356 Micro-Ion® Plus Module

GRANVILLE-PHILLIPS®

Instruction Manual

Instruction manual part number 356007
Revision 04
January 2007

356 Micro-Ion® Plus Module

GRANVILLE-PHILLIPS®

To order products online, visit *www.brooks.com*

For customer service, 24 hours per day, 7 days per week, every day of the year including holidays, toll-free within the U.S.A., phone 1–800–367–4887

For customer service within the U.S.A., 8 AM to 5 PM, weekdays excluding holidays:

- Toll-free, phone: 1–800–776–6543
- Phone: 1–303–652–4400
- FAX: 1–303–652–2844
- Email: *co-csr@brooks.com*

Instruction Manual

© 2006, 2007, Brooks Automation. All rights reserved.
Granville-Phillips, Micro Ion, Conductron, and Convectron are registered trademarks of Brooks Automation. All other trademarks and registered trademarks are the properties of their respective owners.

Contents

Chapter 1 Before You Begin

1.1 About these instructions

These instructions explain how to install, operate, and maintain the Granville-Phillips® Micro-Ion® Plus vacuum gauge module. The module contains a Micro-Ion ionization gauge and a Conductron® heat-loss sensor, which working in combination provide pressure measurement from 1 x 10^{-9} to atmosphere.

- *This chapter* explains caution and warning statements, which must be adhered to at all times; explains your responsibility for reading and following all instructions; defines terms that are used throughout this manual; and tells you how to contact customer service.
- *Chapter 2* explains how to install the module.
- *Chapter 3* explains how to read the analog output. *Chapter 3* also explains how to perform control and monitoring functions by using RS–485 commands, by using switches installed on the 15-pin subminiature D connector, or by using the optional pressure and trip points displays.
- *Chapter 4* explains troubleshooting; Micro-Ion gauge testing, removal and replacement; and module return procedures.
- *Appendix A* provides specifications for the module.
- *Appendix B* explains terminology and explains how the Micro-Ion gauge and Conductron heat-loss sensor measure pressure.

1.2 Caution and warning statements

This manual contains caution and warning statements with which you *must* comply to prevent inaccurate measurement, property damage, or personal injury.

⚠ CAUTION

Caution statements alert you to hazards or unsafe practices that could result in minor personal injury or property damage.

Each caution statement explains what you must do to prevent or avoid the potential result of the specified hazard or unsafe practice.

⚠ WARNING

Warning statements alert you to hazards or unsafe practices that could result in severe property damage or personal injury due to electrical shock, fire, or explosion.

Each warning statement explains what you must do to prevent or avoid the potential result of the specified hazard or unsafe practice.

Caution and warning statements comply with American Institute of Standards Z535.1-2002 through Z535.5-2002, which set forth voluntary practices regarding the content and appearance of safety signs, symbols, and labels.

Each caution or warning statement explains:

a. The specific hazard that you *must* prevent or unsafe practice that you *must* avoid,

b. The potential result of your failure to prevent the specified hazard or avoid the unsafe practice, and

c. What you *must* do to prevent the specified hazardous result.

1.3 Reading and following instructions

You must comply with all instructions while you are installing, operating, or maintaining the module. Failure to comply with the instructions violates standards of design, manufacture, and intended use of the module. Granville-Phillips and Brooks Automation Corporation disclaim all liability for the customer's failure to comply with the instructions.

- *Read instructions* – Read all instructions before installing or operating the product.
- *Retain instructions* – Retain the instructions for future reference.
- *Follow instructions* – Follow all installation, operating and maintenance instructions.
- *Heed warnings and cautions* – Adhere to all warnings and caution statements on the product and in these instructions.
- *Parts and accessories* – Install only those replacement parts and accessories that are recommended by Granville-Phillips. Substitution of parts is hazardous.

1.4 Definitions of terms

- Table 1-1 lists terms describing the Micro-Ion Plus module and its components.

Table 1-1 Terms describing Micro-Ion Plus module and components

Term	Description
Module	The Micro-Ion Plus module, which contains a hot filament Micro-Ion gauge (Bayard-Alpert type ionization gauge) and a Conductron heat-loss sensor.
Micro-Ion gauge	The Bayard-Alpert type ionization gauge, which indicates pressure by producing a current that is proportional to gas density.
Conductron sensor	The heat-loss sensor, which measures pressure as a function of heat loss through the gold-plated tungsten sensing wire.

1.5 Customer service

For customer service:

- Phone **1–800–776–6543** within the U.S.A.
- Email *co-csr@brooks.com*.

Chapter 2 Installation

2.1 Module components

The Micro-Ion Plus module contains a a Micro-Ion gauge (Bayard-Alpert type ionization gauge) and a Conductron heat-loss sensor.

> **⚠ WARNING**
>
> **Using the module to measure the pressure of flammable or explosive gases can cause a fire or explosion resulting in severe property damage or personal injury.**
>
> Do not use the module to measure the pressure of flammable or explosive gases.

> **⚠ WARNING**
>
> **Exposing the module to moisture can cause fire or electrical shock resulting in severe property damage or personal injury.**
>
> To avoid exposing the module to moisture, install the module in an indoor environment. Do not install the module in any outdoor environment.

2.2 Installation procedure

The module installation procedure includes the following steps:

1. Installing appropriate pressure relief devices in the vacuum system.
2. Locating the module.
3. Attaching the module vacuum chamber fitting to its mate on the vacuum chamber.
4. Assembling and connecting module wiring.
5. Calibrating the Conductron sensor at atmosphere.

This chapter also explains what to do if radio frequency interference (RFI) from the module disrupts operation of other electronic devices.

Step 1 *Install pressure relief devices*

Before you install the module, install appropriate pressure relief devices in the vacuum system.

Granville-Phillips does not supply pressure relief valves or rupture disks. Suppliers of pressure relief valves and rupture disks are listed in the *Thomas Register* under “Valves, Relief” and “Discs, Rupture.”

⚠ CAUTION

Operating the module above 1000 Torr (1333 mbar, 133 kPa) true pressure could cause vacuum system rupture or product failure.

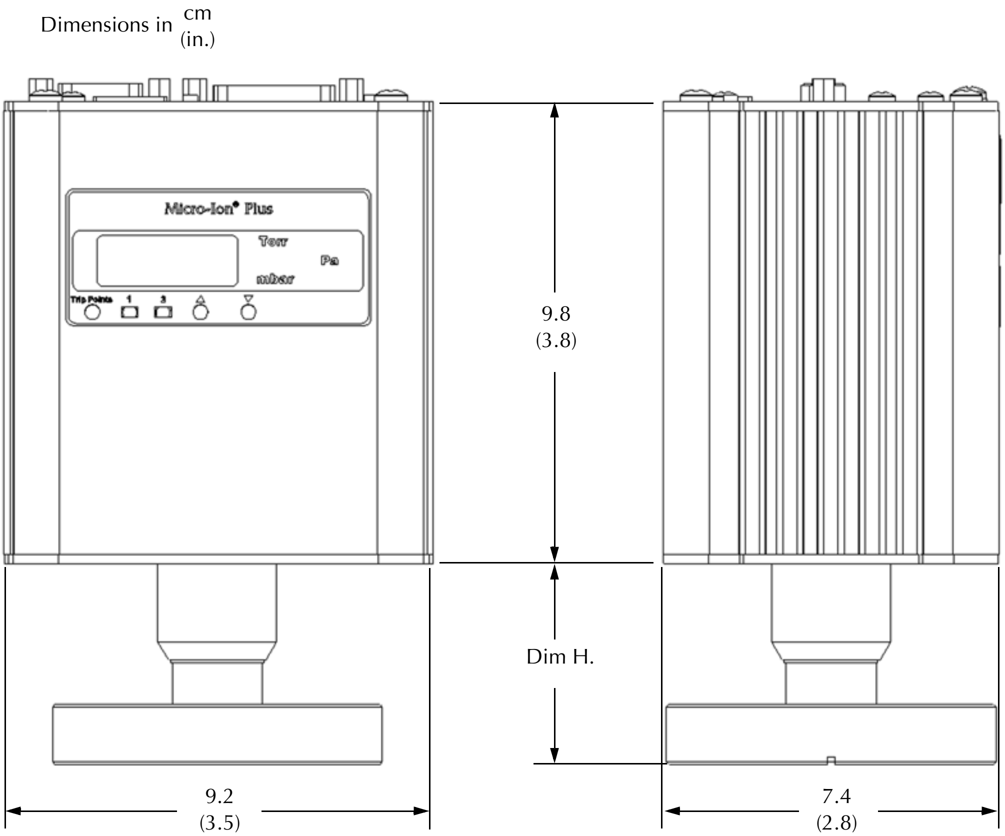
To avoid vacuum system rupture or product failure due to overpressurization, install pressure relief valves or rupture disks in the system if pressure exceeds 1000 Torr (1333 mbar, 133 kPa).

Step 2 *Locate the module*

To locate the module, refer to Figure 2-1 and Table 2-1, and follow the guidelines below.

- For greatest accuracy and repeatability, locate the module in a stable, room-temperature environment. Ambient temperature should never exceed 40 °C (104 °F) operating, non-condensing, or 85 °C (185 °F) non-operating. Bakeout temperature for the Micro-Ion gauge and Conductron sensor, removed from the module, is 150 °C (302 °F).
- Locate the module away from internal and external heat sources and in an area where ambient temperature remains reasonably constant.
- Do not locate the module near the pump, where gauge pressure might be lower than normal vacuum chamber pressure.
- Do not locate the module near a gas inlet or other source of contamination, where inflow of gas or particulates causes atmospheric pressure to be higher than system atmosphere.
- Do not locate the module where it will be exposed to corrosive gases such as mercury vapor or fluorine.

Figure 2-1 Dimensions

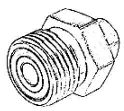
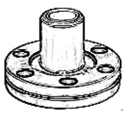


Step 3 *Attach module to vacuum chamber*

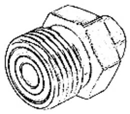
Attach the module vacuum chamber fitting to its mate on the vacuum chamber.

> ⚠ **CAUTION**
>
> **Twisting the module to tighten the fitting to the vacuum chamber can damage the module's internal connections.**
>
> - Do not twist the module to tighten the fitting.
> - Use appropriate tools to tighten the fitting.

Table 2-1 Fittings for Micro-Ion Plus module

Fitting		Dim. H	
		cm	in.
	½–inch VCR-type male	5.8	2.3
	1.33–inch (NW16CF) ConFlat	4.3	1.7
	2.75–inch (NW35CF) ConFlat	4.3	1.7
	NW16KF	2.0	0.8
	NW25KF	2.0	0.8
	NW40KF	2.0	0.8
	NW16KF extended	4.2	1.65
	NW25KF extended	4.2	1.65
	NW40KF extended	4.6	1.8

VCR-type fitting



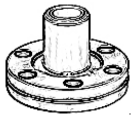
a. Remove the plastic or metal bead protector cap from the fitting.

b. If a gasket is used, place the gasket into the female nut.

c. Assemble the components and tighten them finger-tight.

d. While holding a back-up wrench stationary, tighten the female nut 1/8 turn past finger-tight on 316 stainless steel or nickel gaskets, or 1/4 turn past finger-tight on copper or aluminum gaskets. *Do not twist the module to tighten the fitting*.

ConFlat flange



To minimize the possibility of leaks with ConFlat flanges, use high strength stainless steel bolts and a new, clean stainless steel with OFHC copper gasket. Avoid scratching the seal surfaces.

a. Finger tighten all bolts.

b. Use a wrench to continue tightening 1/8 turn at a time in crisscross order (1, 4, 2, 5, 3, 6) until flange faces make contact. Further tighten each bolt about 1/16 turn.

NW flange

The NW mounting system requires O-rings and centering rings between mating flanges.

Tighten the clamp to compress the mating flanges together and seal the O-ring.

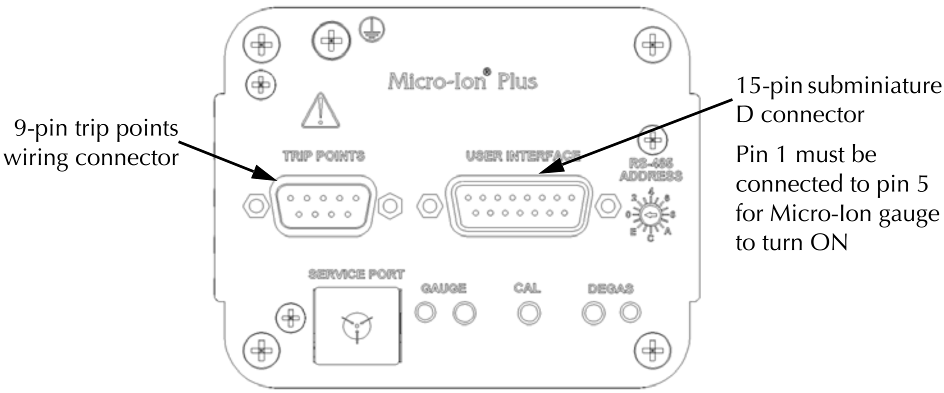
Step 4 *Assemble and connect wiring*

Connecting cable

Cable is user-supplied. Brooks Automation does not supply cable.

- Install externally shielded cable.
- Connect wiring to the 9-pin trip points and 15-pin subminiature D connectors. Pin 1 must be connected to pin 5 for the Micro-Ion gauge to turn ON. See Figure 2-2.

Figure 2-2 9-pin trip point and 15-pin subminiature D wiring connectors



Module power supply

Connect the module power supply to terminals 5 and 8 on the 15-pin I/O wiring connector.

- Terminal 5 (ground) is negative (–).
- Terminal 8 (input) is positive (+).

The module requires a +24 VDC ±15% external power supply. The power supply must provide a 1.5 A current at 24 VDC. Inrush current can momentarily exceed the 1.5 A peak.

Typical module operating power is 18 W for 4 mA emission when the Micro-Ion gauge is ON.

Power inputs are reverse-bias protected.

Micro-Ion gauge will not activate and an emission error will occur if insufficient power is supplied during Micro-Ion gauge activation.

Analog and RS–485 output wiring

Connect wiring for analog and RS–485 outputs to the 15-pin subminiature-D connector, as illustrated in Figure 2-3.

