User Guide **PRD-09002**

H-Module Mounting Guide

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This document provides guidance on how to install or mount the Wolfspeed® H power modules to a cold plate and how to design and construct the mechanical system in which the module will be placed. This document does not describe how to operate the system once these steps are taken.

Contents

CAUTION

Before operating the system, please carefully review the operating limits of Wolfspeed's H series Half-Bridge Modules set forth in the datasheet located at www.wolfspeed.com or available upon request, and please ensure that appropriate safety procedures are followed when working with the system. There can be very high voltages present in the system when connected to an electrical source (and thereafter until applicable capacitors are fully discharged), and some components in the system can reach very high temperatures. Serious injury, including death by electrocution or serious injury by electrical shock or electrical burns, can occur if you do not operate the module within its operating limits or follow proper safety precautions.

1. Introduction

This document provides guidance on how to properly mount Wolfspeed® H power modules and design a system that maximizes its performance and reliability. When mounted, the power module must be securely held in place, while not exceeding the baseplate mounting hole and power terminals force ratings. Similarly, the module's gate driver should be firmly attached to a rigid surface to ensure that it remains in place, while not placing excessive force on the signal pins of the power module it is attached to. Furthermore, the bussing attached to the power module must not induce excessive stress on the module's power terminals. Following the guidance described in this document is recommended to ensure proper mechanical mounting of the H power module family.

1.1 Scope

This document applies to the H power module platform shown in Figure 1. H-module power module products can be identified by the presence of 'HM' or 'HN' in the final 3-4 digits of the part number, such as the CAB760M12**HM**3 or CAR600M17**HN**6.

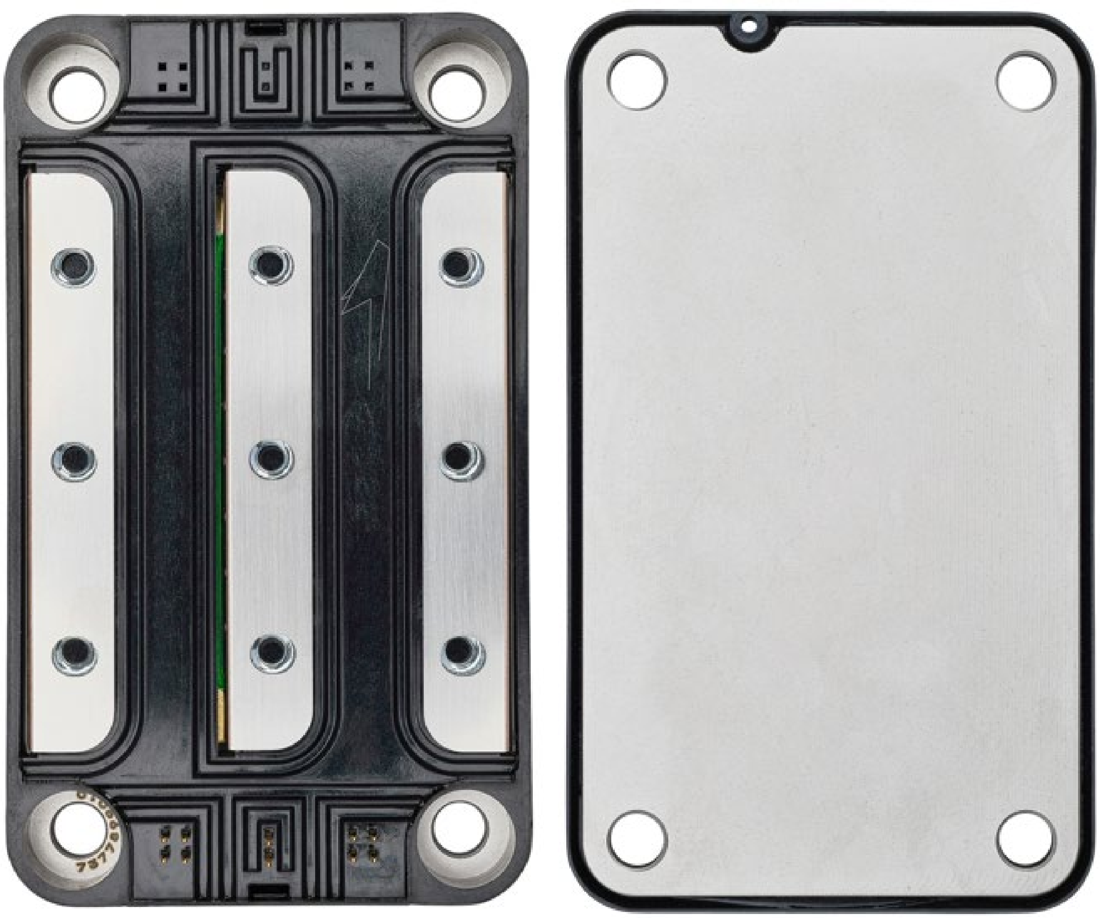

Figure 1: H power module platform – top and bottom view

2. Cold Plate Mounting

Cold plates are necessary to remove heat from the die during operation and maximize the module's performance. Minimizing the thermal impedance between the module baseplate and the cold plate will further improve performance by allowing operation at higher power levels and reducing the die junction temperature. In this section, the cold plate mounting procedure for H modules will be discussed.

