2SD300C17 Description & Application Manual

Dual Channel High-quality and Low-cost SCALE-2 Driver Core

Abstract

The SCALE-2 dual-driver core 2SD300C17 is a second source to Infineon's 2ED300C17-S and 2ED300C17-ST. The driver is fully pin and function-compatible to the 2ED300C17-S/2ED300C17-ST and was designed for applications in which high reliability is expected.

The use of CONCEPT's highly integrated SCALE-2 chipset allows 63% of the components to be dispensed with compared to the 2ED300C17-S/2ED300C17-ST. This advantage is impressively reflected in increased reliability (function and MTBF) with simultaneously lower costs.
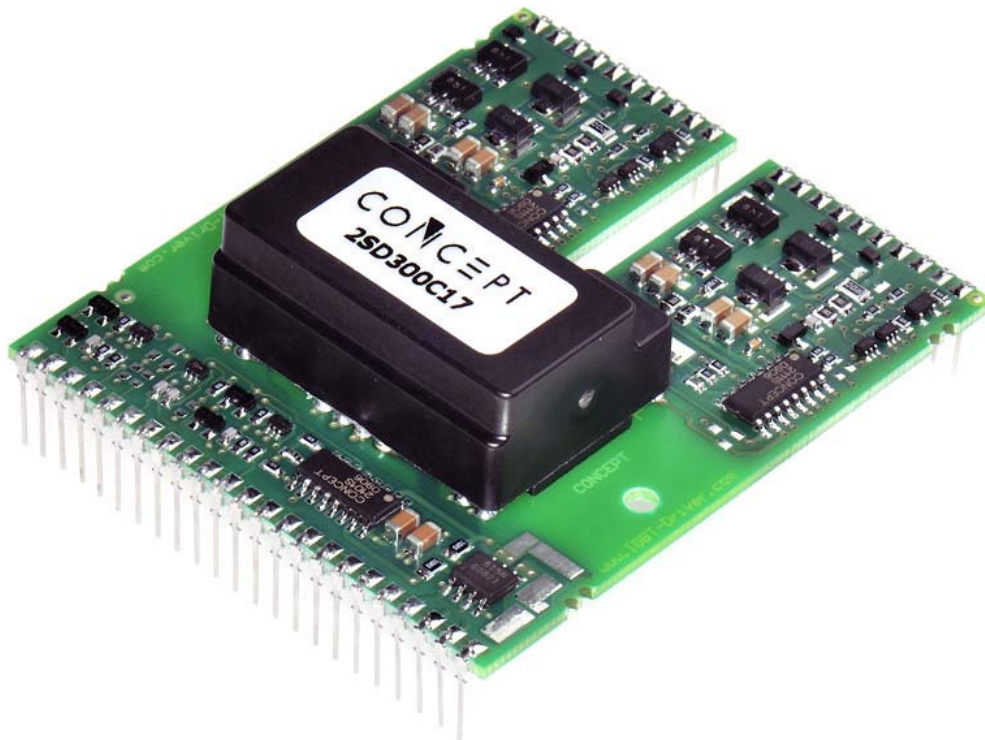
Fig. 1   2SD300C17 driver core

