

# Instruction Manual

## MONOBLOCK® SERIES uXRB130P65

### High Voltage X-Ray Generator

MODEL :  
SERIAL# :  
DATE :

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HIGH VOLTAGE ELECTRONICS  
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## IMPORTANT SAFETY PRECAUTIONS

### SAFETY

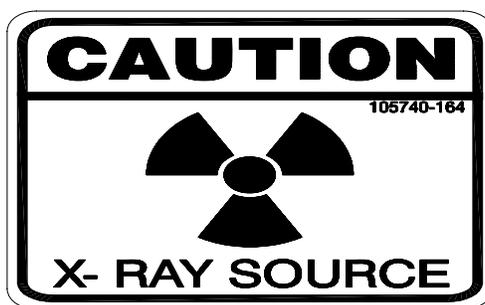
THIS POWER SUPPLY GENERATES VOLTAGES THAT ARE DANGEROUS AND MAY BE FATAL.  
OBSERVE EXTREME CAUTION WHEN WORKING WITH THIS EQUIPMENT.

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.

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# WICHTIGE SICHERHEITSHINWEISE

## SICHERHEIT

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

Das Hochspannungsnetzteil muß immer geerdet sein.

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

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

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



## SERVICESICHERHEIT

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

Reparaturen dürfen nur von qualifiziertem, eingewiesenem Personal ausgeführt werden.

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

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

# PRECAUTIONS IMPORTANTES POUR VOTRE SECURITE

## CONSIGNES DE SÉCURITÉ

CETTE ALIMENTATION GÉNÈRE DES TENSIONS QUI SONT DANGEUREUSES ET PEUVENT ÊTRE FATALES.  
SOYEZ EXTRÊMEMENT 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 entraîner 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 QUESTO 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.

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## WARNING



**Warning: Potential Hazard!**

The equipment described within this manual can produce lethal voltages and radiation.



It is recommended that only experienced personnel install, maintain and operate this equipment.

Special attention should be given to this manual to avoid personal injury to the user or surrounding personnel. It is recommended that this manual is reviewed in its entirety before installing or operating this equipment

# Chapter 1

## 1.0 INTRODUCTION



Figure 1:  $\mu$ XRB160P65

### 1.1 Description of the $\mu$ XRB130P65 Microfocus Monoblock<sup>®</sup> Series

The  $\mu$ XRB130P65 is an integrated 130kV Microfocus X-Ray source, comprised of an end window tube, packaged with a power supply and digital controller. The  $\mu$ XRB130P65 can be operated with either a Windows<sup>®</sup> - based Spellman GUI, (graphical user interface) or by a host computer via a RS232 port, utilizing the Product Interface Specification.

Installation and setup is straightforward. The user simply mounts the unit into a shielded X-Ray cabinet and connects the Power, Ground and RS232 cables. Safety interlocks provide for X-Ray shutoff in the event of enclosure compromise.

### 1.2 Operating Features

- Internal protection for the X-Ray tube to prevent damage to the target when changing kV or mA.
- Auto conditioning, (tube seasoning) to ramp unit up slowly depending how long the unit has been off.

### 1.3 User Interface

All control is through the RS232 port. The unit can be controlled using one of two methods.

#### 1.3.1 GUI (Graphic User Interface)

The Spellman supplied Windows based GUI is described in this document.

#### 1.3.2 SCI (Source Control Interface)

Document #118181-001

The SCI is a software development kit providing easy, high level control of the Spellman  $\mu$ XRB X-Ray source, employing a Digital Control Module, (DCM). The SCI is designed to be as developer friendly as possible, simplifying the tasks of communicating, interfacing and monitoring with the device. This includes the handling of the serial communications interface, polling, event data, error reporting and response parsing.

Since the 32-bit SCI is implemented as a COM object, it can be used in any Windows OS and any programming environment supporting ActiveX COM objects.

## 1.4 Interpreting the Model Numbers

The model number of the  $\mu$ XRB describes its capabilities.

1. Series Name
2. Maximum voltage in kVdc.
3. Polarity of the unit, (P) Positive
4. Maximum power in Watts.
5. Optional light weight version.  
Blank: Standard unit. (Standard)  
LW: Light weight version (Optional)
6. Tube options  
Blank: Narrow Beam (Standard)  
WB: Wide Beam (Optional)
7. Extended tube option:  
Blank: No extension (Standard)  
ET: Extended Tube (Optional)

<u><math>\mu</math>XRB</u>	<u>130</u>	<u>P</u>	<u>65</u>	<u>LW</u>	<u>NB</u>	<u>ET</u>
1	2	3	4	5	6	7

Sample Model Number: Standard tube, (Narrow Beam) in a Light Weight package

**$\mu$ XRB130P65 / LW**

## 1.5 Models / Outline Drawings

### 1.5.1 Narrow Beam

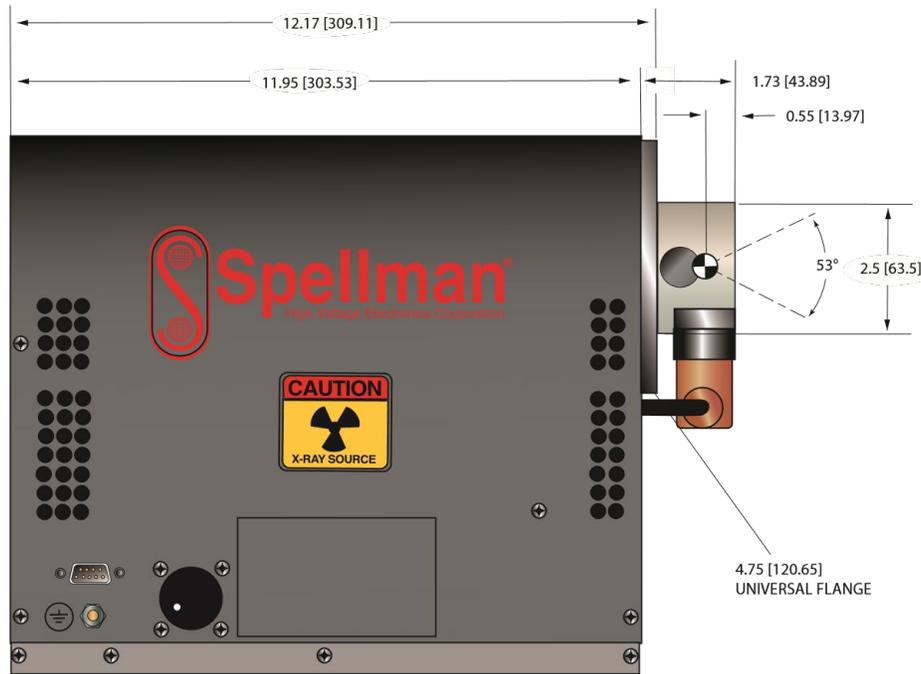


Figure 2: Narrow Beam

### 1.5.2 Wide Beam

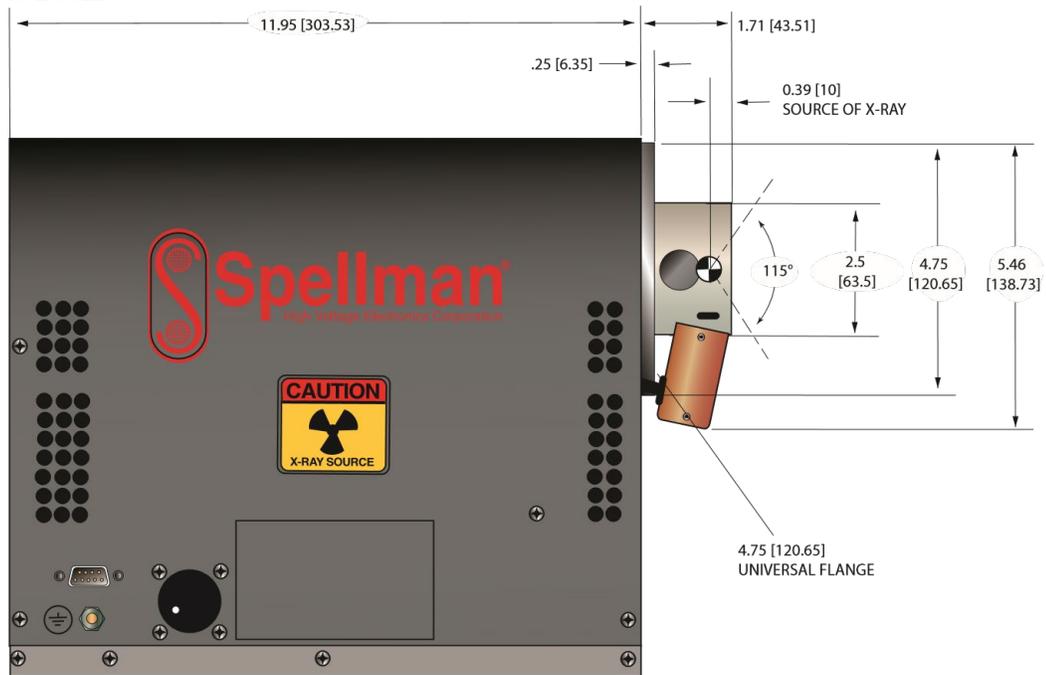


Figure 3: Wide Beam

### 1.5.3 Wide Beam with Extension

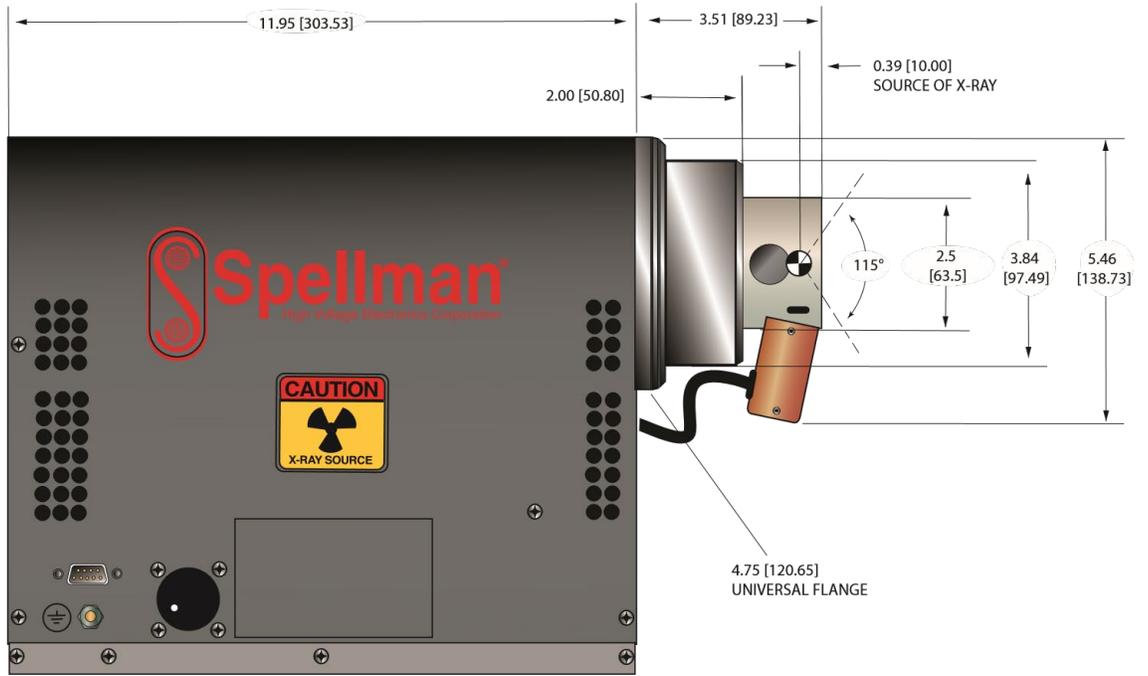


Figure 4: Wide Beam with Extension

# Chapter 2

## 2.0 INSPECTION

Inspect the package exterior for evidence of damage due to handling in transit. Notify the carrier and Spellman immediately if damage is

evident. Do not destroy or remove any of the packing material used in a damaged shipment.

After unpacking, inspect the chassis for any visible damage.

# Chapter 3

## 3.0 INSTALLATION

### 3.1 Physical Specification

For reference, the front of the unit is the surface the tube is mounted to. The back, (rear) side is the side opposite the front. The bottom is the rectangular surface opposite the rounded side.

Models: Standard Weight / No Extension  
Weight: Approximately 30 lbs.  
Center of Mass: Approximately 5.5" from back plate, 6.25" from bottom.

Standard Weight / With Extension  
Weight: Approximately 34 lbs.  
Center of Mass: Approximately 5.5" from back plate, 6.25" from bottom

Light Weight / No Extension  
Weight: Approximately 23 lbs.  
Center of Mass: Approximately 5.5" from back plate, 6.25" from bottom

Light Weight / With Extension  
Weight: Approximately 27 lbs.  
Center of Mass: Approximately 5.5" from back plate, 6.25" from bottom

### 3.2 Mounting

Threaded holes are provided on the bottom, front and rear surfaces.