2.1 Thermal Interface

The H module baseplate should be adhered to a cold plate using a thermal interface material (TIM). Before applying the TIM, it is important to make certain that the contact surfaces—the cold plate mounting surface and module baseplate—are clean and free from any type of debris. This can be achieved by using an alcohol based cleaner and a lint free cloth. Another important parameter to consider when selecting a proper cold plate is the roughness of its surface. Any cold plate surface will have imperfections in the surface finish that will cause void regions to develop in the contact region between the module and the cold plate. Thermally conductive material should be used to fill these void regions. To ensure the filling of these voids and to minimize the thermal impedance, it is recommended to select a cold plate that meets the requirements listed below and in Figure 2.

1. Surface flatness ≤ 25.4 µm per 25.4 mm (DIN EN ISO 1101)
2. Surface roughness R_z ≤ 10 µm (DIN EN ISO 4287)
3. No steps > 10 µm (DIN EN ISO 4287)

Refer to the PRD-07933 TIM material application user guide for instructions on how to properly apply the TIM to the module. H platform products are also available with a Pre-Applied Thermal Interface Material option, having part numbers end with a suffix "T", for e.g. CAB760M12HM3**T.** Wolfspeed uses Honeywell PTM6000HV as the thermal interface material (TIM). A stencil with 4 mil thickness is recommended for the TIM application based on tests conducted with PTM6000HV. Stencil designs are available on request. Following the application of the TIM, the module baseplate should be attached to the cold plate using the procedure described in section 2.2.

A recommended cold plate for the H modules is the Wieland MicroCool CP3009 or CP4009 aluminum friction stir welded cold plates shown in Figure 3. This cold plate has been optimized for H power modules and uses

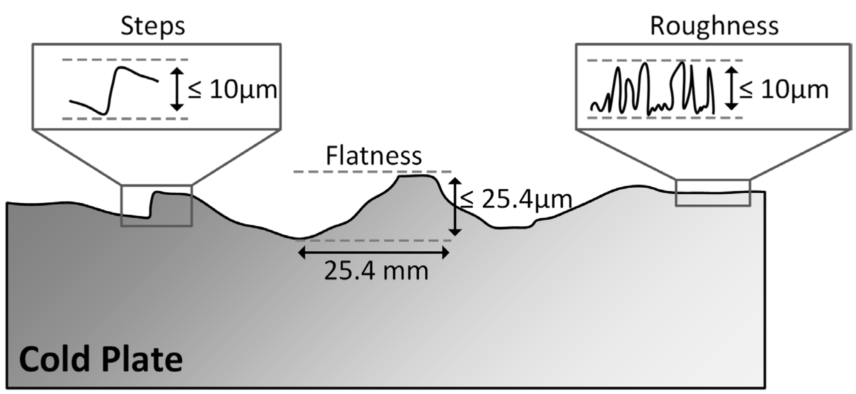

Figure 2: Required cold plate surface tolerances

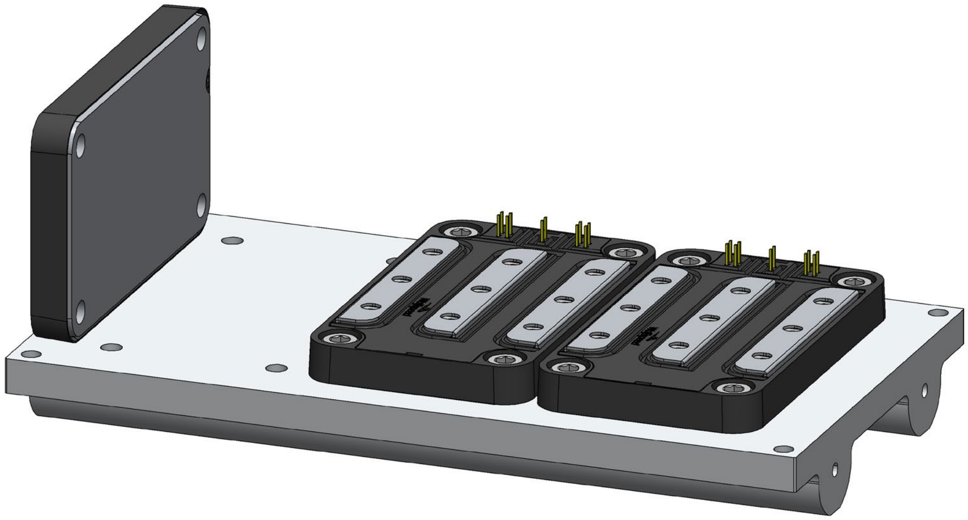

Figure 3: Assembly of direct-cooled H-modules mounted on a CP3009 cold plate

micro deformation technology to allow for very low thermal resistance. Refer to the Wieland CP4009 datasheet for more information [1].

2.2 Bolt Tightening Procedure

Carefully align the mounting holes and place the module onto the cold plate while taking care not to slide the module around. Install Belleville or spring washers and thread in the M6 bolts until seated finger tight. The module baseplate is made of nickel plated AlSiC. Use a torque wrench to tighten the bolts in the sequence described Figure 4 until the desired torque for each bolt is reached. The recommended mounting hole torque range is specified in the module physical characteristics section of the product datasheet. See Section 6 for specific information regarding module torque.

