Technical Explanation
MiniSKiiP® Generation II

Revision:	5.0
Issue date:	2021-12-01
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Keyword: MiniSKiiP, spring, topology, 600V, 1200V, 1700V, PCB, pressure lid, order code

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1. Introduction

1.1 Key Features

- Latest 600V/650V, 1200V and 1700V IGBT technologies
- SEMIKRON inverse and freewheeling diodes in CAL technology
- SEMIKRON thyristors for controlled rectifiers
- SEMIKRON rectifier diodes with high surge currents
- Four different housing sizes
- Current range 4A to 400A for power range up to 110 kW
- Comprehensive setup of circuit topologies: CIBs, sixpack, twin sixpack, H-bridge, half-bridge, 3-level, uncontrolled/half-controlled input bridges with brake chopper and custom specific modules for various applications
- Solderless and rugged spring contact technology for all power and auxiliary connections
- Fast and easy mounting with one or two screw(s)
- Full isolation and low thermal resistance due to DBC ceramic without baseplate
- Integrated PTC or NTC temperature sensor

Figure 1: MiniSKiiP® housing sizes

1.2 Advantages

Utilizing the reliability of pressure contact technology, MiniSKiiP® is a rugged, high-integrated power module including converter, inverter, brake (CIB) topologies for standard drive applications up to 110kW motor power. An integrated temperature sensor for monitoring the heatsink temperature enables an over-temperature shut down. All components integrated in one package greatly reduce handling. The reduced number of parts increases the reliability.

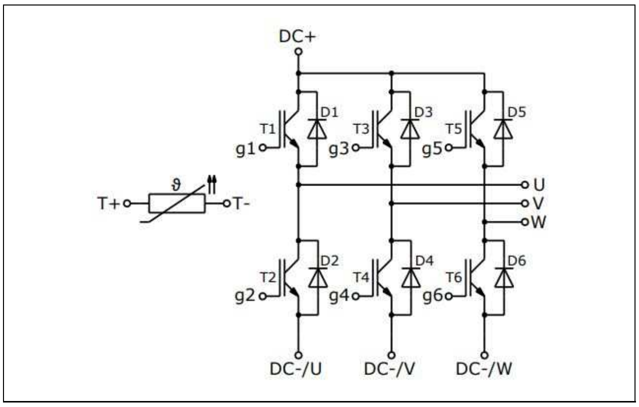
MiniSKiiP® uses a well-approved Al_2O_3 DCB ceramic to achieve an isolation voltage of AC 2.5 kV per 1 min and superior thermal conductivity to the heatsink.

Thanks to optimized current density, matched materials for high power cycling capability and pressure contact technology, MiniSKiiP® is a highly reliable, compact and cost effective power module.

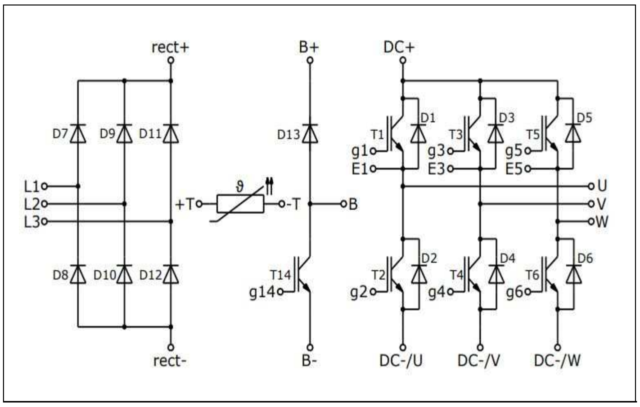
2. Topologies

The MiniSKiiP® product platform offers wide range circuit topologies as catalogue and custom specific types in four package sizes. Converter-Inverter-Brake (CIB), sixpack, twin sixpack, H-bridge, half-bridge, 3-Level, uncontrolled/half-controlled input bridges with brake chopper and custom specific modules are available for various applications. The following figures demonstrate a selection of available circuit topologies.

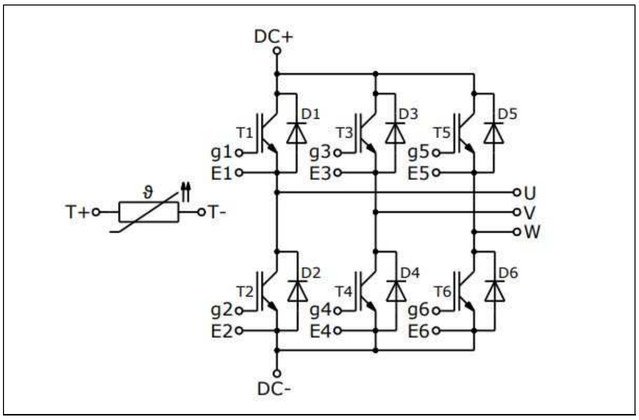
Figure 2: MiniSKiiP® topologies (examples)



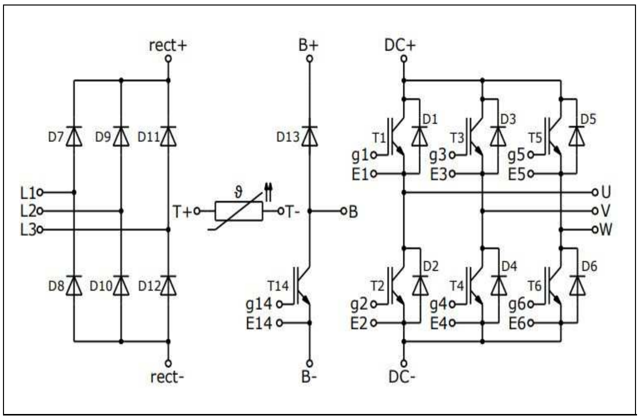
Sixpack with open emitter (AC)



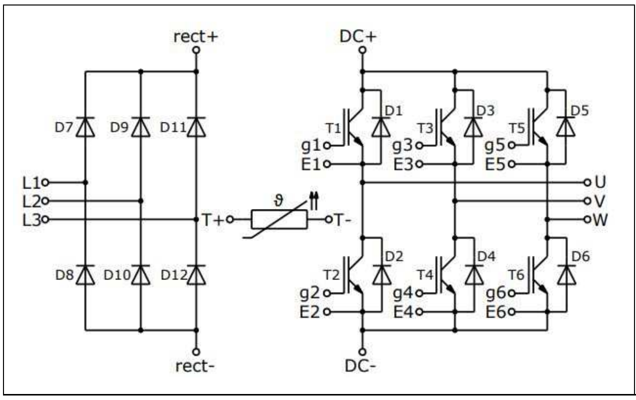
CIB with open emitter (NAB)



