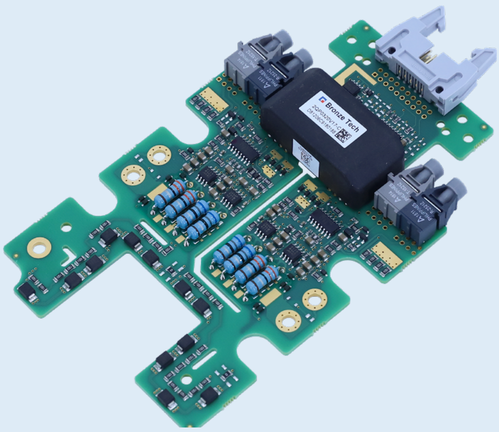
2QP0320Vxx

Description & Application Manual

RoHS
COMPLIANT



The photo is for reference only.

Description

2QP0320Vxx is a medium power, dual-channel Plug-and-Play gate driver designed for high reliability applications based on the ASIC chipset developed by Bronze Technologies.
2QP0320Vxx is suitable for half-bridge topology built with PrimePack™ package IGBT modules up to 1700V. The plug-and-play capability of the driver allows immediate operation without adaptions after assembly.

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Nomenclature

2 QP 03 20 V xx xx – C

- Number of Channels: 2: dual-channel
- Product Family: QP: plug-and-play
- Output power per channel: 03: 3W
- Peak output current: 20: ±20A
- Insulation technology: V: Fiber optic link
- Voltage Class: 12: 1200V; 17: 1700V
- Options: A0: No pull-up for SO
- Compatibility: C: Pin compatible

