Reducing System Cost, Size and Power Consumption in Isolated Data Acquisition Systems using ADS122U04

Introduction

Many high precision data acquisition systems require some form of galvanic isolation between the sensor and the signal chain to break potential ground loops. An example of this would be a temperature transmitter application where the user needs to measure a thermocouple attached to a grounded motor. In many cases, the motor ground and transmitter ground are at different potentials, causing current to leak through this path. As shown below in Figure 1, designers typically use digital isolators to break these ground loops to maintain measurement accuracy.

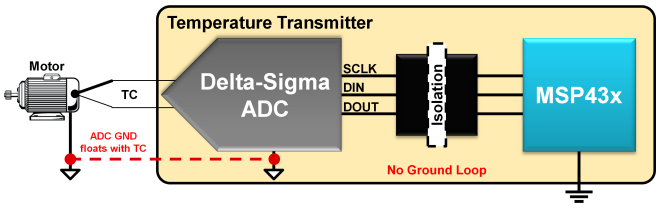

Figure 1. Breaking Ground Loops with Digital Isolation

However, adding digital isolators can pose a considerable design challenge. In these power-sensitive applications, every isolation channel increases system current consumption and adds cost, so minimizing the number of overall channels is a critical design goal. With this in mind, Texas Instruments is taking a unique approach to solving this challenge by introducing the industry's first sensor measurement ADC with a 2-wire UART interface, the ADS122U04.

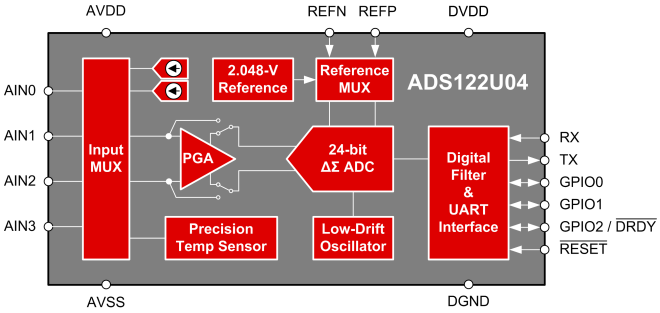

Figure 2. ADS122U04 Block Diagram

Reducing Power Consumption and Cost

Typical digital isolation implementations between ADCs and MCUs use one of two methods: first, isolating the SPI interface directly; or second, using a low-cost MCU as an "SPI-to-UART converter" on the primary side then isolating the RX and TX lines of the MCU's interface only. Examples of these types of implementations are shown below in Figure 3 and Figure 4, respectively.

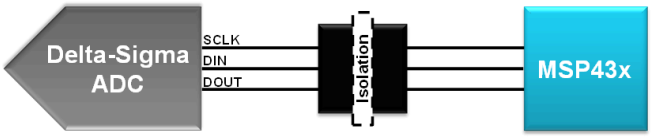

Figure 3. Isolation Scheme Using 3-wire SPI

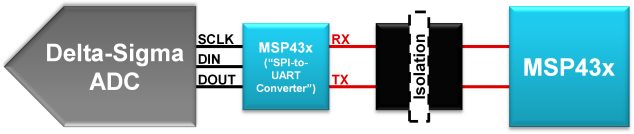

Figure 4. Isolation Scheme Using "SPI-to-UART Converter"

Both of these solutions seek to minimize the number of digital isolation channels using conventional methods, but they both have their shortcomings. The first solution, shown in Figure 3, isolates the SPI interface directly but requires at least three isolation channels and can require up to four or five depending on the system's needs. The second solution shown in Figure 4 reduces the number of isolation channels to two at the expense of a second MCU that consumes additional power, board space, and cost.

The ADS122U04 offers the best of both solutions by combining the direct isolation method of Figure 3 with the reduction in isolation channel count from Figure 4. This ADC replaces the standard SPI interface with a 2-wire UART interface. With this design change, engineers now only need a two channel digital isolator – with no additional components – depicted in Figure 5 below.

