HybridPACK™ Drive G2 power module

Assembly Instructions for the HybridPACK™ Drive G2 power module

About this document

This application note describes the recommended process for assembly the HybridPACK™ Drive G2 power module into the inverter system and also includes the integration of differential Hall-based phase current sensors from [9].

Scope and purpose

The HybridPACK™ Drive **G2** power module is the next generation of the well-established HybridPACK™ Drive power modules and has a compatible mechanical outline to support a modular and scalable inverter system approach. HybridPACK™ Drive G2 modules come with an improved black frame material for enabling higher temperatures and currents. The guiding elements for power module positioning and alignment is optimized for full automated assembly lines. The power module is also prepared for coreless phase current sensor powered by Infineon XENSIV™ differential Hall sensor, which further simplifies the system assembly and also shrinks the system size significantly compared to classical core-based sensor solutions.
This application note shares the best practice how to assemble the HybridPACK™ Drive G2 modules in order to get a robust system design.

Intended audience

Engineers and operators involved in the assembly of the HybridPACK™ Drive G2 power module into power electronics systems.

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1 General Information

The HybridPACK™ Drive G2 power module (see Figure 1) is the next generation of the well-established HybridPACK™ Drive power modules and has a compatible mechanical outline to support a modular and scalable inverter system approach.

HybridPACK™ Drive G2 modules come with an improved frame material for enabling higher temperatures and currents. The guiding elements for power module positioning and alignment is optimized for full automated assembly lines. The module baseplate is a PinFin baseplate for direct fluid cooled systems and support highest power densities. Signal pins are optimized Press-Fit pins, which were qualified according to the latest standards IPC9797:May2020, “Press-Fit Standard for Automotive Requirements” as well as IEC60352-5:2020, “Solderless connections”. The gate driver boards can be fixed by heat stake process or alternative by self-tapping screws. The power module is also prepared for coreless phase current sensors (see Figure 2). The power module has a pocket in the frame and a slotted AC Tab, which enables differential Hall sensors for precise measurement of the motor phase currents. More details for the sensor integration can be found in the chapter 10.

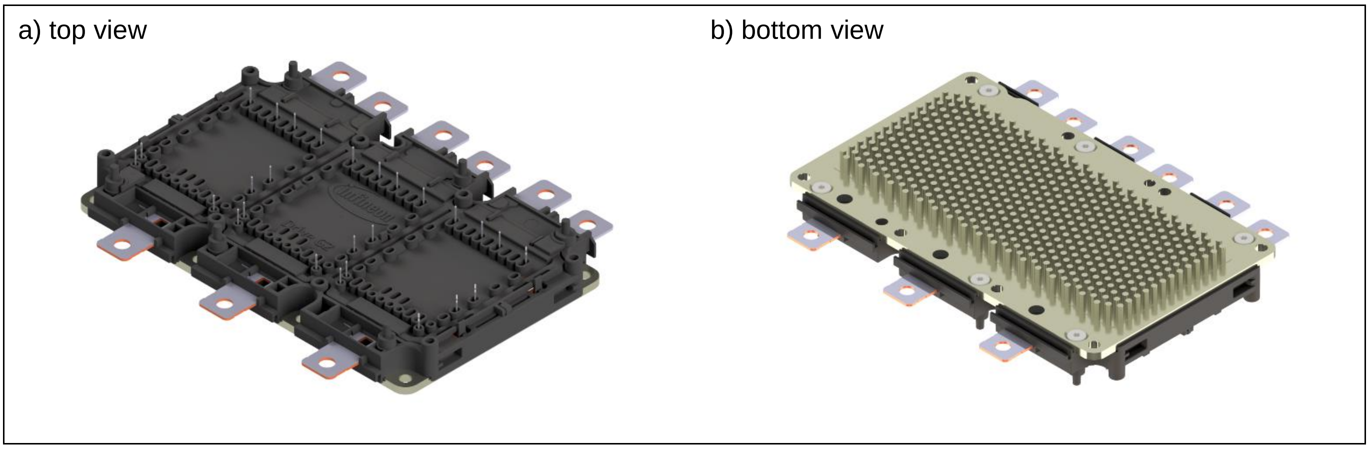


Figure 1 HybridPACK™ Drive G2 Power Module (typical appearance).

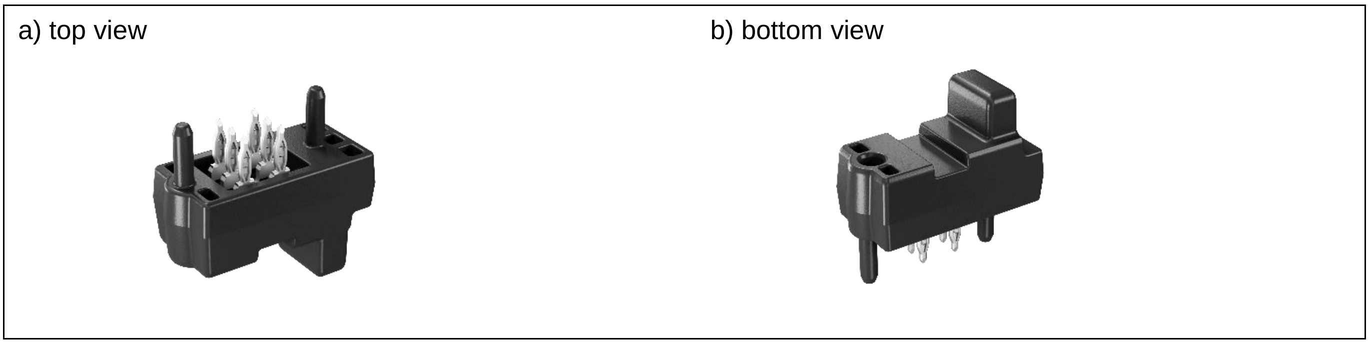


Figure 2 Differential Hall phase current sensor CSM510HP2S or CSM510HP2D for the HybridPACK™ Drive G2 power modules with outer dimension of only 18 x 9mm (x,y axis). For detailed information please refer to product datasheet [9].

1.1 Important note about scope of Application Note

This application note shares the best practice how to assemble the HybridPACK™ Drive G2 power modules.

Please note that semiconductor power modules are electronic-static sensitive components and thus appropriate ESD safety instructions should be followed at all time during the assembly processes.
In addition, maximum permissible values in the corresponding product datasheet are absolute limits which generally, even for short times, may not be exceeded as this may lead to destruction, pre-damage and/or accelerated aging of the component.
Moreover, this application note cannot cover every type of application, condition and system combination. Hence, the application note cannot replace a detailed evaluation and examination by you or your technical divisions of the suitability for the targeted applications and mounting processes.

The application note will, therefore, under no circumstances become part of any supplier agreed warranty, unless the supply agreement determines otherwise in writing.

1.2 Product list in scope of this application note

The scope of the application note is for the following products:

Type Designation	Product Description	Remarks	Status
FSxxxRxxA7Pxyyy	HybridPACK Drive G2 IGBT Module		in development
FSxxxxRxxA8Pxyyy	HybridPACK Drive G2 enhanced IGBT Module		in production
FSxxMRxxA8MAxyyy	HybridPACK Drive G2 SIC MOSFET Module		in production
CSM510HP2S	Differential Hall Phase Current Sensor Module with single ended output	Product can be ordered at [9] Samples are available under Infineon order number SP005861812.	For product status please refer to [9]
CSM510HP2D	Differential Hall Phase Current Sensor Module with differential output	Product can be ordered at [9] Samples are available under Infineon order number SP005861817.	For product status please refer to [9]

Product not listed? Please ask your Infineon sales representative.

2 Recommended Mounting Order

Datasheet drawings specify the power module at the state of delivery (before the assembly) in case not otherwise specified. Minor deformations on the product will occur during the assembly processes. In order to ensure a seamless mounting, it is recommended to follow the mounting order. More details about the process steps are described in the later chapters.

1. **Align PCB (gate driver boards) to the power module (see chapter 3).**
   (if phase current sensors are implemented please see chapter 10 for more detailed information)
2. **Press-in of the PCB (see chapter 4).**
3. **Prepare cooling system with the sealing ring and attach power module to the cooling system (see chapter 5).**
4. **Fix module baseplate on the cooler by screws (see chapter 6).**
5. **Fix the PCB on the power module by heat stake process or alternative by screws (see chapter 7).**
6. **Connect the module power tabs to busbar, capacitor, etc. (see chapter 8).**

3 Module Alignment and X/Y Guiding Holes

The HybridPACK™ Drive G2 power modules come with a new coordinate reference system, which is defined by two 4 mm holes in the baseplate. The so-called x-hole is at the side of the six DC power tabs and the slotted y-hole at the three AC power tabs side. The holes are designed to mate with alignment domes. These alignment domes can be implemented at customer side:

A) In handling and press-tools (see Figure 4A or Figure 6)
B) In cooler/inverter housing (see Figure 4B)

It has to be noted that the options A and B can be used either or and cannot be combined.

The option A has the alignment domes only in manufacturing equipment and provides lowest system BOM cost. Option B requires to adjust the press-tool of Figure 6. The alignment dome (noted Element 1 in Figure 6) has to be replaced by a hollow cylinder with a 4.1mm inner diameter to avoid collisions.

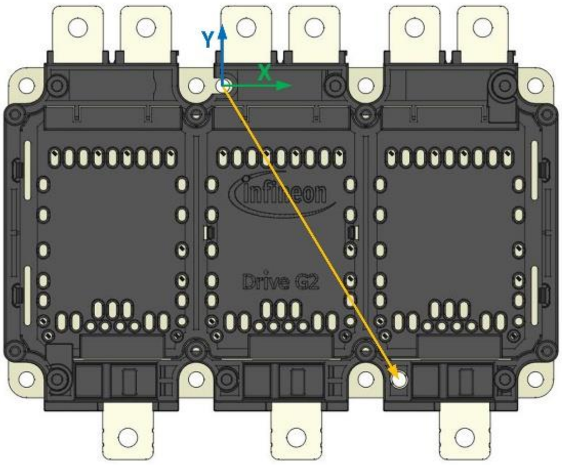


Figure 3 Reference coordinate system defined by x-hole and slotted y-hole in the baseplate. Please see product datasheet for detailed information.

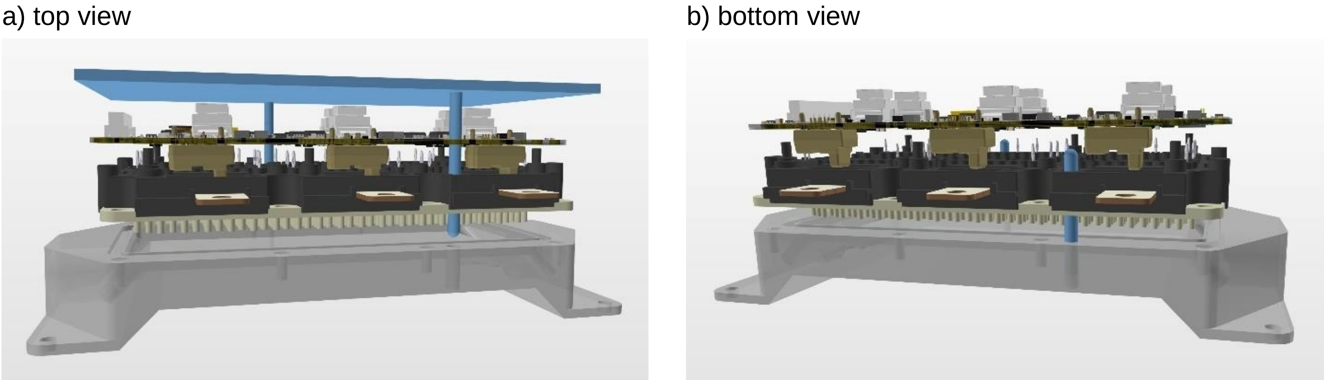


Figure 4 Principal view: Alignment of power module, cooler and PCB by alignment domes in handling and press-tools (a) or by alignment domes in cooler/inverter housing (b). The alignment domes are indicated by light blue color. Detailed information about current sensor alignment see chapter 10.

4 Press-Fit Signal Contacts

4.1 Requirements for the PCB

The Press-Fit signal pin technology used in the HybridPACK™ Drive G2 power modules is designed for standard FR4 PCB (printed circuit boards) with immersion tin plating and was qualified according to IPC9797:May2020, "Press-Fit Standard for Automotive Requirements" and passes also the conditions and criteria's according to IEC60352-5:2020. The PCB material must be compliant with IEC 60249-2-4 or IEC 60249-2-5 for double-sided printed circuit boards and IEC 60249-2-11 or IEC 60249-2-12 for multilayer printed circuit boards. The requirements for the PCB are in Table 1. In case the requirements are not met, there is risk of a not gas tight signal pin connection or of pin and/or PCB via damage.

Please note that the Press-Fit hole specifications are only valid for assembled PCBs. In case of unassembled PCBs (e.g. for testing purposes) it is recommended to perform a standard reflow solder process before starting the power module assembly process.

Table 1 Requirements to the PCB.

No	Description	Unit	min.	typ.	max.	Remarks and known common mistakes
1	Drill tool diameter	mm	1.12	1.15		Wrong drill tool applied. Specify clearly the Press-Fit hole positions and required drill tool size to the PCB manufacturer.
2	Copper thickness in hole	um	25		50	In case the via metallization is lower than specification, the risk is a damaged/cracked via.
3	End hole diameter	mm	1.02		1.10	End hole diameters lower than spec may lead to increased press-in forces and may damage the pins. Larger holes than spec may lead to low press-in forces and can cause not gas tight connections.
4	Copper thickness of conductors	um	35	70 105	400	
5	Hole to hole pattern tolerance	um			±100	In typical PCB manufacturing hole to hole pattern is lower than ±80um.
6	Recommended PCB thickness	mm		1.6		Target value with +/-10% thickness tolerance
7	Metallization of circuit board		Immersion Tin (Sn chemically)			Immersion tin has typ 1-5um metallization in the hole. Other metallization type should be avoided can lead to strong deviation in press-in forces. E.g. HAL leadless show high variations in press-in forces and risk is a not gas tight pin connection, which can fail over application lifetime. PCB with ENIG (Ni Au) plating can lead to increased press-in forces due to hard surface. OSP plated PCBs were not considered during development phase. Other surface than Immersion Tin will not be considered at Infineon module qualification tests.
8	Metallization of pin		Ni/Sn (galvanic)			The Sn plated pin with nickel under layer avoids potential whisker growth out of the upper galvanic tin layer.

Please take note that the PCB Press-Fit holes should not be specified just by the finished end hole diameter. The risk is that wrong processes are applied by the PCB manufacturer. Please give your PCB manufacturer the information that all holes for the signal pins must be manufactured according to Table 1. As PCB design tools typically do not differentiate between "normal" and "Press-Fit holes" it is a well-known workaround to use a "unique hole size e.g. 1.06mm" in the PCB design for all Press-Fit holes. Then the Press-Fit holes are separate in the NC drill files and thus the PCB manufacturer knows exactly the positions where to apply the spec according to Table 1.

A structure of a PCB according to the spec in Table 1 is illustrated in Figure 5. The hole in the PCB is drilled with a drill tool size of 1.15 mm. It is normal that PCB material shrinks after drilling. Therefore, this shown hole size with 1.15mm should not be understood as a check gauge after drilling rather than an illustration for understanding the PCB stack.
Later in the process, the holes will be plated. It is important to have minimum 25um copper in the hole otherwise the press-in forces may damage/crack the via. According to experience, larger annular rings are typically more robust to mechanical forces and thus large annular rings (e.g. 0.5 mm) should be used wherever possible in the design.
The metallization/plating in the holes has to be manufactured in an immersion tin (i.e. chemical tin) process. This process is known to generate very uniform layer thicknesses (typically about 1um) and ensures the correct press-in forces as well as an appropriate contact surface for achieving gas tight Press-Fit connections.

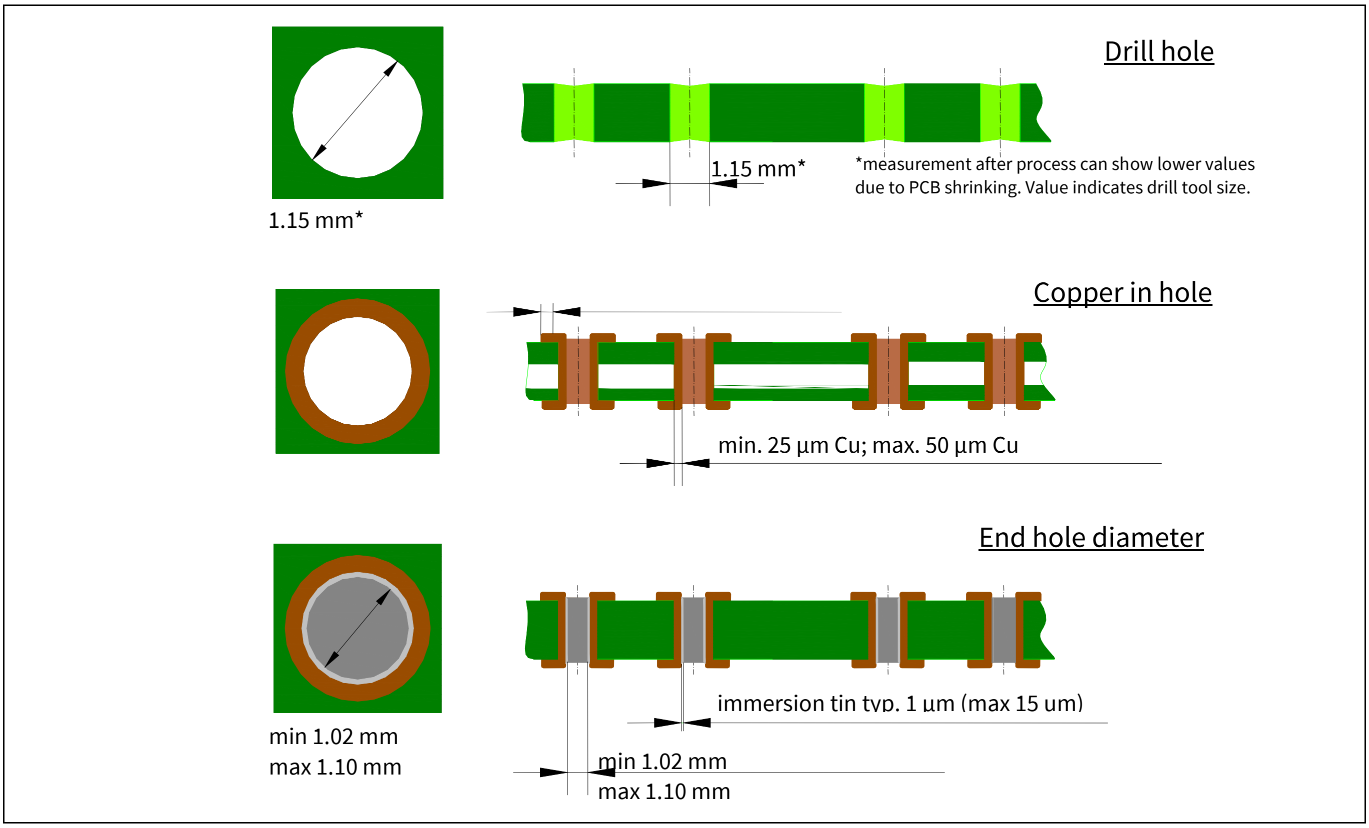


Figure 5 Structure of a PCB according to the specification in Table 1.

