Application Note
AN 26-003

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SKiiP3 to SKiiP7 Transition 1700V

1. SKiiP3 Obsolescence

1.1 IGBT3 Ramp Down

The third generation of IGBTs has been in stable production for decades, however, the IGBT3 chipset is reaching the end of its lifecycle and will be ramped down in the coming years. The seventh generation of IGBTs has been in stable use in other Semikron Danfoss products for several years and will now be used for future SKiiP products.

The following part numbers will be discontinued:

Table 1: Affected Part Numbers

3-Bay Sixpacks	2-Bay Half Bridges	3-Bay Half Bridges	4-Bay Half Bridges
SKiiP 513 GD172-3D	SKiiP 1013 GB172-2D SKiiP 1203 GB172-2D	SKiiP 1513 GB172-3D SKiiP 1803 GB172-3D	SKiiP 2013 GB172-4D SKiiP 2403 GB172-4D

All variants of these parts will be affected, including IPMs (**I**ntelligent **P**ower **M**odules) with any additional suffix. This includes parts with additional features, such as:

U DC link voltage measurement
F Fiber optic interface

Along with all heatsink types:

L Air
W Water
HP High performance liquid cooler
K Custom cooler, typically followed by 3 or 4 digits, such as K123 or K1234

1.2 CAL3 Ramp Down

Production of the CAL3 diode used in the SKiiP3 is also being ramped down. The 1700V SKiiP7 uses the same CAL4 diode introduced in AN 26-001 'CAL3 to CAL4 Transition', so **it is recommended to read this document as well**. The same changes in electrical performance as discussed in that document will also be present when changing from the SKiiP3 to SKiiP7. It can be found at Reference [4].

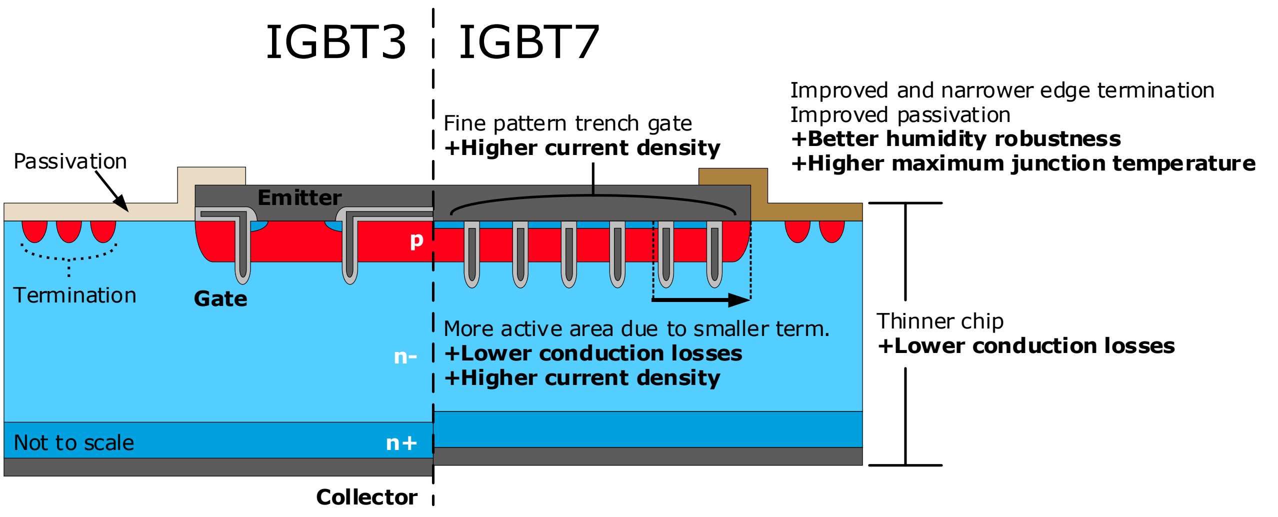
2. SKiiP7 Introduction

2.1 IGBT7 Introduction

In the decades since the release of the third generation of IGBTs, many improvements have been incorporated into contemporary seventh generation IGBT designs. The gate structure has changed significantly. Lithography capabilities have advanced, allowing for smaller resolution patterns and finer details to be produced reliably. So-called 'fine pattern trench' designs, such as IGBT7, have considerably smaller and closer together gate structures, resulting in a higher current density.

