Application Note

Optimizing Field Transmitters and Sensors with Analog Switches and Multiplexers

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ABSTRACT

The form, fit and function of a field transmitter has changed significantly since the first field transmitter was created in the 19^{th} century. Modern applications that use field transmitters and sensors to form a sensing layer, such as industrial process control systems, drive innovation around field transmitter optimization. This application note highlights how TI's family of analog switches and multiplexers improve measurement accuracy, reduce cost, and simplify designs across common applications like flow, pressure, level, and temperature sensors.

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1 Introduction

Field transmitters convert physical process variables such as temperature, pressure, flow, level and proximity into standardized signals for control systems. Modern designs are becoming increasingly universal, where a single hardware platform must accept multiple sensor types and share a common ADC across channels within a low power budget. By understanding the various parametric specs and features analog switches and multiplexers offer, these designs can be simplified to enable accurate and resilient signal chains.

2 Signal Chain Architecture

A typical multi-sensor field transmitter signal chain can include the following elements:

1. **Sensing element**: converts physical quantity to an electrical signal (voltage, resistance, current)
2. **Analog switch or multiplexer (MUX)**: selects the active sensor channel under MCU control
3. **Instrumentation amplifier (INA)**: amplifies the differential sensor signal and converts to single-ended
4. **Analog-to-digital Converter (ADC)**: digitizes the conditioned analog signal with high resolution (typically 16–24 bit for precision industrial measurements)
5. **Microcontroller (MCU)**: controls the MUX and initiates ADC conversions

By inserting a multiplexer before the Amp/ADC stage, one precision signal chain including the ADC and MCU can sequentially read **up to 16 sensor channels**, dramatically reducing BOM cost, PCB footprint, and total power consumption in various field instruments.

