Heat Sinks

Basic Introduction to Heat Sinks

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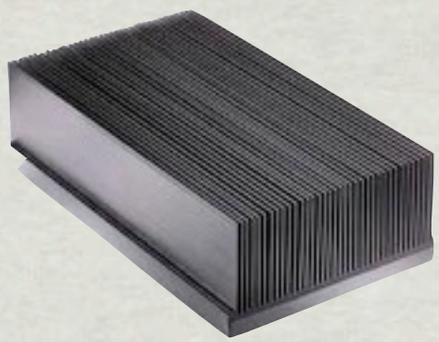
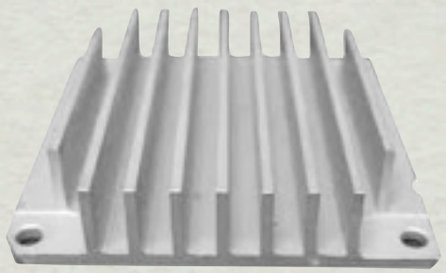
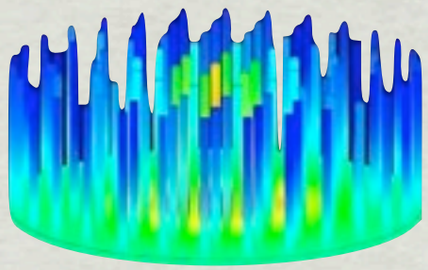
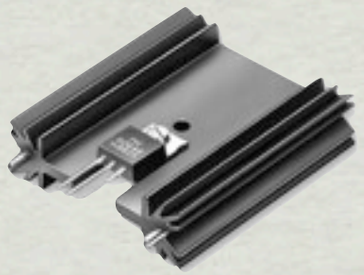
What is a Heat Sink?

- A heat sink is a mechanical device that is used to lower the thermal resistance of another device from it's case to the ambient air.
- Generally used to ensure that the temperature of a component does not exceed a particular temperature.



What does a Heat Sink do?

- It gives excess energy (heat) a place to go
- A properly sized heat sink maintains the semiconductor junction temperature at or below the maximum allowable temperature. (found in the parts data sheet)
- Heat sink cooling capacity must take into account:
  - Maximum power to be dissipated in the part
  - Maximum ambient air temperature
  - Altitude derating
  - Customer usage

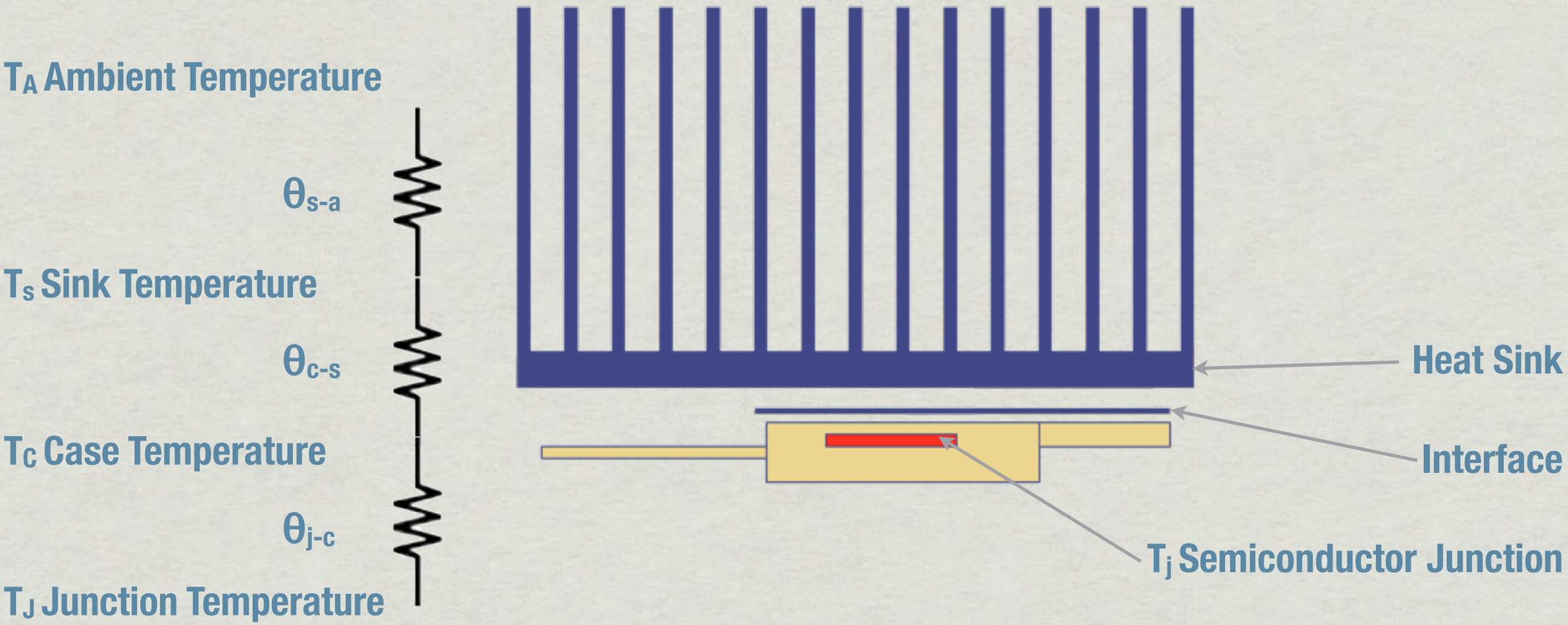
What does a Heat Sink do?

