Lead Bending and Soldering Considerations for International Rectifier's Power Semiconductor Packages

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Introduction

This application note is intended to address the two most frequently asked package-related questions of IR's power semiconductors.

These are:

- How can the legs of through-hole packaged devices be bent safely without endangering part reliability?
- How can through-hole and SMD parts be soldered ensuring no damage to the parts in the process?

Lead bending

Through-hole packaged parts are mostly supplied to customers with the leads projecting straight out of the plastic body. Many practical power circuits however use bulky heatsinks in contact with the device tabs to enhance thermal performance; but this may preclude the straight-leaded orientation arrangement of the standard part. Consequently it is quite usual to change the lead direction to make a more convenient electrical connection on an adjacent printed circuit board. Where the customer carries out this function, there are certain important guidelines that should be observed. (Please note that IR can offer a lead bending option for many of the more common variations- for further details please contact your local Sales office- details available via "contact us" on the IR Web site www.irf.com)

Clamping
In order to limit any stress that the bending action imposes on the leads, it is essential to firmly clamp leads at the body-refer to Figure 1. The minimum distance that a bend should start away from the plastic body will vary from part to part - Table 1 provides these values for the most common power packages. In general, the larger the clamp area the more reliable the quality of the lead form.

Under **no** circumstances must the plastic body be held or restricted while lead forming as this has the potential to mechanically damage the package-particularly at the metal-to plastic interface.

Bend radius
IR recommends that the bend radius should never be less than the thickness of the lead material. The general rule of thumb is to create a radius that is one to two times the material thickness- "T" in figure 1. However, in certain design constrained situations, where lead length is critical, the radii may be made equal to the lead material thickness.

With the majority of lead forms, there will be an element of micro cracking on the solder plating on the outer radii which will expose the copper. This is not at all uncommon and will not affect the strength of the leads. However, if the leadform radii are too small compared with the lead thickness, then deep cracks will appear, leading to reliability issues at some later stage of the part's operating life. Refer to Table 1 for recommended dimensions.

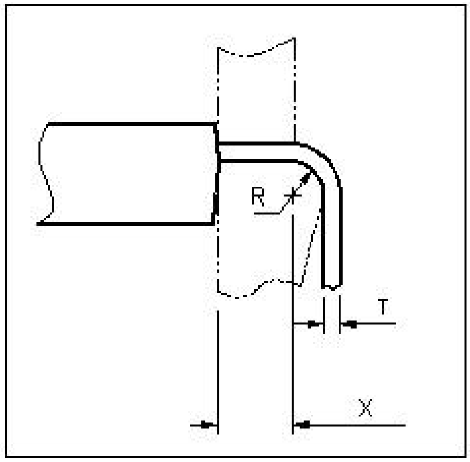

Figure 1. Material Thickness

Table 1. Recommended Leadform Dimensions

Package Outline	*X min. (Clamping Dim)*	*"T" nominal*
Super-247 *Super-220*	*2.75mm* *1.75mm*	*0.6mm (dam bar area only)* *0.8mm*
TO-247	*2.75mm*	*0.6mm*
TO-220	*1.75mm*	*0.46mm*
TO-220 Full-pak	*1.75mm*	*0.46mm*

Hand bending

Where lead bending is required on relatively low quantities of parts, i.e. for development, pre-production and even limited pilot production, bending may carried out by hand. It is still very important to abide by the rules laid down above. Clamp the leads with pliers **ensuring that static precautions are fully observed**. For accuracy of bend it is better to use un-tapered snipe-nose pliers.

Other considerations

There may be other compelling reasons for having a lead bend apart from the requirement to re-direct the leads purely for connection purposes.

Stress relief

For some mechanical arrangements the heatsink and the lead termination point may be subjected to relative movement (Figure 2). In these cases where these forces are unavoidable, it is desirable to introduce a stress-relieving lead bend in order to re-position this stress. With a simple bend of this sort, the stresses which would normally have degraded either the lead-to-body joint or the lead-to-pcb joint, will be absorbed along the lead length.

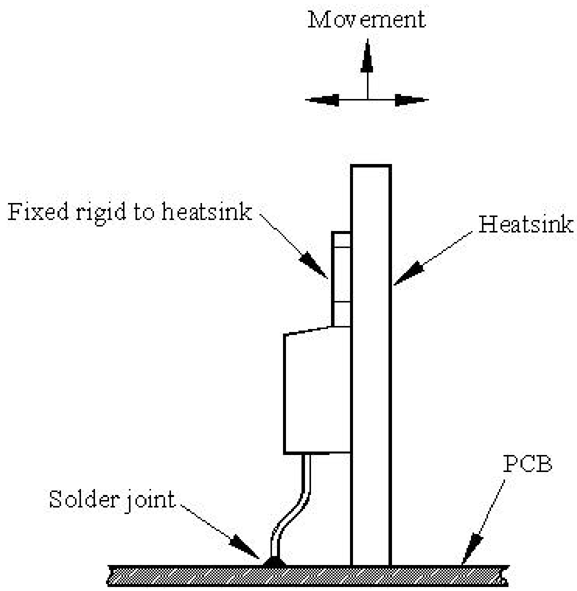

Figure 2. Heatsink and Lead Termination

Board clearance
Where leads are terminated in a PCB or similar substrate, the original in-line alignment of the leads (Gate, Drain, Source for a power MOSFET) may not provide an adequate electrical clearance/ creepage distance between track pads. By offsetting the centre leg as shown in Figure 3 this problem may be avoided.

