1FHD0440 DataSheet

Abstract

The 1FHD0440 is a next-generation high-integration digital IGBT driver developed by Firstack using proprietary ASIC chip technology, designed for two-level converters. It integrates multiple functions including VCE short-circuit protection, di/dt short-circuit protection, advanced dynamic active clamping, power supply detection, and "intelligent fault management," providing optimal protection for IGBTs. Its excellent EMC performance ensures reliable IGBT switching performance even under harsh electromagnetic environments.

The 1FHD0440 is designed for 140mm×190mm IHM-B packaging and supports 4500V IGBT modules with identical packaging from various manufacturers, featuring plug-and-play functionality with an adjustable VGE operating voltage ranging from 15 to 30 V. As the driver lacks built-in isolation power supply, it requires use with external high-voltage isolation modules (FPS08-15K or FPS08-35K) for proper operation.

Fig.1 1FHD0440(including reeds required for the di/dt protection)

Highlights:

- √ Gate voltage dynamically adjustable: 15V~30V
- √ Maximum peak current: 40A
- √ General Optical Fiber interface
- √ Support 4500V module

Applications:

- √ STATCOM
- √ VSC-HVDC
- √ SSCB

Contents

System Block Diagram

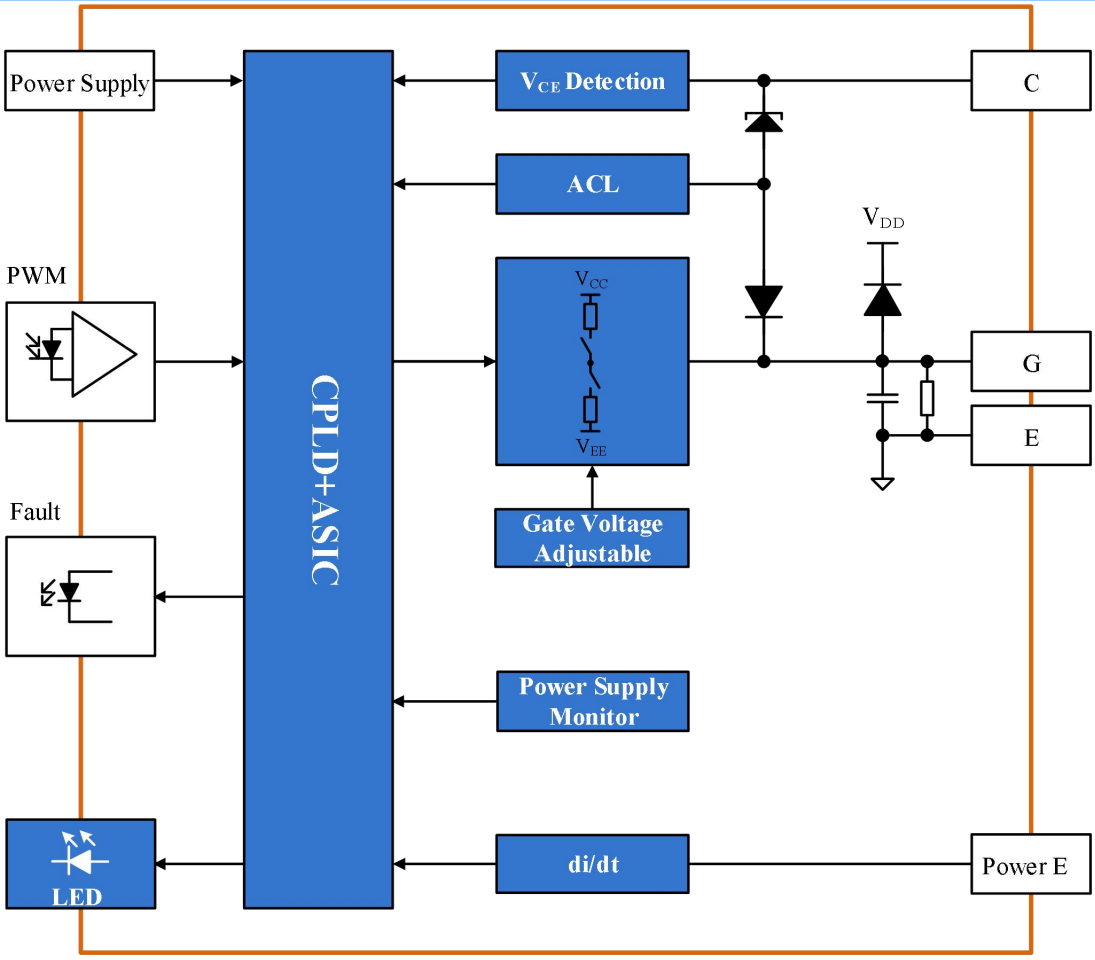

Fig.2 System block diagram

The primary side power supply input DC voltage is 25V, through the isolation power supply to get the supply voltage required by secondary side of the system, which ensures that the system energy source. The PWM signal is transmitted via the receiving fibre optic directly to the secondary side, where it is amplified to obtain the drive signal for the IGBT.

