PPT ANALOG PRESSURE SENSING

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Honeywell's Precision Pressure Transducer (PPT) is truly a smart sensor device but it can also be used to replace conventional analog pressure sensors straight from the box. A benefit of using the PPT in the analog mode is that there is no need for offset or span adjustments to achieve accuracy better than 0.05% across a 40 to 85°C (-40 to 185°F) temperature range. Even though there is capability for the user to configure an mx+b null and span correction in the PPT, the stability of less than 0.025% drift/year minimizes calibration concerns. Every PPT unit has both digital and analog outputs and is individually calibrated at the factory for temperature variations throughout the full scale (FS) pressure range. This application note describes the analog features for PPT version 2.0 and above. Consult the User's Manual to determine the PPT version number.

When you receive a PPT from Honeywell, it is ready to output a calibrated analog voltage when power and a pressure line are connected. The voltage can be measured using a digital voltmeter (DVM) or an analog meter. For example, a 20 psi (pounds per square inch) unit straight from the factory will have the following characteristics:

Pressure range	0 to 20 psi
Pressure resolution	0.005 psi
Analog output range	0 to 5 Volt
Analog resolution	1.22 mV
Accuracy (-45 to 85°C)	0.05 %FS

The positive power supply is connected to pin 5 of the PPT with supply ground connected to pin 4. The analog output is pin 6. A single point ground is recommended for analog output sensing to reduce noise. That is, the device measuring the analog output (DVM) should have its ground reference point (- terminal) connected directly at the PPT signal common point (pin 4). In addition, the supply voltage ground connection must also be connected directly at the PPT signal common (pin 4). This is discussed in more detail in a separate application note.

For the setup shown in Fig. 1, an input pressure of 16.75 psi will drive 4.187 volts on the Analog Output (Aout) pin. This voltage is determined by:

Aout = input pressure x Aout span ÷ FS pressure

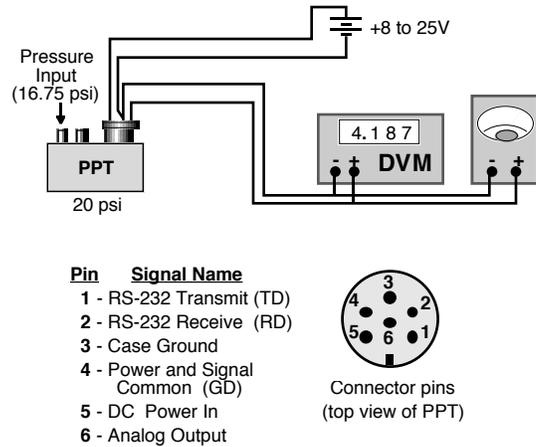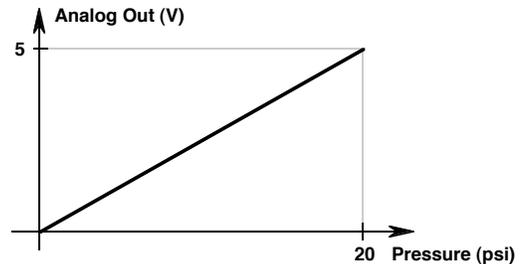Aout = 16.75psi x 5V ÷ 20psi = 4.187V

Figure 1. Connection for Analog Output Mode

The output characteristics, shown in Fig. 2, are linear across the full scale pressure range with a zero volt output corresponding to 0 psi and a five volt output for 20 psi. This curve represents the factory set output characteristics.

(accuracy = 0.05 %FS, resolution = 0.005 psi)

Figure 2. Default Output Voltage vs. Pressure

Most of the measurement parameters and output characteristics of the PPT are user configurable. Any unit can be easily customized to specific applications using command sequences in the digital operating mode. An overview of the PPT user command functions are listed in the Appendix of this application note. Refer to the PPT User's Manual for a complete command listing. It is this feature of the PPT that makes it a unique, low cost, high accuracy pressure sensing instrument. With proper setup, the PPT can replace standard analog pressure sensing devices. Several example below show how to configure the analog output characteristics.

