Series 354

Granville-Phillips® Micro-Ion® *E* Vacuum Gauge Module with Analog or RS–232 Output

GRANVILLE-PHILLIPS®

Instruction Manual

Instruction manual part number 354011E
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Brooks

Series 354

Granville-Phillips® Micro-Ion® *E* Vacuum Gauge Module with Analog or RS–232 Output

This Instruction Manual is for use with all Granville-Phillips Series 354 Micro-Ion Vacuum Gauge Modules with analog output. A list of applicable catalog numbers is provided on the following page.

GRANVILLE-PHILLIPS®

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Instruction Manual

Brooks

Granville-Phillips® Series 354 Micro-Ion® Vacuum Gauge Module with Analog Output or RS-232 Digital Interface

Catalog Numbers for Series 354 Micro-Ion Modules - CE Marked
Power supply and cable are not included.

Analog Output	354001E - Y D - T
RS-232 Interface	354010E - Y D - T

Filament: Yttria-Coated Iridium	Y
Fitting: NW16KF	D
Measurement Unit: Torr	T

Contents

Chapter 1 Safety & Introduction

1.1 About These Instructions

These instructions explain how to install, operate, and maintain the Granville-Phillips® Micro-Ion® E vacuum gauge module.

The module may have an analog output or an RS–232 output. Installation and operating procedures depend on the output.

- *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 the terms that are used throughout this instruction manual; and explains how to contact customer service.
- *Chapter 2* explains how to install the module.
- *Chapter 3* is an operational overview of the module.
- *Chapter 4* explains analog module operation.
- *Chapter 5* explains RS–232 module operation.
- *Chapter 6* explains troubleshooting; Micro-Ion E gauge testing, removal and replacement; and module return procedures.
- *Appendix A* provides specifications for the module.
- *Appendix B* explains how the Micro-Ion E gauge measures 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 inaccurate measurement, 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. Brooks Automation / Granville-Phillips disclaim all liability for the customer's failure to comply with the instructions.

- *Read instructions* – Read all instructions before installing or operating the product.
- *Follow instructions* – Follow all installation, operating and maintenance instructions.
- *Retain instructions* – Retain the instructions for future reference.
- *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 Brooks Automation / Granville-Phillips. Substitution of parts is hazardous.

1.4 Definitions of Terms

The terms listed in Table 1-1 are used throughout this manual in reference to the Micro-Ion E vacuum gauge module.

Table 1-1 Terms Describing the Micro-Ion E Module and Components

Term	Description
Module	The entire Micro-Ion E module, which includes the housing, gauge assembly, electronics, and vacuum chamber fitting.
Gauge assembly	A removable assembly that contains a hot filament Micro-Ion gauge (Bayard-Alpert type ionization gauge).
Micro-Ion E gauge	The Bayard-Alpert type ionization gauge, which indicates pressure by producing a current that is proportional to gas density.

1.5 Service Guidelines

Some minor problems are readily corrected on site. If the product requires service, please contact our Customer Service Department at 303-652-4400 for troubleshooting help over the phone.

If the module must be returned to the factory for service, request a Return Materials Authorization (RMA) from Brooks Automation / Granville-Phillips. Do not return products without first obtaining an RMA. In some cases a hazardous materials document may be required. The Brooks Automation / Granville-Phillips Customer Service Representative will advise you if the hazardous materials document is required.

When returning equipment to Brooks Automation / Granville-Phillips, be sure to package the products to prevent shipping damage. Circuit boards and modules separated from the controller chassis must be handled using proper anti-static protection methods and must be packaged in anti-static packaging. Brooks Automation / 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 Buyer's responsibility. *Before you return the module*, obtain an RMA number by contacting Granville-Phillips customer service:

- Phone **1-303-652-4400** or **1-800-776-6543** within the USA.
- Phone **1-800-367-4887** 24 hours per day, seven days per week within the USA.
- Email *co-csr@brooks.com*
- For Global Customer Support, go to www.brooks.com and click on *Services* to locate the Brooks Automation office nearest you.

2.1 Module Components

The Micro-Ion E module houses a a Micro-Ion E gauge (Bayard-Alpert type ionization gauge).

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 Pressure Relief Devices

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

Brooks Automation / 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."

2.3 Installation Procedure

The module installation procedure includes the following steps:

1. Locating the module.
2. Attaching the module vacuum chamber fitting to its mate on the vacuum chamber.
3. Assembling and connecting module wiring.

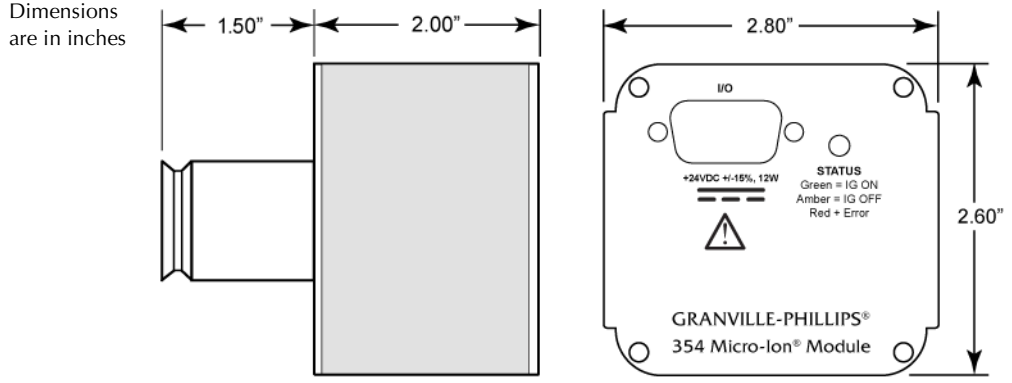
This chapter also explains what to do if radio frequency interference (RFI) disrupts operation of RS–232 version of the module.

Step 1 *Locate the module*

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

- Locate the module where it can be easily accessed.
- 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 with the electronics removed from the module is 200 °C (392 °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 pressure.
- Do not locate the module near a gas inlet or other source of contamination.
- Do not locate the module where it will be exposed to corrosive gases such as mercury vapor or fluorine.

Figure 2-1 Dimensions



Step 2 *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.

The NW16KF flange requires O-rings and centering rings between mating flanges.

a. Tighten the clamp to compress the mating flanges together.

b. Seal the O-ring.

Step 3 *Assemble and connect wiring*

Connecting Cable

Cable is user-supplied. Brooks Automation / Granville-Phillips does not supply cable. Install externally shielded cable.

- Connect the shield at both ends of the cable.
- At the module end of the cable, connect the shield to the outer shell of the subminiature D connector.

Power Supply

Power supply requirement is 24 Vdc ±15%, 12 W maximum.

