Assembly Instructions for the Easy Modules

About this document

Scope and purpose

This application note provides a guideline on how to use and implement Easy modules. The values and recommendations provided in this document should not be considered as datasheet values.

Intended audience

This document is intended for all experts using Infineon Easy modules.

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1 General information

Easy module is baseplate-less module with pin connection to PCB. It is widely used in industrial and automotive applications. The whole family contains four packages, they are Easy 1B, Easy 2B, Easy3B and Easy4B as shown in Figure 1.

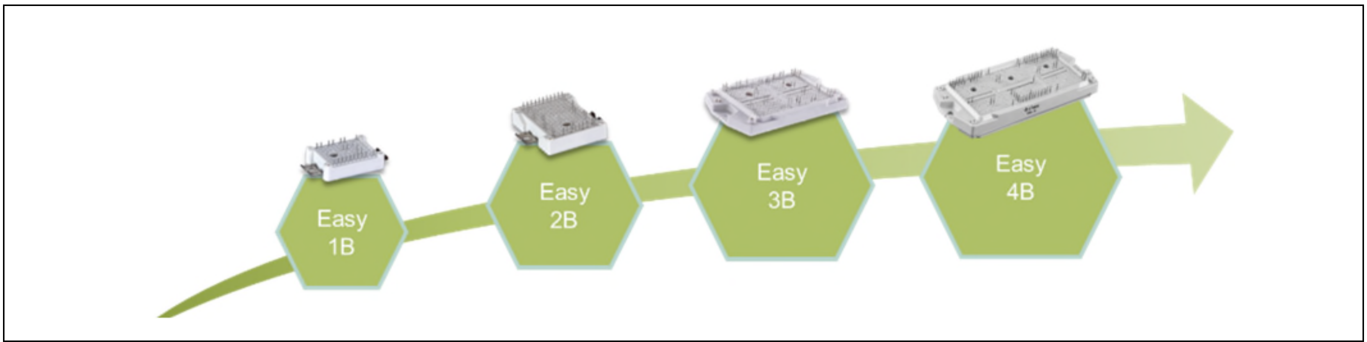


Figure 1 Easy Family

Beside the traditional solder pin, PressFit pin is also provided in Easy package. Pressfit contact is a kind of cold welding, it complies with requirements on high durability, high temperatures, RoHs conformity and simple handing. Infineon uses two types of PressFIT pins in the Easy product series. Depending on power density and performance, a distinction is made between standard and high-current PressFIT pins. The differences are in the material properties as well as in the PressFIT zones.

The high-current pin is equipped with an eye-of-the-needle (EoN) PressFIT zone. The material of the pin provides a higher electrical and thermal conductivity compared to the standard PressFIT pin. For this reason, the high-current PressFIT pin exhibits a higher current capability, and heat dissipation. The benefit of this PressFIT pin is to reduce the thermal load of the printed circuit board within high current applications. However, the printed circuit board requirements are the same for both PressFIT pin types.

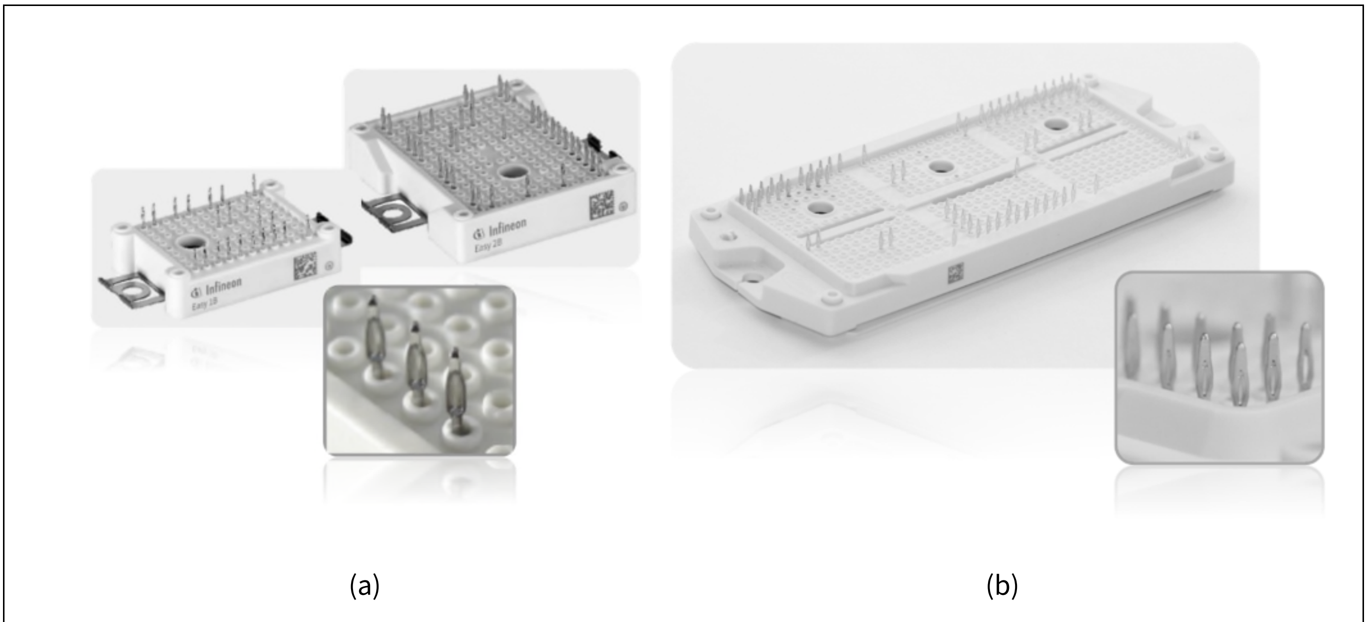


Figure 2 Typical appearance of modules with PressFIT contacts as a standard PressFIT pin (a) or high-current PressFIT pin (b)

Easy PressFIT contacts have a contact zone of approximately 1.7 mm length that adapts itself to the hole in the PCB during the press-in process. It results in a plastic deformation of the pressfit zone. This deformation is intended to accommodate the tolerance, and provides the basis for the cold welding.

Figure 3 and Figure 4 show various sections and REM images that provide a view of the gas-tight bonded materials resulting from the press-in force.

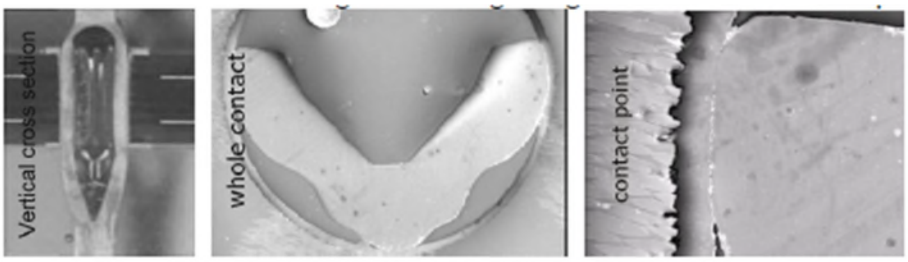


Figure 3 Easy standard PressFIT contact sections

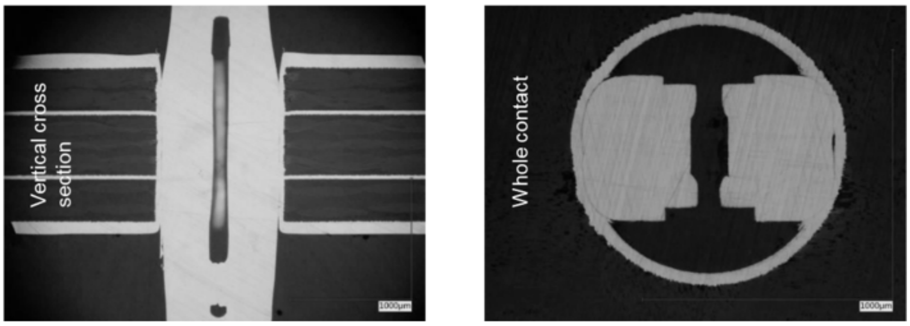


Figure 4 Easy High-Current PressFIT contact sections

1.1 General information on power module handling

The power module is not designed to withstand forces on the module housing as shown in the example of Figure 5. The module pins are located here on a flat table. Forces on the module housing (Fp) are pushing the DCB out of the housing. Therefore, **forces (Fp) applied on the module housing must be avoided during handling.** Please note that this is a different case compared to the normal press-in process, where the DCB is fully supported in the press tool, and the press-in forces affect the DCB, and not the housing.

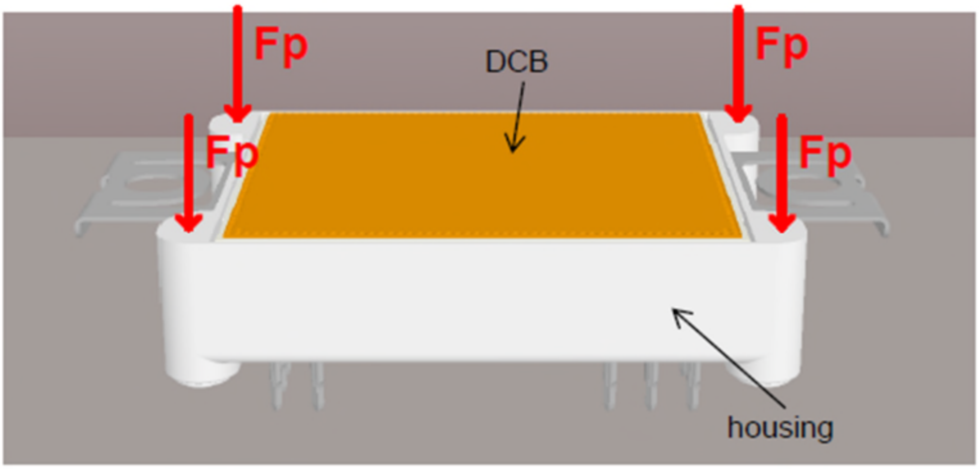


Figure 5 Forces on the housing during module handling should be avoided to prevent a push-out of the DCB

Some modules will have quite low DCB push-out forces (Fp), the minimum value of which is not a confirmed property of the power module. This is not critical for real applications, because the housing is later mounted on the cooling system by the integrated clamps. Thus, the housing will not be moved in a critical way. Furthermore, the sealant between the module frame and the DCB only serves to seal the module when the isolating gel is filled during our production process. After the filling process, the liquid gel is heated and becomes soft but solid. The sealing has no gluing function in the final product.

2 Requirements for printed circuit boards

2.1 PCB requirements for the PressFIT technology

The PressFIT technology used in the Easy modules has been inspected and qualified by Infineon Technologies AG for standard FR4 PCBs according to the IEC 60352-5 and IEC 60747-15 with “chemical tin” and a hot-air-leveling (HAL) surface. Infineon recommends the use of chemical tin metallization. The qualification tests were done on standard FR4 material, which is complaint with the requirements of IEC 61249-2-7.

If other handling technologies are to be used in the production of PCBs, they have to be checked, tested and qualified.

Table 1 Requirements for a PCB

	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 conductive layers	35 µm	70 µm 105 µm	400 µm
Metallization of circuit board	Tin (chemical) recommended		
Metallization of pin	Tin (galvanic)		

In order to ensure that the PressFIT contact sits securely in the PCB, the specification of the hole given in Table 1 must be adhered to.

If the specification of PressFIT holes is limited to only the finished dimension (i.e., the metallized hole), different drill sizes could be used depending on the PCB manufacturer and production philosophy, and also different metallization thicknesses could be provided. This would lead to results that would have to be rejected for quality assurance reasons. The end hole diameter is a function of the drill hole, the copper thickness and the metallization in the hole. If the end hole diameter is too small, the press-in force can be too high. The FR4 material can also have an influence on the press-in force.

The recommendation still applies that the hole in the PCB is to be drilled during manufacturing with a drill size of 1.15 mm, and should not be milled. Experience has shown that a drill hole diameter between 1.12 mm and 1.15 mm is obtained under consideration of the runout tolerances of the spindles after drilling due to shrinking of the FR4 material.

With a copper thickness of 30 µm to 50 µm in the hole and a tin layer of about 1 µm for tin applied chemically, an end hole diameter is obtained as the test dimension. Due to the thinner tin layer thickness, this diameter is always higher than the value of 1 mm stated in the standard (IEC 60352-5). The final hole diameter, considering the drilling diameter, copper thickness and a chemical tin layer, is typically between 1.02 mm and 1.09 mm.

