2BB0435T
Target Description & Application Manual

Base Board for 2SC0435T SCALE-2 driver for 600V, 1200V and 1700V IGBT modules or MOSFETs with an electrical interface for 2-level, 3-level and multilevel converter topologies with paralleling capability

Abstract

The 2BB0435T is a dual-channel Base Board for CONCEPT's SCALE-2 driver core 2SC0435T, a low-cost SCALE-2 dual-driver core for the reliable driving and safe operation of IGBTs.

The Base Board is suitable to drive almost all available dual IGBT modules up to 1700V like 62mm IGBT modules, 130mm x 140mm IGBT modules and others. The plug-and-play capability (only the gate resistors are missing) makes it ready to operate immediately after mounting. The user needs invest almost no effort in designing or adjusting it to a specific application.

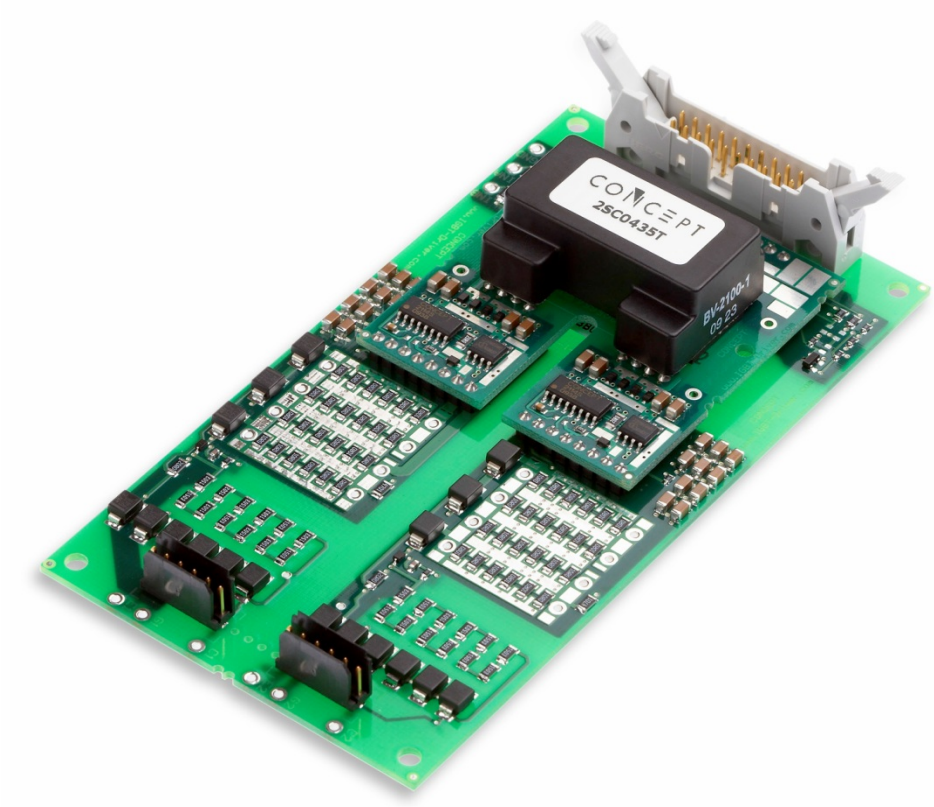

Fig. 1 2BB0435T Base Board with driver 2SC0435T

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System Overview

The 2BB0435T are Base Boards for the driver 2SC0435T. 2SC0435T are SCALE-2 driver cores based on the SCALE-2 technology developed by CONCEPT /1/. This 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 basic topology of the 2BB0435T Base Board is shown in Fig. 2.

