USER GUIDE PRD-02302

Wolfpack Mounting Instructions and PCB Requirements

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This document provides guidelines on the usage and implementation of Wolfpack power modules with press-fit pins. Module handling procedures and PCB requirements are discussed in the beginning. This is followed by detailing of the press-in and press-out process and a presentation of the 3D fixturing. The PCB mounting procedure and a recommended mounting sequence are explained. The heat sink and thermal interface material requirements are then described. Towards the end, system considerations and multi-module applications are briefly discussed, followed by a brief outline of the module creepage and clearance.

CONTENTS

CAUTION

Before operating the system, please carefully review the operating limits for the relevant Wolfspeed Wolfpack power module 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 user guide describes the recommended printed circuit board (PCB) design and mounting procedures for the FM and GM WolfPACK™ series power modules. Pictures of half-bridge FM and GM power modules are shown in Figure 1. The general guidance in this document can be applied to other variants of the FM and GM power modules (such as full-bridge and six-pack). However, all images, dimensions, and examples shown in this document will be of the half-bridge modules. For exact dimensions of each product, please refer to the module's datasheet found on Wolfspeed's website. It is recommended to follow these instructions in order to ensure safe and reliable operation of the Wolfpack series power modules.

Figure 1. Example image of Wolfspeed WolfPACK™ FM (left) and GM (right) module.

1.1 Press-fit pins

Wolfpack power modules use press-fit contacts to circumvent the need to solder or use fastening hardware to attach the module's terminals to a PCB. A picture of the press-fit contacts for an FM power module is shown in Figure 2. The press-fit contact method facilitates the assembly process and results in very low contact resistance. However, special attention should be given to the process of inserting the module into the PCB and the design of the PCB that the module will be pressed into. Non-adherence to proper module insertion procedures and PCB design may lead to press-fit pin damage or module housing damage rendering the module unfit for use. For safe and reliable operation of the WolfPACK™ series modules, it is recommended to follow the guidelines outlined in this document.

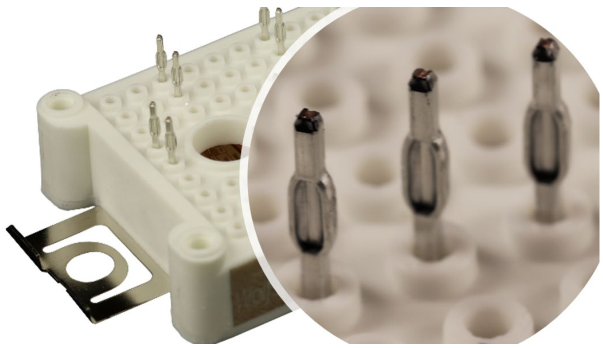


Figure 2. Press-fit contacts for an FM power module

1.2 Handling

Care should be given to ensure that no forces are applied to the bottom of the housing while the substrate is unsupported. The substrate and module housing are not securely attached to each other and applying a force to the housing as shown in Figure 3 may result in the substrate being pushed out of the housing. For the same reason, no forces should be applied to the module's pins. In any practical application, the housing and substrate positions become fixed relative to each other, and these precautions do not pose any issues.

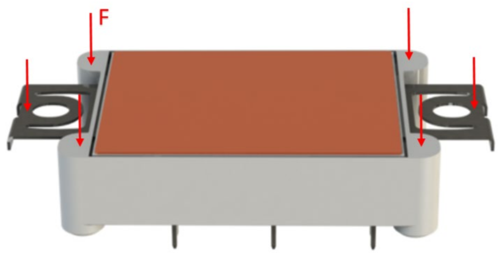


Figure 3. Destructive Forces to be avoided during module handling to prevent a substrate push-out.

1.3 Key Dimensions

The module mounting dimensions for the FM and GM modules are depicted below in Figure 4. The pin pitch is 3.20 ± 0.2 mm and the distance between mounting holes is 53 ± 0.1 mm. Refer to the module datasheets for more detailed information on dimensions and tolerances for designing hardware for these systems.

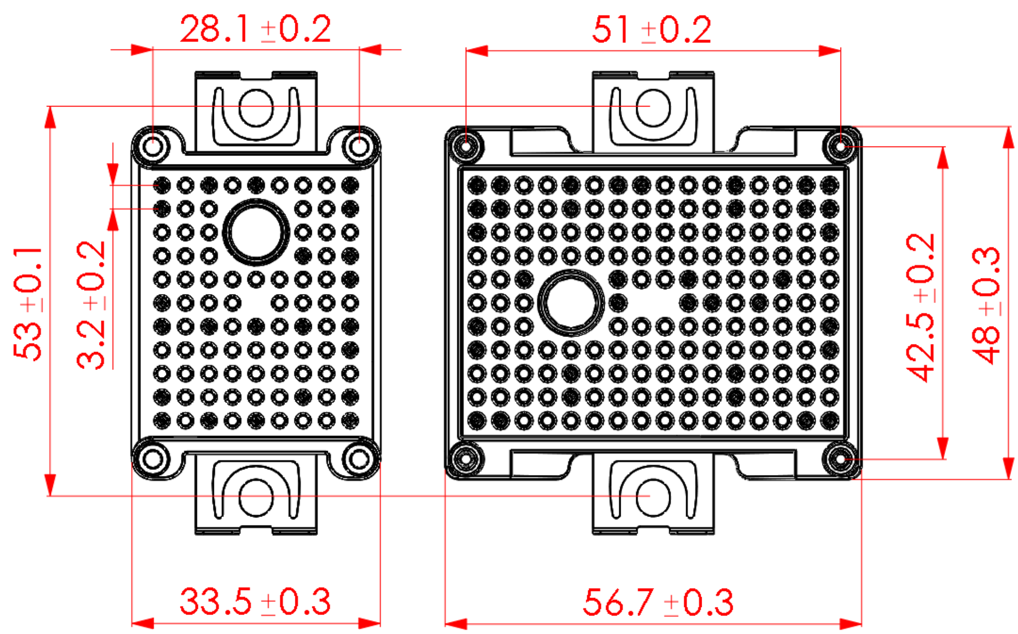


Figure 4. FM (left) and GM (right) Key Dimensions

2. PCB Requirements

Wolfpack press-fit pins allow for a low resistance solderless electrical connection between the module and a PCB. When the PCB is designed and attached properly, the module pins and PCB holes will form a cold weld, providing high reliability. The PCB hole recommendations for Wolfpack modules are detailed in Table 1 and further illustrated for clarity in Figure 5. To ensure this high reliability connection, FR4 PCBs should adhere to IEC 60352-5 and IEC 60747-15, with tin applied chemically. Additionally, double-sided PCBs should satisfy IEC 60249-2-4 or IEC 60249-2-5, while multilayer PCBs should satisfy IEC 60249-2-11 or IEC 60249-2-12. Although users may elect to achieve the correct finished hole diameter by using varying drill sizes—and thus modifying the copper thickness and metallization thickness—no extensive reliability or connection quality testing has been conducted by Wolfspeed to validate such PCB specification modification. Note that the press-fit pins are designed to be inserted into a PCB with a maximum thickness of 2 mm. Exceeding the maximum PCB thickness will hinder the ability for the module to be pressed out using the recommended procedure.

