Mounting Guideline for F1/F2 Full Plastic Case Modules with Press-fit Pins

AND90206/D

Introduction

This application note deals with mounting instructions of modules F1/F2 with full plastic case and press-fit pins. It includes specification of press-fit tooling thermal interface material and mounting with thermal interface material.

Features

- Mounting with Pressfit Pins
- Tolling Design
- PCB Specifications
- Thermal Interface Material

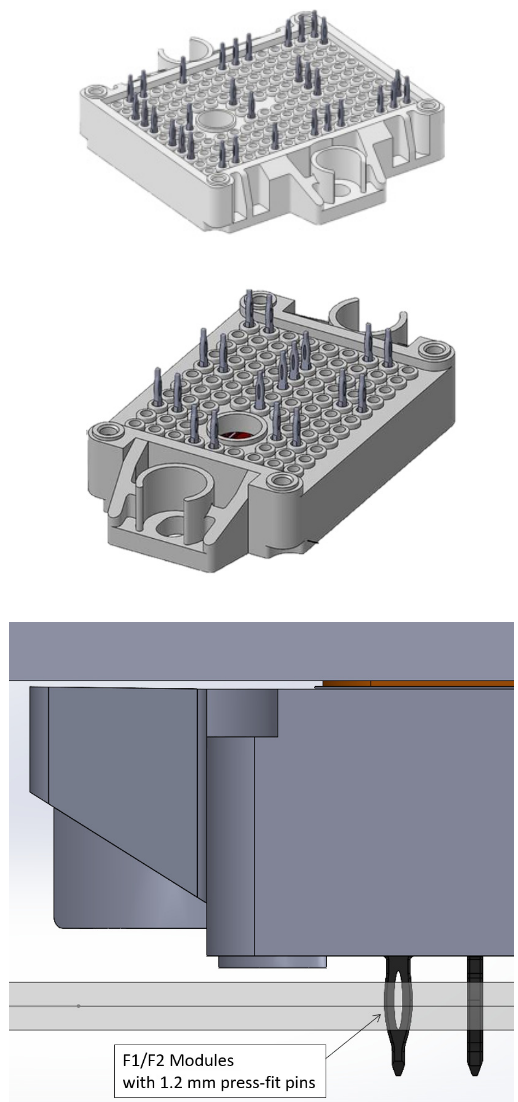

Figure 1. Package Photos

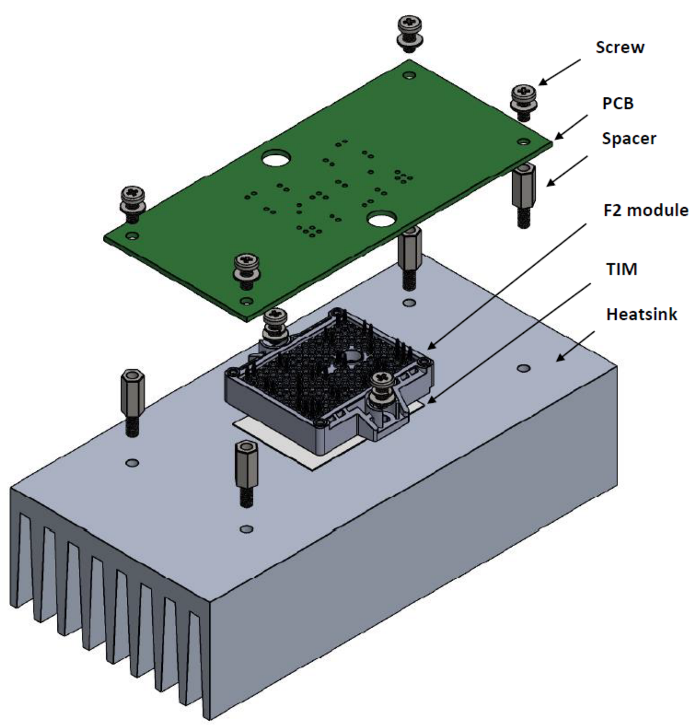

Figure 2. F2 Module Assembly with Heatsink

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Specification of PCB

Minimum PCB thickness is 1.6 mm. Solder mask is recommended on both sides of the PCB. Recommended PCB hole plating options include immersion tin, immersion silver, electroless nickel immersion gold ENIG), and organic solderable preservative (OSP). HAL plating is not recommended. For PCB specifications please see Table 1.

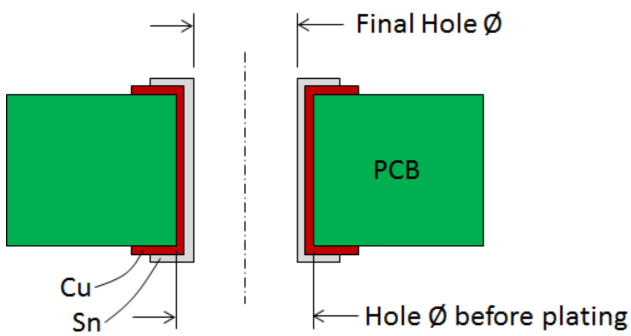

Figure 3. PCB Hole Dimensions

Table 1. PCB SPECIFICATIONS FOR F1 AND F2 MODULES WITH 1.2 MM PRESS-FIT PINS

	Min.	Typ.	Max.
Initial Drilled Hole Diameter Ø [mm]	1.12	1.15	
Cu Thickness in the Hole [μm]	25		50
Sn Thickness [μm] (Chemical Tin)			15
Final Hole Ø [mm]	1		1.09
Annular ring [μm]	200		
Thickness of Conductive Layer [μm]	35	70–105	400
Board Thickness [mm]	1.6		

