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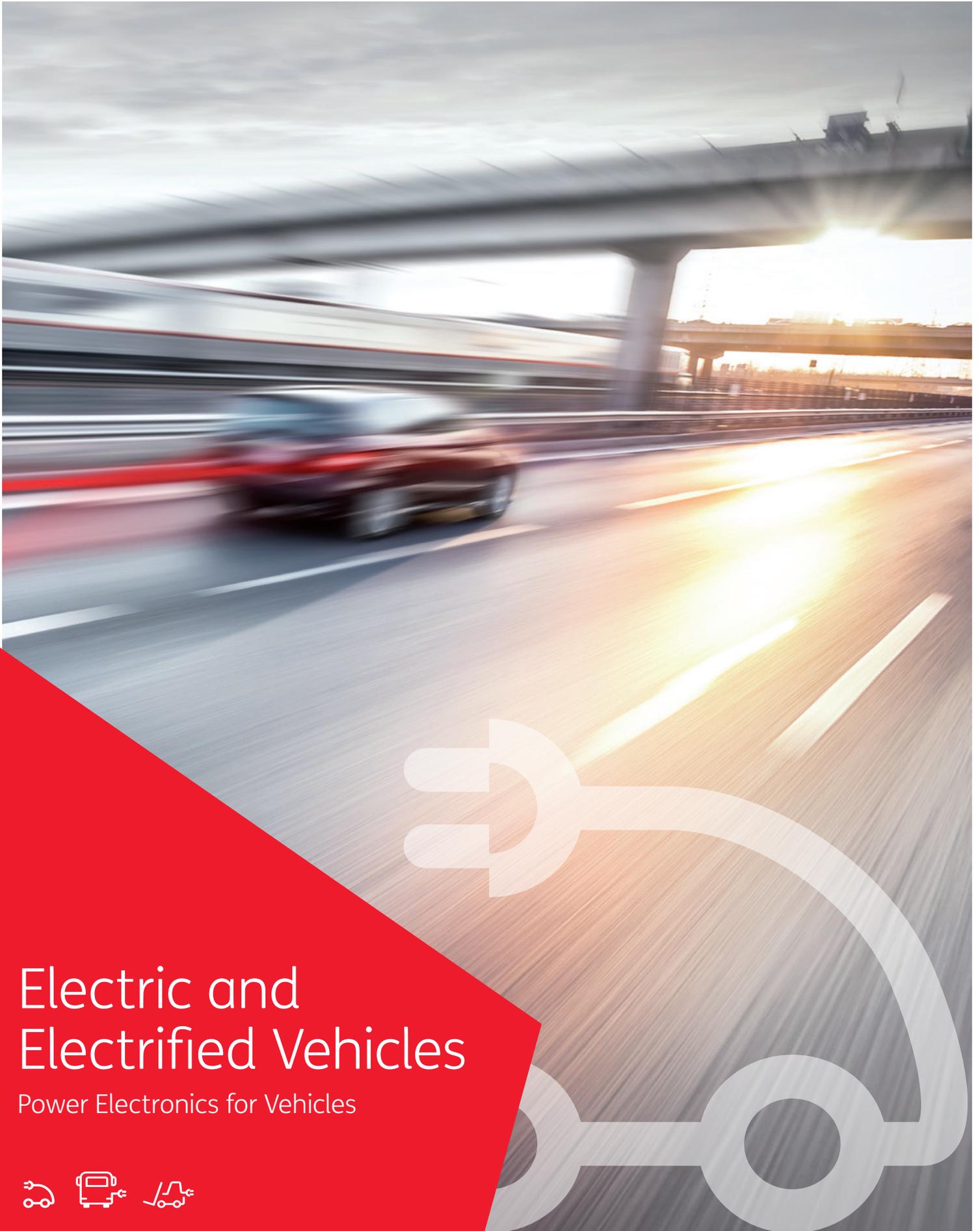
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Electric and Electrified Vehicles

Power Electronics for Vehicles





PERFORMANCE

PASSENGER CARS



Electrical vehicles require highly reliable power electronics for the electrical drive system. SEMIKRON, a leading supplier of power electronics, has been supplying products to the EV markets for more than 10 years. From chips and modules to entire converters, the full range of SEMIKRON products can be found in passenger cars, trucks, buses, industrial and light electric vehicles.

