Mounting instructions for LinPak modules

This application note provides some basic guidelines on how to install the LinPak 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
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 the LinPak IGBT modules undergo a final test before delivering according to IEC60747-9 and IEC60747-15.

2. ESD considerations
IGBTs are sensitive to electrostatic discharge (ESD). All LinPak 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
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. Please refer to the corresponding application notes regarding operation, transportation and storage (see also chapter 11 “Application support” in this document).

- AN 5SZK 9112 Transportation of HiPak and LinPak
- AN 5SZK 9102 Operation of HiPak and LinPak (traction)
- AN 5SZK 9113 Operation (industry) of HiPak and LinPak environmental specification
- AN 5SZK 9111 Storage of HiPak and LinPak – environmental specification
Table of contents

01 General
01 ESD considerations
01 Climatic conditions
03 Electrical connection
03 Safe operating area
03 Gate drive
04 Heat sink specification
05 Application of thermal paste
06 Mounting the module onto the heat sink
06 Mounting of the bus bar and the gate board
08 Application support
08 Revision history
4. Electrical connection
The LinPak is designed for very low stray inductance and compact design. Figure 1a shows the device circuit schematics for a LinPak in phase leg configuration. We strongly recommend to use a PCB (printed circuit board) to connect gate-emitter and the NTC thermistor. The PCB has to be placed in the designated booth between the DC and AC power connections. To exploit the potential of the low inductive LinPak design a laminated bus bar with symmetrical design is mandatory. Figure 1b shows a simple but effective design of the integration of the LinPak in a power electronics circuit.

5. Safe operating area
The peak turn-off over-voltage (V_{C_{EM}}) must be kept below the maximum rated collector-emitter voltage (V_{CES}) of each module. Therefore it is important to use a bus bar of low inductance L_s. Please refer to the module data sheet for the internal module stray inductance (L_{CE}).

\[ V_{\text{CM}} = \frac{1}{d} \left( \frac{dV}{dt} \right) + (L_{CE} + L_a) + V_D \leq V_{\text{CES}} \] (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 (figure 2).

6. Gate drive
It is recommended to operate the LinPak 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 (figure 3).
If the turn-off over-voltage of the module cannot be kept below $V_{CES}$, due to high stray inductance or dc-link voltage, an active clamp circuit can be used, as shown in figure 3. For the LinPak this is usually not necessary if a low inductive bus bar is used and the maximum DC-voltage is kept under control.

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 minimized. In general we can distinguish in different gate-unit implementation concepts that have different impacts especially on paralleling (Paralleling of IGBT modules 5SYA 2098):

- **Common gate-driver for all paralleled IGBT modules**: One central gate-driver that is low-inductive connected to adapter boards on each LinPak. Gate-resistance, gate voltage clamp and possible CGE are mounted on the adapter boards.
  
  **Pro**: Cost effective simple solution, good current sharing provided the dc-link is symmetrical.
  
  **Challenges**: Keep a low inductive connection to the common driver output stage, short-circuit control.

- **Individual gate-driver for each module**: Each module has it’s own full gate-driver
  
  **Pro**: No current loops in auxiliary emitter, current sharing less dependent on bus-bar design. Good short-circuit control.
  
  **Challenges**: Possible jitter of gate-signal has a direct impact on current sharing, higher costs.

- **Common gate-driver insulation and logic, individual output stage on each LinPak connection board**: Means the final usually MOS-Fet output stage, including gate-clamp and gate resistor is on each LinPak adaptor board.
  
  **Pro**: Current sharing less dependent on bus bar design. Good short-circuit control. No gate-voltage jitter.
  
  **Challenges**: Slightly more expensive than common gate-driver.

7. 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 with more than 10 $\mu$m height or particles can lead to deformation of the AlSiC baseplate and cracks in the ceramic and must be strictly avoided. The mechanical specification of the mounting surface is:

- **Flatness**: 30 micrometer ($\mu$m) over entire contact area
- **Roughness**: $R_z$ 15 $\mu$m
- **No ridge larger than 10 $\mu$m**
8. 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 of various viscosity and thermal conductivity are available. 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 100 µm to 180 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. ABB offers for this reason a CAD drawing for a suitable stencil as shown in figure 4. The stencil takes the topology of the ABB module baseplate into account. The thickness for the stencil plate depends on the used type of thermal paste. Typically we use 100 µm to 180 µm of grease layer thickness, but it is strongly recommended to verify this with optical judgement of the paste layer (see the following pictures) or with $R_\text{th}$ measurements.