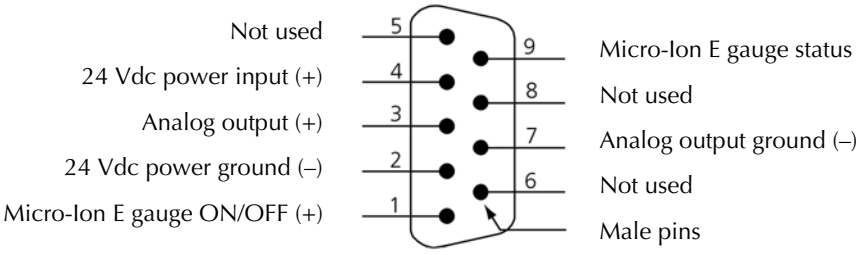
Wiring for Analog Module

- If the module has an analog output, see Figure 2-2.
- Table 2-1 lists pin designations for the 9-pin subminiature D connector.

Table 2-1 Wiring Pin Designations for Analog Module

Pin designation	Function	Pin number
Micro-Ion E gauge ON/OFF (+)	Switch between pins 1 and 2 turns Micro-Ion E gauge ON or OFF	1
24 Vdc power supply ground (–)	Negative connection for 24 Vdc power supply	2
Power supply input (+)	Positive connection for 24 Vdc power supply	4
Analog output (+)	Analog output produces a 0 to 10 Vdc output in linear proportion to the logarithm of vacuum pressure	3
Analog output ground (–)		7
Micro-Ion E gauge status (40 Vdc, 50 mA maximum)	Open collector transistor output indicates Micro-Ion E gauge status • Output is high (“source”) when Micro-Ion E gauge is OFF • Output is low (“sink”) when Micro-Ion E gauge is ON	9
Not used	Reserved	5
Not used	Reserved	6
Not used	Reserved	8

Figure 2-2 WiringTerminals for Micro-Ion E Module with Analog Output



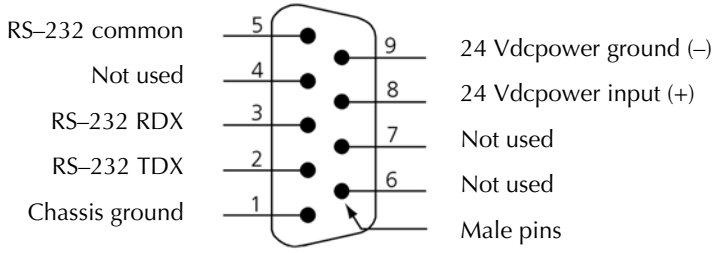
Wiring for RS–232 Module

- If the module has an RS–232 output, see Figure 2-3.
- Table 2-2 lists pin designations for the 9-pin subminiature D connector.

Table 2-2 Wiring Pin Designations for RS–232 Module

Pin designation	Function	Pin number
Chassis ground	Ground connection for module chassis	1
RS–232 TDX	• Pins 2, 3, and 5 enable RS–232 digital communication • Pins, 2, 3, and 5 connect to computer communication port	2
RS–232 RDX		3
RS–232 common		5
Not used	Reserved	4
Not used	Reserved	6
Not used	Reserved	7
24 Vdc power supply input (+)	Positive connection for 24 Vdc power supply	8
24 Vdc power supply ground (–)	Negative connection for 24 Vdc power supply	9

Figure 2-3 Wiring Terminals for Micro-Ion E Module with RS–232 Output



Grounding

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.
- Ground the module housing to the vacuum chamber as illustrated below.
- Make sure the vacuum port to which the module is mounted is properly grounded.

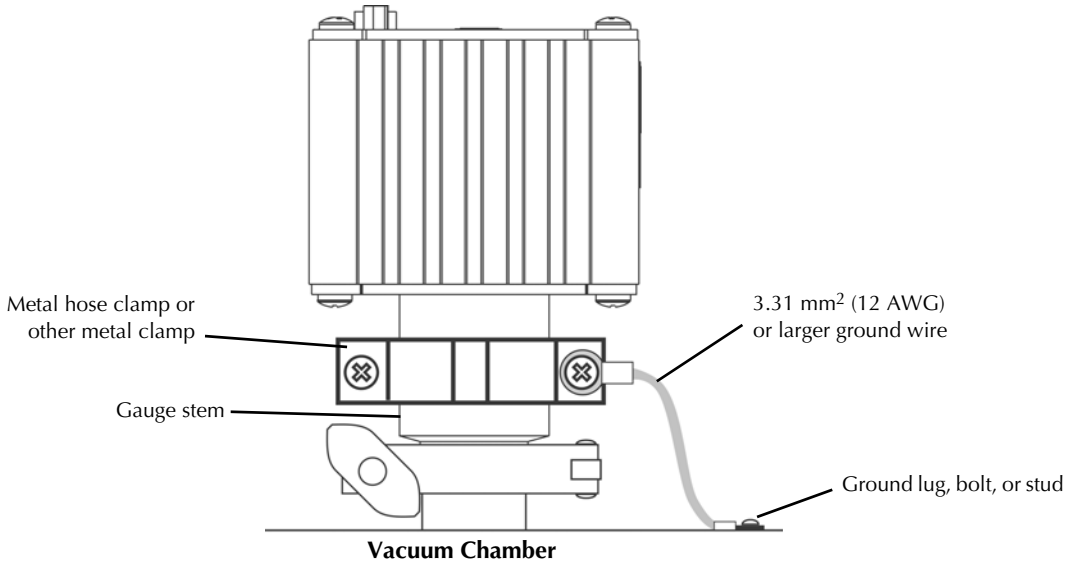
If the analog module has a VCR type fitting or ConFlat flange, the module will be properly grounded via the vacuum chamber connection.

If the analog or RS–232 module has a KF flange, refer to Figure 2-4 and follow these instructions to ground the module to the vacuum chamber:

a. Attach a metal hose clamp or other metal clamp to the gauge stem of the housing.

b. Install a 3.31 mm^2 (12 AWG) or larger copper wire between the clamp and a metal ground lug, bolt, or stud on the vacuum chamber.

Figure 2-4 Vacuum Chamber Ground Connection



2.4 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 can radiate radio frequency energy and, if not installed and used in accordance with the instructions in this manual, may cause harmful interference to other electrical equipment.

3.1 Analog versus RS–232 Operation Procedures

The module may have an analog output or an RS–232 output. The operating procedure depends on the output.

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.

3.2 Analog Operation

If the module has an analog output, the operation procedure includes reading pressure, using the switches installed between wiring pins 1 and 2 (Micro-Ion E gauge ON/OFF), and reading Micro-Ion E gauge ON/OFF status.

Table 3-1 lists tasks that may be performed if the module has an analog output.

