MX4A Active Convection Gauge
Instruction Manual

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1.1   Disclaimer

All information in this manual is subject to change without notice. The Fredericks Company assumes no responsibility for inaccuracies in product specifications or any liability arising from product use. Please contact Televac at sales@televac.com or call 215-947-2500 with comments or questions.

1.2   Description

The MX4A is a convection vacuum gauge with a range of 1×10^{-4} Torr to 1000 Torr. It utilizes a Televac convection vacuum sensor, part number 2-2120-0YY. It has a two color OLED display with selectable units of Torr, Millibar, and Kilopascal. Settings can be changed through RS-485 communications with a PC or on the unit using four capacitive touch buttons located on the top of the unit. The MX4A has 2 set points, one relay and one open collector, and a selectable analog output option. The analog output has a variety of options including four linear outputs, linear by decade, logarithmic, and non-linear.

1.3   Operating Specifications

Table 1: Operating Specifications

Operating Range	1×10^{-4} to 1000 Torr
Communications	RS-485
Programmable Set Points	2
Set Point 1	Open Collector
Set Point 2	Relay
Analog Output	7 selectable 0 to 10 V
Supply Voltage	+22 to +26 V DC
Maximum Power	8 W
Calibration Medium	Dry air or nitrogen
Overpressure	150 PSI
Digital Output Resolution	2 significant digits with exponent
Analog Output Resolution	16 bits
Operating Temperature	0° C to 50° C
Storage Temperature	−20° C to 60° C
Bakeout Temperature	
Brass (P/N: 2-8930-110)	100° C (electronics removed)
Stainless (P/N: All Others)	200° C (electronics removed)
Response Time	≤ 1 second
Accuracy	
1 mTorr to 10 mTorr	±1 mTorr
10 mTorr to 1000 Torr	±10%
Analog Output	±5 mV
Standard Resolution	
1 mTorr to 500 mTorr	1 mTorr
500 mTorr to 5 Torr	10 mTorr
5 Torr to 50 Torr	100 mTorr
50 Torr to 500 Torr	1 Torr
500 Torr to 1000 Torr	10 Torr
Display Readable Distance	3 m (10 feet)

1.4   Dimensions

Figure 1: MX4A Dimensional Drawing

1.05 [26.7]
1.56 [39.6]
.52 [13.2]
3.19 [81]
1.97 [50]

MX4A
CONVECTION GAUGE

≡TELEVAC≡
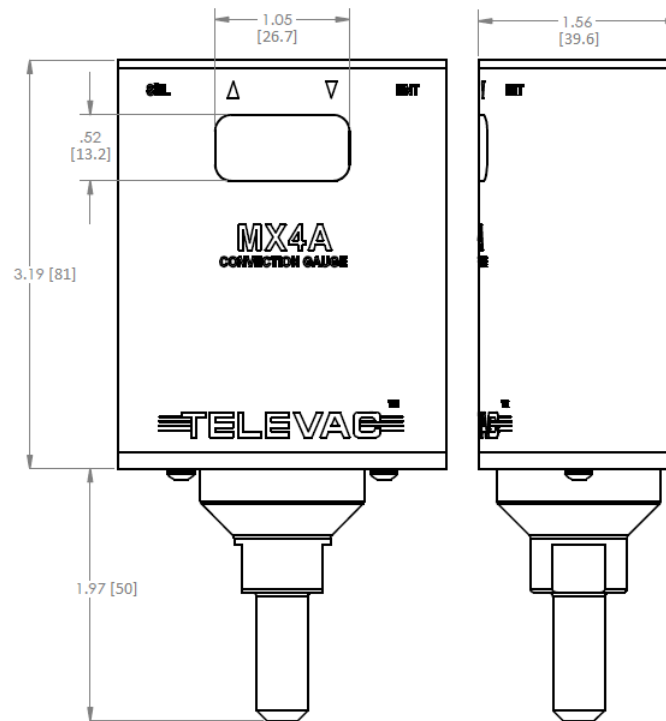
*Dimensions are drawn with 1/8" NPT fitting installed

1.5   Safety Information

**START BY READING THESE IMPORTANT
SAFETY INSTRUCTIONS AND NOTES**

In these instructions the word "product" refers to the MX4A and all of its approved parts and accessories. NOTE: These instructions do not and cannot provide for every contingency that may arise in connection with the installation, operation, or maintenance of this product. Should you require further assistance, please contact Televac at the email address found in the footer of this manual.

