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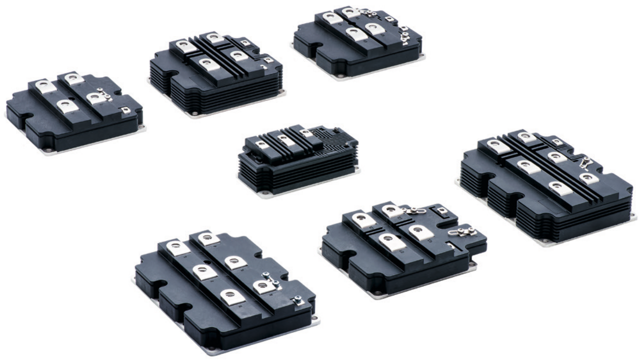
Application Note 5SYA 2039-06

Mounting Instructions for HiPak modules

This application note provides some basic guidelines on how to install the HiPak modules into the converter environment. Following these guidelines ensures safe mechanical, electrical and thermal connections that are crucial for reliable operation of the power modules.



1. General ESD considerations

IGBTs are sensitive to electrostatic discharge (ESD). All HiPak modules are ESD protected during transportation and storage. While handling the modules the gate and auxiliary terminals should be short-circuited with the wire provided or with a metal strip to prevent damage by static charges (IEC60747-1, chap. IX). A conductive-grounded wristlet and a conductive-grounded working place are strongly recommended during assembly.

2. Terminals

The connection between gate-drive circuit and the control terminals of the HiPak modules should be as short as possible. Coaxial or twisted wires or mounting of the gate-drive PCB directly on the auxiliary terminals is highly recommended to prevent any electromagnetic interference (EMI) from the power circuitry to the gate signals.
For single switch devices the power terminals of the collector and the emitter must be interconnected before use as there is no internal high current connection (figure 1a).
A low inductance symmetrical copper bus-bar, mounted directly on top of the module, is highly recommended for all HiPak modules. Figure 1b shows an example of good practice layout that offers symmetrical low inductive connection.

3. Safe operating area

The peak turn-off over-voltage (V_{CEM}) must be kept below the maximum rated collector-emitter voltage (V_{CES}) of the HiPak module. Therefore it is important to use a bus-bar of low inductance L_σ.

$$V_{CEM} = |di/dt| \cdot (L_{\sigma_{CE}} + L_\sigma) + V_{DC} \leq V_{CES} \qquad \text{Eq. 1}$$

Please refer to the module datasheet for the internal module stray inductance (L_σ CE).
The figure designated «Turn-off safe operating area (RBSOA)» in the module datasheet shows the maximum allowed operating conditions with the peak turn-off over-voltage measured at the module power terminals and at the chip (fig. 2).

4. Gate drive

It is recommended to operate the HiPak modules with a turn-on gate voltage of +15 volts (V) for low on-state losses and good short-circuit ruggedness. Turn-on gate-voltages of more than +15 V result in slightly less on-state losses but have a negative impact on short-circuit ruggedness.
A turn-off gate voltage of -5 V...-15 V is recommended for low turn-off losses and high dv/dt immunity.
Clamping of the gate voltage to 15 V for protection against high inductive short-circuit events is also recommended.

