# CPWR-AN41
# FM3 Mounting Instructions and PCB Requirements


*This document is prepared as an application note to install Cree® evaluation hardware. All parts of this application note are provided in English. If the end user of this reference design is not fluent in this language, it is your responsibility to ensure that the user understands the terms and conditions described in this document, including without limitation the hazards of and safe operating conditions prior to use / implementation.*

# Contents



# List of Figures

# 1. Introduction

This document describes the correct procedure for mounting printed circuit boards (PCBs) to WolfPACK™ series power modules that are designed to connect to PCBs via the press-fit contact method. Additionally, this document details the correct process for mounting WolfPACK™ series power modules to a heatsink.

**Before operating the system, please carefully review the operating limits for Cree's FM3 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.**

Press-fit is a method of connecting power modules to a PCB which circumvents the need to solder or use hardware to attach the module's terminals to a PCB. While greatly speeding up the assembly process and achieving very low contact resistance, 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. For safe and reliable operation of the FM3 series modules, it is recommended to follow the guidelines outlined in this document.

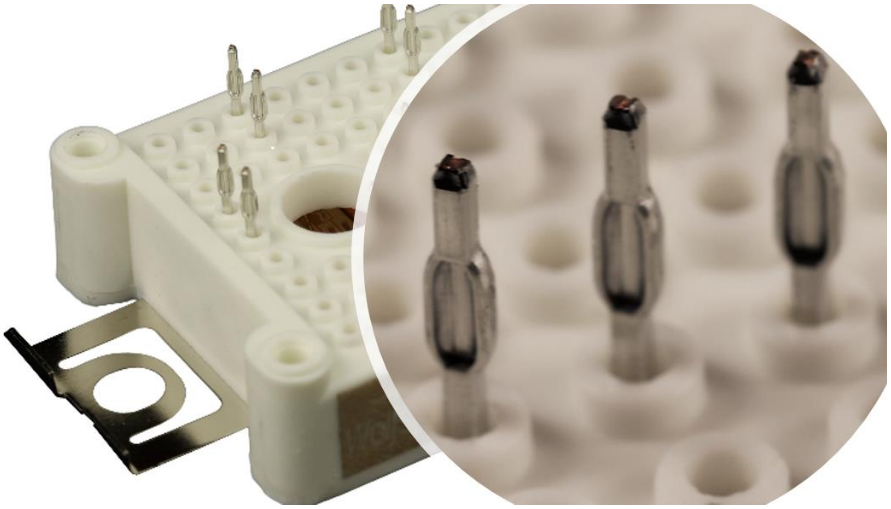


*Figure 1 Press-Fit Contacts*

### 1.1. Handling

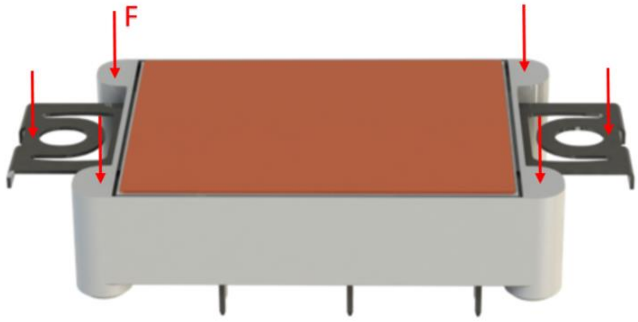



*Figure 2 Destructive Forces on FM3*

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 as such, applying a force to the housing as shown in Figure 2 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. These attributes are not a practical issue, however, as the housing and substrate's positions become fixed relative to each other in any practical application in which the module is mounted to a heatsink.

# 2. PCB Requirements

FM3 series modules are designed to be pressed into a PCB with a maximum thickness of 2 mm. The module mounting dimensions, depicted below, show that the pin pitch is 3.20 ±0.2 mm and the distance between mounting holes is 53 ± 0.1mm.

