AN1907

Surface Mount Solder Attach Method for the MRF9045MR1 in the TO-270 Plastic RF Package

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INTRODUCTION

This application note describes a process to solder attach the TO–270 leaded plastic RF power package to a printed circuit board and heatsink assembly. There are several issues that are of concern that will be addressed here:

1. Establishing a good thermal path between the device and heatsink.
2. Obtaining a high quality solder joint between the device leads and the pads on the printed circuit board (PCB).
3. Maintaining the package integrity so that the leads or molded plastic are not overstressed.

DISCUSSION

The MRF9045MR1 device is an RF Power transistor assembled in a package with the standard JEDEC designation TO–270. The TO–270 is a plastic RF power package (Figure 1) developed by the Wireless Infrastructure Systems Division of Motorola's Semiconductor Products Sector in Tempe, Arizona. It is designed for a single–ended RF power device operating at 28 volts utilizing LDMOS silicon technology. The packaging technology is a conventional over–molded plastic process, commonly used in most semiconductor packages. The technology and the material used (such as lead frame, die attach, wire bond and mold compounds) have been used in many applications and are known to provide robust semiconductor packages. Such plastic packages have been used for power devices in harsh environments (such as under–the–hood applications) without any reliability degradation.

Figure 1. TO–270 Plastic RF Power Package

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PCB ASSEMBLY PROCESS

A TO–270 package soldered to a PCB and heatsink is shown in Figure 2. This assembly was created to develop a typical mounting process flow using a solder reflow process. The gate and drain leads of the device are soldered to the pads on the printed circuit board. The base of the part (source contact) is soldered to a machined cavity in the copper plate through a hole in the PCB. The bottom of the PCB is tin lead plated and attached to the copper plate with screws to ensure adequate RF ground.

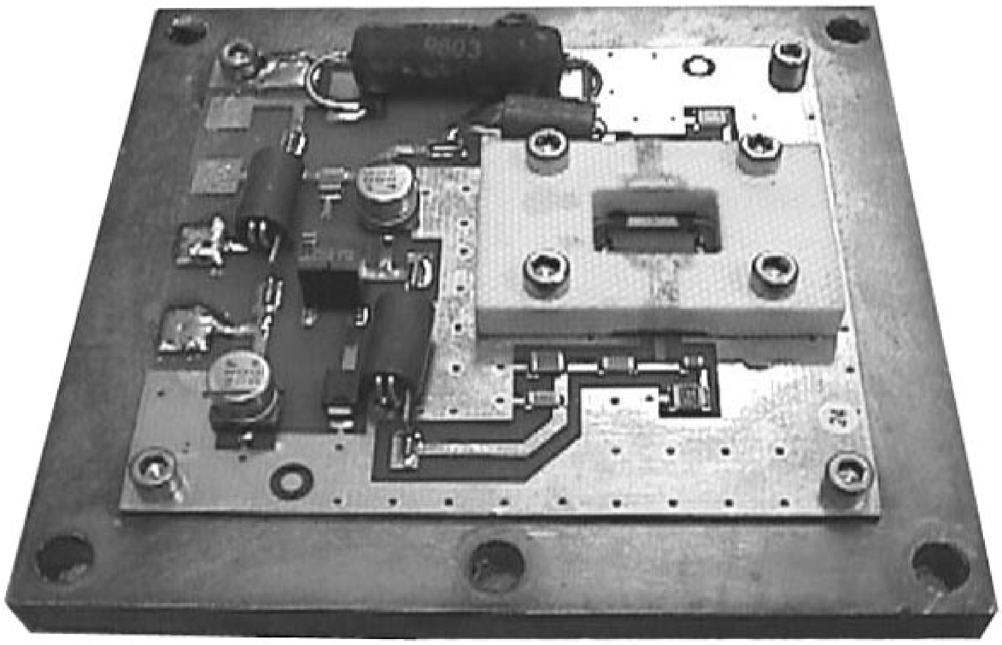

Figure 2. MRF9045MR1 Device Held Down by a Clamp Prior to Soldering

The biggest challenge in assembling any device is to overcome the accumulated tolerances in the stackup between the device, PCB and copper plate and to maintain good thermal and electrical contact where necessary. If the device leads are too high above the PCB surface, they may not contact the solder paste, resulting in a weak or possibly non–existent solder joint. If the device is placed too low, the leads can be bent in an upward direction, resulting in possible delamination in the device.

