How To Choose Strain Gage-based Transducers for PC-based Data Acquisition Applications

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PC-based data acquisition and logger products can be applied to monitor, record and analyze a wide range of signal types. However few are more common than strain gage-based transducers that measure a diverse range of mechanical properties like pressure, load, force, and more. This application note explores some critical items that you should know to ensure that your strain gage-based transducer measurement is successful.

Transducers First

We can't count the number of times that a customer calls with a detailed description of the measurement he wants to make, but without the transducer information that is crucial for the proper selection of a data logger or data acquisition system. Here's an example:

> **Customer:** “Yes, hello. I need to measure the load applied to a railroad car coupling. The load will be measured with an S-beam load cell with 50,000 lbs of capacity, and I need to sample about five samples per second. The measurement will be unattended for a few days, so the data logger will need to operate stand-alone.”
>
> **DATAQ:** "Okay. Have you chosen the load transducer for this application?"
>
> **Customer:** "No."

So near, yet so far. The problem is that load cell electrical properties are at least as critical as their mechanical characteristics. In this example, the customer completely understood the mechanical requirements for the transducer, but until it's actually chosen and its electrical characteristics known, a data logger cannot be reliably recommended. It's like trying to find a part for your car without knowing its make, model and year.

You should choose the transducer first, based upon mechanical requirements (measurement range and form factors). After that, note the output options offered by the transducer manufacturer and take those to your data acquisition or logger supplier. We think in terms of volts, millivolts, or current at full-scale with the transducer's mechanical properties having little or no bearing. The same amplifier that works for a 50,000-pound load cell today, will work for a 50-gram full-scale load cell tomorrow.

The first thing you'll notice when looking at electrical transducer properties is that there are only a few easy-to-understand choices, and these fall into two broad categories: amplified and unamplified (see Table 1).

Amplified Transducers

The strain gage that makes up the heart of your transducer is a device that outputs only millivolts, even at the transducer's full-scale capacity. This signal is not very useful at such low levels and requires amplification. Some transducer manufacturers give you the option to bundle the amplifier right into the transducer. These accept a wide power range (usually 15 to 28 VDC) and output either an amplified voltage or a current signal. The voltage output signal may be in the range of 0 to 10 volts full scale. Current outputs usually range from 4 to 20mA. Either output represents a linearized, high-level equivalent of the actual measurement range (see Table 1).

Unamplified Transducers

Another option is a transducer with an unamplified output. Products in this category rely on a generic measure to express transducer sensitivity called gage factor (GF), a unitless figure expressed as mV/V. A transducer with a GF equal to 2 will output two millivolts for every volt of excitation at its full-scale measurement range (see Table 1). The transducer industry has almost universally settled on two sensitivity figures for their unamplified transducers: Gage factors of 2 or 3.

Some people describe unamplified transducer measurements as ratiometric, but that's just a fancy way to say that the transducer's output is directly proportional to the magnitude of the excitation voltage you apply. I mention this to drive home how important it is to excite an unamplified transducer with a stable voltage, since fluctuations here pass directly through to your measurement. In this sense, unamplified transducer accuracy can be no better than the stability of its excitation voltage.

	50,000 lb. Load Cell Output			
	Amplified		Unamplified (assumes 10 VDC excitation)	
Applied force (lbs)	0-10V FS	4-20mA	2mV/V (GF=2)	3mV/V (GF=3)
0	0V	4mA	0mV	0mV
25,000	5V	12mA	10mV	15mV
50,000	10V	20mA	20mV	30mV

Table 1 - Summary of expected outputs from a 50,000-pound load cell with various electrical characteristics.

And The Winner is….

You may be wondering why anyone would choose an unamplified transducer. It seems so much nicer to work with an amplified signal, and the power supply requirements are much less stringent. This is all sound logic, but there are other considerations, too. Amplified transducers cost more than unamplified versions usually by at least one-third, a cost differential that exceeds the cost of an external amplifier. And when you further consider that the transducer is in harm's way it might make sense to spend as little as possible by pushing back toward the data acquisition system extraneous components that do not contribute to converting mechanical into electrical energy. After all, if you accidentally bash your 50,000-pound amplified load cell into the roundhouse door you've lost both your transducer and your amplifier. Finally, don't let the amplifier and stable excitation requirements of the unamplified transducer get in the way. Many manufacturers, including DATAQ Instruments offer compact solutions that provide extremely stable excitation supplies and amplifiers all in one package. For all these reasons, unamplified transducers are at least as popular as their amplified cousins.