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Infineon

EconoDUAL™3

Mounting instructions / Application note

IFAG IPC MP

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Author: Martin Knecht (IFAG IMM INP MP)

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1 General information

1.1 General application information

Compliance with the requirements for Infineon IGBT modules is assured by appropriate reliability tests and by 100% final tests that are performed during production.

Maximum values in the product data sheets and application notes of IGBT modules are definite limits that may never be exceeded, even not for a short period of time, as this could end in the destruction of the components.

This application note cannot cover all different applications and application conditions. Therefore application notes can not replace a detailed technical evaluation and examination by the user. Therefore, the application notes will under no circumstances become part of any supplier agreed warranty, unless the supply agreement determines otherwise in writing.

1.2 Handling of electrostatic sensitive components

IGBT modules are electrostatic sensitive components. Electrostatic discharge (ESD) may pre-damage these modules or even destroy them.

In order to prevent destruction or pre-damage of the components by electrostatic discharge, the components are delivered according to the approved ESD regulations, in appropriate ESD protected packaging.

The removal of the ESD protection and the handling of the unprotected modules require the installation of ESD conform workplaces. Further information is available e.g. from the ESD security guidelines IEC 61340-5-1 and ANSI/ESD S2020.

Figure1: Electrostatic discharge symbol

2 Assembling instruction for PCB's on modules

2.1 Assembling instruction for PCB's on solderable modules

2.1.1 Additional fixing of the printed circuit board

By using an external driver board, the gate-collector connection should be realized as short as possible to prevent magnetic coupling and to minimize the gate circuit inductivity.

After the solder process, it is recommended to mechanically relieve the contact areas between module and printed circuit board. Relieve of the contact areas is achieved by mounting the PCB onto the module using the four PCB mounting stand-offs (see figure 2) using self-tapping screws or similar fastening methods.

For the development process both evaluation driver boards as well as evaluation module adapter boards (module adapter to hold gate resistors and clamping diodes) are available on request. Further information regarding EconoDUAL™ evaluation drivers is contained in the application note AN2006-04 Evaluation Driver Board for EconoDUAL™ IGBT modules.

Besides screwing the PCB to the mounting domes by hand, an electronically controlled or at least slowly turning electric screw driver (U ≤ 300U/min) is a preferred tool for this process.

Due to a lack of accuracy we do not recommend the use of pneumatic screw drivers.

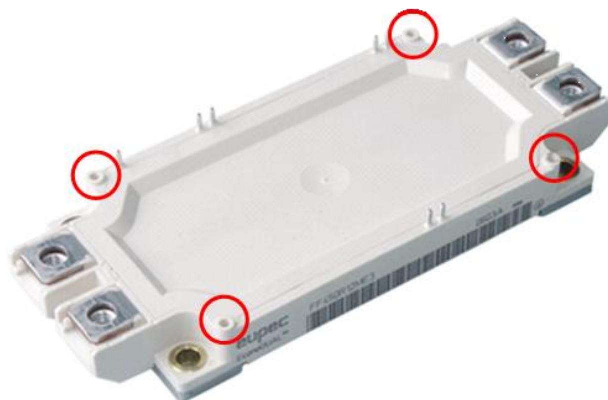


Figure2: PCB mounting stand-offs at EconoDUAL™3 module (marked red)

The effective length of the screw thread entering the PCB mounting stand-offs should be of a minimum length of $l_{min} \geq 4mm$ and a maximum length of $l_{max} \leq 10mm$, taking into account the specific PCB thickness and the weight of the mounted PCB.

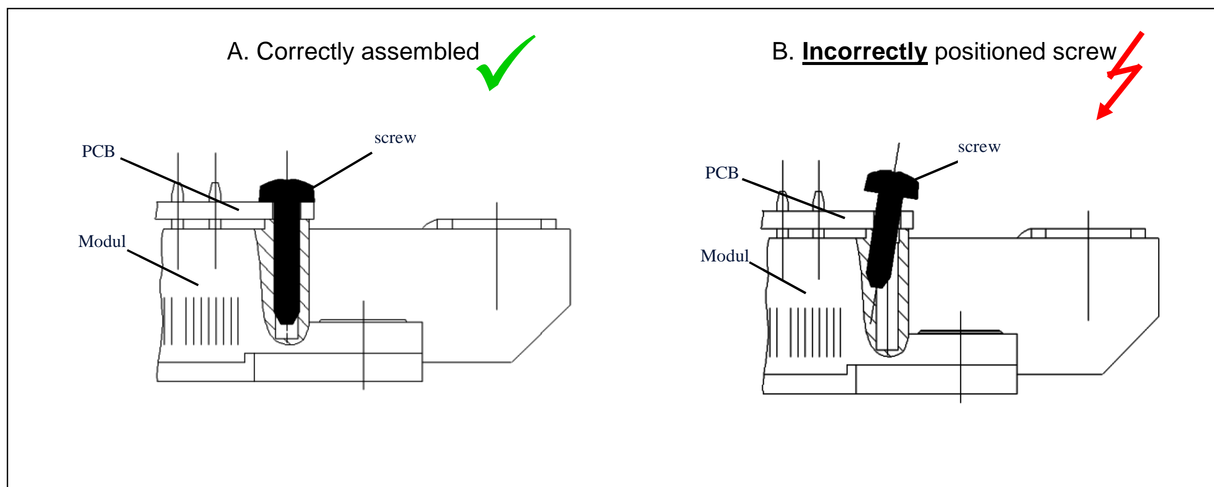


Figure3: A. Correctly assembled screw in the PCB mounting stand-off
B. Incorrectly positioned screw in the PCB mounting stand-off

The upper 1.5mm of the mounting stand-offs serve as guidance only and can't take any force. The thread in the plastic will form itself when the screw is driven in. The recommended self-tapping screw is for example:

- EJOT PT WN 1451 K25x10 A2K : M_{max} = 0.45Nm ± 10%

To avoid damage or splitting of the mounting stand-off, straight insertion of the screws into the stand-offs has to be achieved during assembly (figure 3).