4.2 General hints for the PCB Footprint

PCB footprint typically depend on PCB manufacturing processes and customer specific design rules. The following table can be understood as a best practice and starting point for system design.

Table 2 Hint for PCB footpint holes. PCB bottom layer is defined on side of the power module.

No	Type	PCB Implementation Hint
1	X hole	Hole at 0/0 mm Position End hole Diameter: 4.10 mm +/-0.1 *Optional: Plated hole with 4.7 mm annular ring diameter*
2	Y hole	Hole at 49.274/-82 mm Position End hole Diameter: 4.10 mm +/-0.1 slotted length 4.5 mm Slot Rotation (59° top view) *Optional: Plated hole with 5.1 mm annular ring diameter*
3	Signal Press-Fit pin holes	See Table 1
4	Components keep out around Press-Fit pins	Uncritical packages like SO, TSSOP, QFP or not safety relevant SMD resistors: >=3mm radius from the hole center Others: >=4mm radius from the hole center
5	PCB heat stake fixing*	6x Holes at positions: (HS1: -46.2/0 mm; HS3: 31.47/0 mm; HS4: 78.8/0mm) (HS5: 78.8/-82 mm; HS7: 1.13/-82 mm; HS8: -46.2/-82 mm) End hole Diameter: 3.60 mm +/-0.1 mm *Optional: Plated hole with annular ring diameter top layer 6.6 mm; mid layer 4.2 mm; bottom layer 7.0 mm.*
6	*Optional PCB screw fixing*	*Optional 6x Holes: End hole Diameter: 3.60 mm +/-0.1 mm* *Optional: Plated hole with annular ring diameter top layer 7.0 mm; mid layer 4.2 mm; bottom layer 6.6 mm.*

*: The recommended press- tool uses the PCB area around the heat stake for the press-stop. Plated holes with recommended annular rings ensure by design that PCB thickness is same at Press-Fit pins and press-stop areas.

4.3 Press-Tools

This chapter describes a sample press-tool, which can be adapted to project specific needs like PCB assembly locations, maximum height of other PCB parts, etc. to avoid mechanical collisions during the press-in process. The press-tool is made of two parts and changeable alignment domes (see Figure 6).
A mechanical drawing of the sample press-tools is given in Figure 7 and Figure 11, and a 3D step model can be obtained from Infineon Technologies on request.

The press-tool can be used in a simple toggle lever press for engineering purpose or in a controlled press-machine for serial production (examples see [2]).

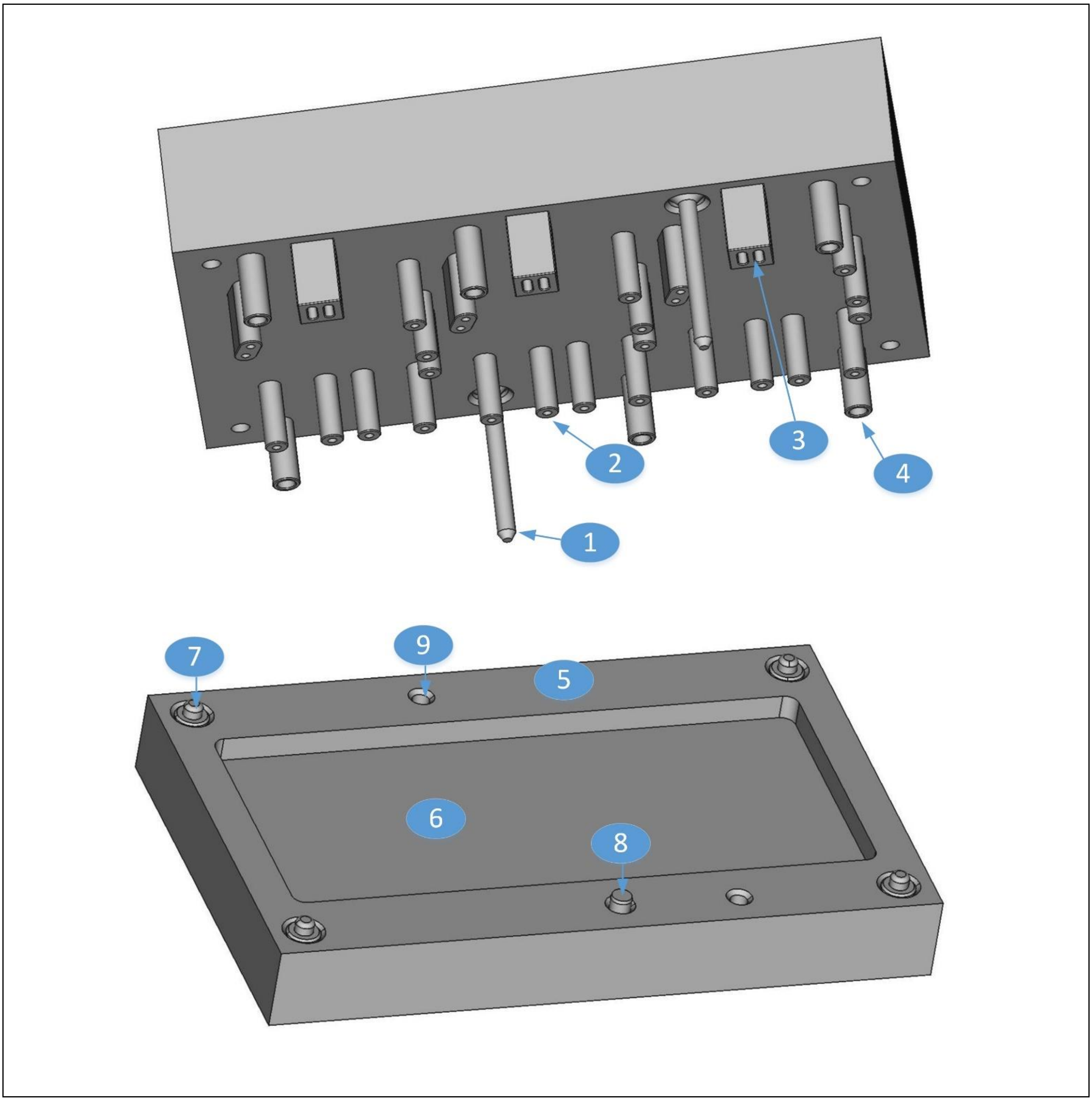


Figure 6 Press-tool (principle view).

The top tool implements:

1. Changeable X/Y alignment domes which provides poka yoke that no wrong assembly orientation of power module and press-tools are possible (2 alignment domes).
2. "Punch" for the signal pins designed as hollow cylinders (n times for all n signal pins)
3. Optional "Punch" for phase current sensor (3 times)
4. Distance keeper (6 times, at heat stake dome position), which simplifies the press-stop criteria.

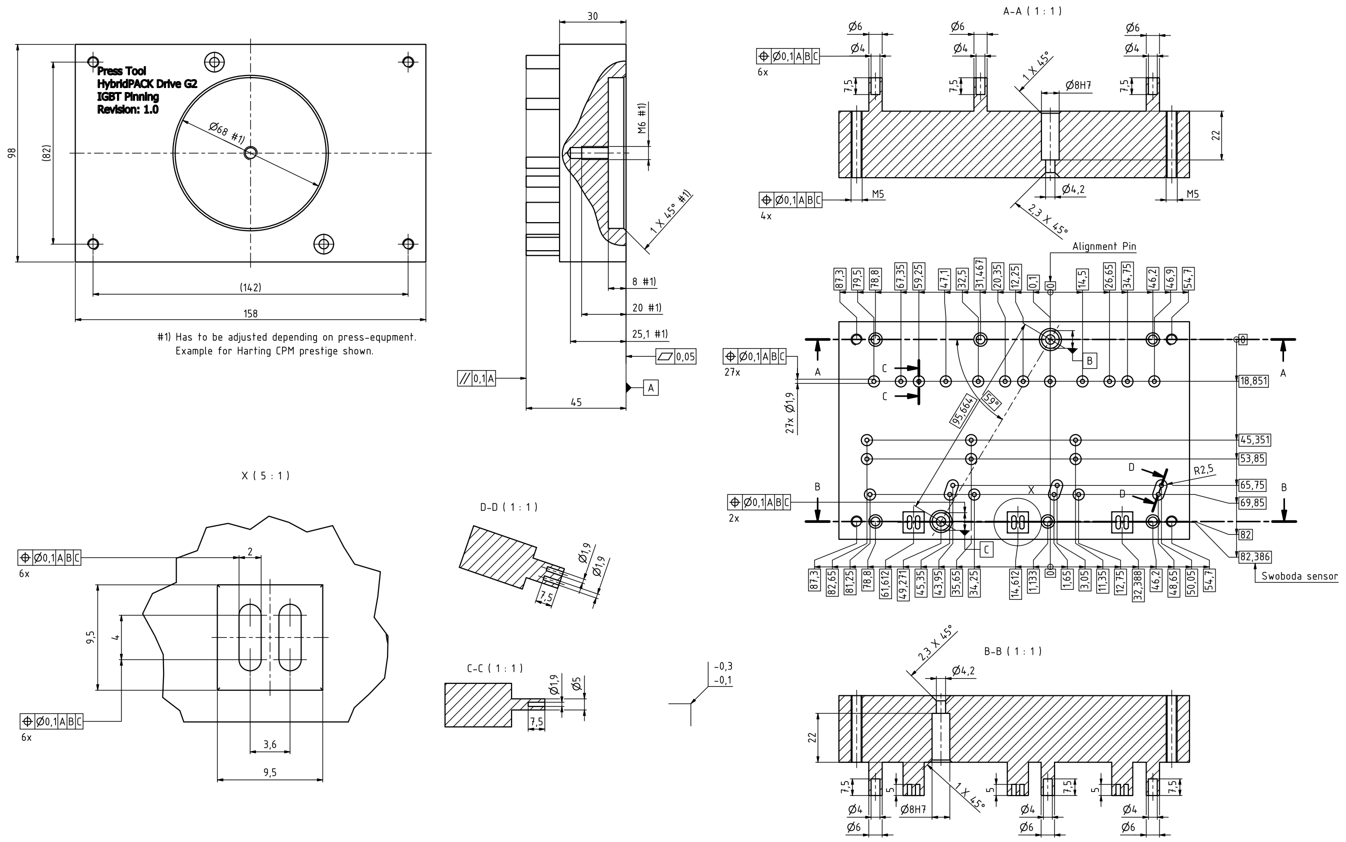
Note: The elements 2-4 are in the same common zone. The top tool height (height of the cylinders) must be adjusted according to the maximum PCB assembly height.
The alignment domes are implemented in the sample tool as changeable inserts. In case of equipment crash or other incidents, the domes can be easily replaced (M4x18 DIN 7991) in service interval without the need of a completely new production tool.

The bottom tool implements:

5. Locating Surface for the power module baseplate
6. Groove to protect the PinFin baseplate structure from scratches and damage
7. Changeable guide element for power module positioning in the bottom tool
8. Poka Yoke element to avoid wrong assembly orientation. The element can be designed also with tactile sensor which lock the press-machine operation.
9. Drill holes for X/Y alignment domes of the top press-tool

Note: The material and/or plating of the bottom part of the tool has to be selected in order to avoid scratches and damage of the baseplate sealing area during the press-in process.

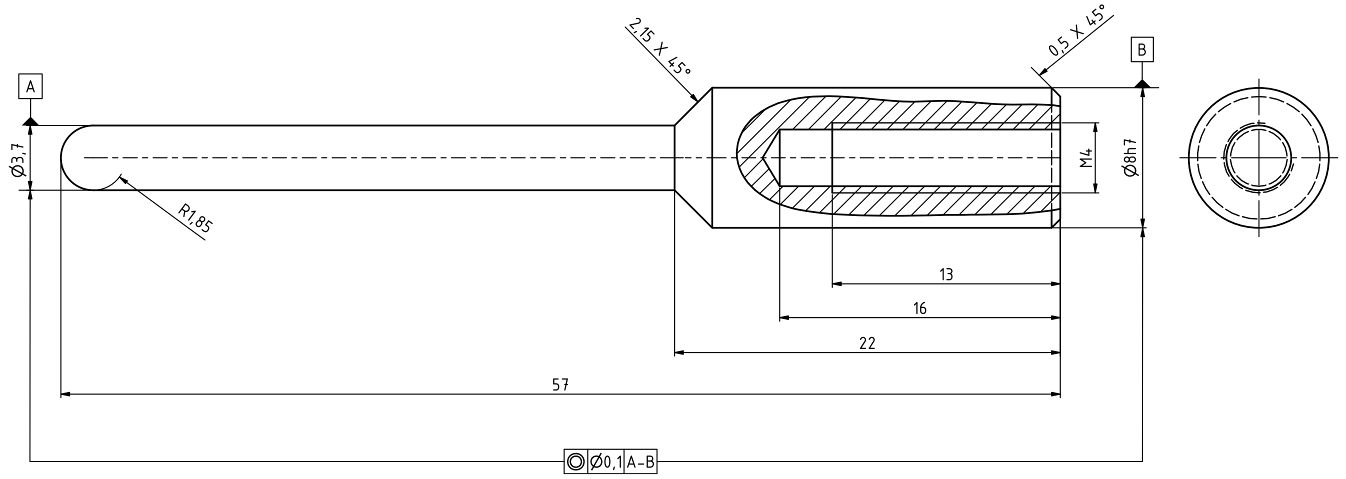
4.3.1 Drawing Press-Tool IGBT Signal Pinning



IFX Drawing No: W00210353

Edges: ISO 13715; Tolerance: ISO 2768 – mK; Surface: EN ISO 1302; Material: 1.4301 (V2A)

Figure 7 Technical drawing of the sample press-tool IGBT signal pinning (top tool).

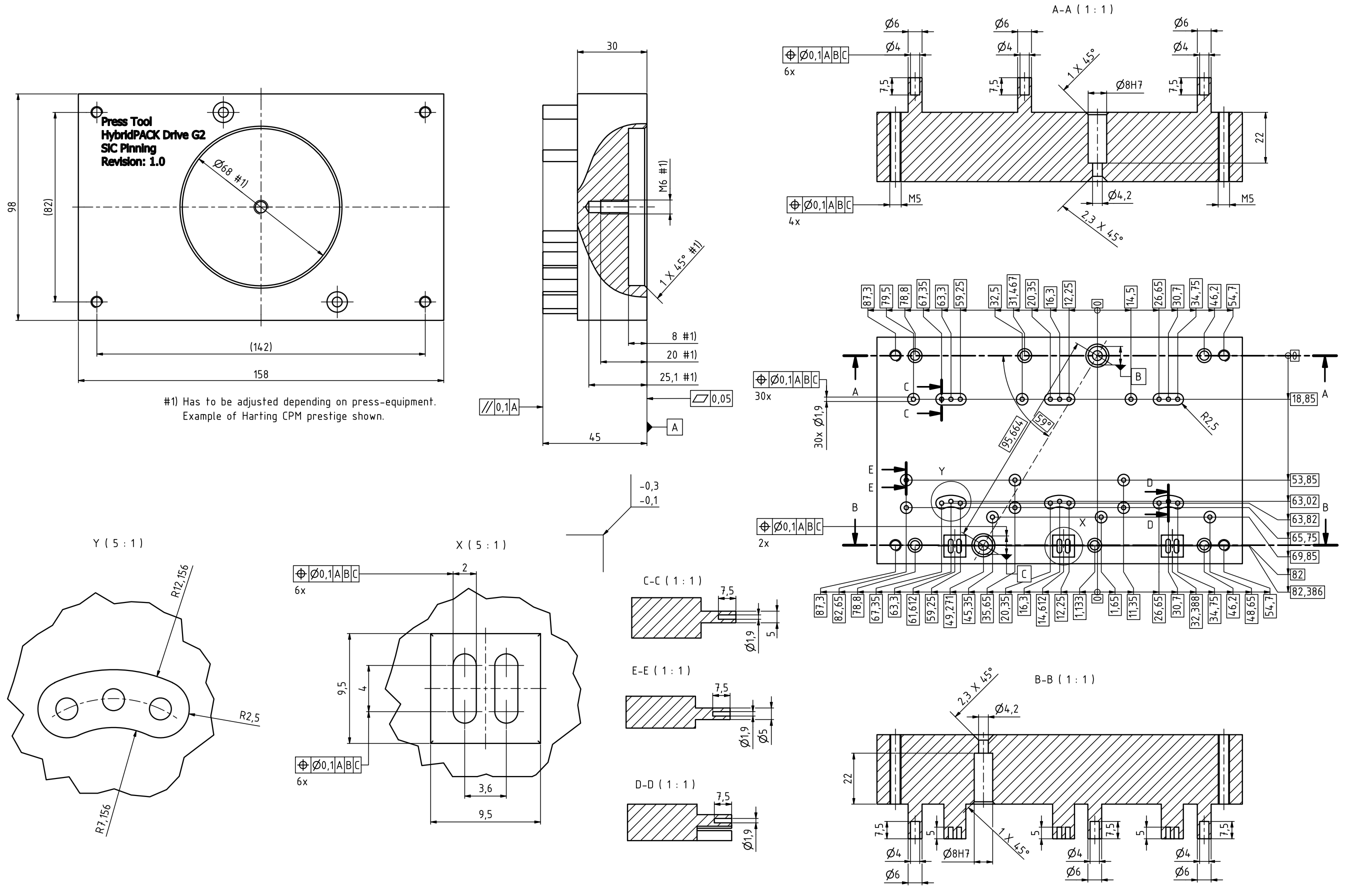


IFX Drawing No: W00209433

Edges: ISO 13715; Tolerance: ISO 2768 – mK; Surface: EN ISO 1302; Material: 1.4301 (V2A)

Figure 8 Technical drawing of the X/Y alignment domes of the sample press-tool (2 times for the top tool). The alignment domes can be fixed by metric M4x18 DIN7991 screws in the top tool.