This product has been designed and tested to offer reasonably safe service provided in it is installed, operated and serviced in strict accordance with these safety instructions.

These safety precautions must be observed during all phases of operation, installation, and service of this product. Failure to comply with these precautions or with specific warnings elsewhere in this manual violates safety standards of design, manufacture, and intended use of the instrument. Televac disclaims all liability for the customer's failure to comply with these requirements.

- READ Instructions – Read all safety and operating instructions before operating the product.
- RETAIN instructions – Retain the safety and operating instructions for future reference.
- HEED warnings – Adhere to all warnings on the product and in the operating instructions.
- FOLLOW instructions – Follow all operating and maintenance instructions.
- ACCESSORIES – Do not use accessories not recommended in this manual as they may require a technician to restore the product to its normal operation.

The MX4A qualifies as a Safety Extra-Low Voltage (SELV) device. As such, it represents little to no hazard concerning electrical shock or burns.

Do not substitute parts or modify instrument. Because of the danger onj introducing additional hazards, do not install substitute parts or perform any unauthorized modifications to the product. Return the product to Televac for service and repair to ensure that safety features are maintained. Do not use this product if it has unauthorized modifications.
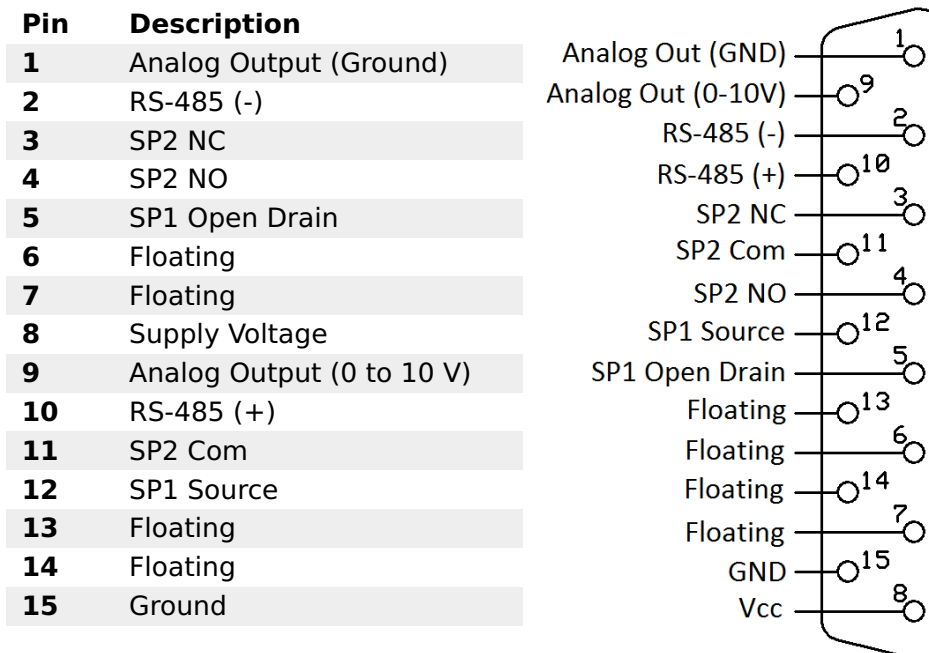
2 Setup

2.1 Installation

Each MX4A is designed to be used in conjunction with a 4A sensor. Mount the 4A sensor in an upright position and as close to the area where vacuum measurement is desired. Failure to mount the 4A sensor in a vertical position will decrease the accuracy of the measurement above 10 Torr. Each 4A sensor has a key that only allows for the MX4A to mate with the sensor in the proper orientation. Rotate the MX4A until the correct alignment is obtained and the MX4A is able to slide onto the 4A sensor. Connect the power connector to the top of the unit and be sure to tighten the screws so that a firm connection is maintained.

