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New Transfer-Molded Compact DIPIPM™

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Agenda

1. Introduction
2. Package and internal schematic of Compact DIPIPM
3. Features of Compact DIPIPM
4. The differences between Mini DIPIPM and Compact DIPIPM
5. Electrical characteristics
6. Conclusion

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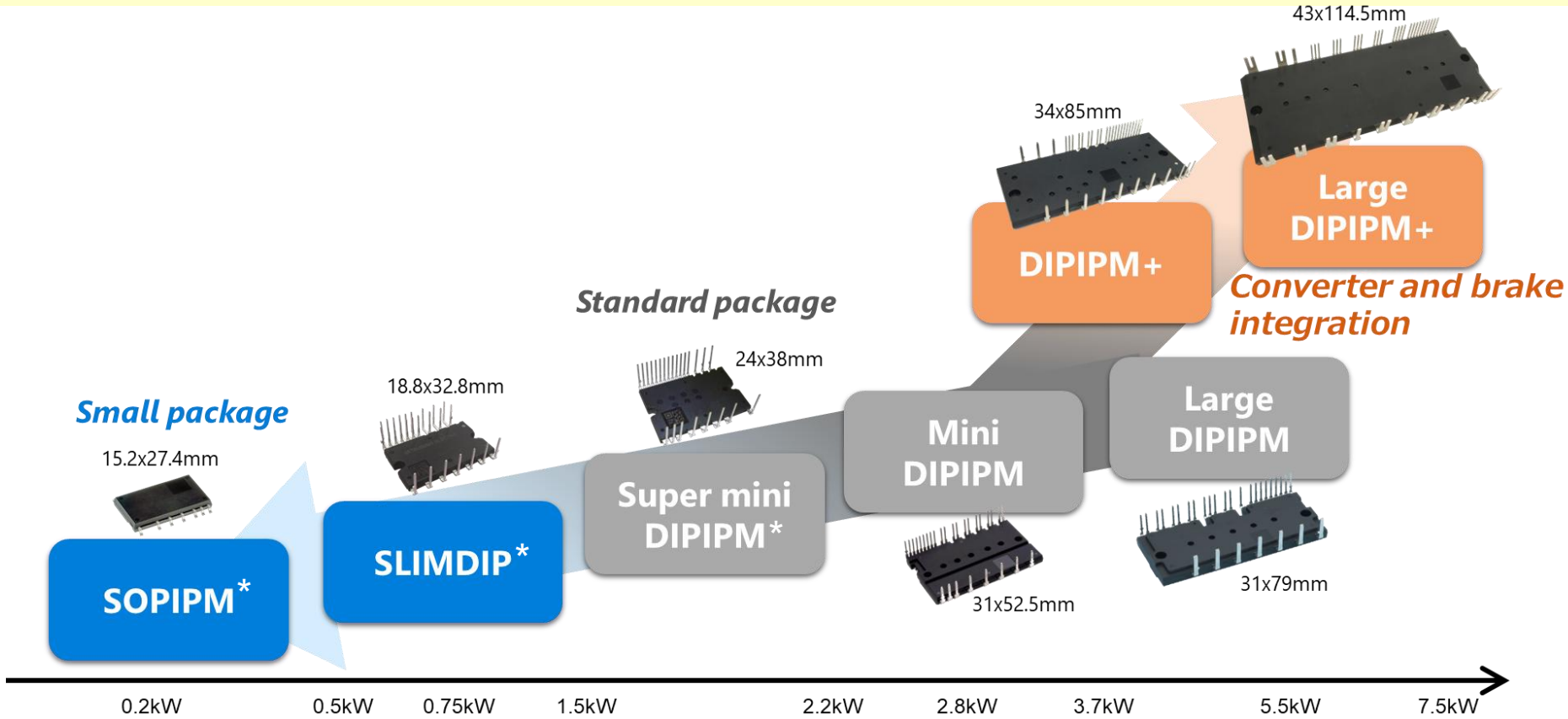
Background

- With the increasing functionality of consumer home appliances and the worldwide rise in energy conservation awareness, adopting inverters in consumer home appliances has rapidly been progressing.
- Since 1997, we have been commercializing DIPIPM with a transfer mold structure.
- The single package has been contributing to improve quality and reduce designing loads of inverter systems.



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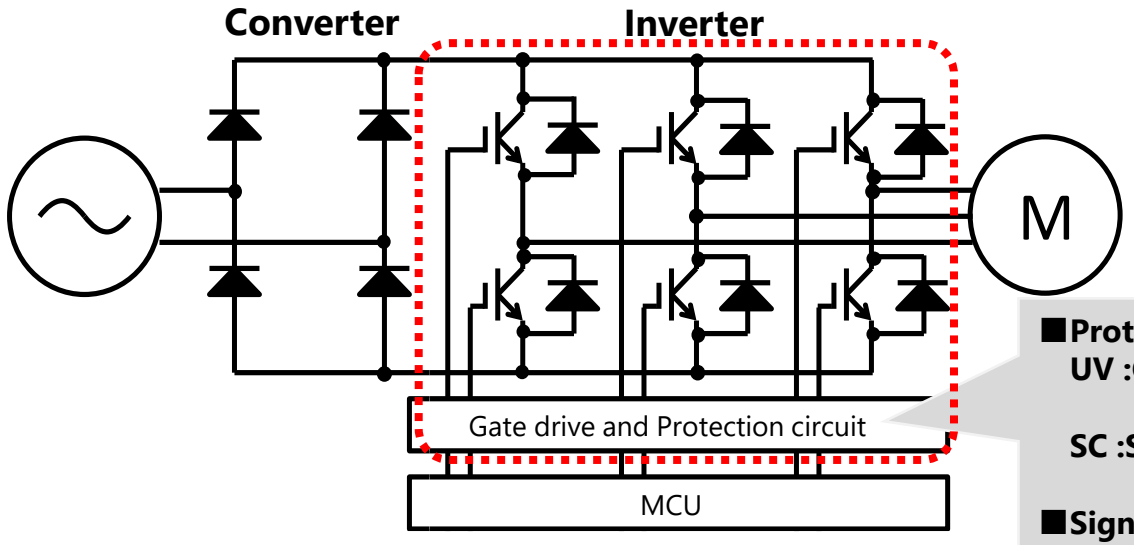
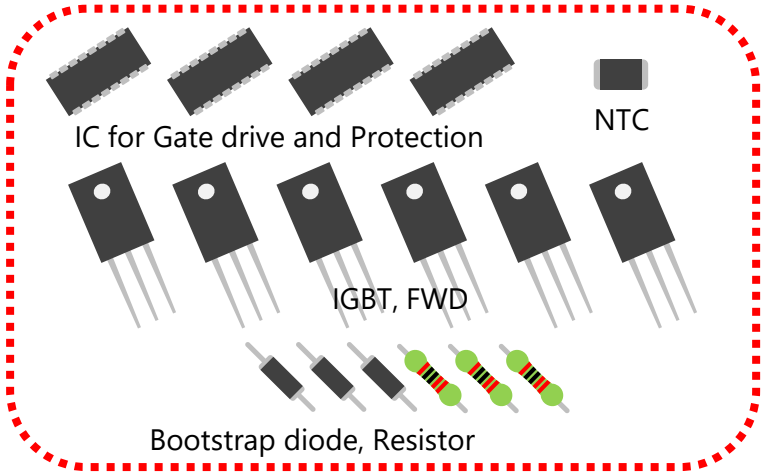
What is DIPIPM？

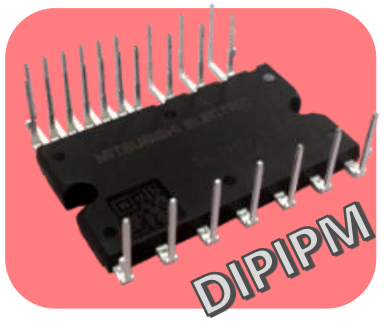
All-in-one module with built-in IGBT/FWD* as well as drive and protection functions.



