Mounting Instruction
SEMITOP® E1/E2

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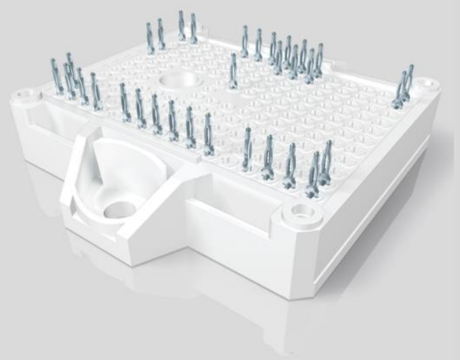
SEMITOP®E1	**SEMITOP®E2**
	

Revision history

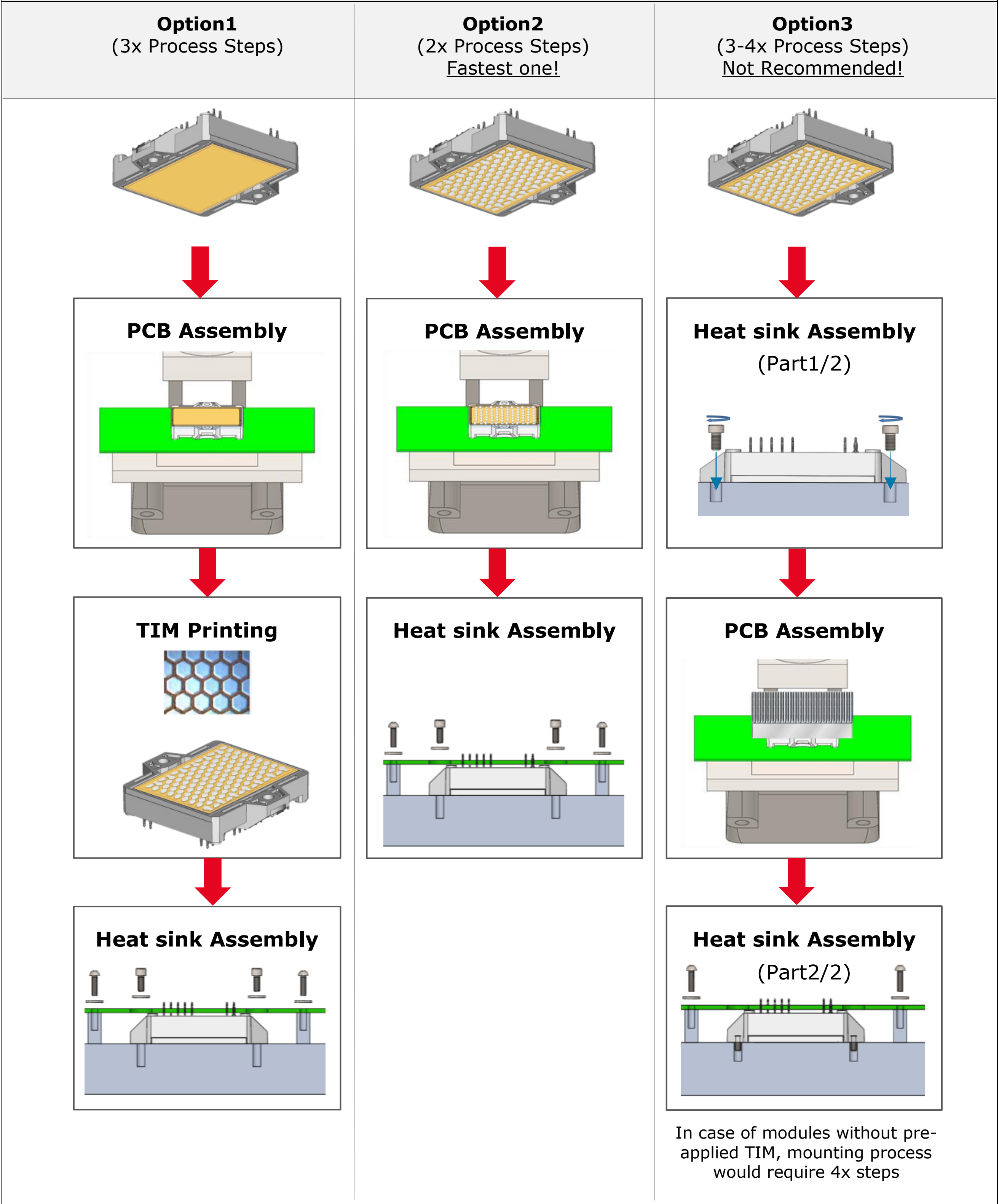
SEMIKRON reserves the right to make changes without further notice herein

Date	Revision n°	Description	Chapter
02.03.2017	01	First release	-
10.04.2018	02	Updated pictures with white housing	-
19.07.2019	03	Updated assembly process of module onto heat sink	5.2
16.04.2020	04	Updated PCB specifications for press-fit soldering	1.1
10.11.2021	05	Update of PCB specifications Integration of guidelines for solder pin Integration of additional information	2.3.1 2.2 -

1. Mounting process overview

Following figure shows possible mounting sequences to assemble SEMITOP®E1/E2, with Solder or Press-fit terminals, onto PCB and heat sink. SEMIKRON recommends fixing the module to the PCB first so this document follows sequence as shown under Option1 and Option2 (module with pre-applied TIM).

Figure 1: Assembly sequence



In case of modules without pre-applied TIM, mounting process would require 4x steps

2. PCB assembly

2.1 Press-fit vs. Solder Terminals

Table 1: Press-fit vs. Solder Terminals

Press-fit			Solder	
+	Just press-in at room temperature	**Joining effort**	With chemicals at high temperature	−
+	Lower	**Assembling time and cost**	Higher	−
+	Higher	**Mechanical ruggedness in harsh environment**	Lower	−
+	Easier	**Rework**	More difficult	−
−	Higher	**Requirements for tolerances of PCB Plated Through Hole**	Lower	+
−	Press-in tool	**Tools required for prototype and low volume production**	No tool	+

2.2 SEMITOP®E1/E2 with Solder terminals

2.2.1 PCB specifications

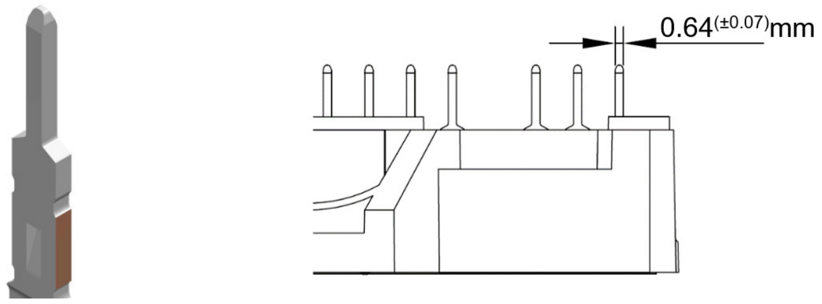
PCB material should meet requirements of IEC 61249-2-7. The maximum number of conductive layers is not limited. PCB should be covered with solder mask on both sides. Minimum distance between edge of the PCB and the centre of the pin hole should be 5mm. Minimum distance between centre of the pin hole and components on the PCB should be 5mm.

After fixing the module to the PCB, all pins must be soldered. The plated-through hole diameters on the PCB has to be designed according to the pin dimensions: $0.64^{\pm 0.07}$ mm. For the directions of the soldering pads design, it is suggested to follow regulation IPC-2221A.

For the PCB specifications, it is recommended to follow the acceptability of the electronic assemblies regulation number IPC-A-610, and for the acceptability of the PCB, to follow the regulation IPC-A-600. Furthermore, for the PCB design, following regulations should be considered: IPC-2221, IPC-2222, IPC-2223, IPC-2226 and IPC-A-7351.

Following figures show the mechanical appearance and dimensions of the terminal. ISO 2768-m general tolerance applies and acceptable burr heights are according to NF E 81-010 Class B. All dimensions refer to the finished product after plating.

Figure 2: Mechanical features of the Solder terminal



Spacers positioning
When PCB is connected to the module via soldering process, the module-to-PCB distance "d_{M-PCB}", described in Figure 15 section 3, is defined by module height. This means, in order to minimize the mechanical stress which may occur on the pin, SEMIKRON recommends to keep spacers as far as possible from module outer edges, **$d_{S-M} \geq$ 50mm** (see Figure 9): as rule of thumb, the ticker the PCB the farther the spacer. Number and position of the spacers depend on the system design, the position and the mass of the external components like capacitors, inductors and others and the actual mechanical stress of the application. Therefore, the final arrangement needs to be thoroughly verified by the customer. In any case, position of the spacers should be designed as symmetrical as possible around the module. See chapter 3.4.1 (Soldering process) for details about height of the spacers.

2.2.2 Soldering on PCB

SEMITOP®E1/E2 modules can be soldered to the PCB using the most common soldering process:

- Hand soldering
- Wave soldering
- Selective soldering

Regardless of the soldering process used to fix SEMITOP®E1/E2 modules to the PCB, SEMIKRON recommends a thorough evaluation of the solder joints to ensure an optimal electrical and thermal connection between SEMITOP®E1/E2 and the PCB pads. As a basic recommendation, valid for any plated through hole (PTH) device, the terminal should present a vertical solder fill of minimum 75% of its dimension, with a fully formed meniscus on the solder side and evidence of minimum 75% wetting of the exposed terminal, barrel and pad. SEMIKRON recommends that the soldering joints should be thoroughly checked by the customer via design of experiments to ensure the high quality of the solder joint itself. If necessary, different parameters should be adjusted in order to optimize the process.

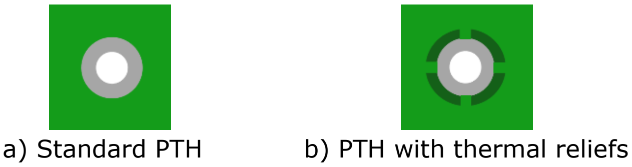
Hand Soldering
For the hand soldering process, usually performed by applying a manual solder iron, it is recommended to comply with the absolute maximum parameters of Table 2.

Table 2: Hand soldering parameters

Soldering phase / Parameter	Maximum Values	Unit
Solder iron temperature	350	°C
Solder joint	260	°C
Soldering time of the terminal	10	s
Number of heat cycles	3	

SEMIKRON suggests not to exceed the **maximum temperature of 260°C** of the joint for a **maximum soldering time of 10 seconds**, especially when several pins must be soldered on large tracks or thick (>100um) copper planes (IEC-EN 60068-2-20). Furthermore, SEMIKRON recommends to provide adequate power to the iron solder machine, dimensioned according to the PCB copper planes thickness and PCB pads layout design. To reduce the effort during soldering, especially at large copper tracks or copper planes, it is recommended to provide the PCB with specific thermal relief pads (please see an example of Thermal relief pads in Figure 3b).

Figure 3: PTH standard vs PTH with thermal relief


a) Standard PTH b) PTH with thermal reliefs

Wave Soldering

For the wave soldering process, the IEC60068-2-20 it is used as reference. It is recommended to follow the wave soldering profile of Figure 4. Temperature and time restrictions, listed in Table 3, must be observed.

