SK08110 Data Sheet

Abstract

SK08110 is a high-end gate driver developed for crimp modules in high reliability fields such as HVDC and offshore wind power. Through the cooperation of Firstack's unique "NC active clamping technology" and "graded shutdown technology", the module can be safely shut down with any large current under the commutation loop of 200+nH stray inductance.

The intelligent fault management system provides all-round protection measures such as V_{CE} overcurrent protection, di/dt short-circuit protection ; the digital gate driver cooperates with the master computer by opening the protection authority, and adopts different protection strategies according to the degree of fault damage to ensure the system operates safely and continuously and smoothly.

Fig.1 SK08110

Contents

System block diagram

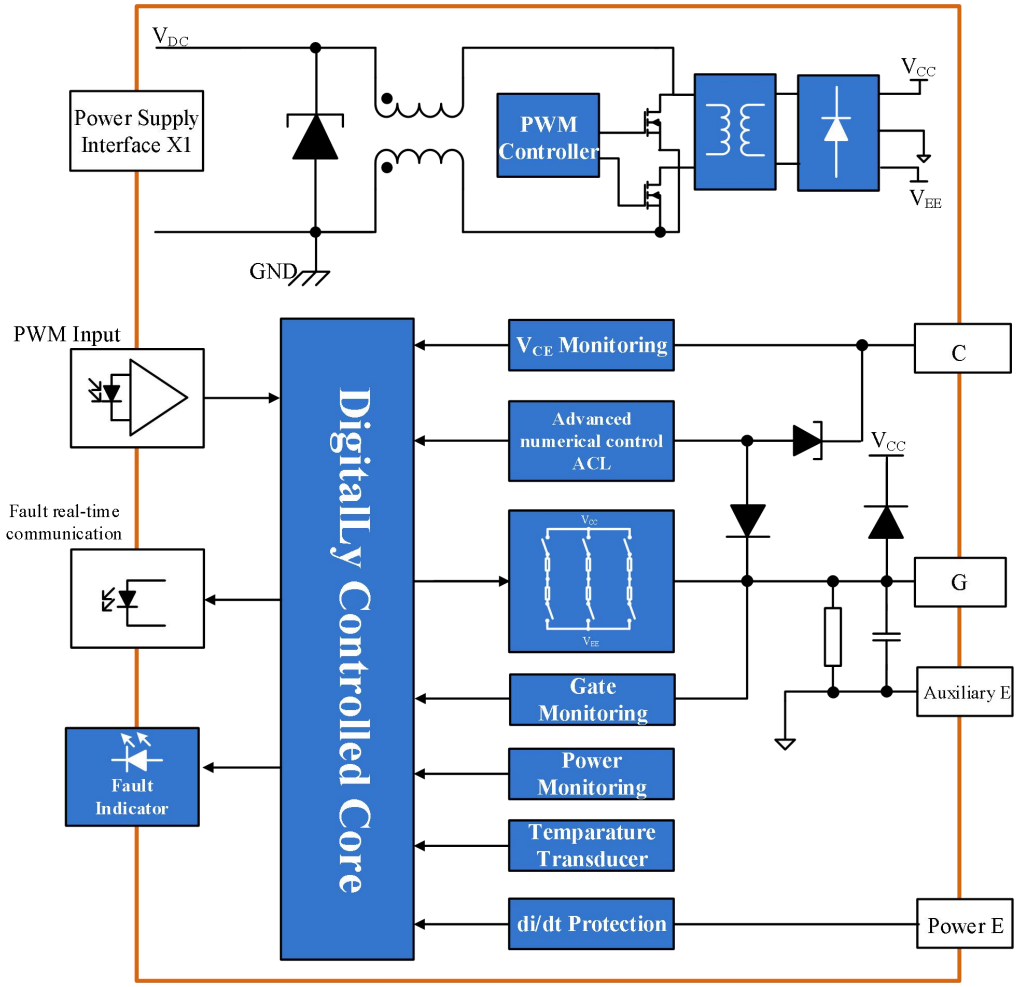


Fig.2 System block diagram

The primary side provides 12V~18V DC voltage, and the power supply voltage required by the system is obtained through the isolated power supply; the PWM signal is transmitted directly to the secondary side through the optical fiber, and the driving signal of the semiconductor device IGBT is obtained through the processing of the relevant unit circuit.

When the gate is turned on, if no short-circuit fault occurs, the main power device is saturated and turned on, the voltage across the IGBT-CE is close to zero, the IGBT-CE detection is reset, and the corresponding soft-off circuit does not start; if a short-circuit fault occurs During the gate opening process, the main power device exits saturation, the voltage across IGBT-CE is close to the bus voltage, the IGBT-CE detection is set, and the corresponding soft turn-off circuit is activated to protect the main power device from damage. At the same time,

the fault signal is transmitted to the master computer through the optical fiber; when there is no PWM signal input, the gate is always in the negative pressure turn-off state.

Use steps and safety notice

Simple use steps of the gate driver are as follows:

1. Choose suitable gate driver

When using the gate driver, pay attention to the model of the IGBT module that the gate driver is adapted to. It is invalid for non-designated IGBT modules. Improper use may cause the gate driver and the module failure.

2. Install the gate driver on the IGBT module

Any treatment of IGBT modules or gate drivers should follow the general specifications for the protection of electrostatic sensitive devices required by the international standard IEC 60747-1, Chapter IX or IEC 60340-5-2 (which means the workplace, tools, etc. must comply with these standards).

If these specifications are ignored, both the IGBT and the gate driver may be damaged.

3. Connect the gate driver to the control unit

Connect the gate driver connector (optical fiber) to the control unit and provide a suitable power supply voltage for the gate driver.

4. Check the function of the gate driver

Check the gate voltage: for the turn-off state, the rated gate voltage is given in the corresponding data sheet; for the turn-on state, the voltage is 15V. Please also check the input current of the gate driver with and without a control signal. For Firstack's digital gate driver, after the gate driver provides a suitable supply voltage, the gate driver status indicator TEST (yellow light) is always on.

