1FSD08110 Data Sheet

Abstract

The plug-and-play 1FSD08110 gate driver is a digital driver developed for 1700V/3300V IGBT modules, such as Infineon IHM and ABB HiPak. It is suitable for two-level, three-level, and multi-level topologies.

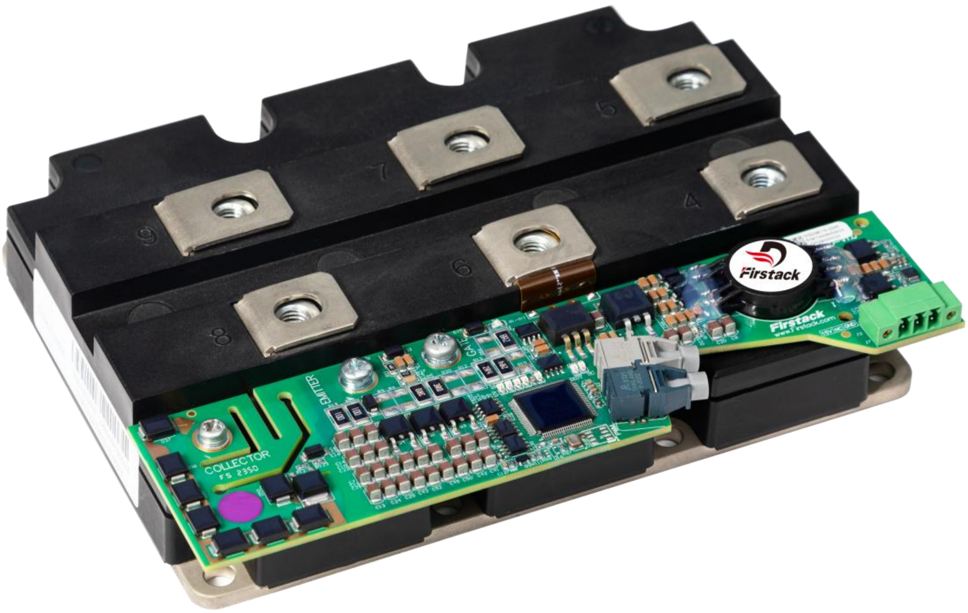


Fig.1 1FSD08110

Highlights:

√ 4W/110A, optical interface

√ Digitally dynamic advanced active clamping

√ Short-circuit protection (soft shut down)

√ V_{CE} & di/dt monitoring

Applications:

√ Industrial drives

√ Smart Grid

Contents

System block diagram

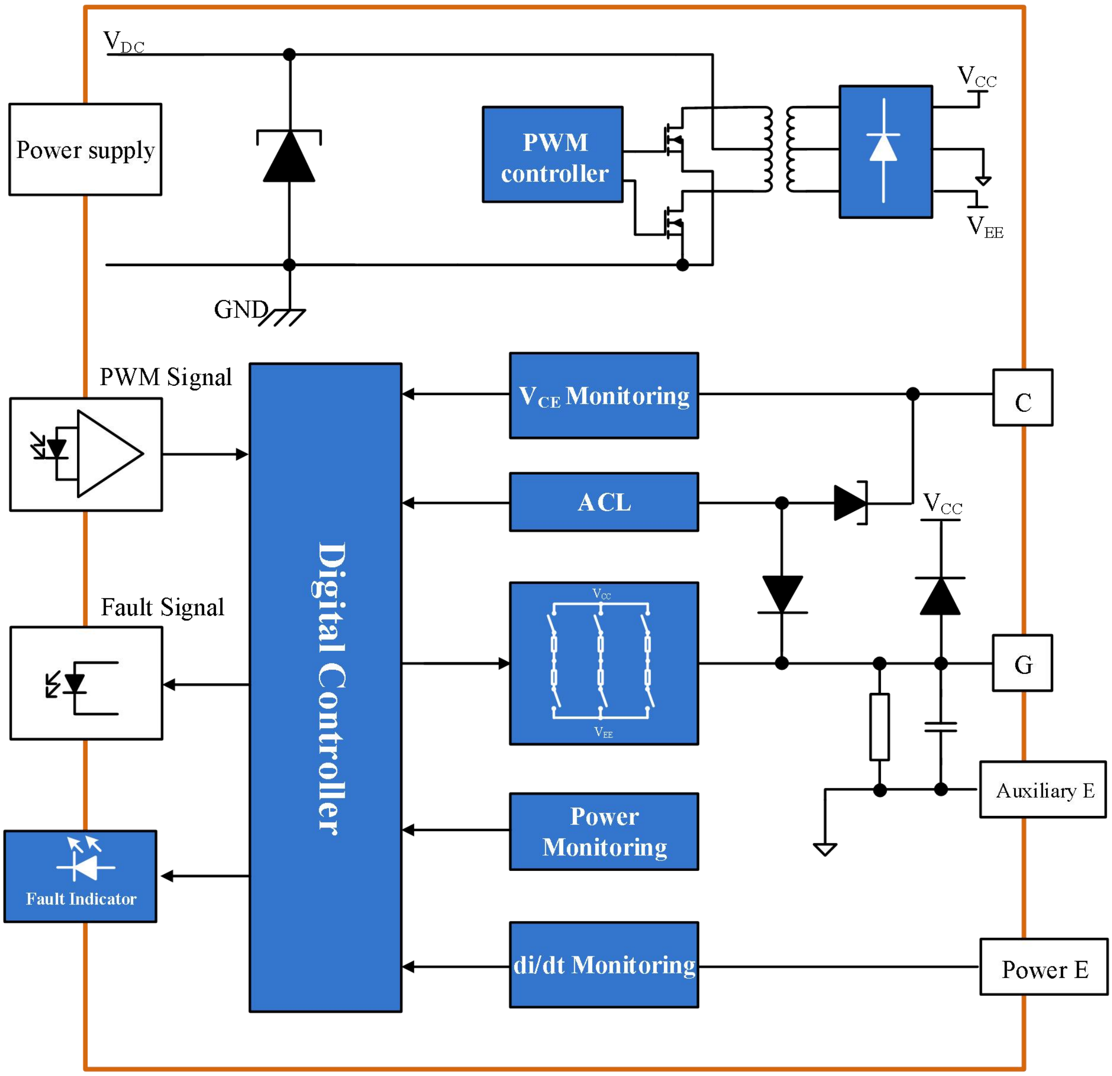


Fig.2 System block diagram

The primary side power supply inputs a DC voltage of 15V, and the power supply voltage required by the system is obtained through the relevant circuit, which ensures the energy source of the system; 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 shut down 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 shut down 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 drive 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 European standard EN 100015 (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

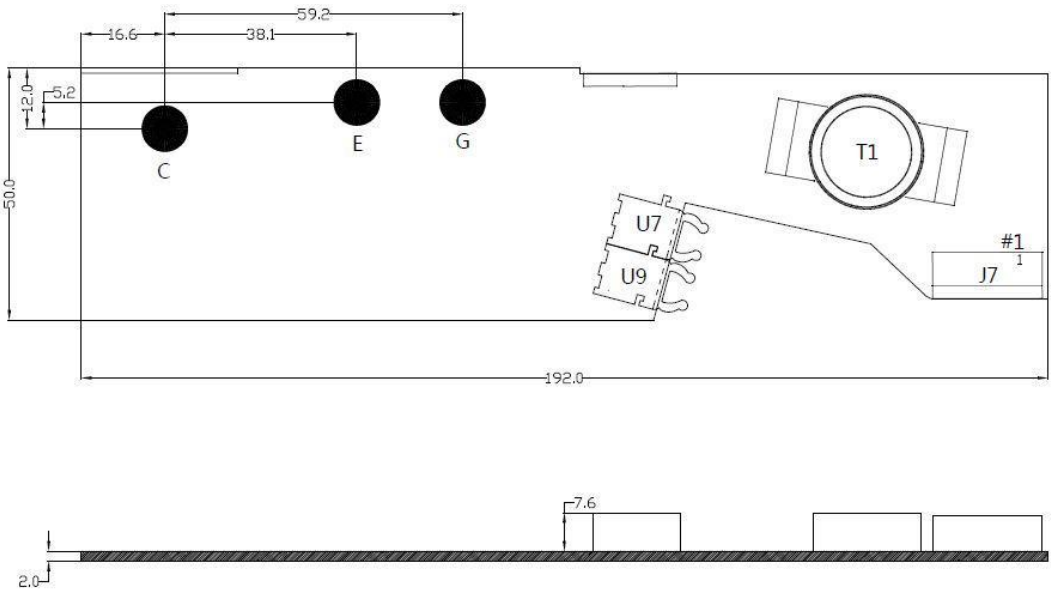
Check the gate voltage: for the turn-off state, the rated gate voltage is given in the corresponding data sheet, for the turn-on state, the voltage is 15V. Please also check the input current of the gate driver with and without a control signal. For Firstack's digital gate driver, the gate driver status 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 or double pulse test method. In particular, Firstack recommends that users ensure that the IGBT module does not exceed the operating range specified by SOA even under the worst conditions, as this is strongly dependent on the specific converter configuration.

