

## What is Signal Conditioning?

Many applications require environment or structural measurements, such as temperature and vibration, from sensors. These sensors, in turn, require signal conditioning before a data acquisition device can effectively and accurately measure the signal. Key signal conditioning technologies provide distinct enhancements to both the performance and accuracy of data acquisition systems.



Figure 1. Signal conditioning provides more accurate sensor measurements.

### Amplification

Amplifiers increase voltage level to better match the analog-to-digital converter (ADC) range, thus increasing the measurement resolution and sensitivity. In addition, using external signal conditioners located closer to the signal source, or transducer, improves the measurement signal-to-noise ratio by magnifying the voltage level before it is affected by environmental noise.

### Attenuation

Attenuation, the opposite of amplification, is necessary when voltages to be digitized are beyond the ADC range. This form of signal conditioning decreases the input signal amplitude so that the conditioned signal is within ADC range. Attenuation is typically necessary when measuring voltages that are more than 10 V.

### Isolation

Isolated signal conditioning devices pass the signal from its source to the measurement device without a physical connection by using transformer, optical, or capacitive coupling techniques. In addition to breaking ground loops, isolation blocks high-voltage surges and rejects high common-mode voltage and thus protects both the operators and expensive measurement equipment.

### Filtering

Filters reject unwanted noise within a certain frequency range. Oftentimes, lowpass filters are used to block out high-frequency noise in electrical measurements, such as 60 Hz power. Another common use for filtering is to prevent aliasing from high-frequency signals. This can be done by using an antialiasing filter to attenuate signals above the Nyquist frequency.

### Excitation

Excitation is required for many types of transducers. For example, strain gages, accelerometers, thermistors, and resistance temperature detectors (RTDs) require external voltage or current excitation. RTD and thermistor measurements are usually made with a current source that converts the variation in resistance to a measurable voltage. Accelerometers often have an integrated amplifier, which requires a current excitation provided by the measurement device. Strain gages, which are very-low-resistance devices, typically are used in a Wheatstone bridge configuration with a voltage excitation source.

### Linearization

Linearization is necessary when sensors produce voltage signals that are not linearly related to the physical measurement. Linearization is the process of interpreting the signal from the sensor and can be done either with signal conditioning or through software. Thermocouples are the classic example of a sensor that requires linearization.

### Cold-Junction Compensation

Cold-junction compensation (CJC) is a technology required for accurate thermocouple measurements. Thermocouples measure temperature as the difference in voltage between two dissimilar metals. Based on this concept, another voltage is generated at the connection between the thermocouple and terminal of your data acquisition device. CJC improves your measurement accuracy by providing the temperature at this junction and applying the appropriate correction.

### Bridge Completion

Bridge completion is required for quarter- and half-bridge sensors to comprise a four resistor Wheatstone bridge. Strain gage signal conditioners typically provide half-bridge completion networks consisting of high-precision reference resistors. The completion resistors provide a fixed reference for detecting small voltage changes across the active resistor(s).

Table 1 provides a summary of common signal conditioning for different types of sensors and measurements.

	Amplification	Attenuation	Isolation	Filtering	Excitation	Linearization	CJC	Bridge Completion
Thermocouple	✓		✓	✓		✓	✓	
Thermistor	✓		✓	✓	✓	✓		
RTD	✓		✓	✓	✓	✓		
Strain Gage	✓		✓	✓	✓	✓		✓
Load, Pressure, Torque (mV/V)	✓		✓	✓	✓	✓		
Load, Pressure, Torque (±5 V, ±10 V, 4-20 mA)	✓		✓	✓	✓	✓		
Accelerometer	✓		✓	✓	✓	✓		
Microphone	✓			✓	✓	✓		
Proximity Probe	✓			✓	✓	✓		
LVDT/RVDT	✓		✓	✓	✓	✓		
High Voltage		✓	✓					

Table 1. Signal conditioning is recommended for sensor measurements.

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