1. Torque bolt number: 1 – 2 – 3– 4 to 1/3 final torque
2. Torque bolt number: 3 – 4 – 2 – 1 to 2/3 final torque
3. Torque bolt number: 2 – 1 – 3 – 4 to final torque

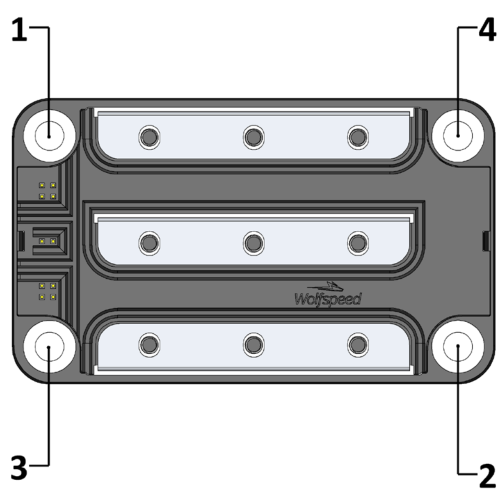

Figure 4: H module cold plate bolt tightening pattern

3. Power Terminal Mounting

The power terminals of the H-module are designed for DIN M4 bolts (class 6.8 minimum) tightened with a recommended torque range of 0.9 – 1.3 N-m (8 – 11.5 in-lb). The engagement depth of the screw into the power terminals must not exceed the maximum penetration depth of 4.25 mm, which is found in the H-Module datasheet located at www.wolfspeed.com or available upon request and depicted in Figure 5. Exceeding the rated torque may result in significant damage to the power module. As such, the mounting hole in the bussing that is attached to the module should be as close to the standard M4 clearance hole of 4.8 mm as possible, given the tolerances in your system. Exceeding the standard M4 clearance hole size may result in damage to the power terminals of the module.

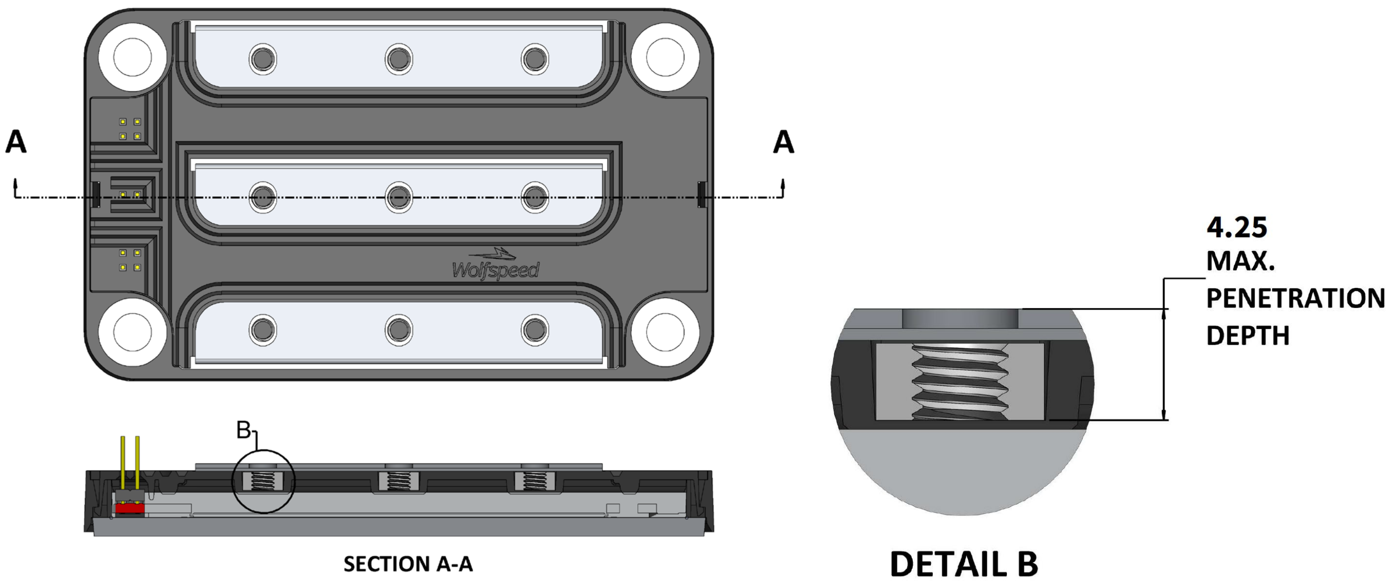

Figure 5: Power terminal maximum penetration depth

3.1 Electrical Contact

The H power module terminals are Ni plated, and a Ni plated bus bar is recommended to interface with the module. Electrical connection is made through the surface mating of the bus bar and the module; the surface area of the contact should be maximized to improve conductivity and longevity of the joint. This can be achieved by cleaning both surfaces before mating to ensure that no debris or grease exists in the joint and ensuring that the proper torque is applied to the terminals. Conductive grease can provide some protection to the point of contact to corrosion, especially for outdoor installations. However, the correct material must be selected for a given environment (for example, an improper grease in marine environments can degrade performance). The bolted terminal torque may decrease over thermal cycles; maintenance of the torque induced force over the product lifetime can improve longevity and performance of the joint.