Table 1. PCB Requirements

	Minimum	Typical	Maximum
Hole drill diameter	1.12 mm	1.15 mm	
Copper thickness in hole	25 µm		50 µm
Metallization in hole			15 µm
End hole diameter	1.00 mm	1.05 mm	1.18 mm
Copper thickness of conductors	35 µm	70 µm – 105 µm	400 µm
Metallization of circuit board	Tin (chemical) recommended		
Metallization of pin	Tin (galvanic)		

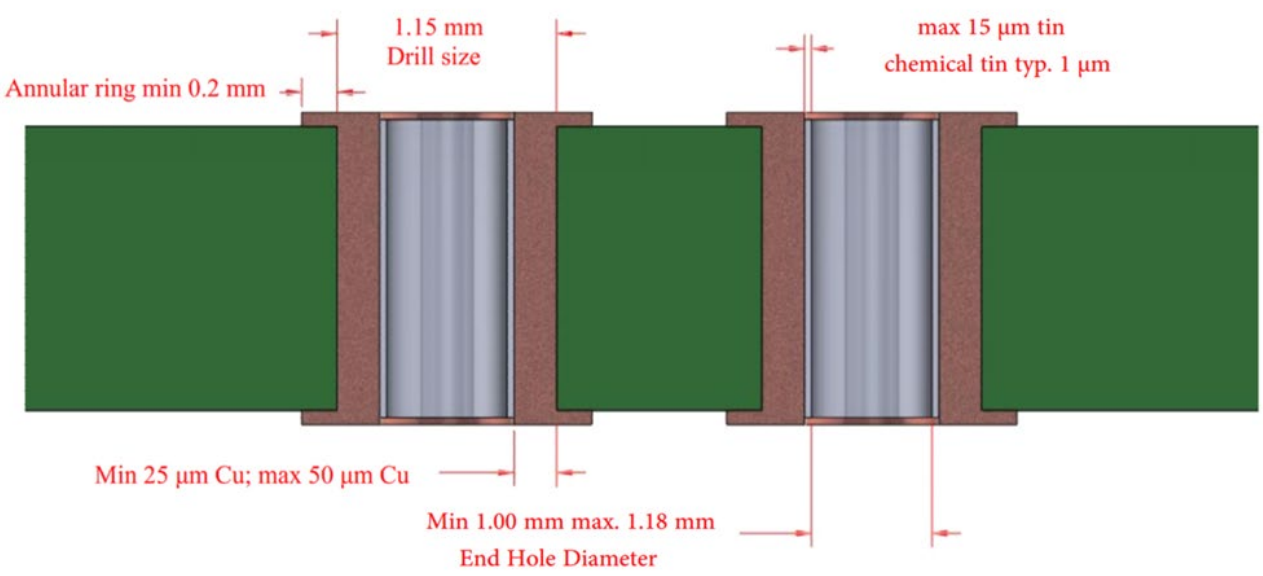


Figure 5. Recommended PCB Structure

The typical end hole diameter recommended by Wolfspeed is 1.05 ± 0.05 mm. Customers are advised not to specify the PCB press-fit holes solely by the end hole diameter. Even if the same end-hole diameter is achieved, achieving that diameter through a different combination of drill hole sizes and processes may not meet the specification. The specification provided to the PCB manufacturer should include all the information listed in Table 1, especially the drill diameter. Figure 6 depicts an example snapshot of the NC drill file shared with the board house where the press-fit pin holes are highlighted. This clearly tells the PCB manufacturer where to apply the specifications listed in Table 1.

NCDrill File Report For: WOLFPACK_DESIGN.PcbDoc 7/14/2023 2:18:36 PM

Layer Pair: Top Layer to Bottom Layer
ASCII RoundHoles File: WOLFPACK_DESIGN.TXT

Tool	Hole Size	Hole Tolerance	Hole Type	Hole Count	Plated	Tool Travel
T1	12mil (0.305mm)		Round	122	PTH	
T2	**45.3 mil (1.15mm)**		**Round**	**22**	**PTH**	
T3	110mil (2.794mm)		Round	4	NPTH	
Total				148		

Figure 6. snapshot of NC drill file shared with PCB manufacturer

PCBs that are designed following the above standards may have a Wolfpack series module pressed in up to three times. After the third module is removed from the PCB, it is recommended that the PCB be replaced. Furthermore, once a module has been pressed into a PCB and removed, its press-fit functionality may be hindered, and it is recommended to solder the module pins to the PCB. Damage to the pins may occur when removing the module from the PCB and should be avoided when possible. A module can be press-fit up to two times before it must be replaced.

If the PCB requires a reflow soldering process for other components, it is recommended to reflow the PCB prior to pressing the module into the PCB as this will avoid exposing the module to high temperatures. It should be noted that if the PCB follows the above specifications, it should retain its critical dimensions such that the reliability of the press-fit connection will remain unaffected even after the reflow process is complete.

If the press-in process is to be conducted prior to mounting the module to a heatsink, the PCB should have clearance holes in it centered above the mounting screw locations to allow the mounting screw head to pass through, as shown in below in Figure 7. Mounting the module to a heatsink prior to pressing the module into a PCB circumvents the need for the mounting clearance holes in the PCB but may complicate the press-in procedure.

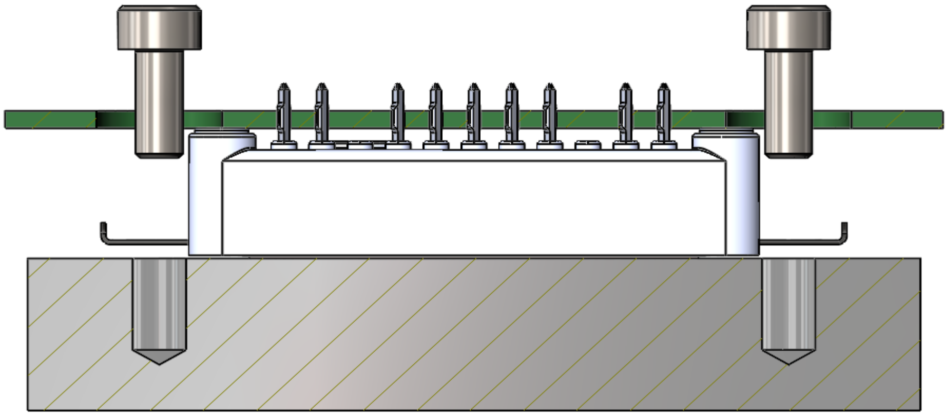


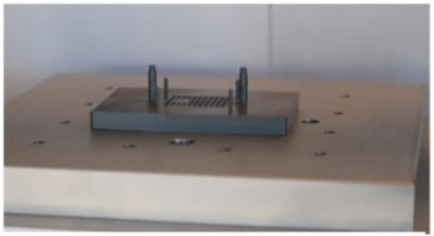
Figure 7. Module with cross-sectional view of heatsink and PCB with module mounting screws

