Spellman®
High Voltage Electronics Corporation

Instruction Manual

High Voltage Power Supply

MODEL :
SERIAL# :
DATE :

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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 HOCHSPANNNUNGSNETZTEIL 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)

JB1 Main AC Input

JB2 Main AC Output Anode (Bipolar)

J6 Anode Feedback (Bipolar)

J7 Anode Inverter Control (Bipolar)

User I/O Connections

Ground Stud

J1 High-Voltage connector
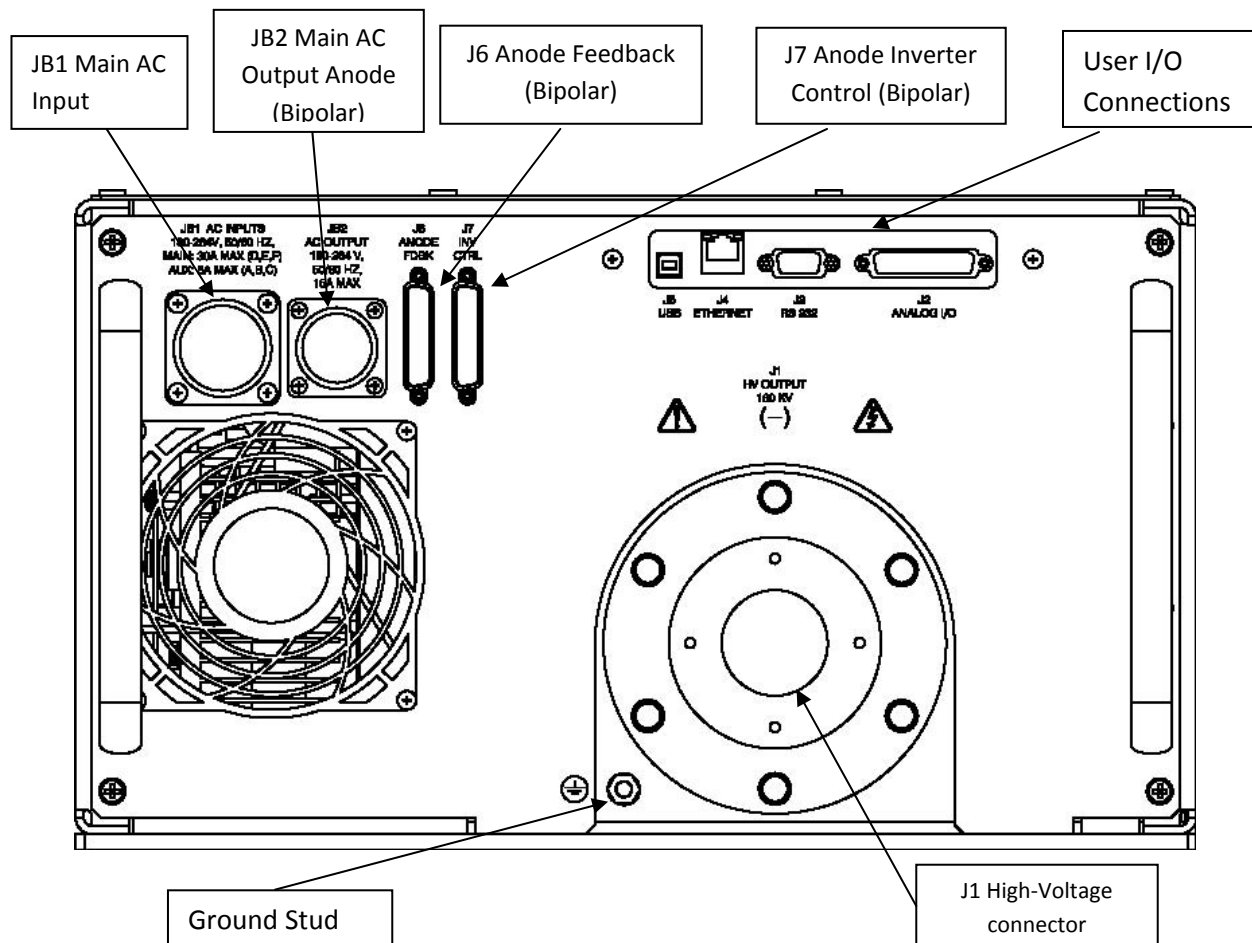
XRV 160kV Cathode

4.2.   Overview of the Connections (Anode 160kV)

AC Input
JB1

J2 Feedback

J3 Inverter
Control

JB1
AC INPUT
180-254 V
50/60 HZ
15A MAX

J2
ANODE
FDBK

J3
INV
CTRL

J1
HV OUTPUT
160 KV
(+)

Ground Stud

J1 High-Voltage
connector
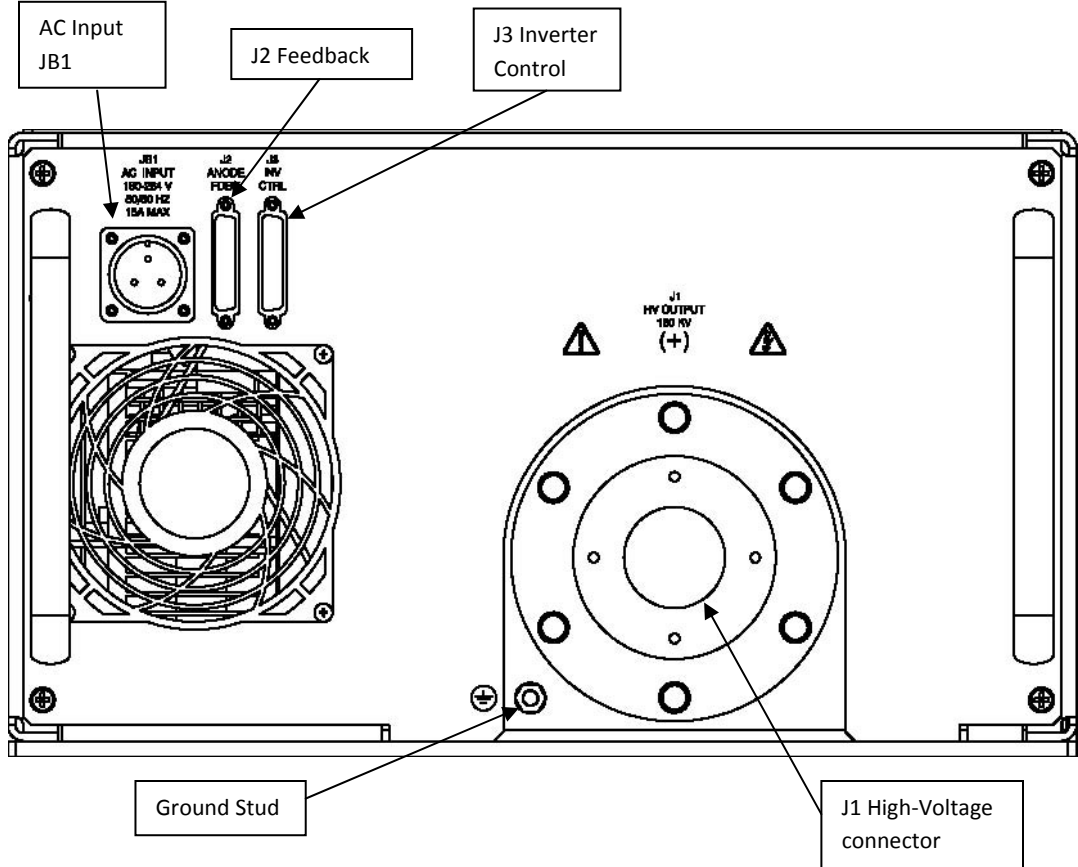
XRV 160kV Anode

4.3. Overview of the Connections (Cathode 225kV)

JB2 Main AC Output Anode (Bipolar)

JB1 Main AC Input

J6 Feedback (Bipolar)

J7 Inverter Control (Bipolar)

User I/O Connections

Ground Stud

J1 High-Voltage connector
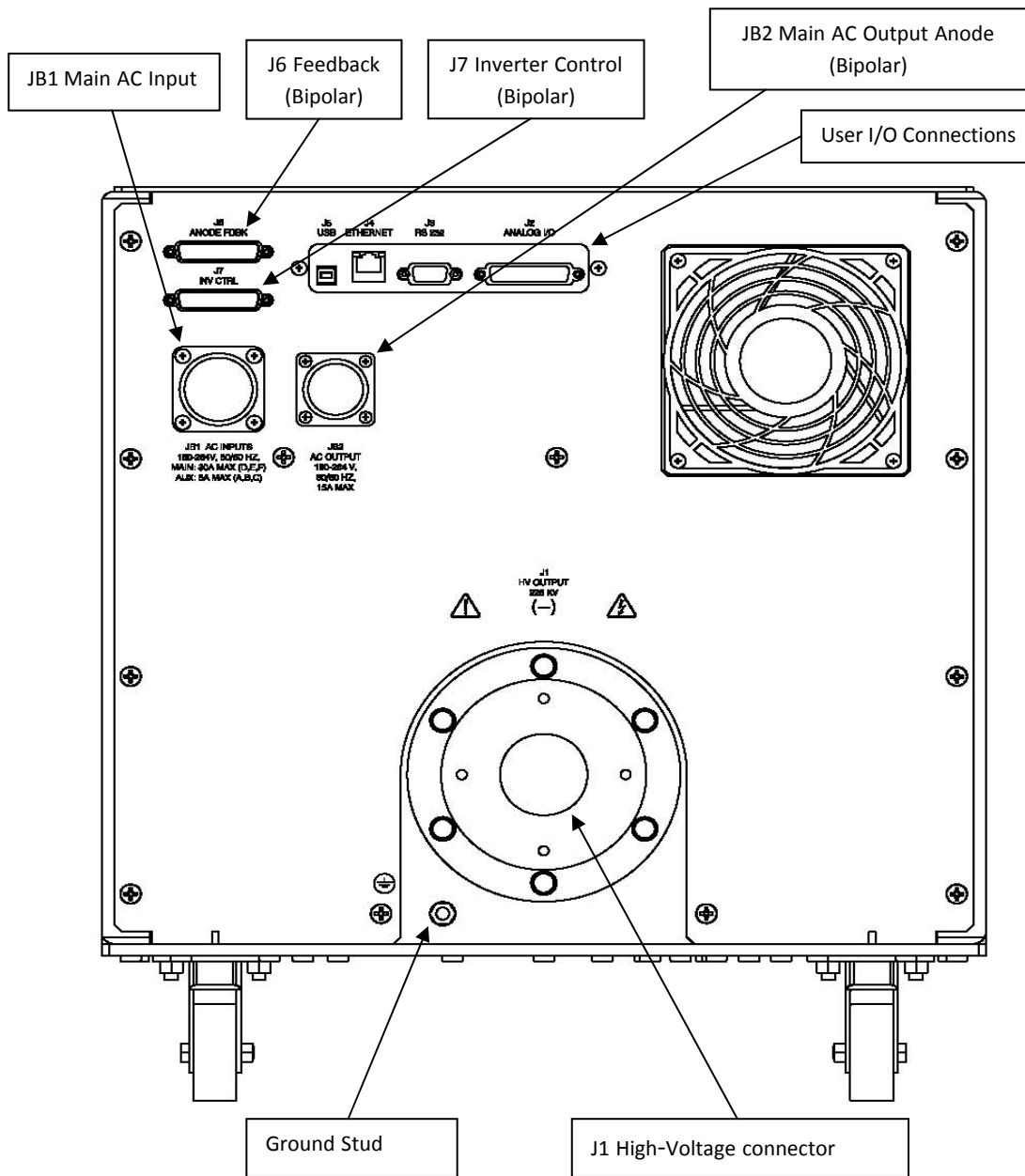
XRV 225kV Cathode

