

KRI GRIDDED RF SERIES ION SOURCE LFN VERSION AUTO CONTROLLER MANUAL



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September 2009
VERSION 1.0

KRI Job # _____

CONTENTS

1. SAFETY ----- 1-1

2. GENERAL DESCRIPTION AND SPECIFICATIONS ----- 2-1

 2.1. Auto Controller ----- 2-2

 2.2. AC Discharge Power Supply----- 2-2

 2.3. Emission Power Supply ----- 2-2

 2.4. Ion Optics Power Supply ----- 2-3

 2.5. RF Power Supply ----- 2-3

 2.6. Mass Flow Controllers ----- 2-3

3. INSTALLATION ----- 3-1

 3.1 Unpack----- 3-1

 3.2 Install in Rack Mount Cabinet ----- 3-2

 3.3 Ground Connections----- 3-2

 3.4 Connections Between Components----- 3-3

 3.5 Connect Controller to Ion Source ----- 3-5

4. OPERATION ----- 4-1

 4.1 General Overview ----- 4-1

 4.2 Gas ----- 4-1

 4.3 Power On ----- 4-1

 4.4 Operating Mode ----- 4-2

 4.4.1 Gas Only Mode ----- 4-2

 4.4.1.1 Start Up ----- 4-3

 4.4.1.2 Shut Down ----- 4-4

 4.4.2 Auto Beam Mode ----- 4-5

 4.4.2.1 Program Select ----- 4-5

 4.4.2.2 Gas Setpoints ----- 4-5

 4.4.2.3 AC Discharge Setpoint ----- 4-6

 4.4.2.4 Emission Setpoint ----- 4-6

 4.4.2.5 Ion Optics Controller Setpoints ----- 4-6

 4.4.2.6 RF Power Setpoint ----- 4-7

 4.4.2.7 Discharge/Beam Enables ----- 4-7

 4.4.2.8 Standby ----- 4-7

 4.4.2.9 Setpoint Adjustment ----- 4-8

 4.4.2.10 Scratchpad ----- 4-8

 4.4.2.11 Saving a Program ----- 4-8

 4.4.3 Manual Beam Mode ----- 4-9

5. REMOTE CONTROL ----- 5-1

 5.1 Remote Control using the DB-37 Connector----- 5-1

5.1.1 Remote enable while using one of the four stored programs -----	5-4
5.1.1.1 Auto Beam -----	5-4
5.1.1.2 Gas Only-----	5-5
5.1.2 Remote control using analog setpoints-----	5-5
5.1.2.1 Auto Beam -----	5-5
5.1.2.2 Manual Beam -----	5-5
5.2 Remote Control using the RS-232 serial interface -----	5-5
5.2.1 Interface Cable -----	5-6
5.2.2 Communication Settings -----	5-6
5.2.3 Communication Overview-----	5-6
5.2.4 Command Queries and Responses-----	5-6
5.2.4.1 VRB – Verbose Command -----	5-7
5.2.4.2 COM – Enable RS-232 Command or Status Query-----	5-8
5.2.4.3 *IDN? – Unit Identification Query -----	5-9
5.2.4.4 *RST Reset Command -----	5-10
5.2.4.5 *TST? Self Test Query -----	5-10
5.2.4.6 OUT – System Level Output Command or Status Query-----	5-11
5.2.4.7 MDE – Mode set Command or Mode Query -----	5-11
5.2.4.8 BEAM? – Beam Good Query-----	5-12
5.2.4.9 Program Value Read/Write Command -----	5-13
5.2.4.10 R – Monitor Command for Reading the Actual Feedback Values ---	5-17
5.2.4.11 CFG? – Query Current System Configuration-----	5-18
5.2.4.12 LRN – Learn Command or Learn Query-----	5-19
6. DIAGNOSTICS -----	6-1
6.1 RF Auto Controller-----	6-1
6.2 AC Discharge Power Supply -----	6-4
6.3 Emission Power supply -----	6-6
7. LIMITED WARRANTY-----	7-1
8. SERVICE AND TECHNICAL INFORMATION-----	8-1

Figures

2-1 Front view of the RF Gridded ion source controller. -----	2-4
2-2 Rear view of the RF Auto Controller and power supplies. -----	2-5
3-1 Front view of controllers for Gridded RF Ion Source. -----	3-7
3-2 Rear view of controllers for Gridded RF Ion Source. -----	3-8
4-1 Simplified block diagram of the ion source, power supplies and auto controller. ----	4-10
5-1 Typical connection scheme using the remote setpoints option (Remote-Remote) on the DB-37 analog/digital remote interface. -----	5-18

Tables

2-1 Controller Specifications..... 2-1
3-1 Inventory List. 3-1
3-2 Pin descriptions for the female DB-15 MFC connectors. 3-5
5-1 Pin descriptions for the female DB-37 connector on the RF Auto Controller..... 5-1
5-2 Connection for remote program selection using pins 16 and 34..... 5-4
6-1 Help codes and error messages for the auto controller 6-1
6-2 Help codes and error messages for the AC Discharge power supply..... 6-4

1. SAFETY

Caution: High Voltage and RF. Only technically qualified personnel should install, maintain, and troubleshoot the equipment described herein.

The controllers for the ion source and neutralizer must be installed in a grounded 19-inch (483 mm) rack mount cabinet before operation.

2. GENERAL DESCRIPTION AND SPECIFICATIONS

The auto controller package combines modular power and automatic control for an RF-Gridded Ion Source. The auto controller is designed to be used in a standard 19-inch (48 cm) rack mount cabinet. The RF Auto Controller, along with the AC Discharge, Emission, Ion Optics and RF power supplies are included in the standard package. Mass Flow Controllers are also included as well as the interconnection and power cables.

The operating specifications, weight and dimensions of each controller are outlined in the following table.

This section gives a general overview of the RF Auto Controller package with more detailed information in the later sections of this manual. Additional information on each controller is given in the Manual for each.

Table 2-1 Controller Specifications.

	Nominal Input voltage	Maximum Input Current	Maximum Output	Weight	Height x Depth
RF Auto Controller	85-275 V, 1Φ, 50-60 Hz	0.75 A	+/- 15 V, 500 mA dc, 0-5 V,	3.0 kg (8 lbs)	4.4 x 53 cm (1.75 x 21 in.)
AC Discharge Power Supply	85-275 V, 1Φ, 50-60 Hz	12.5 A *	40 V, 25 A, AC	7.27 kg (16 lbs)	4.4 x 53 cm (1.75x 21in.)
Emission Power Supply	85-275 V, 1Φ, 50-60 Hz	3.5 A	120 V, 2 A,	7.27 kg (16 lbs)	4.4 x 53 cm (1.75x 21in.)
Ion Optics Controller	85-275 V, 1Φ, 50-60 Hz	12.5 A *	+/-1200 V, 1 A	12.5 kg (27.5 lbs)	8.8 x 53 cm (3.5 x 21 in.)
RF Power Supply	90-264V , 1Φ, 50-60 Hz	15.0 A	600 W	16.82 kg (37 lbs)	13.3 x 46.6 cm** (7.0 x 18.4 in)**
	190-264 V, 1Φ, 50-60 Hz	15.0 A	1 KW	16.82 kg (37 lbs)	13.3 x 46.6 cm** (7.0 x 18.4 in)**
	190-264 V, 1Φ, 50-60 Hz	20.0 A	2 KW	24.9 kg (55 lbs)	13.3 x 57.8 cm (7.0 x 22.8 in)

* The maximum output may be limited by line current draw at low line voltages.

** Half rack power supplies, 24.13 cm (9.50 in) wide.

2.1 RF Auto Controller

The RF Auto Controller is designed to be installed in a standard 19 inch rack mount cabinet and is shown in figures 2-1 and 2-2 along with the AC Discharge, Emission, Ion Optics and RF power supplies. The controller communicates with the power supplies through an RS-485 interface. The RF Gridded ion source can be controlled from the front panels of the power supplies when local mode is selected. Sockets are installed on the rear panel for remote operation using either RS-232 or an Analog interface. When remote mode is selected, the RF Gridded ion source can be completely controlled via connections to the rear panel of the RF Auto Controller. Alternately, programs selected from the front panel can be enabled or disabled from the rear panel when remote mode is selected.

The RF Auto Controller also interfaces with up to four mass flow controllers using cables that connect to the rear panel. Four relay contacts are also available on the rear panel if additional positive shut off valves are desired for the gas feed system.

2.2 AC Discharge Power Supply

The AC Discharge Power Supply is designed to be installed in a standard 19 inch rack mount cabinet and is shown in figures 2-1 and 2-2 along with the RF Auto Controller and Power Supplies. The AC Discharge Power Supply provides current to the discharge filament of the LFN neutralizer. This power supply communicates to the Auto Controller through a RS-485 interface.

Additional information can be found in the individual manual for the AC Discharge Power Supply.

2.3 Emission Power Supply

The Emission power supply is designed to be installed in a standard 19 inch rack mount cabinet and is shown in figures 2-1 and 2-2 along with the RF Auto Controller and Power Supplies. The Emission power supply provides voltage to bias the LFN neutralizer and current to neutralize the ion beam. This power supply communicates to the Auto Controller through a RS-485 interface.

Additional information can be found in the individual manual for the Emission power supply.

2.4 Ion Optics Power Supply

The Ion Optics Power Supply is designed to be installed in a standard 19 inch rack mount cabinet and is shown in figures 2-1 and 2-2 along with the RF Auto Controller and Power Supplies. The Ion Optics Power Supply provides voltage and current to the Grids of the RF Gridded ion source. This power supply communicates to the Auto Controller through a RS-485 interface.

Additional information can be found in the individual manual for the Ion Optics Power Supply.

2.5 RF Power Supply

The RF Power Supply is designed to be installed in a standard 19 inch rack mount cabinet and is shown in figures 2-1 and 2-2 along with the RF Auto Controller and power supplies. The RF Power Supply may be a half rack as shown in the figure, or it may be a full rack depending on the package that was purchased. The RF Power Supply provides RF Power to the Discharge Chamber of the RF Gridded ion source. This power supply communicates to the Auto Controller through a RS-485 interface. The lower right RS-485 socket is dedicated for communication with the RF generator. A special RJ11 to DB9 cable adapter (included) is required for this interface.

Additional information can be found in the individual manual for the RF Generator.

2.6 Mass Flow Controllers

The mass flow controllers are supplied when ordered as a complete system. The controllers are connected to the gas feed for the ion source and LFN as close as possible to the gas feedthrough on the vacuum system. Up to four mass flow controllers can be attached to the RF Auto Controller. The gas flows can be set as a constant ratio or they can be set independently. Gas channel 4/e- is dedicated to supplying the LFN and is specifically controlled to maximize LFN filament life.



Fig. 2-1. Front view of the RF Gridded ion source controller.

