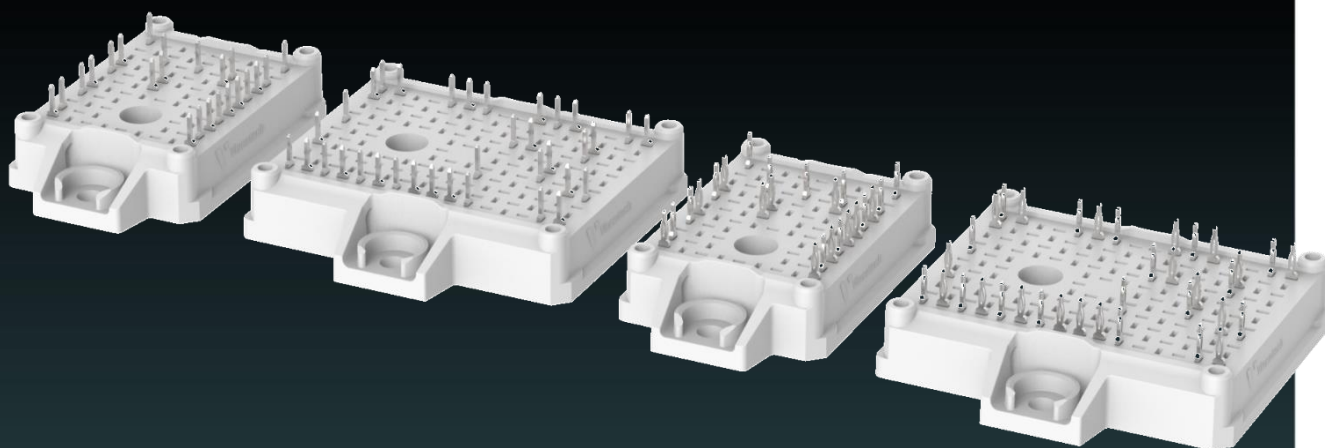




Vincotech

Handling Instructions

for *flowE1/E2* packages



**This document is valid for all type of *flowE1/E2* modules:
Solder & Press-fit pins**

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Created by: M. Géczy

Rev. 14

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Revision History

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19.11.2013.	02	Spec. for heat sink and soldering	
01.11.2013.	01	Initial Release	

1 General assembly instructions

The electrical connections between *flowE* type modules and PCB can be made by 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. Figure 1 shows how this attachment can be achieved with threaded spacers.

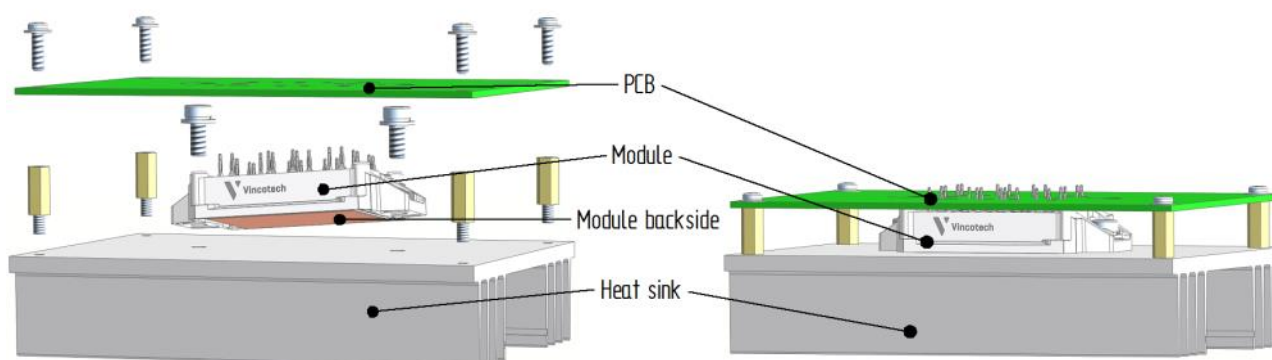


Figure 1: Module with PCB and heat sink

During assembly the pins are not to be drawn or pushed more than ± 0.15 mm or pulled with an overall force greater than 35 N. Using soldered connection the overall compressing force could be 2 times higher on the pins than the pulling force. For Press-fit assembly the maximum compression force is defined by the press-in force, maximum 100 N for every single pin, see section 7.2. Additionally, the special design of the Press-fit pins prevents higher than 0.15 mm compression of pins.

The tension of any single pin must not exceed ± 5 N at a maximum substrate temperature of 100°C.

The recommended assembly sequence:

1. Attach the module to the PCB with soldering or Press-fit technology
2. Position and fix the assembled PCB with spacers to the heat sink
3. Fix the module to the heat sink

1.1 Circuit board fixing for modules with Press-fit pins

Spacers could be used to fix the PCB to the heat sink. The number and the position of the fixing points may depend on the design of the circuit, location of different masses like capacitors or inductors and the environment of the system. For modules with Press-fit pins the fixing points can be as close as 10 mm from the module's outer edges. The position of the spacers should be designed symmetrically around the module. The distance between the top surface of the heat sink and the bottom plane of the PCB is defined by the press-in process and tooling, see section 0. For minimizing the deformations of the PCB and the pulling forces acting on the pins, the recommended height of the spacers are: $12.35^{+0.1}$ mm, see Figure 2.

An air gap may remain between the module and the PCB therefore the tolerance of the domes can be neglected. This remaining gap avoids screwing down the PCB to the domes of the module housing.

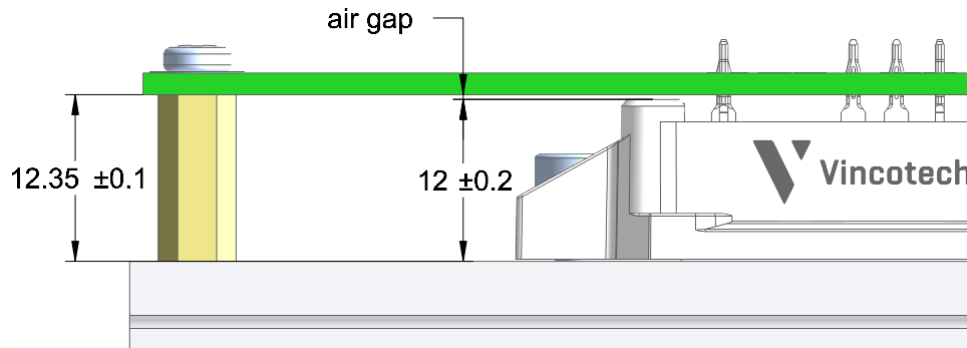


Figure 2: Fixing the PCB for modules with Press-fit pins

1.2 Circuit board fixing for modules with Solder pins

If the module is soldered into the PCB before it is screwed down to the heat sink, the distance between the top surface of the heat sink and the bottom plane of the PCB is defined by the height of the module domes: 12 ± 0.2 mm. Optionally the modules can be screwed to the PCB before the soldering process. Screw type BN82428, $D = 2.5$ mm with a mounting torque of 0.4 Nm can be used. For the choice of the screw length the given PCB thickness and the maximum bore depth (see Figure 6) has to be taken into account. For modules with solder pins the general recommendation for the fixing points is to keep a distance of at least 50 mm from the module's outer edges. The position of the distance keepers should be designed symmetrically around the module. The recommended heights of the spacers for soldered modules are: 11.9 ± 0.1 mm.

