

POWER ELECTRONICS FOR MOTOR DRIVES



# Motor Drives



# Performance Range

Since the first appearance of motor drives, Semikron Danfoss has been committed to supplying solutions for every power range. Almost 50 years ago, Semikron Danfoss introduced the first insulated power module: the SEMIPACK rectifier. Since then, other innovations for motor drives have been introduced, with the MiniSKiiP in particular revolutionizing the design of low and medium power systems.

Today, Semikron Danfoss offers the complete industry standard power module portfolio that serves a power range of 0.2kW to several megawatts.

With the latest generation of IGBTs and SiC MOSFETs from multiple suppliers, our power modules boost performance, power density, and efficiency in motor drive applications.

The portfolio is completed with high power IPMs, power electronic stacks, and a comprehensive product line of driver electronics that help to reduce development effort and time-to-market.

## GENERAL PURPOSE DRIVES

### 0.1kW - 300kW

- Pumps, fans, compressors
- Material handling, conveyors
- Marine drives
- Factory automation

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CI, CIB, sixpacks, half-bridges

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Easy and cost effective assembly

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High power density for compact drive designs

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Wide power range packages for scalable platform design

#### Products

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SEMITOP E

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MiniSKiiP

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SEMiX 1

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SEMiX 2

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SEMiX 3 Press-Fit

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SEMiX 6

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SEMITRANS Classic

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SEMIPACK

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Drivers

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Power Electronics Stacks

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## PERFORMANCE DRIVES

### 0.1kW - 300kW

- Lifts, hoists
- Spindle, turbo applications
- Single/multi-axis servo and motion control
- Robotics controller
- Extruders, compressors

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CI, CIB, sixpacks, twelvepacks, half-bridges, IPMs, Single-PCB, multi-axis, drives and modular drive concepts

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High carrier frequency

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High overload/peak-load capability tolerance

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#### Products

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SEMISTOP E

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MiniSKiiP

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SEMIX 1

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SEMIX 2

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SEMIX 3 Press-Fit

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SEMIX 6

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SEMIPACK

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SKiiP 4/7 IPM

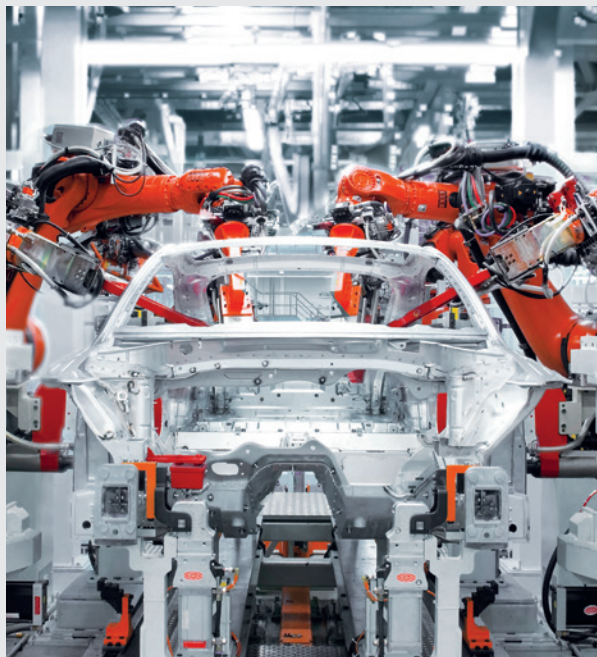
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Drivers

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Power Electronic Stacks

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## HIGH POWER/MEDIUM VOLTAGE DRIVES

### 300kW - 20MW

- Pumps, fans, centrifuges
- Mining, marine drives
- Pulp and paper

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Half-bridges, single switches, IPMs

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Compact designs with high power density

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High reliability in harsh environments

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#### Products

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SEMiX 3 Press-Fit

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SEMISTRANS Classic

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SEMISTRANS 10

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SEMISTRANS 20

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SEMIPACK

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SKiiP 4/7 IPM

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Drivers

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Power Electronic Stacks

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Silicon  
Carbide

# Silicon Carbide MOSFETs: New Degrees of Freedom in Design

Compared to the latest generation of silicon IGBTs, SiC MOSFETs exhibit much lower switching losses. In partial load conditions, also the conduction losses of MOSFETs are lower, thus offering designers new options for efficient drive platforms.

Increased power density allows for more compact drives or more power from given thermal designs. Faster switching with lower losses enables silent motor operation and smaller magnetics. Additionally, with SiC, users can exploit new energy saving potentials. On a system level, this leads to a fast return on investment and reduced total cost of ownership. It also represents an important step towards more efficient energy utilization and decarbonization of the industry. Power modules with silicon carbide MOSFETs allow designers to push boundaries and re-think drives design.

With decades of experience in packaging power modules and supply chain reliability secured by strong, long-term partnerships with top chip manufacturers, Semikron Danfoss is your ultimate partner for silicon carbide.