Under normal operating conditions, when the gate is turned on, IGBT saturated conduction, IGBT CE voltage close to 0V; if a short circuit occurs, IGBT out of the saturation region, the CE voltage close to the bus voltage, at this time the VCE short circuit protection starts soft shut down to reliably turn off the IGBT, and the fault signal through the optical fibre to the controller. When there is no PWM signal input, the driver gate is always in negative 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 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

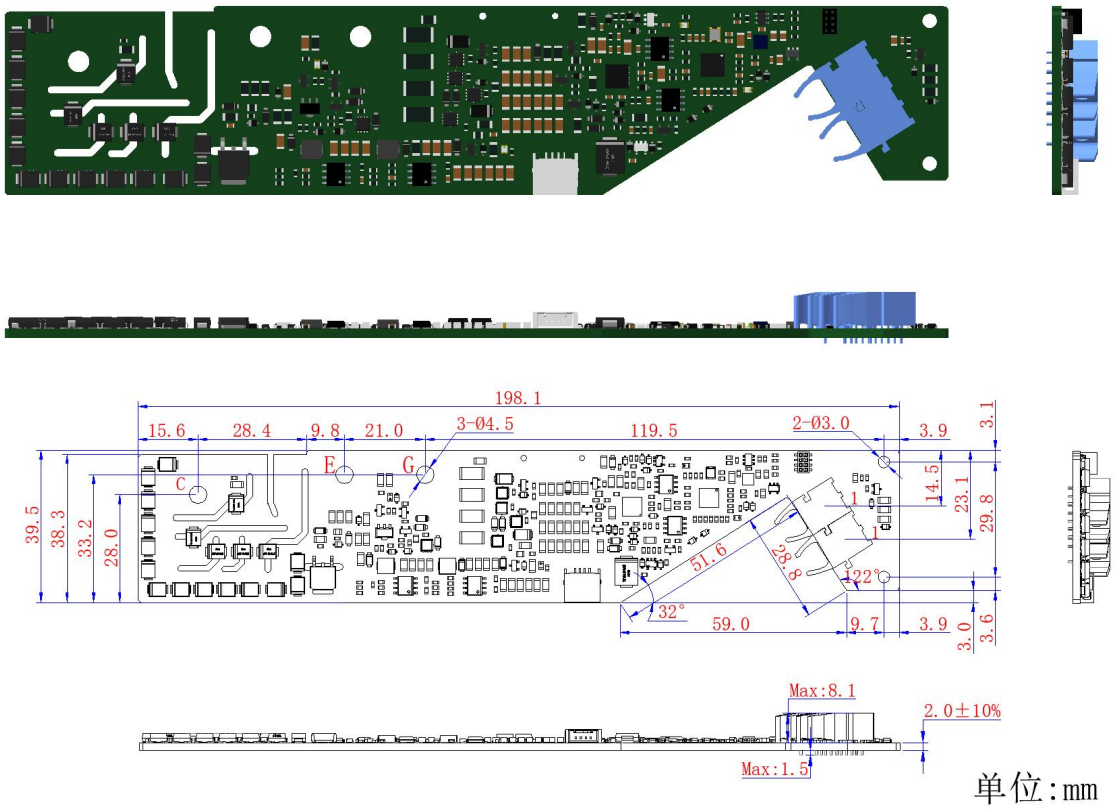

Fig.3 1FHD0440 3D and mechanical dimensions (unit: mm)

(Reed required for di/dt protection function not included)

Note:

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

2. The external dimensions of the PCB shall be ≤400 mm with a tolerance of ±0.5 mm; if the external dimensions exceed 400 mm, the tolerance shall be ±0.8 mm; for other dimensions, refer to the tolerance specifications in GB/T1804-m.

Pin Functional Description

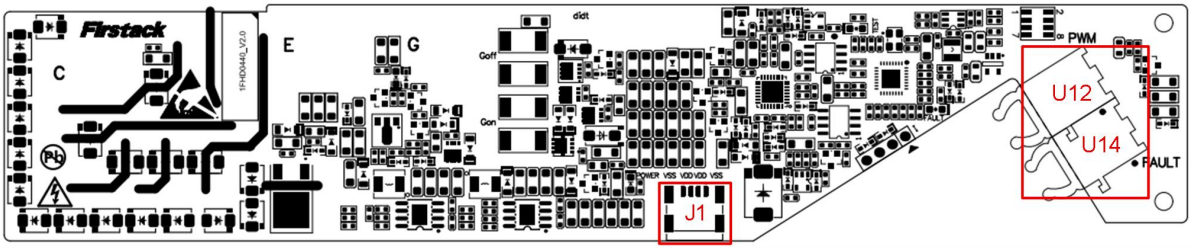

Fig.4 J1 interface

Pin	Silkscreen	Name	Note
1	VSS	GND	Power Supply GND
2	VDD	V_{IN}	Power Supply 25V
3	VDD	V_{IN}	Power Supply 25V
4	VSS	GND	Power Supply GND