Try to avoid connecting the MX4A to the vacuum chamber by long or narrow piping as this may affect the accuracy and response time of the unit. Avoid mounting the unit near a heater within the chamber as this may affect the measurement accuracy. Excessive vibration of the unit may affect accuracy and decrease the life of the unit. Exposure to oils and other contaminants will decrease the accuracy and decrease the life of the sensor. Do not expose the unit to corrosive gases.

2.2 Electrical Information

Power connectors and adaptors for use with the MX4A are available for purchase from Televac. Operators wishing to create their own adaptors should refer to the pin out of the MX4A below. Each connection labeled "Floating" has no connection and should remain so.

Figure 2: MX4A Electrical Connection Information

Pin	Description
1	Analog Output (Ground)
2	RS-485 (-)
3	SP2 NC
4	SP2 NO
5	SP1 Open Drain
6	Floating
7	Floating
8	Supply Voltage
9	Analog Output (0 to 10 V)
10	RS-485 (+)
11	SP2 Com
12	SP1 Source
13	Floating
14	Floating
15	Ground

Analog Out (GND) — 1
Analog Out (0-10V) — 9
RS-485 (-) — 2
RS-485 (+) — 10
SP2 NC — 3
SP2 Com — 11
SP2 NO — 4
SP1 Source — 12
SP1 Open Drain — 5
Floating — 13
Floating — 6
Floating — 14
Floating — 7
GND — 15
Vcc — 8

2.3   Menu Navigation

The MX4A contains many operator customizable features. Changing these features is possible through the menu or via RS-485 communications. To navigate the menu simply use the buttons found on top of the MX4A. The four buttons include the SEL button, an UP arrow, a DOWN arrow, and an ENT button. Using the SEL button allows the operator to change between menu categories. Using the ENT button allows the user to enable value editing and save values in addition to toggling between options where appropriate. Using the UP and DOWN arrows allows navigation through menu options. The UP and DOWN arrow buttons are also used to edit values.

2.4   Menu Structure

1. Measurement

2. Calibration

   (a) Vacuum
   (b) 1 Torr
   (c) 70 Torr
   (d) Atmosphere
   (e) Resolution High/Low
   (f) Default
   (g) Diagnostic
   (h) Analog Output Adjustment
   (i) Gas Type

3. Set Points

   (a) SP1L
   (b) SP1H
   (c) SP2L
   (d) SP2H

4. Units

   (a) Torr/kPa/mbar

5. Output

   (a) Analog Output
       i. Logarithmic
       ii. Linear by Decade
       iii. Non-linear
       iv. Linear 4
       v. Linear 3
       vi. Linear 2
       vii. Linear 1
   (b) RS-485 I/O
       i. Address
       ii. Parity
       iii. Stop Bits
       iv. Baud Rate

2.5   Explanation of Menu Items and Navigation

Below is a general explanation of each level of the menu structure of the MX4A.

2.5.1   Measurement

The measurement screen contains the reading of the sensor in easy-to-read blue digits and includes units. In addition to the digital reading, the yellow bar on the measurement screen provides an analog indication of the pressure based on a logarithmic scale. At 1000 Torr the yellow bar should stretch across the width of the screen. At 0 Torr the yellow bar will disappear, and at 1 Torr, the yellow bar will be half way across the screen.

2.5.2   Calibration

To reach the calibration screen:

- Navigate to the measurement screen.
- Press SEL once.
- Press the UP and DOWN arrows to navigate between panes under the calibration heading.

To ensure that the unit always displays with the most accuracy, the MX4A includes a number of operator-configurable calibration points. While the MX4A is factory calibrated, the use of the included calibration points may become necessary after extended use, contamination, etc. If accuracy is critical, it is recommended to return the sensor to TELEVAC for NIST-traceable calibration.

Note 1: Calibration should be performed in the following order: vacuum adjustment, 1 Torr adjustment, 70 Torr adjustment, 760 Torr adjustment. Failing to calibrate in this order will result in inaccuracies.

Note 2: CHANGING CALIBRATION SETTINGS VOIDS NIST-TRACEABLE CALIBRATIONS!

A. **Vacuum (Zero)**

To reach the vacuum screen:

- The vacuum screen is the first pane of the calibration screen.
- Press ENT to unlock the vacuum screen.
- Press UP or DOWN to adjust the reading.
- When the desired reading is reached, press ENT to save and lock the change.

