MX2A Active Thermocouple 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 MX2A is a thermocouple vacuum gauge with a range of 1×10^{-4} Torr to 1000 Torr. It utilizes a Televac thermocouple vacuum sensor, part number 2-8910-0xx. 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 MX2A 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 three linear outputs, linear by decade, logarithmic, and non-linear.

1.3 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° to +50° C
Storage Temperature	-20° to +60° C
Bakeout Temperature	200° C (electronics removed)
Response Time	≤ 2 second
Accuracy	
1 to 10 mTorr	±1 mTorr
10 mTorr to 10 Torr	±10% of reading
10 to 100 Torr	±30% of reading (vertical operation only)
100 to 1000 Torr	±10% of reading (vertical operation only)
Analog Output	±5 mV
Resolution	
1 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
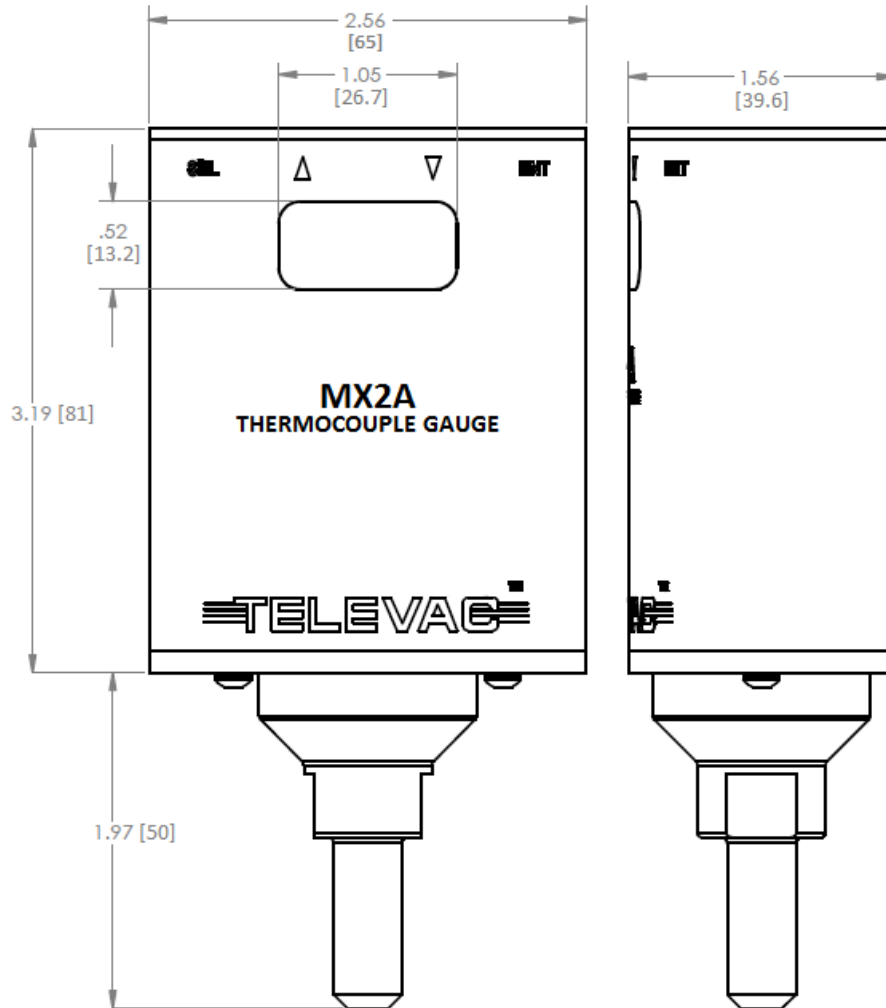
*Dimensions are drawn with 1/8" NPT fitting installed

1.5 Safety Information

START BY READING THESE IMPORTANT SAFETY INSTRUCTIONS AND NOTES

In these instructions the word "product" refers to the MX2A 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 on the second page of this manual.

