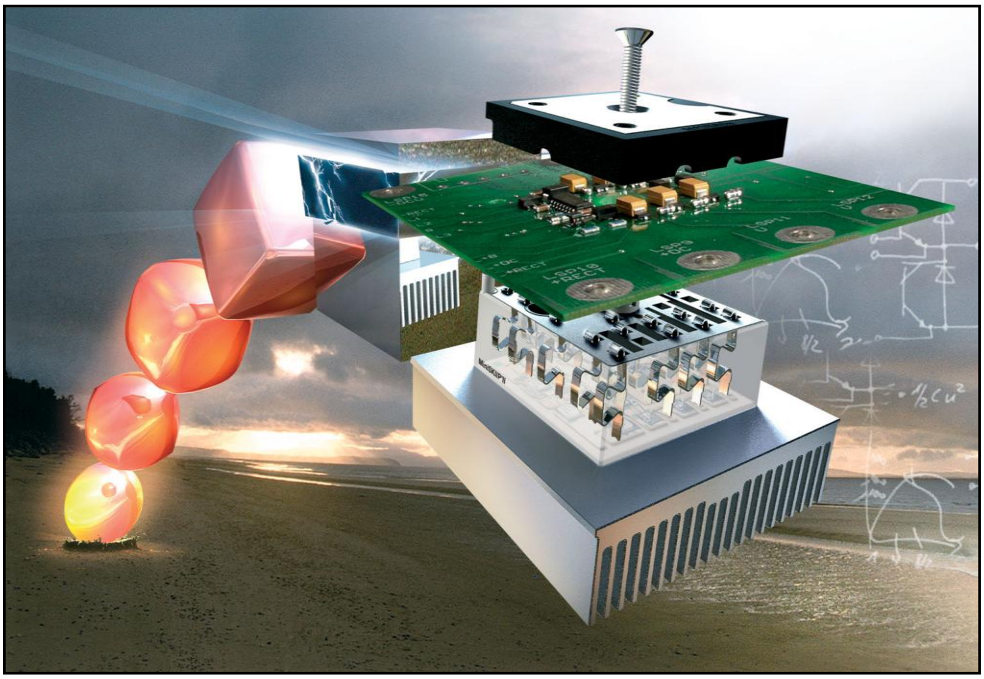
Version 3.1 - /2011

Technical Information
MiniSKiiP® II Generation



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 W up to 37kW 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

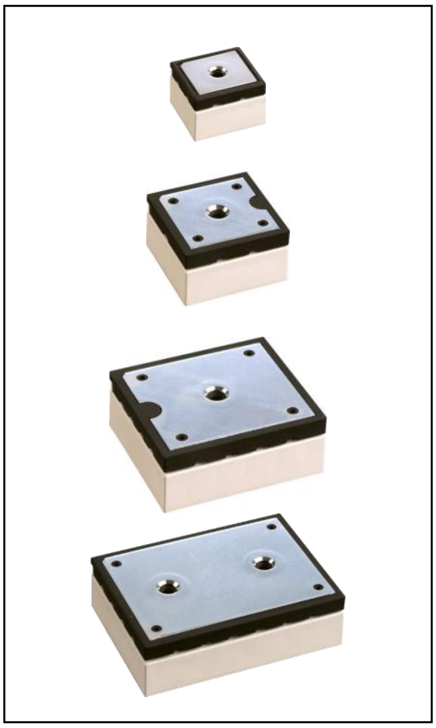


Fig. 1.1

1.2 Advantages

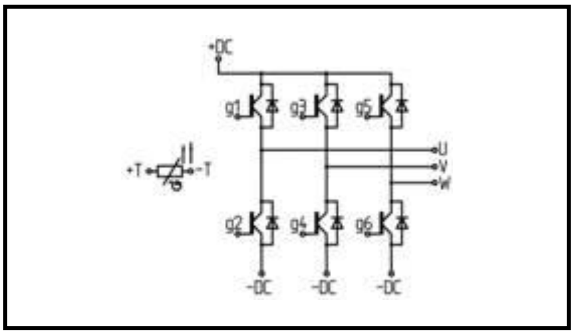
Utilising the reliability of pressure contact technology the patented MiniSKiiP® is a rugged, high-integrated system including converter, inverter, brake (CIB) topologies for standard drive applications up to 37 kW motor power. An integrated temperature sensor for monitoring the heat sink temperature 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

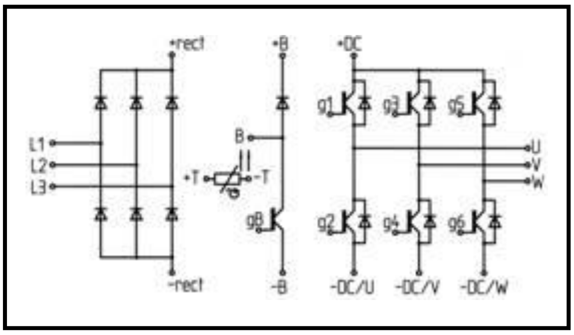
The MiniSKiiP® range offers CIB (Converter Inverter Brake) and sixpack inverter topologies in four package sizes. Diode or thyristor controlled input bridge rectifier modules with optional brake chopper supplement the sixpack modules. 3-level NPC topology is available in housing size 2 and 3. A PTC temperature 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

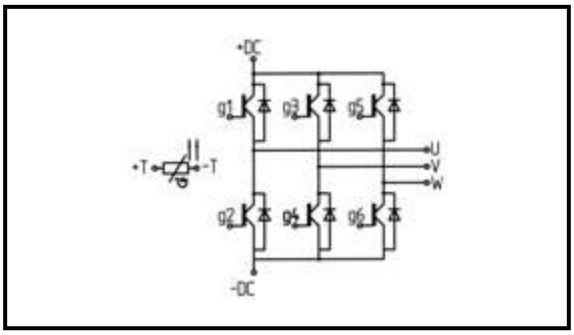
Fig. 2.1. This topology allows a current measurement by shunt resistors on the PCB.