Figure 2-3 Wiring terminals for analog and RS–485 wiring

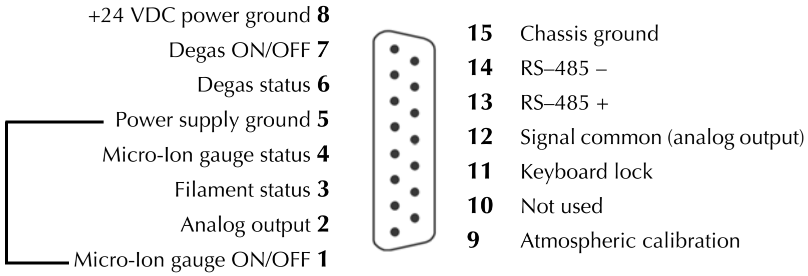


Table 2-2 Connections to 15-pin subminiature D connector

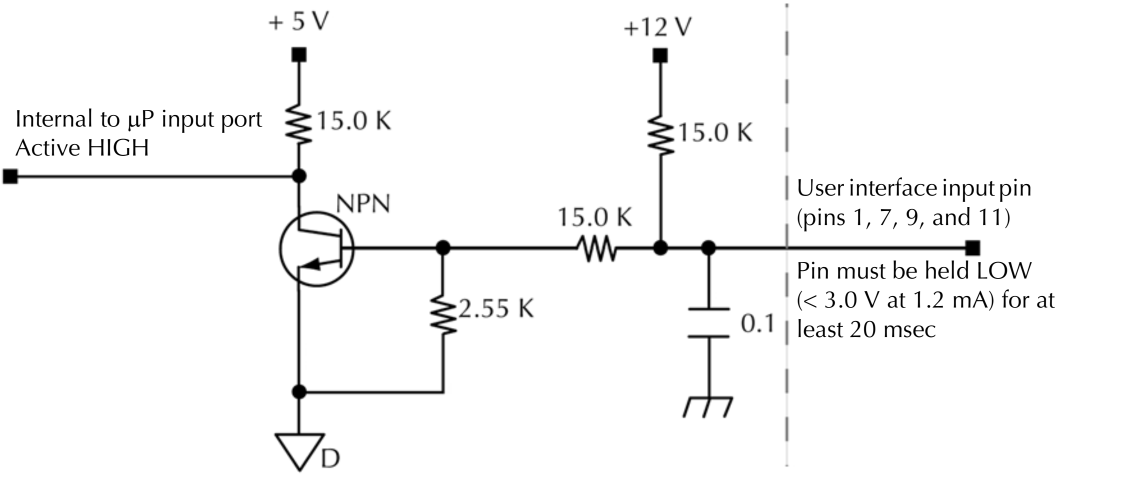
Pin	Function	Input or output	Description
Pin 1	Micro-Ion gauge ON/OFF	Input	• Must be continuously connected to Pin 5 (LOW) to turn gauge ON[a] • Removing ground connection turns gauge OFF
Pin 2	Analog output	Output	• 0.5 VDC/decade, 7 VDC maximum • Ground reference to pin 12
Pin 3	Filament status	Output	(LOW) Indicates an inoperable filament[b]
Pin 4	Gauge status	Output	(LOW) Indicates Micro-Ion gauge is ON[b]
Pin 5	Ground	Input	Power supply ground
Pin 6	Degas status	Output	(LOW) Indicates Micro-Ion gauge degas is ON[b]
Pin 7	Degas ON/OFF	Input	• Continuous LOW will activate 2-minute degas • Pressure must be < 5 x 10^{-6} Torr (6.66 x 10^{-6} mbar, 6.66 x 10^{-4} Pa) for degas[a]
Pin 8	+24 VDC power	Input	+20 to +28 VDC (1.5 A at 24 V)
Pin 9	Calibration	Input	LOW sets atmospheric or vacuum calibration point[a][c]
Pin 10	Not used		Not used
Pin 11	Keyboard lock	Input	Continuous LOW locks keyboard[a]
Pin 12	Signal common	Output	Signal common (analog output)
Pin 13	RS–485+	Input/output	RS–485+
Pin 14	RS–485 –	Input/output	RS–485 –
Pin 15	Chassis ground	Input	Chassis ground (cable shield)

[a] 15 K pull-up to 12 VDC, (LOW) 0 VDC at 0.80 mA. See page 12.
[b] Open collector, no pull-up, 40 VDC, 50 mA. See page 12.
[c] Pin must be held LOW for at least 20 msec to activate calibration.

Control inputs

The module provides an internal 15 K pull-up resistor to 12 VDC, as illustrated in Figure 2-4.

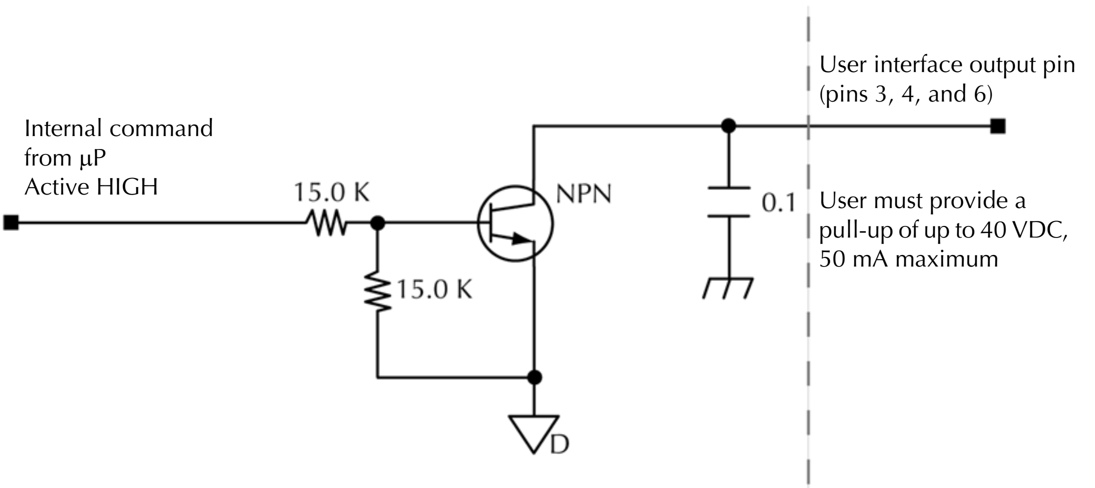
Figure 2-4 Input circuit wiring



Status outputs

The module provides an open collector output with no pull-up, as illustrated in Figure 2-5.

Figure 2-5 Output circuit wiring



Relay wiring

The module has two trip point relays. The contacts are silver alloy-gold clad, rated for 1 A at 30 VDC. The relays can handle resistive or non-inductive loads.

- Figure 2-6 illustrates the 9-pin trip point connector.
- Table 2-3 lists pin connections for the 9-pin male D connector.

Figure 2-6 Trip point relay 9-pin connector

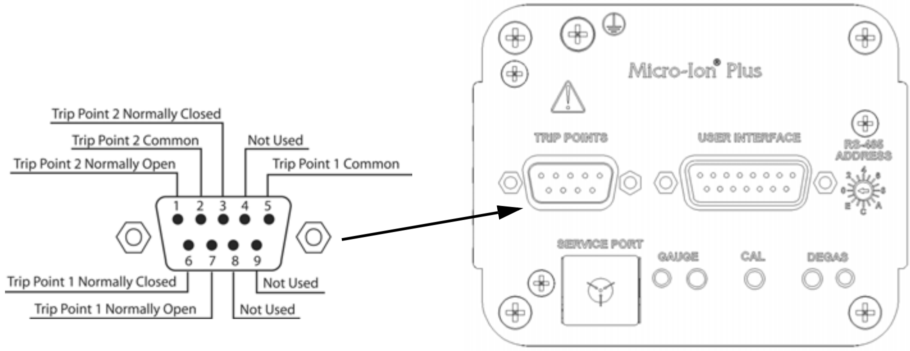


Table 2-3 Trip point relay 9-pin connector pins

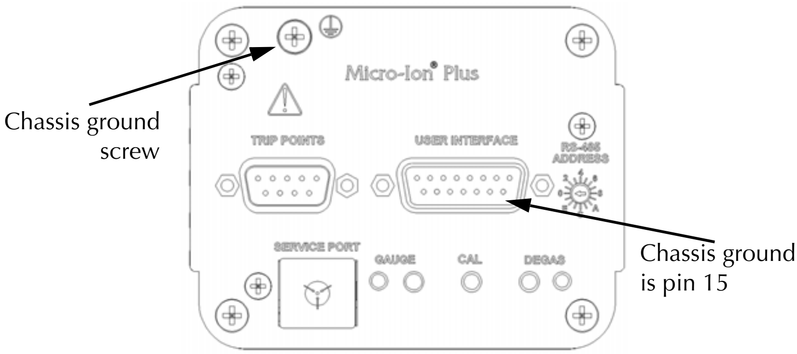
Pin number	Function	Input/output	Voltage level
These voltage levels apply ONLY for resistive or non-inductive loads.			
Pin 1	Relay 2: Normally open	Output	0 to 30 VDC, 1 A
Pin 2	Relay 2: Common	Output	0 to 30 VDC, 1 A
Pin 3	Relay 2: Normally closed	Output	0 to 30 VDC, 1 A
Pin 4	Not used		No connection
Pin 5	Relay 1: Common	Output	0 to 30 VDC, 1 A
Pin 6	Relay 1: Normally closed	Output	0 to 30 VDC, 1 A
Pin 7	Relay 1: Normally open	Output	0 to 30 VDC, 1 A
Pin 8	Not used		No connection
Pin 9	Not used		No connection

Grounding

The module chassis must be properly grounded via the 15-pin subminiature D connector and the chassis ground screw, as illustrated in Figure 2-7.

The module generates 180 VDC during normal operation (Micro-Ion gauge ON) and 250 VDC during Micro-Ion gauge degas.

Figure 2-7 Ground connections



> **⚠ WARNING**
>
> **Improper grounding could cause severe product failure or personal injury.**
>
> Follow ground network requirements for the facility.
>
> - Maintain all exposed conductors at earth ground.
> - Make sure the vacuum port to which the module is mounted is properly grounded.
> - Connect the ground strap to the chassis ground screw on the module control panel.

Step 5 *Calibrate Conductron sensor*

To calibrate the Conductron sensor, see page 43.

An atmospheric calibration is performed on the Conductron sensor at the factory before the module is shipped. The factory calibration sets the atmospheric calibration point to approximately 635 Torr (846 mbar, 84.6 kPa).

Because atmospheric pressure varies according to location, you should set the atmospheric calibration point, *using* N_2 *or air*, before putting the module into operation. Periodic resets of the atmospheric calibration point also improve the accuracy and repeatability of the Conductron sensor.

2.3 Eliminating radio frequency interference

The module has been tested and found to comply with U.S. Federal Communications Commission (FCC) limits for a Class A digital device, pursuant to Part 15 of the FCC rules. These limits provide reasonable protection against harmful interference when the module operates in a commercial environment.

The module generates and can radiate radio frequency energy and, if not installed and used in accordance with the instructions in this manual, may cause harmful interference to radio and television communications. However, there is no guarantee that interference will not occur in a particular installation. If the module causes interference to radio or television reception, which can be determined by turning the module OFF and ON, use one of the following methods to eliminate the interference:

- Re-orient or relocate the receiving antenna.
- Increase the separation between the module and the receiver.
- Connect the module into an outlet on a circuit that is *not* the circuit to which the receiver is connected.
- Consult an experienced radio or television technician for help.

Chapter 3 Operation

3.1 Preparing to operate the module

This chapter explains how to operate the Micro-Ion Plus module.

> **⚠ WARNING**
>
> **Using the module to measure the pressure of flammable or explosive gases can cause a fire or explosion resulting in severe property damage, personal injury, or death.**
>
> Do not use the module to measure the pressure of flammable or explosive gases.

Before putting the module into operation, you must perform the following procedures:

1. Install the module in accordance with the instructions on pages 5–15.
2. Develop a logic diagram of the process control function.
3. Develop a circuit schematic that specifies exactly how each piece of system hardware will connect to the module relays.
4. Attach a copy of the process control circuit diagram to this manual for future reference and troubleshooting.
5. Set the module address, baud rate, and parity as instructed on pages 46–47.

If you need application assistance, phone a Granville-Phillips application engineer at **1–303–652–4400** or **1–800–776–6543** within the U.S.A., or mail *co-csr@brooks.com*.

3.2 Module operational tasks

Table 3-1 lists operational tasks.

Table 3-1 Tasks and page references for module operation

Task	Instructions:
Read the analog output	Page 25
Read vacuum pressure	Page 26
Set mode to read pressure indication when Micro-Ion gauge is OFF	Page 27
Initiate or terminate Micro-Ion gauge degas	Page 27
Turn Micro-Ion gauge OFF or ON	Page 28
Read Micro-Ion gauge ON/OFF status	Page 30
Set or read Micro-Ion gauge delay time	Page 31
Set Micro-Ion gauge filament mode	Page 32
Read Micro-Ion gauge filament status	Page 37
Set or read Micro-Ion gauge emission current switching threshold	Page 37
Set relay trip points	Page 38
Set relay polarity	Page 42
Set relay hysteresis	Page 43
Calibrate Conductron sensor at atmosphere	Page 43
Calibrate Conductron sensor at vacuum	Page 44
Read firmware version for module	Page 45
Read module status character strings	Page 45
Set RS–485 address offset	Page 46
Set RS–485 baud rate	Page 47
Set RS–485 parity	Page 47
Set pressure unit	Page 47
Reset module to power-up state	Page 47
Toggle locked interface functions	Page 48
Unlock interface functions	Page 48
Lock control functions (keyboard)	Page 49
Unlock control functions (keyboard)	Page 49
Read keyboard lock/unlock status	Page 49
Reset parameters to factory defaults	Page 50

3.3 RS–485 physical layer

Table 3-2 lists specifications for the RS–485 physical layer.

Table 3-2 RS–485 physical layer specifications

Function	Description
Arrangement	2-wire half duplex
Address range	0 to 63
Default address	01
Method for setting module address	• Use address switches to set value of 0 to 15 for address (see page 46) • Send SA command to set value of 10, 20, or 30 for address offset (see page 46)
Maximum cable length	• 4000 feet (1610 meters) • A common ground wire should connect all network devices for long cable runs
Maximum number of devices in network	31 devices
Default baud rate	19200 baud (19.2 kbaud)
Data bits	8 data bits
Stop bits and parity	1 stop bit, no parity

3.4 RS–485 command structure

RS–485 commands require entry of integer values, hex code values (such as “0F”), values in engineering notation (such as “2.00E+02”), and ASCII character strings.

Table 3-3 explains the RS–485 command structure. The command should not include a line feed with the carriage return. Including a line feed adds an extra character and may cause a garbled response from the module.

The ↵ symbol at the end of the command represents the carriage return (CR), which is entered as hex code 0D or, if you’re using a terminal, by simultaneously pressing the “Control” and “M” keys.

Table 3-3 RS–485 command structure

Address field	Command field	Data field	Carriage return
#XX	Character string for command from host	Character string data required to execute command	↵
"XX" is 2-digit address	First character is: • PC = Process control • S = Set • T = Calibrate • R = Read or reset • I = Ion gauge • V = Version • K = Keyboard	Data may include: • Hex code • Pressure value in engineering notation • ASCII character string	• Enter hex code "0D" • Simultaneously press "Control" and "M" keys

3.5 RS–485 command set

Table 3-4 lists RS–485 commands that provide pressure values or other information without affecting module operation.

Table 3-5 on page 21 lists RS–485 commands that may affect module operation and have default values.