- Every 10 degree C increase from the maximum allowable junction temperature cuts the life of the semiconductor in **half**!

How is a Heat Sinks Effectiveness Measured?

- θ = degrees C/Watt = Theta = heat dissipation capacity
- Like an Ohm in electrical resistance Theta indicates resistance or opposition to heat flow
- Thermal resistance is temperature rise divided by power (heat).
- Theta is expressed in degrees Celsius rise per one Watt of power output
- Smaller θ = greater heat removal capability

Basic Semiconductor Cooling



Elements of Thermal Resistance

- $\theta_{j\text{-}a}$ = Overall thermal resistance from the semiconductor junction to the ambient air
  - $\theta_{j\text{-}a} = \theta_{j\text{-}c} + \theta_{c\text{-}s} + \theta_{s\text{-}a}$
- $\theta_{j\text{-}c}$ = Thermal resistance from semiconductor junction to case of semiconductor (Inside the Part)
- $\theta_{c\text{-}s}$ = Thermal resistance from case to heat sink (The interface between the part and the heat sink)
- $\theta_{s\text{-}a}$ = Thermal resistance from the heat sink to the ambient air (Thermal resistance of the heat sink)

Parameters Needed to Solve for Maximum Heat Sink Thermal Resistance

- Estimated Parameters:
  - Maximum power to be dissipated (P_{max})
  - Maximum ambient air temperature ($T_{ambient\text{-}air\text{-}max}$)
  - Maximum junction temperature ($T_{junction\text{-}max}$)
  - Thermal resistance from junction to case ($\theta_{j\text{-}c}$) (from parts data sheet)
  - Estimated thermal resistance between case and sink ($\theta_{c\text{-}s}$) (from interface manufacturers data sheet)

Finding the Right Heat Sink

- Find the maximum overall thermal resistance of the system from the semiconductor junction to ambient air ($\theta_{j\text{-}a}$)

$$\theta_{j-a} = \frac{(T_{junction-max} - T_{ambient-air-max})}{Max\ Power\ Dissipated}$$

- To find the maximum heat sink thermal resistance:

$$\theta_{s-a} = \frac{(T_{junction-max} - T_{ambient-max})}{Max\ Power\ Dissipated} - (\theta_{j-c} + \theta_{c-s})$$

  - If the resulting number is negative the solution is impossible!

Example

- Find the maximum heat sink thermal resistance for the following setup:
  - Maximum Power Dissipated in Device: 10W
  - Maximum Junction Temperature: 100C
  - Maximum Ambient Air Temperature: 40C
  - Internal Thermal Resistance: $\theta_{j\text{-}c}$ = 1.0 C/W
  - Interface Resistance: $\theta_{c\text{-}s}$ = 1.5 C/W

$$\theta_{s-a} = \frac{(100C - 40C)}{10W} - (1.0 + 1.5) = 3.5\ C/W$$

- Heat sink must have a thermal resistance of 3.5 C/W or less

Links

- AAVID Thermalloy:
  http://www.aavid.com
- Heat Sink Grease & Calculator:
  http://www.aavid.com/product-group/interface/greases