4FHS0660CA1B15V-Y01A00 Data Sheet

Abstract

4FHS0660CA1B15V-Y01A00 is a high-performance digital gate driver core developed by Firstack for NPC I-type 3-level system. The gate driver adopts ASIC as the digitally controlled core, with complete protection functions and built-in fault management system, which uploads the converter's operating state to the master computer in real time, providing support for "big data management" for the failed converter site. Perfectly solving the two major problems of "turn-off timing sequence" and "large commutation circuit turn-off peak" in NPC I-type topology, the reliability of NPC topology can be comparable to 2-level, allowing customers to use NPC I-type /ANPC 3-level as same as 2-level.

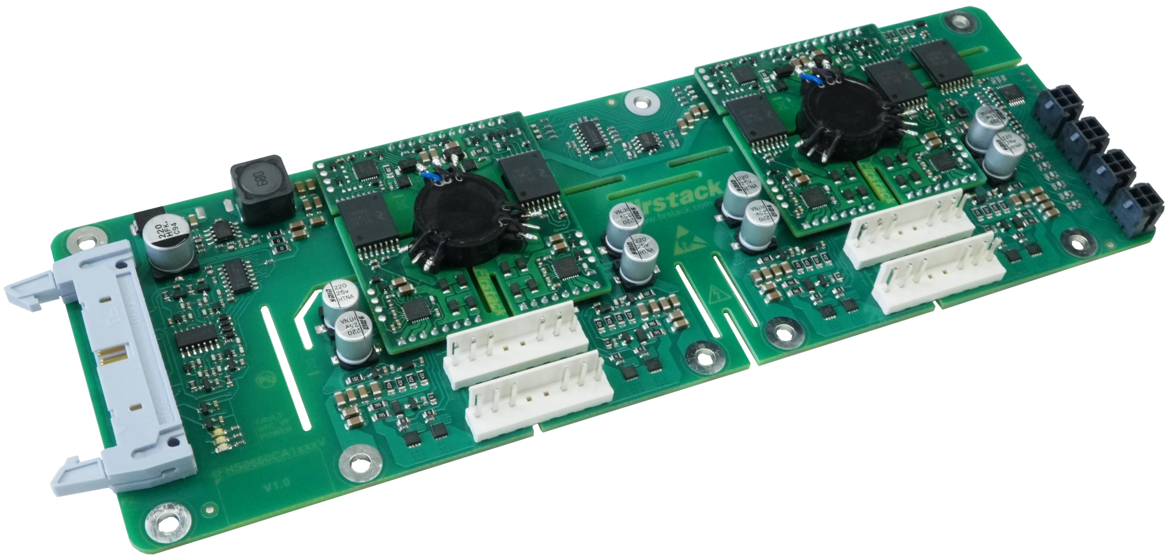

Fig. 1 4FHS0660CA1B15V-Y01A00