The vacuum calibration point allows the gauge to adjust the pressure reading at high vacuum ("zeroing"). This should be used only when the operator knows that the unit is pumping down below 10^{-4} Torr and the unit reads a non-zero number. When the vacuum is below the range of MX4A measurement (preferably as low as 10^{-5} Torr), adjust the unit until it blinks between .0000 and .0001.

For users calibrating against a NIST calibrated standard, maximum accuracy for the MX4A can be obtained by calibrating the MX4A to .0050 Torr instead of the normal .0000 Torr reading.

B. **1 Torr**

To reach the 1 Torr adjustment screen:

- Navigate to the calibration screen.
- Press DOWN one time.
- Press ENT to unlock the 1 Torr adjustment screen.
- Press UP or DOWN to adjust the reading.
- When the desired reading is reached, press ENT to save and lock the change.

The 1 Torr calibration point allows the gauge to adjust the pressure reading at 1 Torr. This should be used only when the operator knows that the unit under calibration is compared to a reference gauge that is NIST traceable calibrated and reading near 1 Torr.

C. **70 Torr**

To reach the 70 Torr adjustment screen:

- Navigate to the calibration screen.
- Press DOWN two times.
- Press ENT to unlock the 70 Torr adjustment screen.
- Press UP or DOWN to adjust the reading.
- When the desired reading is reached, press ENT to save and lock the change.

The 70 Torr calibration point allows the gauge to adjust the pressure reading at 70 Torr. This should be used only when the operator is able to compare the MX4A to a reference gauge that is NIST calibrated and reading near 70 Torr.

For users calibrating against a NIST calibrated standard, maximum accuracy for the MX4A can be achieved by adjusting the unit between 65 Torr and 75 Torr.

D. **Atmosphere**

To reach the atmosphere screen:

- Navigate to the calibration screen.
- Press DOWN three times.
- Press ENT to unlock the atmosphere adjustment screen.
- Press UP or DOWN to adjust the reading.
- When the desired reading is reached, press ENT to save and lock the change.

The atmosphere calibration point allows the gauge to adjust the pressure reading at atmosphere (760 Torr). This should be used only when the operator knows that the unit is exposed to atmosphere or is compared to a reference gauge that is NIST calibrated and reading near 760 Torr.

For users calibrating against a NIST calibrated standard, maximum accuracy for the MX4A can be achieved by adjusting the unit between 740 Torr and 780 Torr.

E. **Resolution High/Low**

To reach the resolution high/low screen:

- Navigate to the calibration screen.
- Press DOWN four times.
- Press ENT to unlock the resolution high/low screen.
- Press UP or DOWN to adjust the reading.
- When the desired reading is reached, press ENT to save and lock the change.

The resolution of the MX4A is set to low by default. Under this setting the resolution is determined by the accuracy of the gauge. The gauge will automatically adjust the resolution based on the pressure. The MX4A always displays four digits on the calibration screen. For operators who are looking for more resolution on the measurement screen, the MX4A can be set to high resolution and will display four digits on the measurement screen.

F. **Default**

To reach the default screen:

- Navigate to the calibration screen.
- Press DOWN five times.

- Press ENT twice to trigger a reset to the factory defaults.

The default screen resets all calibration point adjustments to the default values. This feature should only be used when necessary. Warning: RESTORING TO DEFAULT CALIBRATION SETTINGS VOIDS THE CALIBRATION!

G. Diagnostic

To reach the diagnostic screen:

- Navigate to the calibration screen.
- Press DOWN six times.

The diagnostic screen is used by Televac technicians when inspecting the MX4A for any problems. Under no circumstance does the operator need to access or consider this screen.

H. Analog Output Adjustment

To reach the analog output adjustment screen:

- Navigate to the calibration screen.
- Press DOWN seven times.
- Press ENT to unlock the analog output adjustment screen.
- Press UP or DOWN to adjust the reading.
- When the desired reading is reached, press ENT to save and lock the change.