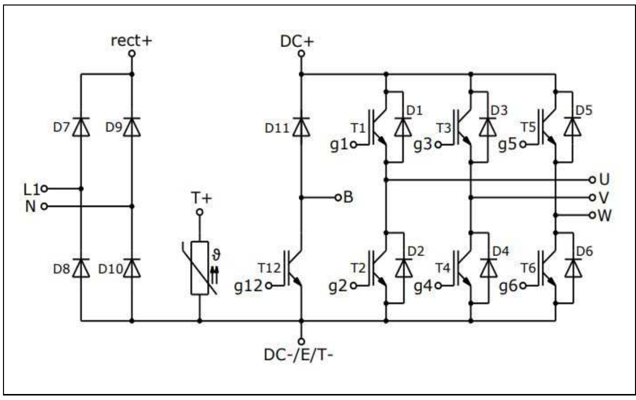
Sixpack with common emitter (AC)



CIB with common emitter (NAB)



3-phase input bridge and 3-phase inverter (NAC)



Single phase input bridge, brake chopper and 3-phase inverter (NEB)

3. Selection Guide

For an easy calculation of losses and device temperatures SEMIKRON offers a tool called "SEMISEL". Electrical parameters and cooling conditions can be adapted to a broad range of applications.
SEMISEL can be found on the SEMIKRON homepage under

http://www.semikron.com/service-support/semisel-simulation.html

4. MiniSKiiP® Qualification

The following tests are minimum requirements for the product release. Tests are executed for release new and/or re-developed modules. The scope of testing may be extended by further product-specific reliability tests.

Table 1: Overview of SEMIKRON reliability tests, test conditions and relevant standards

Test Description	Conditions
High Temperature Reverse Bias (HTRB) IEC 60747-9:2007	1000h
	95% $V_{CE\ max}$
	$T_{j=150°}$ for older Chip generation $T_{j=175°}$ for T7 IGBT
High Temperature Reverse Bias (HTRB) * IEC 60747-2:2016	1000h
	66% V_{RRM}
	$T_s = T_{j\ max} - 20K$
High Temperature Gate Stress (HTGS) IEC 60747-9:2007	1000h
	$\pm V_{GES\ max}$
	$T_{j\ max}$
High Humidity High Temperature Reverse Bias (H3TRB) EN 60068-2-67:1996	1000h
	T_a = 85°C, RH = 85%
	V_{CE} = max. 80V
High Voltage - High Humidity High Temperature Reverse Bias (HV-H3TRB) ** EN 60749-5:2018	1000h
	T_a = 85°C, R_H = 85%
	80% $V_{CE\ max}$
High Temperature Storage (HTS) EN 60068-2-2:2008, IEC 60749-6:2002	1000h
	$T_{stg\ max}$
Low Temperature Storage (LTS) EN 60068-2-1:1993 + A1:1993 + A2:1994	1000h
	$T_{stg\ min}$
Thermal Cycling (TC) EN 60068-2-14:2010	100 cycles
	$T_{stg\ max}$ - $T_{stg\ min}$
Vibration IEC 60068-2-6:2008	20Hz … 500Hz Sinusoidal sweep
	5g

	2h per axis (x, y, z)
Mechanical Shock IEC 60068-2-27:2010	Half sine pulse 18ms
	30g
	3 times each direction (±x, ±y, ±z)
Power Cycling (PC) EN 60749-34:2010	>70k cycles at ΔT= 70K

*) Valid for standard glass passivated rectifier diodes and thyristors.
**) Valid for chip technologies Generation 7 IGBT "T7" or higher

Test level may vary, depending on module layout and technology.

5. Storage & Shelf Life Conditions

MiniSKiiP power modules are qualified according to IEC/TR 60721-4-1 and can be stored in original package (without thermal paste material) for 2 years under climatic class 1K21 (IEC 60721-3-1):

Storage temperature:	5°C…40°C
Relative humidity:	5%...85%
Absolute humidity:	<25g/m^3

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. Sn)

It is <u>not</u> 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 disappears 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 intermetallic phases when mounting the MiniSKiiP®. For the functionality of the MiniSKiiP® spring contact system inside the specification limits a tin layer over the intermetallic phase is not necessary. The intermetallic phase protects the copper area on the PCB as well against oxidation as a long term effect.

6.1.2 NiAu as PCB Surface Finish

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

6.1.3 PCB Design

PCB Design is the 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 parallel as well, and close together. If using the "standard (space) lid", it is possible to use SMD devices under the lid in certain areas. The maximum height of the applicable SMD devices is 3.4mm. 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. FR 4 may be used as the material for the printed circuit board. The thickness of copper layers should comply with IEC 326-3.

6.1.4 PCB Soldering Process and Landing Pads

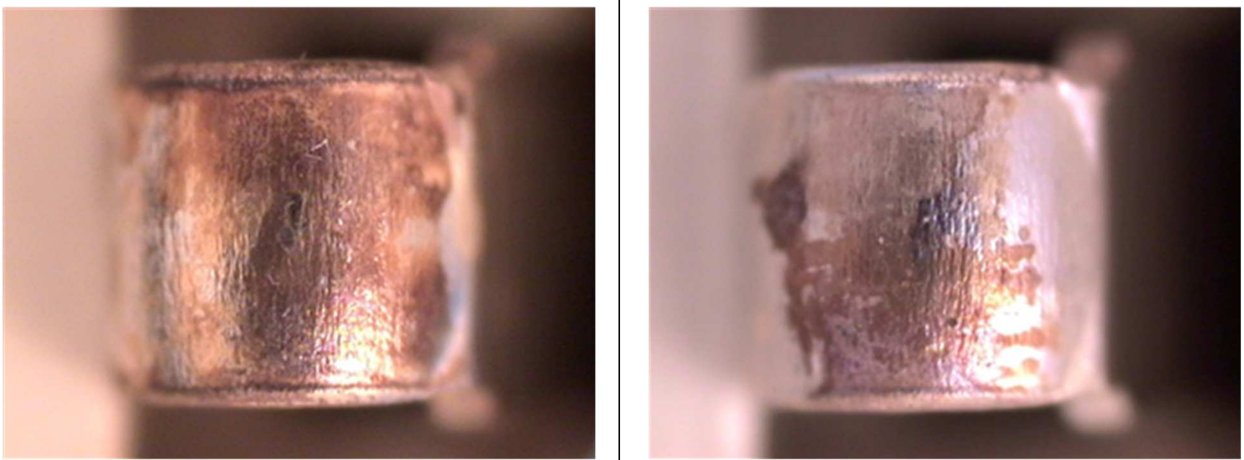
Components can be soldered on PCB using wave, reflow or selective soldering process. The landing pads for the spring contact must be free of any contamination like of solder stop, solder flux, dust, sweat, oil or other substances. If soldering components located on the PCB bottom side via wave soldering process, the contact pads have to be covered using metal stencil to protect the landing pads from solder splashes. Using an adhesive tape for masking the landing pads for protection requires paying particular attention that no residues remain on pads worsening the contact quality. Size and position of the particular landing pads can be found in additional drawing in the internet and intranet (case drawing MiniSKiiP size 0-3). 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.