**SIZE: 1/4 - 20 UNC**

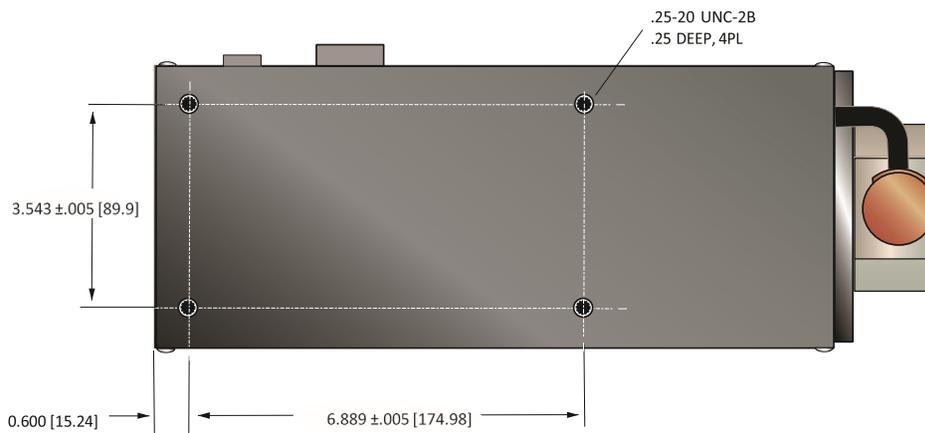


Figure 5: Bottom Mounting

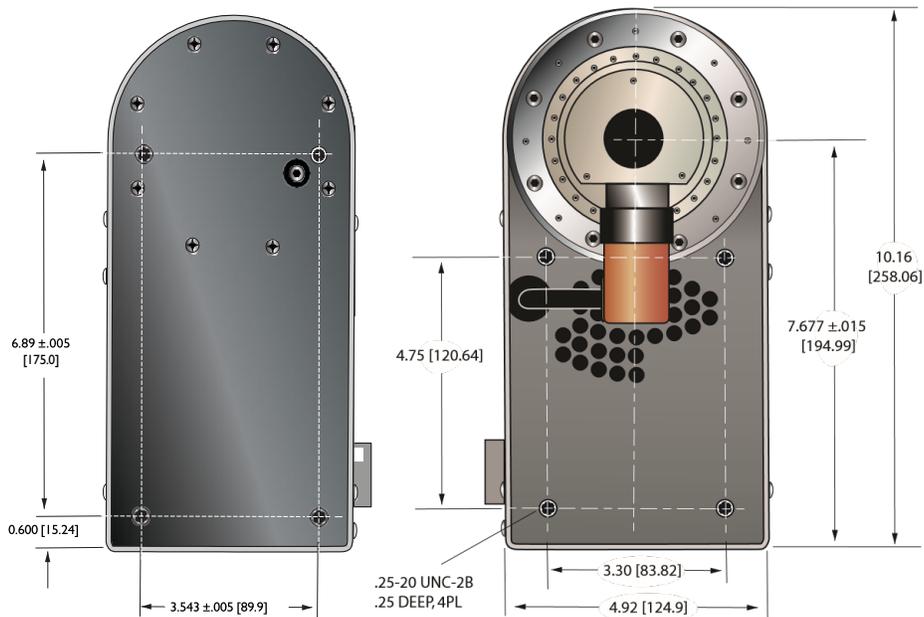


Figure 6: Front and Rear Mounting



**CAUTION:** Although the rear surface has mounting holes, it is not intended as the primary mounting surface. The front surface or the front and bottom surfaces together are the intended primary mounting surfaces.

Do not use the rear surface as the primary mounting surface. Do not use the rear surface without special precautions. If rear surface mounting is required, consult with **Spellman High Voltage**

For installations where the X-Ray source moves, including rotating gantry CT systems, it is strongly recommended to use both the front and bottom mounting surfaces together. The front and bottom mounting surfaces can be rigidly attached to the mounting bracket or gantry. This method achieves the most stable mounting to minimize movement of the X-Ray source

relative to the sample and detector for better image quality.



**CAUTION:** Additional mounting holes cannot be added by the customer, as this is likely to damage the unit and will void the warranty. If there is a unique mounting need, or a problem following these guidelines, please contact the factory.



**CAUTION:** Vibration should be minimized. Besides degrading the image quality, excessive vibration can damage or shorten the life of the unit.

### 3.2.1 Cooling

The  $\mu$ XRB160P65 is cooled by an internal fan which circulates ambient air through the unit. It has a temperature sensor which continually monitors and provides readout of the internal temperature, and an over temperature shut down circuit for protection.

**Important:** The  $\mu$ XRB160P65 requires unrestricted air flow around the cover, in the areas with vent holes for air inlet and outlet. Ambient air temperature should be  $< 32^{\circ}\text{C}$ .

### 3.3 Connections

There are 3 connections: Earth Ground, Control Interface, (RS232) and Power/Interlock.



Figure 7: Connections

### 3.3.1 Grounding

The chassis of the unit must be grounded, by using the connection located on the cover. This uses 8-32 hardware.

### 3.3.2 POWER/INTLK INTERFACE J1

#### 3.3.2.1 +24V requirements

**+24V Power Requirements:** It is very important to ensure that the +24Vdc power system is capable of supplying at least 6 Amps at +24V to the unit while operating at full power.

This is verified by measuring the DC voltage at J1-8 with the unit operating at full power. This voltage must be at least +23Vdc and is recommended to be +24Vdc to +25Vdc under full power operating conditions.

The voltage drops in the +24V supply wiring, and in any interlock switches are critical. The resistance of these circuits should be less than 0.5 ohms.

**Failure to provide adequate power to the unit will prevent it from reaching full kV or power, or successfully completing a conditioning cycle. It can also result in Error messages such as “Operating Fault Detected”.**

#### 3.3.2.2 Power / Interlock Connections

J1 is a 16 pin, AMP, PN 206036-8, low voltage connector for the DC power and interlock connections.

Mating Connector / Pins supplied with the unit:

- Connector: AMP, PN 206037-1. (*Spellman PN 105808-656*)
- Female Contacts, 18-16AWG: AMP, PN 66101-4. (*Spellman PN 105708-682*)

Contact Crimpers: TE Part # 91505-1 or AMP Part # 0091505-1.

Contact Extractor: TE Part # 305183

Table 1: J1 Power / Interlock Connector

J1 INPUT / OUTPUT		
PIN #	SIGNAL	PARAMETERS
1	Chamber Interlock Out	To close Chamber Interlock connect pin 1 to pin 2, R<2Ω
2	Chamber Interlock In	To close Chamber Interlock connect pin 2 to pin 1, R<2Ω
3	X-Ray ON Lamp Out	120Vac @ 3A/250Vac @ 1.5A rated contacts. Close at X-Ray ON
4	X-Ray ON Lamp In	120Vac @ 3A/250Vac @ 1.5A rated contacts. Close at X-Ray ON
5	N/C	N/C
6	Prime Power Interlock Out	To close Power Interlock connect pins 6, 7 to pins 8, 10. R<2Ω
7	Prime Power Interlock Out	To close Power Interlock connect pins 6, 7 to pins 8, 10. R<2Ω
8	Prime Power Interlock In	To close Power Interlock connect pins 8, 10 to pins 6, 7. R<2Ω
9	N/C	N/C
10	Prime Power Interlock In	To close Power Interlock connect pins 8, 10 to pins 6, 7. R<2Ω
11	+24Vdc Input (+)	+24Vdc Input (+)
12	+24Vdc Input (+)	+24Vdc Input (+)
13	+24Vdc Return (-)	+24Vdc Return (-)
14	+24Vdc Return (-)	+24Vdc Return (-)
15	X-Ray On Indicator Out	+24Vdc @ 3A rated contacts. Close at X-Ray On
16	X-Ray On Indicator In	+24Vdc @ 3A rated contacts. Close at X-Ray On

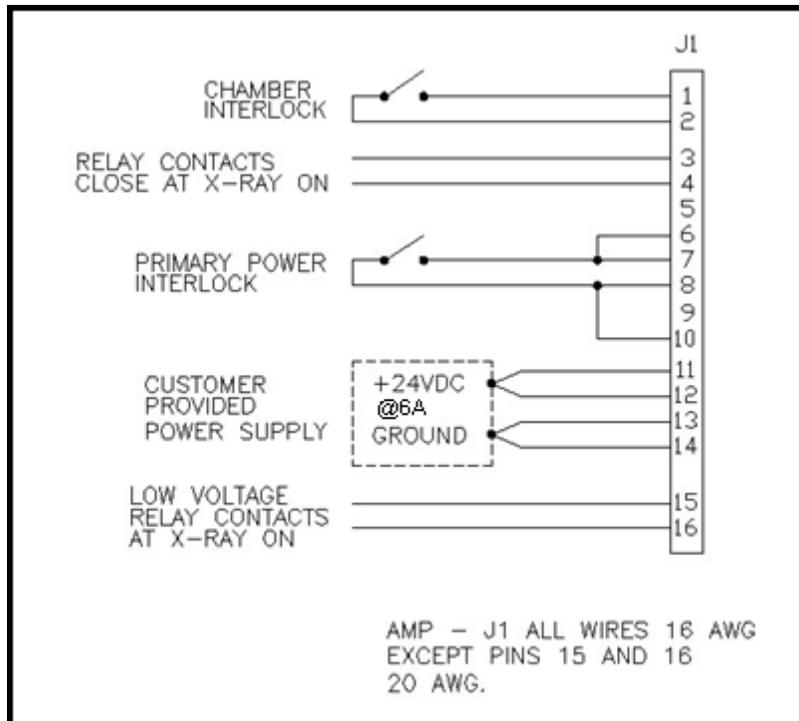


Figure 8: Power Wiring Diagram

1. Pins 1 and 2 are CHAMBER INTERLOCK. Interlock is required to allow X-Rays to be enabled. It is desired that the circuit be less than 0.5 ohms.
2. Pins 3 and 4 are for an X-Ray on light. An internal contact is closed when X-Rays are on.
3. Pins 6 and 7, 8 and 10 are for PRIMARY POWER INTERLOCK.



**CAUTION: Do not apply power to these pins.**

The +24Vdc main supply exits via pins 6 and 7. A contactor/switch, (Interlock) then routes the +24Vdc back to the unit, pins 8 and 10, Interlock Return. At least 22.5Vdc must be present at pins 8 and 10 to allow X-Rays to be enabled.

4. Pins 11 and 12 are the +24Vdc input, and pins 13 and 14 are the returns, (ground).
5. Pins 15 and 16 are an internal contact. The contact is closed when X-Rays are ON. The contact is rated +24Vdc @ 3Amps.

### 3.3.3 RS232 INTERFACE J2

J2 is a 9 pin Female “D” connector. The mating connector is an AMP PN 788903-1.

Flow Control: Hardware, (RTS/CTS)

Table 2: J2 RS232 Connections.

J2 RS-232 DIGITAL INTERFACE		
PIN #	SIGNAL	PARAMETERS
1	DCD	Data Carrier Detect
2	RD	Received Data
3	TD	Transmitted Data
4	DTR	Data Terminal Ready
5	SGNO	Signal Ground
6	DSR	Data Set Ready
7	RTS	Request to send
8	CTS	Clear to Send
9	RI	Ring Indicator

### 3.3.4 Installation Steps

#### 3.3.4.1 Mounting

- Mount the unit as per section 3.2.
- The enclosure must be radiation proof and secure to prevent personnel from accidental exposure to X-Rays. Remember that X-Rays can scatter off objects and thus get around corners.
- Ensure that there is adequate room for airflow around the unit. The maximum ambient air is not to exceed 32°C. Above this ambient the unit may not be able to operate continuously at full power.

#### 3.3.4.2 Main Power

Connect the +24V supply to the unit. The +24V goes to pins 11 and 12, and the ground goes to pins 13 and 14. See **Figure 8**. Use separate 16AWG wire for all four connections. The supply must be capable of handling 6Adc.

#### 3.3.4.3 Prime Power Interlock

Install a SPST switch (>6Amp Rating) onto the access door or panel of the radiation chamber. The switch must open when the access door opens, and close when the door is closed.

The software will indicate an “Unsafe” condition when the switch is open and prohibit X-Ray generation.

Connect the PRIME POWER INTERLOCK as indicated in **Figure 8**. The +24V comes out on pins 6 and 7 and is connected to one side of the switch. The +24V is then returned from the other side of the switch, back to the unit, pins 8 and 10.