The recommended screw and torque is based on laboratory tests. Depending on the screws used and tools it may be necessary to adjust the assembly process accordingly.

After mounting the PCB the solder process (manual soldering, selective soldering or wave soldering) may begin. When adhering to this sequence of assembly, the mechanical strain to the solder points can be minimised.

If the modules, before they enter the soldering process, are pre-heated with the aid of heat plates below the base plate or by circulating air, this process must be adjusted such that a pre-heat temperature of T≤150°C for t≤30min is not exceeded.

During the entire soldering process care needs to be taken that neither too high a soldering temperature nor too long a process time at the auxiliary pins overheats the plastic case and thus deforms it.

According to IEC 68 section 2, a maximum solder temperature of T=260°C for a maximum process time of tmax≤10s has to be observed during the solder process.
Further information regarding solder processes is detailed in the application note AN2005-06 "Soldering Econo und Easy modules".

2.2 Assembling instruction for PCB's on Press-FIT modules

2.2.1 Requirements for the Press-FIT printed circuit board's

The PressFIT technology used in the EconoDUAL™3 modules has been inspected and qualified by Infineon Technologies AG for standard FR4 printed circuit boards with „chemical tin" surface (according to the IEC 60352-5 + IEC60747-15 standards). If other technologies are used for the production of printed circuit boards, they have to be tested, inspected and qualified separately.

Requirements for the printed circuit board (PCB) material are:

Double-sided PCB according to IEC 60249-2-4 or IEC 6249-2-5.

Multilayer PCB according to IEC 60249-2-11 or IEC 60249-2-12.

In order to ensure a good contact between PCB hole and PressFIT pin, the specification of the hole given in table 1 has to be followed.

If the specification of the PCB holes included only the final hole dimension (i.e. the metallized hole), different drill sizes and metalization thicknesses could be used depending on the PCB manufacturer and his production capability. This could result in varying results and so compromise the quality of the electrical contact. For this reason it is recommended to follow the complete guidelines provided in table 1.

A further recommendation is to drill the holes in the PCB with a drill of 1.15mm in diameter, and not to mill it. Experience has shown that with milling the final hole diameter is typically between 1.12mm and 1.15mm due to the runout tolerances of the spindles used and due to shrinkage of the FR4 material.

	Min.	**Typ.**	**Max.**
Drill hole diameter	1.12	1.15	
Copper thickness in hole	>25µm		<50µm
Metallization in hole			<15µm
Final hole diameter	0.94mm		1.09mm
Copper thickness of conductors	35µm	70µm - 105µm	400µm
Metallization of PCB	Tin (chemical)		
Metallization of pin	Tin (galvanic)		

Table 1: Requirements for the printed circuit board

With a copper thickness of 25µm to 50µm in the hole and a tin layer of about 1µm for chemically applied tin, a final hole diameter is obtained as a test dimension. Due to the thinner tin layer thickness compared to e.g. HAL printed circuit boards, the diameter is always higher than the value of 1mm that is given in the according standard (IEC 60352-5). The final hole diameter, considering the drilled hole diameter, copper thickness and tin thickness is typically between 1.02mm and 1.09mm.