Design Restrictions within Mounting Area

PCB bending during the press-in process causes mechanical stress to other PCB components, such as capacitors and resistors. Experiments to verify a safe minimum distance between passive components and the plated through hole were conducted with FR4 PCB. Various sizes (0603, 0805, 1206, 1210, 1812, and 2220) of mechanically sensitive components were evaluated. Based on experimental results, the recommended minimum space between center of the plated through hole and the edge of the component is 4 mm, as shown in Figure 4.

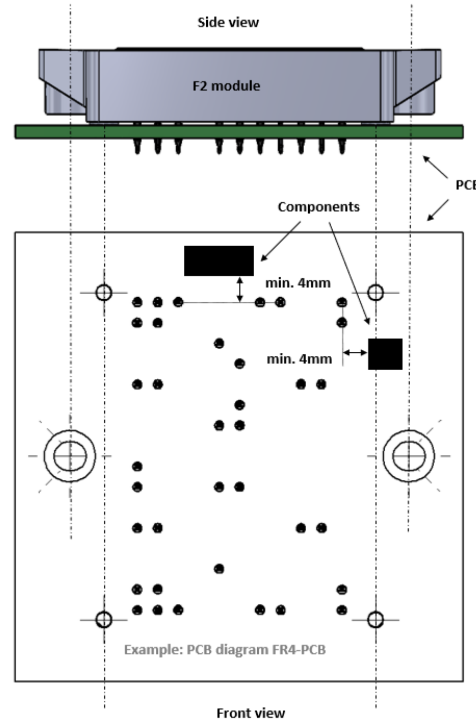

Figure 4. PCB Layout Restrictions

PCB Fixing and Dimensions

Spacers should be used to fix the PCB to the heatsink. Number of space posts is not given. Space posts positions should be designed symmetrically, weight of the PCB components should be considered. PCB bending or flexing should be avoided. Distance from the space post to the module (dimension x) is recommended to be at least 10 mm from module outer edges.

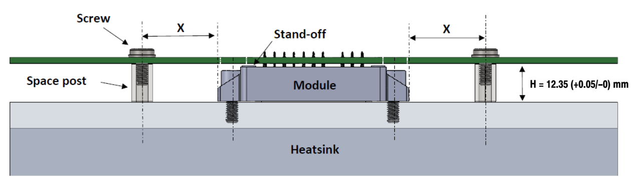

Figure 5. Module Fixed on a Heatsink

Length of the space posts should match the length of press-in tool distance keeper – see section Press-in tool for F2 package.

Recommended length of the space post is 12.35 (+0.05/−0) mm. An air gap may be present between the module and PCB (as in Figure 5), this airgap allows tolerance of the module case.

Press-in Process

The press-fit connection generates a good electrical, and strong mechanical connection between the module and the PCB. This section deals with the mounting process to achieve suitable press-fit connections here are several types of presses available: from simple toggle presses to the automated pneumatic presses shown in Figure 6.

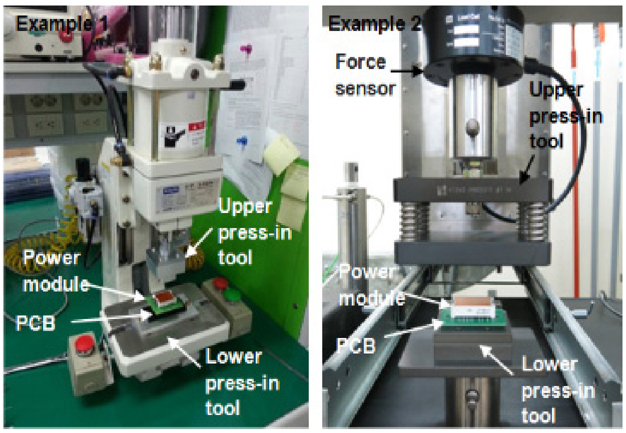

Figure 6. Press-in Machine Example

If possible, monitor the press-in/press-out distance, speed, and force to achieve mechanical stability and high reliability of the press-fit connection. The travel distance during the press-in process should be controlled to ensure that the press-fit zone of the pins sits properly in the plated through hole. The speed also influences the quality of the press-fit connection; therefore, speed recommended by IEC standard should be applied.