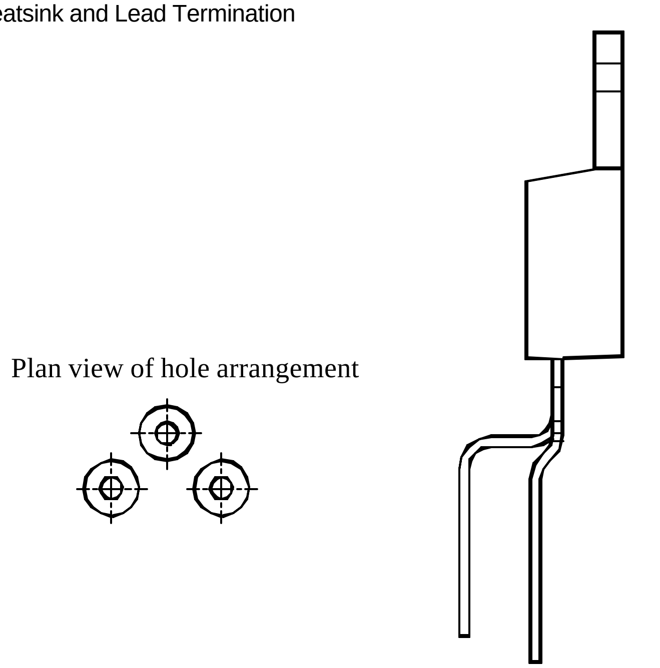

Figure 3. Center Leg Offset

Soldering

Through-hole parts
Most through-hole parts will be soldered into circuit using Wave or Dip soldering. The leads of IR's through-hole parts are prepared with a eutectic solder finish, which melts at about 185 °C.

As a general rule for the soldering process, restrict the temperature of the leads, at 1.6mm from the body, to 300 °C for a maximum of 10 seconds. This will avoid damage to the remainder of the package.
The same temperature restrictions should apply when hand soldering parts.

SMD parts
SMD parts will be soldered to substrates using a number of re-flow techniques. The most common of these are:

- Convection reflow
- Vapour phase reflow
- Infra-red (IR) reflow *

*Generally not recommended for packages larger than "D"-pak as the "black body" absorption tends to encourage too high temperatures.

In all cases the desired temperature profile will consist of three main stages:

- Preheating
- Soldering / reflow
- Cooling

As a recommendation for a suitable temperature profile, IR suggests the guidance of the JEDEC specification JESD22-A112-B. Refer to Table 2 for these details.
As with many JEDEC standards this specification provides recommended ranges for parameters. Within those limits there will be a large number of individual temperature profiles used, which provide variations on particular profile features.

The preheating stage brings the parts to the soldering temperature at a rate that limits excessive thermal stresses within the body of the device. This period may be typically up to 120 seconds.
The soldering stage defines the time necessary, at maximum temperature, to reflow the solder paste and creating an even solder layer between the part heatsink and the substrate track.

Typical Reflow cycle

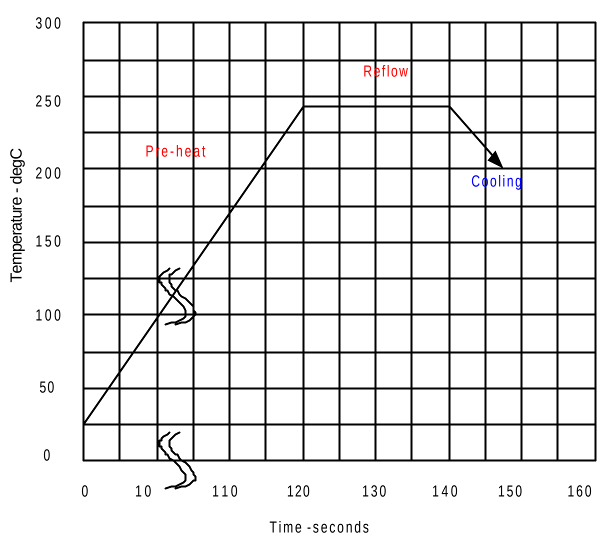

Table 2. JEDEC Reflow recommendations

	Convection or IR /Convection	**VPR**
Average ramp-up rate (183 °C to Peak)	**3 °C / second max**	**10 °C / second max**
Preheat temperature 125 (± 25°C)	**120 seconds**	
Temperature maintained above 183 °C	**60-150 seconds**	
Time within 5 °C of actual peak temperature	**10-20 seconds**	**60 seconds**
Peak temperature range	**(220+5/-0) °C or (235+5/-0) °C**	**215-219 °C or (235+5/-0) °C**
Ramp-down rate	**6 °C / second**	**10 °C / second**
Time 25 °C to peak temperature	**6 minutes max**	

SMD parts are finished with a standard 90 (Sn)/ 10 (Pb) solder plating.