Note: The interlock circuit should have less than 0.5 ohms series resistance. At least +22.5Vdc must be present at pins 8+10 to allow X-Rays to be enabled. Use 16 AWG wire for all 4 wires. It is suggested that the DC supply be set up for +25 to +26Vdc to ensure that adequate voltage is available after the voltage drops through the PRIME POWER INTERLOCK circuit.



**Warning:** It is highly recommended that the PRIME POWER INTERLOCK be used to provide safe operation of the equipment.

#### 3.3.4.4 Chamber Interlock

The CHAMBER INTERLOCK is an optional second interlock, which can be installed at an access door or another location. A SPST switch is connected between pins 1 and 2, see **Figure 8**. This interlock is a low current line and does not have to support the running current. However, it is recommended the circuit has less than 0.5 Ohms series resistance.

Note: If the interlock is not used, pins 1 and 2 must be shorted together.

#### 3.3.4.5 X-Ray On Relays

There are 2 available relays which can be used to switch an external X-Ray beacon lamp or low voltage device on/off, see **Figure 8**. When X-Rays are on the contacts close.

J1, Pins 3 and 4 are rated for 125Vac @ 3A / 250Vac @ 1.5A.

J1, Pins 15 and 16 are rated for 25Vdc @ 3A.

#### 3.3.4.6 RS232

Connect the RS232 cable to J2 as shown in **Figure 7**. Connect the cable to an available serial port on the host computer.

# Chapter 4

## 4.0 SAFETY / WARNINGS



**Extreme caution must be exercised when working with this equipment.**



**The high voltage generated in the power supply is dangerous and may be fatal if encountered. Never remove the X-Ray tube or disassemble the unit.**



**The unit must be grounded. Although the unit is grounded through the mounting hardware, the 8/32 ground screw on the unit must be used.**



**The X-Rays generated in the tube are dangerous. Radiation dosimeters must be worn by anyone working with or observing the operation of this equipment.**

**Users planning to install radiation generating equipment should ensure that they are in compliance with Local, State and National / International regulations.**

# Chapter 5

## 5.0 PRECAUTIONS FOR SAFE OPERATION AND LONG LIFE

- Ensure the supply is securely mounted.
- Do not touch the tube window or subject it to any mechanical pressure or abrasion. Do not allow anything to contact the window, especially adhesives or corrosive materials.
- The  $\mu$ XRB130P65 contains glass and other fragile materials. Do not drop or subject to excessive vibration.
- Use the 8/32 grounding terminal.
- Use the interlock circuits provided as described in the Installation section.
- Do not operate with restricted air flow around the unit. Sufficient cooling air is required for normal operation. Although the unit has an internal fan and an over temperature sensor, ambient air must be less than 32°C and freely circulating for full power operation.

# Chapter 6

## 6.0 CONTROL INTERFACE INSTRUCTIONS

### 6.1 Introduction

The supply has 2 operating options:

1. Customer programmed commands.

This control has a separate user's manual

2. Graphic Users Interface (GUI), as describe in this Manual.

### 6.2 Screen Layout

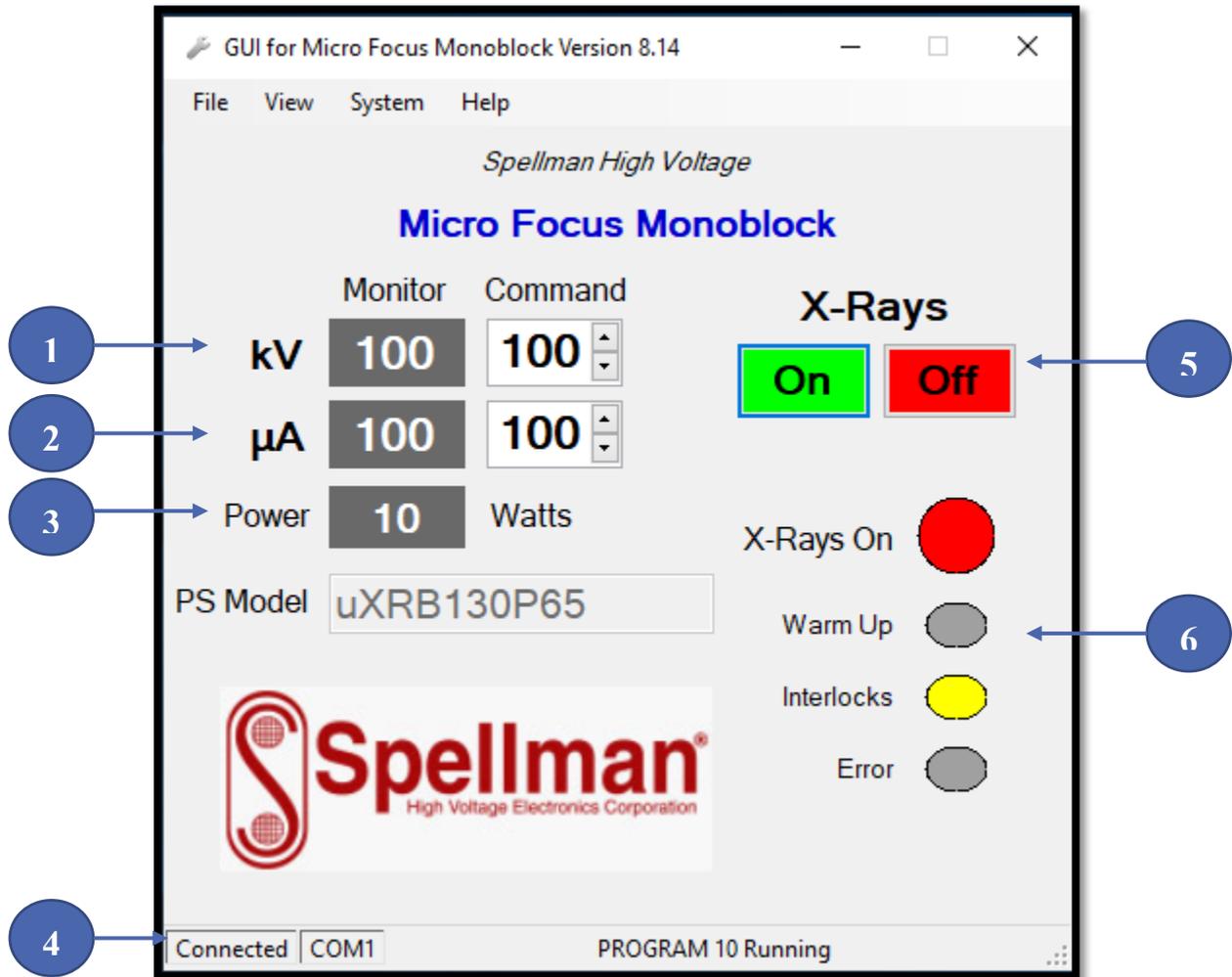


Figure 9: Screen Layout

### 6.2.1 kV Section (Item 1, Figure 9)

The “Monitor” column and the “Command” column divide the kV section of the control interface

The kV monitor box is responsible for polling and displaying kV information acquired from the unit.

The kV command textbox allows the user to specify the desired kV of the supply. Note that the Up/Down arrows can also be used to increment Up/Down the kV.

To set the beam voltage, enter a number into the kV command textbox. The command to change kV will occur when the user presses enter or the focus is lost from the kV command textbox. Alternatively, each time the user clicks the Up/Down arrows, a kV change command will be sent.

### 6.2.2 uA Section (Item 2, Figure 9)

The “Monitor” column and the “Command” column divide the uA section of the control interface

The uA monitor box is responsible for polling and displaying uA information acquired from the unit.

The uA command textbox allows the user to specify the desired uA of the supply. Note that the Up/Down arrows can also be used to increment Up/Down the uA.

To set the beam current, enter a number into the uA command textbox. The command to change uA will occur when the user presses enter or the focus is lost from the uA command textbox. Alternatively, each time the user clicks the Up/Down arrows, a uA change command will be sent.

### 6.2.3 Power Reading (Item 3, Figure 9)

The power reading indicates the current beam power of the supply. This is derived from the formula “ $kV * uA / 1000$ ”, rounded to the nearest integer.

### 6.2.4 Status Bar (Item 4, Figure 9)

This bar is subdivided into three panes.

The first pane displays whether communications has been established with the supply.

The second pane shows the active communications port.

The third pane displays recent event messages.

### 6.2.5 X-Rays On / Off (Item 5, Figure 9)

These large “On” and “Off” buttons are used to turn the X-Rays on and off. When the “On” button is clicked, the command “X-RAY ON” is sent. If the unit verifies that the X-Rays have been enabled, then the “On” button turns bright green and the “X-Rays On” indicator flashes red. When the “Off” button is clicked, the command “XRAY OFF” is sent. If the unit verifies that the X-Rays have been disabled, then the “On” button and the “X-Rays On” indicator turn gray.

For safety reasons, there are differences in the way the GUI interface transmits the “XRAY ON” and “XRAY OFF” commands. The interface only transmits an “XRAY ON” when it has verified communications and has determined the X-Rays are not already on. The “XRAY OFF” signal is transmitted with the highest priority, regardless of any condition.

### 6.2.6 Indicator Lights (Item 6, Figure 9)

The “X-Rays On” indicator flashes red when X-Rays are enabled and turns gray when X-Rays are not present.

The “WARM UP” indicator turns orange when warm up or tube conditioning is in process and turns gray when they are not in process.

The “Interlocks” indicator turns yellow when the interlocks are closed and allows X-Rays to be turned on. When an interlock is open, the indicator turns gray and X-Rays will be prohibited from turning on.

The “Error” indicator turns red when an error has been detected and defaults to gray when no errors are present.

## 6.3 Drop Down Menus

### 6.3.1 File

The File menu contains the Exit submenu, which closes the GUI

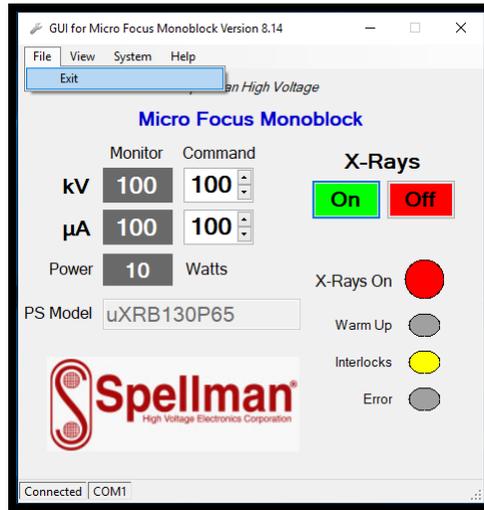


Figure 10: File Menu

### 6.3.2 View Menu

The view menu selects the size of the GUI, “Standard / Compact”. There is an option to keep the GUI on the top layer on the computer screen.

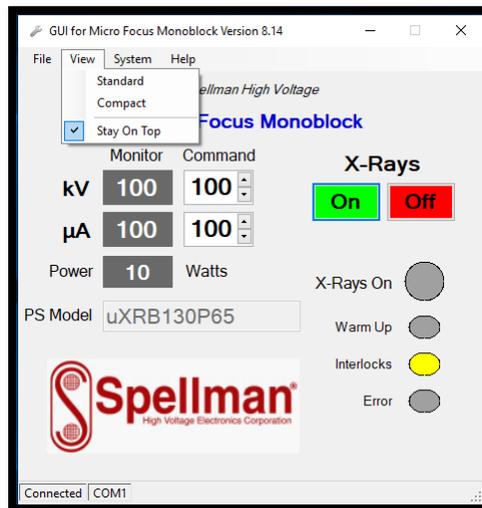


Figure 11: View Menu

### 6.3.3 System Menu

The system menu has the following three command programs.