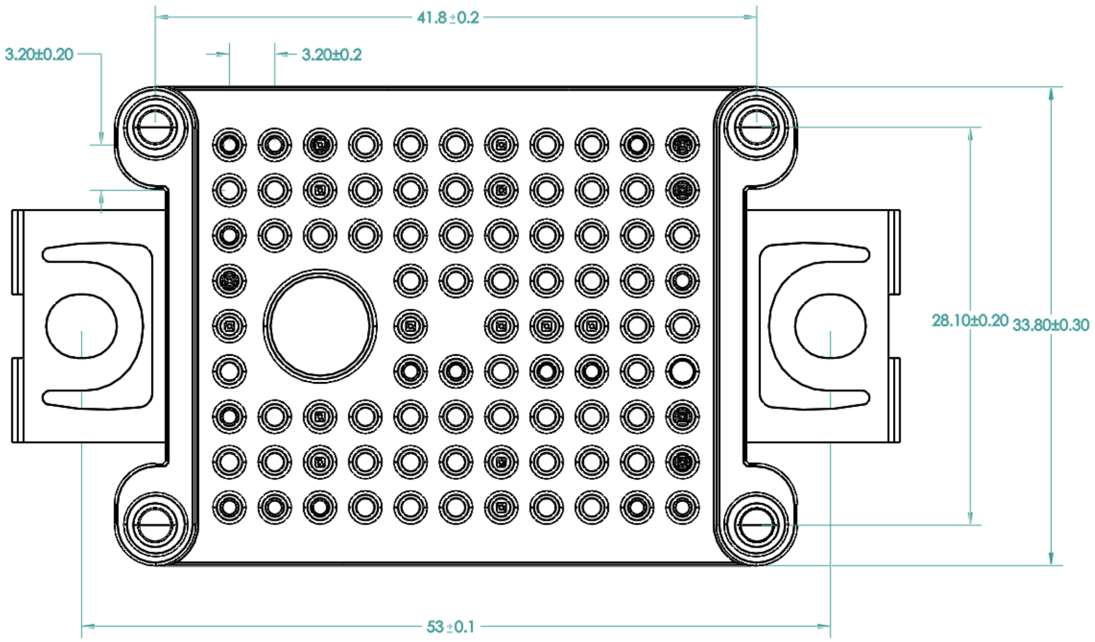



*Figure 3 FM3 Key Dimensions*

The FM3 series 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. To ensure this high reliability connection, FR4 PCBs should adhere to International Electrotechnical Commission (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 multiplayer 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 Cree to validate such PCB specification modification.

*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 | 0.99 mm | | 1.09 mm |
| Copper thickness of conductors | 35 µm | 70 µm<br>105 µm | 400 µm |
| Metallization of circuit board | Tin (chemical) recommended | | |
| Metallization of pin | Tin (galvanic) | | |

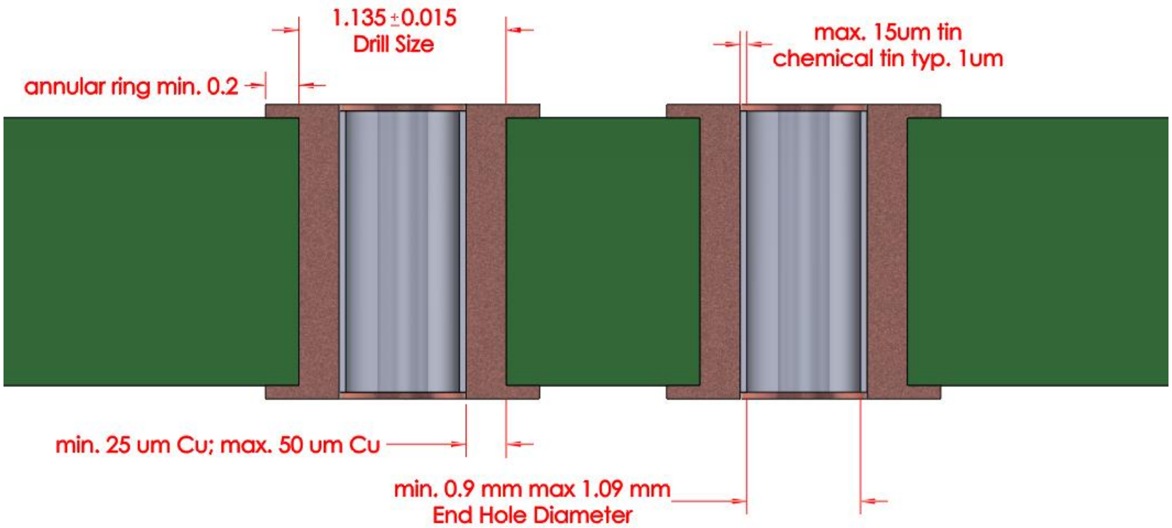



*Figure 4 Recommended PCB Structure*

PCBs that are designed following the above standards may have an FM3 series module pressed in up to three times – that is, the FM3 can be replaced up to two 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 is hindered and it is recommended to solder the module pins to the PCB.

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 Figure 5. 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.

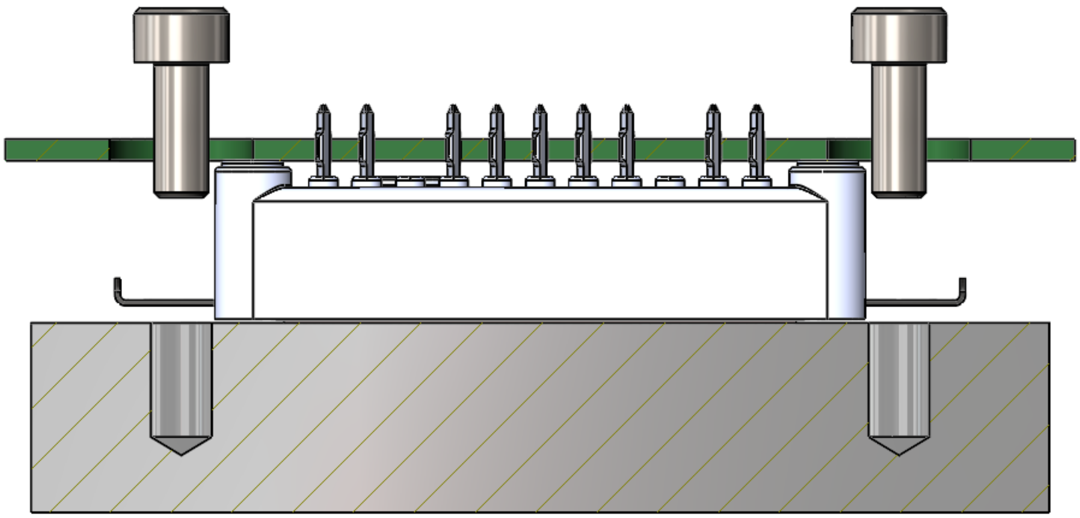
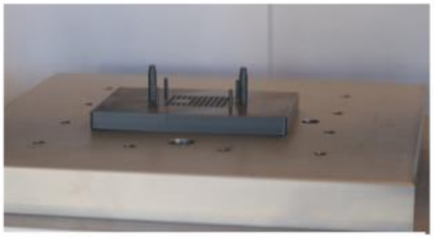