Table 3-4 RS–485 command set for values not affecting module operation

Command	Command type	Non-volatile	Change after reset	Data returned	Can be locked
RD	Read	No	No	Vacuum pressure	No
IGS	Read	No	No	Micro-Ion gauge ON/OFF status	No
RF	Read	No	No	Micro-Ion gauge filament status	No
RE	Read	No	No	Micro-Ion gauge emission current	No
VER	Read	Yes	No	Firmware version	No
RS	Read	No	No	Module status RS–485 string	No
KBS	Read	Yes	No	Keyboard lock/unlock status	No

Table 3-5 RS–485 command set for commands affecting module operation

Command	Command type	Non-volatile	Default	Change after reset	Data returned	Can be locked
DG	Read/write	No	OFF (0)	No	Confirm or state	No
IG	Read/write	No	ON (1)	No	Confirm or state	No
IGM	Read/write	Yes	ON (1)	No	Confirm or state	No
IDT	Read/write	Yes	0 seconds	No	Confirm or state	No
SF	Read/write	Yes	• Manual (MAN) mode for tungsten filaments • Alternating (ALT) mode for yttria-coated iridium filaments	No	Confirm or state	Yes
SER	Read/write	Yes	1.0 x 10^{-5} Torr 1.33 x 10^{-5} mbar 1.33 x 10^{-3} Pa	No	Confirm or state	Yes
PC	Read/write	Yes	0.0	No	Confirm or state	No
PCP	Read/write	Yes	Relay activates with decreasing pressure	No	Confirm or state	No
PCH	Read/write	Yes	Relay deactivates at 10% above activation pressure	No	Confirm or state	No
TS	Write	Yes	Factory setting	No	Confirm	No
TZ	Write	Yes	Automatically set	No	Confirm	No
SA	Write	Yes	00	Yes	Confirm	Yes
SB	Write	Yes	19200 baud	Yes	Confirm	Yes
SP	Write	Yes	8 data bits No parity	Yes	Confirm	Yes
SU	Write	Yes	Torr, mbar, or Pa as specified by customer	Yes	Confirm	Yes
RST	Write	No	None (not applicable)	No	None	No
TLU	Write	Yes	Functions unlocked	No	Confirm	No
UNL	Write	Yes	Functions unlocked	No	Confirm	No
KBL	Write	Yes	Keyboard is unlocked	No	Confirm	No
KBU	Write	Yes	Keyboard is unlocked	Yes	Confirm	No
FAC	Write	Yes	Factory defaults	Yes	Confirm	No

3.6 Data timing and response

The module communicates using half-duplex mode. The host issues a command then waits for a response from the module.

Figure 3-1 illustrates the request and response data timing sequence, including:

- The request sent by the host, response sent by the module.
- Minimum and maximum time duration from the end of the receipt of the request to the start of the response (T_D).
- Time required for the module to process and respond with the data (T_R).
- Time for the module to switch between transmit and receive modes (D).

Table 3-6 lists data timing and response delay limits. The time required for the module to process and send the response depends on the baud rate and command type, as listed in Table 3-7 and Table 3-8.

The minimum response time of the module to a request is 1.2 msec. The host must switch from transmit to receive mode in 12.0 msec or less to ensure proper receipt of response data packets from the module. The host must wait a minimum of 200 µsec after receiving the response before sending a new request command.

Figure 3-1 Data timing and response delays

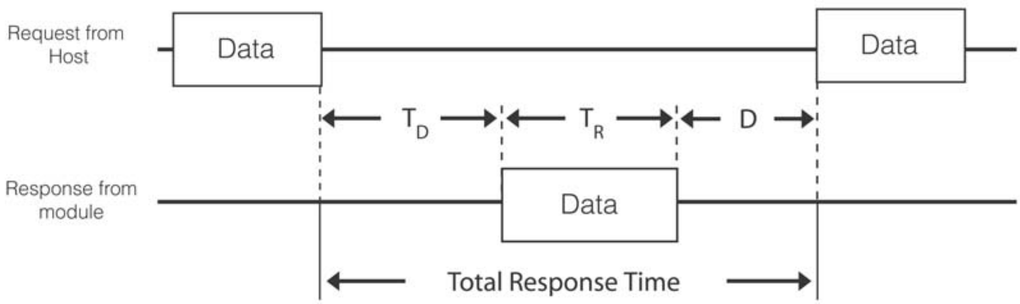


Table 3-6 Data timing and response delay limits

Timing segment	Time limit
Time T_D (time for host to switch from transmit to receive)	1.2 msec minimum 12.0 msec maximum
Time T_R (data processing and response time)	$\left(\frac{1}{Baud} \times 130\right) + Time_P$
Time T_P (data processing time)	See Table 3-8
Time D (time for module to switch from transmit to receive)	200 µsec minimum 1.0 msec maximum
Total response time	Time T_D + $Time_R$ + Time D

Table 3-7 Baud rate and data response time

Baud rate	Response time
1200 baud	108 msec
2400 baud	54 msec
4800 baud	27 msec
9600 baud	13.5 msec
19200 baud (default)	6.75 msec
38400 baud	3.3 msec

Table 3-8 Task and data processing time

Task	Data processing time (T_P)
Read commands	0 sec
Write commands	5 msec
FAC (reset values to factory defaults)	28.0 msec
RST (reset module to power-up state)	No response

3.7 Error responses and display error codes

- Table 3-9 lists error responses that the module returns if you enter a command improperly or if a value in a command is out of range.
- Table 3-10 lists error codes produced by the optional pressure display.

Table 3-9 RS–485 error responses

Response*	Possible causes	Solution
`?XX RANGE ER`	Pressure value in TS, TZ, SER, or IDT command is outside valid limits.	• Make sure atmospheric pressure > 400 Torr (533 mbar, 53.3 kPa), then re-send TS command (see page 43). • Make sure vacuum pressure < 1 x 10^{-3} Torr (1.33 x 10^{-3} mbar, 0.13 Pa), then re-send TZ command (see page 44). • Make sure pressure represented in SER command is > 1.0 x 10^{-7} Torr (1.3 x 10^{-7} mbar, 1.3 x 10^{-5} Pa) and < 1.0 x 10^{-4} Torr (1.3 x 10^{-4} mbar, 1.3 x 10^{-2} Pa), then re-send SER command (see page 37). • Make sure number of seconds in IDT command is 0 to 600, then re-send IDT command (see page 31).
`?XX SYNTX ER`	• Command was improperly entered. • Module does not recognize command syntax.	Re-enter command using proper character string.
`?XX 9.99E+09`	Module cannot indicate a valid pressure value.	• Send RS command to determine module status (see page 45). • If necessary, replace gauge assembly (see page 57).
`?XX  LOCKED`	User attempted to reprogram a locked function without sending TLU or UNL command.	Send TLU or UNL command, then re-send attempted command (see page 48).
`?XX INVALID`	Command syntax is correct, but command cannot be executed in current state (for example, user attempts to initiate degas cycle while Micro-Ion gauge is OFF).	Change module to valid state for command, then re-send attempted command.

* In each response “XX” represents the module address.

Table 3-10 Display error codes

Response	Cause	Solution
Er #1	Conductron sensor is inoperable.	Replace gauge assembly (see page 57).
Er #5	Micro-Ion gauge grid voltage failure.	Cycle power to module.
Er #6	Micro-Ion gauge emission failure.	Cycle power to module.

3.8 Reading the analog output

- The output is logarithmic, 0.50 VDC/decade, where 1000 Torr = 7 VDC, as illustrated in Figure 3-2.
- Output impedance is 100 Ω.

An output signal of 10 VDC occurs any time the gauge is intentionally turned OFF or when an error condition occurs.

Use the following equation to convert output voltage to pressure in Torr:

$$P_{Torr} = 10^{\left(\frac{V_{out} - 5.500}{0.500}\right)}$$

Use the following equation to calculate output voltage from pressure:

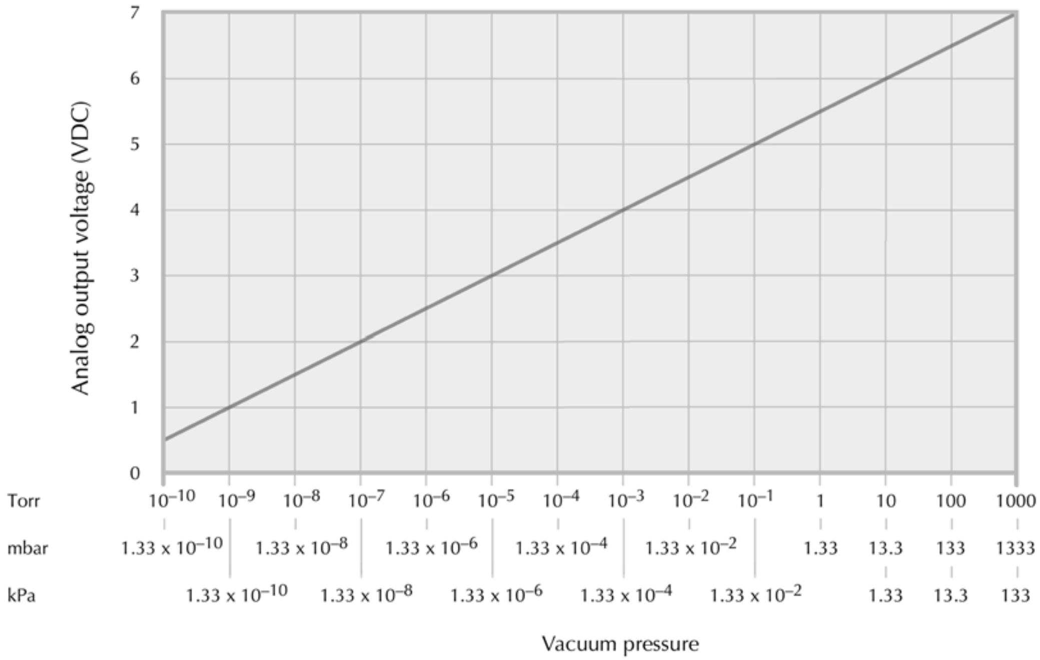
$$V_{out} = 0.500\text{Log}(P_{Torr}) + 5.500$$

To convert Torr to mbar, multiply P_{Torr} by 1.333.

To convert Torr to Pa, multiply P_{Torr} by 133.3.

You may turn OFF the Micro-Ion gauge by using the gauge on/off button, the pin 1 gauge on/off user I/O control pin, or the RS–485 IG command. Error conditions are caused by a Conductron sensor failure, a Micro-Ion gauge high voltage failure, or failure of both gauge filaments.

Figure 3-2 Analog output voltage versus pressure



Operation

RD **Read vacuum pressure**

The example read pressure (RD) command causes the module to return a value that indicates vacuum pressure is 1.50 x 10^{-2}:

Example RD command from host: `#01RD↵`
Example response from module: `*01 1.50E-02↵`

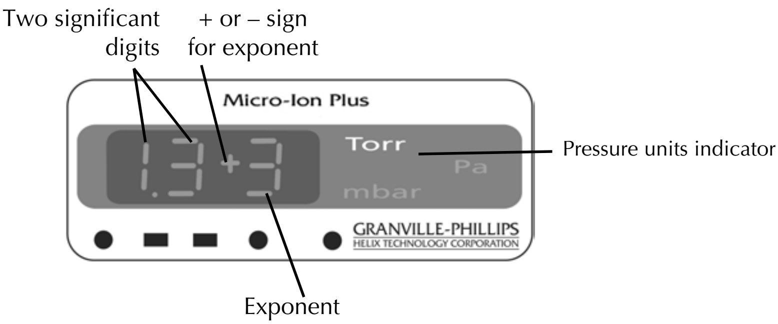
- The returned value is in the unit of measure that has been set for the module.
- If the returned value is not a valid representation of pressure, see page 45.
- You may also use the optional numeric display to read vacuum pressure and error codes.

The optional numerical display is a 7-segment, green LED display. See Figure 3-3. The display shows 2 significant digits, 1-digit exponent, and a ± sign for the exponent, allowing for an XX±Y display.

The displayed pressure range is 0.1x10^{-9} to atmosphere ("At") as measured by the Conductron sensor and Micro-Ion gauge.

If the display reads "At+," pressure is higher than 760 Torr (1000 mbar, 1.00 x 10^5 Pa), and calibration at atmosphere is required. See page 43.

Figure 3-3 Optional numeric display



Pressure values in the 10^{-10} range (such as 6 x 10^{-10}) will be displayed as "0.6–9". The resolution of the numeric display changes over the operating range of the module. See Table 3-11.

Pressure will be displayed in units of Torr, mbar or Pa, as selected. The unit of measure is illuminated on the display panel. The units indicator is always ON when the module is powered.

Table 3-11 Display resolution versus Conductron sensor pressure

Measured pressure			
Torr	**mbar**	**Pa**	**Display resolution**
Less than 50	Less than 66	Less than 6.6 x 10^3	Two digits
50 to 100	66 to 133	6.6 x 10^3 to 13.3 x 10^4	Increments of 10 pressure units
100 to 400	133 to 533	1.33 x 10^4 to 53.3 x 10^4	Increments of 100 pressure units
400 to 760	533 to 1.00 x 10^3	5.33 x 10^4 to 1.00 x 10^5	Display reads "At"
Greater than 760	Greater than 1.00 x 10^3	Greater than 1.00 x 10^5	Display reads "At+"

IGM **Set or read pressure indication**

If the Micro-Ion gauge is OFF, the IGM (ion gauge mode) command can be used to enable or disable pressure indications from the Conductron sensor.

Example IGM command from host: `#01IGM1↵`
Response from module: `*01 PROGM OK↵`

The RS–485 command includes the alpha characters "I", "G", and "M" and the alphanumeric 0 (OFF) or 1 (ON).

- The 0 switch disables pressure indications from the Conductron sensor while the Micro-Ion gauge is OFF.
- The 1 switch enables pressure indications from the Conductron sensor while the Micro-Ion gauge is OFF.

Use the "S" switch to read the pressure output status.

IGMS command from host: `#01IGMS↵`
Example response from module: `*01 0    ALL↵`

- The "0   ALL" character string means all pressure indications are *disabled* when the Micro-Ion gauge is OFF.
- The "1   IG" character string means pressure indications are *enabled* when the Micro-Ion gauge is OFF.

DG **Degas Micro-Ion gauge**

Pressure must be lower than 5 x 10^{-5} Torr (6.66 x 10^{-5} mbar, 6.66 x 10^{-3} Pa) for the degas to initiate. You cannot initiate more than two degas cycles in succession. Once the degas cycle has terminated, you must wait for the filaments to cool off before initiating a third degas cycle.

To degas the Micro-Ion gauge, follow these steps:

1. Turn the Micro-Ion gauge ON. (See page 43.)
2. Make sure vacuum pressure is lower than 5 x 10^{-5} Torr (6.66 x 10^{-5} mbar, 6.66 x 10^{-3} Pa).