1. 001: Tube Conditioning, 9min. 130KV: **Starts 9 minutes conditioning.**
2. 002: Tube Conditioning, 27min. 130KV **Starts 27 minutes conditioning.**
3. 003: Tube Conditioning, 54min. 130KV **Starts 54 minutes conditioning.**

There are also three additional screens:

1. View Diagnostics Screen
2. View Command Log
3. View Serial Ports.

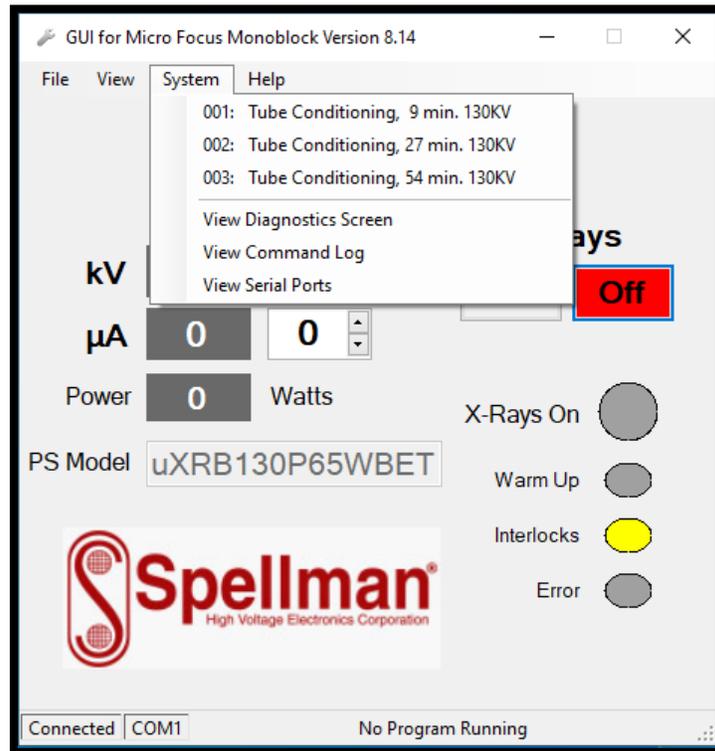


Figure 12: System Menu

### 6.3.3.1 View Diagnostics Screen

This opens the Diagnostics Screen.

In the Diagnostics Screen:

1. System Information. This displays the product models and serial numbers.
2. Acquire Event Log. This lists the recorded events. There are Save and Print options.
3. Acquire Diagnostics. The Diagnostics Mode needs to be selected. This list status of the  $\mu$ XRb130P65. There are Save and Print options.
4. Terminal Mode. The Terminal Mode needs to be selected. This allows manual commands to be sent to the  $\mu$ XRb130P65.

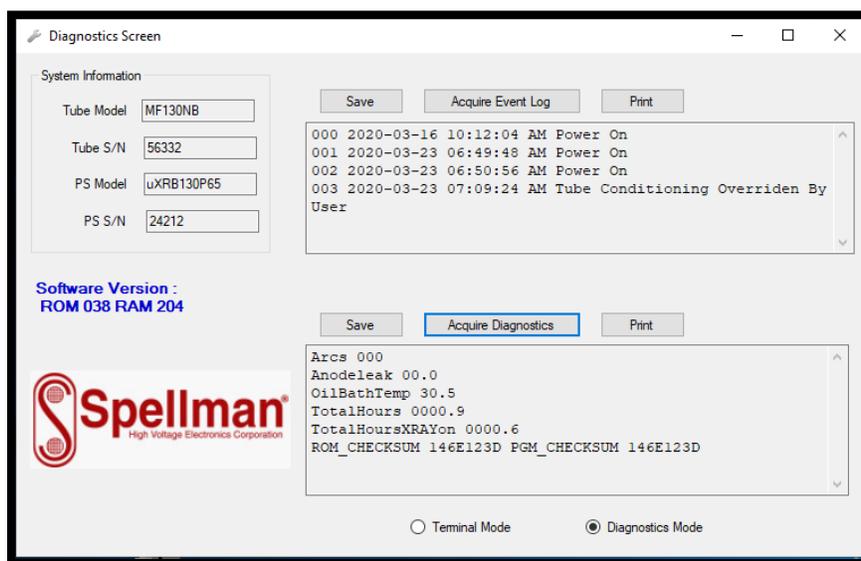


Figure 13: Diagnostics Screen

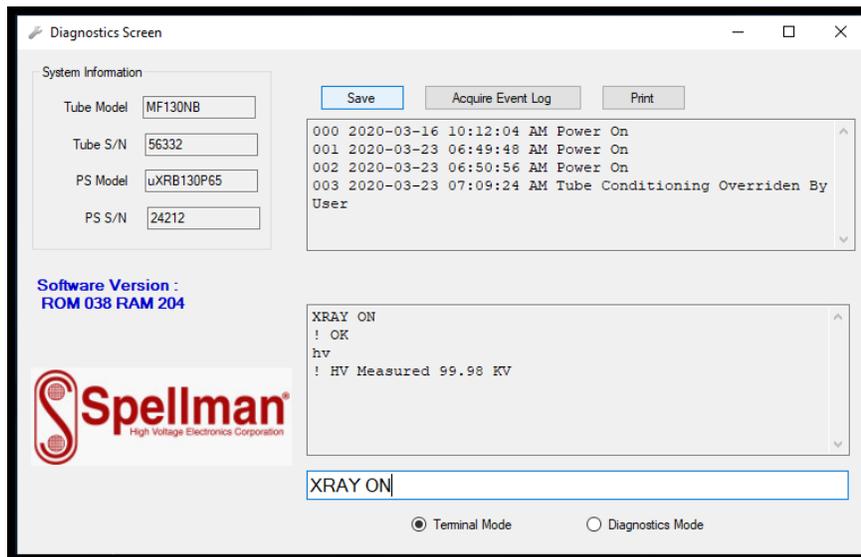


Figure 14: Terminal Mode

### 6.3.3.2 Command Log

This opens the Command Log screen. There are Save and Print options.

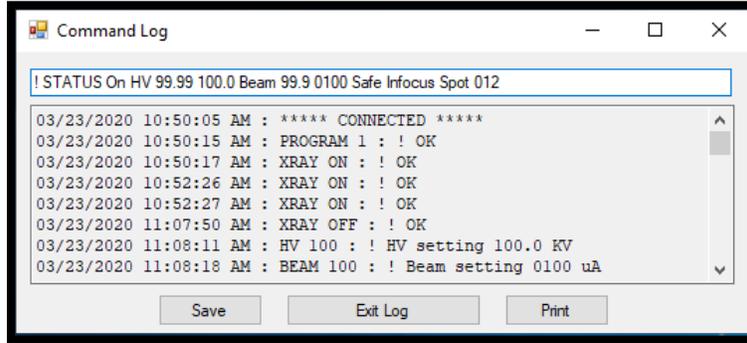


Figure 15: Command Log Screen

### 6.3.3.3 View Serial Ports

A Com Port can be selected and tested to see if there is communication with the  $\mu$ XRB130P65.

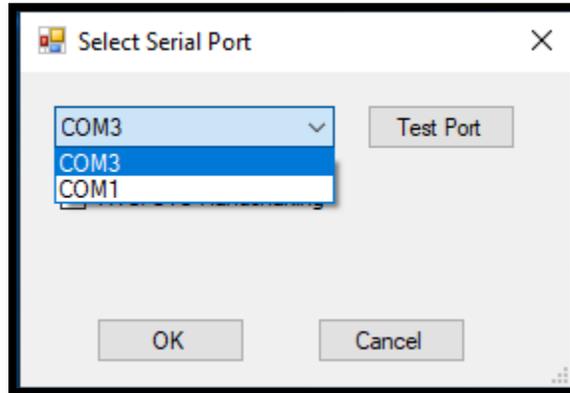


Figure 16: Select Serial Port

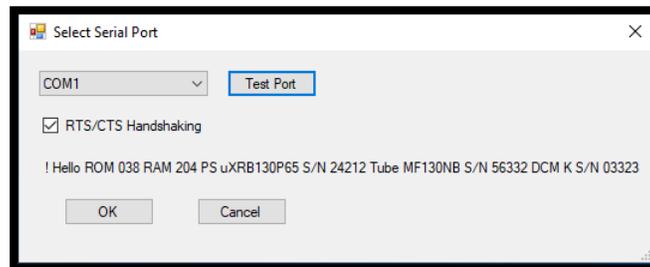


Figure 17: Serial Port Connected

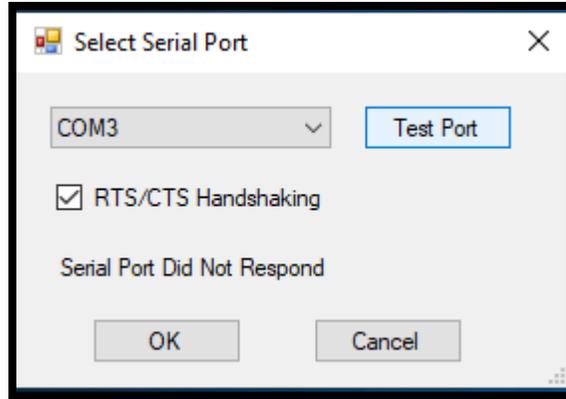


Figure 18: Serial Port Not Connected

### 6.3.4 Help Menu

The Help menu contains the About submenu.

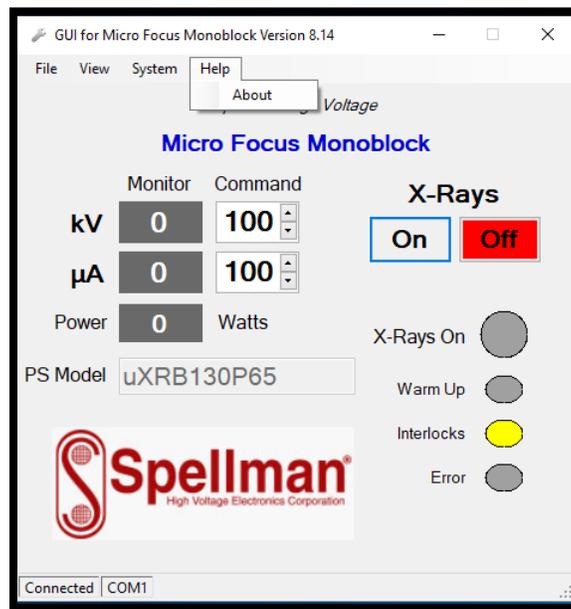


Figure 19: Help Menu



Figure 20: About Menu

## 6.4 Event Messages

Any event messages received from the unit are processed and handled by the GUI interface program. When a message is first received, it is timestamped and placed into the third pane of the status bar, (6.2.4) on the bottom of the form.

After a minute, the message will disappear from the status bar. Additionally, copies of all-time stamped event messages are placed into the Command Log.

Here is a listing of some of the possible events encountered while using the GUI interface.

### 6.4.1 Error Messages

- ! Error 10 No host RTS signal.
- ! Error 12 Prime power interlock interrupted during Xray-on.
- ! Error 13 Chamber interlock interrupted during Xray-on.
- ! Error 14 Arc Detected.
- ! Error 15 Warmup process restarting at slower rate.
- ! Error 16 Too many arcs detected; X-rays are now off.
- ! Error 18 Current program must end before a new program can be started.
- ! Error 19 Tube or power supply operating fault detected.
- ! Error 20 Tube envelope exceeds maximum operating temperature.
- ! Error 28 Tube conditioning required before operating tube.

### 6.4.2 Warning Messages

- ! Warning 01 Warmup process is beginning.
- ! Warning 02 Warmup process is ending.
- ! Warning 03 Warmup process: KV is on.
- ! Warning 04 Warmup process: Beam is on.
- ! Warning 05 Warmup process: about 15 minutes remain.
- ! Warning 06 Warmup process: about 30 minutes remain.
- ! Warning 07 Warmup process: about 5 minutes remain.
- ! Warning 08 Clock change effective after power off/on.
- ! Warning 09 Program execution beginning.
- ! Warning 10 Program execution ending.
- ! Warning 11 Tube conditioning requirement was overridden.

## 6.5 Hot Keys

The following hotkeys have been assigned for accelerated operation of the Source Control Interface.

- Ctrl-X: Exit the Source Control Interface
- Ctrl-S: Open connection setup dialog
- Ctrl-L: Open the command log dialog.
- Ctrl-D: Initiate the tube conditioning feature
- Ctrl-H: Show this help file
- Ctrl-A: Show about dialog

## 6.6 Constant Power Operation

When the kV is changed, the beam current is automatically adjusted to force a constant power level. In order to change the power level, the user must adjust the beam current.

# Chapter 7

## 7.0 OPERATING INSTRUCTIONS

The following is the recommended operating procedure for the initial startup after installation of the supply.

This gives instructions for verifying the proper functioning of the equipment and at the same time, acquaints the user with the controls and operating features.

This procedure assumes that the installation is complete, and the GUI interface is installed

### 7.1 Initial Power On / Communications Setup

Power on the +24V to the supply and start the GUI interface. Confirm that the status as indicated in the message bar at the bottom of the window is “Connected”, and that the Com Error light is off. If a connection has not been established, check the com port settings in the “Connection” drop down menu. If power has just been applied to the unit, the “Warm Up” light will flash for about two minutes.

### 7.2 Verify Interlocks

To verify “PRIMARY POWER” interlock operation, open the test chamber door. The “Interlock” light on the GUI should go out. There should be no response when operating the X-RAY ON command.



**If the Interlock does not work do not proceed. For safety the interlock must be properly working.**

If the optional “CHAMBER” interlock is used, test this also. The “Interlock” light on the GUI should go out. There should be no response when operating the X-RAY ON command.

When both interlocks are closed the “Interlock” light will be Yellow.