The edge termination of the IGBT has also seen considerable improvements. The termination itself is smaller but with improved humidity robustness also included. This means that more space on the chip is available for active area. The passivation, the protective layer on top of the termination, is made from a newer, more robust material, resulting in a more reliable and longer lifetime device.

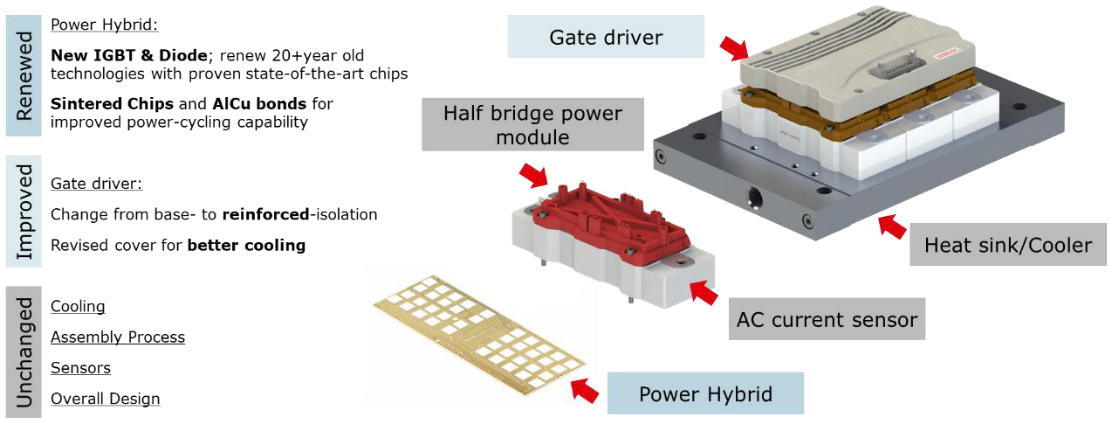
Figure 1: Improvements with New IGBT Generation



2.2 Core SKiiP Technologies

Although the SKiiP7 is a new product, its individual components have a long track record in other SKiiP products as well as other product families.

Figure 2: Core SKiiP Technologies Compared to the SKiiP3



3. Performance Comparison

The table below shows the main datasheet parameters of the following IPMs, scaled to show the same conditions. Overall, the SKiiP7 has lower losses than an equivalent SKiiP3. The SKiiP7 is also capable of maintaining a higher junction temperature than the SKiiP3.

Table 2: Datasheet Main Parameter Comparison

Symbol	SKiiP2013GB172-4D	SKiiP2417GB17E7-4D	Unit	Conditions
$V_{CE(sat)}$	1.9	1.46	V	T_j = 25°C, 1200A, at terminals
$E_{on}+E_{off}$	780	585	mJ	T_j = 125°C, 900V, 1200A
$R_{th(j-s)}$	0.015	0.016	K/W	
T_{jmax}	150	175	°C	

3.1 Dynamic Performance

The switching behavior of the SKiiP7 was optimized to be close to the SKiiP3. However, due to the decades of changes and improvements included in the seventh generation IGBT, the switching behavior of the SKiiP7 does differ slightly from the SKiiP3. The di/dt and dv/dt values produced by the IGBTs are not the same. It may therefore be necessary to check or adapt EMI filtering.

3.2 Driver Board Changes

The driver board has seen substantial updates since the introduction of the SKiiP3. The electrical and mechanical interface have not changed, so a SKiiP7 driver can be used in a system previously designed for a SKiiP3. However, the propagation delay time (the time for a change of the control signal to go through the control board) has been reduced.

This means that when the ON/OFF input into a SKiiP is changed, a SKiiP7 will switch sooner than a SKiiP3. When connecting different generations of SKiiPs in parallel, this will result in uneven switching performances. Please see Section 5.3 for more details on the consequences of this difference.

