The existing 1,200 V Large DIPIPM Ver. 4 Series is compatible with the AC 400 V power supply for overseas markets, and the product line had already been completed up to 35 A. This time, a new 50-A model has been developed and added to the series, and its features are presented in this article. By adopting the 6th-generation light punch through carrier stored trench gate bipolar transistor (LPT-CSTBT), the new product has achieved a lower loss and larger current capacity than those of the conventional products, while keeping the same package size. In addition, by improving precision of temperature detector, heat dissipation structure designing is eased.

1. Introduction

Inverters for motor drive applications employ case-type intelligent power semiconductor modules (IPMs), which consist of insulated gate bipolar transistors (IGBTs) and driver ICs. In 1997, Mitsubishi Electric commercialized the "DIPIPM," the first transfer molded IPM. Since then, the DIPIPM has been conserving energy and reducing cost for various systems, and in 2008, the "1,200 V Large DIPIPM Ver. 4 Series (5−35 A)" was released. This time, in response to the demand for higher current capacity with the same structure, we have developed a new product. This paper describes the features of the new product, which has achieved a higher rated current while keeping the same outline dimensions as the conventional 1,200 V Large DIPIPM Ver. 4 Series.

2. Outline of the 1,200 V Large DIPIPM Ver. 4 Series

As shown in Fig. 1, the newly developed 1,200 V/50 A Large DIPIPM Ver. 4 is fabricated in the same package size as the conventional 1,200 V Large DIPIPM Ver. 4 Series.

2.1 Circuit configuration

The internal circuit is configured in the conventional manner consisting of six sets of IGBT and Free Wheeling Diode (FWD) chips, three-phase AC output inverter power circuit, and control ICs (high voltage integrated circuit [HVIC] and low voltage integrated circuit [LVIC]) that control the power chips. Figure 2 shows the internal circuit diagram of the 1,200 V Large DIPIPM Ver. 4 Series.

(1) Power circuit

The three-phase AC output inverter circuit consists of six IGBTs and six FWDs.

(2) Control ICs

HVIC: upper arm IGBT drive circuit, high-voltage level shifter, under-voltage protection circuit for the control power supply (no error output)
LVIC: lower arm IGBT drive circuit, under-voltage protection circuit for the control power supply, LVIC analog temperature output circuit, short-circuit protection circuit (for short-circuit protection, an external current detection resistor is connected to the emitter sense (VSC) terminal of the lower arm IGBT, and when the voltage exceeds the specified threshold voltage, the lower arm IGBTs are turned off.)

(3) Internal structure

Figure 3 shows a cross-sectional diagram of the 1,200 V Large DIPIPM Ver. 4. The internal structure is configured as follows: power chips, i.e., IGBT and FWD, and control IC chips, i.e., HVIC and LVIC are assembled on a lead frame. Connections are made between the chips using Al wires and Au wires. An aluminum heat sink and insulated heat dissipation sheet are put together, and then transfer-molded to complete the package.

![Fig. 3 Internal structure of 1,200 V Large DIPIPM Ver. 4](image)

3. Features of 1,200 V/50 A Large DIPIPM Ver. 4

The newly developed 1,200 V/50 A Large DIPIPM Ver. 4 model PS22A79 has the following features.

3.1 High current capacity

The new product has enhanced performance by employing the newly developed 6th-generation LPT-CSTBT, which has improved the carrier-storage effect by using a microfabrication technique to reduce the cell spacing, as well as achieved a 15% loss reduction from the level of the conventional 35A model (PS22A78-E) by applying the thin-wafer process. Figure 4 shows the collector current (Ic) – saturation voltage (VCE(sat)) characteristics, and Fig. 5 shows the allowable effective current (Io) – IGBT loss characteristics (typical). This new entry to the series enhances the lineup with the rated current of 50 A in the same package, and helps improve the design efficiency by allowing various products with different current capacity to be used on the same circuit board. Table 1 shows the main electrical characteristics of the 1,200 V/50 A Large DIPIPM Ver. 4.