This product has been designed and tested to offer reasonably safe service provided in it's

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.
√ ACCESORIES – Do not use accessories not recommended in this manual as they may require a technician to restore the product to its normal operation.

The MX2A 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 on 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.

The MX2A is not designed to be serviced by the operator. Any service should be done by a Televac technician. However, in the event of any attempt to service the unit, please remove the power supply to minimize the risk of harm.

The 2A sensor is user-replaceable and additional 2A sensors can be ordered from Televac by the operator. Do not attempt to use other sensors with the MX2A remote. Using another sensor may result in damage to the MX2A and voids any warranty in place.

2.1 Installation

Each MX2A is designed to be used in conjunction with a 2A sensor. The 2A sensor can be mounted in any orientation for accurate measurement up to 10 Torr. For measurements up to atmosphere, mount the 2A sensor in an **upright** position. The sensor should be mounted close to the area where vacuum measurement is desired. Failure to mount the 2A in a vertical position will decrease the accuracy of the measurement between 10 Torr and atmosphere, but will leave the accuracy below 10 Torr unaffected. Each 2A sensor has a key that only allows the MX2A to mate with the sensor in the proper orientation. Rotate the MX2A until the correct alignment is obtained and the MX2A is able to slide onto the 2A 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.
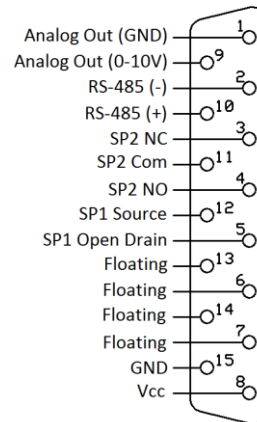
Try to avoid connecting the MX2A to the vacuum chamber by long or narrow piping as this may affect the accuracy and response time of the unit. Avoid mounting the unit near a heater within the chamber as this may affect the measurement accuracy. Excessive vibration of the unit may affect accuracy and 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 the use with the MX2A are available for purchase from Televac. Operators wishing to create their own adaptors should refer to the pin out of the MX2A below. Each connection labeled "Floating" has no connection and should remain so.

2.3 Electrical Connections

Pin	Description
1	Analog Out (Ground)
2	RS-485 (-)
3	SP2 NC
4	SP2 NO
5	SP1 Open Drain
6	Floating
7	Floating
8	Supply Voltage
9	Analog Out (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 MX2A contains many operator customizable features. Changing these features is possible through the menu or via RS485 communications. To navigate the menu simply use the buttons found on top of the MX2A. The four buttons include the SEL button, the UP arrow button, the DOWN arrow button, and the 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 value saving in addition to toggling between options in appropriate menus. 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

The complete menu structure for the MX2A can be found below.

1. Measurement
2. Calibration
   a. Vacuum
   b. Mid (10 Torr)
   c. Atmosphere
   d. Resolution High/Low
   e. Default
   f. Diagnostic
   g. Analog Output Adjustment
   h. 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 MX2A.

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. Calibration

To reach the Calibration screen:

      i.   Navigate to the Measurement screen.
     ii.   Press SEL once.
   iii.   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 MX2A includes a number of operator-configurable calibration points. While the MX2A 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: Calibration should be performed in the following order: Vacuum adjustment, Mid (10 Torr) adjustment, 760 Torr adjustment. Failing to calibrate in this order will result in inaccuracies.

a. Vacuum (Zero Torr)

To reach the Vacuum screen:

      i.   The Vacuum screen is the first pane of the Calibration screen.
     ii.   Press ENT to unlock the Vacuum screen.
   iii.   Press UP or DOWN to adjust the reading.
   iv.   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 MX2A measurement (preferably as low as 10^{-5} Torr), adjust the unit until it blinks between .0000 and .0001.

For user calibration against a NIST calibrated standard, maximum accuracy for the MX2A can be obtained by calibrating the MX2A to .0050 Torr instead of the normal .0000 Torr reading.

b. Mid (10 Torr)

To reach the 10 Torr adjustment screen:

      i.   Navigate to the Calibration screen.
     ii.   Press DOWN one time.
   iii.   Press ENT to unlock the 10 Torr adjustment screen.
   iv.   Press UP or DOWN to adjust the reading.
    v.   When the desired reading is reached, press ENT to save and lock the change.

