TN1250
Technical note

Press-fit ACEPACK™ power modules mounting instructions

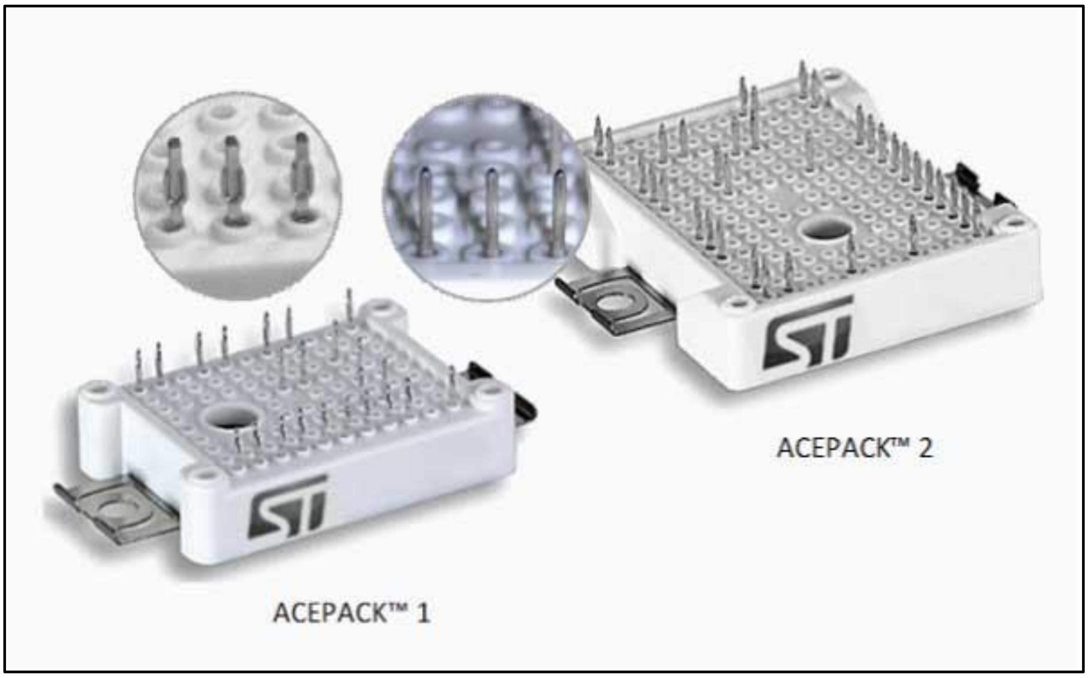
Introduction

ST introduces the ACEPACK™ Power Module family, designed for easy mounting and reliable performance in rugged applications. The available module form factors are ACEPACK™ 1 with 33.8 mm x 48 mm and ACEPACK™ 2 with 56.7 mm x 48 mm body dimensions. Various die selections in silicon and silicon carbide substrates can be housed in several configurations.

These modules feature a compact, fully isolated, low profile housing able to integrate very high power density components in a low junction-to-case thermal resistance DBC. Power modules simplify the design and increase reliability, while PCB size and system costs are optimized.

The following sections provide recommendations for the connection of these modules to a printed circuit board (PCB) and mounting and dismounting methods to achieve adequate connections, reliability and performance in typical applications.