3. Press-In Process

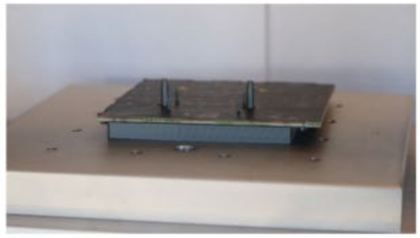
For consistent connection quality, it is recommended to use a machine, press, and/or fixturing to press the module into a PCB. In addition, it is recommended that whatever press-in tool is used also monitors and records the pressing force and travel distance. While the purpose of the machine or press is to provide a consistent seating force, the fixturing also serves to ensure that the force used to seat the module is normal to the module's substrate while holding the PCB in a fixed position. Additionally, the press-in fixturing provides a hard stop for the PCB to stop against to provide consistent seating depth.

Although the press-in process may be conducted before or after mounting the module to a heatsink, it is recommended to conduct the press-in process first, as it generally simplifies the press-in procedure and fixturing requirements. However, this recommendation usually requires that the PCB has holes to allow the mounting screws to be placed and tightened, as was shown in Figure 7.

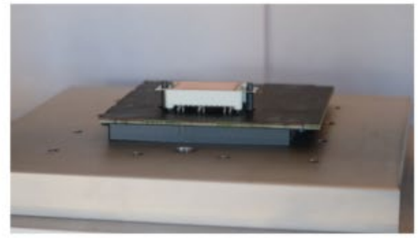
The recommended procedure for press-fitting a single module to a PCB is described in Figure 8 and Figure 9. First, the bottom fixture is placed into the press under the press ram. The PCB should then be aligned and placed onto the bottom fixture. After verifying that the position of the PCB is fixed, the module's pins should then be aligned with the corresponding holes in the PCB. The surface of the tool used to place force onto the PCB must be parallel to the PCB and to the substrate of the module. The module may be pressed into the PCB with a smooth regular movement to the desired depth, or until the PCB contacts the four standoffs on the top surface of the module.



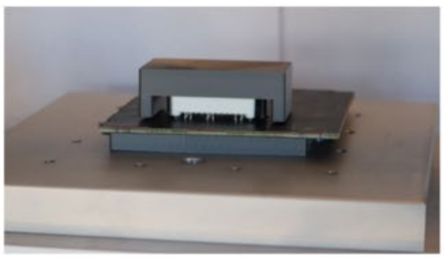
1\.
Bottom piece of fixturing placed into press directly under press ram



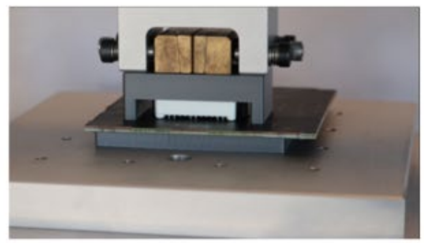
2\.
Holes are aligned and PCB is placed onto bottom fixturing piece



3\.
Module mounting holes are aligned and module is placed onto PCB



4\.
Top piece of fixturing is placed onto the module with the longer two pins aligned



5\.
Press ram presses top fixturing piece down until it contacts the PCB

Figure 8. Example recommended press-in process for single module

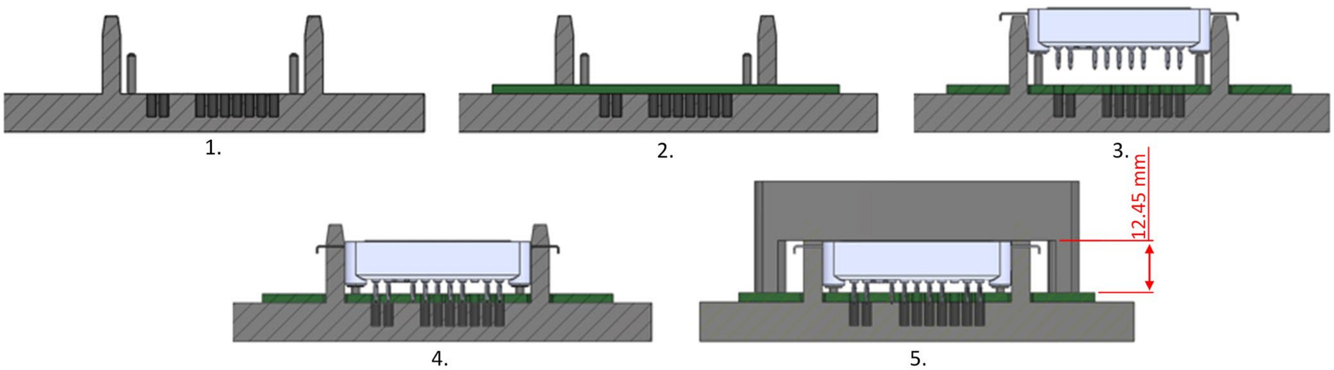


Figure 9. Recommended press-in process visualization

The speed of penetration should be a minimum of 25 mm/min to satisfy IEC 60352-5, but 100 mm/min is the recommended speed. Speeds of 450 mm/min are commonplace in automated assembly lines. An insertion speed of less than 25mm/min may result in increased press-in force which may lead to deformation. The maximum force that should be placed on the module is 4 kN, although the typical force per pin required to press the module into a properly designed PCB is between 60 N and 120 N. The press-in process for Wolfpack series modules can generally be broken down into three distinct sections which are depicted in Figure 10. During the first portion of the press-in process, the pins are slightly deformed while being pressed into the PCB holes. Once the second stage of the process is reached, the module continues to be pressed into its final position, but the force no longer increases because the pins have been deformed to match the PCB hole size. In the third and final stage, the top press-in fixturing tool contacts the PCB and the module can be pressed in no further. At this stage, the fixturing and PCB start to flex, resulting in a steep increase in force with distance relationship. The press-in process should stop before excess force is applied during this stage.

