

2SC0108T Description & Application Manual

Dual Channel Ultra-compact Low-cost SCALE-2 Driver Core

Abstract

The new low-cost SCALE-2 dual-driver core 2SC0108T combines unrivalled compactness with broad applicability. The driver was designed for universal applications requiring high reliability. The 2SC0108T drives all usual IGBT modules up to 600A/1200V or 450A/1700V. The embedded paralleling capability allows easy inverter design covering higher power ratings. Multi-level topologies are also supported.

The 2SC0108T is the most compact driver core available for industrial applications, with a footprint of only 45 x 34.3mm and an insertion height of max. 16mm. It allows even the most restricted insertion spaces to be efficiently used.



Fig. 1 2SC0108T driver core

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Driver Overview

The 2SC0108T is a low cost driver core equipped with CONCEPT’s latest SCALE-2 chipset /1/. The SCALE-2 chipset is a set of application-specific integrated circuits (ASICs) that cover the main range of functions needed to design intelligent gate drivers. The SCALE-2 driver chipset is a further development of the proven SCALE technology /2/.

The 2SC0108T targets low- and medium-power, dual-channel IGBT applications such as general purpose drives, UPS, solar converters and medical applications. The 2SC0108T comprises a complete dual-channel IGBT driver core, fully equipped with an isolated DC/DC converter, short-circuit protection and supply-voltage monitoring.

