THE DATA DETECTIVE

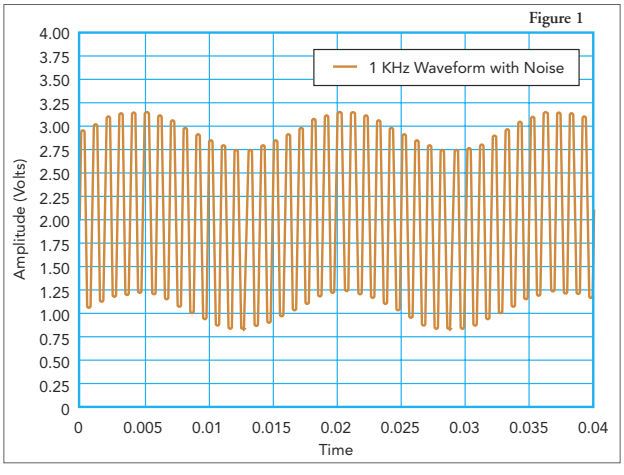
Stay Out of the Loop

Engineers know they must provide a complete circuit in measurement systems because current flow requires a return path. People who work with electronic devices may forget, though, that a ground-return circuit has resistance and a voltage can develop between ground points in electronic equipment. The resulting voltage can "ride" on signals you want to measure and throw off test results.

An example shows how currents can arise in a "ground" loop. Consider a function generator connected to an oscilloscope through a piece of coaxial cable. The cable provides a signal path and a ground, or return path. Both instruments reference their input or output to the ground in their building's electrical supply, which can create a long loop or independent circuit. Voltages of from several tens of millivolts to hundreds of millivolts, usually at the power-line frequency (Figure 1), can occur between the grounds in the two instruments. This sort of ground loop will add unwanted signals to measurement results.

You can eliminate ground loops or reduce their effects through careful design of measurement systems. To start,

Figure 1



ensure that your schematic diagrams include all signal paths, including power-line grounds. Highlighting ground connections and paths may let you identify potential ground loops.

Next, carefully match sensor outputs and instrument inputs. Divide signal sources into grounded and ungrounded categories and then choose an appropriate type of input. Inputs fall into three categories, single ended (ground reference), single ended (non-ground reference), or differential.

Grounded signal sources or sensors work well with differential inputs that reject common-mode signals from ground loops or from induced noise. Rejection comes at a cost, though: Each signal requires two inputs that go through a multiplexer to the + or - input of an instrumentation amplifier.

A pseudo-differential input, or non-references single-ended (NRSE) input also reduces ground loop noise, and it requires only one input per signal. NRSE inputs multiplex one side of a sensor to the + input of an instrumentation amplifier. Instead of referencing the amplifier's - input to local ground, that input connects to the other side of the sensor circuits.

Avoid connecting grounded sensors to single-ended inputs because they produce a ground loop. If you must make such a connection, you may need an isolation amplifier in the circuit to break the ground loop.

Ungrounded, or floating, signal sources inherently eliminate ground loops and they work well with either single-ended or differential inputs. Take care to ensure the common-mode voltage level of the signal, with respect to the measurement system ground, remains within the common-mode input range of the measurement device.

Bias currents on instrumentation-amplifier inputs can push the voltage on these "floating" terminals outside their specified range. A high-resistance path from the inputs to ground will "anchor" the voltage to a local reference. Resistors from about 10 kΩ to 100 kΩ work well with low-impedance sources such as thermocouples or signal-conditioning modules. The resistors do alter the input impedance of the differential inputs slightly, but usually not enough to affect final measurement values. (Always ground unused differential inputs.)

If you run into an elusive ground loop, do not eliminate it by disconnecting their power-line ground (the green wire) to "float" otherwise-grounded instruments. This condition puts users at risk of a lethal shock.

For further reading

"Ground Loops and Returns," National Instruments. zone.ni.com.

The Elusive Noise

Glenn has set up a data-acquisition system to monitor several dozen sensors. For the most part, the acquired data looks good. But the results from one sensor show an underlying low-frequency signal that Glenn knows the sensor cannot produce. Unfortunately, he doesn't know where the signal does come from.

Can you help Glenn track down the underlying signal added to the sensor's output and determine how to eliminate it?

http://rbi.ims.ca/4394-502

Go to http://rbi.ims.ca/4394-502 to solve the challenge!