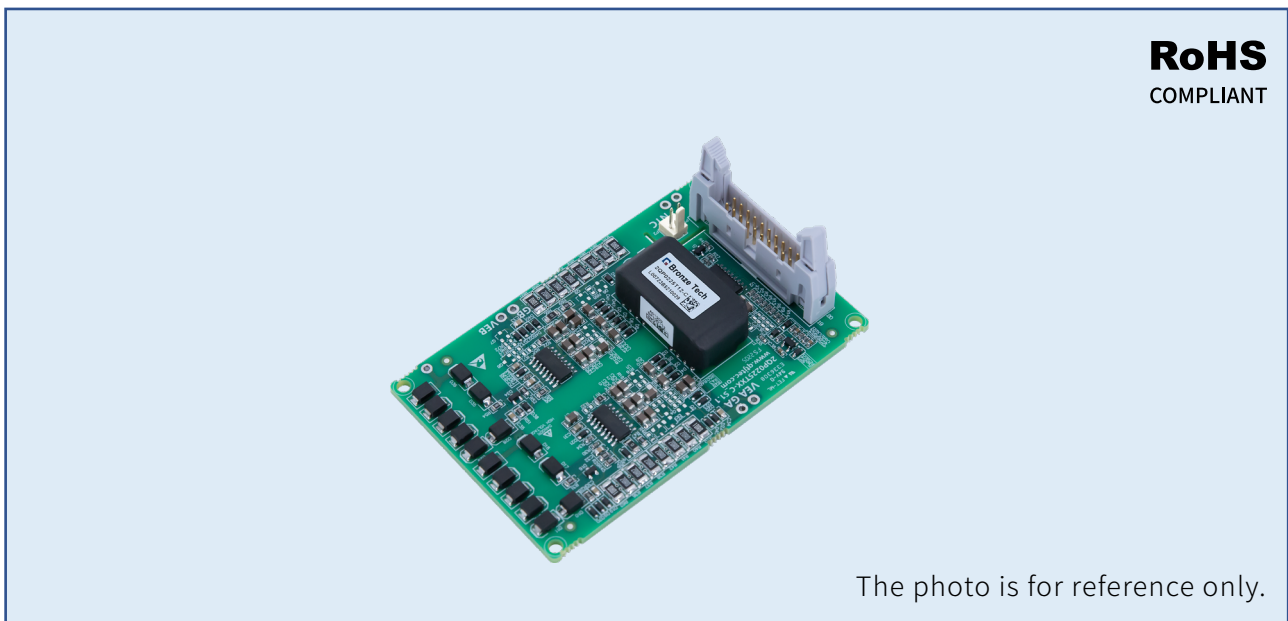


# 2QP0225Txx

## Description & Application Manual



### Description

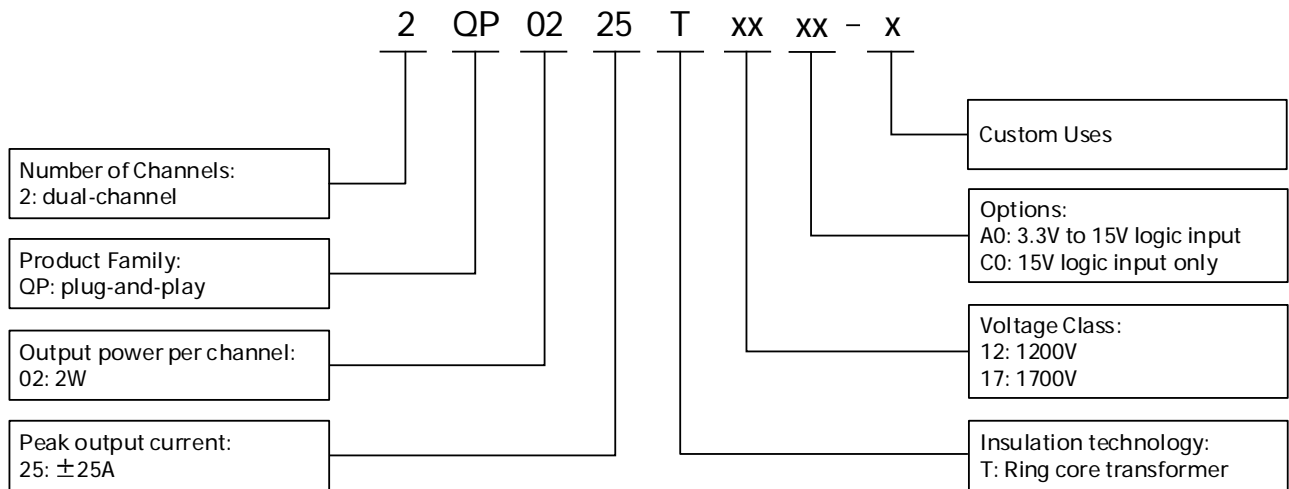
2QP0225Txx is a dual-channel compact plug-and-play gate driver designed for high reliability applications based on the ASIC chipset developed by Bronze Technologies.

2QP0225Txx is suitable for 2-level topologies built with EconoDUAL™ package IGBT modules up to 1700V. The plug-and-play capability of the driver allows immediate operation without adaptations after assembly.