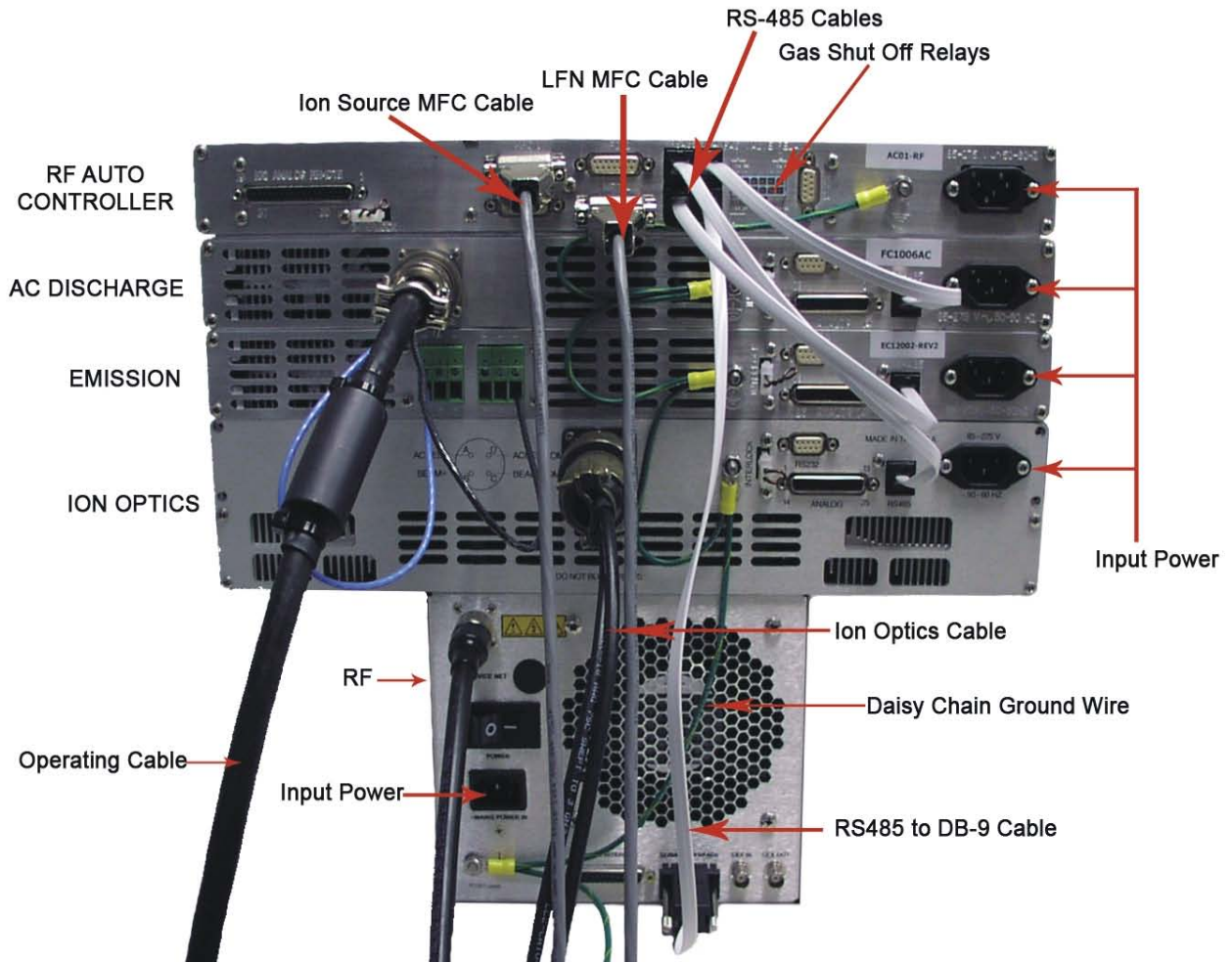


Fig. 2-2. Rear view of the RF Auto Controller and power supplies.

3. INSTALLATION

This section describes how to install the KRI® RF Auto Controller package for the LFN version of the RF Gridded Ion Source.

3.1 Unpack

Unpack the Controller package for the RF Gridded Ion Source. Prior to shipment, the Controller was tested with the ion source to insure quality and verify the standard range of operation. As soon as the Controller has been completely removed from all packing materials, a visual inspection should be made to determine if there has been any damage to the components during shipment. Use the packing lists provided to confirm the completeness of order. If any damage has occurred, contact Kaufman & Robinson, Inc., in addition to the shipping company, to report the damage - see Section 8. Retain packaging materials for any future shipments.

Table 3-1 is an inventory list for the controller package. The inventory list is for the standard package so some items may or may not be included depending on the particular order. For any questions or discrepancies concerning either the inventory list or the shipping list, please find the part name of interest and see Section 8 to contact Kaufman and Robinson, Inc. Refer to Section 2 – General Description and Specifications for additional information about the controller.

Table 3-1. Inventory List.

Quantity	Description	Part Number
1	RF Auto controller	RFAC-01
1	RF Power Supply	RF-601, RF-1001, RF-2001
1	Ion Optics Controller	IOC-1201
1	AC Discharge Power Supply	AC-1006Z
1	Emission Power Supply	EC-1202
1	Power cable, RF	(May vary)
4	Power cable	CBL-A01-PWR
2	Mass flow controller	MF-BKS-XXXX (May vary)
2	Mass flow controller cable 6 m (20 ft) cable	CBL-BKS-GC (May vary)
1	Operating cable,6 m (20 ft) cable	CBL-A04-ATM-HF-EH (May vary)

Quantity	Description	Part Number
1	Ion optics cable,6 m (20 ft) cable	CBL- (May vary)
3	Interface cable, RS-485 (2 feet)	CBL-IFC-485
1	RJ11 to DB9 Adapter Cable	

3.2 Install in Rack Mount Cabinet

The Controller is designed to be mounted in a standard 19-inch (48 cm) rack mount cabinet. To assure that the power cable that came with each controller is connected to that controller, the power cables can be connected as each controller is installed in the cabinet. **Do not connect to input power before the installation is complete.** Refer to table 2-1 for the input power requirements. With the exception of the RF Power Supply, universal single phase 50-60 Hz input power of 85 to 275 volts can be used, so no modification is required to use either a nominal 115 or 208-230 volt input.

The RF Auto Controller and Power Supplies should be mounted one above the other in the cabinet. See Fig. 3-1 for the relative locations of the individual rack mounted units. The wiring and cables may not reach all the controller connections if installed in a different order.

3.3 Ground Connections

An earth ground connection is required for both safety and correct operation. Earth ground should be connected to the vacuum chamber in which the ion source is to be operated as well as the cabinet in which the Controller is installed. Make sure that the ground connections are made by qualified technical personnel. These ground connections are independent of the ground connections described below in section 3.4.

3.4 Connections between Components

The connections between components are shown in Fig. 3-2, which shows the rear panels of the RF Auto Controller and Power Supplies. The individual connections required are given below:

- Attach the green and yellow daisy chain ground wire to the 10-32 ground studs on each of the units as shown in Fig. 3-2. Fasten the other end of this ground wire to rack mount cabinet ground that the controllers are mounted in.

-
- Attach the 8 pin (male) plug connector of the 6 meter (20 feet) operating cable to the socket connection labeled Ion Source on the rear panel of the AC Discharge power supply, refer to Fig. 3-2. Connect the opposite end to the exposed connector on the LFN electrical feedthrough.
 - Attach the 4 pin (male) plug connector of the 6 meter (20 feet) ion optics cable to the socket connection located on the back panel of the Ion Optics power supply. Connect the two opposite ends of the cable to the beam and accel connectors on the ion source. The ion source ends of the cable are labeled, as are mating connectors on the ion source.
 - Insert the opposite end of the operating cable **BLUE** wire into one of the (+) positive connectors located on the rear panel of the Emission power supply and tighten the screw above the appropriate connector.
 - Insert the opposite end of the operating cable **BLACK** wire into one of the (-) negative connectors located on the rear panel of the Emission power supply and tighten the screw above the appropriate connector.
 - Attach the coaxial RF cable to the connector on the back of the RF power supply
 - The RF Power supply may be air cooled or water cooled. If the power supply is water cooled, connect the supplied valve and water cooling lines as described in the manual for the RF power supply.
 - Attach the four RS-485 cables to the sockets labeled RS-485 located on the back panel of the RF Auto Controller as shown in figure 3-2. The bottom right RS-485 socket is dedicated to the RF Power Supply. The remaining three RS-485 sockets are not device specific and may be used in any order.
 - Attach the other ends of the three RS-485 cables to the sockets labeled RS-485 located on the back panels of each power supply. Connect the RS-485 to DB-9 adapter to the RF Generator rear DB-9 socket.
 - Attach the ion source MFC cable to the connector labeled MFC 1 located on the back panel of the RF Auto Controller. Attach the other end to the MFC for the ion source. The pin descriptions for the DB-15 Female connectors are shown below in table 3-2 in case an MFC other than those supplied by KRI are used. **If an**

MFC other than those supplied by KRI is used, make sure the cable is compatible with the pins shown in the table to prevent damage to the MFC.

- Attach the Low Frequency Neutralizer MFC cable to the connector labeled MFC 4 located on the back panel of the RF Auto Controller. Attach the other end to the MFC for the LFN.
- Attach any additional ion source MFC cables to the connectors labeled MFC 2 and MFC 3 located on the back panel of the RF Auto Controller. Attach the other ends of these cables to the corresponding MFC's.
- There is a 12 pin Molex® connector on the back of the auto controller for operating user supplied positive shut off valves. Normally open and normally closed contacts are provided for each MFC as indicated schematically on the rear panel. The contacts are rated for ½ amp at 24 VAC or 35 VDC. The power to operate these valves is user supplied. If positive shut off valves are used, they should be installed on the vacuum side of the MFC as close as possible to the MFC to prevent a gas burst into the vacuum chamber when the valves are opened. The mating connector and pins are supplied with the auto controller.
- The mass flow controller is defined by the ion-source application. The gas flow controller should be mounted as close as possible to the vacuum chamber. See the MFC manual.
- There is a two pin interlock connector located on the back of the RF Auto Controller. The unit comes supplied with a jumper installed in the interlock connector. An additional interlock connector and pins are also supplied. The RF Auto Controller disables the output of the power supplies if this contact is open. If a system interlock is used, a separate isolated contact should be connected to each interlock connector for each power supply. The interlock pins for the RF power supply are located on the 25 pin analog interface for that supply. The unit comes supplied with a plug with a jumper across these two pins. A separate system interlock with its own dedicated contact should be connected to the RF power supply as well.
- If remote control of the RF Auto Controller is used, that cable can be attached at this time to either the female DB-37 connector or the female DB-9 connector. The descriptions for remote control are given in the Remote Control of this manual.