Mechanical tolerances for this device are tightly controlled. The manufacturing process results in a seating plane height of .041 ± 0.001″. The seating plane height is defined as the distance from the bottom of the device lead to the bottom of the package case. There is also a co–planarity specification on this device that indicates how level the leads must be with respect to the flange. The coplanarity limit is .041 ± 0.003″. These tolerances are much tighter than those for any of the metal ceramic devices common in the industry for RF Power application. It is also important to note that the leads of the TO–270 are made from 8 mil thick Cu–194 alloy rather than 5 mil thick Alloy–42 used in most metal ceramic packages. The increased thickness makes the leads for TO–270 packages slightly stiffer than the metal ceramic package leads.

Typical tolerances of the PCB manufacturing process are ± 0.007″. The tolerances of the machined cavity in the copper plate can be kept to ± 0.003″. The recess in the copper plate must be designed so that the device leads are not assembled in a bent–up position. The typical tolerances mentioned here will result in the worst case deflection of the leads to be less than 0.015″. Care should be taken in the design of the heat sink so that the leads are not bent to the point where this can contribute to delamination of the plastic mold compound from the leads. Tests were conducted to show that 0.015″ of lead tip deflection during three solder reflow operations will not cause any delamination of the mold compound from the lead frame.

A special fixture was designed to push the leads down at the tips so that (1) the lead tip is at a fixed distance above the top surface of the PCB and (2) the leads are in contact with the solder paste during the reflow process. A complete assembly is shown in Figure 2. The cross–section of the assembly through the fixture and the TO–270 device is shown in Figure 3. To solder multiple components at one time, a simple fixture can be designed to secure all of the components during the reflow operation. Although the soldering fixture used in the reflow of the printed circuit boards was screw mounted, this can be done with several other techniques.

The reflow fixture used in this assembly process is shown in Figure 4. All soldering is accomplished in one pass using 62/36/2 Sn/Pb/Ag and/or 63/37 Sn/Pb solder.

