APPLICATION NOTE

SiC E1B Modules Mounting Guideline

Scope

Qorvo has pioneered the introduction of SiC JFET based cascodes (SiC FET) with gate drive compatibility to Si MOSFETs, IGBTs, and SiC MOSFETs, based on the 5V threshold voltage and wide gate operating range of +/-25V. These devices are inherently very fast switching, with excellent body diode characteristics.

Qorvo has combined the advantageous SiC JFET based power device with an industry standard power module package, E1B, to further enhance power density, efficiency, cost-effectiveness, and ease of use for industrial power systems.

This application note introduces mounting guideline (PCB and heatsink) for Qorvo's latest E1B power module packages (half-bridge and full bridge).

IMPORTANT: Snubbers are strongly recommended for SiC E1B modules due to their intrinsic fast-switching speed. Also, snubber greatly reduces turn-off switching loss making SiC E1B modules extremely attractive in ZVS (zero voltage turn-on) soft-switching applications such as phase-shifted full-bridge (PSFB), LLC, etc.

This product is recommended for use with solder pin attach and phase change thermal interface materials, and not recommended for implementations using press fit and application of thermal grease. Please refer to mounting guidelines and user guide documents associated with this product for detailed information.

This application note also provides resource links to simulation models, assembly guidelines, thermal characteristics, reliability, and qualification documents.

Resource and reference

[1] SiC E1B Modules Technical Overview

[2] SiC E1B Modules Mounting Guideline

[3] SiC FET & Module User Guide

[4] SiC E1B Modules DPT EVB User Guide

[5] Qorvo SiC Module Link: SiC Modules - Qorvo

[6] Web based loss calculator for part selection: https://www.qorvo.com/design-hub/design-tools/interactive/fet-jet-calculator

[7] Qorvo SiC power solution central hub: https://www.qorvo.com/innovation/power-solutions/sic-power

[8] More design tips: https://www.qorvo.com/innovation/power-solutions/sic-power/sic-fet-design-tips

[9] Origins of SiC FETs and Their Evolution Towards the Perfect Switch

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E1B Module Information

The primary cause of power semiconductor module failure is improper mounting. Poor mounting will result in elevated or excessive junction temperature, which will significantly limit the module's operational lifetime. As a result, proper module installation is critical to achieving reliable heat transfer from SiC device junction to the cooling channel.

The E1B modules are designed to be soldered to a printed circuit board (PCB) and attached to a heatsink with pre-assembled screws and washers, as shown in **Figure 1** and **2**. More extensive information on dimensions and tolerances for designing hardware for these systems can be found in the module datasheets.

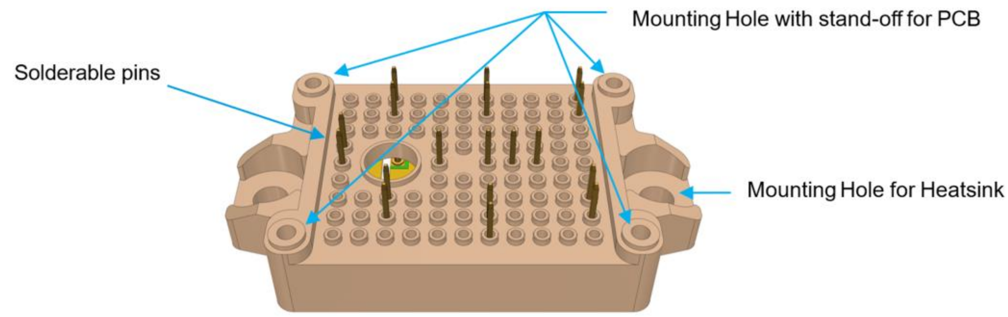


Figure 1. Module Mounting Screw Location (Top View).

