APPLICATION NOTE PRD-05652

MOUNTING RECOMMENDATIONS AND THERMAL MEASUREMENT FOR WOLFSPEED® SIC POWER DEVICES IN THROUGH-HOLE PACKAGES

INTRODUCTION

The trend of current power electronics systems is towards high efficiency and high-power-density designs. Silicon Carbide (SiC) has a unique combination of critical electric field and electron velocity, enabling low on-state resistance at the device level. Compared to its Silicon-based counterpart, SiC MOSFETs have a smaller capacitance and much better reverse recovery on the body diode, resulting in low switching losses. The low on-state resistance and low switching losses provided by Silicon Carbide enables higher power density and higher switching frequencies in a wide variety of power electronics applications. High-power-density systems impose new challenges towards the thermal management of SiC power devices, the basics of which will be covered in this application note.

The mounting method of Wolfspeed® through-hole device (THD) packages can have a significant impact on the overall performance of the device and should be performed following the guidelines in this document. Thermal performance, mechanical reliability, and electrical isolation are a few of the factors that can be affected by the mounting method used to attach the device to the PCB assembly and heat sink. This application note will detail the recommended lead bending and mounting procedures for Wolfspeed Silicon Carbide (SiC) through-hole devices, along with typical thermal measurement and management techniques for proper device functionality.

CONTENTS

1. PACKAGE DESCRIPTION

Through-hole device packages have long, straight leads that are placed into drilled holes on a PCB and soldered, often by wave soldering, into place. This differs from surface-mount device (SMD) packages, which are mounted directly to one side of the PCB. Depending on the application, the leads of a THD package can be carefully bent to various angles prior to soldering to allow better fit into the assembly or to provide increased lead spacing on the PCB. Figure 1 below shows various types of Wolfspeed power through-hole packages:

Figure 1: Through-Hole Package Examples

To aid in the dissipation of heat from the device, an additional heat sink can be attached to the package body or can be shared by multiple devices. Depending on the application, the heatsink can be applied to the package before or after the lead soldering has occurred. Please refer to section 4 of this application note for heat sink mounting recommendations.

2. THERMAL RELATED PARAMETERS IN THE DATASHEET

To create a proper thermal design, we first need to understand the datasheet of the device. Here, we use the datasheet of a 1200V 40mohm SiC MOSFET, C3M0040120D, as an example to introduce the key parameters:

A. JUNCTION TEMPERATURE

T_J , T_{stg}	Operating Junction and Storage Temperature	-40 to +175	°C

Table 1: Junction Temperature (T_J) and Storage Temperature (T_{stg}) [1]

Table 1 defines the maximum device junction temperature (T_J) and storage temperature (T_{stg}) of the through-hole package. In other words, operation is not guaranteed below -40°C or over 175 °C. If the temperature range is exceeded, this may cause permanent damage to the device.

B. THERMAL RESISTANCE

Thermal Characteristics

Symbol	Parameter	Typ.	Unit	Test Conditions	Note
$R_{\theta JC}$	Thermal Resistance from Junction to Case	0.46	°C/W		Fig. 21
$R_{\theta JA}$	Thermal Resistance From Junction to Ambient	40			

Table 2: Thermal Characteristics [1]

$R_{\theta JC}$ (R_θ junction – case) is the thermal resistance from the junction to the case of the package and is a very important parameter for junction temperature evaluation. Junction refers to the semiconductor die of the device and case refers to the copper lead frame of the device. The thermal dissipation path of the heat generated by the device is shown in Figure 2 below. $R_{\theta JA}$ is the thermal resistance from junction to ambient when there is no heat sink equipped for the device and is usually much higher than $R_{\theta JC}$. In high-power applications with a heat sink, $R_{\theta JC}$ can be used in conjunction with the heat sink temperature or heat sink thermal impedance and power dissipation for engineering a calculation of the junction temperature.

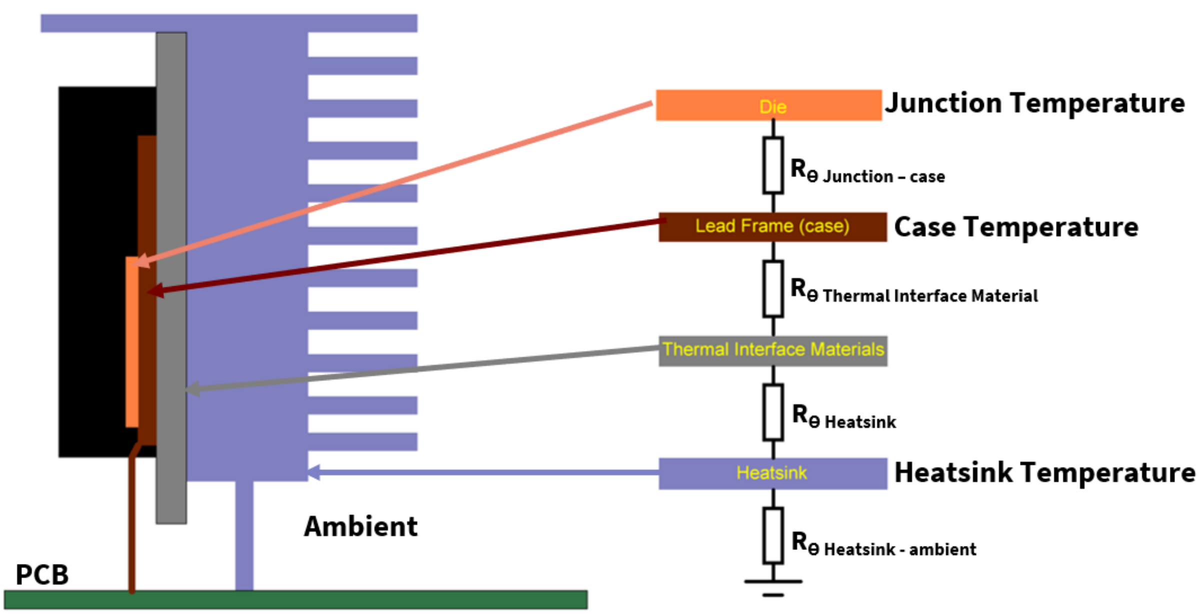

Figure 2: Thermal Path of a TO-247 Device

The transient thermal impedance from junction to case from the C3M0040120D datasheet is shown in Figure 3. This plot includes the transient thermal impedance for different duty cycles as indicated by the label on each curve. The pulse duration is indicated at the X-axis, and the junction to case thermal resistance is shown at the Y-axis. This plot shows that for very short pulses, the thermal impedance is lower than the RθJC shown in the Thermal Characteristics table, which represents a steady-state value.