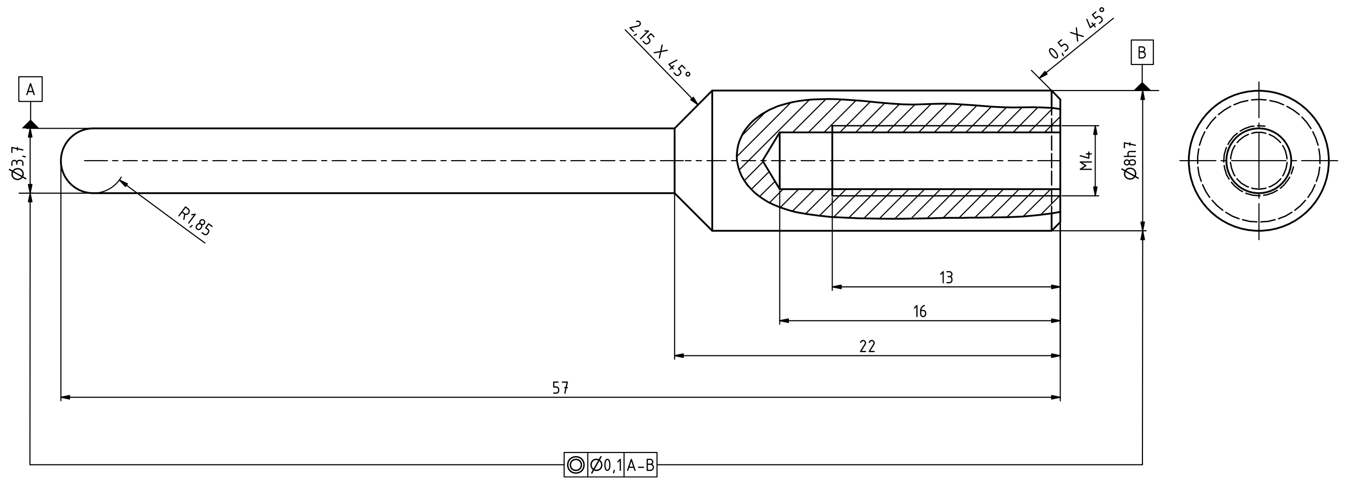
4.3.1 Drawing Press-Tool SIC MOSFET Signal Pinning



IFX Drawing No: W00208361

Edges: ISO 13715; Tolerance: ISO 2768 – mK; Surface: EN ISO 1302; Material: 1.4301 (V2A)

Figure 9 Technical drawing of the sample press-tool SIC MOSFET signal pinning (top tool).

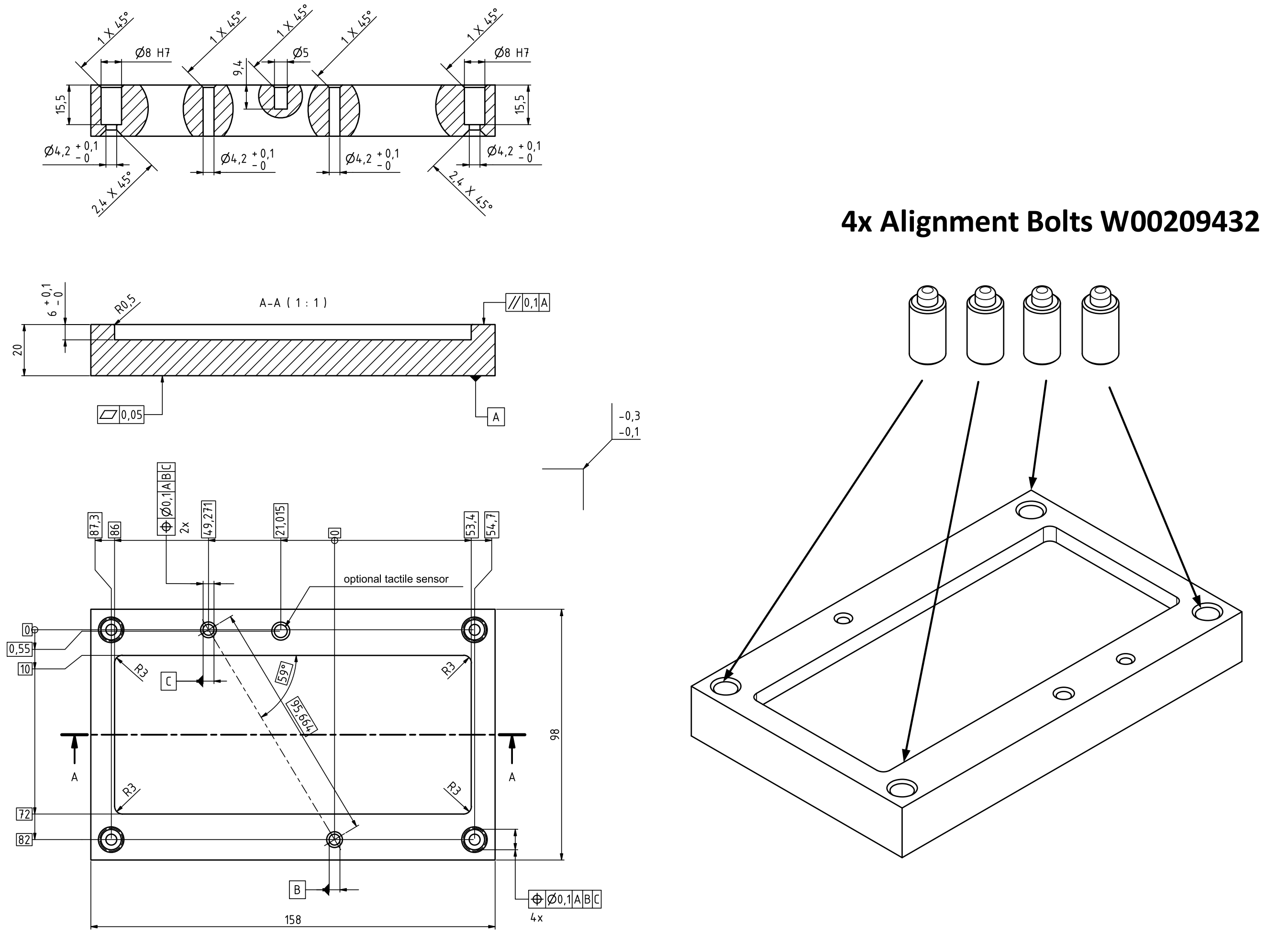


IFX Drawing No: W00209433

Edges: ISO 13715; Tolerance: ISO 2768 – mK; Surface: EN ISO 1302; Material: 1.4301 (V2A)

Figure 10 Technical drawing of the X/Y alignment domes of the sample press-tool (2 times for the top tool). The alignment domes can be fixed by metric M4x18 DIN7991 screws in the top tool.

4.3.1 Drawing Bottom Press-Tool (all versions)



IFX Drawing No: W00209424 (alignment element W00209432)

Edges: ISO 13715; Tolerance: ISO 2768 – mK; Surface: EN ISO 1302;

Material bottom tool: 1.4301 (V2A)

Material alignment nobs: ABS plastic

Figure 11 Technical drawing of the sample press-tool (Bottom Tool).

4.4 Press-In Process

The press-in process is recommended with a controlled force-distance method for serial production. For testing under laboratory conditions, a manual toggle-press also typically gives good results.

The Figure 12 show an example of a HybridPACK™ Drive G2 press-in process with typical PCB according to Table 1. The PCB thickness in this test was 1.6 mm (+/-10%).

Please note it is important that the press-in equipment is designed for the expected high forces. During the press-in process the bottom and top press-tool must be parallel to each other and should be mechanically fixed without tilt.

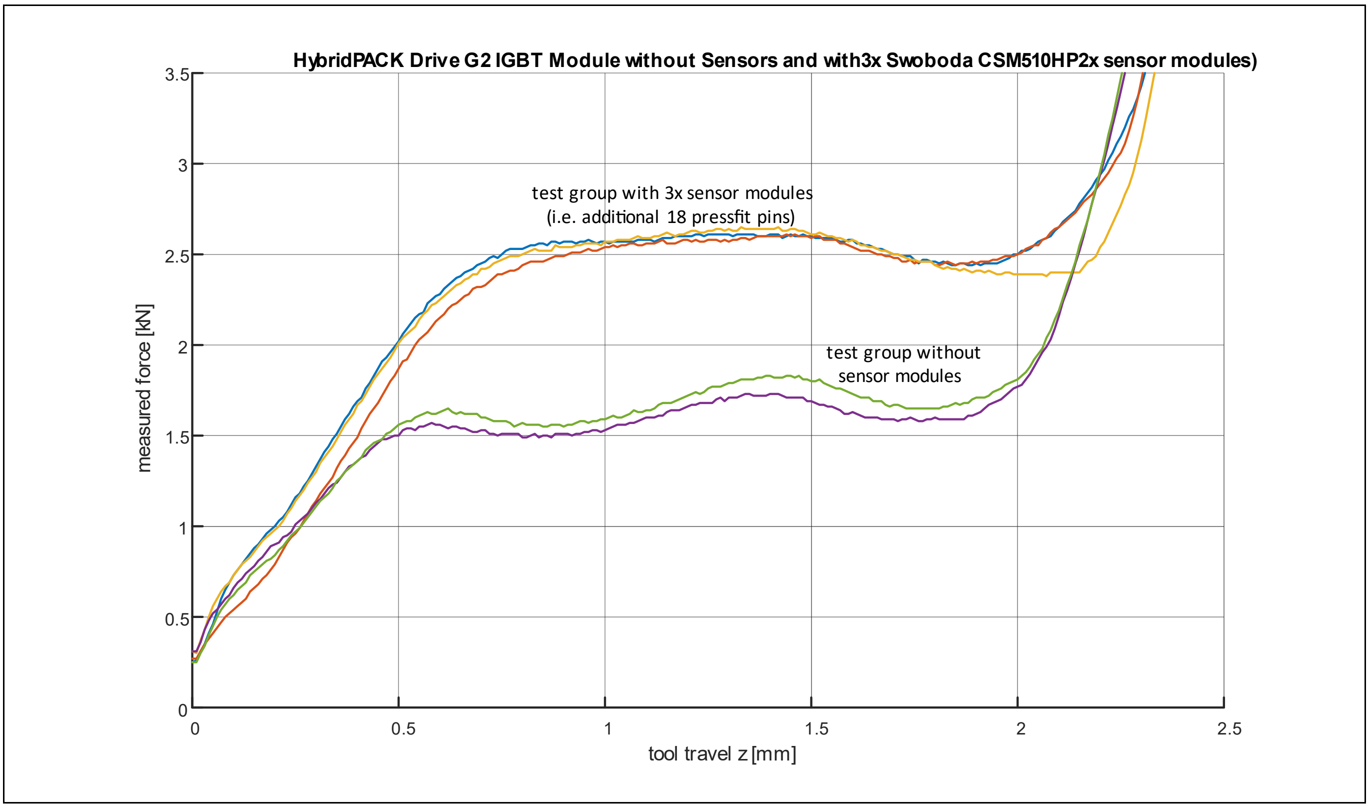


Figure 12 Typical way-force press-in diagram with HybridPACK™ Drive G2 module. The power module in this example was IGBT module with 27 signal pins. The Swoboda CSM510HP2S or CSM510HP2D sensor has 6 signal pins per sensor and 3 sensors are used per system.

Table 3 Overview press-in process

No	Description	unit	min.	typ.	max.	Remarks
1	Press-in speed	mm/s	0.4	2 .. 4	8	During the press-in process, it is not recommended to come under the minimum speed. The maximum press-in speed is typically limited by press-equipment limitations.
2.1	Max allowed press force on module (power module with 3 sensor modules CSM510HP2S or CSM510HP2D)	kN		2 .. 3	3.5	Exceeding the maximum allowed force can lead to increased signal pin mechanical stress and can also damage the frame and baseplate of the power module.
2.2	Max allowed press force on module Bare module (no sensors)	kN		1.2 .. 2	3.0	Exceeding the maximum allowed force can lead to increased signal pin mechanical stress and can also damage the frame and baseplate of the power module.

Figure 13 show typical process parameters. At the beginning the pin slides into the PCB holes and gets deformed. In the beginning the contact is a spring contact only. The pin itself will limit the effective force to prevent damage in the PCB vias. At end of the process the PCB will attach to the power module frame and the force will be introduced into the frame. At this point the process is already finished and the press-in can be stopped. Some press-machines provides the option to stop the process by slope changing points (dF critera). Such a stop-criteria is the most advanced and can be applied, but is not mandatory for the HybridPACK™ Drive G2 power modules. For qualification tests at Infineon Technologies where PCB assembly was required a press-stop criteria by absolute force acc Table 3 was applied.

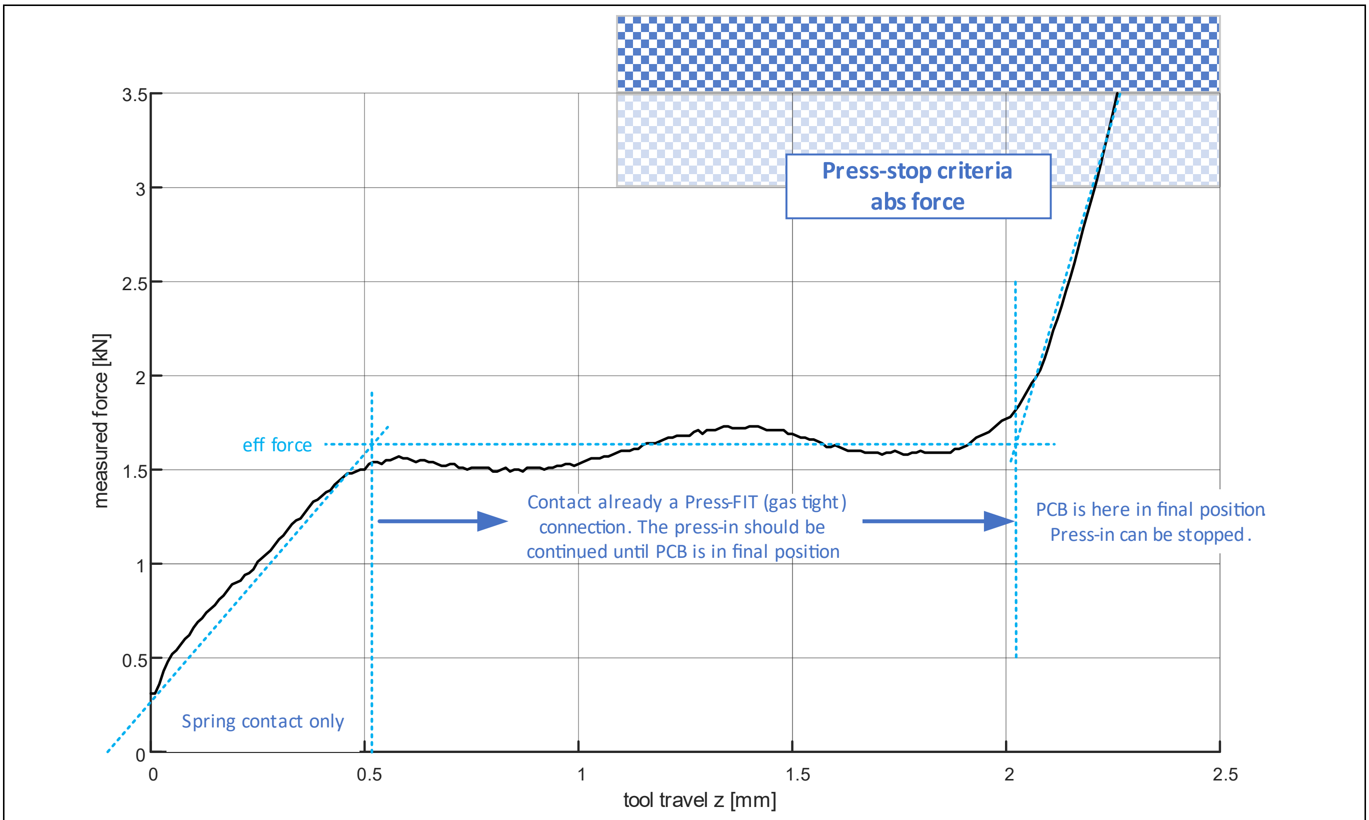


Figure 13 Typical way-force press-in diagram with indication of the typical process parameters.

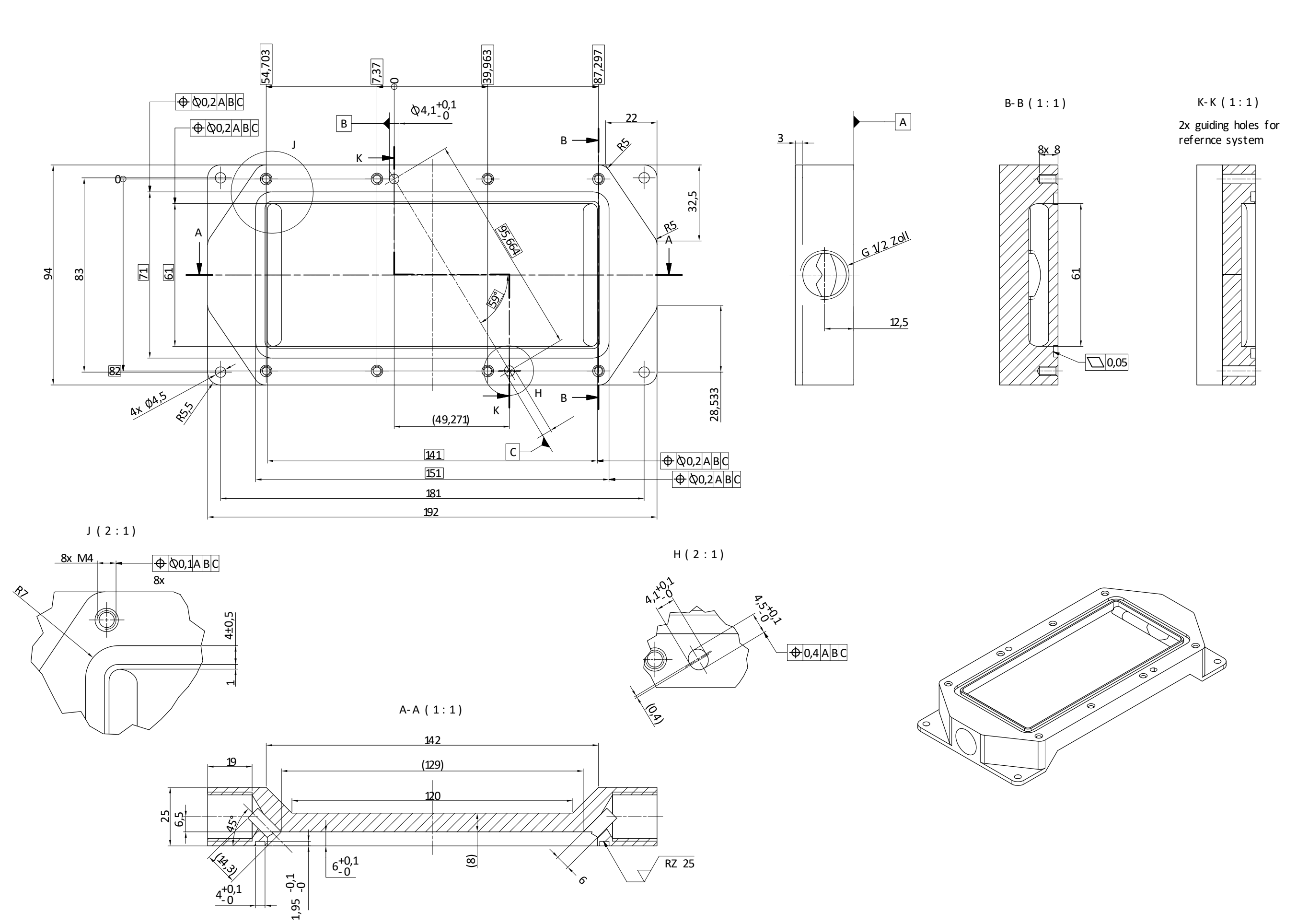
5 Power Module Cooling System

The module power losses must be dissipated in order not to exceed the maximum permissible operating temperature specified in the datasheet. Therefore, the design of cooling system/heat sink is of great importance. HybridPACK™ Drive G2 has a PinFin array on the baseplate, which makes liquid cooling very effective. The baseplate is made of copper (Cu) material with nickel (Ni) plating. The PinFin structure is suitable for cooling fluids like water ethyleneglycol mixture. The fluid mixture requires also an appropriate corrosion protection (see section 5.3 for more details).