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### Nomenclature



### Block Diagram Of Driver Board

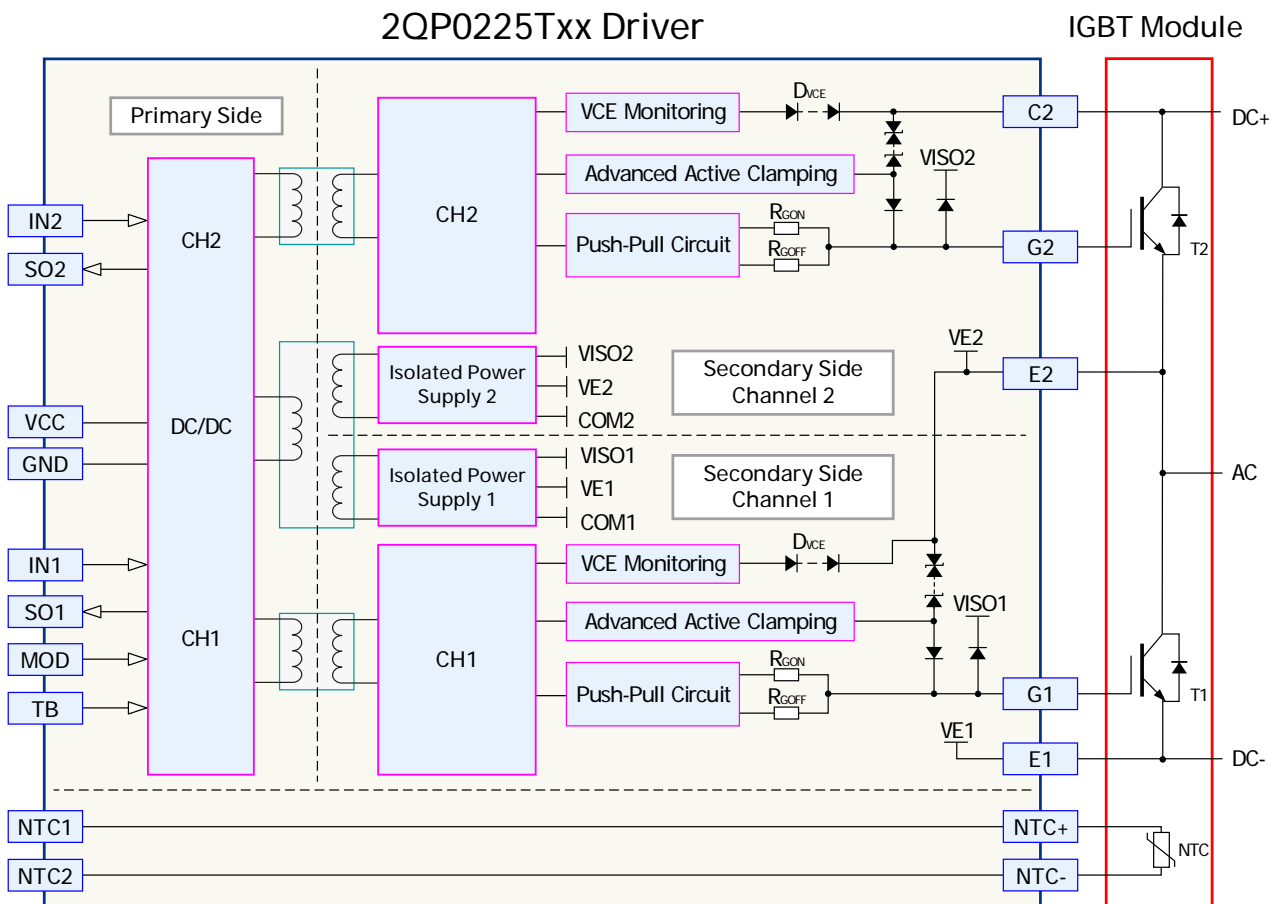


Figure 1. Block diagram of 2QP0225Txx

### Recommended Interface Circuitry for Connector P1

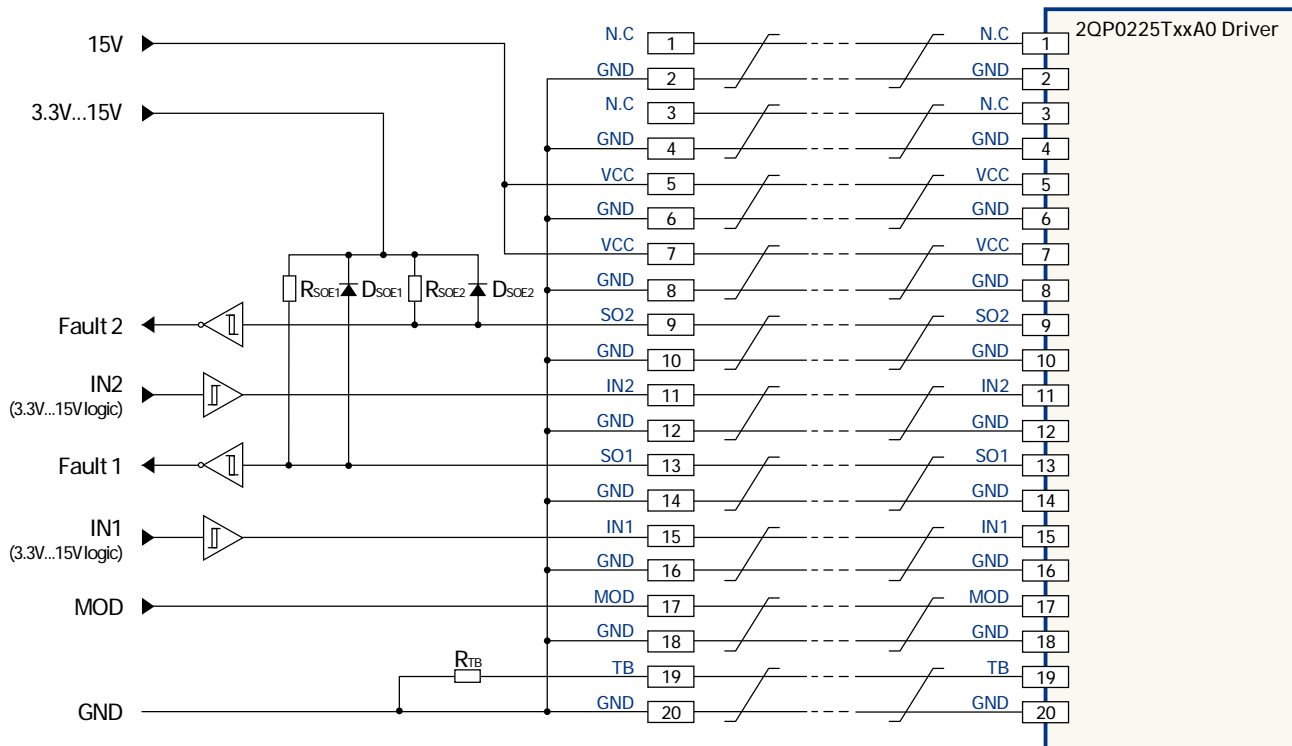


Figure 2. Recommended user interface of 2QP0225TxxA0

