SKiiP4, Semikron's new generation of solder-free half-bridge IGBT modules, delivers 33% more power than SKiiP3 modules

Sintered modules boast higher operating temperature capability and extended service life

In cases with comparable mechanical designs, SKiiP4 modules deliver more power, as well as better load and thermal cycling capability than its predecessor SKiiP 3. Sintered chip connections – and hence the removal of solder joints – are the key to increasing the thermal cycling capability of these modules. *Engelbert Hopf, Deputy Editor-in-Chief, Markt & Technik*

Power electronics specialist Semikron recently made as much as 20 percent of its turnover on solutions in the field of renewable energies. Modules from the SKiiP family play an important role in this context. According to Thomas Grasshoff, Head of Product Management at Semikron, »almost 50 percent of the wind turbines in operation across the globe feature SKiiP modules. Now, the introduction of the new SKiiP4 modules has allowed Semikron to penetrate the market for higher power applications, supplying power converters for wind turbines with power ratings of up to 5MW.

Thomas Grasshoff

"SKiiP modules can be found in around half the wind turbines in operation around the world. With our SKiiP4 modules, we are now also offering compact solutions for wind turbines with outputs of up to 5 MW."

For comparable conditions and module sizes, the SKiiP4 power packs deliver up to a third more power than the current SKiiP3 modules. The new modules have been optimised for a maximum rated current of 3600 A at a maximum voltage of 1700 V. A 1200 V version of the SKiiP4 is also available. What both have in common is that for the first time six parallel half-bridges can be mounted on one heat sink. The technical properties of SKiiP4 make it the most powerful Intelligent Power Module (IPM) on the market at this time. »This new series of intelligent IGBT power modules is allowing us to step up our play on the markets for wind power and solar power installations, traction applications, elevator systems and industrial drives. For the first time, we can offer SKiiP technology for applications in these fields with power ratings of 400 kW to as much as 1.8 MW, « explains Ralf Herrmann, Product Manager for SKiiP at Semikron.

Ralf Herrmann

"The combination of a baseplate-less module design and solder-free connection technology means that there is no upper limit to the thermal cycling capability of SKiiP4 modules."

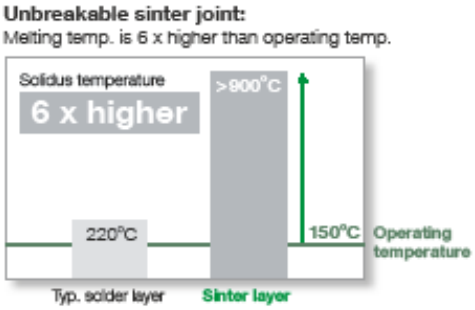
Just how beneficial the improved power density is for customer applications, is emphatically underlined by Mr Grasshoff: »For comparable conditions and module sizes, SKiiP4 offers a mechanical design concept that allows manufacturers of industrial drives to reduce the size of their inverter solutions by a factor of 1.5 - 2 as compared to solutions with SKiiP3 modules.« Thanks to the use of sinter technology to connect the semiconductor components to the ceramic substrate of the module, SKiiP4 solutions also have five times the thermal cycling capability of predecessor IPM solutions. The increase in power density in the modules opens up new design possibilities for customers. For instance, a 4-fold SKiiP3 module can be replaced by a 3-fold SKiiP4 module. At the same time, the mechanical compatibility of SKiiP3 and SKiiP4 modules

means that development engineers can upgrade power without altering their designs.

In terms of overall concept, Semikron has remained faithful to the principle that SKiiP modules are known for: well matched components from the heat sink and gate driver to drivers and protective sensors/functions. A further important factor contributing to increased power density in the modules is the mounting and connection technology. Here, as in previous SKiiP generations, mechanical pressure is used to “press” the chips onto the ceramic substrate of the DCB and the heat sink. This solder-free pressure contact system and the integrated laminated busbars guarantee homogenous current distribution. Every IGBT and diode chip is connected to the main terminal separately. In this way, the internal load resistances and losses are kept to a minimum. The laminated power rails also allow for a low-inductance and low-ohmic interface between the contacts and the silicon chips.

