Spellman®
High Voltage Electronics Corporation

Instruction Manual

X-RAY INSPECTION GENERATOR
XRV SERIES

High Voltage Power Supply

MODEL :
SERIAL# :
DATE :

SPELLMAN
HIGH VOLTAGE ELECTRONICS CORPORATION
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- ***160KV, 225KV, 320KV AND 450KV MODELS***
- ***COMPLETE X-RAY GENERATOR PACKAGE***
- ***POWER FACTOR CORRECTED AC INPUT CIRCUITRY***
- ***INTEGRATED DUAL FILAMENT SUPPLIES***
- ***DIGITAL INTERFACE—USB, ETHERNET AND RS232***
- ***EXCELLENT STABILITY AND REGULATION***

www.spellmanhv.com/manuals/XRV

Spellman's XRV series of X-Ray high voltage power supplies sets the standard for compact 3.0kW to 4.5kW, high performance X-Ray inspection generators. Spanning an output voltage range of 160kV to 450kV in negative or bipolar output polarity configurations, there's a model available for virtually every application requirement.

Active power factor correction circuitry reduces input current requirements while minimizing line related EMI. Spellman's proprietary inverter topology allows for unprecedented efficiencies and power densities. A solid encapsulated high voltage section further reduces size and weight and provides reliable, maintenance free operation.

DSP based SMT control circuitry provides your choice of USB, Ethernet and RS-232 along with analog interfacing, simplifying OEM system integration. The two DC output, current regulated filament power supplies are controlled via sophisticated emission current regulation circuitry to provide accurate and stable X-Ray tube currents. Comprehensive fault diagnostic circuitry, and Arc Sense, Arc Quench and Arc Count functionality is also incorporated into this compact, space saving X-Ray generator.

SPECIFICATIONS

Input Voltage:
180-264Vac, 47-63 Hertz, power factor corrected input to ≥ 0.98

Input Current:
< 25 amps

Output Polarity:
See "model selection" table

Output Current:
See "model selection" table

Output Voltage:
Load: ±0.05% of rated output voltage for a full load change
Line: ±0.05% of rated output voltage over specified input voltage range
Ripple:
See "model selection" table
Accuracy:
0.25%
Stability:
≤0.1% per 8 hours, after 1 hour warm up
Temperature Coefficient:
50ppm/°C

Emission Current:
Load: ±0.05% of rated output current for a change from 30% to 100% of rated output voltage
Line: ±0.05% of rated output current over specified input voltage range
Accuracy:
0.25%
Stability:
100ppm/°C

Filament:
Output:
0-6 amps at a compliance of 10Vdc, maximum
Dual Focal Spot:
Small and large, selectable via interface signal
Configuration:
DC filament drive. Closed loop emission control regulates filament setting to provide desired X-ray tube emission current

Control Interface:
Remote Interface:
Analog, USB, Ethernet and RS-232 are standard
Control Software:
A VB GUI is provided for RS-232/USB, the Ethernet interface has an embedded applet for control
(see page 4)

Operating Temperature
0°C to +50°C

Storage Temperature:
-40°C to +85°C

Humidity:
20% to 85% RH, non-condensing

Mains Input Connector:
Type 97-3102A-24-11P

Interface Connectors:
Digital—Ethernet, RS-232 and USB
Analog—25 pin connector

Output Connector:
See "model selection" table

Cooling:
Forced air

Regulatory Approvals:
Compliant to 2004/108/EC, The EMC Directive and 2006/95/EC, The Low Voltage Directive.

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128060-001 REV.E
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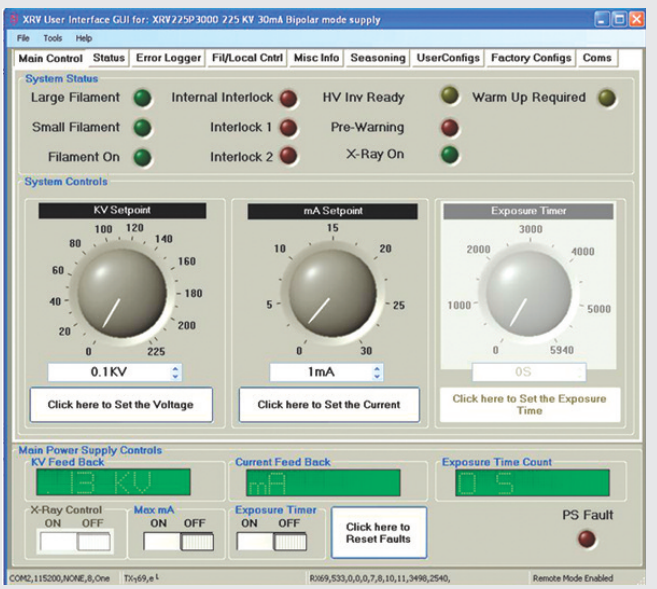
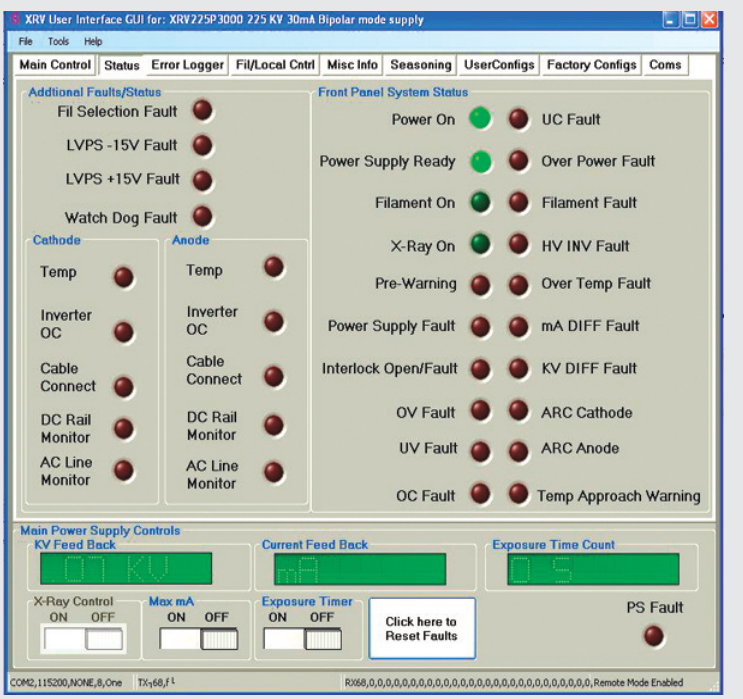
GUI CONTROL SOFTWARE FOR XRV



The GUI is specifically designed for controlling XRV series power supplies. As an alternative to the analog control, the GUI will allow the user to control all necessary functions of the HVPS from a user-friendly windows based menu. Additionally the GUI can be use as a diagnostic tool when the HVPS is controlled via the analog interface.

Features of the GUI control:

- ***Automatic warm-up X-ray tube***
- ***Max watts operation***
- ***Timed or Continuous Exposure modes***
- ***Configuration menu for user options setting of HVPS***
- ***Fault and status monitor***



XRV SPECIFICATIONS

	XRV160/3000	XRV160/4000	XRV225/3000	XRV225/4000	XRV320/4500	XRV450/4500
DC Output Voltage	0 to 160kV	0 to 160kV	0 to 225kV	0 to 225kV	0 to ±160kV	0 to ±225kV
Polarity	Neg/Pos	Neg/Pos	Neg/Pos	Neg/Pos	Bipolar	Bipolar
Output Rated Current	0-30mA	0-50mA	0-30mA	0-30mA	0-30mA	0-30mA
Output Power	3.0kW	4.0kW	3.0kW	4.0kW	4.5kW	4.5kW
Ripple/Noise (p-p)	<0.05%	<0.1%	<0.05%	<0.1%	<0.1%	<0.1%
Dimensions	10.5″H x 17″W x 24″D	10.5″H x 17″W x 24″D	16″H x 17″W x 31″D	16″H x 17″W x 31″D	2 x (10.5″H x 17″W x 24″D)	2 x (16″H x 17″W x 31″D)
Weight	150 lbs. (68kg)	150 lbs. (68kg)	240 lbs. (109kg)	240 lbs. (109kg)	300 lbs. (136 kg)	480 lbs. (218 kg)
Output Connector	R24	R24	R28	R28	Two R24	Two R28

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J1 HV CONNECTOR—R24/R28

PIN	SIGNAL	PARAMETERS
C	HV Output	XRV160 and XRV320—R24 Connector XRV225 and XRV450—R28 Connector
S	Small Filament Output	0 to 6 amps @ 10Vdc
L	Large Filament Output	0 to 6 amps @ 10Vdc

J2 ANALOG INTERFACE—25 PIN D CONNECTOR

PIN	SIGNAL	PARAMETERS
1	Power Supply Fault	Low, sum of faults, HVPS detected a fault, open collector, 50V @ 10mA max
2	mA Program	0 to 10V FS Z in = 10M ohms
3	kV Program	0 to 10V FS Z in = 10M ohms
4	Filament Limit L/S Ref.*	0 to 10V FS Z in = 10M ohms
5	Filament Preheat L/S Ref.*	0 to 10V FS Z in = 10M ohms
6	kV Monitor	0 to 10V FS Z out = 4.99k ohms
7	mA Monitor	0 to 10V FS Z out = 4.99k ohms
8	Filament Current Monitor*	0 to 10V FS Z out = 4.99k ohms
9	Signal Ground	Ground
10	X-Ray Enable	+24Vdc = X-Ray ON, connect to pin 14 with dry contact relay
11	Filament ON*	Filament ON status, low, filament is ON open collector 50V, @ 10mA max
12	Interlock 1	Active low, interlock is closed, safe to enable HV
13	Interlock 2	Active low, interlock is closed, safe to enable HV
14	+24Vdc	+24Vdc @ 100mA, maximum
15	Filament Enable*	Active low, turn filament ON
16	Filament Control*	Active low, filament is regulated by ECR (HV must be ON). Not active, the filament is regulated by the preheat reference
17	Filament L/S Select	Filament selection large or small, low = small spot is selected
18	Filament L/S Confirm	Open collector, 50V @ 10mA max Filament selection confirm, low = small spot is selected
19	HVPS RDY	Low = HVPS ready, open collector, 50V @ 10mA max
20	X-Ray ON*	X-Ray ON status, low = X-Rays are ON open collector, 50V @ 10mA max
21	Interlock Status	Low, interlocks are closed, can enable HV open collector, 50V @ 10mA max
22	GND	Digital ground
23	X-Ray ON Pre-Warn	Pre-warning, low, before X-Ray ON open collector, 50V @ 10mA max
24	Reset	Active low, minimum 10mS transition
25	Arc fault	Low, arc fault, the HVPS has detected an arc open collector, 50V @ 10mA max

*Not active on positive unipolar models

RS-232 DIGITAL INTERFACE— J3 9 PIN FEMALE D CONNECTOR

PIN	SIGNAL	PARAMETERS
1	NC	No Connection
2	TX out	Receive Data
3	RX in	Transmit Data
4	NC	No Connection
5	SGND	Ground
6	NC	No Connection
7	NC	No Connection
8	NC	No Connection
9	NC	No Connection

ETHERNET DIGITAL INTERFACE— J4 8 PIN RJ45 CONNECTOR

PIN	SIGNAL	PARAMETERS
1	TX+	Transmit Data +
2	TX-	Transmit Data -
3	RX+	Receive Data +
4	NC	No Connection
5	NC	No Connection
6	RX-	Receive Data -
7	NC	No Connection
8	NC	No Connection

USB DIGITAL INTERFACE— J5 4 PIN USB "B" CONNECTOR

PIN	SIGNAL	PARAMETERS
1	VBUS	+5 Vdc
2	D-	Data -
3	D+	Data +
4	GND	Ground

JB1 MAIN AND AUXILIARY INPUT POWER— TYPE 97-3102A-24-11P

PIN	SIGNAL	PARAMETERS
A	Auxiliary AC Line Power	180-264Vac
B	Auxiliary Ground	Ground
C	Auxiliary AC Neutral	Neutral
D	Main AC Line Power	180-264Vac
E	Main Ground	Ground
F	Main AC Neutral	Neutral

MODEL SELECTION TABLE

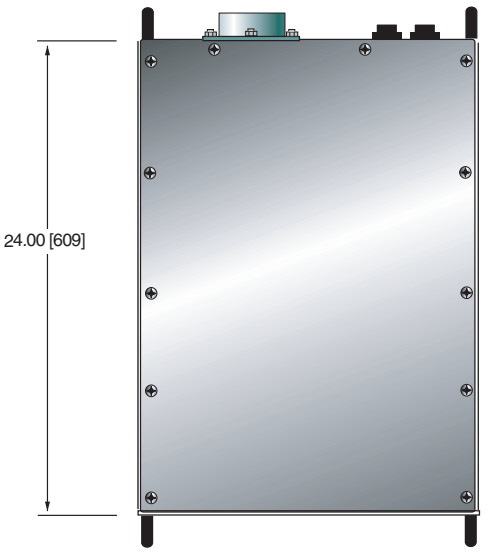
MODEL	VOLTAGE	POWER	POLARITY
XRV160N/P3000	160kV	3.0kW	N or P
XRV160N/P4000	160kV	4.0kW	N or P
XRV225N/P3000	225kV	3.0kW	N or P
XRV225N/P4000	225kV	4.0kW	N or P
XRV320N/P4500	320kV	4.5kW	Bipolar
XRV450N/P4500	450kV	4.5kW	Bipolar

*Positive models do not have integrated filament power supplies
Call Spellman for custom kV and Power models

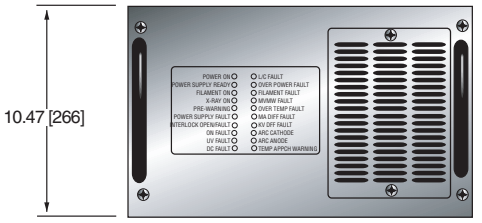
DIMENSIONS: in.[mm]