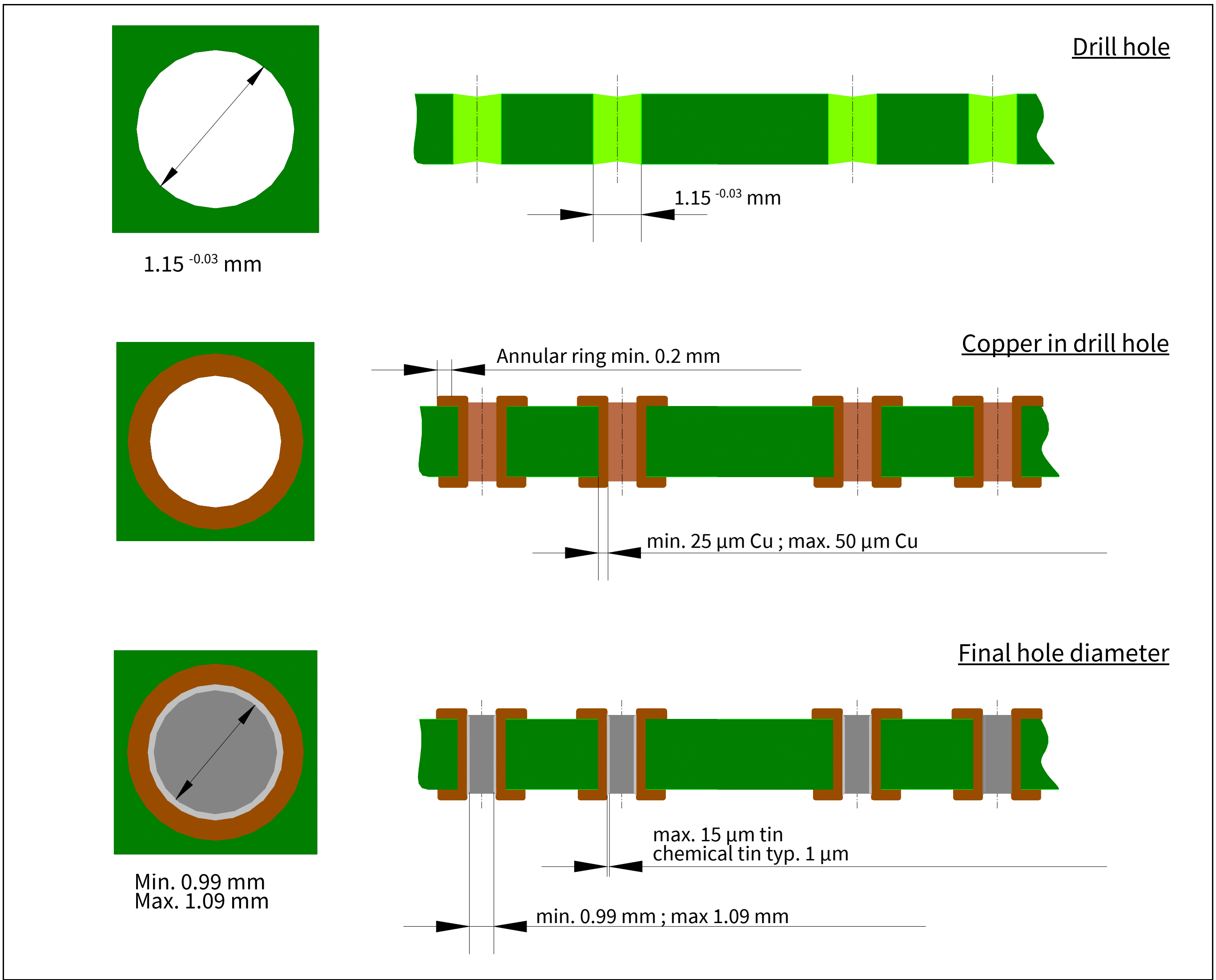


Figure 6 Structure of a PCB

The PressFIT technology has been qualified for FR4 PCB material.

After a reflow soldering process is carried out on a PCB, the module can be pressed into the board without difficulty. The retention forces of the press-fitted pins are not diminished.

Depending on the applied press tools, a certain distance from the middle of the pins to other components must be observed. A distance of 5 mm is recommended.

A PressFIT module can be replaced up to two times. This means that a PCB can be used in total three times. Correct handling of the components is essential.

A module that has been pressed in, and the contact pressed out again, can no longer be pressed back in again. Instead, the module can only be attached to a new PCB via soldering. The plastic deformation of the PressFIT area does not permit a further PressFIT process.

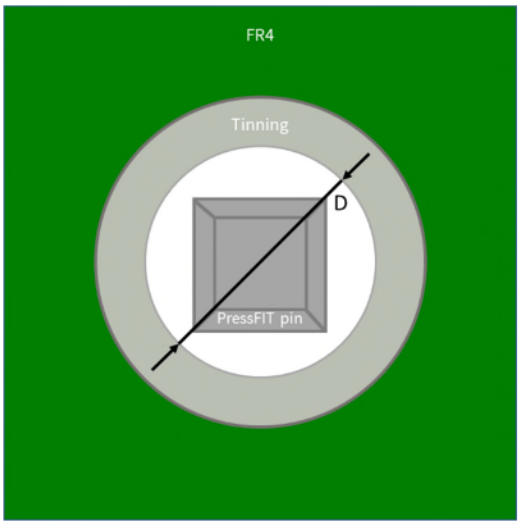
2.2 PCB requirements for soldering the PressFIT modules

The Easy PressFIT pin is qualified for solderability according to the IEC standard 60068-2-20, allowing the assemblies of the EasyPIM™ and EasyPACK products to be soldered to the PCB.

Soldering can be used as an alternative mounting option to the PressFIT technology. This is the case, for example, when a solder pin module is replaced by the Easy PressFIT pin module, as a production line for solder assembly is already in place. The advantages of the PressFIT technology compared to soldering should be considered in terms of its higher reliability and short process time.

The final minimum diameter of the through hole is determined considering the pin circumference and tolerances. In order to mechanically fit the module into the printed circuit board, a final minimum hole diameter of 1.25 mm is recommended for soldering the PressFIT pin modules.

The final hole diameter of the plated through holes for the standard PressFIT and the high-current PressFIT pin is defined as “D=1.25 mm + X” as shown in Figure 7. “X” has to be choosen according IPC2220 Series.



D = 1.25 mm + X

Figure 7 Cross-section of the standard PressFIT and the high-current pin

Due to the interdependence of several factors such as PCB type, thickness, plating, production tolerances, solder process, and solder alloy, the parameter X must be determined by the customers to ensure a good soldering result and a reliable long-term connection.

The final hole size must be defined carefully. If the hole is too large, it may be difficult to ensure a solid electrical and mechanical connection between the pin and the board.

2.3 PCB requirement for solder pin

Easy modules with solder pin are designed to be soldered to the PCB with a thickness of up to 2 mm. The solder pin geometry is provided in the module datasheet. The PCB though hole diameter should be determined similar to the procedure as described in chapter 2.2.

3 The press-in process

This section deals with the press-in process including the necessary tools and parameters for inserting the Easy family modules into the printed circuit board.

3.1 Introduction

The PressFIT modules are inserted into a printed circuit board by using the press-in technology. PressFIT can be performed by using a toggle lever press or a machine. A press-in tool that records the appield force and the travel distance is strongly recommended to monitor the press-in process. Consistent quality and reproducibility are assured in this way.

The press-in force is related to the retention force and the quality of the press-fit connection (electrical resistance and reliability). The PressFIT speed for standard tests is between 25-50 mm/min according to IEC 60352-5. A PressFIT speed of under 25 mm/min can lead to increased press-in forces and a deformation of the pins, or to a connection that is not gas-tight. Infineon recommends a press-in speed of about 100 mm/min. The typical press-in speed for automated assembly lines is up to 450 mm/min.

Note that during the press-in process, the position of the PCB and the pressing area of the pressure plate must be parallel to each other. The pressure plate should be mechanically fixed in position without any tolerance. The module is then pressed into the PCB in a regular motion.

The module pins should penetrate the PCB during press-in until the four stand-off holes of the module, or optional distance spacers, as described in Multi-modules on a PCB (chapter 11.3), contact the board.

To limit the force at the end of the press-in process, distance spacers such as dowel pins can be implemented at the bottom tool of the press-in tool.

If the principles listed above are adhered to, a smooth insertion process for the two components can be achieved.

3.2 General press-in procedure

The press-in procedure can be carried out manually, semi-automatically or fully automatically. We differentiate between two applications:

a) one module on a PCB
b) several modules on a PCB, the modules can be pressed individually or together in one press-in process.

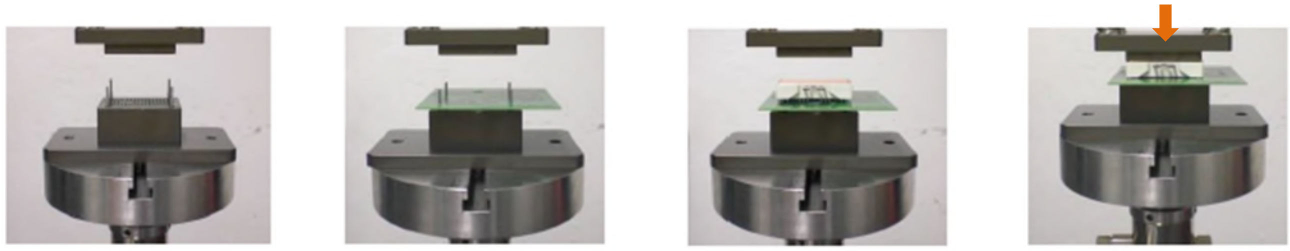
In the following sections, both methods will be described in detail.

3.2.1 General press-in process for one module on a PCB

Figure 8 shows the general press-in process for a Easy2B module on a PCB as carried out in the laboratory. This procedure represents case a), one module on a PCB. The process is completed when the module stand-off holes come in contact with the PCB surface. Further information about the placement of the distance pieces between PCB and heat sink can be found in Chapter 11.1.

The Easy3B/4B modules should be pressed into the PCB using a distance keeper, e.g. at the recommended distance. Please refer to Section 11 for more details about the distance piece.

The press-in process



1.	2.	3.	4
The press is aligned so that all parts of the tool are directly above the other.	The printed circuit board is placed on the tool and held in place by the guiding pins on the tool.	The module is placed on the tool and positioned by using the guiding pins on the tool.	The module contacts are pressed into the PCB by pressing the upper tool part downwards.

Figure 8 General press-in process of an Easy module on a PCB

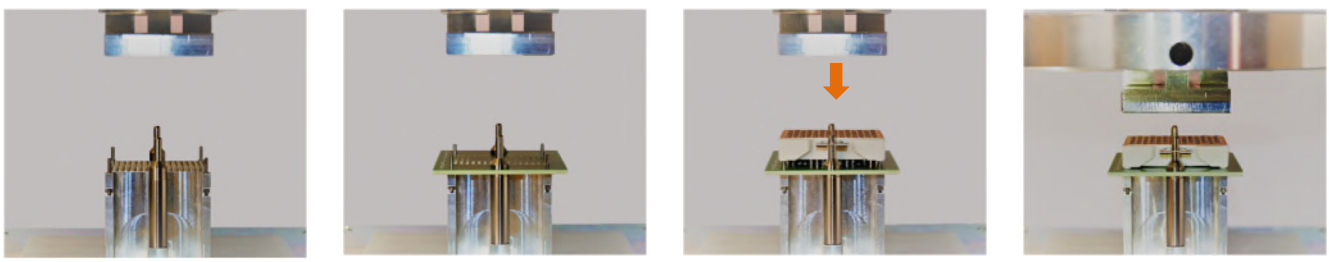
Note! We recommend that the backside of the IGBT module be protected against damage during the press-in process.

3.2.2 Press-in process of a module with thermal interface material (TIM)

The press-in process of the PressFIT TIM module requires different press-in tools than the process described above. This is due to the pre-applied TIM honeycombs and the restricted narrow area between TIM on the direct copper bonded (DCB).

During the entire press-in process of the Easy modules with TIM, damaging the TIM honeycombs must be avoided. Therefore, the press-in tools have to be designed with respect to the position of the TIM material on the module's base plate. The press-in force is to be exerted on the area of the DCB between the honeycombs. In Section 3.4.2, the press-in tools are described in more detail.

All other instructions concerning the positioning of the press-in tools and printed circuit board are similar to the press-in process without TIM, as described in Section 3.2.1. Figure 9 shows the press-in process of the Easy2B with TIM as it is implemented in the laboratory.



1)	2)	3)	4)
The bottom tool is aligned to the upper tool by using the two long alignment pins and the slow-motion function of the press machine.	The printed circuit board is placed on the tool and held in place by the four pins on the tool.	The module is placed on the tool and positioned using the four pins on the tool.	The module contacts are pressed into the PCB by pressing the upper tool part downwards.

Figure 9 Press-in process of an Easy2B module with pre-applied TIM

The press-in process

Figure 10 shows the imprint of an Easy2B module with TIM before and after the press-in process.

Figure 10 Easy2B with TIM before (shown left) and after (shown right) the press-in process

The structure of the presented TIM surface is shown as an example only, and is different for the products within the Easy family.

Note: After the press-in process of the pre-applied TIM module, optical changes may appear on the copper substrate between the TIM honeycomb structure, which can only be observed under certain angles. These imprints of the press-in tool do not have a negative impact on the substrate and can be regarded as a purely optical effect. This effect is highlighted in the following Figure 11 (green circle).

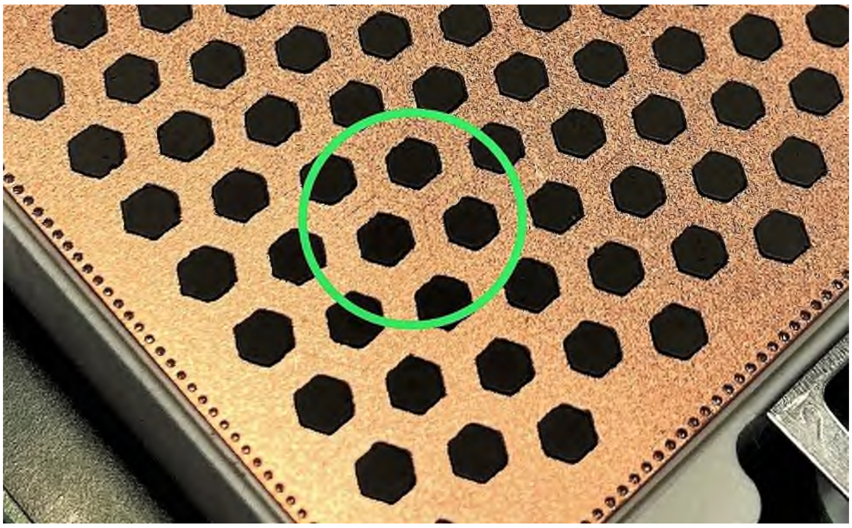


Figure 11 Optical changes on the copper substrate highlighted in green

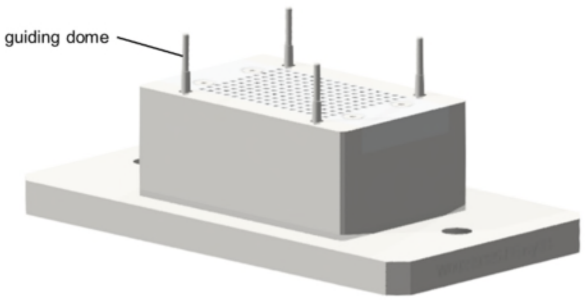
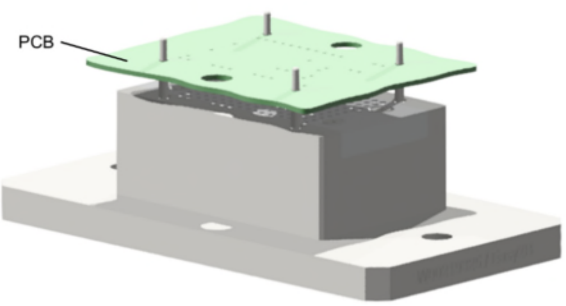
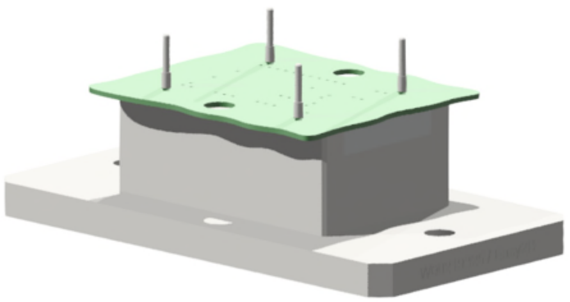
3.2.3 General press-in process for several modules on PCBs

Pressing several power modules onto a large PCB requires a special procedure due to the manufacturing-related tolerances of the modules and the PCB. This procedure is necessary to address the deviations in height between the modules from the DCB and the PCB surface, which could have a significant impact on the thermal performance and the lifetime of the modules. The target is to minimize the deviations in order to prevent a mechanical deformation of the PCB or unwanted forces on the modules and PressFIT pins.