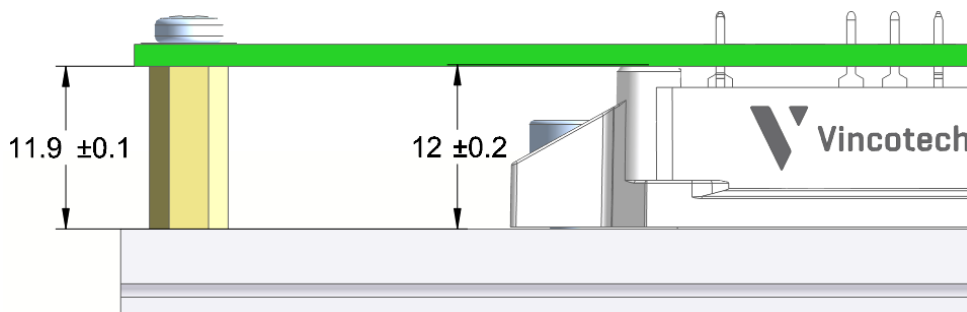


Figure 3: Fixing the PCB for modules with solder pins

2 Specifications 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 modules with Press-fit pins

- Printed board thickness must not be less than 1.6 mm.
- PCB should be covered with solder mask on both sides.
- The PCB can be disassembled and reused 2 times.
- Plated through-hole specifications for Press-fit pin:
 - Hole diameter before plating: $\varnothing 1.15 \pm 0.025$ mm
 - Thickness of the PTH wall $> 25 \mu\text{m Cu}$
 - Plated hole final dimension: $\varnothing 1 + 0.09 / -0.06$ mm
 - Minimum Cu width of the annular ring > 0.3 mm
 - Through hole position accuracy ± 0.1 mm
- Plating material and thickness:
 - Chemical Tin (Sn) plating: $0.5 \mu\text{m}$ 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.

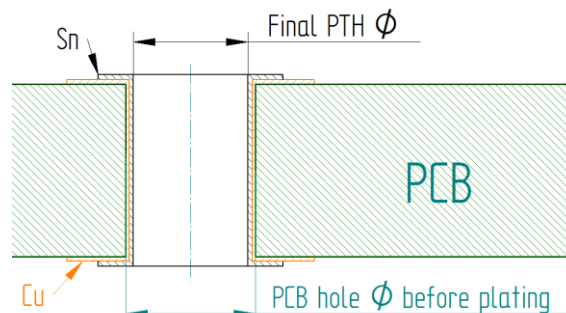


Figure 4: Chemical tin plating (for illustration only, no real proportions)

- HAL Tin (Sn) plating: $0.5 \mu\text{m}$ 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.

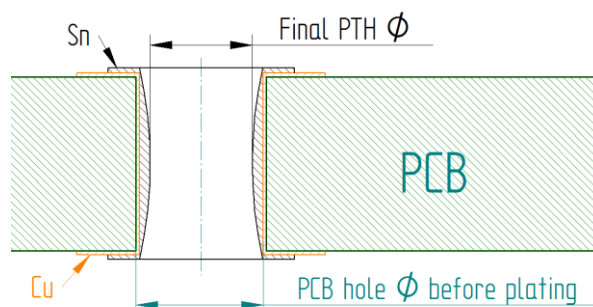


Figure 5: HAL tin plating (for illustration only, no real proportions)

- Chemical Gold (Au), Silver (Ag) and Organic Solderability Preservative (OSP) are released with limitations; in case of a second use of PCB the module has to be soldered after press-in, see section 9 Recommendation for soldering



- 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 components on the PCB: 4 mm.
- For additional requirements the IEC 60352-5 standard should be considered.

2.2 Specification for modules with solder pins

After mounting 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 soldering pin dimension (see Figure 6). For a 3D model please contact your local sales manager.

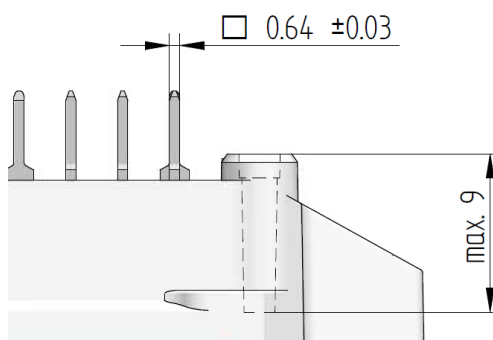


Figure 6: Solder pin dimensions and bore depth

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

In cases where the Press-fit pins are soldered into the PCB the recommended PCB hole diameter is $1.45 \text{ mm} \pm 0.1 \text{ mm}$. 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. Please read section 9 Recommendation for soldering as well.

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:

Polishing (see figure 8.):

- Polishing have to be accepted
- Polishing of modules with Ni plated surface is acceptable if copper doesn't become visible (if the copper is visible, see criteria for scratches)

Steps, Flash (see figure 7.):

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

Scratches (see figure 7.):

- Max depth of $300 \text{ } \mu\text{m}$
- Max width of $600 \text{ } \mu\text{m}$
- The scratched area must not exceed 5 % of the total substrate surface.

Etching holes (see figure 7.):

- Max diameter of $1000 \text{ } \mu\text{m}$ and max. depth of $300 \text{ } \mu\text{m}$
- Max diameter of $2000 \text{ } \mu\text{m}$ and max depth of $250 \text{ } \mu\text{m}$

Other (see figure 8.):

- Discolorations and fingerprints are only surface imperfections (cosmetic) and do not affect the module's functionality

