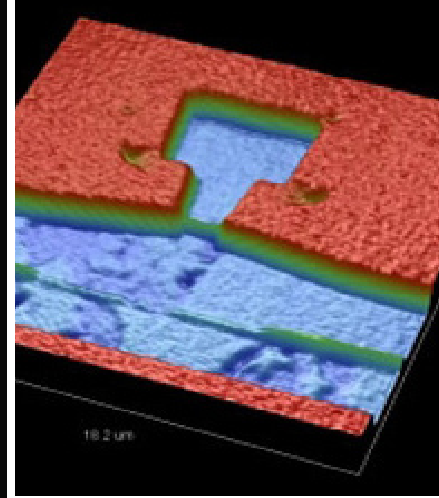

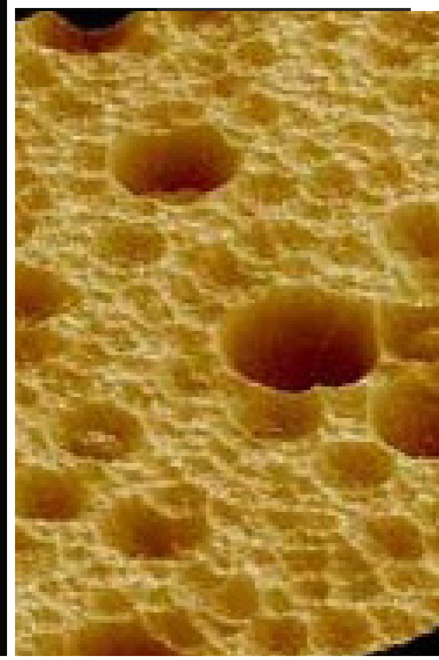

Mark II⊕ Controller

Technical Manual
425959

Solutions for a nanoscale world.™

Mark II®

Controller

Technical Manual

Veeco

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Manual #425959 Rev. I

Table of Contents

Chapter 1: Safety

Understanding the correct installation, operation, and maintenance procedure is necessary for safe and successful operation. This safety alert symbol precedes safety messages in this manual, along with one of the three signal words explained below. Obey the messages that follow these words to avoid possible injury or death.

⚠ DANGER

This symbol marks an imminent hazard which will kill or injure if ignored.

⚠ WARNING

This symbol marks a potential hazard which may kill or injure if ignored.

⚠ CAUTION

This symbol marks a potential hazard which may cause minor injury if ignored.

CAUTION

This symbol marks a potential hazard which may cause damage if ignored.

Please read the following before continuing:

⚠ WARNING

To avoid electrical shock, keep clear of "live" circuits. Follow all local lock-out/tag-out procedures before repairing or replacing any electrical devices.

Obtain, read and understand the Material Safety Data Sheet (MSDS) for any chemicals and materials referenced in this technical manual. Follow all local procedures in the safe handling and use of these materials, including the use of any required personal protective equipment.

It is recommended that only trained, qualified persons using established safety procedures perform any work related to the installation, start-up, operation or maintenance of this system. Qualified service personnel should refer to the Mark™⊕ series Source/Controller Troubleshooting technical manual for detailed information.

WARNING

To avoid electrical shock, check that all hardware interlocks are working. Keep all guards and panels in place during routine system operation.

Complete ion beam systems from Veeco Instruments Inc. are supplied with hardware interlocks and software safeguards at various points in the system. Whenever components or retrofits are added to existing systems, a local review of system safety is recommended.

WARNING

To avoid electrical shock, disconnect the controller from any power source before making connections to the source or other external components.

Since the controller does not have an integral Mains Disconnect, the user must provide a suitable external Disconnect switch for the controller. Connect an additional 12 AWG (or larger) signal ground wire with green/yellow colored insulation between the ground stud located on the unit's rear panel and the process chamber ground point to provide reliable controller operation.

This controller employs components which contain tin, solder and trace amounts of mercury. Recycle or dispose of these items in accordance with local environmental regulations.

CAUTION

To avoid possible environmental contamination, recycle or dispose of this unit and any replaced components in accordance with local regulations.

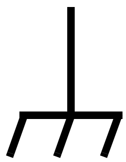
It is recommended that two persons move the unit by grasping the case at the sides.

CAUTION

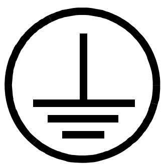
To avoid back and other injuries, two persons should move the controller by grasping the case at the sides.

Symbols Used on the Controller

Refer to manual

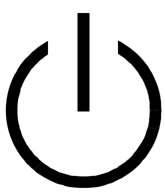


Designates a chassis ground



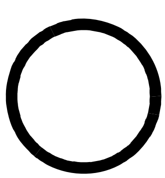
Designates a protective earth grounding point

Dangerous voltage



Unit in standby – power outputs deactivated

Unit on – power outputs active



Unit off – power off

Chapter 2: Overview

The Mark II⊕ Controller is factory configured for use with Veeco's Mark/Mark⊕ series gridless ion source. The unit is able to automatically adjust the filament current, anode voltage and gas flow rate to provide an ion beam with user chosen values for energy and current. An optional interface package is offered to make the controller plug compatible with existing Mark series power supplies, permitting drop in replacement for automated systems.

The unit's modular power supplies may be operated in one of two modes. In the MANUAL mode, each power supply module runs independently. All relevant parameters may be adjusted, including source gas flow. The mass flow controllers (MFCs) may also be turned on or off. The automatic start sequence is disabled in this mode.

In the AUTO mode, the controller monitors and adjusts all parameters to achieve the target anode voltage, anode current and neutralization current. The automatic start sequence is enabled when the BEAM button is pressed. This sequence starts the source gas flow, and applies an anode voltage as well as a filament current to start the source. Once the source starts, the controller adjusts: the filament current (to achieve the desired neutralization) and source gas (to achieve the desired anode current). Maximum filament currents and gas flows can be entered.

Figure 2.1 Mark II⊕ Controller

This Mark⊕ series Controller includes:

- **Anode Supply** – The anode supply is an isolated switching power supply that produces a DC potential needed to accelerate the electrons until they have enough energy to ionize gas atoms to sustain source discharge.
- **Filament Cathode supply** – The filament cathode supply is an isolated switching power supply that produces an AC waveform needed to heat the filament cathode to emission temperature.
- **Gas Flow Controller** – The gas flow controller is designed to control up to four external MFCs as well as a positive shut-off valve for each. Analog control is provided with future capability for digital control (EIA-485).
- **User Interface** – The LCD touch screen on the unit's front provides local controller access. This screen shows operating parameters and event status (including alarm conditions).
- **Remote Interface** – Includes EIA-232 interface[1] which affords unit access via a remote connection to an external PC. The analog/digital controls duplicate the remote interface available from an existing Mark series controller.

Press the parameter's display bar on the touch screen to change its value on the numeric keypad that appears. Target parameters are displayed when a particular module is off; actual values are displayed when the module is on. Six parameters are displayed on the touch screen. Some parameters vary depending on the operating mode.

All adjustable parameters can be changed remotely with the user friendly command set. See "Serial Communications Protocol" on page 61. When remote operation is enabled, the touch screen can be intentionally locked out to prevent unauthorized access. The unit's switch closure input and output communicate status information to an external PC or control system. The input allows on/off beam control; the output indicates beam status.

Each MFC channel may be configured for the valve size, calibration gas and process gas to be used. Secondary MFC channels may be assigned a ratio to control their flow rate relative to the primary (source) MFC channel. Start flows and run ratios may also be specified for each secondary channel, simplifying gas mixture flow control during routine start-up and operation.

1. Formerly known as, and identical to, RS-232.

Chapter 3: Operating Principles

This chapter explains the functions necessary for successful operation. It is intended to help the user understand how the source and controller function together. Information and recommendations are offered to avoid unexpected operating circumstances which may cause equipment damage. It is suggested that this material be read before using the unit for the first time and used as a reference if questions arise during routine operation.

Source Considerations

The Mark II⊕ Controller has been designed to power the Mark/Mark⊕ series end-Hall Effect type gridless ion source and neutralizer. This source type creates a beam of ions through the interaction of electric and magnetic fields in the source's discharge region. Ions accelerate away from the anode with an energy that depends on where they were created. The mean ion beam energy is typically 60% of the discharge voltage. The actual ion beam current is typically 20% of the discharge current. The discharge current is a function of the anode voltage, the source gas flow, and the emission current. The controller automatically adjusts these independent system variables to maintain the target operating condition. Refer to the ion source's technical manual for additional information.

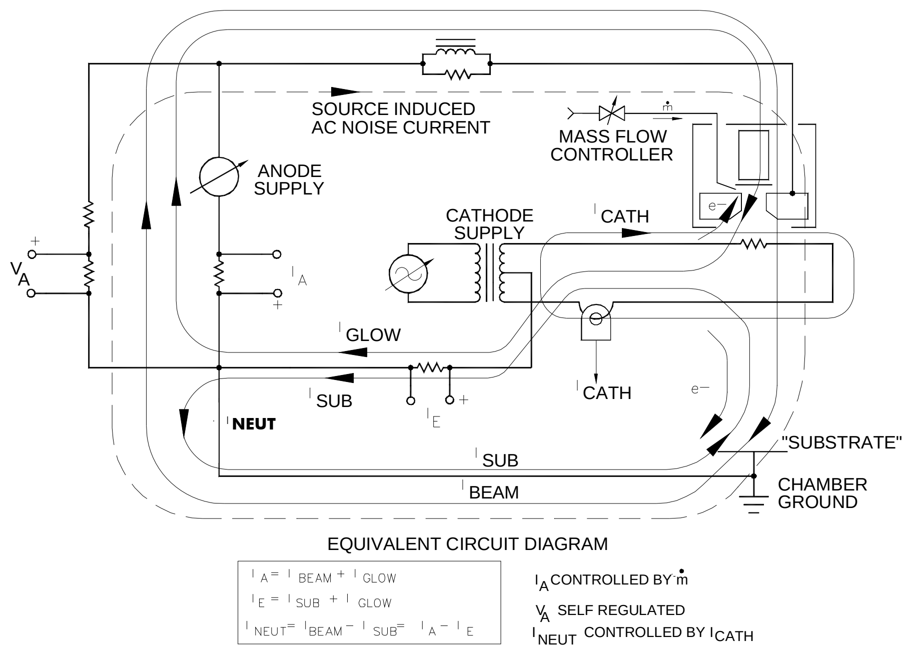
Controller/Power Supply Function

The automatic start sequence is enabled when the BEAM button is pressed and the controller is in AUTO mode. This sequence initiates ramping the source gas flow to the start gas flow setting. Next, the *Anode Voltage*, V_A, is increased until it reaches the user selected starting value. Then, the cathode is heated to thermionic emission temperature by the cathode supply. The filament current rises until there is a source discharge or until it reaches its target value.

The discharge is initiated by electrons that are accelerated toward the anode and strike neutral atoms or molecules, thereby generating ions. This gaseous mixture of electrons and ions constitutes a discharge plasma. The interaction of the electrons in this plasma with the magnetic field also establishes the electric field that accelerates the ions. This acceleration has significant components in both the radial and axial directions. The accelerating potential varies over the discharge region; ions are produced with a substantial spread in energy, depending on their position at ionization.

For steady state operation, the unit adjusts the gas flow and anode supply until the anode current and voltage are at the target values. The cathode supply is adjusted in response to neutralization current changes until the *Emission Current*, I_E, is larger than the *Anode Current*, I_A, by the specified neutralization current offset or ratio. Current neutralization of the ion beam leaving the source is approximately obtained with equal anode and emission currents. An electron deficiency may lead to high plasma potential throughout the process chamber, which can cause arcing. A small excess of electrons (approximately 10%) is generally enough to fully neutralize the beam and prevent this arcing. These neutralizing electrons are obtained by making the cathode current slightly larger than the anode current. Several current paths exist in the discharge region, as shown in Figure 3.1.

Figure 3.1 Equivalent Circuit Diagram



The electron current in the discharge region, referred to as the glow fraction current, I_{GLOW}, is not directly measured by the controller. The sum of the glow current and ion beam current is measured by the system and is displayed as Anode Current by the controller. The downstream ion beam draws an electron current from the filament that is sufficient to space charge neutralize the beam plasma (assuming the cathode is hot enough to supply the required current). This electron current ultimately flows to the process chamber ground or substrate. The Emission Current is displayed by the unit. The current returning to the controller from process chamber ground (the difference between ion beam current, I_{BEAM} and I_{SUB}) is called the neutralization, or *Neutralizer Current*, I_{NEUT}. The controller calculates the difference between I_A and I_E, which it displays as I_{NEUT}. Recall that the mean ion energy corresponds to about

60% of the anode voltage. For example, the ion energy should be about 90eV for an anode voltage of 150V. Operation is typically possible over an ion energy range of 40 to 180eV.

If the process chamber has other rapidly changing gas supplies (*e.g.*, reactive gases introduced at the substrate), pressure fluctuations may occur at the source's anode region during routine operation. Since the anode current is pressure dependent, the anode supply may exhibit an over-current condition in response to a pressure burst. The unit compensates with automatic current limiting in response to this burst, and will attempt to restart if the discharge goes out. If a discharge cannot be restarted, the controller will turn off after a timed period.

CAUTION

To avoid thermal damage to the source's mechanical components from excess current over an extended period, use conservative gas flows whenever the controller is operating in MANUAL mode.

Gas Flow Controller Function

The neutral gas flow introduced to the ion source is regulated by a thermal mass flow controller (MFC) attached to a supply of working gas. The mass flow value appears on the display bar on the unit's front panel. This flow determines the gas pressure inside the source and therefore the electrical resistance of the plasma discharge. More gas causes the resistance to decrease and the discharge current to increase.

The mass flow is a controlling variable of discharge current, which leads to a complication in the control loop compensation design. Because pressure fluctuations travel at a finite speed (the speed of sound), there will be a delay in any change of the actual flow downstream of the MFC in response to a change in its valve position. The standard anode current control parameters are designed for a time delay using argon. If heavier gases are used (such as xenon), or if non-standard gas lines are used, control loop parameters may need to be adjusted for stable operation. In this case, contact "Service Support" on page 39 for recommendations and assistance. Refer also to "Mass Flow Controller(s)" on page 12 for gas line length recommendations. These values assume laminar flow conditions.

NOTE

To maintain laminar flow conditions, avoid introducing abrupt changes in line diameter or sharp bends in the line; these will induce turbulent flow and change the mass transport delay characteristic.

Chapter 4: Installation

Inspection

Unpack the Mark II⊕ Controller and inspect it carefully for any visible damage. If damage is found, notify the shipping company and Veeco immediately. Check that all accessories and options have been included with the unit.

General

The controller is designed to be mounted in a standard 19 inch equipment rack. The unit's top, back and sides should be inaccessible when the controller has electrical power and is operating. Refer to "Mechanical" on page 46 for additional information on the unit's mechanical characteristics and to "Interface Connections" on page 50 for pin assignments on all external device connections.

Figure 4.1 Controller - Rear Panel

CAUTION

To avoid thermal shut down and possible damage, allow enough clearance for air flow to the cooling fan in the back panel as well as the side panel vents.

Connection

NOTE

Read all instructions before connecting power. Refer to "Specifications" on page 44 **for detailed installation requirements.**

Follow these steps to connect the controller (Refer to "Figure 4.1" on page 9 and to the "Drawings" on page 40):

1. Check that the ON/STANDBY and Mains Disconnect switches are in the OFF position before continuing.

⚠WARNING

To avoid electrical shock, keep clear of "live" circuits. Follow all local lock-out/tag-out procedures before continuing.

2. Connect the source cable to
   a. the SOURCE connector on the unit's rear panel
   b. the receptacle on the atmosphere side of the source's electrical feedthrough on the process chamber.

NOTE

Refer to the respective technical manual(s) for installation and start up information.

3. Attach the user supplied interlock cable to
   a. the INTERLOCK connector on the controller's rear panel
   b. the external interlock circuit.

CAUTION

To avoid controller damage, do not wire the external interlock to a powered circuit.

4. Connect the cable(s) between the appropriate connector(s) on the unit's rear panel and the MFC(s). The cable type and rear panel connector used depends on the MFC's communication protocol (analog or digital).

NOTE

The digital MFC feature is not active at this time.

