MiniSKiiP® Generation II

Technical Explanations

Version 3.3 / August 2012

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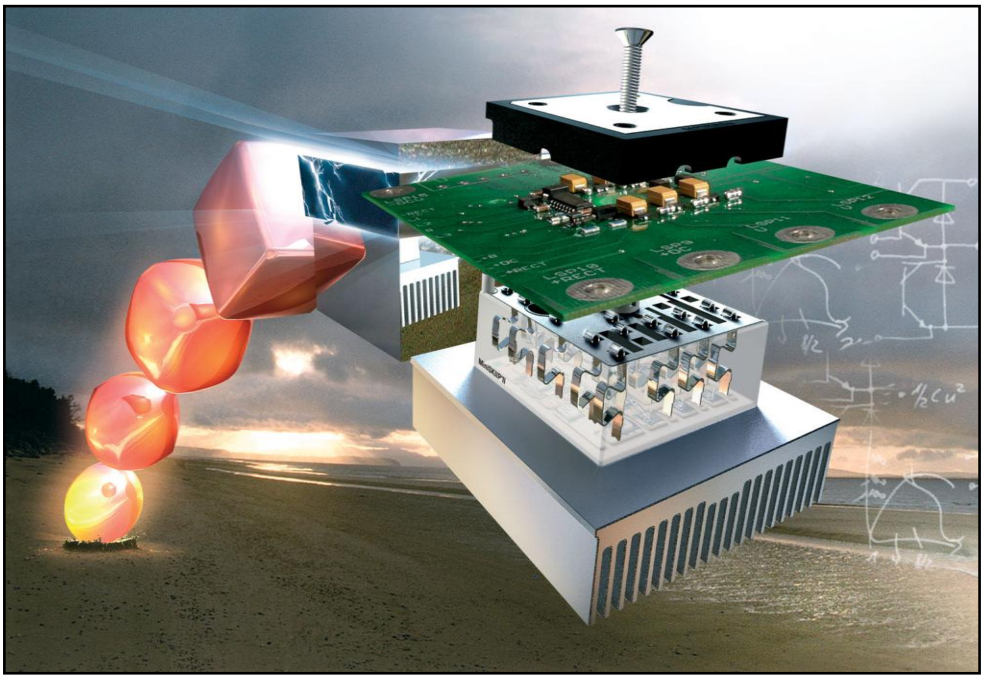

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1 Introduction

1.1 Features

- Compact CIB (**C**onverter **I**nverter **B**rake)
- Converter and Inverter Modules in 4 different case sizes for modern inverter designs from several hundred watts up to 37 kW motor power
- Different topologies: CIBs, sixpack modules, input bridges with brake chopper and 3-level modules for various applications
- Rugged fast mounting spring contacts for all power and auxiliary connections
- Easy one or two screw mounting
- Full isolation and low thermal resistance due to DCB ceramic without base plate
- Integration of latest chip technologies:
  - Fast 1200 V Trench IGBT, 1200V Trench 4, Ultrafast 600 V NPT, 600V and 650V Trench IGBTs with anti-parallel CAL-diodes
  - Thyristors for controlled rectifiers
  - Input diodes with high surge currents
- Integrated PTC temperature sensor

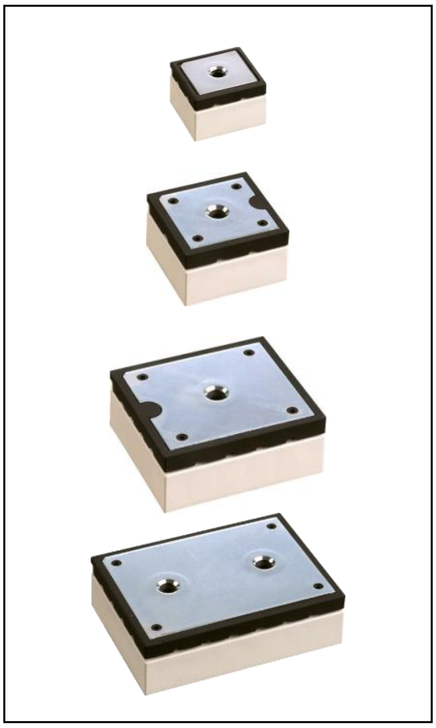


Fig. 1.1: MiniSKiiP® housing sizes

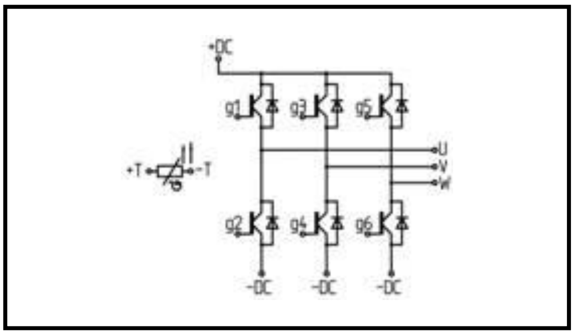
1.2 Advantages

Utilising the reliability of pressure contact technology the patented MiniSKiiP® is a rugged, high-integrated system including converter, inverter, brake (CIB) topologies for standard drive applications up to 37 kW motor power. An integrated temperature sensor for monitoring the heat sink temperature enables an over temperature shoot down. All components integrated in one package greatly reduce handling. The reduced number of parts increases the reliability.
MiniSKiiP® is using a well-approved Al_2O_3 DCB ceramic for achieving an isolation voltage of AC 2.5 kV per 1min and superior thermal conductivity to the heat sink.
Due to optimised current density, matched materials for high power cycling capability and pressure contact technology, MiniSKiiP® is a highly reliable, compact and cost effective power module.

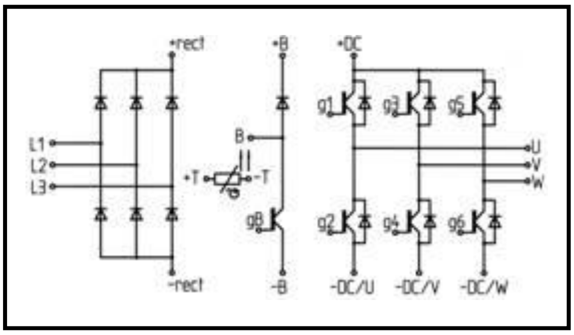
2 Topologies

The MiniSKiiP® range offers CIB (Converter Inverter Brake) and sixpack inverter topologies in four package sizes. Diode or thyristor controlled input bridge rectifier modules with optional brake chopper supplement the sixpack modules. 3-level NPC topology is available in housing size 2 and 3.
A PTC temperature sensor for an indication of the heat sink temperature near the IGBT chips is available for easy readout. The PTC characteristic ensures as well a fail save criteria.

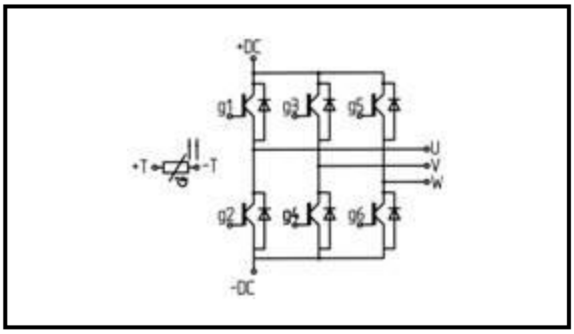
For types in MiniSKiiP® housing size 1 with low current rating, the minus DC connection of each phase leg is left open ("open emitter") as shown in Fig. 2.1. This topology allows a current measurement by shunt resistors on the PCB.



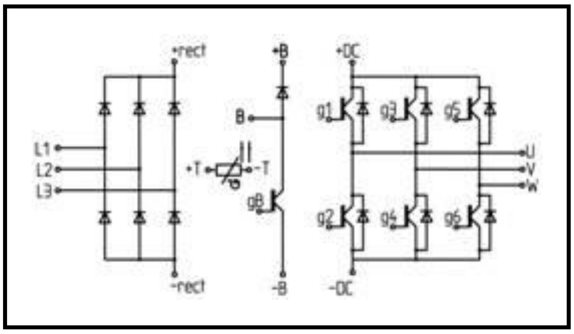
AC with open emitter in MiniSKiiP® housing 1



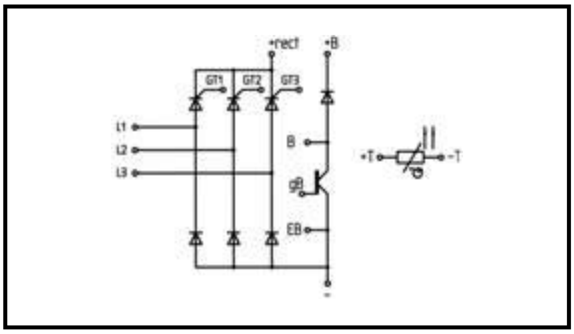
NAB with open emitter in MiniSKiiP® housing 1



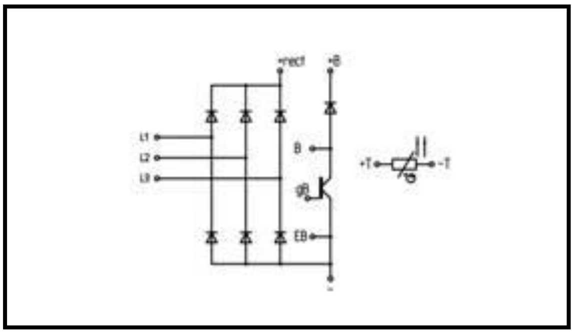
AC in MiniSKiiP® housing 2 and 3



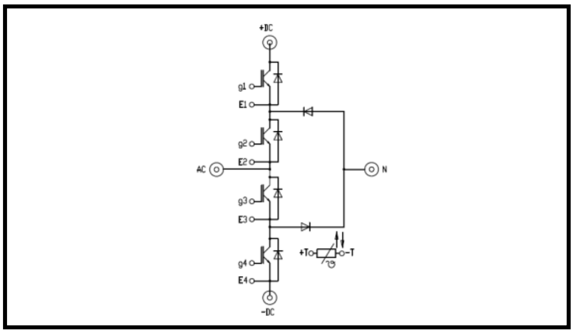
NAB in MiniSKiiP® housing 2 and 3



AHB in MiniSKiiP® housing 2 and 3



ANB in MiniSKiiP® housing 2 and 3



MLI NPC in MiniSKiiP® housing 2 and 3

Fig. 2.1: MiniSKiiP® Topologies

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3 Selection Guide

For drive applications, the following tables and diagrams can be used as a first indication (Fig. 3.1 – Fig. 3.8). In any case, a verification of the selection with an accurate calculation is mandatory. For an easy calculation, SEMIKRON offers a calculation tool called "SEMISEL". It is a flexible calculation tool based on MathCad. Parameters can be adapted to a broad range of applications.

SEMISEL can be found on the SEMIKRON homepage under http://semisel.semikron.com/.

3.1 Selection for 600 V Fast Switching Applications

The following table (Fig. 3.1: Standard motor shaft powers and maximum switching frequencies) shows the correlation between standard motor power (shaft power) and standard MiniSKiiP® under typical conditions. For the calculation parameters, please refer to Fig. 3.2.

f_{sw}(max) [kHz]	< 8	8 - 12	> 12

P [kW]	1.5	2.2	3	4	5.5	7.5	11	15
SKiiP 11NAB065V1	25	4						
SKiiP 12NAB065V1		20	4					
SKiiP 13NAB065V1		25	12					
SKiiP 14NAB065V1			17	4				
SKiiP 25NAB065V1				25	8			
SKiiP 26NAB065V1					20			
SKiiP 37NAB065V1						15		
SKiiP 38NAB065V1						25	8	
SKiiP 39AC065V1							17	6