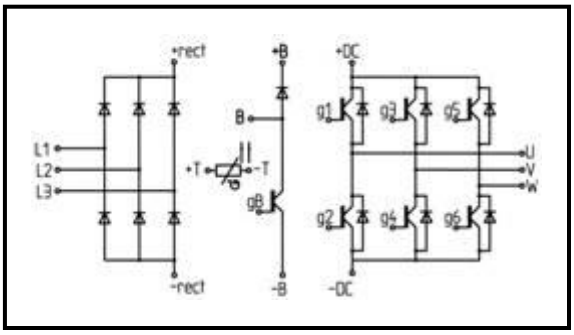
AC with open emitter in housing MiniSKiiP® 1



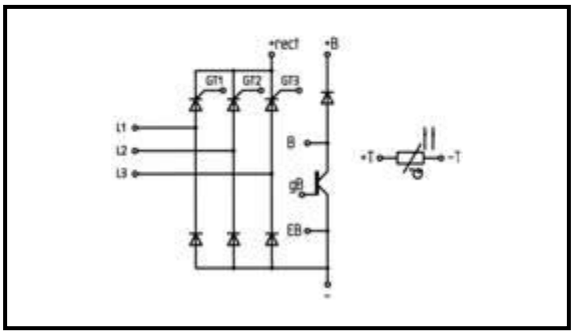
NAB with open emitter in housing MiniSKiiP® 1



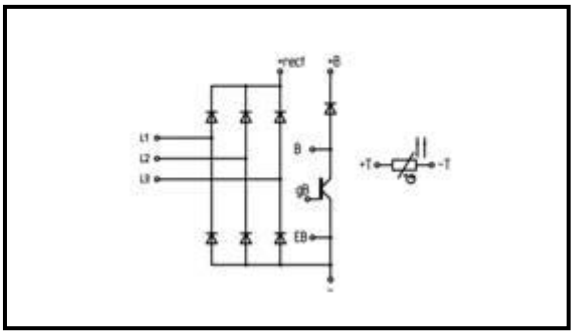
AC in housing MiniSKiiP® 2, 3



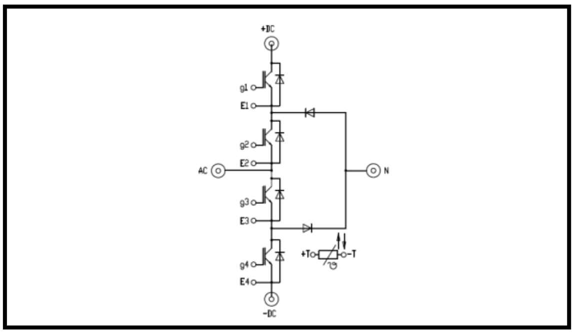
NAB in housing MiniSKiiP® 2, 3



AHB in MiniSKiiP®2, 3



ANB in housing MiniSKiiP® 2, 3



MLI in MiniSKiiP®2, 3

Fig. 2.1 MiniSKiiP® Topologies

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”. SEMISEL 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/.

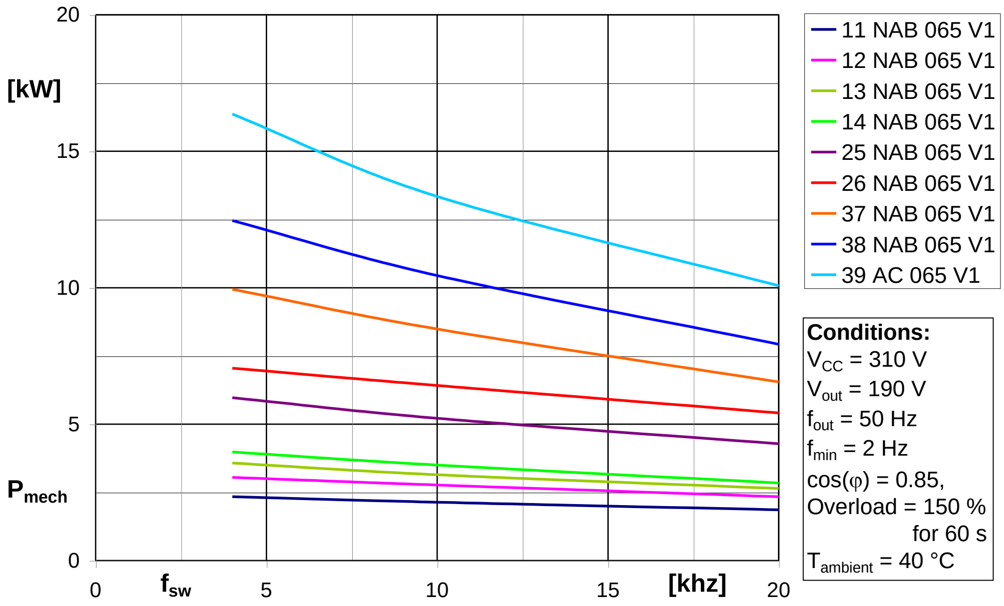
3.1 Selection for 600 V fast switching applications