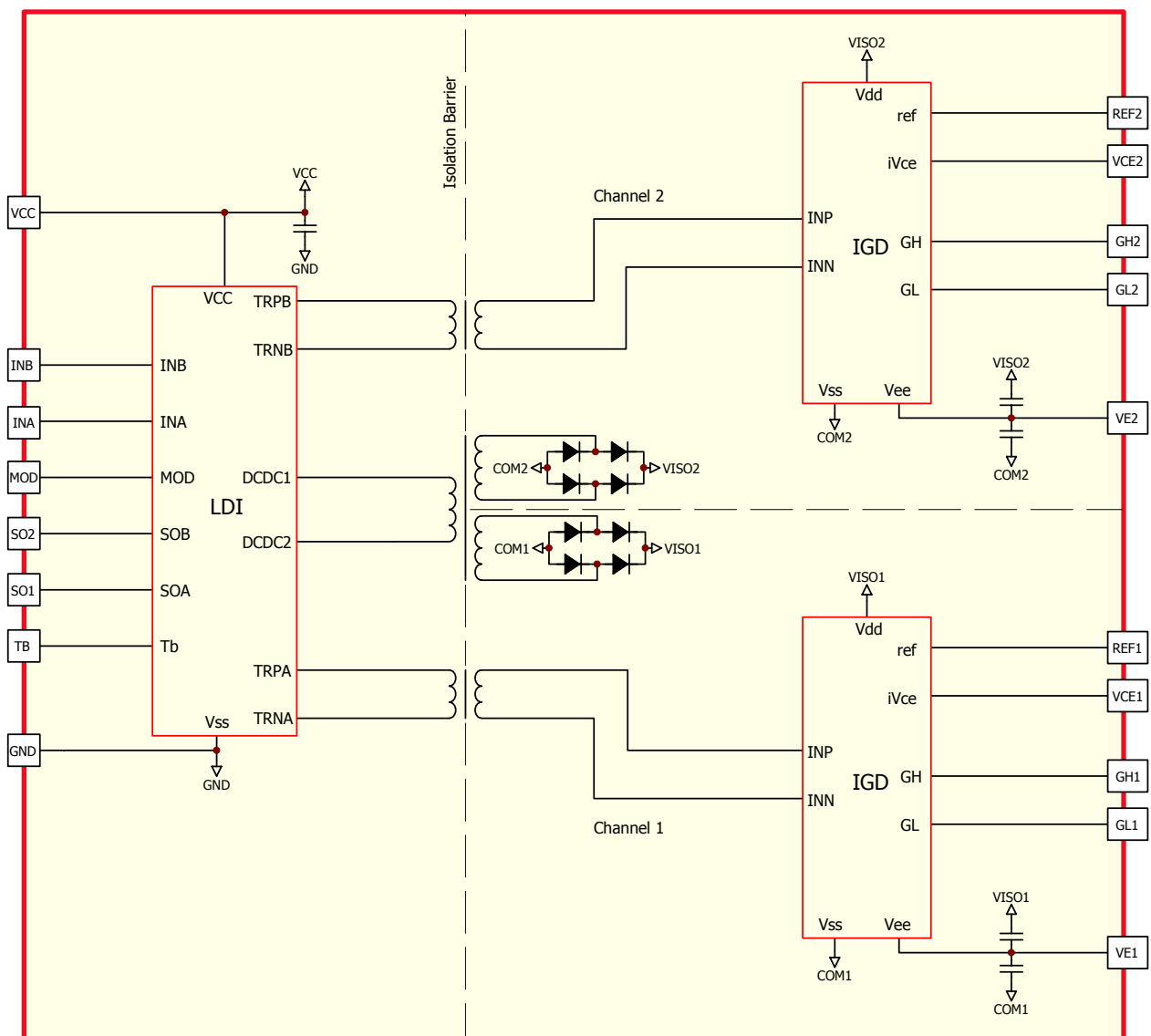
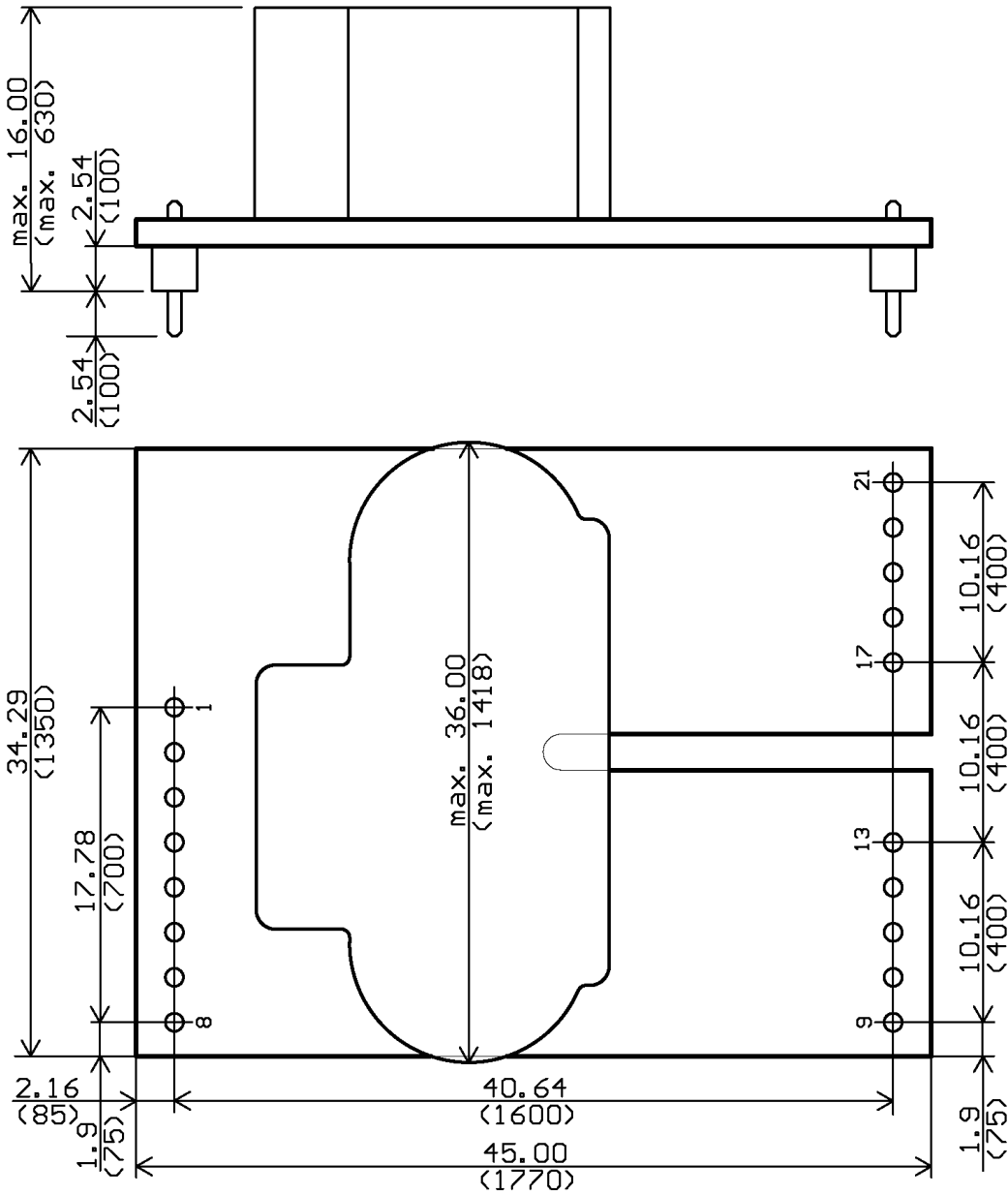


Fig. 2 Block diagram of the driver core 2SC0108T

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Mechanical Dimensions



$\frac{\text{mm}}{\text{mil}}$

Fig. 3 Mechanical drawing

The primary side and secondary side pin grid is 2.54mm (100mil) with a pin cross section of 0.64mmx0.64mm. Total outline dimensions of the board are 34.3mmx45mm. The total height of the driver is max. 16mm measured from the bottom of the pin bodies to the top of the populated PCB.