Driver Connector Manufacturers and Part Numbers

No.	Ref	Manufacture	Part Number	Recommended Matching Terminals
1	J1	ERNI	504255-E	\
2	U12	AVAGO	HFBR-2521Z	HFBR-1521Z
3	U14	AVAGO	HFBR-1521Z	HFBR-2521Z

Note:

1: PWM logic: "Light"=IGBT turn on; "No light"=IGBT turn off;

2: Fault logic: "Light"=the driver is normal; "No light"=the driver has a fault;

3: Torque requirements: C, G, E fixing holes with M4 screws confinement, installation torque recommended 1.8 ~ 2.1Nm.

LED Status Indicator

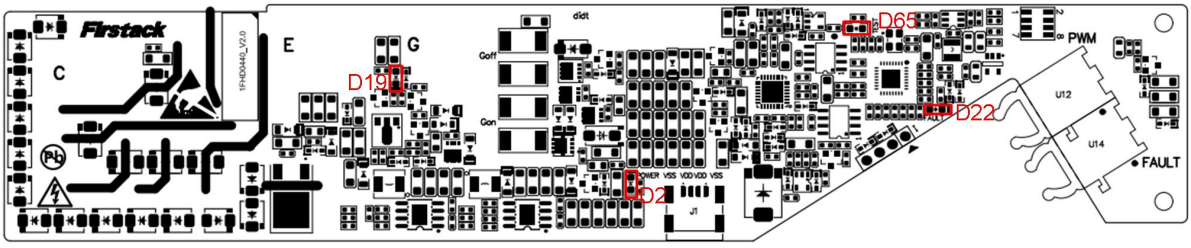

Fig.5 LED status indicator

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:

Driver Status Indicator

No.	Label	Silkscreen	Light	Note
1	D2	POWER	Green	Power indicator light remains on when powered on and turns off when power is removed.
2	D19	GE	Green	Gate open status indicator light: On when open, off when closed
3	D22	FAULT	Red	Driver fault indicator, always on when normal, off when fault
4	D65	TEST	Green	CPLD operation indicator light remains on when powered on

Driving Parameters

Absolute Maximum Ratings[1]

Parameter	Note	Min	Max	Unit
Supply voltage V_{IN}	To GND	0	28	V
Output Power P_{GMAX}	≤85℃，fsw=500Hz		1	W
Gate Peak current			40	A
Operating Voltage	V_{CE}		4500	V
Storage Temperature		-40	85	℃
Operating Voltage		-40	85	℃

The following data were tested under ambient temperature：

Recommended Operating Conditions

Parameter	Note	Min	Typ	Max	Unit
Supply voltage V_{IN}		24	25	26	V

Electrical Characteristics

Parameter	Note	Min	Typ	Max	Unit
Power supply current	Without load, which is quiescent current		0.04		A
	P_G=P_{GMAX} f_{SW}=500Hz		0.08		A

Output Characteristics

Parameter	Note	Min	Typ	Max	Unit
Gate turn-on voltage V_{GEON}	Immediately after turn-on		15		V
	Steady-State		24.2		
Gate turn-off voltage V_{GEOFF}	Steady-State		-10		V

Timing Characteristics

Parameter	Note	Min	Typ	Max	Unit
Turn-on delay $t_{P(LH)}$[2]			310		ns
Delay to increase V_{GE} to 25 V after Turn-ON $t_{P(25)}$			40		us

Turn-off delay $t_{P(HL)}$[3]		320		ns
Duration of Acknowledge Pulse t_{ACK}	500	783	900	ns
Delay of Acknowledgment Pulse $t_{D(ACK)}$		220		ns
didt software filtering time		1		us
Propagation Delay of Fault State Condition $t_{D(Fault)}$		140		ns

Protective Function Characteristics

Parameter	Note		Min	Typ	Max	Unit
Power Supply Monitoring Threshold V_{DC_UVLO}				19		V
Positive Under Voltage Threshold	Referenced to V_{EE}	Set fault	12	12.2	12.4	V
		Clear fault	12.8	13	13.2	V
Negative Under Voltage Threshold		Set fault		-5.7		V
		Clear fault		-5.8		V
Delay Time to Increase VGE to 25V After di/dt Detection $t_{GE(LH)25V}$				38		us
Deactivation of di/dt Detection After Turn-On				33		us
Maximum duration of gate voltage clamping after triggering				88		us
Didt filtering time after gate turn-on				27		us
V_{CE} Monitoring Threshold	Referenced To V_{EE}			10		V
Dynamic Active Clamping Threshold	4500V			3050		V
Static Active Clamping Threshold				3450		V
Soft Shutdown time t_{SSD}				8.32		μs
Short Circuit Time				9		us

t_{SC}				
Fault Duration t_{Fault}	100	200	300	μs
Blocking Time t_{blk}		80		ms

Note：

1． Stresses exceeding the range specified by the absolute maximum rated value may cause permanent damage to the drive.