4.4.   Overview of the Connections (Anode 225kV)
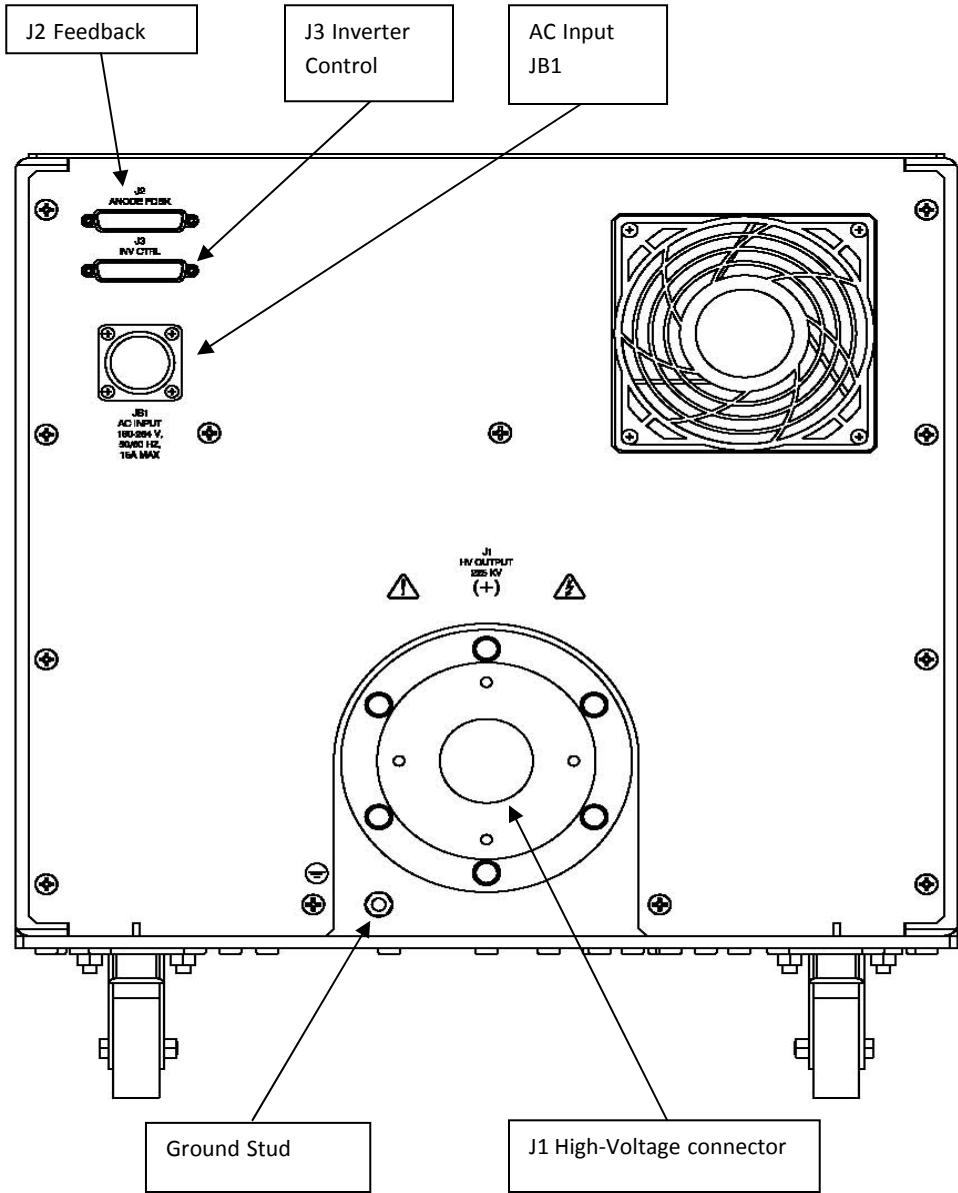
XRV 225kV Anode

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)
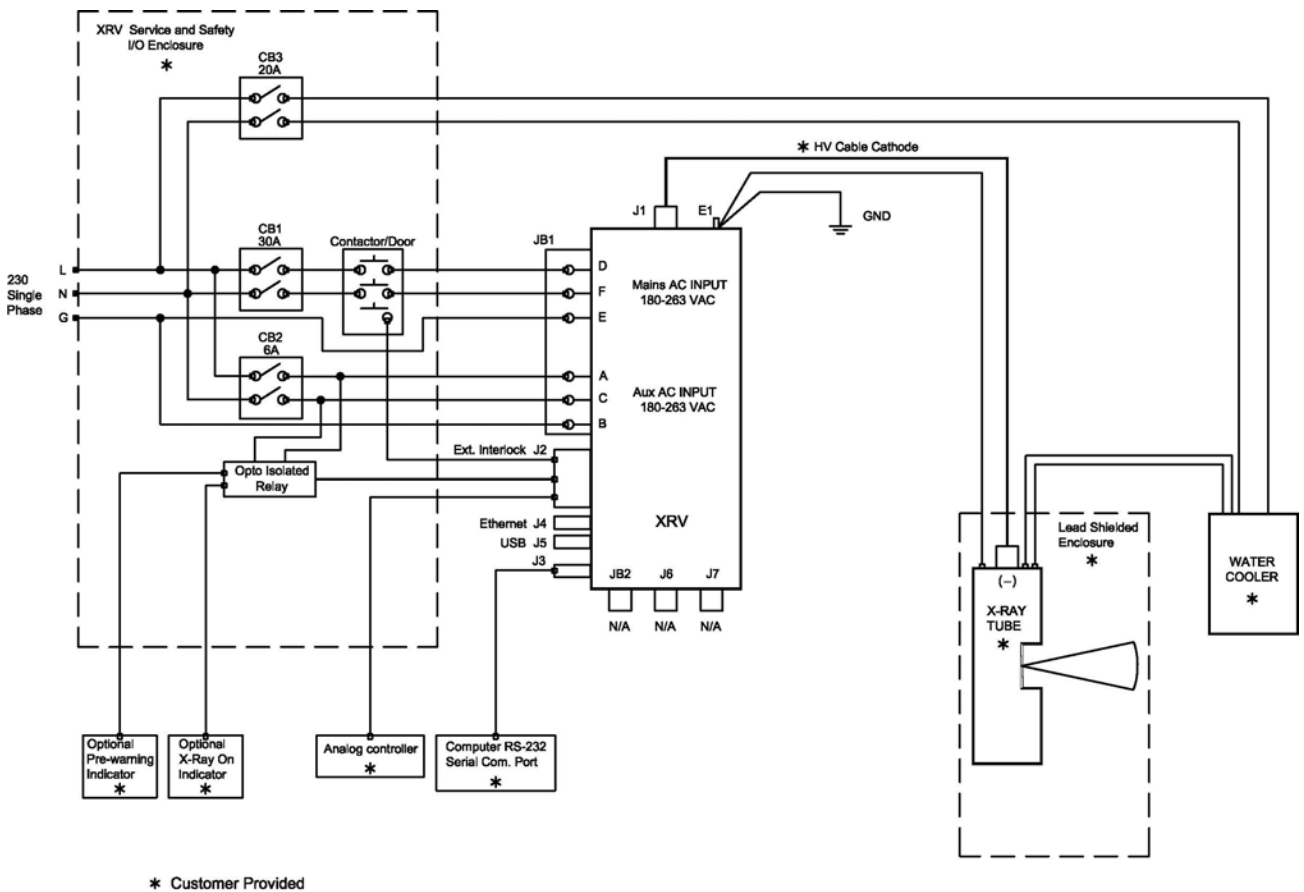
4.10. System Interconnections and Setup (Bi-Polar)
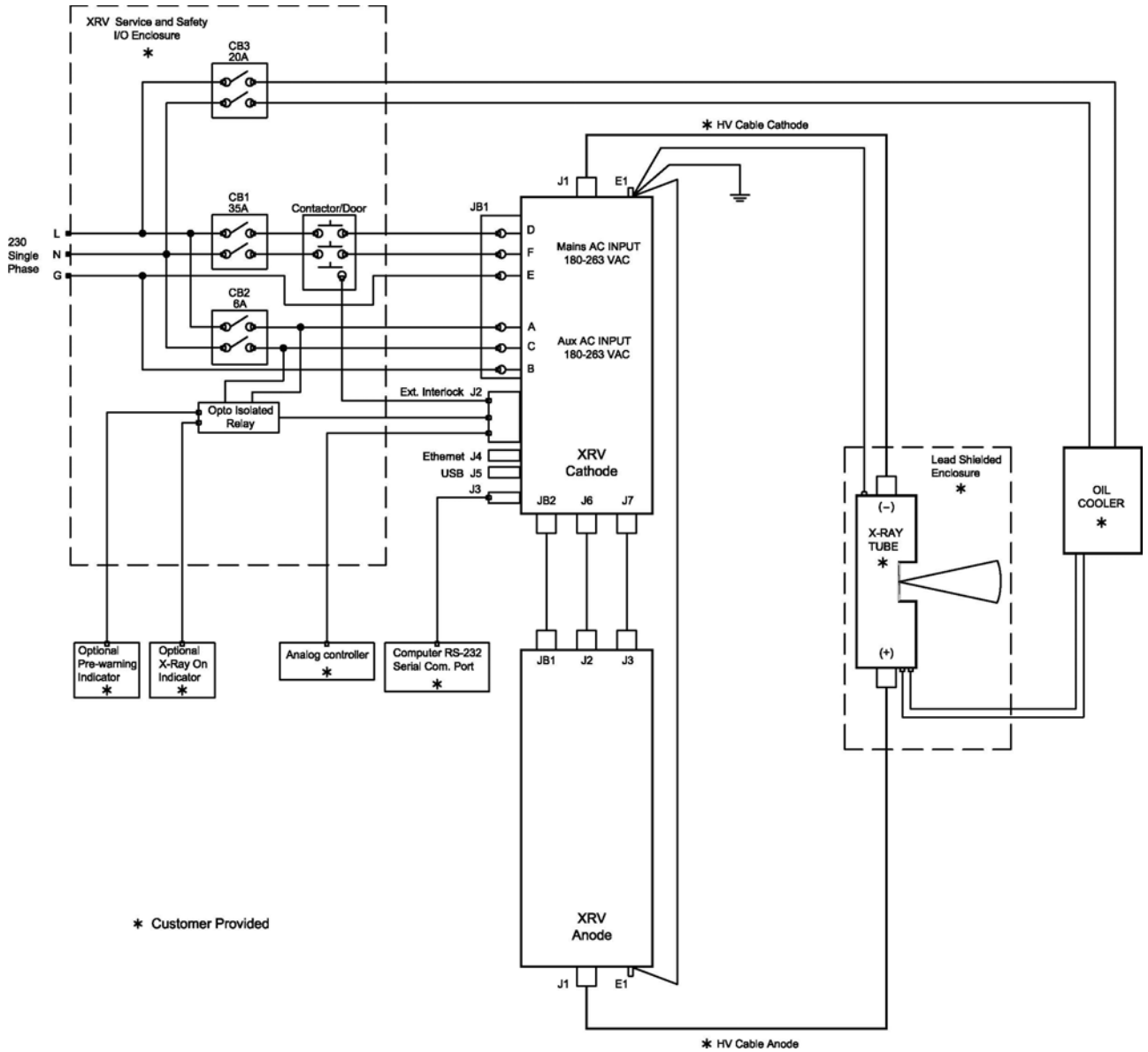
4.11. HV Connector – J1

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

HIGH–VOLTAGE CONNECTOR WIRING

FILAMENT SMALL

FILAMENT LARGE

FILAMENT COMMON
AND CATHODE
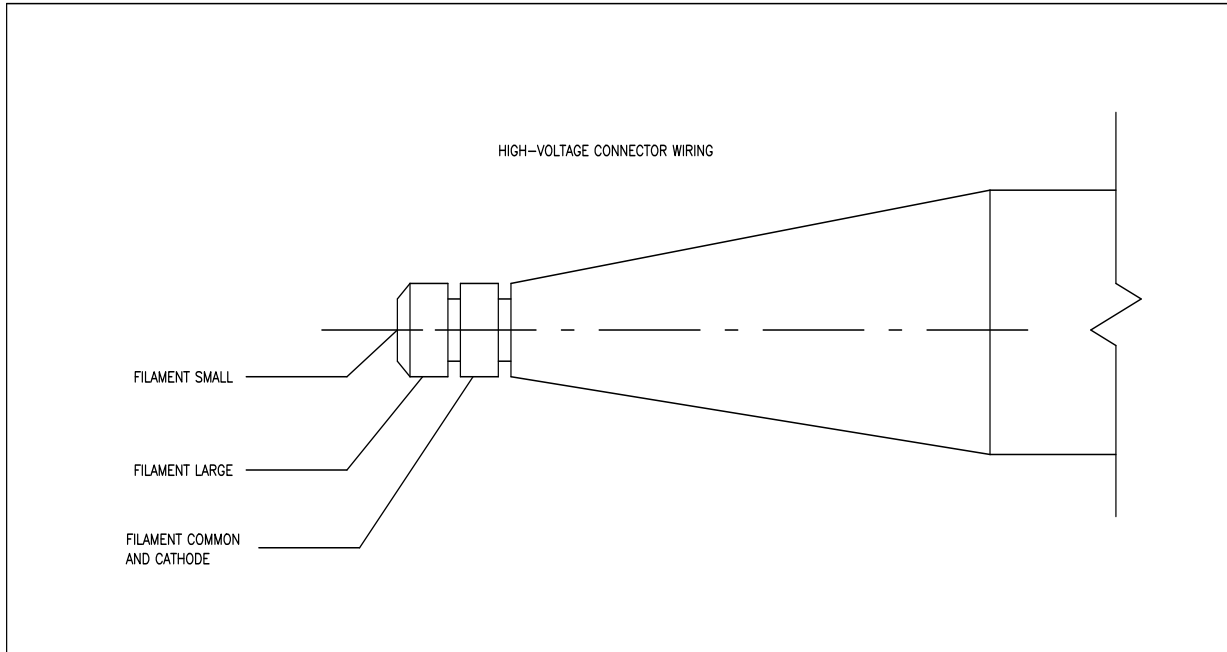
4.12. HV Cable installation instructions:

- 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.

Silicone Compound Area

Mounting Flange

Tip
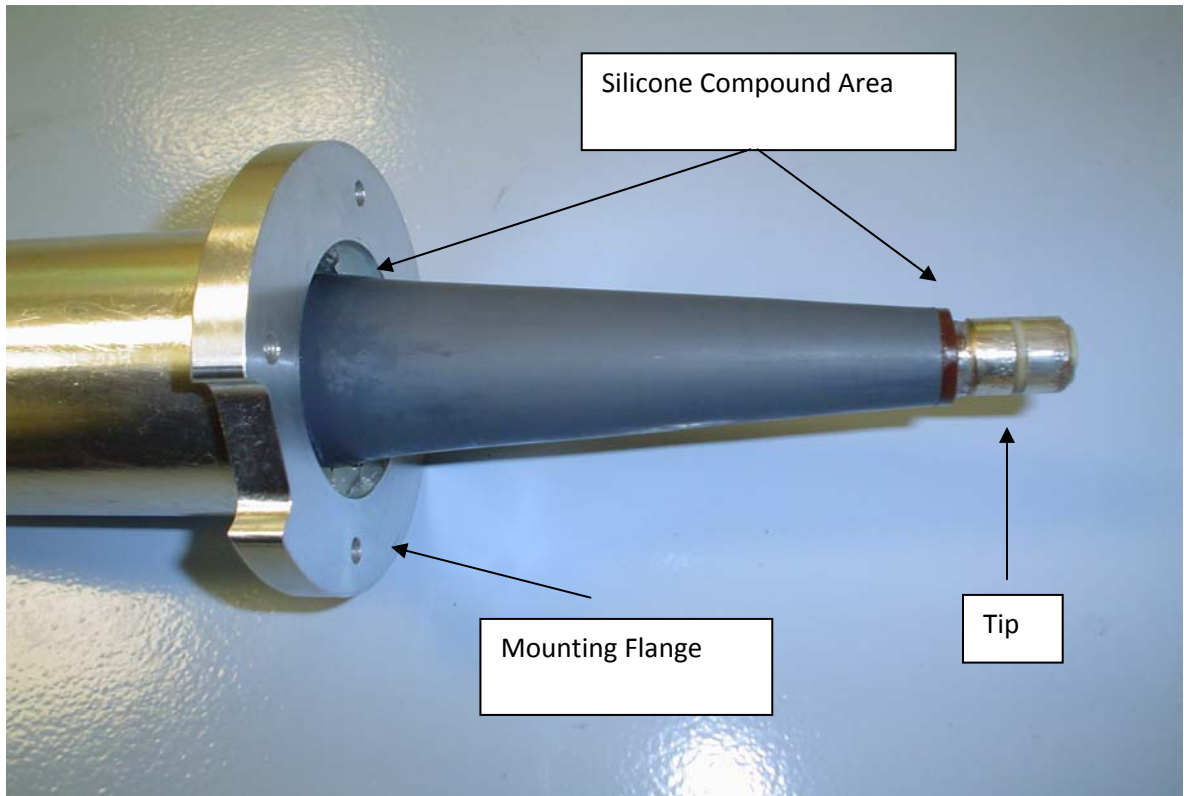
5. USER INTERFACE AND CONTROL

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.
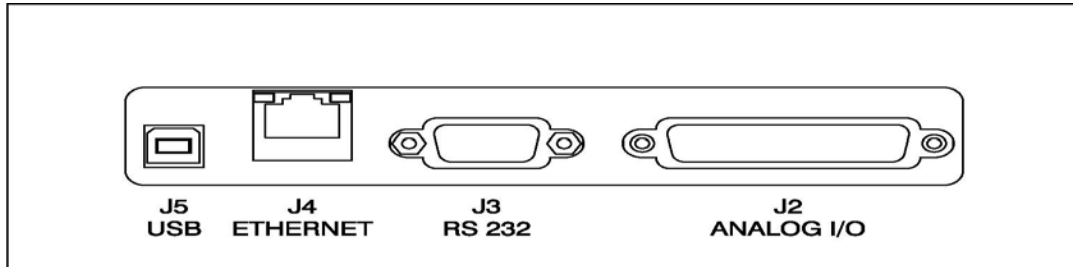
5.1. Computer Interface

5.1.1. RS-232 Digital Interface – J3, 9 pin D, female connector
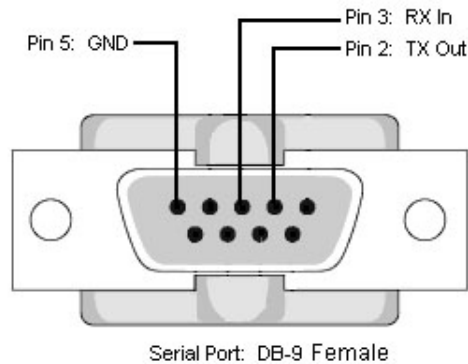
Pin	Signal	Parameters
1	NC	
2	TX out	Receive data (user)
3	RX in	Transmit data (user)
4	NC	
5	SGND	Ground
6	NC	
7	NC	
8	NC	
9	NC	

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.

LED 1 ←————→   ←————— **LED 2**

8 7 6 5 4 3 2 1
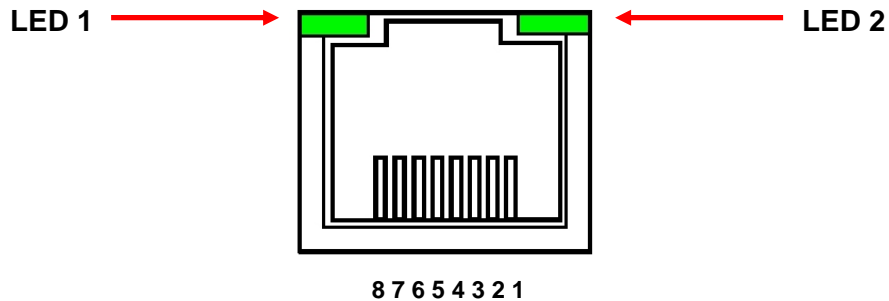
The Ethernet RJ-45 has two LED indicators, as shown in Figure 5. The left LED, LED1 indicates that the network processor has a valid network link. The right LED, LED2 indicates network activity.

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
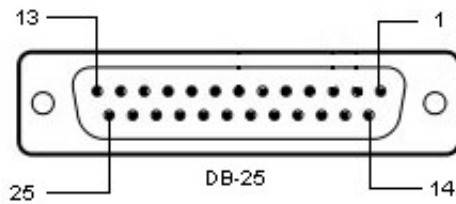
See Data Sheet for Pin Out

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

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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
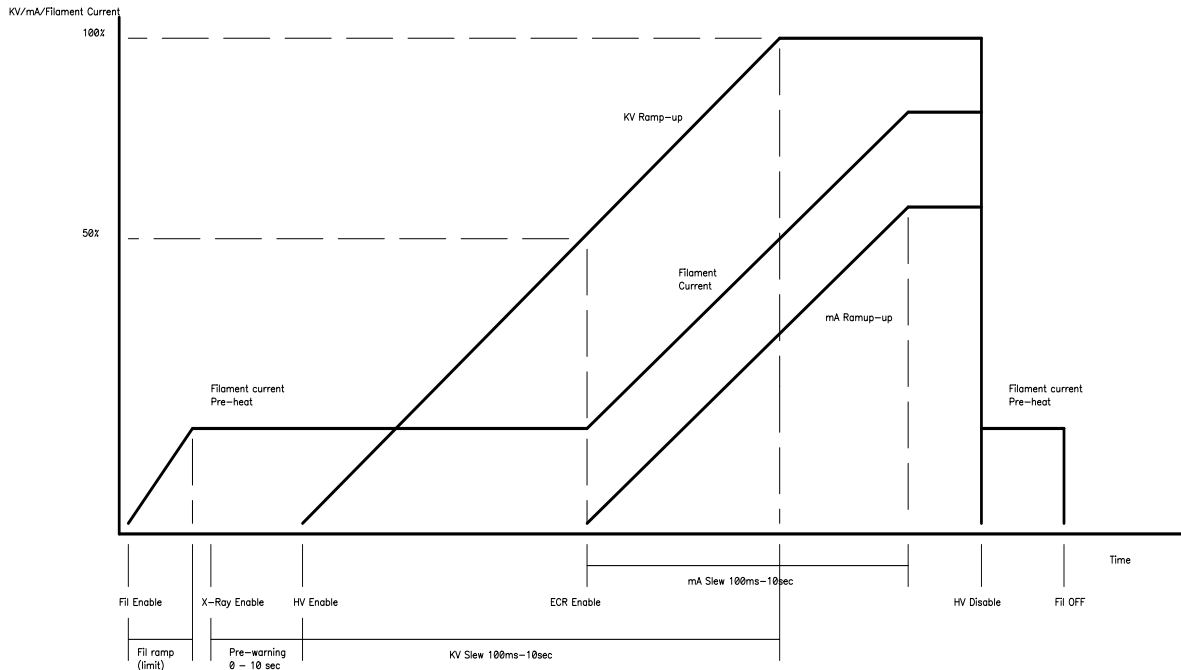
6.2.5.   ARC Counter, ARC Fault