*Figure 5 Module with Cross-Sectional View of Heatsink and PCB with Module Mounting Screws*

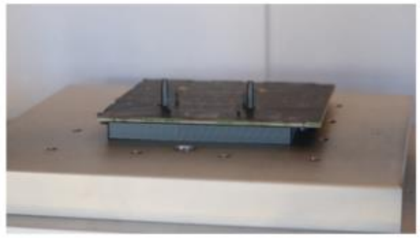
# 3. Press-In Process

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 records the pressing force and travel distance. 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 simplifies the press-in procedure and fixturing requirements. This recommendation however, generally requires that the PCB has holes in it to allow the mounting screws to be placed and tightened, as shown in Figure 5 above.

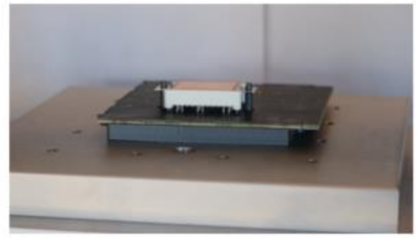
After verifying that the position of the PCB is fixed, verifying that the module's pins are aligned with the corresponding holes in the PCB, and verifying that the surface of the tool used to place force onto the PCB is parallel to the PCB and to the substrate of the module, the module may be pressed 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.



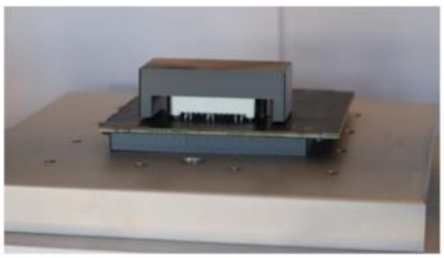
1.
Bottom piece of fixturing placed into press directly under press ram



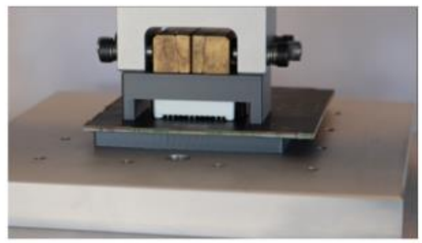
2.
Holes are aligned and PCB is placed onto bottom fixturing piece



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 6 Ideal Press in Process for Single Module*

The speed of penetration should be a minimum of 25 mm/min to satisfy IEC 60352-5, but 100mm/min is the recommended speed. Speeds of 450 mm/min are commonplace in automated assembly lines. An insertion speed of less than 25mm/min will 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 40 and 80 newtons.

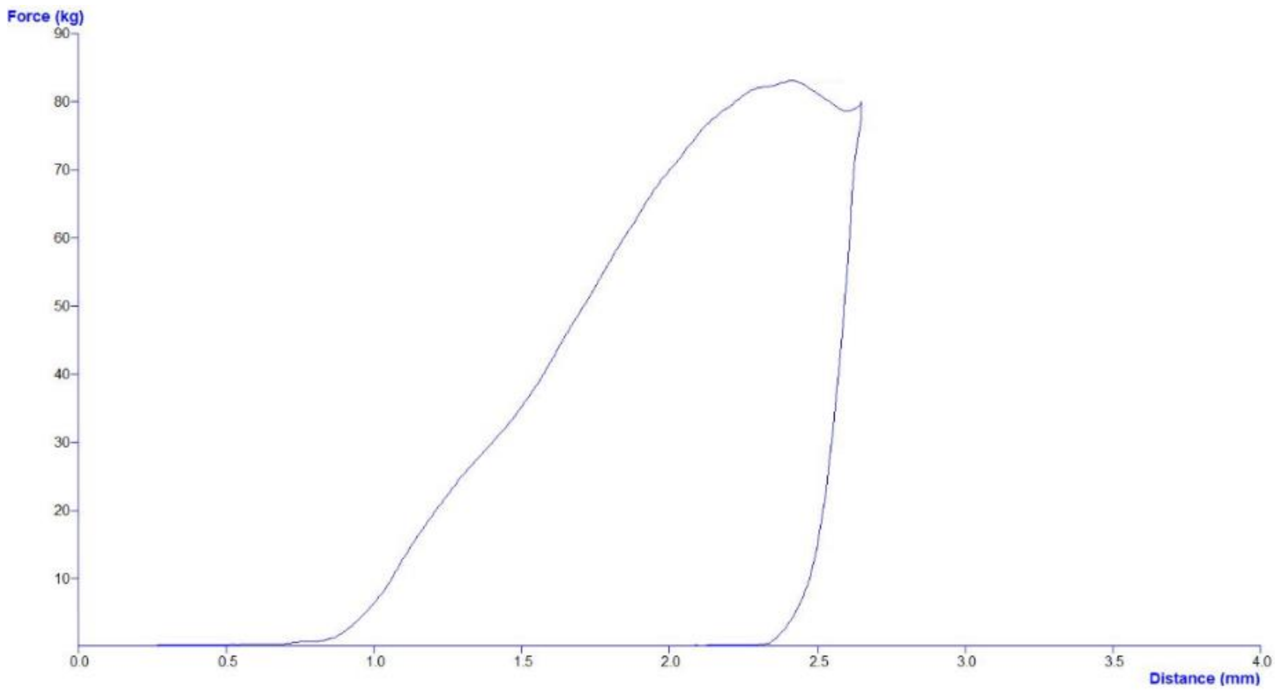



*Figure 7 Typical Press-in Force Profile for 21 Pin FM3*

As mentioned in the previous section, press-in fixturing is recommended to be used in conjunction with a machine or press to help ensure consistent connection quality. While the purpose of the machine or press is to provide a consistent seating force, the fixturing 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 surface for the PCB to stop against to provide consistent seating depth.

