

Mounting Instruction SEMiX®5

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1. ESD Protection

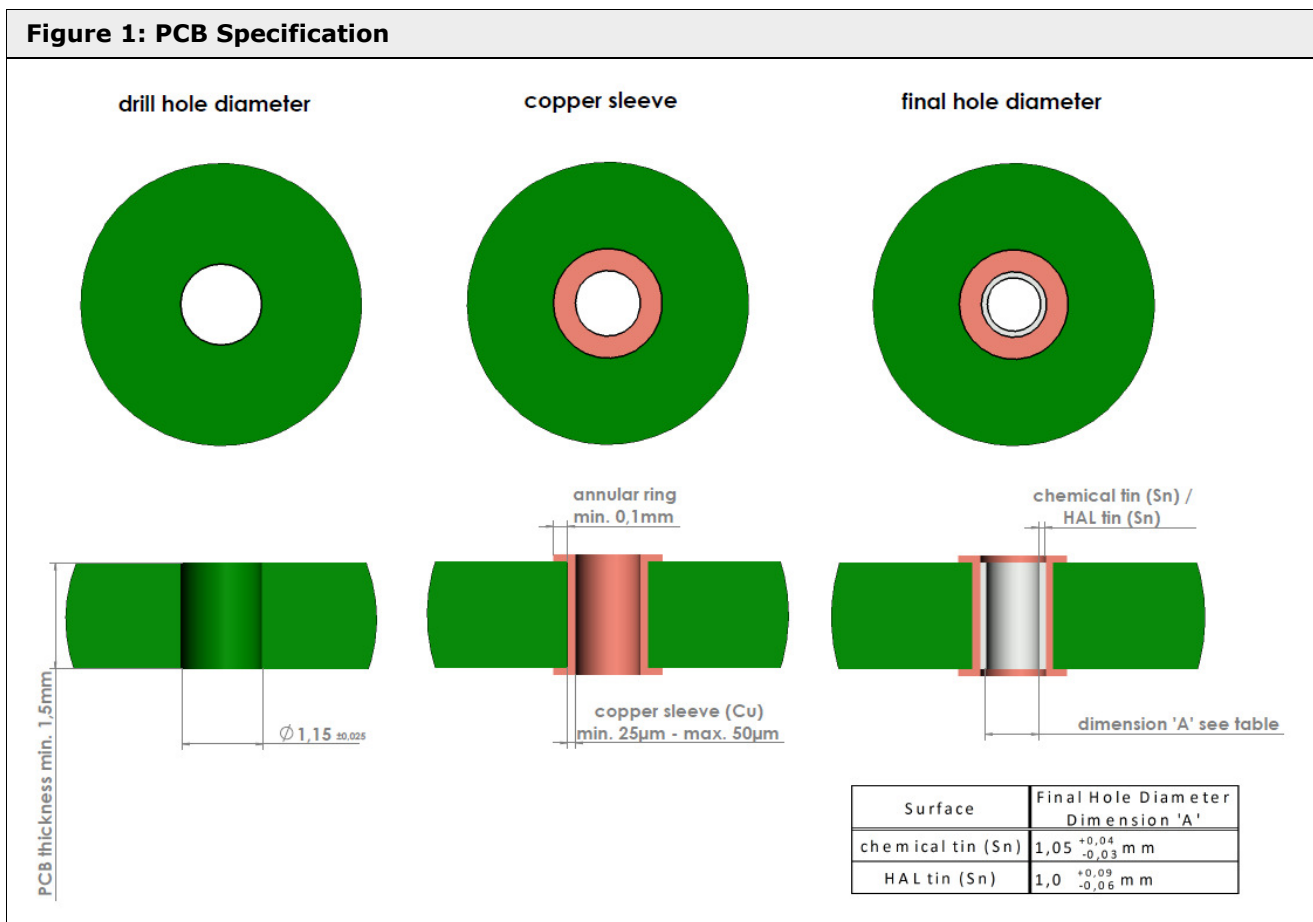
In IGBT modules electrostatic discharge can damage or destroy the sensitive MOS structure of the gate. For this reason, all SEMIX®5 modules are ESD protected by a dedicated cover during assembling process, storage and transport.

During the handling and the assembling of SEMIX®5 modules, it is recommended to wear a conductive grounded wristlet and to stand on a conductive grounded workplace. All staff should be suitably trained for correct ESD handling.

2. Printed Circuit Board Specifications

The following recommendations for printed circuit boards (PCB) do not constitute a complete set of design rules. The responsibility for proper design remains with the user of SEMIX press-Fit modules.

- PCB material: FR4(Base materials for printed circuits; Double Sided IEC 60249-4-9: Multilayer IEC 60249-2-11).
- PCB thickness: min. 1.6 mm
- Specification of holes according to Figure 1 Printed board materials meets the requirements of IEC 61249-2-7 : Double Sided IEC 60249-4-9: Multilayer IEC 60249-2-11.
- Safety zone of 5 mm from each pin to any component for the contact areas of the SEMIKRON press-in tool (see chapter 3.1 Press-in process) or other appropriate distance in case customer tool is developed.



3. Module and Printed Circuit Board Requirements

3.1 Press-in process

The Press-Fit process is performed by using an automatic machine. SEMIKRON offers 3D CAD models of a suitable press-in tool as design support. Example of the SEMIKRON press-in tool for SEMIX®5 is shown in

Figure 2. These can be requested from the local sales contact. To ensure a high process capability of the press-in process, a machine that logs the applied force and distance is recommended.

During the press-in process special care must be taken to align the PCB, module, and press properly (see Figure 4). The Press-Fit process consists of the following steps:

1. The press is aligned to ensure that both parts of the tool and PCN are directly above each other.
2. The PCB and the module are placed in the tool. The positioning is supported by the tool guides.
3. PCB with the module is pushed to the guiding domes in the final position (see Figure 4).