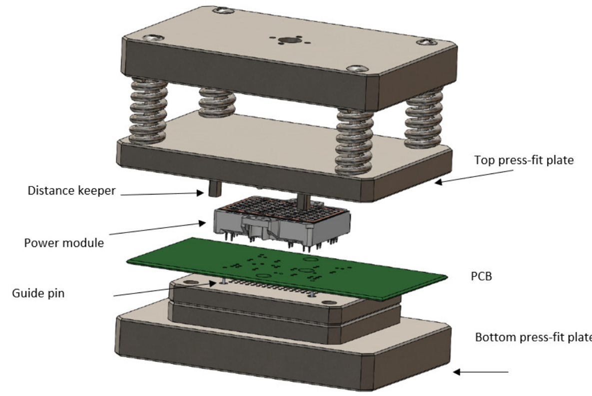

Figure 7. Pressfit Tool for F2 Module

General Press-in Process

Use of tooling with distance keeper is recommended. Figure 8. Shows the general sequence of press in procedure. Press-in procedure. The press-in tool is comprised of two parts: the upper press-in tool is flat (or with special design for modules with TIM. Please see Press-in tool for module with PCM section) to contact with the module backside evenly and the lower press-in tool has engraved spaces to accommodate the press-fit pins and PCB components. The two parts of the tool need to be aligned to each other. In the first step of the assembly, the printed circuit board is placed on the alignment pins of the lower part of the press-in tool (a). Then, the module is placed on top of the printed circuit board using the alignment pins (b).

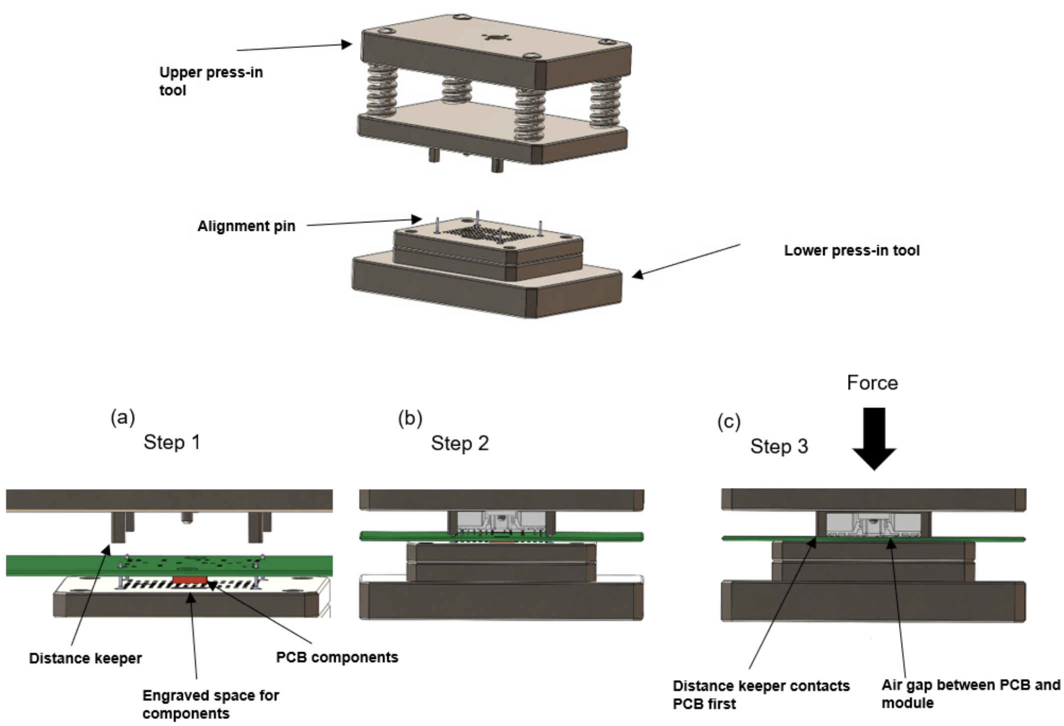

Figure 8. Press-in Process

It is necessary to check if the module and the printed circuit board are in alignment. In the next step, the press-in force is applied via the upper part of the press-in tool to the backside of the module evenly. The module should be pressed-in with a speed of 25~50 mm/min until the distance keepers of the upper tool touch the PCB while press-in distance and force are monitored at the same time (c). It is required to adjust the traveling distance of the press to avoid damages to the module case due to pressure being applied. A simple manual press does not use a distance sensing system, so a distance keeper should be designed on the press-in tool to terminate press-in process appropriately. When the distance keeper contacts the surface, press-in force rises sharply, and the press-in process can be terminated by reaching the limit of the press-in force. The distance keeper should be designed to avoid the collision with other PCB components.

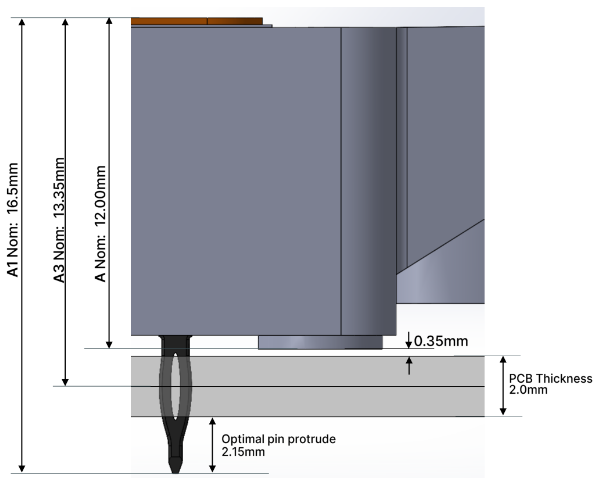

Figure 9. Typical Dimensions After Press-Fit Process

F2 Module dimension parameters			
A	Package height (DBC bottom to case top)	Nominal: 12.00 [mm]	Min: 11.65 [mm] Max: 12.35 [mm]
A1	Total height (DBC bottom to top of pins)	Nominal: 16.50 [mm]	Min: 16.00 [mm] Max: 17.00 [mm]
A3	DBC bottom to center of pressfit pin fish eye	Nominal: 13.35 [mm]	Min: 12.85 [mm] Max: 13.85 [mm]