Figure 1: ACEPACK™ 1 and ACEPACK™ 2

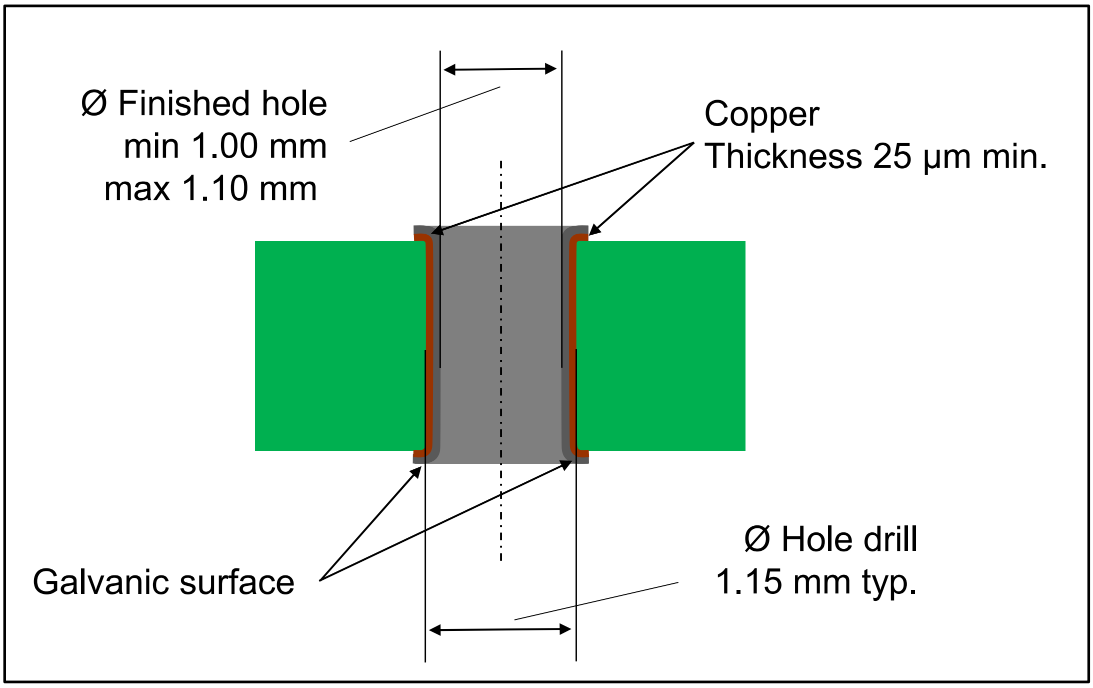


Contents

1 PCB requirements

The press-fit used in the ACEPACK™ module has been qualified for standard FR4 printed circuit boards with tin (chemically) (IEC 60352-5 + IEC60747-15). If other handling technologies are used in the production of printed circuit boards, they would have to be tested, inspected and qualified.

Figure 2: Plated through holes



An adequate design of the plated through holes (PTH) of a PCB is essential to obtain good quality press-fit connections. If the finished hole diameter of the PTH is too small, the press-in force through the plated hole may be too high and cause mechanical damage to the pins and the PTH. If the finished hole diameter is too large, it may not form a reliable connection with the pin.

The initial hole diameter prior to plating is important in determining the reliability of press-fit connections. As per IEC 60352-5 specification, it should be 1.15 mm typical. The thickness of the copper plating applied to the initial hole shall be minimum 25 µm to maximum 50 µm. Then, a surface finish of about 1 µm chemical tin is applied to the hole.

The overall hole diameter is typically between 1.00 mm and 1.10 mm.

Table 1: Printed circuit board requirements for press-fit leads option

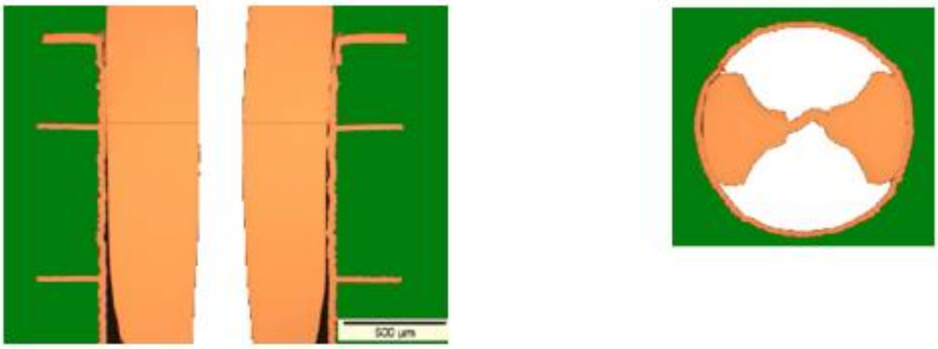
Press-fit leads option				
	Min.	**Typ.**	**Max.**	**Unit**
Hole drill diameter	1.12	1.15	1.20	mm
Copper thickness in hole	25		50	µm
Metallization in hole			15	µm
Finished hole diameter	1.00		1.10	mm
Copper thickness of conductors	35	70-105	400	µm

Press-fit leads option				
	Min.	**Typ.**	**Max.**	**Unit**
Metallization of circuit board	Tin (chemically) / HAL			
Metallization of pin	Tin (galvanic)			

Other tin finish technologies should be avoided before verification. The HAL plating method is not recommended because of uneven plating on the hole.

The electrical and thermal contacts with the circuit board are implemented by means of cold welding when press-fit pins are used. Permanent deformation takes place as a result of PCB insertion and this deformation is intended to accommodate the tolerance and provides the basis for the cold welding. The resulting forces during the press-fit process ensure that the welded materials on the PCB and pin exhibit a continuously consistent and, unlike other contact technologies, very small electrical contact resistance, see *Figure 3: "Materials connected together in a gas-tight manner due to the press-in force"*.