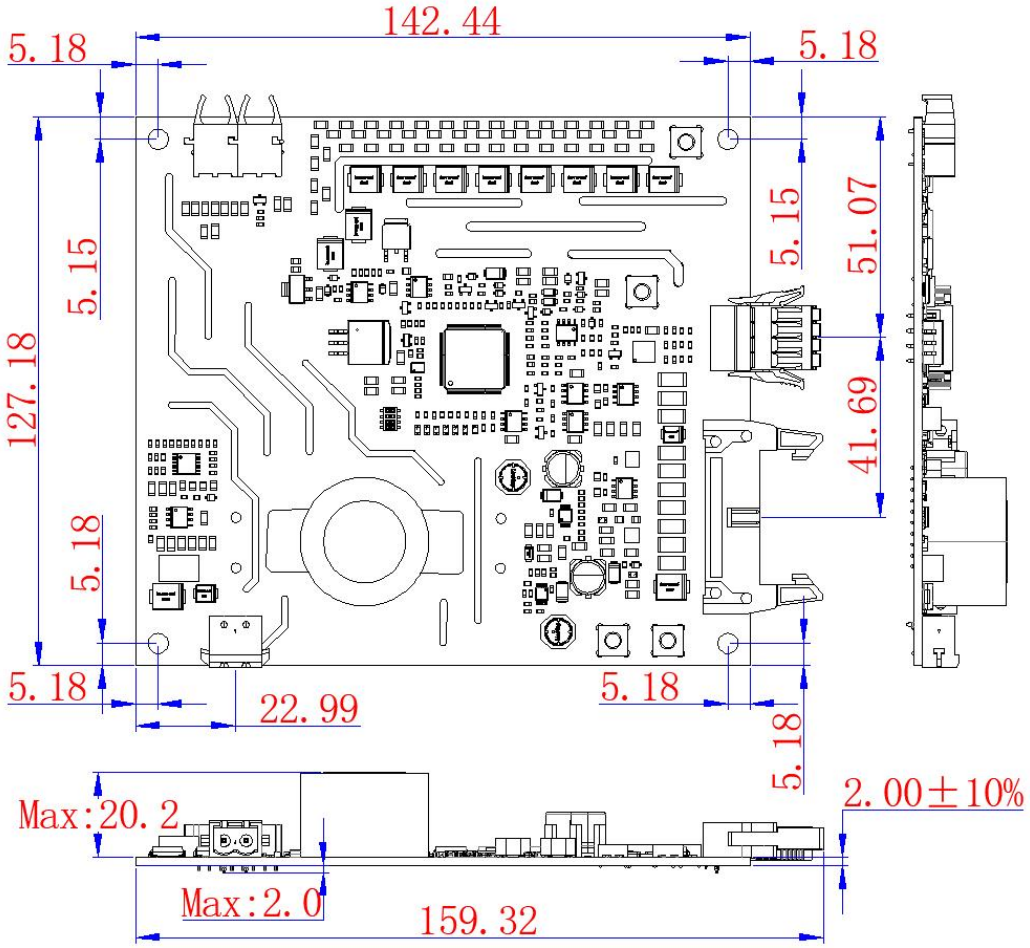
These tests should be performed before installation, because the gate terminal may not be accessible after installation.

5. Set up and test the power unit

The operating condition of the IGBT module strongly depends on the specific converter structure. Before starting the system, it is recommended to check each IGBT module with single pulse and double pulse test method separately.

Firstack specially reminds: even under the worst conditions, it is necessary to ensure that the IGBT module does not exceed the operating range specified by SOA.

Mechanical dimensions



Unit:mm

Fig.3 Mechanical dimensions of SK08110

Note: 1. The thickness tolerance of the board is ±10%;

2. Other dimensional tolerances refer to GB/T1804-m.

Connector manufacturer and model

Number	Ref	Manufacturer	Part number	Recommended matching terminals
1	P1	PHOENIX	MSTBA 2,5/2-G-5,08-RN-1926015	FKC 2,5/2-ST-5,08-RF- 1925692
2	J1, J2, J3, J4	WE		Use 304 carbon steel M4 screws, the torque requirement is 1.2Nm
3	U18	AVAGO	HFBR-1521Z	Versatile fiber-optic failure signal sends fiber-optic
4	U19	AVAGO	HFBR-2521	Versatile fiber-optic PWM signal receives fiber-optic
5	P2	Nextron		20PIN2.54 pitch ejector header connector
6	P4	PHOENIX	MC-1.5-4-G-3.5-RN(1731691)	FMC-1.5-4-ST-3.5-RF(1952047)

Note:

1: Use U20/U21 (ST fiber-optic) together or U18/U19 (versatile fiber-optic) together;

2: It is recommended to install the gate driver board on the insulating board, and use insulating material for the fixing screws.

Pin functional description

P1:

Pin	Pin Name	Description	Pin	Pin Name	Description
1	VDC	Gate driver 15V power supply	2	GND	Gate driver reference ground

P2:

Pin	Pin Name	Description	Pin	Pin Name	Description
1	E	Gate signal E	2	G	Gate signal G
3	E	Gate signal E	4	G	Gate signal G
5	E	Gate signal E	6	G	Gate signal G
7	E	Gate signal E	8	G	Gate signal G
9	E	Gate signal E	10	G	Gate signal G
11	E	Gate signal E	12	G	Gate signal G
13	E	Gate signal E	14	G	Gate signal G
15	E	Gate signal E	16	G	Gate signal G
17	E	Gate signal E	18	G	Gate signal G
19	E	Gate signal E	20	G	Gate signal G

Note: P2 terminal is designed for the gold finger gate of ABB's crimping module.

J1, J2, J3, J4:

Pin	Pin Name	Description	Pin	Pin Name	Description
J1	E	Gate signal E	J2	G	Gate signal G
J3	PE	IGBT module power E pole (can not be connected)	J4	C	IGBT module power C pole

P4:

Pin	Pin Name	Description	Pin	Pin Name	Description
1	NTC1	NTC Input	2	GND	Gate driver secondary GND
3	NTC2	NTC Input	4	GND	Gate driver secondary GND

Note: 1. Compatible with 2 pairs of parallel dual-channel of NTC acquisition, and transmits the temperature data of the channel with the highest temperature.