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Functional block diagram

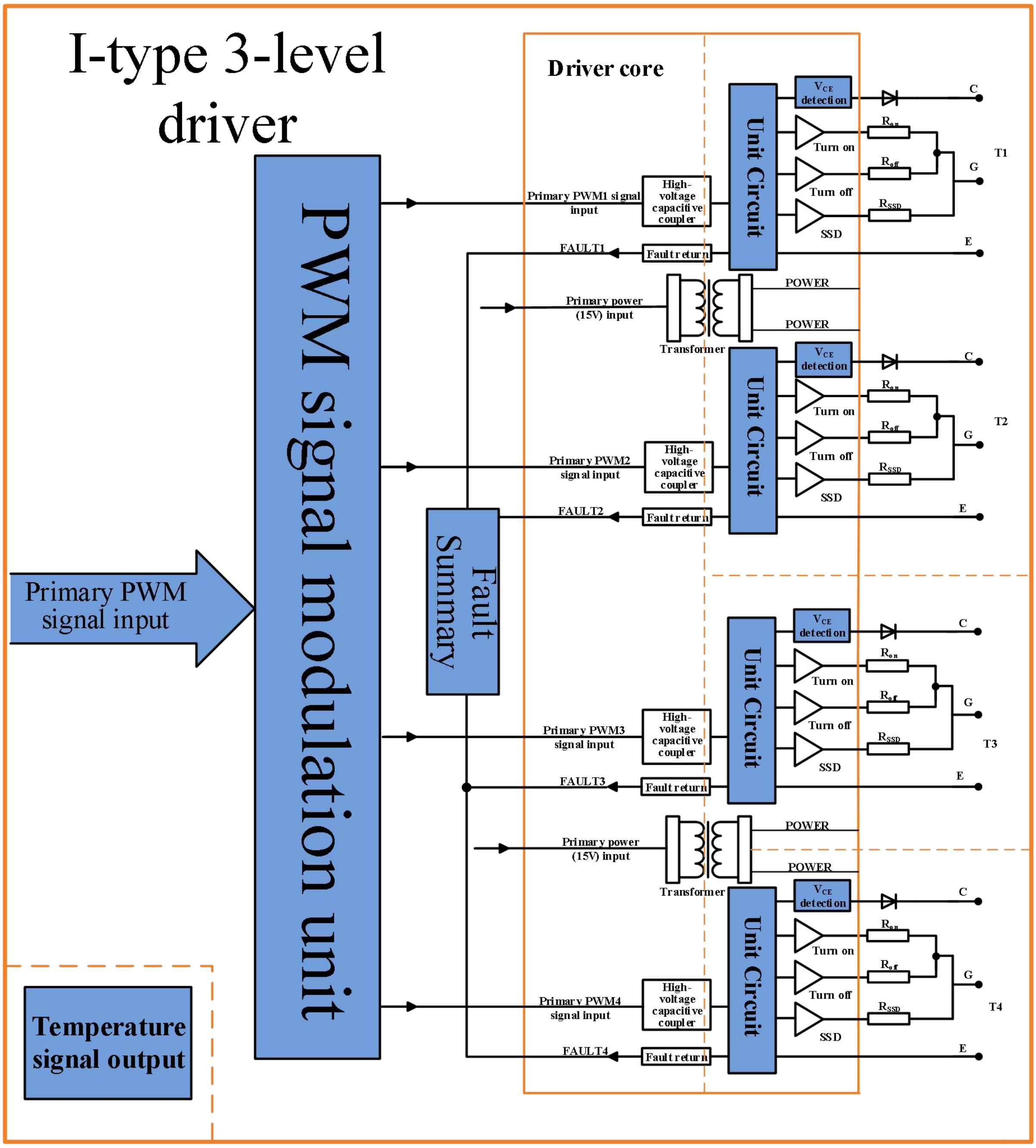

Fig. 2 Functional block diagram

Use steps and matters needing attention

Simple use steps of the gate driver are as follows:

1. Choose suitable gate driver

When use 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 European standard EN 61340-5-1.

If these specifications were ignored, both the IGBT and the gate driver might be damaged.

3. Connect the gate driver to the control unit

Connect the gate driver connector 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. These tests should be performed prior to installation, as the gate terminals 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 single pulse and double pulse test method separately. 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 architecture.

