

Application Note

HybridPACK DSC

About this document

This application note contains information on HybridPACK™ DSC regarding assembly and mounting instructions

Scope and purpose

The HybridPACK™ DSC module has an optimized geometry for enhanced thermal conductivity. In order to utilize this module properly, it is relevant to understand the properties of the module. The application note gives explanations on mounting and assembly of the module. Furthermore, it gives guidance on how to design the printed circuit boards with the correct module tolerance.

Intended audience

Engineers and operators involved in developing a system using the HybridPACK™ DSC power module.

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1 Introduction to HybridPACK™ DSC Power Module

The trademark of **HybridPACK™ DSC** covers molded IGBT power module devices which have bi-directional paths for heat-dissipation by so called double side cooling technology.

The HybridPACK™ DSC-S and HybridPACK™ DSC-L are two different types of the **HybridPACK™ DSC** categorized by the size, number of the switches and their internal structure.



a) HybridPACK™ DSC-S		b) HybridPACK™ DSC-L	
			
		HybridPACK™ DSC-S1 & S2	HybridPACK™ DSC-L
		- FF400R07A01E3_S6 (DSC-S1) - FF450R08A03P2 (DSC-S2)	- FS200R07A02E3_S6
Dimension [Length x width x height] - pin / terminal excluded	42.0 x 42.4 x 4.7 [mm]		86.0 x 43.0 x 6.0 [mm]
Module configuration	Half-bridge		Six Pack (B6)
Power rating	700V / 400A (DSC-S1) 750V / 450A (DSC-S2)		700V / 200A
Additional feature	On-chip temperature sensor On-chip current sensor		2 x NTC On-chip Current sensor

Figure 1: a) HybridPACK™ DSC-S and b) HybridPACK™ DSC-L.

2 Assembly instructions

An adequate integration of the heatsink is a basic condition to use the HybridPACK™ DSC module properly.

The fundamentally different construction in both DSC-S&L packages requires a different approach for designing and assembling a heatsink. Therefore, a consideration on following points is strongly recommended as a starting point:

- Mechanical feature of the heat sink
- Application of thermal interface material
- Choosing a proper clamping concept
- Creepage and clearance coordination

2.1 General requirements on the heatsink

The power loss occurring in the module has to be dissipated in order to avoid exceeding the maximum permissible chip function temperature specified in the datasheet during switching operation ($T_{vj_op} = 150\text{ °C}$ continuously and $T_{vj_op} = 175\text{ °C}$ during short time). Therefore, the design of cooling the system/heatsink is of great importance to achieve the target performance.

The purity condition of the surface in the area where the module has contact with heatsink is also essential, as this interface has decisive influence on the heat transfer of the entire system. Therefore, it is essential to keep the contact surface of the module and heatsink free from any particle contamination.

Additionally, special care has to be taken concerning the isolation distance between the module pins and heatsink for the HybridPACK™ DSC, due to the thin and compact construction of the module.

It is strictly recommended to limit the width of the heatsink and substrate contact area to ensure sufficient isolation coordination (e.g. based on IEC 60664-1)

Module type	Contact surface quality	Restriction of heatsink width
HybridPACK™ DSC-S	Surface flatness $\leq 50\text{ }\mu\text{m}$ Surface roughness $R_z \leq 10\text{ }\mu\text{m}$	$29\text{ mm} < \text{heat sink width} < 31\text{ mm}$
HybridPACK™ DSC-L	Surface flatness $\leq 50\text{ }\mu\text{m}$ Surface roughness $R_z \leq 10\text{ }\mu\text{m}$	$23\text{ mm} < \text{heat sink width} < 31\text{ mm}$

Table 2.1: recommended contact surface quality and heatsink width

In case that a wider heatsink is required, an additional design-countermeasure (e.g. adding step structure) or additional component (e.g. isolation pad) must be considered for the isolation.

As shown in Figure 2, the width and geometry of the heatsink determines the critical creepage and clearance distances.

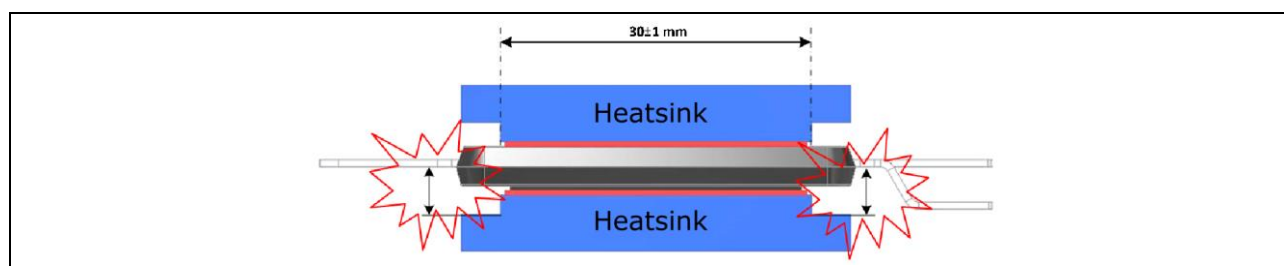


Figure 2: HybridPACK™ DSC with the top and bottom heatsinks

2.2 Application of thermal interface material

To dissipate the losses from the module and to achieve a good heat flow into the heatsink, all localised cavities of the modules have to be filled with a thermal compound. When using a heat conductive paste, a homogeneous application needs to be guaranteed.

An uniform layer of thermal paste over the top and bottom pads will fill all cavities and will at the same time not prevent any metallic contact between the exposed module surface for cooling and the heatsink surface. A compound should be selected which shows permanently elastic features in order to ensure a continuously favourable heat transfer conductance. The paste should be applied in a way that no screw holes are contaminated and that bolt torques are not affected.

Infineon recommends to use the OSR-500 thermal grease specified in Table 2-2 which is the same used on the evaluation kit of the DSC Modules. Basically, The thermal grease with high thermal conductivity is recommended. Also, the thinner the Bond-line thickness the lower the thickness of thermal paste required to achieve better thermal performance. However, the module and cooler flatness along with roughness have to be taken into account in order to choose the appropriate thickness of the thermal paste.



Name	Thermal conductivity	Insulation	Minimum Bond-Line Thickness(BLT)	Operating Range	manufacturer
OSR-500	3 W/mK	Yes	60um	-40 / +200°C	
G790	3 W/mK	Yes	10um	-40 / +200°C	

Table 2.2: information on the thermal grease for the reference system

The mechanical drawing shown on Figure 3 is an example of pattern to apply the thermal paste on the cooler. Using common rollers or fine toothed spatulas on the pattern will create an uniform layer of thermal paste of the Module. Infineon recommends to use a pattern of **150um** thickness in order to guarantee a perfect contact between the module, thermal paste and the cooler.