For this reason, the modules should not be pressed completely into the PCB, but only down to a defined distance. One simple solution would be to use U-shaped distance pieces or additional guiding spacers mounted to the top insert tool. In this case, the distance piece would touch the PCB before the module housing.

Ensure that there is sufficient space on the PCB surface for the spacers between the neighboring modules.

Figure 12 shows the press-in process of the power modules on the PCB, which are pressed into the PCB one after the other. It is also possible to insert several modules into a PCB at the same time. This presents a greater challenge to ensure a consistent quality of the press-in process. A process control is only possible for all modules together with the corresponding press-in curve.

	This picture shows the bottom side of the press tool with guiding domes, which are useful for pre-alignment.
	In the next step the PCB is placed into the bottom tool, whereby the correct placement is obtained by the guiding domes of the bottom tool.
	This picuture shows the press tool with the PCB ready for module assembly.

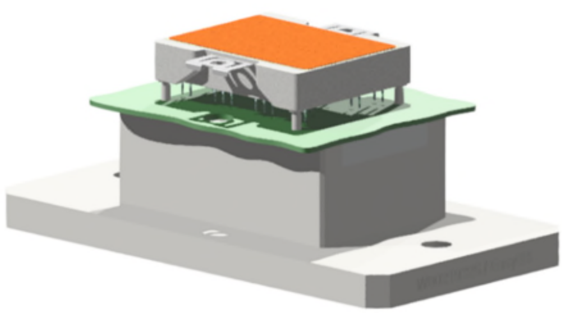
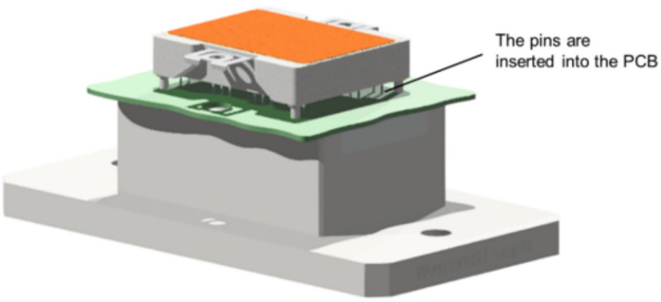
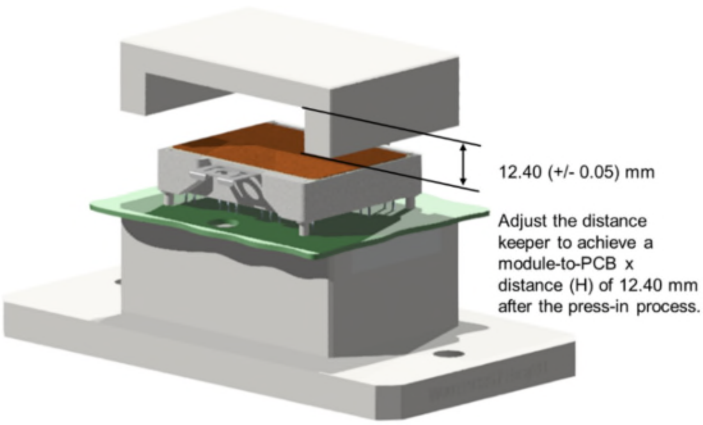
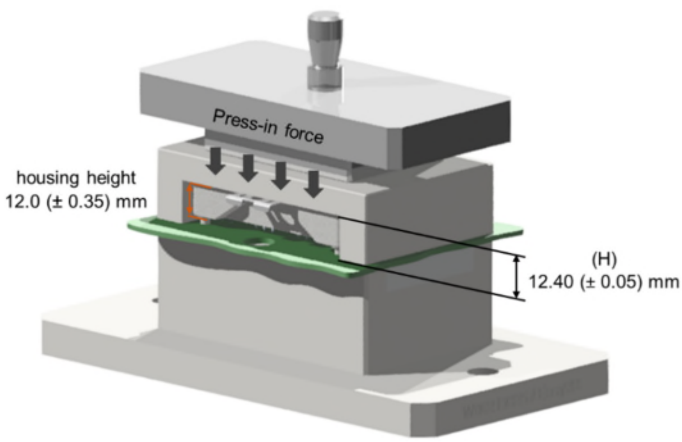
	The module is then placed on the guiding elements and the module pins are inserted into the PCB.
	The module is now placed flush with the press tool after the pins have been inserted into the PCB. The pin touches the PCB at the beginning of the active press zone, which starts at about 2.5 mm from the top of the pin. If the module is not flush with the press tool, or pins are not inserted (module about 2.5 mm higher than the normal case shown here), then mounting should be corrected before the pins are damaged in the later press-in process.
	After the pre-alignement of the module onto the bottom tool, the distance keeper can be used. Set the height of the distance keeper to 12,4 (+/- 0,05) mm as shown in this view. This enables a compensated height of the modules.
	The last step shows the controlled path-force press-in process. The pressing process stops by the increasing force between the PCB and the distance keeper. It is correct when the press-in process is stopped before the PCB is on the module housing. Thus, the distance from the back side of the module to the PCB is independent of the module height.

Figure 12 Press-in of the power modules at a defined distance

3.2.3.1 Press-in only Easy3B and Easy4B modules into a PCB

If only Easy3B and Easy4B modules are used in the system, in principle a shorter distance keeper can be applied. The general principle should be kept as described in the previous section 3.2.3.

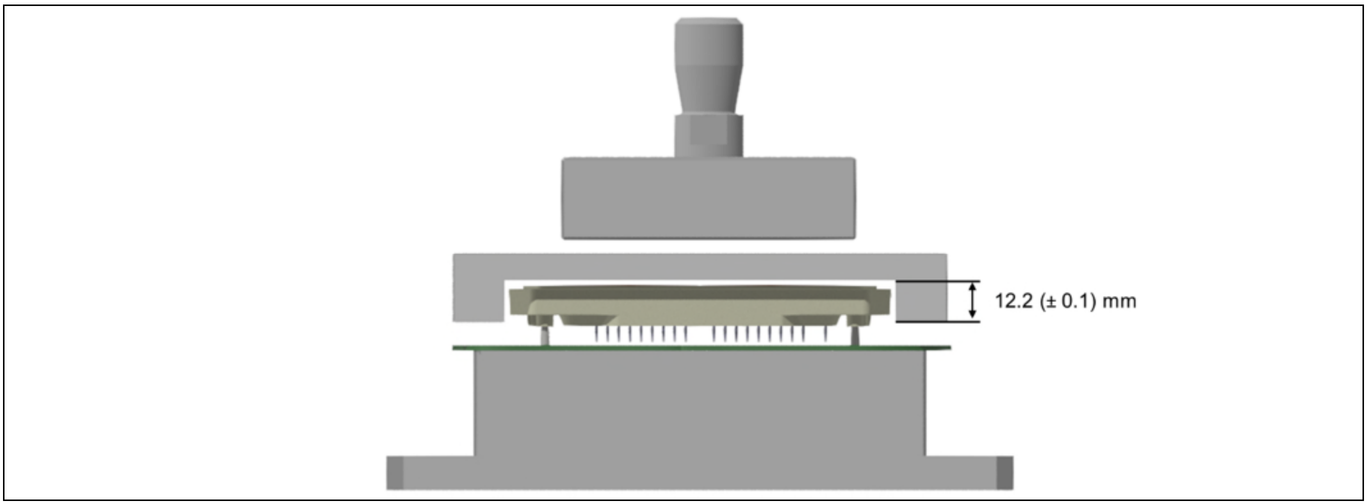


Figure 13 Typical distance keeper for Easy3B/4B modules

3.3 Press-in process parameter

This section deals with the press-in process parameter, which is useful for obtaining a highly reliable and mechanically stable PressFIT connection between the modules and the printed circuit boards.

3.3.1 Press-in behavior

The monitoring of the press-in process is of great importance. For this reason, a press-in machine with a controlled force-distance method is recommended for serial production in order to ensure a consistent quality and reproducibility of the press-in process.

A module can be pressed into a PCB either via a defined path-controlled displacement or by using appropriate distance keepers. Optionally, the four stand-off holes of the module can also be used for pressing in a single module into a PCB as a stop criterion. After a significant slope change of the press-in force at the end of the curve, the process is in principle completed, since the effective part of the press-in process is done.

Further pressing increases the force on the housing. It is therefore beneficial to detect the changing point of the slope, and to stop the press-in process as soon as the point is detected.

There is no significant difference between the methods of using distance keepers or module stand-offs as a stop criterion. A slight change could still present on the rising trail at the end in the slope of the curve due to the different material rigidities.

Instead of that, there is a difference in the curve progression between the press-in process used with distance keepers and the path-controlled procedure, in which a gap is set between the module and the PCB at the end of the process. In the path-controlled procedure, there will not be a rising trail at the end of the curve, due to the lack of contact with the PCB surface. These two methods are displayed in the following Figure 14 and Figure 15.

Depending on the choice of the PressFIT pin and other factors such as the hole diameter, metallization and stiffness of the PCB, the press-in curve of the standard PressFIT, and of the high-current pins can pose some differences in the progression and in the total press-in forces.

In general, the press-in curve is related to the different phases of the press-in path. It can be divided into three main phases.

In the following, these phases will be illustrated and described in the next subchapters.

3.3.1.1 Press-in curve example of standard PressFIT pin module

Figure 14 displays a typical press-in curve of an Easy2B module, which is equipped with 33 standard PressFIT pins.

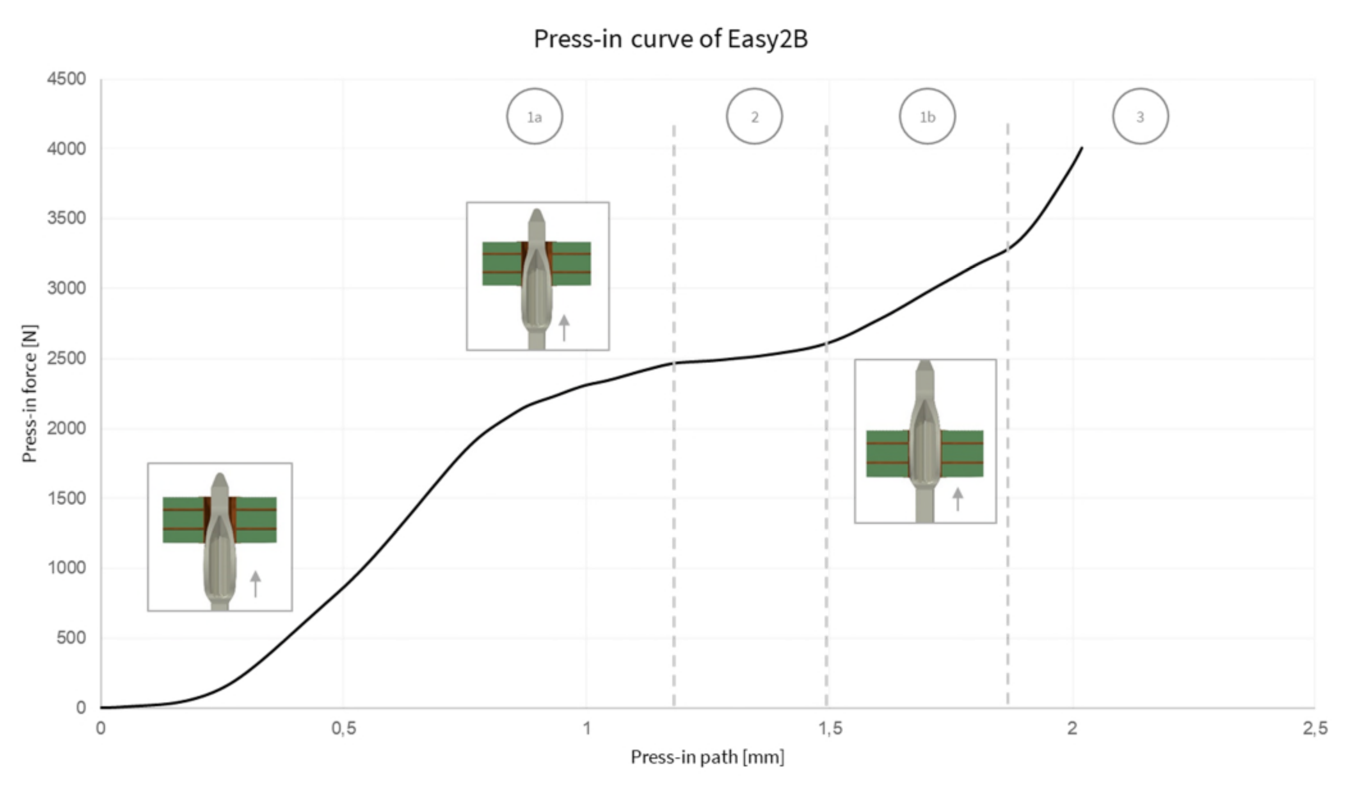


Figure 14 A typical press-in curve of Easy2B with 33 standard PressFIT pins

The first phase (1a) is the beginning of the PressFIT process. The PressFIT zone first comes in contact with the plated through hole of the PCB. While the module is pressed down, the press-in force increases evenly. At this moment, the PressFIT zone is deformed to a certain extent by the plated through hole of the PCB.

