7th-Generation "X Series" 1,200-V/250-A RC-IGBT Modules

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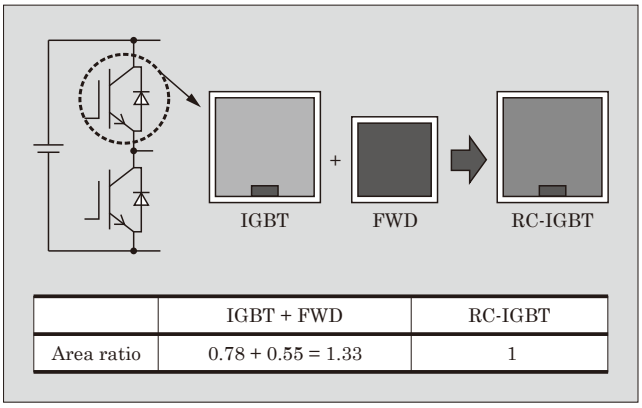
In recent years, the demand for energy has been expanding worldwide due to population growth and economic growth. At the same time, various measures are being taken to counter global warming by reducing CO_2 emissions and to realize a responsible and sustainable society. These circumstances have created increasing expectations for power conversion systems that efficiently and stably convert electrical energy. Expectations are also rising for insulated gate bipolar transistor (IGBT) modules as key devices used in power conversion systems.

It is against this backdrop that Fuji Electric has been using a number of technological innovations to achieve IGBT modules with miniaturization, lower loss, and higher reliability, contributing to power conversion systems with reduced size and higher output currents. These enhancements have helped reduce the cost and improve the performance of equipment. Our 7th-generation "X Series" IGBT modules are the latest products in the series and achieve even higher power density through lower loss and higher reliability.

However, if the power density of IGBT modules is increased by further downsizing and increasing output current, the junction temperatures of the IGBTs and FWDs in IGBT modules will increase, which may cause a reduction of reliability. In order to further increase the power density of IGBT modules while maintaining a high level of reliability, we developed X Series RC-IGBT modules for industrial applications with reverse-conducting IGBT (RC-IGBT) technology in addition to X series technology.

1. RC-IGBT Features

In general, IGBT modules used in power conversion systems consist of two types of semiconductor chips, namely, IGBT and FWD chips. These are connected in antiparallel as shown in Fig. 1 (IGBT + FWD configuration). In contrast, RC-IGBT modules combine the features of inversely connected IGBTs and FWDs into a single chip. Under the same constant current rating conditions, if the area of the RC-IGBT chip is 1, the area of a conventional IGBT chip would be 0.78 and the area of the FWD chip would be 0.55. Therefore, the heat dissipation area of each chip in the RC-IGBT is larger and the thermal resistance is lower than that of conventional chips. Furthermore, the area of the RC-IGBT chip can be reduced by approximately 23% compared to the total area of a conventional IGBT chip and FWD chip.



	IGBT + FWD	RC-IGBT
Area ratio	0.78 + 0.55 = 1.33	1

Fig.1 RC-IGBT chip schematic

The output current of the RC-IGBT module has been expanded while maintaining the same package, thanks to the low loss of X Series chip technology and the improved heat dissipation of the RC-IGBT.

