Application Note AN 2014-12
V1.1, December 2014

AN2014-12 Application and Mounting Instructions for IHM and IHV Modules

www.infineon.com

Edition 2014-12
Published by
Infineon Technologies AG
59568 Warstein, Germany

Attention please!
THE INFORMATION GIVEN IN THIS APPLICATION NOTE IS GIVEN AS A HINT FOR THE IMPLEMENTATION OF THE INFINEON TECHNOLOGIES COMPONENT ONLY AND SHALL NOT BE REGARDED AS ANY DESCRIPTION OR WARRANTY OF A CERTAIN FUNCTIONALITY, CONDITION OR QUALITY OF THE INFINEON TECHNOLOGIES COMPONENT. THE RECIPIENT OF THIS APPLICATION NOTE MUST VERIFY ANY FUNCTION DESCRIBED HEREIN IN THE REAL APPLICATION. INFINEON TECHNOLOGIES HEREBY DISCLAIMS ANY AND ALL WARRANTIES AND LIABILITIES OF ANY KIND (INCLUDING WITHOUT LIMITATION WARRANTIES OF NON-INFRINGEMENT OF INTELLECTUAL PROPERTY RIGHTS OF ANY THIRD PARTY) WITH RESPECT TO ANY AND ALL INFORMATION GIVEN IN THIS APPLICATION NOTE.

Information
For further information on technology, delivery terms and conditions and prices please contact your nearest Infineon Technologies Office (www.infineon.com).

Warnings
Due to technical requirements components may contain dangerous substances. For information on the types in question please contact your nearest Infineon Technologies Office. Infineon Technologies Components may only be used in life-support devices or systems with the express written approval of Infineon Technologies, if a failure of such components can reasonably be expected to cause the failure of that life-support device or system, or to affect the safety or effectiveness of that device or system. Life support devices or systems are intended to be implanted in the human body, or to support and/or maintain and sustain and/or protect human life. If they fail, it is reasonable to assume that the health of the user or other persons may be endangered.

Revision History:
2012-10-01, V1.0
2014-12-01, V1.1
Previous Version: AN2012-10
Page: Subjects (major changes since last revision)
Page 14: material thickness of stencil: 120µm for AlSiC, 100µm for Cu

Author: Thomas Schütze - IFAG IPC HP

We Listen to Your Comments
Any information within this document that you feel is wrong, unclear or missing at all? Your feedback will help us to continuously improve the quality of this document. Please send your proposal (including a reference to this document) to: [IGBT.Application@infineon.com]

Table of contents

1. General

This application note AN2012-06 Rev.1 Mounting instructions for IHM and IHV modules, replaces AN2004-05.

IHM and IHV power semiconductors are electrical components.

Important aspects in the construction of the mechanical layout include the application conditions at which the components are put to use. These application conditions must be observed in the mechanical as well as the electrical and the thermal design.

The notes and recommendations in this document cannot cover all and every application and condition. This application note therefore, will in no way replace a thorough assessment and evaluation of the suitability for the purpose envisaged by the user with the technical departments. Hence, the application notes do under no circumstances become part of the supply contractual warranty, unless the supply contract determines any different in writing.

2. Supply quality

All IGBT modules undergo a final test before delivery according to IEC60747-9 and IEC60747-15. Inwards goods tests of the components at the recipient’s site are therefore not required.

After an additional and final visual inspection, the components ready for shipping are packaged in an ESD protected transport box. Concaves and / or elevations of the base plate in the µm-range are permissible within valid Infineon specification limits and therefore bear no influence on the thermal, electrical or reliability characteristics of the power modules.

Once the user has removed the components from the ESD protected shipping box, further processing should occur in accordance with the directive according to chapter 4.

3. Storage and transport

During transport and storage of the modules extreme forces such as shock and / or vibration loads are to be avoided as well as extreme environmental influences outside those storage conditions recommended by Infineon [1].

Storing the modules at those temperature limits specified by the data sheet is possible but not recommended.

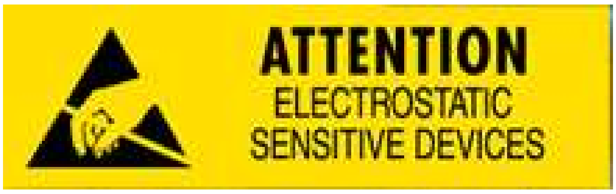
The storage time at the recommended storage conditions according to [1] should not be exceeded.

A pre-dry process of the module packages before assembly, as is recommended with molded components like microcontrollers or TO-packages, is not required with IHM / IHV modules.

4. IGBT modules are electrostatic sensitive devices (ESD)

IGBT semiconductors are electrostatic sensitive devices which require to be handled according to the ESD directives. Uncontrolled discharge, voltage from non-earthed operating equipment or personnel as well as static discharge or similar effects may destroy the devices. The gate-emitter control terminals are electrostatic sensitive contacts. Take care not to operate or measure IGBT modules with open circuit gate-emitter terminals.

Electrostatic discharge (ESD) may partially or even completely damage IGBT modules.



The user must observe all precautions in order to avoid electrostatic discharge during handling, movement and packing of these components.

Important notice:

In order to avoid destruction or pre-damage of the power semiconductor components through electrostatic discharge the devices are delivered in suitable ESD packaging according to the ESD directives.

The installation of ESD workstations is required to unpack the modules and thus remove the ESD protection as well as handling the unprotected modules.

- Subsequent work steps are only to be carried out at special work stations complying with the following requirements
  - High impedance ground connection
  - Conductive workstation surface
  - ESD wrist straps
- All transport equipment and PCBs have to be brought to the same potential prior to further processing of the ESD sensitive components.

Further information can be derived from the standards in their current versions.

- IEC 61340-5-2, Electrostatics–protection of electronic devices from electrostatic phenomena – general requirements
- ANSI/ESD S2020
- MIL-STD 883C, Method 3015.6 for testing and Classification
- DIN VDE 0843 T2, identical with IEC801-2

5. Module labeling, RoHS & Green Product

Infineon IHM / IHV B modules partly comply with the directives according to RoHS. Data sheets, listing product materials, so called Material Data Sheets, may be ordered from Infineon.

