

# ANALOG GROUNDING CONSIDERATIONS

AN-103

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This application note discusses grounding considerations when connecting the analog output on Honeywell's Precision Pressure Transducer (PPT) family. This family includes both the PPT and PPT-R type devices.

The PPT family offer high accuracy smart pressure sensing with network capability at an affordable price. Pressure output is available as a RS-232 (or RS-485) digital value as well as a 0-5 volt analog voltage. A benefit of using the PPT analog output is that there is no need for offset or span adjustments to achieve an accuracy of 0.12% full scale (FS) typical across a -40 to 85°C (-40 to 185°F) temperature range.

## ANALOG GROUNDING PROBLEMS

A concern for any analog output is the amount of noise, or unwanted signal, present at the point to be measured. This is a concern for the PPT since a microprocessor, and other logic devices, are used internally to compensate the pressure readings. These internal circuits create switching noise that could end up on the analog output signal if care is not taken to properly ground connection points. Consider the example shown in Figure 1 below. Here, a power supply (Vs) and load resistor (RL) are connected some distance away from a PPT. The Analog Out signal from the PPT is connected to the load resistor and is

referenced to the ground terminal of the power supply. The Analog Out signal is generated by the internal digital to analog converter (DAC). The voltage VDAC (pin 6) represents the compensated pressure value being read. This voltage creates the desired pressure voltage VOUT that is measured across load RL.

The PPT uses an internal microprocessor and other logic circuits to sample and compensate pressure readings for both digital and analog output values. These circuits generate noisy digital switching currents in IPPT that flows from Ground (pin 4) back to Vs. The ground supply cable resistance, RW3, will cause a voltage drop between pin 4 and Vs.

The Analog Out voltage (VDAC) is driven from the PPT (pin 6) and is dropped across the load resistor RL. Due to wire resistance, RW2 and RW3, some of the VDAC voltage is lost. But more significant than this loss is the noise voltage added to VOUT due to IPPT and RW3. Using Kirchoff's voltage law, the voltages around the RL loop must sum to zero. This results in an equation for the output voltage, VOUT, as:

$$V_{OUT} = V_{DAC} - I_L \cdot R_{W2} + I_{PPT} \cdot R_{W3}$$

The concern here is that VOUT has a component IPPT that contains all the digital switching noise of the PPT. This concern can be greatly reduced, or eliminated, by using the single point ground connection.