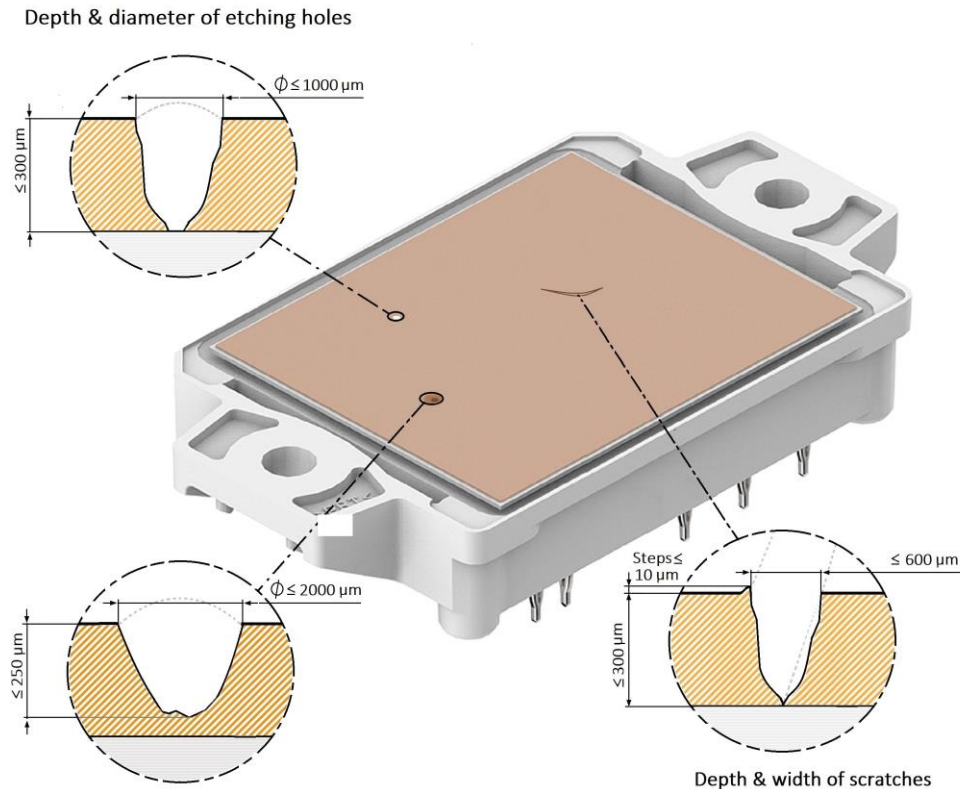


Figure 7: Scratch and etching hole dimensions

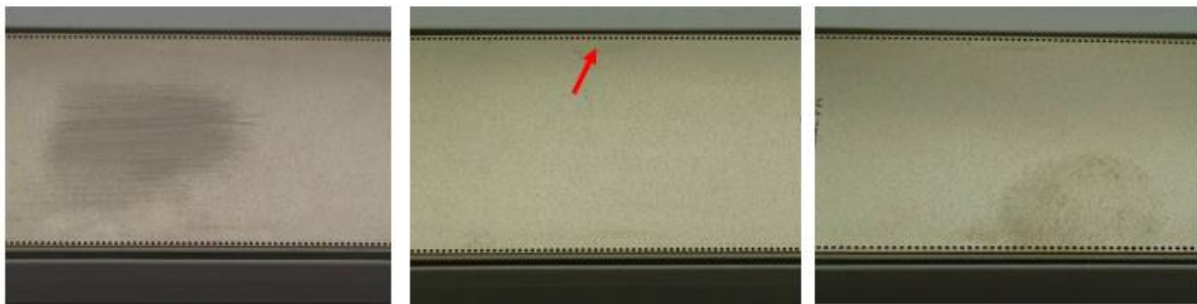


Figure 8 (left to right): Polished surface; Discoloration of substrate; Fingerprint on the surface

4 Specification for heat sink

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

- The flatness tolerance should be $< 25 \mu\text{m}$. In case the thermal paste is thicker than $50 \mu\text{m}$ the flatness tolerance can be $< 50 \mu\text{m}$ (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 OPTION 1: Thermal paste

- A. The advised technology for paste application is screen printing. Applying an inhomogeneous layer of thermal conductive paste in a honeycomb pattern is the preferred solution. For the drawing of the honeycomb pattern please contact your local sales representative. Automatic equipment is recommended for a reliable and repeatable grease deposition to achieve better thickness stability.

Thermal paste (Wacker P12)		
Module type	AlN and Al ₂ O ₃ substrate	Si ₃ N ₄ substrate
<i>flow</i> E1	50 ±20 µm	50 ±20 µm
<i>flow</i> E2	60 ±25 µm	80 ±20 µm

Table 1: Thermal paste thickness

- B. Alternatively a roller or spatula can be used to apply a homogeneous layer of thermal conductive paste over the whole backside of the module,

Any different paste application technology or type of thermal paste should be tested additionally. The mounting procedure for modules is the same as the standard mounting process described in section 1.

5.2 OPTION 2: Pre-applied thermal interface material

- The modules may have already been pre-printed with phase change thermal interface material.
- Once the compound is applied, it is dried to a solid phase change material. The material will only flow above the phase change temperature of 45 °C when pressure is applied.
- Burn-in might be necessary to melt the phase change material. Upon flow, air is expelled from the interface and the material conforms to the surface features of the heat sink and power module. Reducing thermal impedance, the material performs as a highly efficient thermal transfer material.
- The mounting procedure is the same as the standard mounting process described in section 1. Screws to the heat sink can be fastened and tightened in one single step. The phase change material is solid at room temperature, so screws can be tightened immediately without having to give the material any relaxation time.
- Further information about using modules with pre-applied TIM see the application note for "[Handling of Power modules with Phase-Change Material](#)" on Vincotech's website

In case of modules with Press-fit pins a unique press-in tool (see Figure 122) has to be used. This way the module can be mounted to the heat sink after it has been pressed into the PCB. It is also possible to mount the module to the heat sink and then press the assembly onto the PCB.

Phase change material		
Module type	AlN and Al ₂ O ₃ substrate	Si ₃ N ₄ substrate
<i>flow</i> E1	60 ±15 µm	60 ±15 µm
<i>flow</i> E2	60 ±15 µm	80 ±20 µm



Table 2: Phase change material thickness

The thermal interface material thickness might be increased when insufficient spreading is observed. During testing the following parameters may influence the spreading; flatness of heatsink, number of modules assembled together, etc. If applied TIM thickness or pattern deviate from the above recommended values than further qualification is recommended.

6 Specification for mounting screws to the heat sink

A torque wrench shall be used to tighten the mounting screws at the specified torque. 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 account to prevent over-tightening of the fastener.

- Screw size M4
- Min. depth of the screw in the heat sink: 6 mm
- Flat washer according to DIN 433 (ISO 7092)
- Size of outer diameter $\varnothing 8$ mm can be fitted into the module.
- Spring lock washer according to DIN 127 or DIN 128
- Mounting torque range: $1.6 \text{ Nm} < M_s < 2.3 \text{ Nm}$

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.

Screw type DIN 7984 (ISO 14580) flat socket head with outer diameter of $\varnothing 7$ mm is recommended. The small diameter head screw can be assembled more easily close to the flanges of the module.

6.1 Pre-assembled screws

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 M4 according to DIN 6900 (ISO 10644; JIS B1188)
- Flat washer according to DIN 6902 Type C (ISO 10673 Type S; JIS B1256)
- Size of outer diameter $\varnothing 8$ mm can be fitted into the module.
- Split lock spring washer according to DIN 6905 (JIS B1251)
- Mounting torque range: $1.6 \text{ Nm} < M_s < 2.3 \text{ Nm}$

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 (Figure 9) and values.



Torque

- Cycle start: 0.3 Nm
- First target: 0.5 Nm
- Final torque min.: 1.6 Nm
- Final torque mean: 1.9 Nm
- Final torque max.: 2.3 Nm

Speed

- Soft start speed: 96 rpm
- Step 1 speed: max. 250 rpm
- Step 2 speed: max. 12 rpm