2． 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;

3． 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

Functional Instruction

◆ 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.

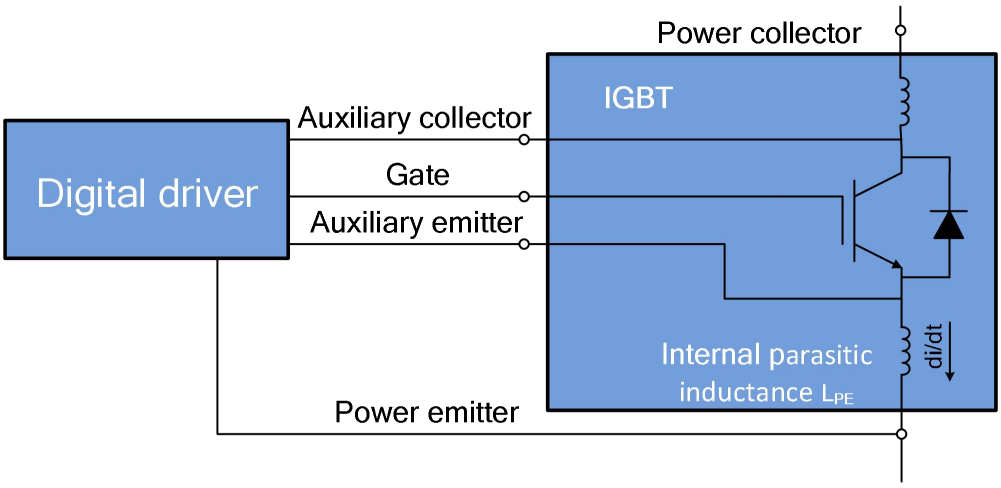

Fig.6 didt detection circuit

◆ Short Circuit—V_{CE} Detection

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.

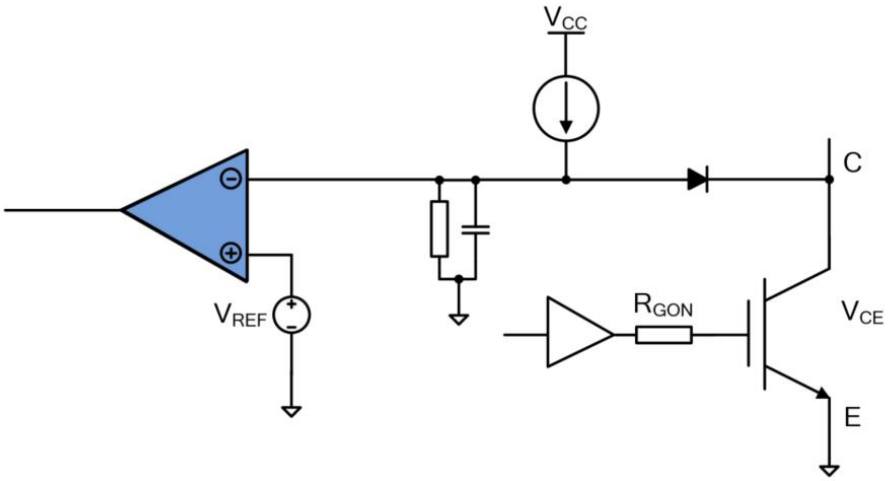

Fig.7 V_{CE} Short Circuit Detection Circuit

◆ 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 controller.

