Large Size and Flexible Pinout Hybrid Modules for PV and PCS Applications

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Abstract

In this paper, a new type of large size module with copper base plate and flexible pinout is introduced, including its external size, high power density and excellent reliability. The package is used in Photovoltaic （PV） inverters and Power Conversion System (PCS). It can reduce the weight and cost of the whole machine compared to the previous module. The package uses a mix of the latest IGBT chip and SiC devices to improve efficiency by more than 0.2%.

1 Introduction

With the increasing power of Photovoltaic （PV） inverters and Power Conversion System (PCS), the size of power devices in this field is also increasing. At the same time, the switching speed of the chip is getting faster and faster, so this flexible pinout hybrid modules are needed to reduce the drive loop area. This will avoid the shock of the fast chip.

2 Description of module packaging

2.1 Package size

The package base mounting holes and PCB self-tapping screw holes are four each, and the top column is a certain distance from the module cover. This distance facilitates the addition of components to the PCB at the top of the module, avoiding insulation problems caused by the pins on the back of the PCB entering the module. The diagram is shown in **Fig.1**.

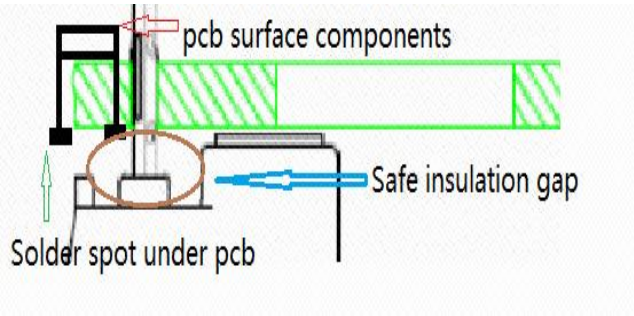

Fig.1 Avoid insulation problems schematic

The cover plate of the package has holes for fixed clearance distances, which facilitate pin according to customized requirements. The advantage of this pinout method is to reduce the Ls of the module and reduce the area of the drive loop. At the same time, this method of pinout can reduce concussion. A physical diagram of the package is shown in **Fig. 2**.

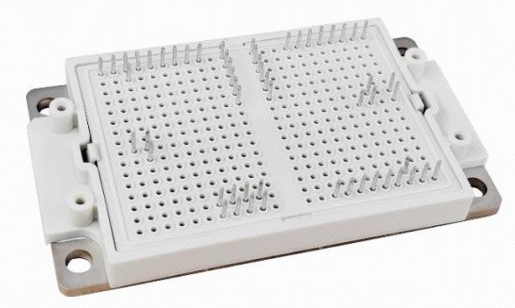

Fig. 2 Module sample diagram

The package is 112mm in length, 62mm in width and 12mm in height. The screw hole aperture of the base plate is 6mm and the hole aperture of the self-tapping screw hole is 2.3mm. See **Fig. 3** for details.

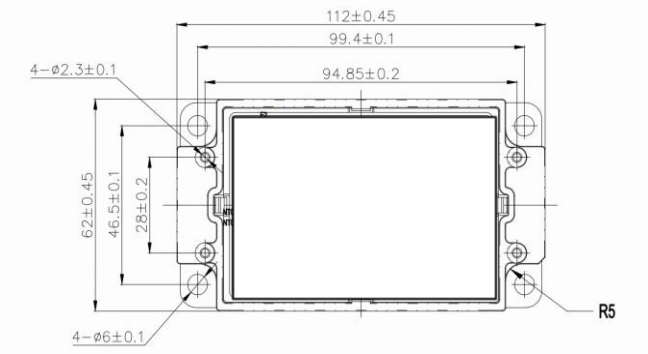

Fig. 3 (a) Top view

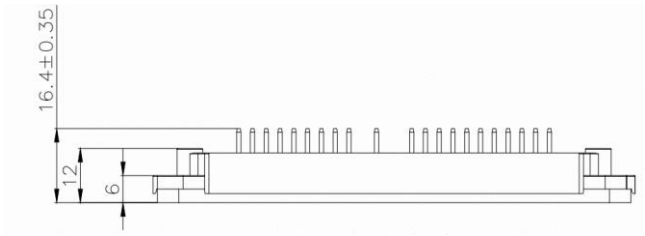

Fig. 3 (b) Side view

2.2 Excellent reliability

Because the size of the package is large. The modules are mostly plastic. Therefore, the reliable installation of the module mainly depends on the curvature of the base plate. The camber of the base plate of the module is strictly controlled. The test of floor camber is shown in **Fig. 4**.