Description and Application Manual

Contents

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Driver Overview

The 2SD300C17 is a 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 2SD300C17 targets medium- and high-power IGBT applications such as windmill and solar converters, general purpose drives, as well as traction including parallel gate driving of IGBT modules. The 2SD300C17 comprises a complete dual-channel IGBT driver core, fully equipped with an isolated DC/DC converter, short-circuit protection, active clamping, soft turn-off and supply-voltage monitoring.
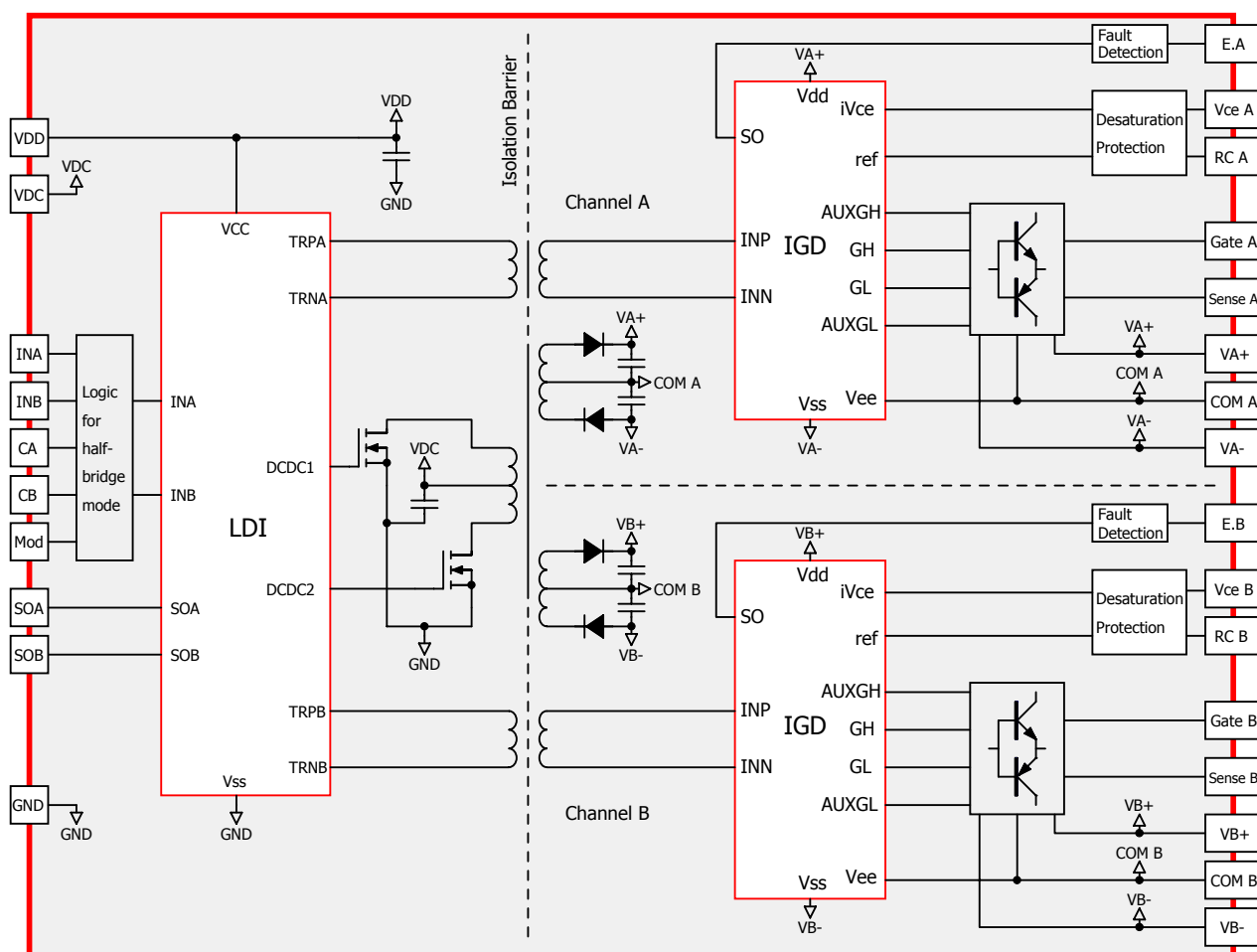
Fig. 2   Block diagram of the driver core 2SD300C17

Description and Application Manual

Mechanical Dimensions

Fig. 3   Mechanical drawing (top view)

The primary side and secondary side pin grid is 2.54mm (100mil).
Total outline dimensions of the board are 60.5mm x 72mm. The total height of the driver is max. 18.5mm measured from the top layer of the host PCB to the top of the populated PCB on the driver.

Recommended diameter of solder pads: Ø 2mm (79mil)
Recommended diameter of drill holes: Ø 1mm (39mil)

