POWER ELECTRONICS FOR WIND TURBINES

SEMIKRON DANFOSS

Wind Energy

Performance Range

With decades of expertise, Semikron Danfoss is a trusted partner in wind energy power electronics. Our solutions ensure efficiency, reliability, and long-term performance in demanding environments.

Our comprehensive portfolio of power modules and stacks supports all wind turbine converter applications, from yaw and pitch drives to multi-megawatt converters. We offer individual power modules in industry standard packages, dedicated drivers, high-power SKiiP® IPMs, and ready-to-use power electronic stacks.

Whether for new installations or as spare parts, our products provide maximum reliability for onshore and offshore wind turbines. With proven field performance, Semikron Danfoss helps driving sustainable and efficient power generation worldwide.

YAW & PITCH DRIVES

5kW - 100kW

- Compact designs and high power density
- High peak overload capabilities
- Multiple axes in one drive or modular drives with common DC bus
- Highest reliability and lifetime

Products

- SEMITOP E
- MiniSKiiP
- SEMiX 2
- SEMiX 6
- SEMIPACK
- Drivers

MAIN CONVERTER

1MW - 18MW

Compact designs and high power density

High reliability in harsh environments
up to 2200V_{DC} and 1380V_{AC}

Products

SEMiX 3 Press-Fit

SEMITRANS Classic

SEMITRANS 10

SEMITRANS 20

SKiiP 4/7 IPM

Drivers

Power Electronics Stacks

SPARE PARTS & SERVICE

1MW - 18MW

Semikron Danfoss advanced power modules
for maximum reliability and efficiency

Customized stacks for dedicated wind turbine converters

Customized heatsinks for IPMs (SKiiP)
for integration into converters

Products

SEMiX Spring

SKiM 93

SEMITRANS Classic

SEMIPACK

SKiiP 4/7 IPM

Drivers

Power Electronic Stacks

Operation & Maintenance

Wind Turbine O&M

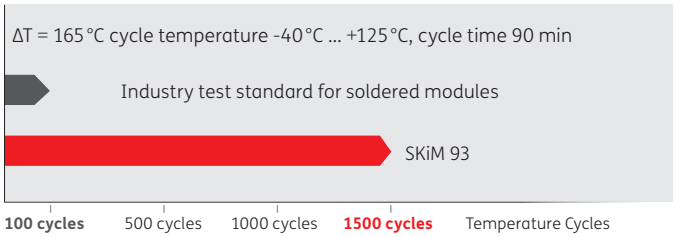
Today, wind turbines with and accumulated capacity of over 1,000GW are in operation in the field worldwide. The demand for reliable spare parts to ensure continuous energy harvesting until the end of turbine life is becoming increasingly important. Semikron Danfoss has a broad portfolio of products to ensure reliable operation and maintenance for wind turbine converters. From individual power modules, IPMs and drivers to dedicated, customized retrofit stacks – Semikron Danfoss has the right solution.

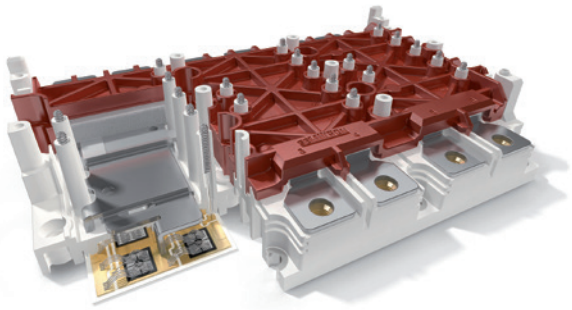
Benefits

Semikron Danfoss offers a broad portfolio with industry standard power modules such as the SEMITRANS and SEMiX family. It includes SKiiP IPMs with customized coolers to fit into your wind turbine converter. The range is rounded off with highly reliable stacks based on solder-free SKiM 93 modules featuring sintered chips. This technology allows for optimized thermal conductivity from chip to heatsink and runs the chip at about 20°C lower junction temperature than typical OEM stacks. Semikron Danfoss also offers newly designed driver boards based on the latest Semikron Danfoss ASIC technology with digital signal transmission and additional protection functions.

Key Features

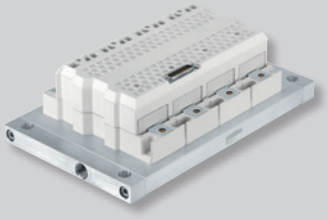
- Broad portfolio of industry standard modules
- Semikron Danfoss advanced power modules for maximum reliability and efficiency
- Customized stacks for dedicated wind turbine converters
- Customized heatsinks for IPMs (SKiiP) for integration into converters
- Drivers and adapter boards with highly reliable Semikron Danfoss ASIC technology



