Application Guide of DC/DC Converter for IGBT/SiC/GaN Gate Driver 2022

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1. Product Overview

1.1 Definition of IGBT

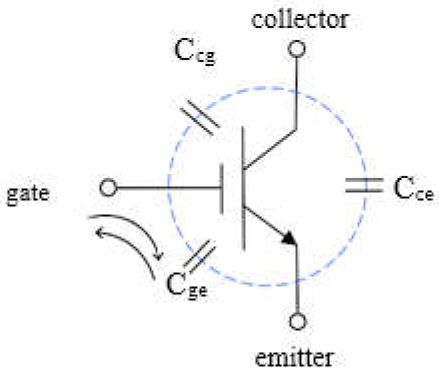

Diagram 1: Charging and Discharging Model of IGBT Gate

IGBT (Insulated Gate Bipolar Transistor) is a switching component with two characteristics: high-power as bipolar transistor, high-speed converting and voltage-driven as MOSFET.

With input characteristic similar to MOSFET, IGBT is a component driven by voltage. As above diagram shows, IGBT's turn-on and turn-off depend on the voltage between G and E. And due to gate capacitance, certain circuit is required to charge and discharge input capacitor ($C_i=C_{ge}+C_{cg}$) so as to switch on and off IGBT.

In addition, SiC MOSFET is also a well characterized switching device with higher switching speed, higher voltage withstand and better temperature characteristics. It facilitates the integration and miniaturization of power systems. However, since the driving voltage and driving frequency of SiC MOSFET are different from those of IGBT, different drivers and power supplies driving these drivers are required.

1.2 Definition of IGBT Driver

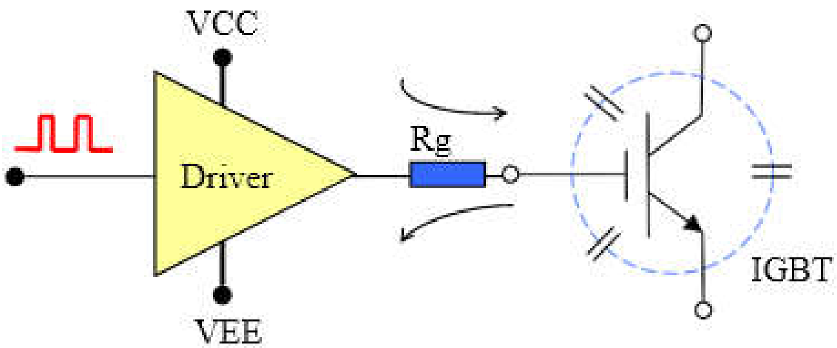

Diagram 2: IGBT driver's function

IGBT driver is a component which rapidly charges and discharges IGBT gate according to control signals, and make it switch on and off normally. Actually, the essential function of IGBT driver is to amplify the control signals. For IGBT emitter or IGBT collector, generally speaking, their electric potentials will change periodically in applications.

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In order to be able to resist the interference of such changes and turn on and off the IGBT stably, the driver also provides signal isolation function to cope with common mode interference.

1.3 Definition of DC/DC Converter for IGBT Driver

DC/DC converter for IGBT driver is a component that powers IGBT driver and offers electric isolation to reduce common-mode interference in practical application.

The IGBT driver with built-in DC/DC converter is also available in the market. This diver reduce the board space, support electric isolation and simplify users' interface design.

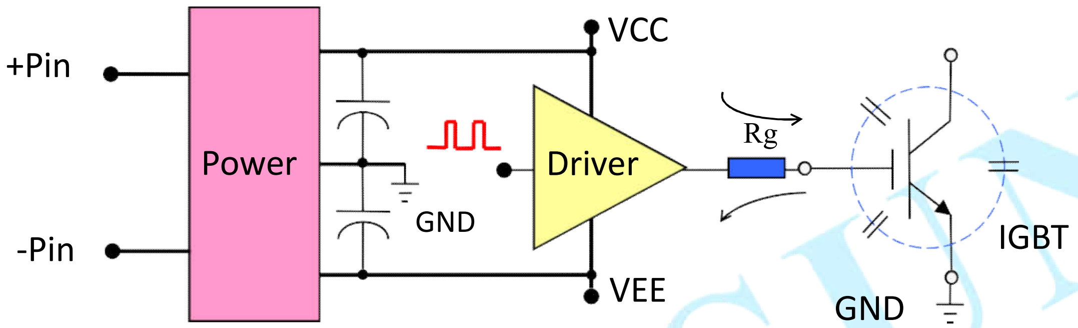

Diagram 3: Relations between IGBT, IGBT Driver and DC/DC converter for IGBT Driver

1.4 Product Lines of DC/DC Converter for IGBT/SiC/GaN Gate Driver

	Input voltage	Part No.	Output voltage/current	Isolation capacitance
DC/DC Power Supply for IGBT Driver	15V	QA152D	+15V/-9V, ±200mA	3
	15V	QA01	+15V/-8.7V, +80mA/-40mA	6.6
	15V	QA01-17	+17V/-8.7V, +80mA/-40mA	6.6
	12V	QA02	+15V/-8.7V, +80mA/-40mA	6.6
	24V	QA03	+15V/-8.7V, +80mA/-40mA	6.6
	12V(9-15)	QA04	+15V/-8.0V, +100mA/-80mA	6.6
	15V	QA01-09	+9V, +111mA	6.6
	15V	QA01-A09	+9V/-9V, ±55mA	6.6
	12V	QA121	+15V/-8.0V, ±120mA	6
	15V	QA151	+15V/-8.0V, ±120mA	6
	24V	QA241	+15V/-8.0V, ±120mA	6
	9-36V	QAU242D2G	24V/150mA, 24V/150mA	15
	12V(7-18)	CQAW01	+15V/-9V, ±200mA	50
Power Supply for SiC MOSFET Driver	15V	QA01C-18	+18V/-3V, ±100mA	5
	5V	QA051C	+20V/-5V, +80mA/-40mA	50
	15V	QA151M	+15V/-5V, ±100mA	3.5
	15V	QA01C	+20V/-4V, ±100mA	3.5
	12V	QA121C2	+15V/-3.5V, ±111mA	3.5