Mechanical dimensions

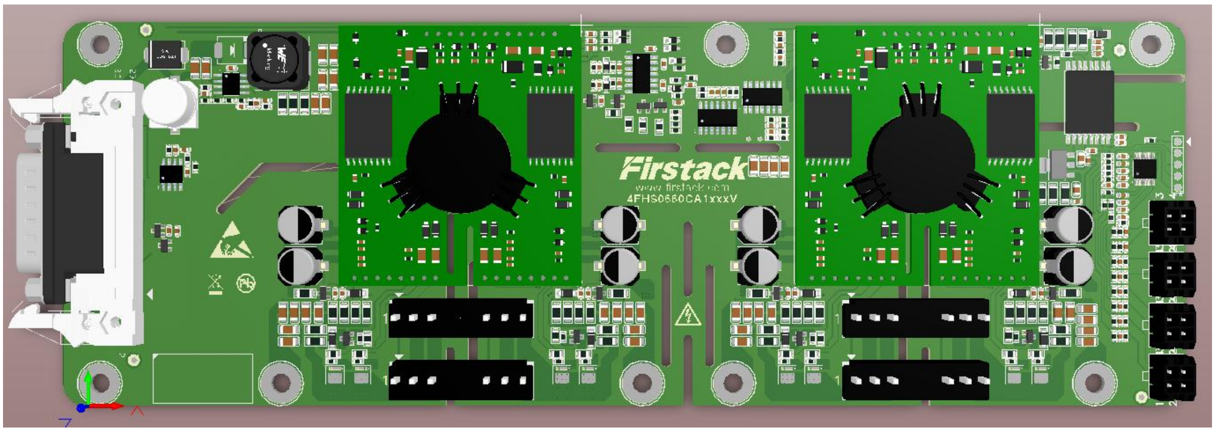

Fig.3 Mechanical dimensions

Connector Manufacturer and Part Number

Number	Label	Manufacturer	Part Number	Recommended Matching Terminals
1	P1	WCON	6223-15MSNS0B02	/
2	P5,P6,P7,P8	WCON	WF3963-WSH08B02	WF3963-H08B01
3	P4,P9,P10,P11	CJT	C3030WV-2x2P-LCP	WE3001-2H02B01

Pin definition

P1 pin definition:

Pin	Name	Description	Pin	Name	Description
1	V_{DC}	Power supply input	2	V_{DC}	Power supply input
3	IN1	T1 PWM signal	4	IN2	T2 PWM signal
5	SO	Fault summary	6	IN3	T3 PWM signal
7	IN4	T4 PWM signal	8	FOUT	Frequency output
9	GND	Primary side reference ground	10	GND	Primary side reference ground
11	GND	Primary side reference ground	12	GND	Primary side reference ground
13	GND	Primary side reference ground	14	GND	Primary side reference ground
15	GND	Primary side reference ground			

P5, P6 pin definition:

Pin	Name	Description	Pin	Name	Description
1	Vcesat-T2	T2 detection signal	5	NC	Free
2	ACOM-T2	T2 reference ground	6	Vcesat-T1	T1 detection signal
3	GATE-T2	T2 gate signal	7	ACOM-T1	T1 reference ground
4	NC	Free	8	GATE-T1	T1 gate signal

P7, P8 pin definition:

Pin	Name	Description	Pin	Name	Description
1	Vcesat-T3	T3 detection signal	5	NC	Free
2	ACOM-T3	T3 reference ground	6	Vcesat-T4	T4 detection signal
3	GATE-T3	T3 gate signal	7	ACOM-T4	T4 reference ground
4	NC	Free	8	GATE-T4	T4 gate signal

P4 pin definition:

Pin	Name	Description	Pin	Name	Description
1	NTC1	Module 1 temperature signal	3	NTC2	Module 2 temperature signal
2	GND-T4	T4 ground	4	GND-T4	T4 ground

P9 pin definition:

Pin	Name	Description	Pin	Name	Description
1	NTC5	Module 5 temperature signal	3	NTC6	Module 6 temperature signal
2	GND-T4	T4 ground	4	GND-T4	T4 ground

P10 pin definition:

Pin	Name	Description	Pin	Name	Description
1	NTC3	Module 3 temperature signal	3	NTC4	Module 4 temperature signal
2	GND-T4	T4 ground	4	GND-T4	T4 ground

P11 pin definition:

Pin	Name	Description	Pin	Name	Description
1	NTC7	Module 7 temperature signal	3	NTC8	Module 8 temperature signal
2	GND-T4	T4 ground	4	GND-T4	T4 ground

*The gate driver samples the temperature signals of 8 modules.

*NTCx is the temperature signal of module x, which is free when not in use.

Driving parameters

Absolute Maximum Ratings

Parameter	Note	Min.	Max.	Unit
V_{DC}	V_{DC} to GND		15.5	V
Logic input and output voltages	Primary side, to GND		15.5	V
SO output	Fault condition		500	mA
Gate peak current	I_{peak}		60	A
Output power per channel	$T_A \le 85°C$		6	W
Test voltage (50Hz V_{AC}/1min)	Primary to secondary side		5	kV_{RMS}
	Secondary to secondary side		4	kV_{RMS}
dv/dt			50	kV/µs
Operating temperature		-45	85	°C
Storage temperature		-45	85	°C

Recommended Operating Conditions

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

Electrical Characteristics

Power supply	Note	Min	Typ	Max	Unit
Power supply current	Without load, Note 1		0.35		A
Coupling capacitance	Primary to secondary side, Note 2		13		pF
Power monitoring					
Threshold			12		V

