# New 1200V SPT+ IGBT Chips in SEMiX Power Module Platform

The main trends in power inverter designs are size reduction and thereby increased power density, as well as shorter development times and cost reduction. Semikron have improved their SEMiX power module range with the new SPT+ 1200V IGBT chip technology in order to accelerate these trends. **C. Daucher, SEMIKRON Elektronik; D. Seng, A. Wahi, SEMIKRON International, Nuremberg, Germany**

**Modern inverters are designed to reduce** size, increase power levels and functionality at a significant cost reduction. The latter can only be reached when focussing on the total costs of the system. A simple design (e.g. DC-link, heatsink), easy assembly and platform technologies consisting of robust devices with reduced needs of passive filtering become vital aspects to be taken into consideration.

## Flexible module platform

SEMiX is a module platform with IGBT and rectifier devices [1]. The main features are the location of the AC and DC main terminals on the opposite sides of the housing and spring contacts for the auxiliary connections (Figure 1). The separated 17mm high main terminals allow for a low inductance design and a simplified DC-link structure. Thanks to the spring contacts the control PCB with driver etc. can be mounted directly onto the power module without any wiring or soldering. The product line is available in five different housings and topologies, hereby providing a more options for inverter designs, from standard drives and power supplies up to customised applications (Figure 2).

The flexibility of the SEMiX package is further improved by the inclusion of rectifier topologies with diodes and thyristors. When the rectifiers are used in combination with SEMiX IGBT modules, the design of the inverter can be optimised with a low inductance DC-link with easy bending and simplified production steps. All components including the IGBT driver and the thyristor firing circuits can be mounted from the top, without any wiring or soldering.

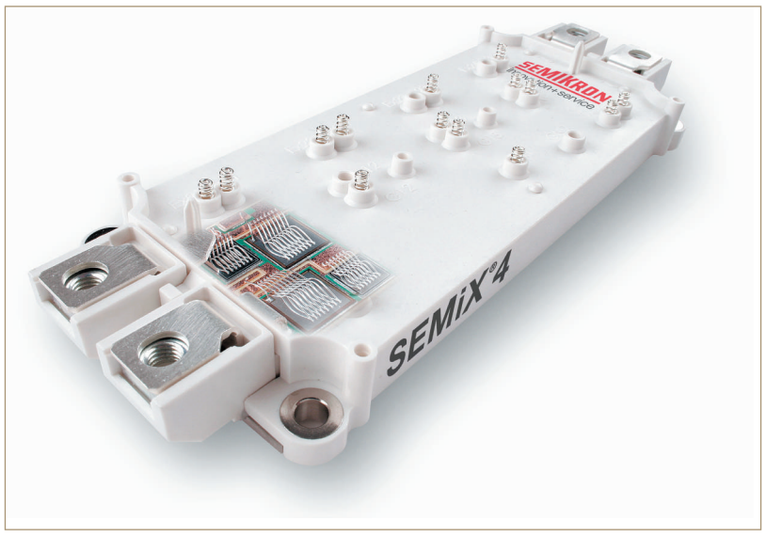


**Figure 1: SEMiX 4 with separated AC and DC main terminals and springs for auxiliary contacts**

## Rugged SPT+ IGBT chips

The Soft-Punch-Through (SPT) chip design is based on a Planar-Gate/Punch-Through IGBT technology. It offers important benefits for most of the applications compared to other technologies, i.e. lower switching losses, larger chip sizes, positive temperature coefficient and lower wafer production costs. SEMIKRON has successfully used this chip for their standard SEMiX IGBT module range above 75A since 2003.

In 2005, the second generation SPT+ IGBT technology was presented (Figure 3), which is now commercially available [2].

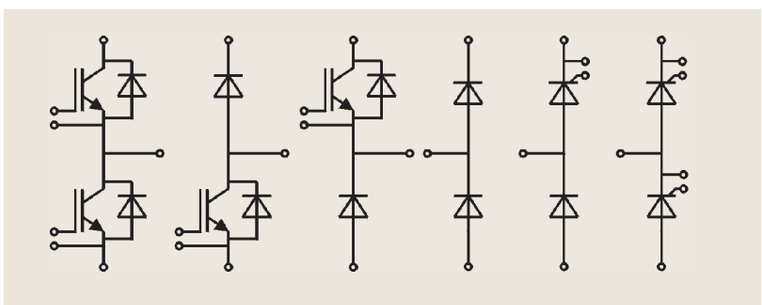

**Figure 2: Available SEMiX module topologies (600V, 1200V, 1700V) and rectifiers**

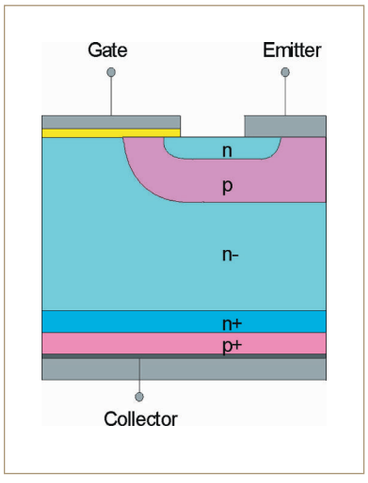


**Figure 3: Principle structure of planar SPT+ IGBT cell**

| $I_{C,nom}$ = 300 A | SPT | SPT+ |
|---|---|---|
| $V_{CE,sat}$@125°C [V] | 2,1 | 2,0 |
| $E_{on}$ [mJ] @ $R_{g,nom}$ | 22,5 | 19,5 |
| $E_{off}$ [mJ] @ $R_{g,nom}$ | 34,5 | 33 |
| $di/dt_{max}$ [A/µs] | 5250 | 5600 |
| $V_{GE\ max}$ [V] | 797 | 748 |
| 100A chip size [mm²] | 158 | 134 |