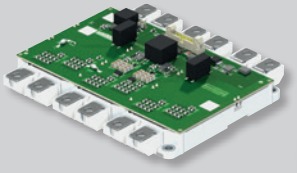


SKiM 93

Industry standard power modules



Intelligent power modules



Drivers and adapter boards

Power electronic stacks

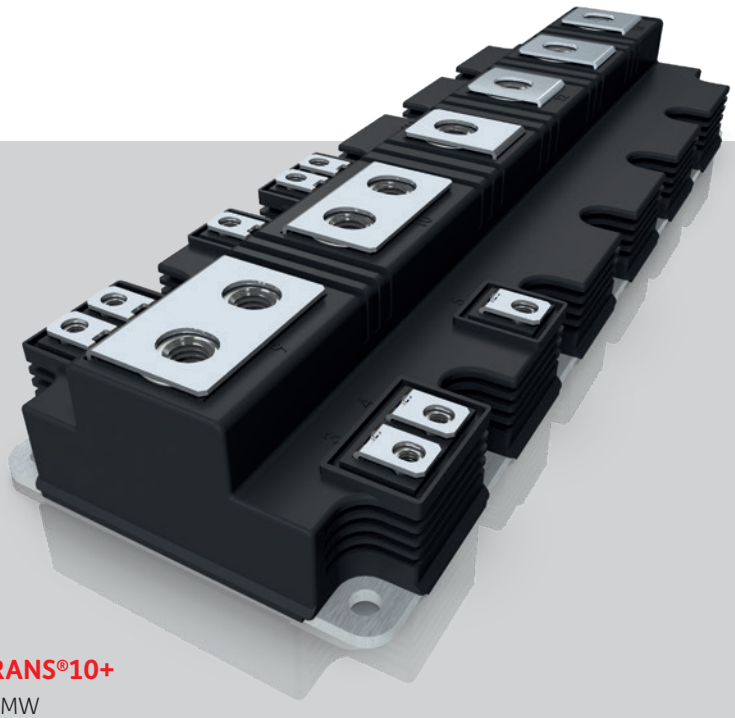
Increased System Voltage with **SEMITRANS®10+** 2300V Power Modules

The trend of increasing wind turbine power and the drive for higher efficiency in energy conversion and distribution demand higher system voltages. Traditional 1700V power modules in 2-level configurations limit voltage scalability. However, the new 2300V/1800A SEMITRANS 10+ enables system voltages of up to $1000V_{AC}$ ($1500V_{DC}$) while maintaining a 2-level topology. This allows for higher power output or reduced current, lowering system costs.

This breakthrough simplifies converter design, increases power density, and reduces system footprint compared to 3-level alternatives. SEMITRANS 10+ with 2300V enables streamlined converter designs with fewer components and delivers a cost-effective solution for modern wind energy systems.

Key Features

- Enables 2-Level Topology up to $1500V_{DC}$
- Latest Generation IGBT 7 with 2300V in half-bridge configuration
- Increased converter power or reduced current for better system efficiency
- Proven Industry standard package
- High power density
- Simple system design and control by 2-level topology



SEMITRANS®10+
up to 16 MW

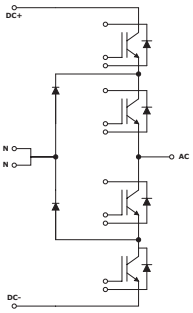
Pushing Performance in **SEMITRANS®10** 3-Level Topologies

Whenever power quality and efficiency are driving factors in power electronics applications, 3-level topologies are the key. This is especially true for renewable energy applications where the combination with the latest Generation 7 IGBTs sets new benchmarks.

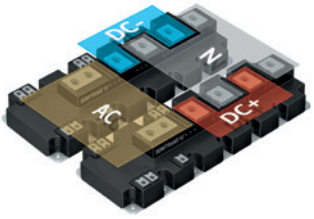
SEMITRANS 10 MLI and SEMITRANS 10 P3L enable wind turbine converters to operate at voltages up to 1000V_{AC} (1500V_{DC}) in a 3-level NPC topology, enhancing overall efficiency. Both modules support the design of equally rated 3-level converters while requiring fewer power modules than traditional half-bridge configurations. This reduces complexity and optimizes the overall system. By limiting the commutation loop to just one or two modules, stray inductance is minimized.

Key Features

- Reduced system cost thanks to 3-level topology
- Fewer modules reduce system cost
- Up to 1.5MW without paralleling
- Lower switching losses thanks to 1200V IGBT
- Available with Generation 7 IGBTs
- Lower THD means lower filter requirements
- Reduced cable diameters or cable losses
- Reduced cooling requirements
- High power density
- Low stray inductance