■Protection function
UV :Control Supply Under Voltage
SC :Short Circuit

■Signal output
VOT :Temperature Output
Fo :Error signal





DIPIPM features

1. Built-in gate drive circuit reduces design time
2. With built-in HVIC, BSD and limiting resistance, it can be driven with a single power supply
3. Extensive protection functions

*IGBT：Insulated Gate Bipolar Transistor
*FWD：Freewheeling Diode

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We have developed the new transfer molded "Compact DIPIPM".

Features

- The package size can be reduced by 43% compared to Mini DIPIPM.
- The series can maintain same isolation distance as Mini DIPIPM, while reducing the package size.
- We can commercialize the product of 600V/50A by applying high heat dissipation insulated thermal radiating sheet.

This paper

We will present the features of Compact DIPIPM and the differences between it and Mini DIPIPM, and report on advantages of Compact DIPIPM.

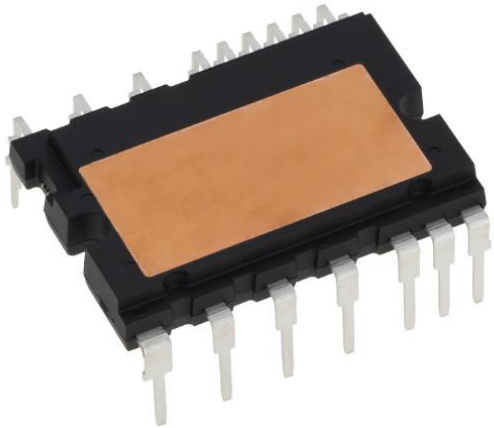

Fig. 1 Outline of Compact DIPIPM

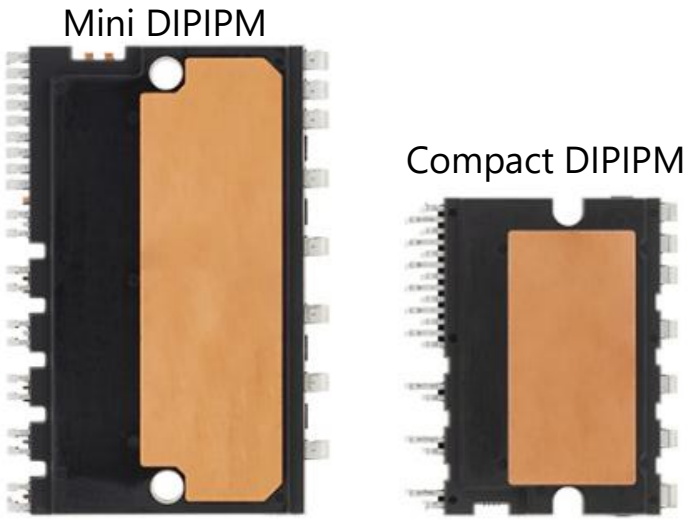

Fig. 2 Mini DIPIPPM and Compact DIPIPM

Table.1 Product line-up and applications

Product	Current / Voltage	Applications
PSS50SF1F6	50A / 600V	PAC / Motor drives for industrial machines
PSS30SF1F6	30A / 600V	

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Package and internal schematic of Compact DIPIPM

Parts of Compact DIPIPM

- RC-IGBT*：Switching element (IGBT and FWD integrated into one chip)
- HVIC*：Drive circuits for P-side IGBT / High-voltage level shift circuits / UV
- LVIC*： Drive circuits for N-side IGBT / UV / SC / VOT / IL*
- BSD*： Element of bootstrap circuit (Built-in limiting resistor)
- Insulated thermal radiating sheet：Heat dissipation and electrical insulation

*RC-IGBT：Reverse Conducting Insulated Gate Bipolar Transistor
* HVIC：High Voltage Integrated Circuit
* LVIC：Low Voltage Integrated Circuit
* BSD：Boot Strap Diode
* IL ：Interlock