Table 3-1 Tasks and Page References for Analog Operation

Task	Instructions:
Turn the Micro-Ion E gauge ON or OFF	Page 20
Read Micro-Ion E gauge ON/OFF status	Page 21
Read vacuum pressure	Page 22

3.3 RS–232 Operation

If the module has an RS–232 output, the operation procedure consists of using RS–232 commands to perform the tasks listed in Table 3-2.

Table 3-2 Commands, Tasks, and Page References for RS–232 Operation

Command	Task	Instructions:
UNL	Unlock interface functions	Page 27
TLU	Toggle functions to locked or unlocked state	Page 28
SB	Set baud rate	Page 28
FAC	Reset values to factory defaults	Page 30
IG	Set Micro-Ion E gauge ON or OFF state	Page 30
IGS	Read Micro-Ion E gauge status	Page 31
RD	Read vacuum pressure	Page 32
SO	Set overpressure limit	Page 33
RST	Reset module to programmed values	Page 33
RS	Read module status	Page 33
VER	Read firmware version for module	Page 34

4.1 Output Functions

The module has an analog output. The 0 to 10 Vdc output is in linear proportion to the logarithm of vacuum pressure, for N_2 or air, as measured by the Micro-Ion E gauge.

The output represents N_2 or air pressure in the measurement unit (Torr, Pa, or mbar) that the customer has specified when ordering the module.

If the process gas is a gas other than N_2 or air, you *must* apply a correction factor to determine the actual pressure for the gas that is being used.

You may use a switch installed between pins 1 and 2 on the module 9-pin connector to turn the Micro-Ion E gauge ON or OFF.

⚠ 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.

4.2 Preparing to Operate the Module

Before putting the module into operation, you must install the module in accordance with the instructions on pages 11–16.

If you need application assistance, phone a Brooks Automation / Granville-Phillips application engineer at **1–303–652–4400** or **1–800–776–6543** within the USA, or email *co-csr@brooks.com*.

4.3 Operational Tasks

Once the module is operating, you may perform the tasks listed in Table 3-1 on page 17.

4.4 Turn the Micro-Ion E Gauge ON or OFF

The Micro-Ion E gauge measures vacuum pressure for N_2 or air within the ranges listed in Table 4-1. As pressure decreases to 5×10^{-3} Torr (6.66×10^{-1} Pa, 6.66×10^{-3} mbar), you *must* turn the Micro-Ion E gauge ON to enable pressure readings. In some instances, you might need to turn the Micro-Ion E gauge OFF.

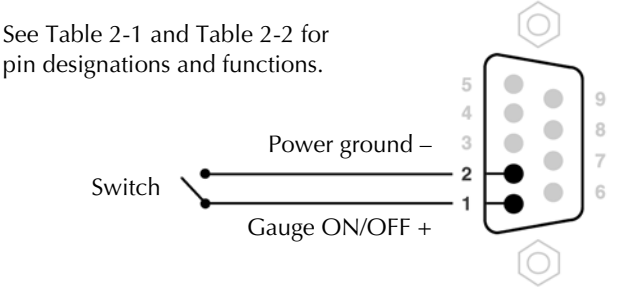
Table 4-1 Micro-Ion E Gauge Pressure Measurement Range

Low pressure limit (N_2 or air)	High pressure limit (N_2 or air)
5×10^{-7} Torr	5×10^{-3} Torr
6.66×10^{-5} Pa	6.66×10^{-1} Pa
6.66×10^{-7} mbar	6.66×10^{-3} mbar

To turn the Micro-Ion E gauge OFF and ON, install a switch between pins 2 (24 Vdc power ground) and 1 (gauge ON/OFF) on the 9-pin connector, as illustrated in Figure 4-1.

- Close the switch to turn the gauge ON.
- Open the switch to turn the gauge OFF.

Figure 4-1 Pins 1 and 2: Switch for Micro-Ion E Gauge ON/OFF

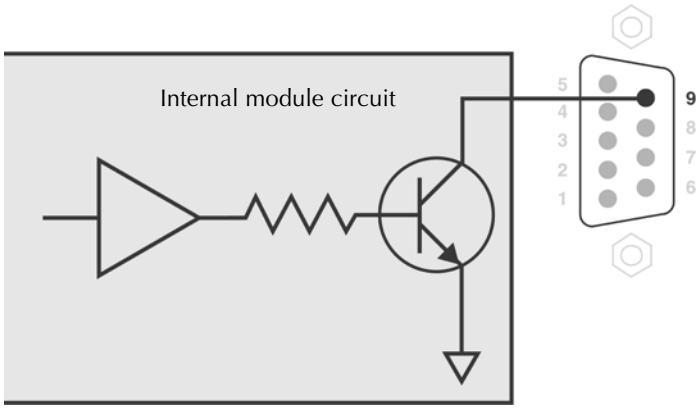


4.5 Micro-Ion E Gauge ON/OFF Status

The gauge ON/OFF status pin (pin 9) is an open collector transistor output rated for 40 Vdc, 50 mA maximum. Apply a voltage and pull-up resistor to monitor the ON/OFF status of the Micro-Ion E gauge.

- Output is low (“sink”) when the Micro-Ion E gauge is ON.
- Output is high (“source”) when the Micro-Ion E gauge is OFF.

Figure 4-2 Micro-Ion E Gauge ON/OFF Status Wiring



4.6 LED Status Indicator

The status LED indicates the operating status of the Micro-Ion E gauge.

- Figure 4-3 illustrates the status LED on the module.
- Table 4-2 lists conditions indicated by the status LED.

Figure 4-3 LED Status Indicator

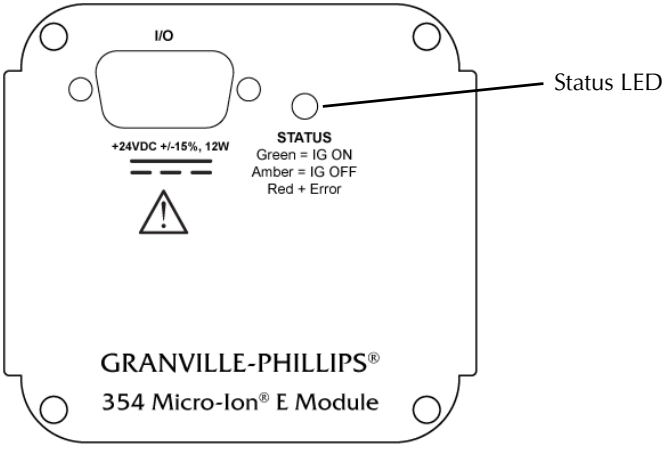


Table 4-2 Conditions Indicated by Status LED

LED Behavior	Condition Indicated
Solid green	Micro-Ion E gauge is ON. See page 20 to turn the gauge OFF.
Solid amber	Micro-Ion E gauge is OFF. See page 20 to turn the gauge ON.
Solid red	• Micro-Ion E gauge fault condition. See page 40 to replace gauge assembly. • Overpressure shutdown. Decrease pressure to alleviate overpressure condition.