Recommended diameter of solder pads: Ø 2mm (79 mil)

Recommended diameter of drill holes: Ø 1mm (39 mil)

Pin Designation

Pin No. and Name	Function
Primary Side	
1 GND	Ground
2 INA	Signal input A; non-inverting input relative to GND
3 INB	Signal input B; non-inverting input relative to GND
4 VCC	Supply voltage; 15V supply for primary side
5 TB	Set blocking time
6 SO2	Status output channel 2; normally high-impedance, pulled down to low on fault
7 SO1	Status output channel 1; normally high-impedance, pulled down to low on fault
8 MOD	Mode selection (direct/half-bridge mode)
Secondary Sides	
9 GH1	Gate high channel 1; pulls gate high through turn-on resistor
10 VE1	Emitter channel 1; connect to (auxiliary) emitter of power switch
11 GL1	Gate low channel 1; pulls gate low through turn-off resistor
12 REF1	Set V_{CE} detection threshold voltage channel 1; resistor to VE1
13 VCE1	V_{CE} sense channel 1; connect to IGBT collector through resistor network
14 Free	
15 Free	
16 Free	
17 GH2	Gate high channel 2; pulls gate high through turn-on resistor
18 VE2	Emitter channel 2; connect to (auxiliary) emitter of power switch
19 GL2	Gate low channel 2; pulls gate low through turn-off resistor
20 REF2	Set V_{CE} detection threshold voltage channel 2; resistor to VE2
21 VCE2	V_{CE} sense channel 2; connect to IGBT collector through resistor network

Note: Pins with the designation "Free" are not physically present.

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Recommended Interface Circuitry for the Primary Side Connector

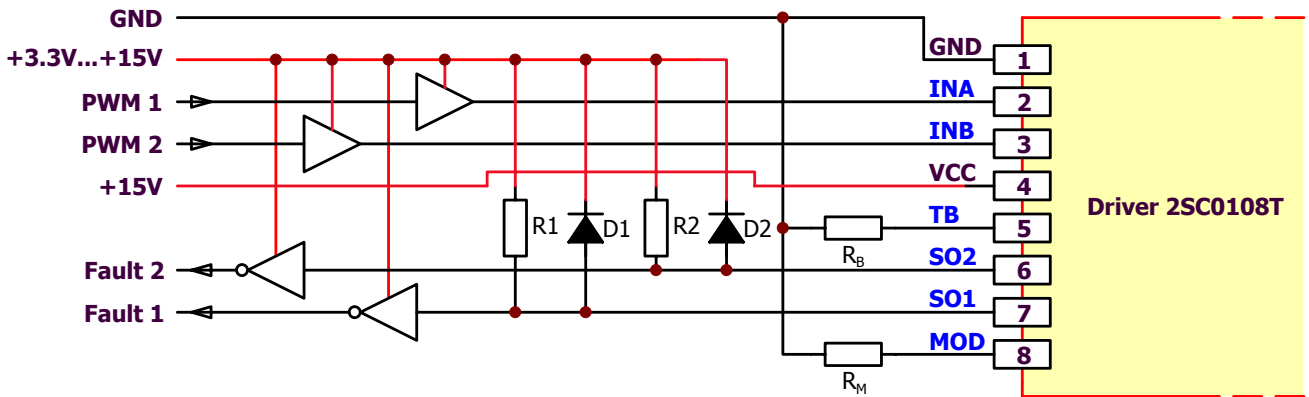


Fig. 4 Recommended user interface of 2SC0108T (primary side)

Description of Primary Side Interface

General

The primary side interface of the driver 2SC0108T is very simple and easy to use.

The driver primary side is equipped with an 8-pin interface connector with the following terminals:

- 1 x power-supply terminal
- 2 x drive signal inputs
- 2 x status outputs (fault returns)
- 1 x mode selection input (half-bridge mode / direct mode)
- 1 x input to set the blocking time

All inputs and outputs are ESD-protected. Moreover, all digital inputs have Schmitt-trigger characteristics.