When adjusting the tool for a specific PCB or developing a tool, the distance between PCB components and the load bearing areas of the tool has to be taken into account in order to avoid damaging of the components. The required force to press-in a single pin into the PCB is 100 N. The press-in force depends on the hole diameter. With holes at the lower limit of the specified tolerance (see Figure 1: PCB Specification) or several modules mounted at the same time, press-in forces may be higher. The upper limit of the press has to be adjusted to 100 N per pin, to avoid damage of the module and the pin. The typical necessary press-in force for the SEMiX@5 module with fifteen pins is about 1.5 kN.

The PCB final hole diameter depends on the surface finish. For instance, for chemical tin (Sn) the final hole diameter dimension is typically 1.05 mm +0.04/-0.03 mm (as indicated in Figure 1).

The press speed should be between 25 mm/min and 50 mm/min according to IEC 60352-5. Each Press-Fit pin head must be placed in the center of the PCB hole.

Figure 3 show the press-in force versus press in the path for Press-Fit module. . The curve shows there are three phases:

1. During the first phase, the force increases nearly linearly and the Press-Fit terminals slide into the hole and deform to fit the hole.
2. In the second phase, the force is relatively stable as it depends on the characteristics of the PCB's metallization specification of Pin Through Holes (PTHs) and after deformation of the PCB hole the force shows a slight decrease.
3. In the third phase, the force continues increasing very quickly up to the final Press-Fit limit.

Press-Fit technology assures both mechanical stability and electrical contact.

Figure 2: Press-in tool SEMiX5

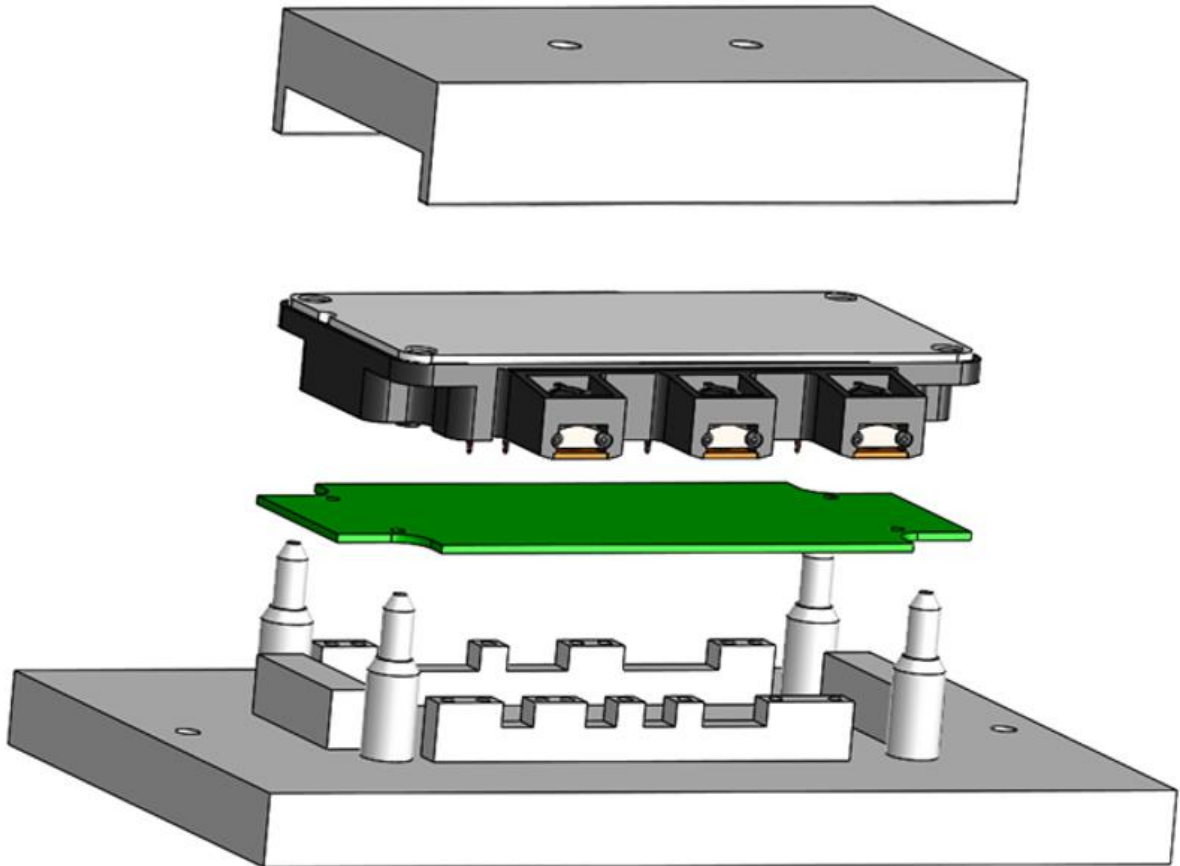


Figure 3: Force path diagram of push insertion for 15 pins SEMiX®5 module

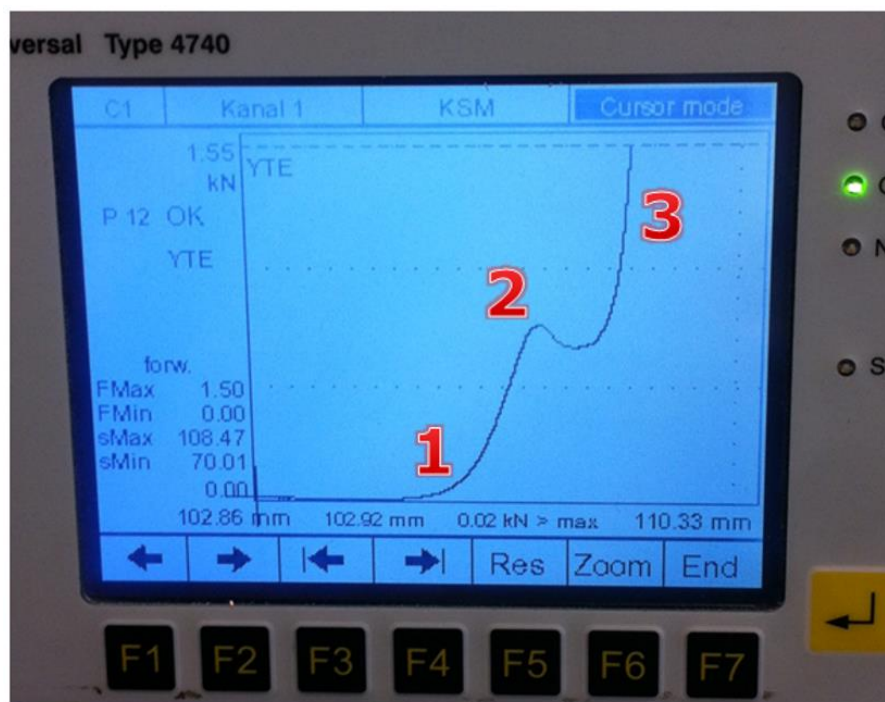


Figure 4: Example of press-in tool for SEMiX@5 and module-PCB alignment (profile)