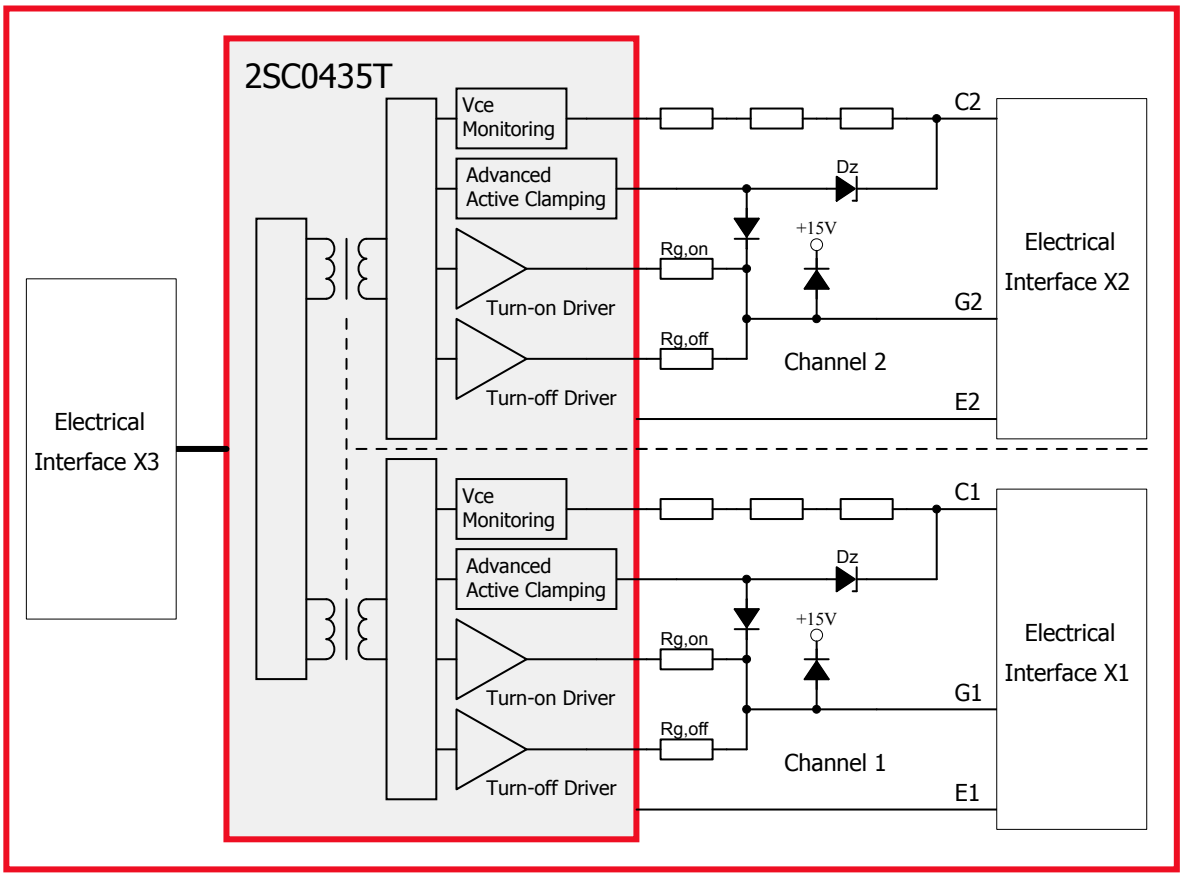


Fig. 2 Basic schematic of the 2BB0435T Base Board with 2SC0435T driver

The Base Board contains all necessary components for optimal and safe driving of IGBT modules or MOSFETs: gate clamping, active-clamping diodes (overvoltage protection at turn-off), Vce monitoring (short-circuit protection) as well as the input electrical connector X3 and both output electrical connectors X1 and X2 to connect the power switch. Moreover, it includes components for setting the turn-off trip level, the response time and the dead time between both channels in half-bridge mode. Its plug-and-play capability means that it is ready to operate immediately after mounting. The user needs invest almost no effort in designing or adjusting the Base Board to a specific application. Only the gate resistors are not assembled in order to provide full flexibility for the user.

For a detailed description of 2SC0435T, please also refer to "Description & Application Manual for 2SC0435T drivers" on www.IGBT-Driver.com/go/2SC0435T.

The Six Steps to Success

The following steps point out the easy way to use 2BB0435T Base Boards in power converters:

1. Choose a suitable Base Board/driver

When applying 2BB0435T Base Boards, you should note that the gate resistors are not assembled. They must be assembled according to the used IGBT module before start of operation.

The type designation of the Base Board also includes a number corresponding to the voltage class of the used power device (see "Ordering Information").

These Base Boards are not valid for IGBT modules of other voltage classes than those specified. Incorrect use may result in failure.

2. Connect the Base Board to the IGBT modules

Any handling of IGBT modules or drivers is subject to the general specifications for protecting electrostatic-sensitive devices according to international standard IEC 60747-1, Chapter IX or European standard EN 100015 (i.e. the workplace, tools, etc. must comply with these standards).

If these specifications are ignored, both IGBTs and drivers may be damaged.

The Base Board can be easily connected to an IGBT module by using the corresponding connectors X1 (channel 1) and X2 (channel 2).

3. Connect the Base Board to the control electronics

Connect the Base Board plug X3 to your control electronics and supply the Base Board with a voltage of +15V.

4. Select the operating mode

The operating mode can be set with input MOD (interface X3: pin 17). For details, see page 12).

5. Check the Base Board function

Check the gate voltage: For the off-state, the nominal gate voltage is specified in the relevant driver data sheet /3/. For the on-state, it is +15V. Also check the input current consumption of the Base Board without clock signals and at the desired switching frequency.

These tests should be performed before installation, as the gate terminals may otherwise not be accessible.