- The connections between the pressure regulators and the flow controller valves should be made with *clean (passivated or hydrocarbon free)* stainless-steel tubing, with all fittings properly installed. **Plastic tubing should not be used to avoid contamination of the gas.**
- If the 6 meter (20 ft.) input power supply cables were not connected to the individual power supplies when they were installed in the cabinet, connect them now. Use plugs that will match the input power sources. **Do not connect to Input Power before the installation is complete.**

Table 3-2. Pin descriptions for the female DB-15 MFC connectors

Pin Number	Description
1	Gas Setpoint Common.
2	Gas Readback In, 0-5 volts.
3	No Contact.
4	Valve Off – Sends a 0 volt signal when the MFC is set to 0 flow or disabled.
5	+15 Volts.
6	-15 Volts.
7	No Contact.
8	Gas Setpoint Out, 0-5 volts.
9	Common
10	Common.
11	No Contact.
12	No Contact.
13	No Contact.
14	Common.
15	No Contact.

3.5 Connect Controller to Ion Source

If the Ion Source has not been installed in the vacuum chamber, do so now, using the Installation/Inspection description in the ion source manual. The ion source installation procedures cover installation of the ion source, vacuum cables, gas tubing inside the vacuum chamber, as well as electrical and gas feedthroughs in the wall of the vacuum chamber. Once installed, connect the operating cable to the electrical feedthrough.

- As the final installation step, turn off the front panel power switches on the Auto Controller, AC Discharge, Emission and RF power supplies and then plug the power cables of the individual controllers into appropriate input power sources. Note that the RF Power Supply has an additional power switch on the back panel. See Table 2-1 in section of this manual for input power requirements.



Fig. 3-1. Front view of controllers for Gridded RF Ion Source.

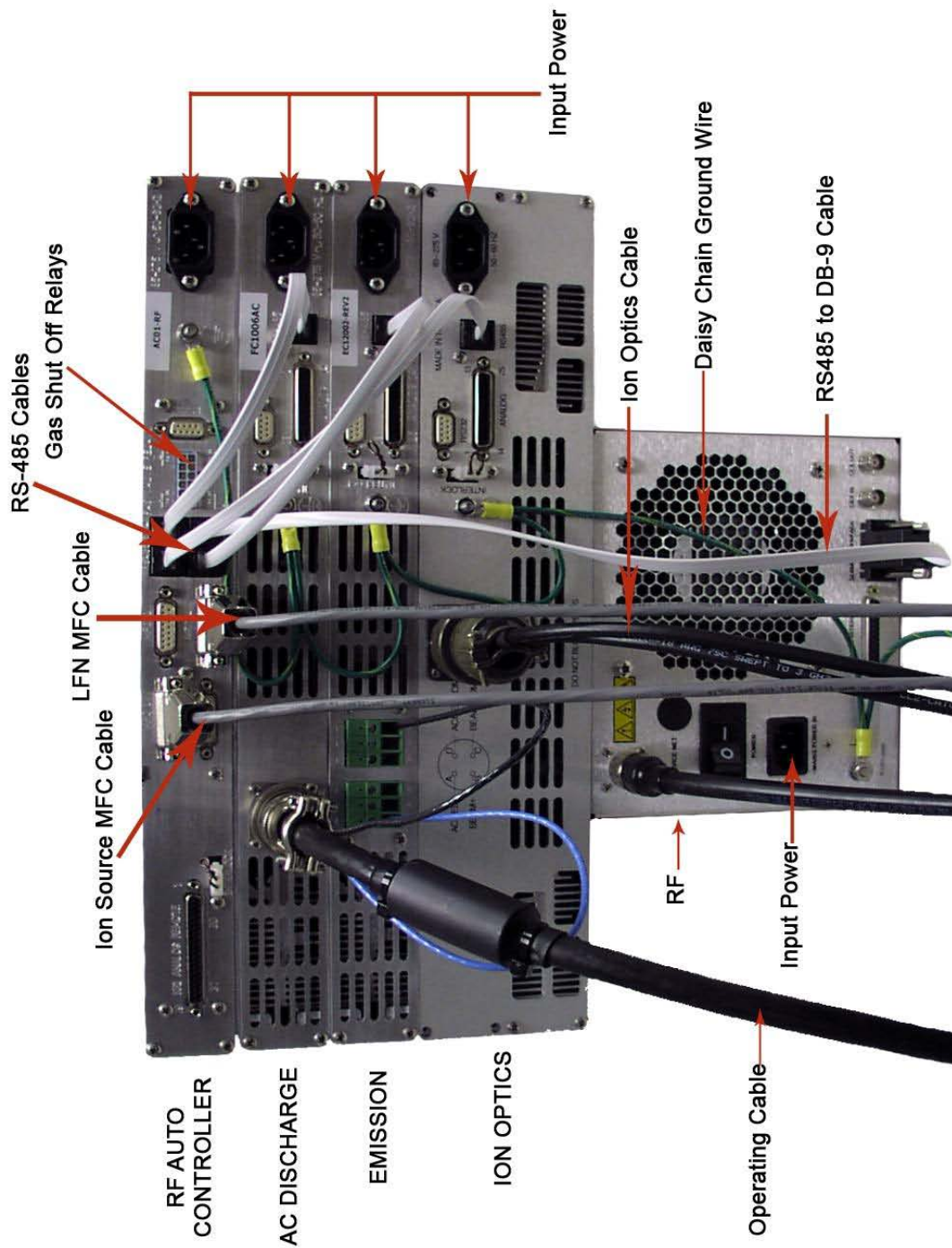


Fig. 3-2. Rear view of controllers for Gridded RF Ion Source.

4. OPERATION

The operation described in this section is done locally from the front panel and serves to both demonstrate and provide familiarization with operation. The description in this section assumes that the installation sequence described in Section 3 of this manual and the installation section in the ion source manual has been carried out.

4.1 General Overview

A simplified block diagram of the ion, power supplies and auto controller is shown in Figure 4-1. The power supplies communicate with the RF Auto Controller VIA the RS-485 cables. The RF Auto Controller maintains gas flow to the ion source and the LFN, in addition to providing control and sequencing for all the power supplies.

During operation, gas is supplied to the ion source through an MFC to establish a pressure sufficient for the RF Power Supply to generate an inductively coupled plasma in the discharge chamber using the RF coil. The Plasma is elevated to beam potential by the screen grid, which is connected to the beam power supply. Positive ions from the plasma are attracted to negative accelerator grid, which is connected to the Accel power supply. These ions pass through the beam and accelerator grid holes and mix with electrons from the LFN to form a neutralized ion beam.

The LFN, which supplies the electrons to neutralize the ion beam, also has gas supplied through an MFC to provide sufficient pressure inside the LFN to generate a plasma using the AC Discharge power supply. The Emission power supply biases the LFN negative so that electrons are ejected from it to neutralize the ion beam.

4.2 Gas

High-purity (99.999+%) argon, oxygen or nitrogen gas can be used in the ion source. For other process gases, please contact Kaufman & Robinson, Inc. The bottle, regulator and mass flow controller(s) should be installed and gas lines evacuated as described in installation section of the Ion Source manual.

4.3 Power On

Switch on the front panel power switches to the RF Auto Controller and Power Supplies. These switches are located on the far left of each power supply front panel.

4.4 Operating Mode

There are three selectable operating modes for the RF Auto Controller. The available selections depend on the system setup. These three modes include Gas Only, Auto Beam and Manual Beam. All three modes can be selected using the white Operating Mode button on the front panel of the RF Auto Controller. All three modes are available only when the auto controller is setup for and has established communication with the defined system components needed to run an RF Gridded Ion Source (i.e. RF, Ion Optics, and neutralizer power supplies). The system configuration is pre-selected before shipment. Contact KRI for instructions on setup for alternate system configurations.

4.4.1 Gas Only Mode

When gas only mode is selected, the RF Auto Controller functions as a gas controller only. Independent control of the each of the four gas channels is possible. This mode is used primarily for purging gas lines during the initial installation or when a gas bottle is changed. It can also be useful for diagnostics and for a more in depth understanding of how a gridded RF ion source and neutralizer operate.

The description below is intended as a tutorial and manually steps through a sequence similar to the sequence that the RF Auto controller performs automatically when using the Auto Beam or Manual Beam modes. Skip down to the Auto Beam or Manual beam if you are already familiar with operation or do not have the time or desire for a more thorough understanding. The procedure below outlines the use with one gas channel for the ion source even though similar operation could be obtained using all the gas channels. Use the Operating Mode Select button on the front panel of the RF Auto Controller to select the Gas Only mode. Selecting the Gas Only mode releases control of the power supplies so that they can be operated independently. There is no feedback to maintain the beam current.

Note that if there is no communication link to any of the power supplies, the RF Auto Controller will flash HLP 9. There will be no communication link if the power is switched off to any of the power supplies or if any RS-485 cable connection on the rear panel is not connected to the RF Auto Controller or any of the power supplies.

The bulleted items in the start up and shut down sequence shown below begin with a bold title to indicate where to look up information or which power supply or controller will be adjusted that during that step in the sequence.

4.4.1.1 Start Up

- **Ion Source or Ion Optics Manual** Look in the operation section of the ion source or ion optics manual to determine the operating conditions. The required parameters are: beam voltage, beam current, accelerator (accel) voltage, approximate RF power for starting, approximate RF power for running the selected beam current, the starting gas flow and the running gas flow.
- **RF Auto Controller** Select gas channel 1 on the RF Auto Controller by pressing and releasing the Gas Channel Select button until the red LED near Gas1 is on. Set the flow to the selected starting flow by turning the Gas adjust knob. Use the same procedure to set gas channels 2 and 3 to 0 sccm. Select gas channel 4/e- and set the flow to 6 sccm. Enable the gas flow by pressing and releasing the Discharge/Standby button.
- **AC Discharge** Set the Discharge Amps on the AC Discharge power supply by turning the discharge adjust knob to 1.5 amps or 0.5 amps greater than the selected beam current, whichever is greater. Press and release the Enable/Standby button to enable the AC Discharge.
- **Ion Optics** Select the Beam Volts on the Ion Optics power supply by pressing and releasing the Select Setpoint button until the yellow LED next to Beam Volts display is on. Then turn the setpoint adjust knob until the display reads 300 volts. Select the beam mAmps in the same manner and then turn the setpoint adjust knob until the display reads 1000 mAmps. Press and release the Beam Enable/Standby button to enable the beam power supply.
- **RF Power Supply** Set the RF power to the starting power by pressing the up and down arrow buttons on the front panel of the RF power supply until the RF starting power is displayed. Press the RF ON/OFF button. The RF discharge should ignite in less than 30 seconds as indicated by the Beam mAmps display. That is, before ignition the Beam mAmps will read 0 or very close to 0. Once the discharge has ignited some level of current will be displayed on the Beam mAmps display. Proceed to the next step after ignition.

Note: If the RF discharge does not ignite it may be necessary to increase the ion source gas flow on gas channel 1 and/or increase the emission current from the Emission power supply.