3. Send the degas gauge initiate (DG1) command to initiate the Micro-Ion gauge degas cycle. The time for gauge degas is two minutes.

   DG1 command from host: `#01DG1↵`
   Response from module: `*01 PROGM OK↵`

4. *If you wish to terminate the Micro-Ion gauge degas cycle before it is completed*, send the degas gauge terminate (DG0) command.

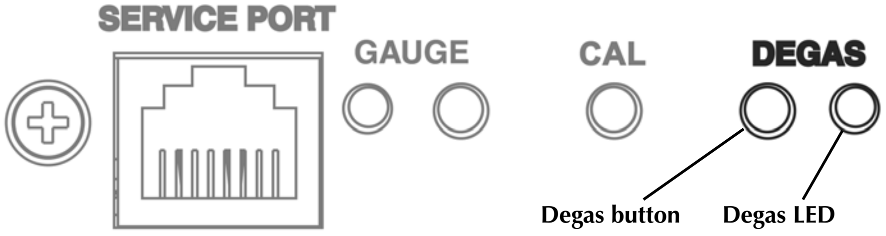
   DG0 command from host: `#01DG0↵`
   Response from module: `*01 PROGM OK↵`

The RS–485 command includes the alpha characters “D” and “G” and the numeric value 0 (terminate) or 1 (initiate).

You may also use the module degas button to initiate a Micro-Ion gauge degas cycle. Press the degas button to initiate or terminate the degas cycle. The degas cycle will run for two minutes unless you terminate it earlier. The degas LED turns solid amber to indicate degas in progress. Figure 3-4 illustrates the degas button and LED on the module control panel.

You may also install a switch between pins 5 and 7 on the 15-pin subminiature D connector that enables you to initiate a Micro-Ion gauge degas. To initiate the degas, close the switch. If the switch remains closed, the degas cycle will run for two minutes. You may terminate the degas cycle by opening the switch.

Figure 3-4 Degas button and LED on module control panel



IG **Turn Micro-Ion gauge ON or OFF**

When the module starts up, the Conductron sensor is ON. As pressure decreases to a level that allows the Micro-Ion gauge to operate, the sensor turns the gauge ON. In some instances, you might need to turn the Micro-Ion gauge OFF.

The RS–485 command includes the alpha characters “I” and “G” and the numeric value 0 (OFF) or 1 (ON).

Send the ion gauge off (IG0) command to turn the Micro-Ion gauge OFF.

IG0 command from host: `#01IG0↵`
Response from module: `*01 PROGM OK↵`

If you send the IG0 command, the Micro-Ion gauge remains OFF until you send an IG1 command.

Send the ion gauge on (IG1) command to turn the Micro-Ion gauge ON.

IG1 command from host:	`#01IG1↵`
Response from module:	`*01 PROGM OK↵`

If the Micro-Ion gauge is in manual filament mode and one filament is inoperable, you must switch to the other filament by sending the IG0 command, then sending the IG1 command.

You may also use the module gauge button to turn the Micro-Ion gauge OFF or ON. Figure 3-5 illustrates the gauge button and gauge LED on the module control panel.

You also may install a switch between pins 1 and 5 on the 15-pin subminiature D connector that enables you to turn the Micro-Ion gauge OFF or ON. Pin 1 must be grounded to pin 5 to enable the Micro-Ion gauge to operate.

- To turn the Micro-Ion gauge ON, close the switch.
- To turn the Micro-Ion gauge OFF, open the switch.

If the gauge is manually turned OFF, the optional numeric display on the module indicates pressure as measured by the Conductron sensor and the gauge status indicator turns to blinking amber.

Table 3-12 describes the gauge status and corresponding LED states.

Figure 3-5 Micro-Ion gauge button and LED on module control panel

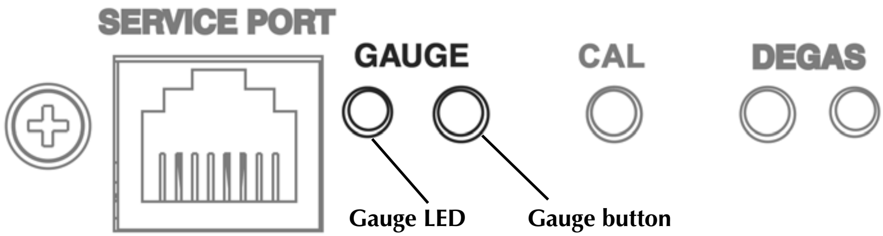


Table 3-12 Micro-Ion gauge status LED

Gauge status	LED state
Micro-Ion gauge and Conductron sensor ON, both gauge filaments OK	Solid green
Micro-Ion gauge and Conductron sensor ON, one gauge filament cannot sustain emission	Blinking green
Micro-Ion gauge is OFF, pressure > turn-on point	Solid amber
• Operator used switch or command to switch Micro-Ion gauge sensor OFF • Optional numeric display indicates pressure as measured by Conductron sensor	Blinking amber
• Micro-Ion gauge is OFF, both filaments are open • Conductron sensor failure • Micro-Ion gauge will not turn ON	Solid red
• Micro-Ion gauge is OFF, primary filament failure • if operating in manual filament mode, press gauge button to turn Micro-Ion gauge ON	Blinking red

IGS **Read Micro-Ion gauge ON/OFF status**

If you send the ion gauge status (IGS) command, the module returns a character string that indicates the ON/OFF status of the Micro-Ion gauge.

IGS command from host: `#01IGS↵`
Example response from module: `*01 1 IG  ON↵`

- The “1 IG ON” response means the Micro-Ion gauge is ON.
- The “0 IG OFF” response means the Micro-Ion gauge is OFF.

Automatic filament selection

As the vacuum system pumps down from atmosphere, the Conductron sensor measures pressure until a pressure of 20 mTorr (2.66 x 10^{-2} mbar, 2.66 Pa) is achieved, then automatically turns ON the Micro-Ion gauge.

Tungsten filaments are more likely than yttria-coated iridium filaments to burn out if they turn ON at a pressure that is too high. To reduce the risk of burnout, the default behavior of Micro-Ion gauge depends on the filament material.

If a rapid increase in pressure from high vacuum levels to pressures of 1 Torr (1.33 mbar, 133 Pa) or higher pressure occurs, tungsten filaments are almost certain to burn out. This risk is not unique to the Micro-Ion gauge and exists for all ion gauges containing tungsten filaments.

Table 3-13 lists default delay times and filament modes for the Micro-Ion gauge. Using RS–485 communications, you can use the IDT and SF commands to change the behavior of the Micro-Ion gauge.

Table 3-13 Defaults for Micro-Ion gauge filament material

Function	Default for tungsten filaments	Default for yttria-coated iridium filaments
Micro-Ion gauge delay time	Module software determines the appropriate amount of time to wait before the Micro-Ion gauge turns ON with decreasing pressure	Micro-Ion gauge turns ON, without delay, as soon as operational pressure is achieved with decreasing pressure.
Micro-Ion gauge filament mode	Manual (see page 32).	Alternating (see page 32).

IDT **Set or read Micro-Ion gauge delay time**

You may send the ion gauge delay time (IDT) command to change the amount of time the Micro-Ion gauge waits to turn ON after pressure has decreased to a point where the gauge can operate.

The example IDT command sets the additional delay time to 20 seconds.

Example IDT command from host: `#01IDT 20↵`
Response from module: `*01 PROGM OK↵`

- The command includes the alpha characters "I", "D", and "T" and the numeric value representing the number of seconds.
- Valid values are 0 to 600 seconds.
- The Micro-Ion gauge will wait the number of seconds specified in the IDT command, *plus* the software-defined delay, before turning on with decreasing pressure.
- With increasing pressure, the Micro-Ion gauge will turn OFF when pressure increases to 30 mTorr (3.99×10^{-2} mbar, 3.99 Pa).

If you send the IDT command without the time value, the module returns a character string that represents the Micro-Ion gauge delay time.

IDT command from host: `#01IDT↵`
Example response from module: `*01 60 IDT↵`

The example response means the delay time is set to 60 seconds. If the SF command is set to T (tungsten), the response does *not* include the additional software-determined delay.

During the delay, outputs indicate pressure as measured by the Conductron sensor.

SF **Set Micro-Ion gauge filament mode**

The Micro-Ion gauge contains two filaments. The Micro-Ion gauge can operate in automatic, alternating, or manual filament mode.

The example set filament (SF) RS–485 command sets the gauge to manual mode.

Example SF command from host: `#01SFMAN↵`
Response from module: `*01 PROGM OK↵`

- Table 3-14 explains settings for the SF command.
- Pages 32–36 contain figures and tables that explain the operation of Micro-Ion gauge, its filaments, the Gauge LED, and the Gauge button in automatic, alternating, and manual modes. Figure 3-6 illustrates the Gauge button and Gauge LED on the module control panel.

Table 3-14 Filament mode settings

Setting	Description
SFALT	• Sets Micro-Ion gauge to alternating mode (see Table 3-16) • Default mode for Micro-Ion gauge with yttria-coated iridium filaments
SFAUTO	Sets Micro-Ion gauge to automatic mode (see Table 3-16)
SFMAN	• Sets Micro-Ion gauge to manual mode (see Table 3-17) • Default mode for Micro-Ion gauge with tungsten filaments
SFT	• Sets Micro-Ion gauge to manual mode (see Table 3-17) • Sets IDT command to a value of 10 seconds (see page 31)
SFY	• Sets Micro-Ion gauge to alternating mode (see Table 3-16) • Sets IDT command to a value of 0 seconds (see page 31)

Figure 3-6 Gauge LED

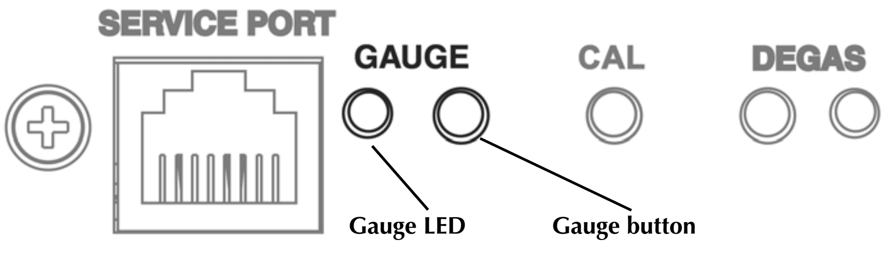


Table 3-15 Micro-Ion filament operation modes

Mode	Description
Automatic	• Filament logic operates filament 1 each time Micro-Ion gauge turns ON • If filament 1 becomes inoperable, Micro-Ion gauge switches to filament 2
Alternating (default for Micro-Ion gauge with yttria-coated iridium filaments)	• Filament logic alternates between filament 1 and filament 2 each time Micro-Ion gauge turns ON • If a filament becomes inoperable, module switches to the operable filament • Default mode for Micro-Ion gauge with yttria-coated iridium filaments
Manual (default for Micro-Ion gauge with tungsten filaments)	• Filament logic operates filament 1 each time the Micro-Ion gauge turns ON • If filament 1 becomes inoperable, press gauge button to turn filament 2 ON (gauge LED will flash red) • After gauge button has been pressed, filament 2 turns ON • Default mode for Micro-Ion gauge with tungsten filaments

Table 3-16 Micro-Ion gauge, gauge LED, and filament states in automatic or alternating mode

Micro-Ion gauge state	Gauge LED state	Filament state
OFF automatically	Amber	Micro-Ion gauge has automatically turned OFF
OFF and disabled	Flashing amber	Micro-Ion gauge is disabled
ON	Green	• Filament 1 or 2 is ON • Both filaments are operable
ON	Flashing green	Filament 1 or 2 is inoperable
OFF	Red	Filaments 1 and 2 are inoperable

Table 3-17 Micro-Ion gauge, gauge LED, and filament states in manual mode

Micro-Ion gauge state	Gauge LED state	Filament state
OFF automatically	Amber	Micro-Ion gauge has automatically turned OFF
OFF and disabled	Flashing amber	Micro-Ion gauge is disabled
ON	Green	Filament 1 is ON
ON	Flashing green	Filament 2 is ON
OFF	Flashing red	• Filament 1 is inoperable • Press gauge button to switch to filament 2
OFF	Red	Filaments 1 and 2 are inoperable