Mechanical dimensions



unit: mm

Fig.3 Mechanical dimensions

Note:

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

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

Connector Manufacturer and Part Number

Number	Ref	Manufacturer	Part Number	Recommended Matching Terminals
1	J7	WÜRTH	691325310003	691364300003
2	U7	AVAGO	HFBR-1521Z	
3	U9	AVAGO	HFBR-2521Z	

J7 pin definition

Pin	Ref	Note	Pin	Ref	Note
1	GND	Ground of Input	2	NC	Not Connect
3	V_{IN}	Input Voltage			

LED status indicator

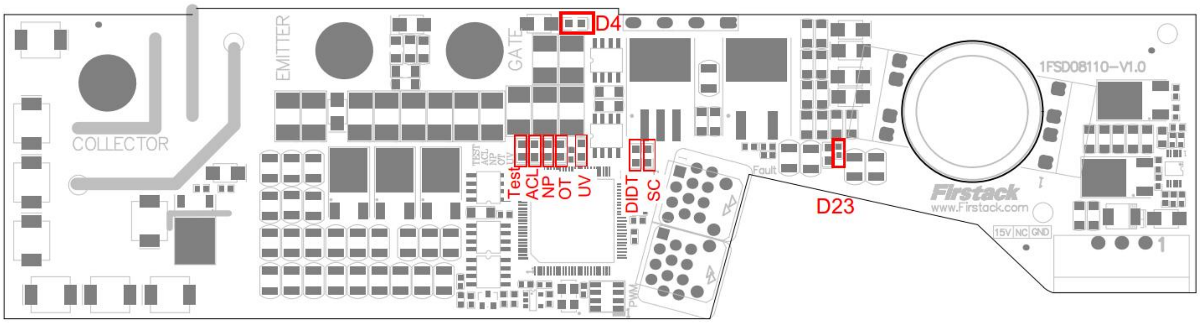


Fig.4 LED status indicator

For the convenience of customers, several LED status indicators 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:

LED Status Indicator

Number	Ref	Interface	Note
1	D23	D23	Power indicator
2	D4	D4	GE indicator. Light up when it is turned on, otherwise off
3	D7	TEST	Light up when the power supply is normal and there is no fault, otherwise off
4	D9	SC	Once triggered by a short-circuit, it is always on, unless restarted
5	D10	NP	This indicator is not enabled
6	D11	OT	Once triggered by overheating, it is always on, unless restarted
7	D13	ACL	Once the ACL is triggered, it is always on, unless restarted
8	D14	DIDT	Once triggered by a short-circuit, it is always on, unless restarted
9	D15	UV	Once triggered by undervoltage, it is always on, unless restarted

Driving parameters

Absolute Maximum Ratings

Parameter	Note	Min.	Max.	Unit
V_{IN}	V_{IN} to GND		16	V
Gate Peak Current			110	A
Output Power	$T_A \leq 85°C$		4	W
Test Voltage(50Hz/1min)		6		kV_{RMS}
Operating Temperature		-40	85	℃
Storage Temperature		-40	85	℃

Recommended Operating Conditions

Parameter	Note	Min.	Typ.	Max.	Unit
V_{IN}		14.5	15	15.5	V

Electrical Characteristics

Power	Note	Min.	Typ.	Max.	Unit
Power Supply Current	Without Load, Note 1		0.15		A
Coupling Capacitance	Primary to Secondary Side		9.5		pF
Power Supply Monitoring					
Threshold			12.7		V
Short-circuit Protection					
V_{CE} Protection					
V_{CE} Threshold			10.2		V
Response Time	Note 2		8		us
didt Protection					
Response Time			3		us
Timing Characteristics					
Turn-on Delay	Note 3		500		ns

Turn-off Delay	Note 4		500		ns
Rise Time	Note 5		15		ns
Fall Time	Note 6		12		ns
Fault Hold Time		30			us
Fault Blocking Time			90		ms

Unless otherwise specified, all data are based on +25°C and V_{IN}=15V.