XRV160

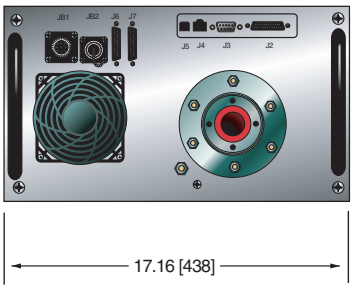
TOP VIEW



FRONT VIEW



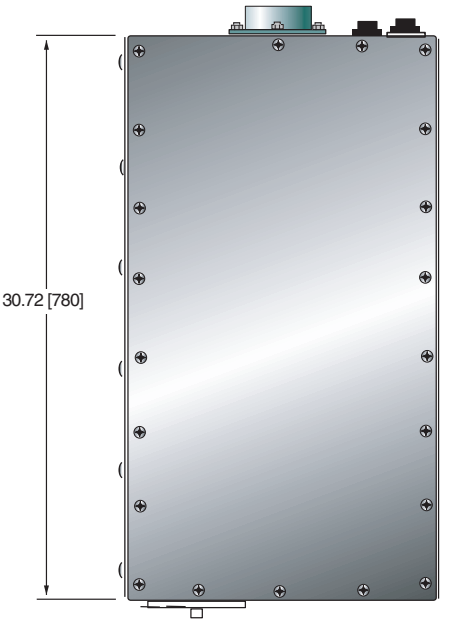
REAR VIEW



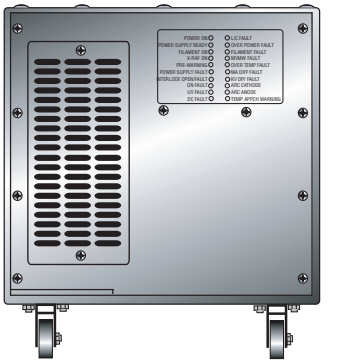
XRV320 is comprised of two XRV160 units configured in a bipolar arrangement

XRV225

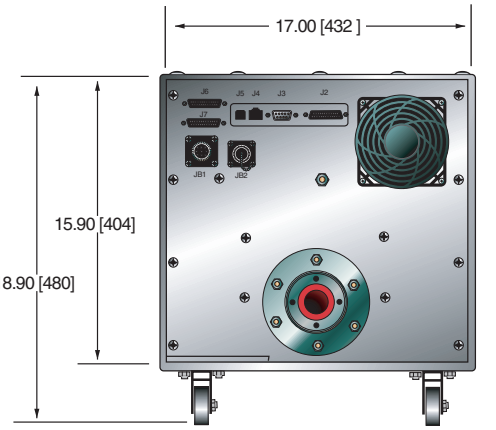
TOP VIEW



FRONT VIEW



REAR VIEW



XRV450 is comprised of two XRV225 units configured in a bipolar arrangement

CE

IMPORTANT SAFETY PRECAUTIONS

SAFETY

THIS POWER SUPPLY GENERATES VOLTAGES THAT ARE DANGEROUS AND MAY BE FATAL. OBSERVE EXTREME CAUTION WHEN WORKING WITH THIS EQUIPMENT.

High voltage power supplies must always be grounded.

Do not touch connections unless the equipment is off and the Capacitance of both the load and power supply is discharged.

Allow five minutes for discharge of internal capacitance of the power supply.

Do not ground yourself or work under wet or damp conditions.

SERVICING SAFETY

Maintenance may require removing the instrument cover with the power on.

Servicing should be done by qualified personnel aware of the electrical hazards.

WARNING note in the text call attention to hazards in operation of these units that could lead to possible injury or death.

CAUTION notes in the text indicate procedures to be followed to avoid possible damage to equipment.

WICHTIGE SICHERHEITSHINWEISE

SICHERHEIT

DIESES HOCHSPANNUNGSNETZTEIL ERZEUGT LEBENSGEFÄHRLICHE HOCHSPANNUNG.
SEIN SIE SEHR VORSICHTIG BEI DER ARBEIT MIT DIESEM GERÄT.

Das Hochspannungsnetzteil muß immer geerdet sein.

Berühren Sie die Stecker des Netzteiles nur, wenn das Gerät ausgeschaltet ist und die elektrischen Kapazitäten des Netzteiles und der angeschlossenen Last entladen sind.

Die internen Kapazitäten des Hochspannungsnetzteiles benötigen ca. 5 Minuten, um sich zu entladen.

Erden Sie sich nicht, und arbeiten Sie nicht in feuchter oder nasser Umgebung.

SERVICESICHERHEIT

Notwendige Reparaturen können es erforderlich machen, den Gehäusedeckel während des Betriebes zu entfernen.

Reparaturen dürfen nur von qualifiziertem, eingewiesenem Personal ausgeführt werden.

“WARNING” im folgenden Text weist auf gefährliche Operationen hin, die zu Verletzungen oder zum Tod führen können.

“CAUTION” im folgenden Text weist auf Prozeduren hin, die genauestens befolgt werden müssen, um eventuelle Beschädigungen des Gerätes zu vermeiden.

PRECAUTIONS IMPORTANTES POUR VOTRE SECURITE

CONSIGNES DE SÉCURITÉ

CETTE ALIMENTATION GÉNÈRE DES TENSIONS QUI SONT DANGEUREUSES ET PEUVENT ÊTRE FATALES.
SOYEZ EXTRÊMENT VIGILANTS LORSQUE VOUS UTILISEZ CET ÉQUIPEMENT.

Les alimentations haute tension doivent toujours être mises à la masse.

Ne touchez pas les connectiques sans que l'équipement soit éteint et que la capacité à la fois de la charge et de l'alimentation soient déchargées.

Prévoyez 5 minutes pour la décharge de la capacité interne de l'alimentation.

Ne vous mettez pas à la masse, ou ne travaillez pas sous conditions mouillées ou humides.

CONSIGNES DE SÉCURITÉ EN CAS DE REPARATION

La maintenance peut nécessiter l'enlèvement du couvercle lorsque l'alimentation est encore allumée.

Les réparations doivent être effectuées par une personne qualifiée et connaissant les risques électriques.

Dans le manuel, les notes marquées « **WARNING** » attire l'attention sur les risques lors de la manipulation de ces équipements, qui peuvent entrainer de possibles blessures voire la mort.

Dans le manuel, les notes marquées « **CAUTION** » indiquent les procédures qui doivent être suivies afin d'éviter d'éventuels dommages sur l'équipement.

IMPORTANTI PRECAUZIONI DI SICUREZZA

SICUREZZA

QUESTO ALIMENTATORE GENERA TENSIONI CHE SONO PERICOLOSE E POTREBBERO ESSERE MORTALI.
PONI ESTREMA CAUTELA QUANDO OPERI CON QUESO APPARECCHIO.

Gli alimentatori ad alta tensione devono sempre essere collegati ad un impianto di terra.

Non toccare le connessioni a meno che l'apparecchio sia stato spento e la capacità interna del carico e dell'alimentatore stesso siano scariche.

Attendere cinque minuti per permettere la scarica della capacità interna dell'alimentatore ad alta tensione.

Non mettere a terra il proprio corpo oppure operare in ambienti bagnati o saturi d'umidità.

SICUREZZA NELLA MANUTENZIONE.

Manutenzione potrebbe essere richiesta, rimuovendo la copertura con apparecchio acceso.

La manutenzione deve essere svolta da personale qualificato, coscio dei rischi elettrici.

Attenzione alle **AVVERTENZE** contenute nel manuale, che richiamano all'attenzione ai rischi quando si opera con tali unità e che potrebbero causare possibili ferite o morte.

Le note di **CAUTELA** contenute nel manuale, indicano le procedure da seguire per evitare possibili danni all'apparecchio.

Table of Contents

1. INTRODUCTION

1.1. Device Classification

The device described herein is a Security Radiological Power Supply. Using Annex H of the "Safety Requirements for Electrical Equipment for Measurement, Control and Laboratory Use", EN61010-1, we have concluded that the model XRV SERIES is classified as a Class I device. Based on our analysis, the device makes no protection against the ingress of water. This device is designed for continuous operation. The device is required to be connected to protective earth ground.

1.2. Intended Use

The XRV SERIES is a negative output 3kW or bipolar output 4.5KW high voltage switching power supply which incorporates the latest in high frequency, high power switching technology used to drive an x-ray tube, as well as to serve as a source of a reliable high voltage for other type of loads. The Power Supply operates from 180-264 Vac 50/60Hz power line. The Power Supply is air-cooled with 4.7 " fan located on the Rear Panel. Air is pulled in through filtered slots in front of the unit and exits in the rear of the HVPS Enclosure. The Power Supply is designed to meet the FDA safety requirements Title 21, part 1020, section 20 (21 CFR 1020.40 Cabinet X-ray Systems) as used in the NDT application.

1.3. Interferences Between Equipment

The device was designed and manufactured to minimize electromagnetic or other interferences. Tests have been performed to evaluate potential risks that could originate from the device itself or the surrounding environment. All test results were acceptable, and there has been no evidence of interference in its intended application.

1.4. Device Description

The Unit provides a high voltage potential for the cathode X-ray tube with two separate filament supplies. There are two basic power supply sections for this purpose:

- (Single-ended version) negative or positive high voltage output, continuously programmable from 0 to Maximum kV DC and with a maximum operating rated specified current.
- (Bipolar version) positive and negative high voltage outputs, continuously programmable from 0 to Maximum kV DC and with a maximum operating rated specified current.

- Dual DC X-ray tube filament supply, floating at the high voltage potential, programmable from 0 to Maximum ADC. User selectable filament supply has two separate outputs, one for the small filament and another large filament.

Both outputs connect to the x-ray tube through a single modified three-pin HV receptacle (J1). The outputs are designed to drive through a shielded HV cable (cable supplied by customer).

The Power Supply is computer controlled via RS232, USB, Ethernet or an Analog User I/O available through a 25 pin DB connector. External Interlock and Warning are accomplished via the rear panel connector J2.

2. WARNINGS & SAFETY INFORMATION

This power supply produces extremely high voltages. DO NOT attempt to adjust any load connection with high voltage on. DO NOT attempt to open the power supply enclosure unless you have studied the manual and know the internal layout. Of course, you should never reach into the enclosures unless the power has been disconnected and you are sure that the output is fully discharged. Be sure of your ground connections.

Assume that high voltage is always ON is the best way to avoid hazard to personnel. Always shut off the supply circuit breaker(s) and follow an appropriate grounding procedure to discharge the output before touching any exposed connections.

DO NOT rely on the unit's instrumentation or controls to determine that the output is safely discharged. The sensors are driven by amplifiers, which are powered by an internal low voltage power supply, as are the indicator LEDs. There may be dangerous voltages present on the output, even if the unit appears "dead".

If not manually discharged, the output may remain charged long after power is disconnected!

Be sure that you have a complete understanding of at least all of the information in this manual before attempting installation. DO NOT allow anyone else to perform any part of the installation process or attempt servicing of the power supply unless they have also read the manual. If there are any unanswered questions, please do not hesitate to contact the manufacturer for further information.

DO NOT obstruct the cooling inlets or outlets; overheating may result, which may damage the power supply.

2.1. SAFETY SYMBOLS

The following safety-related symbols are found on the unit:

Caution: consult operation manual

High-voltage connection dangerous Voltage >1000V

Ground connection

3. UNPACKING

Remove the unit from its shipping container, but do not discard the packing materials; retain the packing materials and carton in case the unit needs to be returned. Inspect the unit for dents or other damage, which may have occurred during shipping. In the unusual event that shipment damage has occurred, contact the transportation company and the manufacturer immediately.

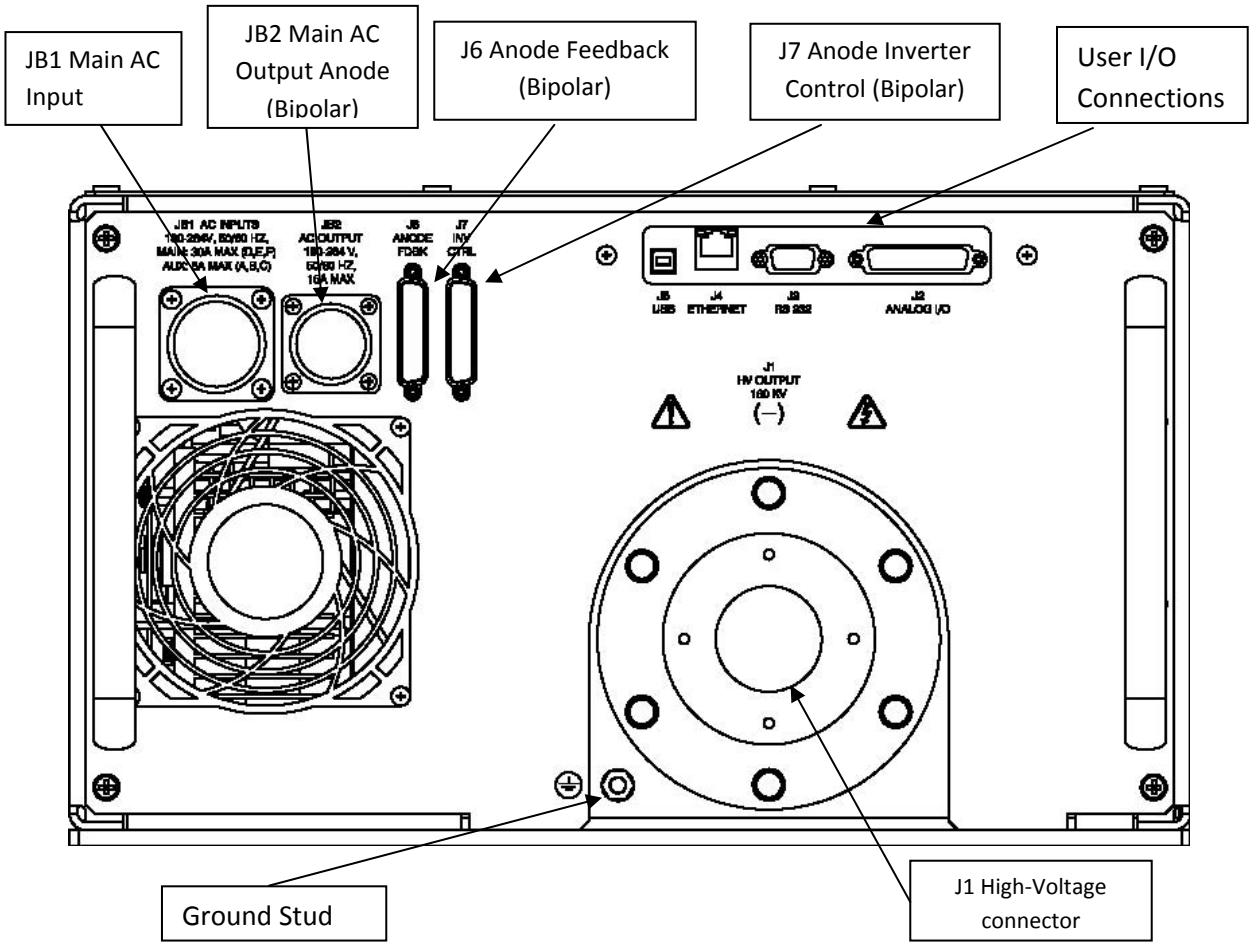
If additional materials have been enclosed in the shipping crate (such as cables etc.), inspect them as well. Then put them aside and DO NOT proceed until the operation manual has been completely read and understood.

