Signals with Zero Offsets

Introduction

Many transducer outputs exhibit a dc offset voltage when the output level would normally be expected to be zero Volts (corresponding to a display reading of "000"). As an example, consider a pressure transducer whose output levels of 1.0Vdc to 6.0Vdc are required to produce display readings of "000" to "400" respectively. To obtain the desired readings, the 1-6V signal has to be attenuated first, and then its 1V offset voltage must be subtracted or nulled to zero.

Attenuating the Input

The resistor divider shown in Figure 1 easily accomplishes the task of reducing the raw input signal (V_{IN}) down to a level which a ±2V-input meter (DMS-30PC-1-RS for example) can accept. However, the attenuated signal (Vatten) at pin 11 ((+) INPUT HI) still has a dc offset which has to be nulled. The following procedure can be used with many other input-voltage/display-reading combinations. Two completely worked-out examples will be provided.

The DMS-EB Application Board for DMS-30 Series meters has locations for installing the required user-supplied components shown in Figures 1 and 2. For large OEM requirements, Murata Power Solutions can provide a completely wired and tested meter to suit your particular requirements. Please consult our sales or marketing engineers for more information.

Example 1. A 1-6V input signal must be conditioned to display "000" to "400".

Step 1. Find the differential input voltage V_{IN} (diff):

V_{IN} (diff) = V_{IN} (max) - V_{IN} (min)

Where V_{IN} is the raw input voltage (1V to 6V) and V_{IN} (diff) is the differential raw input voltage. In this example, V_{IN} (max) = 6V and V_{IN} (min) = 1V. The result is as follows:

V_{IN} (diff) = 6V-1V = 5V

Step 2. Use the required display readings for V_{IN} (min) and V_{IN} (max) to find Vatten(diff):

In this example, when V_{IN} (min) = 1V, the display must read "000", and when V_{IN} (max) = 6V, the display must read "400". The following equation defines Vatten(diff):

Vatten(diff) = Vatten(diffhi) - Vatten(difflo)

Where Vatten(diffhi) and Vatten(difflo) are the respective high and low differential voltages (measured between the meter's pins 11 and 12) needed for the highest display reading (0.400V to read "400") and the lowest display reading (0.0V to read "000"), assuming a meter with a ±2V input range is used.

Vatten(diff) = Vatten(diffhi) - Vatten(difflo)
Vatten(diff) = 0.400V - 0.000V = 0.400V

Step 3. Find the input attenuator ratio r, and then use r to find R2 (see Figure 1):

r = Vatten(diff) / V_{IN}(diff)

Substitute the previously calculated values for Vatten(diff) and V_{IN}(diff):

r = 0.400V / 5V = 0.08

Assuming R1 = 909kΩ and using the calculated value of 0.08 for r, solve the equation below to find R2:

R2 = [r / (1 – r)] x R1
R2 = [0.08 / (1 – 0.08)] x 909,000 = 79,043Ω

The nearest ±1% resistor is 78.7kΩ. The assumed R1 value of 909kΩ is an arbitrary one, however, it does keep the attenuation circuit's impedance near 1MΩ and should reduce any loading the meter may have on the input signal source (V_{IN}).

Step 4. Find the null voltage that must be applied to pin 12 ((–) INPUT LO, see Figure 2):

Please note that all voltages in this step are single-ended values (measured with respect to pin 3, 5V RETURN). The primary goal of this step is to illustrate that all the calculations above actually work! The following two equations will be used:

Vatten(max) = r x V_{IN}(max) and Vatten(min) = r x V_{IN}(min)

Substituting values produces the following results:

Vatten(min) = 0.08 x 1.0V = 0.08V, and
Vatten(max) = 0.08 x 6.0V = 0.480V

When V_{IN} is 1V, Vatten(min) will be 0.08V. It must be nulled by also placing 0.080V on pin 12 ((–) INPUT LO) in order to achieve a display reading of "000". The circuit shown in Figure 2 uses a precision 22-turn potentiometer (R5) to generate 0.08V of zero offset.

When V_{IN} is 6V, Vatten will be 0.48V, however, the meter will display the difference between pins 11 and 12:

0.48V-0.08V = 0.400V (a reading of "400").