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)
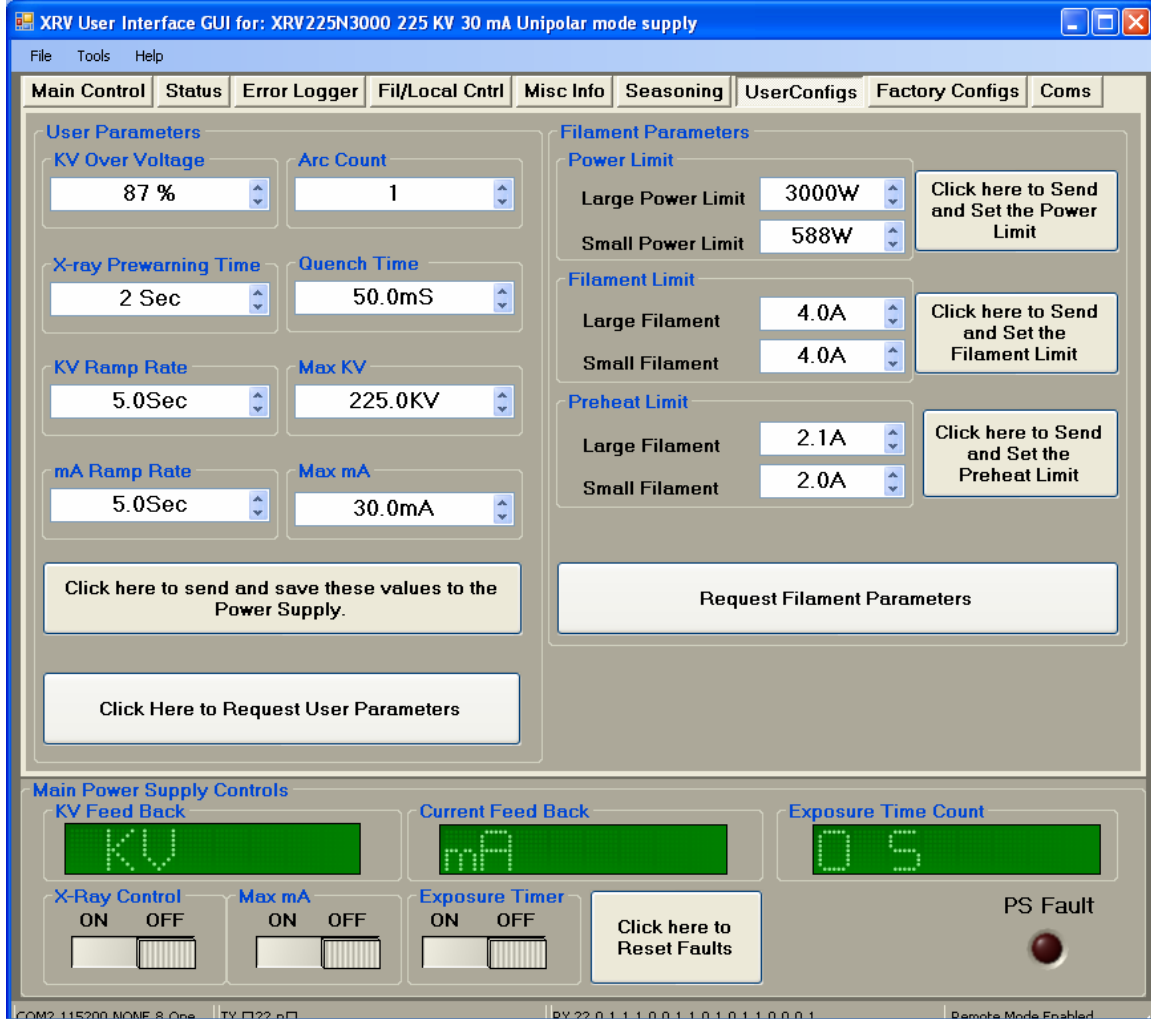
User Parameters

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.
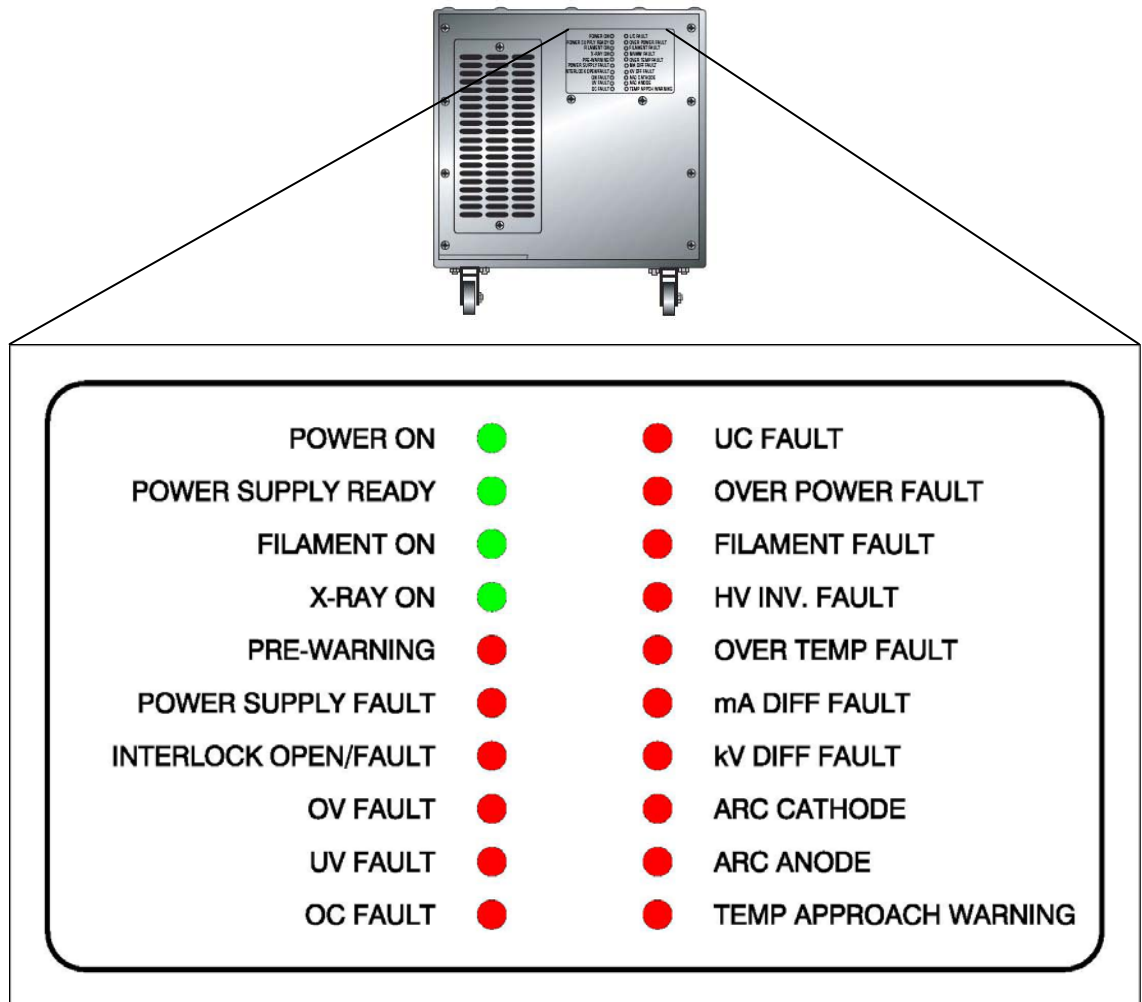
8.2.2.   Front Panel LED Summary

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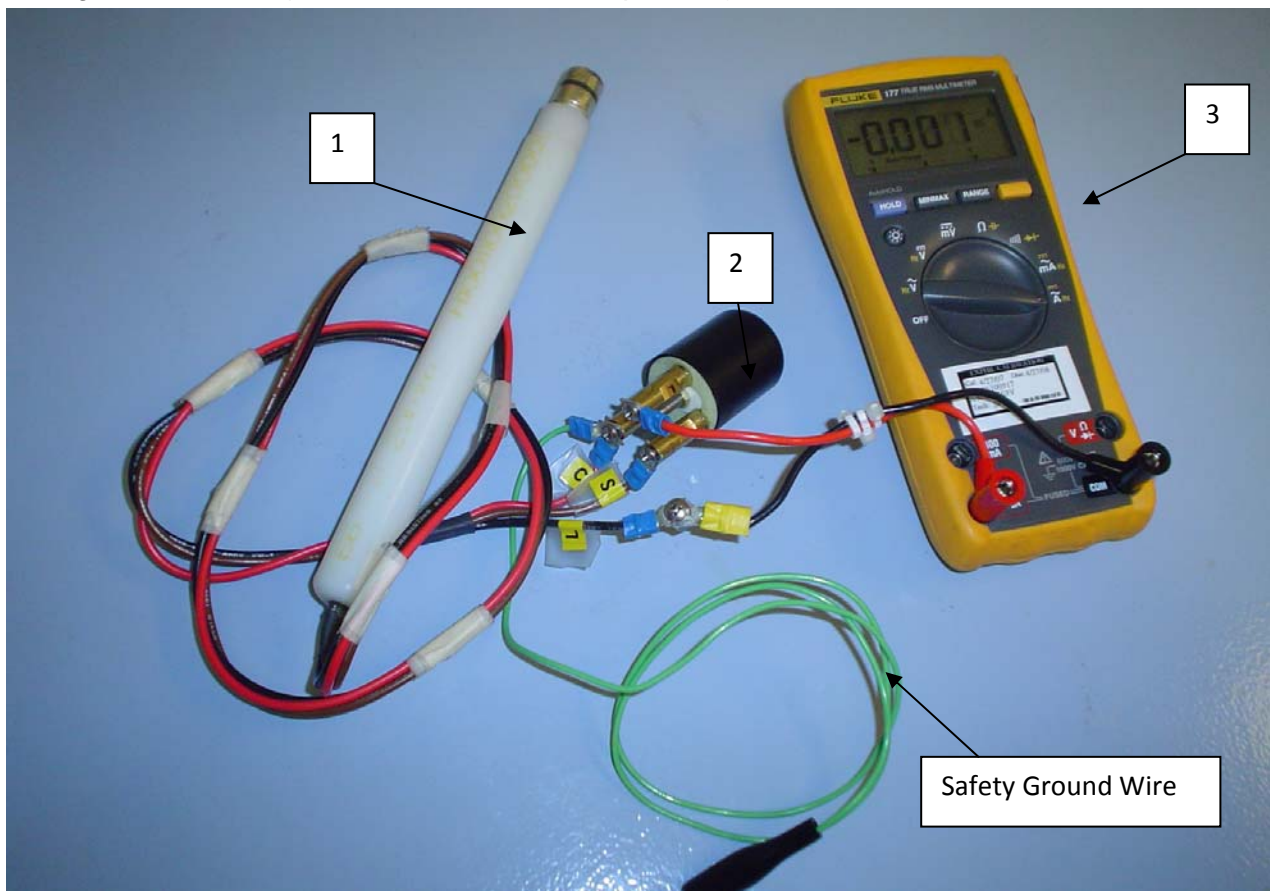
C=Common Connection, L= Large Filament Connection, S= Small Filament Connection

Connect Safety Ground to E1 GND Stud
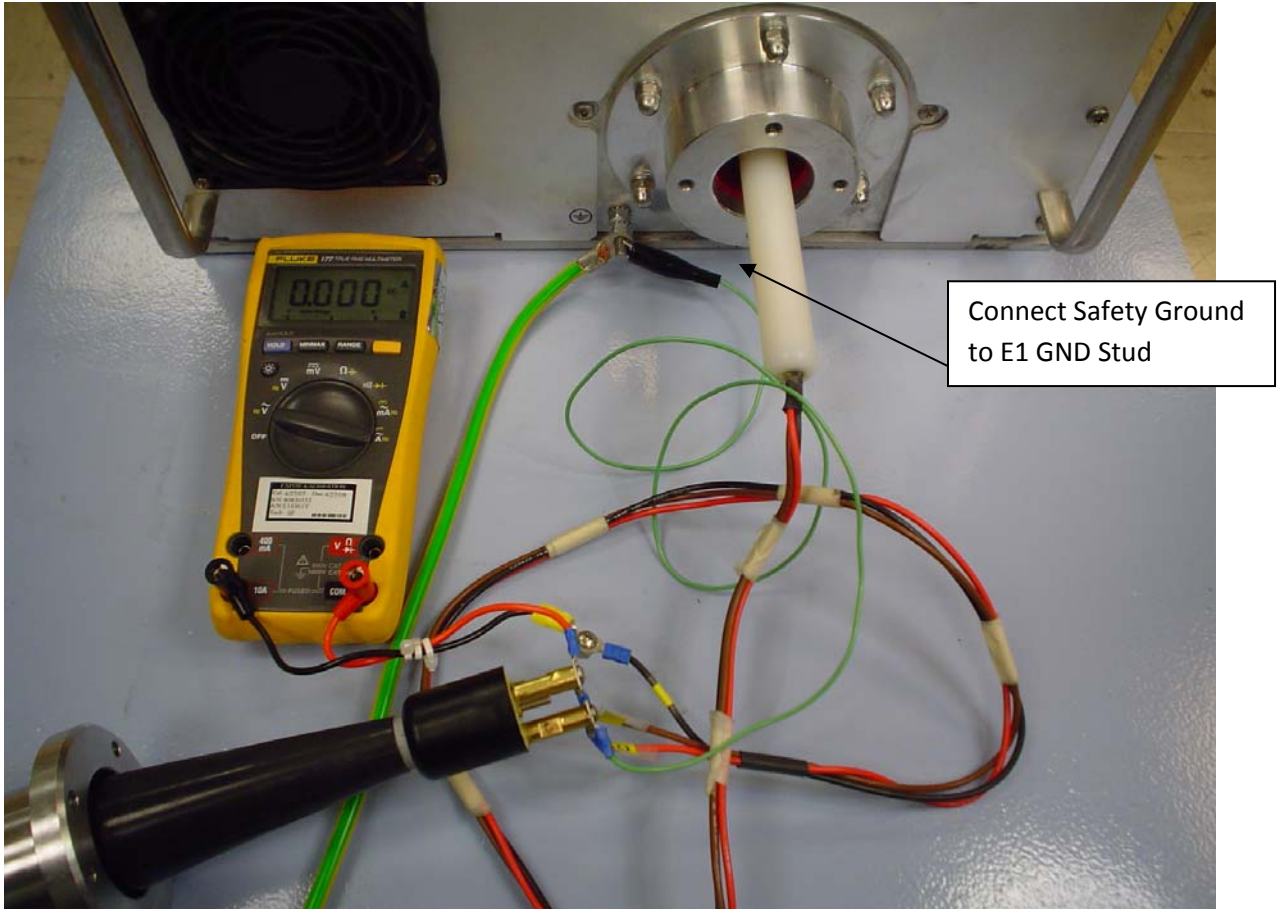
- Turn ON power to the HVPS with Aux Circuit Breaker CB2, Only
- The Main Circuit Breaker must remain OFF during this adjustment!
- Set filament pre-heat setting to Zero, with either RS-232 GUI or Analog Control
- Select Large Filament and Enable Filament.
- Set Max Limit Current for the Large Filament, 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.

Large Filament Cal.
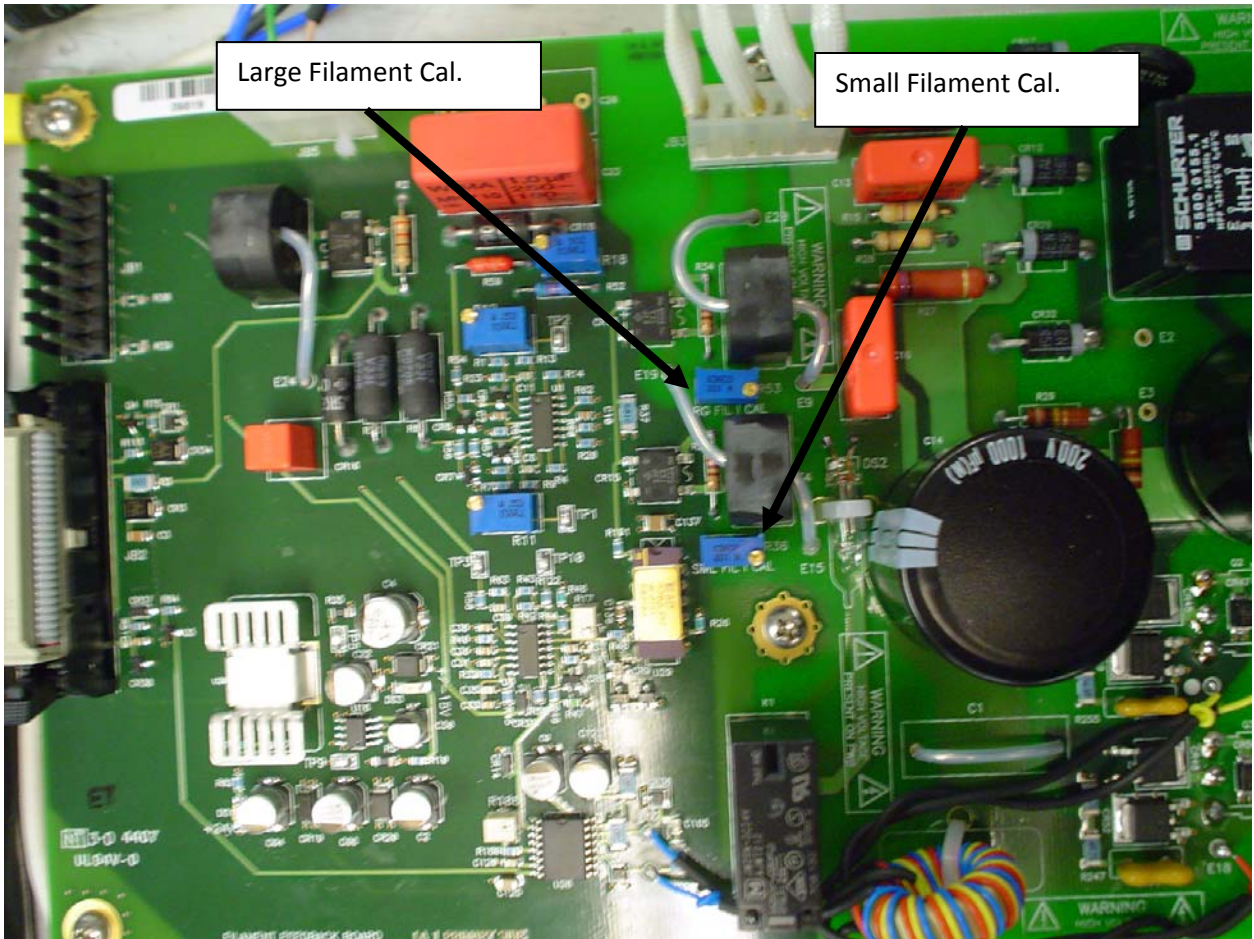
Small Filament Cal.