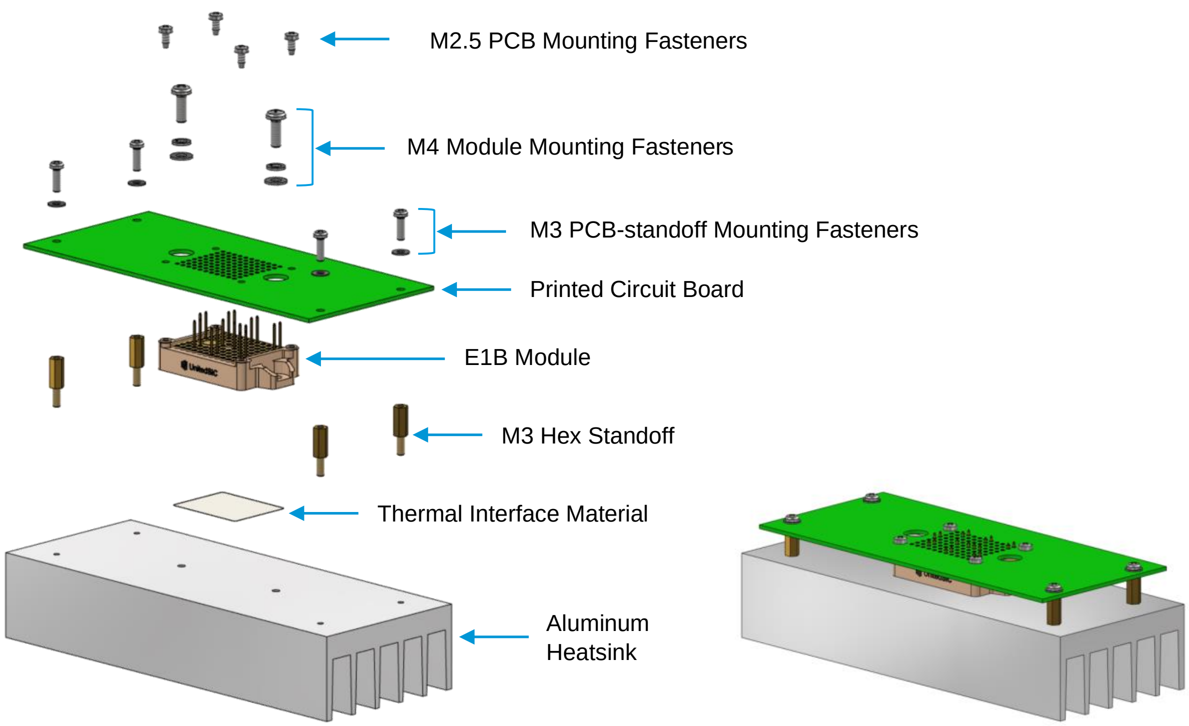


Figure 2. Module Mounting with PCB and heatsink (assembly exploded view).

Recommended Mounting Sequence

Qorvo recommends following mounting sequence for better thermal performance and lifetime of SiC E1B module:

1. Solder the module pin to the Printed Circuit Board (PCB)
2. Mount the PCB onto the module
3. Mount the module to the heat sink

With pre-assembled screw (combine screw, washer, and lock washer), fasten the module onto the heat sink using limiting torque. It should be noted that the size and surface of the heatsink must be considered throughout the soldering process, as proper heat transfer between the module backside and the heatsink interface is critical to the overall performance of a package in a system (see **Figure 2**).

1 Solder the module pin to PCB

The Solderable pins used on the E1B module have been checked and qualified by Qorvo for standard FR4 PCBs.

If the PCB requires a reflow soldering process for other components, it is recommended to reflow the PCB before mounting the module to avoid exposure to high temperatures.

A typical wave soldering profile is shown in **Figure 4** and **Table 1**.

If other handling techniques are used in the manufacture of printed circuit boards, additional testing, inspection, and certification is required.

PCB requirement

FR4 PCB with a maximum thickness of 2mm

Refer to IEC 61249-2-7:2002 to check if PCB material meets the standard requirements.

User to determine the optimum conductive layers for proper design of PCB stack layers but need to ensure multilayer PCBs follows IEC 60249-2-11 or IEC 60249-2-1

If the customer will consider a double-sided PCBs refer to IEC 60249-2-4 or IEC 60249-2-5

Solder pin requirement

Key factors for achieving solder joints with high reliability is the PCB design.

The plated-through hole diameters on the PCB must be manufactured according to the soldering pin dimension (see **Figure 3**).