2. Product Line-Up and EconoPACK™ 1,200 V 250 A

Figure 2 shows the product appearance, line-up and

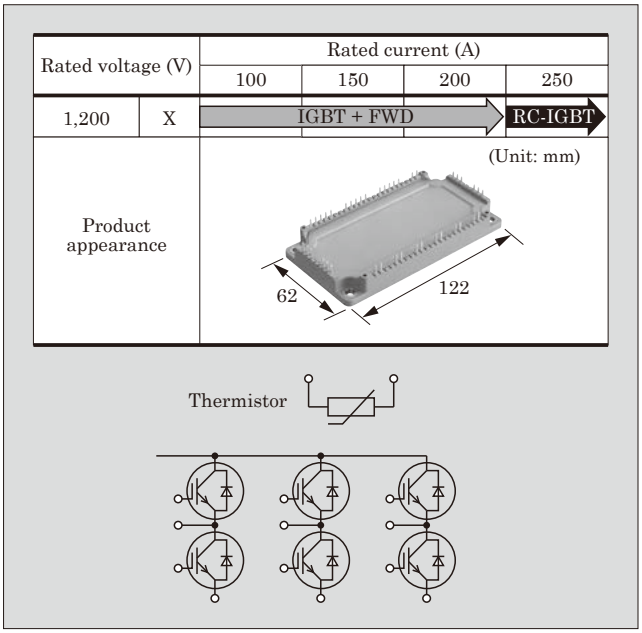


Fig.2 EconoPACK™ 1,200-V line-up

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equivalent circuit diagram of the newly developed 250-A 6-in-1 X Series RC-IGBT module with EconoPACK™*1 package. This package was used to achieve a maximum current rating of 200 A for conventional X Series IGBT modules that combine IGBTs and FWDs.

The X Series RC-IGBT module has improved the saturation-voltage and switching-loss trade-off relationship and has reduced generated loss by applying X Series miniaturization and wafer thinning technology. Moreover, the use of a high-heat-dissipation insulating substrate as one of the package technologies of the X Series and the enlargement of the chip area using RC-IGBT single chip technology, has reduced thermal resistance and improved heat dissipation compared to conventional products. These technologies have increased the current rating to 250 A in the same package as a conventional IGBT + FWD module.

3. Features

Figure 3 shows an operation pattern of switching from continuous rated output operation (100% load) to overload operation (200% load, 3 s) in a power conversion system. By switching to overload operation, the output current increases and the heat generated by the module increases rapidly. Figure 4 shows the results of calculating the power dissipation, junction temperature T_{vj}, and the increase in junction temperature ΔT_{vj} from the steady-state operation during 3 s of overload operation with the operation pattern shown in Fig. 3. The X Series RC-IGBT module has 9% lower power dissipation under the same operating conditions compared to the X Series IGBT module. In addition, the maximum junction temperature $T_{vj\ max}$ is lowered by 31°C.

Figure 5 shows the junction temperature after 3 s of overload operation as a function of the rated output current during the operation pattern shown in Fig. 3.

