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Application Note 5SYA 2106-01

Mounting Instructions for 62PaK modules

This application note provides some basic guidelines on how to install the 62Pak modules into the application environment. Following these guidelines ensures safe mechanical, electrical and thermal connections that are crucial for reliable operation of the power modules.

1. General

The descriptions and recommendations in this document cannot replace an accurate assessment and evaluation of all application related aspects referring to the intended usage of the device. All 62Paks undergo a final test before delivering according to IEC60747-9 and IEC60747-15.

2. ESD considerations

IGBTs are sensitive to electrostatic discharge (ESD). All 62Pak modules are ESD protected during transportation and storage. While handling the modules the gate and auxiliary terminals of both switches should be short-circuited with the provided ESD protection cap or with a metal strip to prevent damage by static charges (IEC60747-1, chap. VIII). A conductive-grounded wristlet and a conductive-grounded working place are strongly recommended during assembly.

3. Climatic conditions, storage and transportation

During transportation and storage of the modules, extreme forces such as shock or vibration loads should be avoided as well as extreme environmental impacts surpassing the recommended storage conditions and limits.

4. Climatic conditions during active, current carrying operation of 62 mm modules

The 62Pak modules have no sealed housing package. The housing package materials as the molding compound and the gel used for the electrical isolation are permeable for humidity and gases. Corrosive gases must be avoided during operation and storage of the devices.
The climate conditions for 62Pak modules in active, current carrying operation are specified according to EN60721-3-3 class 3K3.
In case of a humid atmosphere causing condensation or in case of the operation in climatic conditions surpassing the class 3K3 of EN60721-3-3 liquid droplet depositions must be avoided under all circumstances by appropriate measures.

5. Terminals

The connection between gate drive circuit and the control terminals of the 62Pak module 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.
Figure 1a shows the device circuit with all internal and external connections of the phase leg configuration. A low inductance symmetrical copper bus bar, mounted directly on top of the module, is highly recommended for all 62Pak modules. Figure 1b shows an example of good practice layout that offers symmetrical low inductive connection.

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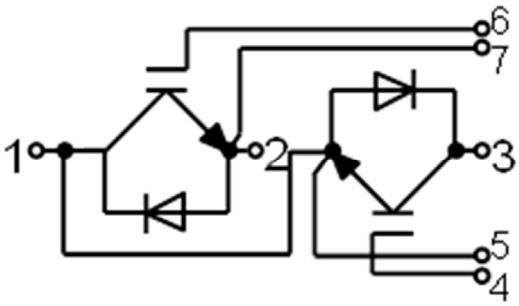
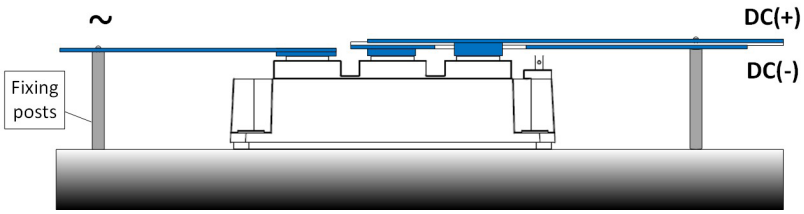


01a Module connections (62Pak)



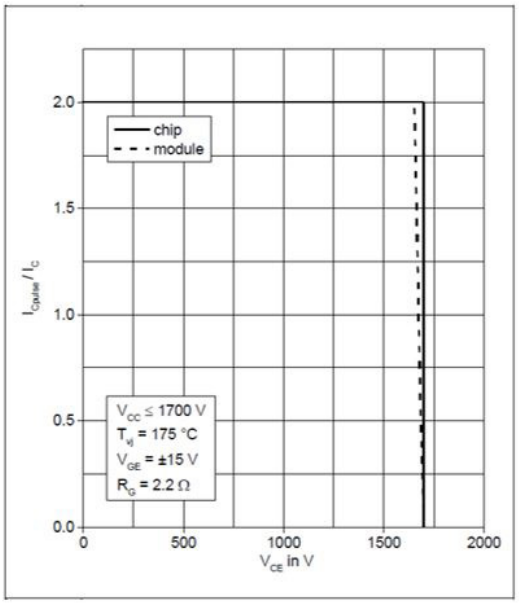
01b Bus bar connection (example single switch type HiPaks)

6. Safe operating area / Voltage rating

The peak turn-off over-voltage (V_{CEM}) must be kept below the maximum rated collector-emitter voltage (V_{CES}) of each switch of the 62Pak module. Therefore it is important to use a bus bar of low inductance Lσ. Please refer to the module data sheet for the internal module stray inductance (LσCE).

$$V_{CEM} = \left|\frac{di}{dt}\right| * (L_{\sigma_{CE}} + L_{\sigma}) + V_{DC} \leq V_{CE} \qquad \text{Eqn. 1}$$

The figure designated «Turn-off safe operating area (RBSOA)» in the module data sheet 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).