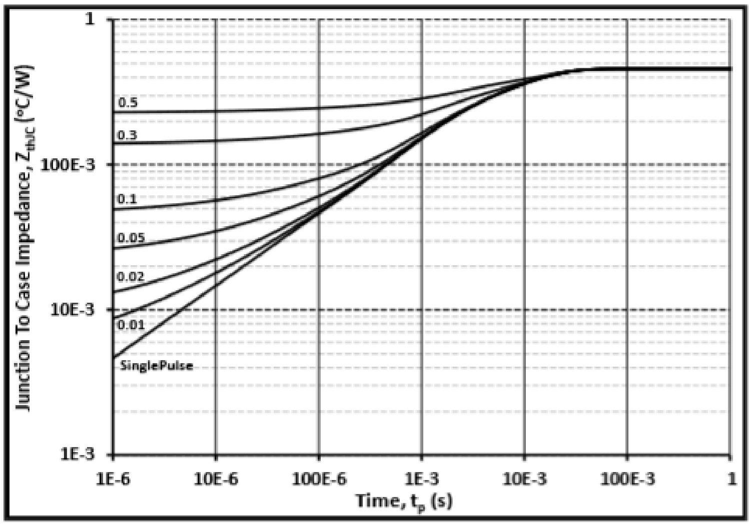

Figure 3: The Transient Thermal Resistance from Junction to Case of C3M0040120D [1]

3. LEAD CUTTING AND FORMING

Numerous manufacturing processes can be performed on the THD packages prior to soldering to the PCB to better fit the package into the assembly. These include lead cutting and lead bending, which must be performed carefully to avoid damage to the package or device itself. The following guidelines can be used for proper lead cutting and bending of THD devices:

Lead Cutting

Wolfspeed 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 either before or after mounting to the PCB. In fact, the electrical performance of the device is optimized when the leads are as short as possible because this will minimize the parasitic inductance between the PCB and the SiC die inside the package. When cutting the leads prior to mounting, leads should be clamped to limit any stress potentially transferring to the package body. Clamping methods should follow the same guidelines as presented in the next section “Lead Bending.” Careful consideration must be taken if lead cutting is being performed after the package is soldered to the PCB, so as to not damage the solder joint integrity from excess mechanical force. Generally, this excess force will not damage the component body.

Lead Bending

In some instances, the package leads must be bent when mounting the device to a heat sink surface that is not perpendicular to the PCB. When lead bending is necessary, these general guidelines should be followed:

- A suitable clamp on the leads between the package body and the bend is required to eliminate any mechanical stresses from being transferred to the package body.

- Clamping force should be enough to ensure no movement of the clamp on the lead during the bending process.

- Clamping force should not be excessive, which can cause lead deformation or weakening.

- The clamp must not contact the body of the device under any circumstances during the bending process. This can transfer stress into the mold compound and result in damage to the part.

- The minimum recommended spacing between the body and the clamp is 0.5mm, however it is recommended to perform the bend after the narrowing of the lead (seating plane).

- Bending the leads at the package is never advisable. A clamp must always be used on the leads.

- Bending leads laterally (parallel to the body plane) is never advisable.

- Leads may be bent a maximum of 90° up or down. Do not unbend or repetitively bend the same location as this may result in weakening the lead.

- If the package being used has mold compound extending onto package leads, the 0.5mm spacing should still be held between the end of the mold compound and the clamp location