Distance keeper calculation example with PCB thickness **2.0 mm and 2.2 mm**			
PCB thick.	Definition	D.K. Calculation	Note
2.0 mm	Optimal value Height of distance keeper of "U–shape" tool	A3 – (PCB thickness/2) = 13.35 – (**2.0**/2) = **12.35** [mm]	The height of distance keepers should be **12.35mm**
2.2 mm		A3 – (PCB thickness/2) = 13.35 – (**2.2**/2) = 12.25 [mm]	Ideal height of distance keepers would be 12.25mm, but we must consider – **A** dimension max. tolerance 12.35mm. So recommended value is **12.35mm**
	Air gap between case top and surface of PCB	Nominal: A3 – A = 0.35 [mm]	The height of spacers to support PCB from the heatsink = Recommended tolerance height of distance keeper +0.05 mm / –0mm

The total press-in force is the result of the number of pins in a module, multiplied with the force required for a single pin. Press-in forces lower than 40 N/pin mean that press-fit pin may have a less secure connection in the plated through hole. The primary reason for the low press-fit force is that the diameter of plated through hole is too large for the press-fit pins. Press-in forces higher than 80 N/pin can cause mechanical damage to the press-fit terminal, the PTH, or to the tracks on the PCB. The recommended press-in speed ranges from 25 mm/min to 50 mm/min in accordance with the recommendations in IEC 60352-5.

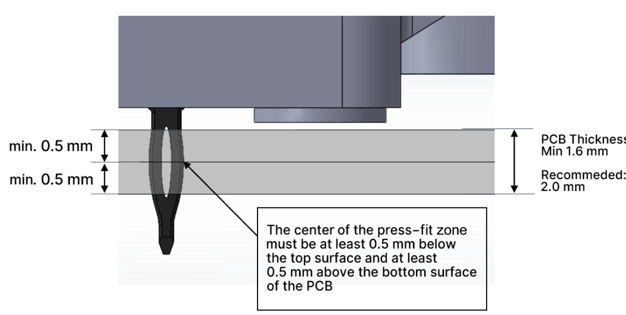

Figure 10. PCB Thickness Specification

The press-fit pins must be pressed into the holes of the PCB to the correct depth. The center of the press-fit zone has to be at least 0.5 mm below the top surface and at least 0.5 mm above the bottom surface of the PCB (Figure 10).

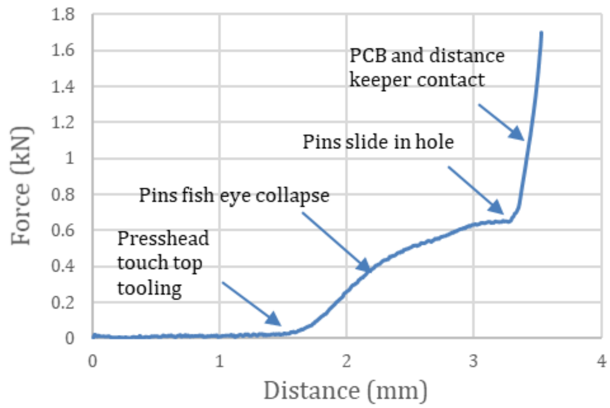

Figure 11. Force vs. Distance during Pressfit Process

Force measured in a module is a sum of all pins being pressed at once (Figure 11).

Force measurement per one pin was conducted, the press-fit pin was mounted in 1.6 mm thick PCB with chemical Sn surface finish. Test conditions and PCB specification are compliant with IEC 60352-5.

Table 2. SINGLE PRESS-FIT PIN TEST

	Press-in Force		Press-out Force	
PCB hole	f0.98 – 1.02 mm	f1.11 – 1.12 mm	f0.98 – 1.02 mm	f1.11 – 1.12 mm
	(min)	(max)	(min)	(max)
Minimum	49.8 N	40.9 N	29.4 N	38.3 N
Mean	55.9 N	47.4 N	40.5 N	48.2 N
Maximum	62.1 N	57.1 N	48.0 N	65.9 N
Sample size	20	20	19	20

Press-in Tool for Module with PCM

To prevent damages on PCM peripheral spacers and point spacers are required. This spacers should not touch PCM on the DBC. 0.4 mm is recommended for the height of spacers. Distance keeper of the press-in tool needs to be 0.4 mm taller than no PCM cases.