6.2 Spring Contact Specification

Material: K88
Surface finishing: silver (Ag) with 1-5µm thickness; contact area (top and bottom) with 3-5µm thickness
Surface protection: metallic passivation 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 strength (550 MPa), very good formability up to sharp bending, outstanding electrical conductivity (80% IACS) as well as remarkable relaxation resistance for a long-term, stable spring force over the specified temperature range. No spring fatigue is expected over the complete MiniSKiiP® lifetime.
To protect the silver surface from deterioration, it is covered with a metallic passivation film. This tarnish protection of the MiniSKiiP spring pins is for cosmetic reasons only and protects the silver surface from sulphuration 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.

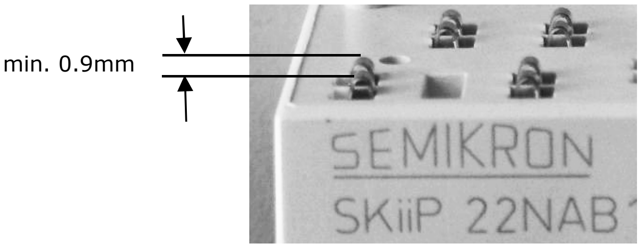
Figure 3: Two examples for discoloured spring surfaces



The discolouration is 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. Therefore, MiniSKiiP modules with discoloured springs due to oxidation and sulphuration can be used for inverter production without any risk.

To ensure a proper contact after mounting, the spring length measures min. 0.9 out of the housing (measured from the top surface of the housing to the head of the spring, Figure 4).
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.

Figure 4: Spring excess length



6.3 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:

Table 2: Electromigration and whisker formation test parameters

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 does whisker growth 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.

6.4 Qualification of Contact System

Table 3: Overview of MiniSKiiP contact system qualification tests for reliability				
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 heatsink**				
	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 100 cycles	Continuous monitoring of contact resistance at I=100mA	
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	

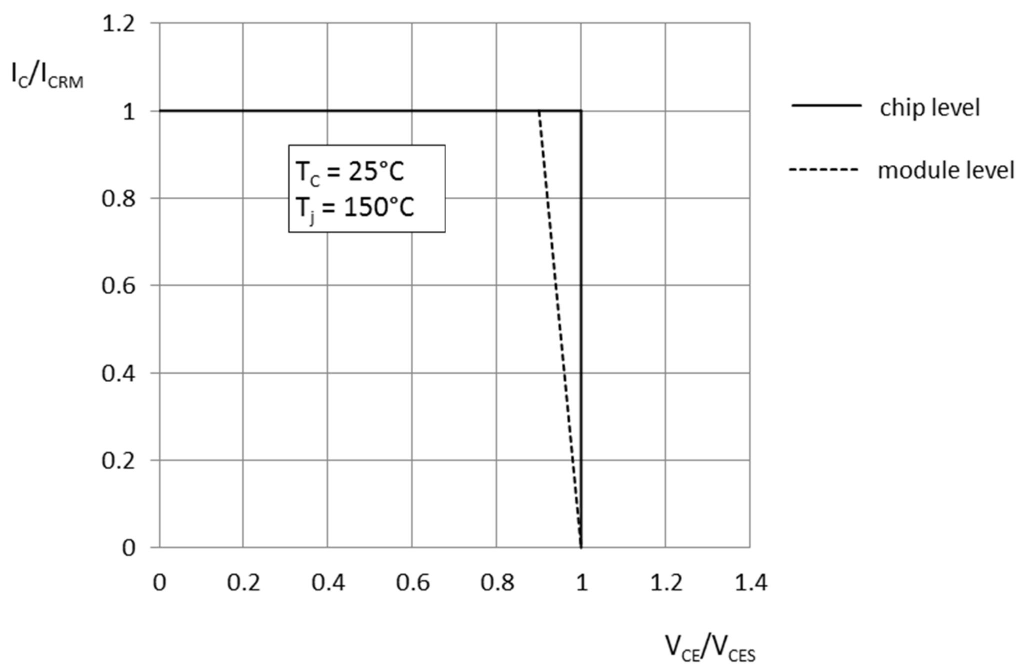
7. Safe Operating Areas for IGBTs

Safe operating areas are not included in the datasheets. They are given as standardized figures and referenced to V_{CES} and I_{CRM} or I_{Cnom}. These figures apply to 600V, 1200V and 1700V.

7.1 Safe Operating Area during Turn-on and Turn-off (SOA, RBSOA)

The following figure shows the maximum collector current (horizontal limit) and maximum collector-emitter voltage (vertical limit). It is important that the maximum ratings apply to currents which do not heat the IGBT to temperatures above the maximum chip temperature T_j = 150°C or 175°C. IGBT modules may be operated as switches only and must not be used in linear mode. The maximum V_{CES} value must never be exceeded. Due to the internal stray inductance of the module, an additional 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 Figure 5).

Figure 5: Safe Operating Area (SOA) / Reverse Biased Safe Operating Area (RBSOA)