3.2 Mechanical Rigidity

When mounting the H-modules into an application, the mechanical structure of the system should be scrutinized to ensure that the bussing connecting to the power terminals,

1) does not place excessive shear force on the power terminals and

2) limits the possibility of forces pulling the terminals away from the module. This is particularly important for systems that may be subject to shock and vibration conditions.

The modules should contribute as little to the mechanical rigidity of the structure as possible. The cold plate and bussing should be fixed together using bolts and spacers or be fixed to a surrounding mechanical structure. If the cold plate and bussing can move independently from each other, then pulling and shear forces may be imparted on the module power terminals, resulting in damage. For additional information on provisions for vibration or mechanical forces, refer to section 5.

4. Signal terminal Mounting

The H-module signal connections are comprised of two 2x2 stacking headers and one 2X1 header both with 2.54 mm pitch. A top-down view of the H power module and the 2x2 header pin dimensions are provided in Figure 6. A compatible female header must be used to attach the gate driver (or PCB) to the signal pins. For each 2x2 connector, it is important to interface with all four pins, and for each 2x1 connector it is important to interface with both pins. Failure to do so may result in damage to the module or reduced performance. This

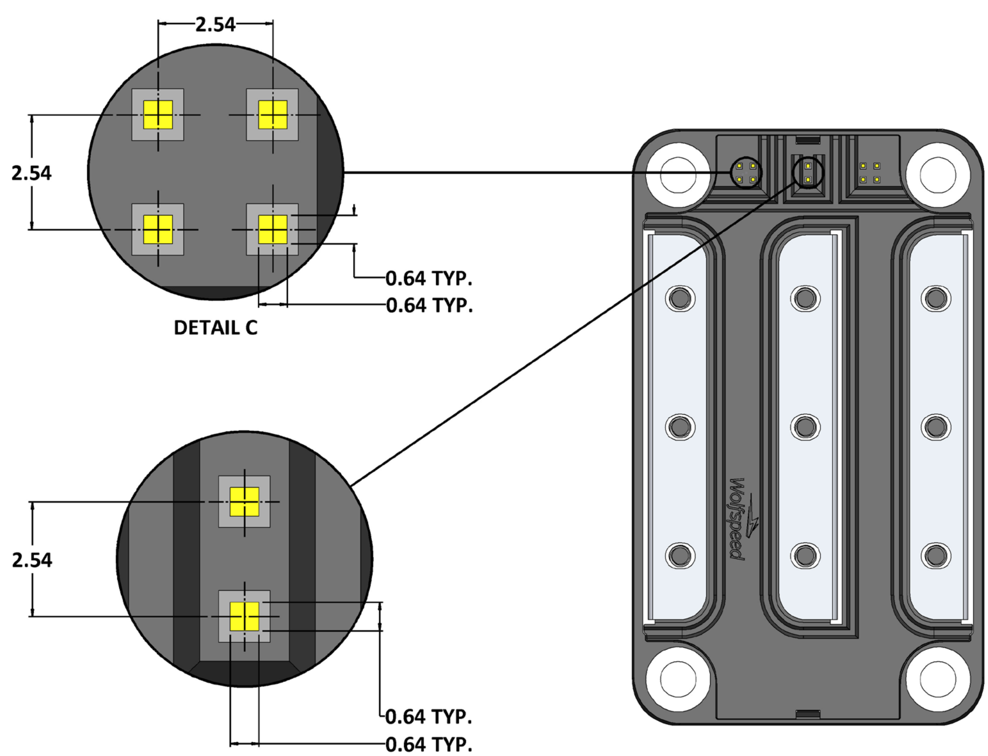

Figure 6: H-module signal terminal locations and dimensions (all units in mm)

section will provide guidance on selecting and mounting an appropriate header to interface with the H power module signal pins.

4.1 Signal Terminal Header Requirements

The recommended receptacle for interfacing with the 2x2 header is the Samtec® ESQ-102-33-L-D-LL header shown in Figure 7 (left) and for the 2x1 pin header is the Samtec® ESQ-101-33-L-D-LL shown in Figure 7 (right).

If an alternative receptacle must be used, ensure that its minimum rated engagement is less than 5.01 mm for both 2x2 and 2x1 signal pin positions.

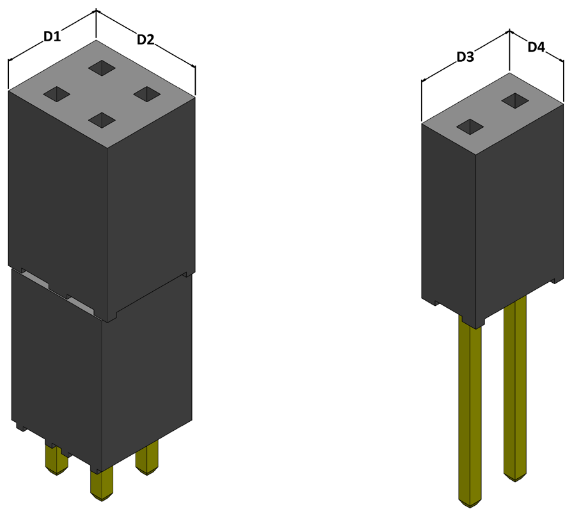

Figure 7: H-module signal headers, recommended Samtec ESQ-102-33-L-D-LL header for attaching to the 2x2 H-module signal pins(left) and Samtec® ESQ-102-33-L-D-LL for the 2x1 signal pins (right) Not to scale.