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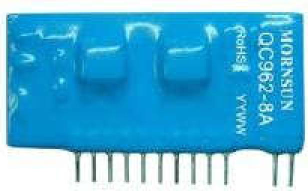
	Input voltage	Part No.	Vo/Io	Isolation Capacitance
Hybrid Integrated IGBT Driver	+18V/-15V (External)	QC962-8A	+18V/-15V, ±8A	
	15V	QP12W08S-37	+15V/-9V, ±8A	
Recommended DC/DC converter for IGBT Driver (Recommended in 2022)	12V	QA123D-2GR3	+15V/-9V, ±100mA	6.6
	15V	QA153D-2GR3	+15V/-9V, ±100mA	6.6
	24V	QA243D-2GR3	+15V/-9V, ±100mA	6.6
	12V	QA123-1509R3	+15V/-9V, ±100mA	6.6
	15V	QA153-1509R3	+15V/-9V, ±100mA	6.6
	24V	QA243-1509R3	+15V/-9V, ±100mA	6.6
	12V(9-15)	QAW123-1509R3	+15V/-9V, ±100mA	6.6
	12V	QA123H-1509R3	+15V/-9V, ±100mA	6.6
	15V	QA153H-1509R3	+15V/-9V, ±100mA	6.6
	24V	QA243H-1509R3	+15V/-9V, ±100mA	6.6
Recommended DC/DC converter for SiC MOSFET (Recommended in 2022)	12V	QA123C-1504R3	+15V/-4V, ±120mA	3.5
	15V	QA153C-1504R3	+15V/-4V, ±120mA	3.5
	24V	QA243C-1504R3	+15V/-4V, ±120mA	3.5
	12V	QA123HC-1504R3	+15V/-4V, ±120mA	3.5
	15V	QA153HC-1504R3	+15V/-4V, ±120mA	3.5
	24V	QA243HC-1504R3	+15V/-4V, ±120mA	3.5
	12V	QA123C-2005R3	+20V/-5V, ±100mA	3.5
	15V	QA153C-2005R3	+20V/-5V, ±100mA	3.5
	24V	QA243C-2005R3	+20V/-5V, ±100mA	3.5
	12V	QA123HC-2005R3	+20V/-5V, ±100mA	3.5
	15V	QA153HC-2005R3	+20V/-5V, ±100mA	3.5
	24V	QA243HC-2005R3	+20V/-5V, ±100mA	3.5

Diagram 4: Product Lines of DC/DC converter for IGBT/SiC/GaN Gate Driver

Fixed input

Wide input



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Built-in isolated DC/DC Converter IGBT Driver QP series

Non-built-in isolated DC/DC Converter IGBT Driver QC962-8A

Diagram 5: MORNSUN Product Pictures

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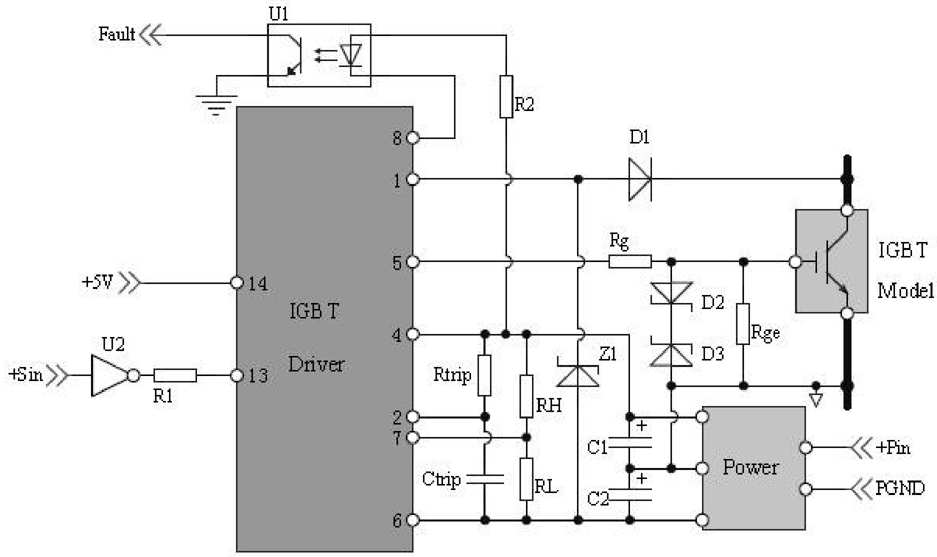
2. Applications

2.1 Typical Applications of IGBT Driver



Pin-Out Details:

1: Fault detection of over-current or short-circuit
2: Short-circuit detection time
4: Positive power input
5: Signal output
6: Negative power input
7: Protection threshold voltage
8: Fault signal output
13: Negative signal input
14: Positive signal input

Diagram 6: Application of non-built-in isolated DC/DC Converter IGBT Drive --QC962-8A

As above diagram, the gate turn-on voltage is usually +15V and turn-off voltage ranges from -6V to -10V. Therefore, the power supply for the driver requires positive and negative dual outputs.

