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.

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.

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.

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 1. Breaking Ground Loops with Digital Isolation

Figure 2. ADS122U04 Block Diagram

Figure 3. Isolation Scheme Using 3-wire SPI

Figure 4. Isolation Scheme Using “SPI-to-UART Converter”
Reducing System Cost, Size and Power Consumption in Isolated Data Acquisition Systems using ADS122U04

This reduction in the number of isolation channels has a measurable 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

<table>
<thead>
<tr>
<th>Isolator</th>
<th>Channel Count</th>
<th>Current @ DC (mA)</th>
<th>Current @ 1Mbps (mA)</th>
</tr>
</thead>
<tbody>
<tr>
<td>ISO7721</td>
<td>2 (1/1)</td>
<td>2.0</td>
<td>3.2</td>
</tr>
<tr>
<td>ISO7731</td>
<td>3 (2/1)</td>
<td>2.9</td>
<td>4.6</td>
</tr>
<tr>
<td>ISO7741</td>
<td>4 (3/1)</td>
<td>3.5</td>
<td>5.9</td>
</tr>
</tbody>
</table>

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 DRDY signal, which would require a third isolation channel.

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.

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

<table>
<thead>
<tr>
<th>Device</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>ADS122U04</td>
<td>24-Bit, 4-Channel, 2-kSPS, Delta-Sigma ADC With UART Interface</td>
</tr>
<tr>
<td>ISO7721</td>
<td>High Speed, Robust EMC Reinforced Dual-Channel Digital Isolator</td>
</tr>
</tbody>
</table>

Table 3. Related TI Technical Documents

<table>
<thead>
<tr>
<th>Document</th>
<th>Title</th>
</tr>
</thead>
<tbody>
<tr>
<td>SLYY112</td>
<td>Fully Integrated Signal and Power Isolation – Applications and Benefits</td>
</tr>
</tbody>
</table>
IMPORTANT NOTICE FOR TI DESIGN INFORMATION AND RESOURCES

Texas Instruments Incorporated (‘TI’) technical, application or other design advice, services or information, including, but not limited to, reference designs and materials relating to evaluation modules, (collectively, “TI Resources”) are intended to assist designers who are developing applications that incorporate TI products; by downloading, accessing or using any particular TI Resource in any way, you (individually or, if you are acting on behalf of a company, your company) agree to use it solely for this purpose and subject to the terms of this Notice.

TI’s provision of TI Resources does not expand or otherwise alter TI’s applicable published warranties or warranty disclaimers for TI products, and no additional obligations or liabilities arise from TI providing such TI Resources. TI reserves the right to make corrections, enhancements, improvements and other changes to its TI Resources.

You understand and agree that you remain responsible for using your independent analysis, evaluation and judgment in designing your applications and that you have full and exclusive responsibility to assure the safety of your applications and compliance of your applications (and of all TI products used in or for your applications) with all applicable regulations, laws and other applicable requirements. You represent that, with respect to your applications, you have all the necessary expertise to create and implement safeguards that (1) anticipate dangerous consequences of failures, (2) monitor failures and their consequences, and (3) lessen the likelihood of failures that might cause harm and take appropriate actions. You agree that prior to using or distributing any applications that include TI products, you will thoroughly test such applications and the functionality of such TI products as used in such applications. TI has not conducted any testing other than that specifically described in the published documentation for a particular TI Resource.

You are authorized to use, copy and modify any individual TI Resource only in connection with the development of applications that include the TI product(s) identified in such TI Resource. NO OTHER LICENSE, EXPRESS OR IMPLIED, BY ESTOPPEL OR OTHERWISE TO ANY OTHER TI INTELLECTUAL PROPERTY RIGHT. AND NO LICENSE TO ANY TECHNOLOGY OR INTELLECTUAL PROPERTY RIGHT OF TI OR ANY THIRD PARTY IS GRANTED HEREIN, including but not limited to any patent right, copyright, mask work right, or other intellectual property right relating to any combination, machine, or process in which TI products or services are used. Information regarding or referencing third-party products or services does not constitute a license to use such products or services, or a warranty or endorsement thereof. Use of TI Resources may require a license from a third party under the patents or other intellectual property of the third party, or a license from TI under the patents or other intellectual property of TI.

TI RESOURCES ARE PROVIDED “AS IS” AND WITH ALL FAULTS. TI DISCLAIMS ALL OTHER WARRANTIES OR REPRESENTATIONS, EXPRESS OR IMPLIED, REGARDING TI RESOURCES OR USE THEREOF, INCLUDING BUT NOT LIMITED TO ACCURACY OR COMPLETENESS, TITLE, ANY EPIDEMIC FAILURE WARRANTY AND ANY IMPLIED WARRANTIES OF MERCHANTABILITY, FITNESS FOR A PARTICULAR PURPOSE, AND NON-INFRINGEMENT OF ANY THIRD PARTY INTELLECTUAL PROPERTY RIGHTS.

TI SHALL NOT BE LIABLE FOR AND SHALL NOT DEFEND OR INDEMNIFY YOU AGAINST ANY CLAIM, INCLUDING BUT NOT LIMITED TO ANY INFRINGEMENT CLAIM THAT RELATES TO OR IS BASED ON ANY COMBINATION OF PRODUCTS EVEN IF DESCRIBED IN TI RESOURCES OR OTHERWISE. IN NO EVENT SHALL TI BE LIABLE FOR ANY ACTUAL, DIRECT, SPECIAL, COLLATERAL, INDIRECT, PUNITIVE, INCIDENTAL, CONSEQUENTIAL OR EXEMPLARY DAMAGES IN CONNECTION WITH OR ARISING OUT OF TI RESOURCES OR USE THEREOF, AND REGARDLESS OF WHETHER TI HAS BEEN ADVISED OF THE POSSIBILITY OF SUCH DAMAGES.

You agree to fully indemnify TI and its representatives against any damages, costs, losses, and/or liabilities arising out of your non-compliance with the terms and provisions of this Notice.

This Notice applies to TI Resources. Additional terms apply to the use and purchase of certain types of materials, TI products and services. These include, without limitation, TI’s standard terms for semiconductor products (http://www.ti.com/sc/docs/stdterms.htm), evaluation modules, and samples (http://www.ti.com/sc/docs/sampterms.htm).

Mailing Address: Texas Instruments, Post Office Box 655303, Dallas, Texas 75265
Copyright © 2017, Texas Instruments Incorporated