Fig. 3.1: Standard motor shaft powers and maximum switching frequencies

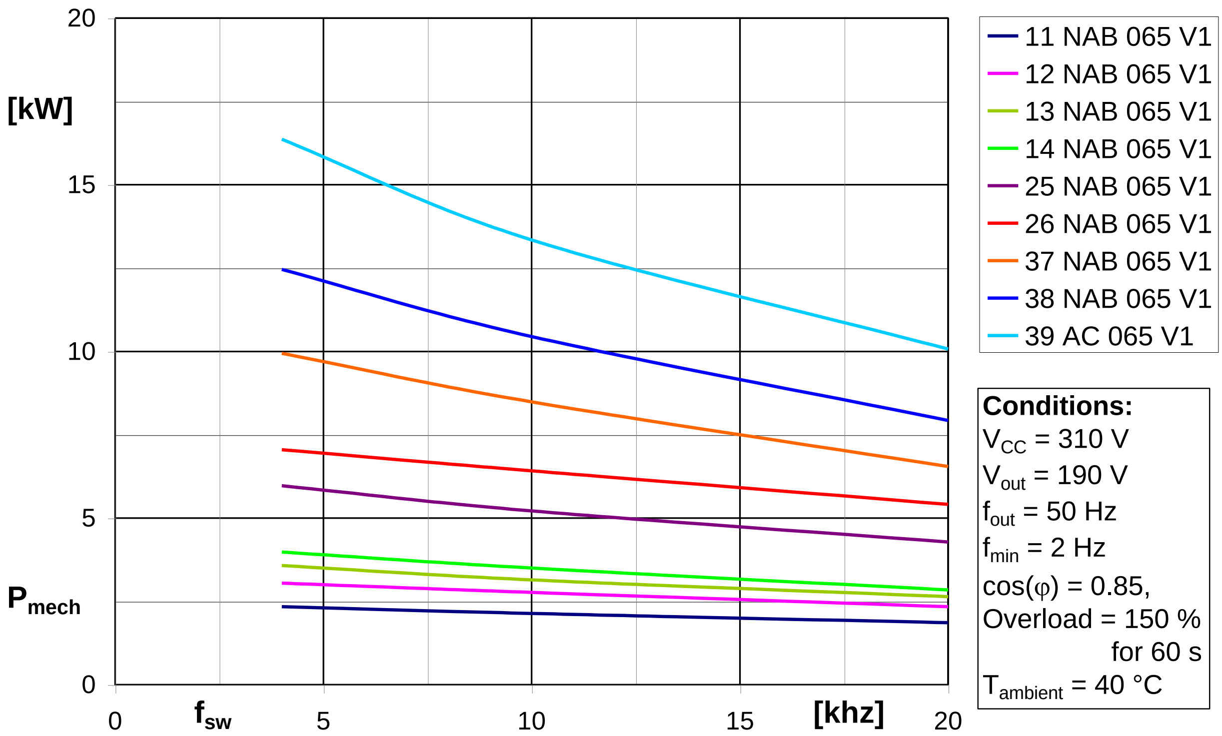


Fig. 3.2: Dependence of max. mechanical power vs. switching frequencies of the inverter for different MiniSKiiP® modules operated with a maximum junction temperature of T_j = 125 °C

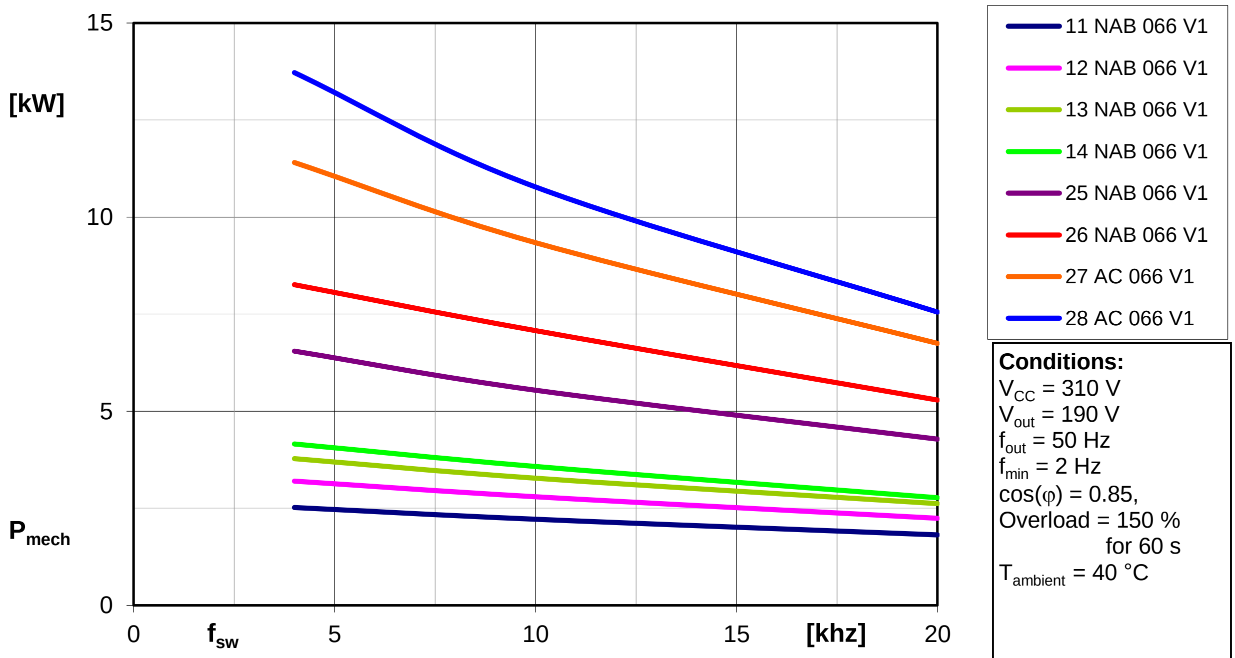
3.2 Selection for 600 V Applications (Trench IGBT)

The following table (Fig. 3.3) shows the correlation between standard motor power (shaft power) and standard MiniSKiiP® under typical conditions. For the calculation parameters, please refer to Fig. 3.3).

f_{sw}(max) [kHz]	< 8	8 - 12	> 12

P [kW]	1.5	2.2	3	4	5.5	7.5	11	15
SKiiP 11NAB066V1	20+	10						
SKiiP 12NAB066V1		20+	7					
SKiiP 13NAB066V1			14					
SKiiP 14NAB066V1			17	5.5				
SKiiP 25NAB066V1				20+	10			
SKiiP 26NAB066V1					19	7		
SKiiP 27AC066V1						17	5	
SKiiP 28AC066V1						20	9	

Fig. 3.3: Standard motor shaft powers and maximum switching frequencies



Conditions:
V_{CC} = 310 V
V_{out} = 190 V
f_{out} = 50 Hz
f_{min} = 2 Hz
cos(φ) = 0.85,
Overload = 150 % for 60 s
$T_{ambient}$ = 40 °C

Fig. 3.4: Dependence of max. mechanical power vs. switching frequencies of the inverter for different MiniSKiiP® modules operated with a maximum junction temperature of T_j = 150 °C

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3.3 Selection for 1200 V Applications

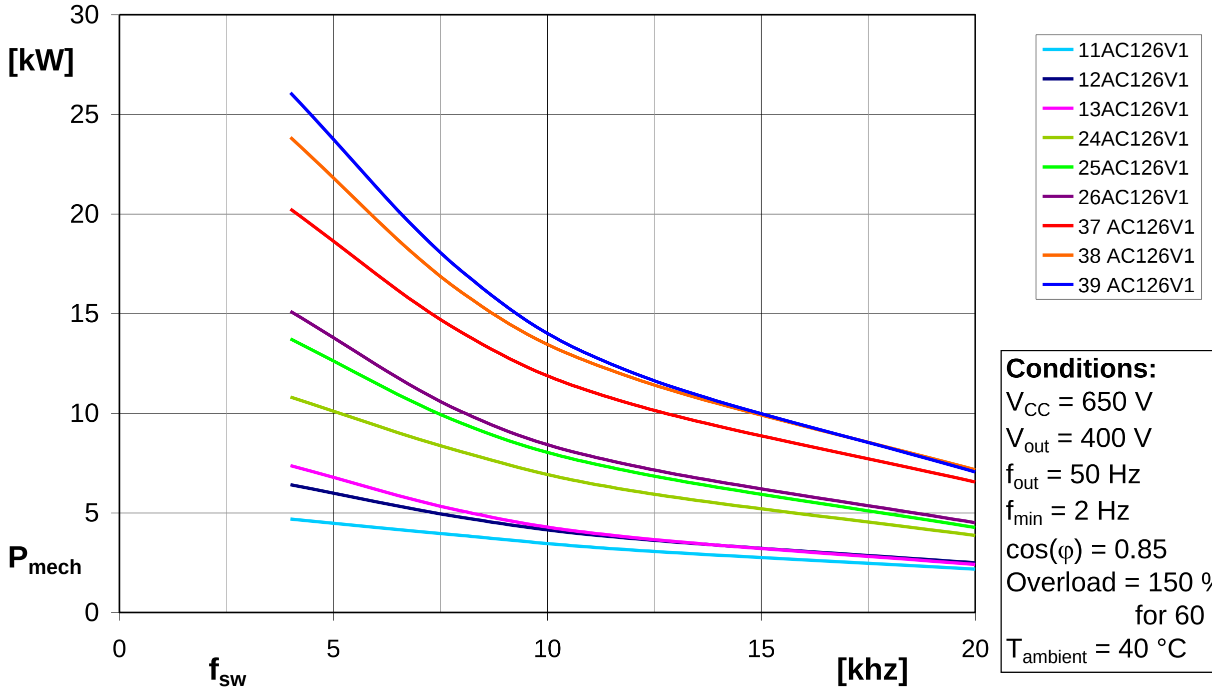
The following table (Fig. 3.5) shows for which standard motor power (shaft power) which standard MiniSKiiP® works proper under typical conditions and switching frequencies. For the calculation parameters, please refer to Fig. 3.6: .

f_{sw}(max) [kHz]	< 8	8 - 12	> 12

P [kW]	2.2	3	4	5.5	7.5	11	15	18.5	22	30
SKiiP 11AC126V1	19	12	7							
SKiiP 12AC126V1		16	9	6						
SKiiP 13AC126V1		16	10	7						
SKiiP 24AC126V1			19	13	7					
SKiiP 25AC126V1				16	10	6				
SKiiP 26AC126V1				17	11	7	4			
SKiiP 37AC126V1					17	11	7	5		
SKiiP 38AC126V1					18	12	8	6	5	
SKiiP 39AC126V1					19	13	9	7	6	

Fig. 3.5: Standard motor shaft powers and maximum switching frequencies

The dependence of maximum mechanical power versus switching frequencies of the inverter for different MiniSKiiP® modules is given in Fig. 3.6: .



Conditions:
V_{CC} = 650 V
V_{out} = 400 V
f_{out} = 50 Hz
f_{min} = 2 Hz
cos(φ) = 0.85
Overload = 150 % for 60 s
$T_{ambient}$ = 40 °C

Fig. 3.6: Dependence of max. mechanical power vs. switching frequencies of the inverter for different MiniSKiiP® modules operated with a maximum junction temperature of T_j = 125 °C

3.4 Selection for 1200V Applications (Trench 4 IGBT)

The following table (Fig. 3.7) shows for which standard motor power (shaft power) which standard MiniSKiiP® works proper under typical conditions and switching frequencies. For the calculation parameters, please refer to (**Fehler! Verweisquelle konnte nicht gefunden werden.Fehler! Verweisquelle konnte nicht gefunden werden.**8).

f_{sw}(max) [kHz]	< 8	8 - 12	> 12

P [kW]	2.2	3	4	5.5	7.5	11	15	18.5	22	30
SKiiP 11AC12T4V1	20+	18	9							
SKiiP 12AC12T4V1		20+	17	9						
SKiiP 13AC12T4V1			18	11	6					
SKiiP 24AC12T4V1				20+	16	7				
SKiiP 25AC12T4V1					17	9	4			
SKiiP 26AC12T4V1					18	10	6			
SKiiP 37AC12T4V1						14	8	5		
SKiiP 38AC12T4V1						17	11	7	6	
SKiiP 39AC12T4V1							13	10	8	4

Fig. 3.7: Standard motor shaft powers and maximum switching frequencies

The dependence of maximum mechanical power versus switching frequencies of the inverter for different MiniSKiiP® modules is given in Fig. 3.8.

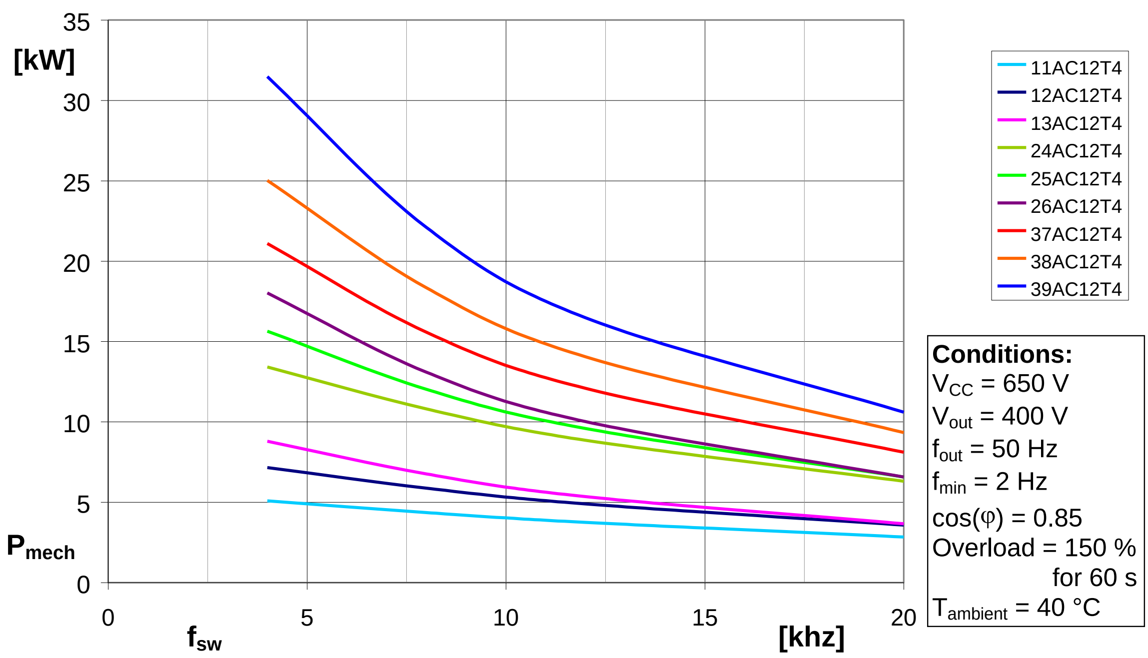


Fig. 3.8: Dependence of max. mechanical power vs. switching frequencies of the inverter for different MiniSKiiP® modules operated with a maximum junction temperature of T_j = 150 °C

3.5 Selection for 3-Level Applications (650V Trench IGBT)

The following table shows the output power rating of 3-level inverters The output power rating based on a switching frequency of 3 kHz.