6. Set up and test the power stack

Before starting up the system, it is recommended that each IGBT module be checked separately under power-cycling conditions. It is usually sufficient to apply the single or double-pulse technique. CONCEPT specially recommends users to check that the IGBT modules switch inside the SOA in the worst case condition, as this strongly depends on the specific converter construction.

Even if only single IGBTs are tested, all the system's gate drivers must be supplied with energy. All the other IGBTs are then kept in the off state by applying negative gate voltages. This is particularly important when switching the IGBTs under test.

The short-circuit behavior can also be verified at this point.

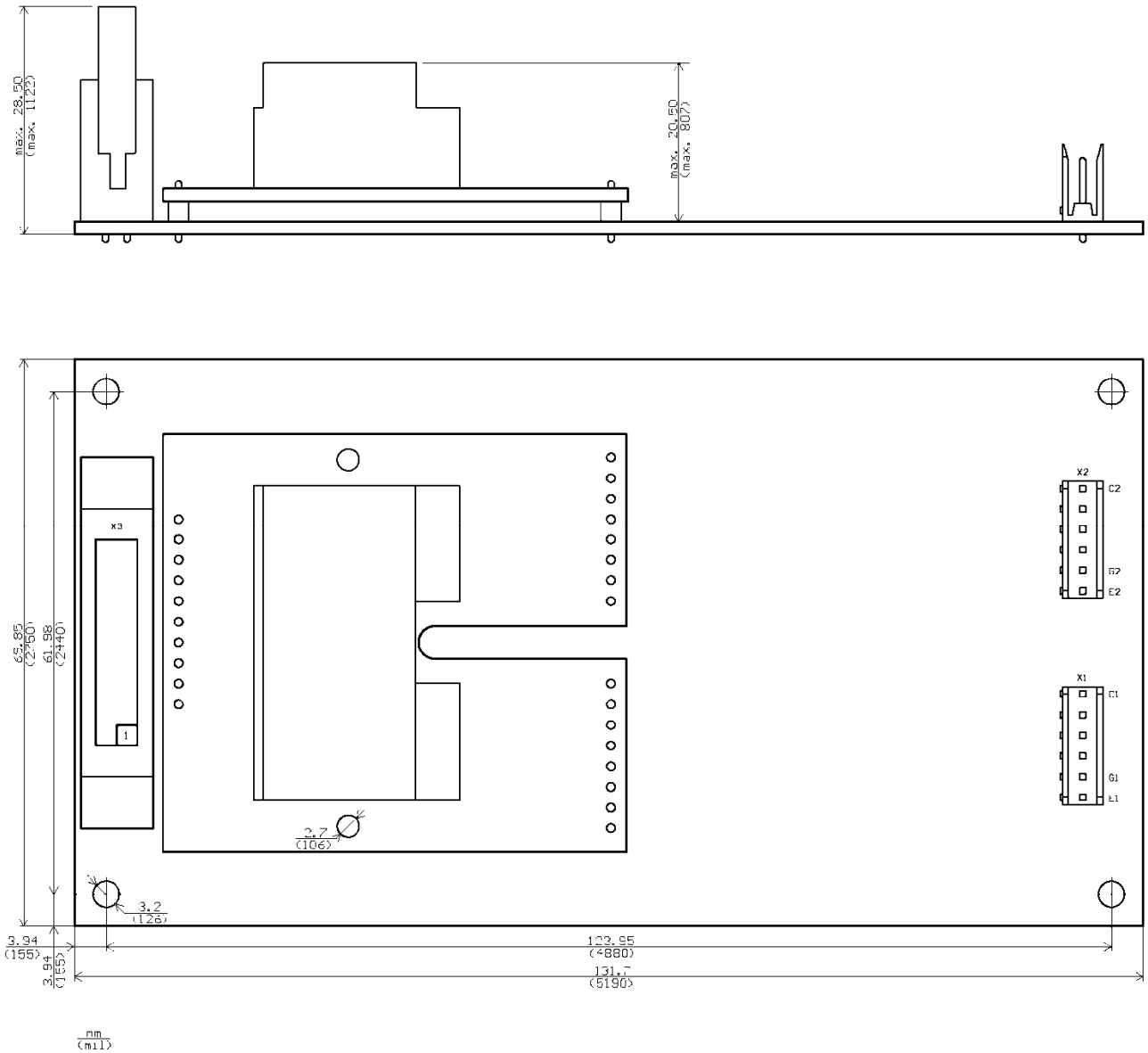
The system is then ready to start under real-world load conditions. This allows the thermal behavior of the whole arrangement to be determined.

The system must be re-qualified over the entire specified range of temperature and load conditions.

CAUTION: All handling with high voltages involves risk to life.

It is imperative to comply with the respective safety regulations!