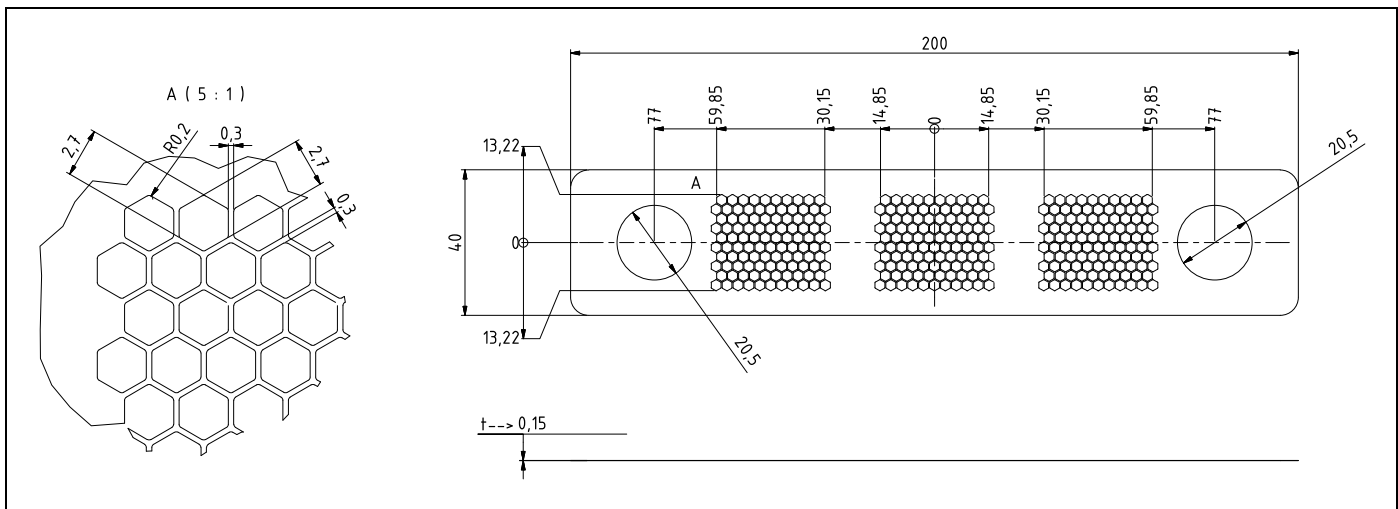


Figure 3: Recommended Pattern for the thermal grease

2.3 Mounting force coordination (compressive force)

The HybridPACK™ DSC is designed to be pressed by the heatsink in the application. The overall thermal performance of the system is influenced by the clamping force.

The higher the clamping force until a certain range, the better the overall thermal performance. According to the characterization of the module, the required compression force range is located between 400N to 800N.

On the other hand, too high clamping force can produce internal stress and reduce the life time of the module. To avoid any unnecessary high compression force, the following limits in Table 2-2 have been introduced.

The compression force above this point will not improve the thermal performance anymore, but will increase the stress to the module. To protect the module from an overcompression force, it is strongly recommended to follow the recommendations of Table 2-2 .

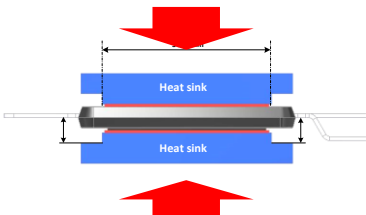
	mounting force reference (data sheet value)	Maximum allowed Mounting force	Mounting force local (One time)
	700 N	≤ 850 N	≤ 150 MPa

Table 2-2: Typical clamping force coordination

Exceeding the maximum values specified in Table2-2 leads to a reduced power module lifetime.

2.4 Interconnection: power terminal and signal pin

This section provides further details regarding the power terminals along with the signal pins.

		Signal Pin	Power Terminal
	Tolerance	y-axis: $\pm 0,4$ mm z-axis: $\pm 0,4$ mm	y-axis: $\pm 0,4$ mm z-axis: $\pm 0,4$ mm
	Type	Solderable Pin	Screwing M4 / M5 screw
	Tightening torque	N.N	≤ 4 Nm
	Coating	Sn Plated	Sn Plated
	Bending force	N.N	X,Y,Z ≤ 80 N
	Endhole size PCB	Typ. Φ 1,6 mm	Φ 6.0 mm

Figure 4: HybridPACK™ DSC power and signal pin

Besides, the special taper shape at the end of the signal pin guides the PCB for easy assembly.

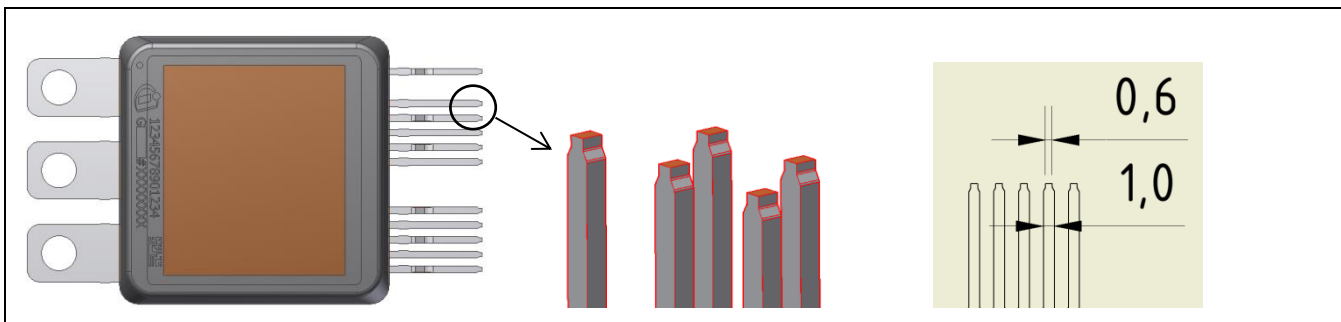


Figure 5: HybridPACK™ DSC power and signal pin

2.4.1 Mounting options for the power terminal

The copper power tabs are tin-plated and are thus well suited for screw type connections including clinch processes as well as welding processes.