Note:

1. **Power Supply Current: gate driver core connected to IGBT, no PWM input;**
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) without connecting the IGBT;**
6. **Fall Time: the amount of time from 90% of the gate turn-on voltage(+15V) to the gate turn-off voltage(-10V).**

Functional description

◆ Short-circuit protection—V_{CE} monitoring

The V_{CE} monitoring circuit determines whether the IGBT is in a short-circuit state by detecting V_{CE} 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.

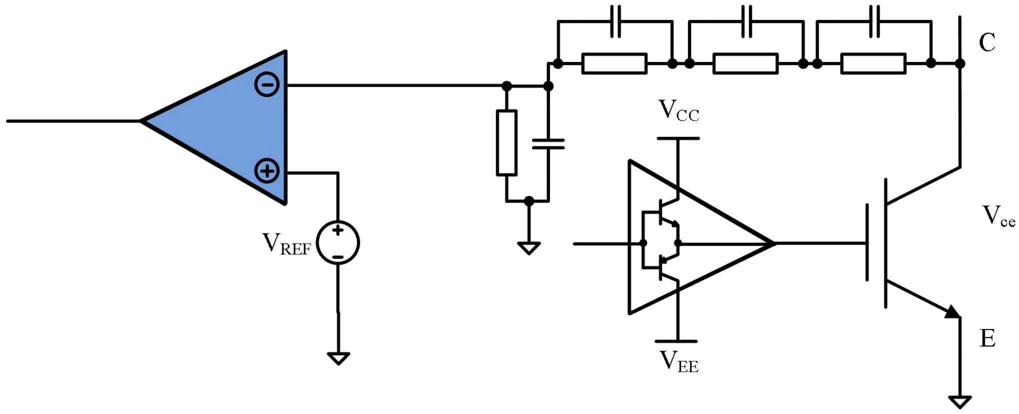


Fig.5 V_{CE} monitoring circuit

◆ Short-circuit protection—di/dt monitoring(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.

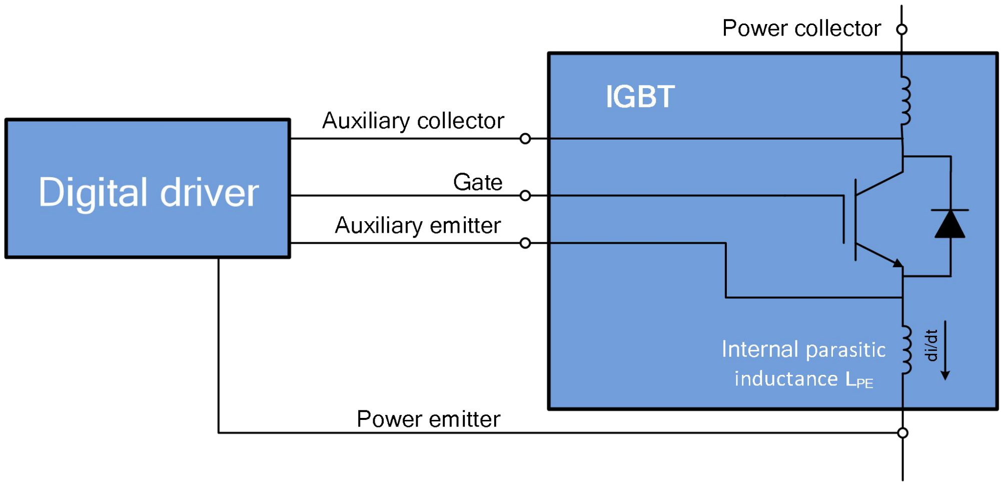


Fig.6 di/dt monitoring

◆ 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 driving circuit determines that an undervoltage fault has occurred and will feedback a fault signal to the master computer. When the fault disappears, the fault terminal on the primary side will automatically reset after one blocking time.

For IGBT bridge arms, Firstack intelligent gate driver strongly suggests that any IGBT 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 spike at both terminals of IGBT, which will cause IGBT overvoltage breakdown. In order to suppress the turn-off spike 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 under 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 spike when the IGBT is turned off, which ensures the safety of the IGBT.