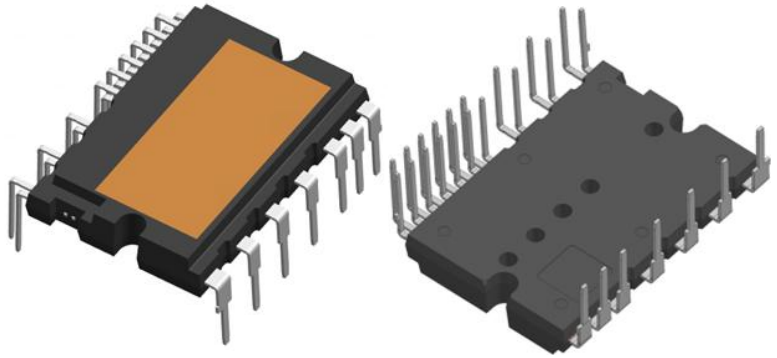


Fig.3 Outline of Compact DIPIPM

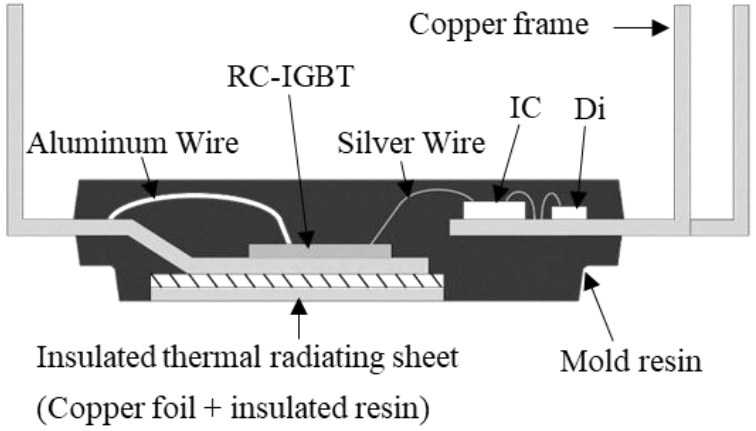


Fig.4 Internal cross-section structure

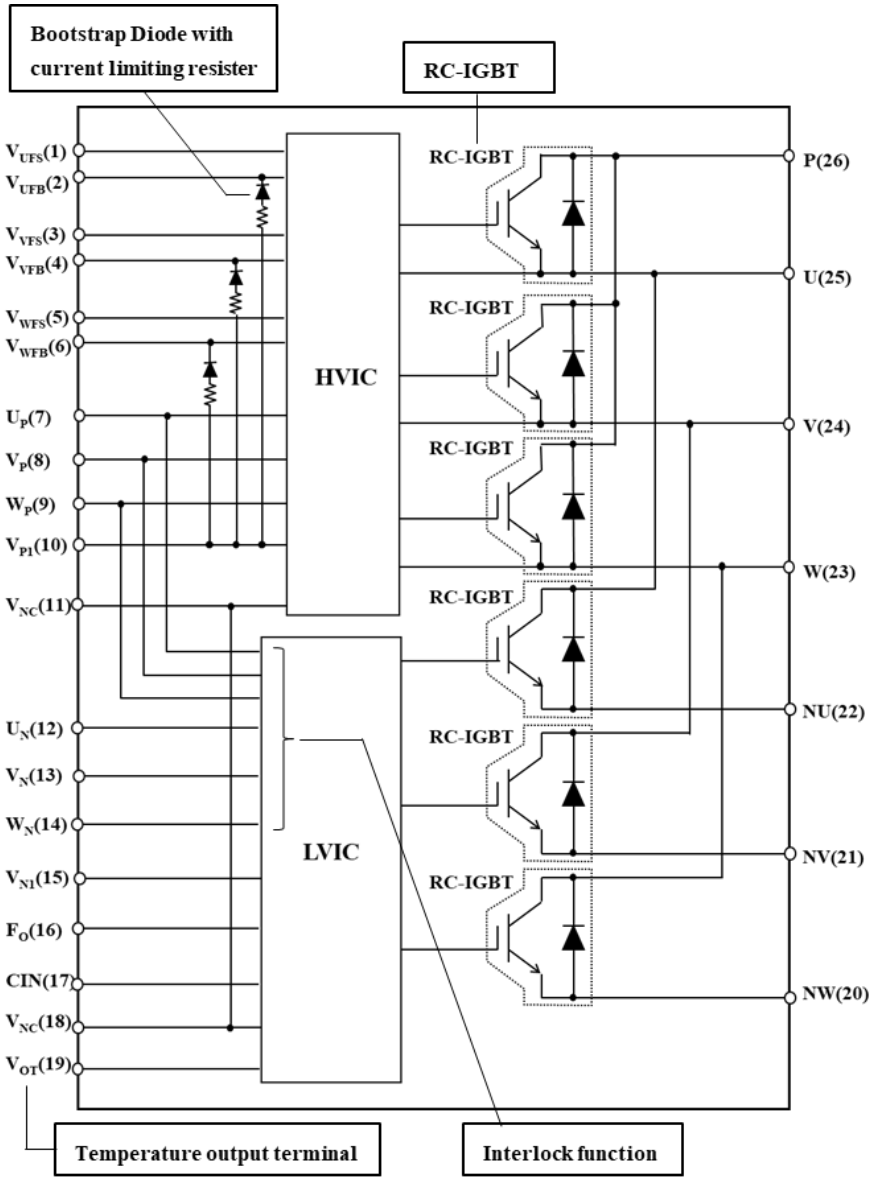


Fig.5 Internal schematic

3.1 Reducing the package size

- Compact DIPIPM contains of RC-IGBT, which has a structure inserted the IGBT and FWD within the same chip to realize a smaller package size with the aim of reducing the board area occupied by the package.
  →The number of power chips mounted can be halved compared with Mini DIPIPM.

- The package size can be reduced by 43% compared to Mini DIPIPM and it can contribute to reducing the board area.

