PLASMA PROCESS GROUP, INC.

IBEAM RF/RFN

Ion Beam Source Power Supply Manual
Radio Frequency Source and Neutralizer

plasma process group

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Chapter 1

Introduction

Thank you for purchasing an ion beam source power supply from Plasma Process Group!

This Manual covers the installation and operation of our IBEAM RF/RFN power supply.

Ion beam technology was developed at NASA in the 1960's as a means of producing thrust on spacecraft. Several spacecraft have used ion beam thrusters for station keeping and trajectory control. Recently, the spacecraft Deep Space 1, demonstrated the long duration performance capabilities and propulsion advantages of ion-beam thrusters. There are numerous publications about ion beam thrusters and some are given here for the interested reader [1-3].

Ion beam sources also have numerous terrestrial applications. In the past decade, ion beams have been used for depositing wear resistant diamond-like carbon coatings on mechanical and optical hardware. They have also been used to fabricate the read/write heads used in computer hard-drives and thin-film optical filters for telecommunication applications. A select few publications involving ion beam deposition technology are given here for the interested reader [4-7].

For this manual, it is assumed the operator of the ion beam source has a basic knowledge and/or technical skills with electrical discharge devices. If necessary, we encourage a review of the introductory chapters for the following references [8-10]. A basic physical knowledge of plasma behavior is required, however, the mathematical descriptions will be kept to a minimum. For any technical assistance, please contact us.

We at Plasma Process Group hope that using your new ion beam source will produce rewarding results.

Limited Warranty

Our workmanship warranty:

All equipment manufactured and sold by Plasma Process Group Inc is warranted to be free of defects and workmanship when shipped. The warranty on all equipment is for one year commencing (a) on final acceptance or (b) 30 days from shipping, whichever occurs first. This warranty covers the cost of parts and labor. Expendable and consumable items, such as grid assemblies, RFN collectors and discharge chambers are excluded from this warranty. This warranty supersedes all other warranties, expressed or implied. Plasma Process Group Inc assumes no contingent liability for damages or loss of production.

Expendable items, including, but not limited to, grid assemblies, RFN collectors, discharge chambers, filaments, fuses, o-rings and seals are specifically excluded from the foregoing warranties and are not warranted.

Seller assumes no liability under the above warranties for equipment or system failures resulting from (1) abuse, misuse, modification or mishandling; (2) damage due to forces external to the equipment including, but not limited to, flooding, power surges, power failures, defective electrical work, transportation, foreign equipment/attachments or Buyer-supplied replacement parts or utilities or services such as process gas; (3) improper operation or maintenance or (4) failure to perform preventative maintenance in accordance with Seller's recommendation (including keeping an accurate log of preventative maintenance). In addition, this warranty does not apply if any equipment or part has been modified without the written permission of Seller.

Technical Contact Information

For Service or Repair contact:

Plasma Process Group Inc (PPG)
www.plasmaprocessgroup.com

Please supply the following information:

- Product
- Model and serial number
- Date Purchased
- Detailed description of problem
- Contact person

If the product is to be returned to PPG for repair you will be assigned a **Return Authorization** number (RA), warranty status of the equipment and shipping information to return the product. The RA number should be attached to the outside of the shipping container. A purchase order number should be included should the equipment not be under warranty. After PPG receives the equipment a firm quote and estimated repair time will be given prior to work being started.

Chapter

2

Theory of Operation

The function of an ion beam source is to produce ions and accelerate these ions to high velocities so they are ejected downstream from the source. The ejected ions are directed to form a "beam" in which the ions are mono-energetic with velocities on the order of km/s. An ion beam source consists of four (4) key elements:

Discharge Chamber, Electron Source, Grids, and Neutralizer.

Presented in Figure 1 is a schematic of an ion beam source. Basically, the source is operated by introducing the source gas into the **discharge chamber**. An **electron source** is used to ionize the gas and establish a plasma. Recall, a plasma is an electrically conductive gas where the density of ions and electrons are approximately equal. Ions created in the **discharge chamber** are then accelerated to high velocities with the source **grids**. A **neutralizer** is placed downstream from the source where it emits electrons to balance the number of positive ions which leave the source.

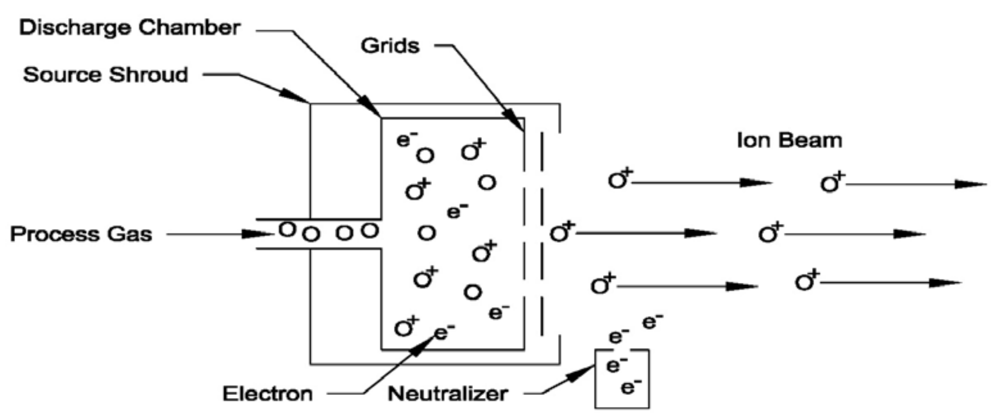

Figure 1. Schematic of an ion beam source.

The different types of ion beam sources are delineated by the specifics of the four (4) key elements. In this introduction, ion beam sources will be classified as either direct current (DC) or radio frequency (RF). A brief, physical description of each of the four elements is presented below.

Discharge Chamber - the discharge chamber is where the source gas is ionized.

For DC sources, the discharge chamber is referred to as the **body**. The body will have a magnetic field produced using permanent magnets. The purpose of the magnetic field is to control the motion of electrons such that they have several ionizing collisions with the source gas occur before being collected on the anode.

For RF sources, the discharge chamber consists of a dielectric material permeable to the RF field produced by the antenna. The RF field ionizes the source gas introduced within the discharge chamber.

Electron Source – mechanism by which electrons are produced to ionize the source gas.

For DC sources, the electron source can be either a hot filament or a hollow cathode. Typically, a filament consists of a tungsten wire which is heated to emit electrons. A hollow cathode is a device which produces electrons by locally ionizing its own feed gas. The electrons from either the filament or hollow cathode are then used to ionize the source gas, which, for the hollow cathode case, may be the same gas it used. The electrons have several ionizing collisions before being collected at the anode surface in a DC source.

For RF sources, the RF field energizes free electrons in the working gas. The energetic electrons have ionizing collisions with the source gas thereby producing ions and additional electrons. As ions leave the discharge chamber, electrons are collected on the screen grid surface.

Grids – the electrostatic apertures by which the ions from the discharge are extracted.

Grids are electrodes separated from each other by a few millimeters. Each grid has several apertures that are aligned and allow for the extraction of ions. The grid closest to the discharge chamber is referred to as the **screen (or S) grid**. Moving downstream, the next grid is referred to the **accelerator (or A) grid**. On some sources, a third grid is used which is the furthest downstream from the discharge chamber and it is referred to as the **decelerator (or D) grid**.

The grid assembly extracts ions from the discharge chamber by applying specific potentials (or voltages) to each grid. A potential (or voltage) diagram of the ion acceleration process is presented in Figure 2. First, the S grid is biased positive (**beam voltage**) with respect to ground and consequently the plasma in the discharge chamber is also biased positive with respect to ground. Next, the A grid is biased negative (**accel voltage**) with respect to ground and establishes an electric field along the source centerline. Positive ions in the discharge chamber that drift close to this electric field are accelerated.

Even if the D grid is not used, the potential downstream from the source is ultimately approximately zero. Depicted in Figure 2 is the electric potential for a 3-grid assembly. The D grid potential is typically held at ground potential (or 0 V). The accelerated ions then decelerate after passing the A grid and exit the aperture with a net, ion energy of approximately **beam voltage**. As depicted in Figure 2, electrons either located in the discharge chamber or downstream from the source are separated due to the established electric field.

Ions extracted through the grid apertures comprise individual beamlets and a typical grid assembly will have numerous apertures. As a result, individual beamlets combine to form a more, broad ion beam.

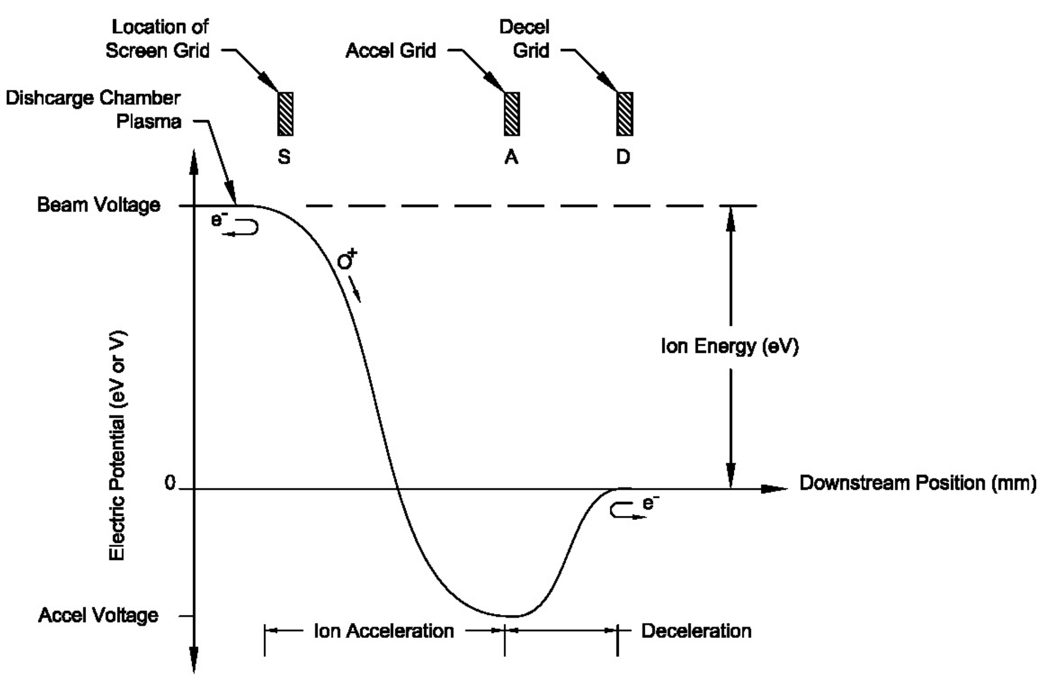

Figure 2. Schematic of the ion acceleration process.

Neutralizer – an electron source downstream from the ion source.

For DC sources, the neutralizer can be a hot filament, hollow cathode, or plasma bridge type. A plasma bridge neutralizer (PBN) is where a hot filament is placed in a smaller discharge chamber through which an inert process gas is supplied. For RF sources, the neutralizer can be either a PBN or RF type. The RF neutralizer (RFN) consists of a small discharge chamber with an RF coil. The RFN utilizes a collector and keeper to emit electrons.

The purpose of the neutralizer is to emit electrons into the environment downstream from the ion beam source. The emitted electrons provide a charge balance for the ions leaving the source. Typically, more electrons are emitted from the neutralizer than ions from the source. This is done to minimize and/or eliminate the space or surface charging that may occur. In most situations, electrons from the neutralizer do not directly combine with the ions in the beam to form high energy neutrals.

Source Parameter Definitions

As electrical devices, ion beam sources require power supplies. Presented in Figures 3 and 4 are the electrical schematics for typical DC and RF sources, respectively.

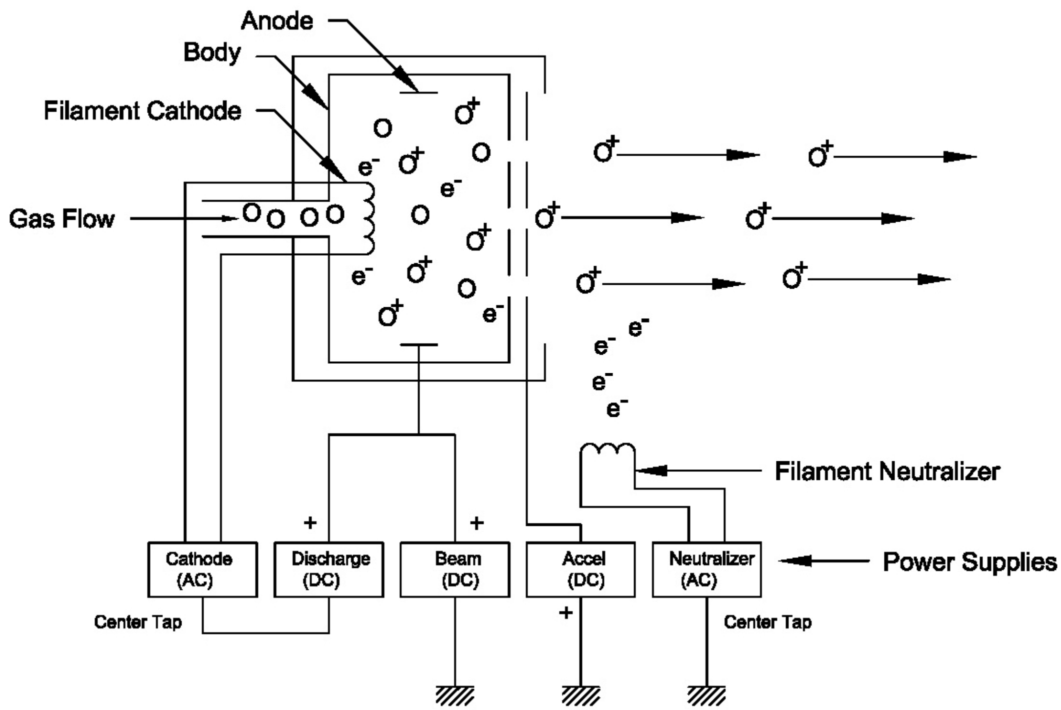

Figure 3. The electrical schematic for a filament DC source.

In Figure 3, the electrical connections for a filament cathode and filament neutralizer DC source are presented. The cathode is heated using an AC power supply. Electrons leaving the filament are collected at the anode with the discharge supply, a DC bias supply. The beam supply, also a DC bias supply, is also connected to the anode and biases the discharge plasma positive with respect to ground. Not illustrated, but commonly used is a resistor placed between the body and anode. The body resistor establishes the proper bias between the anode and body and thereby directs electrons to be collected on the anode surface. The accelerator supply, a DC type supply, biases the accel grid negative with respect to ground. Finally, the neutralizer filament is heated using an AC power supply.

In Figure 4, the electrical connections for a RF source with RF neutralizer are presented. The RF coil for the discharge chamber is energized by the RF supply and is tuned by using a matching network. The beam supply, a DC bias supply, is connected to the screen (S) grid in order to bias the discharge plasma positive with respect to ground. The accelerator supply, a DC type supply, biases the accel grid negative with respect to ground. Finally, the RF neutralizer utilizes an RF supply and matching network for its own discharge and additional DC supplies to emit electrons.