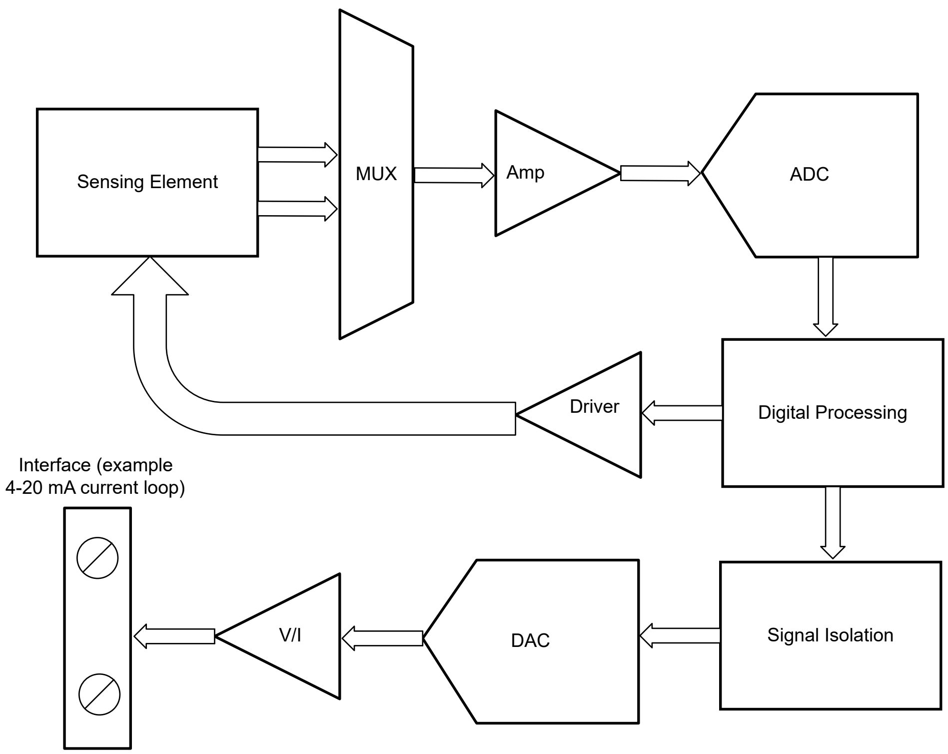

Figure 2-1. 4-20mA Interface Example

3 Types of transmitters and sensors

3.1 Flow Transmitters

Flow transmitters continuously measure fluid velocity and are typically implemented through electromagnetic or ultrasonic technology. Ultrasonic flow meters are commonly paired with a traditional analog switch design. Ultrasonic flow meters measure fluid velocity by calculating the transit-time difference between ultrasonic pulses propagating upstream and downstream through the flow medium. A typical, simple design uses two piezoelectric transducers mounted on a pipe: one acting as transmitter (TX) and the other as receiver (RX). Since the downstream signal arrives faster than the upstream signal, flow velocity is calculated from this difference in time-of-flight (ToF). This transit-time ultrasonic approach is commonly used for both liquid and gas flow measurement and works effectively across a wide range of pipe diameters.

For more information on maximizing the amount of transducers in a system, see the *Switching Ultrasonic and Ultrasound Signals* application note.

Part Number	Vcc Range (V)	Channel Count	Configuration	R_{on} (Ω)	Features
TS5A23157	5	2	2:1	10	
TMUX4819	5 (± 15V signals)	1	2:1	5	• Supports input voltage beyond supply • Supports negative voltages • 1.2V compatible control inputs • 1.8V compatible control inputs • Fail-safe logic • Integrated pulldown resistor on logic pin • Powered-off protection
TMUX1109	5	2	4:1	2.5	• 1.8V logic • Fail-safe logic
TMUX9832	220	32	1:1	See the datasheet	• 1.8V compatible control inputs • Daisy chain mode • Integrated bleed resistors on the outputs • Supports input voltage beyond supply

3.2 Level Transmitters

Level transmitters also use an ultrasonic implementation by measuring the distance to and position of fluids in a container or pipe. Transducers are mounted near the top of the structure being measured, and the ultrasonic pulses the transducers emit hit the liquid surface and reflect back. The sensor calculates the fluid level based on the time between the transmitted (TX) and received (RX) signals. In this use case, low R_{on} analog switches with low charge injection provide the least amount of signal distortion.

Part Number	Vcc Range (V)	Channel Count	Configuration	R_{on} (Ω)	Features
TMUX7234	44V	4	2:1	3.5	• Latch-up immune • 1.8V logic
SN74LVC2G66	5	2	1:1	6	
TS5A3160	5	1	2:1	1	• Powered-off protection

3.3 Pressure Transmitter

Pressure transmitters are typically built around piezoresistive or capacitive Wheatstone bridge sensing elements. Higher-performance pressure transmitters can use two bridge elements to enhance sensitivity, accuracy, and temperature stability. Use a 2:1 MUX to alternate between the positive and negative reference voltages that feed into an Amp/ADC for quick and efficient measurements, reducing the need for multiple ADC inputs. Higher channel and voltage options are available for systems requiring more sensing elements and for higher excitation voltages.

Part Number	Vcc Range (V)	Channel Count	Configuration	R_{on} (Ω)	Features
TS5A3159A	5	1	2:1	0.7	• Powered-off protection
TMUX6219	36	1	2:1	2	• 1.8V logic • Fail-safe logic
TMUX7234	44V	4	2:1	3.5	• 1.8V logic • Fail-safe logic • Latch-up immune

3.4 Temperature Transmitters

Temperature is the most measured physical parameter, and numerous sensor types are used to track it. Each sensor calculates temperature by detecting changes in a physical property, such as resistance or voltage. Thermocouples, RTDs, and NTC thermistors are among the most popular. Analog switches with low R_{on} and multiple channels or high configuration count allow one ADC to serve multiple sensor inputs, reducing the number of amplifiers needed per gain stage and leading to higher accuracy and a smaller system size. TI's analog switch portfolio also offers some of the smallest packages in the industry to further scale down the size of the final design.