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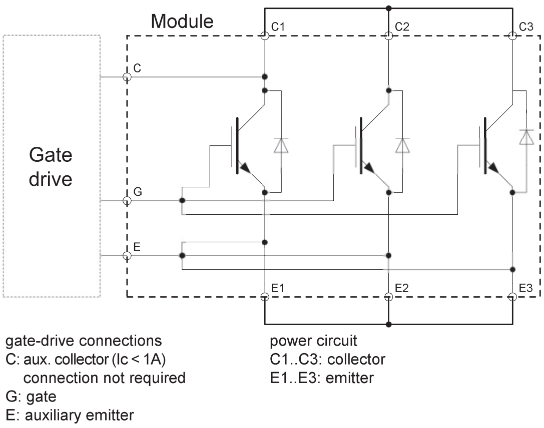
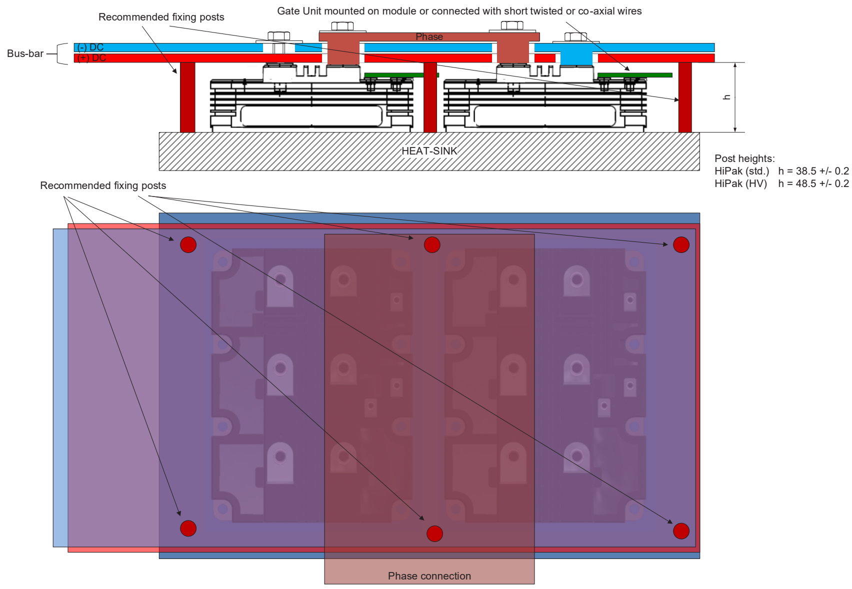
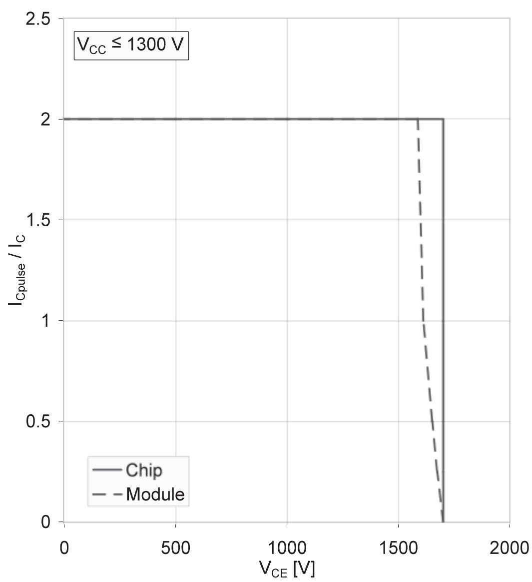


1a Module connections (example HiPak2)

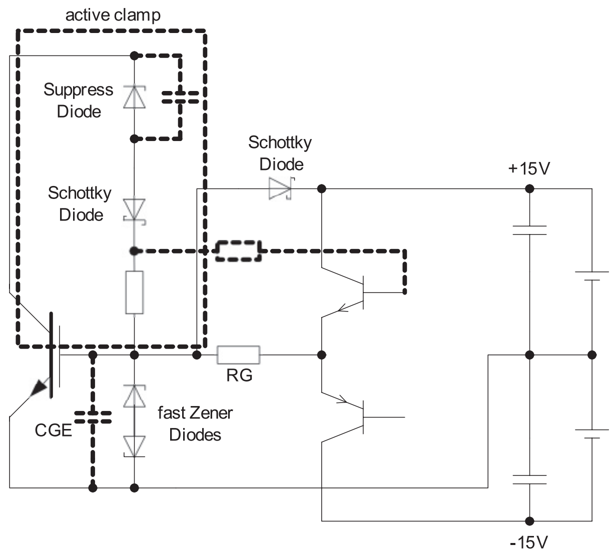


1b Bus-bar connection (example single switch type HiPaks)

This can be achieved by either clamping the gate-voltage as close as possible to the gate-emitter auxiliary terminals of the module with anti-series fast zener diodes, or by a feedback from the gate to the +15 V supply capacitor via a fast Schottky barrier diode (fig. 3).



2 Turn-off safe operating area (RBSOA)



3 Gate-drive recommendations

If the turn-off over-voltage of the module cannot be kept below V_{CES} (1), due to high stray inductance or dc-link voltage, an active clamp circuit can be used, as shown in fig. 3. This is particularly important for HiPak modules with a rated blocking voltage of 1700 V or lower, since these devices exhibit faster switching speeds.