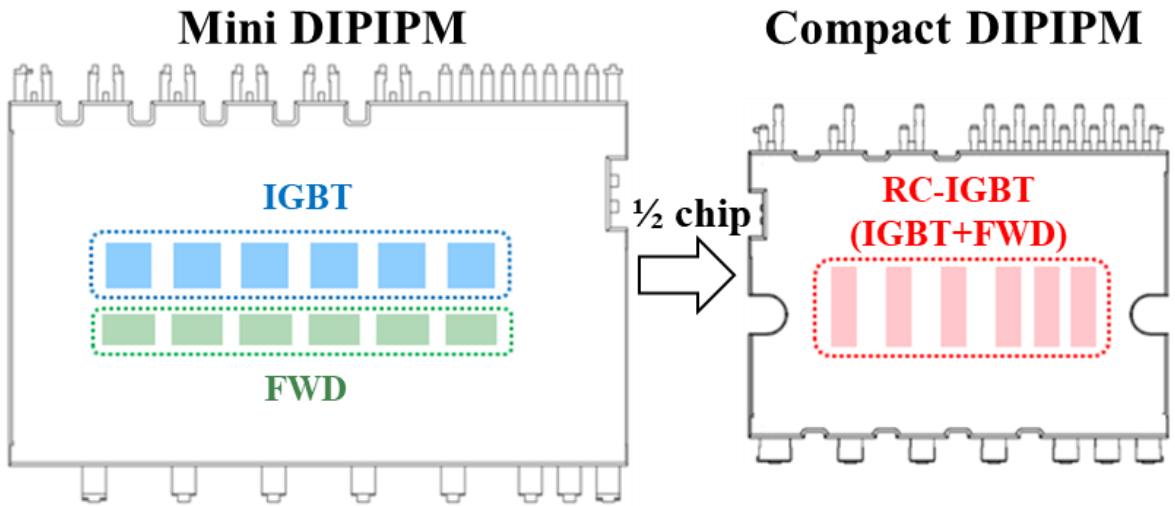


Fig.6 Chip layout comparison

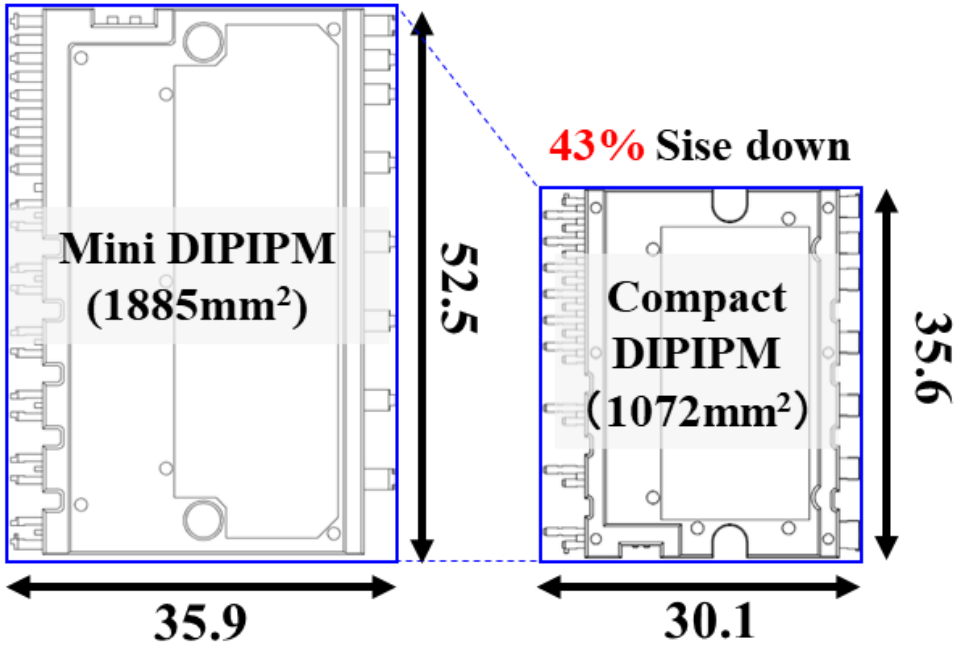


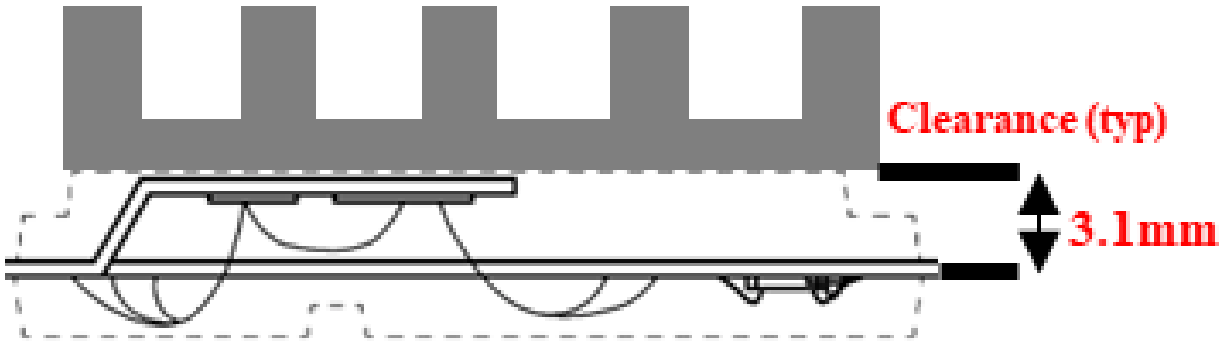
Fig.7 Package size comparison

3.2 Ensuring isolation voltage same as Mini DIPIPM

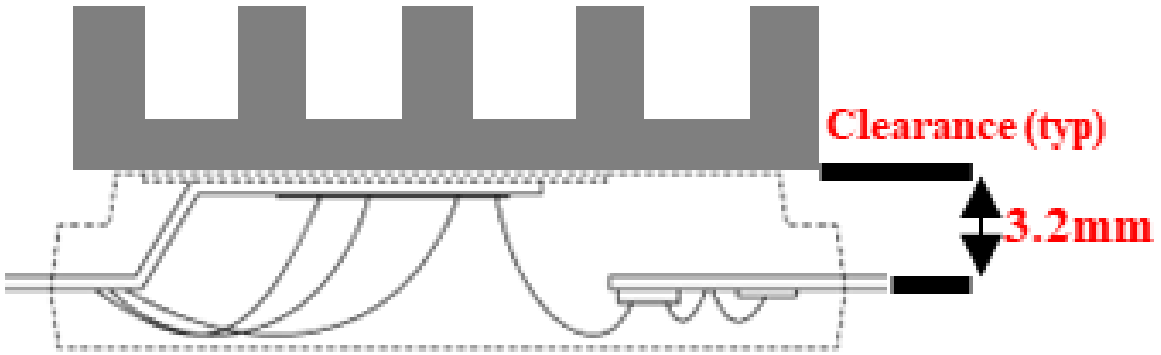
- Package is designed with a deep step cross-sectional structure between the heat dissipation surface and terminals.
  →It can ensure the creepage and clearance distance between the terminals and fins while reducing the package size.

- Compact DIPIPM is maintained clearance distance 3mm and creepage distance 4mm as Mini DIPIPM.

- Compact DIPIPM is maintained same isolation voltage (2500Vrms/1min) as Mini DIPIPM.



(a)Mini DIPIPM



(b)Compact DIPIPM

Fig.8 Typical distance from terminals to heat sink

3.3 Reducing the number of board components

① Incorporating BSD

・Compact DIPIPM can be operated with a N-side control power supply.

・The circuit consists of an external BSC, internal BSD and internal current limiting resistor.
It uses the BSC as a control supply for driving P-side IGBT.

・The BSC supplies gate charge and circuit current of logic circuit on P-side driving IC.

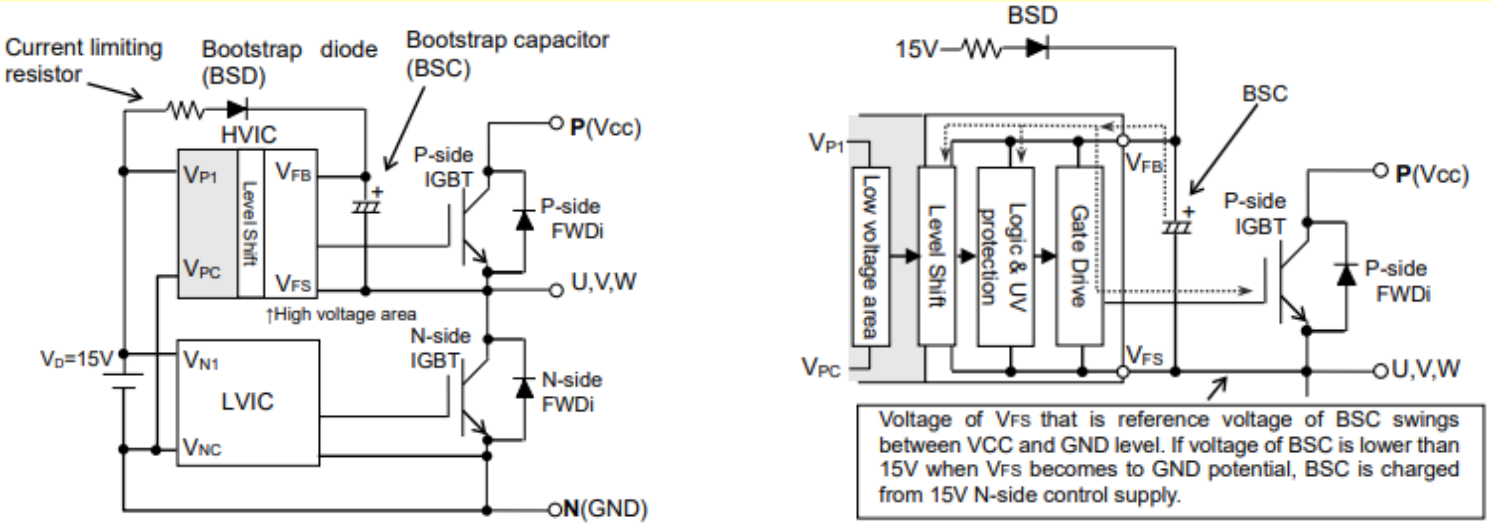


Fig.9 Bootstrap circuit diagram

3.3 Reducing the number of board components

② Monitoring LVIC temperature

・A temperature detection element is placed in the LVIC section and output the LVIC temperature.

