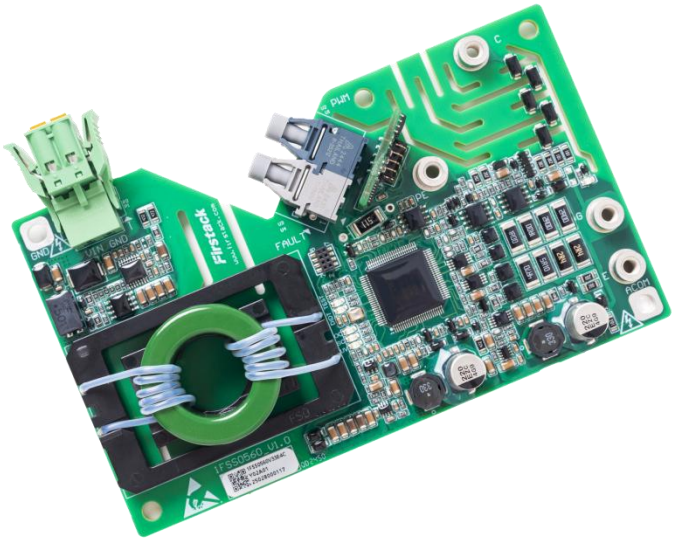
1FSS0560 Data Sheet

Abstract

The 1FSS0560 is designed for both welded and press-pack IGBT modules rated at 4500V/6500V. When connected with an adapter board via wiring harness, it forms a complete drive solution.

By pairing with various adapter boards, this product is compatible with multiple IGBT package types. Additionally, different wiring harness lengths can be selected to flexibly adapt to complex application scenarios, meeting diverse usage requirements.



Highlights:

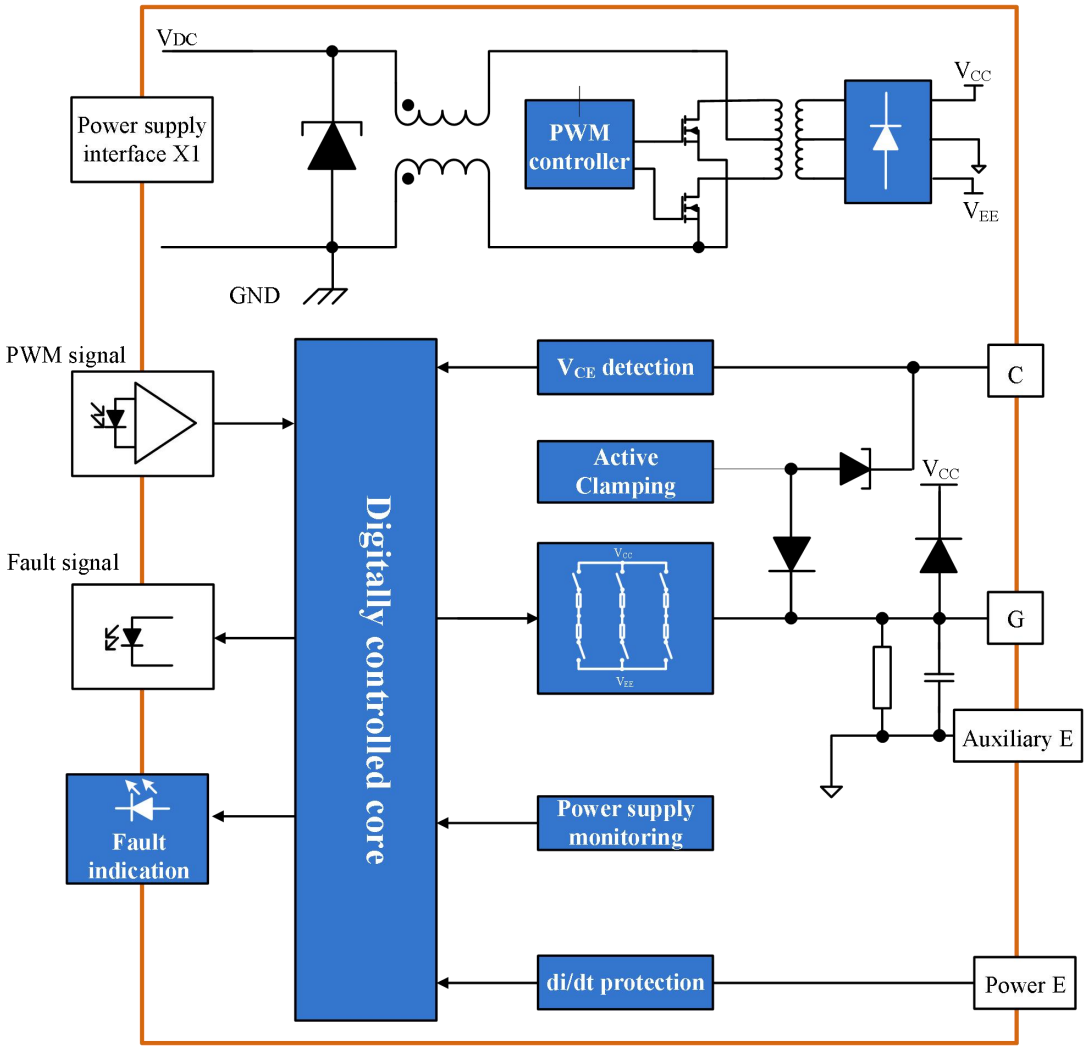
- 5W/60A per channel
- Up to 6500V module
- OC&di/dt protection
- Compatible with multiple IGBT package

Applications:

- Grid
- Rail Transit

Contents

System block diagram



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 part number 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 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 (that is, 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, the gate driver status indicator TEST (green) remains on after the gate driver has been provided with a suitable supply voltage.

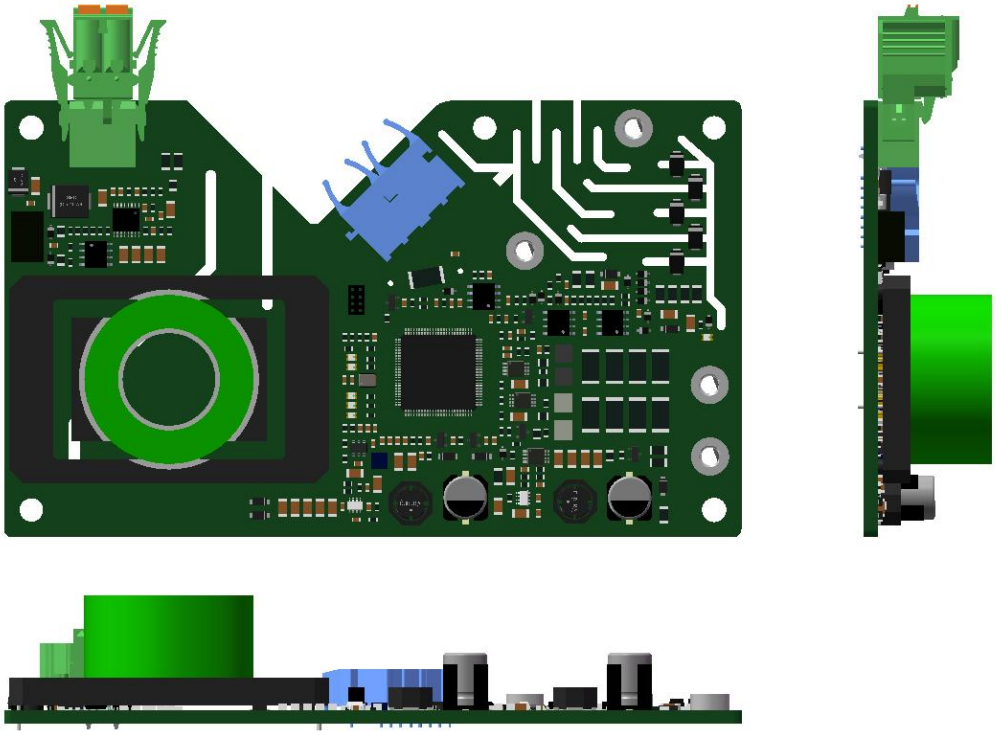
These tests should be performed before installation, because the gate terminal may not be accessible after installation.