Several mounting options are suitable. It is possible to have the following stack order:

screw – power tab – busbar – nut (Figure 6 Opt. 1),

nut – power tab – busbar – screw (Figure 6 Opt. 2),

In these examples, the busbar is always a single part/sheet, but also two or three busbar sheets are possible to be mounted in the stack and thus it is also possible to have instead of the screw head/nut only busbars as a direct interface to the power tabs:

e.g. screw – busbar - power tab – busbar – nut.

Further beneficial mounting options are given by the use of self-clinching nuts. Standard M4 self-clinching nuts can be used in mounting holes designed for M5 screws. Thus, a M4 self-clinching nut can be pressed into the power tab hole and busbars can be connected with a M4 screw (preferably the same screw type as used for mounting the baseplate to the cooling system).

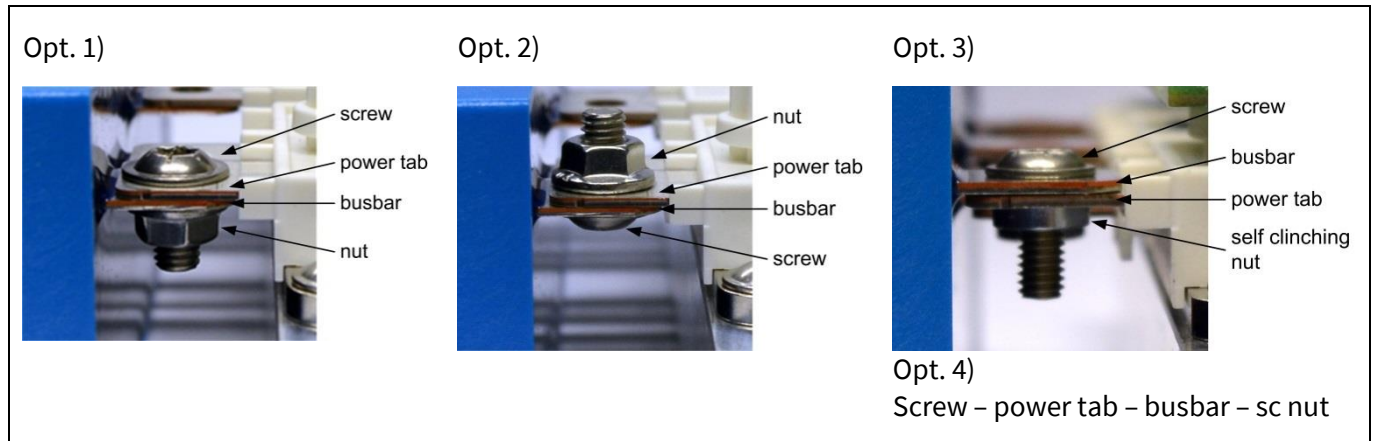


Figure 6: Examples of power tab connection options

Mounting Option	Screw/Nut type	Mounting torque			Remarks
		min.	typ.	max.	
1,2	M5 ISO 4762 screw (M5 ISO 7090 washer) M5 ISO4032 nut	3.6 Nm	4.0 Nm	4.4 Nm	low volume production & lab testing
1,2	M5 ISO 7380-2-A2-(TX) screw M5 ISO6923 nut	3.6 Nm	4.0 Nm	4.4 Nm	low volume production & lab testing
3	M4 ISO 7380-2-A2-(TX) M4 self-clinching nut e.g. “TR-S-M4-1” PEM “S-M4-0ZI”	1.8 Nm	2.0 Nm	2.2 Nm	Low to high volume production & lab testing
4	M5 ISO 7380-2-A2-(TX) screw M5 self-clinching nut	3.6 Nm	4.0 Nm	4.4 Nm	Low to high volume production & lab testing
5	welding	-	-	-	high volume production

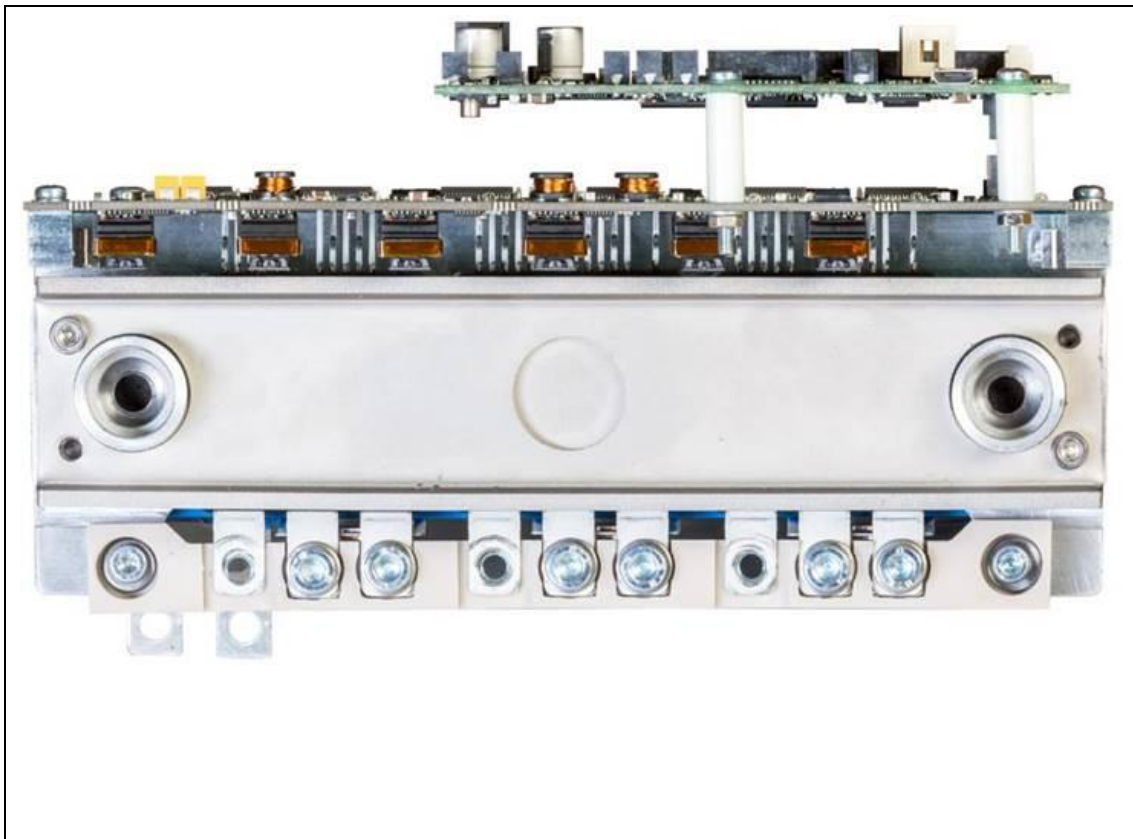
Table 2-3: Power tab mounting options and recommended screw torque

The screw types in Table 2-3 give only a rough overview. Different types may be possible with same mounting torque in case the base of the head or the spot face are comparable to the given types and the busbar material is suitable for such mounting.

