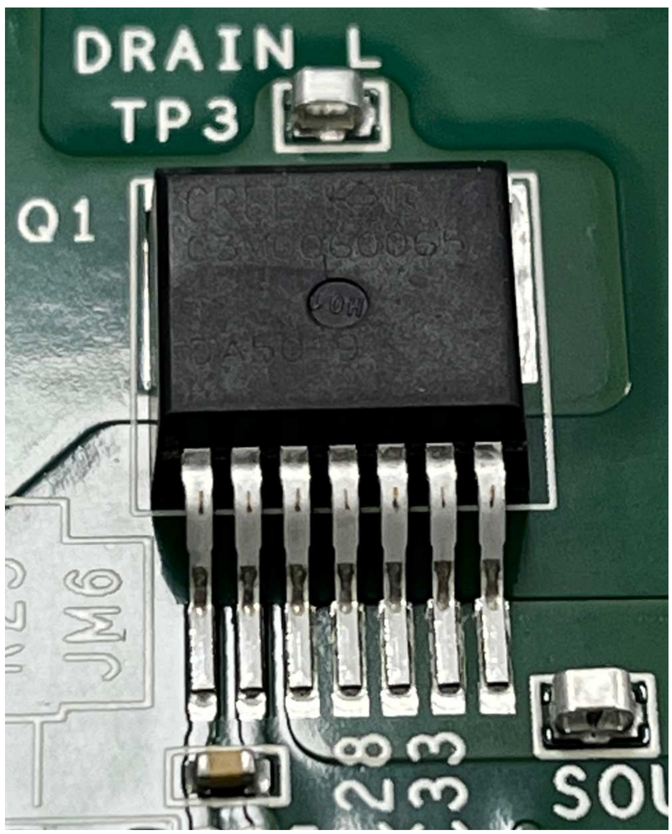
APPLICATION NOTE PRD-05653

SOLDERING RECOMMENDATIONS FOR WOLFSPEED® POWER DEVICES



INTRODUCTION

Developing successful power electronics designs requires careful consideration of all aspects of the design, including the soldering and manufacturing process of the PCB assembly. It can be particularly challenging to develop a soldering process for power electronics assemblies due to the mix of small surface-mount devices found in gate drive and control circuits, along with large power devices, capacitors, and magnetics as well as heavier copper PCBs. This application note details recommended soldering procedures for Wolfspeed® Silicon Carbide (SiC) through-hole and surface-mount devices.

CONTENTS

1. REFLOW SOLDERING OF SURFACE-MOUNT DEVICES

Wolfspeed surface-mount SiC MOSFETs and SiC Schottky diodes are intended for a reflow soldering process. Reflow soldering generally consists of four stages; preheat, soak, reflow, and cooling. A reflow oven may have additional control zones to allow for improved thermal profiling, but the basic stages remain the same. The board typically travels through the reflow oven on a conveyor system. Wolfspeed surface mount devices are qualified to the IPC/JEDEC J-STD-020E standard. Table 1 below shows the recommended values for various parts of the reflow process.

	Sn-Pb Solder	Pb-Free Solder
Minimum Soak Temperature	100 °C	150 °C
Maximum Soak Temperature	150 °C	200 °C
Soak Time	60-120 seconds	60-120 seconds
Liquidous Temperature	183 °C	217 °C
Time Above Liquidous	60-150 seconds	60-150 seconds
Peak Package Body Temperature	245°C (TO-263) 260°C (QFN, TOLL, TO-252)	245°C (TO-263) 260°C (QFN, TOLL, TO-252)
Max Ramp Up Rate – Liquidous to Peak	3 °C/second max	3 °C/second max
Time At Peak Temperature (+/- 5 °C)	30 seconds	30 seconds
Max Ramp Down Rate – Peak to Liquidous	6 °C/second max	6 °C/second max