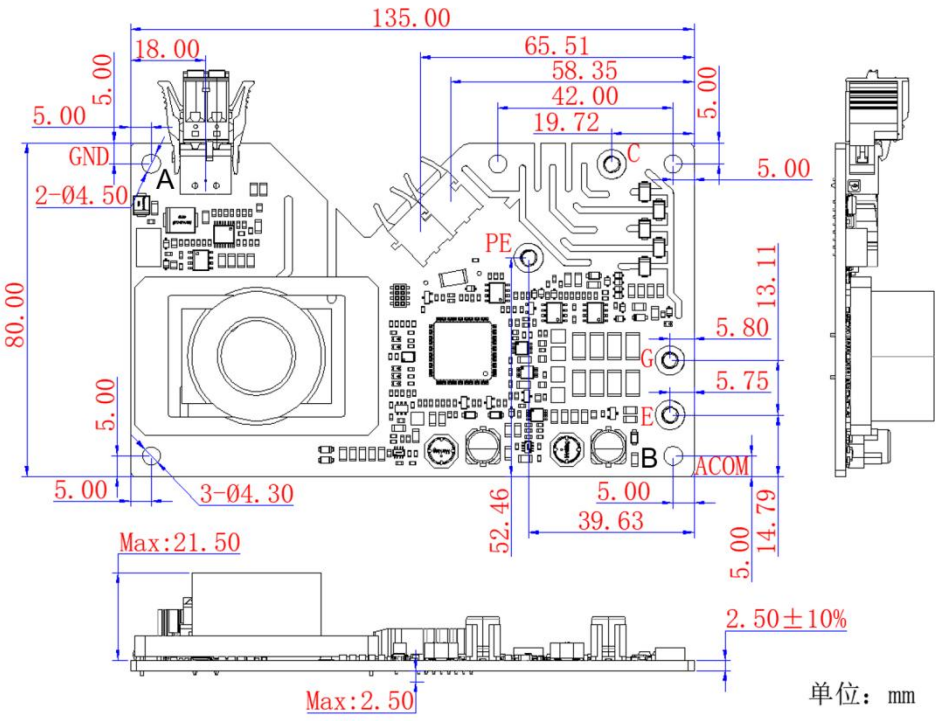
5. Set up and test the power unit

Before starting the system, it is recommended to check each IGBT module with a 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





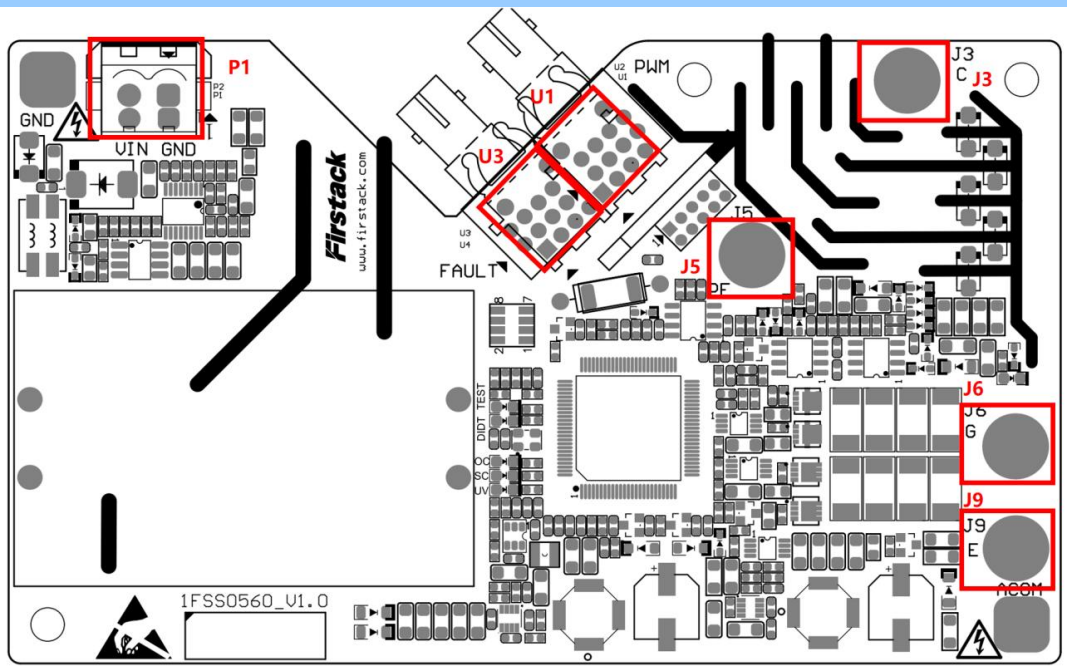
Note:

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

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

3. In the figure, the positioning hole A is electrically connected to the ground of primary side input power supply. The positioning hole B is electrically connected to E of the secondary side power supply. The rest of the positioning holes are not electrically connected.

Interface definition



P1 pin definition:

Pin	Name	Description	Pin	Name	Description
1	GND	Ground of input power supply	2	VIN	15V input recommended

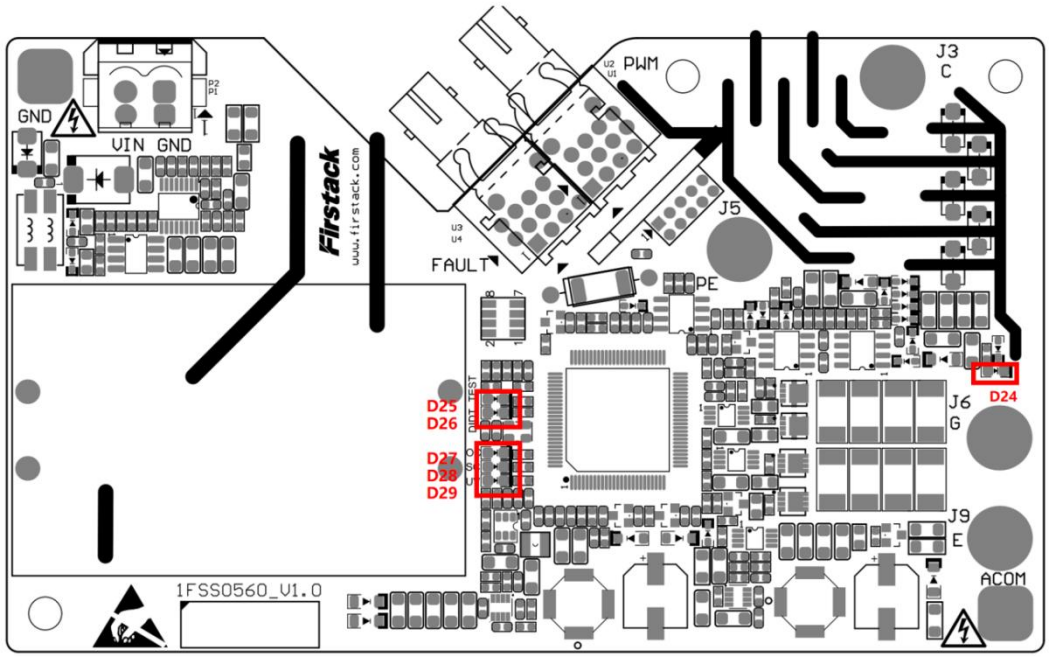
Connector Manufacturer and Part Number

Number	Label	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	P3, P5, P7, P8	WE	5.5mm/8.3mm 7466004R	M4 screws made of 304 stainless steel Max Torque: 1.2Nm
3	U1	Avago	HFBR-2521Z/ AFBR-2521CZ	Note 1
4	U3	Avago	HFBR-1521Z/ AFBR-1521CZ	Note 1

Note:

1. HFBR-2521Z and HFBR-1521Z are used together. AFBR-2521CZ and AFBR-1521CZ are used together. It is recommended to use POF with a fiber core diameter of 1 mm. For the matching connector, we recommend HFBR-4501Z/4511Z or HFBR-4503Z/4513Z. When installing the optical fiber, it is recommended that the bending angle be no less than 90 degrees.

