

## **Everybody Knows - Thermocouples**

**Everybody knows** how thermocouples work - however, the common knowledge is usually incorrect.

Many people continue to think that a thermocouple's voltage is created by the junction of two dissimilar metals - a concept that is erroneous, and thinking this way can lead one to incorrectly measure temperature.

A very important note: ***the thermocouple voltage is not created at the junction***

Thermocouples are more properly thought of as gradient temperature sensors - since the thermocouple voltage is developed along the temperature gradient of the conductors.

Thermocouples develop a voltage difference between the leads due to the Seebeck effect of the conductor material. The Seebeck effect is simply that a conductor in a temperature gradient produces a voltage (the voltage is created even in a single wire).

This Seebeck voltage varies with material and temperature. References [1] and [2] do a wonderful job of explaining this basic concept (as well as providing a clear explanation of the care and feeding of thermocouples).

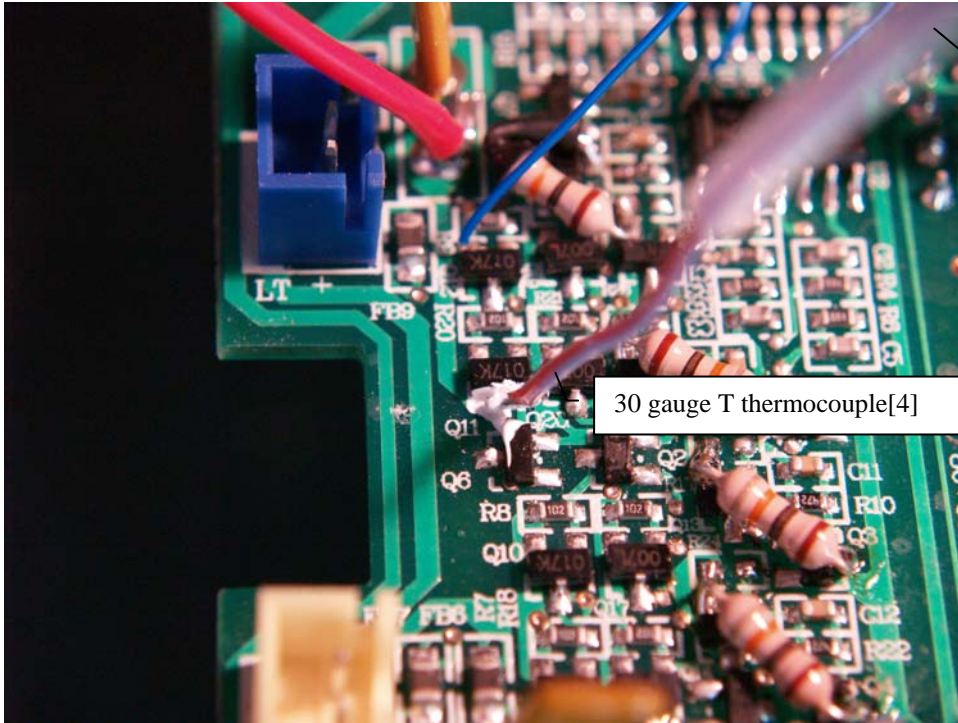
Two dissimilar metallic wire conductors are used in a thermocouple to make use of the relative Seebeck voltage between the two wires to generate a voltage that we can measure and then convert to the indicated temperature endpoint (after the appropriate cold junction compensation).

The important items to remember:

- The thermocouple voltage is generated by the wires, not the junction.
- The thermocouple junction needs to reside in an isothermal environment.
- The accuracy of the thermocouple is critically dependent on the uniformity and integrity of the two thermocouple wires (insure that the thermocouple wire is not cold worked, heat or chemically damaged in the temperature gradient area).

Handy equipment for the electronics lab: Fluke model 52 dual thermometer with two 30gauge type T thermocouples.

An example of thermocouple usage: 30gauge type T thermocouple measuring the foot of an SOT-23 FET (with small dab of heatsink compound to aid thermal conduction):



Thermocouple held 3 inches away with micro-positioner

30 gauge T thermocouple[4]

References:

1. Nicholas and White, *Traceable Temperatures, Second Edition*. John Wiley and Sons, 2001.
2. *The Use of Thermocouples in Temperature Measurement, Fourth Edition*. ASTM, 1993.
3. *Low Level Measurements Handbook, Sixth Edition*, Keithley Instruments.
4. Omega Thermocouples. Omega.com 5SC-TT-T-30-36 5 pack of 36 inch T type thermocouples with PFA insulation, 30 AWG wire \$69.00 .
5. Fluke Model 52 Dual Thermometer. Disclaimer: other than purchasing this instrument thru an electronics distributor, I have no other relationship with Fluke Corp.