Type designation	$I_{c,nom}$ [A]	Blocking voltage [V]	$P_{out,max}$ [kVA]	MiniSKiiP® housing size
SKiiP 26MLI07E3V1	75	650	31	2
SKiiP 27MLI07E3V1	100	650	41	2
SKiiP 28MLI07E3V1	150	650	62	2
SKiiP 39MLI07E3V1	200	650	83	3

Fig. 3.9: MiniSKiiP® MLI modules with NPC topology.

4 MiniSKiiP® Qualification

Standard Tests for Qualification and Re-qualification of Products

The objectives of the test program are:
1. Assure a general product quality and reliability.
2. Evaluate design limits by stressing under a variety of testing conditions.
3. Ensure the consistency and predictability of our production processes.
4. Appraise process and design changes regarding their effect on reliability.

	Standard Test Conditions for	
Reliability Test	**MOS / IGBT Products:**	**Diode / Thyristor Products:**
High Temperature Reverse Bias (HTRB) *IEC 60747*	1000 h, 95% V_{DSmax}/V_{CEmax}, 125°C ≤ T_c ≤ 145°C	1000 h, DC, 66% of voltage class, 105°C ≤ T_c ≤ 120°C
High Temperature Gate Bias (HTGB) *IEC 60747*	1000 h, ± V_{GSmax}/V_{GEmax}, T_{vjmax}	not applicable
High Humidity High Temperature Reverse Bias (THB) *IEC 60068-2-67*	1000 h, 85°C, 85% RH, V_{DS}/V_{CE} = 80% V_{DSmax}/V_{CEmax}, max. 80V, V_{GE} = 0V	1000 h, 85°C, 85% RH, V_D/V_R = 80% V_{Dmax}/V_{Rmax}, max. 80V
High Temperature Storage (HTS) *IEC 60068-2-2*	1000 h, T_{stgmax}	1000 h, T_{stgmax}
Low Temperature Storage (LTS) *IEC 60068-2-1*	1000 h, T_{stgmin}	1000 h, T_{stgmin}
Thermal Cycling (TC) *IEC 60068-2-14 Test Na*	100 cycles, T_{stgmax} - T_{stgmin}	25 cycles, 100 cycles (capsule) T_{stgmax} - T_{stgmin}
Power Cycling (PC) *IEC 60749-34*	20.000 load cycles, ΔT_j = 100K	10.000 load cycles, 20.000 load cycles (capsule) ΔT_j = 100K
Vibration *IEC 60068-2-6 Test Fc*	Sinusoidal sweep, 5g, 2 h per axis (x, y, z)	Sinusoidal sweep, 5g, 2 h per axis (x, y, z)
Mechanical Shock *IEC 60068-2-27 Test Ea*	Half sine puls, 30g, 3 times each direction (±x, ±y, ±z)	Half sine puls, 30g, 3 times each direction (±x, ±y, ±z)

Supplement of the current valid Data Book

For more detailes about qualification tests, please contact MiniSKiiP® product manager musamettin.zurnaci@semikron.com.

5 Storage Conditions

- Unassembled: 20000h / 40°C 70% RH
- Assembled: 20000h / 40°C 70% RH

After extreme humidity the reverse current limits may be exceeded but do not degrade the performance of the MiniSKiiP®.

6 MiniSKiiP® Contact System

6.1 PCB Specification for the MiniSKiiP® Contact System

The material combination between the MiniSKiiP® spring surface and the corresponding contact pad surface of the PCB has an influence to the contact resistance for different currents. Tin Lead alloy (SnPb) is an approved interface for application with MiniSKiiP® modules. A sufficient plating thickness has to be ensured according to PCB manufacturing process. In order to comply with RoHS rules, the use of following PCB finish materials are recommended:

- Nickel Gold flash (NiAu)
- Hot Air Levelling Tin (HAL Sn)
- Chemical Tin (Chem.l Sn)

It is not recommended to use boards with OSP (organic solderability preservatives) passivation. OSP is not suitable to guarantee a long term corrosion free contact. The OSP passivation is dissapearing nearly 100% after a solder process or after 6 month storage.

6.1.1 Conductive Layer Thickness Requirements

No special requirements on the thickness of the tin layer are necessary. All standard HAL and chemical tin boards (lead free process) are suitable. Due to PCB production process variations and several reflow processes it may be possible, that the tin layer has been consumed by the growth of inter metallic phases when mounting the MiniSKiiP®. For the functionality of the MiniSKiiP® spring contact system inside the specification limits a tin layer over the inter metallic phase is not necessary. The inter metallic phase is protecting the copper area on the PCB as well against oxidation as a long term effect.

6.1.2 NiAu as PCB Surface Finish

The material combination NiAu and Ag plated spring has the best contact capabilities. To ensure the functionality of the Ni diffusion barrier, a thickness of at least 5µm nickel under plating is required.

6.2 PCB Design

PCB Design is in responsibility of the customer. SEMIKRON's recommendation is to comply with valid applicable regulations. In order to achieve the best performance layout the DC link should be a low inductance design. The –DC / +DC and –B/+B conductors should be as coplanar as possible with the maximum possible amount of copper area. The gate and the corresponding emitter tracks should be routed as well parallel and close together. If using the "standard (space) lid" a possibility is given for using SMD devices under the lid in certain areas. The maximum height of the applicable SMD devices is 3.5mm. Please make sure that the devices do not conflict either with the pressure points or with the mounting domes of the MiniSKiiP® / MiniSKiiP® lid. This will lead to an incorrect mounting increasing the thermal resistance which may lead to a thermal failure. As material for the printed circuit board, the FR 4 material can be applied. The thickness of copper layers should comply with IEC 326-3.

6.2.1 Landing Pads

The landing pads for the spring contact should be free of any contamination like of solder stop, solder flux, dust, sweat, oil or other substances. If electrical components have to be soldered to the bottom side of the PCB the contact pads have to be covered during the soldering process to protect the landing pads from solder splashes. Size and position of the particular landing pads are specified in the dedicated datasheet for each type. To ensure a reliable contact the landing pad size should be not undercut those measures. The landing pads must be free from plated-through holes (“VIAs”), to prevent any deterioration on a proper contact. In the remaining area, VIAs can be placed freely.

6.3 Spring Contact Specification

Material: K88

Passivation: Silver Abrasiveness approximately 75 to 95HV, thickness 3 to 5µm on the head and heel.
Metallic Tarnishing protection (50 to 55%Cu, 30 to 35% Sn, 13 to 17% Zn) thickness < 0.1µm

The base material K88 is a high-performance alloy for connector applications developed by Wieland Werke and Olin Brass. This alloy offers high yield strenght (550 MPa), very good formability up to sharp bending, outstanding electrical conductivity (80% IACS) as well as remarkable relaxation resistance up to 200°C for a long term stable spring force over the specified temperature range. No spring fatigue expected over the complete MiniSKiiP® lifetime.

To protect the silver surface from deterioration it is covered with a silver passivation film. This tarnish protection of the MiniSKiiP spring pins is for cosmetic reasons only and protects the silver surface from sulfuration and tarnishing for about half a year.

Approximately half a year after production, depending on the thickness of the tarnish protection, the silver springs can begin to decolourize. It is possible that the springs of a single module show different states of discolouration.

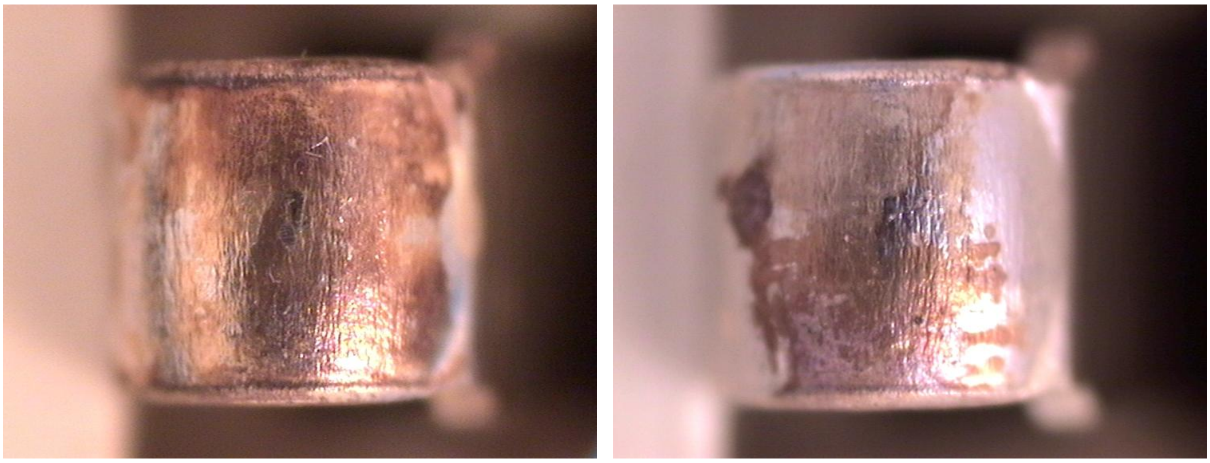


Fig. 6.1: Two examples for discoloured spring surfaces

The yellow marks (Fig. 6.1) are caused by thin sulphide layers that develop on silver plated surfaces over time. The tarnish layers are ultrathin and brittle. These sulphide layers are easily broken during mounting; they do not impair the electrical contact.

Tests have been carried out on the SEMiX contact springs which have equivalent silver plating. Eight modules were stored under corrosive atmosphere conditions (IEC 60068-2-43: T=25±2°C; rel. humidity 75±3%; H_2S 10ppm) for a duration of 10 days. The contact resistances of two spring pairs were measured:

Contact spring pair	R_c before corrosive atm. in mΩ	R_c after corrosive atm. in mΩ
Gate-Emitter Top	222 ± 5	224 ± 7
Gate-Emitter Bot	237 ± 10	241 ± 15

The results show no difference within the test data distribution of the contact resistance before and after the storage in corrosive atmosphere.

Those results are also valid for the silver plated MiniSKiiP contact springs. Therefore MiniSKiiP modules with discoloured springs due to oxidation and sulfuration can be used for inverter production without any risk.

To ensure a proper contact after mounting the measure for the spring looking out of the housing is set to min. 0.9mm (measured from the top surface to the head of the spring, Fig 6.2).

For a proper functionality the spring contacts must not be contaminated by oil, sweat or other substances. Do not touch the spring surface with bare fingers. For this reason SEMIKRON recommends to wear gloves during all handling of the MiniSKiiP® modules.

Do not use any contact spray or other chemicals on the spring.

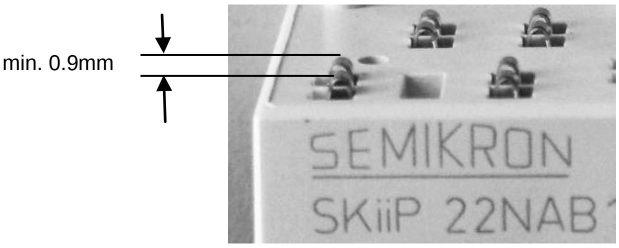


Fig. 6.2: Spring excess length

6.3.1 Spring Contact Material Selection

Ag is the only material suitable to use for all recommended PCB surfaces (NiAu, HAL Sn, chem. Sn and PbSn) without any issues. Au and Sn is not recommended to use as partners in a contact system because of contact corrosion. Due to the huge difference (1.5V) of Au and Sn in the electric potential the Sn gets dissolved and forms corrosion products.

