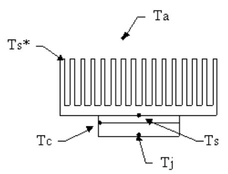
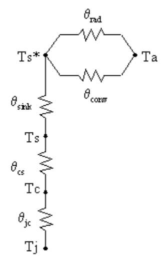
wakefield-vette

Tech Brief …

Removing Heat from a Semiconductor





$$\Theta ja = \Theta jc + \Theta cs + \Theta sa$$

$$\Theta ja = \frac{Tj - Ta}{Q}$$

$\Theta jc = \text{junction} - \text{to} - \text{case}$

$\Theta cs = \text{case} - \text{to} - \text{sink}$

$\Theta sa = \text{sink} - \text{to} - \text{ambient}$

$$\Theta sa = \frac{(\Theta conv)(\Theta rad)}{(\Theta conv + \Theta rad + \Theta sink)}$$

Selecting the Correct Heat Sink ….

The following parameters are necessary to determine the required heat sink:

1. Q - Amount of Power, (heat = (W)), to be dissipated
2. Tjmax - Maximum allowable Junction Temperature (°C)
3. Ta – Ambient Temperature of the surrounding fluid, (Air), (°C)
4. Rθjc - Thermal Resistance of the device “junction-to-case”
3. Rθcs - Thermal Resistance of the Thermal Interface Material, (TIM)
4. Thermal Resistivity (ρ), thickness (t) and contact area (A)
5. Natural or Forced Convection Cooling
8. Air flow – Linear Feet per Minute, (LFM), (If Forced Convection)

$$\Theta ja = \Theta jc + \Theta cs + \Theta sa$$

$$\Theta sa = \Theta ja - (\Theta jc + \Theta cs)$$

$$\Theta ja = \frac{(Tj - Ta)}{Q}$$

$$\Theta sa = \frac{(Tj - Ta)}{Q} - (\Theta jc + \Theta cs)$$

Heat Sink Selection - Example:

- **TO-220 package outline device is dissipating 7 watts (Q)**
- **The Maximum Junction Temperature, is Tj = 125°C**
- **And the Maximum Ambient Temperature, is Ta = 65°C**
- **Component Junction-to-Case Thermal Resistance, is Rθjc = 2.5 °C/W (Note: this information can be obtained from the device's data sheet).**

Assuming that:

- **Interface material is Silicon Grease – Wakefield 120 Series**
- **0.002 inches thick**
- **0.36 in2 contact area**

The Thermal Resistance of Silicon Oil-Based Grease can be found to be as: Thermal Resistivity, (ρ), (120 Series = 56 C-in/W), thickness, (t), (in) and contact area, (A), (in^2)

$$\Theta_{cs} = \frac{(\rho)(t)}{A}$$

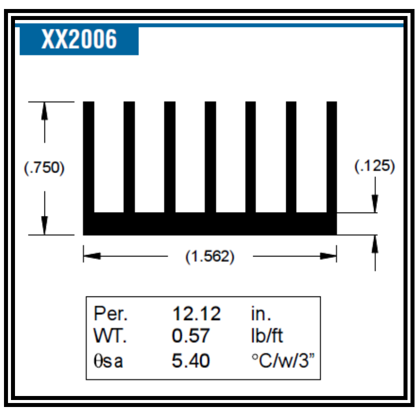
θcs = 56 C-in/W x 0.002 in / 0.36 in^2 = 0.311°C/W

Θsa = [(Tj – Ta) / *Q]* – (Θjc +Θcs)

Θsa = [(125C – 65C) / 7W] – (2.5C/W + 0.31C/W)
Θsa = 5.76°C/W

A heat sink will be required to have a Thermal Resistance of less than or equal to 5.76°C/W.

Extrusion Data:



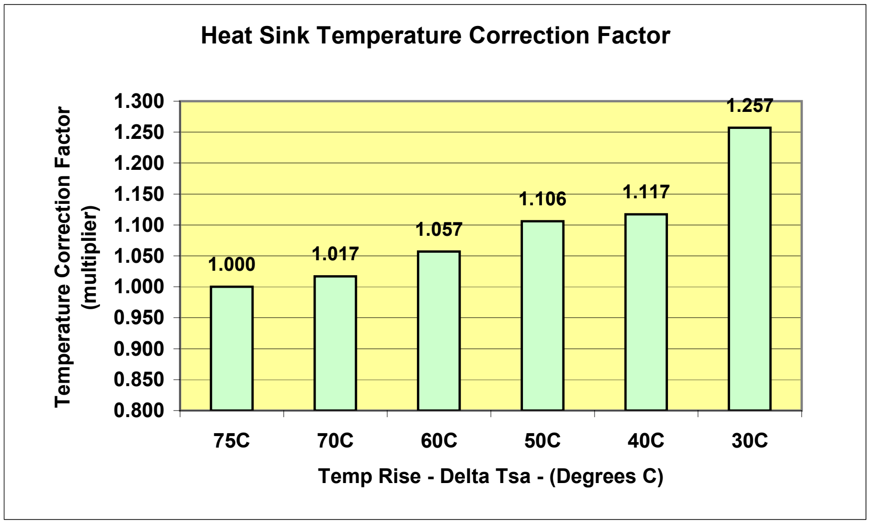
Published Thermal Performance Data

- Natural Convection = Air Flow is estimated at ~57 LFM
- Vertical Orientation
- 3 inch long piece
- Uniform Heat Load – heat source area is entire base of heat sink