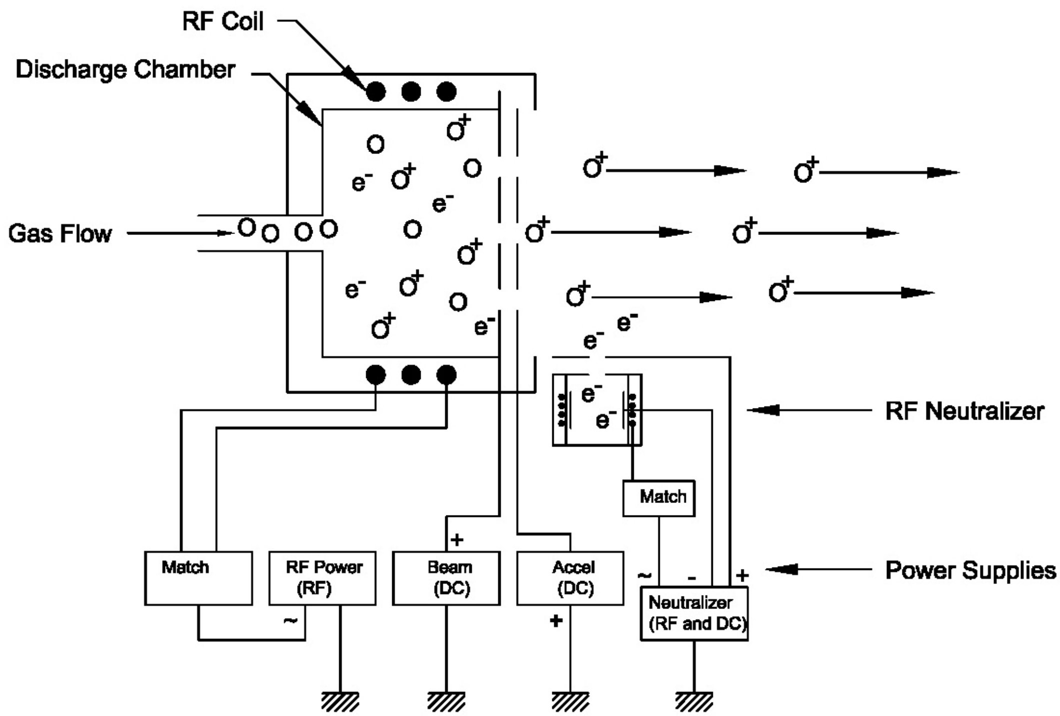

Figure 4. Electrical schematic for a RF source.

Additional power supply details and source parameters are presented in Tables 1 and 2. Ion beam source parameters used by both DC and RF sources are presented in Table 1. Specific parameters that pertain to DC filament, DC hollow cathode, and RF sources are outlined in Table 2. Actual values for these source parameters will be specific to source type, size, grids, and process. Typical values will be given where appropriate.

Table 1. Ion beam parameters for all sources.

Parameter	Definition	Unit
All Sources		
Source Gas Flow	Process gas delivered to the discharge chamber.	sccm
Beam Voltage	Positive voltage applied to the discharge plasma.†	V
Beam Current	The total ion current extracted, or leaving the source.	mA
Accel Voltage	Negative voltage applied to the accelerator (A) grid.	V
Accel Current	Charge-exchange current collected by accelerator (A) grid.	mA
A/B Ratio	Ratio of accel to beam currents. Indicates quality of grid focusing. Typical A/B is < 10%.	%
Neutralizer Emission Current	The electron current emitted by the neutralizer.	mA
E/B Ratio	Ratio of neutralizer emission to beam currents. Typical E/B is >100% to minimize space charging, surface charging and arcing.	%

† For DC sources, beam voltage is applied to the anode. For RF sources, beam voltage is applied to the screen (S) grid.

Table 2. Ion beam parameters for specific types of sources.

Parameter	Definition	Unit
DC Filament Cathode (FC) / Filament Neutralizer (FN)		
Cathode Filament Current	The electrical current applied to the filament cathode. This current heats the filament so that electrons are emitted from its surface.	A
Discharge Voltage	The voltage established between the filament cathode and anode. This determines the electron energy for ionizing collisions in the discharge chamber.	V
Discharge Current	The electrical current established in the discharge chamber between the filament cathode and the anode. This current controls the ion production rate and to first order, the beam current.	A
Neutralizer Filament Current	The electrical current applied to the filament neutralizer. This current heats the filament so that electrons are emitted from its surface.	A
DC Hollow Cathode (HC) / Hollow Cathode Neutralizer (HCN)		
Cathode Heater Current	The electrical current applied to the HC heater.	A
Cathode Keeper Voltage	The voltage established between the HC's body and keeper.	V
Cathode Keeper Current	The electrical current between the HC's body and keeper.	mA
Discharge Voltage	The voltage established between the HC body and anode. This determines the electron energy for ionizing collisions in the discharge chamber.	V
Discharge Current	The electrical current established in the discharge chamber between the HC body and the anode. This current controls the ion production rate and to first order, the beam current.	A
Neutralizer Heater Current	The electrical current applied to the HC heater.	A
Neutralizer Keeper Voltage	The voltage established between the HC's body and keeper.	V
Neutralizer Keeper Current	The electrical current between the HC's body and keeper.	mA

Table 2. Ion beam parameters for specific types of sources continued.

Parameter	Definition	Unit
RF with RF Neutralizer (RFN)		
RFS Forward Power	The RF power applied to the source matching network. This power controls the ion production rate in the source and therefore, the beam current.	W
RFS Reflected Power	The RF power reflected from the source matching network. Typically, the reflected power is <1% of the forward power.	W
RFN Forward Power	The RF power applied to the matching network.	W
RFN Reflected Power	The RF power reflected from the matching network	W

Ion Beam Properties

For ion beam deposition applications, it is necessary to know the energy of the ions leaving the source and the dose that they strike a target downstream.

Ion Energy

The ejected ions from an ion beam source are considered mono-energetic and as depicted by Figure 2, the total ion energy is approximately the beam voltage. In order to illustrate the importance of this aspect, plotted in Figure 5 are two types of energy distributions. The ions in a typical electrical discharge device will have a range of energies that form a distribution that is thermalized; also referred to as Maxwellian. A Maxwellian energy distribution is plotted in Figure 5 where the number of ions is plotted for various energies. For comparison purposes, the energy distribution from an ion beam source is also plotted. Ions that leave the source have a limited energy range, selected by the beam voltage, and are referred to as mono-energetic. The significant attribute of the ion beam source is that energies of the ions can be adjusted by selecting different beam voltages, where as, a Maxwellian discharge will have only limited adjustment in its energy distribution. The beam voltage range is typically 100 to 1500 V.

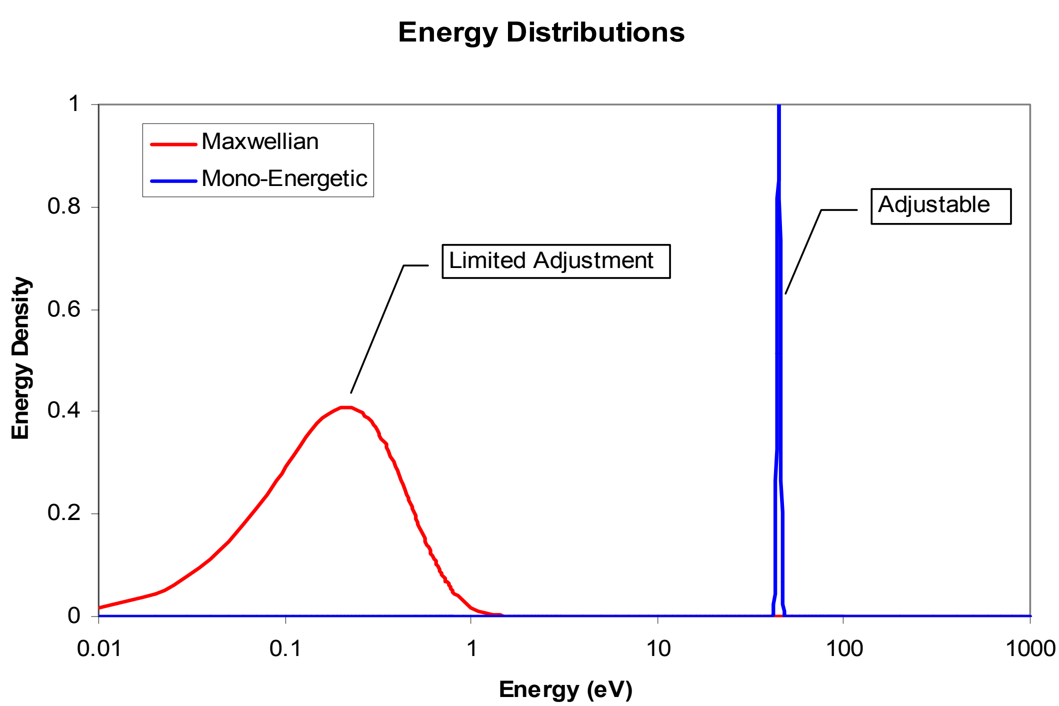

Figure 5. Two types of energy distributions: Maxwellian and Mono-Energetic.

Ion Dose

A measurement of the beam current is also an indication of the number of ions leaving the source. In most applications, it is important to determine the number of ions striking a specific location downstream, such as a target or substrate. This number is also referred to as the dose or flux density. The actual dose downstream from the source is determined by the ion beam focusing characteristics or ion optics.

Ion optics are determined by the beam current and voltage, accel voltage, and grid geometry (i.e. grid thickness, spacing, and shape). In general terms, the ion beam diverges, or spreads out, as it leaves the source. Custom grids can be fabricated to control this divergence and focus the ion beam. Ion optics is a rather detailed subject, and therefore, only brief, general rules of thumb are presented below for a typical grid set.

1) The divergence increases (the beam spreads out) when the accel voltage is increased.
2) The divergence can decrease at higher beam voltages.

Due to the complex nature of ion optics, the beam dose is best determined by measuring it using a Faraday type probe. Recall, a Faraday probe is a small electrode biased negative, usually about 40 V or so, to measure ion current and repel electrons. The probe is typically placed downstream from the source and swept through the beam to measure ion current at locations of interest. The ion current to the probe is divided by the area of the probe to determine the dose of the ion beam in mA/cm^2.

References

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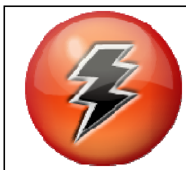
[10] Cecchi, J. L. "*Introduction to Plasma Concepts and Discharge Configurations*," Handbook of Plasma Processing Technology, pp. 14-69, Noyes Pub., New Jersey, 1990.

[11] Monheiser J M, Wilbur P J, "*An Experimental Study of Impingement-Ion-Production Mechanisms*" 28th Joint Propulsion Conference, AIAA Paper 92-3826, 1992.

Chapter 3

Set up and Installation Procedures

Installing and operating the IBEAM RF/RFN power supplies requires good safety practice. The power supply must be turned OFF before performing ANY electrical connections. All warnings and cautions must be observed. The power supply should NEVER be operated with ANY of its output connections MISSING or IMPROPERLY attached. READ ALL INSTRUCTIONS before connecting power.



CAUTION

Danger of High Voltage and Personal Injury

WARNING

ALL POWER OUTPUTS CAN BE LETHAL

WARNING

ELECTRICAL SHOCK HAZARD

WARNING

This power supply produces high voltage outputs. Do not operate unit with missing or improper connections. The unit's interlock needs to be incorporated into the facility/system interlock string. There are no serviceable parts inside the unit. Do not remove unit cover.

Electrical connection layout

On the back of the IBEAM RF/RFN are the electrical connections for the source, neutralizer and communication cables. These are depicted in Figure 6.

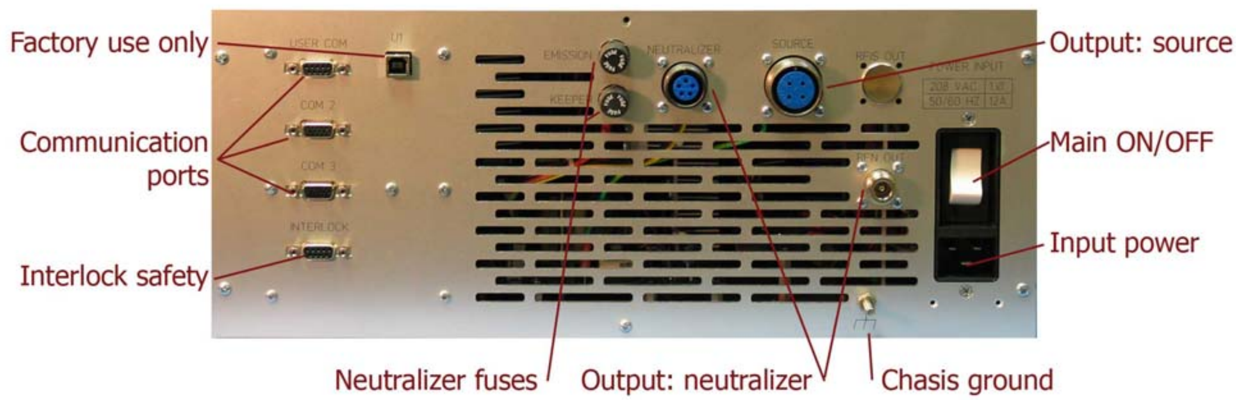


Figure 6. IBEAM RF/RFN rear panel.

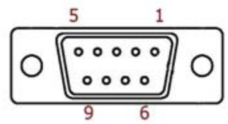
Input power specifications

Input power – 208 VAC, 1 Ø, 50/60 Hz, 16 Amp

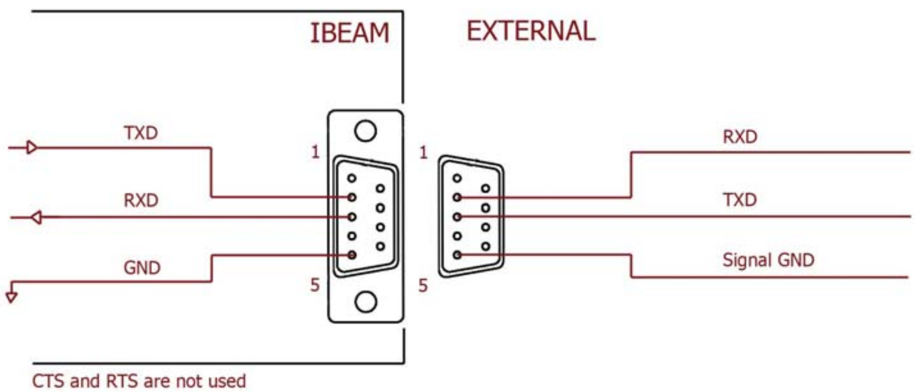
Figure 7. Electrical power connections.

