Low-Power, Unity-Gain Difference Amplifier Implements Low-Cost Current Source

By David Guo

In “Difference Amplifier Forms Heart of Precision Current Source,” published in *Analog Dialogue* in September 2009, the AD8276 unity-gain difference amplifier and AD8603 micropower op amp implement a precision current source. Figure 1 shows how the circuit can be simplified for use in low-cost, low-current applications.

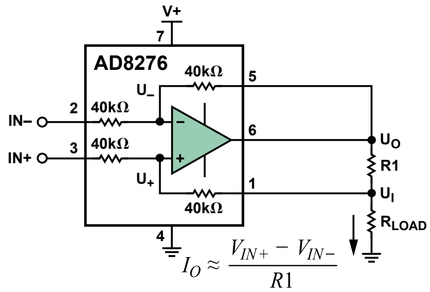

Figure 1. Simple current source for low-cost and low-current applications.

The output current, I_O, is approximately equal to the differential input voltage, $V_{IN+} - V_{IN-}$, divided by $R1$, as shown in the following derivation.

$$\frac{V_{IN-} - U_-}{40k} = \frac{U_- - U_O}{40k} \Rightarrow U_- = \frac{V_{IN-} + U_O}{2}$$

$$\frac{V_{IN+} - U_+}{40k} = \frac{U_+ - U_I}{40k} \Rightarrow U_+ = \frac{V_{IN+} + U_I}{2}$$

$$U_- = U_+ \Rightarrow V_{IN+} - V_{IN-} = U_O - U_I$$

Thus, the differential input voltage appears across R1.

$$R1 << 40k \Rightarrow I_O \approx I_{R1} \Rightarrow I_O \approx \frac{V_{IN+} - V_{IN-}}{R1}$$

Experimental Setup

1. AD5750EVB (AD5750 driver and AD5662 16-bit *nano*DAC®) provides a bipolar input to the AD8276.
2. OI-857 multimeter measures input voltage, output voltage, and resistance.
3. The nominal values of R1 and R_{LOAD} are 280 Ω and 1 kΩ, respectively; the measured values are 280.65 Ω and 997.11 Ω, respectively.
4. The output current is calculated by dividing the measured voltage by R_{LOAD}.

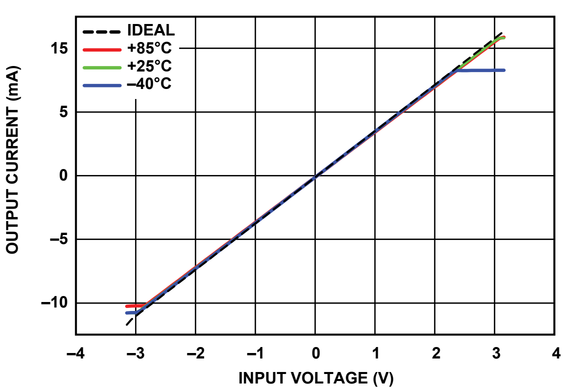

Figure 2. Ideal and real output current vs. differential input voltage.

Experimental Results

Figure 2 shows the output current vs. the input voltage. The differential input voltage, which varies from –3.2 V to +3.2 V, is plotted on the X-axis; the output current is plotted on the Y-axis. The four lines show the ideal current and the real outputs at –40°C, +25°C, and +85°C.

Figure 3 shows the output current error vs. the input voltage. The three lines show the error at –40°C, +25°C, and +85°C.

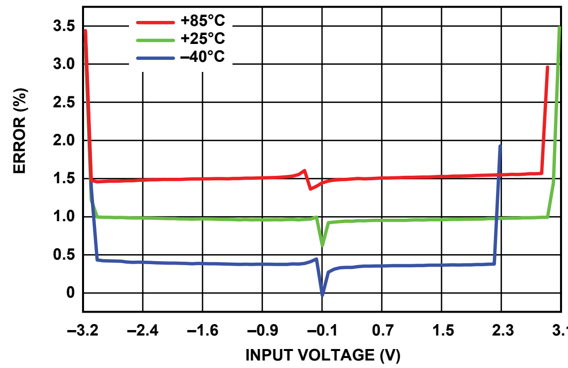

Figure 3. Output current error vs. input voltage.

The real output current is limited by the short-circuit output current of the AD8276, as shown in Figure 4. Here, the short-circuit current is about 8 mA at –40°C.

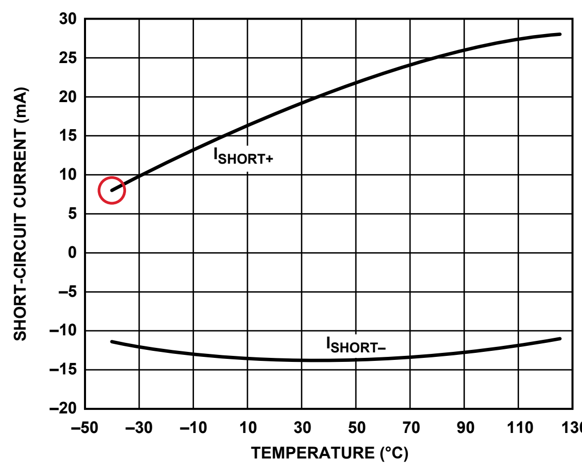

Figure 4. AD8276 short-circuit output current vs. temperature.

Conclusion

By removing the external boost transistor and buffer and adding a single resistor, one can use the AD8276 to construct a low-cost, low-current source with a total error less than about 1.5% over the –40°C to +85°C temperature range. The output current range over temperature is about –11 mA to +8 mA when powered with a ±15-V supply. A unipolar source could be created with a single +5 V supply.

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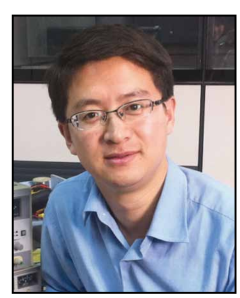

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