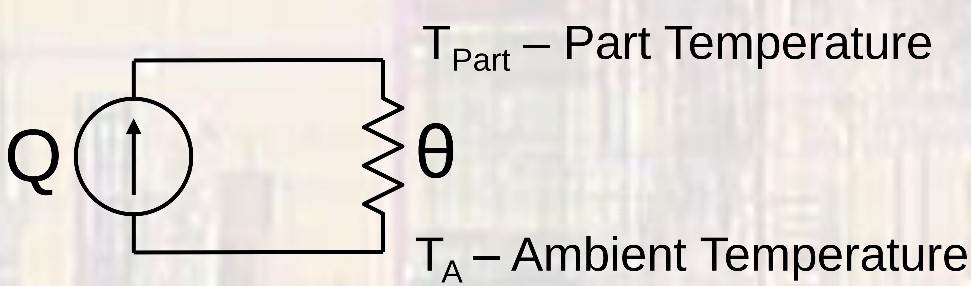
Thermal Design

Last updated 6/23/21

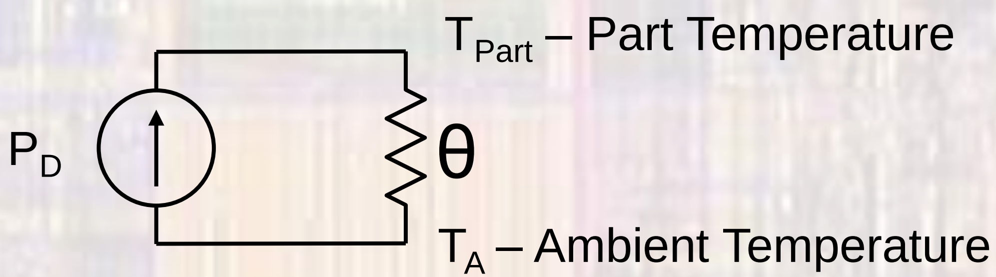
Thermal Design

- Power Dissipation
  - Power dissipated in a part that is not provided to some load is converted into heat
    - Electrical Analogy
      - Temp (ΔT) <-> Voltage
      - Heat Flow (Q) <-> Current
      - Thermal Resistance (θ) <-> Electrical Resistance
      - Where Q corresponds to power dissipated



Thermal Design

- Power Dissipation



A regulator has a θ = 50°C/W

If it dissipates 1W in an area where the ambient temperature is 27°C

Its temperature will be: $T_{part} = (Pd \times \theta) + T_A =$
$(1W \times 50°C/W) + 27°C = 77°C$

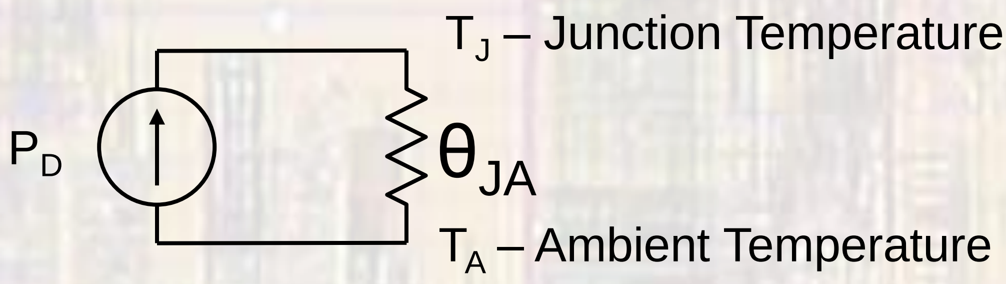
Thermal Design

- Power Dissipation

  - Semiconductor devices are typically characterized by two thermal resistances

    - θ_{JC} – thermal resistance from the junction to the case
    - θ_{CA} – thermal resistance from the case to the ambient

    - Since most users do not care about the intermediate temperature
      - Often combined to be θ_{JA}
      - e.g. θ_{JC} = 60°C/W, θ_{CA} = 180°C/W → θ_{JA} 240°C/W



Thermal Design

- Power Dissipation

A regulator has a θ_{JC} = 60°C/W, θ_{CA} = 180°C/W and a T_{JMax} = 150°C

If it dissipates 1W in an area where the ambient temperature is 27°C

Its junction temperature will be: $T_J = (P_D \times (\theta_{JC} + \theta_{CA})) + T_A$ =

(1W x (60°C/W + 180°C/W) 27°C = 267°C

Thermal Design

- Power Dissipation

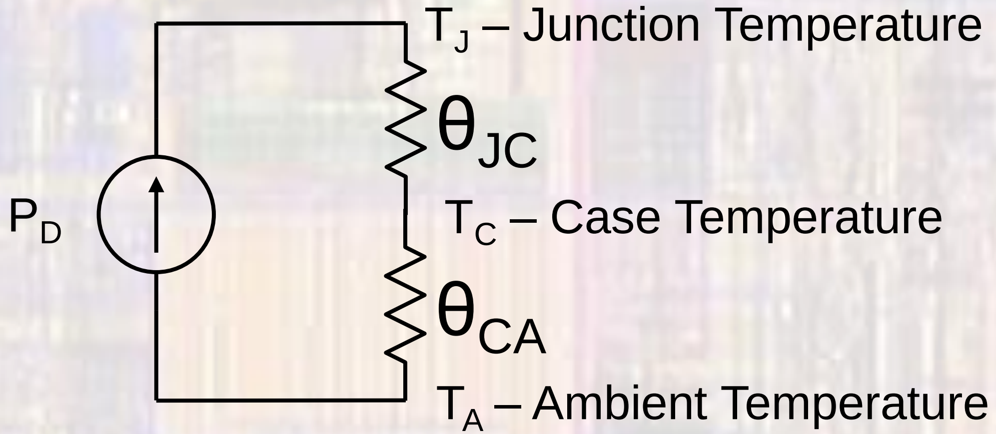
  - We can't impact the θ_{JC} but we can impact θ_{CA}
    - Attach a heat sink

  - Heat Sink
    - By increasing the air–heat interface area heat sinks allow more heat to be dissipated faster
    - Reduce the effective thermal resistance

θ_{CA} = 15 °C/W

Thermal Design

- Power Dissipation



A regulator has: θ_{JC} = 60°C/W, θ_{CA} = 180°C/W and T_{JMax} = 150°C
A heat sink is attached with θ_{CA} = 15°C/W

If it dissipates 1W in an area where the ambient temperature is 27°C

Its junction temperature will be: $T_J = (P_D \times (\theta_{JC} + \theta_{CA})) + T_A$ =
(1W x (60°C/W + 15°C/W) + 27°C = 102°C