・It can be used in the same way as a thermistor.
(to stop the heat dissipation fan, suppress temperature rise due to heat dissipation system failure, etc.)

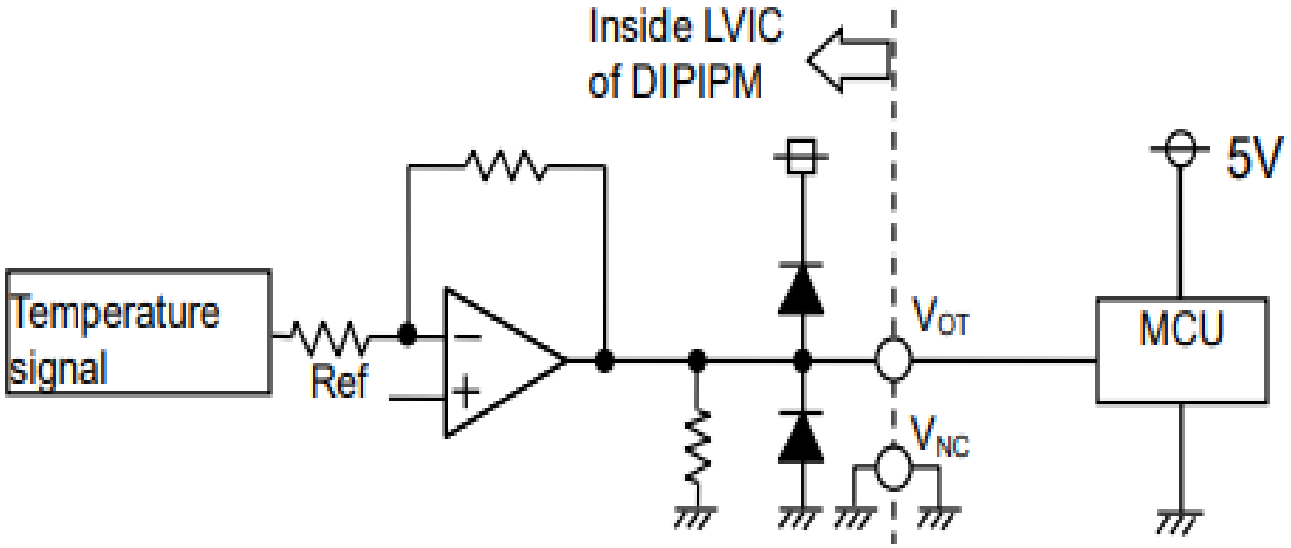


Fig.10 VOT output circuit [2]

[2] Mitsubishi Electric, SLIMDIP Series application note

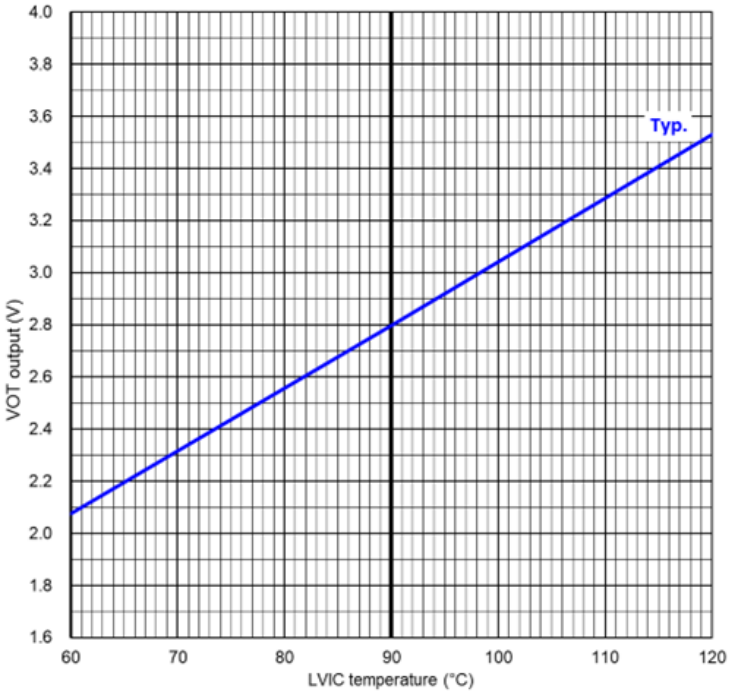


Fig.11 VOT output vs. LVIC temperature (typical)

3.4 Simplifying pattern layout

Compact DIPIPM can simplify the wiring pattern on the system board.

Compact DIPIPM has been possible

- To realize the HVIC with a single element, the pattern wiring of the control power supply can be simplified.
- To improve the design freedom of the BSC peripheral circuits.
- To integrate the input signal terminals.
- To create a layout in which the control power supply terminals and GND terminals don't cross each other.