LED status indicator



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

LED Status Indicator

Number	Label	Interface	Note
1	D24	GE	GE signal indicator, light on when turned on, otherwise off
2	D25	TEST	Light up when the power supply is normal and there is no fault, otherwise off
3	D26	di/dt	Once triggered by a short-circuit, it is always on, unless restarted
4	D27	OC	Once triggered by overcurrent, it is always on, unless restarted
5	D28	SC	Once triggered by a short-circuit, it is always on, unless restarted
6	D29	UV	Once triggered by undervoltage, it is always on, unless restarted

Driving parameters

Absolute Maximum Ratings

Parameter	Note	Min	Max	Unit
V_{DC}	GND	14	28	V
Gate peak current			60	A
Output power	$T_A \leq 85℃$		5	W
Test voltage (50Hz/1min)	Primary to secondary side	10500		V_{RMS}
Operating temperature		-40	+85	℃
Storage temperature		-40	+85	℃

Recommended Operating Condition

Parameter	Note	Min	Typ	Max	Unit
V_{DC}	15V Input	14.5	15	15.5	V

Electrical Characteristics

Power Supply	Note	Min	Typ	Max	Unit
Power supply current	Without load, Note 1		0.15		A
Power Supply Monitoring					
Positive undervoltage threshold			13		V
Negative undervoltage threshold			-7		V
Short-circuit Protection					
di/dt short-circuit protection response time	Note 2		3.5		μs
Blocking time			90		ms

Timing Characteristics				
Turn-on delay	Note 3		840	ns
Turn-off delay	Note 4		700	ns
Rise time	Note 5		15	ns
Fall time	Note 6		15	ns
Fault hold time		32		μs
Output Characteristics				
Gate turn-on voltage			15	V
Gate turn-off voltage			-10	V
Gate Static impedance			10	kΩ
Electrical Isolation				
Creepage distance	Primary to secondary Side	45		mm
Clearance distance	Primary to secondary side	42		mm

Unless otherwise specified, all data are based on +25℃ and V_{DC}=15V.

Note:

1. Power supply current: no PWM input, but IGBT module is connected;
2. Response time: the time from the occurrence of the fault to the start of soft shut down;
3. Turn-on delay: the time required to transmit the rising edge of the PWM signal input from the primary side to the rising edge of the secondary side of the gate driver when the IGBT is not connected;
4. Turn-off delay: the time required to transmit the falling edge of the PWM signal input from the primary side to the falling edge of the secondary side of the 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) when the IGBT is not connected;
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) when the IGBT is not connected.

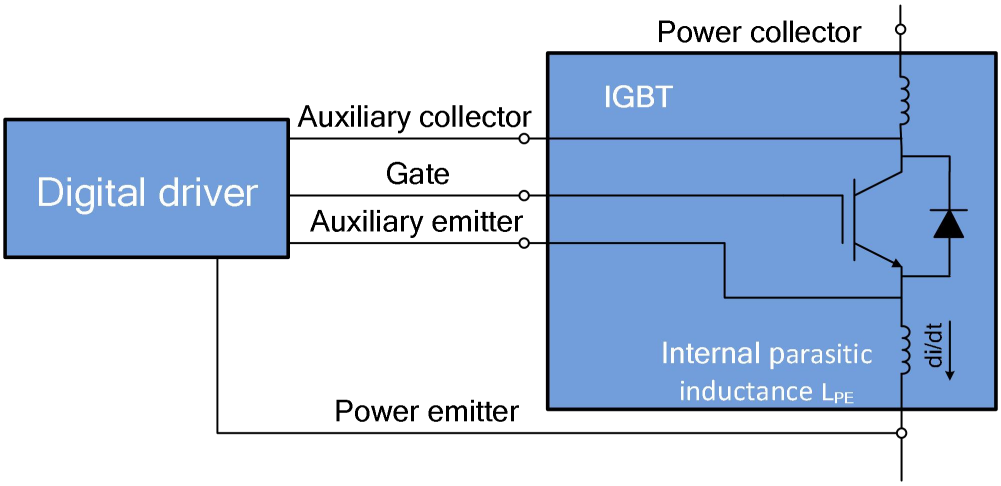
Functional description

◆ Short-circuit protection—di/dt

The di/dt protection is based on voltage measurement of power emitter (PE) and auxiliary emitter (AE). The voltage V_{PA} between the auxiliary emitter and the power emitter is proportional to the rate of change di/dt of the collector current I_C (i.e., di/dt).

During normal operation, the di/dt is generally several tens of amperes per microsecond, while when the IGBT is short-circuited, the di/dt can reach thousands of amperes per microsecond, showing a difference of over a hundred times. Since the di/dt protection directly monitors the rate of current change and does not require a blank time like V_{CE} monitoring, the di/dt protection thus has a faster response.

Compared with V_{CE}-based SC protection, di/dt protection has faster response, higher signal-to-noise ratio and obvious competitiveness in multi-level applications.



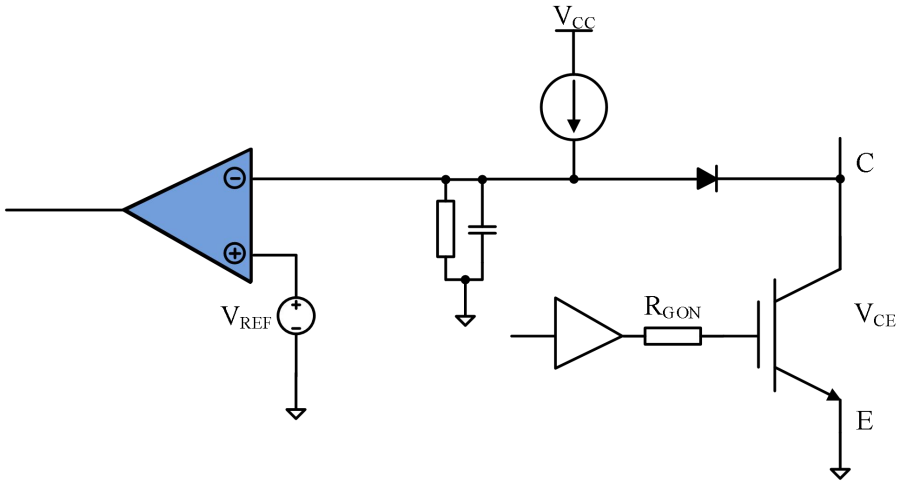
Di/dt detection circuit

◆ Overcurrent protection—OC

The driver circuit determines whether the IGBT is in an overcurrent state by detecting the collector voltage VCE when the IGBT is turned on.

The collector voltage is detected via diodes. When the VCE voltage exceeds the set threshold, the driver determines that the IGBT is in an overcurrent state and simultaneously feeds back

the fault to the master computer.