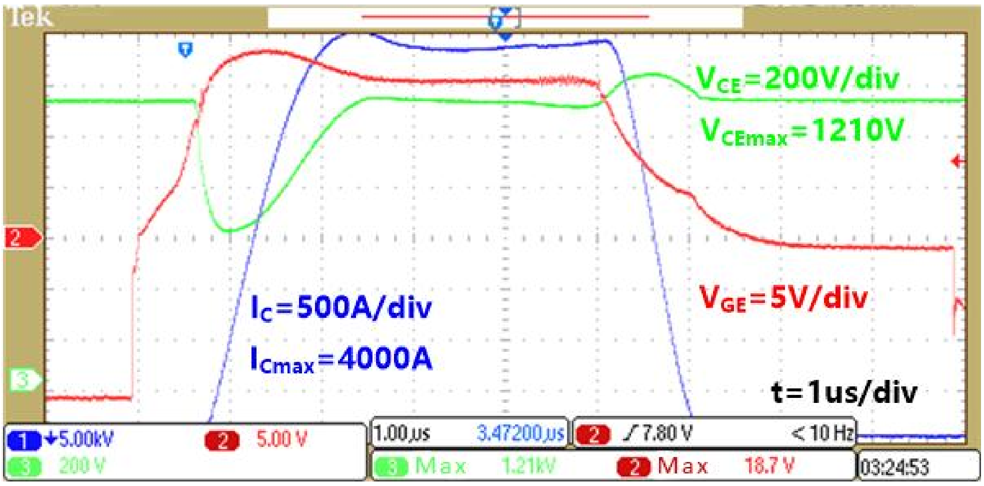


Fig.7 Short-circuit waveform of FF1400R17IP4 at 1100V

Fig.7 shows the short-circuit waveform of the 1700V/1400A IGBT(FF1400R17IP4) controlled by the Firstack IGBT driving 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 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.

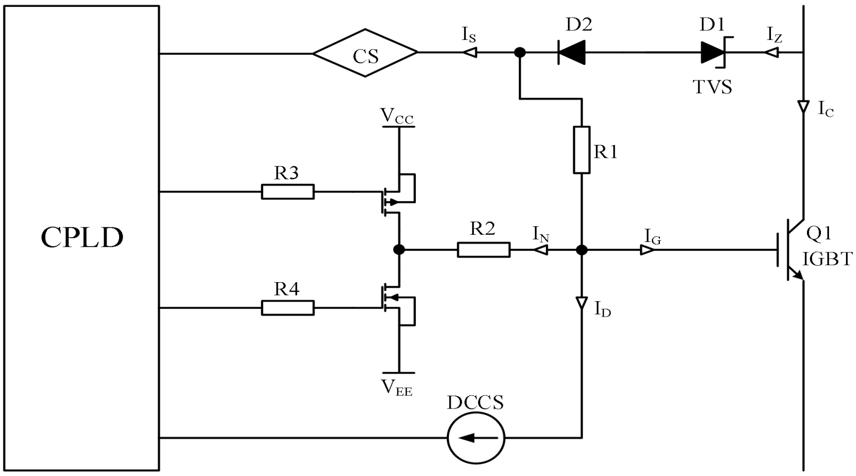


Fig.8 Schematic diagram of active clamping principle

Fig.9 is the short-circuit test waveform based on Infineon FF1000R17IP4 module. At the turn-off moment, V_{CE}(pink) is clamped at 1380V.