The analog output accuracy for the MX4A agrees with the digital reading. However, in extreme temperatures or in significant humidity, the agreement may change slightly. For uses of the MX4A where the analog output accuracy is critical, an adjustment is available to ensure accuracy. When making this adjustment use a calibrated voltmeter to measure the analog output voltage when the MX4A is at a very stable pressure. Compare this voltage reading to the expected voltage. The expected voltage can be determined based on the formulae in the section of this manual entitled Analog Output.

I. Gas Type

The 4A sensor exhibits different sensitivities to different gases. The default gas is set to air. Air and dry nitrogen are approximated to have the same sensitivity and using either does not require any compensation. For users who wish to measure the pressure of Argon gas, the MX4A includes an Argon correction option.

To change the MX4A between air/nitrogen and argon modes:

- Navigate to the calibration screen.
- Press DOWN eight times.
- Press ENT to unlock the gas type screen.
- Press UP or DOWN to change between the gas modes.
- When the appropriate mode is selected, press ENT to save and lock the change.

Figure 3: Graph of MX4A Gas Dependence
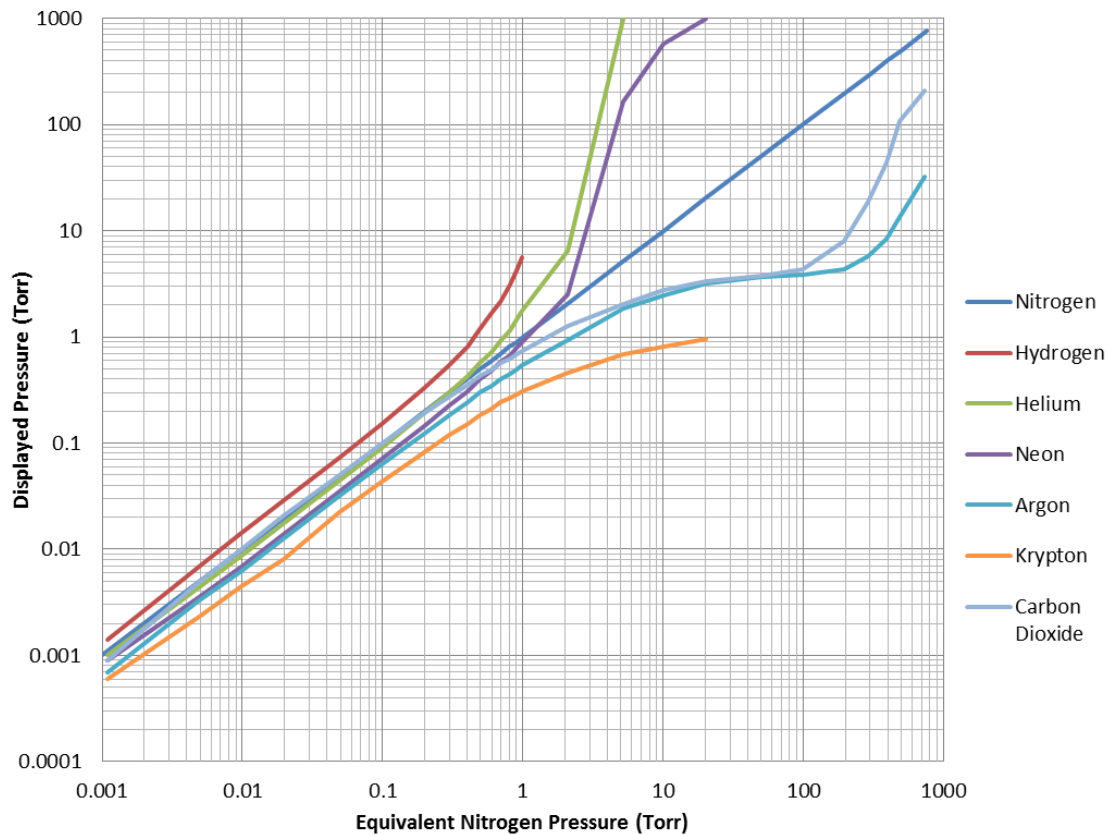
2.5.3 Set Points

To reach the set point screen:

- Navigate to the measurement screen.

- Press SEL two times.

- The set point screen contains set point 1 low.

- To access set point 1 high, set point 2 low, or set point 2 high, press DOWN from the initial set point screen.