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



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. 3.2 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

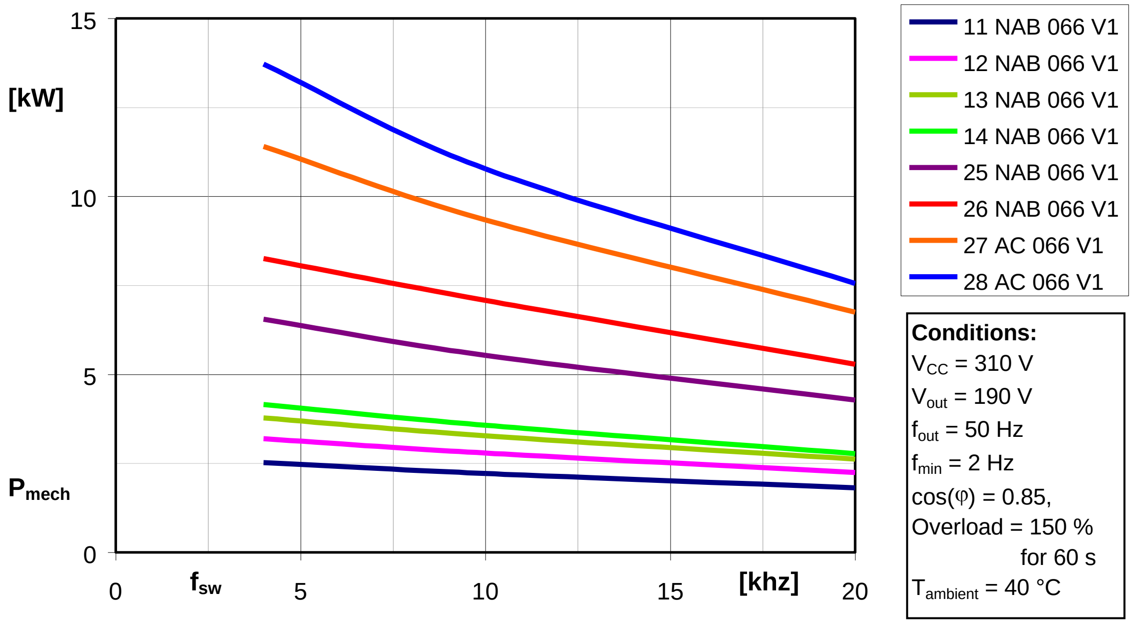
3.2 Selection for 600 V applications (Trench IGBT)

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

3.3 Selection for 1200 V applications

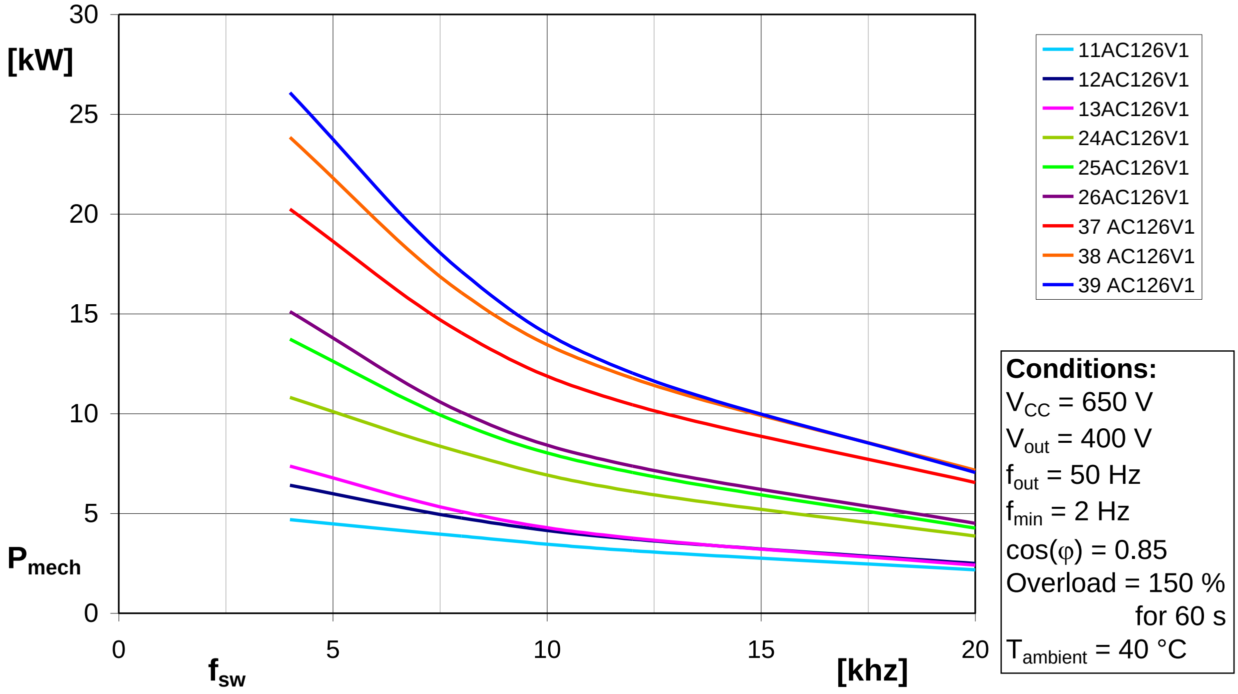
The following table (Fig. 3.5) shows for which standard motor power (shaft power) which standard MiniSKiiP® works proper under typical conditions and switching frequencies. For the calculation parameters, please refer to Fig. 3.6 .