2. When using a single transistor, two NTCs can be connected to any one.

3. The recommended NTC resistor model is MF53-502F-3470-100LM4 screw specification.

4. NTC model requirements: B25/50=3740K±1%; R25=5KΩ±1%.

Connector indication diagram

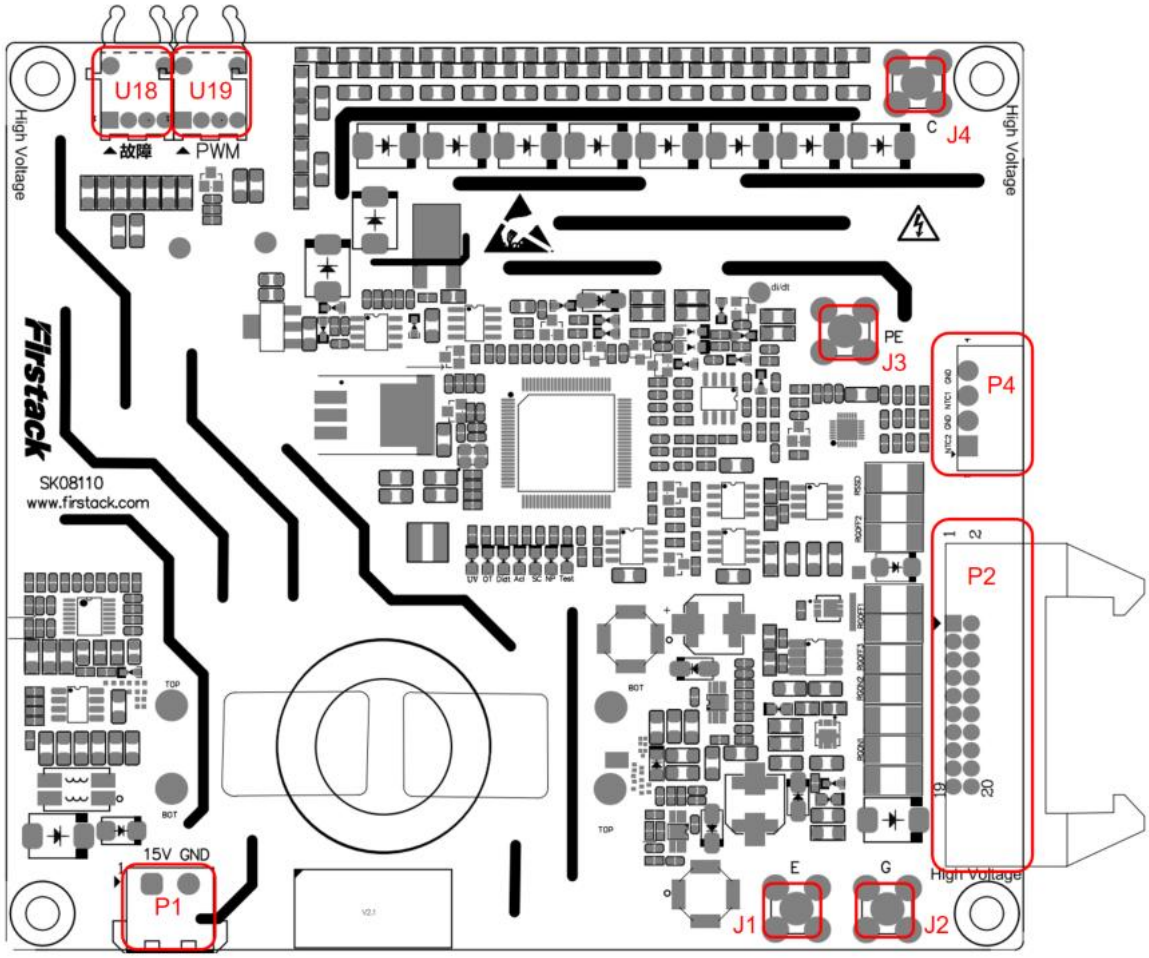


Figure 4.Connector indication diagram

LED status indication

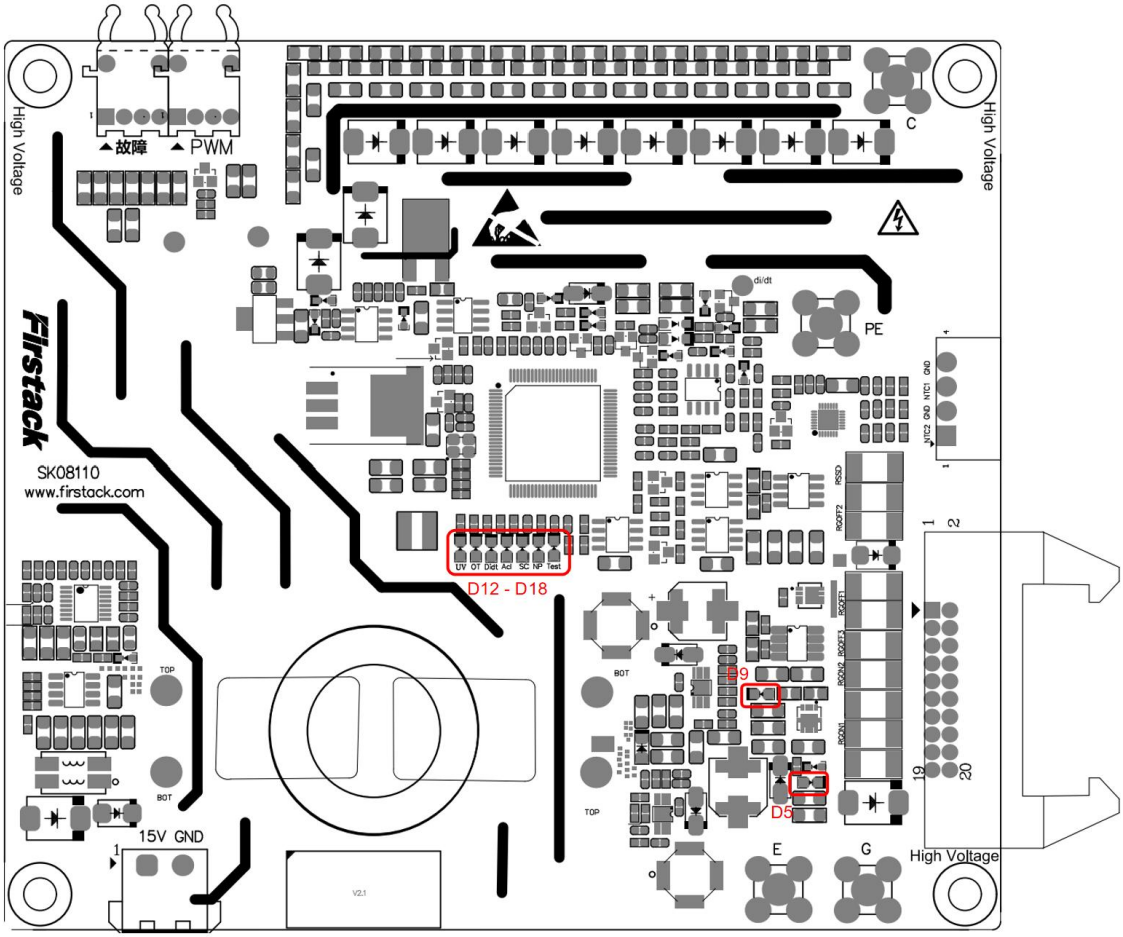


Fig.5 Status indicator

For the convenience of customers, several status indication LEDs are added on the Firstack gate driver board to facilitate customers to know the operating status of the gate driver board and converter. The specific explanation is as follows:

Status indicator

Number	Label	Interface	Note
1	D9		Power signal indicator, always on when power on, green
2	D18	TEST	It is always on when there is no fault, otherwise off, green
3	D12	UV	It is always on when an undervoltage is triggered, unless it is restarted, red
4	D14	Didt	Once the di/dt short-circuit protection is triggered, it is always on, unless restarted, red
6	D16	SC	Once the V_{CE} short-circuit protection is triggered, it is always on, unless restarted, red

7	D15	Acl	Once the ACL is triggered, it is always on, unless it is restarted, red
8	D17	NP	Once the gate is triggered by a short pulse, it is always on, unless restarted, red
9	D13	OT	Once triggered by overheating, it is always on, unless restarted, red
10	D5		Gate open indicator, on when the gate is normally on, off when the gate is off, green

Driving parameters

Absolute Maximum Ratings

Parameter	Note	Min.	Max.	Unit
V_{IN}	GND	14	18	V
Gate Peak Current			110	A
Output Power	25℃		8	W
Test Voltage(50Hz/1min)	Primary to secondary side	10500		V_{RMS}
Operating Temperature		-40	+85	℃
Storage Temperature		-40	+85	℃

Recommended Work Conditions

Parameter	Note	Min.	Typ.	Max.	Unit
V_{DC}		14.5	15	18	V

Electrical Characteristics

Power	Note	Min.	Typ.	Max.	Unit
Power Supply Current	No load		0.23		A
Coupling Capacitor	Primary to secondary side			6.7	pF
Power supply monitoring					
Threshold				10.6	V
Short-circuit Protection					
V_{CE} Threshold			10.2		V
Response Time	Note 1		9.6		us
Blocking Time	Note 2		96		ms
Timing Characteristics					
Turn-on Delay	Note3		600		ns
Turn-off Delay	Note 4		500		ns
Rise Time	Note 5		19		ns

Fall Time	Note 6	24	ns
Output characteristics			
Gate Turn-on Voltage		15	V
Gate Turn-off Voltage		-10	V

Unless otherwise noted, all data are based on +25℃ ring temperature and VDC=15V.

Electrical Isolation			
Test Voltage (50Hz/1min)	Primary to secondary side	10500	V_{RMS}
	Secondary C to secondary side	8000	V_{RMS}
Creepage Distance	Primary to secondary side	66	mm
	Secondary to secondary side	32	mm
Clearance Distance	Primary to secondary side	32	mm
	Secondary to secondary side	18	mm

Notes:

1. Response time: the time from the occurrence of the fault to the start of the soft shut down;

2. Blocking time: the time for blocking the gate signal after the fault occurs;

3. Turn-on delay: the time required to transmit from the rising edge of the PWM signal input to the gate driver to the rising edge of the secondary gate driver when the IGBT is not connected;

4. Turn-off delay: the time required to transmit from the falling edge of the PWM signal input to the drive to the falling edge of the secondary gate driver when the IGBT is not connected;

5. Rise time: the amount of time from 10% of the gate turn-off voltage (-10V) to 90% of the gate turn-on voltage (+15V) without connecting the IGBT;

6. Fall time: the amount of time from 90% of the gate turn-on voltage (+15V) to 10% of the gate turn-off voltage (-10V) without connecting the IGBT;

7. Fault hold time: after the fault occurs, the time that the fault signal is holding.

Function description

◆ Short-circuit protection—di/dt(Reserved)

Di/dt refers to the rate of change of the collector current IC with respect to time. The di/dt protection is based on voltage measurement of power emitter (PE) and auxiliary emitter (AE). V_{PA} is the voltage between the auxiliary emitter and the power emitter, which is proportional to di/dt.

Under normal operation, di/dt typically ranges from tens of amperes per microsecond. When a short circuit occurs in the IGBT, however, di/dt can surge to thousands of amperes per microsecond—a difference of hundreds of times. Since di/dt protection directly monitors the rate of current change, it offers a faster response.

Compared with V_{CE} monitoring, di/dt monitoring is faster and has more obvious competitiveness in multi-level applications.

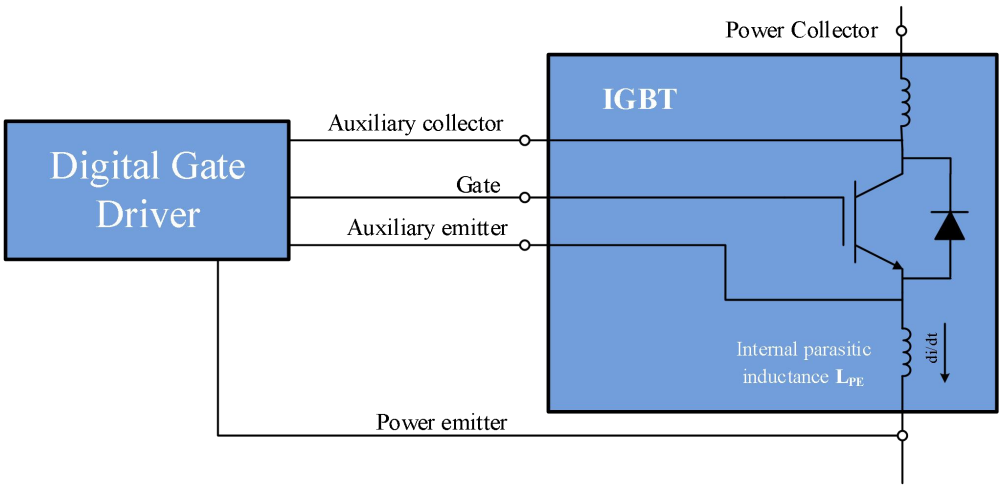


Fig.6 di/dt detection circuit

◆ Short-circuit protection—V_{CE} monitoring

The VCE monitoring circuit determines whether the IGBT is in a short-circuit state by detecting VCE during the IGBT's on state.

V_{CE} is measured through resistive voltage division. When V_{CE} exceeds the threshold voltage, the driver determines that the IGBT is short-circuited, initiates a soft shutdown to slowly turn off the IGBT, and simultaneously reports the fault to the master computer.