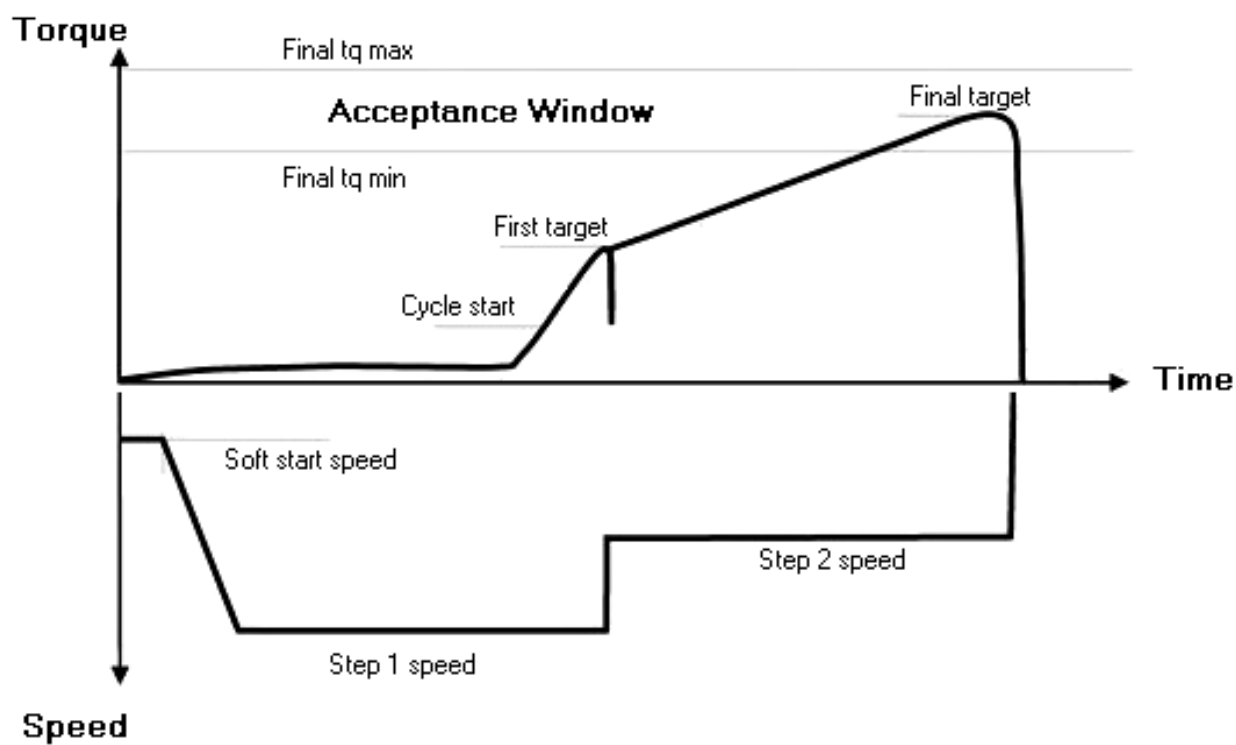


Figure 9: Recommended torque and speed curve

7 Press-in process of modules with Press-fit pins

The preferred process method is to press the module into the PCB from the top (as Figure 10 shows), alternatively the PCB can be pressed onto the module from the top (the module is below the PCB). The former method will be discussed in this document.

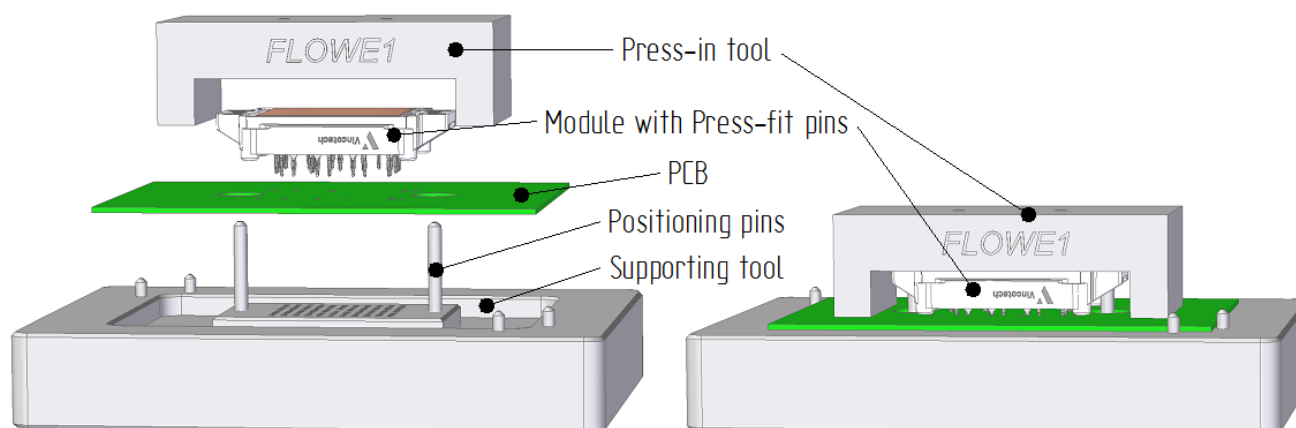


Figure 100: Exploded view and working position of the press-in tool (module pressed in)

In any case the tool has to ensure the correct leveling of the modules and PCB to avoid mechanical stresses during assembly. The press-in tool protects the module from being over pressed. This can best be achieved using the "U" shaped tool that presses the surface of the module precisely $12.4^{+0.05}$ mm from the PCB surface. The pressing points of the tool should press against and leveled by the copper tracks of the PCB. The legs of the tool can look different (e.g. pins can be used) as long as the correct distance is kept between PCB and module. The minimum distance for components from the pressing tool on the PCB is 4 mm. Inserting multiple modules into one PCB can be done one by one, or all at once. Pressing multiple modules at the same time requires a press-in tool according to the above detailed single tool.

The correct leveling of the modules can also be achieved with a position-controlled press-in machine. In this case a simple, flat press-in tool is adequate to press against the modules done either one by one or together. The press-in process has to be controlled according to the requirements stated in section 7.2.1 and 7.3. The position should be controlled to stop the tool at $12.4^{+0.05}$ mm from the PCB surface.

7.1 Press-in tool reference design

7.1.1 Modules without thermal interface material

Material requirements of the press-in tool:

- Tempered aluminum alloy grade 7075-T6 with yield strength of 430 MPa and hardness of 160 HB or
- Tool steel grade 21 MnCr 5 with yield strength of 660 MPa and hardness of 330 HB or better.