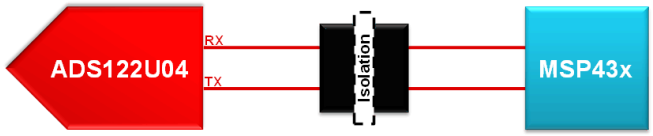

Figure 5. Isolation Scheme Using ADS122U04

This reduction in the number of isolation channels has a measureable effect. Table 1 below compares the current consumption and channel count of TI's ISO77xx series of digital isolators. Using the ADS122U04 with the ISO7721, designers can realize a 31% reduction in power consumption compared to the 3-channel ISO7731 (45% reduction if replacing the 4-channel ISO7741). Similarly, the 2-channel isolator costs 30% less than the 3-channel isolator and 45% less than the 4-channel isolator.

Table 1. ISO77xx Power and Channel Count Comparison

Isolator	Channel Count	Current @ DC (mA)	Current @ 1Mbps (mA)
ISO7721	2 (1/1)	2.0	3.2
ISO7731	3 (2/1)	2.9	4.6
ISO7741	4 (3/1)	3.5	5.9

Additional Features

Designed for loop- or battery-powered applications, the ADS122U04 incorporates two additional features to minimize digital isolation power consumption and channel count: automatic data read mode (ADRM) and three general purpose input/output (GPIO) pins.

In automatic data read mode (ADRM), the ADS122U04 transmits conversion data automatically on the TX pin whenever a new conversion result completes. The host does not have to send a command to request data from the ADC. Shown in Figure 6, ADRM provides an absolute minimum of communication between the ADC and MCU, allowing for longer digital isolator idle time to further reduce power consumption. Additionally, ADRM does not require the host to monitor the $\overline{\text{DRDY}}$ signal, which would require a third isolation channel.

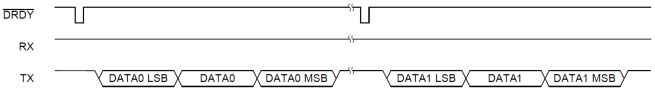

Figure 6. Automatic Data Read Mode Timing Diagram

The ADS122U04's three general purpose input/output (GPIO) pins further help reduce the amount of necessary digital isolation channels for applications that require additional switches and/or multiplexers on the primary side of the system. For example, high-channel count systems may need to expand the ADC's available input channels with an 8:1 multiplexer, similar to Figure 7 below. Without integrated GPIO pins, additional control lines from the MCU would have to be brought across the isolation barrier, requiring more isolation channels and increasing power consumption.

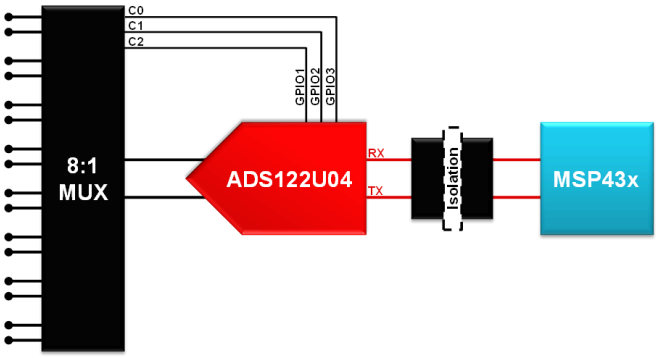

Figure 7. Controlling External MUX with GPIO Pins on ADS122U04

Conclusion

Many data acquisition systems require digital isolation as a means of breaking ground loops. Using TI's ADS122U04, the industry's first sensor measurement ADC with UART interface, designers can now reduce their digital isolator power consumption and cost by >30% compared to conventional implementations while still taking advantage of the high resolution and integration of a 24-bit delta-sigma ADC.

Table 2. Device Information

Device	Description
ADS122U04	24-Bit, 4-Channel, 2-kSPS, Delta-Sigma ADC With UART Interface
ISO7721	High Speed, Robust EMC Reinforced Dual-Channel Digital Isolator

Table 3. Related TI Technical Documents

SLYY112	Fully Integrated Signal and Power Isolation – Applications and Benefits

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