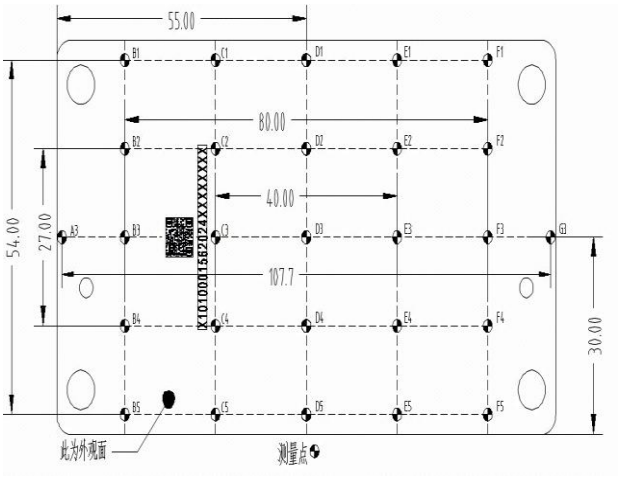

Fig. 4 (a) Radian test point

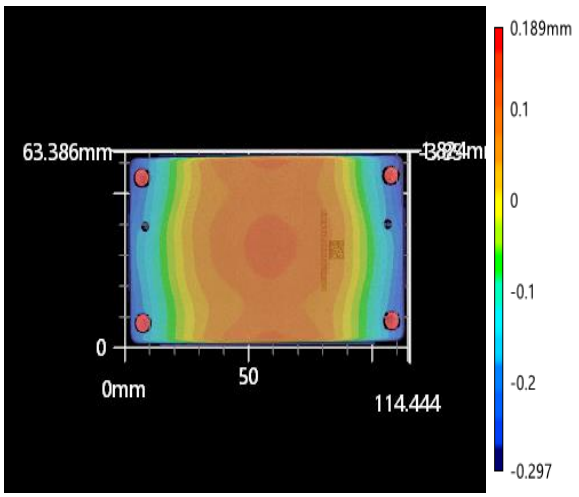

Fig.4 (b) Actual test

The excellent reliability of the package is mainly due to the curvature control of the copper base plate. The deformation of the camber of the copper base plate in the application can still be used, and the thermal grease on the radiator will not be pumped-out.
This ensures a reliable heat dissipation capability of the module. The reliability of the module can be verified by life prediction through temperature cycle test after installation. The specific verification is shown in **Table 1**.

Table 1 Reliability life

No.	Number	Cycle to failure	Life span/year
1	6	2000	12.60
2	6	2150	13.55
3	6	1800	11.34
4	6	1940	12.22

3 Advantages of packaging

Fig. 5 shows the three previous packages. Their drive loops are very long, making them unsuitable for fast chips. These three package s because the pin is far away from the chip, so the Ls is also large.

Fig. 5 Previous package

Compared with the above previous package applied in PV and PCS, the package has the following advantages.

a. High power density and low cost. Previous package requires three pieces of the ANPC topology. The package can be replaced singly. Three modules to spell ANPC are shown in **Fig. 6**.

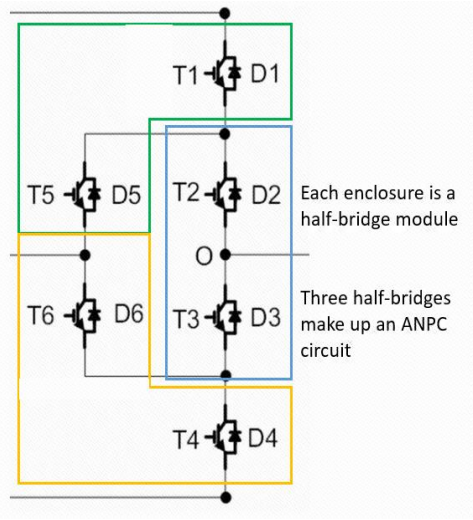

Fig. 6 Three previous half-bridge package applications

b. The module is flexible pinout. The package is easy to configure Kelvin pins and has fewer shocks. The package facilitates the addition of absorption between C and E at three levels. The reason why the package can flexible pinout is shown in the **Fig.7.**