## Silicon Carbide Features

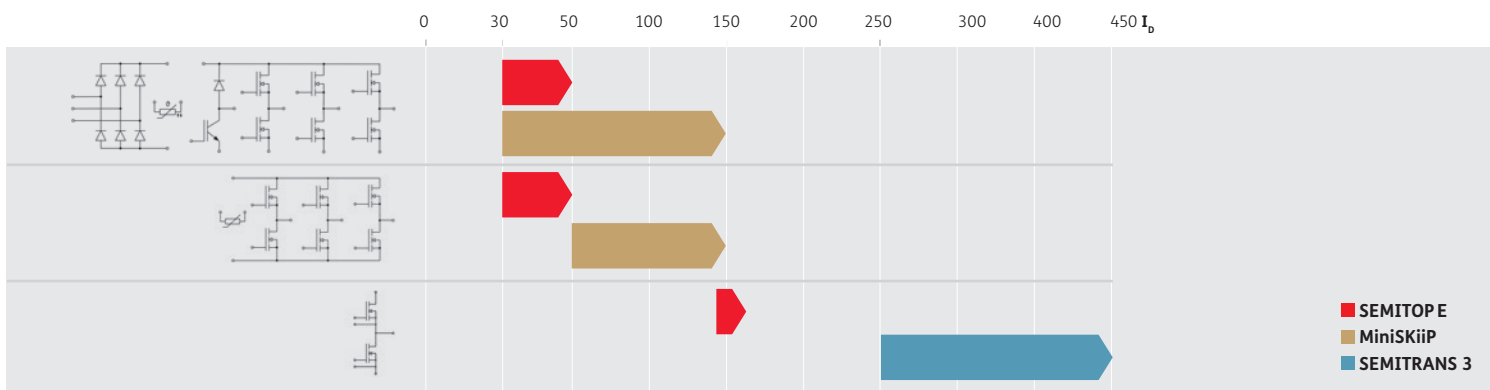
- Greatly reduced conduction losses under partial load
- Lower switching losses by using the body diode as FWD
- Short circuit withstand capability of  $2\mu\text{s}$  in the latest generation of SiC MOSFET chips
- Highest power density and efficiency
- Robustness against ambient conditions

## Applications

- Unipolar gate control
- Variable torque applications like fans, pumps, heat pumps and air conditioning compressors
- Servo drives

## Reliable Supply

- Multiple SiC chip sources
- Long-term partnerships with top SiC chip manufacturers
- More than 15 years of experience in packaging SiC



**SEMISTOP® E**  
Up to 30kW



**MiniSKiiP®**  
Up to 30kW



**SEMISTRANS® 3**  
Up to 200kW

# RGA IGBT for True Multiple Sourcing

With the ROHM RGA IGBT, a newly designed 1200V, trench gate, light punch through IGBT, we offer a powerful alternative to current Generation 7 IGBTs.

The RGA IGBT, which was developed with motor drives in mind, is widely compatible to latest Generation 7 IGBTs. Likewise, it can be continuously operated at  $T_{j,max}=150^{\circ}\text{C}$  and intermittently at  $T_{j,max}=175^{\circ}\text{C}$ . Gate voltages are identical and the gate charge is even lower, thus it can easily be driven by existing driver circuits.

The RGA also offers advantages when comparing it to market available Generation 7 IGBTs. The chip size is optimized so that the thermal resistance is lower and a power module with RGA IGBT runs cooler. This allows for an increase of power or a reduction in cooling. Additionally, while typical Generation 7 IGBTs desaturate at twofold nominal current, the RGA IGBT can handle threefold nominal current, thus offering higher peak current tolerance.

With the ROHM RGA IGBT packed into our MiniSKiiP and SEMITOP E industry standard housings, there is now a true alternative to Generation 7 IGBT power modules.

### Optimized for Motor Drives

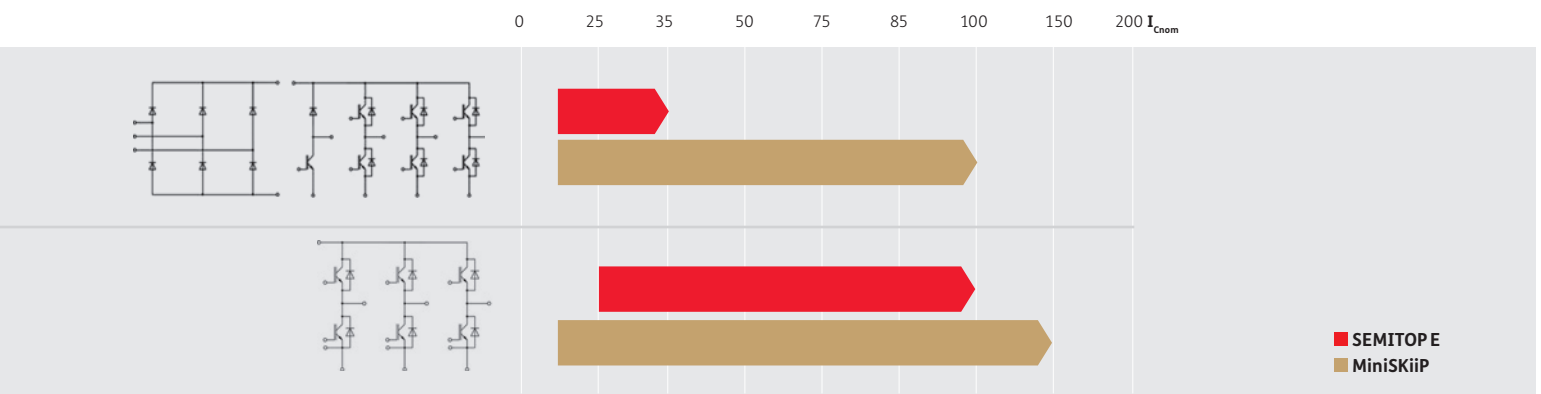
- Low thermal resistance
- High peak current capability
- 1200V, 10 to 150A in CIB and sixpack topologies