Figure 3-7 Automatic filament switching flow chart

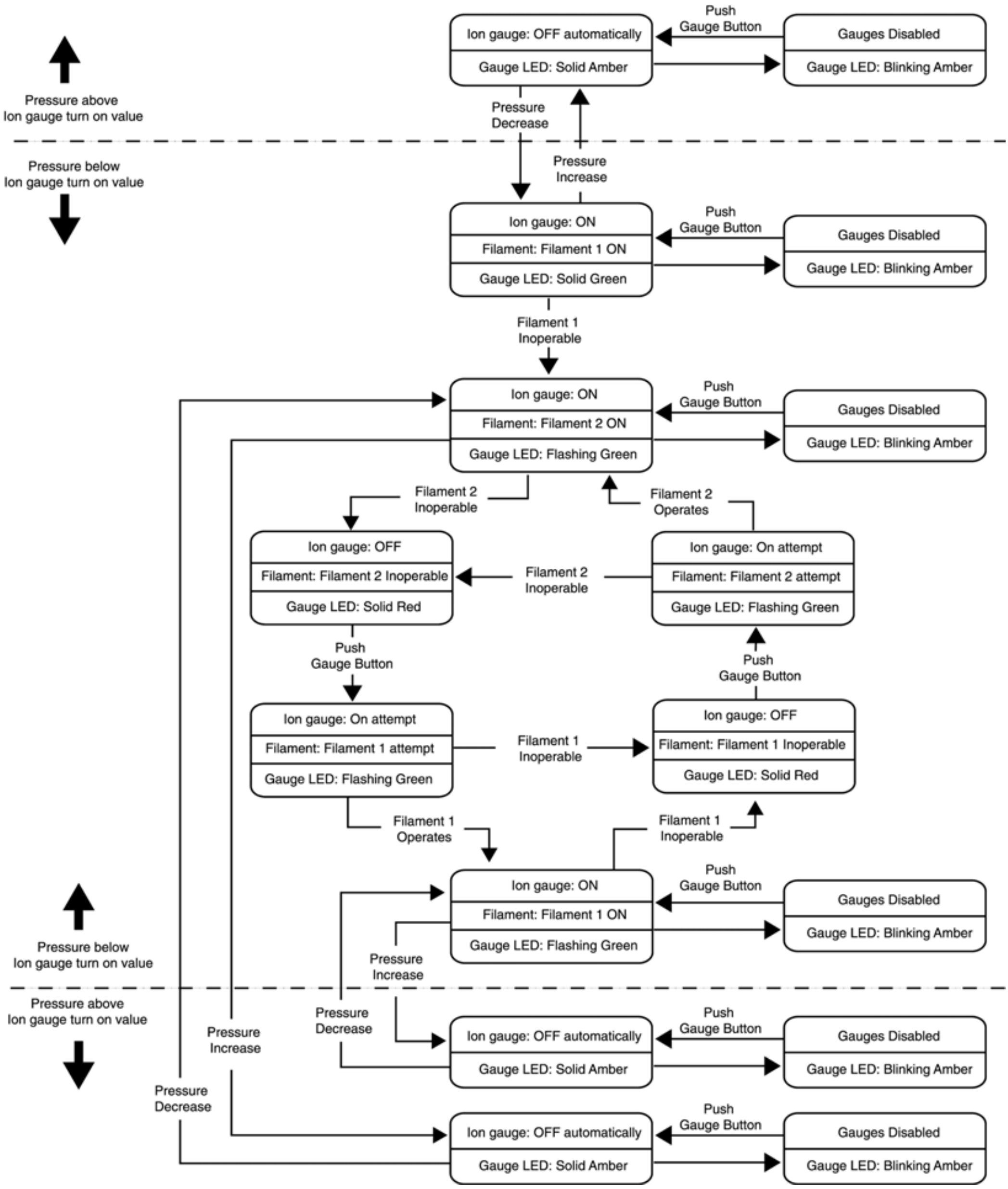
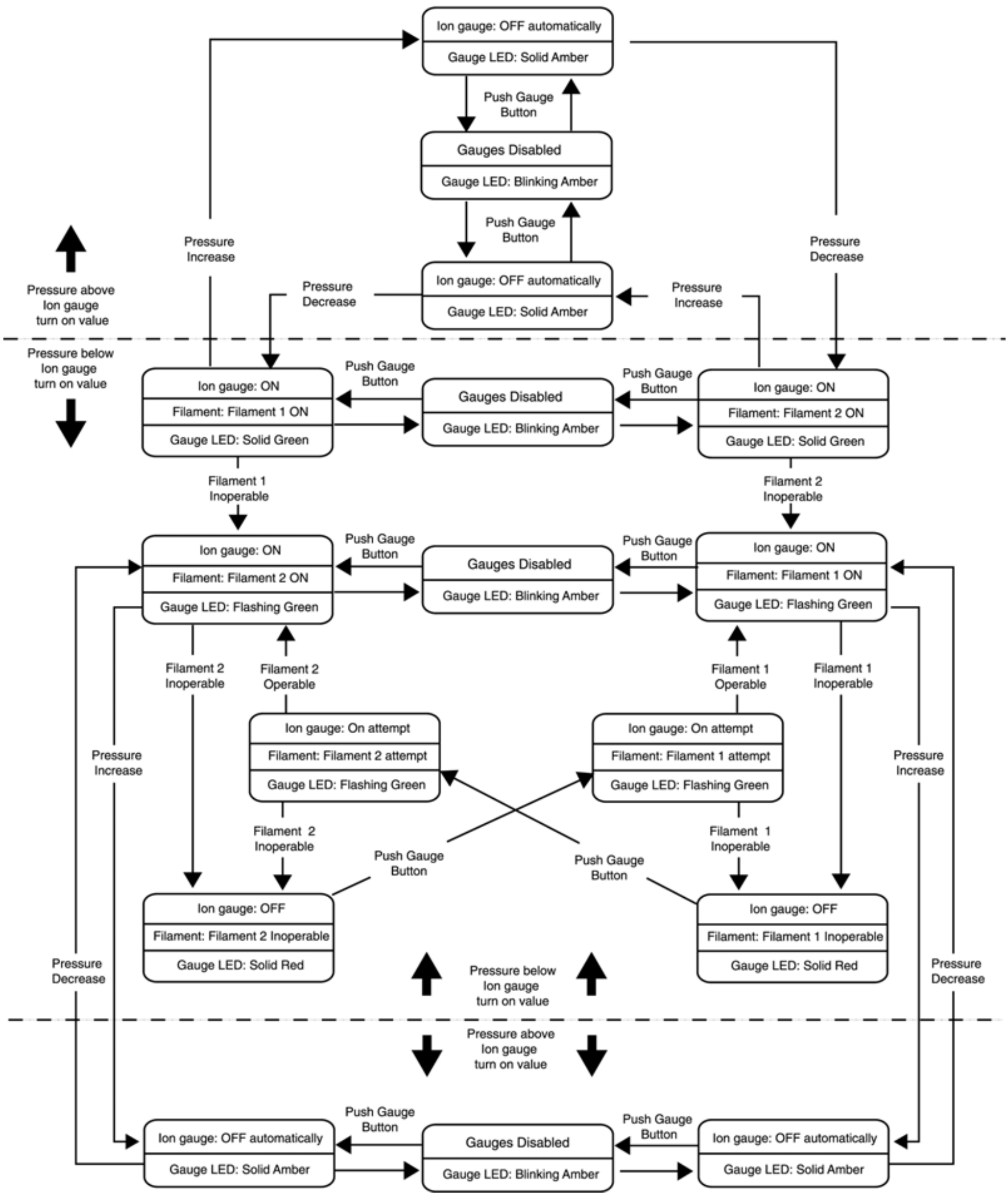
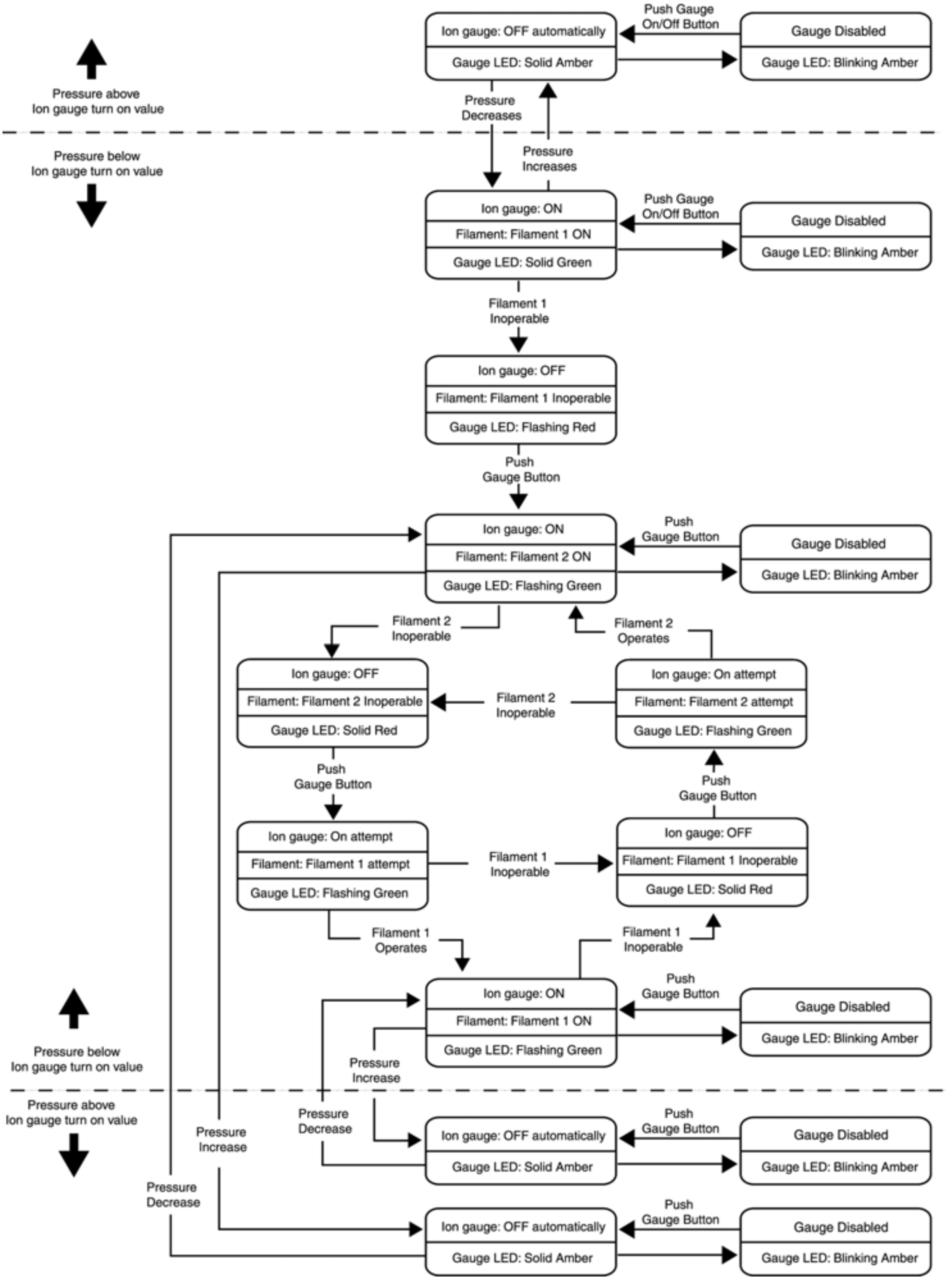


Figure 3-8 Alternating filament switching flow chart



Operation

Figure 3-9 Manual filament switching flow chart



RF **Read Micro-Ion gauge filament status**

The read filament (RF) RS–485 command causes the module to return a character string indicating filament condition.

RF command from host: `#01RF↵`
Example response from module: `*01 FIL SF1↵`

- The "FIL SF1" response means filament 1 is operating.
- The "FIL SF2" response means filament 2 is operating.
- The "FILBOTH" response means a degas cycle is in progress.

SER **Set Micro-Ion gauge emission current threshold**

The Micro-Ion gauge can operate at either of two emission current levels.

- In low-emission mode, the current level is 0.1 mA.
- In high-emission mode, the current level is 4 mA.

As the vacuum pump removes gas from the system, the Conductron sensor measures pressure until it has decreased to a threshold pressure at which the Micro-Ion gauge can operate. At this gauge pressure, the Conductron sensor turns the Micro-Ion gauge ON at the low emission current level (0.1 mA).

As pressure continues to decrease, the Micro-Ion gauge switches from low emission to high emission (4 mA). If pressure increases after the emission current has gone from low to high, the gauge switches back to low emission. Table 3-18 lists default, minimum, and maximum pressure values at which the gauge switches emission current.

Table 3-18 Micro-Ion gauge emission current pressure values

Emission current setting	Minimum switch points	Default switch points	Maximum switch points
Switch to high emission current (4 mA) with decreasing pressure	5.0×10^{-8} Torr 6.6×10^{-8} mbar 6.6×10^{-6} Pa	5.0×10^{-6} Torr 6.6×10^{-6} mbar 6.6×10^{-4} Pa	5.0×10^{-5} Torr 6.6×10^{-5} mbar 6.6×10^{-3} Pa
Switch to low emission current (0.1 mA) with increasing pressure	1.0×10^{-7} Torr 1.3×10^{-7} mbar 1.3×10^{-5} Pa	1×10^{-5} Torr 1.3×10^{-5} mbar 1.3×10^{-3} Pa	1.0×10^{-4} Torr 1.3×10^{-4} mbar 1.3×10^{-2} Pa

The switch back to low emission current with increasing pressure is 100% greater than the switch to high emission current with decreasing pressure.

For example, in default mode, the emission current switches from low to high emission at 5×10^{-6} Torr (6.6×10^{-6} mbar, 6.6×10^{-4} Pa), then switches back to low emission at 1×10^{-5} Torr (1.3×10^{-5} mbar, 1.3×10^{-3} Pa).

Operation

Use the RS–485 set emission range (SER) command to set or read the pressure at which the Micro-Ion gauge switches from high to low emission current with increasing pressure.

Example SER command from host: `#01SER 1.00E-06↵`
Response from module: `*01 PROGM OK↵`

The example SER command sets a value of 1 x 10^{-6} for the pressure at which the Micro-Ion gauge switches from high to low emission current.

To read the emission current switch point, send an SER command without the pressure value.

Example SER command from host: `#01SER↵`
Example response from module: `*01 1.00E-05↵`

RE **Read Micro-Ion gauge emission current**

Send the read emission (RE) command to read the Micro-Ion gauge emission current.

RE command from host: `#01RE↵`
Example response from module: `*01 4.0MA EM↵`

Table 3-19 lists module responses to the RE command.

Table 3-19 Responses to RE command

Response	Description
4.0MA EM	Micro-Ion gauge is in high-emission mode (4.0 mA current)
0.1MA EM	Micro-Ion gauge is in low-emission mode (0.1 mA current)
15MA EM	Micro-Ion gauge degas cycle is in progress (see page 27)
0 IG OFF	Micro-Ion gauge is OFF (see page 43)

PC **Process control relay trip points**

The module includes two relays. Each relay has a programmable trip point.

When the module is shipped from the factory, trip point relays are set to a pressure of 0.0. The relays will not operate until they have been adjusted for the application.

The trip point may be set from 1 x 10^{-9} to 100. The pressure measurement unit restricts the trip points at the extremes of the measurement range. A built-in default hysteresis of 10% prevents oscillation around the trip point.

In default mode, relays activate with decreasing pressure and deactivate at a 10% higher pressure than the activation pressure, as illustrated in Figure 3-10.

You can reverse relay polarity, so relays activate with increasing pressure and deactivate at a lower pressure than the activation pressure, as illustrated in Figure 3-11.

Figure 3-10 Relay behavior with decreasing pressure

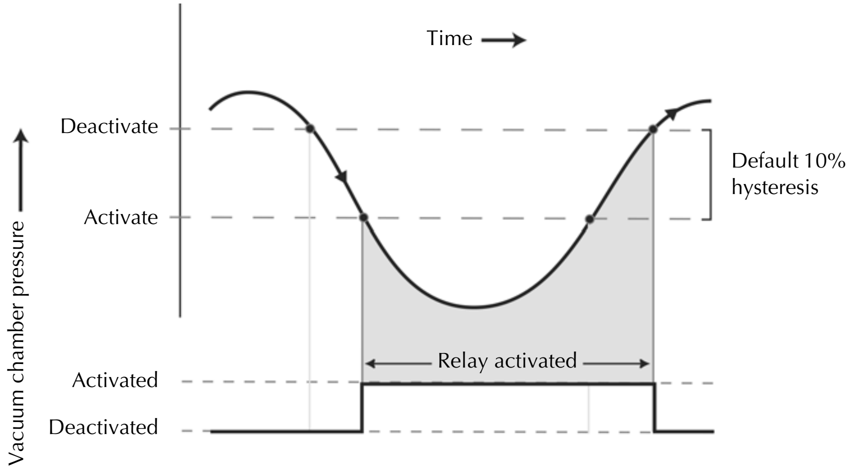
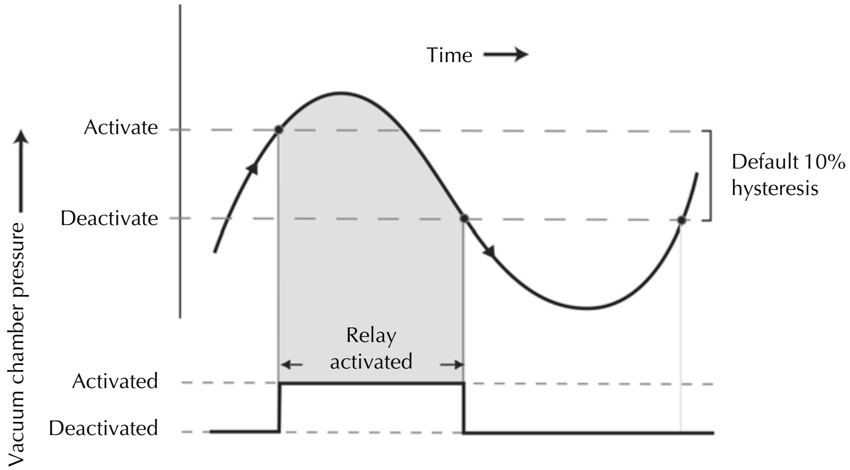


Figure 3-11 Relay behavior with increasing pressure



Relay configuration using the PC command

1. Make sure the module is properly installed and the power supply is ON.
2. Use Table 3-20 to record the activation pressure, activation direction, and hysteresis for each relay.

