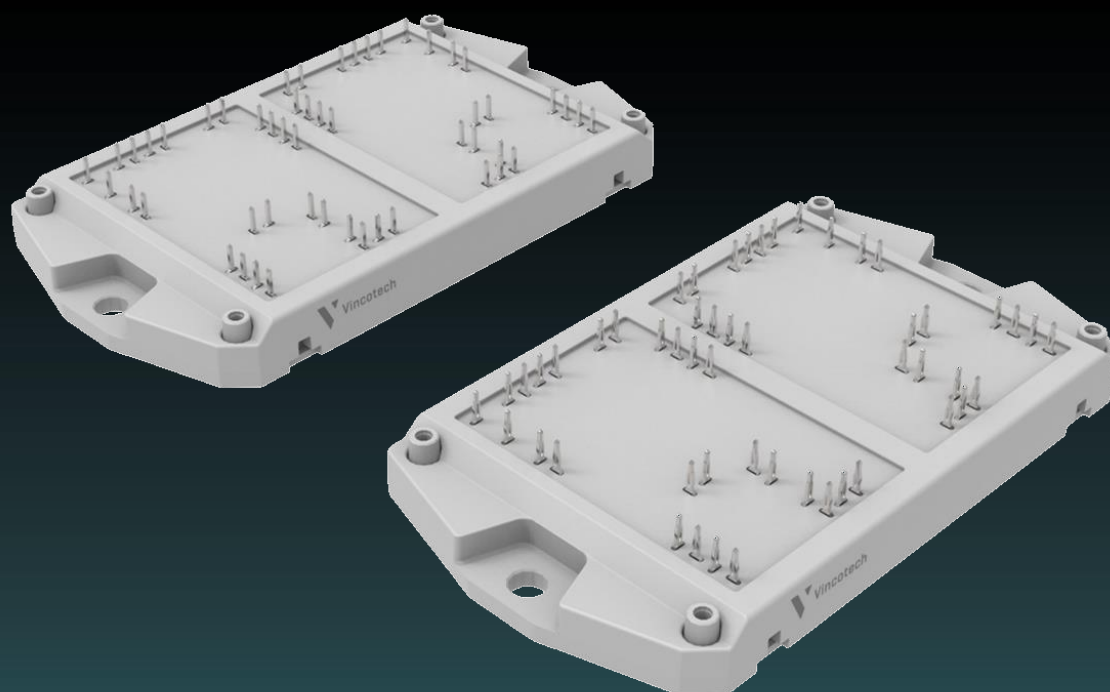




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# Handling Instructions

for *flow* E3 packages



***This document is valid for all type of flow E3 modules:  
12 mm, Press-fit and Solder pins, Al<sub>2</sub>O<sub>3</sub> ceramic***

**Date:** 04.02.2022

**Revision:**

**Created by:** Máté Buza

**Rev. 01**

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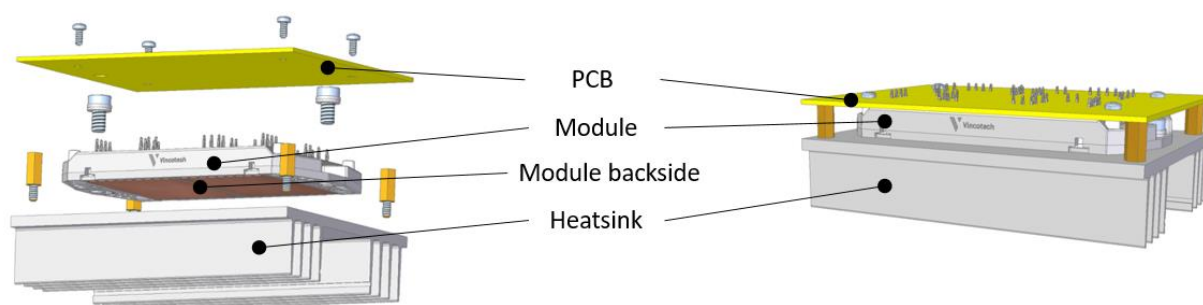
## Revision History

Date	Revision Level	Description	Page Number(s)
04.02.2022	01	Initial release	



## 1 General assembly instructions

The *flow* E3 type modules have to be mounted to a PCB. The electrical connections between module and the PCB made by using soldering or Press-fit technology. In applications where the module is attached to a heat sink, the PCB must also be attached to this heat sink. *1. Figure* shows how this attachment can be achieved with threaded spacers.



1. Figure: Module with PCB and Heatsink

The distance between the top surface of the heat sink and the bottom plane of the PCB is defined by the module type, which is 12 mm. PCB spacers can be used to obtain the correct spacing. The number and the position of the fixing points depend on the design of the circuit, the location of different masses like capacitors or inductors and the environment of the system. General recommendation cannot be given. For recommended heights of these spacers see the sections of mounting option (section **7, 10**).

Recommended assembly sequence:

1. Attach module to the PCB
2. Position and fix the assembled PCB with spacers to the heat sink
3. Fix the module to the heat sink

A single solder pin can be pushed or pulled maximum  $\pm 0.2$  mm with a force not more than 35 N during the assembly process. The special design of the Press-fit pin prevents a deformation of more than 0.1 mm when a push force is applied during the press-in process. A deformation of maximum 0.2 mm by applying a pulling force of not more than 35 N during the assembly process is allowed.

The tension of the pin must not exceed  $\pm 5$  N at a maximum substrate temperature of 100 °C, this condition is fulfilled if the recommended spacers are used.



## 2 Specification for PCBs

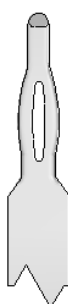
- Printed board material meets the requirements of IEC 61249-2-7.
- The maximum number of conductive layers is not limited.

### 2.1 Specification for Press-fit pins

- Printed board thickness must not be less than 1.6 mm (thinner PCBs require additional testing and will be performed upon request).
- PCB should be covered with solder mask on both sides.
- Plated-through-hole specification:

	<i>flow E3 with Press-fit pin type "T"</i>
Hole drill diameter	$\varnothing 1.15 \pm 0.025 \text{ mm}$
Copper thickness in wall	$> 25 \mu\text{m}$
Metallization in hole	$< 50 \mu\text{m}$
PTH hole diameter	$\varnothing 1 + 0.09 / - 0.06 \text{ mm}$
Minimum Cu width of the annular ring	$> 0.1 \text{ mm}$
Hole position accuracy	$\pm 0.04 \text{ mm}$

Pressfit-pin head  
Type "T"



2. Figure: Press-fit pin type

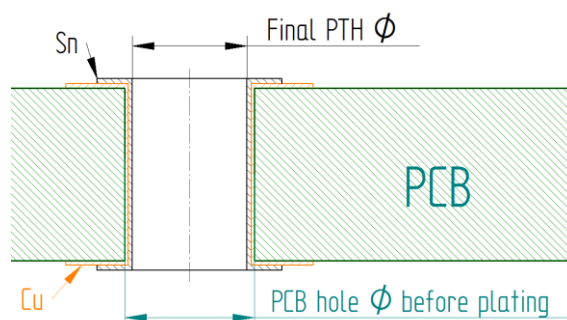
The pin type identifier "T" can be observed in the product part number.  
Example:

**B0-EP10B2A040MM-PB27L08T-/7/**

Plating material:

- for chemical tin plating (Sn): 0.5  $\mu\text{m}$  to 10  $\mu\text{m}$

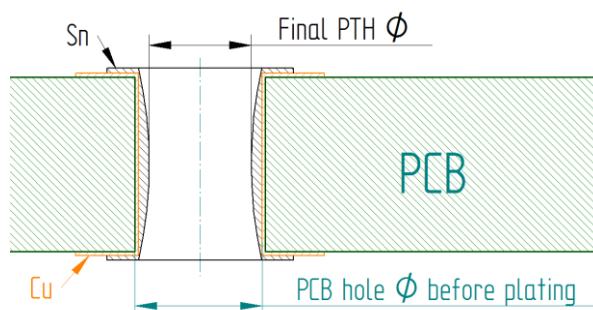
The PCB can be disassembled and reused 2 more times. Upon further reuse of PCB, module has to be soldered after press-in.



3. Figure: Chemical tin plating (for illustration only, no real proportions)

- for HAL tin plating (Sn): 0.5  $\mu\text{m}$  to 50  $\mu\text{m}$

The PCB can be disassembled and reused 2 more times. Upon further reuse of PCB, module has to be soldered after press-in.



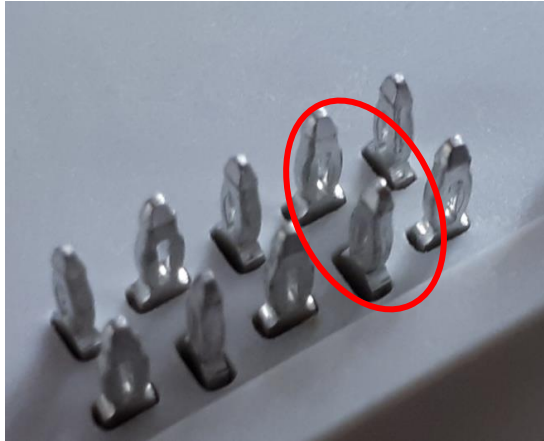
4. Figure HAL: tin plating (for illustration only, no real proportions)

- Au: not generally released; individual release of PCB system required  
Upon any further reuse of PCB with Au the module has to be soldered after press-in.

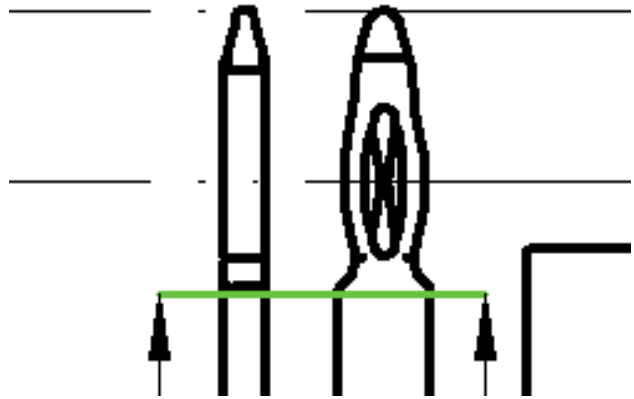
- Minimum distance between edge of the PCB and the centre of the pin hole: 4 mm
- Minimum distance between centre of the pin hole and the component on the PCB: 4 mm
- For any other requirements IEC 60352-5 standard should be considered
- The press-fit pins of *flow* E3 modules are plated with continuous tin finish and nickel underlayer to promote Press-fit function and solderability. Due to process and storage conditions the copper may become visible on the bottom of the pin up to the green line indicated on the picture (5. Figure: Copper visible on Press-fit pins5. Figure). This is merely a cosmetic imperfection and does not influence the Press-fit function as it does not affect the plating quality of the head of the pin.