Figure 4: Wave soldering profile

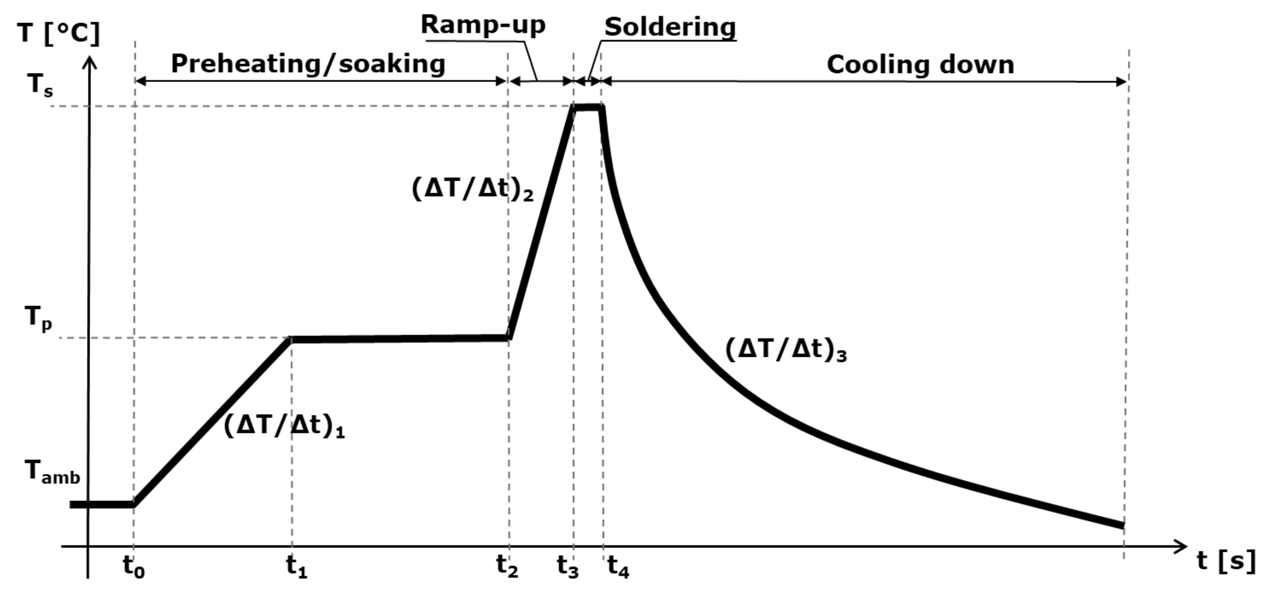


Table 3: Wave soldering parameters

Soldering step	Time frame	Temperature at solder joint			Temperature gradient			Time at max. Temp.
		Ref. Temp.	**Typ.** [°C]	**Max.** [°C]	**Ref. gradient**	**Typ.** [°C/s]	**Max.** [°C/s]	**Max.** [s]
Preheating/ soaking	t_1 - t_0	T_{amb}	20	25	$(\Delta T/\Delta t)_1$	1	3	-
	$t_2 - t_1$	T_p	95	125	-	-	-	100
Ramp-up	$t_3 - t_2$	T_s - T_p	-	-	$(\Delta T/\Delta t)_2$	3	*	-
Soldering	$t_4 - t_3$	T_s	-	260	-	-	-	10
Cooling-down	$\geq t_4$	-	-	-	$(\Delta T/\Delta t)_3$	-4	-6	-

*) High ΔT/Δt values might endanger integrity of the ceramic substrate so maximum gradient must be defined via Design Of Experiment and verified by insulation tests.

Number of SEMITOP®E1/E2 modules that can be assembled on the same PCB is not limited.

Fixing the module to the PCB

In case of SEMITOP®E1/E2 with soldering pins, customer can decide to fix the module on the PCB, via spring clamping methods or, optionally, fixing the module with four screws before the soldering process.

In case of clamping methods, it is recommended to provide specific assembly springs/clamps design to maintain stability of the module on the PCB during the wave soldering process, like any standard PTH product.

In case of modules with pre-applied TIM, in order to prevent from any damaging or contamination of the TIM layer, it is strongly recommended to protect the TIM during the process. SEMIKRON provides plastic caps for the purpose as described in chapter 3.3.2.

Optionally, for the assembly process, customer could use external screws to fix the module on PCB before soldering step. This can be performed with four additional screws to be tightened into the holes provided on top of the standoffs of the module (Figure 5). Table 4 shows possible types of screws that can be used.

In such a case, it is strongly recommended to use an electronic screwdriver with torque/angle control, having **≤ 250rpm**. Due to no accurate control of the stop and hence possible damage to the standoffs, a manual screwdriver is not recommended. For the same reason, pneumatic screwdrivers shall not be used at all. Furthermore, the standoffs are intended for positioning the self-tapped screws only and cannot guarantee any lateral mechanical accuracy. Thus, the standoffs may not be used as anchor pins.

It is recommended to use a magnetic tool for a straight insertion of the screw and to avoid stripping or damaging the self-forming thread on the plastic housing.

Recommended diameters for PCB holes are given in Figure 8b.

Figure 5: Fixing module on PCB by screws

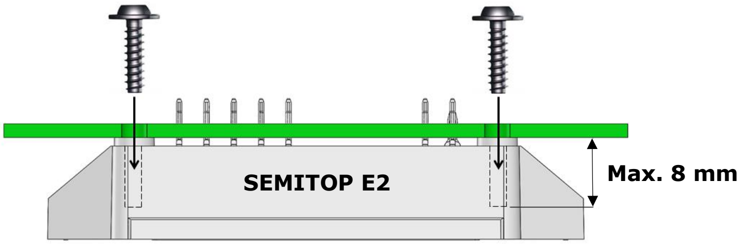


Table 4: Screw types in case of PCB fixing

Type	Value
Ejot PT WN 1451 K25×10 A2K	M_{max}=0.45 Nm ±10%
Ejot DELTA PT WN 5451 K25×8	M_{max}=0.40 Nm ±10%
Metric screws: M2.5×H	M2.5×8 or M2.5×10 (depending on the thickness of the PCB in use)

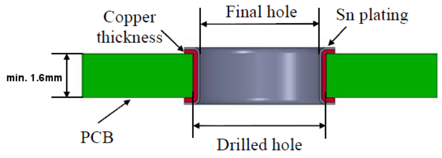
2.3 SEMITOP®E1/E2 with Press-fit terminals

2.3.1 PCB specifications

Following requirements as regards the PTH of the PCB need to be fulfilled according to international standard IEC 60352-5. PCB material should meet requirements of IEC 61249-2-7. For the PCB specifications, it is recommended to follow the acceptability of the electronic assemblies regulation number IPC-A-610, and for the acceptability of the PCB, to follow the regulation IPC-A-600. Furthermore, for the PCB design, following regulations should be considered: IPC-2221, IPC-2222, IPC-2223, IPC-2226 and IPC-A-7351.

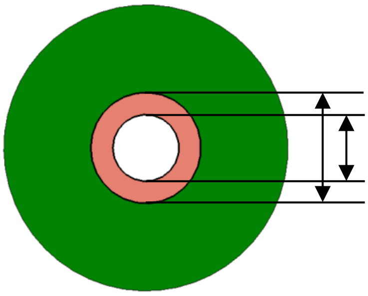
Following table shows specification of the PTH.

Table 5: Specification of PTH for Press-fit subject to press-in process

	Min.	Typ.	Max.	
Drilled hole diameter	1.125mm	1.15mm	1.175mm	
Copper thickness in via	25µm		50µm	
Final hole diameter (Chemical tin)	1.02mm	1.05mm	1.09mm	
Final hole diameter (HAL tin and Ni/Au)	0.94mm	1.00mm	1.09mm	
Cu width of the Annular ring	100µm			
Thickness of PCB	1.6mm			

In case Press-Fit pins have to be soldered to the PCB, following specifications are given.

Figure 6: Specification of PTH for Press-fit subject to soldering process

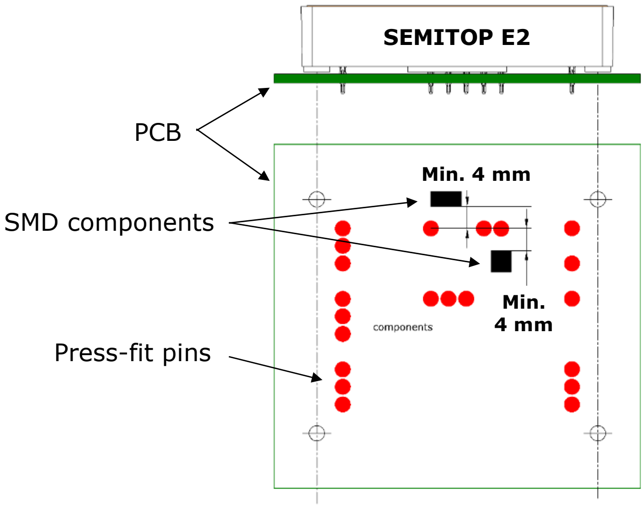


Solder pad: $2.3^{\pm0.1}$ mm

Finished hole size: $1.5^{\pm0.1}$ mm

Particular attention must be paid for those components that need to be placed close to the module pins like resistors, capacitors or diodes. A minimum distance of 4mm is required between the edge of these components and the centre of the PTH; this ensures enough space for the pressing tool.

Figure 7: Minimum distance between components and Press-fit



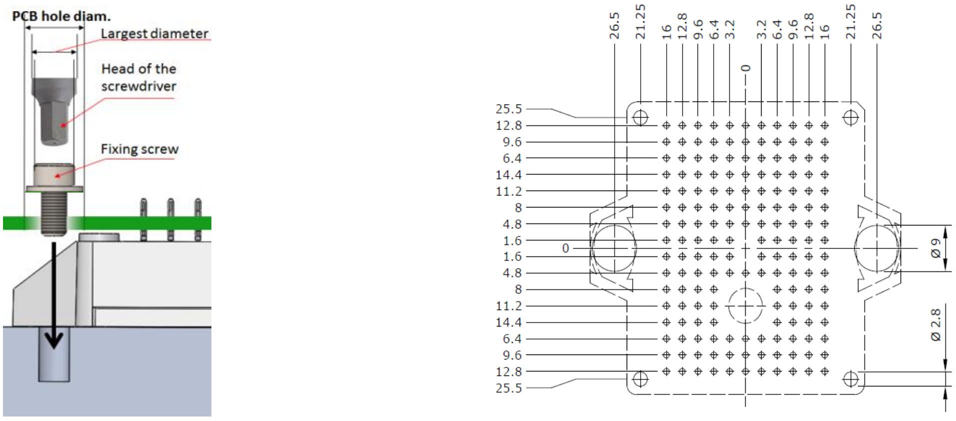
In order to allow fixing of the module+PCB system onto the heat sink, and a possible later disassembly, the PCB must be provided also with adequate holes to insert the screws. The holes dimension depends on the largest diameter between the following ones (see Figure 8a) and can be adjusted accordingly:

- screwdriver head
- screw head
- washer

Recommended diameters for PCB holes are given in Figure 8b.

