Series 909AR Miniature Ionization Gauge Transducer

Operation and Maintenance Manual

mks

Technology for Productivity

HPS® Products

Series 909AR Miniature Ionization Gauge Transducer

Part # 100014442 REV: A

Part # _____ - _____

Please fill in the transducer part and flange type numbers in the space above and have them readily available when calling for service or additional information.

(The part number can be found on your packing slip. Both the part number and serial number are located on the bottom side of the housing.)

For more information or literature, contact:

HPS® Products of MKS Instruments, Inc.
5330 Sterling Drive
Boulder, CO 80301 USA

Phone: 1- 303-449-9861
1-800-345-1967

Fax: 1-303-442-6880

Web: www.mksinst.com/hpshome.html

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Package Contents

Before unpacking the 909AR Miniature Ionization Gauge Transducer (MIGT), check all surfaces of the packing material for shipping damage.

Confirm that the 909AR MIGT package contains these items:

- 1 909AR Miniature Ionization Gauge Transducer
- 1 15-pin female D-sub connector kit
- 1 *909AR Miniature Ionization Gauge Transducer Operation and Maintenance Manual*

Inspect the components for visible evidence of damage during shipment. If anything has been damaged, notify the carrier immediately. Keep all shipping materials and packaging for claim verification.

If any items are missing from the package, call MKS Customer Service at 1-303-449-9861 or 1-800-345-1967.

Do not return the product to MKS unless specified to do so by MKS Customer Service.

MKS Instruments, Inc.
5330 Sterling Dr.
Boulder, CO 80301
USA

Telephone 1-303- 449-9861
Toll-Free 1-800-345-1967 (USA only)
Facsimile 1-303- 449-2003

Symbols Used in this Manual

CAUTION: Risk of electrical shock.

CAUTION: Refer to the manual. Failure to heed the message could result in personal injury, serious damage to the equipment, or both.

Calls attention to important procedures, practices, or conditions.

Safety Precautions

Always disconnect the power supply before removing electronics from the sensor for sensor replacement or bakeout purposes. Lethal voltages and currents may be present while the circuit is operating. Only a qualified technician should replace or adjust electronic components.

Do not operate in explosive environments. The sensor has a heated element which could ignite a gas mixture used in the system.

Properly ground the transducer. The transducer should be connected to earth ground both through the vacuum flange and the back shell of the electrical connector.

Use the proper power source. Use + 24 VDC @ 0.75 Amps.

Do not turn on filament power when system pressure is above $5x10^{-2}$ Torr. Sensor damage will result.

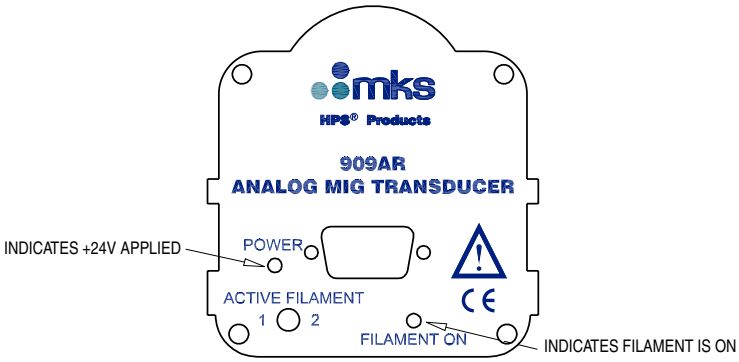
General Specifications

Measuring range	$3x10^{-10}$ to $5x10^{-2}$ Torr
Set point range	$5x10^{-10}$ to $9.0x10^{-3}$ Torr
Analog out	0 to 10 VDC
Repeatability	Approximately ± 5% of reading
Calibration gas	Nitrogen/Air
Response time	50 Milliseconds
Degas power	3 Watts
X-ray limit	$3x10^{-10}$ Torr
Number of filaments	2
Filament type	Y_2O_3 coated iridium
Supply voltage	24 ± 2 VDC
Supply current (max)	0.75 Amps
Relay contact rating	1A @ 30 VAC/VDC
Materials exposed to vacuum	304 stainless steel, glass, tungsten, platinum clad molybdenum, yttria coated iridium
Operating temperature	0 to 40°C
Bakeout temperature (electronics removed)	150°C with KF and Viton® seal; 300°C with CF and copper seal
Installation orientation	Any
CE certification	EN-61326-1, EN-61010-1
Vacuum connections	1” OD tube, mini CF, 2.75” CF, NW16 KF, NW25 KF, NW40 KF
Dimensions (1” OD tube)	2.9” x 3.1” x 4.0” (74 x 79 x 102 mm)
Weight (1” OD tube)	0.70 lbs. (.32 kg)

Feature and Control Locations

With the exeption of the filament switch all user access is through the 15-pin D-sub connector. The **POWER** LED indicates when power is applied to the MIGT; the **FILAMENT ON** LED indicates when power is applied to the MIGT filament. The **FILAMENT ON** light can also be used in conjunction with the **Test RS485–TST** command (described in the **RS-485 Command Set** section) to visually identify which sensor is set to a particular address. This is useful when several HPS transducers are connected to the same system.

The figure below shows the top view of the MIGT.



About the 909AR MIGT

The 909AR MIGT measures vacuum chamber pressures as part of a user's defined system processes. Once integrated into the vacuum system, the MIGT's functions can be controlled by a serial interface, logic lines or relay from a p/c, or manual switches.

This manual describes the installation and configuration tasks necessary to set up the 909AR MIGT.

For additional information on how the MIGT works, see the appendix **Theory of a Hot Cathode Ionization Sensor**.