- **Ion Optics** Press and release the Beam Enable/Standby button to turn off the Beam Volts.
- **RF Power Supply** Use the up and down arrow keys on the RF Power Supply to adjust the RF power to the RF power for the selected operating condition.
- **RF Auto Controller** Reduce the ion source gas flow (Gas1) to the selected operating value.
- **Ion Optics** Set the Beam Volts and the Accel Volts to the selected operating values and set the Accel mAmps to 1000. This is accomplished by pressing and releasing the Select Setpoint button until the yellow LED next to the appropriate display is illuminated and then turning the Setpoint Adjust knob until the selected value is displayed. Simultaneously press and release the Beam Enable/Standby and the Accel Enable/Standby buttons on the ion optics power supply to start the ion beam.
- **RF Power Supply** Use the up and down arrow keys on the RF Power Supply to adjust the RF power until the selected beam current is displayed on the Ion Optics power supply.

4.4.1.2 Shut Down

- **Ion Optics** Simultaneously press and release the Beam Enable/Standby and the Accel Enable/Standby buttons on the Ion Optics power supply to turn off the beam.
- **RF Power Supply** Press and release the RF ON/OFF button to turn off the RF discharge.
- **Emission** Press and release the Enable/Standby button on the emission controller to turn off the emission.
- **AC Discharge** Press and release the Enable/Standby button on the AC Discharge power supply to turn off the LFN Discharge.

4.4.2 Auto Beam Mode

When using Auto Beam mode, the RF Power is automatically adjusted to maintain constant beam current once the ion source is running. Check to see if the green Auto Beam LED indicator above the Operating Mode button is on. If it is not, then continue to press and release the Operating Mode button until the green Auto Beam LED is on.

4.4.2.1 Program Select

The RF Auto controller is shipped with four programs stored. Pressing and releasing the white Program Select button will increment to the next program as indicated by the numbered red LED's on the left side of the Program Select button. The program values will be displayed on the front panels for each program. Program 1 may already be selected when the unit is powered on, if it is not, then press and release the program select button until the red LED for program 1 is on for the initial operation.

The other programs can still be viewed after the RF Auto Controller is enabled with one of the programs running. When a program is running and "Program Select" is pressed, the setpoint values (except for the RF power) of the next program will be displayed for four seconds before switching to that program. This gives time to review the programs before deciding which one to run. Pressing again within four seconds moves to the next program, etc. Cycling around to the program that's currently running will continue operation without change. Otherwise, the parameters will be ramped to the newly selected program.

4.4.2.2 Gas Setpoints

There are four gas channels. Pressing and releasing the Gas Channel Select button will increment to viewing the gas setpoint in sccm, for the next gas channel for each program.

The gas flow may be adjusted by selecting the gas channel and turning the knob on the front panel of the RF Auto Controller before the auto controller is enabled. For the initial operation, leave the gas at the programmed setpoint(s).

4.4.2.3 AC Discharge Setpoint

The setpoint for the AC discharge current in amps is shown in the display labeled Discharge Amps on the AC discharge Power supply. Notice that the yellow setpoint LED below the display is on to indicate that the setpoint is being viewed. Once the RF Auto Controller is enabled, the run value will be displayed and the green run LED will be on.

The discharge setpoint can be adjusted by turning the Adjust knob on the front of the AC discharge Power Supply. For the initial operation, leave the discharge current at the program setpoint.

4.4.2.4 Emission Setpoint

The setpoint for the emission current in amps is shown in the display labeled Emission Amps on the Emission Power supply. Notice that the yellow setpoint LED below the display is on to indicate that the setpoint is being viewed. Once the RF Auto Controller is enabled, the run value will be displayed and the green run LED will be on.

The emission setpoint can be adjusted by turning the Emission Adjust knob on the front of the Emission Power Supply. For the initial operation, leave the emission at the program setpoint.

Note: Emission Voltage should be set to maximum for most processes.

4.4.2.5 Ion Optics Controller Setpoints

The setpoints for the beam/accelerator voltage in volts and the beam/accelerator current in milliamps are displayed on the front panel of the Ion Optics power supply. Notice that the yellow setpoint LED next the corresponding display is on to indicate that the setpoint is being viewed.

The beam/accelerator voltage and current setpoints can be adjusted using the Setpoint Adjust knob on the front of the Ion Optics controller. These adjustments can be made when the RF Auto Controller is in Standby or Enable. The setpoint being adjusted by the knob is indicated by the yellow LED's on the front panel next to the display. These LED's are around the white Setpoint Select button on the front panel of the Ion Optics controller. Pressing and releasing the Setpoint

Select button will switch the parameter being adjusted. For the initial operation leave the beam/accelerator voltage and current at the program setpoints.

4.4.2.6 RF Power Setpoint

The setpoint for the RF Power in Watts is shown in the display of the RF Power supply. The RF power setpoint can be adjusted by pressing the up/down buttons on the RF Power Supply. This can be adjusted at anytime in Manual Beam or Gas Only modes but can only be changed in standby when Auto Beam is selected. For the initial operation, leave the RF power at the program setpoint.

4.4.2.7 Discharge/Beam Enables

Press and release the white Discharge/Standby button on the front panel of the RF Auto Controller to initiate only the RF discharge. Notice that the yellow Standby LED under the button turns off and the green Discharge LED above the button turns on.

Press and release the white Beam/Standby button on the front panel of the RF Auto Controller to initiate the Beam current. Notice that the yellow Standby LED under the button turns off and the green Beam LED above the button turns on.

Notes:

The Discharge and Beam LED's will flash until the current and voltage setpoints are achieved.

The enables are interlocked so pressing the Beam/standby will automatically enable the Discharge.

4.4.2.8 Standby

Press and release the white Beam/Standby button on the front panel of the RF Auto Controller to return to running only the RF discharge. Notice that the yellow Standby LED under the button turns on and the green Enable LED above the button turns off.

Press and release the white Discharge/Standby button on the front panel of the RF Auto Controller turn off the Discharge. Notice that the yellow Standby LED under the button turns on and the green LED's above the button turns off.

After running a program, the discharge power may have been adjusted from the initial setpoint value. With the discharge and beam in standby, the new value for the discharge power will appear on the front panel of the RF Power Supply and the program number LED will be flashing. Press the Acquire Setpoints until the LED stops flashing to acquire the new discharge power setpoint, or press the Program Select button once to revert back to the original stored program.

Note: Pressing the Discharge/standby while running will force both beam and discharge to standby.

4.4.2.9 Setpoint Adjustment

When the RF Auto Controller is in the Auto Beam mode, adjustment can be made to the setpoints before or after the auto controller is enabled as described above.

Making any adjustment to the setpoints will cause the program number indicator to flash indicating that the new setpoints have not been saved. This is called the Scratchpad. The scratchpad is temporary memory storage for programs that have not yet been saved.

4.4.2.8 Scratchpad

The scratchpad becomes active whenever a setpoint is adjusted and is indicated by a flashing program number LED. It is used for setting up new programs. The scratchpad setpoints act as an additional program until the Acquire Setpoints button is pressed. If the power switch on the RF Auto Controller is switched off when the scratchpad is active and then switched back on the scratchpad setpoints will be lost. If another program is selected and allowed to run while the scratchpad is active, the scratchpad values will also be lost.

If the RF Auto Controller is put into standby while the scratchpad is active, then the controller will run the scratchpad setpoints the next time the controller is enabled unless another program is selected before the controller is enabled.

4.4.2.9 Saving a Program

The first step is to select the operating condition. Review the ion source manual to select an operating condition that is within the range of the particular ion source.

Note that the operating range of the ion source may be limited by the vacuum facility pump speed or other process that take place while the ion source is running.

A program can be saved when the RF Auto Controller is enabled or when it is in standby.

Use the program select button to select the program number that will be overwritten. Adjust the setpoints to the desired values as described above and then press and hold the white Acquire Setpoints button on the RF Auto Controller until the red program LED stops flashing. When this LED stops flashing, the program has been saved.

When the scratchpad is active, repeatedly pressing and releasing the Select Program button will cycle through the programs including the scratchpad program. For example: If the scratchpad is active and program 1 was flashing then pressing the Select Program button once will show program 1. The program 1 LED will stop flashing. Pressing the Select Program button four more times will return to the program 1. The red LED indicator will again be flashing the scratchpad values will again be shown on the front panel displays.

4.4.3 Manual Beam Mode

Manual Beam mode sequentially enables the gas, filament and discharge in the same manner that as Auto Beam mode. There is no feedback to adjust the beam current, hence there is no beam current setpoint. Instead, the user manually adjusts the RF power to maintain the beam current.

Select the Manual Beam mode using the Operating Mode button. Select the program to run using the Program Select button. Enable the program by pressing the Beam/Standby button on the Auto Controller. Press the Discharge/Standby button again to stop the program and put the units into Standby.

All of the setpoints can be adjusted before or after the Auto Controller is enabled as in the gas only mode. Since the beam current is being controlled by the RF power, It is necessary to set the Beam mAmps on the ion optics controller to a value that is higher than the beam current that will actually be used.

Saving a program is the accomplished in the same manner as described above for the Auto Beam mode.