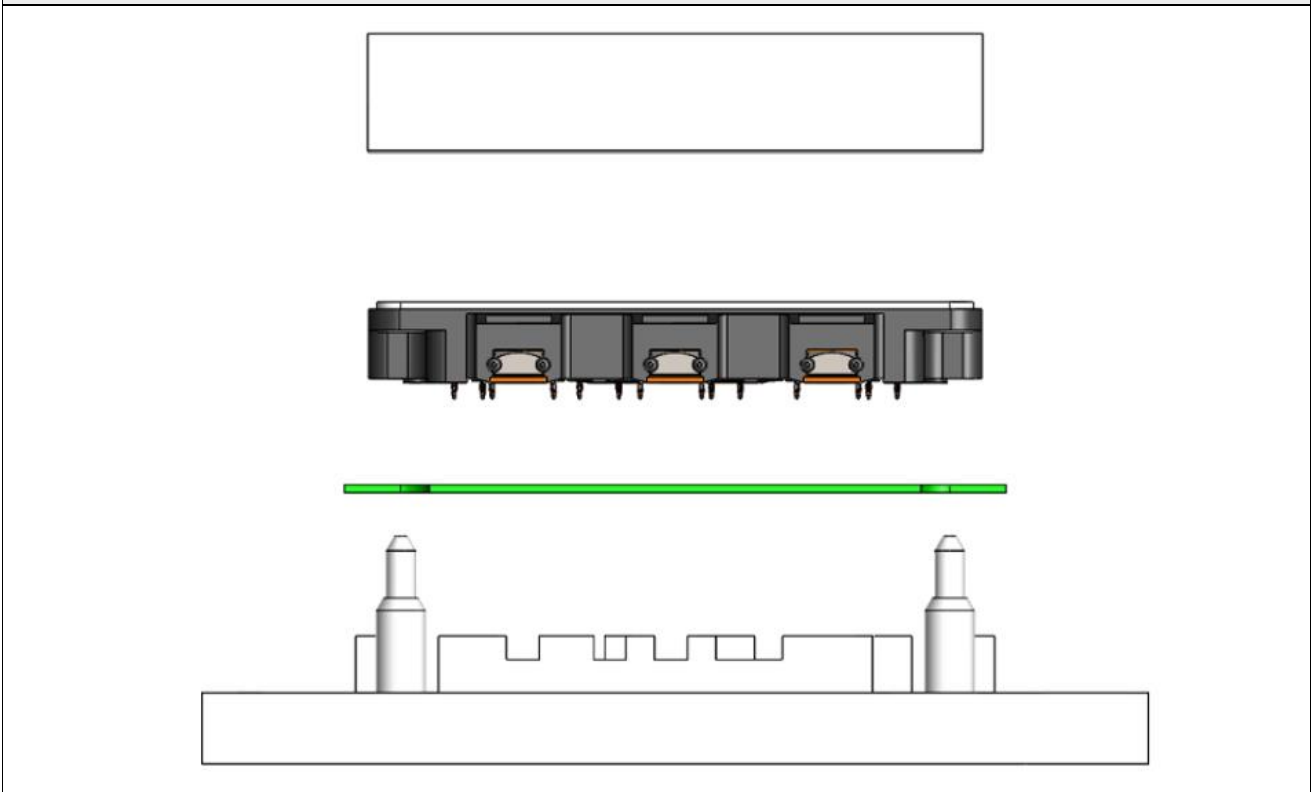
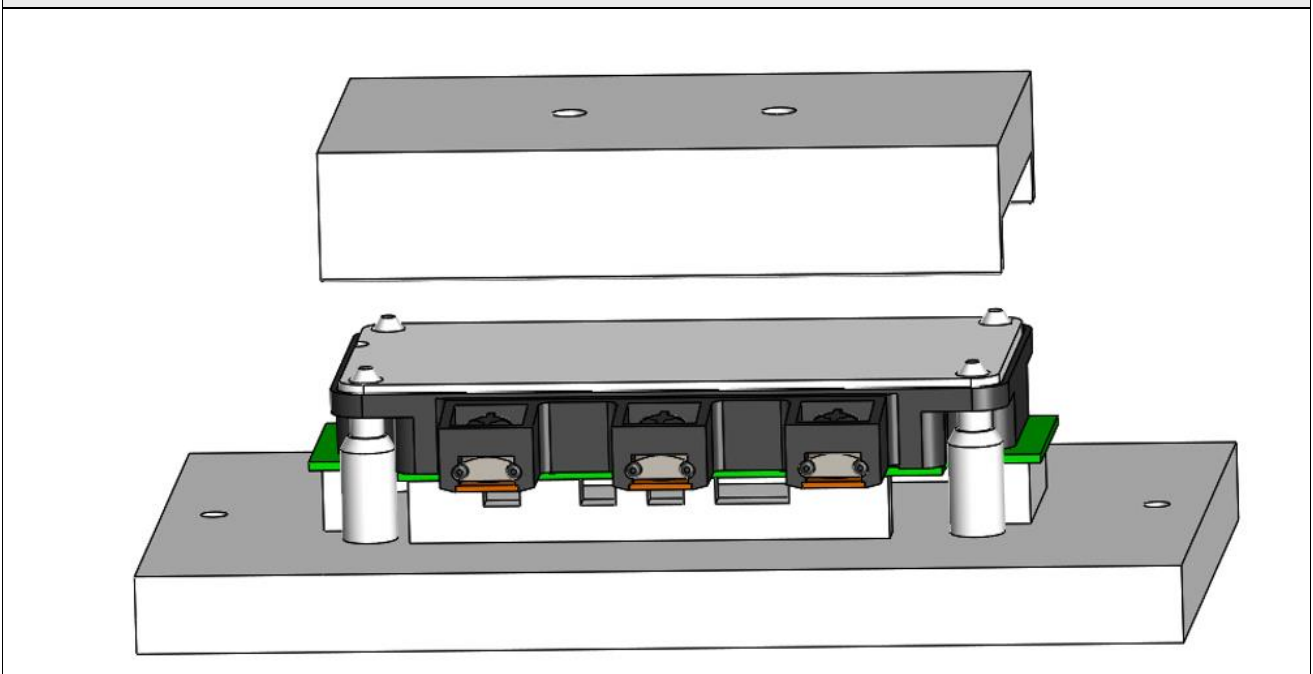