5. If the unit will be controlled with a remote computer, connect the EIA-232 cable to
   a. the REMOTE connector on the controller's rear panel
   b. the remote computer.

NOTE

Route all signal cables at least 0.5m (20 in.) from power and source output leads to avoid inducing interference.

6. If the unit will have positive shut-off (P.S.O.) valve(s), connect the cable(s) between the appropriate row on the GAS FLOW P.S.O. connector on the controller's rear panel and the user supplied P.S.O. valve(s) and power supply.

7. Make the following source gas connections:

   a. the gas supply and the MFC's gas input connector

   b. the gas line between the MFC's gas output connector and the P.S.O. valve (if used)

   c. the P.S.O. valve (if used, or MFC, if not) and the atmosphere side of the source's gas feedthrough to the process chamber.

8. Attach the controller's external ground connection to the process chamber.

9. Attach the controller's power cable. Refer to the "Specifications" on page 44 for more installation information.

NOTE

It is the user's responsibility to meet all local and national electrical codes when installing this equipment.

The unit is ready to power up.

Source

For best results, use the feedthrough(s) provided with the source and the cable furnished with the controller to connect these devices. Refer to "Figure 4.1" on page 9. If the recommended feedthrough is not used, ground the ion source body to the process chamber close to where the unit is grounded on the atmosphere side of the chamber. These two grounding points should not be separated by a bolted joint in the process chamber.

NOTE

Refer to the respective technical manual(s) for installation and start up information.

Attach the controller's external ground connections to the process chamber. This controller ground connection is in addition to the safety ground wire in the line cord, and is required to prevent ground loop currents from adversely affecting source operation.

⚠WARNING

The unit has separate ground connections for user safety. To avoid electrical shock, maintain the safety ground connection during routine operation.

Interlock Connector

The INTERLOCK connector is wired in series with pins on the output SOURCE connector. Refer to "Figure 4.1" on page 9. The controller interlock is made when: the source cable is attached to the SOURCE connector and the user provided external interlock string is attached to the INTERLOCK connector. The unit's outputs are disabled if either the source cable is disconnected at the rear panel or the interlock string is open (the touch screen remains active). Refer to "Interlock" on page 50.

NOTE

If there are two or more interlocked shut-off switches in the system, the system interlock allows these switches to be connected in series.

Mass Flow Controller(s)

It is recommended that the gas outlet is located within 1.8m (6 ft.) of the gas port(s). Use ¼ in. OD stainless steel tubing for the gas line and a reducing union between this tubing and the gas feedthrough. Gas type and gas line length downstream of the MFC may affect source-controller operation; refer to "Gas Flow Controller Function" on page 8. Avoid switching tubing diameters along the gas line unless necessary. Diameter changes may greatly increase the delay before a flow change reaches the ion source. If heavier gases are used (such as xenon), or if non-standard gas lines are used, control loop parameters may need to be adjusted for stable operation. In this case, contact "Service Support" on page 39 for recommendations and assistance. Separate electrical connectors are provided for analog and digital MFCs (although the digital MFC feature is not active at this time). Refer to "Gas Flow Connectors" on page 53.

NOTE

Refer to the MFC's technical manual for additional information on this device.

Positive Shut-off Valve

An MFC is not intended to function as a positive shut-off device and will not be leak tight when closed. The GAS FLOW P.S.O. connector has pairs of dry closure contacts (no voltage is supplied) intended to open up a normally closed shut-off valve located upstream or downstream of each of four MFCs. Refer to "Gas Flow Connectors" on page 53.

NOTE

It is the user's responsibility to provide power to actuate the P.S.O. valves. Refer to the technical information provided with the valves.

Remote Communication

There are two methods of remote communication: analog (via a legacy protocol) and digital (using the EIA-232 command set). A single REMOTE connector has pin assignments for each method. Refer to "Remote Operation" on page 33 for detailed information.

Chapter 5: Operation

General

Refer to "Installation" on page 9 to verify that the Mark II® Controller is ready to power up before continuing. Confirm that installation and start-up information in the source technical manual has been followed as well.

NOTE

These instructions are presented for local operation with the touch screen. Remote operation using Virtual Front Panel software (optional) and a PC (provided by others) may be slightly different.

Start-up

Follow these steps when operating the unit for the first time, or if the system has not been operated for a while.

Chamber Pumpdown

Evacuate the process chamber to the desired operating pressure and hold this pressure until significant out-gassing subsides. This interval is somewhat process dependent. Good vacuum practice helps to reduce the wait time.

Controller Power Up

To energize the controller:

1. Turn the Mains Disconnect switch (provided by others) to the ON position.
2. Turn the ON/STANDBY switch on the controller's front panel to the ON position. The unit's start-up sequence begins.

   Start-up is complete when the touch screen looks similar to "Figure 5.4" on page 19.

NOTE

Screen selections may be made by using the touch screen (in LOCAL mode) or by the user supplied computer (in REMOTE mode). The touch screen selection is typically made by a touch-and-lift motion,

rather than by simply touching. If the wrong screen area is touched, keep finger contact with the screen and slide off the button before lifting away.

The controller is ready to receive configuration information for your system.

Beginning Automatic Operation

This section explains how to configure the unit and prepare it for routine operation. Here is a brief summary of the steps required:

MFC Configuration – If the source and controller were purchased together, MFC configuration settings were entered at the factory. If the MFC range or source gas changes, refer to "MFC Configuration" on page 16.

Gas Line Purging – Air becomes trapped in the gas line(s) during initial device/controller installation and whenever the process gas changes. Use the steps under "Gas Line Purging" on page 20 to remove trapped air from the process gas supply line(s).

Auto Mode Configuration – These modes offer different levels of user influence over controller operation. One is used to compensate for performance differences between the Mark ⊕ controller and legacy equipment. Changing modes also changes the analog inputs used to influence the unit's control algorithms. Refer to "Remote Operation" on page 33 for detailed information on analog inputs. The parameters and control modes are:

- Anode Start Voltage
- Anode Current
- Emission Current.

Refer to "Auto Mode Configuration" on page 21 for more information.

AI Servo Configuration – The Anode Current (AI) Servo Configuration settings permit the user to fine tune anode current/gas flow control loop operation. Refer to "Gas Flow Controller Function" on page 8 and "AI Servo Gain" on page 71. More specifically, the user may:

- match source type to gain factor
- adjust source-controller performance to optimize process
- tailor source-controller performance to existing hardware
- manage process transients

The AI Servo Configuration selections are only applicable when the ANODE CURRENT CONTROL MODE (on the Auto Mode Configuration list) is set to Anode Current Setpoint. Refer to "Auto Mode Configuration" on page 21 **for details.**

Enter Adjustable Parameters – A *Source Run Data sheet* is provided with each new Mark⊕ series ion source. The factory tested parameters recorded on this data sheet are: anode current and voltage, neutralization current, filament current, emission current, source gas flow, and process chamber pressure. The Source Run Data sheet offers useful reference information on source-controller performance at the time of shipment. Operating parameters from existing systems may be utilized instead.

Source Gas Start Flow – The source gas start flow needed to successfully initiate a discharge plasma depends on: the gas type, the vacuum system's pumping speed and other system and/or process related characteristics. Refer to "Source Gas Start Flow" on page 28 to identify this parameter.

NOTE

The unit retains the parameters entered before its last run. Compare these values to those on the Source Run Data sheet before re-entering any data.

MFC Configuration

Several MFC-specific values and parameters must be set in the unit before operating the source. They are accessible from the Select Function dialog box which opens with the UTILITIES button.

These parameters are:

- the MFC's range
- the gas used to calibrate the MFC
- the gas to be run in the MFC
- the gas flow limit.

Follow these steps to properly configure the controller to match the MFC:

1. Press the UTILITIES button; the Select Function dialog box opens.

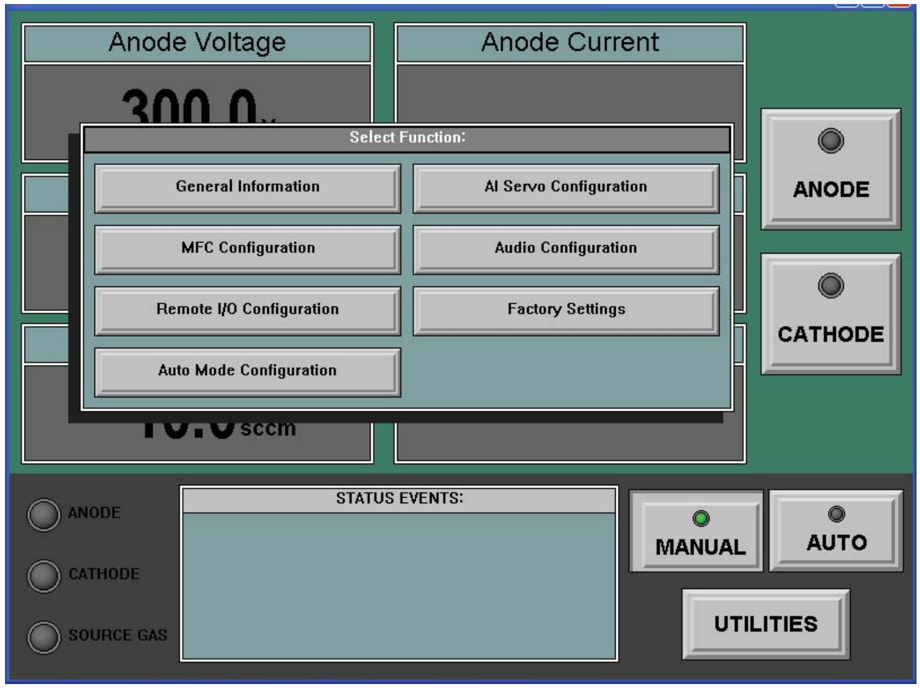


Figure 5.1 UTILITIES - Select Function Dialog Box

2. Press the MFC Configuration button; the MFC Configuration list opens.

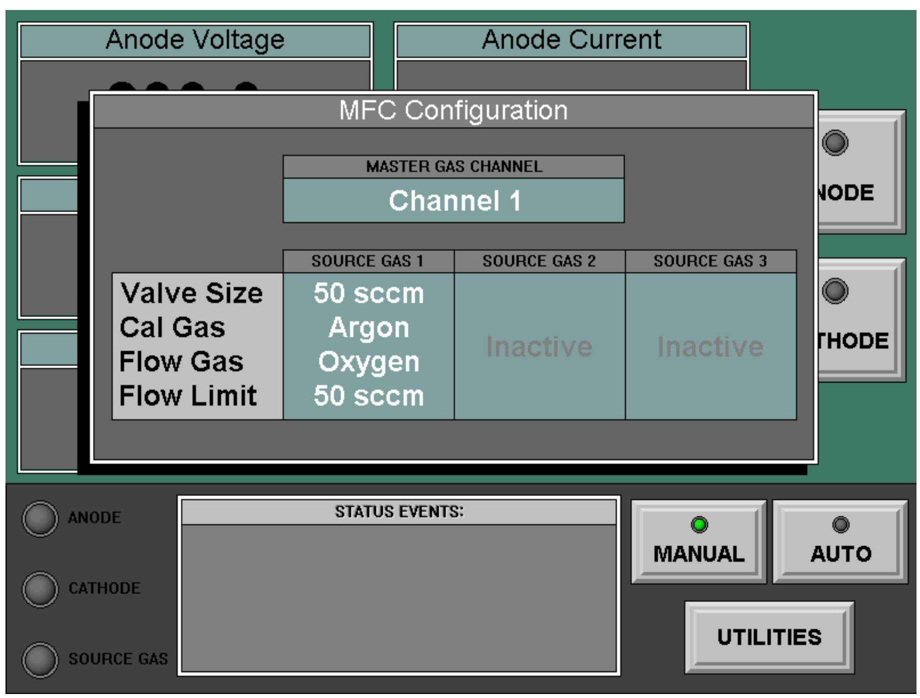


Figure 5.2 UTILITIES - MFC Configuration List

3. Press the values in the SOURCE GAS 1 column; the 'Is this MFC Installed?' dialog box opens.

4. Press the Active button; the MFC Valve Size keypad opens. The valve size is the maximum gas flow used to calibrate the valve.

5. Press the MFC's valve size and ENTER on the keypad; the 'Select the gas that the MFC was calibrated on' list opens.

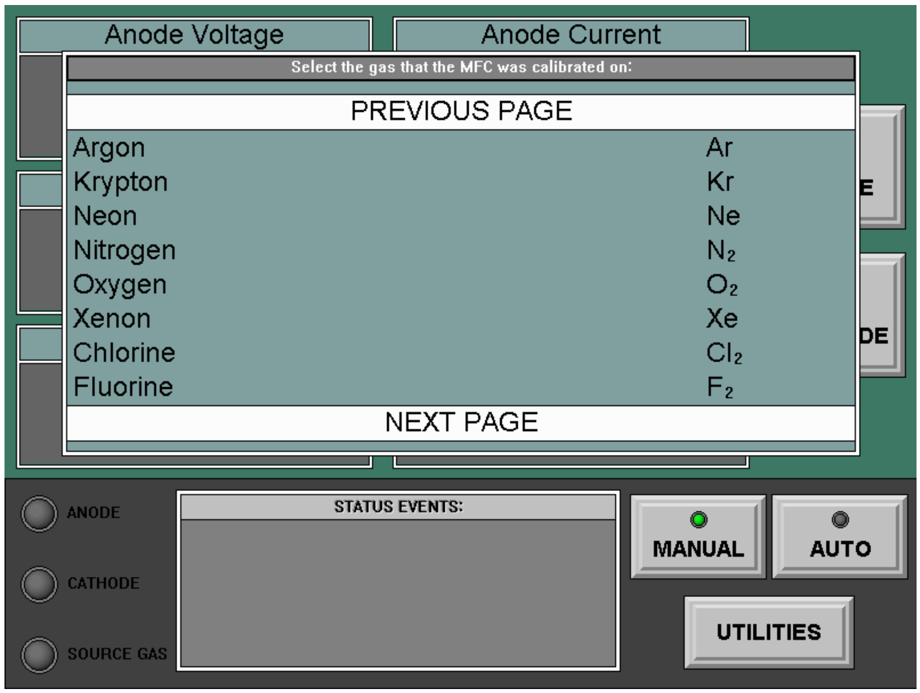


Figure 5.3 MFC Configuration - Calibration Gas Selection

6. Press the gas used to calibrate the MFC; the 'Select the gas that will be flowing in the MFC' list opens.

7. Press the gas to be run in the MFC; the MFC Flow Limit keypad opens.

8. Press the maximum gas flow and ENTER on the keypad. This is the largest value the user can enter in MANUAL mode and which the anode current control loop can utilize in AUTO mode.

9. Repeat steps 1. through 8. for Gas 2, and Gas 3 (if available).

Master Gas Channel Selection

The master gas channel must be selected if multiple source gas MFCs are active. For best results, the master gas channel should allow maximum gas flow when a source discharge is present in AUTO mode. The flow properties of additional gas channels are expressed as a percentage of the master gas channel. The master gas channel is always on when the controller is in AUTO mode and the source discharge is present.

Follow these steps to select the master gas channel:

1. Press the MASTER GAS CHANNEL display bar; the Select Master Gas Channel dialog box opens.

2. Press the desired Channel button; the dialog box closes and the selection appears in the display bar.

Manual Operation

The MANUAL mode offers independent control of each power supply module and MFC. It is intended primarily for diagnostic/troubleshooting purposes and to perform gas line purging; the automatic start sequence is disabled.

NOTE

For best results, Veeco recommends using the controller in AUTO mode for routine operation.