The 10 Torr calibration point allows the gauge to adjust the pressure reading at 10 Torr. This should be used only when the operator knows that the unit is exposed is compared to a reference gauge that is NIST calibrated and reading near 10 Torr.

For users calibration against a NIST calibrated standard, maximum accuracy for the MX2A can be achieved by adjusting the unit between 8 Torr and 12 Torr.

c. Atmosphere (760 Torr)

To reach the Atmosphere screen:

     i.   Navigate to the Calibration screen.
     ii.   Press DOWN two times.
     iii.   Press ENT to unlock the Atmosphere screen.
     iv.   Press UP or DOWN to adjust the reading.
     v.   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 MX2A can be achieved by adjusting the unit between 740 Torr and 780 Torr.

d. Resolution High/Low

To reach the Resolution High/Low screen:

     i.   Navigate to the Calibration screen.
     ii.   Press DOWN three times.
     iii.   Press ENT to unlock the Resolution High/Low screen.
     iv.   Press UP or DOWN to change the resolution.
     v.   When the desired resolution is reached, press ENT to save and lock the change.

The Resolution of the MX2A is set to Low by default. Under this setting the resolution is determined based on the accuracy of the gauge and will automatically adjust the resolution based on the pressure. While the MX2A always displays four digits on the Calibration screen, for operators who are looking for more resolution on the measurement Screen, the MX2A can be set to High resolution and will display four digits on the Measurement screen.

e. Default

To reach the Default screen:

     i.   Navigate to the Calibration screen.
     ii.   Press DOWN four times.

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

The Default screen resets all calibration point adjustments to the default values. Warning: RESTORING TO DEFAULT SETTINGS VOIDS THE CALIBRATION!

f.   Diagnostic

To reach the Diagnostic screen:

i.   Navigate to the Calibration screen.
ii.   Press DOWN five times.

The Diagnostic screen is used by Televac technicians when inspecting the MX2A for any problems. Under no circumstance does the operator need to access or consider this screen.

g.   Analog Output Adjustment

The Analog Output Adjustment is accessible from the Calibration screen by pressing DOWN twice.

i.   Navigate to the Calibration screen.
ii.   Press DOWN six times.
iii.   Press ENT to unlock the Analog Output Adjustment screen.
iv.   Change in the calibration value by pressing UP or DOWN.
v.   When the desired reading is reached, press ENT to save and lock the change.

The analog output accuracy for the MX2A generally agrees with the digital reading exactly. However, in extreme temperatures or in significant humidity, the agreement may change somewhat. For uses of the MX2A 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 MX2A 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.

h.   Gas Type

The 2A thermocouple 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 MX2A includes an Argon correction option.

To change the MX2A between air/nitrogen and argon modes:

i.   Navigate to the Calibration screen.
ii.   Press DOWN seven time.
iii.   Press ENT to unlock the Gas Type screen

iv. Press UP or DOWN to change between the gas modes.
v. When the appropriate mode is selected, press ENT to save and lock the change.

Below is a chart of the response of the MX2A sensor to various gases when the gas type selected for the MX2A is "Air".