Figure 3: Materials connected together in a gas-tight manner due to the press-in force



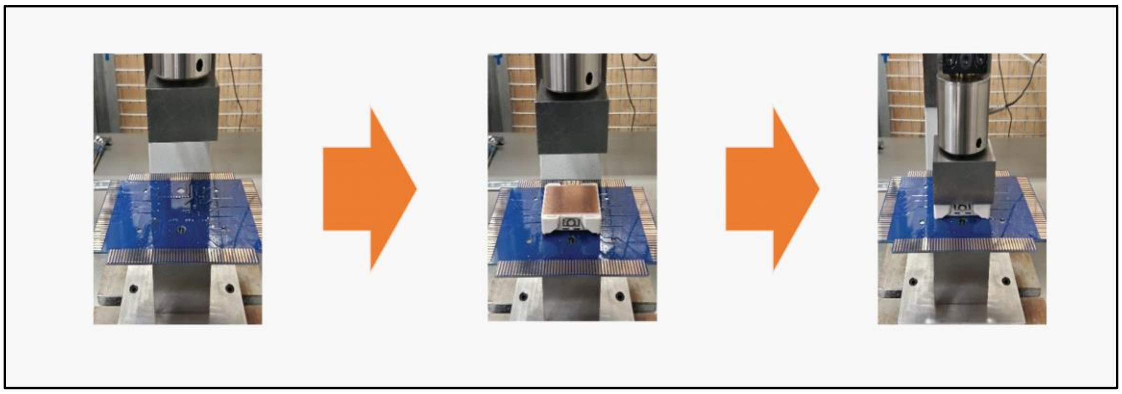
A module that has been pressed in and then pressed out again can no longer be pressed in again. Instead, the module can only be attached to a new printed circuit board by soldering. The plastic deformation of the press-fit zone does not permit further press-fit processes.

2 Module mounting process in a PCB

2.1 General press- in process

The press-fit process is a cost-effective way to assemble power modules without introducing additional thermal loads. The press-fit connection generates a strong mechanical and a good electrical connection between the module and the PCB.

Figure 4: Types of equipment for press-in



Generally, a module can be pressed in until the stand-offs on the four corners of the module touch the PCB.

A press-in tool that records the necessary force and the travel distance is recommended to ensure appropriate quality. 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 influences the quality of the press-fit connection. The speed should not be lower than 25 mm/min according to IEC 60352-5. A lower speed can lead to increased press-in forces and deformation of the pins or a non gas-tight connection.

Typical press-in forces vary with the finished hole diameter of your PCB and more in general on the contact area between press-fit pin and plated through hole. Based on the PCB requirements listed above, the following forces and speeds are recommended:

Table 2: Press-fit requirements in a printed circuit board

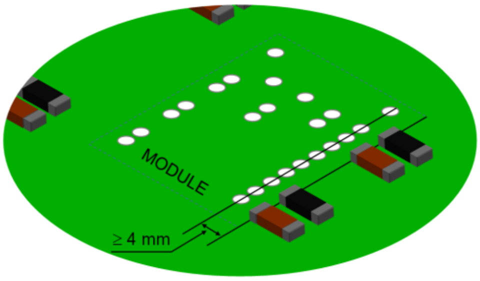
Press-fit requirements in a printed circuit board				
	Min.	Typ.	Max.	Unit
Press-fit speed	25			mm/min
Press-in force(each pin)	60	90	120	N

The maximum applied force per module during pressing should not exceed 4 kN.

Attention should also be paid to other components like resistors, diodes or capacitors that need to be assembled on the PCB area next to the ACEPACK™ module. PCB bending during press-in processes can cause mechanical stress to other PCB components.

It is recommended to leave at least 4 mm between the edge of these components and the middle of the PTH.

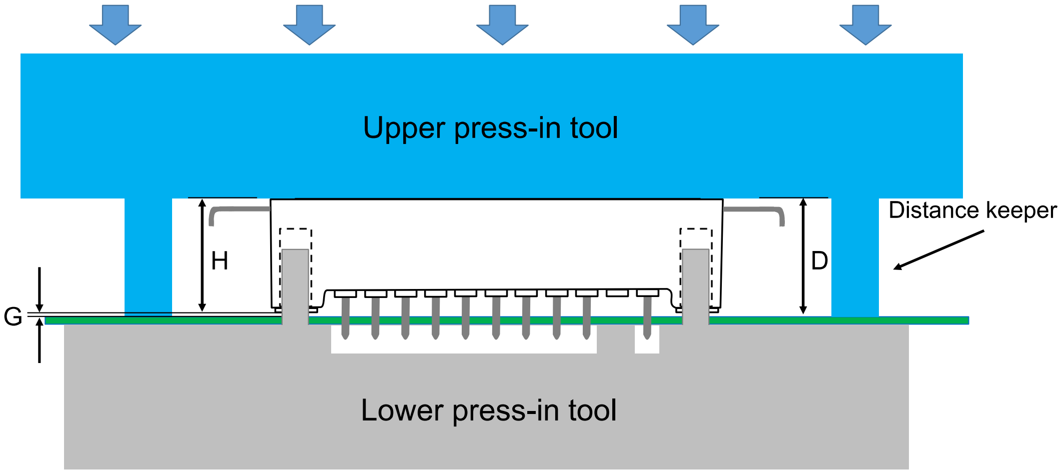
Figure 5: Minimum suggested distance between PTH and components