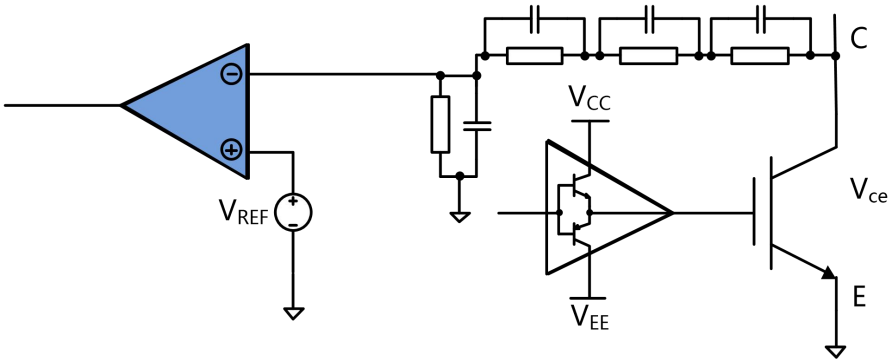


Fig.7 V_{CE} desaturation detection circuit

◆ Undervoltage protection

The driving board monitors the positive and negative power supply of the secondary side at the same time. When the absolute value of the positive or negative voltage of the secondary side is lower than the threshold voltage, the driving circuit determines that an undervoltage fault has occurred and will feed back a fault signal to the master computer.

Firstack intelligent gate driver strongly suggests that any IGBT in IGBT bridge arm should not operate undervoltage. Because of the existence of C_{GC}, when an IGBT in the bridge arm is turned on, its high dv/dt can be coupled to another IGBT through C_{GC}, which leads to a slight turn-on of IGBT. At the same time, low gate voltage will increase the switching loss of IGBT.

◆ Soft shut down

When a direct short-circuit occurs, IGBT will quickly desaturate, and the voltage V_{CE} at both terminals will reach the DC bus voltage; while the current I_C flowing through IGBT will reach 4 times or more of the rated current (depending on IGBT type and gate voltage). At this time, the power consumed by IGBT will instantly reach megawatt level. If the short-circuit current cannot be reduced in a short time, the IGBT will be burned down due to overheating of the chip. However, if the turn-off speed during short circuit is as fast as normal turn-off, a large di/dt will be generated. Due to the existence of parasitic inductance, this di/dt will bring a large voltage peak at both terminals of IGBT, which will cause IGBT overvoltage breakdown.

In order to suppress the turn-off peak in short-circuit, the Firstack intelligent driving circuit introduces soft shut down technology. In case of direct short-circuit of IGBT, on the premise of ensuring that the short-circuit time does not exceed 10us, by slowly reducing the gate

voltage V_{GE}, the IGBT chip will not be burned down due to overheating, and the di/dt will be effectively reduced, thus avoiding the voltage peak when the IGBT is turned off and ensuring the safety of IGBT.

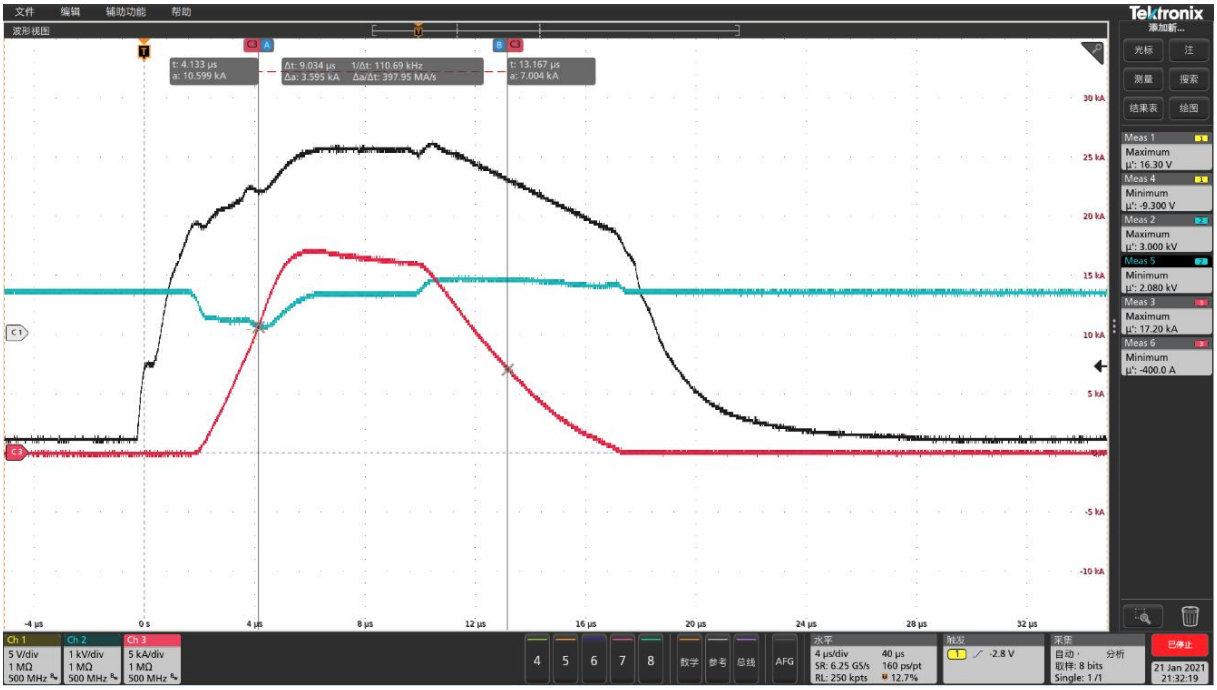


Fig.8 Short-circuit waveform of TG3000SW45ZC-P200 at 2800V

In the above picture, CH1: V_{GE} (black); CH2: V_{CE} (blue); CH3: I_C (red).

Fig.8 shows the short-circuit waveform of the 4500V/3000A IGBT（TG3000SW45ZC-P200）controlled by the Firstack IGBT driving circuit when the DC bus is 2800V. The peak value of short-circuit current is 17200A(5.7 times of rated current). Under the action of soft shut down, I_C drops slowly, V_{CE} has almost no overshoot, and IGBT is safely turned off.

◆ Digitally dynamic advanced active clamping(D^2A^2C)

When the system experiences an overload or a short - circuit on the load side, the turn - off current of the IGBT will be much larger than that in the normal state, which will result in a higher turn-off peak voltage. Under these operating conditions, D^2A^2C can protect the IGBT from failure caused by overvoltage during turn-off.

When V_{CE} exceeds the threshold of the TVS(D1), the TVS will break down. The current flows into the gate, causing the V_{GE} to rise. As a result, the IGBT enters the linear region, thereby limiting the turn-off voltage within a safe range.