### 7.3 X-Ray Exposure

Using the GUI, initiate tube conditioning. Select “003: Tube conditioning 54 min. 130KV” from the drop-down menu. Activate the X-RAY ON button, **this must be activated within 5 seconds from tube conditioning start**. This will start the tube conditioning process.

If there are problems with arcing or leakage, the appropriate message will be seen in the GUI or will be sent to the host computer. At the end of the conditioning cycle, X-Rays are turned off and the unit is operational.

### 7.4 Normal System Operation

After the initial set up and test procedures have been done, normal system operation applies. These guidelines apply to operation with either the GUI interface, or user developed interface on a host computer

## 7.5 Warm Up

There are two types of warm up that are indicated by the GUI. The “Warm Up” light or the messages to the host computer.



### IT IS IMPORTANT TO READ THIS

1. Every time that power is applied to the unit, the warm up light will flash for about 2 minutes until the cathode has reached operating temperature. If power has been off only a few seconds, the warm up time is less than 2 minutes, but there is still some warm up time.
2. The second is the tube conditioning feature, which is also indicated by a flashing warm up light. In this case, messages are displayed at the bottom of the GUI window (or are sent to the host computer).



If the unit detects X-Rays off for >8 hours, the Tube Conditioning will be enforced.

- 001: Tube Conditioning, 9 min. 130KV
- 002: Tube Conditioning, 27 min. 130KV
- 003: Tube Conditioning, 54 min. 130KV

Again, note that that the X-Ray ON command must occur within 5 seconds of selecting Program 1, 2, or 3 or the program will abort without tube conditioning occurring.

If there are problems with arcing or leakage, the appropriate message will be seen in the GUI or will be sent to the host computer. At the end of the conditioning cycle, X-Rays are turned off and the unit is operational.

### 7.5.1 System Operations

Now that the source is fully conditioned, it can be turned on with any kV and beam current settings within the normal range of operations.

However, the following guidelines are best kept in mind when establishing your own operating routine.

- If the source is to be used throughout the working day, continuous operation within specified ratings will maintain the source at its normal operating temperature and minimize warm-up drift.
- Frequent on-off cycling to full power is stressful to the source.
- Occasional arcs are inherent in X-Ray equipment and should not cause alarm. However, frequent arcing, which cannot be stopped by repeating the conditioning procedure is indicative of a fault, and service may be required.
- Prolonged operation at low beam voltages (45kV or less) is not advised and can reduce life expectancy.

### 7.5.1 Turn On Transient Times

The source typically ramps from off to the desired set point in 10 to 20 seconds. At higher power settings, the transition can be up to 25 seconds.

### 7.5.3 Operational Tube Ranges

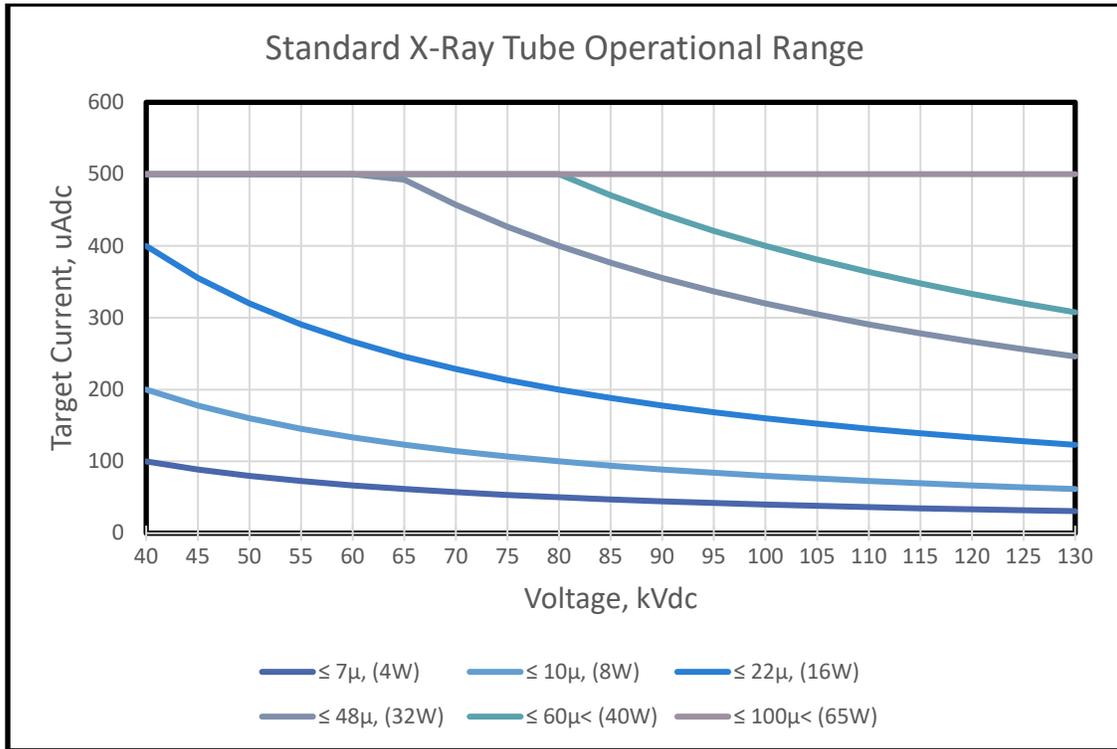


Figure 21: Operational Range, Standard Tube

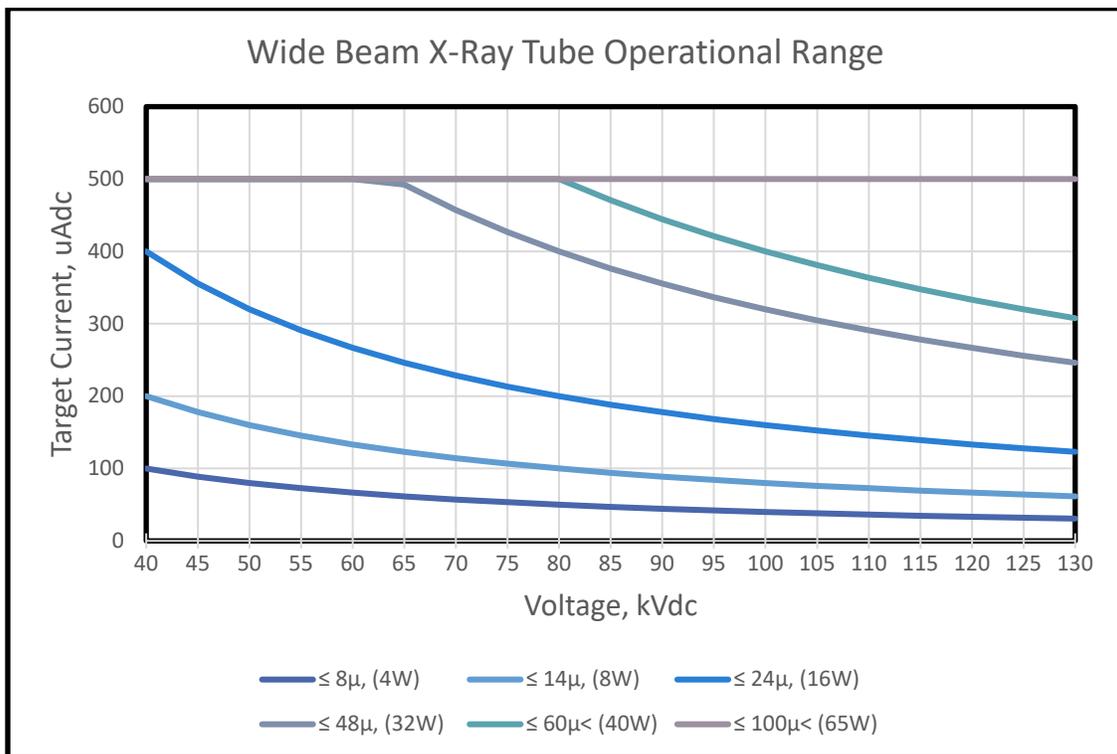


Figure 22: Operational Range, Wide Beam Tube

## 8.0 PREVENTIVE MAINTENANCE

Spellman High Voltage Monoblock® X-Ray Sources are engineered for long life with high performance. However, regular attention to a few details is necessary to sustain the full performance of the source. Source deterioration, or failure, can be as much the result of neglect as well as the result of component or circuit failure.

1. Operating the system at or near nominal ambient conditions (room temperature, 23 degrees Centigrade) with +24 to +26 Vdc input will help ensure optimum performance and long operating life.
2. The unit should have unrestricted airflow around the chassis. Do not impede the natural air circulation around the unit and check periodically to ensure the air holes located on the front and sides are clear of dust and debris and are not blocked by other hardware.
3. Maintain a regular schedule of tube conditioning. Run one of the provided tube conditioning programs whenever the source has not had X-Rays on for more than 8 hours. If the source has not been used for more than 30 days, run the 60-minute conditioning.

# Chapter 9

## 9.0 FACTORY SERVICE

### 9.1 Warranty Repairs

During the Warranty period, Spellman will repair all units free of charge. The Warranty is void if the unit is worked on by anyone other than Spellman personnel.

### 9.2 Factory Service Procedures

Spellman has a well-equipped factory repair department. If a unit is returned to the factory for calibration or repair, a detailed description of the specific problem should be attached.

For all units returned for repair, please obtain an authorization form from the Customer Service Department below. Please state the model and serial numbers which are on the plate on the panel of the power supply, and the reason for return. A Service Order Code Number (SVO number) is needed from Spellman for all returns. The SVO number should be marked clearly on the outside of the shipping container. Packages received without an SVO Number may delay return of the product. The buyer shall pay shipping costs to and from Spellman.

For out-of-warranty repairs, the Standard Cost will be given by Customer Service. A purchase order for this amount is requested upon issuance of the SVO Number. A more detailed estimate may be made when the power supply is received at Spellman. If initial investigation indicates that the cost of completing the repair will exceed the Standard Cost for that unit, Spellman will contact the customer to authorize the repair. If Spellman evaluates a unit and either finds that no defect is found, or if the unit is uneconomical to repair, Spellman will charge a bench evaluation fee.

### 9.3 Factory Service Warranty

Spellman will warrant for three (3) months or balance of product warranty, whichever is longer, the repaired assembly/part/unit. If the same problem shall occur within this warranty period Spellman shall undertake all the work to rectify

the problem with no charge and/or cost to the buyer.

### 9.4 Shipping Instructions

All power supplies returned to Spellman must be sent shipping prepaid. Pack the units carefully and securely in a suitable container, preferably in the original container, if available. The power supply should be surrounded by at least four inches of shock absorbing material.

### 9.5 Customer Service

#### Spellman High Voltage Electronics Corp.

475 Wireless Boulevard

Hauppauge, New York 11788

TEL: (631) 630-3000

FAX: (631) 435-1620

E-mail:

[CustomerService@spellmanhv.com](mailto:CustomerService@spellmanhv.com)

E-Mail: [sales@Spellmanhv.com](mailto:sales@Spellmanhv.com)

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

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



## μXRB130P65 Digital Interface

Serial – RS-232



This information has been prepared for the express purpose of assisting operating and maintenance personnel in the efficient use of the model described herein, and publication of this information does not convey any right to reproduce it or to use it for any purpose other than in connection with installation, operation, and maintenance of the equipment described.

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## 1.0 INTRODUCTION

Spellman Microfocus X-ray Monoblock, ( $\mu$ XRB) employing the Digital Control Module (DCM) require a functioning RS-232 (serial) connection in order to become a fully operational X-ray generator. All commands and queries are passed exclusively through the RS-232 interface. This  $\mu$ XRB Interface Manual describes how to set up a functional connection to the X-ray Source, and specifies the commands and responses sent between the supply and the host.

## 2.0 INTERFACE OPTIONS

The DCM uses “plain text” (“clear text”) dialog throughout. In this respect it is similar to other simple text dialog-controlled devices. A common example of such a device is the telephone modem, which uses the Hayes command set, using commands such as “connect” and responses such as “no carrier.” As with a telephone modem, the DCM can be controlled by a wide variety of hosts. The types of hosts tend to fall into these basic types, from least complex to most complex:

### 2.1 Dumb Terminal

The supply can be connected to a TTY or VT-100 compliant terminal. This is a device with a keyboard to allow user commands to be typed, plus a display (CRT, LED, other display, or a printer). There is a human operator.

### 2.2 PC Terminal Emulator

This is generally a PC running MSDOS or Windows plus an application which emulates the features of a simple terminal. An application of this type, which is commonly available with Windows is “HyperTerminal”. Another suitable application is “Tera Term Pro”.

