Introduction

Isolation of analog and digital signals has always been seen by design engineers as the ideal way to steer conflicting or interfering ground currents away from each other and back to their common supplies. Any ground current change in the analog signal path of an ADC, for instance, will change the effective input voltage seen by the device. An unintentional 1 mA ground return flowing in the analog input reference ground will remove 5 µV from the effective input voltage seen by the ADC via a typical 5 mΩ ground return trace. That might not have been a big deal back in the day when 12-bit converters were state of the art, but today a 24-bit ΔΣ ADC is capable of resolving analog input changes as low as ±300 nV. The 5 µV error caused by the return current translates to 16 LSBs of conversion error, so before you know it, the 24-bit ΔΣ your project needed at the design stage is only a 20-bit ΔΣ by the time it gets to your application board. Add in the switching noise generated by your 10 MHz clock, the conversion noise from the SPI interface and the variation in ground current with converted digital output density and it should become obvious that both ac and dc current changes flowing in the analog portion of the circuit will dramatically reduce the available resolution and accuracy of the ADC employed.

The same argument can be used in DAC circuits. Unwanted digital noise will sum into the analog ground return and create output voltage errors unless the designer deals with the problem.

This application note showcases the basic IsoLoop building blocks and their use in isolated converter applications.

NVE CORPORATION

Applications

Isolated Data Converters are one of the best applications for NVE's IsoLoop isolators. No other isolation technology on the market today can match the IsoLoop's dynamic performance in demanding applications like single and multi-channel $\Delta\Sigma$ ADCs, SAR ADCs, audio DACs and high frequency telecom CODECs. Ultra-low 1 ns distortion, bandwidth up to 75 MHz, transient immunity approaching 40 kV/µs with no internal data clock, and 2500 V standoff voltage make the IsoLoop the only real choice in precision converter isolation.

Delta-Sigma ($\Delta\Sigma$) A/D Converter

Figure 1 illustrates a typical $\Delta\Sigma$ ADC circuit with a four-wire SPI interface. The resolution and dynamic range of the A/D allows direct connection to the sensor bridge with no signal conditioning electronics in between. The system clock is located on the isolated side of the system and four channels of isolation are required. In this case, the four-channel IL717 is a great choice to isolate the control bus from the microcontroller.
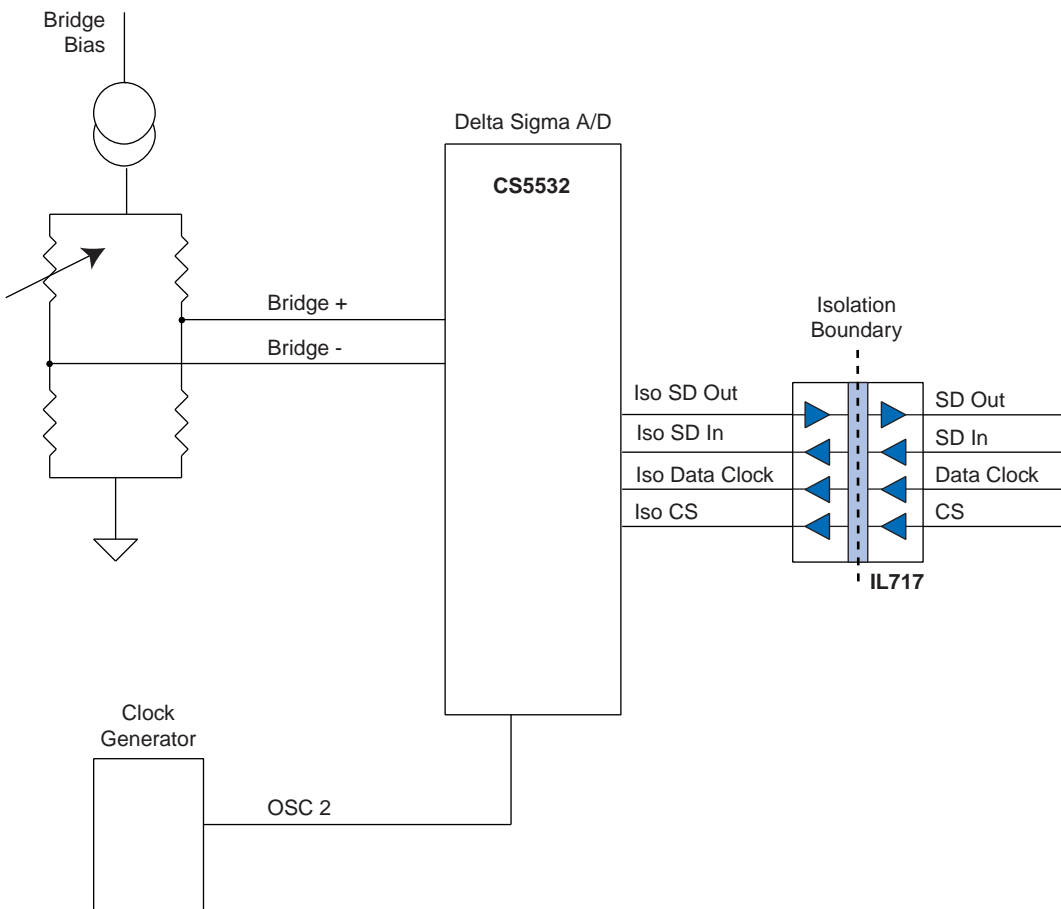
**Fig. 1. Isolated $\Delta\Sigma$ ADC With IL717**