Step 5. Calibrate the circuit:

Apply a 1.0V input (V_{IN}) and adjust R5 (zero adjust) so the display reads "000". Apply 6.0V and adjust R4 (gain adjust) so the display reads "400". The decimal points (DP1-DP3) have not been mentioned above because they are strictly placeholders.

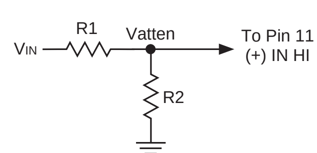

Figure 1. Resistor Divider

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Example 2. A 1-5V input must display "200" to "1200".

Step 1. Find the differential input voltage V_{IN} (diff):

V_{IN}(diff) = V_{IN}(max) - V_{IN}(min)
V_{IN}(diff) = 5V-1V = 4V

Step 2. Use the required display readings for V_{IN}(min) and V_{IN}(max) to find Vatten(diff):

In this example, when V_{IN}(min) = 1V, the display must read "200", and when V_{IN}(max) = 6V, the display must read "1200":

Vatten(diff) = Vatten(diffhi) - Vatten(difflo)
Vatten(diff) = 1.200V-0.200V = 1.000V

Recall that Vatten(diffhi) is the differential voltage between pins 11 and 12 required to display "1200", and Vatten(difflo) is the differential voltage which will display "200".

Step 3. Find the input divider ratio r, and then use r to find R2:

r = Vatten(diff) / V_{IN}(diff)
r = 1V / 4V = 0.25
Again, assuming R1 = 909kΩ, find R2:
R2 = [r / (1 – r)] x R1
R2 = [0.25 / (1 – 0.25)] x 909,000 = 303,000Ω
The closest ±1% resistor is 301kΩ.

Step 4. Find the null voltage that must be applied to (–) INPUT LO (pin 12):

Vatten(min) = r x V_{IN}(min) and Vatten(max) = r x V_{IN}(max)
Substituting values gives the following results:
Vatten(min) = 0.25 x 1V = 0.25V, and
Vatten(max) = 0.25 x 5V = 1.25V

If we examine the min. and max. Vatten values above, 0.250V and 1.250V, we notice that they are only 0.05V above the desired display readings of "200" (or 0.200V) and "1200" (or 1.200V). The required zero-offset voltage will be near, but not exactly, 0.05V.

Step 5. Calibrate the circuit:

The calibration of this example differs from the procedure used in Example 1. In this application, the offset potentiometer (R5) and the gain potentiometer (R4) interact with one another. It is very important to perform the calibration in the sequence presented below.

First, apply a 1.0V input and adjust R5 to its maximum clockwise or counterclockwise position in order to obtain the highest positive display reading (approximately "240" in this example). Next, apply a 5.0V input and adjust the gain potentiometer R4 so the display reads exactly "1250". Then, apply a 1.0V input and adjust R5 so the display reads exactly "200". Lastly, apply a 5.0V input. The display should now read "1200". Re-apply both V_{IN} settings (1V and 5V) to make sure the adjustments did not adversely affect one another. Perform minor adjustments if necessary.

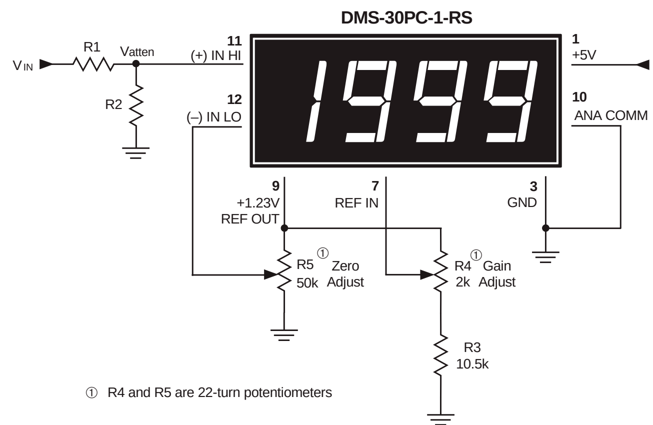

Figure 2. Schematic Diagram

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