VCC terminal

The driver has one VCC terminal on the interface connector. It supplies the primary side electronics as well as the DC-DC converter to supply the secondary sides with 15V.

The driver limits the inrush current at startup and no external current limitation of the voltage source for VCC is needed.

MOD (mode selection)

The MOD input allows the operating mode to be selected with a resistor connected to GND.

Direct mode

If the MOD input is connected to GND, direct mode is selected. In this mode, there is no interdependence between the two channels. Input INA directly influences channel 1 while INB influences channel 2. High level at an input (INA or INB) always results in turn-on of the corresponding IGBT. In a half-bridge topology, this mode should be selected only when the dead times are generated by the control circuitry so that each IGBT receives its own drive signal.

Caution: Synchronous or overlapping timing of both switches of a half-bridge basically shorts the DC link.

Half-bridge mode

If the MOD input is connected to GND with a resistor $71k < R_M < 181k$, half-bridge mode is selected. In this mode, the inputs INA and INB have the following functions: INA is the drive signal input while INB acts as the enable input (see Fig. 5).

When input INB is low level, both channels are blocked. If it goes high, both channels are enabled and follow the signal on the input INA. At the transition of INA from low to high, channel 2 turns off immediately and channel 1 turns on after a dead time T_D .

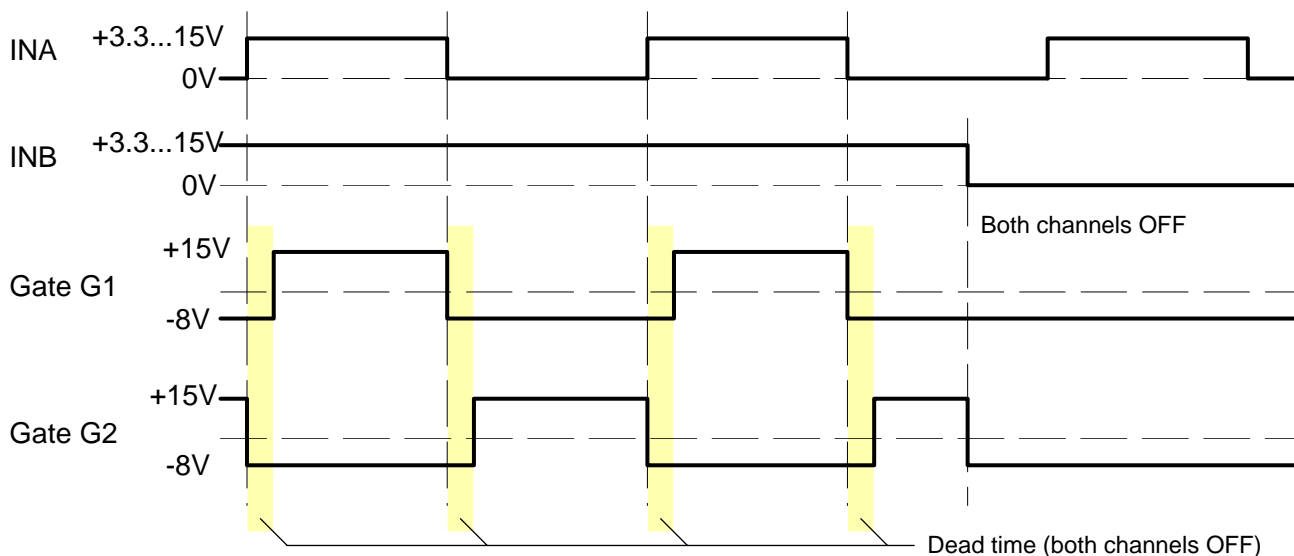


Fig. 5 Signals in half-bridge mode

The value of the dead time T_D is determined by the value of the resistor R_M according to the following formula (typical value):

$$R_M [k\Omega] = 33 \cdot T_D [\mu s] + 56.4 \quad \text{where } 0.5\mu s < T_D < 3.8\mu s \text{ and } 73k\Omega < R_M < 182k\Omega$$

INA, INB (channel drive inputs, e.g. PWM)

INA and INB are basically drive inputs, but their function depends on the MOD input (see above). They safely recognize signals in the whole logic-level range between 3.3V and 15V. Both input terminals feature Schmitt-trigger characteristics (refer to the driver data sheet /3/). An input transition is triggered at any edge of an incoming signal at INA or INB.