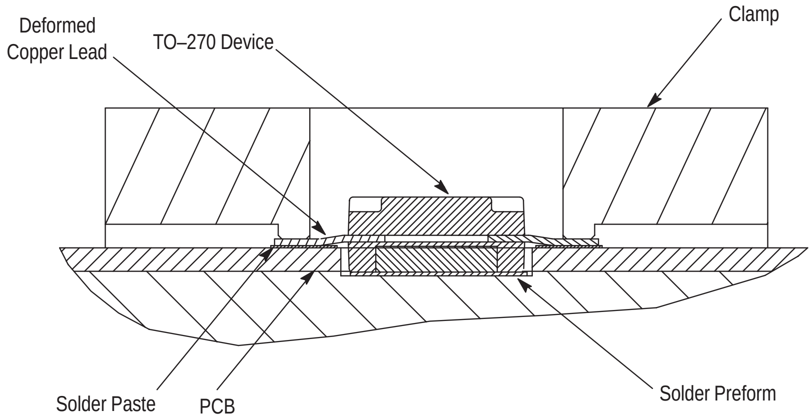

Figure 3. Fixture in Screwed Down Position with Leads Deformed

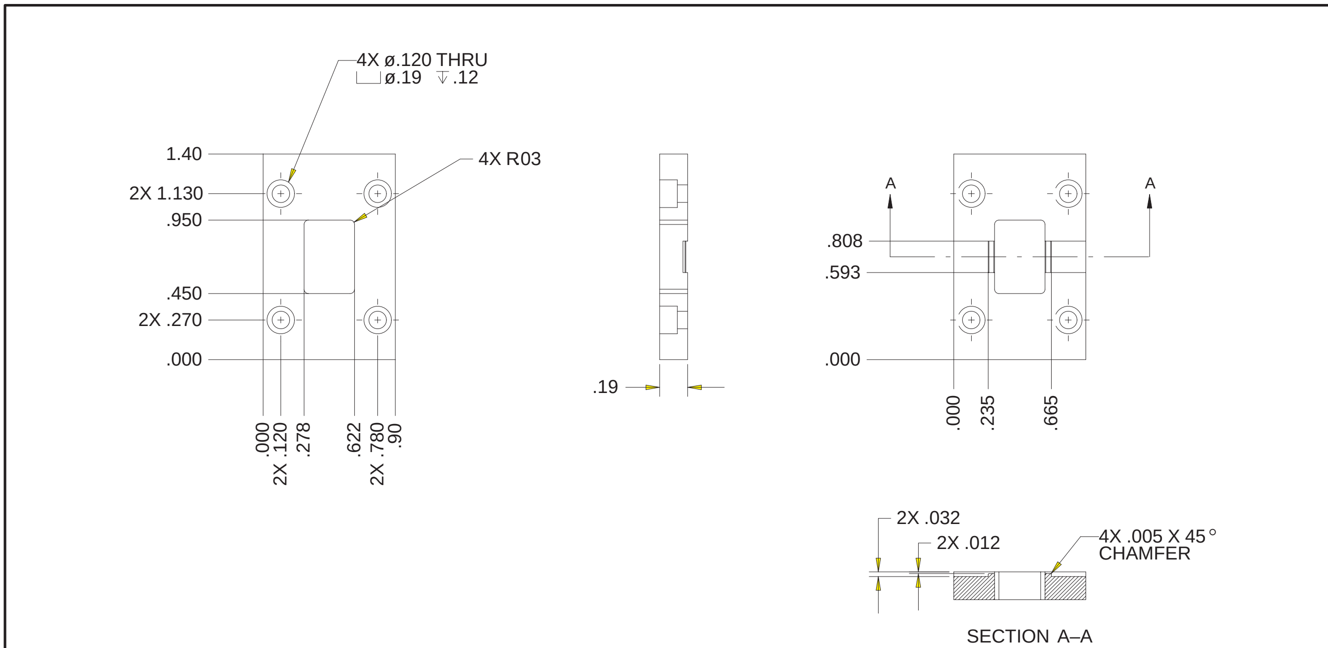

Figure 4. Solder Reflow Fixture

The TO–270 package is provided with SnPb plating on all of the exposed metal surfaces (source pad and gate and drain leads). The PCB is then screen printed with Sn/Pb/Ag solder paste using a 0.006″ thick stainless steel stencil. It is then secured to the copper plate using four #4–40 socket head cap screws. The copper plates are plated with approximately 1,000 to 1,500 microinches of electroless nickel. The plates contain a recessed cavity that is overplated with 0.0003″ to 0.0005″ of tin/lead plating to promote solder reflow.

Prior to placing the device, two 0.002″–thick solder preforms and two drops of no clean flux were set into the cavity. The device was then placed in the cavity through the slot in the PCB. The solder reflow fixture was then bolted down over the part using four #4–40 screws torqued to 5.0 ± 0.5 in.–lbs. (M3 screws with 0.8 N–m of torque). Finally, the entire assembly was placed in a convection reflow furnace. The recommended pad sizes for the drain and gate leads are shown in Figure 5.

