

Industrial Communications Solutions featuring MSP Microcontrollers



Overview

Monitoring and maintaining process variables at the appropriate levels is extremely critical in industrial automation and process control. Another important aspect to complete the feedback loop is industrial communications. The vast majority of industrial applications rely on wired solutions that can either be powered through the communication loop or through a separate power line. The basic signal chain of an industrial system is shown in **Figure 1**.

MSP microcontrollers have a broad portfolio of products catering to industrial sensing, that meet the highest standards and that are optimized for industrial environments and extend product life cycles. These microcontrollers not only provide an ultra-low power advantage, but also have various communication interfaces that are needed for wired communications.

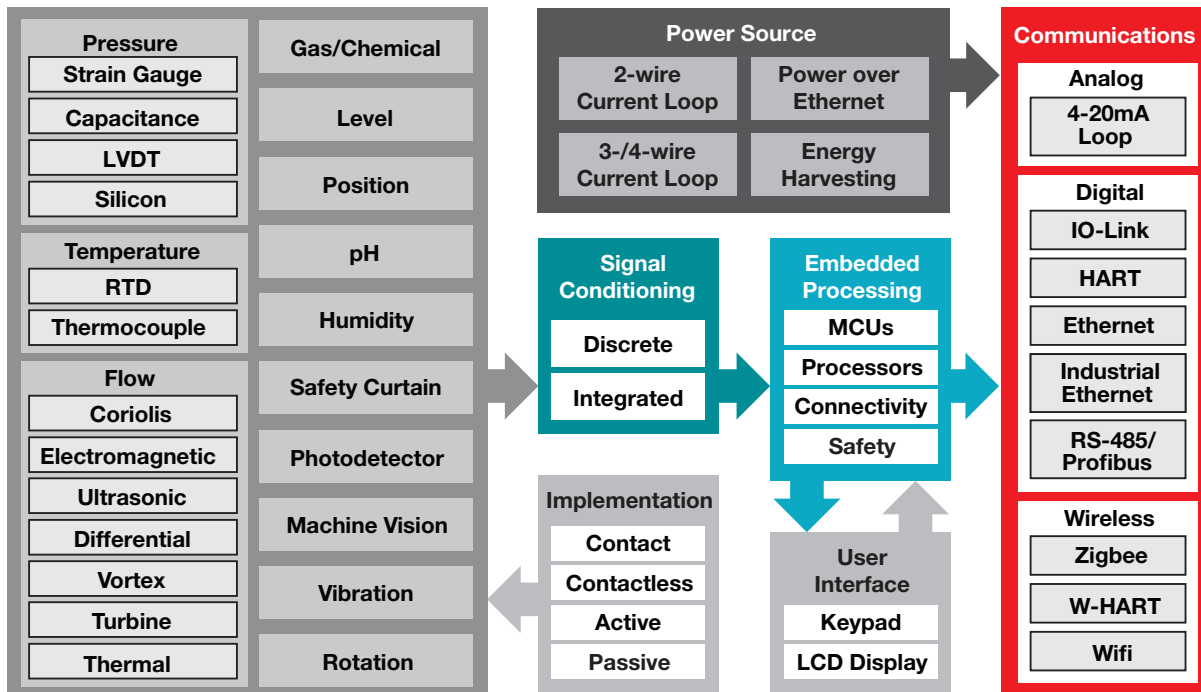


Figure 1. Industrial system signal chain

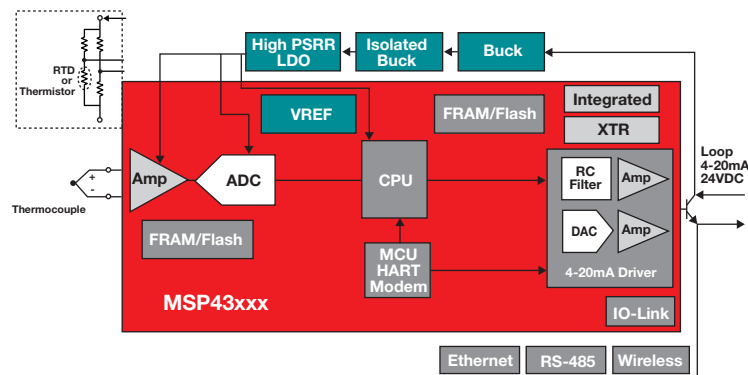


Figure 2: Industrial transmitter = Sensing + Control + Data logging + Communication