Please note! In case module has to be pressed into PCB, fixing the module on PCB is not allowed (see chapter 3.4.1). Therefore, holes in correspondence of the module standoffs are not required.

Figure 8: Specifications of the PCB holes for screws

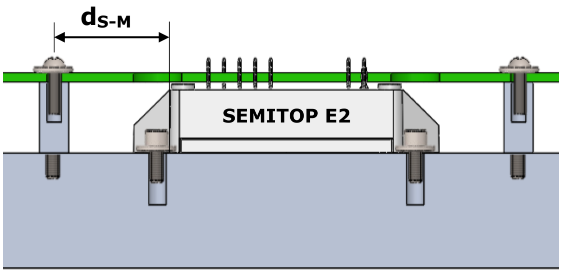


a) Side view of mounting tools b) Top view of a SEMITOP®E2 including PCB holes pattern

Spacers positioning

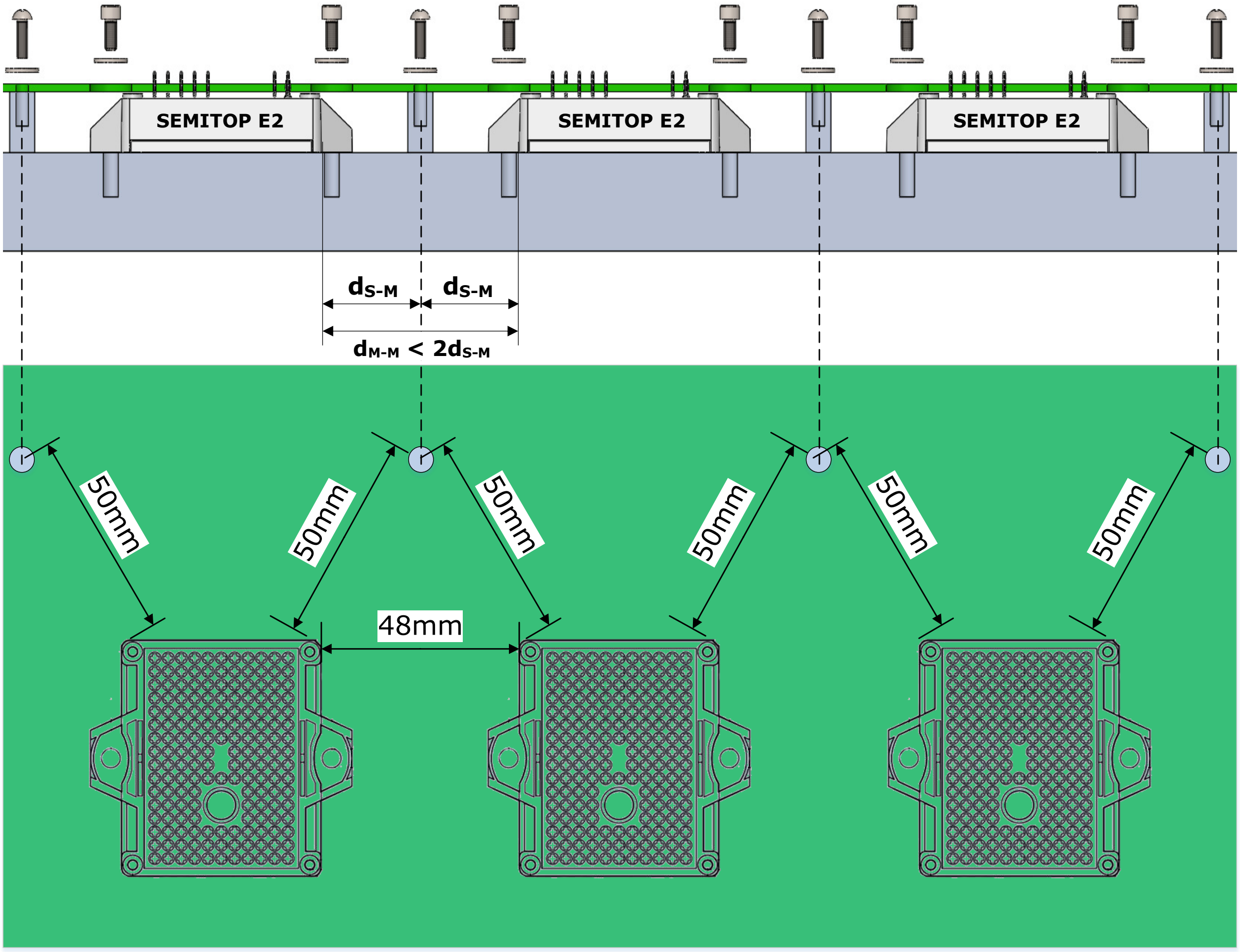
When PCB is connected to the module via press-in process, it is necessary to keep the vibrations at the minimum. Any possible movement between terminals and case must be avoided. Therefore the PCB should be additionally fixed to the heat sink through the use of spacers or by the use of the module domes. Number and position of the spacers depend on the system design, the position and the mass of the external components like capacitors, inductors and others and the actual mechanical stress of the application. Therefore, while a general specification cannot be given, SEMIKRON recommends to keep spacers close to the module at a distance **$d_{S\text{-}M}$ ≤ 50mm** (Figure 9), but the final arrangement needs to be thoroughly verified by the customer. The position of the distance keepers should be designed as symmetrical as possible around the module.

Figure 9: Positioning of the spacers



In case several modules are mounted on the PCB, in order to keep system as compact as possible, the distance between the modules “$d_{M\text{-}M}$” can be shorter than twice the distance between the module and the spacers (see Figure 10 as an example).

Figure 10: Positioning of the spacers (multiple modules)



See chapter 3.4.1 (Press-in process) for details about height of the spacers.

2.3.2 Press-in

Equipment and setup

For a successful press-in process with high process capability, it is recommended to use equipment that allows control of relevant process parameters like force and distance.
Table 6 provides an overview of the available presses and their main characteristics.

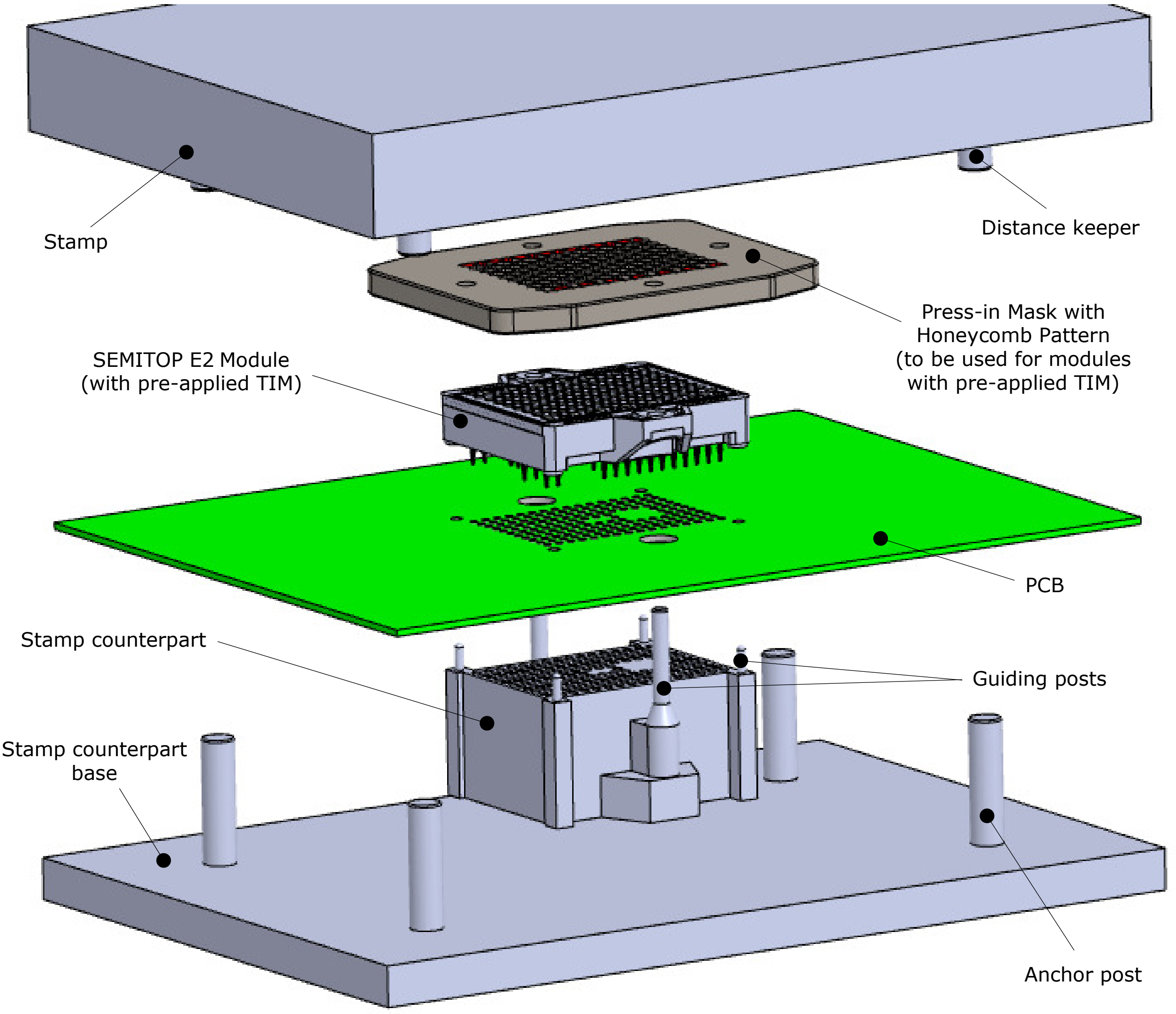
Table 6: Specification of press type

Press type	Control of force	Control of distance	Comments
Manual, hydraulic and pneumatic	Low	Low	Additional visual inspection is recommended to ensure reliable press-in process
Servo electric	High	High	Accurate control of speed and position enables instant reaction to changes of press-in force

Servo electric presses are recommended to mate PCB and press-fit modules. SEMIKRON performed tests using an electric press by KISTLER.

Figure 11 shows a concept view of the press-in equipment. 3D drawings are available upon request.

Figure 11: Schematic view of the press-in setup



Picture is an example only and should not be intended as a proven design.

