

Mounting Method with Mechanical Fasteners for Bolt-Down Metal-Ceramic Packages (Cases 360B, 465, 465B, 375D and Similar Packages)

by: Wendi Stemmons, Jerry Mason, Rich Wetz, Tom Woods and Mahesh Shah

INTRODUCTION

This application note describes a mounting method for a bolt-down metal-ceramic RF power device. This methodology is recommended for mounting of any ceramic/metal flange device with similar materials and construction (metal flanges such as copper tungsten or similar material, ceramic insulator and Alloy-42 leads). This mounting method involves bolt-down of the metal flange to a chassis and the leads soldered to a printed circuit board (PCB). Critical elements that must be carefully addressed are mechanical stress of the assembly and thermal management. The mounting method described here has adequately taken these issues into account. A power life test evaluation was done as verification.

Figure 1 shows an MRF19090 power transistor. This device operates at 1.9 GHz with 90 Watts of output power. Similar devices in our portfolio operate at frequencies as high as 3.5 GHz and power as high as 240 Watts of RF output power. This mounting method is applicable for all such devices that are bolted to the PA chassis.

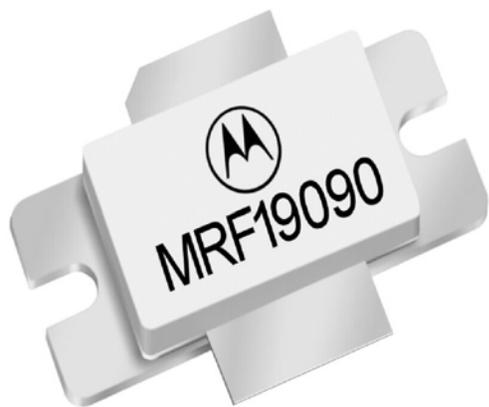


Figure 1. MRF19090 Power Transistor

MOUNTING METHOD

Assemblies of the new design were built in an automated solder mount assembly line with device leads solder-attached to a PCB and the flange bolted to a copper pallet with thermal compound on the interface. The pallets were bolted to fan-cooled, finned aluminum heatsinks with thermal compound on the interface. Power life testing was done at a specific duty cycle and heatsink temperature. Assembly construction of a pallet with this device is shown in Figure 2. Configuration of the pallets onto the aluminum chassis is shown in Figure 3.