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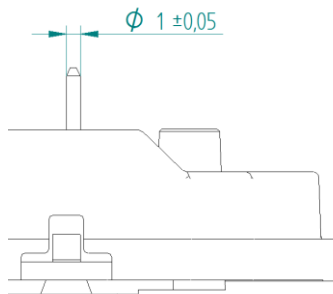


5. Figure: Copper visible on Press-fit pins

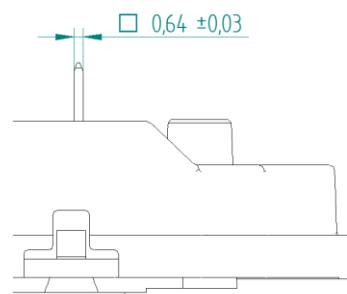


## 2.2 Specification for modules with solder pins

- The module is attached to the PCB by screwing it into the appropriate holes (see section **2.4** and **10**).
- After mounting the module, all pins must be soldered (see section **10** and **11**).
- The hole diameters on the PCB have to be designed according to the soldering pin:
  - available pin types - **W** -type pin
  - **Z** -type pin



**W** -type pin



**Z** -type pin

- The pin type identifier "Z" can be observed in the product part number.  
Example:

B0-E310B2A040MM-PB27L08**T**-/7//

- For further dimensions or a 3D model please contact your local sales manager.

## 2.3 Specification for modules with Press-fit pins that are soldered to the PCB

In cases where the Press-fit pins are soldered instead of pressed into the PCB the recommended PCB hole diameter is stated in the table below. In these cases the annular ring must be designed according to the standards for through hole components to ensure proper soldering of the Press-fit pins.

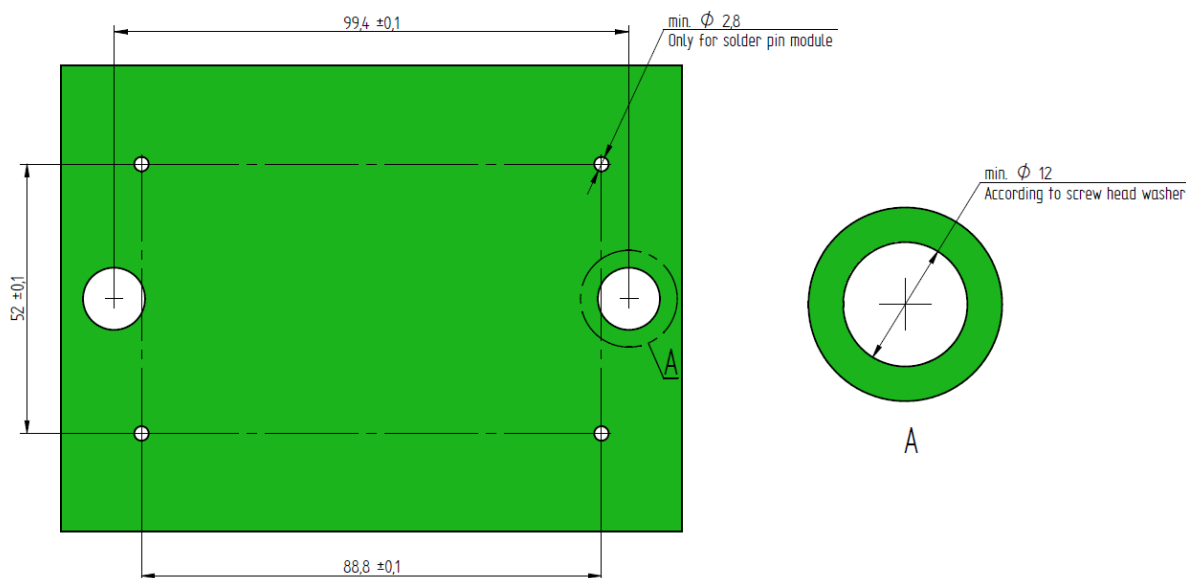
- PCB Hole diameters

	<i>flow E3 with Press-fit pin type "T"</i>
Final hole diameter	$\varnothing 1.4 \pm 0.1$ mm

Please read section **11** also.

## 2.4 Required PCB cutouts

The drawing below shows the required PCB-cutouts



6. Figure: PCB cutouts

### 3 Specification for module backside surface

The module backside is important for the thermal management of the power module. Imperfection is allowed if it does not lead to an  $R_{th}$  increase of >2% (assembled acc. VIN instruction). Acceptance criteria for module backside surface are detailed in the following sections.

#### 3.1 Polishing, discoloration

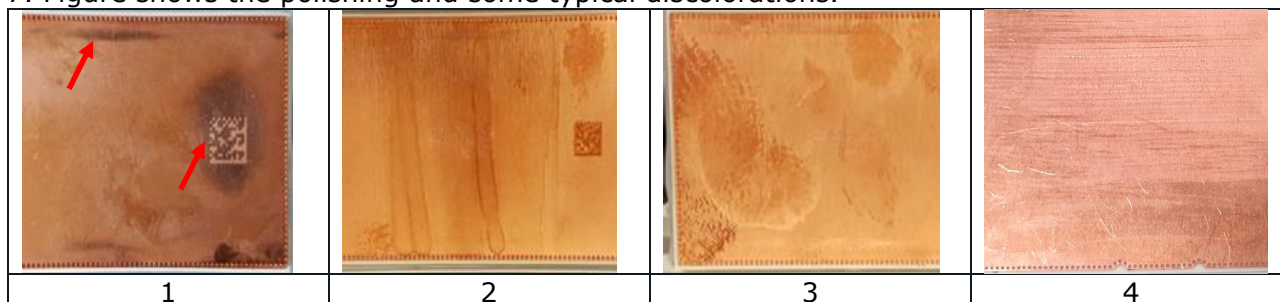
Acceptance criteria for polishing

- Polishing is allowed on the whole surface of the substrate

Acceptance criteria for discolorations

- discolorations – due to production technology – are only surface imperfections (cosmetic), and do not affect the module's functionality

7. Figure shows the polishing and some typical discolorations.



7. Figure: Polished surface (1), discolorations on the surface (4)

### 3.2 Scratches, etching holes, steps

Acceptance criteria for scratches:

- Max width of 600  $\mu\text{m}$
- Max depth of 200  $\mu\text{m}$
- The scratched area must not exceed 5 % of the total substrate surface.

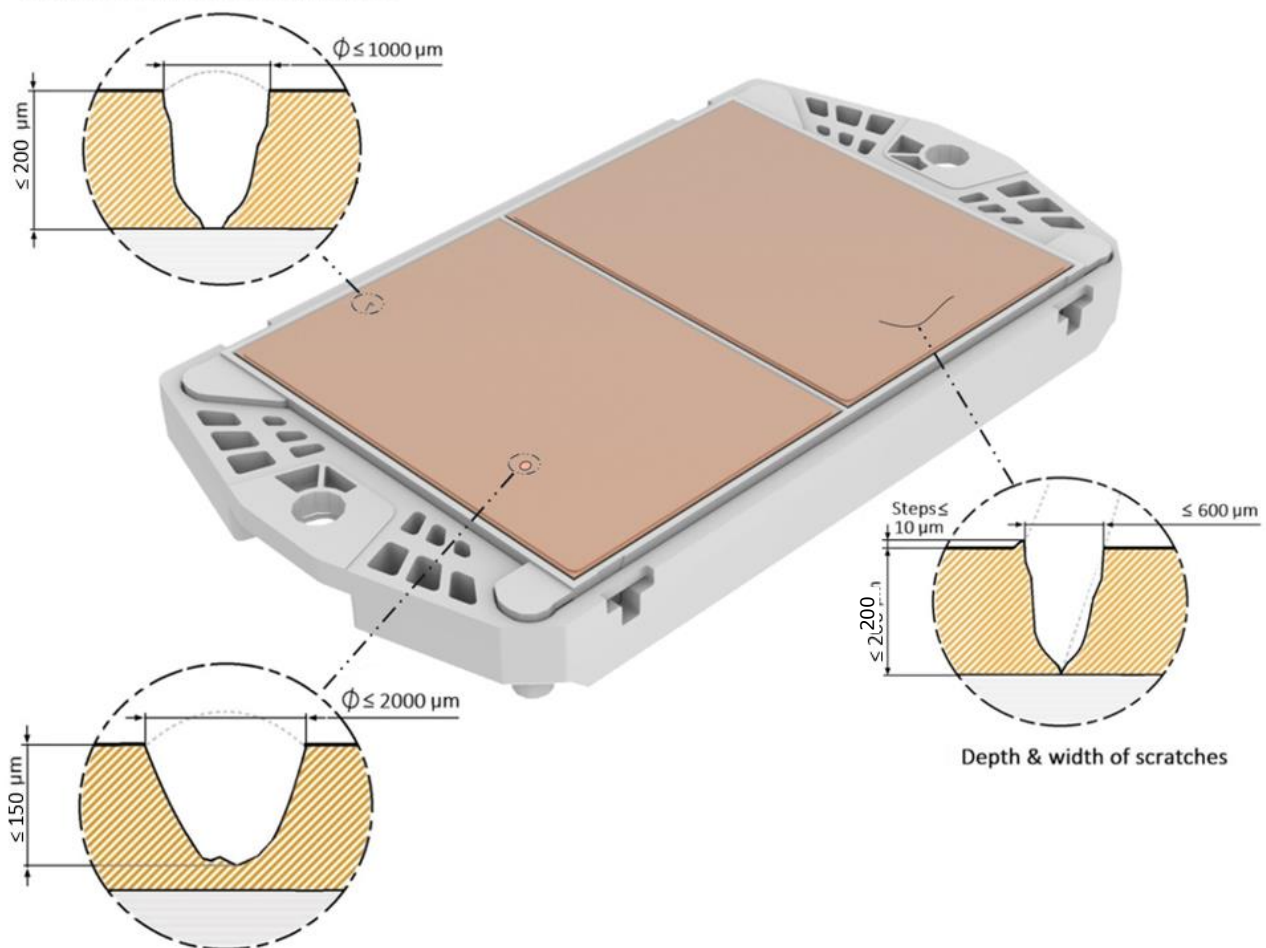
Acceptance criteria for etching holes:

- Max diameter of 1000  $\mu\text{m}$  and  $\rightarrow$  max. depth of 200  $\mu\text{m}$
- Max diameter of 2000  $\mu\text{m}$  and  $\rightarrow$  max. depth of 150  $\mu\text{m}$

Steps, Flash

- Max height of 10  $\mu\text{m}$

Depth & diameter of etching holes



8. Figure: Scratch and etching hole dimensions



## 4 Specification for heat sink

The whole heat sink surface under the module must be plane, clean and free of particles.

