

Staying on Budget: How Digital Isolators Are Transforming Field Transmitters



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What keeps chocolate factories, oil refineries and water treatment plants operating successfully? It's automated machinery, which has the ability to sense, measure and react during every step of a designated process.

Field transmitters give factories a way to automate the sensing, measuring and communicating of critical system vitals such as temperature, pressure and flow. Some estimates indicate that more than 100 million field transmitters are shipped out annually in order to support industrial applications worldwide. Without the measurement output from field transmitters, factory automation would not be as accurate or reliable – limiting its effectiveness.

Before exploring the importance of field transmitters and their design challenges, let's briefly define field transmitters.



Figure 1. Pressure Transmitters

At a basic level, a field transmitter is a device that uses sensors to measure and communicate information about the surrounding environment (temperature, pressure, flow, etc.) This device converts its measurements into a readable electrical signal and then transfers data across long lengths of cable to a centralized device capable of processing the information and calculating next steps. One of the more common field transmitter architectures, frequently referred to as two-wire or loop-powered systems, operates on a 4- to 20-mA bus and is the focus of this article.

Field Transmitter Power Considerations

While it may be obvious why the sensing element of a field transmitter needs to be as close to the source as possible, it may not be as obvious why two-wire transmitters are the preferred option when the power consumption of the sensing technique allows. A 4- to 20-mA transmitter draws current from the receiver based on the measurement it needs to communicate and represent: down to 3.8 mA for the lowest measurement reading and up to 20.5 mA for the highest. The reason why two-wire transmitters are the best fit is because the

current acts as both the power source and signal bus for the system; no secondary power supply is necessary at the sensor location, thus achieving both robust signal integrity and the ability to use cheaper and significantly smaller amounts of wire.

Field Transmitter Design Challenges

Because of the low end of the 4- to 20-mA spectrum, all two-wire field transmitters must be designed to operate off of less than 3.6 mA of current. This creates a difficult power budget for designers, who now must evaluate the power consumption of their every design choice. Not all sensing techniques are able to run on <3.6 mA.

Field transmitters ensure that measurements are taken as close to the source as possible, although they may be hundreds or even thousands of meters from their receiver. While such a setup is designed to help increase accuracy and effectiveness in factory settings, the unintentional ground loops in long-distance deployments may actually have the opposite effect and result in inaccurate measurements, and even decrease factory efficiency.

To overcome this challenge, the addition of an isolation barrier between the sensor and current loop enables independent grounding of both the sensor and the receiver, eliminating unintentional ground loops.

Isolating on a Power Budget

Historically, designers only had two options for isolating their systems within the necessary power budget: optocouplers or pulse transformers. Since both isolation techniques may consume as much as a third of the available current, designers have to make many system architecture decisions to accommodate the isolation, such as throttling data rates; adding additional microcontrollers to reduce communication lines across the isolation barrier; and sourcing the lowest-power, highest-temperature-rated options. Figure 2 shows an example of this pulse transformer architecture.

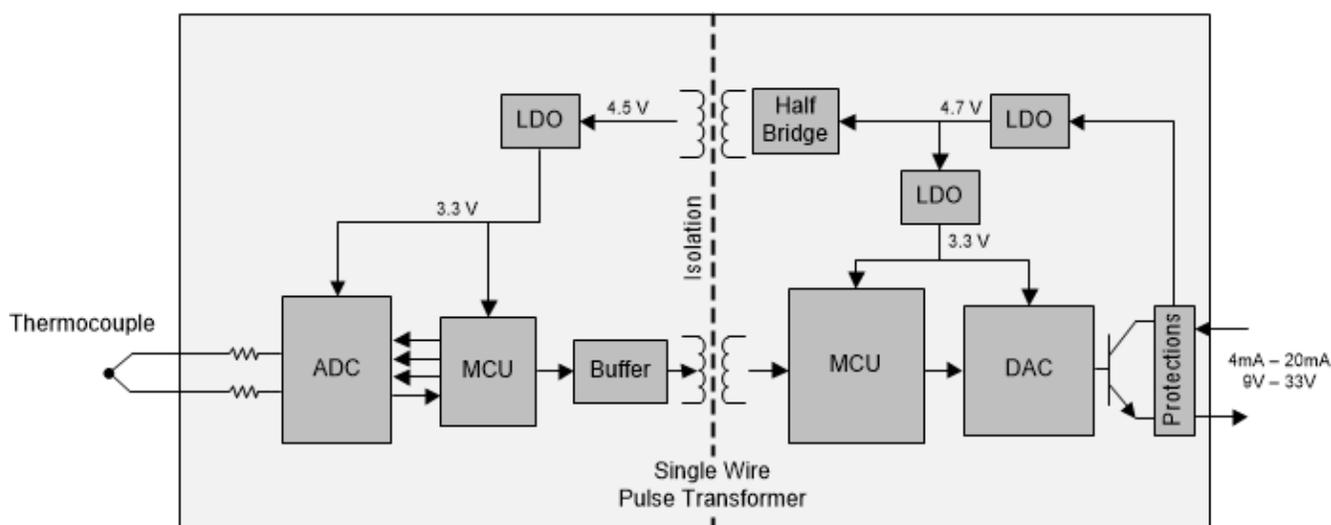


Figure 2. Field Transmitter Example - Single-channel Pulse Transformer for Data Isolation

Despite their many advantages, digital isolators historically had little to no use in field transmitter designs because the amount of current they consumed was outside the budget requirements. But major advancements in digital isolator technology, such as reduced power consumption, have enabled key field transmitter system improvements. For example, TI's [ISO7041](#) ultra-low-power digital isolator can consume as little as 4.2 μ A per channel in quiescent operation.