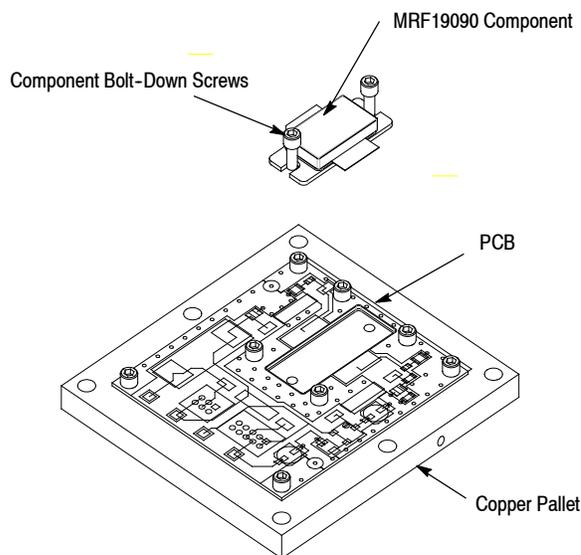


Figure 2. MRF19090 90-Watt Power Device Board Construction

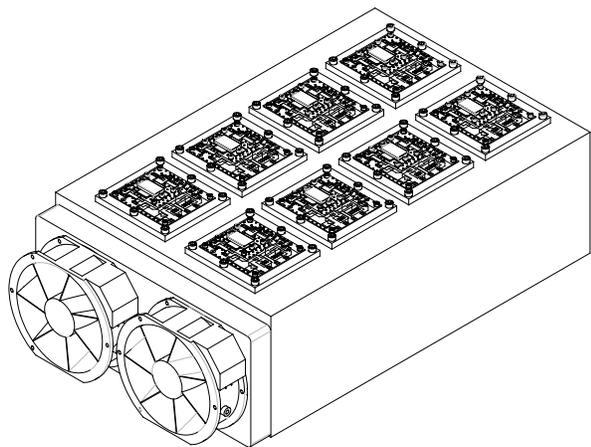


Figure 3. Full Assembly of Power Life Test

The requirement for mating the surface to the bottom side of the RF power transistor is described in detail in Freescale Application Note, "Mounting Recommendations for Copper Tungsten Flanged Transistors" (AN1617). In general, the surface flatness requirement for the mating surface should be no greater than 0.4 mil/in (4 micron/cm). Similarly, the average surface finish (Ra) requirement for the mating surface should be equal to 0.03 mil (0.8 microns). This can be easily achieved by normal machining operations, such as milling, without special surface grinding or polishing.

ASSEMBLY

A challenging aspect of high volume manufacturing of any component in a board assembly involves the stackup

tolerance of the completed system. Achievable device tolerances for the seating plane height of the component are $\pm 0.005"$ (0.13 mm) maximum. Achievable tolerance of the PCB thickness is expected to be $\pm 0.007"$ (0.18 mm). The tolerance for the cavity depth can be kept to $\pm 0.003"$ (0.076 mm) in the recessed area where the component will sit. In the assemblies built for the power life test, the recess in the copper pallet is machined to a depth dimension so that the device leads are assembled with a maximum lead tip deflection of 0.015" (0.38 mm). Typically, a worst case dimensional stack-up analysis indicates a much larger theoretical gap between the top of the PCB and the bottom of the lead. A more realistic approach is to use the square root of sum of squares (SRSS) method in evaluating stackup tolerances.

The direction of the lead deflection is important in controlling stresses on the component and the solder joint. Figure 4 illustrates how the lead deflection should always be toward the backside of the component. A fixture is used to deflect the leads at the tip so they are in contact with the solder. This solder reflow fixture also holds the component in place during reflow. The fixture used for this assembly is depicted in Figure 5. 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 solder fixture used in the reflow of the power cycling boards is screw mounted, this can be done with several techniques (for example, an array of pins). All soldering is accomplished in one pass using 62/36/2 Sn/Pb/Ag or 63/37 eutectic or equivalent Sn/Pb solder. The PCB, device and solder reflow fixture can be assembled to a pallet or a reflow boat for the solder reflow step.

