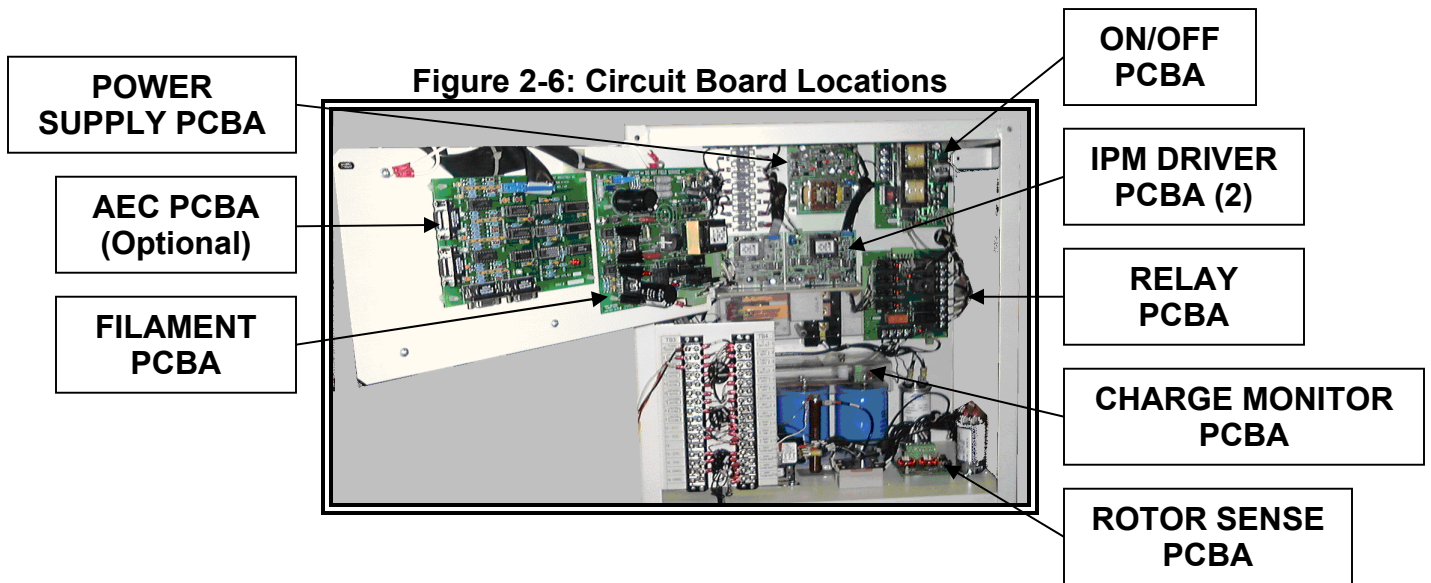
See Table 11-1 and Table 11-2 for Circuit board part numbers.

2.7 CIRCUIT BOARD LOCATIONS

**Figure 2-5: System Controller Board Location**



**Figure 2-6: Circuit Board Locations**



## 2.8 INSTALLATION – HARDWARE PLACEMENT

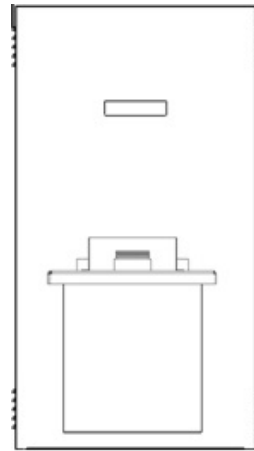
### 2.8.1 Position Power Module

For Tall power module systems, place the Power Module close to the final location, leaving access on all sides (4 inches from the back and 2 inches from the sides). This allows the installer to establish the proper wiring, routing and lengths for all cables.

For compact power module systems, place the Power Module close to the final location, leaving access on all sides. If the system is to be placed under a table, then place it close to the table leaving enough service loop in all cables to allow for final placement under the table.

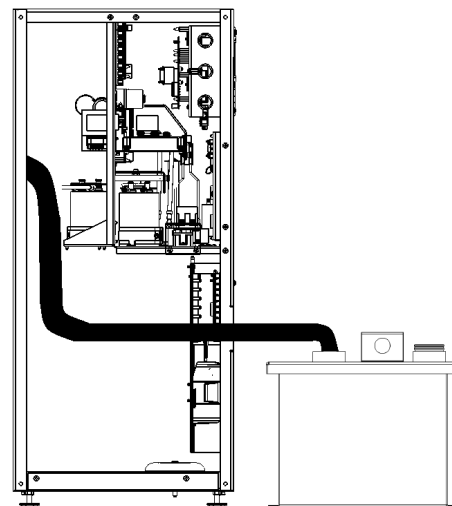
### 2.8.2 Position High Voltage Transformer

For Tall power module systems, ensure that the HV Transformer (Figure 2-3) is mounted to the bottom of the power module frame with two 5/16-18 hex cap screws.



Place the HV Transformer in front of the Power Module to allow service loop for the high voltage cables.

The high voltage cables **cannot be** inserted or removed when the HV Transformer is inside the cabinet.



**NOTE:** The HV Transformer has an 8-32 screw in the oil fill plug. Unscrew 1 full turn counter-clockwise to allow the oil level to expand with temperature and barometric changes.

## 2.9 INSTALLATION – LINE VOLTAGE SETUP

### 2.9.1 Line Voltage

This generator is designed to work with a wide range of line voltages without a need for a line matching transformer.

Measure and note the incoming line voltage (refer to the Line Voltage Determination Chart below for more details).

<b>Line Voltage Determination Chart</b>	
<b>RANGE</b>	<b>VAC</b>
202 to 214	<b>208</b>
215 to 229	<b>220</b>
230 to 250	<b>240</b>
251 to 290	<b>277</b>
361 to 398	<b>380</b>
399 to 428	<b>416</b>
429 to 460	<b>440</b>
461 to 504	<b>480</b>



**NOTE:** It will not be possible to produce the full output capability of the generator, if the maximum load voltage drop under full load is more than 5%. De-rate the unit to a lower kW through the PWR MOD SET screen for AP (or P02 for 2PT), accordingly.

## 2.10 INSTALLATION – SYSTEM INTERCONNECTION

### 2.10.1 Operator's Console/Communication Cables

The Communication Cables for the Operator's Console connect to the Power Module. These shielded cables route from the control room to the Power Module. Do not store excess communication cables inside the Power Module.

Run the two communication cables from the Operator's Console to the Power Module. The cables are keyed so that they will only plug into the proper receptacles. At the power module the cables will plug into H13 and H14 on the System Controller PCBA.

### 2.10.2 Connecting the High Voltage Transformer

Inspect all wiring in the Power Module.

At this time, the Power Module can be connected to the HV Transformer. Three leads marked "P1, P2 and GND" should be routed from the bottom of the Power Module to the HV Transformer and terminated at the connections labeled "A-E and GND" (Figure 2-4) as shown below.

**Note:** Must torque nuts to 45±5 in-lbs. (excessive torque WILL break brass studs)

HV Transformer P/N	Line Voltage	Connect Lead "P1" To	Connect Lead "P2" To
K904-01	202-209 VAC	E	D
	230-290 VAC	E	B
K904-02	361-428 VAC	C	D
	429-504 VAC	A	B

Route the Filament cable and the Feedback cable to the HV Transformer and plug it into the mate-n-lock receptacles at the top of the transformer (Figure 2-4). The cables are keyed so that they will only plug into the proper receptacles.

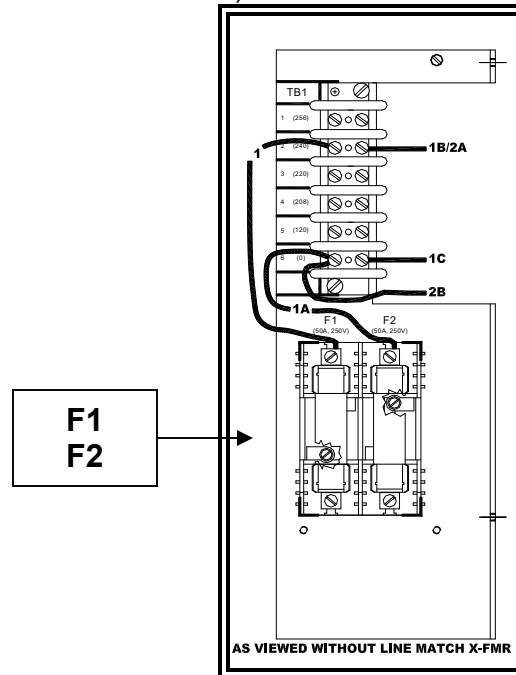
### 2.10.3 Connecting the Mains Input Voltage

Single phase power is terminated at the line fuses (F1, F2) in the Power Module. Three phase power is terminated at the line fuses (FΦ1, FΦ2, FΦ3) in the Power Module. For 3-Phase DELTA power line, connect the wild leg (higher voltage to GND) to fuse FΦ3 to achieve best results. This

Fuse Block is located at the front bottom right corner of the Tall Power Module or at the rear upper left corner of the Short Power Module.  
 Verify the following wire connections:

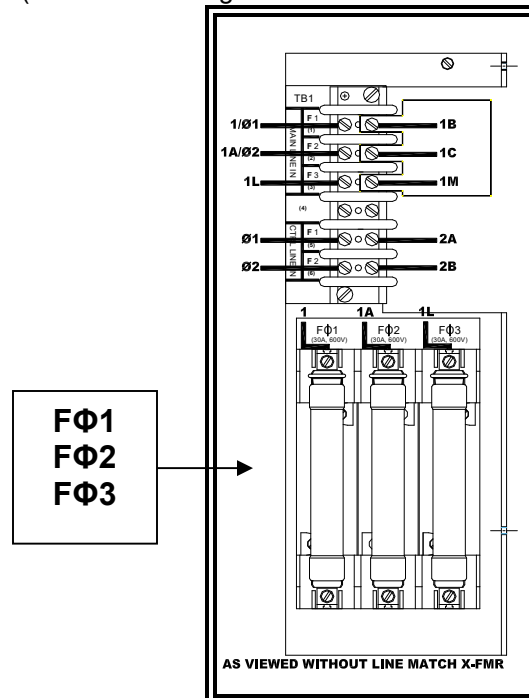
**Figure 2-7: Terminal Strip TB1 (Single Phase)**

(For line matching transformer connections, refer to installation instructions in the Line Matching Transformer Kit - L246.)



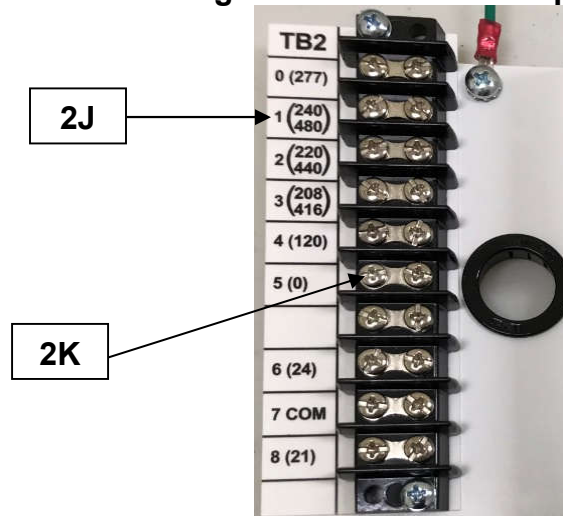
**Figure 2-8: Terminal Strip TB1 (3-Phase)**

(For line matching transformer connections, refer to 03902.)



## 2.10.4 Connecting the Accessory Transformer

Figure 2-9: Terminal Strip TB2

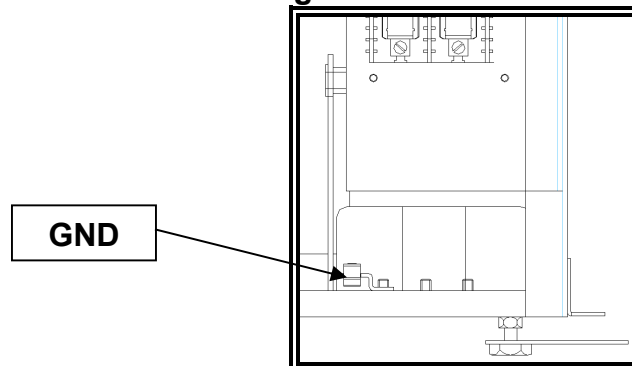


Line Voltage Range From F1 to F2	At Terminal Strip TB2, Connect Wire "2J" to
202 to 214 VAC	TB2-3
215 to 229 VAC	TB2-2
230 to 250 VAC	TB2-1
251 to 290 VAC	TB2-0
361 to 398 VAC	TB2-3
399 to 428 VAC	TB2-3
429 to 460 VAC	TB2-2
461 to 504 VAC	TB2-1

## 2.10.5 Connecting the Incoming GND

Ground is connected to the Ground Lug just below and to the left of the fuse block.

Figure 2-10: GND Terminal



### 2.10.6 High Voltage Cables

At the HV Transformer, remove vent cover and verify oil to be 3/4" from top of the lid. Fill HV receptacles to 3/8" with oil from vent. Then, loosen vent screw and replace vent cover.

Connect the high voltage cables from the HV Transformer (Figure 2-4) to the x-ray tube. With the vent to the front, the cathode (-) receptacle is on the left, by the red and black mAs meter jumpers. The anode (+) receptacle is on the right. Verify polarity and that all connections are made correctly.



#### CAUTION

The high voltage cable terminal pins are delicate. Take particular care to handle them carefully.



#### CAUTION

The HV Cable rings/nuts are delicate and can be damaged by dropping or banging on the floor. This can deform the threads, making it difficult to install them fully into the HV receptacles.

Use a clean, dry, lint-free cloth and alcohol to clean the insulating surfaces of the terminals and receptacles. Use particular care in cleaning the flat insulating surface. Do not touch the insulating surface after cleaning. Coat with vapor proofing compound.

### 2.10.7 Stator Cable

The HF generator stator connections are described in the table below:

**Table 2-1: Tube Stator Cable Connections**

Origin (Tube)	Destination (Power Module)	Function
Black 07	TB3-1	Stator Main
Red 08	TB3-2	Stator Phase
White 09	TB3-3	Stator Common
Blue T5	TB3-4	Thermal Switch (N.C.)
Orange T6	TB3-8	Thermal Switch Return

### 2.10.8 Collimator

The HF generators come with power supply connections to run most commonly available collimators. See collimator specifications for details (Section 1.7.6). The following table describes the generator connections at terminal strip TB3 (for generators w/out optional terminal strip TB5):

**Table 2-2: Collimator Connections**

<b>Generator Connections</b>	<b>TB3-10</b>	<b>TB3-11</b>	<b>TB3-15</b>	<b>DO NOT CONNECT (Cut and Tape)</b>	
Collimator supply cable	C1	C2	GND	CSW1	CSW2

### 2.10.9 Electric Lock Supply

The HF generators come with power supply connections to run most commonly available electric locks. See electric lock specifications for details (Section 1.7.7). The following table describes the generator connections:

**Table 2-3: Electric Lock Connections**

<b>Generator Connections</b>	<b>TB3-15</b>	<b>TB3-13</b>	<b>TB3-14</b>
DC Lock Supply cable	GND	+	-

### 2.10.10 Other Accessory Power

There is NO other power available for other accessory items requiring 110 VAC, 5 or 12 VDC. Connections of ancillary devices requiring other than the 24 Volt supplies listed above, or requiring more current than that listed above, will cause component damage and is not covered under warranty.

## 2.10.11 Table Interface Connections TB5 (Optional TB5)

The interface between the generator and the table is used for the collimator, prep/exposure switch, air switches (used with the latching prep option), and the table interface cable, which carries a variety of other signals.

**Table 2-4: Table Interface Cable Connections at TB5**

Origin	Destination	Function
Collimator cable C1	TB5 - 12	24 VAC
Collimator cable C2	TB5 - 13	24 VAC
Collimator cable GND	TB5 - 11	GROUND
Collimator cable CSW1	TB5 - 5	Hip switch
Collimator cable CSW2	TB5 - 6	Hip switch
Table Interface cable - BROWN	TB5 - 2	Common
Table Interface cable - BLUE	TB5 - 4	Exposure
Table Interface cable - RED	TB5 - 5	Hip switch for collimator
Table Interface cable - GREEN	TB5 - 6	Hip switch for collimator
Table Interface cable - ORANGE	TB5 - 7	+ 24 VDC
Table Interface cable - VIOLET	TB5 - 8	To float-top lock switch
Table Interface cable - BLACK	TB5 - 9	To Solenoid
Table Interface cable - WHITE	TB5 - 10	- 24 VDC
Foot Treadle	TB5 - 1	Common
Foot Treadle	TB5 - 4	Prep/Expose
Traditional Two-stage Footswitch - S1	TB5 - 2	Common
Traditional Two-stage Footswitch - S2	TB5 - 3	Prep
Traditional Two-stage Footswitch - S3	TB5 - 4	Expose

## 2.10.12 Interlocks

Interlocks are used to halt the x-ray system in case of an emergency. The following table describes the generator connections:

**Table 2-5: Interlocks**

Origin	Destination	Function
Xray Tube Thermal interlock	TB3 - 4	Thermal Interlock
Xray Tube Thermal interlock	TB3 - 8	Interlock Return
Door interlock	TB3 - 5	Door Interlock
Door interlock	TB3 - 8	Interlock Return
Collimator interlock	TB3 - 6	Collimator Interlock
Collimator interlock	TB3 - 9	Interlock Return
Spare interlock	TB3 - 7	Spare Interlock
Spare interlock	TB3 - 9	Interlock Return

If any of the interlocks are not being used, a shorting jumper should be placed across the two points that represent the interlock.

TB3-8 and TB3-9 are electrically the same point and can be used interchangeably.

## 2.10.13 Bucky Connections (Optional for Selected Generators)

For the Summit J500 or equivalent 17" Bucky, connect as shown in the tables below. Wire color reference for original Summit factory supplied cable only! Verify before connection.

**Table 2-6: Summit Bucky or Equivalent Connections**

Origin	B1	B2	B3	B4	B6	B8
Wire Color	Blue	Brown	Red	White	Grn/Yel	Black
Function	Bucky motion	Bucky motion return	Switched 110 V Start grid	Bucky 110 V Neutral	Power ground	Bucky 110 V Line
Power Module Destination: (Table bucky)	TB4-1	TB4-2	TB4-3	TB4-9	TB3-15	TB4-8
Power Module Destination: (Wall bucky)	TB4-4	TB4-5	TB4-6	TB4-9	TB3-15	TB4-8

**CAUTION**

If 115 VAC is used as the Bucky Motion Signal (signal to indicate grid is in motion such as with a Midwest 14 x 36 inch Bucky), this voltage **MUST** be converted to a contact closure by a 115 VAC relay as shown below.

To use this Bucky, a 110 VAC relay is needed across B2 and B4 of the Bucky. The N.O. contacts of this relay are used to go to the generator for the "Bucky Motion" signal.

**Table 2-7: 14 x 26 Midwest Bucky Connections**

Midwest 14 x 36 Bucky			B1	B2	B3	B4
Interface relay (110V coil, N.O. contacts)	N.O. Contact	N.O. Contact		Coil		Coil
Generator	TB4-4	TB4-5	TB4-6	-----	TB4-8	TB4-9

**Connecting a US X-RAY Bucky (240 VAC)**

Use Table 2-6 above to connect this Bucky.

Adjust the Bucky power source by removing wire 2L from TB2-4 (120 VAC), and re-connect at TB2-1, 240 VAC (join wire 2J).

## 2.10.14 Sedecal TWBS-TILT Wallstand Connections

Refer to Table 2-6 above to connect Bucky (use designations from below).