Typical Applications for the 909AR MIGT

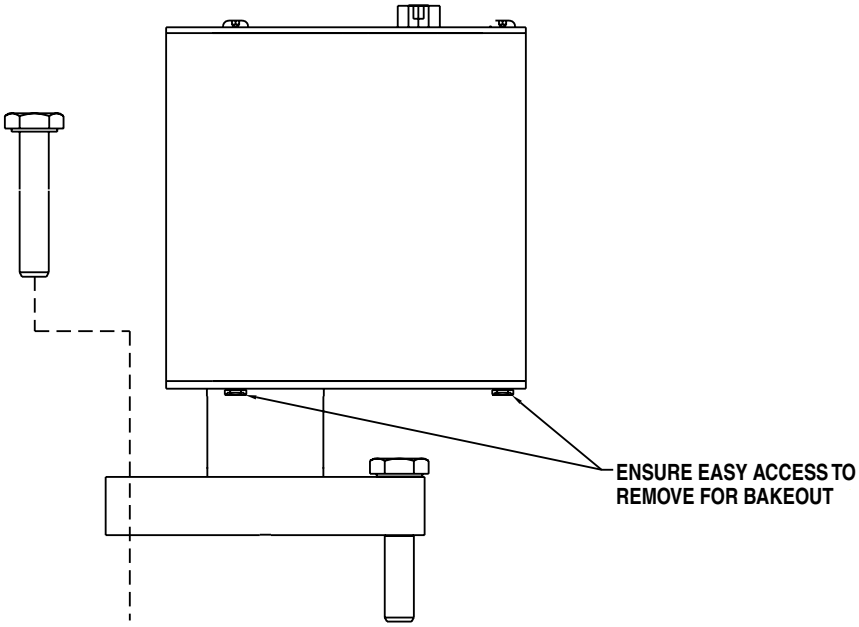
- Measure high vacuum chamber pressure.
- Control system pressure using digital communications or analog output as input to an automatic pressure controller.
- Measure pressure of backfilled gases.
- Sense abnormal pressure and take appropriate security measures using relay set points.
- Start or stop system processes with relay set points.

Installing the 909AR MIGT

Hot Cathode Sensor Installation

Location

Locate the 909AR MIGT where it can measure chamber pressure. Install the device away from pumps and gas sources so it will give the most representative pressure values. If the sensor is going to be baked out, the four screws on the panel closest to the flange will need to be removed (see the **Bakeout** section for details). Locate the sensor to ensure easy access to those four screws.



Orientation

The MIGT can be installed and operated in any position without compromising accuracy.

Contamination

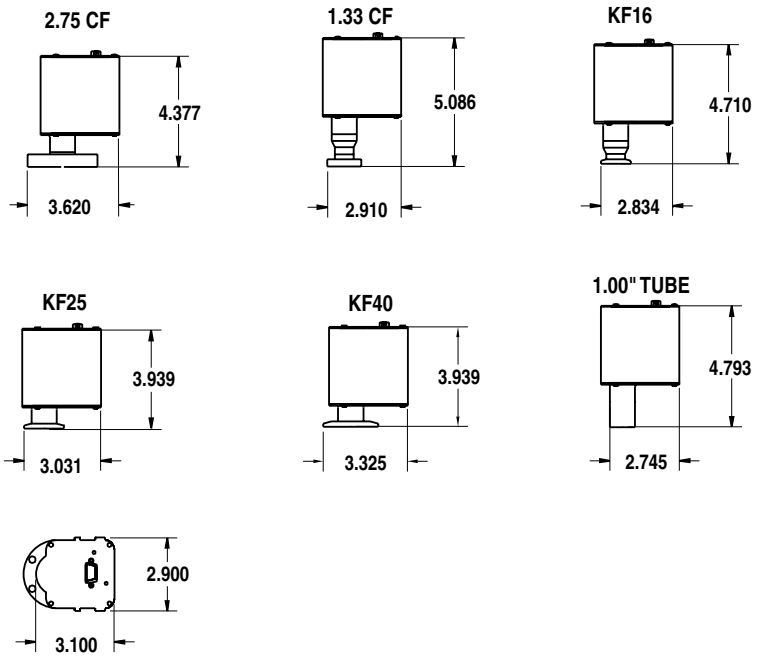
Locate and orient the MIGT where contamination is least likely. For example, if the MIGT is mounted directly above a source of evaporation, the vapor could contaminate the sensor elements and cause the calibration to shift. Whenever possible, install the MIGT with the vacuum port facing down to keep particulates or liquids from entering the device. To prevent inaccurate pressure measurements, shield an MIGT located near an electron or ion source (e.g., near an electron beam source or in a sputtering system) and mount it away from strong magnetic fields.

Vacuum Connection

The MIGT is available with the following flanges:

- 2.75" CF (rotatable)
- 1.33" CF (rotatable)
- KF 16
- KF 25
- KF 40
- 1" tube

The figure below shows the dimensions for each flange type. The top dimensions, also shown below, are valid for any flange configuration.



An 909AR MIGT with a KF flange and/or elastomer O-ring is suitable only for pressure measurement down to 10^{-7} Torr. Use Viton or silicone seals; Buna seals are not recommended for use with any hot cathode sensor or 909AR MIGT. Use only metal clamps on MIGTs with KF flanges to ensure a good electrical connection from the sensor body to the vacuum chamber. Additionally, the vacuum chamber must be grounded.

Electrical Connection

Use a cable with a mating 15-pin D-sub connector with strain reliefs to ensure proper electrical connection and to reduce stress on the connectors.

Ensure a low impedance electrical connection between the MIGT sensor body and the grounded vacuum system to shield the sensor from external electromagnetic sources (see previous section on Vacuum Connection).

Input/Output Wiring

The figure and the **909AR MIGT Electrical Connections Table** on the following page identify the pins of the MIGT connector and their functions; make a cable using this information. To comply with EN61326-1 immunity requirements, use a braided, shielded cable. Connect the braid to the metal hoods at both ends of the cable with the end for power supply connected to earth ground. The connector kit shipped with the MIGT includes a metal shell, which provides an easy and effective means of connecting the braid to it.