### Compatible with Market Standards

- $T_{j,max}=175^{\circ}\text{C}$
- Robust against humidity
- Typical gate voltage -8 to +15V<sub>DC</sub>
- Industry standard packages

### Reliable Supply

- Long-term partnership
- True multiple sourcing option from package down to chip



**SEMITOP® E**  
0.4kW to 30kW



**MiniSKiiP®**  
0.4kW to 45kW

# Flexibility for Compact Drives

The SEMITOP E product line design offers a range of alternative packages for compact PCB-based motor drives. With multiple sourcing down to the chip level, it provides the best supply chain safety.

The baseplate-less design offers superior thermal performance. This, combined with a low-inductance design, also makes SEMITOP E the perfect package for the latest Si and SiC chip technologies.

SEMITOP E modules are available with pre-applied High Performance Thermal Paste (HPTP). Alternatively, for ease-of-handling during assembly, it can also be supplied with pre-applied HP-PCM, the new Semikron Danfoss-exclusive High Performance Phase Change Material.

## Full Flexibility for Compact Drives

CI, CIB, rectifiers with/without chopper, sixpacks

600V / 650V / 1200V: 10A to 200A

Low inductance design ready for SiC

Flexible pin-grid for additional topologies

Press-fit or solder pins

Multiple chip sources for Si and SiC

## Optimized Package

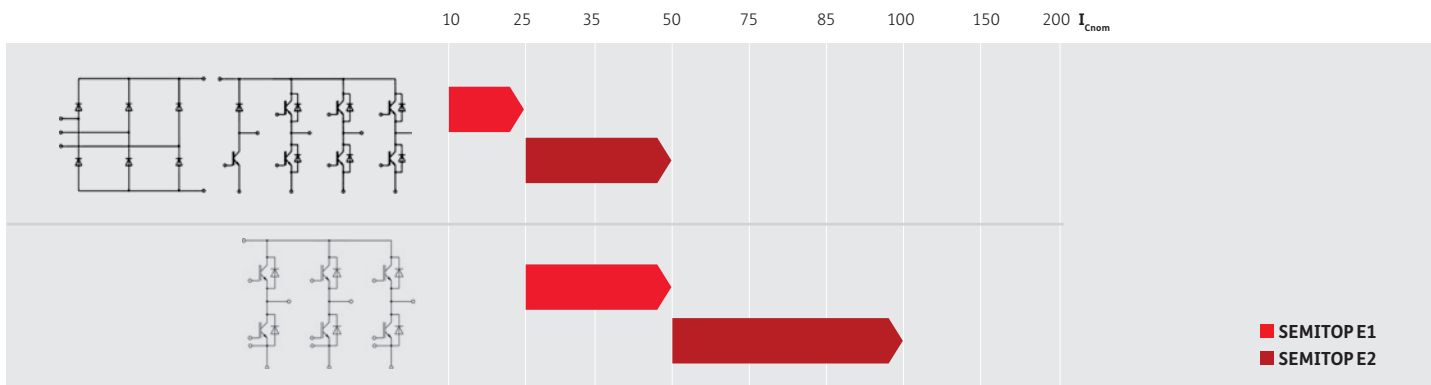
12mm high baseplate-less design

Optimized press-fit pins with strain relief for mounting robustness and reliability in operation

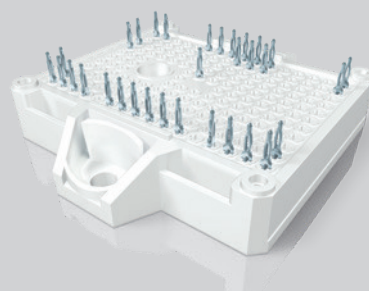
## Superior Thermal Performance

Optimized DBC and pressure system for up to 20% lower  $R_{th,j-s}$  than market standard

Available with pre-applied High Performance Thermal Paste (HPTP) or High Performance Phase Change Material (HP-PCM)



**SEMITOP® E1**  
0.4kW up to 15kW



**SEMITOP® E2**  
4kW to 30kW

# Full Scalability for PCB-Based Designs

With two decades of field experience and more than 70 million modules in the field, the MiniSKiiP platform has proven successful in all standard applications.