4. INSTALLATION

Install the Power Supply in its designated place. Make sure that AC power is off to Power Supply. Turning power to the unit is the last step of the procedure.

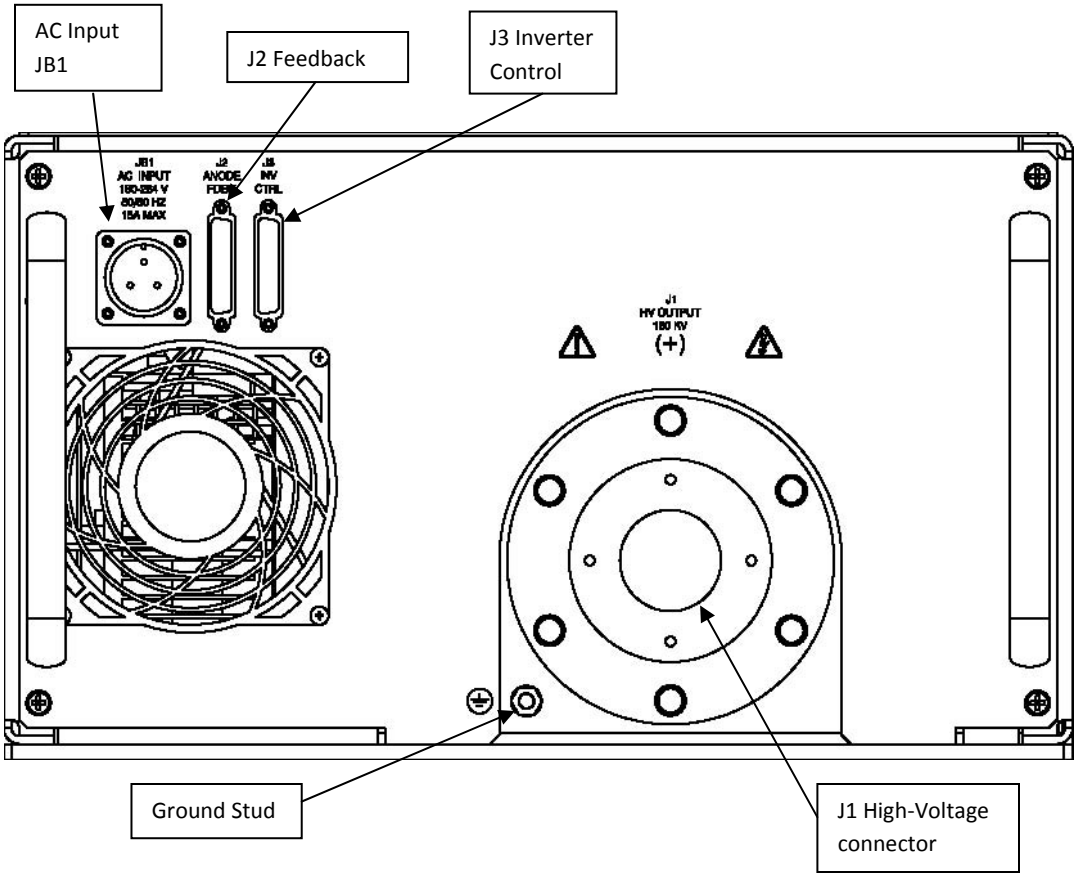
Only persons who are properly trained are allowed to carry out the installation

4.1. Overview of the Connections (Cathode 160kV)



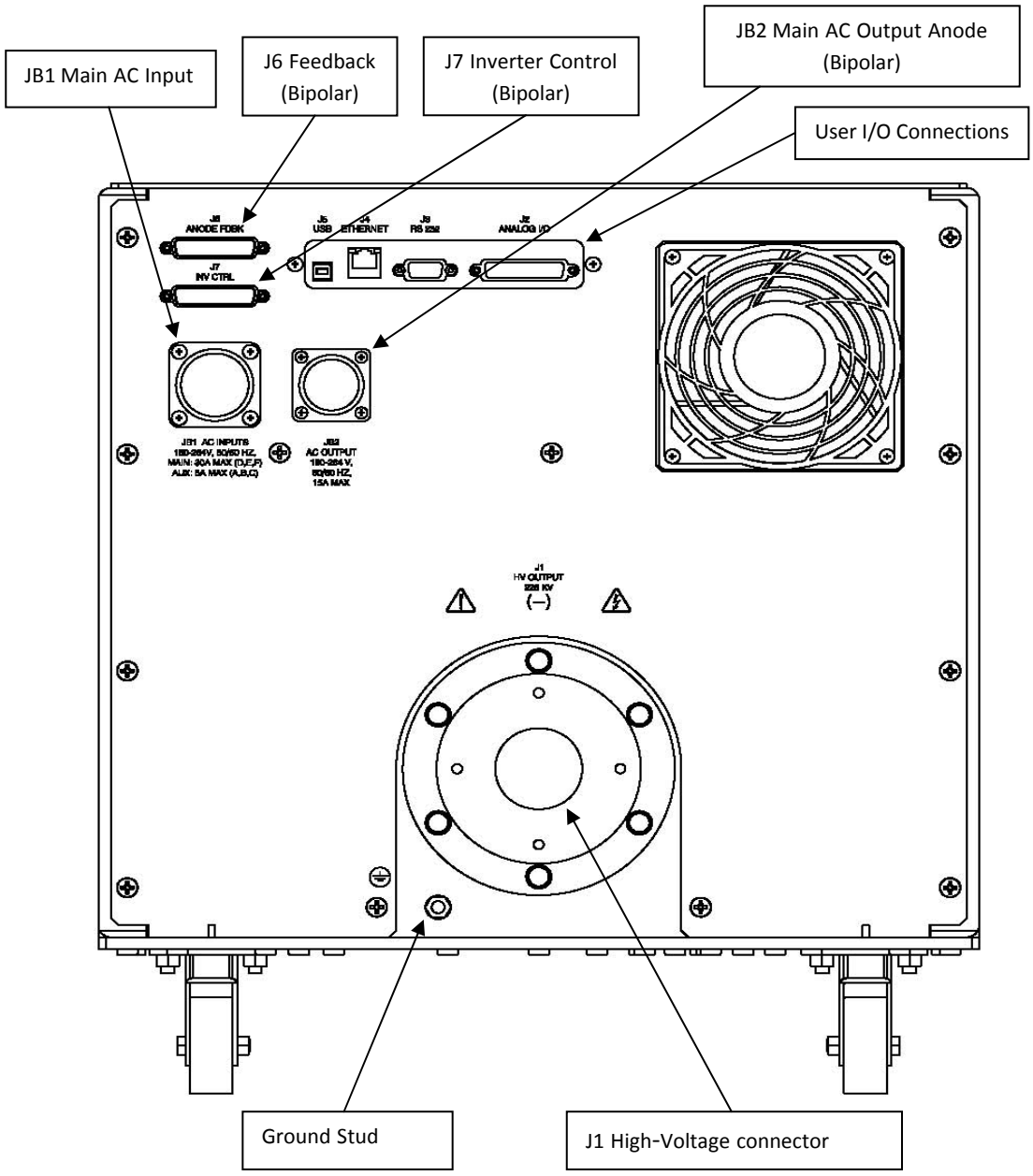
XRV 160kV Cathode

4.2. Overview of the Connections (Anode 160kV)



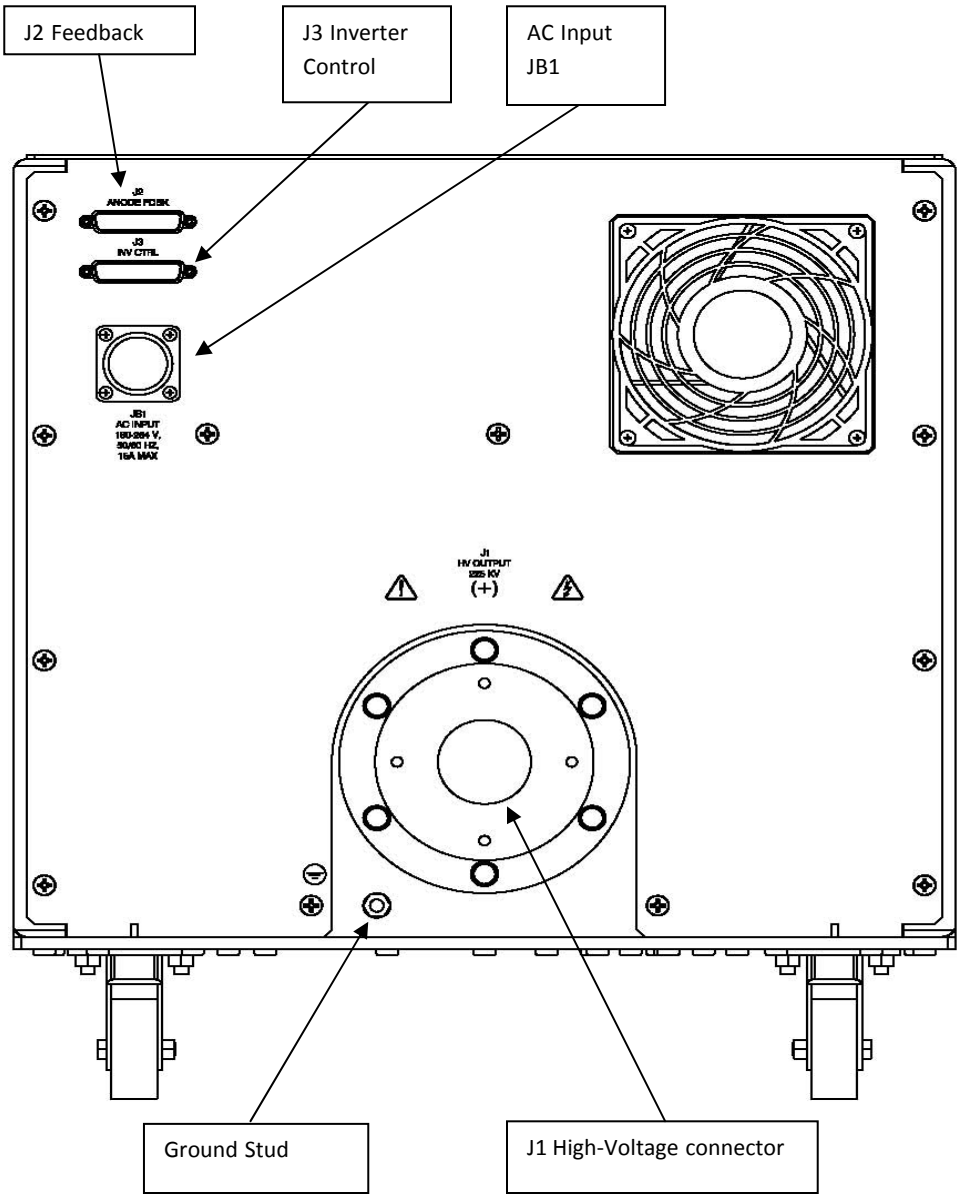
XRV 160kV Anode

4.3. Overview of the Connections (Cathode 225kV)



XRV 225kV Cathode

4.4. Overview of the Connections (Anode 225kV)



XRV 225kV Anode

4.5. Supply Voltage

Before the XRV Power Supply is installed, it is critical that the unit meets the correct input voltage level. It is not field selectable.

To meet the safety requirements the Power Supply has two separate input voltages. The Auxiliary supply is fed at all times and the Main supply is interrupted via a door switch of safety contactor when the High Voltage output is not required.

4.6. Main and Aux AC Input Power JB1 Connector

4.6.1. Main AC input Power

- Voltage: 180VAC – 264VAC, 50Hz / 60Hz,
- Current: 30 Amp max
  Pin D – Line 1
  Pin F – Neutral, Line 2 (US)
  Pin E – Ground

  NOTE: Use 3 conductor cable or single isolated wires rated no less than 600VAC 30 Amps (wire size 10 AWG)

4.6.2. Aux AC Input Power

- Voltage: 180VAC – 264VAC, 50Hz / 60Hz,
- Current: 5 Amp max
  Pin A – Line 1
  Pin C– Neutral, Line 2 (US)
  Pin B – Ground

4.7. System Ground

Connect System Ground Wire (10 AWG minimum) to the Ground Terminal E1 GND of the Power Supply using Ground Stud M6 X 20MM, with M6 Nut