The second phase is caused by the additional sliding effect of some PressFIT pins into the rivets of the DCB, due to the available air gap between the PressFIT pins and the DCB within rivets. The final diameter of the plated through holes of the PCB has a significant impact on this behavior. The smaller the holes, the more pronounced this effect is in the curve. In case this second phase is not detected during the control of the press-in curve, there will be a low sliding effect of the PressFIT pins into the DCB rivets.

Note! The sliding effect of the PressFIT pins into the DCB rivets does not have any mechanical or electrical impact on the module or the PressFIT quality, and can be regarded as non-critical. After sliding has ended, the pin will connect to the rivet again via cold welding.

The subsequent phase (1b) is basically a continuation of the first phase. The PressFIT pins are pressed into the plated through holes of the PCB to the final position.

After the distance keepers have touched the PCB surface, the third phase is reached. The press-in process is in this example successfully completed at a slope change, at about z = 1.85 mm. The module has been subjected to a total force of approximately 3300 N.

3.3.1.2 Press-in curve example of high-current PressFIT pin module

An Easy 4B module with 75 high-current PressFIT pins is chosen as an example to show press-in progress. Its typical press-in progression is displayed in Figure 15. The progression of this curve may differ from the Easy4B press-in curve with standard PressFIT pins. This is mainly due to the geometric shape of the pin in combination with the printed circuit board properties.

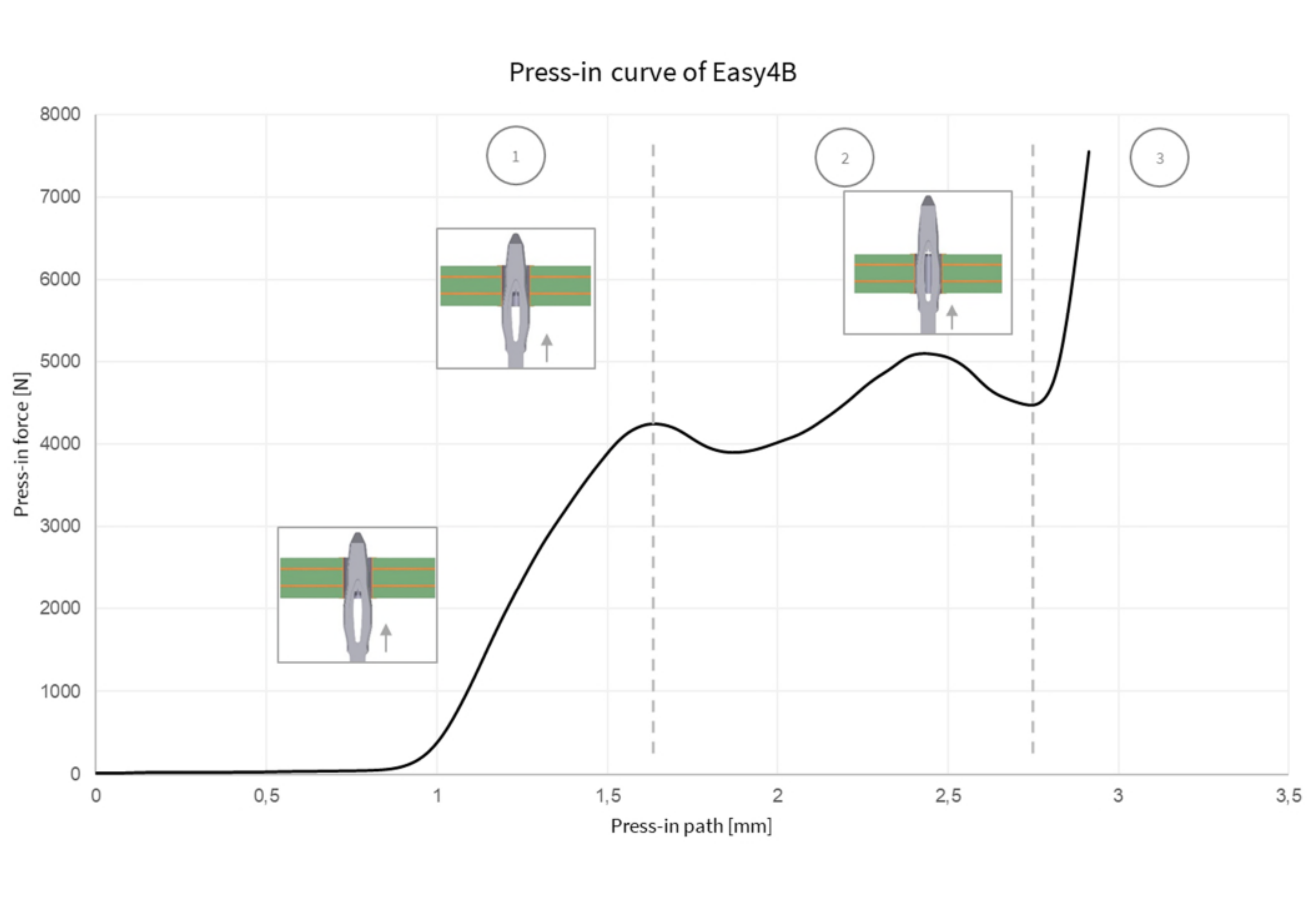


Figure 15 A typical press-in curve of Easy4B with high-current PressFIT pins

The first phase indicates the beginning of the PressFIT zone within the plated trough holes of a PCB. The PressFIT zone first comes in contact with the plated through hole of the PCB, and is then deformed to a certain extent by the plated through holes when the module is pressed down. At this moment, the press-in force increases evenly.

The first curve peak is caused by the geometry of the PressFIT zone. Depending on the metallization, stiffness and especially the final diameter of the PCB hole, this peak is more or less pronounced in the curve. The smaller the holes, the more visible this peak will be. Furthermore, a small diameter hole leads to a steep rise in the press-in force.

In the second phase, the press-in force decreases until the second peak is reached. At this point, the PressFIT pins are pressed to the final position with the widest circumference of the PressFIT pin, and subjected to the maximum permissible deformation. The press-in contact zone is then completely within the plated through hole of the PCB.

The subsequent third phase is generated by the contact of the distance keeper with the PCB. In this example, the effective part of the press-in process is successfully completed at the slope change, at about z = 2.7 mm.

However, this value does not apply for all press-in processes, and is used for reference only. It may vary depending on the zero level. The module has been subjected to a total force of 5050 N in this case.

3.3.2 Press-in force and speed

The total press-in force is generated by the number of pins, and can vary depending on several factors such as the type of PCB, the hole diameter or the metallization used in the PCB.

Depending on the module, a distinction is made between two different PressFIT pins. For insertion of the module into a PCB using the standard PressFIT pin, a force of approximately 60 N to 100 N can be applied for each pin in the module. In comparison, modules with the high-current PressFIT pins require a lower press-in force of approximately 50 N to 80 N per pin.

Table 2 shows the PressFIT speed and the maximum PressFIT force per pin.

	Standard PressFIT Pin		high-current PressFIT Pin	
Press-in force per pin	Typically, 85 N	< 100 N max.	Typically, 60 N	< 80 N max.
Press-in speed	>25 mm/min according to IEC 60352-5 qualification 100 mm/min recommended			

Table 2 PressFIT speed and force per pin

Note! The maximum applied force per module for Easy1B and Easy2B during pressing should not exceed 4 kN. The maximum applied force should not exceed 8 kN for Easy3B, and 12 kN for Easy4B.

The press-fitting speed should not be lower than 25 mm/min according to IEC 60352-5. Infineon recommends a press-in speed of about 100 mm/min. The typical press-in speed for automated assembly lines is up to 450 mm/min.

3.4 Press-in tools

For the three Easy B Series modules, the following press-in tools are recommended for pressing the modules in and out.

3.4.1 Press-in tools for Easy modules without pre-applied TIM

Figure 16 shows these pressing tools for the two housing types, Easy 1B and Easy 2B. The pressing tools for Easy3B housing are shown in Figure 17.

Each of the tools has two parts. The first part presses against the underside of the module, and the second part holds the PCB in place to be pressed against.

No components can be placed in the mounting areas of this special type of press-fitting tool. This prevents damage during the press-fitting process.

When press-fitting multiple modules onto a PCB, arrange the press-in tool in such a way that the modules are on the same level after pressing. In this way, the modules can be mounted on the heat sink with a good thermal connection. The detailed mounting sequence of multiple module into a PCB, please refer to chapter 3.2.3

Figure 16 Standard press-in tools for Easy1B (left shown) and Easy2B (right shown) modules

Figure 17 Press-fitting tools for Easy3B from HARTING Electronics GmbH

The drawing can be adjusted according to different requirements (e.g. module pinning and top side assembly of other parts) and the tools produced by a manufacturer of choice.

3.4.2 Press-in tools for Easy modules with thermal interface material (TIM)

Since the stamp should not touch the TIM material during the press-in process in order to prevent the TIM honeycombs from being harmed, the stamp should only touch the substrate areas without TIM. Figure 18 shows an example of the upper stamp for the press-in of Easy2B modules with TIM, which is made of two parts.

Figure 18 Press-In-stamp (left) and (right) pressure plate of Easy2B

The pressure plate is attached to the main part with four screws. This is an advantage for replacing the pressure plate after several press-in processes, or for changing the TIM honeycomb structure. Furthermore, the main part of the upper stamp contains two countersunk holes for the proper alignment to the bottom.

Figure 19 shows an example of the bottom stamp, which is separated into a baseplate and bottom tool. It supports the PCB around the PressFIT pins with cylindrical shapes, and supports the printed circuit board during the press-in process.

Figure 19 Press-In-baseplate (left) and bottom stamp (right) of Easy2B

The proper alignment of the module is necessary to avoid damaging the TIM honeycomb. Therefore, the four guiding pins help to position the module correctly during the press-in process. In addition, the bottom tool is equipped with two long alignment pins, which will be inserted into the countersunk holes.

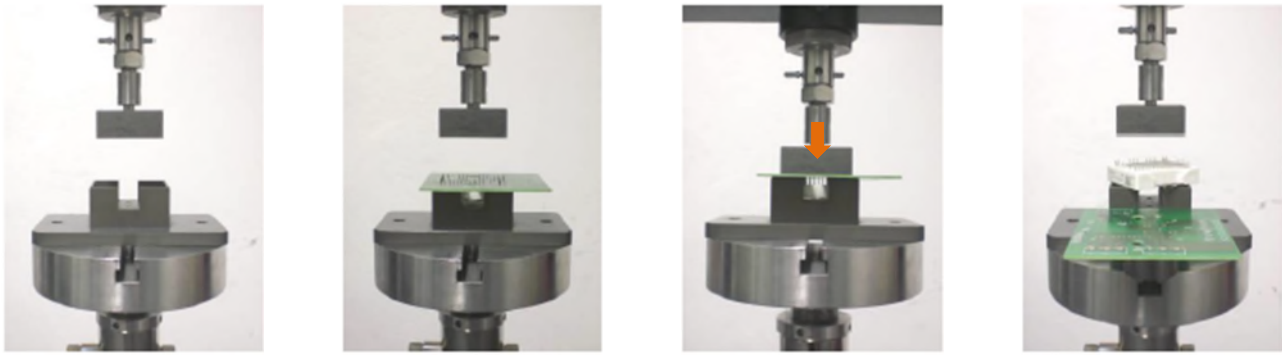
When deciding to adjust the tool by reducing the number of guiding pins for specific printed circuit boards, the press-in process should be checked and verified.

Drawings and 3D step models of the tool can be requested via the Infineon sales channels. The suitability for specific assembly processes and applications has to be tested and qualified by the customer.

4 The press-out process

This chapter deals with the necessary press-out forces and tools for the Easy modules.

PressFIT modules are removed with the appropriate tools as shown in Figure 20 and Figure 21. The PCB is placed with the PressFIT module on the device tray. Force is applied with the extrusion plate on the PressFIT pins that protrude from the PCB. The press-out tools must be aligned parallel to each other so that the individual components (such as the PCB and module) are not damaged. Once the PressFIT zone has been lifted from the PCB, the module falls onto the tray in the lower part of the tool, and is separated from the board.



1)	2)	3)	4)
The press is aligned so that one part of the tool is directly above the other.	The printed circuit board is placed in the extrusion tool with the PressFIT module facing downward.	The module contacts are extruded from the printed circuit board by pressing the upper tool part downwards. The module falls into the tray of the lower tool.	The printed circuit board and module can be separately removed from the tool.

Figure 20 Extrusion of an Easy module

4.1 Press-out tools

As already mentioned above, the press-out tools consist of two parts. The upper part of the tool presses directly downwards on the module pins. The lower part of the tool holds the module with the PCB, and serves as a base for the pressing operation.

The disassembly tools must be aligned parallel to each other in order to obtain an equally distributed extrusion process.

The dimensions of the press-out tool must be considered when designing the PCB so that the components positioned around the module will not be damaged.

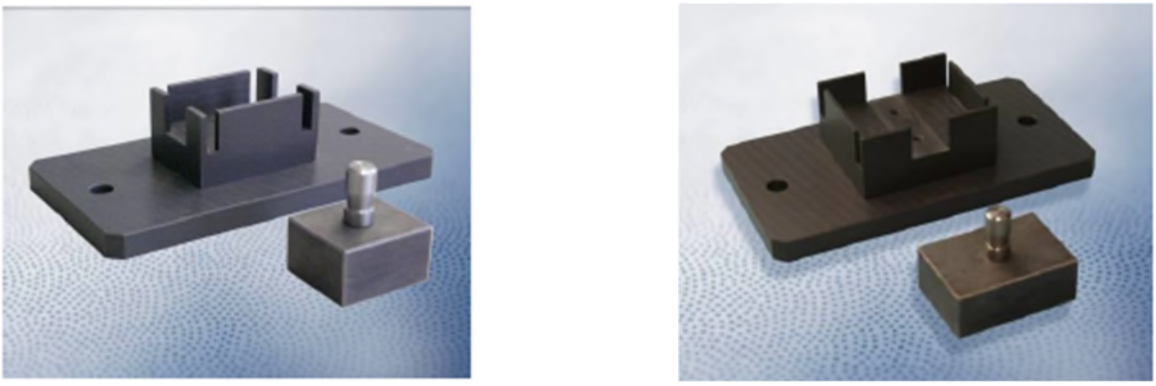


Figure 21 Press-out tools for Easy1B (left) and Easy2B (right) modules

The drawing can be adjusted according to requirements, and the tools produced by a manufacturer of choice.