4.7 Reading Vacuum Pressure

The analog output produces a voltage that represents vacuum pressure for N_2 or air. The 0 to 10 Vdc output is in linear proportion to the logarithm of vacuum pressure, for N_2 or air, as measured by the Micro-Ion E gauge.

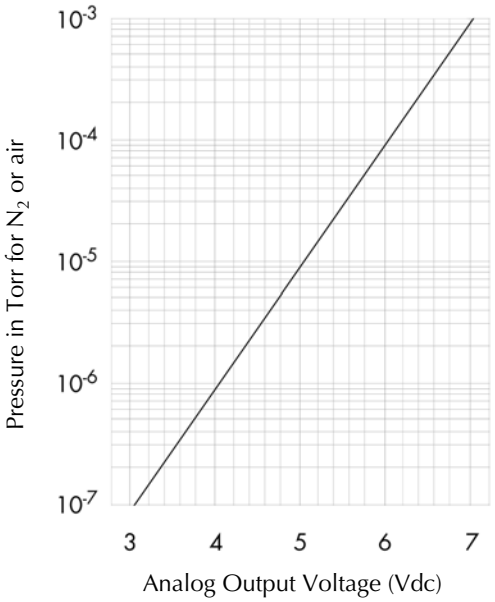
- If the Micro-Ion E gauge is OFF, analog output voltage is > 10 Vdc.
- The output represents N_2 or air pressure in the measurement unit (Torr, Pa, or mbar) that the customer has specified when ordering the module.

If the process gas is a gas other than N_2 or air, you *must* apply a correction factor to determine the actual pressure for the gas that is being used.

N_2 or Air Pressure

The 0 to 10 Vdc output is in linear proportion to the logarithm of vacuum pressure, for N_2 or air, as illustrated in Figure 4-4.

Figure 4-4 Analog Output Voltage Indicating Vacuum Pressure for N_2 or Air



Use one of the following equations to calculate N_2 or air pressure as a function of analog output voltage:

$$Pvacuum_{(Torr)} = 10^{(Volts - 10)}$$

$$Pvacuum_{(mbar)} = 1.33 \times 10^{(Volts - 10)}$$

$$Pvacuum_{(kPa)} = 1.33 \times 10^{(Volts - 11)}$$

Correction Factor

If the process gas is a gas other than N_2 or air, use the following equation and the correction factors listed in Table 4-3 to calculate the actual pressure for the gas that is being used.

$$\frac{\text{Indicated } N_2 \text{ or air pressure}}{\text{Correction factor}} = \text{Actual pressure}$$

Table 4-3 Pressure Correction Factors for Commonly used Process Gases

Process gas	Ar	He	O_2	CO_2	Kr	H_2O
Correction factor	1.29	0.18	1.01	1.42	1.94	1.12
Process gas	Hg	Xe	D_2	Ne	SF_6	NO
Correction factor	3.64	2.87	0.35	0.30	2.5	1.16

For example, if the process gas is neon (Ne), and the indicated pressure for N2 or air is 5 x 10^{-5} pressure units, the correction factor is 0.30, and the actual pressure of the neon is 1.67 x 10^{-4} pressure units:

$$\frac{5 \times 10^{-5} \text{ pressure units}}{0.30} = 1.67 \times 10^{-4} \text{ pressure units}$$

4.8 Overpressure Limit

The Micro-Ion E gauge shuts off if pressure exceeds 1 x 10^{-2} Torr (1.33 Pa, 1.33 x 10^{-2} mbar). You cannot adjust the overpressure limit.

5.1 Output Functions

The module has an RS–232 output. The output represents vacuum pressure, for N_2 or air, as measured by the Micro-Ion E gauge.

If the process gas is a gas other than N_2 or air, you *must* apply a correction factor to determine the actual pressure for the gas that is being used.

You may use RS–232 commands to read vacuum pressure and configure the 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.

5.2 Preparing to Operate the Module

Before putting the module into operation, you must install the module in accordance with the instructions on pages 11–16.

If you need application assistance, phone a Brooks Automation / Granville-Phillips application engineer at **1–303–652–4400** or **1–800–776–6543** within the USA, or email *co-csr@brooks.com*.

5.3 Operational Tasks

Once the module is operating, you may use RS–232 commands to perform the tasks listed in Table 3-2 on page 18.

5.4 Error Responses

If a command cannot be processed, the module returns one of the error responses listed in Table 5-1.

Table 5-1 RS–232 Error Responses

Message from Module	Possible Causes	Solution
COMM ER	Parity error in command from host.	• Verify that parity from host matches parity configuration for module. • Non-programmable parity for module is no parity, one stop bit (see page 44).
RANGE ER	SB command contains an invalid baud rate.	• Re-send SB command containing valid baud rate. • Valid baud rates are 1200, 2400, 4800, 9600, or 19200 (see page 28).
NVRAM ER	Module cannot write data to non-volatile memory (NOVRAM).	• Send FAC command to reset communication values to factory defaults (see page 30). • Re-send set, unlock, or toggle command. • Return module to factory (see page 40).
SYNTX ER	• Command was improperly entered. • Module does not recognize command. • UNL command was sent when software functions were already unlocked.	Re-enter command using proper syntax (see page 27).
9.99E+09	• Module cannot indicate a valid pressure. • Micro-Ion E gauge is OFF.	• Send RS command to determine module status (see page 33). • If necessary, replace gauge assembly (see page 40). • If Micro-Ion E gauge is OFF, send IG1 command (see page 30).
LOCKED	Interface function is locked.	Send UNL or TLU command to unlock interface functions (see page 27).
INVALID	• Micro-Ion E gauge is defective. • IG1 command has been sent.	• If Micro-Ion E gauge is defective, replace gauge assembly (see page 40). • If IG1 command has been sent, send IG0 command (see page 30).

5.5 RS–232 Commands

Some RS–232 commands require entry of ASCII character strings, integer values (such as “2400”), and values in engineering notation (such as “2.00E+02”).

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.

The command should not include a line feed with the carriage return. Including a line feed adds an extra character and causes the module to return a “SYNTX ER” response.

The default interface configuration is 9600 baud, eight bits, one stop bit, no parity.

5.6 RS–232 Command Set

Table 5-2 lists RS–232 commands for the Micro-Ion E module.