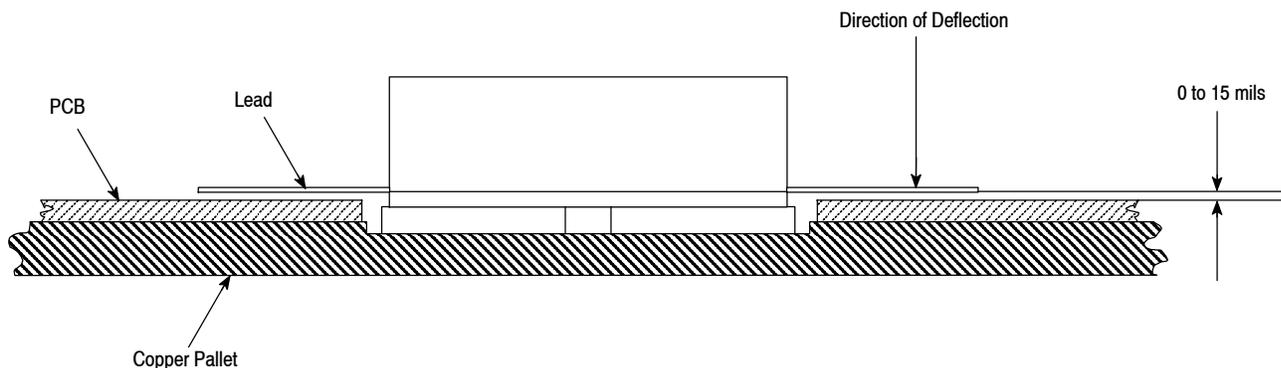


Figure 4. Direction of the Lead Deflection

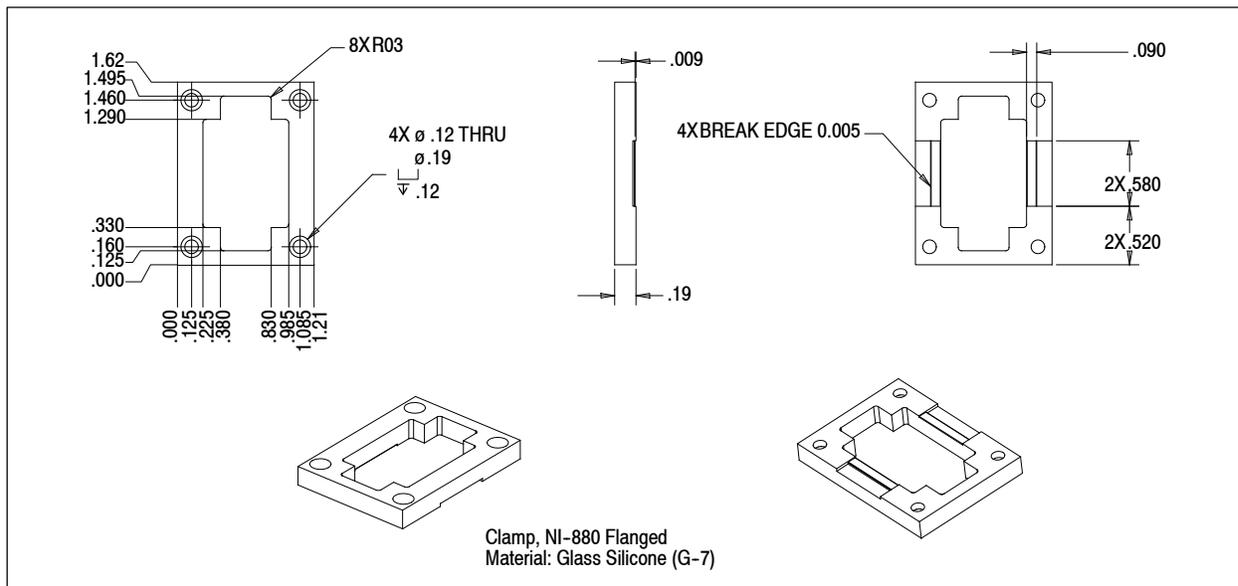


Figure 5. Component Fixture Used for Reflow

Before assembling the PCB, it is necessary to ensure that the level of gold within the solder joint is within the acceptable range based on the customer's reliability expectation. This value is typically between 4% and 8% by weight of Au in Sn. One way to accomplish this is to solder dip the leads into a solder pot of molten Sn/Pb solder. An alternate way is to provide enough thickness of solder paste so that the amount of Au in the solder joint is within the desired limit set by the customer. For the power life test assemblies, the PCB is screen-printed with Sn/Pb/Ag solder paste using a 0.006" (0.15 mm) thick stainless steel stencil. The copper pallets are plated with approximately 1,000 to 1,500 micro-inches (25 to 38 micron) of electroless nickel. The pallets contain a recessed cavity in which the components are placed. The PCB is placed on a reflow boat. The solder reflow fixture shown in Figure 5 is then fixed in place over the part using four #4-40 screws with 5 in.-lbs. of torque (M3 screws with 0.6 N-m of torque). Finally, the entire assembly is placed in a BTU convection reflow furnace. The recommended pad size is shown in Figure 6.

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. 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 the furnace. 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 7 shows a typical reflow profile. Typically, the solder manufacturer defines the soldering profile required to obtain a good solder joint.

No-clean solder flux should be used in the solder paste and soldering process. The reflowed assemblies with the metal-ceramic power transistors should not be put through an aqueous wash to remove the flux residue. The metal-ceramic packages are non-hermetic packages with an internal cavity. If the assemblies are put through an aqueous wash process, water and cleaning chemicals can get in the cavity and could create a long-term reliability risk in the field.

After the reflow operation, the fixtures were disconnected by removing the screws, and the PCBs were removed from the soldering boat. The fixtures can then be reused. Then thermal compound is evenly spread on the backside of the device with a roller to provide an approximately 0.0010" (25 micron) thick uniform grease layer. The PCB and component are secured to a copper pallet using six #4-40 socket head cap screws with maximum 5 in.-lbs. of torque (M3 screws with 0.6 N-m of torque). The process flow is shown in Figure 8.