Mechanical Dimensions



Electrical connector on the Base Board: 71918-120LF from FCI
Recom. cable connector: 71600-020LF from FCI

Recommended twisted pair flat cable: 1700/20 or 2100/20 from 3M™

Fig. 3 Mechanical dimensions of 2BB0435T with 2SC0435T driver (top view)

Recommended Assembly of Components

Recommended components and component values are given in the bill of material included in the production documentation of the Base Boards. However, some components which depend on the voltage class of the power semiconductor used are marked with *** in the schematics and in the bill of material. They are given below. If the Base Boards are ordered by CONCEPT, these components are already assembled.

Note that gate resistor values are not explicitly given as they depend on the power semiconductor used and on the application. The gate resistors must be determined and assembled by the user.

2BB0435T2A0-06

The following components marked with *** in the bill of material are recommended:

D106…D110, D206…D210:	P6SMBJ70A (Semikron) or SMBJ70A-E3 (Vishay)
D111, D211:	P6SMBJ70CA (Semikron) or SMBJ70CA-E3 (Vishay)
R108…R119, R208…R219:	33k
R107, R207	62k

2BB0435T2A0-12

The following components marked with *** in the bill of material are recommended:

D106…D110, D206…D210:	SMBJ130A-E3 (Vishay) or SMBJ130A-TR (ST)
D111, D211:	SMBJ130CA-E3 (Vishay) or P6SMBJ130CA (Diotec)
R108…R119, R208…R219:	150k
R107, R207	120k

2BB0435T2A0-17

The following components marked with *** in the bill of material are recommended:

D106…D110, D206…D210:	P6SMB220A (Diotec) or SMBJ188A-E3 (Vishay)
D111, D211:	P6SMB220CA (Diotec) or SMBJ188CA-E3 (Vishay)
R108…R119, R208…R219:	150k
R107, R207	120k

Assembly Drawing of Gate Resistors

The turn-on and turn-off gate resistors of 2BB0435T Base Boards are not assembled. They must be assembled by the user.
Recommended gate resistors are CRCW1206 / 0.25W / 1% (SMD) from Vishay or PR03 / 3W / 5% (THT).

The component position (SMD) can be found in Fig. 4:

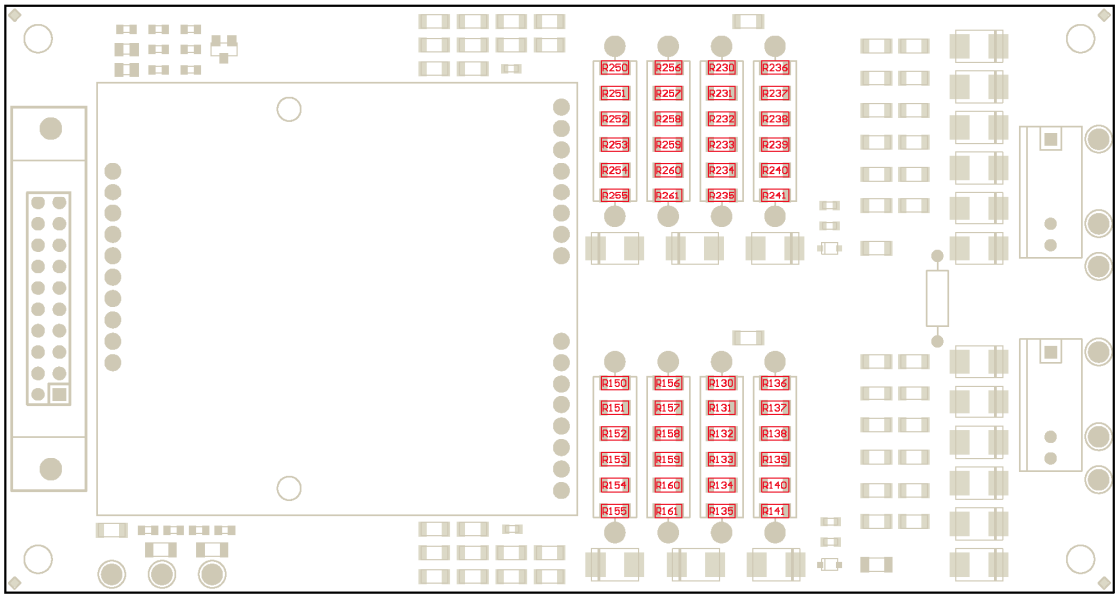


Fig. 4: Assembly drawing of 2BB0435T with highlighted SMD gate resistors
Turn-on gate resistors: R150…R161, R250…R261
Turn-off gate resistors: R130…R141, R230…R241

The component position (THT) can be found in Fig. 5:

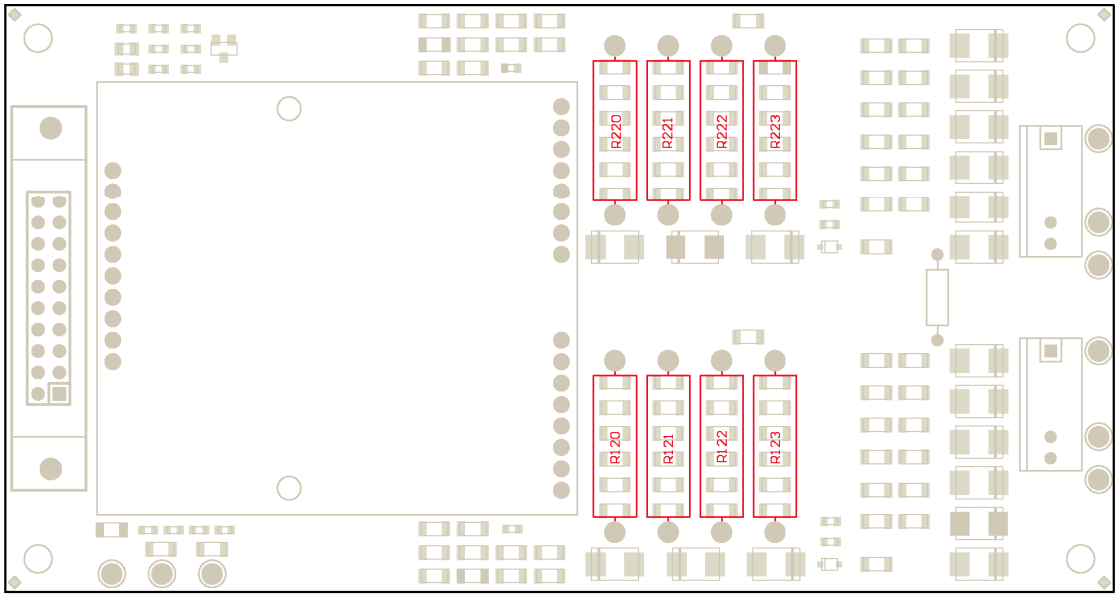


Fig. 5: Assembly drawing of 2BB0435T with highlighted THT gate resistors
Turn-on gate resistors: R120…R121, R220…R221
Turn-off gate resistors: R122…R123, R222…R223

Note that the wires of the THT gate resistors should not project more than 1.6mm after soldering (excess length at bottom side). Furthermore, a minimum distance of 1mm must be maintained between the gate resistor body and the PCB (see Fig. 6).

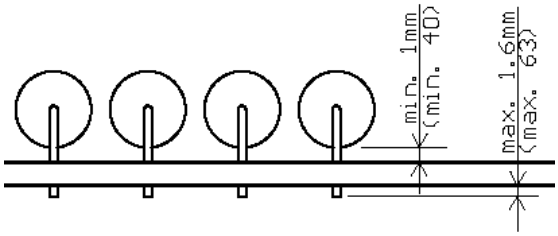


Fig. 6: Minimum and maximum distances when soldering THT gate resistors (in mm/mil)

Pin Designation of Connector X1 and X2

Pin	Des.	Function	Pin	Des.	Function
1	Cx	Collector of channel x	2	N.C.	Not connected
3	N.C.	Not connected	4	N.C.	Not connected
5	Gx	Gate of channel x	6	Ex	Emitter of channel x

Description of Interfaces X1 and X2

X1 and X2 are the connectors to connect the power switch to the channel 1 (X1) resp. channel 2 (X2). Note that the pin assignments 2-4 must remain free (without crimp contact) in order to guaranty sufficient creepage path between both channels.

If the Base Board is used to drive a half-bridge module, it is possible to connect the emitter of channel 2 with the collector of channel1 by soldering a wire or a 0Ω resistor on BR1. If BR1 is not assembled, both Base Board channels are galvanically independent.

Pin Designation of Connector X3

Pin	Des.	Function	Pin	Des.	Function
1	VDC	+15V for DC/DC converter	2	GND	Ground
3	VDC	+15V for DC/DC converter	4	GND	Ground
5	VCC	+15V for primary side electronics	6	GND	Ground
7	VCC	+15V for primary side electronics	8	GND	Ground
9	SO2	Status output channel 2	10	GND	Ground
11	INB	Signal input B	12	GND	Ground
13	SO1	Status output channel 1	14	GND	Ground
15	INA	Signal input A	16	GND	Ground
17	MOD	Mode selection (direct/half-bridge)	18	GND	Ground
19	TB	Blocking time	20	GND	Ground

