

8th Generation LV100 IGBT Module for High Power Central-type PCS

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1. Introduction

To improve PCS efficiency and power density, Mitsubishi Electric developed 8th generation IGBT module CM1800DW-24ME, LV100 package with adopting the new generation chipsets. The package image and main specifications are shown as Table. 1.

Outline	
Part No.	CM1800DW-24ME
Rated voltage	1200 V
Rated current	1800 A
Isolation voltage	4 kV _{rms}
Internal connection	2 in 1

Table 1: IGBT specification

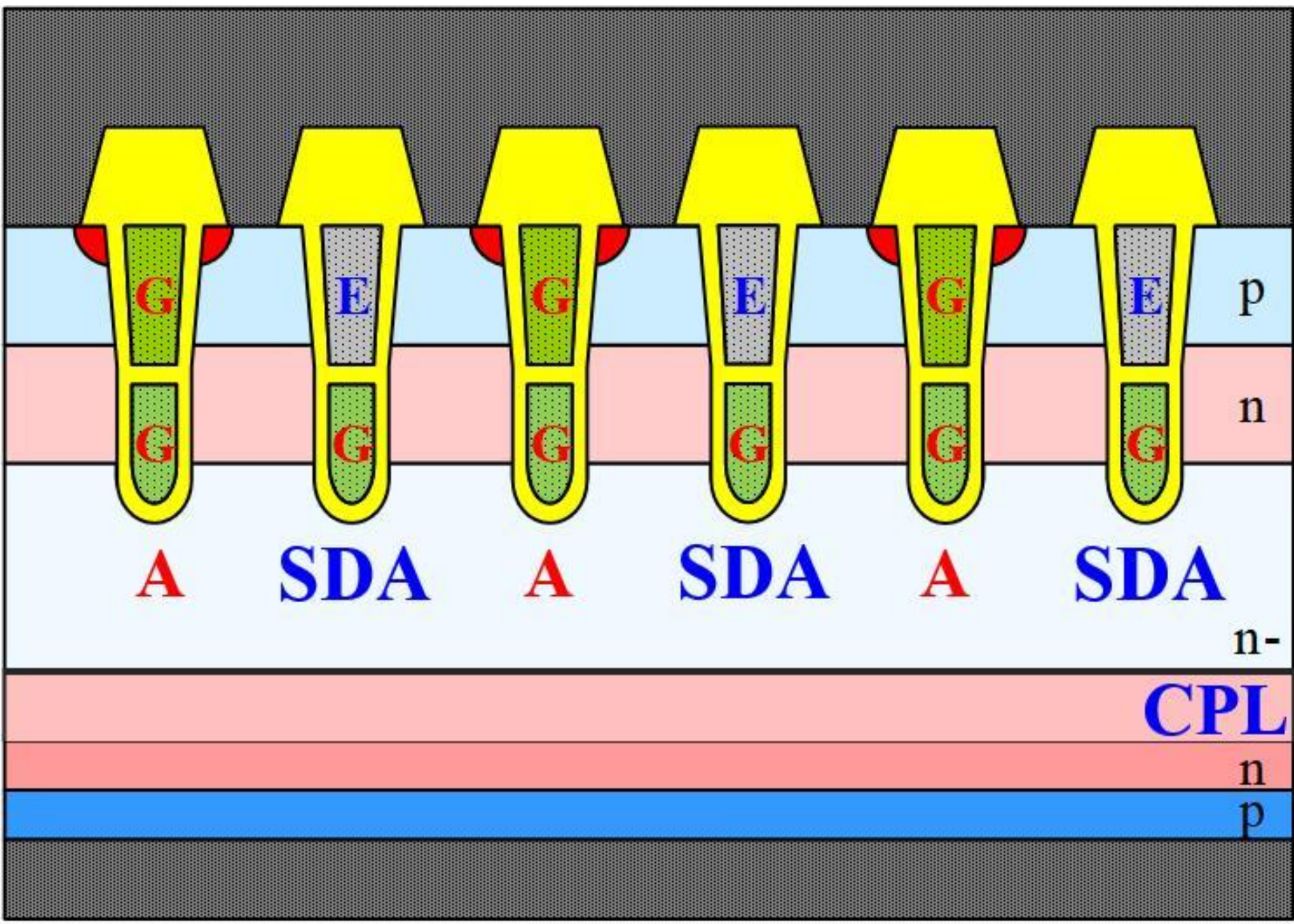


Fig. 1: IGBT Chip Cross-sectional structure

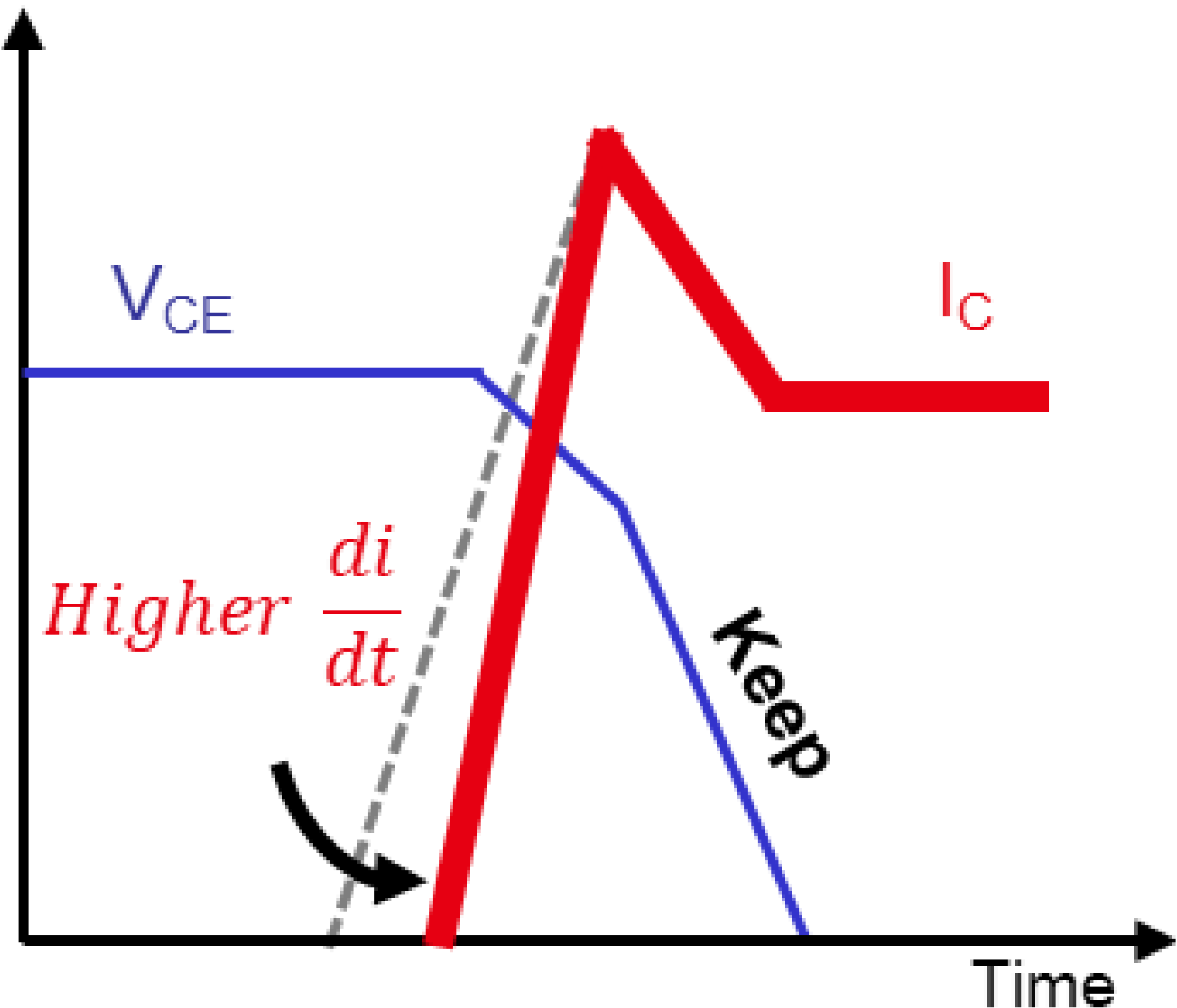


Fig. 2: Illustration of IGBT turn on

8th generation IGBT chip adopts Split Dummy Active (SDA) structure, and the cross-sectional structure with the newest chips is shown in Fig. 1. The reverse transfer capacitor C_{GC} will be larger than conventional 7th generation IGBT chip. In other words, under the same dv/dt condition, the smaller gate resistor than 7th generation IGBT could be used, and the higher turn-on di/dt brings the merit of reducing turn-on loss as shown in Fig. 2.

2. Dynamic characteristics

We built the test bench and conducted the double pulse test. At the conditions: $T_{vj}=150^{\circ}\text{C}$, $V_{CC}=600\text{ V}$, $I_C=3600\text{ A}$, $V_{GE}=\pm 15\text{ V}$, $R_{G(on)}=0.47\ \Omega$, $R_{G(off)}=3.6\ \Omega$, $C_{snubber}=5\ \mu\text{F}$. The turn-on and turn-off switching behaviors could be observed in Fig 3 (a) and (b), respectively, it indicates smooth waveform without oscillation under such high current.

