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APPLICATION BULLETIN
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HEAT SINKING — TO-3 THERMAL MODEL

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A critical issue with all semiconductor devices is junction temperature (T_J). T_J must be kept below its maximum rated value, typically 150°C. The lower the junction temperature the better.

The thermal circuit shown below allows temperature to be estimated with simple calculations. The temperature rise across each interface is equal to the total power dissipated in the device times the thermal resistance (PD • θ). An estimate of the junction temperature can be calculated using the following formula:

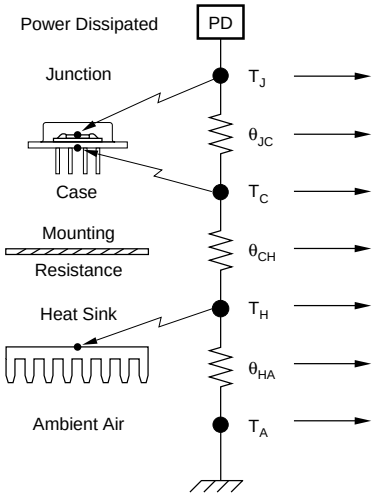
$$T_J = T_A + PD \bullet \theta_{JA}$$

Where,

$$\theta_{JA} = \theta_{JC} + \theta_{CH} + \theta_{HA}$$

T_A (°C) = Temperature of Ambient Air
T_J (°C) = Temperature of the Semiconductor Junction
PD (Watts) = Power Dissipated in Semiconductor
θ_{JC} (°C/Watt) = Thermal Resistance (Junction to Case)
θ_{CH} (°C/Watt) = Thermal Resistance (Case to Heat Sink)
θ_{HA} (°C/Watt) = Thermal Resistance (Heat Sink to Air)
θ_{JA} (°C/Watt) = Thermal Resistance (Junction to Air)

The following example shows typical values for a TO-3 package mounted in two different ways — one for high power applications, the other for low power applications. The value for θ_{JC} of 0.8°C/W is for the OPA512 operating under AC signal conditions. For DC signal conditions, θ_{JC} is about 1.4°C/W.



UNITS	HIGH POWER APPLICATION		LOW POWER APPLICATION	
Watts	100W	10W	10W	1W
°C	145°C	37°C *	158°C *	39°C
°C/Watt	0.8	0.8	0.8	0.8
°C	65°C	29°C	150°C	38°C
°C/Watt	0.1	0.1	0.5	0.5
°C	55°C	28°C	145°C	37°C
°C/Watt	0.3	0.3	12	12
°C	25°C	25°C	25°C	25°C

* Note, the difference in junction temperature that thermal resistance can make even when operating at the same power level.

Calculations begin at the bottom of the chart and assume 25°C ambient temperature in these examples. Each component of thermal resistance produces a temperature rise equal to the product of power dissipated and thermal resistance. The temperature of the junction is equal to the product of power dissipated and the total thermal resistance (PD • θ_{JA}).

Thermal resistances can vary significantly with particular models and mounting. While θ values can be obtained from specifications, calculated temperatures should be confirmed by measurements made at the bottom of the case.

Printed in U.S.A. August, 1992