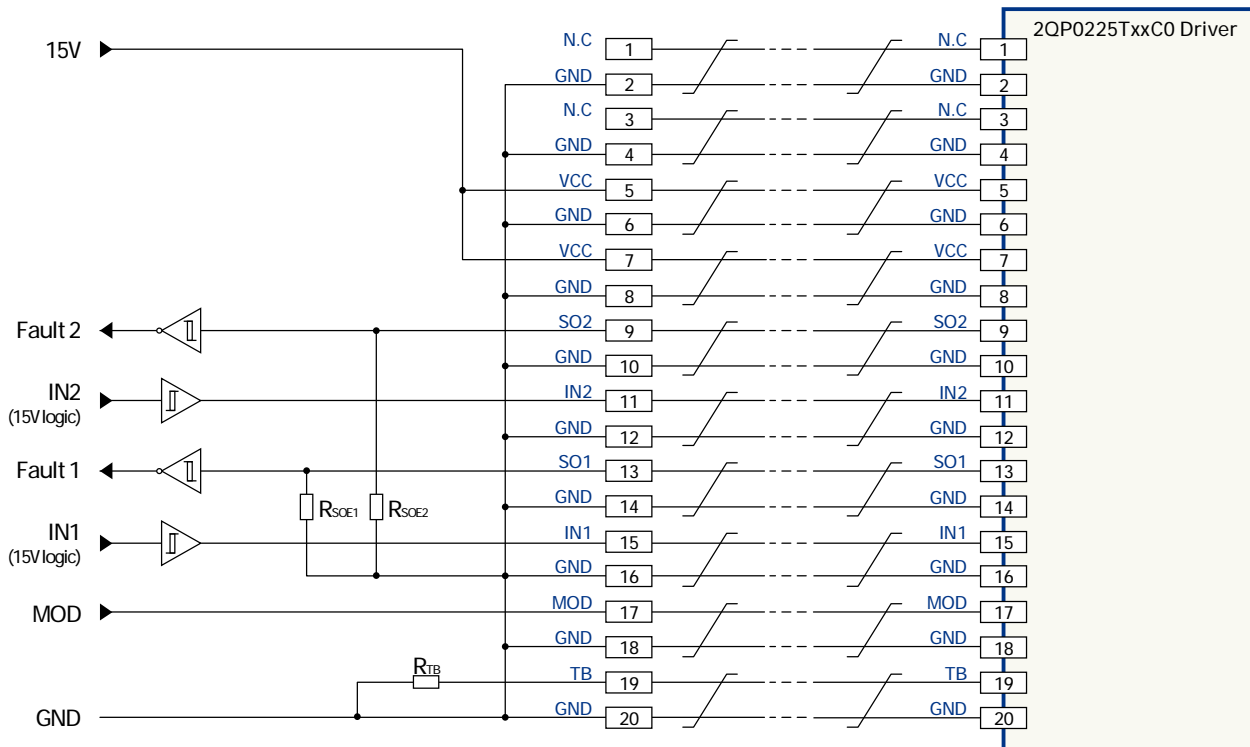


Figure 3. Recommended user interface of 2QP0225TxxC0

Direct Mode					Half-bridge Mode				
MOD pin	IN		IGBT		MOD pin	IN		IGBT	
	IN1	IN2	Gate1	Gate2		IN1	IN2	Gate1	Gate2
Left open or connected to VCC	1	1	1	1	Shorted to GND	1	1	1	0
	0	1	0	1		0	1	0	1
	1	0	1	0		1	0	0	0
	0	0	0	0		0	0	0	0