RS232 communications

Figure 8. Pin-outs and electrical connections for USER COM.
Connector style: DB9

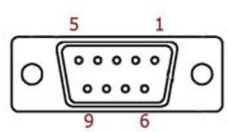


1 - n/c
2 - TXD
3 - RXD
4 - n/c
5 - Signal GND
6 - n/c
7 - n/c
8 - n/c
9 - n/c

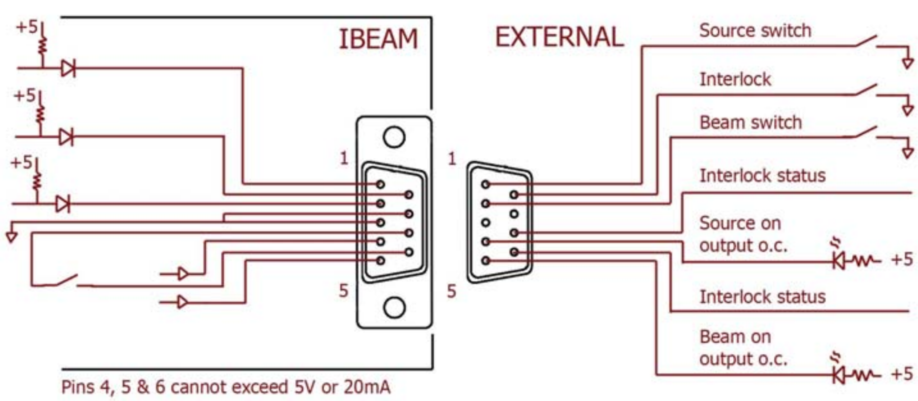


Interlock and remote switches

Figure 9. Pin-outs and electrical connections for interlock and remote switches.
Connector style: DB9

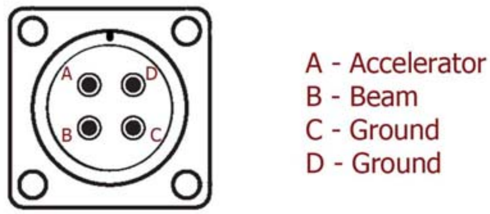


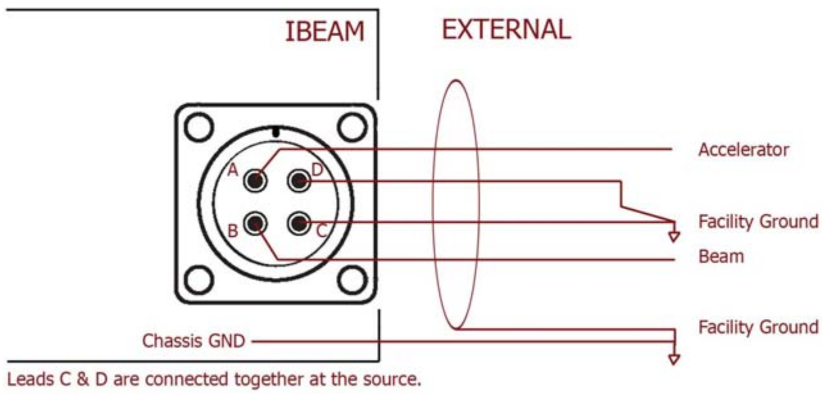
1 - Remote switch for source
2 - Remote switch for beam
3 - GND
4 - Source on output
5 - Beam on output
6 - Interlock
7 - GND
8 - Interlock status
9 - Interlock status



Output: Source

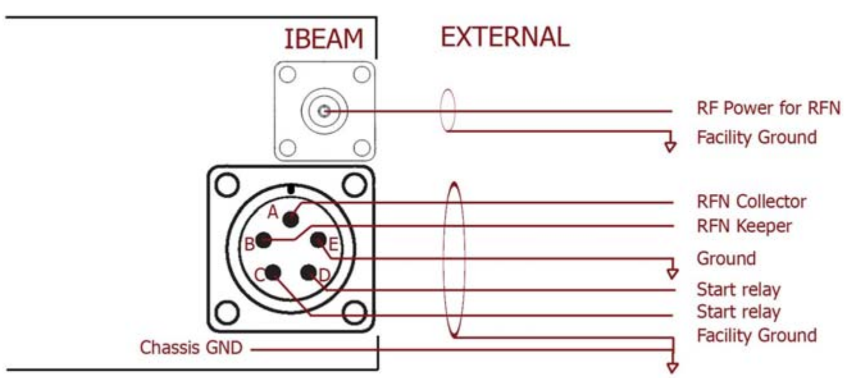
Figure 10. Source pin-out and electrical connections. Connector style: mil spec: 97-3102A-18-4S





Output: Neutralizer

Figure 11. Neutralizer pin-out and electrical connections. Connector style: mil spec: 97-3102A-14S-5S



Mounting the chassis:

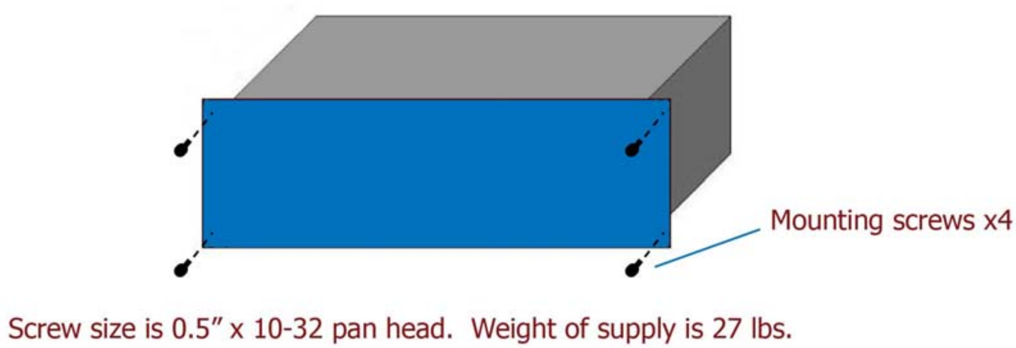


Figure 12. Mounting. The chassis can be installed in a standard 17" rack using 4 screws.

CAUTION

Electrical current. It is important to connect the chassis ground to the facility ground (vacuum tank) (Figs. 10 and 11).

Air cooling:

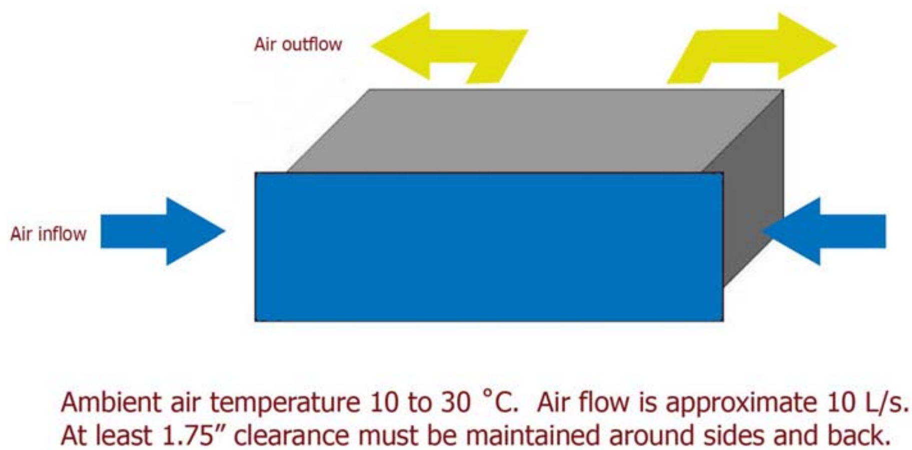
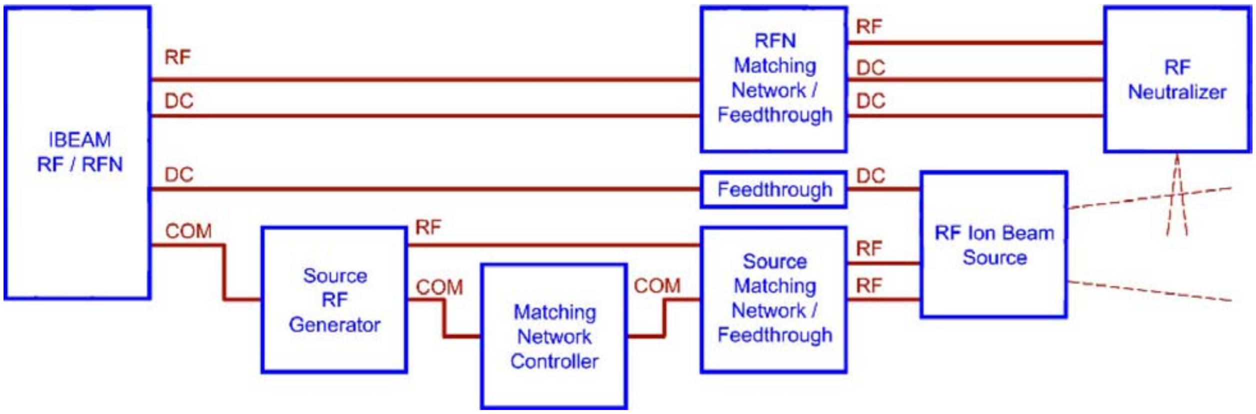


Figure 13. Air flow. The chassis must have adequate air for cooling.

CAUTION

Danger of FIRE. If the power supply does not have proper ventilation, the subcomponents will overheat and may ignite.

Electrical connection setup:



STEP 1. Install the ion beam source and neutralizer in the vacuum system.

STEP 2. Attach the neutralizer and source cables to the output connections (Figs. 10 and 11).

STEP 3. Attach the communications cable, if used, to the USER COM port (Fig. 8).

STEP 4. Connect the input power (Fig. 7).

STEP 5. Connect the interlock. Interlock is satisfied when pin 6 is shorted to pin 7 (Fig. 9).

STEP 6. Turn the main ON/OFF switch to ON.

STEP 7. The unit is ready for power up and operation (See Chapter 4).

Chapter

4

Operation

This section describes basic operation of the IBEAM supply. Computer control is discussed in Chapter 5. For this chapter, it is assumed the ion beam source is installed in the vacuum chamber and is ready for operation. Also, the IBEAM should be connected to the vacuum facility as described in Chapter 3.

Power supply layout

The IBEAM RF/RFN is a single chassis that contains the beam, accel, and power supplies necessary for the RFN as described earlier in Figure 4. The user interface is the front panel and its layout is depicted in Figure 14. The output displays are used to provide voltage and current readings on the individual power supplies. Each supply has an indicator light which illuminates when that supply is selected using the module button on the keypad. The emergency power off will disable power. The parameters for each power supply can be entered by the user through the keypad and presented in the main display. In this section, an overview of the key features and how they relate to source operation are introduced. Example values for typical source operation will be provided.

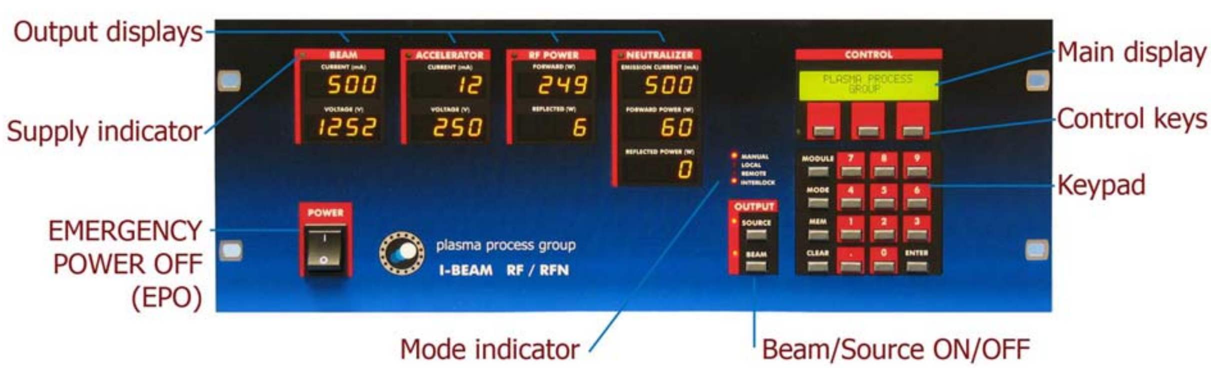


Figure 14. IBEAM RF/RFN front panel.

Keypad entry and power supply adjustments

Adjustments or new target values to the individual power supplies can be input using the keypad. A CLEAR and ENTER key are provided. In order to select a specific power supply, repeatedly press the MODULE button. A green LED (supply indicator) will illuminate near the power supply which indicates parameters for that supply can be entered (see Figure 15).

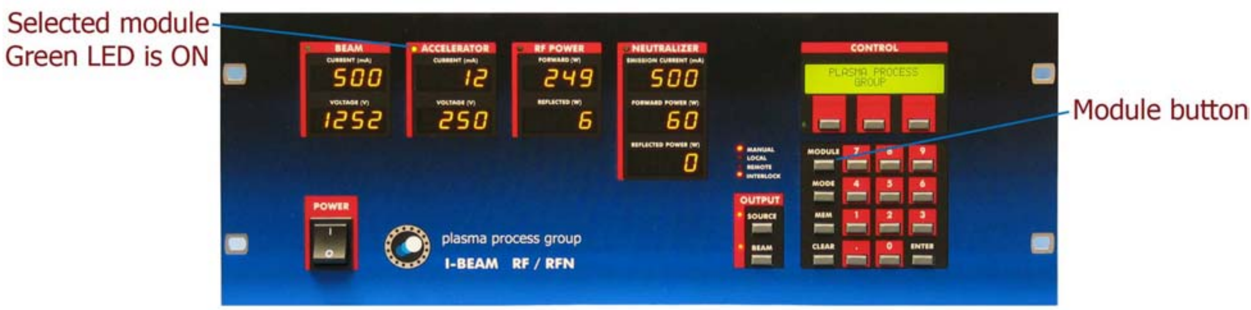


Figure 15. Select the supply by pressing the MODULE button until the green LED lights.

Other global parameters are entered into the CONTROL module. These can be accessed when the green LED is lighted as shown in Figure 16.

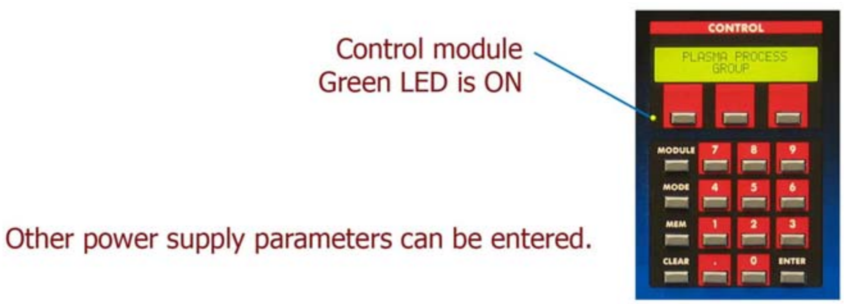


Figure 16. Global parameter entry. To access, press MODULE button until LED lights.

