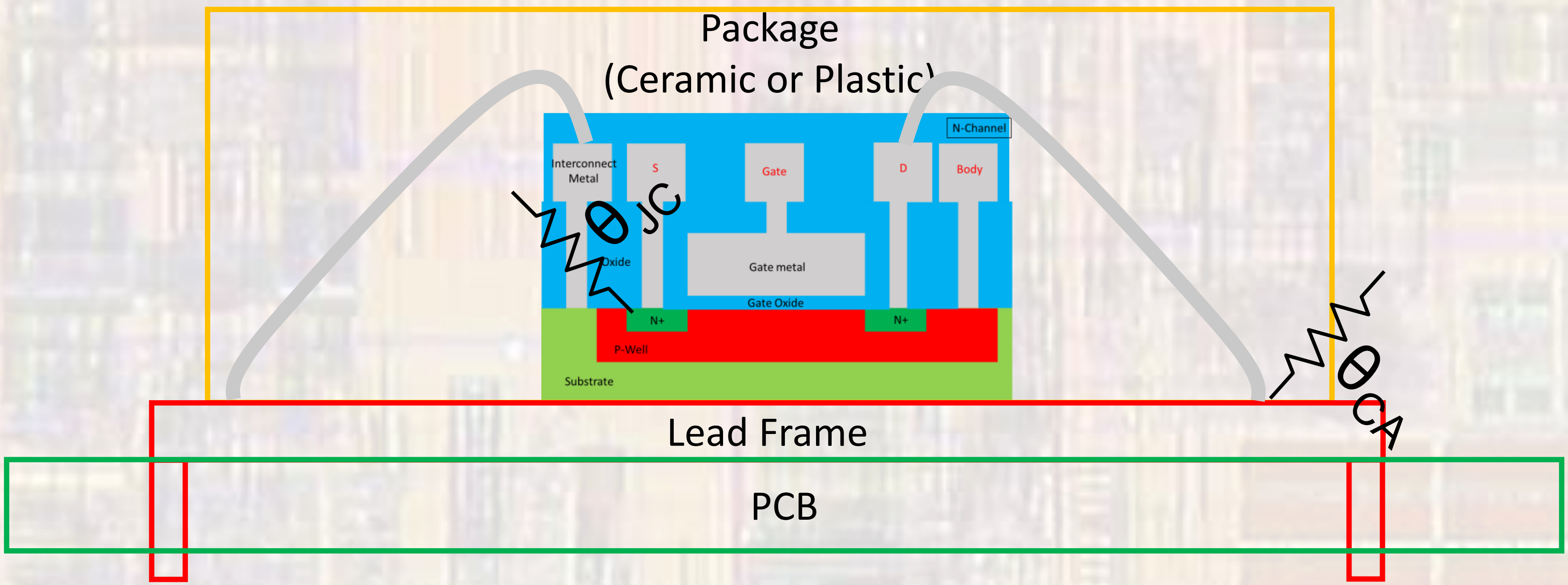
Thermal Considerations

Last updated 1/10/24

Thermal Considerations

- Semiconductor Thermal Constants
  - Semiconductor junctions start to fail at around 150°C
  - Two primary thermal paths
    - Junction to Case (package) - θ_{JC}, Case to Ambient (outside) - θ_{CA}



Thermal Considerations

- Semiconductor Thermal Constants

  - 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 Considerations

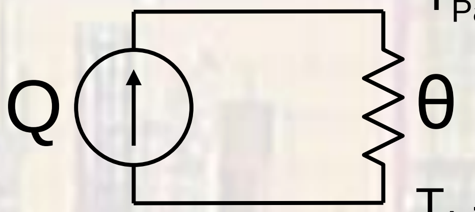
- Power Dissipation
  - Power dissipated in a part that is not provided to some load is converted into heat

  - Electrical Analogy

Thermal	Electrical	Units
Temp (ΔT)	Voltage	(°C)
Heat Flow (Q)	Current	(W)
Thermal Resistance (θ)	Electrical Resistance	(°C/W)

