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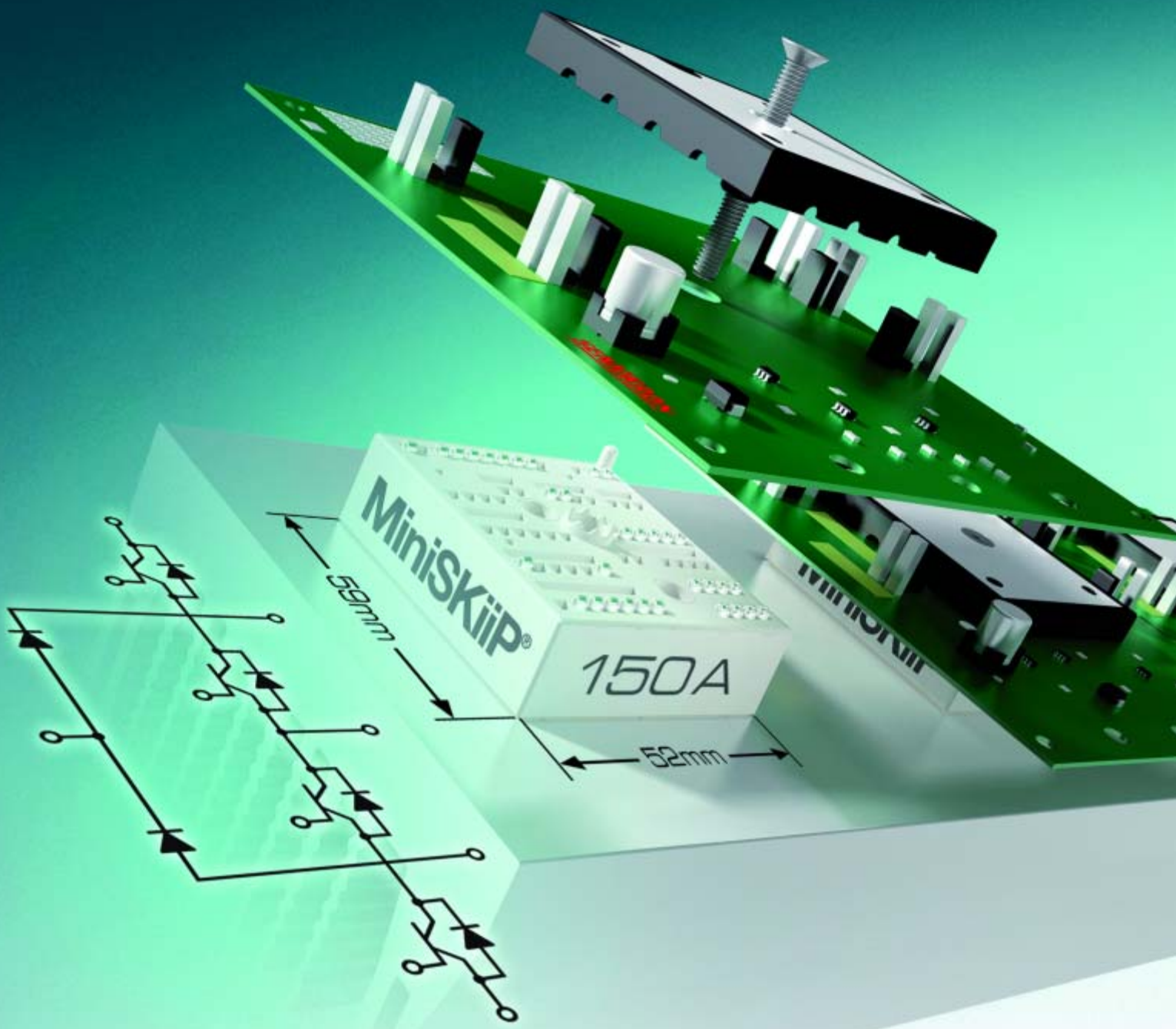

Taking Power Density to a New Level

Efficient inverter assembly now in even more applications

The well established, 15-year-old MiniSKiiP family now has two new additions: MiniSKiiP 3-level modules and the MiniSKiiP IPM. MiniSKiiP modules have proven to be very successful thanks to their power density, reliability and easy and fast one-screw mounting. The 3-level MiniSKiiPs deliver the highest rated current per module area among any competitor products and can help bring about an increase in efficiency in solar and UPS inverters thanks to the reduced switching losses. The IPM solution means short development times for the customer thanks to the removal of the driver development stage. Developments such as these will help the MiniSKiiP family establish itself as a standard platform in inverter technology.