- When the correct set point is selected, press ENT to unlock the set point adjustment screen.

- Press UP and DOWN to change the value.

- When the desired reading is reached, press ENT to save and lock the change.

The MX4A contains two set points for the convenience of the operator. Set point 1 is an N-Channel 60 V MOSFET open collector. It has a maximum current rating of 1 A. The data sheet can be found at www.vishay.com/docs/69958/si2308bd.pdf. Set point 2 is a relay with a maximum switching voltage of 220 V DC (250 V AC) and a maximum switching current of 2 A. The data sheet can be found at www.te.com/catalog/pn/en/1393788-3.

2.5.4 Units

To reach the units screen:

- Navigate to the measurement screen.
- Press SEL three times.
- Press ENT to unlock the units screen.
- Press UP and DOWN to navigate between units.
- When the desired unit is reached, press ENT to save and lock the change.

Depending on the process or the region, the desired units for the MX4A may vary. To accommodate this need, the MX4A includes a unit adjustment feature. The MX4A can be set to display the units in Torr, kPa, or mbar.

2.5.5   Output

To reach the output screen:

- Navigate to the measurement screen.
- Press SEL four times.
- Press UP and DOWN to navigate between the analog output and RS-485 panes.
- When the desired field is present, press ENT to enter the heading.

The MX4A features a number of analog outputs and RS-485 digital output and input.

A. Analog Output

To toggle the analog output type:

- Navigate to the analog output screen.
- Press ENT to unlock the screen.
- Press UP or DOWN to set the desired output type.
- When the desired analog output is reached, press ENT to save and lock the change.

The types of analog output are listed below. For more information on the types of output, please see the heading in this manual labeled Analog Output.

(a) Logarithmic
(b) Linear by Decade
(c) Non-linear
(d) Linear 4
(e) Linear 3
(f) Linear 2
(g) Linear 1

B. RS-485 I/O

To make changes under the RS-485 I/O screen:

- Navigate to the RS-485 I/O screen.
- Press UP or DOWN to reach the desired RS-485 setting.
- Press ENT to unlock the setting.
- Press UP or DOWN to change the fields.
- Press ENT to save and lock the change.

The RS-485 settable fields are listed below. Please see the sections labeled RS-485 Communications and Changing Communications Parameters for more details and a complete list of commands. Listed below are the fields within the RS-485 I/O screen.

   (a) Address
   (b) Baud Rate
   (c) Stop Bits
   (d) Parity

2.6 Analog Output

The MX4A provides the option for outputting the vacuum reading in an analog form. Operators who wish to use PLCs to monitor processes should find this function useful. There are seven different analog output formats to choose between. The formats include Logarithmic, Linear by Decade, Non-linear, Linear 4, Linear 3, Linear 2, and Linear 1.

A. **Logarithmic**

The Logarithmic output is the most useful and accurate output for covering the entire range of the 4A with an analog output. This format uses the formula below to convert the output voltage into a pressure measurement:

$$Pressure\,(Torr) = 10^{.6\times(Voltage-5)}$$

For example, a voltage reading of 3.075 Volts corresponds to pressure of .07 Torr.

$$10^{.6\times(3.075-5)} = .07\,Torr$$

B. **Linear by Decade**

The Linear by Decade output spans the entire range of the MX4A. It uses the units digit of the voltage reading to communicate the decade of the pressure reading and the units after the decimal to communicate the specific pressure using the very generalized expression below, where A, B, C, and D are digits ranging from 0-9:

$$Voltage = A.BCD \rightarrow Pressure(Torr) = 10^{A-6} \times .BCD$$

For example, a voltage reading of 8.367 Volts corresponds to a pressure of 36.7 Torr.

$$10^{8-6} \times .367 = 36.7\,Torr$$

C. **Non-linear**

The Non-linear option outputs the raw signal collected by the 4A sensor. The raw signal is converted to the pressure using a many-point linearization process done by the MX4A. This feature is used for diagnostic purposes.