Moreover, the driver fault detection pin's reference level (pin1) is based on the IGBT emission pole, while the other output pins use Pin6 as the reference level. The value range of pin6 is -6V to -10V, for different voltage values, the reference level of the other output pins of will be different, so the protection threshold voltage will be different.

To solve it, MORNSUN IGBT drivers are designed with the adjustable threshold voltage function (pin 7) which is more flexible for user's design.

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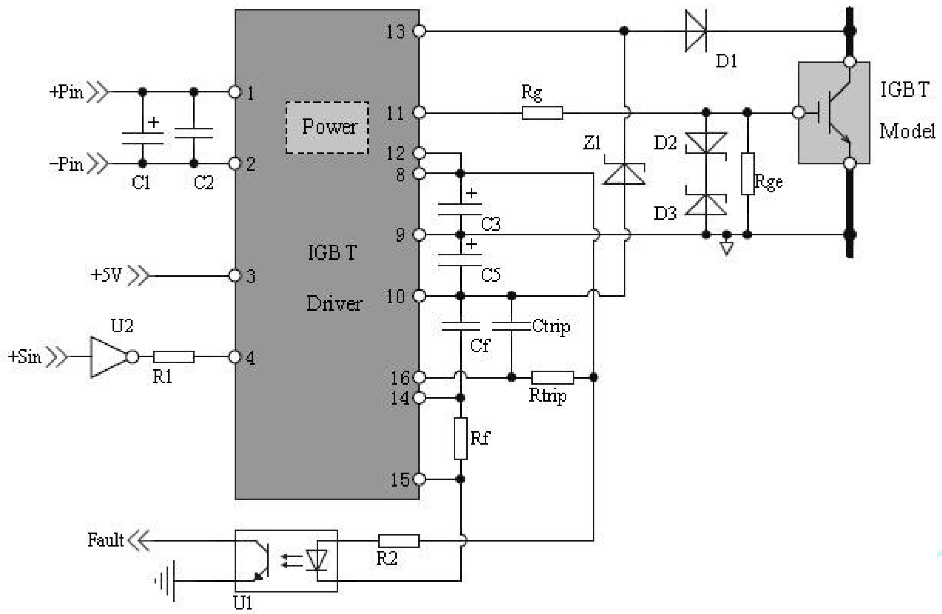

Pin-Out Details:

1: Positive power input
2: Negative power input
3: Positive signal input
4: Negative signal input
8: Positive output of isolated power
9: COM of isolated power
10: Negative output of isolated power
11: Signal output
12: Internal power collector
13: Fault detection of over-current or short-circuit
14: Soft turn-off time
15: Fault signal output
16: Short-circuit detection time

Diagram 7: Application of built-in DC/DC Converter IGBT Driver-QP Series

Above QP series (QP12W08KS-37) integrates built-in DC/DC Converter, which is the required power supply for IGBT gate, offering dual outputs of positive and negative, easier to use.

2.2 Input Signal of the IGBT Driver

There exists a high-speed opto-coupler LED and a resistor in series at the terminals of IGBT signal input. Its input impedance please refer to datasheet.

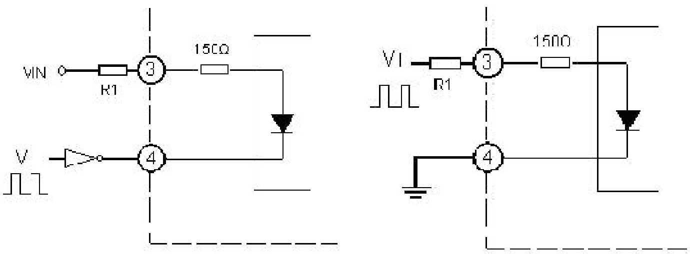

Diagram 8: Input method of IGBT driver

Take QP12W05S37 as an example, according to above left diagram and datasheet, the input current I_{in} ranges from 10mA to 20mA when IGBT powers on (typical value: 16mA). So the R1 should be appropriately adopted to make input current close to 16mA when designed.

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$$R1 = \frac{V_{cc} - U_{ce} - V_L}{I_{in}} - R_{in} \approx \frac{5 - 1.7 - 0.1}{16mA} - 150 = 50\Omega$$

I_{in}: Input current. It depends on users' design and should be within 10-20 mA

U_{ce}: Voltage drop of IGBT driver's internal opto-coupler (1.7V)

R_{in}: Internal resistance of IGBT driver (150Ω)

Vcc: high level voltage. It depends on users' design.

V_L: low level voltage. It depends on users' design.

If supply voltage VCC is 5V, then R1 should be 51Ω in 0603 packaged.
If IGBT powers off, U2 should be high-level output without current between input signal terminals.
Attention: When selecting U2, a component with open-collector outputs is not recommended. Otherwise, pin 4 will have high resistance and a poor performance of resisting common mode interference.