CAD files for the fixturing shown below 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.

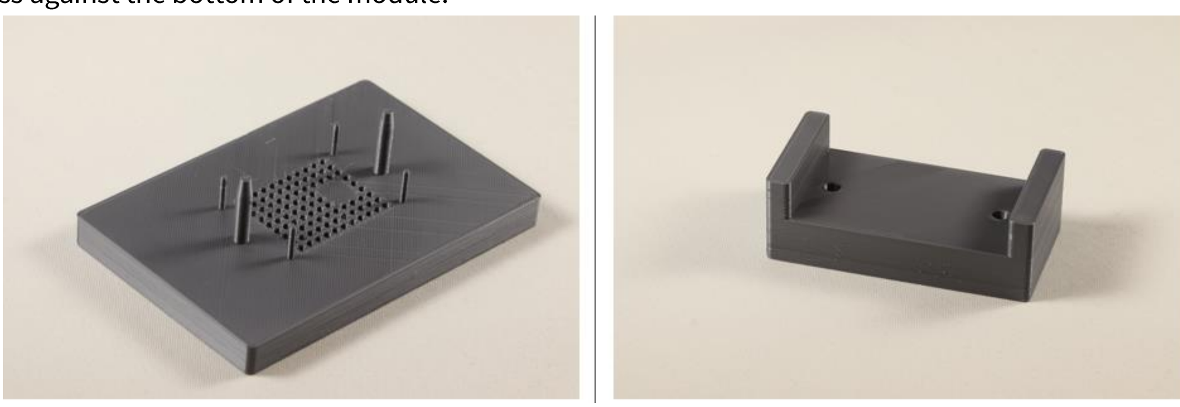


*Figure 6 Press-In Fixturing*

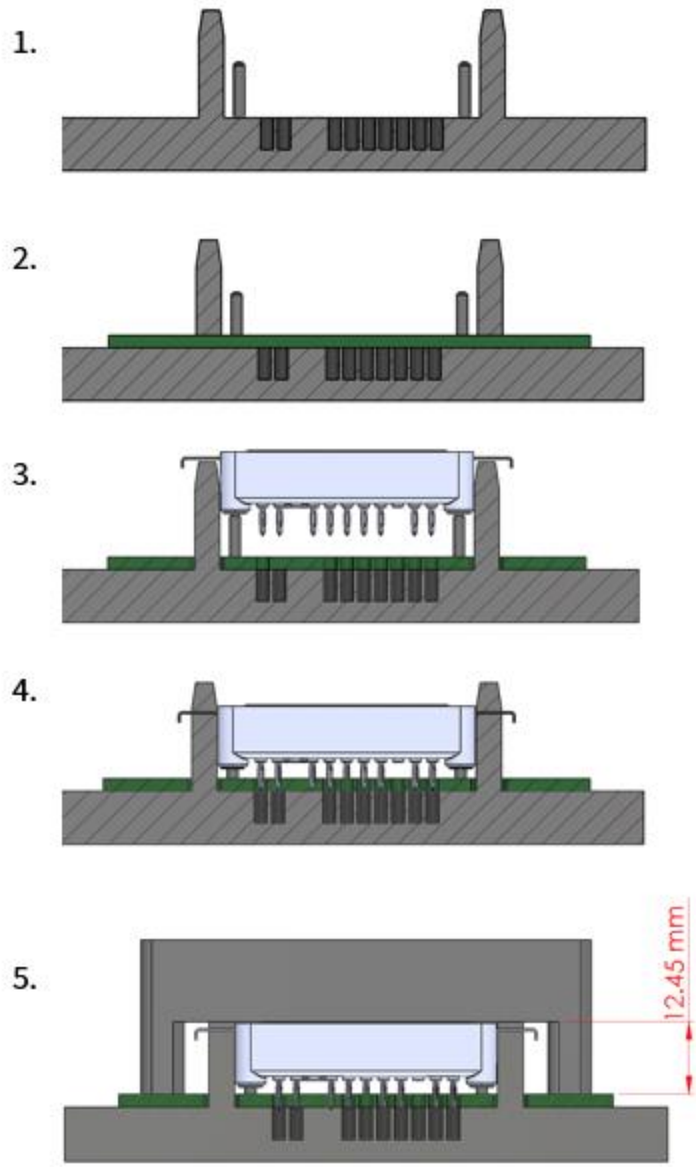



*Figure 7 Press-In Steps*

The press-in fixturing should be designed so that the distance from the bottom surface of the module to the bottom of the PCB, H, is a maximum of 12.45 mm from the bottom of the PCB once pressed in, as shown in Figure 9.

4. 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. The pressing operation should be smooth and regular, with a force of >40 N per pin.