In the reflow step, the board is preheated to 150°C and held constant for a minimum of one minute to stabilize the board temperature. A “spike” above the 183°C liquidus temperature achieves the best reflow characteristics. In order to achieve the appropriate temperature profile, the peak temperature and belt speed of the reflow furnace are determined based on the total mass of the assembly going through soldering. Maximum time above the liquidus temperature is 90 seconds with 30 to 60 seconds typical. Maximum time above 150°C is 5.5 minutes. Figure 6 shows a typical reflow profile. After the reflow operation, the fixture is disconnected by removing the four screws. The fixture can then be reused. The PCB is now secured to a copper pallet using four #4–40 socket head cap screws with 5 in.–lbs. of torque (M3 screws with 0.8 N–m of torque). The complete process flow is shown in Figure 7. An actual board assembly is shown in Figure 8.

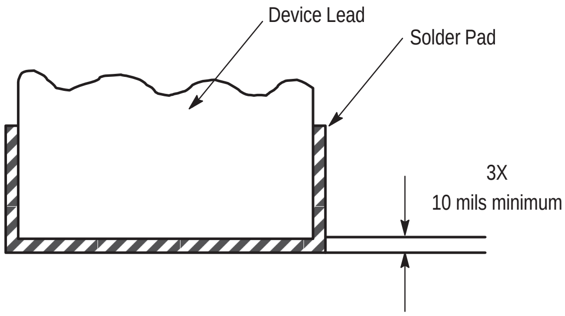

Figure 5. Pad Size and Spacing for Gate and Drain Lead

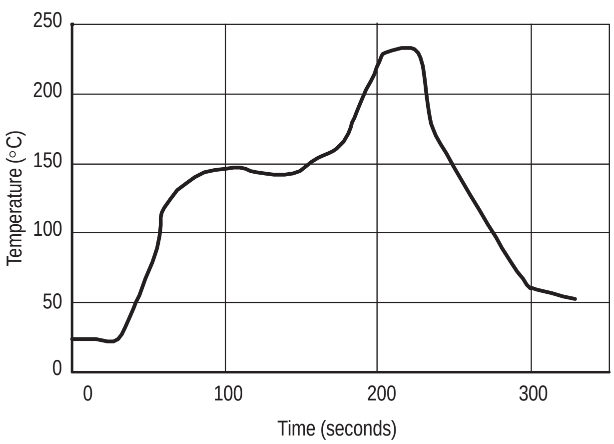

Figure 6. Typical Solder Reflow Profile for Sn63 or Similar Solder

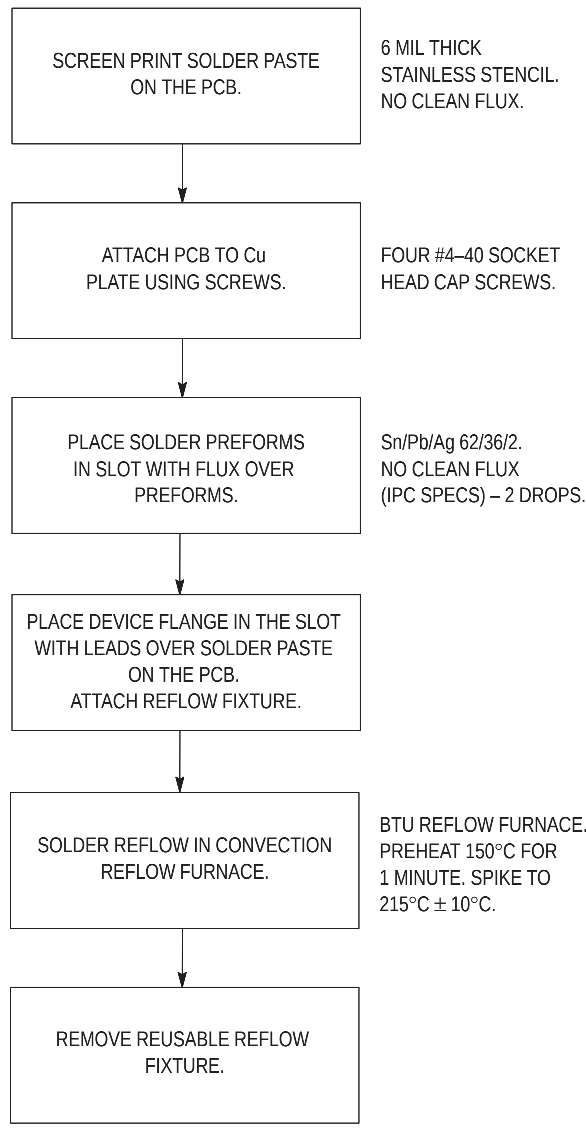

Figure 7. Process Flow for Board Assembly