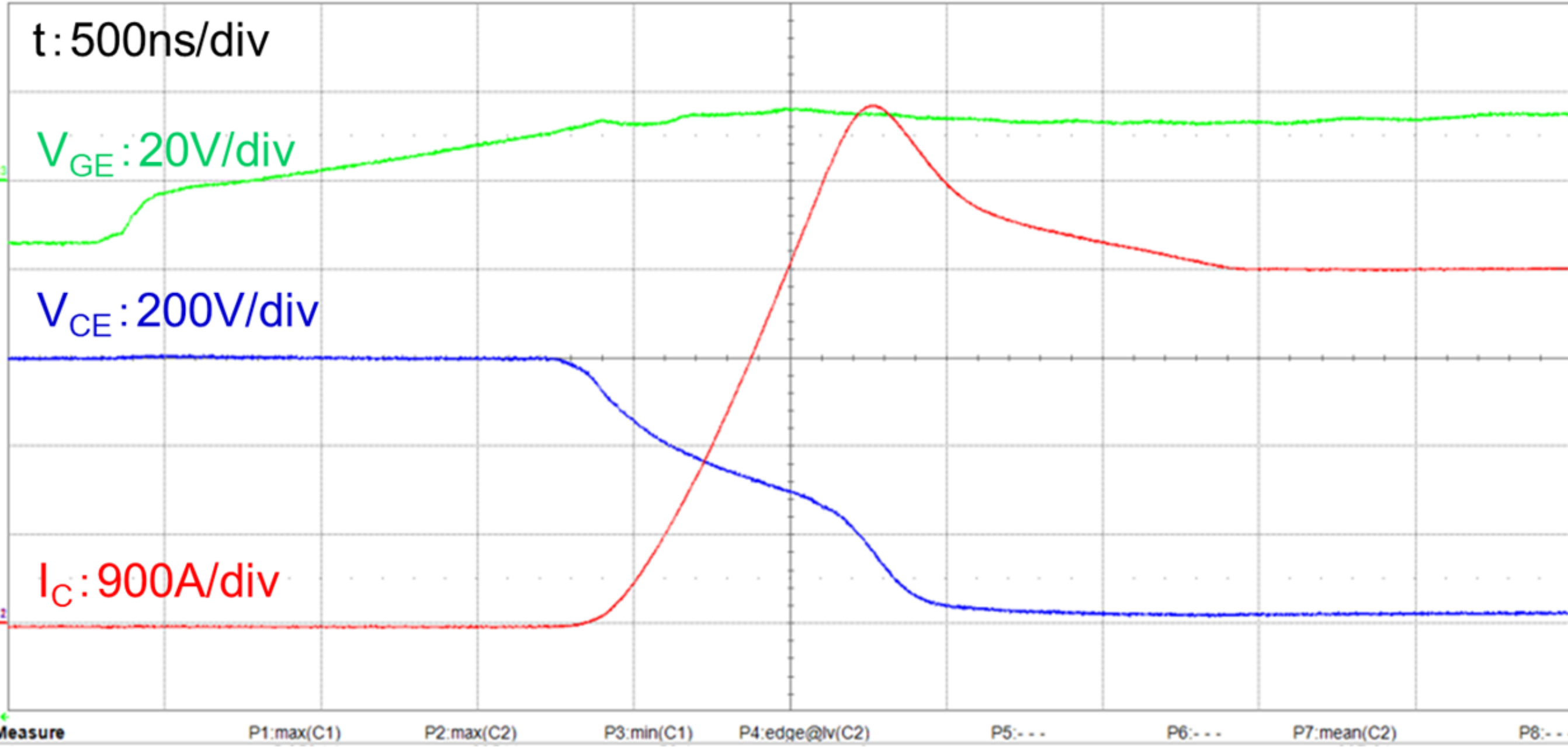


Fig. 3(a): Turn-on waveform

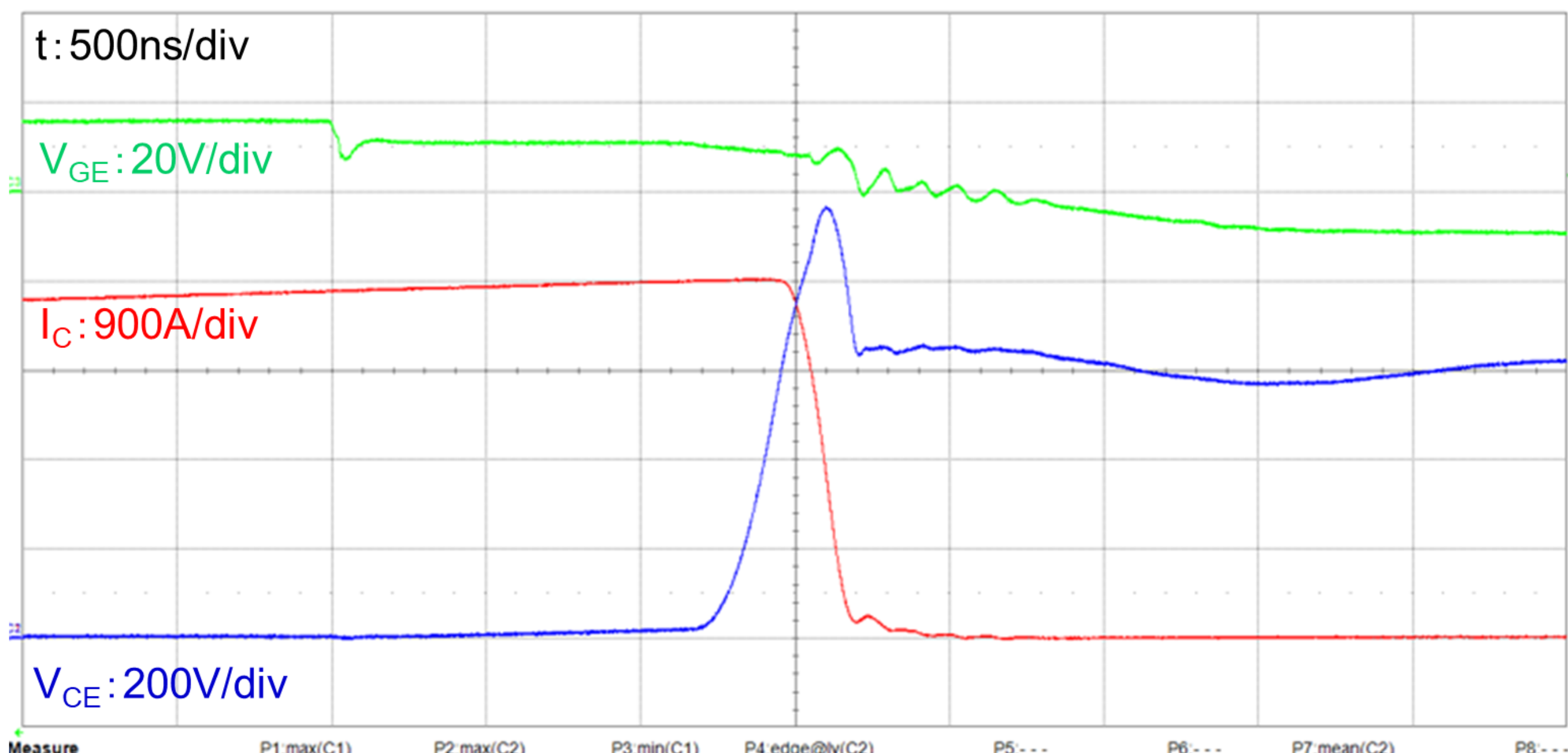


Fig. 3(b): Turn-off waveform

3. PCS with CM1800DW-24ME

A PCS with 2.5 MW output power is becoming the trend for ESS application, especially for China renewable energy market. Hence this paper proposed a solution of minimum power unit of 1.25 MW without parallel IGBT under air-cooling, this allows for a high flexibility in power increases with parallel connection and different heatsink solutions. This paper simulated based on the 1.25 MW central-type PCS, and the typical operating conditions are shown in Table 2.