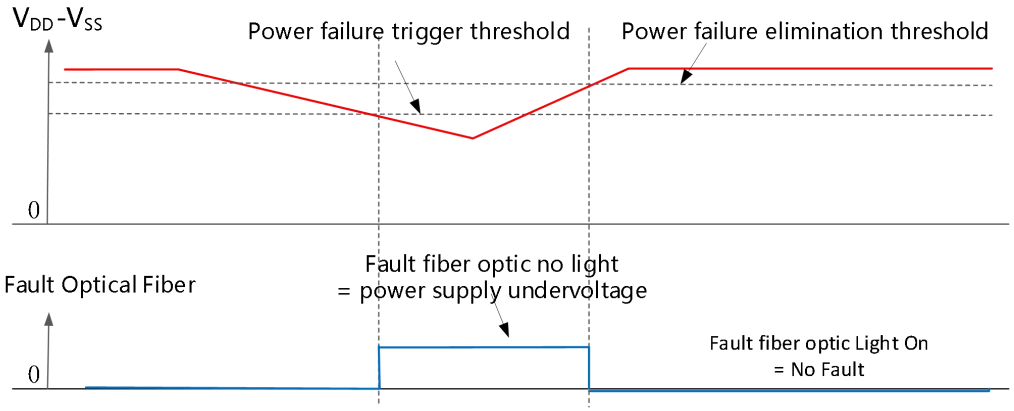

Fig.8 Undervoltage protection logic

Firstack intelligent gate driver strongly suggests that any IGBT in IGBT bridge arm should not operate undervoltage. Because of the existence of CGC, when an IGBT in the bridge arm is turned on, it's high dv/dt can be coupled to another IGBT through CGC, which leads to the slight conduction of the 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 VCE at both terminals will reach the DC bus voltage; while the current IC 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 drive circuit introduces soft shut down technology. In case of direct short-circuit of IGBT, on the premise of ensuring that the short-circuit time is under 10μs, by slowly reducing the gate voltage VGE, 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。

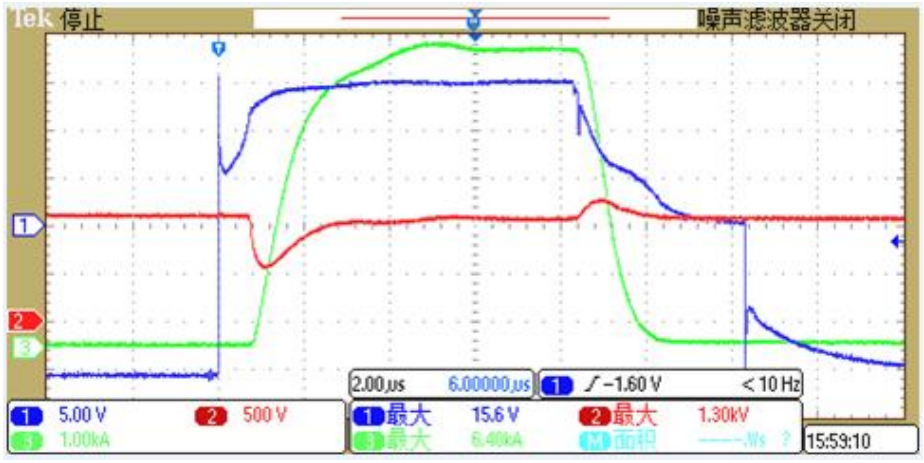

Fig.9 Short-circuit waveform of FF1400R17IP4 at 1100V

In the figure above，CH1:V_{GE}(blue)；CH2:V_{CE}(Red)；CH3:I_C(Green)

Fig.9 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, IC drops slowly, VCE has almost no overshoot, and the IGBT is safely turned off.

◆ Advanced Digitally Controlled Active Clamping

In the event of system overload or a short circuit on the load side, the turn-off current of the IGBT will increase significantly. Under these conditions, advanced digitally controlled active clamping protects the IGBT from failure due to shutdown overvoltage.

When the VCE voltage exceeds the threshold of the TVS, the TVS is broken down and current sinks into the gate,which makes the VGE rise and the IGBT enters the linear region, thus limiting the turn-off voltage to a safe range.

In order to improve the clamping effect, Firstack introduces advanced digitally controlled active clamping, adding a 'digitally controlled current source' at the gate. When the current IZ through the TVS is greater than a certain threshold, turn off the N transistor, and at the same time start the 'digitally controlled current source'. IZ = IG + ID, through the digitally controlled current source, IZ will remain a low value, TVS has been in a weak breakdown state until the end of the shutdown.

