How To Choose a Heat Sink

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THE purpose of using a heat sink for a power semiconductor device is to remove heat developed in the device so that the collector junction temperature remains below the maximum permitted—otherwise, the device may be damaged. To determine the proper heat sink for a given application it is necessary to find the maximum permissible thermal resistance from the collector junction to ambient air. The heat sink is then selected so that this maximum resistance is not exceeded. Here is a simple procedure to follow.

Design Information. The maximum power dissipated by a device is determined from: $P_D = (T_J - T_A)/\theta_{JA}$, where P_D is the maximum power dissipated by the device in watts, T_J is the maximum permissible junction temperature in °C, T_A is the maximum ambient temperature in °C, and θ_{JA} is the thermal resistance from junction to ambient in °C/W.

Most power transistors have a maximum junction temperature specified of 200°C. Designing for a lower temperature, say 20% to 40% less, will increase device reliability and life expectancy. The thermal resistance from junction to ambient is the sum of the individual thermal resistances: junction to case, θ_{JC}; case to heat sink, θ_{CH}; and heat sink to ambient, θ_{HA}.

The thermal resistance from junction to case depends on the style of the case. Some common values are:

Case	θ_{JC}
TO-3	1.5
TO-5	30.0
TO-66	4.0
TO-220	4.0

The thermal resistance from case to heat sink varies with the method of mounting. Factors involved include whether or not silicone grease is used, whether an electrical isolating washer is used, and the degree of mounting pressure used to hold the device to the heat sink. Here are some typical values:

Type of washer	θ_{CH} no grease	θ_{CH} grease
none	0.2	0.1
beryllium oxide	0.4	0.2
anodized aluminum	0.5	0.3
mica	0.8	0.4

Procedure: Use the following steps: 1. Determine, by approximation, the maximum power dissipated by the device by multiplying the collector-emitter voltage times the collector current. For example, assume we have a series pass transistor in a voltage regulator whose output is 5 V at 2 A. The supply is 10 V, and the transistor is a 2N3055. Then the power dissipated is $(10 - 5) \times 2 = 10$ watts.

2. Find T_J and θ_{JC} from the device specification sheet. For the 2N3055, T_J is 200°C, but we will decrease this to 150°C. From the table above, for a TO-3 case, θ_{JC} is 1.5.

3. Specify maximum ambient temperature. Assume 50°C.

4. Calculate maximum permissible $\theta_{JA} = (T_J - T_A)P_D = (150 - 50)/10 = 10$ °C/W.

5. Determine $\theta_{CA} = \theta_{JA} - \theta_{JC} = 10 - 1.5 = 8.5$ °C/W.

6. Determine θ_{HS} from type of mounting. With a mica washing and using grease, $\theta_{HS} = \theta_{CA} - \theta_{CH} = 8.5 - 0.4 = 8.1$ °C/W.

7. Select a heat sink having θ equal to or less than this value. In our example, we could use a Thermalloy 6002 which has a θ of 7.0°C/W. ◇