PLEASE NOTE: During the assembly process, damage to the nickel plating or mechanical deformation of the PinFin structure as well as contamination, scratches or other damages in the sealing area must be strictly avoided.

5.1 Reference Cooler Design

The cooler design has a great impact on the overall cooling performance, which means the combination of thermal resistance/impedance, pressure drop, and cooling flow rate. Thus, for all of these thermal related product specifications a reference cooling system is needed, where the given specification values are valid.
The cooler can be designed differently if other tradeoffs of thermal resistance/impedance, pressure drop and flow rates must be achieved. Therefore, the reference cooler should be regarded as a design example, where the values from the corresponding product datasheet can be achieved.



IFX Drawing No: W00203206; DIN ISO 13715; ISO 2768-mK; DIN EN ISO1302; AlMgSi0.5

Figure 14 Reference cooler design for HybridPACK™ Drive G2 with PinFin Cooling Structure.

The 2x guiding holes for reference system drawn as through holes in the example but can be adjusted to project specific needs like 8 mm depth blind holes or similar.

The following requirements must be considered when other designs than the reference cooler is used.

- **Roughness of the cooler: ≤ RZ25 (DIN EN ISO 1302) in area of the sealing.**
- **Cooler Flatness at the module area: ≤ 50 µm**

Exceeding the requirements above may lead to damage of the power module.

The cooler material should be AlMgSi0.5 or other alternative, which is compatible to copper baseplate with nickel plating and can withstand the mechanical stress required from a specific customer application.

Plastic coolers as already demonstrated for the HybridPACK™ Drive Generation 1 products by [5], [4]. Such coolers can be also applied to the HybridPACK™ Drive G2 power modules.

5.2 Recommendation for the sealing ring

The power module baseplate is designed with a flat region of 6.5 mm surrounding the entire PinFin area, which is called the sealing area.

Several power module qualification tests like power cycling tests require assembly on a cooler. For these tests sample sealing rings from Freudenberg Sealing Technologies [3] part number OR-SF-19023 were applied in the tests. This sealing ring type is already a known design from HybridPACK™ Drive power modules of the 1st generation where all reliability tests from AQG324 were finished with PASS result. Nevertheless, it is necessary to perform system qualification test (e.g. according to LV124) to ensure that final system design and final assembly processes meets the project specific application needs. The system qualification is also mandatory in case other sealing rings and/or coolers have to be used in the applications.

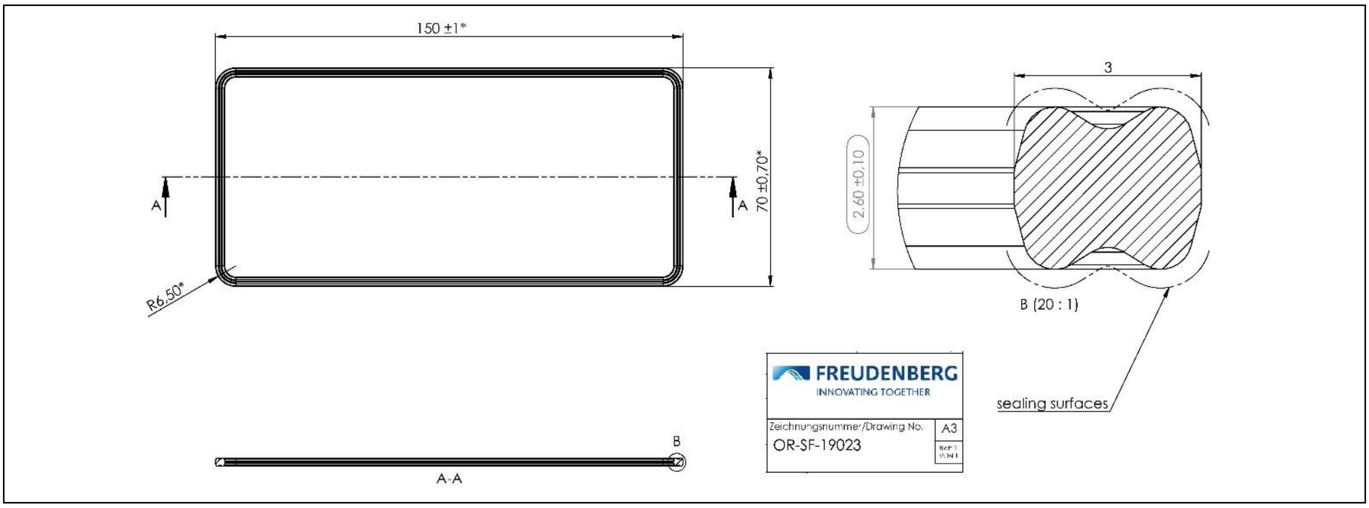


Figure 15 Drawing of sealing ring from Freudenberg Sealing Technologies OR-SF-19023.

Depending on system assembly processes so called assembly nobs at the sealing rings might be useful. Such a design is shown in Figure 16 and provide besides this assembly nob feature at the same sealing characteristics.

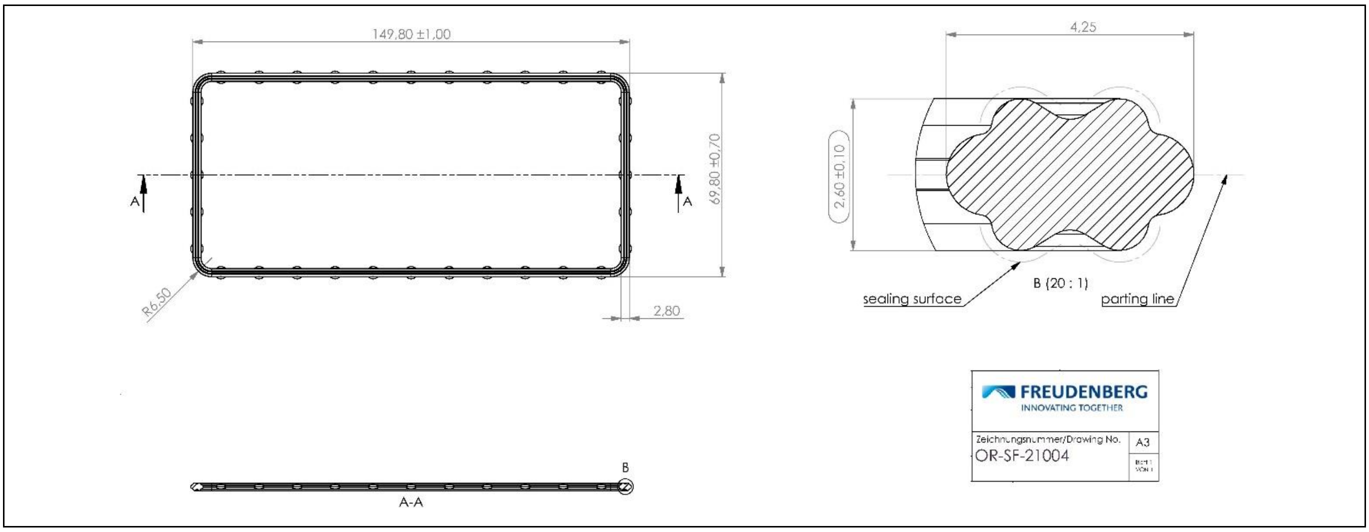


Figure 16 Drawing of sealing ring from Freudenberg Sealing Technologies OR-SF-21004.

PLEASE NOTE: That incorrect placement of the sealing ring in the cooler grove can lead to deformation of the power module baseplate and fluid leakage as consequence. It is to be noted that repair/rework after a wrong assembly is not possible.

5.3 Cooling fluid

A general recommendation for a specific cooling fluid cannot be provided, as the power module is only one single part in the entire cooling system. Following items have to be considered at the system supplier to find appropriate coolant fluid:

- Coolant fluid with its corrosion protection has to be compatible with the aluminum alloy of the cooler material and the nickel over-plated copper baseplate from the power module.
- Also other parts in the coolant system has to be compatible to the fluid type (e.g. Zn screws and chrome parts are typically not allowed in the cooling system).
- The fluid mixture has to provide enough anti-freeze for the application conditions. Freezing events of the fluid has to be strictly avoided. Freezing fluid will lead to plastic deformation of the power module baseplate and will lead to fluid leakage and/or isolation failure consequently.

For power module tests at Infineon where cooling is required (e.g. thermal characterization, power cycling tests) typically BASF Glysantin™ G30™ with an organic-acid-technologie (OAT) silicate-free corrosion protection is applied.

6 Baseplate mounting on the cooler

The power module baseplate is designed to be fixed on the cooling system by means of screws. Using the correct screw types, torques, screw orders and module clamping is essential to avoid damage of the power module during the assembly steps.

6.1 Baseplate mounting with metric screw types

In case of power module baseplate mounting by metric screws the following table has to be considered.

Table 4 Metric baseplate fixing screws requirements

No	Description	min.	typ.	max.	Remarks
1	Metric Screw Type (Recommended)		**ISO 7380-2 A2 (TX) M4x10**		Recommended metric screw
1.1	Metric Screw Type (Option)		ISO 4762 (screw) ISO 7090 (washer) M4x10		Due to production complexity/cost only for lab testing recommended.
2	Mounting torque	1.8 Nm	2.0 Nm	2.2 Nm	
3	Max mounting speed			400rpm	
4	Effective length of screw in cooler	6mm			AlMgSi0.5 cooler material. Typical M4x10 screws are used.
5	Screw order		Acc. section 6.3		Correct screw order is mandatory
6	Module clamping during screw process		2 kN Acc. section 6.3		Clamping or multistep mounting. See section 6.3.

6.2 Baseplate mounting by self-tapping screws

Self-tapping screws can eliminate drillings and thread cuttings as well as corresponding cleaning processes of the cooler/inverter housings. This can lead to significant cost reduction and process time reduction at high production volumes. Furthermore, such self-tapping screws are known to be extremely rugged during vibration stress.

Table 5 Self tapping baseplate fixing screws requirements

No	Description	min.	typ.	max.	Remarks
1	Self Tapping Screw Type (Recommended)		**EJOT ALtracs Plus WN5152 AP 40x12/10**		Recommended screw
2	Mounting torque M_{eff}	1.6 Nm	1.8 Nm	2.0 Nm	Approx. Mw=2 Nm torque is required for the self-tapping. This torque is not effective for the mounting force Ft. Self-tapping force strongly depends on cooler material.
3	Recommended mounting speed	400rpm		600rpm	Lower than 200rpm is not recommended
4	screw holes in cooler		See Figure 17		Self tapping screws should not be used in standard M4 threads.
5	Screw order		See section 6.3		Screw order crosswise from inside to outside is mandatory (typ example see section 6.3)

6	Module clamping during screw process	1.8 kN	2 kN Acc. section 6.3	4 kN	Self-tapping screws require single step mounting and appropriate module clamping.

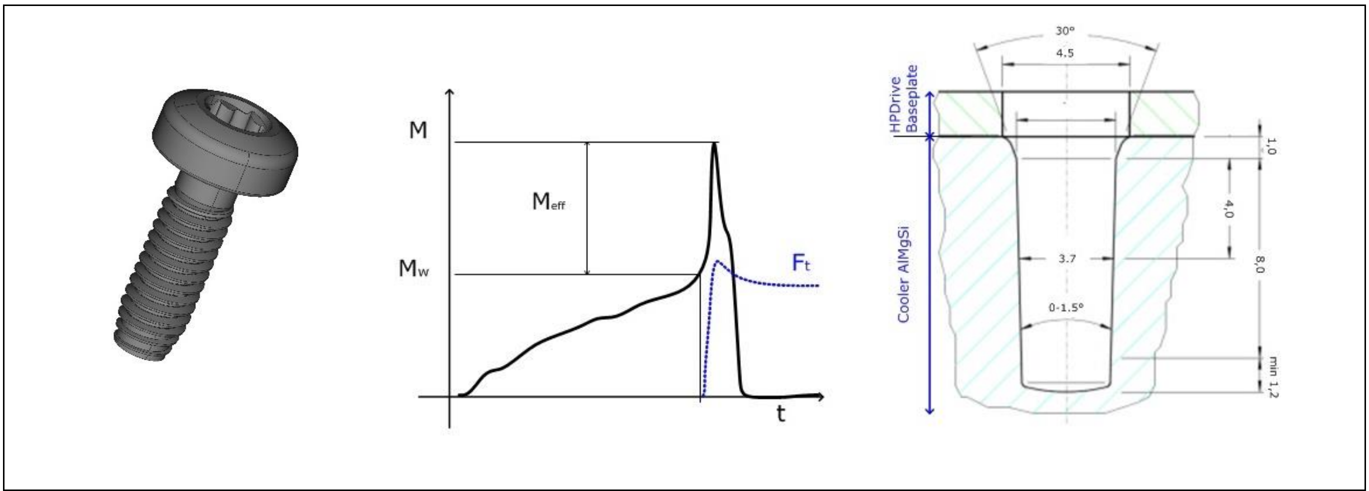


Figure 17 Typical appearance of the self-tapping EJOT ALtracs Plus WN5152 AP 40x12/10. A principal torque and mounting force diagram as well as drawing of the required fixing holes in the cooler. The holes can be also drilled with a standard drill tool (3.7mm 0°).

Further important notes to avoid burrs and flakes in the final system:

The fixing holes in the cooler must be blind holes no clearance holes.

Only one time mounting is feasible.

The geometry of the EJOT screw is designed such that the burrs and flakes are only generated at the bottom of the screw thread.

The screw self-tapping torque depends on the cooler (housing) material. Infineon recommends to perform mounting experiments with final cooler material. In these experiments the screw torque should be recorded. The cooler material specific self-tapping torque can be observed from the recorded data as shown in the example with the reference cooler made of AlMgSi0.5 material.

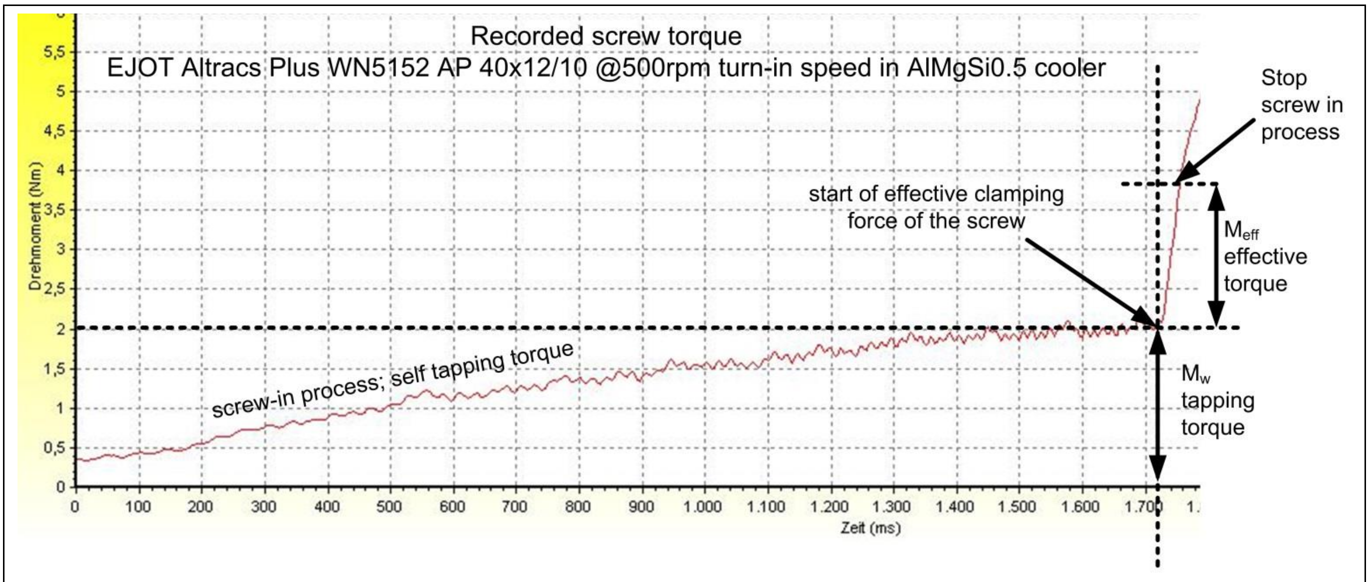
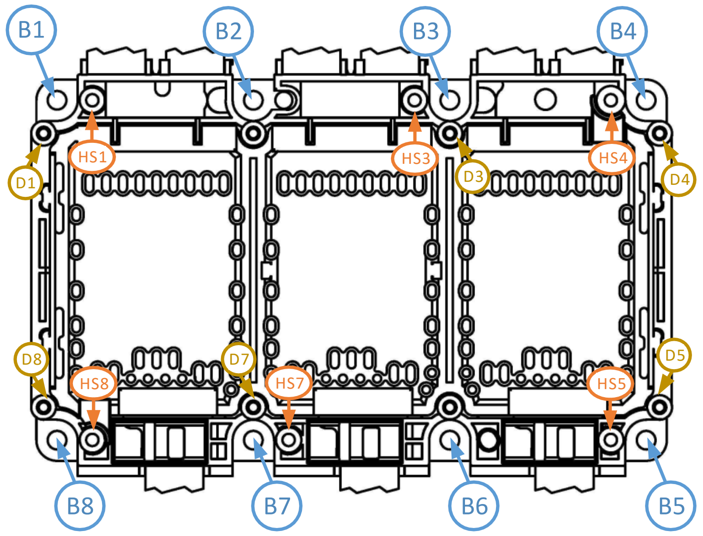


Figure 18 Recorded screw torque in CNC machined cooler from AlMgSi0.5 material. The self tapping torque was at several experiments was in average 2.0Nm. For this part a total screw torque of 3.8Nm would lead to an effective screw torque of the required M_{eff} = 1.8Nm.

6.3 Screw order and module clamping during baseplate screw process

A correct screw order is necessary in order to avoid damage on the part. The eight baseplate holes are labeled in Figure 19 (or see product datasheet). The screws have to be tightened crosswise from inside to outside. The start position B2 is one possible example. The “crosswise inside to outside” mandatory method can be also modified to B3, B7, B6 as start position.