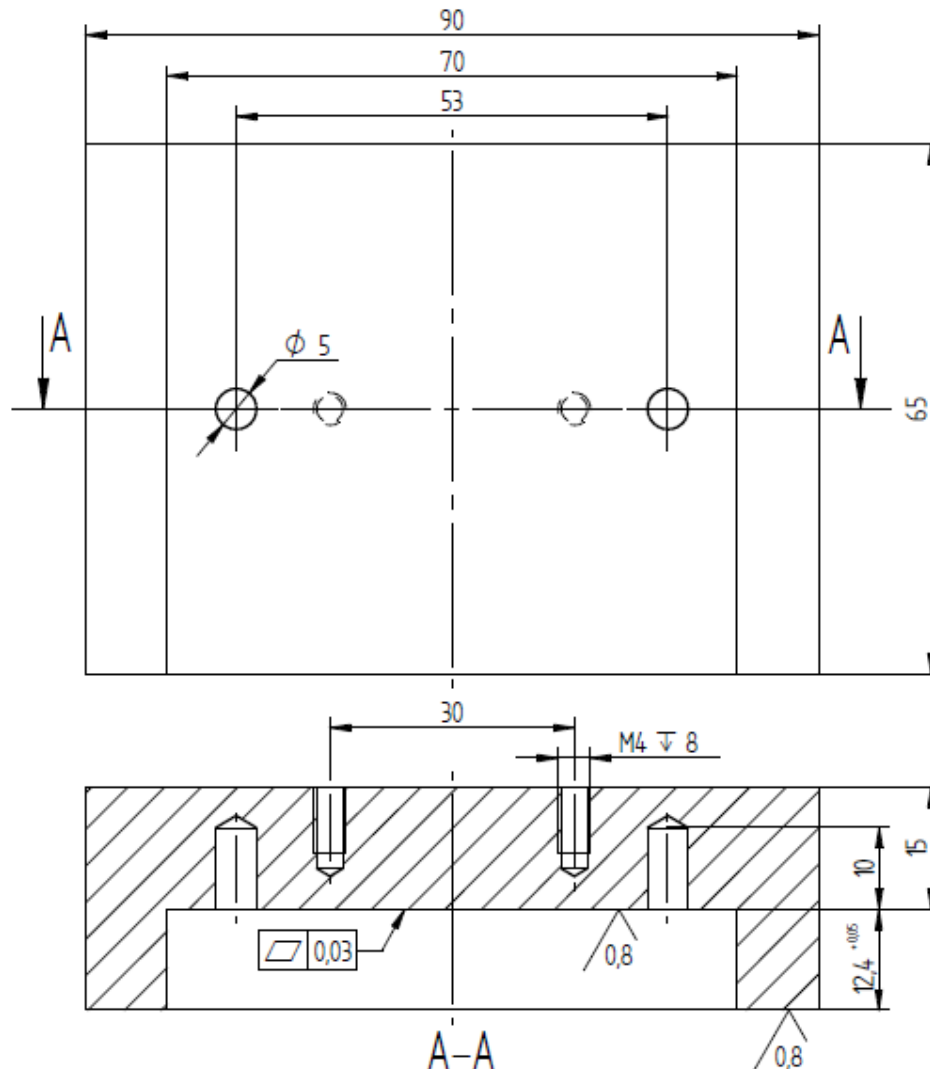


Figure 11: Recommended press-in tool for modules without thermal interface material

7.1.2 Modules with thermal interface material

A unique press-in top shown in Figure 12 is needed to prevent significant damage to the phase change material during the press-in process. Small damages (max: Ø0.6 mm) are allowed.

Requirements for the press-in tool:

- Material: 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.

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



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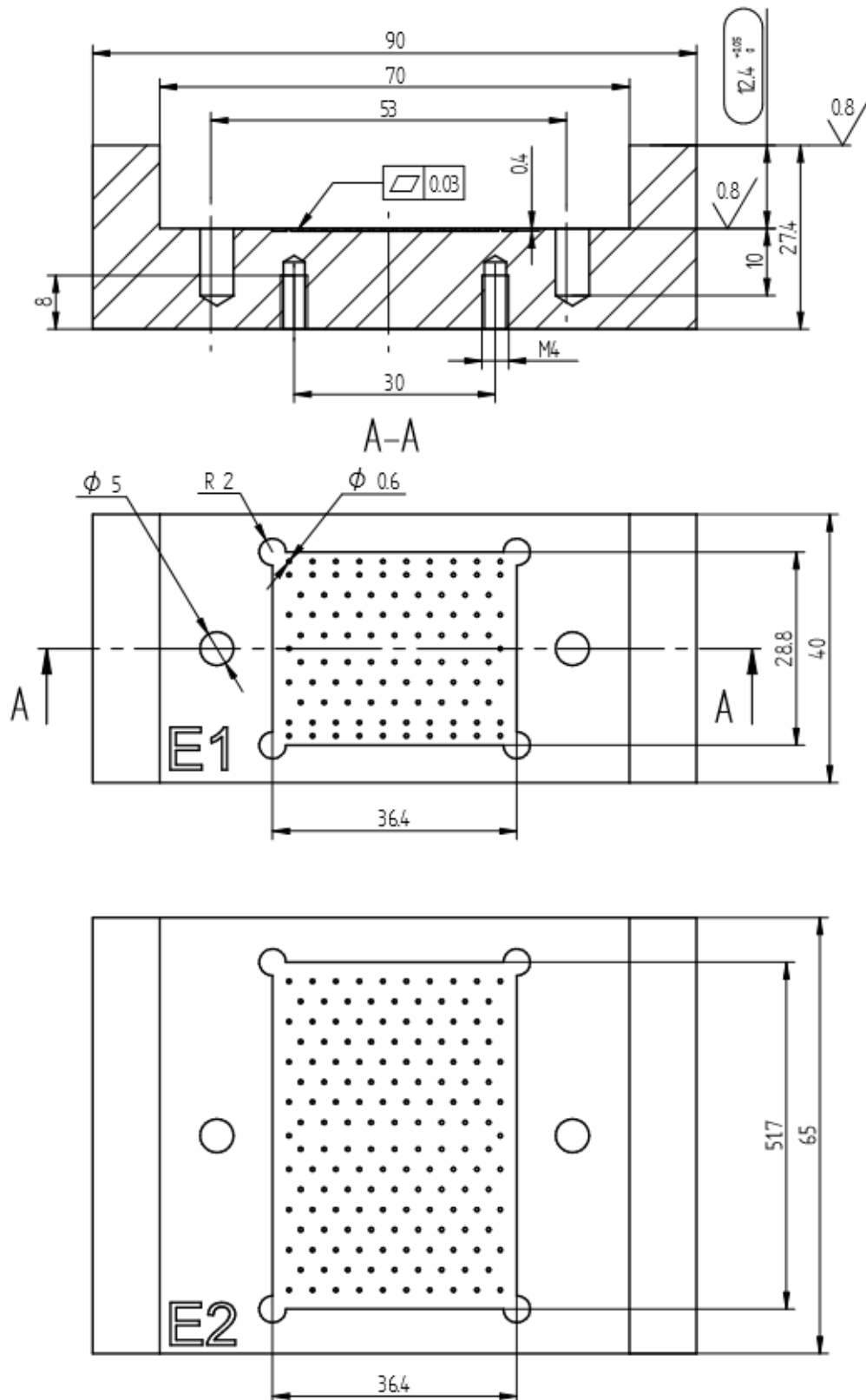


Figure 122: Recommended press-in tool for modules with thermal interface material

7.1.3 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.
- Figure 13 shows the recommended hole and cut-out dimensions for the Press-fit pins. 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 pin is 2 mm. If the pins are close to each other, it is possible to make a lengthwise cut-out for more pins as well (the min. distance of PCB components from the PCB pinhole should also be considered here). 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.