6.3.2 Electromigration and Whisker Formation

To exclude the risk of Electromigration SEMIKRON has performed a corrosive atmosphere test with a high concentration on H_2S. The test was successfully passed, please see test conditions below:

Pre-conditioning	48 hours 25°C 75% Relative Humidity 80V Bias Voltage
Corrosive Atmosphere test following the pre-conditioning	240 hours 25°C 75% Relative Humidity 10ppm H_2S 80V Bias Voltage
Failure criteria	Leakage current > 10µA

Whiskers are electrically conductive, crystalline structures growing out of a metal surface, generated by compressive stresses present in the metal structure and accelerated upon exposure to a corrosive atmosphere. After testing whisker growth has been observed on the edges of the MiniSKiiP® springs in the area of less thick plating on the spring head and in the spring shafts. In no case whisker growth is influencing the creepage and clearance distances at MiniSKiiP®. Spring shafts are non-conductive and made of plastic. Therefore, no issue can arise with the formation of whiskers in the spring shafts. Whisker growth on the spring head is not critical as well because the whisker is connecting spring pad and spring, which is anyway connected.

No whisker growth sideways could be found in between connecting pads with different potentials. The inability of whisker growth sideways is stated as well in the common literature like: Chudnovsky, “Degradation of Power Contact in Industrial Atmosphere: Silver Corrosion and Whiskers”

Fully test reports are available at SEMIKRON. For detailed information please contact MiniSKiiP® product manager musamettin.zurnaci@semikron.com

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6.3.3 Qualification of Contact System

Pre test Printed Circuit Board				
		Kind of Test	Conditions	Evaluation
1	Delivery condition	-	-	Analysis of material compositions: Surface and cross section EDX/SEM
2	After Accelerated Aging Test	High Humidity, High Temperature Storage	85°C 85% RH 1000h	Analysis of material compositions: Surface and cross section EDX/SEM
3	After Accelerated Aging Test	High Temperature Storage	150°C 1000h	Analysis of material compositions: Surface and cross section EDX/SEM

Pressure Contact System Complete assembly: Mechanical Samples mounted with PCBs to a heat sink			
	Kind of Test	Conditions	Evaluation
4	High Temperature Storage	125°C 1000h	Measurement of electrical contact resistance before and after the test
5	High Humidity, High Temperature Storage	85°C 85% RH 1000h	Measurement of electrical contact resistance before and after the test
6	Temperature Cycling with Current	- 40…+125°C 200 cycles	Continuous monitoring of contact resistance for: Load current 6A Sense current 1mA
7	Industrial Atmosphere in dependence upon IEC 60068-2-60	H2S 0.4ppm, SO2 0.4ppm, NO2 0.5ppm, Cl2 0.1ppm, 21Days	Measurement of electrical contact resistance before and after the test
8	Vibration	Sinusoidal sweep, 5 g, x, y, z – axis, 2 h/axis	Continuous monitoring of electrical contact
9	Shock	Half sine pulse, 30g, ±x, ±y, ±z – direction, 2h/axis	Continuous monitoring of electrical contact

For detailed information please contact MiniSKiiP® product manager musamettin.zurnaci@semikron.com

7 Assembly Instructions

7.1 Preparation, Surface Specification

To obtain the maximum thermal conductivity of the module, heat sink and module must fulfill the following specifications.

7.1.1 Heat Sink

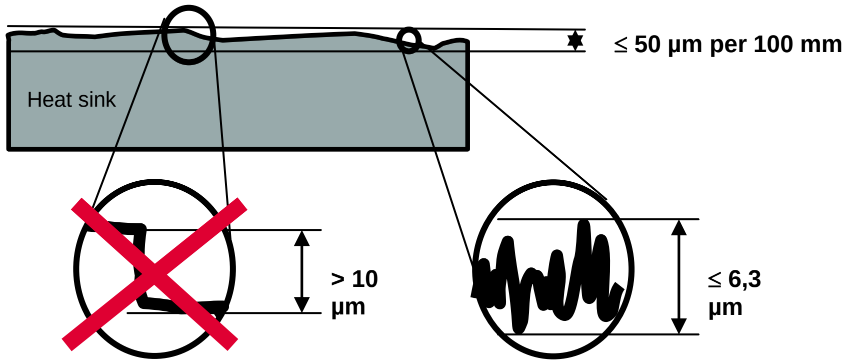


Fig. 7.1: Heat sink surface specification

- Heat sink must be free from grease and particles
- Unevenness of heat sink mounting area must be ≤ 50 µm per 100 mm (DIN EN ISO 1101)
- RZ ≤ 6.3 µm (DIN EN ISO 4287)
- No steps > 10 µm (DIN EN ISO 4287)

7.1.2 Mounting Surface

The mounting surface of MiniSKiiP® module must be free from grease and all kind of particles. MiniSKiiP® is using DBC with a gold flash finish (NiAu). Fingerprints or discolorations (Fig. 7.2) on the bottom side of the DBC do not affect the thermal behaviour and can not be rated as a failure criteria.

Due to rework or a second cleaning process, there might be imperfections of the NiAu flash on the bottom side of the DBC. An imperfection on the NiAu flash does not affect the thermal behaviour (Fig 7.3). The NiAu flash is only required on the top side of the DBC serving the function of spring landing pads. The bottom side is only gold flashed due to the flash process. A single side flash would be much more costly to realize.

Due to the manufacturing process, the bottom side of the MiniSKiiP® may exhibit scratches, holes or similar marks. The following figures are defining surface characteristics, which do not affect the thermal behaviour. Distortions with higher values as specified can be rated as failure.

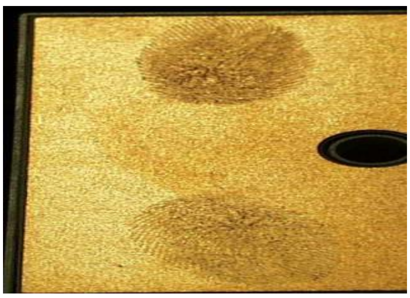


Fig. 7.2: NiAu DCB with fingerprints or discoloration

Fig. 7.3: Bottom surface NiAu DBC after rework

The MiniSKiiP® bottom surface must in any case comply with the following specification (Fig 7.4 to Fig. 7.6)

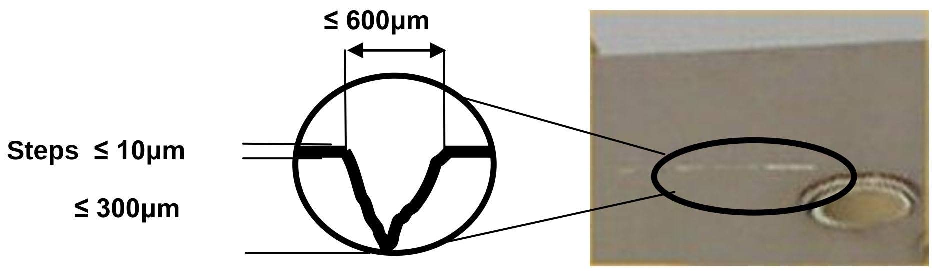


Fig. 7.4: Scratches on the MiniSKiiP® bottom surface

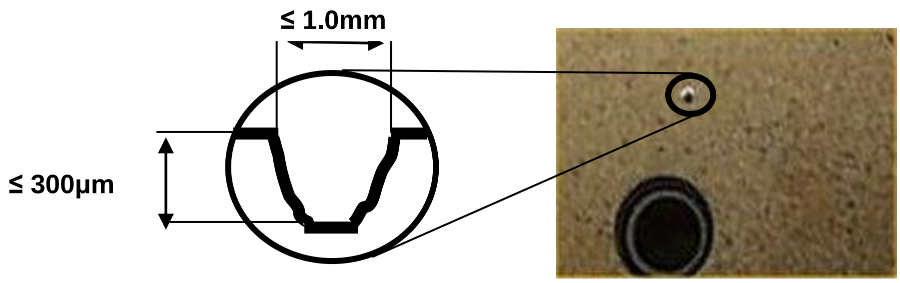


Fig. 7.5: Etching hole (hole down to substrate level) in the MiniSKiiP® bottom surface

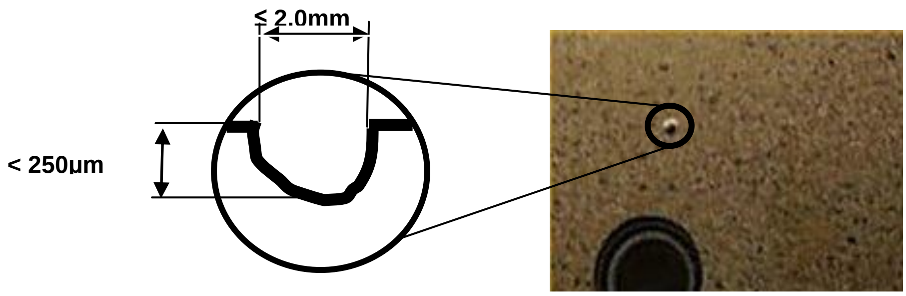


Fig. 7.6: Etching hole (hole not down to substrate level) in the MiniSKiiP® bottom surface

Etched dimples on the edge of the DBC reducing stress between the copper layer and the ceramic substrate (Fig 7.7 and Fig 7.8.) Usually dimples have a diameter of approximately ∅ ≈0.6 mm and a depth of approximately 0.3 mm. Since dimples are never below any IGBT- or Diode chip, there is no influence on the thermal resistance.

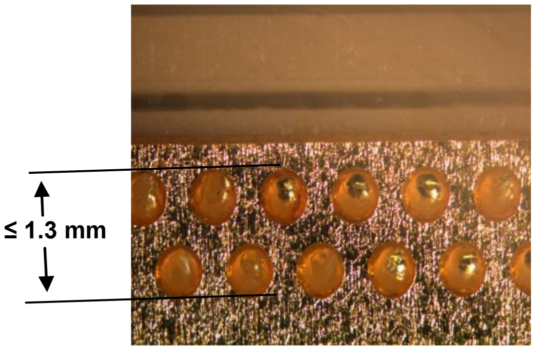


Fig. 7.7: Dimples in the MiniSKiiP® bottom surface

Fig. 7.8: Variance of the DBC position

Due to the manufacturing process, the position of substrate in the plastic housing may vary. The maximum tolerable gap between housing and substrate is 0.55 mm.

7.2 Assembly

7.2.1 Application of Thermal Paste

A thin layer of thermal paste should be applied on the heat sink surface or module bottom surface. SEMIKRON recommends screen printing for applying the thermal paste. The screen printing process offers reproducibility and accuracy of the thickness of the paste (Fig. 7.9). The following values are recommended for „Silicone Paste P 12" from WACKER CHEMIE applied with screen printing process:

MiniSKiiP® 0:	25 µm – 40 µm
MiniSKiiP® 1:	20 µm – 40 µm
MiniSKiiP® 2:	45 µm – 65 µm
MiniSKiiP® 3:	30 µm – 50 µm

Applying past by a hard rubber roller might be applicable but usually has to be handled with extra care for acceptable results. In any case a thickness check should be done to verify the thermal paste thickness. For „Silicone Paste P 12" from WACKER CHEMIE applied by a hard rubber roller SEMIKRON recommends the thermal paste layer thickness to be at least:

MiniSKiiP® 0:	25 µm – 40 µm
MiniSKiiP® 1:	35 µm – 50 µm
MiniSKiiP® 2:	65 µm – 85 µm
MiniSKiiP® 3:	45 µm – 65 µm

Recommended for thickness check would be the gauge from ZEHNTNER called "Wet Film Wheel" (Fig. 7.10). The use of lighter equipment as of a wet film thickness gauge is possible as well (Fig. 7.11). Handling and accuracy might be less favorable.

Fig. 7.9: Screen Priniting Process

Fig. 7.10: Wet film wheel

Zehntner Type ZWW2102

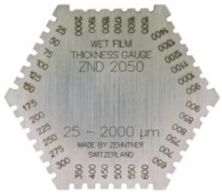


Fig. 7.11: Wet Film Thickness Gauge

Zehntner Type ZND 2102

7.2.2 Mounting the MiniSKiiP®

Place the MiniSKiiP® on the appropriate heat sink area and tighten the screw with the nominal torque: 2.0 Nm < M < 2.5 Nm.

In case of a MiniSKiiP® 3 type with two screws, first tighten both screws with max. 1 Nm and then continue with nominal torque (2.0 Nm < M < 2.5 Nm).

The use of an electric power screwdriver is recommended over a pneumatic tool. The specified screw parameters are better adjustable and especially the final torque will be reached more smoothly. With pneumatic systems, a shock and a higher torque overshoot by reaching the final (preset) torque due to the behaviour of the clutch can be seen.

A limitation of the mounting screw velocity is recommended to allow the thermal past to flow and distribute equally, especially if a more dense paste is used. If tightened with higher velocity the ceramic may develop cracks due to the inability of the paste to flow as fast as necessary and therefore causing an uneven surface. The values below are valid for Wacker P12 thermal paste and use of an electric drilling tool.

The maximum screw velocity for tightening should not exceed 250 rpm. A soft level out (no torque overshoot) will reduce the stress even further and is preferable.

Due to relaxation of the housing and flow of thermal paste, the loosening torque will be reduced. A value of 1 Nm is still sufficient to ensure a proper thermal contact. The design of the housing, the elastic bending of the metal plate in the pressure lid and the adhesion of the thermal paste still ensure electrical contact and sufficient thermal coupling from module to heat sink. Do not re-tighten the screw to nominal mounting torque value again! A retightening of the screws will put DBC, housing and springs under stress.