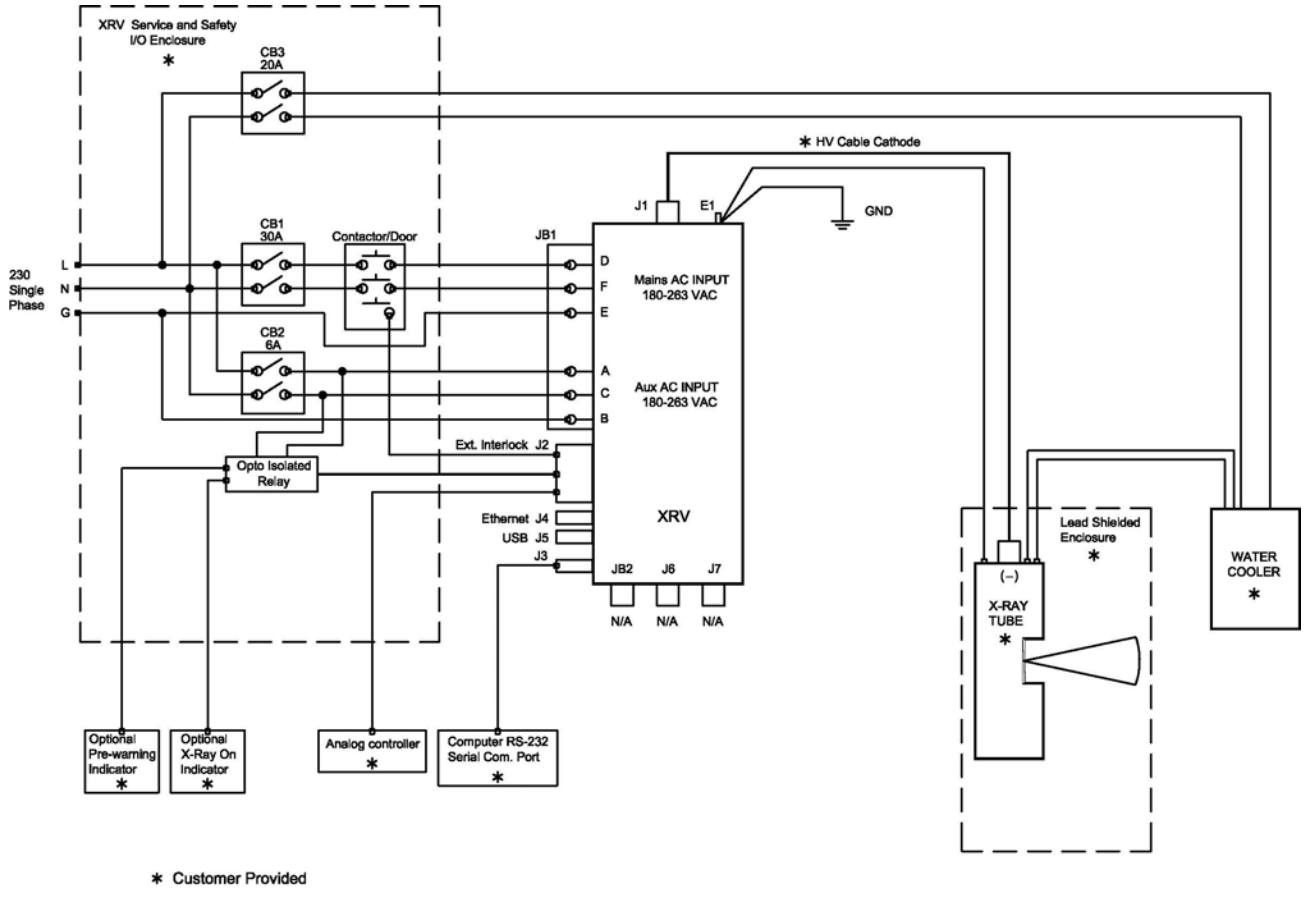
4.8. Interlocks and Warning Connections

Connect Interlocks, Pre-Warning and X-RAY ON Indicator to J2 connector. Make all connections using a 25 D male connector.

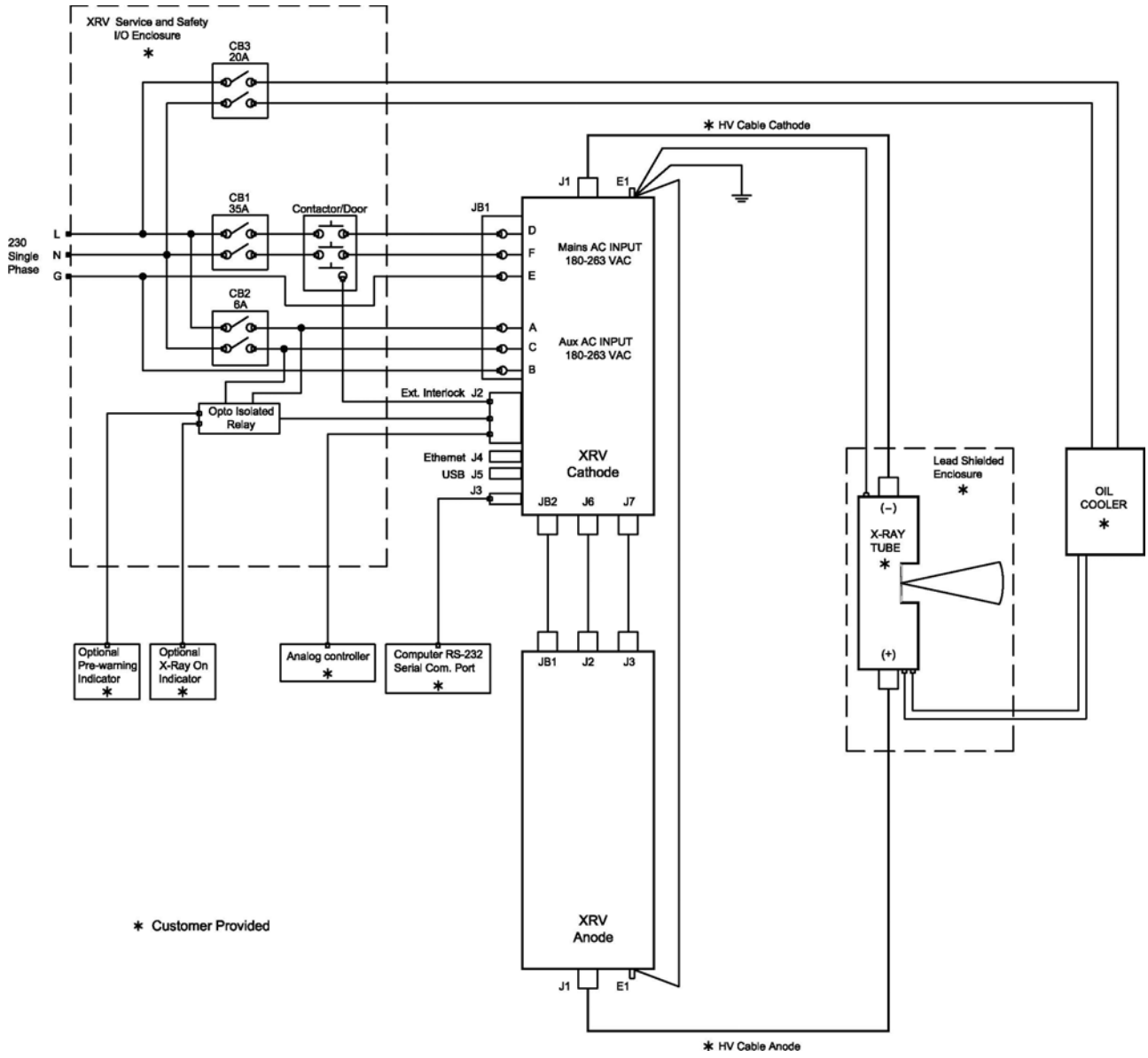
The HVPS has interlock circuits that will immediately turn off the HV output if the interlock is opened. There are three different interlock functions and if any one of the three operates the HV output will cease. These three functions are summarized below.

- All the critical cable connection are interlocked, so disconnecting any of these cables from the PCBs will immediately turn off the HV output.
- Interlock 1 customers external interlocks.
- Interlock 2 second customer's external interlock.

4.9. System Interconnections and Setup (Single Ended)

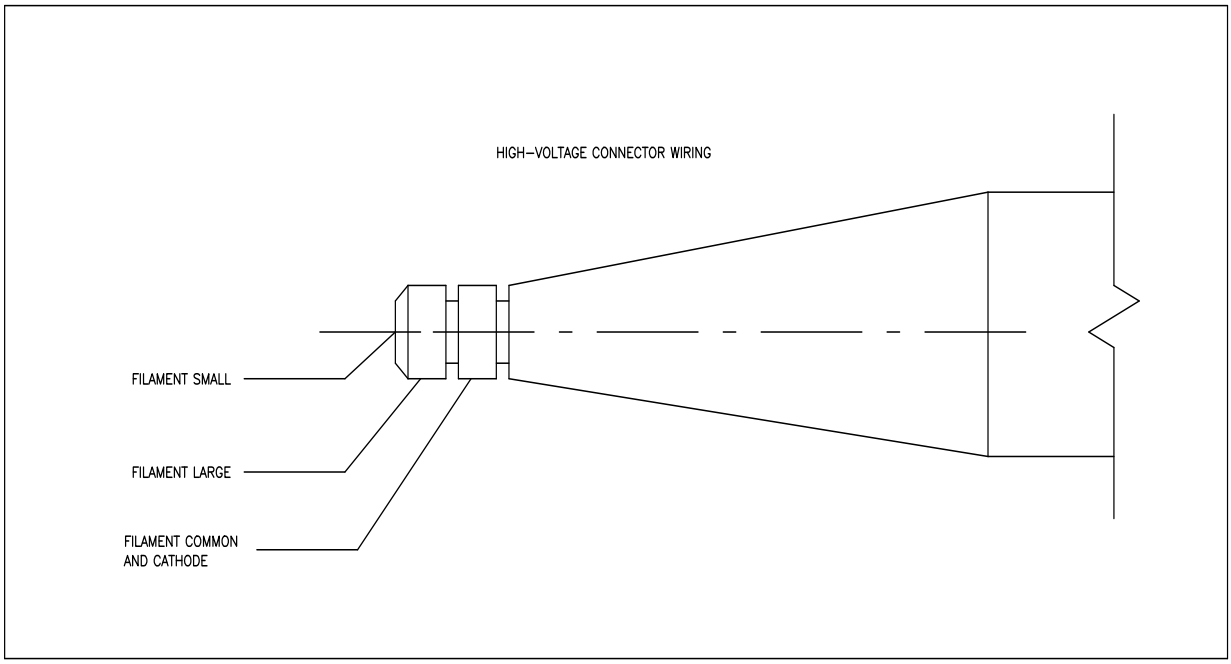


4.10. System Interconnections and Setup (Bi-Polar)



4.11. HV Connector – J1

Pin C – HV Output (Filament Common)
Pin S – Small Filament Output
Pin L – Large Filament Output



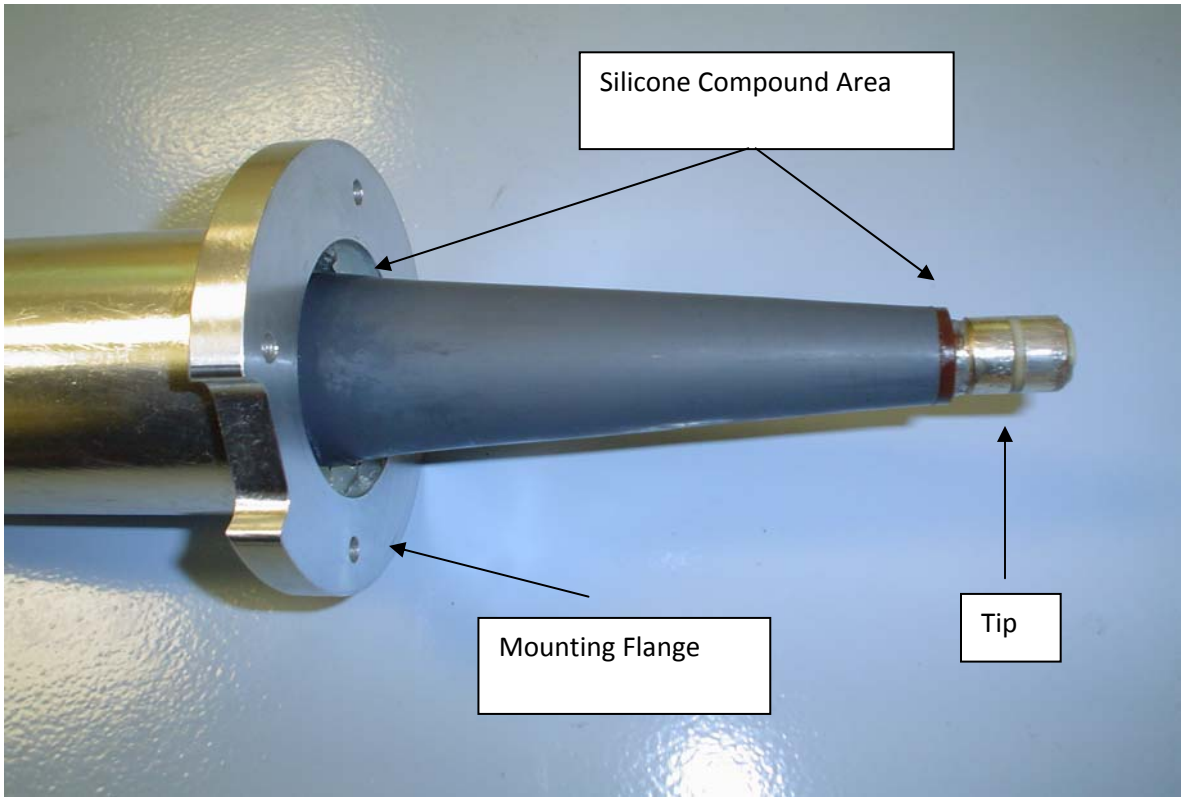
4.12. HV Cable installation instructions:

- Turn Off power to the unit.
- Remove HV cable from the Power Supply

Discharge cable by grounding the high voltage tip of cable to the power supply chassis

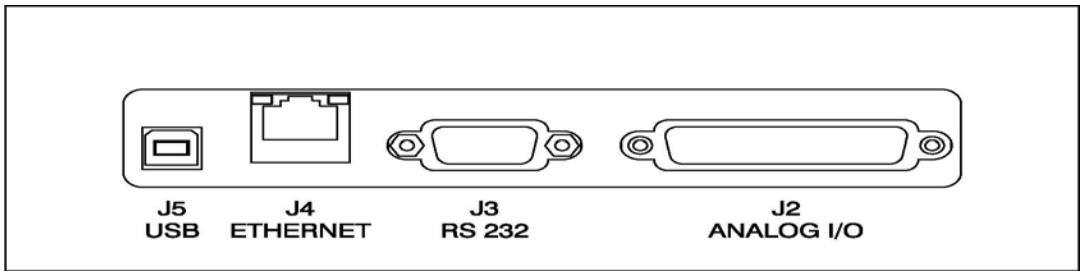
- Clean the X-Ray tube high voltage cable's plug head, and plug tip using lint-free cloth and isopropyl alcohol.
- Insert the high voltage cable plug into the HVPS receptacle.
- Adjust flange to achieve a gap of 4-5mm between the cable mounting flange and the Receptacle.
- Remove plug from the receptacle. Wearing latex gloves apply silicone compound to the rubber area of the connector. Apply 0.1 mm thick layer to the entire exposed area but don't apply any silicone compound to the tip.
- Reinsert the plug and secure the mounting flange to mounting holes on the receptacle of HVPS.

- This procedure should be followed whenever the cable plug is removed from the cablewell.



