

POWER ELECTRONICS FOR E-MOBILITY



# E-Mobility



# Power Electronics for On- and Off-Highway Vehicles

## On-Highway Vehicles

Semikron Danfoss offers more than 20 years of experience and know how in automotive applications. The power module is a key differentiator for an efficient and robust EV drivetrain. As a technology leader, Semikron Danfoss aims to maximize the potential of semiconductors. With our two automotive power module platforms, eMPack and DCM, we offer highly scalable solutions for light duty to heavy duty traction inverter applications.



### Passenger Cars/Light Duty

Power Modules for Electric Drive Train  
**eMPack**

Power Modules for Electric Drive Train  
**DCM**

Inverters for Electric Drive Train up to 96V<sub>DC</sub>  
**SKAI LV**

For the truck and bus market, Semikron Danfoss also offers complete Skai inverter systems. Our SiC and Si Skai HV inverters set the benchmark for power density and offer the highest level of robustness. For two wheelers, forklifts, small delivery trucks and neighborhood vehicles Skai LV is the dedicated product for such applications in the highly fragmented light vehicle market.



### Trucks and Buses/Heavy Duty

Inverters for Electric Drive Train  
**SKAI HV**

Inverters for 48V board net  
**SKAI LV**

Power Modules for Electric Drive Train  
**eMPack**

Power Modules for Electric Drive Train  
**DCM**



# Off-Highway Vehicles

The off-highway vehicles segment today comprises primarily the traditional material handling market where battery operated vehicles like fork-lifts have been well established for decades. Semikron Danfoss has been serving this market for more than 20 years and offers complete SKAI inverter systems for low voltages as well as for voltages of 800V<sub>DC</sub>. The light electric vehicle market, a highly fragmented market with power ranges of up to around 40kW, includes two-wheelers, small delivery trucks, recreational/neighbourhood vehicles and many more smaller, yet fast growing niches.

The SKAI low voltage inverter is the dedicated product for these applications. The electrification of vehicles in the agriculture, forestry and construction sector, in contrast, is still its infancy. There is, however, substantial potential for this area to grow in the future thanks to the costs benefits of battery driven funtions. SKiM 93 power modules are the ideal choice for traction drives, while our SKAI HV inverters, which can incorporate auxiliar funtions as well, are suitable for higher integration levels. This off-highway electric vehicle segment typically relies on industrial standard products.



## Material Handling

Inverters for Electric Drive Train up to 96V<sub>DC</sub>  
**SKAI LV**

Inverters for Electric Drive Train  
**SKAI HV**



## Agriculture, Forestsry and Construction

Inverters for Electric Drive Train  
**SKAI HV**

Inverters for 48V board net  
**SKAI LV**

Power Modules for Electric Drive Systems  
**SKiM 93**



## Light Battery Vehicles

Inverters for Electric Drive Train up to 96V<sub>DC</sub>  
**SKAI LV**



**Pioneering the future** of E-Mobility with  
**high performance** power electronics.

Adding **long term value** to your application  
in **passenger cars, truck and bus** and  
**off-highway**.



# Product Portfolio

## Power Modules



### DCM™

#### Flexible Design through Customization

Si IGBT and full silicon carbide MOSFET technology

750V/1200V half-bridge design for up to 900 A<sub>rms</sub>

DBB Sintering Technology for high reliability

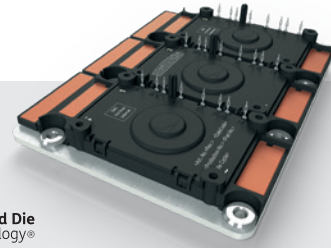
Low thermal resistance thanks to ShowerPower®3D

Robust molded module packaging,

low warpage and reliable mechanical integration

Highest power density

Multisourcing thanks to chip independency



### eMPack®

#### High Performance Package for e-mobility

Silicon carbide MOSFET and full silicon carbide technology

750V / 1200V Sixpack compatible package for up to 900A<sub>RMS</sub>

Double Sided Sintering package for automotive grade reliability

Low thermal resistance thanks to DPD Technology

Flexible cooler arrangements

2.5nH package stray inductance including terminals

Multisourcing thanks to chip independency

# Product Portfolio

## Power Electronic Systems



### SKAI® HV

#### Inverter for On- and Off-Highway Vehicles up to 800V

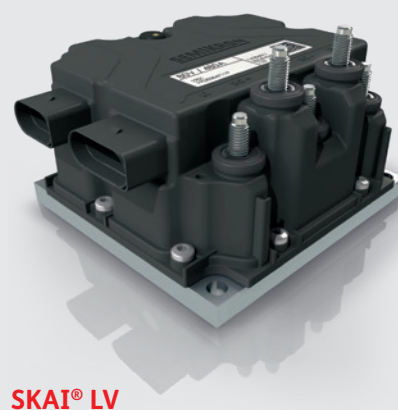
Suitable for battery voltages up to 800V<sub>DC</sub>