Part Number	Vcc Range (V)	Channel Count	Configuration	R_{on} (Ω)	Features
TS5A23167	5	2	1:1	0.75	• Powered-off protection
SN74LV4052A	5	2	4:1	60	
TS5A3359	5	1	3:1	0.7	• Powered-off protection
TMUX7208	44	1	8:1	4	• 1.8V logic • Fail-safe logic • Latch-up immune

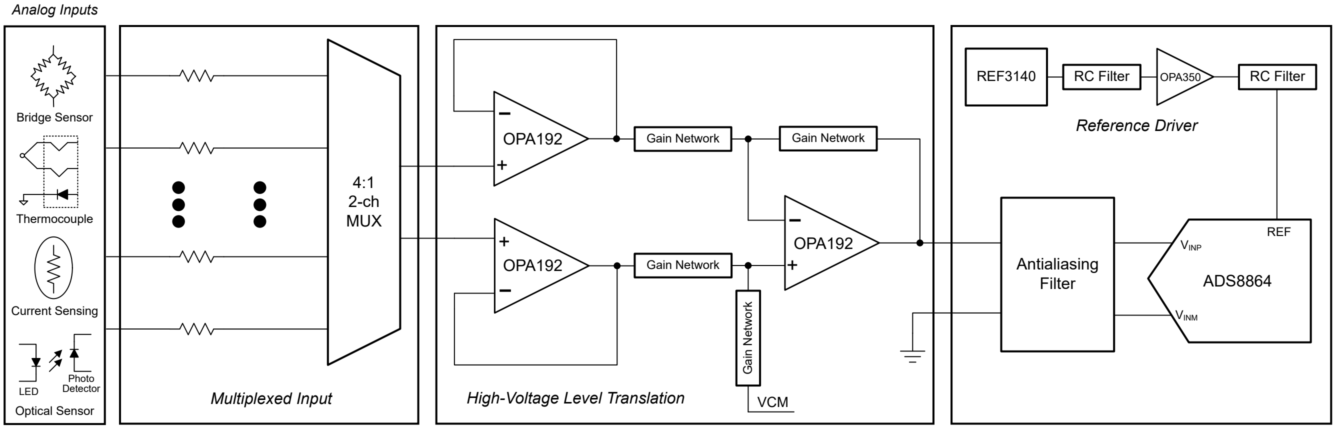

Figure 3-1. Sensing Element Signal Chain

3.5 Proximity Sensor

Proximity sensors are commonly implemented using capacitive, inductive or ultrasonic sensing elements that detect the presence of an object through changes in capacitance, magnetic fields or reflected sound waves. These designs often require multiple sensing elements, which creates a need to optimize signal routing. Use different configurations to switch signals to an ADC, enable time division scanning, or offer isolation using integrated powered off protection.

Part Number	Vcc Range (V)	Channel Count	Configuration	R_{on} (Ω)	Features
TS5A3159A	5	1	2:1	0.7	• Powered-off protection
SN74LVC2G66	5	2	1:1	6	
TS5A3166	5	1	1:1	0.7	
TMUX5411	50	4	1:1	21	• 1.8V logic

3.6 Gas Chemical Cell Process Analytical Sensors

Process analytical sensors require monitoring a mixture of gases using electrochemical cells. Because these sensors often generate currents in the range of a microampere to picoampere, use analog switches with ultra-low leakage current to prevent signal degradation. TI's precision switches, such as the TMUX11xx family, offer this benefit and low R_{on} performance to enable accurate signal chains.

Part Number	Vcc Range (V)	Channel Count	Configuration	R_{on} (Ω)	$I_{(ON)}$	Features
TS5A22362	5	2	2:1	0.52	50nA	• Negative signaling capability
TMUX1108	5	1	8:1	2.5	3pA	• 1.8V logic • Fail-safe logic
TMUX1204	5	1	4:1	9	200nA	• 1.8V logic • Fail-safe logic

4 Summary

The right analog switch or MUX for a field transmitter depends on the electrical characteristics of the sensor, not just the type. Signal distortion, leakage current, R_{on}, and channel configuration all play a role in determining which device fits best, and getting this selection right directly impacts measurement accuracy, design size, and cost. TI's analog switch families span a wide range of R_{on}, voltage handling, channel count, and leakage performance to address these varying requirements, allowing designers to build simpler, more accurate, and lower-cost signal chains regardless of the specific sensing application.

5 Reference

1. Texas Instruments, TMUX9832 No High Voltage Bias, Beyond the Supply, 220 V 1:1, 32-Channel Switch datasheet

6 Revision History

NOTE: Page numbers for previous revisions may differ from page numbers in the current version.

DATE	REVISION	NOTES
July 2026	*	Initial Release