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 (Fig. 3.8).

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.

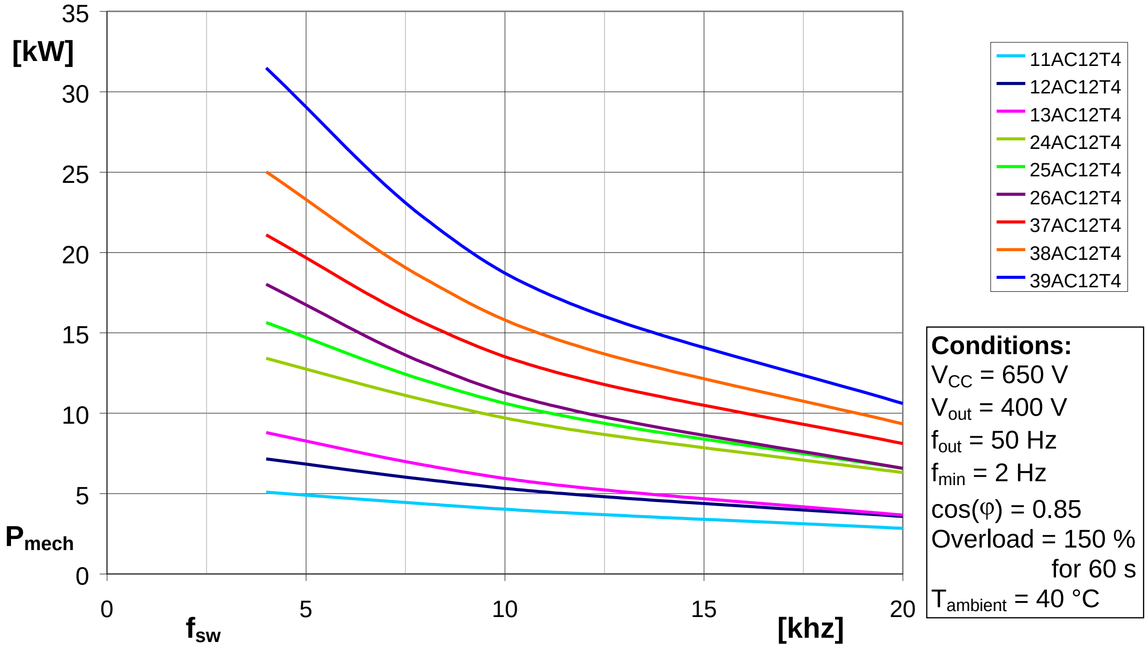


Fig. 3.8 Dependence of max. mechanical power vs. switching frequencies of the inverter for different MiniSKiiP® modules operated with a maximum junction temperature of T_j = 150°C

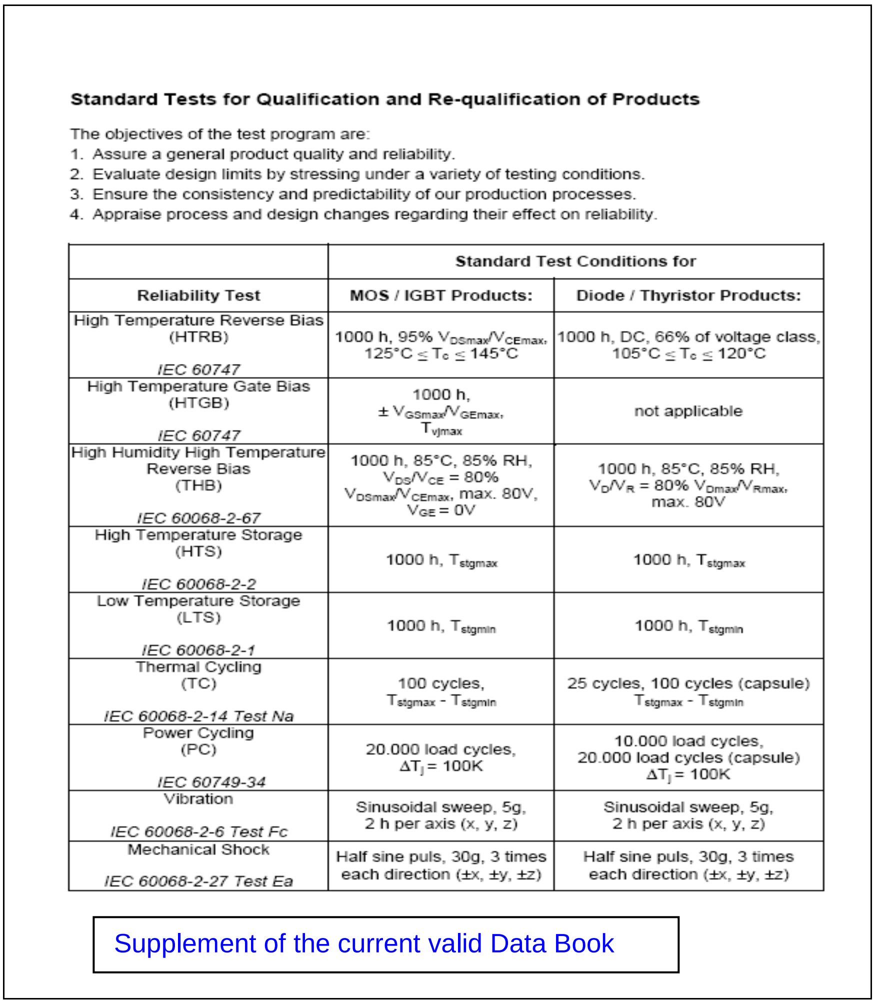
3.5 Selection for 3-level applications (650V Trench IGBT)