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SO1, SO2 (status outputs)

The outputs SO_x have open-drain transistors. When no fault condition is detected, the outputs have high impedance. An internal current source of 500µA pulls the SO_x outputs to a voltage of about 4V when leaved open. When a fault condition (primary side supply undervoltage, secondary side supply undervoltage, IGBT short-circuit or overcurrent) is detected, the corresponding status output SO_x goes to low (connected to GND).

The diodes D1 and D2 must be Schottky diodes and must only be used when using 3.3V logic. For 5V...15V logic, they can be omitted.

The maximum SO_x current in a fault condition should not exceed the value specified in the driver data sheet /3/.

Both SO_x outputs can be connected together to provide a common fault signal (e.g. for one phase). However, it is recommended to evaluate the status signals individually to allow fast and precise fault diagnosis.

How the status information is processed

- a) A fault on the secondary side (detection of short-circuit of IGBT module or supply undervoltage) is transmitted to the corresponding SO_x output immediately. The SO_x output is automatically reset (returning to a high impedance state) after a blocking time T_B has elapsed (refer to "TB (input for adjusting the blocking time T_B)" for timing information).
- b) A supply undervoltage on the primary side is indicated to both SO_x outputs at the same time. Both SO_x outputs are automatically reset (returning to a high impedance state) when the undervoltage on the primary side disappears.

TB (input for adjusting the blocking time T_B)

The terminal TB allows the blocking time T_B to be set by connecting a resistor R_B to GND (see Fig. 4). The following equation calculates the value of R_B connected between pins TB and GND in order to program the desired blocking time T_B (typical value):

$$R_B [k\Omega] = 1.0 \cdot T_B [ms] + 51 \quad \text{where } 20ms < T_B < 130ms \text{ and } 71k\Omega < R_B < 181k\Omega$$

The blocking time can also be set to a minimum of 9µs (typical) by selecting $R_B = 0\Omega$. The terminal TB must not be left floating.

Note: It is also possible to apply a stabilized voltage at TB. The following equation is used to calculate the voltage V_B between TB and GND in order to program the desired blocking time T_B (typical value):

$$V_B [V] = 0.02 \cdot T_B [ms] + 1.02 \quad \text{where } 20ms < T_B < 130ms \text{ and } 1.42 < V_B < 3.62V$$

