10-47 Six identical power transistors are attached on a copper plate. For a maximum case temperature of 75°C, the maximum power dissipation and the temperature jump at the interface are to be determined.

Assumptions **1** Steady operating conditions exist. **2** Heat transfer can be approximated as being one-dimensional, although it is recognized that heat conduction in some parts of the plate will be two-dimensional since the plate area is much larger than the base area of the transistor. But the large thermal conductivity of copper will minimize this effect. **3** All the heat generated at the junction is dissipated through the back surface of the plate since the transistors are covered by a thick plexiglass layer. **4** Thermal conductivities are constant.

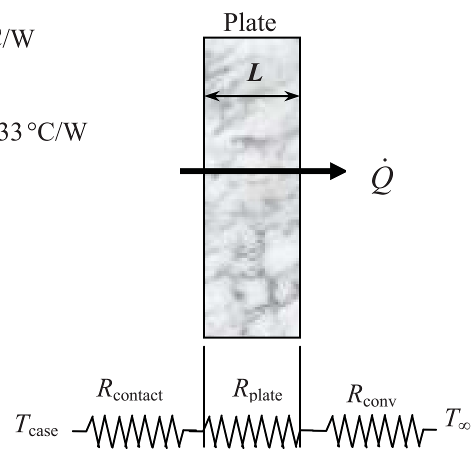
Properties The thermal conductivity of copper is given to be k = 386 W/m·°C. The contact conductance at the interface of copper-aluminum plates for the case of 1.10-1.4 μm roughness and 10 MPa pressure is h_c = 49,000 W/m^2·°C (Table 10-2).

Analysis The contact area between the case and the plate is given to be 9 cm^2, and the plate area for each transistor is 100 cm^2. The thermal resistance network of this problem consists of three resistances in series (contact, plate, and convection) which are determined to be

$$R_{\text{contact}} = \frac{1}{h_c A_c} = \frac{1}{(49{,}000 \text{ W/m}^2 \cdot {}^\circ\text{C})(9\times10^{-4} \text{ m}^2)} = 0.0227\ {}^\circ\text{C/W}$$

$$R_{\text{plate}} = \frac{L}{kA} = \frac{0.012 \text{ m}}{(386 \text{ W/m}\cdot{}^\circ\text{C})(0.01 \text{ m}^2)} = 0.0031\ {}^\circ\text{C/W}$$

$$R_{\text{convection}} = \frac{1}{h_o A} = \frac{1}{(30 \text{ W/m}^2 \cdot {}^\circ\text{C})(0.01 \text{ m}^2)} = 3.333\ {}^\circ\text{C/W}$$



The total thermal resistance is then

$$\begin{aligned} R_{\text{total}} &= R_{\text{contact}} + R_{\text{plate}} + R_{\text{convection}} \\ &= 0.0227 + 0.0031 + 3.333 = 3.359\ {}^\circ\text{C/W} \end{aligned}$$

Note that the thermal resistance of copper plate is very small and can be ignored all together. Then the rate of heat transfer is determined to be

$$\dot{Q} = \frac{\Delta T}{R_{\text{total}}} = \frac{(75-23){}^\circ\text{C}}{3.359\ {}^\circ\text{C/W}} = \mathbf{15.5\ W}$$

Therefore, the power transistor should not be operated at power levels greater than 15.5 W if the case temperature is not to exceed 75°C.

The temperature jump at the interface is determined from

$$\Delta T_{\text{interface}} = \dot{Q} R_{\text{contact}} = (15.5 \text{ W})(0.0227\ {}^\circ\text{C/W}) = \mathbf{0.35{}^\circ C}$$

which is not very large. Therefore, even if we eliminate the thermal contact resistance at the interface completely, we will lower the operating temperature of the transistor in this case by less than 1°C.