Further recommendations:

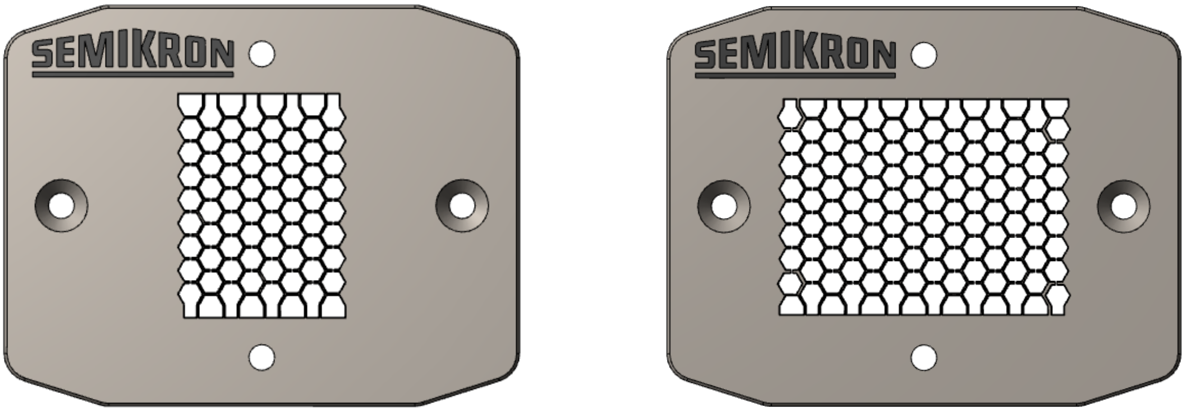
- The "Stamp counterpart" must be designed in order to provide free space for the components mounted on the PCB surface. Therefore, shape and size of the available space for pins and components depends on size and position of the components on the PCB. Position of the pins is shown in the product datasheet of the specific SEMITOP®E1/E2 module in use [1].
- The "Anchor posts" are needed to keep the PCB flat during the press-in phase. "Anchor post" supports the PCB during the press-in process, therefore, in order to prevent from bending of the PCB, it must have the same height as the "Stamp counterpart". The "Stamp counterpart" must be fixed to the "Stamp counterpart base".
- Bottom part of the "Stamp" (or the "Press-in Mask"), getting in touch with module, has to be clean and free from any particles that might damage the module.

Sequence of main press-in steps is:

1. PCB placed onto "Stamp counterpart" by the "Anchor posts" and the "Guiding posts".
2. Module placed onto PCB and aligned by the "Guiding posts".
3. Module pressed into PCB. "Stamp" must be parallel to the "Stamp counterpart base". "Distance keeper" should be aligned to "Anchor post".

Please note! For modules with pre-applied Thermal Interface Material (TIM), in order to prevent from any damage of the TIM layer, a "Press-in Mask with Honeycomb Pattern", like ones shown in Figure 12, should be used.

Figure 12: Press-in Mask with honeycomb pattern



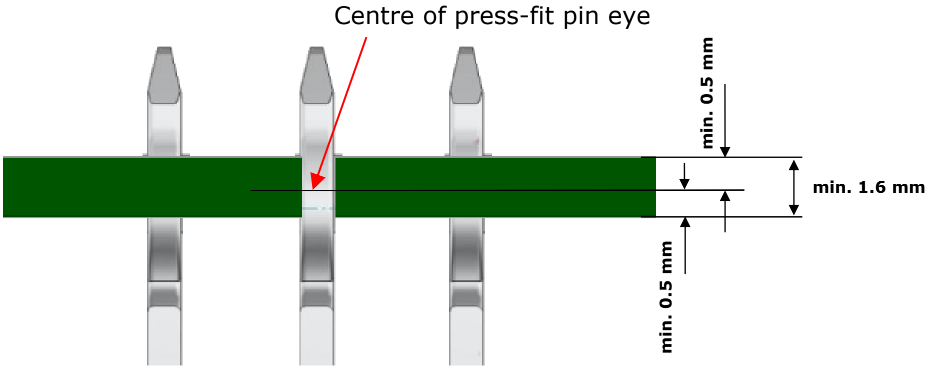
SEMITOP®E1 SEMITOP®E2

SEMIKRON does not provide the tool but SEMIKRON provided pattern should be used to realize it. Shape of the mask can then be designed according to customer needs. 2D/3D drawings are available upon request.

Basic requirements and specifications

To ensure a proper press-fit contact, the centre of the press-fit pin head has to be at least 0.5mm below the top surface and at least 0.5mm above the bottom surface of the PCB (see Figure 13).

Figure 13: Press-fit zone



Following specifications are given for press-in process.

Table 7: Press-in parameters

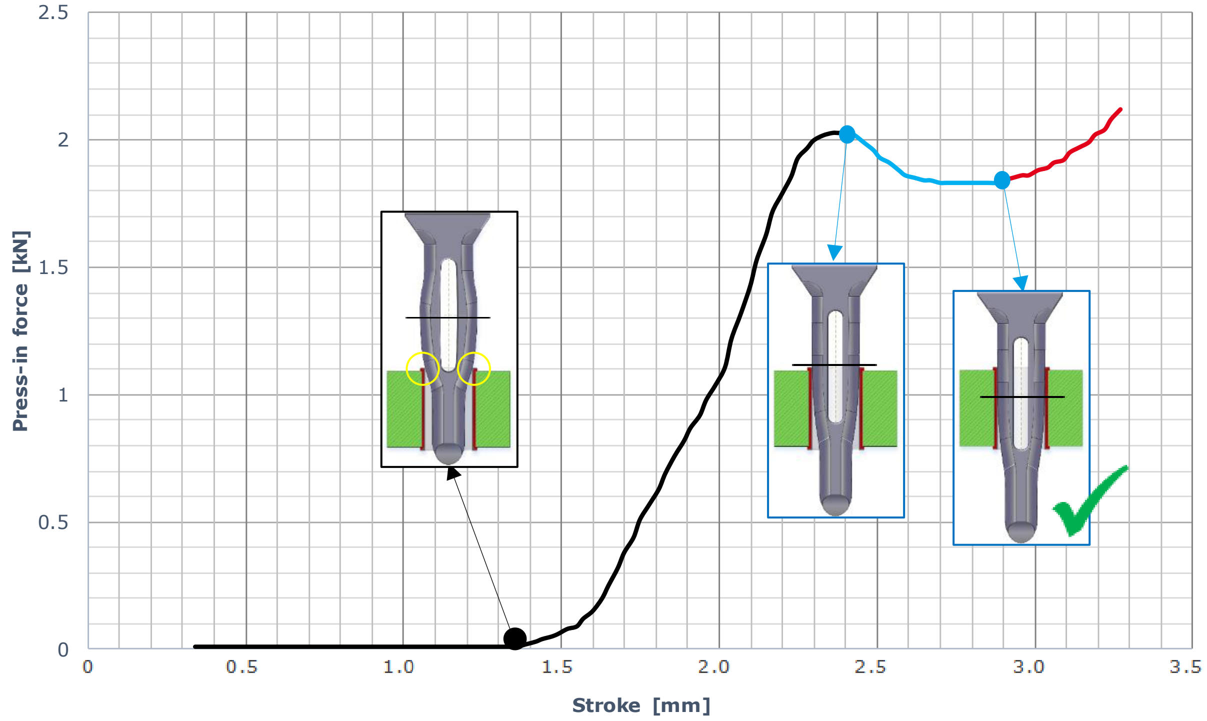
Parameter	Minimum	Typical	Maximum
Press-in force (per terminal)	40 N	60 N	100 N *
Press-in speed	25 mm/min **	50 mm/min	600 mm/min

*) Maximum allowed insertion force. If exceeded, the press-in process is not working properly.
**) According to IEC 60352-5

A typical force vs. distance profile for a press-in process is shown in Figure 14. There are three main steps describing the typical press-in process (valid only for the first insertion):

1. **Black** curve: The press-fit pin is deformed by the PCB hole and starts sliding into it. Maximum deformation of the pin occurs at the peak of the curve.
2. **Blue** curve: The pin slides into the holes down to the final position
3. **Red** curve: "Anchor posts" touch the PCB and start deforming it. Pin insertion is successfully completed and process must be stopped in order to prevent from any PCB damaging

Figure 14: Typical press-in profile of a 32 pins module



Multiple modules can be assemble onto the same PCB. In this case, it is recommended to press modules all at once. Press-in tool must be designed in order to fulfil minimum requirements, given for the single module tool, and has to ensure the correct levelling of the modules and PCB to avoid mechanical stresses.

Press-in process

This section provides a detailed guidance to the press-in process by a simplified view. Principles are valid for both SEMITOP®E1 and SEMITOP®E2, for single as well as multiple modules mounting. All the general specifications given so far remain unchanged.

Figure 15: Press-in process

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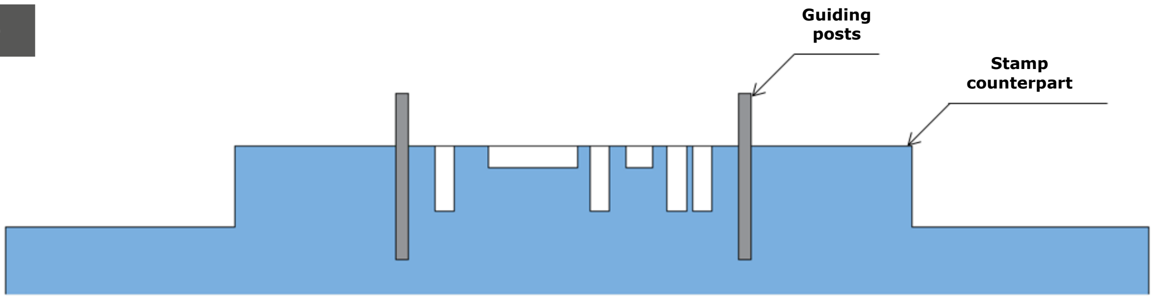
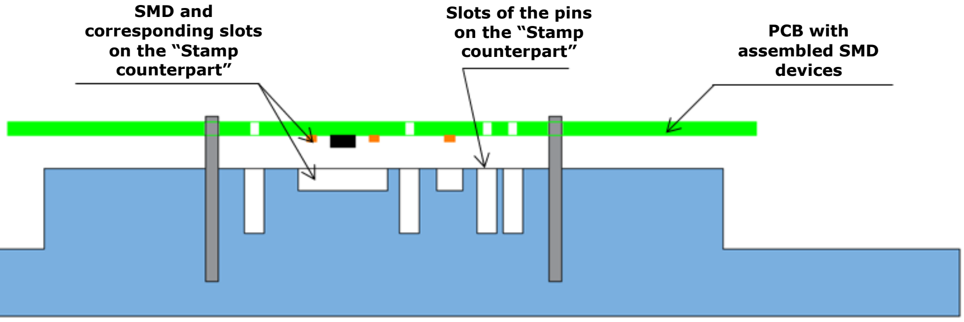


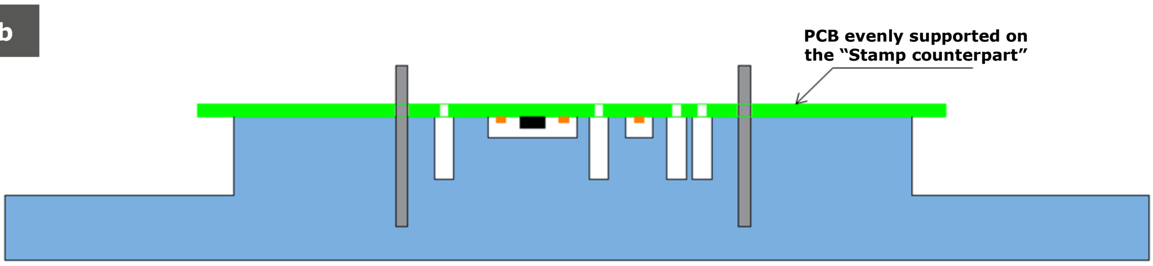
The “Stamp counterpart” supports the PCB during the press-in process while providing alignment for the PCB, by the “Guiding posts” and space for the pins of the module and PCB components. Therefore, shape and size of the tool may vary according to the PCB design.