Parameters	Power rating	DC voltage	AC voltage	AC current	Switching frequency	Power factor	topology
Value	1.25 MW	1500 V	690 Vrms	1046 Arms	2.5 kHz	+1/-1	3-level ANPC

Table 2: The operating condition of 1.25 MW PCS

The circuit topology of three-level active neutral point clamped (3L-ANPC) is shown in Fig. 4, which is built by three half-bridge IGBT modules. For LV100 package, the AC terminals and the DC terminals are aligned on opposite side, and the optimal terminal layout is suitable for 3-level circuit configuration, as shown in Fig. 5. The proposed reference design of power stack are shown in Fig.6, the DC capacitor is placed above the IGBT modules to achieve the compact size.

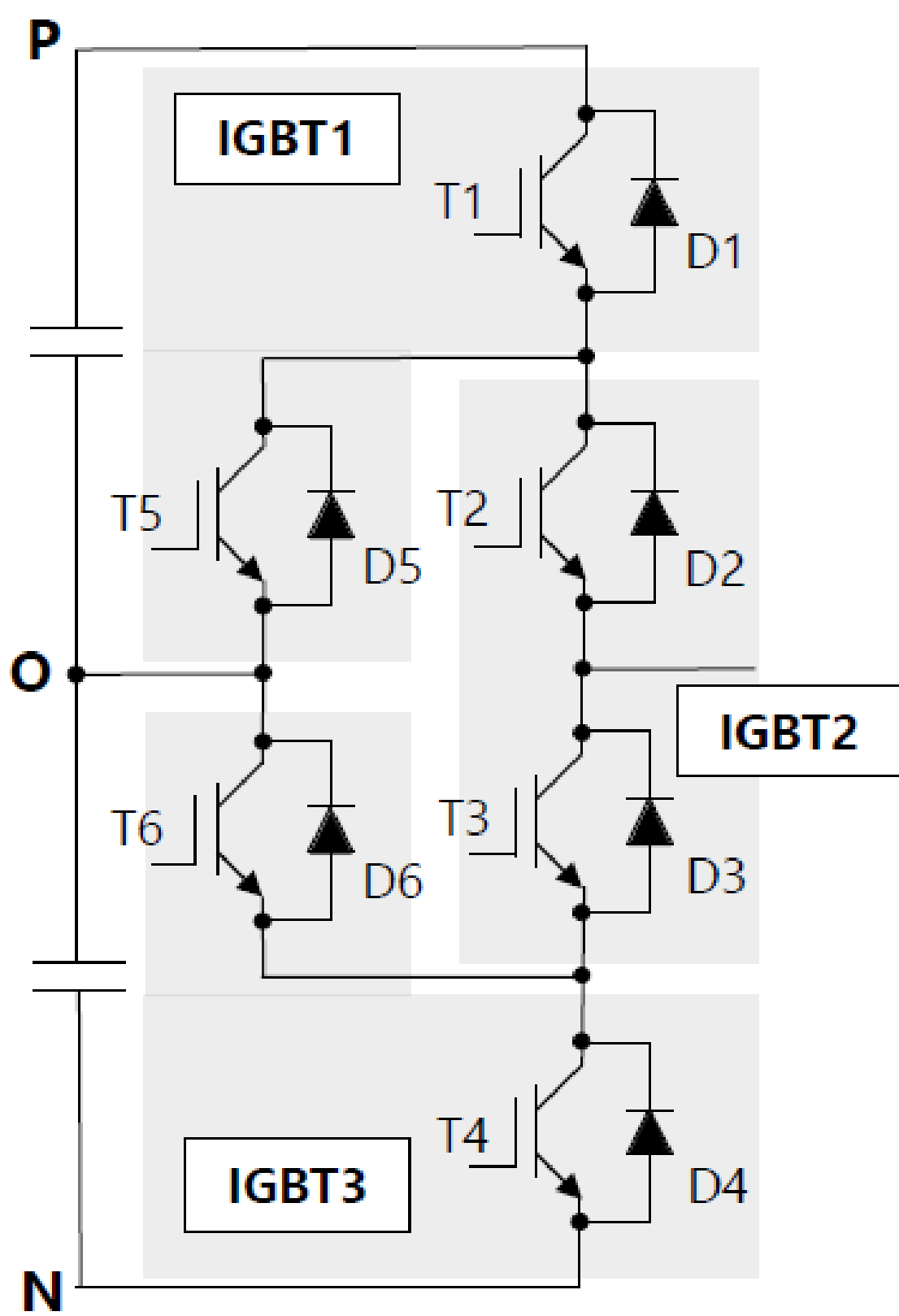


Fig. 4: 3-level ANPC topology setup

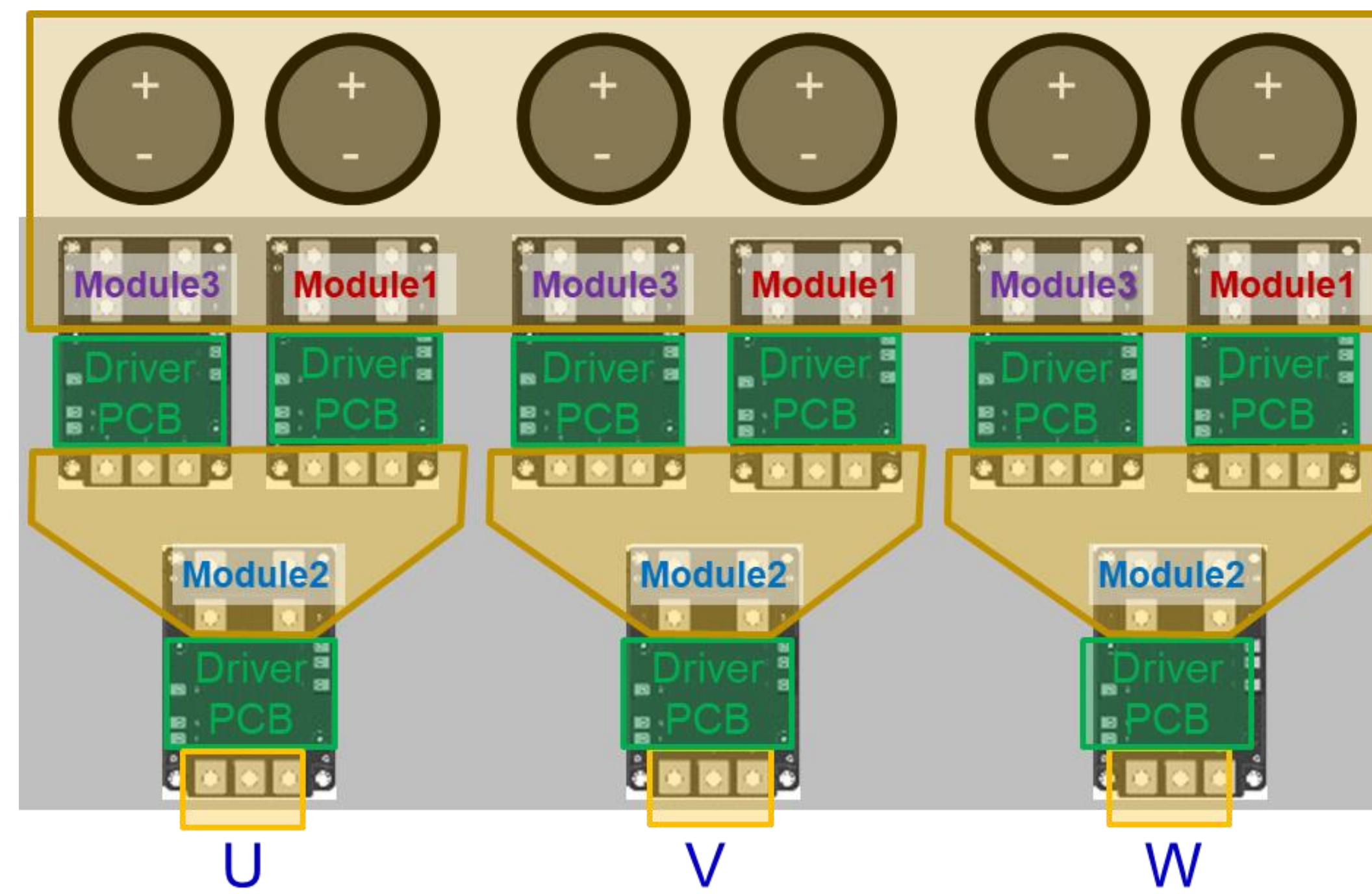


Fig. 5: LV100 IGBT layout

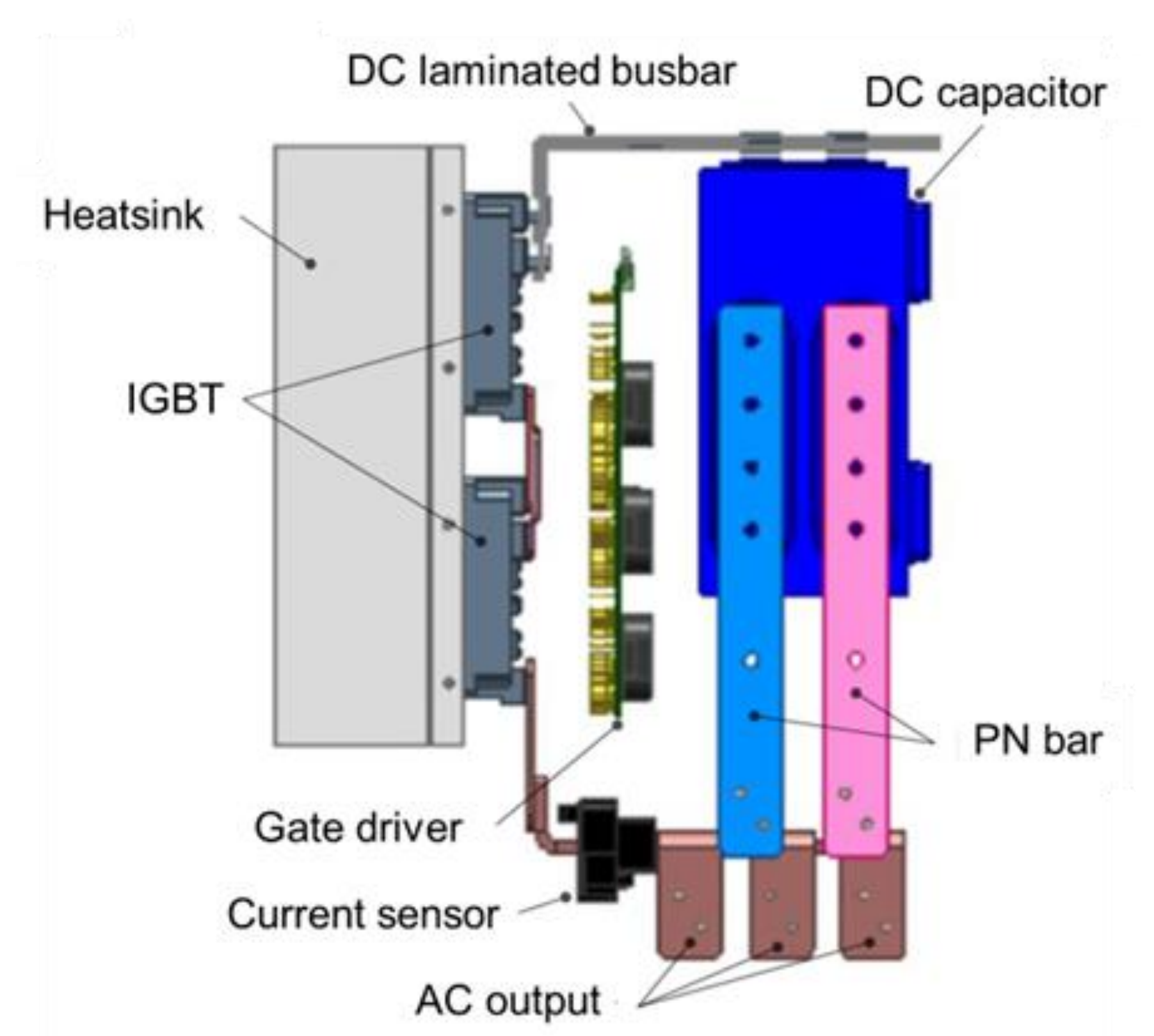


Fig. 6: Reference design of power stack

4. Simulation results of power loss and temperature rise

