

# Precautions on Design Using ASSP Products

## 1. Thermal Design

As explained earlier in relation to maximum ratings, dissipation within a device is closely related to its characteristics. Allowable levels of dissipation are established for each device in order to protect its operating capability, and usage in excess of these conditions is likely to cause damage or destruction to the device and reduce reliability.

Therefore it is necessary that sufficient safety margins in thermal design be provided to allow the device to be used with assurance that its function will not be impaired.

Figure 1 shows the allowable dissipation characteristics of the MB3759 switching regulator controller.

Most integrated circuit devices have characteristics such as those shown in Figure 1. This demonstrates the maximum dissipation and operating range (limited by the thermal characteristics of devices including transistors and resistors), in which reliability considerations impose limits on operating temperature. These characteristics should be borne in mind when preparing thermal designs.

Also, in devices such as power ICs that use heat sinks, heat sink design should be used for both the thermal resistance between the IC junction and case ( $\theta_{j-c}$ ) and a level of thermal resistance in the heat sink that is appropriate for the operating range of the device.

Power ICs in particular are often viewed in terms of thermal resistance, and this value determines the level of allowable dissipation in the device.

Specifically, the allowable dissipation in devices such as power ICs is determined by the ambient temperature and heat sink.

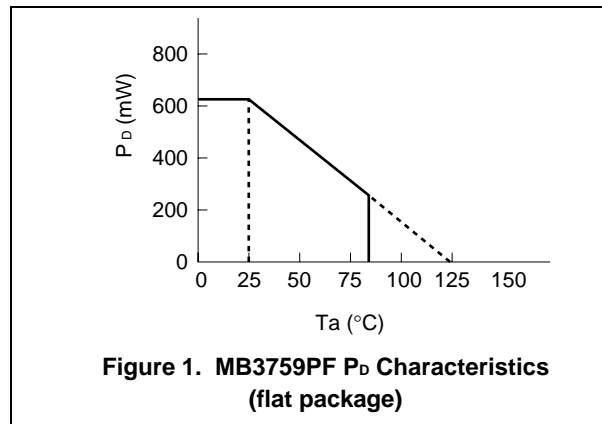
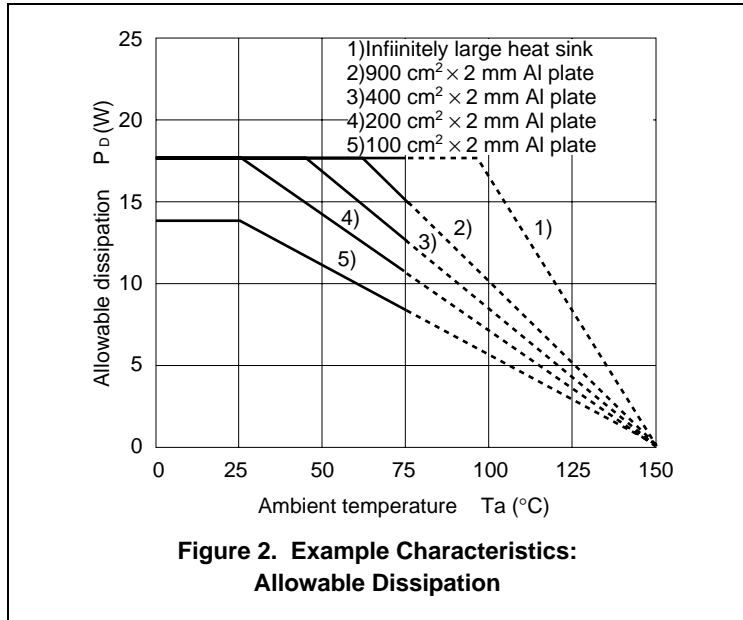


Figure 2 shows example characteristics for allowable dissipation. In this case  $P_{Dmax}$  is limited to the level of 18W, and with the ideal heat sink (where  $T_c=T_a$ ), the thermal resistance (in which thermal resistance of the heat sink  $\theta_{f} = 0$ ) is given by

$$\theta_{j-c} = \frac{150^{\circ}\text{C} - 96^{\circ}\text{C}}{18\text{ W}} = 3^{\circ}\text{C/W}$$