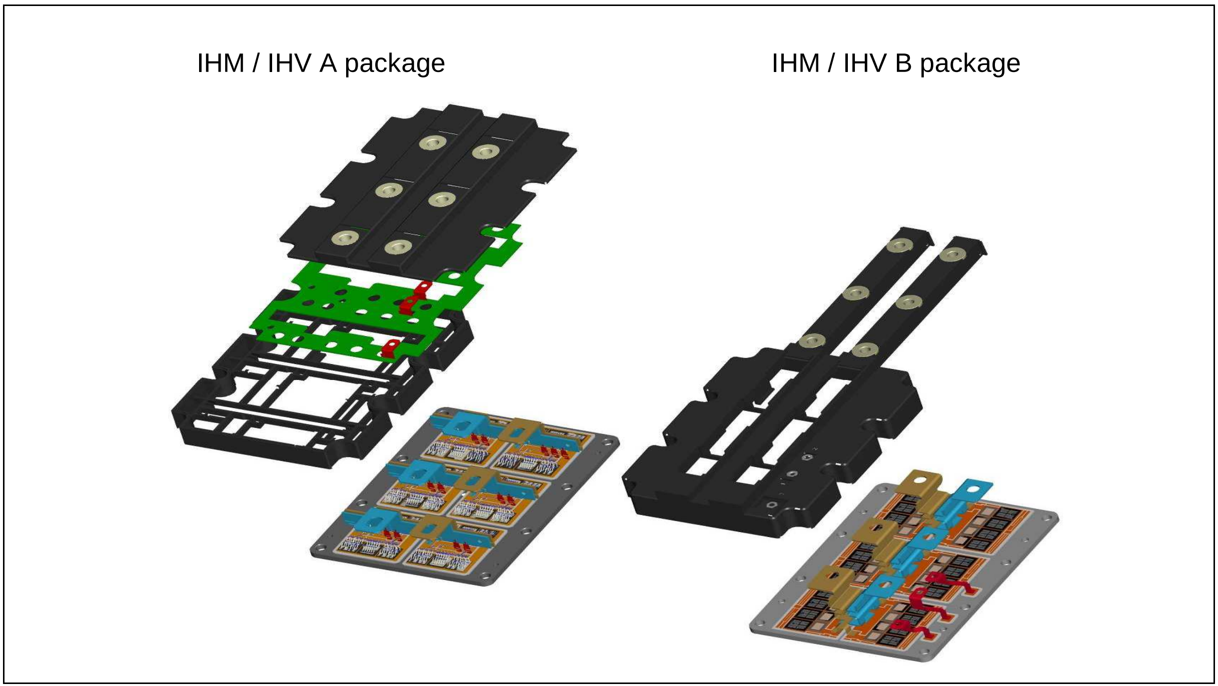


Fig. 1: IHM / IHV A and B packages

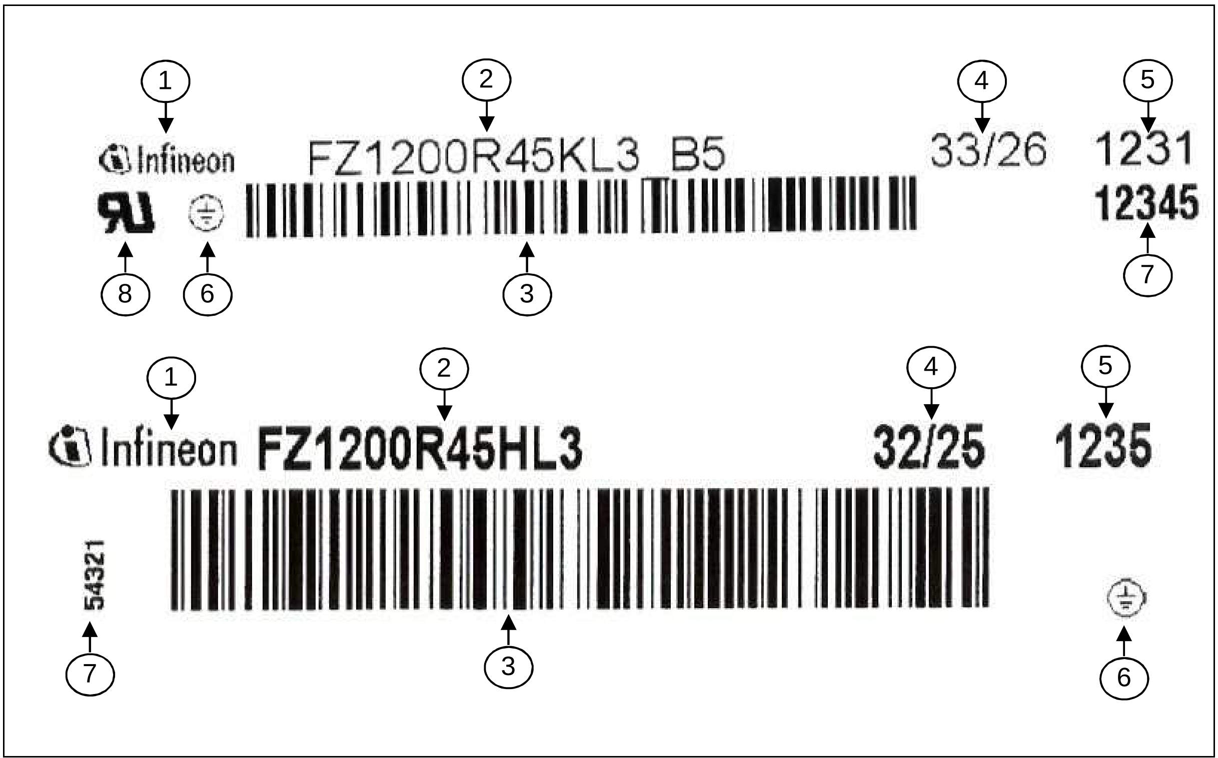


Fig. 1: IHM / IHV label design

1. Infineon Logo

2. Type designation
   acc. Table 1

3. Barcode (Code 128)
   1. - 5. digit : module serial number
   6. - 11. digit : module material number (internal)
   12. - 19. digit: production order number (internal)
   20. - 21. digit : date code (production year)
   22. - 23. digit : date code (production week)
   24. - 25. digit : VCEsat-class
   26. - 27. digit : VF-class

4. VCEsat / VF class
   2 digit averaged terminal value @ 125°C

5. Date code
   1. - 2. digit : date code (production year)
   3. - 4. digit : date code (production week)

6. Grounding symbol

7. Module number
   5 digits, unambiguous in combination with date code

8. UL listed
   if applicable

6. Module selection

IHM / IHV modules are available in the most varied configurations as well as voltage and current ranges with differently optimized IGBTs and diodes.

The complete product overview and a selection and simulation program, IPOSIM, are available online at www.infineon.com.

Maximum values in the product data sheets and application notes are absolute values, which - even for brief periods - must not be exceeded, as this may cause pre-damage or destruction of the components. Further information can be obtained from the application notes [2].

Selecting the most suitable component requires the consideration of various criteria. The overview below in figure 2 serves as a first illustration and hint.

Fig. 2: Typical appearance of the different IHM / IHV packages

FF	**800**	**R**	**17**	**K**	**F**	**6**	**C**	**B2**	
FF									Dual Switch
FZ									Single Switch
FD									Chopper configuration
DZ									Single Diode
DD									Dual Diode
	800								Max. DC-collector current in A
									Type:
		R							Reverse conducting
		S							Fast diode
			17						Collector-emitter-voltage in 100 V
				K					Mechanical construction: Module
				H					Package: IHM / IHV B-Series
				I					Package: PrimePACK™
					F				Fast switching IGBT Chip
					L				Low Loss IGBT Chip
					S				Short tail fast IGBT Chip
					E				Low sat & fast IGBT Chip
					T				Thin & fast IGBT Chip
					P				High Power soft IGBT Chip
						1..n			Internal reference numbers
							C		With Emitter Controlled diode
							D		Higher diode current
							-K		design with common cathode
							G		Module in Big housing
							I		Integrated Cooling
								B1..n	Construction variation
								S1..n	Electrical selection
								P1..n	Selected devices

Table 1: IHM / IHV module type designation overview

6.1 Selecting the module voltage class (V_{CES}) and the operation of modules at elevated heights

When selecting the appropriate voltage class, the IGBT has to exhibit a blocking capability appropriate to the application conditions.

Table 2 shows possible IGBT voltage classes for different supply voltages. This table can be used for an initial IGBT module selection. The maximum collector-emitter voltage (V_{CES}) must not be exceeded even for short periods during switching and has to be considered in the selection of a suitable IGBT voltage class over the entire temperature range.