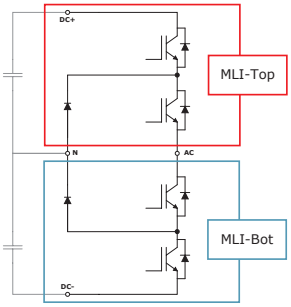


SEMITRANS 10 P3L®
750kW phase leg with single SEMITRANS 10 P3L

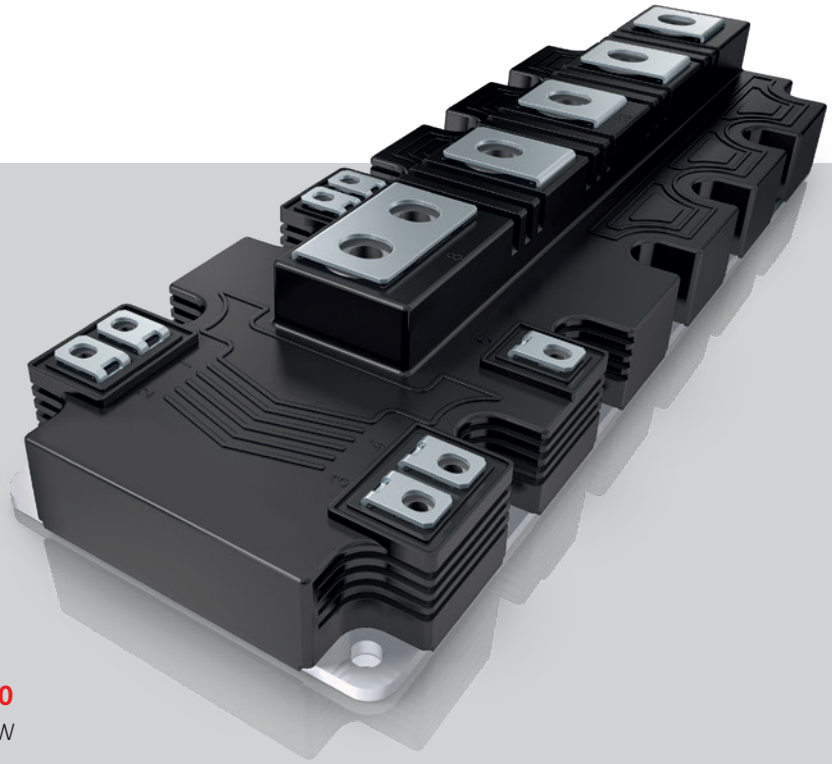


SEMITRANS® 10 MLI
Compact 1.5MW phase-leg with SEMITRANS 10 MLI

SKM1400MLI12TM7



SKM1400MLI12BM7



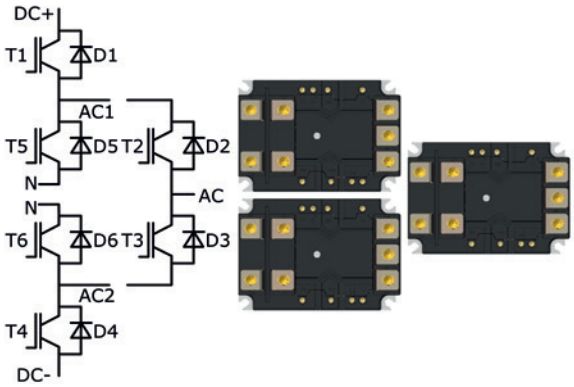
SEMITRANS®10
500kW up to 4MW

Pushing Performance in SEMITRANS®20 3-Level Topologies

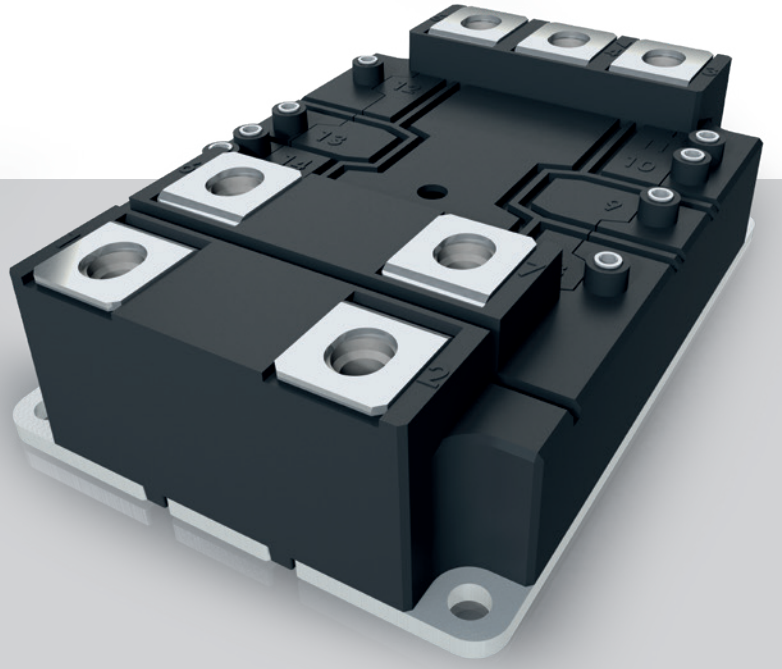
For ANPC topologies, our new SEMITRANS 20 power module combines the lowest stray inductance, highest power density, and latest Generation 7 IGBTs to set a new benchmark. Its design, based on standard half-bridge topology, allows an easy ANPC setup and a low inductance DC-link connection. Combined with sintering technology, power cycling capability is further strengthened. SEMITRANS 20 achieves up to 5 times longer lifetime compared to previous generations of soldering technology. This guarantees safe and reliable operation during the entire lifetime. Our experienced engineers will help you with device selection, simulation, and mechanical design under a variety of application scenarios.

Key Features

- New standard package for multiple source strategy
- As low as 10nH stray inductance
- Easy DC-link connection
- Easy interconnection of input and output stages
- High power density
- Symmetrical structure ensures perfect current sharing in multi-module paralleling
- Flexible and scalable solution to cover various power ranges



Up to 1.5MW ANPC phase leg with three SEMITRANS 20 modules



SEMITRANS®20
from 500kW

TECHNOLOGY HIGHLIGHT

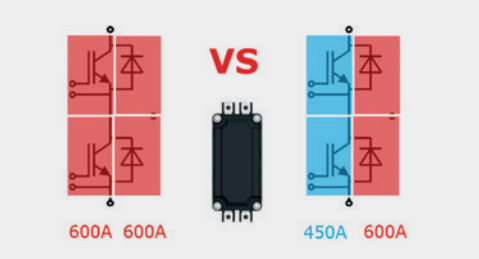
Tailor-made SEMiX®3 Press-Fit **for Wind Applications**

SEMiX 3 Press-Fit helps you reach the same target with less effort. With a deep understanding of user requirements and rich application experience, we are able to allocate valuable silicon to the right circuit position. The lead types of optimized-diode half-bridge and brake chopper modules are perfect examples of our never-ending innovation. Optimized chipsets allow to achieve solutions with the best cost-performance ratio.
The 1700V/450A and 750A half-bridges with enhanced diodes for the machine side achieve the same performance as standard 600A/900A half-bridges, just with up to 25% less IGBT chips.
Additionally, dedicated braking chopper modules with up to 1700V/900A offer considerable savings over using half-bridges in the braking circuit.