The unique mechanical design offers the simplest possible assembly. Heatsink, module and PCB connected with one or two screws in a single step, making solder or press-in processes and tools obsolete. In terms of sensitivity to mechanical or thermal stress, the springs doing the electrical connection between PCB and power module have proven to be far superior to solder or press-fit joints.

With its wide power range, the MiniSKiiP product family provides a unique base for scalable PCB-based drive designs from 0.4kW up to 110kW. With a variety of topologies, it is the perfect match from single-axis drives to single PCB assemblies with multiple axes.

## One Consistent Mounting Concept for Drives up to 110kW

Available as CIB, sixpack, half-bridge, rectifier, brake chopper, twelvepack

Covering 600/650V, 1200V, 1700V

## Easy One-Step Mounting

Easy PCB-based assembly with only one or two mounting screws

High-productivity mounting thanks to automatable production lines

No additional tools, no soldering, no press-in process required

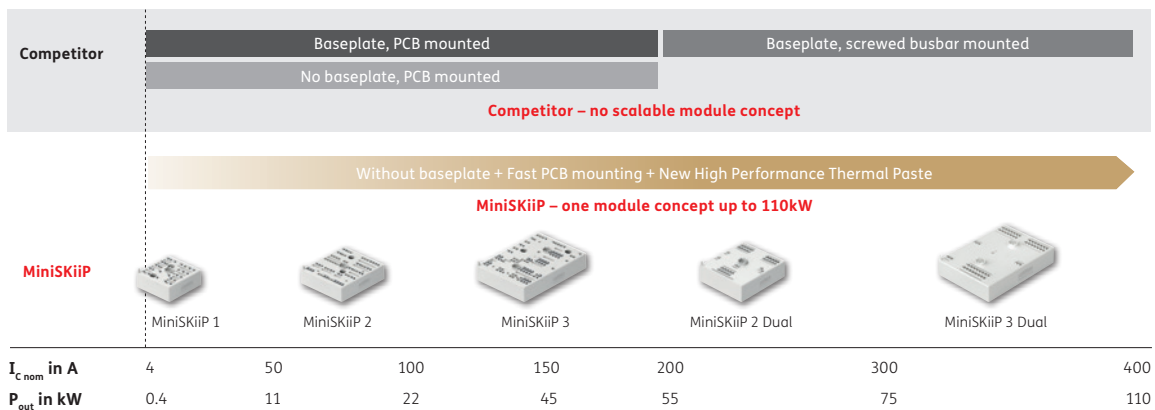
Easy manufacturing of single-PCB multi-axis designs

## Benchmark Performance

Silicon carbide versions offer highest efficiency and power density

Lowest thermal resistance with High Performance Thermal Paste (HPTP)

Spring contacts for superior vibration resistance



**MiniSKiiP®**  
0.4kW up to 110kW



## PRODUCT HIGHLIGHT

# IGBT and Rectifier Module Family for Complete Motor Drive Solutions

SEMiX 3 Press-Fit features IGBT and rectifier modules in the same housing design for a complete medium/high power drive solution. As an industry standard power module available with the latest generation IGBT chips from different suppliers, it gives full supply chain safety.

It's your choice: SEMiX 3 Press-Fit is available with optional ...  
... integrated current measurement shunts.

The integration of the current measurement into the power module replaces expensive and bulky current sensors (i.e. Hall sensors).

This reduces size and cost of the motor drive system.

... plug-and-play driver SKYPER 12 Press-Fit.

Simply pressed onto the power module's press-fit pins, the driver reduces time-to-market thanks to a ready-to-go solution.

... pre-applied phase change material HP-PCM.

Combines the benefits of a phase change material with the performance of the best thermal paste.

### Industry Standard Package with Optional:

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Integrated current shunts

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Plug-and-play gate driver

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Pre-applied phase change material

### Available as a Complete 17mm - High Solution

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Rectifier, brake chopper and half-bridge

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650V / 1200V / 1700V: 225A to 900A

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55kW up to 350kW

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Full multiple source thanks to several IGBT suppliers

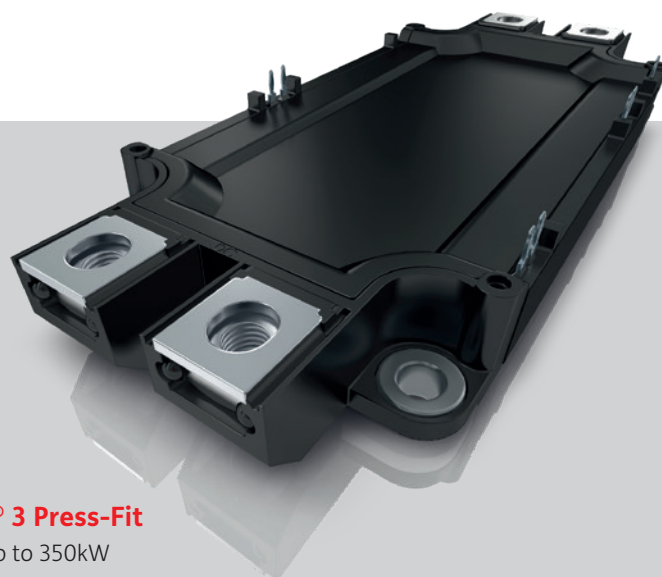
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Hybrid silicon carbide version offers highest efficiency and power density

### The Latest Generation 7 IGBT

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25% higher output power thanks to the latest Generation 7 IGBT



**SEMiX® 3 Press-Fit**

55kW up to 350kW

# Best in Class Rectifiers

When first released, the SEMIPACK set a new industry standard for power semiconductor modules. It was the first fully isolated power module available on the market and it was the basis for many innovations to come.