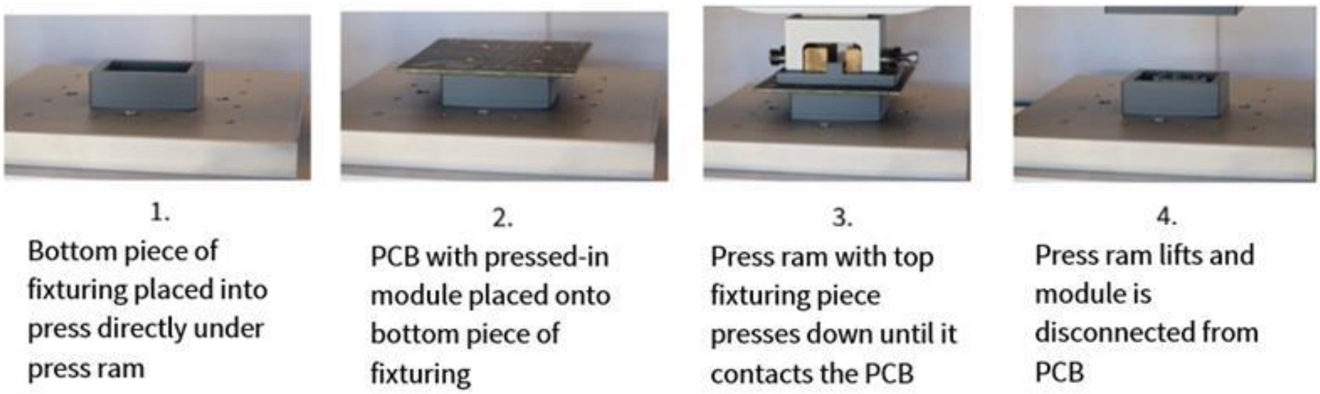



*Figure 8 Ideal Press-Out Process*

## 4.1. Press-Out Fixturing

Press-out fixturing for FM3 series modules should consist of a flat plate used for pressing the pins of the module and a base that is used to hold the PCB in a fixed position while giving the module a place to drop after the press-out process is complete.

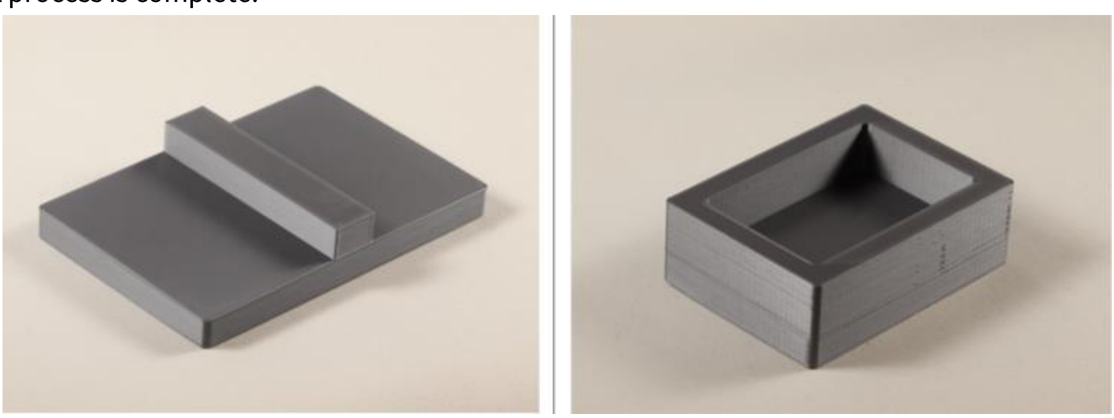


*Figure 9 Press-Out Fixturing*

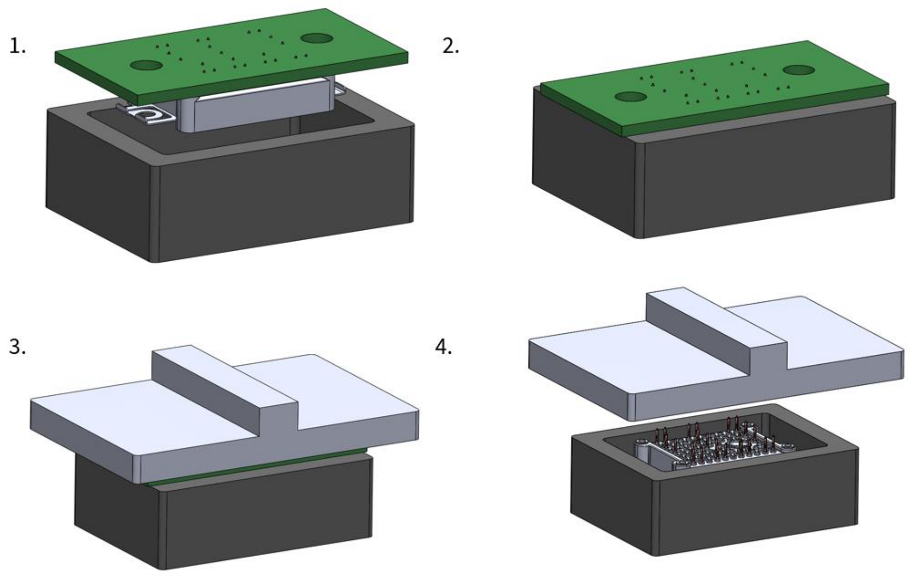



*Figure 10 Press-Out Process*

# 5. 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%
- E JOT ® DELTA PT WN5451 K25
  - Mounting Torque = 0.4 Nm ±10%
- M2.5 x L, depending on PCB thickness