1a



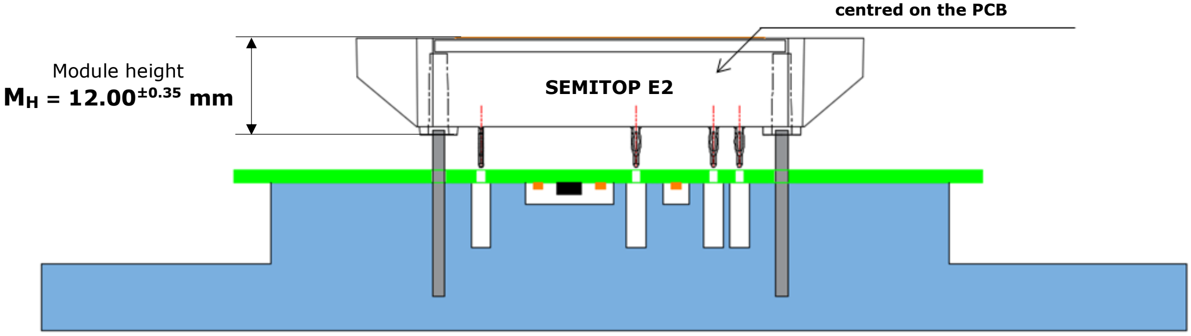
PCB placed onto “Stamp counterpart” by the “Anchor posts” and the “guiding posts”.

1b



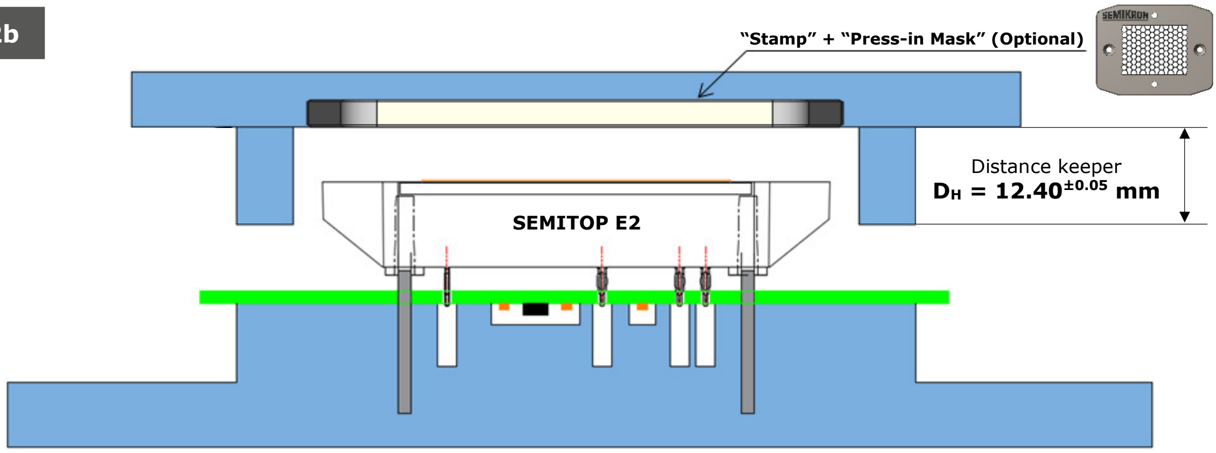
The PCB is supported on the “Stamp counterpart”.

2a



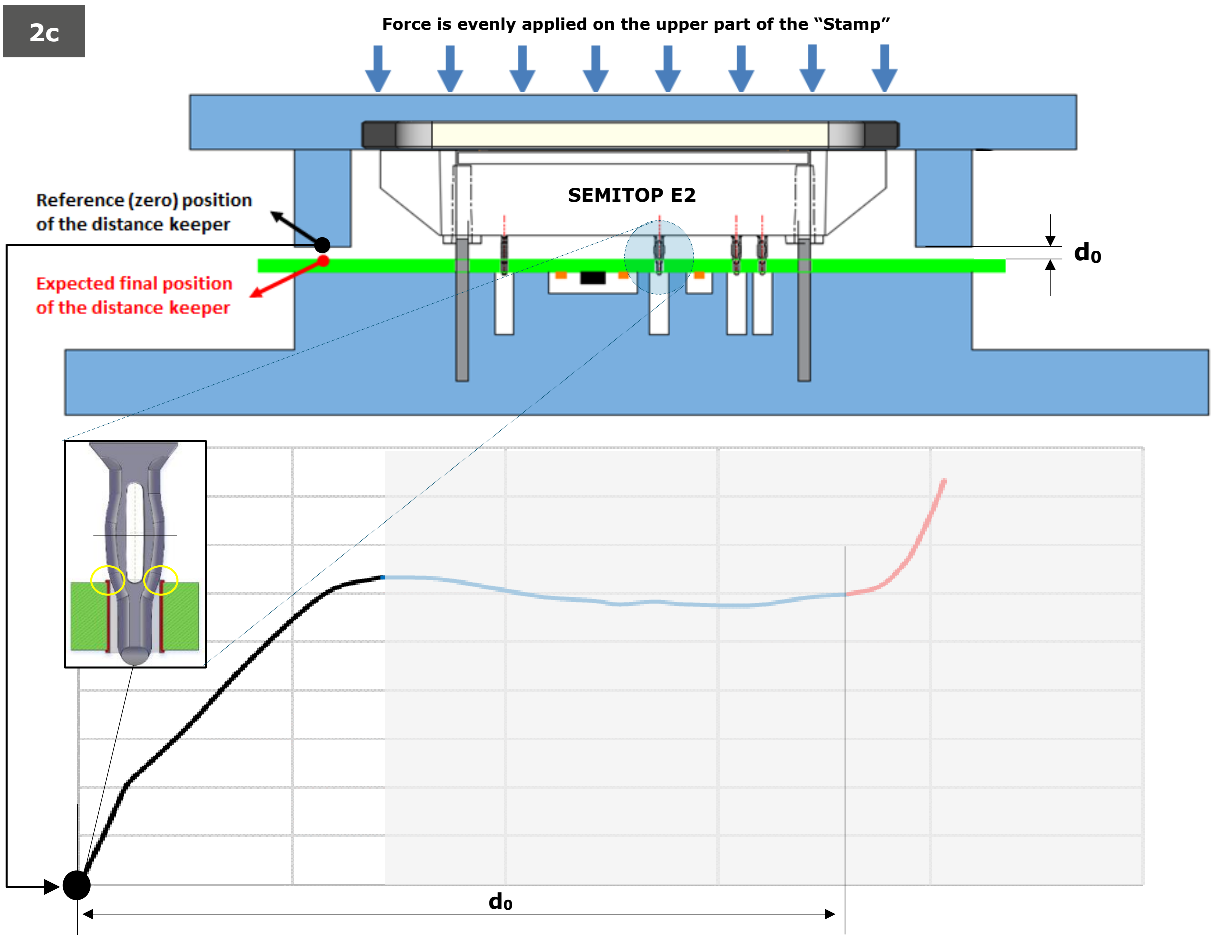
Module is placed onto PCB and aligned by the “Guiding posts” and the pins.

2b

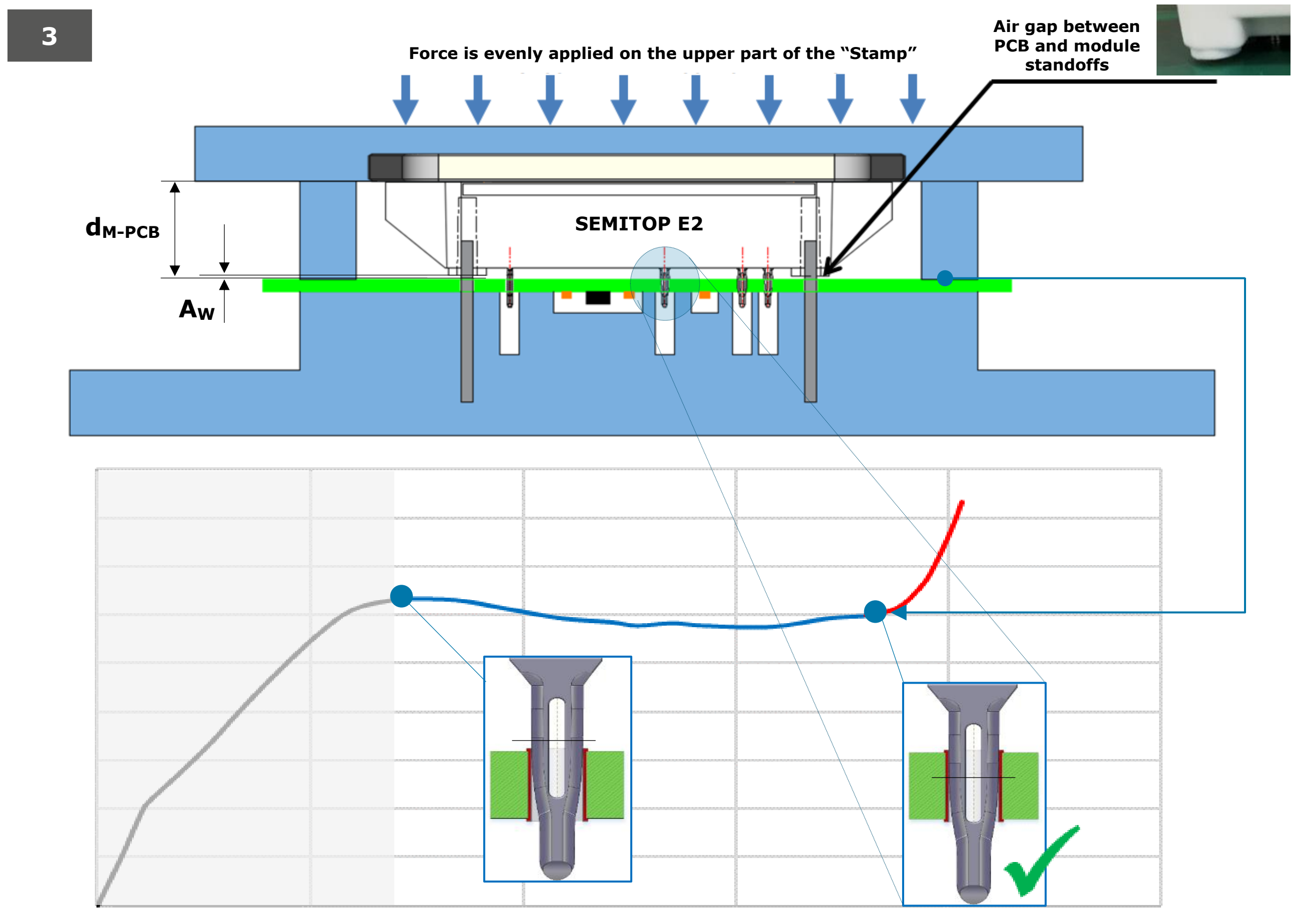


Alignment is complete as soon as the module pins are inserted into the PCB holes up to the beginning of the black curve as shown in Figure 14. If the module is not properly aligned to the "Stamp counterpart" or in case pins are not correctly inserted into the PCB holes, module (or some of the pins) might be damaged during the press-in process. Bottom part of the "Stamp" (or the "Press-in Mask"), getting in touch with module, has to be clean and free from any particles that might damage the module.