D. **Linear 4**

The Linear 4 output is one of four linear outputs that cover a select range of the MX4A with a linear scale. The scale extends from .001 to 1 Torr, with each .010 Volt of the output corresponding to .001 Torr.

$$Pressure\,(Torr) = Voltage \times (.1)$$

E. **Linear 3**

The Linear 3 output is one of four linear outputs that cover a select range of the MX4A with a linear scale. The scale extends from .01 to 10 Torr, with each .010 Volt of the output corresponding to .01 Torr.

$$Pressure\,(Torr) = Voltage \times (1)$$

F. **Linear 2**

The Linear 2 output is one of four linear outputs that cover a select range of the MX4A with a linear scale. The scale extends from .1 to 100 Torr, with each .010 Volt of the output corresponding to .1 Torr

$$Pressure\,(Torr) = Voltage \times (10)$$

G. **Linear 1**

The Linear 1 output is one of four linear outputs that cover a select range of the MX4A with a linear scale. The scale extends from 1 to 1000 Torr, with each .010 Volt of the output corresponding to 1 Torr.
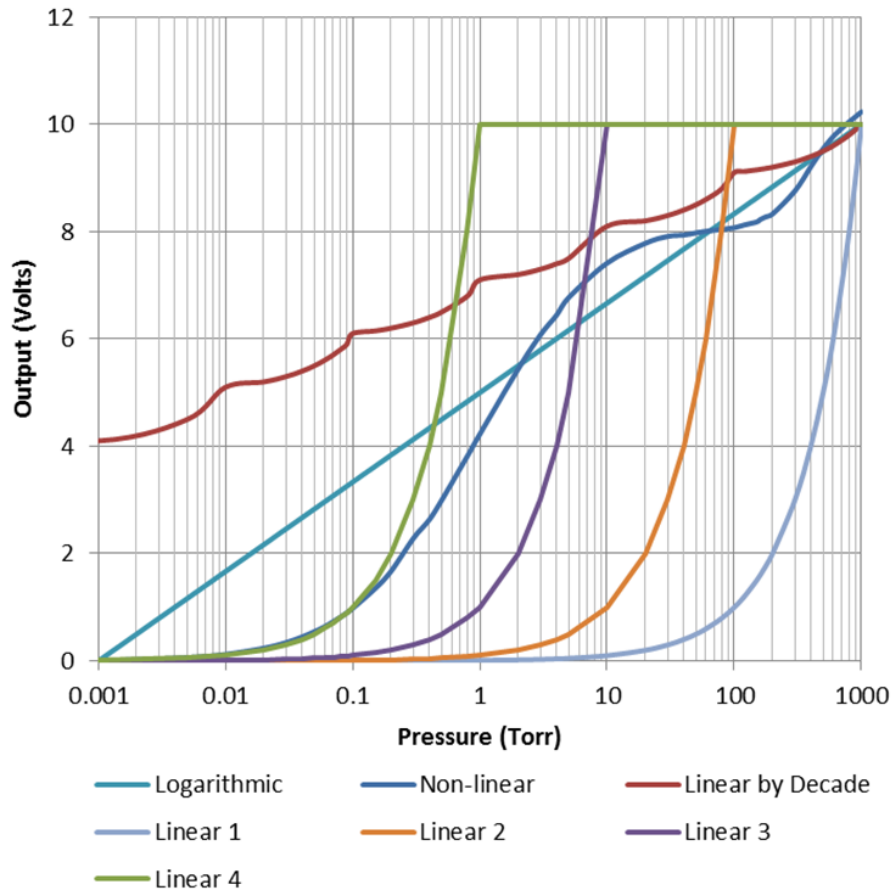
$$Pressure\,(Torr) = Voltage \times (100)$$

Figure 4: Graph of Analog Output Functions Available on the MX4A

3   RS-485 Communications

This gauge communicates with the host computer through an RS-485 interface. Each communication correspondence consists of a command line sent by the host computer and a response from the gauge.

To communicate with the MX4A via RS-485, the user must have an RS-485 capable device to send commands to the MX4A. Each command must be preceded by a * and will be an S, R, W, RC, or WC. See the Communications Specifications heading for information on what settings are necessary to properly communicate with the MX4A.

3.1   Changing Communications Settings

The communication parameters, (baud rate, address, etc.), are changed through the local menu. Please see the section in this manual entitled Explanation of Menu Items and Navigation for more information on navigating and editing within the menu. Below are provided some specifics on the RS-485 Communications of the MX4A.