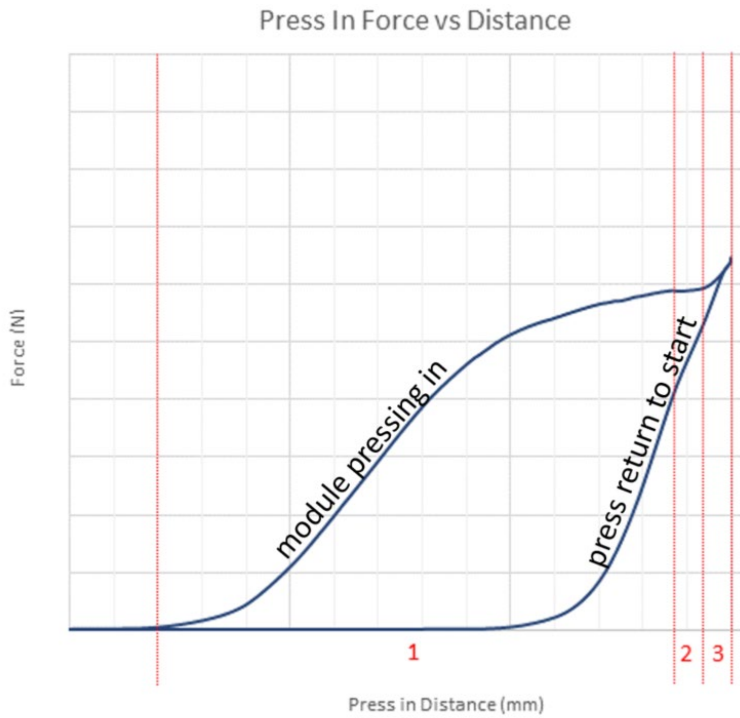


Figure 10. Typical press-in force profile for Wolfpack series module

CAD files for the fixturing shown in Figure 11 are available upon request. The fixturing consists of two pieces—one to hold the PCB in place while providing a solid backstop for the other piece to press against, and another piece to press against the bottom of the module.

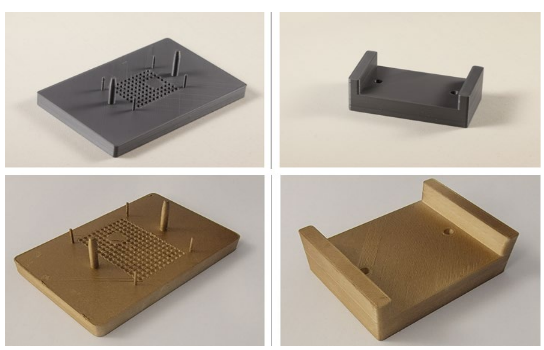


Figure 11. FM (top) and GM (bottom) Press-In Fixturing

4. Press-Out Fixturing

Press-out fixturing for Wolfpack series modules consists of a flat press used for pressing the pins of the module and a support base that is used to hold the PCB in a fixed position while giving the module a place to drop into after the press-out process is complete. The fixturing is shown in Figure 12. 3D step files of the fixturing are available on request.

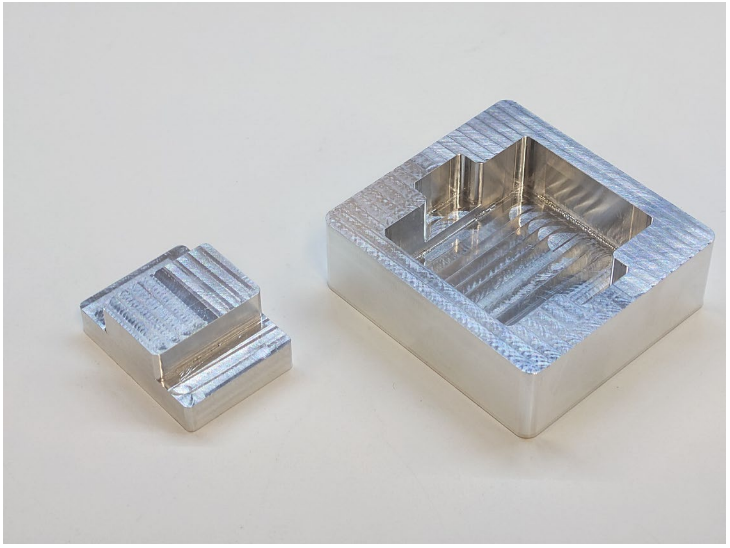


Figure 12. Press-out fixturing components - flat press (left) support base (right)

4.1 Press-Out Process

Just as with the press-in process, the use of a pressing tool and fixturing is recommended to safely remove the module from a PCB. The press-out process should consist of a flat plate pressing directly into the top of the module's pins while the PCB is held fixed, resulting in the module's pins being pushed out of the PCB. This sequence is shown in Figure 13. The pressing operation should be smooth and regular, with a force of >40 N per pin. An illustration of the press out process is shown in Figure 14.