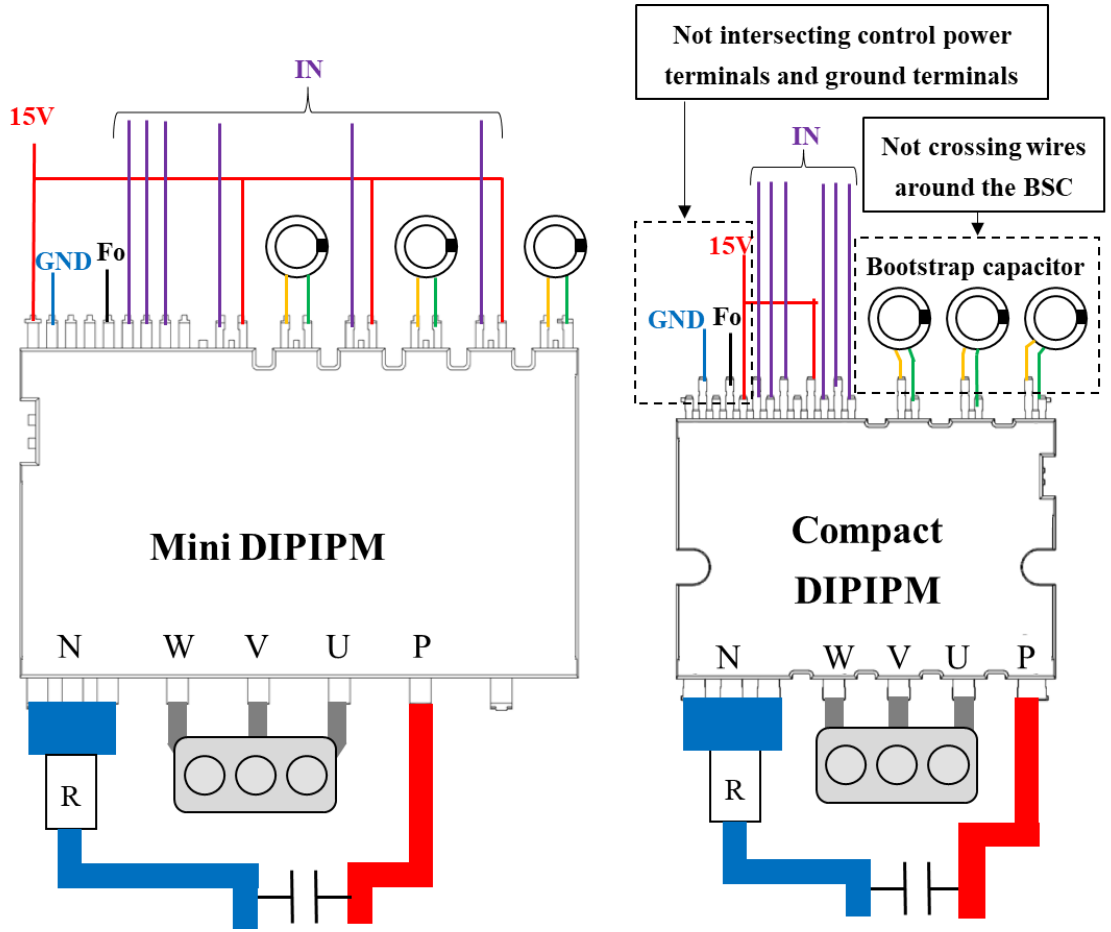


Fig.12 PCB layout

3.5 Interlock function helps protect the system

Compact DIPIPM is equipped with an interlock function that can contribute to safe protection of the system.
→When the same phase P-side and N-side signals are input simultaneously, the gate of N-side IGBT will be turned off.

■Interlock sequence

a1. Normal operation: IGBT ON and outputs current.

a2. When N-side is ON state(H), if P-Side turn ON(L→H), N-Side shut off.

a3. When P-side is ON state(H), if N-side turn ON(L→H), N-side shut off.

a4. If P-side turn OFF(H→L) and N-side is ON state(H), N-side turn ON.

※ F_o signal is not output during Interlock.

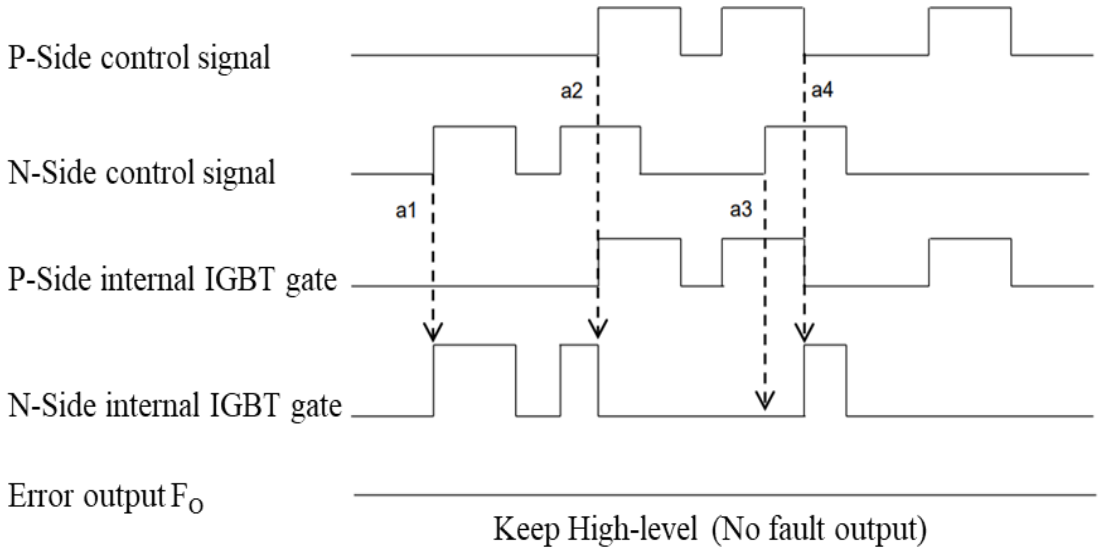
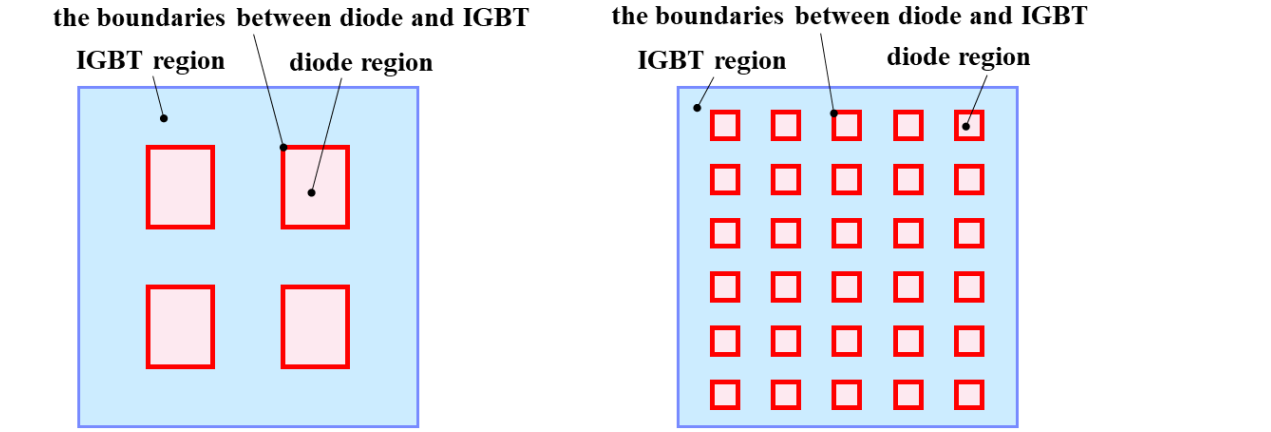


Fig.13 Timing chart of interlock function

3.6 Reducing thermal resistance (between the IGBT chip junction point and the case)

- Insulated thermal radiating sheet in Compact DIPIPM has about 70% higher thermal conductivity than Mini DIPIPM.
- In RC-IGBT, the IGBT and diode mutually function as a heat dissipation area, which reduces thermal resistance and increases power density.
- By increasing the boundary length between the IGBT and the diode, the heat dissipation of the 3rd Gen. RC-IGBT is improved by arranging diodes more densely than in the 2nd Gen. RC-IGBT.