4.2 Signal Terminal Maximum Engagement and Vertical Tolerances

It may be necessary to consider the vertical dimensions and tolerances of the H-module to ensure that the module, gate driver, and bussing assembly will work in production processes. A side view of the H-module with vertical dimensions is provided in Figure 8. On the left, the 17.84 mm ± 0.75 dimension is critical because it defines the minimum and maximum height of the H-module from the bottom of the baseplate to the top of the

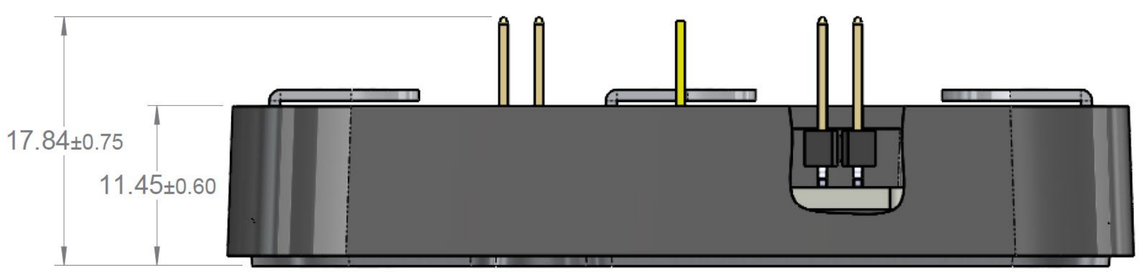

Figure 8: H-module cut out view with pin engagement specifications. All units are in mm.

signal pins. When designing an assembly process for a system, it is necessary to consider this height so that the pin engagement does not result in a total height that exceeds any design specifications. Failure to do so may cause the assembly to fail or the module to become damaged if excessive force is placed on the signal pins.

5. Provisions for System Vibration

Vibrations over time have the potential to cause a failure in any inverter. For applications where vibrations are expected, such as in vehicles, it is important to minimize the amount of force that vibrations will induce at the interfaces. The module itself is a stiff object and is subject to vibrations as part of the qualification process. However, in applications, the entire system will be subject to vibrations. This will include not only the module, but also the interfaces between the module and the system. Thus, it is crucial to understand how the vibration environment will affect the module and all its interfaces. The following sections provide guidance to maximize device lifetime in environments where vibrations are a concern.

5.1 Cold Plate Vibrations

The H-module power terminals and cold plate interfaces depend on bolted elements. Bolts are, in effect, stiff springs; the torque on the bolt induces a force on the threads to create friction that keeps the part fixed, as shown in Figure 9 below. A key design element is ensuring that vibration does not induce a counter force in the interface that will overcome the torque induced force, which can cause the bolt to loosen. Under all circumstances, this bolted interface must be under tension. While solutions such as lock washers, fixing compounds or bolts with inserts can be used to assist the frictional resistance, they should not be used in lieu of the above recommendation.

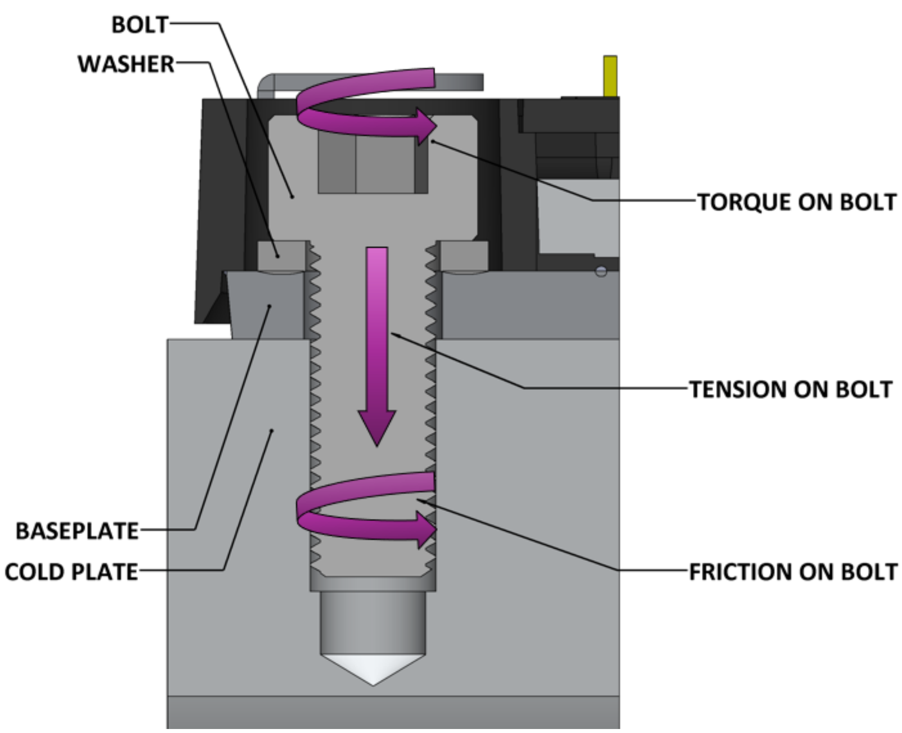

Figure 9: Side cutaway of a baseplate bolt interface.