2.5 Assembly of the reference heatsink

The HybridPACK™ Double Side Cooling itself gives only an indication that two heatsinks are necessary. The concrete shape and interconnection of the heatsinks are dependent on the system construction.

There is no single instruction for mounting which can cover all possible case profiles. Therefore, one example system design is introduced to give a reasonable example for the application of HybridPACK™ DSC.



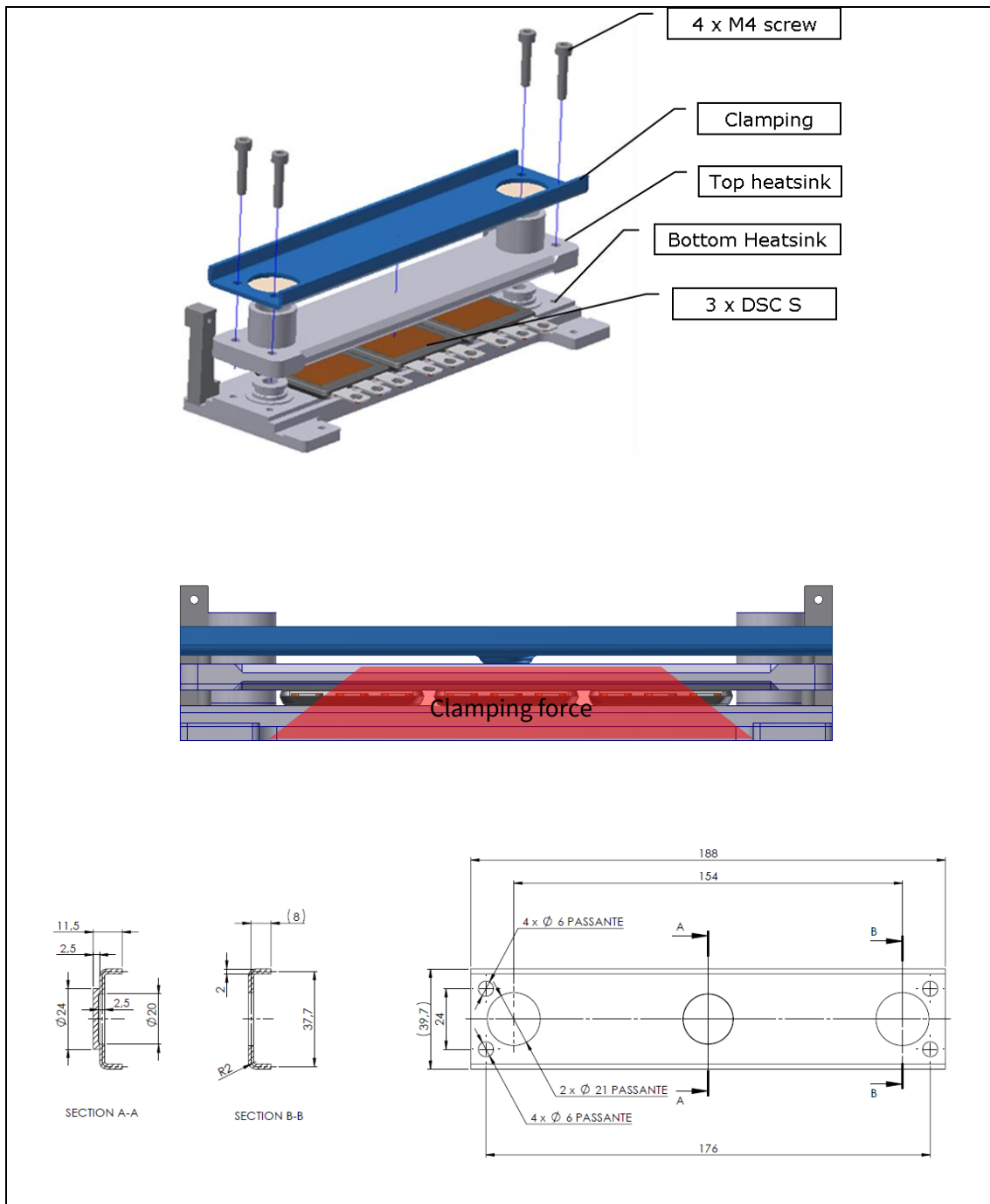


Figure 7: Example of heatsink mounting (top: direct screwing, bottom: with clamping part)

In the example of Figure 7, clamping is realized by the additional clamping part placed on top of the heatsink(highlighted in blue). The advantage of using an additional clamping part is that the clamping force is evenly distributed from the side to the middle of the DSC Row. Therefore, it avoids to have any gap after screwing, between the heatsink and the top/bottom of the dsc modules which could have a bad impact on the thermal performance of the DSC component placed in the middle.

While screwing the heatsink using 4xM4 screws like depicted in Figure 7, please refrain to screw with a torque higher than **1.7 Nm** to avoid any damages on the threads.

