High Speed Hybrid Modules Combining High Speed IGBTs with SIC-SBDs

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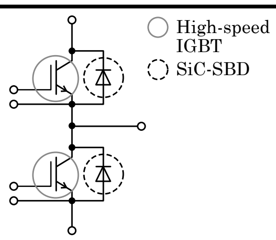
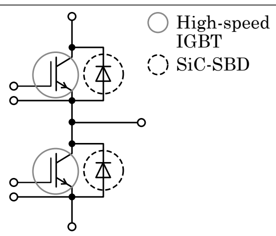
In recent years, there has been greater demand to reduce emissions of greenhouse gases such as CO_2 as a measure to suppress global warming. In order to achieve this, it has become necessary to promote a higher degree of energy savings in a variety of fields. Innovation of components such as power devices, circuits, and control mechanisms is required to advance energy savings in power conversion equipment typified by inverters, and it has become an important goal to achieve even less power dissipation in power devices. Moreover, in order to realize further miniaturization and better efficiency in power conversion equipment, an increasing number of applications are performing power conversion at high frequencies, and there is greater demand for high-speed low-loss switching. It is against this background that Fuji Electric has developed and commercialized high-speed hybrid modules that incorporate a high-speed insulated gate bipolar transistors (IGBT) that can operate at a switching speed of 20 kHz or higher and Schottky barrier diodes (SiC-SBD) into a conventional package (see Table 1).

1. Features

The high-speed hybrid module, which combines high-speed IGBTs and SiC-SBDs, makes use of the same package as conventional Si modules in order to maintain compatibility. The diode makes use of a Fuji Electric SiC-SBD chip (withstand voltage of 1,200 V) while the IGBT makes use of a chip optimized for high-speed switching based on the 6th-generation "V Series." In 1,200-V/200-A rated products, loss is reduced by approximately 56% compared with the 7th-generation "X Series" Si modules.

Table 1 High-speed hybrid module

Package	Equivalent circuit
 Standard 2-in-1 M276	
 Dual XT M254	

1.1 Product line-up

Table 2 shows the product line-up for the high-speed hybrid module. Fuji Electric has recently developed a module with a 2-in-1 circuit configuration.

1.2 Generated loss of inverter

In this section, as an example, the generated loss of an inverter equipped with a 1,200-V/200-A hybrid module that utilizes an M276 package is described. Figure 1 shows the result of simulating generated loss in the inverter. In the high-speed switching region with a switching frequency of 20 kHz or higher, the generated loss of the inverter equipped with the high-speed hybrid module was approximately 56% less than that of the X Series Si module. Furthermore, the rate of reduction increased in correlation with increases

Table 2 High-speed hybrid module product line-up

Package	Circuit configu-ration	Dimensions W × D × H (mm)	Rated voltage (V)	Rated current (A)
Standard 2 in 1	2 in 1	62.0 × 108.0 × 30.9	1,200	200
				300
Dual XT	2 in 1	62.0 × 150.0 × 20.5	1,200	300

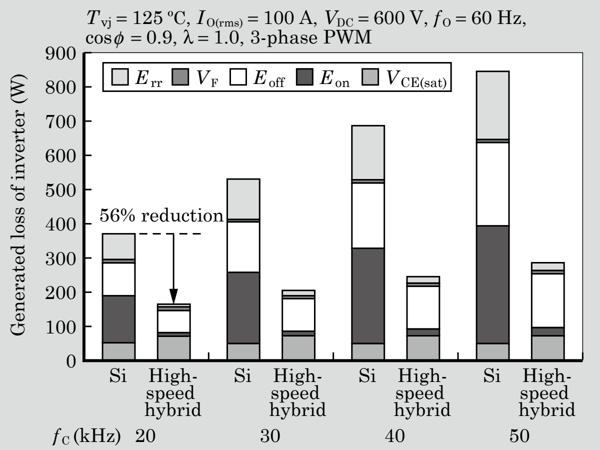


Fig.1 Inverter generated loss simulation results

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in switching frequency, and it can contribute to high-efficiency operation and miniaturization through the high-frequency operation of the inverter.

2. Supporting Technologies

2.1 SiC-SBD based reduction of turn-on loss and reverse recovery loss

Figure 2 shows a comparison between reverse recovery waveforms of the high-speed hybrid module and X Series Si module. The high-speed hybrid module has a considerably small reverse recovery current peak value. This is explained by the fact that SiC-SBD is a unipolar device, and so it causes no minority carrier injection. Compared with the X Series Si module, the 1,200-V/200-A high-speed hybrid module reduces reverse recovery loss by 92%.

Furthermore, the peak value of the reverse recovery current in the free wheeling diode (FWD) is reflected in the peak value of the turn-on current in the IGBT of the opposing arm. As the peak value of the reverse recovery current gets smaller, the peak value of the turn-on current reduces, allowing the IGBT to reduce turn-on loss. Figure 3 shows a comparison between turn-on waveforms of the high-speed hybrid module and X Series Si module. Similar to reverse recovery waveforms, the peak value of the turn-on current is quite small. Compared with the X Series Si module, the 1,200-V/200-A high-speed hybrid module reduces turn-on loss by 84%.