Short-circuit protection detection circuit

◆ Undervoltage protection

The driver 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 drive circuit determines that an undervoltage fault has occurred and will feed back a fault signal to the master computer.

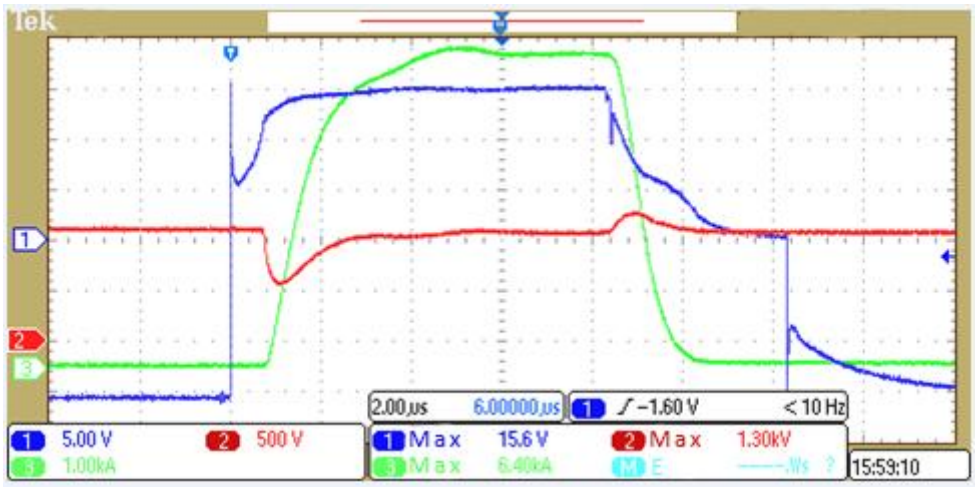
The Firstack intelligent driver strongly recommends that none of the IGBTs in the bridge arm operate in an undervoltage state. Due to the presence of CGC, when a certain IGBT in the bridge arm is turned on, the high dv/dt caused by it can be coupled to the other IGBT, resulting in slight conduction of the other IGBT. Meanwhile, a lower gate voltage will increase the switching loss of the IGBT.

◆ Soft shut down

In the event of a shoot-through short circuit, the IGBT will rapidly desaturate, and the collector-emitter voltage VCE across it will reach the DC bus voltage. The short-circuit current Isc depends on the type of IGBT and the gate voltage. At this point, the power dissipated by the IGBT can instantly reach the megawatt level. If the short-circuit current cannot be reduced within a very short time, the IGBT will be destroyed due to chip overheating. However, if the turn-off speed during a short circuit is as fast as that during

normal turn-off, a large di/dt will be generated. Due to the presence of parasitic inductance, this di/dt will induce a large voltage spike across the IGBT, leading to overvoltage breakdown of the IGBT.

Firstack incorporates a soft shutdown technology. When a shoot-through short circuit occurs in the IGBT, under the premise of ensuring that the short-circuit duration does not exceed 10μs, by gradually reducing the gate voltage VGE, it not only prevents the IGBT chip from being destroyed due to overtemperature but also effectively reduces di/dt, avoids excessive peak voltage during turn-off, and ensures the safety of the IGBT.



Short-circuit waveform of FF1400R17IP4 at 1100V

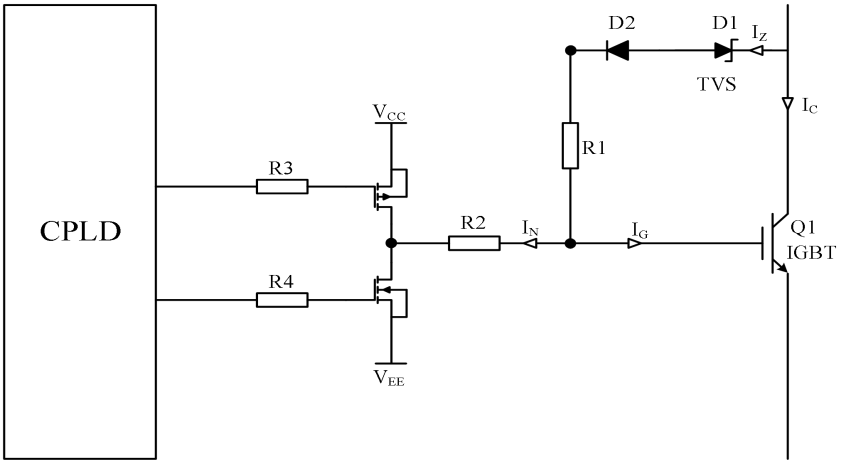
CH1: V_{GE}(blue); CH2: V_{CE}(red); CH3: I_C(green)

The above figure shows the short-circuit waveform of the 1700V/1400A IGBT (FF1400R17IP4) controlled by the Firstack IGBT driver circuit when the DC bus is 1100V. The peak value of short-circuit current is 6400A(4.5 times of rated current). Under the action of soft shut down, I_C drops slowly, V_{CE} has almost no overshoot, and the IGBT is safely turned off.

◆ Active clamping

If the system encounters overload or short-circuit faults on the load side, the turn-off current of the IGBT will increase significantly. Under these conditions, active clamping technology can protect the IGBT and prevent faults caused by turn-off overvoltage.

When V_{CE} exceeds the threshold voltage of the TVS diodes, they will be broken down, and current will flow into the gate. This causes VGE to rise, leading the IGBT to enter the linear region, thereby limiting the turn-off voltage within a safe range. **(TVS diodes are on the adaptor board)**



Schematic diagram of active clamping principle

◆ Impulse anomaly protection (reserved)

Optical fiber communication has the advantages of strong anti-interference capability and high insulation level. However, in the process of using optical fibers, there are also some issues. For example, loose buckles of fiber optic connectors and insufficient bending radius of optical fiber lines can easily lead to phenomena such as light leakage and light attenuation, which in turn generate a large number of stray and high-frequency narrow pulses at the receiving end of the fiber optic head. These narrow pulses will cause the IGBTs to turn on and off quickly, resulting in significant losses. This is extremely harmful to high-voltage and high-power IGBTs and must be strictly prevented.

The Firstack intelligent gate driver employs two methods to guard against these abnormal pulses:

- Monitor the PWM pulse width in real time. When the PWM pulse width is less than a certain preset value, the driver will filter out the narrow pulse without reporting a fault;
- Monitor the PWM frequency in real time. When the time interval between multiple consecutive rising edges is less than a certain preset value, it will determine that abnormal

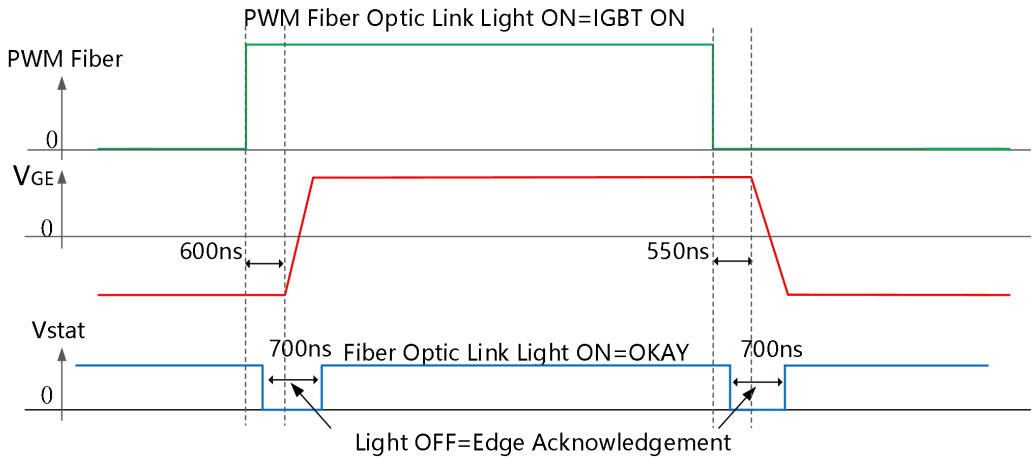
pulses exist and report a fault.

