curs 5 sis

Senzori de temperatură:

$$\frac{\Delta L}{L}(T); \quad \rho(T); \quad tem(T); \quad \varepsilon_r(T); \quad \Delta Q(\Delta T)$$

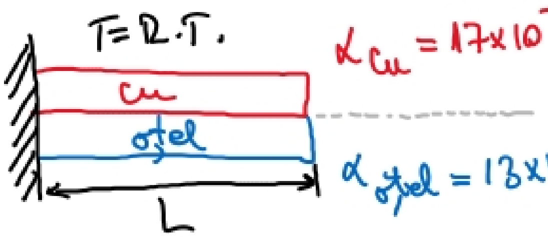
- $\frac{\Delta L}{L}(T)$ → termometre bimetalice
- $\rho(T)$ → RTD; NTC (PTC)
- tem (T) → termocuplu
- $\varepsilon_r(T)$ → senzor capacitiv
- $\Delta Q(\Delta T)$ → senzori piroelectrici

Termometrul bimetalic:

coeficient de dilatare $\alpha_V = \frac{1}{V} \cdot \left(\frac{\partial V}{\partial t}\right)_{p=ct}$.

"thermal expansion coefficient"

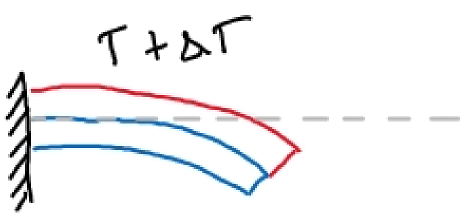
$$\frac{\Delta L}{L_0} = \alpha \cdot \Delta T$$

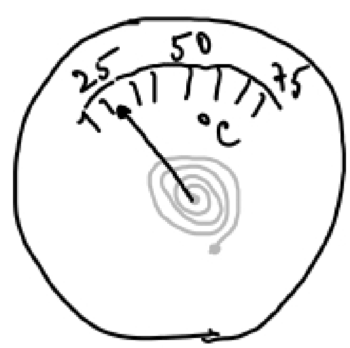


$\alpha_{Cu} = 17 \times 10^{-6} / {}^\circ C$

$\alpha_{oțel} = 13 \times 10^{-6} / {}^\circ C$

$T = 298K = R.T. = 25^\circ C$ → Room Temperature





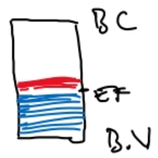
Domeniu de temperatură:

$-30^\circ C - 500^\circ C$

Termometre rezistive

RTD = "Resistance Temperature detector".

metale



Legea Wiedemann - Franz

$$\frac{k}{\sigma} = LT$$

L - nr. Lorenz.

$$L = 2.44 \times 10^{-8} \, W \, \Omega \cdot K^{-2}$$

k - conductivitatea termică
σ - conductivitatea electrică

rezistivitatea unui metal: $\rho = \rho_0 \left[1 + \alpha (T - T_0) \right]$

$$\rho_0 = \rho(T_0)$$

Pt 100 — RTD din Pt ce are $R(0\,°C) = 100\,\Omega$

Pt1000 — $R(0°C) = 1000\,\Omega$

Pentru Pt100:

$-200°C \leq T \leq 0°$

$$\rho(T) = \rho_0 \left[1 + AT + BT^2 + C(T - 100)T^3 \right]$$

$0°C \leq T \leq 850°C$

$$\rho(T) = \rho_0 (1 + AT + BT^2)$$

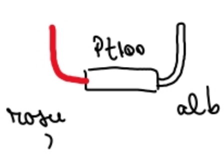
Pt100: $A = 3.90802 \times 10^{-3}\ °C^{-1}$

$B = -5.80195 \times 10^{-7}\ °C^{-2}$

$C = -4.2735 \times 10^{-12}\ °C^{-4}$

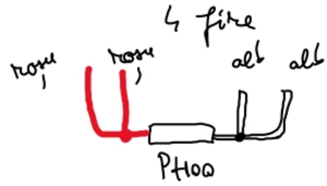
RTD
- → 2 fire
- → 3 fire
- → 4 fire

2 fire



3 fire

4 fire

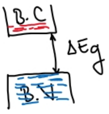


Termistori (NTC, PTC):