Application Problem

How MSP Enables

Application Energy Budget	Industrial 4-20mA wired loop solutions maintain a maximum current budget of 3.5mA. The low power performance of the MSP430 provides a larger margin for sensor solutions.
Complete Solutions	TI offers complete 4-20mA, IO-Link and HART solutions. TI DESIGNS Available.
System Cost	MSP430 Single chip solutions based on smart integrated analog (OPA/DAC/ADC) provide the lowest system cost.
Future Development	Provide a scalable portfolio for customers to leverage hardware and software investments in future projects.

Industrial communication can be broken down into the following:

- 4-20mA wired loop
 - Single chip solution
 - Multi-chip 4-20mA solution
- I/O Link
- HART® Protocol
 - HART modem (PHY)
 - HART field transmitter

4-20mA Wired Loop Communication

The transmitter can either be powered through the communication loop via a 2-wire implementation or through a separate power line not associated directly with the 4-20mA current loop, typically classified as a 3-wire or 4-wire solution. In both cases, a low-dropout (LDO) regulator steps down the current loop supply voltage to power the transmitter. In the 2-wire solution,

it is important to maintain a current threshold below the 3.5mA in order to ensure the minimum transmitted measurement value of 4mA is achieved with margin for alarm low levels. The low active current capability of the MSP microcontroller provides for very low transmitter currents and enables a larger power budget for multiple sensors on a single field transmitter.

Single-chip MSP System Solution

The integrated smart analog on the MSP product family of devices provides for a single-chip solution. The onboard operational amplifier can be configured to carry out signal conditioning of the sensor signal and drive the 4-20mA communication loop. The integrated ADC is used to digitize the sensor signal and processed by the microcontroller while the pulse width modulator (PWM) is used to modulate the current in the 4-20mA loop. This single-chip solution drives the most cost effective system solution.

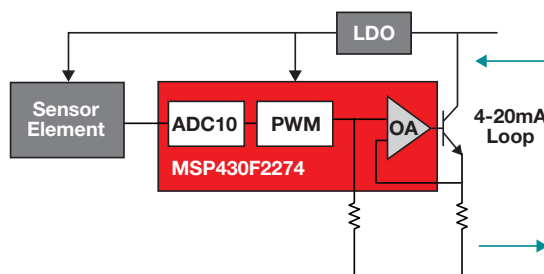


Figure 3. Single chip MSP430F2274 system solution

Device	MCU Speed (MHZ)	Non-Volatile Memory (kbytes)	SRAM (kbytes)	GPIO Pins	GAIN	THD (db)	Offset (mV)	Setting Time (µs)
MSP430FG4619	8	120	8	80	1	-70	-10	7
MSP430FG479	8	60	2	48	—	—	-10	—
MSP430F2274	16	32	1	32	1	-70	-10	7

Get more information: www.ti.com/tool/TIDA-00247

Multi-chip Solution

In this implementation, the MSP microcontroller manages all of the system requirements for the field transmitter solution - from managing the sensor output signal to handling

the protocol requirements for the wired communication loop. This multi-chip solution provides for the highest possible resolution.