Pin Designation

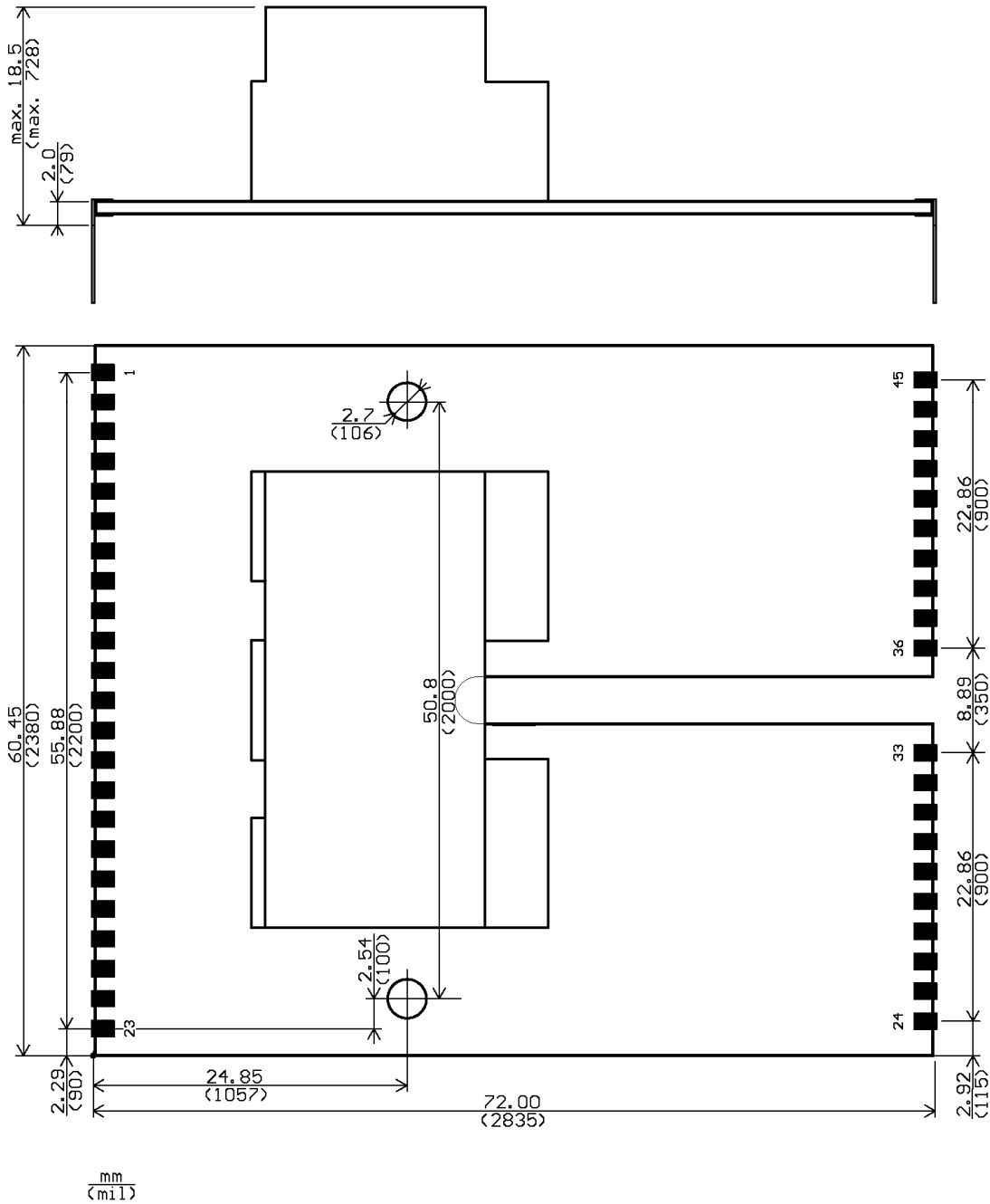| Primary side			Secondary Sides		
Pin	Name	Function	Pin	Name	Function
1	VDD	+15V for primary side electronics	45	Gate A	Gate channel A
2	VDD	+15V for primary side electronics	44	Gate A	Gate channel A
3	VDD	+15V for primary side electronics	43	COM A	Emitter A
4	SOA	Status output channel A	42	COM A	Emitter A
5	N.C.	Not connected	41	VA+	+16V DC/DC output channel A
6	CA	Dead time channel A	40	VA-	-16V DC/DC output channel A
7	INB	Signal input channel B	39	Sense A	Soft turn-off / active clamping input
8	CB	Dead time channel B	38	RC A	Reference RC network channel A
9	Mod	Mode selection	37	Vce A	Collector sense channel A
10	SOB	Status output channel B	36	E.A	External fault input channel A
11	INA	Signal input channel A	35	Free	
12	GND	Ground	34	Free	
13	GND	Ground	33	Gate B	Gate channel B
14	VDC	DC/DC converter	32	Gate B	Gate channel B
15	VDC	DC/DC converter	31	COM B	Emitter B
16	VDC	DC/DC converter	30	COM B	Emitter B
17	VDC	DC/DC converter	29	VB+	+16V DC/DC output channel B
18	VDC	DC/DC converter	28	VB-	-16V DC/DC output channel B
19	GND	Ground	27	Sense B	Soft turn-off / active clamping input
20	GND	Ground	26	RC B	Reference RC network channel B
21	GND	Ground	25	Vce B	Collector sense channel B
22	GND	Ground	24	E.B	External fault input channel B
23	GND	Ground			

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

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Description and Application Manual

