

# Analog Devices' 2-Wire Loop-Powered Transmitter Solution

## Industry Loop-Powered Transmitter System Theory and Trends

Modern field instruments, otherwise known as smart transmitters, are intelligent microprocessor-based field instruments that monitor process control variables (e.g., temperature, mass flow rate, and pressure). The incorporation of extra intelligence, functionality, and diagnostic capabilities, while developing a system which can operate effectively within the limited power available from 4 mA to 20 mA loop, is the immediate challenge facing system designers. Strict safety standards, space constraints, HART® communication, diagnostics, and predictive maintenance will be key trends in the future.

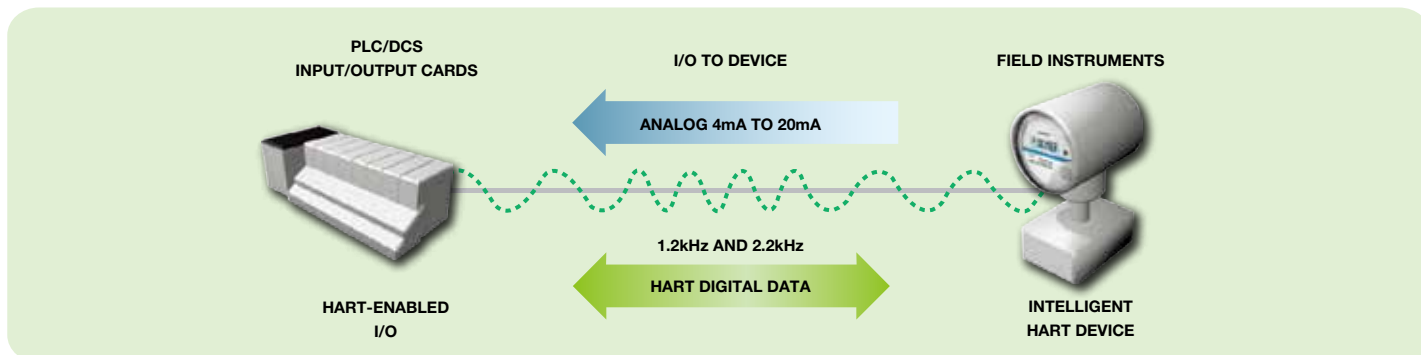


Figure 1. Transmitter communication with HART.

## Industry 2-Wire Loop-Powered Transmitter System Design Considerations and Major Challenges

To have an appropriate 2-wire loop-powered transmitter system design, designers must consider many different system requirements including accuracy, power budget, diagnostics, and silence noise restriction with HART.

- Minimum loop current is 4 mA; the maximum allowable total system power budget available for board design is 3.5 mW.
- Loop voltage range supported from 12 V to 48 V.
- Measurement accuracy can have readings as high as 0.1%; ADC resolution needs 16 bits to 24 bits, and DAC resolution needs 14 bits to 16 bits.
- Low noise precision instrumentation amplifier is typically required for sensor output.
- Space constraints within a transmitter and a high level of on-chip integration is required to maximize functionality.
- HART (Highway Addressable Remote Transducer) communication has an essential role to play in retrieving the field instruments process and diagnostics information; FSK frequency of 1200 Hz and 2200 Hz with an amplitude of 1 mA p-p.

Smart transmitters are often located in hazardous or remote areas. Low temperature drift coefficient and low power consumption are very important for loop-powered transmitters to endure a wide working temperature range. ADI offers a perfect portfolio like precision amplifiers, precision references, precision analog-to-digital converters, and Cortex™-M3 core microprocessors.