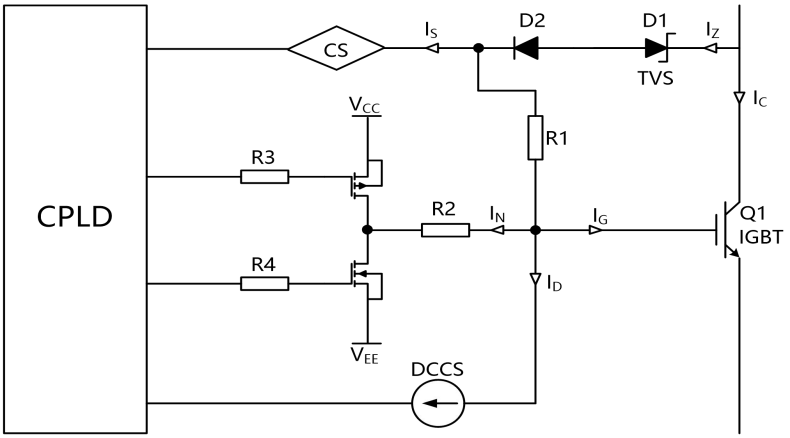

Fig.10 Advanced digitally controlled active clamping schematic

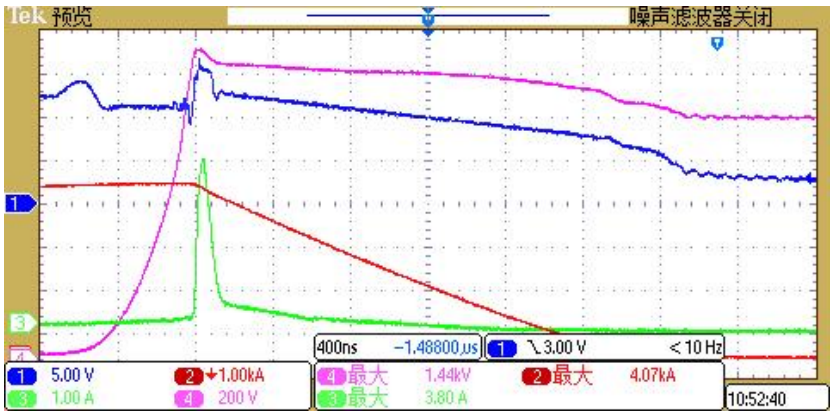

Fig.11 Advanced digitally controlled active clamping waveform

In the figure above, CH1: VGE (blue); CH2: IC (red); CH3: ITVS (green); CH4: VCE (pink)

◆ Fault Optical Fibre Output Logic

During the use of optical fibre, there are phenomena such as the optical fibre snap is not secure/fell off, and the turning radius of the optical fibre cable is not enough. In order to ensure the normal communication of optical fibre, Firstack intelligent gate driver is configured with the optical fibre response function as follows:

When the gate driver is operating normally, for each PWM command received, the lights on the return optical fibre go out for a 700ns on both the rising and falling edges of the PWM command as a response to the received command.

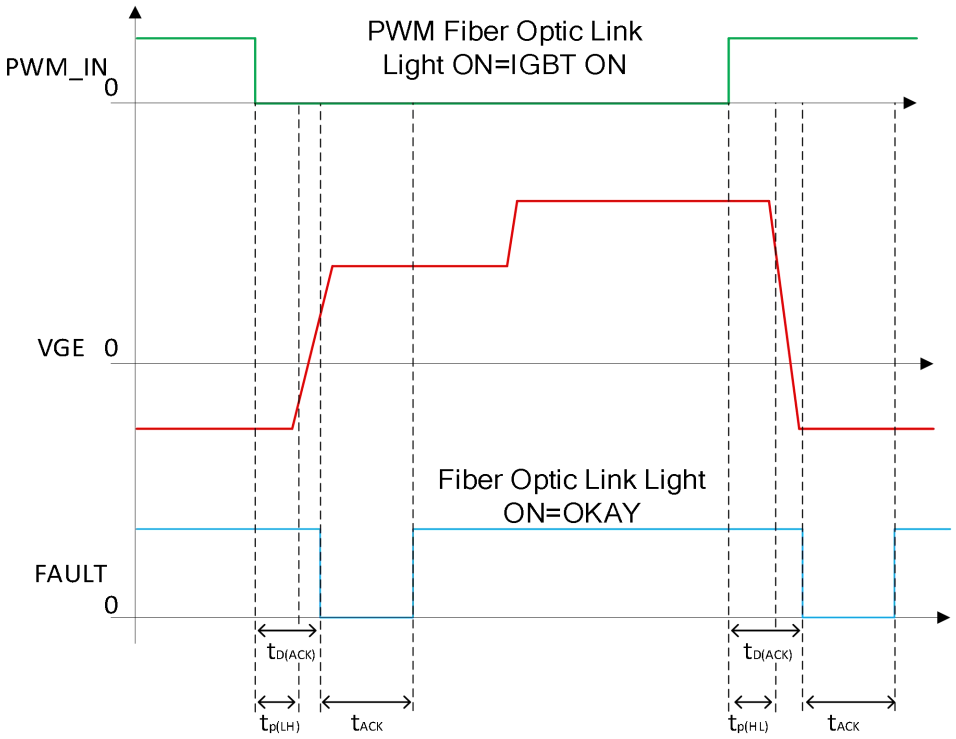

图 12a Normal condition

2. When the driver detects a didt fault, it checks for a desaturation condition. After the didt trigger occurs, V_{CE} is raised to 25 V; if no IGBT reverse saturation is detected during this delay period (as shown in Figure 12b), the driver will raise V_{CE} back to 25 V after a further delay.

