Thermocouples

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1. What are they?
Definition

A thermocouple is a thermoelectric device used to measure temperature.

Most common thermocouple: K type

Set Up

- **$T_{TC}$ - 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
Laws of Thermocouple Usage

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

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

![Operation Diagram](image)

**Characteristic Functions**

![Characteristic Functions Graph](image)

Courtesy of Omega

Courtesy Wikipedia
Seebeck Functions

(a) Unfiltered digitized thermocouple output

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

Courtesy analog.com

Courtesy researchgate.com
3. Applications
4 Basic Types

<table>
<thead>
<tr>
<th>Type</th>
<th>Temperature range (C)</th>
<th>Accuracy</th>
<th>Materials</th>
</tr>
</thead>
<tbody>
<tr>
<td>J</td>
<td>-210 - 760</td>
<td>2.2</td>
<td>iron/constantan</td>
</tr>
<tr>
<td>K</td>
<td>-270 - 1260</td>
<td>2.2</td>
<td>nickel-chromium/nickel-alumel</td>
</tr>
<tr>
<td>T</td>
<td>-270 - 370</td>
<td>1.0</td>
<td>copper/constantan</td>
</tr>
<tr>
<td>N</td>
<td>-270 - 392</td>
<td>2.2</td>
<td>nicrosil/nisil</td>
</tr>
</tbody>
</table>

Applications

- Type K - Plants, refineries
- Type J - Vacuum applications
- Type T - Food industry
- Type N - Furnaces, kilns
How They Are Used

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

Why use thermocouples

**Advantages**
- Small
- Accurate
- Multi use
- React quickly

**Disadvantages**
- Expensive
- Non-linear
- Low volts
- Hard to recalibrate
References

https://www.thermocoupleinfo.com/
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

Thanks!

Questions