# Solder-Free Pressure Contact Modules for Automotive Applications

While some suppliers of power electronics are still improving standard solder contacts in modules, solder-free pressure contact technology has become the solution for state-of-the-art power electronic modules with high power cycling capability. **Thomas Grasshoff, Head of Product Management International, SEMIKRON International, and Christian Daucher, Product Manager Semikron Elektronik, Nuremberg, Germany**

**The new SKiM sixpack IGBT module** family from SEMIKRON takes the pressure contact module design without baseplate to the next level. The robust high power module design makes it well-suited for hybrid electric vehicles and other high end applications. Compared to modules with baseplate and internally soldered main terminals, the SKiM without baseplate and solder-free pressure contact has a 5 times higher temperature cycling capability (Figure 1).

## Designed for demanding environmental requirements

The environmental requirements for electric drive systems in hybrid or electric vehicles are very demanding in terms of ambient temperatures, power and temperature cycling and size.

With the next generation of hybrid vehicles a single coolant loop will be used, taking the water temperature as high as 105°C for regular operation and up to 120°C with power derating. The maximum ambient air rating for the power electronic components is >125°C. Additionally, a compact package and a robust design in terms of vibration and shock is a must. High power densities at coolant temperatures of 105°C can only be achieved with a maximum junction temperature above 150°C.

In power modules with solder contacts and baseplate, the power cycling capability is drastically reduced with higher operation temperatures due to solder fatigue. Matched materials with a careful consideration of the Coefficient of Thermal Expansion (CTE), as well as advanced packaging and bonding technologies, become essential to success.

Most critical is the difference in the CTE of copper (baseplate) and DBC substrate because of the large area solder connection between DBC and baseplate. This joint is mostly stressed at passive temperature cycling. The failure mechanism is solder fatigue which will cause an increase of thermal resistance and early module failure. The higher the temperature changes, the quicker the fatigue sets in.

Quite the opposite occurs with a solder-free pressure contact module without a copper baseplate. In SKiM, a newly developed pressure system based on a laminated bus bar sandwich presses the substrate with the chips directly to the heatsink. Since every IGBT and diode chip has its own connections to the main terminals, the current distribution between the paralleled dice is very homogeneous and the package resistance $R_{CC'+EE'}$ is low. The large area joint between DBC substrate and heatsink is not soldered and the substrate has the ability to 'move' on the heatsink with virtually no limitation in terms of temperature cycling reliability.

Due to costs and high power density requirements, but relative poor thermal performance, AlSiC is not a substitute for copper baseplates.

## Advanced pressure contacts

As a solution to this problem SEMIKRON developed the SKiiP technology more than 15 years ago, a pressure contact system where no

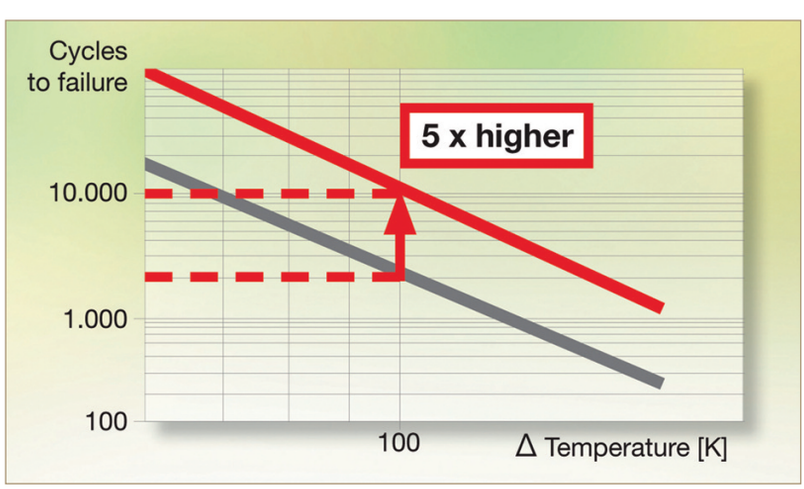


**Figure 1: Comparison between SKiM and a soldered standard module with baseplate (red curve – SKiM module, grey curve – standard module with baseplate and solder contacts)**

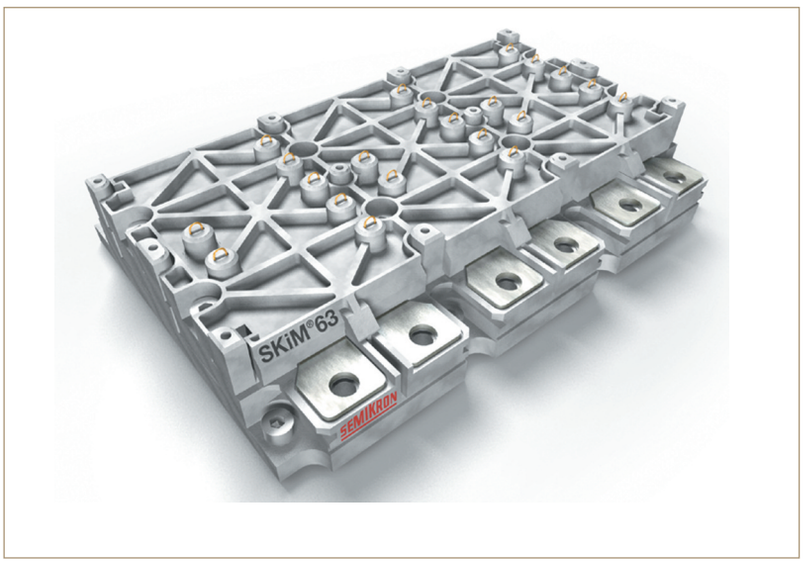


**Figure 2: Solder-free pressure contact module SKiM 63 for demanding automotive applications**

baseplate is necessary. This eliminates the large area solder connections totally and replaces them by pressure contact. This SKiiP technology has now been further advanced specifically for the new SKiM automotive module concept to ensure a robust, reliable and durable module. SKiM was designed to fulfil the stringent requirements for automotive applications with high power densities and harsh environmental conditions.

The electrical circuit of the SKiM IGBT module family is a six-pack with three individual half-bridge sections. Each half-bridge section has its own DC terminals and an integrated NTC temperature sensor. The auxiliary contacts to control the IGBTs are solder-free spring contacts. The IGBT driver is electrically connected by mounting on top of the module. At the common height of 17mm, the DC- and AC-terminals have the same DC terminal positions and construction principle, which makes this module the optimum choice for modular designs with different current levels.

The reduction of carbon dioxide and sustainability are current buzz words. To meet these and future environmental challenges variable speed drives have to be become a more important part of the automotive market. The SKiM module family is a development especially for the automotive market where the fastest growing sectors are hybrid- and electric vehicles and busses.