Recommended Interface Circuitry for the Primary Side Connector
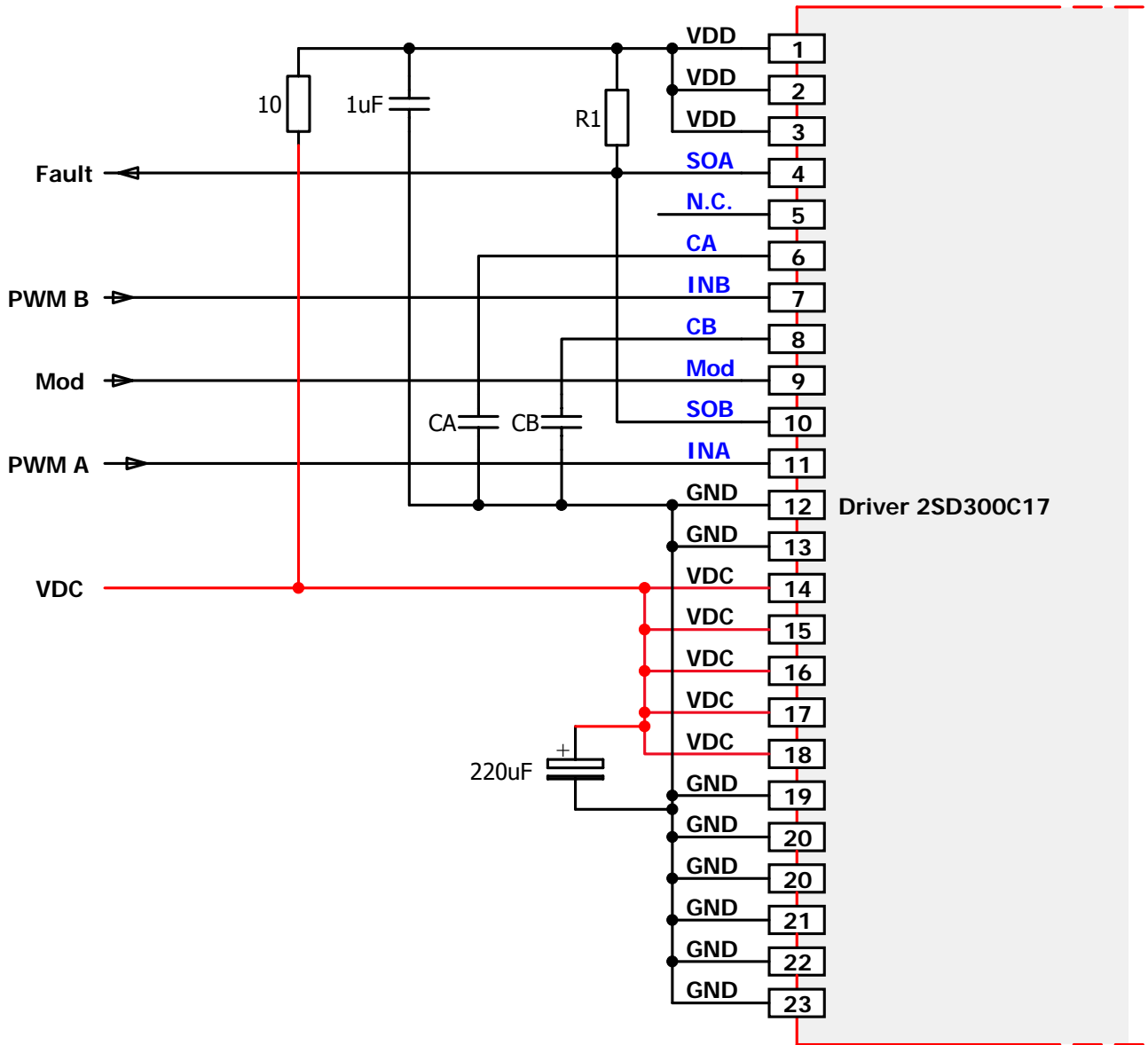

Fig. 4   Recommended user interface of 2SD300C17 (primary side)

All ground pins must be connected together with low parasitic inductance. A common ground plane or wide tracks are strongly recommended. The connecting distance between ground pins must be kept at a minimum.

Description of Primary Side Interface

General

The primary side interface of the driver 2SD300C17 is very simple and easy to use.

The driver primary side is equipped with a 23-pin interface connector with the following terminals:

- 8 x power-supply terminals
- 2 x drive signal inputs
- 2 x status outputs (fault returns)
- 1 x mode selection (half-bridge mode / direct mode)
- 2 x inputs to set the dead time (half-bridge mode)
- 1 x not connected (N.C.)