4.2 Press-out forces

To press a module out of a PCB, a force of approximately >40 N has to be applied for each pin in the module. The extruding forces depend mainly on the diameter of the hole in the PCB.

5 Quality of PressFIT contacts

PressFIT is a solution for connecting control and load current contacts on IGBT modules with a PCB.

The requirements for greater durability, the trend towards higher temperatures and absence of lead, and, of course, very simple handling, are constantly growing.

As an advanced technology on the market, the PressFIT makes it possible to improve reliability up to a factor of 100 compared to manually soldered contacts and other contact types. The results of the reliability analyses in the Siemens standard SN 29500-5 demonstrate the factor.

The assembly process is simple, and consequently saves time and money. The process is reliable, and system reparability is ensured.

An extract from the Siemens standard SN 29500-5 / Edition 2004-06 Part 5 shown in Table 3 illustrates the failure rates of different contact technologies.

Table 3 Failure rates for various contact technologies Siemens standard SN 29500-5 / edition 2004-06 Part 5

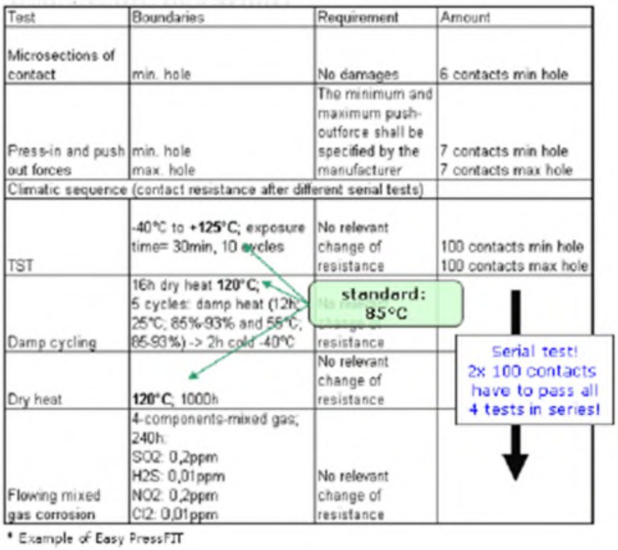
Process	Conductor diameter in mm²	Failure rate λ ref in FIT1)	Notes: Standards/guidelines
Solder manual Automatic	–	0.5 0.03	IPC 6102), class 2
Wire bonding for hybrid circuits Al Au		0.1 0.1	28 µm / wedge bond 25 µm / ball bond
Winding	0.05 to 0.5	0.002	DIN EN 60352 – 1 / IEC 60352 – 1 CORR1
Crimping manual Automatic	0.05 to 300	0.25	DIN EN 60352 – 2 / IEC 60352 – 2 A 1+2
Clips	0.1 to 0.5	0.02	DIN 41611 – 4
PressFIT	0.3 to 2	0.005	IEC 60352 – 5
Insulation piercing connectors	0.05 to 1	0.25	IEC 60352 – 3 / IEC 60352 – 4
Screws	0.5 to 16	0.5	DIN EN 60999 – 1
Terminals (spring force)	0.5 to 16	0.5	DIN EN 60999 – 1

1) 1 FIT = 1 x 10-9 1/h; (one failure per 109 component hours)

2) Acceptance conditions for PCBs

The PressFIT contact has been qualified in accordance with the usual standards for power semiconductor modules at Infineon.

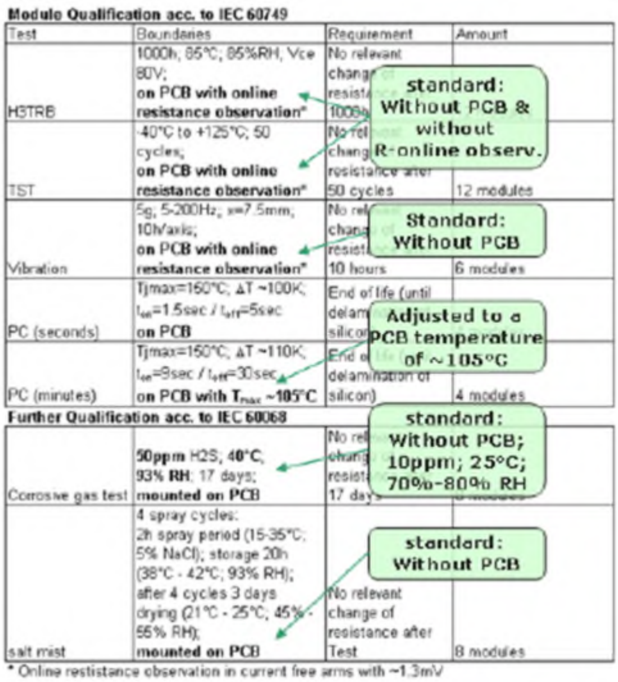
Figure 22 shows a small extract of the various tests. The extract shows that the conditions in the individual tests are to be regarded as considerably stricter than stated in the standards. For example, in a corrosive gas test, the temperatures in scope of individual test is 15 K higher than the condition in the standard. And the H2S concentration is five times higher than the conditions according to the norm. The green fields show the test conditions according to the norm, which is less critical than in the individual tests.



Test	Boundaries	Requirement	Amount
Microsections of contact	min. hole	No damages	6 contacts min hole
Press-in and push out forces	min. hole max. hole	The minimum and maximum push-outforce shall be specified by the manufacturer	7 contacts min hole 7 contacts max hole
Climatic sequence (contact resistance after different serial tests)			
TST	-40°C to **+125°C**; exposure time= 30min, 10 cycles	No relevant change of resistance	100 contacts min hole 100 contacts max hole
Damp cycling	16h dry heat **120°C**; 5 cycles: damp heat (12h; 25°C; 85%-93% and 55°C; 85-93%) -> 2h cold -40°C	resistance	
Dry heat	**120°C**, 1000h	No relevant change of resistance	
Flowing mixed gas corrosion	4-components-mixed gas; 240h: SO2: 0,2ppm H2S: 0,01ppm NO2: 0,2ppm Cl2: 0,01ppm	No relevant change of resistance	

* Example of Easy PressFIT

Single-pin qualification according to IEC 60532-5



Module Qualification acc. to IEC 60749

Test	Boundaries	Requirement	Amount
H3TRB	1000h; 85°C; 85%RH; Vce 80V; **on PCB with online resistance observation***	No relevant chang… resist… 1000h	
TST	-40°C to +125°C; 50 cycles; **on PCB with online resistance observation***	No rel… chang… resistance after 50 cycles	12 modules
Vibration	5g; 5-200Hz; x=7.5mm; 10h/axis; **on PCB with online resistance observation***	No rel… chan… resist… 10 hours	6 modules
PC (seconds)	Tjmax=160°C; ΔT ~100K; t_{on}=1.5sec / t_{off}=5sec **on PCB**	End of life (until delam… silicon)	
PC (minutes)	Tjmax=160°C; ΔT ~110K; t_{on}=9sec / t_{off}=30sec **on PCB with T_{max} ~105°C**	End o… delamination of silicon)	4 modules

Further Qualification acc. to IEC 60068

Test	Boundaries	Requirement	Amount
Corrosive gas test	**50ppm** H2S; **40°C**; **93% RH**; 17 days; **mounted on PCB**	No rel… chang… resist… 17 days	
salt mist	4 spray cycles: 2h spray period (15-35°C; 5% NaCl); storage 20h (38°C - 42°C; 93% RH); after 4 cycles 3 days drying (21°C - 25°C; 45% - 55% RH); **mounted on PCB**	No relevant change of resistance after Test	8 modules

* Online restistance observation in current free arms with ~1.3mV

Module qualification according to IEC 60749 and 60068

Figure 22 Extract from qualification test

Further details on the individual tests can be found in various publications, such as "Reliability of PressFIT connections" at www.infineon.com.

6 Soldering process for pressfit pin and solder pin

Both pressfit pin and solder pin are compatible with standard soft soldering process. The requirement for PBC is described in chapter 2.2 and chapter 2.3.

Manual soldering, automatic soldering, wave soldering are common used soldering processes. Based on IEC 68 section 2, The maximum duration of the soldering temperature of 260°C is 10s.

For module reliability, the maximum module case temperature during soldering process must not exceed 223°C.

7 Mounting a PCB to the module

For mounting a PCB onto the module, additional screws can be used if desired. These screws will be tightened into the stand-offs of the module, to mechanically relieve the PressFIT contact between the module and the PCB.

An electronically controlled, or a slowly turning electric screwdriver, with n ≤ 300 rpm, is the preferred mounting tool.

Due to the lack of accuracy, we do not recommend the use of pneumatic screwdrivers or manual screwdrivers.

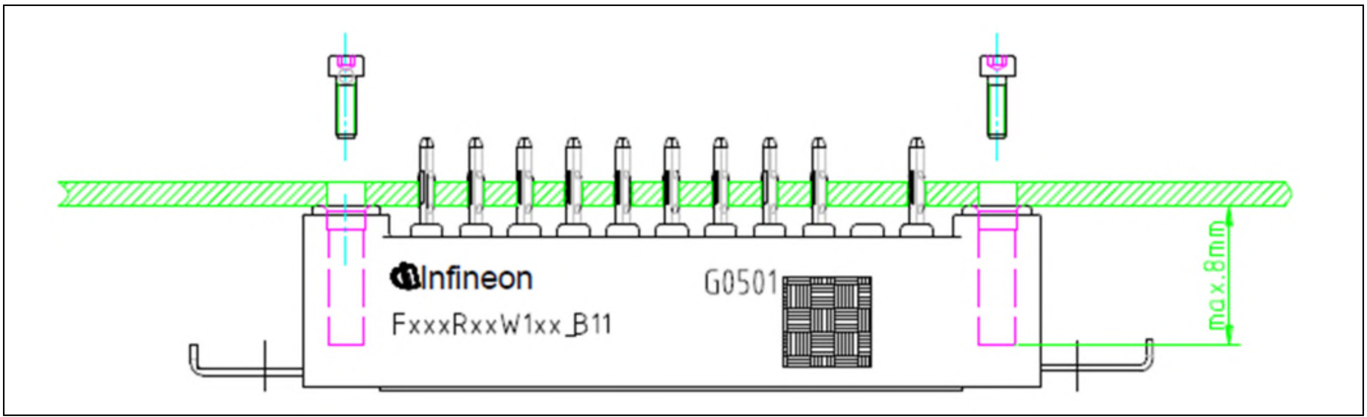


Figure 23 Detailed view of the assembly insert

The effective length of the thread in the stand-off should have a minimum of 4 mm, and a maximum of 8 mm.

The initial 1.5 mm of the mounting stand-off serves as guidance only and cannot withstand any force. The thread in the plastic will form during the screwing process.

For the choice of the screw length, the given PCB thickness has to be considered.

The following screws are tested to fix the PCB to the module:

- Ejot PT WN 1451 K25x10 A2K Mmax=0.45 Nm ±10%
- Ejot DELTA PT WN 5451 K25x8 Mmax=0.4 Nm ±10%
- Metric screws: M2.5xX – for example, M2.5x8 or M2.5x10 depending on the thickness of the PCB used

To avoid damage or splitting of the stand-off, straight insertion of the screw into the stand-off has to be observed during assembly.

The through hole diameter d_h of the PCB refers to the proposed screw types and the subjected manufacturing tolerances of the module. It is recommended to use a diameter of d_h = 3 mm as a guide for the PCB through holes according to the Figure 24. For other self-tapping screw types with a larger nominal thread size, this indication has to be determined and checked again.

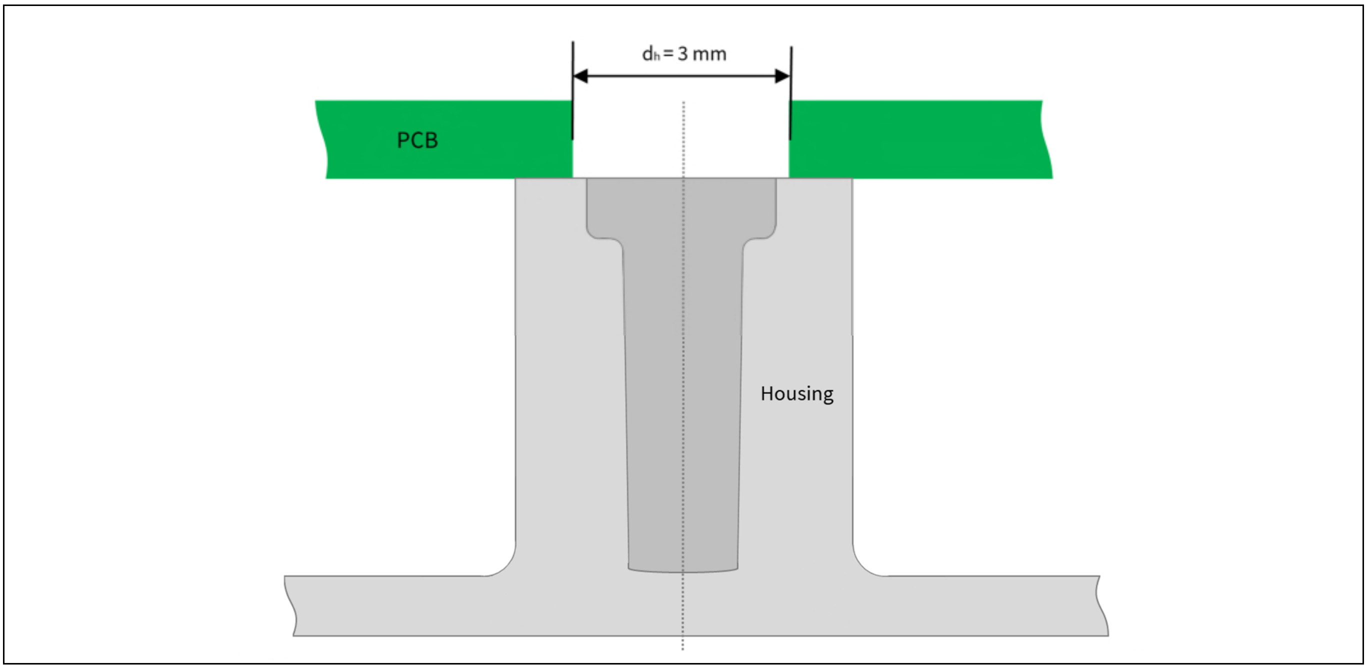


Figure 24 Recommendation of the PCB through-hole diameter for self-tapping screws

Note! If several modules are to be connected with spacers to the same PCB, it is not recommended to fasten the modules onto the PCB. This is due to the manufacturing- related tolerances of the height, and the different gaps between the stand-offs of modules and the PCB.