2c



Force is evenly applied on the upper part of the "Stamp", pins get in touch with PCB and curve of the force starts raising. After ~0.15mm stroke, in which compression of the pin stress relief [2] occurs, pin starts to be deformed by the PCB hole and starts sliding into it. Maximum deformation of the pin occurs at the peak of the black curve.

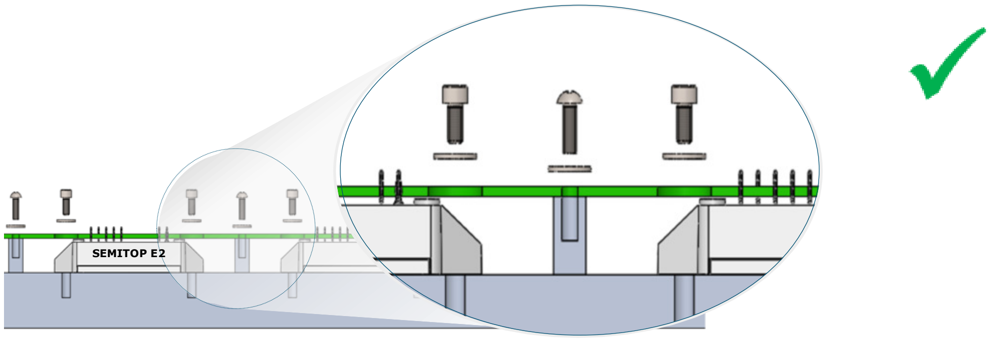


Press-fit pin slides into the holes, down to the final position. "Distance keepers" touch the PCB and start deforming it. Pin insertion is successfully completed and process must be stopped in order to prevent from any PCB damaging. Once "Stamp" is removed, a small "Air gap" might remain between PCB and module standoffs. Width of such a gap "A_W" depends on three main factors: height of the module, height of the distance keeper and level of relaxation of the pin stress relief [2]. Maximum module-to-PCB distance **$d_{M\text{-}PCB(max)}$ ≈ 12.60mm**, therefore **$A_{W(max)}$ ≈ 0.95mm**.

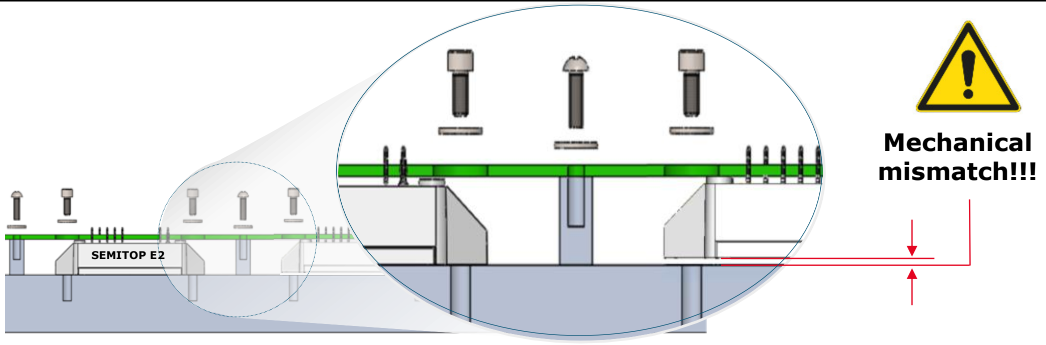
Multiple modules

Typically, press-in of multi-modules applications (e.g. 3x 3-Level NPC modules) is done all at once and using large press-in tools, in order to reduce process cost, time and efforts. In certain cases, it may be necessary to press modules sequentially. In this case, which is possible though not recommended, it is suggested to check PCB warpage and integrity at each step of the press-in process to prevent from any mechanical mismatches on the system assembly (see Figure 16b).

Figure 16: Press-in of multiple modules



a) Multiple modules pressed-in all at once (Recommended)

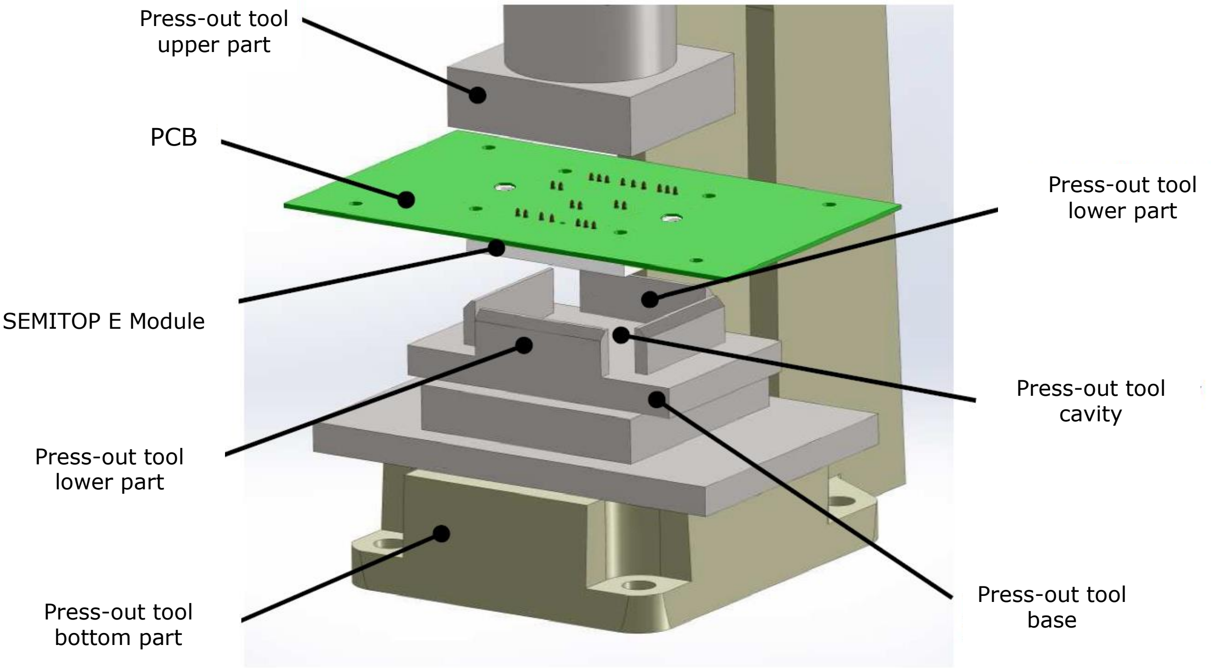


b) Multiple modules pressed-in sequentially

2.3.3 Press-out

Following picture shows a concept view of the press-out equipment.

Figure 17: Schematic view of the press-out setup

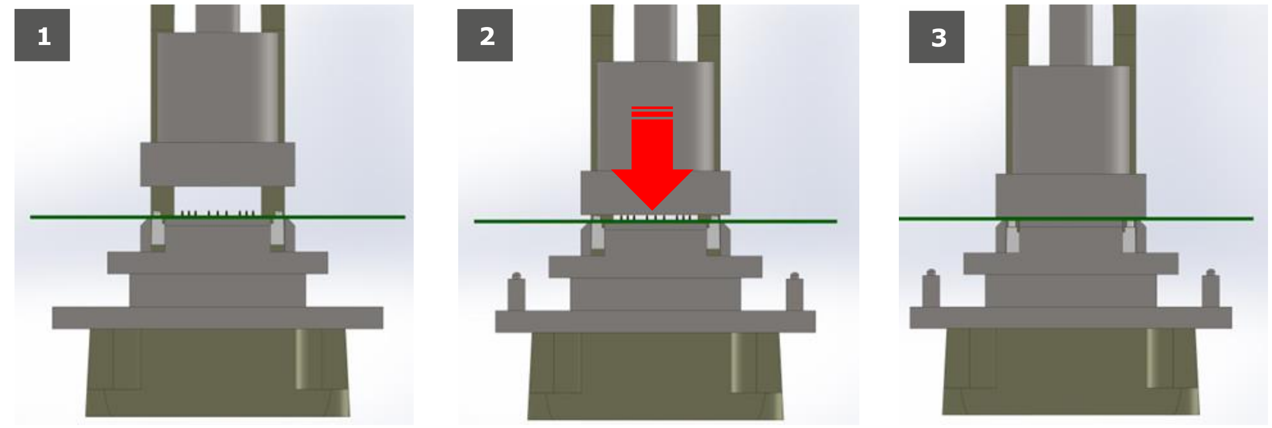


The upper part is used for the direct pressure on pins for the module extrusion. The lower part is used as a base for the pressing operation and it prevents from excessive warpage of the PCB in case it has to be re-used. The upper part of the press-out tool must be designed according to the position of SMD so that the components will not be damaged. The lower part should be designed with the metal walls placed as close as possible to the pins.

Sequence of main press-out steps is shown in the following picture:

1. System "module+PCB" placed onto the support part, alignment via the guiding posts.
2. Module pressed out by upper part of the tool.
3. Module falls down into the cavity located on the base of the support part.

Figure 18: Press-out process



The PCB is placed with the press-fit module assembled in the lower part of the push-out mechanical tool

The press-out tool starts going down until it gets in contact with the terminals; terminals slides out of the PCB

The press-out tool touches the support tool. Module falls down into the tray in the lower part of the push-out mechanical tool and gets separated from the PCB.

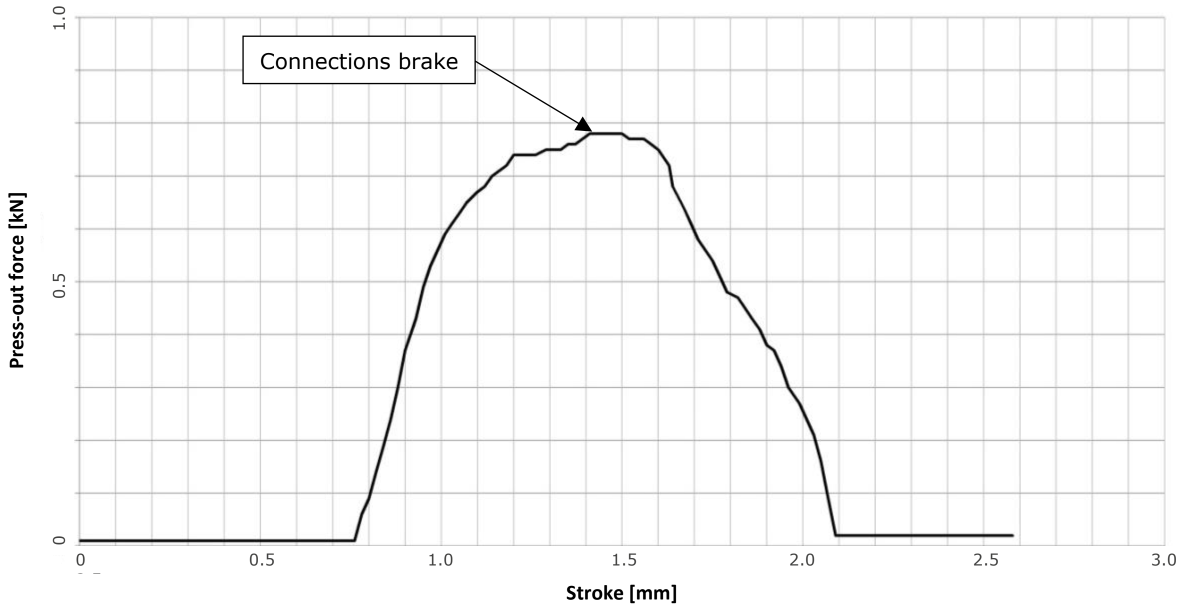
Press-out parameters are given below.