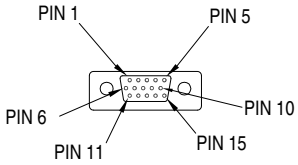
The power supply input is 24 VDC. The positive side of the power supply is connected to pin 3 and the negative side to pin 4 of the male D-sub connector.

Damage may occur to the circuitry if excessive voltage is applied, polarity reversed, or if a wrong connection is made.

If using analog output (described in the **Analog Output** section), the analog output voltages are pins 5 (+) and 6 (-). Connect them to a differential input voltmeter or an analog-to-digital (A/D) converter with a differential input in a system controller.

Do not connect the negative side of the analog output (pin 8) to the negative side of the power supply input (pin 4) or to any other ground. Doing so will cause half of the power current to flow through this wire. Measurement errors in the output voltage may be seen due to the voltage drop from this current. The longer the cable, the worse the error will be.

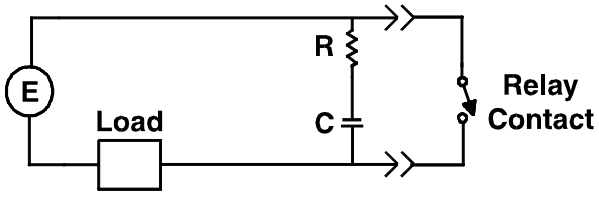
15 Pin 909A (909AR) Pinout



Pin Number	Function	Comments
1	RS485-/RS232 T X D	
2	RS485+/RS232 R X D	
3	+24	
4	Power Ground	
5	Analog Out+	
6	Analog Out-	
7	NC	
8	Relay NO	
9	Relay Common	
10	Relay NC	
11	Guage on/off	Active low (logic 0 or ground enables guage) No Connection = OFF
12	Degas on/off	Active low (logic 0 or ground enables degas) No Connection = OFF
13	Emission Range	Logic 0 or ground enables auto range. No Connection = 0.1mA
14	Degas Status	Open Collector-connected to ground when degas is off
15	Guage Status	Open Collector-connected to ground when guage is off

Relay Inductive Loads and Arc Suppression

If using the set point relay to switch inductive loads (e.g., solenoids, relays, transformers, etc.), the arcing of the relay contacts might interfere with MIGT operation and reduce relay contact life. Therefore, an arc suppression network, shown schematically below, is recommended.



The values of the capacitance C and the resistance R can be calculated by the following equations:

$C = I^2/(1 \times 10^7)$

$R = E/ I^a$

where: C is in farads
R is in ohms
I is DC or Ac_{peak} load current in amperes
E is DC or Ac_{peak} source voltage in volts
a = 1 + (50/ E)
Note that R_{min} = 0.5 Ω and C_{min} = 1.0 x 10-9 F

Operation

MANUAL OPERATION
SERIAL COMMUNICATIONS OPERATION

CAUTION: Never turn on filament power when the system pressure is above $5x10^{-2}$ Torr! Sensor damage will result!

The 909AR MIGT operation parameters are preset at the factory. The table below shows the factory default settings. Use the user interface and the commands described on the following pages to change parameter settings as necessary. The user interface to the MIGT is through RS-485 or RS-232 serial communications. RS485+ is pin 2 and RS485- is pin 1; RS-232 TXD is pin 1 and RS-232 RXD is pin 2.

909AR MIGT Factory Defaults Table

Setting	Default
Address	253
Baud	9600
Unit	Torr
Filament Power	Off
Degas Power	Off
Gas Correction	1
Set Point 1	5.0E-10 Torr
Hysteresis 1	+10% (5.5E-10 Torr)
Enable Set Point	Off
Protect Set Point Pressure	5.0E-2 Torr
Emission Current	Auto *

* If pin 13 is disconnected when power is applied then EC! Auto will need to be set to enable auto range.

Maunal Operation

Gauge On/Off

The gauge is turned on by connecting Gauge on/off (pin 1) to power ground.

Do not turn on the gauge if the pressure is above 5 x 10-2 Torr. Filament damage may resuslt.

Use the analog output to measure pressure (refer to Analog Output section).

When the gauge is off, the gauge status line (pin 9) is connected to power ground through an electronic switch. The gauge status is disconnected or “open collector” when the gauge is on. See Figure 1.

The gauge can turn itself off in one of three ways:

1. Pressure exceeds 5 x 10-2 Torr
2. The circuitry detects low or no emission current (pressure too high or filament burnt out).
3. Active filament has been changed.

In any of these cases the Gauge On/Off must be disconnected and reconnected to system ground to turn the gauge back on.

Emission Current

In the emission current pin (pin 13) is connected to power ground the gauge will perform an emission current range change as follows:

Decreasing pressure: switches to 1mA at 8.0 x 10-5 Torr
Increasing pressure: switches to 0.1mA at 1.0 x 10-4 Torr

If the emission current pin is left disconnected the emission current will always be 0.1mA.

Degas

The degas mode is enabled when the degas pin (pin 12) is connected to power ground. Refer to the degas section for more information.

When degas is off the degas status pin (pin 6) is connected to power ground through an electronic switch. The degas status is disconnected or “open collector” when the degas is on. See figure 1.

Active Filament

The gauge has two filaments of which only one at a time operates. To change the active filament, first turn the Gauge Off (see Gauge On/Off above) flip the filament select switch to the other position. To turn the gauge back on, reconnect pin 11 to system ground.

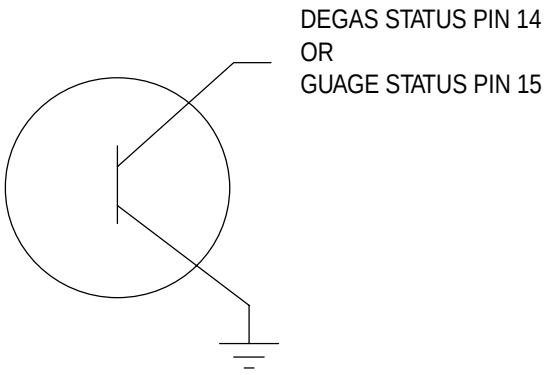


FIGURE 1

EXAMPLE OF STATUS LINE INTERNAL CONNECTION

RS-485/232 Protocol

The MIGT supports 2400, 4800, 9600, and 19200 baud rates (factory default: 9600). The data format is 8 data bits, no parity, and one stop bit.