For rework or test purposes pressure lid and PCB can be disassembled from the MiniSKiiP® module and can be remounted or replaced. If the module was placed on the wrong position of the heat sink, it could be removed and placed correctly, as long as the MiniSKiiP® has not been screwed to the heat sink. It is possible to remove it with necessary diligence, as the thermal paste causes high adhesion. After the removal, all thermal paste has to be removed carefully from the MiniSKiiP® as well as from the heat sink. Alcohol can be used for cleaning.

If the MiniSKiiP® was assembled for some time, the pressure system has already relaxed. Even though the MiniSKiiP can be re-assembled, the pressure distribution on the power hybrid might have changed compared to a new module, which can lead to different thermal resistance values compared to those given in the data sheet.

7.2.3 Mounting Material:

SEMIKRON recommendation for mounting screw:

M4 according to DIN 7991 - 8.8, or similar screw with TORX-head.

Strength of screw:	"8.8"
Tensile strength	Rm= 800 N / mm²
Yield point	Re= 640 N / mm²

The minimum depth of the screw in the heat sink is 6.0 mm.

7.2.4 Removing the MiniSKiiP® from the Heat Sink

The thermal paste provides good adhesion between the module and the heat sink. Since the DBC substrates with the chips are not glued to the case, these would stick to the heat sink when the module was removed as soon as the screws are loosened.

There are two proper ways for removing the module:

- Wait 24 hours after the screws have been loosened and then slide the module carefully from the heat sink.
- Heat up the heat sink up to 60 °C after the screws have been loosened and then slide the module carefully from the heat sink.

7.3 ESD Protection

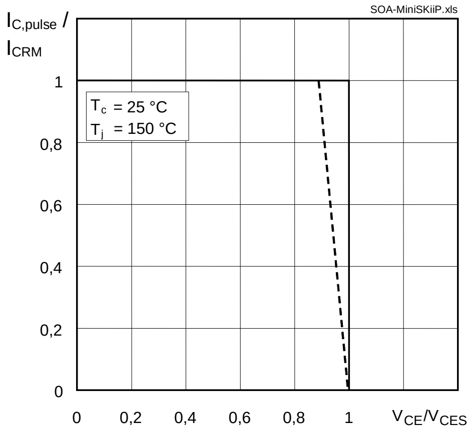
MiniSKiiP® modules are sensitive to electrostatic discharge. All MiniSKiiP® modules 100% checked for ESD failures and latent ESD defects after assembly. During shipment the MiniSKiiP®'s are ESD protected by the ESD Blister box

Special care has to be used when removing the MiniSKiiP® from the ESD blister box. During handling and assembly of the modules use conductive grounded wristlet and a conductive grounded working place all time.

8 Safe Operating Area and for IGBTs

Safe Operating Areas are not included in the datasheets. They are given as standardized figures and apply to 600 V and 1200 V. IGBT modules must not be used in linear mode. The number of short circuits may not exceed 1000. The time between short circuits must be > 1 s. Maximum pulse duration 10µs (6µs at 600V Trench).

For Trench 4 IGBTs (1200V “12T4”) the maximum pulse duration =10µs @ $V_{DC\text{-}Link}$ = 800V.



I_C = $I_C$nom (chip current rating)

Fig. 8.1: Safe Operating Area (SOA)

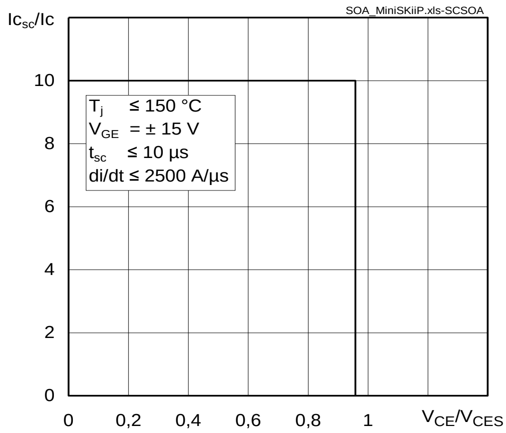


Fig. 8.2: Short Circuit Safe Operating Area (SCSOA)

The maximum V_{CES} value must never be exceeded. Due to the internal stray inductance of the module, a small voltage will be induced during switching. The maximum voltage at the terminals $V_{CEmax,T}$ must therefore be smaller than V_{CEmax} (see dotted line in Fig. 8.1).

9 Definition and Measurement of R_{th} and Z_{th}

9.1 Measuring Thermal Resistance $R_{th(j-s)}$

The thermal resistance is defined as given in the following equation:

$$R_{th(1-2)} = \frac{\Delta T}{P_V} = \frac{T_1 - T_2}{P_V} \qquad (9\text{-}1)$$

The data sheet values for the thermal resistances are based on measured values. As can be seen in equation (9-1), the temperature difference ΔT has a major influence on the R_{th} value. As a result, the reference point and the measurement method have a major influence, too.

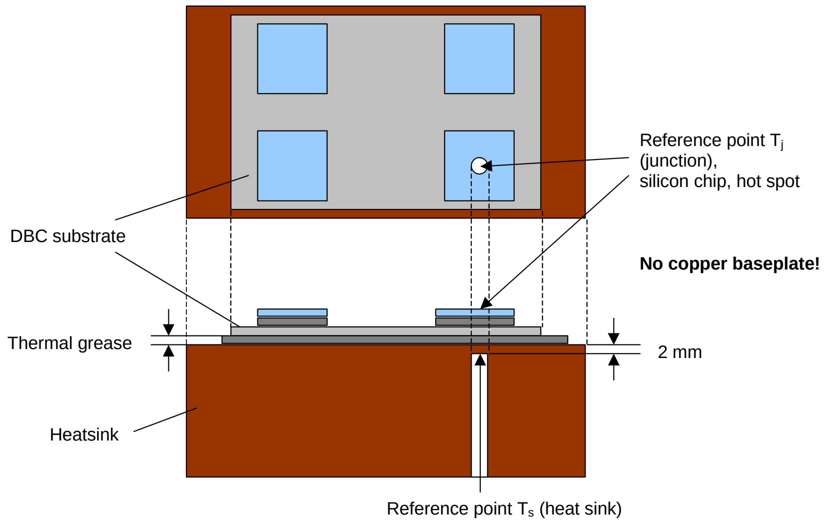


Fig. 9.1: Mesaurement set up

Since MiniSKiiP® modules have no base plate, SEMIKRON gives the thermal resistance between the junction and the heat sink $R_{th(j-s)}$. This value depends largely on the thermal paste. Thus, the value is given as a “typical” value in the data sheets.
The $R_{th(j-s)}$ of the MiniSKiiP® module is measured on the basis of the reference points given in Fig. 9.1. The reference points are as follows:

- T_j - The junction temperature of the chip
- T_s – The heat sink temperature is measured in a drill hole, 2 mm beneath the module, directly under the chip. The 2 mm is derived from our experience, which has shown that at this distance from the DBC ceramic, parasitic effects resulting from heat sink parameters (size, thermal conductivity etc.) are at a minimum and the disturbance induced by the thermocouple itself is negligible.

For further information on the measurement of thermal resistances, please refer to:
→ M. Freyberg, U. Scheuermann, “*Measuring Thermal Resistance of Power Modules*“; PCIM Europe, May, 2003

The given Rth values can be used for a standard thermal design. For a more detailed and more accurate thermal design it is important to create a dynamic thermal model of the heatsink taking in consideration the chip positions.

For more information about chip positions please contact MiniSKiiP® product manager musamettin.zurnaci@semikron.com. Chip position drawing will be sent out immidiately.

9.2 Transient Thermal Impedance (Z_{th})

When switching on a “cold” module, the thermal resistance R_{th} appears smaller than the static value as given in the data sheets. This phenomenon occurs due to the internal thermal capacities of the package. These thermal capacities are “uncharged” and will be charged with the heating energy resulting from the losses during operation. In the course of this charging process the R_{th} value seems to increase. During this time it is therefore called transient thermal impedance Z_{th}. When all thermal capacities are charged and the heating energy has to be emitted to the ambience, the transient thermal resistance Z_{th} will have reached the static data sheet value R_{th}.

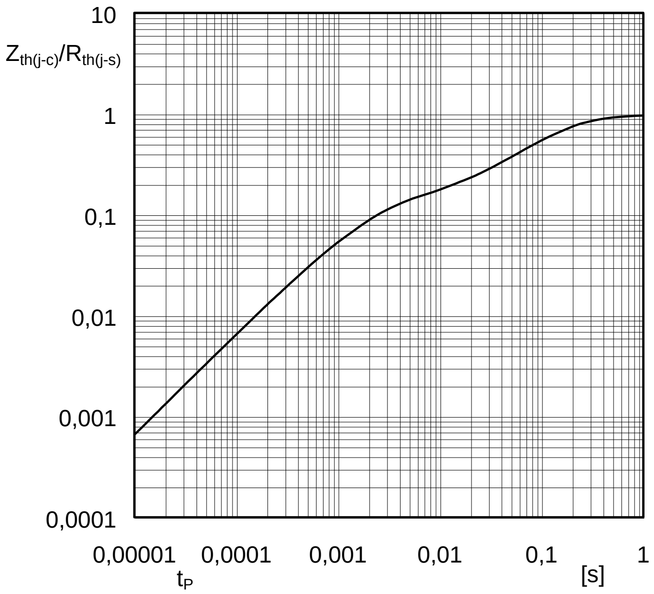


Fig. 9.2: Z_{th}: Transient Thermal Impedance

The transient thermal behaviour is measured during SEMIKRON’s module approval process. Based on this measurement a mathematical model is derived, resulting in the following equation

$$Z_{th}(t) = R_1\left(1 - e^{\frac{t}{\tau_1}}\right) + R_2\left(1 - e^{\frac{t}{\tau_2}}\right) + R_3\left(1 - e^{\frac{t}{\tau_3}}\right) \qquad (9\text{-}2)$$

For MiniSKiiP® modules, the coefficients R_1, τ_1, and R_2, τ_2 can be determined using the data sheet values as given in Tab. 9.1

Parameter	Unit	IGBT, CAL diode
R_1	[K/W]	0.11 x $R_{th(j-s)}$
R_2	[K/W]	0.77 x $R_{th(j-s)}$
R_3	[K/W]	0.12 x $R_{th(j-s)}$
τ_1	[sec]	1.0
τ_2	[sec]	0.13
τ_3	[sec]	0.002

Tab. 9.1: Parameters for $Z_{th(j-s)}$ calculation using equation (9-2)

10 Specification of the Integrated Temperature Sensor

Please note that MiniSKiiP® power modules are equipped with NTC or PTC temperature sensors. To get the detailed info about type of temperature sensor please refer to module datasheet.

10.1 Electrical Characteristics (PTC)

The type “SKCS2 Temp 100” does have a characteristic like a resistance with positive temperature coefficient (PTC) – see Fig. 10.1 .Due to isolation and space reasons the temperature sensor is placed near the edge of the DBC but in close to an IGBT switch. The thermal coupling is not efficient enough to monitor the chip temperature of the switch. The sensor can be used as an indicator for the DBC temperature.

Note: Thermal coupling diminished if water-cooling is used

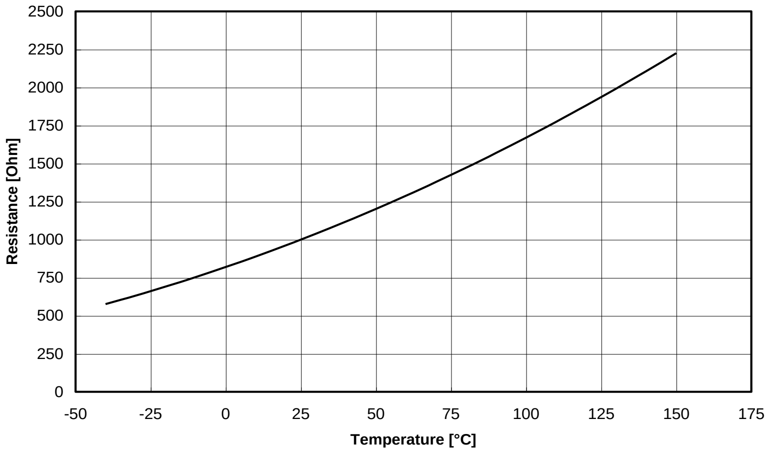


Fig. 10.1: Temperature sensor ”SKCS2 Temp 100“:Resistance as a function of temperature (typical characteristic)

The temperature sensor has a nominal resistance of 1000 Ω at 25°C with a typical temperature coefficient of 0.76 % / K.

Sensor resistance R(T) as a function of temperature:

$$R(T) = 1000\ \Omega \cdot [1 + A \cdot (T - 25\ °C) + B \cdot (T - 25\ °C)^2]$$

with $A = 7.635 \cdot 10^{-3}\ °C^{-1}$ and $B = 1.731 \cdot 10^{-5}\ °C^{-2}$

At 25°C the measuring tolerance is max. ± 3 %, at 100°C max. ± 2 %.

