

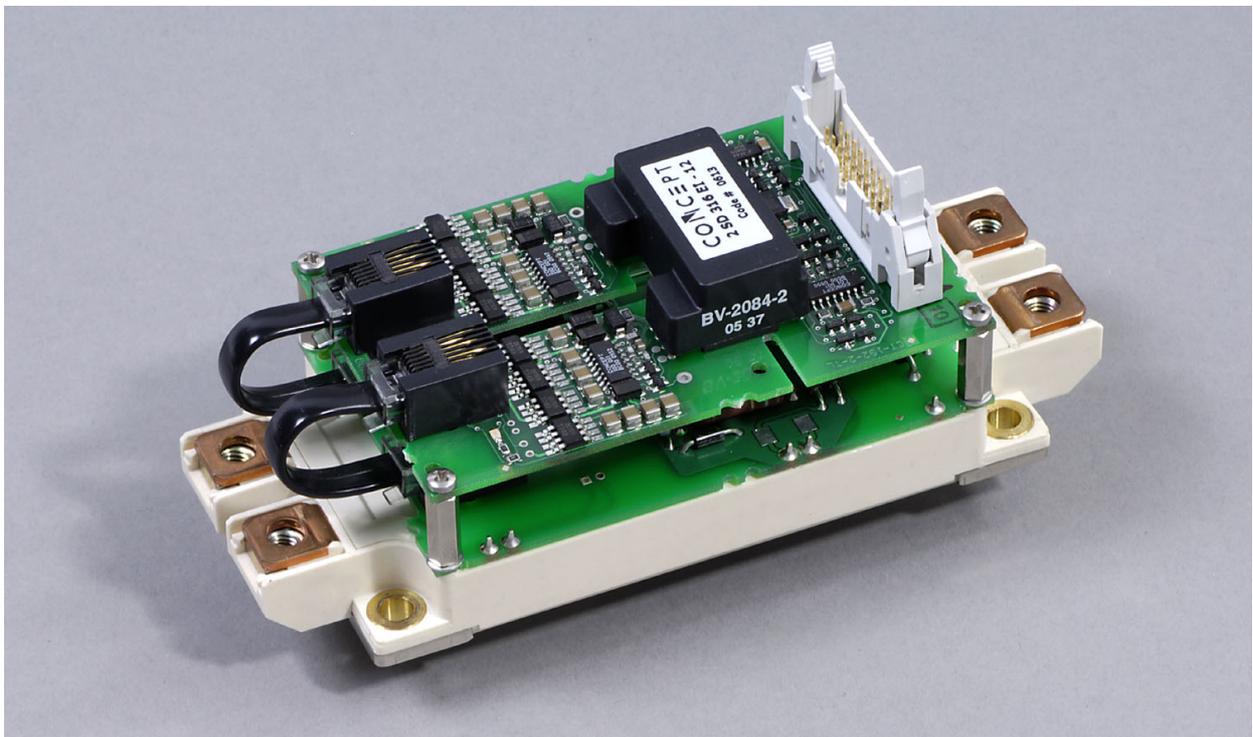
## Description and Application Manual

### Dual-Channel Plug-and-play SCALE IGBT Driver 2SD316EI for EconoDual IGBT Modules

#### Abstract

The 2SD316EI is a dual-channel driver based on CONCEPT's proprietary SCALE chipset, a proven technology for the reliable driving and safe operation of IGBTs.

The driver is matched to EconoDual IGBT modules. Its plug-and-play capability makes it ready to operate immediately after mounting. The user need invest no effort in designing or adjusting it to a specific application.



*Fig. 1 2SD316EI driver and basic board screwed onto a EconoDual IGBT module*

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## System Overview

The standard package of EconoDual modules covers several voltage and current ratings (e.g. 150, 225, 300, and 450A at 1200 and 1700V). Some driver parameters must therefore be matched to the relevant module. As shown in Figs. 1 and 2, this is done by placing all specific components on a separate basic board which is completely assembled and tested by CONCEPT. (The customer must order the basic board corresponding to the relevant IGBT module.)