Standard Addresses

Valid addresses are 1 to 253 (factory default: 253).

Universal Addresses

The MIGT receives and responds to commands sent to address 254. For example, use 254 to communicate with a device if its address is unknown. The MIGT receives and acts upon commands sent to address 255, but does not respond; use 255 to broadcast messages to multiple devices attached to the same system. For example, use 255 to turn on the filaments for all MIGTs connected to the same system.

Query and Command Syntax

Queries return current parameter settings; commands change the parameter setting according to the value the user types in the command syntax. Each query or command must begin with the attention character @ and end with the termination string ;FF.

Syntax required for a query is:
@<device address><query>?;FF.

Syntax required for a command is:
@<device address><command>!<parameter>;FF.

Examples:

Query current baud rate: @253BR?;FF
Change baud rate to 19200: @253BR!19200;FF

where:

@	<attention character>
253	<device address>
BR?	<query> (for query syntax)
BR!19200	<command>!<parameter> (for command syntax)
;FF	<terminator>

Response Syntax (ACK/NAK)

The ASCII characters 'ACK' or 'NAK' preface the query or command response string. The ACK sequence signifies the message was processed successfully. The NAK sequence indicates there was an error.

The response to a query or a successful command is:
@<device address>ACK<data>;FF

The response to a message with an error is:
@<device address>NAK<NAK code>;FF

Examples:

ACK response: @253ACK9600;FF (baud rate changed to 9600)
NAK response: @253NAK160;FF (command had an error—possibly a typo)

The following list provides descriptions of the NAK codes that may be returned.

Error	NAK Code
Unrecognized message	160
Invalid argument	169
Value out of range	172
Command/query character invalid (! or ?)	175
Write to nonvolatile memory failed	196
Read from nonvolatile memory failed	197
Not in measure pressure mode	198
Pressure too high for degas	199

RS-485/232 Command Set

The query and command formats shown in this section are examples; the values may vary for the user's installation.

Set Up and Status Commands

Address – AD

The AD command returns or sets the MIGT address. Note: If multiple devices are installed on the system, an address query using 254 (shown in the query example below) cannot determine the address of only one of the devices.

Values: 001 to 253 (default: 253)

Query: @254AD?;FF
Query Response: @254ACK001;FF
Command: @001AD!002;FF
Command Response: @002ACK002;FF

Baud Rate – BR

The BR command returns or sets the baud rate of the communications protocol. The MIGT responds to this command at the present baud rate; however, the user will need to change the baud rate on the host to ensure future commands are sent at the same rate.

Values: 2400, 4800, 9600, 19200 (default: 9600)

Query: @001BR?;FF
Query Response: @001ACK9600;FF
Command: @001BR!19200;FF
Command Response: @001ACK19200;FF

Device Type – DT

The DT command returns the transducer device type.
Query: @001DT?;FF
Query Response: @001ACKHCIG;FF (hot cathode ionization gauge)

Emission Current – EC

The EC command returns or sets the sensor's emission current to 100uA or Auto range (100uA above $1x10^{-4}$ and 1mA below $1x10^{-4}$ Torr).

Values: 100UA and AUTO for commands;
100UA, 1MA AUTO, and 100UA AUTO for responses
(default: AUTO).

Query: @001EC?;FF
Query Response: @001ACK1MA AUTO;FF
Command: @001EC!AUTO;FF
Command Response: @001ACK100UA AUTO;FF

Auto mode will be lost at power off unless pin 13 is connected to power ground.

Factory Default – FD

The FD command sets all MIGT parameter values to the factory default settings shown in the **909 MIGT Factory Defaults Table** (page 18). Note: The FD command overrides all parameter values the user sets; use with caution!

Command: @001FD!;FF
Command Response: @001ACKFD;FF

Firmware Version – FV

The FV command returns the MIGT firmware version.

Query: @001FV?;FF
Query Response: @001ACK1.00;FF

Gas Correction – GC

The GC command returns or sets the gauge's sensitivity for use with gasses other than air or nitrogen. For example, if Argon is the system gas then the gas correction value would be 1.29. See the **Gas Correction Factor Table** for values.

Values: 0.10 to 50.1 (default: 1)

Query: @001GC?;FF
Query Response: @001ACK1.00;FF
Command: @001GC!1.50;FF
Command Response: @001ACK1.50;FF

Manufacturer – MF

The MF command returns the MIGT manufacturer.

Query:	@001MF?;FF
Query Response:	@001ACKHPS;FF

Model – MD

The MD command returns the MIGT model number.

Query:	@001MD?;FF
Query Response:	@001ACK909AR;FF

Serial Number – SN

The SN command returns the MIGT serial number.

Query:	@001SN?;FF
Query Response:	@001ACK000012345;FF

Test RS485 – TST

The TST command flashes the filament power LED ON and OFF, in order to visually identify the unit.

Values:	ON, OFF

Query:	@001TST?;FF
Query Response:	@001ACKOFF;FF
Command:	@001TST!ON;FF
Command Response:	@001ACKON;FF

Time On – TIM

The TIM command returns the number of hours each filament has been on or clears the time on both filaments to allow the user to replace the sensor.

Values:	CLR

Query:	@001TIM?;FF
Query Response:	@001ACKF1 00024 F2 00000;FF
Command	@001TIM!CLR;FF
Command Response:	@001ACKCLR;FF

Transducer Status – T

The T command returns the current status of the MIGT. Related commands: **Active Filament – AF** (this section); **Set Point Value – SP1** and **Hysteresis Value – SH1** (**Set Point Commands** section).

