BY BONNIE BAKER

Throw those bits away

A high-quality load cell may have a 2-mV/V output-transfer function, meaning that for each volt of excitation you get ±2 mV of the full-scale output signal. With an excitation of 4.096V and a full sensor deflection, the maximum output is ±8.192 mV. In a 12-bit application, half of full-scale might represent 0 to 250 lbs for a bathroom scale. If you want 0.25-lb resolution, you need 1000 points of measurement output. To look at something that is 1/1000th of the full-scale range, you must distinguish a change of 8.192 µV of the sensor output. You can achieve this distinction by keeping the peak-to-peak sensor noise less than 8.192 µV for 99.999% of the time, using a crest factor of 4.4 (**Reference 1**). With this definition, the least-significant bit at the sensor is 8.192 µV, or 931 nV rms.

The load-cell bridge has an excitation voltage of 4.096V (**Figure 1**). The INA326 instrumentation amplifier follows the load cell with a gain of 250V/V. The system's full-scale voltage, 250×±8.192 mV, produces a ±2.048V full-scale signal. The 12-bit ADS7822 digitizes the analog signal.

This 12-bit converter system must have an analog filter. The lowpass OPA333 (www.ti.com/opa333) analog filter's primary function is to remove the high-frequency signal components at the input of the ADC (**Reference 2**). Because the load cell in the circuit operates near dc, you limit the bandwidth to 10 Hz. The components in **Figure 1** cost less than $6.

Now, look at load-cell measurement with a 24-bit system. You can simply put the load-cell signal through a first-order lowpass filter and into the delta-sigma ADC (**Figure 2**). The first-order filter in this circuit eliminates high-frequency noise around the converter's sampling frequency (**Reference 3**). The sensor provides the resistor for the filter RC pair.

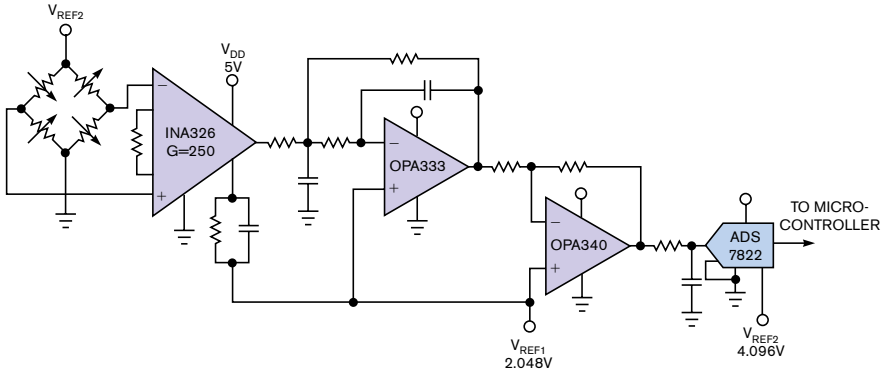

Figure 1 A 12-bit load-cell system achieves accuracy to 0.25 lb.

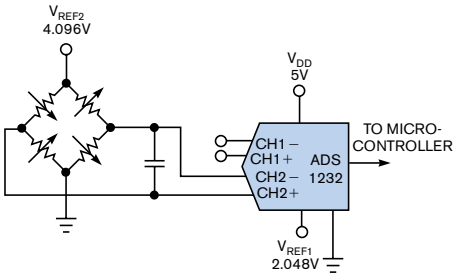

Figure 2 A 24-bit load-cell system has greater-than-0.25-lb accuracy.

Look at the errors for the 24-bit delta-sigma system in **Figure 2**. The ADS1232 (www.ti.com/ads1232) produces 3.7 µV p-p of noise, with a crest factor of 4.4. This figure is much lower than the sensor's least-significant bit. Additionally, the full-scale range of the converter is 4.096V, whereas the sensor's full-scale output range is ±8.192 mV. As you can guess, you will "throw away" most of the output bits of the delta-sigma converter. The components in **Figure 2** cost less than $4.

You may find that the 12-bit converter system ends up costing you more money, real estate, and headaches than the alternative 24-bit system. EDN

REFERENCES

1 Baker, Bonnie, "RMS and peak-to-peak noise trade-off," *EDN*, May 15, 2008, pg 26, www.edn.com/article/CA6558465.

2 Baker, Bonnie, "What's in your SAR-ADC application?" *EDN*, Dec 15, 2008, pg 22, www.edn.com/article/CA6622866.

3 Baker, Bonnie, "Analog filter eases delta-sigma-converter design," *EDN*, June 12, 2008, pg 24, www.edn.com/article/CA6566532.

Bonnie Baker is a senior applications engineer at Texas Instruments and author of A Baker's Dozen: Real Analog Solutions for Digital Designers. *You can reach her at bonnie@ti.com.*