

Unique ADC Front End Enables Multichannel Sensor Applications without Buffers

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As analog designs increase in complexity, designers are using multiple sensors to measure environmental parameters such as temperature, light, acceleration, and humidity. One such example is monitoring voltage, pressure and temperature on a high-voltage battery stack for electric vehicles. Designers may need to accurately measure voltage at each individual battery in the stack. They may use strain gauges to monitor pressure to ensure that the charging cycle isn't physically expanding the batteries. They may also choose to log temperature gradients to be sure the stacks aren't overheating.

Monitoring these signals requires an accurate, multi-channel analog-to-digital converter (ADC). Because these signals vary relatively slowly, a precise delta sigma ADC often works best. Linear Technology's LTC2498 is a 24-bit delta sigma ADC that can measure up to 16 single-ended channels, 8 differential channels, or combinations of both. The circuit in Figure 1 shows a typical application of measuring a bridge sensor differentially and a single-ended thermocouple signal.

Delta sigma ADCs are ideal for measuring minute changes in applications like battery charging, but often are prohibitive or need additional front end signal conditioning because many real world sensors have large impedances. Even small input sampling currents can cause errors on high impedance sensors. The LTC2498 solves this problem by balancing the input currents with the Easy Drive™ technology, a unique analog front-end architecture.

The Easy Drive architecture simplifies the drive requirements of delta sigma ADCs. The solution lies in a purely passive input current cancellation algorithm that enables rail-to-rail inputs without the added power requirements of on-chip buffer amplifiers and the errors they introduce. Easy Drive enables the LTC2498 to directly interface to high impedance sensors, low pass filters, and input bypass capacitors without materially degrading the DC performance. Figure 2 details an example of the LTC2480 single-channel Easy Drive ADC.

The usual problem for high impedance sensors is the delta sigma converter's switched capacitor network. Capacitors are rapidly switched (up to 10MHz) between the input, reference, and ground as a function of the output code. Each time these capacitors are switched to the ADC input, a current pulse is generated and a pattern of charging/discharging pulses is seen at the input pin of the ADC. This pattern is a complex function of the input and reference voltages. External RC networks that do not completely settle during each sample period cause large full-scale errors.

The trick to solving this problem is to take advantage of the oversampling properties of delta sigma converters. The front-end capacitor switching on a per-sample basis is identical to conventional delta sigma converter sampling. The Easy Drive's innovative front-end sampling architecture controls the switching pattern of the capacitor array. When summed over the entire conversion cycle, the total differential input current is zero, independent of the differential input voltage, common mode input voltage, reference voltage, or output code. The common mode input current is constant and proportional to the difference between the input common mode voltage and reference common mode voltage.

Direct digitization of external sensors with high impedances is now possible without the need for internal or external amplifiers. Bridges, RTDs, thermocouples, acoustic, piezo and other sensors can be connected directly to the ADC input. The addition of external capacitors reduces the charge kickback spikes seen at the input of the ADC. An external 1uF capacitor reduces a 1V spike to 18uV.

In addition to directly connecting the ADC to high impedance sensors, the Easy Drive architecture also allows designers to add an RC network to the front end for low pass and anti-alias filtering. External RC networks applied to the input of the LTC2498 simply integrate (average) the input current spikes generated by the ADC. Since the average differential input current is zero, the total error introduced by

the external RC network is zero if the resistance tied to the plus/minus inputs of the ADC is balanced. Resistances up to 100k Ohms, combined with capacitors up to 10uF may be placed in front of the ADC with less than 0.002% full-scale error (see Figure 3), while conventional delta sigma ADCs with the same input network have greater than 10% full-scale errors (100,000ppm). No errors are introduced even if the external resistances are not balanced, as long as the common mode input voltage is equal to the common mode reference voltage.

The Easy Drive architecture makes it possible to measure all types of sensors without an internal buffer. Multi-channel and single channel ADCs using the Easy Drive technology are currently available in 16- and 24-bit versions. All Easy Drive ADCs include no latency conversions, on-chip oscillators with guaranteed line frequency rejection, precise DC specifications and the ease-of-use common to all of Linear Technology's delta sigma ADC converters. The temperature sensor internal to the LTC2498 makes cold junction compensation simple and accurate. These features, plus up to 16 input channels, make the LTC2498 ideal for measuring multiple sensors for test, measurement and data acquisition designs.

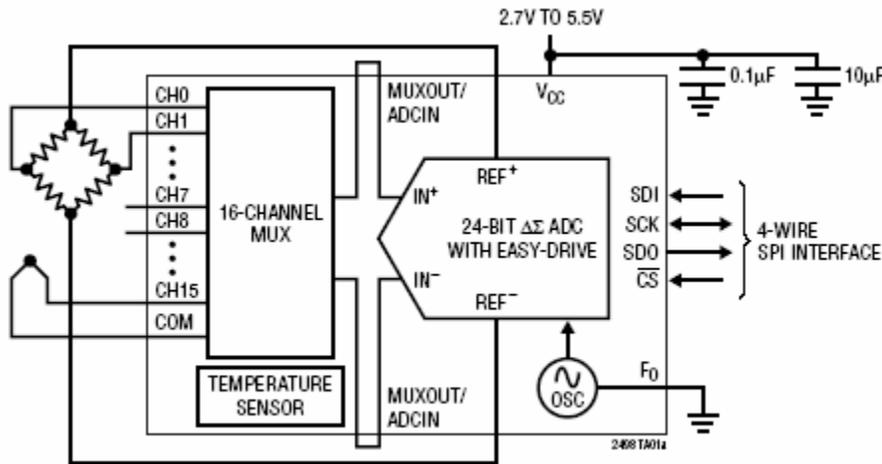


Figure 1. The LTC2498 measures up to 16 single-ended, 8 differential channels or combinations of both.

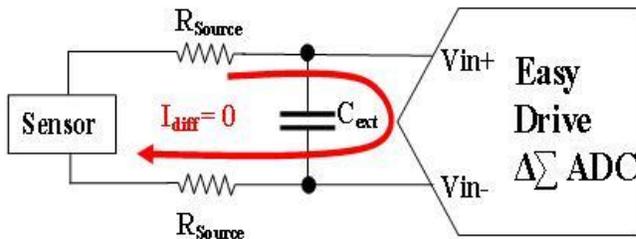


Figure 2. Easy Drive technology automatically cancels differential input current, thus allowing direct digitization of large external RC networks.

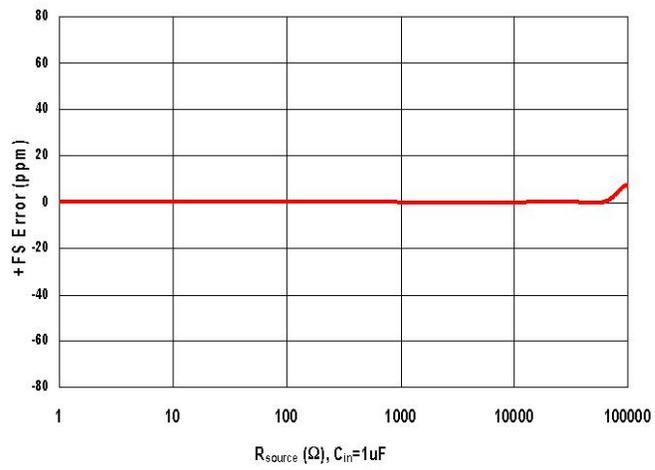


Figure 3. The Easy Drive technology dramatically reduces full-scale errors due to incomplete settling of large external RC networks.