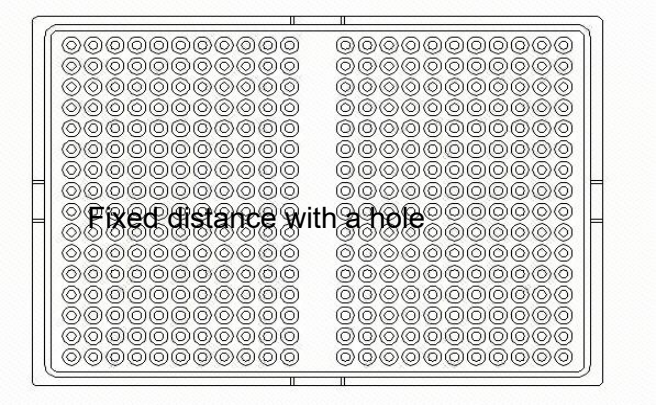

Fig.7 Package cover plate example

c. Module gate's leads are short. The package can be configured with fast chip, reduce the power loss and improve the efficiency of the whole machine. But previous package are prone to shock with fast chips due to long

gate control leads. The influence of gate loop on drive oscillation is shown in **Fig.8**.

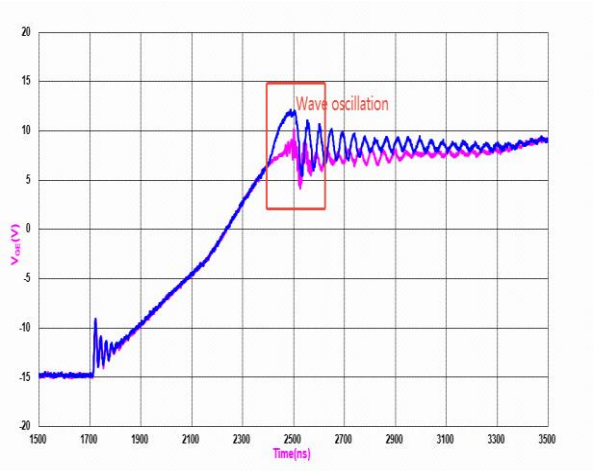

Fig.8 The gate waveform is different due to the length of drive circuit

d. Suitable for mixing SiC. The package can be configured with fast chips and can take advantage of SiC MOS and SiC SBD.

4 New type of package thermal simulation

The package can be adapted to fast chips, which can reduce module loss in applications. At the same time, the package is large in size and has a copper base plate, which has good heat dissipation capacity. Therefore, the package has a high-power density.

1100V PV inverter power increased to 150KW. A 150KW PV inverter single-phase can be achieved using one of these packages. Product specification 560A 1200V, circuit topology is NPC-T.

The simulation data are shown in **Fig. 9**.

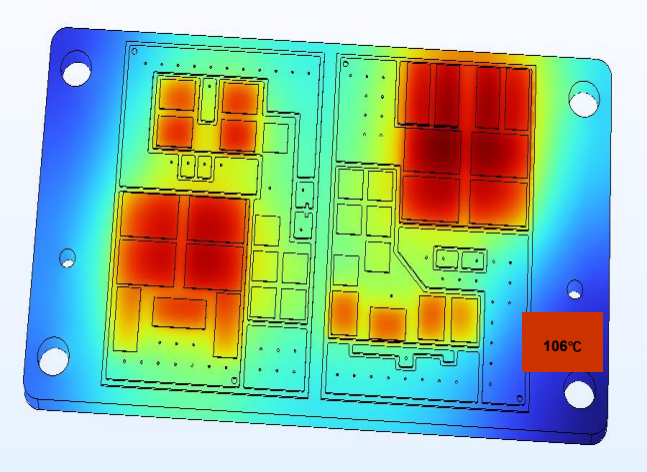

Fig. 9 Thermal simulation of 150KW module

From the simulation results, it can be seen that the heat dissipation of the package with copper base plate is uniform, and the maximum junction temperature is lower than 110℃, which meets the application.

High power density and excellent heat dissipation are the advantages of this large package。

5 The third-generation semiconductor applications in advanced packaging

The package can be applied in different power segments. The power range for specific applications is shown in **Table 2**.

Table 2 Different power segment products

Application field	Power /KW	Product specification	Circuit topology	Mixed SIC/ (yes or no)
PV	150	560A 1200V	NPC-T	NO
	225	400A 1000V	NPC-I	NO
	320	600A 1000V	NPC-I	YES/NO
	400	800A 1200V	NPC-I	NO

PCS	125	560A 1200V	NPC-T	YES/NO
	150	600A 750V	NPC-I	NO
	210	450A 1200V	NPC-I	YES
	400	800A 1200V	NPC-I	NO

Taking the 150KW PCS module as an example, the advantages of SiC hybrid module in this package are introduced. Detailed chip configurations are shown in **Table 3**.