Isolating Multiple ΔΣ Converters

With multiple ADCs arranged in a channel-to-channel isolation configuration, clock jitter and edge placement accuracy of the system clock must be well matched between ADCs to maintain accuracy and dynamic range across channels. For highest clock signal fidelity, use a single clock on the system side and distribute the clock to each ADC. Figure 2 shows such a multiple ΔΣ application. With its very low level of channel-to-channel distortion, NVE's five-channel IL261 is uniquely qualified to isolate multiple ΔΣs.
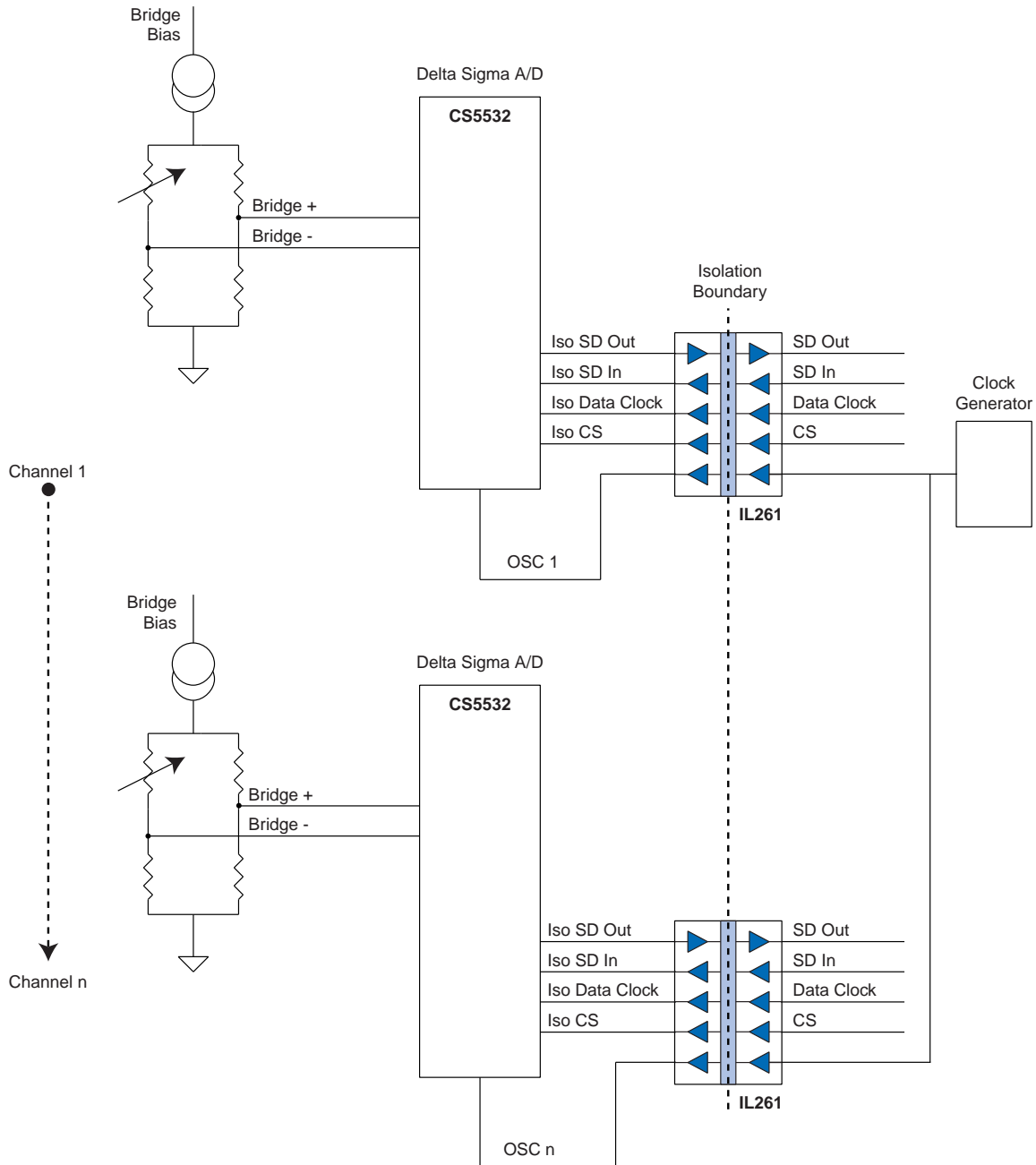
**Fig. 2. Multiple Isolated ΔΣ Converters With IL261**

