Temperature Sensor (4B)

- RTD (Resistance Temperature Detector)
- Thermistor (Thermally Sensitive Resistor)
- Thermocouple
- Diode, TR Temperature Sensor

Please send corrections (or suggestions) to youngwlim@hotmail.com.

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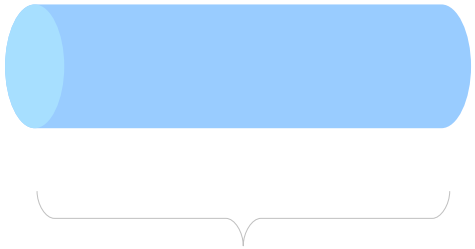
Electrical Resistance of Metal

Electrical Resistance:

$$R = \rho \frac{L}{A}$$



ρ **resistivity**

- Nickel
- Copper
- Platinum

L: length

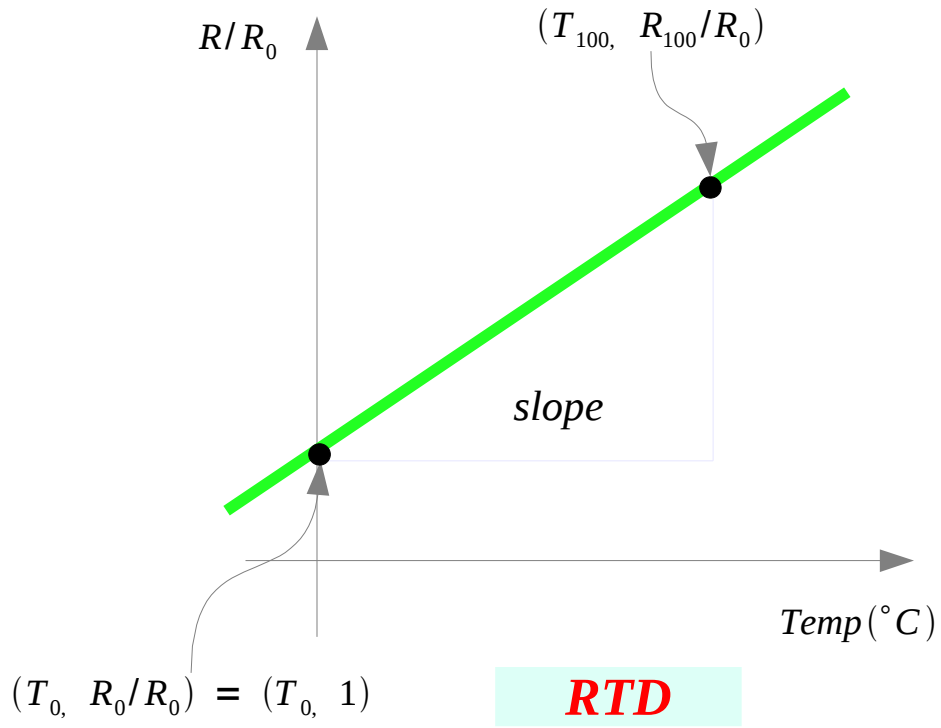
A: cross section area

RTD Temperature Characteristics

Temperature Coefficient of Resistance: α

$$R = \rho \frac{L}{A}$$

$$R = R_0[1 + \alpha(T - T_0)]$$



RTD

$$\frac{R}{R_0} = 1 + \alpha(T - T_0)$$

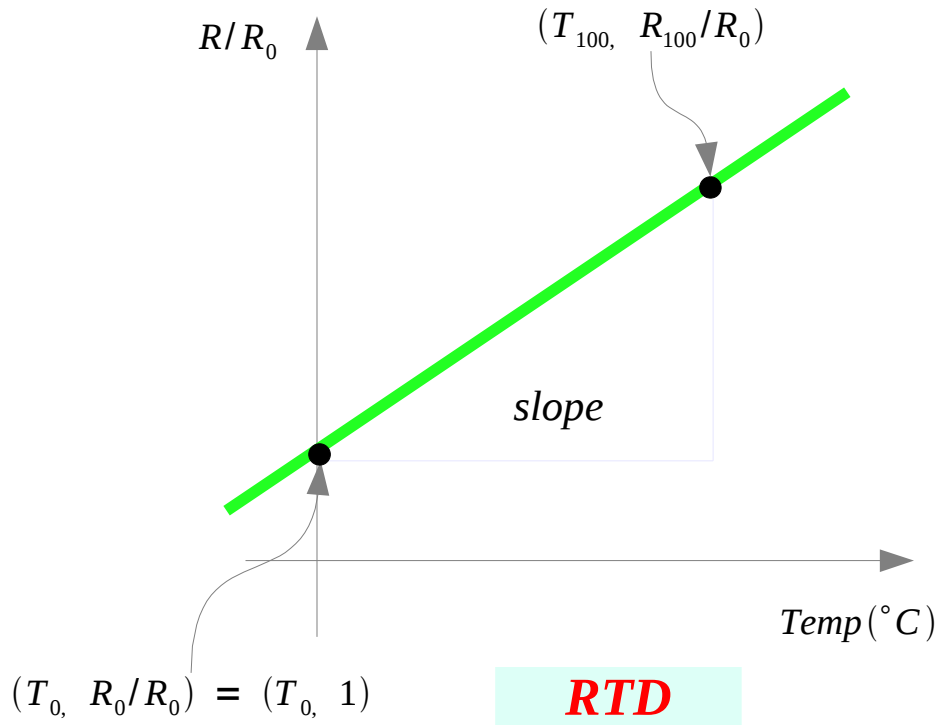
$$\frac{R - R_0}{R_0} = \alpha(T - T_0)$$