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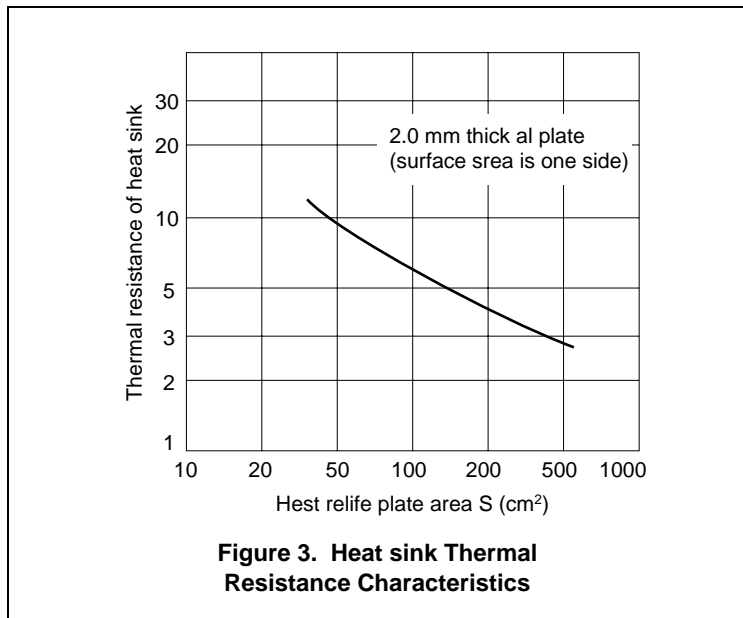


Here the thermal resistance required under the conditions in Figure 3, to operate at  $T_A=60^\circ\text{C}$ ,  $P_D=15\text{W}$ , is

$$\theta_{j-a} = \frac{150^\circ\text{C} - 60^\circ\text{C}}{15\text{W}} = 6^\circ\text{C/W}$$

$$\begin{aligned} \theta_f &= \theta_{j-a} - \theta_{j-c} \\ &= 6^\circ\text{C/W} - 3^\circ\text{C/W} \\ &= 3^\circ\text{C/W} \end{aligned}$$

and therefore the area of the heat sink for this example is  $400\text{cm}^2$  or more.



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## 2. External Components

The external components for the ASSP products define the requirements as oscillating frequency or operating constants. Using the components exceeding the recommended tolerance range of deviation may cause the system to malfunction due to the difference of the time setting. Exercise utmost caution especially when you use the capacitors with large leak current or capacitors or resistors susceptible to variations due to the external stresses. Use due caution to the fact that some physical locations of the external components may affect the ASSP products.

## 3. Reference: About Absolute Maximum Ratings

### (1) Absolute Maximum Ratings

The principal factors limiting the operation of semiconductor devices are voltage, current, allowable dissipation and temperature. Failure to observe any one of these elements can be a cause of damage to or destruction of semiconductor devices.

To prevent damage or destruction, certain maximum values called absolute maximum ratings (maximum ratings) are established.

Absolute maximum ratings are values which if exceeded even instantaneously will result in damage or destruction.

Therefore, users of semiconductor devices must take care that the maximum ratings for each devices are not exceeded under any condition.

The factors that determine maximum ratings are closely interrelated. Users should not therefore assume that satisfying the voltage and current ratings is sufficient, and that power dissipation limits can safely be exceeded.

### (2) Maximum Voltage Ratings

Maximum voltage ratings are established for supply voltage, input voltage, output voltage, and otherwise as necessary. Supply voltage is the maximum voltage that may be applied at the power supply terminal. Input and output voltages are the maximum voltages that may be applied at the input and output terminals, and are defined according to the voltage ratings of each input or output transistor.

Users should also aware that reverse connection of supply terminals can lead to forward bias current at separation and connection, which can damage the device.

### (3) Maximum Current Ratings

Maximum current ratings are determined by the allowable current level of internal bonding wires, as well as the current level at which the allowable dissipation levels of the device are exceeded.

### (4) Allowable Dissipation

Dissipation within the device is the source of increases in junction temperature ( $T_j$ ) as power is converted into thermal energy, which causes a dramatic decline in the performance of the device. The relation between internal dissipation and junction temperature is given by the following formula:

$$T_j = P_D \times \theta + T_A$$

where  $P_D$ : dissipation

$\theta$ : thermal resistance

$T_A$ : ambient temperature

Here thermal resistant is a constant for each device and assuming that junction temperature does not vary, if the ambient temperature is held constant then the level of dissipation within the device is necessarily limited. This factor is also affected by the material in which the device is sealed.

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## (5) Maximum Temperature Ratings

### a. Junction Temperature

Semiconductor devices are sensitive to temperature, because as temperature increases the thermal agitation of the crystal becomes intense creating greater numbers of electron-hole pairs and making normal operation more difficult to achieve.

Junction temperature in silicon devices is between 150 °C and 175 °C, but with epoxy resin sealing is limited to 125 °C or less.

### b. Storage Temperature

Storage temperature is the temperature level at which the device can be stored. Although devices are not normally operated at this temperature, it is generally determined to be the same as junction temperature.

### c. Operating Temperature

Operating temperature is the range of temperature at which the circuits of the device function normally. Device characteristics, however, may impose requirements other than those of the standard values.