Directly under the main display are 3 control keys. These are used as SELECT buttons for parameters that are presented in the main display directly above (see Figure 17).

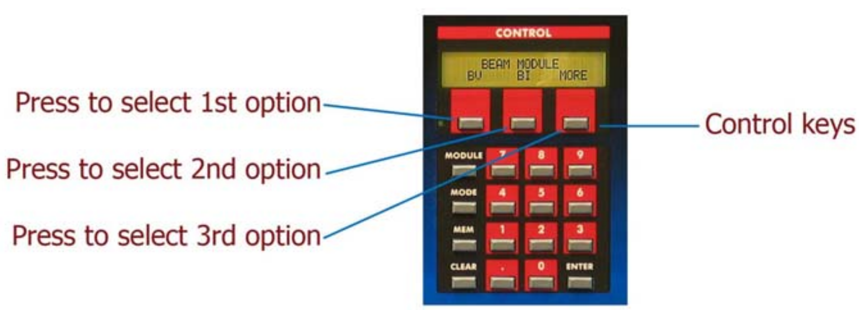


Figure 17. Control keys are used to select options in the main display.

The options for each module in the main display will utilize abbreviations. The following is a listing of these abbreviations for specific modules, the corresponding parameter and description. An acceptable range is provided. The source check-out sheet should be consulted for typical values.

Module	Abbreviation	Parameter and description	Acceptable Range
Beam	BEAM V or BV	**Beam voltage** After the beam is turned on, the power supply will ramp to the beam voltage.	0 to 1500 V
Beam	BI	**Beam current** After the beam is turned on, the power supply will ramp the beam current.	0 to 600 mA
Beam	BV PULSE	**Beam voltage pulse** Pulse voltage to start the source. Typical is 1000 V.	0 to 1500 V
Beam	BV IDLE	**Beam voltage idle** Idle voltage for the source when beam is off. Higher than 50 V is not recommended.	0 to 75V
Accelerator	ACCEL	**Accelerator voltage** Below 100 V is not recommended.	0 to 1000 V
RF Power	RFS FWD	**Source RF forward power** RF power that controls the beam current.	0 to 500 W
RF Power	START POWER	**Source RF power to start discharge.** Recommended is 200 to 250 W.	0 to 500 W
RF Power	IDLE POWER	**RF power at idle condition (beam off).** Recommended is 200 to 250 W.	0 to 500 W
RF Power	POWER LIMIT	**Software RF power limit.** Recommended is 500 W.	0 to 500 W
Neutralizer	EI	**Emission Current** The electron emission current from the RFN.	100 to 900 mA
Neutralizer	RFN FWD	**Neutralizer RF forward power** RF power that controls the emission current.	30 to 75 W
Control	SETUP	Select to change global parameters listed below	
Control	BEAM I TOL	**Beam current tolerance** If the beam current exceeds the tolerance, an alarm is triggered. Recommended is 20%. 0% is OFF.	0 to 100%
Control	A/B RATIO	**Accelerator to beam current ratio** If the accelerator current exceeds the A/B ratio times the beam current, an alarm is triggered. Default is 10%.	0 to 99%
Control	E/B RATIO	**Emission to beam current ratio** Neutralizer emission will ramp to the E/B ratio times beam current. Recommended is 125%.	0 to 200%
Control	REMOTE S/B	**Remote source / beam control settings** This will activate the remote control settings of either RS232, switches or both (see Chapter 5).	toggle
Control	ALARM	Audio alarm	enable/disable
Control	RFN TUNE UP	Allows the user to adjust C1 on the RFN matching network. RFN gas should be off.	enable/disable
Control	RFN BURN IN	Allows the user to run just the RFN.	enable/disable

Continued …

Module	Abbreviation	Parameter and description	Acceptable Range
Control	SOURCE TEST	Allows the user to immediately turn beam on.	enable/disable
Control	SECURITY	Factory use	
MEM key	STORE	Store beam parameters into memory	0 to 9
MEM key	RECALL	Recall beam parameters from memory	0 to 9
All	INC or DEC	Increase or decrease value by 1	

All values are entered as TARGETS. When the SOURCE and BEAM are ON, the modules will ramp to these target values. If a target value cannot be achieved, an alarm will trigger. See Chapter 6 for a listing of the power supply alarms.

User interface examples

The following are examples of how to set target values and other user interface navigation.

Example 1: Put the IBEAM in LOCAL mode and select the RF Power module.

STEP 1. Press MODE button until LOCAL mode is selected.
STEP 2. Press MODULE button until RF Power supply is selected.
The red LED for LOCAL and green RF Power indicator LED should be ON.

Example 2: Set the beam voltage to 1225 V.

STEP 1. Press MODULE button until Beam supply indicator LED is ON.
STEP 2. Use the Control keys to select BV (If IBEAM is in LOCAL mode).
STEP 3. Use keypad to type 1225, then ENTER.

Example 3: Set the beam current to 100 mA (IBEAM must be in LOCAL mode).

STEP 1. Press MODULE button until Beam supply indicator LED is ON.
STEP 2. Use the Control keys to select BI.
STEP 3. Use keypad to type 100, then ENTER.

Example 4: Set the accelerator voltage to 200 V.

STEP 1. Press MODULE button until Accelerator supply indicator LED is ON.
STEP 2. Use keypad to type 200, then ENTER.

Example 5: Set the source RF power to 200 W (IBEAM must be in MANUAL mode).

STEP 1. Press MODULE button until RF Power indicator LED is ON.
STEP 2. Use keypad to type 200, then ENTER.

Example 6: Change the source RF power to 204 W (IBEAM must be in MANUAL mode).

STEP 1. Press MODULE button until RF Power indicator LED is ON.

STEP 2. Select INC (increment) in the control keys, and press it 4 times.

Example 7: Set the neutralizer emission current to 750 mA (IBEAM must be in MANUAL mode).

STEP 1. Press MODULE button until Neutralizer supply indicator LED is ON.
STEP 2. Use the Control keys to select EI.
STEP 3. Use keypad to type 750, then ENTER.

Example 8: Put the IBEAM into RFN test mode.

STEP 1. Press MODULE button until Control module indicator LED is ON.
STEP 2. Select SETUP in the control keys. RFS PWR LIMIT should be displayed.
STEP 3. Select NEXT until RFN BURN IN is displayed.
STEP 4. Touch any key on the keypad to toggle to ENAMBLE, then ENTER.

Example 9: Take the IBEAM out of RFN test mode.

STEP 1. Press MODULE button until Control module indicator LED is ON.
STEP 2. Select SETUP in the control keys. RFS PWR LIMIT should be displayed.
STEP 3. Select NEXT until RFN BURN IN is displayed.
STEP 4. Touch any key on the keypad to toggle to DISABLE, then ENTER.

Example 10: Adjust the E/B ratio to 150%.

STEP 1. Press MODULE button until Control module indicator LED is ON.
STEP 2. Select SETUP in the control keys. RFS PWR LIMIT should be displayed.
STEP 3. Select NEXT until E/B RATIO is displayed.
STEP 4. Use keypad to type 150, then ENTER.

If the MEM key is pressed, the STORE or RECALL options are displayed. Each memory location stores beam current, beam voltage, accelerator voltage, and neutralizer emission current target values. Also stored are the A/B and E/B ratios, cathode and neutralizer filament current limits. Memory location 0 is reserved for the last running condition. There are ten (10) available memory locations.

Example 11: Store all target values into memory location 7.

STEP 1. Press MEM button.
STEP 2. Select STORE in the control keys.
STEP 3. Use keypad to type 7, then ENTER.

Example 12: Recall all target values from memory location 4.

STEP 1. Press MEM button.
STEP 2. Select RECALL in the control keys.
STEP 3. Use keypad to type 4, then ENTER.

Mode indicator and adjustments

Excluding special test modes, the power supply can be operated in one of 3 possible modes. These are MANUAL, LOCAL, and REMOTE. Adjustment of the parameters for the 5 individual power supplies will depend upon which mode is selected. The mode can be selected by pressing the MODE button on the key pad. Below is a table that has the power supply parameters and which of those can be adjusted in the various modes. The special test modes are discussed in Chapter 6.

Source Parameter, abbreviation	LOCAL	REMOTE	MANUAL
Beam Current, BI (mA)	Adjustable	Adjustable	-
Beam Voltage, BV (V)	Adjustable	Adjustable	Adjustable
Accelerator Current (mA) †	-	-	-
Accelerator Voltage, ACCEL (V)	Adjustable	Adjustable	Adjustable
RF Source Forward Power (W)	-	-	Adjustable
RF Source Reflected Power (W)†	-	-	-
RF Neutralizer Emission Current (mA)	Adjustable (E/B RATIO)	Adjustable (E/B RATIO)	Adjustable
RF Neutralizer Forward Power (W)	-	-	Adjustable
RF Neutralizer Reflected Power (W) †	-	-	-

† These parameters cannot be adjusted using the IBEAM power supply. The accelerator current is induced by charge-exchange ions created in the vicinity of the accelerator grid [see reference 11]. The production of these charge-exchange ions is proportional to the source gas flow rate and chamber pressure. The charge-exchange ions are attracted to the accelerator grid, impinge, and are detected as accelerator current. The impingement process will result in sputtering of the accel grid and excessive accelerator current will reduce the life of the grid. For properly aligned grids and reasonable operating conditions, the accelerator current is typically less than 10% of the beam current. The RF Source and RF Neutralizer reflected power is dependent upon the matching networks and how well they are tuned.

In LOCAL mode, the IBEAM allows the user to set a specified beam current (or ion dose). When the source and beam switches are ON, the IBEAM will attempt to run the source at the specified beam current. More specifically, the IBEAM will adjust the RF source forward power to control the beam current. Increasing the RF source forward power will increase the rate of ion production in the discharge chamber. As this is done, the plasma density increases in the discharge chamber, thereby more ions can be extracted and an increased beam current is achieved. LOCAL mode is useful for applications requiring a constant beam current (or dose) on a target or substrate. The IBEAM controls the RF source forward power to maintain a steady beam current.

In REMOTE mode, the IBEAM essentially behaves the same as LOCAL mode. REMOTE refers to the interface with the power supply utilizing the RS232 connection. A computer terminal or software program is utilized for parameter adjustment.

In MANUAL mode, the IBEAM allows the user to control the RF source forward power manually from the front panel. The result is the user can increase or decrease the beam current manually. The beam current is not as stable as LOCAL mode. However, MANUAL mode is useful for determining or optimizing other source parameters and troubleshooting source operation. In MANUAL mode the user cannot select a beam current; it is adjusted by increasing or decreasing the RF source forward power.

SUMMARY:

LOCAL – User selects beam current and the IBEAM controls RF source forward power.

REMOTE – Same as LOCAL, IBEAM is controlled using RS232.

MANUAL – User selects RF source forward power which manually controls beam current.

Beam/Source ON/OFF

The power supply has two ON/OFF buttons for output labeled SOURCE and BEAM. When the SOURCE button is toggled to ON, the RFN begins its start-up sequence. The RFN starts by applying RF power while the start / run relay is toggled. Once the RFN establishes a discharge between its keeper and collector, the RFN will go into a 5 minute warm-up period. As soon as the RFN has started, RF power is then applied to the source. When the RF power reaches the RF starting power, the BEAM and ACCEL are pulsed to the BV PULSE setting which should start the discharge inside the source. The BEAM and ACCEL are then ramped down to the BV IDLE setting. The source has started and the BEAM button can then be toggled to ON.

When the BEAM button is toggled to ON, power is applied to the beam and accelerator supplies. The beam and accelerator voltage will ramp in a steady fashion to their desired settings. The beam can be turned off by pressing either the BEAM or SOURCE button. Turning the beam off by pressing the BEAM button will leave the source ON. Turning the beam off by pressing the SOURCE button will extinguish the beam and source.

Operation example

The following is a step by step example of operating the source.

Step 1) **Pumpdown.**

The ion beam source requires a high vacuum environment for proper operation. As there are several different types of vacuum systems, general guidelines will be presented. Also, the vacuum environment will depend upon the application for the ion beam source. The required pumping speed of the vacuum system will depend upon how much process gas is used by the ion beam source and the vacuum environment required for the process. Problems may arise with operation of the ion beam at higher pressures. Presented in Table 4.1 are general vacuum specifications guidelines.

Table 4.1. Vacuum specifications.

Specification	Value	Comments
Chamber base pressure	10^{-6} Torr	Lower is OK
Chamber operating pressure when the source gas is on.	10^{-5} to 10^{-3} Torr	The discharge may go out at lower pressures. Grid arcing will occur at higher pressures.
Typical pumping speed	1000 l/s (air)	Process dependent.

Step 2) **Turn the process gas on**.

After the vacuum chamber has achieved its base pressure, turn on the RFN and source gas. The amount of gas is typically measured in standard cubic centimeters per minute, or sccm. The required amount can be selected based upon the application. It is recommended to wait 5 to 10 minutes after the gas has been turned on in order to purge the gas line. Recommended flow rates for a system using a 1000 l/s pump are presented in Table 4.2.

Table 4.2. Typical source gas flow rates for a 1000 l/s pumping station.

Specification	Value	Comment
RFN	5 sccm Argon	Typical flow rate.
12 cm Source gas flow	6 to 12 sccm Argon	Typical flow range.
16 cm Source gas flow	8 to 14 sccm Argon	Typical flow range.

Step 3) **Turn on the water cooling**.

Turn on the source water cooling at this time. The water cooling must have a flow switch connected to the interlock string. If the source cooling stops flowing, the power supply output will shut off.

Step 4) **Turn the source on and allow it to warm-up**.

CAUTION

Make sure all electrical connections have been properly made and that the power supply interlock has been satisfied.

Turn the power supply on.

Set the BV PULSE and BV IDLE to the recommending starting conditions in Table 4.3. Similarly, adjust the neutralizer starting current.

Table 4.3. Recommending starting conditions.

Source	BV PULSE	BV IDLE	Start RF power
12 cm Source	750 to 1000 V	25 to 45 V	200 W
16 cm Source	750 to 1000 V	25 to 45 V	200 W

Turn on the source by pressing the SOURCE button. When the SOURCE button is pressed, the power supply will begin to start the RFN. The RFN starts by applying RF power while the start / run relay is toggled. Once the RFN establishes a discharge between its keeper and collector, the RFN will go into a 5 minute warm-up period. As soon as the RFN has started, RF power is then applied to the source. When the RF power reaches the RF starting power, the BEAM and ACCEL are pulsed to the BV PULSE setting which should start the discharge inside the source. The BEAM and ACCEL are then ramped down to the BV IDLE setting. The source has started.

An established plasma discharge is indicated by a current displayed in the BEAM module. If the BEAM current is less than the START I the IBEAM will indicate the source discharge has extinguished and display an error.

The recommended warm up period is 10 minutes. As the source heats it may release trapped water vapor gases which may result in a temporary increase in chamber pressure. Presented in Table 4.4 are typical source warm up conditions. If the discharge cannot be established, or other starting issues arise, please refer to Chapter 6 - Troubleshooting.