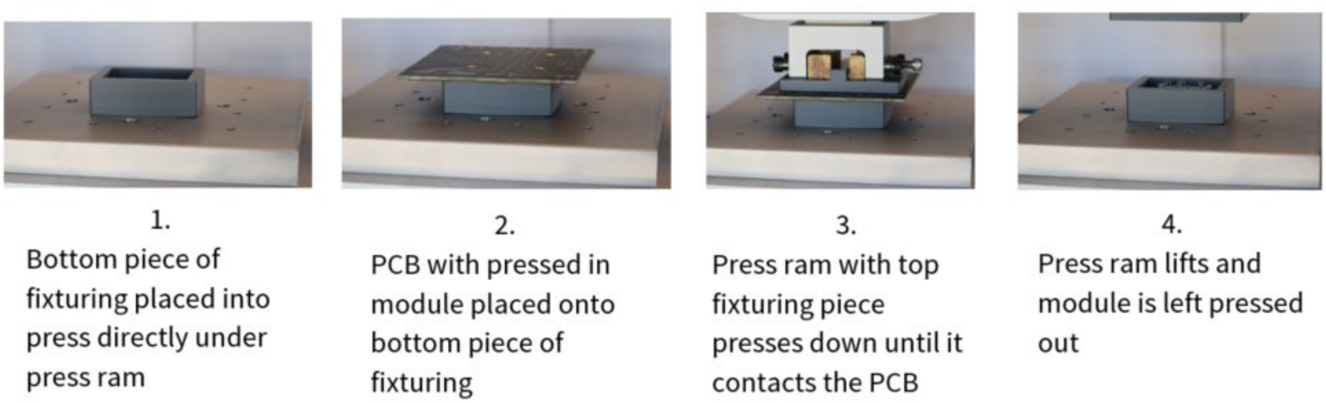


Figure 13.Example of the recommended press-out process

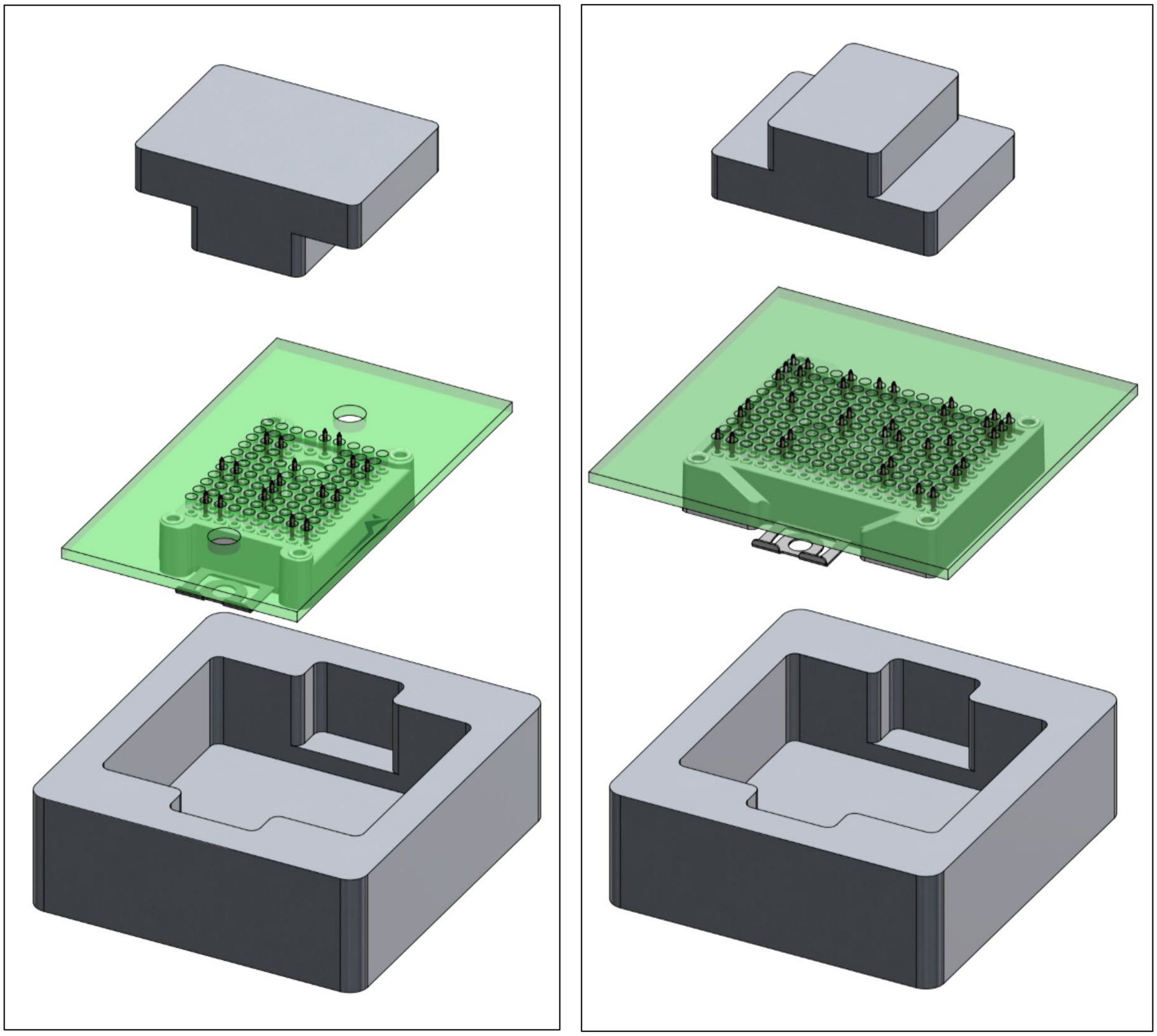


Figure 14. Press-out process - FM module (left) GM module (right)

5. Additional PCB Mounting

If increased mechanical robustness or suitability to high shock environments is desired, the PCB may be attached to the module using the four mounting holes that are located at each corner of the module. These holes are compatible with the following self-tapping screws, which should penetrate at least 4 mm but no more than 8 mm:

- Ejot PT WN1451 K25
- Mounting Torque = 0.45 Nm ±10%
- Ejot DELTA PT WN5451 K25
- Mounting Torque = 0.4 Nm ±10%
- M2.5 x L, depending on PCB thickness

Figure 15. Wolfpack PCB Mounting Holes

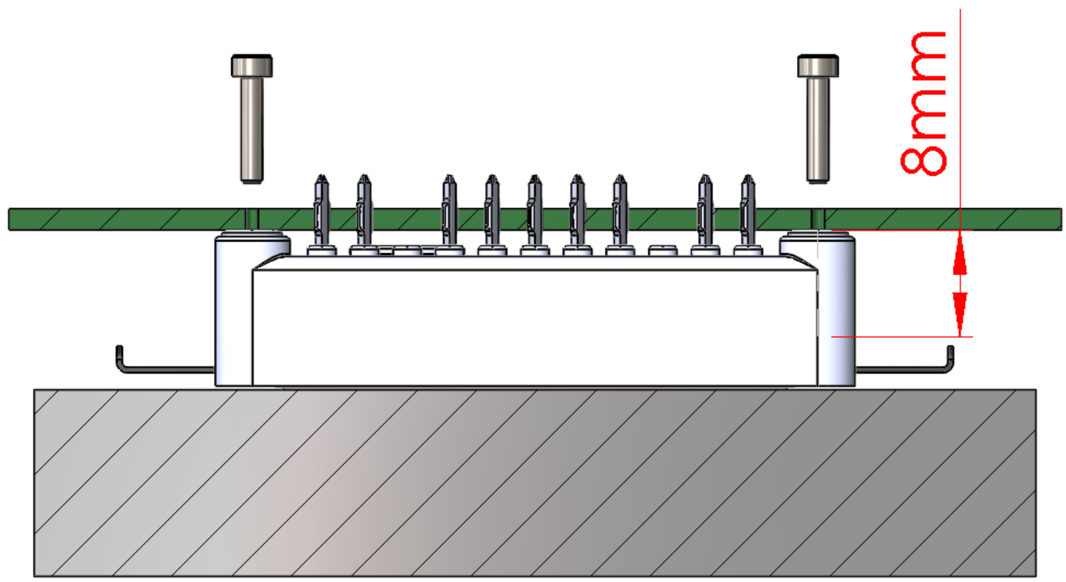


Figure 16. PCB Mounting Hole Penetration Depth

If increased mechanical robustness or suitability to high shock environments is desired, the PCB may be attached to the module using the four mounting holes that are located at each corner of the module. These holes are compatible with the following self-tapping screws, which should penetrate at least 4 mm but no more than 8 mm.

6. Heatsink and Thermal Interface Material Requirements

To maximize the amount of power that can be dissipated within the module, the module must be mounted to a heatsink. The heatsink and module contact surfaces will naturally have different surface shapes, therefore, voids will exist within the region that they contact each other. To ensure the filling of these voids with a thermally conductive material and to minimize the thermal impedance between the module and heatsink, the user should select a heatsink with roughness ≤ 10 µm and flatness ≤ 25.4 µm per 25.4 mm.