Line voltage **Nominal DC link voltage**	**Preferred IGBT** **voltage class**
400 V_{RMS} (620V_{DC})	1200 V
600 V_{DC} (max. appr. 900 V_{DC})	
690 V_{RMS} (1070V_{DC})	1700 V
750 V_{DC} (max. appr. 1100 V_{DC})	
1500 V_{DC} (max. appr. 2100 V_{DC})	3300 V
up to 2500 V_{DC} controlled	4500 V
3000 V_{DC} (max. ca. 4500 V_{DC})	6500 V

Table 2: IGBT blocking capability as a selection criterion of the supply voltage

Operation of IGBT components at heights >2000m above sea level or high DC voltages may necessitate in limiting the operating range.

- Due to the lower air pressure the cooling capability of air cooling systems needs to be evaluated.

- The isolation properties, especially the clearance distances need to be adjusted due to the lower dielectric strength of the air. See also Chapter 7.

- Possible statistical failure rates due to the operation of the power semiconductors at elevated heights (cosmic radiation) and / or at high voltage have to be considered when selecting a suitable voltage class and generally during the design phase.

- With operating temperatures T<25°C, the reduced blocking capability typical for IGBTs and the switching behavior of the components at these temperatures in the particular application has to be kept in mind and should be studied independently in the user’s design. The specification of the blocking capability in dependence of the temperature T = -40°C to T = +25°C is available upon request through your sales representative for Infineon power devices.

The power cycling capability for the envisaged lifetime needs to be calculated on the basis of the load profile. Further information on the subject is available on request and in [3].

6.2 Climatic conditions during active, current carrying operation of IHM / IHV modules

IHM / IHV modules are not hermetically sealed. The housings and the molding compound, used for the electrical isolation within the housing, are permeable for humidity and gases in both directions. Therefore humidity differences will be equalized in both directions.
Corrosive gases must be avoided during operation and storage of the devices.

The climatic conditions for Infineon IHM / IHV modules in active, current carrying operation are specified as per EN60721-3-3 class 3K3 for fixed installations.

The operation of the modules in humid atmosphere caused by condensation and/or the operation in climatic conditions beyond class 3K3 of EN60721-3-3 must be avoided and additional countermeasures need to be taken in such cases.

7. Module creepage and clearance distances

When calculating the isolation characteristics, consider the application specific standards, particularly regarding clearance and creepage distances.

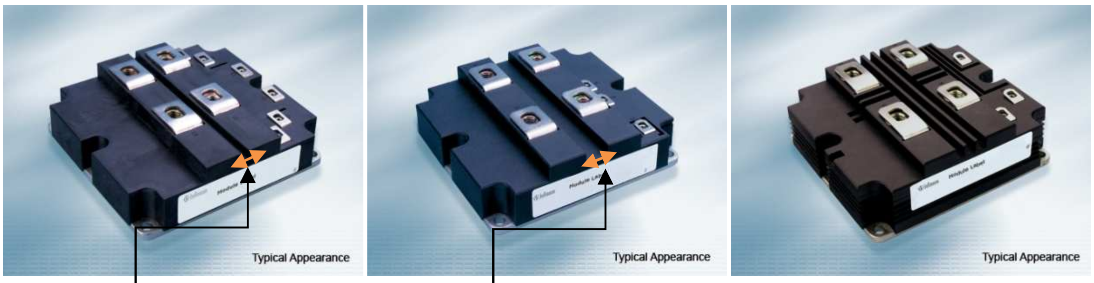
The module-specific IHM / IHV package drawings can be taken from the data sheets or can be acquired in electronic form as a CAD file via your sales partner for Infineon modules.

In particular with the selection of the bolts and washers, clearance and creepage distances must be considered. Please also note the information in Chapter 6.1. In order to suit the application requirements here, if necessary, avoid electrically conducting components or plated-through holes or take isolation measures, e.g. lacquer.

Clearance and creepage distances indicated in the IHM / IHV module data sheets are those specified with the not assembled and unconnected module. These values are the existing shortest clearance and creepage distances for pollution degree PD2 in accordance with IEC60664-1. The following tables show an overview of these clearance and creepage distances of the different package variants.

Description	**Values**	**Remark**
Creepage distances		
terminal to heat sink terminal to terminal	15 mm 32.2 mm 56 mm	IHM IHV IHV high isolation
Clearance distances		
terminal to heat sink terminal to terminal	10 mm 19.1 mm 26 mm	IHM IHV IHV high isolation

Table 3: Clearance and creepage distances of different IHM / IHV module types



IHM (30 mm base width) IHV (40 mm base width) IHV high isolation

Fig. 3: Shortest creepage distances of the not assembled and unconnected IHM / IHV modules

In any case, clearance and creepage distances in the application are to be examined and to be compared with the requirements from the user-specific standards and, if necessary, to be assured by design measures.

8. Module assembly and connections

All protective measures against electrostatic discharge during handling and assembly of the IGBT modules have to be taken by the user. See also section 4.

8.1 Quality of the heat sink surface for module assembly

The energy occurring as losses in the module must be dissipated by a suitable heat sink, in order not to exceed the maximum temperature during switching operation (T_{vjop}), specified in the data sheets. In addition see [4]. The quality of the heat sink surface within the space of the module placement is of great importance, since this contact between the heat sink and the module is of crucial influence to the heat dissipation of the module.

For optimal heat dissipation the condition of the contact area of the heat sink to each IHM / IHV module may not exceed the following values.

Base plate size	**Surface roughness**	**Surface flatness**
140x 73 mm module	≤ 15 µm	< 30 µm
140x130 mm module	≤ 15 µm	< 30 µm
140x190 mm module	≤ 15 µm	< 50 µm

Table 4: surface roughness and flatness heat sink requirements for different IHM / IHV module base plate sizes

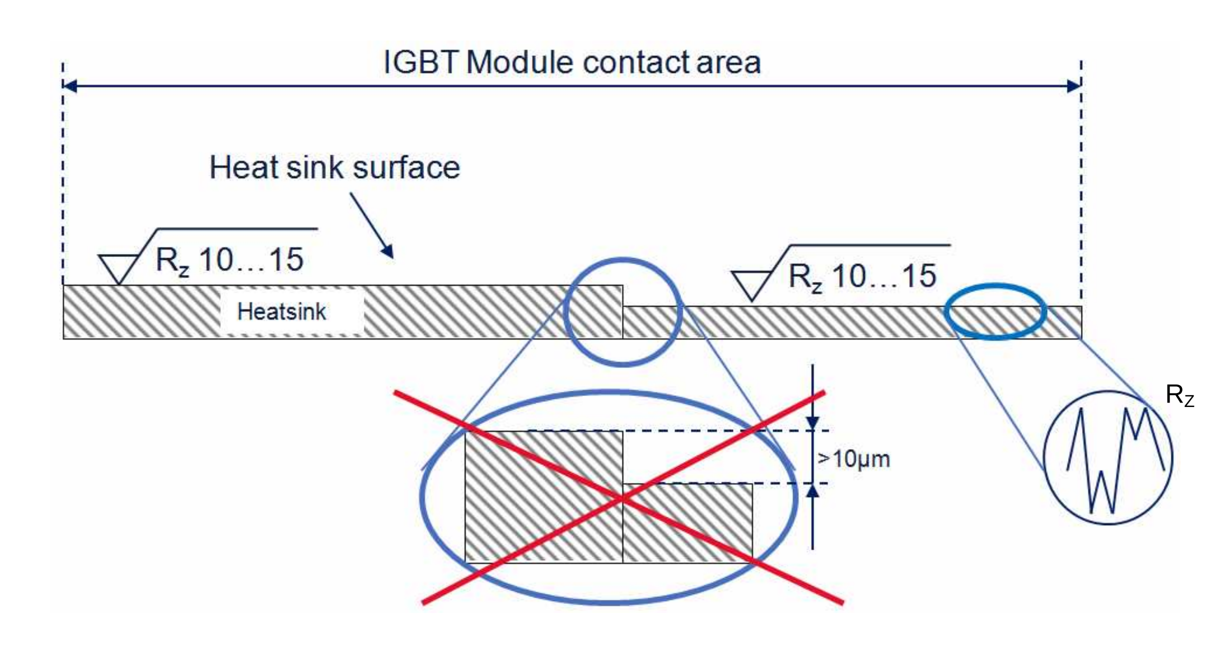


Fig. 4: Recommendation for the condition of the heat sink surface before module assembly

The contact areas, the base plate of the module and the surface of the heat sink must be free of damage and contamination, which would worsen the thermal contact. Before the module is mounted it is recommended to clean the contact areas with a lint free cloth.