Table 4.4. Typical warm up data.

Source	Gas	Pressure	Beam		Accelerator		Source RF		Neutralizer	
		x 10^{-4}	I	V	I	V	FWD	REF	RF	Emission
		(Torr)	(mA)	(V)	(mA)	(V)	(W)	(W)	(W)	(mA)
12 cm	8 sccm Ar	4.8	90	40	0	0	200	3	40	500
16 cm	12sccm Ar	6.5	19	40	0	0	200	5	40	500

Step 5) **Set the beam conditions and turn the beam on**.

Set the beam and accelerator voltage for the desired condition. Optimized beam and accelerator voltages will be specific for a given process. Recommended conditions for typical applications are presented in Table 4.5. The comments in Table 4.5 are for standard grids. Grids can be customized for ion beam directional control.

Table 4.5. Typical beam and accelerator voltage settings.

Application	Beam V	Accel V	Comments
Low energy etch or assist beam	300 V	700 V	Beam is spread out.
Low rate sputtering	750 V	300 V	Beam is mid sized.
High rate sputtering	1250 V	250 V	Beam is focused.

Next, select how the beam current will be controlled, that is, either MANUAL, LOCAL or REMOTE. In order to select which mode to run press the MODE button. A description of these modes is listed in Table 4.6. For troubleshooting source problems, MANUAL mode is recommended. For most applications, LOCAL mode is useful for running a process.

Table 4.6. Definition of the power supply operational MODES.

MANUAL	The operator can adjust the cathode current for beam current control.
LOCAL	The operator selects a beam current and the power supply regulates cathode current.
REMOTE	Same as LOCAL, except that a computer is controlling the power supply.

If MANUAL MODE is selected, when the BEAM button is pressed, the extracted beam current is determined by the given discharge conditions. Beam current is increased or decreased by adjusting the source RF power.

If the LOCAL mode is selected, a target value for beam current can be set in the BEAM module. When the BEAM button is pressed, the power supply will regulate the discharge current by adjusting the source RF power to extract the target beam current.

Step 6) **Adjusting the beam conditions**.

The beam current and voltage can be adjusted while the beam is on. However, for some conditions, the beam may need to be turned off while keeping the source on. Also, switching between MANUAL and LOCAL power supply modes may be necessary to achieve desired beam conditions. Some beam currents may not be achievable at various beam voltages (e.g. high beam current at low beam voltage). Please consult the source check out sheet for the nominal range of beam currents and voltages.

If there are issues with the beam current and voltage please consult Chapter 6 - Troubleshooting.

Step 7) **Optimizing the accelerator voltage.**

For some applications it can be useful to optimize the accelerator voltage. If the application requires low beam voltage (i.e. low ion energy) the accelerator voltage is usually required to be high and the beam spreads out as it leaves the source. On the other hand, if the application requires higher beam voltage (i.e. high ion energy), the accelerator voltage can be optimized to improve the accelerator grid life.

After a beam current and voltage are selected, start with a high accelerator voltage. Put the power supply in MANUAL mode. Decrease the accelerator voltage and examine the accelerator current. When the accelerator current begins to increase, electrons will begin to back-stream. At this condition, the accelerator voltage is too low. The accelerator voltage is optimized by increasing it above this setting by 50 to 75 V. Illustrated in Table 4.7 is an example of optimizing the accelerator voltage at a given beam condition.

Table 4.7. Electron back-streaming occurs at an accelerator voltage of 250 V. Optimized is 300V.

Source	Gas	Pressure	Beam		Accelerator		Source RF		Neutralizer	
		x 10^{-4}	I	V	I	V	FWD	REF	RF	Emission
		(Torr)	(mA)	(V)	(mA)	(V)	(W)	(W)	(W)	(mA)
12 cm	10sccm Ar	5.8	339	500	9	400	230	2	40	500
	10sccm Ar	5.8	333	500	8	350	230	2	40	500
	10sccm Ar	5.8	328	500	8	300	230	2	40	500
	10sccm Ar	5.8	323	500	9	250	230	2	40	500
	10sccm Ar	5.8	317	500	11	200	230	2	40	500

The accelerator to beam current (A/B) ratio in the power supply may require adjustment. The ratio is entered into the power supply and will induce an alarm if the A/B ratio is exceeded. A typical A/B ratio is 10% and at this condition, the power supply will alarm if the accelerator current is greater than 10% of the beam current.

Step 8) **Neutralizer operation**.

When the BEAM button is pressed, the neutralizer emission current will change. If the power supply is in MANUAL mode, the emission current is determined by the settings in the neutralizer module. If the power supply is in LOCAL mode, the emission current will adjust to the E/B ratio where the E/B ratio is emission current to beam current ratio. For typical applications, E/B is set to 125% or greater. At this condition, the emission of electrons from the neutralizer is more than the beam current. This will assist with the downstream conditions and minimize surface charging and arcing.

Step 9) **Turning the source off and cool down.**

The beam and source are shut off by pressing the source button. The power supply can be then turned off. It is recommended to leave the process gas running while the source cools for 10 minutes. It is recommended cooling the source about 20 minutes before the vacuum chamber is vented. Always leave the RFN gas on while venting as this will help prolong the RFN life.

Chapter

5

Remote Control

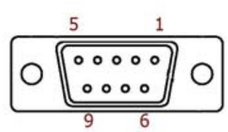
The IBEAM can be controlled with a computer interface via RS232 communication link or using the remote switch feature or both. The IBEAM communication mode is toggled via the Control module under REMOTE S/B (see Chapter 4). The 3 possible modes are:

REMOTE S/B – RS232	This is used for RS232 serial communication only.
REMOTE S/B – SW ONLY	This is used for remote switch control only.
REMOTE S/N – RS232/SW	This is used for both RS232 and switch control.

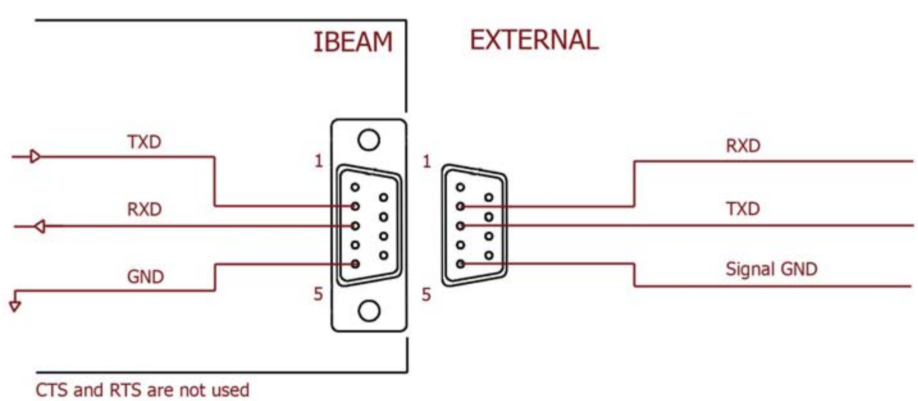
RS232 communications

The RS232 link is provided at the USER COM port located on the rear of the unit (see Chapter 3). Below is the pin-out and wiring diagram for the connections.

Figure 8. Pin-outs and electrical connections for USER COM.
Connector style: DB9



1 - n/c
2 - TXD
3 - RXD
4 - n/c
5 - Signal GND
6 - n/c
7 - n/c
8 - n/c
9 - n/c



The handshake protocol is:

Baud rate	9600 bps
Data bits	8
Stop bits	1
Parity	none

A quick reference list of standard commands and their description are:

Command	Description
A	Attention, put IBEAM in REMOTE mode
AB	Set A/B ratio
AV	Set accelerator voltage
B	Turn beam on/off
BI	Set beam current
BV	Set beam voltage
M	Set the power supply mode
R	Recall conditions from memory
RC	Request running conditions
S	Turn source on/off
ST	Store running conditions to memory

Commands are sent to the IBEAM with carriage return <cr>. The IBEAM will respond with an echo of the command followed by a specific response. If an invalid command is sent, the IBEAM will respond with a <lf><cr>?<lf><cr><eot>, where <lf> is a line feed and <eot> is end of transmission. Certain commands are sent with additional values included before the carriage return <cr>.

The specifics of each command are described in the following section. For these examples, the command contained within the quotes needs to be sent. For example "*command*<cr>" is to send *command* followed by carriage return <cr>. Do not send the quotes.

Command Details

Serial command: **A**

Description: Attention and put IBEAM in REMOTE mode.
Usage: A<cr>
Example: Send "A<cr>". The IBEAM will switch to REMOTE mode (if not already in REMOTE mode).
Response: <lf><cr>OK<lf><cr><eot>

Serial command: **AB**

Description: Set the accelerator to beam (A/B) ratio.
Usage: AB(0-99)<cr>
Example: Send "AB10<cr>". The A/B ratio will be set to 10%. If the accelerator current exceeds 10% of the beam current, an error will be displayed. Acceptable range is from 0 to 99%. Default is 10.
Response: <lf><cr>OK<lf><cr><eot>

Serial command: **AV**

Description: Set the accelerator voltage.
Usage: AV(0-1000)<cr>
Example: Send "AV250<cr>". The accelerator voltage will be set to 250 V. Acceptable range is from 0 to 1000 V. Below 100 V is not recommended.
Response: <lf><cr>OK<lf><cr><eot>

Serial command: **B**

Description: Turn the beam on or off
Usage: B(1 or 0)<cr>
Example: Send "B1<cr>". The beam will turn on. Send "B0<cr>". The beam will turn off.
Response: <lf><cr>OK<lf><cr><eot>

Serial command: **BI**

Description: Set the beam current.
Usage: BI(0-300)<cr>
Example: Send “BI125<cr>”. The beam current target will be set to 125 mA. After the beam is turned on, the power supply will ramp to 125 mA. Acceptable range is from 0 to 600 mA. The source check-out sheet should be consulted for normal ranges.
Response: <lf><cr>OK<lf><cr><eot>

Serial command: **BV**

Description: Set the beam voltage.
Usage: BV(0-1500)<cr>
Example: Send “BV1250<cr>”. The beam voltage target will be set to 1250 V. After the beam is turned on, the power supply will ramp to 1250 V. Acceptable range is from 0 to 1500 V. The source check-out sheet should be consulted for normal ranges.
Response: <lf><cr>OK<lf><cr><eot>

Serial command: **M**

Description: Set the power supply mode.
Usage: M(0,1 or 3)<cr>
Example: Send “M0<cr>”. The IBEAM will be set to MANUAL mode.
Send “M1<cr>”. The IBEAM will be set to LOCAL mode.
Send “M3<cr>”. The IBEAM will be set to REMOTE mode.
Response: <lf><cr>OK<lf><cr><eot>

Serial command: **R**

Description: Recall conditions from memory.
Usage: R(0-9)<cr>
Example: Send “R2<cr>”. The beam conditions stored in memory location 2 will be recalled. Acceptable range is from 0 to 9. Each memory location stores beam current, beam voltage, accelerator voltage, and RFS forward power. Also stored are the A/B and E/B ratios. Memory location 0 is reserved for the last running condition.
Response: <lf><cr>OK<lf><cr><eot>

Serial command: **RC**

Description: Request running conditions.
Usage: RC<cr>
Example: Send "RC<cr>". The current running conditions will be sent to the buffer. It is recommended this command should not be sent more than 1 time per second.
Response: <lf><cr>_AAAA,_BBBB,_____,_CCCC,_DDDD,_EEEE,_FFFF,_GGGG,
__HHH,__III,__JJJ,KLMNO,P,QRST1,<lf><cr><eot>

Where: AAAA is the RFS forward power (W)
BBBB is the RFS reflected power (W)
CCCC is the beam current (mA)
DDDD is the beam voltage (V)
EEEE is the accelerator current (mA)
FFFF is the accelerator voltage (V)
GGGG is the emission current (mA)
HHH is the RFN forward power (W)
III is the RFN reflected power (W)
JJJ is the emission voltage (V)
K is beam module errors (see module errors below)
L is accelerator module errors (see module errors below)
M is RFN module errors (see module errors below)
N is emission module errors (see module errors below)
O is RFS module errors (see module errors below)
P is mode (0=manual, 1=auto, 2=remote)
Q is mode (0=both off, 1=source on, 2=beam on, 3=both on)
R is status bit (0: RFS started, 1:RFN started, 2:BI at target, 3:EI at target)
S is source fatal code (0=no error, 3=RFN out, 4=COM out, 5=RFS out)
T is beam fatal code (0=no error, 1=BI tolerance, 2=EI error)

And module errors are:
0 or '_' is no errors
1 or 2 is cannot achieve requested target
4 is module in current limit
5 is interlock open
6 or 7 is module in over temperature
: or 8 is module will not start or went out

Serial command: **S**

Description: Turn the source on or off
Usage: S(1 or 0)<cr>
Example: Send "S1<cr>". The source will turn on.
Send "S0<cr>". The source and beam will turn off.
Response: <lf><cr>OK<lf><cr><eot>

Serial command: **ST**

Description: Store running conditions to memory.

Usage: ST(0-9)<cr>

Example: Send "ST7<cr>". The current beam conditions are stored in memory location 7. Acceptable range is from 0 to 9. Each memory location stores beam current, beam voltage, accelerator voltage, RFS forward power, E/B ratio and A/B ratio. Memory location 0 is reserved for the last running condition.

Response: <lf><cr>OK<lf><cr><eot>

Operation example

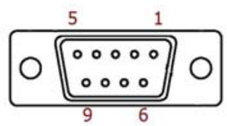
The following is a line-by-line short example of how turn on the beam and monitor its conditions. Each line represents a command sent to the IBEAM. The time duration between each command line should be a least one (1) second. For data logging operations, it is recommended requesting the running conditions should not be performed more than once (1 time) per second. Similarly, setting new target conditions should be limited to once (1 time) per second. If faster response in turning the beam on/off is required, please examine the description on remote switches later in this chapter.

Line	Command	Description
1	A<cr>	Put the IBEAM in remote mode
2	BV1250<cr>	Set the beam voltage to 1250 V.
3	BI100<cr>	Set the beam current to 100 mA.
4	AV250<cr>	Set accelerator voltage to 250 V.
5	S1<cr>	Turn the source on.
6	*delay*	Wait about 10 minutes before turning on the beam.
7	B1<cr>	Turn the beam on.
8	RC<cr>	Request running conditions.
9	*delay*	Wait at least 1 second before sending next command.
10	*loop to line 8*	Data log beam conditions until event occurs.
11	B0<cr>	Turn beam off.
12	S0<cr>	Turn source off.