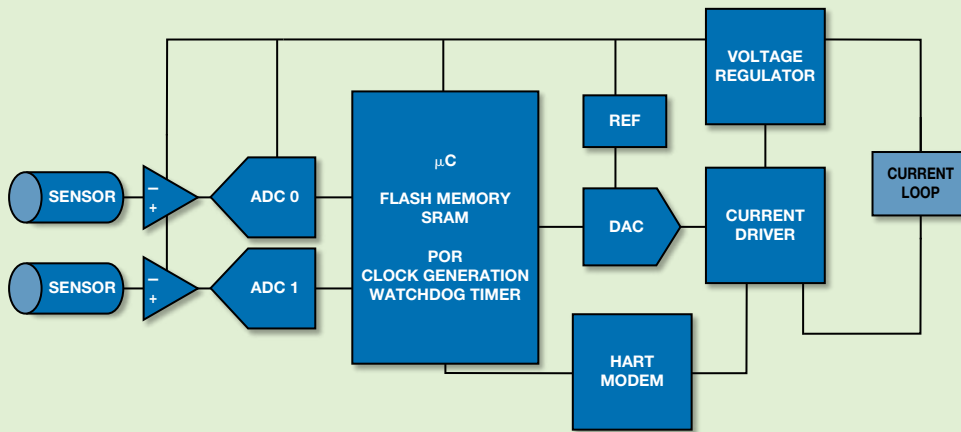


Figure 2. General smart transmitter signal chain.

Figure 2 shows a typical 2-wire smart transmitter's architecture, which combines sensors, signal conditioning, MCU, current driver, reference, HART modem, and so on. Again, smaller size, higher integration, and intelligent diagnostics will be the key trends for field instrument.

### Total Solutions from ADI (High End Market)

For the high end market, a total solution provided from ADI with sample developed and registered with the HART Communication Foundation focuses on the 2-wire loop-powered transmitter with high performance. Figure 3 shows that only three chips were used to build the demo, which represents the leading integration level in the market.

### Main Signal Chain

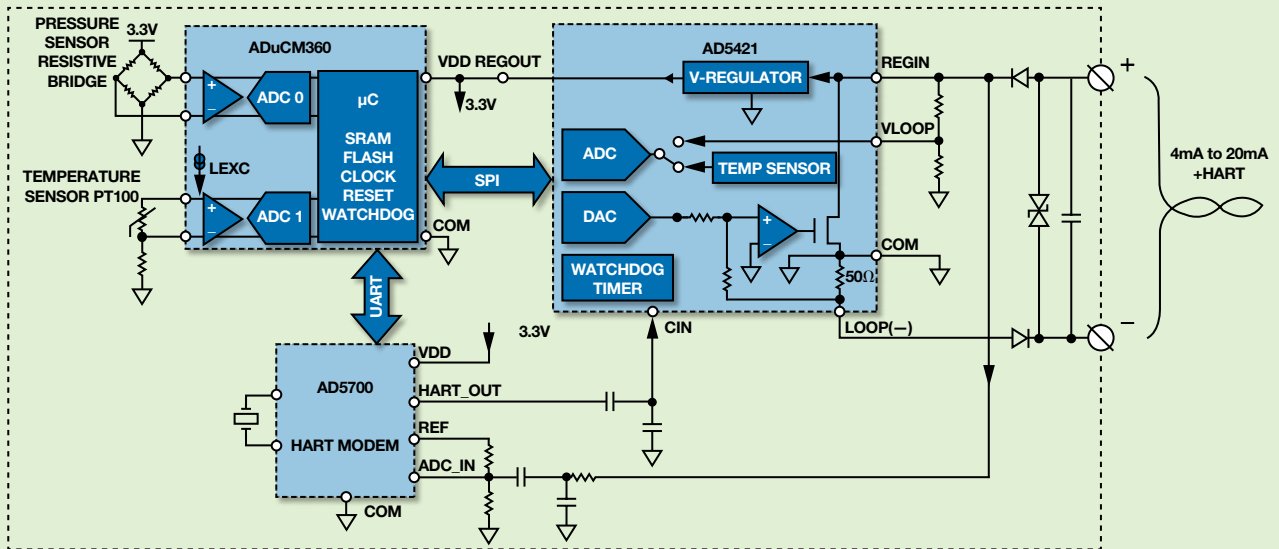
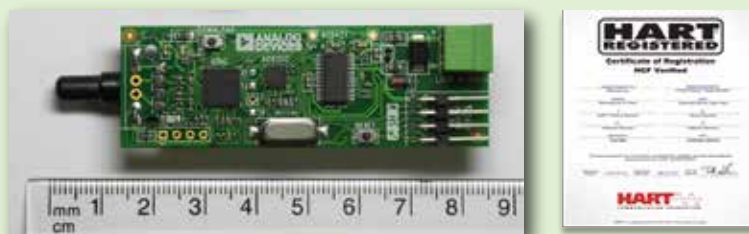


Figure 3. HART enabled smart transmitter demo block diagram.