2.2 Multiple modules press-in process

When multiple modules are assembled on the same PCB and the same heat sink, the height tolerances among the modules must be minimized to guarantee adequate contact on the heatsink and avoid mechanical stress on the PCB. In this case, a press-in tool with distance keepers is required to ensure the same distance between PCB and the top of the modules, as shown in *Figure 6: "Press-in process for multiple modules PCB"*.

Figure 6: Press-in process for multiple modules PCB



D = Distance keeper height (12.40 +0.05/-0 mm)

H = Package height (12.0 ±0.35 mm)

G = Gap between package stand-off and PCB (G = D - H)

During the process, once the distance keeper contacts the surface of the PCB, the press-in force rises and the press-in process can be stopped, thus preventing direct contact between the case and the PCB. The distance keepers and the other board components should be designed so that no contact among them can occur during the press-in process.

The module and the PCB are first placed on the lower press-in tool and the module is then aligned to the PCB with the guide pins. Then, the upper press-in tool can start moving down the module until the distance keepers touch the surface of the PCB.

3 Fixing a PCB to the ACEPACK™ module

Figure 7: ACEPACK fixing PCB and cross-section

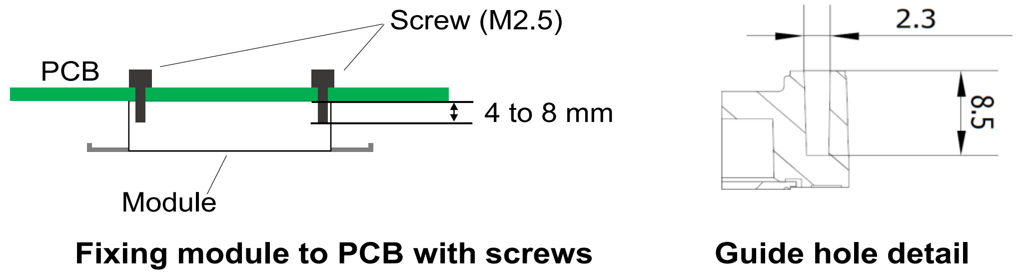
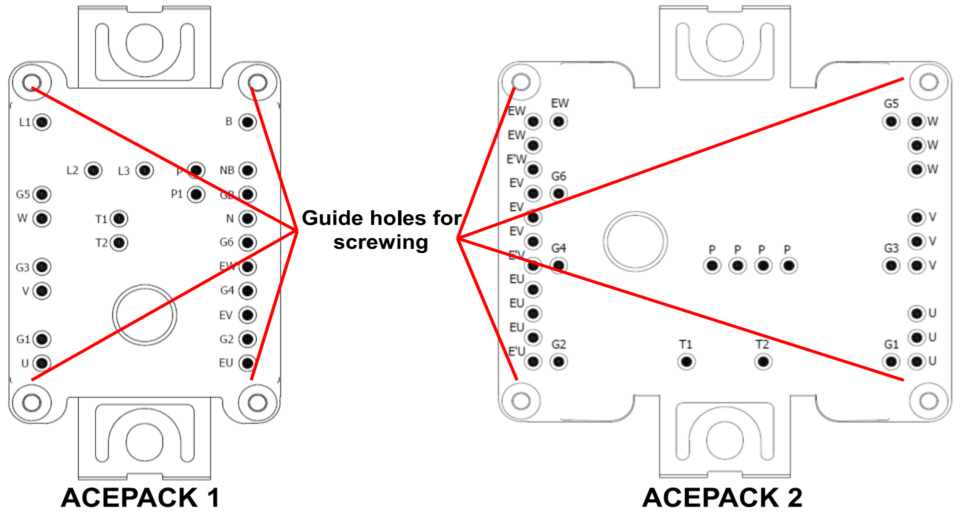


Figure 8: Guide hole for the screws in ACEPACK 1 and ACEPACK 2



After the PCB mounting process, it is recommended to fix the PCB to the module with screws to ensure reliable contact. If an air gap remains between the module stand offs and the PCB, do not screw to avoid PCB bending. The figures above show the details for screwing the module. The effective length of a screw excluding the PCB thickness should be 4.0-8.0 mm. Screwdriver speed lower than 300 rpm and screwdriver torque 0.4 Nm ± 10% is recommended.