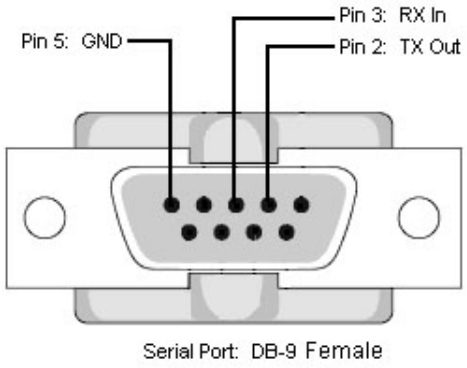
5. USER INTERFACE AND CONTROL

There are two ways the HVPS can be controlled. Using computer control with “GUI” Graphic User Interface control Software via RS232, Ethernet or USB interface connected to the HVPS. The second way is connecting the unit to J2 a manual analog controller. The Analog controller must meet the interface requirement as indicated on page 18 (J2 I/O PINOUT) for both analog and digital logic signals.



5.1. Computer Interface

5.1.1. RS-232 Digital Interface – J3, 9 pin D, female connector



Pin	Signal	Parameters
1	NC	
2	TX out	Receive data (user)
3	RX in	Transmit data (user)
4	NC	
5	SGND	Ground
6	NC	
7	NC	
8	NC	
9	NC	

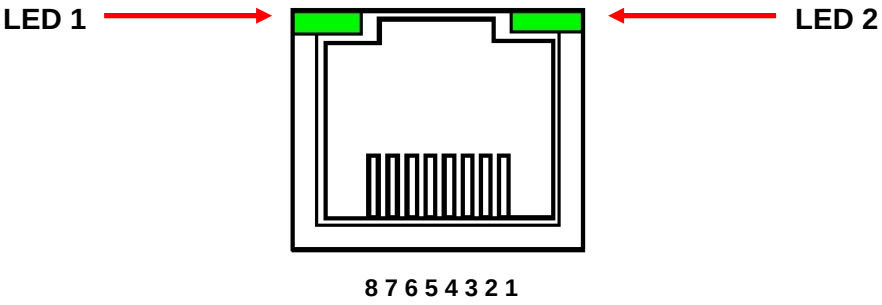
Communication Parameters:

Baud Rate	115200
Parity	NONE
Data Bits	8
Stop Bits	1

5.1.2. Ethernet Digital Interface – J4, 8-pin RJ45 connector

The Ethernet interface has the following attributes:

- 10-Base-T (rev A-B), 10/100-Base-T (rev C and higher)
- IP address can be set by the system integrator
- Network Mask can be set by the system integrator
- TCP Port Number can be set by the system integrator
- RJ-45 connector
- Network attachment via Crossover and Standard Ethernet cables.
- Supported Operating System: Windows XP Professional.



The Ethernet RJ-45 has two LED indicators, as shown in Figure 5. The left LED, LED1 indicates that the network processor has a valid network link. The right LED, LED2 indicates network activity.

Pin	Signal	Parameters
1	TX+	Transmit data +
2	TX-	Transmit data -
3	RX+	Receive data +
4	NC	
5	NC	
6	RX-	Receive data -
7	NC	
8	NC	

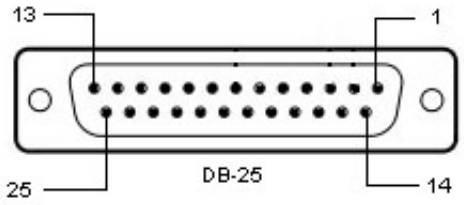
5.1.3. USB Digital Interface-J5, 4 pin USB “B” connector

The USB interface has the following attributes:

- Compliant with USB 1.1 and USB 2.0 specifications
- Type B male connector
- Included driver can be communicated with via standard Windows serial communications methods

Pin	Signal	Parameters
1	VBUS	+5 VDC
2	D-	Data -
3	D+	Data +
4	GND	Ground

5.2. Analog Interface User I/O J2, 25 Pin D female connector



See Data Sheet for Pin Out

6. THEORY OF OPERATION

6.1. Introduction

The XRV SERIES is a 3kW (Single ended) / 4.5KW(Bipolar) high voltage switching power supply which incorporates the latest in high frequency, high power switching technology used to drive an NDT x-ray tube, as well as to serve as a source of a reliable high voltage for other type of loads.

The power supply employs a switch mode power supply using PWM scheme with zero current switching for low losses. The power supply operates from an AC source of 230 volts nominal. The initial turn-on to charge the internal capacitor bank of inverter is through a step start control circuit, which reduces in-rush current.

The main power is applied to HV Inverter Module assembly, arranged in half bridge fashion. The inverter modules drive the HV transformer T1, which is located near the HV assembly. The details of the inverter operation is described in section 8.3

The secondary of the HV transformer is fed into a multiplier to achieve the desired voltage magnitude. A current limiting resistor is located at the HV output to limit to the arc current when the electron source arcs.

A compensated HV divider is located at the output of the multiplier to provide voltage feedback. The feedback signal from the HV divider is fed into a summing junction of an error amplifier (two pole / two zero configuration) in the system control board. The program or reference voltage is also fed to the same junction so that they follow each other. The program voltage is conditioned by the DSP to provide active ramping of the high voltage. The error voltage output will proportionally provide input to the PWM drive chip. The output of the PWM circuit provide to the actual IGBT switches.

The following sections provide detailed working descriptions of different sections of the power supply:

6.2. System Control Board (460130-XXX)

6.2.1. Overview

The 460130-XXX control board is designed to provide all of the functions needed to control X-ray power supplies. Connectors to each of the major subsystems of the HVPS route signals to and from the system control board. Analog circuits are used for the

main functions of kV and mA regulation. The DSP provides the digital circuitry to monitor report and latch fault conditions. The DSP works together with ADCs, DACs to coordinate the control, calibration and to implement Remote (RS 232 or other) control via serial communications. The DSP implements a programmable arc counter and also disables the kV regulator with the goal of quenching the arc. Additional functions on the regulator card include precision references, kV and mA ref ramp, turn on and turn off and on card low voltage regulators.

6.2.2. kV Regulator

The kV regulator is responsible for regulating the voltage of the power supplies main output. It is implemented by a voltage error amplifier which compares a reference kV ref to the feedback level kV FB. The reference level is set to zero volts whenever the HV in not enabled. This level is then ramped up by hardware or SW to the anticipated level that the power supplies is programmed to go to. The ramp-up or slew rate should be selectable from SW command via serial interface. The slew rates should be 0-10sec to full scale. The ramp-up generator is enabled by HV enable/Arc Rollback, a signal from control logic in DSP. When the enable signal goes false, the ramp-down is immediate. This enable signal will also enable/disable the PWM or the drive inverter for the high voltage. The kV error amplifier system is connected to PWM Controller. The PWM outputs are used to drive the gates of the HV inverter.

The regulator inputs/outputs are normalized to 10V=Full scale. These circuits should be able to operate linearly with >=11V range for testing and burn in purposes (110% full scale). The reference level signal path must be designed such that it can be sourced from externally applied analog voltages or optionally from a analog voltage created as a result of a remote control serial command (e.g. DAC). This implies an analog switch selecting the two paths that may be controlled by Local Analog/Remote control jumper. Also to facilitate trouble shooting a jumper for selecting closed loop or open loop control should be provided. The 2 pin headers maybe used for test purposes and produces HV output controlled only by the kV reference independent of the kV feedback.

The kV regulator provides the following analog monitors signals:
KV monitor: 0 to +10V = 0 to Maximum Rated kV full scale voltage output

6.2.3. mA Regulator

The mA regulator is very similar to the kV regulator architecture but controls the filament inverter. Normal function is to operate in Emission Current Regulation (ECR) mode by controlling the HV output current through regulation of the filament inverter. When it is

not possible to generate emission current, as when the HV is off, the mA regulator will regulate the filament current, in a current preheat mode.

The secondary function of the mA regulator is to regulate, or limit, the filament current when emission current regulation is not possible, such as when the HV is turned off. In this mode there are two separately set parameters: Filament Current Limit and Filament Preheat Limit. Filament Preheat Limit can be supplied locally on the “Filament Program” pins, or through remote command. The Filament Preheat is in effect when HV is less than 50% of the programmed value. When HV is being turned on, the transition from, Filament Preheat to Filament Current Limit is automatically switched through logic controlled by the DSP from Preheat to ECR. The Filament Current Limit setting is set to the maximum filament current specification for the X-Ray Tube manufacture. The regulator may allow the filament current to rise towards the Filament Current Limit setting. If, under normal conditions, the system achieves Emission Current Regulation, the ECR loop of the error amplifier takes control, since it requires less current than the Filament current limit setting. If there is a problem with the Emission Current Regulation (ECR), the Filament current will rise but then be limited to the Filament Current Limit setting. In this case a Filament Regulation Error will occur and a Filament Fault will occur. Lastly, the maximum filament current is set by design and factory settings.

The mA error (Filament control loop) amplifier system is connected to the PWM Controller. The PWM outputs are used to drive the gates of Filament inverter. The PWM Controller and Filament inverter drive circuits are located on the Filament/Feedback PWA

The mA regulator provides the following analog monitors signals.
mA monitor: 0 to +10V = 0 to Maximum Rated mA full scale current output
Filament current Monitor: 0 to +10V= 0 to Maximum Current full scale Filament current

6.2.4. Fault Detection

Faults related to subassemblies are, whenever possible, detected on the relevant subassembly and converted to a digital signal presented to the system control board as active low signals, and go directly to DSP to be latched. All other faults are detected by SW in the DSP. These include faults like over temperature, low voltage power supply status, over current, over voltage, mA/kV differences and HV arc detection. All of these fault conditions, externally or on card detected, are input and latched within the DSP. In addition to these latched fault conditions, each of the connectors to the regulator card include signal wires to confirm that the cables are connected, which are not latched, but directly included in the fault logic.

Software Comparator

Function	HW	Threshold
HV Over Voltage (window compare to program ref)	DSP	+10%
HV under voltage (window compare to program ref)	DSP	_-10%
mA Over Current (window compare to program ref)	DSP	Fast
mA under Current (window compare to program ref)	DSP	Fast
Over Power (user setting)	DSP	+5%
½ kV ref vs. kV mon (used in switching from preheat to ECR)		---
LVPS Fault (window compare)	DSP	
Over Temp (fixed thres)	DSP	50 Deg C
Temp Warning	DSP	45 Deg C
DC Rail Monitor (window comparator)	DSP	+/-10%
AC Line Monitor (window comparator)	DSP	+/-10%
kV Diff (Bipolar units , compares Cathode - Anode)	DSP	+/-10%
mA Diff (Bipolar units , compares Cathode- Anode)	DSP	+/-5%

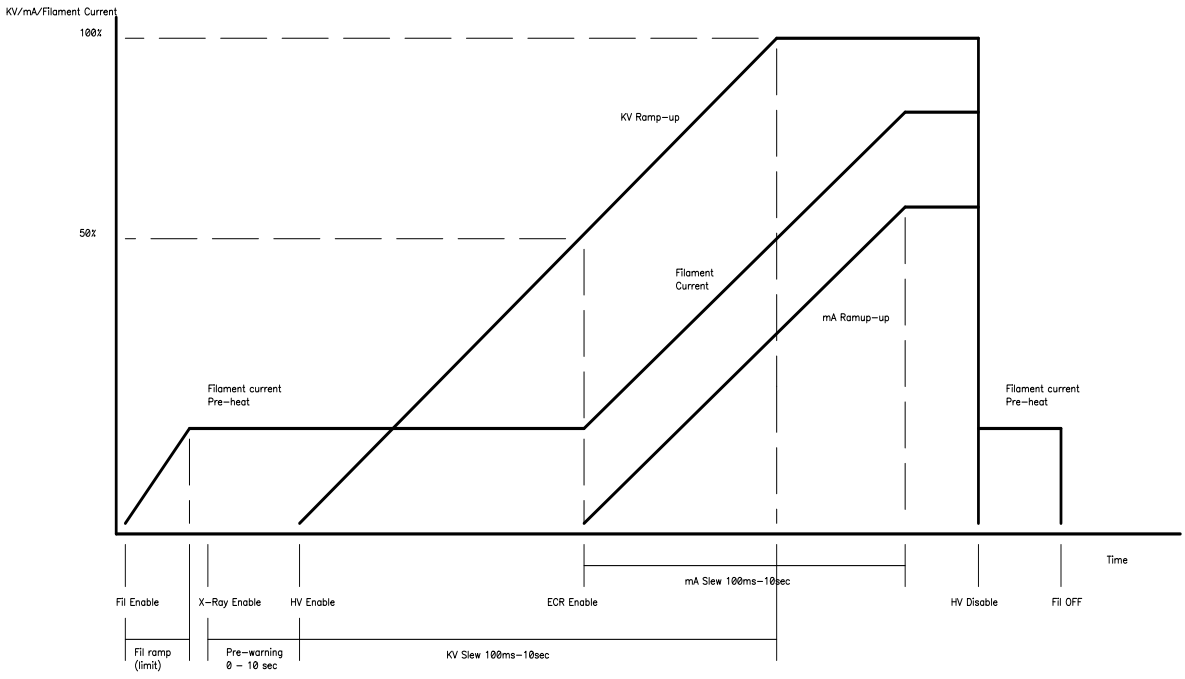
Digital logic functions are implemented in the DSP. All of the fault latching is done in the DSP. The DSP is field programmable. An array of Fault/Status LED's located on the front panel provided a visual indication of the status of the HVPS, and to identify fault conditions.

The DSP supports remote communications and diagnostics over RS-232, Ethernet and USB. The other main function of the DSP is to support and control the factory settings, which include DAC settings, ADC output settings, Digital Pot values and operational configuration settings. These factory settings and user setting are programmed over the communication port like RS-232 using the GUI control software.

LED Summary on System Control

LED	Description	Color	Status During Normal Operation
DS1	3.3V supply	Green	ON
DS2	DSP Alive	Green	Flashes
DS3	Communication Active	Green	Flashes
DS4	USB Connected	Green	ON if USB is connected
DS5	HV in current limit	Red	OFF
DS6	Filament in current limit	Red	OFF
DS7	Over temp cathode inverter	Red	OFF
DS8	Over temp cathode inverter	Red	OFF
DS9	Cable connection Cathode	Red	OFF
DS10	Cable connection Anode	Red	OFF
DS11	Local Control selected	Green	OFF (ON if Local Control selected)

X-ray ON/OFF timing Sequence



6.2.5. ARC Counter, ARC Fault

Arcs in the HV are sensed by a current transformer in the “Low End” of the multiplier and fed to comparator on System Control board. These comparators have a threshold that is varied with the kV program reference level. Arc management is handled in the DSP. The ARC signal will be received and latched by the DSP, which at Hardware speeds disables the kV regulator with the goal of quenching the arc. This quenching is also known as “rolling back”. The DSP is then responsibility if it is appropriate to turn the HV back on after the arc. The DSP first increments an Arc Counter. If this is the first arc is detected and the Arc Threshold is >1, then the DSP out an Arc Quench time roll back interval and then re-enables the kV output. This sequence can continue until the number of arcs detected exceeds the number of arcs programmed into the arc counter threshold register. User can set the Arc Quench Time from 10ms to 1sec and the arc count reset will be 100 X the Arc Quench time, 100 sec max. The arc counter threshold setting can be set by GUI control software. Values of zero will disable the arc counter, and allows arcs to continue without being stopped after a set count.

