

# Industrial Automation Solutions

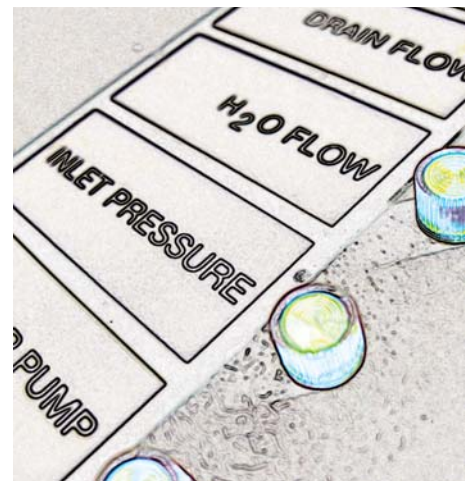
## Sensors and Field Transmitters

TI's sensor solutions speed the design cycle with the right devices, software, tools and support.



Monitoring and maintaining process variables at the appropriate levels is extremely critical in industrial automation and process control. A sensor in the industrial environment is either continuously or periodically measuring vital parameters such as temperature, pressure, flow, etc. The primary challenge of sensing in industrial environments is conditioning low signal levels in the presence of high noise and high surge voltage.

This warrants for extremely low noise, low drift, precision programmable gain amplifiers and instrumentation amplifiers with an appropriate common-mode voltage. The rate of change of the measured signal is usually not very rapid and hence high-resolution precision delta-sigma converters are widely used in industrial sensors. Low power consumption is another key requirement for industrial sensors as many of them are powered off the traditional 4–20 mA loop. Digital connectivity features such as PROFIBUS, IO-Link, and wireless connectivity are increasing in popularity as they provide continuous monitoring, fault diagnostics and reduce start up times, greatly improving productivity and efficiency of the automation loop.



Texas Instruments (TI) has a broad portfolio of products catering to industrial sensing, ranging from best-in-class precision amplifiers and data converters to interface products, power products and high-performance microprocessors. TI's cutting-edge semiconductor manufacturing processes provide industrial designers with products that meet the highest standards and that are optimized for industrial environments and extended product life cycles.

### ***What's inside:***

#### **Field Transmitter:**

Temperature Sensor

#### **Field Transmitter:**

Pressure Sensor

#### **Flowmeters:**

- Electromagnetic
- Coriolis

#### **Electronic Weigh Scale**

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## Field Transmitter: Temperature Sensor

### Features and Benefits

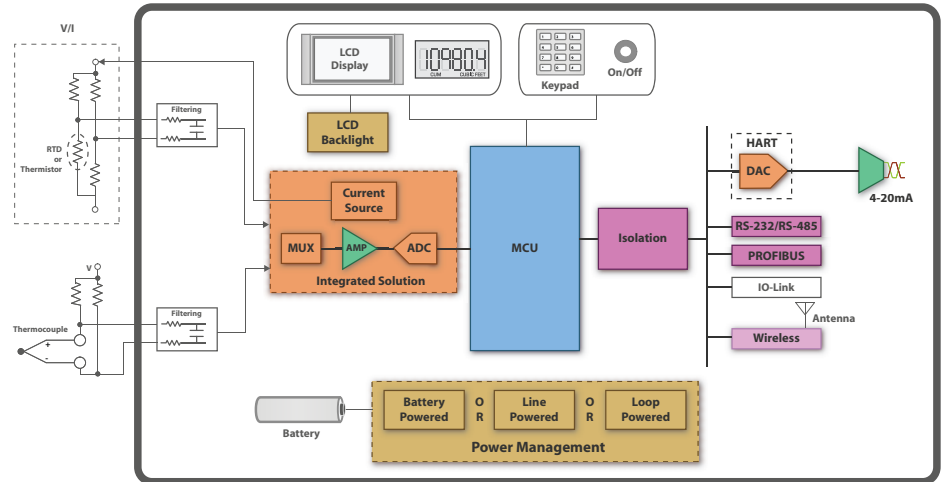
- Highly integrated solution
  - Dual matched-current DACs
  - Low-drift internal reference
  - Low-noise PGA, temperature sensor, burnout detection
- 24 bits, no missing codes, single-cycle settling, up to 2 kSPS
- 50-/60-Hz rejection

Temperature sensors are used to measure temperature and have a wide range of uses in industrial and commercial applications. Temperature measurements are commonly made by using a resistance temperature detector (RTD), thermistor or thermocouple.