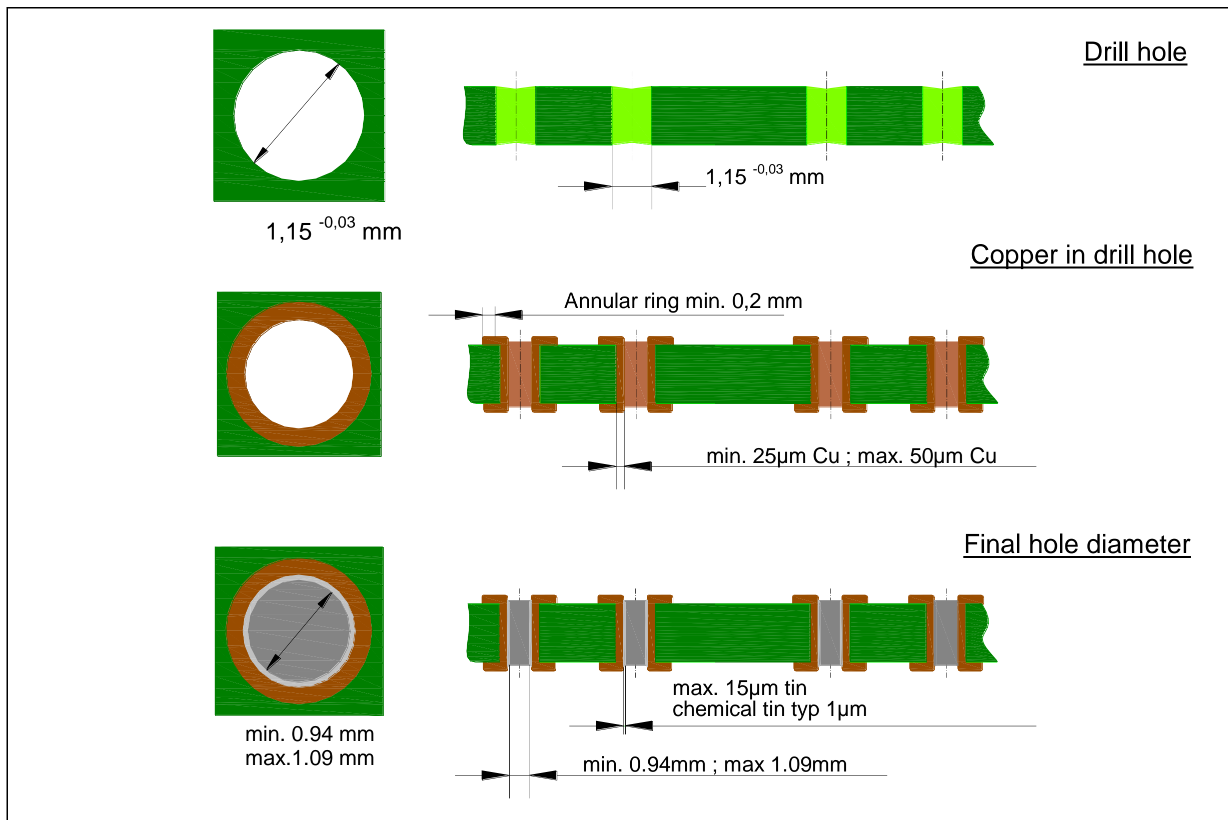


Figure 4 Structure of the printed circuit board

The PressFIT technology is qualified for FR4 printed circuit board material.

After a reflow soldering process is carried out on a printed circuit board, the module can still be pressed into the board. The contact and retention forces of the PressFIT pins are not lessened.

As with Easy and Econo PressFIT modules, a distance of 5mm from the middle of each pin to other components on the PCB has to be observed. The same dimensions have to be considered in case of Press-tools developed by the user when positioning components on the PCB.

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

A module that has been pressed in and then pressed out again can no longer be pressed in. Instead, the module can be attached in a new PCB by soldering. The plastic deformation of the PressFIT pin does not allow further press-fitting.

2.2.2 The press-in process

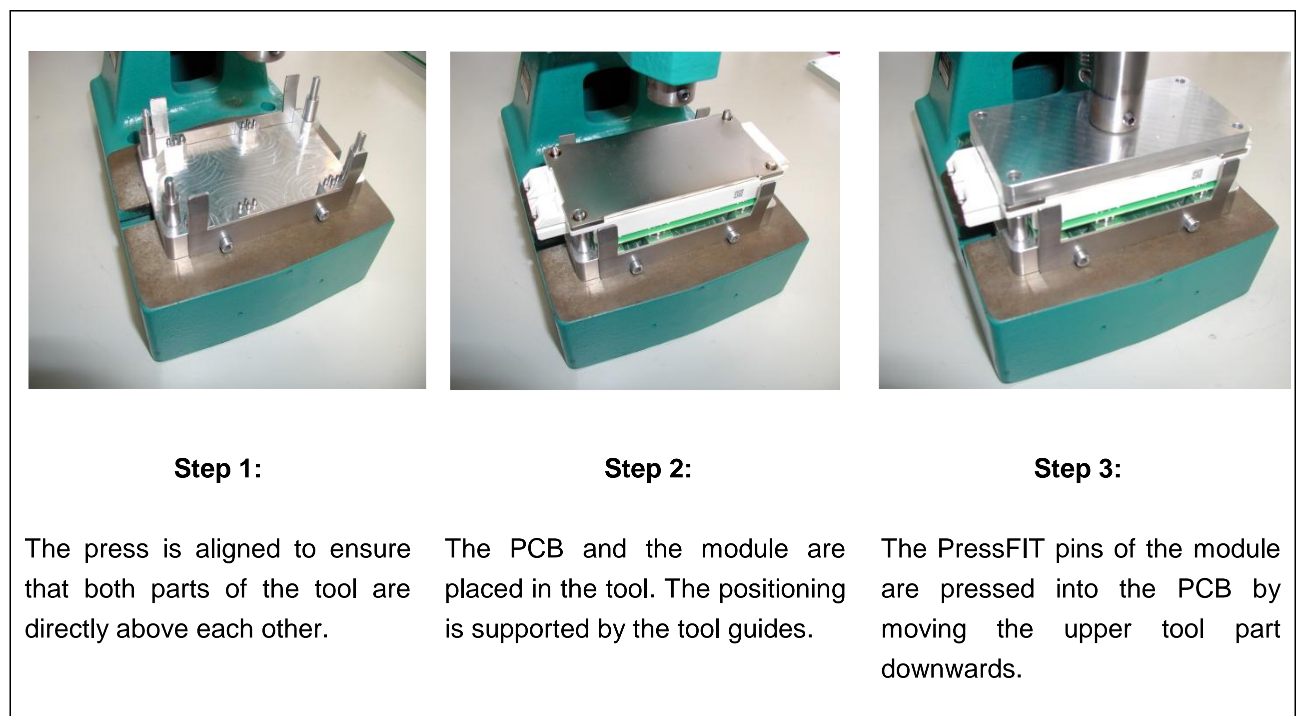
The PressFIT module is inserted into a printed circuit board by press-in. The press-fitting can be performed either using a simple toggle lever press or a machine. A press-in tool that records the necessary force and the distance moved is recommended as this will assure constant quality. Doing so, a consistent quality is assured. The press-fitting speed should be between 25mm/min and 50mm/min according to IEC 60352-5.

Please note that during the press-in process the placement area of the printed circuit board and the pressing area of the pressure plate have to be parallel towards each other. The pressure plate should be mechanically fixed in position. The module should be pressed into the printed circuit board by a uniform movement.

The module pins should penetrate the printed circuit board during press-in until the bearing areas of the module housing are touched by the PCB.