Power modules for auxiliary applications such as DC/DC converters, fuel cell compressor inverters, or exciter functions for drive systems need reliable solutions in small footprints. For these applications, SEMIKRON's SEMITOP E1/E2 series offers flexible solutions tailored to the individual requirements.

- Mild Hybrid Electric Vehicle
- Plug-in Hybrid Electric Vehicle
- Battery Electric Vehicle
- Hybrid Electric Vehicle

Power Modules for Electric Drive Systems (EDS)

SEMIX Spring

SEMIX 3 Press-Fit

SEMIX 5

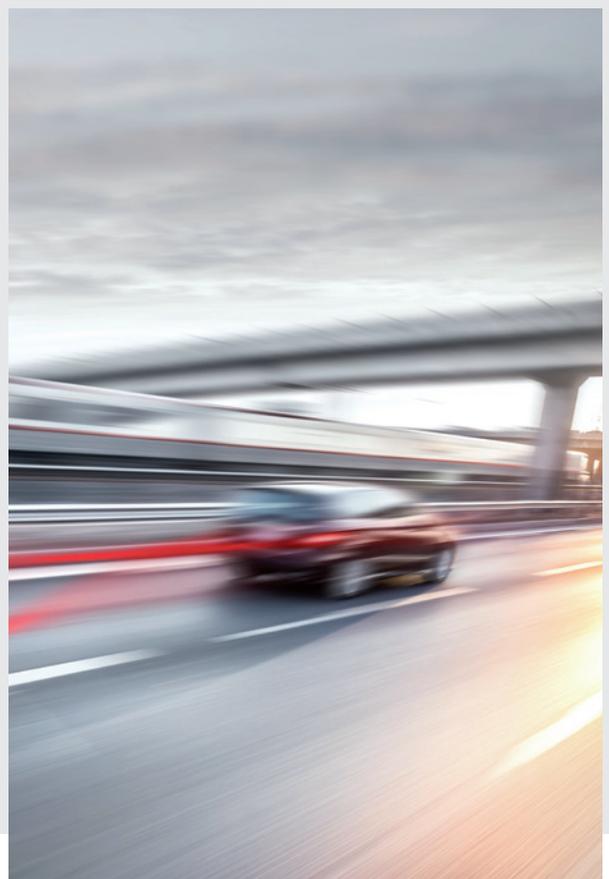
SKiM 63/93

Power Modules for Auxiliary Inverters

SEMITOP E1/E2

Converter/Inverter for 48V Mild Hybrid Systems

SKAI 3 LV



TRUCKS & BUSES



- Buses
- Trucks

Power Modules for Electric Drive Systems (EDS)

SKiM 63/93

SEMiX Spring

SEMiX 3 Press-Fit

Converter/Inverter for Electric Drive Systems (EDS)

SKAI 2 HV

INDUSTRIAL & LIGHT EV



- Forklifts
- Material Handling
- Motorcycles and Quads
- Light Electric Vehicles
- Agricultural Vehicles
- Construction Vehicles

Power Modules for Electric Drive Systems (EDS) and Auxiliaries

SKiM 63/93

SEMiX Spring

SEMiX 3 Press-Fit

SEMiX 5

SEMITOP E1/E2

Converter/Inverter for Electric Drive Systems (EDS)

SKAI 3 LV

SKAI 2 HV





Applications

High-Performance Power Electronics – Our Commitment to eMobility

SEMIKRON offers products for every possible application in the automotive environment. Our dedicated automotive portfolio includes power modules and integrated converter/inverter systems.

SEMIKRON modules are already in use in electric vehicles today. The SEMiX baseplate modules are popular with leading Chinese passenger car manufacturers. For higher power densities, the established baseplate-less module SKiM 63/93 is the first choice for electric and plug-in electric vehicles. This module has propagated widely through applications such as passenger cars, trucks and buses worldwide. Our power modules are also suitable for non-traction applications such as DC/DC converters or pumps used in fuel cells.

Alongside the main vehicle categories, SEMIKRON modules can also be found in motorcycles as well as agricultural and construction vehicles.