Figure 3 shows a multi-channel sampling system with separate A/D cells. The IL262 is used to control the SPI lines and send back ADC *BUSY* commands to the host, allowing efficient interrupt-driven sampling. The *BUSY* line may also be used as a Frame Synchronization signal in video applications.
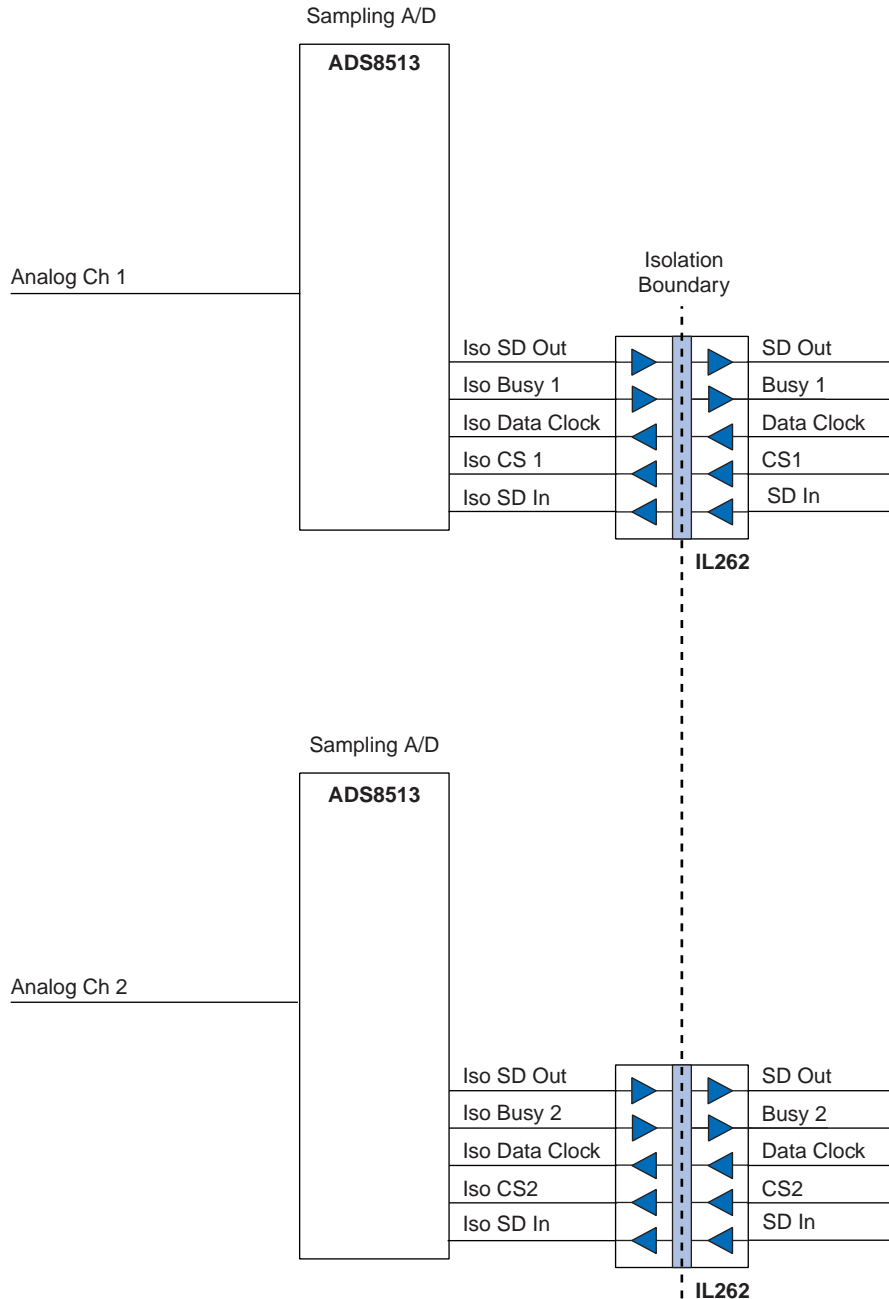
Fig. 3. Isolated Multi Channel Sampling With IL262