To limit the force at the end the press-in process, springs could be implemented at the upper part of the press-in tool. The spring-biased force of the tool can be adjusted to the amount of pins and the according necessary press-in force. The springs may be not necessary in certain cases, especially if the press-in force is controlled and limited.

The following illustrations show the press-in process of an EconoDUAL™ 3 as it is implemented in the Infineon Technologies AG lab.



Step 1:	Step 2:	Step 3:
The press is aligned to ensure that both parts of the tool are directly above each other.	The PCB and the module are placed in the tool. The positioning is supported by the tool guides.	The PressFIT pins of the module are pressed into the PCB by moving the upper tool part downwards.

Figure 5 Example of the press-in process for an EconoDUAL™3 module.

2.2.3 Press-in tool

Infineon has developed an example press-in tool for the EconoDUAL™3. Figure 6 shows the press-in tool. Drawings of the tool can be requested through the normal Infineon channels. The suitability for the specific assembly process and application has to be tested and qualified by the user.

When adjusting the tool for a specific PCB or developing a tool, the positioning of PCB components close to the load bearing areas of the tool has to be taken into account in order to prevent damaging of these components during the press-in process.

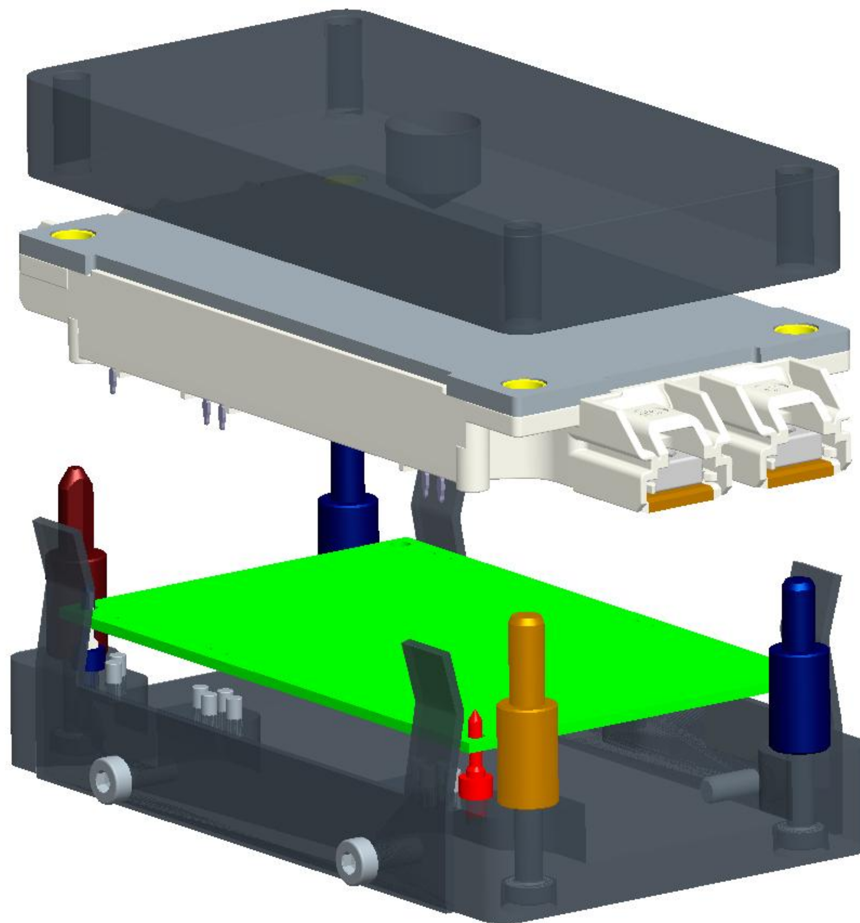


Figure 6: Example of a press-in tool for EconoDUAL™3.

2.2.4 Press-in forces

To press a module into a printed circuit board, a force of approximately 110N has to be applied for each pin of the module. The press-in forces depend on the PCB hole diameters. As the EconoDUAL™3 feature 7 PressFIT pins; the typical necessary press-in force is approximately 0.8kN. If the holes in the PCB are at the lower limit of the tolerance and/ or several modules will be pressed in parallel, the press-in force can be much higher. It is the responsibility of the customer that surface mounted devices on the PCB will not be damaged.

	Min.	Typ.	Max.
Drill hole diameter		1.15mm	
Press-in speed		25mm/min	
Copper thickness in hole	25µm		50µm
Typical Press-in force per pin		110N	

Table 2: Typical press-in forces

2.2.5 Additional fixing of the printed circuit board

After the press-in process, it is recommended to mechanically relieve the contact areas between module and printed circuit board (like mentioned in 2.1.1).

3 Requirements towards the heat sink for module assembly

The power loss generated in the module has to be dissipated via a heat sink in order not to exceed the maximum permissible temperature specified in the data sheets during switching (T_{vjop}). Detailed information can be found in Application Note 2008-01 „Definition and use of junction temperature values“.

The condition of the heatsink surface in the module mounting area is of great importance, as the interface between heatsink and and module has a large influence on efficient towards the heat transfer from the module to the ambient.

The contact surfaces, the base plate of the module and the surface of the heatsink have to be free of degradation and contamination and should be cleaned with a fresh, lint free cloth.

The contact surface between module baseplate and heatsink should not exceed the following values:

- Surface flatness ≤ 30µm
- Surface roughness R_z ≤ 10µm

The heat sink has to be of sufficient stiffness for the assembly and the subsequent shipping in order not to exert additional strain or pulling forces to the base plate of the module. The heatsink has to be handled twist-free during the entire assembly process, particularly when the PCB is linked with the heatsink.