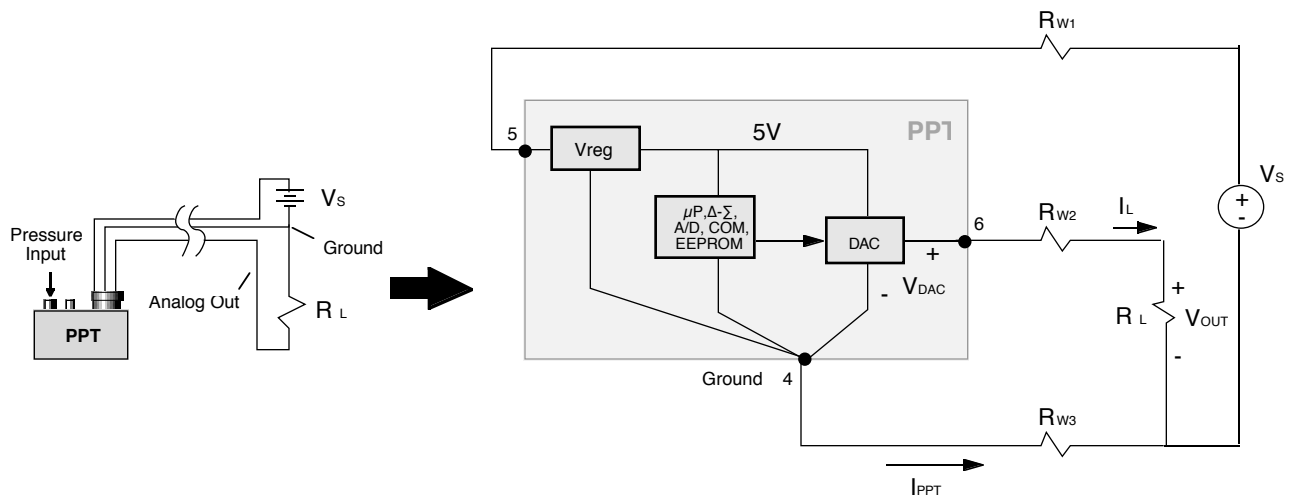


Figure 1 - Incorrect method of analog grounding

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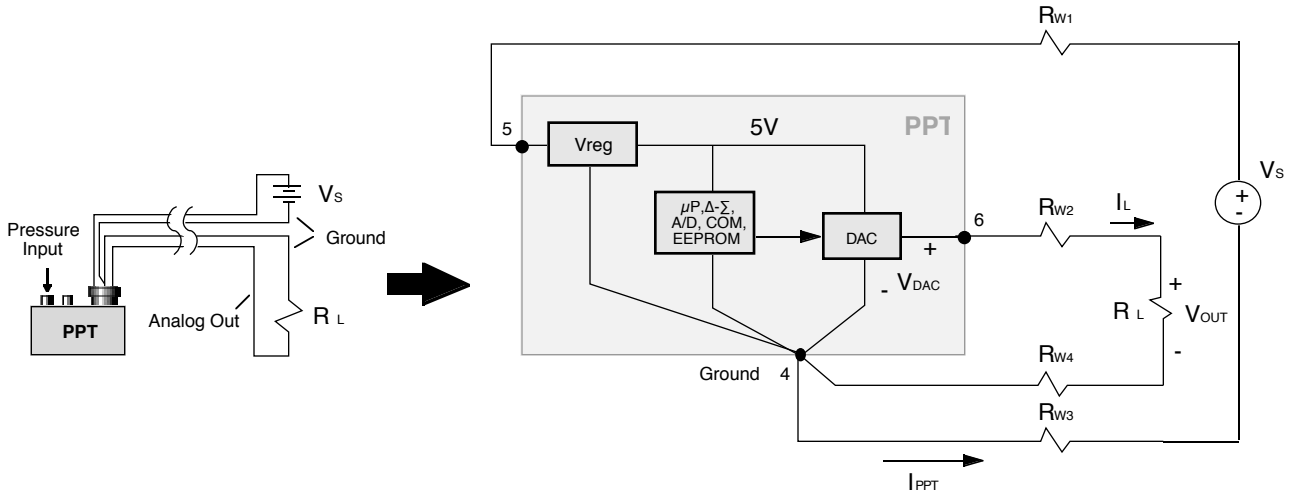


Figure 2 - Proper analog grounding using a single point connection

## CORRECT ANALOG GROUNDING

Using a single point connection at the PPT Ground (pin 4) terminal eliminates the effect of the  $I_{PPT}$  digital switching noise. The disadvantage of this is a duplicate wire must be run from the PPT to the load resistance  $R_L$  (see Figure 2). The benefit is that the equation for  $V_{OUT}$  does not include the  $I_{PPT}$  term:

$$V_{OUT} = V_{DAC} - I_L \cdot R_{W2} - I_L \cdot R_{W4}$$

The equivalent circuit using a single point ground is also shown in Figure 2 above. The pressure signal from the PPT is output on pin 6 as  $V_{DAC}$ . This signal now appears across the load  $R_L$  without any switching noise component from current  $I_{PPT}$ . This technique is strongly recommended for transmitting the analog pressure output from the PPT.

## ANALOG GROUNDING EXAMPLE

To demonstrate the effects of analog grounding on the output voltage an example is presented here with typical conditions. Assume the following values for the circuits shown in Figure 1 and Figure 2.

$$\begin{aligned} R_{WIRE} &= R_{W1} = R_{W2} = R_{W3} = R_{W4} = 1\Omega \\ R_L &= 20K\Omega \\ I_{PPT} &= 11\text{ mA} \\ V_{DAC} &= 0 - 5\text{ volt output} \quad (1.22\text{mV resolution}) \end{aligned}$$

The worst case grounding considerations will result when  $I_L$  is at its maximum value. Since the  $V_{DAC}$  output can vary from zero to five volts, then  $I_L(\text{max})$  is:

$$\begin{aligned} I_L(\text{max}) &= V_{DAC}(\text{max}) / (R_L + R_W) \\ &= 5V / 20,002\Omega \quad (R_L + 2R_W = 20,002) \\ &= 250\mu A \end{aligned}$$

Poor analog grounding: (Fig. 1)

$$\begin{aligned} V_{OUT} &= V_{DAC} - I_L \cdot R_{W2} + I_{PPT} \cdot R_{W3} \\ &= V_{DAC} - 250\mu A \cdot 1\Omega + 11\text{mA} \cdot 1\Omega \\ &= V_{DAC} - 10.75\text{mV} \end{aligned}$$

Good analog grounding: (Fig. 2)

$$\begin{aligned} V_{OUT} &= V_{DAC} - I_L \cdot R_{W2} - I_L \cdot R_{W4} \\ &= V_{DAC} - 250\mu A \cdot 1\Omega - 250\mu A \cdot 1\Omega \\ &= V_{DAC} - 0.5\text{mV} \end{aligned}$$

The ideal condition is  $V_{OUT} = V_{DAC}$ . Note that for the poor grounding situation, the DAC output voltage is reduced by 10.75mV. That is an error over 8 times the DAC output resolution of 1.22mV. Furthermore, any variation of  $I_{PPT}$  will cause a direct noise level on  $V_{OUT}$ . For the good analog grounding case, the  $V_{OUT}$  error is only 0.5mV. This is less than one-half the DAC output resolution and there is no  $I_{PPT}$  component

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