LEADING inside

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The Importance of Differential Measurement

Many real world applications require amplifying a very small signal in a high noise environment. Usually, the signal sensor is located some distance from the amplifier. As a consequence, a large amount of noise and hum is often introduced.

Effective signal recovery often depends on carefully choosing the optimum amplifier for a particular application. There are three common types of systems in use: single-ended input and output (operational amplifier based), differential input, single-ended output (instrumentation amplifier based), and differential input and differential output (differential amplifier based) systems. Some designers may be tempted to use a single-ended, shielded cable system, similar to that shown in Figure A.

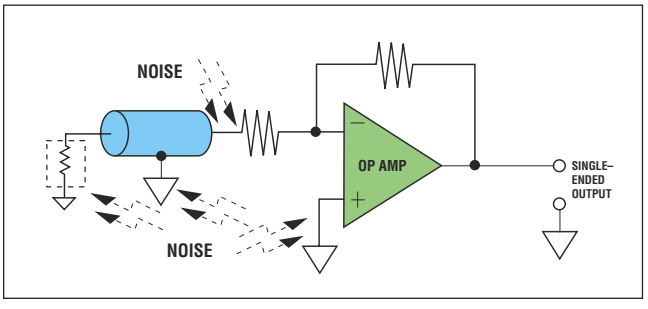

Figure A. A single-ended measurement system

Here, the input is applied between the shielded cable and common or "ground," then travels through the cable to the op amp. A single-ended system like this is very prone to noise pickup because the signal is referenced to ground, i.e., the signal flows through the system ground, with noise being added along the way. With a single-ended system like this, both the signal and the noise are amplified. The common practice of removing the noise at the amplifier output, using low-pass, high-pass, or band-pass filtering, is often ineffective. In some cases, the total noise can be much greater than the signal itself.

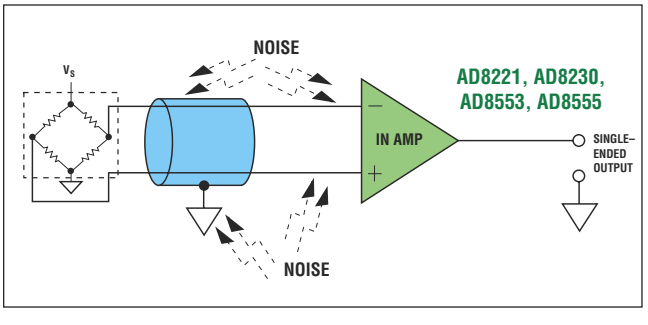

Figure B. A differential input, single-ended output measurement system

Figure B shows a better method for recovering weak signals. Here, the input signal source is differential. Simply stated, this means that the signal is applied *between* two input lines, with *no* signal traveling through the ground connection. This type of system normally uses an in-amp which has a differential input and a single-ended output. Much of the noise that is the same (common mode) on both lines is rejected by the in-amp, which only amplifies the differential input signal.

Note that the inputs of most instrumentation amplifiers require a dc return path (using resistors, for example) for the amplifier's input bias currents. This is very important for ac-coupled, single-supply applications where it is also often necessary to have the amplifier's input common-mode reference and output reference raised above ground.

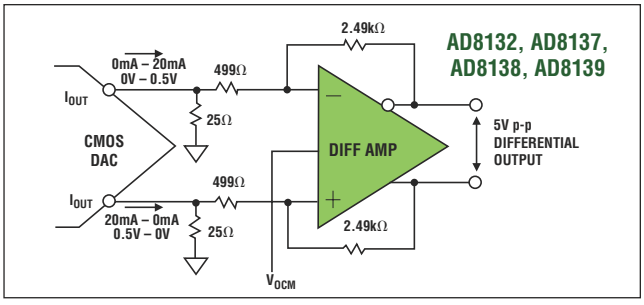

Figure C. A differential input, differential output amplifier used as a high-speed DAC buffer

Figure C is a system featuring an amplifier that has both a differential input and output. These are commonly used in high bandwidth applications, such as driving ADCs or buffering DACs.

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