Figure 5: PCB with module pressed into the tool



3.1.1 Remark on the Press-In Tool

The SEMIKRON press-in tool proposed in the previous chapter is available as “evaluation sample” only. Please refer to the final disclaimer of this document for the limitations.

3.2 Fixing system of the PCB on the module

It is necessary to fix the PCB on the module with four additional screws. SEMIKRON recommends the following **self-tapping** screws:

- Ejot Delta PT WN 5451 K25x10 A2K: $M_{Max}=0.65 \text{ Nm} \pm 10\%$ for screws up to 8 mm length.
- Ejot Delta PT WN 5451 K25x10 A2K: $M_{Max}=\mathbf{0.80 \text{ Nm}} \pm 10\%$ for screws up to **10 mm** length.

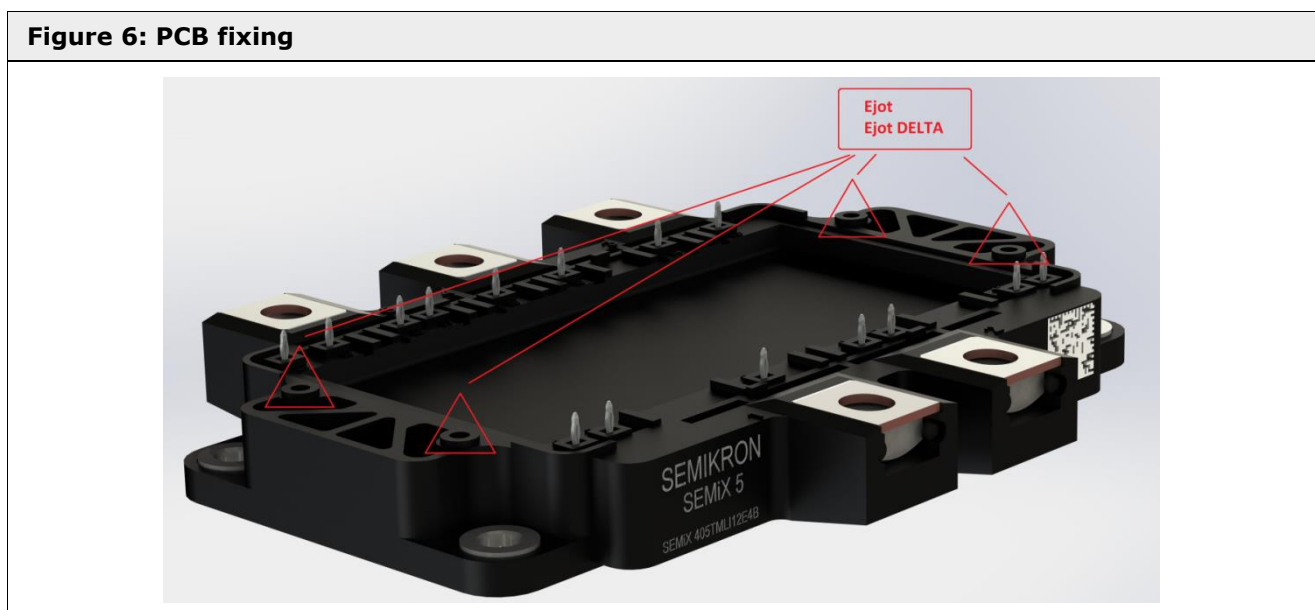
(www.ejot.de)

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

An electronic controller or slow-turning electric screwdriver is recommended. The screwing speed must be below 300 rpm and a soft torque limitation is recommended in order to avoid damage of the housing. SEMIKRON does not recommend the use of pneumatic screwdrivers, due to the lack of accuracy and clutch behavior with excess torque.

The effective length of the screw thread entering the PCB mounting stand-offs should be a minimum length of $I_{min} \geq 4\text{mm}$ and maximum length of $I_{max} \leq 10\text{mm}$, taking into account the specific PCB thickness and the weight of the mounted PCB. The number of times a driver may be assembled and disassembled strongly depends on the screw surface and mounting torque.

It is recommended to mechanically fix the PCB to the contact areas shown in Figure 6.