MX2A Gas Dependence
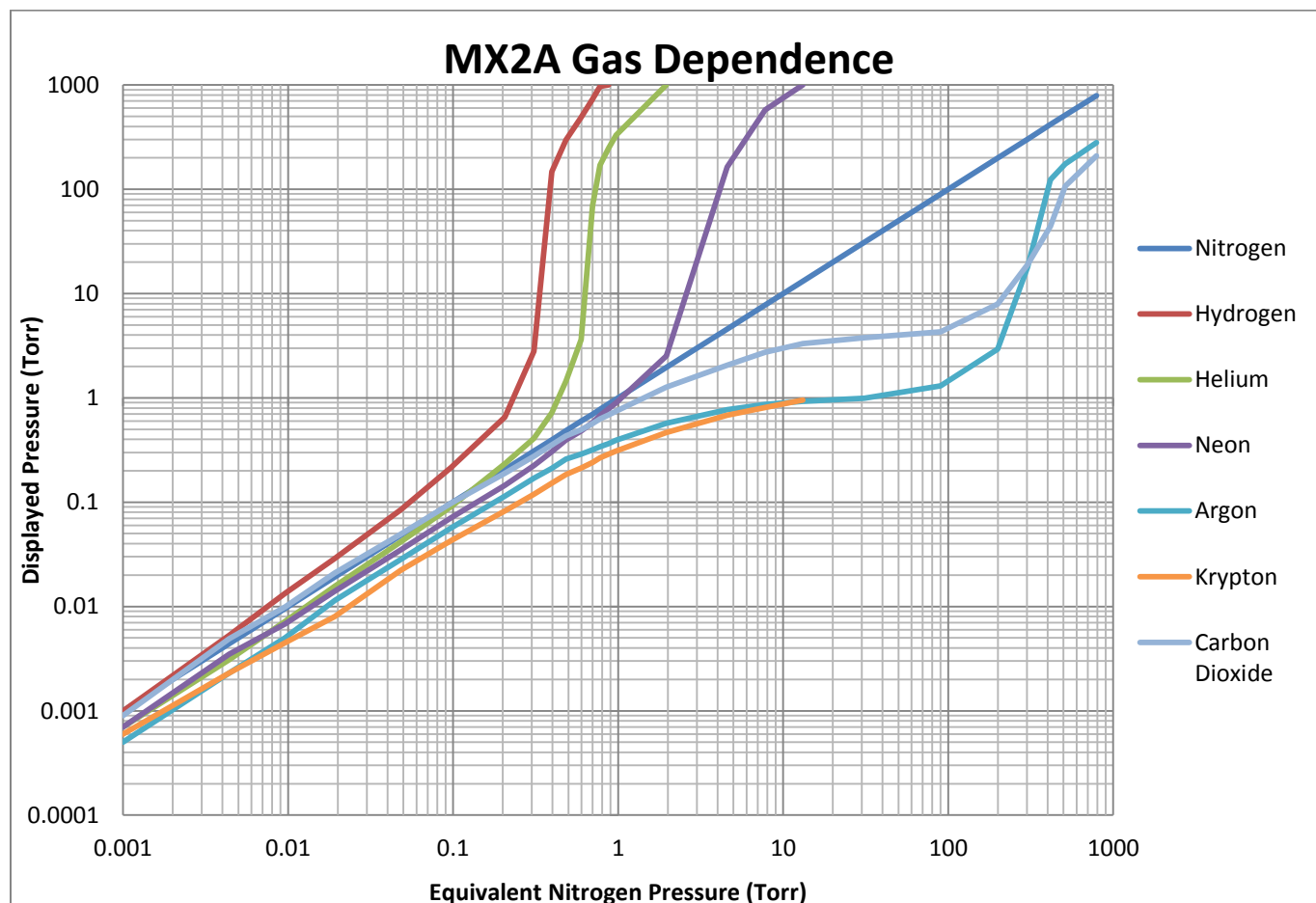
3. Set Points

The MX2A contains two set points for the convenience of the operator. The first set point controls an open collector. The second set point controls a relay. 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 http://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 2A. The data sheet can be found at http://www.te.com/catalog/pn/en/1393788-3.

To reach the Set Point screen:

i. Navigate to the Measurement screen.
ii. Press SEL two times.
iii. The Set Point screen contains Set Point 1 Low.
iv. To access Set Point 1 High, Set Point 2 Low, or Set Point 2 High, press DOWN from the initial Set Point screen.
v. When the correct set point is selected, press ENT to unlock the Set Point adjustment screen.
vi. Press UP and DOWN to change the value.
vii. When the desired reading is reached, press ENT to save and lock the change.