Table 5-2 RS–232 Command Set for Micro-Ion E Module

Command	Set by Command	Non-volatile	Change After Reset	Data Returned	Locked
UNL	Yes	Yes	No	Confirm	No
TLU	Yes	Yes	No	Confirm	No
SB	Yes	Yes	Yes	Confirm	Yes
FAC	Yes	Yes	Yes	Confirm	Yes
IG	Yes	No	No	Confirm or state	No
IGS	No	No	No	State	No
RD	No	No	No	Pressure	No
SO	Yes	Yes	No	Confirm	No
RST	Yes	No	No	None	No
RS	No	No	No	State	No
VER	No	Yes	No	Software version	No

UNL Unlock Interface Functions

In default operating mode, some interface functions are locked. Send the unlock interface functions (UNL) command to unlock interface functions.

UNL command from host: UNL ↵
Response from module: PROGM OK ↵

If you send the UNL command while interface functions are already unlocked, the module returns a SYNTX ERR response (see page 26).

TLU **Toggling Locked Functions**

Send the toggle lock/unlock (TLU) command to set locked functions to an unlocked state or unlocked functions to a locked state. The module processes the command, then returns a character string that indicates whether or not interface functions are unlocked.

TLU command from host: TLU ↵
Example response from module: 1 UL ON ↵

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

You must send the UNL or TLU command before you send any of the commands listed in Table 5-3.

Table 5-3 Locked Interface Functions

Command	Interface Function	Instructions:
SB	Setting module baud rate	Page 28
SO	Setting overpressure limit	Page 33
FAC	Resetting values to factory defaults	Page 30

SB **Set Baud Rate**

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

Example SB command from host: SB2400 ↵
Response from module: PROGM OK ↵

Valid values are 1200, 2400, 4800, 9600 (default), or 19200 baud.

The module communicates in half-duplex mode. Neither the module nor the host computer can send and receive signals at the same time. The host issues a command, then waits for a response from the module.

The time between reception and transmission of data does not depend on the baud rate. The host must shut off within the time T, then must wait for the module to process the command (time H) and return a response (time D), as illustrated in Figure 5-1.

- Table 5-4 lists limits on timing and response delays.
- Table 5-5 lists the time required for the module to respond to each command type.

Figure 5-1 Data Timing and Response Delays

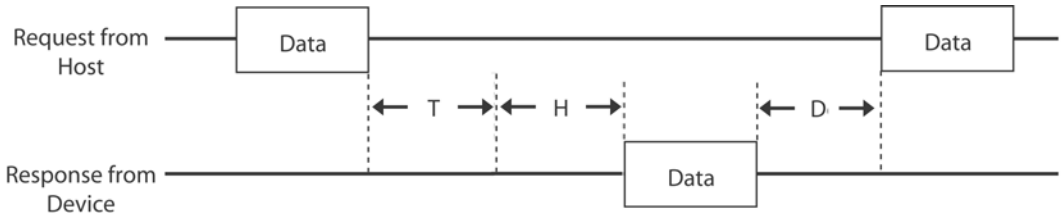


Table 5-4 Data Timing and Response Delay Limits

Timing Segment	Time Limit
Time T	2 msec minimum 18 msec maximum
Time D	300 µsec maximum
Time H	Depends on baud rate and command type. Use the following equation to calculate the total response time for each task listed in Table 5-5: Response time = $Time_H + Time_T$

Table 5-5 Response Time per Command Type

Command	Response Time in msec (Time H)
IGS (read Micro-Ion E gauge status)	3.3 msec
RD (read pressure)	3.3 msec
VER (read module firmware version)	3.3 msec
RS (read module status)	3.3 msec
UNL (unlock interface functions)	21 msec
TLU (toggle locked functions)	21 msec
SB (set baud rate)	21 msec
SO (set overpressure limit)	21 msec
IG (turn Micro-Ion E gauge ON or OFF)	21 msec
FAC (reset default baud rate)	109 msec
RST (reset values to factory defaults)	• No response • Communication resumes after 2 sec

FAC **Reset Baud Rate to Factory Defaults**

You may restore the baud rate to its default value of 9600 baud by sending a factory reset (FAC) command.

FAC command from host: FAC ↵
Response from module: PROGM OK ↵

After sending the FAC command, you *must* send the reset (RST) command.

Reset command from host: RST ↵
Response from module: None

For more information about the RST command, see page 33.

IG **Turn Micro-Ion E Gauge ON or OFF**

The Micro-Ion E gauge measures vacuum pressure for N_2 or air within the ranges listed in Table 5-6. As pressure decreases to 5×10^{-3} Torr (6.66×10^{-1} Pa, 6.66×10^{-3} mbar), you *must* send the ion gauge on (IG1) command to turn the Micro-Ion E gauge ON and enable pressure readings.

IG1 command from host: IG1 ↵
Response from module: PROGM OK ↵

The command includes the alpha characters "I" and "G" and the numeric value 1 (ON).

In some instances, you might need to turn the Micro-Ion E gauge OFF.

Send the ion gauge off (IG0) command to turn the Micro-Ion E gauge OFF and disable pressure readings.

IG0 command from host: IG0 ↵
Response from module: PROGM OK ↵

The command includes the alpha characters "I" and "G" and the numeric value 0 (OFF).

Table 5-6 Micro-Ion E Gauge Pressure Measurement Range

Low Pressure Limit (N_2 or air)	High Pressure Limit (N_2 or air)
5×10^{-7} Torr	5×10^{-3} Torr
6.66×10^{-5} Pa	6.66×10^{-1} Pa
6.66×10^{-7} mbar	6.66×10^{-3} mbar

IGS **Read Micro-Ion E 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 E gauge.

IGS command from host: IGS ↵
Example response from module: 1 IG ON ↵

- The "1 IG ON" response means the Micro-Ion E gauge is ON.
- The "0 IG OFF" response means the Micro-Ion E gauge is OFF and the module will return a "9.99E+09" error response to the RD (read pressure) command.

The status LED indicates the operating status of the Micro-Ion E gauge.

- Figure 5-2 illustrates the status LED on the module.
- Table 5-7 lists conditions indicated by the status LED.

Figure 5-2 LED Status Indicator

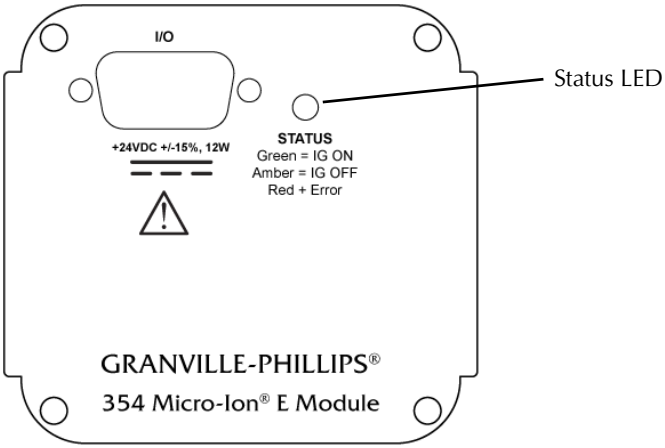


Table 5-7 Conditions Indicated by Status LED

LED Behavior	Condition Indicated
Solid green	Micro-Ion E gauge is ON. See page 30 to turn gauge OFF.
Solid amber	Micro-Ion E gauge is OFF. See page 30 to turn gauge ON.
Solid red	• Micro-Ion E gauge fault condition. See page 40 to replace gauge assembly. • Overpressure shutdown. Decrease pressure to alleviate overpressure condition.