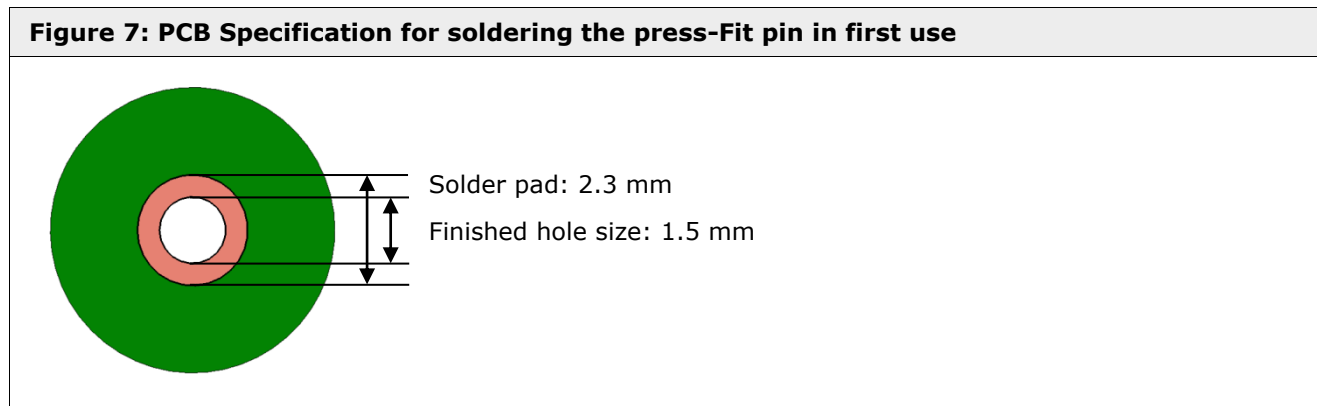
3.3 Press-out Process

The tool to disassemble modules from the PCB is similar to the press-in tool. 3D CAD models can be provided to assist in development. Same application notes previously mentioned are applicable here. The recommended press-out speed and necessary force match with the press-in process.

A SEMiX®5 Press-Fit module which was pressed-in and then pressed-out **cannot be pressed in again**. The mechanical deformation of the Press-Fit pin does not allow further Press-Fitting. In this case, the module can be connected safely with the PCB by soldering.

3.4 Soldering

As mentioned in section 3.3 the PCB needs to be soldered to the module if the module is connected for a second time (i.e. if the Press-Fit function has already been used). In the case that the Press-Fit pin is soldered during the first use (e.g. if a module with solder pins is replaced with a Press-Fit type), the following recommendation must be followed (see Figure 7).



4. Heat Sink Surface Specifications

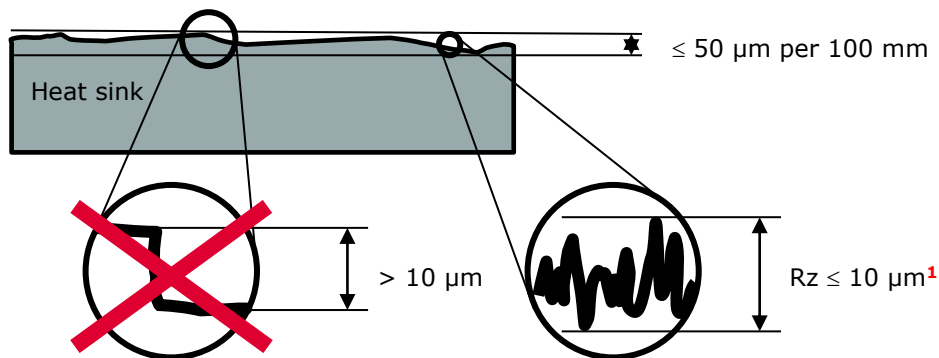
To obtain the maximum thermal conductivity, the surface of the module in contact with the heatsink must be free from grease and particles. It is recommended to clean the mounting surfaces with lint-free wipes and a grease-dissolving solvent (e.g. Isopropyl alcohol) with precautions depending on local regulations. Furthermore, in order to ensure a reliable electrical contact over the long-term the Press-Fit pins have to be maintained cleaned and should never be touched by hands.

The heat sink must meet the following specifications (Figure 8: Heat sink surface specifications):

- Unevenness of heat sink mounting area must be $\leq 50 \mu\text{m}$ per 100 mm (DIN EN ISO 1101)
- Roughness (R_z) $\leq 10 \mu\text{m}^1$ (DIN EN ISO 4287)
- No steps $> 10 \mu\text{m}$ (DIN EN ISO 4287)
- Porosity of cast heat sinks $\leq 0.5 \text{ mm}$

¹⁾ SEMIKRON recommends roughness less or equal $6.3 \mu\text{m}$ in case PCM used. In case of different thermal paste than SEMIKRON thermal grease types please contact your SK representative.

Figure 8: Heat sink surface specifications



5. Applying Thermal Paste

To avoid air gaps at the interface between the bottom side of the module and the heat sink (and consequently low thermal conductivity), a thin layer of thermal paste must be applied. The thermal grease can be applied either to the base plate of the module or to the mounting area of the heat sink. In certain cases, a hard rubber roll might be suitable for an even distribution of the grease.

SEMIKRON recommends applying a 50 - 100 μm thick layer:

- P12 silicone paste from WACKER CHEMIE : (www.wacker.com)
- Free-silicone paste HTC from ELECTROCUBE (www.eletrocube.com).

The thickness of the layer can be determined using a measurement gauge. For checking and measuring thickness, SEMIKRON recommends making the measure in four different points near the corner of the module. SEMIKRON recommends using for such measure the gauge from ZEHNTNER called "Wet Film Wheel" as shown in Figure 9.

Figure 9: Recommended gauge to measure thermal paste thickness



<http://www.zehntner.com/products/categories/film-thickness/zww-2100-2108>

Incorrect application of thermal paste is shown in Figure 10 where a thermal paste void is highlighted. The correct application of thermal paste on SEMIX@5 heat sink is shown in Figure 11 when module is mounted according to SEMIKRON specifications.