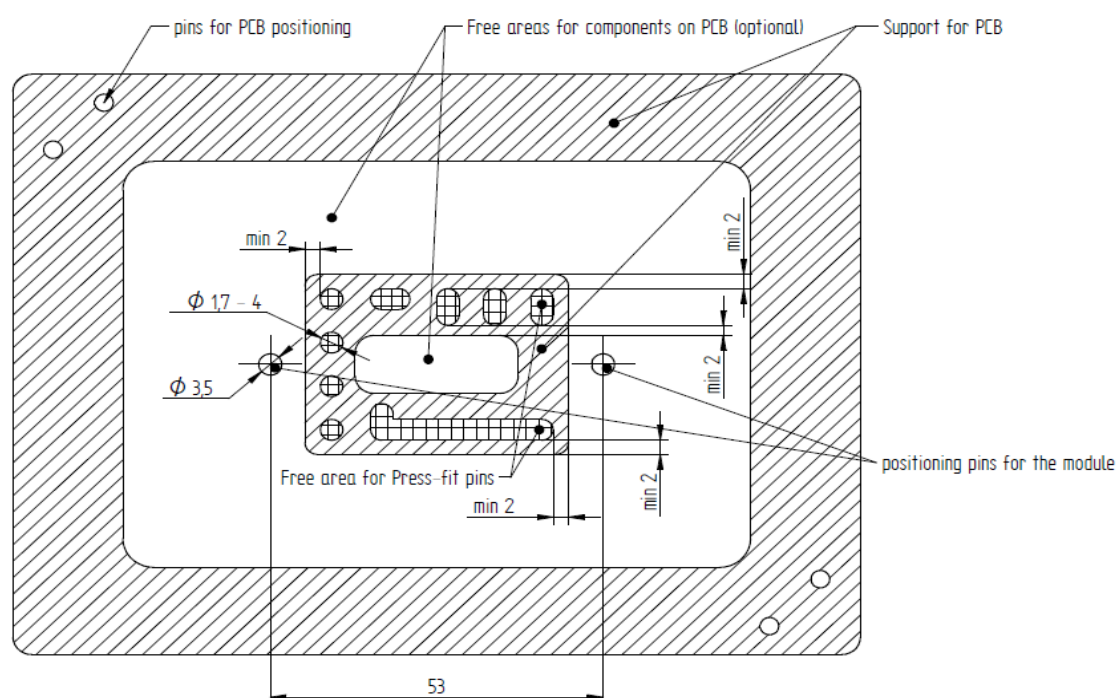


Figure 133: The recommended hole and cutout dimensions for supporting tool

7.2 Press-in process parameters

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

- Insertion force:
 - Chemical Tin: 45 N / pin to 100 N / pin
 - HASL Tin: 45 N / pin to 100 N / pin
 - Other plating types: 20 N / pin to 100 N / pin
- Insertion speed: 50 mm/min to 600 mm/min

7.2.1 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 head 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. (Figure 14).
- This condition is automatically fulfilled with the use of the recommended press-in tool. Figure 10 shows the closed press-in tool with the module.

If a position controlled press-in process is implemented care has to be taken to ensure the same conditions are reached.

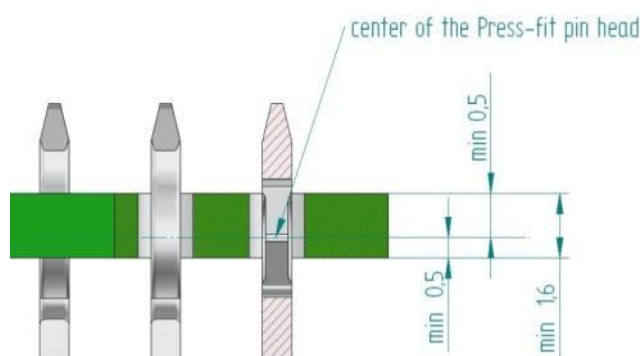


Figure 144: Press-in depth in PCB

7.3 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. Figure 15 shows a normal 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 center of the pin heads are inside the holes and do not deform any longer. Depending on the number of layers and thickness of the PCB this section may have multiple peaks. The section ends with a local minimum.
- Third, raising section (red): press-in tool touches the PCB and the sliding of the pins is stopped. As the tool abuts on the PCB the force raises sharply.
- Relaxation section (black): after releasing the press-in tool, the PCB, the DCB and the pins can relax, therefore the module height – measured between the DCB backside copper and PCB bottom layer – will be slightly bigger by 0,05...0,2 mm compared to the press-in height ('X' value of press-in tool)

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.
- In order to avoid any damage to the PCB the press-in force of the tool has to be controlled to stop the process during the third, raising section. The force control should stop at the upper limit insertion force times x number of the pins.

If the press-in force does not fit in the interval defined above, it can indicate faulty plating, or improper diameter of the holes.

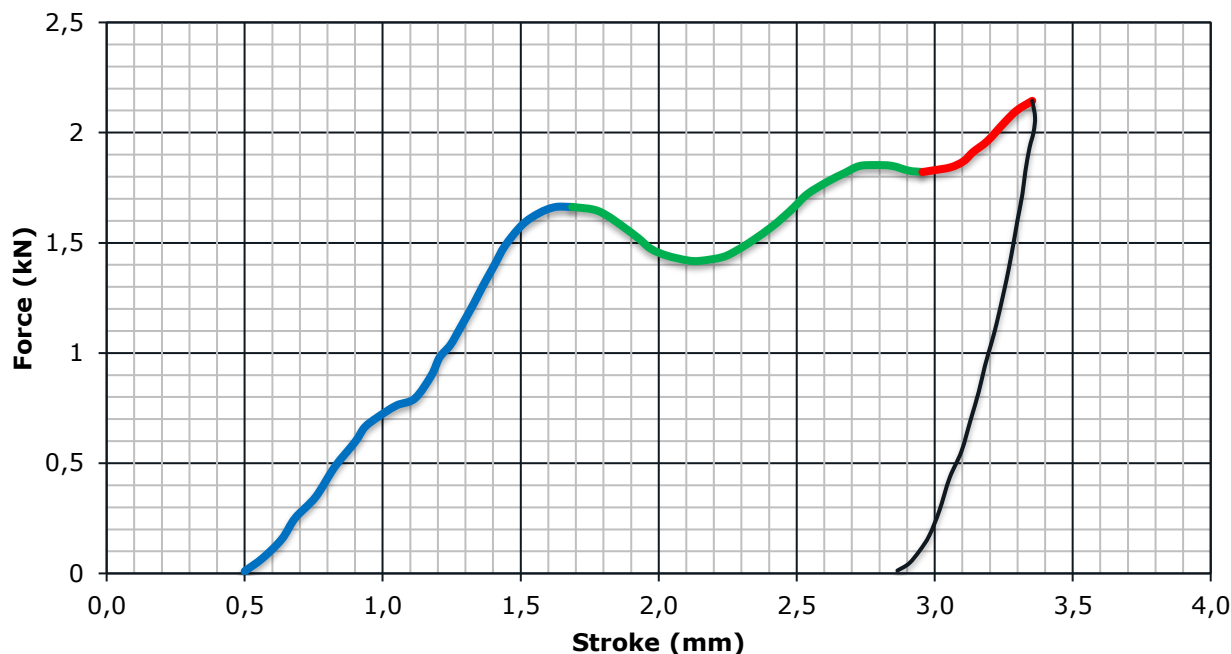


Figure 155: Typical press-in diagram of a module with 21 pins

8 Press-out process for modules with Press-fit pins

Please note: In the case an out-pressed module is to be used again, it is necessary to solder the module to the PCB because of the remaining deformation of the pin. This is because of 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. Additional information for the annular ring can be found in section 2.1.