For thermal paste application we recommend the following procedure:

1. A stencil print equipment as shown in figure 5 is recommended.
2a. Low viscosity pastes 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.
2b. 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.

---

ABB Switzerland Ltd.
Semiconductors
Fabrikstrasse 3
5600 Lenzburg
Switzerland
abbsem@ch.abb.com

abb.com/semiconductors

---
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.

9. 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 Nm according to the sequence of figure 9. 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 9.

10. Mounting of the bus bar and the gate board
The bus bars must be mounted onto the DC+, DC- and AC 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 blocks close to the modules on each side is strongly recommended (figure 1b).
Mounting instructions for LinPak modules

5SYA 2107-02

We reserve the right to make technical changes or modify the contents of this document without prior notice. With regard to purchase orders, the agreed particulars shall prevail. ABB AG does not accept any responsibility whatsoever for potential errors or possible lack of information in this document.

We reserve all rights in this document and in the subject matter and illustrations contained therein. Any reproduction, disclosure to third parties or utilization of its contents – in whole or in parts – is forbidden without prior written consent of ABB AG. Copyright © 2017 ABB
All rights reserved

We reserve all rights in this document and in the subject matter and illustrations contained therein. Any reproduction, disclosure to third parties or utilization of its contents – in whole or in parts – is forbidden without prior written consent of ABB AG. Copyright © 2017 ABB
All rights reserved

Applying the paste onto the stencil using a scraper

Example of module after stencil print

The height of the block should be approximately 0.5 mm lower than the height of the power terminal taking all tolerances into account. Ideally, this results in a mild negative preload on the power terminals avoiding a damaging tension in Fz+ direction (figure 10).

Fixing blocks 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. Before connecting the auxiliary terminals it is also highly recommended to mount the gate board according the sequence in figure 9 to the gate board fixation inserts. 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 all terminals process are shown in figure 10.

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 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 austenitic A2-70 (chromium nickel) steel.
- The screw lengths have to be selected in order to prevent exceeding the maximum tightening depth of the main connections.

Torquing sequence of the LinPak module to heat sink and the gate board to the LinPak module

The auxiliary emitter and collector terminals are not designed to carry any load current. Maximum forces at the all terminals process are shown in figure 10.

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 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 austenitic A2-70 (chromium nickel) steel.
- The screw lengths have to be selected in order to prevent exceeding the maximum tightening depth of the main connections.
10 Maximum allowed forces at the module terminals

<table>
<thead>
<tr>
<th>Recommended mounting torques</th>
<th>Screw</th>
<th>Torque values</th>
</tr>
</thead>
<tbody>
<tr>
<td>module mounting screws</td>
<td>M6</td>
<td>4 [Nm] - 6 [Nm]</td>
</tr>
<tr>
<td>power terminals screws</td>
<td>M8</td>
<td>8 [Nm] - 10 [Nm]</td>
</tr>
<tr>
<td>auxiliary terminals screws</td>
<td>M3</td>
<td>0.9 [Nm] - 1.1 [Nm]</td>
</tr>
<tr>
<td>gate board fixation screws</td>
<td>M3</td>
<td>0.9 [Nm] - 1.1 [Nm]</td>
</tr>
</tbody>
</table>

Table 01

11. Application support
Data sheets and application notes for the devices and your nearest sales office can be found on the ABB Switzerland Ltd., Semiconductors website: www.abb.com/semiconductors

12. Revision history

<table>
<thead>
<tr>
<th>Version</th>
<th>Change</th>
<th>Authors</th>
</tr>
</thead>
<tbody>
<tr>
<td>01</td>
<td>initial release</td>
<td>Martin Bayer, Raffael Schnell</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Fabian Fischer, Dominik Trüssel</td>
</tr>
<tr>
<td>02</td>
<td>March 2018</td>
<td>Martin Bayer, Raffael Schnell</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Fabian Fischer, Dominik Trüssel</td>
</tr>
</tbody>
</table>