SLIMDIP Series Lineup Expansion and Future Prospects

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Abstract

Mitsubishi Electric has been marketing “DIPIPM” with a transfer-molded structure incorporating a power chip and an IC chip that drives it since 1997, contributing to a greater level of quality and lowering the design load for inverter systems with the use of a single package. Ever since launching the industry’s smallest[*1] “SLIMDIP-S” and “SLIMDIP-L” packages in 2015, the lineup has been expanded to include the “SLIMDIP-W” suitable for high carrier frequency drive, the “SLIMDIP-X” with lower noise, and the “SLIMDIP-Z” with a higher current rating up to 30A. These are contributing to a greater energy conservation of home appliances such as air conditioners, washing machines and refrigerators, which are increasingly multi-functional and higher performance in recent years.

1. Introduction[(1)]

After being the first in the industry[*2] to market the DIPIPM, Mitsubishi Electric has continued to develop and market a range of products to suit the changing needs of the market. The white goods market has made rapid advances in recent years for greater use of inverters, in response to the increased functionality of home appliances and global awareness of energy conservation. The SLIMDIP series is a low-capacity Intelligent Power Module (IPM) developed for white goods such as home air-conditioners and low-capacity fan drives, and features a smaller product size and lower cost while covering a a broad range of capacities with a single package. The SLIMDIP series comprises an inverter circuit made up of six Reverse Conducting - Insulated Gate Bipolar Transistor (RC-IGBT) elements, driven by three elements, High Voltage Integrated Circuit (HVIC), Low Voltage Integrated Circuit (LVIC) and BootStrap Diode (BSD).

The RC-IGBT used in the SLIMDIP series features Mitsubishi Electric’s proprietary 7th generation IGBT technology.

This paper provides and overview of the SLIMDIP series and outlines its features and future prospects.

2. Overview of SLIMDIP Series[(1)]

2.1 Power section

The three-phase AC output inverter circuit comprises RC-IGBTs (6 elements) featuring IGBTs and Free Wheeling Diodes (FWDs) on a single chip. The RC-IGBT cross-section structure is shown in Fig. 1.

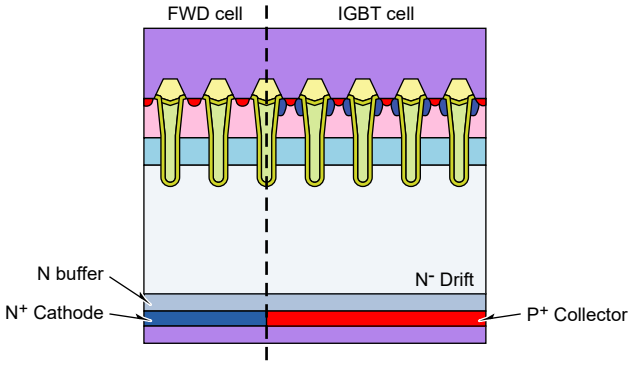
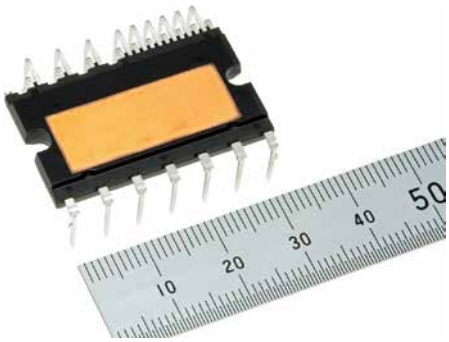


Fig. 1 RC-IGBT cross-section structure[(2)]

*1 According to our research, April 23, 2015
*2 According to our research, August 25, 1997

2.2 Control section

The SLIMDIP series package and internal circuit are shown in Fig. 2.



SLIMDIP series (18.8 x 32.8 x 3.6mm)