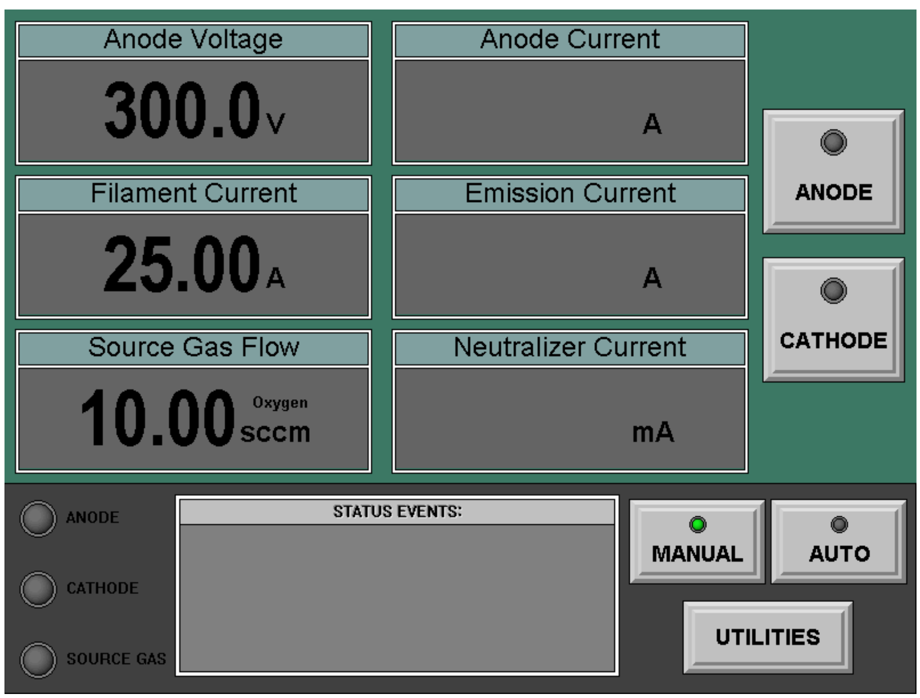


Figure 5.4 Touch Screen - MANUAL Mode

Gas Line Purging

Follow these steps to remove any trapped air in the gas line(s) after initial installation or whenever the process gas supply changes.

NOTE

Purge the line(s) after process chamber pumpdown, but before beginning source operation.

1. Press the MANUAL button; the button's indicator changes to green.
2. Press the Source Gas Flow display bar; the Flow Target keypad opens.

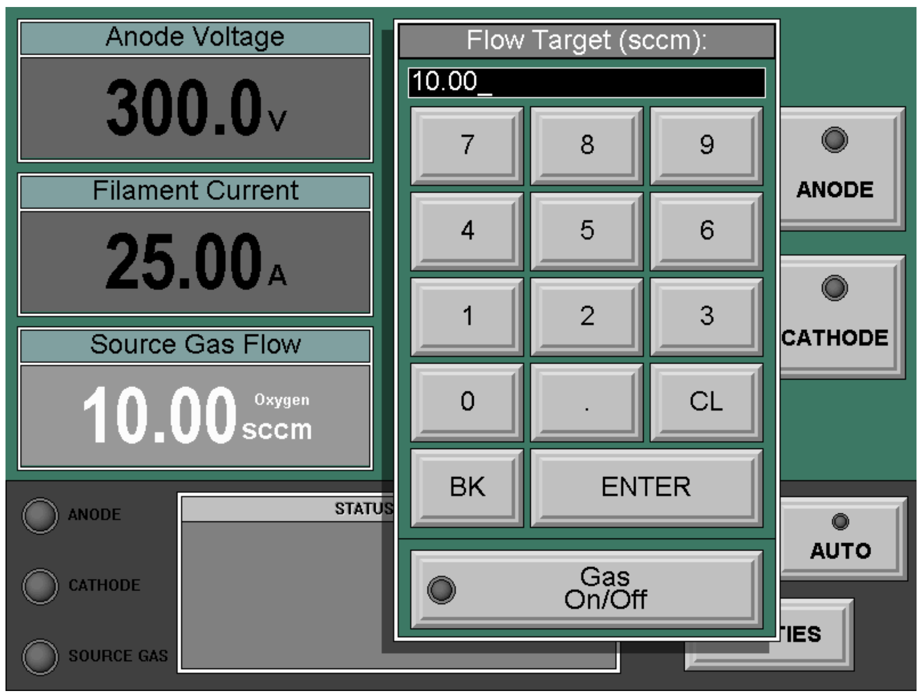


Figure 5.5 Source Gas - Flow Target Keypad

Press the maximum allowable gas flow for the MFC's size and gas type and ENTER on the keypad.

3. Press the GAS On/Off button; the button's indicator changes to green.
4. Close the shut-off valve on the gas regulator or at the supply source; allow at least 15 minutes to purge the gas line from the process chamber feedthrough back to the main shut-off valve.

NOTE

More time may be necessary if gas cleanliness is a major concern.

5. Press the Source Gas Flow display bar and the GAS On/Off button again; the green indicator goes out.

6. Open the main shut-off valve on the gas regulator or the supply source.

7. Adjust the gas regulator valve to 140kPa ±10kPa (20 psig ±2 psig).

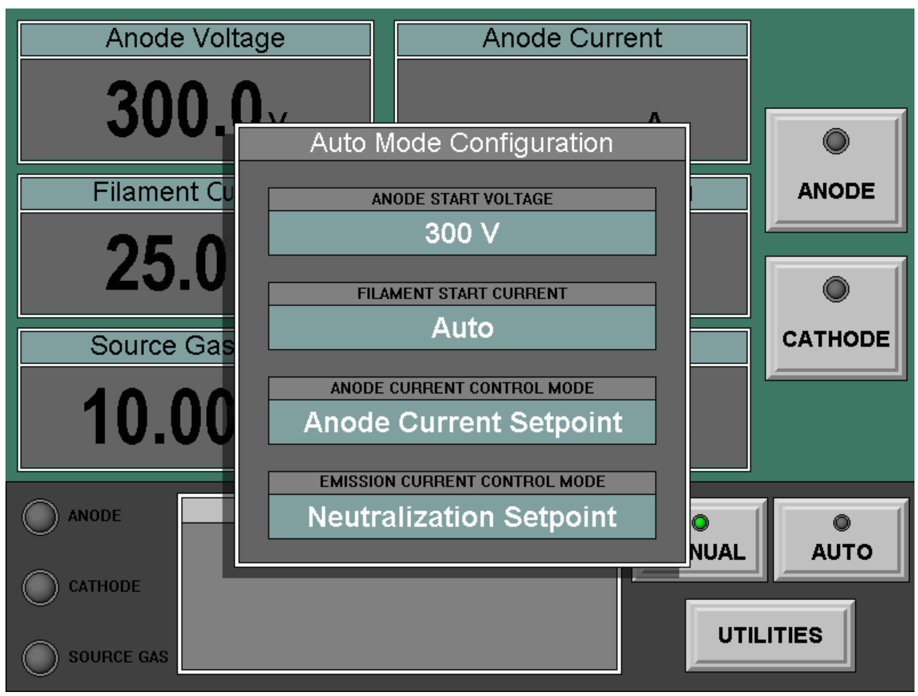
Auto Mode Configuration

The Auto Mode Configuration of analog inputs 2 and 3 may be set from the front panel. The available modes are summarized in Table 6.1: on page 33.

1. Press the UTILITIES button; the Select Function dialog box opens.

2. Press the Auto Mode Configuration button; the Auto Mode Configuration list opens.

Figure 5.6 Auto Mode Configuration List



3. To select the ANODE START VOLTAGE, press the display bar. The Anode Start Voltage keypad opens. This parameter sets the anode voltage used in the auto start sequence. The factory setting is 300V; some legacy systems may utilize an anode start voltage of 170V. Once the parameter is entered, the keypad closes and the value appears on the display bar.

4. The FILAMENT START CURRENT has Auto mode as the factory setting. This means that during the auto start sequence, the controller will raise the cathode current until the source ignites, then adjust to the target value.

   To manually adjust the filament start current, press the display bar. The Filament Start Current keypad opens. Press the desired value and ENTER on the keypad. During the auto start sequence, the controller will raise the cathode current to this value before turning on the anode.

NOTE

The Auto mode is the recommended choice, unless the process is particularly sensitive to electrostatic discharge issues.

5. To select the ANODE CURRENT CONTROL MODE, press the display bar. The 'Which type of Anode Current Control?' dialog box opens with the following buttons:

   - Anode Current Setpoint
   - Source Gas Setpoint.

   Choosing the *Anode Current Setpoint* control mode means that the controller will vary the source gas flow to attempt to maintain a constant anode current. Choosing the *Source Gas Setpoint* control mode means the controller will maintain a constant start/run gas flow; the anode current will vary over time.

NOTE

The Anode Current Setpoint control mode is the recommended choice.

   After one of the buttons is pressed, the dialog box closes and the selection appears on the display bar.

6. To select the EMISSION CURRENT CONTROL MODE, press the display bar. The 'Which type of Emission Current Control?' dialog box opens with the following buttons:

   - Neutralization Setpoint – The controller adjusts the neutralizer current to either an offset or a ratio of the anode current, entered from the Neutralizer Current display bar.
   - Emission Current Setpoint – Some processes may cause the anode current to vary. When the *Emission Current Setpoint* is chosen, the neutralizer current is derived from the parameter entered on the Emission Current display bar.
   - Filament Current Setpoint – This option is offered for legacy users who prefer manual control of emission current.

NOTE

The Neutralization Setpoint control mode is the recommended choice.

After one of the buttons is pressed, the dialog box closes and the selection appears on the display bar.

7. Press a neutral screen area to close the Auto Mode Configuration list.

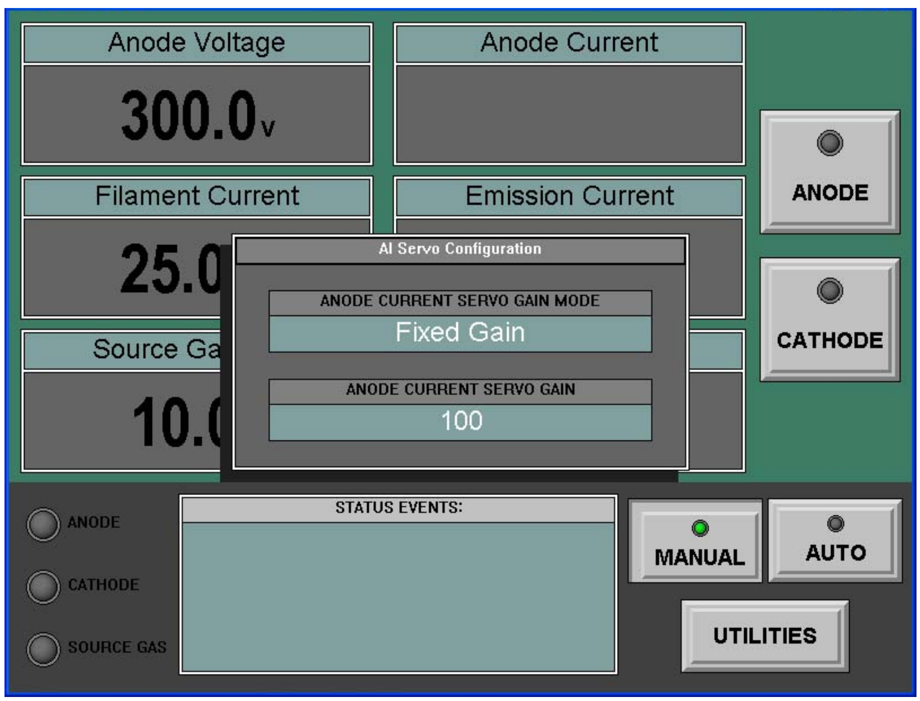
AI Servo Configuration

Follow these steps to set the AI Servo Configuration:

1. Press the UTILITIES button; the Select Function dialog box opens. Refer to "Figure 5.1" on page 17.

2. Press the AI Servo Configuration button; the AI Servo Configuration list opens.

Figure 5.7 UTILITIES - AI Servo Configuration List.



3. To select the ANODE CURRENT SERVO GAIN MODE, press the display bar; the AI Servo Gain Mode dialog box opens.

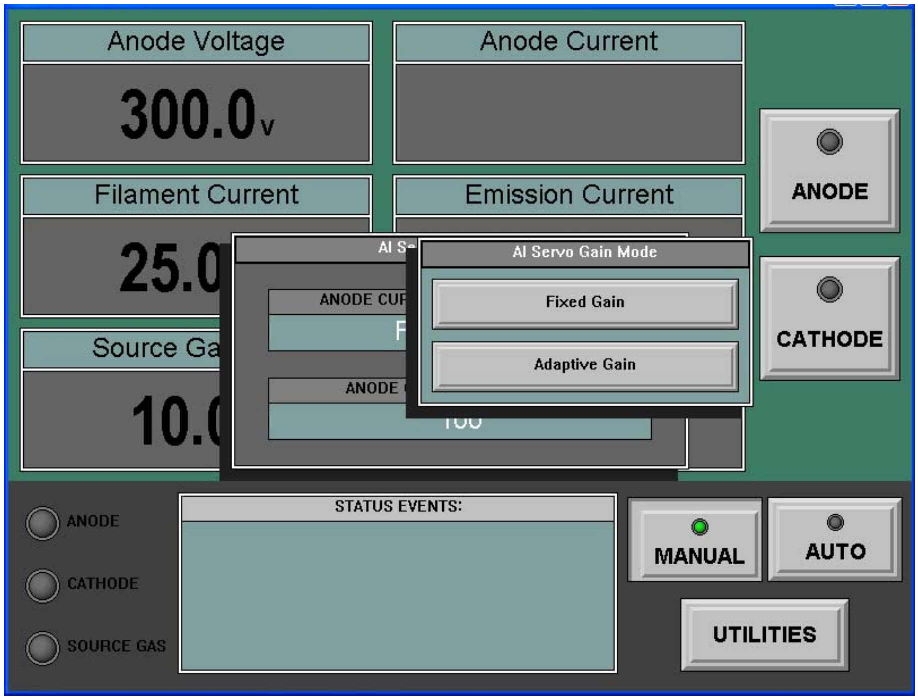


Figure 5.8 UTILITIES - AI Servo Gain Mode Dialog Box.

The are two different AI Servo Gain modes available for anode current setpoint control, depending on local application needs:

- Fixed Gain – This is a constant gain factor; it is either a factory recommended value that is ion source type-specific, or a user selected setting.
- Adaptive Gain[1] – This mode enables the controller to monitor changes in the source's process environment and dynamically adjust the gain factor during automatic operation.

After one of the buttons is pressed, the dialog box closes and the selection appears in the display bar.

4. Confirm which Mark series ion source (Mark or Mark ⊕) is connected to the Mark ⊕ Controller. Refer to the ion source technical manual for details or contact "Service Support" on page 39 for assistance.

The ANODE CURRENT SERVO GAIN factor must now be chosen (or verified); this factor will always be used (Fixed Gain mode) or be used initially (Adaptive Gain mode).

1. Patent Pending

5. To match the servo gain to the source type, press the ANODE CURRENT SERVO GAIN display bar; the Select Ion Source Type dialog box opens.

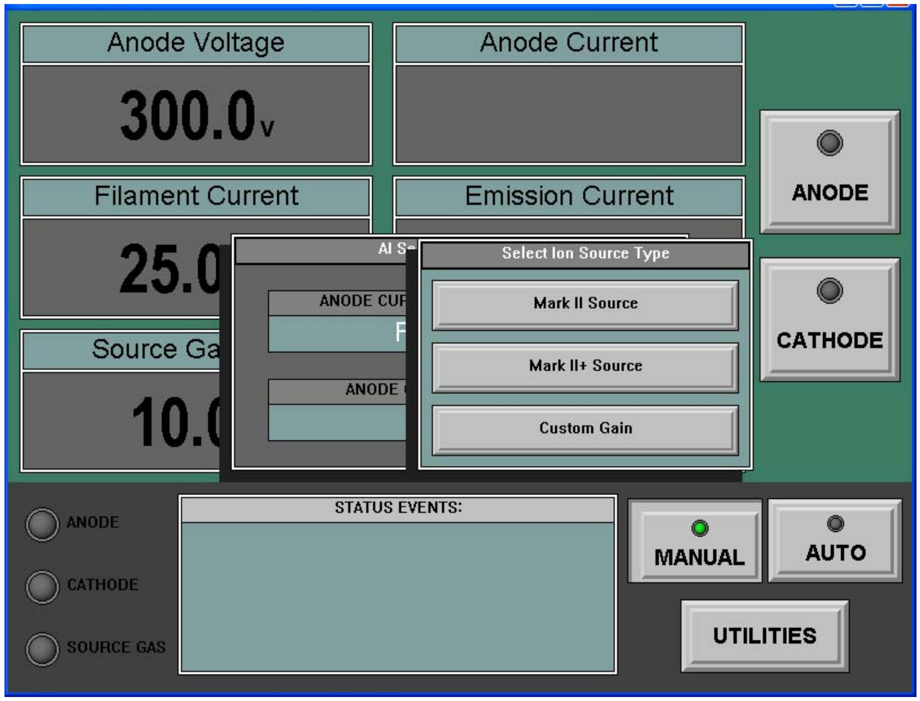


Figure 5.9 ANODE CURRENT SERVO GAIN - Select Ion Source Type Dialog Box.