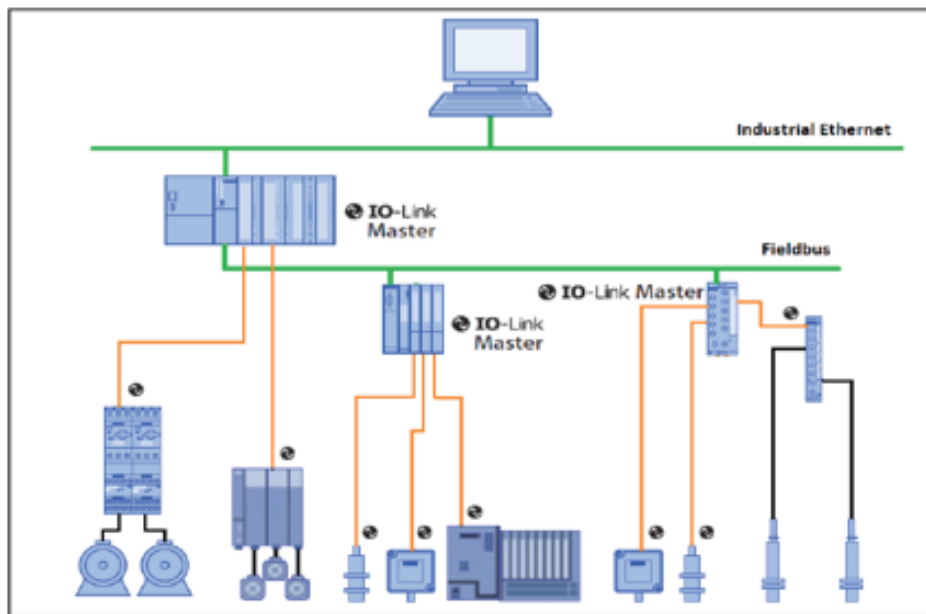
MSP™ MCU Family	ADC					Inputs and Outputs						
	Slope	10-Bit SAR	12-Bit SAR	16-Bit Sigma Delta	24-Bit Sigma Delta	DAC	Comp	Temp Sensor	1.8V	5V	CapTouch	Voltage Monitoring
F1xx	✓	✓	✓				✓	✓				✓
F2xx	✓	✓	✓	✓	✓	✓	✓	✓				✓
G2xx/i2xx	✓	✓			✓		✓	✓			✓	✓
F4xx	✓	✓	✓	✓	✓	✓	✓	✓				✓
F5xx	✓	✓	✓			✓	✓	✓	✓	✓		✓
F6xx	✓	✓	✓		✓	✓	✓	✓				✓
FR5xx	✓	✓					✓	✓			✓	✓

Get more information: www.ti.com/tool/TIDA-00165

IO-Link PROTOCOL

The other communication protocol for industrial applications is the IO-Link. IO-Link is known as the USB of Factory Automation since it is a simple & cheap point to point protocol that can be broken down into master and slaves. The masters can have multiple ports and on each port only

one device is connected. The IO-LINK devices can be: sensors, RFID readers, valve, motors. The IO-LINK reuses the cables and connectors from installed base of industrial sensors & actuators that reduces cost for this option of communication.



MSP™ MCU Family	ADC					Inputs and Outputs						
	Slope	10-Bit SAR	12-Bit SAR	16-Bit Sigma Delta	24-Bit Sigma Delta	DAC	Comp	Temp Sensor	1.8V	5V	CapTouch	Voltage Monitoring
FR5xx	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓

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HART® Protocol

The **HART communications protocol** is a digital industrial automation protocol. It's most notable advantage is that it can communicate over legacy 4-20 mA analog instrumentation wiring. Thus, the HART Protocol is one of the most popular industrial protocols today since it has made a good transition protocol for users who were comfortable using the legacy 4-20 mA signals, but wanted to implement a

“smart” protocol. HART uses low frequencies (1200Hz and 2200Hz representing 1 and 0). The single-chip implementation integrates handling of the protocol and providing PHY layer support. **Figure 5** shows a typical implementation where the PHY layer (or Modem) is provided by a separate chip. **Figure 6** shows the HART protocol and PHY layer running on a single MSP device.