Today SEMIPACK is still setting benchmarks. With a mean on-state current of up to 145A and a super low thermal resistance, the 6th generation of the SEMIPACK 1 is the most powerful 20mm module available on the market.

The complete SEMIPACK product line consists of uncontrolled, half-controlled and full-controlled rectifier modules in six module lines covering voltage classes from 1200V to 2200V, insulation voltages of 3.6kV and 4.8kV, and rated currents from 20A to 1360A.

With all of this, the SEMIPACK is the ideal rectifier solution for any motor drive application.

## Reliable Performance

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Proven standard

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Most powerful 20mm module on the market

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## Scalable Product Range

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Six industry standard housings

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20A...1360A and 1200V...2200V

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Uncontrolled, half-controlled, fully-controlled rectifier legs and switches

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## Setting Benchmarks - 6<sup>th</sup> Generation of SEMIPACK 1

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$I_{TAV}/I_{FAV}$  up to 145A and  $I_{TSM}/I_{FSM}$  up to 2210A

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New, lighter baseplate for optimal heat spread

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Up to 50% lower  $R_{th}$  compared to the market standard

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Full lineup for motor drives up to 75kW

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**SEMIPACK® 1**  
6<sup>th</sup> Generation



# Product Portfolio

## Power Modules



### MiniSKiiP®

0.4kW 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

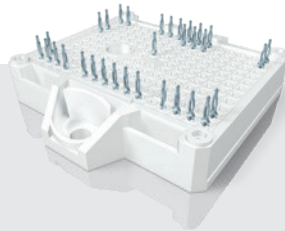
1200V hybrid and full SiC: 30 to 150A

Comprehensive set of topologies: CIB, sixpack, twelvpacks, 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

RGA IGBT and Generation 7 IGBT for true multiple sourcing



### SEMITOP® E

0.4kW to 55kW

#### Exceeding the Standard for Superior Performance

PCB-based and press-fit connected baseplate-less industry standard power module in two housing sizes

650V / 1200V IGBT: 10A to 200A

1200V SiC: 30A to 150A

Rectifier, CI, CIB, sixpack, and half-bridge topologies

Optimized mounting concept and pre-applied high performance thermal interface material provide lowest thermal resistance in class

Full line up with Generation 7 IGBT

RGA IGBT and Generation 7 IGBT for true multiple sourcing



### SEMIPACK®

800V to 2200V

#### Bipolar Modules from the Market Leader

6 housing sizes SEMIPACK 1 to 6

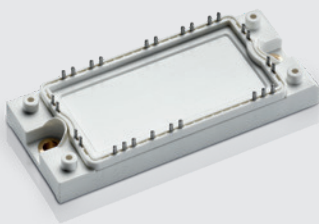
1200V to 2200V: 20A to 1360A

Semikron Danfoss diode and thyristor chips

Diode and thyristor in un-, half- and full-controlled topologies

Different technologies for certain packages: high reliability pressure contact or cost-effective wire bonded modules

Enhanced isolation voltage of 4.8kV/1s available on request



### SEMiX® 1/2

1.5kW to 18.5kW

#### Industry Standard for Low Power Drives

Optimized heat spreading by baseplate design

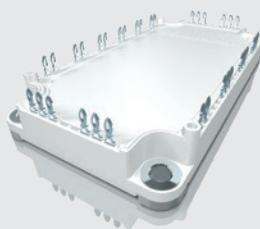
Solder pins

650V / 1200V IGBT: 15A to 75A

CI, CIB and sixpack topologies

Fully compatible industry standard package for multiple sourcing

SEMiX 2 with latest Generation 7 IGBT



### SEMiX® 6

15kW to 75kW

#### The Complete Press-Fit Standard

PCB-based and press-fit based industry standard baseplate power module.