6. Press the button for the source installed; the dialog box closes and the selection appears in the display bar. The controller is now set to the factory recommended anode current servo gain for the selected ion source. Refer to “AI Servo Gain” on page 71 for details.

NOTE

In most cases, it is sufficient to confirm Fixed Gain mode and match the servo gain to the installed ion source type to facilitate effective anode current regulation by the Mark ⊕ Controller.

Custom Gain

The Custom Gain adjustment is intended for situations where the Mark ⊕ controller’s dynamic response is unsatisfactory for reasons related to local process and/or hardware conditions. Refer to “AI Servo Gain” on page 71 for details.

When these conditions arise, the factory recommended servo gain values may be used as a starting point, to experimentally determine a more appropriate custom gain setting.

1. Repeat steps ”1.” on page 23 through ”3.” on page 24 and step ”5.” on page 25. Press the Custom Gain button; the Custom AI Servo Gain keypad opens.

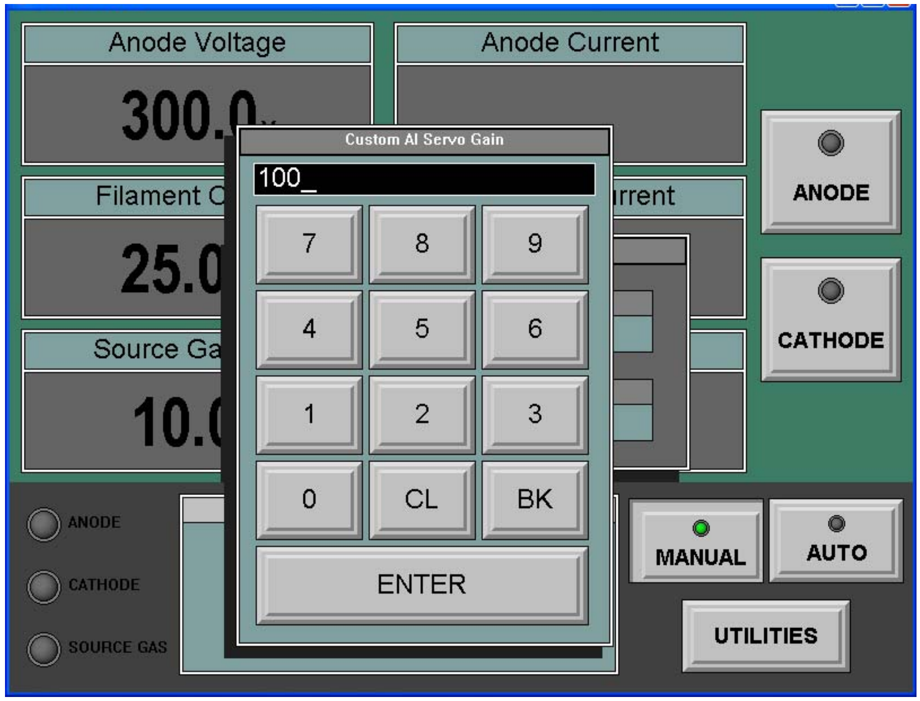


Figure 5.10 Select an Ion Source Type Dialog Box - Custom Gain.

2. Press the desired setting and Enter on the keypad; the keypad closes, and the selection appears on the display bar.

   Refer to Table F.1: on page 72 for suggested custom gain factor ranges, as well as the factory default values.

NOTE

Veeco recommends using the source type specific Anode Current Servo Gain values, as they have been tested and optimized for the routine ion source ignition and setpoint change conditions.

Enter Adjustable Parameters

Follow these steps to enter adjustable parameters into the controller:

1. Press the AUTO button; the button's indicator changes to green. The BEAM button replaces the ANODE, and CATHODE buttons on the right side of the screen.

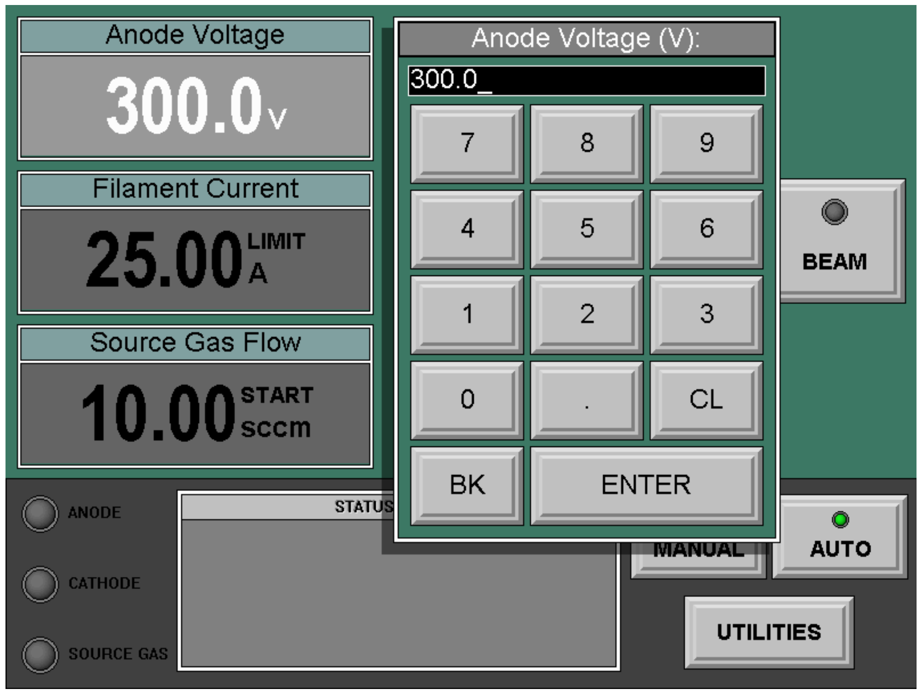


Figure 5.11 Anode Voltage Keypad

2. Press the Anode Voltage display bar; the Anode Voltage keypad opens.

3. Press the desired value and ENTER on the keypad.

4. Repeat Steps 2 and 3 for
   - Filament Current Limit (A)
   - Source Gas Start Flow (sccm); see "Figure 5.12" on page 28.
   - Anode Current (A)
   - Neutralizer Current (mA).

NOTE

The Neutralizer Current may be entered either as a fixed value or as a ratio of the Anode Current, when Neutralization Setpoint is chosen as the Emission Current Control Mode.

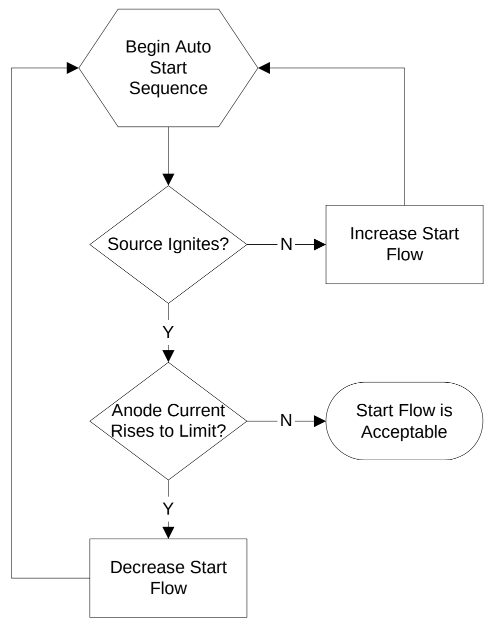
Source Gas Start Flow

Follow these steps to identify the start flow parameter:

1. Choose a trial value, either from the Source Run Data sheet or prior operating experience.

2. Use Figure 5.12 to optimize the start gas flow.

Figure 5.12 Finding a Start Gas Flow



Automatic Operation

Press the BEAM button; the button's indicator changes to green. The auto start sequence begins. The controller starts the source gas flow and applies an anode voltage as well as a filament current to begin a source discharge. Once discharge begins, the unit adjusts the filament current and source gas flow (up to their target limits) to maintain the target anode current and neutralization parameters.

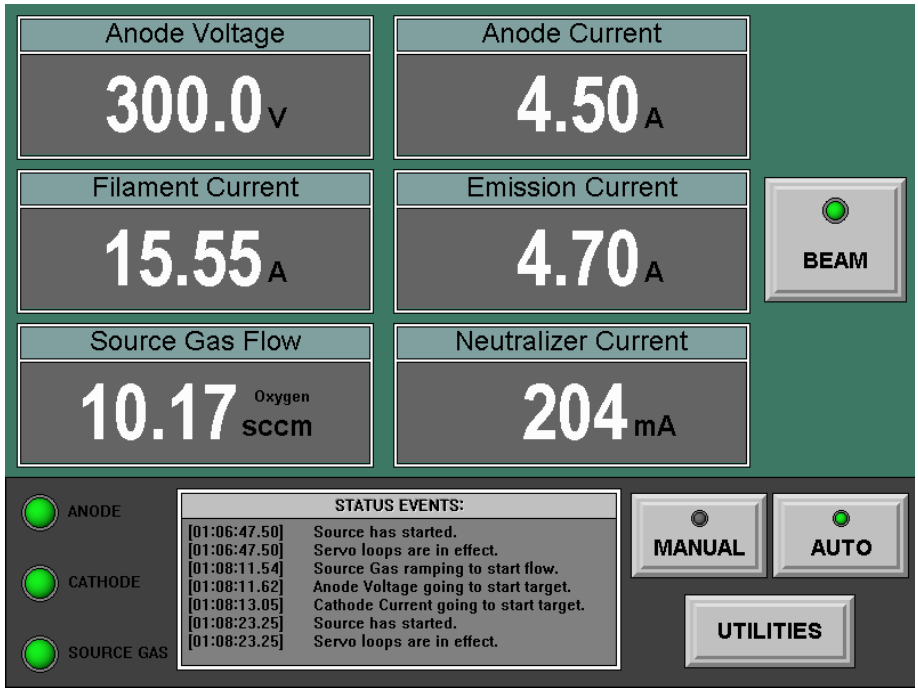


Figure 5.13 Touch Screen - AUTO Mode, Beam On

STATUS EVENTS Window

The STATUS EVENTS window displays the steps the controller performs and reports any errors or faults that may occur. The unit retains over 200 lines of status event history, although only the last seven are displayed in this window. Press the STATUS EVENTS window; the Full Status Event list appears to show this retained status event history.

Status Indicators

The unit has these visual status indicators to the left of the STATUS EVENTS window: ANODE, CATHODE, and SOURCE GAS. The following colors represent the module's state:

- grey (dimmed) – standby condition, module off
- green – module on, operation within target limits
- yellow (flashing) – fault and/or abnormal condition, or operation outside target limits.

Press any of the module status indicators to open the MODULE STATUS INFORMATION window. This window provides module activity details and general controller condition.

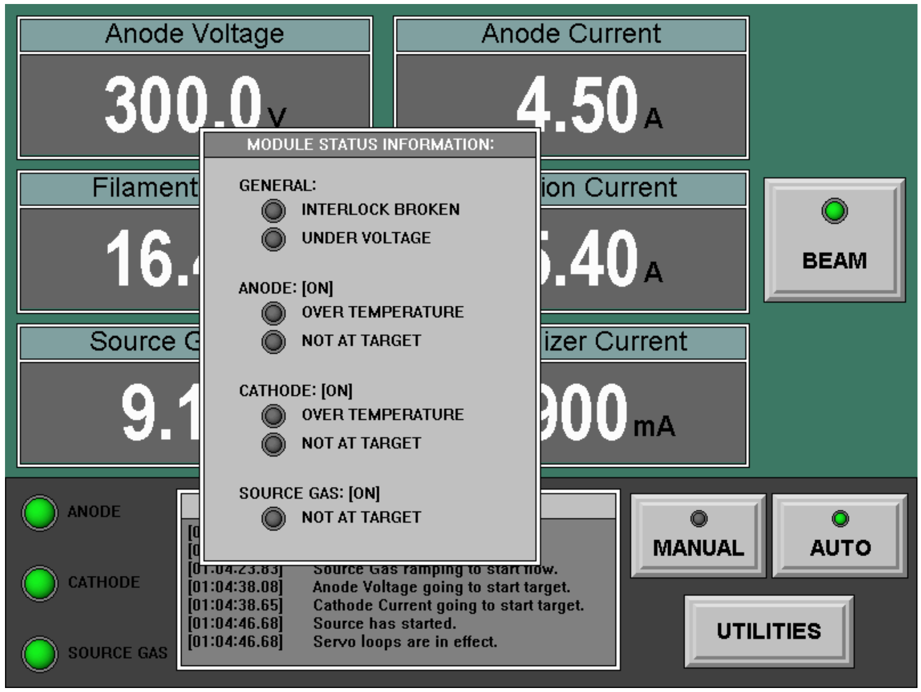
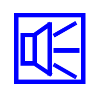


Figure 5.14 Touch Screen - Module Status Information

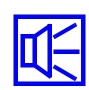
Audible Status Indicators

The controller has two audio alarms:

- The **module status** alarm sounds if any module status indicators display a fault and/or abnormal condition, or operation outside target limits.



- The **beam fault** alarm sounds if a fault turns off the beam when the controller is in AUTO mode.



The controller alarms may be silenced by touching a neutral screen area or by clearing the fault condition.

NOTE

These sounds may be heard by clicking either of the buttons above, when viewing this page on a sound capable work station.

Follow these steps to change the alarm sound settings:

1. Press the UTILITIES button; the Select Function dialog box opens.

2. Press the Audio Configuration button; the Audio Configuration List opens.

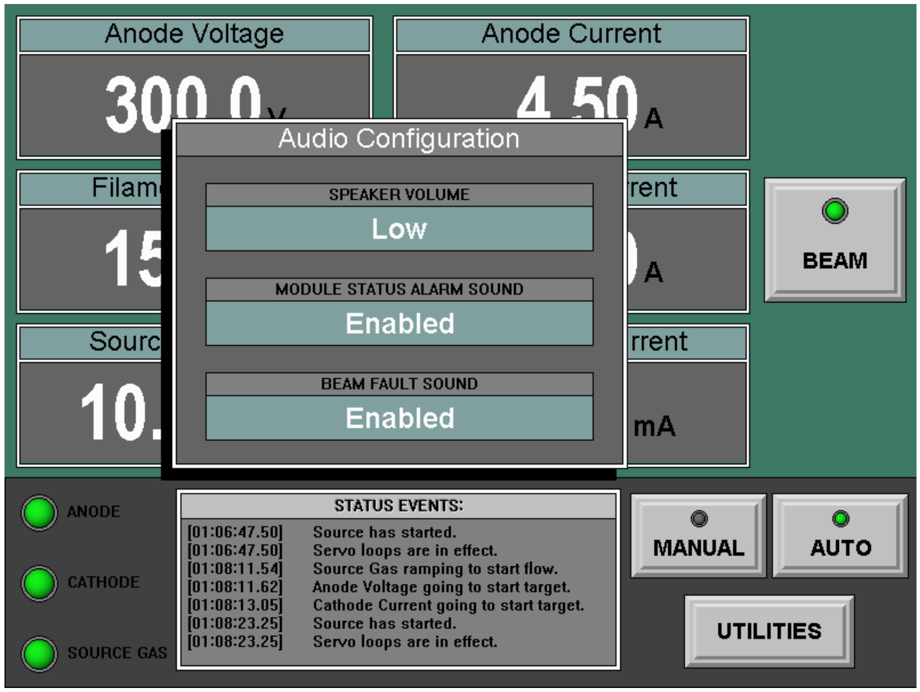


Figure 5.15 Audio Configuration List.

3. Press the desired display bar to

   a. adjust the SPEAKER VOLUME (Muted, Low, Medium or High)

   b. enable or disable the MODULE STATUS ALARM and/or the BEAM FAULT sound(s).

Shut Down

1. Press the BEAM button; the green indicator goes out.

2. Wait at least 15 minutes before venting the process chamber to atmosphere.

CAUTION

To avoid overheating and possible magnet damage, let the source cool at least 15 minutes before venting the process chamber to atmosphere.