The following table (Fig. 3.7) shows the output power rating of 3-level inverters The output power rating based on a switching frequency of 3 kHz.

Type designation	$I_{c,nom}$ in A	Blocking voltage	$P_{out,max}$ in kVA	Housing
SKiiP 26MLI06R6V1	75	650 V	31	MiniSKiiP® 2
SKiiP 27MLI06R6V1	100	650 V	41	MiniSKiiP® 2
SKiiP 28MLI06R6V2	150	650 V	62	MiniSKiiP® 2
SKiiP 39MLI06R6V1	200	650 V	83	MiniSKiiP® 3

Fig. 3.7 The output power rating based on a switching frequency of 3 kHz.

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}, $125°C \leq T_c \leq 145°C$	1000 h, DC, 66% of voltage class, $105°C \leq T_c \leq 120°C$
High Temperature Gate Bias (HTGB) *IEC 60747*	1000 h, $\pm V_{GSmax}/V_{GEmax}$, 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

More detail to the above specified quality test or specific test results are available upon request. A complete essay is available for customer presentatation. Please contact SEMIKRON MiniSKiiP® Product Management.

5 Storage Conditions

Unassembled	20 000 h /60 °C 95% RH
Assembled	20 000 h /60 °C 95% 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 apply with RoHS rules the use of the following PCB finish materials can be recommended:

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

Not recommended for use are 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.

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

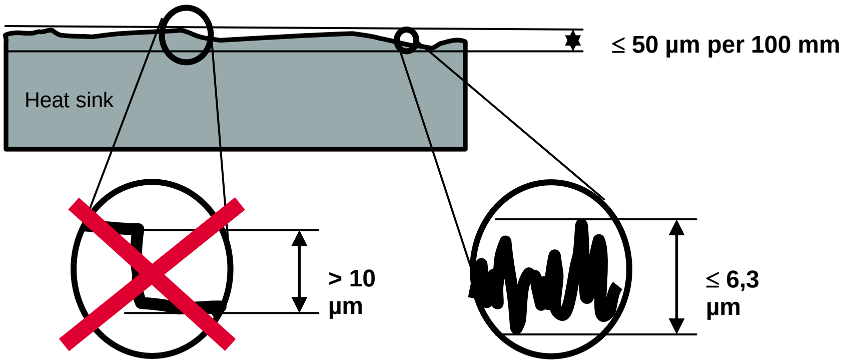


Fig. 7.1 Heat sink surface specification

- 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.

