# Lumped Modeling in Thermal Domain

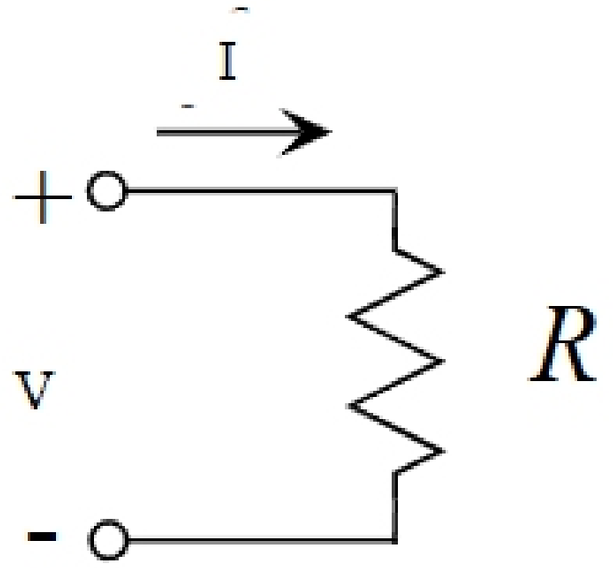
- ☑ Last lecture
  - Lumped modeling
  - Self-heating resistor

- Today:
  - Self-heating resistor
  - Other dissipation mechanisms
    - Friction, dielectric, magnetic, damping
  - Coupled flows

- 📖 Reading: Senturia, Chapter 11, p.278-296

# Resistor Self-Heating

- **Temperature dependent resistance**
  - Voltage-Current relation, V=IR(T) (Ohm's Law)
    - Now we consider resistor self-heating and temperature dependence of resistance, R(T)
      - Joule Heating, $P_{dissipation}=VI=I^2R>0$
      - For small to moderate temperature variation, approximate R(T) using first order Taylor series expansion.

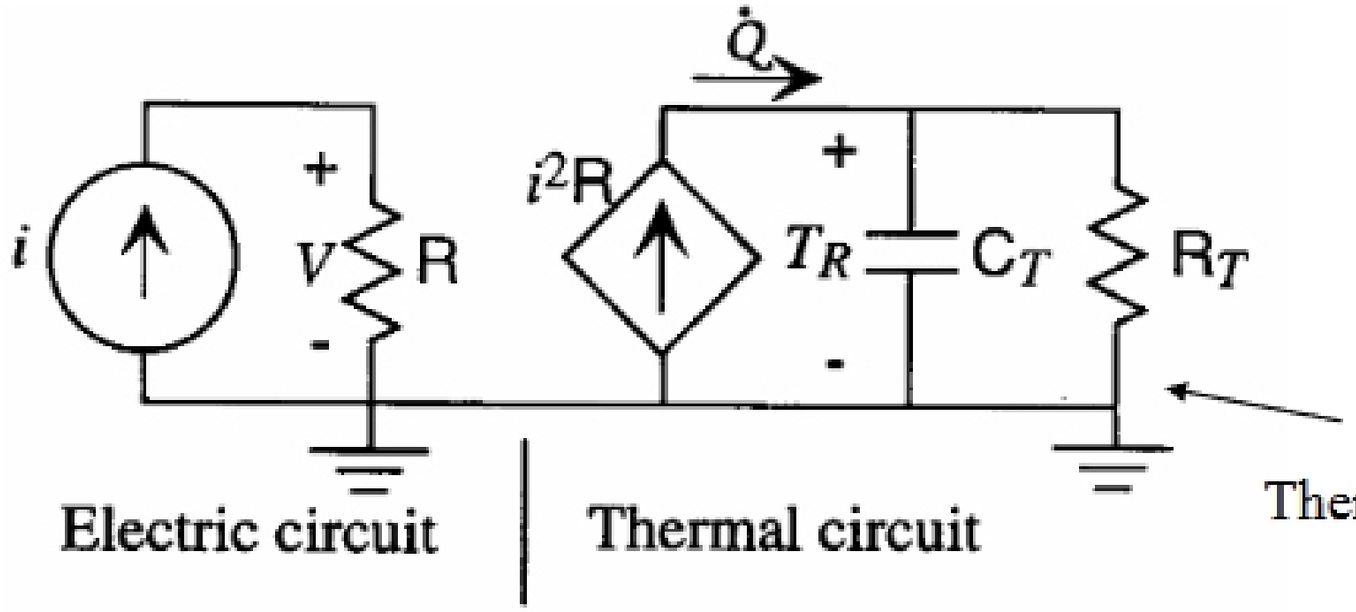



$$R(T) \cong R(T_0)[1+\alpha_R(T_R - T_0)]$$

where $\alpha_R$ = temperature coefficient of resistance [1/K]

# Resistor Self-Heating

- **Circuit model for resistor self-heating-- Current Source**




Governing equation is:

$$C_T \frac{dT_R}{dt} = -\frac{T_R}{R_T} + i^2 R_0 (1 + \alpha_R T_R)$$

$$\frac{dT_R}{dt} = -\frac{1}{R_T C_T}\left(1 - \alpha_R R_0 R_T i^2\right) T_R + \frac{i^2 R_0}{C_T}$$

Ref. Senturia, Microsystem Design, p. 231.