$$\alpha = \frac{1}{R_0} \cdot \frac{R - R_0}{T - T_0}$$

RTD Sensitivity

Temperature Coefficient of Resistance: α

$$R = \rho \frac{L}{A} \quad \Rightarrow \quad R = R_0[1 + \alpha(T - T_0)]$$



$$\alpha = 0.004 \ [/^\circ C]$$

0.4 *percent change in resistance for* $1\,[^\circ C]$ *change in temperature*

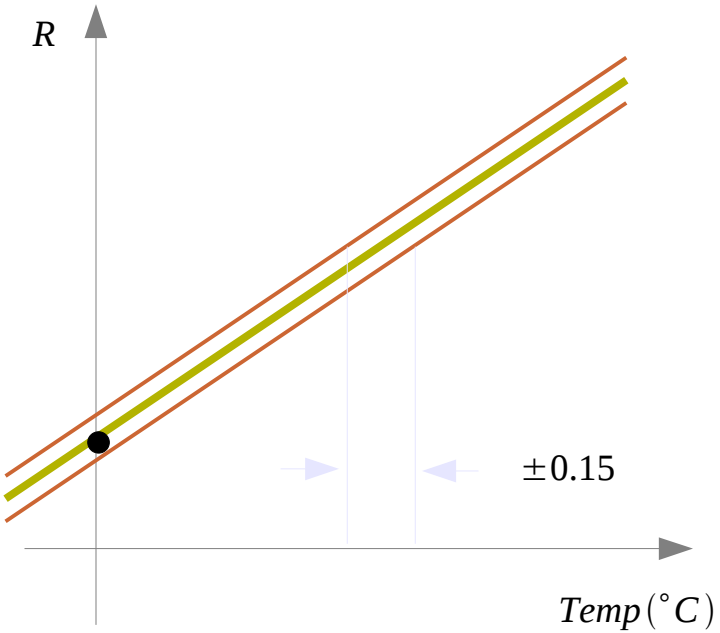