02 Turn-off safe operating area (RBSOA)

There are several limiting factors regarding the voltage class and the operating range of the device if used at heights higher than 2000 m above sea level. The lower air pressure will effect the cooling performance. The changed dielectric strength of the air will reduce the clearance distance of the device. The statistical failure rate due to higher cosmic radiation levels will also impact the maximum operation voltage. Therefore, all these topics should be carefully reflected in the design phase. The application notes referring to the 62Pak will support the optimized usage of the device according to appropriate application conditions (see also page 8, Application support).

7. Gate drive

It is recommended to operate the 62Pak 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. 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). 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. If the data sheet specifies a gate-emitter capacitor (CGE), it is recommended to mount CGE as close as possible to the module, preferably on the gate-emitter terminals. Otherwise especially when long gate-wires are used the effect of CGE gets considerably minimised.

8. Heat sink specification

The mounting area on the heat sink and the module must be clean and free of particles in order to obtain the maximum thermal conductivity between the module and the heat sink. In addition ridges

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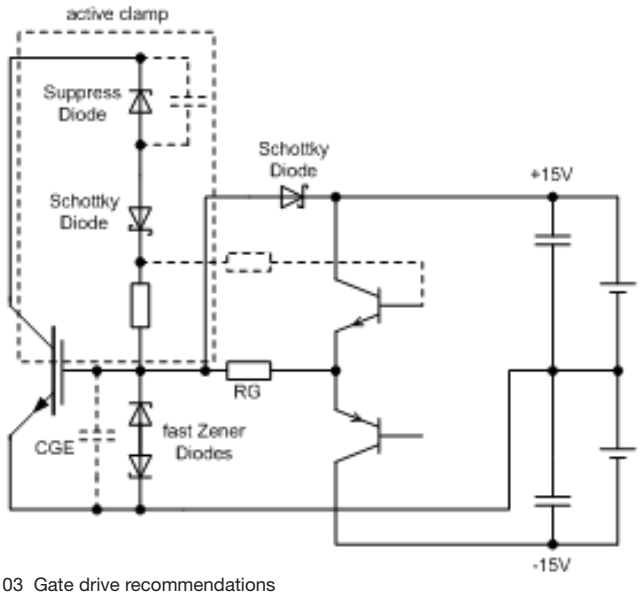


03 Gate drive recommendations

with more than 10 µm height or particles can lead to deformation of the Cu baseplate and cracks in the ceramic and must be strictly avoided. The mechanical specification of the mounting surface is:

- Flatness: 30 micrometer (µm) over entire contact area
- Roughness: Rz 15 µm
- No ridge larger than 10 µm

9. Application of thermal paste

In order to avoid air gaps at the interface between the module and the heat sink thermal paste must be applied. The function of the grease is to minimize 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.

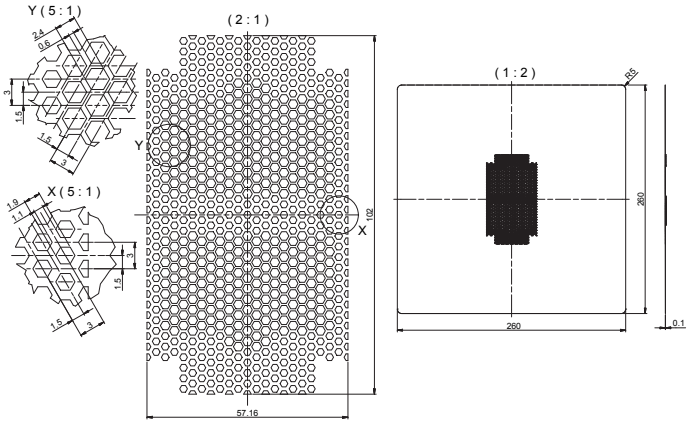
Prior to application of the paste both heat sink and baseplate area of the module have to be cleaned (e.g. with ethylene glycol). Both surfaces must be absolutely clean and free from damages. The thermal paste can be applied either to the mounting area of the heat sink or to the base area of the module. 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 50 µm or 100 µm (depending on stencil thickness, 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 Hitachi Energy's 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. Typically we use 50 µm or 100 µm of grease layer thickness, but it is strongly recommended to verify this with optical judgement of the paste layer (fig. 9/10) or with R_{th} measurements.