### 2.3 Microcontroller / PC Based Manual Control System

The user may use the  $\mu$ XRB as a component in a customized microcontroller or PC based manual control system. In this type of installation, the user must write firmware for the host controller, which will operate an RS232 port. The host receives direct input (keystrokes or mouse clicks) from an operator and sends the

appropriate commands as defined in this document to the  $\mu$ XRB. The RS-232 port plus the host controller firmware form a module which functions as a substitute for a PC terminal emulator.

### 2.4 Microcontroller / PC Based Automated Control System

This type of host is very similar to that in 2.3, except that the host controller has the capability of automated or semi-automated operation. With the control system functioning in an autonomous (unattended) mode, the user will need to provide significant additional customized software. In this case the firmware is functioning as both terminal and terminal operator. This type of system must not only communicate with the  $\mu$ XRB, but it must make decisions about what commands to send, receive and evaluate responses.

For installations of types 2.1 and 2.2, the user will need to create a functioning connection and then become familiar with the commands and responses. In this document, these types of installations will be referred to as **terminal** installations. An operator will issue commands and receive responses.

For installations of types 2.3 and 2.4, the user will need to create a custom program or software/firmware application which can run the serial connection. This will issue the plain-text commands and monitor the plain-text responses as needed to accomplish the user’s system requirements. Installations of this type will be referred to in this document as **host controller** installations. It is well beyond the scope of this document to attempt to provide detailed assistance for the creation of a host controller application because each user’s needs will vary greatly, but some general guidelines will be offered.

### 3.0 ESTABLISHING A CONNECTION

All types of installations require the same kind of serial connection, RS-232. RS-232 is a serial communications standard in which a “data communications equipment”, (DCE) is connected to another device, the “data terminal equipment”, (DTE).



Beware of “serial printer” cables which have 9-pin connectors but only 5 pins wired, these will not work.



A “Null-Modem” or “crossover” type cable or adapter must not be used. DCE to DTE wiring of this type uses a direct 1-to-1 connection.

#### 3.1 Hardware Connection

1. The connector on the  $\mu$ Focus is a 9-pin “D” type, with a male shroud and female pins.
2. Pins 1-8 must be present and wired. Pin 9 (Ring Indicator, “RI”) is unused and may be omitted. The other 8 wires must be wired from end to end in the cable.

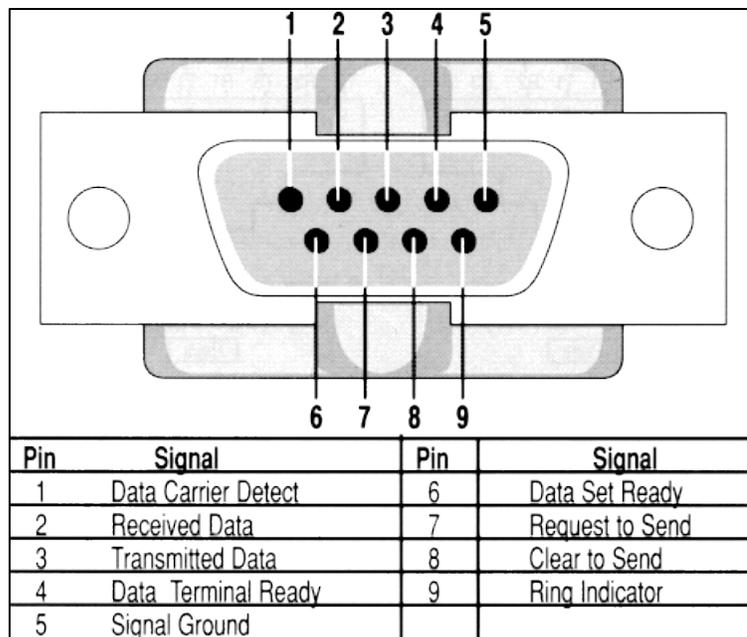


Figure 1:  $\mu$ XRB Internal RS-232 Configuration

## 3.2 CONFIGURING THE COM PORT

After the proper cabling is in place, the com port must be opened in the correct mode. In the case of a PC running a terminal emulation, these settings must be set:

### 3.2.1 Baud Rate

38400. The baud rate of the  $\mu$ XRB is fixed and cannot be changed.

### 3.2.2 Data Handshaking

The port must be configured for “hardware handshaking” also known as “CTS/RTS handshaking”. This is a byte-by-byte handshaking method in which the DTE checks for a TRUE on the CTS line immediately before beginning to send each byte to the DCE, and the DCE checks for a TRUE on the RTS line before sending each byte to the DTE. Modern PC’s have com port interface chips called UART’s which implement this handshaking automatically, but it must be enabled by the host computer. Do not attempt to implement “software handshaking” also known as “X-on, X-off”.

### 3.2.3 Device Handshaking

Set the port to enable “modem-type” sensing of DSR and DTR.

### 3.2.4 Byte Size

The byte size is 8 bits. However, note that only the ASCII character set is recognized by the  $\mu$ XRB. This means that characters with the high bit set (128-255) may not be sent to the  $\mu$ XRB. Such characters may be either ignored by the  $\mu$ XRB or translated to an ASCII character by setting the high bit off. The 8-bit byte is expected to always consist of a high bit set to zero. Using a terminal emulation setting equivalent to “TTY” (Teletype 33) will prevent

non-ASCII characters from being sent accidentally to the unit. If the terminal emulation program being used cannot be set to emulate “TTY” then a second choice would be “VT-100”, but note that it is possible that some keystrokes such as arrow keys may cause unexpected responses from the  $\mu$ XRB and it is best to avoid them.

### 3.2.5 Parity

Set parity to “none” or “N”. Parity is not used, and no parity bit is sent or permitted.

### 3.2.6 Stop Bits

Set “stop bits” to “1”. The above combination of byte, parity, and stop bits is sometimes written as “8N1” or “8,n,1” and is one of the standard settings in terminal emulation programs.

### 3.2.7 Duplex Type

Set the type of connection to “full duplex” or “local echo off” if the program offers a choice. “Half Duplex” is not needed because characters sent by the host to the  $\mu$ XRB are automatically echoed back to the host, where they are received and displayed. The setting “half duplex” or “local echo on” means that the emulator prints the character just typed and is meant for communicating with devices which can only receive data, not send data. Standard 2-way communication is generally meant to be “full duplex”.

### 3.2.8 Application Specific Settings

Some terminal emulation applications do best with some additional settings, which deviate from the program defaults. For Tera Term, set “local echo” to “off” and set the terminal type to “VT100”. For HyperTerminal, set terminal emulation to “TTY”, set “Send line ends with line feeds” to ON, and set “Line Delay” to 10 milliseconds.

## 4.0 CHARACTER BY CHARACTER COMMUNICATION RULES

Communication with the  $\mu$ XRB is achieved by sending plain text lines to the unit, each line consisting of at least one command word, followed by an optional argument word. This section summarizes the expected behavior of the  $\mu$ XRB as individual characters are sent. (See the command summary for additional information on commands and responses.)

### General:

1. The  $\mu$ XRB is insensitive to "white space" such as spaces and tabs. Command words may be preceded and followed by spaces without affecting their syntax.
2. Every alphanumeric or printable character received by the  $\mu$ XRB is "echoed" back to the sender. Some end-of-line characters and control characters cause special behavior. See character echoing rules, below.
3. The  $\mu$ XRB behavior is not defined for cases in which a non-ASCII character is received. Even though the data byte is defined to be 8 bits, it is important to never send any characters in the range of 128-255.
4. The  $\mu$ XRB will not evaluate a line until the end-of-line characters are received. If 78 or more characters are sent without any end-of-line character, the  $\mu$ XRB may choose to terminate the incoming string by supplying its own end-of-line CRLF and process the line.

### 4.1 Character by Character Echo Rules

All normal, alphanumeric and/or printable characters received by the  $\mu$ XRB are echoed as-is back to the sender. However, special rules apply in some cases, below:

1. Characters with the high bit set may or may not be echoed or may be echoed improperly. Characters over ASCII 127 should not be sent to the  $\mu$ XRB. Response to high-bit characters is not defined.
2. No control characters are echoed back, except for the special treatment given to CR, LF, BS and US. These are echoed according to additional special rules below.
3. Linefeeds (LF), which are preceded by a carriage return (CR), are ignored and are not echoed.
4. Linefeeds (LF), which are not preceded by a carriage return (CR), are echoed as is.
5. Carriage returns (CR), are echoed back to the sender as CR-LF instead of just CR. See rule 3.
6. Backspace characters (BS), are echoed back as the combination BS-SP-BS (Backspace, Space, Backspace). This results in erasing the contents of the character location preceding the backspace, if there are any. This feature implements a "destructive backspace" to be compatible with the TTY standard. There is no need for the terminal emulator to "interpret" the BS character except as a single step in the reverse direction on the current line.
7. The unit separator character (US, ASCII 31, 0011111 binary, control-underscore) is not echoed back.



**Warning:** The  $\mu$ XRB software will reset and reboot on receipt of US. After it recovers, the host must resend any desired settings. Never intentionally send the US character to the  $\mu$ XRB.

## 4.2 The End of Line Characters

The  $\mu$ XRB will evaluate a received text line only when an End-of-Line indication is received. This is normally a CR [carriage return] & LF [linefeed] (ASCII 13 & 10, with no intervening character) but can be a stand-alone CR or a stand-alone LF.

The  $\mu$ XRB decides it has received an end-of-line indication according to these rules:

1. Whenever receiving a CR: treated as “end of line”.
2. Whenever receiving a LF, ignored entirely if immediately preceded by a CR. Otherwise, it is treated as “end of line”.

3. Whenever receiving a string exceeding approximately 78 characters, none of which are the CR or LF character, the  $\mu$ XRB may insert a CRLF itself to end the line, and begin evaluation of the command words. In this case, the line format is lost for the next line, which invites loss of data. It is important to properly terminate each line with CRLF.

## 4.3 General Command Syntax

Most commands are a single word, sent one-per-line, with the line ending in the CR-LF characters. The  $\mu$ XRB responds to the command after detecting the end-of-line indication. A few commands may require an argument or argument string. Some sample command formatting is shown below:

**Table 1: Sample Command Formatting**

COMMAND1
COMMAND2 ARG1
COMMAND3 ARG1,ARG2
COMMAND4 ARG1,ARG2,ARG3

## 4.4 Command Words

Command words always begin with the first printable non-space alphanumeric character on the line. Command words will end with a space character or an end-of-line, whichever happens first. Lines containing no command words, only an end-of-line with or without spaces, are echoed but otherwise ignored.

## 4.5 Arguments

Arguments are optional and are only used for certain command words. If an argument follows a command, it must begin with the first printable non-space alphanumeric character to follow the end of the command word. The argument ends with the next “comma “,” or end-of-line”, whichever happens first. If an argument follows an argument, it begins with the first printable non-space alphanumeric character to follow the preceding comma and ends with the next comma or end-of line, whichever happens first.

## 4.6 Responses

Responses are the replies sent by the  $\mu$ XRB, which are in addition to the simple echoing of the command line. All responses to commands, plus all error messages and warnings begin with an exclamation mark followed by a space. A response to some commands, such as the “hello” command, may exceed 110 characters, so the host software must be capable of holding a string that long. Most responses are lines which contain a series of numbers or of words. Some commands, which have no specific response, are acknowledged with a response which includes the word "OK". Whenever “OK” is sent by the  $\mu$ XRB, it should be noted that the unit is acknowledging that it has successfully received a command, not that it has successfully executed any task required by the command. The responses are intended to be parsed with the space character, but programmers should allow for multiple spaces as possible separators.

#### **4.7 Command Interchange**

A command interchange begins when the host sends the first character of a new line to the  $\mu$ XRB. The character is echoed from the  $\mu$ XRB to the host, but no other action is taken. The host continues sending characters until the entire line, the command word plus arguments, is sent. When the end-of-line characters are sent by the host, the  $\mu$ XRB first echoes them (CR-LF) and then begins evaluating the line just received. If a command is found, it is executed, and the response line or lines are sent to the host.

#### **4.8 Error / Warning Message**

The  $\mu$ XRB may at any time begin sending an error message or a warning message. If such a message is sent during the command interchange, the letters already sent by the host for the current command do not need to be sent again. The command string may continue being sent from the host to the  $\mu$ XRB even while the  $\mu$ XRB is sending the error or warning message. Error and warning messages always begin with the exclamation-space combination, so they may be distinguished from characters echoed due to a command interchange.

## 5.0 COMMAND SUMMARY

The standard command words for all products are defined below. When the lower-case letter “n” appears, it represents an integer digit 0-9.

The string “nnn” refers to any number from 0 through 999. When an integer argument is specified, the unit will ignore leading zeroes sent by the host. That is, sending “Program 09” is the same as sending “Program 9”.

Below is a quick reference list of the basic commands. See the Command Reference for additional commands implemented for each product and added detail for each command.