*Figure 11 FM3 PCB Mounting Holes*

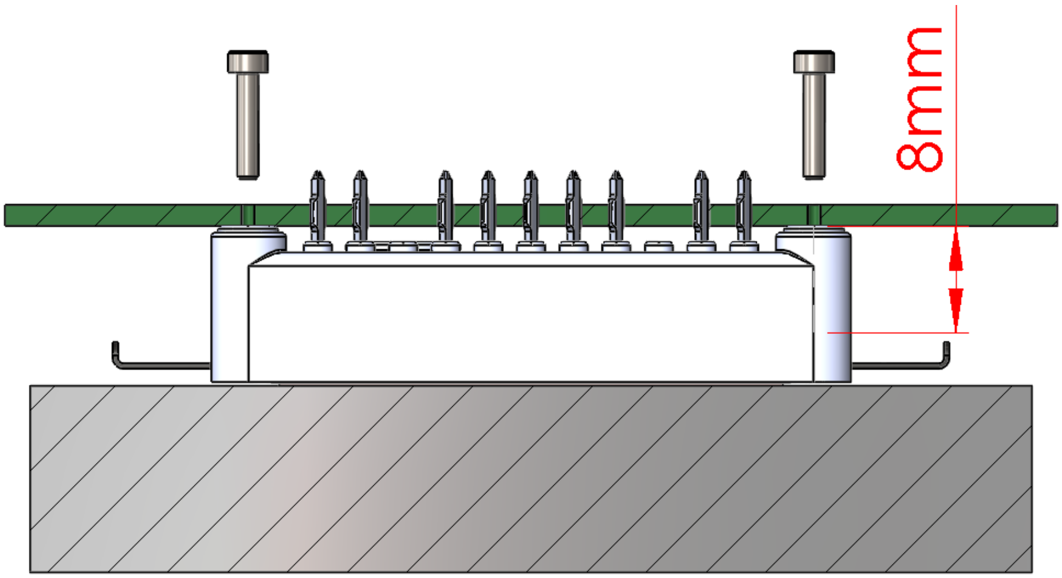



*Figure 12 PCB Mounting Hole Penetration Depth*

If different mounting screws are used, care should be taken to ensure that the initial 1.5 mm of the mounting holes are not used as thread engagement, as their only purpose is to serve as a guide for proper alignment. PCB mounting screws should be inserted straight into the mounting holes using an electric screwdriver with rpm < 300. Pneumatic or manual screwdrivers are not recommended. Inserting a screw with rpm > 300 or while misaligned may cause the housing to split. The maximum force that should be applied to the module via the PCB mounting holes is 20 N.

# 6. Heat Sink 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, and voids will therefore exist within the region where 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 ≤ 50 μm.

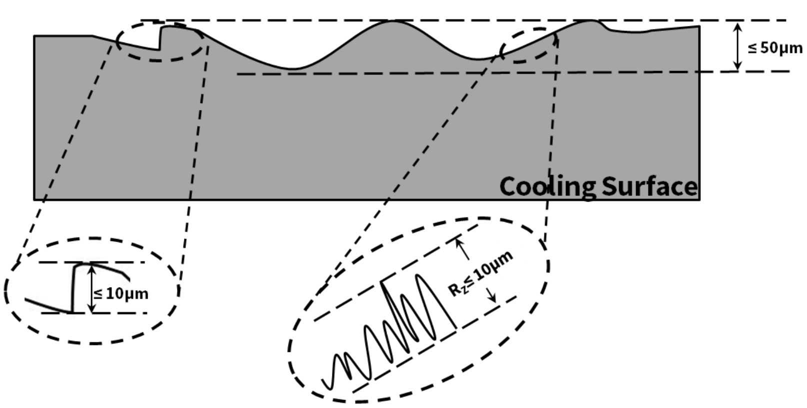



*Figure 13 Heatsink Requirements*

A thin layer of thermal interface material (TIM) should be applied to either the bottom surface of the module or the mounting surface of the heatsink. Ideally, this layer of TIM will fill 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 a stencil fixture, as described in further detail in Cree's FM3 TIM Application Note, Document CPWR-AN42, 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 "Module Mounting" section of this document.

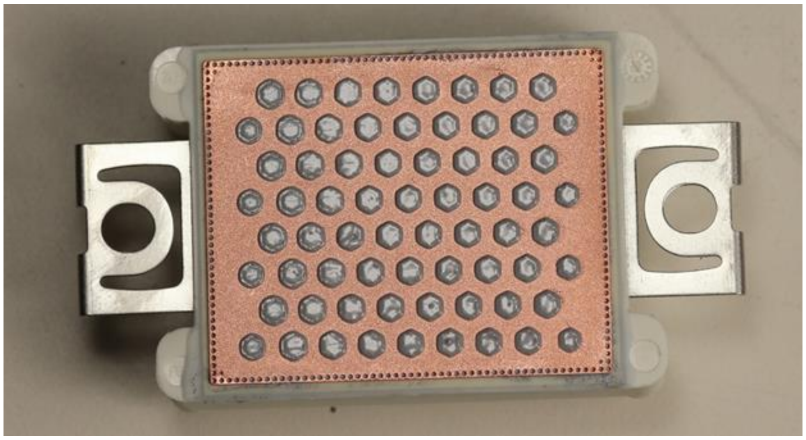


*Figure 14 FM3 with Stencil-Printed TIM Layer*

# 7. Module Mounting

The module is attached to a heatsink using two M4 screws with the mounting locations as shown in Figure 5. When mounting the module, it is imperative that the module's mounting surface remain in full contact with the heatsink. 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:

Method 1: Insert both screws and tighten them simultaneously.