650V / 1200V IGBT: 75A to 250A

1600V and 2200V rectifier diodes:

200A and 300A

Bridge rectifier (B6U), CIB and sixpack 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 to 350kW

#### Exceeding the Standard for Superior Performance

Industry standard press-fit design with 17mm high housing

650V / 1200V / 1700V IGBT: 225A to 900A

1200V Hybrid SiC: 600A

Complete motor drive topologies available: half-bridge, rectifier, and brake chopper

Direct driver assembly

Available with integrated shunt resistor for current measurement

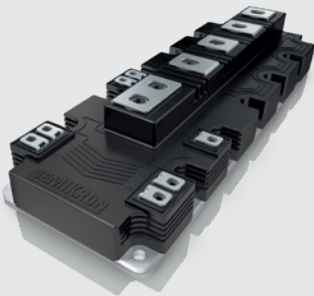


**SEMISTRANS® Classic**

25kW to 500kW

**The Proven Power Electronics Package**

- Robust industry standard package for multiple sourcing in 6 housing sizes
- 600V / 650V / 1200V / 1700V IGBT: 50A to 900A
- 1200V Full SiC: 250A to 450A
- Half-bridge, single switch and brake chopper topology
- Multiple IGBT sources including IGBT M7
- Extended 62mm portfolio
- 1200V IGBT: 800A
- 1700V IGBT: 500A

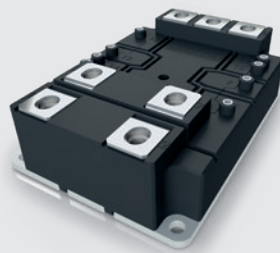


**SEMISTRANS® 10**

110kW to 1MW

**Robust High Power Module**

- Established high power module package
- 1200V / 1700V IGBT: 450A to 1800A
- Half-bridge, buck/boost, TNPC, NPC, and split NPC topologies
- Full multiple source thanks to alternative 1700V chip source and IGBT M7



**SEMISTRANS® 20**

500kW to 1MW

**The New Standard in High Power**

- The latest industry standard power module for high power applications
- 1200V / 1700V IGBT: 900A to 1400A
- Half-bridge topology
- Low stray inductance, high power density package
- Excellent reliability thanks to sintered chips and latest packaging technology



# Intelligent Power Modules – IPMs

## For Maximum Reliability

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

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Half-bridges and sixpacks

1200V / 1700V IGBT: 500A to 3600A

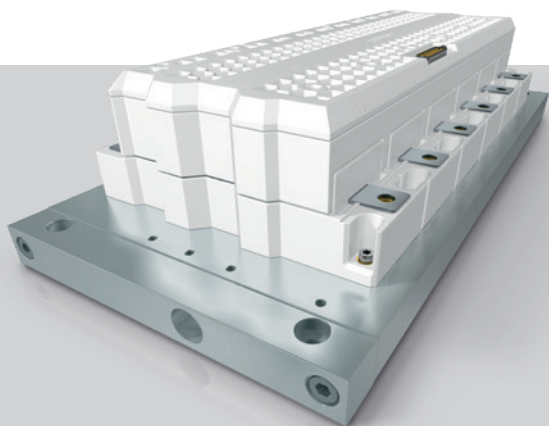
2000V SiC: 1200A to 2400A

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Flexible cooling options: air, water or customized cooling options

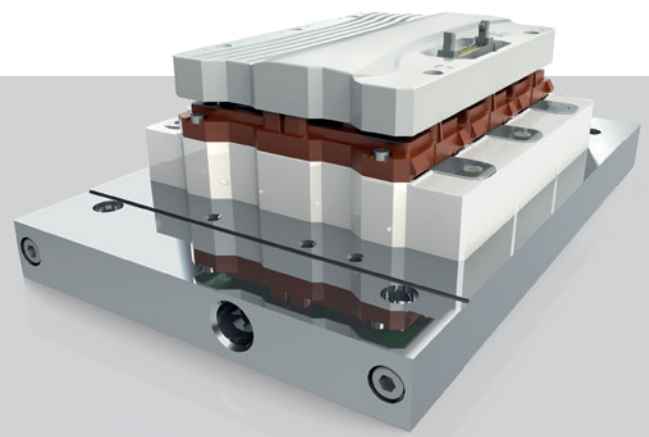
Parallel operation for even higher output power possible

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### SKiiP®4

Up to 2MW  
available with SiC MOSFET



### SKiiP®7

150kW up to 2.4MW





# 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 Rectifier-, IGBT- and SiC-based stacks for AC voltages from 380V to 690V. Our standard stacks cover an output current range from 70A to 4000A.

## Water-Cooled IGBT Stacks

SKiiPRACK  
SEMISTACK RE

## Air-Cooled IGBT Stacks

SEMIKUBE  
SEMIKUBE SlimLine

## Diode/Thyristor Stacks

SEMISTACK CLASSIC B6U/B6C/W3C

## 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

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Shortest time to market

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Cost savings in R&D, production and qualification