Input and output logic					
Input impedance			10		kΩ
Turn-on threshold	Note 3	3.3			V
Turn-off threshold	Note 4			1.3	V
SOx output potential			15		V
Short-circuit protection					
V_{CE} monitoring threshold			13		V
Response time	T1, T4, Note 5		7.0		us
	T2, T3, Note 5		8.7		us
Blocking time	T1, T4		85		ms
	T2, T3		75		ms
Timing characteristics					
Turn-on delay	T1, Note 6		1400		ns
	T2, Note 6		1400		ns
	T3, Note 6		1400		ns
	T4, Note 6		1400		ns
Turn-off delay	T1, Note 7		1400		ns
	T2, Note 7		1400		ns
	T3, Note 7		1400		ns
	T4, Note 7		1400		ns
Rise time	T1, Note 8		220		ns
	T2, Note 8		500		ns
	T3, Note 8		500		ns
	T4, Note 8		220		ns
Fall time	T1, Note 9		900		ns

	T2, Note 9	3500	ns
	T3, Note 9	3500	ns
	T4, Note 9	900	ns
Fault hold time		17	ms
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, Note 10	15.5	mm
	Secondary to secondary side	10.5	mm
Clearance distance	Primary to secondary side	14.5	mm
	Secondary to secondary side	9	mm

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

Note:

1. Power supply current: connected to IGBT, but no PWM input;
2. Coupling capacitance: the values of coupling capacitance are within the range of values given in the table;
3. Turn-on threshold: the input voltage value at the moment of level-flip when turn on;
4. Turn-off threshold: input voltage value at the moment of level-flip when turn off;
5. Response time: the time from the occurrence of the fault to the start of soft shut down;
6. 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 gate driver of the secondary side;
7. 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 gate driver of the secondary side;
8. Rise Time: the amount of time from 10% of the gate turn-off voltage(-10V) to 90% of the gate turn-on voltage(+15V)(influenced by gate parameters);
9. Fall Time: the amount of time from 90% of the gate turn-on voltage(+15V) to the gate turn-off voltage(-10V)(influenced by gate parameters);
10. Creepage distance: refer to IEC61800-5-1-2007, meet the basic isolation requirements of pollution level 2 at an altitude of less than 2km.

Function description

◆ Short-circuit protection

The driving circuit determines whether the IGBT is in a short-circuit state by detecting the collector voltage V_{CE} when the IGBT turns on.

The V_{CE} voltage is detected by high-voltage diodes. When the V_{CE} voltage exceeds the set threshold, the gate driver determines that the IGBT is in a short-circuit state and returns the fault to the master computer at the same time. However, the driver does not turn off the IGBT by itself, but keeps the IGBT in the on state, which is turned off uniformly by the ASIC.

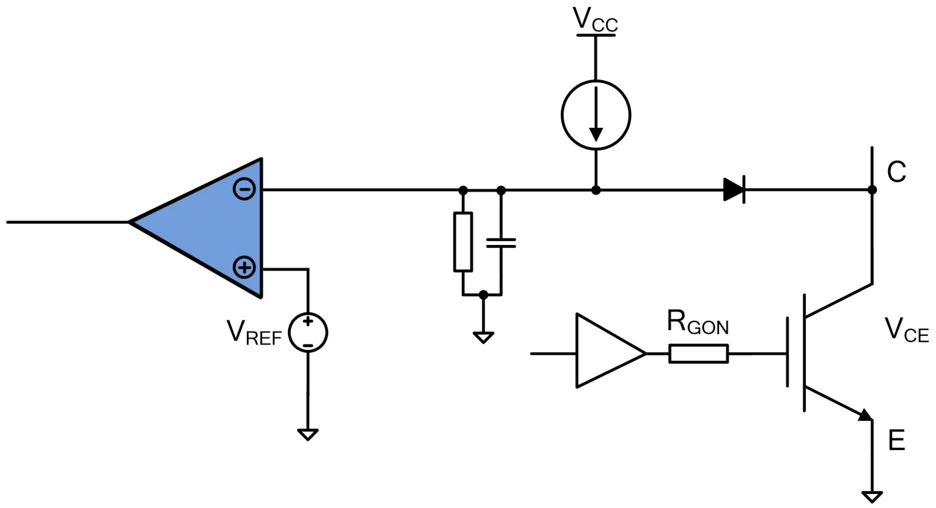

Fig.4 V_{CE} desaturation detection circuit

◆ 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 driving circuit determines that an undervoltage fault has occurred and will feed back a fault signal to the master computer. The gate driver will turn off the IGBT according to the order of turning off the IGBT outside first and then the IGBT inside.