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

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.

*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<br>Aluminum alloy hardened<br>Aluminum cast alloy | 6.4 mm<br>4.8 mm<br>8.8 mm |

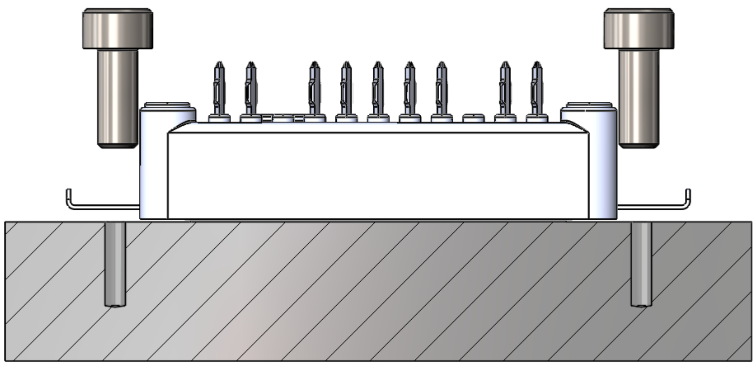


*Figure 15 FM3 Mounting Method 1*

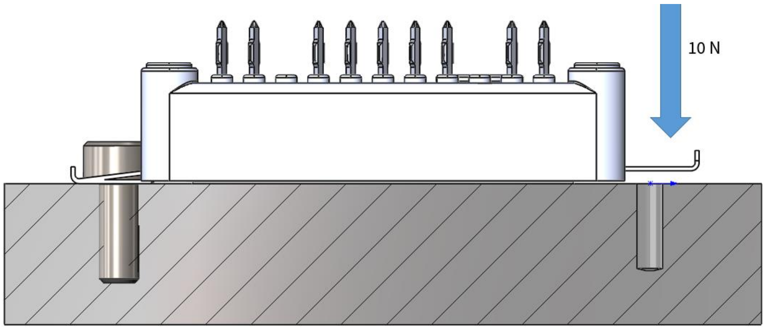



*Figure 16 FM3 Mounting Method 2*

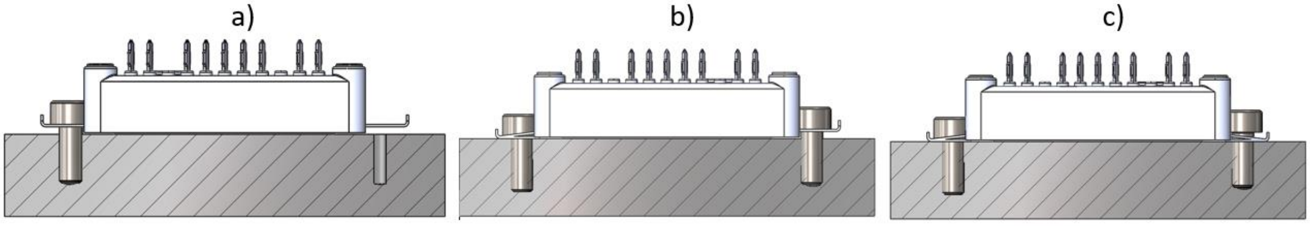



*Figure 17 FM3 Mounting Method 3*

# 8. System Considerations

The maximum 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 as 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. If the module is pressed into the PCB prior to being mounted to a heatsink, the bolt that 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.

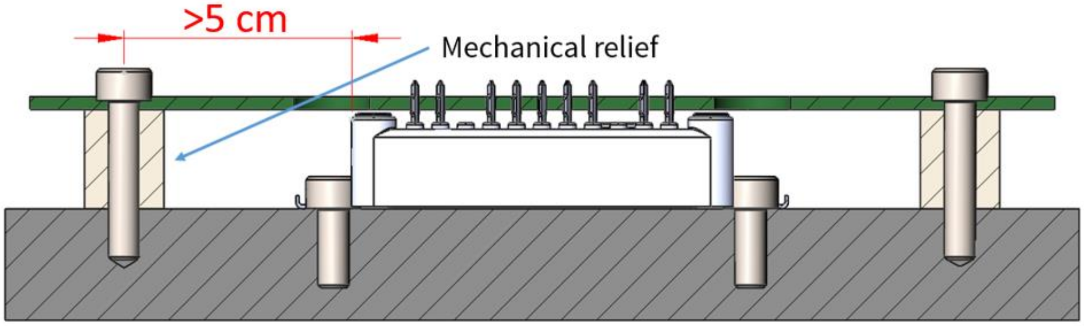



*Figure 18 PCB Mechanical Relief*

As stated previously, once pressed in, the distance from the bottom surface of the module to the bottom of the PCB, H, should be a maximum of 12.45 mm which results in a small gap between the PCB and module. If the PCB rests directly on the top face of the module, the distance H becomes 12.00 mm. Ideally, the system's PCB mechanical supports have a height of 12 mm and the distance H is 12.45 mm. 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 height of the PCB mechanical supports is not greater than the height H, as this situation would lead to 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 H being less than 12.45mm, 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 shown in Figure 11, as this would result in an upward force on the module away from the heatsink.