The heat sink must be of sufficient stiffness for the assembly and the subsequent transport, so it will not exert additional mechanical stresses on the base plate of the module. During the entire assembly process the heat sink must rest free of twisting, e.g. on a suitable carrier jig.

8.2 Thermal interface material

Due to the individual surface shape of the module base plate and the heat sink, these do not sit solidly across the entire area, so that it cannot be avoided that gaps will form between the two components over parts of the contact surface.

To dissipate the losses occurring in the module and to allow a good flow of heat into the heat sink, all the voids will need to be filled with a suitable heat-conductive material.

The thermally conductive material should have long-term stability properties appropriate to the application and ensure a consistently good thermal contact resistance. Also it should be applied so that the mounting holes are not contaminated and, thus, torque values falsified.

8.2.1 Application of thermal paste in a screen printing process

The user has to select and qualify the thermal paste used for suitability and long-term stability. To apply the heat conductive material, e.g. thermal grease in combination with the screen printing the suitability has to be verified independently and individually by the user.

To achieve an optimal result, the module, the geometry of the application, the contact area of the heat sink as well as the applied material have to be considered as one unit.

To apply thermal paste manually with a layer thickness in the µm-range is inherently problematic because an optimally filled layer should close all gaps but not prevent the metallic contact between the base plate and heat sink surface. Therefore it is recommended to apply thermal grease with a stencil printing process. With this method it is possible not only to have a customized application according to the type of module but a reproducible adjustment of the layer thickness.

Further information on the use of screen printing stencils for the application of thermal compound can be found in the guidelines [5]. The module-specific drawings of a printing stencil can be obtained from the distribution partner for Infineon modules. It should be observed, that the material thickness of the stencil has to be 120µm for modules with AlSiC base plates and 100µm for modules with Cu base plates.

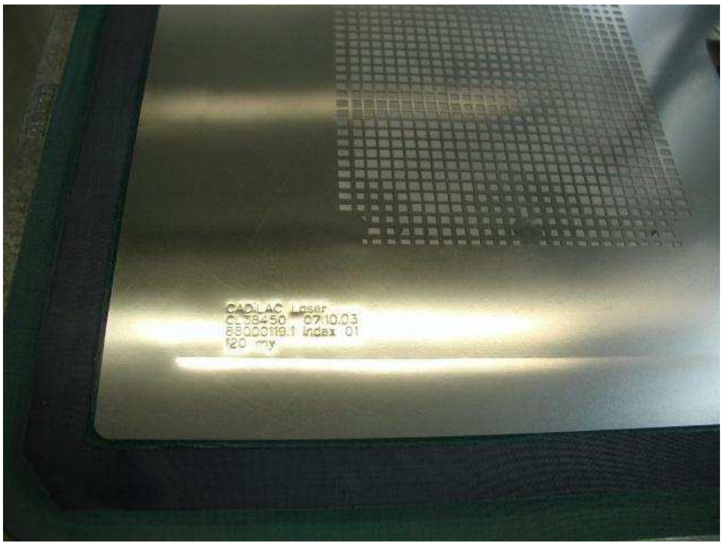


Fig. 5: Stencil for Infineon IHM / IHV modules

The following pictures show examples for the screen printing of thermal paste.

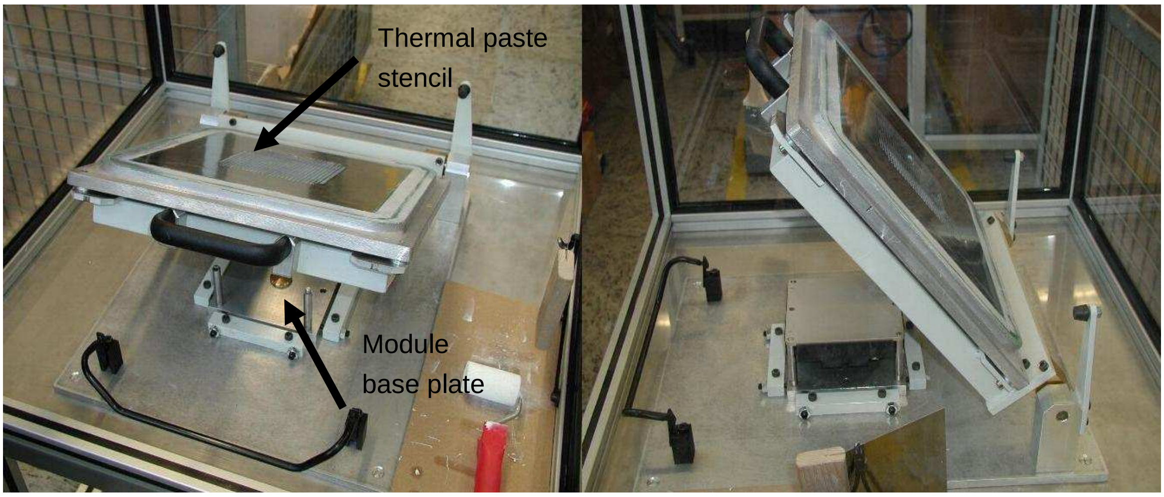


Fig. 6: Example of an applicator jig to spread thermal paste in a screen printing process, detailing a module base plate

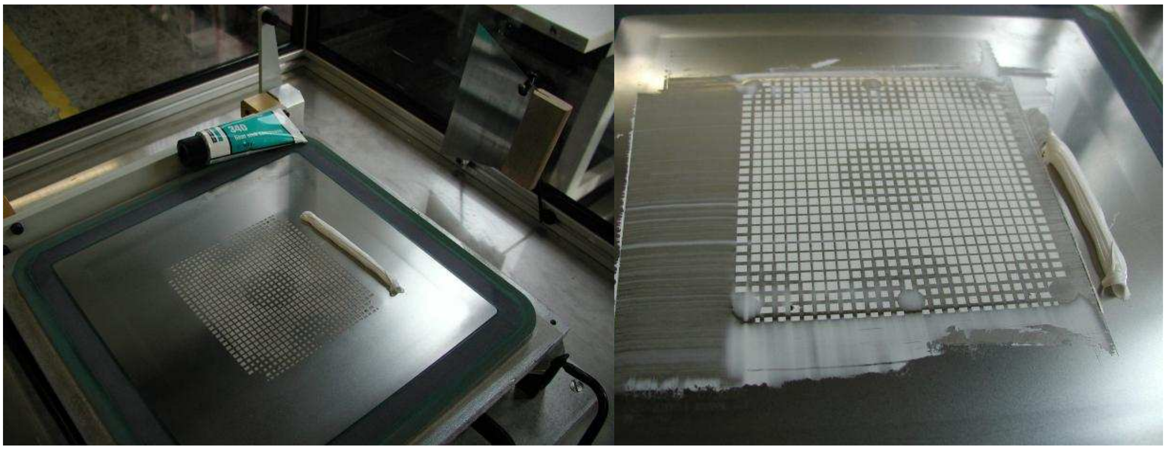


Fig. 7: Application of thermal grease using a stencil

1. Clean the stencil of possible thermal grease residues. This step can be carried out with suitable solvents like isopropanol or ethyl alcohol. Observe the safety regulations when handling these materials.
2. Align stencil and module. Perhaps with a jig holding the module as shown in Fig. 6.
3. Lower the stencil onto the module base plate.
4. Apply the thermal paste over the stencil, see Fig. 7. It is imperative that all stencil holes are filled with thermal paste.
5. Lift the template and remove the module.
6. Visual inspection after application of the material ensures that every point of the template is filled. The application of paste itself using a template, especially when performed manually, can be affected by a poor alignment of the stencil and small variations in the amount of paste, and thus increase the expected temperature by a few degrees.
7. The measurement of the thickness of the deposited material is therefore strongly recommended and ensures that an adequate amount of material was applied.