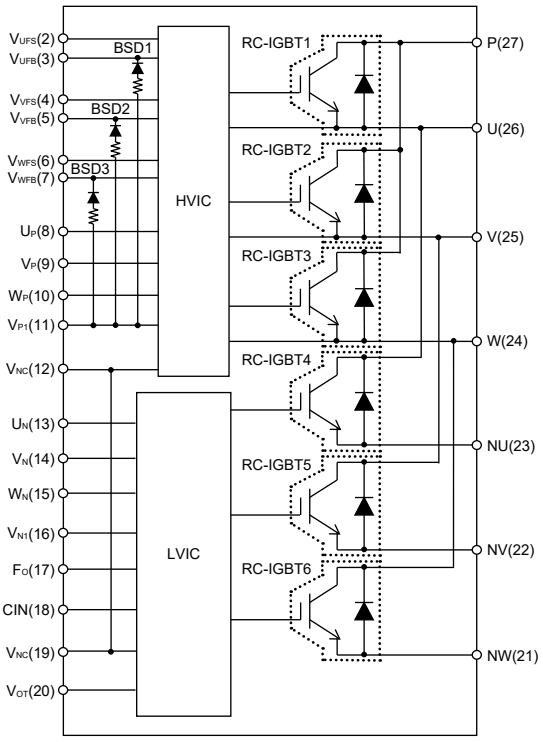


Fig. 2 Inter block diagram

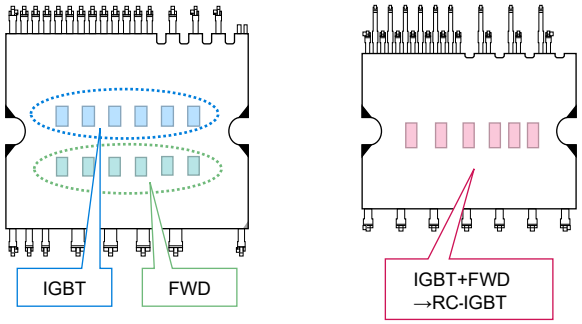
The HVIC (1 element) contains a P-side IGBT drive circuit, a high-voltage level shift circuit, and a floating control supply under voltage protection function (UV, without error signal (Fo) output). The use of a bootstrap type circuit also allows for a single 15V power supply drive.

The LVIC (1 element) contains an N-side IGBT drive circuit, and a control supply under voltage protection function (UV) and short-circuit protection function (SC) as well as an over temperature protection function (OT) and a temperature output function (VOT) as protection function. The short-circuit protection detects over-current with the shunt resistance of the external connection, and feeds back to LVIC to shutoff the IGBT. It outputs Fo when UV, SC and OT are tripped.

3. Features of SLIMDIP Series[1]

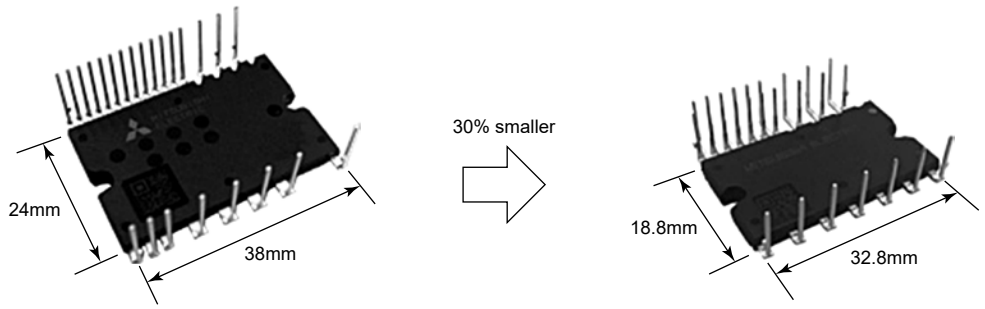
3.1 RC-IGBT mounting

The SLIMDIP series uses RC-IGBTs with a structure featuring IGBTs and FWDs that are formed on a single chip, in order to achieve a smaller package size with the aim of reducing area of the board. The RC-IGBT used here features Mitsubishi Electric's proprietary 7th generation IGBT technology. The number of chips mounted is halved as shown in Fig. 3. As a result, the package size was made 30% smaller than that of the super mini DIPIPM as shown in shown in Fig. 4.



(a) Super mini DIPIPM (b) SLIMDIP series

Fig. 3 Chip layout comparison



(a) Super mini DIPIPM (b) SLIMDIP series

Fig. 4 Package size comparison

3.2 Simplified wiring pattern

In addition to the smaller package size, the SLIMDIP also features a simplified wiring pattern on the system board. The bootstrap circuit used for driving the P-side IGBTs of the DIPIPM needs an external capacitor to be connected to stabilize the control power supply voltage. The conventional pin layout of the super mini DIPIPM series required an extra board area because the control power supply terminal reference was routed to the power side. The SLIMDIP series features three reference terminals of the P-side drive power supply on the control side, eliminating the need to run long wiring patterns on the board and thus contributing to simplified board design and reduced board area (Fig. 5).

