Application Brief

Optimizing Field Sensor and Transmitter Applications With MSPM0 MCUs

There are many different types of process inputs in the world of process control. Including temperature, humidity, flow, level, and pressure. These process inputs need to be measured by sensors that can convert measurements into suitable signal formats (either analog or digital), and then transmit those signals through a transmitter to a receiver, which interprets the signal and makes a control decision. There are currently two main ways for connecting sensors to receivers: analog transmitters in the form of a 4 to 20-mA current loop, and with digital transmitters like IO-Link. There are two main ways for connecting sensors to receivers:

1. Analog transmitters in the form of a 4 to 20-mA current loop
2. Digital transmitters like IO-Link

Both methods require a microcontroller (MCU) to interface with an analog-to-digital converter (ADC) and digital-to-analog converter (DAC) in the system, store application software and calibration data, and perform many other functions.

Process control example for a 4 to 20-mA current loop

Let's start with a 4 to 20-mA current loop. These control loops are used for transmitting remote sensor information to programmable logic controllers (PLCs) over long distances in industrial process-monitoring, control, and automation applications. Figure 1 shows a typical resistance temperature detector (RTD) temperature measurement transmitter for a two-wire, 4 to 20-mA current loop system. It consists of four major blocks:

- ADC: For RTD sensor measurement, this is typically a low-power low-noise sigma-delta ADC with an internal PGA and programmable current source.
- DAC: Output for the current-loop control, this is typically a low-power DAC with an integrated operational amplifier.
- MCU: Controls the whole system operation including data processing and calibration algorithm.
- DCDC converter: Transmitter power supply.

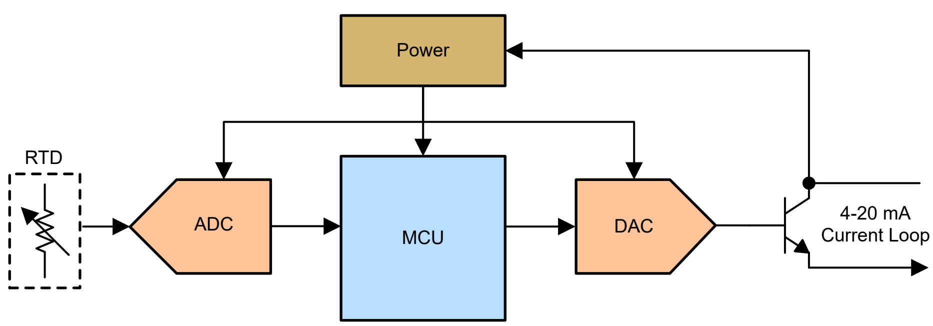

Figure 1. Typical Block Diagram of RTD Temperature Transmitter

The MCU is a key component of the system because it is needed to store data collected from the RTD, for data processing and sensor calibration, and for overall control operation of the system. By using an Arm® Cortex®-M0+ based MSPM0 from the MSPM0L13xx, MSPM0G150x, and MSPM0G350x MCU families, engineers can also leverage integrated analog modules. These are designed to streamline analog signal chain development, reduce cost, and reduce PCB size. These integrated analog modules can improve the RTD temperature transmitter as Figure 2 shows.