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	407106-001	407118-001	407106-001	407118-001
Assembly Drawing Anode	-	-	407110-001	407098-001
Fil/FDBK Bd. Assy Cathode	460158-001	460158-001	460158-001	460158-001
Fil/FDBK Bd. Assy ANODE	-	-	460158-002	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

To obtain information on Spellman's product warranty please visit our website at:

http://www.spellmanhv.com/en/About/Warranty.aspx

XRV Digital Interface Manual:
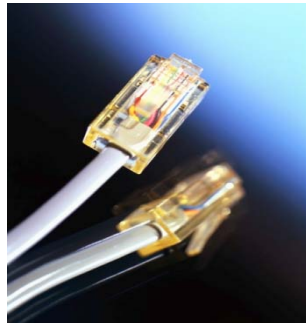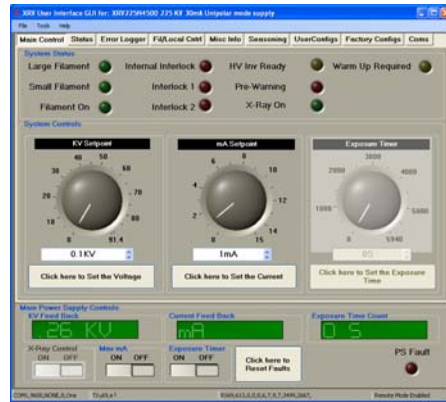
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XRV DIGITAL INTERFACE MANUAL   118156-001   REV A

Document Revision Information		
Description	**Rev**	**Date**
Initial Document Creation	1.0	August 15, 2008
Revised	2.0	November 7, 2012
Corrections made to commands 22 and 68 in RS232 mode	3.0	August 7, 2013
Removed command 61. It is improperly coded in Firmware Removed command 55. It is not a real interlock	4.0	March, 2014
Modified command 38 to agree with firmware	5.0	May, 2014
Removed command 62 because improperly coded in Firmware.	6.0	Nov. 07, 2014
Added 4.1 section to clarify communication method	7.0	March 12, 2015
Clarifications made to Section 7.0 - Scaling Factors.	8.0	July 23, 2015
Correction made to Command 99 (Remote/local mode)	9.0	September, 2015

Table of Contents

1. SCOPE

This document applies to the XRV Standard Platform from Spellman High Voltage, assembly 460-130-XXX. Information pertaining to the communications protocol, XRV hardware and Software will be provided. Software snippets will also be provided using C# Visual Studio 2005 IDE.

*Note- Software snippets are provided as a guideline only! It is the end users responsibility to develop a robust communications application. However these snippets can be used to provide a foundation.

2. Functional Description

The standard XRV power supply logic is powered by the embedded control board which uses a state of the art Digital Signal Processors (DSP) in conjunction with a Field Programmable Gate Array (FPGA).

3. Communication Interfaces

The following section describes the various communications interfaces available on all standard XRV products. The XRV control board provides interfaces via the following standard communication interfaces:

- Serial (configurable up to speeds of 115200 via firmware selection)
- Ethernet
- USB

3.1 RS-232 Interface

The RS-232 interface has the following attributes:

- 115K bits/second (Default, can be changed to accommodate slower communications)
- No Parity
- 8 Data Bits
- 1 Stop Bit
- No Hand shaking
- DB-9 Connector as Shown
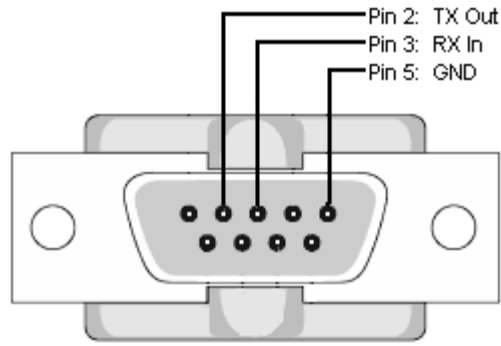
Figure 1- RS-232 Female Connector on XRV Control Board

3.2 RS-232 Cabling-

A standard RS-232 cable where line 2 is connected straight through to pin 2 and 3 line is connected straight through to line 3. Please refer to the following chart.

PC to XRV Board Cable Details	
PC Connector (DB-9 Male)	XRV Connector (DB-9 Female)
Pin 2: TX Out	Pin 2: TX In
Pin 3: RX In	Pin 3: RX Out
Pin 5: Ground	Pin 5: Ground

3.3 Ethernet Interface

The Ethernet interface has the following attributes:
- 10-Base-T (rev A-B), 10/100-Base-T (Rev E 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 Systems: Windows 98 2ED, Windows 2000 (SP2), Windows NT (SP6), Windows XP Professional
- LED1 indicates that the network processor has a valid network link
- LED2 indicates network activity.

LED 1 ⟶   ⟵ **LED 2**

8 7 6 5 4 3 2 1
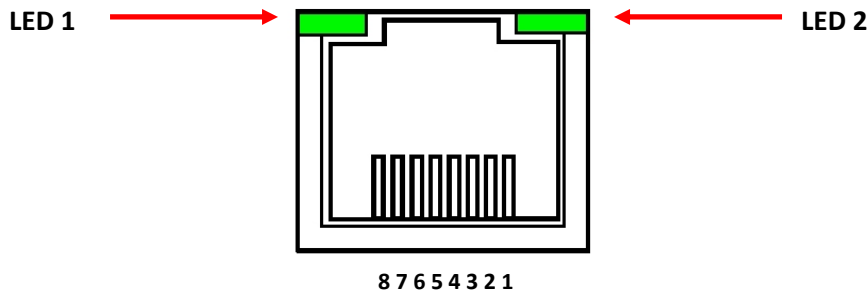
Figure 2- Ethernet RJ45 Jack (Front View)

PIN	DESCRIPTION
1	TX+
2	TX-
3	RX+
4	-
5	-
6	RX-
7	-
8	-

Figure 3- Ethernet Functional Pin Description

3.4 Ethernet Cabling-

Category 5 (CAT5) Ethernet patch cables are used to connect the XRV to the host computer. There are two ways to connect to the XRV board via Ethernet: the first is to directly cable between the host and the XRV board and the second is through the use of a switch, hub, or network. The following figures depict a direct (Non-standard) and standard CAT cable respectively.
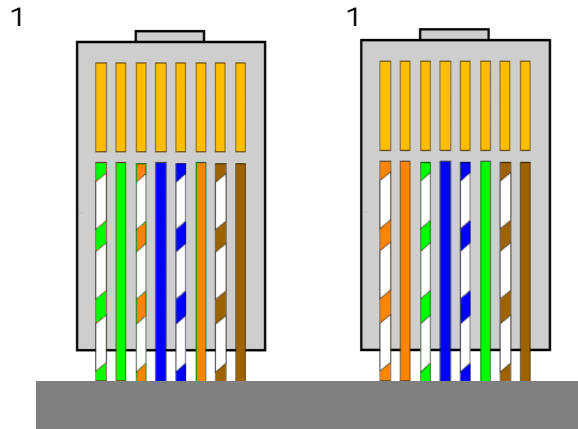
Figure 4- Crossover Cable for a Direct Connection

A standard connection through a hub, switch, or network uses a standard CAT5 patch cable. Please refer to the two cable ends shown below.
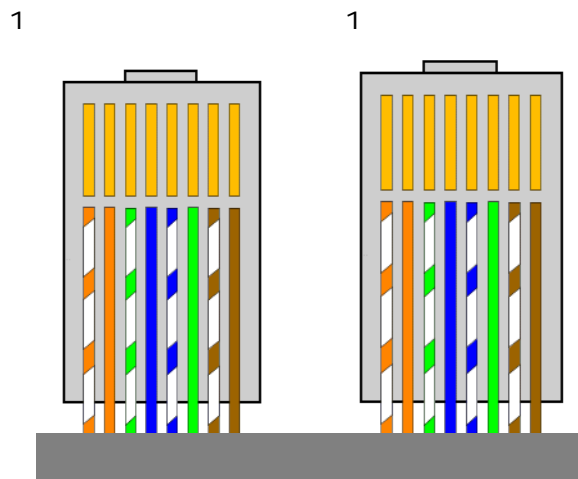
Figure 5- Standard CAT 5 Patch Cable

3.5 USB Interface

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

Figure 6- USB Type B (Front View)

PIN	DESCRIPTION
1	Vbus +5V
2	D-
3	D+
4	Ground

Figure 7- USB Functional Pin Description

3.6 USB Cabling

A high-quality double shielded USB 2.0 Type A to B (host to slave) cable should be used in all applications. This type of cable is a standard PC to peripheral cable that utilizes full-size connectors.

Figure 8- USB A to B Cable

3.7 HIGH EMI Environments

If the XRV USB interface is being used in a high-EMI environment, ferrites should be added to the USB cable. Figure 10 illustrates the possible combinations of ferrites that can be used to achieve acceptable operation under these conditions.

The XRV should be controlled from a host interface which is compliant with Annex A of EN 61326-1. Proper attention to cable locations is the responsibility of the installer.
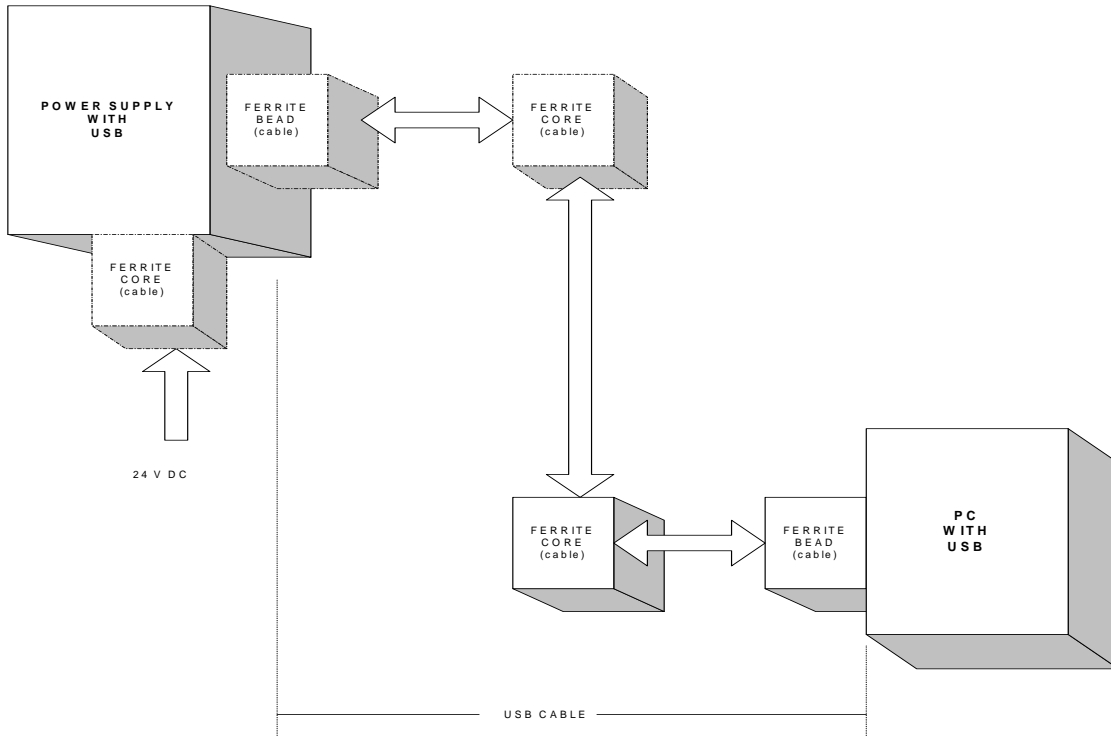
Figure 9- Block Diagram of USB Cable Utilizing Ferrites

Ferrite beads should be attached to the USB cable next to the connectors – both sides should be installed. In extreme cases ferrite cores may be added where the cable is looped 3 or 4 times around the core as shown in figure 11. Cores of 1.5 to 2 inches should be used at both ends of the cable. In addition, a ferrite core may be required on the 24VDC input.

Figure 10- Example of a USB Cable Using Ferrites

Please refer to the USB Interface Setup section, for an explanation of how USB works and why EMI may present a problem for this communications interface.

4. Getting Started with Communications Software

The following sections detail how to communicate with the XRV Power Supply using Visual Studio's C# platform. Please note that these code snippets are provided as an example only and are to be used as a general guide line and in no way to be considered a complete program.

4.1 Some important information before you begin

Using either USB, Serial or Ethernet communications, Spellman recommends employing a "Send one, Get one" communication style. Below is an example:

1. Send one message
2. Wait for reply. The unit typically replies within 10 m-seconds. A maximum timeout period of 50 m-seconds is recommended.
3. Delay 125 m-seconds before the next command is sent.
4. Send next message.

The XRV was designed to support only Half Duplex Communications. The XRV doesn't buffer new messages while still processing another message.

Warning * - Sending more than one command at a time before receiving a response to the previous command will cause the previous command to be dropped.

The XRV Power supply behaves as a slave device. It only responds to commands sent by the Host and it never initiates a communication session. The XRV acknowledges every message received by sending a message back even if has no data to send. If the message was decoded successfully, the $ character is sent back. If the message was not received correctly, an error message will be sent back.

4.2 RS-232 Communications

The RS-232 interface makes use of a standard 'command/response' communications protocol. See section 6.0 for the syntax of the serial interface protocol.

All software that addresses the RS-232 interface must adhere to the following parameters:

- 115K bits per second
- No Parity
- 8 Data Bits
- 1 Stop Bit
- No handshaking

4.2.1 Enabling RS-232 Communications Objects in Visual Studio C#)

- Add communications support via RS-232 by first adding the Serial Port Component to the project via the following steps: Right click in the toolbox area in the Visual Studio C# IDE.
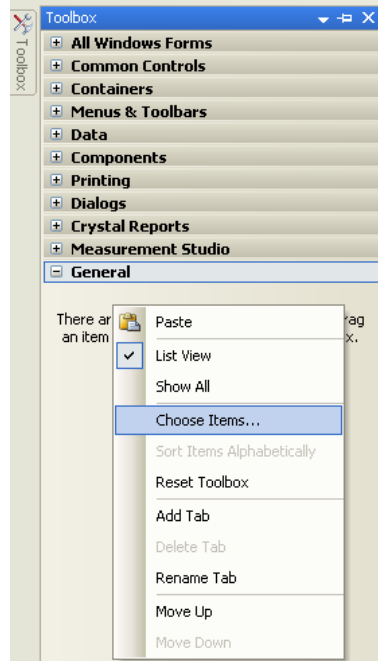
- Select "Choose Items".
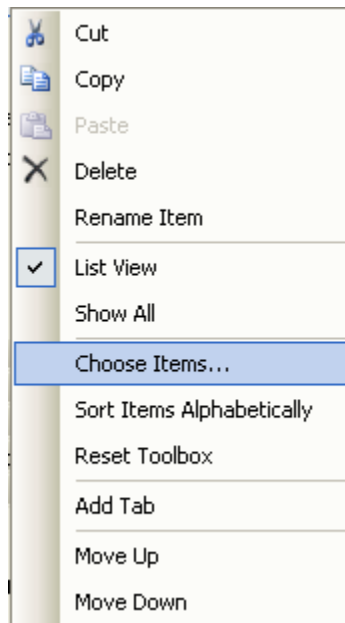
- Navigate to "Serial Port" in the .Net Framework Components List and place a checkmark next to that option.
- Click "OK"
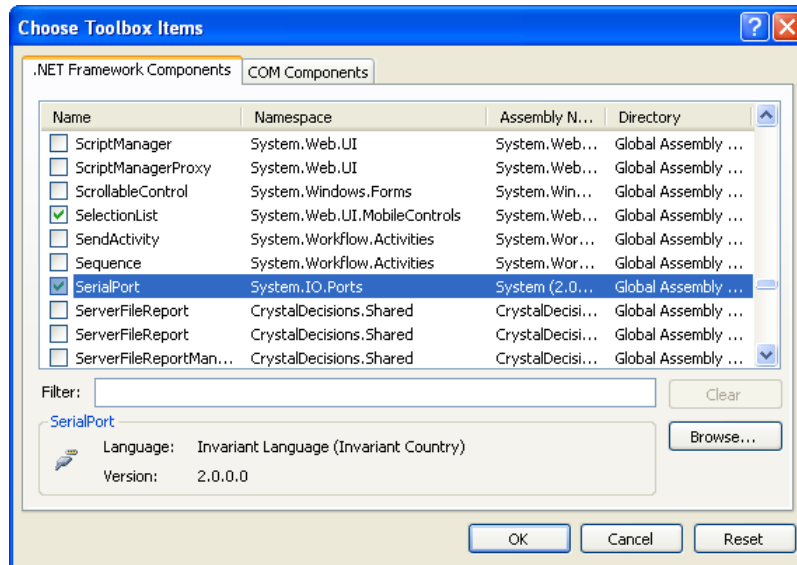
- Once these steps have been completed, the Serial Port communications component will be available.
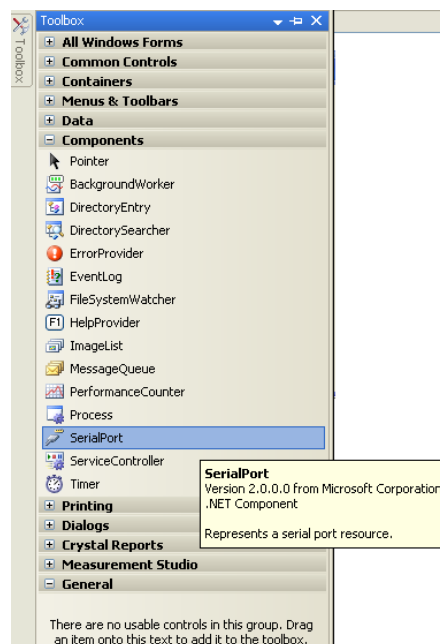
- Drag and drop the Serial Port component on to your windows Form.
- Right Click on the newly added component and Select "Properties".