7.2 Safe Operating Area During Short Circuit (SCSOA)

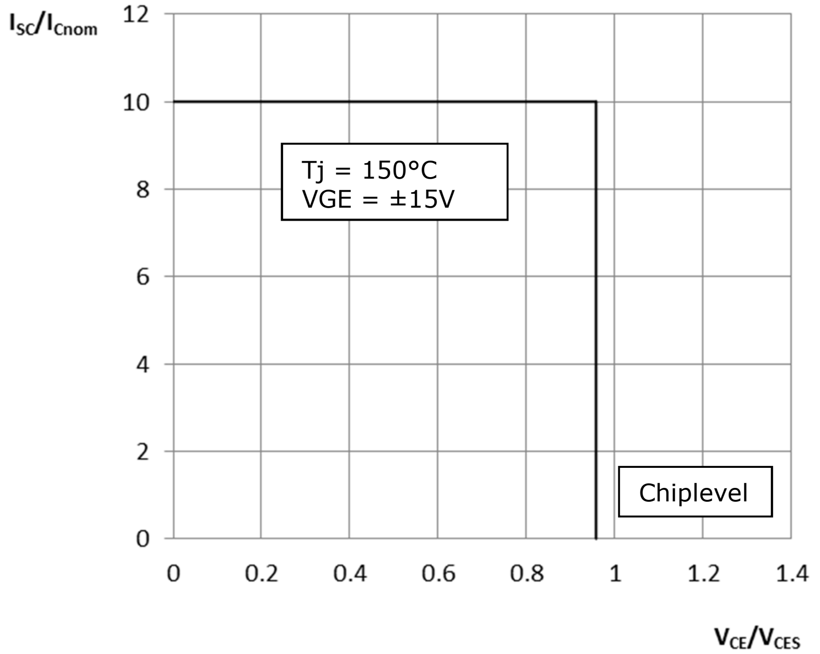
Under certain conditions, the IGBT is essentially capable of turning off short circuits actively. In doing so, high power losses are generated by the IGBT working in the active operating area, causing a temporary increase in chip temperature to far beyond $T_{j,max}$. However, the positive temperature coefficient of the collector-emitter voltage causes the circuit to stabilize and the short-circuit current is limited to 4..6 x I_{Cnom}.

The following boundary conditions need to be fulfilled to ensure a safe operation:

- The maximum short circuit duration is defined in the datasheets (maximum DC link voltage decreases to 360V for a 600V IGBT and 800V for a 1200V IGBT)
- The number of short circuits may not exceed 1000 during the total operation time of the IGBT
- The time between two short circuits has to be at least 1s

The Figure 6 gives an example of the permissible SCSOA with a defined di/dt during turn-off. It must be taken into consideration that the voltage at the terminals is exceeded by the chip voltage to the amount of Ls*di/dt, meaning the maximum external voltage has to be reduced accordingly.

Figure 6: Short Circuit Safe Operating Area (SCSOA) - Example



8. Definition and Measurement of R_{th} and Z_{th}

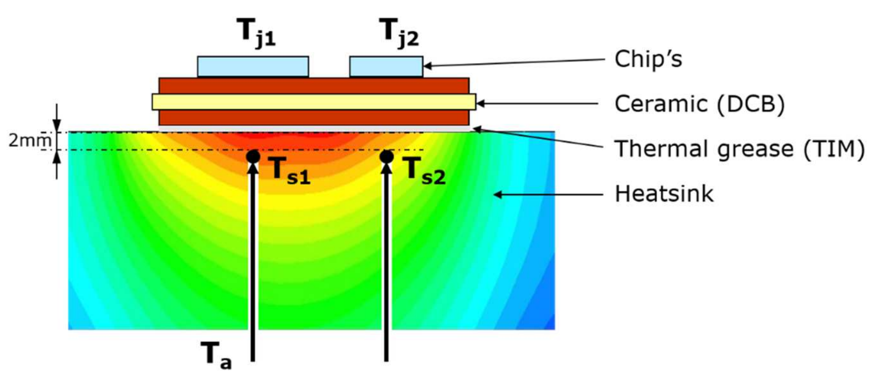
8.1 Measuring Thermal Resistance $R_{th(j-s)}$

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

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

The datasheet values for the thermal resistances are based on measured values. As can be seen in equation above, 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.

Figure 7: Measurement set up



Since MiniSKiiP® modules have no baseplate, SEMIKRON gives the thermal resistance between the junction and the heatsink $R_{th(j-s)}$. This value depends largely on the thermal paste but also used on the heatsink used for cooling. Thus, the value is given as a "typical" value in the datasheets.
The $R_{th(j-s)}$ of the MiniSKiiP® module is measured on the basis of the reference points given in Figure 7. The reference points are as follows:

T_j – Also called „virtual junction temperature", is an area related average value of the chip temperature

T_s – The heatsink temperature, which is measured in a drill hole 2 mm beneath the module, directly under the chip.

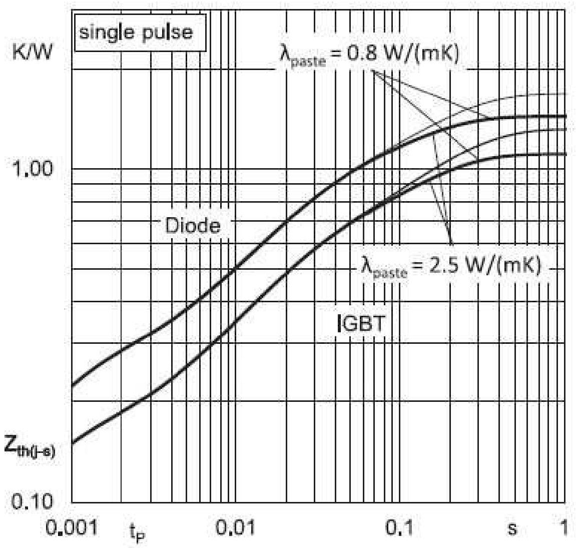
For further information on the measurement of thermal resistances, please refer to Application note: AN-14-004

The given R_{th} 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.

8.2 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 datasheets. 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, the impedance 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 datasheet value R_{th}.

Figure 8: Z_{th} - Transient thermal impedance with thermal paste Wacker P12/HPTP



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

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

The Foster Elements for R_i and Tau_i are available on request.

9. Specification of the Integrated Temperature Sensor

Please note that MiniSKiiP® power modules are equipped with a temperature sensor of NTC (=negative temperature coefficient) characteristic or of PTC (positive temperature coefficient) characteristic. To get the detailed info about type of the temperature sensor in a specific module please refer to module datasheet.
The temperature sensor is generally placed near the edge of the DBC yet close to an IGBT switch due to insulation and space restrictions. The thermal coupling is not efficient enough to monitor the chip temperature of the switch. Therefore, the temperature sensor can be used as an indicator for heatsink temperature. The recommended value for the trip temperature is about 115 °C (air-cooling), based on a heatsink with a standard thermal lateral spread. A Finite Element Simulation including the cooling system is recommended to determine the sensor temperature under worst-case conditions.