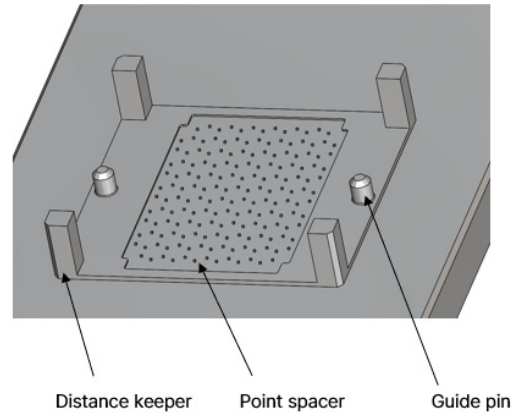

Figure 12. Press-fit Tool for F2 Module with PCM

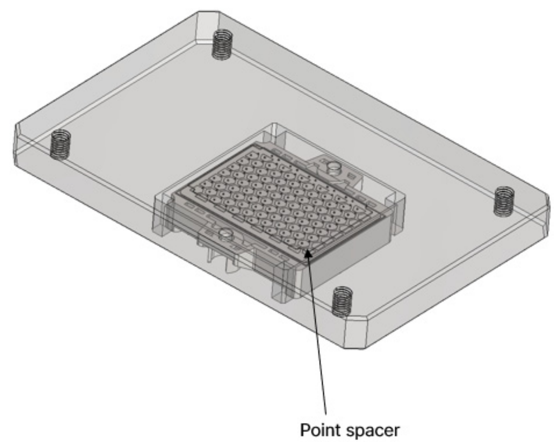

Figure 13. Point Spacer Alignment with PCM

Peripheral spacer and point spacer prevent pre-applied PCM from being deformed or damaged during press-in process. Peripheral spacer distributes mechanical stress by press-in process over the edge of DBC

Press-out Process

In some situations, it is necessary to remove power modules from the PCB. It is possible to disconnect the contact between module pins and PTH. The press-out process can be performed with the same equipment used in the press-in process. Careful handling in the press-out process is essential to avoid mechanical damage to both the module and the PCB. PCB can be re-used once with a new module. Please note: in case a module which was pressed out of a PCB should be used again, it is necessary to solder the module to the PCB; this is because the press-fit zone will remain deformed after the press-out process. An additional press-in cycle will result in low holding forces between the press-fit pin and PCB hole.

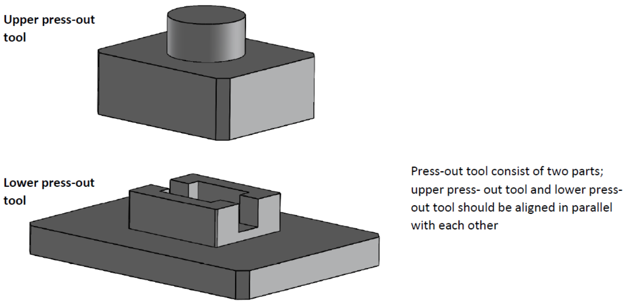

Figure 14. Press-out Tool

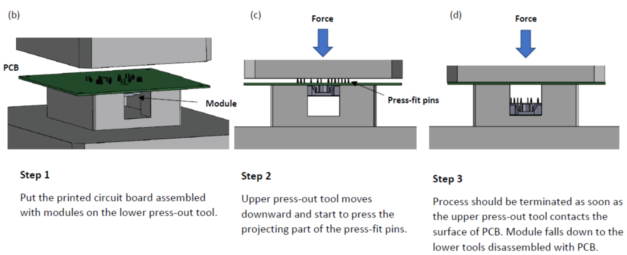

Figure 15. Press-out Process of Power Module

Heatsink Specification

The following surface qualities are required for the heatsink to achieve a good thermal conductivity, according to DIN 4768-1. Roughness (Rz) should be 10 μm or less and flatness, based on a length of 100 mm, should be 50 μm or less. The heatsink should have no contamination, unevenness, and burrs on the surface contacting the module.

The interface surface of the heatsink must be free of particles and contamination. Avoid handling the heatsink surface with bare hands or contacting any foreign materials. If it is necessary to remove contamination from heatsink, cleaning can be accomplished using dry cloth soaked with solvent, such as isopropyl or ethylene alcohol.

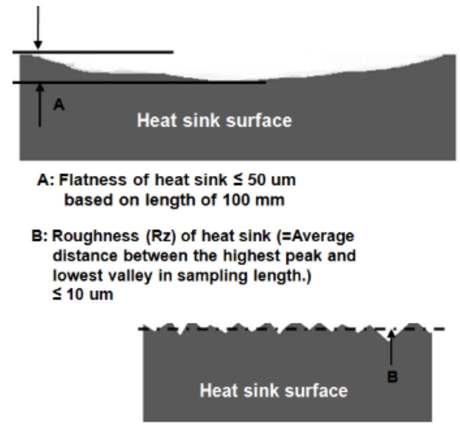

Figure 16. Heatsink Surface Specification

Thermal Grease

Thermal grease can be applied to the heatsink or the module substrate using a rubber roller or spatula or by screen printing. Alternatively, apply thermal paste by screen printing, for example using a honeycomb pattern. The recommended thermal paste thickness is 80−180 μm. Thickness of the TIM layer more than this recommendation will unnecessarily increase thermal resistance. When applying thermal grease, the material must be applied uniformly on the whole surface which is in contact to the module substrate surface. If the module is re-mounted, surfaces should be cleaned, and TIM needs be applied again.