6.3. Inverter Module Assembly

Inverter Module Assembly consists of EMI Filter Assembly (406577-XXX), Power Inverter Board (460156-XXX) which includes Power Factor Correction (PFC) Circuits, DC rail voltage filter caps(304440-XXX), L1 PFC Boost Choke ,and Temperature Switch (SW1), and cooled by Fan B1.

When the nominal 230VAC power is applied to the Power Supply, it proceeds to EMI filter, then arrives to the Inverter Power Board where a Line Voltage Detector monitors the AC input line, which will issue fault signal in case the input line voltage is lower then 180VAC and above 265 VAC. Simultaneously 230VAC arrives to the PFC circuits where the rail capacitor bank is initial charged through the inrush current limiting resistor. When the capacitor bank is sufficiently charged, relay activates, and its contacts short the inrush current limiting resistor. The above-mentioned components belong to a Soft Start circuit that limits the inrush peak current to <50A max. As soon as the SS relay is being activated, the PFC circuit starts to operate, boosts rectified line voltage to 400VDC and supplies it to the Half-Bridge Inverter. The DC Rail is monitored for 400 VDC +/-10% if for some reason this is not the case, the system control board will issue a DC Rail Fault and the SS relay will be disabled.

A Half-Bridge topology power inverter uses Insulated Gate Bipolar Transistor (IGBT) power switches and PWM (Pulse Width Modulation) to control switching at a frequency of 25kHz. This technique, combined with secondary resonance tuning, create Zero Current Switching

to minimize IGBT switching losses and to reduce EMI noise that might be produced by the High Power Switching power supply. The IGBT's are mounted on the heat sink and located between the IGBT's , mounted directly on the heat sink is a thermal switch that monitors the temperature of the inverter plate. If heat temperature exceeds 80 deg C, Over Temp Fault will occur.

The inverter modules drive the HV transformer T1, which is located near the HV assembly.

6.4. Filament Inverter/Feedback (460158-XXX)

6.4.1. Filament Inverter

The Filament Inverter uses two IGBTs in a half bridge configuration to drive filament transformers Small or Large Filament located on the HV Assembly. The Filament Inverter uses the same PWM technique as the HV Inverter but in this case it's hard switching. The IGBT's are driven by the PWM located on Filament /Feedback board via the Gate Driver Transformer. Filament Inverter current is monitored on the primary side of Filament Transformers using Current Transformer and a RMS converter that is calibrated to provide actual filament current that is scaled 10VDC= maximum specified Amps. If Filament Current fails to be regulated to the programmed Filament current, Filament regulation error will occur and a filament fault will be issued by the DSP. Filament selection L/S is monitored by a filament confirm signal to the DSP and if filament selected is not equivalent to confirm signal, the DSP will issue Filament Fault.

6.4.2. kV and mA Feedback

The Low End 460158-XXX PWB includes kV and mA Feedback Calibration circuitry and Arc Detector circuit. The kV and mA Feedback Signals are scaled to 10VDC each that represents full-scale value for nominal output voltage and current. The Filament Inverter/Feedback PWB receives arcs and kV and mA feedback signals from the High Voltage Section and sends arcs and calibrated feedback signals to the System Control board. ICs U1 and U2 are used for calibration of voltage and current feedback signals. The Arc Detector, Current Transformer T1, detects arcs in the Load or in the HV Section and then it's rectified by CR2, which provides an arc pulse to the system control.

6.5. Transformer Assembly T1

The Transformer Assembly consists of a HV Transformer primary winding and secondary winding which is then connected to HV Assembly by HV connectors. The HV Transformer leakage inductance together with the combined capacitance of the transformer secondary, and the HV Section, produces a resonant tank on the primary side of transformer. This resonant frequency is close to the HV Inverter switching frequency, provides for soft switching thus reducing heat dissipation and EMI. The HV Transformer T1 steps-up the drive from the Power Inverter Assembly to the level sufficient for producing a desired DC High Voltage by the HV Multiplier Assembly located in the HV Assembly Section.

6.6. HV Assembly

6.6.1. HV Multiplier Assembly

The HV Section contains HV Multiplier Assembly, Current Limiting Assembly, HV Divider and HV Output Cablewell J1. All these components are encapsulated in silicon rubber. The Current Limiting Resistors limit the X-Ray Tube arcing current. The HV Divider provides a HV Feedback Signal for the feedback. The HV multiplier assembly is connected to the terminals of the Cablewell J1. The HV Cablewell J1 is a 3 socket type HV receptacle.

6.6.2. Filament Rectifier /Transformer Assembly

Filament Transformer T1, T2 supplies voltage to the Dual Filament Rectifier. Dual Filament Rectifier rectifies and filters the voltage with LC type filter. This DC voltage supplies the appropriate filament, large or small on the J1 socket.

7. TURNING UNIT ON AND CONTROL

NEVER ATTEMPT TO RAISE HIGH VOLTAGE WITHOUT HIGH VOLTAGE CABLE BEING INSTALLED AND SECURED IN THE POWERS SUPPLY CABLEWELL! THE OTHER HIGH VOLTAGE CABLE END MUST BE CONNECTED TO AN X-RAY TUBE OR OTHER LOAD!

There are two ways the HVPS can be controlled. One is using RS-232 interface and connecting the HVPS to a computer, which supports the command structure outlined below. The second way is connecting the unit to a manual analog control via J4. The Analog controller must meet the interface requirement as indicated specification sheet (J2 Analog Interface) for both analog and digital logic signals.

HVPS control using the X-Ray Power Supply Controller software

- Check all connections, interlocks and grounds.
- Check that the Tube Cooling System is On and functioning normally.
- Turn On the mains power to the System.
- See Manual for installation and control instruction.

HVPS control using Analog Control

- The Analog controller must meet the interface requirement as indicated on page 20, J2 Analog I/O for both analog and digital logic signals.
- Select analog control on install jumper JP12 on System Control Assembly 46130-XXX.
- On the system control Assembly 460130-XXX has a user jumper logic level selection. Select JP11 1-4 for 5v logic JP11 2-5 for 15v logic and JP11 3-6 for 24v logic
- Check all connections, interlocks and grounds

Check that the Tube Cooling System is ON and functioning properly

7.1. User I/O Options and Settings

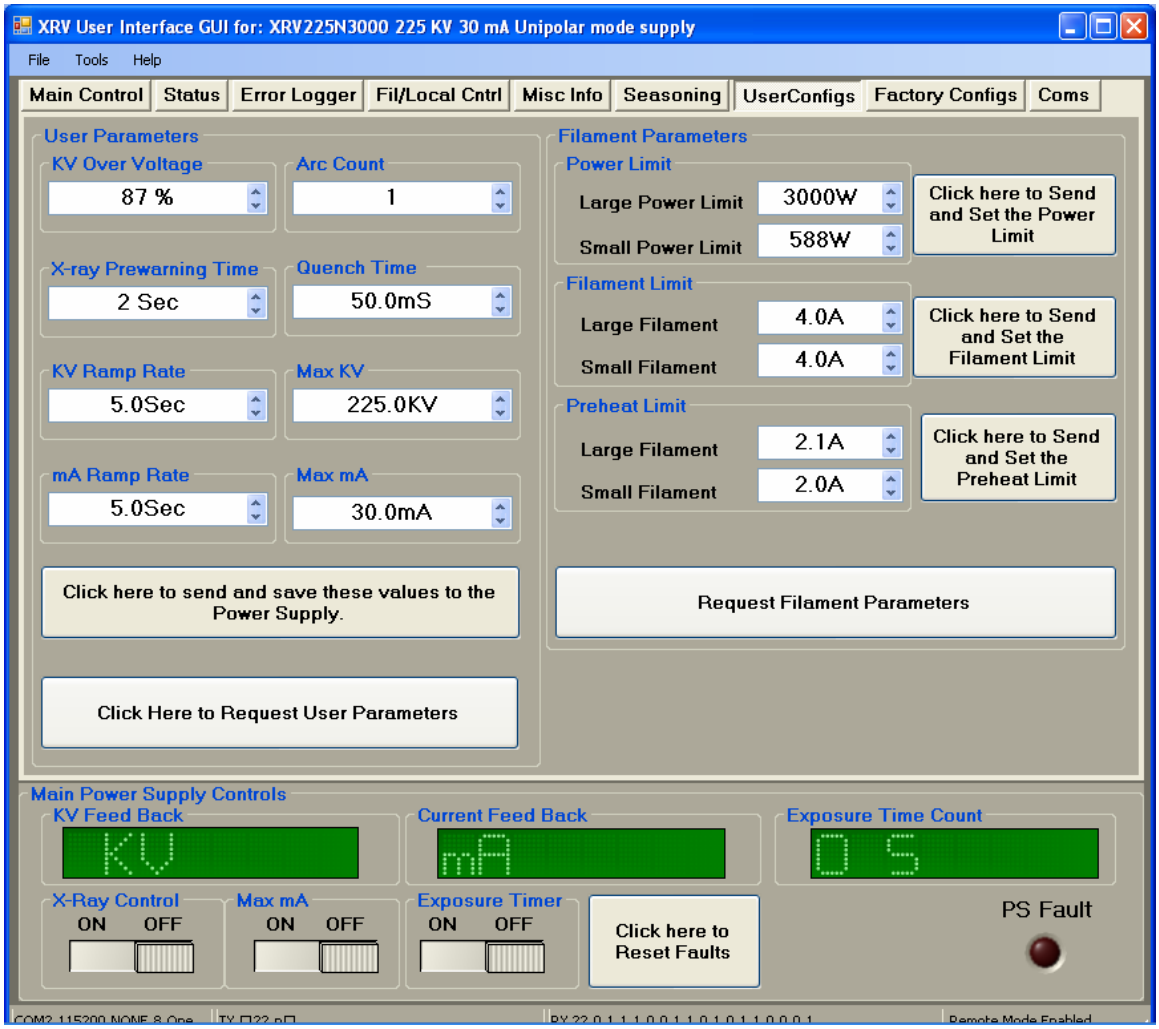
This should only be performed with trained personnel only.

7.1.1. Changing user settings or setting X-ray tube operating limits.

Enter upper operating limits

- Connect the RS-232 cable from PC to J3 of HVPS.
- Turn ON power to the HVPS
- Start the GUI software and establish communication with HVPS, select User Configs. Tab, which is password protected, contact factory for password.
- Enter power limit for small/large filament
- Enter filament limit small/large
- Enter pre-heat current small/large

User configurations (example)



User Parameters

KV over voltage: Over Voltage Fault will occur at this setting. This percentage is related to a full-scale reading of analog converter on the system control board. The default setting for all units is 87%; this value should not be changed without consulting the factory.

XRV160	100% =192kV, 87% = 167kV
XRV225	100%= 270kV, 87% = 234kV
XRV320	100%= 384kV, 87% = 334kV
XRV450	100%= 540kV, 87% = 469kV

X-ray Pre-warning: delay time from X-ray ON and the actual turn on of HV. The Pre-warning indicator will be on during this time. The time values are in seconds.

KV ramp rate: time in seconds for the kV high voltage output to go from 0 to FS rated output voltage.
mA ramp rate: time in seconds for the mA output current to go from 0 to FS rated output current.
Arc Count: number of arcs before arc fault is issue and HV is turned off.

Quench time: time that HV is held off after an arc has been detected, applies only when Arc Counter >1, Arc Counter will reset 100X this set value (100sec max).

Max kV: maximum kV setting for the unit must be less or equal the high voltage power supply output ratings for kV.

Max mA: maximum mA setting for the unit must be less or equal the high voltage power supply output ratings for mA.

Save user parameters: click in box "click here to send and save these values to the power supply" all user parameter are saved in memory inside the HVPS.

Recall user parameters: click in box "click here to request user parameters" all user parameters are recalled from HVPS memory to GUI controller, for viewing.
Filament Parameters

Large Power Limit: This is maximum power that can be set (product of kV multiplied mA) when Large Filament is selected. Over power fault will occur if actual power exceeds 5% above this set value. This value is stored in HVPS memory.

Small Power Limit: This is maximum power that can be set (product of kV multiplied mA) when small Filament is selected. Over power fault will occur if actual power exceeds 5% above this set value. This value is stored in HVPS memory.

Large Filament Limit: Maximum Current the HVPS will produce before it it goes into current limit mode. This value must be less than or equal to 6 Amperes.

Small Filament Limit: Maximum Current the HVPS will produce before it goes into current limit mode. This value must be less than or equal to Maximum current specified (Amperes).

User Options			
Parameter/Function	**Range**	**Default**	**Notes**
Large Filament Power Limit XRV160,225 XRV320,450	 0-3000 Watts 0-4500 watts	 3000 watts 4500 watts	See tube data
Small Power Limit XRV160,225 XRV320,450	 0-3000 Watts 0-4500 watts	 3000Watts 4500 watts	See tube data
Max kV XRV160 XRV225 XRV320 XRV450	 0-160kV 0-225kV 0-320kV 0-450kV	 160kV 225kV 320KV 450kV	
Max mA	0-30 ma	30ma	
Filament Current Limit Large	0-6 Amps	4 Amps	Cal. Current with actual load
Filament Current Limit Small	0-6 Amps	4 Amps	Cal. Current with actual load
Filament Preheat Current Large	0-6 Amps	2 Amps	Typical value: Current Limit Large/2
Filament Preheat Current Small	0-6 Amps	2 Amps	Typical value: Current Limit Samll/2
Arc Trip Counter	0-30	1	
Arc Quench Time	10msec-1sec	50 msec	Counter will reset in 100X set value (100sec max.)
kV Slew Time	100 msec-10sec	5 sec	Typical 5 sec
mA Slew Time	100 msec-10sec	5 sec	Typical 5 sec
Pre-warn Time	0-30sec	1 sec	Warning before HV ON (X-Ray ON)

7.2. Application Software Installation

System Requirement:

- An IBM or compatible computer with w/ male RS232 D 9 connector
- Windows XP
- CDROM drive
- Color Monitor with display resolution of 1024 X 768

7.2.1. Installing GUI Software from the CD provided

Insert the XRV disk in the CD Drive, double click on My Computer icon and the CD drive icon, and double-click on the XRV setup. Follow the instructions on displayed screen.

