

Temperature Sensor (4A)

- Temperature Sensor Type
- Temperature Sensor Characteristics

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Temperature Sensor Type - Physical Effect

Physical Effect	Temperature Sensor Type	Temp Range [°C]
Electrical Resistance Changes	RTD (metal)	[-200, +850]
	Thermistor (semiconductor)	NTC PTC CTR
Thermo-electric Effect	Thermo-couple	[-200, +1600]
	Thermo-pile	[-40, +100]
Semiconductor Characteristics	Diode Transistor	[-50, +100]
Pyro-electric Effect	Pyro-electric IR Detector	-

Principles of Operation (1)

Electrical Resistance Changes:

As temperature increases, resistance changes

- **RTD** (Resistance Temperature Detector) – metal
- **Thermistor** (Thermal Resistor) – semiconductor

Thermo-electric Effect:

- Two different kinds of metal used
- Temperature difference → Potential difference

Diode & Transistor Characteristics:

- With constant I, V is proportional to T (temperature)

Pyro-electric Effect:

- generates a temporary electrical potential
when certain materials are heated or cooled

Principles of Operation (2)

RTD (Resistance Temperature Detector) – metal

- **R is linearly modeled**
- **α : temperature coefficient of resistance (TCR)**

Thermistor (Thermal Resistor) – semiconductor

- **NTC (Negative Temperature Coefficient)**
R decreases as T increases
- **PTC (Positive Temperature Coefficient)**
R increases as T increases
- **CRT (Critical Temperature Coefficient)**
R decreases abruptly as T increases to the critical temperature

Principles of Operation (3)

Thermo-electricity:

- a temperature difference creates an electrical potential
- an electrical potential creates a temperature difference

Pyro-electricity:

- generates a temporary electrical potential when certain materials are heated or cooled
- the opposite effect is called **electro-caloric effect**

Principles of Operation (4)

Thermo-electricity:

Thermo-couple

- Seebeck EMF (Electro-Motive Force) – Voltage
- Seebeck Coefficient – linear coefficient

Thermo-pile

- Thermo-couples in series connection

RTD Sensor Types

Types	Temp Range [C]	Temp Coef	Characteristic
Pt	[-200, 640]		<ul style="list-style-type: none">• The most stable• If $T < 20K$, bad sensitivity• Influenced by magnetic field• Accuracy• Repeatability
Cu	[0, 120]		
Ni	[50, 300]	Large	

Thermistor Sensor Types

Material	Output Voltage	Temp Range	Usage
NTC	Low Temp	[-100, 0]	In-rush current limiting device Automotive
	Mid Temp	[-50, 300]	
	High Temp	[200, 700]	
PTC	Large	[-50, 150]	Constant Temperature Heating Thermal Switch (Cutoff)
CTR		[0, 150]	Temperature Alarm

IC Temperature Sensor

One Chip

→ **Transistor Temperature Sensor**

+ **Amplification Circuit**

+ **Correction Circuit**

References

- [1] <http://en.wikipedia.org/>
- [2] Nam Ki Min, Sensor Electronics, Dong-il Press