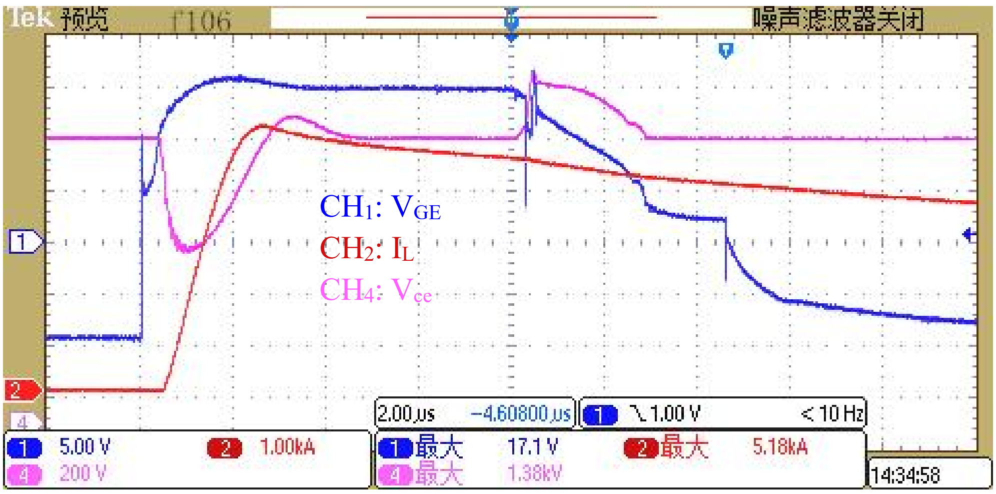


Fig.9 Digitally controlled active clamping waveform

In the picture above, CH1: V_{GE}(blue); CH2:I_C(red); CH4: V_{CE}(pink)

◆ Muti-level turn-off(Reserved)

In some applications with large stray inductance, such as the large commutation loop of the NPC I three - level converter, the IGBT faces the risk of an excessively high turn-off peak voltage every time it is turned off.

Considering the overheating problem of the TVS, the active clamping technology is not suitable for these applications. In this case, the muti-level turn-off technology can play a significant role. By using different turn-off resistors during the turn-off process, the entire turn-off process can be optimized to suppress the turn-off voltage spike.