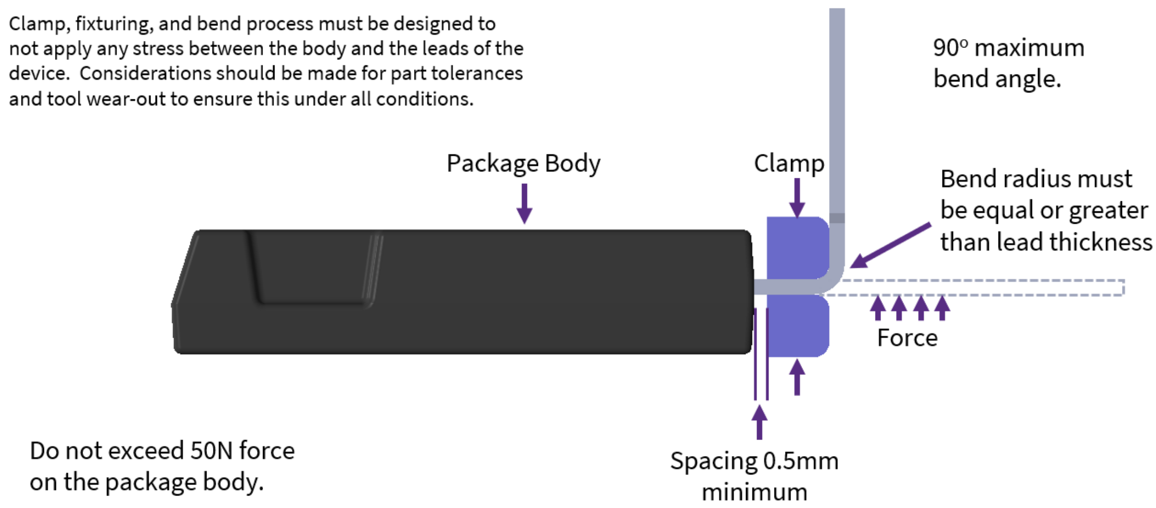

Figure 4: Clamping Requirements for Lead Bending

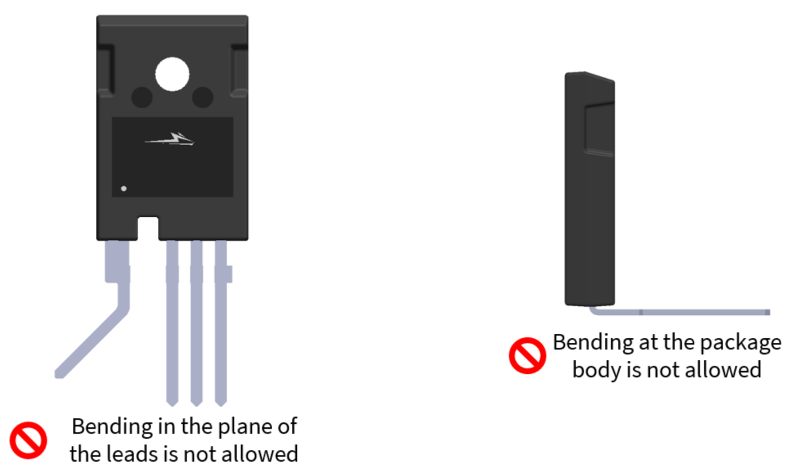

Figure 5: Poor Lead Bending Examples

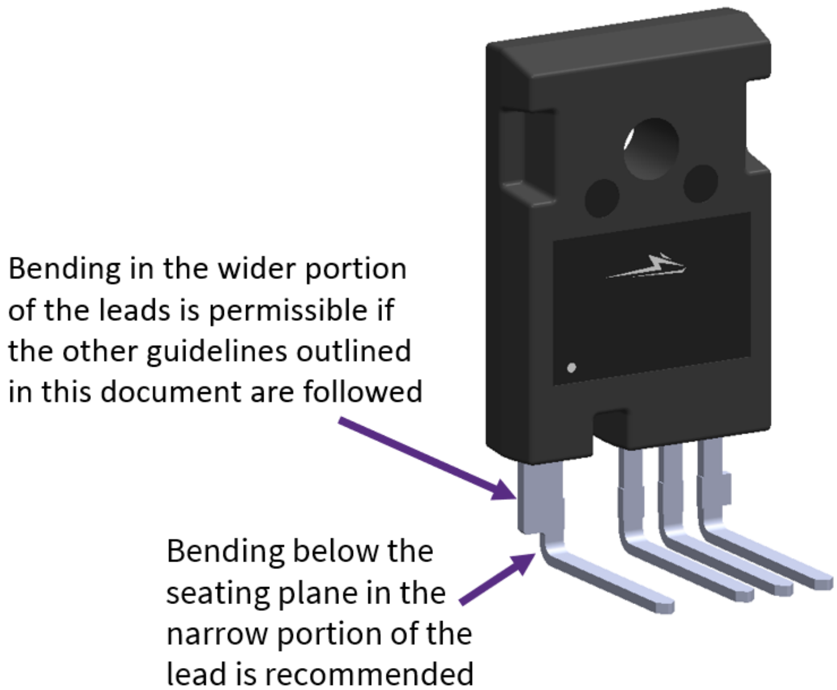

Figure 6: Recommended Bending Position

These lead bending guidelines must be followed to avoid damage to the device. The lead bending and cutting procedure should be qualified and tested to ensure the process is repeatable and does not damage the device or leads

4. MOUNTING OF TO-247 PACKAGES

Many different factors contribute to the assembly quality of a THD package, including:

- Hardware
- Thermal interface materials
- Heat sink and PCB quality
- Insulating material (if necessary)
- Mounting torque
- Soldering method

Any of these individual factors can cause less than ideal performance in an assembly if attention to detail is not prioritized. THD parts are typically inserted into the PCB with automated placement equipment or manually by a technician. Avoiding any damage or additional bending to the leads is critical during this step of the assembly process. Appropriate design of the PCB is needed to account for any tolerances in the package leads, including lead diameter and pitch and the properties of the solder being used. For more details about the recommended soldering process please see PRD-05653 “Soldering Recommendations for Wolfspeed Power Devices.”

Heatsink Mounting

Through-hole packages are typically attached to a heat sink to improve the thermal performance of the device using either a screw, clip, or pressure bar depending on the application. The first method of attachment is using a screw through the hole in the middle of the package body. A basic diagram of this setup can be seen below:

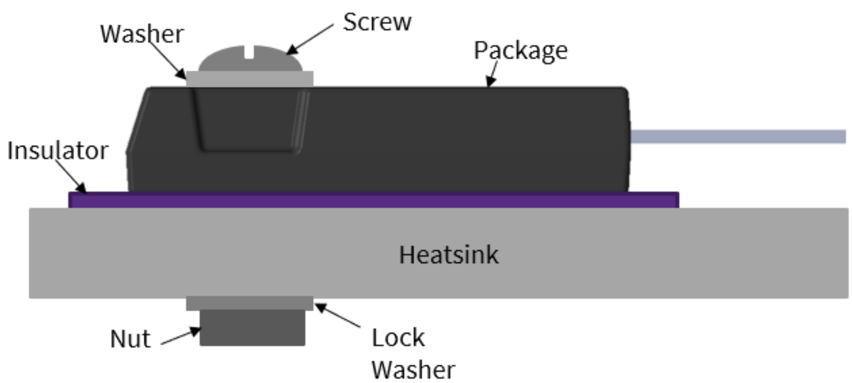

Figure 7: Screw Mounting of a Through-Hole Package

It is recommended that a washer is used between the screw head and the package body to distribute the clamping force and prevent damage to the package body. A compression washer and nut are also recommended for use, although a tapped heatsink is acceptable. In the case of a tapped hole in the heat sink, a compression washer should be added between the screw head and the flat washer. The compression washer should be designed and tested to maintain consistent clamping force between the package and heat sink over time accounting for any thermal cycling and vibration that may occur in the application.