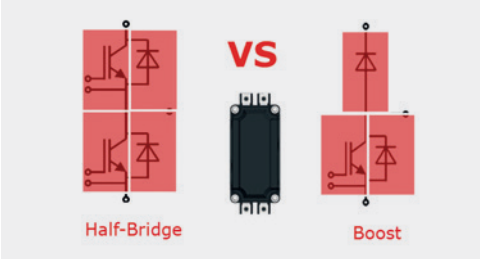
Key Features

- Cost-effective solution strengthens your competitiveness
- Diode enhanced 1700V/450A and 750A half bridges use less material without sacrificing performance and reliability
- Market-available standard package
- Open to customized requirements
- Dedicated braking choppers with 450A/600A/900A in 1700V
- Optionally available with H_2S protection

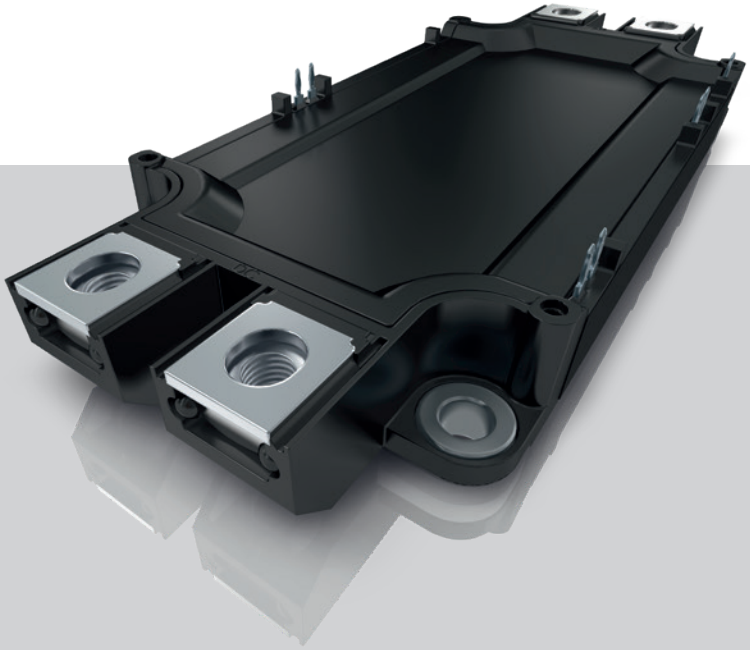
It's Your Choice:
A flexible, cost-effective solution with the same performance or a standard module.



25% less IGBTs in diode-enhanced half-bridge for the machine side converter

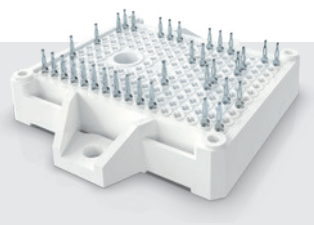


Boost topology used as brake chopper



SEMiX®3 Press-Fit
55kW up to 16MW

Product Portfolio
IGBT and Rectifier Modules



SEMITOP® E
0.4kW up to 75kW

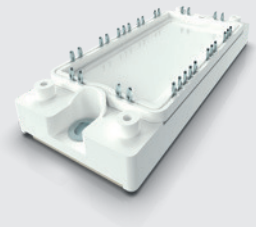
Exceeding the Standard for Superior Performance

- PCB-based and press-fit connected baseplate-less industry standard power module in two housing sizes
- 1600V rectifiers: up to 150A
  650V / 1200V IGBT: 10A to 100A
  1200V SiC: 30A to 300A
- Rectifier, CI, CIB and sixpack, and half-bridge topologies
- Optimized mounting concept and pre-applied High Performance Thermal Paste provide lowest thermal resistance in class
- Full line-up with Generation 7 IGBT
- Hybrid and full SiC modules up to 1200V/300A

MiniSKiiP®
0.4kW up to 110kW

Solder-Free Spring Technology for Minimum Assembly Time

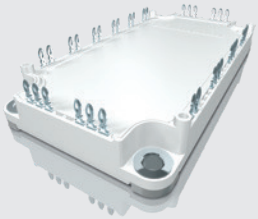
- Full family of power modules up to 110kW
- 650V / 1200V / 1700V IGBT: 4A to 400A
  1200V hybrid SiC and full SiC: 50A to 150A
  1600V / 2200V rectifiers: up to 229A
- Comprehensive set of topologies: CIB, sixpack, twelvepacks, H-bridge, half-bridge, 3-level, bridge rectifiers with brake chopper
- Easy and flexible PCB routing without pin holes
- Easy manufacturing of single-PCB multi-axis designs



SEMiX® 2
1.5kW up to 18.5kW

Reliable Standard for Low-Power Drives

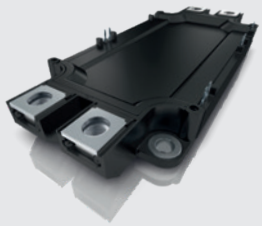
- Baseplate design for mounting robustness and optimized heat spreading
- Solder or press-fit pins
- 1600V Rectifiers: 100A
  650/1200V IGBT: 15 ot 75A
- Bridge rectifier (B6U), CI, CIB
- Fully compatible industry standard package for multiple sourcing
- Latest Generation 7 IGBTs