CUSTOM ANALOG VOLTAGE CONTROL

If the analog meter, or programmable logic controller (PLC), has a low level input limit of 1 volt and a high level input of 4.85 volt (instead of 0 and 5 volts), the PPT can be easily configured to accommodate this. The lower and higher limit can be set to any value between 0 to 5 volts in 50 millivolt increments. To do this requires using the PPT digital connections and a computer. Connect the three pins of the PPT to the COM port of a computer using a DB-9 pin or DB-25 pin connector. The transmit (TD), receive (RD) and ground (GD) pins of the PPT are connected as shown in Fig. 3.
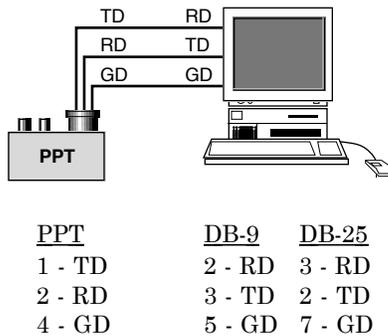

PPT	DB-9	DB-25
1 - TD	2 - RD	3 - RD
2 - RD	3 - TD	2 - TD
4 - GD	5 - GD	7 - GD

Figure 3. Connections for Digital Command Mode

By using a terminal emulation program (any program that talks to a modem) the PPT can be user-configured to a new zero pressure output voltage. The PPT default communications settings are 9600 baud, 8 data bits, no parity, 1 stop bit. These same settings must be selected in the terminal program in order to communicate with the PPT.

When power is applied to the PPT, it will auto-matically transmit a startup message that describes the PPT range and type. When everything is ready, type in the following command and look for a response. This will insure that the communications between the computer and the PPT are working properly. The <cr> symbol means press the ENTER or RETURN key.
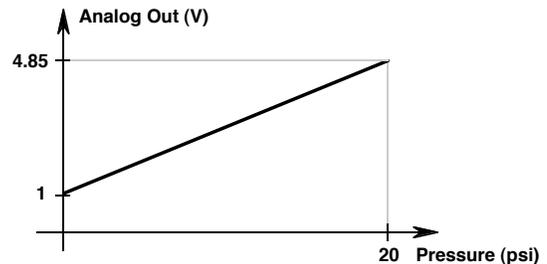
Type in:	*99S=<cr>
PPT response:	?01S=00052036

This command requests the PPT's factory serial number and will be different from the number shown here. If a response is received similar to this then the PPT is communicating properly with the computer. If not, then consult the PPT User's Manual for correct setup and settings.

To configure a new zero pressure output voltage of 1 volt, and full scale output of 4.85 volts, enter the following commands:

Input	Comment
*00WE=RAM<cr>	Write enable for all changes
*00L=20<cr>	Set low limit to 1.00V
*00H=97<cr>	Set high limit to 4.85V
*00DA=ON<cr>	Turn the analog output on
*00AN=ON<cr>	Turn user voltage limits on
*00WE<cr>	WE for Store to EEPROM
*00SP=ALL<cr>	Store change in EEPROM

Now the PPT will drive the output voltage to 1 volt when a 0 psi pressure is present, see Fig. 4. The analog out voltage will be 1.00 to 4.85 volts for a 0 to 20 psi pressure input. This change will be available from now on whenever the PPT power is applied.
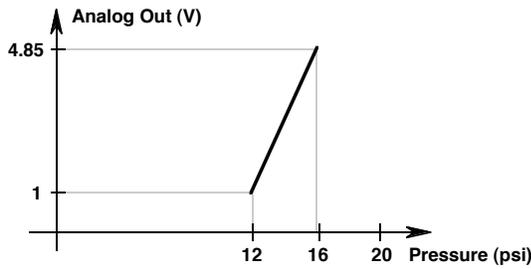