SEMIKRON recommends a measuring current range of 1 mA ≤ Im ≤ 3 mA.

For realising a trip level by an additional protection network the recommended value for the trip temperature is about 115 °C (air cooling), based on a heat sink with a standard thermal lateral spread.

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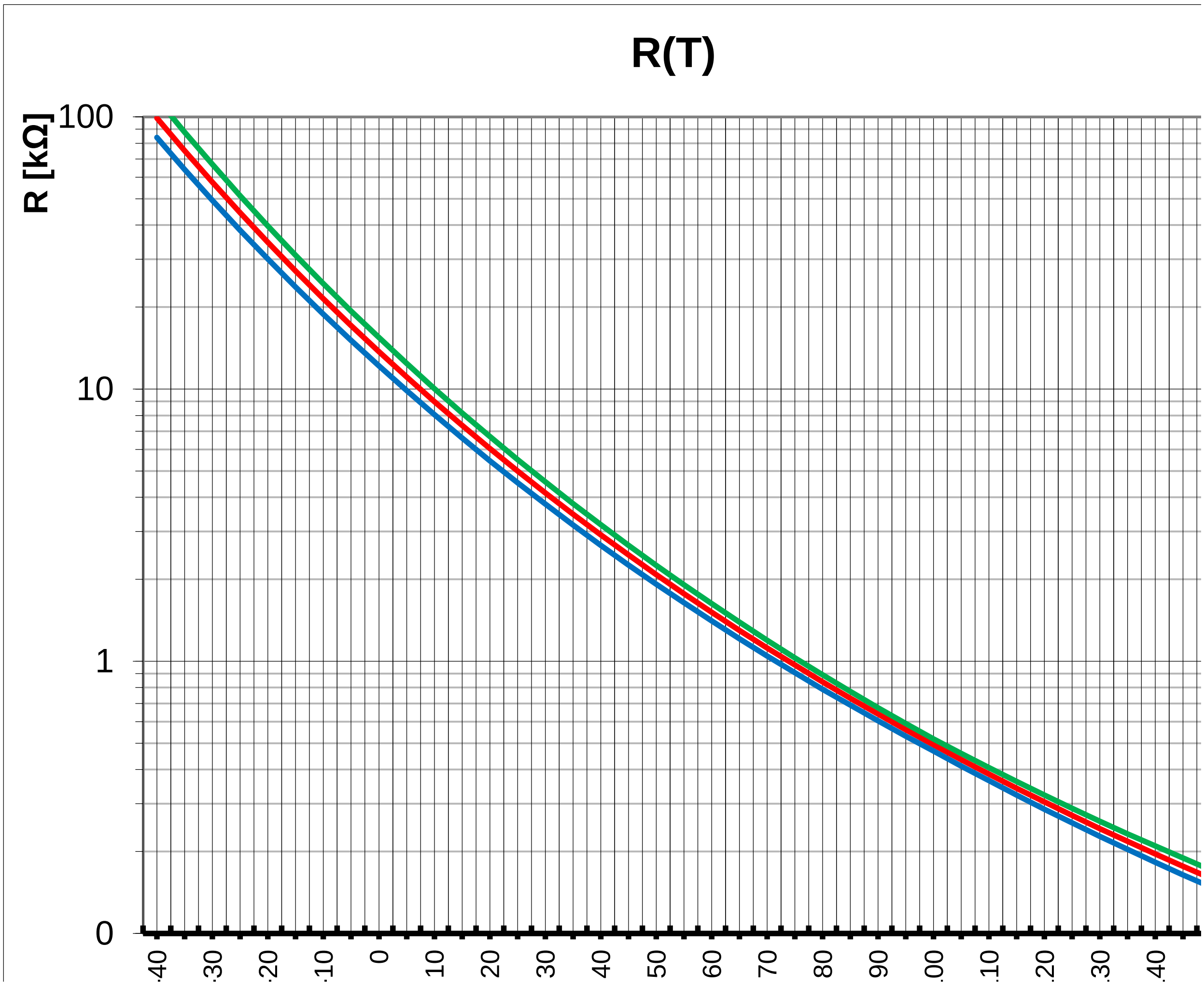
10.2 Electrical Characteristics (NTC)

Selected MiniSKiiP® power modules are equipped with sensor type “KG3B” which has a NTC characteristic – see Fig. 10.2 .
The sensor can only be used as an indicator for the DBC and heat sink temperature.
In combination with a monitoring circuit the temperature sensor can protect against over-temperature. The temperature sensor has a nominal resistance of 5000 Ω at 25°C (298.15 K). Following table and diagram show its characteristics.

Fig.10.2: Typical sensor resistance R(T) as a function of temperature (NTC)



Tab. 10.2: Typical sensor resistance R(T) as a function of temperature (NTC)

Temperature [°C]	Temperature [°F]	R (min.) [kΩ]	R (typ.) [kΩ]	R (max.) [kΩ]
-40	-40	83.9	99.0	116.6
-30	-22	49.4	57.5	66.9
-20	-4	30.0	34.6	39.7
-10	14	18.	21.5	24.4
0	32	1 .2	13.7	15.4
10	50	8.04	9.00	10.0
20	68	5.45	6.05	6.69
25	77	**4.53**	**5.00**	**5.50**
3	86	3.78	4.15	4.56
40	04	2.67	2.91	.17
50	122	1.92	2.08	2.25
60	140	1.41	1.51	1.63
70	158	1.05	1.12	1.20
80	176	0.789	0.840	0.891
90	194	0.604	0.639	0.675
100	212	0.468	0.493	0.518
110	230	0.364	0.385	0.406
120	248	0.286	0.304	0.322
130	266	0.227	0.243	0.259
140	284	0.183	0.196	0.209
150	302	0.148	0.159	0.171

10.3 Electrical Isolation

Inside the MiniSKiiP® the temperature sensor is mounted close to the IGBT- and diode dice on the same substrate. The minimum distance between the copper conductors is ≥ 0.71 mm. (
Fig. 10.2)

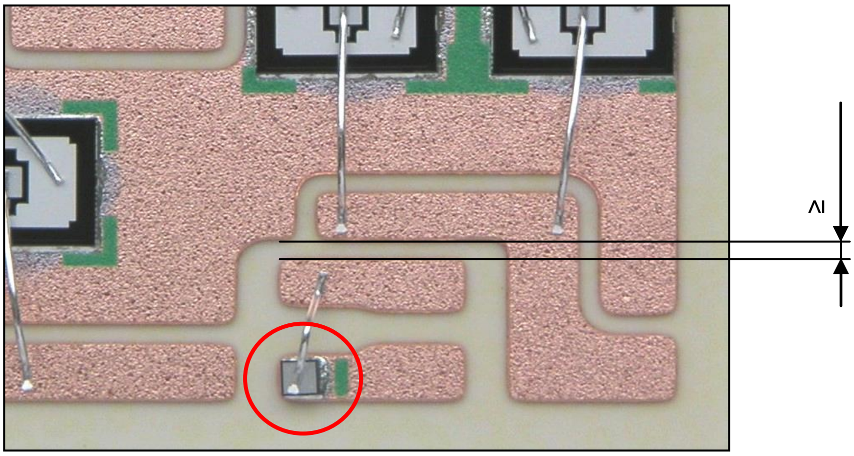


Fig. 10.2: Temperature sensor on DBC substrate

Since the MiniSKiiP® module is filled with silicon gel for isolation purposes, the design requirements for the specified isolation voltage (AC 2.5 kV for 1 min) are met (exception: the temperature sensor of some MiniSKiiP® 0 types has no basic insulation. The maximum potential differences are given in the data sheets. The isolation is 100 % end tested on all parts.

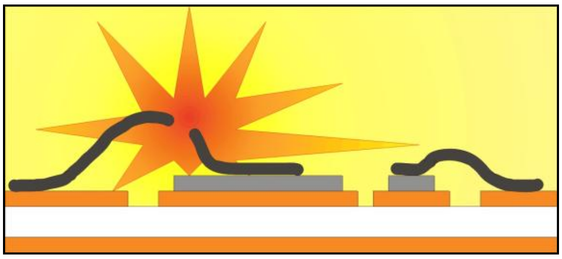


Fig. 10.3: Sketch of high energy plasma caused by melted off bond wire

During short circuit failure and therewith electrical overstress, the bond wires can melt off producing an arc with high energy plasma (Fig. 10.3). In this case, the direction of plasma expansion is not predictable; the temperature sensor might be touched by plasma and exposed to a high voltage level.
The safety grade "Safe electrical Isolation" according to EN 50178 can be achieved by different additional means, described there in detail.

11 Creepage- and Clearance distances

The pressure lid of MiniSKiiP® is designed as a hybrid construction with a metal inlay. The mounting screw is electrically connected with the metal inlay and the heat sink. Since the pressure lid has the same electrical potential as the heat sink creepage - and clearance distance considerations are required. Due to the design, only creepage distances are relevant.

The distance between the metal inlay of the lid and the printed circuit board (Fig. 11.1, 1.) are > 8.1 mm as given in Fig. 11.2. The internal distance between screw and board (Fig. 11.1, 2.) is > 8.5 mm, as given in Fig. 11.3.

Inside the MiniSKiiP® a transparent silicone gel with a dielectric strength of 23 kV/mm ensures electrical isolation from the DBC substrate to the heat sink (Fig. 11.1, 3.) as well as from the DBC to the screw (Fig. 11.1, 4.).

Fig. 11.1: Cross section picture of MiniSKiiP® shows, where the distances are examined.

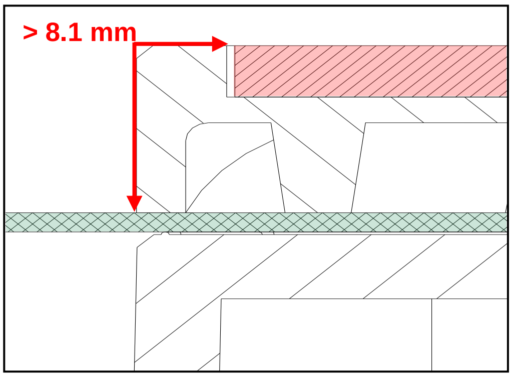


Fig. 11.2: Cross section sketch with distance from pressure plate to PCB

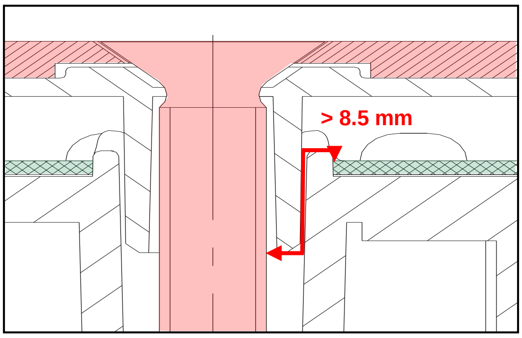


Fig. 11.3: Cross section sketch with distance from screw to PCB

12 Laser Marking

All MiniSKiiP® modules are laser marked. The marking contains the following items (see Fig. 12.1):

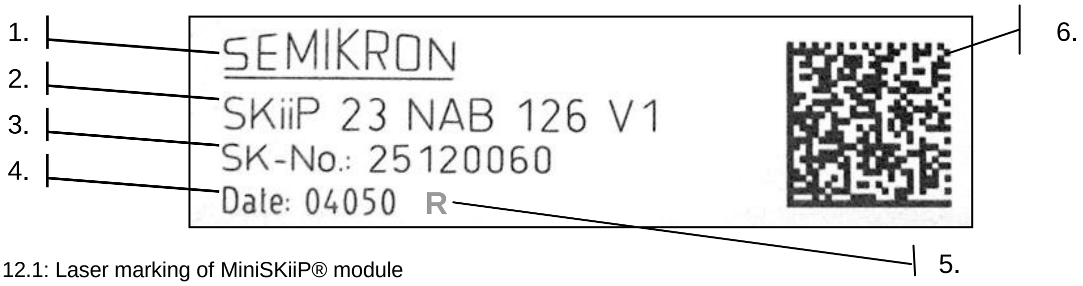


Fig. 12.1: Laser marking of MiniSKiiP® module

1. SEMIKRON logo
2. Type designation
3. SEMIKRON part number
4. Date code – 5 digits: YYMML (L=Lot of same type per week)
5. "R" Identification for compliance with RoHS
6. Data Matrix Code

The Data Matrix Code is described as follows:

- type: EEC 200
- standard: ISO / IEC 16022
- cell size: 0.46 mm
- field size: 24 x 24
- dimension: 11 x 11 mm plus a guard zone of 1 mm (circulating)
- the following data is coded:

❶	❷	❸	❹	❺	❻	❼	❽	❾	❿	⓫
SKiiP23NAB126V1		25120060	4DE0500001		0	2		0001		04050

❶	16 digits	type designation	❷	1 digit	blank
❸	10 digits	part number	❹	12 digits	production tracking number
❺	1 digit	blank	❻	1 digit	measurement number
❼	1 digits	line identifier (production)	❽	1 digit	blank
❾	4 digits	continuous number	❿	1 digit	blank
⓫	5 digits	datecode			