The Semikron converter/inverter system SKAI 2 HV for up to 850V_{DC} bus is a high level integration system that combines typical SEMIKRON module performance with a matching controller and software system. The SKAI 2 HV is widely accepted and used as a traction inverter in various bus and truck series as well as in agricultural and construction vehicles all over the world.

The SKAI 3 LV converter/inverter system represents the low-power low-voltage end of SEMIKRON's auto-motive solutions. Its compact dimensions have enabled it to meet industrial forklift truck applications. It is equally well suited to other industrial or on-road vehicles. The SKAI 3 LV also forms the perfect base for customized solutions for mild hybrid vehicles using 48V_{DC} bus systems.

References

150,000 SKiM 63/93 are deployed in electric and hybrid buses, passenger cars and electric motorbikes

10,000 buses use SKiM 5 in pre-assembled stacks

More than **200,000** hybrid and all-electric cars are powered by SEMiX power modules

53,000 SKAI 2 HV drive electric and hybrid buses

1.5 million SKAI LV used in material handling vehicles

Outlook

With the new power module concept eMPack, SEMIKRON is breaking the limits of existing power module technologies delivering more power, wider flexibility and all in a smaller footprint.

Type	Product	15kW	30kW	60kW	90kW	120kW	150kW	200kW
CONVERTER INVERTER	SKAI 3 LV	PassCar, BV, Aux						
	SKAI 2 HV				HDV			
MODULES	SKiM 63/93			LDV, HDV, PassCar				
	SEMIX 5			PassCar				
	SEMITOP E1/E2	Aux						



Outlook New Product Concept eMPack®

Pioneering the Future of eMobility with High-Performance Power Electronics

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 an important competitive advantage to vehicle manufacturers.

SEMIKRON's new power module platform eMPack, which is based on a single module concept, is being developed for EDS inverter architectures covering a power range from ~50kW up to ~750kW.

The combination of Silicon Carbide technology with SEMIKRON's fully sintered, low stray inductance Direct Pressed Die Technology (DPD) enables unmatched power densities combined with high reliability for automotive application.

Key factors

Silicon Carbide MOSFET and Silicon IGBT options

750V/1200V compatible package delivering up to 900A_{rms}

Double Sided Sintering package enabling automotive grade reliability

Low thermal resistance thanks to DPD technology

Flexible cooler arrangements

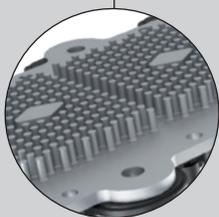
~2.5nH package stray inductance (incl. terminals)

Simplified mounting concept (all from top)



eMPack®

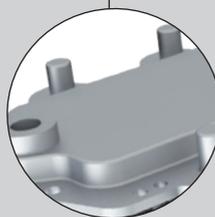
100kVA up to 750kVA



PINFIN cooler option

eMPack®

100kVA up to 750kVA



Customer specific cooler options
e.g. closed aluminium cooler

eMPack®

50kVA up to 120kVA
ultra compact design



Flexible cooler options
e.g. PINFIN cooler



Product Portfolio

Power Modules



SEMIX® 5

Extended standard for superior thermal and dynamic performance

Industry standard baseplate module with optimised AC and DC screw connections

650V/1200V/1700V IGBT: 100A to 400A

Sixpack, NPC, TNPC Vienna Rectifier, Back-boost converter and half-controlled Bridge Rectifier topologies

Optimised module layout for maximum heat transfer and minimum stray inductance

Housing features rugged moulded power terminals for superior mechanical stability and press-fit pins for fast solder-free driver board assembly



SEMIX® 3 Press-Fit

Exceeding the standard for superior performance

Industry standard press-fit design with 17mm high housing

650V/1200V/1700V IGBT: 225A to 700A

1200V Hybrid SiC: 600A

Half-Bridge and split-NPC topologies

Direct driver assembly

Available with integrated shunt resistor



SEMITOP® E1/E2

Exceeding the standard for superior performance

Best solution for On-Board auxiliary systems and battery chargers

Extreme flexibility for connection to PCB thanks to pin matrix

Many topologies available: CIB, Sixpack, 3-level NPC and TNPC, Half-bridge, H-bridge, Rectifier bridges