2.2 High-speed IGBT based reduction of turn-off loss

The high-speed IGBT is based on existing V Series IGBT. It reduces turn-off loss by using an active structure that significantly reduces parasitic capacitance and by reducing the concentration of impurities in the collector layer responsible for suppressing hole injection. Figure 4 shows a comparison between turn-off waveforms of the high-speed hybrid module and X Series Si module. Compared with the X Series Si module, the high-speed hybrid module achieves a

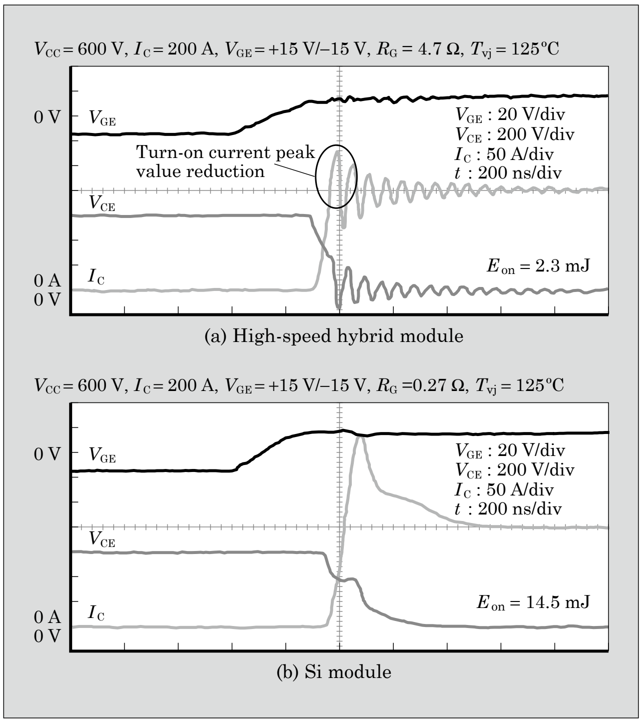

Fig.3 Turn-on waveforms

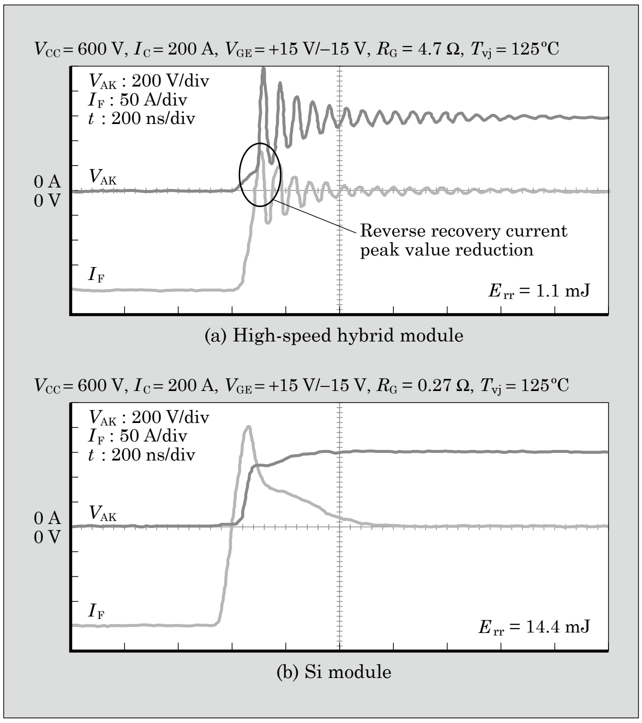

Fig.2 Reverse recovery waveforms

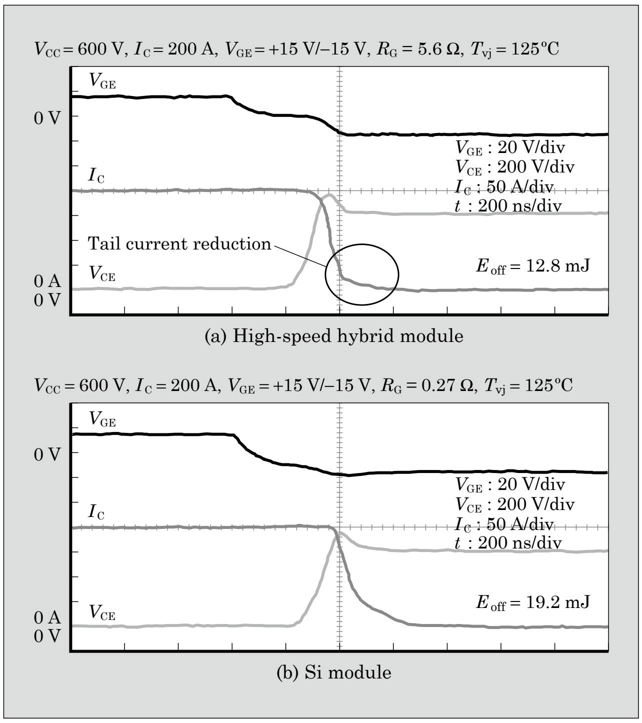

Fig.4 Turn-off waveforms

33% reduction by greatly improving tail current during turn-off.

Launch time

August 2019

Product inquiries

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