2.3 Values of IGBT Gate Resistance

Limitation 1: Maximum Output Current of IGBT Driver

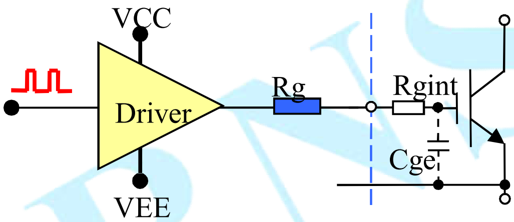

Diagram 9: Typical circuit driven by IGBT gate

In general, IGBT driver has a rated maximum output peak current and the output current of IGBT driver equals to IGBT gate current. But practically, peak current does not completely depend on the driver but also the gate resistance Rg and the gate capacitance Cg, etc. The peak current signifies the driver's signal amplifying ability and its limited gate peak current.
Therefore, the driver's output peak current should be within the limited range when designing the driver's external circuit. Ideally, the formula of gate peak current is:

I_{peak}: IGBT gate peak current

V_{cc}: positive power of IGBT driver

V_{ee}: negative power of IGBT driver

R_g: gate resistance

R_{gint}: IGBT's gate inner resistance. For more details please refer to datasheet.

$$I_{peak} \le \frac{V_{CC} - V_{EE}}{R_g + R_{g\,\mathrm{int}}} \le 5A$$

Normally, calculation errors will appear when the driver's output waveform is not sharply fluctuating (rise time

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within 1 μ s). But for MORNSUN products, if IGBT gate signals are not fluctuating, the gate resistance calculated by formula can be reduced to 50%. Also, the actual value of gate peak current can be confirmed only by measurement.

In any case, the gate current should be no higher than its rated value and the gate resistance should be within the limited range.

Limitation 2: Avoiding Oscillation Phenomenon of IGBT Gate

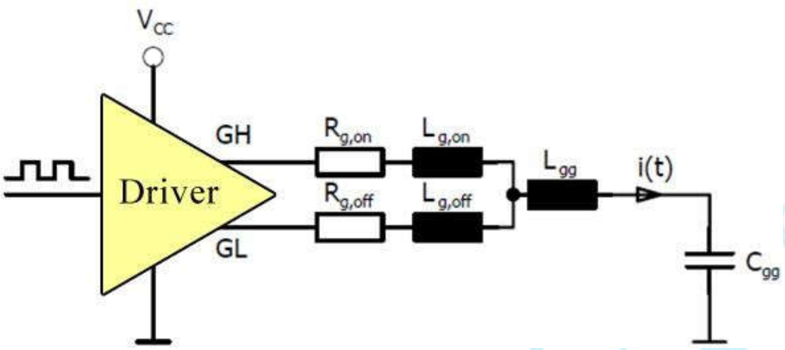

Diagram 10: Typical IGBT Gate Drive Model

Actually, stray inductance of loop circuits may affect signals. To simplify the analysis as above diagram, supposing $R'g=R_{gon}=R_{goff}$ and $L'_g=L_{gg}+L_{gon}=L_{gg}+L_{goff}$, the loop equals to the famous RLC second order circuit whose formula is as below:

$$L'_g \times \frac{d^2 i(t)}{dt} + R'_g \frac{di(t)}{dt} + \frac{i(t)}{C_{gg}} = 0$$

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To avoid oscillation, it should be ensured that RLC second order circuit response appears over-damped.

$$R'_g = R_g + R_{g\ int} > 2\sqrt{L_g / C_{gg}}$$

According to above two limitations, the gate resistance should be within the limited range. And after the value of R_g is confirmed, the two limiting conditions should be tested and verified.

■ Gate Resistance Value

Generally speaking, the driver's output peak current will increase if R_g decreases and the switching noise increases accordingly. Then the switching loss will decrease when the speed of power-on and power-off increase, and vice verse. Therefore, users can firstly select the gate resistance as following table and fine tune it in practical applications. Please remember that the actual gate resistance should be confirmed by measure.

Table 1: Recommended values for IGBT gate resistor

IGBT Rated Current (A)	50	100	200	300	600
Recommended R_g (Ω)	10-20	5.6-10	3.9-7.5	3-5.6	2-3Ω

■ Gate Resistor Power

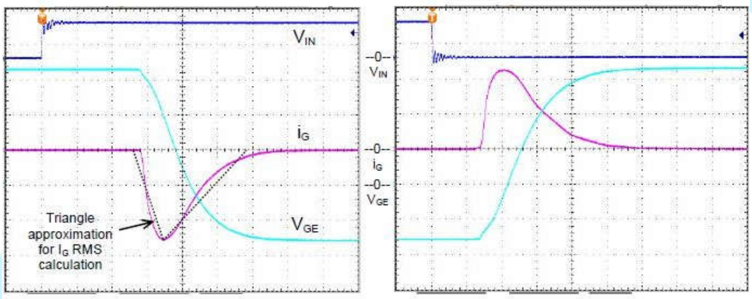

Diagram 11: Gate resistor current wave

After the gate resistance confirmed, the package is determined by power. As above diagram, current waveform of gate resistor resembles a discontinuous triangular wave. And the waves of charging and discharging look the same in opposite directions. Assuming that duty ratio of IGBT signal is 0.5, peak current I_{peak} and duration of pulse t_p, then the formulas of gate current valid value and gate resistor power are as below:

$$i_{g(RMS)} = i_{peak}\sqrt{\frac{2 \times t_p \times f}{3}}\ ,\quad P = \frac{2}{3} \times i^2_{peak} \times t_p \times f \times R_g$$

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Notes:

$i_{g(RMS)}$: Gate current valid value

I_{peak}: IGBT gate drive peak current, measured by test

T_p: Duration of pulse, measured by test

f: IGBT switching frequency

Rg: Gate resistance

2.4 Output Power of IGBT Driver

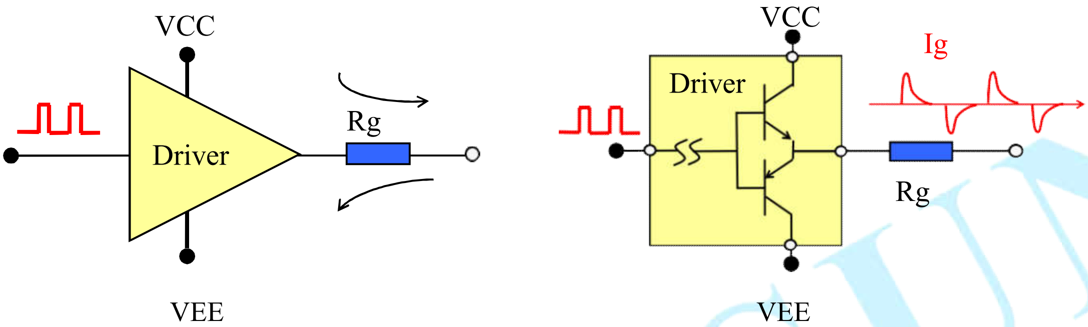

Diagram 12: Characteristics of IGBT driver output terminal

■ **Instantaneous Power (Current)**

Output terminal of IGBT driver is linked with a totem-pole amplifying circuit. And its current Ig is usually pulsating as the above typical wave because the object it drives is equivalent to capacitive load.

The maximum output current of IGBT driver depends on the degree of totem-pole amplifying circuit's tolerance. For an IGBT driver, Ig should be within the limited range; otherwise, the driver will be damaged.

Generally speaking, for an IGBT driver with a large input capacitance, the higher requirements for drive capability are, the greater endurance ability of instantaneous current should be. MORNSUN has developed two types of IGBT drivers with endurance ability of instantaneous current ±5A and ±8A respectively.

■ **Average Output Power (Current)**

IGBT driver's average output power is the basis of its requested power supply and can be calculated by the following formula:

$$I_g = Q_g \times f$$

$$P_g = (V_{CC} - V_{EE}) \times I_g$$

I_g: IGBT's average gate current

V_{CC}: Positive power to IGBT driver

V_{EE}: Negative power to IGBT driver

Q_g: Gate charge (For more details please refer to IGBT datasheet). It should be converted into actual driving voltage amplitude

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f: Switching frequency of the driver signal

No matter whether it is a built-in DC/DC converter driver or not, both the positive and negative sides of the IGBT gate power supply are capable of outputting the calculated average gate current Ig.

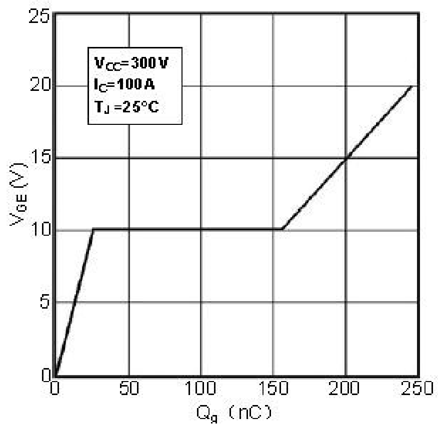

Diagram 13: Example of IGBT gate C/V changes

Above IGBT module has 200nC charge when powered by a 0V-15V power module. According to IGBT characteristics, there exists no Miller Effect in the range of below 0V. Therefore its slope should appropriately be equal to 0V-10V.

In conclusion:

0V-15V: IGBT gate charge is 200nC

-10V-0V: IGBT charge is 25nC.

-10V/+15V voltage swing and 20KHz switching frequency: Average output current of IGBT gate is 4.5mA. In these conditions, the driving power consumption of IGBT is 0.1125W.

2.5 Selection Guide of Output Capacitor

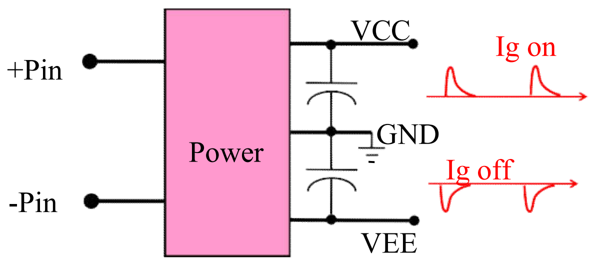

Diagram 14: Load condition of power supply for IGBT driver

With IGBT driver's pulsating load, the instantaneous current is so high that it generates ripple in the output voltage, which will be added to gate drive signals and cause distortion. The smaller ripple is, the higher SNR (Signal to Noise Ratio) of drive signal will be. It is recommended that a paralleled electrolytic capacitor respectively connected to positive and negative power so as to ensure the stability of voltage. Some recommendations are as below:

Brands: Rubycon; ZLH Series, 10μF/35V, 220μF/35V, 150μF/25V, 330μF/25V

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Requirements for electrolytic capacitor: capacitance, ESR, Maximum ripple current

■ Capacitance and ESR

IGBT driver's output ripple is related to output capacitance and ESR. Lower power supply ripple output (peak voltage less than 200mV) can only be achieved by:

$$C \geq C_{\min} = \frac{i_g \times dt}{du} = \frac{Q}{\Delta U} \quad ; \quad R_c \leq R_{c\max} = \frac{\Delta U}{I_{g\_peak}}$$

Take IGBT with gate charge and discharge capacity of 2.5μC as an example, in the worst situation the current will reach±5A when gate voltage is +15/-10V. To ensure that power supply ripple is less than 200mV, equivalent capacity should be at least 12.5μF and ESR should be no more than 40mΩ. But above formulas just take ripple into consideration caused by pulsating load, other factors can also lead to voltage ripple's increasing and should be taken into consideration.

Generally, the capacity of ceramic capacitor is difficult to reach tens of μF, so usually aluminum electrolytic capacitor is recommended. However, the ESR of aluminum electrolytic capacitors will affect the ripple, so it is necessary to select an electrolytic capacitor with a suitable ESR according to actual needs.