$$100\,\Omega \rightarrow 0.4\,\Omega$$

RTD Accuracy

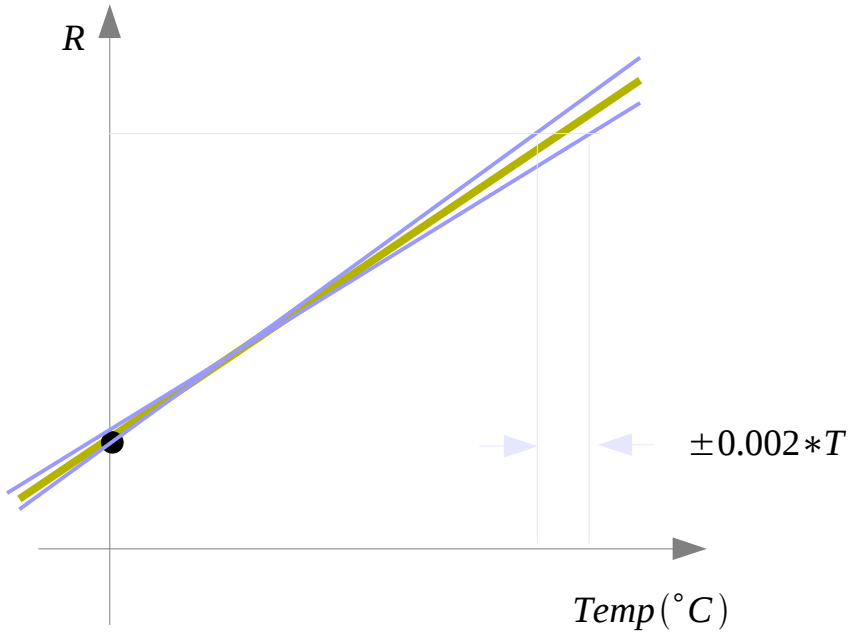
Temperature Coefficient of Resistance: α

$$Class\ \ A:\ \pm(0.15 + 0.002\,T)\ \ [^{\circ}C]$$

$$Class\ \ B:\ \pm(0.30 + 0.005\,T)\ \ [^{\circ}C]$$



RTD

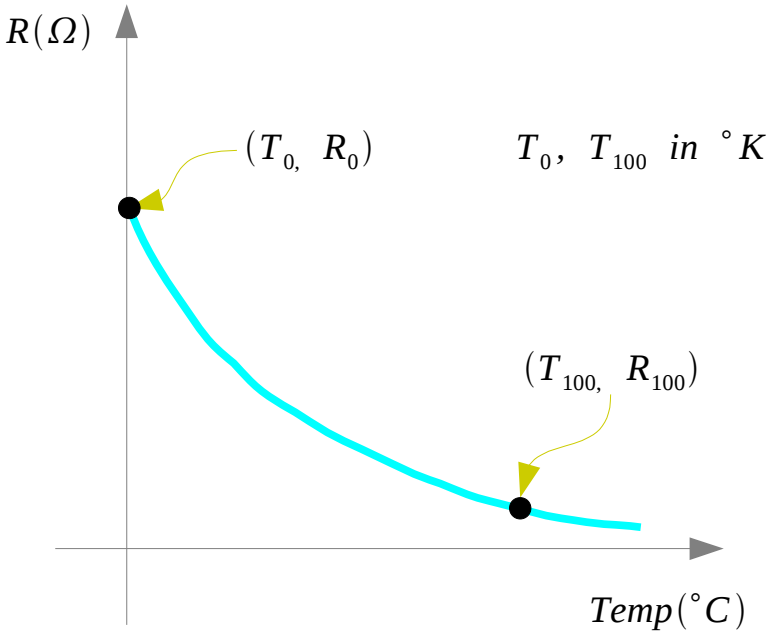


RTD

NTC Thermistor Temperature Characteristics (1)