Values:
A = Set point 1 value out of bounds
D = Degas fault, pressure too high to activate degas
F = Filament fault, filament cannot turn on
G = Gauge on
O = OK, no errors to report
P = Pressure fault, system pressure above protect pressure

Query: @001T?;FF
Query Response: @001ACKO;FF

Transducer Temperature – TEM

The TEM command returns the transducer's on-chip Microprocessor temperature in ^{o}C. If the temperature exceeds 70^{o}C, the ambient temperature may be too high or the filament power is too high (nominal temperature rise is 30^{o}C above ambient). See the **Filament Status – FS** or **Transducer Status – T** commands (this section) for how to query the filament power level. See the **Maintenance and Troubleshooting** section for more information on troubleshooting temperature problems.

Query: @001TEM?;FF
Query Response: @001ACK32.0;FF

Unit – U

The U command returns or sets the pressure unit to Torr, mBar, or Pascal. The units affect all pressure measurements, including set point values.

Values: TORR, MBAR, PASCAL (default: TORR)

Query: @001U?;FF
Query Response: @001ACKTORR;FF
Command: @001U!MBAR;FF
Command Response: @001ACKMBAR;FF

User Tag – UT

The UT command returns or sets the user tag label to assign for MIGT identification.

Values: Up to 30 ASCII characters

Query: @001UT?;FF
Query Response: @001ACKCHAMBER1;FF
Command: @001UT!CHAMBER2;FF
Command Response: @001ACKCHAMBER2;FF

Pressure Measurement and Degas Commands

Filament Power – FP

CAUTION: Never turn on filament power when system pressure is above $5x10^{-2}$ Torr! Sensor damage will result!

The FP command turns the filament either ON or OFF. To query the ON/OFF status of the filament, use the **Filament Status – FS** command, or the **Transducer Status – T** command with the G value (**Set Up and Status Commands** section).

Values: ON, OFF

Command: @001FP!ON;FF
Command Response: @001ACKON;FF

Pressure Reading – PR1

The PR1 command returns the measured pressure in scientific notation.

Query: @001PR1?;FF
Query Response: @001ACK6.3E-7;FF

Degas Power – DG

Read the Degasing the Sensor section of this manual before using the DG command.

The DG command turns degas ON or OFF, or indicates if the MIGT is in degas mode. Degas turns off automatically after 30 minutes, but can be turned off sooner.

Values:	ON, OFF (default: OFF)
Query:	@001DG?;FF
Query Response:	@001ACKOFF;FF
Command:	@001DG!ON;FF
Command Response:	@001ACKON;FF

Set Point Commands

Set Point Value – SP1

The SP1 command returns or sets the set point value. The set point value is the pressure below which the set point relay will be energized (i.e., N.O. and C contacts will be closed). The set point must be enabled for the SP1 command to function (see the **Enable Set Point – EN1** command, next page) .

Values:	Two-digit number in scientific notation from 5.0E-10 to 9.0E-3 Torr (default: 5.0E-10 Torr)
Query:	@001SP1?;FF
Query Response:	@001ACK1.0E-6;FF
Command:	@001SP1!2.5E-7;FF
Command Response:	@001ACK2.5E-7;FF

Hysteresis Value – SH1

The SH1 command returns or sets the pressure value above which the set point relay will be de-energized (i.e., N.C. and C contacts will be closed). The hysteresis value must always be above the set point value (see the **Set Point Value – SP1** command, above). If the hysteresis and set point are the same value, or nearly the same value, the relay may chatter when the system pressure is near the set point.

Values:	Two-digit number in scientific notation from 5.0E-10 to 9.0E-3 Torr (default: +10% (5.0E-10 Torr))
Query:	@001SH1?;FF
Query Response:	@001ACK2.8E-7;FF
Command:	@001SH1!1.0E-7;FF
Command Response:	@001ACK1.0E-7;FF

Enable Set Point – EN1

The EN1 command returns enable status or enables the set point relay.

Values:	OFF, ON (default: OFF)
Query:	@001EN1?;FF
Query Response:	@001ACKOFF;FF
Command:	@001EN1!ON;FF
Command:	@001ACKON;FF

Set Point Status – SS1

The SS1 command returns the status of the set point relay.

Values:	SET, CLEAR
Query:	@001SS1?;FF
Query Response:	@001ACKCLEAR;FF

Protect Set Point – PRO

The PRO command returns or sets the pressure value at which the MIGT will turn itself off to prevent sensor damage. The protect set point cannot be disabled and is valid during degas.

Values:	1.0E-6 to 5.0E-2 Torr (default: 1.0E-2 Torr)
Query:	@001PRO?;FF
Query Response:	@001ACK1.0E-2;FF
Command:	@001PRO!5.0E-3;FF
Command Response:	@001ACK5.0E-3;FF

Degasing the Sensor

Sensitivity of the sensor may drift if the sensor elements become contaminated with system process gasses. This becomes more of a problem the lower the pressure being measured (i.e., ($\leq 10^{-8}$ Torr). To rid the sensor elements of the excess system process gasses, periodically degas the sensor. How frequently to run degas varies for each system installation.

The 909AR MIGT uses Electron Bombardment (EB) degas to remove adsorbed gas from the sensor. Pressure can still be measured during degas, but due to the gas rapidly coming off the sensor elements, sensor pressure may be significantly higher than system pressure.

Degas is only activated if the indicated pressure is below $1x10^{-5}$ Torr.

Set points are active during degas.

When degas is turned on, it is likely that the sensor pressure will increase to values exceeding $1x10^{-4}$ Torr. When the indicated pressure exceeds $1x10^{-4}$ Torr, degas turns off. Degas automatically turns on again when the indicated pressure drops back below $1x10^{-4}$ Torr (patent# 6756785).

Expect the filament power status to be HIGH during degas.