Pre-applied Phase–Change Material

Modules can be pre-applied with phase-change material. Typical thickness of the TIM layer is 160 μm and its thermal conductivity is 3.4 W/mK.

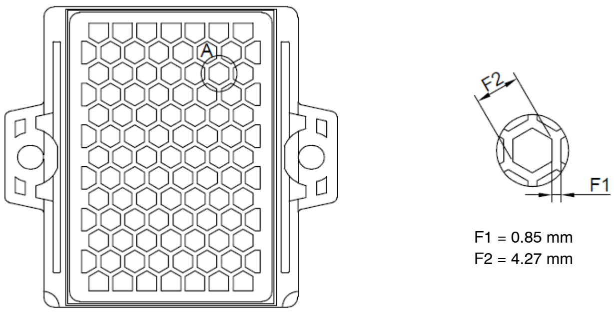

Figure 17. Tim Pattern Example on F2 Module

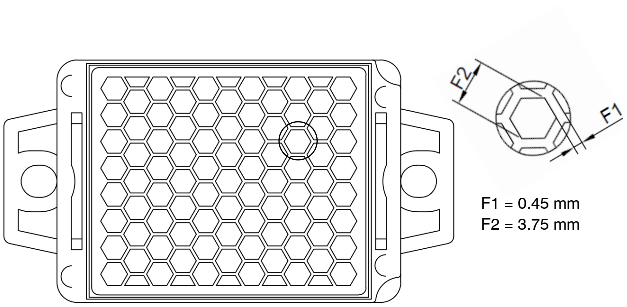

Figure 18. Tim Pattern Example on F1 Module

It comes pre-applied on the DBC surface ready to be mounted on the heatsink. The honeycomb pattern allows the press tool to touch copper DBC and allows PCM to spread on a whole surface. For proper TIM spreading in application, TIM spreading temperature must be achieved on the TIM material, this temperature is specified as minimum 45 °C. For best spreading results it is recommended to apply 80 °C for 20 minutes.

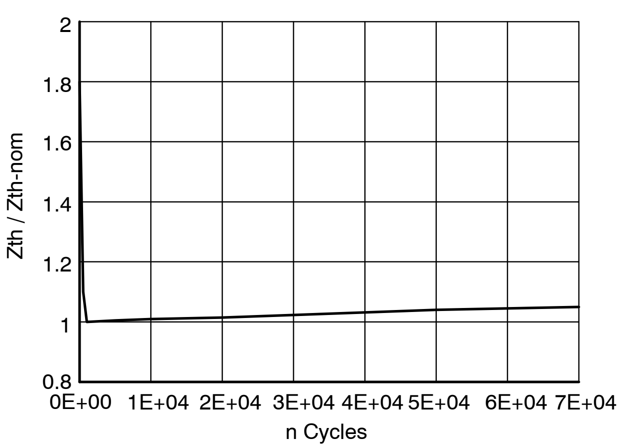

Figure 19. Thermal Impedance Affect by Power Cycling

When the module is assembled and the TIM layer is not fully melted, the thermal impedance is relatively high. Once the device is under load and begins temperature cycling, the thermal impedance decreases to its nominal value.

Final Thickness after Mounted on Heatsink

We specify the PCM layer thickness in the datasheet, typically 160 μm or 120 μm. When the module is assembled on heatsink and undergoes thermal cycling, the PCM melts, resulting in a reduced final thickness of the PCM/TIM layer. For calculating the final TIM thickness in F1 and F2 modules, we can use the following conversion ratios:

- For the F1 module, the final TIM thickness is calculated using a conversion ratio of 0.63:
  F1_final thickness = 120 μm × 0.63 = 76 μm
- For the F2 module, the final TIM thickness is calculated using a conversion ratio of 0.53:
  F2_final thickness = 160 μm × 0.53 = 86 μm

Screw Specification

When using screws with flat washers:

- Metric screw: M4 (recommended screw type DIN7984)
- Flat washer: D = 8 mm ISO 7092 (DIN 433)
- Spring washer: D = 8 mm DIN 127 or DIN 128
- Mounting torque: 1.6–2.0 Nm
- PN: Kombi-screew ETTINGER 081.58.446
  Farnell order code: 2494544
- Screw holes on heatsink need to be countersunk. A torque wrench shall be used to tighten the mounting screws at the specified torque. Excessive torque may result in damage or degradation of the device. The inaccuracy of torque wrench tightening method can range up to ±12%. This must be considered to prevent over-tightening the fastener. Due to excessive temperature fluctuations washers should be used to prevent the loosening of the screws. After accurate tightening of the screws the spring washer exerts a constant force on the joint. The flat washer distributes this force on the plastic surface. When using screws with pre-assembled washers: Screws with pre-assembled washers (SEMS or kombi screws) combine the screw and the washers into a single component. These screws eliminate the need to slip the washers into place by hand, boosting the speed and efficiency of the assembly process. The specifications of these screws are provided below:
- Screw size: M4 according to DIN 6900 (ISO 10644; JIS B1188)
- Flat washer: According to DIN 6902 Type C (ISO 10673 Type S; JIS B1256) Washer outer diameter: 8 mm diameter can be fitted onto the module
- Split lock spring washer: According to DIN 6905 (JIS B1251)

- Mounting torque range: 1.6−2.0 Nm
- Recommended insertion of screw thread in the heatsink is 6 mm.