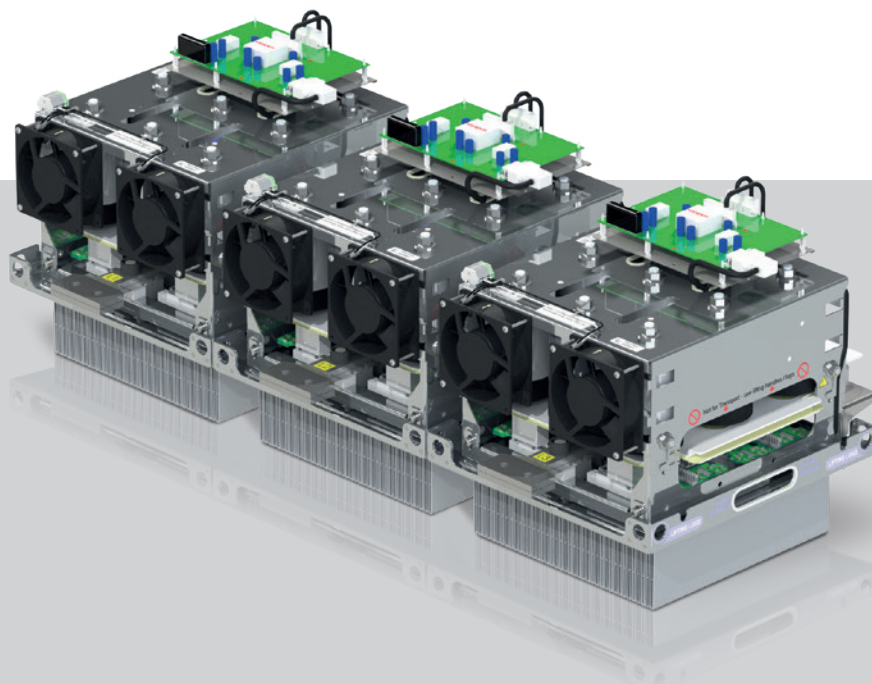
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Global Semikron Danfoss stack production footprint

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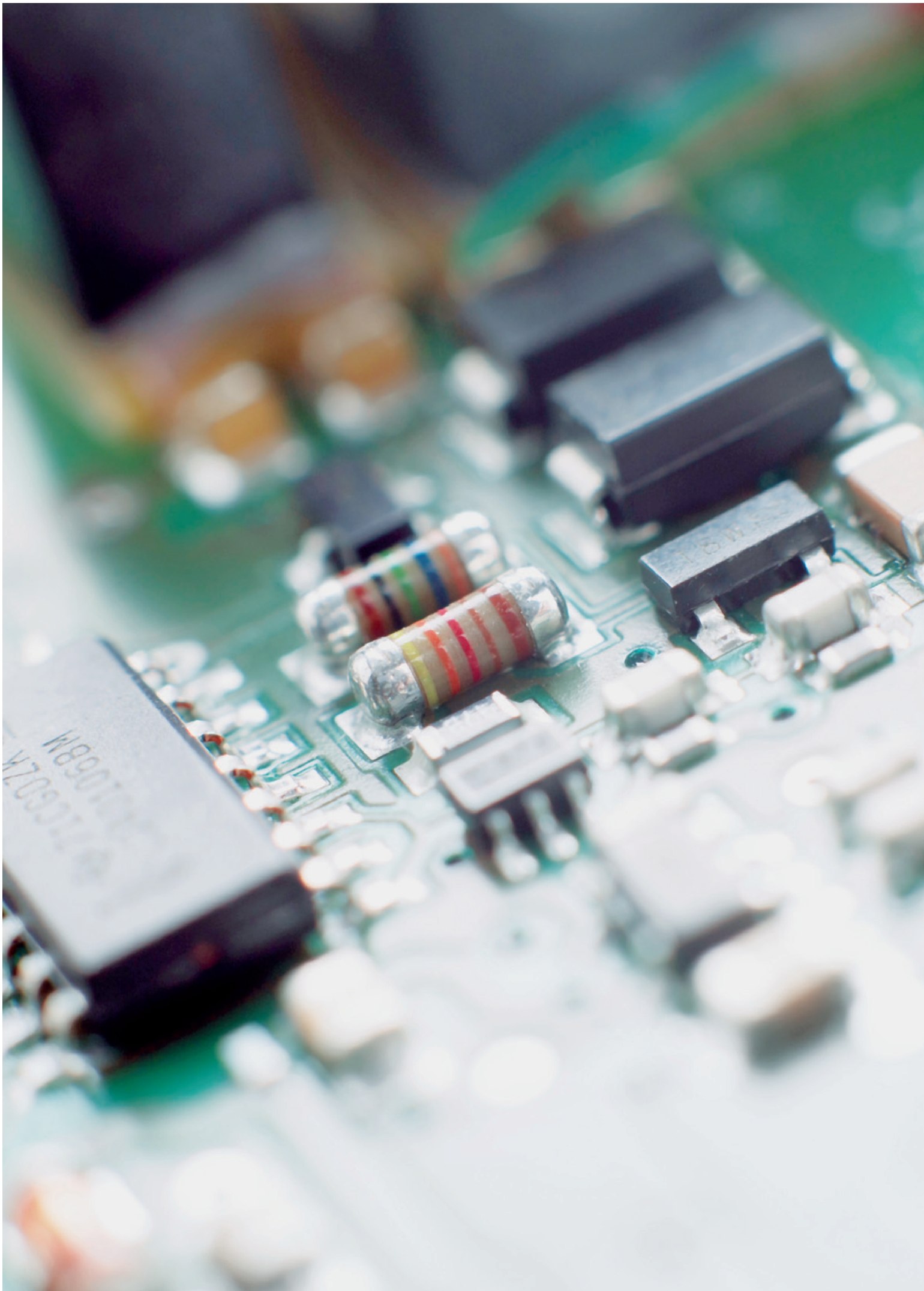
Highly experienced engineering team