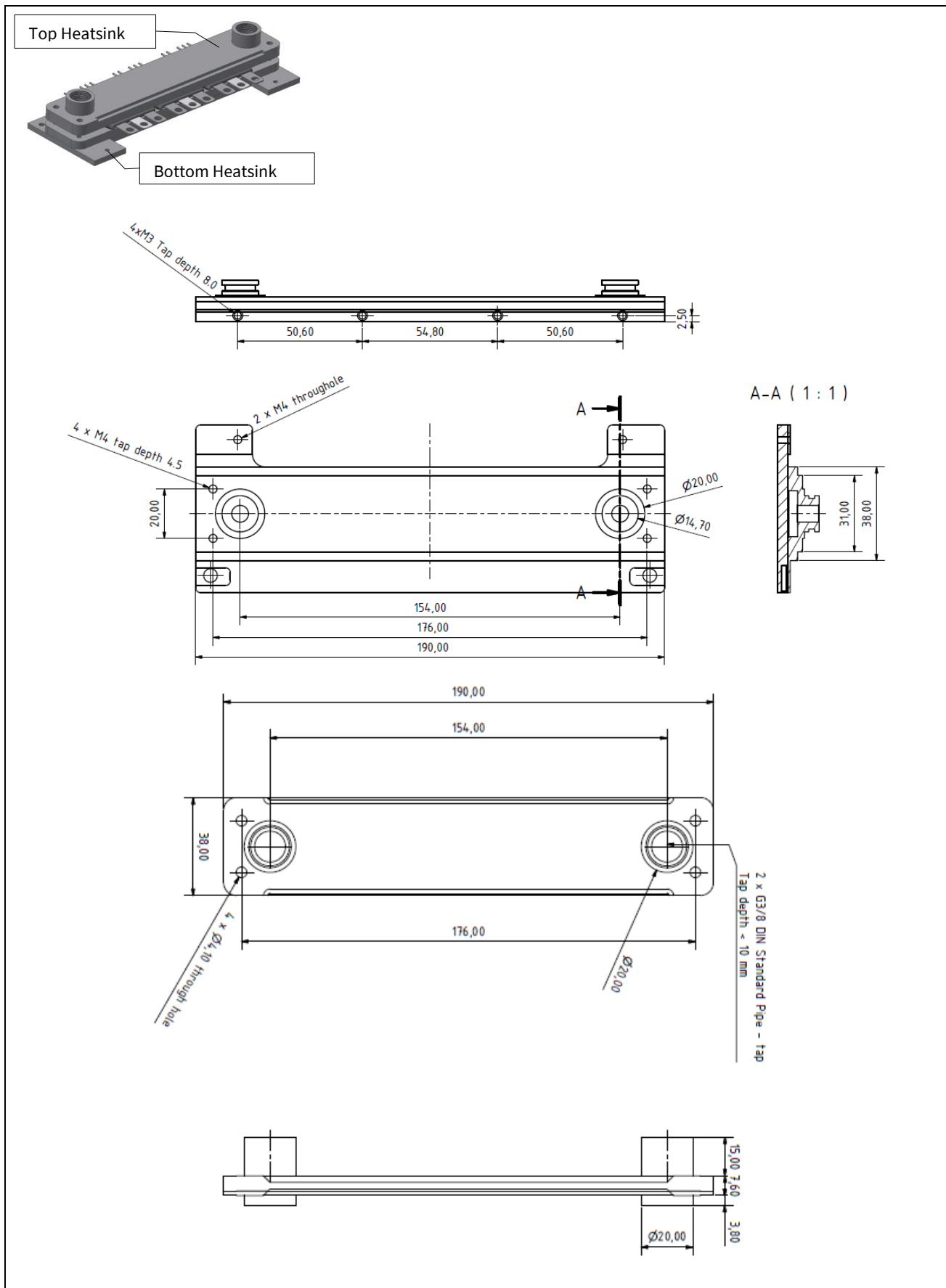


Figure 8: Example of the heatsink for double side cooling

2.5.1 Mounting screws for the reference clamping

As long as a proper compression force to the module is applied, one is free to choose a mounting screw under the condition that the screw itself is automotive qualified and the system is reliable against mechanical shock and vibration. The weight of the heatsink system including the three modules is an essential criterion to strengthen the stability of the system. Additionally, resonance and eigenfrequency of the heatsink system are relevant parameters.

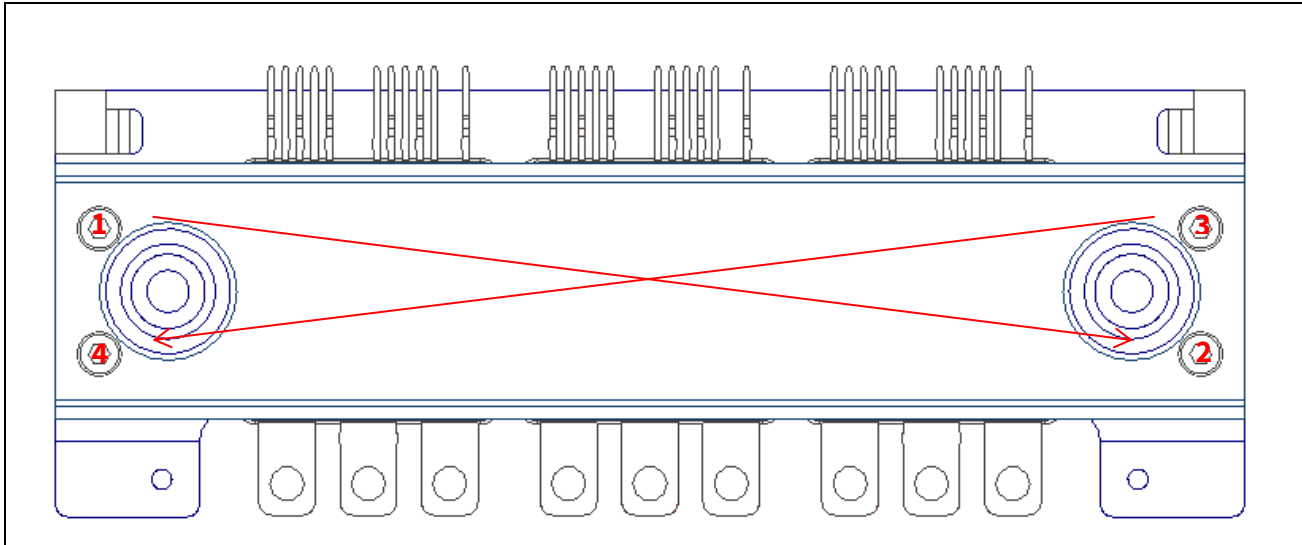


Figure 9: Screwing sequence for optimal torque uniformity

2.5.2 Stacking multiple modules

Thanks to its form factor, the molded component HybridPACK™ DSC has the advantage to offer a power scalability by stacking more modules together. Hence, with an appropriate cooler design, the fact of stacking twice or thrice rows will offer higher power performance while still conserving a more compact solution than actual frame modules. Also depending on the desired applications, for example by combining a motor main inverter in addition to a generator inverter (hybrid vehicles), the HybridPACK™ DSC can be stacked differently between DSC-S and/or DSC-L as shown in Figure 10. In this example, the possibilities are non exhaustive and are related to the target applications. However, some combinations should be preferred to simplify the connections between the different bus bars and the power terminals.

