Thermal Management for the High Power 15W LED emitters.

A. Introduction

The most challenging issue when using a high power 15W LED is to manage the temperature of the device junctions during normal operation by transferring junction generated heat to the ambient environment. This is achieved by attaching the heat sink to the LED package directly. Once the correct heatsink has been selected, it must be carefully joined to the LED package to ensure efficient heat transfer through the thermal interface material.

Following is a brief overview of the basic thermal modeling and some thermal properties of materials used to manage the heat produced by the devices.

B. The basic thermal modeling

The thermal resistance of a LED package is defined as the ratio of temperature differences between the junction of the LED and the ambient atmosphere over the power dissipation.

$$R\Theta_{\text{Junction-ambient}} = (\Delta T_{\text{junction – ambient}}) / P_d \quad (1)$$

Where

ΔT = T junction – T ambient
P_d = Power dissipation (= Forward current (If) * Forward voltage (Vf))

As heat generated at the junction of the LED die, its thermal path can be summarized and modeled as shown in the figure 1.0 below

$$R\Theta_{\text{Junction-Ambient}} = R\Theta_{\text{junction-case (J-C)}} + + R\Theta_{\text{thermal interface}} + R\Theta_{\text{Hsk-ambient (Hsk-A)}} \quad (2)$$

Where

$R\Theta_{junction\text{-}case}$ can be found in the specific data sheet
$R\Theta_{thermal\ interface}$ is the thermal resistance of the material interface between the case and the heat sink
$R\Theta_{HSK\text{-}ambient\ (HSK\text{-}A)}$ is the thermal resistance from the heat sink to ambient air

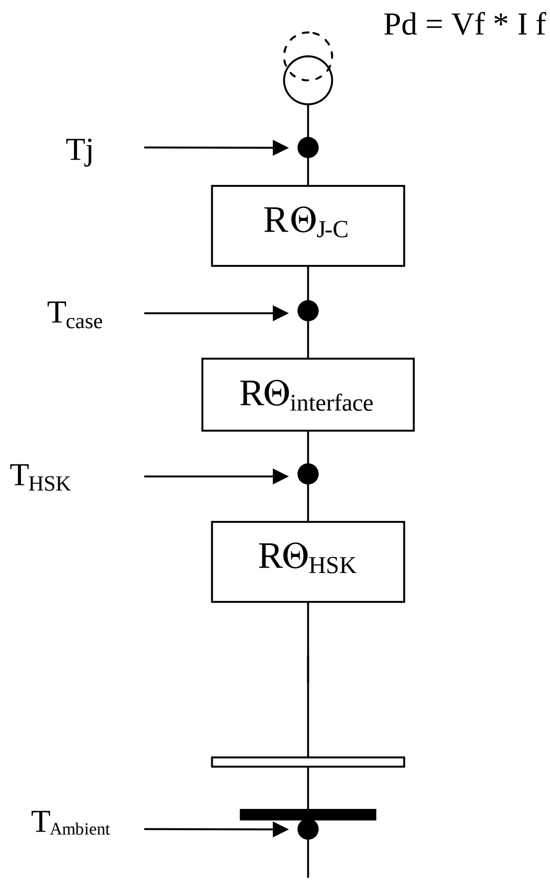


Figure 1: Thermal path Series Resistance Model

For an array of n LED emitters, the total $R\Theta_{junction\text{--}interface}$ would follow the equation below

$1 / R\Theta_{junction\text{-}case} = \Sigma\ (1/ R\Theta\ (_{junction\text{-}case)\ i})$ where i = 1…..n