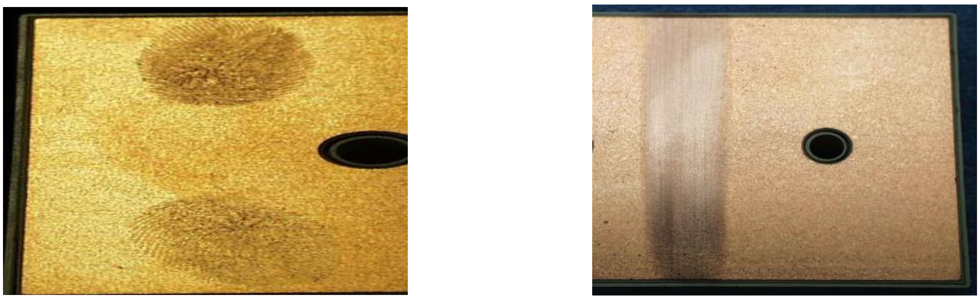


Fig. 7.2 NiAu DCB with fingerprints or discoloration

Fig. 7.3 Bottom Surface NiAu DBC after rework

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

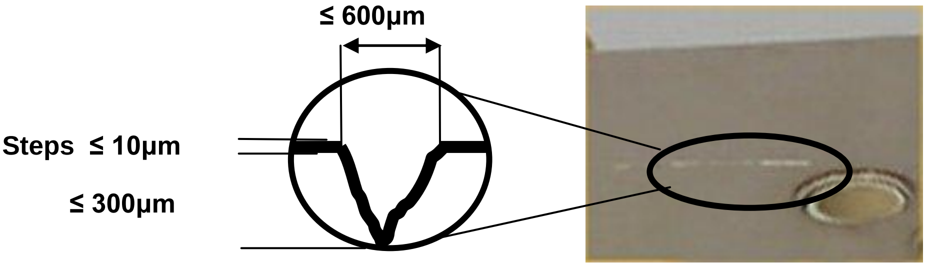


Fig. 7.4 Scratches on the MiniSKiiP® bottom surface

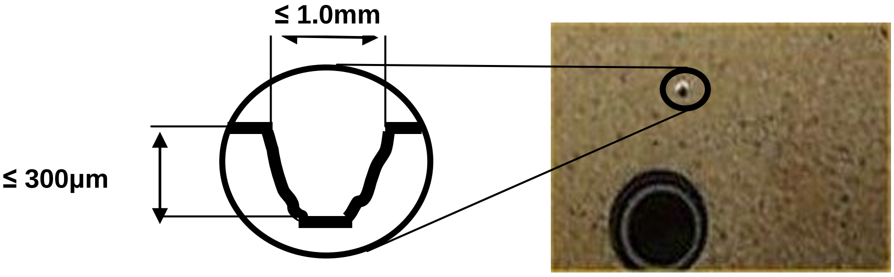


Fig. 7.5 Etching hole (hole down to substrate level) in the MiniSKiiP® bottom surface

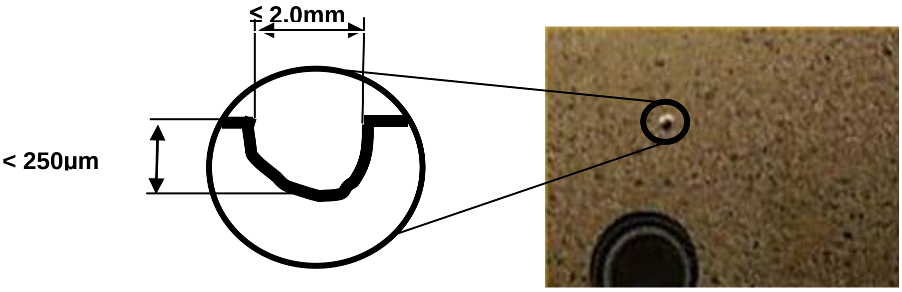


Fig. 7.6 Etching hole (hole not down to substrate level) in the MiniSKiiP® bottom surface

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.

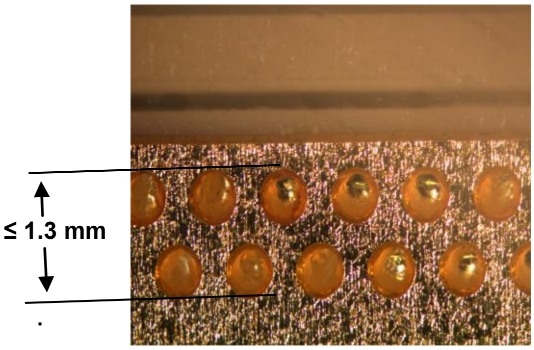


Fig 7.7 Dimples in the MiniSKiiP® bottom surface

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

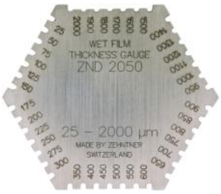


Fig. 7.11 Wet Film Thickness Gauge

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.

7.3 **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 Specification of the integrated temperature sensor

8.1 Electrical characteristic

MiniSKiiP®'s (with exception of certain special types) are equipped with a temperature sensor type "SKCS2 Temp 100". The SKCS2 does have a characteristic like a resistance with positive temperature coefficient (PTC) – see

Fig. 8.1 .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

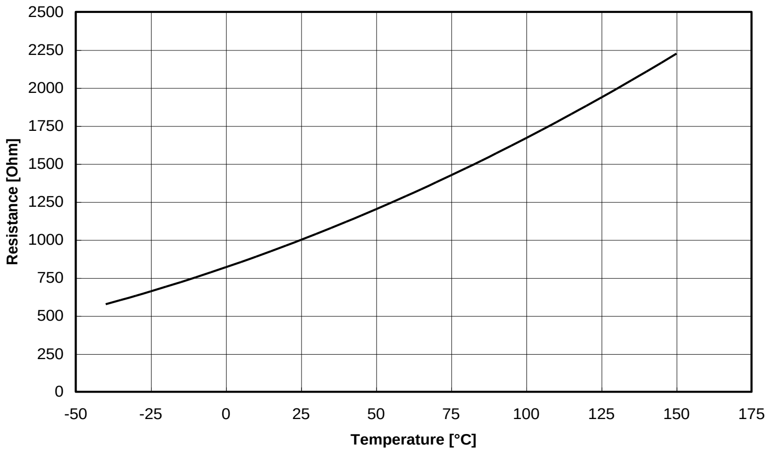


Fig. 8.1 Temperature sensor "SKCS2 Temp 100":Resistance as a function of temperature (typical characteristic)

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:

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

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

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.