SEMiX® 6
15 up to 75kW

The Baseplate Standard for Mid-Power PCB-based Designs

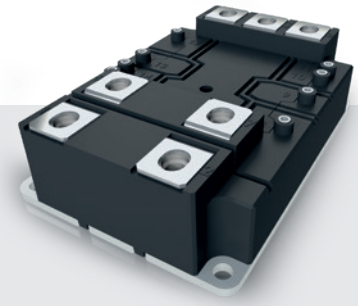
- Baseplate design for mounting robustness and optimized heat spreading
- Improved thermal management by design for minimized R_{th}
- Solder or press-fit pins
- 1600 / 2200V Rectifiers: 120A to 630A
  650 / 1200V IGBT: 75A to 250A
- Bridge rectifier (B6U), CIB, sixpack, and H-bridge topologies
- Latest press-fit pin technology for optimal assembly and connection reliability
- IGBT 4 and IGBT M7 ensure high supply chain safety



SEMiX®3 Press-Fit
55kW up to 16MW

Exceeding the Standard for Superior Performance

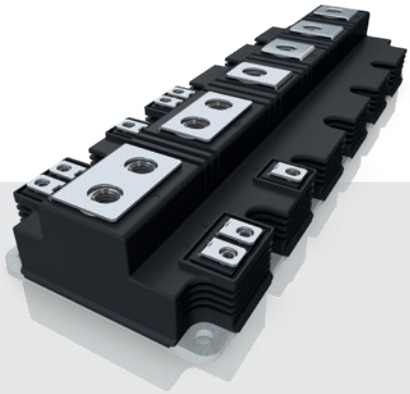
- Industry standard press-fit design with 17mm high housing
- 650V / 1200V / 1700V IGBT: 225A to 900A
  1700V IGBT: 450A and 750A diode enhanced half-bridges 450A / 600A / 900A chopper
  1200V Hybrid SiC: 600A
- Direct driver assembly
- Available with integrated shunt resistor
- Optional with H_2S protection



SEMITRANS® 20

from 500kW

The New Standard in High Power
The latest industry standard power module for high power applications
1200V / 1700V IGBT: 1200A to 1800A 2000V Full-SiC: 1700A, 1mOhm
Half-bridge topology
Low stray inductance, high power density package
Outstanding reliability thanks to the latest packaging technology



SEMITRANS® 10

500kW up to 16MW

Robust High Power Module
Established high power module package
1200V / 1700V / 2300V IGBT: 450A to 1800A
Half-bridge and split NPC topologies
Latest Generation 7 IGBTs for for 3-level NPC modules

Intelligent Power Modules – IPMs
The Most Powerful IPM in the Market

The SKiiP IPM product line set the benchmark for high performance and robust inverter designs. Both SKiiP 4 and SKiiP 7 feature high power densities combined with flexible cooling options such as air or water cooling, as well as with customized heatsinks. Reliable driver technology, integrated current sensors and comprehensive protection functions complete the IPM design.

SKiiP 7 has become increasingly popular through the industrial applications. With its sixpack or half-bridge topologies, it covers a current range of 500A to 2400A.

The SKiiP 4, available in half-bridge topology, has been optimized for ultra-high power cycling requirements and covers a higher power range up to 3600A.

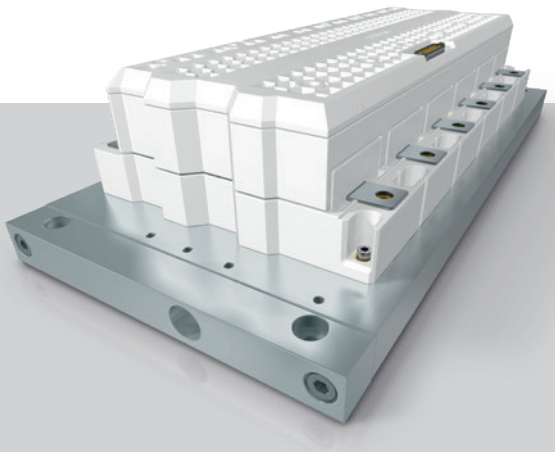
To ensure maximum reliability and service life, the power circuitry is 100% solder-free. Sinter die attach technology replaces the solder layer, the common cause of module lifetime limitations, thus improving power and thermal cycling capability.

High Performance Cooling (HPC) technology has been introduced, to provide 25% more output power capability compared to standard water cooling. A double-sided mounting HPC is also available, enabling ever higher power density.

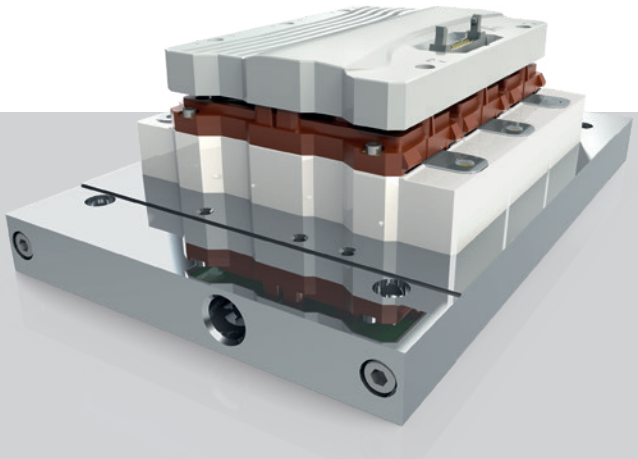
The integrated gate driver in the SKiiP 4 has set new standards in terms of reliability and enhanced functionality through its CAN interface. The digital driver guarantees safe isolation between the primary and secondary side for both switching signals and parameter measurements. The CAN interface allows setting the SKiiP 4 configuration parameter and reading application parameter.