For the best thermal performance possible, adequate and consistent contact pressure between the package and heat sink is critical to minimize contact resistance. Proper torqueing of the screw will lead to the desired contact between the two surfaces, but care must be taken not to over-torque. Over-torqueing can damage the package body and deform the isolation foil, which can cause tilting of the package and reduced thermal performance. In general, Wolfspeed recommends a screw torque of 0.7Nm for through-hole packages with a maximum torque of 1Nm. The process and tools used to torque the screws should be accurate and repeatable to prevent damage. Self-tapping screws can have inconsistent clamping forces and should not be used for these applications. The design of the heat sink and insulation are also important and should be as flat and clean as possible to allow for good thermal contact. For best results, the heat sink should be manufactured with the following characteristics:

- Surface roughness of 10µm
- Flatness of less than 20µm per 100mm
- Machined using proper tools and quality control methods
- Assembled in a clean environment

One disadvantage of the screw-mounting method is the reduced electrical creepage distance from the back tab of the device to the heat sink through the screw. This often limits the application of a screw mount to lower-voltage applications.

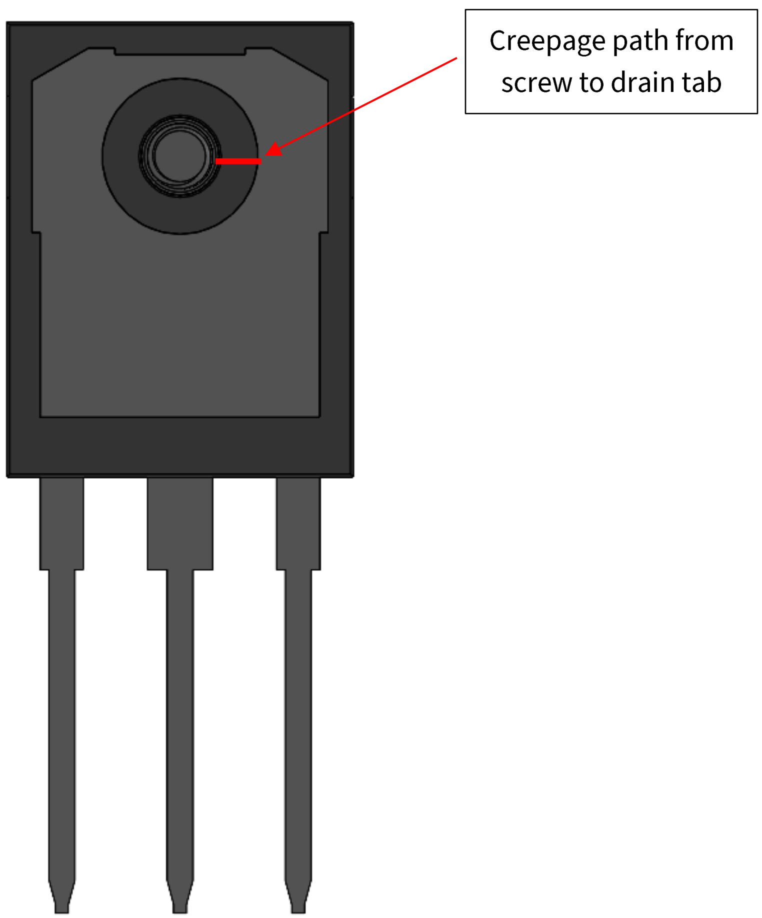

Figure 8. Creepage on Screw Mounting TO-247

Spring clips can also be used to mount through-hole packages to the heat sink. This attachment method has become popular due to its straightforward and reliable assembly which is suitable for mass production. Two basic diagrams of popular clip mounting designs can be seen below, a retaining clip and a Maxclip style:

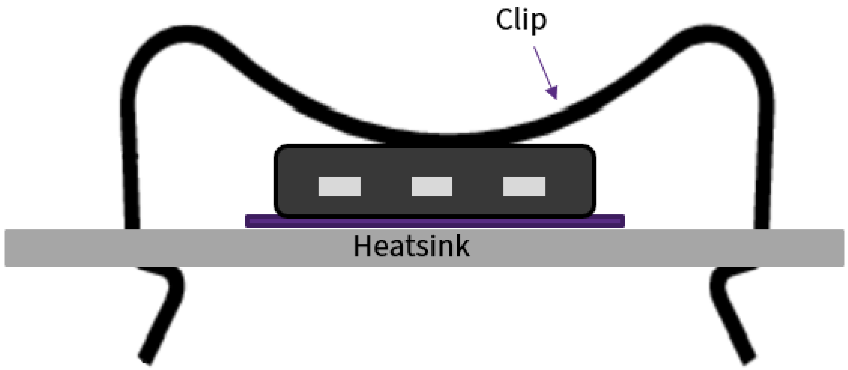

Figure 9: Retaining Style Spring Clip

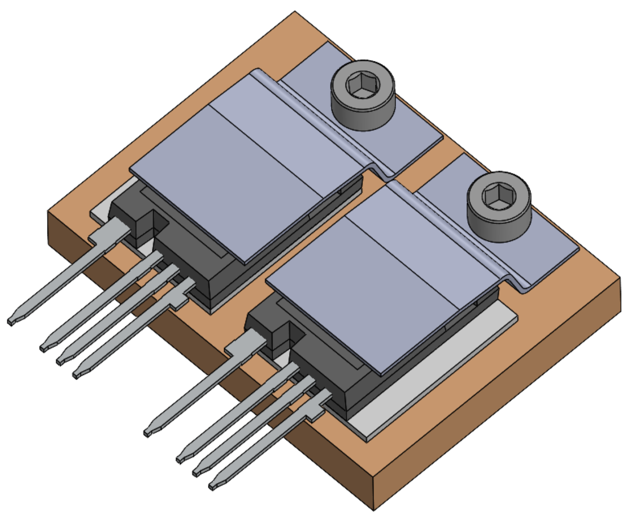

Figure 10. Maxclip Style Spring Clip

Clip mounting provides a uniform contact pressure across the package body, which reduces the chances of the package tilting and mitigates the concern for over- or under-tightening. When using a clip to mount the package to the heat sink, a 15N minimum clamping force is suggested to provide adequate thermal contact with a maximum pressure of 150 N/mm^2. The clips used should be rounded with a smooth finish where it contacts the package to reduce concentrated loads. Adequate contact on the package is important to prevent potentially damaging or cracking the mold compound. The contact area for the clip should be located between the screw hole and the bottom of the package where the leads exit. This will provide the maximum clamping force in the area where the die is located in the package. Numerous clip solutions are available for use to mount a through-hole package to a heat sink, including saddle clips, U clips, heat sink anchored clips, and clips with a screw.