Total: 53 digits

13 The Restriction of Hazardous Substances in Electrical and Electronic Equipment (RoHS) Directive (2002/95/EC)

MiniSKiiP® [1] is in compliance with the RoHS Directive (2002/95/EC). Newer MiniSKiiP® [1] modules are marked with "R" behind the date code to show the compliance with RoHS in the laser marking as well (Fig 10.1-5)

[1] Not valid for MiniSKiiP® size8 modules including current sensors ("I" types) with date code earlier than 0601

14 Bill of Materials

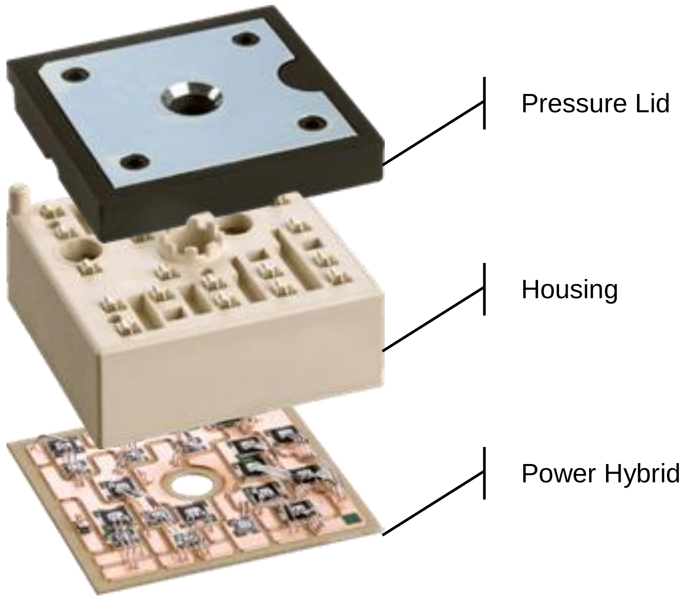


Fig. 14.1: MiniSKiiP® power module components

14.1 Pressure Lid

Steel plate:	St 52.3 - 3G - 0,3 (DIN 1623 T2), zinc plated
Plastic part:	"Ryton PPS BR 111 black" (PPS + 60-65% glass fibre, does not contain any free halogens)

14.2 Housing

Housing:	"Noryl V0 2570- 8303" (PPE + PA + 30% glass fibre, halogen free according to DIN/VDE 0472, part 815)
Contact springs:	Copper alloy "K88", Ag plated (abrasiveness approx. 75 to 96 HV); metallic passivation (50 to 55% Cu, 30 to 35% Sn, 13-17%Zn)
Soft gel:	Silicone gel "Silopren 103"

14.3 Power Hybrid

Substrate:	Three layer –Copper (0.3mm), Al2O3 (0.38mm), Copper (0.3mm), NiAu flash
Wire bonds:	Aluminum alloy
Chips, T-Sensor:	Silicon with Aluminum metallization top side and silver metallization bottom side (lead free)
Chip solder:	SnAg solder + organic flux (cleaned after soldering)

Note: MiniSKiiP® is a lead free product according to the EU directives 2000/53/EG and 2002/95/EG and therefore in compliance with the RoHS directive (see chapter 11)

15 Packing Specification

15.1 Packing Box

Standard packing boxes for MiniSKiiP® Modules:

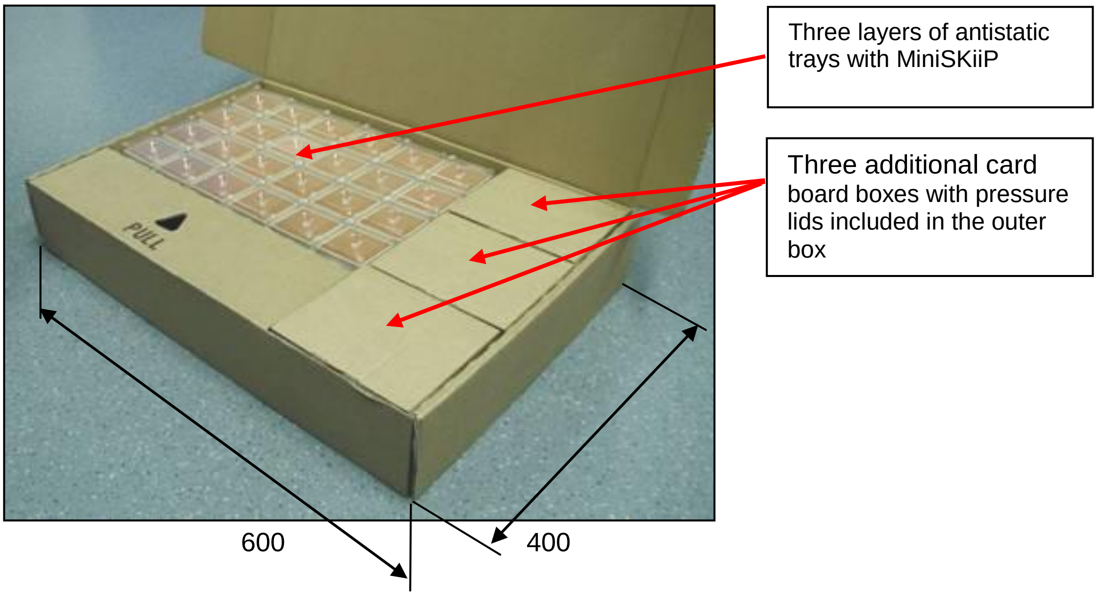


Fig. 15.1: Outer cardboard box, dimensions: 600 x 400 x 100 mm³ (l x w x h)

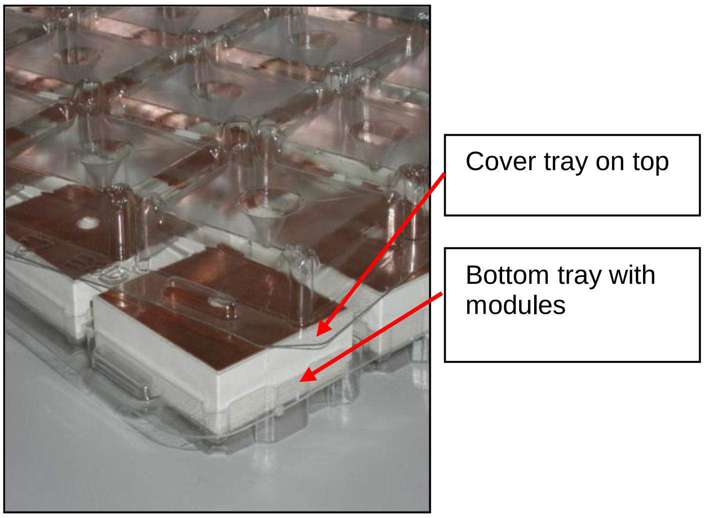


Fig. 15.2: Antistatic tray, dimensions: 440 x 275 x 30 mm³

Fig. 15.3: Card board box with pressure lids, dimensions: 150 x 130 x 95 mm³

Quantities per package:	**MiniSKiiP® 0**	3 trays with 66 modules = **198 pcs**	(≈ 8.0 kg)
	MiniSKiiP® 1	3 trays with 40 modules = **120 pcs**	(≈ 8.5 kg)
	MiniSKiiP® 2	3 trays with 24 modules = **72 pcs**	(≈ 9.5 kg)
	MiniSKiiP® 3	3 trays with 16 modules = **48 pcs**	(≈ 9.8 kg)

Bill of materials:	Boxes:	Paper (card board)
	Trays:	A-PET (not electrically chargeable)
	Dry Pack:	Activated and grained clay in paper bags

15.2 Marking of Packing Boxes

All MiniSKiiP® packing boxes are marked with a sticker label.

This label is placed on the packing box as can be seen in Fig. 15.4:

Fig. 15.4: Place for label on MiniSKiiP® packing boxes

The label contains the following items (see Fig. 15.5)

Fig. 15.5: Label of MiniSKiiP® packing boxes

1. SEMIKRON Logo
2. Type designation
3. “Dat. Cd:” Date code – 5 digits: YYMML (L=Lot of same type per week)
4. “Au.-Nr :” Order Confirmation Number / Item Number on Order Confirmation
5. “Menge :” Quantity of MiniSKiiP® modules inside the box – also as bar code
6. “Id.-Nr :” SEMIKRON part number – also as bar code

Bar Code due to

- standard: EEC 200
- Format: 19/9

16 Type Designation System

❶	❷	❸	❹	❺	❻	❼
SKiiP	1	1	NAB	06	5	V1

❶ SKiiP: **S**EMIKRON **i**ntegrated **i**ntelligent **P**ower

❷ case number e.g. 1 = housing size 1

❸ “current class” number for devices with the same case

❹ circuit specification (examples)
AC = 3 ~ inverter
AHB = 3 ~ rectifier half controlled, brake chopper
ANB = 3 ~ rectifier not controlled, brake chopper
NAB = 3 ~ rectifier, brake chopper, 3 ~ inverter

❺ voltage class
06 = 600 V
12 = 1200 V

❻ IGBT chip technology
3 = Standard NPT IGBT (MiniSKiiP® I Generation)
5 = Ultra fast NPT IGBT(MiniSKiiP® II Generation)
6 = Fast Trench IGBT(MiniSKiiP® II Generation)
T4 = Trench 4 (MiniSKiiP® II Generation)

❼ V - number (only internal use)

17 Caption of the Figures in the Data Sheets

17.1 Caption of Figures in the Data Sheets of “065”, “066” and “126” Modules

For MiniSKiiP® II Generation modules with “065”, “066” and “126” IGBT chip technologies (Ultra fast NPT IGBT and Fast Trench IGBT) the following captures of figures are given in the data sheet:

Fig. 1 Inverter IGBTs: Collector current I_C as a function of the collector-emitter voltage VCE (typical output characteristics); Parameters: Gate-emitter voltage V_{GE}, T_j= 25 °C, T_j = 125 °C

Fig. 2 Maximum rated continuous DC collector current I_C as a function of the heat sink temperature T_s

Fig. 3 Collector current IC as a function of the Gate-emitter-voltage V_{GE} (typical transfer characteristics)

Fig. 4 Maximum safe operating area for periodic turn off (RBSOA) at T_j ≤ 150 °C and V_{GE} =±15V

Fig. 5 Typical Turn-on and Turn-off energy dissipation E_{on} and E_{off} of one IGBT switch as a function of the collector current I_C for inductive load using a suitable R_G ; T_j = 125 °C

Fig. 6 Typical Turn-on and Turn-off energy dissipation E_{on} and E_{off} of one IGBT switch as a function of the gate series resistance R_G for inductive load using a suitable I_c ; T_j = 125 °C

Fig. 7 Typical gate charge characteristic: Gate-emitter voltage V_{GE} as a function of the gate charge Q_G

Fig. 8 Transient thermal impedance Z_{thjs} of one IGBT switch and corresponding inverse diode as function of time

Fig. 9 Forward characteristics of an inverse diode. Typical and maximum values at T_j= 25 °C and T_j = 125 °C

Fig. 10 Forward characteristics of an input bridge diode. Typical and maximum values at T_j= 25 °C and T_j = 125 °C

Fig. 11 Thyristor gate voltage V_G against gate current I_G (total spread) showing the region of possible (BMZ) and certain (BSZ) triggering for various junction temperatures T_j. The voltage and current of triggering pulses have to be in the region of certain triggering (BSZ), but the peak pulse power P_G must not exceed that given for the pulse duration t_p used. The curve 20 V, 20 Ω is the inverter characteristic of an adequate trigger element.