Baseplate fixing after module assembly into cooler	
baseplate screw order	Position
1	B2
2	B6
3	B3
4	B7
5	B4
6	B8
7	B1
8	B5

Figure 19. Indicated positions of baseplate screws (Bx) with correct screw order listed in the table.

It is required to fix properly the power module to the cooler during the screwing process in order to avoid tilting of the module with a possible damage (i.e. plastic deformation of the baseplate).

Following methods are preferred for module fixation during the screw process:

1. **Multi-Step Screw Mounting (only possible with metric screws!):** Place 1st and 2nd screw and fix with lowest torque (this avoids only module tilting and will not to provide a high clamping force). Fix 3rd to 8th screw with low torque (e.g. 0.4-0.6 Nm). The clamping force of 3rd to 8th screw will ensure that the sealing ring is already finally compressed. Fix all screws with final torque as specified.

2. **Module Clamping (all recommended screw types):** After the power module (with PCB) is placed onto the cooling system the module should be clamped in z axis of the module with a total force of **Fc = 2 kN** to ensure that the sealing ring is fully compressed during the screwing process. The clamping can be performed by hollow cylinders (outer diameter 6mm; inner diameter 3.6mm) in the area of the heat stake domes (HS1, HS3, HS4, HS5, HS7, HS8 see in Figure 19). The clamping force will be introduced in the seating location of the heat stake domes. In case the screw domes (D1, D3, D4, D5, D7, D8) will be used for clamping it is important that the PCB is not further pushed down during the clamping process.

7 PCB mounting on the module housing

The HybridPACK™ Drive G2 power module has implemented two options for fixing the PCB on the power module. The primary option is the fixation via the heat stake domes, which bring the advantage of minimum inverter BOM. The second option is via self-tapping screws, which is a process known from the established 1st generation of HybridPACK™ Drive power modules.
Please take note that fixing the PCB to the module (either by heat stake process or by screws) is recommended only after the power module is attached and fixed to the cooling system.

7.1 PCB mounting by heat stake process

The heat stake method for fixing printed circuit boards to the plastic frame can enable lowest system BOM cost. General information about heat stake method can be found at [8]. The heat stake process can be easily adjusted to project specific needs, by different thermode geometries, heating/cooling profiles, as well as different force profiles. The Table 6 specifies the maximum allowed boundary conditions of the power module during the heat stake process. The section 0 describes the heat stake process within the specification of Table 6 which was selected for evaluation tests.

Table 6 Requirements for the heat stake process

No	Description	unit	min.	typ.	max.	Remarks
1	Maximum force on heat stake dome at start of the process	kN			0.5	This force is allowed onto the undeformed dome at beginning of the heat stake process
2	Maximum force on heat stake dome at end of the process	kN			1.8	This force is allowed at end of the process where the dome was already deformed.
3	Simultaneous heat stake process on all 6 domes			allowed		
4	Maximum temperature during heat stake process	°C			280°C	Has to be limited to maximum 10s

7.1.1 Example heat stake process

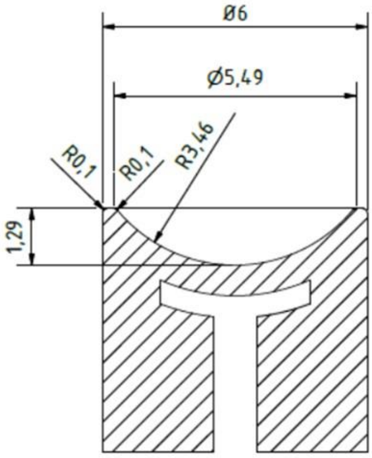
This describes an exemplary heat stake process, which was developed by Hartmann Feinwerkbau GmbH [8] together with Infineon Technologies AG for evaluation and reference purpose. The example shows the process on one single dome, but simultaneous processing all six domes is also possible (see Figure 23).

a)

b)

Figure 20 Power module dome before (a) and after (b) the heat stake process.

Exemplaric Thermode Design



Setup for Heat Stake Evaluation Tests

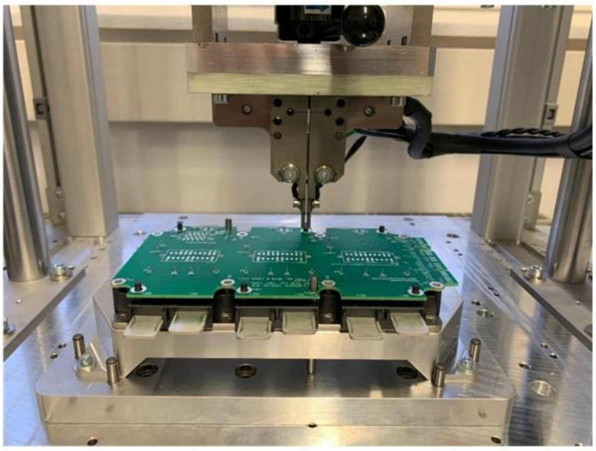


Figure 21 Example Thermode design and setup of the evaluation tests [8].

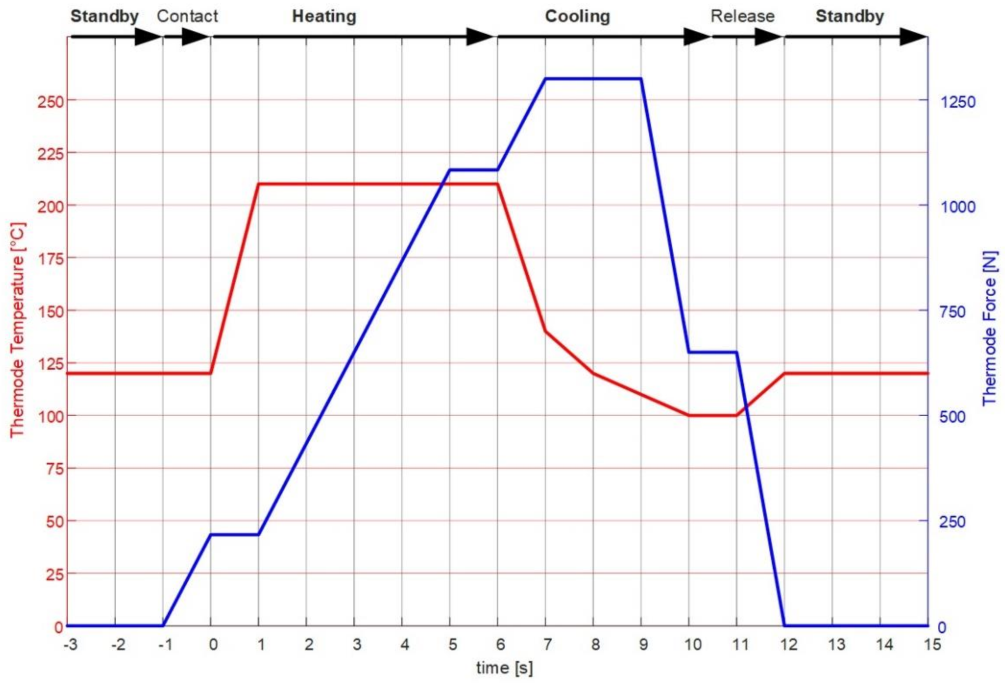


Figure 22 Example heat stake process. A short description can be found in Table 7.

Table 7 Short description of the heat stake process

Phase	Description
Standby	The equipment is in standby and ready for the process.
Contact	The thermode is located on the power module heat stake dome and apply a low contact force.
Heating	The thermode is heated up and force increases together with temperature to deform the plastic dome. The force can be applied by hydraulic or compressed air system.
Cooling	At the beginning of the cooling phase the force is further increased to the final end value. The dome is during the cooling phase already deformed. In the second phase of the cooling the force is quite rapidly ramped down to prepare the next release phase.
Release	The force is released. At the same time the thermode can be already controlled to the standby temperature.
Standby	The tool is ready for the next heat stake process.

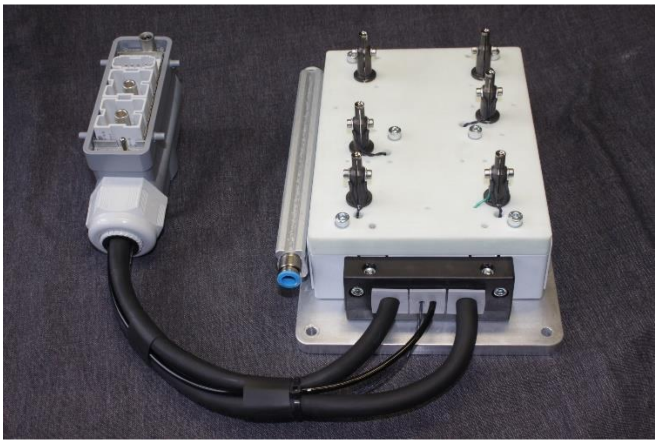


Figure 23 Tooling example for heat stake process of all six domes at the same time [8].

7.2 PCB mounting by self-tapping screws

The PCB mounting by screws is an alternative method to the heat stake method. Please note that one mounting option has to be selected. PCB fixation by both (heat stake and screws) was not tested and is therefore not recommended. The power module PCB screw domes were designed for the following screw type and process:

Table 8 PCB fixing screws requirements

No	Description	min.	typ.	max.	Remarks
1	Self Tapping Screw Type		**EJOT Delta PT WN5451 30x10**		Recommended screw. Screw tests at Infineon were performed with Zn5 plated screws.
2	Mounting torque **Meff** (see product datasheet) **Meff + Mw** (for 1.6mm PCB)	0.45 Nm 1.1 Nm	0.50 Nm **1.2 Nm**	0.55 Nm 1.3 Nm	Mw ≈ 0.7 Nm torque is required for the self-tapping of the 10 mm screw length, 1.6 mm PCB thickness and 500 rpm mounting speed. This self-tapping torque is not effective for the mounting force and varies with PCB thickness and effective screw length.
3	Recommended mounting speed	400 rpm	**500 rpm**	800 rpm	Lower than 400 rpm is not recommended and can lead to dome crack or damage on the screw. The maximum rpm mainly depends on the applied screw equipment.
4	Screw order		Crosswise from inside to outside		Preferred order see Figure 25

The initial 1.5 mm (approximately) of the mounting stand-off, which can be seen in the drawing, serve as guidance and cannot take any force. The thread in the plastics will form itself by driving in the EJOT screws. It is important to have an appropriate minimum turn-in speed, which causes a self-heating of the screw in order to have a proper thread forming in the plastic housing without splitting and cracking. Within the screwing process there are no pauses recommended, like screw tightening in several steps (see also smooth torque waveform over the time in Figure 24). An electronically speed controlled screwdriver is the preferred aid for this purpose. Furthermore, a straight insertion of the screw into the stand-off must be observed during assembly.

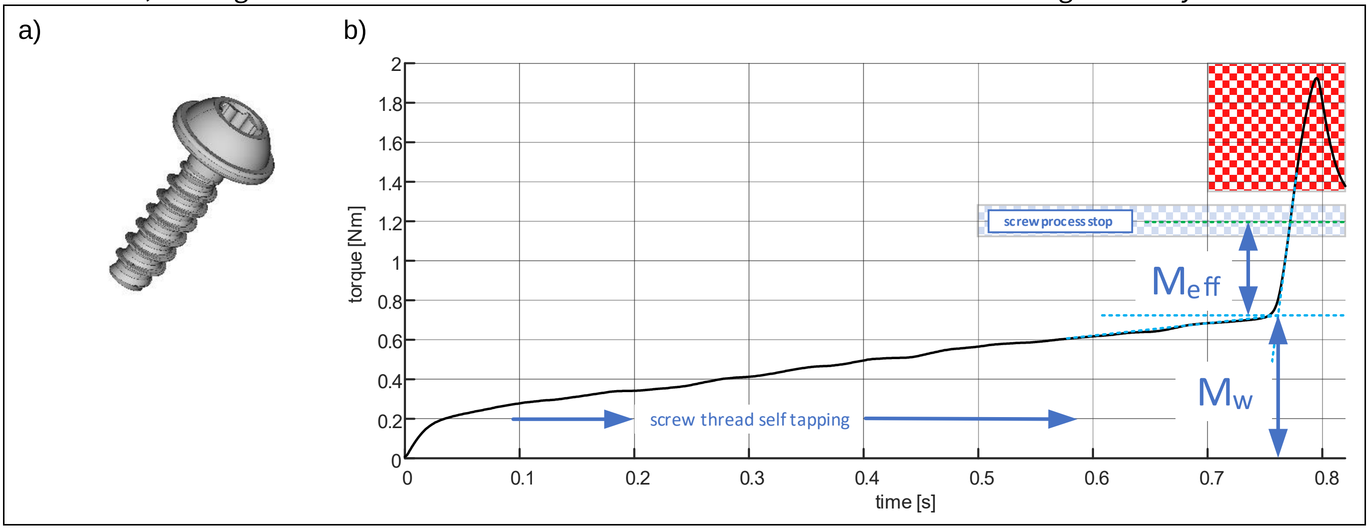
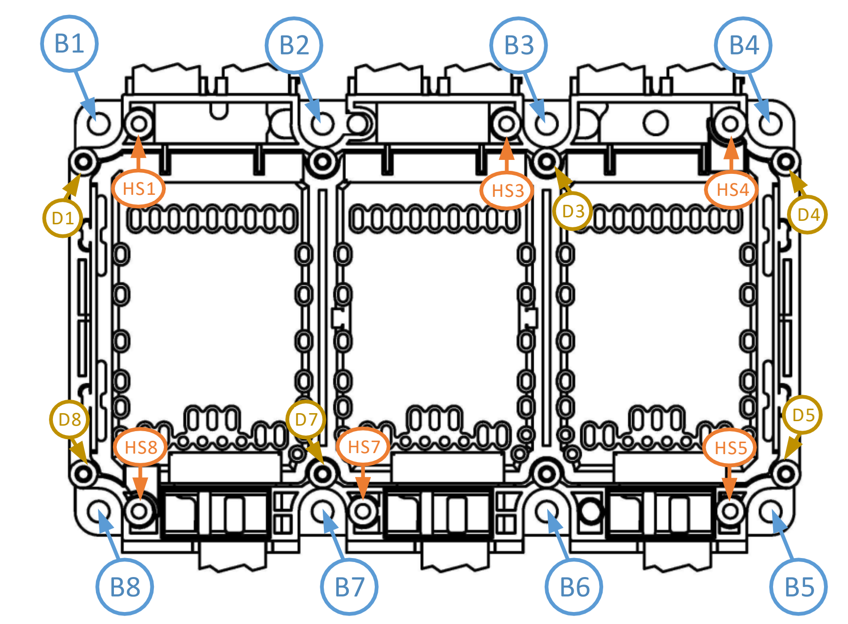


Figure 24 Picture of EJOT Delta PT typical appearance (a), measured screw torque diagram until failure (b).



PCB fixing to power module by screws	
PCB screw order	Position
1	D3
2	D7
3	D5
4	D1
5	D4
6	D8

Figure 25. Indicated positions of PCB screws (Dx) with correct screw order listed in the table.

8 Connecting to the Power Tabs (Terminals)

The copper power tabs are tin-plated and are thus well suited for screw type connections as well as welding processes. The allowed forces/movement of the power tabs (see section 8.3) during assembly has to be considered for screw as well as welding processes.

The power tabs can be in general connected from topside as well as from bottom side to the counterparts, like DC-Link capacitor. There is also no restriction in case three or more busbars are connected in the stack together. In order to have best system compatibility between HybridPACK™ Drive G2 power modules with A7 and A8 as well as the Drive Generation 1 power modules with A6 (1.0 OR 1.5mm thick power tabs), recommended is a connection from topside. The power tab topside has always the same location to the housing independent of the product variant.

8.1 Power tab connecting by screws

Several mounting options and screws or nuts are suitable like the following examples:

- **screw – power tab – busbar** – nut
- **nut – power tab – busbar** – screw
- screw – **busbar - power tab – busbar** – nut

In following tables, only the interface screw/nut to the power tab is described. Interfaces from customer busbar to screw/nuts have to be evaluated by the customer. The screw types in Table 9 give only a rough overview. Different types may be possible with same mounting torque in case the base of head or the spot face are comparable to the given types and the busbar material is suitable for such mounting.

Table 9 Power tab mounting options and recommended screw torque

Option	Screw/Nut type	Mounting torque			Remarks
		min.	typ.	max.	
1	M5 ISO 7380-2-A2-(TX) screw	3.6 Nm	4.0 Nm	4.4 Nm	
2	M5 ISO6923 nut	3.6 Nm	4.0 Nm	4.4 Nm	
3	M5 ISO 4762 screw (M5 ISO 7090 washer)	3.6 Nm	4.0 Nm	4.4 Nm	Only considered for low volume production & lab testing
4	M5 ISO4032 nut	3.6 Nm	4.0 Nm	4.4 Nm	
5	M4 ISO 7380-2-A2-(TX) screw	1.8 Nm	2.0 Nm	2.2 Nm	For continuous terminal currents >500Arms recommended are M5 screw options.
6	M4 ISO6923 nut	1.8 Nm	2.0 Nm	2.2 Nm	

8.2 Power tab connecting by welding

The different variants of HybridPACK™ Drive G2 power modules have same power tab material but variants with the following ending in the type designation have no screw holes and are therefore well suited for welding the power tabs:

FSxxxRxxA7PxYYY OR FSxxxxRxxA8PxYYY OR FSxxMRxxA8MAxYYY (YYY => Power Tab Variant)

- YYY= **___ (no ending)**: Short Tabs DC&AC without holes
- YYY= **LBC**: Short DC Tabs without holes, Long AC Tabs with holes

An example of such power module type without hole can be seen in Figure 26 . These plain power tabs can be connected by means of welding processes. The welding process with its specific parameters have to be evaluated by the customer. A general recommendation to the process type or parameters is not possible as it is also depending on the companion material of the busbar and the available welding equipment at the customer. Studies of institutes give a comprehensive guide for the pre-selection of applicable welding process types and can be found e.g. at [6], [7].

Material property of the power tabs for selecting the welding process:

Copper Type: oxygen free copper type
Plating: galvanic tin

Please note that the power module frame has to be limited to 185°C during the welding process.

A laser welding equipment supplier, which has already successfully performed pre-tests on the HybridPACK Drive power tabs can be found under [7]. A weld line result is shown in Figure 26b.