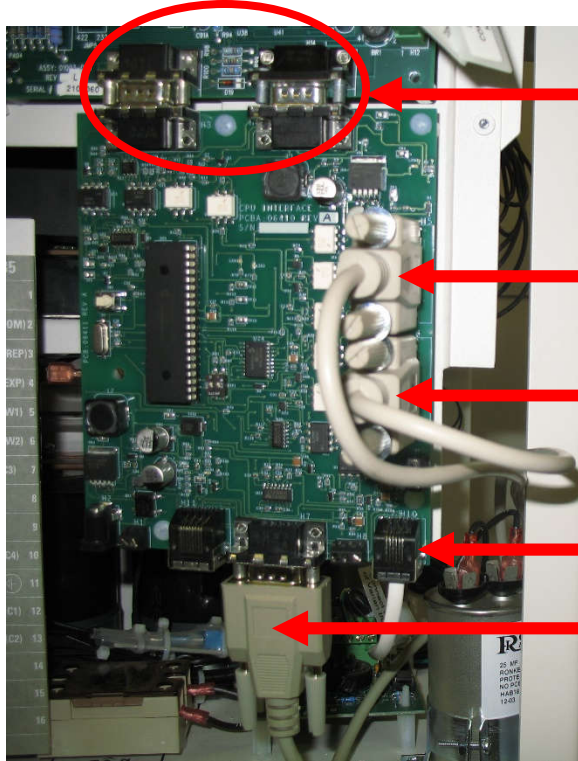
Wallstand Wire #	Bucky Designation
12	B1
13	B2
11	B3
8	B4
9, 10	B8
Green/Yellow	B6

If the Wallstand contains a 240 VAC Bucky (i.e. US X-RAY), adjust the Bucky power source by removing wire 2L from TB2-4 (120 VAC), and re-connect at TB2-1, 240 VAC (join wire 2J).

Wallstand lock connections:

Wallstand Wire #	VDC	Generator TB3
1, 5, 7	24 (+)	13
2, 6, 8	0 (-)	14

2.10.15 Digital Integration Connections



Two DB9 Headers from Controller Brd. to be connected to H3 & H4

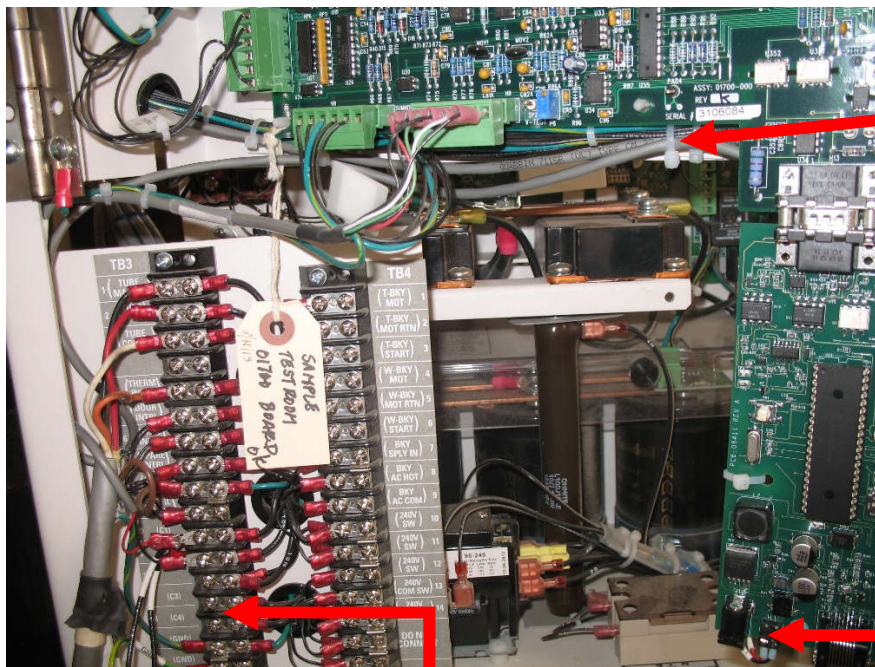
Two DB9 Cables from Console to be connected to H5 & H6

Hand Switch Cable (optional) to be connected to H10

DB9 Cable to PC to be connected to H7



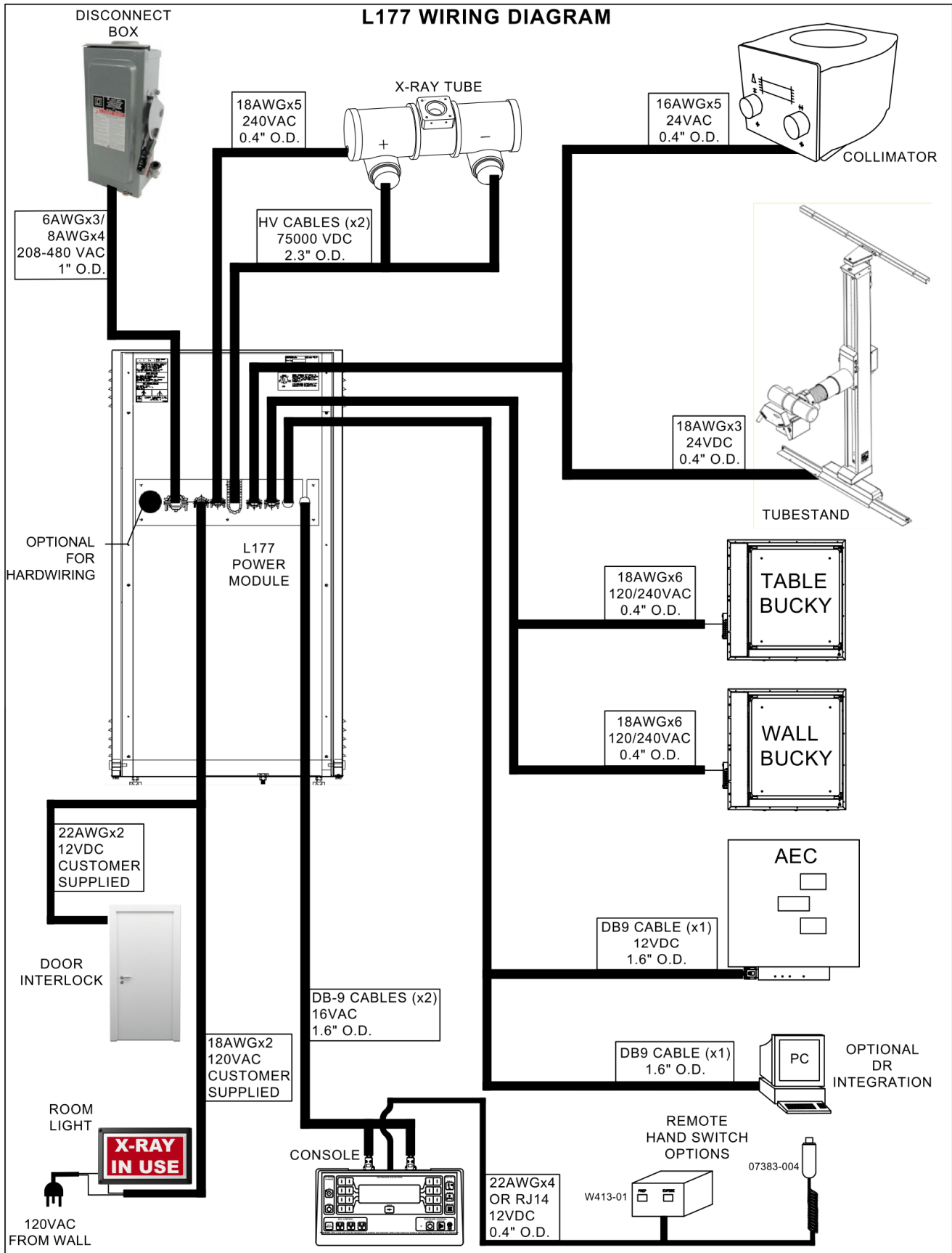
TB3-C3 & TB3-C4 have 40VDC present at all times! Proceed with caution.

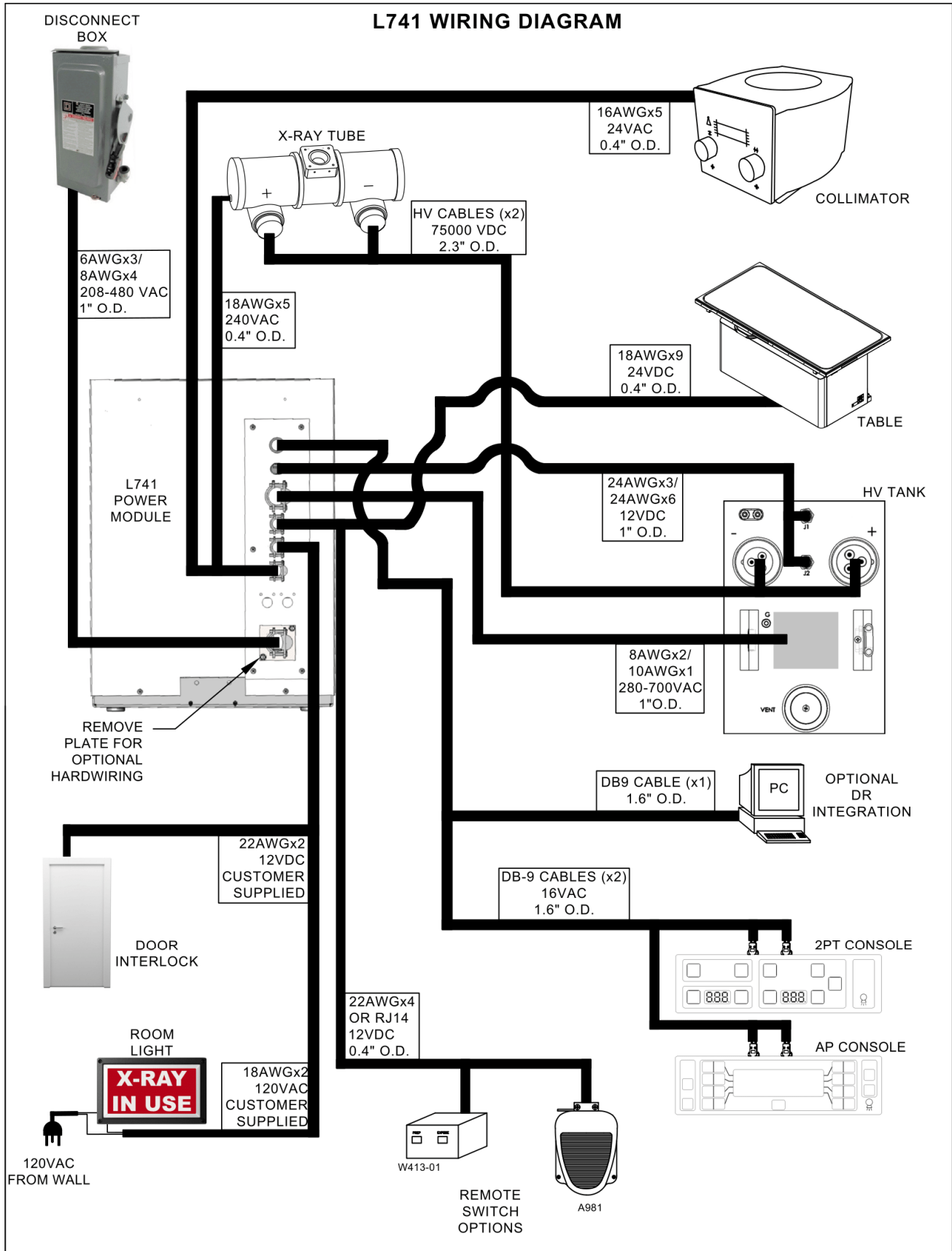


Route cable as shown. Use cable tie to secure the cables.

Connect Power Supply Cable (06755):  
 H1-Pin 1: Red  
 H1-Pin 2: Black  
 TB3-C3: Red  
 TB3-C4: Black

2.10.16 Overall Wiring Diagrams





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## 3 INITIAL POWER UP AND INSPECTION

### 3.1 GENERAL

The HF systems come in a standard configuration with typical default calibration values stored in memory. If required, the factory defaults can be reloaded into memory. After initial inspection and interconnections have been made, the system will be ready for power up, voltage checks and calibration.



#### **WARNING**

The main storage capacitors retain their charge for some time after the unit is turned off. Although the areas where this voltage may be present are covered with a protective layer of Lexan, it is imperative that all service personnel are respectful of the significant shock hazard the capacitor bank voltage represents. Prior to servicing the power components, ensure that the LED on the Charge Monitor PCBA is not lit, and verify there is no capacitor bank voltage with a DC voltmeter.

### 3.2 SYSTEM CONFIGURATION

System configuration will be done via the Operator's Console in Calibration Mode. In-depth System Configuration and Calibration will be performed in later sections.

Observe DIP1 and DIP3 on the System Controller PCBA in the Power Module and verify that all switches are set to their default setting. Refer to the charts below for information on the functions of the switches.

Table 3-1: DIP1 Functions (System Controller PCBA)

	AP Generators		2PT Generators	
DIP Switch	OPEN/ OFF/LEFT	CLOSED/ON/RIGHT	OPEN/ OFF/LEFT	CLOSED/ON/RIGHT
DIP1-1	Normal Operation	Simulator mode (demo)	Normal Operation	Simulator mode (demo)
DIP1-2	Normal Operation	Disables capacitor bank charging. Exposure with mA and kVp is allowed. Exposures will discharge the capacitor bank.	Normal Operation	Disables capacitor bank charging. Exposure with mA and kVp is allowed. Exposures will discharge the capacitor bank.
DIP1-3	Normal Operation	Disables Rotor and Filament. This allows exposure (kVp only) to check for high voltage breakdown of the transformer (hipot test).	Normal Operation	Disables Rotor and Filament. This allows exposure (kVp only) to check for high voltage breakdown of the transformer (hipot test).
DIP1-4	mA Feedback Disabled	Normal Operation mA Feedback ENABLED (ON)	mA Feedback Disabled	Normal Operation mA Feedback ENABLED (ON)
DIP1-5	For AUTO CAL	For MANUAL CAL	For AUTO CAL	For MANUAL CAL
DIP1-6	Normal Operation	Not Used	Normal Operation	Not Used
DIP1-7	Normal Operation	Not Used	Normal Operation	Not Used
DIP1-8	Normal Operation	Not Used	Normal Operation	When booted up in calibration mode, this reloads the factory defaults for all configuration and calibration data. Used to clear error E14.

Table 3-2: DIP3 Settings for 300mA and 500mA Gen. (System Controller PCBA)

DIP Switch	OPEN/OFF/LEFT	CLOSED/ON/RIGHT
DIP3-1	300mA Generator	500mA Generator
DIP3-2	300mA Generator	500mA Generator
DIP3-3	Normal Operation	Not used
DIP3-4	Normal Operation	Not used

### 3.3 POWER-UP

#### 3.3.1 Start-Up

##### AP Generators:

Turn the main disconnect switch ON. Press the Operator's Console ON key and observe the display screen during the start-up phase. The screen will display the date and time, and the choice of AP or MANUAL (2 Point) mode of operation.

Note that in MANUAL mode of operation, EXPOSURE COUNT can be selected to momentarily display the total number of exposures taken on this x-ray control.

##### 2PT Generators:

Turn the main disconnect switch ON. Press the Operator's Console ON key and observe the kVp Display and the mAs Display during the start-up phase. The kVp display should momentarily display the software version number for the Operator's Console and the mAs Display should momentarily display the software version number for the System Controller.

Within five seconds of power up the kVp and mAs windows should display valid technique selections.

#### 3.3.2 Status of LEDs

Upon power up, there are a number of LEDs which will illuminate on boards within the power module. Verify that the following are true.

System Controller PCBA: LED1 lights will strobe back and forth across the bar.

Power Supply PCBA: LED2 and LED3

Power On/Off PCBA: LED1

Relay PCBA: LED6

Filament PCBA: LED1 and LED2, LED 3 for large filament

---

### 3.3.3 Power Supply Test and Fuse Designation

To see fuse current ratings see Table 11-3.

Verify the following output voltages from the power supplies referenced to ground.

**Table 3-3: Fusing for DC Voltages**

F3	Not Used
F4	+5/+12 VDC
F5	-12 VDC

The following fuses are also present.

**Table 3-4: Fusing for AC Voltages**

Fuse ID	Function
F1	Mains (single phase)
F2	Mains (single phase)
F $\Phi$ 1	Mains (3-phase)
F $\Phi$ 2	Mains (3-phase)
F $\Phi$ 3	Mains (3-phase)
F6	240 VAC return
F7	240 VAC hot
F8	Collimator supply (24 VAC)
F9	Electric lock supply (24 VDC)
F10	Relay PCBA supply (24 VDC)
F11	Console supply (20 VAC)
F12	Bucky supply (120 VAC)
F13	Tube Rotor supply (240 VAC)
F14	Tube Rotor common (240 VAC)
F15	Switched AC power (240 VAC)
F16	Switched AC power (240 VAC)
F17	480 VAC hot
F18	480 VAC return

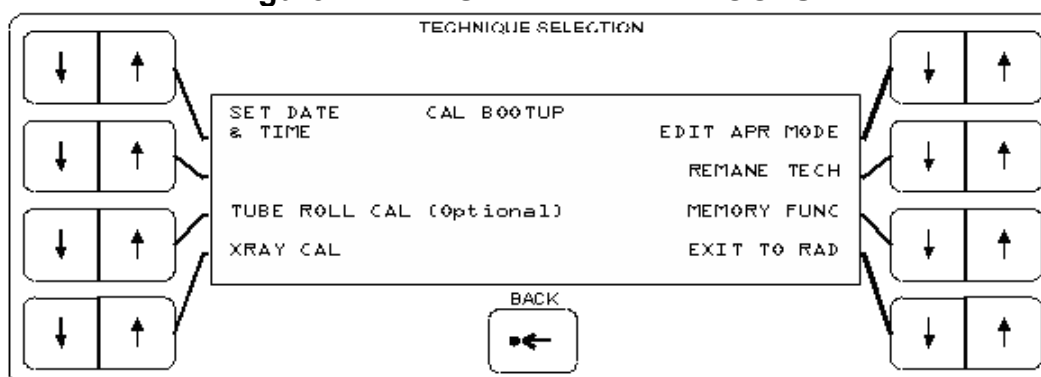
## 4 AP GENERATOR CONFIGURATION AND CALIBRATION

### 4.1 CAL BOOTUP SCREEN

4.1.1 This screen is the entry point for all Operator's Console based system configuration such as tube type and image receptor selection. It is also where manipulation of the anatomical technique database and calibration screens are accessed.

4.1.2 To access the CAL BOOTUP screen: Turn the control OFF. Press and hold the BACK button while pressing the ON button. The CAL BOOTUP screen will display as shown below.

**Figure 4-1: AP SCREEN – CAL BOOTUP**



**Table 4-1: CAL BOOTUP MODE**

MODES	DESCRIPTION OF MODES
SET DATE & TIME	Program local time.
TUBE ROLL CAL	To calibrate the tube roll potentiometer.
XRAY CAL	To enter configuration and calibration screens.
EDIT AP MODE	Changes to the technique database.
RENAME TECH	Add more techniques. Change view names.
MEMORY FUNC	Save configuration and/or technique data to a manufacturer supplied diskette and transfer it between sites. Use as described in Section 7.
EXIT TO RAD	Return to AP or MANUAL modes of operation.