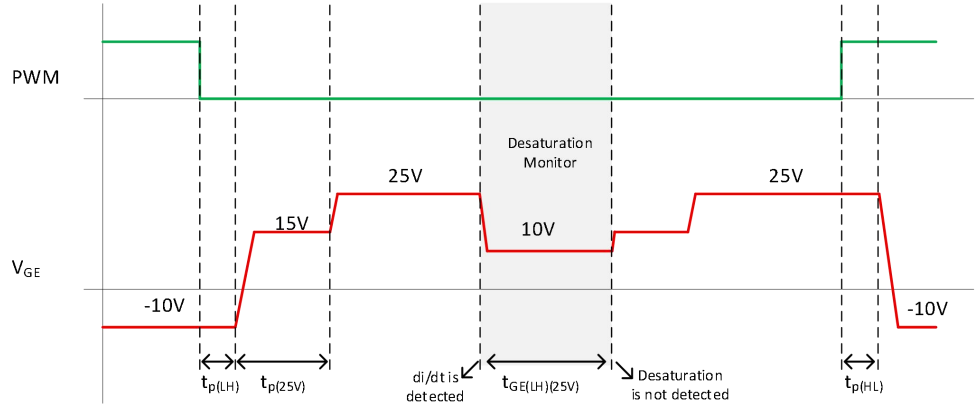

图 12b di/dt No desaturation occurred during the fault condition.

3. When the driver detects a didt fault, it identifies the desaturation condition. After didt is triggered and V_{CE} rises to 25 V during the delay period, if IGBT desaturation is detected (as shown in Figure 12c), after the gate voltage is clamped at 10 V for the specified duration, the driver completes the transition from initial detection of de-saturation to initiating soft shut down, maintaining this state until the required negative voltage is achieved; the total time required is denoted as t_{SSD}.

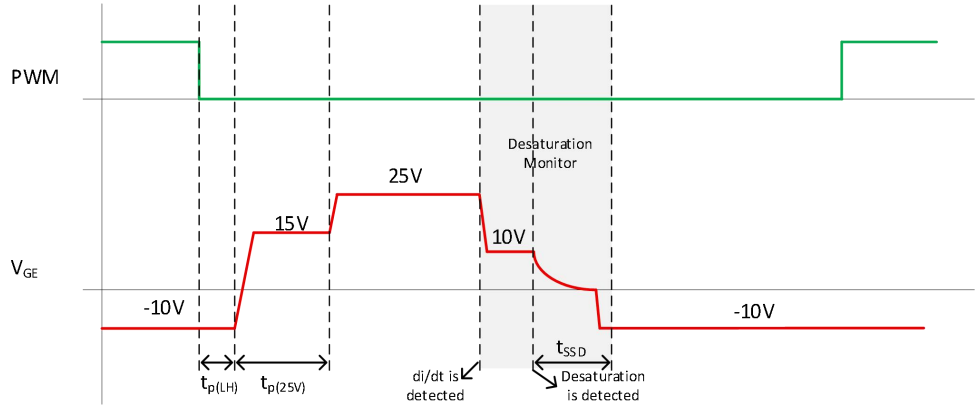

图 12c didt desaturation occurs during a fault condition.

Gate Resistor Indication

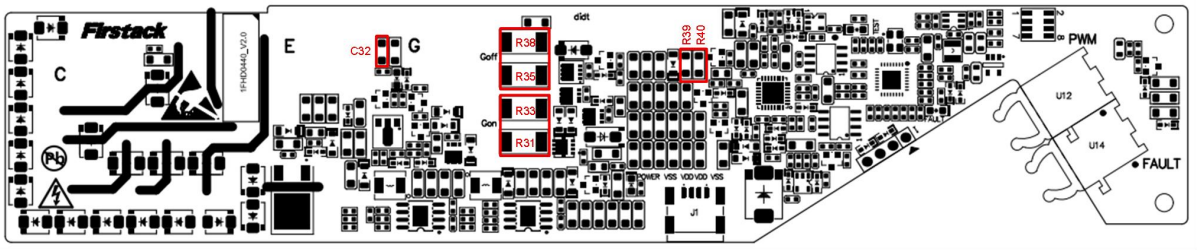

Fig.13 Gate resistor indication

Calculation formula of gate resistor

Parameter	Label	Package	Instruction
C_{GE}	C32	1206	Gate Capacitor
R_{GON}	R31//R33	2512	Turn-on resistor
R_{GOFF}	R35//R38	2512	Turn-off resistor
R_{SSD}	R39//R40	1206	20Ω//20Ω，Welded

Gate driver	Module voltage	di/dt	C_{GE}(nF)	R_{gon}(Ω)	R_{goff}(Ω)
1FHD0440V45A1-Y0000	4500V	Yes	NC	NC	NC

Note:

1. FHD0440V45A1-Y0000 This is a bare version of the gate resistor without paint coating; customers can solder it according to their requirements.