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

VDC terminal

The driver has 5 VDC terminals on the interface connector to supply the DC-DC converters for the secondary sides. VDC should be supplied with a stabilized +15V power supply.

It is recommended to use a stabilizing capacitor of 220µF between VDC and GND.

VDD terminal

The driver has 3 VDD terminals on the interface connector to supply the primary side electronics with 15V.

It is recommended to connect the VDD terminals to VDC via a 10Ω resistor. An additional stabilizing capacitor of 1µF should be placed between VDD and GND.

It is also possible to run VDC and VDD directly in parallel without a 10Ω resistor.

Mod (mode selection)

The Mod input allows the operating mode to be selected.

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 A while INB influences channel B. High level at an input (INA or INB) always results in turn-on of the corresponding IGBT. 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.

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Description and Application Manual

Half-bridge mode

If the Mod input is connected to VDD, half-bridge mode is selected. In this mode, the input INA influences channel A while INB influences channel B. However, only one channel can be turned-on at a given time and a defined dead time (interlock time) between both channels is generated (see Fig. 5). The dead time between both channels can be adjusted with the input pins CA and CB (see "CA and CB (input for adjusting the dead time in half-bridge mode)" on page 9). If both signals INA and INB are high, both gate signals are low (-15V).

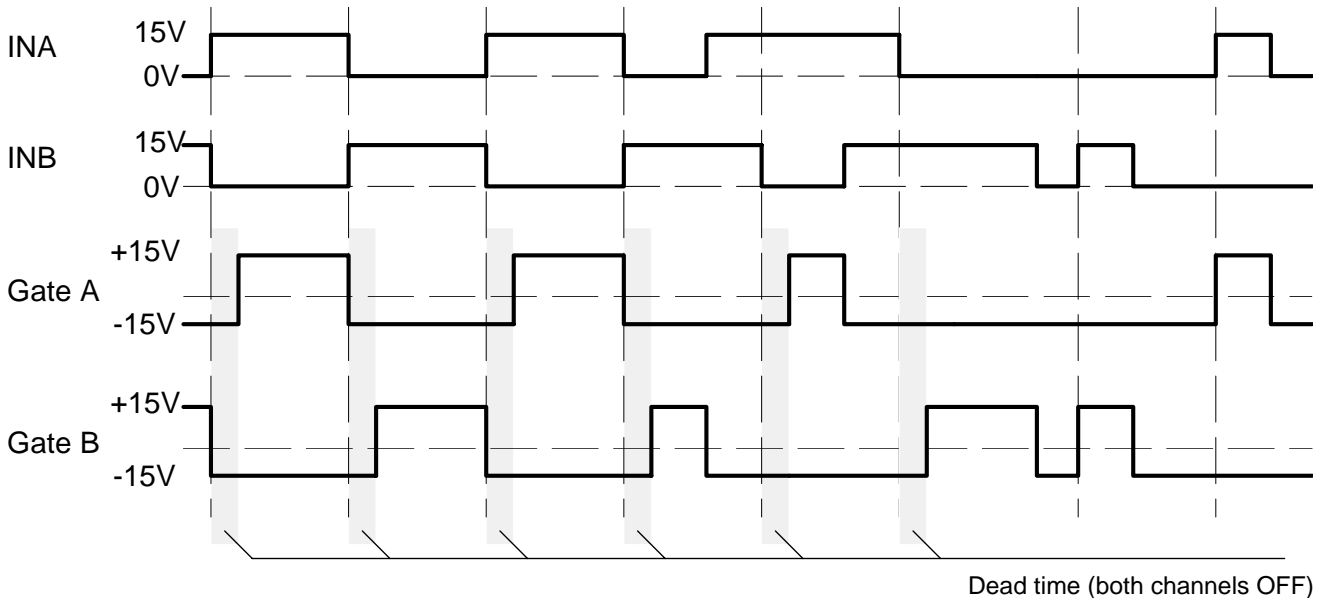The following Fig. 5 shows the driver behavior in half-bridge mode.

Fig. 5   Signals in half-bridge mode

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).

15V logic-level signals should be applied at INA and INB.

No pulse shorter than 1.5µs should be applied to the driver inputs. A pulse shorter than 1.5µs could occasionally activate the soft turn-off function of the driver.

SOA, SOB (status outputs)

The outputs SOx have open-drain transistors. When a fault condition is detected in channel "x", the status output SOx goes to low (connected to GND). Otherwise, the output has high impedance.