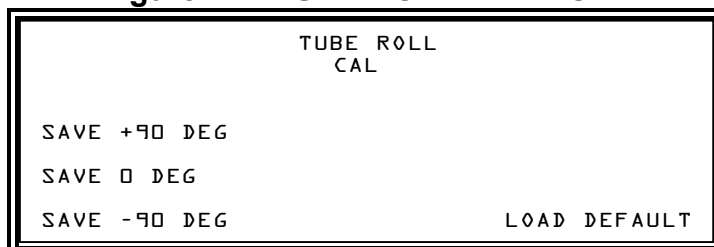


Note: Use the BACK button just below the console display to return to the previous screen whenever necessary. From the CAL BOOTUP screen the EXIT TO RAD command returns the system to normal operation.

## 4.2 TUBE ROLL CAL SCREEN AND CALIBRATION (OPTION WITH SOME SYSTEMS)

- 4.2.1 This selection will allow the installer to calibrate the tube roll display. Ensure the “roll” potentiometer has been pre-set before the calibration procedure (see mechanical system manual for “roll” pot pre-set procedure).
- 4.2.2 Once in the CAL BOOTUP screen, select TUBE ROLL CAL. The following screen will be displayed.

**Figure 4-2: TUBE ROLL CAL MODE**



- 4.2.3 Rotate the entire Operator’s Console and tube head to the left until the primary beam is horizontal. This will be the +90 degree point. Use a level to verify this position. Push the SAVE +90 DEG up/down buttons to input this setting. Unit will give an audible tone and display SAVING. +90 degree calibration is complete.
- 4.2.4 Rotate the entire Operator’s Console and tube head until the primary beam is pointed vertically downward. This will be the 0 degree point. Use a level to verify this position. Push the SAVE 0 DEG up/down buttons to input this setting. Unit will give an audible tone and display SAVING. 0 degree calibration is complete.
- 4.2.5 Rotate the entire Operator’s Console and tube head to the right until the primary beam is horizontal. This will be the –90 degree point. Use a level to verify this position. Push the SAVE -90 DEG up/down buttons to input this setting. Unit will give an audible tone and display SAVING. -90 degree calibration is complete.
- 4.2.6 Tube roll calibration is complete. Verify various tube angle displays and repeat calibration if necessary.
- 4.2.7 NOTE: The “roll” angle will only be displayed in normal operating RAD mode. The “roll” display will not be displayed in any of the set-up utility menus or during an error condition in normal RAD mode.
- 4.2.8 NOTE: Use the BACK button just below the console display to return to the previous screen whenever necessary. From the CAL BOOTUP screen the EXIT TO RAD command returns the system to normal operation.

### 4.3 XRAY CAL SCREEN

- 4.3.1 For all system configuration and generator calibration select XRAY CAL.
- 4.3.2 The console will require the installer to ENTER PASSWORD TO CONTINUE.
- 4.3.3 Press the outer most upper left, lower left, lower right and upper right arrow buttons in a counter-clockwise sequence to enter the password.



#### WARNING

- 4.3.4 Only personnel authorized to make system configuration selections and perform generator calibration are to access the XRAY CAL screen. Unauthorized changes by persons unfamiliar with the system will cause equipment damage NOT COVERED BY WARRANTY!
- 4.3.5 The XRAY CAL screen will display as shown below.

**Figure 4-3: XRAY CAL MODE**

XRAY CAL		
TUBE SETUP		AEC WALL SET
PWR MOD SET		AUTO CAL
PWR MOD CAL		FIL# TBL
AEC TBL SET		MORE

**Table 4-2: XRAY CAL MODE**

MODES	DESCRIPTION OF MODES
TUBE SETUP	To select x-ray tube type used at this installation.
PWR MOD SET	To select kW, configure buckys/grid cabinets
PWR MOD CAL	To adjust independent mA leading edge points, master mA leading edge for large and small spot, mA stabilized levels and master kVp.
AEC TBL SET	Set up Table AEC and target voltages
AEC WALL SET	Set up Wall AEC and target voltages
AUTO CAL	Perform AUTO CAL
FIL# TBL	To view all filament numbers, which control mA leading edge
MORE	Miscellaneous settings

---

4.3.6 Press the BACK button to return to the CAL BOOTUP screen if desired.

## 4.4 TUBE SETUP SCREEN

Table 4-3: TUBE SETUP Screen

MODES	DESCRIPTION OF MODES
TUBE	Press the arrow buttons beside the display to toggle through the compatible tubes. Select the tube type being used here.
kV LIMIT	Default is 125. Can be reduced if high voltage breakdown is a problem.
STND-BY I	Sets stand-by filament current, factory set to 2.5 filament Amps.
BST TIME	Rotor delay time, factory set to 1.5 seconds.
AC LINE VOLTAGE	Press the arrow buttons beside the display to toggle through the available voltages. Select the corresponding line voltage.
TUBE SEA.	Tube seasoning modes. Default is A-S (perform Auto Tube Seasoning during Auto Calibration).
EXP #	Exposure counter. Automatically records total # of exposures taken.

4.4.1 Press the SAVE PAGE button to store any changes to the values.

4.4.2 Press the BACK button to return to the XRAY CAL screen.

## 4.5 PWR MOD SET SCREEN

4.5.1 The PWR MOD SETUP screen will display as shown below.

**Figure 4-4: POWER MODULE SETUP MODE**

KW LIMIT:30	POWER MOD SETUP	SHUT DOWN TIME:2 hr
LINE FREQ:60		POWER CHK:ON
T RECP:GRID		K904-XX:01
W RECP:OFF		SAVE PAGE

**Table 4-4: POWER MODULE SETUP MODE**

MODES	DESCRIPTION OF MODES
KW LIMIT	Set kW limit, adjustable in 1 kW increments. Values lower than 30 allow for operation on poor power lines where line voltage drop is a problem. Maximum mAs and mA will not be affected, only kW. After a successful Auto Calibration, this value may be adjusted automatically based on the actual power capability of the incoming line.
LINE FREQ	Set your line frequency: 50Hz or 60Hz
T RECP	Toggle between BUCKY, GRID (grid cabinet), and OFF (no receptor)
W RECP	Toggle between BUCKY, GRID (grid cabinet), and OFF (no receptor)
SHUT DOWN TIME	Select hours of inactivity which cause automatic turn off of control
POWER CHK	Evaluate "Power capability of incoming line" during AUTO CAL. ON = Perform check
K904-XX	Selects K904 HV Transformer version (-00, -01, -02 ...)

4.5.2 Press the SAVE PAGE button to store any changes to the values.

4.5.3 Press the BACK button to return to the XRAY CAL screen.

## 4.6 OTHER SCREENS: PWR MOD CAL, FIL# TBL

4.6.1 These screens are branches of the XRAY CAL screen which relate specifically to calibration of kVp and mA.

4.6.2 Their use will be described in the generator calibration.

## 4.7 MORE SCREEN

**Figure 4-5: MORE SCREEN MODE**

```

XRAY CAL +
MISC. 1
MISC. 2
VIEW AC DATA
TUBE SEASON

```

- 4.7.1 Some of the configurations in the screen below are reserved for factory use only. Changing the factory defaults for “FIL 2 A” and “FIL 4 A” will put the x-ray tube at risk and void warranty.

**Figure 4-6: MISC. 1 SCREEN**

```

MAX EXP.          XRAY CAL +
TIME (S):5.0     MISC. 1  FIL 2 A:+0.00
MAX mA:500              FIL 4 A:+0.00
REV. LCD:N              P-OFF ERR:---
E-CNT RESET           SAVE PAGE

```

**MISC. 1 SETUP MODE**

<b>MODES</b>	<b>DESCRIPTION OF MODES</b>
MAX EXP. TIME (S)	Max. Exposure Time allowed Factory set to 5.0 seconds
MAX mA	Max. mA Station allowed Factory set to 500 mA
REV. LCD	Factory set only N – Normal display (white background) R – Reversed display (black background)
E-CNT RESET	Factory set only
FIL 2 A	Factory set only
FIL 4 A	Factory set only
P-OFF ERR	Last generator error caused a power shut down. Viewing only, can be reset to “---”.

## 4.7.2 GEN MODEL and AP TYPE (can only be preset by factory)

**Figure 4-7: MISC. 2 SCREEN**

PREP:2-POS.	XRAY CAL + MISC. 2	L550-01 GEN MODEL:30
ROLL ANGL:0FF		AP TYPE:CM
EXP BEEP:@EXP		DGT-TTOP:0FF
BKY/DGTL:EXP		SAVE PAGE

**Table 4-5: MISC. 2 SETUP MODE**

MODES	DESCRIPTION OF MODES
PREP	2-POS. – Select two-stage Prep/Exp switch LATCH – Select latching Prep switch
ROLL ANGL	OFF – Tube roll angle display disabled ON – Tube roll angle display enabled
EXP BEEP	@ EXP – Exp. beep tone during exposure @ END – Exp. beep tone at end of exposure
BKY/DGTL	EXP – Bucky request at beginning of exposure PREP – Bucky request at beginning of prep 0.1s to 1.5s – exposure start delay time for digital trigger.
GEN MODEL	Factory set only, based on generator selected
AP TYPE	Viewing only
DGT-TTOP	Allow Table Bucky to be used with Table Top receptor (for digital trigger). Default is OFF.

## 4.7.3 VIEW AUTO CAL Saved DATA

**Figure 4-8: VIEW AC DATA**

(1.0/2.0)	AUTO CAL	L550-01
TUBE:T0S-7239	SAVED DATA	GEN MODEL:30
kV LIMIT:125		SYSTEM kW:30
mA LIMIT:300		

## 4.8 BUCKY/DIGITAL TRIGGER SETUP EQUIPMENT

### Usage:

1. To integrate a digital detector to a HF AP Generator via the Bucky control circuitry.
2. To allow various time delays of a 120VAC trigger start signal for a digital detector (see table below).
3. If other than 120VAC is required, an optional Relay Kit (06355-001) is available.

### Setup:

1. Go to "XRAY CAL/ PWR MOD SET" screen to select BUCKY for "T RECP" or "W RECP".
2. Go to "XRAY CAL/MORE/MISC. 2" screen to select the desired "BKY/DGTL" options below

**Table 4-6: Bucky/Trigger options**

Options	BKY/DGTL
At Exp. request, send Receptor Start Signal, delay 0.1 sec. Start exposure.	0.1S
At Exp. request, send Receptor Start Signal, delay 0.2 sec. Start exposure.	0.2S
At Exp. request, send Receptor Start Signal, delay 0.3 sec. Start exposure.	0.3S
At Exp. request, send Receptor Start Signal, delay 0.4 sec. Start exposure.	0.4S
At Exp. request, send Receptor Start Signal, delay 0.5 sec. Start exposure.	0.5S
At Exp. request, send Receptor Start Signal, delay 0.6 sec. Start exposure.	0.6S
At Exp. request, send Receptor Start Signal, delay 0.7 sec. Start exposure.	0.7S
At Exp. request, send Receptor Start Signal, delay 0.8 sec. Start exposure.	0.8S
At Exp. request, send Receptor Start Signal, delay 0.9 sec. Start exposure.	0.9S
At Exp. request, send Receptor Start Signal, delay 1.0 sec. Start exposure.	1.0S
At Exp. request, send Receptor Start Signal, delay 1.1 sec. Start exposure.	1.1S
At Exp. request, send Receptor Start Signal, delay 1.2 sec. Start exposure.	1.2S
At Exp. request, send Receptor Start Signal, delay 1.3 sec. Start exposure.	1.3S
At Exp. request, send Receptor Start Signal, delay 1.4 sec. Start exposure.	1.4S
At Exp. request, send Receptor Start Signal, delay 1.5 sec. Start exposure.	1.5S
<b>DEFAULT –</b> At Exp. request, send Receptor Start Signal. Wait for Receptor Return Signal. Start exposure 60 msec. after Receptor Return Signal received. Display Error "NO BUCKY MOT" if Receptor Return Signal is not present in 2 seconds.	<b>EXP</b>
At Prep request, send Receptor Start Signal. Wait for Receptor Return Signal. Display Error "NO BUCKY MOT" if Receptor Return Signal is not present in 0.5 second.	<b>PREP</b>

## 4.9 USE OF TEST EQUIPMENT FOR CALIBRATION

- 4.9.1 Calibration will be done through software adjustments on the Operator's Console. The XRAY CAL screen, which is password protected, allows access to the screens which control kVp, mA leading edge, and stabilized mA levels.
- 4.9.2 It is best to view both the kVp and the mA waveforms simultaneously when calibrating the system. The PWR MOD CAL screen is set up to allow control of mA leading edge, stabilized mA and stabilized kV all at one time.
- 4.9.3 The installer is responsible for achieving waveforms which are both of the proper amplitude and of the proper "square" waveshape, where the desired amplitude is achieved and maintained throughout the entire exposure.
- 4.9.4 A Machlett Dynalyzer (or equivalent high voltage divider) and a storage oscilloscope are recommended for calibration. The Dynalyzer will indicate total kVp and mA, while the scope allows a view of the waveform shape. It is preferable for the scope to be dual trace, 100 MHz response. Some hand-held scope/meters have a frequency response and pixel resolution that does not give a reliable and discernible view of the output waveforms. Using a dual trace storage oscilloscope, connect to the Dynalyzer kVp and mA output. Set the scope to trigger from the kV waveform.
- 4.9.5 If using a mAs meter, attach the leads between the mA jumpers on the HV transformer, put a kVp meter in the x-ray beam, and a scope on the kV/mA test points on the System Controller board. The meters and scope will give the proper total output, and the scope the proper waveform.
- 4.9.6 Connect the scope to the kVp and mA test points on the System Controller board. Set the scope to trigger from the kV waveform.
- 4.9.7 The test points are located in the upper left hand corner of the System Controller PCBA, which is on the front of the hinged door in the Power Module. Make exposures, monitoring and adjusting the leading edge and stabilized levels of mA and kVp until satisfactory outputs have been achieved across the operating range.

**Table 4-7: Test Points**

Test Point	Description
TP8	1V = ~33.3kVp
TP9	<b>300mA</b> Generators: 1V = 100mA <b>500mA</b> Generators: 1V = 150mA
TP2	GND

- 
- 4.9.8 A mAs meter can be put between the red and black terminals behind the cathode receptacle. Be certain to remove the jumper when using the mAs meter and replace the jumper when removing the meter at end of calibration.
- 4.9.9 While it is possible to calibrate this generator without a Dynalyzer, is it absolutely essential that an oscilloscope be used for calibration. Because the leading edge and stabilized levels of kV and mA are independently controlled, the shape of the waveforms must be verified and adjusted to proper levels during installation. Using a kV meter and mAs meter alone will not allow the installer to calibrate the unit properly, with component damage a possible result.

## 4.10 AP CALIBRATION OVERVIEW

**Perform Test Equipment setup** (See section 4.9)**Check kV:**

Take exposures at **50kV@50mA@2.5mAs** and **110kV@50mA@2.5mAs**.

If out of tolerance, then perform kV Calibration (See section 4.12).

**Perform Leading Edge Auto Calibration** (See section 4.13)

Auto Tube Seasoning (ATS) will start automatically at the beginning of auto calibration process. Once ATS is finished, the generator will proceed to doing leading edge Auto Calibration (AC).

If ATS/AC does not complete for any reason (HV breakdown, error codes, lockups, etc), the installer should re-attempt ATS/AC up to three more times. If four (4) ATS/AC attempts have been made and failed to complete successfully, perform Leading Edge Manual Calibration (See section 4.14).

In some cases, after initial Calibration attempt(s) has aborted, you may find it necessary to Restore Factory Defaults. Then, repeat a fresh AC attempt.

Define Display information (the following displayed codes may appear during ATS/AC):

Displayed Codes	Function	Time
PERFORM TUBE SEASONING	Season tube	10 min
PRE-CAL LARGE FOCUS	Test if X-ray system is working	20 sec
SYSTEM POWER TEST	Check line drop (Power Limit Test)	20 sec
CALIBRATING FOCUS	Leading edge Calibration	5 min
PROCESS DATA WAIT 3 SEC	Data processing	3 sec
COPY PM DATA	Saving new checksum to Console CPU	1 min
CALIBRATION COMPLETE	Calibration FINISHED	---

Optional Leading Edge Manual Calibration is available if needed (See section 4.14).

**Check Stabilized mA Feedback:**

Take exposures at **50kV@50mA@5.0mAs** and **50kV@300mA@30mAs**.

If out of tolerance, then perform Stabilized mA Calibration (See section 4.15).

**Perform Tube Seasoning (if needed):** See section 4.11

**AEC Calibration (if present):** See section 5.14

**Perform Conformance Testing:** See section 7

## 4.11 TUBE SEASONING

- 4.11.1 Close the Collimator shutters.
- 4.11.2 Set switch **DIP1-5** (Sys. Controller) to **CLOSED/ON/RIGHT**  
Set switch **DIP1-4** (Sys. Controller) to **OPEN/OFF/LEFT**
- 4.11.3 For Auto Tube Seasoning: Turn on generator and enter Calibration mode.  
Go to XRAY CAL/MORE/TUBE SEASON and follow on-screen instructions.

To **ABORT Auto Tube Seasoning**: Press & release the EXP button during Auto Tube Seasoning. The “TUBE SEASON ABORTED!” message will be displayed. Press the RESET button to exit.

- 4.11.4 For Manual Tube Seasoning: Turn on generator and enter 2PT RAD mode.
  - 4.11.4.1 Select Large Focal Spot. Select 20.0 mAs and 200 mA.  
**If 200 mA is not available**, select 10.0 mAs and 100 mA.
  - 4.11.4.2 Take the following exposures (**wait 30 sec after each exposure**):  
60kV, 60kV, 70kV, 70kV, 80kV, 80kV, 90kV, 90kV, 100kV, 100kV,  
110kV, 110kV, 120kV, 120kV, 125kV and 125kV.  
Make sure to properly select mA per step 4.11.4.1 above, after selecting a new kV station.
  - 4.11.4.3 If an error occurs, use the following method to correct it:
    - Leave mAs and mA the same.
    - Repeat exposure with previous kV (lower).
    - Keep reducing kV until no more error occurs.
    - Increase kV to value when error first occurred & repeat exposure.
    - If the error persists, reduce kV again.
- 4.11.5 When finished with Tube Seasoning:  
Set switch **DIP1-5** (Sys. Controller) to **OPEN/OFF/LEFT**  
Set switch **DIP1-4** (Sys. Controller) to **CLOSED/ON/RIGHT**

## 4.12 KV CALIBRATION PROCEDURE

Required kV test equipment:

1. kV meter (Non-Invasive, Dynalyzer, or equivalent)
2. Digital storage oscilloscope

Notes:

1. Recalibration of the kVp is highly discouraged. The generator is calibrated at the factory to a tight tolerance. If a calibration of kVp seems necessary, there is most likely something wrong with either the kV measuring equipment or the generator.
2. When calibrating kVp, actual output readings should be taken from a kV meter. TP8 (kVp test point) on the Sys. Controller board is only to be used to view the waveform shape and may be inaccurate in amplitude and should NOT be used to calibrate kV.