Block Diagram Of Driver Board

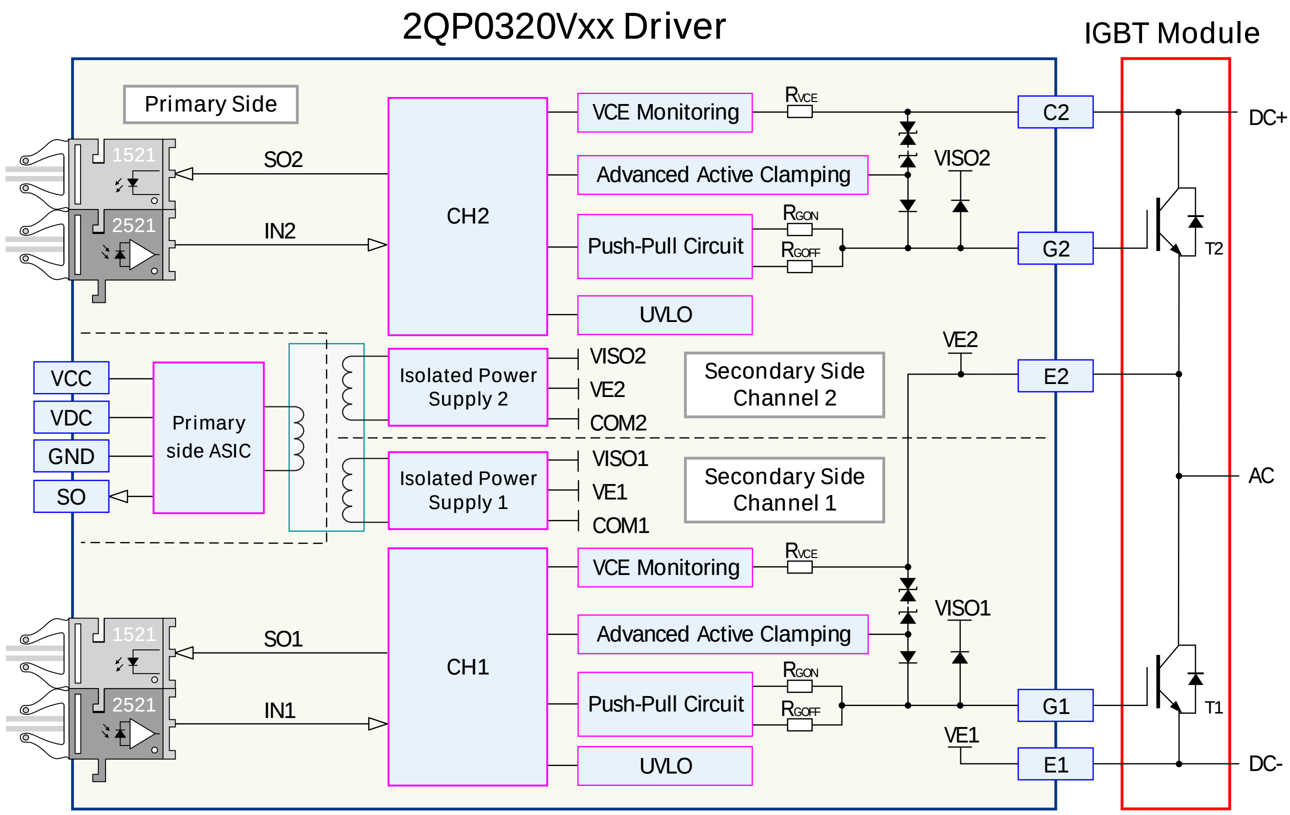

Figure 1. Block diagram of 2QP0320Vxx

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Recommended Interface Circuitry for Connector P1