Table 3: Propagation Delay Times

Symbol	Description	SKiiP3	SKiiP7
$t_{d(on)IO}$	Input-output turn-on propagation time	1.4µs	1.1µs
$t_{d(off)IO}$	Input-output turn-off propagation time	1.4µs	1.1µs

4. Qualification Tests

4.1 Standard Qualification Tests

The SKiiP7 has been subjected to the following standard qualification tests.

Table 4: Qualification Tests for SKiiP7 Qualification

Test	Test Conditions	Standard
High Temperature Reverse Bias (HTRB)	1000h, V_{GE} = 0V, T_j = 150°C	IEC 60747-9
High Temperature Gate Bias (HTGB)	1000h, V_{GE} = ±20V, T_j = 150°C	IEC 60747-9
High Voltage, High Humidity, High Temperature, Reverse Bias (HV-H3TRB)	1000h, T_{amb} = 85°C, 85% RH, V_{GE}=0V, V_{CETest}=80% V_{CEMax}	IEC 60068 Part 2-67
High Temperature Storage	1000h, T_{amb} = +125°C	IEC 60068 Part 2-2
Low Temperature Storage	1000h, T_{amb} = -40°C	IEC 60068 Part 2-1
Power Cycling (EOL-Test)	dT=70K 243k cycles, 3s/3s	IEC 60747-9

4.2 Enhanced Humidity Testing

The H3TRB test has historically been used to confirm that chip and module designs are robust when used in humid environments. In this test, voltage is applied, collector to emitter, and the device is stored in a high humidity and high temperature environment for an extended period of time. Devices are checked for signs of degradation, including corrosion of the surface of the edge termination and a change in the electrical characteristics.

In recent years, however, as chip technology has improved and the demands on chips have increased, the H3TRB test has been overtaken by HV-H3TRB test. The collector-emitter voltage has been increased from 80V, regardless of the rating of the device, to roughly 80% of the maximum blocking voltage. For example, a 1700V rated IGBT was previously tested at only 80V but now is tested at 1360V. This increase in voltage significantly increases the stress on the device and demonstrates its enhanced capabilities.

Table 5: Humidity Qualification Tests

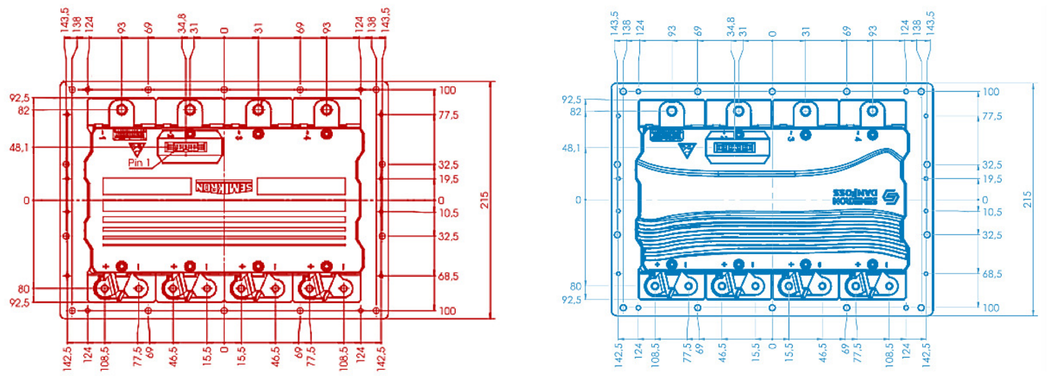
H3TRB Test	T_{amb} = 85°C, 85% RH, V_{GE}=0V, V_{CETest} = 80V regardless of chip rating
HV-H3TRB Test	T_{amb} = 85°C, 85% RH, V_{GE}=0V, V_{CETest} = 80% V_{CEMax}