### Block Diagram With Connection to IGBT Module

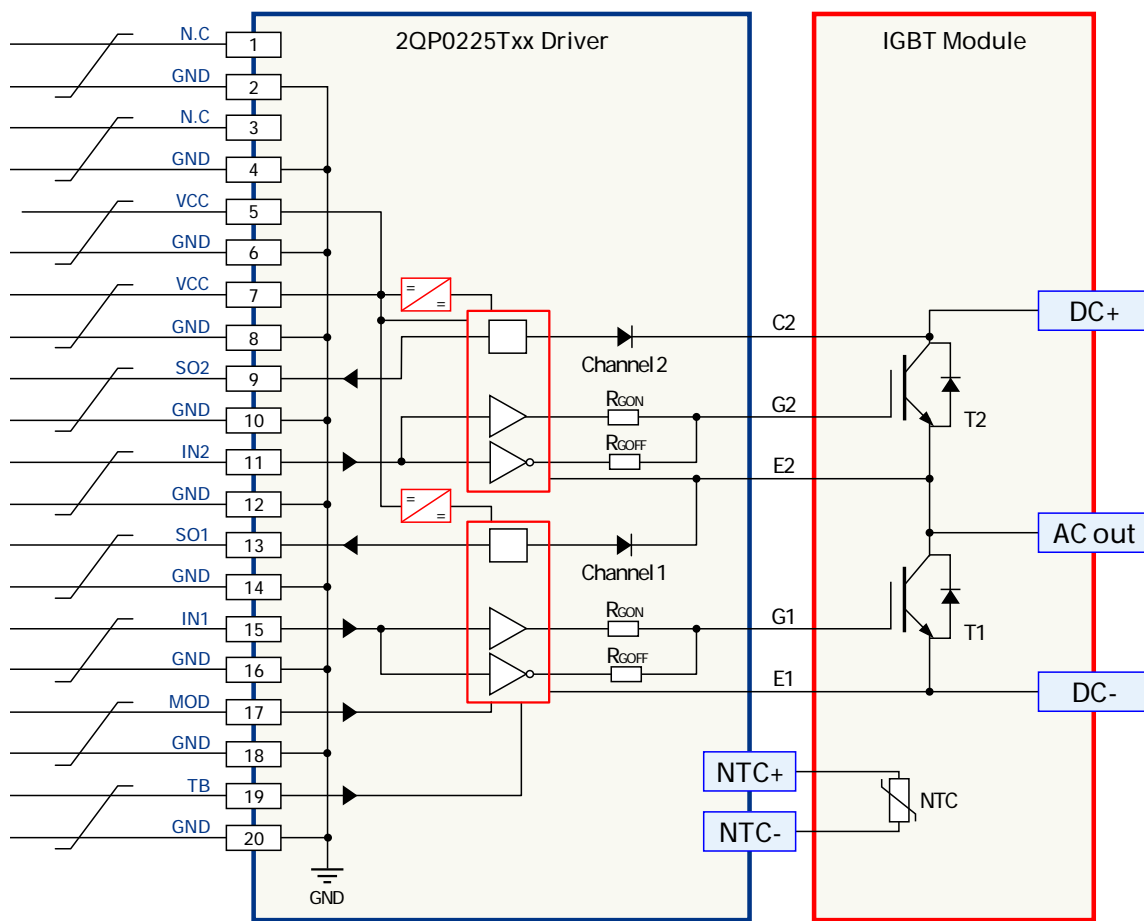


Figure 4. Block diagram covering driver 2QP0225Txx and IGBT module

## Pin Designation

### Connector P1<sup>1)</sup>

Pin	Symbol	Description	Pin	Symbol	Description
1	N.C	Not connected	2	GND	Ground
3	N.C	Not connected	4	GND	Ground
5	VCC	15V supply voltage	6	GND	Ground
7	VCC	15V supply voltage	8	GND	Ground
9	SO2	Status output channel 2	10	GND	Ground
11	IN2	Signal input channel 2	12	GND	Ground
13	SO1	Status output channel 1	14	GND	Ground
15	IN1	Signal input channel 1	16	GND	Ground
17	MOD	Mode selection (direct/half-bridge)	18	GND	Ground
19	TB	Set blocking time	20	GND	Ground

Note: 1) 20-pin shrouded socket with eject hooks is default configuration.

It is recommended to use the flat cable connector 71600-020LF from FCL.

### Connector P2

Pin	Symbol	Description
1	NTC1	Module NTC resistor terminal 1
2	NTC2	Module NTC resistor terminal 2

Note: 1) 2-pin shrouded connector with friction lock is default configuration.

It is recommended to use the connector 0022012027 from Molex.