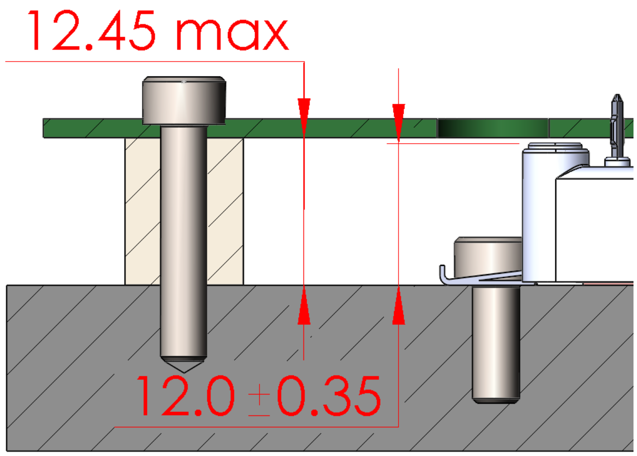



*Figure 19 Air Gap Indicating No PCB Mounting Screws Needed*

In applications involving multiple modules, the best approach to avoid tolerance stacking issues is to first press each module into the PCB while enforcing the proper height H, apply TIM to the modules using the procedure outlined in Section 6, and 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 depicted below. 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.

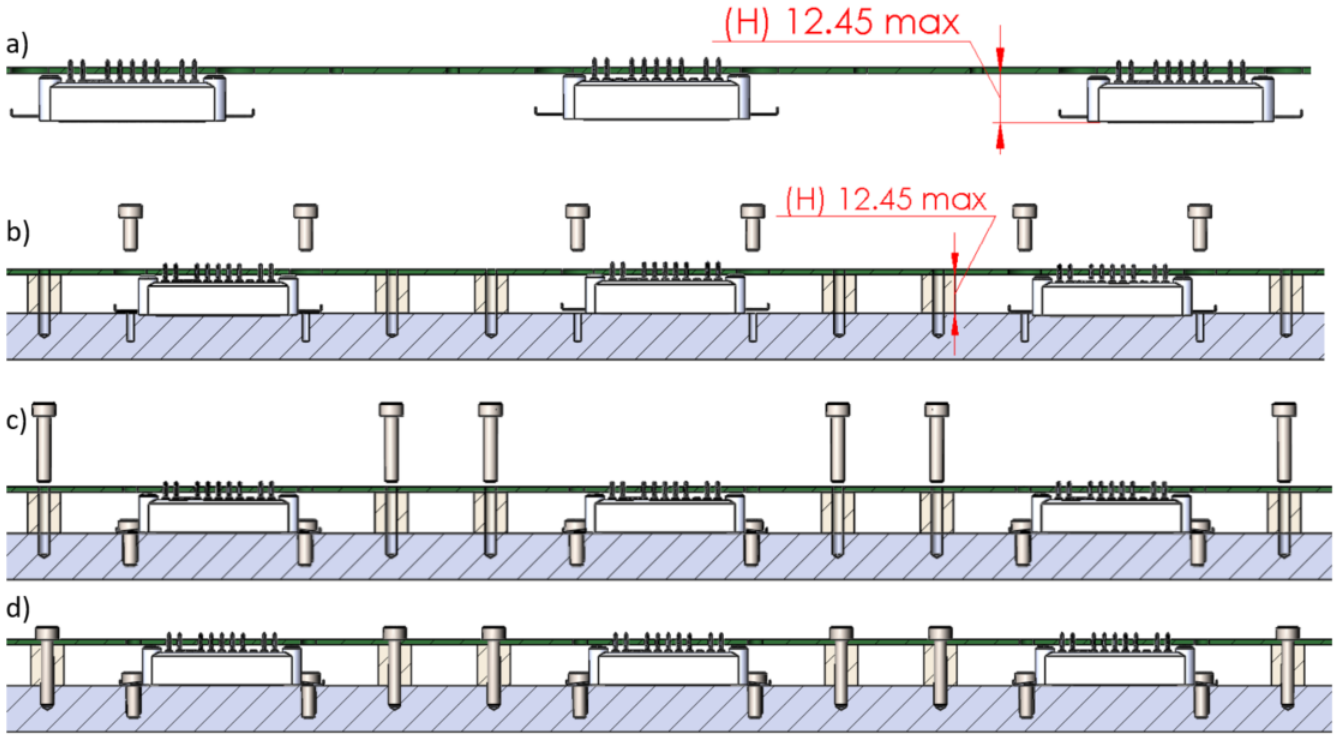



*Figure 20 Multiple Module Tolerance Considerations and Assembly Sequence*

# 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 an FM3 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 18.  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.

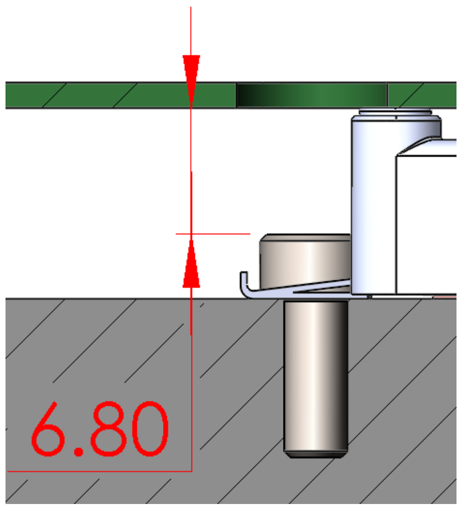



*Figure 21 Special Creepage and Clearance Considerations*

# 10. Revision History

| Revision | Date | Notes |
|---|---|---|
| **1** | 2021-01-11 | Initial Release |