To prevent drive distortion caused by excessive power supply ripple, after adding the parallel electrolytic capacitors are calculated, it is recommended to measure the output voltage ripple of the front-end module with the parallel electrolytic capacitors to evaluate whether the margin is sufficient.

In order to prevent the power supply module from overload work resulting in abnormalities, it is recommended that the driver drive pulse width ≤ 300us, duty cycle ≤ 2%, and electrolytic capacitor front-end module output current value MAX. ≤ 3*full load current; if the actual pulse width is small, the maximum output current of the power supply can be appropriately increased.

■ Maximum Ripple Current

High ripple current may affect the life of electrolytic capacitor. So the capacitors should be properly used as guided. According to the formula of gate resistor current, the ripple current of each electrolytic capacitor should be:

$$i_{RMS} = i_p \sqrt{\frac{t_p \times f}{3}}$$

Above values can be measured by test, but the allowable value of ripple current should be lower than the calculated.

2.6 Fault Detection and Feedback Principle

Fault herein mainly means short circuit in IGBT bridge arm. Once it happens, IGBT will be in desaturation status

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and Vce rapidly rises, which will cause more power consumption of IGBT module. To avoid it, the power should be cut off within certain seconds once short circuit happened.

The sustainable short-circuit time is limited by the energy of IGBT. The relevant rated value please refer to datasheet.

Generally speaking, if the gate voltage is 15V, it should be shut off within 10μs after desaturation to avoid damage.

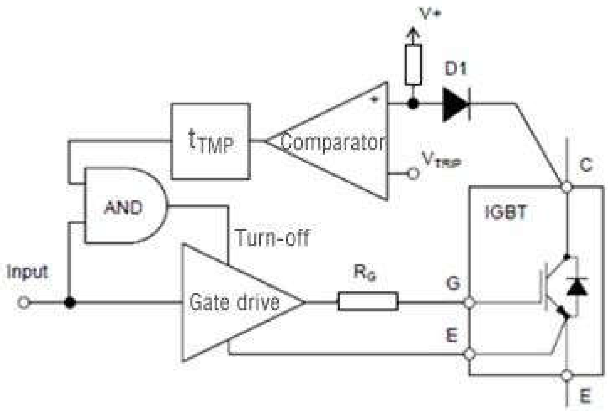

Diagram 15: Principle of fault detection and feedback

Above diagram shows the fault detection principle of built-in protection. Built-in protection responds faster than through additional controllers.

The driver detects the collector electric potential of IGBT module by fast-recovery rectifier diode. When the input signal is at high level (IGBT powers on), the diode will turn off once Vce exceeded the nominal value.

Short-circuit detection time delay: Protection won't be triggered if fault is solved during this period. Fault output pin: If the fault is not solved in the first stage, then fault output will be at low level.

Soft turn-off time: If the fault is not solved in the first stage, then the driver will lower gate voltage and makes IGBT power off.

Protection reset time: The driver will timing after the first stage is over. And the gate voltage cannot increase in certain time.

Self-recovery: The driver is detected step by step and will withdraw short-circuit protection once the fault was solved. Otherwise, the protection will be triggered again and then it continues and moves to the next state till the fault is solved.

2.7 Parameter Description in Fault State

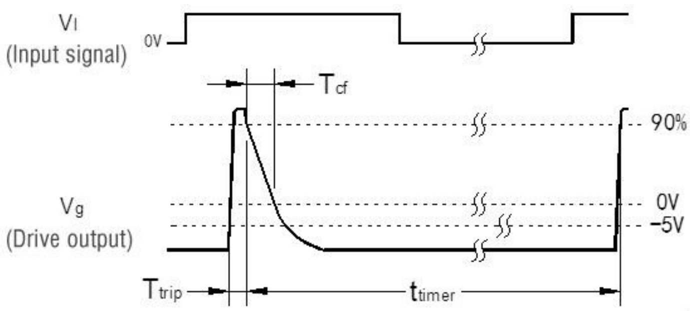

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Diagram 16: Definitions of short-circuit detection time delay, soft turn-off time and protection reset time

■ **Fault Suppression Time (blind time)**

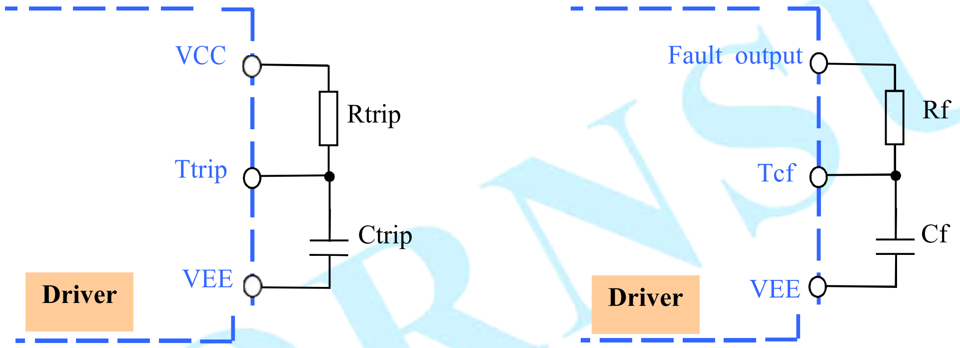
Definition: Time that IGBT gate voltage remains high level in fault condition (Ttrip)

Function: If Vce isn't down in time at the beginning of IGBT powering on, it will wrongly trigger short-circuit protection. To avoid it, the driver is designed with pins to adjust the time by users. Adjusting method can be found as below or refer to datasheet.