Characteristic Temperature: β

$$R = R_0 \exp\left[\beta\left(\frac{1}{T} - \frac{1}{T_0}\right)\right]$$



NTC Thermistor

$$\ln R = \ln R_0 + \beta\left(\frac{1}{T} - \frac{1}{T_0}\right)$$

$$\ln R - \ln R_0 = \beta\left(\frac{1}{T} - \frac{1}{T_0}\right)$$

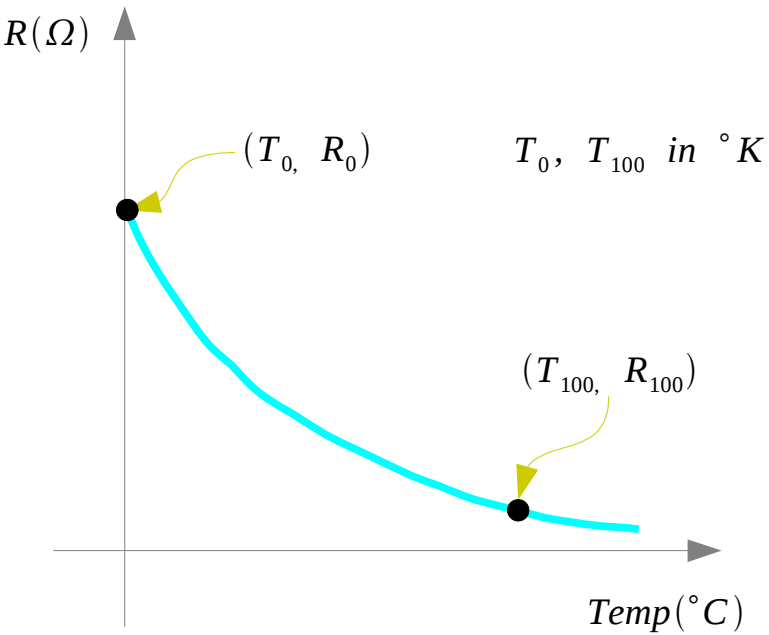
$$\beta = \frac{1}{\left(\frac{1}{T} - \frac{1}{T_0}\right)} \ln\frac{R}{R_0}$$

NTC Thermistor Temperature Characteristics (2)

$$\beta = \frac{1}{\left(\frac{1}{T} - \frac{1}{T_0}\right)} \ln \frac{R}{R_0}$$

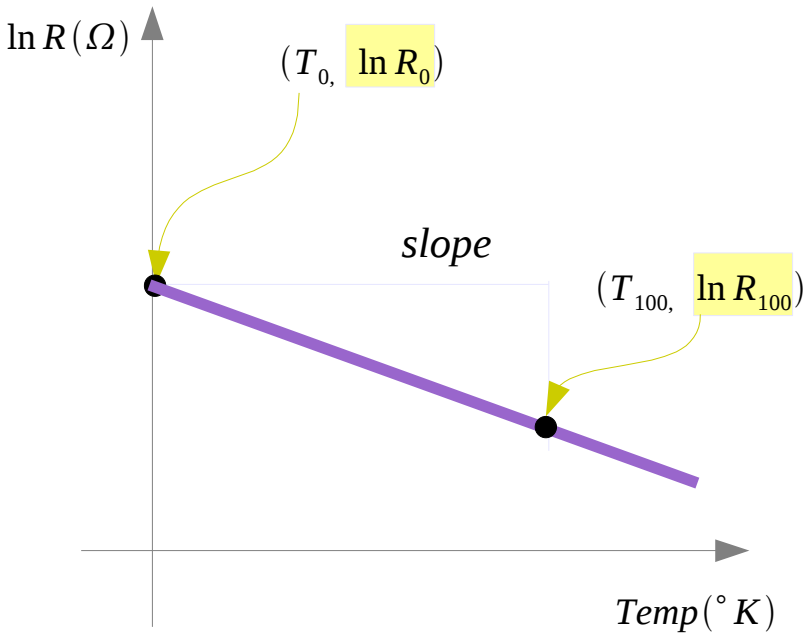
$$\beta = T_{100} \cdot T_0 \cdot slope \qquad slope = \frac{\ln R_{100} - \ln R_0}{T_{100} - T_0}$$