5.2 Power Terminal Vibrations

The power terminals are made of a copper conductor with a bolted interface. The module terminal is bent down to trap a threaded nut that allows the bus to be bolted firmly to the terminal. This external power connection can be a lug on the end of a cable but in most cases will be some form of laminated copper sheets or even thick copper printed wiring board. This trapped nut and the bolt form a bolted interface requiring sufficient torque to prevent an induced vibration from causing the interface to come apart.

When the bussing is bolted to the terminal, it should not impart tension on the module terminal part that connects into the module. Instead, it should impart some compression, as shown in Figure 10, and be designed so that vibration in the system does not ever impart tension on the interface. The maximum compression force on the module terminals should not exceed 100 N as shown in Figure 10.

Vibrations that cause the interface between the bussing and the module terminals to oscillate between compression and tension are likely to lead to fatigue failure. The power interface structure needs to be analyzed across the vibration environment to ensure that they will not overcome the compressive force on the terminal.

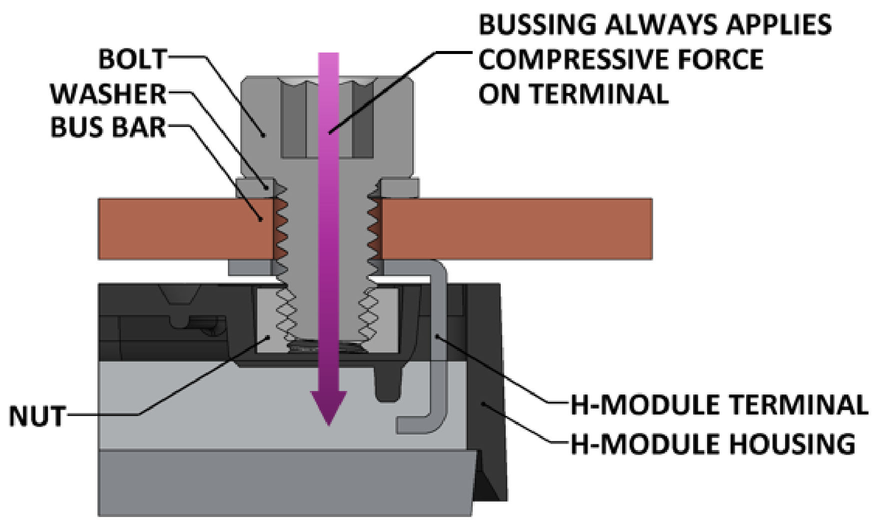

Figure 10*: H-module power terminal force side cutaway of the bolted interface between the power terminal and bus, and compression force during the assembly process.*

5.3 Signal Terminal Vibrations

Like the power terminals, the signal pins are susceptible to long-term damage from vibrations. A cross-sectional view of the signal pin connection interface is provided in Figure 11. The male H-module gate signal pins press into the female gate drive connector pins. However, because the male H-module signal pins and the female header are not locked together, vibrations in the vertical axis (along the length of the pins) can cause the pins to rub together. Over time, this will erode the metal surfaces, which can cause the connection to fail and allow corrosion. To avoid this issue, the gate driver and H-module must be fixed relative to each other such that vibrations in the system (particularly on the gate driver PCB) do not cause the pins to repeatedly slide against each other.

As with the terminals it is important to ensure that the signal pins do not receive excessive stress or strain from external components. Not only is an excessive external force likely to damage the pins, but the solder joints are at risk of damage or complete failure as well.

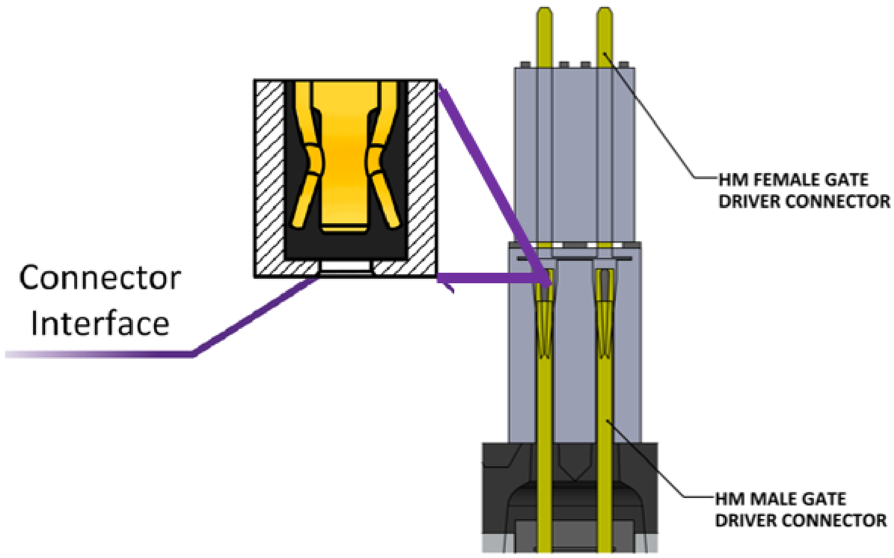

Figure 11: Side cutaway of a gate connector mated to the gate pins of the H-module.