Isolating Multi-Channel A/D Converters

If input channel-to-channel isolation is not required, there are a number of A/D converters with multiplexed inputs available. The IL261 can be used to address channels in a multi-channel device such as the ADS7825. Four analog inputs can be sampled using the scheme in Figure 4:
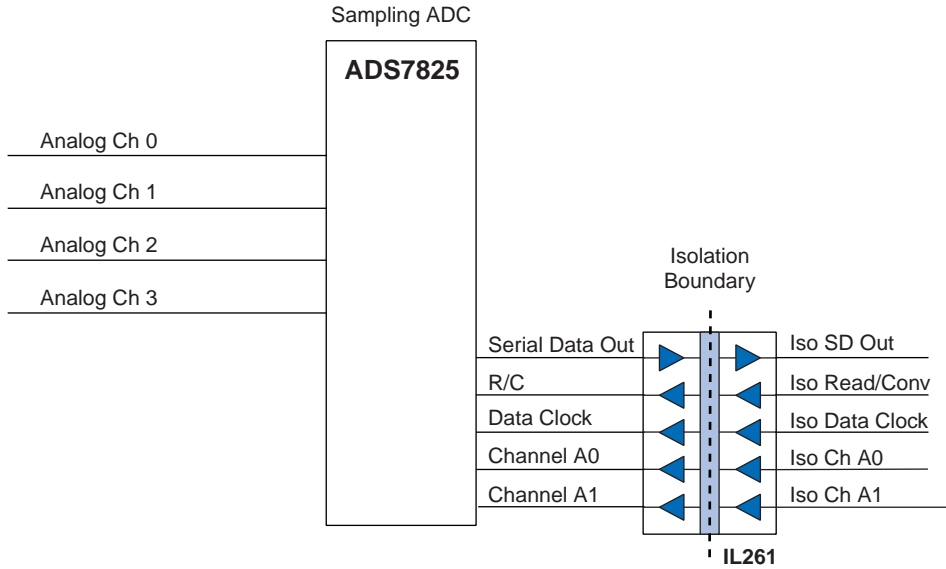
Fig. 4. Isolated Multi-channel ADC With IL261

Isolated Audio DAC

Figure 5 shows the PCM1681 isolated using two IL260s:
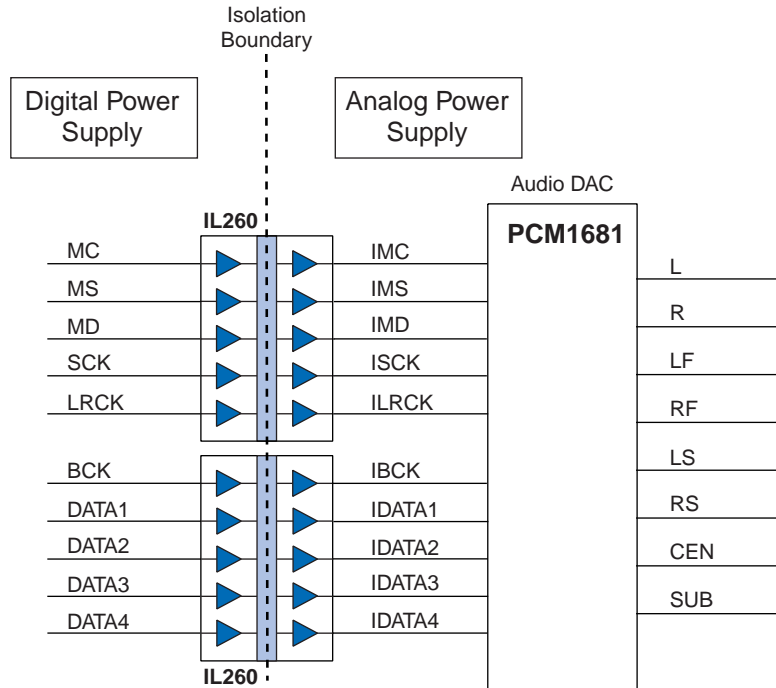
Fig. 5. Isolated Audio DAC Using Two IL260s