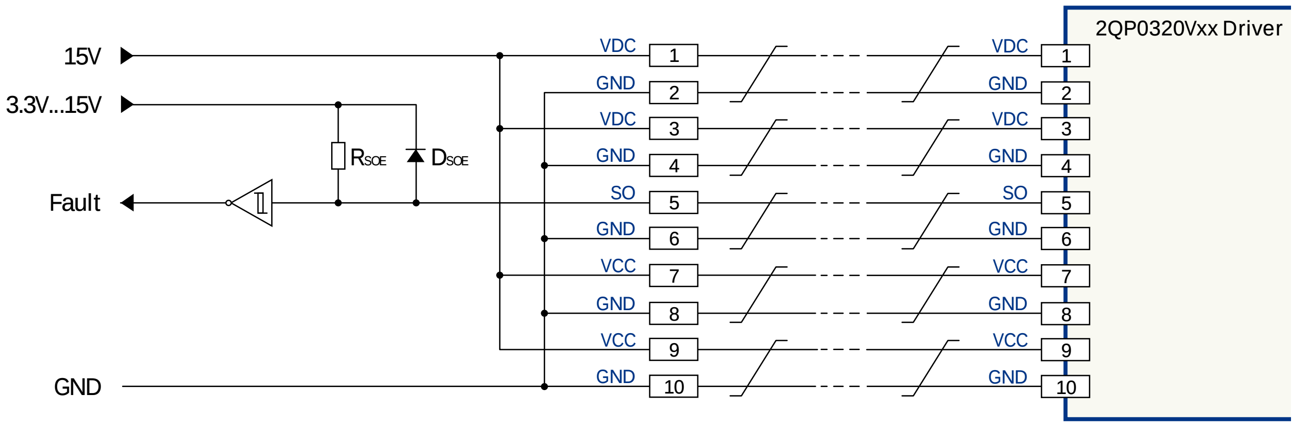

Figure 2. Recommended user interface of 2QP0320VxxA0

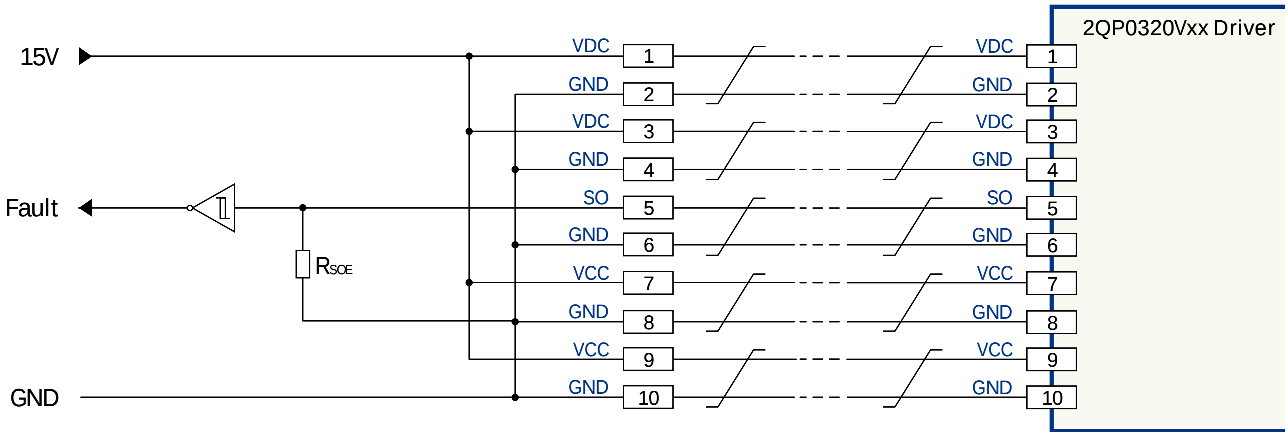

Figure 3. Recommended user interface of 2QP0320VxxC0

Direct Mode

MOD pin	IN		OUT	
	IN1	IN2	Gate1	Gate2
Left open or connected to VCC	1	1	1	1
	0	1	0	1
	1	0	1	0
	0	0	0	0

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Pin Designation

Connector P1[1)]

Pin	Symbol	Description	Pin	Symbol	Description
1	VDC	15V for DC/DC converter	2	GND	Ground
3	VDC	15V for DC/DC converter	4	GND	Ground
5	SO	Status output (power supply)	6	GND	Ground
7	VCC	15V for primary side electronics	8	GND	Ground
9	VCC	15V for primary side electronics	10	GND	Ground

Note: 1) 20-pin shrouded connector with eject hooks is default configuration.
It is recommended to use the flat cable connector 71600-020LF from FCL.

Fiber Optic Interface

Pin	Symbol	Description	Pin	Symbol	Description
1	IN1	Signal input channel 1	3	IN2	Signal input channel 2
2	SO1	Status output channel 1	4	SO2	Status output channel 2

Note: 1) PWM input, receiver type is: HFBR-2521Z from Broadcom.
2) Status output, transceiver type is: HFBR-1521Z from Broadcom.

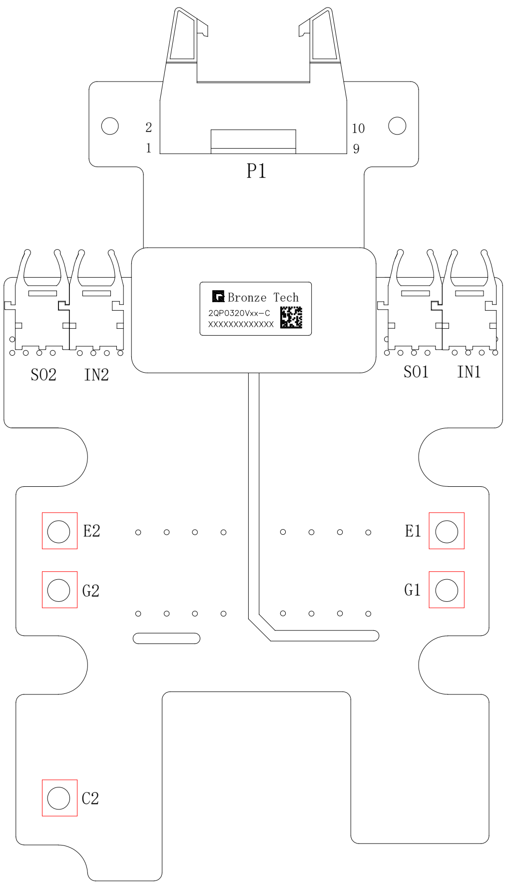

Figure 4. 2QP0320Vxx Pin layout

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Function Description

Power Supply and Monitoring

The DC/DC converter of the driver provides galvanic isolation between primary side power supply and secondary side gate driving circuitry.

Supply voltage monitoring is deployed for the primary-side and two secondary-sides of the DC/DC converter for undervoltage lockout (UVLO).

Note: A stable primary side supply voltage is required.