Troubleshooting

Refer to the Mark⊕ series Source/Controller Troubleshooting technical manual for detailed information.

Chapter 6: Remote Operation

General

The Mark II® Controller may be operated remotely via analog/digital control or EIA-232.[1] All remote control signals are available on the REMOTE connector on the rear of the unit. See "Table C.2:" on page 51.

Analog Remote Control

There are three analog inputs that may be used to set certain targets for the controller. Each input consists of two pins. The positive (+) pin must carry the 0 to 5V DC signal which is referenced to the negative (–) pin. For example, Analog 1+ uses pin 4 and is referenced to Analog 1– which uses pin 17. The default input signal range is 0 to 5V DC where 5V represents the full scale value. It is possible to change the input range to 0 to 10V DC. Contact "Service Support" on page 39 for assistance, if this voltage range is required. Analog Inputs 2 and 3 may be set by following "Auto Mode Configuration" on page 21. The relationship between the analog inputs and Auto Mode Configuration is shown Table 6.1:

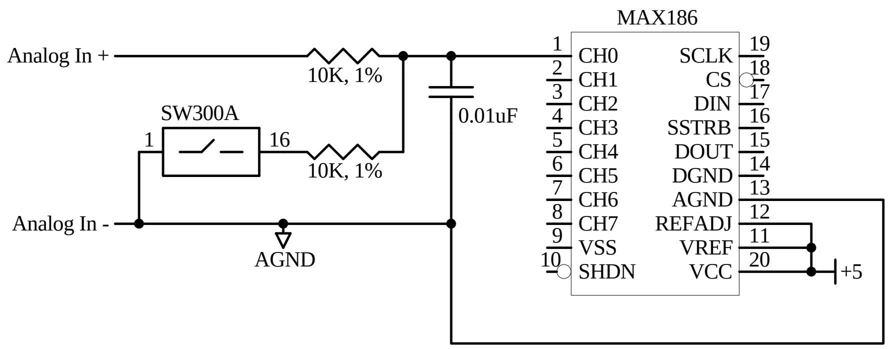
Table 6.1: Analog Input vs. Auto Mode Configuration

Analog Input	Auto Mode Configuration	Controller parameter
1	Full Scale Anode Voltage	value = 5V full scale
2	Anode Current Setpoint	5A
	Source Gas Setpoint	value = 5V full scale
3	Neutralization Setpoint	target = 1.1V + (2.1 * I_{NEUT})
	Emission Current Setpoint	7A
3	Filament Current Setpoint	25A

1. Formerly known as, and identical to, RS-232.

Once Analog Input 3 is set to represent the neutralizer current, the target is calculated by the equation shown in Table 6.1: on page 33:

Figure 6.1 Analog Input Equivalent Circuit



When the analog inputs are enabled, a signal must be connected to each one. A floating input will cause its respective target to be undefined.

CAUTION

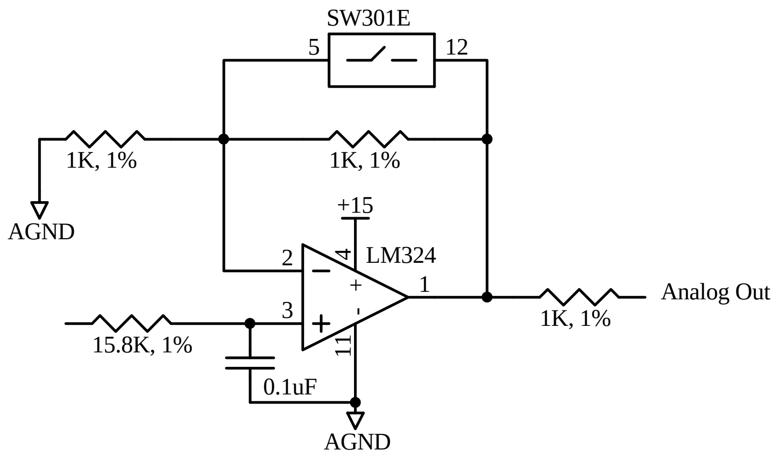
Floating analog inputs may result in source damage.

The analog inputs are only read and processed when the Remote Run signal is active. The controller uses these signals as targets only. They do not directly control any parameters.

Analog output usage is not mandatory. However, the outputs can be monitored to verify that the controller is operating at the desired parameters. The analog outputs are active even if the unit is not controlled remotely. The analog output signals are referenced to analog ground (pin 10). The available output parameters are: source gas flow, emission current, neutralizer current, anode current, anode voltage and cathode current. The default output range is 0 to 5V DC, where 5V represents a parameter's full scale value. The output range may be changed to 0 to

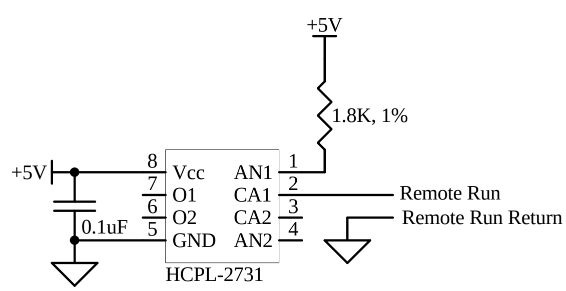
10V DC full scale. Contact "Service Support" on page 39 for assistance, if this voltage range is required.

Figure 6.2 Analog Output Equivalent Circuit



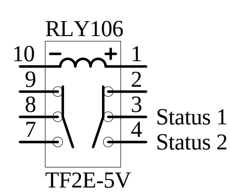
The Remote Run signal is used to place the unit into REMOTE mode and to start/run the source. This signal is activated by connecting the Remote Run and Remote Run Return pins. The controller will initiate the start sequence when it detects this signal. Once the source has started, the unit will use the analog inputs to generate the targets for each parameter.

Figure 6.3 Remote Run Equivalent Circuit



The Status signal becomes active whenever the source is ignited.

Figure 6.4 Status Signal Equivalent Circuit



Remote operation is possible using just the Remote Run signal. In this mode, the analog inputs are ignored and the targets must have been set up previously with the EIA-232 interface or from the unit's front panel. Refer to "Remote Run Only" on page 37.

Analog I/O Configuration

Follow these steps to configure the analog inputs from the controller's front panel.

Remote I/O

1. Press the UTILITIES button; the Select Function dialog box opens.
2. Press the Remote I/O Configuration button; the Remote I/O Configuration list opens.

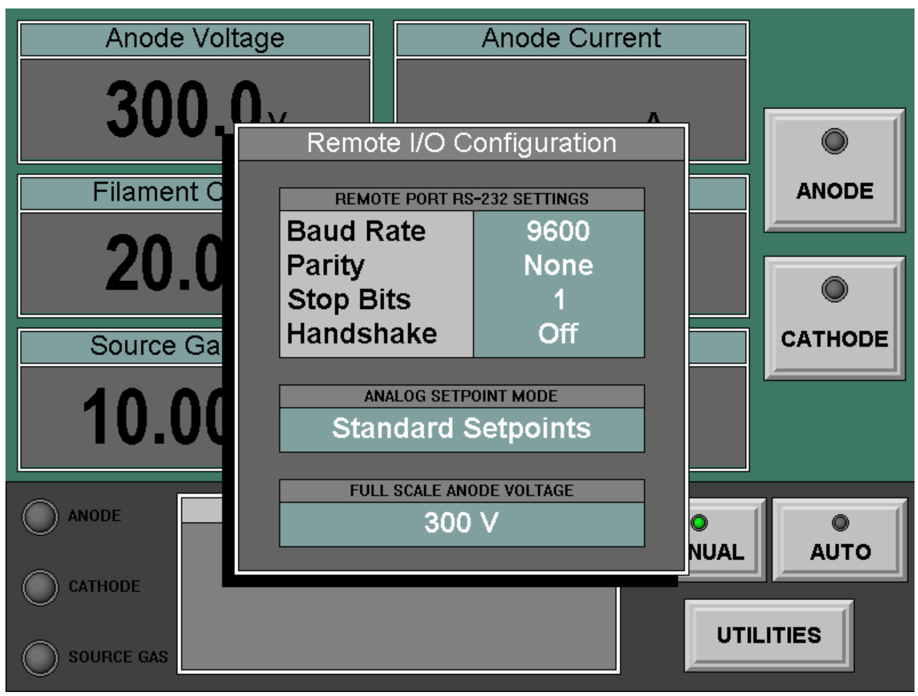


Figure 6.5 Remote I/O Configuration List

3. To select the REMOTE PORT RS-232 SETTINGS, press the display bar on the right. A series of dialog boxes open in succession for the following parameters:
   - **Baud Rate** (1200, 2400, 4800, 9600, 19200)
   - **Parity** (Even, Odd, None)
   - **Stop Bits** (1,2)
   - **Handshake** (No, Yes).

After the last button is pressed, the dialog box closes and all of these selections appear on the display bar.

NOTE

The Handshake parameter has no effect when the analog control option is installed.

4. Follow the steps in "Remote Run Only" or "Remote Run with Analog Control" on page 38 to properly configure ANALOG SETPOINT MODE.

5. To select the FULL SCALE ANALOG VOLTAGE, press the display bar. The Full Scale Analog Voltage keypad opens. This parameter sets the maximum voltage corresponding to a 5V DC signal on Analog Input 1. Once the parameter is entered, the keypad closes and the value appears on the display bar.

6. Press any neutral screen area to close the Remote I/O Configuration list.

Remote Run Only

1. Follow these steps to disable the analog inputs from the controller's front panel:
   a. Press the UTILITIES button; the Select Function dialog box opens.
   b. Press the Remote I/O Configuration button; the Remote I/O Configuration list opens.
   c. Press the ANALOG SETPOINT MODE display bar. The Select Analog Setpoint Mode dialog box opens.
   d. Press the Ignore Analog Setpoints button.
   e. Press any neutral screen area to close the Remote I/O Configuration list.

2. Connect the common contact of a relay or switch to the Remote Run pin and the normally open contact to the Remote Run Return pin on the REMOTE connector.

3. Confirm that the source will run at the desired parameters in AUTO mode.

Closing the relay or switch contacts will cause the controller to go to AUTO mode and turn on the BEAM switch. The unit's status can be monitored by the Status signal and the analog outputs if desired.

Remote Run with Analog Control

1. Follow these steps to enable the analog inputs from the controller's front panel:
    a. Press the UTILITIES button; the Select Function dialog box opens.
    b. Press the Remote I/O Configuration button; the Remote I/O Configuration list opens.
    c. Press the ANALOG SETPOINT MODE display bar. The Select Analog Setpoint Mode dialog box opens.
    d. Press the Standard Analog Setpoints button.
    e. Press any neutral screen area to close the Remote I/O Configuration list.
2. Connect the common contact of a relay or switch to the Remote Run pin and the normally open contact to the Remote Run Return pin on the REMOTE connector.
3. Connect a 0 to 5V DC signal to Analog Inputs 1, 2, and 3.
4. Confirm that the source will run at the desired parameters in AUTO mode.
5. Adjust the analog control signals to the desired voltage.

Closing the relay or switch contacts will cause the unit to go to AUTO mode and turn on the BEAM switch. The controller will use the pre-programmed start values to ignite the source. Once the source has ignited the unit will go to the target values specified by the analog inputs. The controller status can be monitored by the Status signal and the analog outputs if desired.

The Select Analog Setpoint Mode dialog box also has an Enhanced Analog Setpoints button.This choice allows more extensive parameter configuration than the Standard Analog Setpoints mode. Contact "Service Support" on page 39 for recommendations and assistance.

Chapter 7: Service Support

For service, contact:

Veeco Instruments Inc.
2330 East Prospect
Fort Collins, CO 80525
Phone: 1.888.221.1892
Fax: 970.493.1439
ftcsupport@veeco.com

When contacting Veeco Instruments Inc. for parts or service:

Provide the ion source model number and serial number.

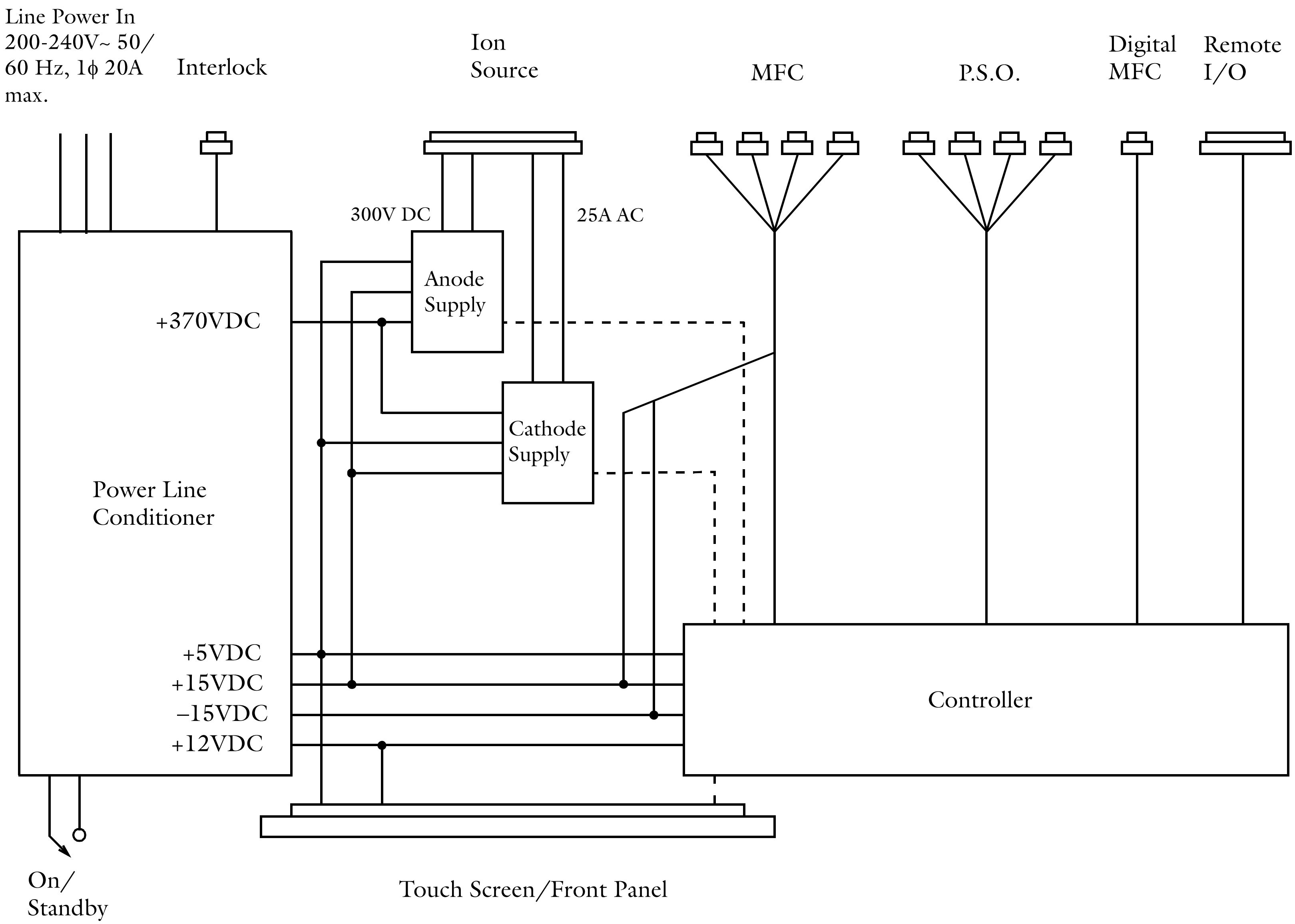
Provide the controller model and serial number; a list of all operating parameters and/or error messages displayed by the unit; gas flow rate; and process chamber pressure.