The temperature inside the MIGT increases during degas; for electronic component life, keep degas time as short as possible. Degas operation automatically terminates after 30 minutes. When the sensor's indicated pressure has dropped back near pre-degas values, there is not much benefit to further degas operation; therefore, degas should be terminated.

Do not operate in degas mode more than 30 minutes every 4 hours.

Sensitivities Relative to Nitrogen

If using a gas other than air/nitrogen in the system, then user will need to change the gas correction factor to provide an accurate pressure reading (see **Gas Correction – GC** in the **Set Up and Status Commands** section). The table below shows GC values for some commonly used gasses. These correction factors are all relative to the nitrogen factor (which in the case of the MIGT is 1). For example, if using Argon gas in the system, use the GC command as follows: @253GC!1.29;FF.

Gas Correction Factor Table

Gas	Symbol	Gas Correction Factor (GC)
Air		1.00
Argon	Ar	1.29
Carbon Dioxide	CO_2	1.42
Deuterium	D2	0.35
Helium	He	0.18
Hydrogen	H_2	0.46
Krypton	Kr	1.94
Neon	Ne	0.30
Nitrogen	N_2	1.00
Nitrogen Oxide	NO	1.16
Oxygen	O_2	1.01
Sulfur Hexaflouride	SF_6	2.50
Water	H_2O	1.12
Xenon	Xe	2.87

Analog Output

Analog output is an optional method of measuring pressure. The analog voltage signal are pins 5 (+) and 6 (-). Connect them to a differential input voltmeter or ADC. The output is logarithmic, spanning 0-10V. The pressure/voltage relationship is P (Torr) = $10^{(Vo-10)}$.

Analog Output: Pressure = $10^{(Vo-10)}$ Torr

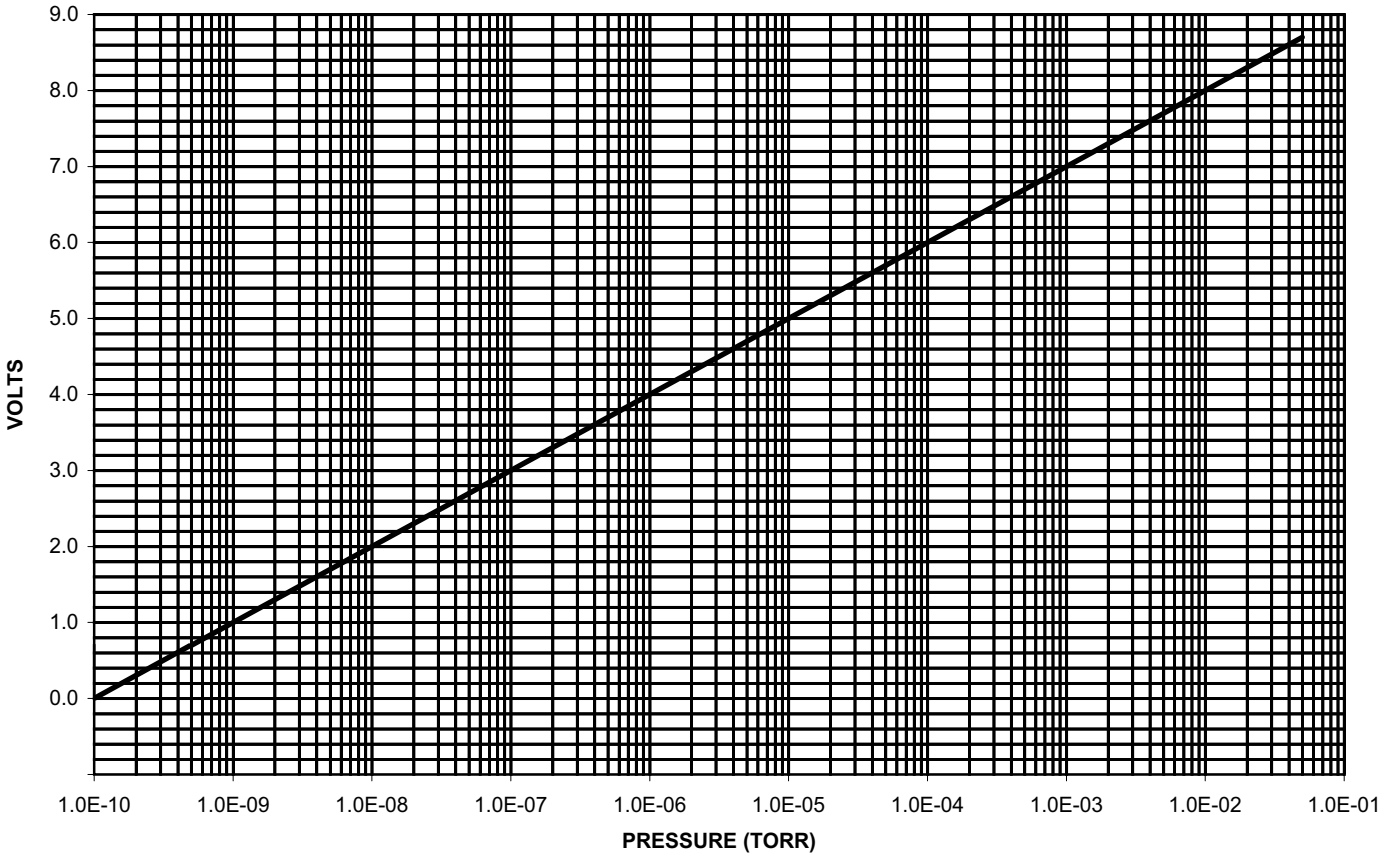
Do not connect the negative side of the analog output (pin 8) to the power supply return (pin 4) or to any other ground. The voltage drop from the supply current will produce errors in the analog output voltage. The longer the cable, the worse the error will be.