If the datasheet specifies a gate-emitter capacitor (C_{GE}), it is recommended to mount C_{GE} as close as possible to the module, preferably on the gate-emitter terminals. Otherwise especially when long gate-wires are used the effect of C_{GE} gets considerably minimised.

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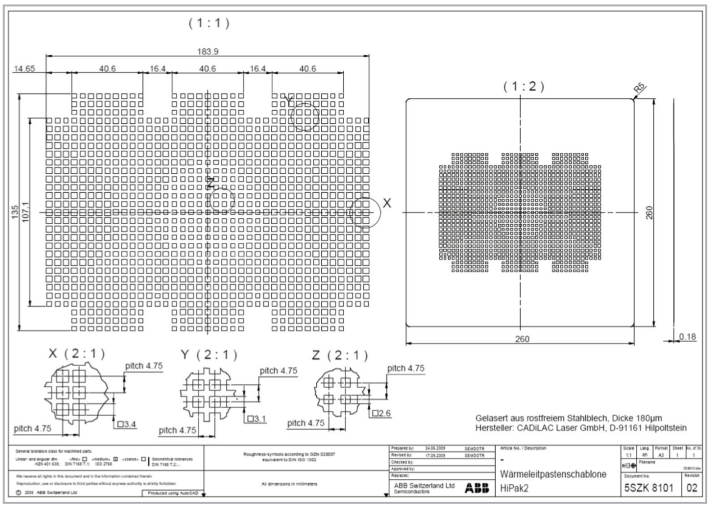
5. Heatsink specification

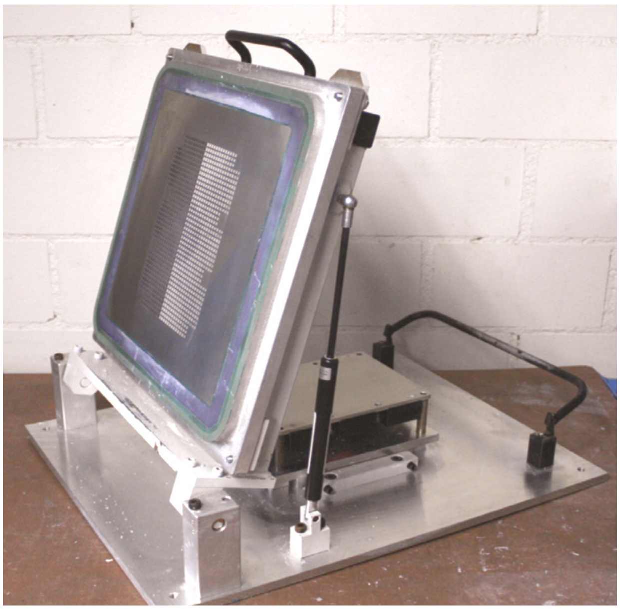
The mounting area on the heatsink and the module must be clean and free of particles in order to obtain the maximum thermal conductivity between the module and the heatsink. In addition ridges with more than 10 µm height or particles can lead to cracks in the brittle AlSiC base-plate or the ceramic and must be strictly avoided.
The mechanical specification of the mounting area is:
Flatness: ≤ 30 micrometer (µm) over entire contact area
Roughness: Rz ≤ 15 µm
No ridge larger than 10 µm