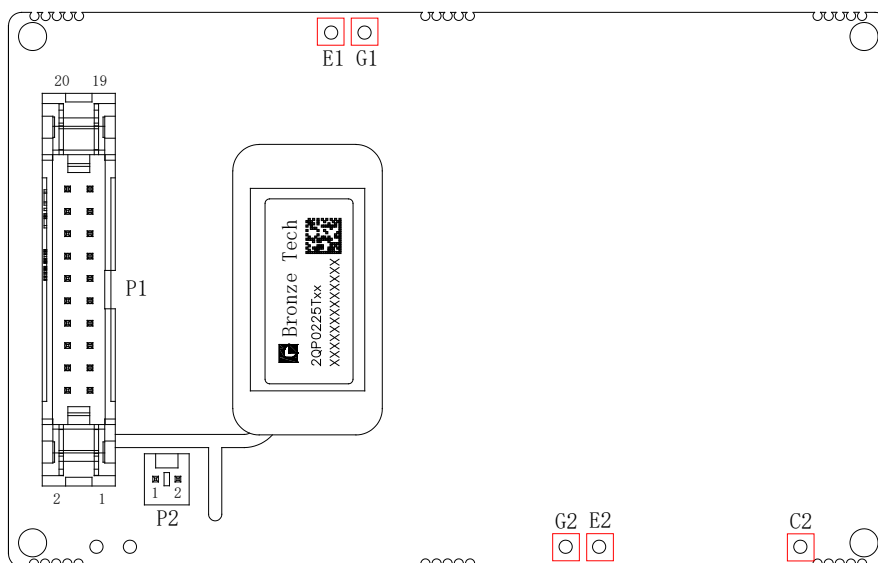


Figure 5. 2QP0225Txx Pin layout

## 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.

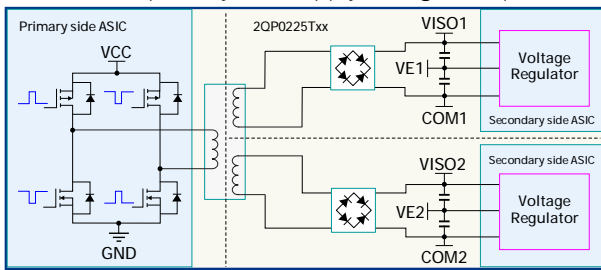


Figure 6. Power supply circuitry

### Primary Side Supply Monitoring:

The supply voltage  $V_{CC}$  is monitored on the primary-side for undervoltage lockout. When  $V_{CC}$  drops to the UVLO set fault threshold  $V_{CCUV+}$ , UVLO is triggered, two secondary-side gate drive outputs are locked in off state and keep the IGBT off. Meanwhile, the fault signal  $SO1$  and  $SO2$  are 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 signals  $SOx$ .

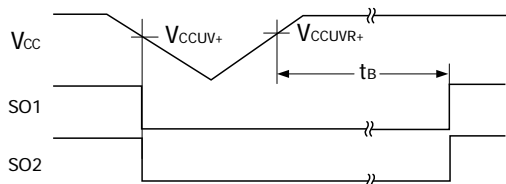


Figure 7. Primary-side UVLO logic

### Secondary Side Supply Monitoring:

The driver also monitors the secondary side power supply to ensure proper operation of the IGBT. To describe the undervoltage protection on the secondary side, an example is the case in which the secondary side full voltage  $V_{CCO}$  (VISO to COM) drops from the rated value to 0V:

- 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 a set fault signal is transmitted to the primary side and asserts  $SOx$  pin immediately.

- 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  $V_{CC}$  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.

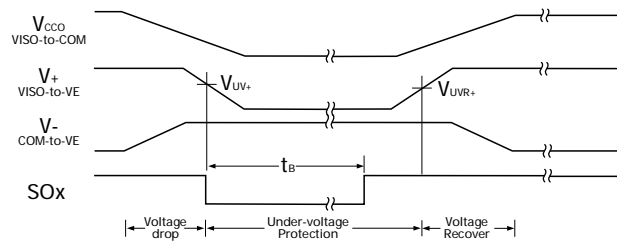


Figure 8. Secondary-side UVLO logic

### Input Signal

The triggering signal is input from  $INx$  port. The turn-on threshold  $V_{INH}$  and turn-off threshold  $V_{INL}$  are defined by different resistor configurations on the driver board.

Part Number	$R_{INx1}$	$R_{INx2}$	$R_{INx3}$
2QP0225TxxA0-x	4.7k $\Omega$	Unassembled	1k $\Omega$
2QP0225TxxC0-x	Unassembled	1.2k $\Omega$	3.3k $\Omega$

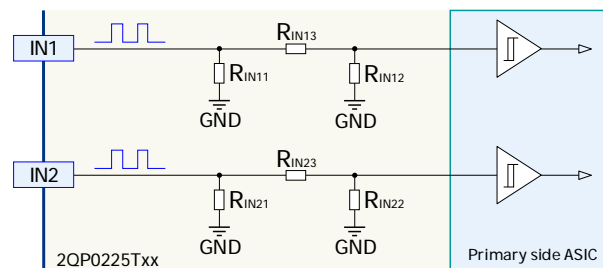


Figure 9. INx input circuitry

### Transmission Logic and Mode Selection

The driver can be configured as direct or half-bridge mode. Operating mode of the driver can be configured by the MOD pin connection.

**Direct Mode:**

If the MOD pin is left open or connected to VCC, direct mode is selected and the two channels are independent. Input IN1 corresponds to Channel 1, while input IN2 corresponds to Channel 2. A logic high turns on the corresponding IGBT, while a logic low 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.

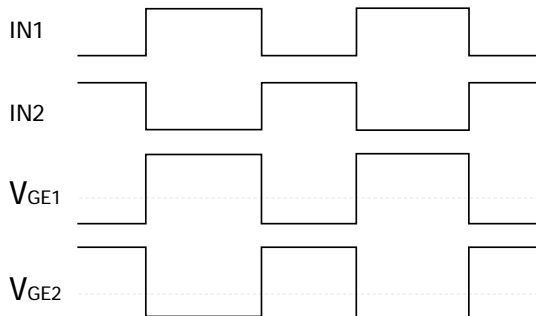


Figure 10. Transmission logic in direct mode

**Half-Bridge Mode:**

If the MOD pin is shorted to ground, the driver operates in half-bridge mode. In this mode, IN1 serves as PWM signal and IN2 as enabling signal.

When IN2 is low, both channels are locked in off state. If IN2 is high, both channels are enabled. The gate output signals of both channels are determined by IN1. At the transition of IN1 from low to high, the gate output of Channel 2 is turned off immediately. After a dead time DT elapses, the gate output of Channel 1 is turned on. At the transition of IN1 from high to low, the gate output of Channel 1 is turned off immediately. After the dead time DT elapses, the gate output of Channel 2 is turned on.

