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). Such field devices are becoming more intelligent, as some processing capabilities are being distributed into the field domain from centralized control rooms. This has simultaneously increased the complexity of the smart transmitter signal chain and added additional challenges to the design of the end product. The incorporation of extra intelligence, functionality, and diagnostic capabilities, while developing a system which can operate effectively within the limited power available from the 4 mA to 20 mA loop, is the immediate challenge facing system designers. A sample solution developed by Analog Devices, Inc., and registered with the HART® Communication Foundation focuses on such a design.

![Figure 1. Smart transmitter signal chain.](image1)

The two sensors shown in Figure 1 and Figure 2 are common to smart transmitter designs, whereby the primary variable is dependent on a secondary variable (e.g., temperature compensation of a primary variable). The ADuCM360 on-chip ADC 0 measures the field instrument primary sensor: in this case, it’s a resistive bridge pressure sensor, while the ADC 1 is used to measure the secondary temperature sensor signal. This allows for temperature compensation of the primary sensor. As with the ADCs, both instrumentation amplifiers are also integrated onto the ADuCM360, along with excitation current sources, voltage reference, and other support analog circuitry. All the field instrument digital functions are provided by the low power 32-bit ARM Cortex™-M3 RISC processor. The microcontroller is, thus, a complex component, with the potential to require a lot of power, so the more processing that can be done per milliwatt, the better. Therefore, the clock frequency at which the controller is operated is adjusted to maintain the required operation and still operate within the low power budget. The same is true of the clock signal for any of the microcontroller peripherals/interfaces. Another crucial aspect for the ADuCM360 to stay within its allocated power budget is the ability to dynamically switch the power to the individual blocks. Such a power gating feature ensures that power is provided to each functional block, as and when it is required, but is switched off when that particular functional block is not in use.

As well as processing the measurements, the ADuCM360 is used to control the DAC, which, in turn, controls the loop current. This AD5421 is a complete, loop powered, digital-to-4 mA-to-20 mA converter that incorporates the reference, loop interface stage, and programmable voltage regulation circuitry necessary to extract a low power supply from the loop, to power both itself and the rest of the transmitter signal chain. The DAC also provides a number of on-chip diagnostic features, all of which can be configured and read by the microcontroller, but can also operate autonomously. As an example, if the communication between the microcontroller and the DAC fails, the on-chip watchdog timer will automatically set the DAC analog output to a 3.2 mA “alarm” current after a defined period. This indicates to the host that the field instrument failed to operate.

![Figure 2. HART enabled smart transmitter demo block diagram.](image2)
Finally, the AD5700 HART modem, along with the UART interface of the microcontroller, enables HART (Highway Addressable Remote Transducer) communication in the smart transmitter design and plays an essential role in retrieving the instrument’s process and diagnostics information. The HART output is scaled to the required amplitude by the capacitive divider and coupled to the CIN pin of the DAC, where it is combined with the DAC output, to drive and modulate the output current. The HART input is coupled from LOOP+ via a simple passive RC filter. The RC filter works as the first stage band-pass filter for the HART demodulator and also improves the system electromagnetic immunity, which is important for robust applications working in harsh industrial environments. The clock for the HART modem is generated by the on-chip low power oscillator with a 3.8664 MHz external crystal with two 8.2 pF capacitors to ground, connected directly to the XTAL pins. This configuration utilizes the least possible power.

Figure 3. HART enabled smart transmitter demo system.

In conclusion, the circuit outlined above demonstrates one possible solution to the multifaceted challenge involved in the design of a loop-powered smart transmitter to meet ever increasing market demands. The DEMO-AD5700D22 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 and multifeature market leading smart transmitter design. For more information on this demo circuit, please visit www.analog.com/CN0267.