Practical Considerations in Using IEPE Accelerometers With Modern Data Acquisition Systems

Technical Paper 326

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Endevco Sensing Systems technical paper 326
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To benefit from data acquisition systems which integrate accelerometer signal conditioners, the user must verify several key performance specifications – or risk the unintended degradation of measurement data.

Traditionally, signal conditioning amplifiers were the domain of accelerometer manufacturers. These high quality, highly flexible amplifiers allow the user to configure almost any combination of input accelerometer sensitivity and output scale factor, for use with a downstream data acquisition system.

Recently, with the rapid increase in popularity of integral electronic piezoelectric (IEPE) accelerometers, and the seemingly simple ease of constructing an IEPE signal conditioner, several data acquisition system manufacturers have begun to integrate signal conditioning into their systems. While use of these signal conditioner/data acquisition systems appear to be a great convenience and cost reducer for the user, there are several factors for the user to consider to ensure the resulting signal meets their expectations. This is particularly true of mission-critical technologies, such as the development of flight hardware.

Power requirements – Current

Unlike piezoelectric charge accelerometers, IEPE accelerometers require power to operate. The signal conditioner/data acquisition system must be able to supply the appropriate power required by the accelerometer. The user should always refer to the accelerometer's datasheet for power requirements, as different IEPE accelerometers will have different requirements. (Note that there is no industry consensus standard on IEPE, such as an ISA or ANSI specification.) Without appropriate power from the signal conditioner/DAQ system, the user cannot be assured the accelerometer is operating properly and runs the risk of poor quality or invalid measurement data.
Refer to Figure 1 for a general schematic of the IEPE power scheme. The IEPE power scheme uses constant current, rather than constant voltage, to power the accelerometer's internal electronics. IEPE accelerometers are frequently specified to operate over a wide range of constant current, with the minimum often being 2 mA. Whatever the required minimum, the user should ensure that their data acquisition system can supply this minimum amount of current. This should be specified in the data acquisition system's specifications, or it can be measured. To measure it, refer to Figure 2. Using a 1 kΩ resistor connected from the IEPE power source to ground, measure the current that flows through the resistor using a current meter. This is the constant current that the system can supply. The 1 kΩ resistor simulates the presence of an accelerometer and the data acquisition system turns on the constant current source.

For applications requiring long cables, or the measurement of high amplitude, high frequency vibrations, more current than the accelerometer's minimum specified constant current may be required from the data acquisition system.

Power requirements – Compliance voltage

IEPE accelerometers also require a voltage in order to output a distortion-free signal. Known as the compliance voltage, this is the maximum voltage available from the constant current source. If the signal conditioner/

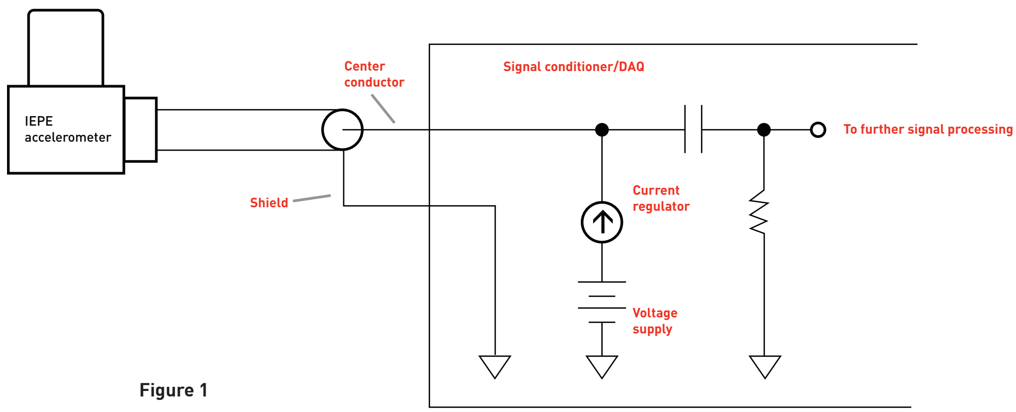

Figure 1

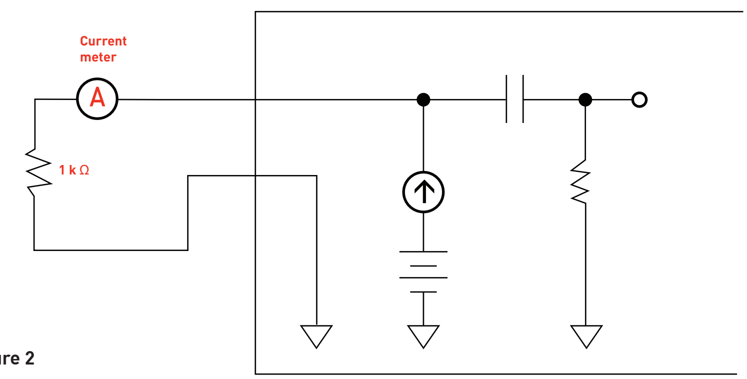

Figure 2

data acquisition system does not supply a high enough compliance voltage, the accelerometer may not reach its specified fullscale range, resulting in a distorted output signal and erroneous data. IEPE accelerometers are often specified to operate over a range of voltage, with the minimum frequently being 18 Vdc, but as high as 24 Vdc.