Note: Thermal coupling diminished if water-cooling is used

9.1 Electrical Characteristics (PTC)

The type "SKCS2 Temp 100" does have a characteristic like a resistance with positive temperature coefficient (PTC) – see Fig. 9

Note: Thermal coupling diminished if water-cooling is used

Figure 9: Temperature sensor "SKCS2 Temp 100": Resistance as a function of temperature

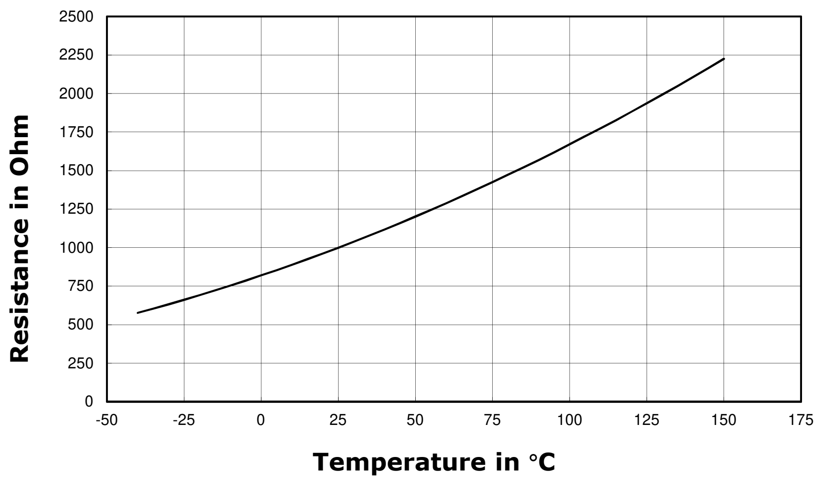


Table 4: Equitation and Parameter of the PTC resistance

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

Symbol	Tolerance	min	typ	max	Unit
R_{25}	±3%	970	1000	1030	Ω
R_{100}	±2%	1637	1670	1703	Ω
A			$7.635 * 10^{-3}$		1/°C
B			$1.731 * 10^{-5}$		1/°C²

The temperature sensor has a nominal resistance of 1KΩ±3 % at 25°C (at 100°C ± 2 %) with a typical temperature coefficient of 0.76 % / K.

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

9.2 Electrical Characteristics (NTC)

The standard "KG3B" temperature sensor exhibits a negative temperature coefficient characteristic with a nominal resistance value at 25°C of 5kΩ±5%. The temperature-dependent resistance of the NTC sensor is described by the following equation:

Figure 10: Typical sensor resistance of "KG3B-35-5" as a function of temperature

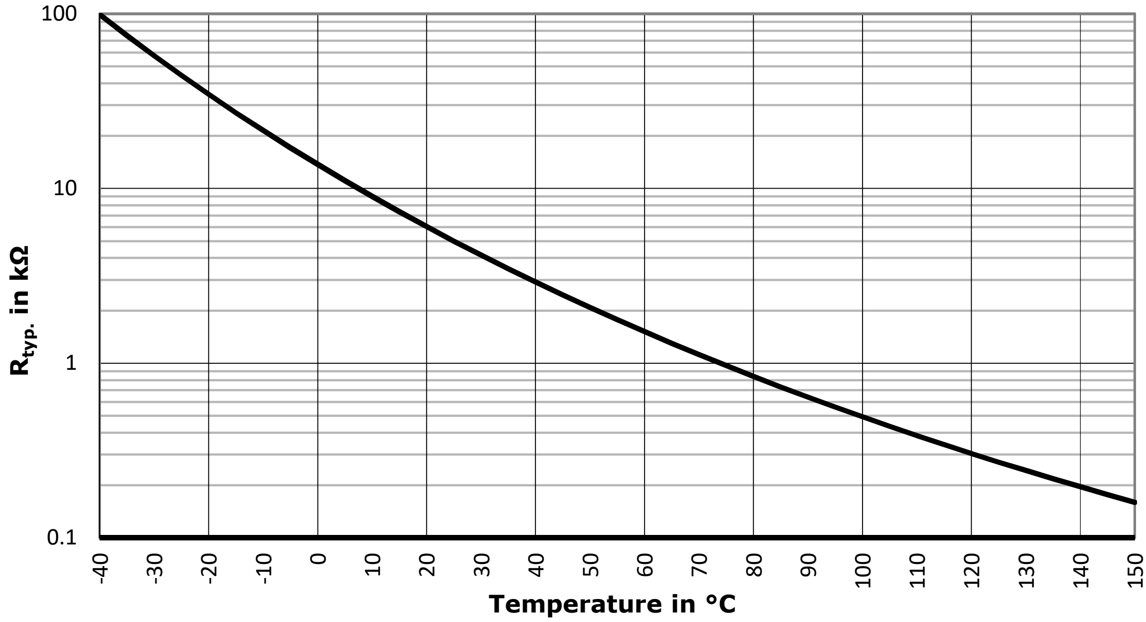


Table 5: Equitation and Parameter of the NTC resistance

$$R_2 = R_1 \cdot e^{\left[B_{(T_1/T_2)} \cdot \left(\frac{1}{T_2} - \frac{1}{T_1}\right)\right]}$$

R_2 : resistance at absolute temperature T_2 [K]
R_1 : resistance at absolute temperature T_1 [K]
B : B-value $B_{(T1/T2)}$ [K]

Symbol	Tolerance	min	typ	max	Unit
R_{25}	±5%	4.75	5.00	5.25	kΩ
R_{100}	±5%	468	493	518	Ω
$B_{(25/50)}$			3375		K
$B_{(25/85)}$			3420		K
$B_{(100/125)}$			3550		K

9.3 Electrical Isolation

Inside the MiniSKiiP® the temperature sensor is mounted close to the IGBT and diode dice on the same substrate. All MiniSKiiP modules provide functional isolation between temperature sensor and the remaining circuit, if not otherwise stated in the datasheet. The isolation is tested in production.