### Auxiliary Cost Effective Solutions From ADI (Mid/Low End Market)

For the mid/low market, customers used to be concerned with keeping costs down; ADI provides two additional cost effective solutions with the ADuCM360 and the AD693, as shown below. The AD5700 HART modem could also be a common variation for these circuits.

As the ADuCM360 contains a high resolution 16-bit PWM, it can easily implement a 4 mA to 20 mA output with simple RC filters, amplifiers, and transistors. This is a very typical method used in low end smart transmitter customers.

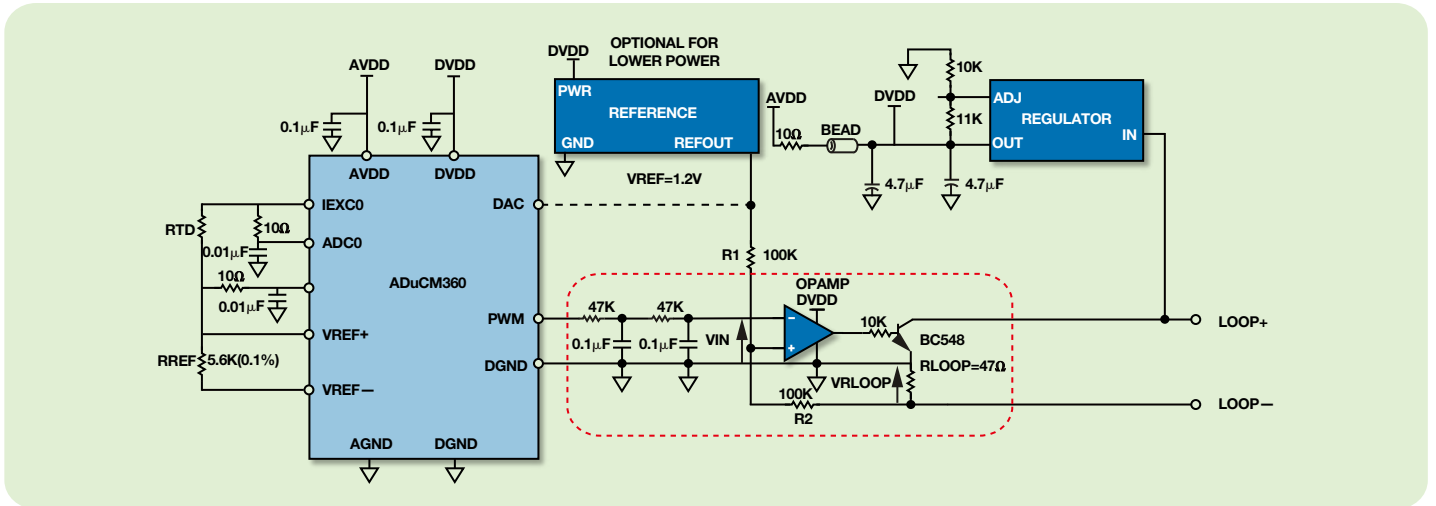


Figure 4. Cost effective solution with the ADuCM360 PWM.

Besides a smart transmitter solution, ADI also provides a pure analog loop-powered transmitter solution—the AD693, a sensor transmitter, which is a very standard single-chip solution to implement various signal conditioning, like thermocouple, RTD, and pressure signal inputs.