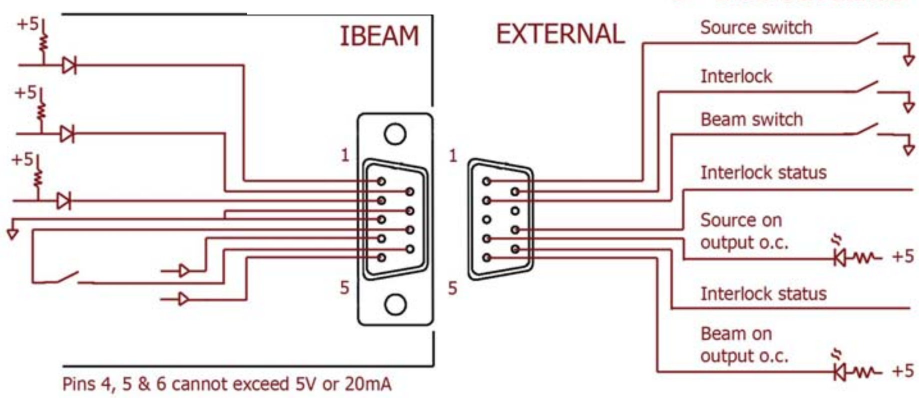
Remote switches

For faster control, certain functions of the IBEAM can be performed using remote switches. The remote switch link is provided at the INTERLOCK port located on the rear of the unit (see Chapter 3). Specifically, the source and beam switch can be toggled remotely. For these features to work, the remote switch must be enabled from the CONTROL module (see Chapter 4). Below is the pin-out and wiring diagram for the connection.

Figure 9. Pin-outs and electrical connections for interlock and remote switches.
Connector style: DB9



1 - Remote switch for source
2 - Remote switch for beam
3 - GND
4 - Source on output
5 - Beam on output
6 - Interlock
7 - GND
8 - Interlock status
9 - Interlock status



The switch closures work to turn on the source and beam. Their function is identical to the Beam/Source ON/OFF output buttons on the front panel. To turn the source ON, the source switch (pin 1) is shorted to ground. Similarly, to turn the beam ON, the beam switch (pin 2) is shorted to ground. Either can be turned OFF by opening the short. The switch closures are driven by an internal 5 V signal. Additional voltage or power is not required.

The signal timing on the remote switches is about 50 ms. That is, when the state of the remote switches changes, it takes about 50 ms for the power supply to respond. The switch closures have indicators (pins 4 and 5) that can be used for feedback if necessary.

Chapter 6

Troubleshooting

As there are many variables with the ion beam source, the troubleshooting is divided into the various stages of operation. First, common issues with the power supply are presented. It is important to be aware of the electrical nature of the ion beam source. Most issues arise from electrical shorting or openings that disrupt proper operation. These issues may not present themselves easily, say with a multi-meter, as it may be a plasma short or a thermal open that creates the issue.

This chapter is divided into:

Power Supply – Problems that are detected by the power supply.

Starting the source – RFN and RFS problems.

Turning the beam on – Beam, accelerator, and grid problems.

Neutralizer operation – RF Neutralizer problems.

Special diagnostics and testing.

WARNING

This power supply produces high voltage outputs. For troubleshooting recommendations that require checking electrical connections and continuity TURN OFF ALL POWER SUPPLIES before testing.

Power Supply Error Codes

The IBEAM will display various error codes in the output displays. These are in the form of letter E followed by two numbers (e.g. E##). The errors may pertain to a particular module or the entire unit. Below is a listing of these codes.

Table 6.1 Problems as detected by the power supply.

Error	Description	Possible problems and solutions
03	Output of module is lower than requested.	1. Facility voltage is too low – Check facility voltage. 2. Electrical connection is poor – Check electrical connections 3. Power supply fuse has failed – Check fuses.
04	Output of module is higher than requested.	1. Electrical short – Check electrical connections. 2. Plasma short – Check the source and feedthru for electrical wire proximity problems or coated insulators. 3. Gas flow is too high – Check gas flow level.
05	Module is in current or voltage limit.	1. Electrical short – Check electrical connections. 2. Plasma short – Check the source and feedthru for wire proximity problems or coated insulators. 3. Electrical short – Check for flakes or debris.
06	Module is at over temperature.	1. Cooling issue – Make sure fan is operational and unobstructed. 2. Dust buildup – Clean any dust buildup on power supply.
10	RFN failed to start.	1. RFN operation issue – Check the RFN troubleshooting section in this chapter. 2. RFN gas issue – Run the RFN gas for about 5 minutes and try again.
13	Beam current is out of tolerance.	1. Severe arcing – Clean and inspect the grids 2. RF power too high – See turning on the beam Table 6.3
20	Interlock is open	1. Water flow – Check water flow. 2. Vacuum – Check vacuum interlock. 3. Interlock cable is not connected – Check cable and connections.
24	E/B Ratio (emission current to beam current ratio)	1. Emission current too low – Check RFN operation. 2. Neutralizer location – Neutralizer is too far from beam. 3. RFN went out – Check RFN operation. 4. IBEAM is in test mode – Check IBEAM RFN test settings.
25	A / B Ratio (accel current to beam current ratio)	1. Accel current is too high – Check alignment of grids. 2. Accel voltage is too low – Increase accel voltage. 3. Unstable beam condition – Examine data provided with source. 4. Grid spacing incorrect – Check grid spacing. 5. Debris between the grids – Clean and inspect the grids. 6. Leakage current on grid insulators – Clean / replace insulators.
71	Source is out	1. See description next page.
81	Max RF power	1. RF power too high – Check RF circuit, matching network, antenna. 2. Source gas too low – Check source gas flow rate and pressure.
87	Communication	1. Lost communication with RF generator – Check RS232 and power.

Power Supply Error code -71-

Error -71- occurs if the source is turned on and the beam current drops below the beam current low threshold (BV IDLE). The power supply monitors the beam current (with the beam on or off) to determine if a discharge has been established. The low threshold value (BV IDLE) is factory preset to 10 mA. This means if the beam current drops below 10 mA, error -71- is activated.

There are a number of possible problems and solutions for this error. It is recommended to examine these issues first and then call the factory if the error cannot be cleared.

1. Momentary RF interrupt – Check antenna, RF circuit, matching network, RF power supply.
2. Improper grid assembly / connection – Check grid spacing and mount assembly against drawings.

Starting the Source

Recall, when the source button is pressed, the following steps occur and the next step will not commence unless the current step is completed.

STEP 1. Start the RFN.
STEP 2. Tune the RFS to the starting forward power.
STEP 3. Pulse the beam and accel grids to the BV PULSE setting
STEP 4. Electrons from the RFN are pulled into the source to create a discharge.
STEP 5. Relax the beam and accel grids to the BV IDLE setting.
STEP 6. Monitor the BV IDLE current to determine if the source discharge is ignited.

Suggestions for troubleshooting source starting issues are provided in Table 6.2

Table 6.2 Problems with RFN or RFS.

Problem description	Possible problems and solutions
Cannot achieve STEP 1	1. Examine RF Neutralizer operation section in this chapter.
Cannot achieve STEP 2	1. Source matching network issues – Check matching network electrical and communication connections. Check controller power is turned on. Older matching networks may require factory service. 2. RFS generator issues – Check RFS generator for errors. 3. Antenna issues – Check source antenna for proper alignment, spacing and positioning. Check to ensure antenna is not electrically connected to ground. Check source coolant is not conductive (pH of 7).
Cannot achieve STEP 3	1. Source gas is off or low flow – Check source gas flow rate. 2. Beam and/or accel grid are not connected – Check connections. 3. BV PULSE is low or 0 V – Have power supply serviced.
Cannot achieve STEP 4	1. RFN is not coupling – Check orientation of RFN or any shielding. 2. RFN went out – Check RFN.
Cannot achieve STEP 5	1. IBEAM continues to pulse – Check steps 3 and 4 again. 2. Beam and/or accel grid are shorted to ground – Check connections.
High BV IDLE current.	1. Beam and/or accel grid are shorted to ground – Check connections. 2. Gas flow is higher than expected – Check gas flow operation. 3. RFS idle power is higher than expected – Check idle power setting.

Turning on the Beam

Table 6.3 Problems with BEAM and ACCEL.

Problem description	Possible problems and solutions
Beam will not turn on	1. RFN TUNE UP mode is enabled – Disable (Chapter 3). 2. RFN BURN IN mode is enabled – Disable (Chapter 3).
Beam current zero.	1. Discharge is not started or is out – Check discharge (Table 6.2) 2. Faulty connection – Check cable and feedthru connections (Table 6.5). 3. Possible power supply problem – Have power supply serviced.
Beam current lower than normal	1. Gas flow is lower than expected – Check gas flow and operation. 2. RFS forward power is too low – Check RFS operation (Table 6.2) 3. RFS forward power has loss – Check source antenna for proper alignment, spacing and positioning. Check to ensure antenna is not electrically connected to ground. Check source coolant is not conductive (pH of 7).
Beam current higher than normal	1. Screen grid is electrically shorted – Check electrical connections. Look for signs of plasma shorts, coated insulators and electrical lead wire proximity issues. 2. If both accel and beam current are high - Check the grid alignment and spacing. Check for accel to screen grid shorting (Table 6.5) 3. Spring tab in contact with grid mount stack. 4. Screen grid has debris or flakes – Clean screen grid. 5. Gas flow is higher than expected – Check gas flow and operation.
Accel current zero.	1. Discharge not started or is out – Check discharge (Table 6.2) 2. Faulty accelerator grid connection – Check spring connections. 3. Faulty connection – Check cable and feedthru connections (Table 6.5). 4. Possible power supply problem – Have power supply serviced.
Accel current lower than normal	1. Accel grid has a faulty electrical connection – Check connections. 2. Gas flow is lower than expected – Check gas flow operation.
Accel current higher than normal	1. Accel grid is electrically shorted – Check accel electrical connections. Look for signs of plasma shorts inside the source, coated insulators and electrical lead wire proximity issues. 2. If both accel and beam current are high - Check the grid alignment and spacing. Check for accel to screen grid shorting (Table 6.5) 3. Accel grid insulators are coated – Check insulators and clean / replace. 4. Accel grid insulators are coated – Perform high-pot test (Table 6.5). 5. Gas flow is higher than expected – Check gas flow operation. 6. Beam voltage is too low – Examine the source run data.
Arcing	1. Debris or flakes are in proximity to the grids – Check and clean the screen and accel grid. 2. Accel grid is coated with dielectric material – Clean the accel grid. 3. Grids have contamination – Clean grids ultrasonically in Micro-90 and water. Rinse and wipe with alcohol. Bake grids under a heat lamp to remove water vapor. Wipe with alcohol and blow with dry nitrogen. 4. Source was not warmed up long enough – increase warm up time.

RF Neutralizer Operation

The RF neutralizer is started by performing these steps controlled by the power supply.

STEP 1. Apply starting RF power (start cycle).
STEP 2. Apply emission voltage to see if RFN has started (run cycle).
STEP 3. Repeat step 1 if RFN has not started (10 times before alarm).
STEP 4. If RFN has started, warm up at 65 W, 500 mA for 5 minutes.
STEP 5. Decrease RFN forward power to normal range for a given emission current.

Troubleshooting RFN starting issues is divided by these steps and suggestions are provided in Table 6.4. If possible, it can be advantageous to view the RFN as it is starting. Special testing procedures are also presented in the next section.

Table 6.4 Problems with the neutralizer.

Problem description	Possible problems and solutions
STEPS 1-3 alarm RFN reflected power high.	1. Collector is loose, not connected or changed shape – Repair RFN. 2. RFN matching network is out of adjustment – Perform RFN tuning as described in this chapter.
STEPS 1-3 alarm no discharge present	1. RFN gas flow is low – Check gas flow rate and loose gas connections. 2. Failed keeper fuse – Check keeper fuse.
STEPS 1-3 alarm discharge present	1. Keeper has faulty connection or is coated – Check keeper. 2. Shielding too close to the RFN – Move shielding.
RFN forward power is low (~15W)	1. RF connection is open – Check all RF connections. 2. Collector is loose, not connected or changed shape – Repair RFN. 3. RFN matching network is out of adjustment – Perform RFN tuning as described in this chapter.
Neutralizer emission current lower than normal	1. Collector has been oxidized and needs to be replaced. 2. RFN gas flow is too low – Check gas flow rate. 3. Poor electrical connection – Check all electrical connections. 4. E/B ratio is set incorrectly – Check the E/B ratio (Local mode).
Neutralizer emission current higher than normal	1. Neutralizer is electrically shorted – Check electrical connections in cable, feedthru and near RFN. 2. E/B ratio is set incorrectly – Check the E/B ratio (Local mode).
Emission current is zero	1. RFN gas is off or low – Check gas operation. 2. Failed emission fuse – Check emission fuse. 3. Collector or keeper is not electrically connected – Check connections.
Emission current is unstable	1. Collector is new – Reduce RFN forward power 2. RFN gas flow is low – Check gas flow rate and loose gas connections.

Special Testing

Electrical connections

CAUTION

These test require that the power supply is powered off. Turn the front panel EPO to OFF. Turn the rear panel main switch to OFF.

Table 6.5 Electrical diagnostics and testing procedures.

Problem description	Possible problems and solutions
Beam current zero.	1. Faulty connection – Check cable and feedthru connections. Note: With the source off and at atmosphere, disconnect the source cable from the power supply. Use an ohm meter and measure the resistance between pin B and the screen grid. The reading should be 2 ohms or less to indicate the screen grid is properly connected.
Accel current zero.	1. Faulty connection – Check cable and feedthru connections. Note: With the source off and at atmosphere, disconnect the source cable from the power supply. Use an ohm meter and measure the resistance between pin A and the accelerator grid. The reading should be 2 ohms or less to indicate the accel grid is properly connected.
Beam current and Accel current higher than normal	1. Check for accel to screen grid shorting. Note: With the source off and at atmosphere, disconnect the source cable from the power supply. Use an ohm meter and measure the resistance between pin A and pin B. Also check between pin A (and pin B) and ground. The readings should be open to indicate the screen grid is not shorted to the accel grid or ground.

RF Neutralizer tuning

The RF neutralizer and matching network are tuned at the factory and should not require any adjustments in the field. However, if necessary, the IBEAM can be set up to perform special testing and tuning of the RFN. These procedures may be required if a new collector was installed in the RF neutralizer.

In the control module there are 2 settings that can be enabled (see Chapter 4). These are RFN TUNE UP and RFN BURN IN. If the IBEAM is in either of these modes, the BEAM button will not turn the BEAM on.

RFN TUNE UP should be used only when the RFN has undergone a refurbishment. This mode allows the RFN forward power to be applied for longer durations so that the match network capacitor C1 (and only C1) can be adjusted. The RFN TUNE UP procedure is:

STEP 1. Turn RFN gas to off.
STEP 2. ENABLE the RFN TUNE UP in the IBEAM Control module.
STEP 3. Press the SOURCE button and note the RFN forward and reflected power.
STEP 4. Adjust C1 on the RFN match network to maximize forward power.
STEP 5. Turn the SOURCE button OFF.
STEP 6. DISABLE the RFN TUNE UP in the IBEAM Control module.