4 Application of the thermal interface material

Due to the individual surface shapes of the module base plates and the heat sinks, there are inherent air gaps in-between both mating surfaces. To dissipate the losses in the module and to achieve an efficient heat flow from the chip into the heat sink, these gaps or cavities must be filled by a thermal interface material (TIM). An optimum layer thickness displaces all air, but also does not prevent the metal-to-metal contact between the baseplate and the heat sink surface where it occurs.

When using a thermal conductive paste (TCP), a homogenous application has to be ensured.

A TIM should be selected that shows permanent elastic features in order to ensure a constant good heat transfer resistance. The TIM should be applied in a way that no screw holes are contaminated so that screw torques's are not compromised.

4.1 Application of thermal conductive paste by screen printing

It's everything but easy to apply thermal conductive paste manually with a constant thickness in the μm-range. Homogenity and reproducability of the resulting thermal layer are always questionable. Therefore it is recommended to apply the thermal conductive paste by screen printing (see figure 7). Besides applying the TCP homogeneously and reproducably, this method offers the possibility to adjust the distribution of the paste to the individual module.

Proposals for module specific drawings of such screen printing stencils can be requested using the normal Infineon channels. The suitability of the stencil in combination with the specific TCP and the assembly process and application has to be tested and qualified by the user.

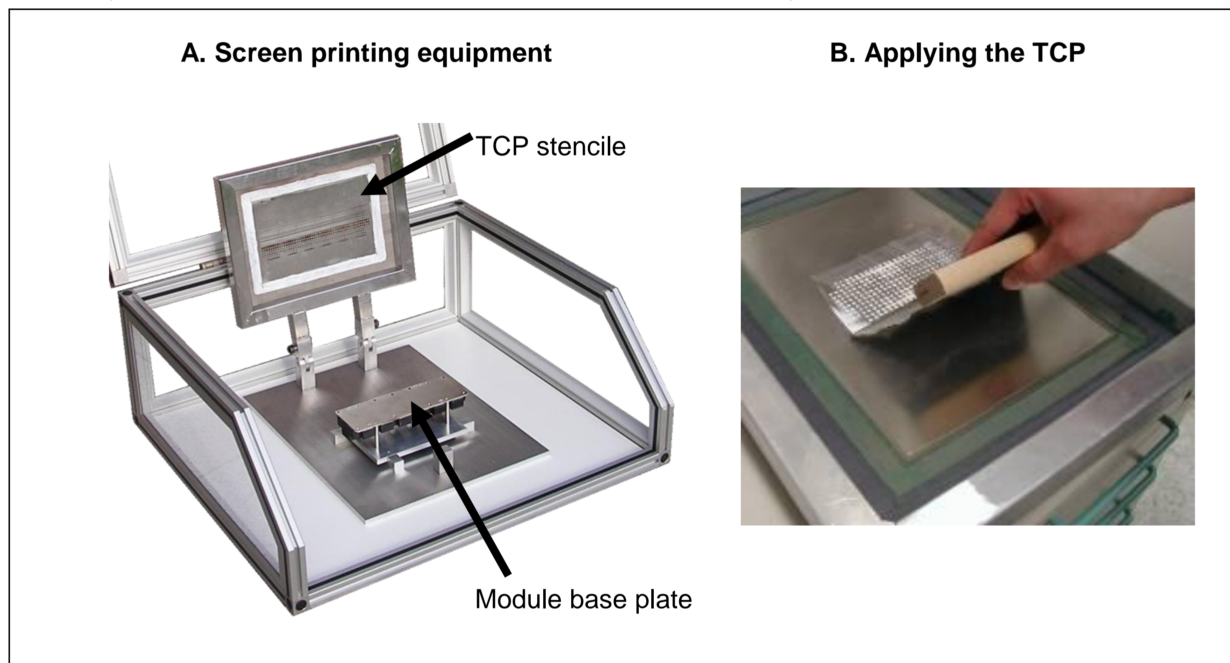


Figure 7: A. Example of screen printing equipment to apply TCP
B. Applying the TCP by using a stencil

A typical distribution of thermal conductive paste on the base plate of an EconoPACK™ 4 applied by screen printing is shown in figure 8.

Figure 8 Base plate of an EconoDUAL™3 after applying TCP by screen printing

Further information of the use of stencils to apply thermal conductive paste by screen printing can be found in the application note AN2006-02 „Application of screen print templates to paste thermal grease within Infineon modules “.

4.2 Alternative: Applying TCP by roller or spatula

If the application of thermal conductive paste can't be done by the recommended screen printing process, the paste could be applied using a roller or spatula alternatively. The layer thickness of the applied grease should be typically between 50µm and 100µm.

As a guideline for the required the amount of thermal conductive paste depending on the thickness d the following volumes can be given:

$$d = 50\mu m \rightarrow V_{TCP} \approx 0{,}4cm^3$$

$$d = 100\mu m \rightarrow V_{TCP} \approx 0{,}8cm^3.$$

These volumes can be either measured with the aid of a syringe or applied from a tube.

Common rollers or fine toothed spatulas can be used to apply the thermal conductive paste. Unfortunately, the homogeneity and reproducibility of the resulting layer thickness is always questionable. For qualification and verification of the assembly process and during training phases, the thickness of the paste can be controlled by the aid of a wet film comb.

5 Mounting the module to the heat sink

5.1 Screws to mount the module to the heat sink

To mount the modules the following is recommended: DIN M5 bolts which comply at least with class 6.8, e.g. according to DIN912 (ISO4762), ISO 7380, DIN6912, DIN7984 in combination with a suitable washer and spring washer, e.g. according to DIN433 or DIN125 or comparable combined screws.