2. For gate resistance and capacitor soldering, refer to Firstack's "General Guide for Soldering Gate Resistors in IGBT Drivers (Surface Mount Type)"

3. Connect and install the 1FHD0440 with the DCDC FPS08-15K_V3.1; refer to Firstack's "1FHD0440 Installation Manual".

Naming Rule

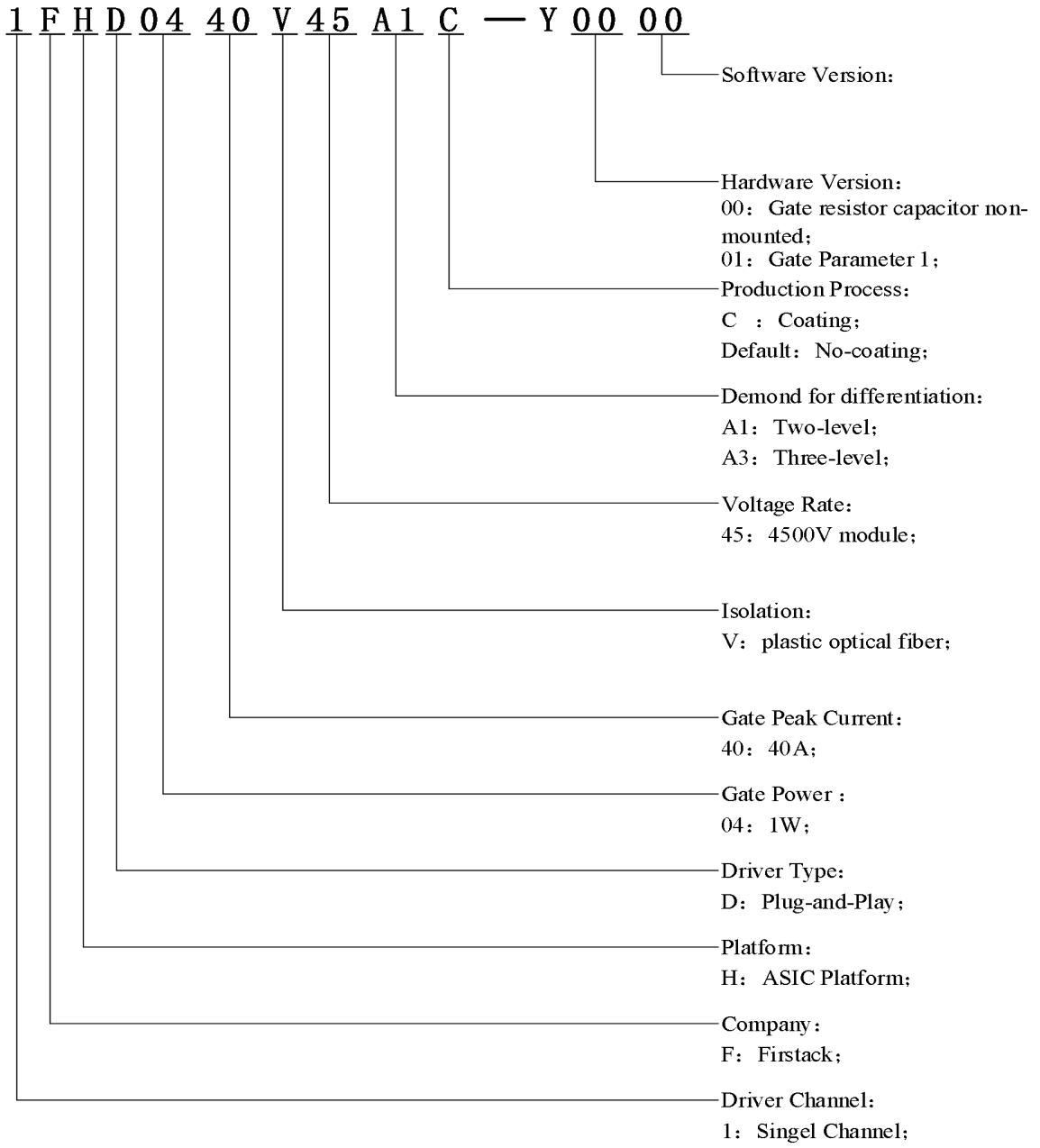

Fig.14 Naming Rule Diagram

Note:

1: If there is any requirement, please contact Firstack for technical support

Ordering Information

1FHD0440 can support a variety of IGBT modules of different manufacturers with different models but the same package, you can provide the specifications of the IGBT model you are using at the time of purchase, so that we can provide the gate driver that best meets your needs.

Change Record

2026.06.02 First Version

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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