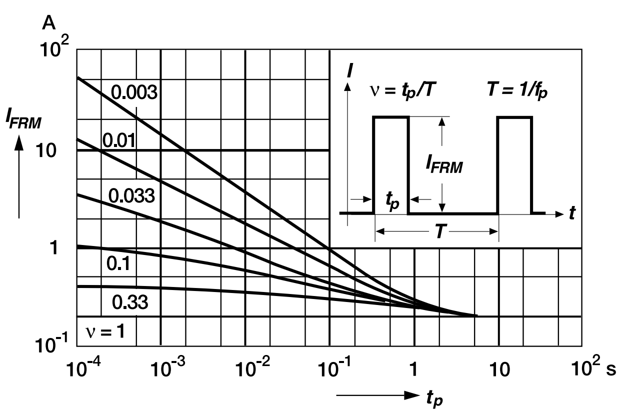
Pulse Power Rating of Semiconductors

The admissible dissipation of diodes, rectifiers and Zener diodes which operate from sinusoidal supplies is based on the arithmetic mean value of junction temperature and power dissipation. Devices which handle pulses are capable of passing short-term currents far in excess of the maximum admissible static dissipation, and in this case it is admissible to exceed the continuous dissipation curve for the duration of each pulse. The magnitude of the admissible current is then inversely proportional to the pulse duty factor, because power is dissipated only intermittently, and the thermal capacity of the system and heat conduction prevent an undue rise in junction temperature. Some of the data sheets contain diagrams which allow the rating of a device operating under pulsed conditions to be determined.

In Figure 1, which applies to diodes and rectifiers, the maximum admissible pulse current amplitute is plotted as a function of pulse duration for an ambient (or case) temperature of + 25°C. If the device is to operate at higher ambient temperatures, then it is necessary to derate the current values derived from this diagram in accordance with the “admissible dissipation versus temperature” curve.

Fig. 1



For Zener diodes it is preferable to provide a plot which gives the terminal pulse resistance rather than the admissible current amplitude as a function of t_p (the duration of the rectangular pulse which causes power to be dissipated), as shown in Figure 2. The operational junction temperature can then be calculated by use of the formula

$$T_j = T_{amb} + P_I \cdot r_{thA},$$

or, if additional power P_D is continuously dissipated, by use of the formula

$$T_j = T_{amb} + P_D \cdot R_{thA} + P_I \cdot r_{thA},$$

If the diode is fitted to a heat sink, then the equation becomes

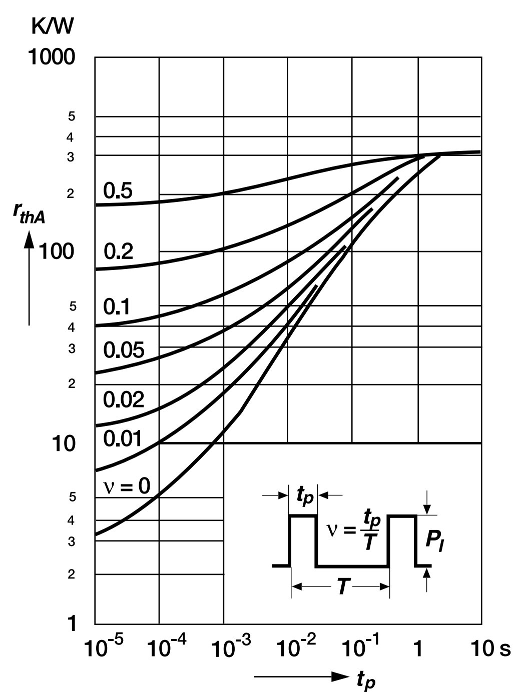
$$T_j = T_{amb} + P_{tot} \cdot R_{thS} + P_I \cdot r_{thC},$$

where P_{tot} is the mean value of P_I (= pulse dissipation). If additional power is continuously dissipated, then the above equation must be extended to

$$T_j = T_{amb} + P_{tot} \cdot R_{thS} + P_D \cdot R_{thC} + P_I \cdot r_{thC},$$

where P_{tot} is the mean value of the total dissipated power.

Fig. 2



Heat Removal from Semiconductor Components

The operation of any semiconductor device involves the dissipation of power with a consequent rise in junction temperature. Because the maximum admissible junction temperature must not be exceeded, careful circuit design with due regard not only to the electrical, but also the thermal performance of a semiconductor circuit is essential.