Table 8: Press-out parameters

Parameter	Minimum	Typical	Maximum
Press-out force (per terminal)	30 N		
Press-out speed		50 mm/min	

Typical force vs. distance profile for a press-out process is shown in the following picture. The curve exhibits a peak indicating the breaking of the cold weld joint between terminal and PCB.

Figure 19: Typical press-out diagram of a 21 pins module



2.3.4 Reworking of the assembly "module and PCB"

Each SEMITOP®E1/E2 can be used only once. In case the system "module+PCB" needs to be disassembled, following options are possible:

- **Module can be reused** by soldering the press-fit pins to the PCB. Due to the pin deformation by the initial press-in process, any additional press-in process will result in a weak holding force between the terminal and the PCB hole and is therefore not recommended. In case press-fit modules have been soldered to the PCB and need to be disassembled and reused, standards for through hole components should be followed.

- **PCB can be reused**. How many times depend on the plating of the via:
    - Sn > 0.5µm: PCB can be disassembled and used two more times
    - HAL tin plating Sn >0.5µm: PCB can be disassembled and reused two additional times
    - Au 0.05 - 0.2 µm over 2.5 - 5 µm Ni: PCB cannot be reused

3. Heat sink assembly

Before setting up the electrical connection (including any electrical incoming test), the module must first be mounted onto the heat sink as described in this chapter.

3.1 Module specifications

3.1.1 Cosmetic defects

Due to the manufacturing process, the bottom side of the SEMITOP®E1/E2 may exhibit cosmetic imperfections like:

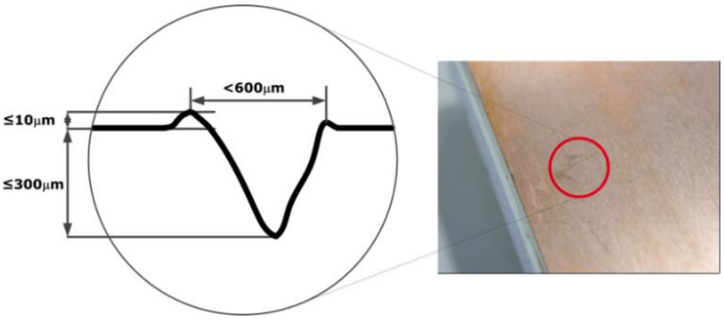
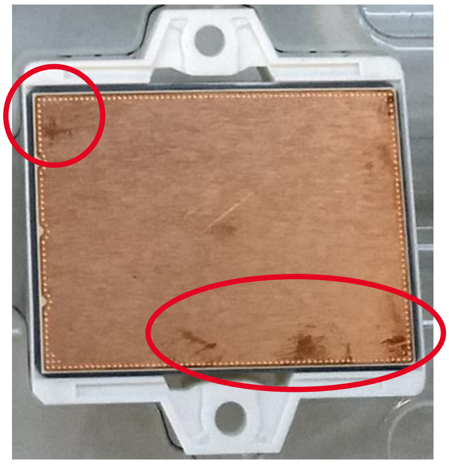
- Scratches & dents
- Etching holes
- Small marks
- Copper discoloration/oxidation

The following table describes the allowed cosmetic defects and provides the information to consider them as acceptable by incoming inspection from customer side.

The acceptance criteria are defined in order to ensure thermal behaviour, reliability and mounting process are not negatively affected. Only those modules, which fulfil acceptance criteria, are shipped.

Further information are available upon request.

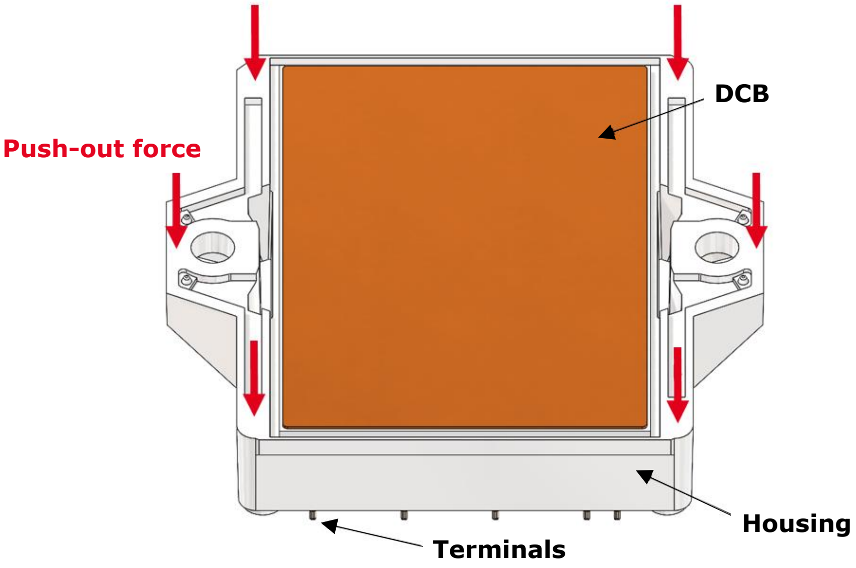
Table 9: Acceptance criteria of cosmetic defects

Cosmetic defect description	Picture
Dents and Scratches ➢ Depth < 300 µm ➢ Width < 600 µm ➢ Roughness < 10 µm ➢ Number of scratches and dents is not limited ➢ Each scratch must be within the copper	
Copper Oxidation caused by: ➢ Flux used during chip soldering process ➢ Heat during pin solding process No limitation to amount of oxidation. Oxidation observed at time of manufacturing can be very different from what observed at customer's inspection since it can be affected by environmental conditions during transportation, exposure to humidity and/or pollution and stocking of modules at customer's warehouse.	
Copper polishing applied to remove possible residues collected during manufacturing process.	

3.1.2 Module handling

SEMITOP®E1/E2 modules are not designed to withstand forces on the module housing as shown in the Figure 20. When terminals are laid and in touch with a horizontal flat plane, possible force applied on housing, described by red arrow, turns into a push-out force on the DCB. Same force may be applied when module is mounted on heat sink with TIM and operator pulls it up by holding the housing.

Figure 20: Push-out force on DCB



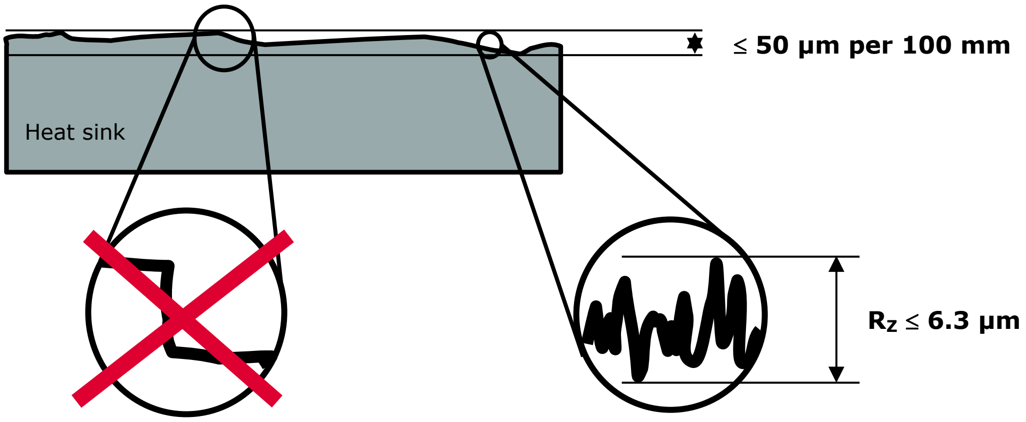
The sealing material between plastic housing and DCB substrate has no glue function. It prevents from potential leakage of insulating gel during filling process in production. Therefore, holding strength at the interface between housing and DCB cannot be considered as a property of the power module and push-out force on DCB must be avoided.

Typical press-in/out processes do not generate push-out force on DCB since press-in/out forces are applied on the DCB/terminals, not on the housing.

3.2 Heat sink preparation

In order to achieve the maximum thermal conductivity, the bottom side of the module must be free from dust and dirt. The heat sink must fulfil following mechanical specifications.

Figure 21: Heat sink surface specifications



- Flatness of heat sink mounting area must be ≤ 50 µm per 100 mm (DIN EN ISO 1101)
- Roughness "R_Z" ≤ 6.3 µm (DIN EN ISO 4287)
- No steps
- Machined without overlaps

Surface of heat sink should be free of grease, e.g. by cleaning the heat sink in a fat-dissolving solvent. A good indication is given by the DIN 53364, surface tension ≥ 32 N/m. Tap holes must be free of turnings. The supplier of the heat sinks should chose adequate packaging to avoid contamination and mechanical damage during transport.

3.3 Thermal Interface Material (TIM)

To avoid air gaps at the interface between the module and the heat sink a Thermal Interface Material (TIM) must be applied. TIM should follow the shape of the two surfaces (module and heat sink), allowing a metal-to-metal contact where it is possible, and filling the remaining gaps.

Further information about TIM can be found on website:
- Technical explanation of TIM [3]
- General guidelines on TIM application [4]

Wacker-Chemie P12 (WP12) is the standard TIM used by SEMIKRON to perform qualification tests. SEMIKRON recommends a hard rubber roller or a screen print for an even distribution of the TIM.

Following table shows the recommended average thickness of the applied TIM layer.

Table 10: Recommended TIM thickness (Wacker P12)

Module types	Minimum	Typical	Maximum
SEMITOP®E1	30 µm	40 µm	50 µm
SEMITOP®E2	40 µm	50 µm	60 µm

Please note! Deviations from the recommended specifications may affect reliability and/or technical performance of the modules therefore SEMIKRON assume no liability in this regard.