![Fig. 4 Collector current (Ic) – VCE(sat) characteristics](image)

![Fig. 5 Allowable effective current – IGBT loss characteristics](image)

### Table 1 Electrical characteristics of the 1,200 V/50 A Large DIPIPM Ver. 4

<table>
<thead>
<tr>
<th>Item</th>
<th>Symbol</th>
<th>Conditions</th>
<th>Minimum</th>
<th>Standard</th>
<th>Maximum</th>
<th>Unit</th>
</tr>
</thead>
<tbody>
<tr>
<td>Collector-emitter saturation voltage</td>
<td>VCE(sat)</td>
<td>V_D = V_DB = 15V, V_IN = 5V, Ic = 50A, Tj = 125°C</td>
<td>–</td>
<td>1.90</td>
<td>2.60</td>
<td>V</td>
</tr>
<tr>
<td>FWD forward voltage drop</td>
<td>VEC</td>
<td>Tj = 25°C, Ic = 50A, V_N = 0V</td>
<td>–</td>
<td>2.50</td>
<td>3.20</td>
<td>V</td>
</tr>
<tr>
<td>Switching time</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>μs</td>
</tr>
<tr>
<td>t_on</td>
<td></td>
<td>V_CE = 600V, V_D = V_DB = 15V</td>
<td>0.70</td>
<td>1.50</td>
<td>2.40</td>
<td></td>
</tr>
<tr>
<td>t_off</td>
<td></td>
<td>Ic = 50A, Tj = 125°C</td>
<td>–</td>
<td>0.50</td>
<td>–</td>
<td></td>
</tr>
<tr>
<td>t(on)</td>
<td></td>
<td>Inductive load (Upper – lower arm)</td>
<td>–</td>
<td>0.50</td>
<td>0.80</td>
<td></td>
</tr>
<tr>
<td>t(off)</td>
<td></td>
<td>V_IN = 0 ⇒ 5V</td>
<td>–</td>
<td>2.50</td>
<td>3.70</td>
<td></td>
</tr>
<tr>
<td>t(on/off)</td>
<td></td>
<td></td>
<td>–</td>
<td>0.40</td>
<td>0.80</td>
<td></td>
</tr>
</tbody>
</table>

3.2 Optimization of short-circuit protection

The new product has adopted the same protection method as the 1,200 V Large DIPIPM Ver. 4, i.e., the sense current detection method, where a milliamperc-level sense current is divided from the emitter current and the corresponding voltage is detected for...
To obtain the sense current, IGBTs with an on-chip current sensor are used for the lower arm power chips. Since the shunt resistor inserted into the emitter current path is no longer needed, an inductance-induced surge voltage across the NU/NV/NW terminals and VNC terminal can be suppressed, resulting in increased flexibility of circuit board design. In addition, to detect ampere-level emitter current, a high-wattage-type shunt resistor is required, but the sense current detection method can reduce the loss and increase the flexibility of the shunt resistor selection.

### 3.3 Precision improvement of temperature detection

The temperature detection function, which has already been integrated in the conventional series, has a temperature detector built into the control IC (LVIC) and provides an output of the analog voltage signal. This function eliminates the need for the external thermistor and reduces the system cost. This time, by using laser trimming technology, the output characteristics of the analog voltage signal have been made adjustable, resulting in higher precision of the output. When the analog voltage signal is used to control the junction temperature of the IGBT chip below a certain temperature, variance in the signal needs to be considered; therefore, if the temperature precision is low, the normal operating range of the device needs to be narrowed. The improved precision allows operation at almost the maximum rating condition, and helps mitigate the requirements for the heat dissipation design and reduction of size. Figures 6 and 7 show the analogue temperature output \( V_{OT} \) versus LVIC temperature characteristics for the conventional and new product, respectively.

### 4. Conclusion

This paper has presented the structure, functions, and features of the newly developed 1,200 V/50 A Large DIPIPM Ver. 4. We will extend the application of the developed technologies and increase the current capacity to enhance the lineup. We will also continue to provide the inverter market with advanced products by integrating bootstrap diodes to contribute to global environmental conservation.

### References