(accuracy = 0.05%FS, resolution = 0.005 psi)

Figure 4. Custom Output Voltage vs. Pressure

CUSTOM PRESSURE RANGE LIMITS

What if the pressure range of interest is only in the 12 to 16 psi span. Using a pressure sensor that is capable of measuring 0 to 20 psi means that 80% of the full scale range is not going to be used. By using the smart features of the PPT, a 20 psi unit can be configured to select an operating pressure window that becomes full scale range. That is, a window pressure range of 12 to 16 psi will output the lowest analog voltage for a 12 psi pressure and the highest analog voltage for a 16 psi pressure. This can be easily configured in the digital mode by using the pressure Window (W=) and Offset (O=) commands.

Input	Comment
*00WE=RAM<cr>	Write enable for all changes
*00O=60<cr>	Starting pressure at 60 %FS
*00W=20<cr>	Pressure window at 20 %FS
*00WE<cr>	WE for Store to EEPROM
*00SP=ALL<cr>	Store change in EEPROM

From the previous example and the changes above, a pressure input of 12 psi will output 1.00 volt and a pressure of 16 psi will output 4.85 volts, see Fig. 5.

(accuracy = 0.05 %FS, resolution = 0.001 psi)

Figure 5. Custom Output Voltage vs. Pressure

Expanding the pressure range this way increases the output resolution to 0.001 psi (by maintaining 12 bit output levels) with absolutely no loss of the 0.05 %FS accuracy across temperature. The FS, in this case, refers to the original 20 psi range

USER COMPENSATION CONTROL

The user can adjust the pressure curve gain and offset parameters using the **X=**, **Y=**, and **Z=** commands. The **X=** command adjusts the slope of the pressure output curve for positive pressures. This applies to all absolute and gauge devices and modifies the positive full scale slope of differential PPTs. The **Y=** command adjusts the negative full scale slope of differential PPTs. The **Z=** command adjusts the offset of the pressure output curve. This applies to all absolute, gauge, and differential PPTs. The range of adjustment for all these commands is ±0.3%FS in 0.005% increments.

The purpose of these commands is to allow the user to fine tune the compensation for the pressure values specific to an application. This adjustment is made after the PPT automatically temperature compensates the pressure reading according to the factory calibration. The user supplied values (**X=**, **Y=**, **Z=**) are used as an mx+b correction. The X= and Y= command supplies the slope adjustment, or 'm', value and the **Z=** command supplies the offset adjustment, or 'b', value. Figures 6 and 7 illustrate the effects of these commands.
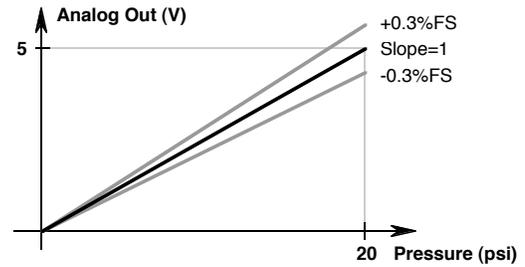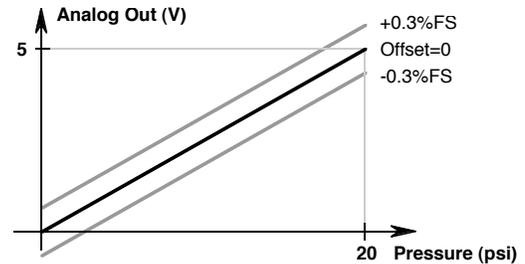