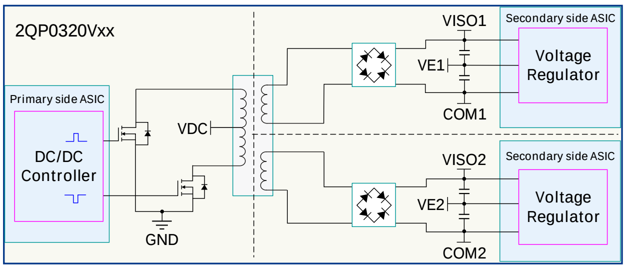

Figure 5. Power supply circuitry

Primary Side Supply Monitoring:

The supply voltage V_{CC} is monitored in the primary-side for undervoltage lockout. When V_{CC} drops to the UVLO set fault threshold V_{CCUV+}, the fault signal SO is pulled down. When V_{CC} returns to the UVLO clear fault threshold V_{CCUVR+}, the driver continues to maintain the lockout state for a period t_B, then exits the lockout state and pulls up fault signal SO.

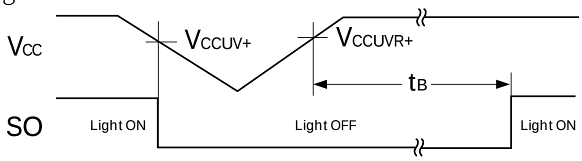

Figure 6. Primary-side UVLO logic

Secondary Side Supply Monitoring:

The secondary power supply voltage is also monitored to ensure a safe IGBT switching. To demonstrate the behavior of the secondary side UVLO, a scenario is considered in below where the primary side supply voltage V_{CC} decreases from the nominal value towards zero:

1) At first the positive voltage V+ (VISO to VE) is held constant on the nominal value, while the negative voltage V- (COM to VE) deviates from the nominal value towards zero along with the decreasing V_{CC}.

2) As soon as V- reaches -5V, V- is held constant and V+ starts to fall towards zero if V_{CC} further collapses.

3) When V+ reaches the set fault threshold V_{UV+}, UVLO protection is initiated. The IGBT is turned off and held in off state, meanwhile SOx output (light off) is asserted immediately and will recover after t_B elapses.

4) The counting of t_B starts when a UV fault is detected. This is different from the primary side supply voltage monitoring, where the counting of t_B starts after UV fault is cleared. If a new fault is detected before t_B of the previous fault elapses, t_B is recounted from the new fault.

5) When Vcc rises again, the driver firstly restores V+.

6) If V+ further increases and reaches its nominal value, V+ is held constant and V- starts to recover towards its nominal value.

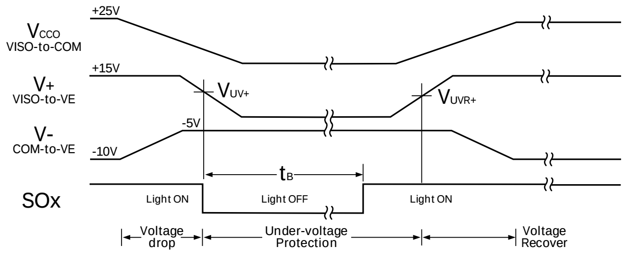

Figure 7. Secondary-side UVLO logic

Input Signal

The control signals are input via fiber optic link. The input signal threshold can be configured by the user side circuitry.

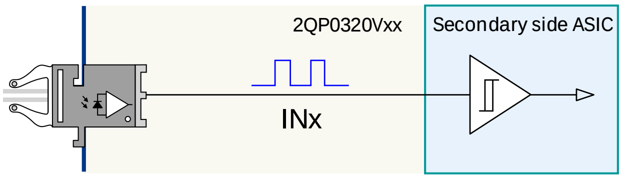

Figure 8. INx input circuitry

Transmission Logic

The driver is configured as direct mode. Input IN1 corresponds to Channel 1, while input IN2 corresponds to Channel 2. A light ON turns on the corresponding IGBT, while a light OFF turns it off.

Note: In direct mode, make sure to add a proper dead time in the input signals to avoid shoot-through of the two switches in a bridge.

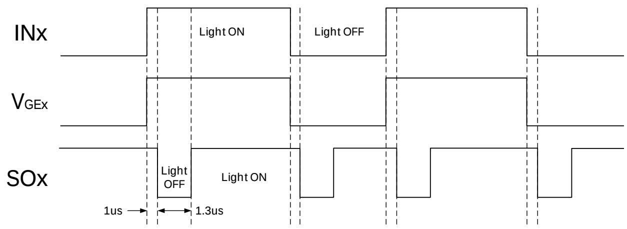

Figure 9. Transmission logic in direct mode

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Status Output Signal

Primary side SO signal:

The output SO has open-drain transistor on the driver board.