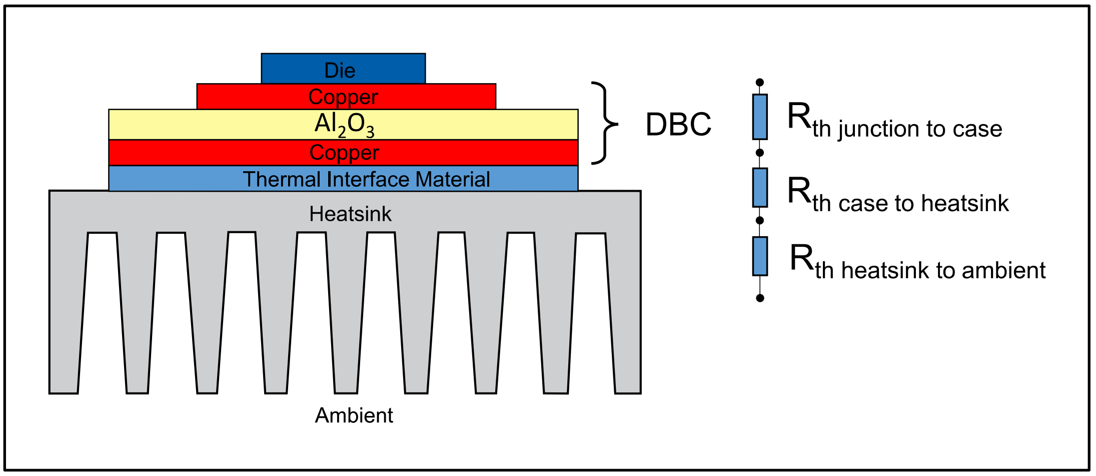
Screwing into a plastic cavity is a delicate operation, and care has to be taken to avoid stand-off damage. We suggest using M2.5 x L self-tapping screws, with length L depending on the PCB thickness (stand off thread has to be between 4 and 8 mm). The screws will self-tap into the stand-off cavity. The vertical position of the screw must also be maintained to prevent lateral insertion. A crosswise sequence for mounting the screws is suggested and the screwdriver should have a slow rotating speed. Typical mounting torque is 0.45 Nm ± 10 %.

Do not exceed 1 Nm to avoid screw/plastic damage.

4 Mounting the module to a heat sink

The heat produced by a module must be dissipated to avoid overheating and consequent damage. The thermal performance of a module in combination with a heat sink can be characterized by the sum of all thermal resistances along the thermal path: junction-to-case, case-to-heatsink,and heatsink-to-ambient, as shown in the figure below.

Figure 9: Dissipation mechanism



Proper contact between the module substrate and the surface of the heat sink is crucial for managing the overall thermal efficiency of the system. Thermal Interface Materials (TIMs) are thermally conductive materials used to allow proper matching of the two surfaces and improve heat transfer.

4.1 Requirements for a heat sink

In order to maximize heat transfer efficiency, the heat sink contact surface must be flat and clean. The required heat sink surface qualities to achieve good thermal conductivity must be 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. In particular, the flatness must be less than above value in the module mounting area, including the two clamp screws. Furthermore, the interface surface of the heat sink must be free of particles and contamination.