Table 3-20 Relay trip points and activation direction

Relay	Activation pressure for trip point	Activation direction	Hysteresis (as percentage of activation pressure)
Relay 1		☐ Activate with increasing pressure ☐ Activate with decreasing pressure	
Relay 2		☐ Activate with increasing pressure ☐ Activate with decreasing pressure	

3. Refer to the following example process control (PC) command sequence to program the pressure at which the relay will activate:

   The example PC command sequence causes relay 1 to activate when vacuum pressure decreases to 1.01 x 10^{-1}.

   Example PC command from host: `#01PC1 1.01E-01↵`
   Response from module: `*01 PROGM OK↵`

   The "PC1" command identifies process control relay 1. The "PC2" command identifies process control relay 2.

Relay configuration using trip point buttons and LEDs

1. Make sure the module is properly installed and the power supply is ON.
2. Use the optional display LEDs and recessed interface buttons to configure trip points. Use the trip points select button to activate the configuration mode and select the desired trip point for configuration.

   Figure 3-12 illustrates the trip point buttons and LEDs. The corresponding LED flashes to indicate the selected trip point.

Figure 3-12 Trip point buttons and LEDs

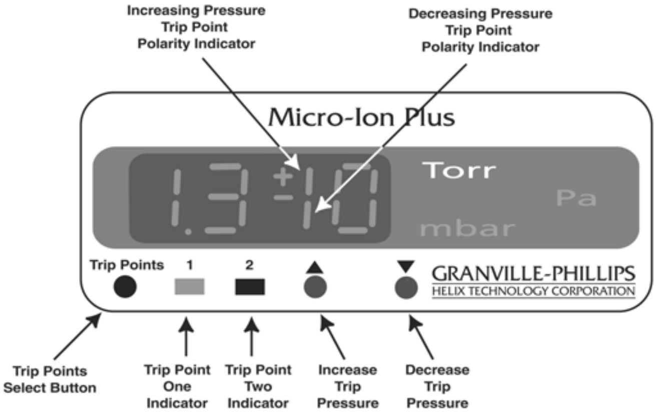


Table 3-21 indicates the status of trip point indicators during operation and configuration of trip point 1 or trip point 2.

Table 3-21 Trip point indicator status

Trip point 1 indicator

State	Trip point 1 indicator
Trip point relay 1 activated	Solid green
Trip point relay 1 deactivated	OFF
Trip point 1 configuration mode	Flashing green

Trip point 2 indicator

State	Trip point 2 indicator
Trip point relay 2 activated	Solid green
Trip point relay 2 deactivated	OFF
Trip point 2 configuration mode	Flashing green

3. *Activate the trip point configuration mode and select the desired trip point relay*. Press the Trip Points button.
   - The first press of the button activates the configuration mode and selects trip point one (LED 1 flashes).
   - Pushing the button a second time selects trip point two (LED 2 flashes).
4. *Set the trip point pressure value*. Press the up or down arrow until the display indicates the desired activation pressure for the trip point. Press the Trip Points button to store the indicated activation pressure and select the other relay.
5. Use Table 3-20 on page 40 to record the activation pressure and activation direction for each relay.
6. *If desired, select the appropriate polarity for the trip point*. If you wish to change the trip point polarity, press the up arrow or down arrow to scroll the display through the "0.0+0" display value. The upper segment of the exponent "1" digit flashes for increasing pressure, or the lower segment flashes for decreasing pressure.
7. *Return the display to the measured vacuum pressure reading*. Push the Trip Points button a third time to set the configuration values, deactivate the trip point configuration mode, and return the display to the measured vacuum pressure reading.

PCP **Set relay polarity**

In default mode, relays activate with decreasing pressure and deactivate at a 10% higher pressure than the activation pressure, as illustrated in Figure 3-10 on page 39.

The example process control polarity (PCP) command causes relay 1 to activate with increasing pressure.

Example PCP command from host: `#01PCP1 +↵`
Response from module: `*01 PROGM OK↵`

- The "PCP1" command identifies process control relay 1. The "PCP2" command identifies process control relay 2.
- The + sign causes the relay to activate with increasing pressure.
- The – sign causes the relay to activate with decreasing pressure.

PCH **Set relay hysteresis**

- Default hysteresis is 10% below activation pressure if relay activates with increasing pressure (+).
- Default hysteresis is 10% above activation pressure if relay activates with decreasing pressure (–).

The example process control hysteresis (PCH) command causes relay 1 to deactivate when increasing pressure is 20% lower than the activation pressure, if relay 1 polarity activates with increasing pressure (+).

Example PCH command from host: `#01PCH1 20↵`
Response from module: `*01 PROGM OK↵`

- The “PCH1” command identifies process control relay 1. The “PCH2” command identifies relay 2.
- Valid values are any percentage, from 5% to 100%, that is divisible by 5.

TS **Calibrate module at atmosphere**

An atmospheric pressure calibration of the Conductron sensor is performed with air at the Granville-Phillips Longmont facility prior to shipment. The factory calibration sets the atmospheric calibration point (“At”) to approximately 635 Torr (846 mbar, 8.46×10^4 Pa).

To ensure proper performance, the atmospheric pressure calibration of the Conductron sensor should be reset, using the process gas, once the module has been installed and is still at atmospheric pressure. Periodic resets of the atmospheric pressure calibration point will improve the accuracy and repeatability of the Conductron sensor near atmospheric pressure.

Because performance varies depending on the process gas, you may wish to reset the atmospheric calibration point if a gas other than N_2 or air is being used.

Figure 3-13 Illustrates the CAL button on the module control panel.

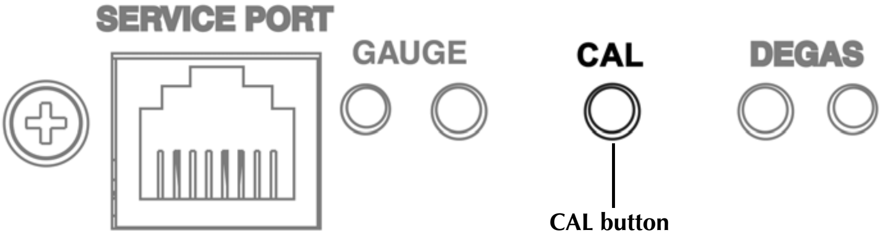
1. Shut off the pump and, *using the process gas*, allow vacuum pressure to increase to atmospheric pressure. (Atmospheric pressure must be > 400 Torr [533 mbar, 5.33 kPa] to enable calibration at atmosphere.)
2. To perform the atmospheric pressure calibration, press the CAL button, toggle pin 9 on the 15-pin subminiature D connector or, using the RS–485 interface, send the calibration (TS) command:

   Example TS command from host: `#01TS↵`
   Example response from module: `*01 PROGM OK↵`

If the module returns a “RANGE ER” message in response to the TS command, the atmospheric calibration has failed. The raw sensor voltage is outside the normal range for the Conductron sensor. See page 24 to troubleshoot the problem.

If the module has an optional display, the display will indicate “– – –” during the pushbutton calibration.

Figure 3-13 ATM (or CAL) button on module control panel



TZ **Calibrate module at vacuum**

The Conductron sensor turns the Micro-Ion gauge ON when pressure decreases to 2.0 x 10^{-2} Torr (2.66 x 10^{-2} mbar, 2.66 Pa). If the gauge assembly has been replaced or the electronics module swapped for another module, you might need to recalibrate the Conductron sensor at vacuum so that the Micro-Ion gauge will turn ON. If the Conductron sensor needs to be recalibrated, the optional display or other pressure output remains at a reading of > 20 mTorr (2.66 x 10^{-2} mbar, 2.66 Pa) when actual pressure is lower. The Conductron sensor offset is automatically calibrated when the Micro-Ion gauge turns ON.

Follow this procedure to recalibrate the Conductron sensor for vacuum pressure:

Maximum calibration pressure is 1 mTorr (1.33 x 10^{-3} mbar, 0.13 Pa).

1. Turn the pump ON and allow the vacuum chamber to decrease to a pressure of < 1 x 10^{-4} Torr (1.33 x 10^{-4} mbar, 1.33 x 10^{-2} Pa) or a lower pressure.
2. Press the CAL button, toggle pin 9 to ground on the 15-pin subminiature D connector or, using the RS–485 interface, send the calibration (TZ) command.

   Example TZ command from host: `#01TZ↵`
   Example response from module: `*01 PROGM OK↵`

If the module returns a “RANGE ER” message in response to the TZ command, the vacuum pressure calibration has failed. The raw sensor voltage is outside the normal range for the offset of the Conductron sensor. See page 24 to troubleshoot the problem.

The Micro-Ion gauge will turn ON after the TZ command has been sent.

VER **Read firmware version**

The example read firmware version (VER) command causes the module to return a value that represents the Brooks Automation internal part number 14851 and firmware revision 07 for the module:

Example VER command from host: `#01VER↵`
Example response from module: `*01 14851-07↵`

- The first five digits (preceding the dash) are the internal part number. This number will change depending on the module.
- The last two digits (following the dash) are the firmware version.

RS **Read module status RS–485 strings**

Send the read status (RS) command to read RS–485 character strings that indicate the module operating status.

RS command from host: `#01RS↵`
Example response from module: `*01 00 ST OK↵`

The example response indicates the module is operating normally.

Table 3-22 lists module responses to the RS command.

Table 3-22 Module status RS–485 strings

Response	Cause	Solution
`00 ST OK`	Module is operating normally.	No solution necessary.
`01 CGBAD`	Conductron sensor is inoperable.	• Cycle power to module. • If necessary, replace gauge assembly (see page 57).
`05 IG HV`	Micro-Ion gauge grid voltage failure.	Cycle power to module or send IG1 command to clear status response (see page 43).
`06 IG EM`	Micro-Ion gauge emission failure.	
`07 IGFIL`	One Micro-Ion gauge filament is open.	• If SF command is set to AUTO, ALT, or Y, operation automatically switches to the other filament (see page 32). • If SF command is set to MAN or T, send IG0 command, then send IG1 command to switch filaments (see page 32).
`08 POWER`	Power cycle has occurred, module is starting up.	No solution necessary. The "`00 ST OK`" string will be generated next if the module is operating properly.

SA **Set address offset**

The default address for the module is 01. You *may* assign any address from 0 to 63 (decimal equivalent).

The address consists of the hexadecimal switch setting plus the hexadecimal SA (set address offset) value. For example, to set a value of 60 for the address, set the switch to C_{hex} (12), then send an SA value of 30_{hex} (48).

To set the address, follow these steps:

1. Send an SA (set address offset) command to the module. The example SA command sets the address offset to 30_{hex} (48):

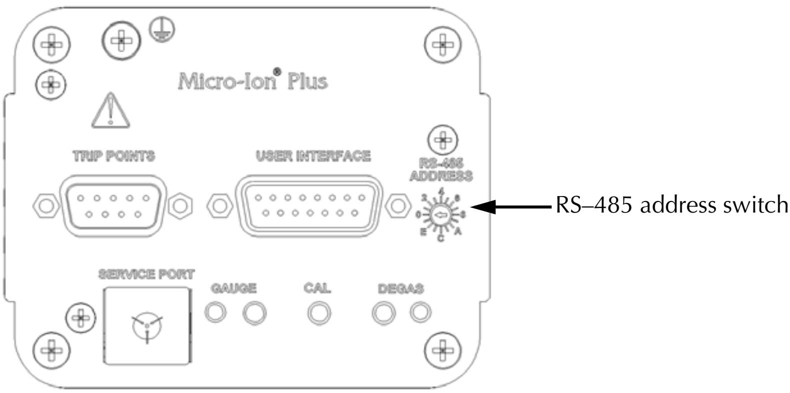
   Example SA command from host: `#01SA30↵`
   Response from module: `*01 PROGM OK↵`

   Valid SA command values are 00, 10_{hex} (16), 20_{hex} (32), or 30_{hex} (48).

2. Use the rotary switch located on the top of the module to set a value of 0 to 15 (see Figure 3-14).
   - Set the switch on one of the unlabeled marks for the values 1, 3, 5, 7, 9, B_{hex} (11), D_{hex} (13), or F_{hex} (15).
   - Set the switch on one of the labeled marks for the values 0, 2, 4, 6, 8, A_{hex} (10), C_{hex} (12), or E_{hex} (14).

3. Cycle power to the module to activate the new address offset.

Figure 3-14 Address switch



SB **Set baud rate**

The example set baud rate (SB) command sequence sets the baud rate to 2400 baud:

Example SB command from host: `#01SB2400↵`
Response from module: `*01 PROGM OK↵`

Allowable SB values are 1200, 2400, 4800, 9600, 19200 (default), or 38400 baud.

The response time from the module depends on the baud rate and the task that the host commands the module to perform.

Table 3-7 on page 23 lists baud rates and corresponding response times.

The module driver automatically shuts OFF 80 µsec after returning its response to the host.

SP **Set parity**

The example set parity (SP) command sequence sets parity at seven data bits, odd parity:

Example SP command from host: `#01SPO↵`
Response from module: `*01 PROGM OK↵`

- An SPO command sets parity at seven data bits, odd parity.
- An SPE command sets parity at seven data bits, even parity.
- An SPN command sets parity at eight data bits, no parity. This is the default parity.

SU **Set pressure unit**

The example set unit (SU) command sets the pressure unit to Torr:

Example SU command from host: `#01SUT↵`
Response from module: `*01 PROGM OK↵`

- An SUT command sets the pressure unit to Torr.
- An SUM command sets the pressure unit to millibar.
- An SUP command sets the pressure unit to Pascal.

RST **Reset module to power-up state**

The reset (RST) command resets the module to power-up status.

RST command from host: `#01RST↵`
Response from module: None

Sending the RST command has the same effect as cycling power to the module. Communication is re-enabled two seconds after you've sent the RST command.

TLU **Toggle locked functions**

In default operating mode, all interface functions are unlocked.

Use the toggle lock/unlock (TLU) command to lock or unlock any of the interface functions listed in Table 3-23.