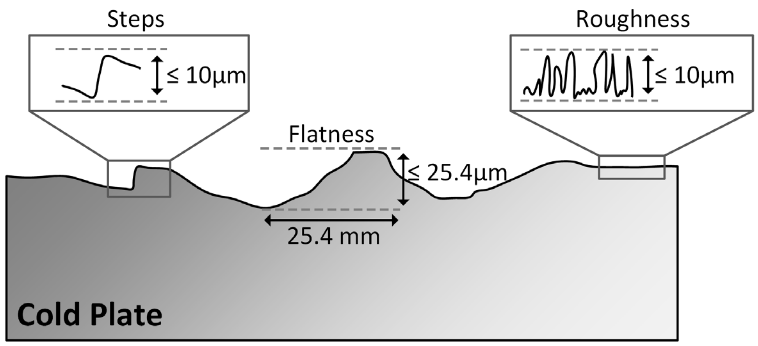


Figure 17. Heatsink Requirements

A thin layer of thermal interface material (TIM) should be applied to either the bottom copper of the module or the mounting surface of the heatsink. Ideally, this layer of TIM will fill all the voids between the two contact surfaces without preventing the surfaces from contacting each other. While this may be done using several different methods, it is recommended to use a stencil with 6 mil thickness and stencil fixture, as described in further detail in Wolfspeed's TIM Application Note, Document PRD-07933, located at www.wolfspeed.com or available upon request. Following the application of the TIM, the module baseplate should be attached to the cold plate using the procedure detailed in the section 7 of this document.

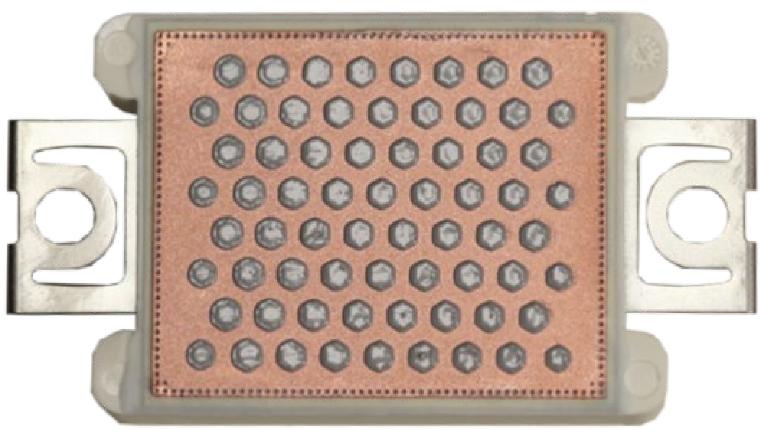


Figure 18. FM with Stencil-Printed TIM Layer

Customers can now buy all Wolfpack FM and GM modules with pre-applied TIM (as shown in Figure 19), in addition to the standard variant. This saves the customer from all the trouble associated with the TIM application process. For more details, refer to PRD-07933 TIM Application Note.

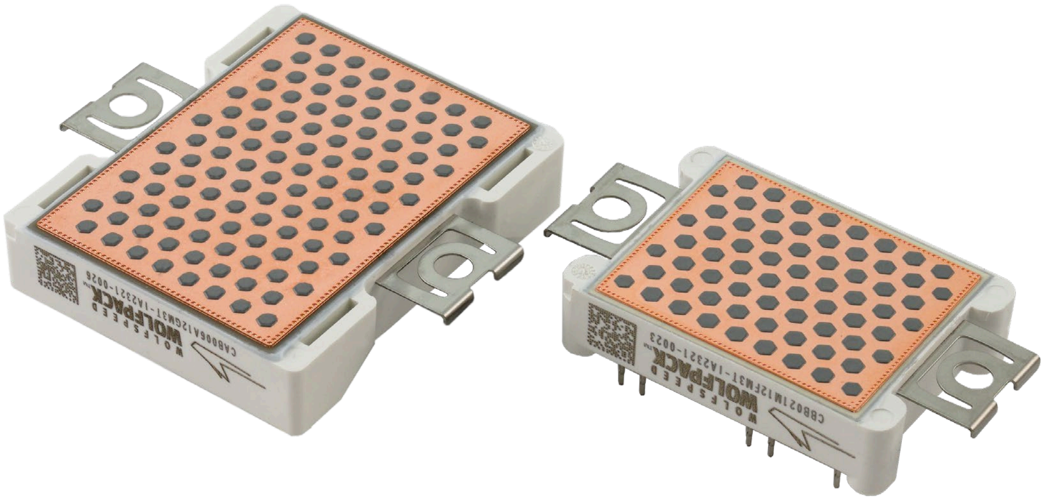


Figure 19. GM module (left) and FM module (right) with pre-applied TIM layer

7. Heatsink Mounting

The module is attached to a heatsink using two M4 screws with the mounting locations as shown in Figure 20. When mounting the module, it is imperative that the module's mounting surface remain in full contact with the heatsink, as shown in Figure 21. If the module rocks to any one side during mounting, it is recommended that the user clean off the TIM and re-apply a new TIM print. The recommended mounting torque is 2 – 2.3 Nm. To ensure proper seating of the module while mounting, the user should choose one of the following methods to mount the module after centering the mounting tabs over the mounting holes. The mounting screw requirements are provided in Table 2.

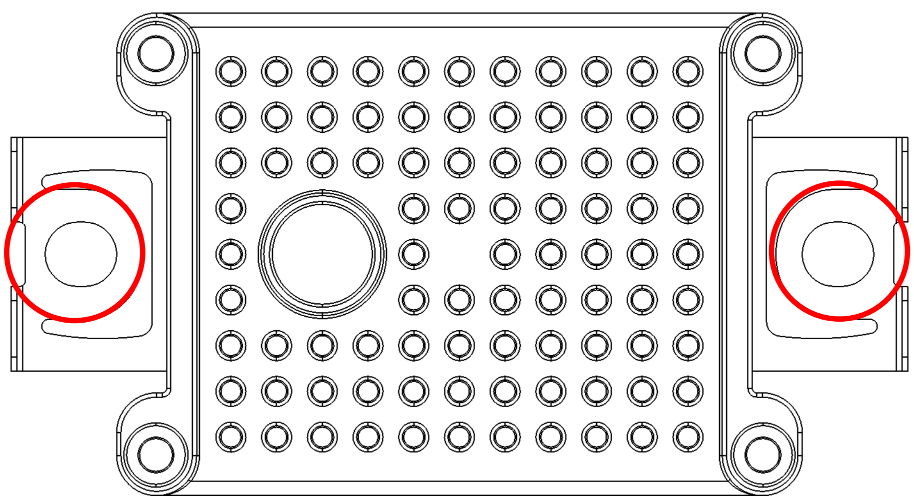


Figure 20. M4 screw mounting locations on FM module

Method 1: Insert both screws and tighten them simultaneously (Figure 21).