Analog Output Table

Voltage	Pressure
10 Volts	Filament is off
8.7 Volts	$5x10^{-2}$ Torr
8.0 Volts	$1x10^{-2}$ Torr
7.0 Volts	$1x10^{-3}$ Torr
6.0 Volts	$1x10^{-4}$ Torr
5.0 Volts	$1x10^{-5}$ Torr
4.0 Volts	$1x10^{-6}$ Torr
3.0 Volts	$1x10^{-7}$ Torr
2.0 Volts	$1x10^{-8}$ Torr
1.0 Volts	$1x10^{-9}$ Torr
0.0 Volts	$1x10^{-10}$ Torr
0 Volts	No power applied to the transducer

The following graph shows the correlation of analog output to pressure.

909AR MIGT ANALOG OUTPUT



Bakeout/Sensor Replacement

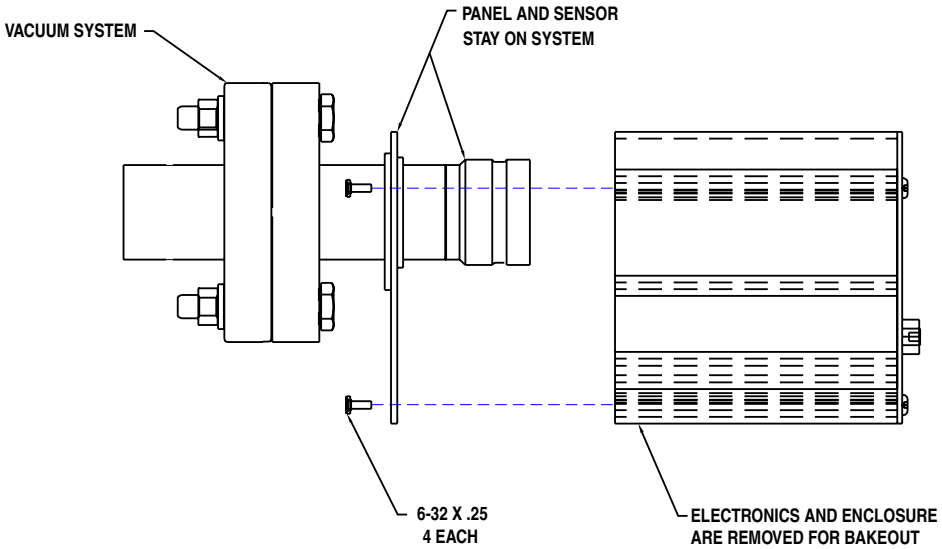
CAUTION: Disconnect the power supply before disassembly! Lethal voltages and currents may be present while the circuit is operating. Only a qualified technician should replace or adjust electronic components.

Bakeout

If building the system for the first time, or after performing routine maintenance, the system may need to be baked out to remove any water vapor.

The sensor can be baked out to 300°C with a metal seal flange (CF) and 150°C with a Viton® seal flange (KF). To bake out the sensor, first remove the electronics. To do this:

1. Disconnect the cable from the 909AR MIGT.
2. Remove the four screws (as shown in the figure below). The screws may be difficult to access when the sensor is attached to the vacuum system.
3. Pull the metal housing and the electronics from the sensor. The bottom panel remains attached to the sensor.



Avoid removing the other four screws, two jack screws, top panel, and electronics that leave the housing attached to the sensor. The housing has labels that may come off, discolor, or burn at temperatures above 60^{o}C, and the housing will discolor at temperatures above 200^{o}C.

To re-assemble the electronics, use the disassembly steps in reverse order.

Sensor Replacement

Before disassembling the electronics for sensor replacement, use the **Time On – TIM** command (described in the **Set Up and Status Commands** section) to clear the filament time.

To disassemble the electronics for sensor replacement, use the procedure in the **Bakeout** section.

To re-assemble the electronics, use the disassembly steps in reverse order.

For sensor part numbers, see the **Accessories and Part Replacement** section.

Maintenance and Troubleshooting

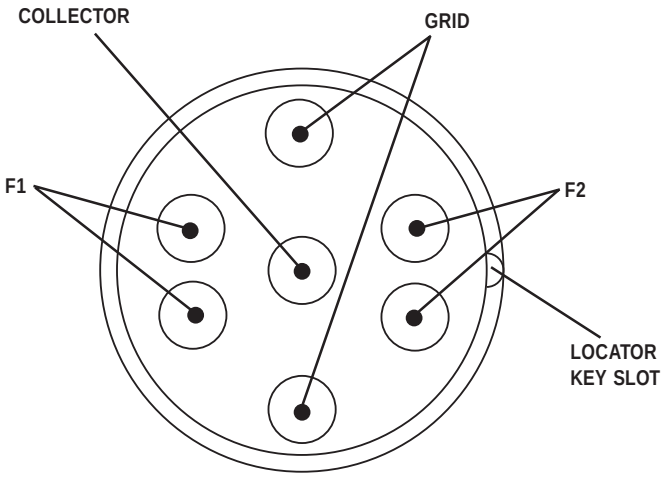
Maintenance and Troubleshooting Table

Symptom	Possible Cause/Remedy
Power LED not on	Connector miswired, +24 V not applied
No response to RS-485/232 commands	- Attention character (@) missing - Address incorrect - Termination characters (;FF) missing - Baud rate incorrect - Electrical connections missing or incorrect
Filament light does not come on/stay on	- System pressure is above protect set point value - +24 V cannot supply adequate current - Sensor filament has failed (see figure on the following page to test filaments)
Pressure reading incorrect	- Transducer not located properly to measure system pressure - Gas Correction factor not correct for the gas in the system - Sensor contaminated (degasing the sensor may fix this) - Leak in the vacuum system
Set point does not trip	- Set point not enabled - Set point hysteresis value not set to proper value - Connector miswired
Degas does not start	System pressure above $1x10^{-5}$ Torr when degas command is sent.

