Bodo´s Power Systems®

200A/600V Silicon Carbide Hybrid Intelligent Power Module for Servo-Inverter Applications

In Multi-Axis Servo-Drives several servo amplifiers are operating from a common DC-link power supply. Mechanically those servo amplifiers usually are mounted in a so called "book-shelf-arrangement" in a common mechanical rack. This specific construction principle is providing a limited space at each inverter's backside for cooling the power semiconductors.

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With its S1-Series IPM Mitsubishi Electric was providing a dedicated solution for this specific application (module ratings see Table 1). The baseplate width of S1-IPM is only 50mm (see Figure 1), allowing a narrow housing for each servo amplifier and thus a compact size of the whole multi-axis servo rack.

As next step Mitsubishi Electric now is introducing its new Silicon Carbide Chip technology into this proven IPM design. A new 200A/600V 6in1 IPM (type name PMH200CS1D060) was developed by using SiC Schottky Barrier Diodes (SBD). This approach is called "Hybrid SiC" module. For better understanding the used terminology, please refer to Figure 2.

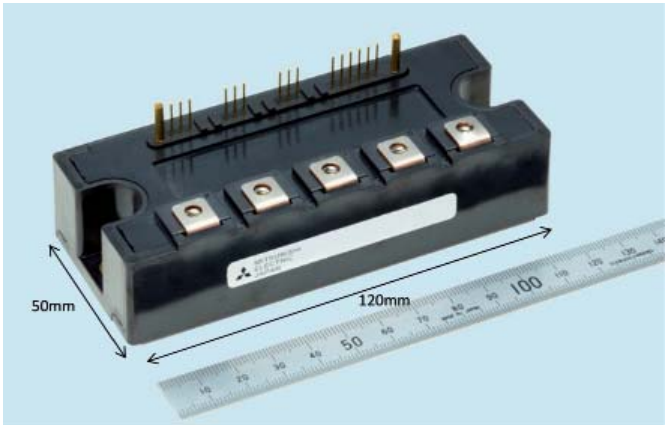

Figure 1: S1-series package outline, Baseplate footprint: 50x120mm

S1-Series IPM	Vces (V)	Ic(A)					
	600	-	50	75	100	150	200
	1200	25	50	75	100	-	-

Table 1:S1-Series line-up

A hybrid SiC module is containing Silicon-based IGBT in combination with SiC-based Schottky barrier diodes. The main benefit of using SiC Schottky barrier diodes as free-wheeling diodes is the drastically reduced switching loss in the diode itself. As shown in Figure 2 this results also in a substantial reduction of IGBT-turn-on loss.

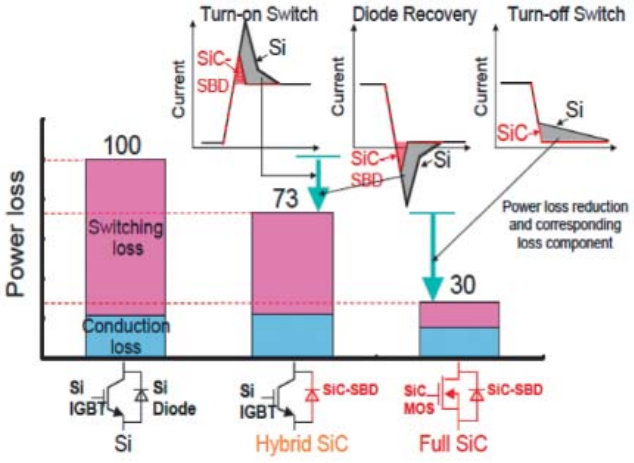

Figure 2: Evolution of SiC technology in power modules

Both effects are very welcome in servo inverter applications which are operating typically at high PWM switching frequencies. This was the motivation and background for developing this new 200A/600V hybrid SiC IPM dedicated for servo inverter applications.

The switching energy characteristics of the new SiC hybrid module PMH200CS1D060 are shown in Figure 3; the switching energy characteristics of its Si-based predecessor type PM200CS1D060 are shown in Figure 4.