Both SOx outputs are not connected to a single signal on the driver. They can be connected together to provide a common fault signal (e.g. for one phase) if required.

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

Preliminary

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 SOx output immediately. The corresponding SOx output is automatically reset (returning to a high impedance state) after the blocking time has elapsed (refer to the driver data sheet for timing information /3/).

b) A supply undervoltage on the primary side is indicated to both SOx outputs at the same time. Both SOx outputs are automatically reset (returning to a high impedance state) when the undervoltage on the primary side disappears (refer to the driver data sheet for timing information /3/).

Note that no external reset input is available on the driver. The driver is automatically reset after the blocking time has elapsed.

CA and CB (input for adjusting the dead time in half-bridge mode)

Terminals CA and CB allow the generated dead time between both channels A and B to be determined in half-bridge mode. The dead time can be defined with a capacitor placed between pins CA and CB and GND (see Fig. 4).

The following table 1 shows the dead time as a function of the capacitance of CA and CB:

Capacitance of CA and CB	Dead time
0pF	1.3µs
47pF	1.7µs
100pF	2.1µs
220pF	3.0µs
330pF	3.8µs
470pF	4.8µs
1nF	8.8µs

Table 1   Generated dead time as a function of CA and CB in half-bridge mode

In direct mode, it is recommended to connect the inputs CA and CB with a 470pF capacitor to GND. CA or CB must not be connected to any external potential (e.g. GND or VDD).

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Description and Application Manual

Recommended Interface Circuitry for the Secondary Side Connector

Fig. 6 shows the recommended interface circuit for the secondary side of the driver (channel A). The same circuit can be used for channel B (not shown).
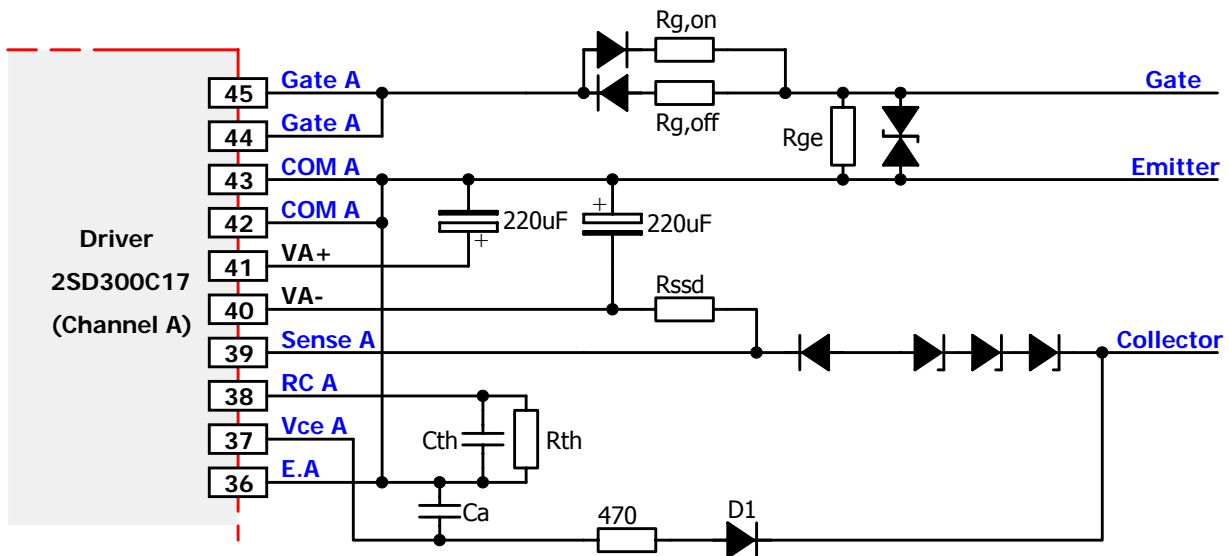

Fig. 6   Recommended user interface of 2SD300C17 (only channel A, secondary side)

Description of Secondary Side Interface

General

The driver's secondary sides are each equipped with a 10-pin interface connector with the following terminals (x stands for A or B):

- 2 x DC/DC output terminals (Vx+ and Vx-)
- 2 x emitter terminals COM x
- 1 x reference terminal RC x for overcurrent or short-circuit protection
- 1 x collector sense terminal VCE x
- 2 x gate terminals Gate x
- 1 x sense terminal for active clamping and/or soft-turn-off Sense x
- 1 x external fault input E.x

All inputs and outputs are ESD-protected.