- For initial Use configure the Comport with the following Attributes:
  - 115200 Baud
  - 8 Data Bits
  - 1 Stop Bit
  - No Parity

Properties	▾ 📌 ✕
serialPort1 System.IO.Ports.SerialPort	▾
⊞ (ApplicationSettings)	
(Name)	**serialPort1**
BaudRate	**115200**
DataBits	8
DiscardNull	False
DtrEnable	False
GenerateMember	True
Handshake	None
Modifiers	**Public**
Parity	None
ParityReplace	63
PortName	COM1
ReadBufferSize	4096
ReadTimeout	**200**
ReceivedBytesThreshold	1
RtsEnable	False
StopBits	One
WriteBufferSize	2048
WriteTimeout	-1

4.2.2 Code for Opening the RS-232 Comport

```csharp
                        //Section 1 //
    if (serialPort1 == null)
    {
        serialPort1 = new SerialPort();
    }
    else if (serialPort1.IsOpen == true)
    {
        serialPort1.Close();
    }
                    //Section 2 //
    serialPort1.PortName = COM1;
    serialPort1.DataBits = 8;
    serialPort1.BaudRate = 115200;
    serialPort1.Parity = Parity.None;
    serialPort1.StopBits = StopBits.One;


                     //Section 3 //
    try
    {
        if (serialPort1.IsOpen == true)
        {
            serialPort1.Close();
        }
        serialPort1.Open();
    }
    catch (Exception oex)
    {
        MessageBox.Show(oex.ToString());
    }
```

Code Block Description

Section 1-
Determines if a serialPort1 instance has allready been instantiated. If it hasn't it instatiates it however if one has allready been instantiated and the port is open it closes it to prevent comport errors.

Section 2-
Sets the appropriate serial communications settings (Com1, 115200 Baud, 8 databits, 1 Stop bit, No Parity).

Section 3-
An attempt or "try" is made to open the communcations port. If no that port isnt currently open then it opens it. However if it is it will terminate it and reopen it. If however an exception occurs this will be caught by the "catch" statement and the user will be alerted to this.

4.2.3 Transmitting out of the RS-232 Comport

```
            //Section 1 //
try
{
   serialPort1.Write(Data2Send, X, Y);
}
            //Section 2 //
catch (Exception oex)
{
   MessageBox.Show(oex.ToString());
}
```

Code Block Description

Section 1

Transmits the entire message stored in the Data2Send variable,

Where X= Offset (Usually set to 0), Y= total number of bits to send (this is up to the user to define).

Section 2-

In the event that the serial port experiences a problem an exception will be invoked and will warn the developer/end user of a communications problem.

4.2.4 Receiving from the RS-232 Comport

The following section of code can be called any number of ways, e.g. via Polling or on a thread. In this example this function is called from a timer called CommandPoller which was added to the project via the toolbox in the same manner as that the comport was added. This timer function is called approximately every 125mS. Note that the Items in Green below are up to the user to define.

```csharp
using System.IO.Ports;
public void CommandPoller_Tick(object sender, EventArgs e)
{
            //Section 1 //
    byte[] byteRead = new byte[100];
    serialPort1.ReadTimeout = 200;
            //Section 2 //
     try
     {
        int i = 0;
        do
        {
            byteRead[i] = (byte)serialPort1.ReadByte();
        }while (byteRead[i++] != SOME_END_CHARACTER);
     }
            //Section 3 //
    catch
    {
        ReceptionErrorDetected(byteRead);
    }
}
```

Code Block Description

Section 1-

This section creates a new array byte variable called "byteRead" who can store up 100 characters. Note- 100 is only the suggested length and can be modified. This is followed by setting the serial port time out to 200mS (more on this is a Section 2).

Section 2-

Begins with a "try" or an attempt to read data from the serial port, by reading one byte at a time into the "byteRead" array until Some_End_Character is received. However if the end character is never reached the comport will time out after 200 mS allowing the program to continue normal operations.
*Note- If data was successfully obtained from the serial port; this data should be passed to a data parsing routine.

Section 3-

If either nothing is received in the buffer the while statement **is not** satisfied**,** then the do while function will terminate after 200mS.

4.3   USB Communications

4.3.1 About the USB Driver in C#

The Interop.USB_dll.dll dynamic link library will be provided which needs to be added to the project. The library has three functions that can be called from the C# code.

The three functions are:

- FindTheHid – finds the connection with the correct VID, PID and Serial Number
- WriteReport(str) – Writes a string to the connected HID interface
- ReadReport() – Returns a string from the connected HID interface

4.3.2 Code for Opening the USB Comport

```csharp
Using usbNet;
...
...
usbPort.UsbComms;
...
...

usbComms = new UsbPort();
usbComms.usbConnect();

. . .
. . .

public void usbConnect()
{
        usb.FindTheHid();

}
```

4.3.3   Transmitting out of the USB Comport

Use the following code to send a total of 'count' characters stored in 'buffer' array.

```
. . .
. . .
```

```
public void Write(byte[] buffer, int offset, int count)
{
    string str = null;

    for (int i = offset; i < count; i++)
    {
        str = str + System.Convert.ToChar(buffer[i]);
    }

    try
    {
        usb.WriteReport(ref str);

    }
    catch (Exception oex)
    {
        MessageBox.Show(oex.ToString());
        LoggingFile.ErrorLogger(oex.ToString());
    }

}
. . .
. . .
```

4.3.4 Receiving from the USB Comport

Use the **following c**ode to receive a group of characters delimited by ETX (03)

```
public int Read(byte[] buffer)
{
    string str = null;
    int i = 0;


    try
    {
        do
        {

            str = str + usb.ReadReport();
            i++;
        } while (!(str.EndsWith((System.Convert.ToString('\x03')))) && i < 2);

        for (i = 0; i < str.Length; i++)
        {
            buffer[i] = (byte)str[i];

        }


    }
    catch
    {
        usbConnect();
    }
```

```
        return (i);
    }
    . . .
    . . .
```

4.4 Ethernet Communications

The XRV board contains an embedded diagnostic web server that can be accessed through any standard web browser by browsing to the XRV's IP address. The XRV is pre-configured for the following IP address:

http://192.168.1.4

The Ethernet interface communicates using the following protocols:

- TCP/IP
- HTTP
- TFTP
- FTP

4.4.1 Diagnostic Web Server

The diagnostic web server can control and monitor the XRV from a web browser. It displays operating status of the Power Supply and allows the unit to be configured in real time. The application consists of three web pages; a page displaying contact information, a license agreement, and a monitoring and control applet that is at the heart of this application. The Web Server application for the MNX50P50 is presented as an example in the following pages. When prompted use the following User name and Password.

User Name = admin
Password = shvapplet

4.4.2 Web Pages

Upon establishing a connection with the Diagnostic web server the following screen will be displayed.

Figure 11- Java Applet Welcome Screen

4.4.3 License Agreement Page

The following figure displays Spellman High Voltage's Software License Agreement. After reading the entire License Agreement scroll to the bottom of the page and click "I Accept".
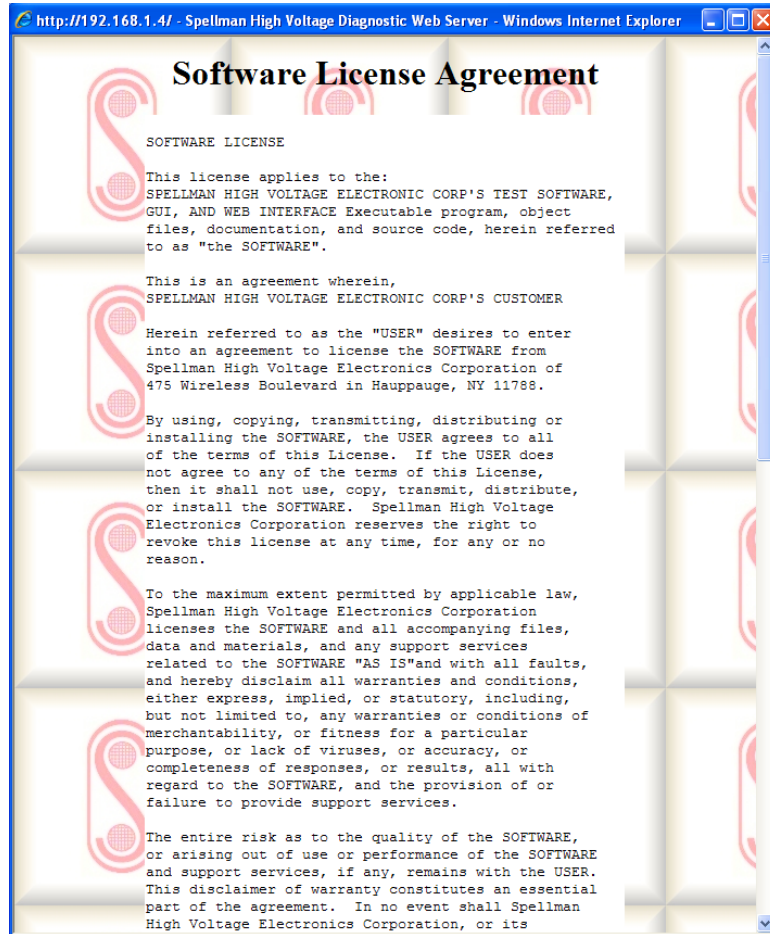
4.4.4 Main Applet Control Page

The following will be displayed upon accepting the license agreement. The various tabs at the top of the applet are used to control the XRV via the applet itself.
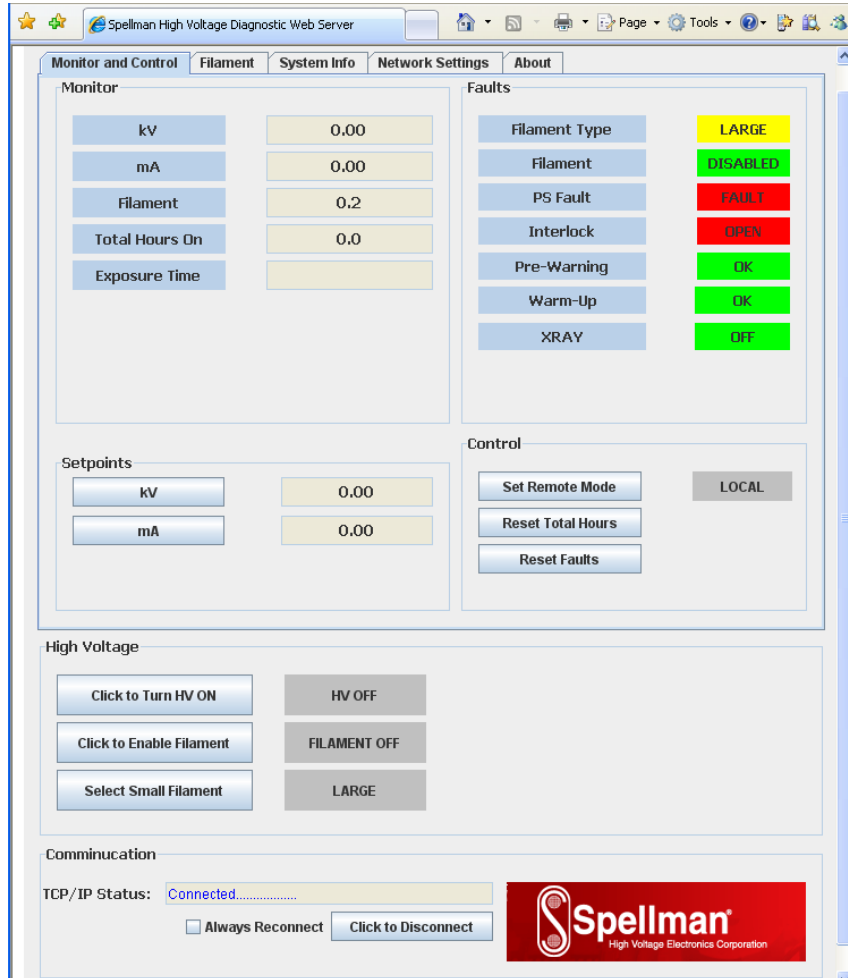
4.4.5 Program Set Point Screen

In order to change the KV set point for the XRV, click the KV button within the set points box. The following window below will be displayed. For this XRV it must be within 0-225KV. Once the desired KV value has been entered, click "Apply" then "Ok" to send this value to the XRV. This sequence can also be performed for setting the mA.
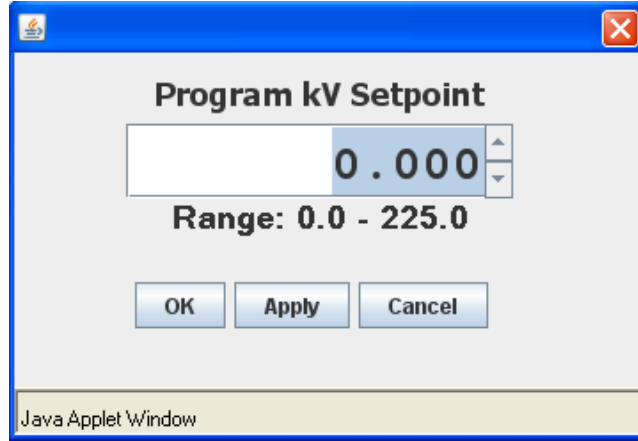
4.4.6 High Voltage/ Filament Control

To change the high voltage status, Enable/Disable the filament or Select a Large/Small Filament simply click on the corresponding buttons within the High Voltage Control Section as displayed below. Additionally the gray boxes next to the High Voltage Control Buttons will display the current state of the power supply. For this example the HV is off, a small filament has been selected and the filament is off.
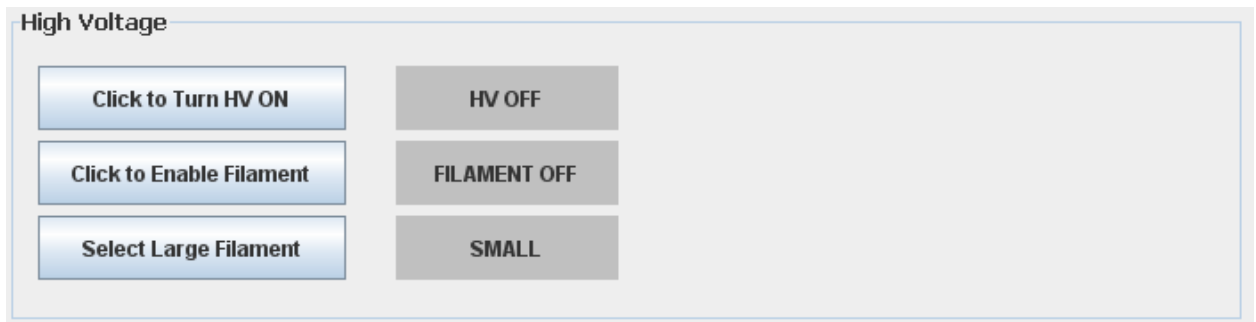
4.4.7 Filament/User Settings

Changing the filament/User settings can be accomplished via the Filament Tab as shown below.

The maximum allowable programmable power limit is a function of the XRV itself. For this example it is 3000 Watts for both the large and small filament. The Filament and Pre-heat limit values should be set to the appropriate values as dictated by the X-ray tube manufacturer.

There are several user settings which can be modified and should only be changed by qualified personnel. The following is a list of the above parameters and their meanings:

- Over Voltage- XRV will turn off High Voltage if the unit exceeds 34% of the total unit output power. This value can be changed from 0-100%.
- Voltage/Current Ramp Rate- Changing this value will change how quickly the XRV ramps the voltage and/or current.
- X-Ray Pre-warning- Warns the user for up to 30 seconds before X-rays will be produced.
- Arc Count- Number of arcs before the supply will shut down, up to 10 are allowed.
- Arc Quench- Amount of time between arcs in which the supply will shut down before automatically re-ramping the high voltage. Range is = 0- 5000 mS.
- Max KV, mA- Prohibits the user from inadvertently setting too high of a value from the main control tab. For this example a value greater than 32.97 KV will not be allowed.