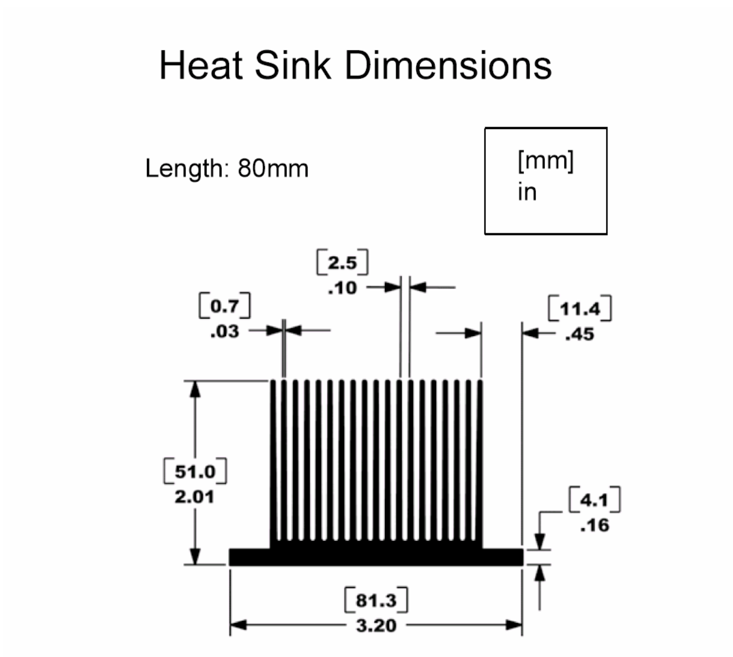
$1 / R\Theta_{interface} = \Sigma\ (1/ R\Theta\ (_{interface\ i})$ where i = 1…..n

$R\Theta\ j_{unction\text{-}ambient} = R\Theta\ _{junction\text{-}case} + R\Theta_{interfacxe}$
$+\ R\Theta_{Hsk\text{-}ambient}$

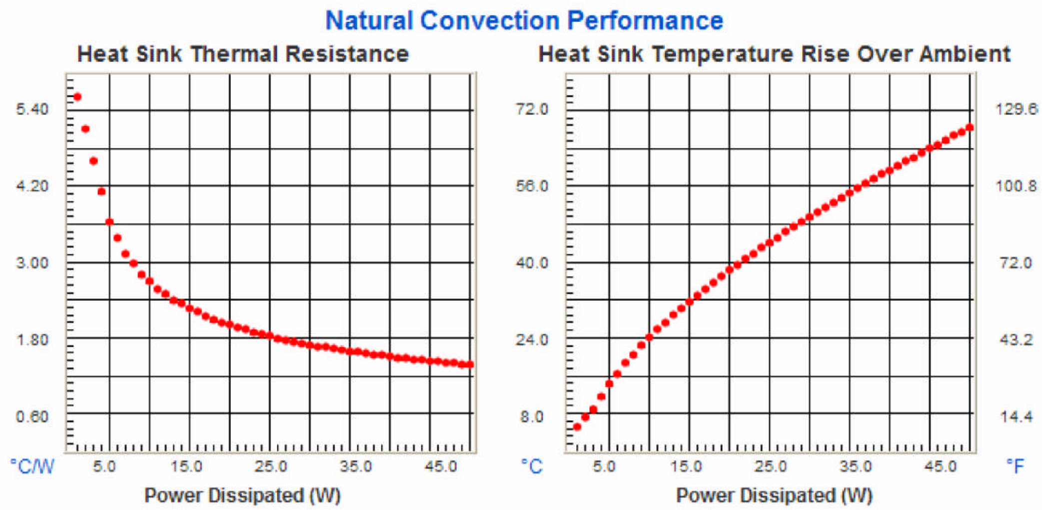
$Tj = Ta + P * [R\Theta_{Junction\ \text{-}ambient}]$