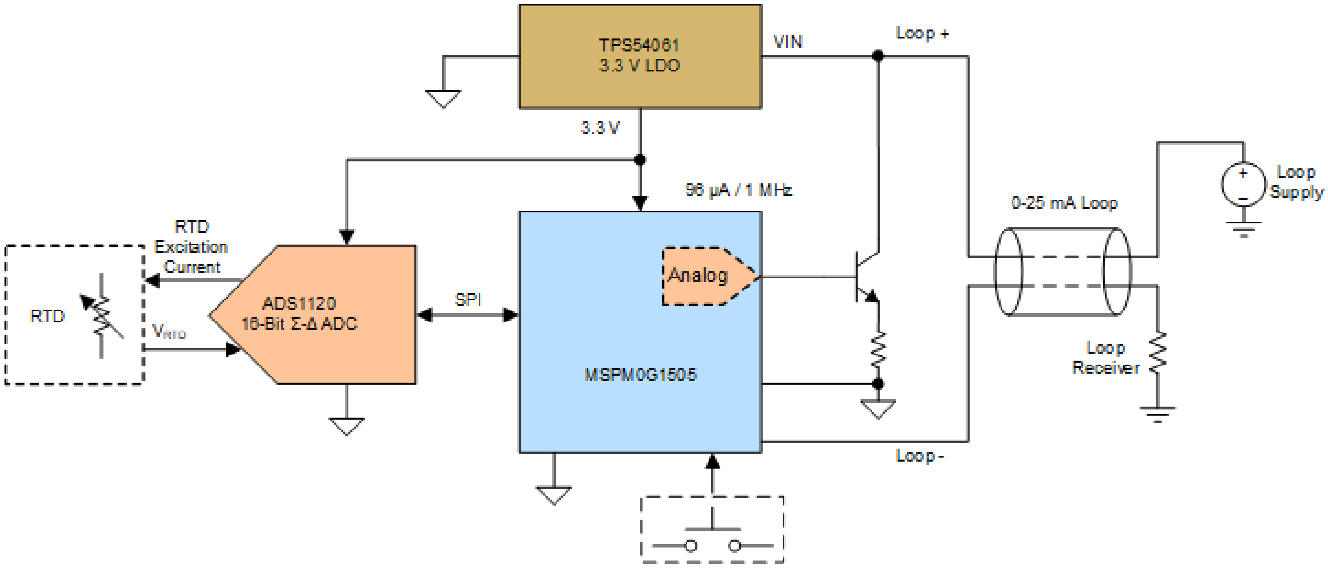

Figure 2. Block Diagram of RTD Temperature Transmitter Based on MSPM0G1505

In this example, an MSPM0G1505 runs the application firmware, including the algorithms for system calibration and data processing. A key benefit of the MSPM0G1505 is that allows the designer to move the DAC block into the MCU. It also provides additional integrated analog like chopper-stabilized op-amps, which allows even more components to be absorbed into the MCU.

Optimizing RTD temperature transmitters with integrated differentiated analog components

Figure 3 shows how the internal analog components in the MSPM0G1505 can be configured to generate the loop current at the receiver. The internal 12-bit DAC can be used as the reference voltage, and works with the internal op-amps to directly drive the output. The first op-amp is configured a buffer to internally enhance the DAC drive capability. The second op-amp is configured as a general-purpose amplifier, where the OPA1_IN0+ and OPA1_IN0- pins on the MCU are dedicated as noninverting and inverting inputs. The output of the first op-amp is connected to the noninverting input of the second op-amp. The output of the second op-amp controls the gate voltage of an external transistor, and the loop current is then the sum of the current through R1 and R2.