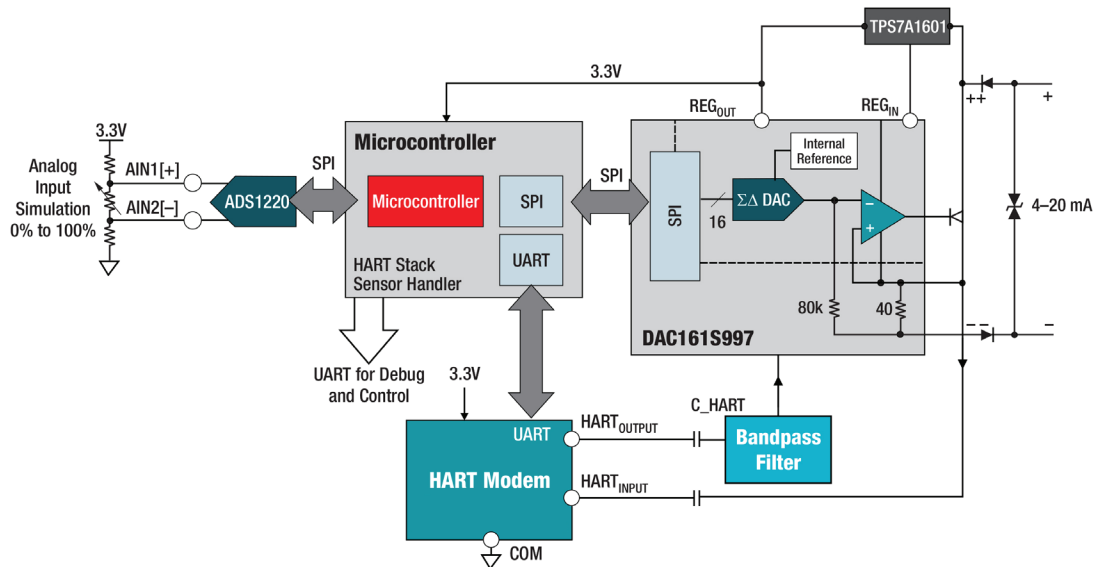


Figure 5. Typical HART field transmitter design with standalone modem.

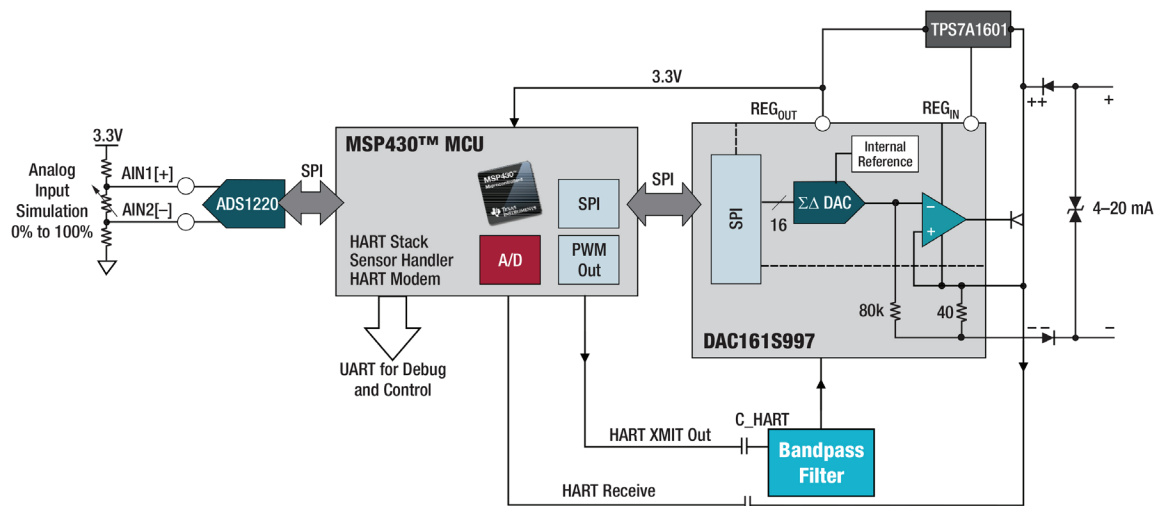


Figure 6. HART protocol and Modem running on a single chip MSP solution.

MSP™ MCU Family	ADC					Inputs and Outputs						
	Slope	10-Bit SAR	12-Bit SAR	16-Bit Sigma Delta	24-Bit SigmaDelta	DAC	Comp	Temp Sensor	1.8V	5V	CapTouch	Voltage Monitoring
F5xx	✓	✓	✓			✓	✓	✓	✓	✓		✓
FR5xx	✓	✓					✓	✓			✓	✓



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