Simplifying a ±10 V PLC Analog Input Module Signal Chain Using the ADS125H02

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TEXAS INSTRUMENTS

Introduction

In factory automation and process control systems, programmable logic controllers (PLCs) use analog input (AI) modules to monitor process-level sensor inputs, including:

- Voltage (±10 V, ±5 V, 0-10 V, 0-5 V)
- Current (0-20 mA, 4-20 mA)
- Temperature (thermocouples / RTDs)
- Weight (load cells / strain gages)

Sensor inputs can be directly measured with highly-integrated 16- or 24-bit delta-sigma ADCs, reducing system size and component count. For example, Figure 1 shows an AI module block diagram designed to accept flow, temperature, pressure, or level transmitter inputs.

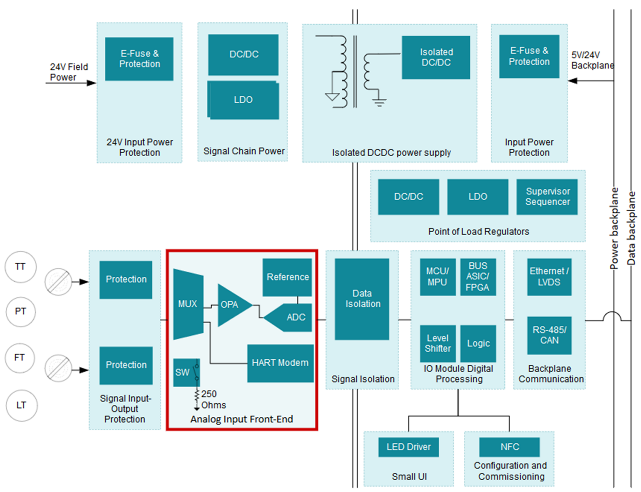

Figure 1. AI Module Block Diagram

However, measuring ±10 V process signals typically requires additional conditioning circuitry to reduce these voltages to the 2.5-V to 5-V input range of the ADC while maintaining high input impedance (>1 MΩ).

AI module manufacturers commonly use buffers followed by either passive (resistor divider) or active (difference amplifier) methods to attenuate these ±10 V process signals. Unfortunately, these configurations require multiple components that introduce system challenges including higher cost, larger PCB footprint, increased complexity, and additional DC errors (offset, gain error and drift).

To help solve these design challenges, Texas Instruments has released the ADS125H02, a 24-bit delta-sigma ADC that can measure full-scale input ranges from ±20 mV to ±20 V. The ADS125H02 combines a true high-voltage, high-input impedance front end with a precision analog signal chain (PGA, VREF, excitation current sources, oscillator, and so forth) to help:

- Reduce system cost
- Shrink PCB area
- Lower system complexity
- Remove multiple DC error sources

This application note examines two traditional ±10 V measurement implementations and compares them to the simplified method enabled by the ADS125H02.

Traditional ±10 V Measurement Solutions

As discussed in the previous section, existing solutions to measure ±10 V analog inputs typically use one of two methods: a resistor divider or a difference amplifier. Figure 2 shows an example signal chain using a buffered resistor divider.

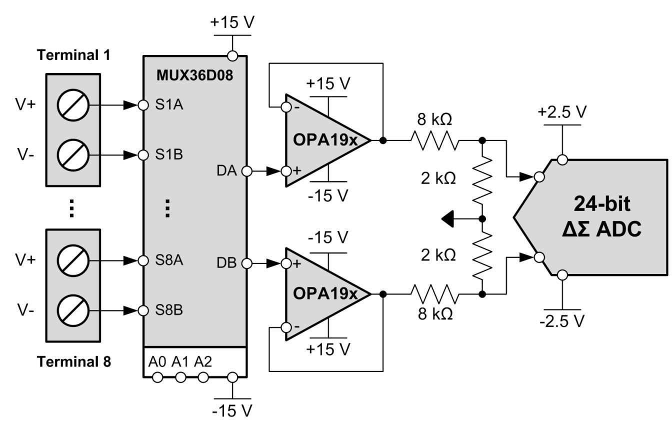

Figure 2. Measuring ±10 V with High-Voltage Multiplexer, Buffers, and Resistor Divider

In Figure 2, a multiplexed voltage input module is measured using two field terminals per channel (V+ and V-). After the multiplexer, two buffers (OPA192) provide high input impedance. Then, a resistor divider attenuates the ±10 V input signal by a factor of 5 so it can interface to the low-voltage signal range of the ADC.

[Figure 3](#) shows an alternative signal chain compared to [Figure 2](#), with the resistor divider replaced by a difference amplifier. Note that these discrete components (OPA192 and resistive gain network) can be replaced with an integrated device, such as the [INA143](#).

