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Temperature Transducers

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Sources: http://www.ibiblio.org/kuphaldt/socratic/sinst/book/liii_2v14.pdf - chp 21
Various google images

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Transducer

- A **Transducer** is a device that converts variations in a physical quantity, such as pressure or brightness, into an electrical signal.

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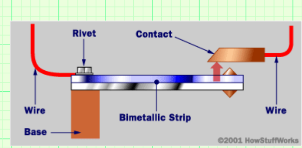
Bi-Metallic Strip

- Two strips of dis-similar metal that expand or contract at different rates

- Can be used in Temperature Switches



Bi-Metallic Strip

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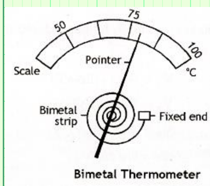
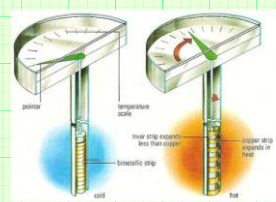
- Or dial thermometers





Filled Bulb

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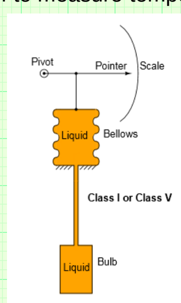
- Filled-bulb systems exploit the principle of fluid expansion to measure temperature



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- The last two types (Bi-metallic Strip and Filled bulb) convert temperature to a mechanical action….But how do we get a mechanical motion to an ELECTRONIC SIGNAL?

Thermistors and RTDs

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- Temperature sensors where temperature effects a change in electrical resistance.
- Self Heating Error
  - In order to measure the resistance of either device, we must pass an electric current through it. Unfortunately, this results in the generation of heat due to power dissipation:

$$P = I^2R$$

  - To minimize effect limit current (but this limits voltage drop across component) or use a pulse current to read

Thermistors and RTDs

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- Thermistors are devices made of metal oxide which either increase in resistance with increasing temperature (a positive temperature coefficient) or decrease in resistance with increasing temperature (a negative temperature coefficient)
  - highly sensitive and nonlinear
  - typically used where high accuracy is unimportant.

Thermistors and RTDs

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- RTDs are devices made of pure metal wire (usually platinum or copper) which always increase in resistance with increasing temperature.
  - insensitive but very linear

Silicon

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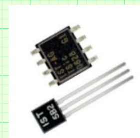
- The **silicon bandgap temperature sensor** is an extremely common form of temperature sensor
- The principle of the sensor is that the forward voltage of a silicon diode, which may be the base-emitter junction of a bipolar junction transistor (BJT), is temperature-dependent.



Thermocouples

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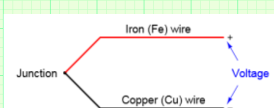
- Dissimilar metal junctions
- When two dissimilar metal wires are joined together at one end, a voltage is produced at the other end that is approximately proportional to temperature.



- This form of electrical temperature sensor is called a thermocouple

Thermocouple

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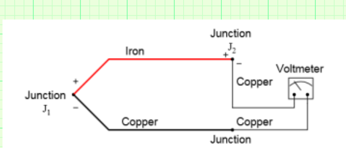
- BUT…..when we connect any kind of electrical instrument to the thermocouple wires, we inevitably produce another junction of dissimilar metals!



Thermocouple

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- Thus, thermocouple systems are fundamentally **differential temperature sensors**.
- Provide an electrical output proportional to the **difference in temperature** between two different points.
- The wire junction we use to measure the temperature of interest is called the **measurement junction**.
- The other junction is called the **reference junction** (or the **cold junction** , because it is typically at a cooler temperature than the process measurement junction)

Thermocouples

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- Thermocouples exist in many different types, each with its own color codes for the dissimilar-metal wires. Here is a table showing the more common thermocouple types and their standardized colors

Type	**Positive wire** *characteristic*	**Negative wire** *characteristic*	**Plug**	**Temp. range**
T	Copper (blue) *yellow colored*	Constantan (red) *silver colored*	Blue	−300 to 700 °F
J	Iron (white) *magnetic, rusty?*	Constantan (red) *non-magnetic*	Black	32 to 1400 °F
E	Chromel (violet) *shiny finish*	Constantan (red) *dull finish*	Violet	32 to 1600 °F
K	Chromel (yellow) *non-magnetic*	Alumel (red) *magnetic*	Yellow	32 to 2300 °F
N	Nicrosil (orange)	Nisil (red)	Orange	32 to 2300 °F
S	Pt90% - Rh10% (black)	Platinum (red)	Green	32 to 2700 °F
B	Pt70% - Rh30% (grey)	Pt94% - Rh6% (red)	Grey	32 to 3380 °F

Thermocouples

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- thermocouple is nothing more than a pair of dissimilar-metal wires joined together. However, in industrial practice, we often must package thermocouples in a more rugged form than a bare metal junction.

Thermocouples

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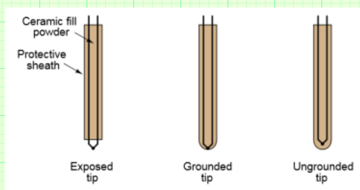
- They can also have various type styles:



Thermocouples

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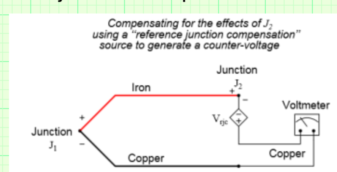
- To compensate for the reference junction voltage use a reference junction compensation (aka cold junction compensation circuit)



Thermocouple

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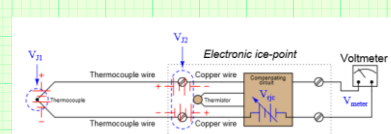
- Some instrument manufacturers sell *electronic ice point* modules designed to provide reference junction compensation for un-compensated instruments such as standard voltmeters



Thermocouple

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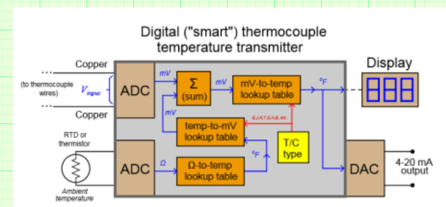
- Some use a “smart thermocouple” which do software compensation:



Non-Contacting (IR)

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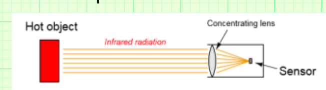
- Infrared Temp Sensors



- Note the “sensor” actually measures a temperature change caused by the infrared radiation.

- Distance and Field of View (FOV) can effect measurement