The power loss and thermal rise were simulated with PLECS software based on Table.2 conditions, and the heatsink temperature $T_s = 100^\circ\text{C}$, $R_{G(on)} = 0.47 \Omega$, $R_{G(off)} = 3.6 \Omega$ were set in simulation. Moreover, ANPC-PWM1 was adopted for modulation strategy.

The power loss distribution and temperature of T1 under PF=1 are shown in Fig. 7 (a) and (b), respectively, the maximum temperature is less than 140°C with considering temperature ripple.

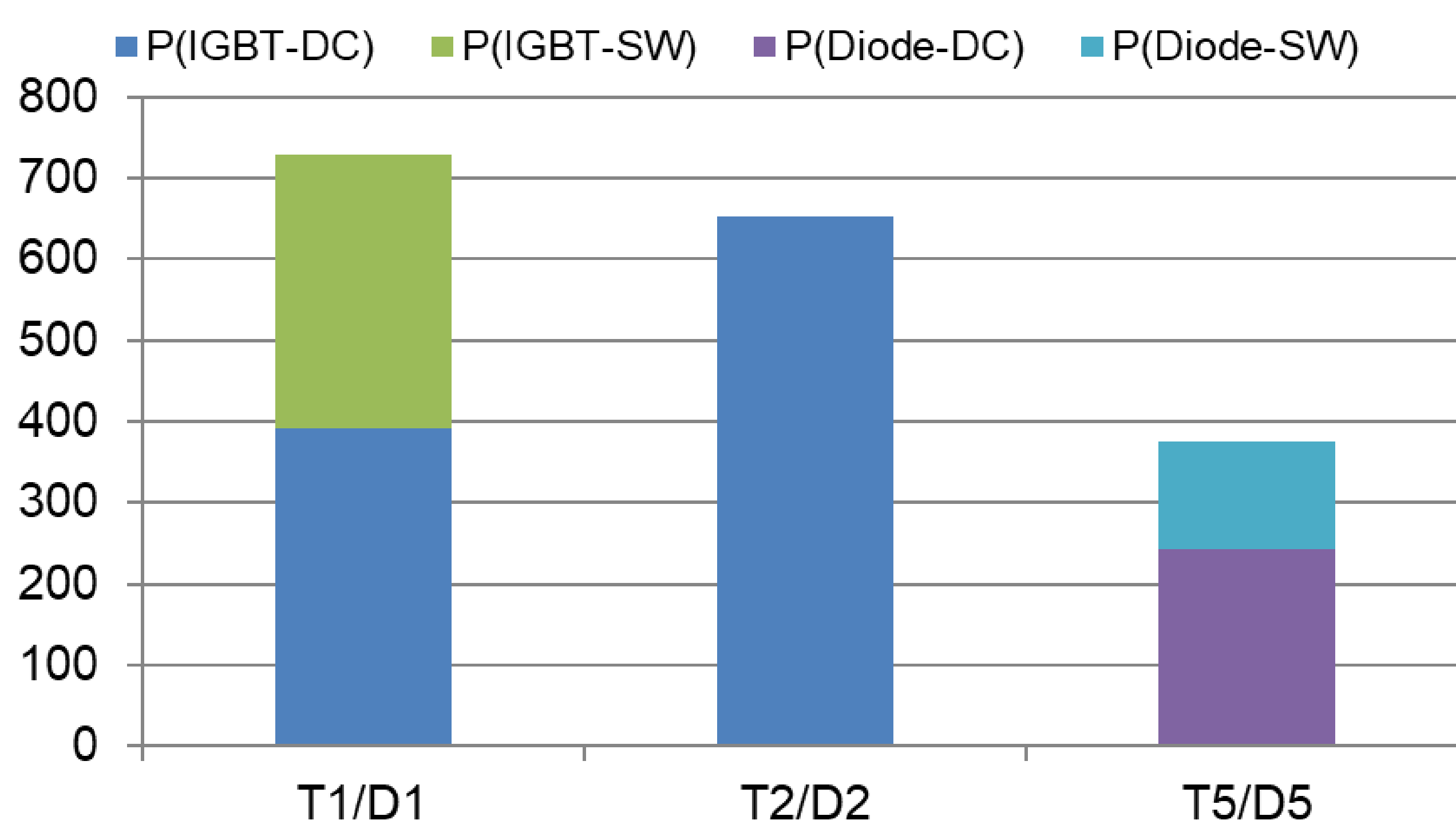


Fig. 7(a): Power loss distribution (PF=1)