Key Features

Half-bridges and sixpacks
1200V / 1700V IGBT: 500A to 3600A 2000V SiC: 1200A to 2400A
Flexible cooling options: air, water or customized cooling options
Parallel operation for even higher output power possible



SKiiP®4
Up to 2MW
available with full SiC MOSFETs



SKiiP®7
150kW up to 2.4MW


WLL 650/1300 kg

Power Electronic **Stack Platforms** for **Fully Qualified** Inverter Assemblies Tailored to Your **Specific Needs**

Standard Stacks

Our Power Electronic Stacks enable our customers to succeed in dynamic markets and meet any global challenge. We deliver IGBT- and SiC-based stacks for AC voltages from 380V to 1000V. Our standard stacks cover an output current range from 70A to 1400A. Our new SEMIKUBE MLI brings all benefits of 3-level topologies in an off-the-shelf product. It includes all safety and sensing measures for your fast time-to-market.

Water-Cooled Stacks

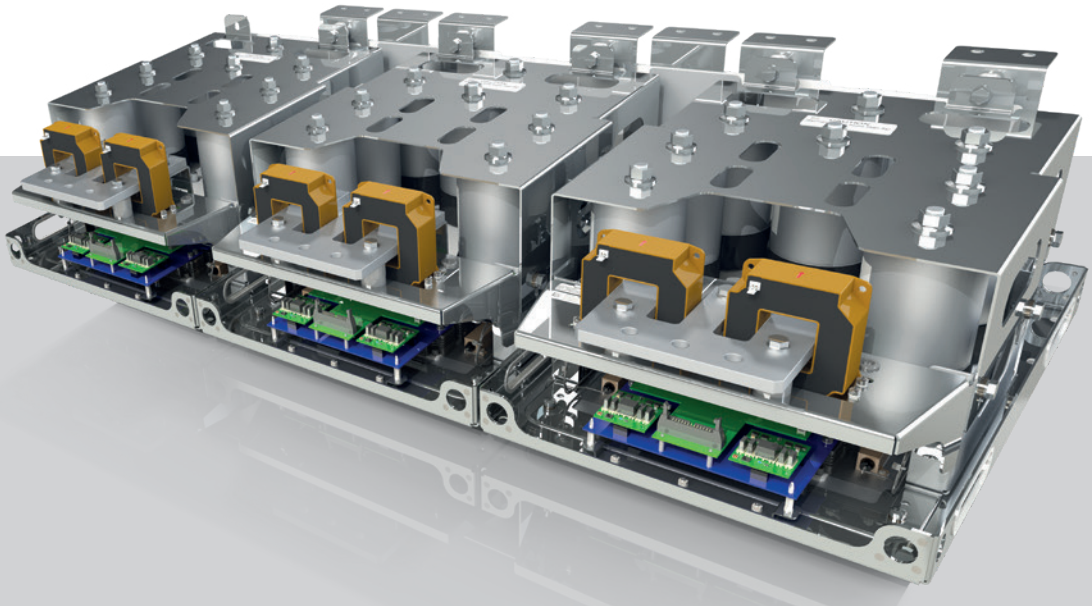
SEMIKUBE MLI
SEMISTACK RE

Customized Stacks

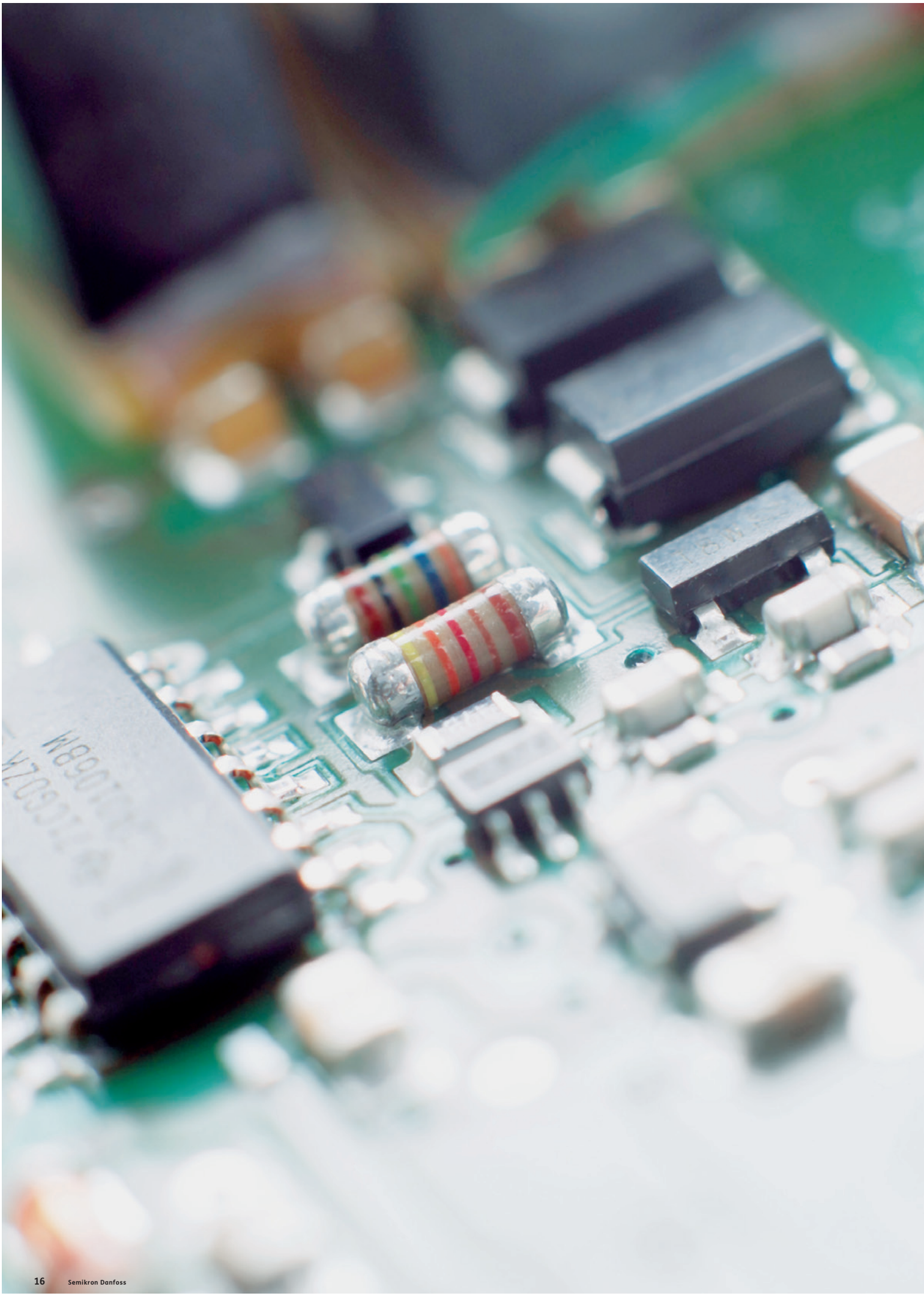
In addition to standard stacks, Semikron Danfoss has vast experience in developing customer-specific solutions. Engineers are available in our stack centers around the globe to offer specific solutions by adapting existing platforms or designing customized converters.

Four Key Factors to Your Success

- Shortest time to market
- Cost savings in R&D, production and qualification
- Global Semikron Danfoss stack production footprint
- Highly experienced engineering team



SEMIKUBE®MLI
Water-Cooled 3-Level NPC Stack



Product Portfolio
IGBT Driver

The unique product portfolio enables access to all established industries with a one-stop solution that combines state-of-the-art power modules and driver electronics.

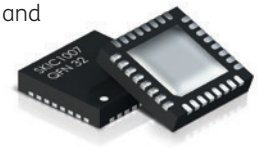
Our IGBT drivers are available as two- channel driver cores suitable for any standard semiconductor power module or as Plug-and-Play solutions, which perfectly fit the SEMiX 3 Press-Fit, SEMITRANS 10 and compatible modules.