**Figure 4-9: 50kV Screen**

kVp STEP:50	POWER MOD CALIBRATION	SET 50kV:50
FIL AMPS:4.26		SET 50mA:50
mA:50 SM		MASTER mA
TIME(ms):50	TABLE TOP	SAVE PAGE

**Figure 4-10: 110kV Screen**

kVp STEP:110	POWER MOD CALIBRATION	SET 110kV:110
FIL AMPS:4.20		
mA:50 SM		MASTER mA
TIME(ms):50	TABLE TOP	SAVE PAGE

**kV calibration procedure** (follow procedure exactly):

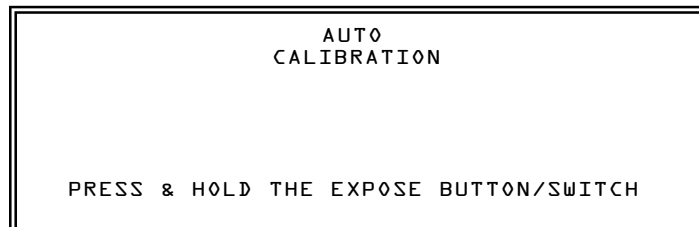
1. Set switch **DIP1-4** (Sys. Controller) to **OPEN/OFF/LEFT**  
Set switch **DIP1-5** (Sys. Controller) to **CLOSED/ON/RIGHT**
2. Enter Power Module Cal Mode: **XRAY CAL -> PWR MOD CAL**
3. Select 50kVp, 50mA and SET & SAVE 50kV: 50 (upper right corner). DO NOT take x-ray.
4. Select 110kVp, 50mA and SET & SAVE 110kV: 110 (upper right corner). DO NOT take x-ray.
5. Set time: 50ms, and mA: 50 SM
6. Take 3 exposures at 50kVp, and average the readings from a kV meter.  
Note: The actual kVp measured may vary from 50 to 60 kVp.
7. Take 3 exposures at 110kVp, and average the readings from a kV meter.  
Note: The actual kVp measured may vary from 110 to 120 kVp.
8. Select 50kVp, 50mA and SET & SAVE 50kV to the kV meter average of 50kVp exposures.
9. Select 110kVp, 50mA and SET & SAVE 110kV to the kV meter average of 110kVp exposures.
10. Enter normal RAD mode and verify the kV accuracy.
11. Set switch **DIP1-4** (Sys. Controller) to **CLOSED/ON/RIGHT**.  
Set switch **DIP1-5** (Sys. Controller) to **OPEN/OFF/LEFT**.

#### 4.13 LEADING EDGE AUTO CAL PROCEDURE

##### Setup Auto CAL:

1. READ SECTIONS 4.9 BEFORE CALIBRATION!
2. CLOSE the Collimator shutters or COVER the opened X-ray tube's port with lead.
3. Set DIP switches on Sys. Controller (Failure to do this will result in a failed Auto CAL attempt):
  - a. **300mA** Generators: Set **DIP3-1 & DIP3-2** to **OPEN/OFF/LEFT**
  - b. **500mA** Generators: Set **DIP3-1 & DIP3-2** to **CLOSED/ON/RIGHT**
  - c. Set **DIP1-5** to **OPEN/OFF/LEFT**
4. Shut off mA Feedback: Set **DIP1-4** to **OPEN/OFF/LEFT**.
5. Go to **XRAY CAL->TUBE SETUP** screen and select correct X-RAY Tube.
6. Adjust kV LIMIT (if necessary, due to a HV limit in HV component).
7. Save Tube and kV LIMIT: Press SAVE PAGE.

**Figure 4-11: Auto CAL screen**



##### Start Auto CAL:

1. Go to **XRAY CAL->AUTO CAL** screen to enter Auto CAL mode.
2. Start X-RAY: Press & hold the EXP button. When the message "RELEASE THE EXPOSE BUTTON/SWITCH" appears on the bottom of the display, release the EXP button. Auto CAL process will start after 3 seconds. Exposure beep tone is disabled during Auto CAL.

To **ABORT Auto CAL**: Press & release the EXP button during Auto CAL. The "AUTO CAL ABORTED!" message will be displayed. Press the RESET button to exit.

3. The Auto Calibration time can take up to 5 minutes (or 15 minutes with Auto Tube Seasoning). AUTO CAL COMPLETE will appear, when calibration is done. Press any button to exit Auto CAL mode.
4. If an error occurs during Auto Calibration (i.e. E34/IPM Overload, E38/mA Overload or Console locked up), re-run Auto Calibration for up to three more times.  
If an error occurs after the fourth Auto Calibration, perform Leading Edge Manual Calibration (See section 4.14).

##### Verify Accuracy:

1. Recycle power to enter normal RAD mode.
2. Turn on mA Feedback: Set **DIP1-4** (Sys. Controller) to **CLOSED/ON/RIGHT**.
3. Verify the kVp and mAs accuracy for various kVp and mA stations, as needed.

#### 4.14 LEADING EDGE MANUAL CALIBRATION

##### Setup

1. READ SECTIONS 4.9 BEFORE CALIBRATION!
2. CLOSE the Collimator shutters or COVER the opened X-ray tube's port with lead.
3. Set DIP switches on Sys. Controller board:
  - a. **300mA** Generators: Set **DIP3-1** & **DIP3-2** to **OPEN/OFF/LEFT**
  - b. **500mA** Generators: Set **DIP3-1** & **DIP3-2** to **CLOSED/ON/RIGHT**
  - c. Set **DIP1-5** to **CLOSED/ON/RIGHT**
4. Shut off mA Feedback: Set **DIP1-4** to **OPEN/OFF/LEFT**.
5. Go to **XRAY CAL->TUBE SETUP** screen and select correct X-RAY Tube.
6. Adjust kV LIMIT (if necessary, due to a HV limit in HV component).
7. Save Tube and kV LIMIT: Press SAVE PAGE.
8. Scope: Connect CH1 (1 V/div) to **TP8** (kVp) and CH2 (1 V/div) to **TP9** (mA).  
Set Time Base to 10 ms/div. Set Trigger Type to Edge. Set Trigger Source to CH1.  
Set Trigger Slope to Rising. Set Trigger Mode to Normal. Set Trigger Coupling to DC.

##### Start Leading Edge Calibration:

1. Go to **XRAY CAL->PWR MOD CAL** screen.
2. **Leading Edge Overall Adjustment for Small Focal Spot.**
  - a. Set 50 kV, 50 mA, 30 ms and take an exposure.
  - b. If the leading edge of the mA needs adjusting: go to MASTER mA and adjust the **SM F.S.** number, Save Page, then go back, retake exposure.
  - c. Repeat step 2.b. until 50 mA is properly set.
3. **Leading Edge Overall Adjustment for Large Focal Spot.**
  - a. Set 50 kV, 300 mA, 30 ms and take an exposure.
  - b. If the leading edge of the mA needs adjusting: go to MASTER mA and adjust the **LG F.S.** number, Save Page, then go back, retake exposure.
  - c. Repeat step 3.b. until 300 mA is properly set.
4. **Leading Edge Fine Tuning for all mA and kV points (optional)**
  - a. This can be done for the following kV stations: **40, 50, 70, 90, 110, 125**.  
For each kV station you may need to adjust every mA station available.  
Possible mA stations (not all mA stations will be present):  
**25S, 50S, 75S, 100S, 100L, 150L, 200L, 250L, 300L, 350L, 400L, 450L, 500L**
  - b. Set time to 30 ms
  - c. Set kV and mA (example 40 kV, 50 mA) and take an exposure.
  - d. If the leading edge of the mA needs adjusting: adjust **FIL AMPS**, Save Page, retake exposure.
  - e. Repeat step 4.d. until the leading edge is properly set.
5. Leave **DIP1-5** (Sys. Controller) in **CLOSED/ON/RIGHT** position.
6. Turn on mA Feedback: Set **DIP1-4** (Sys. Controller) to **CLOSED/ON/RIGHT**.

## 4.15 STABILIZED mA FEEDBACK CALIBRATION

**Setup:**

1. READ SECTIONS 4.9 BEFORE CALIBRATION!
2. CLOSE the Collimator shutters or COVER the opened X-ray tube's port with lead.
3. Set DIP switches on Sys. Controller board:
  - a. **300mA** generators: **DIP3-1** & **DIP3-2** are both **OPEN/OFF/LEFT**
  - b. **500mA** generators: **DIP3-1** & **DIP3-2** are both **CLOSED/ON/RIGHT**
  - c. **DIP1-5** is set to **CLOSED/ON/RIGHT**
4. Turn on mA Feedback: Set **DIP1-4** (Sys. Controller) to **CLOSED/ON/RIGHT**
5. Remove the jumper from the banana plug on top of the HV Transformer (K904). Connect a mA meter to the banana plug (Red to Red, Black to Black). Note: if using a Fluke multi-meter to measure mA, set for DC Amp (or ADC) and record Max mA.

**Figure 4-12: Calibration – 50 mA Set**

kVp STEP:50	POWER MOD CALIBRATION	SET 50kV:50
FIL AMPS:4.20		SET 50mA:46
mA:50 SM		MASTER mA
TIME(ms):250	TABLE TOP	SAVE PAGE

**Figure 4-13: Calibration – 300 mA Set**

kVp STEP:50	POWER MOD CALIBRATION	SET 300mA:286
FIL AMPS:4.78		MASTER mA
mA:300 LG		SAVE PAGE
TIME(ms):250	TABLE TOP	

**Calibration:**

1. Enter Power Module Cal Mode: **XRAY CAL -> PWR MOD CAL**
2. Select 50kV, 50mA and SET & SAVE 50mA: 50 (upper right corner). DO NOT take x-ray.
3. Select 50kV, 300mA and SET & SAVE 300mA: 300 (upper right corner). DO NOT take x-ray.
4. Set time: 250ms
5. Take 3 exposures at 50kV, 50mA, and average the readings from the mA meter.
6. Take 3 exposures at 50kV, 300mA, and average the readings from the mA meter.
7. Select 50kV, 50mA and SET & SAVE 50mA to the mA meter average of 50mA exposures.
8. Select 50kV, 300mA and SET & SAVE 300mA to the mA meter average of 300mA exposures.
9. Enter normal RAD mode and verify the mA accuracy.
10. Set **DIP1-5** (Sys. Controller) back to **OPEN/OFF/LEFT**
11. **Re-install jumper to the banana plug on top of the HV Transformer before continuing.**

## 4.16 FILAMENT NUMBER TABLE AND RECORDING CALIBRATION VALUES.

4.16.1 All of the filament numbers can be viewed at one time by selecting the XRAY CAL screen. Selecting FIL# TBL will display all of the numbers that control mA leading edge, with the mA stations in columns and the kVp stations in rows. Notice how the numbers neatly decrease as kVp increases (space charge compensation) and how for a given kVp the values increase as mA increases.

Table 4-8: 300mA Typical Filament Values

FIL # TABLE	25 mA	50 mA	75 mA	100 mA (Small)	100 mA (Large)	150 mA	200 mA	250 mA	300 mA
40 kVp	3.92	4.06	4.18	4.31	4.13	4.28	4.43	4.50	4.62
50 kVp	3.90	4.04	4.15	4.28	4.10	4.25	4.40	4.46	4.57
70 kVp	3.88	4.02	4.13	4.25	4.07	4.22	4.36	4.43	4.52
90 kVp	3.86	4.00	4.11	4.22	4.04	4.18	4.33	4.40	4.47
110 kVp	3.84	3.98	4.09	4.20	4.01	4.16	4.30	4.38	4.45*
125 kVp	3.82	3.96	4.07	4.18	3.99	4.14	4.27	4.36*	4.43*

Table 4-9: 500mA Typical Filament Values

FIL # TABLE	50 mA	100 mA	200 mA	300 mA	350 mA	400 mA	450 mA	500 mA
40 kVp	4.06	4.31	4.43	4.62	4.70	4.76	4.82	4.86
50 kVp	4.04	4.28	4.40	4.57	4.65	4.71	4.76	4.82
70 kVp	4.02	4.25	4.36	4.52	4.59	4.65	4.71*	4.75*
90 kVp	4.00	4.22	4.33	4.47	4.55*	4.60*	4.67*	4.71*
110 kVp	3.98	4.20	4.30	4.45*	4.50*	4.56*	4.63*	4.67*
125 kVp	3.96	4.18	4.27	4.43*	4.47*	4.53*	4.59*	4.63*

4.16.2 \* Exposure for 30 kW single phase generators is not possible at these techniques. Enter values which follow the pattern established at lower kVp for the mA station.

4.16.3 Each tube type has individual default filament numbers. These tube specific defaults will likely be changed during calibration. This chart is shown for reference only, not as a site-specific calibration record. The actual filament amps required at this installation will be determined during calibration.

4.16.4 As kVp is increased, the filament value number is decreased slightly

due to the space charge effect.

- 4.16.5 We recommended recording the final calibrated FIL#TBL and MASTER mA/MASTER kV values from the XRAY CAL screen in the tables below for future reference.

**Table 4-10: For Recording 300mA Filament Table**

<b>FIL # TABLE</b>	<b>25 mA</b>	<b>50 mA</b>	<b>75 mA</b>	<b>100 mA (SM)</b>	<b>100 mA (LG)</b>	<b>150 mA</b>	<b>200 mA</b>	<b>250 mA</b>	<b>300 mA</b>
40 kVp									
50 kVp									
70 kVp									
90 kVp									
110 kVp									
125 kVp									

**Table 4-11: For Recording 500mA Filament Table**

<b>FIL # TABLE</b>	<b>50 mA</b>	<b>100 mA</b>	<b>200 mA</b>	<b>300 mA</b>	<b>350 mA</b>	<b>400 mA</b>	<b>450 mA</b>	<b>500 mA</b>
40 kVp								
50 kVp								
70 kVp								
90 kVp								
110 kVp								
125 kVp								

**Table 4-12: For Recording MASTER kV and MASTER mA Calibration Values**

<b>MASTER mA Small Focal Spot</b>	<b>MASTER mA Large Focal Spot</b>	<b>SET 50kV</b>	<b>SET 110kV</b>

Note that in AP edit mode, only the highest mA available on each focal spot (based on kW and exposure time limits) is selectable.

## 5 2PT GENERATOR CONFIGURATION AND CALIBRATION

### 5.1 GENERAL

Calibrations will be done completely through software adjustments. The Calibration Mode has two sections: the Programming Section and the Filament Value Section. The Programming Section controls system configuration selections such as tube type and image receptors, as well as master adjustments for mA leading edge (preheat), stabilized mA, kVp and automatic exposure control adjustments. The Filament Value Section allows independent adjustment of the mA leading edge at points across the kVp range.

NOTE: It is best to view both the kVp and the mA waveforms simultaneously when calibrating the system. This way initial adjustments can be made to either kVp or mA if one is dramatically in error. While both are on closed loop feedback systems, they should each be reasonably close to the desired level before fine adjustments are made.

### 5.2 MOVING AROUND IN CALIBRATION MODE

To enter Calibration mode, turn the control OFF. When the control is turned back ON press and hold the mA button (located to the right of the mAs display) until the kVp display changes to "CAL", then release the button. During turn on, the kVp and mAs displays will momentarily indicate the software version used in the console and power module (for example, "2.06" and "5.02").

The control will automatically boot into the Programming Section of the Calibration Mode. When in the Programming Section, the kVp display will show the programming location (starting at P1), and the mAs display will indicate the value stored in this location. A typical display upon entering the Programming Section will be "P1" and "1", indicating a value of "1" at programming point #1.

To move from the Programming Section to the Filament Value Section, press and hold the mA button, momentarily press the "LG" focal spot button, then release both. When in the Filament Value Section, the kVp display will show a kVp value, and the mAs display will show a number which represents actual filament amps. To change the exposure time, press and hold the mA button, use the kVp Up/Down buttons to adjust exposure time in 10 msec steps. To change the mA station, press and hold the mA button, use the mAs Up/Down buttons to select a mA station. This allows the installer to select kVp, mA and time, make exposures, and change the filament amps at this technique to control mA preheats (leading edge) at this specific technique.

To move back to the Programming Section, press and hold the mA button, press the SM focal spot button, then release both buttons. The normal "P#" and "value #" displays of the Programming Section will again be displayed. The control will go back to the P# last visited. This is useful during calibration, where techniques are selected and exposures made from the Filament Value Section, then adjustments to the outputs are made from the Programming Section.

### 5.3 SWITCH AND DISPLAY FUNCTIONS IN CALIBRATION MODE

#### 5.3.1 To enter Calibration Mode:

5.3.1.1 With power off, hold down mA button, then press the ON button and wait until “CAL” appears on kVp display.

#### 5.3.2 To exit Calibration Mode:

5.3.2.1 Hold down mA button, then press LG FOCAL SPOT and SM FOCAL SPOT buttons simultaneously or simply recycle power.

#### 5.3.3 To switch between Programming and Filament Value Sections of Calibration Mode:

5.3.3.1 Hold down mA button. Press SM FOCAL SPOT button for Programming area. Press LG FOCAL SPOT button for Filament Value area.

**Table 5-1: Button Functions in Programming Area**

<b>PROGRAMMING SECTION OF CALIBRATION MODE</b>	
When in this mode, the kVp window displays the P#, which is the programming station. The mAs window displays the # value at this location.	
Pressing this button . . .	will perform this function . . .
kVp up	increment to next P#
kVp down	decrement to next P#
mAs up	increment the value at this location
mAs down	decrement the value at this location
SM focal spot	SAVE A CHANGE to the number
LG focal spot	displays exposure count
prep or exposure	are not allowed
mA and LG focal spot together	go to Filament Value area
mA, LG and SM focal spot together	exit Calibration Mode

Table 5-2: Programming Stations, Functions and Values

PROGRAMMING STATION (P#)	FUNCTION	RANGE OF VALUES WITHIN THIS STATION
P01	X-ray Tube Type	1 = Toshiba E7239 (1.0 x 2.0 mm FS) 2 = Toshiba E7242 (0.6 x 1.5 mm FS) 3 = Varian RAD 13 (1.0 x 2.0 mm FS) 4 = Toshiba E7252 (0.6 x 1.2 mm FS) 5 = Kailong H1074 (1.0 x 2.0 mm FS) 6 = Kailong H1076 (0.6 x 1.5 mm FS) 7 = Kailong H1080 (0.6 x 1.2 mm FS) 8 = Toshiba E7254 (0.6 x 1.2 mm FS) 9 = Toshiba E7255 (0.6 x 1.2 mm FS) 10 = Toshiba E7884 (0.6 x 1.2 mm FS) 11 = Toshiba E7886 (0.7 x 1.3 mm FS) 12 = Varian RAD 8 (1.0 x 2.0 mm FS) 13 = Varian RAD 14 (0.6 x 1.2 mm FS) 14 = Varian RAD 21 (0.6 x 1.2 mm FS) 15 = Varian RAD 44 (1.0 x 2.0 mm FS) 16 = Varian RAD 56 (0.6 x 1.0 mm FS) 17 = Varian RAD 60 (0.6 x 1.2 mm FS) 18 = Varian RAD 68 (1.0 x 2.0 mm FS) 19 = Varian RAD 74 (0.6 x 1.5 mm FS)
P02	Power Setting (kW)	8 through 52; 20/30 is default
P03	Filament Set Point	Factory set only
P04	Filament Set Point	Factory set only
P05	Standby Current	2.0 to 3.2 (Amps) in 0.1 Amp steps
P06	Boost Delay Time	0.5 to 3.0 (seconds) in 0.1 sec steps
P07	Unused	
P08	Max. mA Limit	--- (Not Selected), 200, 250, 300, 350, 400, 450, 500
P09	Max. Exposure Time	0.5 to 5.0 (seconds) in 0.1 sec steps
P10	AC Line Voltage	---, 208, 220, 240, 277, 380, 416, 440, 480
P11	Tube Seasoning	A-S = Auto CAL with Tube Seasoning OFF = Auto CAL w/out Tube Seasoning SEA = Tube Seasoning only
P12	Line Frequency	50 or 60 (Hertz)
P13	Auto Shutdown	0 to 10 (hours); 0 disables feature
P14	K904 HV Transformer Version	---, -00, -01, -02
P15	Bucky for Table Top	OFF = Bucky disabled for Table Top 1 = Bucky enabled for Table Top
P16	Max kVp	125 default, field selectable in 1 kVp increments if necessary.