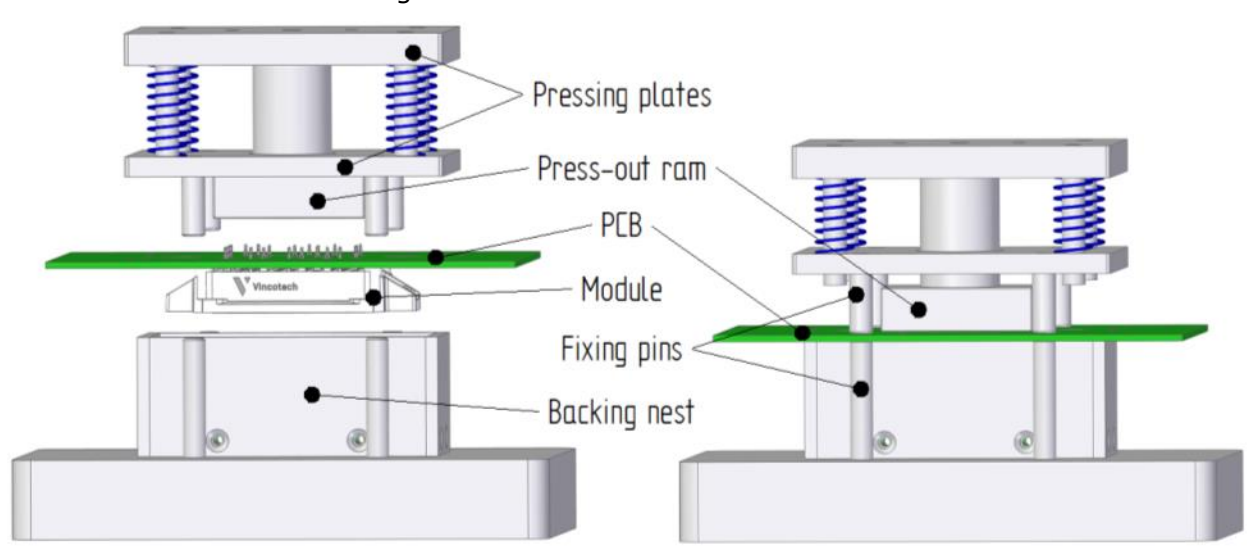


Figure 166: Exploded view and working position of the press-out tool

8.1 Press-out tool reference design

The specific tool to disassemble the modules from the PCBs has two parts similarly 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 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 of 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 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

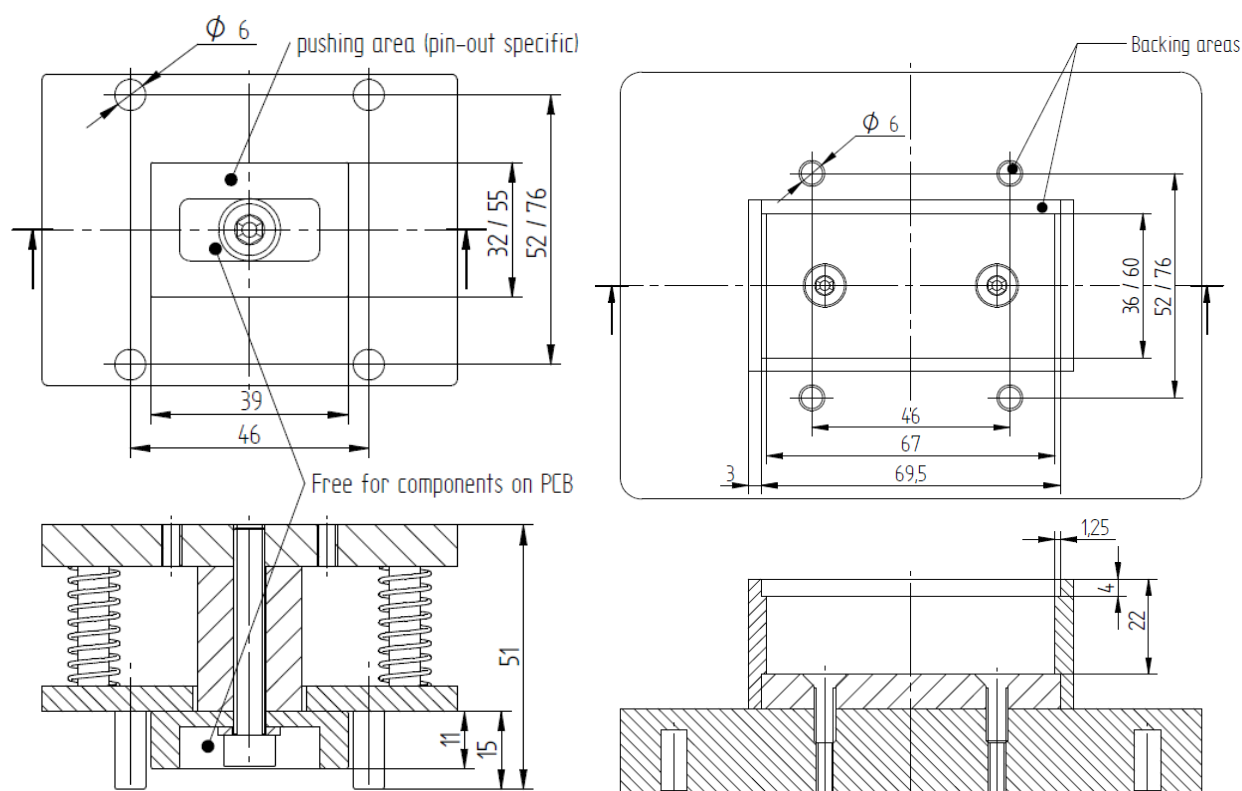


Figure 177: Recommended dimensions of the upper (left) and the lower (right) press-out tool

8.2 Press-out process parameters

- Retention force: minimum 20 N / pin
- Retention speed: 50 mm/min to 600 mm/min

8.3 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 pliers by hand. The cutting should be done in such a way that the cutting edge is under the cutting plane as indicated in Figure 18, where the two parts of the pin head get united. After clipping away all of the pin-heads, it is possible to remove the module from the PCB.