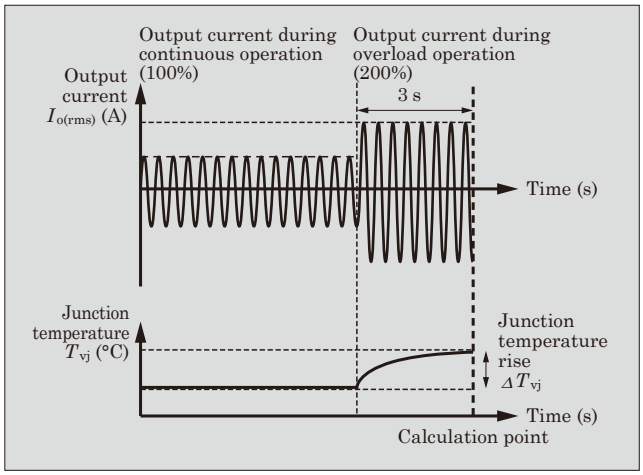

Fig.3 Operation pattern during overload operation

*1 EconoPACK™ is a trademark or registered trademark of Infineon Technologies AG

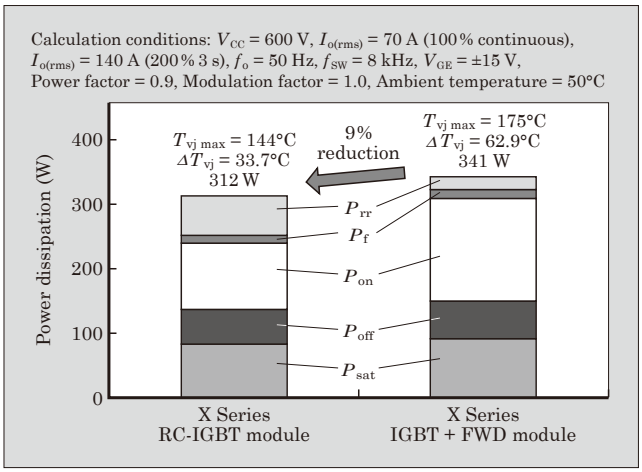

Fig.4 Generated loss and junction temperature during overload operation

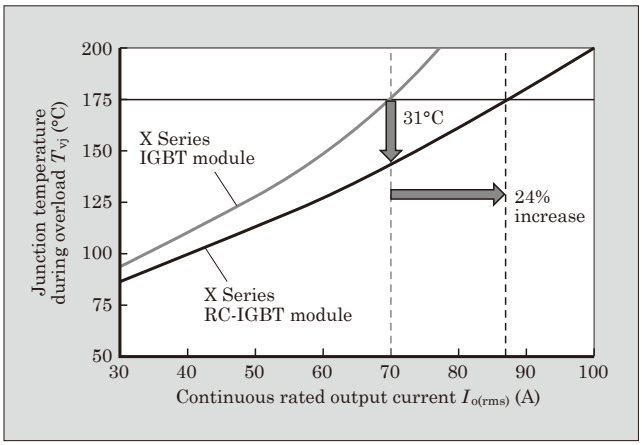

Fig.5 Output current and junction temperature during overload operation

At a junction temperature of 175°C, the X Series RC-IGBT module can increase output current by 24% compared to the X Series IGBT module. As a result, output current expansion and size reduction of power conversion systems can be achieved by applying the X Series RC-GBT module.

4. Ensuring Reliability in EconoPACK™ 1,200-V/250-A RC-IGBT

Figure 6 shows T_{vj} waveforms in X Series IGBT module and X Series RC-IGBT module chips after 3 s of overload operation shown in Fig. 3. In conventional IGBT + FWD configurations, the IGBT and FWD both repeatedly generate and dissipate heat. On the other hand, in the RC-IGBT module, the IGBT and FWD regions of the single chip generate heat alternately. This means that heat can be dissipated in the entire region including the FWD region when the IGBT region is operating, and similarly, heat can be dissipated in the entire region including the IGBT region when the FWD region is operating, resulting in high heat dissipation. As a result, the amplitude of junction tempera-

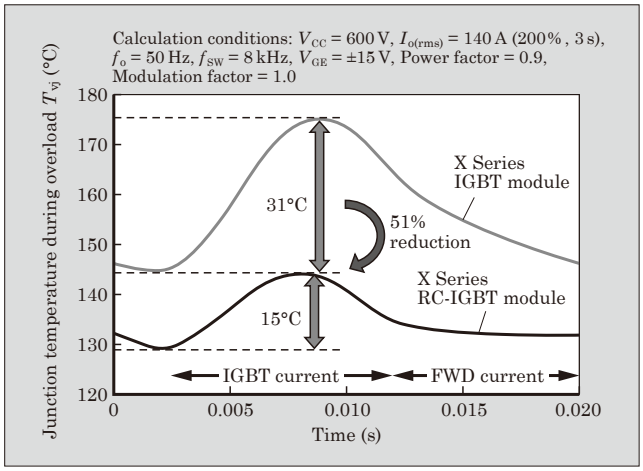

Fig.6 Temperature change of junction temperature T_{vj} during overload

ture change (ΔT_{vj}) can be significantly reduced compared to the conventional IGBT + FWD configuration.

Therefore, the X Series RC-IGBT module can significantly reduce the ΔT_{vj} shown in Figs. 3 and 4 and T_{vj} shown in Fig. 6, and can greatly reduce the thermal stress in the module. This means that the RC-IGBT module provides a higher rated current than the conventional IGBT + FWD module while ensuring the same high reliability.

Launch Date

October 2021

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