Figure 11: Temperature sensor on DBC substrate

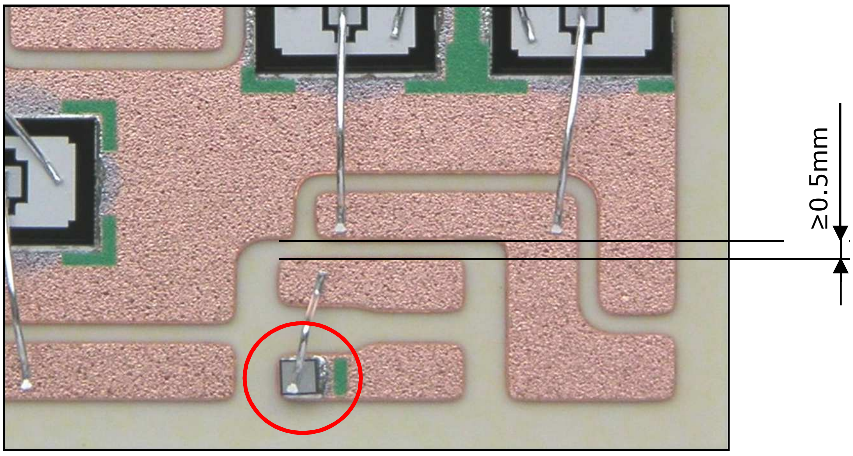
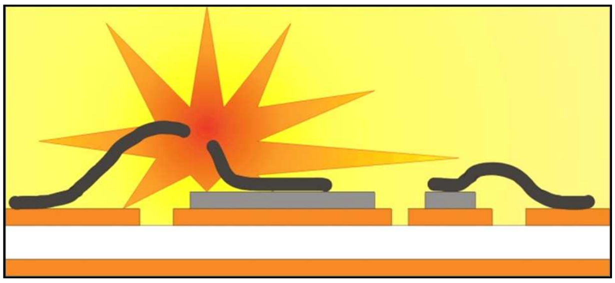


Figure 12: Sketch of high-energy plasma caused by melted off bond wire



During short circuit failure and the added electrical overstress, the bond wires or chip can melt off producing high-energy plasma causing an electrical arc. In this case, the direction of plasma expansion is not predictable; the temperature sensor might be touched by the arc and exposed to a high voltage level. The grade of electrical protection can never be higher than basic insulation.
The safety grade protective separation according to EN 61800-5-1 can be achieved by different additional means, described there in detail.

10. 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 heatsink. Since the pressure lid has the same electrical potential as the heatsink 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 (Figure 13, 1.) is > 8.6mm for standard lid and 5.8mm for the slim lid (as given in Figure 14). The internal distance between screw and board (Figure 13, 2.) is > 6.1 mm with a one millimeter PCB, as given in Figure 15. If the PCB is thicker than 1 mm the creepage distance will be reduced by this value (for example: PCB = 1.5mm; Creepage distance is 6.1mm – 0.5mm = 5.6mm)
Inside the MiniSKiiP® a transparent silicone gel with a dielectric strength of 23 kV/mm ensures electrical isolation from the DBC substrate to the heatsink (Figure 13, 3.) as well as from the DBC to the screw (Figure 13, 4.).

CTI values:
Housing size 1-3: Insulation material group I (CTI ≥ 600)
Housing size 0: Insulation material group IIIa (400 > CTI ≥ 175)
Standard lid 0-3: Insulation material group IIIa (400 > CTI ≥ 175)
Slim lid 0-3: Insulation material group IIIa (400 > CTI ≥ 175)

Figure 13: MiniSKiiP® assembly cross-section indicating distances

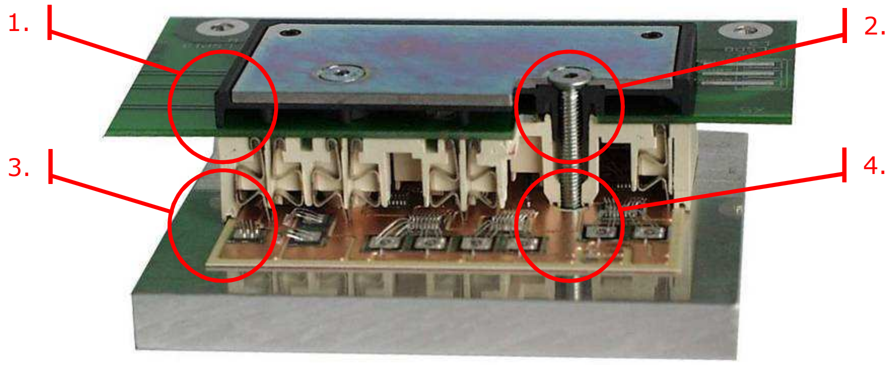
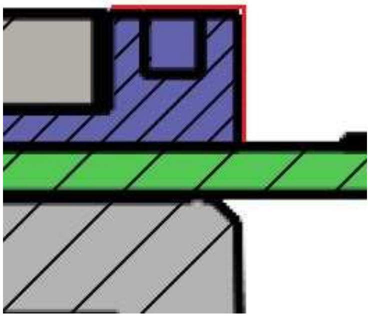
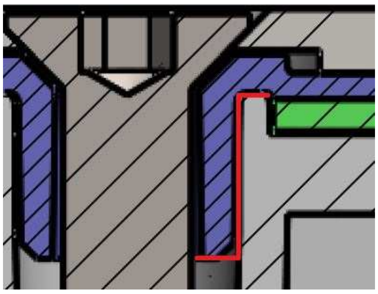


Figure 14: Cross-section sketch with distance from pressure plate to PCB (slim lid shown)



>8.6 mm for standard lid
>5.8 mm for slim lid

Figure 15: Cross-section sketch with distance from screw to PCB (slim lid shown)



>6.1 mm for standard and slim lid

11. Thermal Material Data

For thermal simulations, it is necessary to have the thermal material properties e.g. layer thicknesses, specific thermal capacities and conductivity of the layers. The layer structure is shown in Figure 16 below and the material data in Table 6.