7.2.2. Downloading Application Software via FTP Site

XRV GUI software

ftp://8.11.166.21/digital-eng/XRV%20Standard/

User= xrvstandard

Password= xrvstandard

Download folder to local computer and install application software, double-click on the XRV setup icon.

8. MAINTENANCE, RECOGNIZING FAULTS AND FILAMENT ADJUSTMENTS

8.1. Maintenance

Very little maintenance is required, since there are no serviceable parts inside. Keep fan filter clean and all vents free from obstruction or dirt build up. There are two Warnings that must be checked periodically. The first is Temp Approach Warning indicates that ambient temperature is above 45°C and a latch Over Temp Fault will occur if above 50°C.

High Voltage Plug Connections

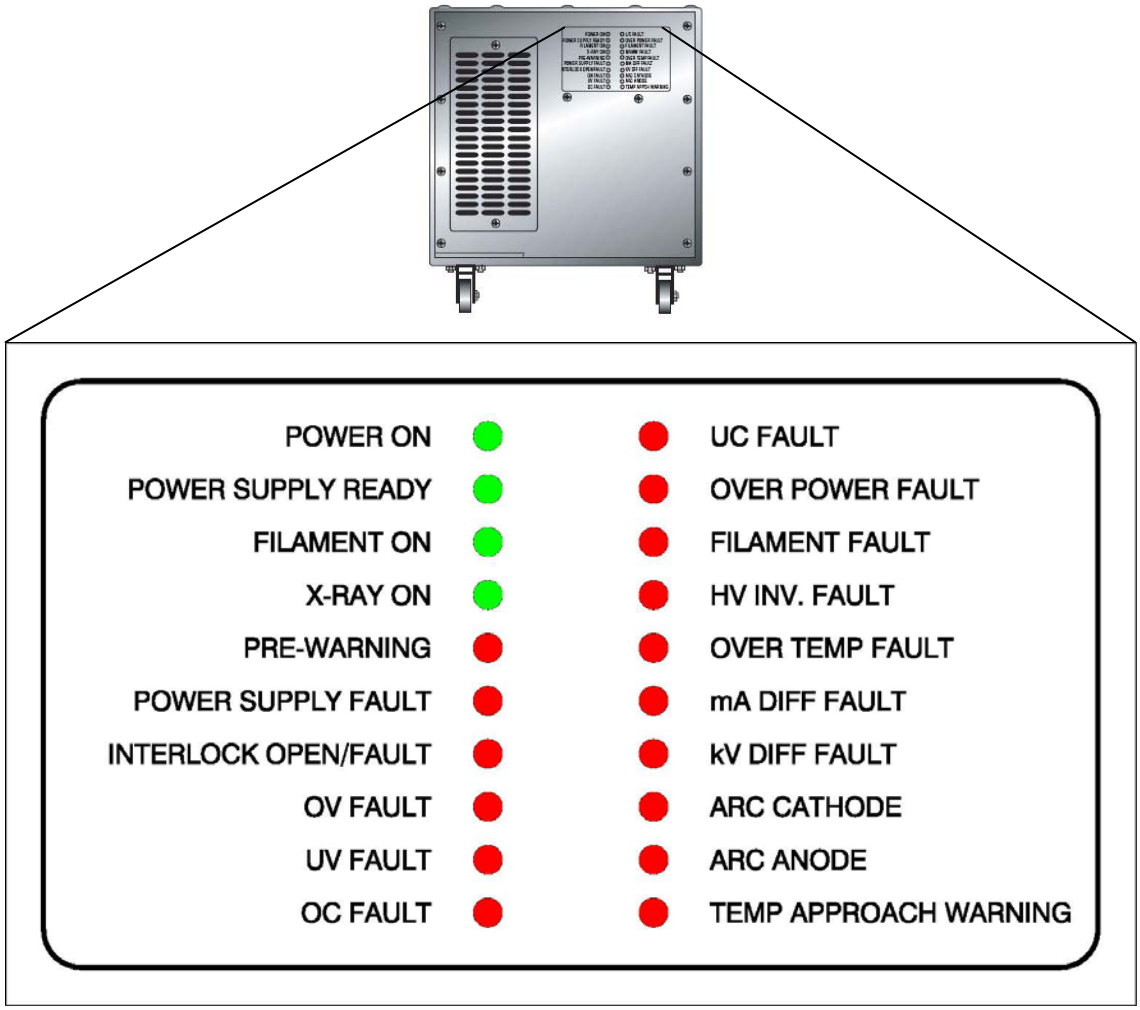
The high voltage plug connection of the HVPS should be cleaned, greased and the surface pressure be readjusted in interval of approx. 3 months. (see section *** HV Cable installation instructions)

8.2. RECOGNIZING FAULTS

Faults and unit operation can be recognized by the front panel LED display or by GUI computer control.

8.2.1. Front Panel Faults

During normal operation, only Green LEDs should be illuminated on the front panel. Any red LED indicates a fault or incorrect operation. LED's on the control board report any faults or incorrect operation that the XRV recognizes and that occur during normal operation.



8.2.2. Front Panel LED Summary

LED	Description	Color	Status During Normal Operation
Power ON	Aux Power is ON	Green	ON
Power Supply Ready	Power is Ready if Program Voltage Requested = Actual	Green	OFF- ON
Filament ON	Filament Is ON	Green	ON
X-Ray ON	X-ray's are ON	Green	ON
Pre-Warning	X-ray ON is imminent	Red	OFF-ON-OFF
Power Supply Fault	General Power Supply Fault	Red	OFF
Interlock Open/Fault	Interlock is open or interlock fault has occurred	Red	OFF
OV Fault	Over Voltage Fault	Red	OFF
UV Fault	Under Voltage Fault	Red	OFF
OC Fault	Over Current Fault	Red	OFF
UC Fault	Under current Fault	Red	OFF
Over Power Fault	Over power Fault	Red	OFF
Filament Fault	Filament Fault	Red	OFF
HV Inv. Fault	HV Inverter Fault	Red	OFF
Over Temp Fault	Over Temperature Fault	Red	OFF
mA Diff Fault	mA Difference Fault (Bi-polar)	Red	OFF
kV Diff Fault	kV Difference Fault (Bi-polar)	Red	OFF
Arc Cathode	Arc Cathode Detected	Red	OFF
Arc Anode	Arc Anode Detected	Red	OFF
Temp Approach Warning	Temperature Approach Warning	Red	OFF

OV Fault

This fault occurs when the system output voltage exceeds the maximum allowable voltage, +10% above the programmed voltage or for full output operation.

This may be caused by:

- System Control PWB failure
- Filament/Feedback PWB failure
- HV Divider Failure

Diagnosis

- The OVER VOLTAGE FAULT LED will be illuminate.
- HV output will be disabled.

Over Current Fault

This fault occurs when the HVPS output current exceeds the maximum allowable current..

This may be caused by:

- X-Ray tube, HV cable
- Regulator PWA failure
- Low End PWA

Diagnosis

- The OVER CURRENT FAULT LED will illuminate.
- HV output will be disabled.

Temperature Fault

This fault occurs when a high temperature condition is detected on the inverter assembly. The system control board then latches the temperature fault to prevent damage to the inverter.

This may be caused by:

- Ambient temperatures beyond specification

Diagnosis

- The Over Temp LED will illuminate.
- HV output will be disabled.
- Check the ambient temperature of the room. It must be less than 60ºC.

Arc Fault

This fault occurs when the system output has experienced arcs beyond the maximum allowable of one arc.

This may be caused by:

- Problems with the x-ray tube
- Failure in the HVPS High Voltage Assembly ,Filament Transformer section
- High Voltage Cablewell

Diagnosis

- The Arc Ext. FLT, LED will illuminate.
- Issue a reset and set 1/2 Maximum rated kV output.
- Listen for multiple arcs and attempt to localize the problem to X-Ray Tube or HVPS.
- If none are detected, via the interface, issue a reset and set Maximum rated kV output.
- Listen again for multiple arcs and attempt to localize the problem to X-Ray Tube or HVPS.
- For X-ray tube problems, refer to the appropriate documentation.

Filament Fault

This fault occurs when the system detects a problem with the filament selection or filament current regulation.

This may be caused by:

- System control board PWA failure
- Filament Inverter Problem
- X-Ray tube’s Filament

Diagnosis

- The Filament Fault LED will illuminate.
- Via the control interface, issue a reset and command the filament in pre-heat mode.
- Check X-Ray tube’s Filament

HV Inverter Fault

This fault occurs when the DC Rail supply did not properly come up to 400 VDC within 3 sec from Setup Start Enable.

This may be caused by:

- Bad or OFF Circuit Breaker for AC Mains.
- Problem in Power inverter PWB
- Problem with System Control PWB
- AC Main Line too low.
- Problem with the HV inverter
- Problem inside the HV Multiplier Assembly and HV Transformer

Diagnosis

- The HV Inverter LED will illuminate.
- Via control interface, issue a reset.
- If HV Inverter LED is still illuminated then,
- If the problem appears to be in the HVPS, verify on Power Inverter input line is 230 AC +/-10 If not Check Main AC Line.
- Verify that DC BUS is at 400VDC.

Interlock Open/Fault

This fault occurs when the system does not detect the proper External interlock signal .

This may be caused by:

- Problem with the cool or door interlock
- Failure of the Regulator PWA
- Failure of the I/O Interface

Diagnosis

- Verify that a proper interlock signal is being supplied to the HVPS. Install interlock bypass plug into J2 (pin 12, 13 connected to 22)