The completed, reflowed board/pallet assemblies are screw mounted to the aluminum heatsink after evenly spreading the backside of the copper pallet with ~0.001" (25 micron) of thermal compound. An actual board assembly used for the power life test with the MRF19090 device (Case 465B) is shown in Figure 9. Care should be taken to ensure that adequate electrical and thermal contact is established between the pallet and the bottom of the device flange.

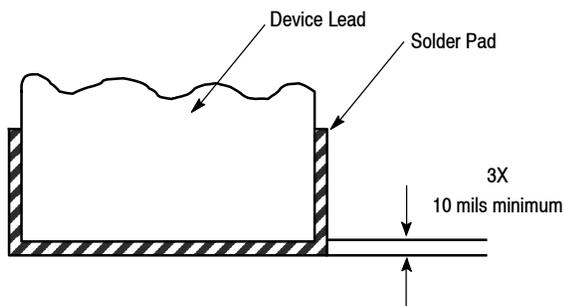


Figure 6. Pad Size in Relation to the Lead

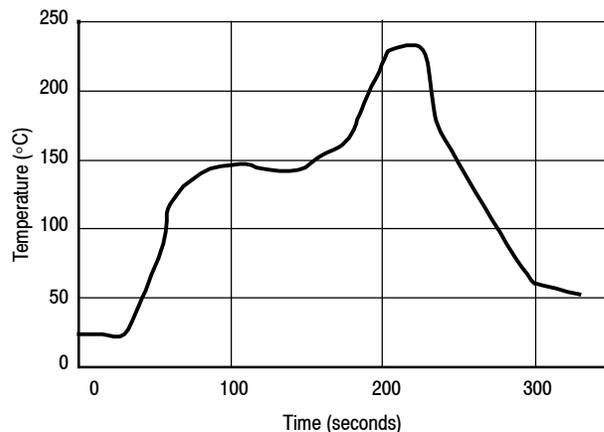


Figure 7. Typical Solder Reflow Profile for Sn/Pb/Ag Solder

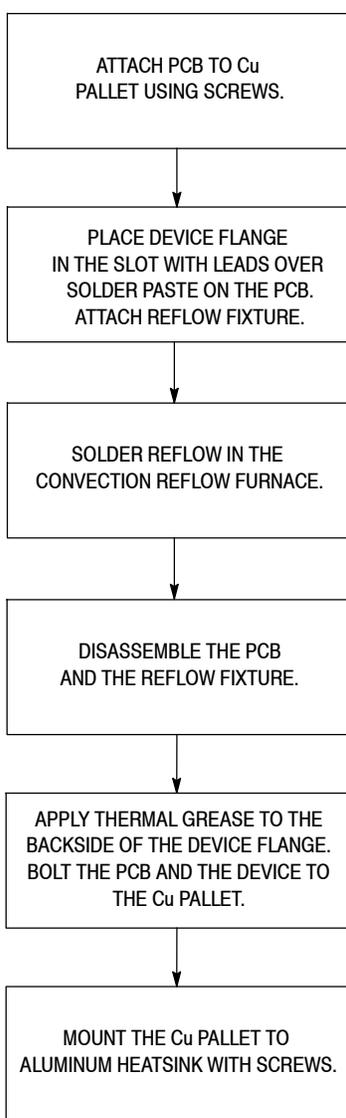


Figure 8. Process Flow for Board Assembly

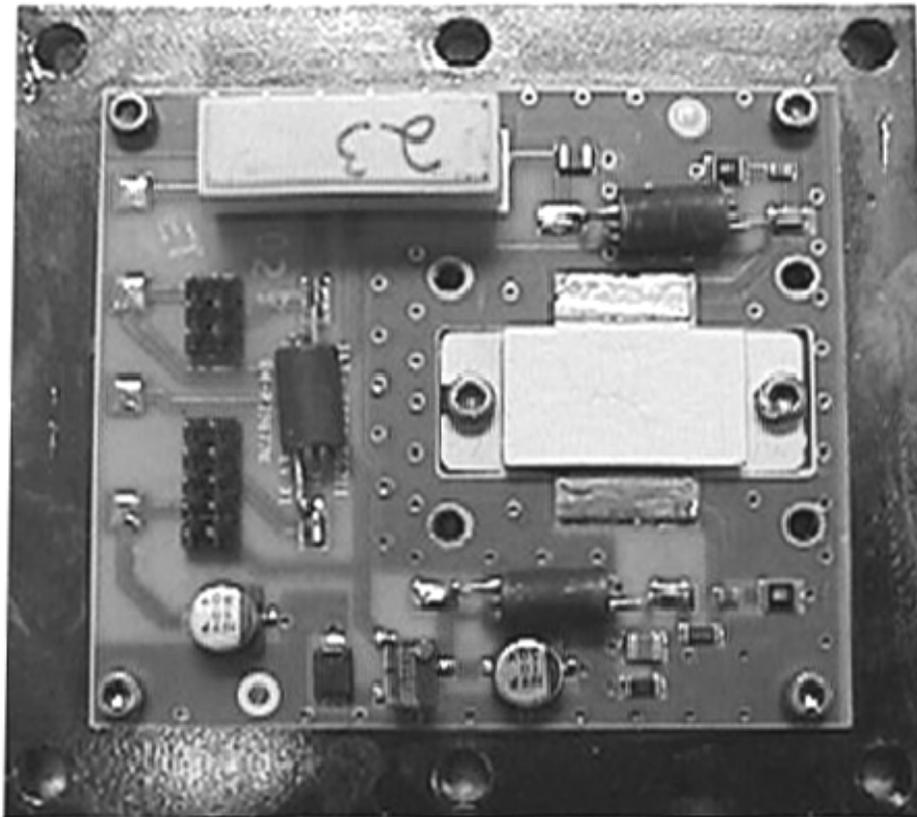


Figure 9. Power Life Test Board

RESULTS

The assemblies were cycled under DC conditions at 26 Volts and 135 Watts of dissipated power. At 90 Watts of RF output power at 40% efficiency, the dissipated power is 135 Watts (see Figure 10). A peak case temperature of more than 90°C was achieved as measured by a thermocouple directly under the flange of each device. The MRF19090 device has the specified