By Alexander Langenbucher, Product Manager, Semikron

More than 15 million MiniSKiiP modules can be found in drives and frequency converters across the globe. European inverter manufacturers, in particular, use these modules for low-power applications of up to 30 kW. Three quarters of these applications are standard drives for pumps, robotic arms, printing presses or compressors. This figure is expected to increase by a further three million MiniSKiiP modules this year. Besides the established European market, the MiniSKiiP family is gaining ground on Asian markets, too. This product is also available from two other suppliers, a fact that ensures that customer demand for improved supply reliability is met. Thanks to the lower losses, the new 3-level topology boosts the efficiency of IGBT semiconductor modules and, consequently, the overall efficiency of power inverters. That is why 3-level MiniSKiiP modules are set to become standard in the coming years, especially in solar inverters and uninterruptable power supply systems.

In air conditioning systems and industrial drives, the MiniSKiiP IPM will continue to gain ground. These modules feature an integrated driver and the corresponding driver circuits, and boast optimized switching properties. This means that any application where the driver properties don't have to be specifically adapted can be covered, which is true in around 80 per cent of applications. The result is the gate driver no longer has to be adapted to the power modules and the time-to-market for products featuring MiniSKiiP IPMs is far shorter.

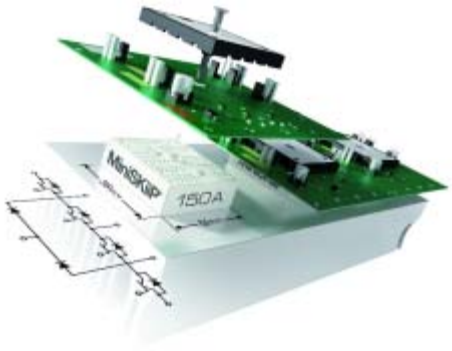

Figure 1: The 3-level MiniSKiiP module allows for the design of compact 3-level inverters thanks to the highest current density in the market and no space consuming busbars needed.

Greater efficiency, lower costs

An increase in energy costs of around 40 per cent over the past ten years has made the use of an inverter for drive control increasingly appealing. Besides high efficiency, energy cost savings can be made, inverter losses reduced and the resulting overall inverter costs cut. The high level of efficiency is of great importance, particularly in the markets for UPS systems and solar inverters. It is these very markets that will now profit from the 3-level topology in terms of efficiency gains and line quality improvements.

The first 3-level topology was in fact proposed almost 30 years ago. Technological progress on the inverter market, however, did not move quickly enough in this direction. To begin with, for efficiency reasons, this configuration was used in high-voltage applications. Today, in addition to UPS systems and solar inverters, this topology can also be found in applications where high switching frequencies are needed. Thanks to the far lower losses in comparison to a conventional 2-level solution, 3-level topology enables savings of up to 40 per cent in the overall losses – and even more for higher switching frequencies.

3-level topology reduces harmonics

A reduction in switching losses is the first, fundamental difference between 2-level and 3-level topology and results from switching only half of the voltage level. Modules in 3-level topology may need more power semiconductors – ten per phase leg in a 3-level module (four IGBTs in series) and four in a 2-level module; this, however, is compensated for somewhat by the higher current densities of the 600V semiconductors in comparison to 1200V semiconductors. Another difference which brings about several advantages at the same time is the improved spectral performance. To keep the harmonics as low as

possible, a 2-level module needs large filters, while 3-level modules have an intermediate stage for the output voltage. In this way, the output signal can be met far better, i.e. it becomes more harmonic, and the filter size – and hence the filter costs – can be reduced.

The better quality of the output voltage signal, or of the lower distortion factor for the same switching frequency, is of great importance in electric energy supply networks. Since inverters do not cause sinusoidal current in the energy supply network and these harmonics – put simply – distort the line voltage, a low THD (Total Harmonic Distortion) in the line voltage equals good voltage quality in the line. Owing to the low distortion factors of the output current, applications which need a high switching frequency do not require, for example, expensive line filters. It is also possible to optimize such an application to suppress inverter noise in work environments such as offices or factories.

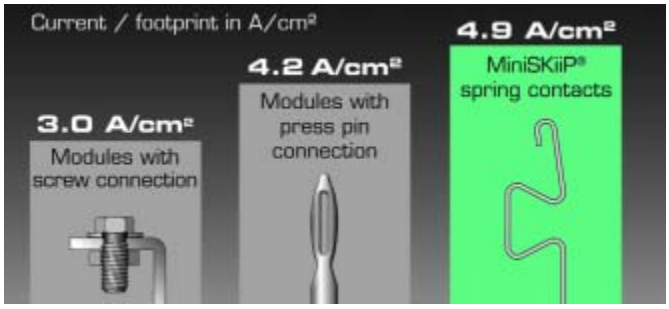

Figure 2: Comparison: power density of 3-level MiniSKiiP with competitor modules

One-step assembly

The layout of the 3-level MiniSKiiP modules has been optimized: the four different commutation paths cover a minimum area and their terminals are as close together as possible. In this way, module inductance and the resultant overvoltages are kept to a minimum. And there is more: thanks to the use of spring contacts, the power density of 3-level MiniSKiiP modules is as high as 4.9 A/cm², 0.7 A/cm² more than in modules with press pins and 1.9 A/cm² more than modules with screw connections. In the MiniSKiiP family, the rated current per module area is almost twice as much as in other 3-level modules, and no solid bus bars are needed between the three phases. This fact, coupled with the smaller filter size as mentioned above, makes it possible to develop much smaller inverters.