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## SEMIKUBE®

Air-cooled IGBT Power 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

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Reinforced insulation for signal and power transmission

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Two-channel driver

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Up to 1700V transients

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Up to 1500V continuous DC bus voltage

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8Apk to 35Apk per channel

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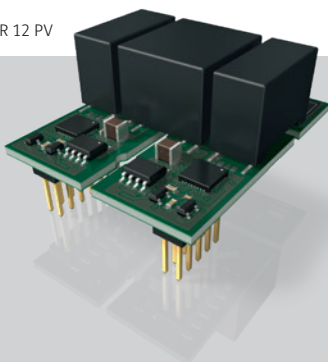
1W to 4.2W peak per channel

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Suitable for multi-level topologies and Generation 7 IGBT

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SKYPER 12 PV



### Driver Cores

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

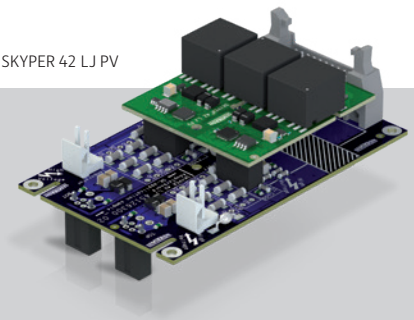
SKYPER 12 Press-fit



### Plug-and-Play Driver

Two-channel drivers for direct module mounting with electrical or optical interface

SKYPER 42 LJ PV



### 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 on the market to offer power modules with pre-applied thermal interface material (TIM). We now have over two decades of experience and more than 30 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 on the modules in a clean environment on an automated silkscreen and stencil printing line. Statistical process control (SPC) is used to guarantee consistency. Special packaging is implemented to ensure that the TIM arrives at your production line in pristine condition.

Semikron Danfoss offers either thermal grease or phase change material depending on customer requirements (e.g. performance increase, reduced handling effort) and module type (with or without baseplate). The reliable assembly of baseplate-less modules is aided by a low-viscosity material such as thermal paste. Our High Performance Thermal Paste (HPTP) achieves this and, with optimized filler content, provides best in class thermal performance.

Alternatively, for ease-of-handling during assembly, most power modules are also available with pre-applied phase change material (PCM). Phase change materials have a solid consistency at room temperature. With the application of heat during first operation, the PCM flows to fill gaps and provide a thermal interface. With HP-PCM, the new Semikron Danfoss-exclusive High

Performance Phase Change Material, we combine the benefits of a phase change material with the performance of the best available paste.

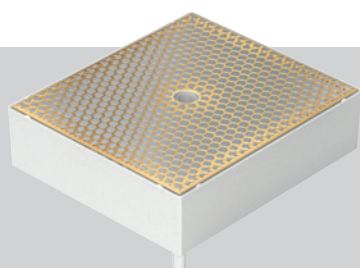
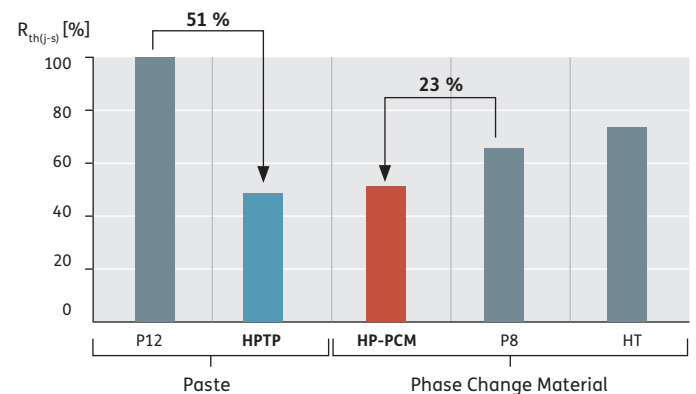
### Key Features

- Module-specific patterns for optimized TIM distribution
- Simplified logistics and reduced production costs
- Improved assembly robustness
- Increased lifetime and reliability

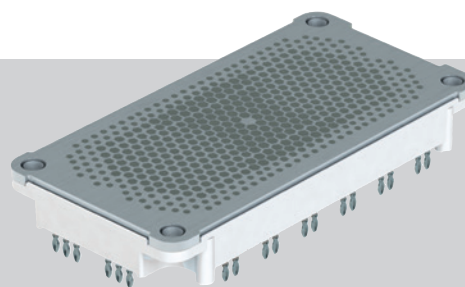
### Portfolio

**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<sub>2</sub> 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.



05/2024



### **Semikron Danfoss GmbH**

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Note: All information is based on our present knowledge and is to be used for information purposes only. The specifications of our products may not be considered as an assurance of component characteristics.