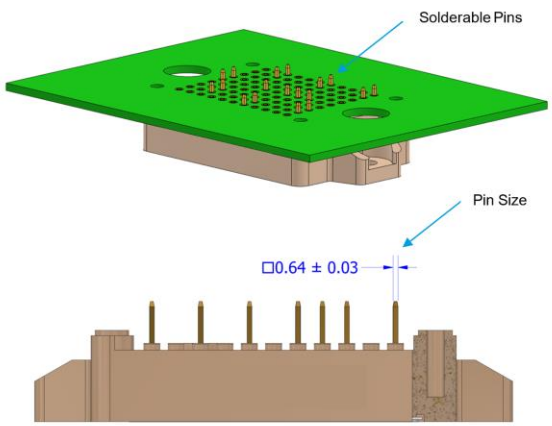


Figure 3. Module mounting to PCB prior mounting to a heat sink.

If the PCB hole design is not correct, potential problems can occur.

If the final hole diameter is too small, it may not be properly inserted and will cause the pins to break and damage the PCB.

If the final hole diameter is too large, it may not result in good mechanical and electrical performance after soldering.

Solder quality should refer to IPC-A-610.

The recommended parameters for wave soldering process temperature profiles are based on IPC-7530, IPC-9502, IEC 61760-1:2006.

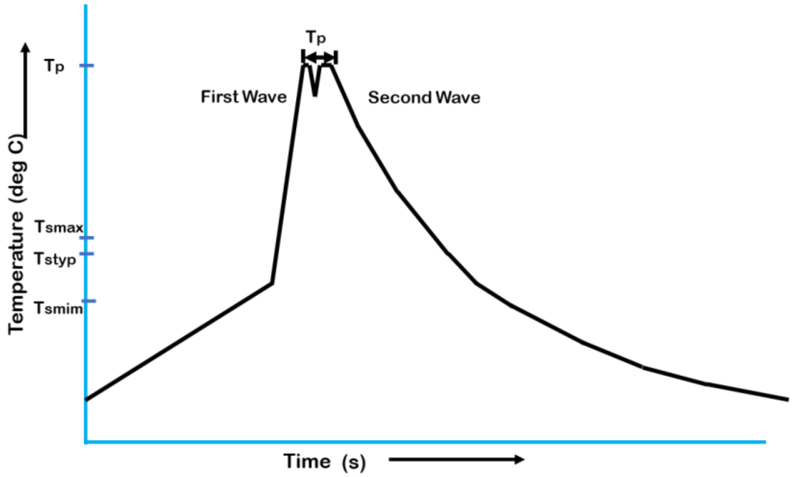


Figure 4. Typical wave soldering profile. (reference EN EN 61760-1:2006)

Profile Feature		Standard SnPb solder	Lead (Pb) free solder
Preheat	• Temperature min. (Tsmin)	100 °C	100 °C
	• Temperature typ. (Tstyp)	120 °C	120 °C
	• Temperature max. (Tsmax)	130 °C	130 °C
	• Temperature max. (Tsmax)	70 seconds	70 seconds
△ preheat to max Temperature		150 °C max.	150 °C max
D preheat to max Temperature		235 °C – 260 °C	250 °C – 260 °C
Time at peak temperature (tp		10 seconds max 5 seconds max each wave	10 seconds max 5 seconds max each wave
Ramp-down rate		~ 2 K/s min ~3.5 K/s typ ~5 K/s max	~ 2 K/s min ~3.5 K/s typ ~5 K/s max
Time 25°C to 25°C		4 minutes	4 minutes

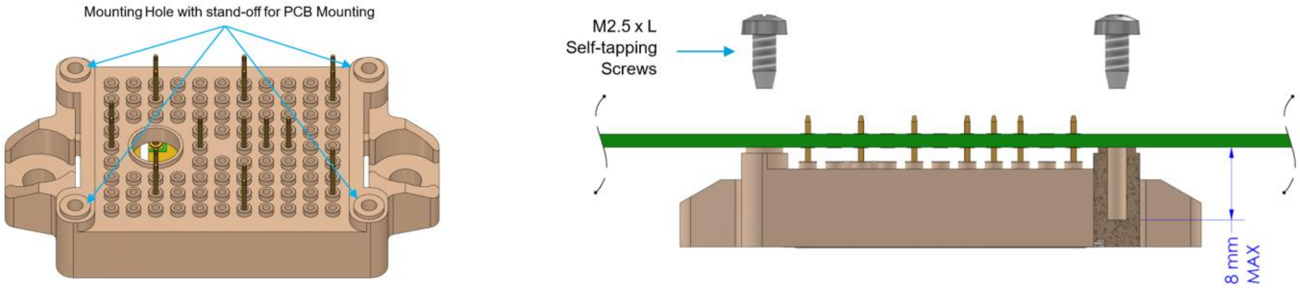
Table 1. Typical wave soldering profile. (reference EN EN 61760-1:2006)