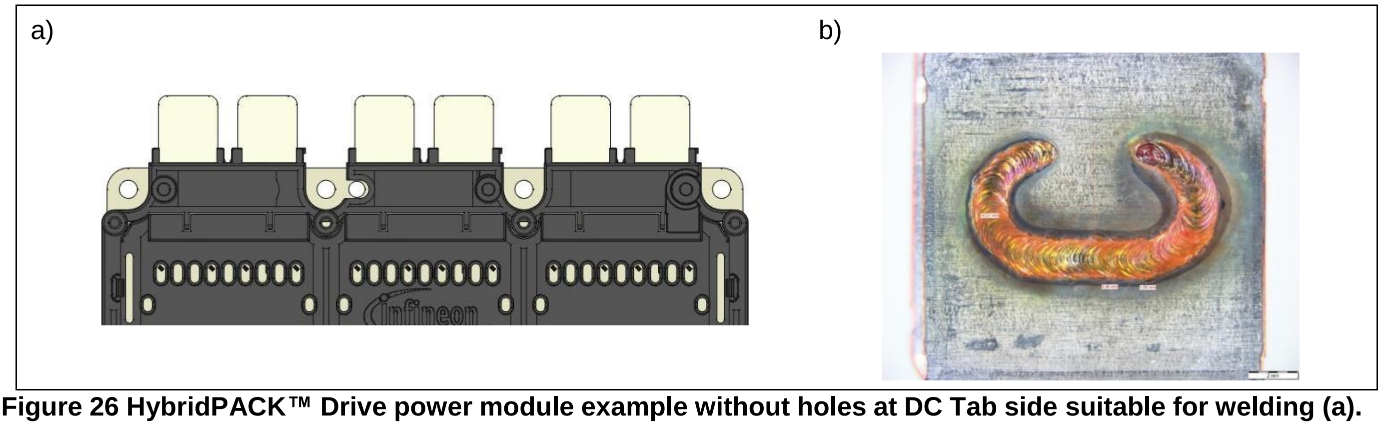


Figure 26 HybridPACK™ Drive power module example without holes at DC Tab side suitable for welding (a). A weld line result on the power tabs (b).

8.3 Forces on Power Tabs and allowed bending area

During assembly forces on the power tabs will be applied due to position tolerances of power tabs as well as the counterpart, like capacitor busbars. As forces cannot be directly measured during assembly and thus can be hardly used as criteria for system design validation the HybridPACK™ Drive G2 modules have an allowed bending room of the power tabs (see Figure 27).
The bending room to has to be understood as single event during assembly. The room can be applied simultaneous to all power tabs. A cyclic bending within the room during application lifetime is not allowed.

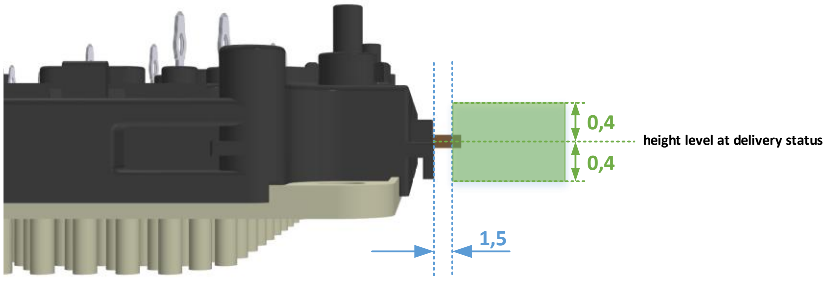


Figure 27 Allowed bending room of the power tabs. Principal view can be applied to all power tabs of the module.

9 System Assembly Clearance & Creepage Distances

The datasheet of the HybridPACK™ Drive specifies clearance & creepage distances of the product itself. It is obvious that external parts can modify these distances in the system and thus it is mandatory to check clearance and creepage distances of the entire final system assembly.

Please note: The distance to the cooler, housing, (all external parts), must also be checked. This can be done only on system level. Appropriate keep out or covering with isolating parts (plastic) can typically increase critical distances in the system design.

For systems with high DC working voltages it is recommended to use the mounting method according to Figure 4a, where the alignment domes are within the assembly tools. The alignment domes will be removed after the assembly steps and will not limit the final clearance creepage distances of the product.
The mounting method according to Figure 4b, where the alignment dome is within the cooler housing, can reduce the creepage distances to 8.8 mm within the system setup. This method can be used for “lower” DC working voltages and/or in case the alignment dome is made with an isolating material.

10 Phase Current Sensor Integration

The HybridPACK™ Drive G2 power module is prepared for the coreless phase current sensor powered by Infineon XENSIV™ differential Hall sensor. The XENSIV™ hall sensor TLE4973 is implemented in Swoboda CSM510HP2S or CSM510HP2D sensor modules, which fit into the sensor pocket and power tab slot of the power module. The sensor modules are available at Swoboda Technologies [9]. Limited number of samples for evaluation purpose can be ordered also at Infineon (see section 1.2 for order numbers).

A vertical cross section through the power module, sensor and PCB is shown in Figure 28. After the press-in processes, the sensor is located on the "rotation-bar" of the module (1). The module sensor pocket and power tab slot is designed slightly wider than the Swoboda CSM510HP2S or CSM510HP2D sensor (2). A remaining gap between the sensor and PCB (3) was intended by design to compensate mechanical tolerances.

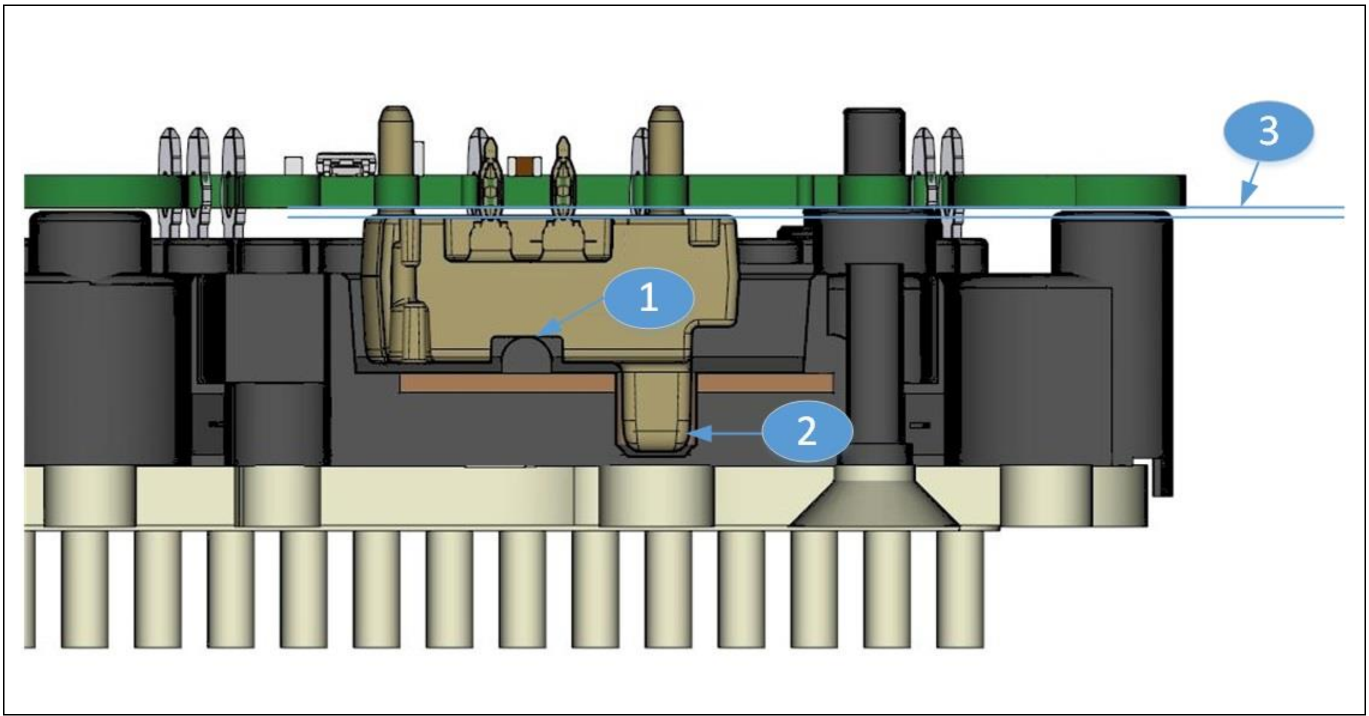


Figure 28 Vertical cross section of Swoboda CSM510HP2x sensor in HybridPACK™ Drive G2 power module.

10.1 Information for PCB Footprint

The correct placement of the three sensors in the PCB design is shown in Figure 29. The PCB holes for the sensor and the power module can be designed with same hole size and PCB specification. Please refer to Table 1 also for the PCB holes of the sensors. More details of the PCB footprint can be taken from Figure 30, which shows the sensor part in the same top view in Figure 29.

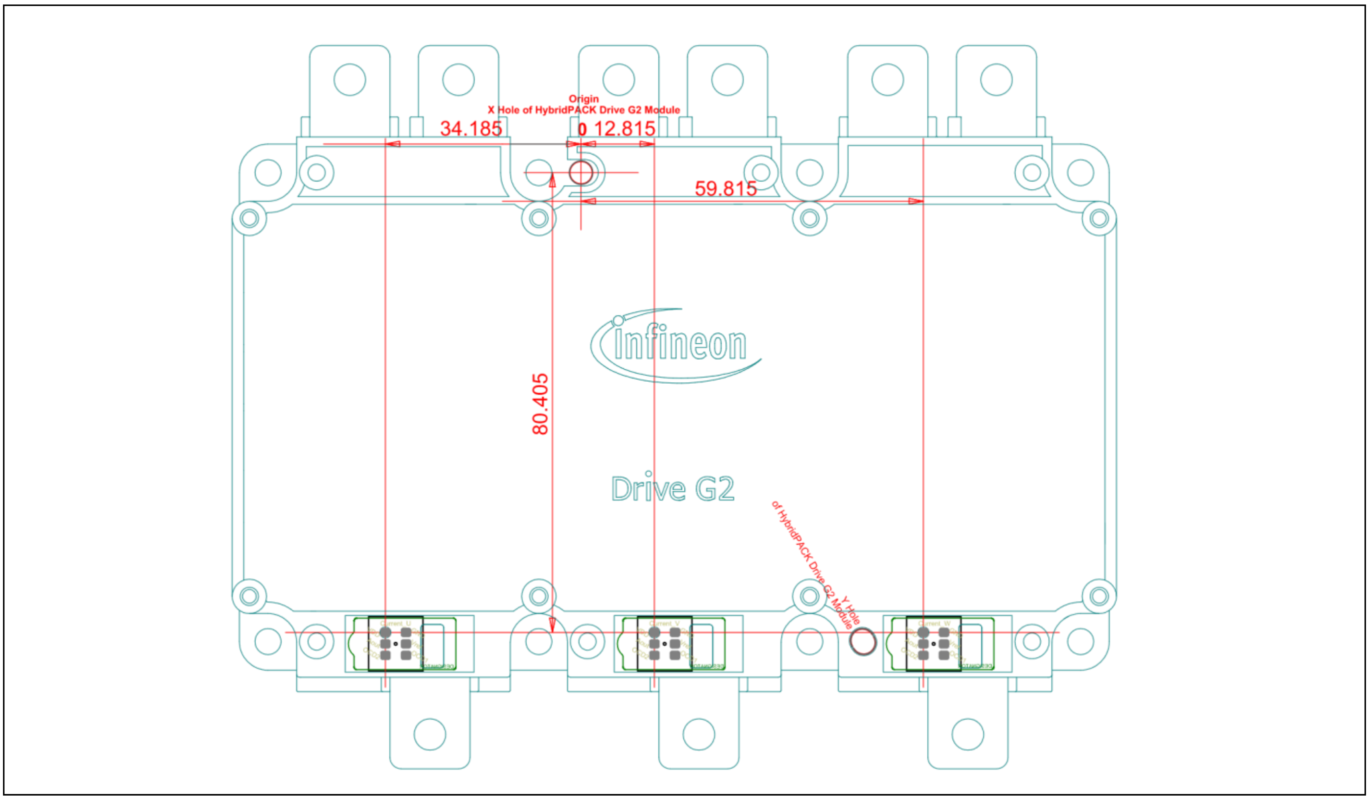


Figure 29 Sensor Integration Swoboda CSM510HP2x. PCB Footprint Recommendation.

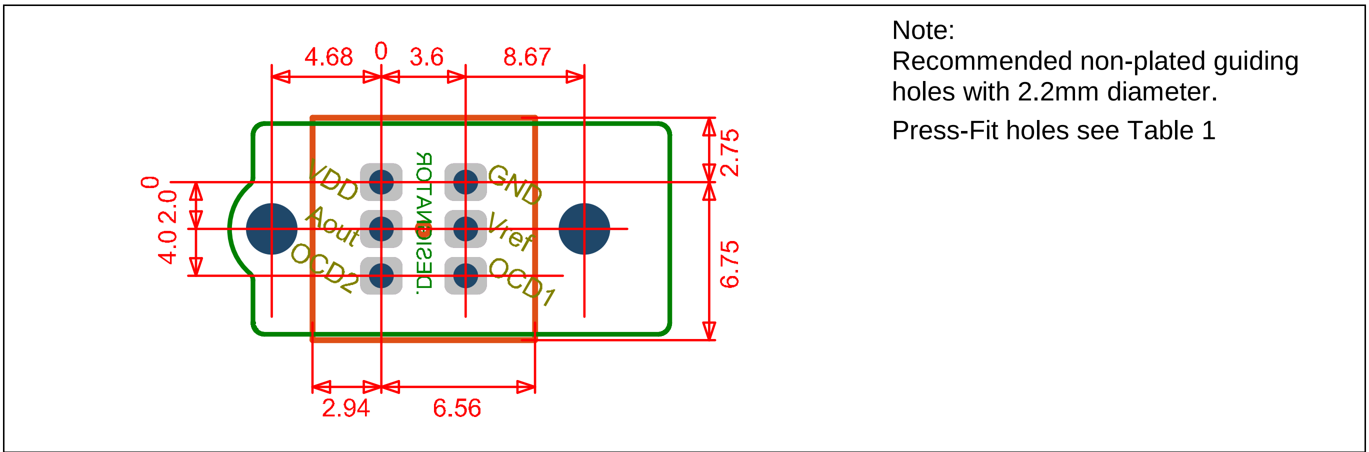


Figure 30 Sensor Integration Swoboda CSM510HP2x. PCB Footprint Recommendation.

10.1 System design guideline for magnetic parts close to the sensor

The phase current sensor detects differential magnetic field above and below the AC power tab. This differential field is caused by the current flowing in the AC tabs. Any magnetic parts in the nearfield of the sensor can disturb the sensor signal. Thus, it is important in system design to place magnetic parts not too close to the sensors.
The following system design guidelines should be followed in order to avoid unintended signal disturbances. The Figure 31 indicates the different location areas for component placement and Table 10 lists the examples of allowed*/restricted* parts in these areas.
**) The categorization of allowed and restricted parts in the areas is a non-binding recommendation based on best practice/experimental studies and has to be validated in the individual system design.*

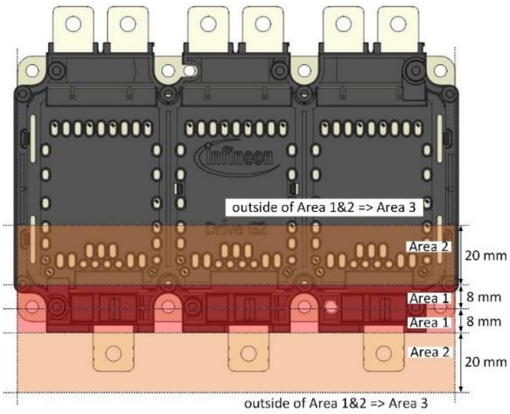


Figure 31 Area categorization in the surrounding of the sensor module. The area is indicated with dimensions in x-y but same dimensions can be applied to z direction (center is the AC Tab). Allowed/restricted parts in the individual areas are noted in Table 10.

Table 10 Allowed/Restricted parts close to the sensor. Area definition in Figure 31.

Area	Allowed Parts Examples*	Restricted Parts Examples*
1	All "non-magnetic" parts (plastics, aluminum, copper, etc) (PCB) Printed Circuit Boards with Cu traces Standard components on PCB like ceramic capacitors, resistors, ICs (opamps, LDOs, …) Baseplate fixing screws according to chapter 6 PCB fixing to the module according to chapter 7	Any kind of shields or other ferromagnetic parts like Ni plated busbars. Transformers, chokes with larger than 10 mm edge length. To be avoided: other screw types not recommended in this application note
2	All "non-magnetic" parts (plastics, aluminum, copper, etc) (PCB) Printed Circuit Boards with Cu traces Standard components on PCB including SMD chokes and transformers Baseplate fixing screws according to chapter 6 PCB fixing to the module according to chapter 7 Power tab screws/nuts according to chapter 8 or weld lines	Any kind of shields or other ferromagnetic parts should be avoided with exception: Cu busbars with Ni plating can be typically connected to the AC tabs in area 2. To be avoided: other screw types not recommended in this application note
3	All	none

10.2 Assembly process of the Phase Current Sensor

The phase current sensor modules can be assembled by two different concepts:

- The assembly concept via self-alignment on power module “rotation-bar” allows to put the sensors first into the power module and subsequent the gate driver board is aligned and pressed onto the power module. This concept is described more detailed in subsection 0.
- For the alternative concept via two-step press-in process, the sensors have to be pre-pressed into the gate driver board with an appropriate gap. In subsequent step, the gate driver board with pre-assembled sensors will be aligned and pressed onto the power module. The concept is described more detailed in subsection 10.2.2.

Independent of the applied assembly process, there is no need to adjust heights or tools when HybridPACK Drive G2 A7 or A8 with different AC tab thicknesses are used for wide range of inverter platforms. The rotation bar in the module is designed in such way that the co-developed differential Hall sensor is always positioned in correct z height. One sensor will fit to the entire HybridPACK™ Drive G2 platform, independent of the product derivate (A7 vs A8, voltage classes, current levels).

10.2.1 Sensor assembly via self-alignment on power module “rotation- bar”

The three sensors can be placed directly into the power module sensor pockets. The shape of the power module sensor pocket and the shape of the sensor modules prevent a wrong assembly orientation (i.e. poka-yoke). The self-alignment feature is demonstrated in Figure 32. Please note that Figure 32 uses a special modified power module with cut-out of the sensor pocket in order to make the sensor visible in this example. The sensor module was also special prepared for an over-scaled sensor tilt angle. This demonstrate the self-alignment feature at a scenario, which exceeds worst case tolerances.

A) It is normal for the sensor modules to be slightly tilted after they are placed into the power module sensor pockets. For illustration purpose an over-scaled extreme tilted example is shown.
B) The PCB is moved in z direction towards the power module and the highest alignment dome of the sensor modules touches the PCB.
C) The alignment dome of the sensor module slides on the PCB. At the same time, the sensor rotates on the power module rotation bar and the sensor alignment domes automatically align with the PCB holes.
D) The PCB is elf-aligned and all signal pins of the power modules and the sensors are located in the PCB holes. The press-tool further moves in the z-direction and applies the press-in forces to the part.
E) The press-in process it the stop criteria, where the PCB is in its final position located on the heatstake/screw domes.
F) The press-tool is released. The PCB and sensors are in the final position.

