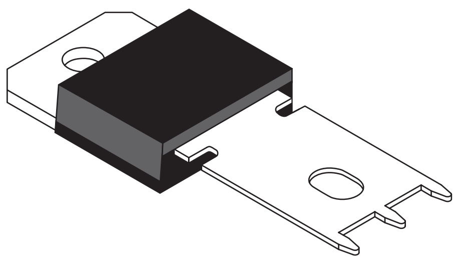
PowerTab^{TM} Mounting Guidelines



1.0 INTRODUCTION

The PowerTab^{TM} package has been designed to fill the gap in the market between the TO-247, more expensive metal case devices and non-isolated power modules. It is the natural replacement for metal case outlines such as DO-203AA and DO-203AB, but it is also suitable for new innovative solutions, thanks to a package outline that combines low profile, excellent die to footprint ratio and sturdy connectivity. It utilises a large lead for high current connection, carrying both a mounting hole and PCB insertion pins. The body is compatible with a TO-218 outline, with an exposed heatsink and non-isolated mounting hole.

It is anticipated that the devices would find typical applications in busbar assemblies or finned heatsinks, reducing component count and cost of ownership.

2.0 SCOPE

This application note covers the various fixment methods that are possible with this device, and the associated thermal properties resulting from their use:

a. Optimum mounting torque

b. Type of fixings

c. Effect of torque on thermal resistance (“wet” and “dry”)

d. Effect of pressure on contact thermal resistance (“wet” and “dry”)

3.0 MECHANICAL CONSIDERATIONS

3.1 TYPE OF FIXINGS

The PowerTab possesses mounting holes in the tab and lead for electrically connecting the device to heatsinks or busbars. The lead also carries PCB insertion pins so that the lead end may be soldered into a board.

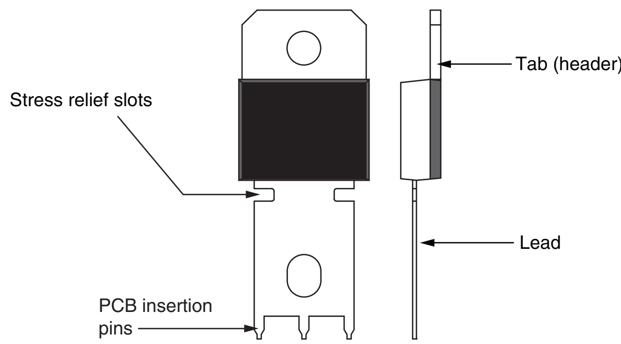


Fig. 1

3.2 TAB CONNECTION

Using the mounting hole in the tab allows a designer to attach the PowerTab to a heatsink. The tab of a PowerTab acts as one of the terminals. There is no common additional lead, so the mounting hole contact must be very good, with the heatsink forming part of the circuit. For the best results the surface of the heatsink must be as smooth and flat as possible to maximise the contact area of the tab. A good flatness specification would be 0.02 mm (0.0007") maximum per 10 mm (0.393"). Ensure also that the heatsink mounting hole has been deburred.

The mounting hole in the tab is designed to accept a M4 screw, No. 6-32 screw or 6-40 screw. A self tapping type screw may also be used. However, only a certain type of screw and washer may be used to attach the tab to the heatsink because of the proximity of the mounting hole to the plastic body.

The recommended method of attachment is a socket headed M4 screw, with a plain washer, as shown in the figure 2. The washer used must be no larger than the diameter of the socket head. If a larger washer is used, it can bear directly on the edge of the plastic body, causing the body to crack when the screw is tightened. The largest possible diameter washer that may be used is 7.2 mm (0.283"). An alternative is a suitably sized rectangular washer.