9 Laser marking

All MiniSKiiP® modules are laser marked. The marking contains the following items (see Fig. 9.1):

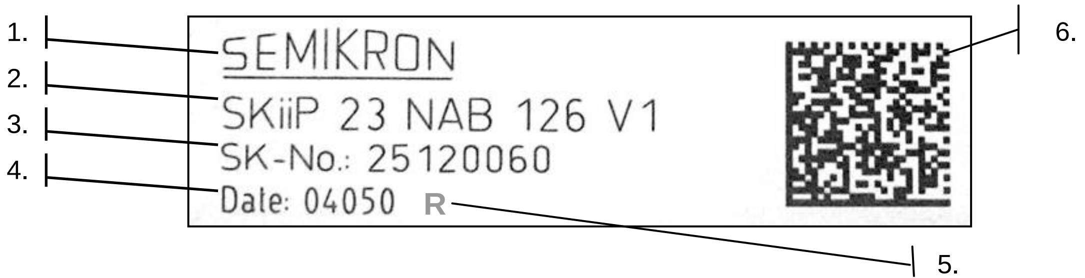


Fig. 9.1 Laser marking of MiniSKiiP® module

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: 37 digits

10 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)

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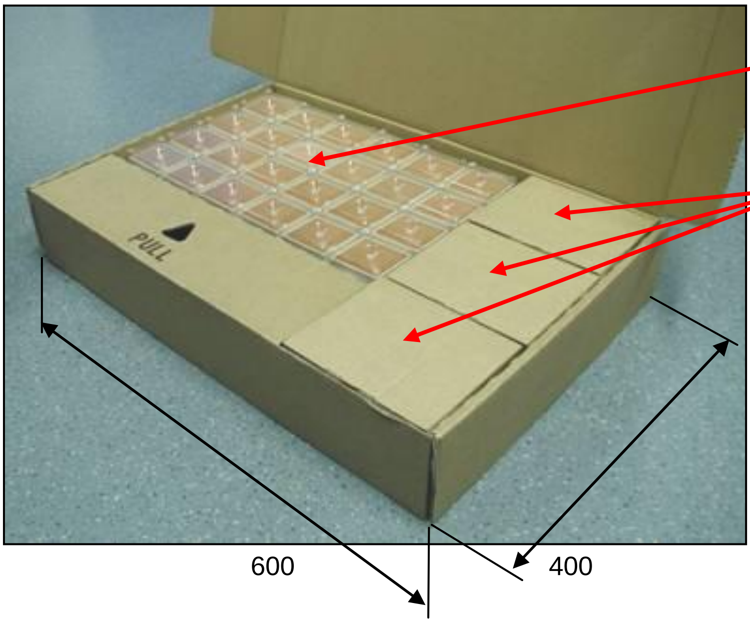
[1] Not valid for MiniSKiiP® size8 modules including current sensors (“I” types) with date code earlier than 0601

11 Packing specification

11.1 Packing box

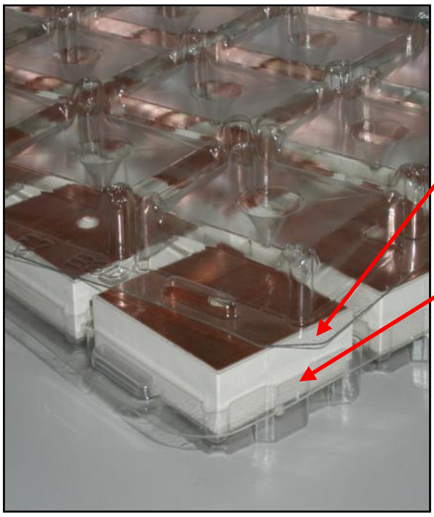
Standard packing boxes for MiniSKiiP® Modules:



Three layers of antistatic trays with MiniSKiiP

Three additional card board boxes with pressure lids included in the outer box

Fig. 11.1 Outer cardboard box, dimensions: 600 x 400 x 100 mm³ (l x w x h)



Cover tray on top

Bottom tray with modules

Fig. 11.2 Antistatic tray, dimensions: 440 x 275 x 30 mm³

Fig. 11.3 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

11.2 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. 11.4:

Fig. 11.4: Place for label on MiniSKiiP® packing boxes

The label contains the following items (see Fig. 11.5)

Fig. 11.5 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

12 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)

13 Caption of the figures in the data sheets

13.1 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 $T_j \leq 150$ °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.

13.2 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)

13.3 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 detailes information on the definition of the data sheet value please refer to PI 08-23 or to Alexander.Langenbucher@semikron.com

13.4 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.

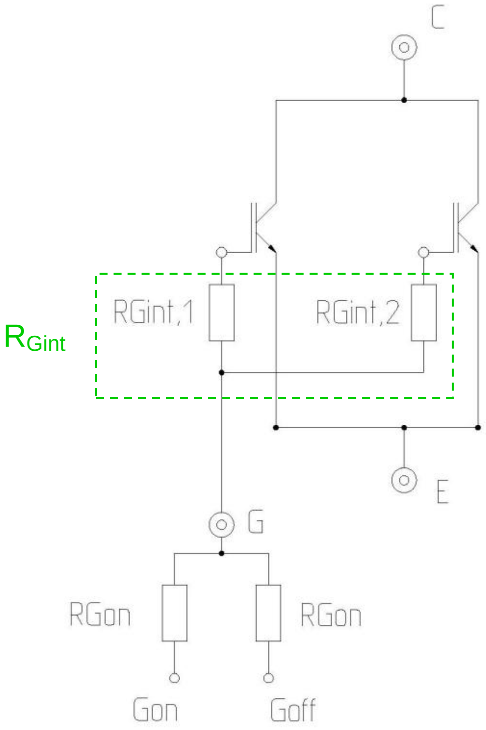


Fig. 13.1: Two IGBTs with internal gate resistors paralleled

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. 13.1 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.