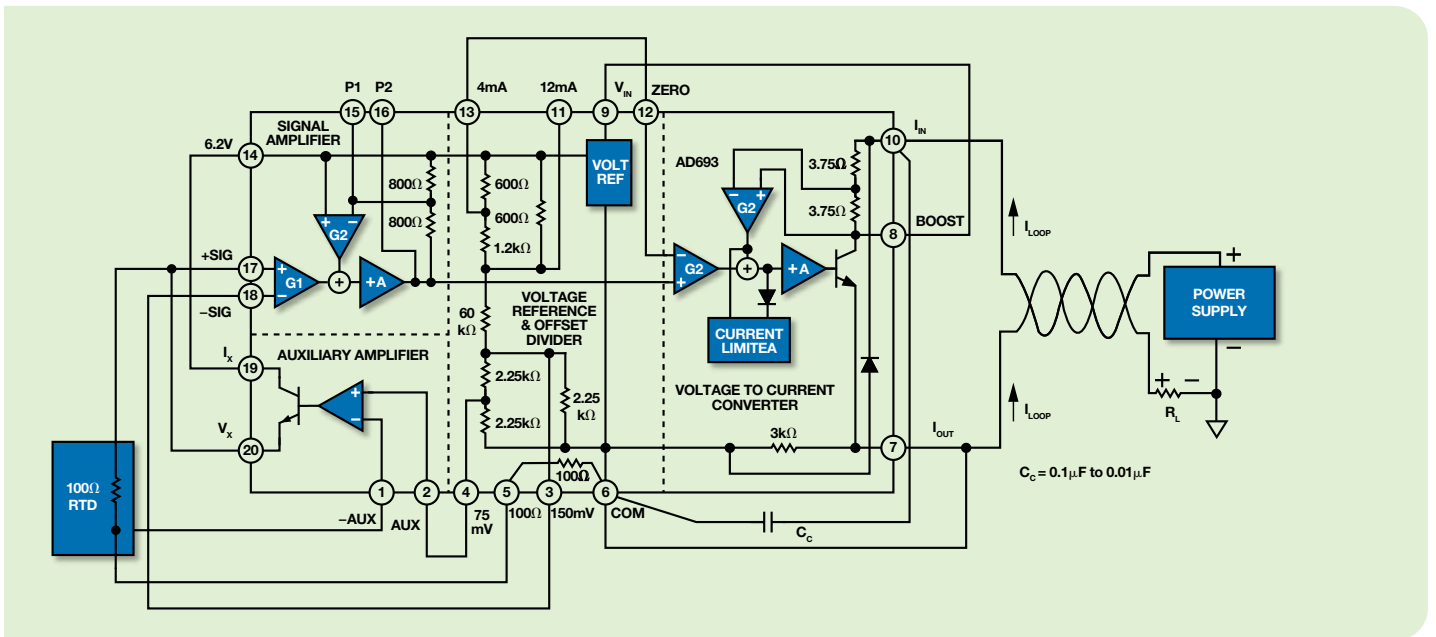


Figure 5. Cost effective solution with the AD693 for analog transmitter.

## Main Product Introduction

Device	Description	Key Features	Benefits
<b>AFE + MCU</b>			
ADuCM360/ ADuCM361	Analog microcontroller (ARM Cortex-M3 core)	Dual 24-bit $\Sigma$ - $\Delta$ ADC (ADuCM360) Single 24-bit $\Sigma$ - $\Delta$ ADC (ADuCM361) Programmable ADC output rate (3.5 kHz to 3.906 kHz), 12-bit DAC Programmable current sources, temperature sensor Internal reference 4 ppm/°C 16 MHz Cortex, 128 kB Flash, 8 kB RAM Core consumes 290 $\mu$ A/MHz, power-down mode: 4 kA (wake-up timer active)	Ultralow power, high precision, leading integration chip solution
<b>HART Modem</b>			
AD5700/ AD5700-1	Low power HART modem	HART—compliant fully integrated FSK modem, 1200 Hz and 2200 Hz sinusoidal shift frequencies, 115 $\mu$ A max in receive mode. Integrated receive band-pass filter, optional clocking configurations, buffered HART output, 2 V to 5.5 V power supply	Lowest power, smallest footprint, on-chip oscillator
<b>4 mA to 20 mA Loop Driver</b>			
AD5421	Loop-powered DAC	16-bit resolution and monotonicity, pin selectable NAMUR-compliant ranges. Downscale alarm 3.2 mA, upscale alarm 22.8 mA/24 mA, TUE: 0.05% max, output TC: 3 ppm/°C typ. Quiescent current: 300 $\mu$ A max	Very low power, leading integration with best performance, compatible with HART connection
AD693	Loop-powered sensor transmitter	Loop-powered operation, instrumentation amplifier front end. Precalibrated 30 mV or 60 mV input spans, precalibrated PT100 interface. Precalibrated output spans 4 mA to 20 mA unipolar, 12 mA to 8 mA bipolar	A complete monolithic low level V-I loop signal conditioner
<b>Amplifier</b>			
ADA4051-1	Zero-drift micropower OP	Very low supply current: 13 $\mu$ A typ. $V_{os}$ 15 $\mu$ V max Offset drift: 20 nV/°C, PSRR 110 dB min, CMRR 110 dB min. Rail-to-rail input/output	High cost performance
<b>Regulator</b>			
ADP1720	Linear regulator	Supply range: 4 V to 28 V, low light load current: 28 $\mu$ A at 0 $\mu$ A load, low dropout: 275 mV @ 50 mA, initial accuracy: $\pm$ 0.5%, logic controlled enable, current and thermal overload protection	Low power consumption
<b>REF</b>			
ADR3412	Low power reference	1.2 V precision output, supply current: 100 $\mu$ A max, low noise (<10 Hz): 8 $\mu$ V p-p typ. Supply range: 2.3 V to 5.5 V, long term stability: 30 ppm/1000 hrs @ 50°C	Low power, small package