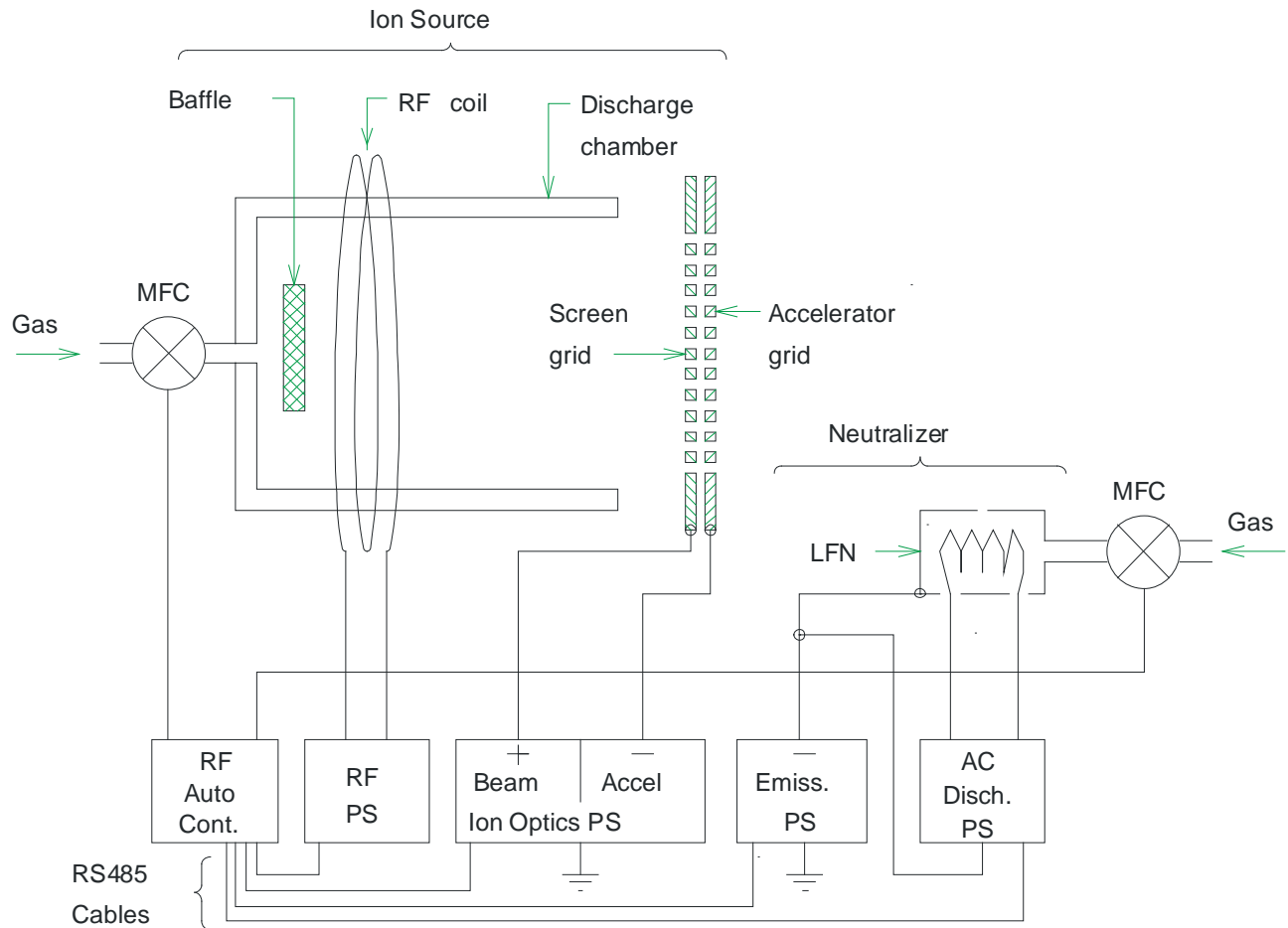


Figure 4-1. Simplified block diagram of the ion source, power supplies and auto controller.

5 REMOTE CONTROL

The RF Auto Controller has a female DB-37 analog/digital interface and a female DB-9 RS-232 serial interface. Both are located on the back panel of the RF Auto Controller. There are a variety of options ranging from simply enabling stored programs using contactors attached to the DB-37 to sending in and running the new program values using the RS-232 serial interface.

5.1 Remote Control using the DB-37 Connector

There are two main options when using the DB-37 connector for remote control. One option is to enable one of the four programs stored in the auto controller. These programs are entered and stored using the front panel as described in the operation section 4 of this manual and selected by the 2 "program select" pins in this connector. The other option is to input the desired operating parameters and then use the RF Auto Controller for sequencing and/or automatic feedback to keep the beam current constant.

Pin descriptions for the DB-37 connector are given below in Table 5-1. Examples of remote I/O using this connector are given in the following subsections.

Table 5-1. Pin descriptions for the female DB-37 connector on the RF Auto Controller.

Pin Number	Description
1	Emission current out. 0-5 volts corresponds with 0 to the maximum emission current in amps for the Emission power supply. Referenced to pin 8.
2	Cathode current out. 0-5 volts correspond with 0-25 amps of cathode heating current for the AC Discharge power supply.
3	Beam voltage setpoint. 0-5 volts corresponds with 0 to the maximum output voltage for Beam power supply. Referenced to pin 8.
4	Emission current setpoint. 0-5 volts corresponds with 0 to the maximum emission current in amps for the Emission power supply.
5	Auxiliary + 12 volts, 100 mA max. Referenced to pin 8.
6	Emission voltage out. 0-5 volts corresponds with 0 to the maximum emission voltage in volts for the Emission power supply. Referenced to pin 8.
7	RF Power out. 0-5 volts corresponds with 0 to the maximum output Power for the RF Power Supply. Referenced to pin 8.
8	Common.
9	Gas 1 flow out. 0-5 volt corresponds with 0 to the maximum output in sccm for MFC 1. Referenced to pin 27.
10	Gas 3 flow out. 0-5 volt corresponds with 0 to the maximum output in sccm

Pin Number	Description
	for MFC 3. Referenced to pin 27.
11	Gas 1 setpoint. 0-5 volts corresponds with 0 to the maximum output for the MFC 1. Referenced to pin 13.
12	Gas 3 setpoint. 0-5 volts corresponds with 0 to the maximum output for the MFC 3. Referenced to pin 13.
13	Gas setpoint common.
14	Gas 3 disable. When connected to common pin 13, the gas flow for MFC 3 will be disabled regardless of the setpoint voltage applied to pin 12. Additionally, the gas valve relay on the back panel for gas 3 is deactivated and the valve off signal is applied to the MFC 3.
15	Gas 4 disable. When connected to common pin 13, the gas flow for MFC 4 will be disabled regardless of the setpoint voltage applied to pin 31. Additionally, the gas valve relay on the back panel for the gas 4 is deactivated and the valve off signal is applied to the MFC.
16	Program select 0. Used in conjunction with program select 1, pin 34. See table 5-2 below for program selection.
17	Analog setpoint select (Remote-Remote). When connected to common pin 8, the analog setpoints are sent in to VIA connections to the DB-37 connector, instead of using the pre-programmed setpoints in the 4 programs. All the program indicators on the front panel will be off, since there is no active program when if setpoints are being sent in.
18	Discharge enable. Connect to common pin 8 to enable, remove connection to common pin 8 to disable. Enable starts the LFN neutralizer and the RF discharge.
19	Run Fault. This pin is low (0 volts) unless there is a run fault, when it will be high (+5 volts). If there is a run fault, then a HLP code will be displayed on the front panel as well.
20	Beam current out. 0-5 volts corresponds with 0 to the maximum output current for Beam power supply
21	Beam voltage out. 0-5 volts corresponds with 0 to the maximum output voltage for Beam power supply.
22	Beam current/RF power setpoint. In Auto Beam Mode, 0-5 volts corresponds with 0 to the maximum output current for Beam power supply. In Manual Beam mode, 0-5 volts corresponds with 0 to the maximum output power for RF power supply.
23	Beam good 1. Shorted to pin 24 when the beam is good, otherwise open. The criteria for Beam good is that the beam voltage must be ± 0.128 amps and the beam voltage must be ± 12.8 volts

Pin Number	Description
24	Beam good 2. Shorted to pin 23 when the beam is good, otherwise open. The criteria for Beam good is that the beam voltage must be ± 0.128 amps and the beam voltage must be ± 12.8 volts
25	Accelerator voltage out. 0-5 volts corresponds with 0 to the maximum output voltage for Accelerator power supply.
26	Accelerator voltage setpoint. 0-5 volts corresponds with 0 to the maximum output voltage for Accelerator power supply.
27	Gas flow out common.
28	Gas 2 flow out. 0-5 volt corresponds with 0 to the maximum output in sccm for MFC 2. Referenced to pin 27.
29	Gas 4 out. 0-5 volt corresponds with 0 to the maximum output in sccm for MFC 4. Referenced to pin 27.
30	Gas 2 setpoint. 0-5 volts corresponds with 0 to the maximum output in sccm for MFC 2. Referenced to pin 13.
31	Gas 4 setpoint. 0-5 volts corresponds with 0 to the maximum output for the MFC 4. Referenced to pin 13.
32	Gas 1 disable. When connected to common pin 13, gas 1 will be disabled regardless of the setpoint voltage applied to pin 11. Additionally, the gas valve relay on the back panel for the gas channel is deactivated and the valve off signal is applied to the MFC.
33	Gas 2 disable. When connected to common pin 13, gas 2 will be disabled regardless of the setpoint voltage applied to pin 30. Additionally, the gas valve relay on the back panel for gas 2 is deactivated and the valve off signal is applied to the MFC.
34	Program select 1. Used in conjunction with program select 0, pin 16. See table 5-2 below for program selection.
35	Local/Remote select – When connected to common pin 8. Remote is selected. When open, local mode is selected.
36	Beam enable. Connect to common pin 8 to enable, release connection to pin 8 to disable. If the Discharge* (pin 18) is enabled, then this pin enables the Beam and Accel power supplies in the Ion Optics power supply. Releasing the beam enable will disable the Beam and Accel power supplies in the Ion Optics power supply. If the Discharge* enable (pin 18) is not enabled, then enabling this pin will not enable the Beam and Accel power supplies in the ion optics controller.

Pin Number	Description
	*See the pin 18 above for a description of the Discharge enable.
37	Accelerator current out. 0-5 volts corresponds with 0 to the maximum output current for the Accel power supply.

5.1.1 Remote enable while using one of the four stored programs

The DB-37 I/O allows program selection through the rear input ports. When using the remote enable, programs are entered and stored using the front panel as described in Operation section 4 of this manual. After the programs have been set using the front panel, switch the front panel from local to remote by connecting DB-37 pin 35 to pin 8 on the rear panel connector. Only the Auto Beam and Gas Only modes are practical when remotely enabling the stored programs, since adjustment of the RF power would be required to maintain the beam current in the Manual Beam Mode. Make sure the desired operating mode is selected before switching to remote.

Pins 16 and 34 on the rear panel DB-37 connector are used to select the four programs by making contact to common at pin 8. The programs are selected by making the connections to common or leaving the connections open as indicated below in table 5-1.

Table 5-1. Connections for remote program selection using pins 16 and 34

Program number	Pin 34	Pin 16
1	Open	Open
2	Open	Common (pin 8)
3	Common (pin 8)	Open
4	Common (pin 8)	Common (pin 8)

5.1.1.1 Auto Beam

Once the Auto Beam program is selected, it can be enable by connecting discharge enable pin 18 and beam enable pin 36 to common pin 8 on the rear panel DB-37 connector. If a discharge preheat is desired before initializing the ion beam, connect discharge enable pin 18 to common pin 8 for the desired discharge preheat time and then connect the beam enable pin 36 to common pin 8 to start the ion beam. Pin 18 may be connected to pin 36 if no beam preheat will ever be used, then only one contact is required to enable the ion beam.

Turn off the ion beam by releasing the connection from pin 36 to pin 8. Turn off the discharge by releasing the connection from pin 18 to pin 8. The discharge may also be left on to preheat for another process cycle.

5.1.1.2 Gas Only

Once the Gas Only program has been selected as described above, the gas can be enabled by connecting the discharge enable pin 18 to common. Releasing pin 18 from common will disable the gas only program.

5.1.2 Remote control using analog setpoints

When using remote enable along with the remote analog setpoints the desired operating parameters are applied to the analog pins as described in Table 5-1. Switch the front panel from local to remote by connecting remote/local pin 35 to common pin 8 on the DB-37 and then select remote setpoints by connecting pin 17 to pin 8.

5.1.2.1 Auto Beam

Using Auto Beam mode requires applying setpoint parameters to the analog input pins on the DB-37 pin connector as described in Table 5-1 above and illustrated in Figure 1 below. The connections shown in Figure 1 are for a typical installation. Notice that only gas 1 one is used for the ion source. Gas 2 and gas 3 could also be used by connecting the additional setpoint and output pins described in Table 1.