Low Density Arranged Diode
→short boundary length between IGBT and Diode
→low heat dissipation from diode to IGBT

(a) The 2nd Gen. RC-IGBT

High Density Arranged Diode
→long boundary length between IGBT and Diode
→high heat dissipation from diode to IGBT

(b)The 3rd Gen. RC-IGBT

Fig.14 Diodes arrangement on RC-IGBTs

The differences between Mini DIPIPM and Compact DIPIPM

① There is no need a capacitor (C_{FO}) to adjust the F_o pulse width for Compact DIPIPM when an error occurs, and the F_o pulse width is output at a minimum of 200μs.

② Compact DIPIPM is designed to withstand temperatures of -40℃, and it is possible to operate in colder climates.

③ That improved heat dissipation due to reduced junction to case thermal resistance $R_{th(j-c)}$ allows instantaneous operation up to $T_{j(max)}$ = 175℃, and it is possible to operate in high temperature.

Table.2 Differences function and terminal shape

	Item	Mini DIPIPM with BSD	Compact DIPIPM
	Interlock function	No	Built-in
	Terminal shape	Control side Straight	Control side zigzag
①	External C_{Fo}	Need	Not need (t_{Fo}>200μs)
	UV	Built-in	Built-in
	SC	Built-in	Built-in
	V_{OT}	Built-in	Built-in

Table.3 Differences main specifications

	Item	Mini DIPIPM with BSD	Compact DIPIPM
②	T_c [℃]	-20～100	-40～125
②	T_j [℃]	-20～150	-40～150
	$T_{j\,max}$ [℃]	-	175
③	$R_{th(j-c)Q}$ (50A/600V) [℃/W] ※1	1	0.85
③	$R_{th(j-c)F}$ (50A/600V) [℃/W] ※2	2	-
③	$R_{th(j-c)Q}$ (30A/600V) [℃/W] ※1	1.1	1.05
③	$R_{th(j-c)F}$ (30A/600V) [℃/W] ※2	2.8	-
	V_{iso} [Vrms/min]	2500	2500

(※1) $R_{th(j-c)Q}$ is thermal resistance of Inverter IGBT part or RC-IGBT part.
(※2) $R_{th(j-c)F}$ is thermal resistance of Inverter Free Wheeling Diode part.

Switching waveforms of Compact DIPIPM

There is no obvious vibration during turn-on and turn-off operations, and the tail current falls quickly and smoothly.

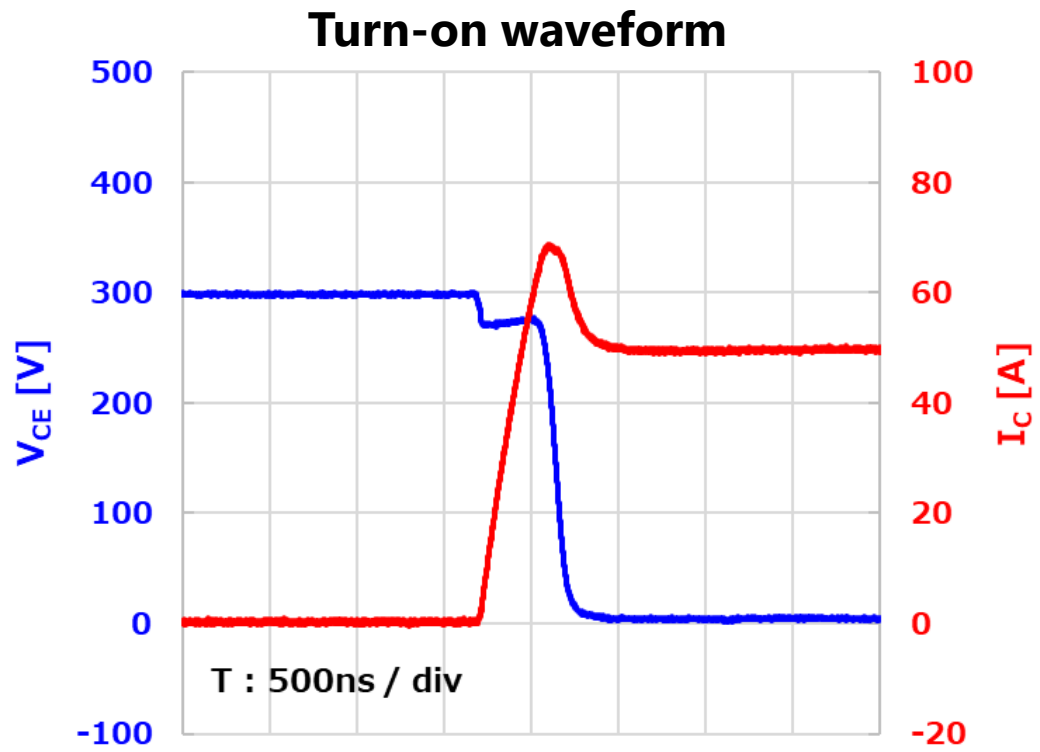


Fig.15 Compact DIPIPM turn-on waveform

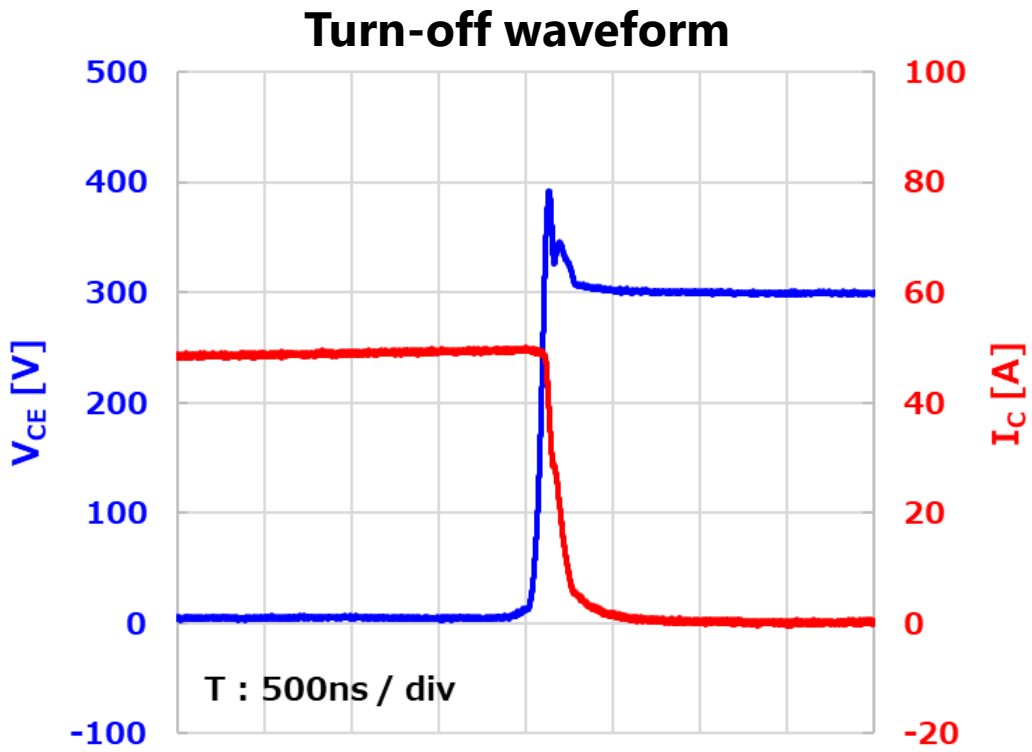


Fig.16 Compact DIPIPM turn-off waveform

Condition：V_{cc}=300V, I_o=50A, T_j=150℃, V_D=V_{DB}=15V, V_{IN}=0⇒5 V, Inductive Load

Loss simulation

We compared the loss simulation result of 50A Compact DIPIPM and 50A Mini DIPIPM with BSD (PSS50S71F6).