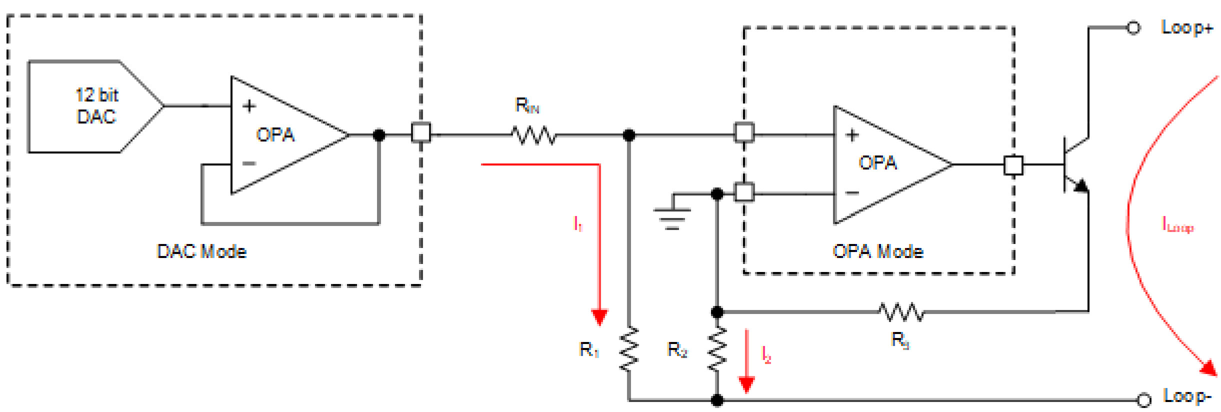

Figure 3. Configuration and Connections of MSPM0G1505 Internal Analog

Leveraging the integrated peripherals of the MSPM0G1505 enables a low-component count and low-cost solution. It also helps to reduce the PCB size and facilities the layout. With the industry's first chopper-stabilized op-amps integrated into an MCU, it's now possible to simplify designs by bringing the analog signal chain into the MCU, without compromising on performance. MSPM0 chopper-stabilized op-amps provide <±0.5 mV of input offset drift across the -40°C to 125ºC operating range, significantly reducing measurement error in high gain applications. With a flexible on-chip analog interconnect, it's possible to create a wide variety of analog circuits, including inverting/non-inverting amplifiers, buffers, PGAs (from 1x to 32x gain), and differential or cascaded amplifier topologies, using on-chip DACs for setting bias points. MSPM0 also supports 1.8 V for low power operation. This further reduces power consumption, as in some cases only 25 mW is available for the entire 2-wire transmitter.

RTD temperature transmitter IO-Link design

Now, let's take a look at another form of a field transmitter. IO-Link provides an alternative to discrete connections. This digital interface on the sensor and actuator level offers advantages when it comes to maintenance and repair, in addition to providing seamless communication and improved interoperability. Figure 4 shows an RTD temperature transmitter upgraded with the IO-Link standard.

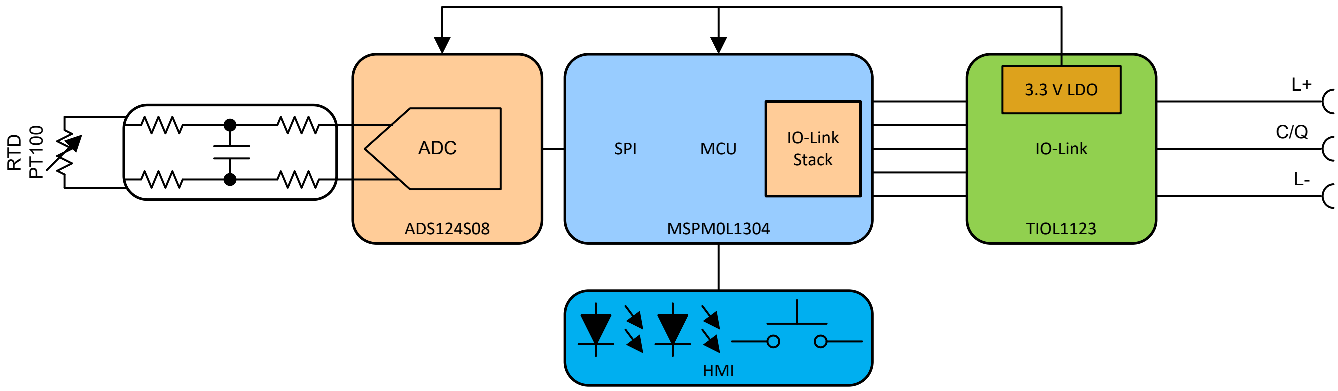

Figure 4. Block Diagram of RTD Temperature Transmitter Based on MSPM0L1304

The MSPM0L1304 can be used for calculating the temperature based on the measured RTD resistance. A look-up table translates the measured voltage levels into the respective temperature values. For this, the MSPM0L1304 gets a data set once the ADC provides the data ready information. Once calculated, the temperature data is transmitted through the IO-Link interface. When the system is connected to an IO-Link master system, the temperature information is shown in the master software. The MSPM0L1304 also has the IO-Link stack for the IO-Link communication.

Summary

MSPM0 MCUs continue the trend of bringing TI's extensive analog experience to performance and cost optimized MCU products. MSPM0L13xx, MSPM0G150x, and MSPM0G350x MCU families offer additional integrated analog modules designed to streamline analog signal chain development, reduce cost, and reduce PCB size. The MSPM0 portfolio offers pin-to-pin compatible packages, variable memory sizes and peripheral feature sets, and ultra-low power with 1.8 V support that's ideal for field sensor and transmitter applications.

Resources

Order a MSPM0 LaunchPad™ development kit today to start evaluating MSPM0. Jump start your design with MSPM0 code examples and interactive online trainings. You can also find other resources using these links:

- MSPM0 overview page
- MSPM0 Academy
- MSPM0 LaunchPad development kits
  - LP-MSPM0L1306 LaunchPad development kit
  - LP-MSPM0G3507 LaunchPad development kit