High-Performance Difference Amplifier with Precision Supply-Referenced Level Shift

By Moshe Gerstenhaber and Michael O'Sullivan

Designed on small-geometry processes, high-performance ADCs typically run on single 1.8-V to 5-V supplies. When processing ±10-V or larger signals, an amplifier circuit ahead of the ADC can attenuate the signal to keep it from saturating the ADC inputs. A difference amplifier (diff amp) is commonly used when the signal includes a large common-mode voltage.

The ability of a diff amp to reject a common-mode voltage is determined by the ratio match of the gain-setting resistors; the closer the match, the higher the common-mode rejection (CMR). For discrete amplifiers with 0.1% external resistors, CMR is limited to 54 dB. ICs that integrate precision laser-trimmed resistors with an op amp can achieve CMR better than 80 dB.

Early diff amps, like many other analog ICs, typically operated on dual ±5-V to ±15-V supplies. As ADCs and other components moved to lower supply voltages, for a time the only circuit requiring dual supplies was the diff amp at the front end. But adding a negative supply for this single circuit was quite inconvenient.

New diff amps can operate on single 2.7-V to 15-V supplies, but the op amp inputs and output would all be pinned to the negative rail (ground) under some operating conditions. To measure signals containing negative common-mode voltages, the common-mode input must be raised off the negative rail. To measure negative signals, the amplifier output must be raised off the negative rail. Both of these level shifts can be accomplished by applying a positive voltage to the *reference* pin. With a single 5-V supply, for example, a 2.5-V source on the reference pin sets the output to midsupply and raises the common-mode voltage seen at the op amp inputs. The source must be low impedance to avoid degrading the CMR and low drift to maintain accuracy over temperature. Figure 1 shows a typical solution that uses two external precision resistors and a low-drift precision op amp.

Figure 2 shows an alternative solution that offers lower cost and higher performance by using the AD8271 difference amplifier, with its multiple integrated precision-trimmed resistors. The on-chip resistors set the device output to midsupply. The resistors are all manufactured from the same low-drift thin-film material, so their ratio match over temperature is excellent; they are trimmed to match the other resistors in the circuit, so they do not degrade the excellent CMR.

Precision Programmable-Gain Difference Amplifier

The AD8271 low-distortion, programmable-gain difference amplifier comprises a precision op amp and seven laser-trimmed gain-setting resistors, enabling user-selectable differential gains of 0.5, 1, or 2. It can also be configured in over 40 single-ended configurations, with gains ranging from −2 to +3. Two grades are available: the *B*-grade specifies 0.02% max gain error, 2-ppm/°C max gain drift, 600-μV max offset, and 80-dB min common-mode rejection; the *A*-grade specifies 0.05% max gain error, 10-ppm/°C max gain drift, 1000-μV max offset, and 74-dB min common-mode rejection. Both grades specify –110-dB harmonic distortion, 15-MHz bandwidth, and 30-V/μs slew rate. This combination of speed and precision makes the device ideal for instrumentation amplifiers, driving ADCs, level shifting, and automatic test equipment. Operating on a single 5-V to 36-V supply, or dual ±2.5-V to ±18-V supplies, the AD8271 draws 2.3 mA. Available in a 10-lead MSOP package, it is specified from –40°C to +85°C and priced from $1.25 in 1000s.

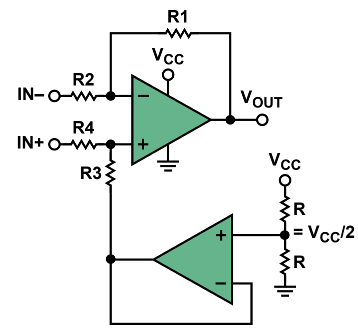

Figure 1. Single-supply difference amplifier with midsupply output.

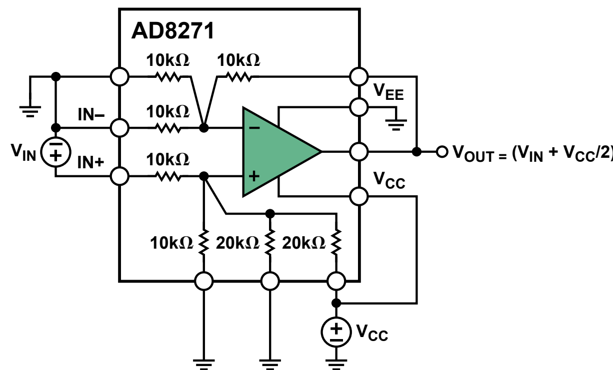

Figure 2. AD8271 shifts output to midsupply with no external components.

Authors

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