Recommended Interface Circuitry for the Secondary Side Connectors

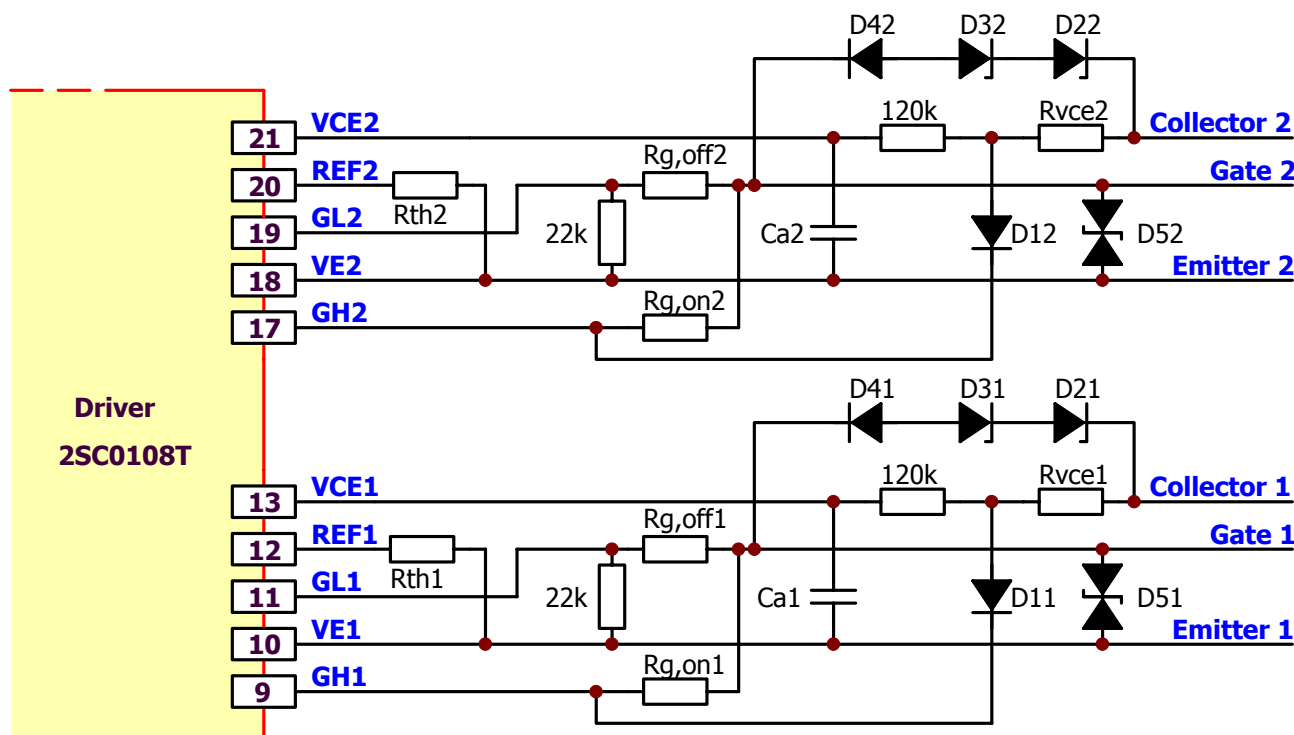


Fig. 6 Recommended user interface of 2SC0108T (secondary sides)

Description of Secondary Side Interfaces

General

Each driver’s secondary side (driver channel) is equipped with a 5-pin interface connector with the following terminals (x stands for the number of the drive channel 1 or 2):

- 1 x emitter terminal VEx
- 1 x reference terminal REFx for overcurrent or short-circuit protection
- 1 x collector sense terminal VCEx
- 1 x turn-on gate terminal GHx
- 1 x turn-off gate terminal GLx

All inputs and outputs are ESD-protected.

Emitter terminal (VEx)

The emitter terminal must be connected to the IGBT auxiliary emitter with the circuit shown in Fig. 6.

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Reference terminals (REFx)

The reference terminal REFx allows the threshold to be set for short-circuit and/or overcurrent protection with a resistor placed between REFx and VEx. A constant current of 150µA is provided at pin REFx.

Collector sense (VCEx)

The collector sense must be connected to the IGBT collector with the circuit shown in Fig. 6 in order to detect an IGBT overcurrent or short-circuit.

- It is recommended to dimension the resistor value of R_{VCEx} in order to get a current of about 0.6-1mA flowing through R_{VCEx} (e.g. 1.2-1.8MΩ for $V_{DC-LINK}=1200V$). It is possible to use a high-voltage resistor as well as series connected resistor. In any case, the min. creepage distance related to the application should be considered.
- The diode D1x must have a very low leakage current and a blocking voltage of > 40V (e.g. BAS416). Schottky diodes must be explicitly avoided.

For more details about the functionality of this feature and the dimensioning of the response time, refer to "VCE monitoring / short-circuit protection" on page 12.

Gate turn-on (GHx) and turn-off (GLx) terminals

These terminals allow the turn-on (GHx) and turn-off (GLx) gate resistors to be connected to the gate of the power semiconductor. The GHx and GLx pins are available as separated terminals in order to set the turn-on and turn-off resistors independently without the use of an additional diode. Please refer to the driver data sheet /3/ for the limit values of the gate resistors used.

A resistor between GLx and VEx of 22k (higher values are also possible) may be used in order to provide a low-impedance path from the IGBT gate to the emitter even if the driver is not supplied with power. Lower resistance values are not allowed.

A transient voltage suppressor device (D5x) may be used between gate and emitter (e.g. SMBJ13CA) if the gate-emitter voltage becomes too high in the IGBT short-circuit condition, thus leading to excessive short-circuit currents.

Note however that it is not advisable to operate the power semiconductors within a half-bridge with a driver in the event of a low supply voltage. Otherwise, a high rate of increase of V_{ce} may cause partial turn-on of these IGBTs.

Active clamping

Active clamping is a technique designed to partially turn on the power semiconductor as soon as the collector-emitter (drain-source) voltage exceeds a predefined threshold. The power semiconductor is then kept in linear operation.

Basic active clamping topologies implement a single feedback path from the IGBT's collector through transient voltage suppressor devices (TVS) to the IGBT gate. The 2SC0108T supports basic active clamping.

It is recommended to use the circuit shown in Fig. 6. The following parameters must be adapted to the application:

- TVS D2x, D3x: it is recommended to use:
 - 1x440V TVS (or 2x220V TVS) with 600V IGBTs with DC-link voltages up to 400V
 - 2x440V TVS (or 4x220V TVS) with 1200V IGBTs with DC-link voltages up to 800V and
 - 3x440V TVS (or 6x220V TVS) with 1700V IGBTs with DC-link voltages up to 1200V
- D4x: it is recommended to use Schottky diodes with blocking voltages >35V (>1A depending on the application).