Table 3-23 Interface functions affected by TLU command

Command	Interface function	Instructions:
SER	Set emission current threshold for Micro-Ion gauge	Page 37
SA	Set address offset	Page 46
SB	Set baud rate	Page 47
SP	Set parity	Page 47
SU	Set pressure unit	Page 47
KBL	Lock control functions (keyboard)	Page 49
KBU	Unlock control functions (keyboard)	Page 49
FAC	Reset values to factory defaults	Page 50

The module processes the command, then returns a character string that indicates whether or not interface functions are unlocked.

TLU command from host: `#01TLU↵`
Response from module: `*01 1 UL  ON↵`

- The "1 UL ON" response means interface functions are locked.
- The "0 UL OFF" response means interface functions are unlocked.

UNL **Unlock interface functions**

If you've used the TLU command to lock interface functions listed in Table 3-23, you must send the unlock interface functions (UNL) command to unlock a function before reprogramming it.

UNL command from host: `#01UNL↵`
Response from module: `*01 PROGM OK↵`

- If you send the UNL command while interface functions are already unlocked, the module returns a "SYNTX ER" response (see page 24).
- You can unlock all locked functions by sending the TLU command.
- If you attempt to reprogram a locked function without sending the UNL or TLU command, the module returns a " LOCKED" response (see page 24).

KBL **Lock keyboard**

The keyboard lock (KBL) command enables you to lock the CAL (or ATM), Gauge, Degas, and Trip Points buttons on the module.

KBL command from host: `#01KBL↵`
Response from module: `*01 PROGM OK↵`

After you've locked the buttons, you must use the KBU command to unlock them.

You may also ground pin 11 on the 15-pin subminiature D connector to lock the CAL, Gauge, Degas, and Trip Points buttons on the module.

To unlock the buttons, remove the pin 11 ground.

If you've locked the buttons by grounding pin 11, you cannot use the KBU command via RS–485 to unlock them. Remove the ground before sending the KBU command.

KBU **Unlock keyboard**

After you've locked the CAL (or ATM), Gauge, Degas, and Trip Points buttons, use the keyboard unlock (KBU) command to unlock them.

KBU command from host: `#01KBU↵`
Response from module: `*01 PROGM OK↵`

If you've locked the buttons by grounding pin 11 on the 15-pin subminiature D connector, the KBU command will not change the locked state. Remove the ground before sending the KBU command.

KBS **Keyboard lock/unlock status**

Use the keyboard status (KBS) command to determine whether the CAL (or ATM), Gauge, Degas, and Trip Points buttons are locked or unlocked.

KBS command from host: `#01KBS↵`
Response from module: `*01 1 KB OFF↵`

- The "1 KB OFF" response means the ATM (or CAL), Gauge, Degas, and Trip Points buttons are unlocked.
- The "1 KB ON " response means the ATM (or CAL), Gauge, Degas, and Trip Points buttons are locked.

FAC **Reset values to factory defaults**

Table 3-24 lists default settings for the RS–485 version of the module. After you've reconfigured the module, you must cycle power to the module before the new settings will take effect.

You may restore parameters listed in Table 3-24 to their default values by sending a factory reset (FAC) command.

FAC command from host: `#01FAC↵`
Response from module: `*01 PROGM OK↵`

Reset command from host: `#01RST↵`
Response from module: None

Table 3-24 Factory default settings for RS–485 module

Parameter	Default setting
Digital communication	• Parity: 8 data bits, no parity, 1 stop bit • Baud rate: 19.2 kbaud • Module address: 01 • Address offset: 00
Emission current threshold	• 5 x 10^{-6} Torr (7 x 10^{-6} mbar, 7 x 10^{-4} Pa) with decreasing pressure • 1 x 10^{-5} Torr (1 x 10^{-5} mbar, 1 x 10^{-3} Pa) with increasing pressure
Relays	• Trip point: Sets to 0.0 vacuum pressure; relay must be configured to be operable • Hysteresis and activation direction: Relay activates at 10% above vacuum pressure trip point (–) with decreasing pressure
Pressure output units and optional pressure display	Pressure unit is Torr, mbar, or Pa as specified on sales order and catalog number tag

Chapter 4 Maintenance

4.1 Customer service

For customer service:

- Phone **1–800–776–6543** within the U.S.A.
- Email *co-csr@brooks.com*.

Damage requiring service

Shut off power to the module and refer servicing to qualified service personnel under the following conditions:

- The product has been exposed to rain or water.
- The product does not operate normally, even if you have followed the operation instructions.
- The product has been dropped or the module enclosure has been damaged.
- The product exhibits a distinct change in performance.

If the module requires repair:

- See pages 57–58,
- Phone **1–800–776–6543** within the U.S.A., or
- Email *co-csr@brooks.com*.

4.2 Troubleshooting

If any of the conditions described on page 51 have occurred, troubleshooting is required to determine the repairs that are necessary.

Precautions

Because the module contains static-sensitive electronic parts, follow these precautions while troubleshooting:

- Use a grounded, conductive work surface. Wear a high impedance ground strap for personal protection.
- Do not operate the module with static sensitive devices or other components removed from the product.
- Do not handle static sensitive devices more than absolutely necessary, and only when wearing a ground strap.
- Use a grounded, electrostatic discharge safe soldering iron.

> **⚠ WARNING**
>
> **Substitution or modifying parts can result in severe product damage or personal injury due to electrical shock or fire.**
>
> - Install only those replacement parts that are specified by Granville–Phillips.
> - Do not install substitute parts or perform any unauthorized modification to the module.
> - Do not use the module if unauthorized modifications have been made.

Symptoms, causes, and solutions

Table 4-1 lists failure symptoms, causes, and solutions indicated by something other than an RS–485 error message from the module.

Table 4-1 Troubleshooting symptoms and causes

Symptom	Causes	Solutions
Gauge indicator does not illuminate.	• Power supply is disconnected, OFF, or inadequate for load. • A switching power supply may have shut down due to current surge during power-up. • Power supply wiring is faulty. • Power supply connector is wired incorrectly.	• Make sure power supply is ON. • Make sure power supply can withstand startup inrush current (see page 10). • Replace or repair power supply wiring (see page 10). • Reconnect wiring to power supply connector (see page 10).
Process control trip point does not function properly.	• Trip point connector is wired incorrectly. • Trip points are set to invalid values.	• Reconnect wiring to trip point connector (see page 13). • Reconfigure trip points (see page 38).
Micro-Ion gauge will not stay on.	• Vacuum chamber pressure > 3×10^{-2} Torr (3.99×10^{-2} mbar, 3.99 Pa). • Er #6: Micro-Ion gauge failure due to broken filament or contamination. • Er #5: Micro-Ion gauge failure due to damage, contamination, or power supply failure.	• Decrease vacuum chamber pressure to < 3×10^{-2} Torr (3.99×10^{-2} mbar, 3.99 Pa). • If filament is broken or mechanical damage has occurred, replace gauge assembly (see page 57). • If contamination is present, degas Micro-Ion gauge (see page 27).

Table 4-1 Troubleshooting symptoms and causes (continued)

Symptom	Causes	Solutions
Pressure reading is inaccurate.	• Mechanical damage has occurred. • Micro-Ion gauge electrode structure is contaminated by process in vacuum chamber. • Vacuum leak in chamber.	• If mechanical damage has occurred, return module to factory (see page 57). • If contamination is present, degas Micro-Ion gauge (see page 27) or remove gauge and sensor (see page 57) and bake out to 150 °C (302 °F). • If vacuum chamber leaks, check vacuum system.
Display reads "OFF".	• Gauge button has been pressed, Micro-Ion gauge is OFF. • Connection between pins 1 and 5 on 15-pin connector is open.	Turn Micro-Ion gauge ON (see page 28).
Module LED is flashing red.	Module is in manual filament mode, filament 1 is inoperable.	Press gauge button to switch to filament 2.
Module LED is solid red.	• Power supply amperage is too low. • Micro-Ion gauge filaments are open. • Conductron sensor has failed.	• If power supply amperage is too low, install power supply with a higher current rating (see page 10). • If a filament is open or Conductron sensor has failed, replace gauge assembly (see page 57).
Display reads "0.3–9" when Micro-Ion gauge turns ON	• Micro-Ion gauge collector is coated. • Electrometer in module is faulty. • Vacuum chamber pressure is < 3×10^{-10} Torr (3.99×10^{-10} mbar, 3.99×10^{-8} Pa).	• Perform Micro-Ion gauge continuity test (see page 54). • Replace gauge assembly (see page 57). • Return module to factory (see page 57).
Vacuum chamber pressure < 20 mTorr (2.66×10^{-2} mbar, 2.66 Pa), but pressure display is > 20 mTorr (2.66×10^{-2} mbar, 2.66 Pa) and Micro-Ion gauge will not turn ON.	Conductron sensor offset is not correctly set.	Calibrate Conductron sensor at vacuum pressure (see page 44).

Maintenance

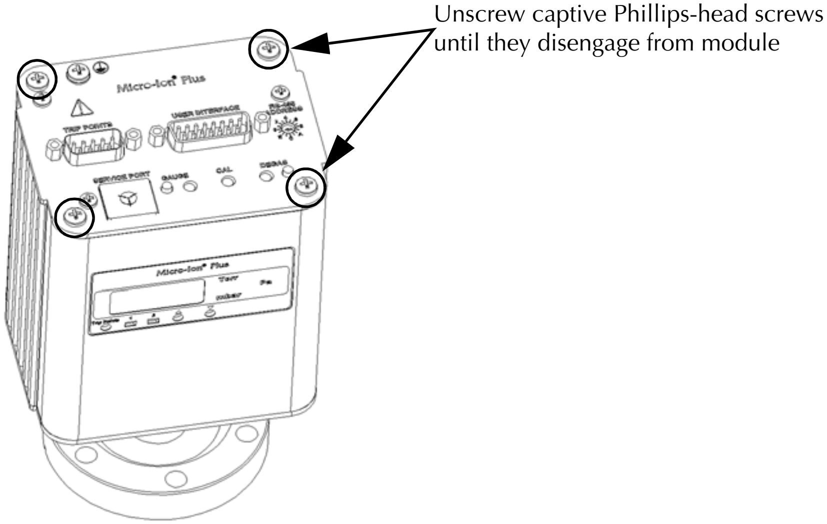
4.3 Micro-Ion gauge continuity test

If a problem with pressure measurement is traced to the module, the Micro-Ion gauge can be tested with an ohmmeter. This test can detect open filaments or shorts between gauge elements, but may not detect inaccurate pressure measurement associated with vacuum leaks or other materials within the gauge.

The gauge may be left on the system for the test. The module electronics will be removed to gain access to the pins on the gauge.

1. Turn OFF power and disconnect all electrical connectors to the Micro-Ion Plus module.
2. Unscrew the four captive Phillips-head screws until they disengage from the gauge. See Figure 4-1.

Figure 4-1 Removing the gauge, Step 2



3. *Carefully* unplug the module electronics from the gauge to expose the gauge and end plate assembly. See Figure 4-2 and Figure 4-3.

Figure 4-2 Removing the gauge, Step 3

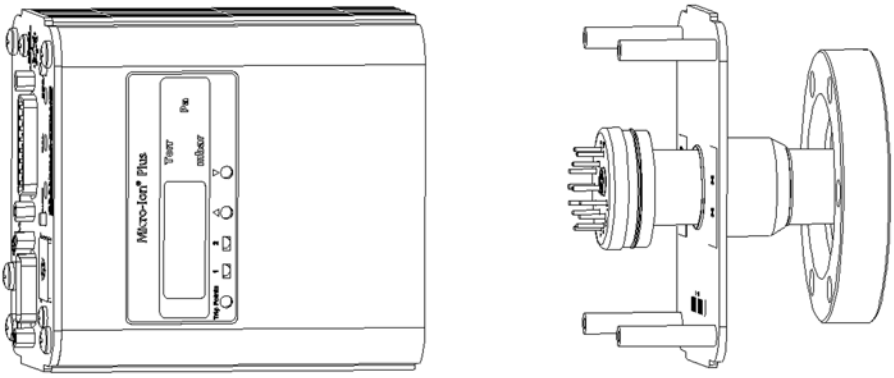
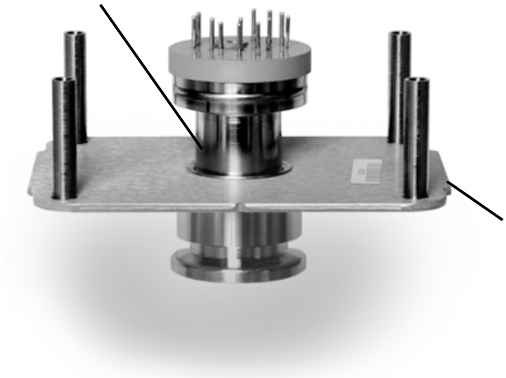
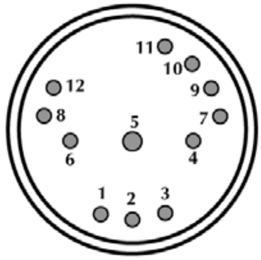


Figure 4-3 Micro-Ion Plus replacement gauge



4. Use a digital multimeter to measure the resistance between pins 2 and 3 (the filament pins), and between pins 1 and 2. See Figure 4-4. The readings should be < 0.2 Ω.

Figure 4-4 Micro-Ion gauge pins



Pin No.	Function
1	Filament #2
2	Filament Common
3	Filament #1
4	Grid
5	Collector
6	Grid
7	Heat-loss Sensor Current
8	Heat-loss Sensor Common
9	Heat-loss Sensor Voltage
10	Heat-loss Compensator Voltage
11	Heat-loss Compensator Current
12	Heat-loss Sensor Common

5. Measure the resistance of filament pins 1, 2, or 3 to any of pins 4, 5, or 6, or the gauge case. The reading should be > 100 MΩ.
6. Measure the resistance between pins 4 and 6 (the grid pins). The reading should be < 0.1 Ω.
7. Measure the resistance of pin 5 (the collector pin) to the gauge case. The reading should be > 100 MΩ.
8. Measure the resistance between pins 10 or 11 and pins 8 or 12. Resistance between heat-loss sensor wires should be 6 to 9 Ω.
9. Measure the resistance between pins 7 or 9 and pins 8 or 12. Resistance between heat-loss sensor wires should be 6 to 9 Ω.
10. Measure resistance between pins 10 or 11 and the gauge case. The reading should be > 100 MΩ.
11. If any of the tests result in different readings than listed above, Contact Granville-Phillips customer service to order a replacement gauge.

Table 4-2 Test resistance values

Pins	Normal values
1 to 2 or 2 to 3	< 0.2 Ω
1, 2 or 3 to pins 4, 5, or 6	> 100 MΩ
4 to 6	< 0.1 Ω
4 or 6 to pins 1, 2, 3, or 5	> 100 MΩ
pin 5 to case	> 100 MΩ

4.4 Replacing the gauge assembly

Do not plug in or unplug any connectors with power applied to the module. Disconnect power from the module before replacing the Micro-Ion gauge.

