Diodes, Voltage Forward and Heat Dissipation

This document will explain the requirements for adding a heat sink to a blocking diode, and how to select an appropriate heat sink for a given scenario.

When current flows through a diode, there is a small voltage drop across the diode junction known as the forward voltage, referred to as Vf. The forward voltage of a given diode is an important characteristic, and so will readily be found in the manufacturers' datasheet.

Blocking diodes are usually a type of diode known as a "Schottky" as they have a lower forward voltage of around 0.35v. It is this voltage drop, multiplied by the forward current gives the power loss in the diode, and dissipated as heat.

For example, a diode with a forward voltage of 0.35v that has 10 amps flowing through it will be dissipating 0.35v x 10A =3.5 Watts.

Power diodes are often packaged with heat dissipation in mind, below is a TO-220 case, common for this type of diode

The metal tab of this diode is where the heat is dissipated, and the higher the current flowing through this diode, the hotter the tab will become. As the tab is relatively small it will heat up quickly, and so it is a common practice use a heat sink to conduct the heat away from the diode, dissipating it to prevent the diode from overheating. The manufacturer's datasheet will outline the working temperature range of the diode, and this must be observed to prevent failure of the diode and wider damage to the system.

The main characteristic of a heat sink is its thermal conductivity, which is its ability to dissipate energy (in watts) with a given increase in temperature (^C). The thermal conductivity is given in °C/Watt.

For example :

Diode Vf = 0.35v
Forward Current generated by turbine = 10A
Power dissipation = 0.35v x 10A = 3.5 watts.
Using a heat sink rated at 3 °C/w
Temperature increase = 3.5w * 3^C/w = 10.5 °C

If the ambient temperature is 20°C, the diode and heat sink assembly will reach 41°C, which is acceptable.

Heatsinks

Heatsinks come in all shapes and sizes, and are commonly made from black anodised aluminium and have large surface areas to dissipate the heat. Typically “fins” are used to increase their surface area.

It is also common practise to use the copper on printed circuits boards as heatsinks, but this practice should be used with care, taking into account the consequences of routinely heating a PCB.

Ultimately any heat will be dissipated into the atmosphere, and so care should be taken to ensure that air is free to flow around a heat sink. This may be a consideration if the application requires a sealed enclosure. In some cases it is necessary to force air flow using cooling fans, a common practice in PCs and Laptops.

What sort of heatsink should I buy ?

When selecting a heat sink, the important factors to understand and consider are:

- The forward voltage of the blocking diode
- The maximum working temperature
- The maximum current that the diode will be conducting
- The ambient temperature the diode will be operating in

The forward voltage and the maximum current will give the maximum dissipation:

0.35v X 10A = 3.5w

Subtracting the ambient temperature from the maximum safe working temperature of the diode will give the maximum allowable temperature rise:

85°C (max working) - 20°C (ambient) = 65°C rise

The heat sink must not allow a temperature rise of more than 65^C when dissipating 3.5w, and therefore must have the rating:

65°C / 3.5w = 18.6°C/w, or lower