2 Mounting PCB onto module

When the PCB is soldered directly on the top of the module, the mechanical stresses are present especially on the solder joint. To reduce these stresses, an additional screw can be utilized to fix the PCB into the four standoffs of the module, see **Figure 5**.

The modules are compatible with the self-tapping screws (M2.5 x L (mm)), depending on PCB thickness.

The length of the thread entering the standoff hole should have a minimum of Lmin 4mm and a maximum of Lmax 8mm. It is recommended to use an electronically controlled screwdriver or electric screwdriver to ensure better accuracy.



(a) (b)

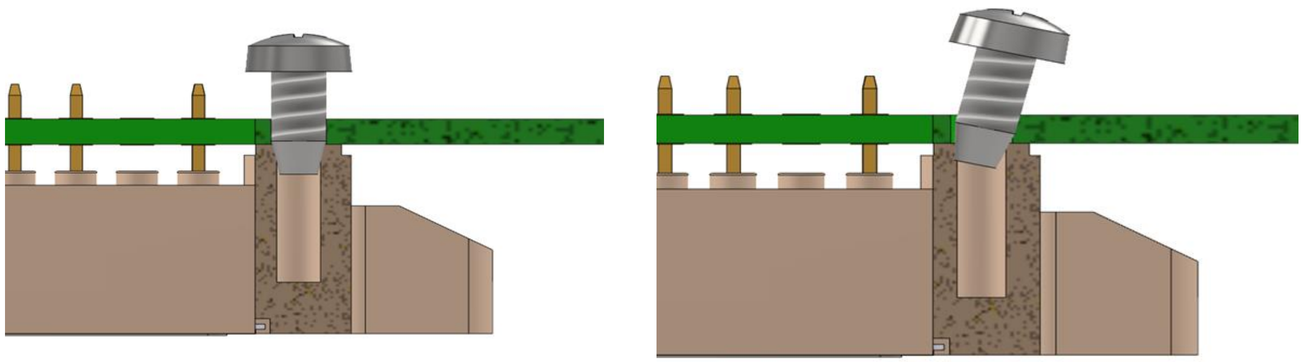
Figure 5. PCB mounting on E1B module (a) E1B PCB mounting hole with standoff, and (b) Maximum scre thread engagement depth.

PCB mounting requirement

The standoff holes depth of 1.5mm serves as a screw entry guide only and should not apply any force.

Key factor is the amount of torque allowed for the pre-tightening and tightening process:

- Pre-Tightening = 0.2~0.3 N.m
- Tightening = 0.5 N.m MAX



(a) (b)

Figure 6. PCB mounting on E1B module: vertical alignment of self-tapping screw (a) aligned, and (b) misaligned.

3 Mounting module to heatsink

Heatsink requirement

The surface condition of heatsink is a vital factor on the entire heat transfer system and must be in full contact with the heatsink. The module substrate surface and the heat sink surface must be uniform, clean, and free of contamination before mounting. This is to prevent voids, to minimize the thermal impedance and maximize the amount of power that can be dissipated within the module and attain the target thermal resistance based on datasheet. The heatsink' s surface qualities are required to attain a good thermal conductivity as per DIN 4768−1.

- Roughness (Rz): ≤10 um
- Flatness of the heatsink based on a length of 100 mm: ≤ 50 µm

Thermal interface material (TIM)

Thermal interface material used between module case and heatsink is key to achieve reliable and high-quality thermal performance. **Thermal grease or thermal paste is not recommended for a baseplate-less module like E1B**. Without a thick copper baseplate serving as a heat spreader, the thermal grease pump-out effect (by thermal expansion and contraction of TIM layer between module case and heatsink during power cycling or temperature cycling) can exacerbate non-uniformity of the TIM layer and can have significant negative impact on power cycling lifetime of the module.