If the dissipated power is low, then sufficient heat is radiated from the surface of the case; if the dissipation is high, however, additional steps may have to be taken to promote this process by reducing the thermal resistance between the junction and the ambient air. This can be achieved either by pushing a star- or flag-shaped heat dissipator over the case, or by bolting the semiconductor device to a heat sink.

P, the power to be dissipated, T_j the junction temperature, and T_{amb}, the ambient temperature are related by the formula

$$P = \frac{T_j - T_{amb}}{R_{thA}} = \frac{T_j - T_{amb}}{R_{thA} + R_{thS}}$$

where R_{thA} is the total thermal resistance between junction and ambient air. The total thermal resistance in turn comprises an internal thermal resistance R_{thC} between the junction and the mounting base, and an outer thermal resistance R_{thS} between the case and the surrounding air (or any other cooling medium). It should be noted that only the outer thermal resistance is affected by the design of the heat sink. To determine the size of the heat sink required to meet given operating conditions, proceed as follows: First calculate the outer thermal resistance by use of the formula

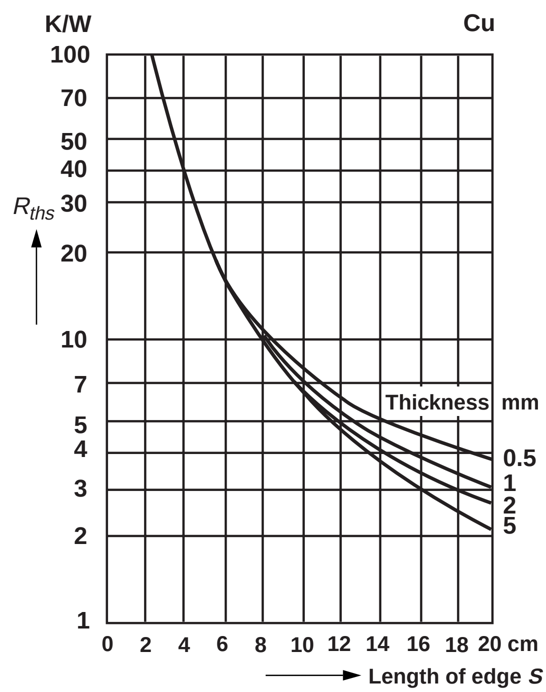
$$R_{thS} < \frac{T_j - T_{amb}}{P} = R_{thC}$$

and then, by the use of the following diagrams, determine the size of the heat sink which provides the calculated R_{thS}-value. To determine the maximum admissible device dissipation and ambient temperature limit for a given heat sink, proceed in the reverse order to that described above.

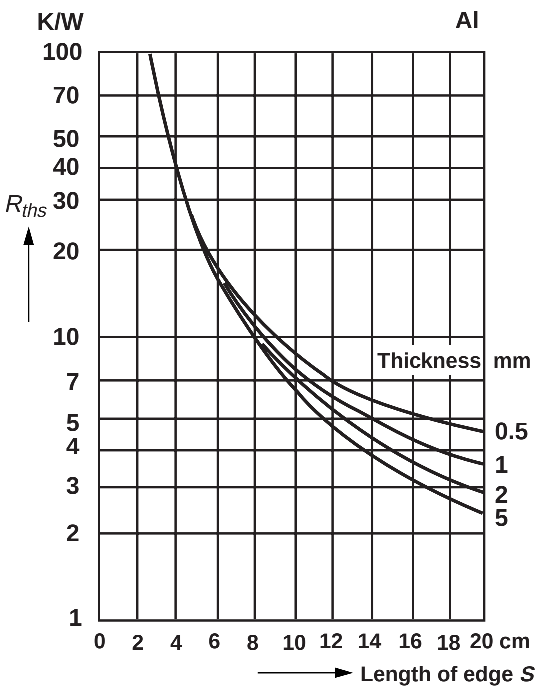
The calculations are based on the following assumptions: Use of a squareshaped heat sink without any finish, mounted in a vertical position; semiconductor device located in the centre of the sink; heat sink operated in still air and not subjected to any additional heat radiation. The calculated area should be increased by a factor of 1.3 if the sink is mounted horizontally, and can be reduced by a factor of approximately 0.7 if a black finish is used.

The following curves give the thermal to ambient resistance of square vertical heat sinks as a function of side length. It is assumed that the heat is applied at the centre of the square.

Copper Cooling Fin



Aluminum Cooling Fin



Steel Cooling Fin