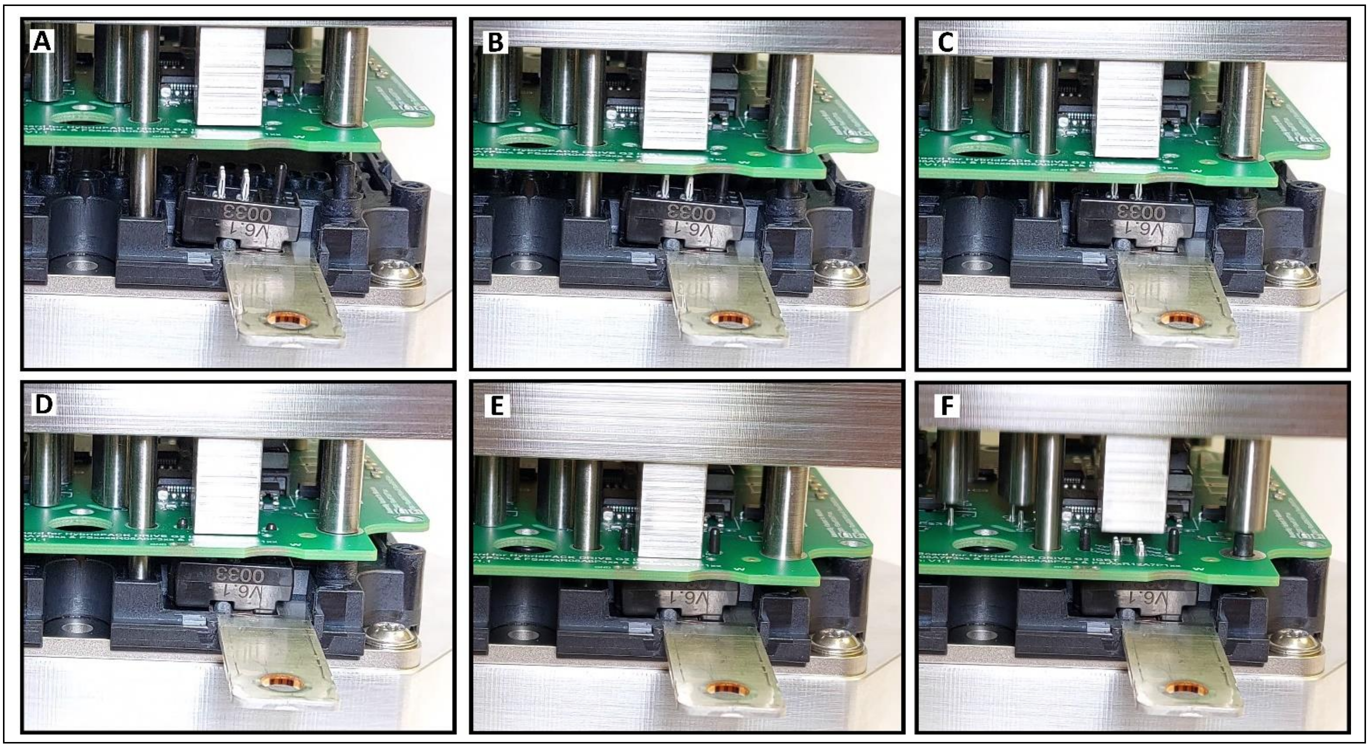


Figure 32 Sensor assembly option uses self-alignment on power module “rotation-bar”. Please note that the picture show an over-scaled extreme example for illustration purpose.

10.2.2 Sensor assembly via two-step press-in process

In this assembly concept the sensor modules are first positioned to the gate driver board and partially pressed-in with certain distance. The final press-in process is the second step.

10.2.2.1 Step 1: Pre-Press-in Process

Figure 33 illustrates the pre-press-in process

A) Example of a sensor pre-press-in bottom tool.
B) Positioning of the sensor modules on to the bottom tool.
C) The gate driver board is aligned by guiding domes in the bottom tool.
D) The gate driver board is already positioned on the sensors and all 18 sensor signal pins are in the PCB holes. The system is now ready for the pre-press-in.
E) The top tool is aligned and the press-equipment will perform a press-in with controlled way force method. The tools should have distance keepers in order to stop the press-process in such way that about 1mm gap between sensor and PCB is ensured.
F) Shows the status of the pre-pressed sensors in the PCB. The Press-Fit pins and sensors are not yet in the final position but the system has enough retention force for further handling (limited transport) purpose.

The two-step press-in process, described above, shows the pre-mounting of three phase current sensors simultaneously. It is also possible to use a pre-press concept by smaller tools, where only one sensor is pressed-in at a certain distance (e.g. by robot or manual with handling tools).

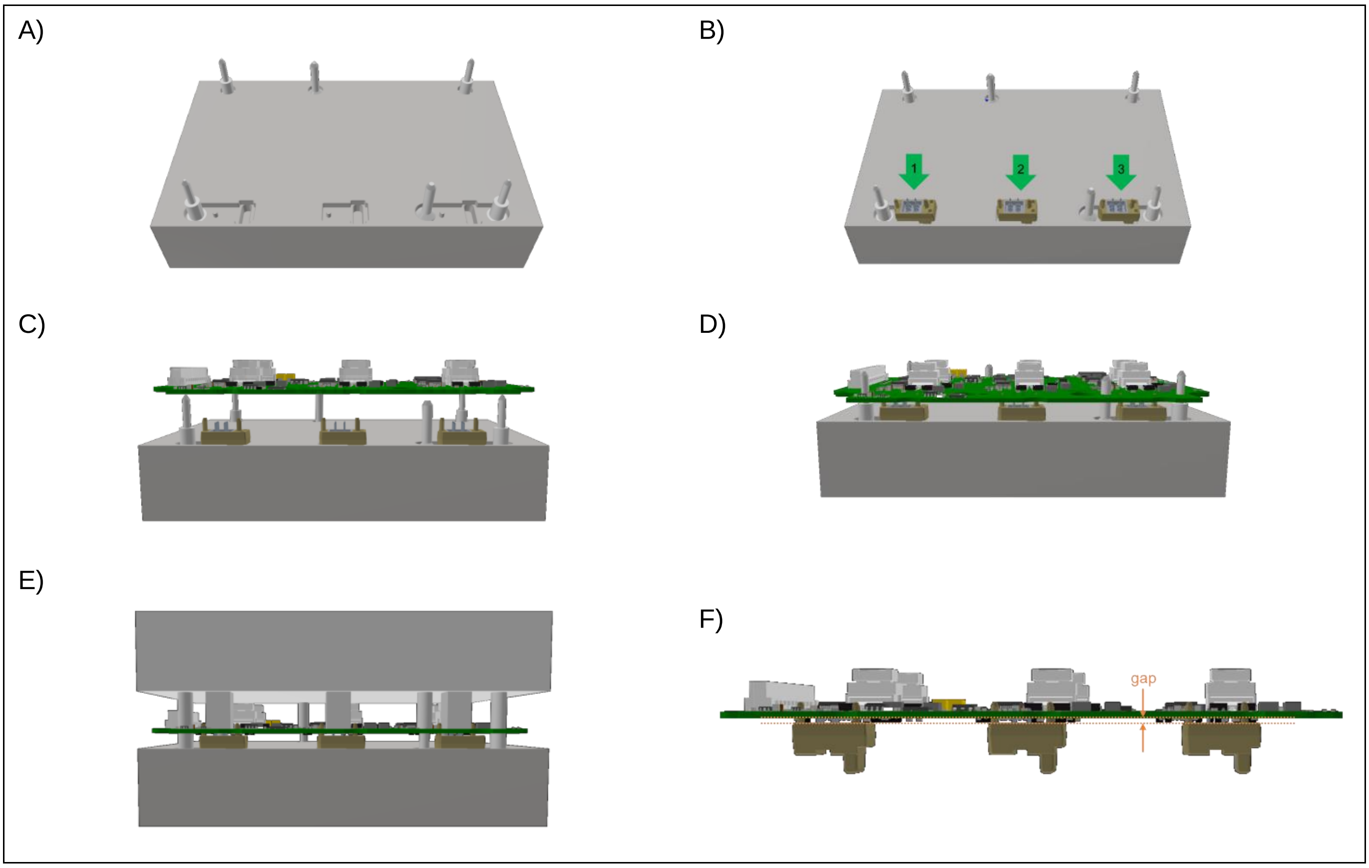


Figure 33 Sensor to PCB pre-press-in process (Example).

10.2.2.2 Step 2: Final Press-in Process

Figure 34 illustrates the final press-in process

A) The gate driver board with the pre-assembled sensors are aligned with the power module. Please see section 3 for detailed information about PCB to module alignment.

B) The gate driver board including the sensors are pressed onto the module. See section 4.3 and 4.4 for more details. The sensors will position automatically to their correct final position, during this process. A press-in curve with the 3 phase current sensors is included is also shown in Figure 12.

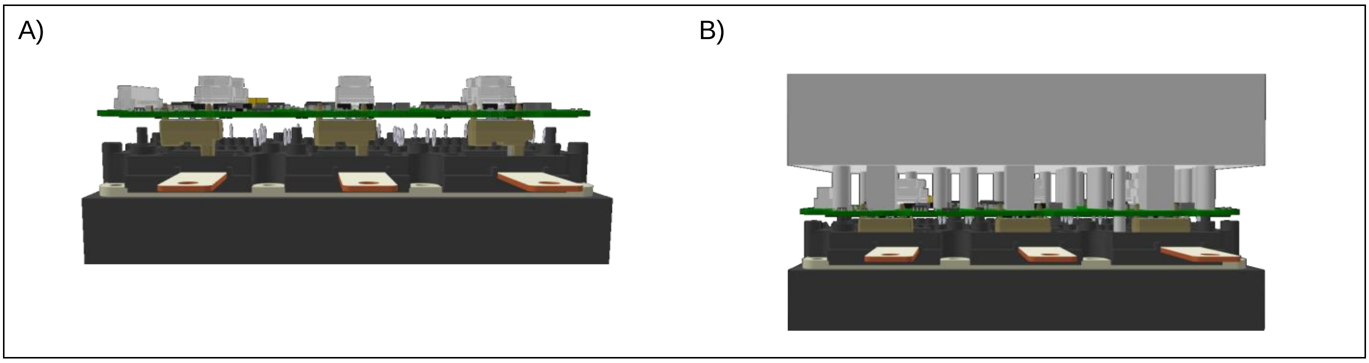


Figure 34 PCB with pre-assembled sensors pressed onto the module. The sensors will position automatically into their final correct positions due to the power module “rotation bar”.

10.3 Information about typical sensor parameters

This section should not be understood as product specification of TLE4973 sensor chip and/or the Swoboda sensor module. The following table and information will give a short overview about typical settings in the use case of the HybridPACK™ Drive G2 power module.

- Typical current rail transfer factor to Hall sensor: **12.5 uT/A**

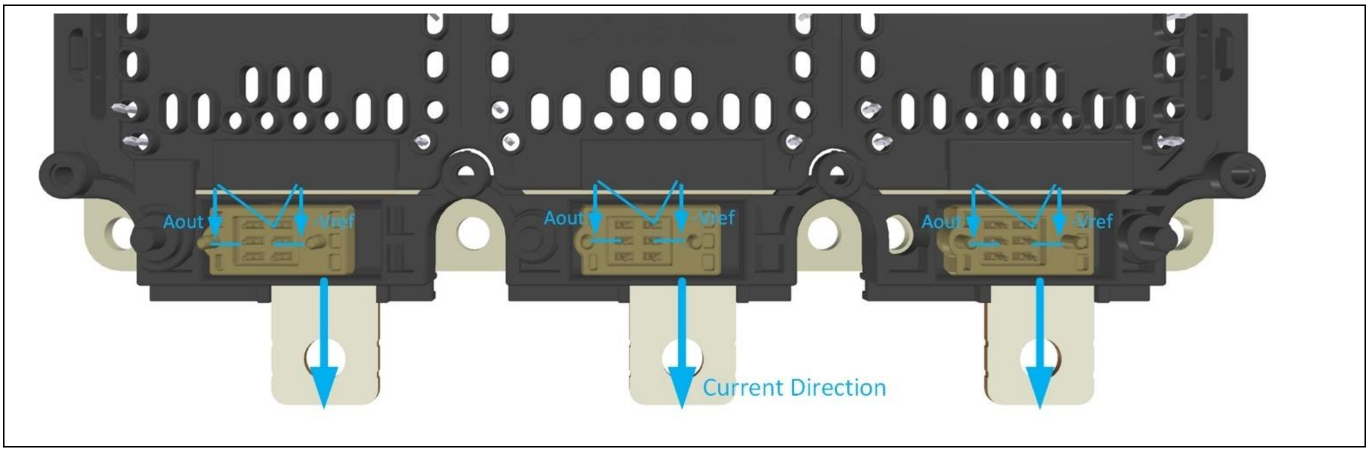


Figure 35 A positive current in direction as shown in the picture lead to positive output voltage swing at the Aout pin and in case of full differential mode at same time to negative output voltage swing at the Vref pin.

Table 11 Typical measurement ranges with Swoboda CSM510HP2S or CSM510HP2D sensor modules. This is only an extract of the most common parameter sets to be used with HybridPACK Drive G2 power modules.

Measurement Range (Full Scale)	Sensitivity Range (Programmable)	Sensitivity (S)	Gain 1/S Fulldiff (Semidiff) Mode	Over Current Detection (OCD) threshold setting. (Setting: Current Threshold)
± 567 A	S6 (Code 24)	3.17 mV/A	158 (315) A/V	6: ±678 A 10: ±901 A 14: ±1125 A 18: ±1348 A 22: ±1571 A 26: ±1795 A 30: ±2018 A 34: ±2241 A 38: ±2465 A 42: ±2688 A 60: ±3693 A
± 756 A	S5.5 (Code 18)	2.38 mV/A	210 (420) A/V	
± 850 A	S5 (Code 16)	2.12 mV/A	236 (472) A/V	
± 972 A	S4.5 (Code 14)	1.85 mV/A	270 (541) A/V	
± 1134 A	S4 (Code 12)	1.59 mV/A	314 (629) A/V	
± 1361 A	S3.5 (Code 10)	1.32 mV/A	379 (758) A/V	6: ±1695 A 9: ±2114 A 11: ±2393 A (default) 12: ±2532 A 30: ±5045 A 57: ±8814 A
± 1701 A	S3 (Code 8) Default setting	1.06 mV/A	472 (943) A/V	
± 2268 A	S2 (Code 6)	0.79 mV/A	633 (1266) A/V	

11 Traceability, Data Matrix and Part Markings

Traceability of materials, equipment and processes is a must for key automotive components. Therefore, the HybridPACK™ Drive G2 power modules are produced at Infineon in a seamless traceability environment. Nevertheless, traceability must not be aborted after the modules are shipped to the customer and assembled into the inverters. In order to reap the full benefit of a traceability chain, the unique module number (module ID) should be linked to the inverter ID at customer side.
Figure 36 shows the module labels and where to find the DMX-code necessary for tracing the module-ID.

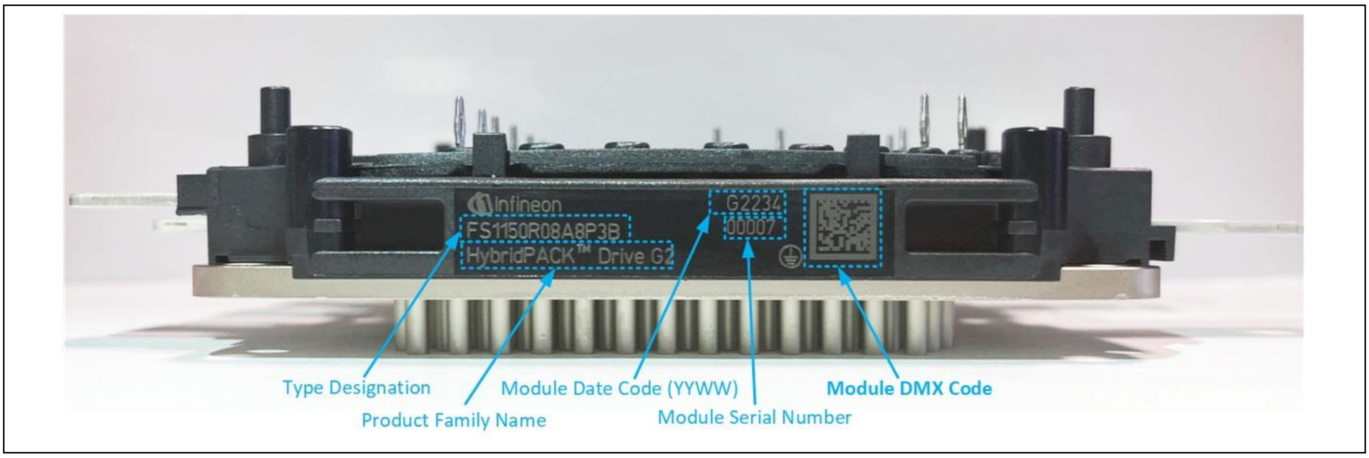


Figure 36 Picture of module labels (typical appearance). For a seamless traceability the DMX code which is the module ID (or alternative the type designation + date code + serial number) should be recorded and linked to the inverter ID.

The DMX code is readable with all professional data matrix code scanners compatible to the IEC24720 and IEC16022 standard.

The content of the 23 digit code is as follows:

Example:	00007	049704	81592881	22	34
	Serial No	Material No	Production Order No	Datecode Year	Week

Engineers in the lab can also use free DMX code reader apps on their smartphones.
Android: QR Extreme, QR Droid, and many others supporting data matrix codes.
iOS: i-nigma QR, and many others supporting data matrix codes

Remark: Only productive parts without _ENG label have full traceability implemented. Prototypes and Engineering Samples can have different part markings and have depending on development status none or just parts of the traceability measures implemented.

11.1 Traceability of the shipping boxes (trays)

The Figure 37 show an example of the typical HybridPACK™ Drive shipping boxes (called tray). A full tray contains six power modules. The power module gripper pockets are well accessible and should be used to pick the modules out of the boxes. The tray label codes are shown in Figure 38 and the most relevant codes which can be used for traceability are explained in following.

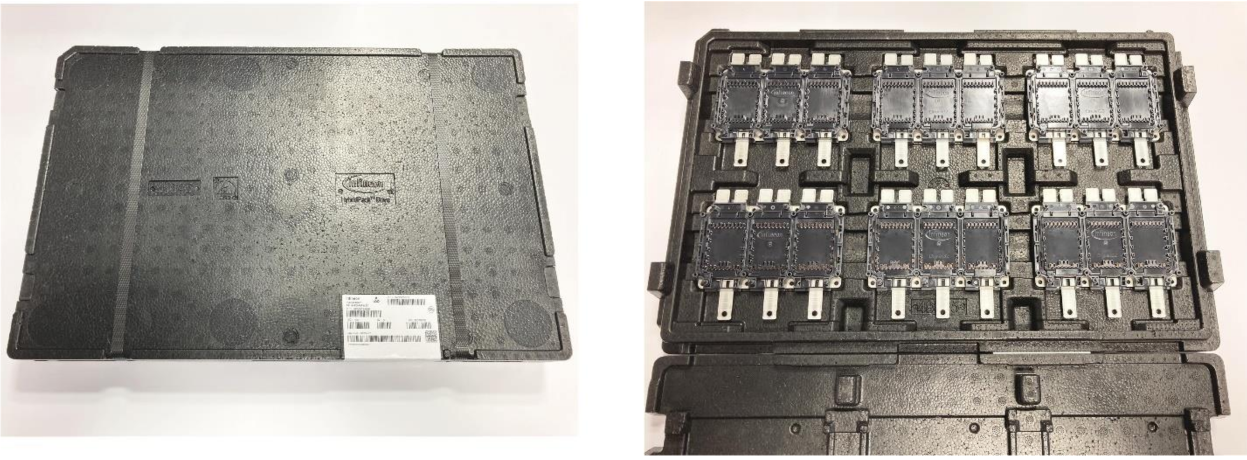


Figure 37 Typical appearance of the power module trays (shipping boxes). The full tray contains six HybridPACK Drive G2 power modules.