For IGBT bridge arms, Firstack intelligent gate driver strongly suggests that any IGBT should not work 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.

◆ Muti-level turn-off

In some applications with large stray inductance, such as NPC I-type 3-level large commutation circuit, each time the IGBT is turned off, it will face the risk of excessive turn-off peaks. Due to the limitation of the thermal capacitance of TVS, active clamping technology is not suitable for these occasions, and the muti-level turn-off technology can play a significant role at this time. By using different turn-off resistances during the turn-off process, the entire turn-off process is optimized to suppress the turn-off peak.

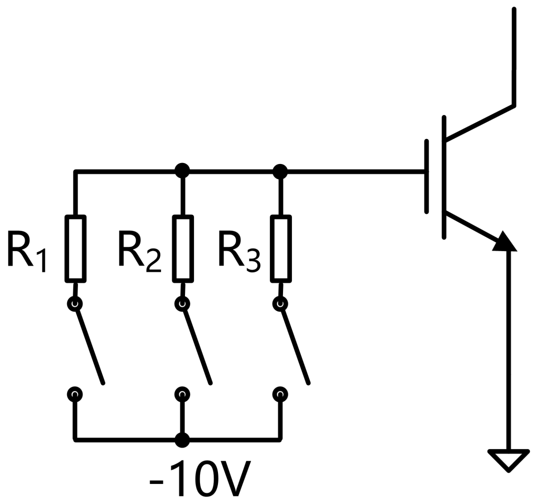

Fig.5 Muti-level turn-off schematic

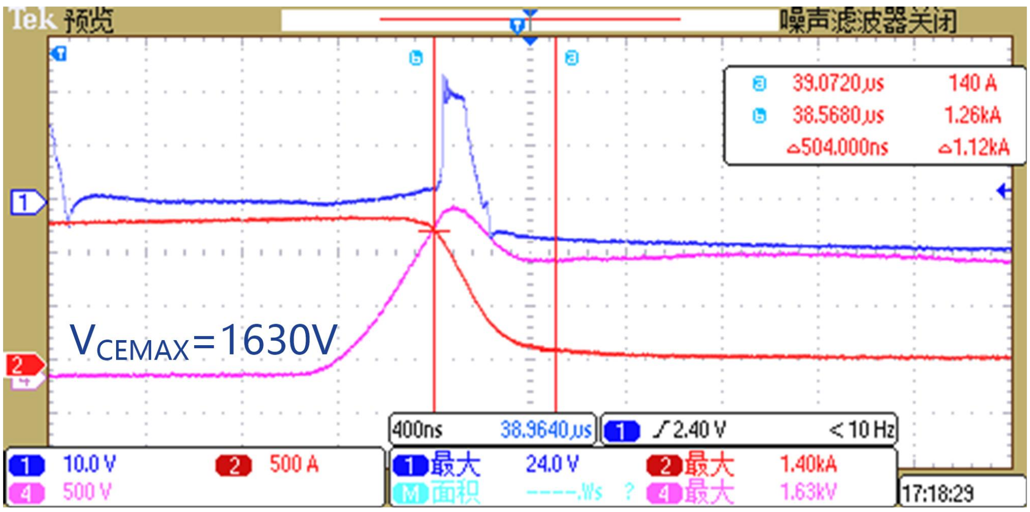

Fig.6 a Without muti-level turn-on/off

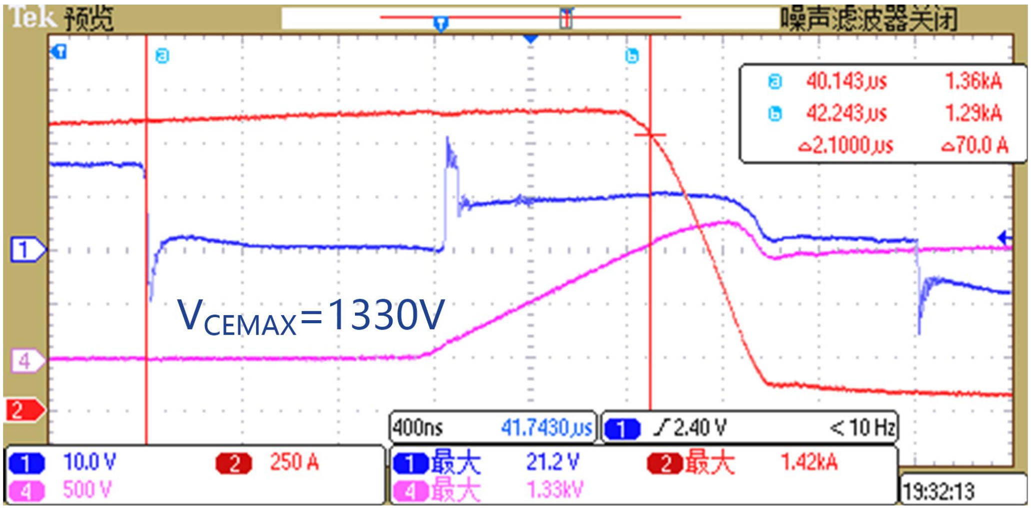

Fig.6 b With muti-level turn-on/off

The above tests are based on the Infineon FF1400R17IP4 module.

◆ Short pulse suppression

In many applications, the module may encounter a short pulse situation, and the IGBT will face the risk of too high turn-off peaks every time the IGBT is turned off by a short pulse. We detect the time of the input signal, when the time is less than 500ns, the signal will be filtered out directly, which needs to be verified according to the actual test situation.

◆ NTC sampling