Once the set points are applied, enable by connecting beam enable pin 36 and discharge enable pin 18 to common pin 8 on the rear panel DB-37 connector. If a discharge preheat is desired before initializing the ion beam, connect discharge enable pin 18 to common pin 8 for the desired discharge preheat time and then connect the beam enable pin 36 to common pin 8 to start the ion beam.

Turn off the ion beam by releasing the connection from pin 36 to pin 8. Turn off the discharge by releasing the connection from pin 18 to pin 8. The discharge may also be left on to preheat for another process cycle.

5.1.2.2 Manual Beam

The Manual Beam Mode is the same as the Auto Beam Mode described above with one very important exception. The exception is no feedback to control the

beam current with the RF power. Instead, the RF power is controlled directly on pin 22, so it is necessary to monitor the beam current and adjust the RF power to obtain the required beam current.

5.2 Remote Control using the RS-232 Serial Interface

The RS-232 serial interface provides full remote control of the RF Auto Controller. The remote/local select pin 35 must be connected to common pin 8 on the DB-37 connector to enable remote control.

5.2.1 Interface cable

The interface cable for the Auto controller must be a straight through type and must have a male DB-9 connector to connect to the female connector on the rear panel of the RF Auto Controller.

5.2.2 Communication settings

The baud rate is 19.2 kb/s with 8 data bits, one stop bit and no parity. Contact KRI if another baud rate is required.

5.2.3 Communication overview

The acceptable command/response behavior for the RF Auto-Controller is described below. The action/reaction of the RF Auto-Controller to commands may be dependent on several factors or conditions, such as configuration and current system states. These dependencies are outlined below for each command/response category.

5.2.4 Commands, queries and responses

The auto controller can be configured to use various types of neutralizers. The configuration described in this manual includes only those commands that are used with the LFN. Contact KRI for instructions on configuring the auto controller for a neutralizer other than LFN.

The following conventions are used for the command and query descriptions in the following subsections:

“ “ – Text or numerical values inside double quotation marks indicate the exact response from the RF Auto Controller. The quotation marks are not

included in the actual response.

- ' ' – Text inside single quotation marks indicates a state or mode for the auto controller.
- < > – Text inside arrow head brackets indicates parameters that are included with a command or command string. The brackets are not included when issuing the command.
- () – Parentheses surround a numerical value or set point included in the command. The parentheses are not included when issuing the command.

All commands are upper-case sensitive. Lower-case commands and queries will be interpreted as invalid commands.

Any command or query that requires a response must be terminated, at the minimum, with a Carriage Return (CR) character. (ASCII 13 or Hex 0x0D). However, the exact response is determined by whether 'Terse' or 'Verbose' mode is active, as described below in the Verbose Command section. All commands are expected to be terminated with a CR/LF indicated by <cr><lf> in the description below.

5.2.4.1 VRB - Verbose Command

The VRB command sets a flag for more descriptive responses to commands and queries.

The default power-up state of the unit is 'Terse' mode. In this mode, the response to a command is strictly limited to a carriage return (CR) (ASCII 13 or Hex 0x0D). The response to a query will also include values or parameters as a response, but with no descriptive text. Invalid commands or syntactical errors are ignored.

Once the VRB command is issued, the unit will remain in 'Verbose' mode, the until it is reset to 'Terse' by a power down/power up sequence or the *RST command is issued. In the 'Verbose' mode, the response to a valid command or query is "OK" followed by CR/LF and the ">" symbol as the next line prompt for the following command/query. The response to a query will also include the requested information with descriptive test. Invalid commands generate an "Invalid Command" response followed by CR/LF

and the ">" as the next line prompt.

Command: VRB

Example: VRB<cr><lf>

Response: "OK"

The RS-232 remote must be 'Enabled' as described in the next section before the issuing the VRB command.

5.2.4.2 COM - Enable RS-232 Command or Status Query

The COM command will enable, disable or query the status of RS232 remote control of the auto controller depending on the parameter following it.

The default power-up state is 'Disabled'. In order to 'Enable' the RS232 remote control, the rear panel Local/Remote pin 35 on the DB-37 connector input must be connected to common pin 8 to put the auto controller into 'Remote' mode, The unit must be in the 'Standby' state to 'Enable' the RS-232 remote mode. Once 'Enabled', the RS-232 remote control locks out all front panel controls, except for the ON/OFF switch and Gas Select. The Gas Select button is left active to allow monitoring of individual gas flow channels. Once the RS-232 is 'Enabled' the unit must be in 'Standby' in order to return control to the front panel 'Local' or rear analog 'Remote'.

The state of the system can be controlled or queried based on the format of the command. If the ? character is included in the command, the present state of RS-232 remote control will be returned.

Command: COM:<parameter> - 'Enable' or 'Disable' RS-232 remote.

Command: COM? – Get the RS-232 remote control state.

Parameter/Response:

1 = Enabled

0 = Disabled

? = Return current state.

COM:1 – Place unit in ‘RS-232 Remote’ control.

If the unit is not in rear panel remote and standby, the unit issues the following response:

“Unit must be in STANDBY AND rear panel REMOTE”.

COM:0 – Disable ‘RS232 remote’ control.

If the unit is not in ‘Standby’ when this command is issued, the unit responds with:

“Unit must be in STANDBY”.

COM? – Query of remote control state.

If the unit is in ‘Verbose’, the response is “Enabled” or “Disabled”.

If the unit is in ‘Terse’, the response is “1”, or “0”.

Example: COM:0<cr><lf> – Disable RS-232 remote control.

Example: COM:1<cr><lf> – Enable RS232 remote control.

Example: COM? <cr><lf> – Get present output state.

If COM is not ‘Enabled’, then the response to commands will be “Comm Inactive” in both ‘Terse’ and ‘Verbose’ modes. The unit will respond to query’s regardless of the COM state.

5.2.4.3 *IDN? - Unit Identification Query

The *IDN? command will return a unit identification string. The form of this command follows the SCPI standard query form.

Command: *IDN?

Response:

The KRI Auto-Controller will return information in the following form:
<Manufacturer>,<Model>,<Front panel firmware version>, <Main board

firmware version>,<FPGA firmware version>. The form of the firmware version number is month/day/year (MMDDYY).

Example: *IDN?<cr><lf>

Example response: "KRI,ACRF1,102862,052690,111506"

5.2.4.4 *RST – Reset Command

The RST command will return to the unit to 'Standby' and clear any 'recoverable' error message. In addition, the 'Scratch pad' program will be reset to the values in the currently active program and all modifications will be lost. The unit will also be set to 'Terse' mode

Command: *RST

Example: *RST<cr><lf>

Note: The only 'recoverable' errors are:

HLP 10 – Start Failure
HLP 11– Run Fault

5.2.4.5 *TST? – Self Test Query

The *TST? command performs a unit self test and report results.

A non-zero return value will correspond to the associated front panel error message as outlined below. If more than one error is active during the query, a string of all active HLP xx numbers will be displayed, where xx are numbers. The response will be the same in 'Terse' or 'Verbose' mode.

Command: *TST?

Example: *TST?<cr><lf>

Error message definitions:

0 = No error. Unit functioning normally.
4 = HLP 4 – Unit not ready.
7 = HLP 7 – Open interlock.

- 9 = HLP 9 – Invalid configuration.
- 10 = HLP 10 – Start fault or broken cathode.
- 11 = HLP 11 – Run fault.
- 12 = HLP 12 – Gas fault.
- 13 = HLP 13 – Internal communication error.

Example Response: “10”

5.2.4.6 OUT - System Level Output Control Command or Status Query

The OUT command ‘Enables’, ‘Disables’, or queries of output state of the system depending on the parameter following it.

Command: OUT:<parameter> - To set the output state.

Command: OUT? – To get the output state.

Parameter/Response in ‘Auto Beam’ or ‘Manual Beam’:

- 00 = Beam Standby, Discharge Standby
- 01 = Beam Standby, Discharge Enabled
- 11 = Beam Enabled, Discharge Enabled
- ? = return current state.

Example: OUT:00<cr><lf> - Put both Beam and Discharge in ‘Standby’.

Example: OUT:01<cr><lf> - Put Discharge in ‘enable’ and Beam in ‘Standby’.

Example: OUT? <cr><lf> – Get present state of output.

If the unit is in ‘Verbose’, the response will be a combination of “Beam Standby”, “Beam Enabled”, “Discharge Standby”, or “Discharge Enabled”.

If the unit is in ‘Terse’, the response will be “00”, “01”, or “11”.

If the RS-232 is not enabled, the unit will respond with “Comm Inactive”.

If the Operating Mode is ‘Auto Beam’ or ‘Manual Beam’ issuing a ‘Discharge Standby’ command will automatically issue a ‘Beam Standby’ command

regardless of the parameter passed as part of the OUT command.

If the Operating Mode is 'Gas Only', then only the gas will be enabled when either the OUT:11 or OUT:01 command is issued.

6.2.4.7 MDE - Mode Set Command or Mode Query

The MDE command sets or queries the Operating Mode of the system when the unit is in 'standby' and the COM is 'enabled'. The state of the Operating Mode can be queried at any time. In the case of a mode set command it takes a parameter indicated below. If it is a mode query, then it returns the same form as the parameter indicating the current mode.

Command: MDE:<parameter>

Command: MDE?

Parameter/Response:

0 = Auto Beam

1 = Manual Beam

2 = Gas Only

Example: MDE:0<cr><lf> - Put unit in 'Auto Gas'

If COM is active and unit is 'Enabled', the response of the unit is: "Unit must be in STANDBY".

If the COM is not 'Enabled', the command is ignored both in 'Terse' and 'Verbose'.

Example: MDE?<cr><lf> - Returns present mode.

If the unit is in 'Verbose', the response is "Auto Beam", "Manual", or "Gas Only".

If the unit is in 'Terse', the response is "0", "1", or "2".

5.2.4.8 BEAM - Beam Good Query

The BEAM query Indicates if a stable operating point has been achieved.

Command: BEAM?

Response is "1" if beam good, "0" if beam not good. This response is for both 'Terse' and 'Verbose' mode.

Criteria for Beam Good:

Beam Current within ± 0.128 A.

Beam Voltage within ± 12.8 Volts

5.2.4.9 P - Program Value Read/Write Command

The P command selects or queries the active program, or sets or queries the active operating values for a program depending on the parameters included with the command. The operating values are the gas flows for the MFC's, and the currents and voltages or power for the power supplies. The P command can be used to set or query the values for individual parameters or for a string of parameters depending on the format of the command.

The general form of the program read/write command is:

Command: P<program#>:<parameter> (value)

The <parameter> and (value) fields are optional. The command can be turned into a query by substituting ? for the <program#>, <parameter>, and (value) fields. The interpretation of the query is dependent on where the ? appears as outlined below.

- **Set or query the active program number**

P<program#><cr><lf> - Set active program to <program#>

P<?><cr><lf> - Get active program number.

Acceptable program numbers would be 1 to 4. Query of the active program number may also return 0 for the 'Scratch pad'. The 'Scratch pad' is the program that holds and maintains any modified program set points for the currently active program.