Recommended Interface Circuitry for Connector X3

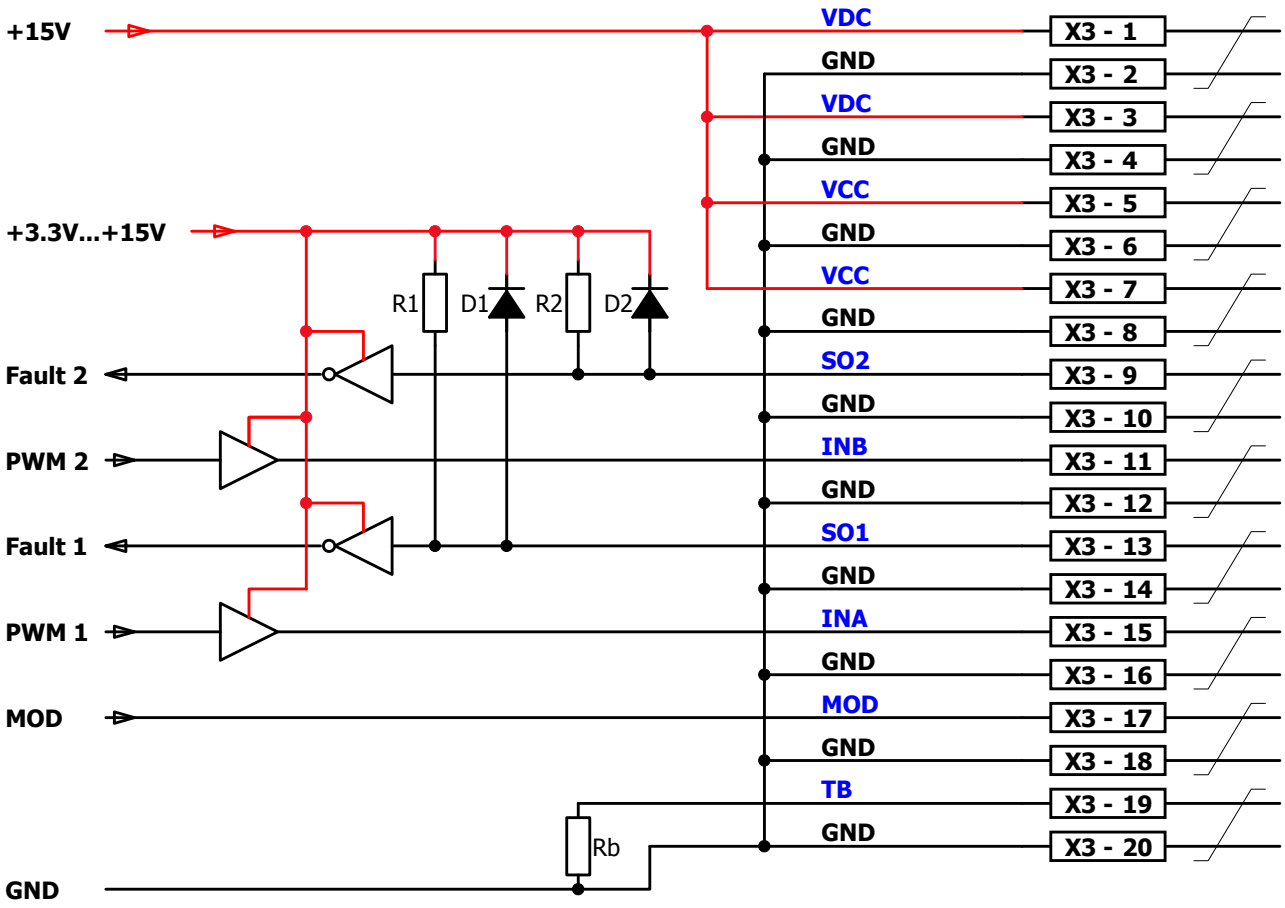


Fig. 7 Recommended user interface of 2BB0435T

Description of Interface X3

General

The standard DIC20 interface X3 of the Base Board 2BB0435T is very simple and easy to use. It has the following terminals:

- 4 x power-supply terminals (but only one 15V power supply is needed)
- 2 x drive signal inputs
- 2 x status outputs (fault returns)
- 1 x mode selection (half-bridge mode / direct mode)
- 1 x input to set the blocking time

The Base Board is equipped with a 20-pin interface connector. All even-numbered pins are used as GND connections. The odd-numbered pins are used as inputs or status outputs. It is recommended to use a 20-pin twisted flat cable. Each input and output signal is then twisted with its own GND wire. All GND pins are connected together on the 2BB0435T Base Board and should also be connected on the control-board side. This arrangement produces a very low-inductance connection with high immunity against interferences.

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

MOD (mode selection)

The MOD input allows the operating mode to be selected.

Direct mode

If the MOD input is not connected (floating), or connected to VCC, direct mode is selected.