In conclusion, those circuits outlined above demonstrate some possible solutions to the multifaceted design challenges, that is, the selection of components for a smart/analog transmitter signal chain with sufficiently low power consumption, to ensure adherence to the limited power budget while still retaining the necessary performance specifications, functionality, and diagnostics capability to meet the ever increasing market demands. The generic transmitter signal chain discussion, along with the solution offered by Analog Devices, addresses these challenges directly, balancing the allocation of power required by each component, resulting in a comprehensive signal chain addressing the power, performance, size, and diagnostic requirements of a modern, multifeature market-leading smart transmitter design.

### CFTL Link

- Complete 4 mA to 20 mA loop-powered field instrument with HART interface (CN0267)—[www.analog.com/CN0267](http://www.analog.com/CN0267)
- Complete 4 mA to 20 mA HART solution with additional voltage output capability (CN0278)—[www.analog.com/CN0278](http://www.analog.com/CN0278)
- Complete 4 mA to 20 mA HART solution (CN0270)—[www.analog.com/CN0270](http://www.analog.com/CN0270)
- 4 mA to 20 mA loop-powered temperature monitor using the ADuC7060/ADuC7061 precision analog microcontroller (CN0145)—[www.analog.com/CN0145](http://www.analog.com/CN0145)
- Complete closed-loop precision analog microcontroller thermocouple measurement system with 4 mA to 20 mA output (CN0300)—[www.analog.com/CN0300](http://www.analog.com/CN0300)

For more information about the electromagnetic flow meter, please contact ADI.

### Customer Interaction Center

**Technical Hotline** 1-800-419-0108 (India)  
1-800-225-5234 (Singapore)  
0800-055-085 (Taiwan)  
82-2-2155-4200 (Korea)

**Email** [cic.asia@analog.com](mailto:cic.asia@analog.com)

**EngineerZone** [ez.analog.com](http://ez.analog.com)

**Free Sample** [www.analog.com/sample](http://www.analog.com/sample)

### What ADI Can Provide to Customers

- **ADC** ADIsimADC—[www.analog.com/zh/ADIsimADC](http://www.analog.com/zh/ADIsimADC)  
 $\Sigma$ - $\Delta$  ADC register configuration assistant—  
[www.analog.com/SigmaDeltaRegisterConfigurationAssistant](http://www.analog.com/SigmaDeltaRegisterConfigurationAssistant)
- **DAC** ADIsimDAC—[www.analog.com/ADIsimDAC](http://www.analog.com/ADIsimDAC)
- **AMP** ADIsimOpAmp—[www.analog.com/ADIsimOpAmp](http://www.analog.com/ADIsimOpAmp)  
ADIsimDiffAmp—[www.analog.com/ADIsimDiffAmp](http://www.analog.com/ADIsimDiffAmp)
- **Power** EVB ADIsimPower—[www.analog.com/ADIsimPower](http://www.analog.com/ADIsimPower)
- **Processor** EVB emulation tools and some software