04 Stencil drawing for HiPak2 type modules

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 an example of a module baseplate after stencil printing with high viscosity paste:
4. It is crucial to make a visual judgement of the paste layer quality after mounting the module onto the heat sink 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 baseplate edges. Figure 9 shows a good example with the complete surface covered with paste after its removal.

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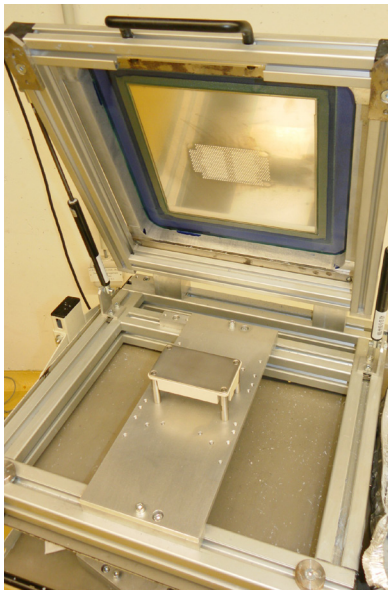
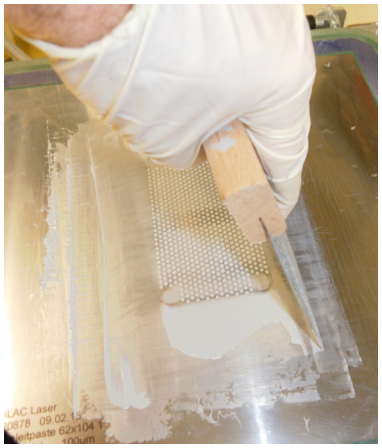
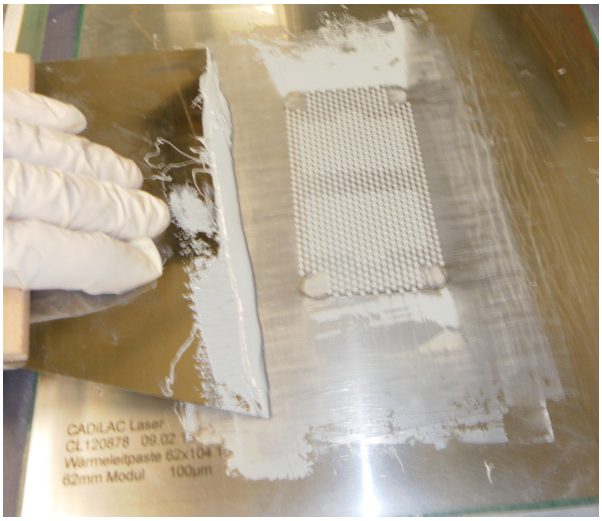


05 Stencil print equipment

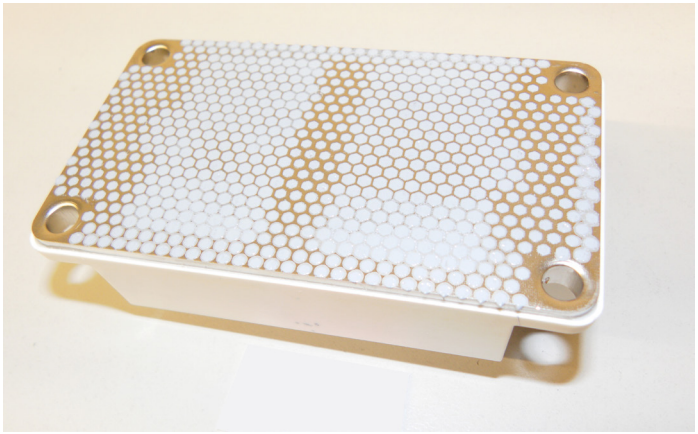
06a Applying the paste onto the stencil using a rubber roller and a scraper