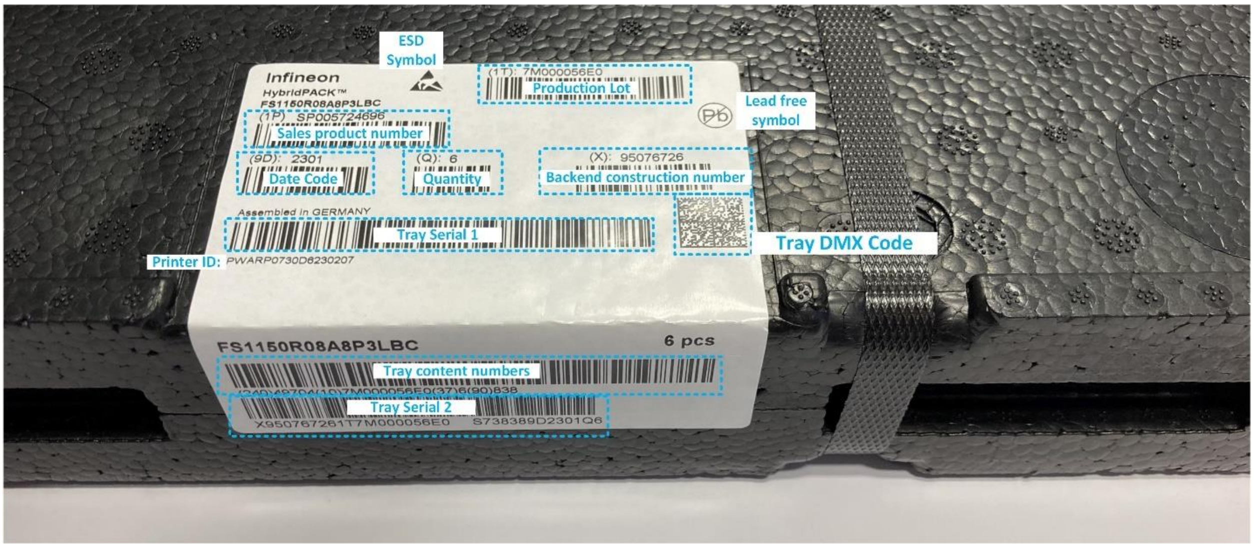


Figure 38 Tray label (typical appearance).

Date code: has the format YYWW (YY year, WW week of production)

Tray Serial 2: This number is the preferred option for traceability measures as it is readable also if trays are stored in a stack. The number is a composition of the backend construction number, the production lot, the tray serial number, the date code, and the quantity. In this example it contains the following data: X95076726 1T7M000056E0 S738389 D2301 Q6.

Tray Serial 1: This number can be used for implementation of traceability measures. However, this barcode may be sometimes not readable e.g. if several trays are stored in a stack. The number is a composition of the backend construction number, the production lot and the tray serial number. In this example it contains the following data:
X95076726 1T7M000056E0 S73838.

Tray DMX code: This number can be used for implementation of traceability measures, however it is not readable when trays are stored in a stack. The DMX code on the tray is a composition of all numbers stored in the other bar codes. In this example it contains the following data (not relevant data is indicated with “#”):

Δ## X95076726 1T7M000056E0 9D2301 Q6 1PSP005724696 ### ### ####FS1150R08P3LBC##### S73838Δ
Backend construction number - production lot – date code - quantity - sales product number – product name (type designation) - tray serial number.

11.2 Traceability of the Phase Current Sensor Modules CSM510HP2x

The phase current sensor modules from [9] have a 14x14 DMX code printed on the package. This code contains a 16-digit bijective number, which can be used for traceability of the package. The sensor has the TLE4973 chip implemented, which has a bijective Chip ID number stored and is readable via the DCDI protocol from the Microcontroller. Please refer to the product datasheet of the TLE4973 for more information.

Figure 39 Tray label (typical appearance).

12 Technical Drawing - Pin Position & Pin Gauge

The HybridPACK™ Drive G2 power modules specifies the signal pin positions by gauge test (see corresponding product datasheets). The gauge test ensures that pin positions as well as heat stake dome positions in power module delivery state mates with customer printed circuit boards (PCB).
The hole pattern specification of the pin gauge is shown in Figure 40. The signal pin pattern is adjusted to IGBT or SIC MOSFET power modules but principle hole pattern spec from the drawing will remain same. The real production equipment might have different appearance but hole pattern and test method remain the same as shown here. The two 4 mm holes defining the coordinate system is only a marker of the power module coordinate system. The gauge is aligned by the heat stake domes to the power module. The parts are tested at the Infineon power module production line, if pin gauge can be applied to the module. A low force in module z-direction on the gauge is allowed (typical up to 10..20 N, which is uncritical for the module and its pins). When the pin gauge can be smoothly attached to the module the test is rated as PASS.
The basic description of the test and pin gauge specification is placed only for information how these modules are tested at Infineon production. It is not needed at customer side to test power modules at incoming inspection again.

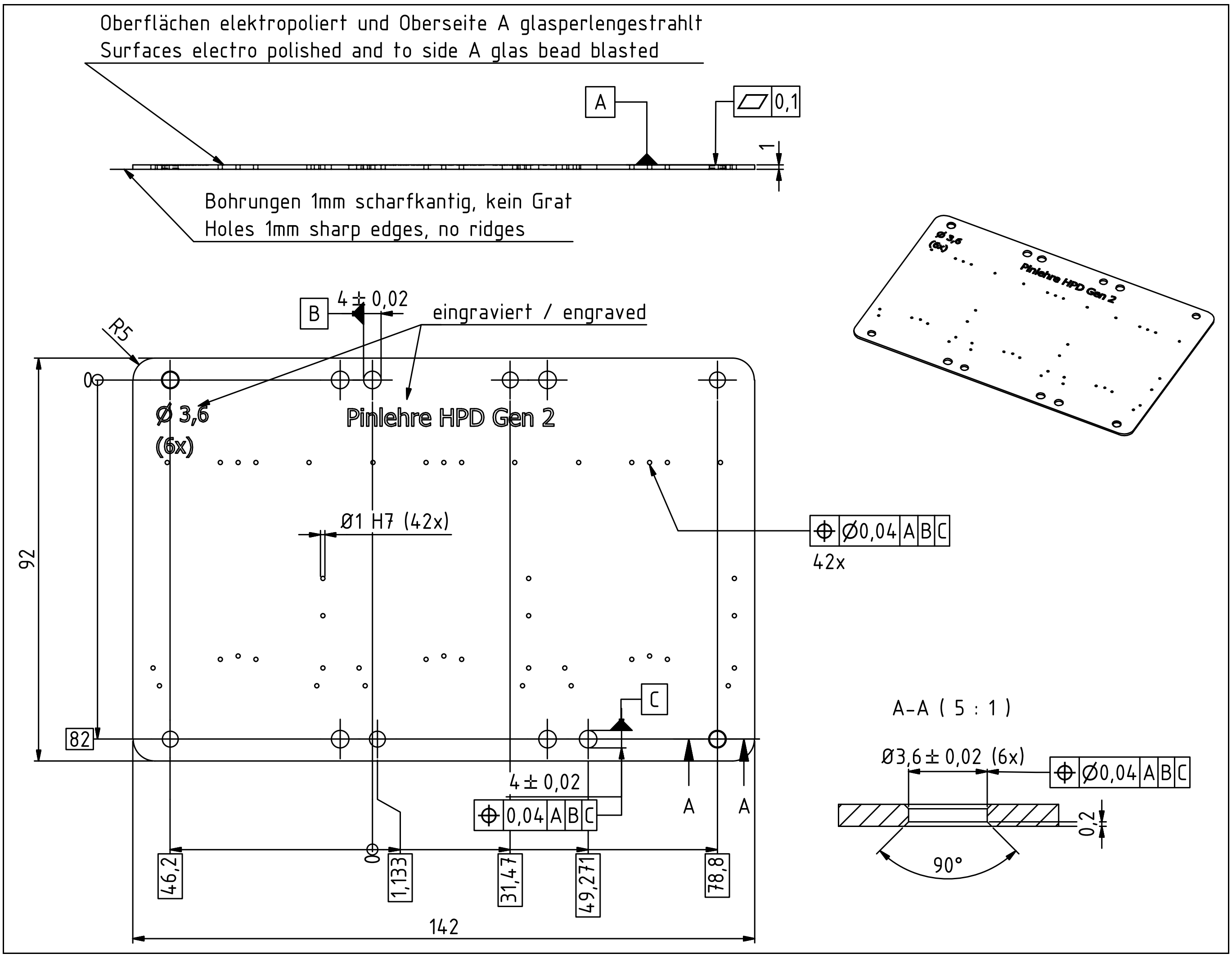


Figure 40 Hole pattern specification of pin gauge. Hole pattern can be adjusted for another signal pinning (e.g. IGBT module vs SIC MOSFET module) with same hole size spec.

13 Storage, Transport and Handling

During transport and storage of the modules, extreme forces through shock or vibration have to be avoided as well as extreme environmental influences. Storage of the modules at the limits of the temperature specified in the datasheet is possible, but not recommended. The recommended storage conditions are described in [1].

Pre-drying of the power module prior to the press-in process (as is recommended for molded discrete components, such as microcontrollers, TO-cases etc. designed for solder processes) is not required for the HybridPACK™ Drive G2 power modules.

For power module handling the implemented gripper pockets should be used (see Figure 41 and product datasheet package outline drawings). These 3 mm deep pockets are implemented in a functional uncritical area. If it happens at all, abrasion or scratches from handling has in this gripper pocket area no influence on the power module function. Gripper tools can be designed as tight fit and do not need much clamping force for handling the modules. Clamping forces of <20 N on each pocket is regarded as a very safe value.

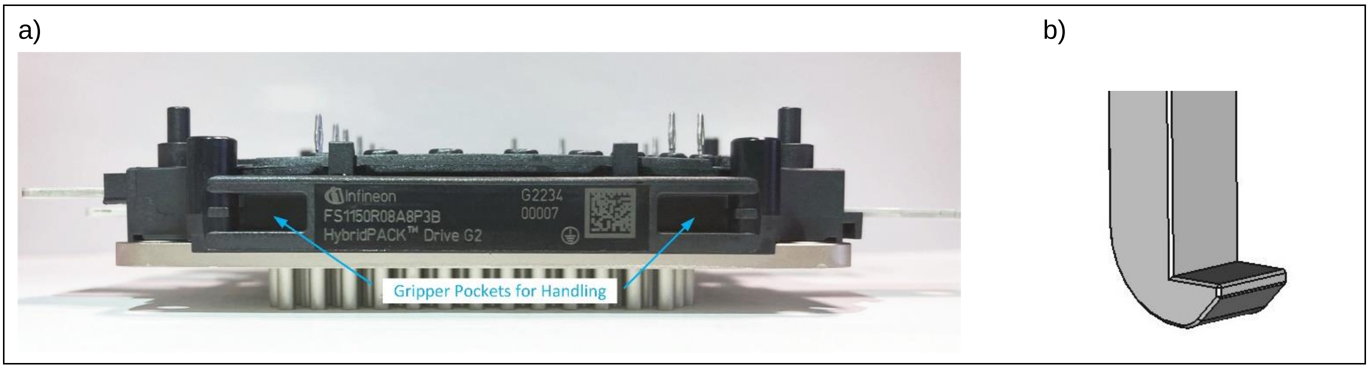


Figure 41 Gripper pockets for power module handling (a). Typical handling gripper design principle view (b).

14 Power Module Appearance

This chapter explains frequent questions about the typical power module appearance.

14.1 Power Tab Tin Plating

The power tabs are made of copper with a partial tin plating. The plating has the role to avoid visual discoloration and oxidation of the copper between power module production and the mounting processes. After assembly, the tin plating has no function and the contact resistance is the same as an un-plated pure copper power tab. In order to provide the maximum possible compatibility to various connecting techniques like screw type connections, clinching and welding, it is mandatory to make the plating as soft as possible. Due to the desired compatibility and the required softness, visible scratches and/or not completely over-plated edges due to the stamping process are of logical consequence (i.e. partial plating) and is no reason for an objection as it does not influence the product performance or quality.

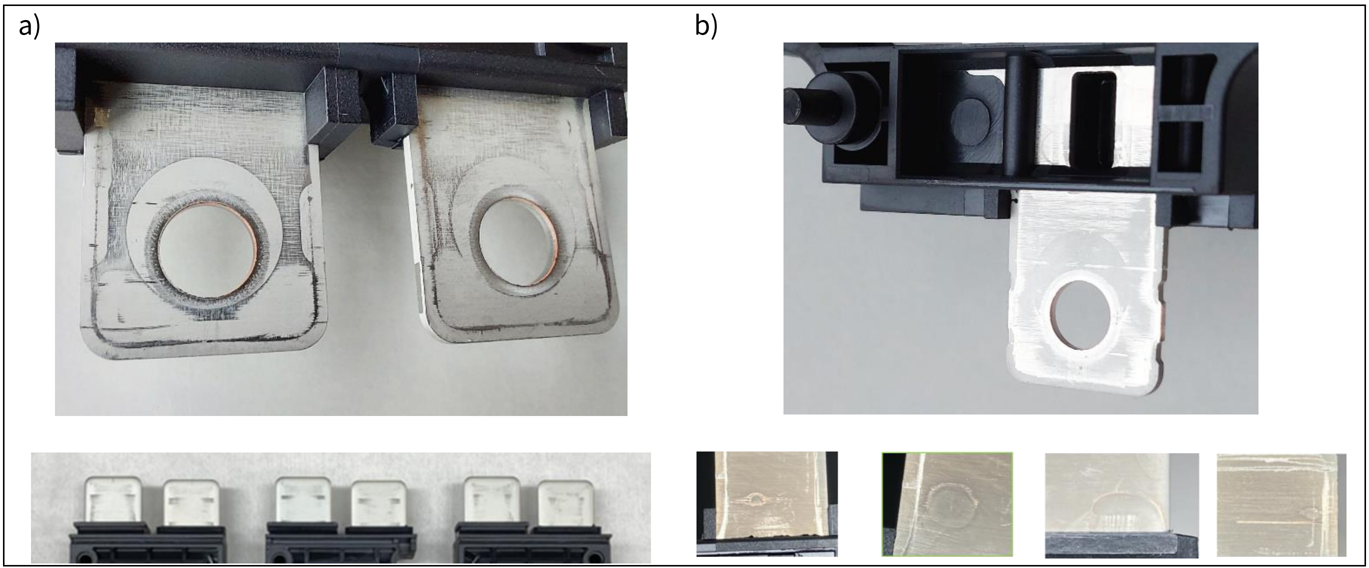


Figure 42 Typical appearance of the copper power tabs, which have a very soft tin plating and provides maximum compatibility to different mounting processes.

14.2 Baseplate Surface

A typical appearance of the baseplate surface is a so called “marbling” or “white spots” structure. This structure can be observed after the galvanic nickel and its cleaning process of the baseplates. The roughness of the baseplate, the chemical structure as well as the thickness of the Ni layer is not different to baseplates where this structure is not visible by naked eye. Such an appearance as shown in the Figure 43 is a normal appearance and is no reason for an objection as it does not influence the product performance or quality.

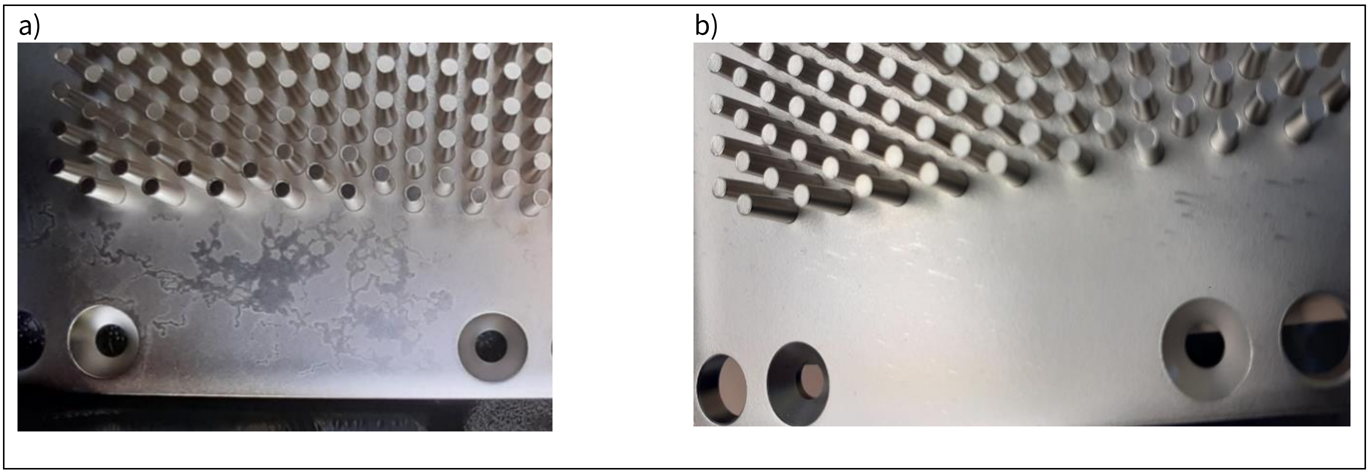


Figure 43 Typical appearance of power module baseplate surface with a “marbling” or “white spots” structure.

15 References and Revision History

The referenced application notes can be found at http://www.infineon.com

[1] Infineon Technologies AG, "Storage of Products Supplied by Infineon Technologies", Application Note, V7.0 Jun 2018.

[2] Harting Technology Group, http://www.harting.com

[3] Freudenberg Sealing Technologies, http://www.fst.com

[4] Infineon Technologies AG, "AN-PLASTIC-COOLER", Application Note, V7.0 Jun 2018.

[5] Erwin Quarder Gruppe, „HybridPACK Drive Kunststoff Kühler", https://www.quarder.de/produkte-technologien/hybridpack-drive-kuehler/

[6] Copper Development Association, "Welding copper and copper alloys", http://www.copper.org/publications/pub_list/pdf/a1050.pdf

[7] Trumpf Laser- und Systemtechnik GmbH, https://www.trumpf.com

[8] Hartmann Feinwerkbau GmbH, http://www.hartmann.gs/english

[9] Swoboda Technologies, https://www.swoboda.com/en/products-solutions/product-overview/current-sensors

Revision History

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