Half-bridge mode

If the MOD input is low level (connected to GND), half-bridge mode is selected. The dead time is set by a resistor on the 2BB0435T.

TB (input for adjusting the blocking time)

The terminal TB allows the factory-set blocking time to be reduced by connecting an external resistor to GND (see Fig. 7). The following equation calculates the necessary resistor R_b connected between pins TB and GND in order to define the desired blocking time T_b (typical value):

$$R_b[k\Omega] = \frac{7650 + 150 \cdot Tb[ms]}{99 - Tb[ms]} - 6.8 \quad \text{where} \quad 20\text{ms} < T_b < 90\text{ms}$$

The blocking time can also be set to a minimum of 9µs by selecting R_b=0Ω.

If not used, the input TB can be left open.

How Do 2BB0435T Base Boards Work in Detail?

Overview

All drivers of the SCALE-2 driver family with an electrical interface are equipped with usual protection functions such as V_{ce} monitoring for short-circuit protection, operation inhibit after fault, supply-undervoltage shutdown and status feedback.

Outstanding features of 2BB0435T Base Boards are: compact size, simple mounting - directly to the IGBT module over the interfaces X1/X2, Advanced Active-Clamping function, very low propagation delay time. Active clamping describes an active scheme designed to protect the IGBTs against overvoltage during turn-off. It is particularly relevant when turning an IGBT off in cases of high DC-link voltage and collector current or short circuit. The 2BB0435T Base Boards also allow parallel operation of IGBT modules in order to increase the system power (see "Parallel connection of 2BB0435T" on page 14).

V_{ce} monitoring / short-circuit protection

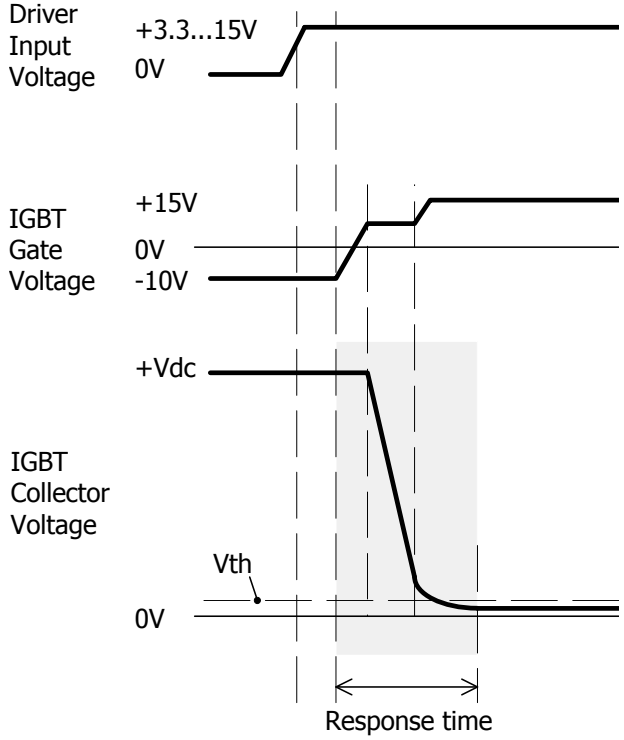


Fig. 8 Turn-on characteristic of an IGBT

The basic V_{ce} monitoring circuit implemented in 2BB0435T SCALE-2 Base Boards is illustrated in Fig. 2. Both IGBT collector-emitter voltages are measured with a resistor network. V_{ce} is checked after the response time (see Fig. 8) at turn-on to detect a short circuit. If this voltage is higher than the programmed threshold Vth, the driver detects a short circuit at the IGBT and signals it immediately to the corresponding SOx output. The corresponding IGBT is immediately switched off. The IGBT is kept off (non-conducting) and the fault is shown at pin SOx as long as the blocking time is active.

The blocking time is applied independently to each channel. It starts when V_{ce} exceeds the threshold of the V_{ce} monitoring circuit.

It should be noted that the response time increases at DC-link voltages lower than about 550V (1200V and 1700V versions) or 400V (600V version). Please read the Base Board data sheet for timing information /4/.

Note: The desaturation function is for short-circuit detection only and cannot provide overcurrent protection. However, overcurrent detection has a lower time priority and can be easily provided by the application.

Advanced Active Clamping

Active clamping is a technique designed to partially turn on the IGBT in case the collector-emitter voltage exceeds a predefined threshold. The IGBT is then kept in linear operation. The basic circuit for active clamping can be found in /5/.

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 2BB0435T Base Boards support CONCEPT's Advanced Active Clamping based on this principle: when active clamping is activated, the turn-off MOSFET of the driver is switched off in order to improve the effectiveness of the active clamping and to reduce the losses in the TVS. This feature is mainly integrated in the secondary-side ASIC.