**Table 2: Command Reference**

Command	Command Meaning	Max # of Arguments	Arguments	Comments
BEAM	Report beam current	0	none	Reply is in uA.
BEAM nnn	Change beam current setting	1	nnn	Argument is a whole number representing uA
BEAM SETTING	Report Beam Current Setting	1	"SETTING"	Replies with the word "setting" followed by a whole number representing uA.
DIAGn	List diagnostic data	0		Command takes the form "Diag1", "Diag2"... "DiagN". Replies with collected diagnostic strings. Contents depend on application.
HELLO	Identify yourself please.	0	None	Replies with "OK" followed by a software version identifier, system, tube, and DCM model numbers and serial numbers
HELP	List commands and arguments	0		Reply is a summary of commands available.
HV	Report Anode Voltage	0	None	Reply is in kV.
HV nnn	Change Anode Voltage Setting	1	nnn	Argument is a whole number representing number of KV.
HV SETTING	Report Anode Voltage Setting	1	"SETTING"	Replies with the word "setting" followed by a whole number representing KV.
INTERLOCK	Report Interlock Status	0	None	Replies “SAFE” or “UNSAFE” according to the status of the interlocks.
PROGRAM	Report program status	0	None	Replies with program “Running” or “Idle”.
PROGRAM LIST	Reports list of available tube conditioning and warm-up programs	0	None	The leading whole number identifies the program.

PROGRAM n	Start preprogrammed tube conditioning or accelerated warmup.	1	N	Argument is a whole number representing program to start.
PROGRAM END	Stops any program currently running	0	None	Stop any currently running program.
RDLOG	Displays the next readable event data from the Event Log.	0	None	Displayed data is not in plain text.
STATUS	Report summary of status	0	None	Reply is a compact string summarizing current conditions in the device. See command description.
TIMESTATS	Report status of time clocks	0	None	Reply is a string of clock conditions in the device. See command description.
XRAY	Report whether X-rays may be generated.	0	None	Reply is "ON" or "OFF"
XRAY	Activate X-ray generation	1	"ON"	If interlock is "SAFE", command attempts to activate X-ray generation.
XRAY	Deactivate Xray generation	1	"OFF"	Command attempts to deactivate X-ray generation.

## 6.0 COMMAND REFERENCE

Detailed command descriptions with examples follow. When examples are given, do not rely on numerical formatting as shown, for instance, a decimal point may or may not be included and leading zeroes may or may not be suppressed. Capitalization and spacing in responses may not be exactly as shown.

### 6.1 BEAM

The  $\mu$ XRB reports the most recent actual beam current measurement expressed in microamps.

Example:

```
BEAM
! Beam measured 49.9 uA
```

### 6.2 BEAM nnn

The  $\mu$ XRB attempts to change the beam current to the value "nnn" expressed in microamps. If the desired setting is not allowed, the closest allowed setting is used.

Example:

```
BEAM 50
! Beam setting 0050 uA beam 50
! Beam Setting 50.00 uA
```

### 6.3 BEAM SETTING

The  $\mu$ XRB will report the most recent beam current setting.

Example:

```
BEAM SETTING
! Beam setting 0050 uA
```

### 6.4 DIAGn

This is a "soft" command intended to display collections of diagnostic strings whose contents may vary according to application and code revision. The command consists of "DIAG" with a whole number appended, the first "DIAGn" command using the number "1". The user or host may attempt to obtain additional diagnostic data by following a successful "DIAGn" command with one containing the next sequential number until a "DIAGn" command is not recognized, in the fashion below.

**Note 1:** The information given by these diagnostic commands is meant for human reading only. This command must not be relied on when implementing a host controller installation.

**Note 2:** the numeric part of the command must not contain any leading zeroes.

Example:

```
DIAG1
! Diag1 Arcs 000 Anodeleak 01.1 Cathodeleak 00.2
DIAG2
! Diag2 This code revision 10-22-2002.
DIAG3
! Diag3 Oilbath 84
DIAG4
! Error 06 Command not understood
```

## 6.5 HELLO

The  $\mu$ XRB will reply with identifying strings for its ROM, RAM,  $\mu$ XRB model,  $\mu$ XRB serial number, tube model, tube serial number, DCM model and DCM serial number.

**Note:** Identifying strings may be as short as 1 character or as long as 11 characters. The entire string may exceed 100 characters and force a line wrap on some terminal programs or input string receiving software.

Example:

```
HELLO
! Hello ROM 003 RAM 056  $\mu$ XRB11 S/N 99999 Tube 8040 S/N 99999 DCM F S/N 000
```

## 6.6 HELP or ?

The  $\mu$ XRB will reply with an abbreviated summary of the commands that are intended for customer use. Typing a single question mark “?” is equivalent to typing “help”. The help text is intended only for only reading.

Example:

```
HELP
! Command List:
Status          Show status string
KV              Accelerating voltage commands.
Beam            Beam current commands.
Xray            Source on/off commands.
Interlock       Show interlock status.
Hello           Show ID of firmware, system, tube, and controller.
Help            List commands.
Parameters      Show settings limits for this product.
Program         Scripted actions.
Diag1           Diagnostic data.
Diag2           Diagnostic data.
Diag3           Diagnostic data.
Diag4           Diagnostic data.
Diag5           Diagnostic data.
Diag6           Diagnostic data.
Diag7           Diagnostic data.
Diag8           Diagnostic data.
Diag9           Diagnostic data.
Diag10          Diagnostic data.
Diag11          Diagnostic data.
Diag12          Diagnostic data.
Diag13          Diagnostic data.
Diag14          Diagnostic data.
Diag15          Diagnostic data.
Diag16          Diagnostic data.
Diag17          Diagnostic data.
Diag18          Diagnostic data.
Set             Settings
Timestats      Operating hours and Clock-based data.
RdLog           Read next encoded event data entry.
Ready          Show seconds remaining during warmup or conditioning.
```

## 6.7 HV KV

The  $\mu$ XRB will report the most recent accelerating voltage measurement in whole KV.

**Note:** the command “KV” is synonymous with “HV”.

Example:

```
HV
! HV Measured 70.2 KV
```

## 6.8 HV nnn KV nnn

The  $\mu$ XRB attempts to set the accelerating voltage to the value “nnn” expressed in KV. (The string “KV nnn” is equivalent.) A decimal point is allowed, but text following the decimal is ignored. If the desired setting is not allowed, the closest allowed setting is used.

Example:

```
HV 50
! HV setting 50 KV
```

## 6.9 HV SETTING

The  $\mu$ XRB will report the most recent accelerating voltage setting. (The string “KV setting” is equivalent.)

Example:

```
HV SETTING
! HV setting 70 KV
```

## 6.10 INTERLOCK

The  $\mu$ XRB will reply with the word "safe" if it senses that the installation interlocks are closed, and "unsafe" if an interlock is sensed to be open.

Example:

```
INTERLOCK
! Safe
```

## 6.11 PARAMETERS

The  $\mu$ XRB will reply with a string indicating the maximum and minimum settings, as defined by the product family. This information is intended as a formatting convenience for the host graphical user interface, if any.

Example:

```
PARAMETERS
! Parameters HV 20 to 130 Beam 0 to 500
```

## 6.12 PROGRAM LIST

This command is used to display a list of available tube conditioning and warm-up programs. The response generated includes a description of several programs; each identified by a whole number. These numbers correspond to a program process number “n” which can be executed by typing “PROGRAM n”.

Example ( $\mu$ XRB10):

```
PROGRAM LIST
001 Tube conditioning 15 minute 130KV
002 Tube conditioning 30 minute 130KV
010 Tube conditioning
override
```

### 6.13 PROGRAM

This command, without arguments, requests the ID number of the currently running program. If none is running at the time the command is issued, the reply given is the word “idle”.

Example:

```
PROGRAM
! Program Running 5
```

```
PROGRAM
! Program Idle
```

### 6.14 PROGRAM n

This command is used to initiate the preprogrammed process number “n”. If the process “n” exists in memory, it will begin immediately. If it does not exist, or if another process is running, an error message will appear.

Example:

```
PROGRAM 1
! OK
```

### 6.15 PROGRAM END

This command terminates the currently running program, if any. The reply “OK” indicates only that the command was received, not that a program had been running when the command was issued.

Example:

```
PROGRAM END
! OK
```

### 6.16 RDLOG

This command displays a line of data representing the contents of the next available entry in the Event Log. Every time the command is repeated, the next line (in order of time recorded) is shown, unless all lines have been seen, in which case the next access reverts to the oldest entry. The response contains an exclamation mark followed by a space, then three digits indicating the sequential address being accessed (lowest is 000), another space, then one of 16 letters A-P identifying the type of event recorded, another space, then a decimal timestamp indicating the time of the event. The timestamp is the number of 4-second intervals which had elapsed from midnight, January 1, 2000, to the time the event occurred. The user or host may attempt to obtain a complete list of events in the Event Log by sending repeated RDLOG commands and aggregating the data until a duplicate of a previously read response is obtained, at which time the Event Log has been completely read. Reading the Event Log does not erase events. When new events occur, they are automatically added. If there is inadequate space in the log for new events, the oldest event is overwritten. The 3-digit sequential addresses are reused.

Example:

```
RDLOG
! 020 B 106843667
RDLOG
! 021 E 106677660
```

### 6.17 SETDAY nn SETHOUR nn SETMINUTE nn SETMONTH nn SETWEEKDAY nn SETYEAR nn

The time and date of the internal clock in the  $\mu$ XRb products may be adjusted with these 6 commands. When they are received, the clock will be updated immediately but for best results it is advisable to restart the unit after resetting the clock. Warning number 8 will always appear after a clock command is issued. In general, the  $\mu$ XRb will automatically keep proper time without resetting, except that it will not automatically compensate for the effect of daylight savings time. Hours are expressed as 0 - 23. Years are expressed as 1-98 to set a range of 2001-2098. Weekdays are expressed as 1-7 for the range of Monday-Sunday. When the clock is set, the internal seconds counter is reset to zero.

Example:

```
SETHOUR 18
! OK
Tuesday, February 18, 2018, 18:14:00
! warning 08 Clock change effective after power off/on.
```

### 6.18 STATUS ST

This command is included as a convenience for periodic polling in host controller installations. The  $\mu$ XRb will reply with a compact set of status words.

These are:

1. The word "status".
2. "On" or "Off" depending on the x-ray status (see Xray command).
3. The word "HV" followed by the measured HV and the HV setting.
4. The word "Beam" followed by the measured Beam and the Beam setting.
5. "Safe" or "Unsafe" depending on the interlock condition. (See Interlock Command)
6. "Infocus", "Nofocus" or "Warmup" depending on the focus/ready status. "Infocus" indicates that the unit is ready. "Nofocus" means that the unit is in a transitional state and is not yet ready. "Warmup" means that the unit is either busy raising the temperature of the tube heater (or filament), or is in the process of running a preprogrammed program (see "Program" command), or is performing a high voltage auto conditioning process. If "Warmup" appears, an estimate of time remaining may be obtained by using the "Ready".
7. The word "Spot" followed by the expected spot size from the internal look-up table.

Examples:

```
STATUS
! Status On HV 70.2 070.0 BEAM 49.9 0050 Safe Infocus Spot 7
STATUS
! Status On HV 100.1 100.0 BEAM 51.9 0052 Safe Infocus
```

## 6.19 TIMESTATS

Replies with the current value for the following clocks:

1. "NonOpSecsRemain" is the number of seconds that the x-rays can remain off without requiring a tube conditioning program to be executed.
2. "Total\_Hours" is the total hours that power has been applied to the unit.
3. "Total\_Hours\_XRAY\_on" is the total hours that the x-rays have been on.

The response may be up to 85 characters long in a single line.

Example:

```
TIMESTATS
! TIMESTATS NonOpSecsRemain 604793 TotalHours 23425.4 TotalHoursXRAYon 1976.2
```

## 6.20 XRAY / XRAYON / XRAYOFF

This command accepts the optional argument "ON" or "OFF". In this context, "ON" means that the  $\mu$ XRB will attempt to set the system to be capable of producing X-Rays, and "OFF" means the opposite. The acknowledgement "OK" received in response is an acknowledgement that the command was received, **not that the command was successfully executed**. The command "XRAY ON" sets the unit to enable generation of X-Rays. The command "XRAY" without arguments, asks for the status, and receives the reply "ON" or "OFF".



The response "ON" confirms that the  $\mu$ XRB is set to enable X-Rays, and it should be assumed that X-Rays are present, whether kV and beam are programmed or not.

The response "OFF" indicates that the  $\mu$ XRB senses that the power to the main generator is off. Again, since the  $\mu$ XRB has no way of measuring x-rays itself, a reply of "OFF" does not certify that all x-rays are absent.