junction to case resistance (θ_{JC}) of 0.65°C/W. Based on this, the junction temperature at 135 Watts power dissipation will be approximately 190°C when the sink temperature is 90°C. The temperature rise is calculated based on the θ_{JC} plus the interface resistance of 0.1°C/W. The devices were powered at a 50% duty cycle for 2000 cycles representing 1000 hours of cycling.

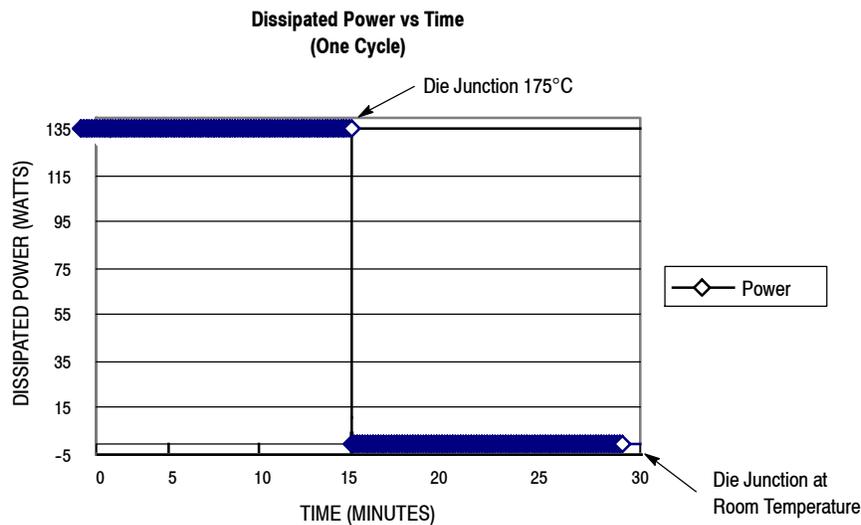


Figure 10. Power as a Function of Time for One Cycle

Lead and solder joint temperatures were measured on several PCBs using a scanning infrared microscope after the power cycling. Lead temperatures were found to be approximately 100°C at 135 Watts of power dissipation and a 90°C sink temperature. Figure 11 displays a typical image taken from the infrared microscope. Following the power life testing, solder joints were visually inspected and found to have no cracks after 2000 cycles. This prescribed mounting methodology satisfies the thermal and mechanical requirements of mounting a power transistor in a metal-ceramic package.