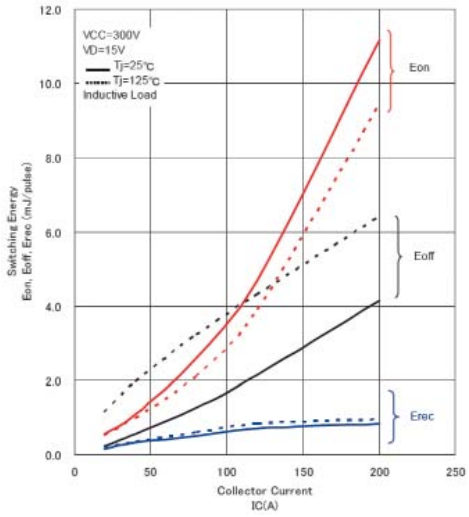

Figure 3: Switching loss of PMH200CS1D060 (Hybrid SiC-Module)

When comparing those characteristic curves (for example at Tj=125°C and rated current 200A) we can find 2 improvements caused by the SiC Schottky barrier diode in PMH200CS1D060:

- FWDi switching loss is reduced from 5mJ to 1mJ
- IGBT turn-on loss Eon is reduced from 11mJ to 9,5mJ
- Carrier life time control of IGBT chip was improved to suit with SiC Schottky barrier diode specification. As a results of improvement, IGBT turn-off loss Eoff was improved from 7.5mJ to 6.5mJ.

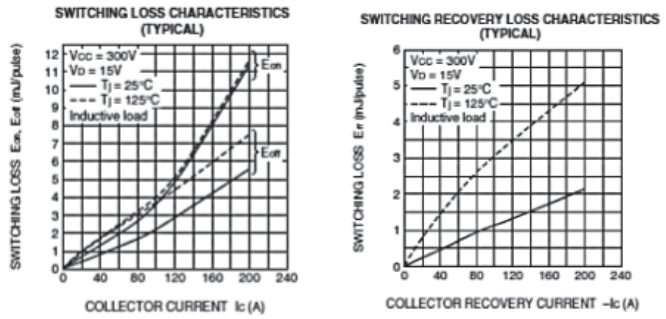

Figure 4: Switching Loss of PM200CS1D060 (Si-Module)

A substantial switching loss reduction in PMH200CS1D060 has been obtained. This is helping the inverter designer to overcome the typical for servo applications thermal constrains in high overload situations, particularly at high PWM switching frequency.

All other specific features of S1-series IPM have been preserved. For completeness they will be briefly reviewed as follows (see Figure 5):

- Short circuit protection by current sense emitters in each IGBT chip
- Over temperature protection by monolithically integrated Tj-sensors in each IGBT chip
- Control power supply under voltage protection
- Error output from n-side switches

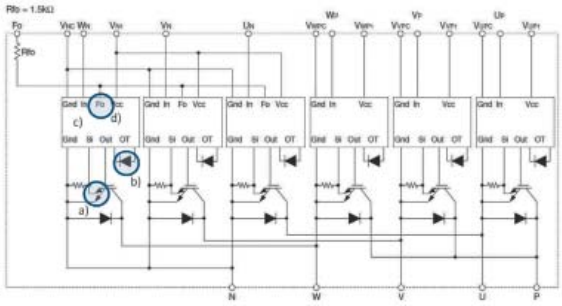

Figure 5: Functional block diagram PMH200CS1D060

Summary

Mitsubishi Electric has developed a new 200A/600V 6in1 Intelligent Power Module with Silicon Carbide (SiC) Schottky barrier diodes and improved Si-IGBTs. This hybrid SiC design approach leads to a substantial reduction of switching losses, particularly in the free-wheeling diode. In combination with the slim module package and the dedicated protection functions of S1-series IPM the newly developed hybrid SiC IPM type PMH200CS1D060 is offering an excellent technical solution for new multi-axis servo inverter designs.

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