To enhance the clamping effect, Firstack Technology has introduced digitally controlled active clamping and added a "digitally controlled current source" to the gate. When I_Z exceeds the threshold, the N MOSFET will be turned off, and the "digitally controlled current source" is activated simultaneously. At this time, $I_Z = I_G + I_D$. Through the digitally controlled current source, I_Z is maintained at a low value, and the TVS remains in a weak breakdown state until the turn-off process is completed.

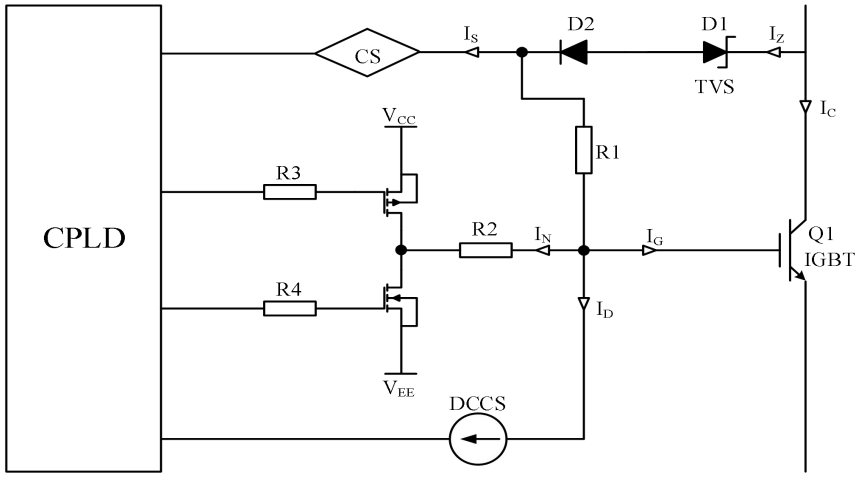


Fig.9 Schematic diagram of active clamping principle

◆ Multi-level turn-on (reserved)

For high-voltage and high-power modules, the energy of each switch is very large, often reaching several joules or even more than ten joules. In order to optimize the turn-on process, especially to reduce the switching loss, Firstack intelligent gate driver introduces the function of "multi-level turn-on", which optimizes the turn-on process by using different gate resistances in the turn-on process.

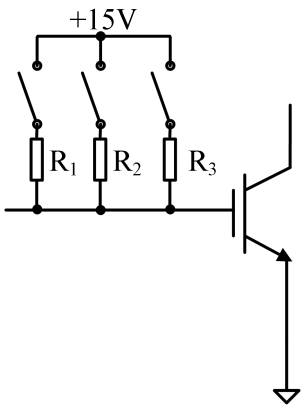


Fig.10 Multi-level turn-on schematic diagram

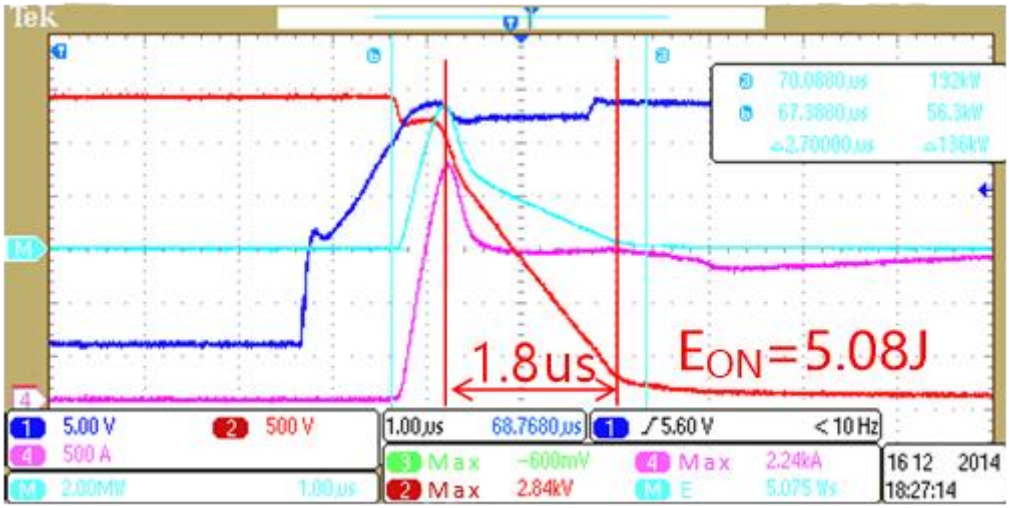


Fig.11a Without multi-level turn-on

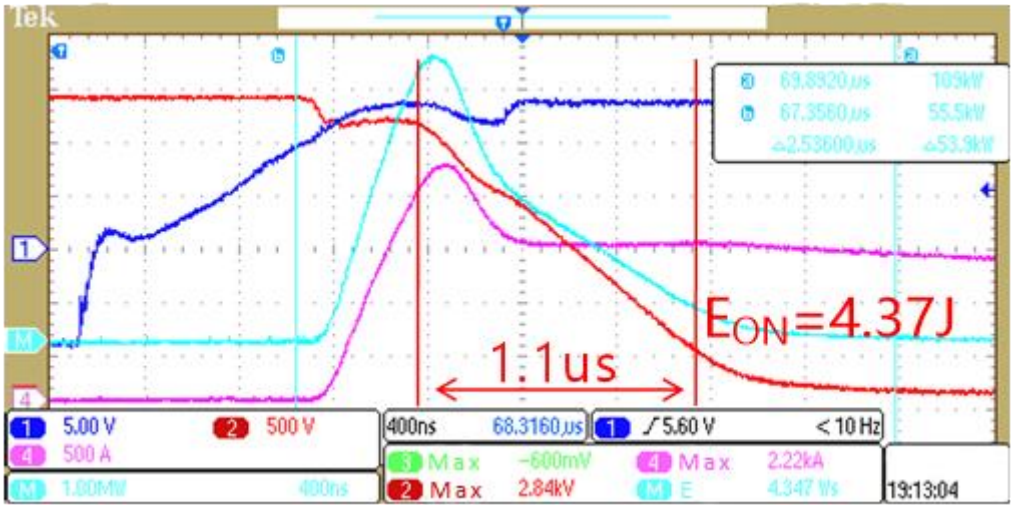


Fig.11b With multi-level turn-on

◆ Multi-level turn-off (reserved)

In some applications with large stray inductance, such as NPC I type 3-level converter circuit, IGBT will face the risk of high turn-off peak every time it is turned off. Because of the limitation of TVS heat capacity, active clamping technology is not suitable for these occasions, and multi-level turn-off technology plays a key role. By using different turn-off resistors in the turn-off process, the whole turn-off process can be optimized and the turn-off peak can be suppressed.