Method 2: Secure the module in place relative to the heatsink with a force of approximately 10 N and then tighten the mounting screws (Figure 22).

Method 3: Insert one screw and tighten until the screw contacts the mounting tab without bending it. Next, insert the second screw and tighten to the recommended mounting torque of the module (2 – 2.3 Nm). Lastly, tighten the first screw to the recommended mounting torque of the module (Figure 23).

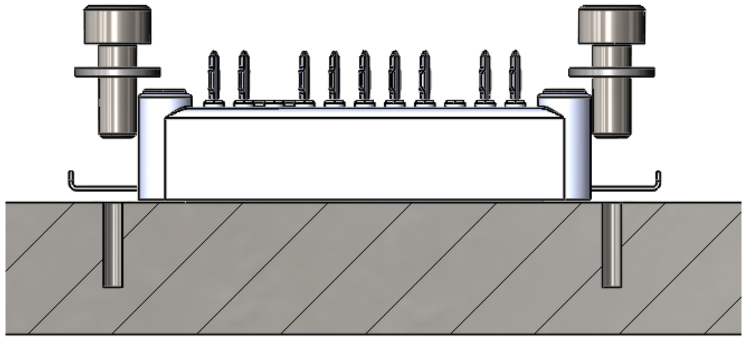


Figure 21. Mounting Method 1

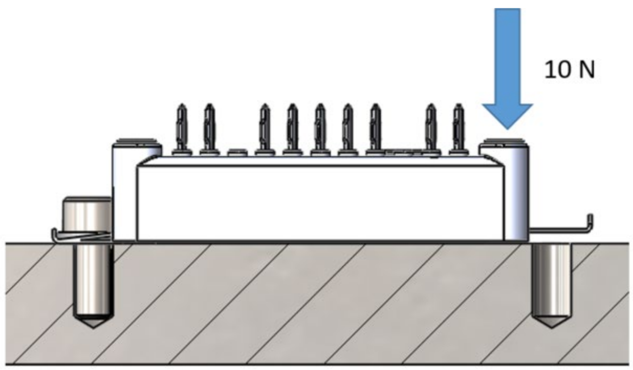


Figure 22. Mounting Method 2

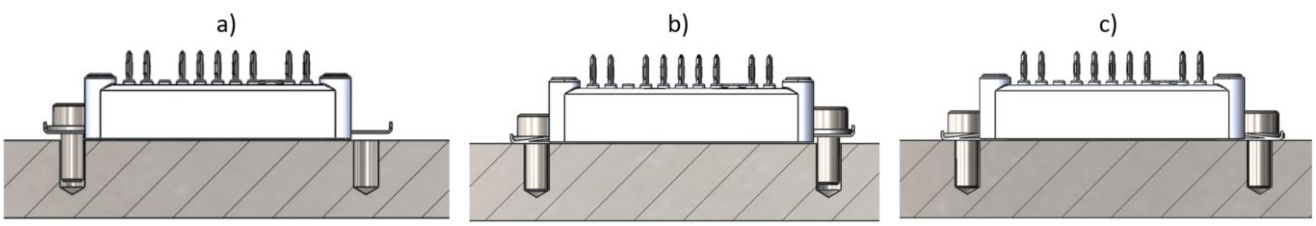


Figure 23. Mounting Method 3

Table 2. Mounting Screw Requirements

Description	Value
Mounting Screw	M4
Mounting Torque	2.0 – 2.3 Nm
Washer (DIN) 125	D = 9 mm
Thread engagement for property class 4.8 to 6.8 screws	
Aluminum alloy not hardened	6.4 mm
Aluminum alloy hardened	4.8 mm
Aluminum cast alloy	8.8 mm

8. System Considerations

The maximum upward pulling force that should be placed on any single pin of the module is 6 N and the maximum total pulling force of the module is 20 N. As such, designers should minimize the amount of outside force than can be placed on the module's pins by providing extra mechanical stress relief. One way to accomplish this is to fix the PCB to the heatsink or some other structure which is fixed to the heatsink via a bolt in such a way to lock the position of the pins and housing relative to each other while holding the PCB 12 mm above the surface of the heatsink. An example of this is provided in Figure 24. If the module is pressed into the PCB prior to being mounted to a heatsink, the bolt which fixes the PCB to the heatsink should be a minimum of 5 cm from the edge of the module to minimize any forces that may be placed on the module's pins. However, if the module is pressed into a PCB after being mounted to a heatsink, the bolt should be as close to the module as the system allows.

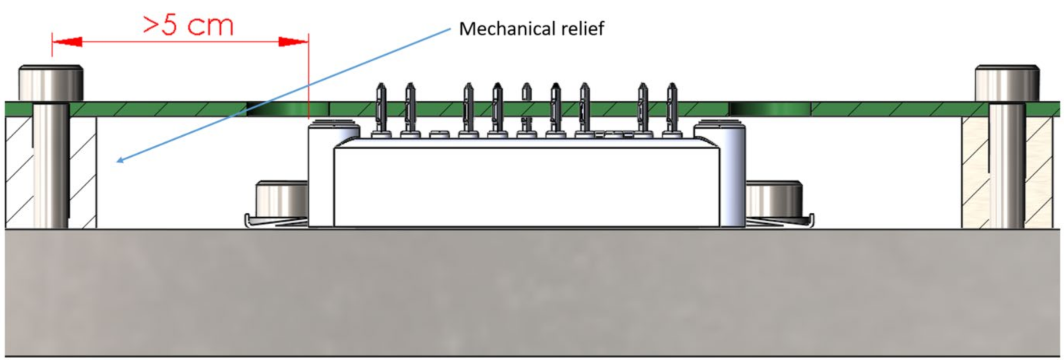


Figure 24. PCB mechanical relief

As stated previously, once pressed in, the distance from the bottom copper of the module to the bottom of the PCB should be a maximum of 12.45 mm, which results in a small gap between the PCB and module, as shown in Figure 25. If the PCB rests directly on the top face of the module, the distance becomes 12.00 mm. Ideally, the system's PCB mechanical supports should have a height of 12 mm with an additional 0.45 mm of air gap to the PCB. This configuration leads to the PCB exerting a small force on the module in the downward direction towards the heatsink. While this situation is ideal, it is not required. However, it is crucial that the PCB mechanical supports do not exert an upward force on the module's pins, pulling the module away from the heatsink and possibly decreasing thermal performance. Therefore, if the press-in process results in the distance being less than 12.45 mm, the height of the PCB's mechanical supports must be reduced. When this idea is extended to multiple modules on the same heatsink and PCB, the height tolerance of the PCB's mechanical supports and the modules must be considered at every place that there is a support for the PCB, which should be located symmetrically about the power modules. If a gap exists between the PCB and module housing, the PCB must not be screwed down to the module using the mounting holes, as this would result in an upward force on the module away from the heatsink.