Figure 6. Custom Slope (X=) Options

Figure 7 Custom Offset (Y=) Options

REMOTE ANALOG SENSING

What if a strip chart recorder, or other analog input device, is being used to monitor a pressure point in a remote location. Either the pressure source must be piped to the sensor or the analog output signal must have a long interconnect distance to the recorder. The first alternative presents obvious technical difficulties and cost implementations. For the second alternative, the analog pressure signal between the sensor and recorder will be subjected to electrical noise, line interference and connector electrical losses. The pressure signal would require shielding, single point ground connections and line filtering. One solution to eliminate the effects of line losses and noise sources would be to transmit the pressure information digitally to the strip chart recorder using PPT1 (see Fig. 8). Then, near the recorder, convert the signal back to an analog form using PPT2.
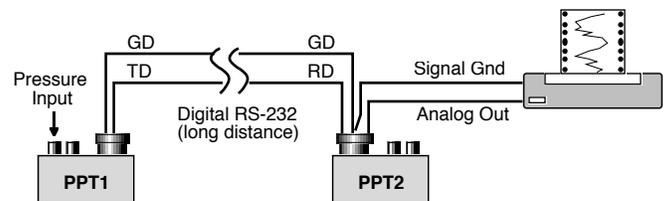

Figure 8 Sensing Remote Analog Pressure

This can easily be accomplished using two PPT units, one at the pressure point and one by the chart recorder. A two wire digital interface would transmit PPT1 pressure information to the PPT2 recorder point. The digital RS-232 line is more tolerant of noisy environments and connector losses. Commercially available RS-232 drivers and repeaters are available to extend the distance between the two PPT units, up to several miles if necessary. The PPT2 unit can be placed close to the chart recorder with very little, if any, noise on the analog output. When the RS-232 baud rate is set to 28,800 baud, the reading delay imposed by the digital transmission is 2 msec. The benefit of using two PPTs this way is that it is quick and easy to implement and that no software development is required. Using this technique, the RS-232 connections can be configured as a single two-wire bus that accommodates up to nine pairs of PPT units simultaneously sensing remote pressures.

The PPT units should be configured as follows so that they will begin recording when power is applied.

Input	Comment
(commands for PPT1)	
*00WE=RAM<cr>	Write enable for all changes
*00ID=01<cr>	Set device ID to 1
*01ID=91<cr>	Set group ID to 91
*01DA=U<cr>	Pressure to digital send mode
*01MO=P4<cr>	Power-up binary send mode
*01WE<cr>	Enable EEPROM write
*01SP=ALL<cr>	Store settings to EEPROM
(commands for PPT2)	
*00WE=RAM<cr>	Write enable for all changes
*00ID=02<cr>	Set device ID to 2
*02ID=91<cr>	Set group ID to 91
*02DA=R<cr>	Digital in to analog out mode
*02NE=DAC<cr>	Enable write to DAC
*02WE<cr>	Enable EEPROM write
*02SP=ALL<cr>	Store settings to EEPROM

To connect additional PPT pairs to the RS-232 bus, configure each pair with a unique group number. Nine groups are available from number 90 trough 98.

LIMIT SET TO TRIP ALARM

The PPT can be configured to monitor a pressure point and independently trigger an alarm if the pressure exceeds, or drops below, a predetermined set point. In this mode there is no need for a control processor interface, and the PPT and alarm can operate from a battery. Figure 9 illustrates the trip point setting for a stand-alone setup (Figure 10). In this setup, the single point ground connection is not important because the analog out signal does not convey the precision pressure information. It is used as a digital logic level to activate the alarm and switches from 0 to 5 volts.
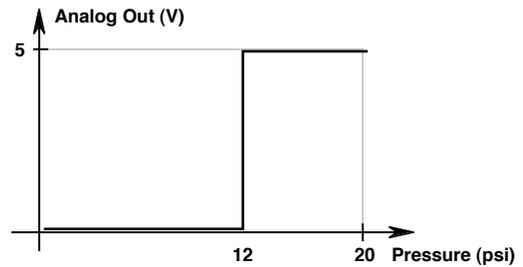

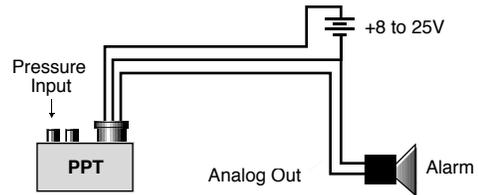*Figure 9. Pressure Trip Point Setting*

Figure 10. Pressure Limit Activated Alarm

The PPT must first be configured in the digital mode to determine the pressure set point. If a PPT is configured for a full scale reading of 40 inches of mercury (inHg), and an alarm condition is desired for pressures of 30 inHg and above, then type in the following commands in the digital command mode.