6. Application of thermal paste

In order to avoid air gaps at the interface between the module and the heatsink thermal paste must be applied. The function of the grease is to minimise the thermal interface resistance by filling the remaining voids and allowing a metal-to-metal contact wherever possible. Possible paste types are: Wacker P12, Electrolube HTC(P), Dow Corning TC-5121 etc. (please consider the application recommendations of the paste manufacturers).
It is of crucial importance that the paste is applied as a homogenous, even and reproducible layer. An uneven layer of paste can lead to cracks in the ceramic insulator inside the module.
Prior to application of the paste both heatsink and base-plate area of the module have to be cleaned (e.g. with ethylene glycol). Both surfaces must be absolutely clean and free from damages.
The thermal paste can be applied either to the mounting area of the heatsink or to the base area of the module. A rubber roller or better stencil or screen print is recommended for an even distribution of the grease. For manual application it is recommended to apply a paste layer of roughly 100 µm (depending on paste type and viscosity). The thickness can be checked by a measuring gauge (for example Wet Film Comb, www.elcometer.com).
An advanced method for paste application is stencil-printing. Hitachi Energy offers for this reason a CAD drawing for a suitable stencil (5SZK 8101). The stencil takes the topology of the module baseplate into account. Figure 4 shows the drawing of the stencil. The thickness for the stencil plate depends on the used type of thermal paste. Usually 180 µm are sufficient but it is strongly recommended to verify this with optical judgement of the paste layer (fig. 9/10) or with R_{th} measurements.
For thermal paste application we recommend the following procedure:
1. A stencil print equipment as shown in figure 5 is recommended:
2. a) For low viscosity pastes (e.g. Wacker P12, Electrolube HTC(P)) the paste can be applied using a rubber roller. Surplus paste has to be removed with a scraper (figure 6). The final paste thickness can depend whether the scraper is pushed or pulled.
2. b) For high viscosity or stickier pastes (e.g. Dow Corning TC-5121) application with a rubber roller is difficult as the paste might stick to the roller. In this case the paste can be applied directly with the scraper (figure 7). The final paste thickness can depend whether the scraper is pushed or pulled.
3. Figure 8 shows examples of module baseplates after stencil printing (upper - low vicosity, lower high viscosity paste):
4. It is crucial to make a visual judgement of the paste layer quality after mounting the module onto the heatsink for a couple of samples. Sufficient grease layer thickness can be assumed if the complete module surface is covered with paste and a small stripe of surplus grease is visible along the base-plate edges.