$$= \frac{\ln \frac{R_{100}}{R_0}}{T_{100} - T_0}$$



NTC Thermistor

Log Scale



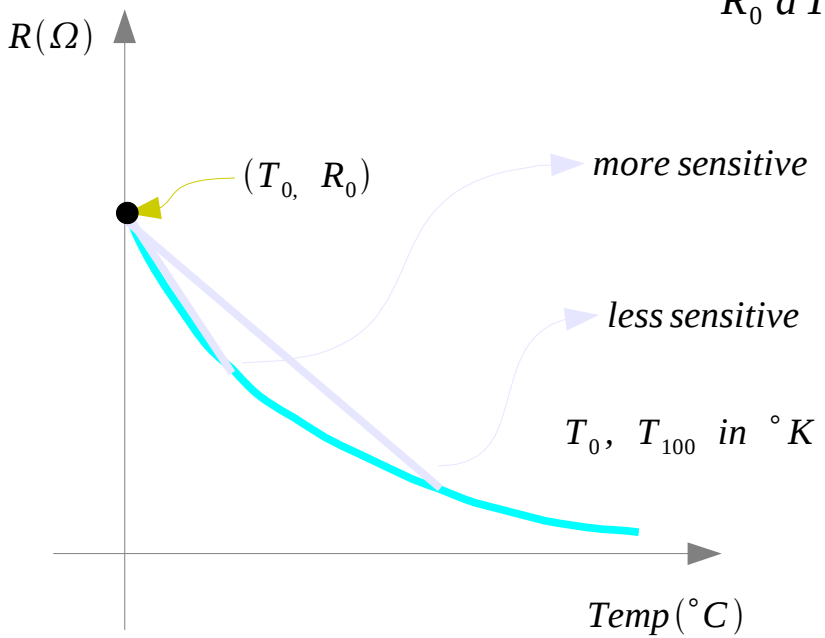
NTC Thermistor

NTC Thermistor Temperature Characteristics (3)

TCR: α **Characteristic Temperature:** β

$$R = R_0[1 + \alpha(T - T_0)]$$

$$\alpha = \frac{1}{R_0}\frac{dR}{dT}$$



NTC Thermistor

$$R = R_0 \exp\left[\beta\left(\frac{1}{T} - \frac{1}{T_0}\right)\right]$$

$$\frac{dR}{dT} = \beta\left(-\frac{1}{T^2}\right)R_0$$

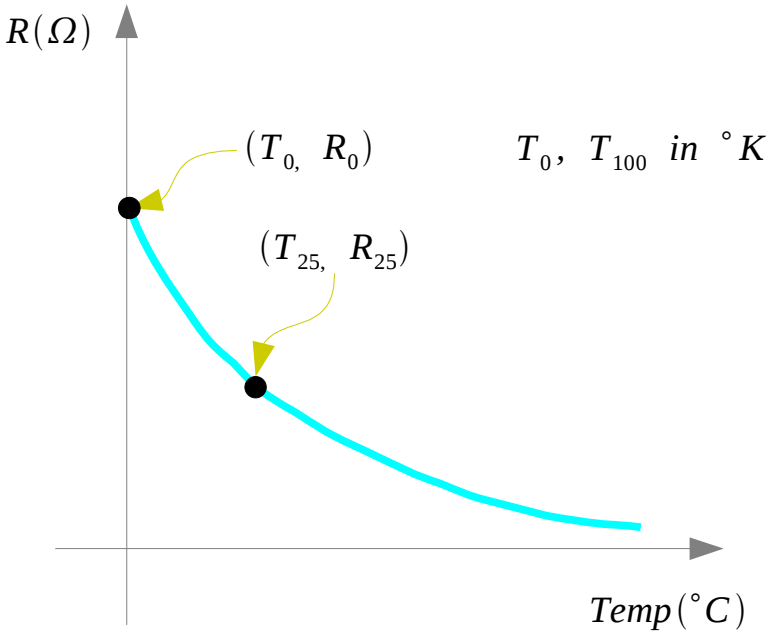
$$\alpha = \frac{1}{R_0}\frac{dR}{dT} = -\frac{\beta}{T^2} < 0$$

$$\alpha = -\frac{\beta}{T^2}$$

NTC Thermistor Sensitivity

TCR: α **Characteristic Temperature:** β

$$R = R_0 \exp\left[\beta\left(\frac{1}{T} - \frac{1}{T_0}\right)\right]$$



NTC Thermistor

$\beta = 4000[\mathring{K}]$ *when* $T = 25[^\circ C]$

$$\alpha = -\frac{\beta}{T^2} = -\frac{4000}{(25+273.16)^2} = -0.045$$

$\alpha = -4.5$ *percent*$/^\circ K$

References

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