Note that the active clamping performance can be improved by increasing the value of the turn-off gate resistors $R_{g,offx}$.

If active clamping is not used, the TVS D2x and D3x as well as the diode D4x can be omitted.

How Do 2SC0108T SCALE-2 Drivers Work in Detail?

Power supply and electrical isolation

The driver is equipped with a DC/DC converter to provide an electrically insulated power supply to the gate driver circuitry. All transformers (DC/DC and signal transformers) feature safe isolation to EN 50178, protection class II between primary side and either secondary side.

Note that the driver requires a stabilized supply voltage.

Power-supply monitoring

The driver's primary side as well as both secondary-side driver channels are equipped with a local undervoltage monitoring circuit.

In the event of a primary-side supply undervoltage, the power semiconductors are driven with a negative gate voltage to keep them in the off-state (the driver is blocked) and the fault is transmitted to both outputs SO1 and SO2 until the fault disappears.

In case of a secondary-side supply undervoltage, the corresponding power semiconductor is driven with a negative gate voltage to keep it in the off-state (the channel is blocked) and a fault condition is transmitted to the corresponding SOx output. The SOx output is automatically reset (returning to a high impedance state) after the blocking time.

Within a half-bridge, it is advised not to operate the IGBTs with an IGBT driver in the event of a low supply voltage. Otherwise, a high rate of increase of V_{ce} may cause partial turn-on of these IGBTs.

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V_{CE} monitoring / short-circuit protection

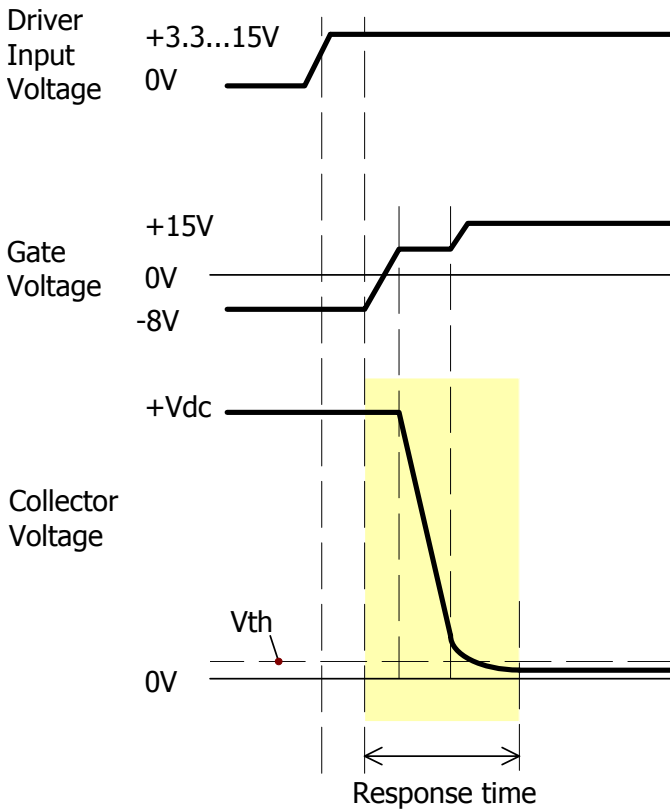


Fig. 7 Turn-on characteristic of an IGBT

threshold V_{thx} , the driver detects a short circuit or overcurrent. The driver then switches off the corresponding power semiconductor. The fault status is immediately transferred to the corresponding SOx output of the affected channel. The power semiconductor is kept in off state (non-conducting) and the fault is shown at pin SOx as long as the blocking time T_B is active.

The blocking time T_B is applied independently to each channel. T_B starts as soon as V_{CE} exceeds the threshold of the V_{CE} monitoring circuit outside the response time span.

The value of the response time capacitors C_{ax} can be determined with the following table in order to set the desired response time ($R_{vcex}=1.8M\Omega$, DC-link voltage $V_{DC-LINK}>550V$):

Each channel of the 2SC0108T driver is equipped with a V_{CE} monitoring circuit. The recommended circuit is illustrated in Fig. 6. A resistor (R_{thx} in Fig. 6) is used as the reference element for defining the turn-off threshold. The value of the current through R_{thx} is $150\mu A$ (typical). It is recommended to choose threshold levels of about 10V (R_{thx} values around $68k\Omega$). In this case the driver will safely protect the IGBT against short-circuit, but not necessarily against overcurrent. Overcurrent protection has a lower timing priority and is recommended to be realized within the host controller.