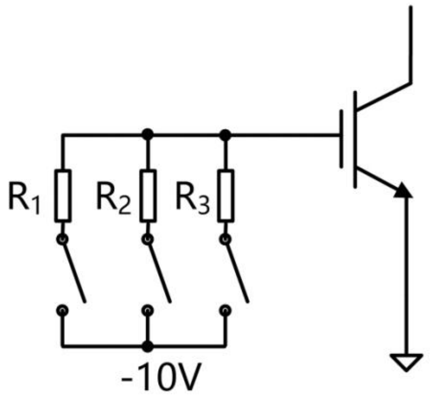


Fig.10 Muti-level turn-off schematic diagram

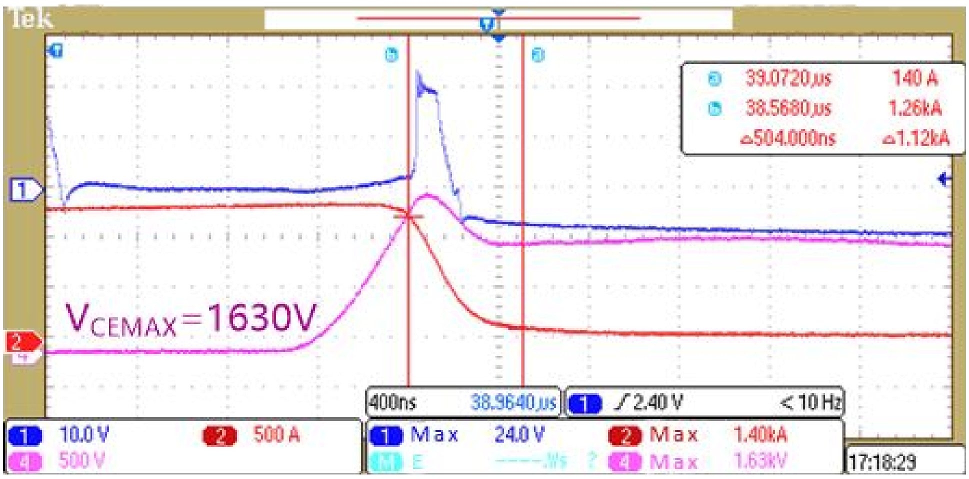


Fig.11a Without muti-level turn-off

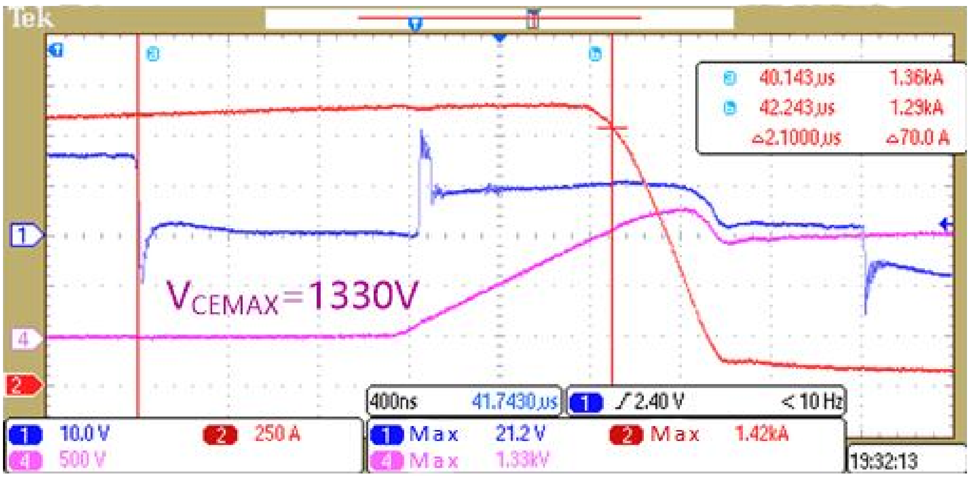


Fig.11b With muti-level turn-off

◆ Fiber optic port response signal

The fiber optic port response function includes two aspects. On the one hand, it monitors normal fiber optic communication, and on the other hand, it is used to transmit fault signals back to the master computer, as follows:

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 receive the command.

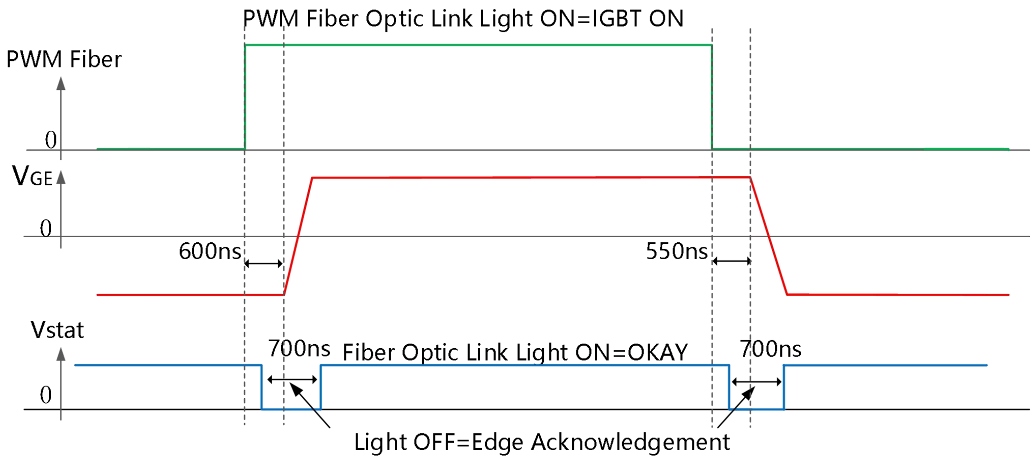


Fig.12a Normal condition

2. When the fault is detected by the driver board, the light of the return fibre optic head will go out for more than 30us, which will be used as a fault signal to inform the master computer.

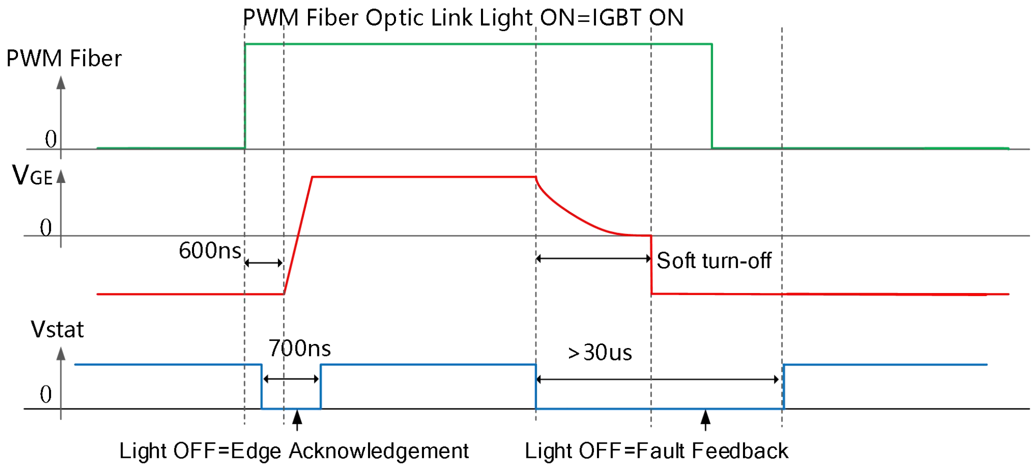


Fig.12b Fault condition

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.