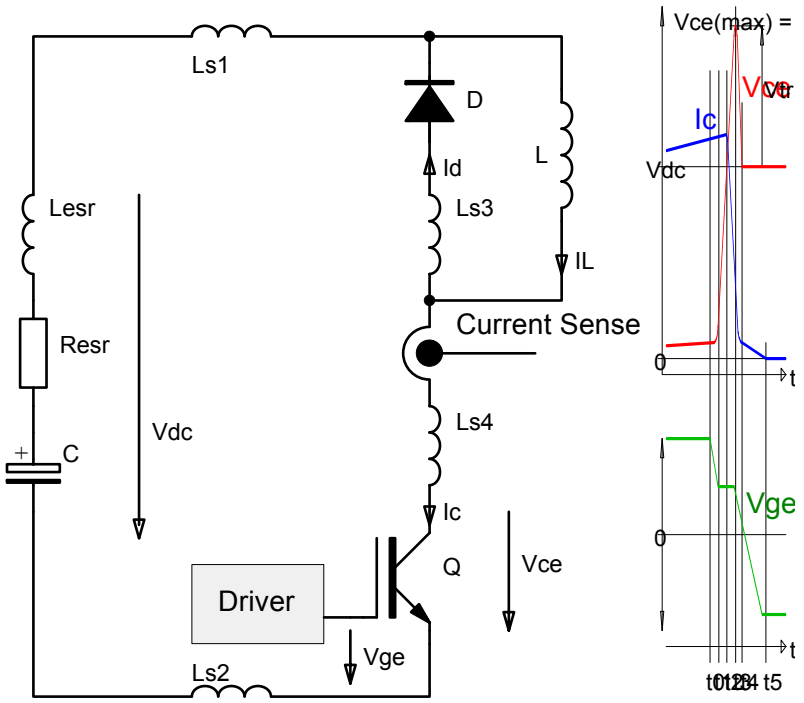


Fig. 9 Test circuit (left) and typical switching behavior (right)

Legend to Fig. 9

t0 = Initiation of the turn-off process
t1 = Start of turn-off time
t2 = Start of collector current fall time
t3 = Maximum collector voltage
t4 = IGBT is blocking, start of tail current
t5 = End of tail current

In comparison with other driving methods, active clamping allows enhanced utilization of the IGBT modules during normal operation by increasing the switching speed and therefore reducing switching losses. The overvoltage at fault-current turn-off is also managed by active clamping. For the maximum permitted DC-link voltage, refer to the Base Board data sheets /4/.

Parallel connection of 2BB0435T

If parallel connection of 2BB0435T Base Boards is required, please refer to the application note AN-0904 /7/ on www.IGBT-Driver.com/go/app-note and to /6/.

3-level and multilevel topologies

If 2BB0435T Base Boards are to be used in 3-level or multilevel topologies, please refer to the application note AN-0901 /8/ on www.IGBT-Driver.com/go/app-note.

Low-inductance layout

The active-clamping function should not lead anyone to forget about the inductances of the power stack. For several reasons, it is recommended to reduce the DC-link stray inductance to about 30nH…100nH depending on the IGBT modules used with 2BB0435T Base Boards.

Bibliography

/1/ "Smart Power Chip Tuning", Bodo's Power Systems, May 2007

/2/ "Description and Application Manual for SCALE Drivers", CONCEPT

/3/ Data sheets SCALE-2 driver core 2SC0435T, CONCEPT

/4/ Data sheets Base Board 2BB0435T, CONCEPT

/5/ "Advantages of Advanced Active Clamping", Power Electronics Europe, November/December 2009

/6/ "Intelligent Paralleling", Bodo's Power Systems, March 2009

/7/ Application note AN-0904: Direct Paralleling of SCALE-2 Gate Driver Cores, CONCEPT

/8/ Application note AN-0901: Methodology for Controlling Multi-Level Converter Topologies with SCALE-2 IGBT Drivers, CONCEPT

Note: These documents are available on the Internet at www.IGBT-Driver.com

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 needs. 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 25 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.

CONCEPT Base Board Type #	Related IGBTs
2BB0435T2A0-06	600V IGBT modules
2BB0435T2A0-12	1200V IGBT modules
2BB0435T2A0-17	1700V IGBT modules

Note that the Base Boards 2BB0435T2A0-xx are delivered without driver 2SC0435T and without gate resistors. For orders of 1000 pieces or more (per delivery) the Base Board can be assembled with the driver 2SC0435T and the required gate resistors.

Product home page: www.IGBT-Driver.com/go/2BB0435T

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

Information about Other Products

For drivers adapted to high-voltage or high-power IGBT modules

Direct link: www.IGBT-Driver.com/go/plug-and-play

For other drivers, evaluation systems product documentation and application support

Please click onto: www.IGBT-Driver.com

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