4.4.8 System Information-

The system information page (see below), displays all of the XRV's possible fault conditions and various on board voltage health monitors.

| Monitor and Control | Filament | System Info | Network Settings | About |

System Voltages

+15V Supply	14.9
-15V Supply	15.5
kV Anode	0.0
kV Cathode	5.9
AC Anode	1.1
AC Cathode	0.4
DC Anode	0.9
AC Cathode	0.9
Temperature	73.1
KV Monitor	0.20
MA Monitor	0.00
Filament Fdbk	0.0

System Status

Temp Approach	OK	+15 Volt	OK
Board Temp	OK	-15 Volt	OK
Temp Anode	OK	DC Line Anode	OK
Temp Cathode	OK	DC Line Cathode	FAULT
Interlock	OPEN	Arc Anode	OK
Watchdog	FAULT	Arc Cathode	OK
Over Voltage	OK	AC Line Anode	OK
Under Voltage	OK	AC Line Cathode	FAULT
Over Current	OK	Filament Feedback	OK
Under Current	OK	Filament Select	FAULT
Inverter Anode	OK	Cable Anode	FAULT
Inverter Cathode	OK	Cable Cathode	FAULT

4.4.9 Network Settings

The Network Settings tab displays all of the XRV network settings information. All of the settings within this tab can be changed to suit the customer's needs (except MAC Address). **It is highly recommended that once the default values have been changed that this information is stored in a secure place.**

Note:

 XRV Control boards Rev B and earlier - If these custom settings are forgotten/lost, there is no way to restore the Control board to its default factory settings without sending the unit back for repair.

XRV Control boards Rev C and later - follow these steps in order to restore control board to its default factory configuration.

1. With power off, on controller board, place a jumper on JP17 located nearby Ethernet module.
2. Power up the unit and ping it using default IP address 192.168.1.4. Controller should reply.
3. Go to your Internet browser and enter default IP address 192.168.1.4
4. After entering username (admin) and password (shvapplet), go to Network Settings.
5. Change the IP address, subnet mask and Port number to desired values. Default values are:
   - 192.168.1.4
   - 50001
   - 255.255.255.0

6. Wait for a couple of minutes to make sure web diagnostic finishes update operation.
7. Disconnect and close browser.
8. Power the unit off.
9. Remove JP17 jumper
10. Power the unit back on.
11. Ping the unit using new IP address just entered above.

Port 50000 is assigned to XRV Diagnostics Webserver and should not be used.

4.4.10 About Screen

The about screen depicts all of the XRV's pertinent model information including firmware revisions.

4.4.11 Code for Opening the Ethernet Port

//Section 1 //

```
using System.Net.Sockets;
m_socClient = new Socket(AddressFamily.InterNetwork, SocketType.Stream,
        ProtocolType.Tcp);
System.Net.IPAddress ipAdd = System.Net.IPAddress.Parse(IPAddress);
System.Net.IPEndPoint remoteEP = new IPEndPoint(ipAdd,int.Parse(PORTNUMBER));
```

//Section 2 //

```
        try
        {
            m_socClient.Connect(remoteEP);
        }
        catch (Exception oex)
```

```
        {
            MessageBox.Show(oex.ToString());
        }
```

Section 1-

Configures the local Ethernet as an internetwork, streaming, TCP enabled port, whose IP
address and port number are set by the user. The designer is responsible for
providing this information, for this example they are set to the XRV's default
range which is 192.168.1.4 and 50000.

Section2-

The try/catch sequence is used before attempting to establish a connection with the
remote end point ("remoteEP") which again for this example is 192.168.1.4 and
50000. Should this step fail, the catch mechanism will display to the
programmer/user any potential issue.

4.4.12 Transmitting out of the Ethernet Port

```
                          //Section 1 //
try
{
        if (m_socClient.Connected)
        {
                int x = m_socClient.Send(CMD2SEND,CMD_SIZE,
                SocketFlags.Partial);
        }
}
                          //Section 2 //

catch (Exception oex)
{
        MessageBox.Show(oex.ToString());
}
```

Section 1

If the Soceket connection has been established succesfully then a
command will be transmitted out of the ethernet port. It is up to the
user to define what the command to send (CMD2SEND) and command size
(CMD_SIZE) are.

Section 2

The catch sequence will be triggered if the socket is in any other
state except for connected or not connected. If this exception is
thrown then the programmer/user will be alerted to this issue.

4.4.13 Receiving from the Ethernet Port

```
                           //Section 1 //
        try
        {
            Buffer returnCommandBuffer = new Buffer();
            if (m_socClient.Connected)
            {
                int x = m_socClient.Receive(100);
                 returnCommandBuffer.add(100, x);
            }
        }
                           //Section 2 //

        catch (SocketException se)
        {
            MessageBox.Show(se.Message);
        }
```

Section 1-

Begins with a try/catch sequence which if the socket is connected begins
to move data from the socket to the retun command buffer. Note that the
size of the array for this array is 100 however this can be changed to
meet your needs.

Note- If data was successfully obtained from the Ethernet port; this data should be passed to a data
parsing routine.

Section 2-

The catch sequence will be triggered if the socket experiences any socket
exception error.

5.0 ETHERNET COMMANDS

5.1 TCP/IP FORMAT

Each Ethernet command will consist of a TCP/IP header followed by the required data bytes. Figure 27 summarizes the TCP/IP header configuration. Please note that this functionality is provided by the software implementation of the Open Systems Interconnection (OSI) TCP/IP protocol stack, specifically the upper 4 layers.

Byte							
0	Protocol Version	Header Length	Type of Service		Total Length		
4	Packet ID			Flags	Fragmentation Offset		
8	Time to Live		Protocol		Header checksum		
12	Source Address						
16	Destination Address						
20	Source Port			Destination Port			
24	Sequence Number						
28	Acknowledgement Number						
32	Data Offset	Reserved	Code Bits	Window			
36	Checksum			Urgent Pointer			
40	Data Byte 1		Data Byte 2		Data Byte 3		Data Byte N

The format of Data Bytes 1 through N are as follows:

<STX><CMD><,>ARG><,><ETX>

Where:
<STX> = 1 ASCII 0x02 Start of Text character
<CMD>= 2 ASCII characters representing the command ID
<,>   = 1 ASCII 0x2C character
<ARG> = Command Argument
<,>   = 1 ASCII 0x2C character
<ETX> = 1 ASCII 0x03 End of Text character

5.2   COMMAND ARGUMENTS

The format of the numbers is a variable length string. To represent the number 42, the string '42', '042', or '0042' can be used. This being the case, commands and responses that carry data are variable in length.

5.3   COMMAND OVERVIEW

Data Byte section of the TCP/IP Datagram		
Command Name	Command Code	Argument Length
Program kV	10	1
Program mA	11	1
Program Filament Limit	12	1
Program Filament Pre-Heat	13	1
Request kV Set point	14	None
Request mA Set point	15	None
Request Filament Limit Set point	16	None

Request Filament Pre-Heat Set point	17	None
Request Analog Monitor Read backs	19	None
Request HV On Hours Counter	21	None
Request Status	22	None
Request Software Version	23	None
Request Model Number	26	None
Request User Configuration	27	None
Request Scaling	28	None
Reset HV On Hours Counter	30	None
Reset Faults	31	None
Set Large/Small Filament	32	1
Request Power Limits	38	None
Request FPGA Rev	43	None
Request KV Monitor	60	None
Request -15V LVPS	65	None
Request Faults	68	None
Request System Voltages	69	None
Filament Control	70	1
XRV Controller Present	71	1

Program Power Limits	97	2
Program HV On	98	1
Local/Remote Mode	99	1

5.4   RESPONSE OVERVIEW

The command responses will follow the same network TCP/IP header format as outlined above in section 6.1. This list is comprised of Commands with complex responses only. Commands using a simple response will use the <$> character (ASCII 0x24) as a "Success" response or a single character error code. These will be seven ASCII characters in length.

Response Name	Code	Argument Length
Request kV Set point	14	1
Request mA Set point	15	1
Request Filament Limit Set point	16	1
Request Filament Pre-Heat Set point	17	1
Request Analog Monitor Read backs	19	8
Request Total Hours High Voltage On	21	1
Request Status	22	17
Request DSP Software Version	23	1
Request Model number	26	1
Request User Configuration	27	12
Request Scaling	28	3
Request Power Limits	38	6
Request FPGA Revision and Build numbers	43	2

Request kV monitor	60	1
Request –15V LVPS	65	1
Request Faults	68	27
Request System Voltages	69	10

5.5 COMMAND STRUCTURE

5.5.1 Program kV

Description:
The host requests that the firmware change the set point of kV.

Direction:
Host to supply

Syntax:
<STX><10><,><ARG><,><ETX>

Where:
<ARG> = 0 - 4095 in ASCII format

Example:
<STX>10,4095,<ETX>

Response:
<STX><10><,><$><,><ETX>

<STX><10><,><ARG><,><ETX>

where <ARG> = error code

Error Codes TBD, 1 = out of range

5.5.2 Program mA

Description:
The host requests that the firmware change the set point of mA.

Direction:
Host to supply

Syntax:
<STX><11><,><ARG><,><ETX>

Where:
<ARG> = 0 - 4095 in ASCII format

Example:
<STX>11,4095,<ETX>

Response:
<STX><11><,><$><,><ETX>

<STX><11><,><ARG><,><ETX>

where <ARG> = error code

Error Codes TBD, 1 = out of range

5.5.3   Program Filament Limit

Description:

The host requests that the firmware change the set point of Filament Limit.

Direction:

Host to supply

Syntax:

<STX><12><,><ARG><,><ETX>

Where:

<ARG> = 0 - 4095 in ASCII format

Example:

<STX>12,4095,<ETX>

Response:

<STX><12><,><$><,><ETX>

<STX><12><,><ARG><,><ETX>

where <ARG> = error code

Error Codes TBD, 1 = out of range

5.5.4   Program Filament Pre-Heat

Description:

The host requests that the firmware change the set point of Filament Pre-Heat.

Direction:

Host to supply

Syntax:

<STX><13><,><ARG><,><ETX>

Where:

<ARG> = 0 - 4095 in ASCII format

Example:

<STX>13,4095,<ETX>

Response:

<STX><13><,><$><,><ETX>

<STX><13><,><ARG><,><ETX>

where <ARG> = error code

Error Codes TBD, 1 = out of range

5.5.5 Request kV Set point

Description:
The host requests that the firmware report the kV set point.

Direction:
Host to supply

Syntax:
<STX><14><,><ETX>

Response:
<STX><14><,><ARG><,><ETX>

Where:
<ARG> = 0 - 4095 in ASCII format

Example:
<STX>14,4095,<ETX>

5.5.6 Request mA Set point

Description:

The host requests that the firmware report the current mA set point.

Direction:

Host to supply

Syntax:

<STX><15><,><ETX>

Response:

<STX><15><,><ARG><,><ETX>

Where:

<ARG> = 0 - 4095 in ASCII format

Example:

<STX>15,4095,<ETX>

5.5.7 Request Filament Limit Set point

Description:

The host requests that the firmware report the current Filament Limit set point.

Direction:

Host to supply

Syntax:

<STX><16><,><ETX>

Response:

<STX><16><,><ARG><,><ETX>

Where:

<ARG> = 0 - 4095 in ASCII format

Example:

<STX>16,4095,<ETX>

5.5.8 Request Filament Pre-Heat Set point

Description:

The host requests that the firmware report the current Filament Pre-Heat set point.

Direction:

Host to supply

Syntax:

<STX><17><,><ETX>

Response:

<STX><17><,><ARG><,><ETX>

Where:

<ARG> = 0 - 4095 in ASCII format

Example:

<STX>17,4095,<ETX>

5.5.9 Request Analog Monitor Read backs

Description:

The Request major ADC feedback command requests that the firmware send the Analog to Digital Feedback monitors for the main monitoring channels.

Direction:

Host to supply

Syntax:

<STX><19><,> <ETX>

Example:

<STX>19, <ETX>

Sending this command will request all essential A/D values. See responses for a description.

Response:

<STX><19><,><Arg1><,><Arg2><,><Arg3><,><Arg4><,><Arg5><,><Arg6><,>

<Arg7><,><Arg8><,><ETX>

<Arg 1> - KV Feedback.

<Arg 2> - mA Cathode Feedback.

<Arg 3> - Filament Feedback.

<Arg 4> - KV program Feedback [Note 1]

<Arg 5> - mA Program Feedback [Note1]

<Arg 6> - Program Limit Feedback [Note 1]

<Arg 7> - Program Preheat Feedback [Note 1]

<Arg 8->- mA Anode Feedback [Note 2]

<u>Error Codes</u>:

None

<u>Note 1-</u>

For Local mode operation only.

<u>Note 2-</u>

Bipolar units only.

5.5.10 Request Total Hours High Voltage On

<u>Description:</u>
The host requests that the firmware sends the present value of the Total Hours High Voltage On.

<u>Direction:</u>
Host to supply

<u>Syntax:</u>
<STX><21><,><ETX>

<u>Example:</u>
<STX>21,<ETX>

<u>Response:</u>
<STX><21><,><ARG><,><ETX>

Where:
<ARG> : NNNNN.N hours
<.> = ASCII 0x2E
N =0-9 in ASCII format

<u>Example:</u>

<STX>21,99999.9,<ETX>

5.5.11 Request Status

Description:

The Request Status command requests that the firmware send the status of the unit.

Direction:

Host to supply

Syntax:

<STX><22><,> <ETX>

Example:

<STX> 22, <ETX>

Response:

<STX><22><,><Arg1><,><Arg2><,><Arg3><,><Arg4><,><Arg5><,><Arg6><,>

<Arg7><,><Arg8><,><Arg9><,><Arg10><,><Arg11><,><Arg12><,><Arg13><,>

<Arg14><,><Arg15><,><Arg16><,><Arg17><,><ETX>

Argument Number	Description	Argument Number	Description
1	1 = HV Enabled	10	1= Large Filament Confirmation
2	1= Interlock 1 Closed	11	1= Small Filament Confirmation
3	1= Interlock 2 Closed	12	Reserved

4	1= ECR Mode Active	13	Reserved
5	1= PS Fault	14	Reserved
6	0 = Remote Mode, 1 = Local Mode Note*1	15	Reserved
7	1= Filament Enabled 0= Filament Disabled	16	1= Power Supply Ready
8	1 = Large Filament 0= Small Filament	17	1= Internal Interlock Closed
9	1= X-rays Eminent		

Error Codes:

None

Note*1- In order to for the supply to be in remote mode, insure that JB2 pin 14 is open (no connection). If this pin is grounded the unit will be in local mode and thereby will not be able to be controlled in remote mode.

5.5.12 Request DSP Software Part Number/Version

Description:
The host requests that the firmware sends the DSP firmware version.

Direction:
Host to supply

Syntax:
<STX><23><,><ETX>

Example:
<STX>23,<STX>

Response:
<STX><23><,>< ARG><,><ETX>

Where:

<ARG> consists of eleven ASCII characters representing the current firmware part

number/version. The format is SWM9999-999

Example:

<STX>23,SWM9999-999,<ETX>

5.5.13 Request Model Number

Description:

The Request Model Number Command requests that the firmware send the Model number of the unit.

Direction:

Host to supply

Syntax:

<STX><26><,> <ETX>

Example:

<STX>26, <ETX>

Response:

<STX><26><,><ARG><,><ETX>

Where ARG = XRV160N3000,X3525 or XRV160N3000,0000

Error Codes:

None

5.5.14 Request User Configuration <27>

Description:

The Request User Configuration command, requests that the firmware send the user configuration.

Direction:

Host to supply

Syntax:

<STX><27><,> <ETX>

Example:

<STX><27><,><ARG1><,><ARG2><,><ARG3><,><ARG4><,>

<ARG5><,><ARG6><,><ARG7><,><ARG8><,><ARG9><,><ARG10><,>

<ARG11><,><ARG12><,><ETX>

Where:

<ARG 1> = Reserved for Spellman

<ARG 2> = Over Voltage Percentage-

<ARG 3> = Voltage Ramp rate- 1-10 Seconds max.

<ARG 4> = Current Ramp Rate- 1-10 Seconds max.

<ARG 5> = x-ray Pre warning time. 1-10 Seconds max.

<ARG 6> = arc count- Number of arcs allowed before shutting down supply.

<ARG 7> = Reserved for Spellman

<ARG 8> = Quench time-

<ARG 9> = Reserved

<ARG 10> = max KV- Maximum user range.

<ARG 11> = max mA- Maximum user range.

<ARG 12> = Watchdog Timer in seconds.

Error Codes:

None

5.5.15 Request Scaling <28>

Description:

The Request Scaling command requests that the firmware send the current unit scalings.

Direction:

Host to supply

Syntax:

<STX><28><,> <CS> <ETX>

Example:

<STX>28, <CS><ETX>

Response:

<STX><28> <,><Arg1> <,> <Arg2> <,> <Arg3><,><CS><ETX>

Where

Arg1 = 160 (This is the raw value, 160= 160 KV).

Arg2 = 30   (This is the raw value, 30 = 30 mA).

Arg3 = Supply Polarity 0 = Uni-Polar, 1= Bipolar.

Error Codes:

None

Note 1-

In order to scale the User Interface two different scalings are used one for program values and the other for feedback values. Refer to Section 8 to determine how to calculate scaling factors

5.5.16 Reset Run Hours

Description:
The host requests that the firmware resets the run hour counter.