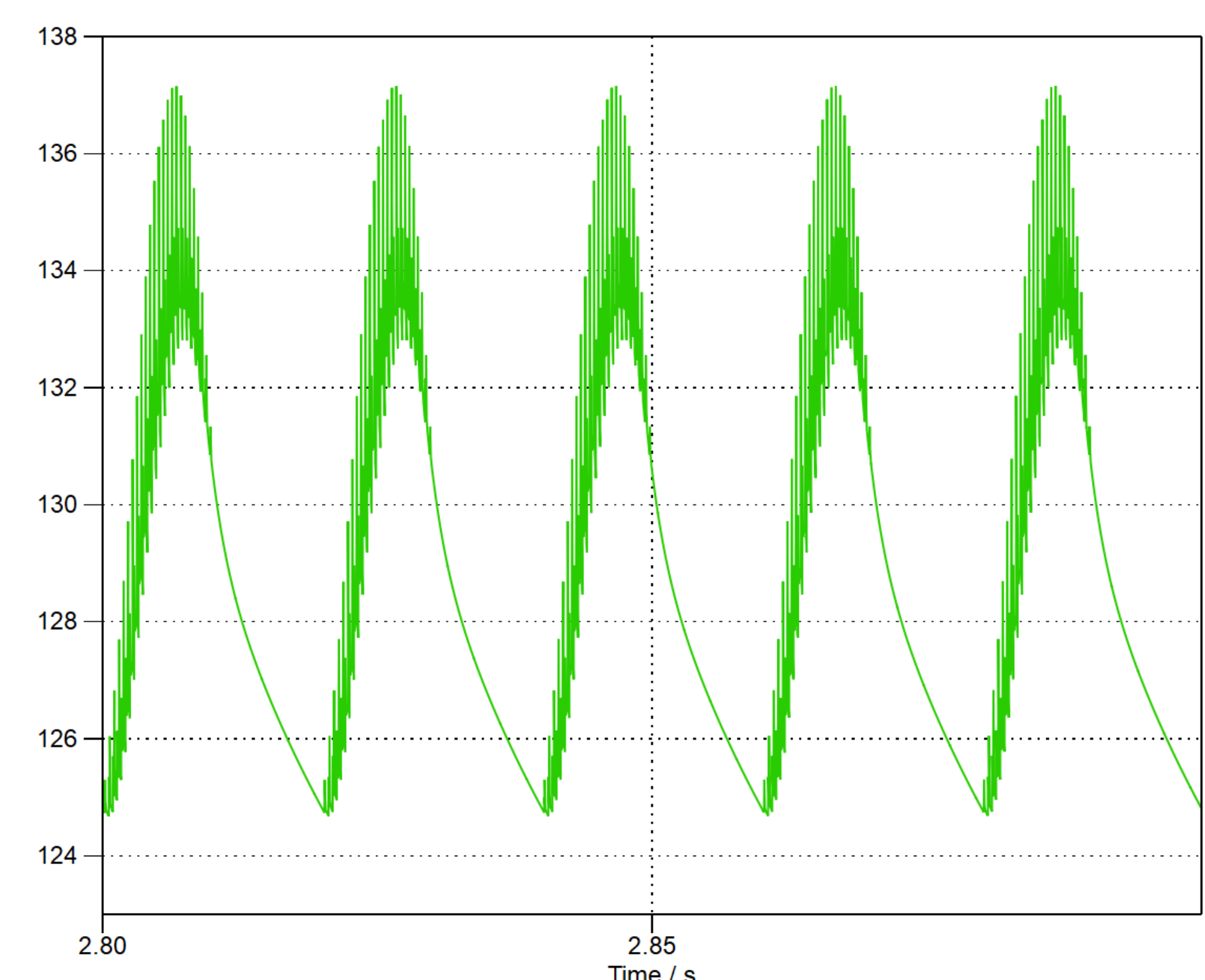


Fig. 7(b): T1 junction temperature (PF=1)

Fig. 8 (a) and (b) indicate the results under PF=-1 and the D2 withstands the highest stress. In addition, the total power loss of single IGBT module is less than 1300 W, it can meet the power requirement of 1.25 MW under strong forced-air cooling.