Sintered power semiconductors

EMI compliant

Peak current 400 A<sub>rms</sub>

Peak apparent power 300kVA



### SKAI® LV

#### Inverter for Vehicles up to 120V

Power platform for utility and light electric vehicles

For compact designs

30kVA/l power density

V<sub>battery</sub>: 24V<sub>DC</sub> up to 96V<sub>DC</sub>

600A<sub>rms</sub> peak current during acceleration

Easy-to-use gate driver

IP66 enclosure

## DCM™ and eMPack®



In passenger car applications, power electronics have to rise to considerable challenges: they must be compact and efficient, while remaining robust and reliable under the changing conditions that occur during cold start and repeated acceleration and deceleration. Semikron Danfoss offers a wide range of products that rise to the occasion in any application in the automotive sector, be it battery-powered electric vehicles, mild hybrids, plug-in hybrids or other hybrid drive vehicles.

Our dedicated automotive portfolio includes power modules and integrated converter/inverter systems that are often based on innovative semiconductor technologies such as silicon carbide (SiC), significantly improving efficiency in standard passenger vehicle applications in comparison to silicon-based technology (IGBTs).



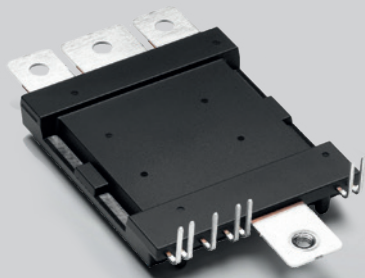
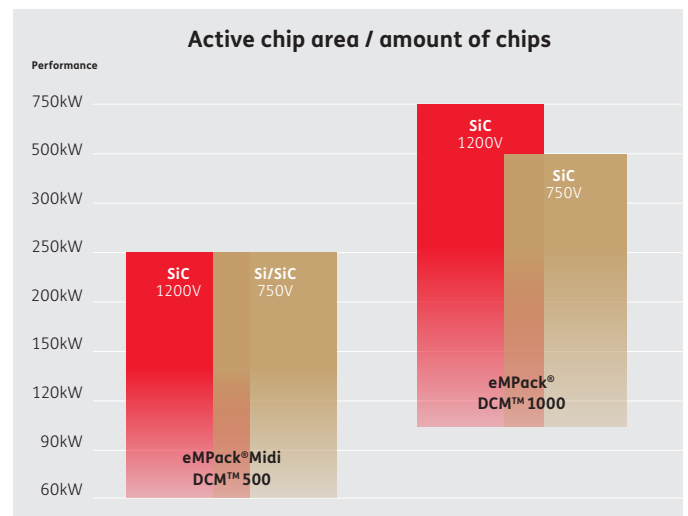
# Two Leading Power Module Platforms

Semikron Danfoss' new power module platforms DCM and eMPack, which are both based on a highly scalable module concept, are developed for EDS inverter architectures covering a power range from 100kW up to 750kW. Both platforms cover 400V and 800V battery system applications. The combination of Silicon Carbide technology with our fully sintered and lowest stray inductance enable unmatched power densities combined with high reliability for automotive application.

As chip independent power module manufacturer, we are able to provide latest performance standards, reduced risks and increased supply security.

## Product Features

- High efficiency SiC technology
- Ultra-low stray inductance
- Superior reliability in a fully sintered package
- Dedicated configurations for all BEV power ranges
- Compact package



### DCM™

750V up to 1200V  
500 to 800Arms



### eMPack®

750V up to 1200V  
~ 300 to + 1000Arms

The DCM technology platform is designed to be scalable. In the same package, we can scale the power up or down to meet different inverter voltage classes with blocking voltages of 750V-1200V, while having different output currents from 200 to 900A.

Furthermore, our power modules are based on quality components, patented packaging and cooling technologies to achieve outstanding, measurable results in terms of reliable performance and robustness – all adding up to ensure a cost-effective solution that lasts. Our certified processes assure for consistent high quality and streamlined path from development to volume manufacturing.