- The flatness tolerance should be:  $< 50 \mu\text{m}$  in general.
- In case the thermal paste thinner than  $50 \mu\text{m}$ , the flatness tolerance has to be  $< 50 \mu\text{m}$  accordingly.  
(A flatness tolerance specifies a tolerance zone defined by two parallel planes within which the surface must lie.)
- The surface roughness should be less than:  $R_z < 10 \mu\text{m}$ .
- Heat sink surface imperfections should be within the values described for the module backside surface (please refer to section 3)

## 5 Specification for thermal interface materials

### 5.1 Modules with qualified phase change material (PCM)

- Type of PCM: only **PTM6000HV** from Honeywell is allowed
- Applied in a standard honeycomb pattern (see 9. *Figure.* for details)

#### 5.1.1 Modules are available also with pre-applied PCM

- Ordering option code: **- /7/**

Example order: B0-SP07BBA300S501-LM46L58T-**/7/**  
The product will be delivered with PTM6000HV

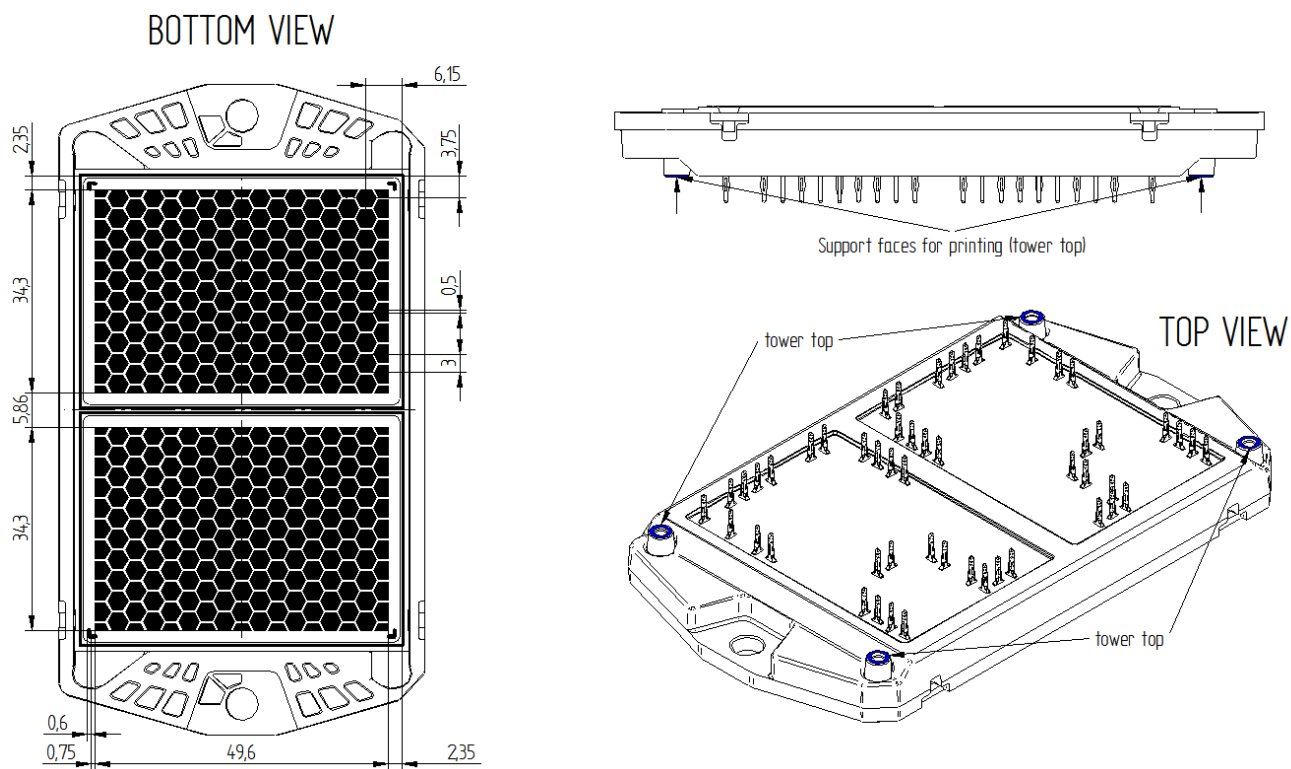
- In case the module has Press-fit pins, a unique press-in tool has to be used (see section **8.1.1**).
- Further information about using modules with pre-applied TIM see also the application note for "*Power modules with Phase-Change Material*" on Vincotech's website

### 5.2 Application of TIM

- Pattern: the below pattern and size is recommended (see 9. *Figure.*, drawing on the left)
- Thickness (wet):  $65 \pm 15 \mu\text{m}$
- Technology: stencil or screen printing
- After apply of paste drying is needed; recommended parameters: 45 min at  $60^\circ\text{C}$
- To ensure stable quality of the printing, the module has to be supported and fixed on the specified surfaces, showed below on 9. *Figure.* (drawings on the right). If the module is supported on other faces than specified (e.g. housing top) this may cause uneven thickness of the printed PCM.
- For PCM (PTM6000HV)
  - after apply of paste, drying is needed
  - recommended parameters: 45 min at  $60^\circ\text{C}$



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9. Figure: Pattern specification of PCM and support surfaces



## 6 Specification for fastening screws to the heat sink

- Screw size M5, recommended screw type DIN 7984 (ISO14580)
- The recommended material strength class for the screw is 8.8 (ISO-898-1)-any deviation from the recommended material can be used but should be tested
- Flat washer D=max. 10 mm DIN 433 (ISO 7092)
- Spring washer D=max. 10 mm DIN127 or DIN 128
- Mounting torque:  $1,3 \text{ Nm} < M_a < 1,5 \text{ Nm}$

A torque wrench shall be used to tighten the mounting screws at the specified torque as excessive torque may result in damage or degradation of the device. The inaccuracy of torque wrench tightening method can range up to  $\pm 12 \%$ . This has to be taken into account to prevent over-tightening the fastener.

Due to excessive temperature fluctuations washers should be used to prevent the loosening of the screws. After accurate tightening of the screws the spring washer exerts a constant force on the joint. The flat washer distributes this force on the plastic surface.

### 6.1 Screw with pre-assembled washers

Screws with pre-assembled washers (SEMS or kombi screws) combine the screw and the washers into a single component. These screws eliminate the need to slip the washers into place by hand, boosting the speed and efficiency of the assembly process. The specifications of these screws are provided below:

- Screw size M5 according to DIN 6900 (ISO 10644; JIS B1188)
- The recommended material strength class for the screw is 8.8 (ISO-898-1)-any deviation from the recommended material can be used but should be tested
- Flat washer according to DIN 6902 Type C (ISO 10673 Type S; JIS B1256)  
Size of outer diameter  $\varnothing 10 \text{ mm}$  can be fitted into the module.
- Split lock spring washer according to DIN 6905 (JIS B1251)
- Mounting torque range:  $1,3 \text{ Nm} < M_s < 1,5 \text{ Nm}$

### 6.2 Mounting with automatic screwdriver

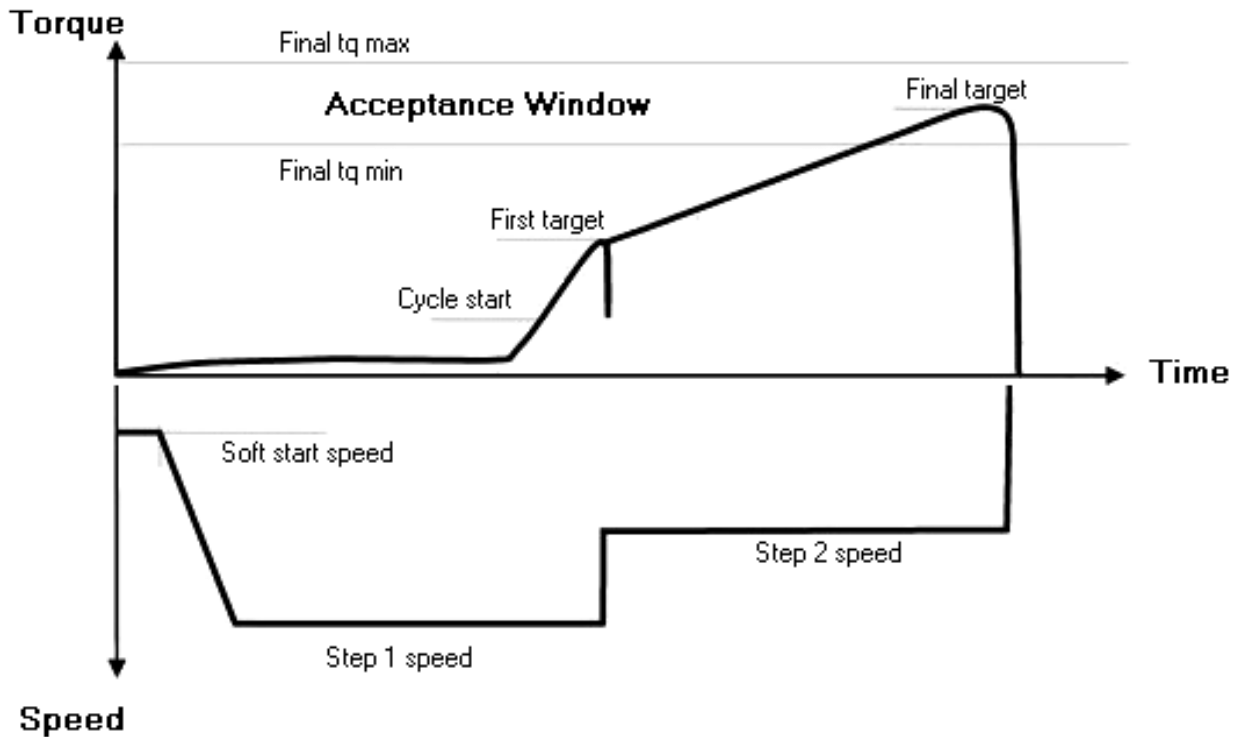
For a fast, reliable and repeatable screwing process an automatic screwdriver with two stage tightening method is recommended. The screwdriver starts fast in the first stage and slows down after the first target torque is reached to accurately tighten the screw to the final target. For torque and speed recommendations see below the curves (*10. Figure*) and values:

Torque

- Cycle start: 0.3 Nm
- First target: 0.5 Nm
- Final torque min.: 1.6 Nm
- Final target: 1.8 Nm
- Final torque max.: 2 Nm

Speed

- Soft start speed: 96 rpm
- Step 1 speed: max. 650 rpm
- Step 2 speed: max. 12 rpm



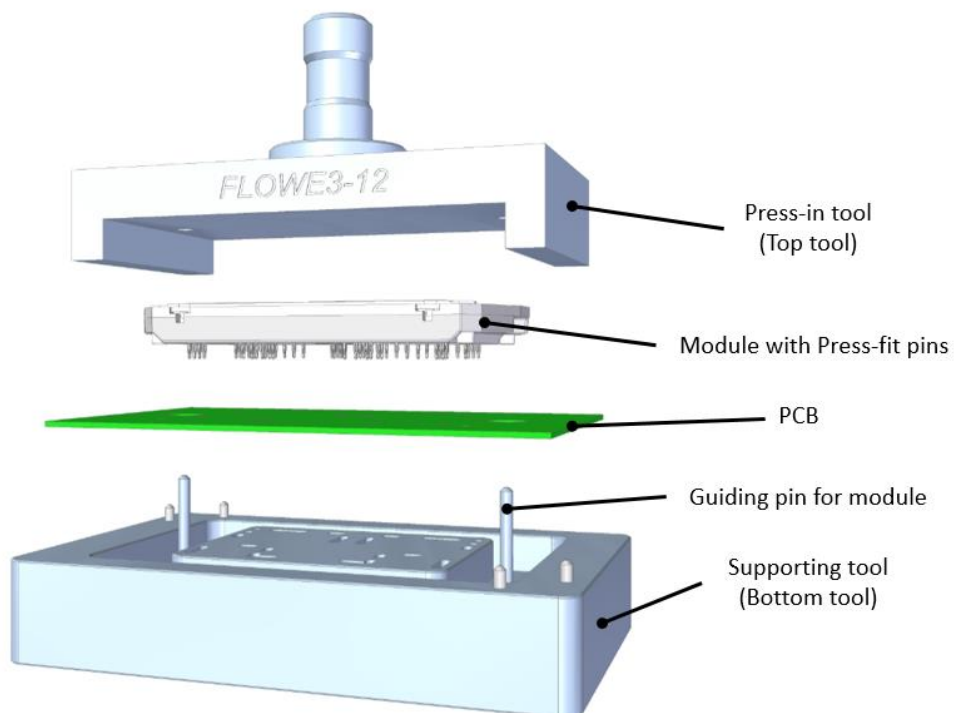
10. Figure: Recommended torque and speed curve

## 7 Mounting of modules with Press-fit pins

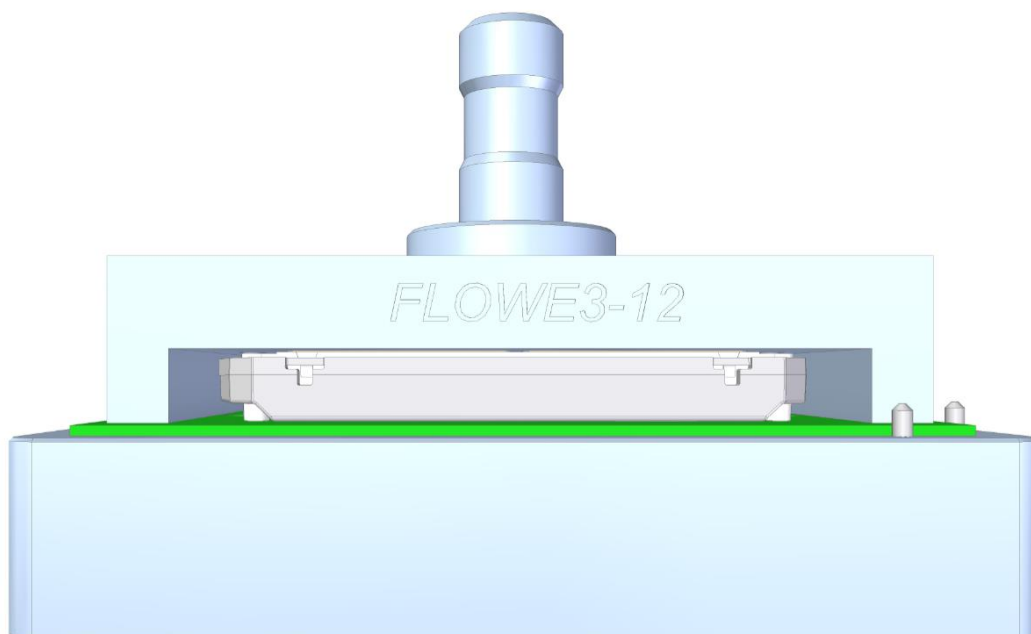
- In the case of modules with Press-fit pins, the usage of the mounting by screwing to the PCB of the module is not possible.
- For press-in procedure see section **8**.
- Recommended spacer height:
  - 12.35 <sup>+0.1</sup> mm

## 8 Press-in process of modules with Press-fit pins

### 8.1 Press-in construction



11. Figure: Recommended construction for the press-in process



12. Figure: Press-in tools closed, module is pressed in



- The module can be pressed into the PCB from the top (as *11. Figure* & *12. Figure* show) or the PCB can be pressed onto the module from the top (the module is below the PCB).
- The preferred method is to press the module into the PCB from the top. This method will be discussed in this document.
- Pressing multiple modules into one PCB can be done one by one (subsequently) or all at once.
- Pressing multiple modules at the same time requires a press-in tool according to the above detailed single tool. The tool has to ensure the correct leveling of the modules and PCB to avoid mechanical stress.
- The "U-shape" tool (*12. Figure*) is only because to keep the distance between the PCB and the module. Depending on the PCB layout the geometry and the position of this distance keeper can be different. Minimum distance between tool and the components on the PCB: 4 mm

## 8.1.1 Press-in tool

The press-in tool protects the module from being over pressed.

### 8.1.1.1 Modules with thermal interface material

A unique press-in top tool (shown in *13. Figure*) is needed to prevent significant damage to the phase change material during the press-in process. Small damages (max: Ø 0.6 mm) are allowed.

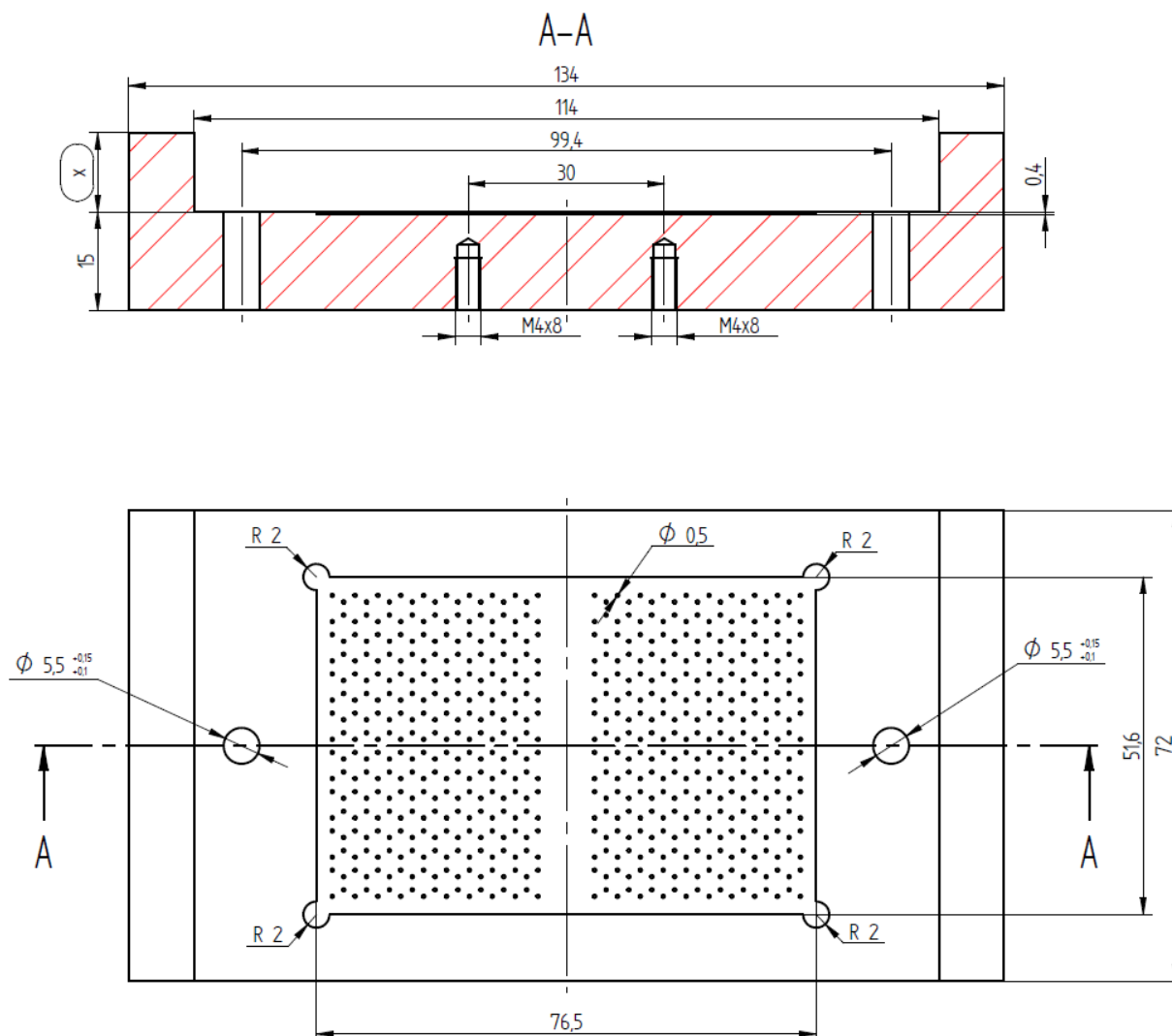
Requirements for the press-in tool:

- Tool steel grade 21 MnCr 5 with yield strength of 660 MPa and hardness of 330 HB or better.
- Maintenance: Due to inherent contamination from process and product tolerance differences, it is recommended to clean the press-in tool regularly. The desired cleaning interval is once every 100 modules with soft wipes soaked in Isopropyl alcohol.

The dimension ballooned oblong on the *13. Figure*:

- $x=12.4^{+0.05}$  mm

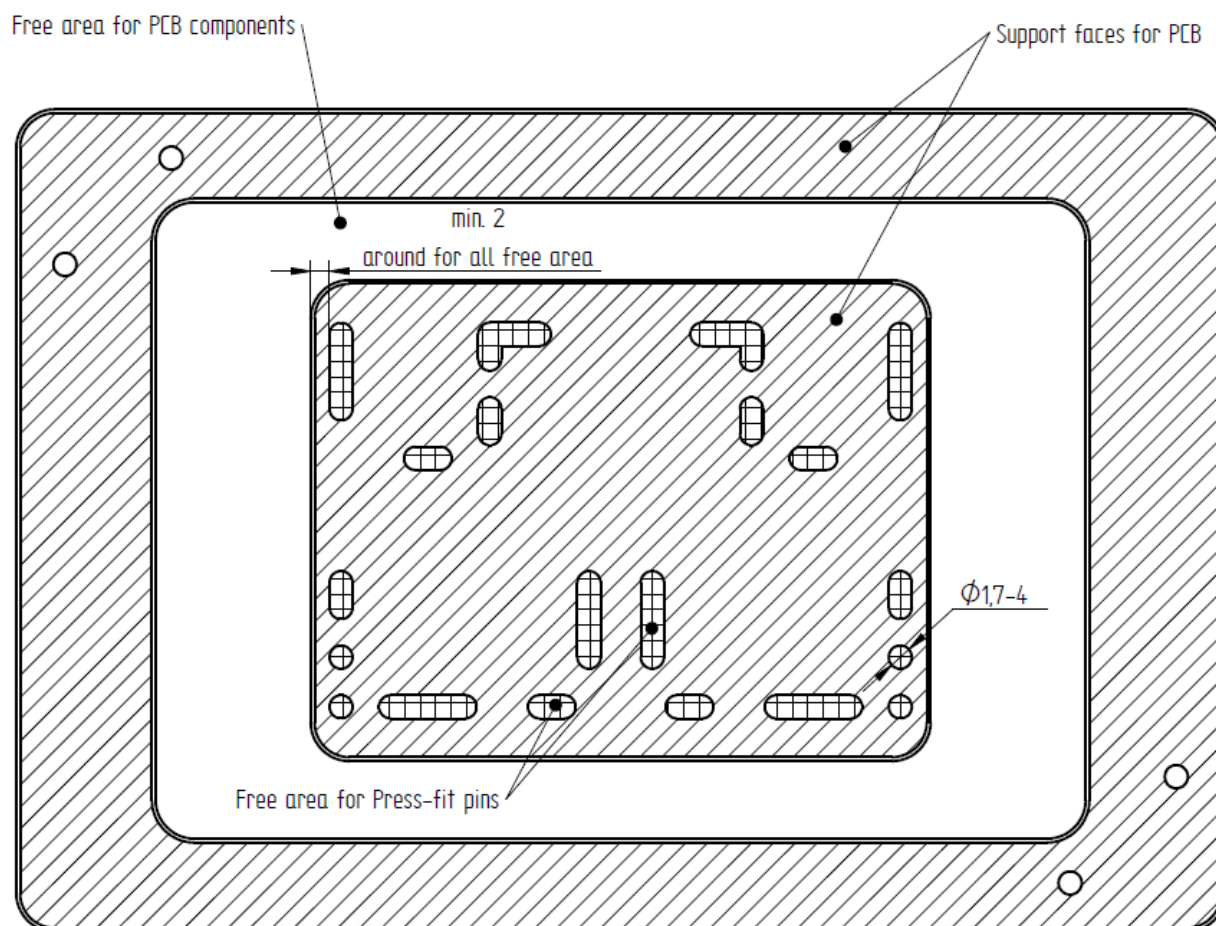
For more information or a 3D model please contact your local sales manager.



13. Figure: Recommended press-in tool for modules with thermal interface material

### 8.1.2 Supporting tool

- The supporting tool supports the PCB during the press-in process. The size and position of the holes and cut-outs depends on the components on the PCB.
- 14. Figure shows the recommended hole and cut-out dimensions for the Press-fit pins, depending on the pinouts. The recommended diameter of the holes / cut-outs for the pins in the supporting tool is between 1.7 mm and 4 mm (depending on the positioning accuracy). The minimal supporting place around the hole is 2 mm (the min. distance of PCB components from the PCB pinhole should be also considered here). If the pins are close to each other then it is possible to make a lengthwise cut-out for more pins as well. It is necessary to position the PCB and the module as well. The depth of the cut-outs for the pins is 6 mm.
- The module can be positioned with pins from the bottom tool through the fixing holes of the modules.
- Material of the supporting tool: POM (Polyoxymethylene) ESD proof or any metal alloy.
- The thickness of the supporting tool has to be at least 20 mm.



14. Figure: The recommended hole and cutout dimensions for supporting tool

## 8.2 Press-in process parameters

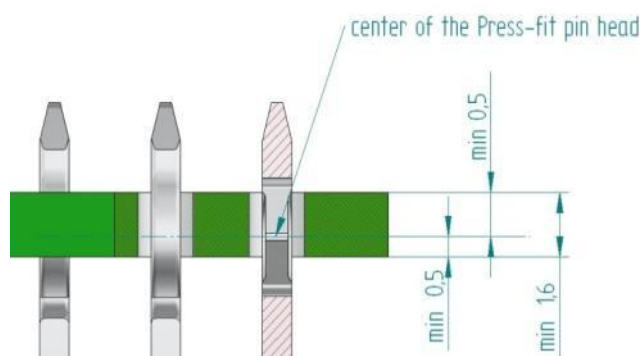
The total press-in force depends on the number of the pins, the hole-diameter and the plating (type/quality) of the PCB.

Press-in process parameters

	<i>flow E3 with</i> Press-fit pin type "T"
Press-in force	20-100 N/pin
Press-in speed	1 – 10 mm/s

### 8.2.1 Basic requirements for the press-in process

The Press-fit pins have to be pressed to the correct depth into the holes of the PCB. The center of the Press-fit pin zone has to be at least 0.5 mm below the top surface and at least 0.5 mm above the bottom surface of the PCB. (15. Figure).



15. Figure: Press-in depth in PCB

This condition is automatically fulfilled with the use of the recommended press-in tool. 12. Figure shows the closed press-in tool with the module.

## 8.3 Process control parameters

If the press machine is equipped with the possibility to record the force-stroke values during the process, the following quality relevant values should be taken into consideration. 16. Figure shows a typical press-in diagram.

Three different sections can be seen on the diagram:

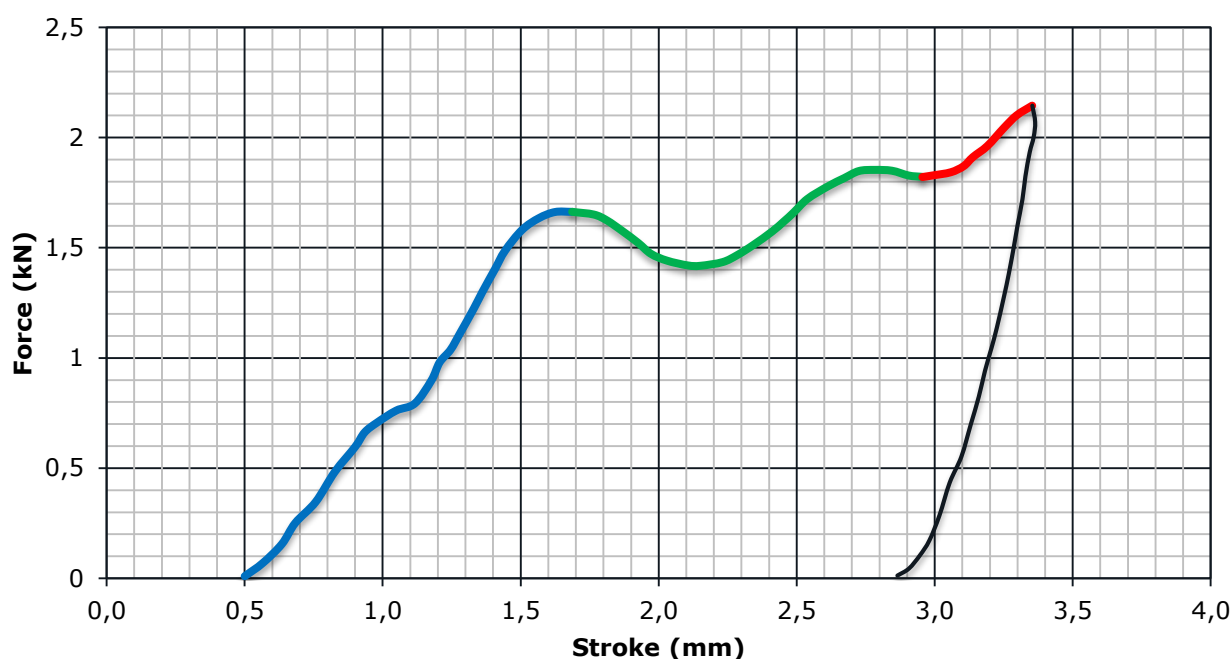
- First raising section (blue): The heads of the Press-fit pins slide into the holes and deform to fit in the holes. This section ends with a local maximum.
- Second section (green): The pin slides in the holes to reach the final position. The centre of the pin heads are inside the holes and do not deform any longer. This section ends with a local minimum.
- Second raising section (red): press-in tool touches the PCB and the sliding of the pins is stopped. The press-in tool starts to bend the PCB.