RFN BURN IN should be used only when the RFN has undergone a refurbishment and the RFN TUNE UP has been performed. This mode allows manual control of the RFN forward power and emission current. The RFN BURN IN procedure is:

STEP 1. Set the RFN gas to 5.0 sccm Ar and turn it on.
STEP 2. ENABLE the RFN BURN IN found in the IBEAM Control module.
STEP 3. Set the emission current to 100 mA and RFN forward power to 75 W.
STEP 4. Press the SOURCE button and allow the RFN to start.
STEP 5. Allow the RFN to run for 10 min at 100 mA, 75 W.
STEP 6. Adjust the emission current to 300 mA and RFN forward power to 65 W.
STEP 7. Allow the RFN to run for 10 min at 300 mA, 65 W.
STEP 8. Adjust the emission current to 500 mA and RFN forward power to 55 W.
STEP 9. Allow the RFN to run for 40 min at 500 mA, 55 W.
STEP 10. Turn the SOURCE button OFF.
STEP 11. Set the RFN BURN IN to DISABLE in the IBEAM Control module.

During the burn in procedure, the keeper voltage can be checked in the RFN module window. Press UPDATE periodically to check the keeper voltage remains below 25 V. If the keeper voltage is greater than 25 V, the collector may be oxidized or is not properly connected.

Electron Backstreaming

If the accelerator grid voltage is set too low, it is possible for electrons from the neutralizer to migrate into the discharge plasma. This condition is referred to as electron backstreaming. Electron backstreaming will lead to erroneous beam current readings and will result in a lower etch rate on the target (or a lower deposition rate). The source can be quickly tested to determine if electron backstreaming is taking place.

In Table 6.6 are data from an example of electron backstreaming. As the accelerator voltage is decreased from 400 to 200V, the discharge current erroneously increases at 250V. Note the beam current also increases. Similar to these data, testing for backstreaming should be conducted with a fixed RFS forward power. The power supply is running in manual mode.

Table 6.6. Electron back-streaming example.

Source	Gas	Pressure	Beam		Accelerator		Source RF		Neutralizer	
		x 10^{-4}	I	V	I	V	FWD	REF	RF	Emission
		(Torr)	(mA)	(V)	(mA)	(V)	(W)	(W)	(W)	(mA)
12 cm	10sccm Ar	5.8	339	500	9	400	230	2	40	500
	10sccm Ar	5.8	333	500	8	350	230	2	40	500
	10sccm Ar	5.8	328	500	8	300	230	2	40	500
	10sccm Ar	5.8	323	500	9	250	230	2	40	500
	10sccm Ar	5.8	317	500	11	200	230	2	40	500

Chapter 7

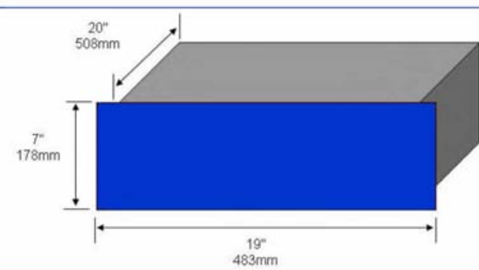
Specifications

Below are specifications for the IBEAM RF/RFN power supply.

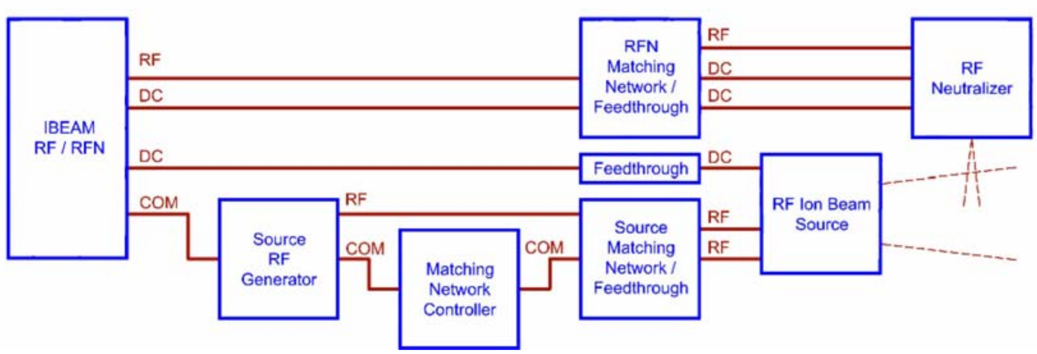
Specifications

Power Outputs	Five individual supplies to drive a RF discharge and RF neutralizer source
Beam supply	1500 VDC, 600 mA
Accelerator supply	1000 VDC, 50 mA
RF power monitoring	RF discharge generator sold separately.
RF generator for RFN	100 W
Keeper for RFN	60 V, 300 mA
RFN Emission	120 V, 1000 mA
Output Connections	
Source	4 pin industry standard: 97-3102A-18-4S Mil Spec
Neutralizer	5 pin industry standard: 97-3102A-14S-5S Mil Spec
Interface	
Communications	RS-232, DB 9 female
Interlock	DB 9 female
Remote switching	DB 9 female
Power Input	208 VAC, 50/60 Hz, 16 A, 1 phase

Housing	
Mounting	19" rack mount, 4U height
Size	19" x 7" x 20"
(Width x Height x Depth)	483 mm x 178 mm x 508 mm
Weight	27 lbs (12 Kg)



RF Ion Beam System Block Diagram



Appendix

A

Interfacing to a system

The IBEAM RF utilizes industry standard electrical connections and software control commands. As a result, it can replace existing power supplies. More specifically, the IBEAM RF is a direct replacement for the RF2001, RF2051 and RF2070 built by Veeco Instruments, Inc. In order to install an IBEAM RF into an existing system, 2 interface boxes are required (Figure A.1). The interface boxes are installed on a system as depicted in Figure A.2. Figure A.3 is an electrical connection diagram. These boxes will utilize existing electrical cables on a system.

One interface box is installed behind the RF2001 controller where its electrical connections are accessed. The IBEAM RF power supply should be installed in either of the existing locations of the RF2051 and RF2070 (see Figure A.2). The other interface box is installed directly behind the IBEAM RF power supply. Neither interface box requires power. The boxes are designed to pass all RS232 communication, remote switches, and interlock status between the system and the IBEAM RF.

Figure A.1 Interface boxes required for direct replacement of RF2001 / RF2070 / RF2051.

Figure A.2 Interface box installation locations.

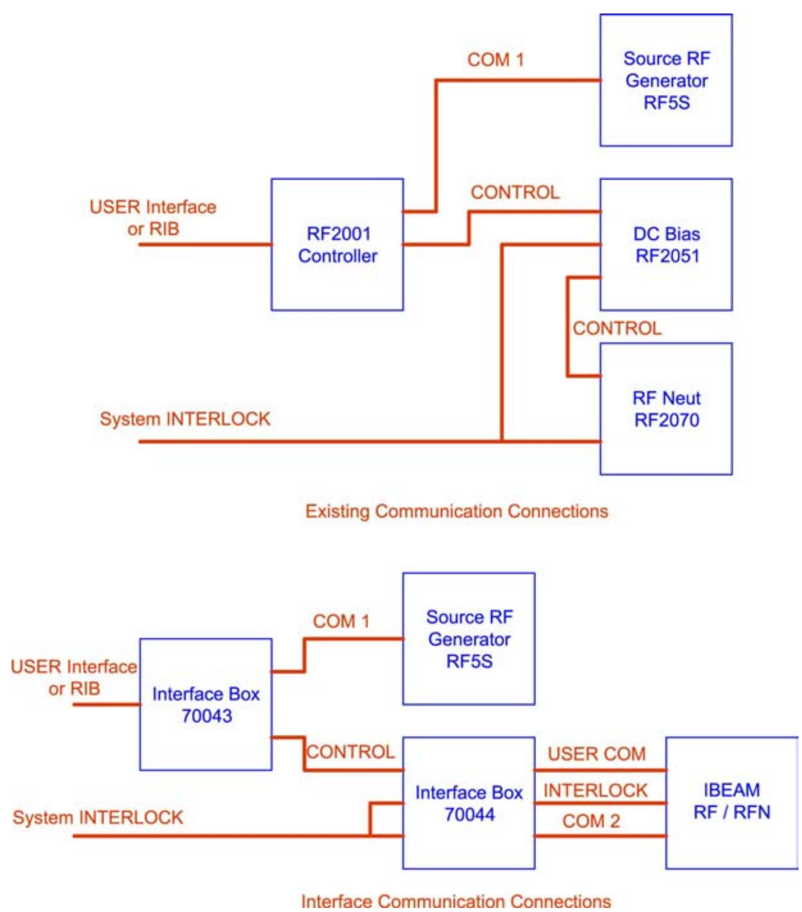


Figure A.3 Electrical schematic for the interface box installation.

The first interface box (part number 70043) is installed behind the RF2001 controller. It will accept the USER INTERFACE connection from a system and a COM 1 line from the RF5S generator. The existing RF2001 CONTROL cable can then be used. Below are its electrical connection schematics.

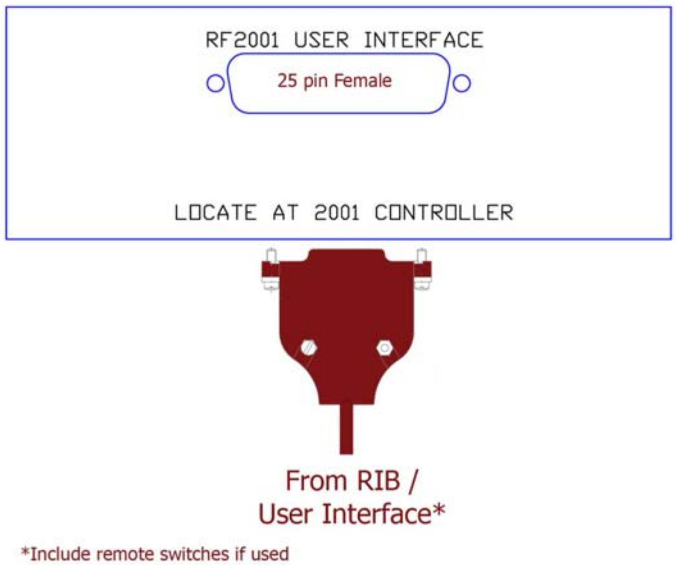


Figure A.4 Front side of the interface box located at RF2001 (part number 70043).

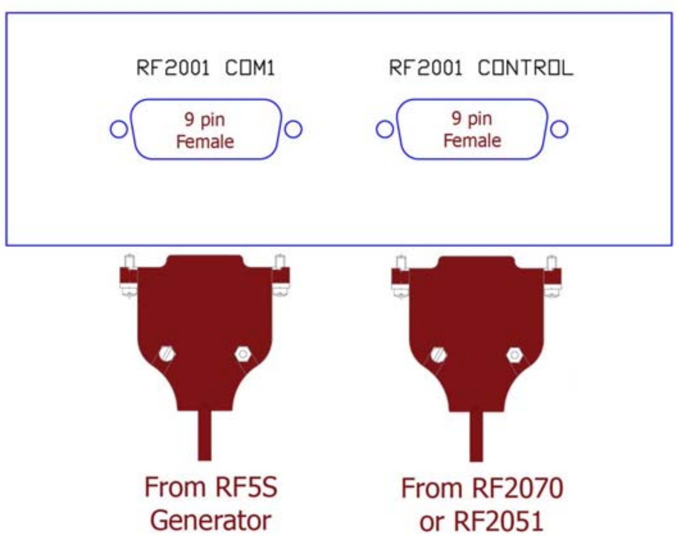


Figure A.5 Backside of the interface box located at RF2001 (part number 70043).

The second interface box (part number 70044) is installed behind the IBEAM RF power supply. It will accept the RF2001 CONTROL, RF2051 INTERLOCK and RF2070 INTERLOCK cables. The 3 cables attached to the interface box are to be connected to the IBEAM RF. Below are its electrical connection schematics. Note: if the interlock string is not satisfied, try switching the interlock cables at the interface box.

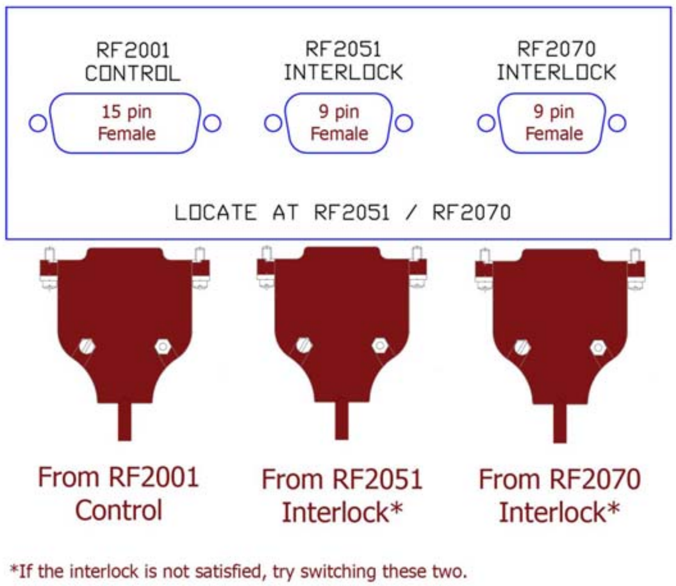


Figure A.6 Front side of the interface box located at IBEAM RF (part number 70044).

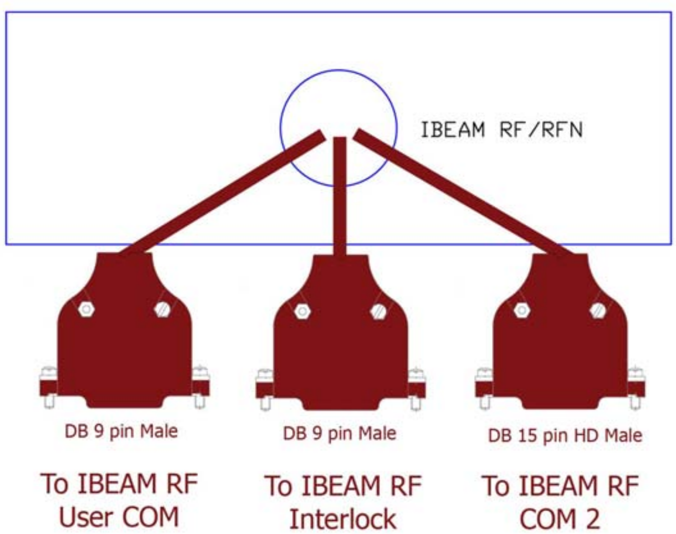


Figure A.7 Backside of the interface box located at IBEAM RF (part number 70044).