8 Condition of the heat sink for module assembly

The power losses occurring in the module must be transferred into a heat sink to ensure that the module operates properly within the specified maximum temperature T_{vjop} of the semiconductors, and to achieve the intended electrical and lifetime performance.

The condition of the heat sink surface in the area where the module is mounted is of great importance, as this interface between heat sink and module has a decisive influence on the heat transfer of the entire system.

The contact surfaces, the surface below the module and the surface of the heat sink have to be free of degradation and contamination to prevent excess mechanical stress to the module as well as an increase in thermal resistance.

The contact surface between module and heat sink should not exceed the following values:

- Surface flatness based on a length of 100 mm ≤ 50 µm
- Surface roughness Rz ≤ 10 µm
- Steps ≤ 10 µm

Note 1: The flatness of the heat sink should not exceed the values listed above. This area includes the entire module mounting area as well as that of the clamps.

Note 2: If the layer of thermal grease applied is too thick, e.g. as a consequence of cavities, the thermal resistance R_{th} between module and heat sink will increase.

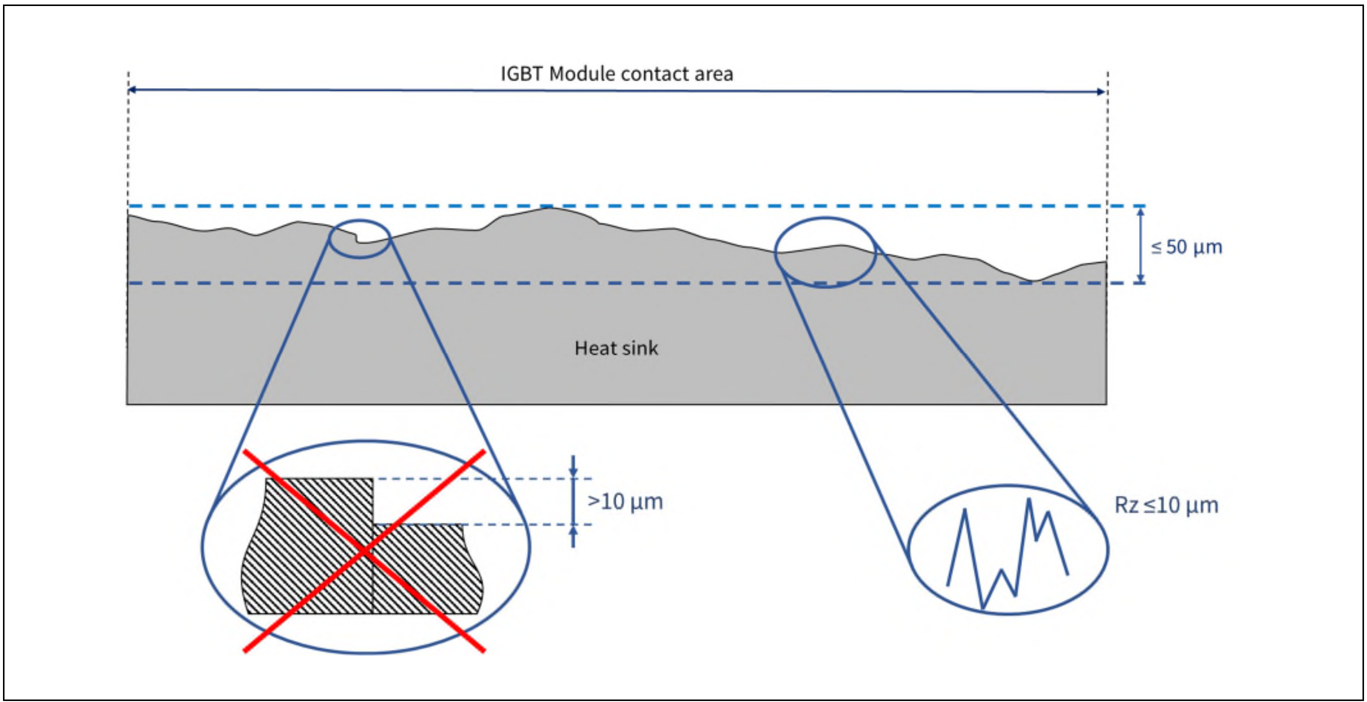


Figure 25 Recommendation for the quality of the heat sink surface for module installation

9 Applying the thermal grease

Due to the individual surface shape (e.g. roughness and flatness) of the heat sink and the module, the lower surface of the module and the surface of heat sink do not touch across the entire area. Therefore, a certain localized separation between the two components cannot be avoided.

To dissipate the losses occurring in the module and to achieve a good flow of heat into the heat sink, all localized cavities have to be filled with a thermal compound. When using a heat conductive paste, a homogenous application needs to be assured.

A well-applied layer will fill all cavities, and at the same time will still allow the metallic contact between module base and heat sink surface. A compound should be selected which shows permanently elastic features in order to assure a continuously favorable heat transfer resistance.

Before the module is mounted onto the heat sink, it is recommended to apply an even layer of thermal grease to the module base or to the heat sink, based on the module size and the thermal grease used. The grease can be applied using either a spatula, a roller, or by silk screen printing. The quantity of thermal grease is sufficient if a small amount of grease is visible around the module after assembly to the heat sink.

For Al_2O_3 substrate modules, the typical thermal grease thickness is 80 µm.

For AlN substart modules, the typcial thermal grease thickness is 40 µm.

The recommendation is to apply the thermal grease by means of a screen print process. Apart from an optimized and module-specific distribution of the heat conductive paste, a homogenous and reproducible layer thickness can be achieved with this procedure. If a screen print process is used, the layer thickness could be reduced to values under the above-mentioned numbers. The size of the module and the viscosity of the thermal grease are important factors in this case.

Further notes regarding the application of screen print templates for the application of thermal grease can be found in the application note AN2006-02 Application of silk screen.

10 Assembling the module on heat sink

10.1 Assembling Easy1B/2B module on heat sink

The module is mounted onto the heat sink using M4 screws. It is also possible to use an additional flat washer. The heat sink has to be provided with threaded holes as shown in Figure 26.

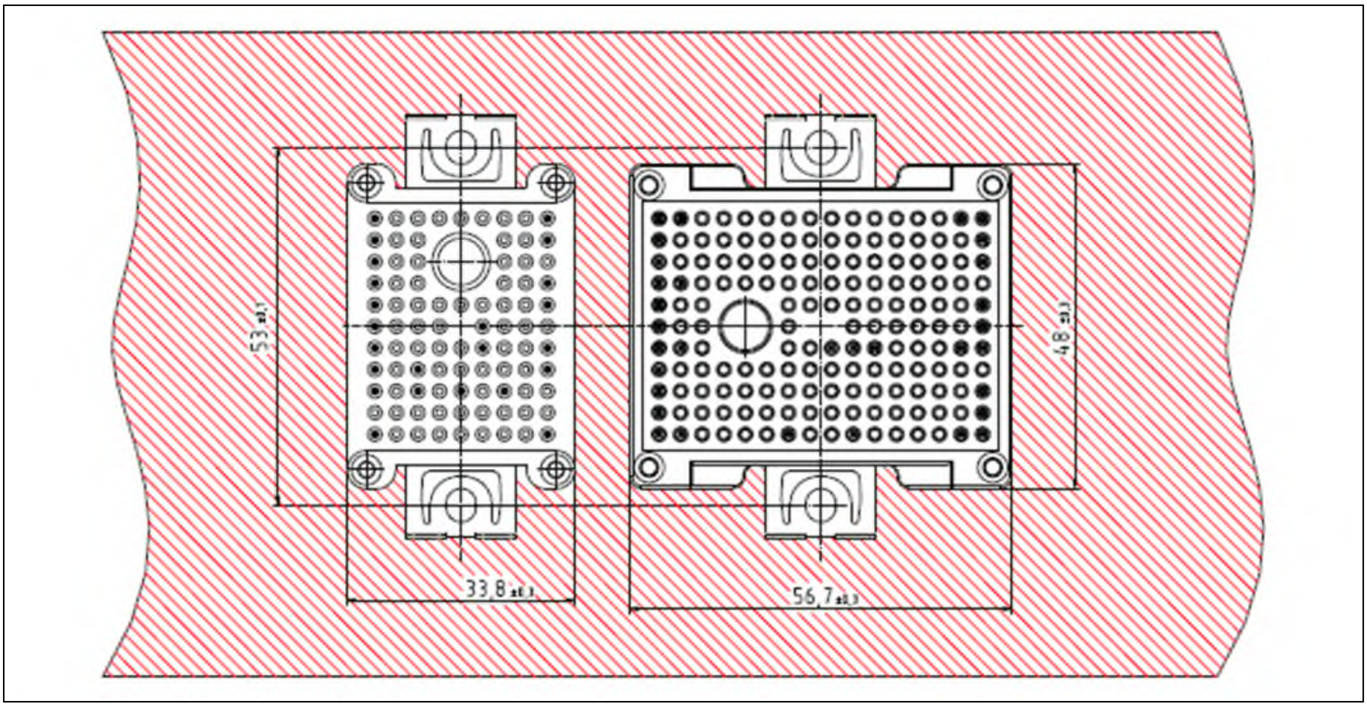


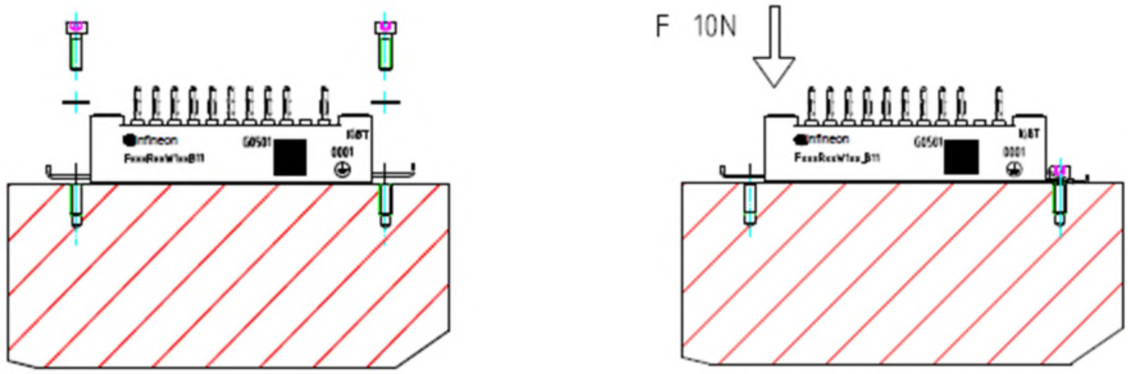
Figure 26 Spacing of the threaded holes

Note: If the module is first pressed into the PCB, or if a later disassembling of the module is desired, the PCB must contain suitable through-holes. The hole size depends on the screwdriver size or the screw's head diameter or washer.

The module should be positioned onto the heat sink in such a way that the holes of the screw clamps are exactly above the threaded holes of the heat sink. The mounting surface must be clean and free of contamination.

The module can be fastened by screwing in and tightening both screws at the same time (Figure 27a) or by holding down the module during the mounting process with a force of approximately 10 N so that the module cannot rise up (Figure 27b).

For modules with AlN substract, it is recommended to tighten both screws with half torque first, and then tighten both screws with max. torque afterwards.



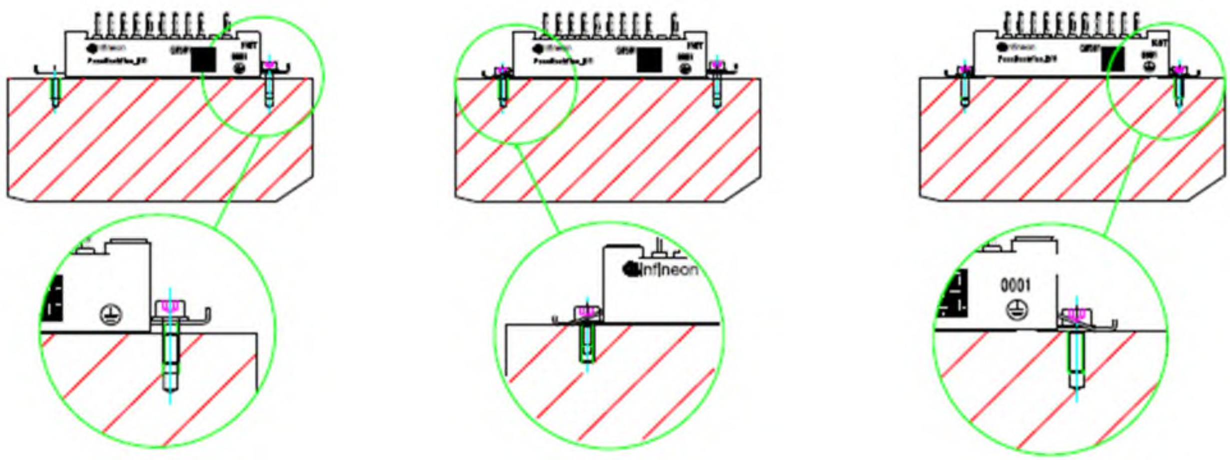
a) Fastening the module by simultaneous screwing in and tightening of the screws.

a) Fastening the module while holding down the module during screwing.