Pressure bars are another common mounting method used on through-hole packages in the power industry. A pressure bar sits across numerous packages and applies equal pressure to each package by way of screws through the bars into the heatsink. The metal bar must be designed to be flat and have little to no bow in order to prevent unequal pressure distribution among packages and to reduce stress on package edges. Failure to do this may result in increased thermal contact resistance or damaged package molding. A basic diagram of a pressure bar setup can be seen in Figure 11 below:

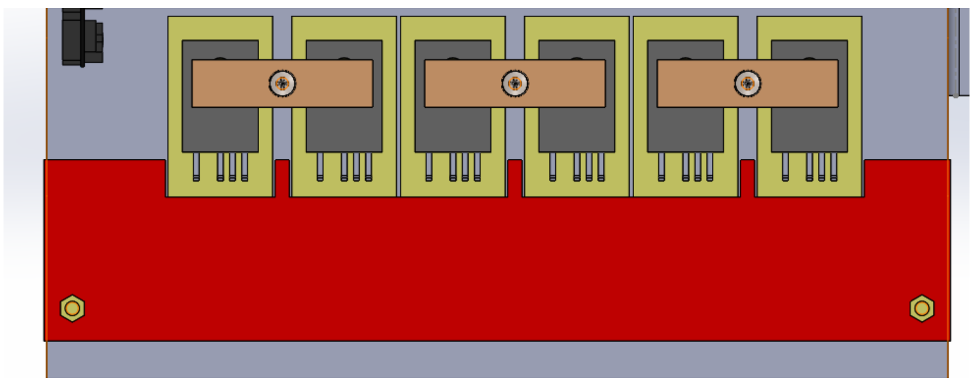

Figure 11: Heat Sink/Baseplate Assembly with Insulator and Pressure Bars.

Isolation is another factor that should be considered in the heat sink assembly design. For many applications with 650V devices where only functional isolation is required, mounting the device to the heat sink with a screw and shoulder washer is a cost-effective solution. Figure 12 shows a typical assembly using this method:

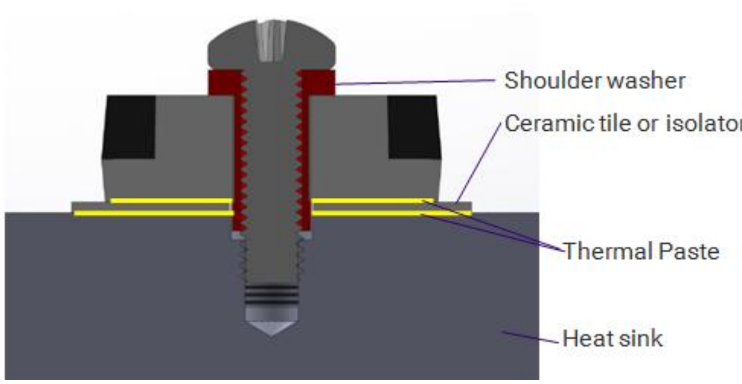

Figure 12: Cross Section Mounting View with the Insulating Shoulder Washer.

With 1200V or higher devices, a clip or pressing bar solution is more cost-effective since the screw mounting often cannot meet the requirement for creepage.

For applications requiring basic safety isolation, an isolating thermal interface material needs to be used between the package and the heat sink. The TIM material should extend beyond the package, exposed drain ears, and leads a enough to meet the minimum creepage per the applicable safety requirement for the system and account for the maximum assembly tolerance in manufacturing. Typically, a distance greater than 4mm is required for 800V systems.

5. THERMAL MANAGEMENT TECHNIQUES

This section of the document discusses mounting and isolation methods in general. It is the customer's responsibility to ensure that the design conforms to all required isolation, safety, and mechanical standards or practices for their application.

There are two general ways to design the heat sink into a system with SiC through-hole devices. The first method is to have the heat sink either electrically floating or connected to one of the high-voltage rails (usually -BUS) in the system. In this case, only functional isolation is required for the heat sink assembly. The second method is to ground the heat sink to protected earth (PE) or chassis in the system. In this case, the requirements of the isolation between device and cooling plate will be driven by the safety standard requirements, such as IEC-60664-1, which may require basic or reinforced isolation.

The difference between functional isolation and safety isolation is that safety isolation has clear requirements for creepage and clearance, while functional isolation has no formal third-party requirements in most applications.

In many cases, isolation will be required between the power device and heat sink, since the mounting surface of the THD package is connected to the drain terminal for a MOSFET, or the cathode for a Schottky diode. Adding isolation will increase the thermal resistance of the case-to-heat sink interface, so it is important to understand the different thermal interface materials and mounting methods available to find the optimal solution for each design. Without proper thermal management, the design may require a lower $R_{DS(on)}$ MOSFET (or higher I_F diode) to reduce the power loss and junction-to-case thermal resistance in order to meet the thermal requirements, potentially resulting in higher system cost.

As shown back in Figure 2, the actual junction temperature is not only related to the power loss and the junction-to-case thermal resistance of the device, but it is also related to the case-to-heat sink thermal resistance and temperature of the heat sink.

The case-to-heat sink thermal resistance depends on the area of the drain tab of the devices, the thermal interface material (TIM) selection, and the mechanical pressure to mount the device on the heat sink. There are numerous isolating TIM materials available, including silicone rubber [2], ceramic pads (Aluminum Oxide or Aluminum Nitride Ceramic) [3], and Kapton® tape coated with a phase change or grease material – among others.