Some of the advantages, which are discussed in further detail in the application note "[How to Isolate Two-Wire Loop-Powered Field Transmitters](#)," include:

- **Ultra-low-power scalability.** Total power consumption under 20 μ A at 10 kbps provides significant power back to the system and enables other system improvements that were historically impossible to accomplish within the power budget.
- **Increased data rate/throughput.** Data rates up to 2 Mbps enable data-transfer improvements between the sensor and the transmitter.

- **Wider temperature ranges.** Extended temperature ranges from -55°C to 125°C can enable transmitter use in extreme conditions without the need to source higher-temperature-rated, higher-cost optocouplers.
- **Reduced solution size.** Higher channel counts in less than half the area, along with reduced height requirements, lead to more compact designs and reduced printed circuit board cost.
- **Improved reliability and predictability.** Highly controlled semiconductor processes provide reliable isolation with well-defined industry-standard isolation barrier lifetimes and much lower device-to-device variation compared to optocouplers.

For a head start on an isolated 4- to 20-mA design, the TI reference designs [Isolated Power and Data Interface for Low-Power Applications Reference Design](#) and [RTD Replacement for Cold Junction Compensation in a Temperature Sensor Reference Design](#) provide an isolated temperature transmitter design with TI's latest devices. [Figure 3](#) is a block diagram showing both designs working together.

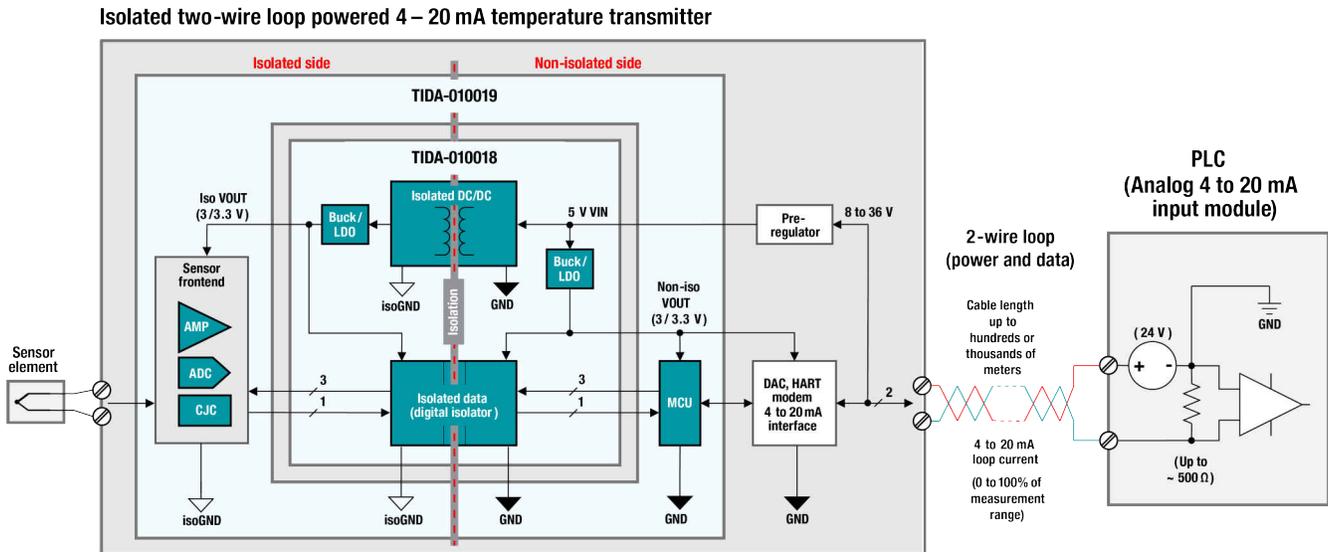


Figure 3. Isolated Temperature Transmitter Reference Design Block Diagram

The need for precise and abundant sensor measurements is why field transmitters are critical to running intelligent and safe processes in the world of factory automation. While reducing overall system cost continues to drive the need for low-power two-wire solutions, times have changed, and digital isolators such as the 4 channel [ISO7041](#) and 2 channel [ISO7021](#) can improve reliability and enhance features while sticking to power and cost budgets. As automation continues to expand and improve, no stone must go unturned in order to increase throughput, improve consistency, and reduce cost and energy.

Additional Resources

- Explore our growing [portfolio of digital isolators](#).
- Learn more about our [factory automation and control solutions](#).

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