PowerTab^{TM} Mounting Guidelines

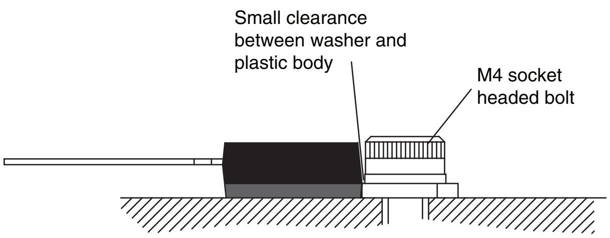


Fig. 2

Similarly, M4 nuts cannot be used (on the plastic side) for the tab connection, since there is inadequate clearance between the hole and plastic body to rotate the nut. Using the plastic body to prevent the nut rotating will inevitably crack the plastic and is not recommended.

Rivets may be used but the following precautions must be noted:
The diameter of the hole in the heatsink must be of a smaller diameter than that of the PowerTab mounting hole, the crimping force is controlled to give a slow pressure build-up and the rivet used must be of a soft material. Too high a crimping speed and pressure is likely to damage the die inside the package and deform the header, lifting it away from the heatsink.

Wherever possible, the use of heatsink compound is recommended to mount the package to improve the heat dissipation.

The recommended mounting torques, with and without heatsink compound, may found under section 4.1 of this application note - "Contact thermal resistance as a function of torque on the mounting screw" and also in summary form in Section 5.0.

3.3 CLIP MOUNTING

If desired, use may be made of a clip to attach the package to a heatsink. The recommended point for the placement of the clip is directly over the die, ie in the middle of the plastic body. This will give the best contact thermal resistance. Also refer to section 4.2 and 5.0 of this application note for the optimum clip force.

3.4 LEAD CONNECTION

The mounting hole in the lead of the PowerTab is oval in shape. This slotted hole allows for some movement between the two mounting holes in an assembly, and for any assembly tolerances. Any M4 screw, No. 6-32 or 6-40 screw or nut combination may be used to secure the lead. The use of a plane and spring washer is recommended to allow for movement of the lead due to thermal expansion or vibration. This will also, along with the stress relief slots, minimize the possibility of the plastic body cracking under tension/compression stresses. The step difference between the back of the heatsink and the back of the lead is nominally 3.0 mm. This means that in busbar configurations, the lead will either need forming down to the same level as the heatsink, or the lead busbar will need to be raised by 3.0 mm to the same level as the back of the lead. A typical busbar configuration is shown in Figure 3.

Care must be taken when tightening the fixing to prevent distortion of the lead. The lead fixing can be typically tightened to 3.00 Nm (2.21 lbf · ft) without distortion.

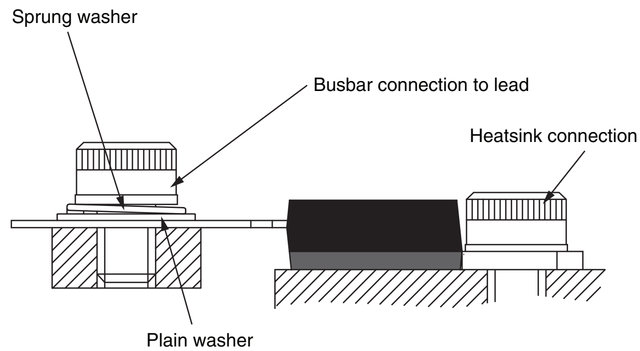


Fig. 3

Another solution is a laminated busbar, as supplied by the Rogers Mektron Busbar Division. Here a single busbar is stamped to the step height of the package and an isolating laminate and second busbar added. The PowerTab^{TM} packages can then be bolted (or rivetted) down to this strip to form a single assembly, with two large single outputs. A typical example is shown below in Figure 4.