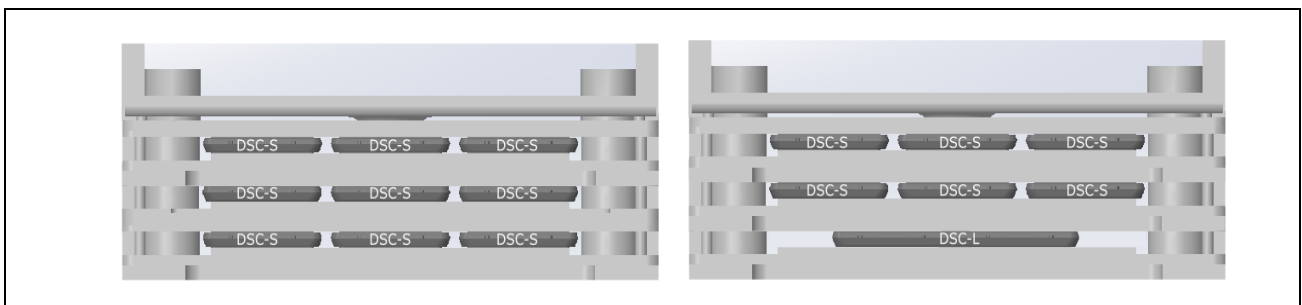


Figure 10: Example of possible stacking combinations while using HybridPACK™ DSC products

Also, in order to guarantee an uniformity on temperature and mechanical stress over the different devices, the different rows should respect a clamping force symmetry along the cooler length as shown in Figure 11. While clamping only 2 modules on the same row, the clamping force should be evenly distributed. Therefore, positioning the 2 modules on the left and right-hand sides should be preferred to distribute the clamping force equally over the modules.

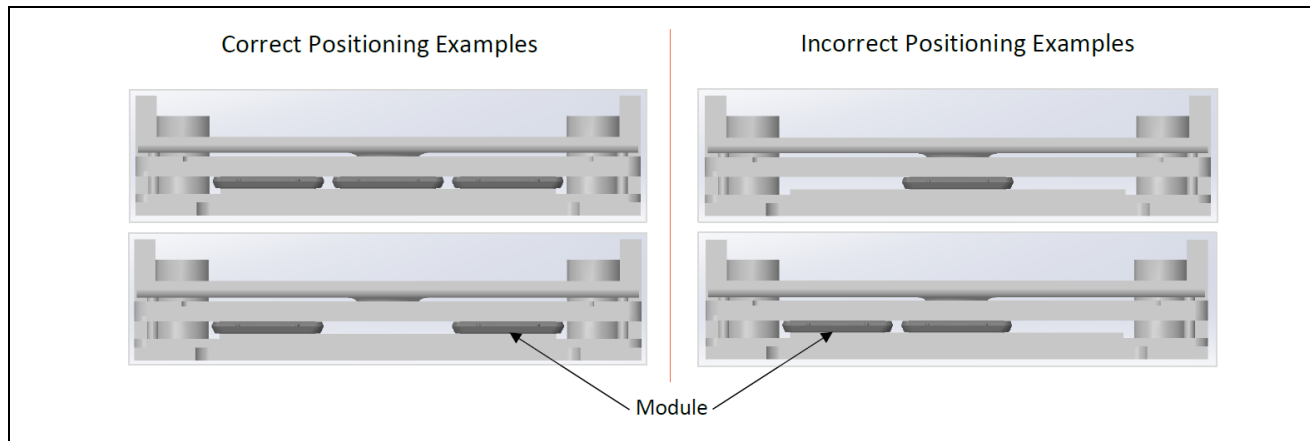


Figure 11: Recommendation on HybridPACK™ DSC position using a standard heatsink

2.6 Example of the PCB mounting

To guarantee a minimum stability of the PCB to the heatsink, and to reduce any mechanical looseness from the PCB to the heatsink and component pins, each width extremity should at least contain 2 screws and each length at least 3-4 screws. Also, to simplify the mounting of PCB to the cooler and DC link together in production, the PCB screw holes diameters of the gate driver PCB should be identical.

In order to manage the guidance of the DSC module pins, a certain tolerance is required so that each pin of the different modules can fit uniformly to the PCB holes. The PCB drawing tolerance in the example of Figure 12 is used for the standard assembly.

Finally, the overall system design should carefully consider the tolerance chain to validate the final size of the PCB holes.

There is no specific process to mount the PCB driver board on the cooler with already placed DSC components. However, to simplify the mounting between the PCB interface and the cooler, the easiest way is to plug all the DSC components to the PCB board before clamping them to the cooler. Some looseness should be required to avoid any mechanical stress of the pins while screwing the cooler on the driver board. Optionally, the bus bar can be screwed before clamping. In such way, the DSC components should be correctly placed over the bottom plate of the cooler and correctly plugged on the PCB.

After clamping the DSC components with the top cooler, the pins of the DSC can finally be soldered on the driver board. For some additional details on soldering the pins of the modules, the document “General Recommendation for Assembly of infineon Packages” can be found on the web page of Infineon in the package section:

<https://www.infineon.com/cms/en/product/packages/>

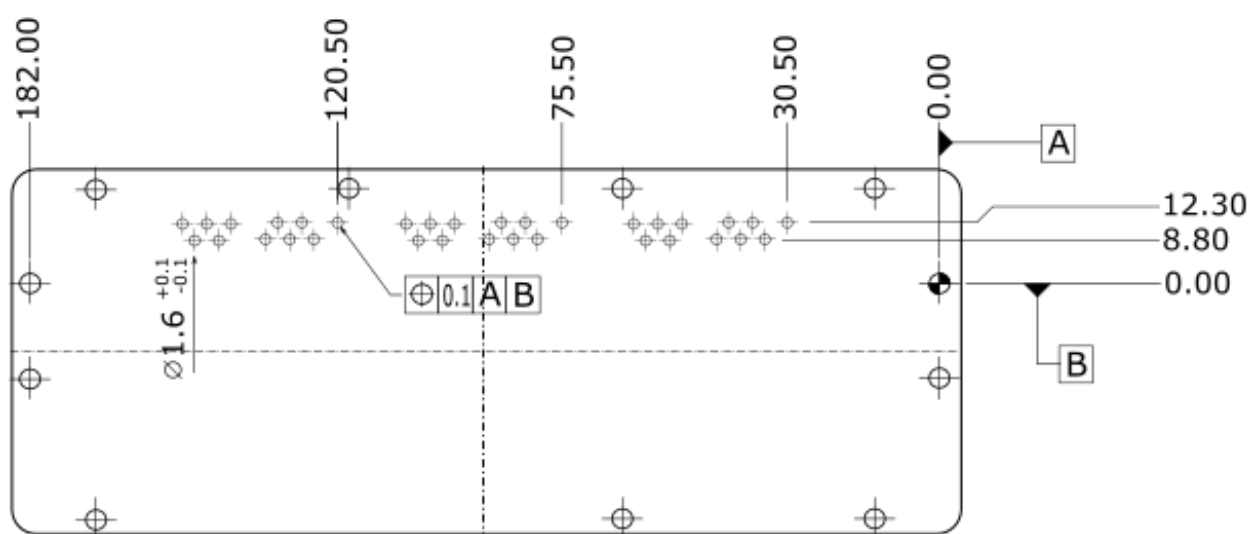
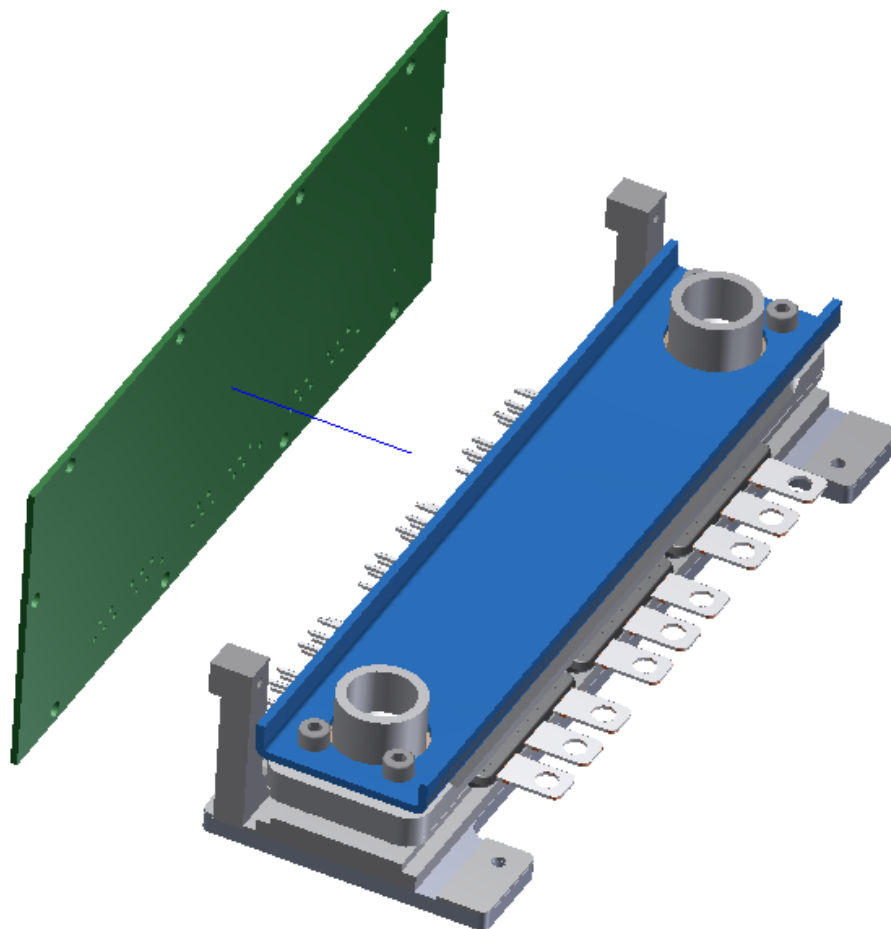


Figure 12: Example of PCB hole position for screwing the standard heatsink (HybridKit™ DSC)

2.6.1 PCB hole size definition considering the tolerance chain

Besides the reliable solder contact between signal pin and PCB, the total tolerance chain should be considered to ensure the feasibility of the assembly.

	Tolerance
Module positioning: Module - heatsink	±0.5 mm
Module tolerance: Signal pin position	±0.4 mm
PCB assembly tolerance: PCB - Heatsink	±0.5 mm
PCB hole position tolerance:	±0.1 mm

Table 2-4: typical example for tolerance chain-calculation

Considering all the max. dimensions to calculate the total tolerance leads to unrealistically tight tolerance requirements.

Since each tolerance is an outcome from the 6 sigma consideration which contains the term of probability, the proper consideration on the probability needs to be considered.

In general, the basic equation to add up the total sigma is known by the below equation:

$$\text{Total sigma} = \sqrt{A^2 + B^2 + C^2 \dots + Z^2}$$

Where A,B,C... Z represent the individual tolerances.

In this example, 3 sigma level tolerance need to be considered to get 6 sigma level of total tolerances.

$$6 \text{ sigma} = \sqrt{3^2 + 3^2 + 3^2 + 3^2}$$

If the tolerance value in Table 2-4 is applied for the calculation, the total resulting deviation is about 0.4 mm. Based on this result, the min. PCB hole size for the DSC Pins can be calculated: $\geq \Phi 1,6 \text{ mm}$

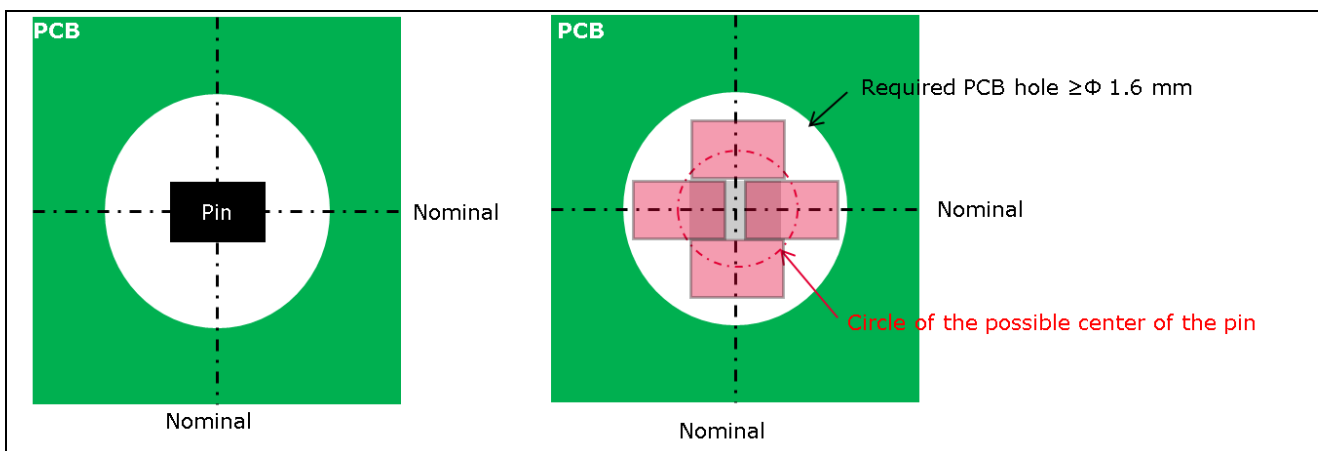


Figure 15: Pin tolerance versus PCB hole

3 Traceability, Data Matrix and Part Markings

Traceability of materials, equipment and processes is a must for automotive key components. Therefore, the HybridPACK™ DSC is produced at Infineon in a seamless traceability environment. But traceability must be continued 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 on the customer side.