RTDs have wire winding or thin-film serpentine elements that exhibit changes in resistance with changes in temperature. Thermistors, typically made of ceramic or polymer material, also exhibit significant changes in resistance with changes in temperature. Thermocouples consist of two

dissimilar metal wires welded together to form two junctions. Temperature differences between the junctions cause a thermoelectric potential (i.e., a voltage) between the two wires. Holding the reference junction at a known temperature and measuring this voltage permits the temperature of the sensing junction to be deduced. A constant and linear excitation source is a critical aspect of RTD/thermistor sensing, while cold junction compensation is the key to a good temperature measurement with thermocouples.

With its high integration, excellent resolution and accuracy, the **ADS1248** offers a single-chip solution to all of these types of temperature measurements. The **ADS1118** is a lower-cost solution which has the basic core needed for any temperature measurement and an extremely accurate on-chip temperature sensor that is perfect for accurate cold junction compensation.



## Field Transmitter: Pressure Sensor

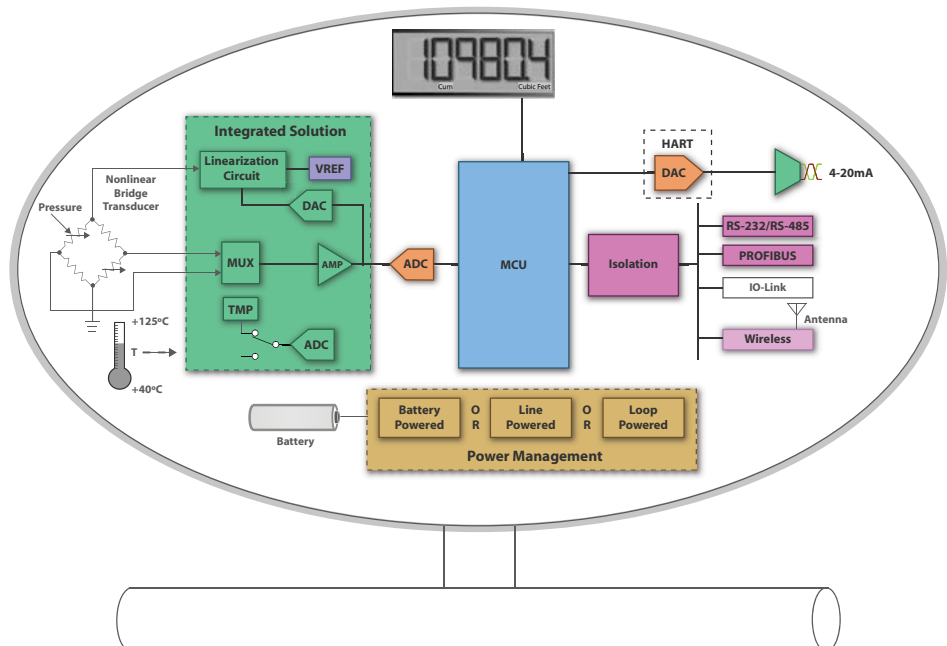
### Features and Benefits

- Bridge excitation and sensor signal conditioning
- Sensor error compensation: span, offset and temperature drifts
- Sensor linearization circuitry
- Digital calibration via one- or two-wire serial interface
- Low, time-stable total adjusted error

Pressure sensors convert a physical value – weight, tire pressure, level, force or flow – into a differential signal in the range of millivolts per volt and use metal thick-film, ceramic thin-film, or piezoresistive technologies, to name a few. The majority of designers use the cost-effective piezosensors that can sense 25 mbar to 25 bar. However, these sensors are very nonlinear and temperature-dependent and have a large offset and large offset drift. They also require attention to electronic calibration and compensation.

TI's **PGA309** sensor conditioner is an ideal choice in combination with low-cost piezoresistive or ceramic thin-film pressure sensors. It is a

complete signal conditioner for bridge sensors with versatile features that enable linearization, temperature compensation and digital calibration.