Sensor Test Resistance Values Table

Pin	Resistance
Filament 1 or 2 to same filament	<2 Ω
Grid to grid	<1 Ω
Grid to collector or either filament	>20M Ω
Any pin to the sensor body	>20M Ω

The figure below shows the locations of the pins.



Accessories and Part Replacement

Description	Part Number
Sensor with 2.75” CF	100011508
Sensor with 1.33” CF	100011600
Sensor with NW40 KF	100011602
Sensor with NW25 KF	100011601
Sensor with NW16 KF	100011603
Sensor with 1” tube	100011820
Connector Kit (female 15-pin D-sub)	100008104
Operation and Maintenance Manual	100011798

Warranty

Extent of the Warranty
MKS Instruments, Inc. (MKS), HPS® Products, warrants the HPS® Products Series 909 Miniature Ionization Gauge Transducer and its accessories to be free from defects in materials and workmanship for one (1) year from the date of shipment by MKS or authorized representative to the original purchase (PURCHASER). Any product or parts of the product repaired or replaced by MKS under this warranty are warranted only for the remaining unexpired part of its one (1) year original warranty period. After expiration of the applicable warranty period, the PURCHASER shall be charged MKS' current prices for parts and labor, plus any transportation for any repairs or replacement.

ALL EXPRESS AND IMPLIED WARRANTIES, INCLUDING THE IMPLIED WARRANTIES OF MERCHANTABILITY AND FITNESS FOR A PARTICULAR PURPOSE, ARE LIMITED TO THE WARRANTY PERIOD. NO WARRANTIES, EXPRESS OR IMPLIED, WILL APPLY AFTER THIS PERIOD.

Warranty Service
The obligations of MKS under this warranty shall be at its option: (1) to repair, replace, or adjust the product so that it meets applicable product specifications published by MKS or (2) to refund the purchase price.

What is Not Covered
The product is subject to above terms only if located in the country of the seller from whom the product was purchased. The above warranties do not apply to:

I. Damages or malfunctions due to failure to provide reasonable and necessary maintenance in accordance with MKS operating instructions.
II. Damages or malfunctions due to chemical or electrolytic influences or use of the product in working environments outside the specification.
III. Fuses and all expendable items which by their nature or limited lifetime may not function for a year. If such items fail to give reasonable service for a reasonable period of time within the warranty period of the product, they will, at the option of MKS, be repaired or replaced.
IV. Defects or damages caused by modifications and repairs effected by the original PURCHASER or third parties not authorized in the manual.

Condition of Returned Products
MKS will not accept for repair, replacement, or credit any product which is asserted to be defective by the PURCHASER, or any product for which paid or unpaid service is desired, if the product is contaminated with potentially corrosive, reactive, harmful, or radioactive materials, gases, or chemicals. When products are used with toxic chemicals, or in an atmosphere that is dangerous to the health of humans, or is environmentally unsafe, it is the responsibility of the PURCHASER to have the product cleaned by an independent agency skilled and approved in the handling and cleaning of contaminated materials before the product will be accepted by MKS for repair and/or replacement. In the course of implementing this policy, MKS Customer Service Personnel may inquire of the PURCHASER whether the product has been contaminated with or exposed to potentially corrosive, reactive, harmful, or radioactive materials, gases, or chemicals when the PURCHASER requests a return authorization. Not with standing such inquiries, it is the responsibility of the PURCHASER to ensure that no products are returned to MKS which have been contaminated in the aforementioned manner.

Other Rights and Remedies

I. These remedies are exclusive. HPS® SHALL NOT BE LIABLE FOR CONSEQUENTIAL DAMAGES, FOR ANTICIPATED OR LOST PROFITS, INCIDENTAL DAMAGES OR LOSS OF TIME, OR OTHER LOSSES INCURRED BY THE PURCHASER OR BY ANY THIRD PARTY IN CONNECTION WITH THE PRODUCT COVERED BY THIS WARRANTY, OR OTHERWISE. Some states do not allow exclusion or limitation of incidental or consequential damage or do not allow the limitation on how long an implied warranty lasts. If such laws apply, the limitations or exclusions expressed herein may not apply to PURCHASER.
II. Unless otherwise explicitly agreed in writing, it is understood that these are the only written warranties given by HPS®. Any statement made by any persons, including representatives of MKS, which are inconsistent or in conflict with the terms of the warranty shall not be binding on MKS unless reduced to writing and approved by an authorized officer of MKS.
III. This warranty gives PURCHASER specific legal rights, and PURCHASER may also have other rights which vary from state to state.
IV. For MKS products sold outside of the U. S., contact your MKS representative for warranty information and service.

Warranty Performance
To obtain warranty satisfaction, contact the following: MKS Instruments, Inc., HPS® Products, 5330 Sterling Drive, Boulder, CO 80301, USA, at phone number 1-303-449-9861. You may be required to present proof of original purchase.

Appendix: Theory of a Hot Cathode Ionization Sensor

Hot cathode ionization sensors use thermionic electrons—electrons emitted from a hot filament (emission current)—to create ions in a defined volume. In their passage from the cathode through the gas volume, the electrons collide with gas atoms or molecules to form ions. The number of gas molecules ionized depends on the energy of the ionizing electrons, typically about 150 eV, and the ionization probabilities of the constituent gases. The total amount of ionization is related to the molecular concentration. The ions are accelerated to a collector electrode, where they create a current (collector current) in a circuit, which includes an electrometer. The measured current is proportional to the gas density, which in turn is directly related to the pressure, provided that other parameters like temperature are held constant. The response to pressure changes in such a device is virtually instantaneous.

Mathematically the pressure is related to ion current, or collector current, by the relationship:

$P = Ic/(K \times Ie)$

where:

P is pressure (e.g., Torr),
Ic is collector current (Amps),
Ie is the emission current (Amps),
K is a sensitivity constant (e.g., in the case of the MIGT, the sensitivity is 12/Torr).

The sensitivity (K) is dependent on gauge geometry and electrode potentials.