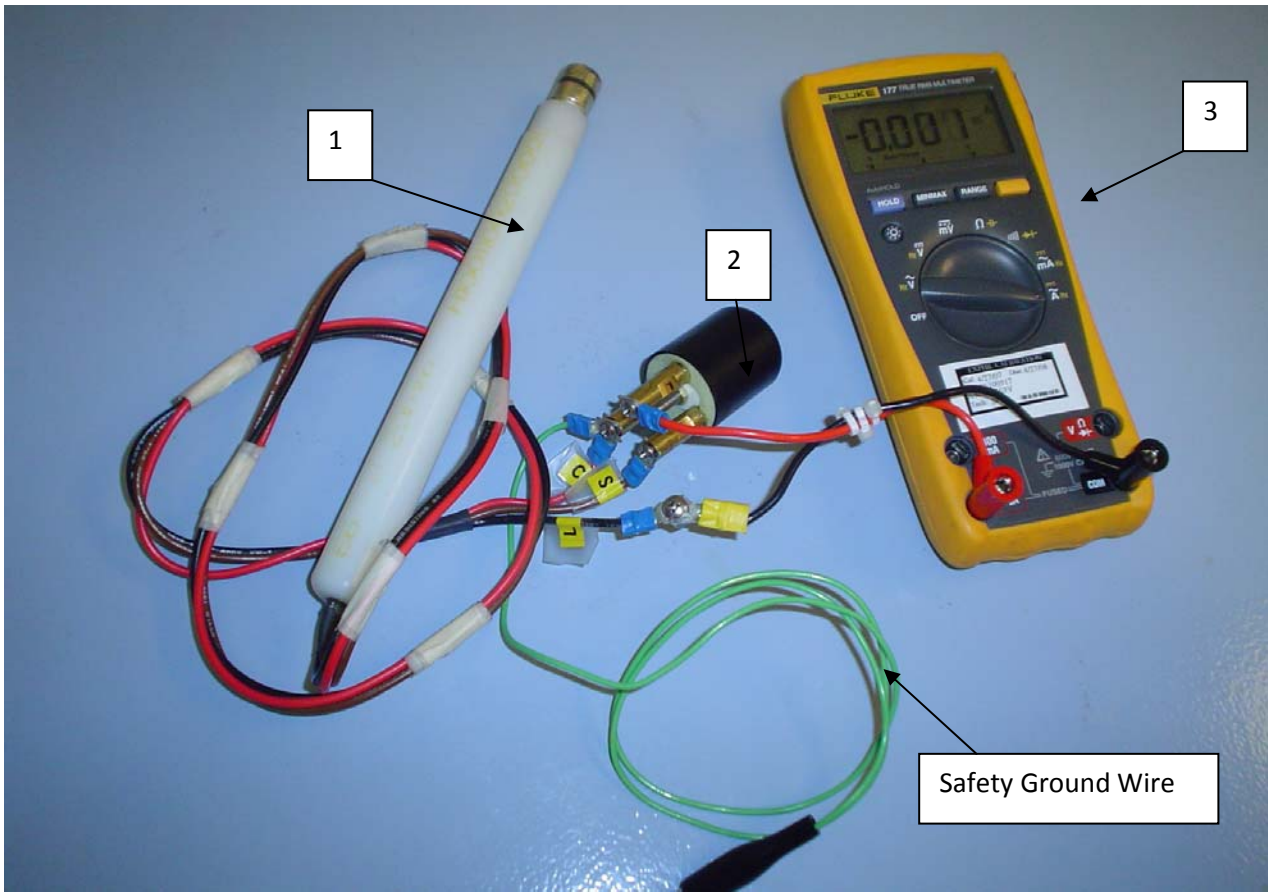
8.3. Filament Adjustments

Trained personnel only

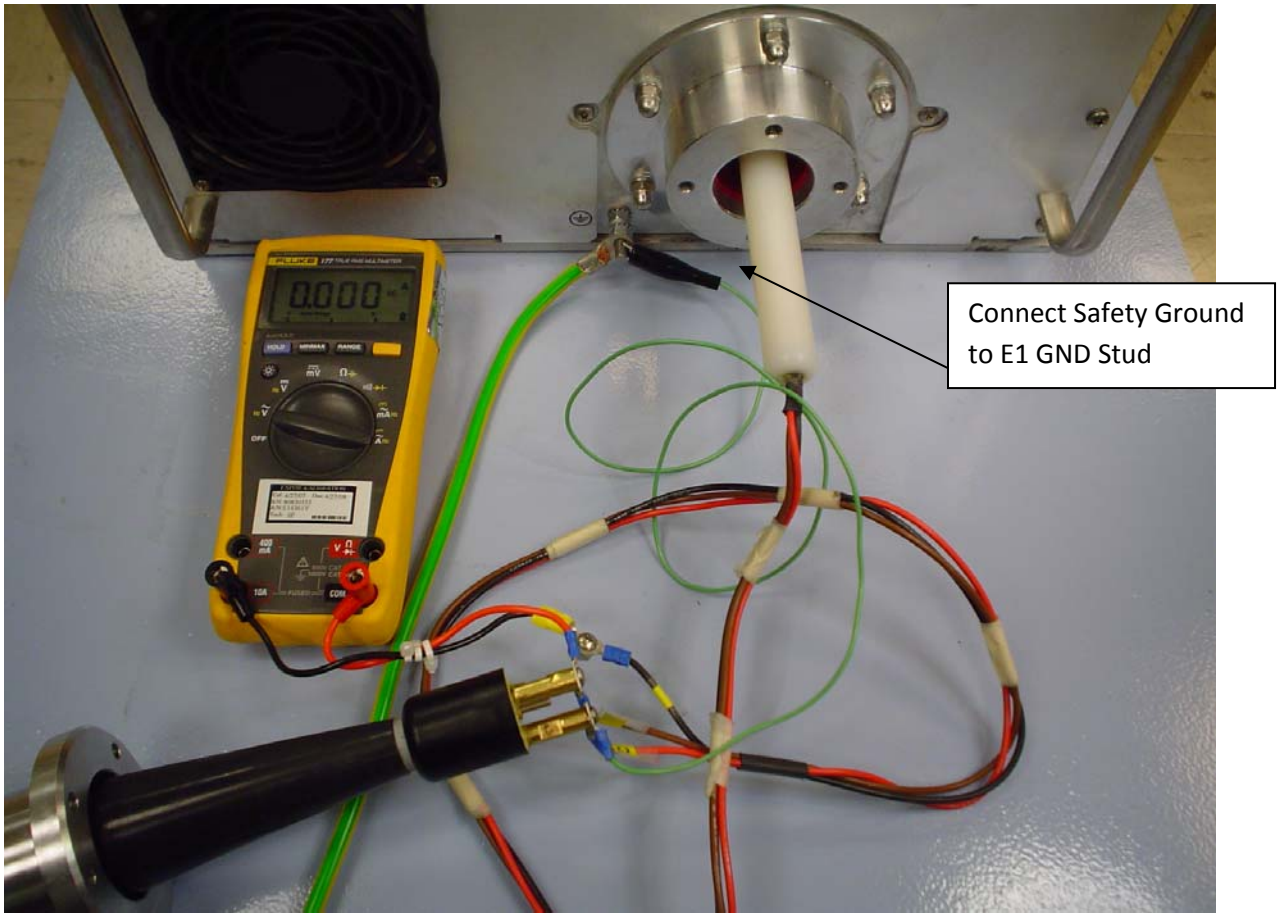
Filament current calibration is performed at the initial installation and every time the tube is changed with a different type. This calibration is performed at the tubes current limit for both large and small filament.

The filament current is measured directly in the high voltage cable connected to the tube. The filament current limit data for small and large can be found in the Tube Specification Data Sheet.

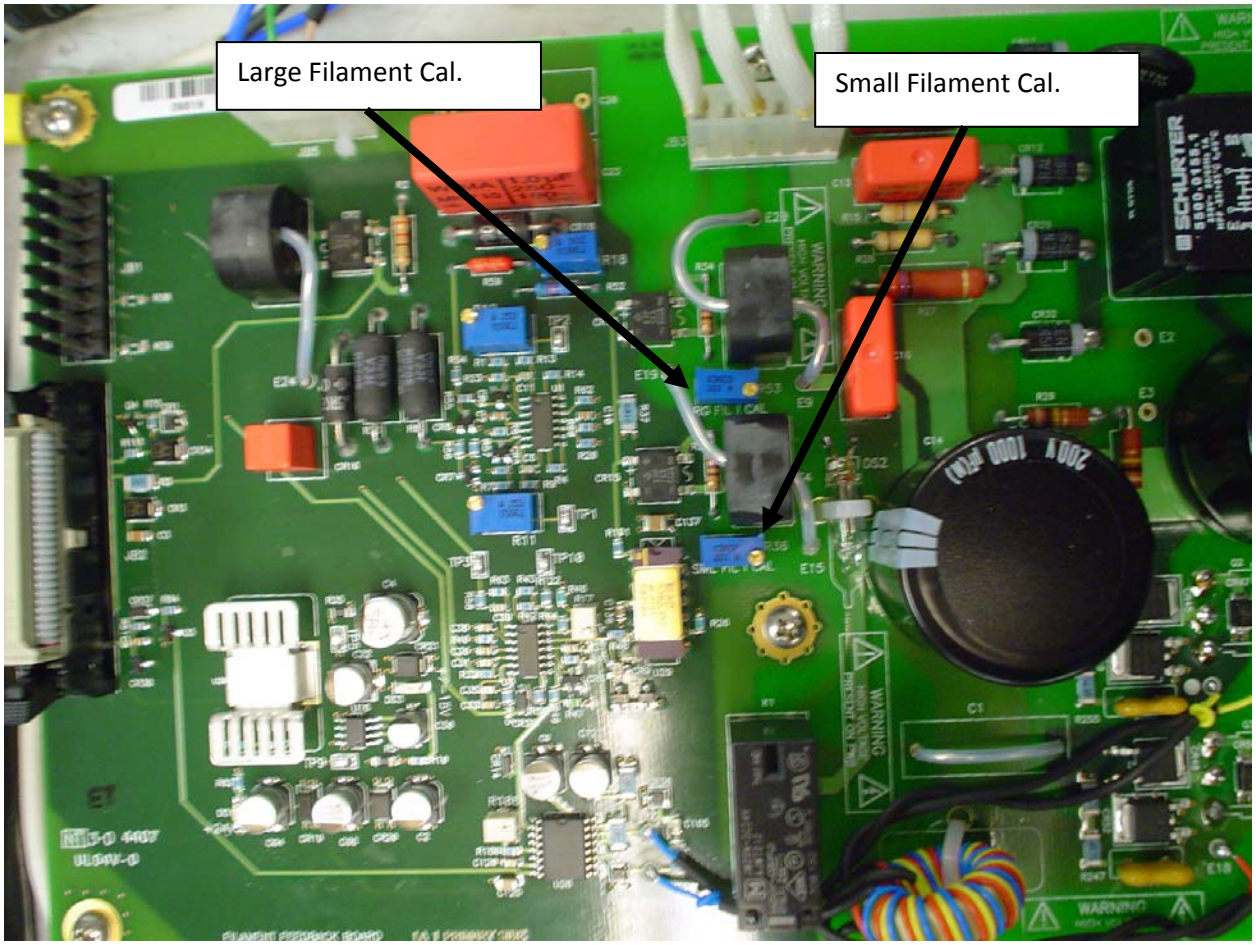
Test equipment required:
1=Measuring Adapter for high voltage socket
2= Measuring Adapter for high voltage cable plug
3= Digital Multimeter (set for DC Current 10 Amps Max.)



C=Common Connection, L= Large Filament Connection, S= Small Filament Connection



- Turn ON power to the HVPS with Aux Circuit Breaker CB2, Only
- The Main Circuit Breaker must remain OFF during this adjustment!
- Set filament pre-heat setting to Zero, with either RS-232 GUI or Analog Control
- Select Large Filament and Enable Filament.
- Set Max Limit Current for the Large Filament, with either RS-232 GUI or Analog Control
- Starting from zero current slowly increases filament large pre-heat setting and at the same time monitoring the actual current (from the digital multimeter). Never exceed maximum tube current!
- Increases actual filament current till 10% below the maximum filament current as specified in the tube data sheets.
- The actual filament current and the monitored current that is read by either GUI or Analog Control should be within 1% tol. If reading is not at spec, readjust R53 (LARGE FIL I CAL) on Filament/Feedback XRV PWB 460158-XXX.
- Turn off the filament.



The same procedure should be followed for the small filament by connecting digital miltimeter (3) in series with the small filament wire of measuring adapter (1) and small filament wire of measuring adapter (2) on the high voltage cable side. Small/Large Filament Current Calibration

- Turn off power to the HVPS via main Circuit Breaker
- Remove HV Cable from J1 socket from cathode generator if installed.
- Discharge cable by grounding the high voltage tip of cable to the power
- Supply chassis ground.
- Connect common wire of measuring adapter (1) to ground E1 of HVPS and also common of measuring adapter (2) of on the high voltage cable side.
- Connect small filament wire of measuring adapter (1) to small filament wire of measuring adapter (2)
- To measure DC current in large filament, connect digital multimeter(3) in series with the large filament wire of measuring adapter (1) and large filament wire of measuring adapter (2) on the high voltage cable side.
- Insert measuring adapter (1) into high voltage socket J1

- Set filament pre-heat setting to Zero, with either RS-232 GUI or Analog Control
- Set Max Limit Current for the Small Filament, with either RS-232 GUI or Analog Control
- Select Small Filament and turn the Filament ON.
- Starting from zero current slowly increases filament small pre-heat setting and at the same time monitoring the actual current (from the digital multimeter). Never exceed maximum tube current!
- Increases actual filament current till 10% below the maximum filament current as specified in the tube data sheets.
- The actual filament current and the monitored current that is read by either GUI or Analog Control should be within 1% tol. If reading is not at spec, readjust R36 (SMALL FIL I CAL) on Filament/Feedback XRV PWB 460158-XXX.
- Turn off the filament and Aux Circuit Breaker.

9. FIELD REPLACEABLE ITEMS

The following is a list of field replaceable items. These items, when determined to be faulty, can be replaced in the field.

Description	Drawing Ref	Qty	Spellman Part Number
HV Assembly, Cathode 160/320			407003-001
HV Assembly, Anode 160/320			407111-001
Inverter Module Assembly 160/320			407105-001
HV Transformer 160/320			407006-001
HV Assembly, Cathode 225/450			406996-001
HV Assembly, Anode 225/450			407108-001
Inverter Module Assembly 225/450			407000-001
HV Transformer 225/450			406999-001
System Control Board			460130-001
Front Panel LED Display			460124-001
24V LVPS			LLP-150-24
EMI Filter			10KE1

10. SCHEMATICS AND DRAWING LIST

Schematics and drawings are available upon request

DESCRIPTION	XRV160	XRV 225	XRV320	XRV450
System Diagram	441202-001	441204-001	441177-001	441178-001
Overall Drawing	407175-001	407181-001	407035-001	407034-001
Assembly Drawing Cathode Assembly Drawing Anode	407106-001 -	407118-001 -	407106-001 407110-001	407118-001 407098-001
Fil/FDBK Bd. Assy Cathode Fil/FDBK Bd. Assy ANODE	460158-001 -	460158-001 -	460158-001 460158-002	460158-001 460158-002
Fil/FDBK Bd. Schematic	441170-001	441170-001	441170-001	441170-001
Inverter Module Assembly	407105-001	407000-001	407105-001	407000-001
Power Inverter Bd. Assy	460156-002	460156-001	460156-002	460156-001
Power Inverter Bd, Sch.	441164-001	441164-001	441164-001	441164-001
System Control Assy	460130-001	460130-001	460130-001	460130-001
System Control Bd. Sch	441105-001	441105-001	441105-001	441105-001
Front Panel LED Display Assembly	460124-001	460124-001	460124-001	460124-001
Front Panel LED Display Schematic	340352-001	340352-001	340352-001	340352-001

SPELLMAN HIGH VOLTAGE ELECTRONICS

WARRANTY

Spellman High Voltage Electronics **("Spellman")** warrants that all power supplies it manufactures will be free from defects in materials and factory workmanship, and agrees to repair or replace, without charge, any power supply that under normal use, operating conditions and maintenance reveals during the warranty period a defect in materials or factory workmanship. The warranty period is twelve (12) months from the date of shipment of the power supply. With respect to standard SL power supplies (not customized) the warranty period is thirty-six (36) months from the date of shipment of the power supply.

This warranty does not apply to any power supply that has been:

- Disassembled, altered, tampered, repaired or worked on by persons unauthorized by **Spellman;**
- subjected to misuse, negligent handling, or accident not caused by the power supply;
- installed, connected, adjusted, or used other than in accordance with the original intended application and/or instructions furnished by **Spellman.**

THE FOREGOING WARRANTY IS IN LIEU OF ALL OTHER WARRANTIES, EXPRESS OR IMPLIED, INCLUDING THOSE OF MERCHANTABILITY OR FITNESS FOR A PARTICULAR PURPOSE.

The buyer's sole remedy for a claimed breach of this warranty, and **Spellman's** sole liability is limited, at **Spellman's** discretion, to a refund of the purchase price or the repair or replacement of the power supply at **Spellman's** cost. The buyer will be responsible for shipping charges to and from **Spellman's** plant. The buyer will not be entitled to make claim for, or recover, any anticipatory profits, or incidental, special or consequential damages resulting from, or in any way relating to, an alleged breach of this warranty.

No modification, amendment, supplement, addition, or other variation of this warranty will be binding unless it is set forth in a written instrument signed by an authorized officer of **Spellman.**

Factory Service Procedures

For an authorization to ship contact **Spellman's** Customer Service Department. Please state the model and serial numbers, which are on the plate on the rear panel of the power supply and the reason for return. A Return Material Authorization Code Number (RMA number) is needed from **Spellman** for all returns. The RMA number should be marked clearly on the outside of the shipping container. Packages received without an RMA Number may delay return of the product. The buyer shall pay shipping costs to and from **Spellman**. Customer Service will provide the Standard Cost for out-of-warranty repairs. A purchase order for this amount is requested upon issuance of the RMA Number (in-warranty returns must also be accompanied by a "zero-value" purchase order). A more detailed estimate may be made when the power supply is received at **Spellman.** In the event that the cost of the actual repair exceeds the estimate, **Spellman** will contact the customer to authorize the repair.

Factory Service Warranty

Spellman will warrant for three (3) months or balance of product warranty, whichever is longer, the repaired assembly/part/unit. If the same problem shall occur within this warranty period **Spellman** shall undertake all the work to rectify the problem with no charge and/or cost to the buyer. Should the cause of the problem be proven to have a source different from the one that has caused the previous problem and/or negligence of the buyer, **Spellman** will be entitled to be paid for the repair.

Spellman Worldwide Service Centers

For a complete listing of Spellman's Global Service facilities please go to:
http://www.spellmanhv.com/customerservice/service.asp