NTC = „Negative Temperature Coefficient"

PTC = „Positive Temperature coefficient"

NTC - semiconductori



$T = 0\,K \rightarrow \sigma \sim 0$

$T \nearrow \Rightarrow \sigma \nearrow \ (\rho \searrow)$

$$\rho = \rho_0 e^{-\alpha T}$$

Ecuația Steinhart - Hart:

$$\frac{1}{T} = A + B \ln\rho + C \ln\rho^3$$

$$A = \frac{1}{T_0} - \frac{1}{B}\ln\rho_0$$

$$B = \frac{1}{\beta}$$

$$C = 0$$

$$\frac{1}{T} = \frac{1}{T_0} + \frac{1}{\beta}\ln\frac{R}{R_0}$$

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

→ răspuns neliniar

$R_0 = R(T_0)$

$T_0 = 25°C$

$$R = r_\infty e^{\frac{\beta}{T}}$$

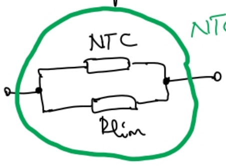
$$r_\infty = R_0 e^{-\frac{\beta}{T_0}}$$

NTC → $-40 - 125°C$

$R = \rho \cdot \frac{l}{S}$ $\qquad \frac{\rho}{\rho_0} = \frac{R}{R_0}$

$R_0 = \rho_0 \cdot \frac{l}{S}$

Liniarizarea răspunsului:



NTC lin $\qquad$ R(NTC lin) - liniar

Liniarizare între T_1 și T_2

$$T_3 = \frac{T_1 + T_2}{2}$$

Din R(T) știm $R_1 = R(T_1)$

$R_2 = R(T_2)$

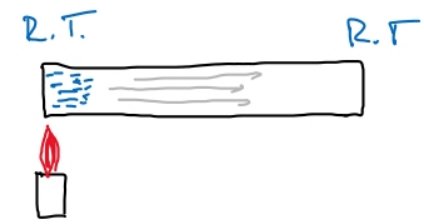
$R_3 = R(T_3)$

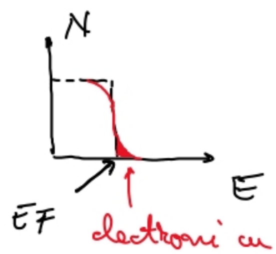
Rlim se determină din relația:

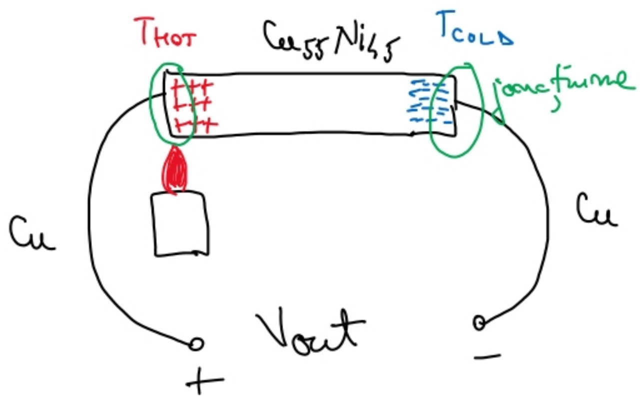
$$\frac{R_3 R_{lim}}{R_3 + R_{lim}} = \frac{\frac{R_1 R_{lim}}{R_1 + R_{lim}} + \frac{R_2 R_{lim}}{R_2 + R_{lim}}}{2}$$

Termocuplul

Efectul Seebeck:





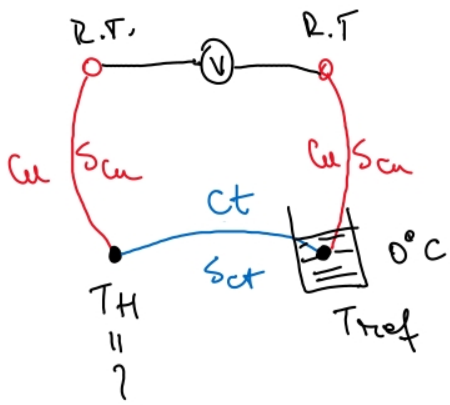


$$\Delta V = \int_{T_{COLD}}^{T_H} S(T)\,dT$$

S - coef. Seebeck

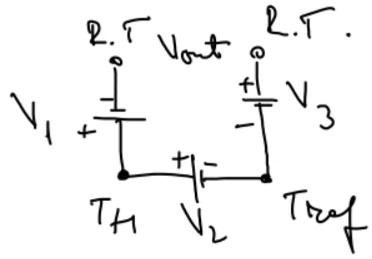
$$S = \frac{\Delta V}{\Delta T}\bigg|_{I=0}$$

schema echivalentă:



Ct = constantan = $Cu_{0.55}Ni_{0.45}$

→



$V_1 = S_{Cu}(T_H - R.T)$

$V_2 = S_{Ct}(T_H - T_{ref})$

$V_3 = S_{Cu}(R.T - T_{ref})$

$$V_{out} = V_1 - V_2 + V_3 =$$

$$= S_{Cu}(T_H - R.T) - S_{Ct}(T_H - T_{ref}) + S_{Cu}(R.T - T_{ref}) =$$

$$= S_{Cu}T_H - \cancel{S_{Cu}RT} - S_{Ct}T_H + S_{Ct}T_{ref} + \cancel{S_{Cu}RT} - S_{Cu}T_{ref} =$$

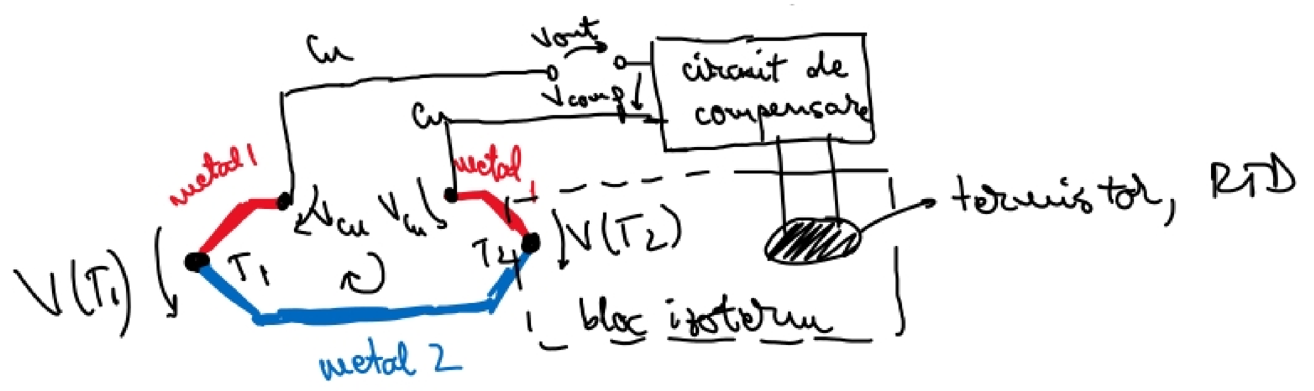
$$= S_{Cu}(T_H - T_{ref}) - S_{Ct}(T_H - T_{ref})$$

$$\boxed{V_{out} = (S_{Cu} - S_{Ct})(T_H - T_{ref})}$$

$$S = S(T)$$

Eliminarea necesității temperaturii de referință:

·) circuit de compensare a joncțiunii de referință → „cold junction compensation”;



$$V_{out} + V_{comp} + \cancel{V_{cu}} + V(T_2) - V(T_1) - \cancel{V_{cu}} = 0$$

Punem condiția: $T_1 = 0°C \Rightarrow V_{out} = 0\,V$

$$V_{comp} + V(T_2) - V(0°C) = 0$$

$$\boxed{V_{comp} = -V(T_2) + V(0°C)}$$

$$V_{out} - \cancel{V(T_2)} + V(0°C) + \cancel{V(T_2)} - V(T_1) = 0$$

$$\boxed{V_{out} = V(T_1) - V(0°C)}$$