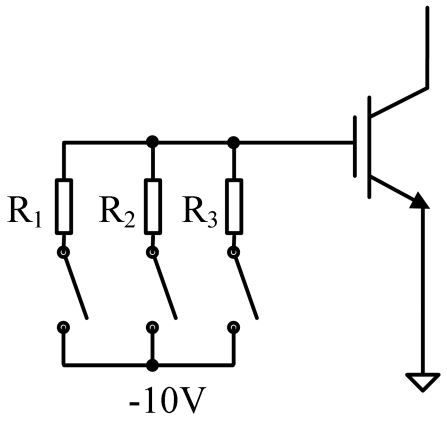


Fig.12 Multi-level turn-off schematic diagram

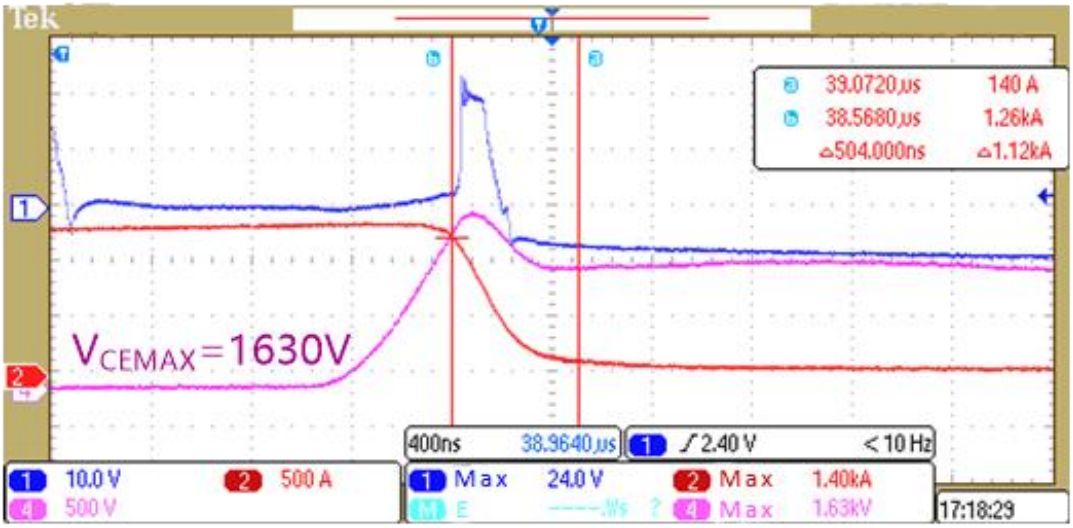


Fig.13a Without multi-level turn-off

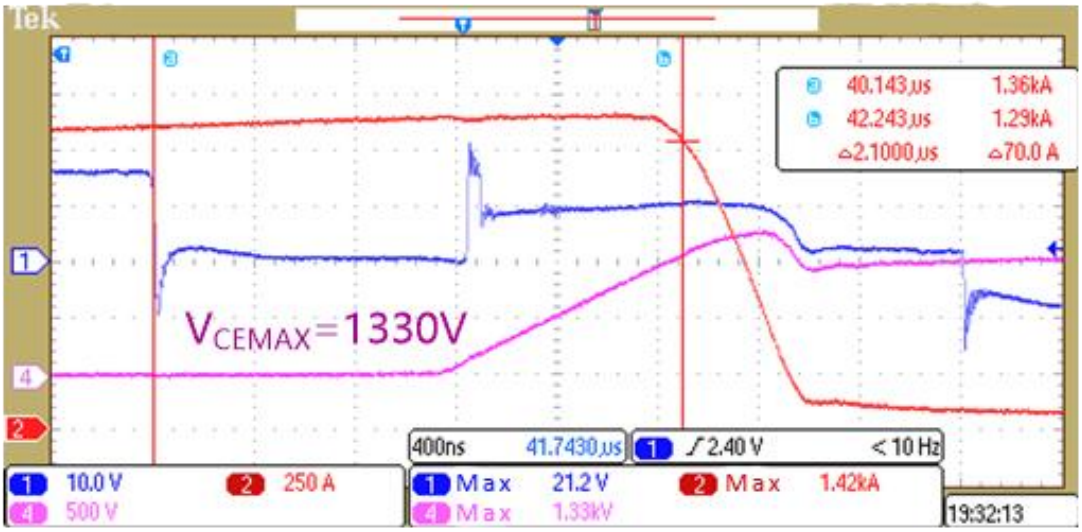


Fig.13b With multi-level turn-off

◆ Optical fiber port notification signal

In the process of using optical fiber, there are some phenomena, such as the buckle of optical fiber mouth is not firm/falling off, and the turning radius of optical fiber line is not enough. In order to ensure the normal optical fiber communication, the Firstack intelligent gate driver is configured with the fiber port response function, as follows:

1、When the driving board works normally, every time a PWM command is received, the lamp returning to the optical fiber head will turn off for a short time of 700ns at the rising edge and falling edge of the PWM command as a response to receiving the command.

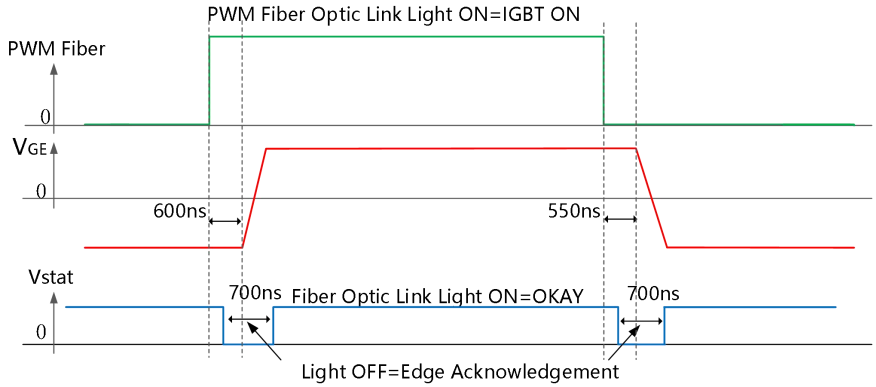


Fig.15a Normal condition

2、When the fault is detected by the driving board, the lamp returning to the optical fiber head will be extinguished for more than 30us, which will be used as a fault signal to inform the master computer.