4 Stencil drawing for HiPak2 type modules



5 Stencil print equipment

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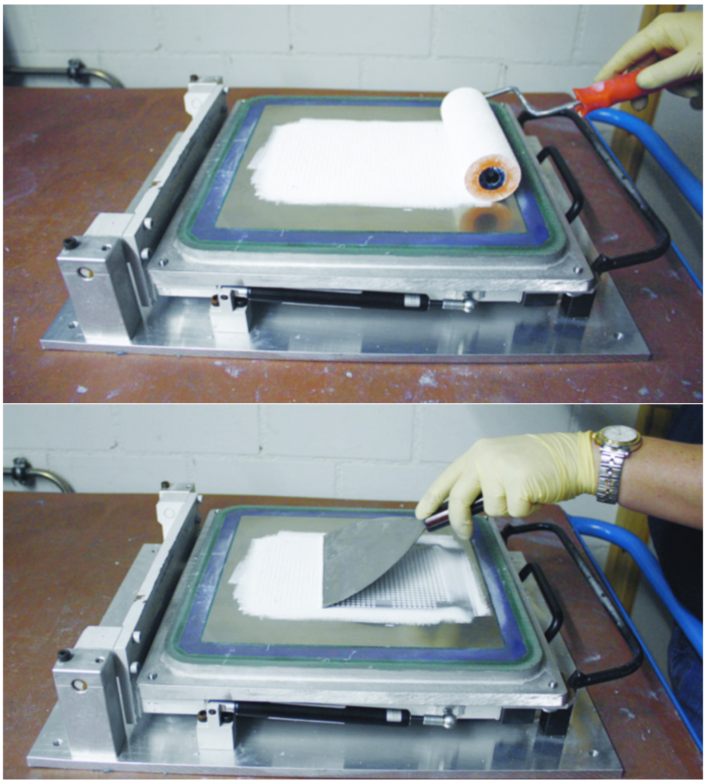
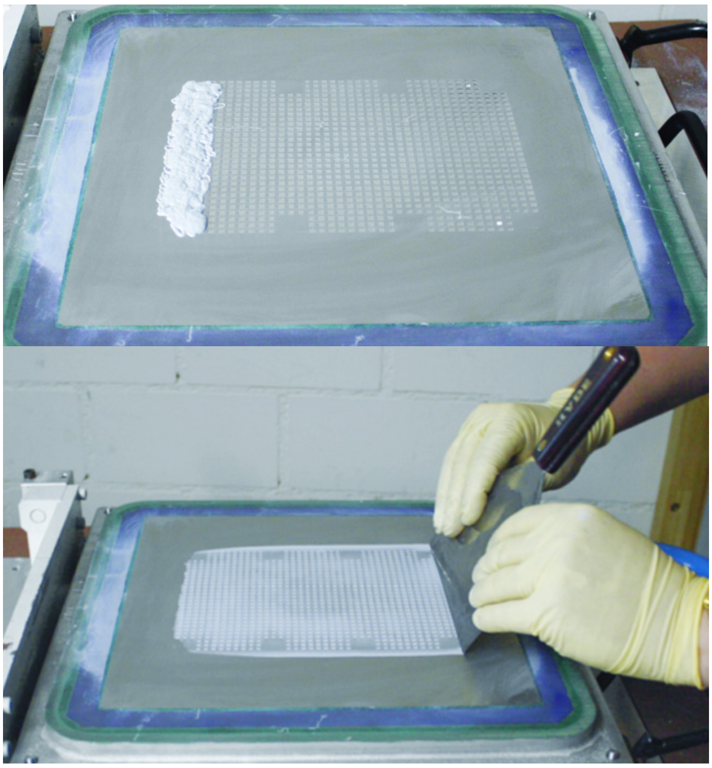
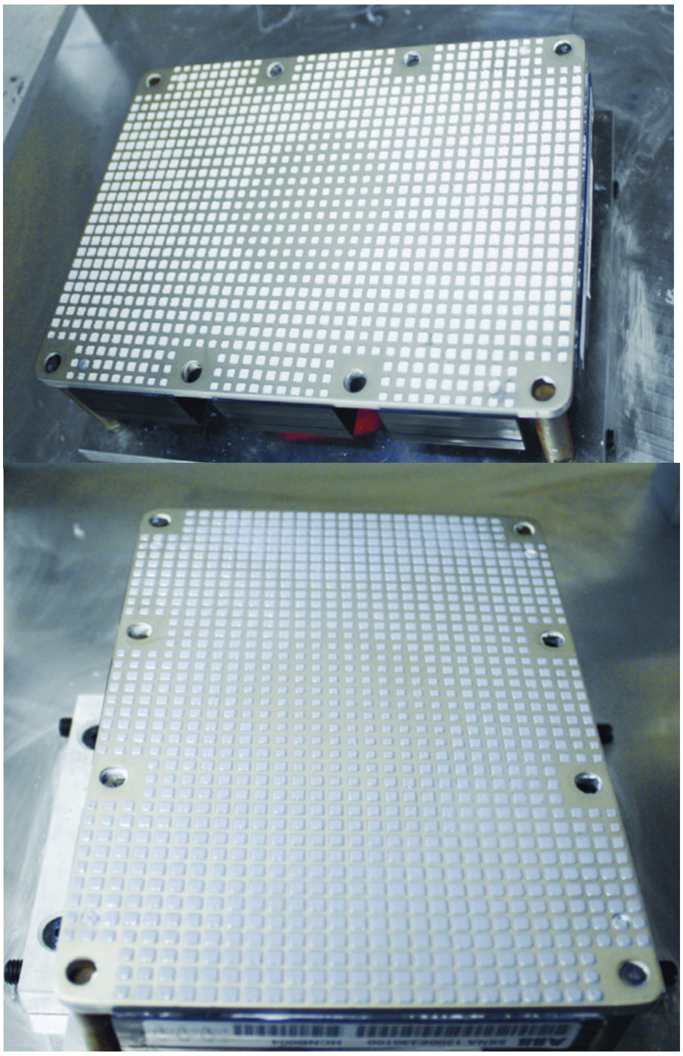