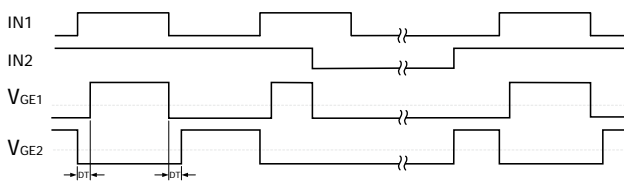


Figure 11. Transmission logic in Half-bridge mode

**Status Output Signal**

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

Part Number	RSOx1	RSOx2
2QP0225TxxA0-x	33Ω	Unassembled
2QP0225TxxC0-x	33Ω	10kΩ

**2QP0225TxxA0-x:**

When no fault is detected, QSOx keeps off, the outputs SOx have high impedance. When a fault is detected, the corresponding SOx is pulled down to ground.

It is recommended to mount external pull-up resistors as demonstrated in the diagram of recommended user interface of 2QP0225TxxA0-x. The diodes DSOEx are only required when using 3.3V input logic level. For 5V...15V logic, they can be omitted.

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

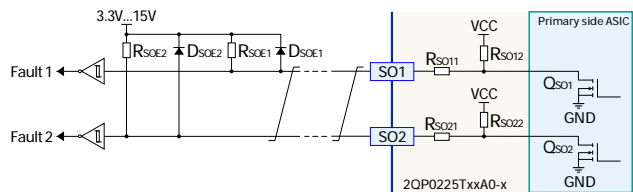


Figure 12. SOx user interface of 2QP0225TxxA0-x

**2QP0225TxxC0-x:**

When there is no fault, QSOx keeps off, and each of the SOx is pulled up to VCC via a resistor on the driver board. When a fault is detected, the corresponding SOx is pulled down to ground. It is recommended to assemble external pull down resistors RSOEx to ground as demonstrated in the diagram of recommended user interface of 2QP0225TxxC0-x, which allows a missing SOx connection to be detected (safe logic in the event of a defective cable). Note that RSOEx (pull down resistor on the user's board) must have sufficiently high resistance (e.g. 150 kΩ), as they form a voltage divider together with the internal pull-up resistor (typically 10kΩ) on the driver board.

SO1 and SO2 can be connected together to provide fault information of the entire driver. However, for fast and precise fault diagnosis, it is recommended to detect the information independently.

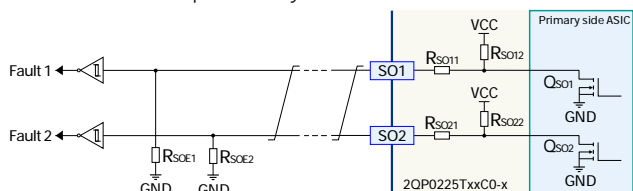


Figure 13. SOx user interface of 2QP0225TxxC0-x

**Blocking Time Setting**

The blocking time tB can be configured by an external resistor RTB between TB pin and GND.

The following formula describes the relationship between tB and RTB (at typical values).



$$R_{TB}[\text{ms}] = \frac{8250 + 150 \cdot t_B[\text{ms}]}{95 - t_B[\text{ms}]}$$

$$(R_{TB} \geq 150\text{k}\Omega, 20\text{ms} \leq t_B \leq 95\text{ms})$$

When  $R_{TB}$  is  $150\text{k}\Omega$ , the blocking time  $t_B$  is  $20\text{ms}$ . When  $TB$  is left open, the blocking time is  $95\text{ms}$ .

Note:  $R_{TB}$  should not be smaller than  $150\text{k}\Omega$ , which means the blocking time  $t_B$  cannot be shorter than  $20\text{ms}$ , otherwise the blocking time  $t_B$  will be inaccurate and unstable. If  $TB$  pin is shorted to ground,  $t_B$  is fixed to  $10\mu\text{s}$ .

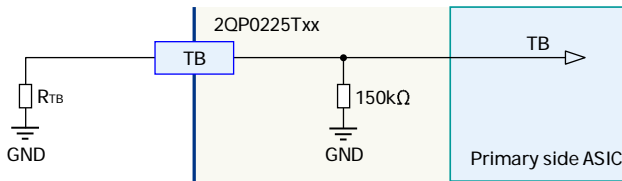


Figure 14. Blocking time setting

**IGBT Turn-on and Turn-off**

To turn on the IGBT,  $Q_{ON}$  is turned on,  $Q_{OFF}$  is turned off, and then the gate resistor  $R_{GON}$  is pulled up to charge the IGBT gate. Thus to turn on the IGBT.

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 down to discharge the IGBT gate. Thus to turn off the IGBT.

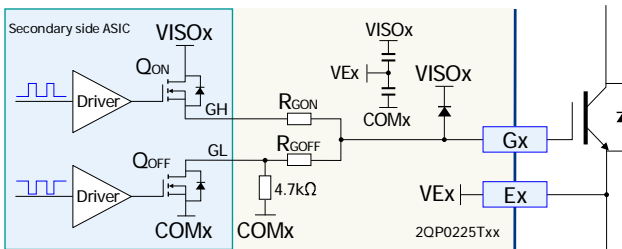


Figure 15. Gate drive output circuitry

**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.

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. The break down threshold is defined as the voltage applied on the TVS chain when the leakage current becomes  $1\text{mA}$ .