Direction:
Host to supply

Syntax:
<STX><30><,><ETX>

Example:
<STX>30,<ETX>

Response:
<STX><30><,><$><,><ETX>

5.5.17   Reset Faults

Description:

The host requests that the firmware resets all Fault messages and indicators.

Direction:

Host to supply

Syntax:

<STX><31><,><ETX>

Example:

<STX>31,<ETX>

Response:

<STX><31><,><$><,><ETX>

5.5.18 Set Large/Small Filament <32>

Description:

The Set Large/ Small Filament state, requests that the firmware sets the Large or Small filament state.

Direction:

Host to supply

Syntax:

<STX><32><,><ETX>

Example:

<STX>32, <ARG><,><ETX>

Where ARG =

1 = Large Filament

0 = Small Filament

Response:

<STX><32><,><$><,><ETX>

Response Codes:

$ = Success. Note 1.

1 = User tried changing the filament size while High Voltage was on.

Note 1-

User must reenter values for both KV and mA as they have been defaulted back to 0.

5.5.19 Request Power Limit <38>

Description:

The Request Power Limit requests that the firmware send the programmed values for the large and small filament.

Direction:

Host to supply

Syntax:

<STX><38><,><ETX>

Example:

<STX><38><,><ETX>

Response:

<STX><38><,><ARG1><,><ARG2><,><ARG3><,><ARG4><,><ARG5><,>

<ARG6> <,> <ETX>

Argument Number	Description
1	Large Limit
2	Small Limit

3	Filament Large Limit
4	Filament Small Limit
5	Preheat Large Limit
6	Preheat Small Limit

Error Codes:

None

5.5.20 Request FPGA Part Number <43>

Description:

The Request FPGA Part Number Rev requests that the firmware send the FPGA Software part and build number.

Direction:

Host to supply

Syntax:

<STX><43><,><ETX>

Example:

<STX>43,<ETX>

Response:

<STX><43><,><Arg1><,><Arg2><,><ETX>

Where Arg1 = Software Part number (e.g. SWM00199-001)

       Arg2 = Build number (e.g. 3261)

Error Codes:

None

5.5.21 Request kV Monitor

Description:
The host requests that the firmware report kV monitor.

Direction:
Host to supply

Syntax:
<STX><60><,><ETX>

Response:
<STX><60><,><ARG><,><ETX>

Where:
<ARG>=0-4095 in ASCII format representing unscaled value.

Example:
<STX>60,4095,<ETX>

5.5.22 Request –15V LVPS

Description:
The host requests that the firmware report –15V LVPS.

Direction:
Host to supply

Syntax:
<STX><65><,><ETX>

Response:
<STX><65><,><ARG><,><ETX>

Where:
<ARG>=0-4095 in ASCII format representing non scaled value.

Example:
<STX>65,4095,<ETX>

5.5.23 Request Faults

Description:

The "Request Faults" command, requests that the firmware send the XRV's fault status.

Direction:

Host to supply

Syntax:

<STX><68><,><ETX>

Example:

<STX><68><,><ETX>

Response:

<STX><68><,><ARG1><,><ARG2><,><ARG3><,><ARG4><,><ARG5><,>

<ARG6><,><ARG7><,><ARG8><ARG9><,><ARG10><,><ARG11><,>

<ARG12><,><ARG13><,><ARG14><,><ARG15><,><ARG16><,><ARG17><,>

<ARG18><,><ARG19><,><ARG20><,><ARG21><,><ARG22><,><ARG23><,>
<ARG24><,><ARG25><,><ARG26><,><ARG27><,><ETX>

For all arguments a 1 = fault a 0 = no fault.

Argument Number	Description	Argument Number	Description
1	Filament Select Fault	15	Cable Connect Cathode Fault
2	Over Temp Approach	16	AC Line Mon Anode Fault
3	Over Voltage	17	AC Line Mon Cathode Fault
4	Under Voltage	18	DC Rail Mon Anode Fault
5	Over Current	19	DC Rail Mon Fault Cathode
6	Under Current	20	LVPS Neg 15 Fault
7	Over Temp Anode	21	LVPS Pos 15 Fault
8	Over Temp Cathode	22	Watch Dog Fault Note*1
9	Inverter Fault Anode	23	Board Over Temp
10	Inverter Fault Cathode	24	Over Power Fault
11	Filament Feedback Fault	25	KV Diff
12	Anode Arc	26	mA Diff
13	Cathode Arc	27	Inverter Ready/Not Ready
14	Cable Connect Anode Fault		

<u>Note*1-</u> The watch dog bit is tripped if the supply does not receive any data from the host within 5 seconds. In order to prevent the supply from faulting out with a watch dog fault, the host must be in constant communication with the supply. Sending any command to supply will continuously clear out the watch dog fault and thereby allow the supply to continue running.

5.5 24 Request System Voltages <69>

Description:

The Request System Voltages command, requests that the firmware send the various housekeeping, and miscellaneous voltages to the host.

Direction:

Host to supply

Syntax:

<STX><69><,><ETX>

Example:

<STX><69><,><ETX>

Response:

<STX><69><,><ARG1><,><ARG2><,><ARG3><,><ARG4><,><ARG5><,>

<ARG6> <,> <ARG7><,><ARG8><,><ARG9><,><ARG10> <,> <ETX>

Argument Number	Description	Scaling Factor	Argument Number	Description	Scaling Factor
1	Temperature	0.05911815	6	DC Rail Mon Cathode	0.11399241
2	Reserved	N/A	7	AC Line Mon Anode	0.088610

3	KV Mon Anode	(Unit Max * 20%) / 4095	8	DC Rail Mon Anode	0.11399241
4	KV Monitor Cathode	(Unit Max * 20%) / 4095	9	Lvps Pos15	0.00427407
5	AC Line Mon Cathode	0.088610	10	Lvps Neg15	0.00576703

Error Codes:

Note 1-

None

5.5.25 Control Filament <70>

Description:

The Control Filament command host requests that the firmware enables or disables the filament.

Direction:

Host to supply

Syntax:

<STX><70><,> <ETX>

Example:

<STX>70, <Arg1><,><ETX>

Where Arg1 =

1 = Enable Filament

0 = Disable Filament

Response:

<STX><70><,><$><,><ETX>

Error Codes:

Note 1-

None

5.5.26 XRV Controller Present <71>

Description:

Inform the power supply that it is communicating with a XRV Controller unit.

Direction:

Host to supply

Syntax:

<STX><71><,> <ETX>

Example:

<STX>70, <Arg1><,><ETX>

Where Arg1 =

1 = XRV Controller is Present

0 = XRV Controller is not Present

Response:

<STX><71><,><$><,><ETX>

Error Codes:

Note 1-

None

5.5.27 Program Power Limit <97>

Description:

The Program Power Limit command requests that the firmware changes the power limit of the supply.

Direction:

Host to supply

Syntax:

<STX><97><,><ARG1><,><ARG2><,><ETX>

Arg1 = Large Power Limit

Arg2 = Small Power Limit

Where:

<ARG> = 0 – 3000 Watts for Unipolar or 0-4500 Watts for Bipolar in ASCII format.

Example:

<STX><97><,><4095><,><2048><,><ETX>

Response:

<STX><97><,><$><,><ETX>   or

<STX><97><,><ARG><,><ETX>

Where <ARG> = error code

Error Codes:

1 = Large Limit Entered invalid

2 = Small limit entered invalid.

Uni-polar Supply = 3000W

Bipolar Supply = 4500 W

Note1-

Checksum only sent for Serial and USB Communications.

5.5.28 Control HV <98>

Description:

The Control HV command, requests that the firmware turn on or off High Voltage.

Direction:

Host to supply

Syntax:

<STX><98><,><ARG><,><ETX>

Where:

<ARG> 1 = on, 0 = off in ASCII format

Example:

<STX>98<,>1<,> <ETX>

Response:

<STX><98><,><X><,><ETX>

If X = $ then the command was accepted and HV will turn on.

If X = 1 then there was a fault within the PS and the unit cannot turn on. User should refer to status command for what fault is causing this issue.

5.5.29 Program Local/Remote Mode

Description:
The host requests that the firmware switch between Local and Remote Mode.

Direction:
Host to supply

Syntax:
<STX><99><,><ARG><,><ETX>

Where:
<ARG> 0 = Remote, 1 = Local, in ASCII format

Example:
<STX>99,0,<ETX>

Response:
<STX><99><,><$><,><ETX>   or

<STX><99><,><ARG><,><ETX>

Where <ARG> = error code

Error Codes TBD,

1 = out of range

6.0   SERIAL COMMANDS – RS-232 / USB

6.1   SERIAL INTERFACE PROTOCOL

 Serial communications will use the following protocol:

<STX><CMD><,>ARG><,><CSUM><ETX>

Where:
<STX> = 1 ASCII 0x02 Start of Text character
<CMD>= 2 ASCII characters representing the command ID
<,>   = 1 ASCII 0x2C character
<ARG> = Command Argument
<,>   = 1 ASCII 0x2C character
<CSUM> or <CS>   = Checksum (see section 7.3 for details)
<ETX> = 1 ASCII 0x03 End of Text character

6.2 COMMAND ARGUMENTS

The format of the numbers is a variable length string. To represent the number 42, the string '42', '042', or '0042' can be used. This being the case, commands and responses that carry data are variable in length.

6.3   CHECKSUMS

The checksum is computed as follows:
- Add all the bytes before <CSUM>, except <STX>, into a 16 bit (or larger) word. The bytes are added as unsigned integers.
- Take the two's complement.
- Truncate the result down to the eight least significant bits.
- Clear the most significant bit (bit 7) of the resultant byte, (bitwise AND with 0x7F).
- Set the next most significant bit (bit 6) of the resultant byte (bitwise OR with 0x40).

Using this method, the checksum is always a number between 0x40 and 0x7F. The checksum can never be confused with the <STX> or <ETX> control characters, since these have non-overlapping ASCII values.

If the DSP detects a checksum error, the received message is ignored – no acknowledge or data is sent back to the host. A timeout will act as an implied NACK.

The following is a checksum calculation example:
     Message Received is (in Hex):   02 32   32 2C 31 2C 53 03
     We add: 32 + 32 + 2C + 31 + 2C

And get   ED

Take two's complement: 100 – ED = 13

Truncate to the last 8 bits: 13

Clear most significant bit: 13

Set bit 6:   53

Thus, the checksum is: 53

The following is sample code, written in Visual Basic, for the generation of checksums:

```
Public Function ProcessOutputString(outputString As String) As String

    Dim i As Integer

    Dim CSb1 As Integer

    Dim CSb2 As Integer

    Dim CSb3 As Integer

    Dim CSb$

    Dim X

    X = 0

    For i = 1 To (Len(outputString))       'Starting with the CMD character

    X = X + Asc(Mid(outputString, i, 1))    'adds ascii values together

    Next i


    CSb1 = 256 - X

    CSb2 = 127 And (CSb1)        'Twos Complement

    CSb3 = 64 Or (CSb2)         'OR 0x40

    CSb$ = Chr(Val("&H" & (Hex(CSb3))))

    ProcessOutputString = Chr(2) & outputString & CSb$ & Chr(3)


    End Function
```

6.4 COMMAND OVERVIEW

Data Byte section of the TCP/IP Datagram		
Command Name	Command Code	Argument Length
Program RS-232 unit baud rate	07	1
Program kV	10	1
Program mA	11	1
Program Filament Limit	12	1
Program Filament Pre-Heat	13	1
Request kV Set point	14	None
Request mA Set point	15	None
Request Filament Limit Set point	16	None
Request Filament Pre-Heat Set point	17	None
Request Analog Monitor Read backs	19	None
Request HV On Hours Counter	21	None
Request Status	22	None
Request Software Version	23	None
Request Model Number	26	None

Request User Configuration	27	None
Request Scaling	28	None
Reset HV On Hours Counter	30	None
Reset Faults	31	None
Set Large/Small Filament	32	1
Request Power Limits	38	None
Request FPGA Rev	43	None
Request kV monitor	60	None
Request –15V LVPS	65	None
Request Faults	68	None
Request System Voltages	69	None
Filament Enable	70	1
XRV Controller	71	1
Program Power Limit	97	2
Program HV On	98	1
Local/Remote Mode	99	1

6.5   RESPONSE OVERVIEW

The command responses will follow the same format as outlined above in section 6.1. This list is comprised of Commands with complex responses only. Commands using a simple response will use the <$> character (ASCII 0x24) as a "Success" response or a single character error code. These responses will be eight ASCII characters in length.

Response Name	Command Code	Argument Length
Request kV Set point	14	1
Request mA Set point	15	1
Request Filament Limit Set point	16	1
Request Filament Pre-Heat Set point	17	1
Request Analog Monitor Read backs	19	8
Request Total Hours High Voltage On	21	1
Request Status	22	17
Request DSP Software Version	23	1
Request Model number	26	1
Request User Configuration	27	12
Request Scaling	28	3
Request Power Limits	38	6
Request FPGA Revision and Build number	43	2
Request kV monitor	60	1
Request −15V LVPS	65	1
Request Faults	68	27
Request System Voltages	69	10

6.6 COMMAND STRUCTURE

6.6.1 Program RS232 Baud Rate

Description:
The host requests that the firmware change the Baud rate for RS-232.

Direction:
Host to supply

Syntax:
<STX><07><,><ARG><,><CSUM><ETX>

Where:
<ARG> 1 = 9.6k in ASCII format
<ARG> 2 = 19.2k in ASCII format
<ARG> 3 = 38.4k in ASCII format
<ARG> 4 = 57.6k in ASCII format
<ARG> 5 = 115.2k in ASCII format

Example:
<STX>07,1,<CSUM><ETX>

Response:
<STX><07><,><$><,><CSUM><ETX>

<STX><07><,><ARG><,><CSUM><ETX>

where <ARG> = error code

Error Codes TBD,

1 = out of range

6.6.2 Program kV

<u>Description:</u>
The host requests that the firmware change the setpoint of kV.

<u>Direction:</u>
Host to supply

<u>Syntax:</u>
<STX><10><,><ARG><,><CSUM><ETX>

<u>Where:</u>
<ARG> = 0 - 4095 in ASCII format

<u>Example:</u>
<STX>10,4095,<CSUM><ETX>

<u>Response:</u>
<STX><10><,><$><,><CSUM><ETX>

<STX><10><,><ARG><,><CSUM><ETX>

where <ARG> = error code

Error Codes TBD, 1=out of range

6.6.3   Program mA

Description:
The host requests that the firmware change the set point of mA.

Direction:
Host to supply

Syntax:
<STX><11><,><ARG><,><CSUM><ETX>

Where:
<ARG> = 0 - 4095 in ASCII format

Example:
<STX>11,4095,<CSUM><ETX>

Response:
<STX><11><,><$><,><CSUM><ETX>

<STX><11><,><ARG><,><CSUM><ETX>

where <ARG> = error code

Error Codes TBD, 1=out of range

6.6.4 Program Filament Limit

Description:
The host requests that the firmware change the set point of Filament Limit.

Direction:
Host to supply

Syntax:
<STX><12><,><ARG><,><CSUM><ETX>

Where:
<ARG> = 0 - 4095 in ASCII format

Example:
<STX>12,4095,<CSUM><ETX>

Response:
<STX><12><,><$><,><CSUM><ETX>

<STX><12><,><ARG><,><CSUM><ETX>

where <ARG> = error code

Error Codes TBD, 1 = out of range

6.6.5 Program Filament Pre-Heat

Description:
The host requests that the firmware change the set point of Filament Pre-Heat.

Direction:
Host to supply

Syntax:
<STX><13><,><ARG><,><CSUM><ETX>

Where:
<ARG> = 0 - 4095 in ASCII format

Example:
<STX>13,4095,<CSUM><ETX>

Response:
<STX><13><,><$><,><CSUM><ETX>

<STX><13><,><ARG><,><CSUM><ETX>

where <ARG> = error code

Error Codes TBD, 1 = out of range

6.6.6 Request kV Set point

Description:
The host requests that the firmware report the kV set point.

Direction:
Host to supply

Syntax:
<STX><14><,><CSUM><ETX>

Response:
<STX><14><,><ARG><,><CSUM><ETX>

Where:
<ARG> = 0 - 4095 in ASCII format

Example:
<STX>14,4095,<CSUM><ETX>

6.6.7   Request mA Set point

Description:
The host requests that the firmware report the current mA set point.

Direction:
Host to supply

Syntax:
<STX><15><,><CSUM><ETX>

Response:
<STX><15><,><ARG><,><CSUM><ETX>

Where:
<ARG> = 0 - 4095 in ASCII format

Example:
<STX>15,4095,<CSUM><ETX>

6.6.8   Request Filament Limit Set point

Description:
The host requests that the firmware report the current Filament Limit set point.

Direction:
Host to supply

Syntax:
<STX><16><,><CSUM><ETX>

Response:
<STX><16><,><ARG><,><CSUM><ETX>

Where:
<ARG> = 0 - 4095 in ASCII format

Example:
<STX>16,4095,<CSUM><ETX>

6.6.9 Request Filament Pre-Heat Set point

Description:
The host requests that the firmware report the current Filament Pre-Heat set point.

Direction:
Host to supply

Syntax:
<STX><17><,><CSUM><ETX>

Response:
<STX><17><,><ARG><,><CSUM><ETX>

Where:
<ARG> = 0 - 4095 in ASCII format

Example:
<STX>17,4095,<CSUM><ETX>

6.6.10 Request Analog Monitor Read backs

Description:

The Request major ADC feedback command requests that the firmware send the Analog to Digital Feedback monitors for the main monitoring channels.