The clearance and creepage distances that are specified in the EconoDUAL™3 data sheets are the shortest clearance and creepage distances at the unassembled and unconnected module.

When selecting suitable M5 screws, washers and spring washers to mount the module, it is recommended to consider the resulting clearance and creepage distances between the power terminals and the nearest screw head or washer during the development phase and according to the valid standards.

5.2 Mounting the module to the heat sink

Mounting of the module has to be carried out within the permissible module tolerances. Further information and module drawings are given in the relevant data sheets.

The clamping force of the module, resulting from the assembly process to the heatsink, depends on the applied torque and the condition of the heat sink. The following torque values specified in the data sheet result from steel screws in aluminium heat sinks with a dry M5 thread and their typical friction factors of μ_G=0,2…μ_G=0,25 (μ_G=friction coefficient thread in heat sink):

$$M_{min}=3Nm \text{ to } M_{max}=6Nm.$$

The module fastening screws have to be tightened uniformly in the recommended sequences with the specified torque.

Other material combinations of screws and/or heatsink material may require an adjustment of the mechanical parameters.

To ensure a good thermal contact to the heatsink, the following procedure is recommended when tightening the four M5 fastening screws:

1. Place the module with the applied thermal compound onto the heat sink and fix with the screws
2. Fix the screws with 0.5Nm (hand tight, crosswise) in the following sequence (see figure 9)
   Screw number: 1 – 2 – 3 – 4
3. Tighten the screws with 3Nm – 6Nm in the same sequence (crosswise)
   Screw number: 1 – 2 – 3 – 4

Depending on the viscosity of the used thermal compound, an intermediate step 2a may be required, especially for pastes with high viscosity. This additional step will give the thermal compound the chance to distribute during the assembly process and to adapt to the module base plates and heat sink’s shape. After a certain time, depending on the used thermal compound, step 3 has to be carried out.

2.a. Tighten the screws with approximately 2Nm in the same sequence (crosswise)
   Screw number: 1 – 2 – 3 – 4

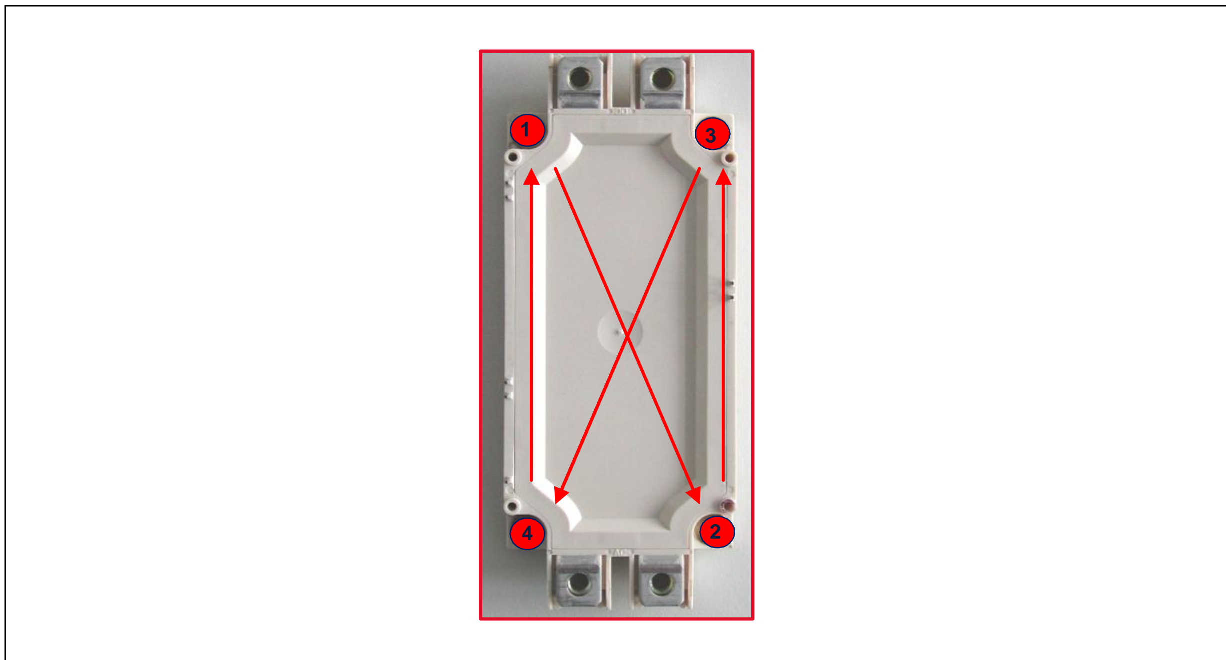


Figure 9 Tightening sequence to mount the module to the heat sink

When using thermal compound, it may be necessary (depending on the type of paste) to check the tightening torques of the fastening screws for the correct value after a heat-up test. When using thermal foils instead of TCP, it is definitely recommended to perform this additional check. The application notes and the given torques are valid only when using thermal conductive paste. Therefore, own tests and measurements with the envisaged heat conductive foils are absolutely necessary!

When selecting the thermal interface material between module and heat sink, the thermal contact and the long-term stability should be considered and discussed with the manufacturer of the thermal interface material.

6 Connecting the busbars to the power terminals

Connecting the module has to be carried out within the permissible module tolerances given in the individual datasheets.

The DC power side should be connected to a laminated bus bar in order to keep the switching overvoltages as low as possible by minimising the stray inductance. Adherence to the maximum permissible voltage at the power terminals and at the IGBT chip has to be assured according to the relevant data sheet (see RBSOA).