Part Number	IGBT Voltage	TVS Chain Breakdown Threshold @ 25°C
2QP0225T12xx	1200V	1020V
2QP0225T17xx	1700V	1560V

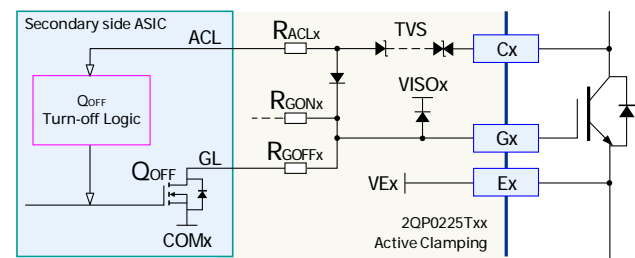


Figure 16. Active clamping circuitry

**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.

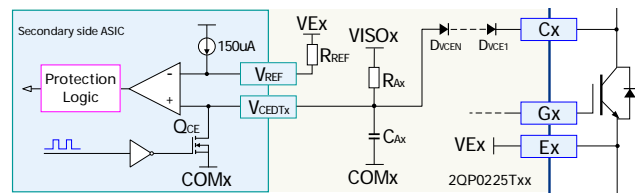


Figure 17. Short-circuit protection circuitry

**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  $R_{Ax}$ ,  $V_{CEDTx}$  rises. Then the IGBT is turned on,  $V_{CE}$  quickly drops to saturation voltage  $V_{CE-SAT}$  and  $V_{CEDTx}$  reaches  $V_{CE-SAT}$ . As  $V_{CE-SAT}$  is significantly lower than the protection threshold  $V_{REF}$ , the comparator does not flip over and the protection is not initiated.

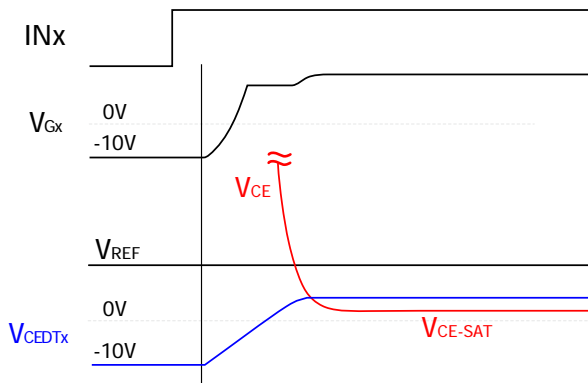


Figure 18. Signal waveform at normal turn-on

**Class I Short-Circuit Protection:**

When Class I short circuit (bridge shoot-through) occurs, due to the rapid increase of the short circuit current, the IGBT desaturates and result in rapidly increased  $V_{CE}$ .  $C_{Ax}$  is charged and  $V_{CEDTx}$  rises until it is clamped at  $V_{ISOx}$ . 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 pull down the  $SOx$  pin, 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.

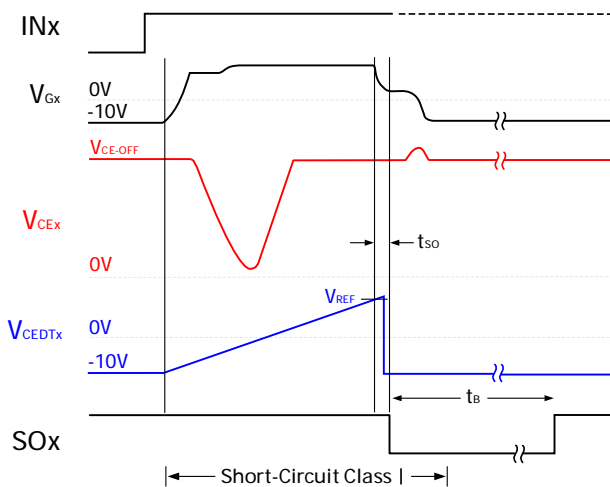


Figure 19. Class I short-circuit protection

**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 short circuit impedance 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.

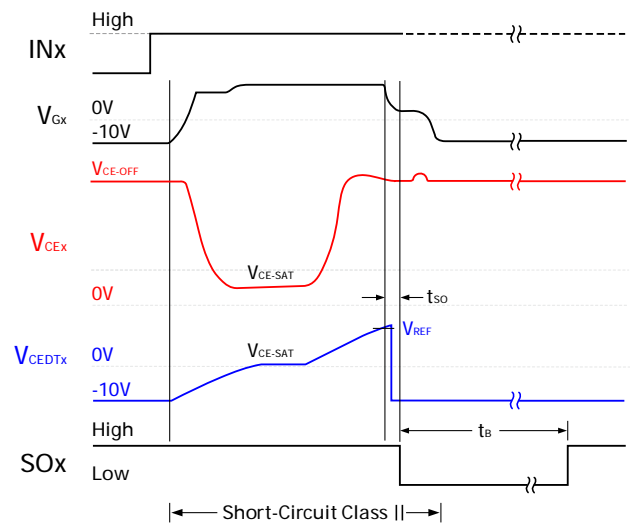


Figure 20. Class II short-circuit protection

**Soft Shut Down**

Due to the stray inductance, excessive voltage spikes are generated when the short-circuit of IGBT is turned off. In order to suppress voltage spikes without affecting the speed of turn-off during normal operation, it is necessary to deploy soft shut down function.

The secondary-side ASIC of the driver has an embedded soft shut down function. When fault condition is detected, soft shut down function is activate to protect the IGBT.

The mechanism is described below:

- 1) When fault is detected (short circuit or undervoltage), the  $Q_{ON}$  is turned off immediately by the protection function, while  $Q_{OFF}$  remains off, thus the gate voltage of the IGBT is unchanged.
- 2) An internally generated voltage reference  $V_{REF\_SSD}$  drops with a pre-defined slope. As the gate voltage is unchanged, there is a difference between  $V_{GH}$  and  $V_{REF\_SSD}$ , thus the hysteresis comparator generates a positive output.
- 3) The  $Q_{OFF}$  is turned on by the comparator output, the gate voltage and  $V_{GH}$  gradually drop. When  $V_{GH}$  drops too fast, so that  $V_{GH}$  becomes lower than  $V_{REF\_SSD}$ ,  $Q_{OFF}$  is turned off until  $V_{REF\_SSD}$  falls below  $V_{GH}$ . The aforementioned process is repeated.