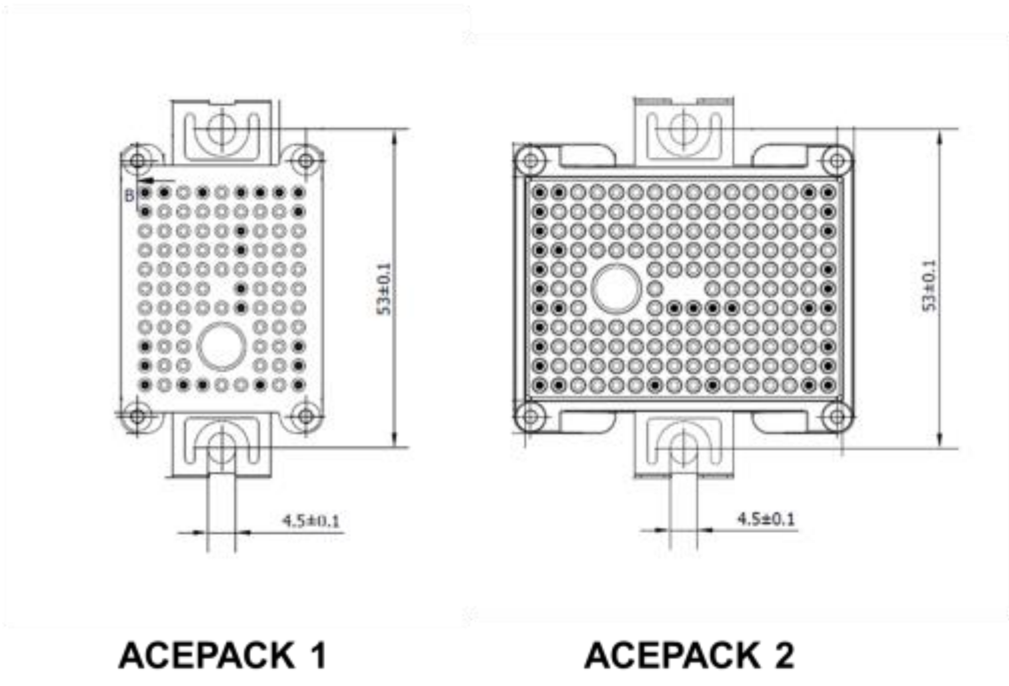
4.2 Application of thermal paste

Thermal paste thickness strongly affects the thermal resistivity between the module and the heat sink. An even layer of 80 µm is recommended. Thermal grease quantity is sufficient if a small amount of it can be seen out of the module after the heat sink mounting process.

4.3 Heatsink mounting

Heatsink mounting on the modules requires aligning the clamp screw holes of the module with the two thread holes on the heatsink.

Figure 10: Screw clamping zone dimensions



In the figure below shows one-step and three-step fastening methods.

In the one-step method, the two screws are simultaneously fastened to avoid tilting on one side of module. It is recommended to synchronize the two electric screwdrivers with the same rpm and maximum torque.

In the three-step method:

1. fasten the first screw only until it touches the screw clamp and does not provoke tilting of the module.
2. fasten the second screw to the final torque (see *Table 3: "Technical data of the mounting screw"*).
3. fasten the first screw to full torque, securing the module to the heatsink.