Part Number	R_{SOx1}	R_{SOx2}
2QP0320VxxA0-xx	33Ω	Unassembled
2QP0320VxxC0-xx	33Ω	10kΩ

2QP0320VxxA0-xx:

When no fault is detected, Q_{SO} keeps off, the output SO have high impedance. An internal current source pulls the SO outputs to a voltage of about 5V. When a fault is detected, SO is pulled down to ground.

It is recommended to mount external pull-up resistor as demonstrated in the diagram of recommended user interface of 2QP0320VxxA0-xx. There the diode D_{SOE} are only required when using 3.3V input logic level. For 5V⋯15V logic, it can be omitted.

In a fault condition, the maximum SO current must not exceed 20mA.

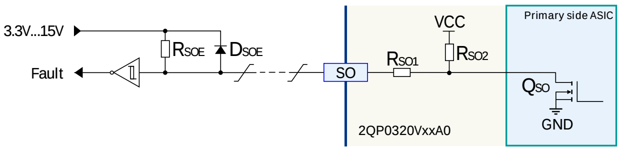

Figure 10. SOx user interface of 2QP0320VxxA0-xx

2QP0320VxxC0-xx:

When no fault is detected, Q_{SO} turns off, and SO is pulled up to VCC via an internal resistor of 10kΩ on the driver board. When a fault is detected, SO is pulled down to ground. It is recommended to mount external pull down resistors R_{SOE} to ground as demonstrated in the diagram of recommended user interface of 2QP0320VxxC0-xx, which allows a missing SO connection to be detected (safe logic in the event of a defective cable). Note that R_{SOE} must have sufficiently high resistance (e.g. 150 kΩ), as it form a voltage divider together with the internal pull-up resistor of 10kΩ on the driver board.

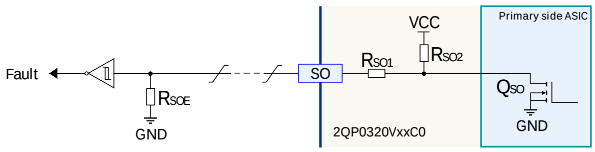

Figure 11. SOx user interface of 2QP0320VxxC0-xx

Fiber optic SOx signal:

When no fault is detected, the SOx fiber optic link light is turned on. When a fault is detected, Q_{SOx} is turned off, thus the fiber optic link light is turned off and held off for a period of t_B.

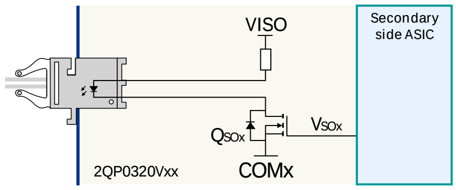

Figure 12. SOx output of 2QP0320Vxx

IGBT Turn-On and Turn-Off

To turn on the IGBT, Q_{ON} inside the ASIC of the driver is turned on and Q_{OFF} is turned off. The gate resistor R_{GON} is pulled up to charge the gate and the IGBT is turned on.

To turn off the IGBT, Q_{OFF} inside the ASIC of the driver is turned on and Q_{ON} is turned off. The gate resistor R_{GOFF} is pulled to COMx to discharge the gate and the IGBT is turned off.

To enhance the driving capability, two MOSFETs are connected in parallel to Q_{ON} and Q_{OFF}.

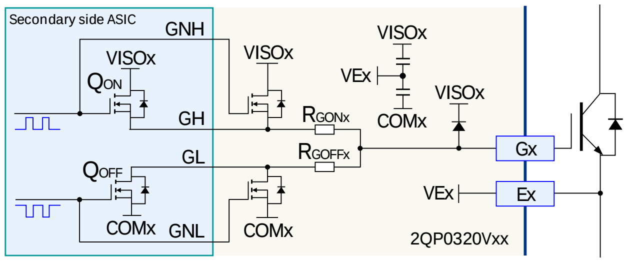

Figure 13. Gate drive output circuitry

Active Clamping

Fast IGBT turn-off may lead to voltage spikes, which is critical when DC-link voltage and load current are high. Voltage spikes can cause damage to the IGBT. The turn-off voltage spike is mainly correlated to the stray inductance L_S and the slew rate of the IGBT turn-off current di/dt. By adjusting the turn-off gate resistor R_{GOFF}, di/dt can be reduced and the voltage overshoot is reduced. However, the impact of L_S is inevitable. It can be more pronounced under high current in short circuit or overload. The driver is equipped with active clamping function to effectively prevent the overvoltage damage on IGBT.