With rated currents of up to 3600 A, the SKiiP4 module is currently the most powerful IPM on the market. A SKiiP4 module is one third more powerful than a SKiiP3 module with the same mechanical dimensions. SKiiP4 modules are ideal for use in wind and solar power applications, traction applications, elevator systems and industrial drives with power ratings of 400 kW – 1.8 MW. Five times the thermal cycling capability as compared with conventional modules results in high reliability and extended service lifetime.

The power circuitry of SKiiP4 modules comprises IGBT4 chips and CAL4 diodes produced in-house at Semikron. Unlike in previous solutions, the chips in SKiiP4 modules are not soldered to the ceramic substrate but are joined using sinter bonds. In the sintering process, the chips are first positioned on a layer of silver paste. High pressure is then applied to create a permanent bond between chip and DCB. The silver layer is 4 times thinner and exhibits a far lower thermal resistance than a conventional solder connection. The high melting point of silver, which lies at +962 °C, prevents premature material fatigue due to stress induced by load cycling.



The melting point of silver lies at +962°. This is six times higher than the maximum operating temperature of the SKiiP4 module. Material fatigue of the sinter joint between the chips and DBC is thereby prevented.

Owing to the baseplate-free design of SKiiP4 modules, the solder-free connection between PCB and heat sink is quasi-flexible. This means that there is no upper limit to the thermal cycling capability, emphasises Mr Herrmann. In fact, Semikron’s in-house tests showed the thermal cycling capability to be five times higher than in standard modules.

Semikron’s first experience with sintered IGBT modules was two years ago, when it launched SKiM 63 and SKiM 93, the first ever solder-free, sintered 6-pack IGBT modules. »These modules were used in solutions for applications in the 22 to 150 kW power range, « explains Grasshoff, » which is a typical output range for electric and hybrid vehicles«. Sinter technology was used in these modules for the first time and brought about a 5-fold increase in module thermal cycling capability in comparison to conventional solutions, taking the thermal cycling capability to as many as 10,000 cycles for a Delta temperature of 100 Kelvin.

Semikron’s SKiiP4 modules are the first SKiiP solutions to offer a maximum junction temperature of +175 °C. The modules will initially be available in three mechanical designs with rated currents of 1800, 2400 and 3600 A. The modules will feature 3, 4 or a maximum of 6 integrated IGBT half-bridges. Customers can choose between a 1200 V and a 1700 V blocking voltage. Unlike previous SKiiP generations where the gate driver concept was based on analogue edge-

triggered signal transmission, the IGBT driver used in SKiiP4 modules employs digital signal transmission. »The use of digital technology, including pulse pattern and pulse width modulation, guarantees greater interference immunity in signal transmission, « says Mr Grasshoff reassuringly, »Signal integrity is far better than in edge-triggered signal transmission and is not affected by temperature fluctuations or ageing effects either.« The switching and sensor signal transmission channels feature galvanic isolation, meaning the user does not have to provide additional isolation. Important application parameters, such as the current state of integrated protective functions in the SKiiP4 module, are passed on to the user via a diagnosis channel with a CAN-Open characteristic, guaranteeing optimum evaluation.

For customers who require a maximum reliability guarantee for the performance of SKiiP4 modules in their particular application, Semikron offers, in addition to the standard function tests performed on all SKiiP modules, an optional burn-in test, a long-term test performed to check the basic functions and stresses of the IPM under worst-case real inverter conditions.

»One of the main reasons for doing a burn-in test «, explains Mr Herrmann, »is to determine statistic premature failure of individual IGBT cells and remove the cells in question. « The burn-in test is suitable for both air-cooled and water-cooled systems. To provide a realistic test set-up, the customer may choose between 1Q or 4Q operation.

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