Figure 11: Module to heatsink fastening method

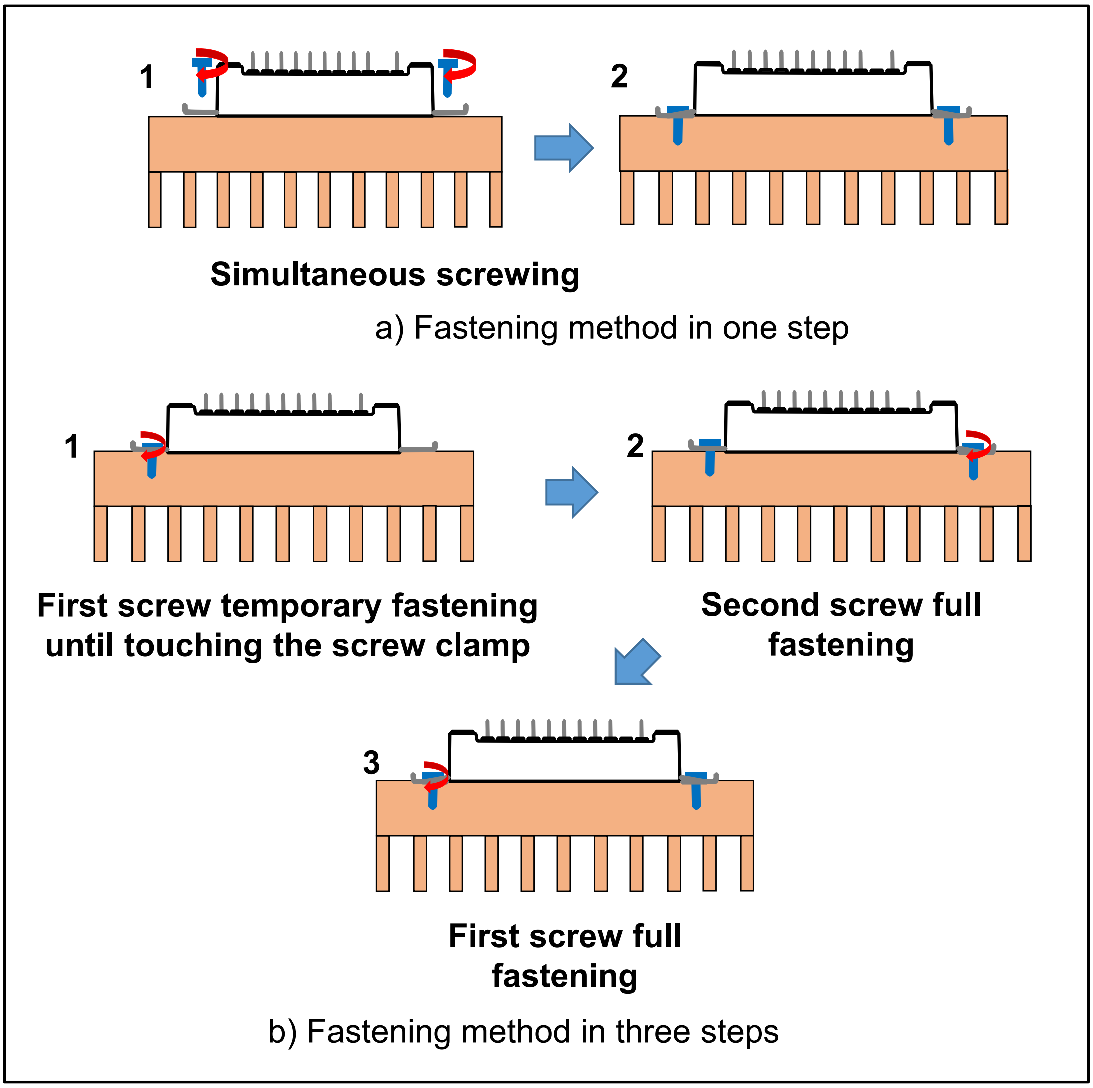


Table 3: Technical data of the mounting screw

Description	Value
Mounting screw	M4
Recommended mounting tourque	2.0 – 2.3 Nm

5 Assembly of the PCB and heat sink

After modules are assembled to the PCB and the heat sink, the overall structural integrity needs to be considered to avoid mechanical stress to any of the system components. If the PCB is large and heavy with other components assembled to it, there is some risk that the PCB can bend, creating mechanical stress on 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 heat sink to prevent movement of the PCB.

The recommended height of the space posts is 12.4 (+0/-0.1) mm. The effective distance between center of stand-off and the space post (= X) is 50 mm minimum, as shown in the following figure.

Figure 12: Assembly procedure when space posts are used

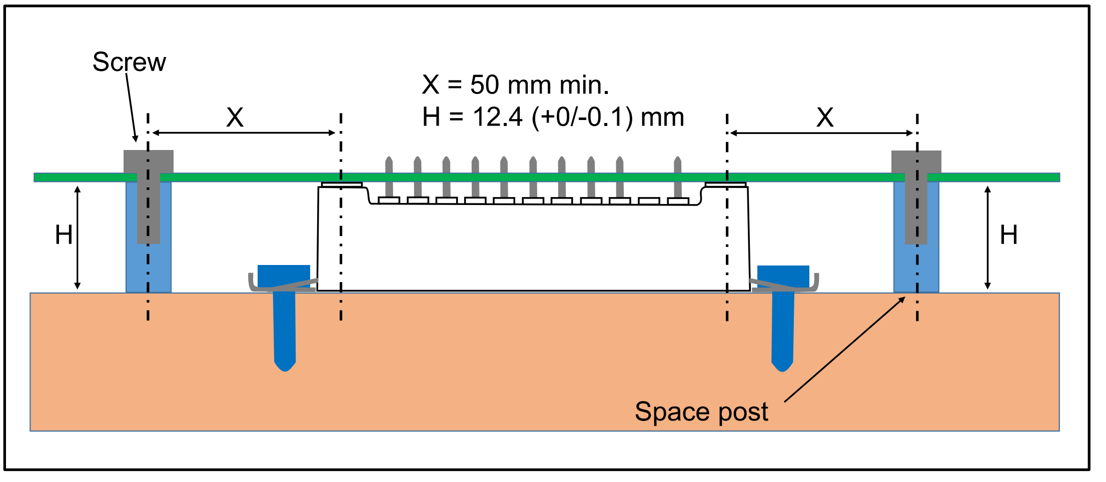
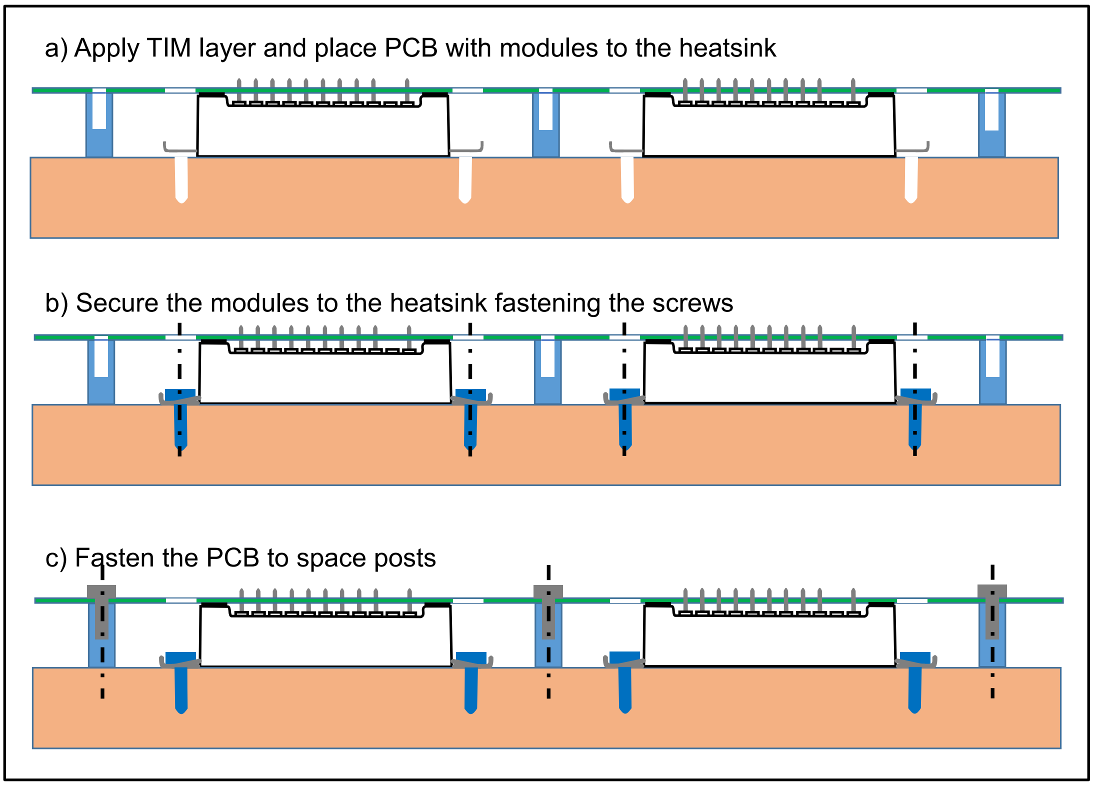