Result

By reducing the package size while thinning the chip and optimizing the driving capacity, the total loss can be reduced 8.5% less than Mini DIPIPM with BSD.

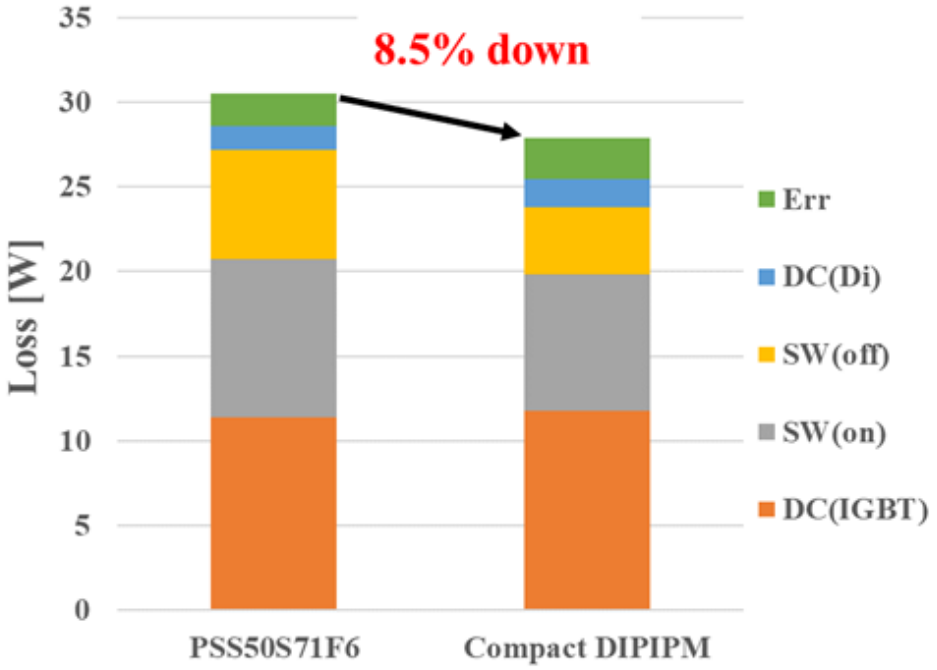


Fig.17 Loss simulation result

■Simulation Condition

- Modulation method：SVPWM
- V_{cc}=390V
- I_o=25Arms
- PF=0.97
- M=1
- f_c=6.6kHz
- f_o=60Hz
- V_D=V_{DB}=15V

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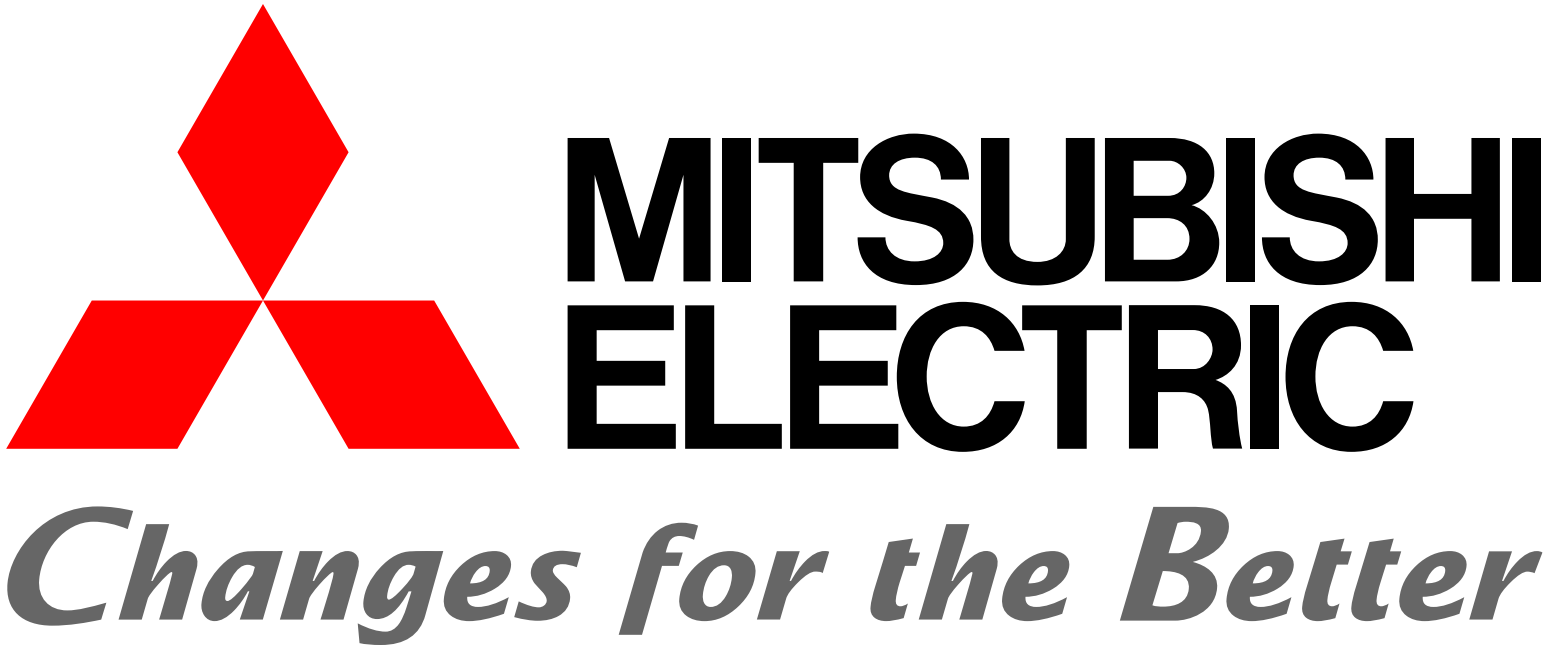
We have developed new transfer-molded Compact DIPIPM and described the advantages below.

Advantages of Compact DIPIPM

- By applying RC-IGBT, the package size can be reduced by 43% compared with Mini DIPIPM.
- It can maintain same isolation distance as Mini DIPIPM, while reducing the package size.
- The simplified wiring pattern achieved pin layout can reduce the design load of the inverter system.
- The Interlock function can simplify the short-circuit protection circuit outside of the Compact DIPIPM.

We believe that the Compact DIPIPM is particularly suitable for inverter home appliances and can contribute to reducing system costs.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