After a settling time the heat sink and the belonging module should show a good distribution of the paste and a stripe of excessive paste along the edges.

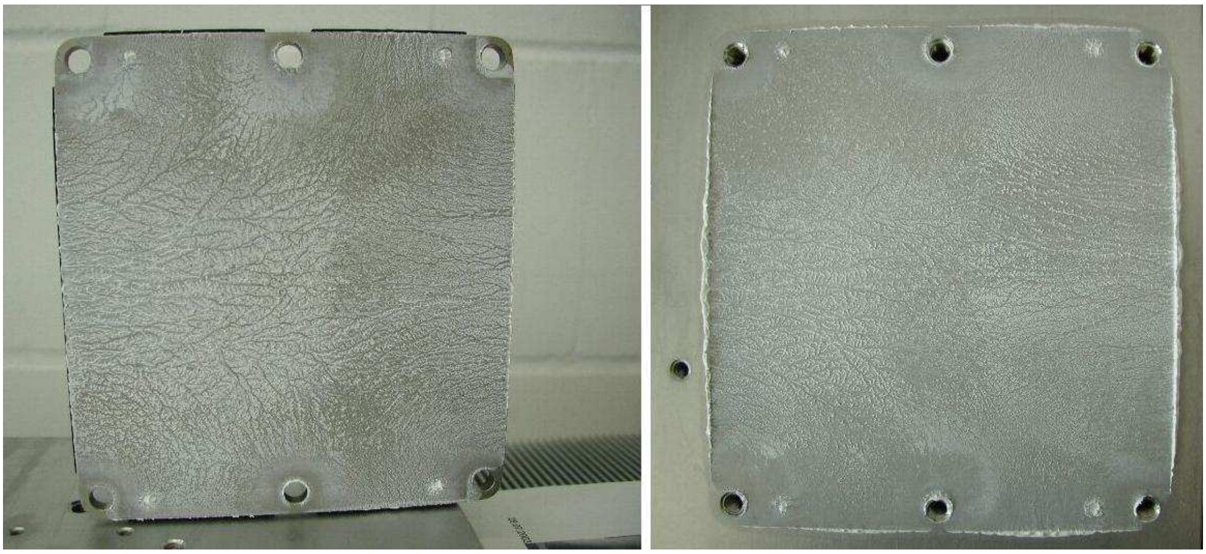


Fig. 8: Distribution of the paste on the surface of module (left) and heat sink (right)

Just after mounting the paste, which is leaking at the edges, shows the structure of the screen. Depending on the paste viscosity a homogeneous stripe of paste should form in a time frame of few minutes (low viscous paste) to several hours (high viscous paste).

Fig. 9: Module edges show leaking of excessive paste

When applying the paste with the aid of a tool on the template, the possible wear of the template and the possible concomitant reduction in the layer thickness is to be checked at intervals. Templates are to be replaced if they no longer have the predetermined thickness.

8.2.2 Alternative ways to apply thermal paste

If it is not possible to apply the thermal compound by the recommended screen printing process, the paste can alternatively be applied manually. Typically a uniform layer thickness of 100 µm thermal paste is sufficient on the base plate of the module. The suitability and long-term stability of the thermal compound used and its application is to be qualified by the user.

Base plate size	**Amount of thermal paste**
140x 73 mm module	1.02 cm^3 / 0.06 in^3
140x130 mm module	1.82 cm^3 / 0.11 in^3
140x190 mm module	2.66 cm^3 / 0.16 in^3

Table 5: Quantities representing a guideline of the required amounts of thermal paste for a 100 µm layer

This amount can be measured from a syringe or applied from a tube.

Common rollers or fine toothed spatulas like notched trowels can be used to apply the thermal grease. Regarding homogeneity and reproducibility of the paste thickness the manual application is subject to large tolerances. With the help of a wet film comb the thickness can be checked after applying the thermal compound, see Figure 10. Place the comb perpendicular to the surface of the heat sink and scrape the comb slowly over it through the thermal paste layer. Wet film combs have teeth of various lengths on their sides. The paste thickness lies between the biggest value of the "coated" or "wet" teeth and the smallest value of the "uncoated" or "dry" teeth.

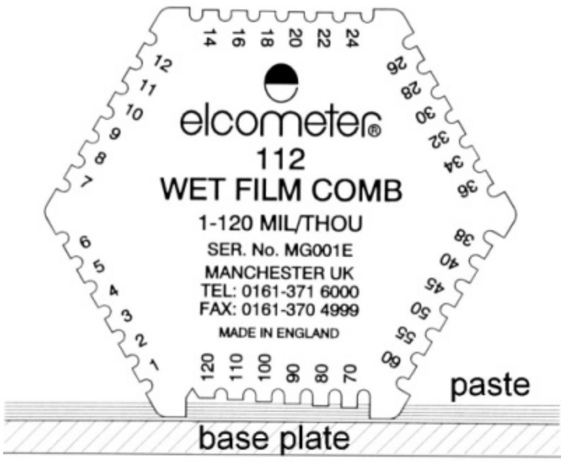


Fig. 10: Wet film gauge to check the layer thickness of the thermal compound

The application guidelines, the thermal contact and the long-term stability of the thermal interface materials to be considered in the selection must always be qualified by the user for the proposed procedure and the intended application and may be discussed with the compound manufacturer.

8.3 Module assembly onto the heat sink

The module assembly must comply with the tolerances specified in the module data sheets. The module-specific outline drawings can be taken from the data sheets.

The bolt mounting of the module on the heat sink has to be such that the sum of all occurring forces does not result in exceeding the yield point of the joined parts. Setting devices, such as spring washers, will increase the elasticity of the connection and thus compensate the settling effects. Thereby the pre-tension force will largely be retained, and thus a loosening of the assembly counteracted.

Description	Value	Note
Mounting bolt	M6	1.
Maximum recommended torque	M_{max} = 5.75 Nm	2.
Recommended property class of the bolt	8.8	
Minimal thread length into the heat sink	1.6 – 2.2 x d	3.

Table 6: Technical data of the mounting bolts

1. according to ISO4762, DIN6912, DIN7984, ISO14581 or DIN7991 in combination with a suitable washer, e.g. according to DIN433 or DIN125 or complete combination bolts according to DIN6900, recommended for module assembly.

2. thread clean and not lubricated or contaminated by thermal grease

3. into aluminum; according to technical literature depending on material properties of heat sink and screw; d: diameter of bolt

Other material combinations of bolts and / or heat sink material may require an adjustment of the mechanical parameters and an evaluation of the corrosion stability.

To avoid unnecessary strain and tension of the base plate, the heat sink has to show sufficient stiffness and has to be handled distortion free during assembly and transport.

