*Technical Article*

# *How to Design for Precision RTD Measurements with ADCs*

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In theory, temperature measurements using resistance temperature detectors (RTDs) should be simple: measure a temperature with an RTD that changes resistance with temperature, measure the resistance of the RTD, and convert that resistance to temperature through an equation or look-up table. What could possibly go wrong?

Many design considerations come into play. You need to select the correct RTD wiring configuration to limit the errors from lead resistance in your application and use the correct circuit topology to measure the RTD; you will need current analog-to-digital converter (IDAC) excitation current sources to drive the RTD. You'll also need a precision analog-to-digital converter (ADC) with additional features to measure the whole thing. For example, if a standard PT100 RTD is changing roughly 0.4Ω/°C, you'll need accuracy and precision to get measurements in the 0.1°C range.

TI can help you design your RTD circuit with precision ADCs. You can achieve the accuracy you need by selecting the right measurement method and reducing errors in the measurement.

The application note, "A Basic Guide to RTD Measurements," gives an overview of RTDs with a discussion on important parameters, tolerance, configurations and basic measurements using ADCs. This document also gives several circuit topologies to help you decide which RTD wiring configuration to use, and the advantages and disadvantages of each. It explains the process of setting up a precision RTD measurement, identifying and reducing measurement errors, and converting the measurement to a temperature.

TI offers several cookbook circuits that provide more in-depth information about different RTD configurations. There are step-by-step design notes with calculations, ADC configuration settings and pseudo-code to help you design your system and get it up and running. These circuits can help you avoid errors in measurements and guide you toward a solution.

Table 1 lists the RTD cookbook circuits available for downloading.

**Table 1. RTD Circuit Topology Comparison**

| RTD circuit topology | Advantages | Disadvantages |
|---|---|---|
| Two-wire RTD, low-side reference | Lowest system-level cost | Least accurate, no lead-resistance cancellation |
| Three-wire RTD, low-side reference, two IDAC sources | Allows for lead-resistance cancellation | Sensitive to IDAC current mismatch; swapping IDAC currents and averaging two measurements removes the mismatch |
| Three-wire RTD, low-side reference, one IDAC current source | Allows for lead-resistance cancellation | Requires two measurements, first for RTD measurement, second for lead-resistance cancellation |
| Three-wire RTD, high-side reference, two IDAC current sources | Allows for lead-resistance cancellation; less sensitive to IDAC mismatch than using a low-side reference | Requires extra resistor for biasing; added voltage may not be compatible with low supply operation |
| Four-wire RTD, low-side reference | Most accurate, no lead-resistance error | Most expensive |

A typical RTD measurement system requires a precision ADC, current excitation sources, a precision reference resistance and some lower-cost filter components. The precision ADC often includes internal current references, so the main expense is the reference resistance and data converter.

The next time you need to design a precision RTD measurement system, start with "A Basic Guide to RTD Measurements" and download the cookbook circuits that we have available. You'll be able to put your system together and make precision temperature measurements with TI's ADCs.