PROGRAMMING STATION (P#)	FUNCTION	RANGE OF VALUES WITHIN THIS STATION
P17	Set Table Receptor	OFF=No Table, 1=Bucky, 2=Grid cabinet
P18	Set Wall Receptor	OFF=No Wall, 1=Bucky, 2=Grid cabinet
P19	Table AEC Enable	OFF = No AEC, 1 = Standard AEC, 2 = CAEC (If OFF, no access to P20 - P24)
P20	Table AEC Config.	Set field selection. Typically 2 if AEC, inactive if CAEC
P21	Table 50 kVp AEC Comp.	.00 to 4.50 (VDC); 2.60 is default
P22	Table 70 kVp AEC Comp.	.00 to 4.50 (VDC); 1.50 is default
P23	Table 100 kVp AEC Comp.	.00 to 4.50 (VDC); 1.15 is default
P24	Table 125 kVp AEC Comp.	.00 to 4.50 (VDC); 0.85 is default
P25	Wall AEC Enable	OFF = No AEC, 1 = Standard AEC, 2 = CAEC (If OFF, no access to P26 - P30)
P26	Wall AEC Config.	Set field selection. Typically 2 if AEC, inactive if CAEC
P27	Wall 50 kVp Comp.	.00 to 4.50 (VDC); 2.60 is default
P28	Wall 70 kVp Comp.	.00 to 4.50 (VDC); 1.50 is default
P29	Wall 100 kVp Comp.	.00 to 4.50 (VDC); 1.15 is default
P30	Wall 125 kVp Comp.	.00 to 4.50 (VDC); 0.85 is default
P32	Max. mA Value selected w/Auto CAL	Viewing only
P33	Last Gen. Error caused a power shut down	Viewing only (can be reset to --- and save)
P34	Gen. Model Number selected w/Auto CAL	Viewing only
P35	Max. kVp Value selected w/Auto CAL	Viewing only
P36	Max. System Power acquired w/Auto CAL	Viewing only
P37	X-ray Tube selected w/Auto CAL	Viewing only

PROGRAMMING STATION (P#)	FUNCTION	RANGE OF VALUES WITHIN THIS STATION
P38	Prep Type	1 = Latch, 2 = 2-Position
P39	Roll Angle Display	1 = OFF, 2 = ON
P40	Exposure Beep Type	1 = Exp. Beep at start of exposure 2 = Exp. Beep at end of exposure
P41	Bucky/Digital Control	The range is 1 to 17
P42	Gen. Model Number	Factory set only
P43	System Power Test during Auto CAL	OFF = Disabled 1 = Enabled
P44	Calibration Mode	OFF = Manual Calibration enabled A-C = Auto Calibration enabled
P45	Calibration Set Point at 50 mA	The range is 30 to 70 Typical value is 50
P46	Calibration Set Point at 300 mA	The range is 250 to 350 Typical value is 300
P47	Master mA leading edge adjustment for Small Focal Spot	-0.50 to +0.50, 0.01 steps. This number will adjust mA leading edge for all stations on Small focal spot.
P48	Master mA leading edge adjustment for Large Focal Spot	-0.50 to +0.50, 0.01 steps. This number will adjust mA leading edge for all stations on Large focal spot.
P49	Calibration Set Point at 50 kVp	The range is 40 to 65 Typical value for K904-00 is 55 Typical value for K904-01 & -02 is 52
P50	Calibration Set Point at 110 kVp	The range is 90 to 130 Typical value for K904-00 is 116 Typical value for K904-01 & -02 is 110

## 5.4 DETAILED EXPLANATION OF PROGRAMMING STATIONS

### 5.4.1 P01 – X-ray Tube Type

With P1 displayed in the kVp window, enter the number in the mAs display for the x-ray tube used for this system. The tube protect data will be loaded into memory. As with all P# value changes, press the SM button to store a change in the number.



If the x-ray tube you are using is not listed in Table 5-2, select a tube with similar tube loading characteristics. Summit assumes no responsibility for your selection.

### 5.4.2 P02 – Max. kW

With P2 displayed in the kVp window, enter the number for kW output of the generator. This will be preset to 20 or 30 kW (depending on generator model).



If the main power supply cannot maintain a load voltage within 5% of the no-load voltage, this value can be reduced without affecting the maximum available mAs. Reducing this number will change maximum mA at higher kVp, and improve performance on poor power lines.



After a successful Auto Calibration, this number may be adjusted automatically based on the actual power capability of the incoming line.

### 5.4.3 P03 and P04 - Filament Current Set Points

This is an adjustment for the analog to digital conversion of actual filament current. It is used for precise control of filament current, temperature and emission. The values of P03 and P04 are factory set.

### 5.4.4 P05 - Standby Filament Current

The number displayed for P05 is the factory set value of filament current in idle mode. The generator will control filament current to keep it at this value when the system is on but not in prep or expose. This number is factory set.

### 5.4.5 P06 - Boost Delay Time

The time between initiation of “Prep” and the indication of “Ready”. This should be set to the minimum amount of time for the anode to reach the proper speed and the filament to come up to emission temperature, typically about 1.5 seconds. Note that Toshiba E7252AL tube may need shorter boost time (0.5-0.9 second).

### 5.4.6 P07 - (unused)

### 5.4.7 P08 – Max. mA

Typically set to 500, it can be reduced to solve issue with IPM Overload.

#### 5.4.8 P09 – Max. Exposure Time

To accommodate some Digital Receptors, which require limited exposure window time, use this adjustment to set the generator's Max. Exposure Time (in seconds) accordingly.

#### 5.4.9 P10 - AC Line Voltage

Line Voltage measured from line fuse F1 to F2. See table below for proper line voltage selection:

<b>Line Voltage Range From F1 to F2 (VAC)</b>	<b>P10 Selection</b>
202 to 214	208
215 to 229	220
230 to 250	240
251 to 290	277
361 to 398	380
399 to 428	416
429 to 460	440
461 to 504	480

#### 5.4.10 P11 - Tube Seasoning

Selectable tube seasoning modes:

A-S = Perform auto tube seasoning during Auto Calibration (default)

OFF = No tube seasoning during Auto Calibration

SEA = Perform auto tube seasoning only

#### 5.4.11 P12 - Line Frequency

Typically set to 60 (for 60 Hz), it can be set to 50 (for 50 Hz) as needed.

#### 5.4.12 P13 - Auto Shutdown Time

If desired, the system can be programmed to turn itself off if not used within a specific amount of time. When set to "0" this feature is disabled. It can be set for 1 to 10 hours in one-hour increments.

5.4.13 P14 - K904 HV Transformer Version

See table below for proper K904 HV Transformer version selection:

<b>HV Transformer Version</b>	<b>P14 Selection</b>
K904-00	-00
K904-01	-01
K904-02	-02

5.4.14 P15 - Bucky Drive Control for Table Top Receptor

Allow Table Bucky to be used with Table Top receptor (for digital trigger). Default is OFF.

5.4.15 P16 – Max. kVp

Typically set to 125, it can be reduced if high voltage breakdown is a problem.

5.4.16 P17 - Table Image Receptor

If there is no table bucky or grid cabinet in the system, this can be set to “0,” which will disable the selection of table receptor. If the table receptor is a bucky, set to “1,” and if the table receptor is a grid cabinet set to “2.”

5.4.17 P18 - Wall Image Receptor

If there is no wall image receptor in the system, this can be set to “0,” which will disable the selection of wall receptor. If the wall image receptor is a bucky, set to “1”, and if it is a grid cabinet set to “2.”

5.4.18 P19 through P30 enable and adjust Automatic Exposure Control. Refer to the AEC/CAEC manual for more details.

5.4.19 P19 - Enables AEC for Table Receptor

Set to 0, for no table AEC. Set to 1 for AEC with standard "V" pattern ion chamber, or set to 2 for CAEC operation.

5.4.20 P20 - Configures AEC Table Receptor Fields

Set left/center/right orientation fo enabled ion chamber fields. Typically set to 2.

5.4.21 P21 - Table 50 kVp Ion Chamber Calibration

Adjust to achieve density. See AEC/CAEC manual for details.

5.4.22 P22 - Table 70 kVp Ion Chamber Calibration

Set to 1.50

- 
- 5.4.23 P23 - Table 100 kVp Ion Chamber Calibration  
Adjust to achieve density. See AEC/CAEC manual for details.
- 5.4.24 P24 - Table 125 kVp Ion Chamber Calibration  
Adjust to achieve density. See AEC/CAEC manual for details.
- 5.4.25 P25 - Enables AEC for Wall Receptor  
Set to 0 for no wall AEC. Set to 1 for AEC with standard "V" pattern ion chamber, or set to 2 for CAEC operation.
- 5.4.26 P26 - Configures AEC Wall Receptor Fields  
Set left/center/right orientation to enable ion chamber fields. Typically set to 2 for AEC, inactive for CAEC.
- 5.4.27 P27 - Wall 50 kVp Ion Chamber Calibration  
Adjust to achieve density. See AEC/CAEC manual for details.
- 5.4.28 P28 - Wall 70 kVp Ion Chamber Calibration  
Set to 1.50
- 5.4.29 P29 - Wall 100 kVp Ion Chamber Calibration  
Adjust to achieve density. See AEC/CAEC manual for details.
- 5.4.30 P30 - Wall 125 kVp Ion Chamber Calibration  
Adjust to achieve density. See AEC/CAEC manual for details.
- 5.4.31 P47 - Master mA Leading Edge Adjustment for Small Focal Spot  
Use P47 as an overall mA leading edge adjustment to equally change the amplitude of mA leading edge for all Small focal spot mA stations. Independent control of mA leading edge for each kVp/mA point is available in the "Filament Value section" of calibration.
- 5.4.32 P48 - Master mA Leading Edge Adjustment for Large Focal Spot  
Use P48 as an overall mA leading edge adjustment to equally change the amplitude of mA leading edge for all Large focal spot mA stations. Independent control of mA leading edge for each kVp/mA point is available in the "Filament Value section" of calibration.

## 5.5 FILAMENT VALUE SECTION (USED FOR mA CALIBRATION)

5.5.1 In the Filament Value Section of Calibration Mode, the installer will select kVp, mA and time. Independent control of mA preheat at each available kVp point for a given mA station is performed here. Selection of exposure factors are made here and Programming numbers P47, P48, P49 and P50 are used as master adjustments for small and large spot mA preheats and kVp calibration. Exposures can be made when in this mode.

5.5.2 The chart below is a matrix of kVp and mA, showing typical filament current values which result in a square mA waveform. Your values may be different as each tube has individual default values, but the effect of reduced filament current at higher kVp and increased filament current at lower kVp will still hold true.

**Not all mA stations are available on all generator models.**

**Table 5-3: Typical Filament Values for a Toshiba 1 x 2 mm X-ray Tube**

	40 kVp	50 kVp	70 kVp	90 kVp	110 kVp	125 kVp
<b>25 mA</b>	3.92	3.90	3.88	3.86	3.84	3.82
<b>50 mA</b>	4.06	4.04	4.02	4.00	3.98	3.96
<b>75 mA</b>	4.18	4.15	4.13	4.11	4.09	4.07
<b>100 mA (Small)</b>	4.31	4.28	4.25	4.22	4.20	4.18
<b>100 mA (Large)</b>	4.13	4.10	4.07	4.04	4.01	3.99
<b>150 mA</b>	4.28	4.25	4.22	4.18	4.16	4.14
<b>200 mA</b>	4.43	4.40	4.36	4.33	4.30	4.27
<b>250 mA</b>	4.50	4.46	4.43	4.40	4.38	4.36*
<b>300 mA</b>	4.62	4.57	4.52	4.47	4.45*	4.43*
<b>350 mA</b>	4.70	4.65	4.59	4.55*	4.50*	4.47*
<b>400 mA</b>	4.76	4.71	4.65	4.60*	4.56*	4.53*
<b>450 mA</b>	4.82	4.76	4.71*	4.67*	4.63*	4.59*
<b>500 mA</b>	4.86	4.82	4.75*	4.71*	4.67*	4.63*

- 
- 5.5.3 \* Exposure is not always possible at these techniques. Enter values, which follow the pattern established at lower kVp for the mA station.
- 5.5.4 See the Programming Section 5.4 to configure your system before calibration. Once this has been achieved, refer to Section 5.11 for a complete explanation of mA calibration. At the end of this section is a chart to record the actual filament currents and Programming numbers required to achieve the desired outputs at this installation.

## 5.6 BUTTON FUNCTIONS IN THE FILAMENT VALUE SECTION

**Table 5-4: Filament Value Mode Button Functions**

Filament Value Section of Calibration Mode	
In this area, the kVp window displays kVp in steps of 40, 50, 70, 90, 110, and 125 kVp. The mAs window displays the filament current value for this combination of kVp and mA.	
Pressing this button . . .	will perform this function . . .
kVp up	increment kVp to next step
kVp down	decrement kVp to next step
mAs up	increment filament current value
mAs down	decrease filament current value
SM focal spot	SAVE A CHANGE to the filament current value
LG focal spot	performs no function
prep and expose	are allowed
mA and SM focal spot	go to Programming area
mA, SM and LG focal spot	exit Calibration Mode
If the mA button is pressed and held, some button functions and displays are different than as shown above. If the mA button is held down . . .	
The kVp window shows the time setting in milliseconds, and the mAs window shows the mA station selected. Pressing kVp up/down increases/decreases time. Pressing mAs up/down increases/decreases the mA station. This allows the installer to adjust the mA and time of exposure to obtain a good picture of the mA waveform on their test equipment.	

## 5.7 BUCKY/DIGITAL TRIGGER SETUP EQUIPMENT

### Usage:

1. To integrate a digital detector to a HF 2PT Generator via the Bucky control circuitry.
2. To allow various time delays of a 120VAC trigger start signal for a digital detector (see table below).
3. If other than 120VAC is required, an optional Relay Kit (06355-001) is available.

### Setup:

1. Set P17 or P18 to "1" to select the Bucky option for Table or Wall Receptor, respectively.
2. Go to P41 and select the desired Bucky/Digital Trigger Start options below.

**Table 5-5: Bucky/Trigger options**

Options	P41
At Exp. request, send Receptor Start Signal, delay 0.1 sec. Start exposure.	1
At Exp. request, send Receptor Start Signal, delay 0.2 sec. Start exposure.	2
At Exp. request, send Receptor Start Signal, delay 0.3 sec. Start exposure.	3
At Exp. request, send Receptor Start Signal, delay 0.4 sec. Start exposure.	4
At Exp. request, send Receptor Start Signal, delay 0.5 sec. Start exposure.	5
At Exp. request, send Receptor Start Signal, delay 0.6 sec. Start exposure.	6
At Exp. request, send Receptor Start Signal, delay 0.7 sec. Start exposure.	7
At Exp. request, send Receptor Start Signal, delay 0.8 sec. Start exposure.	8
At Exp. request, send Receptor Start Signal, delay 0.9 sec. Start exposure.	9
At Exp. request, send Receptor Start Signal, delay 1.0 sec. Start exposure.	10
At Exp. request, send Receptor Start Signal, delay 1.1 sec. Start exposure.	11
At Exp. request, send Receptor Start Signal, delay 1.2 sec. Start exposure.	12
At Exp. request, send Receptor Start Signal, delay 1.3 sec. Start exposure.	13
At Exp. request, send Receptor Start Signal, delay 1.4 sec. Start exposure.	14
At Exp. request, send Receptor Start Signal, delay 1.5 sec. Start exposure.	15
<b>DEFAULT –</b> At Exp. request, send Receptor Start Signal. Wait for Receptor Return Signal. Start exposure 60 msec. after Receptor Return Signal received. Display Error "E29" if Receptor Return Signal is not present in 2 seconds.	<b>16</b>
At Prep request, send Receptor Start Signal. Wait for Receptor Return Signal. Display Error "E29" if Receptor Return Signal is not present in 0.5 second.	17

## 5.8 2PT CALIBRATION OVERVIEW

### Perform Test Equipment setup (See section 4.9)

#### Check kV:

Take exposures at **50kV@50mA@2.5mAs** and **110kV@50mA@2.5mAs**.  
If out of tolerance then perform kV Calibration (See section 5.10).

### Perform Leading Edge Auto Calibration (See section 5.11)

Auto Tube Seasoning (ATS) will start automatically at the beginning of auto calibration process. Once ATS is finished, the generator will proceed to doing leading edge Auto Calibration (AC).

If ATS/AC does not complete for any reason (HV breakdown, error codes, lockups, etc), the installer should re-attempt ATS/AC up to three more times. If four (4) ATS/AC attempts have been made and failed to complete successfully, perform Leading Edge Manual Calibration (See section 5.12).

In some cases, after initial Calibration attempt(s) has aborted, you may find it necessary to Restore Factory Defaults. Then, repeat a fresh AC attempt.

Define Display info. (the following displayed codes may appear during ATS/AC):

Displayed Codes	Function	Time
A-C SEA	Season tube	10 min
A-C PCL	Test if X-ray system is working	20 sec
A-C SPC	Check line drop (Power Limit Test)	20 sec
A-C - - -	Leading edge Calibration	5 min
A-C CLC	Data processing	3 sec
A-C PAS	Calibration FINISHED	---

Optional Leading Edge Manual Calibration is available if needed (See section 5.12).

#### Check Stabilized mA Feedback:

Take exposures at **50kV@50mA@5mAs** and **50kV@300mA@30mAs**.  
If out of tolerance then perform Stabilized mA Calibration (See section 5.13).

**Perform Tube Seasoning (if needed):** See section 5.9

**AEC Calibration (if present):** See section 5.14

**Perform Conformance Testing:** See section 7

---

## 5.9 TUBE SEASONING

- 5.9.1 Close the Collimator shutters.
- 5.9.2 Set switch **DIP1-5** (Sys. Controller) to **CLOSED/ON/RIGHT**  
Set switch **DIP1-4** (Sys. Controller) to **OPEN/OFF/LEFT**
- 5.9.3 For Auto Tube Seasoning: Turn on generator and enter Calibration mode. Set P11 to SEA and save. Go to Fil. Cal. mode, press & hold EXP switch for 3 seconds. Then, release EXP switch to start tube seasoning.

To **ABORT Auto Tube Seasoning**: Press & release the EXP switch during Auto Tube Seasoning. The “E56” error message will be displayed. Press any button to exit.

- 5.9.4 For Manual Tube Seasoning: Turn on generator and enter RAD mode.
  - 5.9.4.1 Select Large Focal Spot. Select 20.0 mAs and 200 mA.  
**If 200 mA is not available**, select 10.0 mAs and 100 mA.
  - 5.9.4.2 Take the following exposures (**wait 30 seconds after each exposure**): 60kV, 60kV, 70kV, 70kV, 80kV, 80kV, 90kV, 90kV, 100kV, 100kV, 110kV, 110kV, 120kV, 120kV, 125kV and 125kV.  
Make sure to properly select mA per step 5.9.4.1 above, after selecting a new kV station.
  - 5.9.4.3 If an error occurs, use the following method to correct it:
    - Leave mAs and mA the same.
    - Repeat exposure with previous kV (lower).
    - Keep reducing kV until no more error occurs.
    - Increase kV to value when error first occurred & repeat exposure.
    - If the error persists, reduce kV again.