Appendix A: Drawings

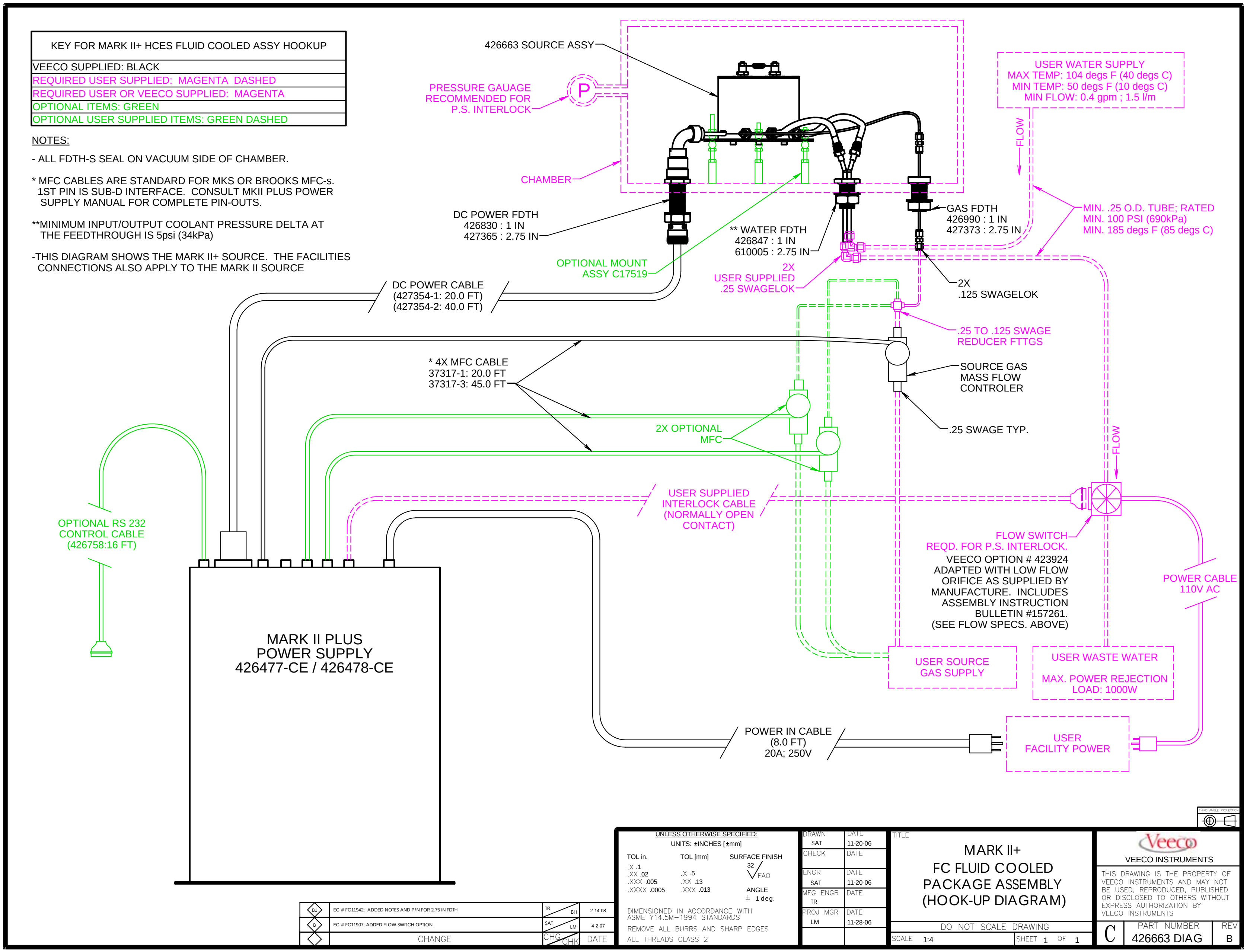
Table A.1: Drawings

Drawing Number	Description
n.a.	"Controller Block Diagram"
426663 DIAG	"Mark II⊕ Filament Cathode, Fluid Cooled Wiring Diagram"
426668 DIAG	"Mark II⊕ Filament Cathode, Radiantly Cooled Wiring Diagram"

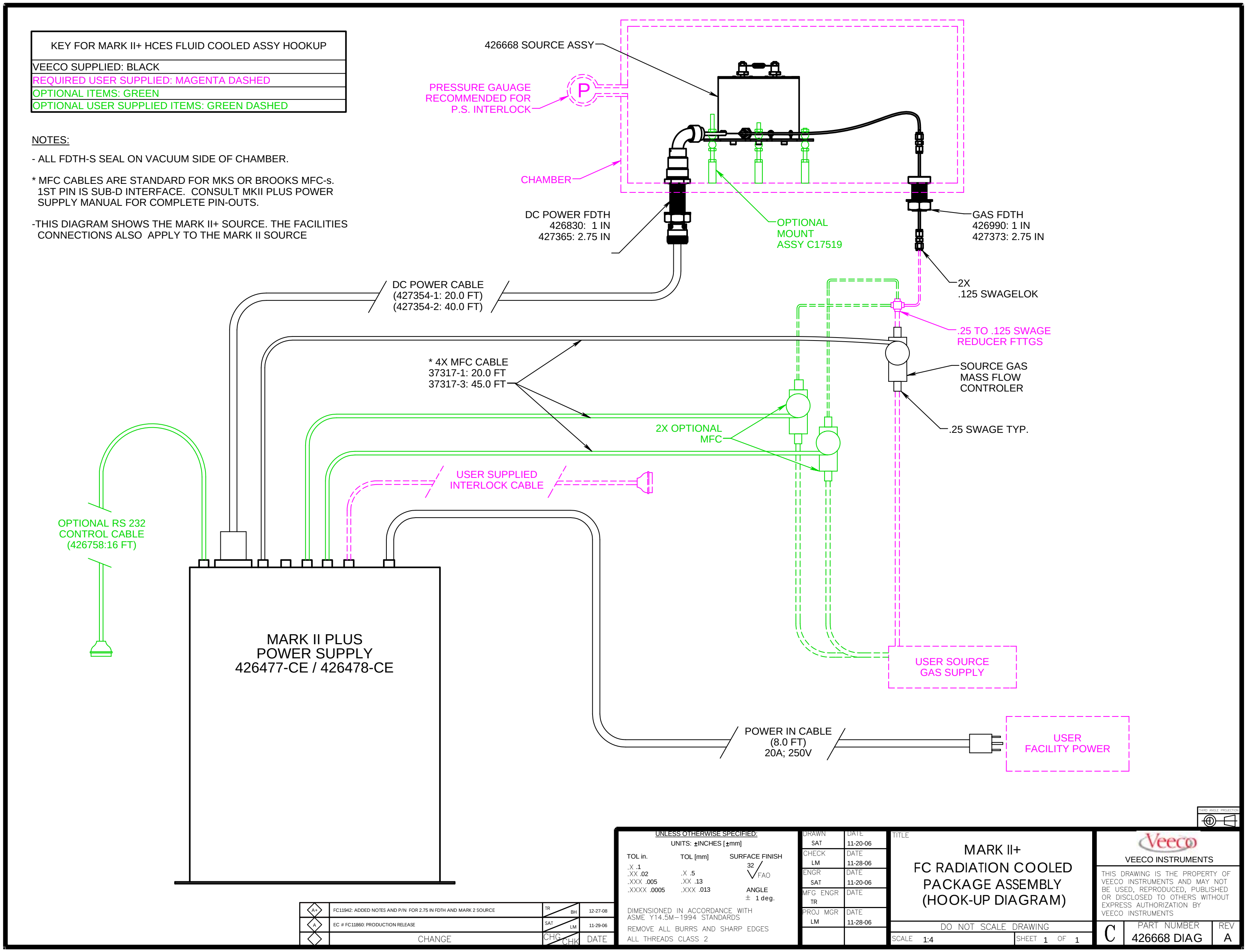
Controller Block Diagram



Mark II⊕ Filament Cathode, Fluid Cooled Wiring Diagram



Mark II⊕ Filament Cathode, Radiantly Cooled Wiring Diagram



Appendix B: Specifications

General

The Mark II$^{\oplus}$ Controller consists of a single chassis containing the cathode power supply, the anode power supply and a gas flow controller, with separate connecting cables. The unit is designed for continuous operation.

The controller is CE marked and its nameplate includes the following information:

Veeco Instruments Inc.
Terminal Drive
Plainview, NY 11803 USA

Ion Source Controller

Model: Mark II+

Rev: X

Serial Number: XXXXXXXX

Part Number: XXXXXXXXXX

Input Voltage: 200 – 240V ~

50/60 Hz 1 Phase

20A Max

Manufactured for Veeco by:

RPM Technology
4430 Innovation Drive
Fort Collins, CO 80525 USA

The Veeco CE representative in Europe is:

Vice President of International Sales and Marketing
Veeco Instruments S.A.
11, Rue Marie Poussepin
Zi De La Gaudree
91412 Dourdan, France

Electrical

Installation

The controller is a Class I grounded type equipment intended to be mounted in an enclosed instrument rack, which only allows the front of the unit to be accessible during operation. Since the controller does not have an integral Mains Disconnect, the user must provide a suitable external Disconnect switch for the controller. This external Disconnect switch is required whether the controller is attached to the Mains Supply by means of a plug-socket connection or is hard wired.

NOTE **It is the user's responsibility to meet all local and national electrical codes when installing this equipment.**

Grounding

The power cord contains a green ground wire, which must be connected to the facility's ground. Connect an additional 12 AWG (or larger) signal ground wire with green/yellow colored insulation between the ground stud located on the unit's rear panel and the process chamber ground point to provide reliable controller operation.

Characteristics

- Input Power: 200 to 240 V~, phase to neutral or phase to phase, 50/60 Hz

NOTE **The input power should not fluctuate more than ±10% during operation.**

- Current: 20A (fuse protected)
- Transient Over voltage: conforms to Installation Category II

Environmental

The controller is intended for indoor use only, requiring ordinary protection, and is not protected against harmful ingress of moisture. It is designed to operate in a laboratory environment with minimal shock or vibration.

- Ambient Temperature:
  - Operational: 10 to 35°C (50 to 95° F)
  - Storage: -20 to 60 °C (-4 to 140° F)
- Cooling: forced air
- Ambient Environment: Pollution Degree 2
- Relative Humidity:
  - operational – 20 to 85% non-condensing
  - storage – 20 to 95% non-condensing
- Altitude: below 2,500m (8,200 ft.)

Mechanical

The controller is designed to be mounted in a standard 19 inch equipment rack so that the top, bottom, sides and back are inaccessible when the unit has power and is operating. The controller should be secured to the rack at the sides with slides, not by the front panel. The unit may be located up to 7m (22.75 ft.) from the process chamber with the standard cable set. It is recommended that two persons move the controller by grasping the sides of the unit's case.

⚠ **CAUTION**

To avoid back and other injuries, two persons should move the controller by grasping the case sides.

Dimensions

- Height: 17.8cm (7 in.)
- Width:
  - case – 43.2cm (17 in.)
  - front panel – 48.9cm (19.25 in.)
- Depth:
  - case – 55.2cm (21.75 in.)
  - case and connectors – 66cm (26 in.)
- Weight: 19.1kg (42.1 lbs.)

Transport

The controller will meet the transportation shock and vibration requirements of the International Safe Transit Association (ISTA) specification, parts 2 and 2A, when properly packaged in its factory supplied shipping container.

Controller

The controller has the following characteristics:

Common Supply/Module Features

These features are common to the Cathode and Anode Supplies and Current Modules

- Current Limit protection
- Thermal protection
- Auto Start and Re-start
- Manual Start

Anode Supply

- Voltage Range: 0.0 to 300.0V DC (run)
- Current Range: 0.0 to 5.0A DC
- Adjustable Current target
- Adjustable Voltage target
- Anode Current and Voltage displays
- Over Voltage protection
- Auto Current regulation

Cathode Supply (Filament Cathode)

- Current Range: 0.0 to 25.0A RMS
- Maximum Voltage: 50V RMS
- Adjustable Current target
- Cathode Current display
- Emission Current display
- Adjustable Current limit
- Neutralizer Current display

Interfaces

Refer to "Interface Connections" on page 50 for detailed interface information.

Remote User Interface

Analog

- Analog Inputs
  - Anode Voltage set point (0 to 5V DC = 0 to full scale)
  - Anode Current or Source Gas set point (0 to 5V DC = 0 to full scale)
  - Current set points – Neutralizer or Emission
- Analog Outputs (0 to 5V DC = 0 to full scale)
  - Anode Current actual
  - Anode Voltage actual
  - Source Gas flow
  - Cathode Current actual
  - Emission Current actual
  - Neutralizer Current actual

Digital

- Digital Input – Beam On/Off
- Digital Output – Beam OK? status (relay contact closure)

Serial Interface

Complete power system operation can be accomplished via a single EIA-232 serial interface from a DB-25 receptacle on the controller's rear panel.

MFC Interface (analog)

- Four MFC outputs via supplier specific protocol on DB-15
- Four positive shut-off valves via dry closure contact on two pins of an eight pin soft shell connector (no voltage is supplied to these pins)

Controller Interlock

An electrical interlock is provided that will disable the controller if the interlock string (provided by others) is opened.

Appendix C: Interface Connections

General

The Mark II® Controller rear panel is the connection point for the various components and communication interfaces. Refer to "Figure 4.1" on page 9. The protocols and pin assignments are summarized here.

Interlock

Physical – The INTERLOCK connector is a type DB-9 receptacle.

Electrical – Refer to **Table C.1:** for pin assignment.

CAUTION

To avoid controller damage, do not wire the external interlock to a powered circuit.

Table C.1: Interlock Connector Pin Assignment

Pin No.	Signal Name	Signal Type	Function
1	Interlock 1	Input	The INTERLOCK pins must be connected together via the user supplied interlock string for the controller to operate.
6	Interlock 2	Input	
2	Bus Power Status 1	Output	The Bus Power Status pins are attached to a dry closure contact (no voltage is supplied) that indicate the state of the unit's power line conditioner bus power: a closed circuit indicates that DC bus power is present/in tolerance and an open circuit indicates that bus power is not available.
7	Bus Power Status 2	Output	
3,4, 5,8,9	n.a.	n. a.	No connection.

Physical – The REMOTE connector is a type DB-25 receptacle.

Electrical – This interface is legacy system compatible. Refer to **Table C.2:**

NOTE

Linearity is assumed for the entire range. The maximum anode voltage value is adjustable. The 0 to +5V DC ranges may be changed to 0 to +10V DC. Refer to **"Analog Remote Control" on page 33** **and** **"Analog I/O Configuration" on page 36.**

Table C.2: Remote Interface Connector Pin Assignments

Pin No.	Signal Name	Signal Type	Function
1	GAS FDBK	OUTPUT	Source Gas Flow Actual: 0 to +5V DC output, where +5V DC represents full scale output from the MFC (referenced to pin 10).
2	EI FDBK	OUTPUT	Emission Current Actual: 0 to +5V DC output where 0V DC represents 0A DC of emission current and +5V DC represents 7A of emission current (referenced to pin 10).
3	NI FDBK	OUTPUT	Neutralization Current Actual: 0 to +5V DC output where 0V DC represents 0A DC of neutralization current flowing and +5V DC represents 2A of neutralization current (referenced to pin 10).
4	AV STPT+	INPUT	Anode Voltage Set Point: 0 to +5V DC input signal where +5V DC represents the maximum anode voltage value (referenced to pin 17). Refer to "Remote I/O" on page 36 to adjust this value.
5	AI STPT+/ SG STPT+	INPUT	Anode Current: 0 to +5 V DC input signal, where +5V DC represents a maximum anode current setting of 5A DC; 3.00V DC represents a DC anode current of 3A (referenced to pin 18). Source Gas Set Point: 0 to +5V DC input signal, where +5V DC represents the MFC's full scale output (referenced to pin 18).
6	NI STPT+/ EI STPT+/ CI STPT+	INPUT	Neutralization Current Set Point: 0 to +5V DC input signal (referenced to pin 19) where the following relationship exists: NI STPT+ = 1.1V + (2.1*I_{NEUT}). For example, 1.73V DC would yield a neutralization current of 0.3A DC. Emission Current Set Point: 0 to +5V DC input signal where 5V DC represents 7A of emission current (referenced to pin 19). Cathode Current Set Point: 0 to +5V DC input signal where 5V DC represents 25.0A (referenced to pin 19).