◆ Optical fiber port acknowledge 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. It's compatible with two modes, as follows:

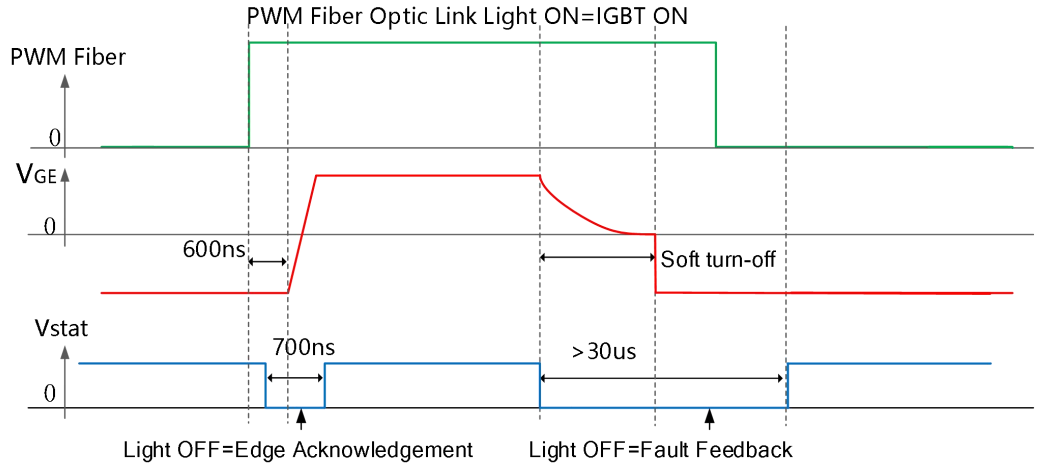
Mode 1: Compatible with Power Integrations fault protocol

1. When the driver board operates normally, every time a PWM command is received, the return-signal optical fiber head will turn off for 700ns at the rising edge and falling edge of the PWM command as a response to receiving the command.



Normal condition in mode 1

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

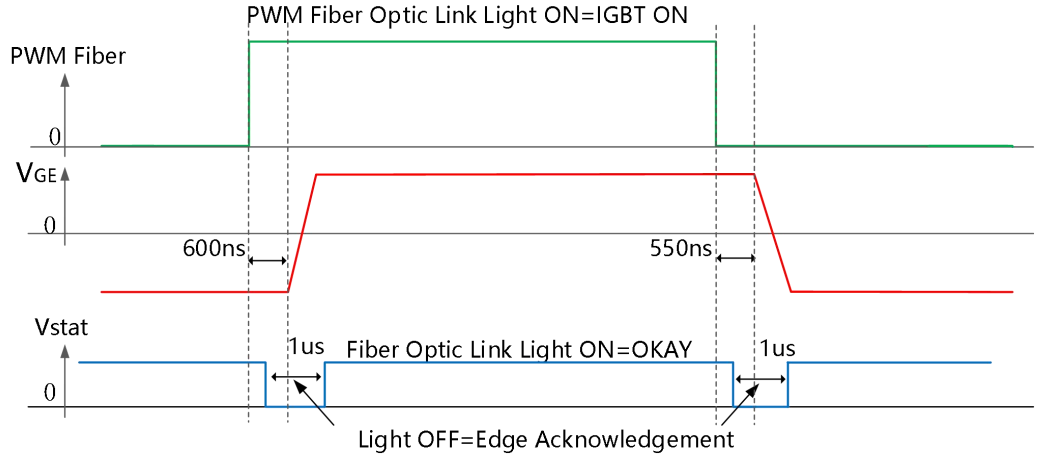


In case of failure

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

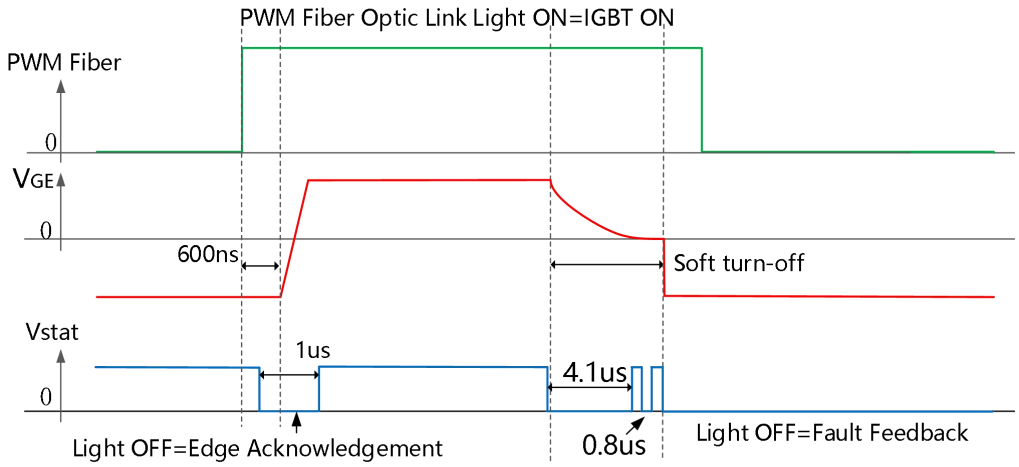
Mode 2: Compatible with Inpower fault protocol

1. When the driver board operates normally, every time a PWM command is received, the return-signal optical fiber head will turn off for 1us at the rising edge and falling edge of the PWM command as a response to receiving the command.



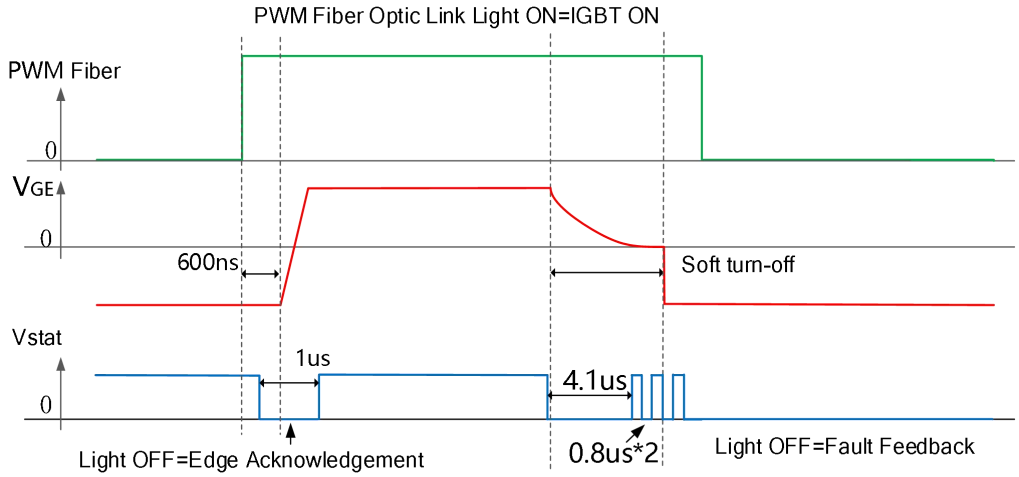
Normal condition in mode 2

2. When the OC1 fault is detected by the driver board, the return-signal optical fiber head will send a low-level pulse for about 4.1us, and a low-level narrow pulse for about 0.8us, which will be used as the fault signal to inform the master computer.