Ceramic pads generally have better thermal conductivity than the other solutions, even though they tend to be significantly thicker than the other options. The thermal resistance of ceramic pads is lower due to the material's much higher thermal conductivity. When using a ceramic pad, both sides of the pad need to have thermal grease applied to provide a good interface between the device and heat sink. For a TO-247 package, the case-to-heat sink thermal resistance can be 0.2~0.5 K/W, depending on which ceramic material is used, the thermal grease, and the flatness of the heat sink. With a typical 1mm thickness, the parasitic capacitance from the drain to the heat sink is also much smaller compared to thermal pads, which will reduce common mode noise coupling. Ceramic pads are brittle and require careful handling and assembly to avoid cracking. Ceramic pads are well suited for high-power applications where the requirements for thermal performance and EMI are very demanding. Flexible pads are better suited for lower power ratings, large sizes, or complex mechanical structures due to their flexibility. Figure 13 shows the thermal resistance of different isolating thermal pads from Bergquist with different pressure on a TO-220 power device [2].

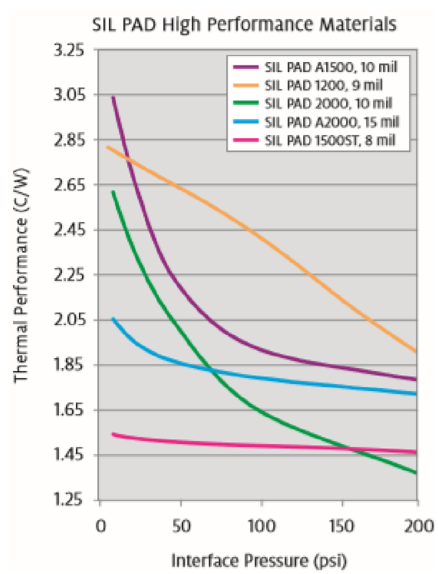

Figure 13: Thermal Resistance of Different Sil-Pad® Insulators with Different Pressure.

Table 3 shows the thermal resistance, breakdown voltage, and temperature range of some Sil-Pad® insulators from Bergquist [2]. Sil-Pad® 1500ST is the best-in-class thermal material to meet basic isolation. AlN and Al_2O_3

are the most common ceramic pad materials. The thermal conductivity of AlN is approximately 170W/m·K, and for Al_2O_3 it is 25 W/m·K.

	SIL PAD 1500ST	SIL PAD 2000	SIL PAD A2000	SIL PAD K-4	SIL PAD K-6	SIL PAD K-10
COLOR	BLUE	WHITE	WHITE	GREY	BLUE-GREEN	BEIGE
Thickness (in./mm)	.008 ± .001 (.20 ± .025)	.010 ± .001 (.25 ± .025)	.015 ± .001 (.38 ± .025)	.006 ± .001 (.15 ± .025)	.006 ± .001 (.15 ± .025)	.006 ± .001 (.15 ± .025)
Thermal Performance TO-220 Test @ 50 psi °C/W	1.51	2.02	1.86	3.13	2.76	2.01
Thermal Impedance (°C-in.^{2}/W)	0.23	0.33	0.32	0.62	0.64	0.41
Thermal Conductivity (W/m-K nominal)	1.8	3.5	3.0	0.9	1.1	1.3
Voltage Breakdown (Vac.)	3,000	4,000	4,000	6,000	6,000	6,000
Continuous Use Temperature (°C)	-60 to 180	-60 to 200	-60 to 200	-60 to 180	-60 to 180	-60 to 180
Construction	Silicone/ Fiberglass	Silicone/ Fiberglass	Silicone/ Fiberglass	Silicone/Film	Silicone/Film	Silicone/Film

Table 3: Thermal Resistance, Isolation and Temperature Range of Different Sil-Pad® Insulators

When analyzing the thermal requirements of a system, it is important to consider all tradeoffs in order to optimize the system. Selecting a smaller heat sink or fan may save cost on those components, but it could result in the design requiring a lower $R_{DS(on)}$ MOSFET (or higher I_F diode), or a better thermal interface material in order to meet the design targets, which will add cost. An optimized design seeks to minimize the total cost by looking at several different thermal solutions.

6. THERMAL MEASUREMENT OF DISCRETE SIC DEVICES

For semiconductor devices, the junction temperature is one of the key parameters to be evaluated in the qualification procedure. However, since the die is protected by the device package, normally the junction is not accessible for a direct thermal measurement. As an alternative, case-temperature (T_C)-based junction temperature estimation is a reasonable approach and is shown in Equation 1 below. Power dissipation (P_D) in the device is required in the calculation and must be calculated or measured separately. This method is commonly adopted in engineering practice.

$$T_J = T_C + P_D * R_{\theta JC} \quad (1)$$

Equation 1: Estimating junction temperature using case temperature

Normally, the case of a power device (See Figure 2) is attached to a heat sink and is not accessible for a direct thermal measurement. Therefore, an alternative measurement position is needed for the case temperature. Alternative measurement locations were identified through testing, which is described below.

As shown in Figure 14, some alternative points can be considered for case temperature measurement. The drain "ear" is part of the lead frame, so it can be representative of case temperature. The mold compound is very thin at the left or right side of the package, making it very close to the lead frame so it can also be considered as a testing point. The other two options that were investigated are a point in the center of the TO-247 package face and the drain lead at the point where it emerges from the package body.