For the connection of the power terminals DIN M6 screws are required which comply at least with class 6.8, in combination with a suitable washer and spring washer or complete combination screws. These should be tightened with the recommended torque of

$$M_{min}=3Nm \text{ to } M_{max}=6Nm.$$

When selecting the screw length, the layer thickness of the connected parts has to be substracted from the total length of the screws. The effective length of engagement into the module thread may not exceed the maximum specified depth of 10mm.

The connected parts have to be mounted to the power terminals in a way that the specified forces (see figure 10) are not exceeded during assembly or later in operation.

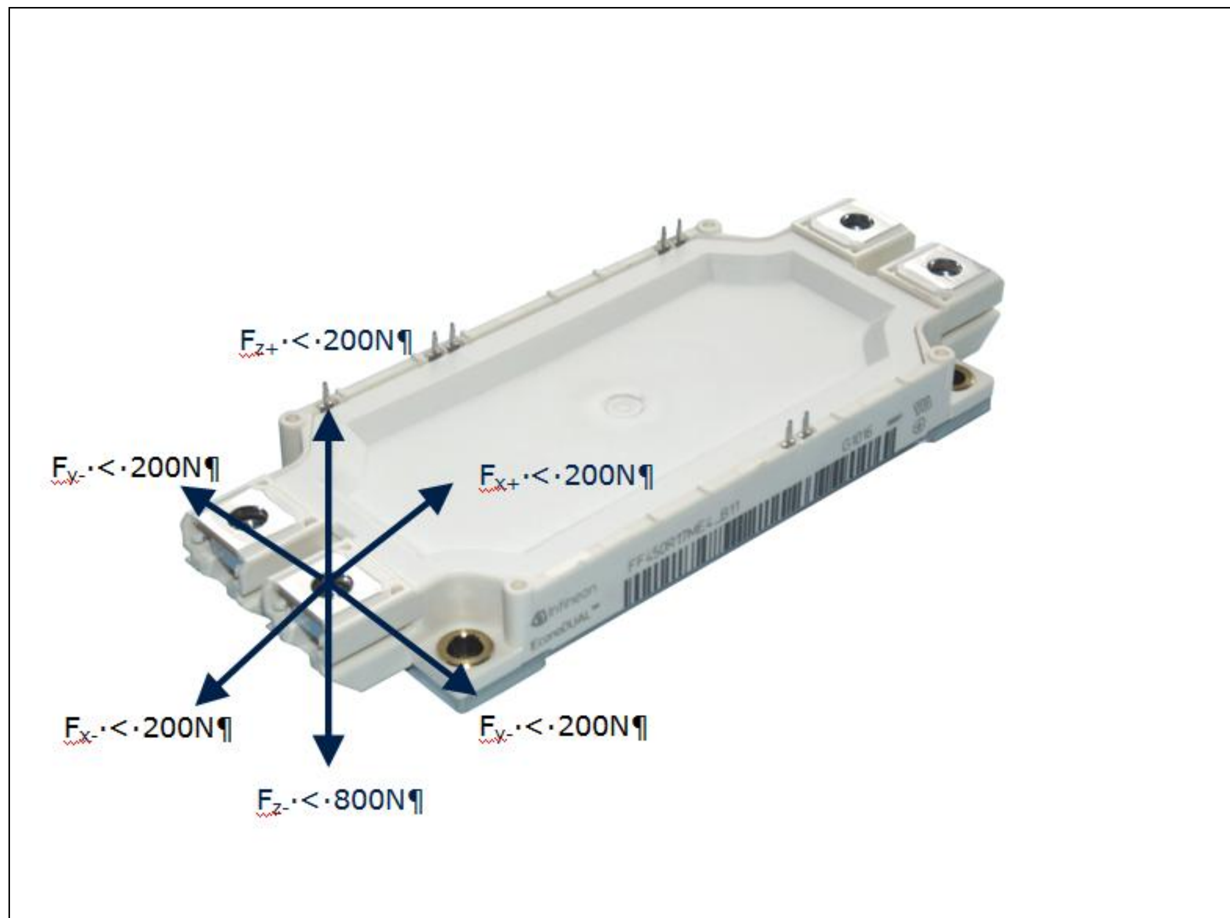


Figure 10: Maximum permissible pull and push forces at the power terminals of the EconoDUAL™3 only during the screw-in operation.

6.1 Connecting the power terminals with ideal strain relief

To connect the power terminals with the best possible strain relief, an assembly according to the concept drawings in figures 11 or 12 is recommended.

Taking into account all tolerances, the mounting block should be approximately 0.5mm lower than the height of the power terminals in order to ideally give a pre-tension to the power terminals and especially to avoid a damaging permanent force in F_{z+} direction (see figure 10).