■ **Soft Turn-off Time**

Definition: Time that IGBT gate voltage powers off down to 0V in fault condition (Tcf)

Function: Once short circuit happened, if IGBT turn off too fast, it may cause high current surge, and voltage overshoot in collector. However, soft turn-off protection helps IGBT slowly lower gate voltage and reduce current surge efficiently. The rated time depends on users themselves only if it was within adjustable and available ranges, especially for MORNSUN products designed with internal soft turn-off time.



a. Adjusting method of Fault suppression time

b. Adjusting method of Soft turn-off time

Diagram 17: Adjusting method of fault suppression time and soft turn-off time

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To meet various applications, MORNSUN IGBT drivers are designed with adjustable fault suppression time and soft turn-off time. Above diagram illustrates a typical product QP12W08KS-37 adjusting method. In fact, different products have different methods. For more details please refer to datasheet.

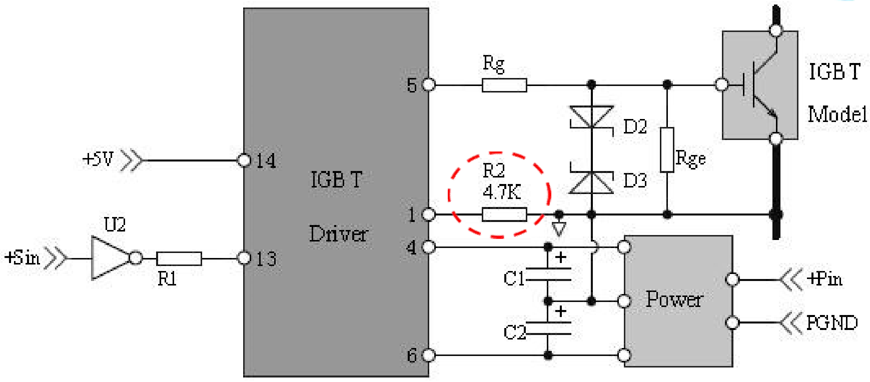
Generally, IGBT module can endure short-circuited fault within 10μs but the final solution should meet the formula Ttrip + Tcf ≤ 10μs and refer to the measured value.

■ **Protection Reset Time**

Definition: Time that since IGBT gate voltage powers off to the next reset in fault condition. (Ttimer)

Function: After solving the fault, IGBT self-recovers to normal operation without resetting. The rated value please refer to datasheet.

2.8 Methods of Invalidating Protections



Pin-Out Details:

1: Fault input (useless)	6: Negative power input
4: Positive power input	13: Negative drive signal input
5: Drive signal output	14: Positive drive signal input

Diagram 18: Method of Invalidating Protection for QC series

When will protections need to be invalidated?

1) Checking and revising the system, especially when separating drive circuit from main circuit.

2) Users think that there is no needs of using IGBT short-circuit protection. They have estimated it at the start of designing the system.

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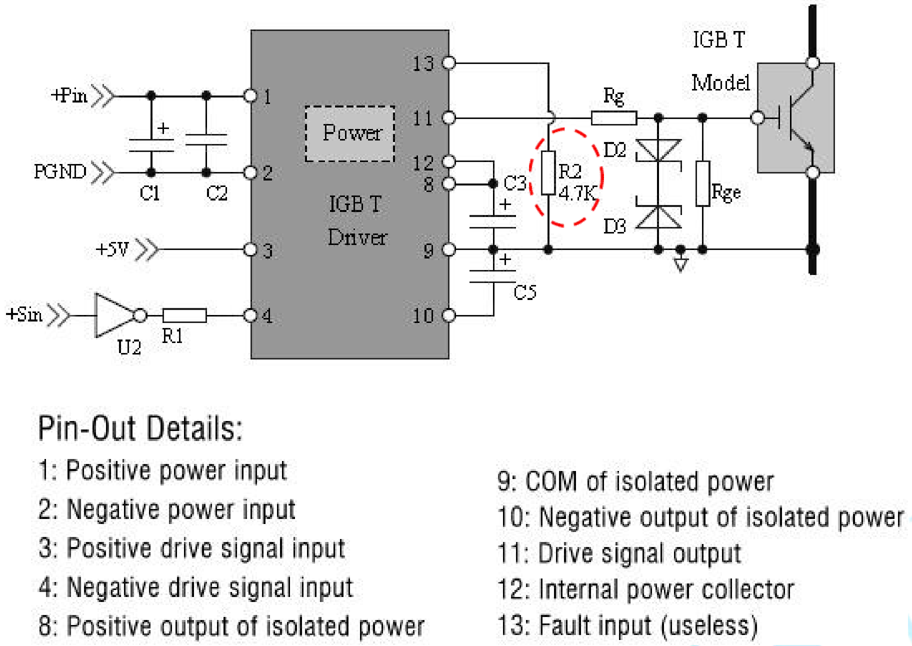

Diagram 19: Method of Invalidating Protection for QP series

Connecting IGBT driver's fault detection pin by a 4.7kΩ resistor with IGBT emitter, the pin voltage will be lower down to its rated value and the protection will be invalidated.

If IGBT driver is designed with no protections, then it can be simplified and all parameters mentioned above will not be needed. But please remember to dangle the relevant pins of driver.

3 Special Notes

3.1 Notes for Triggering Under-voltage Protections When Powering On

When the drive voltage cannot meet the requirements of IGBT saturated conductivity, if the IGBT turns on at this time, the IGBT may be damaged. Therefore, when the power supply system is abnormal and the supply voltage is insufficient, or during the establishment of the power supply voltage, the output of the IGBT driver will be locked to a low level to prevent IGBT start-up. In other words, when voltage is normal, IGBT's low level lock will be released and turn on the IGBT.