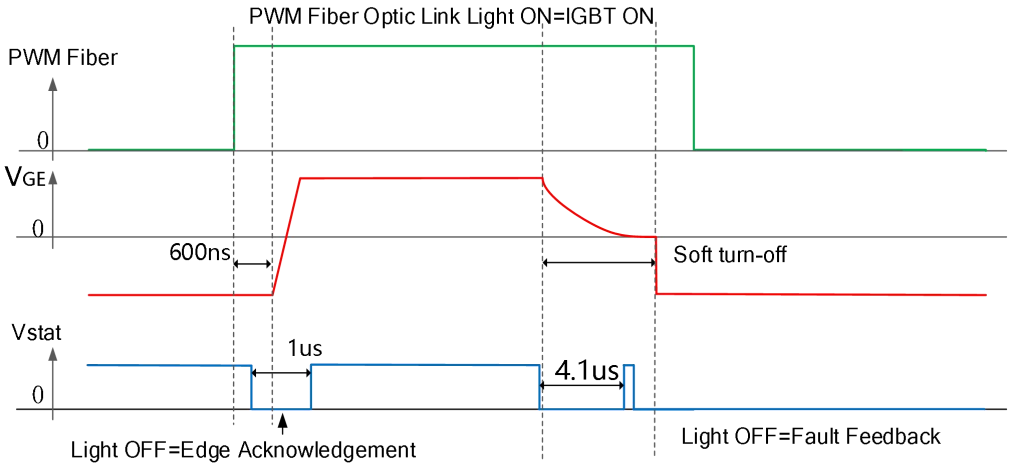
OC1 fault condition

3. When the OC2 fault is detected by the driver board, the return-signal optical fiber head will send a low-level pulse for about 4.1us, and two low-level narrow pulse for about 0.8us, which will be used as the fault signal to inform the master computer.



OC2 fault condition

4. When the di/dt fault is detected by the driver board, the return-signal optical fiber head will send a low-level pulse for about 4.1us, which will be used as the fault signal to inform the master computer.



Di/dt fault condition

Gate resistor indication

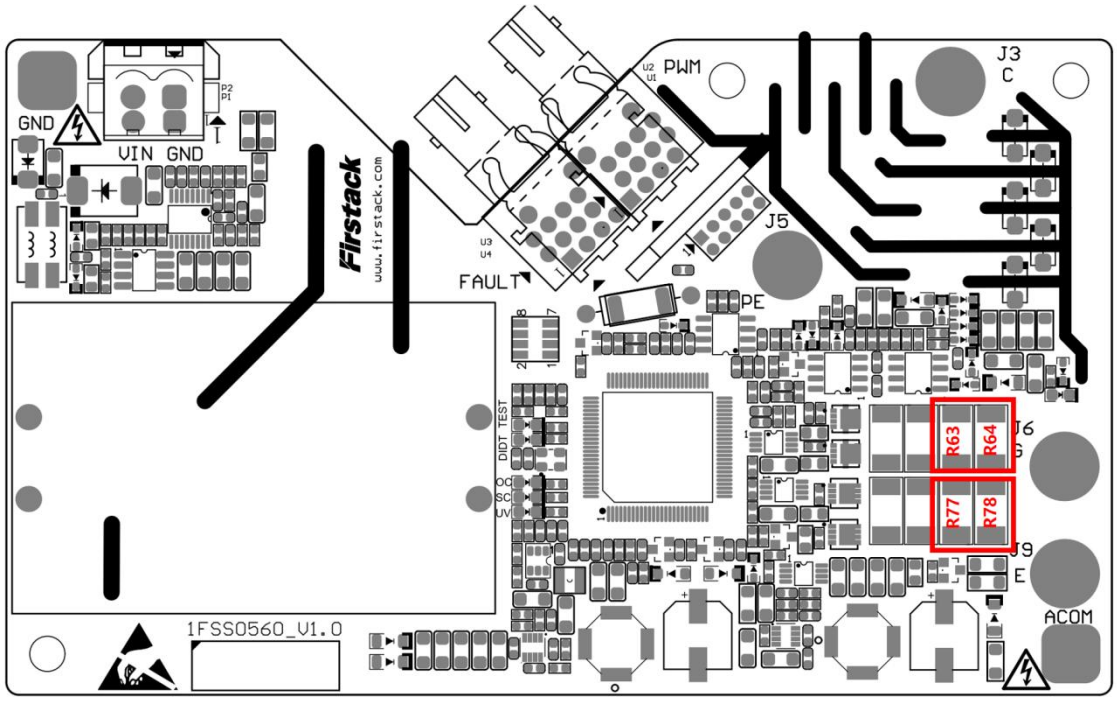


Fig.11 Gate resistor indication

Calculation formula of gate resistor

R_{GON}	R_{GOFF}
R63//R64	R77//R78

Note: For different IGBT models, the program of gate driver board is different. Please do not change the gate resistor parameter at will.

Product selection

IGBT model: FZ1200R45HL3

Core Board:

Part number	Faulty protocol	R_{GON}	R_{GOFF}
1FSS0560Z45B3C-Y0100	Compatible with Inpower protocol	2.55Ω	8Ω
1FSS0560V45A1C-Y0001	Compatible with Power integration protocol	0Ω	0Ω

Adaptor board:

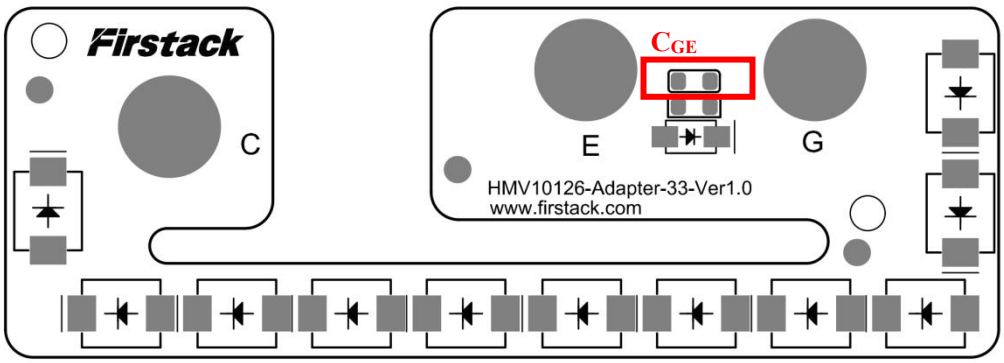
Part number	C_{GE}
A-HMV10126-45-IP-A1	100nF
A-XHPC10126-45-Y0000	Not welding
A-HV10126-45-Y0000	Not welding

Adaptor board scheme 1: A-HMV10126-45-IP-A1

The A-HMV10126-45-IP-A1 is suitable for IGBT modules with similar package such as IHV.

The parameters and silk screen of this adaptor board are as follows.