1. Turn OFF power and disconnect all electrical connectors to the module.
2. Remove the module from the vacuum system.
3. Unscrew the four Phillips-head screws until they disengage from the gauge. See Figure 4-1.
4. While holding the vacuum connection flange, gently unplug the gauge and end plate out of the module as shown in Figure 4-2. The gauge and end plate are shown in Figure 4-3.
5. Insert the new gauge into the module by gently inserting the gauge pins into the socket on the circuit board. Look at the gauge pin arrangement to be sure you do not have the replacement gauge and end plate assembly improperly rotated.
6. Tighten the four Phillips-head screws.
7. Install the module on the vacuum system.
8. Calibrate the Conductron sensor at atmosphere (see page 43).
9. If Micro-Ion gauge doesn't turn ON at 20 mTorr (2.66 x 10^{-2} mbar, 2.66 Pa) with decreasing pressure, recalibrate the Conductron sensor at vacuum (see page 44).

4.5 Returning a damaged module

- If the module must be returned to the factory for service, request a Return Authorization (RA) from Granville-Phillips.
- Do not return products without first obtaining an RA.

When returning equipment to Granville-Phillips, if possible, use the original packaging. Otherwise, contact your shipper or Granville-Phillips for safe packaging guidelines. Use conductive or static dissipative envelopes to store or ship static sensitive devices or printed circuit boards.

Granville-Phillips will supply return packaging materials at no charge upon request. Shipping damage on returned products as a result of inadequate packaging is the customer's responsibility.

Photocopy the service form, fill it out, and return it with the module. A module that is returned without a service form (including the RA number) will be sent back to the customer at the customer's expense.

Before you return the module, obtain an RA number by phoning Granville-Phillips Customer Service at **1–800–776–6543** within the U.S.A. or by emailing *co-csr@brooks.com*.

Service Form

RA number ______________________________ Model number ______________________________

Serial number ____ Date ______________

Name __________________________________ Phone number ______________________________

Company ____

Street address ____

City ___________________________________ State ______________ ZIP _______________

Please help Granville-Phillips provide the best possible service by giving us information that will help us determine the cause of the problem and protect our analysis and calibration equipment from contamination.

Problem description: ____

____

____

____

Application description: ____

____

____

____

Has this product been used with
high vapor pressure or hazardous materials? Yes ❏ No ❏

If Yes, please list the types of gas, chemicals (common names, specific chemical,) biological materials, or other potentially contaminating or harmful materials exposed to the product during its use.

____

____

____

PRODUCTS EXPOSED TO RADIOACTIVE MATERIAL CANNOT BE ACCEPTED BY GRANVILLE-PHILLIPS UNDER ANY CIRCUMSTANCES.

Corporate officer signature ____

Contact name ____________________________ Phone number ______________________________

Measurement range for air and N_2

Measurements will change with different gases and gas mixtures. Micro-Ion Plus gauges are not intended for use with flammable or explosive gases. Atmospheric pressure value is based on calibration at time of use.

Torr	1 x 10^{-9} Torr to atmosphere (“At”)
mbar	1 x 10^{-9} mbar to atmosphere (“At”)
Pa	1 x 10^{-7} Pa to atmosphere (“At”)

Micro-Ion gauge emission current

Emission current	0.1 and 4 mA, autoranging
Micro-Ion gauge auto on	2 x 10^{-2} Torr, 2.66 x 10^{-2} mbar, 2.66 Pa, with decreasing pressure
Micro-Ion gauge auto off	3 x 10^{-2} Torr, 3.99 x 1^{-2} mbar, 3.99 Pa, with increasing pressure
Micro-Ion gauge degas	Electron bombardment, 3.75 W with 2-minute timer
Default switch to high (4.0 mA)	5.0 x 10^{-6} Torr, 6.6 x 10^{-6} mbar, 6.6 x 10^{-4} Pa, with decreasing pressure
Default switch to low (0.1 mA)	1 x 10^{-5} Torr, 1.3 x 10^{-5} mbar, 1.3 x 10^{-3} Pa, with increasing pressure, adjustable, 50% hysteresis (automatically set)
Filament selection	Alternating, automatic, or manual modes • For a Micro-Ion gauge with yttria-coated iridium filaments, default is alternating • For a Micro-Ion gauge with tungsten filaments, default is manual

Outputs and indicators

Analog output	Logarithmic, 0.50 VDC/decade, where 1000 Torr = 7 VDC
Digital RS–485 output	
Interface	RS–485 two-wire, half-duplex
Communications format	ASCII format, eight data bits, no parity, one stop bit
Baud rates	1200, 2400, 4800, 9600, 19200 (default), or 38400 baud
Address	0 to 63, selected by using address switch and RS–485 SA command
LED status indicator	Module status indicator lights up to indicate module status.
Pressure display (optional)	X.X±Y display format includes two significant digits, a 1-digit exponent, and a ± sign for the exponent.
Trip point indicators (optional)	LED indicator for relay 1 or relay 2 is solid green when corresponding relay is activated or blinks green when corresponding relay is being configured.

Trip point relays

Relay type	Two single-pole, double-throw relays (SPDT) Relay contacts are silver alloy-gold clad, rated for 1 A at 30 VDC. The relays can handle resistive or non-inductive loads.
Relay contact ratings	1 A at 30 VDC resistive or non-inductive
Minimum hysteresis	5%
Range	1.0×10^{-9} to 100 Torr 1.0×10^{-9} to 133 mbar 1.0×10^{-7} to 1.33×10^{4} Pa
Default activation pressure	Default activation pressures are set to 0.0.

Micro-Ion Plus module

Micro-Ion gauge sensitivity	
At 4 mA emission (high)	18 Torr, 13.5 mbar, 1.35 x 10^{-1} Pa
At 0.1 mA emission (low)	20 Torr, 15 mbar, 1.5 x 10^{-1} Pa (± 15% variation)
X-ray limit	< 3 x 10^{-10} Torr, < 3.99 x 10^{-10} mbar, < 3.99 x10^{-8} Pa The x-ray limit is the absolute lowest indication from the gauge. It is not practical to make repeatable measurements near the x ray limit
Micro-Ion gauge filament material	Tungsten or yttria-coated iridium
Conductron sensing wire material	Gold-plated tungsten
Internal volume	10.8 cm^3, (0.67 $in.^3$) to the port screen

Physical characteristics

Weight	567 gm (20 oz.) with NW16KF fitting
Power required	+24 VDC ±15% external power supply. Power supply must provide 1.5 A current at 24 VDC. Inrush current can momentarily exceed the 1.5 A peak. +24 VDC ±15% external power supply must be certified to IEC standard with a safety extra-low voltage classified output.
Operating environment	+10 °C to +40 °C ambient, non-condensing, indoor use only, ordinary protection for moisture, maximum altitude 3000 meters
Operating conditions	Suitable for continuous operation. Category 1 for installation over voltage. Pollution degree 2, Class 1
Non-operating temperature	–40 °C to +70 °C
Case material	Aluminum extrusion
Connectors	15-pin subminiature D connector for module power supply, analog outputs, and RS–485 outputs
Materials exposed to gas	Yttria-coated iridium, gold-plated tungsten, 304 stainless steel, tantalum, tungsten, nickel iron alloy, nickel, borosilicate glass
CE Mark compliance	
EMC Directive	89/336/EEC; EN 50081–2, EN 50082–2
Low Voltage Directive	73/23/EEC; EN61010–1

Appendix B Theory of Operation

B.1 Theory of operation

The Micro-Ion Plus vacuum gauge module consists of two separate pressure measuring devices: a hot filament Micro-Ion gauge (Bayard-Alpert type ionization gauge), and a Conductron heat-loss sensor. Whenever power is applied to the module, the Conductron sensor is ON. As the system is pumped down, the Conductron sensor turns ON the Micro-Ion gauge at the pressure switch point. As pressure increases, the Micro-Ion gauge is turned OFF by the Conductron sensor. The measurement range of the Micro-Ion gauge and the Conductron sensor overlap. When pressure is within the measurement range of the gauge and the sensor, the pressure output is a blended signal in the “transition range” between the gauge and the sensor.

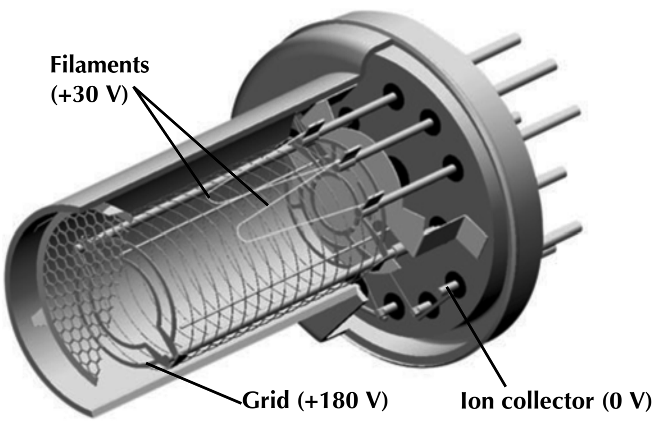
B.2 Micro-Ion gauge operation

The functional parts of the Micro-Ion gauge are the filaments (cathodes), grid (anode) and an ion collector, as illustrated in Figure B-1. These electrodes are maintained by the controller at +30, +180, and 0 volts, relative to ground, respectively.

The filaments are heated to such a temperature that electrons are emitted and accelerated toward the grid by the potential difference between the grid and filaments. All of the electrons eventually collide with the grid, but many first traverse the region inside the grid many times.

When an electron collides with a gas molecule, an electron is dislodged from the molecule, leaving it with a positive charge. Most ions are then accelerated to the ion collectors. The rate at which electron collisions with molecules occur is proportional to the density of gas molecules, and hence the ion current is proportional to the gas density (or pressure, at constant temperature).

Figure B-1 Micro-Ion gauge



The amount of ion current for a given emission current and pressure depends on the Micro-Ion gauge design. This gives rise to the definition of ionization gauge sensitivity, frequently denoted by “S”:

$$S = \frac{\text{Ion current}}{\text{Emission current} \times \text{Pressure}}$$

When used with N_2 or air, the ionization gauge has a nominal sensitivity of 20 $Torr^{-1}$ (15 $mbar^{-1}$, 0.15 Pa^{-1}) at high emission current or 18 $Torr^{-1}$ (13.5 $mbar^{-1}$, 0.135 Pa^{-1}) at low emission current.

The module electronics for the gauge varies the heating current to the filament to maintain a constant electron emission and measures the ion current to the ion collectors. The pressure is then calculated from these data.

Micro-Ion gauge degas is accomplished by increasing the emission current to 15 mA and raising the grid bias to 250 VDC, resulting in an increased temperature of the grid to drive off adsorbed gases.

B.3 Conductron sensor operation

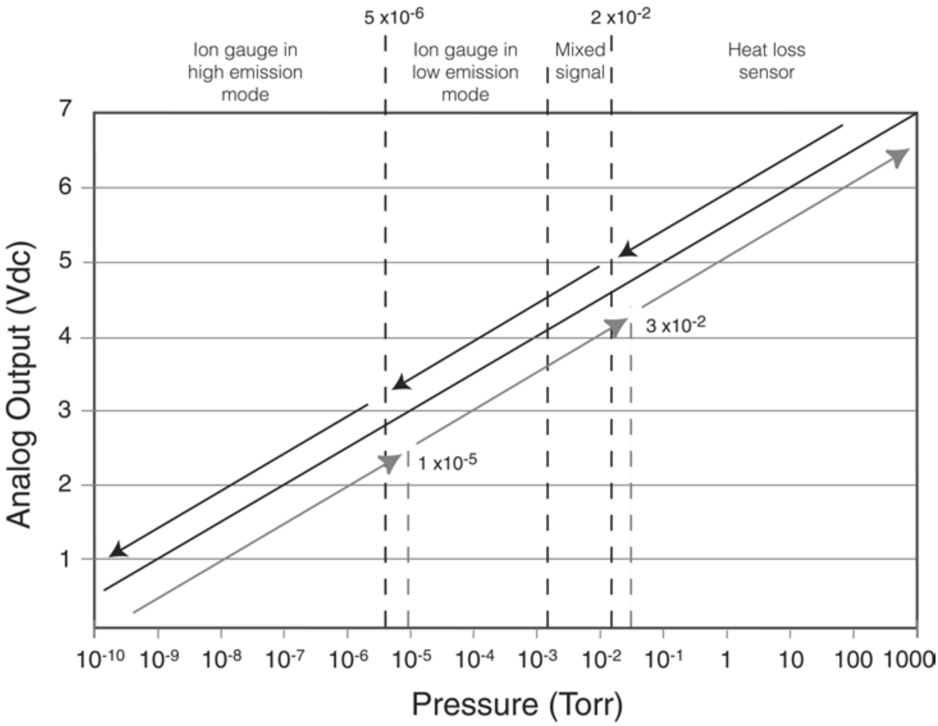
The Conductron heat-loss sensor uses Granville-Phillips’ Conductron sensor proprietary geometry and control circuitry. The sensor is comprised of two coplaner wire elements, a sensing wire, and a compensating wire that corrects for ambient conditions. The resistance of the sensing wire increases as its temperature increases. The controller continually adjusts a heating current that flows through the sensing wire to keep the sensor at a regulated temperature.

If pressure increases, the heat loss through gas conduction from the sensor increases, and the sensor temperature decreases, causing the resistance of the sensor to decrease. As this occurs, an error amplifier senses a change in the resistance differential between the sensor element and the compensation element, and generates an increase in the heating current through the sensor. The increased current through the sensor increases its temperature (and its resistance), and the resistance differential between the two elements is reestablished at a higher sensor input voltage and current. When calibrated, using a series of pressures and ambient temperatures, the input voltage and current are measured as an indication of the system pressure.

B.4 Auto ranging

As the vacuum system pumps down from atmosphere, the Conductron sensor measures pressure until a sufficiently low pressure level is achieved, then automatically turns ON the Micro-Ion gauge in the low emission mode. During the first decade that both sensors are operating, the control electronics mixes the signals. As the pressure is further reduced, the Micro Ion gauge switches from low emission to high emission. As pressure increases, the opposite occurs at slightly higher pressures. This sequence is illustrated in Figure B-2.

Figure B-2 Auto ranging actuation points



Index

M

O

W

X

356 Micro-Ion® Plus Module

GRANVILLE-PHILLIPS®

Brooks Automation
6450 Dry Creek Parkway
Longmont, CO, U.S.A. 80503–9501
Phone 1–303–652–4400

15 Elizabeth Drive
Chelmsford, MA, U.S.A. 01824–4111
Phone 1–978–262–2400

To obtain a copy of this instruction manual online, visit our website at *www.brooks.com*
(Adobe® Reader® version 5.0 or higher required)
© 2006, 2007, Brooks Automation.

Instruction Manual

Instruction manual part number 356007
Revision 04
January 2007