The pressing-in has to be stopped at the beginning of the second raising section, not exceeding the actual max force of the first rising section, to avoid damaging the PCB or the deformation of the plastic housing. The press-in force or the motion stroke of the tool has to be controlled to stop at the beginning of the second raising section.



Possible process control parameter settings are as follows:

- The local maximum value (end of blue section) of the force-stroke diagram has to be:
  - higher than the lower limit insertion force times the number of the pins and,
  - smaller than the upper limit insertion force times the number of the pins
- These limits are marked on the diagram. If the press-in force does not fit in the interval defined above, it can indicate faulty plating, or improper diameter of the holes.

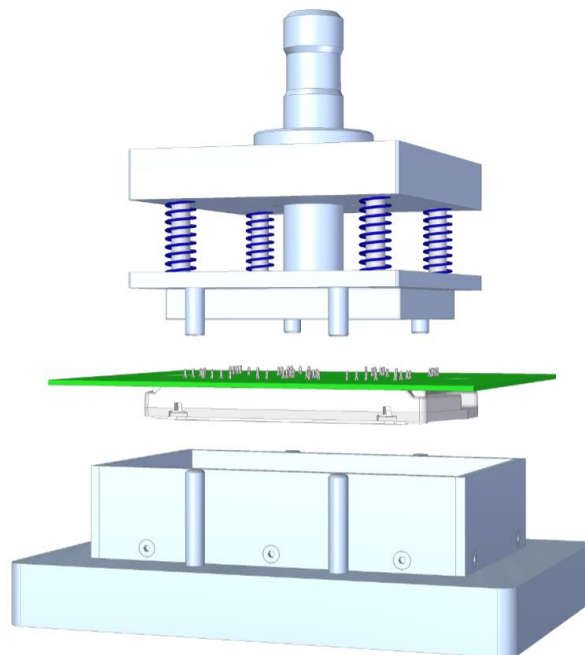


16. Figure Typical press-in diagram of a 33 pin module

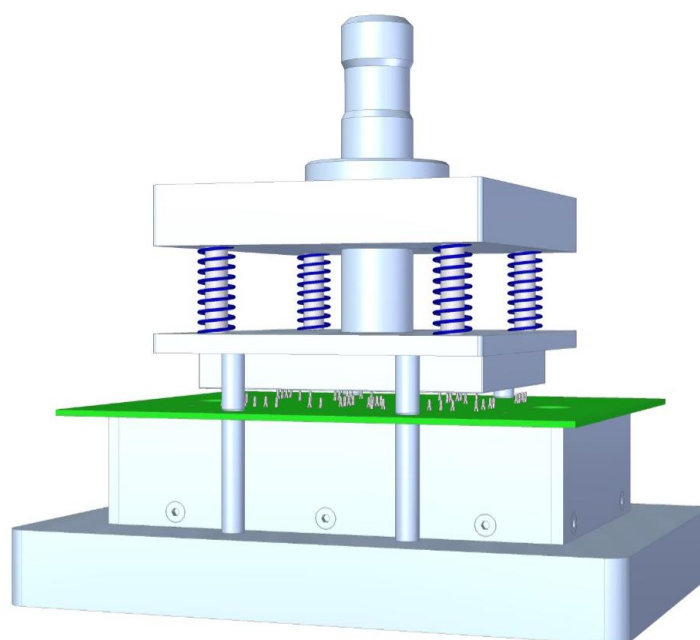


## 9 Press-out process for modules with Press-fit pins

Please note: In the case an out-pressed module should be used again, it is necessary to solder the module to the PCB because of the remaining deformation of the pins. This is because the Press-fit zone will keep a remaining deformation after the press-out process. An additional press-in cycle will result in low holding forces between the Press-fit pin and the PCB hole.



17. Figure: Exploded view of the press-out tool



18. Figure: Working position of the press-out tool

## 9.1 Press out tool

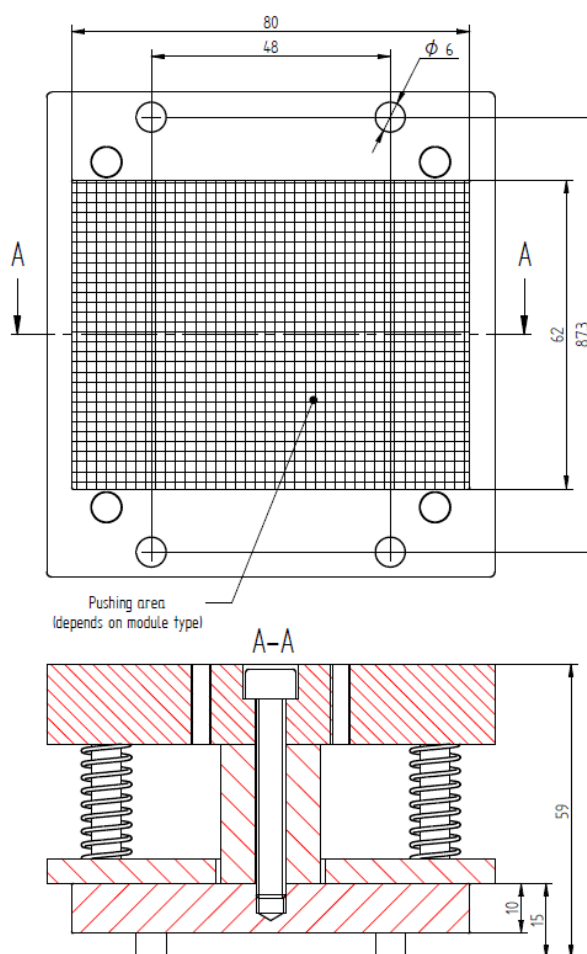
The specific tool to disassemble the modules from the PCBs has two parts, similar to the press-in tool. The lower part serves as a backing for the PCB. It has a backing nest and supporting pins. It is important that the backing has to be as close as possible to the side of the modules. The supporting pins are in line with the fixing pins of the upper part. There may be components mounted to the PCB in the area of the backing. It is possible to cut out the nest in this case.

The upper part consists of two pressing plates that are connected by springs. The pins on the lower plate serve to fix the PCB. With the aid of these parts, the bending of the PCB can be prevented during pressing.

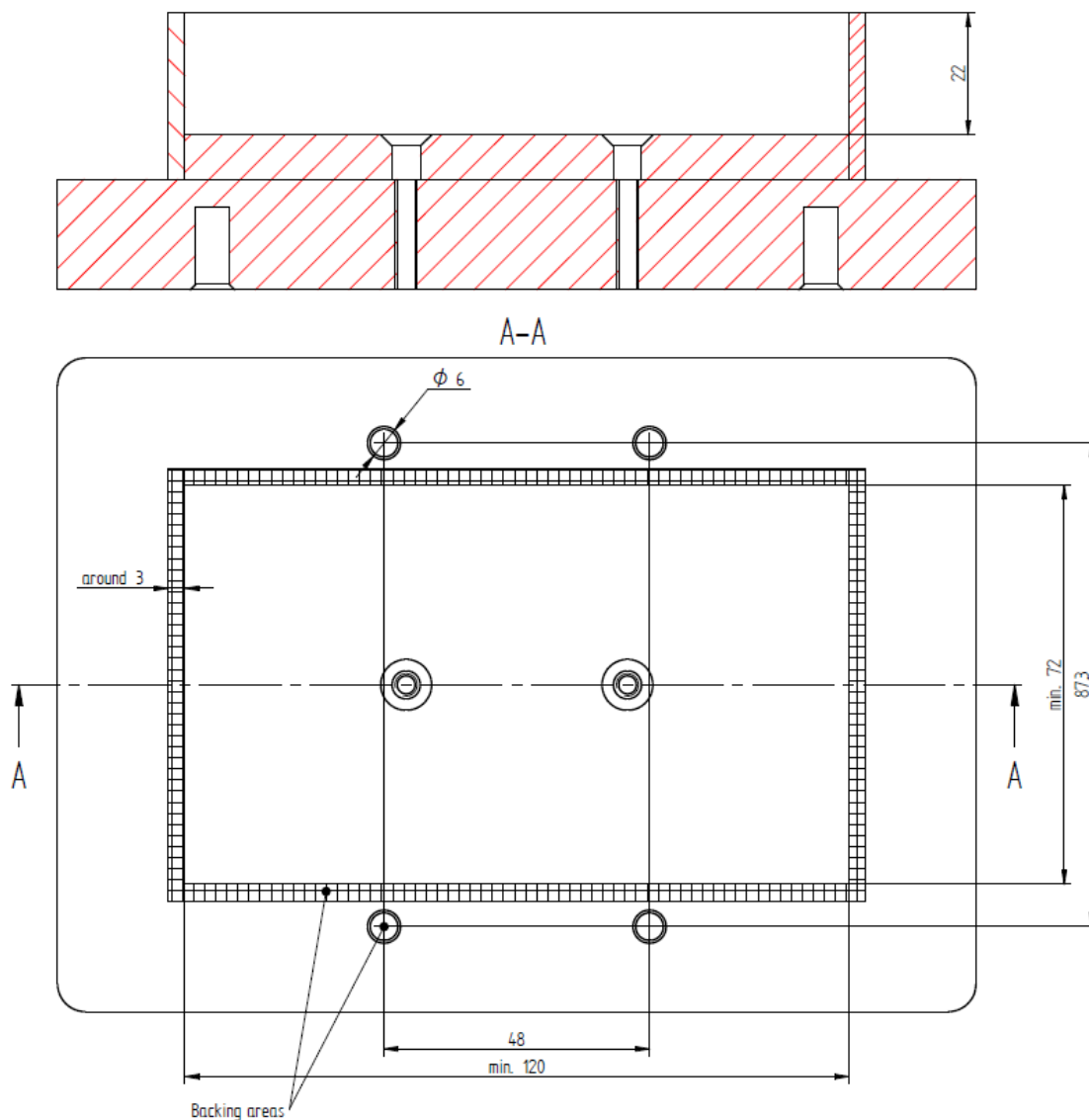
The ram fastened to the upper plate is designed according to the positions of the parts on the PCB and the layout of the pins.