Figure 27 Module fastening options

Alternatively, one screw can be applied initially. It is important that the module does not lift up. To prevent this, tighten the first screw loosely to avoid a press force to the clamp (Figure 28a). Then, tighten the second screw completely (Figure 28b). Finally, tighten the first screw completely (Figure 28c).

For modules with AlN substract, it is recommended to tighten the screws with half torque for Step 2 and Step 3 first, and then tighten both screws with max. torque afterwards.



a) Step 1 **b) Step 2** **c) Step 3**

Figure 28 Fasten the module by applying one initial screw and tightening both screws sequentially

Table 4 **Technical data of the mounting screw**

Description	Values
Mounting screw	M4
Recommended mounting torque	Ma = 2.0 – 2.3 Nm [1)]
Aluminium cast alloy Aluminium alloy hardened Aluminium alloy not hardened	2.2 x d = 8.8 mm [2)] 1.2 x d = 4.8 mm [2)] 1.6 x d = 6.4 mm [2)]
Washer acc. to DIN 125	D = 9 mm

[1)] The maximum permissible mounting torque of the screw must not be exceeded

[2)] As per technical literature

10.2 Assembling Easy3B and Easy4B module on heat sink

For the assembly of the Easy3B and Easy4B module to the heat sink, Infineon recommends the use of DIN M5 screws, in combination with a M5 washer.

Position the module correctly to the heat sink, so that the mounting area of the module is congruent with the threaded holes in the heat sink. Make sure that there are no foreign objects between the module and the heat sink.

The module can be fixed by screwing and tightening both screws at the same time (see Figure 29).

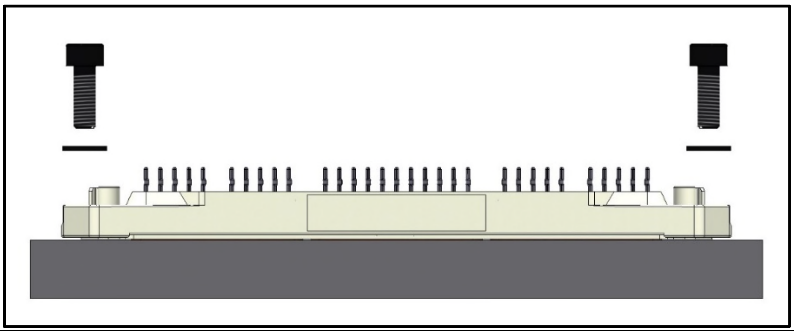


Figure 29 Steps for alternative fastening of the module

Alternatively, the module can be mounted to the heat sink in several steps (see Figure 30):

- Step 1: The first screw can be screwed in slightly. Do not fully tighten it, so that no pressure is exerted.
- Step 2: The second screw needs to be firmly screwed to the heat sink.
- Step 3: Finally, the first (loose) screw needs to be screwed on firmly to the heat sink.

Note: If the module is first pressed in to the PCB, or if a later disassembling of the module is desired, the PCB must contain suitable through-holes. The hole size depends on the screwdriver size or the screw's head diameter or washer.

Assembling the module on heat sink

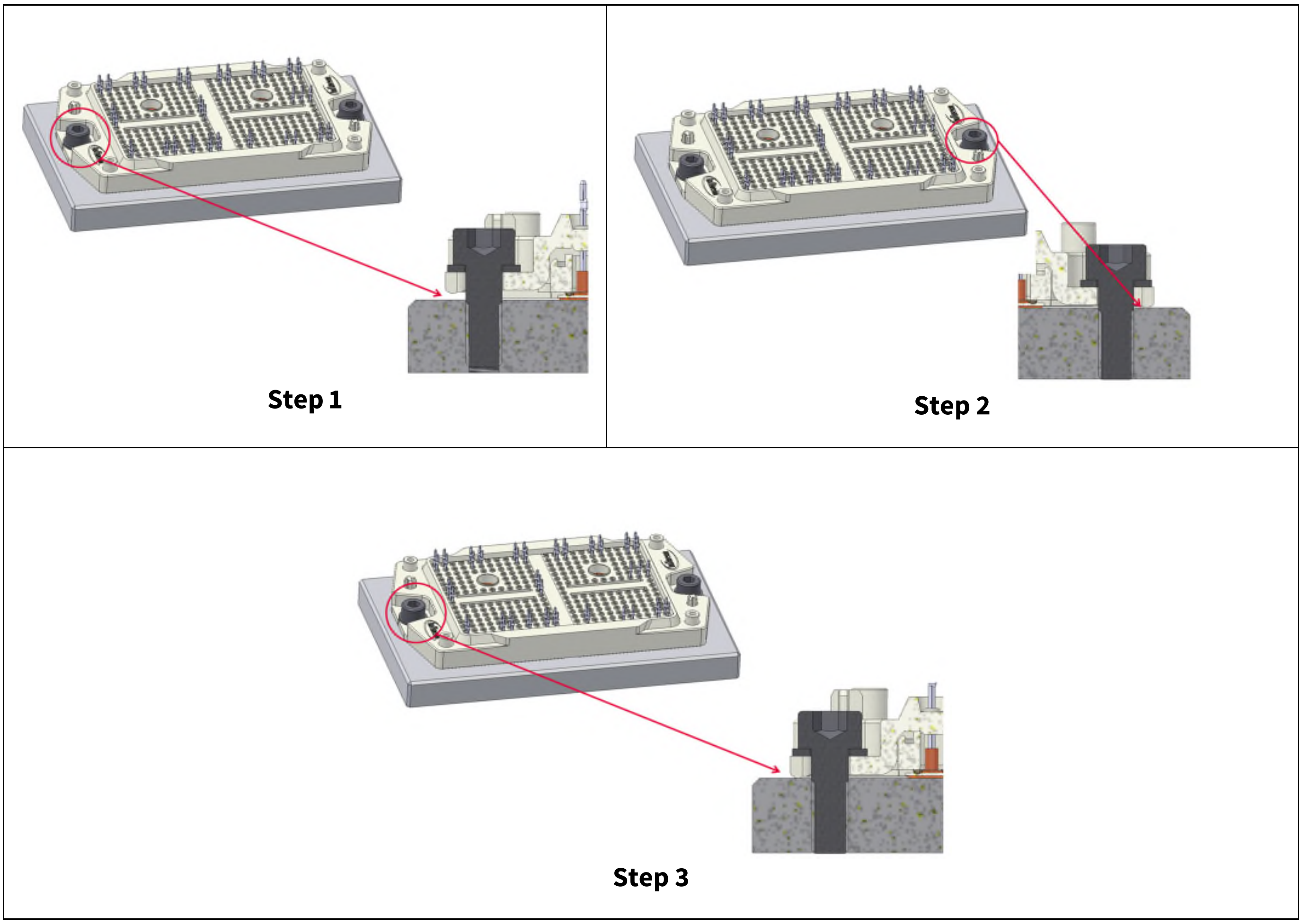


Figure 30 Module fastening steps

The following values are recommended for the mounting process:

Table 5 Recommended parameters for heat sink mounting

Description	Values
Mounting screw	M5
Recommended mounting torque	Ma_{max} = 1.5 Nm [1)]
Recommended property class of bolt	4.6 – 5.6
Minimal thread length into the heat sink	2 x d = 10 mm
Pre-tightening torque	0.3 – 0.5 Nm
Tightening torque Ma	1.3 – 1.5 Nm
Screw velocity (pre-tightening)	U ≤ 250 U/min
Screw velocity (tightening)	U ≤ 20 U/min
Recommended washer	M5

[1)] The maximum permissible mounting torque of the screw must not be exceeded

11 System considerations regarding mechanical robustness

If the module is correctly mounted to the heat sink and to the PCB, the screw clamps will apply the necessary pressure. This pressure, together with the correct amount of thermal grease, will ensure a low thermal resistance and an optimal thermal flow between the module and the heat sink. Since the PCB is connected to the module by pressed-in pins only, suitable measures have to be taken to ensure that vibrations are kept at a minimum. Any possible movement between the terminals and the module case has to be avoided. Each single pin may only be subjected to a maximum press and pull force of 6 N vertical to the heat sink. The overall pulling force to the module of 20 N must not be exceeded. The compressive force could be 10 times higher than the possible pulling force. A low compressive load to the module is preferred. Therefore, the circuit board should additionally be fixed to the heat sink at a position close to the module. In principle, this can be done in several ways depending on the number of modules used, and on the type of press-in procedure.

11.1 Module is pressed into a PCB by contacting the stand-offs with the PCB

If the module is pressed into the PCB by contacting the module stand-offs with the PCB surface, it is recommended to keep a distance of at least x = 5 cm from the module's outer edges to the 12 mm distance keepers. In this case, the module can be fixed to the PCB by using additional self-tapping screws (recommended) after the PCB is connected to the heat sink. Air gaps between the module stand-offs and the PCB should be prevented as shown in Figure 31. This procedure is not recommended for the Easy3B/4B modules.

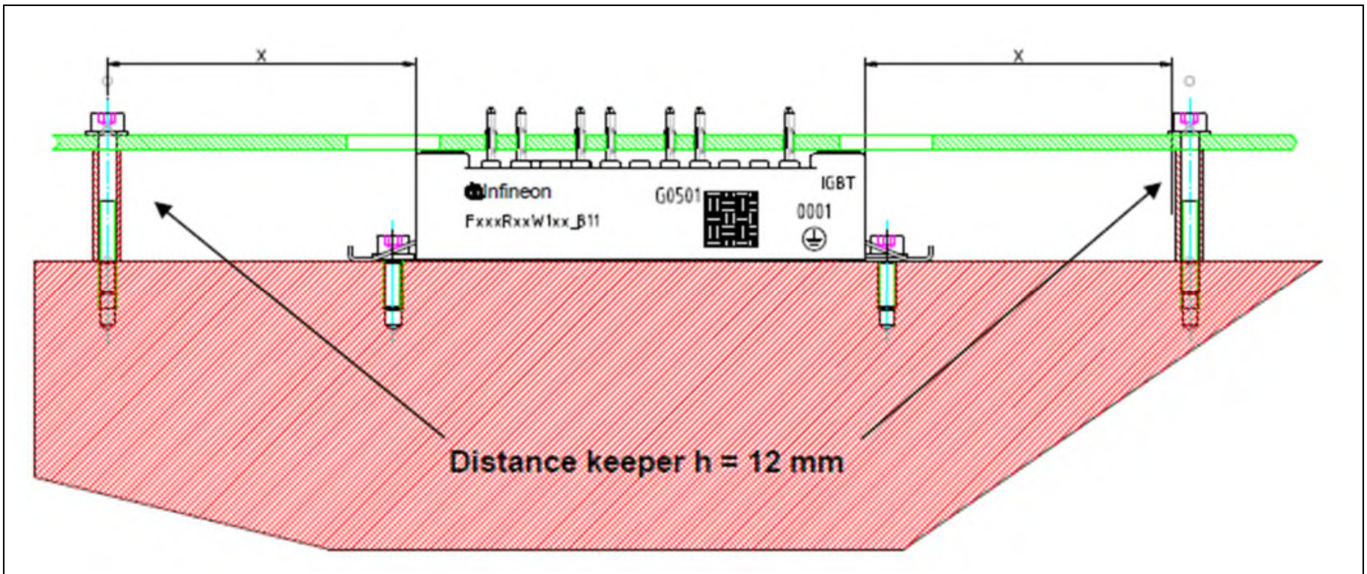


Figure 31 Mounting the PCB

11.2 Module is pressed into a PCB at a certain distance

This case is similar to the assembly instructions for pressing multi-modules on a PCB. A single module can also be inserted into the PCB at a defined distance, i.e., not less than the max. possible height of the module housing. The distance keepers of the press-in process could be e.g. ⩾ 12.35 mm for an Easy1B/2B module.

In this case, the distance keepers can be positioned as close as possible x ⩽ 5 cm to the module for connecting the PCB to the heat sink. Ensure, that the distance keepers used during the press-in process are at the same height as those used in the system. As a result, no mechanical stress will occur. The module should not be fixed to the PCB in this case, since an air gap might be present.

11.3 Multi-modules on a PCB

For assembling several modules on a PCB, the modules have to be pressed into the PCB at a certain distance, as explained in Chapter 3.2.3. The module height tolerance is then quasi compensated in this press-in process. In this case, the distance keepers from the PCB to heat sink can be close to the power modules. The position of the distance keepers should be designed symmetrically around the power module(s).

The height of the distance keepers from PCB to heat sink should be exactly the same as those used in the press-in process.

- For applications including Easy1B/2B with Al_2O_3 DCB, the height (H) of the distance keeper indicated in Figure 32 should be typically 12.4 ± 0.05 mm.
- For applications including Easy1B/2B with AIN DCB, the height (H) of the distance keeper indicated in Figure 32 should be typically 12.6 - 0.05 mm.
- For applications using only the Easy3B/4B module, the height (H) of the distance keeper indicated in Figure 32 should be typically 12.2 ± 0.1 mm.