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A feedback path from the IGBT collector to the gate is established using transient voltage suppressor devices(TVS). When the V_{CE} peak voltage exceeds the breakdown threshold, the TVS chain will break through and the current through it will charge the IGBT gate, which turns on the IGBT partially and suppresses the excessive V_{CE} of the IGBT.

Part Number	IGBT Voltage	TVS Chain Breakdown Threshold @ 25°C
2QP0320V12xx	1200V	912V
2QP0320V17xx	1700V	1320V

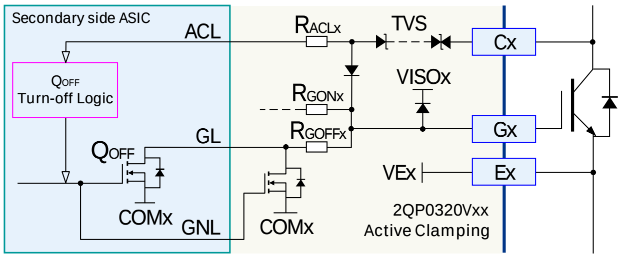

Figure 14. Active clamping circuitry

IGBT Short-Circuit Protection

The V_{CE} detection circuitry is used for IGBT short- circuit protection. The detection of two channels are independent from each other. The short-circuit detection is only valid when the IGBT is turned on. When the IGBT is in off state, the input signal turns on Q_{CEx} and clamps V_{CEDTx} to COMx. In this case, the comparator outputs logic low.

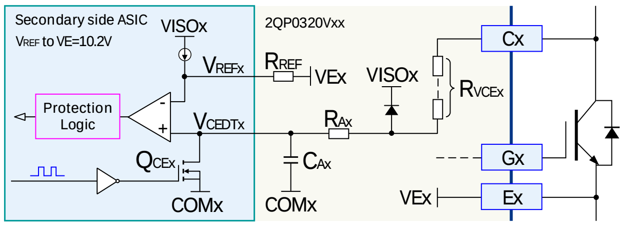

Figure 15. Short-circuit protection circuitry

Normal Turn-On:

When the logic input will turn on the IGBT, Q_{CE} is firstly turned off and releases the clamping of V_{CEDTx}. At this moment, IGBT is still in off state and V_{CE} is high. C_{Ax} capacitor is charged through the resistor chain composed of R_{VCEx} and R_{Ax}, V_{CEDTx} rises. Then the IGBT is turned on, V_{CE} quickly drops to saturation voltage $V_{CE\text{-}SAT}$ and V_{CEDTx} reaches $V_{CE\text{-}SAT}$.

As $V_{CE\text{-}SAT}$ is significantly lower than the protection threshold V_{REF}, the comparator does not flip over and the protection is not initiated.

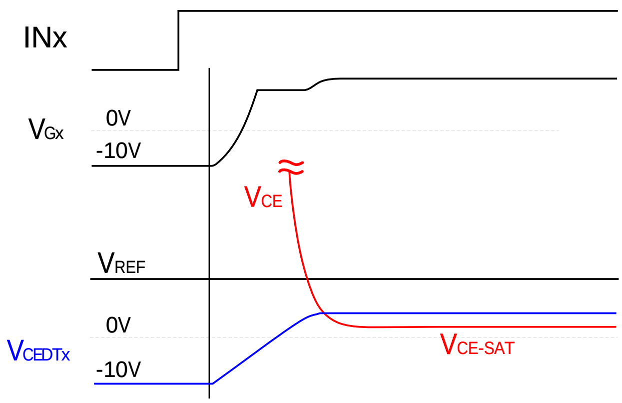

Figure 16. Signal waveform at normal turn-on

Class I Short- Circuit Protection:

When Class I short circuit (bridge shoot-through) occurs, due to the rapid increase of the short cirucit current, the IGBT desaturates and result in rapidly increased V_{CE}. C_{Ax} is charged and V_{CEDTx} rises until it is clamped at VISOx. During this process, V_{CEDTx} exceeds V_{REF} and the comparator's output flips, which consequently triggers the short-circuit protection.