The mounting scheme design significantly influences both the thermal and electrical performance of the device. The mounting method described here uses thermal grease as an interface material between the source contact of the MRF19090 device and the customer's chassis. There are

number of options available for the interface layer. It is highly recommended that the customer carefully evaluate which interface material will provide adequate thermal, mechanical and electrical performance for their power amplifier assembly. The selection of the interface material will depend on the customer's sink temperature as well as the amount of power being dissipated by the transistor in the application. The total thermal resistance between the junction and the sink should be such that the temperature rise between the junction and the sink at maximum power and maximum sink temperature condition will still keep the junction temperature below the maximum value based on the expected lifetime. Similarly, the interface layer should also be evaluated to provide proper electrical contact with the source contact. The mounting method described here is a guide; it should not be substituted for a complete system-level performance analysis.

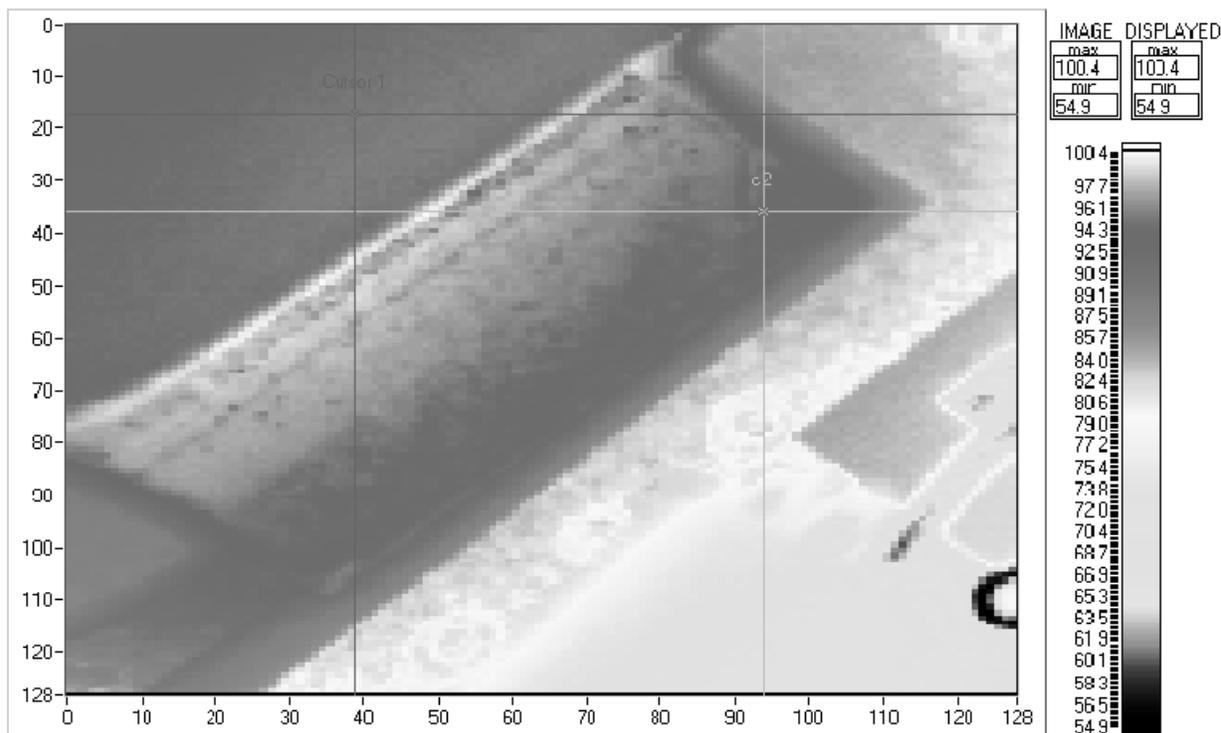


Figure 11. Typical IR Scan Image of the MRF19090 Lead and Solder Joint

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