It is not possible to press the module out with a flat plate if the PCB is thicker than 2.5 mm, due to the lower overhang of the pins. In this case, pressing sticks positioned according to the pin layout are necessary.

- Recommended spring force: 25 N/mm
- Recommended number of springs: 4 Pieces



19. Figure: Recommended dimensions of the upper tool



20. Figure: Recommended dimensions of the lower tool

### 9.1.1 Press-out process parameters

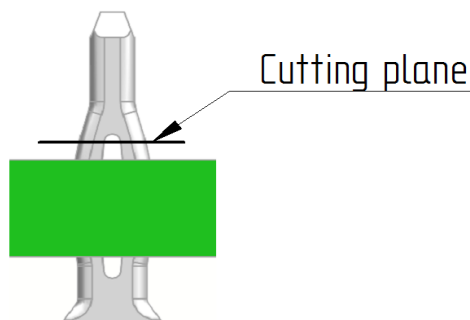
The total press-in force depends on the number of the pins, the hole-diameter and the plating (type/quality) of the PCB.

Press-out process parameters

	<i>flow E3 with Press-fit pin type "T"</i>
Press-out force	>20 N/pin
Press-out speed	1 – 10 mm/s

## 9.2 Disassembling by hand

If the Press-fit pin-head is overlapped by the PCB in such a way that the spring-end is out of the PCB, the disassembling is possible with hand pliers. The cutting should be done in a way that the cutting edge is under the area where the two parts of the pin head join shown as level 'A-A' in 21. *Figure*. After clipping away all of the pin-heads, it is possible to remove the module from the PCB.

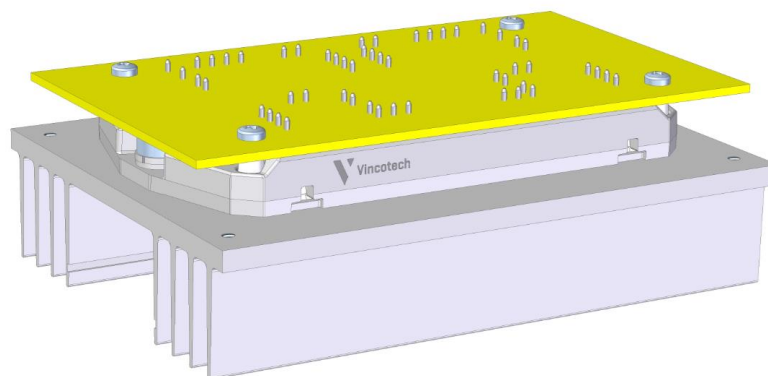


21. Figure Cutting plane

## 10 Mounting of modules with solder pins

### Mounting sequence:

1. Insert the module pins into the PCB
2. Fix the module to the PCB with 4 screws by the towers
  - for screws a hole of  $\varnothing 3 \pm 0.2$  mm is needed on PCB (see also section **2.4**)
  - screw type: BN82428,  $D = 2.5$  mm and  $L = 6$  mm with a mounting torque: 0.4 Nm
3. Fix the assembled PCB to the heat sink
  - recommendation for spacer:
    - o not necessary to use surrounding the module
    - o general height:  $11.9 \pm 0.1$  mm
4. Fix the module on heat sink (see section **6**)



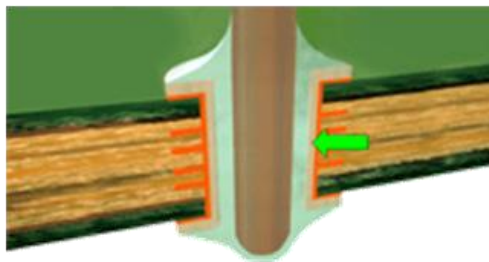
22. Figure: Assembly illustration

For minimum overhang of pins IPC-A-610E standard and module datasheet drawing should be considered

## 11 Recommendation for soldering

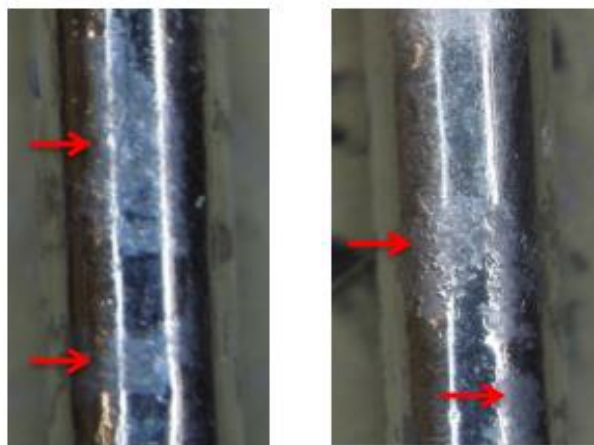
### 11.1 Solderability specification

- Plated through holes should exhibit a vertical solder fill of 75 %, with a fully formed fillet on the solder side and evidence of 75 % wetting on the component side lead, barrel and pad.



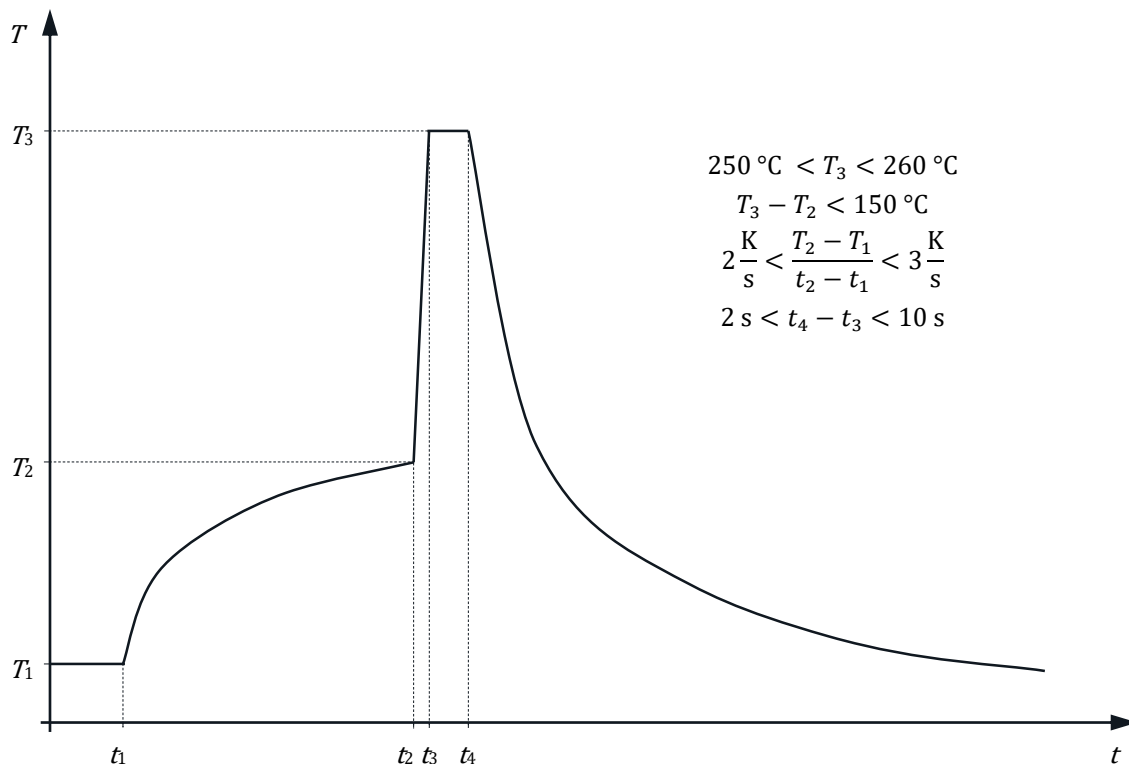
23. Figure: Plated through hole, good soldering

- The solder pins of the *flow* E3 modules are plated with a nickel underlayer and a continuous tin finish to promote solderability. The tin finish can be discoloured due to production process or storage conditions. This is merely a cosmetic imperfection and does not influence the solderability of pins. Different solder pins on the same module may exhibit different levels of discoloration as shown in the examples in 24. Figure.



24. Figure Examples of discolored solder pins

## 11.2 Wave soldering of modules with solder pins



25. Figure: Typical profile for wave soldering

Soldering of certain modules with Press-fit pins is also possible using the wave soldering process.

## 11.3 Hand soldering parameters

- Max. solder iron temperature: 350 °C
- Max. contact time with component lead: 10 s
- Number of heat cycles: 3

## 12 ESD protection

Modules are sensitive to electrostatic discharge which can damage or destroy sensitive semiconductors. All modules are ESD protected in the shipment box by semi conductive plastic trays. During the handling and assembly of the modules it is recommended to wear a conductive grounded wrist band and ensure a conductive grounded working place.