In home theatre applications like Figure 5, the isolation devices ensure the best performance possible because they eliminate much of the digital noise that tends to find its way onto the analog output if a PCB layout approach is all that's used to ensure high-fidelity sound. Most home theatre A/V receivers with decent sound and video specifications already use separate power supplies for analog and digital components, so adding the isolators isn't a big extra expense. What cost there is can usually be offset by reducing the number of layers in the motherboard that are dedicated to current steering.

Reducing the Footprint
Size definitely matters in the age of perpetual miniaturization of all things electronic. The IL7xx Series is available in MSOP packages that offer the smallest IEC 61010 safety recognized isolators on the market. These tiny devices take up less than 3 mm x 5 mm of board space, yet they'll withstand a voltage of 2300 V_{RMS} across the isolation barrier. Use the IL710-1 and the IL711-1 to create three-wire SPI-compatible isolated interfaces for DACs and ADCs. The ADC shown in Figure 6 is also an MSOP device, so all three chips shown occupy less board space than a typical 16-pin wide-body SOIC.
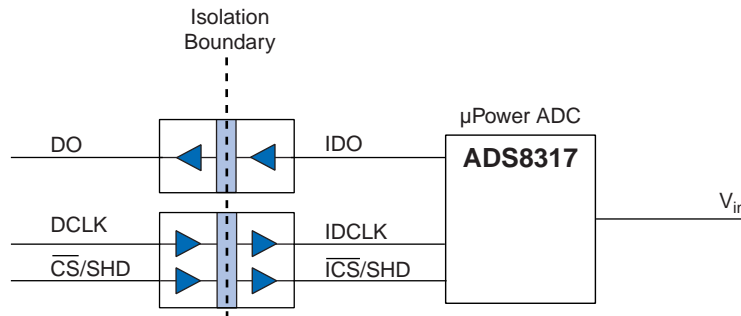
**Fig. 6. µPower ADC Isolated with IL711 and IL710**

Logic Level Shifting
The IsoLoop elegantly overcomes the problems of interfacing a device or function connected to one supply voltage to a device connected to another, different, voltage. All of the IL7xx and IL2xx devices are capable of translating 3.3 V and 5 V logic levels from any input series to any output series. In other words, a 3.3 V input signal can be converted to a 5 V logic signal and vice versa with no restrictions.

Lower Cost, More Flexible Isolation
The IL7xx and IL2xx Series of digital isolators are used as shown in the preceding text to isolate most types of ADC and DAC with bandwidths below 75 MHz. NVE's IL6xx series can be used to provide the same benefits as those devices, but at a lower cost per digital channel. The tradeoff is the addition of an external resistor, sized to provide 5 mA into the coil of the isolator. "Tradeoff" is perhaps the wrong term because the same resistor also provides considerable input signal flexibility. For instance, an IL610 is not only capable of the same 3 V to 5 V level shifting as the IL2xx and IL7xx Series, it can also take an input signal from any logic source, including 1.7 V, 2.4 V, 24 V, 4-20mA, differential RS-485 and RS-422. At this point it's fair to say that optocouplers have been able to do all that for years, which of course is true, but the IL6xx series offers the flexibility of the optocoupler diode input with the digital precision and fidelity that can only be achieved with an IsoLoop GMR isolated output stage. Throw in bandwidth of dc to 75 MHz, precision PWD of 3 ns, propagation delay of 6 ns, dc stability with input failsafe, and there's no optocoupler or opto replacement on earth capable of providing the same flexibility and quality of noise-free converter performance. The IL6xx series is available in the same packages as the IL7xx,