Table 1: Reflow time and temperature recommendations

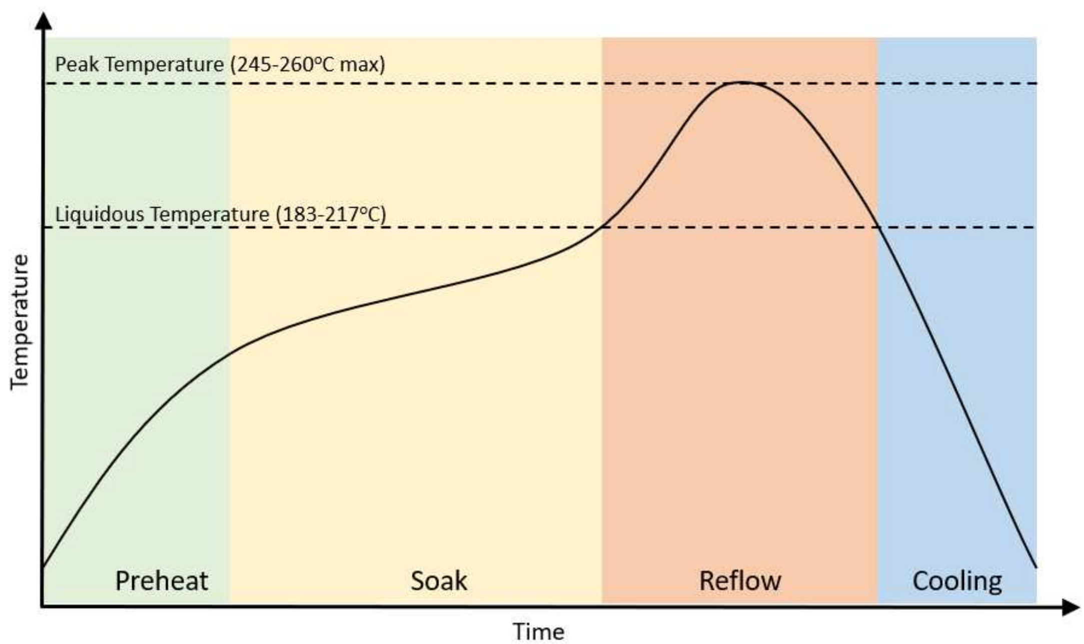


Figure 1: Typical reflow process for surface-mount components

There are several different types of reflow soldering equipment including infrared (IR), forced convection, and vapor phase. It can be difficult to provide even heating to a large power electronics assembly using an IR oven since the level of heat absorption into components and joints depends on the material and surface finish. Vapor phase ovens can provide very high-quality results, but only support batch processing, limiting their ability to be used in high-volume production. Convection ovens are best suited to high-volume power electronics designs because they can provide even heating to boards with components that have a large thermal mass and different surface finishes.

Developing a soldering profile for a surface-mount device should start with the solder paste manufacturer's recommended profile, ensuring that the temperature and time limits of all components on the assembly are followed. There is a significant difference in the temperature characteristics of a tin-lead solder compared to a lead-free alloy. Lead-free solders have a higher liquidus and peak temperature required for proper reflow and are also more sensitive to variations in temperature and ramp rates than leaded solder. During the development of the reflow process, thermocouples should be used at various points on the PCB and on critical components to ensure that the temperature profile aligns with the solder and device requirements. Power electronics assemblies will typically require longer preheat and soak phases than low-power boards due to the high thermal mass of power components and heavy copper foil on the PCB.

In order to maximize the performance of surface-mount SiC power devices, thermal vias are generally utilized in the large power pad of the footprint. These vias help transfer heat from the device through the PCB to a heatsink located on the opposite side of the PCB. This application note does not address the thermal design, however, there are a few soldering considerations related to placing vias in the pad. Vias have the potential to wick solder away from the joint depending on the geometry of the vias and the reflow profile. Vias may be plugged to avoid this issue, however that will increase the cost of the PCB. Vias should not be tented on the bottom of the board, as this can lead to excessive voiding in the solder joint as the trapped air in the vias will expand into the solder joint as the board goes through the reflow process. It is the customer's responsibility to validate the solder joint and ensure that the via design is not causing voiding or excessive solder thieving. X-ray inspection may be used to assess the solder joint on these pads since they are not visible externally.