Instead, **TIM using phase change material is strongly recommended for E1B modules**. **Figure 7** shows the power cycling results for the 1200V 100A half-bridge module (UHB100SC12E1BC3N) using two different methods, thermal grease versus phase change material. The horizontal axis shows the number of cycles. The vertical axis shows device VDS during Tj_rise at 100C. The red curve shows power cycling with thermal grease. The blue curve shows power cycling with phase change material. Despite identical mounting process, the grease mounted samples (red curve) survived only 12,000 cycles before thermal runaway due to thermal resistance degradation from thermal grease pump-out effect. For the same E1B module using phase change TIM material a significantly improved power cycling beyond 58,000 cycles without failure is demonstrated.

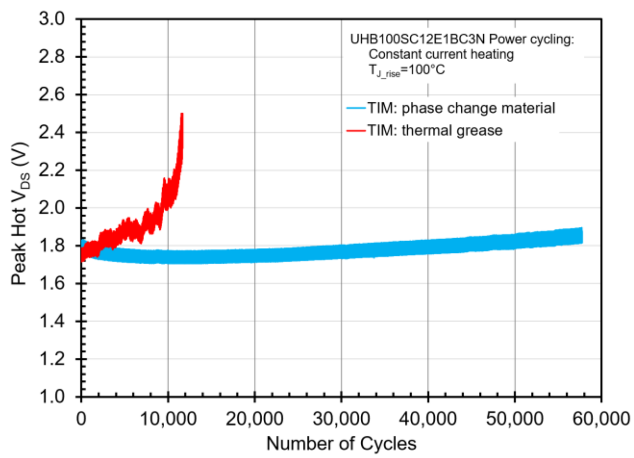
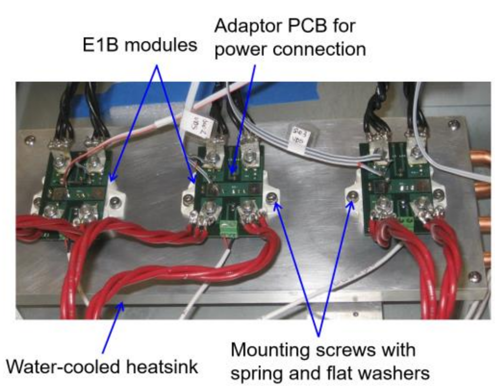


Figure 7. E1B module power cycling performance with different TIM for heatsink: thermal grease vs phase change material.

Figure 8 shows power cycling test conditions and setup.



(a)

Setup	Description
DUT	UHB100SC12E1BC3N
Heating method	Constant DC current
Tj rise	100 °C
Water cool heatsink temp	20 °C
Heating time per cycle	5 s
Cooling time per cycle	26 s
TIM (phase change)	Laird TPCM 7200

(b)

Figure 8. E1B module power cycling test (a) setup, and (b) test condtions.

Typically, after mechanical mounting, phase change material should be baked in oven to allow TIM to change its phase to further fill microscopic voids between module case and heatsink and reduce thermal resistance from module case to heatsink. In the above example shown in **Figure 7** and **Figure 8**, thermal resistance from device junction to water is reduced from 0.52 °C/W to 0.42 °C/W after 1 hour baking at 65 °C. Please consult TIM supplier for detailed instructions.

Note: Any different phase change material type should be evaluated and tested additionally by the customer by following instructions from a TIM (phase change material) vendor to ensure optimal performance.

Mounting module to heatsink

The mounting procedure is also an important factor to guarantee an effective contact of module and heatsink with phase change material in between. Note that heatsink and the module should not touch across the entire area to avoid a localized separation between the two components. **Table 2** summarizes mounting guidelines for heatsink attachment.

HEATSINK MOUNTING	DESCRIPTION
Screw size	M4
Screw type	DIN 7984 (ISO 14580) flat socket head
Depth of screw in heatsink	> 6 mm
Spring lock washer	DIN 128
Flat washer	DIN 433 (ISO 7092)
Mounting torque	0.8 N.m to 1.2 N.m
TIM	Phase change material, such as Laird Tpcm

Table 2. Qorvo SiC E1B module heatsink mounting recommendation.