Table C.2: Remote Interface Connector Pin Assignments (Continued)

Pin No.	Signal Name	Signal Type	Function
7	BEAM ON+	INPUT	Beam On switch: This input signal is used in conjunction with pin 20. When these two pins are shorted, the controller is placed in AUTO mode and the beam is turned on. When these two pins are open, the beam is turned off.
8	SRC LIT+	OUTPUT	Source Lit Status: This output signal is used in conjunction with pin 21. When these two pins are shorted, it indicates that there is sufficient anode current to consider the source started. If these two pins are open for a preset time while the source is running, it indicates that the source discharge has been lost.
9	n.a.	n.a.	Reserved.
10	FDBKCOM	OUTPUT	This is the return connection for the feedback signals (pins 1, 2, 3, 14, 15, and 16).
11	ISORX	INPUT	EIA-232 controller receive.
12	ISOTX	OUTPUT	EIA-232 controller transmit.
13	ISOGND	n.a.	EIA-232 ground only.
14	AI FDBK	OUTPUT	Anode Current Actual: 0 to +5V DC output, where 0V DC represents 0A and +5A DC represents 5A DC (referenced to pin 10).
15	CI FDBK	OUTPUT	Cathode Current Actual: 0 to +5V DC output, where 0V DC represents 0A and +5V DC represents 30.0A (referenced to pin 10).
16	AV FDBK	OUTPUT	Anode Voltage Actual: 0 to +5V DC output (referenced to pin 10). Refer to "Remote I/O" on page 36 to adjust this value.
17	AV STPT–	INPUT	This is the return connection for the Anode Voltage Set Point input signal (referenced to pin 4).
18	AI STPT–/ SG STPT–	INPUT	This is the return connection for the Anode Current/Source Gas Set Point input signal (referenced to pin 5).
19	NI STPT–/ EI STPT–/ CI STPT–	INPUT	This is the return connection for the Neutralization/Emission/ Cathode Current Set Point input signal (referenced to pin 6).
20	BEAM ON–	INPUT	This is the return connection for the Beam On switch (referenced to pin 7).
21	SRC LIT–	OUTPUT	This is the return connection for the Source Lit Status output signal (referenced to pin 8).
22,23, 24,25	n.a.	n.a.	Reserved.

Gas Flow Connectors

Analog MFC

Physical – There are four numbered GAS FLOW connectors; each is a type DB-15 receptacle. GAS FLOW 4 is reserved.

Electrical – The interface is pin compatible with the Brooks® brand thermal mass flow controller (MFC), but may be used with MFCs using the same supply voltage and signals shown in **Figure C.3:**

Table C.3: Gas Flow Connector Pin Assignments

Pin No.	Name In	Name Out	Function
1	GASFLOW COMMAND COM	n.a.	Pin 8 common reference.
2	GASFLOW+	INPUT	MFC Gas flow: the 0 to 5V DC input signal represents 0 to full scale MFC gas output (referenced to pin 10). For example, for a 20sccm MFC, a +2V DC signal represents 40% of full scale flow or 8sccm (see also pin 10).
3, 4, 7, 9, 12, 13, 15	COM	OUTPUT	Output common reference.
5	+15V	OUTPUT	+15V DC supply voltage to the MFC.
6	–15V	OUTPUT	–15V DC supply voltage to the MFC.
8	GASFLOW COMMAND	OUTPUT	The 0 to +5V DC output signal represents the MFC's set point. For example, if 10sccm were required on a 20sccm unit, +2.5V DC would exist on this signal (referenced to pin 1).
10	GASFLOW–	INPUT	This input signal is used in conjunction with GASFLOW+ (pin 2). For typical operation, GASFLOW– is tied to common in the MFC.
11, 14	n.a.	n.a.	Reserved.

Digital MFC

NOTE

This feature is not yet available.

Physical – The DIGITAL MFC connector is a female RJ-12, Molex® brand part number 95003-2661; the mating connector (available separately) is 90075-0031 or equivalent.

Electrical – Supports EIA-485. Refer to **Figure C.4:** for pin assignment.

Table C.4: Digital MFC Connector Pin Assignment

Pin No.	Name	Function
2	DX+	Digital plus signal
3	DX–	Digital minus signal
1, 4, 5, 6	n.a.	No connection.

Gas Flow Positive Shut-Off (P.S.O.)

Physical – The GAS FLOW P.S.O. connector is an eight pin, Molex® brand Mini-Fit, Jr.™ soft shell type; the mating connector (available separately) is part number 39-01-2080, strain relief part number 15-04-0343, pin part number 39-00-0039.

Electrical – Each normally open dry closure contact is rated for 24V AC/DC, 1A (no voltage is supplied to these pins). Pins 1, 3, 5 and 7 are the common contact. These contacts are not fused. Refer to Table C.5: and "Figure C.1" on page 55 for pin assignment and orientation.

Table C.5: Gas Flow P. S. O. Connector Pin Assignment

Pin No.	Name	Function
1, 2	MFC 4 PSO CONTROL	open circuit: valve closed closed circuit: valve open
3, 4	MFC 3 PSO CONTROL	
5, 6	MFC 2 PSO CONTROL	
7, 8	MFC 1 PSO CONTROL	

Figure C.1 Rear Panel Gas Flow P.S.O. Connector Pin Orientation

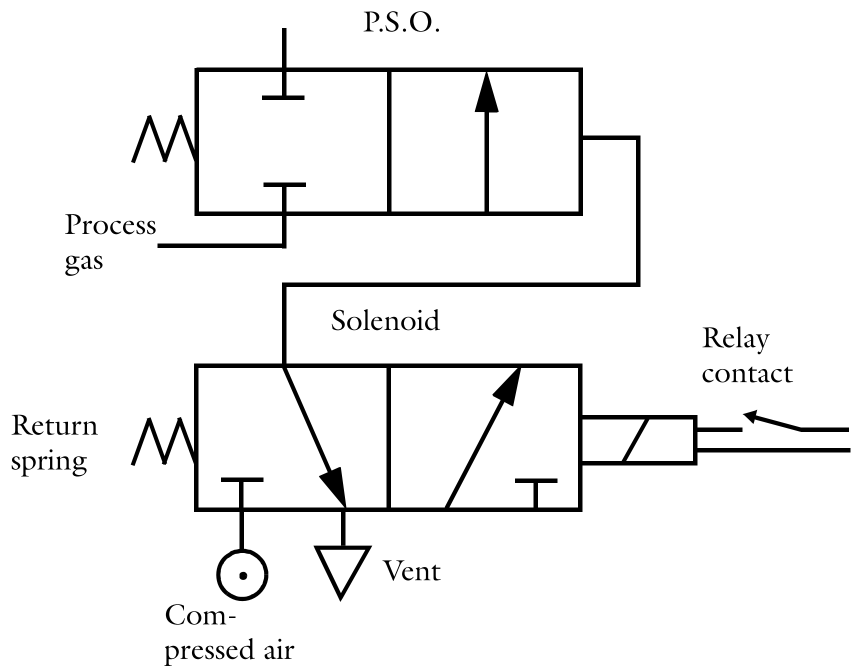
NOTE

The coil inductance of certain solenoids may cause a voltage spike when the valve opens. The voltage transients on P. S. O. contacts must not exceed 100V.

High inductance solenoid coils may require the use of either a catch diode (for DC solenoids) or an RC snubber network (for AC solenoids). Contact "Service Support" on page 39 for recommendations and assistance.

P.S.O. valves are installed in a number of ways. **Figure C.2** shows one common configuration. The P.S.O. valve (provided by others) should be normally closed, to match the Gas Flow P.S.O. relay's normally open contacts. This relay closes when the controller turns on the gas flow. Electrical current flows to the P.S.O. solenoid; compressed air then opens the P.S.O. valve. Conversely, when the controller stops the gas flow, the relay opens; this closes the solenoid valve, as well as the P.S.O. valve.

Figure C.2 Typical P.S.O. Valve and Solenoid Configuration



NOTE

The left side of each valve symbol above shows the valve ports/gas flow when the valve is de-energized; the right side shows the energized state. Additional symbol explanation appears in ISO 1219.

Source

Physical – The SOURCE connector is a 16-pin AMP® brand metal shell CPC type.

Electrical – Refer to **Table C.6:** for pin assignment.

Table C.6: Source Interface Connector Pin Assignments

Pin No.	Name In	Name Out	Function
1	ANODE	OUTPUT	This output signal is the DC Voltage to the source (referenced to pin 15). Its operating range is +60 to 300V DC with an adjustable current of up to 5A DC (see also pin 15).
7	CATHODE	OUTPUT	This output signal is the AC voltage to the source cathode (referenced to pin 10). Its maximum voltage is 50V AC with a current capability of about 25.0A RMS (see also pin 10).
10	CATHODE	OUTPUT	This output signal is the AC voltage to the source cathode (referenced to pin 7). Its maximum voltage is 50V AC with a current capability of about 25.0A RMS (see also pin 7).
14	SOURCE INTERLOCK 1	INPUT	This is the source interlock connection. It must be connected to pin 16 in order for the controller to function (see also pin 16).
15	POWER RETURN	OUTPUT	This is the return path for the ANODE signal. It is always attached to vacuum chamber ground (see also pin 1).
16	SOURCE INTERLOCK 2	INPUT	This is the source interlock connection. It must be tied to pin 14 in order for the controller to function (see also pin 14).
2, 3, 4, 5, 6, 8, 9, 11, 12, 13	n. a.	n. a.	No connection.

Appendix D: Virtual Front Panel

Requirements

The Mark⊕ series Virtual Front Panel software allows the operator to perform controller functions from a separate PC. This is possible if the following are true:

- The PC and the controller are physically connected to each other via the proprietary communications cable (available separately).
- The Virtual Front Panel software is loaded and configured on the remote PC, using the Veeco provided CD or file.

The Virtual Front Panel software is provided only with Mark⊕ series Non LCD Blank Virtual Front Panel Controllers, as shown in Figure D.1.

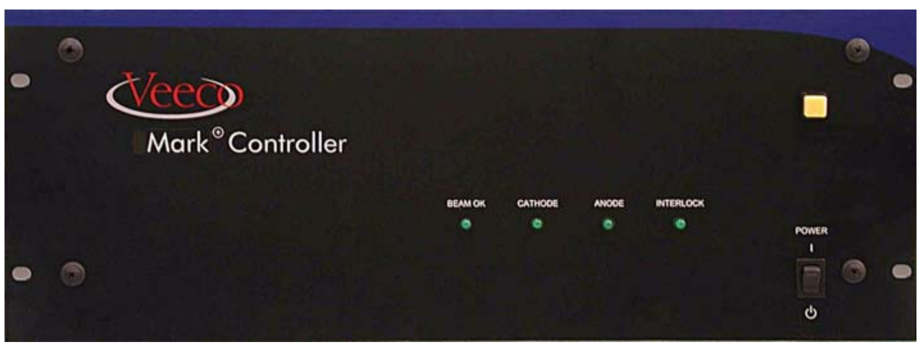


Figure D.1 Mark⊕ Series Non LCD Blank Front Controller For Use With Virtual Front Panel

Installation

Follow these steps to install the Virtual Front Panel program:

1. Close all open desktop applications software on the PC; temporarily disable all virus detection and firewall software.
2. Insert the Veeco supplied CD into the PC's drive. The software's setup screen opens and the InstallShield® Wizard launches.

NOTE

If this screen does not appear, view the CD's contents with Windows Explorer and double click the setup.exe file.

3. Click the Next> button on the Welcome window; the Software License Agreement window opens.
    a. Click the Yes button if you accept the agreement; the Choose Destination Location dialog box opens.
    b. The default location is C:\Program Files; click the Browse button to enter an alternate location.
    c. Click the Next> button on the Choose Destination Location dialog box. The Select Program Folder window opens.
    d. The software will create a Mark+ Virtual Front Panel folder and a desktop icon. Type in an alternate name or choose an existing folder if desired.
    e. Click the Next> button; installation progress is displayed on the setup screen.
    f. Click the Finish button; the setup software closes.
4. To verify communications:
    a. Check that the communications cable is attached between the controller and the PC.

NOTE

If the desktop icon or Start menu entry does not appear, look in the C:\Program Files\Mark+ Virtual Front Panel folder (or other chosen location) for the MarkPlusVFP.exe program.

b. Run the Virtual Front Panel program, by either selecting it from the Start menu or double clicking the Mark+ VFP icon on your desktop; the Select Comm Port dialog box opens.

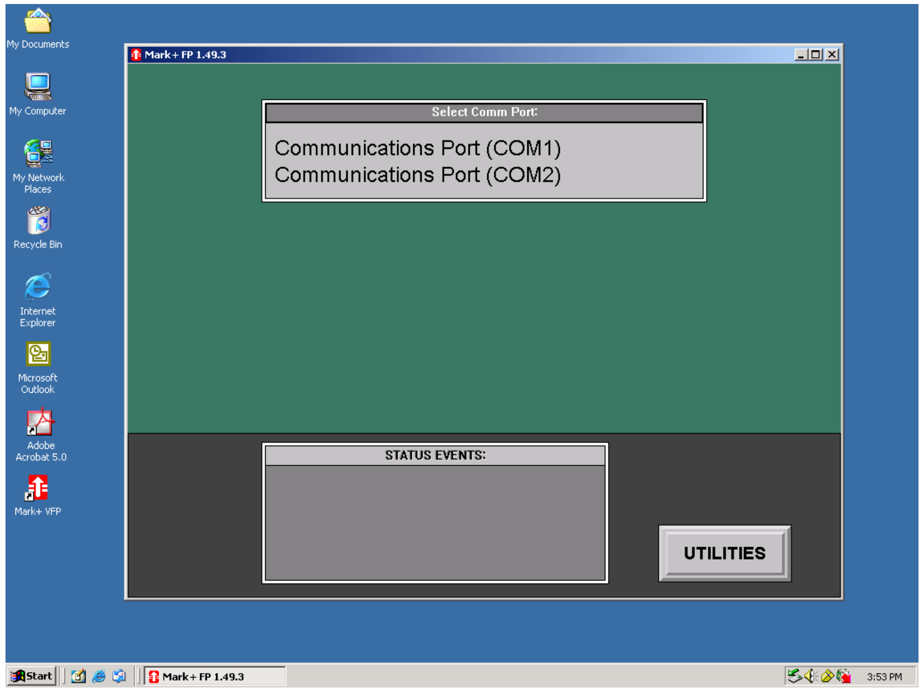


Figure D.2 Virtual Front Panel Select Comm Port Dialog Box

c. Choose the Communications Port attached to the communications cable; the 'Scanning Communications Settings to Establish Link to the Controller' message appears.

Once a communications link is established, the PC's screen will show the controller's front panel display, if the "Requirements" on page 58 are met and the controller is on and initialized. Use the PC's screen and pointing device in place of the controller's touch screen display.

NOTE

If you are unable to connect to the system, check that all of the steps above were followed correctly and that all listed requirements above are met.

5. Enable virus protection and firewall software.

Appendix E: Serial Communications Protocol

General

The Mark⊕ series Serial Communications Protocol has two command types: a *query* command and a *set* command. Each command must include a four character checksum, followed by a carriage return [CR] to be sent successfully. The command format is:

[Cmd][4-ch Checksum][CR]

The controller responds with an acknowledgement containing a response code (or string), a timestamp, and a checksum, followed by a carriage return [CR] and a line feed [LF]. The timestamp and checksum are reported in ASCII hexadecimal format. The response arrives in one of the following two formats:

> ACK: A[Response String],[8-ch Timestamp],[4-ch Checksum][CR][LF]
>
> NAK: N[1-ch NAK Code],[8-ch Timestamp],[4-ch Checksum][CR][LF]

Table E.1: NAK Codes

Code	Description
0	Invalid Checksum
1	Invalid Command
2	Parameter Too High
3	Parameter Too Low
4	Cannot Execute Command (Typically Wrong Mode)
5	Receive Buffer Overflow
6	Receive Framing Error
7	Receive Overrun Error
8	Receive Parity Error
9	Not enough characters to be a valid command
:	Non-hexadecimal character in checksum field

Table E.1: NAK Codes (Continued)

;	Function Code Number out of range
<	Event Type Number out of range
=	Too many characters to be a valid command (18 characters maximum)
>	Invalid character in the event type/function code field
?	Command is not valid for this controller configuration

The carriage return and line feed are defined as:

[CR] = 0x0D

[LF] = 0x0A

Checksum Algorithm

The checksum offers packet integrity for routine data communications. The checksum algorithm is:

1. Sum all bytes in a 16 bit register using an ‘add with carry’ operation (consider the first byte to be index 0, the even bytes are the lower-order portion of the 16 bit add and the odd bytes are the higher-order bits).

