DESIGN NOTES

Digitize a $1000 Sensor with a $1 Analog-to-Digital Converter

Design Note 456

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Introduction

The LTC2450 is a 16-bit, single-ended input, delta-sigma ADC in a 2mm × 2mm DFN package, but don't let its small size and low cost fool you. The LTC2450 has impressive DC specs, including 2LSB INL, 2LSB offset and a 0.01% gain error, making it a perfect match for many high-end industrial sensors, as well as a wide variety of data acquisition, measurement, control and general purpose voltage monitoring applications.

Digitize an Accurate Sensor with an Accurate ADC

The Setra Model 270 is an exquisitely accurate barometric pressure sensor often used in weather stations and semiconductor manufacturing. A 600 to 1100 millibar input range corresponds to a 0V to 5V output. Despite its high accuracy, it does not require an expensive ADC to take full advantage of this sensor's performance. The LTC2450's DC specifications are more than adequate for the 270's 0.05% accuracy. Figure 1 shows the basic connections, and Figure 2 shows the change in barometic pressure from walking up and down a flight of stairs, taking a short break on each stair. After sample 2500, the sensor is resting on the bottom stair measuring only the change in ambient pressure. The spikes at the end of the graph are from a door opening and closing. The Setra 270 must be treated as a 4-terminal device, as the negative output is nominally 5V above the negative excitation. Figure 3 shows an isolated supply for the sensor's excitation, and the 4.7µF capacitor keeps switching noise from affecting the measurement.

Not So Obvious Features

Mixed signal designers often try to extract more resolution from an ADC by averaging samples. Averaging reduces the signal bandwidth and improves resolution, but it consumes processing resources, complicates firmware and necessitates the use of a fast ADC even though the application may require a much slower data rate. It also does not improve accuracy. The LTC2450 is inherently very accurate, and it does the averaging for you. The front-end sample rate of the LTC2450 is 3.9Msps, which is decimated to 30 samples per second by a Sinc[1] digital filter. The filter's effective bandwidth is approximately 30Hz, which means noise between 30Hz and 3.9MHz is greatly attenuated. When combined with a simple 1-pole filter, wideband noise is generally not a concern.

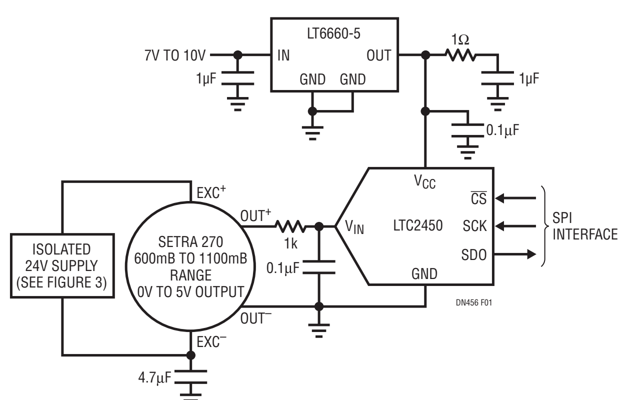

Figure 1. 16-Bit Barometric Pressure Measurement

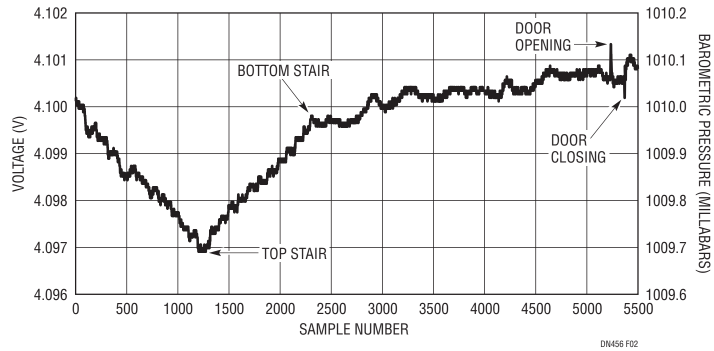

Figure 2. Stairway Pressure

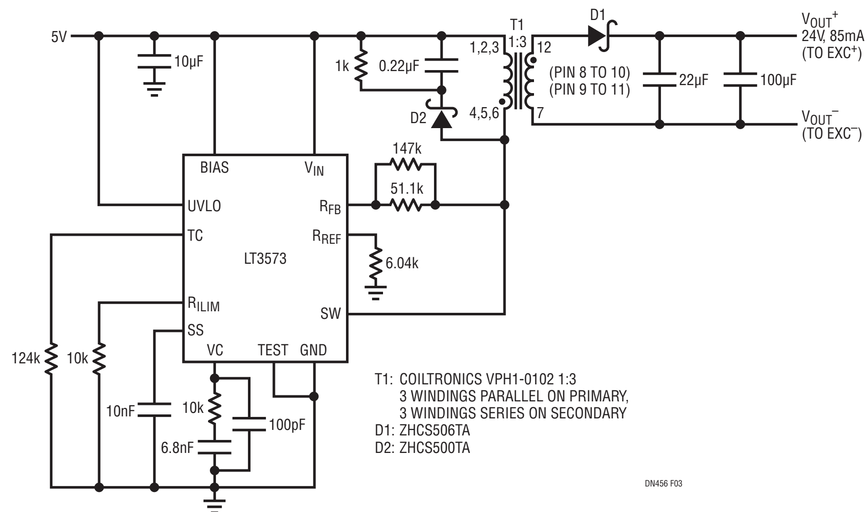

Figure 3. 24V Isolated Excitation Supply

A breakthrough feature of the LTC2450 is the proprietary modulator switching scheme that reduces the average input current by orders of magnitude compared to ADCs with similar specifications. Ordinarily, an RC filter produces offset and gain errors due to the ADC's average input current flowing through the resistor. The very low 50nA average sampling current of the LTC2450 produces less than a 1LSB error with a 1k, 0.1µF filter. This filter is more than adequate for limiting the wideband noise of most active devices driving the ADC, as well as preventing sampling current "spikes" from the modulator from affecting the source.

Conclusion

With manufacturers claiming up to 32 bits of resolution on their precision ADCs, and a confusing array of choices between 8 and 32 bits, often with highly obfuscated data sheets, where does a "medium speed, medium resolution" part like the LTC2450 fit in? It fits pretty much anywhere where you would use a 4-1/2 digit (40,000 count) digital voltmeter to test your circuit. At the other end of the performance spectrum, the LTC2450 is more economical than many 12-bit ADCs. The next time you are searching for an ADC, consider the LTC2450. It may be just what you need for performance, while occupying a tiny amount of board space that matches its tiny price ($1.15 each in 1000-piece quantities).

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