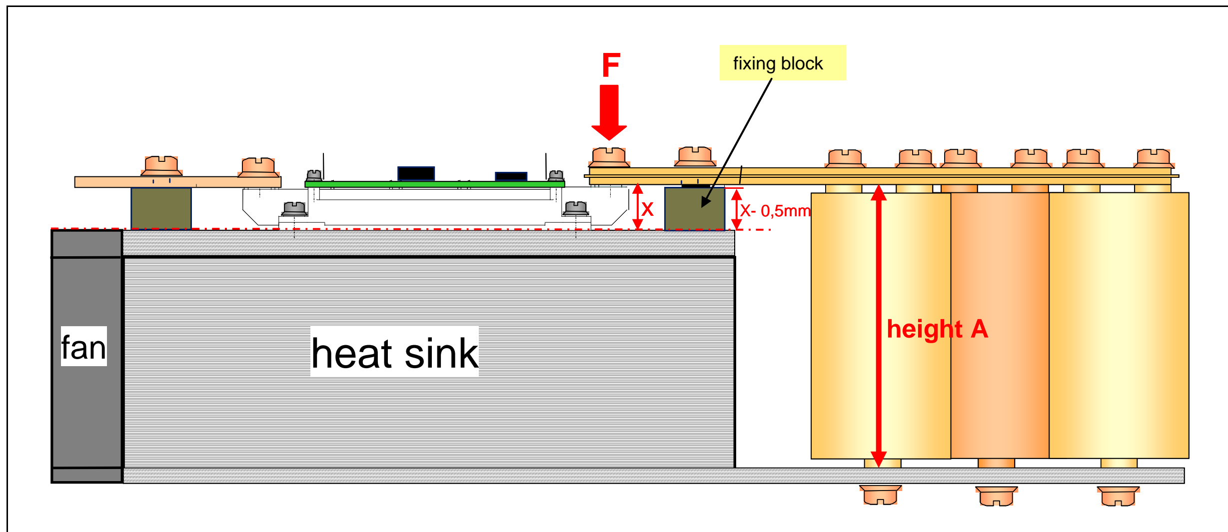


Figure 11 Concept drawing 1 of EconoDUAL™3 assembly with ideal strain relief

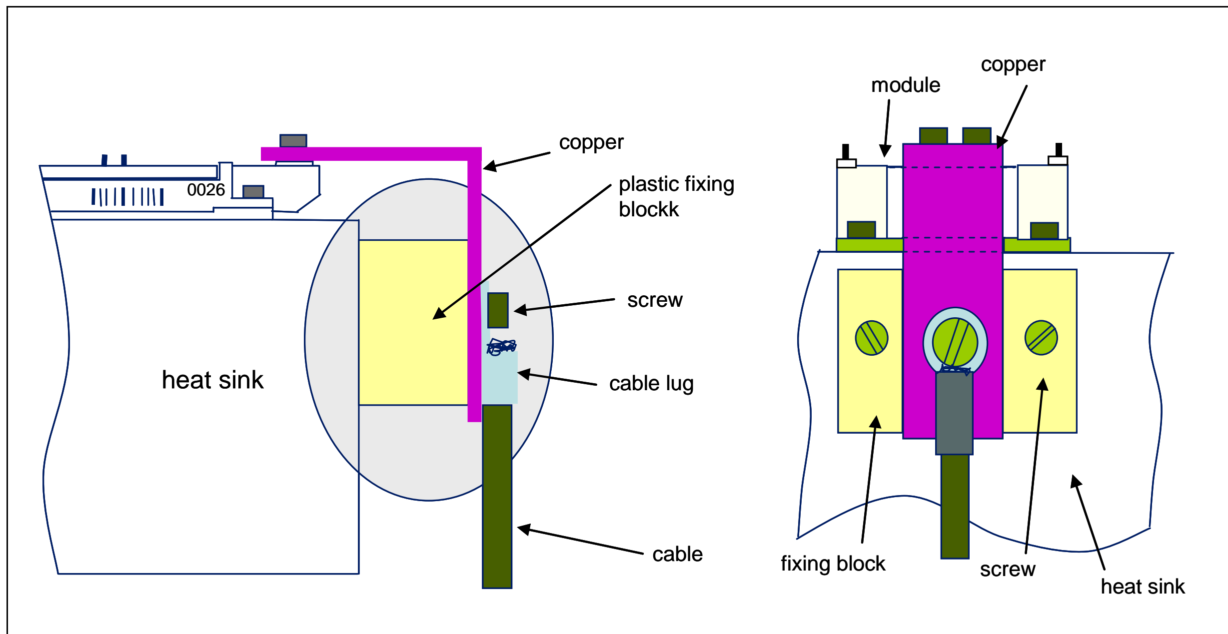


Figure 12 Concept drawing 2 of EconoDUAL™3 assembly with ideal strain relief

7 Mechanical loads (vibration and shock)

The EconoDUAL™3 modules exhibit a rugged construction, developed with a clear focus to offer the best mechanical robustness in the application.

However, the maximum permissible values given in this application note for pull and push forces at the power terminals in chapter 6 as well as the press-in forces at the auxiliary terminals given in chapter 2.2.4 are values for a one-time mechanical load during the mounting process.

The impacts of continuous mechanical loads on the module, especially generated by vibration or shock, strongly depend on the mechanical set-up of the inverter and the load profile in the application and can't be specified in general.

The ability of the modules for the operation under such specific mechanial loads has to be tested and qualified by the user in his mechanical set-up and using the specific mechanical load profile.

8 Storage and transportation of IGBT modules

During transport and storage of the modules extreme forces by shock or vibration have to be avoided as well as extreme environmental influences.

Storing the modules at the limits of the specified temperature in the data sheet is possible, however, not recommended.

The recommended storage conditions according to TR14 should be assured fort he recommended storage time of maximum 2 years.

If stored according to the recommended conditions, pre-drying of the module prior to the assembly process like recommended for moulded discrete components (e.g. microcontrollers, TO-cases etc.) is not required for EconoDUAL™3 modules.

9 Climatic conditions during active, current carrying operation of EconoDUAL™ 3 modules

EconoDUAL™ 3 modules are not hermetically sealed. The housings and the molding compound, used for the electrical isolation within the housing, are permeable for humidity and gases in both directions. Therefore humidity differences will be equalized in both directions.

Corrosive gases must be avoided during operation and storage of the devices.

The climatic conditions for Infineon EconoDUAL™ 3 modules in active, current carrying operation are specified as per EN60721-3-3 class 3K3 for fixed installations.

The operation of the modules in humid atmosphere caused by condensation and/or the operation in climatic conditions beyond class 3K3 of EN60721-3-3 must be avoided and additional countermeasures need to be taken in such cases.