The DCM platform consists of the smaller DCM500 and the more powerful DCM1000 product families

## Product Features

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Highest flexibility in design, customized interfaces

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Scalable across voltage classes

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Advanced bonding technologies for highest power cycling robustness

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High power density

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Robust molded module packaging

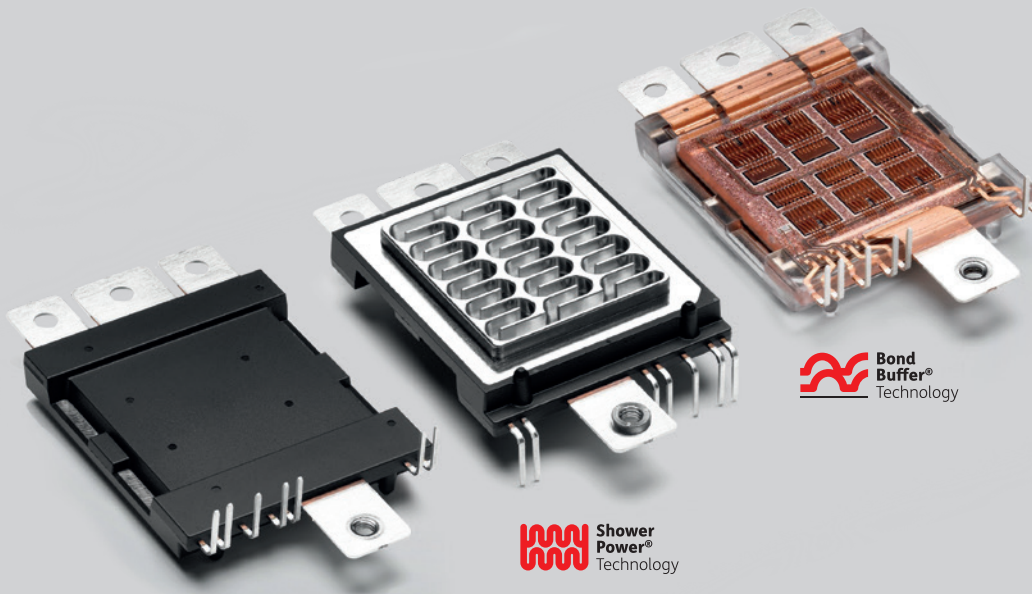
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Direct liquid cooling with ShowerPower 3D

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## DCM™

100kW up to 750kW



 Bond  
Buffer®  
Technology

 Shower  
Power®  
Technology



The transition of complete car platforms to full electric battery vehicle architectures is progressing rapidly. These architectures will demand scalable power electronics solutions for electric drive systems (EDS) that are capable of realizing a wide performance range in an economic way, resulting in competitive advantage to vehicle manufacturers.

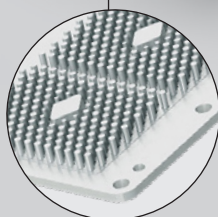
Semikron Danfoss' new power module platform eMPack, which is based on a common module concept, is being developed for EDS inverter architectures covering a power range from 100kW up to 750kW. eMPack covers 400V and 800V battery system applications. The combination of Silicon Carbide technology with our fully sintered, low stray inductance Direct Pressed Die Technology (DPD) enables unmatched power densities combined with high reliability for automotive application.

## Product Features

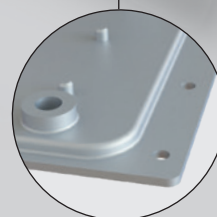
- High efficiency SiC technology
- Ultra-low stray inductance
- Superior reliability in a fully sintered package
- Dedicated configurations for all BEV power ranges
- Compact package

## eMPack®

100kW up to 750kW



PINFIN cooler option



Customer-specific cooler options, e.g. closed aluminium cooler

## SKAI® LV



More and more utility vehicles such as forklift trucks now run on electric power. In fact, what was once state of the art for indoor vehicles, is now increasingly finding its way into outdoor vehicles, as powertrain electrification continues to advance and enter new vehicular applications. Today, power electronic systems are as commonplace in motorbikes, quads and other light electric vehicles as they are in agricultural and construction vehicles.

The SKAI LV converter/inverter system is a platform solution that is designed for use in combination with existing or optimized controller systems, enabling the quick development of optimized, cost-efficient custom solutions for utility and light electric vehicles. The compact design of the SKAI LV makes it the right fit for use in industrial forklift trucks as well as in other industrial or road vehicles.