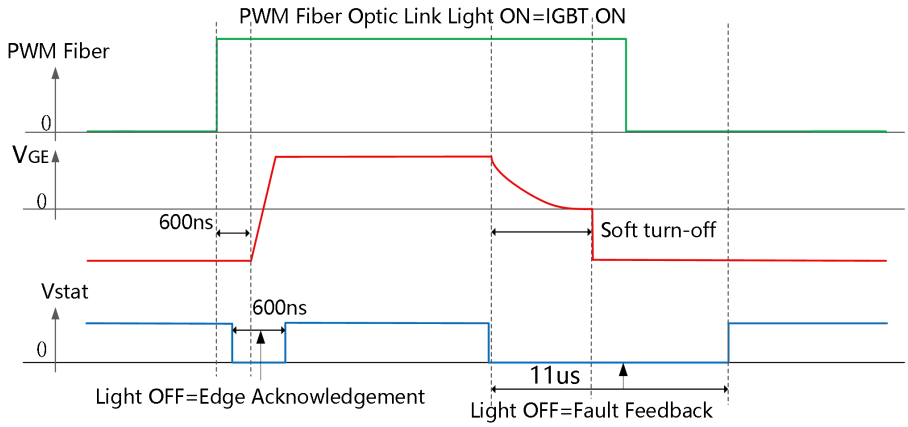


Fig.15b In case of failure

The master computer can accurately distinguish the response information from the fault information by returning the length of the light-off time of the optical fiber head.

Gate resistor indication

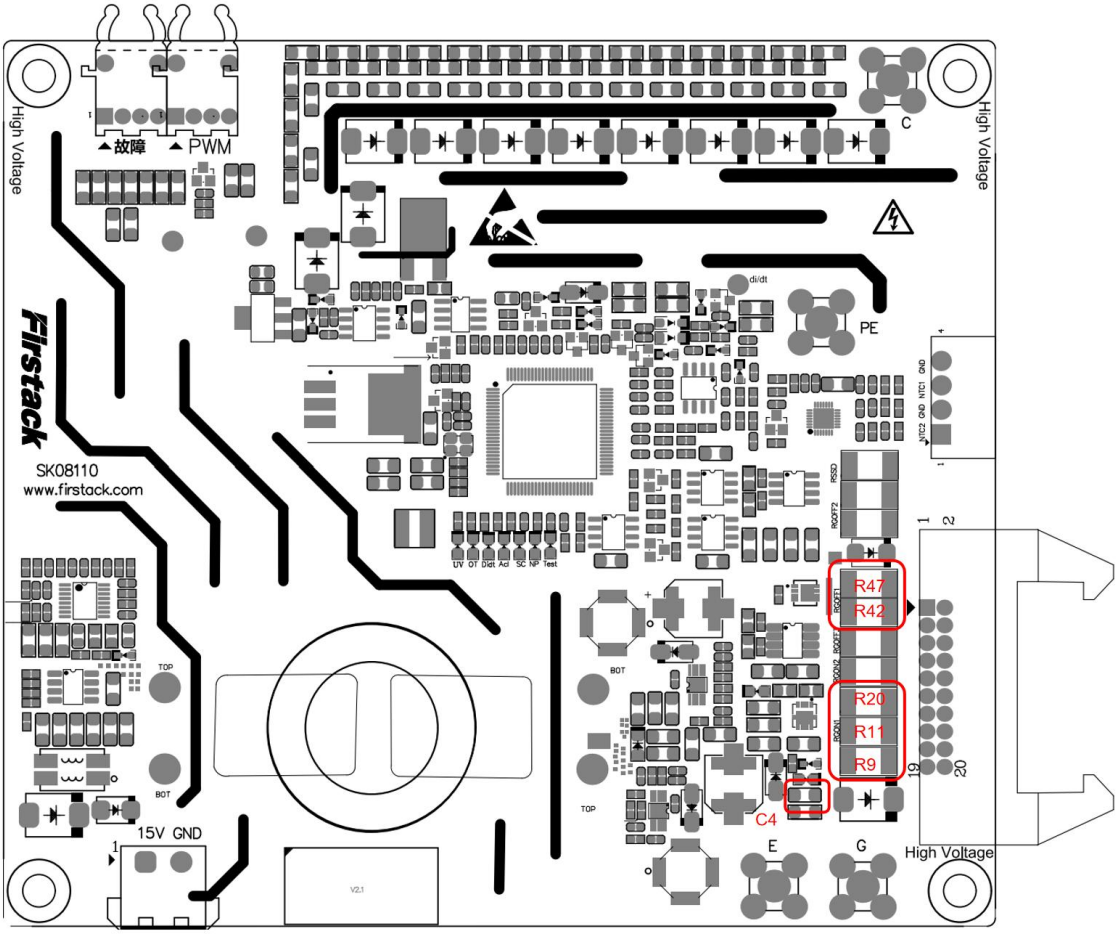


Fig.18 Gate resistor indication

	Rgon	Rgoff	Cge
Single IGBT	R9//R11//20	R42//R47	C4

Gate driver model selection of common IGBT modules

IGBT model	Gate driver model selection	Cge（nF）	Rgon（Ω）	Rgoff（Ω）
TG3000SW45ZC-P200	SK08110V-Y0001	330	1.85	13.5
TG2000SW45ZC-P200	SK08110V-Y0001	330	1.85	13.5
TG1500SW45YB-P200	SK08110V-Y0001	330	1.85	13.5
TG5000SG45ZC-P200	SK08110V-Y0001	330	1.85	13.5
5SNA3000K452300	SK08110V-Y0001	330	1.85	13.5
5SNA2000K452300	SK08110V-Y0001	330	1.85	13.5

Note:

1，SK08110V-Y0001 do not use multi-level turn-off technology or multi-level turn-on technology

2，Recommended dead time of inverter controller for normal operation ≥ 20us;

Ordering information

SK08110 can support different types of crimping modules from CRRC, ABB and Toshiba. If you have a purchase request, please contact us, and we can provide the gate driver that best meets your needs.

Technical support

Firstack's professional team will provide you with business consultation, technical support, product selection, price, lead time and other related information, and guarantee to answer your questions within 48 hours.

Legal disclaimer

This manual gives a detailed introduction about the product, but cannot promise to provide specific parameters. No warranty or guarantee, express or implied, is given herein as to the delivery, performance or applicability of the product.

Firstack reserves the right to modify technical data and product specifications at any time without prior notice. Firstack's general payment terms and conditions apply.

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