RTD Interface Circuit

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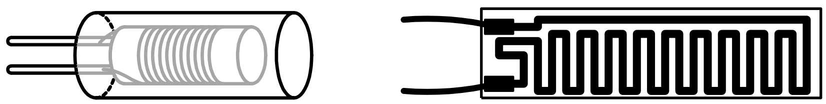
For high-accuracy temperature measurements, RTDs (Resistance Temperature Detectors) are among the preferred transducer technologies. These devices are useful for measuring temperature over a range extending from near absolute zero (-273°C) to over 900°C. The International Temperature Scale (ITS-90) specifies the use of a platinum RTD for measuring temperature over a range extending from the triple-point of hydrogen (13.803°K) to the freezing point of silver (961.78°C).

Figure 1. Wound-wire and Thin-film RTDs



Physically, most precision RTDs are fabricated from either fine metal wire wound on an insulating form or metal film bonded to a substrate and patterned to obtain a high resistance, as illustrated in Figure 1. The resistance of an RTD is a function of its ambient temperature, and for most metals varies ≈ 0.3-0.4%/°C. While many metals can be used to construct RTDs, platinum is often used because of its resistance to oxidation and chemical attack and because it is both mechanically and chemically stable over a wide range of temperatures.

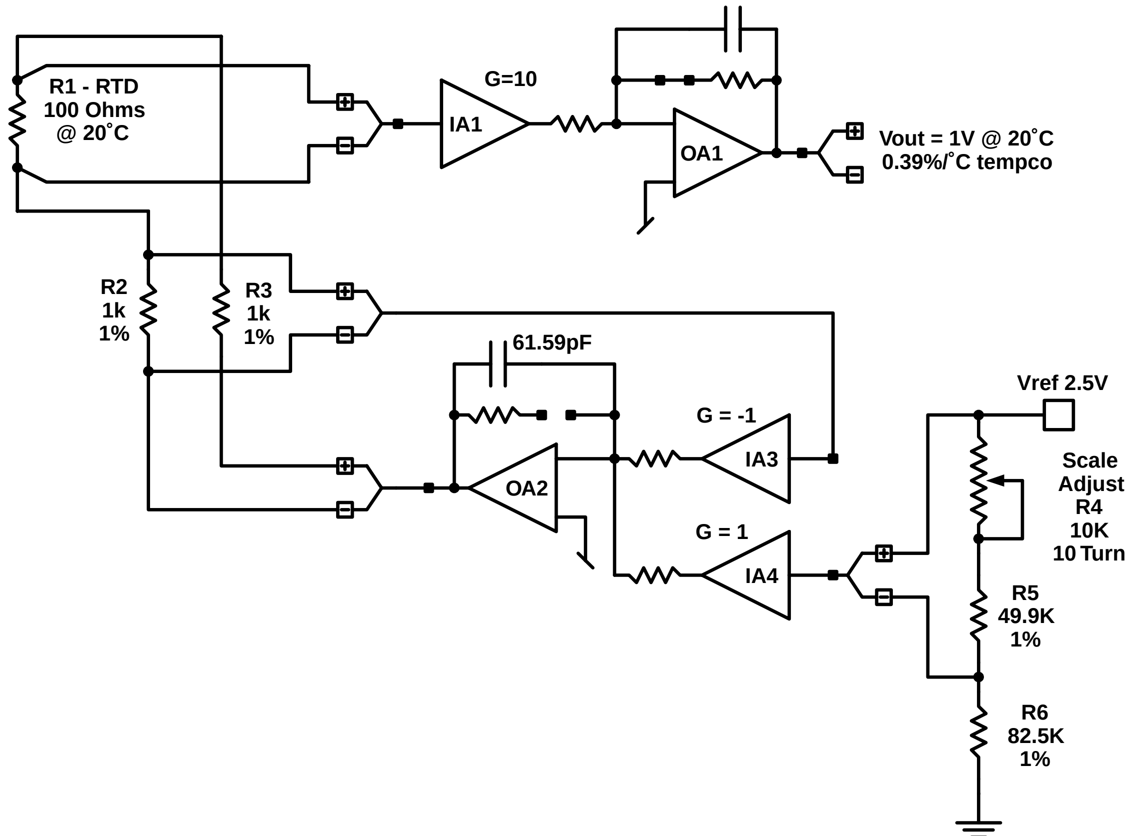
The best transducer, however, is only as good as the interface electronics supporting it. While there are many ways to measure resistance, one of the most accurate is to force a constant current through the resistor and measure the resulting voltage. In the case of an RTD, an additional wrinkle occurs because current flowing through the device will cause self-heating. For precise measurements, this self-heating effect must be taken into account, and one will want to use as little current as possible, consistent with obtaining an accurate resistance measurement.

The circuit of Figure 2 provides a simple, but useful, front-end interface to a 100Ω RTD. It provides a stable excitation current of 1 mA, and an output signal of 10mV/Ω when the sense amplifier is set to a gain of 10, resulting in a 1V output for a 100Ω RTD resistance. Because this circuit only uses two PACBlocks, it can be implemented in either an ispPAC10 or ispPAC20.

This circuit has two parts, a constant-current excitation generator and a sense amplifier. The excitation generator is referenced from a voltage derived from a resistive divider tied to the VREFout pin (R4,R5,R6). The particular resistor values shown in Figure 2 were chosen so as to provide enough trim range (~ +/- 9%) to compensate for various errors in both the RTD nominal resistance and gain errors in the circuit. Alternatively, if this circuit were implemented with an ispPAC®20 device, the internal DAC could be used to establish a reference voltage, trading off trim resolution for the ability to perform the trim automatically. A constant current through the RTD is developed through the use of a feedback loop using R2, OA2 and IA3. OA2 forces a voltage across the series connection of R1, R2, and R3, and uses IA3 to measures the voltage drop across R2, which is proportional to the current. This information is then used to adjust the force voltage so that the drop across R2 is constant, regardless of the RTD's (R1's) resistance. In this way, a constant current (nominally 1mA) is maintained through R1. Although R3 is not critical to the circuit's function, it makes the circuit symmetric between the outputs of OA2, and maintains the RTD's terminal voltages close to 2.5V. This reduces the common-mode rejection requirements of the sense amplifier because the average (common-mode component) of the RTD terminal voltages will not change as a function of RTD resistance.

The sense amplifier consists of IA1 and OA1, and it provides a gain of 10 for the voltage signal measured across the RTD. Because of the ispPAC device's low input offset voltages (typically 20µV for the ispPAC10 and ispPAC20), a low voltage can still be accurately measured across the RTD and provide an accurate temperature measurement. At 25°C, where the RTD's resistance is 100Ω, and the voltage across it is 100mV, the 20µV amplifier input offset voltage contributes less than 0.1°C of system measurement error.

Figure 2. Precision RTD Interface Circuit Using Two PACblocks



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