All mounting screws have to be uniformly tightened with the specified mounting torque. A preferred tool for this is an electronically controlled or at least slow moving electrical screwdriver. The work can also be accomplished manually with the aid of a torque wrench. Due to missing accuracy and precision we advise against the use of pneumatic screwdrivers.
For a good thermal contact to the heat sink we recommend the following procedure of tightening the 6 or 8 screws of 140x130mm (or 140x190 mm) modules after the application of paste and the positioning of the module on the heat sink.

For thermal pastes with low viscosity:

1. Fix module loosely with two diagonal screws e.g. # 3 - 6 or 1 - 5. Press gently by hand on the module and distribute the paste by a slight rotary motion

2. Tighten the screws with 0.5 Nm±15% in the following sequence:
screw # 2 - 5 - 3 - 6 - 1 - 4 (or 2 - 6 - 3 - 7 - 4 - 8 - 1 - 5)

3. Tighten the screws with 5 Nm±15% in the same sequence.

For thermal pastes with high viscosity add the following step between 2. and 3.:

2.a Tighten the screws with 2 Nm ± 15% in same sequence as before. The retention time depends on the material used and is determined in the user's own responsibility by investigation / experiments with the favored material. As a guide for initial investigation during the development phase, a retention time of about 15min to 30min can be expected.

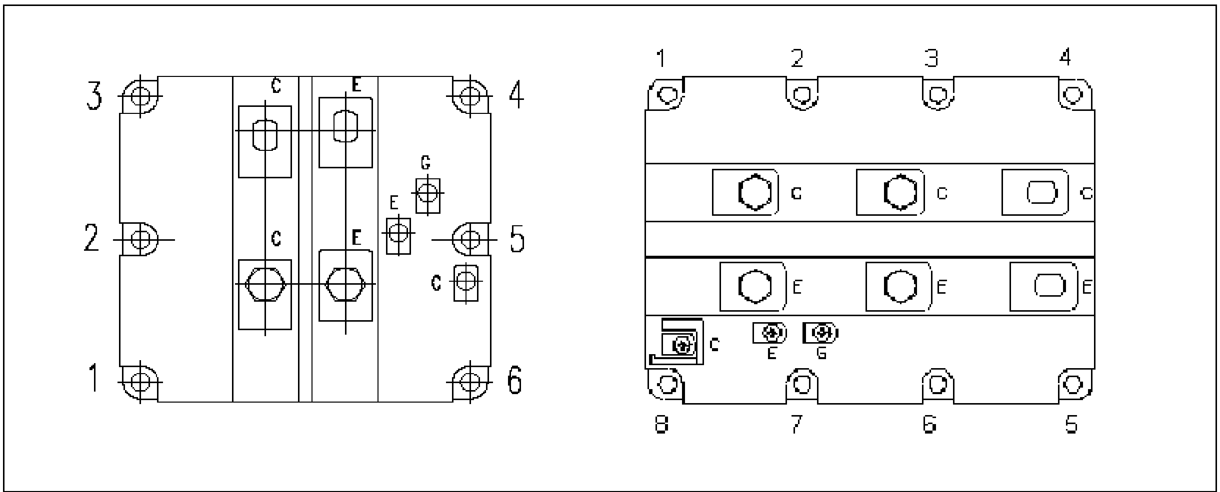


Fig. 11: Terminal numbering for tightening sequence

The tightening sequence is the same for all IHM / IHV modules and types.

The three step procedure must be strictly adhered to for both copper and AlSiC base plate modules to allow the paste to flow and the modules to slowly relax and conform its shape to the heat sink.

When using standard thermal compound, it may be necessary, depending on the nature of the paste, to check the tightening torques for the correct value of the bolts after a burn-in period. When using phase change film for heat conduction instead of thermal grease it is recommended that the additional verification step must be carried out. The use of solid foil cannot be recommended due to unsuitable properties for power devices.

For the qualification and verification of the assembly process and the suitability of the thermal design some experiments and measurements are essential with the thermal compound or an alternative material provided. The maximum junction temperature occurring under application conditions is to be reviewed by thermal measurements. The maximum junction temperature (T_{vjop}) in pulsed operation must not exceed the specified maximum junction temperature in the data sheets [4]!

For thermal measurements close to the chip, it is necessary to place the sensor probe under the chip, like in Fig. 12. Knowledge of the exact chip positions is essential. The module-specific chip positions may be enquired via the distribution of Infineon IGBT power modules.

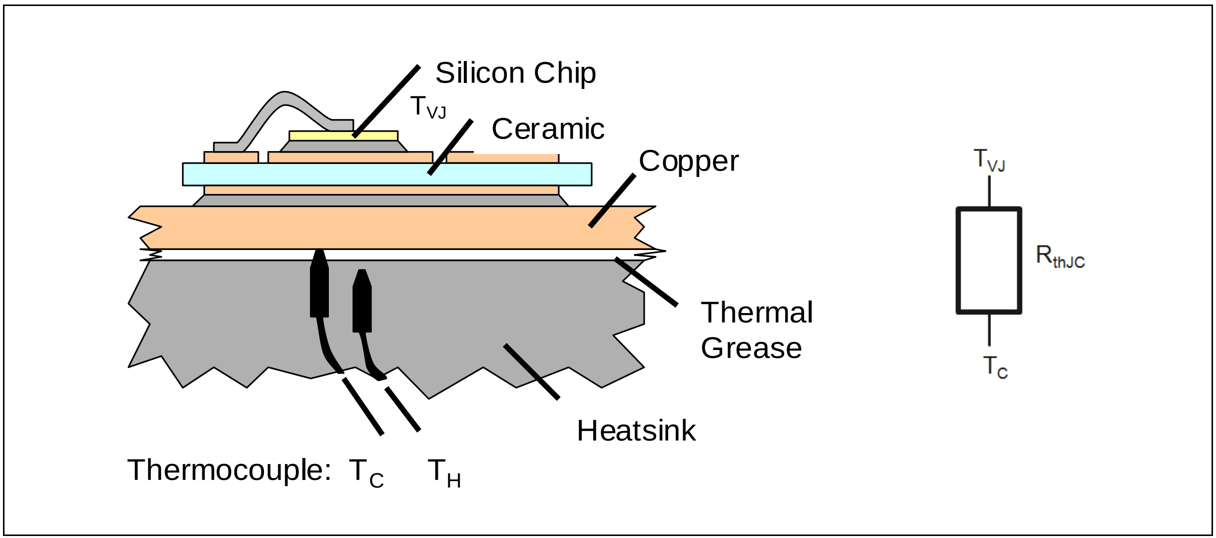


Fig. 12: Example of temperature measurement set-up using a thermo-couple

The junction temperature T_{VJ} can be determined by the following formula.

$$T_{VJ} = T_C + P_V \cdot R_{thJC}$$

The switching and conduction losses (P_V) as well as the base plate (T_C) temperature must be given for the calculation:

T_{VJ}: virtual junction temperature

T_C: case temperature

P_V: total power losses

R_{thJC}: thermal resistance, junction to case

8.4 Connection of the power and auxiliary terminals

The module must be connected within the permissible module tolerances specified in the outline drawings in the respective data sheets. The position and tolerance of adjacent components such as PCBs, DC-bus, mounting bolts or cables has to be designed such that, after the connection, no sustained effect on the static and / or dynamic tensile forces are exerted on the terminals.

To connect the power terminals of IHM / IHV modules M8 bolts are required. The bolts should be selected according to ISO4762, DIN7984 or DIN7985 with at least property class 8.8, in combination with a suitable washer and lock washer or combination screws according to DIN6900. The thread should be clean and not lubricated. The screws are to be tightened with a torque specified in the datasheet. Recommended is the use of a torque value near the maximum torque. The maximum torque values in Table 7 must not be exceeded, however.