3.2   Communications Specifications

Table 2: RS-485 Communication Specifications

Interface	RS-485 compatible
Data Transfer Method	Synchronous/half duplicate method
Baud Rate	1200/4800/9600/19200/38400
Default Data Format	1 start bit, 8 data bits, 0 parity bits, 1 stop bit
Error Detection	Parity bit
Parity Bit	None/even/odd
Stop Bit	1
Transfer Distance	Max 100 meters

3.3   RS-485 Command List

Table 3: RS-485 Commands

Command	Description
R1	Read units
R2	Read SP1L and SP1H
R3	Read SP2L and SP2H
W1	Set pressure units
W2	Set SP1L,SP1H
W3	Set SP2L,SP2H
W4	Set gas type
S1	Read pressure data
RC1	Read vacuum adjustment
RC2	Read 1 Torr adjustment
RC3	Read 70 Torr adjustment
RC4	Read atmosphere adjustment
WC1	Write vacuum adjustment
WC2	Write 1 Torr adjustment
WC3	Write 70 Torr adjustment
WC4	Write atmosphere adjustment

3.4   RS-485 Sample Commands

Table 4: RS-485 Command Examples

Command	Output	Description
*0R1<CR>	0001	Units are in Pa
	0002	Units in Torr
	0003	Units in mbar
*0R2<CR>	ppsePPSE	Lower set point 1 given by ppse
		Upper set point 1 given by PPSE
*0R3<CR>	ppsePPSE	Lower set point 2 given by ppse
		Upper set point 2 given by PPSE
*0W10001<CR>	0001	Units are in kPa
*0W10002<CR>	0002	Units are in Torr
*0W10003<CR>	0003	Units are in mbar
*0W2ppsePPSE<CR>	ppsePPSE	Assign set point 1 lower to ppse and
		Assign set point 1 upper to PPSE
*0W2ppsePPSE<CR>	ppsePPSE	Assign set point 2 lower to ppse and
		Assign set point 2 upper to PPSE
*0W4xx<CR>	GG	Change gas type: N2=Nitrogen/Air, AR=Argon
*0S1<CR>	ppse	Vacuum reading is ppse
*0RC1<CR>	Baaa	Read Vac. Adjustment
*0RC2<CR>	Baaa	Read 1 Torr Adjustment
*0RC3<CR>	Baaa	Read 70 Torr Adjustment
*0RC4<CR>	Baaa	Read Atm. Adjustment
*0WC1Baaa<CR>	PPSE	Vac. Adjustment is Baaa, reading is PPSE
*0WC2Baaa<CR>	PPSE	1 Torr Adjustment is Baaa, reading is PPSE
*0WC3Baaa<CR>	PPSE	70 Torr Adjustment is Baaa, reading is PPSE
*0WC4Baaa<CR>	PPSE	Atm. Adjustment is Baaa, reading is PPSE

Table 5: Understanding the Sample Commands: ppse, PPSE, and Baaa

Letters	Description
pp	Mantissa of pressure
s	Sign of exponent (0 is negative and 1 is positive)
e	Exponent of pressure
PP	Mantissa of pressure
S	Sign of exponent (0 is negative and 1 is positive)
E	Exponent of pressure
B	Sign of number (0 is negative and 1 is positive)
aaa	Number between 000 and 499

Table 6: Examples for ppse, PPSE, and Baaa

Letters	Description
ppse=2412	Pressure = 2.4×10^2
ppse=8703	Pressure = 8.7×10^{-3}
PPSE=3402	Pressure = 3.4×10^{-2}
PPSE=5211	Pressure = 5.2×10^1
Baaa=0249	Adjustment = -249
Baaa=1382	Adjustment = 382

3.5   RS-485 Error Codes

Table 7: Error Code Explanations

Error Code	Description
0N001	Command error (invalid character command or number after character)
0N002	Units error (invalid number received after "*0W1")
0N003	Set point value error (invalid or out of range number after "*0W2" or "*0W3")
0N004	Calibration value error (invalid or out of range number after "*0WC1", "*0WC2", "*0WC3", or "*0WC4")
0N005	Gas error (invalid characters after "*0W4")