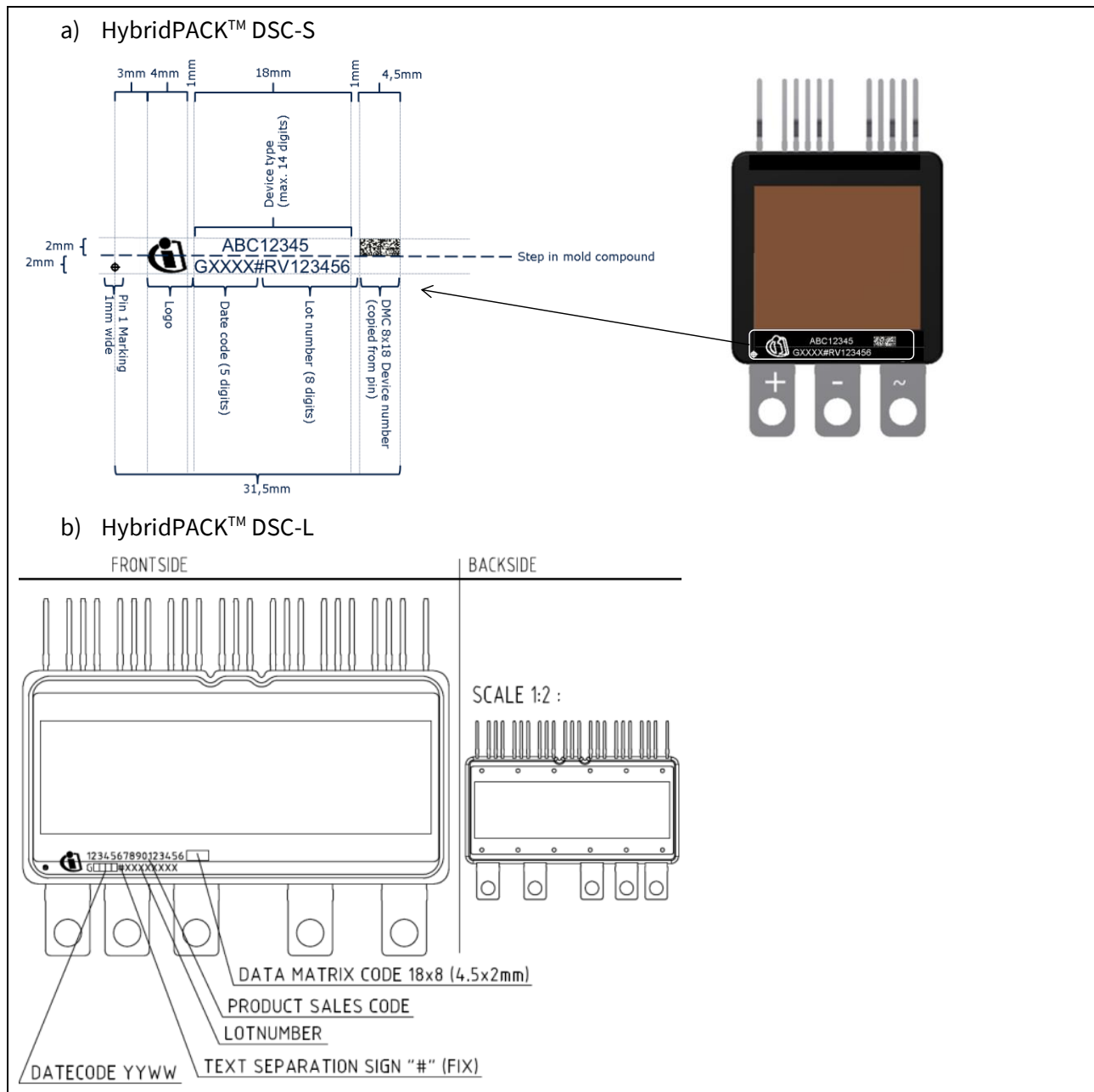


Figure 14: Picture of module labels (typical appearance HybridPACK™ DSC-S and L)

4 Storage and Transport

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 according to IEC60721-3-1, class 1K2 should be assured for the recommended storage time of max. 2 years.

Max. air temperature: $T_{\text{maxair}} = +40^{\circ}\text{C}$

Min. air temperature: $T_{\text{minair}} = +5^{\circ}\text{C}$

Max. relative humidity: 85%

Min. relative humidity: 5%

Condensation: not permissible

Precipitation: not permissible

Iceing: not permissible

Please also note that ground straps should be worn while working with the components and valid ESD safety instructions should be followed at all time, since IGBT modules are electronic-static sensitive components. In addition, maximum permissible values in the product datasheet and application notes are absolute limits which generally, even for short times, may not be exceeded as this may lead to destruction of the component. Moreover, this application note cannot cover every type of application and condition. Hence, the application note cannot replace a detailed evaluation and examination by yourself or your technical divisions of the suitability for the targeted applications. The application note will, therefore, under no circumstances become part of any supplier agreed warranty, unless the supply agreement determines otherwise in writing.

Revision history

Document version	Date	Changed by	Description of changes
0.1	01.2016		Initial version of application note
1.0	21.09.2017	Y.Inpil	Renewed application note with new Following topics are combined in this new application note - mounting instruction
1.2	22.01.2019	A.Thomas	p.16 added Figure 13 regarding the applied thermal compound picture overall document modified to simplify the assembly understanding
1.3	25.08.2020	A.Thomas	p.4 Table1 thermal grease recommendations p.5 Thermal Paste Pattern added

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HvbridPACK DSC**

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