The tightening torque must be chosen so that the applied pre-tension force leads to a pure frictional bond of the components. Knowledge of the friction coefficient μ is a prerequisite to accurately determine preload and tightening torque. The friction depends on many different factors, such as material combination, surface, lubrication, temperature, etc. The torque values specified in Table 6 assume a clean pair with a galvanised metric M6 steel bolt. Should the coefficient of friction in the construction differ from this, adjust the torque value accordingly.

Terminal	Bolt	Max. torque
Power	M8	8 - 10 Nm
Auxiliary	M4	2 Nm +5%,-10%

Table 7**:** Tightening torque M for the mounting bolts of the electrical connections

The choice of bolt length depends on the maximum thread depth specified for the module and the gauge of the connecting parts. The sum of these values must not be smaller than the selected bolt thread length. The effective thread length of the bolts into the module power terminals must not exceed the maximum specified depth of 16mm. For auxiliary terminals this is 8mm. Other material combinations of bolts and / or the DC busbar material may require an adjustment of the mechanical parameters and an evaluation of the corrosion stability in combination.

The design of the threaded connection for the power terminals must be such that the sum of all loads occurring does not exceed the yield point of the joined parts. Settling devices will increase the elasticity of the connection and thus compensate the settling effects. Thereby the pre-tension force will largely be retained, and thus a loosening of the assembly is counteracted.

The connecting parts must be mounted onto the electrical contacts in a manner that the specified maximum permissible forces are not exceeded during the assembly process.

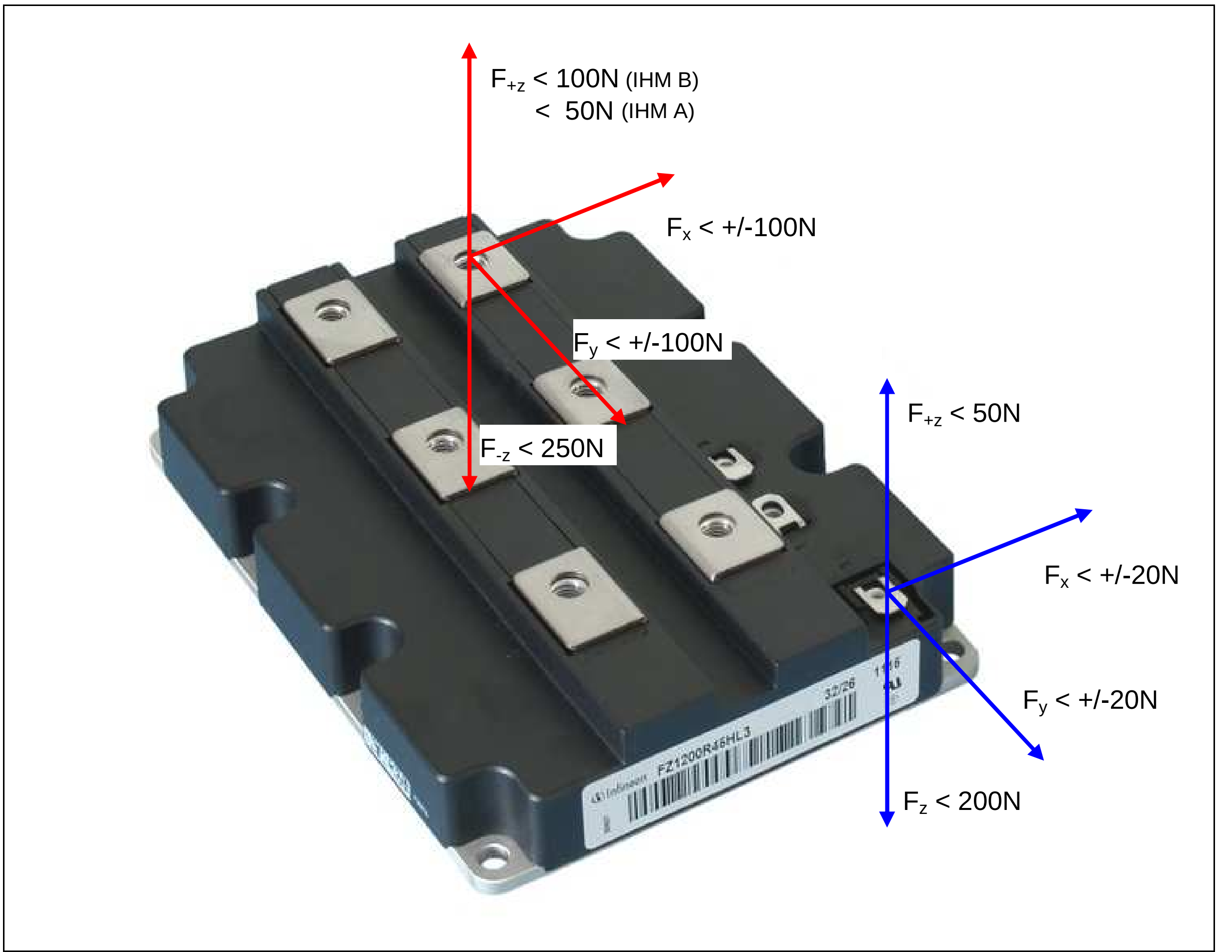


Fig. 13: Maximum permissible forces during the assembly process at the terminals of a IHM / IHV module

It is recommended to have an assembly which leaves the power and auxiliary terminals permanently free of mechanical stress. Since such an assembly is inherently problematic over the entire temperature range, the construction should be such that the power terminals of all package variants as well as the auxiliary terminals exhibit a load bias by means of suitable spacers.

It must be ensured that the direction of the bias force always acts in the direction of the base plate. The suitability of the support must be evaluated individually in the structure.

Static forces in other directions as well as exposure to vibration and / or thermal expansion should be avoided.

The auxiliary terminals have to be connected accordingly, observing the common ESD guidelines. No load current is permitted to flow through the auxiliary collector.