- 5.9.5 When finished with Tube Seasoning:  
Set switch **DIP1-5** (Sys. Controller) to **OPEN/OFF/LEFT**  
Set switch **DIP1-4** (Sys. Controller) to **CLOSED/ON/RIGHT**

## 5.10 KV CALIBRATION PROCEDURE

### Moving around:

**To P# mode:** Hold mA button, then press SM FOCAL SPOT button

**To Fil# mode:** Hold mA button, then press LG FOCAL SPOT button

**To Save:** Press SM FOCAL SPOT button

See Table 5-4 for details on setting kV, mA, and Time

Required kV test equipment:

1. kV meter (Non-Invasive, Dynalyzer, or equivalent)
2. Digital storage oscilloscope

### Notes:

1. Recalibration of the kVp is highly discouraged. The generator is calibrated at the factory to a tight tolerance. If a calibration of kVp seems necessary, there is most likely something wrong with either the kV measuring equipment or the generator.
2. When calibrating kVp, actual output readings should be taken from a kV meter. TP8 (kVp test point) on the Sys. Controller board is only to be used to view the waveform shape and may be inaccurate in amplitude and should NOT be used to calibrate kV.

**kV calibration procedure** (follow procedure exactly):

1. Set switch **DIP1-4** (Sys. Controller) to **OPEN/OFF/LEFT**  
Set switch **DIP1-5** (Sys. Controller) to **CLOSED/ON/RIGHT**
2. With power off, enter Calibration mode (hold mA button, then press ON button).
3. Scroll to P49. Set P49 to 50 and SAVE change.
4. Scroll to P50. Set P50 to 110 and SAVE change.
5. Enter Fil# mode.
6. Set time and mA to 50 ms, 50 mA
7. Take 3 exposures at 50 kVp, and average the readings from a kV meter.  
Note: The actual kVp measured may vary from 50 to 60 kVp.
8. Take 3 exposures at 110 kVp, and average the readings from a kV meter.  
Note: The actual kVp measured may vary from 110 to 120 kVp.
9. Enter P# mode.
10. Scroll to P49. Enter the average of 50 kV and SAVE change.
11. Scroll to P50. Enter the average of 110 kV and SAVE change.
12. Recycle power to enter normal RAD mode and verify the kV accuracy.
13. Set switch **DIP1-4** (Sys. Controller) to **CLOSED/ON/RIGHT**  
Set switch **DIP1-5** (Sys. Controller) to **OPEN/OFF/LEFT**

## 5.11 LEADING EDGE AUTO CAL PROCEDURE

### Moving around:

**To P# mode:** Hold mA button, then press SM FOCAL SPOT button

**To Fil# mode:** Hold mA button, then press LG FOCAL SPOT button

**To Save:** Press SM FOCAL SPOT button

### Setup Auto CAL:

1. CLOSE the Collimator shutters or COVER the opened X-ray tube's port with lead.
2. Set DIP switches on Sys. Controller (Failure to do this will result in failed Auto CAL attempt)
  - a. **300mA** Generators: Set **DIP3-1** & **DIP3-2** to **OPEN/OFF/LEFT**
  - b. **500mA** Generators: Set **DIP3-1** & **DIP3-2** to **CLOSED/ON/RIGHT**
  - c. Set **DIP1-5** to **OPEN/OFF/LEFT**
3. Shut off mA Feedback: Set switch **DIP1-4** to **OPEN/OFF/LEFT**.
4. With power off, enter Calibration mode (hold mA button, then press ON button).  
Adjust P1 to select correct X-RAY Tube. Save.
5. Adjust P16/kV LIMIT (if necessary, due to a HV limit in HV component). Save.

### Start Auto CAL:

1. Go to P44 and select "A-C" to enable Auto CAL. Save.
2. Enter Fil# mode.
3. Start X-RAY: Press & hold the EXP button. When the message "A-C" & "---" appears, release the EXP button. Auto CAL process will start after 3 seconds. Exposure beep tone is disabled during Auto CAL.

**To ABORT Auto CAL:** Press & release the EXP button during Auto CAL. An error message will display E56. Press the RESET button to exit.

4. The Auto Calibration time can take up to 5 minutes (or 15 minutes with Auto Tube Seasoning). "A-C" & "PAS" will appear when calibration is done. Press any button to exit Auto CAL mode.
5. If an error occurs during Auto Calibration (i.e. E34/IPM Overload, E38/mA Overload or Console locked up), re-run Auto Calibration for up to three more times.  
If an error occurs after the fourth Auto Calibration, perform Leading Edge Manual Calibration (See section 5.12).

### Verify Accuracy:

1. Recycle power to enter normal RAD mode.
2. Turn on mA Feedback: Set switch **DIP1-4** (Sys. Controller) to **CLOSED/ON/RIGHT**.
3. Verify the kVp and mAs accuracy for various kVp and mA stations, as needed.

## 5.12 LEADING EDGE MANUAL CALIBRATION

### Moving around:

**To P# mode:** Hold mA button, then press SM FOCAL SPOT button

**To Fil# mode:** Hold mA button, then press LG FOCAL SPOT button

**To Save:** Press SM FOCAL SPOT button

See Table 5-4 for details on setting kV, mA, and Time.

### Setup

1. READ SECTIONS 4.9 BEFORE CALIBRATION!
2. CLOSE the Collimator shutters or COVER the opened X-ray tube's port with lead.
3. Set DIP switches on Sys. Controller board:
  - a. **300mA** Generators: Set **DIP3-1** & **DIP3-2** to **OPEN/OFF/LEFT**
  - b. **500mA** Generators: Set **DIP3-1** & **DIP3-2** to **CLOSED/ON/RIGHT**
  - c. Set **DIP1-5** to **CLOSED/ON/RIGHT**
4. Shut off mA Feedback: Set **DIP1-4** to **OPEN/OFF/LEFT**.
5. With power off, enter Calibration mode (hold mA button, then press ON button). Adjust P1 to select correct X-RAY Tube. Save.
6. Adjust P16/kV LIMIT (if necessary, due to a HV limit in HV component). Save.
7. Scope: Connect CH1 (1 V/div) to **TP8** (kVp) and CH2 (1 V/div) to **TP9** (mA).  
Set Time Base to 10 ms/div. Set Trigger Type to Edge. Set Trigger Source to CH1.  
Set Trigger Slope to Rising. Set Trigger Mode to Normal. Set Trigger Coupling to DC.

### Start Leading Edge Calibration:

1. Enter Fil# mode.
2. **Leading Edge Overall Adjustment for Small Focal Spot.**
  - a. Set 50 kV, 50 mA, 30 ms and take an exposure.
  - b. If the leading edge of the mA needs adjusting: go to P# mode and adjust the **P47**, save, then go back to Fil# mode, retake exposure.
  - c. Repeat step 2.b. until 50 mA is properly set.
3. **Leading Edge Overall Adjustment for Large Focal Spot.**
  - a. Set 50 kV, 300 mA, 30 ms and take an exposure.
  - b. If the leading edge of the mA needs adjusting: go to P# mode and adjust the **P48**, save, then go back to Fil# mode, retake exposure.
  - c. Repeat step 3.b. until 300 mA is properly set.
4. **Leading Edge Fine Tuning for all mA and kV points (optional)**
  - a. This can be done for the following kV stations: **40, 50, 70, 90, 110, 125**.  
For each kV station, you may need to adjust every mA station available.  
Possible mA stations (not all mA stations will be present):  
**25S, 50S, 75S, 100S, 100L, 150L, 200L, 250L, 300L, 350L, 400L, 450L, 500L**
  - b. Go to Fil# mode.
  - c. Set kV and mA (example 40 kV, 50 mA) and take an exposure.
  - d. If the leading edge of the mA needs adjusting: adjust filament number, save, retake exposure.
  - e. Repeat step 4.d. until the leading edge is properly set.
5. Leave **DIP1-5** (Sys. Controller) in **CLOSED/ON/RIGHT** position.
6. Turn on mA Feedback: Set switch **DIP1-4** (Sys. Controller) to **CLOSED/ON/RIGHT**.

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## 5.13 STABILIZED mA FEEDBACK CALIBRATION

### Moving around:

**To P# mode:** Hold mA button, then press SM FOCAL SPOT button

**To Fil# mode:** Hold mA button, then press LG FOCAL SPOT button

**To Save:** Press SM FOCAL SPOT button

See Table 5-4 for details on setting kV, mA, and Time

### Setup:

1. READ SECTIONS 4.9 BEFORE CALIBRATION!
2. CLOSE the Collimator shutters or COVER the opened X-ray tube's port with lead.
3. Set DIP switches on Sys. Controller board:
  - a. **300mA** generators: **DIP3-1** & **DIP3-2** are both **OPEN/OFF/LEFT**
  - b. **500mA** generators: **DIP3-1** & **DIP3-2** are both **CLOSED/ON/RIGHT**
  - c. **DIP1-5** is set to **CLOSED/ON/RIGHT**
4. Turn on mA Feedback: Set **DIP1-4** (Sys. Controller) to **CLOSED/ON/RIGHT**
5. Remove the jumper from the banana plug on top of the HV Transformer (K904). Connect a mA meter to the banana plug (Red to Red, Black to Black). Note: if using a Fluke multi-meter to measure mA, set for DC Amp (or ADC) and record Max mA.

### Calibration:

1. With power off, enter Calibration mode (hold mA button, then press ON button).
2. Scroll to P45. Set P45 to 50 and SAVE change.
3. Scroll to P46. Set P46 to 300 and SAVE change.
4. Enter Fil# mode.
5. Set time: 250 ms
5. Take 3 exposures at 50 kV, 50 mA, and average the readings from the mA meter.
6. Take 3 exposures at 50 kV, 300 mA, and average the readings from the mA meter.
7. Enter the P# mode.
8. Scroll to P45. Set P45 to the mA meter average of 50 mA exposures and SAVE change.
9. Scroll to P46. Set P46 to the mA meter average of 300 mA exposures and SAVE change.
10. Recycle power to enter normal RAD mode and verify the mA accuracy.
11. Set **DIP1-5** (Sys. Controller) back to **OPEN/OFF/LEFT**
12. **Re-install jumper to the banana plug on top of the HV Transformer before continuing.**

**Table 5-6: For Recording Actual Filament Current Settings at This Installation**

	40 kVp	50 kVp	70 kVp	90 kVp	110 kVp	125 kVp
25 mA						
50 mA						
75 mA						
100 mA (Small)						
100 mA (Large)						
150 mA						
200 mA						
250 mA						
300 mA						
350 mA						
400 mA						
450 mA						
500 mA						

**Table 5-7: For Recording Programming Numbers Used for Calibration**

<b>Programming Station</b>	<b>Value Saved</b>	<b>Date</b>
<b>P1</b>		
<b>P45</b>		
<b>P46</b>		
<b>P47</b>		
<b>P48</b>		
<b>P49</b>		
<b>P50</b>		

#### 5.14 CALIBRATION OF AUTOMATIC EXPOSURE CONTROL

5.14.1 The option of Automatic Exposure Control for Synergy Generators has its own complete manual.

## 6 TROUBLESHOOTING

### 6.1 GENERATORS ERROR CODES

6.1.1 The HF generators have an extensive internal monitoring system. A number of error codes are displayed to alert the operator or service engineer to the status of the system. Some error codes are momentary alerts, and will automatically reset once the offending button has been released. Other error codes indicate simple or serious problems with the system. The Table 6-1 shows all error codes, what they mean, and how to correct them.

In case you have to call the Summit technical support team for help, we recommend you to have the information below ready before conducting the call, to better serve your needs:

- Generator Model No.: L300-##  
L500-##  
L550-##  
00210-###  
02968-###  
03900-###  
03901-###
- Power Module Serial No.: XXX###-####  
(located in back of generator)
- Line voltage from L1 to L2 (VAC): \_\_\_\_\_
- What mode did the error occur in? Normal RAD mode  
Configuration mode  
During Auto CAL
- What technique caused the error? kVp  
mA  
mAs
- Does the error occur during: Idle (No one touching Gen.)  
Prep cycle  
Expose cycle
- What were the error codes? Refer to Table 6-1
- Additional information about error/environment (hot/cold/dry/wet).

Table 6-1: Table of Error Codes for HF Generators

INVALID SETTINGS & SELECTIONS				
Error	AP Display	Likely Cause	How to clear the fault	Secondary Actions
E01	kVp LIMIT	Operator Selected value out of range	Release kVp button	Unit resets to valid techniques
E02	mAs LIMIT	Operator Selected value out of range	Release mAs button	Unit resets to valid techniques
E03	TUBE LIMIT	Operator Selected value out of range	Release the button	kVp and mAs are reset
E04	kW LIMIT	Operator Selected value out of range	Release the button	Unit resets to valid techniques
E05	TIME LIMIT	Operator Selected value > 5 seconds	Release the button	Unit resets to valid techniques
E06	TIME LIMIT	Operator Selected value < 0.004 second	Release the button	Unit resets to valid techniques
E07	BUTTON	Press another button to make desired change	Release the button	Unit resets to valid techniques
E08	mA LIMIT	User attempted to select mA that is out of range for the system	Release the button	Unit resets to valid techniques
E09	cm LIMIT	User attempted to select a cm value beyond AP data	Release the button	Unit resets to valid techniques
E18	APR DATA LMT	Receptor configuration at odds with AP receptor selection	Press RESET and correct configuration error	
E19	DENSITY LMT	User attempted to select >75% change in density	Release the button	Unit resets to valid techniques
E40	NO WALL AEC	Receptor configuration at odds with AP receptor selection	Release the button	
E41	NO TABLE AEC	Receptor configuration at odds with AP receptor selection	Release the button	

<b>INVALID SETTINGS &amp; SELECTIONS</b>				
<b>Error</b>	<b>AP Display</b>	<b>Likely Cause</b>	<b>How to clear the fault</b>	<b>Secondary Actions</b>
E42	NO T-TOP AEC	Receptor configuration at odds with AP receptor selection	Release the button	
E52	CAL DATA LMT	Attempted data entry beyond limits	Release the button	
-	TUBE ANGLE	Tube Angle beyond limits	Bring back the tube	

<b>ERROR CODES</b>				
<b>Error</b>	<b>AP Display</b>	<b>Likely Cause</b>	<b>How to clear the fault</b>	<b>Secondary Actions</b>
E10	MICRO-P	Electrical noise, HV arcing, +5v supply, System Control PCBA	Cycle power	The filament is disabled
E11	NO COMM.	Communication cables	Cycle power & find break in serial link	
E12	+/-12V LIMIT	Power supply PCBA or DC fusing	Cycle power and find defective components	
E13	EEP R/W	The calibration data (checked during operation) is corrupted	Cycle power. Call for service. See "troubleshooting guide" below.	
E14	EEP CHECKSUM	Calibration data (checked at power up) is corrupted	Press any button. See "troubleshooting guide" below.	
E15	PREP PRESSED	Prep signal active stuck ON at power up	Find the damaged component	
E16	EXP PRESSED	Expose signal active stuck ON at power up	Find the damaged component	
E17	SYS COOL DOWN	Wait 10 times exposure length before next exp	Press any button	Unit counts down until exposure is allowed
E20	DOOR INTLK	Open connection or opto chip on System Control PCBA	Verify TB3-5 is at ground. Press any button.	
E21	TUBE INTLK	Open connection or opto chip on System Control PCBA	Verify TB3-4 is at ground. Press any button.	Open connection or opto chip on System Control PCBA

<b>ERROR CODES</b>				
<b>Error</b>	<b>AP Display</b>	<b>Likely Cause</b>	<b>How to clear the fault</b>	<b>Secondary Actions</b>
E22	COLMTR INTLK	Open connection or opto chip on System Control PCBA	Verify TB3-6 is at ground. Press any button.	
E23	GENRL INTLK	Open connection or opto chip on System Control PCBA	Verify TB3-7 is at ground. Press any button.	
E24	FAIL KV FB	Anode/Cathode kV feedback missing or wrong polarity	Cycle power & fix kV feedback circuit	See Troubleshooting
E25	DC BUS LOW	Checked at prep; not enough capacitor bank voltage.	Cycle power and find damaged component	Confirm K1, BR1, R1, K660 Relay PCBA and K445 Charge Monitor PCBA are OK
E26	STILL ANODE	No rotor current during prep	Press any button	Check rotor supply voltage, stator
E27	ANODE ROT.	Rotor current sensed when not in prep	Cycle power and find defective components	Confirm rotor voltage and SSR1 is not shorted
E28	PREP HELD	Prep switch or operator	Release prep button	20 sec is max prep time
E29	NO BUCKY MOT	No B1/B2 closure	Confirm closure and opto chip on Cntrl. PCBA, press any key.	Confirm image receptor configuration
E30	mA PRESENT	Check System Control PCBA at H9 pins 5 and 6	Cycle power and find defective components	
E31	kVp PRESENT	Check System Control PCBA at H9 pins 1 and 3	Cycle power and find defective components	
E32	LOW FIL AMPS	Open secondary, Filament PCBA, or poor mA leading edge calibration	Cycle power	Check mA output with/without feedback
E33	HI FIL AMPS	Filament PCBA, or poor mA leading edge calibration	Cycle power	Check Filament PCBA, and mA output with and without feedback
E34	IPM OVERLOAD	Excessive current through inverter	Cycle power and find defective components	See Trouble-shooting Guide

<b>ERROR CODES</b>				
<b>Error</b>	<b>AP Display</b>	<b>Likely Cause</b>	<b>How to clear the fault</b>	<b>Secondary Actions</b>
E35	EXP. RELEASE	Prep/exp switch or operator error	Press any key	
E36	LOW AEC RAMP	Ion chamber signal too low	Press RESET button	Increase Back up mAs or kVp
E37	kVp OVERLOAD	Secondary arcing, kVp > 135	Press any button	Inspect secondary and calibration
E38	mA OVERLOAD	Secondary arcing, calibration, mA is > 380 (for 300mA HF Gen.) or >570 (for 500mA HF Gen.)	Cycle power	Inspect secondary and calibration
E39	BACKUP MAS	Back up mAs too low	Press RESET button	Increase Back up mAs
E44	KVP TOO LOW	Fail secondary or IGBTs	Press any button	
E45	NO ZCO	Missing ZCO signals	Cycle power	
E46	KEY CODE BRD	Wrong Key Code board used	Cycle power	
E47	TUBE NOT CALIBRATED	Wrong Tube (or no tube) selected	Select correct tube and run Auto CAL	
E48	KV NOT CALIBRATED	Selected kV not calibrated	Reduce kV or run Auto CAL with a higher kV limit	
E49	CONSOLE RST! PLS. RELEASE PREP/EXP SW!	Console power was recycled during prep	Release Prep/Exp switch	
E50	CPU ERROR! WAIT FOR RST FROM CPU	Digital workstation error	Restart digital workstation	
E51	NO MEM CARD	User error in database transfer operation	Release button, cycle power and insert card when power is OFF	See Memory Card Functions
E53	APR CHECKSUM	A change in AP data since last power up	Press any button. Re-burn AP defaults from the memory function screen or load AP data from a Memory Card.	
E54	INVALID GEN MOD. NO.	EEPROM data corrupted	Acquire Software replacement kit	

ERROR CODES				
Error	AP Display	Likely Cause	How to clear the fault	Secondary Actions
E55	AUTO CAL FAILED	Generator malfunction during Auto CAL	See troubleshooting guide	Call tech support
E56	AUTO CAL ABORTED! or TUBE SEASON ABORTED!	Auto CAL or Tube Season stopped prematurely by user	Rerun Auto CAL or Tube Season	
E57	EXPOSE HELD	Expose held down for > 10 seconds after start of Auto CAL or Tube Season	Rerun Auto CAL or Tube Season	
E58	mA TOO LOW	Anode and Cathode cables reversed	Switch Anode and Cathode Cables	Call tech support
E59	FIL I SENSOR	Filament PCBA	Cycle power	Call tech support
E60	CPU ERROR! COMM. ATTACK	Digital workstation error	Restart digital workstation	Call tech support
E61	mA LOW ERROR PRE-CAL (LG)	Filament PCBA, HV feedback cable or tube	Press any button for 2PT or RESET for AP	Call tech support
E62	mA LOW ERROR PRE-CAL (SM)	Filament PCBA, HV feedback cable or tube	Press any button for 2PT or RESET for AP	Call tech support
E63	mA CAL ERROR LARGE FOCUS	Filament PCBA, HV feedback cable or tube	Press any button for 2PT or RESET for AP	Call tech support
E64	mA CAL ERROR SMALL FOCUS	Filament PCBA, HV feedback cable or tube	Press any button for 2PT or RESET for AP	Call tech support
E65	mA LOW ERROR T-SEASON CHK	Filament PCBA, HV feedback cable or tube	Press any button for 2PT or RESET for AP	Call tech support
E66	mA LOW ERROR T-SEASONING	Filament PCBA, HV feedback cable or tube	Press any button for 2PT or RESET for AP	Call tech support
E67	mA LOW ERROR SYS PWR TEST	Filament PCBA, HV feedback cable or tube	Press any button for 2PT or RESET for AP	Call tech support
E68	AC LINE VOLT NOT SELECTED	No AC Line Voltage selected	Select correct AC Line Voltage and save.	
E69	K904 VER. NOT SELECTED	No K904 Version selected	Select correct K904 Version and save.	
E70	ERR. AC LINE OR K904 VER.	AC line voltage conflicts with K904 version	Verify AC Line Voltage & K904 Version as follow: <b>K904-00:</b> N/A <b>K904-01:</b> 208 V to 277 V saved as AC line voltage <b>K904-02:</b> 380 V to 480 V saved as AC line voltage	

<b>ERROR CODES</b>				
<b>Error</b>	<b>AP Display</b>	<b>Likely Cause</b>	<b>How to clear the fault</b>	<b>Secondary Actions</b>
E71	mA FEEDBACK DISABLED	mA feedback turned off	Turn on mA feedback (Set DIP1-4 to CLOSED/ON/RIGHT)	
E72	mAs LIMIT FOR 208 VAC	Selected mA and Exp. Time over mAs Limit for 208 VAC line	Reduce mA or Exp. Time (Calibration mode only)	
E73	MAX mA LIMIT EXCEEDED	Selected mA over Max. mA Limit	Reduce mA (Calibration mode only)	
E74	mA NOT CALIBRATED	Selected mA not calibrated	Reduce mA or run Auto CAL with a higher mA Limit	

## 6.2 TROUBLESHOOTING GUIDE

When error at boot up prevents you from accessing service mode & prevents access to Restore Defaults, try again after setting DIP1-1 on for DEMO mode. Locate DIP1 on System Controller PCBA and set DIP1-1 to Closed/On/Right.