17.2 Caption of Figures in the Data Sheets of “12T4” Modules

For MiniSKiiP® II Generation modules with “12T4” IGBT chip technologies (Trench 4) the following captures of figures are given in the data sheet:

Fig. 1 Inverter IGBTs: Collector current I_C as a function of the collector-emitter voltage VCE (typical output characteristics); Parameters: Gate-emitter voltage V_{GE}, T_j= 25 °C, T_j = 150 °C

Fig. 2 Maximum rated continuous DC collector current I_C as a function of the heat sink temperature T_s

Fig. 3 Typical Turn-on and Turn-off energy dissipation E_{on} and E_{off} of one IGBT switch as a function of the collector current I_C for inductive load using a suitable R_G ; T_j = 150 °C

Fig. 4 Typical Turn-on and Turn-off energy dissipation E_{on} and E_{off} of one IGBT switch as a function of the gate series resistance R_G for inductive load using a suitable I_c ; T_j = 150 °C

Fig. 5 Collector current IC as a function of the Gate-emitter-voltage V_{GE} (typical transfer characteristics)

Fig. 6 Typical gate charge characteristic: Gate-emitter voltage V_{GE} as a function of the gate charge Q_G

Fig. 7 Typical Turn-on and Turn-off switching times ($t_{d,on}$, $t_{d,off}$, t_r, t_f) as a function of the collector current I_C for inductive load using a suitable R_G ; T_j = 150 °C

Fig. 8 Typical Turn-on and Turn-off switching times ($t_{d,on}$, $t_{d,off}$, t_r, t_f) as a function of the gate series resistance R_G for inductive load using a suitable I_c ; T_j = 150 °C

Fig. 9 Transient thermal impedance Z_{thjs} of one IGBT switch and corresponding inverse diode as function of time

Fig. 10 Forward characteristics of an inverse diode. Typical and maximum values at T_j= 25 °C and T_j = 150 °C

Fig. 11 Typical peak reverse recovery current I_{RRM} of the inverse diode as a function of the fall rate di_F/dt of the forward current with corresponding gate series resistance R_G of the IGBT during turn-on

CIB-Modules

Fig. 12 Forward characteristics of an input bridge diode. Typical and maximum values at T_j= 25 °C and T_j = 150 °C

IGBT-Modules

Fig. 12 Typical recovery charge Q_{rr} of the inverse diode as a function of the fall rate di_F/dt of the forward current (Parameters: forward current I_F and gate series resistance R_G of the IGBT during turn-on)

17.3 Calculation of max. DC-Current Value for "12T4" IGBTs

In the data sheets for MiniSKiiP® IGBT 4 types ("12T4") the maximum DC-current $I_{C,max}$ is given. Three different considerations lead to limitations of the $I_{C,max}$:

- Thermal resistance for continuous operation
- Limitation by main terminals
- Chip size and bond configuration

For detailed information about definition of the data sheet value please refer to PI 08-23 or contact MiniSKiiP® product manager musamettin.zurnaci@semikron.com.

17.4 Internal and External Gate Resistors

Inside most of the SEMIKRON modules, IGBT chips are paralleled on the power hybrid to achieve higher currents. Therefore the large IGBT dice contain internal gate resistors to perform acceptable decoupling when paralleled.

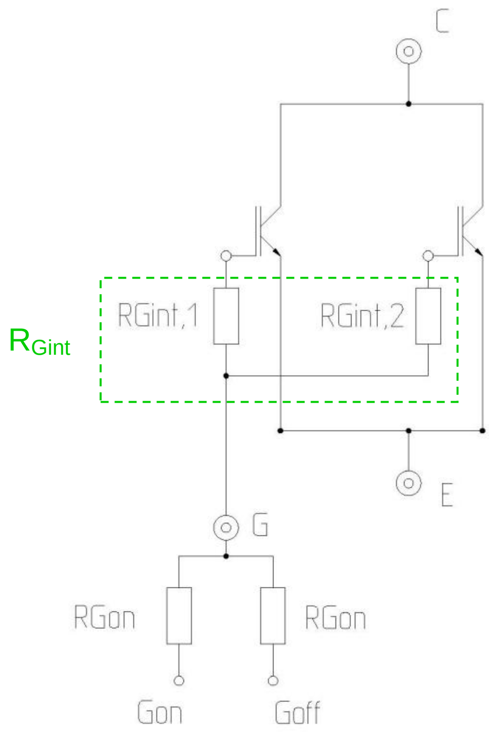


Fig. 17.1: Two IGBTs with internal gate resistors paralleled

In some MiniSKiiP® data sheets the total interal gate resistor is given, which is the equivalent resistance for the paralleled gate resistors on each chip. An example is given in Fig. 17.1 where two IGBT dice are paralleled to one switch of the module with the external power connectors "C" and "E" and the external gate connector "G". Each chip has his own gate resistor ($R_{Gint,1}$ and $R_{Gint,2}$). The equivalent restistance R_{Gint} given in the data sheet is

$$R_{Gint} = \frac{1}{\frac{1}{R_{Gint,1}} + \frac{1}{R_{Gint,2}}}$$

Assuming that $R_{Gint,1} = R_{Gint,2}$(the same IGBT-type) the data sheet value R_{Gint} is half the value of the resistor on a single chip ($R_{Gint,1}$ and $R_{Gint,2}$) in this example:

$$R_{Gint} = \frac{1}{\frac{1}{R_{Gint,1}} + \frac{1}{R_{Gint,1}}} = \frac{1}{\frac{2}{R_{Gint,1}}} = \frac{R_{Gint,1}}{2}$$

The external gate resistor values R_{Gon} and R_{Goff} given in the data sheets are recommendations from SEMIKRON to achieve smooth swichting behaviour together with low switching losses. Since the switching behaviour strongly depends on the external assembly, the external gate resistors R_{Gon} and R_{Goff} have to be tested in the customer application and – if necessary – adjusted.

18 Accessories

18.1 Evaluation Board MiniSKiiP® 2nd Generation

The evaluation boards (example
Fig. 18.1) are offered to customers for design support to enable a fast and convinient way to connect the MiniSKiiP® with a lab or breadboard circuit.

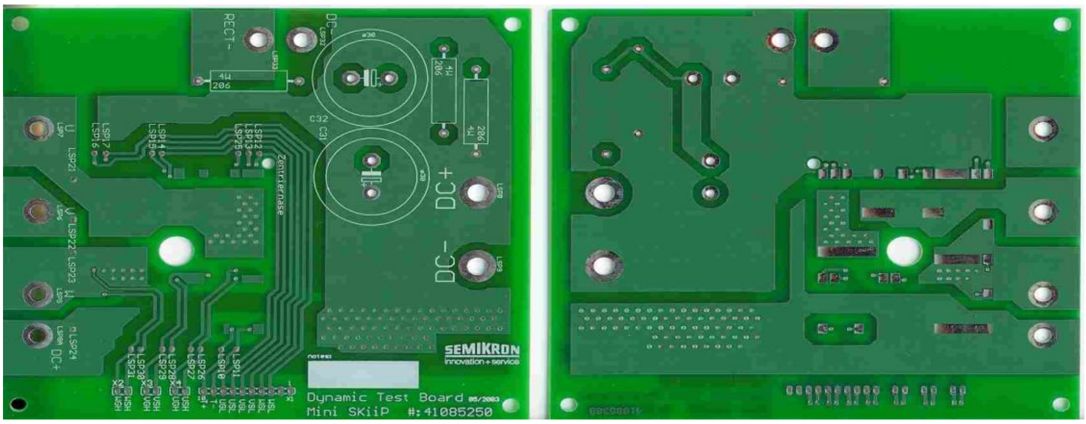


Fig. 18.1: Dynamic Evaluation Board for MiniSKiiP®2 “AC” Types

Generic Specification

Material : FR4 2 layer board
Dimensions : specific to board, see below
Thickness : 1.5mm
Conductor : 70µm Cu, PbSn plating
Mounting : all 4 corners prepared for klipp on feet stand offs,
Ø 4mm or therated stand offs, screw Ø 4mm
Auxiliary terminals: prepared for use of solder pins, board to wire connectors or board to board connectors.

Static board connectors:
5pol single in line, grid dimension 5mm, pin Ø 2mm
7pol single in line, grid dimension 5mm, pin Ø 2mm

Dynamic board connectors:
2pol single in line, grid dimension 2.54mm, pin Ø1 mm;
10pol single in line, grid dimension 2.54mm, pin Ø1 mm

Main terminals of static and dynamic boards are prepared for use of cable sockets and screws:

- +/- DC connection: Ø 5mm
- Phase out (U,V,W) connection: Ø 4mm.

Maximum continious current: Idmax = 30Amp*****

* *limited by the current capability of the narrowest part of the conductor path. Not all evaluation board layouts are suitable for full current rating of the corresponding MiniSKiiP® type! New generation boards lead free and with higher current capability are in preparation.*

18.1.1 Static Test Boards

For static measurements only. This layout is optimized to have the shortest connection between the Terminal and the Chips/Springs. The static test board allows an easy and fast connection to the MiniSKiiP® in a lab circuit to valuate the static values like VCEsat, Vf, Rth, etc.

18.1.2 Dynamic Test Boards

The dynamic board layout is optimized for dynamic operation. Therefore a low stray inductance design was realized. The boards allow as well the use of capacitors and resistors for a DC link pre-charge circuit.

Recommendation: 2 electrolytic capacitors 330µF / 400V, Ø 30mm
2 resistors 68KΩ/ 4W, 1 resistor 330Ω/ 4W

Dynamic test boards are for use under application near conditions for breadboard constructions but with limited current.
As stated above the dynamic test boards are not designed for use in the final customer product and not for use of max module current.

18.1.3 Order Codes for Test Boards

18.1.3.1 Evaluation Board Mini0 “AC” Type

Static Board IdentNo: 41085315, size: 160 mm x 100 mm
Dynamic Board Ident No: 41085310, size: 130 mm x 132 mm

18.1.3.2 Evaluation Board Mini0 “NAC” Type

Static Board Ident No: 41094855, size: 160 mm x 100 mm
Dynamic Board Ident No: 41094850, size: 130 mm x 132 mm

18.1.3.3 Evaluation Board Mini0 “NEB” Type

Static Board Ident No: 41094875, size: 160 mm x 100 mm
Dynamic Board Ident No: 41094870, size: 130 mm x 132 mm

18.1.3.4 Evaluation Board Mini1 “AC” Type

Static Board Ident No: 41085245, size: 160 mm x 100 mm
Dynamic Board Ident No: 41085240, size: 135 mm x 105 mm

18.1.3.5 Evaluation Board Mini1 “NAB” Type

Static Board Ident No: 41085295, size: 160 mm x 100 mm
Dynamic Board Ident No: 41085290, size: 125 mm x 135 mm

18.1.3.6 Evaluation Board Mini2 “AC” Type

Static Board Ident No: 41085255, size: 160 mm x 100 mm
Dynamic Board Ident No: 41085250, size: 130 mm x 140 mm

18.1.3.7 Evaluation Board Mini2 “NAB” Type

Static Board Ident No: 41085305, size: 160 mm x 100 mm
Dynamic Board Ident No: 41085300, size: 130 mm x 140 mm

18.1.3.8 Evaluation Board Mini2 “MLI” Type

Static/Dynamic Board Ident No: 45103600, size: 120 mm x 105 mm

18.1.3.9 Evaluation Board Mini3 “AC” Type

<u>for all IGBT technologies except “12T4”</u>
Static Board Ident No: 41085335, size: 160 mm x 100 mm
Dynamic Board Ident No: 41085330, size: 163 mm x 114 mm

<u>for IGBT technology “12T4”</u>
Static/Dynamic Board Ident No: L5047100, size: 160 mm x 125 mm

18.1.3.10 Evaluation Board Mini3 “NAB” Type

Static Board Ident No: 41085235, size: 160 mm x 100 mm
Dynamic Board Ident No: 41085230, size: 163 mm x 114 mm

18.1.3.11 Evaluation Board Mini3 “MLI” Type

Static/Dynamic Board Ident No: 45102900, size: 145 mm x 105 mm

Additional boards for special types may be availabe on request. Please contact MiniSKiiP® product manager musamettin.zurnaci@semikron.com.

18.2 Pressure Lid order codes

With the introduction of MiniSKiiP 2nd generation, the order procedure for the pressure lids changes. The lids are no longer part of the MiniSKiiP itself. They have to be ordered and booked separately.

18.2.1 Standard Lids

The following order codes are worldwide present in the NAVISION system:

25121000 standard lid for MiniSKiiP II housing size 0
25121010 standard lid for MiniSKiiP II housing size 1
25121020 standard lid for MiniSKiiP II housing size 2
25121030 standard lid for MiniSKiiP II housing size 3

18.2.2 Slim Lids

The following order codes are worldwide present in the NAVISION system:

25121040 slim lid for MiniSKiiP II housing size 0
25121050 slim lid for MiniSKiiP II housing size 1
25121060 slim lid for MiniSKiiP II housing size 2
25121070 slim lid for MiniSKiiP II housing size 3

18.3 Mechanical Samples

The following order codes for Mechanical Samples are worldwide present in the NAVISION system:

25221100 mechanical sample MiniSKiiP II housing size 0
25221110 mechanical sample MiniSKiiP II housing size 1
25221120 mechanical sample MiniSKiiP II housing size 2
25221130 mechanical sample MiniSKiiP II housing size 3

19 Disclaimer

Important notice:

The techinacl data and hardware of the above offered evaluation boards are serving for technical support only. Any warranty is excluded. Technical details may change without notice.

No components are included in delivery. All boards will be delivered without Connectors, SMDs, Standoffs etc. All above mentoined components are standard components available at electronic distributors. No components are available from SEMIKRON neither as kits nor as individual parts.

The evaluation boards are not suitable to replace final PCBs or for use in customer end-products.

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20 Disclaimer

The specifications of our components may not be considered as an assurance of component characteristics. Components have to be tested for the respective application. Adjustments may be necessary. The use of SEMIKRON products in life support appliancesand systems is subject to prior specification and written approval by SEMIKRON. Wetherefore strongly recommend prior consultation of our personal.