The assembly of MiniSKiiP modules is very simple: the module is connected to the heat sink and driver board with a single screw, creating the electric and thermal connection at 150 A rated module current. Time-consuming solder processes are not needed and the PCB can be easily replaced, if necessary, thanks to the use of spring contact technology. In other words, single-step assembly – another merit that will help make the MiniSKiiP become an industrial standard – which can bring about savings of up to five US dollars per inverter assembly, irrespective of the case size.

Integrated driver for easier inverter development

All these advantages regarding assembly also apply to MiniSKiiP IPMs. For a case volume of 49 cm3, however, these deliver not only 50% more current density than IPMs with comparable topology, but also offer additional functions, because the driver is already integrated. The HVIC (High-Voltage-Integrated-Circuit) driver in SOI (Silicon-On-Insulator) technology contains an innovative level converter to control the high-side or low-side IGBTs in order to improve electromagnetic immunity and switching behaviour. In addition to the drivers, the gate resistors used enable the IPMs to cover 80 percent of all applications. This is particularly attractive for SMEs which, on the one hand, do not have to worry about driver integration and, on the other hand, do not need the relevant driver development capacities either. Only the controller has to be programmed and connected.

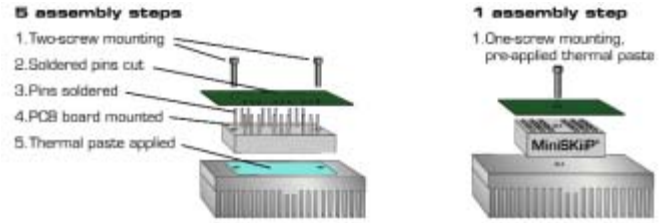

Figure 3: Comparison of the assembly of a competitor solder module (left) and MiniSKiiP (right). Thanks to the fast and easy one-screw mounting of MiniSKiiP modules the production costs of inverters can be reduced significantly. The number of production steps and the time-consuming solder processes are not needed thanks to the use of spring contact technology.

In order to give the user sufficient configuration possibilities, the MiniSKiiP IPM has both an ITRIP input for current monitoring and an additional multi-purpose error input with a higher switching threshold. These inputs give additional freedom of adaptation in an application. Every MiniSKiiP module comes with a suitable integrated temperature sensor.

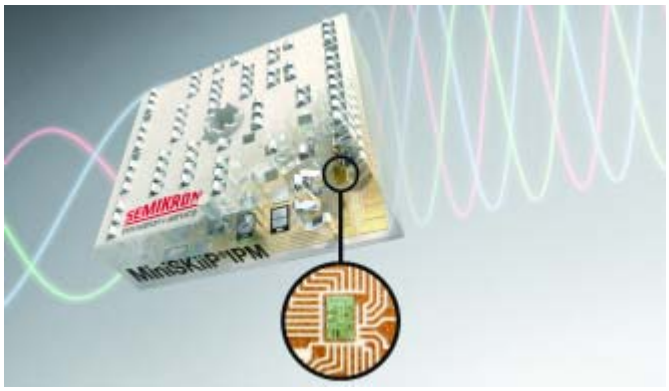

Figure 4: The MiniSKiiP IPM with integrated driver was developed for frequency inverters for industrial drives and UPS applications with a voltage range of 600V and 1200V with up to 15kW output power and is based on the MiniSKiiP spring contact technology.

Conclusion

MiniSKiiP is an established name in the world of power electronics. These modules are prized for their excellent power density, but also their fast and easy assembly. In fact, to connect the MiniSKiiP module, PCB and heat sink, just one single screw is needed. Instead of solder contacts, all of the power, gate and auxiliary connections to the PCB are made using pressure contacts. Thanks to the spring contact system - a unique selling point of this system over competitor IGBT modules – the electrical contacts boast longer service life and greater reliability, and the vibration resistance of the entire system is improved. With the new additions to the MiniSKiiP range – the efficient 3-level MiniSKiiP with its low distortion factor and the MiniSKiiP IPM featuring integrated driver – these modules now enable cost-effective, efficient inverter use in many new areas of application.

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