# Ultra Compact MOSFET Inverter Platform

The SKAI LV is a platform for low-voltage inverter systems for on- and off-road applications. This platform constitutes the 3rd generation of low-voltage inverter systems and the 7th generation of MOSFET inverter technology developed by Semikron Danfoss, with more than 2 million MOSFET inverters in the field.

To create an optimized application-specific motor control system, simply integrate a customized control board. The SKAI LV platform is based on the same power-technology found in high-voltage, high-reliability applications today, providing access to high-power, maximum reliability technologies across a wide range of low-voltage on and off-road applications.

## Product Features

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Voltage, current and temperature sensors

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Gate driver with protection

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Low inductance, low loss power section

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DC link capacitors

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Air and plate cooling

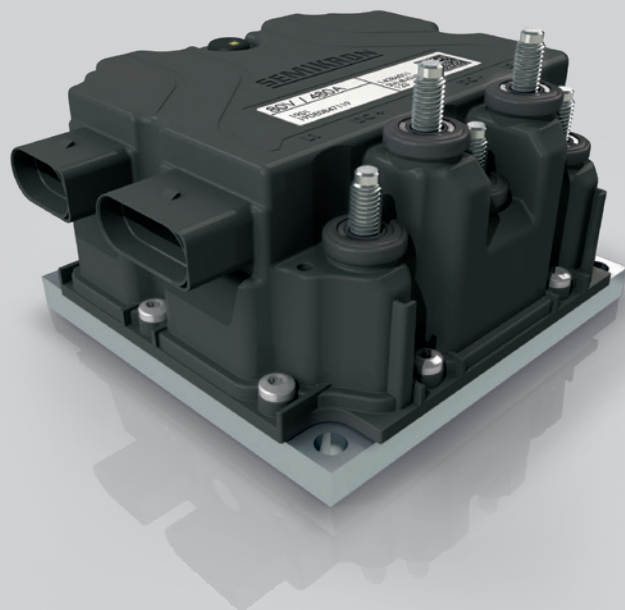
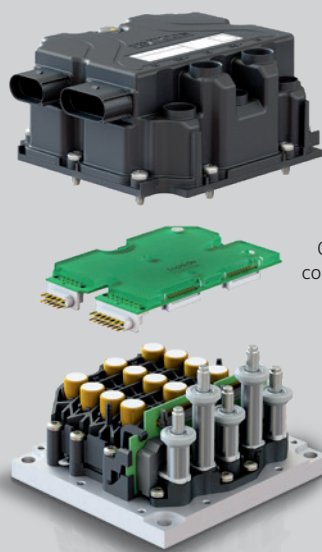
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Easy-to-use gate driver interface

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Platform for customised designs

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**SKAI® LV**

MOSFET Inverter System up to 55kVA

## SKAI® HV



Hybrid electric or all-electric buses are already in widespread use in our cities today and are an effective way of reducing pollutant emissions or avoiding them altogether. This move towards cleaner mobility is also being seen in trucks, with more and more manufacturers introducing hybrid electric or all-electric trucks to their fleets.

In heavy-duty off-road utility vehicles such as construction site vehicles and agricultural machinery, the power electronics are exposed to particularly harsh ambient conditions. They have to be ultra-compact and lightweight, while exhibiting good vibration, impact, and shock resistance in order for them to work reliably on uneven terrain. They have to be able to work at both very low and very high ambient and coolant temperatures and boast excellent thermal and power cycling capabilities at the same time.



# Compact Power Electronic System

SKAI HV comprises a versatile 3-phase converter platform designed for use in electrified vehicles. It covers key requirements such as high power density, exceptional ruggedness and automotive EMI compliance.

The SKAI HV power electronic platform comprises highly integrated motor controllers, which provide the ideal powertrain solution for mobile electric and hybrid applications. Power densities of up to 24kVA/litre bring notable size reductions compared with other existing standard motor controller products. The systems are designed to operate with supply voltages of up to 800V<sub>DC</sub> and with output power ratings of up to 300kVA. The IGBT based SKAI2 HV motor controller operates on sintered, 100% solder free 1200V power semiconductors and features polypropylene film DC-link capacitors, all integrated into a waterproof IP67 enclosure. The compact motor controllers can withstand high vibration amplitudes suitable for chassis assembly in commercial vehicles.

Semikron Danfoss provides engineering services like thermal simulation or lifetime estimation in order to support customers with the integration of SKAI HV.