Cost Efficient
Achieve outstanding system compactness and create space- and cost-effective inverter designs with our drivers, utilizing highly integrated ASIC technology. Isolated DC-link voltage and temperature sensor signals at the driver's interface along with over-voltage and over-temperature lockout also help to reduce system costs significantly.

Time Efficient
More than 25 years of experience in developing innovative IGBT driver electronics enables Semikron Danfoss to have a short-term solution for almost every challenge related to driver electronics. Our Plug-and-Play drivers connect directly to most common standard IGBT modules. The IGBT driver cores fit with the adapter boards or application sample PCBs. For the latter, Semikron Danfoss shares the entire manufacturing data to decrease development time, speeding up the time-to-market.

Reliable
Our SKYPER are well-known, highly robust and reliable IGBT driver solutions under demanding environmental conditions. Over many years of field operation experience the proprietary IGBT driver technology has been relentlessly developed further. This technology sets new standards for the essential features of safe gate control, reliable gate protection and reinforced insulation.

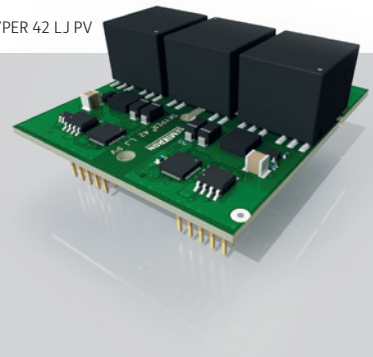
Compact Design
Our SKIC ASIC technology enables very compact system design with minimal peripheral components. With highly integrated signal processing and multi-channel failure management, our ASICs offer robust gate control



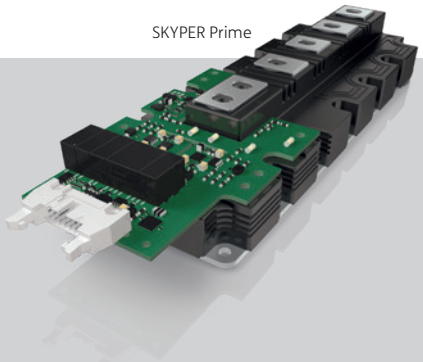
Key Factors

Reinforced insulation for signal and power transmission
Two-channel driver
Up to 1700V transients
Up to 1500V continuous DC bus voltage
8Apk to 35Apk per channel
1W to 4.2W peak per channel
Suitable for multi-level topologies and Generation 7 IGBT