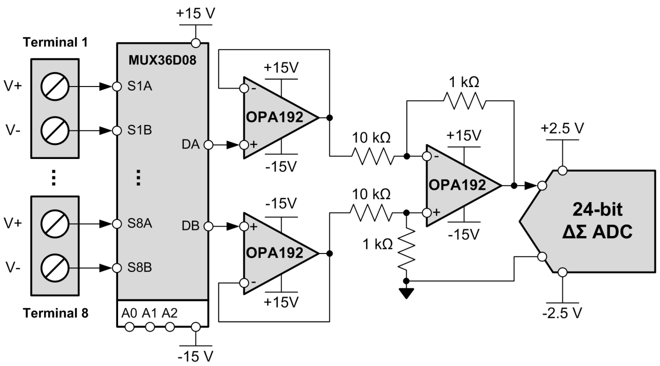

Figure 3. Measuring ±10 V with High-Voltage Multiplexer, Buffers, and Difference Amplifier

The signal chains in [Figure 2](#) and [Figure 3](#) require multiple amplifiers and a resistor network to measure the ±10 V inputs, increasing system size and cost while adding additional DC errors and noise.

Simplified ±10 V Measurement Solution

The ADS125H02 measures ±10 V signals directly - without any external attenuation - to help mitigate these design challenges. This ADC includes a high-voltage, high-input impedance (1 GΩ minimum) PGA that enables direct connection to the signal multiplexer as shown in [Figure 4](#).

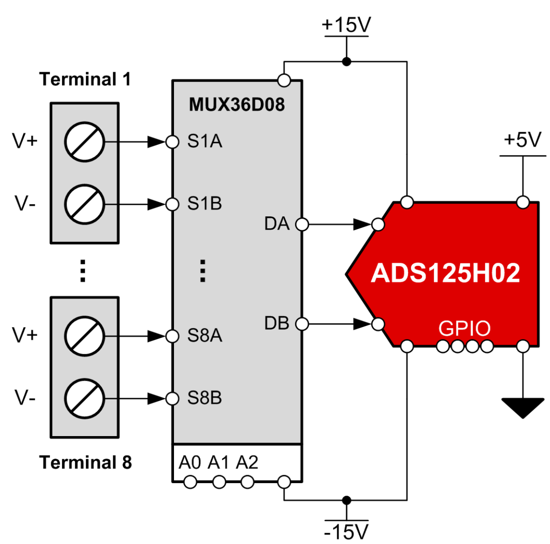

Figure 4. Simplified ±10 V Measurement Solution Using the ADS125H02

Connecting the ADS125H02 directly to the output of the multiplexer removes the need for the buffers and the subsequent attenuation stage. This simplification keeps design cost and size to a minimum, while eliminating time- and temperature-dependent drift errors contributed by these components.

Moreover, the single differential input of the ADS125H02 allows module manufacturers to design systems like those shown in [Figure 4](#) with any number of input channels – for example, 2-, 4-, 8-, and 16-channel voltage input – using one ADC. No ADC channels are wasted, and designers only need to expand the number of multiplexer channels to realize these different configurations. As a result, the ADS125H02 enables a highly-efficient, modular solution.

You can further simplify multichannel ±10 V measurement systems by using the four GPIO pins of the ADS125H02, which can be used to control the previously mentioned multiplexers ([Figure 5](#)).

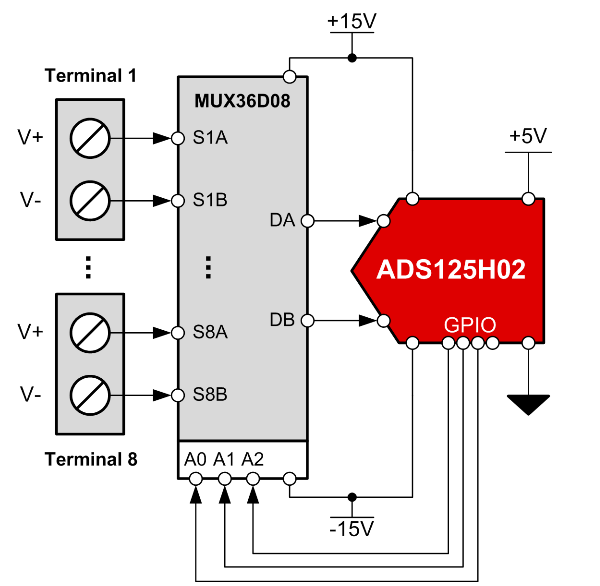

Figure 5. Controlling a Multiplexer with ADS125H02 GPIO Pins

These GPIOs eliminate additional control lines that must be brought across an isolation barrier, streamlining your design while also reducing system cost and size.

Conclusion

As the need for factory automation and process control systems continues to grow, so too will the need for precision, high-voltage signal measurements. Texas Instruments' ADS125H02 simplifies the signal chain for these ±10 V process signals as well as reduces AI module system cost, size, and DC errors.

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