- Where Q corresponds to electrical power wasted (turned to heat)

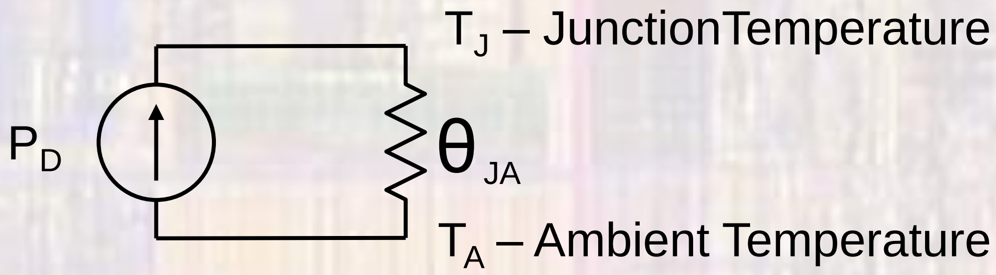
T_{Part} – Internal Part Temperature



T_A – Ambient Temperature

Thermal Considerations

- Power Dissipation



A part has a θ_{JA} = 50°C/W

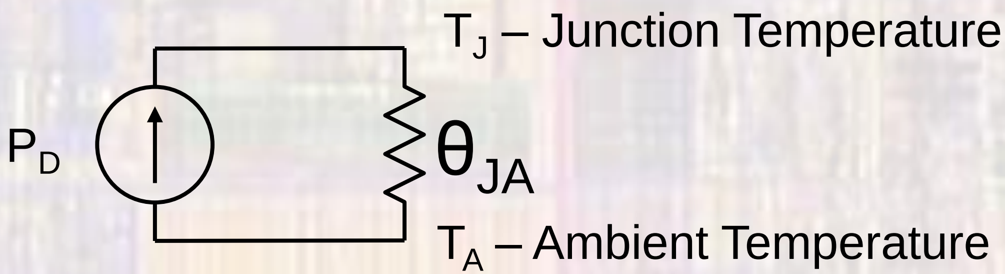
It dissipates 1W of wasted power
The ambient temperature is 27°C

Its junction temperature will be:

$$T_J = (Pd \times \theta_{JA}) + T_A = (1W \times 50°C/W) + 27°C = 77°C$$

Thermal Considerations

- Power Dissipation



A regulator has a θ_{JA} = 240°C/W and a T_{JMax} = 150°C

It dissipates 2W with 50% efficiency → 1W of wasted power
The ambient temperature is 27°C

Its junction temperature will be:

$$T_J = (P_D \times \theta_{JA}) + T_A = (1W \times 240°C/W) + 27°C = 267°C$$

Thermal Considerations

- Power Dissipation

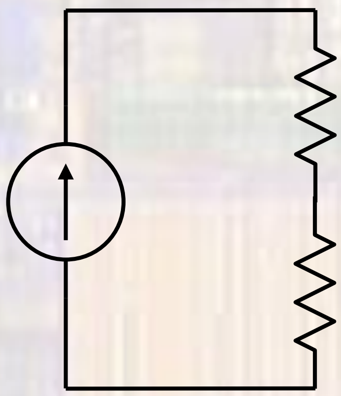
  - We can't impact the θ_{JC} but we can impact θ_{CA}
    - Attach a heat sink

  - 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}

θ_{CA} = 15 °C/W

Thermal Considerations

- Power Dissipation



A regulator has: θ_{JA} = 240°C/W (θ_{JC} = 60°C/W, θ_{CA} = 180°C/W) and T_{JMax} = 150°C
A heat sink is attached with a new θ_{CA} = 15°C/W

It dissipates 2W with 50% efficiency → 1W of wasted power
The ambient temperature is 27°C

Its junction temperature will be:

$$T_J = (P_D \times (\theta_{JC} + \theta_{CA})) + T_A = (1W \times (60°C/W + 15°C/W) + 27°C = 102°C$$