### 6.2.1 E10 – ERROR MICRO-P

Verify System Controller PCBA grounding.

### 6.2.2 E13 – ERROR EEP R/W

If at any point during normal operation the calibration data stored within the Operator's Console and within the Power Module are in disagreement this error code will display. Cycling power will usually clear the error.

### 6.2.3 E14 – ERROR EEP CHECKSUM

#### 6.2.3.1 AP Generators:

If during boot-up of the system, the **calibration data** stored within the Operator's Console and the Power Module are in disagreement, this error code will display.

- Press the **RESET** button, go to **MEMORY FUNCTIONS** screen and select **PM\_TO\_CONS**.
- Perform Leading Edge Auto Calibration (this will refresh the calibration data).

#### 6.2.3.2 2PT Generators:

If during boot-up of the system, the **calibration data** stored within the Power Module and its saved checksum are in disagreement, this error code will display.

- Turn off power to the generator to clear the error.
- Set switch DIP1-8 on the System Controller PCBA to the CLOSED/ON/RIGHT position.
- Press and hold the mA button. Turn on power to the generator to burn factory defaults.
- Set & save Tube Type in **P1**, Max. kW Limit in **P2**, AC Line Voltage in **P10** and K904-XX Version in **P14**.
- Set switch DIP1-8 on the System Controller PCBA to the OPEN/OFF/LEFT position.
- Perform Leading Edge Auto Calibration (this will refresh the calibration data).

### 6.2.4 E15 – ERROR PREP PRESSED

Prep signal active stuck ON at power up.

- Turn OFF power and remove both DB9 cables from System Controller PCBA (H14 and H15) or from Digital Interface PCBA (H5 and H6) if present.
- Turn ON generator by placing a wire across H11 pins 1 and 3.

- Note if LED1 bar 9 (close to bottom bar) of System Controller PCBA is ON or OFF.
- Turn OFF generator by placing a wire across H11 pins 2 and 3.
- Follow below:
  - If LED1 bar 9 was OFF, the issue is in the Console:
    - Faulty remote prep/exp switch (if present) or Digital Exp Trigger (if present) is connected to J5 (2PT Gen.) or H6 (AP Gen.) of Console PCBA.
    - Faulty Membrane Switch.
    - Console PCBA needs to be replaced.
  - If LED1 bar 9 was ON, the issue is in the Generator:
    - Digital Interface PCBA (if present) is not properly seated at the H14 and H15 connectors of the System Controller PCBA.
    - Faulty remote prep/exp switch (if present) or Digital Exp Trigger (if present) is connected to TB5 (if present) at terminals 1-4.
    - Digital Interface PCBA (if present) needs to be replaced.
    - System Controller PCBA needs to be replaced.

#### 6.2.5 E16 – ERROR EXP PRESSED

Expose signal active stuck ON at power up.

Same troubleshooting procedure as section 6.2.4 above.

#### 6.2.6 E24 – ERROR FAIL KV FB (or KV IMBALANCE)

Anode or cathode kVp is missing or wrong polarity. On System Controller PCBA, confirm 9.0-10.5K Ohms between H9-1 and H9-3 as well as between H9-2 and H9-3, where both of these values must be within  $\pm 0.2K$  Ohm of each other. Confirm a positive signal on R71 and negative signal on R70 of equal amplitude during the exposure. Check for induced noise on these kV feedback signals.

#### 6.2.7 E32 – ERROR LOW FIL AMPS

If problem occurs during idle on small or large focal spot:

Possible issue:

- Open filament in tube
- Damaged Filament PCBA (or any filament pcba cable)
- Open cathode cable

Verify that filament supply voltage is present at the Filament PCBA and that there is continuity in the high voltage secondary.

If problem occurs during exposure:

Possible issue:

- Leading edge mA and/or stabilized mA need to be calibrated.
- Damaged Filament PCBA (or any filament pcba cable)

If problem occurs during generator turn on:

Possible issue:

- Damaged Filament PCBA (or any filament pcba cable)
- Power module software needs to be upgraded. If problem persists then a new controller board may be needed as well.

#### 6.2.8 E33 – ERROR HI FIL AMPS

This can occur with mA feedback ON and a leading edge which is too high or too low. The mA stabilizer can overcompensate for the filament number and generate this error code. Confirm feedback circuit integrity of about 68 ohms between H9-4 and H9-5 as well as between H9-4 and H9-6 on System Controller PCBA. Also inspect the Filament PCBA for shorted components.

#### 6.2.9 E34 - IPM OVERLOAD

Possible causes (contact Tech Support if problem continues):

- Tied to **mA overload**, coming from a misadjustment of mA. In this case, first perform **Tube Seasoning** section 4.11 (for AP Gen.) or section 5.9 (for 2PT Gen.), then **Leading Edge Autocal**, and finally **verify/calibrate stabilized mA** feedback.
- **Improper power supply voltages** on IPM Driver PCBA. Check IPM driver power supply test points.
- **Secondary arcing**. Take an exposure at 125kV, 50mA, 50mAs. If this causes an error, then see section 6.3, Testing for High Voltage Breakdown.
- Incoming line voltage too low (or too much voltage drop under load) for high power exposure.
- The following high power exposures should be taken to ensure proper operation:
  - For 20kW/300mA generators (66kV, 300mA, 15mAs)
  - For 30kW/300mA generators (100kV, 300mA, 15mAs)
  - For 30kW/500mA generators (60kV, 500mA, 25mAs)
  - For 40kW/500mA generators (80kV, 500mA, 25mAs)
  - For 42kW/500mA generators (84kV, 500mA, 25mAs)
  - For 50kW/500mA generators (100kV, 500mA, 25mAs)
  - For 52kW/500mA generators (104kV, 500mA, 25mAs)

#### 6.2.10 E38 - mA OVERLOAD

Excessive mA. Can come from poorly adjusted mA stabilizer or leading edge. Secondary arc in the mA circuit is possible. Scope the mA waveform with feedback enabled and disabled to determine cause.

### 6.2.11 E55 - AUTO CAL FAILED

If prior error code was E58:  
See E58 in error code table.

If prior error code was E34 or E38:  
Perform Tube seasoning (as described in section 4.11 for AP Gen. or section 5.9 for 2PT Gen.).

If no prior error code was displayed:  
Make sure your controller software is  $\geq 4.04$   
If software is  $\geq 4.04$ , replace Filament PCBA

If no resolution is found, perform Manual Leading Edge Calibration and call Tech Support to assist in finding a resolution.

### 6.2.12 E60 – CPU ERROR! COMM. ATTACK

The DR software is sending messages faster than the generator can process them

If this error occurs, the DR software manufacturer must be notified with details as to what led to the error.

The DR software manufacturer will need to update the software for a permanent remedy. A temporary remedy is for the end user to slow down their selections.

Some examples of when this can occur:

- End user swiftly scans through previously taken images.
- End user swiftly changes generator techniques.

### 6.2.13 LOUD HUMMING NOISE AT EXPOSURE

Loud noise at exposure usually comes from two sources: wires shaking in the conduits or the sounds coming out of the generator.

The more power you pull, the louder the sound will get.

This is normal, safe, and it exists in most offices.

For sounds coming from the conduits:

- Upgrade the incoming wire size. The bigger the wire, the less the noise in the conduits, and the quieter the generator (due to less line drop).

For sounds coming from the generator:

- Make sure the generator's cover is installed properly.
- Add sound absorption materials to the room (ex. carpeting, acoustic wall/ceiling tiles).
- Move the generator as far away from the patient (wallstand and table) as possible. Place the generator closer to the disconnect or in a different room.

### 6.3 TESTING FOR HIGH VOLTAGE BREAKDOWN

The HF generators filament current feedback can be bypassed to allow for shooting the system with an open secondary (no tube or HV cables) to investigate the source of secondary arcing. This procedure should only be performed by personnel familiar with high voltage tests and/or under the guidance of Technical Support.

When DIP1-3 is in the CLOSED (ON) position (System Controller PCBA), the rotor and filament interlocks and feedbacks are disabled. In this condition, the generator will make kVp, but not mA and will not spin the anode of the tube. This allows potential to be placed on the high tension transformer.

Monitor the kVp feedback test point TP8 on the System Controller PCBA to look for evidence of high voltage breakdown, such as spikes to high potential or spikes to ground. If none are present, the cables or tube would be suspect. Also monitor the mA feedback point TP9 as there should be no mA. If present, the HV Transformer is suspected. When finished with this test, ensure that DIP1-3 is returned to the OPEN (OFF) position.

#### **PROCEDURE:**

##### OIL FILL:

1. Make sure power is off.
2. Remove the HV cables from the HV Transformer (and discharge the HV cables by letting the cable pins touch the metal 2in receptacle NUT).
3. Fill both the Anode and Cathode HV Transformer receptacles with ~2in (5cm) of HV (Diala) Oil.

##### DIP SWITCH SETTINGS:

1. Set DIP1-2 to Open/Off/Left
2. Set DIP1-3 to Closed/On/Right
3. Set DIP1-5 to Closed/On/Right

##### EXPOSURE:

1. Set Generator to 400 mAs
2. Take the following exposures and look for signs of breakdown:  
50 kV, 60 kV, 70 kV, 80 kV, 90 kV, 100 kV, 110 kV, 125 kV (10 times in a row)

##### RETURN TO NORMAL OPERATION

1. Re-install HV cables
2. Set DIP1-2 to Open/Off/Left
3. Set DIP1-3 to Open/Off/Left
4. Set DIP1-5 to Open/Off/Left

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#### 6.4 KW LIMIT TOO LOW

On 40/42KW and 50/52KW Generator, a Key Code board (04430-\* connected to header "H15" on System Controller PCBA) is needed for the generator to operate with techniques past 30KW. If a 30KW limit has been encountered on a generator designed for higher power, then one cause can be damaged or missing Key Code board.

On 20KW Generator, a Key Code board (as decribed above) is also needed for the generator to operate with techniques past 15KW. If a 15KW limit has been encountered on a generator designed for 20KW, then one cause can be damaged or missing Key Code board.

## 7 CONFORMANCE TESTING

### 7.1 OVERVIEW

The individual radiographic components (X-ray generator and control, X-ray tube, and HV cables) are calibrated by the manufacturer to ensure each component is operating to their individual specifications. It is the **system assembler** (the technician installing the radiographic equipment) **responsibility** to ensure the individual components are operating within specifications **as a system at the site**. This will ensure the site electrical service is within specifications as well. The system must comply with State/Local requirements as well as the following:

- Accuracy FDA/DHHS CFR21: 1020.31(a)(4)
- Reproducibility FDA/DHHS CFR21: 1020.31(b)
- Linearity FDA/DHHS CFR21: 1020.31(c)

A copy of the compliance reports (in this section) need to be left at the site.

### 7.2 COMPLIANCE EQUIPMENT REQUIREMENTS

The following calibrated equipment is required to perform conformance testing: mR meter, kVp meter, and mAs meter.

### 7.3 COMPLIANCE EQUIPMENT ERROR

The accuracy of the kVp and mAs meters must be taken into account when performing the compliance testing for accuracy.

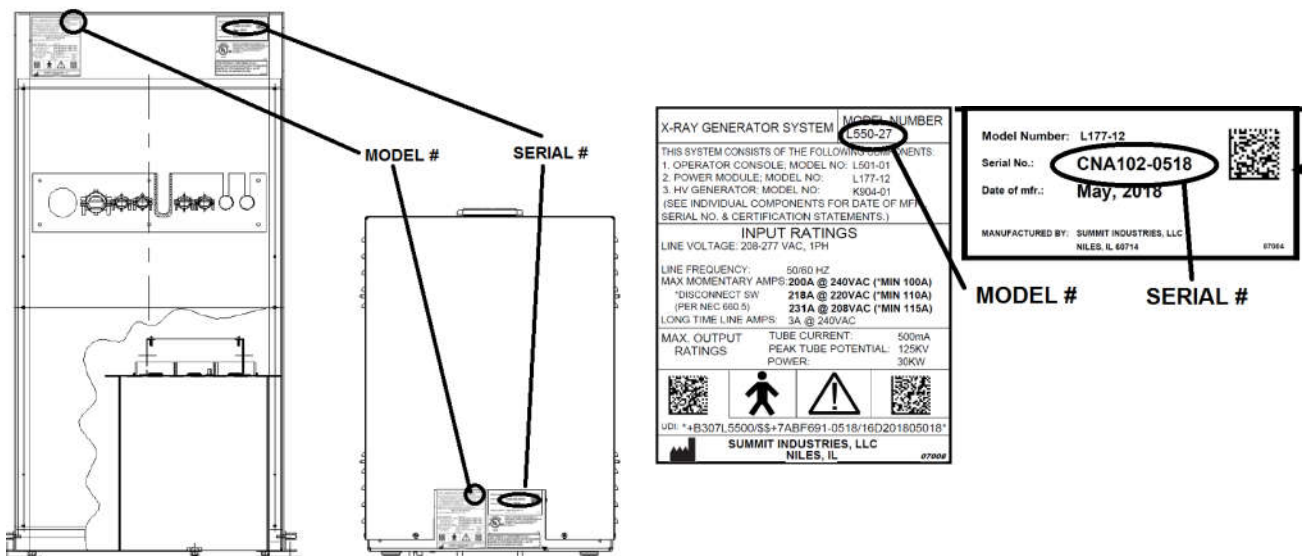
Test Criteria = Compliance Equipment Accuracy + Generator Accuracy

Ex. mAs meter accuracy: 1%, generator accuracy:  $\pm(10\%+1)$  mAs

**Test Criteria =  $\pm(10\%-1\%+1)$  mAs =  $\pm(9\%+1)$  mAs**

### 7.4 MODEL AND SERIAL NUMBER OF GENERATOR

The system assembler must note the Generator Model (**not** the Console Model) and Power Module (PM) Serial No. located on the back in the reports.



## 7.5 ACCURACY OF kVp AND mAs OUTPUTS

Ensure the generator meets the published specifications of  $\pm(5\%+1)$  kVp and  $\pm(10\%+1)$  mAs.

1. To be performed on each Focal Spot.
2. Select kVp and mAs as described in the table below.
3. Take exposures and record measured kVp and mAs for each exposure.

Table 7-1: Generator Accuracy

Selected Exposure Factors			Measured Outputs (The values below assume 1% test equipment error)		Pass
Focal Spot	kVp	mAs	kVp $\pm(4\%+1)$	mAs $\pm(9\%+1)$	
SM	50	10.0	$47.0 \leq \underline{\hspace{2cm}} \leq 53.0$	$8.1 \leq \underline{\hspace{2cm}} \leq 11.9$	<input type="checkbox"/>
SM	110	10.0	$104.6 \leq \underline{\hspace{2cm}} \leq 115.4$	$8.1 \leq \underline{\hspace{2cm}} \leq 11.9$	<input type="checkbox"/>
LG	50	26.0	$47.0 \leq \underline{\hspace{2cm}} \leq 53.0$	$22.7 \leq \underline{\hspace{2cm}} \leq 29.3$	<input type="checkbox"/>
LG	110	26.0	$104.6 \leq \underline{\hspace{2cm}} \leq 115.4$	$22.7 \leq \underline{\hspace{2cm}} \leq 29.3$	<input type="checkbox"/>
Who Perform Test (Print Name): _____			Date of Conformance Test: _____		
Test Equipment for kVp, Model: _____			Serial No.: _____		
Test Equipment for mAs, Model: _____			Serial No.: _____		
X-ray Tube Type/Mode No.: _____			Serial No.: _____		
Generator Model No.: _____			PM Serial No.: _____		

**Leave a copy of this Table with the installed Generator.**

## 7.6 REPRODUCIBILITY

Ensure the generator meets the FDA Reproducibility requirement of 0.050.