Figure 16: Sketch of MiniSKiiP® assembly indicating material layers

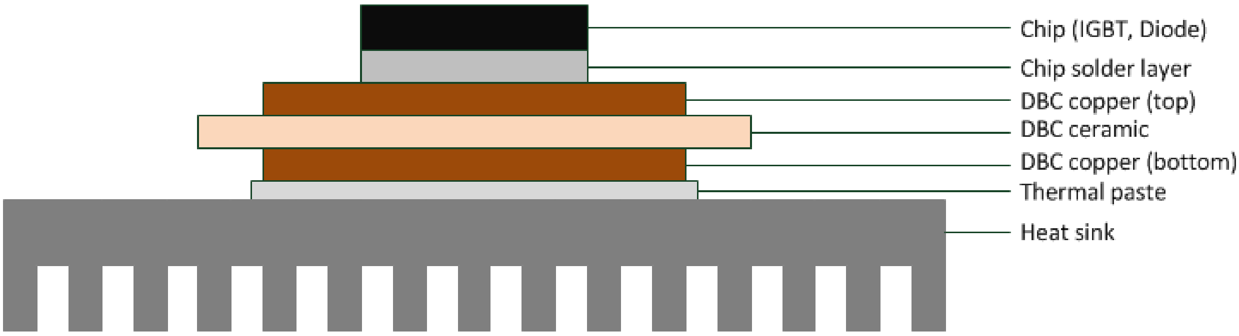


Table 6: Material data for thermal simulations

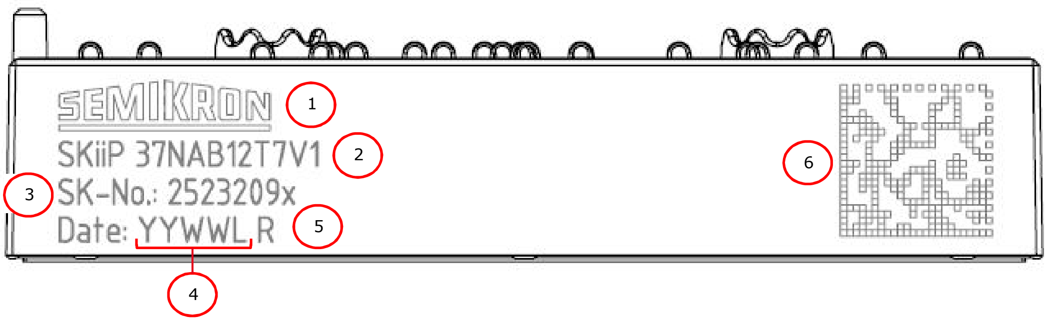
Layer	Material	Layer thickness [μm]	Spec. Thermal conductivity λ @25°C [W/(m*K)]	Spec. Thermal Capacity @25°C [J/(kg*K)]	Density @25°C [kg/m³]
1200V IGBT T7	Si	112	148	700…750	2330
1200V CAL4F diode	Si	261	148	700…750	2330
1600V PEP Net diode	Si	310	148	700…750	2330
Chip solder layer	SnAg	~100	57	214	7800
DBC Copper (top)	Cu	300	394	385	8960
DBC Ceramic	Al_2O_3	380	24	830	3780
DBC Copper (bottom)	Cu	300	394	385	8960
Thermal Interface Material (TIM)	Customer specific	20…40	1…2.5 (See datasheet)	700	2500

Especially the thermal conductivity of Silicon is temperature dependent, it declines by about 0.5 W/(m·K) per K to about 100 W/(m·K) at 125°C.
For all other material data, please ask product management.

12. Laser Marking

All MiniSKiiP® modules passed the production line tests will be laser marked. The marking contains following info items:

Figure 17: Laser marking contents of MiniSKiiP®



1. SEMIKRON logo
2. Type designation
3. SEMIKRON part number
4. Date code – 5 digits: YYWWL (L=Lot of same type per week)
   Info: The module sample status, an "E", will follow after the 5 date code digits
   "E": Evaluation, engineering or application samples
5. "R": Identification for compliance with RoHS
6. Data matrix code

The data matrix code consists of 53 digits and, 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:

Table 7: MiniSKiiP® data matrix code description

Position	1	2	3	4	5	6	7	8	9	10	11
Content	Type designation		Part number	Production tracking number		Measurement number	Production line identifier		Continuous number		Date code
Digits	16	1	10	12	1	1	1	1	4	1	5
Example	SKiiP37NAB12T4V1		25231570	14DE05006456		1	2		0018		14470

13. RoHS Compliance

RoHS: The Restriction of Hazardous Substances in Electrical and Electronic Equipment (RoHS) Directive (2002/95/EC)
MiniSKiiP® is in compliance with the RoHS Directive (2002/95/EC). Newer MiniSKiiP® modules are marked with "R" behind the date code to show the compliance with RoHS in the laser marking as well (Figure 17, 6.)

14. Packing Specification

14.1 Packing Box

Standard packing boxes for MiniSKiiP® Modules:

Figure 18: Outer cardboard box, dimensions: 595 x 400 x 150mm³ (l x w x h)

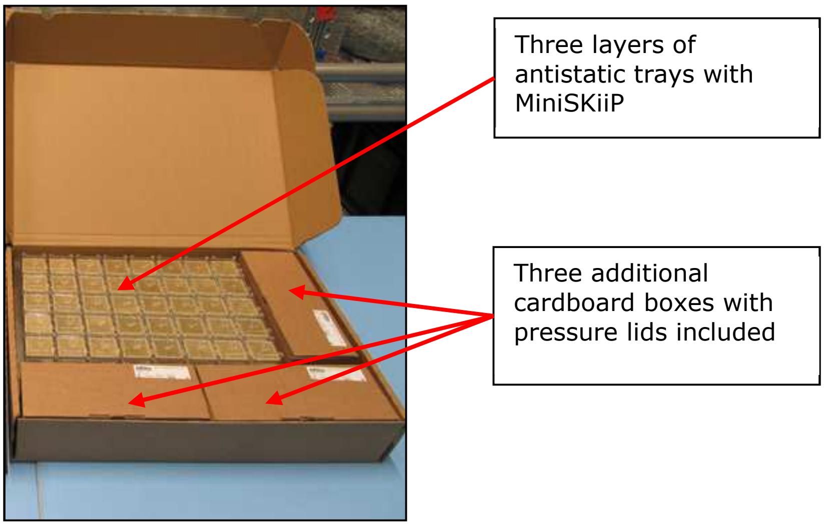


Figure 19; Antistatic tray, dimensions: 440 x 275 x 30 mm³

Figure 20: Cardboard for pressure lids, dimensions: 257 x 100 x 100 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 (cardboard)		
	Trays:	A-PET (not electrically chargeable)		
	Dry Pack:	Activated and grained clay in paper bags		

14.2 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 Figure 21:

Figure 21: Place for label on MiniSKiiP® packing boxes

Information about product. Details about label content can be found here:
https://www.semikron.com/product-package-content

Products with pre-applied TIM have additional labelling. Details can be found here:
https://www.semikron.com/dl/service-support/downloads/download/semikron-technical-explanation-thermal-interface-materials-en-2019-09-25-rev-03.pdf