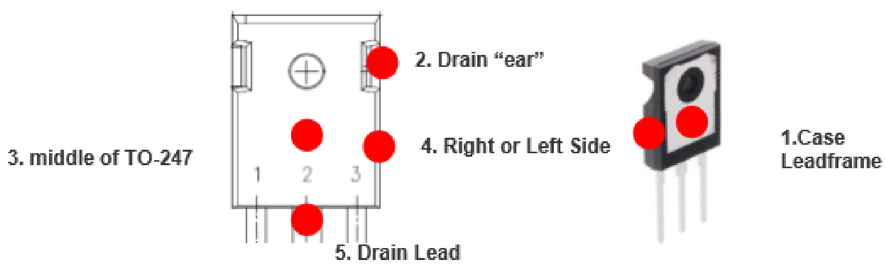

Figure 14: Possible Thermal Measurement Points for TO-247 SiC Devices

A special setup was designed to identify the relationship between the temperature of alternative points and the junction temperature. The schematic of the setup is as shown in Figure 15.

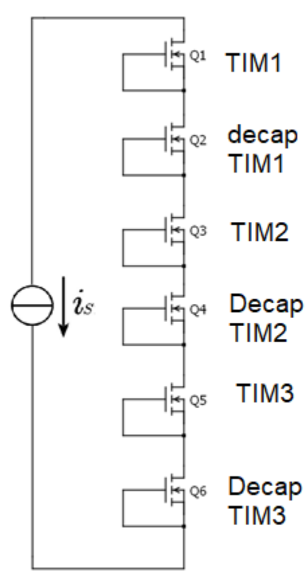

Figure 15: Schematics of the Thermal Setup for Wolfspeed® THD SiC Packages

The actual setup for thermal measurement of Wolfspeed THD Silicon Carbide packages is shown in Figure 16. Here, six packages of C3M0065090D SiC MOSFETs were connected in series and mounted to a large heat sink. The gate of each device was short-circuited to its source to make sure the channels were off. As shown in Figure 16, three different thermal interface materials (TIM) were used in the test. Q1 and Q2 were equipped with Sil-Pad® 2000 from The Bergquist Company, Q3 and Q4 were equipped with 1mm AlN ceramic TIM, and Q5 and Q6 were equipped with Sil-Pad® 1500ST from Bergquist. To expose the die for thermal measurement, partial-decapped devices were used for Q2, Q4 and Q6. Decapped parts have the mold compound removed to expose the die and lead frame. In this case, only a portion of the mold compound was removed to allow for thermal imaging of the die, but still maintain a surface for clamping the package to the heat sink.

A constant DC current of 9.24A was applied to the devices through the body diode. The power loss on each device is the result of the voltage drop of the body diode and the source current. In this test, all devices have exactly the same source current and similar voltage drops, resulting in measured power loss on the devices being very similar. As shown in Figure 17, the drain ear, middle of molding compound, side of molding compound, drain lead, the die (for the decapped devices) and the heat sink (close to each DUT) are painted in black before conducting the test to enable infrared thermal measurements on the different surfaces.

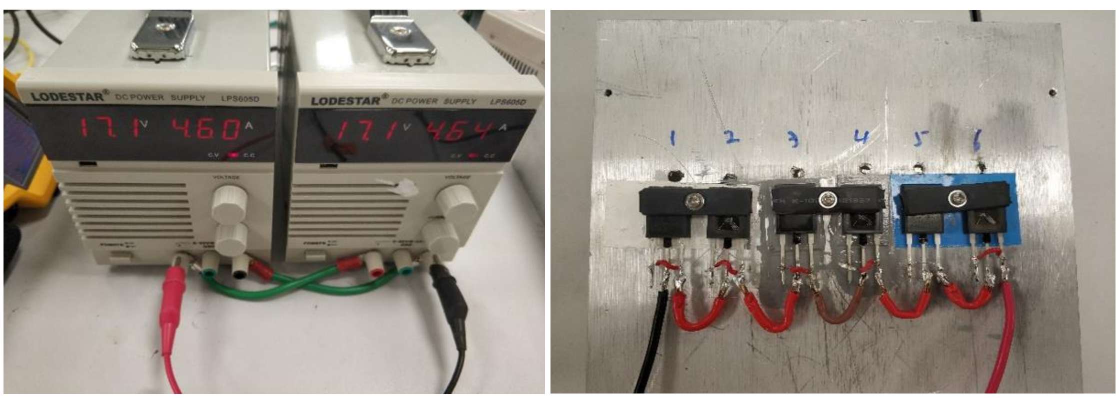

Figure 16: Actual Setup for Thermal Measurement of Wolfspeed® TO-247 SiC Devices

The first portion of the test was to simulate convection cooled situations in outdoor applications, with no air flow at all applied to the heat sink and devices. The temperature of the heat sink, drain ear, middle of molding compound, side of molding compound, drain lead and T_J (for the decapped devices) were measured with a thermal camera. Figure 18 shows the measurement of T_J directly using a thermal camera. The voltage drops on each device were also recorded to allow for calculating the actual power loss in each device. Table 4 on the next page shows the results of this test. The drain lead has a slightly lower temperature than drain ear, while the middle and side of the package have higher temperatures.