Appendix B

Software Upgrade

To upgrade the software on the IBEAM RF, follow the steps below:

1. Turn the power to the IBEAM OFF.
2. Locate the communication port on the rear of the IBEAM.

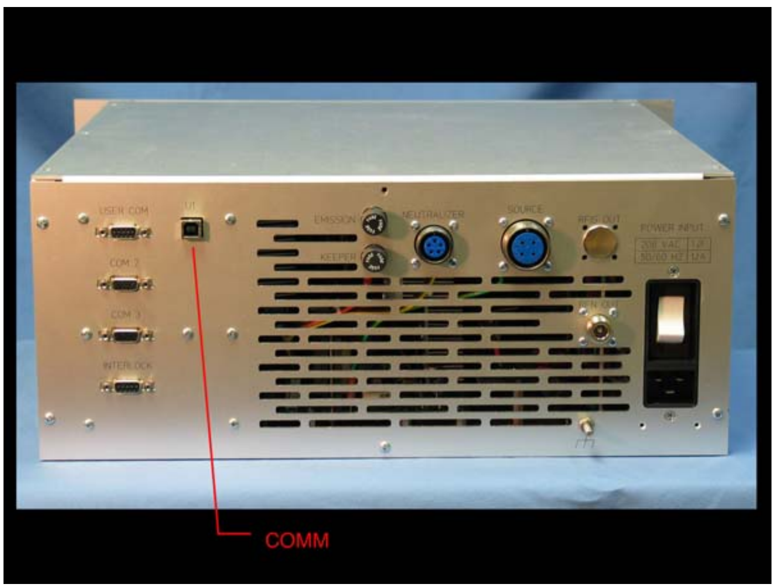


Figure B.1 Communication port for software upgrade.

3. Turn the computer ON.
4. Connect the USB-to-USB cable to the IBEAM and computer.
5. Launch the IBEAM DOWNLOAD shortcut on the computer desktop.
6. Under the TRANSFER menu, find SEND FILE.

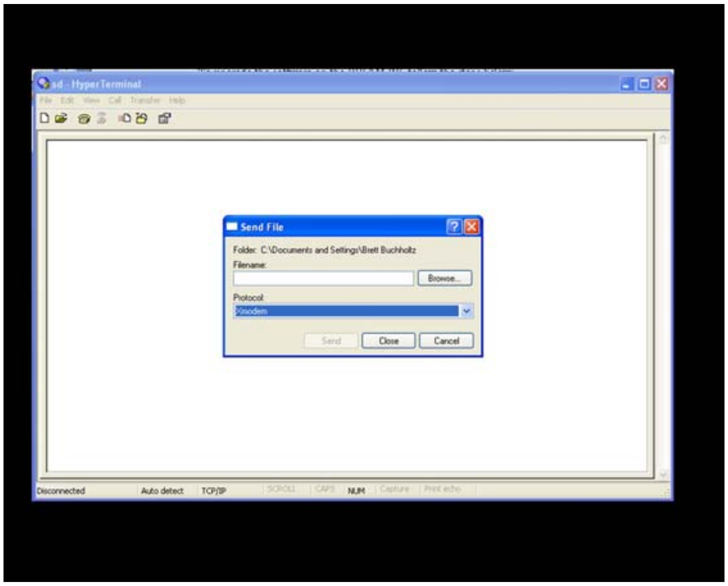


Figure B.2 IBEAM download software.

7. Use the BROWSE button to find the new software. The file is V#.## and is located on the desktop.
8. Check the protocol to ensure it is set for XMODEM.
9. Hit the SEND button, then within 15 seconds, turn the power ON to the IBEAM.
10. A status bar will indicate progress and the IBEAM will start to turn on (but it will not appear to be operational).
11. When the software upload is complete, the IBEAM will continue turning on in a normal fashion. After the IBEAM is fully up and running, disconnect the USB cable.

Appendix

C

Matching network tuning

The equipment required to tune the matching network is a voltmeter with a coaxial cable adaptor and a small, insulating screw driver. To tune the matching network, follow the steps below:

1. Start the source under normal gas conditions and let it warm up at its idle power for 15 minutes or longer. The source IDLE power should be within the range 200 to 250 W.
2. Connect the voltmeter (with coaxial adaptor) to the back of the matching network controller J4.
3. On the RF5S generator:
   a. Press the PROG button once
   b. Press the OPTIONS button until "MAX POWER" appears
   c. Press the ► button once until "L:#### mV T:#### mV" is displayed where # is a number. These are the positions (in mV) of the matching network load and tune capacitors.
4. On the matching network controller, identify the LOAD and TUNE switches that are labeled AUTO / MAN / REM. Place both of them in the MAN position. Also identify each -/+ toggle switch for the LOAD and TUNE – these will be used in Step 5 below.
5. Determine the LOAD middle position (P0). It is very easy for the source to extinguish during this step. If the source does go out, flip the toggle switches back to REM, restart the source and then place them back to MAN. To complete step 5 for do the following:
   a. Note: for all of these steps the reflected power should be 0 W
   b. Carefully tap the TUNE -/+ toggle to adjust the reflected power to 0 W.
   c. Note the position of the load cap in the RF5S window (e.g. L:2833 mV).
   d. Carefully tap the LOAD (-) toggle switch to decrease its position and note its value in the RF5S window (e.g. L:2750 mV).

e. Carefully tap the TUNE -/+ toggle to adjust the reflected power to 0 W.
    i. If the reflected power can be adjusted to 0 W repeat step 5d again.
    ii. If the reflected power cannot be adjusted to 0 W, the last LOAD position where 0 W reflected power was observed is the LOAD lower position (P1) (e.g. L:2600 mV). Move on to step 5f.
f. Carefully tap the LOAD (+) toggle switch to increase its position and note its value in the RF5S window (e.g. L:2850 mV).
g. Carefully tap the TUNE -/+ toggle to adjust the reflected power to 0 W.
    i. If the reflected power can be adjusted to 0 W repeat step 5f again.
    ii. If the reflected power cannot be adjusted to 0 W, the last LOAD position where 0 W reflected power was observed is the LOAD upper position (P2) (e.g. L:3000 mV). Move on to step 5h.
h. Determine the LOAD middle position, P0 = P1 + (P2 – P1)/2
    i. Example P0 = 2600 + (3000 – 2600)/2 = 2800 mV

6. Place the LOAD cap in the middle position (P0) by adjusting the LOAD -/+ toggle switch (e.g. L:2800 mV). Carefully tap the TUNE -/+ toggle to adjust the reflected power to 0 W.
7. Examine Figure C.1 and identify the location of the PHASE and MAG zero potentiometers.
8. With the source still running at idle power, the matching network controller switches in MAN position, and the LOAD cap in the middle position (P0) do the following:
    a. Adjust the MAG ZERO potentiometer to 0 mV as measured using the voltmeter attached to J4 on the controller.
    b. Adjust the PHASE zero potentiometer to -50 mV as measured using the voltmeter attached to J3 on the controller.
9. Set the LOAD and TUNE switches back to REM on the matching network controller. Manually increase the RF power to 400 W (with the beam off) then decrease to 200 W several times to ensure the matching network will automatically adjust for different RF powers. The maximum reflected power should be less than 6 W at higher RF powers.

10. If the source does not maintain low reflected power or the LOAD cap middle position (P0) drifts, check all antenna connections for corrosion. Repeat all tuning steps if significant changes to the antenna or matching network are performed.
11. Determine the LOAD and TUNE presets by first turning off the source. Then, press the source button and observe the RF5S window which should display “L:#### mV T:#### mV”. Just after the RFN starts and before the beam is pulsed, note the values for the LOAD and TUNE (e.g. L:3050 mV T:1650 mV).
12. Turn all power supplies off and then turn on just the RF5S generator.
    a. Press the PROG button once, press the OPTIONS until “MAX POWER” appears
    b. Press ► until “LOAD PRESET A: #### mV” is displayed.
    c. Use the ▼or ▲ to adjust the LOAD to 200 mV higher than that observed in step 11 (e.g. LOAD PRESET A: 3250 mV).
    d. Press ► again “TUNE PRESET A: #### mV” is displayed.
    e. Use the ▼or ▲ to adjust the TUNE to 200 mV higher than that observed in step 11 (e.g. TUNE PRESET A: 1850 mV).
13. Restart all power supplies, disconnect the voltage meter.

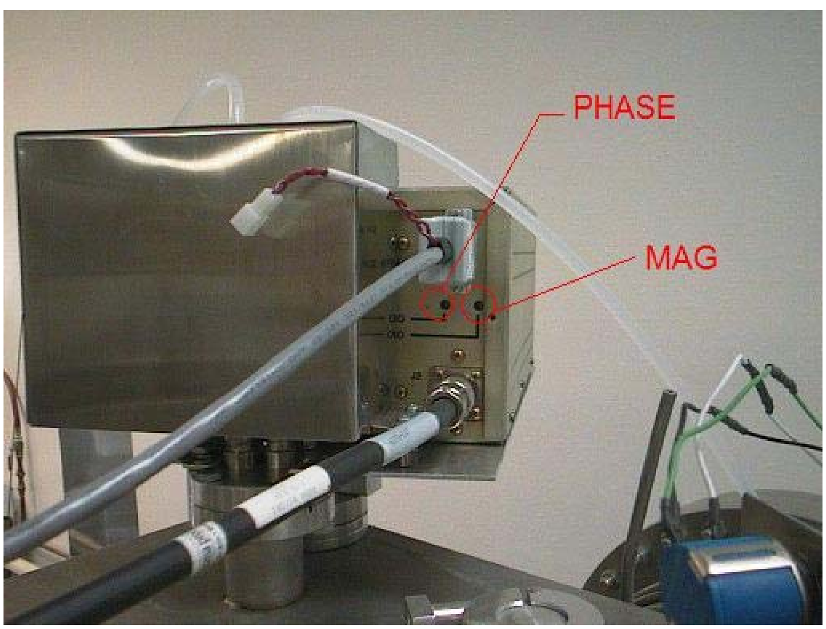


Figure C.1 PHASE and MAG zero potentiometers.

Appendix

D

Source RF generator setup

In certain applications, the source RF generator will be a RF5S type of generator. The generator is programmed from its front panel. For optimized performance, the RF generator should be programmed with the following values. To program the RF5S generator, follow the steps below:

1. On the RF5S generator:
   a. Press the PROG button once
   b. Press the OPTIONS button until the desired column appears.
   c. To scroll thru the column values press the ► button.
   d. To edit any of the values press ▼or ▲ buttons.
   e. To finish programming, press the PROG button again, turn the power supply OFF and then back ON.
2. The programming columns, item descriptions and factory default values are listed on the following page.

RF5S generator setup - Software v. 6.2I

Analog Column	Presets Column	Source Column	Operate Column	System Column
Analog Disabled	Presets Disabled	Start Power 0W	Power 500 W	Compliance 50%
Control RF Power	Pres. Clock Disabled	Idle Power 0W	L:#### T:####	REF Power Alarm 37W
Fwd Power Leveling	Program Preset #	PBN Start Crnt 0mA	Load Preset A: ----*	Communications 232
Polarity Negative	P1 thru P6	Pwr/Beam Factor 0	Tune Preset A: ----*	Baud rate 9600 bps
Voltage Range 5V	Control RF Power	Strt Sense Vlt 0 V	Load Preset B-D 0mV	Serial Mode Computer
Exciter Master	Ramping Disabled	Strt Dtect Crnt 0mA	Tune Preset B-D 0mV	Service code 0
Panel RF ON Disabled	P1-P6 Setpoint 0W	Strt Pulse Vlt 0V	Using Preset Pair A	
Panel Setpt Disabled	P1-P6 Pwr Leveling		Load&Tune Enabled	
RF ON&OK Disabled	P1-P6 Interval 0:00:00		Ramp Time 0:00:001	
	P1-P6 Auto Seq Disabled		Setpt Ramp Disabled	
			Probe Constant 200	
			VIC 5	
			PIC 5	
			Voltage Scale 3	
			RF ON Clock Disabled	
			Watts Default 0W	
			Volts Default -0V	

*Load and Tune presets should be set to source starting conditions for faster start. Safe values are 5000 mV, however, the source may not start rapidly. If the RF5S generator is swapped, record these from the old generator and program them into the new generator.

Appendix

E

Software upgrade setup

In order to upgrade the software on the IBEAM RF power supply, Plasma Process Group, Inc. will provide a portable computer and the steps listed in Appendix B can be followed. If a new software version is provided without a computer, this section describes how to set up a computer to download the new version of software. This is a one-time setup required for a selected computer.

The IBEAM RF power supply uses a special USB connector that operates as a serial port. The integrated circuit (IC) chip for this is a CP2102. In order to use the USB cable as a serial cable, the target computer must have the appropriate software drivers installed. To install the drivers on the target computer, follow these steps:

1. Follow this link to get the software drivers for the CP2102 device. https://www.silabs.com/products/mcu/Pages/USBtoUARTBridgeVCPDrivers.aspx
2. Download the VCP DRIVER KIT for 2000/XP/Server 2003/Vista (v5.40)
3. Run the CP210x_VCP_Win2K_XP_S2K3.
4. Follow the steps to copy the driver files to the desired location. The default directory is C:\SiLabs\MCU\CP210x.
5. The final window will give an option to install the driver on the target system. Select the "Launch the CP210x VCP Driver Installer" option if you are ready to install the driver.
6. If selected, the driver installer will now launch providing an option to specify the driver installation location. After pressing the "Install" button, the installer will search your system for copies of previously installed CP210x Virtual COM Port drivers. It will let you know when your system is up to date. The driver files included in this installation have been certified by Microsoft.

7. If the “Launch the CP210x VCP Driver Installer” option was not selected in step 5, the installer can be found in the location specified in step 4, by default C:\SiLabs\MCU\CP210x\Windows_2K_XP_S2K3_Vista. At this location run CP210xVCPInstaller.exe.
8. To complete the installation process, connect a USB cable between the host computer and the IBEAM power supply (the IBEAM power supply should be powered OFF). Windows will automatically finish the driver installation. Information windows will pop up from the taskbar to show the installation progress.
9. If needed, the driver files can be uninstalled by selecting “Silicon Laboratories CP210x USB to UART Bridge “Driver Removal” option in the “Add or Remove Programs” window.

If there are issues with the above procedure, make sure the USB cable is utilizing COM4 :

1. Open up the Device Manager on the computer.
2. Scroll down to “Ports” and open the branch. Find the CP210x Usb to Uart Bridge (the actual line might say something different on your system depending on the driver that was used but should contain ‘CP210x’). In this example, the CP2102 is located on Com Port 4. This port number is what Windows HyperTerminal must be set for to in order to communicate with the IBEAM power supply.
3. To change/verify the HyperTerminal com port setting for IBEAM DOWNLOAD link on the desktop:
4. With the power supply connected but power switch is off, right click on the ‘IBEAM DOWNLOAD’ icon on you computer desktop, click on the ‘Connect To’ tab. Go down to the ‘Connect using’ window and set this to the same com port that you found the CP210x is using in your Device manager/Ports window. Press ‘Apply’ and close the IBEAM DOWNLOAD Properties window. Now with the IBEAM still connected and power switch still off. Double click on the IBEAM DOWNLOAD icon to run HyperTerminal. Turn on the IBEAM and you should see the letter ‘C’ showing up in the HyperTerminal screen – with no download taking place you will see ‘CCCCCCCCCC1’ on the HyperTerminal screen. If you have received this string successfully then you have the proper communications setup needed to download new software into the IBEAM power supply. To download the new IBEAM software, follow the instructions in Appendix B.