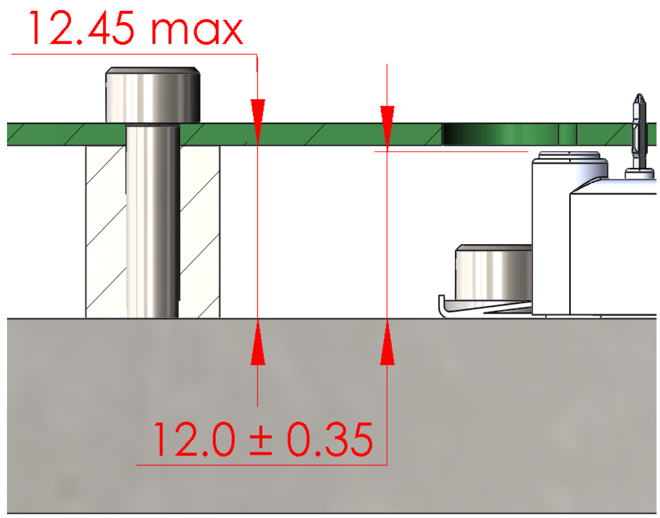


Figure 25. Air gap indicating that no PCB mounting screws needed

8.1 Mounting Multiple Modules

In applications involving multiple modules, the best approach to avoid tolerance stacking issues is to first press all the modules into the PCB while enforcing the proper height H (denoted in Figure 26), apply TIM to the modules using the procedure outlined in Section 6, and finally place the assembled PCB with modules onto the heatsink and attach the modules to the heatsink using a recommended method from Section 7. This process is outlined in Figure 26. Mounting all modules into the heatsink first and then pressing them into the PCB does not allow for slight variations in the modules' height and may result in unwanted force being placed on the terminals of some modules. Furthermore, using the recommended procedure circumvents the need to have at least 5 cm between the module and the PCB supports.

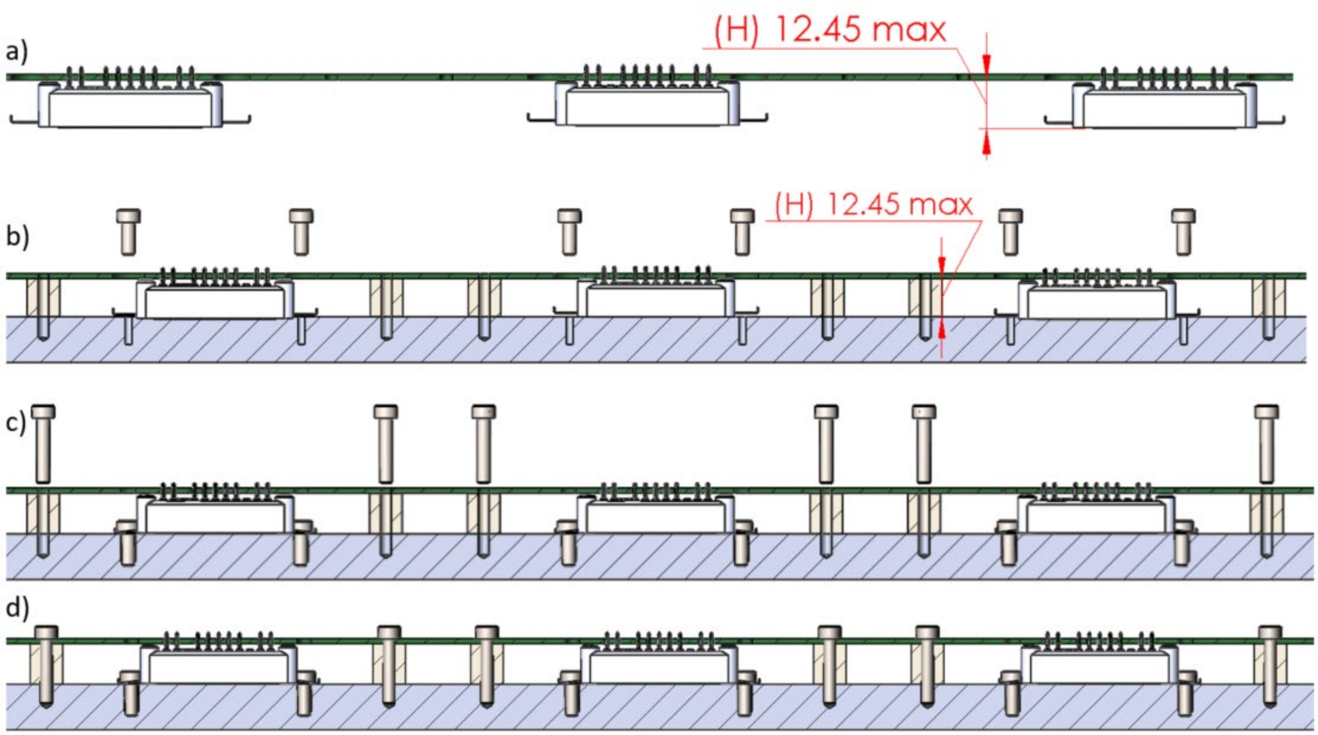


Figure 26. Multiple Module Tolerance Considerations and Assembly Sequence

9. Creepage and Clearance Considerations

In many cases, minimum specific creepage and clearance distances must be satisfied to meet application specific standards. These distances should consider the distance from the top of the mounting screw head to the bottom of the PCB, which will vary depending on the screw that is selected. For a Wolfpack module used in conjunction with a DIN 912 M4 hexagon socket head screw and a DIN 125 M4 washer, the distance from the top of the screw head to the bottom of the PCB is 6.8 mm, as shown in Figure 24. If left unconsidered, placing through-hole or other current carrying devices on the PCB in the area above the screw head may violate many creepage and clearance standards.

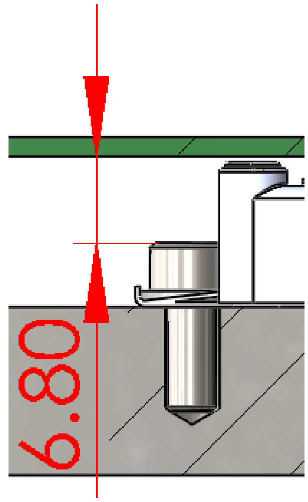


Figure 27. Special Creepage and Clearance Considerations

Revision History

Date	Revision	Changes
January 2020	1	Initial release.
November 2021	2	Updated with GM3 information
September 2023	3	• Table 1 and Figure 5 updated. Press-in force values are updated to 60N and 120N on page 9. • FM3 pre-applied TIM image added (Figure 19). • Press out fixturing and Figure 14 updated. • Figure 20 added.