Input	Comment
*00WE=RAM<cr>	Write enable for all changes
*00DU=INHG<cr>	Set units to in. Hg
*00H=75<cr>	Set alarm to 30 inHg (75%FS)
*00L= 75<cr>	Set alarm to 30 inHg (75%FS)
*00WE<cr>	Enable EEPROM write
*00SP=ALL<cr>	Store settings to EEPROM

The analog output signal will drive from zero to five volts when the input pressure rises to 30 inHg. The signal will drop to zero volts when the pressure drops below 30 inHg. The analog output pin is capable of driving a 10 KΩ load to 4.8 volts.
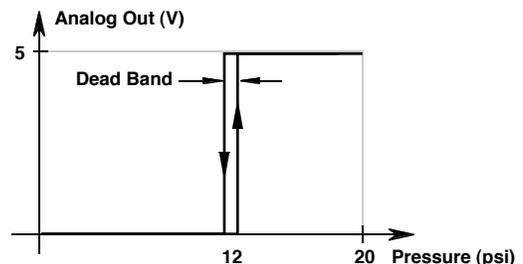

Figure 11. Trip Point with Dead Band

The PPT can be configured to transmit pressure in the digital mode and receive analog values, for the DAC output, to drive a voltage independent of pressure (see Figure 12). When operating in this mode (**DA=D** or **N**), the PPT will continue to provide calibrated pressure readings through the digital serial bus. In addition, the control processor can control the analog output voltage from the PPT independent of the pressure readings. This capability allows a single PPT unit to operate in a closed loop mode for systems requiring valve control.
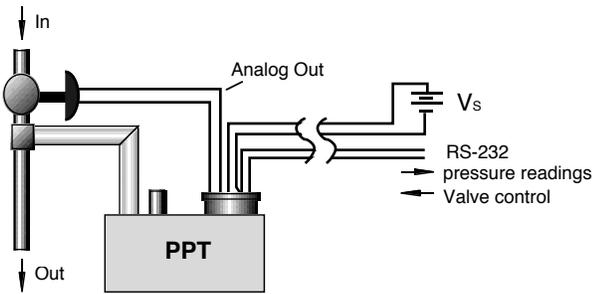
Figure 12. Digital Pressure and Analog Valve Control

To configure the PPT to both read digital pressures and independently drive an analog voltage, enter the following commands:

Input	Comment
*00WE=RAM<cr>	Write enable for all changes
*00DU=INHG<cr>	Set units to in. Hg
*00H=75<cr>	Set alarm to 30 inHg (75%FS)
*00L= 75<cr>	Set alarm to 30 inHg (75%FS)
*00WE<cr>	Enable EEPROM write
*00SP=ALL<cr>	Store settings to EEPROM

APPENDIX: COMMAND FUNCTIONS

A key benefit of using Honeywell's PPT is the user configurations for both the digital and analog outputs. Here is a list of several command actions:

- Set high and low analog output full scale limits
- Turn-down FS range by as much as 30:1
- Control analog output voltage from RS-232 pins
- Integration times (filter) of 10 msec to 12.5 sec
- Store a message of up to 32 characters
- Unit diagnostics and over/under range flags
- Eleven pressure units accurate to 5 digits
- Set tare limit as a %FS or at the current reading
- Read sensor temperature in °C or °F
- Output pressure in ASCII or binary format
- Connect up to 89 units on a 2 wire RS-232 bus
- Define up to 9 groups for common broadcast