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3.2 Method of Estimating and Examining IGBT Performance

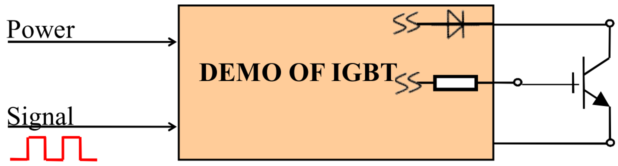

Diagram 20: Principle of MORNSUN DEMO board and its terminals

It is recommended to estimate IGBT performance and test as Fig. 6 and Fig.7. Including gate resistor Rg, fault detection port, etc. Firstly collecting external devices as above diagram such as power supply, signal generator and IGBT module, then measuring main voltages by oscilloscope and lastly comparing the differences between measured values and rated values, the overall assessment is done and over.

In addition, some DEMO boards connect the driver and the driver plate by clamping so as to facilitate the replacement of different products or detect whether the driver is of high quality or not. Test sequences are recommended as follow:

1) To Test whether power supply for the driver works normally or not (optional)

For built-in power-type driver (QP Series), testing performance of power comes first, including power input nominal value and power output voltage whether within the limited range. But it is not suitable for non-built-in power-type driver.

2) To test whether signal amplification function works normally or not

Set the nominal value of power input and its driver waveform at the input terminal. Then compare waveform of the input signal and the output signal before the gate resistor. Next, test the time of signal rising delay & falling delay and output rising & falling time. Lastly, check the results with datasheet.

3) To test whether protection functions work normally or not

First disconnect IGBT collector and DEMO board, and then set the nominal value of power input and its driver waveform at the input terminal. Next, test short-circuit detection time delay, soft turn-off time and protection reset time. Lastly, check the results with datasheet.

3.3 Avoiding Wrongly Triggering the Protection Functions

Protection functions of MORNSUN QP and QC series IGBT driver are mainly achieved by detecting under-saturated pressure drop of IGBT. So more attention should be paid to IGBT start-up time particularly in high-power applications to reduce the interference in the switching process which is harmful to the driver. The following reasons are for your reference:

■ **Disordered IGBT Start-up Setting**

Normal start-up order: short-circuit detection time delay> Gate Rising Time + IGBT start-up time

Above is necessary to avoid wrongly triggering the protection functions. Generally, IGBT start-up time is a specific rated parameter. To achieve the goal, it’s recommended to reduce the gate signal rising time (mainly

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reducing the gate resistance) or extend short-circuit detection time delay.

■ **IGBT Switching Noise**

Oscillation of the collector affects fault detection of the driver when IGBT powers on. Because it may wrongly trigger the protection functions caused by the signal transient value (which actually is superposed with certain switching noise) reaching to the protection threshold voltage. Suppressing the switching noise will be the best solution to it. Unfortunately, for the whole system, the cost will be increased and the efficiency will be reduced. Therefore, extending short-circuit detection time delay from beginning to end is recommended.

Early in the design, users can adjust the short-circuit detection time delay, and preset a longer time such as 5~6μS without damaging IGBT, then optimize it by test after the system normally operates.

3.4 Avoiding Wrongly Triggering IGBT during Body Diode's Reverse Recovery

The following diagram shows the principle of wrongly triggering IGBT when dv/dt occurs. IGBT2 switches into off and negative IGBT2 gate voltage increases.

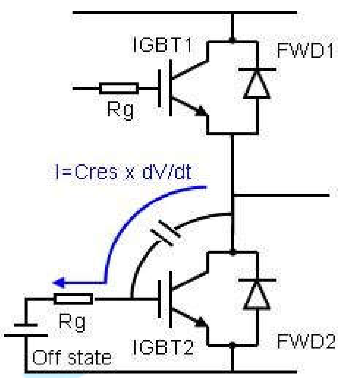

Diagram 21: Principle of wrongly triggering IGBT

Body diode of IGBT2 is in reverse recovery status and its voltage increases. This change is recorded as dv/dt. So the current I is C_{res} (reverse transfer capacitance of IGBT) multiplied by dv/dt, which makes gate voltage increase through the gate resistance Rg. Once the gate voltage exceeds the total value of negative IGBT2 gate voltage and threshold voltage, wrongly triggering IGBT2 will occur and the two IGBT short-circuit.

Based on it, it's recommended to:

Design a parallel capacitor between gate and emitter (recommended value: < 0.1× Cge)

increase gate resistance (switch off)

Increase negative gate voltage amplitude

Above methods should be firstly confirmed according to actual requirements. Please note that they have effects on switch loss and drive loss.

4 Precautions

1) Internal DC/DC isolated power supply for QP series can be only used for driving itself, not as external power source.

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2) The wire connecting the driver and IGBT gate as well as emitter should be no longer than 1m.
3) The wire connecting the driver and IGBT gate as well as emitter should be twisted-pair.
4) Appropriate gate resistance can be increased to reduce IGBT high voltage peak in collector when switching off.
5) Setting different gate resistance values is available for IGBT powering on and off.
6) External capacitor or resistor should be close to the driver if adjusting soft turn-off time and blind time is necessary. At the same time, the selected values should be within the recommended ranges.
7) It's recommended to select electrolytic capacitors with low ESR as filter capacitor and place near to the driver.
8) The withstand voltage of FRD D1 which connects fault detecting pins and IGBT collector should be higher than peak voltage of the collector when switching off the IGBT. Also, more diodes in parallel is available.
9) When testing the module alone, if not properly used fault detection pins, will cause the driver to enter a false-action protection state, then it is recommended that the function of the fault detection pins first mask, see Figure 2.8 above for details.

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