**CAUTION:** It is important to remember that the command "XRAY OFF" is the preferred way of shutting off X-Rays. Using "XRAY OFF" allows the  $\mu$ XRB to attempt to disable the beam before disabling the high voltage generator and thus minimize the possibility of shortened tube life due to transient conditions.

The strings "X" and "XRAY" when received by the  $\mu$ XRB are treated as being synonymous with "XRAY" and work identically.

Examples:

```
XRAY ! XRAY
OFF
```

If INTERLOCK is SAFE and the unit is otherwise ready, the string "XRAY ON" attempts to enable the X-ray generator, enabling HV and BEAM.

Example:

```
XRAY ON
! OK
```

The string “XRAY OFF” may be sent anytime. The  $\mu$ XRB will attempt to disable the high voltage generator, and will acknowledge the command with “OK”, which does not imply that the attempt to set x-rays off will be successful.

Example:

```
XRAY OFF
! OK
```

## Appendix A: Sending Commands and Evaluating Responses

The X-ray Source ("μXRB") listens continuously on the RS232 line for commands. When it receives a carriage return (or linefeed) it examines the text preceding it to see if it has received a command. If it has, it processes the command. All commands are echoed by the μXRB, character by character, as they are received. Then, as part of the command processing, a response will be sent.

It is important for the host to wait for the μXRB response before issuing a new command. If a second command is sent before the previous command is processed, the second command will be treated as if it were more important than the first command, because it is more recent. The second command will interrupt the first command which will be resumed later.



It is possible to overload the μXRB by sending several commands before allowing the unit to respond. If an overload occurs, the firmware may behave in unexpected ways, commands may be ignored and unsafe conditions may occur. The host computer must not allow this to happen.

It may see:

```
interloc
interlock
interlock<CR>
interlock<CR><LF>
interlock<CR><LF>!
interlock<CR><LF>!<SP>
interlock<CR><LF>!<SP><SP>
interlock<CR><LF>!<SP><SP>sa
interlock<CR><LF>!<SP><SP>safe
interlock<CR><LF>!<SP><SP>safe<CR><LF>
```

After sending a command, the host device may examine the response as it arrives, character by character. The response varies by command, but it is possible for the host to watch the response and know when a response is complete. Most responses are a single line, and once that line is received, the host can assume that the command is processed and a new command can be issued.

In an ideal situation, a host device will issue a command and will observe that an echo of the command was received. Shortly after the echo is received the response will be complete. As an example, consider the command "Interlock". The command causes the status of the interlock to be sent by the μXRB.

Note: A carriage return followed by a linefeed will be displayed in this memo as <CR><LF> and a space as <SP>. To issue the "Interlock" command the host would send:

```
interlock<CR><LF>
```

After sending the command, the host input buffer can be examined. Characters are being received while characters are being sent. Therefore the input buffer may be filling and the host can see it in several states each time it looks.

After seeing the second <CR><LF>, the host knows that, for this command, no further response is expected. If the host has another command to send, it can clear its receive buffer and send it now. This method allows the host to send commands timed as closely together as possible.

If the response seems incomplete, the host should not wait indefinitely. The host can assume that after 50ms have passed, no additional response will arrive. In fact, another simple command method is to send a command, always wait 50ms, then examine the input buffer. This method reduces the rate in which commands can be sent but, in most cases,, there will not be a need to send more than 20 commands per second.

The host must be prepared for unexpected events. The most common events that may require special processing are:

1. A character is lost or garbled, sending to the  $\mu$ XRB. The  $\mu$ XRB will not recognize the command and will reply with an error message.
2. A character is lost or garbled in the echoed command (or <CR><LF> ending it) as received by host.
3. A character is lost or garbled in the response sent by the  $\mu$ XRB, or the <CR><LF> ending it, as received by host.
4. An error or warning message is sent by the  $\mu$ XRB while a command was being sent by the host, splitting the echoed command string into two parts.
5. An error or warning message is sent by the  $\mu$ XRB at a time when no command has been sent by the host.

Case 1, repeating the command is the best choice.

Case 2 can usually be ignored.

Case 3 requires repeating the command or verifying some other way (as with the status command), that the command was received properly.

Cases 4 and 5, it is important to try to recognize the error message and act on it. The error message may explain why the command will not work as desired.

When sending to the  $\mu$ XRB, the host must respect the CTS/RTS handshaking used by the UART in the host computer. Due to faulty implementation in Windows, sending a string of characters may violate the UART implementation using that operating system. This happens when Windows begins sending a long string but the  $\mu$ XRB turns off CTS in the middle of the transmission of the string. Instead of stopping the transmission of the string at the next character as required by CTS=FALSE, Windows may continue to transmit. Because of this, Windows operating system may fail to properly implement RS232 hardware handshaking. Some of the string sent after CTS went FALSE could be lost. If this is a problem, it can be avoided by never sending multiple characters using Windows API or high level routines. By sending single character strings only, Windows is forced to check CTS before each send. Other operating systems may or may not have this problem.

Keep in mind that the command and response system is one meant for an operator at a keyboard, but also compatible with programmed control. Just as an operator types a command and observes a response, the host program must also issue a command and evaluate the response.

## Appendix B: Implementing a Simple Software Interface

### TYPICAL IMPLEMENTATION:

The software interface to the  $\mu$ XRB requires a constant polling mechanism in order to maintain current status information. The pseudocode below demonstrates this polling mechanism, which is an integral part to any interface in communication with the  $\mu$ XRB.

### POLLING ROUTINE:

Main Loop:

Check for messages or errors from  $\mu$ XRB

// DETECT AND SEND COMMANDS

If a new kV value is desired, send "kV" command with new value.

Else, if a new uA value is desired, send "uA" command with new value.

Else, if a new x-ray setting is desired, send "XRAY" command with new setting.

// GET NEW STATUS INFORMATION

Request status information ("ST" command) from  $\mu$ XRB and place into a string.

Parse current kV value from returned string.

Parse current uA value from returned string.

Parse current X-Ray information from returned string.

Request and output diagnostic information ("DIAG#" command)

Request and output interlock status ("INTERLOCKS" command)

Request and output focus status ("FOCUS" command)

Goto MainLoop:

**Note:** This routine is divided into two parts in order to limit the number of commands sent per poll. This ensures that the  $\mu$ XRB will have adequate time to respond to all commands.

### VISUAL BASIC IMPLEMENTATION OF POLLING ROUTINE:

If kvHasChanged = true then

    result = SendCommand("KV" + kvValue + enterKey)

ElseIf uaHasChanged = true then

    result = SendCommand("BEAM" + uaValue + enterKey)

ElseIf xrayHasChanged = true then

    result = SendCommand("XRAY" + strXRayValue + enterKey)

End if

result = SendCommand("ST" + enterKey)

    xrayStatus = spaceParse(result, returnXRays)

    kvStatus = spaceParse(result, returnKVStatus)

    uaStatus = spaceParse(result, returnUAStatus)

UpdateForm()

**Note:** The polling routine is an ideal location to request information from the  $\mu$ XRB that needs to be updated on a regular basis. Diagnostic information, interlock status and focus status are examples of additional requests that can easily be implemented into the polling routine.

### **INTERLOCK STATUS:**

The following example requests status information from the  $\mu$ XRB with the “ST” command and places the result into the StatusString variable. Then the relevant interlock information is extracted from the string through a parsing routine. The program will then use the information in the string to display current interlock status.

```
StatusString = SendCommand("ST" + enterKey)
If SpaceParse(StatusString, intInterlock) = "Safe"
    Then shpInterlocks.BackColor = vbYellow
End If
If SpaceParse(StatusString, intInterlock) = "Unsafe"
    Then shpInterlocks.BackColor = vbGrey
End If
```

**Note:** The same method can be used to process any information acquired from the  $\mu$ XRB. For example, to gather and process focus information, parse the “StatusString” at the location where “InFocus” or “NoFocus” appears. Then use the information to display current focus status.

### **DIAGNOSTICS INFORMATION:**

A **Do...While Loop** or similar looping mechanism is fundamental in acquiring diagnostics information because of the non-standard number of diagnostics strings. The following loop tries to gather diagnostic information with commands "Diag1", "Diag2"... "DiagN" until an error has occurred. The loop exits when an error has occurred, otherwise it applies the diagnostics information.

```
Diagnumber = 1
Do
    LoopStatus = SendCommand("diag" + Trim$(Str$(Diagnumber)) + vbCrLf)
    If Mid(LoopStatus, 1, 10) <> "! Error 06" Then
        txtDiag.Text = txtDiag.Text + LoopStatus
    End if
    Diagnumber = Diagnumber + 1
Loop Until Mid(LoopStatus, 1, 10) = "! Error 06"
```

### **SERIAL OUTPUT:**

If the Windows API is used for serial communications, it is advised to send a series of characters instead of sending a whole string. Using the Windows API to send a whole string can result in the intermittent loss of characters. By using a “for loop” and sending a series of characters, the Windows API is forced to check CTS (Clear-To-Send) status more often. This resolution also applies to the Microsoft Communication Control.

## Appendix C: Error Messages, Warnings, and Logged Events

The following table shows errors and warnings of the  $\mu$ XRB10. The last column identifies the messages which may appear as a direct response to a command; all other messages may appear at any time.

"Error" conditions are ones which are likely to interfere with expected functionality. "Warning" conditions may be a variety of less critical information.

The table also includes the Event Log codes accessible by the RDLOG command for each revision.

**Table 3: Error Codes**

<b>Error Codes</b>	<b>Response to a Command</b>
! Error 01 No A-D conversions detected.	N
! Error 02 Timer set to illegal date.	N
! Error 03 Timer set to illegal time.	N
! Error 04 RAM clock not set properly.	N
! Error 05 RAM clock not running.	N
! Error 06 Command not understood.	Y
! Error 07 Illegal argument following command.	Y
! Error 08 Command argument out of range.	Y
! Error 09 RAM clock setting is invalid.	N
! Error 10 No host RTS signal.	N
! Error 11 Missing command argument.	Y
! Error 12 Prime power interlock interrupted during X-Ray ON.	N
! Error 13 Safety interlock interrupted during X-Ray O.N	N
! Error 14 Arc detected.	N
! Error 15 Warmup process restarting at slower rate due to arcs.	N
! Error 16 Too many arcs detected; X-rays are now off.	N
! Error 17 Program ID not found.	Y
! Error 18 Current program must end before a new program can be started.	Y
! Error 19 X-Ray source operating fault detected.	N
! Error 20 X-Ray source exceeds maximum operating temperature.	N
! Error 21 High voltage generator regulation fault detected.	N
! Error 22 Heater current regulation fault detected.	N
! Error 23 Beam current regulation fault detected.	N
! Error 24 Control grid regulation fault detected.	N
! Error 25 Focus voltage regulation fault detected.	N
! Error 26 DC supply voltage outside of recommended range.	N
! Error 27 ROM code checksum does not match expected value	N
! Error 28 Tube conditioning required before operating tube.	Y
! Error 29 HV generator power fault detected.	N
! Error 30 Multiple CRC errors in RAM code space none detected.	N
! Error 31 RAM code space repair failed.	N

**Table 4: Warning Codes**

<b>Warning Codes</b>	<b>Response to a Command</b>
! Warning 01 Warmup process is beginning.	N
! Warning 02 Warmup process is ending.	N
! Warning 03 Warmup process: KV is on.	N
! Warning 04 Warmup process: Beam is on.	N
! Warning 04 Warmup process: Beam is on.	N
! Warning 05 Warmup process: about 15 minutes remain.	N
! Warning 06 Warmup process: about 30 minutes remain	N
! Warning 07 Warmup process: about 5 minutes remain.	N
! Warning 08 Clock change effective after power off/on.	Y
! Warning 09 Program execution beginning.	N
! Warning 10 Program execution ending.	N
! Warning 11 Tube conditioning requirement was overridden	N
! Warning 12 Running MANUFACTURING code only.	N
! Warning 13 Failed a pre-ship limits check, recheck settings by hand.	N
! Warning 14 CRC error in RAM code space detected and successfully corrected.	N

**Table 5: Event Logs**

<b>Event Logs</b>
Event Log A = (unused)
Event Log B = Power-On
Event Log C = Tube Conditioning Completed Successfully
Event Log D = Xray forced off (primary power interlock SAFE1 broken during Xon)
Event Log E = Arc detected
Event Log F = Serial disconnect; Shutdown due to RTS loss.
Event Log G = Xray forced off (emergency switch/power sw./SAFE2 hit during Xon)
Event Log H = Hardware fault detected. (xain3: overtemp/reg-error/24v-error/etc)
Event Log I = temperature higher than TEMPERATURE_SHUTDOWN during Xon
Event Log J = HV Regulation error detected
Event Log K = tube conditioning overridden by user.
Event Log L = (unused)
Event Log M = (unused)
Event Log N = (unused)
Event Log O = (unused)
Event Log P = (unused)