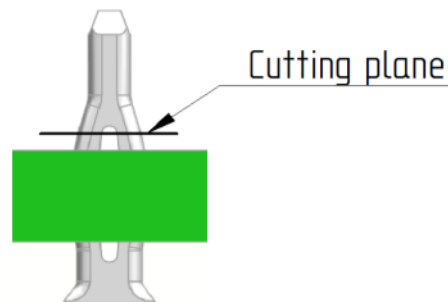


Figure 188: Cutting plane

9 Recommendation for soldering

9.1 Solderability specification

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

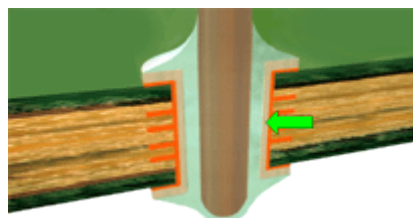


Figure 199: Plated through hole, good soldering

9.2 Wave soldering of the modules with solder pins

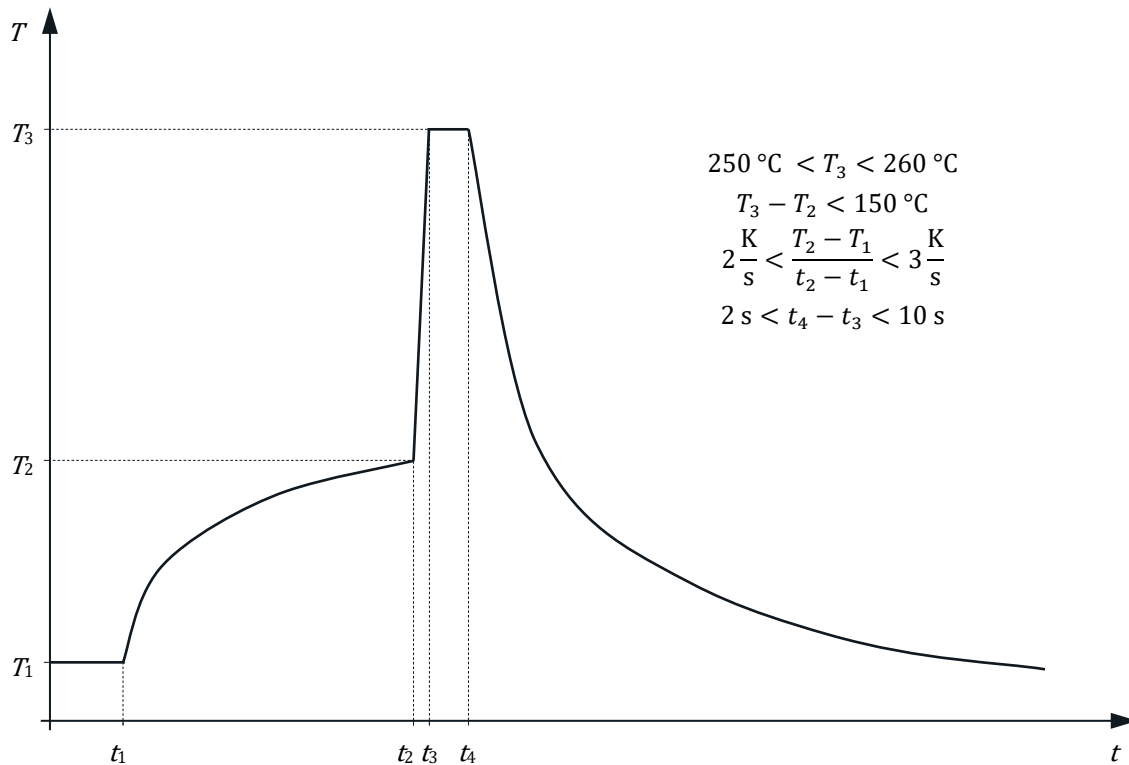


Figure 20: Typical profile for wave soldering

Soldering of certain modules with Press-fit pins is also possible using the wave soldering process. Wave soldering cannot be performed on all type of Press-fit modules.

9.3 Hand soldering parameters

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

10 ESD protection

Modules are sensitive to electrostatic discharge which can damage or destroy the 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 wristlet 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



11 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, 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 in section 11.1.

Flammability classification of the plastic material for *flowE* packages 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.

11.1 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.

11.1.1 Climatic conditions

1K2

Air temperature:	5 °C to 40 °C
Humidity:	5 % to 85 % RH but max. 1 g/m ³ to 25 g/m ³ absolute
Rate of change of temperature:	0.5 °C/min
Air pressure:	70 kPa to 106 kPa
Solar radiation:	700 W/m ²
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 ²
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 ³ to 25 g/m ³
Condensation:	No
Precipitation:	No
Formation of ice:	No

11.1.2 Biological conditions

1B1

Flora and fauna:	Negligible
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2B1

Flora and fauna:	No
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11.1.3 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 ³
Hydrogen sulphide:	0.01 mg/m ³
Chlorine:	0.01 mg/m ³
Hydrogen chloride:	0.01 mg/m ³
Hydrogen fluoride:	0.003 mg/m ³
Ammonia:	0.3 mg/m ³
Ozone:	0.01 mg/m ³
Nitrogen oxides:	0.1 mg/m ³ (Expressed in equivalent values of Nitrogen dioxide.)

2C2

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

11.1.4 Mechanically active substances

1S2

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

2S1

Sand in air:	No
Dust (sedimentation):	No



11.1.5 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 ²

Non stationary vibration, including shock

Shock response spectrum type L

peak acceleration: 40 m/s²

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 ²
Frequency range:	200 Hz to 500 Hz
peak acceleration:	15 m/s ²

Stationary vibration, random

Acceleration spectral density: 1 m²/s³

Frequency range: 10 Hz to 200 Hz

and

Acceleration spectral density: 0.3 m²/s³

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/s²

and

Shock response spectrum type II.

peak acceleration: 300 m/s²

Free fall: Internal standard: F23047-A1004-S000-01-76

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/s²

Static load 10 kPa



11.2 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 the safety of all modules. This is also valid any time after unpacking. Figure 22 shows the trays in wrong and in good position.

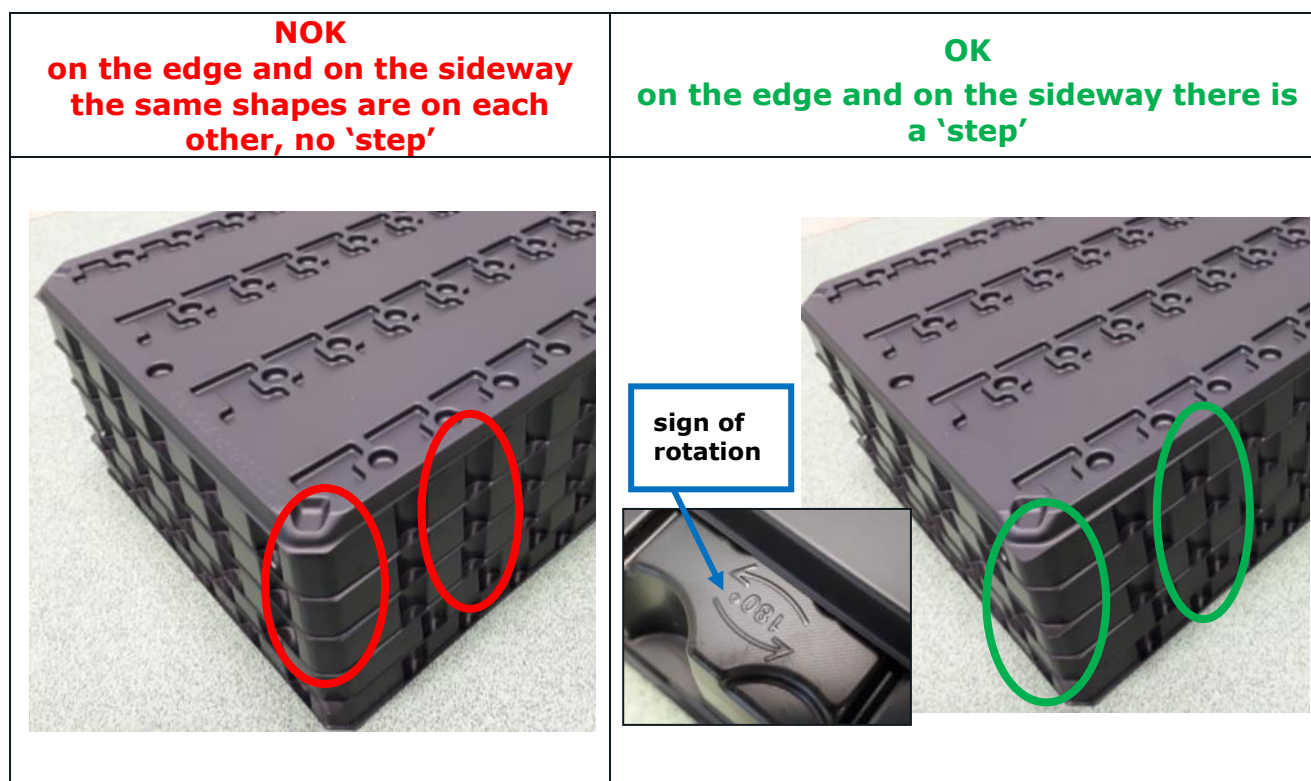


Figure 21: Layer of trays

12 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.