15. Type Designation System

Table 8: MiniSKiiP® type designation

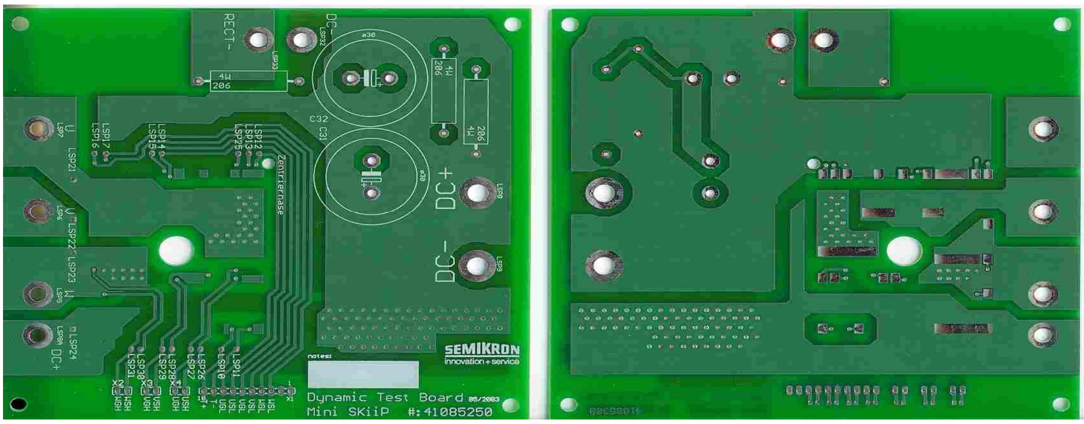
Position	1	2	3	4	5	6	7
Content	**Product Group**	**Housing Size**	**Current Class**	**Topology**	**Voltage Class**	**IGBT Technology**	**Version**
Values	SKiiP	0 1 2 3	0-9	**AC:** Sixpack;**NAB:** 3-phase rectifier, brake chopper, 3-phase inverter (CIB); **ANB**: 3-phase uncontrolled rectifier, brake chopper; **AHB**: 3-phase half controlled rectifier, brake chopper; **GH:** H-bridge; **GB:** half bridge; **ACC:** 12-pack; **MLI:** 3-level (NPC); **TMLI:** 3-level (TNPC); **NAC:** 3-phase rectifier, 3-phase inverter (CI); **NEB:** 1-phase rectifier, brake chopper, 3-phase inverter	06=600V 07=650V 12=1200V 16=1600V 18=1800V 17=1700V 22=2200V	5=Ultra fast NTP 6=Trench 3 E3=Trench 3 E4=Trench 4 T4=Trench 4 F4=Fast trench 4 S5=Trench 5 T7=T7	Vx=Version number
Example	SKiiP	3	7	NAB	12	T4	V1

16. Accessories

16.1 Evaluation Boards

The evaluation boards (example Figure 22: Dynamic evaluation board for MiniSKiiP®2 "AC" types) are offered to customers for design support to enable a fast and convenient way to connect the MiniSKiiP® with a lab or breadboard circuit.

Figure 22: 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 clip on feet stand offs, Ø 4mm or threaded 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 continuous current: I_{dmax} = 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.*

16.1.1 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 evaluate the static values like V_{CEsat}, V_f, R_{th}, etc.

16.1.2 Dynamic Test Boards

The dynamic board layout is optimized for dynamic operation. Therefore, a low stray inductance design was realized. The boards also allow 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.

16.1.3 Order Codes for Evaluation Boards

Evaluation board can be ordered using following P/Ns:

Table 9: MiniSKiiP® evaluation boards

Housing size	Topology	Static Board P/N	Static Board Dimensions	Dynamic Board P/N	Dynamic Board Dimensions
0	AC	41085315	160mm x 100mm	41085310	130mm x 132mm
0	NAC	41094855	160mm x 100mm	41094850	130mm x 132mm
0	NEB	41094875	160mm x 100mm	41094870	130mm x 132mm
1	AC	41085245	160mm x 100mm	41085240	135mm x 105mm
1	ACC	41097595	160mm x 100mm	41097590	130mm x 134mm
1	NAB	41085295	160mm x 100mm	41085290	125mm x 135mm
2	AC	41085255	160mm x 100mm	41085250	130mm x 140mm
2	ACC	41100585	160mm x 100mm	41100580	130mm x 134mm
2	NAB	41085305	160mm x 100mm	41085300	130mm x 140mm
2	MLI			45103600	120mm x 105mm
2	TMLI (28TMLI)			45115200	176mm x 131mm
2	TMLI (29TMLI)			45124800	176mm x 131mm
2	ANB (1700V)			45114100	176mm x 131mm
2	NAB (1700V)			45117900	176mm x 131mm
2	GB			45117200	140mm x 115mm
3	AC			L5047100	160mm x 125mm
3	NAB	41085235	160mm x 100mm	41085230	163mm x 114mm
3	MLI			45102900	145mm x 105mm

3	AC (1700V)			45117500	176mm x 131mm
3	NAB (1700V)			45118100	176mm x 131mm
3	GB			45117300	140mm x 115mm
3	TMLI (39TMLI)			45112000	105mm x 145mm

Additional boards for special types may be available on request. Please contact our closest sales office.

16.2 Pressure Lid

Table 10: MiniSKiiP® II pressure lids		
Size	**Slim Type P/N**	**Standard Type P/N**
0	25121040	25121000
1	25121050	25121010
2	25121060	25121020
3	25121070	25121030

Please refer to chapter "ordering codes" to select the correct order (variant) code.

MiniSKiiP® II pressure lid drawings in special file formats are available on request.
Please contact our closest sales office.

16.3 Pre-Applied Thermal Paste

SEMIKRON offers MiniSKiiP® power modules with following types of pre-applied thermal paste:

- Wacker P12 (silicone-based)
- High performance thermal paste HPTP (silicone-based)

Figure 23: MiniSKiiP® with pre-applied thermal paste

Please refer to chapter 19. "Variant Codes" to select the correct order.

16.4 Mechanical Sample

Mechanical samples can be ordered using following P/Ns:

Table 11: MiniSKiiP® II mechanical samples	
Housing size	**P/N**
0	25231100
1	25231110
2	25231120
3	25231130

17. Variant Codes

Table 12: MiniSKiiP® variant codes	
Variant code	**Description**
M00	MiniSKiiP® module without any accessory
M01	MiniSKiiP® module + thermal paste (P12, λ=0.8 W/mK)
M05	MiniSKiiP® module + thermal paste (HPTP, λ=2.5 W/mK)
M10	MiniSKiiP® module + slim pressure lid (2.8mm height)
M11	MiniSKiiP® module + slim pressure lid (2.8mm height) + thermal paste (P12, λ=0.8 W/mK)
M15	MiniSKiiP® module + slim pressure lid (2.8mm height) + thermal paste (HPTP, λ=2.5 W/mK)
M20	MiniSKiiP® module + standard pressure lid (6.5mm height)
M21	MiniSKiiP® module + standard pressure lid (6.5mm height) + thermal paste (P12, λ=0.8 W/mK)
M25	MiniSKiiP® module + standard pressure lid (6.5mm height) + thermal paste (HPTP, λ=2.5 W/mK)

18. Disclaimer

IMPORTANT NOTICE:

The technical 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 mentioned 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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