6. Mounting Torque Technical Specifications

For modules utilizing a phase change thermal interface material including the pre-applied TIM option for the H-module, there exists the potential for a reduction of downward force on the module after the TIM transitions from a solid to a liquid during the first heating of the system. This phenomenon is caused by two factors: the convex geometry of the H-module baseplate and the spreading of the TIM that occurs during the phase change event. Testing was performed to understand the effects of this torque reduction on the final compression between the H-module baseplate and the cold plate interfacing surface. The subsections below outline the general trends that occur during the mounting process. In summary, an initial applied torque for each bolt of 4.5 – 6.0 N-m (40 – 53 in-lb) results in a negligible reduction in torque after the phase change of the TIM during first heating. The addition of Belleville washers paired with the module mounting screws can reduce the torque reduction during the phase change event.

6.1 Torque Reduction due to Baseplate Geometry

As part of the force reduction investigation, three H-modules were mounted per instructions outlined in Section 2 to a Wieland Microcool CP-3009 coldplate. The distance between the points on the baseplate (see Figure 12) and the mounting surface of the cold plate were measured as torque was applied in increments of 5 in-lb. See Figure 14 for graphical results. The removal torque for each bolt is equal to the application torque until the baseplate is tightened enough to flatten its convexity and interface completely with the cold plate (when measured distance between baseplate and cold plate is 0 mm), which occurred between 3.5 and 4.0 N-m (30-35 in-lb). After this point, there is a measured reduction in removal torque from application torque due to material compression, friction, and other factors that are negligible at lower torque values (overall torque reduction is about 20%). This reduction in torque between application and removal due to the baseplate geometry sets the baseline for the next section.

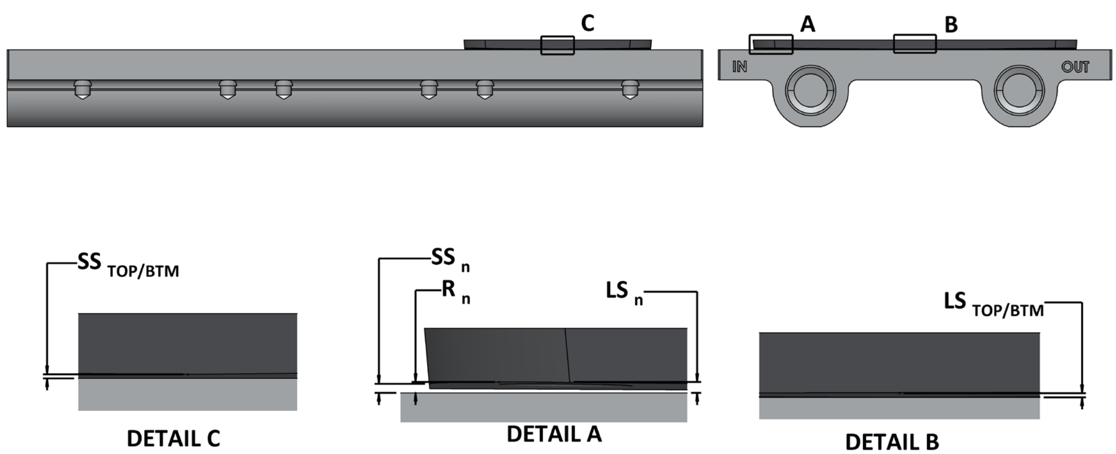

Figure 12: H module mounted on a cold plate (top) and locations of incrementally measured distance between base plate and cold plate (bottom)

6.2 Torque Reduction due to Phase Change Thermal Interface Material

A phase change material, Honeywell PTM6000HV, was applied to the same H-modules in section 6.1, and the modules were baked out per the manufacturer's instructions. The modules were then mounted to the cold plate per Section 2 and feeler gauge measurements were taken to determine the reduction in TIM height and the overall torque reduction (see Figure 13 and Figure 14 for graphical results). It was determined that there was an additional ~8% absolute torque reduction due to TIM height difference due to the material spreading as it transitions from a solid to a liquid. This extra torque loss is negligible in the recommended application torque range and will not affect the performance of the module. To counteract the reduction in torque from the phase change material spreading, Belleville washers between each bolt and the module baseplate can reduce the lost torque by approximately .5 N-m (5 in-lb).