The short-circuit protection logic turns off the IGBT immediately to ensure its safety. At the same time, set fault signal is sent to the primary side to light off the SOx, so as to alert a fault state. The channel is locked in fault state for a period t_B before recovering to the normal state.

The protection circuits of the two channels are independent from each other. Therefore, when short-circuit protection is initiated on one channel, the other channel remains operating normally. It is recommended to check the SOx signal timely and activate system lockout when necessary.

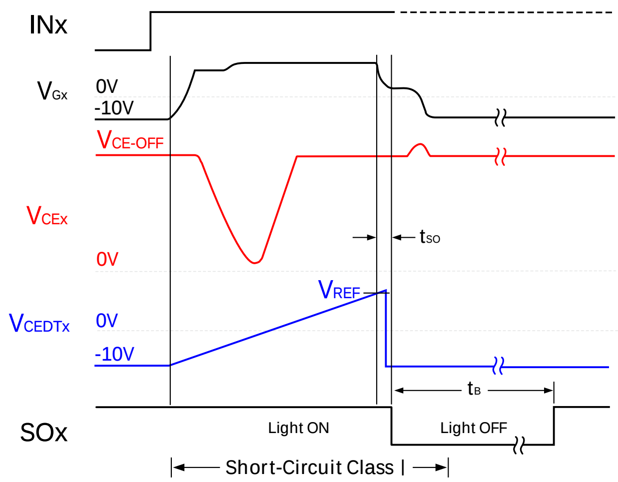

Figure 17. Class I short-circuit protection

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Class II Short-Circuit Protection:

When a Class II short circuit (e.g. phase to phase short circuit) occurs, the current ramps up slowly as the loop is relatively high. The IGBT still enters saturation state normally. As the short-circuit current increases, V_{CE} increases gradually until it exceeds the protection threshold, then the driver initiate short-circuit protection. The response time in Class II short-circuit protection is longer than that of Class I.

In another case, If bridge shoot-through occurs under low DC-link voltage, the short circuit current is low and also resulting in increased protection response time.

Note: When a Class II short circuit occurs, the short circuit impedance varies greatly, which leads to uncertain timing of IGBT desaturation. Therefore, before the protection is initiated, the IGBT may have been already damaged by a considerable sum of heat accumulated. In this case, the driver's short-circuit protection cannot guarantee the intactness of the IGBT. Extra overcurrent protection measures have to be introduced.