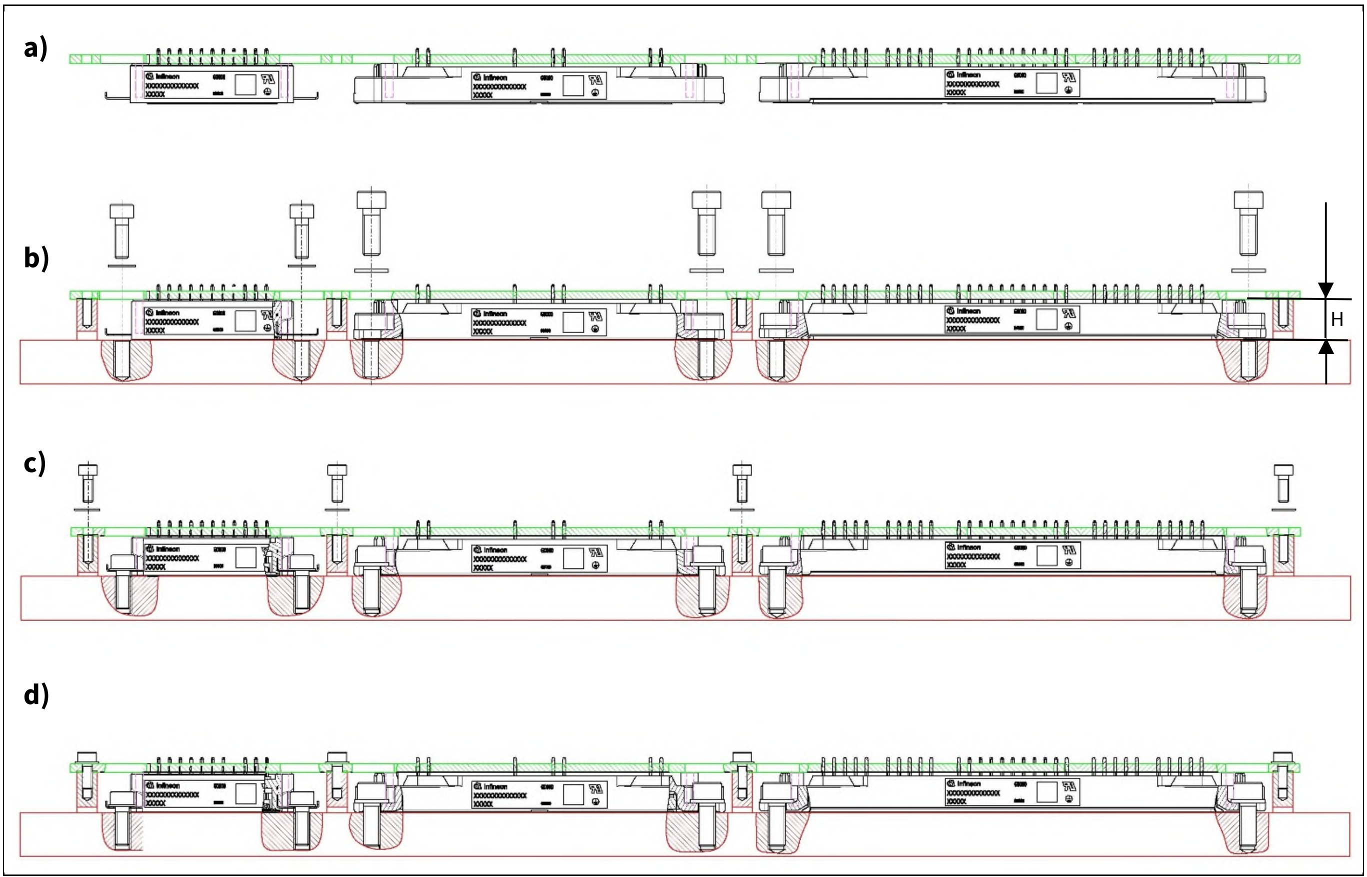


Figure 32 Mounting example of the PCB and modules to the cooling system (drawing not true to scale)

Figure 33 shows a zoom of the final system assembly. Depending on the height of the module, a small air gap remains between module and PCB.

As the value (H) of Figure 32b must not be higher than the module-to-PCB height of Figure 32a, it is ensured that no pull forces are applied to the power modules, which would be critical considering the thermal contact between module and heat sink.

Please note: It is possible to press the module tighter to the PCB than the maximum 12.45 mm. This will increase the overlapping zone in the active press zone (contact area: pin to PCB). Please remember to lower the fixing elements of the cooling system (Figure 32b) accordingly if the modules are pressed tighter to the PCB! The value (H) of Figure 32b must not be higher than the module-to-PCB height of Figure 32a! A force of the PCB on the module in the direction of the cooling system is not critical, and is desired, as it improves the thermal contact.

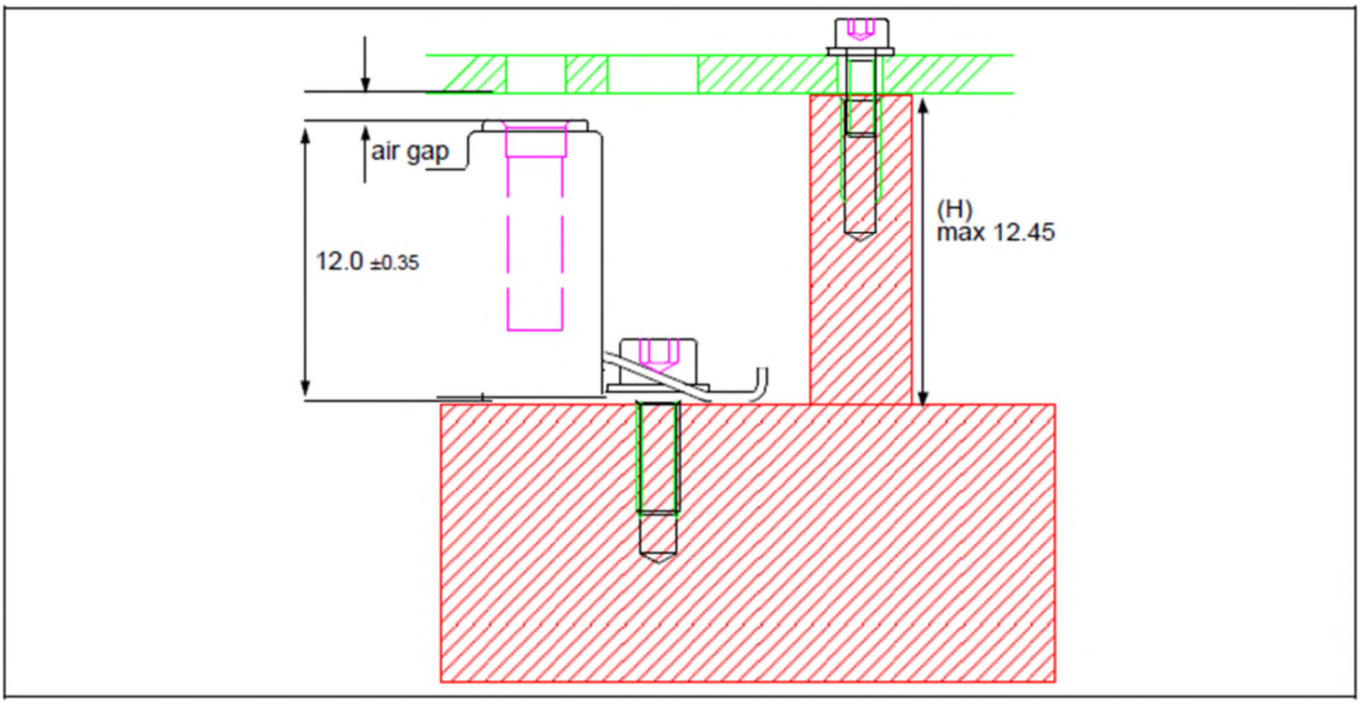


Figure 33 Zoom illustration of final system assembly (drawing not true to scale)

Please note that using this pressing concept with a remaining air gap does not allow the PCB to be screwed down to the stand-offs (guiding holes) as shown in Chapter 7.

11.4 Module assembly sequence

No matter if a single module in one PCB or multi modules in one PCB, it is always recommened to assemble the module first to PCB, then assemble the PCB with module to the heatsink. Such assembly sequence is much easier to position and better suitable for automation.

When assembling just one solder pin module to a PCB, it is permissible to assemble the module to heatsink first and then solder the PCB to module. This is shown in Figure 34.

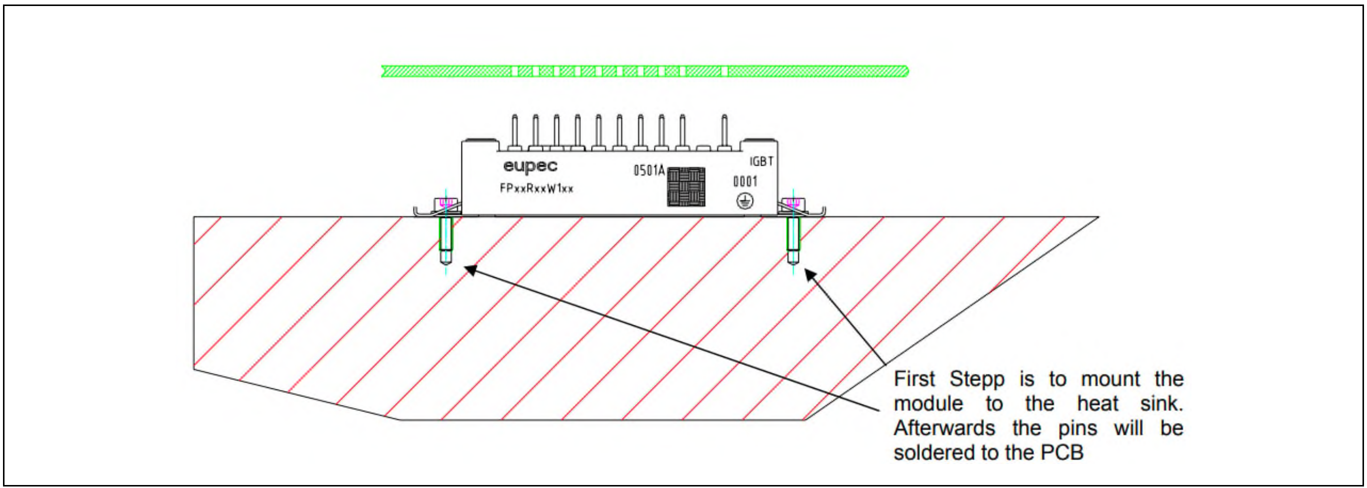


Figure 34 Mounting of the module onto the heat sink before soldering

12 Clearance and creepage distances

According to the 3rd revison of IEC 60664-1, mechanical tolerances must be considered when calculating the clearance and creepage distance Older datasheets also contain information on typical clearance and creepage in a table in the datasheet. However, this does not consider tolerances and the many different relations between different pin positions. Therefore the following chapters provide an overview about the creepage distance and clearance for Easy modules to enable a design based on the new requirements. These values can be used for first checking of fulfillment of application condition. When the module clearance or creepage distance is not sufficient for the corresponding application, please contact Infineon sales office for further technical support.

12.1 Pin-to-Pin creepage distance

Creepage distance is defined as the shortest distance along the surface of a solid insulating material. For the Easy modules we consider the outer and the inner surface of the housing. The CTI value of this material is provided in the module datasheet.

12.1.1 Creepage distance for standard PressFIT and solder pin

Figure 35 shows the typical pin-to-pin creepage distance for Easy package. The values below the pins indicate the creepage distance from the pin to the origin pin, assuming only unpopulated positions in between. The origin pin can be any pin in Easy module. Based on the relative position to the origin pin, the pin to pin creepage distance can be easily read out. For Easy3B/4B, there are several DCB in one module, the creepage distance across DCBs is also shown here.

a) within on DCB (unit mm) | b) across DCBs (only for Easy3B/4B, unit mm)

Figure 35 Pin-to-pin creepage distance for standard pins

12.1.2 Creepage distance for High-Current PressFIT

In some modules in Easy3B/4B package, high current pressfit pin is applied. Due to geometry difference to standard pins, the creepage distance is slightly different. Figure 36 shows the creepage distance for Easy3B/4B with high current pin.

a) Within one DCB (unit mm)	b) across DCBs (unit mm)

Figure 36 Pin-to-pin creepage distance for high current pin in Easy3B/4B

12.2 Pin to pin Clearance

Since, the Easy module always must be assembled in PCB, the pin-to-pin clearance is limited on PCB side when the pad diameter is more than 1.7 mm. In such case, the clearance must be checked on PCB level.

12.3 Pin to heatsink clearance and creepage distance

If the pin to heatsink clearance and creepage distance is provided in the datasheet, the values provided do not consider the mounting hardware. For the overall system, it is also important for the area of the screw clamp, which is located under the PCB. 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 such as lacquering must be considered.

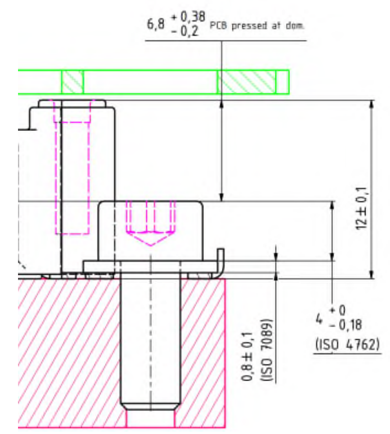


Figure 37 Air path between clip and PCB for Easy1B and Easy2B packages

The clearance distance between the screw and the PCB depends on the screw itself. For Easy1B/2B packages, when the PCB touch the module stand-off, the distance from heatsink to PCB is 6.6 mm with a hexagon socket head M4 screw according to DIN 912, a washer according to DIN 125, and the clamp illustrated in Figure 37.

For Easy3B/4B packages, when the PCB reach the distance keeper (12.2mm +/-0.1) the distance from hestsink to PCB is 2.94 mm with a hexagon socket head M5 screw according to DIN 912, and an M5 washer according to DIN 125. A detailed drawing can be seen in Figure 38.

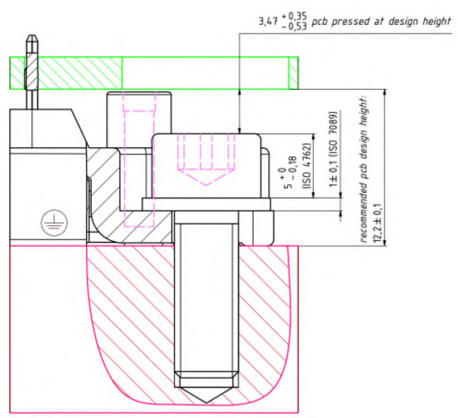


Figure 38 Air path between clip and PCB for Easy3B packag

Revision History

Document revision	Date	Description of changes
Initial revision	18.08.2023	

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