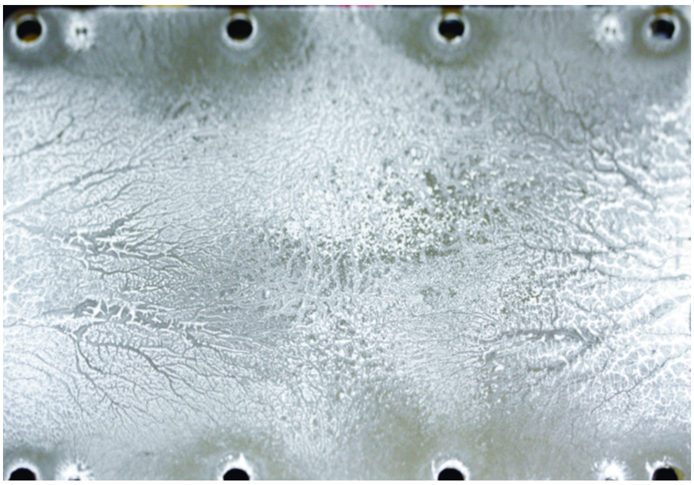
6 Applying the paste onto the stencil using a rubber roller and a scraper



7 Applying the paste onto the stencil using a scraper



8 Example of modules after stencil print



9 Example of good paste coverage

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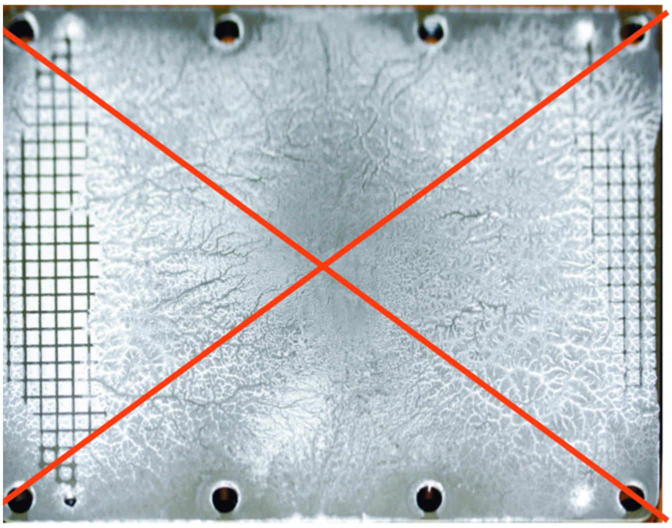

10 Example insufficient paste coverage

Figure 9 shows a good example with the complete surface covered with paste.
Figure 10 shows an example for insufficient paste coverage. The reason for this can be either an insufficient paste layer thickness when using manual application or an insufficient thickness of the stencil plate.

7. Mounting the module onto the heatsink

After applying the thermal grease, the module is placed on the heatsink. Any movement of the module should be avoided once positioned on the heatsink. The fixing screws are inserted and evenly tightened by hand (~0.5 Nm) or by electric or pneumatic screwdrivers with a torque limit of 0.5 Newtonmeter (Nm) according to the sequence of figure 11. Then the screws are tightened again to the final torque (per table 1), following the same sequence. The use of torque wrenches with automatic release is recommended.
The two step procedure must be strictly followed to allow the module base-plate to relax and conform to the heatsink.
Depending on the viscosity of the used thermal grease it is strongly recommended to re-check the torque after 15 - 30 minutes and if necessary re-torque to the final torque value following again the sequence shown in figure 11.

8. Mounting of the bus-bar and auxiliary connections

The bus-bars must be mounted onto the collector and emitter power terminals with the recommended torque of table 1. It is important that the mounting torque is above the minimum requirement and better close to the maximum recommended value to allow good electrical and thermal contact. The cross sections of the bus-bars must be sufficiently large to avoid heating of the module by bus-bar resistive losses. Permanent mechanical stress to the power and auxiliary terminals has to be avoided. Special attention has to be paid on avoiding forces due to shock and vibration as well as forces due to thermal expansion of the bus-bar during operation.
Thus supporting the bus-bar with fixing posts close to the modules on each side is strongly recommended (fig 1b). The height of the post should be:

- HiPak (standard) h = 38.5 +/-0.2 mm
- HiPak (HV) h = 48.5 +/-0.2 mm

Fixing posts should be located as close as possible to the module, preferably in the range of maximum 20..30 mm.
The use of washers and spring washers is highly recommended.
The auxiliary terminals must be connected with the required torque (table 1), while observing the ESD guidelines. The auxiliary emitter and collector terminals are not designed to carry any load current.
Maximum forces at the terminals during the assembly process are shown in figure 12. Connecting parts (bus-bar, gate-unit) must be designed and assembled in a way that those forces are not exceeded.
Important notes:

- Impact wrenches can damage the module or can cause jamming of the screw and are thus not recommended.
- Do not use too fast screwing speed as this might yield in too high torque values or jamming of the screw.
- The use of washers and lock- or spring washers is recommended.
- In order to avoid jamming of the screw always use screw material that matches the material of the thread. E.g. threads in the heatsink or the nuts of the terminals. The terminal nuts of the module are made of austenitic (chromium nickel) steel.
- The screw lengths have to be selected in order to prevent exceeding the maximum tightening depth of the main and auxiliary connections.