5. Application Specific Considerations

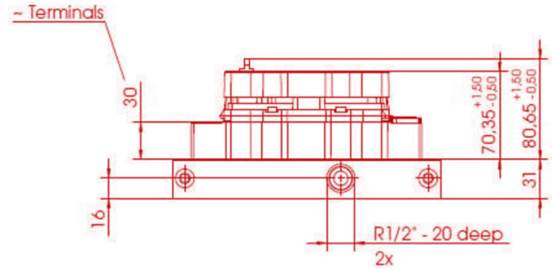
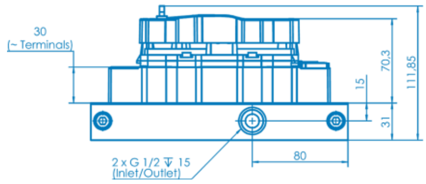
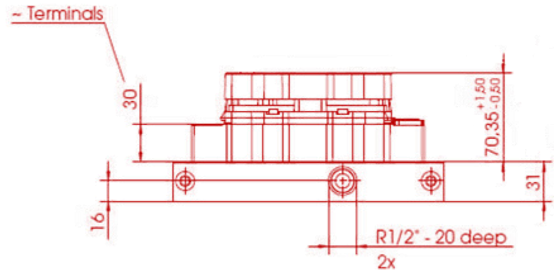
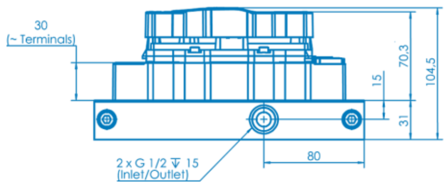
5.1 Mechanical Compatibility

The SKiiP7 is mechanically compatible with the SKiiP3. The power terminals and gate connector are the same type and in the same locations. A SKiiP7 can be used as a replacement for a SKiiP3 without mechanical modifications.

Figure 3: SKiiP3 (left, red) and SKiiP7 (right, blue) Outline Drawing



There are minor differences in the plastic covers and standard liquid coolers of both SKiiP3 and SKiiP7. See the following table for comparison of both SKiiP3 and SKiiP7 with standard water cooling. Please note that some differences come from changes in tolerance.

Table 6: Differences in Mechanical Tolerances, SKiiP3 (left, red) and SKiiP7 (right, blue)	
 SKiiP3 w/ water cooler and DIN41651 connector	 SKiiP7 w/ water cooler and DIN41651 connector
 SKiiP3 w/ water cooler and D-Sub connector	 SKiiP7 w/ water cooler and D-Sub connector

5.2 Power Consumption

The 24V power consumption of the SKiiP7 is not inherently the same as the SKiiP3. The idle power consumption, the power consumed when the SKiiP is powered on but not switching, is slightly lower for the SKiiP7. The switching frequency coefficient is roughly the same between types, but the output-current dependency is lower for the SKiiP7. These coefficients can also vary slightly from model to model, so it is best to doublecheck the new and old load currents.

Table 7: 24V Power Consumption Coefficients

Term	**Explanation**	**SKiiP3** SKiiP 2013 GB 172-4D	**SKiiP7** SKiiP 2417 GB177-4D
Idle current [mA]	How much current is drawn with the SKiiP is powered up but idle	330	305
k_1 [mA/kHz]	How much the current consumption increases with higher switching frequencies	55	53
k_2 [mA/A^2]	How the current consumption increases with higher load currents	0.00035	0.00018