- 4) In this way, the gate voltage drops with the same trend as  $V_{REF\_SSD}$  to ensure soft shut down.

The soft shut down period is fixed at 2.0 us. When gate voltage drops to 0V,  $Q_{OFF}$  is kept on to pull  $V_{GL}$  directly to  $COMx$ .

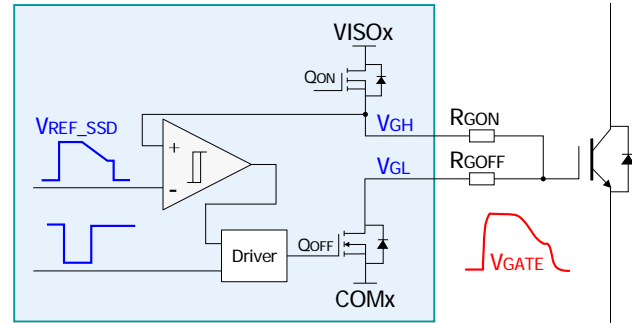
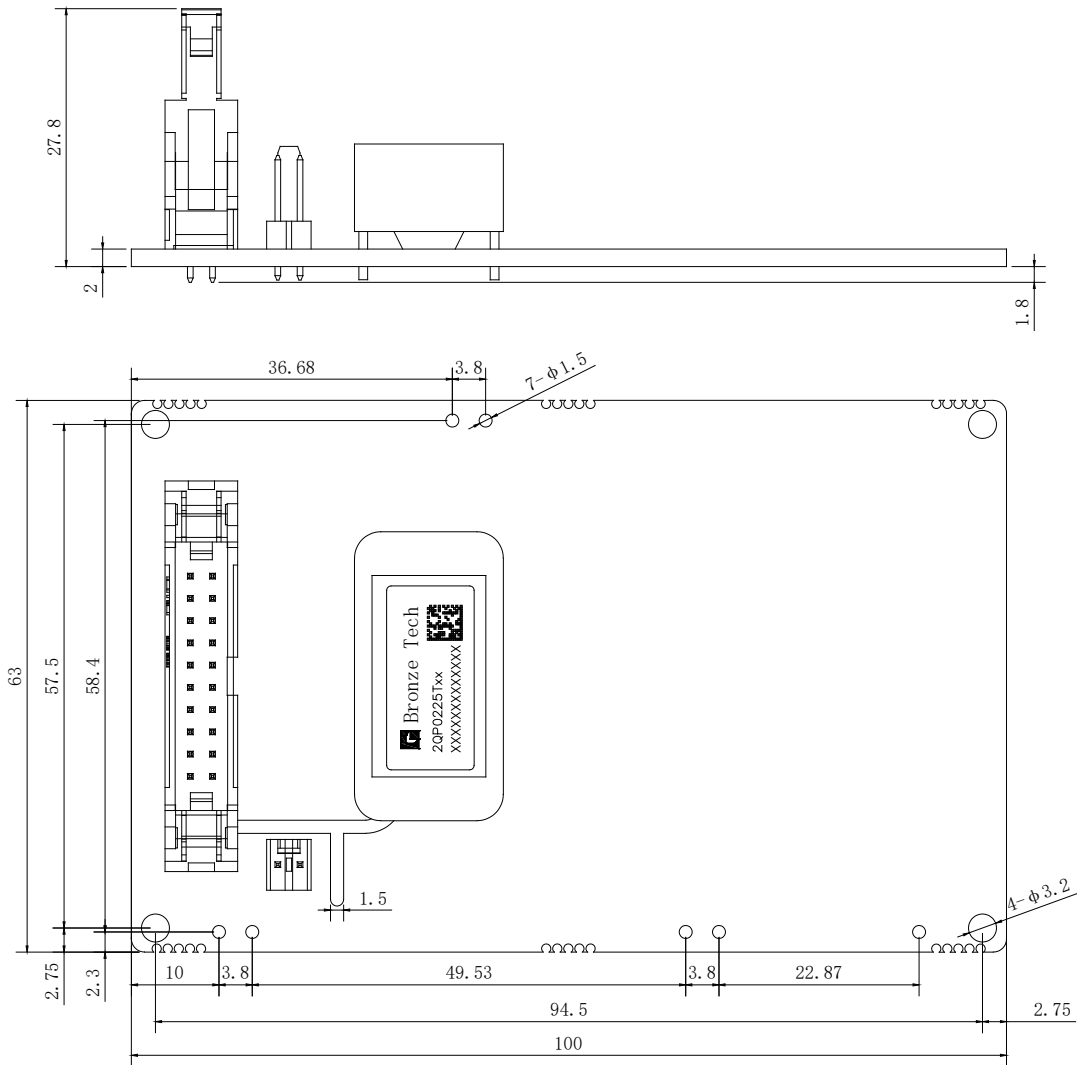


Figure 21. Soft Shut Down

**Mechanical Dimensions**



**Figure 22. Mechanical drawing of 2QP0225Txx**

- Note: 1) Legend unit: mm.  
 2) The margin tolerance conforms with the ISO 2768-1, Class f.  
 3) PCB Thickness Tolerance  $\pm 10\%$ .

## Revision History

REVISION	NOTES	DATE
V1.0	Initial release	10-Oct-2023
V1.1	Active Clamping updated, Updated Nomenclature Chart	30-May-2024
V1.1.1	Notes on optimising mechanical dimensions	28-Dec-2024

## 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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