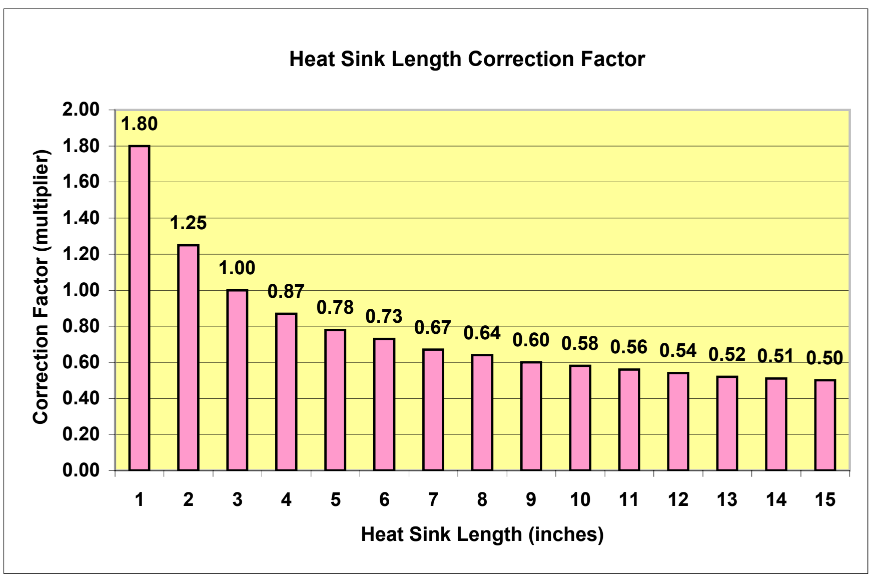
Heat Sink Temperature & Length Correction Factors:

As ΔT Decreases, the Heat Sink Efficiency Decreases …

Correct (°C/W/3in) = (Temperature Correction) x (Published °C/W/3in)



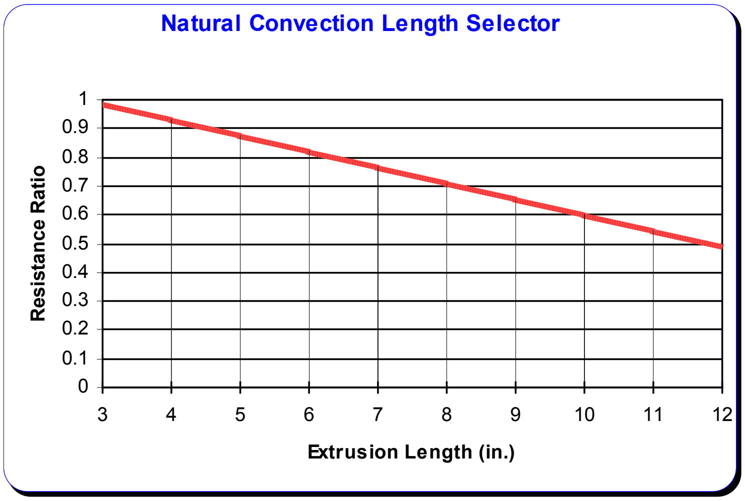
(Length Correction) x (Published °C/W/3in) = Correct (°C/W)



Selecting Extrusions Lengths for Natural Convection

Wakefield Solutions provides the Thermal Resistance of heat sinks in term of 3" lengths. To select heat sinks other than 3", *WAKEFIELD THERMOVATIONS™* has developed a size selector graph shown below. When a preferred extrusion is selected, this graph will assist in establishing the approximate length necessary to obtain a desired Thermal Resistance.

The above Graph indicates "Resistance Ratio" Verses the Extrusion Length



- Resistance Ratio = desired θ_{sa} / θ_{sa} for 3" length (from catalog)
- Resistance Ratio = (-0.055 x Extrusion Length, (in)) + 1.15
- Extrusion Length = (Resistance Ratio – 1.15) / (-0.055)

Suppose that we have selected the Wakefield XX2006 heat sink design (from Example 1) but now need a lower θ_{sa} value of 5.0°C/W rather than the given catalog value of 5.4°C/W/3". We have available surface area to use an extruded heat sink longer than 3" and want to find out how long the sink must be to get to the desired 5.0°C/W Thermal Resistance.

Since we have both the desired resistance and the 3" length resistance, we can use Eq. (5) to find the Resistance Ratio: Resistance Ratio = (5.0 / 5.4) = 0.93

Next, we can find 0.93 on the Y-axis of the chart and follow it horizontally to the line. Reading the value on the X-axis reveals an extrusion length of approximately 4 inches. This result means that we can use a 4" or longer piece of the XX2006 to fulfill our thermal performance requirements.

Alternatively use Eq. (7) to find the extrusion length once we know the Resistance Ratio:

Extrusion Length = (0.93-1.15)/(-.055) = 4.0 inches