Parameters of Adaptor Board	C_{GE}(nF)
A-HMV10126-45-IP-A1	100nF



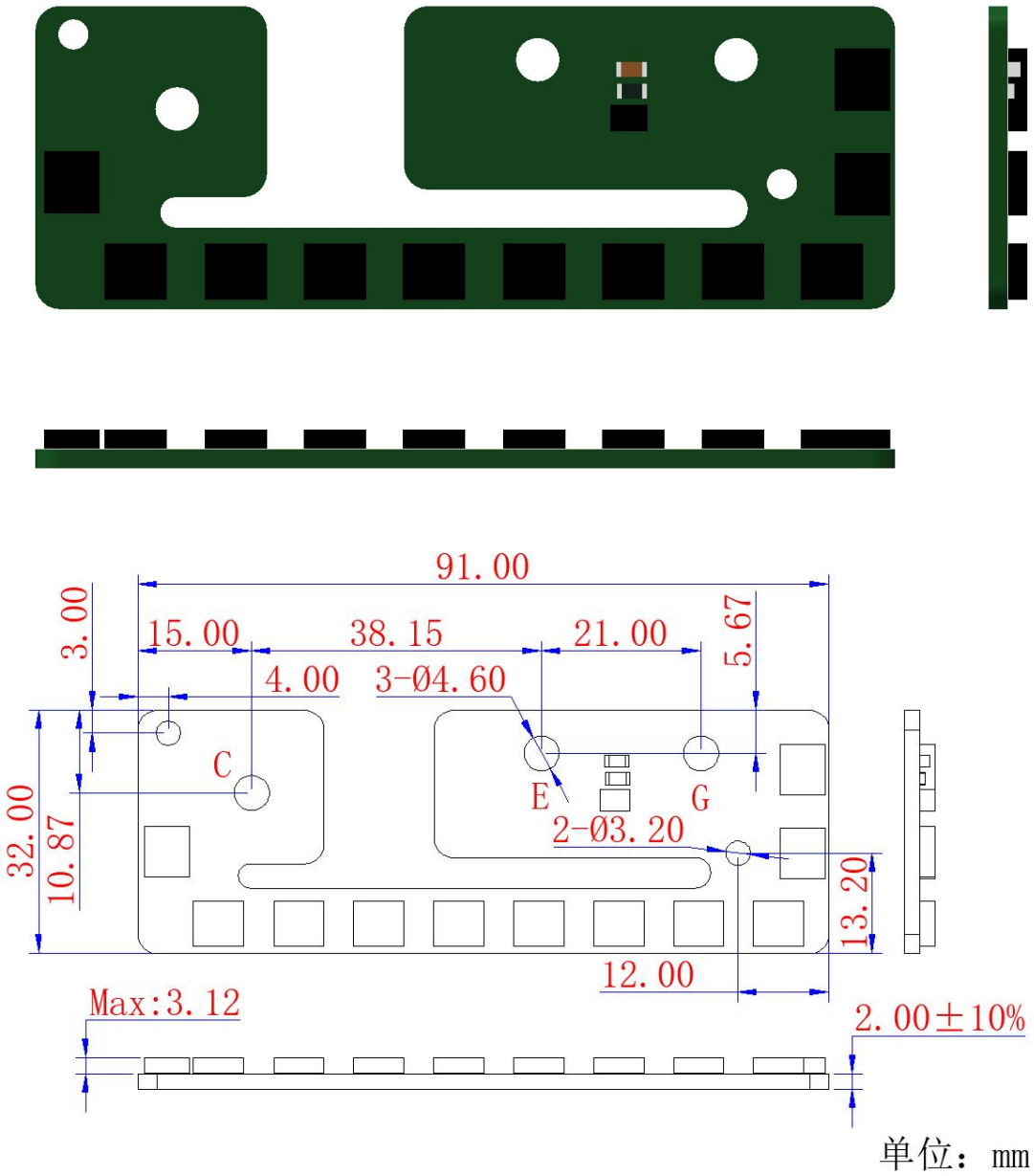


Fig.12 Mechanical dimensions of adaptor board(unit: mm)

Note:

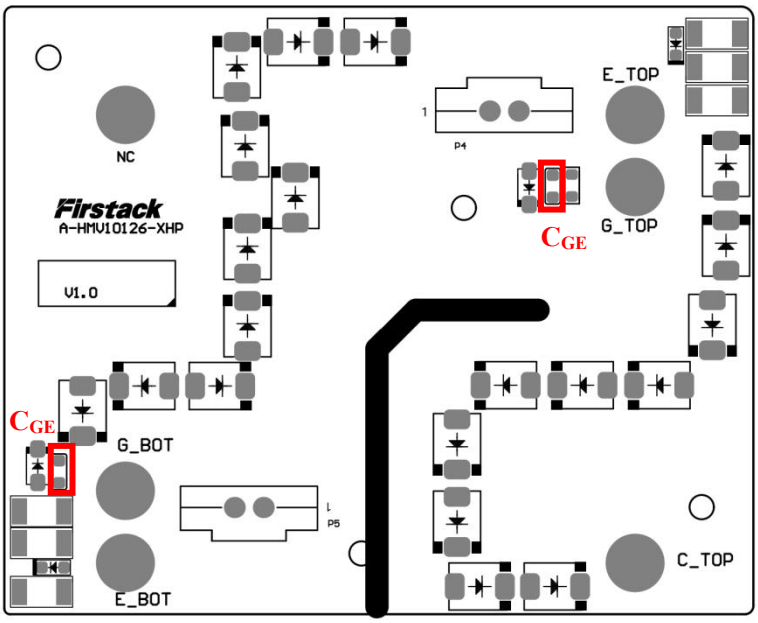
1. The thickness tolerance of the board is ±10%;

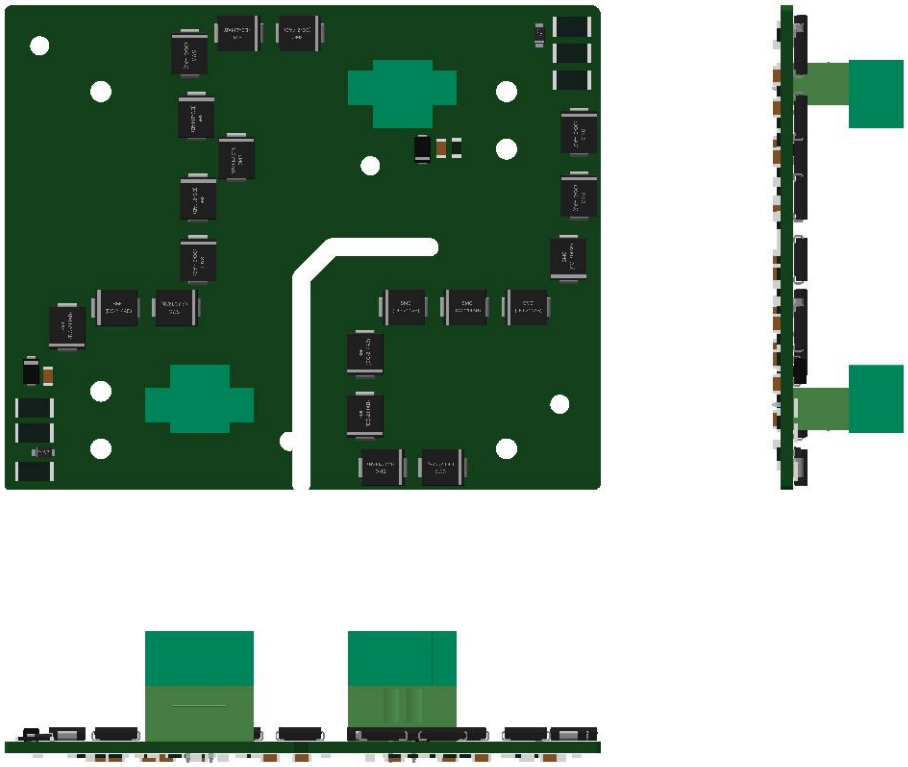
2. Other dimensional tolerances refer to GB/T1804-m.

Adaptor board scheme 2: A-XHPC10126-45-Y0000

The A-XHPC10126-45-Y0000 is suitable for IGBT modules with similar package such as XHP. The parameters and silk screen of this adaptor board are as follows.