Figure 10: View of SEMiX5 module and heat sink with thermal paste void

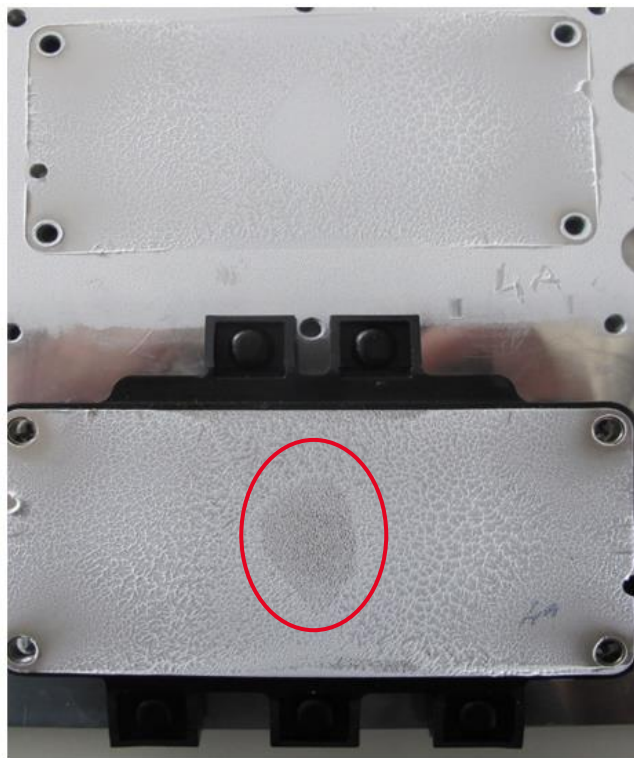
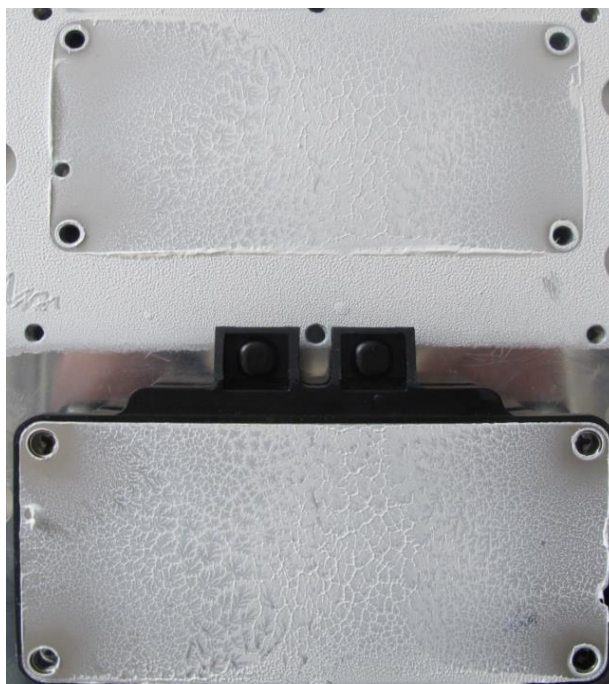


Figure 11: Good thermal paste print



5.1 SEMiX®5 with pre-applied Phase Change Material

SEMiX®5 is available with pre-applied TIM (Phase Change Material HALA P8, and HALA HT). Technical information is available in the "Thermal Interface Material" section of the SEMIKRON website.

6. Mounting to the Heat Sink

To mount the module, SEMIKRON recommends DIN M5 screws of a minimum class 6.8, e.g. according to DIN912 (ISO4762), ISO 7390, DIN6912, DIN7984, in combination with a suitable washer.

To comply with creepage and clearance distances, it is suggested to check the resulting distances according to the relevant standards when selecting a screw type (see also chapter 7: Creepage and clearance distances).

The SEMiX®5 has to be placed on the matching heat sink area; place down the screws in the threatened mounting holes, turn the screw till it goes in contact to the rivets surfaces with no torque and ensure that the module is not tilting in any direction.

Then the four screws have to be pre-tightened by applying a torque of 0.5 Nm maximum, following a crosswise mounting sequence (Figure 12). Maximum speed in the pre-tightening phase must be 200 rpm or below.

In the last step, the final torque, M_s , has to be applied, again crosswise: min. 3.0 Nm and max. 6.0 Nm as indicated in Table 1.

The module must be tightened only by using an electric screwdriver with electronic control of the torque and angle to ensure an homogenous distribution of the thermal paste layer. **Screwing speed has to be limited to a maximum of 200 rpm.** It is recommended that **the screwdriver bit length be less than 3 cm** to avoid excessive vibrations.

Maximum peak torque could accidentally exceed specified values due to wrong mounting conditions, e.g. screw frictions inside the mounting holes due to damaged threads, presence of thermal paste residuals inside the holes, screw tilting, rotation of the module during titling etc... Please verify that these cases do not happen during the module assembly.

Pneumatic screwdrivers must not be used due to clutch behavior with torque overshoot.

Table 1: Torque specification for heat sink fixing

| Module | Torque | | Unit |
|----------|--------|-----|------|
| | min | max | |
| SEMiX® 5 | 3 | 6 | Nm |

6.1 Typical mounting conditions

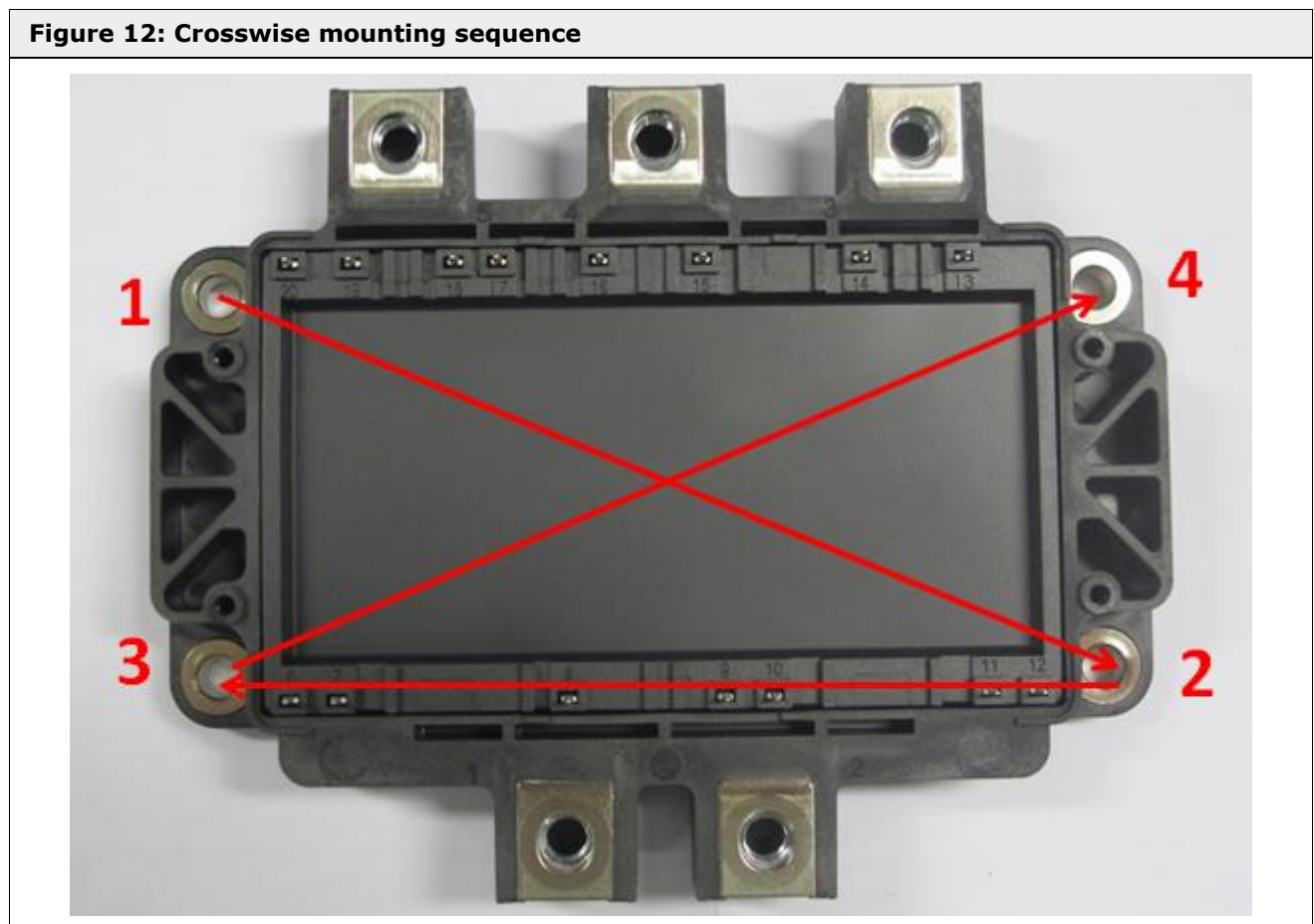
SEMIKRON qualified SEMiX®5 module with the following thermal pastes:

- Wacker P12
- HALA TPC-Z-PC-P8 PCM
- HALA TPC-V-PC-P-HT PCM

Table 2 reports the typical mounting conditions used for SEMiX®5. This information could be used as starting point for customers mounting process set-up.

| Table 2: SEMiX@5 typical mounting conditions with standard thermal paste (²) | |
|---|--|
| Semikron thermal grease type | $\lambda_{\text{grease}}=0.81 \text{ W}/(\text{m}\cdot\text{K})$ |
| Thermal grease thickness | 80 μm |
| Monting torque [pre-tightening following a crosswise mounting sequence (Figure 12)] | 0.5 Nm |
| Mounting torque (final torque) | 4.5 Nm |
| Maximum thermal grease penetration according to DIN ISO 2137 | 300 (0.1 mm) |

In case customer uses different thermal paste or exceeding the typical mounting conditions please contact your SEMIKRON representative for further support.



7. Creepage and clearance distances

SEMiX@5 Press-Fit modules comply with the creepage and clearance distances required in DIN EN 50178 for the following boundary conditions:

- Maximum peak voltage: 1700 V
- Maximum DC-link voltage (rms): 1250 V
- Line over-voltage category: 3
- Pollution degree: 2

²) For PCM TIM details refers to the Technical Explanations Thermal Interface Materials

- Maximum height of operation above sea level: 4000 m (2000m for 1700V variant)
- Basic insulation of temperature sensor
- Comparative Tracking Index (CTI) of the housing: Class IIIb ($100 \leq CTI < 175$)

| Table 3: Nominal creepage and clearance distances | | |
|---|--|---------|
| Creepage | Terminal to terminal | 20 mm |
| | Terminal to base plate | 17.7 mm |
| Clearance | Terminal to terminal | 8.3 mm |
| | Terminal to base plate (= heat sink potential) | 8.5 mm* |

* A lens head screw of type ISO 7380 (M5) is necessary to achieve this clearance distance.

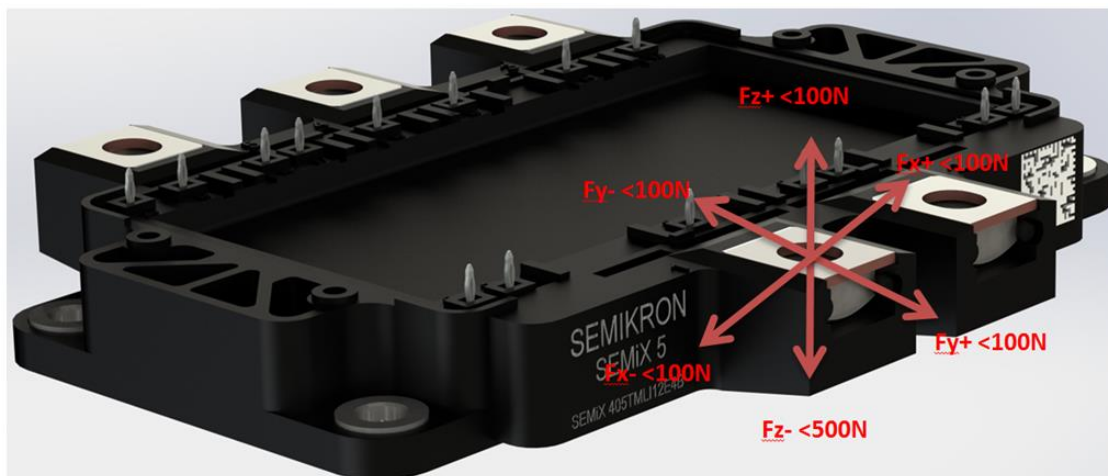
8. Mounting the busbars to the power terminals

SEMIKRON recommends M6 screws of class 6.8 in combination with suitable washer or spring washer. Fixing screws should respect torque limits as indicated in Table 1.

The effective length of the screw in the module has to be $8.5 \text{ mm} \pm 1.5 \text{ mm}$. The mounting torque, M_t , has to be $4.5 \text{ Nm} \pm 1.5 \text{ Nm}$.