Any parameters following the ? character for this command will be ignored.

Any parameters following <program#> without the <:> as a delimiting character before the <parameter> field will be ignored.

Example: P4<cr><lf> - Set active program number to 4

Example: P?<cr><lf> - Get active program number

- **Set or query the values for individual program parameters.**

P<program#>:<parameter> (value) – Set specific <program#> <parameter> to (value)

P<program#>:<parameter> (?) – Get specific <program#> <parameter> (value)

There are 12 <parameters> for setting an individual (value). Each of these <parameters>, which are three letters long, are listed below along with the description and the number of significant digits and decimal places shown as x:

1. GS1 – Gas Channel 1, xxx.x
2. GS2 – Gas Channel 2, xxx.x
3. GS3 – Gas Channel 3, xxx.x
4. GS4 – Gas Channel 4, xxx.x
5. BMI – Beam Current Target, x.xxx
6. BMV – Beam Voltage Target, xxxx.x
7. ACI – Accelerator Current Target, x.xxx
8. ACV – Accelerator Voltage Target, xxxx.x
9. RFP – RF Power Target, xxxx
10. EEI – Electron Emission Current Target, x.xx
11. EEV – Electron Emission Voltage Target, xxx.x
12. LFI – LFN Discharge Current Target, x.xx

The (values) for each <parameter> may have decimal points and decimal places included or omitted if there are no significant digits beyond the decimal point. However, if the first significant digit falls after a decimal point, then a zero must precede the decimal point or an “Invalid Command” response will be generated. Decimal places

beyond the anticipated place will be truncated.

Example: P4:GS1 10<cr><lf> - Set program 4 channel 1 gas flow to 10 sccm.

Example: P1:BMV?<cr><lf> - Get program 1 beam voltage value.

Example response in 'Terse' mode: "600.0"

Example response in 'Verbose' mode: "Beam Volts = 600.0"

- **Set or query the values for ALL program parameters**

The parameter <ALL> can be used to set or get all program parameter values. The order of the parameters is the same as the order shown above, as are the significant digits and the decimal point criteria.

P<program#>:ALL (value),(value),(value)...<cr><lf> – Set ALL program parameters to value list.

P<program#>:ALL?<cr><lf> - Get all the program values.

NOTE!! In the following examples, the comma-delimited strings are shown with their mnemonic equivalents listed above. In real use, these abbreviations would be actual numerical values. These numerical values must be valid for the configuration being programmed remotely since the Auto-Controller does not know the maximum ranges of the units attached. The target values returned include the Gas Channels, Beam voltage and current, Accelerator voltage and current, RF Power, Emission, and LFN Discharge current.

In using the ALL parameter to set targets, the list of values must be comma delimited and appear in the order shown. Any value that is to remain unchanged can be omitted, but the comma delimiter between parameters must be included in the input string. In the second example, BMI and EEV remain unchanged in the target program.

Example: P1:ALL GS1, GS2, GS3, GS4, BMI, BMV, ACI, ACV, RFP, EEI, EEV, LFI<cr><lf>

Example: P1:ALL GS1, GS2, GS3, GS4, ,BMV, ACI, ACV, RFP, EEI, ,

LFI<cr><lf>

When using the ALL command in 'Terse' mode to get all the program values, they will be returned as a comma delimited string of values in the same order as those shown above. The decimal points and the number of decimal places are shown in the example below.

Example: P1:ALL?<cr><lf>

Example Response:

"6.5, 0.0, 0.0, 0.0, 6.0, 0.011, 500.0, 1.000, 75.0, 44, .02, 120.0, 1.50"

When using the ALL command in 'Verbose' mode, a list including the name of the value, and the actual numerical value will be returned. A line feed <lf> will separate the returned values.

Example: P1:ALL?<cr><lf>

Example response:

"Gas Channel 1 = 6.5
Gas Channel 2 = 0.0
Gas Channel 3 = 0.0
Gas Channel 4 = 6.0
Beam Amps = .011
Beam Volts = 500.0
Accelerator Amps = 1.000
Accelerator Volts = 75.0
RF Power = 44
Emission Amps = .02
Emission Volts = 120.0
Low Frequency Discharge Amps = 1.50"

The command can also be used to set or get a single value for a program.

Example: P1:BMV 600 – Set the beam voltage for program 1 to 600 volts.

Example: P0:RFP? – Get the scratchpad RF power value.

If the auto controller is in the 'Auto Beam' mode, then the beam current (BMV) will be the setpoint beam current. The RF power (RFP) will be the starting power, and the power that is used when only the Discharge is enabled. Once the Beam is enabled, the RF power will be automatically adjusted to maintain the beam current.

If the auto controller is in the "Manual Beam" mode, the beam current (BMI) will be the maximum beam current and must be set to a value that is greater than the actual beam current. The RF power (RFP) must be continually adjusted to maintain the beam current after the beam is enabled. The RF power setpoint will also be the value used when only the Discharge is enabled.

If the Auto Controller is in the 'Gas Only' mode, all the setpoints and queries will still be valid, but only the gas will be enabled when issuing the OUT command. Either the out OUT:11 or OUT:01 can be issued to enable the gas. Issuing the OUT:00 command will disable the gas. In using the ALL parameter to set targets, the list of values must be comma delimited and appear in the order shown below. Any value that is to remain unchanged can be omitted, but the comma delimiter between parameters must be included in the input string. In the second example, GS2 remains unchanged in the target program. In 'Gas Only' mode, the supply targets are still active, so that a series of eight comma delimiters will need to follow the command if the ALL parameter is used.

Example: P1:ALL GS1, GS2, GS3, GS4, , , , , , , , , <cr><lf>

Example: P1:ALL GS1, , GS3, GS4, , , , , , , , , <cr><lf>

The RF Auto Controller does not know what (values) are acceptable for the power supply <parameters>. If (values) larger than the output for the power supplies are programmed, the auto controller will set those (values) to the maximum value. However, this is not true for the gas channel values. If a gas channel (value) is larger than the defined maximum, the auto controller will respond with:

"Target value greater than defined max".

If a gas channel maximum is set to 0 or off, then sending a (value) to that gas channel will generate the following response:

“Gas Channel x disabled” where x is the gas channel number.

It is very important to understand the operating limits of the RF Ion Source and LFN to prevent damage. Review the ion source, ion optics and LFN manuals to determine appropriate operating conditions. Contact KRI for assistance in establishing operating conditions if necessary.

5.2.4.10 R - Monitor Command for Reading the Actual Feedback Values

The R command is used to get the actual feedback values from the auto controller. It uses the same parameters as those described above for the P command, except that there is no program number required and the ? character is not used.

R:<parameter> – Get the current running (value) of <parameter>

Values are reported in Amps, Volts Watts, or sccm, appropriate for the selected parameter(s).

Example: R:GS2<cr><lf> – Get current value of Gas Channel 2 feedback.

Example: R:ALL<cr><lf>

Example response in ‘Verbose’ mode:

“Gas Channel 1 = 6.5
Gas Channel 2 = 0.0
Gas Channel 3 = 0.0
Gas Channel 4 = 6.0
Beam Amps = 0.011
Beam Volts = 500.0
Accelerator Amps = 0.001
Accelerator Volts = 75.0
RF Power = 44
Emission Amps = 0.02
Emission Volts = 120.0
Filament Amps = 10.3
Filament Volts = 16.5

Low Frequency Discharge Amps = 1.50”

In ‘Terse’ mode the response will be a comma delimited string of values only in the same as order shown above for the ‘Verbose’ mode.

5.2.4.11 CFG? – Query current system configuration

The CFG? Command is a query of what the Auto-Controller thinks the current configuration is based on the initial setup. The initial setup is done at KRI. Contact KRI if a setup other than Low Frequency Neutralizer is required.

Command: CFG?

In VERBOSE, the responses are:

“Unknown”

“Hollow Cathode Neutralizer”

“Low Frequency Neutralizer”

“Filament”

“Gas Only”

In ‘TERSE’, the responses are: “0”, “1”, “2”, “3” or “4”, respectively.

5.2.4.12 LRN – Learn Command or Learn Query

The current status of LRN can be queried any time. The COM must be active to set the LRN flag. Setting the LRN flag with COM in-active is ignored. Setting the LRN mode using the serial command temporarily overrides the LRN mode setting established in ‘setup’. The value in ‘setup’ is restored on a power down/up or reset.

Command: LRN:<parameter>

Command: LRN?

Parameter/Response: 1 = ON, 0 = OFF

<parameter> can be separated from the command by 1 or less spaces.

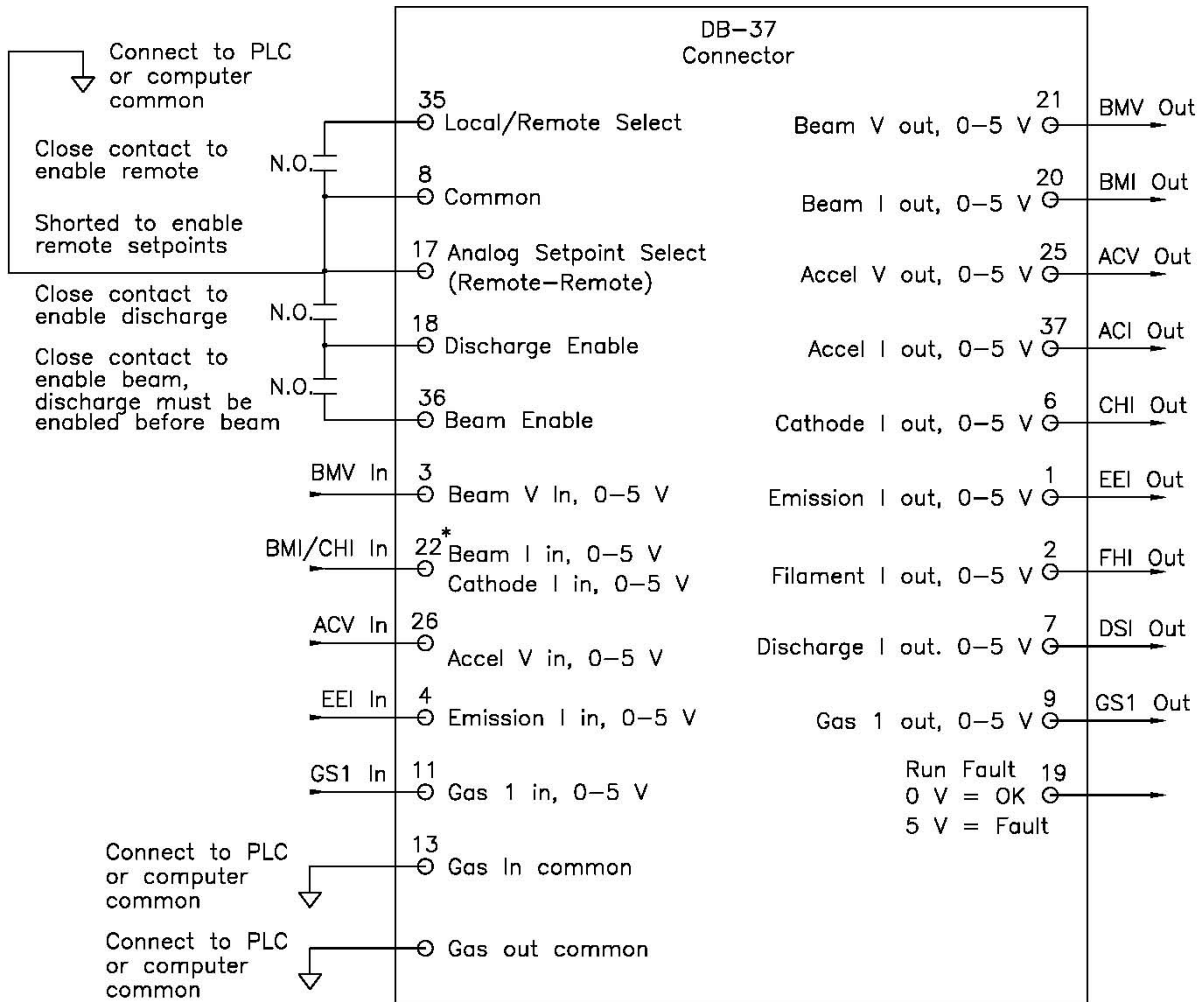
Example: LRN:0<cr><lf>

Example: LRN:1<cr><lf>

Example: LRN?<cr><lf>

In VERBOSE, the response is "On", or "Off".