Table 3 Chip configuration comparison

Edition	Chip unit	Number of chips	Chip specification	Technology platform
Si module	T1~T4	3	200A 750V	M7U
	D1~D6	3	200A 750V	M7D
SiC hybrid module	T1~T4	3	200A 750V	M7U
	D2/D3	3	200A 750V	M7D
	D1/D4/D5/D6	7	50A 1200V	/

The corresponding number of the chip unit is shown in **Fig. 10**.

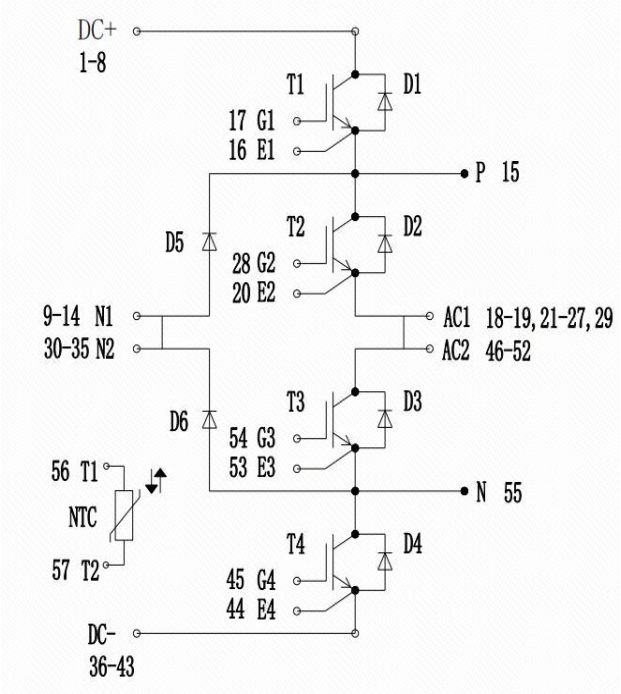

Fig. 10 Circuit Diagram

Since the PCS application is bidirectional power conversion. Therefore, the FRDS of D1, D4, D5, and D6 in the NPC-I topology must be replaced with SiC SBD. Because the IGBT of the inner tube is continued by D1, D4 diodes, and the IGBT of the outer tube is continued by D5/D6. The comparison of losses before and after the use of SIC in the package is shown in **Fig. 11**.

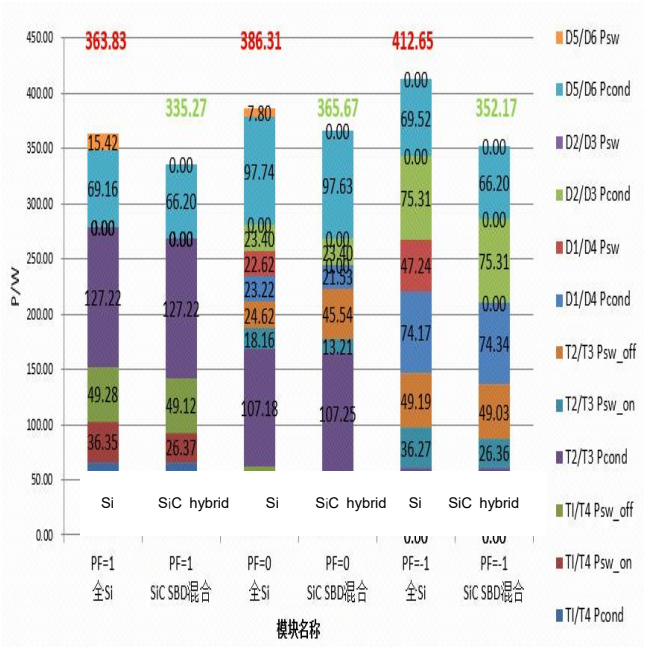

Fig. 11 FRD and SIC SBD scheme loss comparison stacking diagram

Through simulation, the current discharge, pur e reactive power and charging loss of 150KW PCS before and after using SIC SBD were co mpared. The results show that the loss of FR D is about 5.65%~17.18% higher than that of SIC SBD in each working condition. If only th e power device loss is considered, the efficien cy of the whole machine can be increased by about 0.08%~0.24%.

6 Conclusion

This advanced package is easy to use with h ybrid SIC devices. High efficiency and low los s can be achieved. And the package is more suitable for PV and PCS applications than tra ditional package. The package is the largest s ize in terms of the flexible pinout.

7 References

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