Gate resistor indication

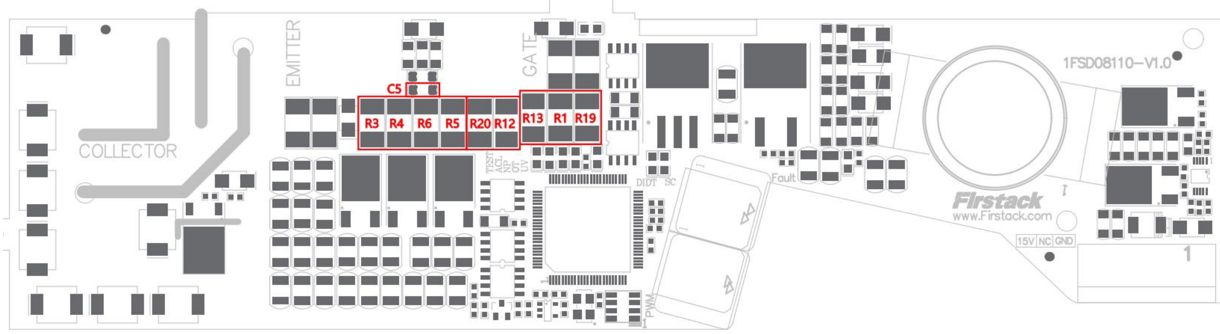


Fig.13 Gate resistor indication

Calculation formula of gate resistor

	Rgon	Rgoff	Cge
Single IGBT	R3 // R4 // R5 // R6	R1 // R12 // R13 // R19 // R20	C5

Gate driver model selection of common IGBT modules

IGBT model	Gate driver model selection	Cge(nF)	Rgon(Ω)	Rgoff(Ω)
ALL 1700V model	1FSD08110- 17-A1	NC	NC	NC
ALL 3300V model	1FSD08110-33-A2	NC	NC	NC
TIM2400ESM17-TSA000	1FSD08110Y01	NC	0.8	1.7
FD1200R17HP4-K_B2	1FSD08110Y02	NC	2	2.2
5SNA1500E330305	1FSD08110-5SNA1200E330100	330	1.5	≈3*
5SNA1200E330100	1FSD08110-5SNA1200E330100	330	1.5	≈3*
5SNA1000N330300	1FSD08110-5SNA1200E330100	330	1.5	≈3*
FZ1200R33HE3	1FSD08110-FZ1200R33HE3	330	1.5	≈4*
FZ1000R33HE3	1FSD08110-FZ1200R33HE3	330	1.5	≈4*
FZ1500R33HE3	1FSD08110-FZ1500R33HE3	330	1.5	≈5*
CM1200HC-66H	1FSD08110-CM1200HC-66H	330	1.5	≈4*
TIM1000ECM33-PSA011	1FSD08110-TIM1000NSM33	330	1.5	≈4*
TIM1000NSM33-PSA011	1FSD08110-TIM1000NSM33	330	1.5	≈4*
DIM1000NSM33-TS000	1FSD08110-TIM1000NSM33	330	1.5	≈4*
TIM1500ESM33-PSA012	1FSD08110-TIM1500ESM33-PSA012	330	1.5	≈5*

Note:

1. We strongly recommend that customers use the IGBT module models listed in the table and their corresponding gate parameters. These modules have been fully matched and verified by us, and large order quantities will also offer advantages in delivery lead time.

2. * is equivalent gate turn-off resistance, these models have multi-level turn-off function. The specific turn-off characteristics are subject to actual testing.

3. The application requirements for the above gate parameters stipulate that the busbar inductance should be less than 300 nH;

4. Recommended dead time of master computer for normal operation ≥ 4us;

5. If customers find that the parameters of the IGBT modules in our recommended list are unsuitable, we recommend that they use models without pre-set gate parameters: 1FSD08110-17-A1 and 1FSD08110-33-A2. These models offer significant advantages in terms of price and lead time. Customers are required to manually weld the gate resistors and capacitors for these models and apply three-proof coating. For detailed information, please refer to our instruction manual "IGBT Driver General Model SMT Gate Resistance Welding Instruction Manual".

Ordering information

The 1FSD8110 can support 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.

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

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