14 Accessories

14.1 **Evaluation board MiniSKiiP® 2nd generation**

The evaluation boards (example Fig. 14.1) are offered to customers for design support to enable a fast and convinient way to connect the MiniSKiiP® with a lab or breadboard circuit.

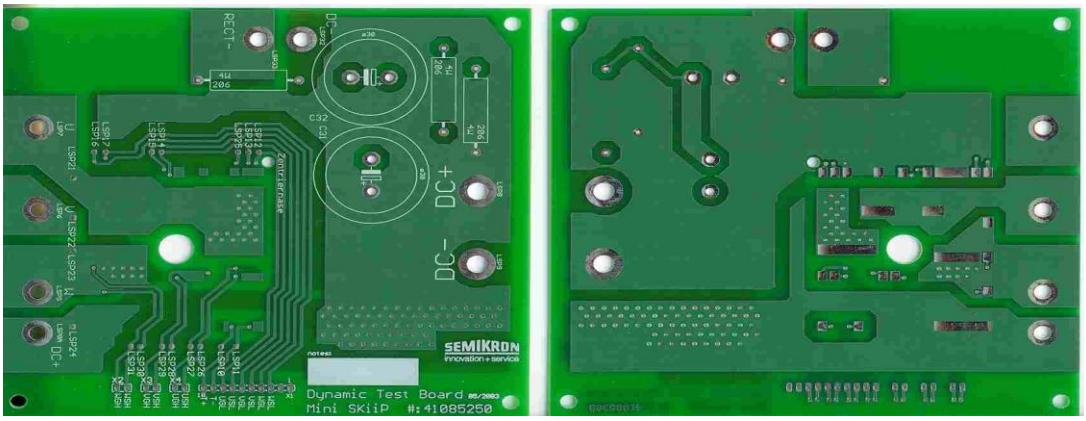


Fig. 14.1: Dynamic Evaluation Board for MiniSKiiP®2 “AC” Types

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.*

14.1.1 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.

14.1.2 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.

14.1.3 Order Codes for Test Boards

14.1.3.1 Evaluation Board Mini0 “AC” type

Static Board	IdentNo: 41085315 Dimension: 160 mm * 100 mm
Dynamic Board	Ident No: 41085310 Dimension: 130 mm * 132 mm

14.1.3.2 Evaluation Board Mini0 “NAC” type

Static Board	Ident No: 41094855 Dimension: 160 mm * 100 mm
Dynamic Board	Ident No: 41094850 Dimension: 130 mm * 132 mm

14.1.3.3 Evaluation Board Mini0 “NEB” type

Static Board	Ident No: 41094875 Dimension: 160 mm * 100 mm
Dynamic Board	Ident No: 41094870 Dimension: 130 mm * 132 mm

14.1.3.4 Evaluation Board Mini1 “AC” type

Static Board	Ident No: 41085245 Dimension: 160 mm * 100 mm
Dynamic Board	Ident No: 41085240 Dimension: 135 mm * 105 mm

14.1.3.5 Evaluation Board Mini1 “NAB” type

Static Board	Ident No: 41085295 Dimension: 160 mm * 100 mm
Dynamic Board	Ident No: 41085290 Dimension: 125 mm * 135 mm

14.1.3.6 Evaluation Board Mini2 “AC” type

Static Board	Ident No: 41085255 Dimension: 160 mm * 100 mm
Dynamic Board	Ident No: 41085250 Dimension: 130 mm * 140 mm

14.1.3.7 Evaluation Board Mini2 “NAB” type

Static Board	Ident No: 41085305 Dimension: 160 mm * 100 mm
Dynamic Board	Ident No: 41085300 Dimension: 130 mm * 140 mm

14.1.3.8 Evaluation Board Mini2 “MLI” type

Static/Dynamic Board	Ident No: 45103600 Dimension: 120 mm * 105 mm

14.1.3.9 Evaluation Board Mini3 “AC” type

for all IGBT technologies except “12T4”

Static Board	Ident No: 41085335 Dimension: 160 mm * 100 mm
Dynamic Board	Ident No: 41085330 Dimension: 163 mm * 114 mm

for IGBT technology “12T4”

Static/Dynamic Board	Ident No: L5047100 Dimension: 160 mm * 125 mm

14.1.3.10 Evaluation Board Mini3 “NAB” type

Static Board	Ident No: 41085235 Dimension: 160 mm * 100 mm
Dynamic Board	Ident No: 41085230 Dimension: 163 mm * 114 mm

14.1.3.11 Evaluation Board Mini3 “MLI” type

Static/Dynamic Board	Ident No: 45102900 Dimension: 145 mm * 105 mm

Additional boards for special types may be availabe on request. Please direct all requests and questions to Alexander.Langenbucher@Semikron.com

14.2 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.

14.2.1 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

14.2.2 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

14.3 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

15 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.

Disclaimer:

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16 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.