With the advancement of module packaging technology, more and more modules begin to integrate temperature sensors internally, and NTC is one of these ways. Modules like PrimePACK™, EconoDUAL™ and so on have NTC integrated internally. The NTC is located on the DCB, which is a few millimeters away from the chip, but the arc generated when the chip fails may touch the NTC, so when dealing with the NTC, it is necessary to meet the EN50178 specification for safety reasons.

Firstack intelligent driver integrates a temperature monitoring circuit, through the comparison circuit, when the IGBT temperature exceeds the threshold, the level flips, through the isolation device to upload the over-temperature signal to the master computer, then the master computer carries out shutdown protection uniformly.

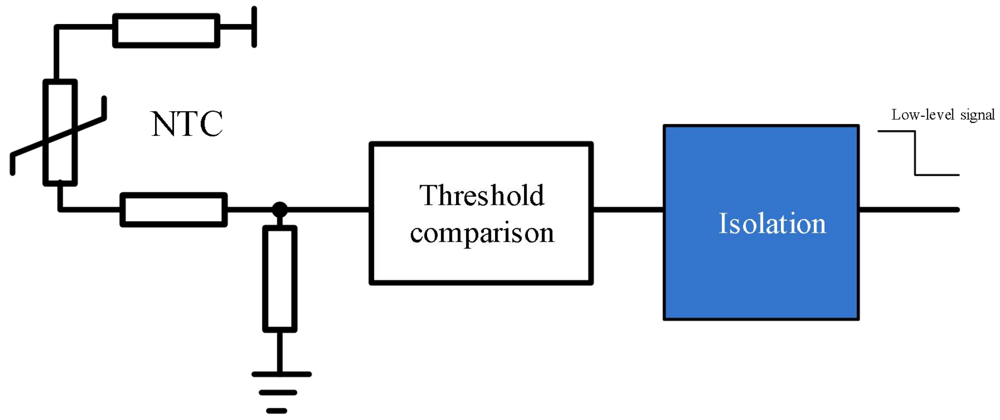

Fig.7 Temperature monitoring schematic

The 4FHS0660CA1xxxx detects the temperature of the 8 IGBTs in real time and sends low level signal to the master computer when one of the IGBTs exceeds the set threshold.

◆ Intelligent fault management system

In NPC I-type 3-level, the DC bus voltage $V_{DC\text{-}LINK}$ is higher than the withstand voltage value of any IGBT, so whether in normal operation or fault condition, it must be ensured that the IGBT outside S_4(S_1) is turned off before the IGBT outside S_3(S_2), otherwise S_3(S_2) will be damaged because of withstanding the full DC bus voltage $V_{DC\text{-}LINK}$ alone.

