

How to Isolate Two-Wire Loop-Powered Field Transmitters



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Improving process, quality, and consistency starts with automation in today's expanding industrial world. Growth in system monitoring equipment, such as field transmitters, has made manufacturing in factories more efficient and reliable. Loop-powered field transmitters are a sensor variant which use the two-wire 4 mA to 20 mA bus for both communication and power for the equipment. This removes the need for additional wiring and components to separately power the system, saving the factory cost on both materials and installation.

A field transmitter consists of a sensor, a transmitter, and, in certain circumstances, an isolator. Isolation is needed when the sensor has the ability to be electrically connected to a voltage potential that is different than the loop supply. Since the entire system is powered from 4 mA–20 mA, the zero scale value sets the maximum budget for the system, which can be on the order of 3.3 mA. Power savings from any of the components, including the isolator, can be distributed among the system allowing for more end product differentiation. Figure 1 shows a typical block diagram including the current flow used for the communication bus and power for the system.

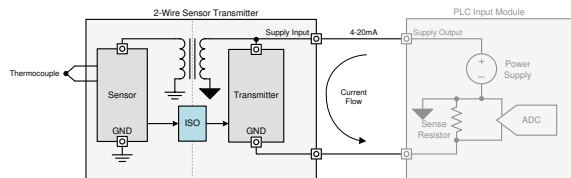


Figure 1. Loop-Powered Field Transmitter with a PLC Input Module

Implementing isolation within 4 mA to 20 mA loop-powered field transmitters can be challenging for process automation end equipment designers. Since these systems operate off a strict power budget, decisions are made to trade off performance with features. Designers may fear that integrating isolation uses board space they may not have, while taking significant power away from the other critical blocks in the system, potentially limiting equipment capability. However, advancements in digital isolation technology have brought power consumption down an order of

magnitude and increased isolator channel density, giving designers more design flexibility in sensor design systems.

Historically, the only available low power isolation options were either pulse transformers or opto-couplers. These isolation solutions can consume anywhere from 500 μ A up to 1 mA per channel, forcing designers to minimize the number of communication lines brought across the isolation barrier or slowing data transfer speeds. Additional components, such as a second micro controller (MCU), could be used to decrease the communication lines across the isolation barrier, further consuming more of the constrained power budget. In these solutions, communication speed and, in some cases, data transfer rate can be limited to just a single direction with so few isolation lines. A typical implementation, shown in Figure 2, uses a pulse transformer as a unidirectional solution for implementing isolation in a field transmitter and an additional MCU to convert the isolated data interface to a single line.

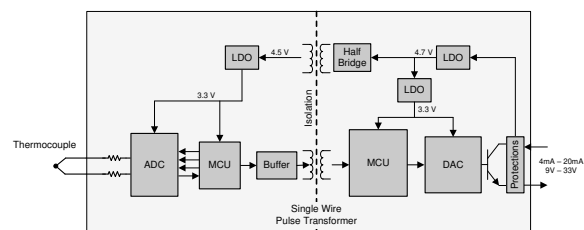


Figure 2. Field Transmitter - Single Channel Pulse Transformer for Data Isolation

Texas Instruments' [ISO70xx](#) digital isolator family integrates two to four ultra-low-power digital isolator channels in a small 8-pin D and 16-pin DBQ package. This device offers up to 3.0 kVrms isolation rating per UL1577 and 400 Vrms of isolation working voltage per VDE. In loop-powered field transmitters, the [ISO70xx](#) family can be used to replace opto-couplers or a pulse transformer at a fraction of the power and footprint size. Figure 3 shows an example of the four channel [ISO7041](#) used in a field transmitter.

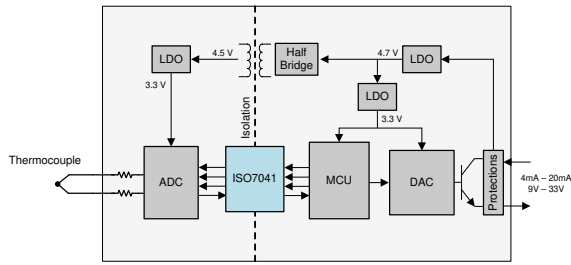


Figure 3. Field Transmitter - ISO7041 for Multi-channel and Bi-directional Data Isolation

Benefits using digital isolators in field transmitters:

- Power scalability: The ISO7041 power scales with the data transfer rate as shown in Figure 4. At 10 kbps, all four channels consume under 20 μ A combined. The power savings can be distributed to the sensor to improve accuracy or precision of the system.

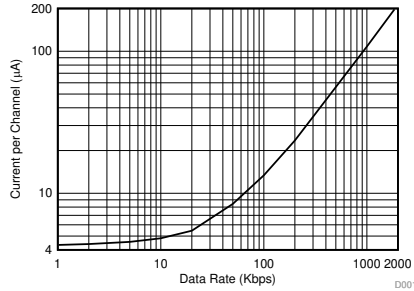


Figure 4. ISO7041 Individual Channel Power Versus Data Rate

- Increased data throughput: Four digital isolator channels can operate at up to 2 Mbps while consuming very low power for easy two way communication. This flexibility allows designers to rethink and re-architect how they transfer data between the sensor and transmitter.
- Extended temperature range: The ISO7021 and ISO7041 are rated from -55°C to 125°C while most opto-couplers are rated up to a maximum of 85°C. There are some opto-couplers available in the market rated for 105°C that come at a higher cost.
- Smaller solution size: A single channel pulse transformer for data isolation can require a circuit board surface area as large as 50 mm² with an additional height requirement of 5 mm. Opto-coupler designs can occupy similar board area or more depending on the amount of data lines. The ISO7041 in the 16-pin DBQ package offers four channels of data isolation across 17.5 mm² of area with a height requirement of 2.5 mm. Overall, a digital isolator solution is a more compact design, including lower package height.

- Stability and reliability: ISO70xx uses TI's capacitive isolation technology where the high voltage capacitors made from SiO₂ dielectric provide high level of isolation. The high voltage capacitors are constructed in a well controlled semiconductor process and offer very low part-to-part variation. Also, the isolation barrier lifetime is well defined by the time dependent dielectric breakdown (TDDB) technique. Opto-couplers have a lot of manufacturing variability and no defined technique in the standard to calculate lifetime of the device.

For years, a single pulse transformer was the only power efficient way to isolate data between the sensor and transmitter in a 4 mA–20 mA loop-powered field transmitter. Later, low speed opto-coupler solutions were able to replace pulse transformers at adequate power budgets. Now, ultra-low-power digital isolators are available to provide data isolation between the sensor and transmitter at extremely low power levels. The ISO70xx is the latest release in low power technologies for galvanic isolation. For a deeper explanation of TI's isolation technology, refer to the *Enabling High Voltage Signal Isolation Quality and Reliability White Paper*. The size, scalability, technology robustness, and ultra-low-power consumption of the ISO70xx digital isolators make them an optimal choice for power constrained designs.

Table 1. Related Technical Documents

Literature Number	Document Title
TIDU813B	Uniquely Efficient Isolated DC/DC Converter for Ultra-Low Power and Low Power Apps Reference Design
SLAA426	Considerations for Selecting Digital Isolators
SLLY063	High-voltage reinforced isolation: Definitions and test methodologies
SLLA284A	Digital Isolator Design Guide

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