1. To be performed on each Focal Spot. (Note: mR value may be greater for Small Focal Spot compared to Large Focal Spot).
2. Select 70 kVp, 5.0 mAs.
3. Take N exposures and record each of the measured mR values ( $X_i$ ).
4. Calculate and record the average mR ( $\bar{X}$ ).
5. Calculate and record  $|X_i - \bar{X}|$  for each exposure.
6. Calculate and record  $|X_i - \bar{X}|^2$  for each exposure.
7. Calculate and record the Sum of all  $|X_i - \bar{X}|^2$  values.
8. Calculate and record Standard Deviation (S):

$$S = \sqrt{\frac{1}{N-1} \sum_{i=1}^N (X_i - \bar{X})^2}$$

9. Calculate and record Coefficient of Variation (CV):

$$CV = \frac{S}{\bar{X}}. \text{ This value must be } \leq 0.050$$

**Table 7-2: Sample Generator Reproducibility**

Exposure No. (N = 5)	$X_i$ (mR) (Step 3)	$\bar{X}$ (mR) (Step 4)	$ X_i - \bar{X} $ (Step 5)	$ X_i - \bar{X} ^2$ (Step 6)
1	22.4	22.14	0.26	0.068
2	22.1	22.14	0.04	0.002
3	22.2	22.14	0.06	0.004
4	22.1	22.14	0.04	0.002
5	21.9	22.14	0.24	0.058
$\bar{X}$ (mR <sub>average</sub> ) (Step 4)	22.14			
Sum of all $ X_i - \bar{X} ^2$ (Step 7)				0.134
Standard Deviation (Step 8): $S = \sqrt{\frac{1}{4} * 0.134} = 0.183$				
Coefficient of Variation (Step 9): $CV = \frac{S}{\bar{X}} = \frac{0.183}{22.14} = 0.008 \leq 0.050$ <b>Pass</b> <input checked="" type="checkbox"/>				

**Table 7-3: Generator Reproducibility (Small Focal Spot, 70 kVp, 5.0 mAs)**

Exposure No. (N = 10)	$X_i$ (mR) (Step 3)	$\bar{X}$ (mR) (Step 4)	$ X_i - \bar{X} $ (Step 5)	$ X_i - \bar{X} ^2$ (Step 6)
1				
2				
3				
4				
5				
6				
7				
8				
9				
10				
$\bar{X}$ (mR <sub>average</sub> ) (Step 4)				
Sum of all $ X_i - \bar{X} ^2$ (Step 7)				
Standard Deviation (Step 8): $S = \sqrt{\frac{1}{9} * (\text{Sum of all }  X_i - \bar{X} ^2)}$ =				
Coefficient of Variation (Step 9): $CV = \frac{S}{\bar{X}} =$ <span style="float: right;"><b>≤ 0.050</b> Pass <input type="checkbox"/></span>				
Who Perform Test (Print Name): _____ Date of Conformance Test: _____				
Test Equipment for mR, Model: _____ Serial No.: _____				
X-ray Tube Type/Mode No.: _____ Serial No.: _____				
Generator Model No.: _____ PM Serial No.: _____				

**Leave a copy of this Table with the installed Generator.**

**Table 7-4: Generator Reproducibility (Large Focal Spot, 70 kVp, 5.0 mAs)**

Exposure No. (N = 10)	$X_i$ (mR) (Step 3)	$\bar{X}$ (mR) (Step 4)	$ X_i - \bar{X} $ (Step 5)	$ X_i - \bar{X} ^2$ (Step 6)
1				
2				
3				
4				
5				
6				
7				
8				
9				
10				
$\bar{X}$ (mR <sub>average</sub> ) (Step 4)				
Sum of all $ X_i - \bar{X} ^2$ (Step 7)				
Standard Deviation (Step 8): $S = \sqrt{\frac{1}{9} * (\text{Sum of all }  X_i - \bar{X} ^2)}$ =				
Coefficient of Variation (Step 9): $CV = \frac{S}{\bar{X}} =$ <span style="float: right;"><b>≤ 0.050</b> Pass <input type="checkbox"/></span>				
Who Perform Test (Print Name): _____ Date of Conformance Test: _____				
Test Equipment for mR, Model: _____ Serial No.: _____				
X-ray Tube Type/Mode No.: _____ Serial No.: _____				
Generator Model No.: _____ PM Serial No.: _____				

**Leave a copy of this Table with the installed Generator.**

## 7.7 LINEARITY

Ensure the generator meets the FDA Linearity requirement of 0.100.

1. To be performed on each Focal Spot.
2. Select 70 kVp and 5.0 mAs.
3. Take N exposures and record mR values for Series One.
4. Select 70 kVp and the next adjacent mAs station (5.3 or 6.0 mAs).
5. Take N exposures and record mR values and **selected** mAs for Series Two.
6. Calculate and record  $\frac{mR}{mAs}$  for each exposure in Series One.
7. Calculate and record  $\frac{mR}{mAs}$  for each exposure in Series Two.
8. Calculate and record the average  $\frac{mR}{mAs}$  ( $\bar{X}_1$ ) for Series One.
9. Calculate and record the average  $\frac{mR}{mAs}$  ( $\bar{X}_2$ ) for Series Two.
10. Calculate and record Linearity (L):

$$L = \frac{|\bar{X}_1 - \bar{X}_2|}{(\bar{X}_1 + \bar{X}_2)} \leq 0.100$$

**Table 7-5: Sample Generator Linearity**

Exposure No. (N = 5)	Series One			Series Two (Next adjacent mAs station)		
	mR (Step 3)	mAs	$\frac{mR}{mAs}$ (Step 6)	mR (Step 5)	mAs 5.3 or 6.0 (Step 5)	$\frac{mR}{mAs}$ (Step 7)
1	22.4	5.0	4.48	27.1	6.0	4.52
2	22.1	5.0	4.42	27.0	6.0	4.50
3	22.2	5.0	4.44	26.9	6.0	4.48
4	22.1	5.0	4.42	26.7	6.0	4.45
5	21.9	5.0	4.38	26.7	6.0	4.45
$\bar{X}_1$ ( $\frac{mR}{mAs}$ Average) (Step 8)			4.43			
$\bar{X}_2$ ( $\frac{mR}{mAs}$ Average) (Step 9)						4.48
Linearity (Step 10): $L = \frac{ \bar{X}_1 - \bar{X}_2 }{(\bar{X}_1 + \bar{X}_2)} = \frac{ 4.43 - 4.48 }{(4.43 + 4.48)} = 0.006 \leq 0.100$ <b>Pass</b> <input checked="" type="checkbox"/>						

**Table 7-6: Generator Linearity (Small Focal Spot, 70 kVp, 5.0 mAs & 5.3/6.0 mAs)**

Exposure No. (N = 10)	Series One			Series Two (Next adjacent mAs station)		
	mR (Step 3)	mAs	$\frac{mR}{mAs}$ (Step 6)	mR (Step 5)	mAs 5.3 or 6.0 (Step 5)	$\frac{mR}{mAs}$ (Step 7)
1		5.0				
2		5.0				
3		5.0				
4		5.0				
5		5.0				
6		5.0				
7		5.0				
8		5.0				
9		5.0				
10		5.0				
$\bar{X}_1$ ( $\frac{mR}{mAs}$ Average) (Step 8)						
$\bar{X}_2$ ( $\frac{mR}{mAs}$ Average) (Step 9)						
Linearity (Step 10): $L = \frac{ \bar{X}_1 - \bar{X}_2 }{(\bar{X}_1 + \bar{X}_2)} =$				<b>≤ 0.100</b>		<b>Pass</b> <input type="checkbox"/>
Who Perform Test (Print Name): _____ Date of Conformance Test: _____						
Test Equipment for mR, Model: _____ Serial No.: _____						
X-ray Tube Type/Mode No.: _____ Serial No.: _____						
Generator Model No.: _____ PM Serial No.: _____						

**Leave a copy of this Table with the installed Generator.**

**Table 7-7: Generator Linearity (Large Focal Spot, 70 kVp, 5.0 mAs & 5.3/6.0 mAs)**

Exposure No. (N = 10)	Series One			Series Two (Next adjacent mAs station)		
	mR (Step 3)	mAs	$\frac{mR}{mAs}$ (Step 6)	mR (Step 5)	mAs 5.3 or 6.0 (Step 5)	$\frac{mR}{mAs}$ (Step 7)
1		5.0				
2		5.0				
3		5.0				
4		5.0				
5		5.0				
6		5.0				
7		5.0				
8		5.0				
9		5.0				
10		5.0				
$\bar{X}_1$ ( $\frac{mR}{mAs}$ Average) (Step 8)						
$\bar{X}_2$ ( $\frac{mR}{mAs}$ Average) (Step 9)						
Linearity (Step 10): $L = \frac{ \bar{X}_1 - \bar{X}_2 }{(\bar{X}_1 + \bar{X}_2)} =$				<b>≤ 0.100</b>		<b>Pass</b> <input type="checkbox"/>
Who Perform Test (Print Name): _____ Date of Conformance Test: _____						
Test Equipment for mR, Model: _____ Serial No.: _____						
X-ray Tube Type/Mode No.: _____ Serial No.: _____						
Generator Model No.: _____ PM Serial No.: _____						

**Leave a copy of this Table with the installed Generator.**

## 8 REQUIRED MAINTENANCE

### 8.1 OVERVIEW

Routine maintenance is to be performed 30 to 60 days after the initial installation and every six months thereafter. It is the responsibility of the equipment owner to see that this maintenance is performed as scheduled to meet warranty obligations. The installing dealer or other factory authorized service organization will be able to perform this maintenance. The following list is a minimum checklist. Your maintenance procedure may be more extensive than that shown below.

### 8.2 ROUTINE MAINTENANCE CHECKS

#### Console:

- Inspect communication cables for wear, binding, and tight coupling.
- Operate all of the switches on the console and verify that they function properly. Some switches (such as AEC controls) may not be enabled.
- Note that all text and numbers on the console screen illuminate properly.

#### Power Module:

- Inspect internal connections for wear, binding, and tight coupling.
- Measure line voltage and verify that TB1/TB2 are set properly.
- Inspect the HF tuning capacitor (C7), located right below the Relay PCBA, for any form of deformation. A normal capacitor must have a flat top and parallel posts. If the capacitor is suspect, then it should be replaced immediately to prevent damage to other components within the generator.
- Examine the oil level of the high voltage transformer and verify that it is about  $\frac{3}{4}$  in from the top of the lid.

#### System:

- Inspect all system cables for wear, binding, and tight coupling.
- Inspect High Voltage cables for signs of breakdown (carbon tracking), abrasion, or wear. Regrease and retighten into the HV transformer and x-ray tube.

#### X-Ray:

- Perform tube seasoning/calibration.
- Verify kVp and mAs outputs are within accuracy limits.
- Verify kVp and mA waveforms are of the proper amplitude and shape.
- Annually perform complete system conformance testing per section 7 of install and service manual.



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## 9 THEORY OF OPERATION

### 9.1 POWER MODULE

The Power Module contains microprocessor-driven control circuitry to spin the anode of the x-ray tube, generate filament supply voltages, supply power for locks and collimation, maintain monitoring of system status, and retain calibration information. Primary voltage for the high voltage transformer is supplied by IPMs operating in a pulse width modulated resonant circuit.

### 9.2 OPERATOR'S CONSOLE

The Operator's Console is a microprocessor controlled entry/display port connected with the System Controller PCBA through serial communications.

For AP systems, the AP techniques and calibration data is stored in the Console and compared to the data in the Power Module to confirm data accuracy. It is possible to upload site-specific calibration data from the Power Module in the event of changing to a new Console. The factory default values for calibration and AP techniques can be re-burned into the Console. AP techniques can be uploaded to a Memory Card or downloaded from a Memory Card into the Console if desired. The Operator/User can manipulate the AP techniques, changing and storing as required to achieve the character of images desired.

### 9.3 HIGH VOLTAGE TRANSFORMER

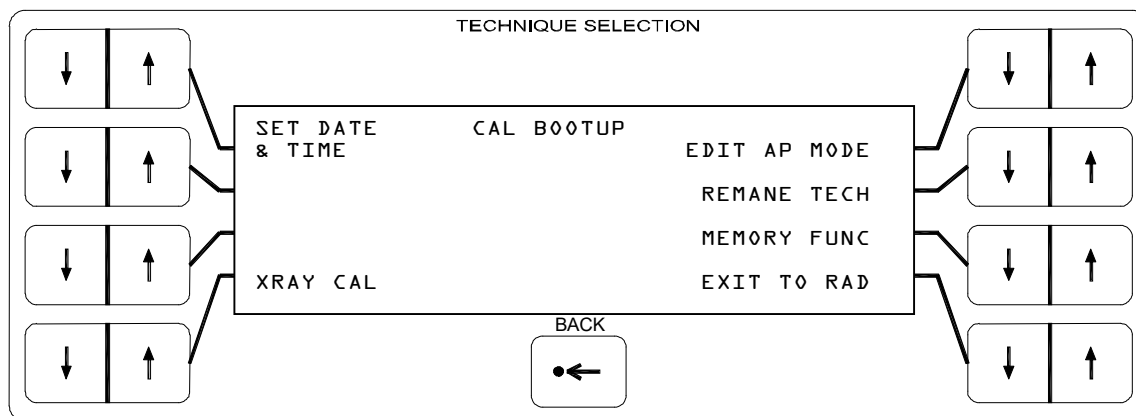
The High Voltage Transformer steps up the voltage received at P1 and P2 to levels required to make the x-ray tube conduct, ranging from 40 to 125 thousand volts. Filter capacitors within the transformer are part of the tuned resonant circuit. The assembly is filled with Shell Diala AX, a highly refined non-PCB dielectric oil.

## 10 MEMORY FUNCTIONS (HF AP GENERATORS)

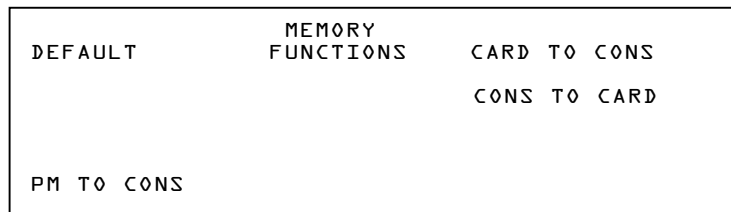
The HF AP generators have a feature which allows saving the modified anatomical techniques to a remote Memory Card. It is also possible to transfer this information from one generator to another. The Memory Card is capable of storing the modified anatomical techniques for up to eight different generators. Contact the manufacturer for information about purchasing this Memory Card.

### 10.1 THE MEMORY FUNCTION SCREEN.

Turn the Operator's Console ON while holding down the BACK button. The Console will display as shown below.



Select MEMORY FUNC. The Console will display as shown below.



- **DEFAULT:** To reload factory defaults into both Power Module and Operator's Console for AP techniques or calibration.
- **CARD TO CONS:** To download modified AP techniques from the Memory Card into the Console.
- **CONS TO CARD:** To upload AP techniques from Console to the Memory Card.
- **PM TO CONS:** To reload the factory default values from the Power Module into the Console. This should be done if the Console is replaced.

## 10.2 THE DEFAULT SCREEN

The DEFAULT screen will display as shown below.

```

                                LOAD DEFAULT
DFLT AP&CAL
DFLT ALL AP
DFLT AP REG
DFLT CAL DAT

```

DFLT AP&CAL allows reloading the factory defaults for both calibration and AP data into the Power Module and Operator's Console. Because calibration data is involved, this screen is password protected using the XRAY CAL password. The Console will then ask for confirmation with a NO or YES answer before replacing the data.

DFLT ALL AP allows the user or service personnel to replace all of the existing AP techniques with the factory default values. No password is required, just a NO or YES response.

DFLT AP REG allows the user or service personnel to replace the existing AP techniques with the factory default values one anatomical region at a time. Choose a region and respond NO or YES.

DFLT CAL DAT allows the service personnel to reload the factory default calibration data into the Power Module and Console. Because calibration data is involved, this screen is protected by the XRAY CAL screen password. Enter the password and choose NO or YES.

## 10.3 THE POWER MODULE TO CONSOLE SCREEN.

The PM TO CONS screen will allow the installer to reload the site-specific calibration data from the Power Module into a replacement Operator's Console. This is required so that the data stored in these two locations is in agreement. Select PM TO CONS, enter the XRAY CAL password, and choose NO or YES.

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## 10.4 MEMORY CARD FUNCTIONS

The Memory Card will store AP data for up to eight different installations. It can be stored at a specific site as a back-up for modified techniques, or carried by the applications/service personnel to storage or downloading for multiple sites.

### 10.4.1 The CARD TO CONS Screen

The CARD TO CONSOLE screen allows AP data from one of eight storage locations on the Memory Card to be downloaded into the Operator's Console. This can be useful if this site is using the same film/screen combination as a previous installation which has modified AP techniques, or if the x-ray service company has an established technique database they like to offer. A confirmation screen will ask if you wish to copy all AP techniques from the selected memory card with a NO or YES response. After the data transfer is complete, cycle power.

NOTE: If EEPROM CHECKSUM ERROR is displayed, return to the MEMORY FUNCTIONS screen and select PM TO CONS. This will re-copy the existing calibration data from the power module into the Operator's Console and clear the error.

### 10.4.2 The CONS TO CARD Screen

The CONSOLE TO CARD screen allows uploading AP technique database information from an Operator's Console into the Memory Card. This can be useful for on-site back-up storage of a modified AP database, or for carrying a modified database to be downloaded at another site. A confirmation screen will ask if you wish to copy all AP techniques from the Operator's Console to the memory card with a NO or YES response. The modified techniques will remain in the Operator's Console, but now there will be a back-up copy in the Memory Card.

## 11 ADDITIONAL INFORMATION

### 11.1 CIRCUIT BOARD IDENTIFICATION

**Table 11-1: Operator's Console Circuit Board Identification**

Part #	Description
L440	2PT Compact Console
L510	AP Compact Console
L670	2PT Door Mounted Console

**Table 11-2: Power Module Circuit Board Identification**

Part #	Description
08020	System Controller Board
01780-000	IPM Driver Board (2 each)
02850	Filament Driver Board
K444	Rotor Sense Board
K660	Relay Board
K445	Charge Monitor Board
01710-000	ON/OFF Board
K650	Power Supply Board
L070	AEC Board (Optional for AEC Ready Generators only)

### 11.2 ACCESSORY KITS

- Fuse Kit - Part number 04160

## 11.3 FUSE VALUES

Table 11-3: Fuse Values

Fuse ID	Function	Description
F1	Mains (single phase)	60 Amp, 250 V, Dual Element, Time Delay, Class RK5
F2	Mains (single phase)	60 Amp, 250 V, Dual Element, Time Delay, Class RK5
F $\Phi$ 1	Mains (3-phase)	60 Amp, 250 V, Dual Element, Time Delay, Class RK5 (for 208 to 250 VAC) OR 30 Amp, 600 V, Dual Element, Time Delay, Class RK5 (for 380 to 480 VAC)
F $\Phi$ 2	Mains (3-phase)	60 Amp, 250 V, Dual Element, Time Delay, Class RK5 (for 208 to 250 VAC) OR 30 Amp, 600 V, Dual Element, Time Delay, Class RK5 (for 380 to 480 VAC)
F $\Phi$ 3	Mains (3-phase)	60 Amp, 250 V, Dual Element, Time Delay, Class RK5 (for 208 to 250 VAC) OR 30 Amp, 600 V, Dual Element, Time Delay, Class RK5 (for 380 to 480 VAC)
F3	N/A	0.5 Amp, 250 VAC, Fast Acting
F4	+5/+12 VDC	0.5 Amp, 250 VAC, Slow Acting
F5	-12 VDC	0.5 Amp, 250 VAC, Slow Acting
F6	240 VAC return	10 Amp, 250 VAC, Slow Acting
F7	240 VAC hot	10 Amp, 250 VAC, Slow Acting
F8	Collimator supply (24 VAC)	7 Amp, 250 VAC, Slow Acting
F9	Electric lock supply (24 VDC)	5 Amp, 250 VAC, Slow Acting
F10	Relay PCBA supply (24 VDC)	1 Amp, 250 VAC, Slow Acting
F11	Console supply (20 VAC)	0.8 Amp, 250 VAC, Slow Acting
F12	Bucky supply (120 VAC)	1.5 Amp, 250 VAC, Slow Acting
F13	Tube Rotor supply (240 VAC)	8 Amp, 250 VAC, Slow Acting

<b>Fuse ID</b>	<b>Function</b>	<b>Description</b>
F14	Tube Rotor common (VAC)	8 Amp, 250 VAC, Slow Acting
F15	Switched AC power (240 VAC)	3 Amp, 250 VAC, Slow Acting
F16	Switched AC power (240 VAC)	3 Amp, 250 VAC, Slow Acting
F17	480 VAC hot	4 Amp, 500 VAC, Slow Acting
F18	480 VAC return	4 Amp, 500 VAC, Slow Acting