As SEMiX®5 is a power module and not part of the mechanical construction the maximum mechanical forces on the main terminals as given in Figure 13 must not be exceeded throughout the entire mounting process. For the main terminal connections, it is better to apply a force in z- direction rather than in z+ direction. The SEMiX®5 module is not meant to secure the DC-link or AC-connection, which is why additional mechanical components (supports) have to be applied there.

Figure 13: Maximum forces at the main terminals



9. Packaging Specifications

9.1 Packaging box and blister/ ESD cover

9.1.1 Carton

Figure 14: SEMiX®5 Carton Box

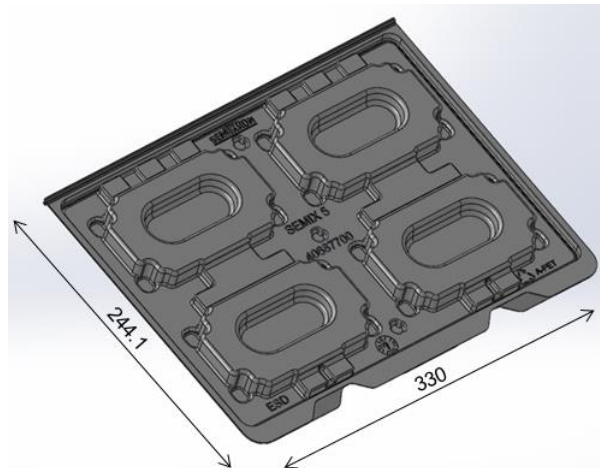


Box: external dimension 350 x 270 x 50 mm

9.1.2 Blister

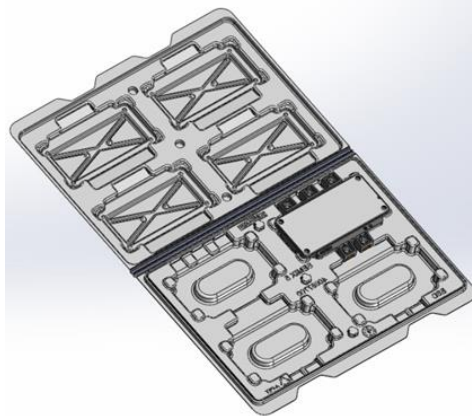
In Figure 15 it is shown the blister when closed and in Figure 16 the SEMiX®5 blister opened. Blister size and material is compliant with pre application of thermal paste

Figure 15: Blister (closed)



Dimension (closed): 330 x 244.1 mm

Figure 16: Blister (opened)



Dimension (opened): 330 x 489 mm

9.2 Marking of packaging boxes

9.2.1 Description label

Figure 17 shows an example picture of a typical SEMiX405TMLi12E4B label, With respect the numbers indicated in the Figures the details of the label are explained:

Figure 17: SEMiX@5 description label



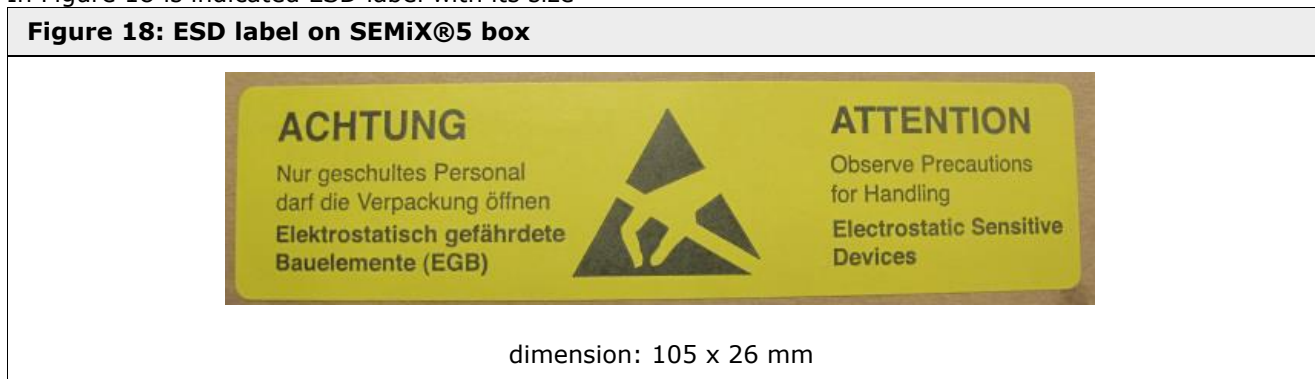
- 1 SEMIKRON Logo
- 2 "Lot"

Date code with 6 digits "YYMML". Lot of production.

- 3 "QTY" "R" means the module is ROHS compliance
Quantity of SEMiX5 modules per package with relative bar code
- 4 SEMiX@5 Type designation
- 5 "Order" (not used: always 0)
- 6 "Id-Nr" Part number of the module and bar code
- 7 Datamatrix Not used

9.2.2 ESD Label

In Figure 18 is indicated ESD label with its size



9.3 Storage Conditions

SEMiX@5 products are qualified according to IEC 60721-3-1 and can therefore be stored in original package for maximum 2 years starting from date code under climatic class 1K2. Therefore the following frame conditions apply

| Table 4: Storage conditions | |
|-----------------------------|-------------------------|
| Storage temperature | 5°C ... 40°C |
| Relative humidity | 5% ... 85% |
| Duration | 2 years |
| Climatic class | 1K2 (IEC 60721-3-1) |
| Condensation | Not allowed at any time |

SEMiX@5 products have been tested for climatic conditions in their original packaging. Packaging is very often limiting the allowed climatic conditions. Therefore, there are less restrictive conditions for the products itself. Based on our experience the temperature range mentioned in IEC 60721-3-1 for 1K2 can be enlarged for transportation and storage. Therefore the following conditions⁽³⁾ are possible :

| Table 5: Shelf life conditions | |
|--------------------------------|-------------------------|
| Relative humidity | Max. 85% |
| Storage temperature | -25°C ... +60°C |
| Condensation | Not allowed at any time |
| Storage time | Max. 2 years |

³) These conditions have not explicit been tested by Semikron

Please note that a higher temperature load can decrease storage time, in extreme cases down to half a year.

In case humidity or/and temperature go above the specified values please contact your Semikron Representative for further support.

HISTORY

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