Methods of Screw Clamping

There are two recommended screw clamping methods which apply to all modules. The F1 module is used as an example. Figure 20 describes one method for fastening the module to the heatsink. Fasten two screws simultaneously to prevent tilting or rising of one side of module during fastening. Electric screwdrivers can tighten the screws with the specified torque. Screw holes on heatsink need to be countersunk. If method 1 cannot be applied, the method as described in Figure 21 is also acceptable. Fasten the first screw loosely to prevent tilting or rising of the module (step 1). Then insert the second screw with final torque to be fully tightened with the heatsink (step 2). Finally, apply full torque to the first screw for solid tightening with the heatsink. For F1/F2 packages using plastic clips, the torque is between 1.6−2.0 Nm using M4 screws.

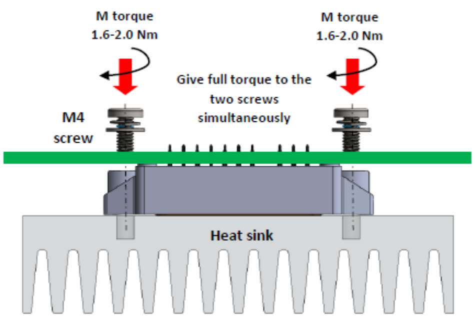

Figure 20. Fixing Screws on the Heatsink

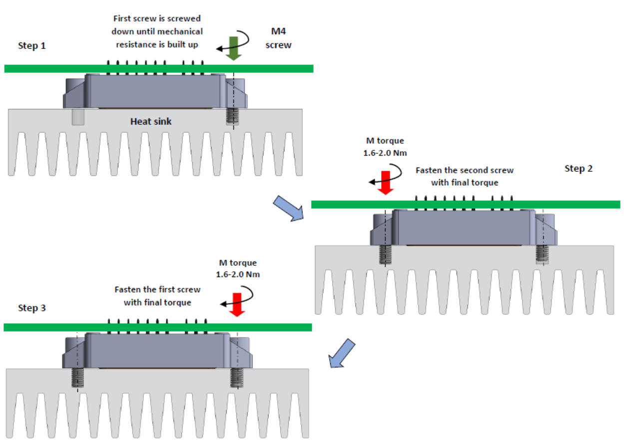

Figure 21. Fixing One after One for Power Module

Assembly of Multiple Modules on the PCB and Heatsink

The overall structure of the mounted module should be considered. If the PCB is large and heavy with other components assembled to it, there is some risk the PCB can bend, creating mechanical stress to the module and the PCB. When multiple modules are applied to the same PCB, height tolerance between modules can result in the mechanical stresses on the board and modules. To reduce stress, space posts should be added on the heatsink, as illustrated on figure 19 to prevent movement of the PCB. The recommended height of the space posts is 12.35 (+0.05/−0) mm. The effective distance between center of stand-off and the space post (= X) is 50 mm minimum. If distance keepers are used during the press-in process, resulting in tighter height tolerances; distances between the stand-off of the case and the space post (= X) smaller than 50 mm can be used. Figure 19 shows the assembly procedure when space posts are used and the overall assembly structure: Modules are first pressed into the PCB following the recommendations introduced in Section “Heatsink Surface” before heatsink mounting. Maintaining tight height tolerances between module and PCB is important. Next, the thermal interface material is applied. Then the modules and the PCB are placed on the heatsink (a). Then the module is mounted onto the heatsink via the module plastic clamp. Finally, the PCB needs to be fixed on the space posts (c).