Integration of latest chip technologies for superior performance: 1200V IGBT T7, 650V IGBT5, SJ MOS, 1200V SiC MOSFET

Hybrid and full SiC modules up to 1200V/250A



SEMIX® SPRiNG

Excellent cost/performance ratio

Scalable housing sizes with spring contacts

600V / 1200V / 1700V IGBT: 75A to 600A

Half-bridge, chopper and sixpack topologies

Unified interface for driver connection

Optimised for compact and simple inverter design



SKiM® 63/93

High reliability design using sinter technology

Power module in sixpack configuration with three separate half-bridges

650V/1200V/1700V IGBT: 300A to 900A

1200V Hybrid SiC: 450A

Low-inductance design thanks to symmetrical layout

Solder-free module and driver PCB mounting

Benchmark performance in power and thermal cycling tests thanks to sintered chips, AlCu wire bonds and pressure contacts

Increased power density thanks to baseplateless module design



Product Portfolio On-Road Systems

Most Compact Power Electronic System Off-the-shelf for Electro-Mobility

SKAI 2HV comprises a versatile 3-phase AC/DC and DC/AC converter product platform designed for use in electrified vehicles. It covers key requirements such as high power density, exceptional ruggedness and automotive EMI compliance. The integrated motor control software SKAIware ensures highly efficient operation of the electric drive train.

Short facts

Suitable for battery voltages $24V_{DC}$ up to $850V_{DC}$

Sintered power semiconductors

EMI compliant

Off-the-shelf versions with gate driver interface, vector control software, automotive power connections

Key features

Compact integration into IP67 enclosure

Voltage, current and temperature sensors

Gate driver with protection

IGBT/ MOSFET power semiconductors

Fully programmable digital signal processor

EMI filters

Versatile cooling system (liquid cooled, forced air cooled, base plate)

DC link capacitors

Motor control software

Benefits

The SKAI 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/liter bring about notable size reductions compared with other existing standard motor controller products. The systems are designed to operate with supply voltages of $24V_{DC}$ to $850V_{DC}$ and with output power ratings of up to 300kVA. The IGBT based SKAI 2 HV motor controller operates on sintered, 100% solder-free 600V or 1200V power semiconductors and it features polypropylene film DC-link capacitors. It is integrated into a waterproof IP67 enclosure. The compact motor controllers can withstand high vibration amplitudes of up to 10g rms.

SKAIware motor control software adds to the system function and finishes off this tried-and-tested package for the SKAI 2HV nicely. SEMIKRON provides engineering services to support customers with the integration of SKAI 2HV motor controller systems. Other available services include, for instance, lifetime estimation, field application support, individual parameterization of motor control software, and more.

Product range

Versatile SKAI 2 HV off-the-shelf versions are available. Cooling methods are liquid, forced air cooling or baseplate. Various optional services also exist, such as end-of-line flashing of customer specific software, lifetime estimation based on application profile analysis, field application support, individual parameterization of motor control software and further services (on request).



SKAI® 2 HV

100kVA up to 300kVA



Product Portfolio for Off-Road Systems up to 48V

Ultra Compact MOSFET Inverter Platform

SKAI 3 LV is the 3rd generation of industrial MOSFET inverters and constitutes the 7th generation of MOSFET inverter technology manufactured by SEMIKRON, with more than 1.5 Million MOSFET inverters in the field. The 3rd generation is a platform concept that offers standard design versions or can be customised to meet your needs. The converter connects easily to a customer control board for quick and easy designing, while leaving the control to the customer.

3-phase MOSFET inverter system up to 55kVA

- For material handling and battery powered vehicles
- Voltage, current and temperature sensors
- Gate driver with protection
- Low inductance, low loss power section
- DC link capacitors
- Air and plate cooling
- Easy-to-use gate driver interface
- Platform for customised designs