DC/DC output (Vx+, Vx-) and COM x terminals

The driver is equipped with blocking capacitors on the secondary side of the DC/DC converter (for values, refer to the data sheet /3/). It is recommended to use additional external blocking capacitors of 220µF to reduce the dynamic voltage drop due to high pulse currents.

The blocking capacitors must be placed between Vx+ and COM x as well as between COM x and Vx- (see Fig. 6). They must be connected as close as possible to the driver's terminal pins with minimum inductance. Capacitors with high ripple current capability should be used.

Reference terminal (RC x)

The reference terminal *RC x* allows the threshold to be set for short-circuit and/or overcurrent protection with a resistor Rth placed between *RC x* and COM x. Moreover, instead of a static reference, a dynamic reference is used to check the collector-emitter voltage of the IGBT at turn-on. The time constant of the dynamic reference can be set with a capacitor Cth placed between *RC x* an COM x. It allows the short-circuit duration to be adjusted in case of IGBT short-circuit.

The following table 2 shows the static reference as well as the short-circuit duration (short-circuit type I) according to IEC 60747-9 for different values of Rth and Cth. The short-circuit duration was measured under the following conditions:

- IGBT module: FF1000R17IE4 from Infineon
- Rg,on=1.2Ω and Rg,off=1.8Ω
- Rssd=10kΩ, Ca=1nF (see Fig. 6)
- DC-link voltage: 1000V

Resistance Rth	Threshold	Short-circuit duration				
		Cth=0pF	Cth=100pF	Cth=220pF	Cth=470pF	Cth=1nF
2kΩ	1.9V	2µs	2.1µs	2.3µs	2.7µs	3.6µs
5.4kΩ	3.9V	2.2µs	2.6µs	3.1µs	3.9µs	5.6µs
12kΩ	5.8V	2.5µs	3.5µs	4.2µs	5.5µs	7.6µs
32kΩ	7.8V	3.7µs	4.9µs	5.9µs	7.4µs	10µs
70kΩ	8.8V	5.1µs	6µs	7µs	8.6 µs	11.7µs

Table 2   Dynamic threshold voltage for overcurrent and/or short-circuit protection

Note that the short-circuit duration is dependent on the IGBT module used and the gate resistors. It is therefore recommended to measure it in the final application. The short-circuit duration should not exceed the maximum value given in the IGBT module data sheet.

Collector sense (VCE x)

2SD300C17 drivers are equipped with a dynamic collector sense function. 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. For more details about the functionality of this feature, refer to "Vce monitoring / short-circuit protection" on page 14.

CO∩C∃PT

Description and Application Manual

Gate terminals Gate x

These terminals allow the turn-on and turn-off gate resistors to be connected to the gate of the power semiconductor. Please refer to the driver data sheet /3/ for the limit values of the gate resistors used.

The auxiliary emitter of the IGBT must be connected directly to the COM x terminals of the driver.

A resistor Rge of maximum 10kΩ between Gate x and COM x is recommended in order to provide a low-impedance path from the IGBT gate to the emitter even if the driver is not supplied with power. Moreover, gate clamping should be realized with a zener diode between Gate x and COM x.

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 Vce may cause partial turn-on of these IGBTs.

Sense input (Sense x)

The Sense x inputs can be used:

- to adjust the soft turn-off behavior
- to activate active clamping.

Both techniques allow the IGBT to be protected against collector-emitter overvoltages in case of overcurrent and/or short-circuit turn-off. Note that soft turn-off does not offer 100% protection against turn-off overvoltages. If the pulse duration determined by the corresponding input INx is shorter than the driver response time (time between gate-emitter turn-on and short-circuit detection), the driver will switch off the short-circuit without the soft turn-off function. In this case, active clamping can be used to limit the turn-off overvoltage.

A typical value of R_{ssd}=10kΩ is recommended. If necessary, this value can be modified in order to adjust the soft turn-off behavior of the driver.

Active clamping can be realized with a feedback from the collector to the Sense x input according to Fig. 6. It is recommended to use the following transient voltage suppressors (TVS):

- 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

External fault input E.x

The 2SD300C17 is equipped with an external fault input on each driver channel. This allows a fault to be generated on the corresponding channel. The external fault is handled in the same way as an overcurrent/short-circuit or supply undervoltage fault.

If the external fault input E.x is not used, it must be connected to COM x.