**Table 1: Comparison of electrical parameters (typical values)**

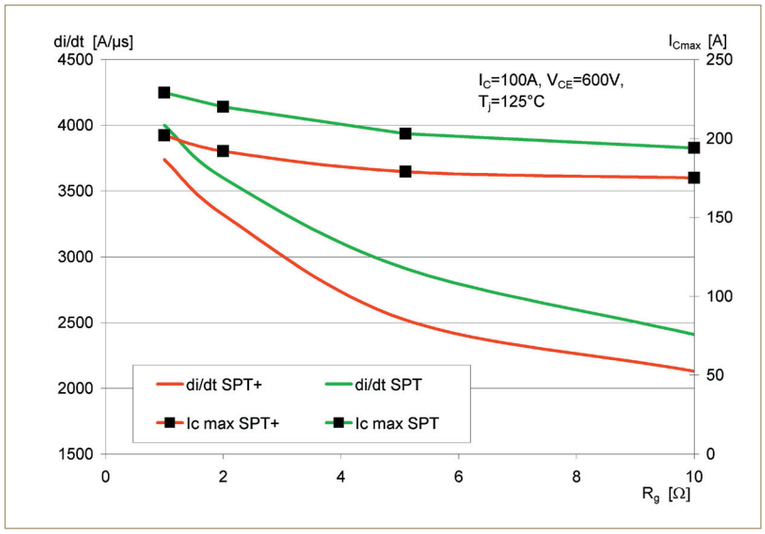


**Figure 4: Softer switching behaviour of SPT+ versus SPT**

With the new SPT+, the charge carrier profile was enhanced compared to the earlier SPT IGBT generation. This improvement allowed a reduction of the chip size and additionally optimised the electrical performance [3]. A smooth switching behaviour while maintaining the high turn-off ruggedness is now combined with reduced on-state losses. A comparison of the most important electrical parameters of both chip technologies is given in Table 1.

The previous IGBT chip generation in 2002 required an increased design effort in several applications handling high switching speed. The high di/dt values caused over-voltages and EMI issues. The new SPT+ chip technology addresses these concerns and behaves smooth and soft especially during turn off. As a result the over-voltages are reduced though lower values for the gate resistors are possible. Figure 4 shows the lower di/dt values of the SPT+ IGBT in comparison with the present SPT and the resulting reverse peak currents.

## Inverter performance and design

Figure 5 shows the maximum output current IRMS as an example of a three-phase inverter with sinusoidal currents. These currents are calculated for SEMiX modules with SPT and SPT+ chip sets and identical nominal current ratings. The cooling conditions, $V_{CC}$ voltages, power factor etc. are similar for both modules. It can be seen that the new SPT+ chip has a better performance than the present SPT chip generation due to the reduced on-state losses.

For higher switching frequencies, the total power losses increase. The thermal resistance of the heat sink $R_{th(s-a)}$ becomes the limiting factor so that the difference in IGBT chip performances are not recognisable in this calculation.

Besides the module characteristics the mechanical design of the inverter is also important for the overall system performance. A low inductance DC connection and a balanced current sharing between paralleled modules are mandatory. The new IGBT chip technology in combination with SEMiX packages offers the opportunity designing very compact stacks with minimum effort. Figure 6 shows an example of a low profile rack mountable stack design.

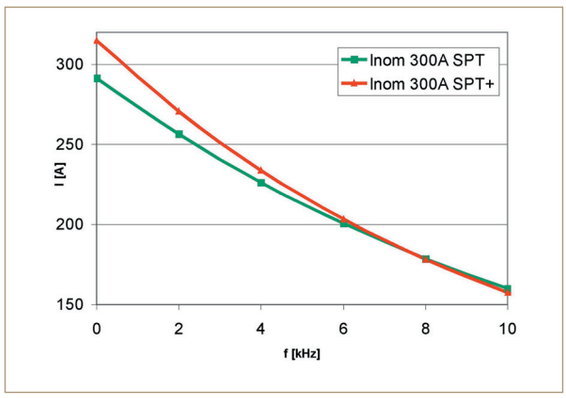


**Figure 5: Module output current versus switching frequency; conditions: cosj = 0,85, $V_{cc}$ = 600V, $T_a$ = 40°C, heatsink P x 16_360_16B, $T_j$ = 125°C**

## Conclusion

The new SEMiX IGBT modules with SPT+ chips offer reduced overall losses and - most important - a softer switching behaviour resulting in lower voltage over shoots. The new IGBT chip technology in combination with modern SEMiX packages allow for new concepts in frequency inverter designs. This means a reduction of the overall losses, reduced cooling effort, lower volume and weight and at the end lower system cost.

## References

*[1] R. Annacker, T. Grasshoff; 'SEMiX - A new platform for IGBT modules'; PCIM Europe, Issue 08, 2003*

*[2] M. Rahimo et al., 'SPT+, the Next Generation of Low-Loss HV-IGBTs'; Proceedings PCIM '05, Nuremberg, Germany, 2005*

*[3] M. Rahimo, A. Kopata, S. Eicher; 'Next Generation Planar IGBTs with SPT+'; Power Electronics Europe, Issue 06, 2005*

**Figure 6: Low profile inverter design with SEMiX rectifier and IGBT modules driven by SKYPER PRO**