RD **Read Vacuum Pressure**

Send a read pressure (RD) command to read vacuum pressure for N2 or air. If the process gas is a gas other than N2 or air, you *must* apply a correction factor to determine the actual pressure for the gas that is being used.

N_2 or Air Pressure

The RD command causes the module to return a value that indicates vacuum pressure for N_2 or air.

RD command from host: RD ↵
Example response from module: 3.50E–04 ↵

The example response indicates vacuum pressure for N_2 or air is 3.5×10^{-4} Torr (4.66×10^{-2} Pa, 4.66×10^{-4} mbar).

If the returned value is not a valid representation of pressure, see page 38.

Correction Factor

If the process gas is a gas other than N_2 or air, use the following equation and the correction factors listed in Table 5-8 to calculate the actual pressure for the gas that is being used.

$$\frac{\text{Indicated } N_2 \text{ or air pressure}}{\text{Correction factor}} = \text{Actual pressure}$$

Table 5-8 Pressure Correction Factors for Commonly Used Process Gases

Process Gas	Ar	He	O_2	CO_2	Kr	H_2O
Correction Factor	1.29	0.18	1.01	1.42	1.94	1.12
Process Gas	Hg	Xe	D_2	Ne	SF_6	NO
Correction Factor	3.64	2.87	0.35	0.30	2.5	1.16

For example, if the process gas is neon (Ne), and the indicated pressure for N2 or air is 5×10^{-5} Torr, the correction factor is 0.30, and the actual pressure of the neon is 1.67×10^{-4} Torr (2.22×10^{-2} Pa, 2.22×10^{-4} mbar):

$$\frac{5 \times 10^{-5} \text{ Torr}}{0.30} = 1.67 \times 10^{-4} \text{ Torr of Ne}$$

SO **Set Overpressure Limit**

Send the set overpressure value (SO) command to set the highest pressure at which the Micro-Ion E gauge will operate. The value represented by the SO command is the pressure, in Torr, at which the Micro-Ion E gauge shuts OFF with increasing vacuum pressure.

Example SO command from host: SO1.50E–03 ↵
Response from module: PROGM OK ↵

The example SO command causes the Micro-Ion E gauge to shut OFF when vacuum pressure increases to 1.5×10^{-3} Torr (1.99×10^{-1} Pa, 1.99×10^{-3} mbar). The highest valid overpressure limit is 1×10^{-2} Torr (1.33 Pa, 1.33×10^{-2} mbar).

RST **Reset Module to Programmed Values**

The reset (RST) command restores the user-programmed baud rate and overpressure limit to the module non-volatile memory (NVRAM).

RST command from host: RST ↵
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.
- You must send the RST command immediately after you've sent the FAC command. See page 30.

RS **Read Module Status**

Send the read status (RS) command to read the module operating status.

RS command from host: RS ↵
Example response from module: 00 ST OK ↵

Table 5-9 lists module responses to the RS command.

Table 5-9 Module Status Responses

Response	Description
08 POWER	• Module is starting up. • The "00_ST_OK" string will be generated next if the module is operating properly.
00 ST OK	Module is operating normally.
01 OVPRS	Micro-Ion E gauge has shut OFF due to overpressure condition.
02 EMISS	• Micro-Ion E gauge emission failure. • Cycle power to module to clear status response.
04 HIVLT	• Micro-Ion E gauge grid voltage failure. • Cycle power to module to clear status response.

VER **Read Firmware Version**

The read firmware version (VER) command causes the module to return a value that represents the Granville-Phillips internal part number and firmware version for the module. The example response indicates the internal part number is 16497 and the firmware version is 01.

VER command from host: VER ↵
Example response from module: 16497 01 ↵

- The first five digits are the Granville-Phillips internal part number.
- The last two digits are the firmware version.

6.1 Customer Service

For customer service:

- Phone **1–303–652–4400** or **1–800–776–6543** within the USA.
- 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. Operate only those controls that are covered in the instruction manual.
- 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:

- Phone **1–303–652–4400** or **1–800–776–6543** within the USA, or
- Email *co-csr@brooks.com*.
- For Global Customer Support, go to www.brooks.com and click on *Service* to locate the Brooks Automation office nearest you.

6.2 Troubleshooting

If any of the conditions described above 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.
- Rely on voltage measurements for troubleshooting module circuitry. Do not use an ohmmeter.
- 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 Brooks Automation / 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.

⚠ WARNING

Failure to perform a safety check after the module has been repaired can result in severe property damage or personal injury due to electrical shock or fire.

If the module has been repaired, before putting it back into operation, make sure qualified service personnel perform a safety check.

Symptoms, Causes, and Solutions

Table 6-1 on page 37 lists failure symptoms, causes, and solutions indicated by something other than an RS–232 error message from the module.

Table 6-2 on page 38 lists failure symptoms, causes, and solutions indicated by an RS–232 error message from the module.

Table 6-1 Failure Symptoms, Causes, and Solutions

Symptom	Possible Causes	Solution
Output voltage = 0 V.	24 Vdc power supply cable is improperly connected or faulty.	Repair or replace power supply cable (see page 13).
Pressure reading is too high.	• Conductance in connection to vacuum chamber is inadequate. • Plumbing to module leaks or is contaminated. • Chamber pressure is too high due to leak, contamination, or pump failure. • Power supply or output cable is improperly connected or faulty.	• If conductance is inadequate, reconnect port to a larger conductance port on the vacuum chamber, or install larger conductance plumbing (see page 12). • If plumbing leaks or is contaminated, clean, repair or replace plumbing. • If pump failed, repair or replace it. • If cable is improperly connected or faulty, repair or replace cable (see page 13).
Pressure reading is inaccurate.	Temperature or mechanical vibration is extreme.	Relocate module or eliminate source of heat or vibration.
• Indicated pressure is different than pressure indications from other measurement devices. • LED status indicator is solid red.	Micro-Ion E gauge is defective.	Replace gauge assembly (see page 40).
Output voltage is < 0.10 V.	A circuit board is faulty.	Return module to factory (see page 40).

RS–232 Error Responses

Table 6-2 lists failure symptoms, causes, and solutions that are indicated by an error response from the module.