Solder paste is applied to the board using a stencil with cutouts for the surface mount pads. The size of the openings and the thickness of the stencil depends on the size of the pads on the entire PCB. For large power devices such as the DPAK and D2PAK, the opening for the large pad (drain or cathode) may need to be windowed to reduce the amount of paste deposited on the pad. The large discrepancy in pad sizes between the small leads and large pad on these devices can lead to tilting or tombstoning of the device if the volume of solder paste is not reduced on the large pad.

2. WAVE SOLDERING OF THROUGH-HOLE DEVICES

Wolfspeed's through-hole devices such as TO-247 and TO-220 packages are intended for wave or selective soldering processes. Wave soldering follows a similar set of stages as reflow soldering, but instead of applying solder paste to the pads before mounting the device, the board travels over one or two waves of molten solder after being preheated. At the beginning of the wave soldering process, a flux is applied to the board usually through a spraying process to clean the component pins and PCB pads, prevent oxidation, and enhance the ability of the solder to flow into the joints. Next, the board goes through a preheating stage to raise the temperature of the PCB to the temperature indicated by the solder manufacturer. After pre-heating, the board passes over one or two solder waves such that the bottom side of the PCB and the through-hole leads are in the solder for 2-5 seconds in each wave, allowing the solder to raise the temperature of the joint and wet out into the joint and hole. After passing over the wave, the board goes through a cool-down ramp to solidify the joint. Wolfspeed through-hole devices are tested for soldering at 260°C for 10 seconds.