# Flowmeters: Electromagnetic/Coriolis

## Features and Benefits

- Multiple channels and simultaneous sampling for measuring multiple process variables at the same time
- Excellent AC and DC performance
- Selectable operating modes: High speed, high resolution, low power

The **electromagnetic flowmeter** consists of a nonferromagnetic tube wrapped with a magnetic coil. Electrodes in the tube's inner isolated surface are in contact with a conductive liquid that flows through the tube. The coils around the pipe generate a magnetic field within the tube. The magnetic field induces a voltage in the liquid that is proportional to the speed of the liquid in the tube. This voltage is measured via the electrodes. Because the measured voltage is very low, precise low-noise signal conditioning is required.

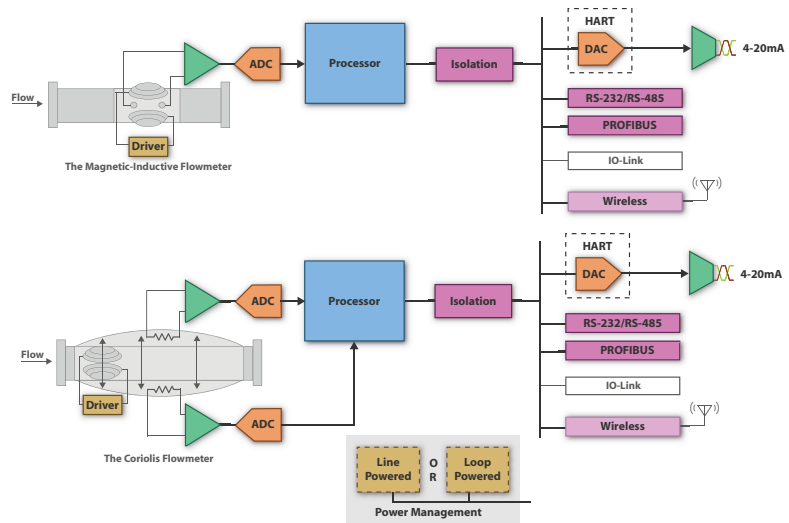
**Coriolis flowmeter** is a popular flowmeter that directly measures mass flow rate. Applying a strong magnetic field to a pipe through which fluid is flowing makes the pipe oscillate at a particular resonant frequency. When the fluid starts flowing through the pipe, it is subject to Coriolis force. The oscillatory motion of the pipe superimposes on the linear motion of the fluid, exerting twisting

forces on the pipe. This twisting is due to Coriolis acceleration acting in opposite directions on either side of the pipe and to the fluid's resistance to the vertical motion. Sensor electrodes placed on both the inlet and outlet sides pick up the phase difference caused by this motion. This phase shift due to the twisting forces is a direct measurement of mass flow rate.

Low-noise instrumentation amplifiers followed by precision ADCs is typical of the signal-chain path. Precision DACs or PWM drivers are used to

excite the field coils. Multiple-channel ADCs with simultaneous sampling architectures make it possible to take multiple measurements such as temperature, phase, density, etc. at the same time.

TI's **ADS1274**, which is a 24-bit, 4-channel, simultaneous-sampling delta-sigma converter with up to 144 kSPS, is the perfect front end for flowmeters requiring multiple measurements (Coriolis). The **ADS1259** is a high-linearity, low-drift, 24-bit, delta-sigma converter commonly used in electromagnetic flowmeters.



# Electronic Weigh Scale

## Features and Benefits

- Complete front-end solution for weigh scales
- Very low-noise PGA
- Only 17-nV input-referred noise with gain of 128
- 23.5 effective bits with gain of 1
- Excellent 50-/60-Hz rejection: 100 dB (min)