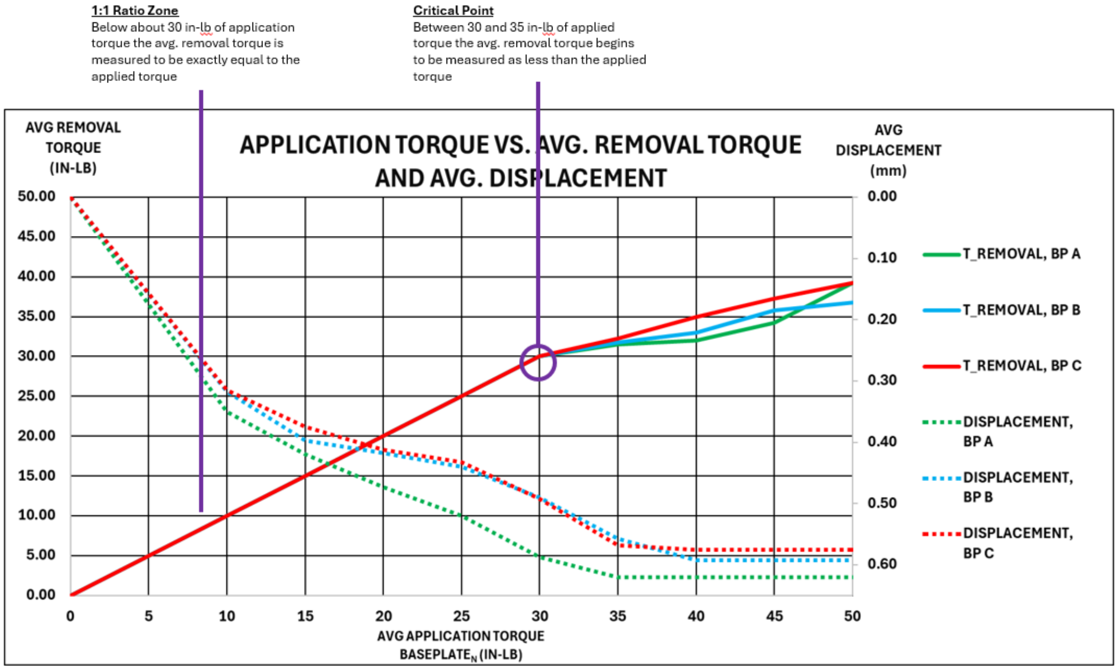

Figure 13: Average removal torque and average baseplate displacement shown against average application torque per bolt for the H-module

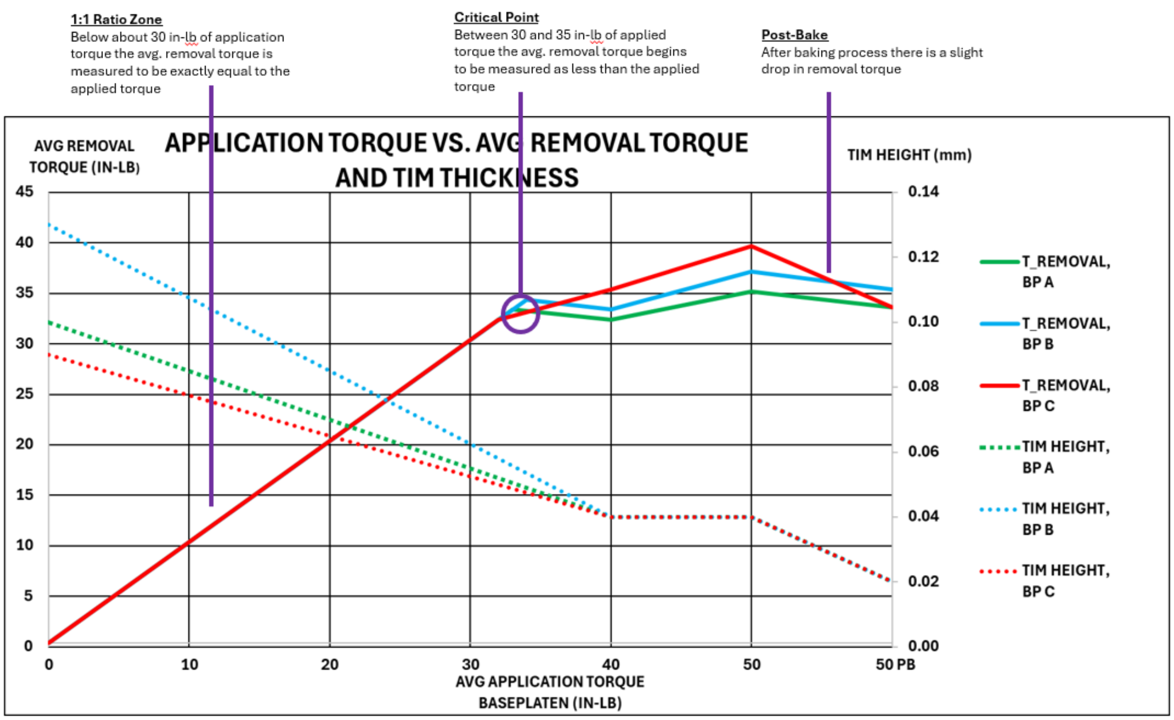

Figure 14: Average removal torque and average TIM height shown against average application torque per bolt for the H-module

Revision History

Date	Revision	Changes
December 2025	1	

References

[1] Wieland Microcool, "CP 4009 Aluminum Friction Stir Welded Cold Plate," [Online]. Available: https://www.microcooling.com/our-products/cold-plate-products/4000-series-standard-cold-plates/cp4009/.