4. Units

To reach the Units screen:

i. Navigate to the Measurement screen.
ii. Press SEL three times.
iii. Press ENT to unlock the Units screen.
iv. Press UP and DOWN to navigate between units.
v. 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 MX2A may vary. To accommodate this need, the MX2A includes a unit adjustment feature. The MX2A can be set to display the units in Torr, kPa, or mbar.

5. Output

To reach the Output screen:

    i.   Navigate to the Measurement screen.
    ii.   Press SEL four times.
    iii.   Press UP and DOWN to navigate between the Analog Output and RS-485 panes.
    iv.   When the desired field is present, press ENT to enter the heading.

The MX2A features a number of analog outputs and RS-485 digital output and input.

a. Analog Output

To toggle the Analog Output:

    i.   Navigate to the Analog Output screen.
    ii.   Press ENT to unlock the screen.
    iii.   Press UP or DOWN to set the desired output type.
    iv.   When the desired analog out 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.

    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

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

    i.   Navigate to the RS-485 I/O screen.
    ii.   Press UP or DOWN to reach the desired RS-485 setting.
    iii.   Press ENT to unlock the setting.
    iv.   Press UP or DOWN to change the fields.
    v.   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 with the RS-485 I/O screen.

    i.   Address
   ii.   Baud Rate
  iii.   Stop Bits
  iv.   Parity

2.6 Analog Output

The MX2A 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 from which to choose. The formats include Logarithmic, Linear by decade, Non-linear, Linear 4, Linear 3, Linear 2, and Linear 1.

1. **Logarithmic**: The Logarithmic output is the most useful and accurate output for covering the entire range of the 2A 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.

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

2. **Linear by Decade**: The Linear by decade output spans the entire range of the MX2A. 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.

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

3. **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 MX2A. This feature is used for diagnostic purposes.

4. **Linear 4**: The Linear 4 output is one of four linear outputs that cover a select range of the MX2A with a linear scale. The scale extends from .001 to 1 Torr, with each .001 Volt of the output corresponding to .001 Torr.

5. **Linear 3**: The Linear 3 output is one of four linear outputs that cover a select range of the MX2A with a linear scale. The scale extends from .01 to 10 Torr, with each .001 Volt of the output corresponding to .01 Torr.

6. **Linear 2**: The Linear 2 output is one of four linear outputs that cover a select range of the MX2A with a linear scale. The scale extends from .1 to 100 Torr, with each .001 Volt of the output corresponding to .1 Torr.

7. **Linear 1**: The Linear 1 output is one of four linear outputs that cover a select range of the MX2A with a linear scale. The scale extends from .1 to 1000 Torr, with each .001 Volt of the output corresponding to .1 Torr.