If it is used, the following conditions must be met in order to ensure proper function of the driver:

- The slew rate of E.x should be higher than 0.1V/μs
- The pulse width applied to E.x must be longer than 100ns
- As soon as one channel is in a fault condition (SOx output goes to low), the other channel must be switched off (it is not switched off by the driver)
- The dead time between both channels must be higher than 2μs + reaction time of the host system (time between fault feedback SOx of the driver and turn-off command for the other channel)

How Do 2SD300C17 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 the 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 case of a primary-side supply undervoltage, both IGBTs are driven with a negative gate voltage to keep them in the off-state (both channels are blocked) and the fault is transmitted to both outputs SOA and SOB until the fault disappears.

In case of a secondary-side supply undervoltage, the corresponding IGBT 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.

CONCEPT

Description and Application Manual

Vce monitoring / short-circuit protection

Fig. 7   Turn-on characteristic of an IGBT or MOSFET
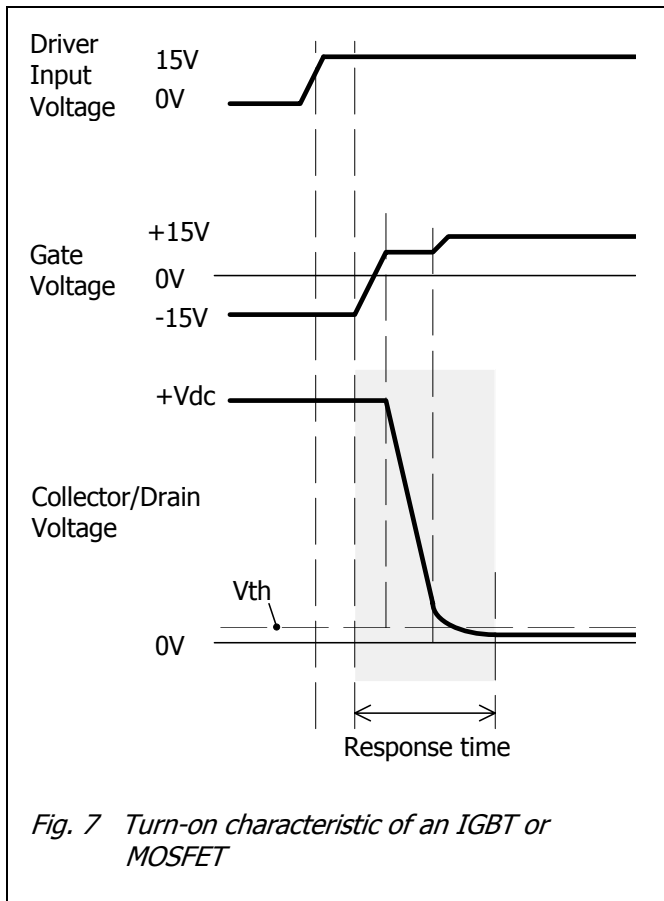
The 2SD300C17 driver is equipped with a Vce monitoring circuit. The recommended circuit is illustrated in Fig. 6. A resistor and a capacitor (Rth and Cth in Fig. 6) are used as the reference elements for defining the dynamic turn-off threshold.

It is recommended to use a value of Ca=1nF and fast diodes such as 1U4007 (2 diodes for 1200V or 1700V IGBTs) for D1.

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

Vce is checked after the response time at turn-on to detect a short circuit or overcurrent. If this voltage is higher than the programmed threshold Vth, the driver detects a short circuit or overcurrent, switches the power semiconductor off and signals the fault immediately to the corresponding SOx output. The power semiconductor is kept off (non-conducting) and the fault is shown at pin SOx as long as the blocking time is active.

Note that only the channel with a Vce monitoring fault (short-circuit or overcurrent) is turned-off and blocked until the blocking time has elapsed.

Blocking time

In case of a secondary side fault (short-circuit or overcurrent, supply undervoltage, external fault input), the fault is immediately transmitted to the primary side and shown at the corresponding output SOx. The corresponding channel is blocked during the blocking time (for timing information, refer to the driver data sheet). After the blocking time, the driver channel is automatically reset and the fault at the corresponding SOx output disappears.

Note that the other channel (channel without fault) is not turned off and no fault is generated at the corresponding SOx output.

Preliminary

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 2SD300C17, CONCEPT

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

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

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Description and Application Manual

Ordering Information

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

Type Designation	Description
2SD300C17A0	Dual-channel SCALE-2 driver core (uncoated)
2SD300C17A0-T	Dual-channel SCALE-2 driver core (coated with varnish)

Product home page: www.IGBT-Driver.com/go/2SD300C17

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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