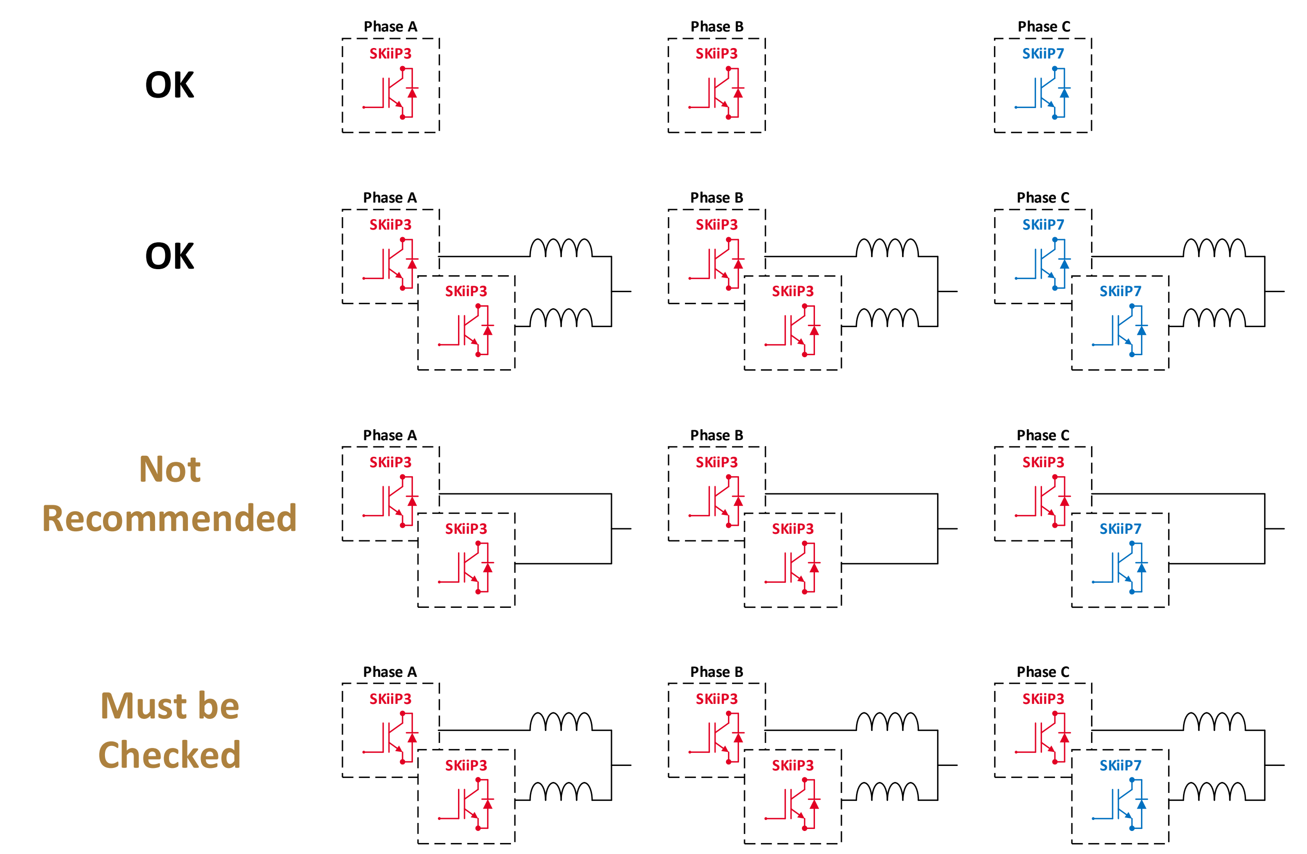
5.3 Using SKiiP7 as a Service Part

When replacing an older SKiiP3 IPM with a newer SKiiP7 IPM, some factors must be considered. The forward voltage drops of both types are not well matched. The difference in propagation delay times also means that the SKiiP7 will switch sooner than a SKiiP3. Consequently, good current sharing will likely not occur if SKiiPs are connected in hard parallel, i.e. with minimal inductance between them.

It is recommended to avoid hard-paralleling SKiiP7 IPMs with SKiiP3 IPMs. Poor current sharing could result in unbalanced static and dynamic losses between the IPMs. This may result in overheating and damage to a unit.

If a current-sharing inductor is used, the user must confirm that both SKiiPs remain in their safe operating area under all load conditions prior to installing 'mixed' systems in the field. See the SKiiP3 Technical Explanation [3] Section 7.9 for more information on this topic.