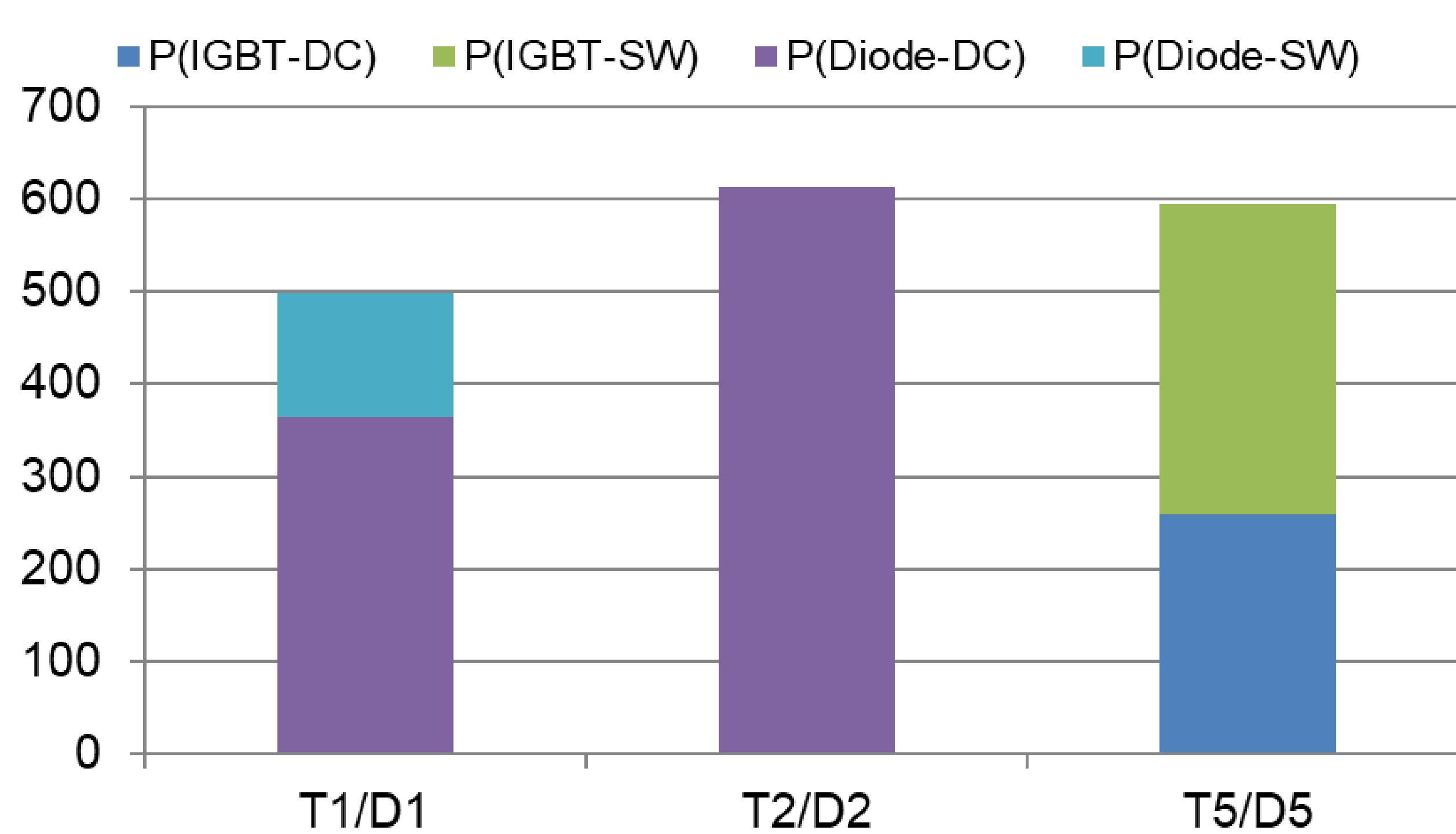


Fig. 8(a): Power loss distribution (PF=-1)

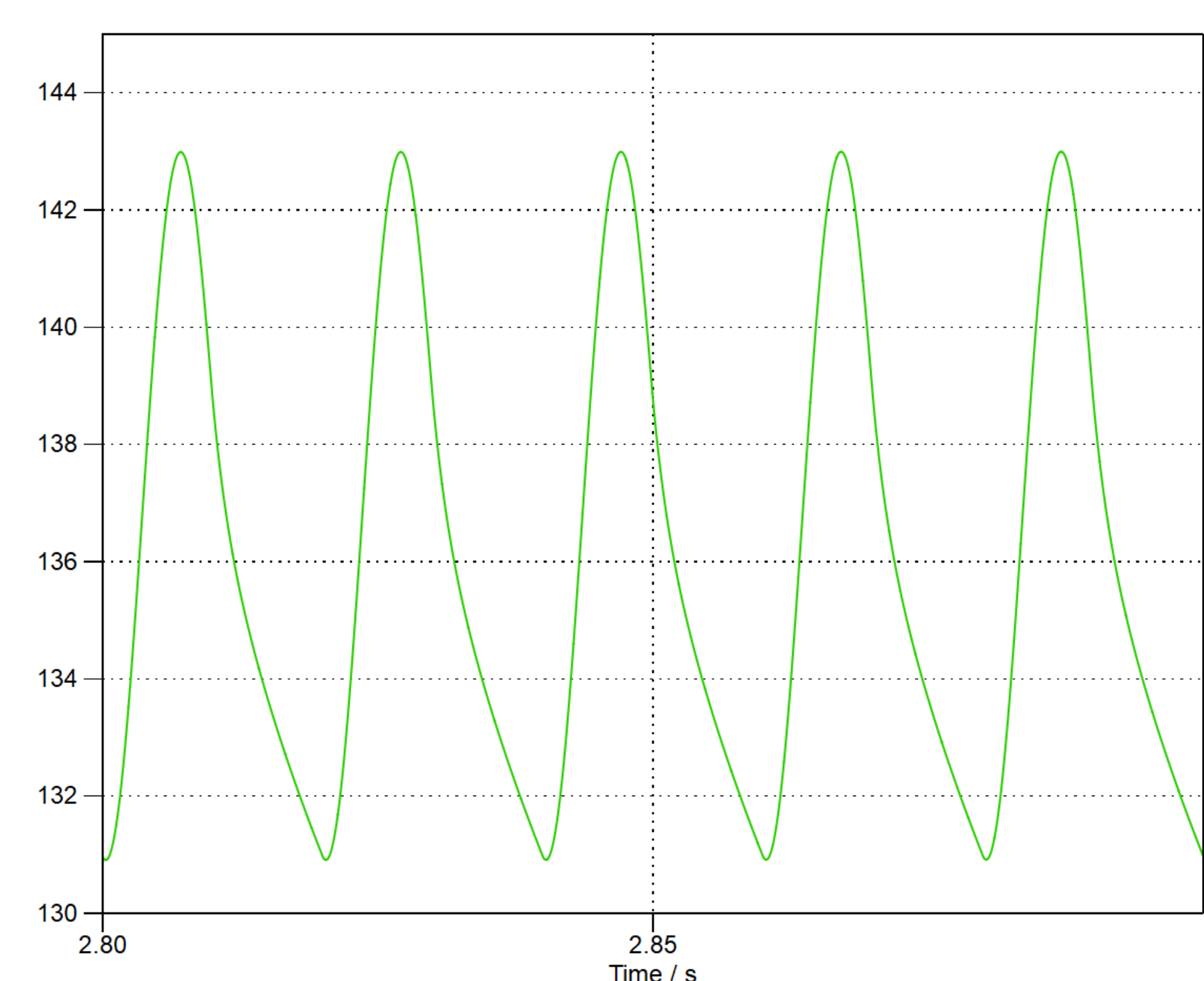


Fig. 8(b): D2 junction temperature (PF=-1)

5. Conclusion

This paper introduced LV100-package IGBT module with 8th generation chips, the new SDA chip technology was designed for reducing the turn-on switching loss. Then, the dynamic characteristics were evaluated by DPT test, and the results indicate the enough margin between the rated voltage and peak value of spike voltage. Finally, this paper proposed a design example for 1.25 MW central-type PCS with IGBT placement and power stack layout. In addition, the power loss and temperature rise were simulated to show the effectiveness of proposed IGBT module for meeting the design requirement.