2. Invert all bits in the sum.

3. Convert the result to a four digit ASCII hexadecimal string.

For transmitted commands, include all characters in the command section in the sum. To verify received responses, include all characters up to the checksum (but not including it) in the sum. A sample checksum calculation implementation in the C++ programming language is: unsigned short CalculateChecksum (const unsigned char* pData, int DataLen).

```
{
unsigned long CS = 0;
unsigned short* psData = (unsigned short*)pData;
for (int Index = 0; Index < (DataLen / 2); Index++, psData++)
CS += *psData;
If (DataLen % 2 != 0)
CS += pData[DataLen - 1];
CS = (CS >> 16) + (CS & 0xFFFF);
CS += (CS >> 16);
return (unsigned short) ~CS;
}
```

Query Commands

Table E.2: Query Commands

Name	Syntax	Response
Read Target Minimum Value	MN	See Read Target State, RT
Read Target Maximum Value	MX	See Read Target State, RT
Read No. of Event Types	NE	Aa,[Timestamp],[Checksum][CR][LF] where a = Number of Event types
Read Actual State	RA	Aa,bc,defghi,jklmno,ppppp,qqqqq,rrrrr,sssss,ttttt,uuuuu,vvvvv,wwwww,[Timestamp], [Checksum][CR][LF] where a = Events Available, ‘0’ = No, ‘1’ = Yes b = Control Mode, ‘0’ = Manual, ‘1’ = Auto c = Control Mode Last Set By, 0 = Set by controller 1 = Set by front panel RS232 2 = Set by user RS232 3 = Set by user digital I/O d = Beam On/Off e = Anode Module On/Off f = Source Gas 1 On/Off g = Source Gas 2 On/Off h = Source Gas 3 On/Off

Table E.2: Query Commands (Continued)

Name	Syntax	Response	
Read Actual State (continued)	RA	i = Cathode Module On/Off	Bit 0 = On/Off Bit 1-2 = 0 = Set by controller 1 = Set by front panel RS232 2 = Set by user RS232 3 = Set by user digital I/O Bits 4-7 = 0x3
		j = Beam/Control State	Bit 0 = Interlock Made? Bit 1 = Undervoltage Sensed? Bit 2 = In Gas Purge Mode?
		k = Anode Module State l = Cathode Module State	Bit 0 = Over temp Bit 1 = Over current Bits 4-7 = 0x3
		m = Source Gas State	Bit 0 = Gas 1 Not at Target? Bit 1 = Gas 2 Not at Target? Bit 2 = Gas 3 Not at Target? Bits 4-7 = 0x3
		n = Controller State	Bit 0 = Legacy Installed? Bit 1 = Remote Run Active? Bit 2 = Locked? Bit 3 = Test Mode On/Off Bits 4-7 = 0x3
		o = Master Gas Channel	0 = No Gases Installed 1 = MFC 1 is Master Gas Channel 2 = MFC 2 is Master Gas Channel 3 = MFC 3 is Master Gas Channel

Table E.2: Query Commands (Continued)

Name	Syntax	Response
Read Actual State (continued)	RA	p = Anode Voltage q = Anode Current r = Source Gas 1 Flow s = Source Gas 2 Flow t = Source Gas 3 Flow u = Cathode Current v = Emission Current w = Neutralizer Current
Read Current Event	RE	Aaaa:bbb:ccc...c, d,[Timestamp],[Checksum][CR][LF] where: a = Event Tag (increments with each event) b = Event Code (See "Event List" on page 69.) c = Event Data (See "Event List" on page 69.) d = More Events? '0' = No, '1' = Yes
Read Power Supply Model	RM	Aabcd,[Timestamp],[Checksum][CR][LF] where: a = Source Type: '1' = End Hall Gridless Source b = Anode Type: '1' = Mark I, '2' = Mark II, '3' = Mark II High Output, '4' = Mark III c = Cathode Type: '1' = Filament, '2' = HCES d = Number of Source Gases Installed? '0' = None, '1' = 1, '2' = 2, '3' = 3

Table E.2: Query Commands (Continued)

Name	Syntax	Response
Read Target State	RT	Aaaaaa,bbbbb,ccccc,ddddd,eeeee,fffff,ggggg,hhhhh,iiiii,jjjjj,kkkkk,lllll,mmmmm,nnnnn,ooooo,ppppp,qqqqq,[Time stamp],[Checksum][CR][LF] where a = Anode Voltage b = Anode Current c = Source Gas 1 Flow d = Source Gas 1 Start Flow e = Source Gas 1 Flow Limit f = Source Gas 1 Run Proportion g = Source Gas 2 Flow h = Source Gas 2 Start Flow i = Source Gas 2 Flow Limit j = Source Gas 2 Run Proportion k = Source Gas 3 Flow l = Source Gas 3 Start Flow m = Source Gas 3 Flow Limit n = Source Gas 3 Run Proportion o = Cathode Current p = Cathode Current Limit q = Neutralization Ratio [xxxx%] or Neutralizer Current [xxxxx] (mA)
Read Version	RV	Avv.vv,[Timestamp],[Checksum][CR][LF] where vv.vv = Software Version Number

Set Commands

Table E.3: Set Commands

Name	Syntax	Units	Description
Set Anode On/Off	A	n.a.	Turns the anode on and off when the controller is in the MANUAL mode.
Set Anode Current	AI	amperes	Sets the anode current when the controller's AI SETPOINT feature is active in the AUTO mode.
Set Anode Voltage	AV	volts	Sets the target voltage for the anode.
Set Beam On/Off	B	n.a.	Turns the beam on and off when the controller is in the AUTO mode.
Set Cathode On/Off	C	n.a.	Turns the cathode on and off when the controller is in the MANUAL mode.
Clear Current Event	CE	n.a.	CEaaa[Checksum][CR] where a = Event Tag Clear Event will occur only if this tag matches the tag of the top event in the queue.
Set Filament Cathode Current	CI	amperes	Sets the filament cathode current when the controller's CI SETPOINT feature is active in the AUTO mode or when the controller is in MANUAL mode.
Set Filament Cathode Current Limit	CL	amperes	Sets the maximum AC current that the cathode module can supply to the filament.
Disable All Event Types	DA	n.a.	Deactivate all event reporting.
Disable Event Type	DE	n.a.	DEaaa[Checksum] [CR] where aaa = Event Type to disable: 000 = Module On/Off Change 001 = Module Fault Status Change 002 = Source Startup Events 004 = Controller Fault Events
Enable Event Type	EE	n.a.	EEaaa[Checksum] [CR] where: aaa = Event Type to enable. See DE above.
Set Emission Current	EI	amperes	Sets the emission current when the controller's EI SETPOINT feature is active in the AUTO mode.
Set Source Gas 1 On/Off	G1A	n.a.	Turns Source Gas channel 1 on and off when the controller is in the MANUAL mode.
Set Source Gas 1 Flow	G1F	sccm	Sets Source Gas channel 1 flow when the controller's SG SETPOINT feature is active in the AUTO mode or when the controller is in MANUAL mode.
Set Source Gas 1 Flow Limit	G1L	sccm	Sets the maximum allowable gas flow for Source Gas channel 1.

Table E.3: Set Commands (Continued)

Name	Syntax	Units	Description
Set Master Gas to MFC 1	G1M	n.a.	Sets Source Gas channel 1 as the master gas channel.
Set Source Gas 1 Flow Run Proportion	G1P	%	Sets Source Gas channel 1 flow as a proportion (percentage) of the Master Gas channel flow when the controller is in the AUTO mode.
Set Source Gas 1 Start Flow	G1S	sccm	Sets Source Gas channel 1 start flow when the controller is in the AUTO mode.
Set Source Gas 2 On/Off	G2A	n.a.	Turns Source Gas channel 2 on and off when the controller is in the MANUAL mode.
Set Source Gas 2 Flow	G2F	sccm	Sets Source Gas channel 2 flow when the controller is in MANUAL mode.
Set Source Gas 2 Flow Limit	G2L	sccm	Sets the maximum allowable gas flow for Source Gas channel 2.
Set Master Gas to MFC 2	G2M	n.a.	Sets Source Gas channel 2 as the master gas channel.
Set Source Gas 2 Flow Run Proportion	G2P	%	Sets Source Gas channel 2 flow as a proportion (percentage) of the Master Gas channel flow when the controller is in the AUTO mode.
Set Source Gas 2 Start Flow	G2S	sccm	Sets Source Gas channel 2 start flow when the controller is in the AUTO mode.
Set Source Gas 3 On/Off	G3A	n.a.	Turns Source Gas channel 3 on and off when the controller is in the MANUAL mode.
Set Source Gas 3 Flow	G3F	sccm	Sets Source Gas channel 3 flow when the controller is in MANUAL mode.
Set Source Gas 3 Flow Limit	G3L	sccm	Sets the maximum allowable gas flow for Source Gas channel 3.
Set Master Gas to MFC 3	G3M	n.a.	Sets Source Gas channel 3 as the master gas channel.
Set Source Gas 3 Flow Run Proportion	G3P	%	Sets Source Gas channel 3 flow as a proportion (percentage) of the Master Gas channel flow when the controller is in the AUTO mode.
Set Source Gas 3 Start Flow	G3S	sccm	Sets Source Gas channel 3 start flow when the controller is in the AUTO mode.
Set Lock Mode	L	n.a.	(‘0’ = Unlocked, ‘1’ = Locked)
Set Control Mode	M	n.a.	(‘0’ = Manual, ‘1’ = Auto)
Set Neutralizer Current	NI	amperes	Sets the neutralizer current when the controller’s NI SETPOINT feature is active in the AUTO mode.
Set Neutralization Ratio	NR	%	Sets the neutralizer current as a proportion (percentage) when the controller’s NI SETPOINT feature is active in the AUTO mode.

Event List

Table E.4: Event List

Type	Name	Code	Data	Description
Module On/Off Status (type 000)	‘Module On/Off Change’	3	ABCD	A = (Hex) New On/Off State (0 = Off, 1 = On) B = (Hex) Module ID (see above) C = (Hex) Source of change: 1 = Controller 2 = Front Panel RS232 3 = User RS232 4 = User Digital I/O
Module Fault Status (type 001)	‘Module Over Temp’	1	AB	A = (Hex) New OverTemp State (0 = Off, 1 = On) B = (Hex) Module ID, 1 = Anode 2 = Filament Cathode 3 = Emission 4 = Keeper 5 = Source Gas 1 6 = Source Gas 2 7 = Source Gas 3 8 = HCES Gas 9 = Beam
	‘Module Not at Target’	2	AB	A = (Hex) New ‘Not At Target’ State (0 = Off, 1 = On) B = (Hex) Module ID: see ‘Module Over Temp’ above.

Table E.4: Event List (Continued)

Type	Name	Code	Data	Description
Source Startup (type 002)	'Source Startup'	4	A	A = (Hex) Info: 1 = Source Gas Ramping To Start Target 2 = Anode Voltage Ramping to Start Target 3 = Filament Current Ramping to Start Target 4 = Ramping Filament Current to Ignite Source 5 = Source Discharge Has Started 6 = Switching Gas Mix to Run Proportions 7 = Servo Loops are Active 8 = Source Unable to Start Discharge 9 = Source Discharge Went Out A = Source Discharge Has Restarted C = Waiting for HCES to Start F = HCES Has Started (Auto Mode) 10 = HCES Unable to Start Discharge
Controller Fault (type 004)	'Controller Fault'	6	A	A = (Hex) Info: 1 = Source Discharge Has Gone Out 2 = Cathode Filament is Open 3 = Source Unable to Start Discharge 4 = Source Discharge Too Unstable 5 = Cathode Current has reached the limit 6 = Source Gas has reached the limit 7 = Power module has an overtemperature fault 8 = Cathode Current is not servoing to the requested target 9 = Source Gas is not servoing to the requested target A = Anode Voltage not at target B = Cathode Current not at target C = Source Gas not at target D = Keeper Current not at target E = HCES Gas not at target F = Interlock Broken 10 = Undervoltage Fault 11 = HCES Unable to Start Discharge 12 = HCES Gas is not servoing to the requested target

Appendix F: AI Servo Gain

General

The Anode Current (AI) Servo Configuration permits the user to fine tune anode current/gas flow control loop operation and match the anode current servo gain factor to the particular source type. Also included here are the factory recommended default values for current and legacy Veeco source types and companion Mark II⊕ Controller. In most manufacturing installations and applications, it is sufficient to confirm Fixed Gain mode and match the servo gain value to the installed ion source type to facilitate effective anode current regulation by the controller.

The AI Servo Configuration governs the dynamic response of the closed-loop control algorithm when the Mark ⊕ controller operates automatically with the ANODE CURRENT SETPOINT mode enabled. Refer to "Gas Flow Controller Function" on page 8 and "Auto Mode Configuration" on page 21. The controller makes continuous adjustments to the ion source's input gas flow to achieve a constant anode current output.

In earlier controller firmware versions, the feedback gain factor of this servo algorithm, was fixed at a particular value for the controller-source combination. This factor has the primary influence on whether the anode current control is responsive and well-regulated during routine operation. The AI Servo Configuration list (chosen from the Select Function dialog box) now allows users to adjust the gain factor to further improve the closed-loop feedback control response.

NOTE

The AI Servo Configuration selections are only applicable when the ANODE CURRENT CONTROL MODE (on the Auto Mode Configuration List) is set to Anode Current Setpoint. Refer to "Auto Mode Configuration" on page 21 for details.

Servo Gain Values and Settings

The "AI Servo Configuration" on page 23 permits users to address the following application situations:

Match source type to gain factor – Use the Select Ion Source Type dialog box to configure the controller for a specific ion source type.

Adjust source -controller performance to optimize process – Use the Custom Gain adjustment to empirically investigate different gain settings to improve anode current response for unique end-user process environments. Some examples are:

- optimize ion source controller response as the anode current approaches its set point
- enhance anode current control speed and stability when
    - starting up the ion source
    - using gases other than argon, oxygen or nitrogen
    - making step changes in the anode set points while the ion source is operating.

Tailor source -controller performance to existing hardware – Use the Custom Gain adjustment to adapt the controller's output response to accommodate local process equipment variations. Some examples are: input gas line length, mass flow controller performance, atypical pumping speeds, process fixturing, or external introduction of gas chemistries and mixtures.

Manage process transients – The Adaptive Gain mode allows the controller to sense process environment changes that affect the ion source operation and to automatically adjust the AI Servo gain factor, to improve anode current response in the new environment. Some examples are: process system vacuum pressure burst, beam shutter motion and abrupt process chemistry changes.

Table F.1: presents the factory recommended default values for Mark/ Mark $^{\oplus}$ ion sources; suggested custom gain factor ranges are also included, to avoid over-responsive and under-responsive control behavior.

Table F.1: AI Servo Gain Values and Settings

Gain	Comment
100	The factory recommended default value for the Mark II/II$^{\oplus}$ ion source.
30 to 300	The recommended custom range setting for the Mark II/II$^{\oplus}$ ion source.

Custom Gain Setting

The Custom Gain setting (on the Select Ion Source Type dialog box, "Figure 5.9" on page 25) is intended for situations where the controller's anode current dynamic response is unsatisfactory for reasons related to local process and/or hardware conditions, as outlined earlier. In these instances, the user may start with the factory recommended AI Servo Gain value and then experimentally determine a more appropriate custom gain setting.

A *lower* AI Servo Gain factor will result in slower gas adjustment to meet the anode current setpoint. If the ion source routinely takes substantially longer than a minute to reach the target anode current setpoint at start-up, it is likely that the fixed AI Servo Gain value is too low.

A *higher* AI Servo Gain factor will result in faster gas adjustment to meet the anode current setpoint. If the ion source strongly overshoots and oscillates around the target anode current setpoint at start-up, it is very likely that the fixed AI Servo Gain value is too high.

Appendix G: Environmental Safety

The equipment that you bought has required the extraction and use of natural resources for its production. It may contain hazardous substances that could impact health and the environment. In order to avoid the dissemination of those substances in our environment and to diminish the pressure on the natural resources, we encourage you to use the appropriate take-back systems. Those systems will reuse or recycle most of the materials of your end life equipment in a sound way.

The crossed-out wheeled bin symbol invites you to use those systems. If you need more information on the collection, reuse and recycling systems, please contact your local or regional waste administration. You can also contact us for more information on the environmental performances of our products.