AD8495 Interface to Type T Thermocouples

By Scott Hunt
Product Applications Engineer, Analog Devices, Inc.

Thermocouples are a common, inexpensive way to make precision temperature measurements over wide temperature ranges. Type T thermocouples (copper constantan) are sensitive, stable, easy to manufacture, and moisture tolerant—and the copper-to-copper connection to the printed circuit board eliminates the need for an isothermal block. These are some of the main reasons that type T thermocouples are chosen for many applications, from catheters to food processing, that don't need the full temperature range available from other thermocouples such as type K.

ADI makes thermocouple amplifiers with built-in cold-junction compensation, but not for type T thermocouples. Fortunately, type T and type K amplifiers have similar voltage characteristics up to about 100°C. Type K thermocouple conditioners such as AD8495 or AD8497 can take advantage of this similarity to measure type T thermocouples with very low errors. The output voltage for higher temperatures will deviate from the ideal 5 mV/°C transfer function of the AD8495, so it is necessary to account for the difference with a lookup table or polynomial. The figure was generated using the type T thermocouple table from NIST and the transfer function of the AD8495 in order to show the AD8495 output at various reference junction temperatures.

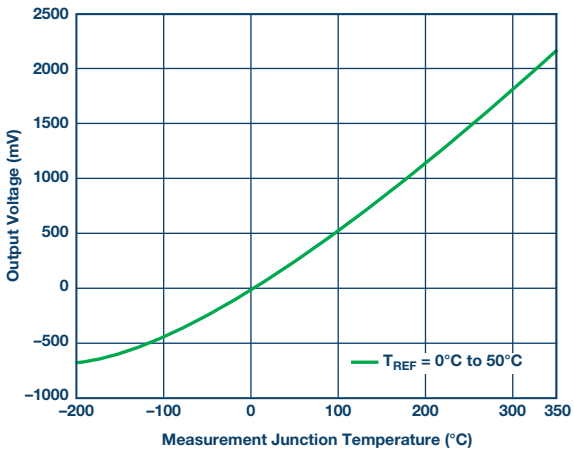

Figure 1. AD8495 calculated output with type T thermocouple.

The graph or this 6th order polynomial can be used to map the output voltage to the measurement temperature. V_{OUT} (mV) = $a_0 + a_1 \times T + a_2 \times T^2 + \ldots + a_6 \times T^6$, where the coefficients are:

a_6	a_5	a_4	a_3	a_2	a_1	a_0
2.115×10^{-16}	-2.116×10^{-12}	2.602×10^{-9}	-4.238×10^{-6}	5.548×10^{-3}	4.728	1.099

Over the full –200°C to +350°C measurement temperature range and 0°C to 50°C reference junction temperature range, the calculated error of this polynomial is approximately –2.50 mV to +2.28 mV, which is less than about ±0.5°C. Thermocouple tolerance and AD8495 amplifier errors must be added.

Notice that the output voltage is negative for temperatures below 0°C. The output voltage is measured with respect to the reference pin (REF), so the voltage at REF can be raised to accommodate the negative output voltage with a single supply. See the AD8495 data sheet for important considerations when designing with thermocouples, including grounding, filtering interference, and layout practices in order to keep the device temperature equal to the reference junction temperature.

About the Author

Scott Hunt [*scott.hunt@analog.com*] is a product applications engineer in the Linear Products Group in Wilmington, MA. Scott joined Analog Devices in 2011 after receiving a bachelor's degree in electrical engineering from Rensselaer Polytechnic Institute. Scott specializes in integrated precision amplifiers including instrumentation amplifiers, differential amplifiers, and thermocouple amplifiers.

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Analog Devices, Inc.
Worldwide Headquarters

Analog Devices, Inc.
One Technology Way
P.O. Box 9106
Norwood, MA 02062-9106
U.S.A.
Tel: 781.329.4700
(800.262.5643, U.S.A. only)
Fax: 781.461.3113

Analog Devices, Inc.
Europe Headquarters

Analog Devices GmbH
Otl-Aicher-Str. 60-64
80807 München
Germany
Tel: 49.89.76903.0
Fax: 49.89.76903.157

Analog Devices, Inc.
Japan Headquarters

Analog Devices, KK
New Pier Takeshiba
South Tower Building
1-16-1 Kaigan, Minato-ku,
Tokyo, 105-6891
Japan
Tel: 813.5402.8200
Fax: 813.5402.1064

Analog Devices, Inc.
Asia Pacific Headquarters

Analog Devices
5F, Sandhill Plaza
2290 Zuchongzhi Road
Zhangjiang Hi-Tech Park
Pudong New District
Shanghai, China 201203
Tel: 86.21.2320.8000
Fax: 86.21.2320.8222

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