Table 6-2 Troubleshooting RS–232 Error Responses

Message from Module	Possible Causes	Solution
COMM ER	Parity error in command from host.	• Verify that parity from host matches parity configuration for module. • Non-programmable parity for module is no parity, one stop bit (see page 44).
RANGE ER	SB command contains an invalid baud rate.	• Re-send SB command containing valid baud rate. • Valid baud rates are 1200, 2400, 4800, 9600, or 19200 (see page 28).
NVRAM ER	Module cannot write data to non-volatile memory (NOVRAM).	• Send FAC command to reset communication values to factory defaults (see page 30). • Re-send set, unlock, or toggle command. • Return module to factory (see page 40).
SYNTX ER	• Command was improperly entered. • Module does not recognize command. • UNL command was sent when software functions were already unlocked.	Re-enter command using proper syntax (see page 27).
9.99E+09	• Module cannot indicate a valid pressure. • Micro-Ion E gauge is OFF.	• Send RS command to determine module status (see page 33). • If necessary, replace gauge assembly (see page 40). • If Micro-Ion E gauge is OFF, send IG1 command (see page 30).
LOCKED	Interface function is locked.	Send UNL or TLU command to unlock interface functions (see page 27).
INVALID	• Micro-Ion E gauge is defective. • IG1 command has been sent.	• If Micro-Ion E gauge is defective, replace gauge assembly (see page 40). • If IG1 command has been sent, send IG0 command (see page 30).

6.3 Micro-Ion E Gauge Continuity Test

If a problem with pressure measurement is traced to the module, the Micro-Ion E gauge can be tested with an ohmmeter.

This test should only be performed while the Micro-Ion E gauge is exposed to atmospheric pressure and the electronics is removed from the module.

The continuity test can detect an open filament or shorts between gauge elements, but may not detect inaccurate pressure measurement associated with vacuum leaks or adsorbed gases within the gauge.

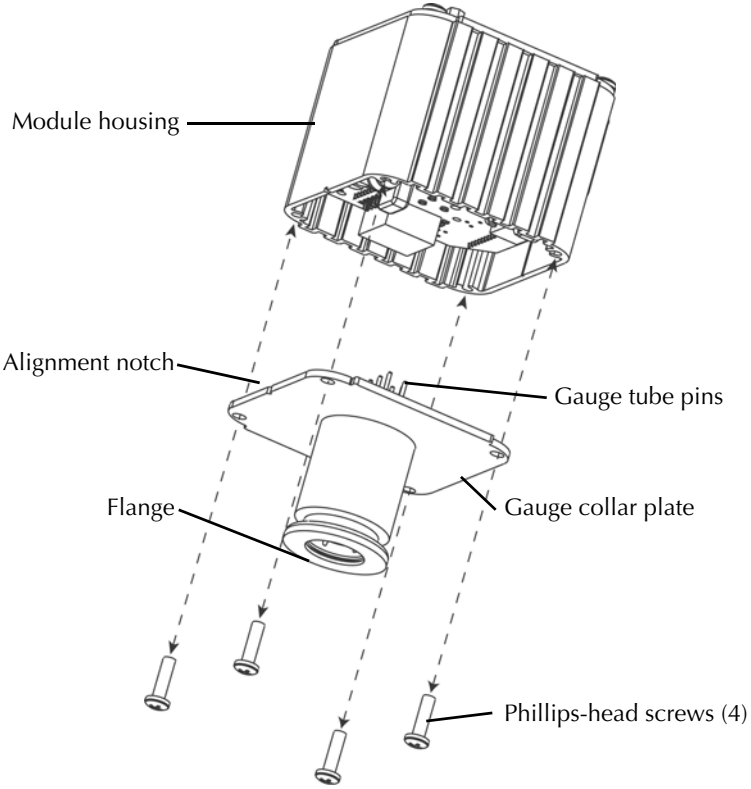
⚠ WARNING

Removing or replacing the Micro–Ion E gauge in a high voltage environment can cause an electrical discharge through a gas or plasma, resulting in serious property damage or personal injury due to electrical shock or fire.

Vent the vacuum chamber to atmospheric pressure and shut off power to the module before you remove or replace the Micro–Ion E gauge.

1. Shut OFF power to the module.
2. Remove the 9-pin subminiature D connector from the module.
3. Remove the module from the vacuum chamber.
4. Remove the four Phillips-head screws from the gauge collar plate (see Figure 6-1).
5. While holding the flange, *gently* pull the Micro-Ion E gauge assembly away from the housing. The gauge tube pins will disconnect from the module.

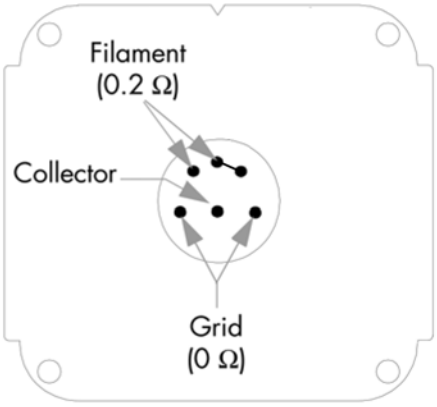
Figure 6-1 Removing Micro-Ion E Gauge Assembly



6. Use a digital multimeter to measure the resistance between the filament pins (see Figure 6-2). The reading should be approximately 0.2 Ω.
7. Measure the resistance of filament pins to the gauge case. The reading should be infinity.
8. Measure the resistance across the grid pins. The reading should be approximately 0 Ω.
9. Measure the resistance of the grid pins to the gauge case. The reading should be infinity.
10. Measure the resistance of the collector pin to the gauge case. The reading should be infinity.

If resistance values are not the specified values, the Micro-Ion E gauge is defective. Contact Brooks Automation / Granville-Phillips customer service to order a replacement gauge.

Figure 6-2 Micro-Ion E Gauge Pins



6.4 Service Guidelines

Some minor problems are readily corrected on site. If the product requires service, please contact our Customer Service Department at 303-652-4400 for troubleshooting help over the phone.

If the module must be returned to the factory for service, request a Return Authorization (RA) from Brooks Automation / Granville-Phillips. Do not return products without first obtaining an RA. In some cases a hazardous materials document may be required. The Brooks Automation / Granville-Phillips Customer Service Representative will advise you if the hazardous materials document is required.

When returning equipment to Brooks Automation / Granville-Phillips, be sure to package the products to prevent shipping damage. Circuit boards and modules separated from the controller chassis must be handled using proper anti-static protection methods and must be packaged in anti-static packaging. Brooks Automation / 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 Buyer's responsibility. *Before you return the module*, obtain an RA number by contacting Granville-Phillips customer service:

- Phone **1-303-652-4400** or **1-800-776-6543** within the USA.
- Phone **1-800-367-4887** 24 hours per day, seven days per week within the USA.
- Email *co-csr@brooks.com*
- For Global Customer Support, go to www.brooks.com and click on *Services* to locate the Brooks Automation office nearest you.