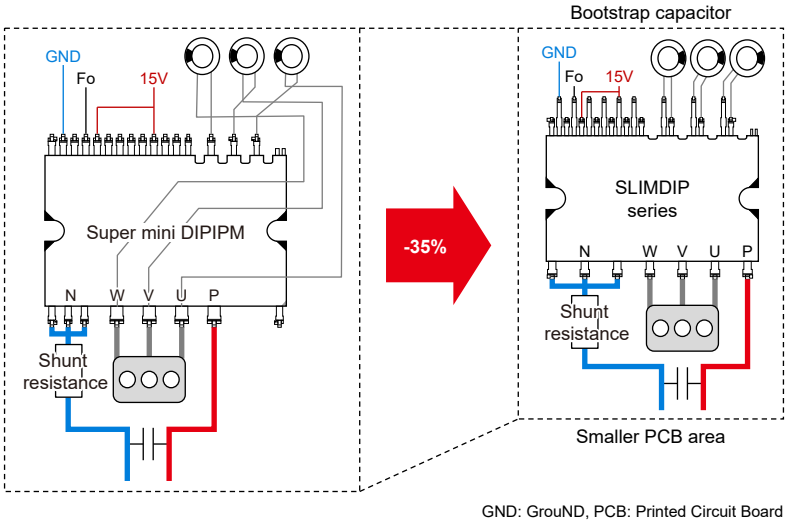


Fig. 5 PCB layout comparison

3.3 Increase in features and maximum ratings

The super mini DIPIPM series specification had either an over temperature protection (OT) or temperature output function (VOT) available as a temperature protection function, but the SLIMDIP series provides both functions. The maximum case temperature Tc and insulation withstand voltage have also been increased compared to the super mini DIPIPM Ver. 6, contributing to better system design by increasing both the functionality and maximum rating.

3.4 Expanded lineup

Beginning with the SLIMDIP-S and SLIMDIP-L lineup in 2015, the SLIMDIP-W, SLIMDIP-M, SLIMDIP-X, and SLIMDIP-Z have been released in the same package with rated currents from 5 to 30A. The addition of the SLIMDIP-X and SLIMDIP-Z lineups as shown in Table 1 increased the scope of applications of the SLIMDIP series. The 15A rated current lineup includes the SLIMDIP-L for low-carrier frequency drive and the SLIMDIP-W for high-carrier frequency drive, enabling the most suitable device to be selected for each application. Figure 6 Effective current-carrier frequency characteristics.

Table 1 SLIMDIP Line-up

Model	Main Applications	Rating	Carrier Frequency
SLIMDIP-S	Refrigerators, Fans	5A/600V	High speed
SLIMDIP-M	Fans, Washing machines	10A/600V	High speed
SLIMDIP-L	Air-conditioners	15A/600V	Low speed
SLIMDIP-W	Washing machines, Air-conditioners	15A/600V	High speed
SLIMDIP-X	Air-conditioners	20A/600V	Medium speed
SLIMDIP-Z	Air-conditioners	30A/600V	Medium speed

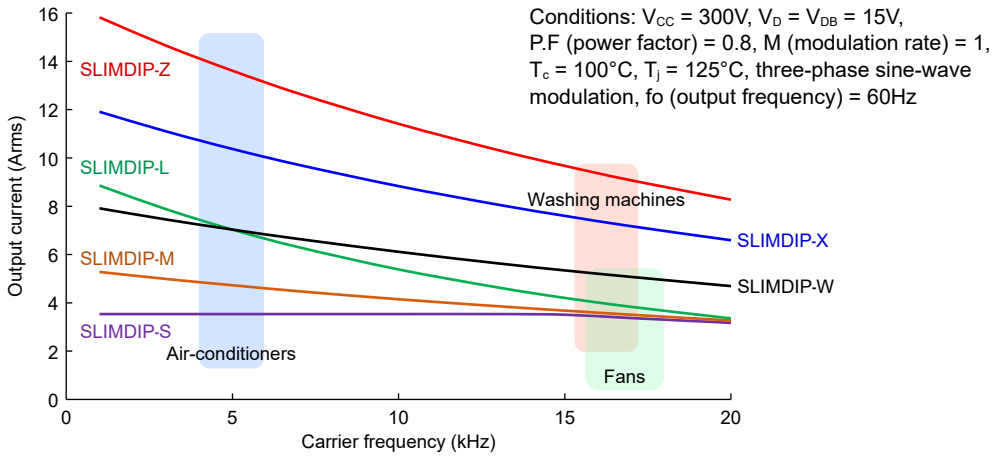


Fig. 6 Characteristics of carrier frequency-output current

4. Future Prospects

There has been a growing focus on energy performance in recent years as countries tighten regulations toward decarbonizing their economies. Yet there is a greater focus on costs, especially throughout Asia, and demand is likely to become increasingly polarized into the future. In response to market requirements, we will use the SLIMDIP series to provide a comprehensive level of support for the shift to inverters and greater efficiency of white goods by focusing on a stable supply of power semiconductors compatible with 12-inch wafers with excellent production efficiency, while also pursuing added value by applying next-generation power semiconductors such as Silicon Carbide (SiC).

5. Conclusion

The SLIMDIP series has significantly lowered the design load of the customer inverter systems with smaller packages using RC-IGBTs, simplified wiring pattern with pin layouts, and greater functionality and ratings compared to current products. Regulations in each country have become increasingly stringent toward decarbonization in recent years, and the expectations placed on power devices are growing every year. We will continue developing products suited to market requirements so that we are able to contribute to the spread of inverter devices across a wide range of applications.

References

(1) Shibata, S., et al.: “SLIMDIP Series” Power Module Using RC-IGBT, Mitsubishi Denki Giho, 90, No. 5, 307-310 (2016)
(2) Yasuda, Y., et al.: Latest Trend and Prospect of Power Module Technology, Mitsubishi Denki Giho, 96, No. 3, 139-143 (2022)