Other mounting considerations

The overall assembly of the mounted module should be considered. If the module is properly attached to the heat sink and circuit board, the proper performance of the product will be achieved.

Appropriate measures must be taken to minimize vibration too since the PCB is soldered only to the module. Weak soldered terminals must be avoided. Individual pins can only be loaded perpendicular to the heat sink with maximum pressure, tension, and adequate distance between the PCB and heatsink needs to be evaluated by the customer's application.

To minimize the mechanical stress on the PCB and module, especially when the PCB has heavy component it is recommended to use space posts, see **Figure 9**.

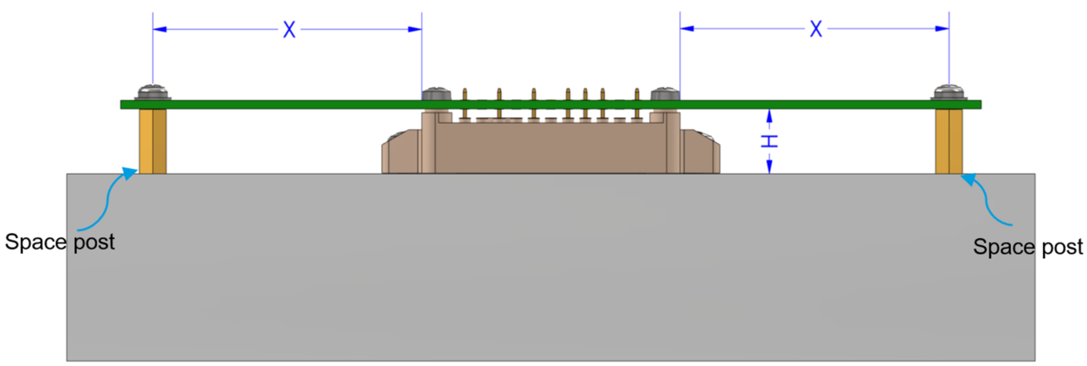


Figure 9. E1B module PCB and heatsink mounting with spce post.

The recommended dimension (X) between the space post and edge of the PCB mounting hole is ≤ 50 mm.

In case multiple modules are mounted on the same PCB, the height variation between modules can result in mechanical stresses on the solder joint. To minimize stress, the recommended height (H) of the space posts is 12.10 (±0.10) mm.

Clearance and creepage requirement

The mechanical spacing of the assembly between the module and PCB must meet the clearance and creepage distance required by IEC 60664-1 Revision 3. **Figure 10** shows the illustration.

The minimum clearance is the distance between the screw head and the bottom surface of the PCB must have adequate distance to prevent electrical conductivity in this area. Alternatively, additional insulation measures, such as PCB slot, coating or special potting may need to be implemented to meet appropriate clearance and creepage distance standards.

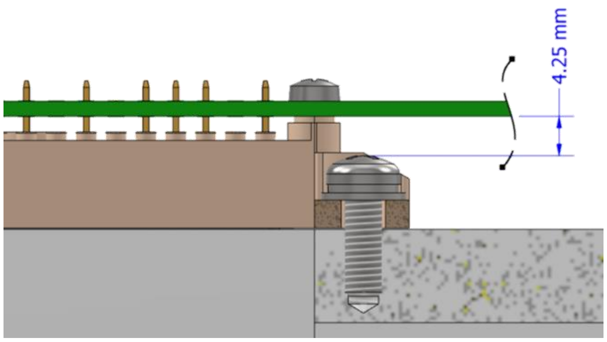


Figure 10. Clearance between screw and PCB.

The screw type determines the minimum clearance gap between it and the PCB. With a pan head screw in accordance with ISO7045, a lock washer in accordance with DIN 127B and flat washer DIN 125A, and the clamp that is shown in **Figure 10**, the distance will be 4.25 mm. Typical clearance and creepage is available in the datasheet. Further details on module clearance or creepage distance may contact the application support or sales and marketing.

Contact Information

For the latest specifications, additional product information, worldwide sales and distribution locations:

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Important Notice