## Product Features

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Compact integration into IP67 enclosure

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Voltage, current and temperature sensors

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Gate driver with protection

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IGBT power semiconductors

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Fully programmable digital signal processor

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EMI filters

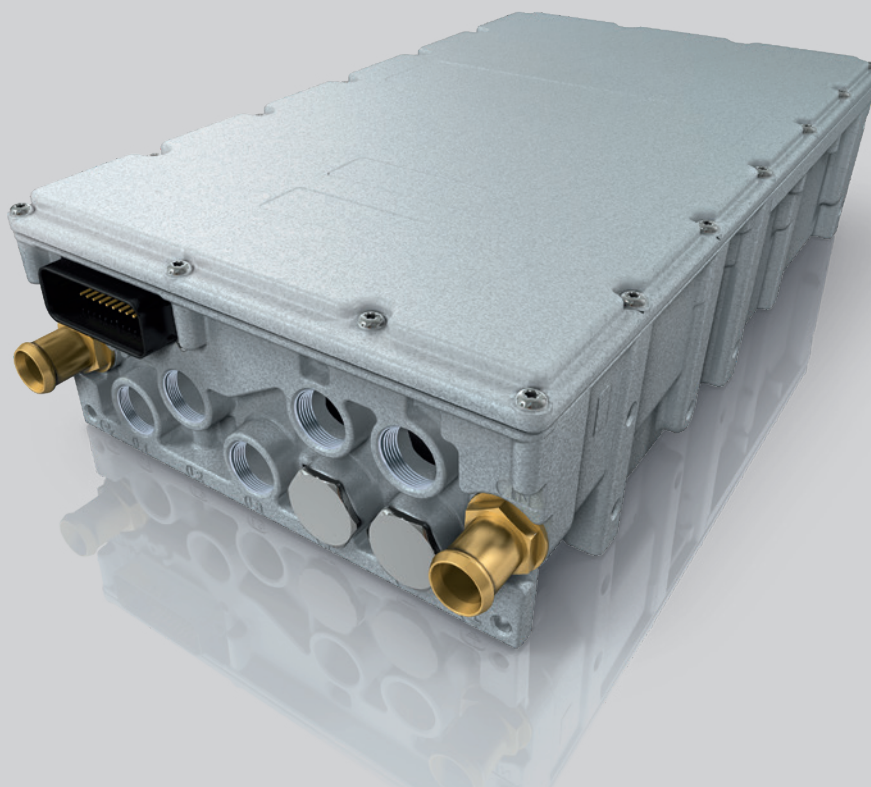
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Liquid cooling system

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DC-link capacitor

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**SKAI<sup>®</sup>2 HV**  
Up to 300kVA



 SEMIKRON  
DANFOSS

# Helping Your Business Use Our Products

## Application Expertise is our Strength

Being able to access service, technical support and experts that our customers can always rely on is instrumental to our customers' success.

Today, increased product diversity in power semiconductors calls for customer support far beyond the information contained in data sheets. Only comparison under application-specific conditions – such as voltage, switching frequency or cooling conditions – can demonstrate the differences in performance of available devices. That's why we continue to invest in our professional application engineering support, including lab space and reference designs.

## Customize your Power Solution

Besides standard configurations, Semikron Danfoss also offers customer specific topologies in various housings, addressing the market need for innovation and differentiation.

It allows us to provide an unmatched flexibility in power module designs. Our highly skilled and specialized engineers at Semikron Danfoss work closely with you to design power modules for your specific drivetrain design, allowing you to scale your power solution according to your specifications.

In recent years, we have built a network comprising 24 sites across the globe to provide fast, comprehensive application support. Our application engineering teams work with our customers both locally and globally, throughout the entire project life cycle. We strive to understand and help our customers overcome both big and small challenges throughout their projects. For example, we conduct topology studies to fully understand the advantages in the end user application and carry out benchmark investigations when needed. It is this application-centred approach that sets us apart from others.

## How can Semikron Danfoss help you with Inverter Design?

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Application and performance calculations

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DC link design and capacitor selection

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Isolation coordination

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Lifetime calculations

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Measurement support

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Application samples and reference designs

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## 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.



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### **Semikron Danfoss GmbH**

Husumer Strasse 251  
24941 Flensburg, Germany

### **Semikron Danfoss International GmbH**

Sigmundstrasse 200  
90431 Nuremberg, Germany

[www.semikron-danfoss.com](http://www.semikron-danfoss.com)

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