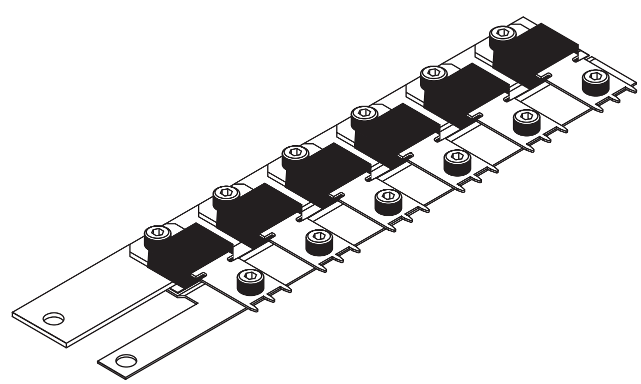


Fig. 4

PowerTab^{TM} Mounting Guidelines

3.5 LEADFORMING

In some applications, forming or bending the lead to an angle of 90° is desirable (Figure 5). This could facilitate connection to a PCB situated above the package. The minimum recommended distance of the bend point from the plastic body is 2.50 mm (0.098"). This will produce a leadform as shown in Figure 5.

The form occurs at the lower edge of the stress relief slots in the lead. The vertical height of the lead, measured from the underside of the unformed section of lead is typically 16.6 mm (0.653"). The stress relief slots, as well as making the leadforming operation simpler, help to reduce the stresses imposed on the plastic body caused by differential expansion at higher operating temperatures. During the leadforming operation, it is very important that the area of lead between the plastic and the bend is securely clamped, to ensure that the plastic is not cracked by this operation.

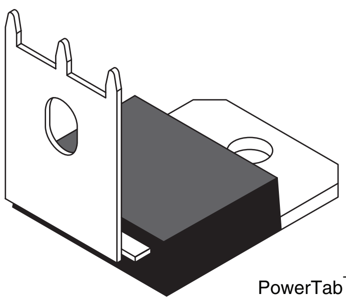


Fig. 5

Care must also be taken not flex or bend the lead over sharp angles repeatedly. If the lead is bent through 30° and back again more than twice, it will be considerably weakened and liable to breakage.

4.0 THERMAL CONSIDERATIONS

One of the major considerations when mounting all power semiconductor packages is the dissipation of heat. This is because the performance of the device is limited by the junction temperature of the die and the glass transition temperature of the plastic. Indeed there are maximum allowable temperatures above which the device is not functional. The way in which a device is mounted can have a large effect on the thermal contact between the header and the heatsink and hence on the ability of the package to dissipate heat. This is often referred to as the contact thermal resistance and is quoted in datasheets. In the present note we shall concentrate on the thermal resistance between the case and the heatsink as this is the most dependent on the mounting technique.

The physical source of the contact resistance is a result of the fact that surfaces are never perfectly flat. Even for two well prepared surfaces contact only actually occurs at several points separated by large air gaps. As air is a very good thermal insulator this is undesirable and increases the thermal resistance. There are two ways of reducing the volume of air trapped between the surfaces. One is to increase the force holding the two surfaces together and the other is to improve the quality of the contact area by filling in the gaps. In the case of the former this can be done by either applying a force above the die with a clip or by increasing the torque on the screw which mounts the tab to the heatsink. The second technique requires the use of a heatsinking compound. This is usually a silicone grease loaded with electrically insulating, thermally conductive material such as alumina. The purpose of the grease is to fill the gaps without increasing the distance between the two surfaces. If the layer of grease is too thick then the thermal resistance will be increased. When using heatsinking compound in conjunction with a PowerTab it is important to remember that electrical contact to the drain can only be made through the mounting tab. In addition to this, care must be taken to avoid getting any compound in the screw threads or mounting holes as this will affect the accuracy of the torque measurement.

For the purpose of this application note the contact thermal resistance has been measured as a function of both the torque on the mounting screw and the force above the die. In both cases measurements have been performed with and without heatsinking compound.