C. Heatsink

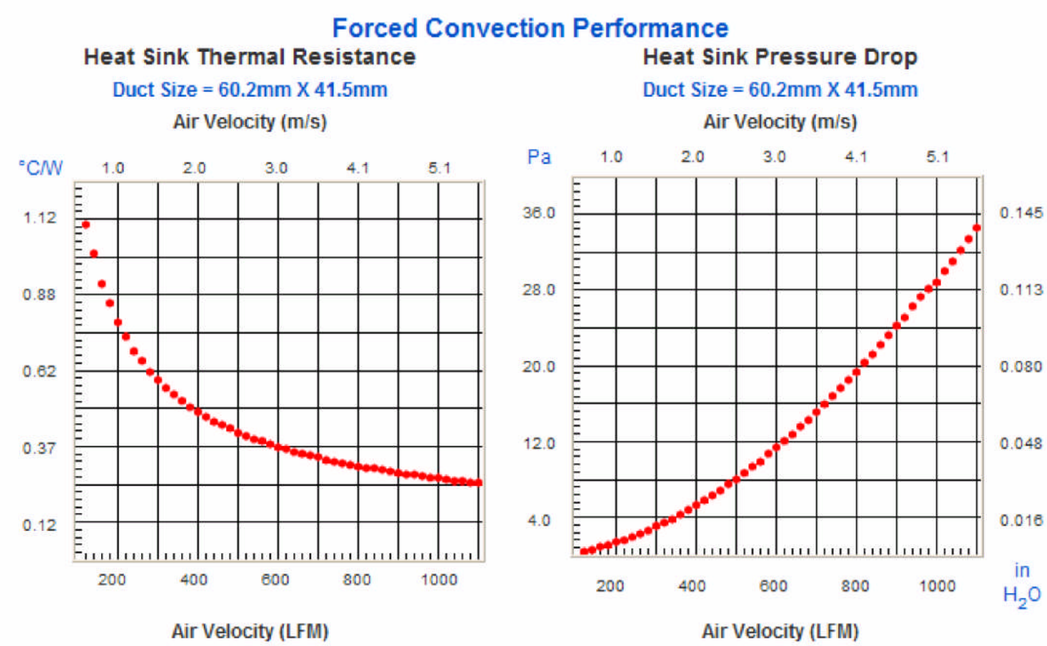
Heatsink should be chosen based on its good thermal transfer and perfect flatness of the contact area. Below are some guidelines for heatsink selection and data regarding natural and forced convections for reference. Please note that heatsink geometry or dimensions can be different depending the space constraints, however, thermal resistance should be closely matched.



Characteristics



Characteristics



D. Thermal Resistance of the Thermal Interface Materials

Once the heatsink has been chosen, the next step is to select the thermal interface material. One of many important characteristics of the thermal interface is its thermal conductivity, the rate of conductive heat transfer, Q, across the interface is given by

$$Q = \frac{kA(T_{case} - T_{Hsk})}{L}$$

Where k is the thermal conductivity of the interface, A is the heat transfer area, L is the interface thickness and Tcase and T_{Hsk} are the device case and heat sink temperatures. The thermal resistance of a joint, $R_{case\text{-}HSK}$, is given by

$$R_{case\ -\ Hsk} = \frac{(T_{case} - T_{Hsk})}{Q}$$

and on rearrangement,

$$R_{case\ -\ Hsk} = \frac{L}{kA}$$

Thus, the thermal resistance of the joint is directly proportional to the joint thickness and inversely proportional to the thermal conductivity of the medium making up the joint and to the size of the heat transfer area. Thermal resistance is minimized by making the joint as thin as possible, increasing joint thermal conductivity by eliminating interstitial air and making certain that both surfaces are in intimate contact. It is recommended to use some thermal interface materials with thermal conductivity of 3 W/m – ^{0}C or greater, and table 1 provides a list of some materials for reference

Material Type	Model Name	Manufacturer	Thermal Conductivity W/m-^{0}C)
Epoxy Paste Adhesive	ME7359	AI Technology Inc.	11.4
Thermally Thermoplastic Elastomer (TPE)	D8102	Coolpoly	3

Table 1: Thermal resistance of the thermal interface materials

E. Summary

The basic concept of thermal management detailed in this application note shows the importance of selecting the right materials for thermal interface to the heat sink or other cooling methods to ensure the device operating reliably within the expected ambient temperature range. Additional information about thermal management solutions can be found at:

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