Figure 4: Replacement Configurations

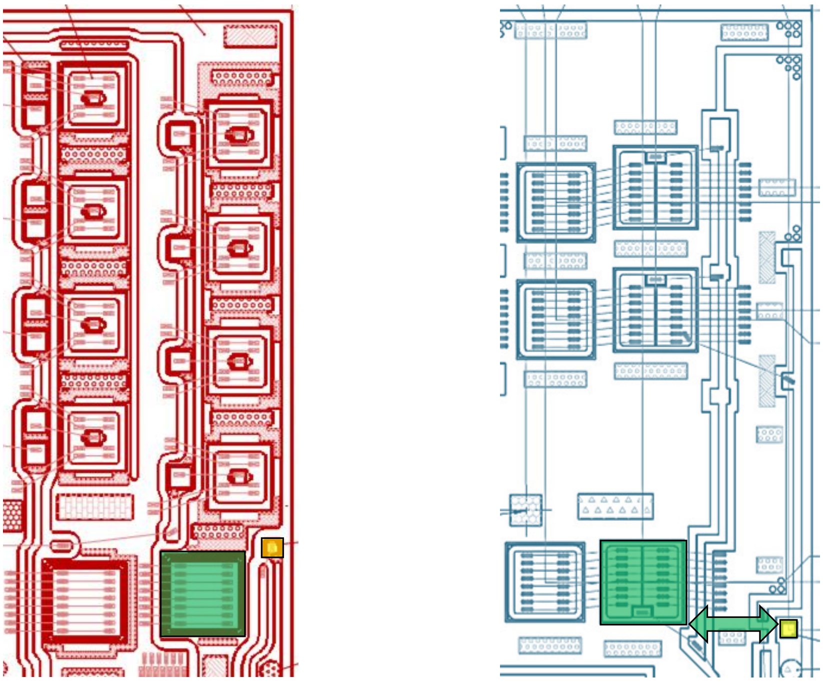


5.4 Temperature Sensor

The temperature feedback of the SKiiP7 behaves slightly differently to its predecessor. Firstly, for the SKiiP7 any value below 30°C will simply be reported as 30°C. This may result in different temperature feedback at low temperatures when operating SKiiP3 and SKiiP7 in the same inverter.

Secondly, the temperature sensor of the SKiiP7 is farther away from the IGBT than the SKiiP3. As shown below, the temperature sensor (highlighted in yellow) of the SKiiP3 is roughly 1.6mm from the closest IGBT, whereas the SKiiP7's temperature sensor is roughly 8.8mm from the nearest IGBT. This, along with the difference in losses, will likely result in deviations of the temperature feedback.

Figure 5: SKiiP3 (left, red) and SKiiP7 (right, blue) Temperature Sensor Location on Power Hybrid



A new temperature sensor is also used for the SKiiP7. It is of the same series as the SKiiP3, but with an improved tolerance. The more exact tolerance of the SKiiP7 means that a truer value will be reported with no other impacts on performance.

Table 8: Differences in Temperature Sensor Tolerances

	Tolerance of NTC
SKiiP3	2%
SKiiP7	1%

Symbols and Terms

Letter Symbol	Term
CAL	Controlled Axial Lifetime
di/dt, dv/dt	Rate of change in current (i) or voltage (v) in time
E_{on}, E_{off}	Turn-on and -off switching losses
IPM	Intelligent Power Module
NTC	Negative Temperature Coefficient, a type of temperature sensor
RH	Relative Humidity
$R_{th(j-s)}$	Thermal Resistance, junction to sink
T_{amb}	Ambient Temperature
T_j, T_{jmax}	(Maximum) Junction Temperature
V_{CE}	Collector Emitter Voltage, the forward voltage drop during conduction
V_{CEMax}	Maximum Collector Emitter Voltage, used to describe the blocking voltage of a power module, occasionally used informally for a MOSFET module with Drain-Source terminals or diode module with Anode-Cathode terminals

A detailed explanation of the terms and symbols can be found in the "Application Manual Power Semiconductors"

References

www.semikron-danfoss.com

[1] Arendt, Wintrich, et al. Application Manual Power Semiconductors. 2025. 3rd ed., Semikron Danfoss International GmbH, https://assets.danfoss.com/documents/latest/530447/AB509142199100en-000205.pdf.
[2] Julian, Fajer, et al. Technical Explanation CAL Freewheeling Diodes. Semikron Danfoss International GmbH, 3 Feb. 2025, https://assets.danfoss.com/documents/latest/465650/AJ500950023946en-000102.pdf
[3] Anastasia, Schiller. Technical Explanation SKiiP3. Semikron Danfoss International GmbH, 24 Aug. 2017, https://assets.danfoss.com/documents/latest/431397/AJ500938669888en-000101.pdf
[4] Prindle, Daniel, et al. CAL3 to CAL4 Transition, Semikron Danfoss International GmbH, 20 Jan. 2026, https://assets.danfoss.com/documents/latest/567387/AB550129236549en-000101.pdf

IMPORTANT INFORMATION AND WARNINGS

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