providing the designer with yet another degree of freedom. Figure 7 shows a ΔΣ ADC interfaced with the three-channel IL614. To reduce board space requirements, an IL610 and IL611 combination could have been used to provide the same interface with MSOP packages.
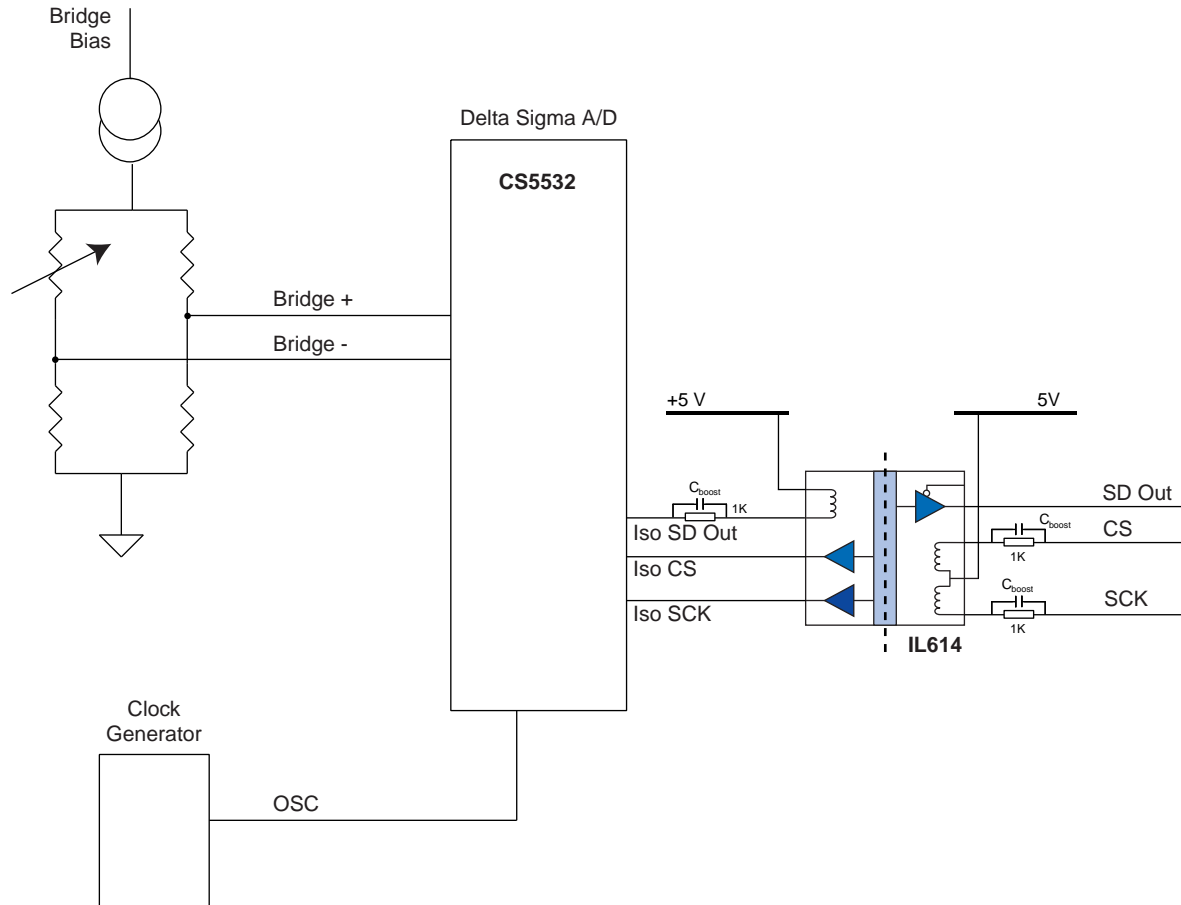
Fig. 7. Isolated ΔΣ ADC With an IL614

Application Tips

Power Supply Decoupling
Both isolator power supplies should be decoupled with low-ESR 47 nF ceramic capacitors. Decoupling capacitors should be located as close as possible to the V_{DD} pins.

Package Size vs. High-Voltage Standoff
IsoLoop Isolators are available in a broad range of package sizes from tiny MSOPs to wide-body SOIC packages for demanding high-voltage standoff.

The IsoLoop MSOP package is rated at 2300 V_{RMS} for 1 minute. All other package types have a rated voltage of 2500 V_{RMS}. MSOPs have a maximum working voltage of 130 V_{RMS} while narrow-body (0.15") SOIC packages have a maximum working voltage of 150 V_{RMS}. PDIPs and wide-body (0.3") SOIC packages have a maximum working voltage of 300 V_{RMS}.