N_2 or Air Pressure Measurement Specifications

Measurements will change with different gases and mixtures.

Absolute Pressure Range	Torr	5×10^{-7} to 5×10^{-3}
	mbar	6.66×10^{-7} to 6.66×10^{-3}
	Pa	6.66×10^{-5} to 6.66×10^{-1}
Overpressure Limit	Overpressure is the pressure at which the Micro-Ion E gauge shuts OFF with increasing pressure.	
	Torr	1×10^{-2}
	Pa	1.33×10^{-2}
	mbar	1.33
X-ray Limit	X-ray limit is the absolute lowest indication from the gauge. It is not possible to make repeatable measurements near the x-ray limit.	
	Torr	$< 3 \times 10^{-10}$
	mbar	$< 4 \times 10^{-10}$
	Pa	$< 4 \times 10^{-8}$
Response Time	< 25 msec	

Temperature Specifications

Operating Temperature	0 to 40 ° C (32 to 104 ° F) ambient, non-condensing
Storage Temperature	–40 to +70 ° C (–40 to +158 ° F)
8akeout Temperature	200 ° C (392 ° F) maximum with electronics removed

Outputs and Indicators

Module with Analog Output

Analog Pressure Output	Logarithmic, 0 to 9 Vdc, 1 volt per decade
Pressure Measurement unit	Torr, Pa, or mbar
Micro-Ion E Gauge ON/OFF	Open collector transistor output is rated for 40 Vdc, 50 mA maximum. • Output is low ("sink") when Micro-Ion E gauge is ON. • Output is high ("source") when Micro-Ion E gauge is OFF.

Module with RS–232 Output

RS–232 Pressure Output	RS–232 output indicates N_2 or air pressure in Torr. • Two significant digits, 1-digit exponent, and + or – sign for exponent. • If vacuum pressure exceeds 1 x 10^{-2} Torr (1.33 Pa, 1.33 x 10^{-2} mbar), output indicates pressure value of 9.99E+09.
Pressure Measurement unit	Torr
Interface	RS–232 two-wire, half-duplex
Communications Format	ASCII format, eight data bits, no parity, one stop bit
Baud Rates	1200, 2400, 4800, 9600 (default), or 19200 baud

LED Status Indicator	Module status indicator lights up to indicate module status: • LED is solid green to Micro-Ion E gauge is ON. • LED is solid amber if Micro-Ion E gauge is OFF. • LED is solid red to indicate Micro-Ion E gauge fault condition or overpressure shutdown.

Micro-Ion E Gauge

Emission Current	10 µA
Filament	One Yttria-coated iridium filament
Filament Bias	30 Vdc ± 0.5 V
Grid Bias	180 Vdc ± 5 V
Sensitivity to N_2	14/Torr 0.105/Pa 10.5/mbar
Internal Volume	10.8 cm^3 (0.66 $in.^3$)

Electrical Connectors

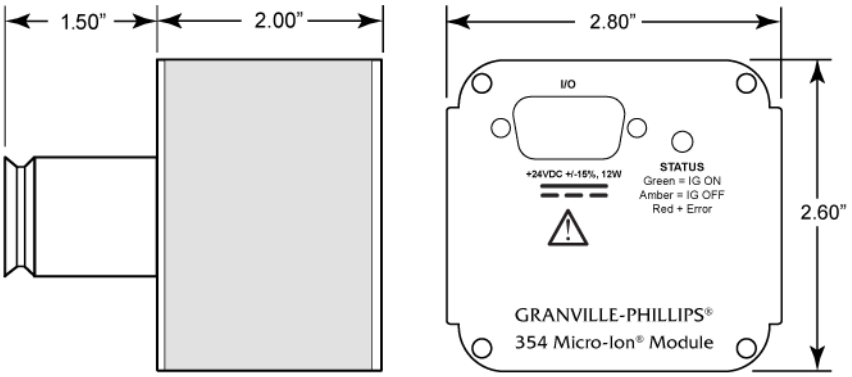
I/O Connector	9-pin subminiature D male
Power Requirements	24 Vdc ±15%, 12 W maximum

Physical Specifications

Weight	340 g (12 oz.)
Case Material	Powder-coated extruded aluminum
Materials Exposed to Vacuum	304 stainless steel, tantalum, tungsten, yttria-coated iridium, alumina, CuAg eutectic, Kovar, borosilicate glass
IP Rating	IP20

Dimensions

Dimensions are in inches



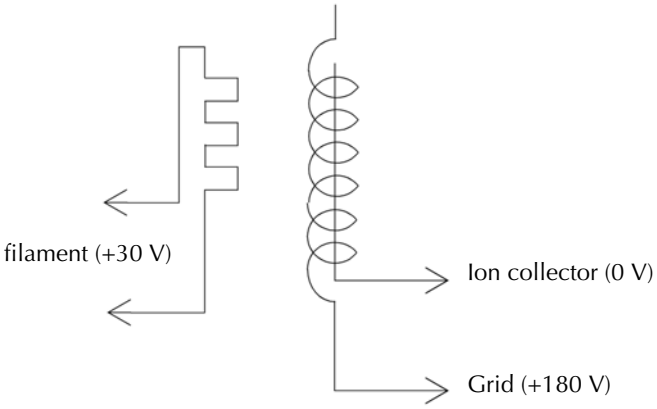
B.1 Module Operation

The Micro-Ion E vacuum gauge module houses a Micro-Ion gauge (Bayard-Alpert type ionization gauge).

B.2 Micro-Ion E Gauge Operation

The functional parts of the Micro-Ion E gauge are the filament (cathode), grid (anode), and ion collector. Figure B-1 is a schematic diagram of the Micro-Ion E gauge. The electrodes are maintained by the controller at +30, +180, and 0 volts, relative to ground, respectively.

Figure B-1 Micro-Ion E Gauge Schematic Diagram



The filament is heated to such a temperature that electrons are emitted and accelerated toward the grid by the potential difference between the grid and filament. 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 the molecule with a positive charge, thereby transforming the molecule into a positive ion. Most ions then accelerate to the ion collectors. The rate at which electrons collide with the ion collectors is proportional to the density of the gas molecules; therefore, ion current is proportional to gas density (or pressure, at constant temperature).

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

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

Micro Ion gauge sensitivity for N_2 or air is 20/Torr (0.15/Pa, 15/mbar).

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.

Index

Series 354

Granville-Phillips® Micro-Ion® *E* Vacuum Gauge Module with Analog or RS–232 Output

GRANVILLE-PHILLIPS®

Customer Service/Support

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Phone: +1-978-262-2400

For customer service, 24 hours per day, 7 days per week, every day of the year including holidays within the USA:

Phone: +1-800-367-4887

www.brooks.com

Instruction Manual

Instruction manual part number 354011E

Revision A - October 2013

Brooks