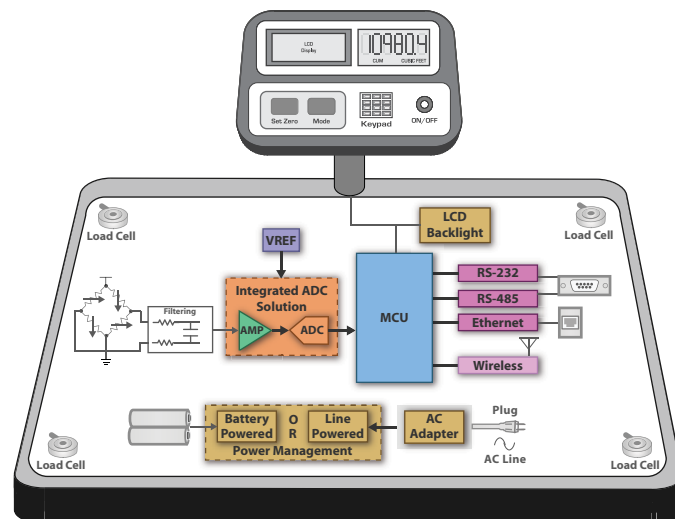
Electronic weigh scales, which are found in many industrial applications, use a load cell as the primary transducer. Load-cell designs can be distinguished according to the type of output signal they generate – pneumatic, hydraulic or electric. Strain-gauge load cells convert the load acting on them into electrical signals in the range of millivolts per volt. A major challenge in designing weigh scales is that they must sample multiple load cells while producing extremely low input referred noise.

Another important factor is the analog circuitry's long-term stability with regard to offset drift and gain. Here the accuracy of the amplified input signal, either single-ended or differential, must be guaranteed over years of operation. Hence

the signal chain has to handle the small signals accurately in the presence of noise in addition to conditioning for offset, drift, temperature dependency and other factors.

TI's **ADS1232** is designed as a highly integrated delta-sigma ADC for low-level, high-precision measurements, especially for weigh-scale

applications. The device consists of a low-drift, low-noise instrumentation amplifier (selectable gain) and a high-order, chopper-stabilized modulator followed by a digital filter in a monolithic device. This is a single-chip solution that can be directly interfaced as a front end to a load-cell bridge output.



# Industrial Automation Solutions

## Sensors and Field Transmitters portfolio at a glance

### Power Management

Industrial field transmitters could be powered in one of three ways: loop, line or battery.

Texas Instruments (TI) offers a complete line of high-performance power management products designed for industrial applications. The devices shown are well-suited for powering sensors that may require low noise and high efficiency in both line- and loop-powered (4–20 mA) topologies. Many TI DC/DC converters feature current-mode control with fast dynamic response and a pulse skipping eco-mode with **low quiescent current** which **saves energy at light loads**. Battery-powered transmitters can be designed using TI's low-power Buck and Buck-Boost converters.

### Processor and Connectivity

The MSP430™ MCU, with its integrated analog peripherals, is the perfect platform for designers looking to implement calibration routines, compensation algorithms, etc. The computing power and rich peripherals set accented by **ultra-low power** consumption, makes the **MSP430 MCU** the universal choice for sensor design.

For flowmeter applications which require more signal processing than offered by a standard MCU, the **C5000™** platform of DSPs is the optimal solution. The C5000 DSP has an FFT accelerator core that enables computing FFTs in a matter of seconds while drawing very little current. The ultra-low-power architecture of the C5000 DSP

offers superior signal-processing power while still being able to be powered off the 4–20-mA loop.

Traditional analog (**4–20 mA**) interface remains the popular choice for industrial control and sensor applications. The other popular protocols include **HART**, **PROFIBUS** and **IO-Link**. TI's IO-Link interface products have integrated regulators and diagnostic outputs. In addition, wireless options based on **IEEE 802.15.4** protocols are becoming more prevalent. TI is committed to provide solutions for both traditional and emerging industrial interfaces.