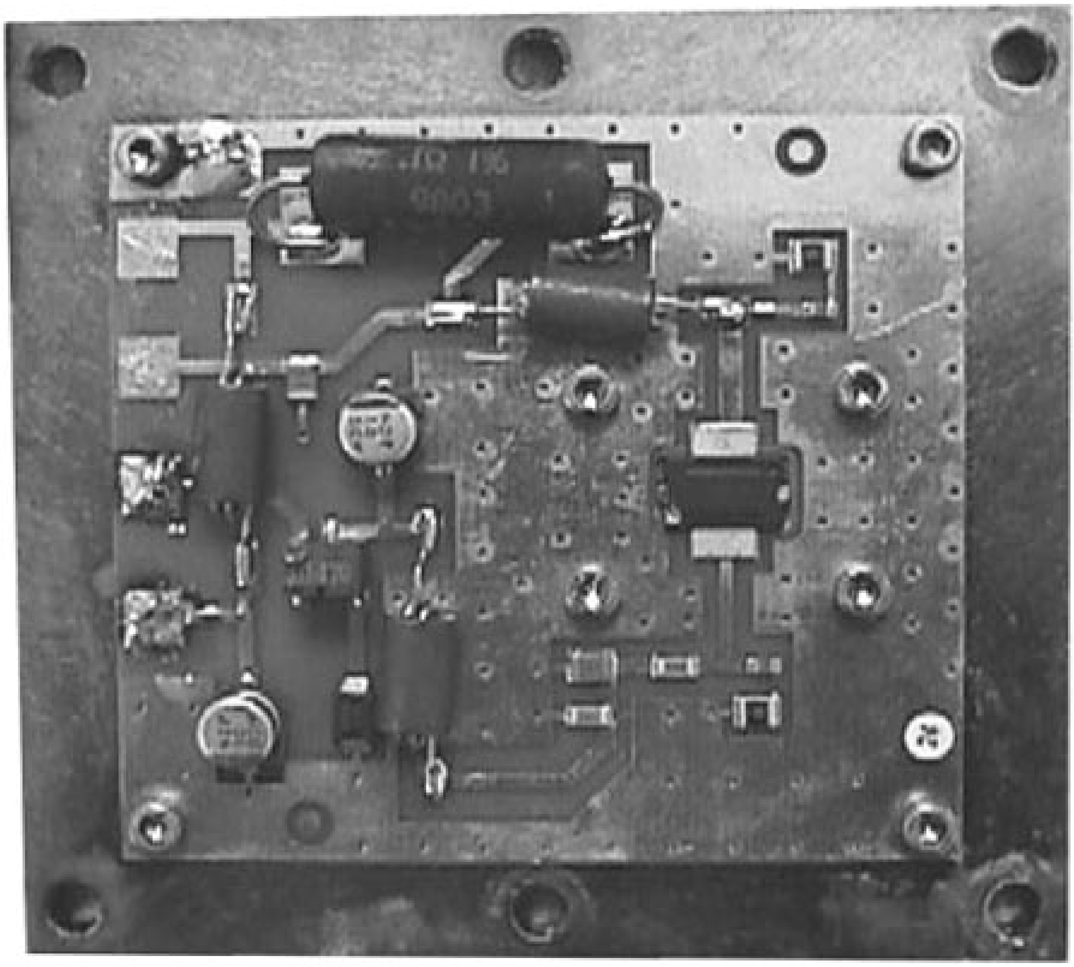

Figure 8. Complete PCB Assembly with TO–270 Device on a Cu Pallet

RESULTS

As mentioned earlier, the lead tips could be pushed down by 0.015″ maximum to provide a good solder joint. An evaluation was performed to determine whether bending the lead and then reflowing the components caused any delamination on the lead to plastic interface. The leads to plastic interface of several TO–270 packages were examined using acoustic microscopy. The leads were then pushed down at the tips by 0.015″ using a fixture similar to the one used for the soldering operation. The assembly was then exposed to the standard reflow temperature profile three times. Figures 9 and 10 show sonoscan images of the interface on two typical parts before the reflow exposure. Figures 11 and 12 show sonoscan images of the interface on the same parts after three reflow exposures. There is no evidence of delamination in the parts caused by combined stresses of the soldering temperature exposure (a maximum of three times) and lead deflection of 0.015″.

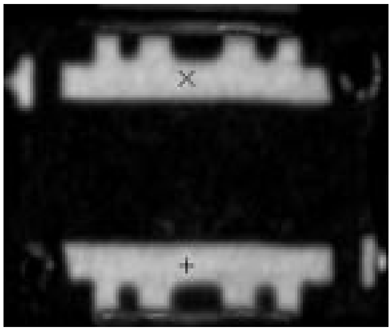

Figure 9. Lead to Plastic Interface of Part A Prior to Lead Bending and Reflow as Viewed Using an Acoustic Microscope