In order to ensure that the 2SC0108T can be applied as universally as possible, the response time capacitor C_{ax} is not integrated in the driver, but must be connected externally.

During the response time, the V_{CE} monitoring circuit is inactive. The response time is the time that elapses after turn-on of the power semiconductor until the collector voltage is measured (see Fig. 7).

Both IGBT collector-emitter voltages are measured individually. V_{CE} is checked after the response time at turn-on to detect a short circuit or overcurrent. If the measured V_{CE} at the end of the response time is higher than the programmed

C_{ax} [pF]	R_{thx} [k Ω]/ V_{thx} [V]	Response time [μ s]
0	43 / 6.45	1.2
15	43 / 6.45	3.2
22	43 / 6.45	4.2
33	43 / 6.45	5.8
47	43 / 6.45	7.8
0	68 / 10.2	1.5
15	68 / 10.2	4.9
22	68 / 10.2	6.5
33	68 / 10.2	8.9
47	68 / 10.2	12.2

Table 1 Typical response time in function of the capacitance C_{ax} and the resistance R_{thx}

As the parasitic capacitances on the host PCB may influence the response time it is recommended to measure it in the final design. It is important to define a response time which is smaller than the max. allowed short-circuit duration of the used power semiconductor.

Note that the response time increases at DC-link voltage values lower than 550V and/or higher threshold voltage values V_{thx} . The response time will decrease at lower threshold voltage values.

Parallel connection of 2SC0108T

If parallel connection of 2SC0108T drivers is required, please refer to the application note AN-0904 on www.IGBT-Driver.com/go/app-note.

3-level or multilevel topologies

If 2SC0108T drivers are to be used in 3-level or multilevel topologies, please refer to the application note AN-0901 on www.IGBT-Driver.com/go/app-note.

Desaturation protection with sense diodes

2SC0108T drivers are equipped with a desaturation protection function with a resistor network (see "Collector sense (VCE_s)" on page 10). If you require desaturation protection with collector sense diodes, please consult CONCEPT's technical support service.

Bibliography

- /1/ "Smart Power Chip Tuning", Bodo's Power Systems, May 2007
- /2/ "Description and Application Manual for SCALE Drivers", CONCEPT
- /3/ Data sheet SCALE-2 driver core 2SC0108T, CONCEPT

Note: These papers are available on the Internet at www.IGBT-Driver.com/go/papers

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The Information Source: SCALE-2 Driver Data Sheets

CONCEPT offers the widest selection of gate drivers for power MOSFETs and IGBTs for almost any application requirements. The largest website on gate-drive circuitry anywhere contains all data sheets, application notes and manuals, technical information and support sections: www.IGBT-Driver.com

Quite Special: Customized SCALE-2 Drivers

If you need an IGBT driver that is not included in the delivery range, please don't hesitate to contact CONCEPT or your CONCEPT sales partner.

CONCEPT has more than 20 years experience in the development and manufacture of intelligent gate drivers for power MOSFETs and IGBTs and has already implemented a large number of customized solutions.

Technical Support

CONCEPT provides expert help with your questions and problems:

www.IGBT-Driver.com/go/support

Quality

The obligation to high quality is one of the central features laid down in the mission statement of CT-Concept Technologie AG. The quality management system covers all stages of product development and production up to delivery. The drivers of the SCALE-2 series are manufactured to the ISO9001:2000 quality standard.

Legal Disclaimer

This data sheet specifies devices but cannot promise to deliver any specific characteristics. No warranty or guarantee is given – either expressly or implicitly – regarding delivery, performance or suitability.

CT-Concept Technologie AG reserves the right to make modifications to its technical data and product specifications at any time without prior notice. The general terms and conditions of delivery of CT-Concept Technologie AG apply.

Ordering Information

The general terms and conditions of delivery of CT-Concept Technologie AG apply.

Type Designation	Description
2SC0108T2A0-17	Dual-channel SCALE-2 driver core (standard version, -20°C...85°C)
2SC0108T2B0-17	Dual-channel SCALE-2 driver core (-40°C...85°C)

Product home page: www.IGBT-Driver.com/go/2SC0108T

Refer to www.IGBT-Driver.com/go/nomenclature for information on driver nomenclature

Information about Other Products

For other driver cores:

Direct link: www.IGBT-Driver.com/go/cores

For other drivers, product documentation, evaluation systems and application support

Please click onto: www.IGBT-Driver.com

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