In TERSE, the response is "1", or "0", respectively.



22* In Auto Beam mode this pin sets the beam current and the cathode is adjusted automatically to maintain the beam current. In Manual Beam mode, the beam current must be monitored and the users PLC or computer adjusts the cathode to maintain the beam current.

Figure 5-1. Typical connection scheme using the remote setpoints option (Remote-Remote) on the DB-37 analog/digital remote interface.

6. DIAGNOSTICS

The following information is intended to facilitate troubleshooting of the RF Auto Controller and associated power supplies. This information assumes that the auto controller and power supplies are connected to power and that all interconnects between power supplies and the ion source cable are made correctly. It is also assumed that all gas connections are in good condition and that the gas circuit is complete from the gas bottle to the ion source.

Power must be removed from the Auto Controller and power supplies prior to performing maintenance.

6.1 RF Auto Controller

The auto controller front panel display has an additional function of displaying help codes and error messages. These messages are also available using the remote serial interface. If it becomes necessary to display a help code or an error message, the auto controller may switch to standby mode depending on the particular code or message. The front panel display will alternate between displaying “HLP” and a number for the help code. The error messages will be displayed by alternating two abbreviated words. A description of the help codes and the error messages is given below in table 7-1 along with possible corrective action that may need to be taken.

Table 6-1. Help codes and error messages for the Auto Controller.

Help Code or Error Message	Description	Possible Causes And Corrective Action
HLP 8	RS-232 Interface Serial Common Error. High current flowing in the ground connection of the serial interface between the unit and the Computer. Shows up only in remote RS-232 operation. Display says HLP 8 for 5 seconds.	Informational display only. No action taken on unit operation. Unit recovers from error condition if problem goes away. Make sure all of the equipment has adequate grounding.

Help Code or Error Message	Description	Possible Causes And Corrective Action
HLP 9	Communication for remote RS-485 communication is missing.	<p>Check the connections of the RS-485 cables.</p> <p>Make sure all power supplies have input power and are turned on.</p> <p>The HLP 9 message will be cleared when communication is restored.</p>
HLP 10	Start failed. The LFN or RF discharge did not start.	<p>Press and release the Discharge/Standby button twice to clear the code. The unit remains in standby until the Discharge/Standby or Beam/Standby is pressed again. In Analog remote, the code is cleared when the Beam and Discharge are disabled. In RS-232 Remote, the code is cleared when the *RST command is issued.</p> <p>Quartz discharge chamber has a conductive coating and needs to be cleaned or replaced.</p> <p>LFN did not start. If A HLP 3 code is also displayed on the AC Discharge power supply, the LFN cathode needs to be replaced.</p>

Help Code or Error Message	Description	Possible Causes And Corrective Action
HLP 11	Run Failed. The LFN or RF discharge was started and went out.	<p>Press and release the Discharge/ Standby button twice to clear the code. The unit remains in standby until the Discharge/Standby or Beam/Standby is pressed again. In Analog remote, the code is cleared when the Beam and Discharge are disabled. In RS-232 Remote, the code is cleared when the *RST command is issued.</p> <p>For initial operation at a new operating condition, the gas flow may be too low. Increase flow.</p> <p>The initial RF power may be too low. Increase the RF Power.</p> <p>LFN cathode broken. If A HLP 3 code is also displayed on the AC Discharge power supply, the LFN cathode needs to be replaced.</p>
HLP 12	Initial Gas Failure. The gas flow did not initialize during the start up sequence.	<p>Press and release the STANDBY/ENABLE button or remove the remote enable signal to clear the code. The unit remains in STANDBY until STANDBY/ENABLE is pressed again or the remote enable signal is reapplied.</p> <p>Gas bottle is empty and needs to be replaced.</p> <p>Make sure that any valves in the system are open.</p>

Help Code or Error Message	Description	Possible Causes And Corrective Action
		MFC is faulty or MFC cable is faulty or disconnected. Repair or replace MFC or cable. Make sure MFC cable is connected.
HLP 13	Master Communication Error.	Switch off the power until the display is dark and then switch the power back on to reset.
Int LOC	Open Interlock – An open interlock prevents the Auto Controller from going to the ENABLE state and holds it in STANDBY.	This is a user defined fault in remote operation. Review the interlock scheme for the system in question.
Not Rdy	Not Ready. – Auto Controller held in STANDBY.	Insufficient line voltage. Fault will clear itself when the Auto Controller receives sufficient line voltage.

6.2 AC Discharge Power Supply

The AC Discharge power supply front panel displays have the additional function of displaying help codes and error messages. If it becomes necessary to display a help code or an error message, the AC Discharge power supply may switch to standby mode, depending on the type of code or message. The front panel will display “HLP” and a number for the help code. The error messages will be displayed as one or two abbreviated words. A description of the help codes and the error messages is given below in table 7-2 along with possible corrective action that may need to be taken.

Table 6-2. Help codes and error messages for the AC Discharge power supply.

Help Code or Error Message	Description	Possible Causes and Corrective Action
HLP 1	Current Latch – A high current was encountered. Power supply latched off to prevent a failure.	Switch off the power until the display is dark and then switch the power back on to reset. Contact KRI® if this code continues to be

Help Code or Error Message	Description	Possible Causes and Corrective Action
		displayed after the power is switched off and on.
HLP 2	Thermal Failure.	Open or shorted thermistor detected. Contact KRI.
HLP 3	Broken Cathode	Turn the AC discharge power switch off and change the LFN Cathode. The code will be cleared when the supply is switched back on.
HLP 7	RS-485 Serial Communication Lost. – HLP 7 is displayed when the unit is in REMOTE and unit is in STANDBY.	<p>Communication for remote RS-485 communication was detected and then lost.</p> <p>Check connection of the RS-485 cables.</p> <p>Make sure Auto Controller has input power and is turned on.</p> <p>The code will be cleared when the communication issue is resolved.</p>
HLP 8	RS-232 Interface Serial Common Error. – High current flowing in the ground connection of the serial interface between the unit and the PC. Shows up only in remote RS-232 operation. Display says HLP 8 for 5 seconds.	<p>Informational display only. No action taken on unit operation. Unit recovers from error condition if the problem goes away.</p> <p>Make sure all of the equipment has adequate grounding.</p>
Hot	Thermal Overload – Internal temperature in the power supply is too hot. Power supply is in STANDBY.	<p>Leave the power supply turned on until the Hot message is cleared.</p> <p>Make sure there is no blockage of the vents on the rear panel.</p> <p>Ambient temperature is too high.</p>

Help Code or Error Message	Description	Possible Causes and Corrective Action
		Reduce ambient temperature below 40°C.
Not Rdy	Not Ready. – Keeper Power Supply is in STANDBY.	Insufficient line voltage. Message will clear itself when there is sufficient line voltage.

6.3 Emission Power Supply

The emission power supply has the same HLP codes and error messages as the AC discharge supply, except that there is no HPL 3.

7. LIMITED WARRANTY

Kaufman & Robinson, Inc. (KRI) warrants to the purchaser or end user of the equipment it sells that such equipment will be free from defects in material and workmanship under normal use and service. This warranty is for a period of fifteen (15) months from the date of original shipment F.O.B KRI's facility, Fort Collins, Colorado, or one year from the date the equipment is placed in use by the purchaser or end user thereof, whichever occurs first. This warranty is void if the equipment is not used, operated, and maintained in accordance with the manual accompanying the equipment. KRI shall not be responsible for any direct or indirect loss or damage resulting from accident, negligence of a user, alteration, abuse, or misuse of the equipment. Upon acceptance of this Limited Warranty, purchaser waives all warranties, guarantee, or remedies not specifically stated in this Limited Warranty. This warranty does not cover ordinary wear and tear or expendable components.

KRI's obligation under this Limited Warranty is, at KRI's option, to repair or replace any defective equipment or parts of the equipment, without charge to the purchaser, which are returned, shipping prepaid, to the KRI facility, 1306 Blue Spruce, Unit A, Fort Collins, Colorado, 80524 USA. For return or repair of equipment, purchaser must contact KRI for a Return Materials Authorization prior to shipment of the equipment to KRI. If KRI has designated an Authorized Warranty Service Representative in the purchaser's country, contact may be made with the Authorized Warranty Service Representative and defective equipment may be delivered to such Authorized Warranty Service Representative to service warranty claims.

This warranty is in lieu of all other warranties, expressed or implied, including the implied warranties of merchantability and fitness for any particular purpose. The purchaser acknowledges the purchaser is not relying in KRI's skill or judgment to select or furnish equipment suitable for any particular purpose.

This Limited Warranty will be construed in accordance with the Uniform Commercial Code as adopted by the State of Colorado.

This warranty does not cover expendable parts; expendable parts are as follows:

Alumina Insulators, Filaments, EH1000 Reflector, Gas Line Isolator and Vacuum Cables.

8. SERVICE AND TECHNICAL INFORMATION

For technical information, repairs or replacement during Warranty, or repairs thereafter, please contact:

Kaufman & Robinson, Inc.
1306 Blue Spruce Dr. Unit A
Fort Collins, CO 80524
Tel.: 970-495-0187
Fax.: 970-484-9350
Internet: www.ionsources.com

Please include the following details relating to the problem encountered or the item to be returned:

- Product
- Serial number
- Detailed description of problem
- KRI order number
- Name and address of company
- Contact person

If return to KRI is required, you will be given an authorization number and instructed where to send it.