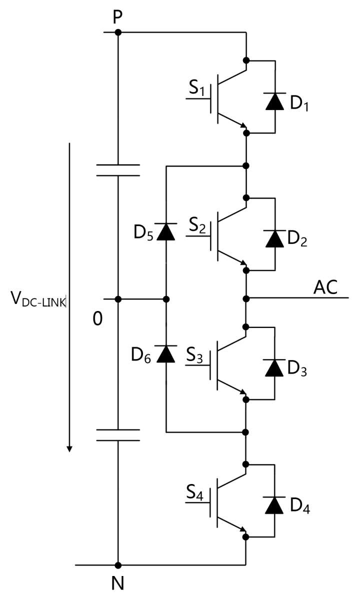

Fig.8 NPC I-type 3-level topology

In the traditional I-type 3-level gate driver design, the correct turn-off timing is generally ensured by the master computer, for example, when a short-circuit fault occurs in S_3, the driver board first informs the master computer of the fault signal of S_3, and then the master computer will unify and coordinate the turn-off timing, and thus there are also several risks as follows:

1, Short-circuit protection time exceeds the maximum withstand time of IGBT: S_3 itself short-circuit detection time is generally about 8μs, plus the fault communication time, the master computer filtering time, as well as the turn-off time of S_4 (high-voltage high-power module turn-off time is generally longer, in the range of 4~6μs), the entire protection time will be more than 10μs, which also exceeds the short-circuit safety of the IGBT operating range;

2, Protection is dependent on the master computer: from the single point of failure analysis, when the master computer fails, the protection can not be completed properly, there are security risks.

Another risk is that traditional driver IC and even the vast majority of plug-and-play drivers tend to directly turn off the IGBT in the event of an undervoltage fault, which is not applicable to the NPC I-type 3-level scheme, resulting in a significant safety risk.

Based on the analysis above, Firstack has developed a drive solution specifically for NPC I-type 3-levels: by integrating Firstack's unique "intelligent fault management system" on the primary side, it ensures the correct turn-off timing under any operating conditions.

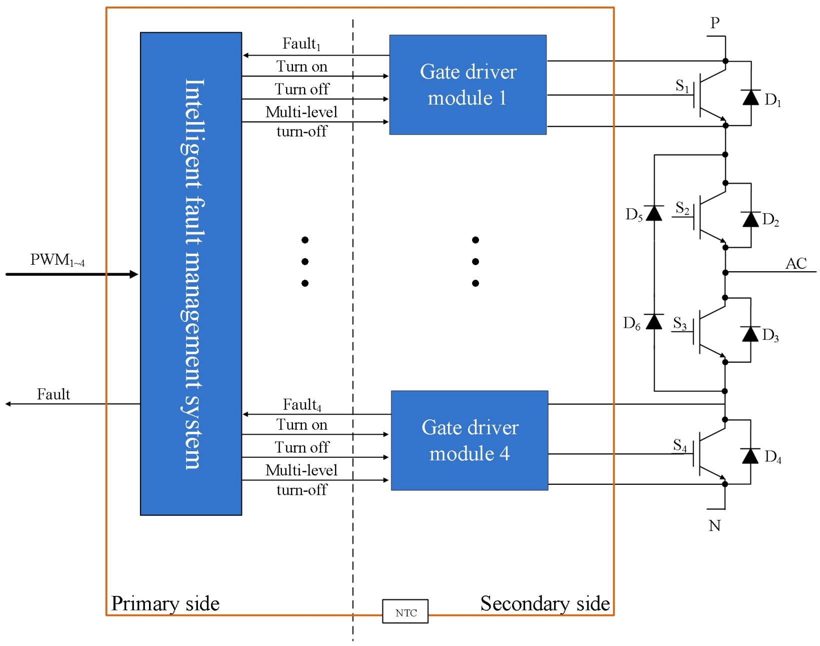

Fig. 9 Intelligent fault management system

The intelligent fault management system will monitor all four PWM signals and all four IGBT status in real time, and then give the optimal operation instruction through Firstack's unique control algorithm. When the whole machine is in continuous operation and the following faults occur, safety can be ensured:

1: PWM command fault: when the master computer is disturbed and sends wrong commands, or the PWM transmission path is disturbed and wrong commands appear on the gate driver side;

2: Connector disconnection: in the operation of the whole machine, the connector is disconnected due to vibration and other factors, resulting in uncontrolled PWM command status;

3: Gate driver power supply abnormality: in the operation of the whole machine, because of the failure of the power supply terminal, causing the gate driver power supply abnormality.

4: Short-circuit/undervoltage fault.

Ordering information

The 4FHS0660CA1B15V-Y01A00 supports different models of AB modules 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 and technical support. Please contact the Firstack technical sales team if you require the application manual for further information of the technical application.

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.

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