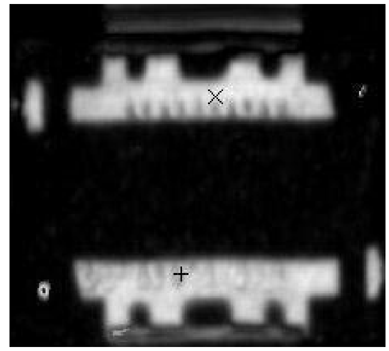

Figure 10. Lead to Plastic Interface of Part B Prior to Lead Bending and Reflow as Viewed Using an Acoustic Microscope

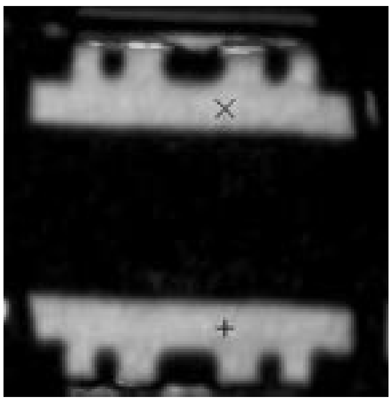

Figure 11. Lead to Plastic Interface of Part A After Bending and Reflow (Three Times) as Viewed Using an Acoustic Microscope

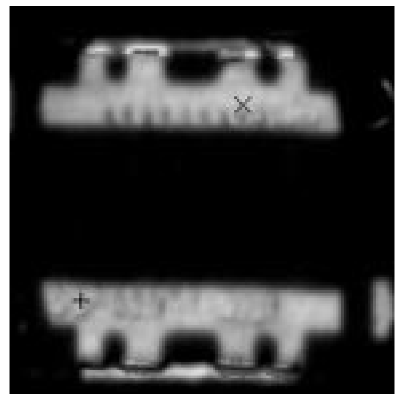

Figure 12. Lead to Plastic Interface of Part B After Bending and Reflow (Three Times) as Viewed Using an Acoustic Microscope

The device MRF9045MR1 in the TO–270 package has a typical junction to case resistance (θ_{JC}) of 0.8 °C/W. For the installation described here, the device is soldered down in the cavity of a copper pallet. The difference between the maximum temperature in the solder joint at the source contact and the maximum temperature in the die will be equal to 0.8 times the dissipated power (in watts). Once the ambient temperature in the base station is known, the system design can be evaluated to determine the temperature at the solder joint at the source contact of the device. The temperature rise calculated above based on the power dissipation can be added to determine the junction temperature.

NOTES

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