# Thermocouples

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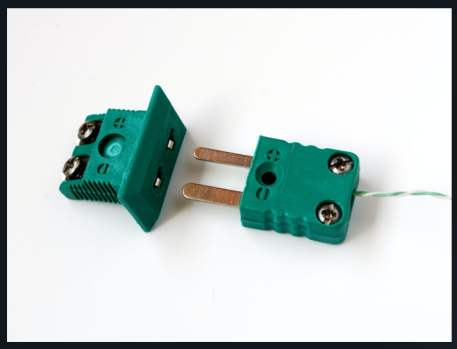
## 1. What are they?

# Definition



*Most common thermocouple: K type*

A thermocouple is a thermoelectric device used to measure temperature.

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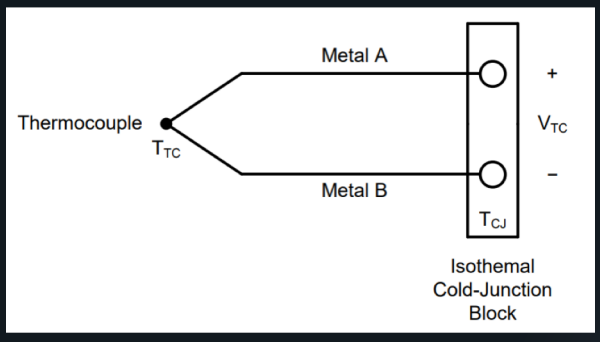
# Set Up




*Texas Instrument diagram of thermocouple voltage.*

- $T_{TC}$ - Hot junction
  - The junction that is placed on the surface or in the environment that is being measured
- $T_{CJ}$ - Cold Junction
  - The junction that remains at a known constant temperature
- Differential Voltage
  - Voltage created by different temperatures fed by dissimilar metals

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# Laws of Thermocouple Usage

- 1st Law: Homogeneous Material
- 2nd Law: Intermediate Material
- 3rd Law: Law of Successive or Intermediate Temperatures

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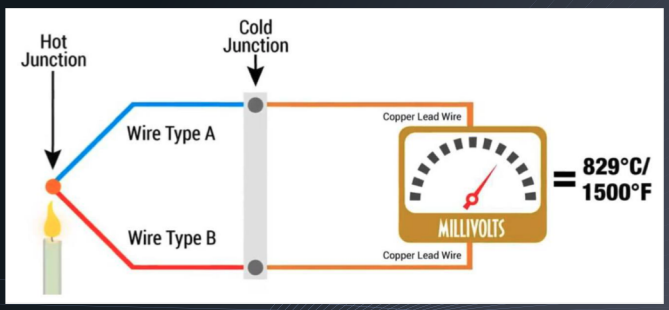
## 2.
## How do they work?

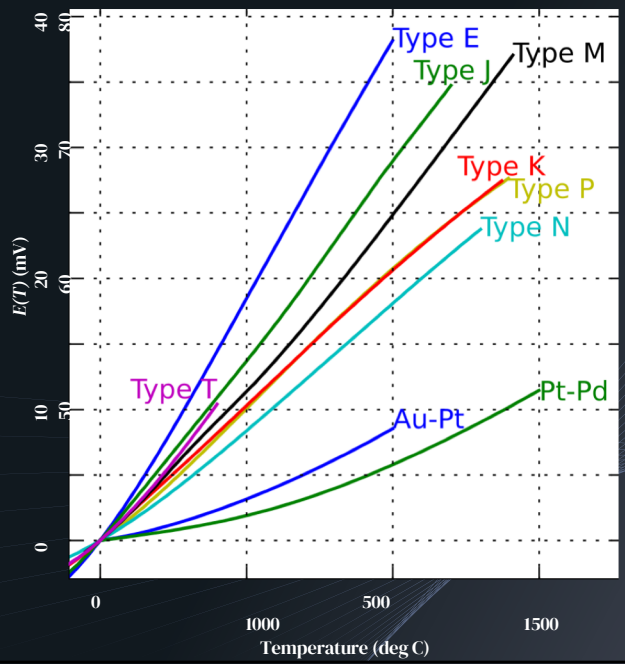
# Operation

- Unknown temperature applied to Hot Junction
- Known temperature applied to Cold Junction
- Hot and Cold Junction voltages added together
- Voltage compared to characteristic function