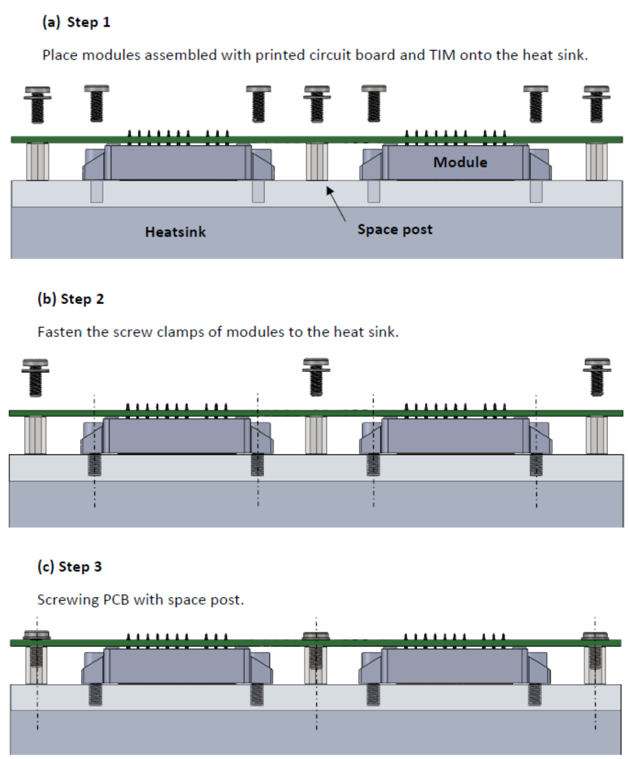

Figure 22. Assembling Multiple Modules on a PCB

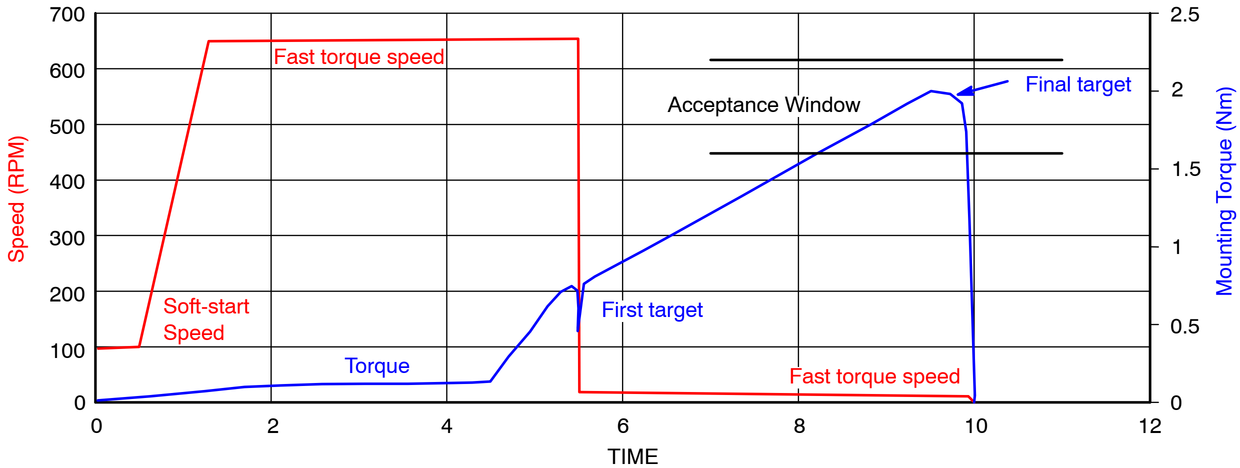

Figure 23. Automatic Screw Drive

Mounting with an Automatic Screwdriver

For a fast, reliable, and repeatable screwing process, it is recommended to use an automatic screwdriver with a two-stage tightening method (screw type as specified in section Screw Specification).

The screwdriver operates at high speed in the first stage until it reaches the preset torque, then slows down to accurately tighten to the final target torque.

Recommended Torque Values:

- Cycle start: 0.9 Nm
- Pre-tightening torque: 0.65 Nm
- Minimum final torque: 1.6 Nm
- Target final torque: 2.0 Nm
- Maximum final torque: 2.2 Nm

Recommended Speeds:

- Soft start: 96 rpm
- Stage 1: max. 650 rpm
- Stage 2: max. 12 rpm

Handling of PCM Pre-applied Module

During a transport and storage of the modules extreme thermal and mechanical shock should be avoided. The tray is designed to prevent direct contact to the PCM layer of the module substrate as shown in the Figure 24. PCM_ pre applied modules should be stored in this tray box before its use. Table 3 shows recommended storage conditions.

Table 3. RECOMMENDED STORAGE CONDITIONS FOR MODULES WITH PCM

Storage temperatures	10 – 40 °C
Humidity condition	10 < RH < 55%
Time	Max 12 months

PCM printing layer should be treated as a functional area of the module and be protected from damage or removing when handling or mounting. PCM pre-applied module is delivered in a tray box with a tight cover.

Figure 24. Modules in a Transport Tray Box

It is recommended to open the cover carefully side-by side to prevent mechanical damage to the PCM layer. Also during the assembly process attention is needed not to touch the PCM layer directly. If the PCM layer is contaminated or more thant 10% of the entire printed area is damaged, then it is recommended to remove the PCM layer according to instructions stated below. In case of rework prior to operation of modules, standard PCB / heat sink disassembly process can be applied. If the module was operated and the PCM melted and distributed already, then bond strength between heat sink and the module may be strong, and the module cannot be easily removed from the heatsink. In such cases it is recommended to use a knife to detach the module or apply some heat (45–60 °C) to re-melt PCM to detach the module easily. Use a soft plastic scraper to remove the PCM layer from the module back side and heat sink. For the removal of remaining PCM residues it is recommended to use microfiber cloth and isoprophyle alcohol.

REVISION HISTORY

Revision	Description of Changes	Date
3	Updated Screw Specification section (add another bullet); inserted the graph Automatic Screw Drive + the following text (Mounting with an Automatic Screwdriver section); inserted the graph Thermal Impedance Affect by Power Cycling + the following text (Final Thickness after Mounted on Heatsink section); modified the dimensions in Figure 17; added Figure 18	6/25/2025

This document has undergone updates prior to the inclusion of this revision history table. The changes tracked here only reflect updates made on the noted approval dates.