06b Applying the paste onto the stencil using a rubber roller and a scraper



07 Applying the paste onto the stencil using a scraper



08 Example of modules after stencil print

09 Example of good paste coverage

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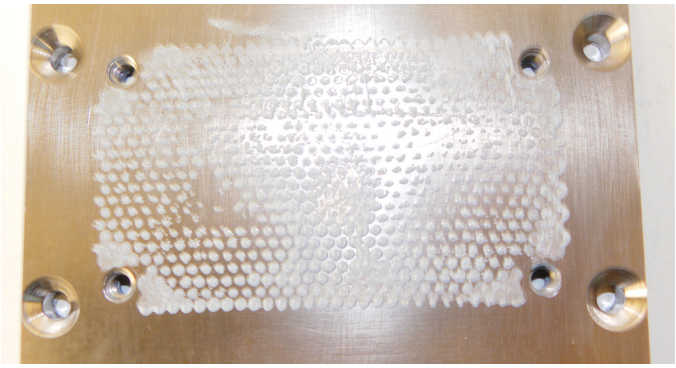
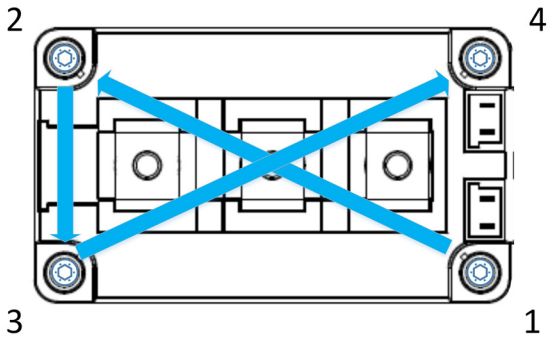


10 Example insufficient paste coverage

10. Mounting the module onto the heat sink

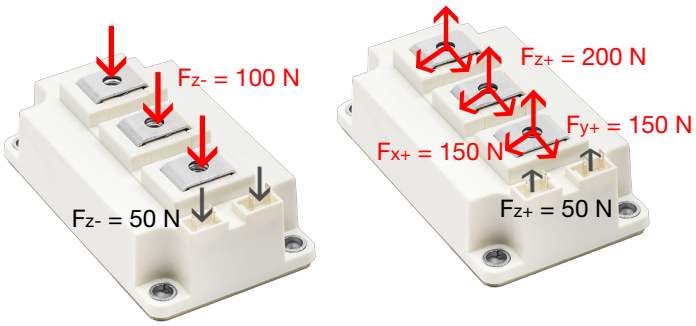
After applying the thermal grease, the module is placed on the heat sink. Any movement of the module should be avoided once positioned on the heat sink. The fixing screws are inserted and evenly tightened by hand (~0.5 Nm) or by electric or pneumatic screwdrivers with a torque limit of 0.5 Newtonmeter (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 baseplate to relax and conform to the heat sink. Depending on the viscosity of the used thermal grease or in case of phase change material it is strongly recommended to recheck the torque after 15 - 30 minutes and if necessary retorque to the final torque value following again the sequence shown in figure 11.



11 Torquing sequence

11. 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 bar must be sufficiently large to avoid heating of the module by bus bar resistive losses. Permanent mechanical stress to the power and auxiliary terminals e.g. by rotating forces 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.
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:
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:
h = 30.5 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 insulated twin female connectors, e.g. a form cable from “2E – Mechatronic” (www.2e-mechatronic.de), or single female (e.g. DIN 46245) plugs 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.



12 Maximum permissible pushing and pulling forces exclusively during the assembly process at ambient temperature of 25 °C

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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 screws always use screw material that matches the material of the thread. E.g. threads in the heat sink or the nuts of the terminals. The terminal nuts of the module are made of 10B21 carbon steel.
- The screw lengths have to be selected in order to prevent exceeding the maximum tightening depth of the main connections.

	Screw	torque values	
		min. [Nm]	max. [Nm]
Mounting screws base -heatsink	M6	3	6
Main terminal screws	M6	3	6
Auxiliary terminals	Plug	-	-

Table 1: Recommended mounting torques of 62 mm modules

6. Revision history

Version	Change	Authors
01		Martin Bayer, Raffael Schnell

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