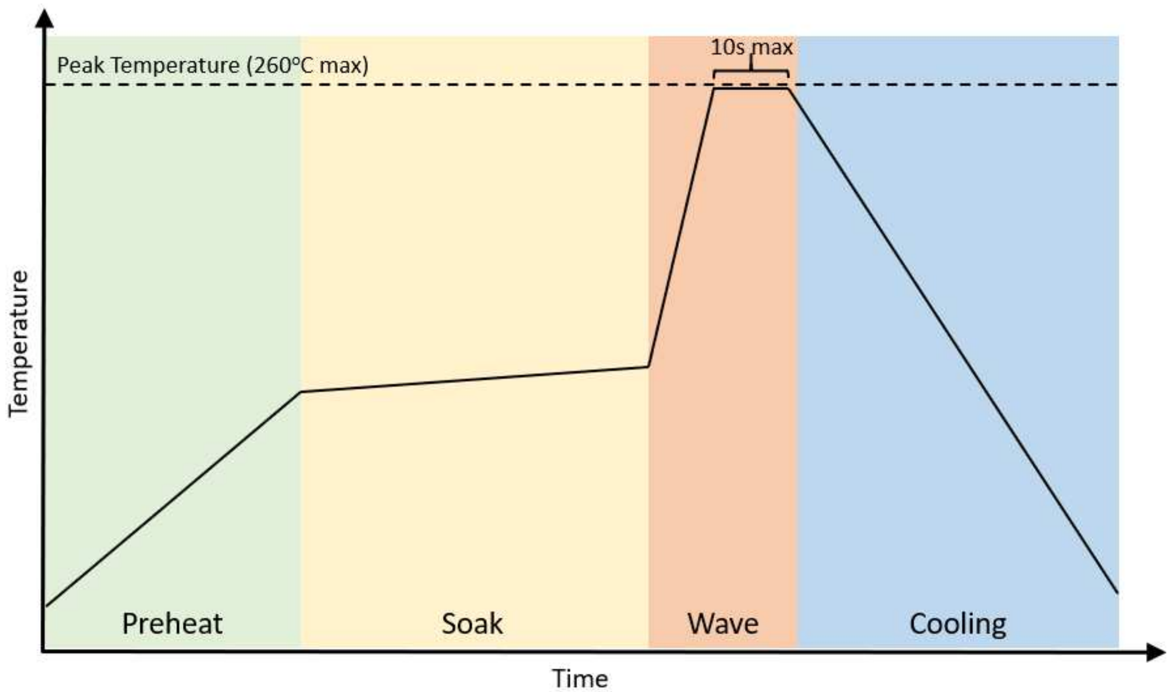


Figure 2: Typical wave soldering process for through-hole components

Many assemblies using through-hole devices have heatsinks attached to them for proper cooling in the application. Depending on the assembly, these heatsinks may be mounted to the devices before or after the devices are soldered to the board. Additional preheating time may be required if the heatsinks are attached before the soldering process to ensure good solder flow, especially on the drain pin of MOSFETs since the heatsink will tend to wick heat away from that pin and could result in a cold solder joint if not properly preheated. If the heatsinks are attached after the soldering process, care should be taken to avoid putting mechanical stress on the solder joints during the assembly process.

Proper pad design can also improve the solderability of through-hole devices. Thermal reliefs can improve solder wet-out into the joint for boards that have heavy copper weights or large copper pours attached to the device pins. Additionally, elliptical pad shapes can reduce the chance of solder bridging on packages with narrower pin spacing.

3. HAND SOLDERING

Hand or manual soldering Wolfspeed discrete devices is acceptable as long as the soldering temperature limits specified in the applicable datasheet are followed. Typically, this is a maximum lead temperature measured 1.6mm from the package body of 260°C for 10 seconds for both through-hole and surface-mount devices.

Due to the high-power nature of the PCB assembly, additional techniques may be required to solder, rework, or remove devices. A benchtop preheater can be used to locally heat the board in the area to be soldered in much the same way that pre-heating in the wave and reflow solder process is used. Once the joint is preheated, a high-power soldering iron can be used to complete the process without applying excessive heat to the part.

Figure 3: A benchtop PCB preheating tool

Additionally, for surface mount devices, a hot-air pen can be useful for applying additional heat to many pins simultaneously to help reflow or remove the part evenly.

Figure 4: Hot-air pen for manual soldering or rework

4. CLEANING

The flux used in soldering processes may leave a residue on the board or around the solder joints. If a "no-clean" flux is used, it generally does not need to be removed unless the application requires it. If cleaning is required, the process and cleaning agents should be based on the flux manufacturer's recommendations, and in consideration of all components and materials on the PCB assembly.

5. INSPECTION

After the soldering process, the quality of the solder joints can be assessed through visual inspection, automated optical inspection (AOI), or x-ray inspection for joints that are not visible externally. The IPC A-610 standard is widely used to assess the acceptability of all types of solder joints and should be used to verify the quality of the process.

6. LEAD TRIMMING

Through-hole devices are built with relatively long leads to allow for use in a variety of applications. In many instances, the leads will be longer than needed and must be trimmed, exposing the base metal in the leads. The solderability of the base copper is not as good as the finish plating on the leads as it will tend to oxidize quickly in air. Therefore, the exposed end of a trimmed lead should not be a part of the main solder joint. No guarantee is made for soldering over exposed copper core locations, and doing so is not required for joint integrity by standards including IPC J-STD-001 or IPC A-610.

7. SUMMARY

Following the soldering guidelines stated here in conjunction with the solder paste and flux manufacturer's recommendations will help the customer create robust solder connections and limit the risk of damaging components. This guideline is applicable to all Wolfspeed discrete power devices.

The soldering process is not an exact science. The information and profiles presented here should be used as guidelines and not as absolutes. Many factors, including the size of the PCB, copper weight, pad design, surrounding components, type and quality of soldering equipment, and application requirements, need to be considered when developing a PCB layout and soldering process.