Graph of Analog Output Functions Available on the MX2A
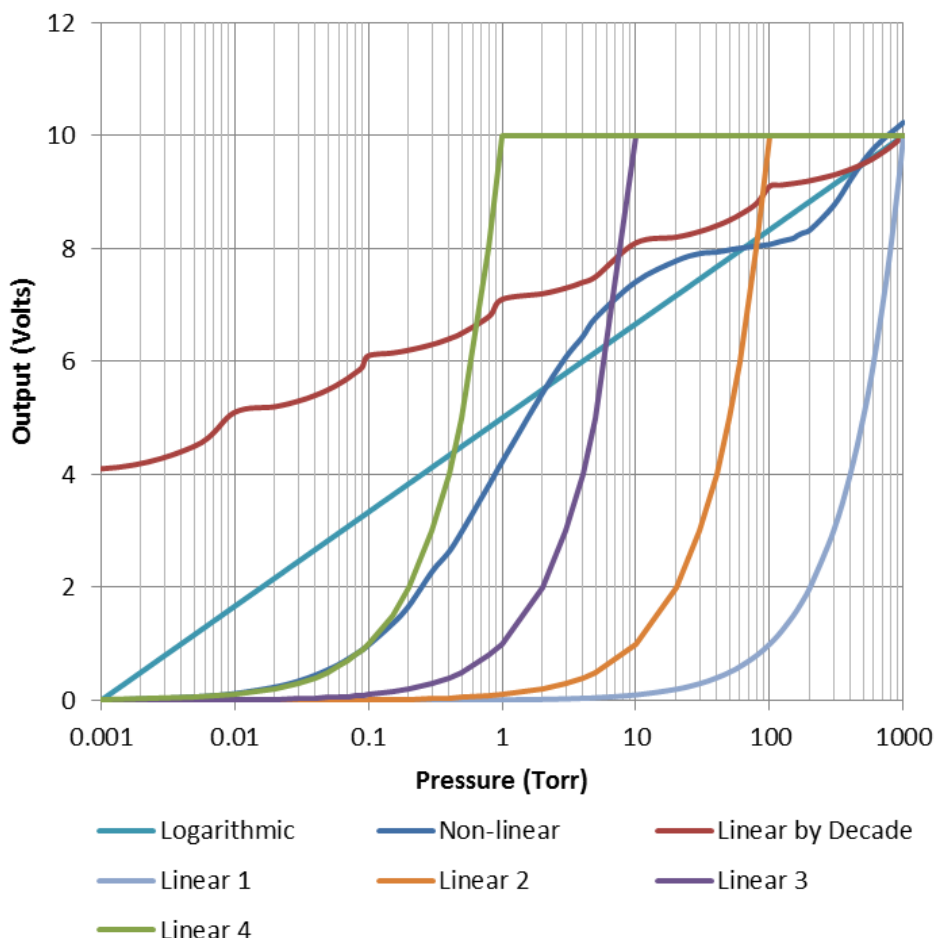
RS-485 Communications

The MX2A communicates with the host computer through an RS-485 interface. Each communication correspondence consists of a command sent by the host computer and a response from the gauge.

To communicate with the MX2A via RS-485, the user must have an RS-485 capable device to send commands to the MX2A. 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 MX2A.

3.1 Changing Communication Parameters

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 MX2A.

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

3.3 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
S1	Read Pressure Data
RC1	Read Vac. Adjustment
RC2	Read 10 Torr Adjustment
RC3	Read Atm. Adjustment
WC1	Write Vac. Adjustment
WC2	Write 10 Torr Adjustment
WC3	Write Atm. Adjustment

3.4 Sample RS-485 Commands (assume address 0)		
Command	**Sample 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
*0W3ppsePPSE<CR>	ppsePPSE	Assign set point 2 lower to ppse and
		Assign set point 2 upper to PPSE
*0S1<CR>	ppse	Vacuum reading is ppse
*0RC1<CR>	Baaa	Read Vac. Adjustment
*0RC2<CR>	Baaa	Read 10 Torr Adjustment
*0RC3<CR>	Baaa	Read Atm. Adjustment
*0WC1Baaa<CR>	PPSE	Vac. Adjustment is Baaa, reading is PPSE
*0WC2Baaa<CR>	PPSE	10 Torr Adjustment is Baaa, reading is PPSE
*0WC3Baaa<CR>	PPSE	Atm. Adjustment is Baaa, reading is PPSE

Understanding ppse, PPSE, and Baaa: Both ppse and PPSE are simply generic pressure readings in whichever units are selected	
Letters	**Description**
pp	Mantissa of a pressure
s	Sign of exponent (0 is negative and 1 is positive)
e	Exponent of pressure
PP	Mantissa of a pressure
S	Sign of exponent (0 is negative and 1 is positive)
E	Exponent of pressure
B	Sign of exponent (0 is negative and 1 is positive)
aaa	Number between 000 and 499

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 Error Code Explanations	
0N0001	Command error (invalid character command or number after character)
0N0002	Units error (invalid number received after "*0W1")
0N0003	Set point value error (invalid or out of range number after "*0W2" or "*0W3")
0N0004	Calibration value error (invalid or out of range number after "*0WC1", "*0WC2", "*0WC3", or "*0WC4")
0N0005	Gas error (invalid characters after "*0W4")