Please take into consideration the following standards for handling electrostatic-sensitive devices: EN61340-5-1, ANSI S20.20



## 13 Environmental conditions

The modules can be subjected to environmental conditions characterized by the following classes:

Storage:	1K2 / 1B1 / 1C1 / 1S2 / 1M2
Transportation:	2K2 / 2B1 / 2C1 / 2S1 / 2M2*
Operation:	3K3

These classes are defined in the IEC 60721-3-1 and IEC 60721-3-2 and IEC 60721-3-3 standards. The modules with wire pins have 1 year shelf life and the modules with Press-fit pins have 2 years shelf life with the given storage conditions.

Flammability classification of the plastic material for *flow* E3 are V-0 and 5-VA (self-extinguishing, no dripping of flaming particles) according to UL 94, IEC 60695-11-10 and IEC 60695-11-20 test methods.

### 13.1 Parameters of environment classes

The parameters detailed below are for informative purposes only. This section does not substitute the above mentioned standards. Please read the IEC 60721-3-1 and IEC 60721-3-2 standards for the description of the environment classes.

#### 13.1.1 Climatic conditions

##### 1K2

Air temperature:	5 °C to 40 °C
Humidity:	5 % to 85 % RH but max. 1 g/m <sup>3</sup> to 25 g/m <sup>3</sup> absolute
Rate of change of temperature:	0.5 °C/min
Air pressure:	70 kPa to 106 kPa
Solar radiation:	700 W/m <sup>2</sup>
Movement of surrounding air:	1 m/s
Condensation:	No
Precipitation:	No
Water from other sources than rain:	No
Formation of ice and frost:	No

##### 2K2

Temperature:	-25 °C to 60 °C
Change of temperature air/air:	±25 °C
Relative humidity not combined with rapid temperature changes:	max. 75 % (at 30 °C temperature)
Relative humidity combined with rapid temperature changes:	No
Low air pressure:	70 kPa
Change of air pressure:	No
Solar radiation:	700 W/m <sup>2</sup>
Movement of surrounding air:	No
Precipitation:	No
Heat radiation:	No
Water from other sources than rain:	No
Wetness:	No



3K3

Relative humidity:	5% to 85%
Absolute humidity:	1 g/m <sup>3</sup> to 25 g/m <sup>3</sup>
Condensation:	No
Precipitation:	No
Formation of ice:	No

## 13.1.2 Biological conditions

1B1

Flora and fauna:	Negligible
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2B1

Flora and fauna:	No
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## 13.1.3 Chemically active substances

1C1

Sea and road salts:	No (Salt mist may present in sheltered locations of coastal areas.)
Sulphur dioxide:	0.1 mg/m <sup>3</sup>
Hydrogen sulphide:	0.01 mg/m <sup>3</sup>
Chlorine:	0.01 mg/m <sup>3</sup>
Hydrogen chloride:	0.01 mg/m <sup>3</sup>
Hydrogen fluoride:	0.003 mg/m <sup>3</sup>
Ammonia:	0.3 mg/m <sup>3</sup>
Ozone:	0.01 mg/m <sup>3</sup>
Nitrogen oxides:	0.1 mg/m <sup>3</sup> (Expressed in equivalent values of Nitrogen dioxide.)

2C2

Sea salts:	none
Sulphur dioxide:	0.1 mg/m <sup>3</sup>
Hydrogen sulphide:	0.01 mg/m <sup>3</sup>
Nitrogen oxides:	0.1 mg/m <sup>3</sup> (Expressed in the equivalent values of Nitrogen dioxide.)
Ozone:	0.01 mg/m <sup>3</sup>
Hydrogen chloride:	0.1 mg/m <sup>3</sup>
Hydrogen fluoride:	0.003 mg/m <sup>3</sup>
Ammonia:	0.3 mg/m <sup>3</sup>

## 13.1.4 Mechanically active substances

1S2

Sand:	30 mg/m <sup>3</sup>
Dust (suspension):	0.2 mg/m <sup>3</sup>
Dust (sedimentation):	1.5 mg/(m <sup>2</sup> *h)

2S1

Sand in air:	No
Dust (sedimentation):	No

## 13.1.5 Mechanical Conditions

1M2

Stationary vibration, sinusoidal	
Frequency range:	2 Hz to 9 Hz



displacement amplitude: 1.5 mm  
Frequency range: 9 Hz to 200 Hz  
peak acceleration: 5 m/s<sup>2</sup>

Non stationary vibration, including shock

Shock response spectrum type L  
peak acceleration: 40 m/s<sup>2</sup>

Static load: 5 kPa

## 2M2

Stationary vibration sinusoidal

Frequency range: 2 Hz to 9 Hz  
displacement amplitude: 3.5 mm  
Frequency range: 9 Hz to 200 Hz  
peak acceleration: 10 m/s<sup>2</sup>  
Frequency range: 200 Hz to 500 Hz  
peak acceleration: 15 m/s<sup>2</sup>

Stationary vibration, random

Acceleration  
spectral density: 1 m<sup>2</sup>/s<sup>3</sup>  
Frequency range: 10 Hz to 200 Hz, and  
Acceleration  
spectral density: 0.3 m<sup>2</sup>/s<sup>3</sup>  
Frequency range: 200 Hz to 2000 Hz

The later range can be neglected transporting with vehicles with high damping.

Non stationary vibration, including shock

Shock response spectrum type I.  
peak acceleration: 100 m/s<sup>2</sup>

and

Shock response spectrum type II.  
peak acceleration: 300 m/s<sup>2</sup>

\*Free fall: weight and drop height deviate from 2M2

tested acc. to internal standard: F23047-A1004-S000-01-76

Specimen Weight [kg]	Drop Heights [mm]	
	Standard Level	Extra Level
up to 9,5 kg	460	760
over 9,5 to 18,6 kg	310	610
over 18,6 to 27,7 kg	200	460
over 27,7 kg	200	310
<b>Number of Drops</b>	<b>3</b>	<b>7</b>

Toppling Around any of the edges.

Rolling, pitching

Angle:  $\pm 35^\circ$

Period: 8 s

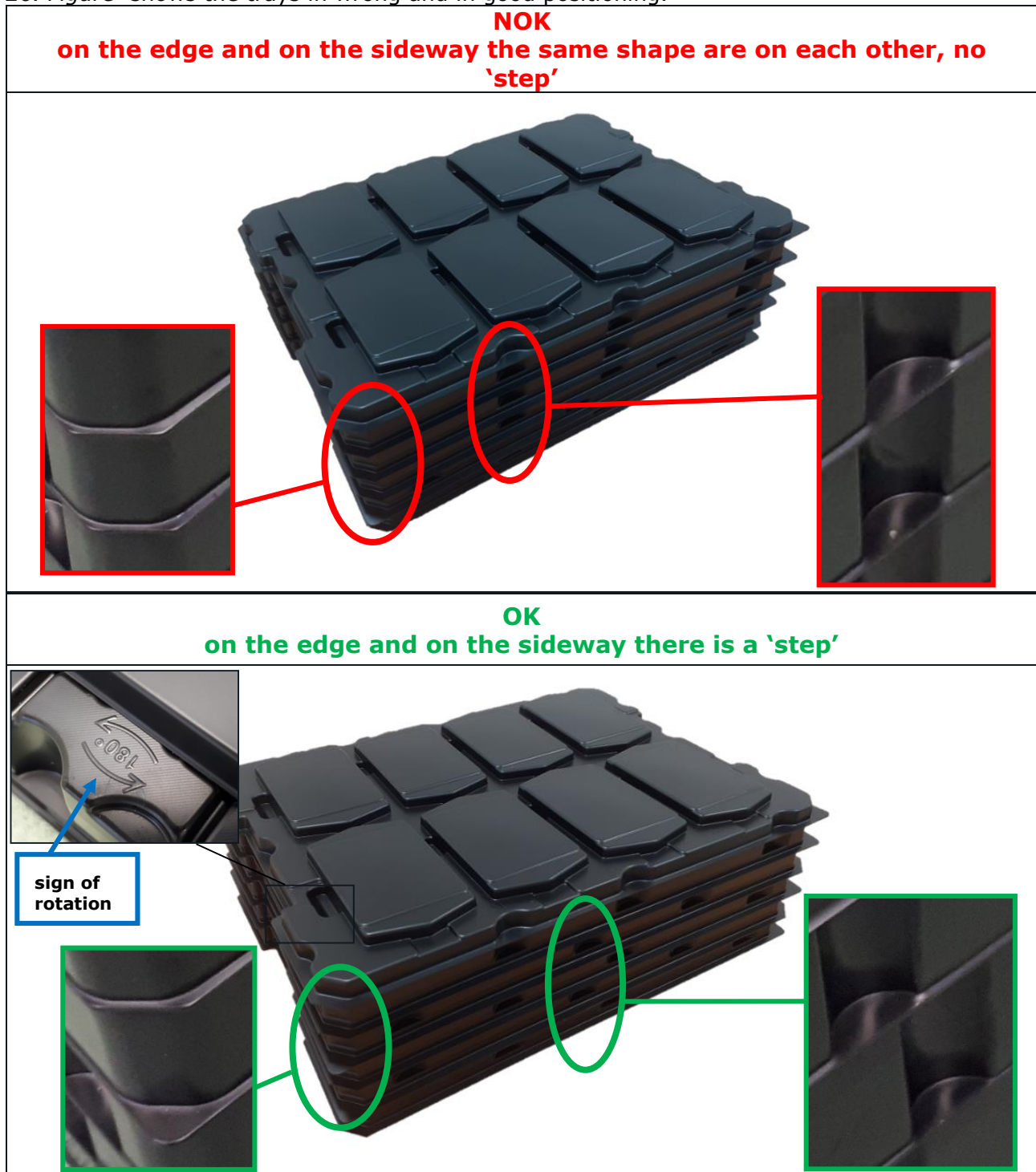
35° may occur for short time periods but 22.5° may persist permanently.

Acceleration 20 m/s<sup>2</sup>

Static load: 10 kPa

### 13.2 Handling of trays

The modules are transported in layer of trays and every layer has to be rotated on each other by 180° to guarantee that all the modules are safe. This is also valid any time after unpacking. 26. Figure shows the trays in wrong and in good positioning.



26. Figure: Layer of trays



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## 14 Disclaimer

The information and recommendations in this document are based on standards and common engineering practices. Customer specific applications and specifications may require additional processes and tests that may supersede those recommended in this document.