Parameters of Adaptor Board	C_{GE}(nF)
A-XHPC10126-45-Y0000	Not welding





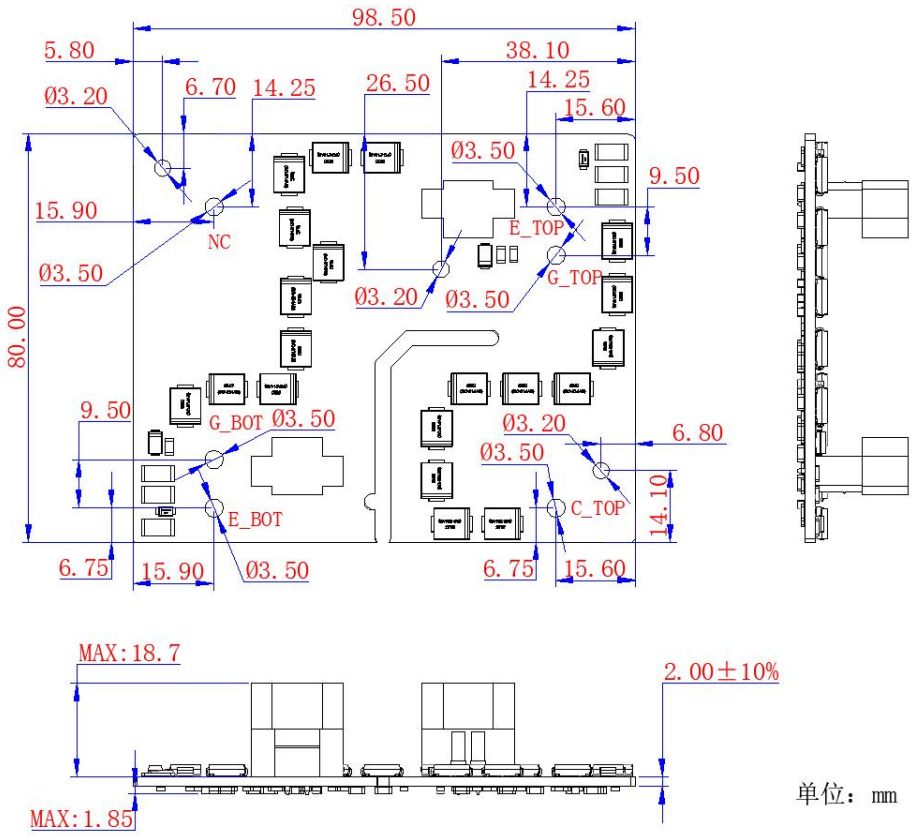


Fig.13 Mechanical dimensions of adaptor board(unit: mm)

Note:

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

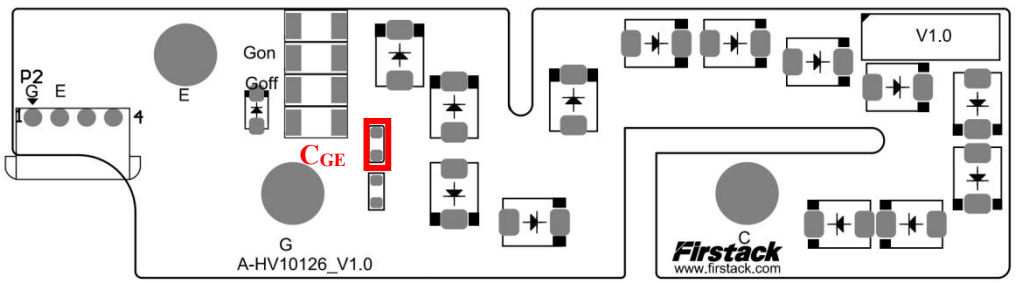
2. Other dimensional tolerances refer to GB/T1804-m.

Adaptor board scheme 3: A-HV10126-45-Y0000

The A-HV10126-45-Y0000 is suitable for IGBT modules with similar package such as IHV.

The parameters and silk screen of this adaptor board are as follows.

Parameters of Adaptor Board	C_{GE}(nF)
A-HV10126-45-Y0000	Not welding



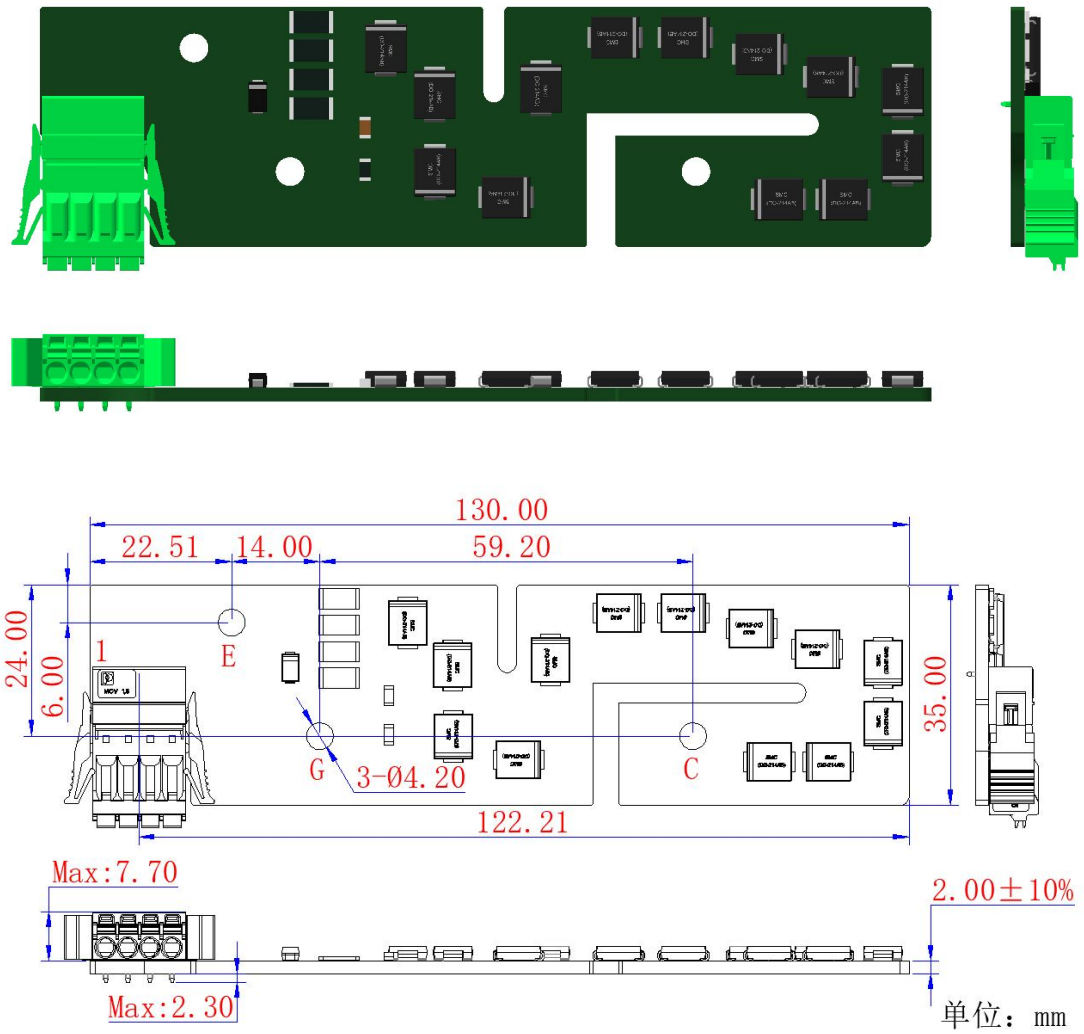


Fig.14 Mechanical dimensions of adaptor board(unit: mm)

Note:

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

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

Ordering information

The 1FSS0560 can support IHV and IHM modules of different models from multiple manufacturers. 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 to the product, but cannot promise to provide specific parameters for the delivery, performance or applicability of the product. This article does not provide any express or implied warranties or guarantees.

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