Recommended mounting torques	Screw	Torque values	
		min. [Nm]	max. [Nm]
Module mounting	M6	4	6
Power terminals HiPak1&2	M8	8	10
Power terminals HiPak0	M6	4	6
Auxiliary terminals HiPak1&2	M4	2	3
Auxiliary terminals HiPak0	Faston 2.8 x 0.5 mm		

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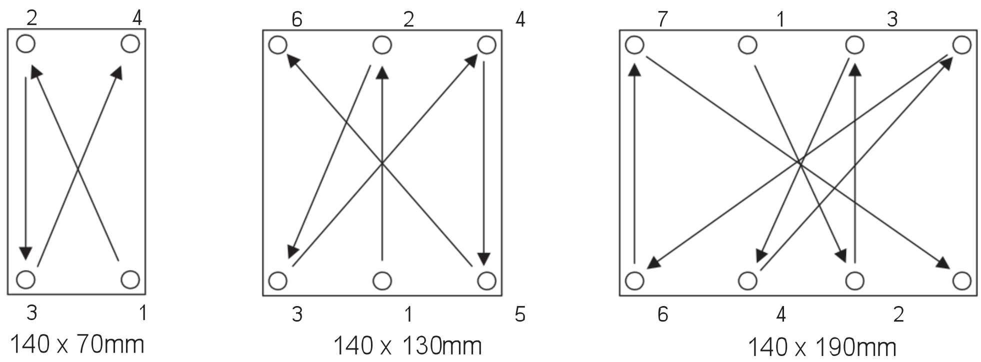
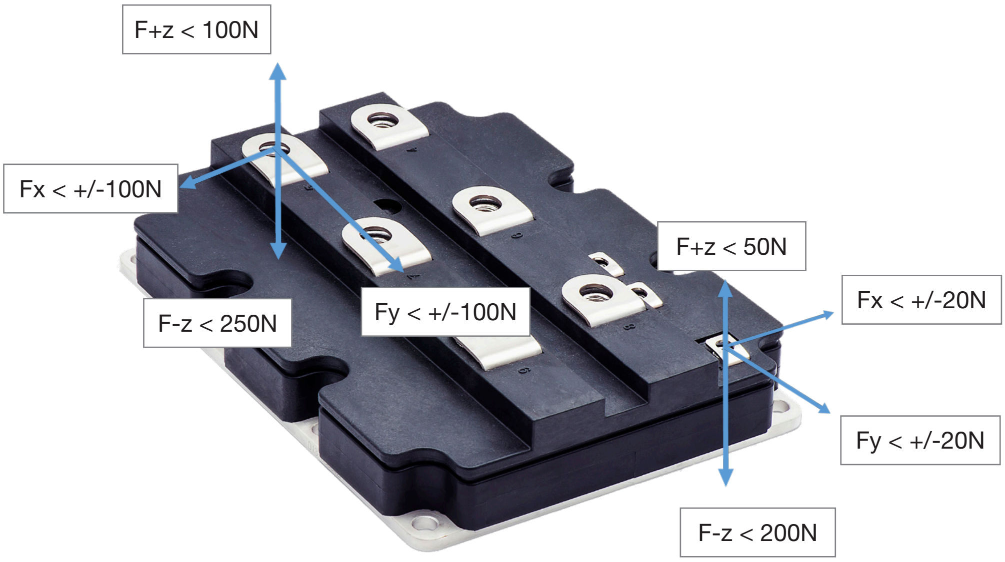


11 Torquing sequence



12 Maximum allowed forces at the module terminals during assembly

9. Revision history

Version	Change	Authors
05		Raffael Schnell Samuel Hartmann
06		Raffael Schnell

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