The thickness of the applied grease can be verified by a measuring gauge from ZEHNTNER called "Wet Film Wheel" like the one shown in the picture:

Figure 22: Wet film wheel Zehntner Type ZWW2102

3.3.1 Pre-applied TIM

In order to simplify the module assembly, SEMITOP®E1/E2 are also offered with pre-applied TIM. TIM is applied by SEMIKRON prior to delivery to the customer, thus eliminating this critical process step from the customer manufacturing process. Furthermore, TIM printing process is more efficient, reproducible and controllable. Main advantages are:

- Optimized thickness of TIM layer
- High process reliability due to automated screen printing process

Figure 23: SEMITOP®E1/E2 with Pre-Applied TIM

SEMITOP®E1 SEMITOP®E2

SEMITOP®E1/E2 modules are available with following pre-applied TIM:

- HPTP (High Performance Thermal Paste)
- HALA HT (Phase Change Material)

Further information about modules with pre-applied TIM (e.g. storage conditions) can be found on website:

- Technical explanation of TIM [3]
- Datasheet of modules with pre-applied TIM [1]

3.3.2 Add-on Service and Accessories

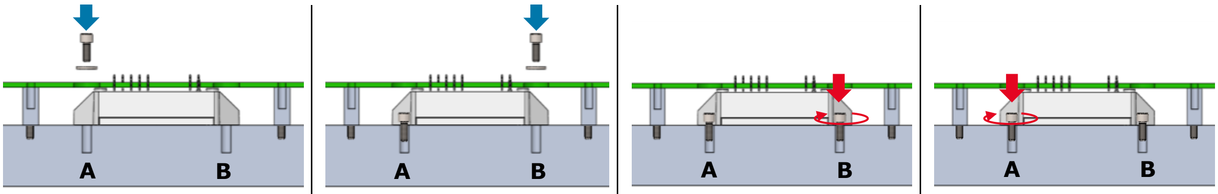
SEMIKRON offers additional services to customer in order to support design and industrialization phase:

- Support for stencil design (in case of "home-made" TIM printing process).
- Support for "press-in mask" design (shown in Figure 12).
- Plastic cap to protect TIM from dust and contamination which may be collected on production line.

3.4 Mounting Module+PCB onto heat sink

Once module is fixed into PCB (Soldered or Pressed), heat sink is properly cleaned and TIM is printed, "module+PCB" can be mounted onto the heat sink.
Pre-tightening must be applied at both screws, then the nominal tighten values should be applied. Therefore, the assembly procedure to the heat sink follows the process below:

Figure 24: Mounting Module+PCB onto the heat sink



Step 1

Screw is tightened into slot A at **pre-torque value.**

Speed ≤ 250 rpm

Step 2

Screw is tightened into slot B at **pre-torque value.**

Speed ≤ 250 rpm

Step 3

Screw into slot B to be tightened at **final torque value.**

Speed ≤ 12 rpm

Step 4

Screw into slot A to be tightened at **final torque value.**

Speed ≤ 12 rpm

Same concept applies if the mounting procedure starts from slot B

It is recommended to tighten the screws with the following parameters.

Table 11: Specifications for heat sink assembly

Module	Screw	Washer	Spring lock washer	Mounting pre-torque	Final Mounting torque
SEMITOP®E1	2x M4 DIN 7985x12	2x DIN 433	2x DIN127 or DIN128	0.5Nm ±0.1Nm	1.6Nm÷2.3Nm
SEMITOP®E2	2x M4 DIN 7985x12	2x DIN 433	2x DIN127 or DIN128	0.5Nm ±0.1Nm	1.6Nm÷2.3Nm

Maximum recommended tightening speeds:

1. **250rpm** up to **pre-torque** value
2. **12rpm** up to **final torque** value

SEMIKRON recommends:

- A torque wrench with automatic control (see Table 12). Electric power screwdriver is recommended over a pneumatic tool. The specified screw parameters are better adjustable and especially the final torque will be reached more smoothly. A limitation to the mounting torque screw speed is recommended to allow the thermal paste to flow and distribute equally. If tightened with higher speed the ceramic may develop cracks due to the inability of the paste to flow as fast as necessary and therefore causing an uneven surface. The maximum screw speed should not exceed 250rpm if recommended TIM paste is used. A soft stop (no torque overshoot) will reduce the stress even further and is preferable.
- Screws and washers as shown in the above table. For different screws and/or washers, different mounting conditions might apply. In this case, SEMIKRON recommends that the mounting conditions should be thoroughly checked by the customer via Design Of Experiments to ensure high quality of the mounting process.
- Tighten the screws only once. After the mounting do not re-tighten the screws to the nominal mounting torque value. Due to relaxation of the housing and flow of thermal paste, the loosening torque is lower than the mounting torque. However, the construction of the housing, the washers and the adhesion of the thermal paste still ensure sufficient thermal coupling of the module to the heat sink.
- Do not exceed the mounting torque because a further increase of the maximum mounting torque will not improve the thermal contact but could damage the module.

Table 12: Specification of screwdriver type

Press type	Torque/Angle control	Accurate stop control	Recommendation
Manual, pneumatic	🚫	🚫	🚫
Electronic	✓	✓	✓

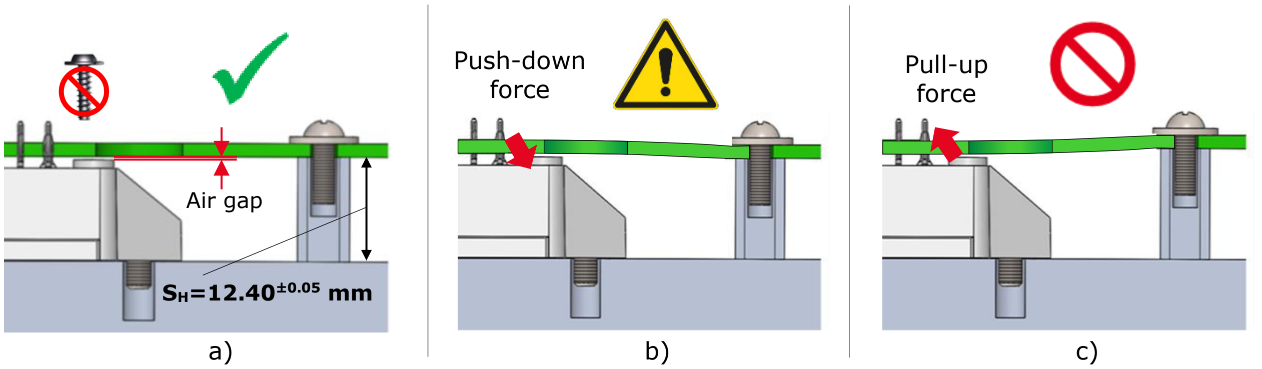
After mounting "module+PCB" to the heat sink, PCB has to be additionally fixed to the heat sink by the spacers. In order to minimize mechanical stress on the pins, spacers should be placed in the proper position and designed with proper height. According to type of mounting method (Press-in or Soldering), different solutions apply, as shown in the next chapter.

3.4.1 Spacers height

Press-in process

Height of the spacers “S_H” must never be higher than the module-to-PCB distance “$d_{M\text{-}PCB}$” (described in Figure 15, section 3). This ensures that no pull-up forces are applied to the power modules (see Figure 25c), regardless of module height “M_H”. Despite a light push-down force is allowed (Figure 25b), optimum result is shown in Figure 25a, where pin is not subject to any mechanical stress. Therefore recommended height of the spacers is **$S_H=D_H=12.40^{\pm 0.05}$ mm** (see also Figure 15, section 2b). Details about spacers positioning are given in chapter 2.3.1.

Figure 25: Spacers height for press-in process



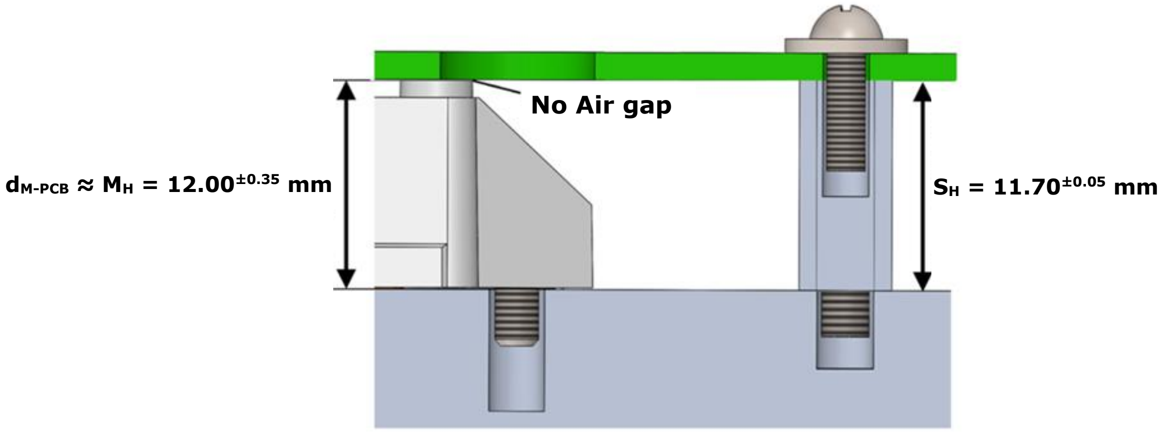
a) b) c)

Please note! Remaining “Air gap” between module’s standoffs and PCB does not allow fixing the module on PCB by screws.

Soldering process

In case of soldered pins, there is no “Air gap” between PCB and module, therefore module-to-PCB distance “$d_{M\text{-}PCB}$” is defined by module height “M_H” (see Figure 26). This means, recommended height of the spacers is **$S_H=11.70^{\pm 0.05}$ mm**. See chapter 2.2.1 for details about spacers positioning.

Figure 26: Spacers height for soldering process



ESD Protection

SEMITOP®E1/E2 modules are sensitive to electrostatic discharge. Discharge can damage or destroy IGBT/MOSFET structure of the gate. All SEMITOP®E1/E2 modules are ESD protected during transport, storage and mounting process with an ESD cover. When handling and assembling the modules it is recommended that a conductive grounded wristlet is worn and a conductive grounded workplace is used. All staff should be trained suitably for correct ESD handling.

Symbols and Terms

Table 13: Symbols and Terms

Symbol/Terms	Description
PCB	Printed Circuit Board
PTH	Plated Through Hole
HAL	Hot Air Leveling
SMD	Surface Mounting Device
d_{S-M}	Spacer to Module distance
d_{M-M}	Module to Module distance
M_H	Height of the Module
D_H	Height of the Distance keeper
d_0	Distance keeper to PCB distance at time 0 (no force applied by the press)
d_{M-PCB}	Module to PCB distance
A_W	Width of the "Air gap"
S_H	Height of the Spacer
R_Z	Roughness
TIM	Thermal Interface Material
WP12	Wacker-Chemie P12 (TIM)
HPTP	High Performance Thermal Paste (TIM)
PCM	Phase Change Material (TIM)
ESD	Electrostatic Discharge

Further explanation can be found in the "Application Manual Power Semiconductors" [5].

Index of figures and tables

Figures

Tables

References

[1] www.SEMIKRON.com
[2] SEMITOP®E1/E2 Technical Explanations (2021-03-25 - Rev-00)
[3] Thermal Interface Materials (2019-09-25 - Rev-03)
[4] Thermal Paste Application (AN_18-001 / 2018-01-19 - Rev-00)
[5] Application Manual Power Semiconductors (A. Wintrich, U. Nicolai, W. Tursky, T. Reimann), 2nd edition, ISLE Verlag 2015, ISBN 978-3-938843-83-3

IMPORTANT INFORMATION AND WARNINGS

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