Figure 13: "Heat sink mounting" shows the overall assembly procedure when space posts are used. First the PCB with the modules is placed onto the heatsink (a). Then the modules are fastened to the heatsink through the screw clamps (b). Finally the PCB is fixed on the space posts.

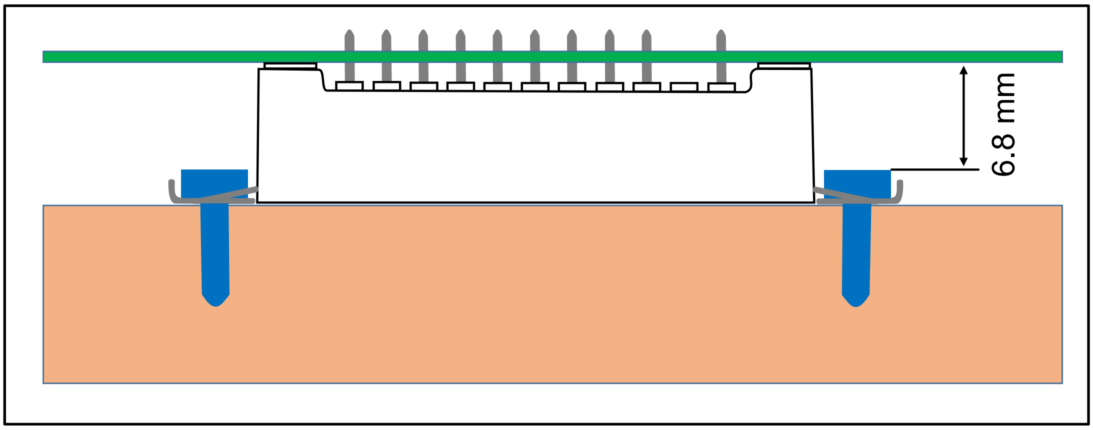
Figure 13: Heat sink mounting



6 Clearance and creepage distances

When defining the layout of the PCB, application-specific standards, especially regarding clearance and creepage distances, must be considered. This is particularly important for the area of the screw clamp located under the printed circuit board. In order to meet the respective requirements regarding clearance and creepage distances, current carrying devices or through-holes in this area should be avoided, or additional isolation measures like lacquering must be taken.

Figure 14: Air path between clip and PCB



The minimum clearance distance between the screw and the PCB depends on the screw itself. The distance is 6.8 mm with a hexagon socket head screw according to DIN 912, a washer according to DIN 125 and the clamp, see *Figure 14: "Air path between clip and PCB"*.

The clearance and creepage distances specified in the datasheet are minimum values, irrespective of other devices that may be mounted close to the module.

In any case, the application-specific clearance and creepage distances must be checked and compared with relevant standards and guaranteed through appropriate construction methods, if required.

7 Revision history

Table 4: Document revision history

Date	Revision	Changes
07-Nov-2017	1	Initial release.