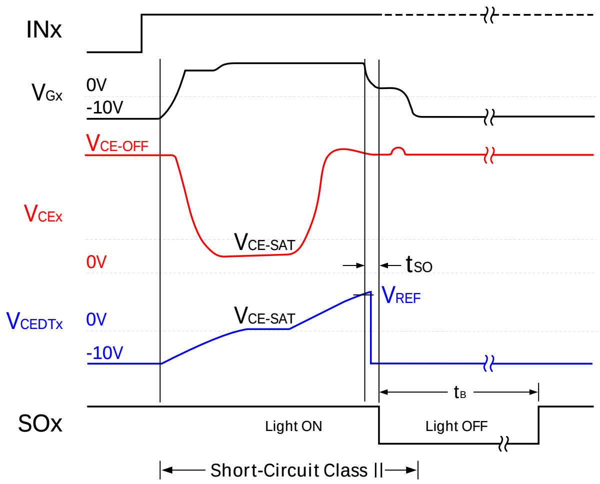

Figure 18. Class II short-circuit protection

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Mechanical Dimensions

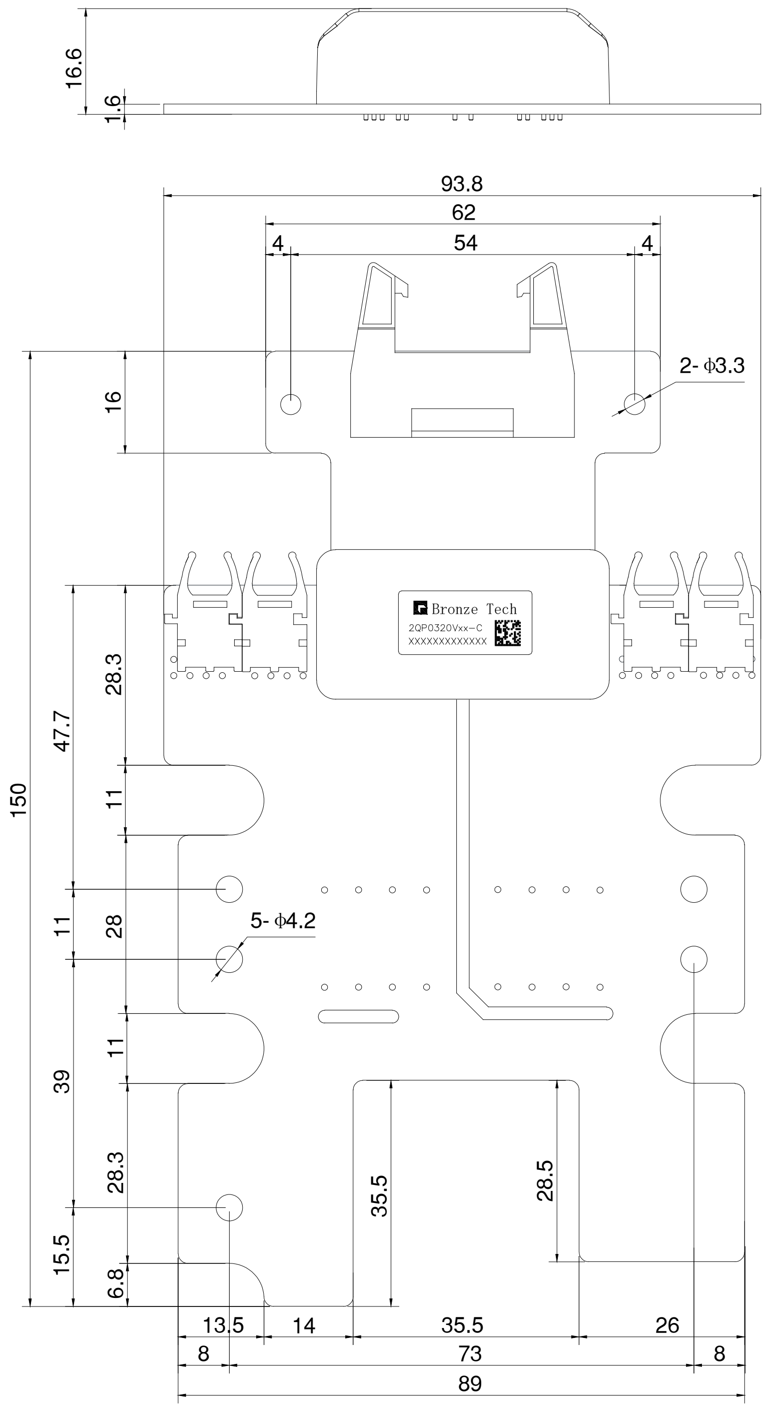

Figure 17. Mechanical drawing of 2QP0320Vxx

Note: 1)Legend unit: mm.

2)The margin tolerance conforms with the ISO 2768-1.

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Revision History

REVISION	NOTES	DATE
V1.0	Initial release	26-Dec-2023

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Precautions

- All operations on the IGBT module and driver shall conform with the electrostatic-sensitive device (ESD) protection requirements stipulated in IEC 60747-1/IX or EN100015.
- To protect ESDs, IGBT module and driver operation, including the operation sites and tools, must conform with these standards.

The IGBT and driver may be damaged due to negligence in ESD protection.

- Before powering on the driver, make sure that the driver and control board are connected correctly, without empty connection, false connection, or false soldering.
- After the driver is installed, its surface voltage to the ground may exceed the safety voltage. Therefore, do not touch it with bare hands.

Operations may involve life hazards. Be sure to follow the corresponding safety protocols !

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