Key features

For compact designs

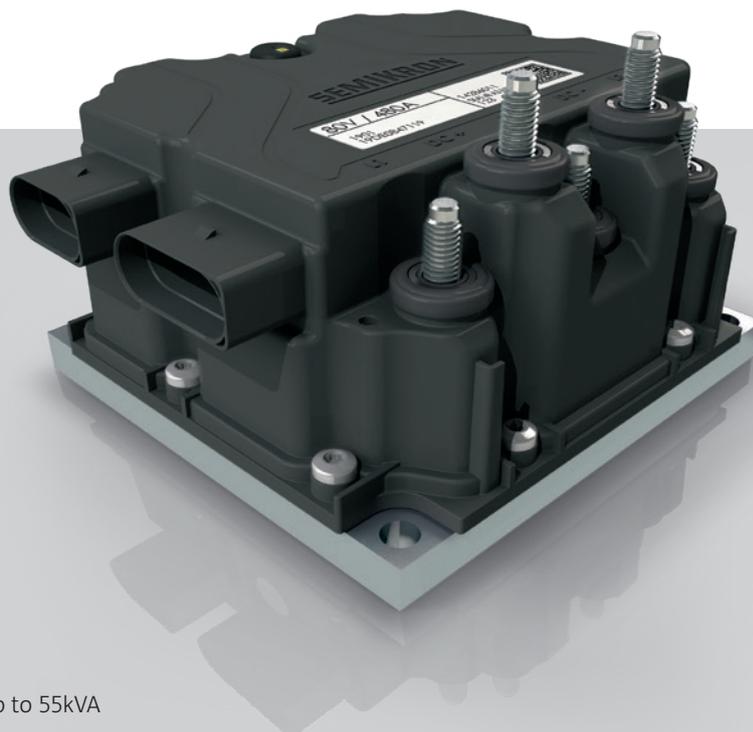
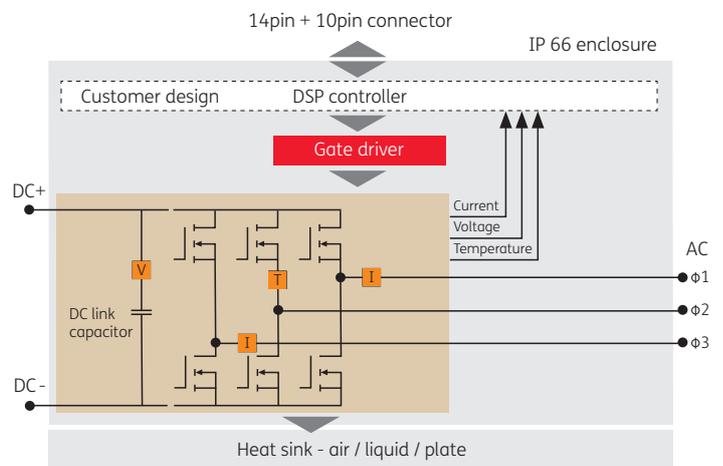
30kVA/l power density

V_{battery} : 24V_{DC} up to 160V_{DC}

600A_{rms} peak current during acceleration

Easy-to-use gate driver

IP66 enclosure



SKAI® 3 LV

MOSFET Inverter System up to 55kVA



pressure
element

flex-layer

sinter
chip

sinter

DBC

Direct Pressed Die Technology

A Breakthrough in Power Electronics Packaging

Since SEMIKRON introduced sintering technology in power electronics in 2009, it has been continuously enhanced breaking one technology limit after the other. Direct Pressed Die is the latest innovation combining unreached reliability with ultra-low R_{th} .



Single Sided Sintering Technology

Single Sided Sintering (SSS) technology utilises a highly reliable silver sinter layer to connect the chip to the ceramic substrate (DBC), replacing the standard solder layer.



Double Sided Sintering Technology

In Double Sided Sintering technology (DSS) two sinter layers are used: the chip is sintered to the DBC and a flex layer is sintered on top of the chip. The flex layer replaces the wire bonds, resulting in maximum reliability and current capability.



SKiN® Technology

SKiN technology is based on Double Sided Sintering. It also integrates the heatsink using a third sinter layer. SKiN technology is free of bond wires, thermal grease and solder, combining maximum reliability with minimum thermal resistance.



Direct Pressed Die Technology™

Direct Pressed Die (DPD) technology includes a Double Sided Sintered (DSS) chip on a ceramic substrate that is pressed onto the heatsink by a defined force directly on top of the chip. This optimises reliability and thermal resistance, combined with flexibility with regard to cooling and integration in standard power modules.