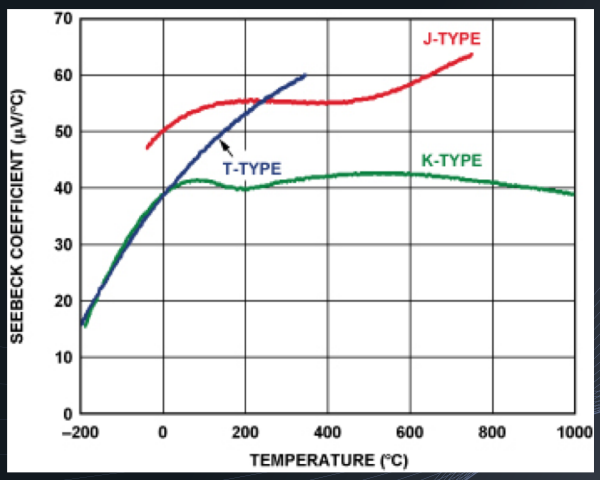

*Courtesy of Omega*

## Characteristic Functions

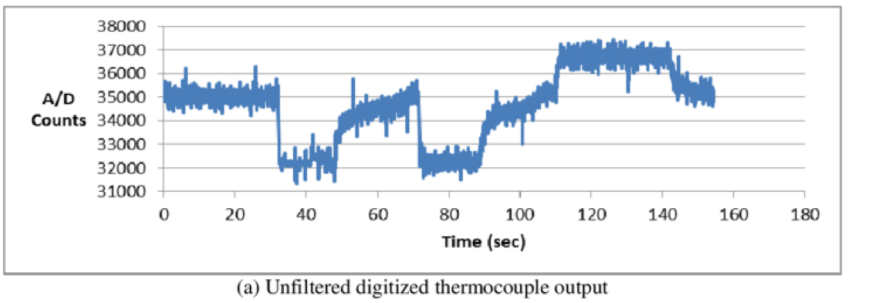



*Courtesy Wikipedia*

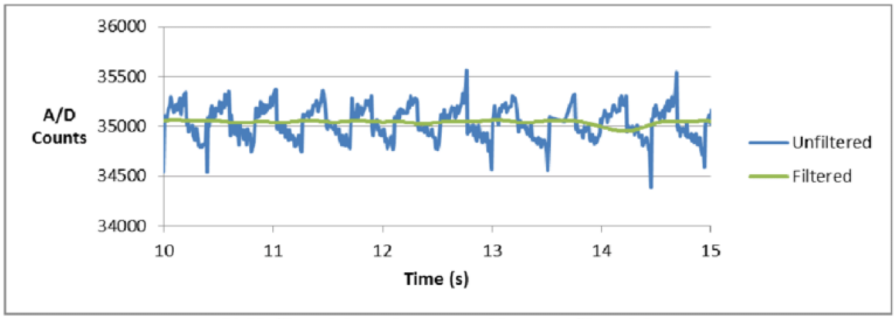
## Seebeck Functions




Courtesy analog.com



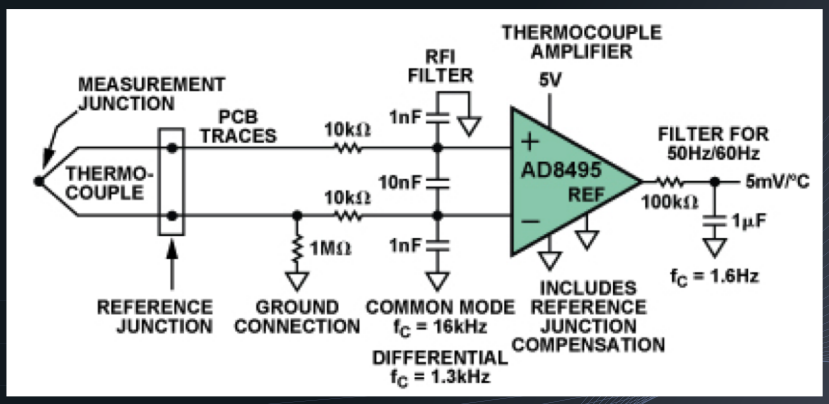

(a) Unfiltered digitized thermocouple output




(b) Unfiltered data, close up, and lowpass-filtered data.

Courtesy researchgate.com

## Example Thermocouple Conditioning Circuit




# 3. Applications

# 4 Basic Types

| Type | Temperature range (C) | Accuracy | Materials |
|---|---|---|---|
| J | -210 - 760 | 2.2 | iron/constantan |
| K | -270 - 1260 | 2.2 | nickel-chromium/nickel-alumel |
| T | -270 -370 | 1.0 | copper/constantan |
| N | -270 - 392 | 2.2 | nicrosil/nisil |

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# Applications

- Type K - Plants, refineries
- Type J - Vacuum applications
- Type T - Food industry
- Type N - Furnaces, kilns

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# How They Are Used

- Hooked to controllers
- Two probes
  - Hot - test
  - Cold - reference
- Shuts off valve

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# Why use thermocouples

**Advantages**

- Small
- Accurate
- Multi use
- React quickly

**Disadvantages**

- Expensive
- Non-linear
- Low volts
- Hard to recalibrate

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# References

https://www.thermocoupleinfo.com/

https://www.analog.com/en/analog-dialogue/articles/measuring-temp-using-thermocouples.html#

http://www.ti.com/lit/an/sbaa274/sbaa274.pdf

https://en.wikipedia.org/wiki/Thermocouple

https://www.omega.com/en-us/resources/thermocouples

https://www.researchgate.net/figure/Unfiltered-and-Filtered-Thermocouple-Output_fig10_268469128

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# Thanks!

# Questions

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