The user must ensure their data acquisition system can meet this minimum voltage. Compliance voltage should be in the data acquisition system's specifications, but its approximate value can also be measured in the following simplified way. Refer to Figure 3. Connect a 50 kΩ resistor from the IEPE power source to ground. The voltage measured across the resistor is the approximate compliance voltage.

Note that in some special circumstances, it may be permissible to operate an IEPE accelerometer slightly below the required minimum constant current and compliance voltage; under no circumstance should the accelerometer be operated above the specified maximums. Doing so risks permanently damaging the accelerometer.

Noise considerations

Many IEPE accelerometers have excellent noise specifications. If the signal conditioner/data acquisition system cannot take advantage of this capability, this high performance is degraded. The user must evaluate the noise performance of the data acquisition system to ensure it does not degrade the quality of the measurements being taken by the accelerometer.

Some lower cost signal conditioner/data acquisition systems may especially have a problem in this area.

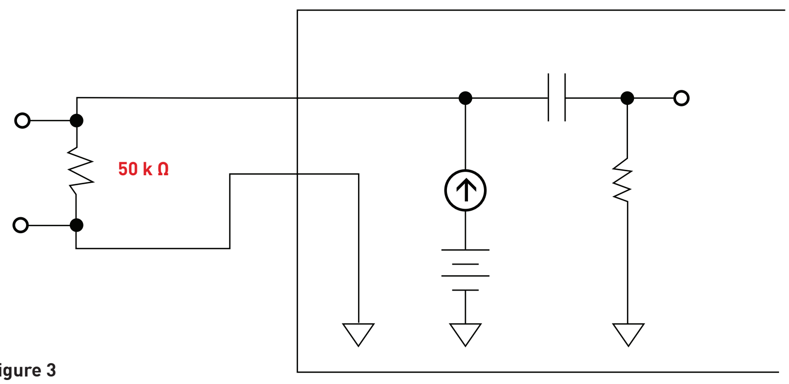

Figure 3

Frequently, the voltage supply used on these lower cost systems is derived from simple switching DC-to-DC converters, which typically are noisy. Inherent in the way the IEPE powering scheme works (see Figure 1), any noise originating from the voltage supply for the constant current regulator will directly couple into the accelerometer's output signal. There is not much the user can do to reverse this significant drawback to some signal conditioner/data acquisition systems.

High frequency response

The frequency responses of IEPE accelerometers are usually well specified, but, as with noise performance, the user must ensure the signal conditioner/data acquisition system does not degrade this performance to unacceptable or unexpected levels.

The high frequency response of the system is dependent on the maximum acceleration signal amplitude to be measured; the length and capacitance of the cable between the accelerometer and signal conditioner/data acquisition system; and the constant current available from the data acquisition system to drive this cable.

This dependency can be expressed mathematically as

$$f_{\max} = \frac{1000 \times I}{2\pi a S L C} \qquad \text{(units in Hz)}$$

where I = **constant current available to drive the cable (units in Amps)**

a = **amplitude of acceleration signal expected (or desired) to be measured (units in gpk)**

S = **sensitivity of accelerometer (units in V/g)**

L = **total cable length (any length unit)**

C = **cable capacitance per unit length (units in F/unit length, note that length unit must match cable length unit)**

(Note that 1 mA should be subtracted from the total constant current from the signal conditioner/DAQ. This 1 mA is used by the accelerometer's electronics itself, while the remaining current is available to drive the cable.)

From this equation, it is clear that available current from the data acquisition system is directly proportional to the high frequency cutoff (-3 dB). Insufficient current from the data acquisition system, even if enough to meet minimum requirements of the accelerometer, will reduce the measurement system's bandwidth. The user must calculate how much current is available from the signal conditioner/data acquisition system and ensure the system frequency bandwidth is adequate for the measurement. This warrants particular attention if the system utilizes long cables, or the measurement involves high amplitudes and/or high frequencies.

Low frequency response

Properly powered, IEPE accelerometers output a DC bias voltage and a dynamic AC signal proportional to acceleration. This is inherent in the IEPE powering scheme. This DC bias must be filtered out within the signal conditioner/data acquisition system in order for the dynamic signal to be further processed. This is typically done with an RC network, thus setting the low frequency response of the system. The user must verify that the low frequency cutoff for their signal conditioner/data acquisition system is adequate for the application. The accelerometer may be specified down to a very low frequency, but if the data acquisition system isn't specified to the same (or better) level, it will degrade performance.

Conclusion

In summary, there are several factors for a user to consider when using an IEPE accelerometer with integrated signal conditioner/data acquisition systems.

1. Does the signal conditioner/DAQ system supply adequate constant current to properly power the accelerometer?

2. Does the signal conditioner/DAQ system meet the compliance voltage requirement of the accelerometer?

3. Does the noise performance of the signal conditioner/DAQ system match the noise performance of the accelerometer?

4. Does the signal conditioner/DAQ system supply adequate current to run long cables? To measure high amplitude and/or high frequency accelerations?

5. Does the low frequency response of the signal conditioner/DAQ system match that of the accelerometer?

Correctly managing these factors will help the user avoid erroneous performance degradation and ensure the quality of the measurement data is at the level they expect and require.