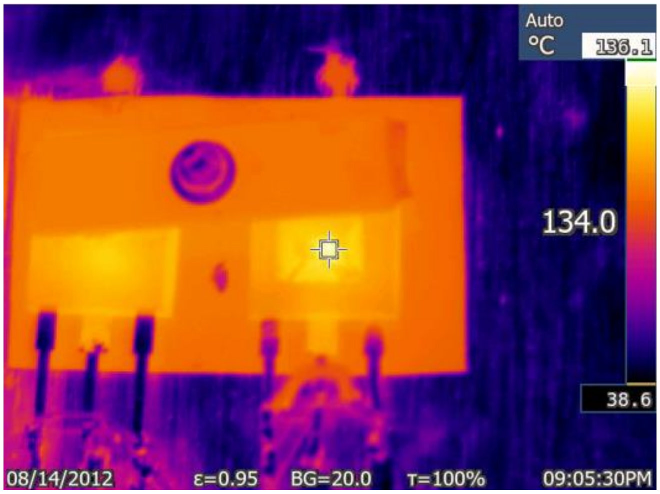

Figure 17: Thermal Measurement of Wolfspeed® TO-247 SiC Devices

Description	Q1	Q2 Decap	Q3	Q4 Decap	Q5	Q6 Decap
TIM	Sil-Pad® 2000		AlN 1mm		Sil-Pad® 1500ST	
Drain Ear (°C)	114.6	115.5	102.6	102.7	110	109.4
Middle of package (°C)	121.1	--	108	--	116.8	--
Right side of package (°C)	118.2	119.5	106.2	107.4	112.9	113.9
Drain Lead (°C)	112	113.4	99.5	101.5	107.6	107.1
Die Temperature T_J (°C)	--	140	--	127.2	--	134
Heatsink (°C)	88.5	89.1	91.6	91.8	91.4	91.1
Power loss on the device (W)	27.07	26.31	26.48	26.21	25.87	26.80
Heatsink to Drain Ear (case) Rise(°C)	26.1	26.4	11	10.9	18.6	18.3
Junction to Case Rise(°C)	--	24.5	--	24.5	--	24.6
TIM Thermal resistance(°C/W)	0.964	1.004	0.415	0.416	0.719	0.683
Measured Junction to Case Thermal Resistance (°C/W)	--	0.931	--	0.935	--	0.918

Table 4: Thermal Test Results on Wolfspeed® C3M0065090D TO-247 SiC Devices with Different TIM

Table 5 shows the resulting estimated junction temperature using each of the possible measurement points on Q3 and the $R_{\theta JC}$ value (1C/W) from the datasheet according to Equation 1. The result is then compared to the measured T_J on Q4 (127.2°C), which should be very similar to Q3 T_J. These results show that the drain ear and the drain lead can be used to estimate T_J with good accuracy in this condition.

Description	Q3 Measured	TJ Calculated	T_J Estimation Error
Drain Ear (°C)	102.6	129.1	+1.9
Middle of package (°C)	108	134.5	+7.3
Right side of package (°C)	106.2	132.7	+5.5
Drain Lead (°C)	99.5	126	-1.2

Table 5: Using Various Package Temperatures to Estimate T_J

To simulate indoor applications with forced-air cooling, airflow was applied to the surface of devices with varying fan power to represent varying air flow speeds. Airflow over the top of the package can impact the temperature readings because there will be a larger temperature gradient between the die and the package in this scenario. For this test, only Q3 and Q4 were analyzed, and the results are shown in Table 6. The result is similar to the previous case without airflow as the temperature of the middle of the package, side of the package, and drain lead are close to drain ear measurement. However, the equivalent thermal resistance $R_{\theta JC}$ and the thermal resistance case-to-heatsink becomes smaller since more power dissipation has gone through the top-side molding compound and leads. If the datasheet $R_{\theta JC}$ is used to estimate T_J by applying Equation 1 under forced-air conditions, the estimated T_J will be higher than actual value.

Description	Q3 Decap	Q4	Q3 Decap	Q4	Q3 Decap	Q4
Air Flow	None		4W cooling fan		15W cooling fan	
TIM	AlN 1mm		AlN 1mm		AlN 1mm	
Drain Ear (°C)	102.6	102.7	72.2	72.5	58.8	59.9
Middle of package (°C)	108	--	75.1	--	61.2	--
Right side of package (°C)	106.2	107.4	73	74.1	59.4	60.4
Drain Lead (°C)	99.5	101.5	72.9	72.1	60.8	60.3
Die Temperature TJ (°C)	--	127.2	--	96.4	--	82.5
Heatsink (°C)	91.6	91.8	61.5	61.7	50.2	50.5
Power loss on the device (W)	26.482	26.205	26.24	25.96	26.15	25.87
Heatsink to Drain Ear (case) Rise(°C)	11	10.9	10.7	10.8	8.6	9.4
Junction to Case Rise(°C)	--	24.5	--	23.9	--	22.6
TIM Thermal resistance(°C/W)	0.415	0.416	0.408	0.416	0.329	0.363
Measured Junction to Case Thermal Resistance (°C/W)	--	0.935	--	0.920	--	0.874

Table 6: Thermal Test Results on Wolfspeed® TO-247 SiC Devices at Different Air Flow Conditions

Table 7 shows the error in TJ estimates for the 4W and 15W cooling fan scenarios. These results show that when there is airflow over the surface of the package, the resulting TJ estimate will be slightly higher since the effective thermal impedance of the device will be lower than what is stated in the datasheet.

Description	T_J Estimation Error	T_J Estimation Error
Fan Power	4W	15W
Drain Ear (°C)	+2.0	+2.4
Middle of package (°C)	+4.9	+4.8
Right side of package (°C)	+2.8	+3.1
Drain Lead (°C)	+2.7	+4.4

Table 7: Using Various Package Temperatures to Estimate T_J

Depending on how the device is mounted in the application, some parts of the package may be more accessible for thermal measurement. If the drain ear is not available, the center or side of the package, or the drain lead can be used to estimate case temperature. This test data shows that several points on the device package can be used to estimate the junction temperature of the device with reasonable accuracy when the devices are mounted to an air-cooled heat sink.

7. SUMMARY

Following the mounting guidelines stated here in conjunction with other assembly best practices, such as a proper thermal design and thermal measurement, will help the customer create a robust and effective assembly that optimizes system-level performance when utilizing Wolfspeed through-hole devices. Understanding how to properly measure case temperature and estimate junction temperature are critical for designing highly reliable systems. Developing a thermal solution requires careful consideration of the heat sink, TIM, grease and assembly of these components to keep the power device in a safe temperature range of operation. This guideline is applicable to all Wolfspeed THD discrete devices.

References

[1] Datasheet of C3M0040120D, www.wolfspeed.com

[2] Selection Guide Thermal Interface Materials from Bergquist

[3] Digikey, https://www.digikey.com/catalog/en/partgroup/aluminum-oxide-ceramic/51058

[4] Ref Design, “22kW Bi-directional High Efficiency DC/DC Converter”, https://www.wolfspeed.com/power/products/reference-designs/crd-22dd12n

Revision History

Date	Revision	Changes
Feb. 2022	1	First issue
May. 2023	2	Added Mounting Sections