Direction:

Host to supply

Syntax:

<STX><19><,> <CS> <ETX>

Example:

<STX>19, <CS><ETX>

Sending this command will request all essential A/D values. See responses for a description.

Response:

<STX><19><,><Arg1><,><Arg2><,><Arg3><,><Arg4><,><Arg5><,><Arg6><,>

<Arg7><,><Arg8><,><CS><ETX>

<Arg 1> - KV Feedback.

<Arg 2> - mA Cathode Feedback.

<Arg 3> - Filament Feedback.

<Arg 4> - KV program Feedback [Note 1]

<Arg 5> - mA Program Feedback [Note1]

<Arg 6> - Program Limit Feedback [Note 1]

<Arg 7> - Program Preheat Feedback [Note 1]

<Arg 8->- mA Anode Feedback [Note 2]

<u>Error Codes</u>:

None

<u>Note 1-</u>

For Local mode operation only.

<u>Note 2-</u>

Bipolar units only.

6.6.11 Request Total Hours High Voltage On

Description:
The host requests that the firmware sends the present value of the Total Hours High Voltage On.

Direction:
Host to supply

Syntax:
<STX><21><,><CSUM><ETX>

Example:
<STX>21,<CSUM><ETX>

Response:
<STX><21><,><ARG><,><CSUM><ETX>

Where:
<ARG> : NNNNN.N hours
<.> = ASCII 0x2E
N = 0 - 9 in ASCII format

Example:

<STX>21,99999.9,<CSUM><ETX>

6.6.12 Request Status

Description:

The Request Status command requests that the firmware send the status of the unit.

Direction:

Host to supply

Syntax:

<STX><22><,> <CSUM><ETX>

Example:

<STX> 22, <CSUM><ETX>

Response:

<STX><22><,><Arg1><,><Arg2><,><Arg3><,><Arg4><,><Arg5><,><Arg6><,>

<Arg7><,><Arg8><,><Arg9><,><Arg10><,><Arg11><,><Arg12><,><Arg13><,>

<Arg14><,><Arg15><,><Arg16><,><Arg17><,><CSUM> <ETX>

Argument Number	Description	Argument Number	Description
1	1 = HV Enabled	10	1= Large Filament Confirmation

2	1= Interlock 1 Closed	11	1= Small Filament Confirmation
3	1= Interlock 2 Closed	12	Reserved
4	1= ECR Mode Active	13	Reserved
5	1= PS Fault	14	Reserved
6	0 = Remote Mode, 1 = Local Mode Note*1	15	Reserved
7	1= Filament Enabled 0= Filament Disabled	16	1= Power Supply Ready
8	1 = Large Filament 0= Small Filament	17	1= Internal Interlock Closed
9	1= X-rays Eminent		

Error Codes:

None

Note*1- In order to for the supply to be in remote mode, insure that JB2 pin 14 is open (no connection). If this pin is grounded the unit will be in local mode and thereby will not be able to be controlled in remote mode.

6.6.13 Request DSP Software Part Number/Version

Description:
The host requests that the firmware sends the DSP firmware version.

Direction:
Host to supply

Syntax:
<STX><23><,><CSUM><ETX>

Example:
<STX>23,<CSUM><STX>

Response:
<STX><23><,>< ARG><,><CSUM><ETX>

Where:

<ARG> consists of eleven ASCII characters representing the current firmware part

number/version. The format is SWM9999-999

Example:

<STX>23,SWM9999-999,<CSUM><ETX>

6.6.14 Request Model Number

Description:
The host requests that the firmware sends the unit model number

Direction:
Host to supply

Syntax:
<STX><26><,><CSUM><ETX>

Example:
<STX>26,<CSUM><ETX>

Response:
<STX><26><,><ARG><,><CSUM><ETX>

Where:

<ARG> consists of five ASCII characters representing the model number. The format is

XNNNN, where N is a numeric character.

Example:

<STX>25,X9999,<CSUM><ETX>

6.6.15 Request User Configuration

Description:

The Request User Configuration command, requests that the firmware send the user configuration.

Direction:

Host to supply

Syntax:

<STX><27><,> <CS> <ETX>

Example:

<STX><27><,><ARG1><,><ARG2><,><ARG3><,><ARG4><,>

<ARG5><,><ARG6><,><ARG7><,><ARG8><,><ARG9><,><ARG10><,>

<ARG11><,><ARG12><,><CS><ETX>

Where:

<ARG 1> = Reserved for Spellman

<ARG 2> = Over Voltage Percentage-

<ARG 3> = Voltage Ramp rate- 1-10 Seconds max.

<ARG 4> = Current Ramp Rate- 1-10 Seconds max.

<ARG 5> = x-ray Pre warning time. 1-10 Seconds max.

<ARG 6> = arc count- Number of arcs allowed before shutting down supply.

<ARG 7> = Reserved for Spellman

<ARG 8> = Quench time-

<ARG 9> = Reserved

<ARG 10> = max KV- Maximum user range.

<ARG 11> = max mA- Maximum user range.

<ARG 12> = Watchdog Timer in seconds.

Error Codes:

None

6.6.16 Request Scaling

Description:

The Request Scaling command requests that the firmware send the current unit scalings.

Direction:

Host to supply

Syntax:

<STX><28><,> <CS> <ETX>

Example:

<STX>28, <CS><ETX>

Response:

<STX><28> <,><Arg1> <,> <Arg2> <,> <Arg3><,><CS><ETX>

Where

Arg1 = 160 (This is the raw value, 160= 160 KV).

Arg2 = 30   (This is the raw value, 30 = 30 mA).

Arg3 = Supply Polarity 0 = Uni-Polar, 1= Bipolar.

Error Codes:

None

Note 1-

In order to scale the User Interface two different scalings are used one for program values and the other for feedback values. Refer to Section A to determine how to calculate scaling factors

6.6.17 Reset Run Hours

<u>Description:</u>
The host requests that the firmware resets the run hour counter.

<u>Direction:</u>
Host to supply

<u>Syntax:</u>
<STX><30><,><CSUM><ETX>

<u>Example:</u>
<STX>30,<CSUM><ETX>

<u>Response:</u>
<STX><30><,><$><,><CSUM><ETX>

6.6.18   Reset Faults

<u>Description:</u>
The host requests that the firmware resets all Fault messages and indicators.

<u>Direction:</u>
Host to supply

<u>Syntax:</u>
<STX><31><,><CSUM><ETX>

<u>Example:</u>
<STX>31,<CSUM><ETX>

Response: <STX><31><,><$><,><CSUM><ETX>

6.6.19 Set Large/Small Filament

Description:

The Set Large/ Small Filament state, requests that the firmware sets the Large or Small filament state.

Direction:

Host to supply

Syntax:

<STX><32><,> <CS> <ETX>

Example:

<STX>32, <Arg1><,><CS><ETX>

Where Arg1 =

1 = Large Filament

0 = Small Filament

Response:

<STX><32><,><$><,><CS><ETX>

Response Codes:

$ = Success. Note 1.

1 = User tried changing the filament size while High Voltage was on.

Note 1-

User must reenter values for both KV and mA as they have been defaulted back to 0.

6.6.20 Request Power Limits

Description:

The Request Power Limit requests that the firmware send the programmed values for the large and small filament.

Direction:

Host to supply

Syntax:

<STX><38><,><CS><ETX>

Example:

<STX><38><,><CS><ETX>

Response:

<STX><38><,><ARG1><,><ARG2><,><ARG3><,><ARG4><,><ARG5><,>

<ARG6> <,> <CS> <,> <ETX>

Argument Number	Description
1	Large Limit
2	Small Limit

3	Filament Large Limit
4	Filament Small Limit
5	Preheat Large Limit
6	Preheat Small Limit

Error Codes:

None

6.6.21 Request FPGA Revision

Description:

The Request FPGA Part Number Rev requests that the firmware send the FPGA Software part and build number.

Direction:

Host to supply

Syntax:

<STX><43><,> <CS> <ETX>

Example:

<STX>43, <CS><ETX>

Response:

<STX><43><,><Arg1><,><Arg2><,><CS> <ETX>

Where Arg1 = Software part number (e.g. SWM00199-001)

       Arg2 = Build number (e.g. 3261)

Error Codes:

None

6.6.22 Request kV Monitor

Description:
The host requests that the firmware report kV monitor.

Direction:
Host to supply

Syntax:
<STX><60><,><CSUM><ETX>

Response:
<STX><60><,><ARG><,><CSUM><ETX>

Where:
<ARG>=0-4095 in ASCII format representing unscaled value.

Example:
<STX>60,4095,<CSUM><ETX>

6.6.23 Request –15V LVPS

Description:
The host requests that the firmware report –15V LVPS.

Direction:
Host to supply

Syntax:
<STX><65><,><CSUM><ETX>

Response:
<STX><65><,><ARG><,><CSUM><ETX>

Where:
<ARG>=0-4095 in ASCII format representing unscaled value.

Example:
<STX>65,4095,<CSUM><ETX>

6.6.24 Request Faults

Description:

The "Request Faults" command, requests that the firmware send the XRV's fault status.

Direction:

Host to supply

Syntax:

<STX><68><,><CSUM><ETX>

Example:

<STX><68><,><CSUM><ETX>

Response:

<STX><68><,><ARG1><,><ARG2><,><ARG3><,><ARG4><,><ARG5><,>

<ARG6><,><ARG7><,><ARG8><ARG9><,><ARG10><,><ARG11><,>

<ARG12><,><ARG13><,><ARG14><,><ARG15><,><ARG16><,><ARG17><,>

<ARG18><,><ARG19><,><ARG20><,><ARG21><,><ARG22><,><ARG23><,>
<ARG24><,><ARG25><,><ARG26><,><ARG27><,><CSUM><ETX>

For all arguments a 1 = fault a 0 = no fault.

Argument Number	Description	Argument Number	Description
1	Filament Select Fault	15	Cable Connect Cathode Fault
2	Over Temp Approach	16	AC Line Mon Anode Fault
3	Over Voltage	17	AC Line Mon Cathode Fault
4	Under Voltage	18	DC Rail Mon Anode Fault
5	Over Current	19	DC Rail Mon Fault Cathode
6	Under Current	20	LVPS Neg 15 Fault
7	Over Temp Anode	21	LVPS Pos 15 Fault
8	Over Temp Cathode	22	Watch Dog Fault Note*1
9	Inverter Fault Anode	23	Board Over Temp
10	Inverter Fault Cathode	24	Over Power Fault
11	Filament Feedback Fault	25	KV Diff
12	Anode Arc	26	mA Diff
13	Cathode Arc	27	Inverter Ready/Not Ready
14	Cable Connect Anode Fault		

<u>Note*1-</u> The watch dog bit is tripped if the supply does not receive any data from the host within 5 seconds. In order to prevent the supply from faulting out with a watch dog fault, the host must be in constant communication with the supply. Sending any command to supply will continuously clear out the watch dog fault and thereby allow the supply to continue running.

6.6.25 Request System Voltages

Description:

The Request System Voltages command, requests that the firmware send the various housekeeping, and miscellaneous voltages to the host.

Direction:

Host to supply

Syntax:

<STX><69><,> <CS><ETX>

Example:

<STX><69><,> <CS><ETX>

Response:

<STX><69><,><ARG1><,><ARG2><,><ARG3><,><ARG4><,><ARG5><,>

<ARG6> <,> <ARG7><,><ARG8><,><ARG9><,><ARG10><CS> <,> <ETX>

Argument Number	Description	Scaling Factor	Argument Number	Description	Scaling Factor
1	Temperature	0.05911815	6	DC Rail Mon Cathode	0.11399241
2	Reserved	N/A	7	AC Line Mon Anode	0.088610

3	KV Mon Anode	(Unit Max * 20%) / 4095	8	DC Rail Mon Anode	0.11399241
4	KV Monitor Cathode	(Unit Max * 20%) / 4095	9	Lvps Pos15	0.00427407
5	AC Line Mon Cathode	0.088610	10	Lvps Neg15	0.00576703

Error Codes:

Note 1-

None

6.6.26 Filament Enable

Description:

The Control Filament command host requests that the firmware enables or disables the filament.

Direction:

Host to supply

Syntax:

<STX><70><,> <CS> <,> <ETX>

Example:

<STX>70, <Arg1><,><CS><ETX>

Where Arg1 =

1 = Enable Filament

0 = Disable Filament

Response:

<STX><70><,><$><,><CS><ETX>

Error Codes:

Note 1-

None

6.6.27 XRV Controller Present

Description:

Inform the power supply that it is communicating with a XRV Controller unit.

Direction:

Host to supply

Syntax:

<STX><71><,> <CS> <,> <ETX>

Example:

<STX>70, <Arg1><,><CS><ETX>

Where Arg1 =

1 = XRV Controller is Present

0 = XRV Controller is not Present

Response:

<STX><71><,><$><,><CS><ETX>

Error Codes:

Note 1-

None

6.6.28 Program Power Limit

Description:

The Program Power Limit command requests that the firmware changes the power limit of the supply.

Direction:

Host to supply

Syntax:

<STX><97><,><ARG1><,><ARG2><,><CS><ETX>

Arg1 = Large Power Limit

Arg2 = Small Power Limit

Where:

<ARG> = 0 – 3000 Watts for Unipolar or 0-4500 Watts for Bipolar in ASCII format.

Example:

<STX><97><,><4095><,><2048><,><CS><ETX>

Response:

<STX><97><,><$><,><CS><ETX>

<STX><97><,><ARG><,><CS><ETX>

Where <ARG> = error code

Error Codes:

1 = Large Limit Entered invalid

2 = Small limit entered invalid.

Uni-polar Supply = 3000W

Bipolar Supply = 4500 W

Note1-

Checksum only sent for Serial and USB Communications.

6.6.29 Program HV On

Description:

The Control HV command, requests that the firmware turn on or off High Voltage.

Direction:

Host to supply

Syntax:

<STX><98><,><ARG><,><CSUM><ETX>

Where:

<ARG> 1 = on, 0 = off in ASCII format

Example:

<STX>98<,>1<,> <CS><ETX>

Response:

<STX><98><,><X><,><CS><ETX>

If X = $ then the command was accepted and HV will turn on.

If X = 1 then there was a fault within the PS and the unit cannot turn on. User should refer to status command for what fault is causing this issue.

6.6.30   Program Local/Remote Mode

Description:
The host requests that the firmware to switch between Local and Remote Mode.

Direction:
Host to supply

Syntax:
<STX><99><,><ARG><,><CSUM><ETX>

Where:
<ARG> 0 = Remote, 1 = Local, in ASCII format

Example:
<STX>99,0,<CSUM><ETX>

Response:
<STX><99><,><$><,><CSUM><ETX>   or

<STX><99><,><ARG><,><CSUM><ETX>

Where <ARG> = error code

Error Codes TBD,

1 = out of range

6.7   SERIAL COMMAND HANDLING

6.7.1   Command Time Out

The host computer should set a serial time out at approximately 100mS. This allows the DSP to process the incoming message, and transmit a response. The DSP will initiate a reply to incoming messages in approximately 1-2mS, with a worst case of 5mS.

6.7.2   Buffer Flushing

The DSP will flush the incoming serial data buffer every time an STX is received. This provides a mechanism to clear the receive buffer of partial or corrupt messages.

6.7.3   Handshaking

The only handshaking implemented on the host interface, is built in to the implementation of this protocol. That is, the host must initiate all communications. If the supply receives a program command, an acknowledge message is sent back to the host via the "$" message. If the host does not receive an acknowledgement within the time out window, the host should consider the message lost or the device off-line.

Similarly, if the supply receives a request command, the requested data is sent back to the host. If the host does not receive the requested data within the time out window, the host should consider the message lost or the device off-line.

This essentially uses the full-duplex channel in a half-duplex communication mode.

7.0 Scaling Factors

Although the XRV can either be a 160KV, 30mA or 225KV, 30 mA (depending on the model purchased) the unit can accept feedback (A/D) values which are 20% higher than the programming (D/A) values. Note that the XRV is a 12 bit based unit meaning, 0-Full scale for KV, ma, Preheat or Filament = 0 - 4095 bits. For your convenience these calculations are also displayed in the Graphical User interface (GUI) under the Misc tab. Both the programming and feedback scaling values have been calculated and are displayed here.

7.1 DAC Programming

To calculate the scaling factors for the DAC use the following formula:

Scaling Factor = (X / 4095)

Where X = Max KV, Max mA, Max Filament or Max Preheat.

For this example let's assume a 160 KV unit at 30 mA.

KV Scaling Factor = 160KV /4095 bits

KV Scaling Factor = 39.072039 Volts/bit

mA Scaling Factor = 30mA / 4095 bits

mA Scaling Factor = .00732601 mA/bit

7.2 A/D Feedback

To calculate the scaling factors for the A/D use the following formula:

Scaling factor for feedback value = ((X+ (X *0.2))/4095)

Where X = Max KV, Max mA, Max Filament or Max Preheat.

For this example let's assume a 160 KV unit at 30 mA.

KV Feedback Scaling Factor = ((160 + (160 *0.2)) / 4095)

KV Feedback Scaling Factor = 46.88 volts/bit

7.3 Power Scaling Factor Calculation

To calculate the units power scaling factor use the following formula

Power Scaling Factor= (Max Unit KV * Max Unit mA)/4095

For example:

XRV160N3000 = 160KV @ 30mA

Power Scaling Factor = (160 * 30)/4095 = 1.1721612 watts/bit