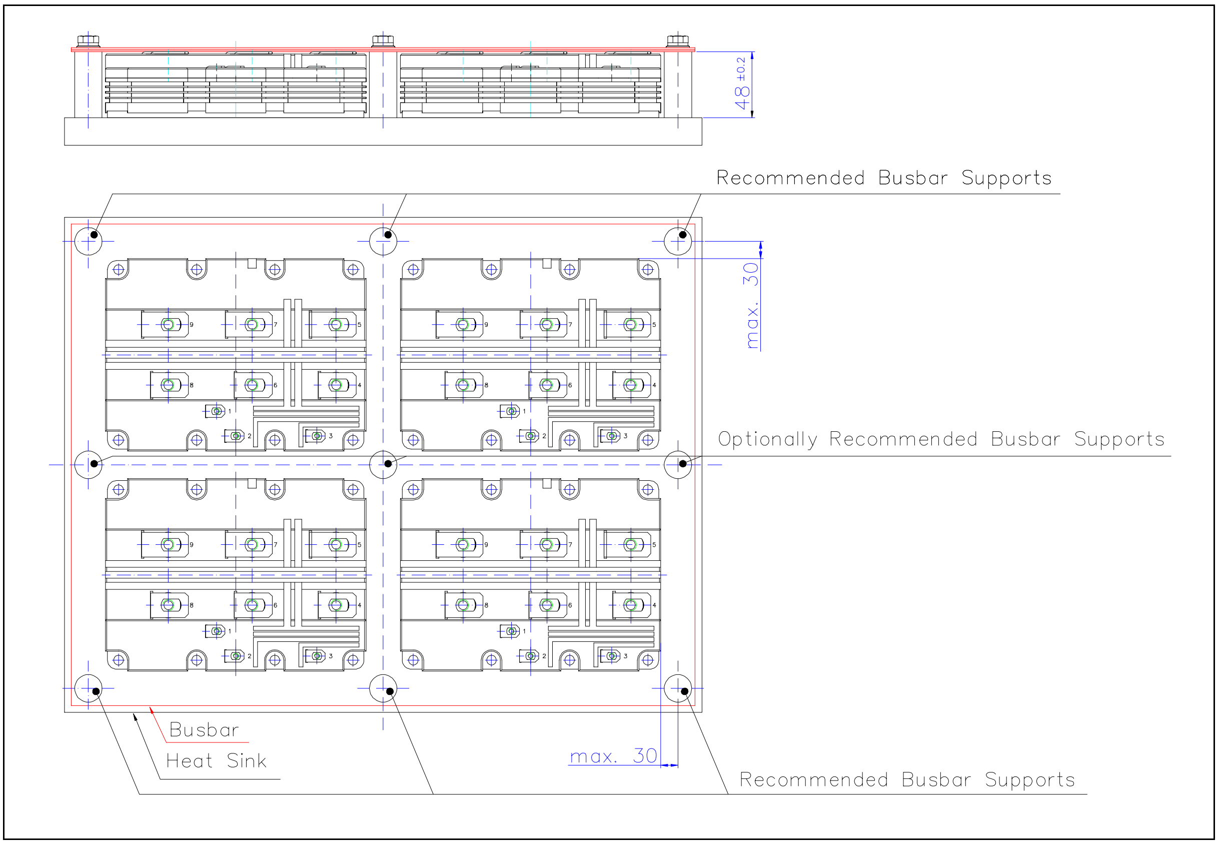


Fig. 14: Example for busbar support

The DC busbars have to be designed such that the maximum temperature at the power terminals $T_{Terminal}$ =125°C will not be exceeded.

To design the power busbars it is necessary to consider not only the current rating but also the additional power loss of the module's terminal connections.

8.5 Example of a low inductive, symmetrical phase-leg design

In addition to the maximum temperature at the terminals it is mandatory to assure compliance with the maximum collector-emitter voltage (V_{CE}) at the power terminals and, hence, at the IGBT chip corresponding to the respective RBSOA diagram given in the module data sheet.

It is recommended to connect the DC side via a laminated DC bus bar in order to minimize the systemic switching overvoltage by reducing the leakage inductance as far as possible.

For a low-inductance structure and a symmetric current distribution in the DC-bus circuit a balanced connection design of all modules is recommended [7]. The upper design in Fig. 15 gives a desired symmetric set up of the phase leg, where the current loops for all three subsystems are symmetric in relation to their DC-capacitor, to the other leg and to the phase output.
The lower design represents an asymmetric arrangement where the modules are oriented with their long side along the direction of the busbar. Di/dt during switching will result in different voltage drops along the emitter and collector chain as well as along the auxiliary emitters. As a result the gate-emitter voltages are different for each of the three subsystems, leading to different turn-on speed, current peaks current mis-sharing within the module.

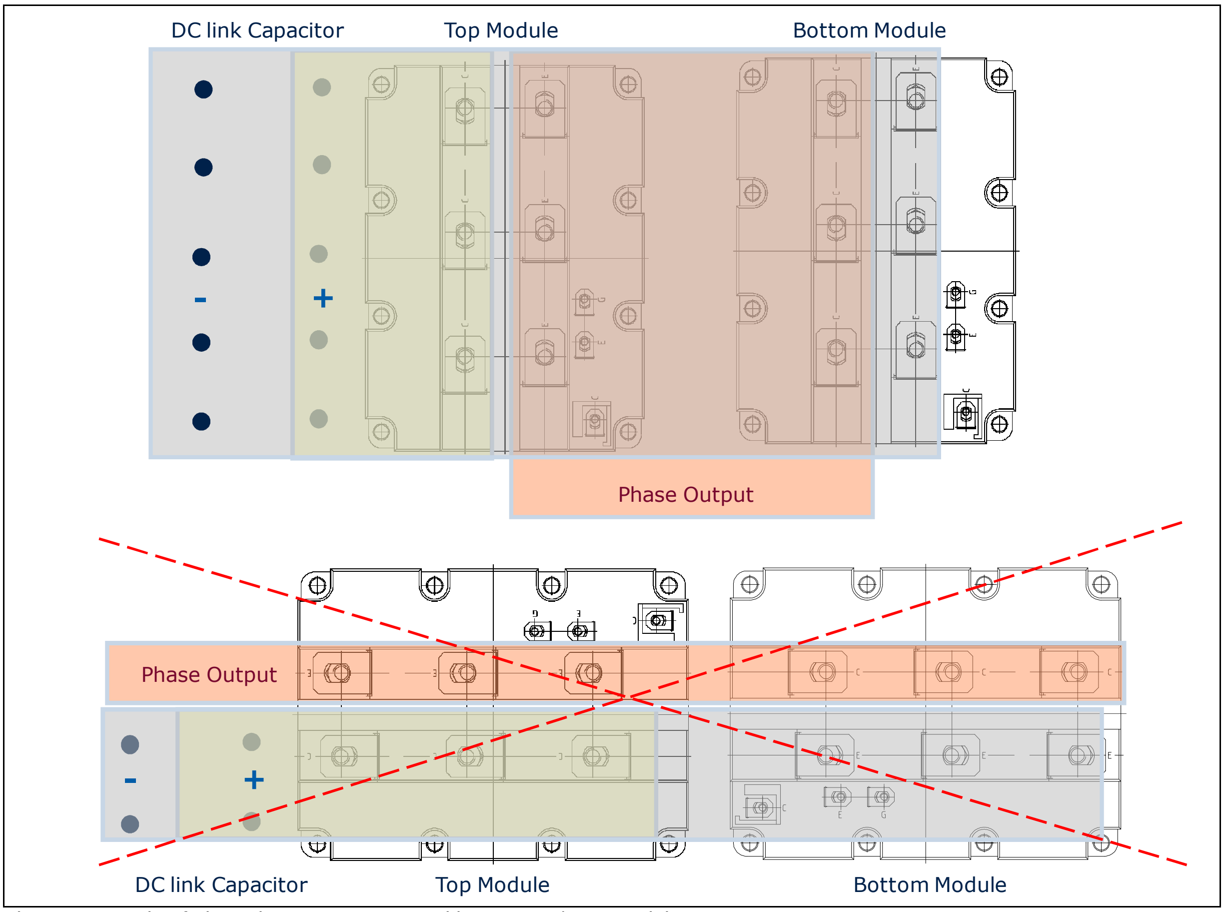


Fig. 15: Example of phase-leg arrangements with two IHM / IHV modules
Top: symmetric set up of the phase leg
Bottom: asymmetric arrangement; modules oriented with long side along the bus

9. References

[1] TR14 Storage of Products supplied by Infineon Technologies

[2] AN2011-05 Industrial IGBT Modules - Explanation of Technical Information

[3] AN2010-02 Use of Power Cycling Curves for IGBT4

[4] AN2008-01 Definition and use of junction temperature values

[5] AN2006-02 Application of silk screen print templates

[6] Infineon Technologies IGBT Modules -Technologies, Driver and Applications; A. Volke, M. Hornkamp, ISBN 978-3-00-032076-7

[7] Power Circuit design for clean switching; R. Bayerer, D. Domes, CIPS 2010