Dual Difference Amplifier with On-Chip Resistors Implements Precision ADC Driver

By Chau Tran

Introduction

Discrete difference amplifiers assembled from op amps and external gain-setting resistors exhibit mediocre accuracy and significant drift over temperature. With standard 1%, 100-ppm/°C resistors, the initial gain error of up to 2% can vary by up to 200 ppm/°C—and monolithic resistor networks, often used for precise gain setting, are bulky and expensive. Furthermore, most discrete op-amp circuits have poor common-mode rejection and an input voltage range smaller than the power supply voltage. While *monolithic differential amplifiers* have better common-mode rejection, they still suffer from gain drift due to the inherent mismatch between on-chip devices and the external gain resistor.

The versatile AD8270 dual difference amplifier, shown in Figure 1, overcomes these limitations, providing a complete, inexpensive, high-performance solution in the smallest available package. Each channel, which includes a low distortion amplifier and seven trimmed resistors, can be configured to implement a wide variety of high-performance amplifiers with various gains. All precision resistors are integrated on chip, so resistance matching and temperature tracking are excellent. Operating on a single 5-V to 36-V supply, or dual ±2.5-V to ±18-V supplies, and drawing a maximum supply current of only 2.5 mA per amplifier, the AD8270 is useful for driving high-performance ADCs.

This article shows two pin-strapped circuits that provide 0.1% gain accuracy with less than 10 ppm/°C gain drift—using *no external resistors*.

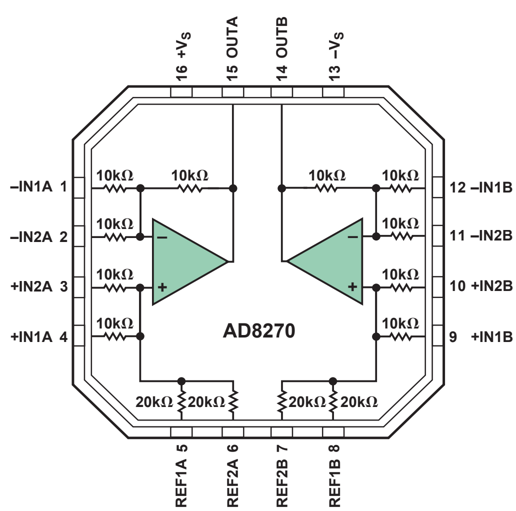

Figure 1. AD8270 functional block diagram.

Differential ADC Driver

The AD8270 can be configured to provide a differential output centered on a desired common-mode voltage, as shown in Figure 2. Amplifier A is configured for a gain of +½ and Amplifier B is configured for a gain of –½, so the combined gain is G = V_{OUT}/V_{IN} = ½ – (–½) = 1. The output common-mode voltage, $(OUT+ + OUT–)/2$, is equal to V_{OCM}.

When driving ADCs, the gain should be chosen such that the signal swing is close to the full-scale input range of the ADC. The impedance at the inverting and noninverting inputs of the amplifiers should be equal to eliminate the effect of bias currents and to maximize the common-mode rejection. The AD8603 unity-gain follower sets the common-mode output voltage of the differential amplifier to V_{OCM}, centering the signal in the middle of the ADC's input range. This pin can be tied to ground when the circuit is operated with dual supplies, to $V_S/2$ for single-supply operation, or—as shown—to the ADC's reference pin when driving single-supply ADCs, allowing ratiometric operation. The AD8603 can be eliminated if V_{OCM} is a low-impedance source.

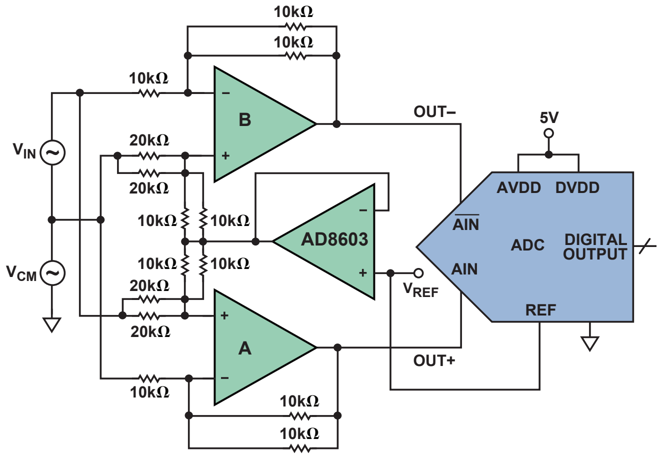

Figure 2. Differential amplifier drives ADC.

Operation at Gains Less Than 1 (Differential to Single-Ended)

To drive ADCs with low input ranges, the AD8270 gain block may be modified to provide gains of less than 1; an example is shown in Figure 3.

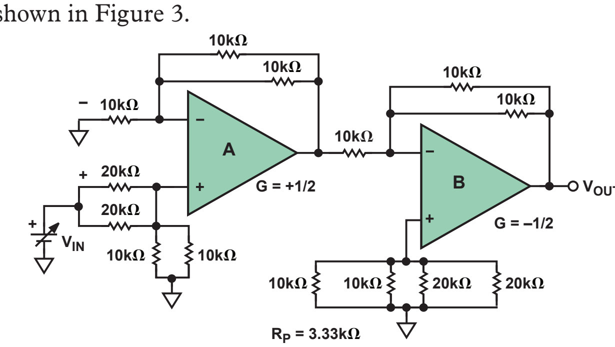

Figure 3. Connection for gains less than 1.

Pin strapping configures Amplifier A for a gain of +½. Amplifier B, configured for a gain of –½, attenuates the signal again, so the total gain for this connection is equal to –0.25.

$$G = \frac{V_{out}}{V_{in}} = \left(\frac{5\ \text{k}\Omega}{15\ \text{k}\Omega}\right)\left(1 + \frac{5\ \text{k}\Omega}{10\ \text{k}\Omega}\right)\left(-\frac{5\ \text{k}\Omega}{10\ \text{k}\Omega}\right) = -0.25$$

Conclusion

The AD8270 dual difference amplifier—with its low offset voltage, low offset drift, low gain error, low gain drift, and 14 integrated precision resistors—can be used to implement accurate, stable amplifiers. Its wide power supply range allows it to accommodate a wide range of input voltage; and its space-saving package reduces PCB area, simplifies layout, decreases cost, and improves performance.

Author

Chau Tran [chau.tran@analog.com] joined Analog Devices in 1984 and works in the Instrumentation Amplifier Products (IAP) Group in Wilmington, MA. In 1990, he graduated with an MSEE degree from Tufts University. Chau holds more than 10 patents and has authored more than 10 technical articles.