4.1 CONTACT THERMAL RESISTANCE AS A FUNCTION OF TORQUE ON THE MOUNTING SCREW

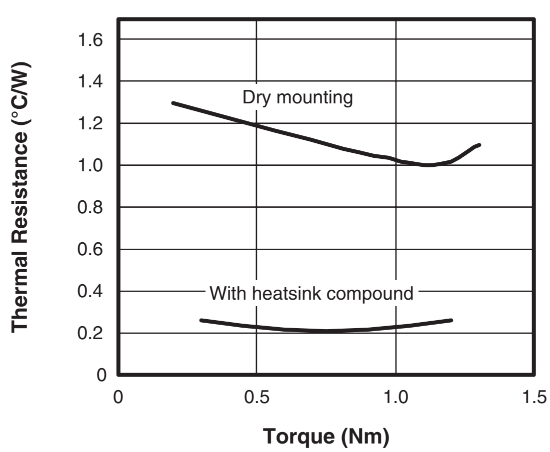


Fig. 6

Figure 6 shows the contact thermal resistance as a function of torque with and without heatsink compound. The package was mounted using a M4 screw in accordance with the mounting instructions described in this application note. It can be seen from the graph that in the case of a dry mounted

APPLICATION NOTE

device the contact thermal resistance can be reduced to a minimum of 1 °C/W by increasing the torque up to an optimum value of 1.1 Nm. Further increasing the torque is not beneficial since the header/mounting tab becomes deformed, lifting the package away from the heatsink and hence increasing the thermal resistance. The use of heatsink compound reduces the thermal resistance by a factor of 78 % to 0.22 °C/W. The dependence on torque is also reduced. This measurement was acheived using a device with 60 W power applied for 100 s, on an "infinite" heatsink.

Recommended torque:
Without heatsink compound: 1.1 Nm (0.81 lbf · ft) to give a thermal resistance, case to sink, of 1 °C/W.
With heatsink compound: 0.8 Nm (0.59 lbf · ft) to give a thermal resistance, case to sink, of 0.22 °C/W.

4.2 CONTACT THERMAL RESISTANCE AS A FUNCTION OF FORCE ABOVE THE DIE (CLIP MOUNTING)

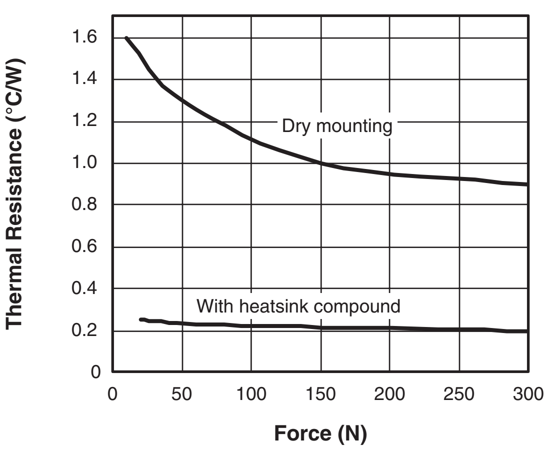


Fig. 7

Figure 7 shows the contact thermal resistance as a function of force above the die with and without heatsink. It can be seen from the graph that when heatsink compound is not used the contact resistance decreases with increasing force. However there is a point beyond which the advantage gained by increasing the force is offset by the additional cost required to do so. The use of heatsink compound reduces the thermal resistance by a factor of 85 % and also makes the thermal resistance less dependent on the applied force.

This measurement was acheived using a device with 60 W power applied for 100 s, on an "infinite" heatsink.

Recommended force:
Without heatsink compound: 20 N (4.5 lbf) minimum to give a thermal resistance, case to sink, of 1.5 °C/W.
With heatsink compound: 20 N (4.5 lbf) minimum to give a thermal resistance, case to sink, of 0.23 °C/W.

5.0 SUMMARY TABLE

Screw Mounting	**Maximum allowable torque**	**Thermal mounting**	
	2.4 Nm (21.24 lbf · in)	Without heatsink compound	With heatsink compound
		1 °C/W at 1.1 Nm	0.22 °C/W at 0.8 Nm
Clip Mounting	**Maximum allowable force**	**Thermal mounting**	
	250 N (56.21 lbf)	Without heatsink compound	With heatsink compound
		1.5 °C/W at 20 N	0.23 °C/W at 20 N