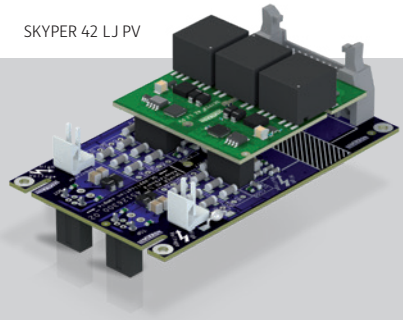
SKYPER 42 LJ PV



SKYPER Prime



SKYPER 42 LJ PV



Driver Cores
Two-channel driver cores for PCB integration with Semikron Danfoss ASIC technology and integrated safety functions

Plug-and-Play Driver
Two-channel drivers for direct module mounting with electrical or optical interface

Adapter Board and Application Samples
Adapter boards for driver core mounting to Semikron Danfoss IGBT and SiC modules

Thermal Interface Materials
Stay Cool: Heat Dissipation is Our Job

Semikron Danfoss was the first power module manufacturer to offer modules with pre-applied thermal interface material (TIM). We now have over two decades of experience and more than 33 million pre-printed modules in the field. We design print patterns for each module type for the best TIM distribution and thickness when the module is mounted to a heatsink. These patterns are printed in a clean environment using automated silkscreen and stencil machines. Statistical process control (SPC) is used to ensure consistency. Special packaging ensures the TIM arrives in pristine condition.

We offer either thermal grease or phase change material (PCM) based on customer needs (e.g., performance or reduced handling effort) and module type. Baseplate-less modules benefit from low-viscosity materials like thermal paste. Our High Performance Thermal Paste (HPTP) provides top-tier thermal performance with optimized filler content.

For easier assembly, most power modules are also available with pre-applied PCM. PCM is solid at room temperature but becomes fluid during operation, filling gaps for thermal contact. HP-PCM, our exclusive High Performance Phase Change Material, combines the benefits of PCM with the performance of the best thermal paste.

For field serviceability, compressible graphite sheets are an innovative option. Panasonic Industry has overcome the shortcomings of traditional graphite sheets with a new compressible pyrolytic graphite sheet called G-TIM (GraphiteTIM).

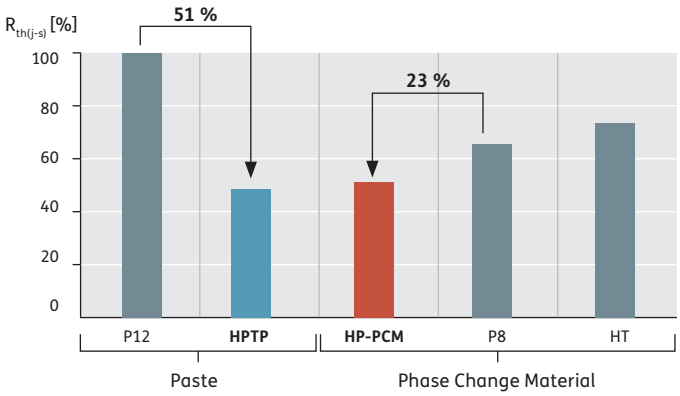
This compressible sheet conforms to the underside of the module during mounting. The crystalline structure of the graphite outstanding long-term stability. Panasonic offers pre-cut graphite sheets for Semikron Danfoss modules.

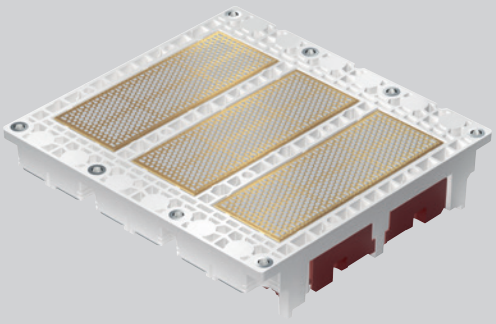
Key Features

- Best possible thermal performance
- Simplified logistics and reduced production costs
- Improved assembly robustness
- Increased lifetime and reliability

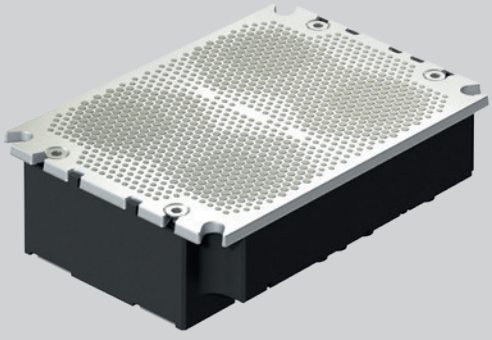
Portfolio

- **HPTP:** High Performance Thermal Paste
- **HP-PCM:** High Performance Phase Change Material





Baseplate-less module with pre-applied thermal paste



Baseplate module with pre-applied phase change material

THE ULTIMATE PARTNER IN POWER ELECTRONICS

Semikron Danfoss is a global technology leader in power electronics. Our product offerings include semiconductor devices, power modules, stacks and systems. In a world that is going electric, Semikron Danfoss technologies are more relevant than ever. With our innovative solutions for automotive, industrial and renewable applications we help the world utilize energy more efficiently and sustainably and thus to significantly reduce overall CO_2 emissions – facing one of the biggest challenges today. We take care of our employees and create value for our customers by investing significantly in innovation, technology, capacity, and service to deliver best-in-industry performance and for a sustainable future.

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SEMIKRON DANFOSS

Semikron Danfoss GmbH
Husumer Strasse 251
24941 Flensburg, Germany

Semikron Danfoss International GmbH
Sigmundstrasse 200
90431 Nuremberg, Germany

www.semikron-danfoss.com