| Function                                                 | Features                                                                                                                                                        | Part Number  | EVM/Demo                      |
|----------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------|-------------------------------|
| High-Precision Instrumentation Amplifier                 | Micropower (50 $\mu$ A), zero drift, low offset voltage (25 $\mu$ V max), low offset drift 0.1 $\mu$ V/°C, rail-to-rail output instrumentation amplifier        | INA333       |                               |
| Complete <b>Pressure/Bridge</b> Sensor Conditioner       | Amplification, bridge excitation, digital calibration (for span, offset and temperature drift), linearization, temperature compensation                         | PGA309       | PGA309EVM-USB                 |
| Single-Chip <b>Temperature</b> -Measurement Front End    | High integration, low-noise PGA, 24-bit ADC, internal reference, dual-current DACs, temperature sensor, burnout detection                                       | ADS1248      | ADS1248EVM/<br>ADS1248EVM-PDK |
| Integrated Single-Chip Temperature Measurement Front End | High accuracy on-chip temp sensor for CJC. World's smallest 16-bit ADC as of 2011Q3. Integrated PGA for better utilization of dynamic range. Low power.         | ADS1118      | ADS1118EVM                    |
| <b>Weigh-Scale</b> Front End                             | High integration, 24-bit precision ADC, on-board PGA, temperature sensor                                                                                        | ADS1232      | ADS1232EVM                    |
| <b>Flowmeter</b> Signal Acquisition                      | Quad-channel simultaneous sampling, 144 kSPS, 24-bit ADC                                                                                                        | ADS1274      | ADS1274EVM/<br>ADS1274EVM-PDK |
| DAC                                                      | 12-bit, single-channel, 80 $\mu$ A, 1.8-V to 5.5-V DAC in SC-70 package, can be used to drive HART signal                                                       | DAC7311      | DAC7311EVM                    |
| Ultra-Low Power MCU                                      | Ultra-low power, industrial feature set, 5V tol. I/O, high-resolution timer, stand-by in LPM3: 1.1 $\mu$ A                                                      | MSP430F51x2  | MSP-TS430RSB40                |
| Ultra-Low Power MCU                                      | Ultra-low power, universal memory, ADC10, active mode: 107 $\mu$ A/MHz at 8 MHz                                                                                 | MSP430FR5739 | MSP-EXP430FR5739              |
| IO-Link MCU                                              | Ultra-low power, 32-KB Flash, 1-KB RAM, IO-Link stack V1.1 (TMG)                                                                                                | MSP430F2274  | MSP-FET430U38                 |
| Low-Power DSP                                            | Industry's lowest-powered DSP, energy-efficient FFT hardware accelerator, standby mode <0.15 mW, active mode < 0.15 mW/MHz, dynamic voltage a frequency scaling | TMS320C5515  | TMDXEVM5515                   |
| 4–20-mA Transmitter                                      | Low $I_q$ , $V_{regulator}$ , $V_{ref}$ for sensor excitation, low span and non-linearity error                                                                 | XTR115       | XTR115EVM                     |
| PROFIBUS                                                 | 4-KV peak-isolated PROFIBUS transceiver with low bus capacitance and bus-pin ESD protection                                                                     | ISO1176      | ISO1176EVM                    |
| IO-Link PHY                                              | IO-Link device node PHY with overcurrent/overvoltage/overtemperature protection, small footprint 4 mm $\times$ 4 mm QFN-20 package, internal voltage regulator  | SN65HVD101   |                               |
| RS-485                                                   | 4-KV peak-isolated, 5-V, full-duplex RS-485 transceiver                                                                                                         | ISO3080      | ISO485EVM                     |
| Wireless Transceiver                                     | 2.4-GHz 802.15.4/ZigBee® RF transceiver, excellent link budget (103 dBm), 400-m line of sight, extended temperature (–40 to +125°C)                             | CC2520       | CC2520DK                      |
| Linear Regulator                                         | –3-V to –36-V input, –200-mA, ultra-low noise, high PSRR, low-dropout linear regulator                                                                          | TPS7A3001    | TPS7A30-49EVM-567             |
| Linear Regulator                                         | 100-V input, 50-mA, single-output low-dropout linear regulator                                                                                                  | TPS7A4001    | TPS7A4001EVM-709              |
| Isolated Regulator                                       | 0.95-V to 6-V Input, 2-W isolated DC/DC converter with integrated FETs                                                                                          | TPS55010     | TPS55010EVM-009               |
| Isolated Regulator                                       | 5-/12-/24-V input, 1-W isolated regulated DC/DC converter modules                                                                                               | DCR01        |                               |
| DC/DC Converter                                          | 4.5- to 60-V input, 50-mA synchronous buck converter                                                                                                            | TPS54062     | TPS54062EVM-695               |
| DC/DC Converter                                          | 3.5- to 60-V input, 1.5-A DC/DC converter with light load efficiency and low $I_q$                                                                              | TPS54160     | TPS54160EVM-230               |

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