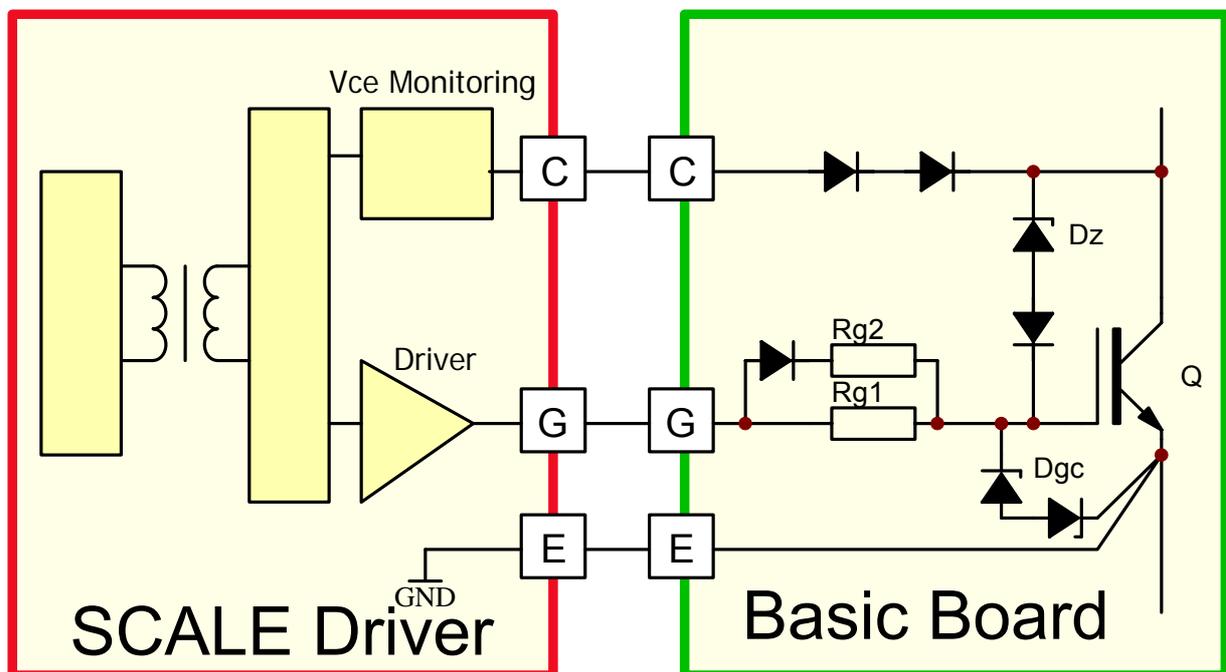


Fig. 2 Separation of universal (left) and IGBT-specific functions (right)

The basic board contains all gate resistors, gate-clamping and active-clamping diodes (overvoltage protection) as well as the diodes for the collector-sense function (surge-current and short-circuit protection). Moreover, it includes components for setting the turn-off trip level and the response time. It contains only the usual through-hole components and can consequently be easily adjusted by the user to fit any special needs and applications.

The 2SD316EI driver is a complex PCB equipped with SMD components such as CONCEPT's proprietary chipset. It is mounted on top of the relevant basic board by means of spacer bolts. The standardized 2SD316EI driver matches all modules within the EconoDual series. It is based on the proven SCALE technology developed by CONCEPT and implemented more than a hundred thousand times. For further information on this technology, refer to /1/ and /2/.

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**The Eight Steps to Success**

The following steps point out the easy way to design high-power converters by using 2SD316EI drivers with EconoDual modules:

**1. Calculate the power dissipation of the IGBT modules**

First choose the EconoDual IGBT module suited for your application and determine its specific on-state and switching losses. This data is used to approximate the size of the required heat sink.

**2. Choose a suitable driver / basic board pair**

When applying 2SD316EI drivers for EconoDual modules, you should note that the basic boards are specifically adapted to a particular type of IGBT module.

The type designation of the basic board consequently also includes the type designation of the corresponding module.

**These basic boards are valid only for the specified IGBT modules. Neglect of this warning may lead to failure.**

**3. Design the power stack**

When designing a power stack, be sure to minimize the parasitic inductances.

To speed-up your startup with 2SD316EI drivers for EconoDual modules, CONCEPT offers ready-to-use evaluation systems; see page **Fehler! Textmarke nicht definiert..**

Some key issues relating to component selection are discussed in /4/.

**4. Attach the drivers 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 747-1, 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.**

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The driver can be easily mounted onto an IGBT module by soldering the basic board pins. The driver is then screwed onto the basic board by means of the spacer bolts.

The connection between the SCALE driver and the basic board is made by two modular cables. Be sure to verify that the connectors are properly snapped-in.

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### 5. Connect the driver to the control electronics

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Connect the driver plug X1 to your control electronics and supply the driver with a voltage of +15V.

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### 6. Select the operating mode

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The operating mode can be set with input *MOD* (interface *X1*: pin 17). For details, see page 9.

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### 7. Check the driver function

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Check the gate voltage: For the off-state, the nominal gate voltage is –15V. For the on-state, it is +15V. Also check the input current consumption of the driver without clock signals and at the desired switching frequency.

It is recommended that these tests be performed before installation, as the gate terminals may otherwise not be accessible.

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### 8. Set-up and test the power stack

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Before starting up the system, you are recommended to check each IGBT module separately under power-cycling conditions. It is usually sufficient to apply the single or double-pulse technique.

The short-circuit behavior can now be verified.

After this step, the system is ready to start under real-world load conditions. This allows the thermal behavior of the whole arrangement to be determined. The system must now be re-qualified over the entire specified range of temperature and load conditions.



**CAUTION: The data contained in this product description is intended exclusively for technically trained staff. Handling all high-voltage equipment involves risk to life. Strict compliance with the respective safety regulations is mandatory!**

### Pin Designation of SCALE Driver 2SD316EI

#### Pin designation of interface X1

1	VDC (+15V for DC/DC converter)	2	GND
3	VDC (+15V for DC/DC converter)	4	GND
5	VDD (+15V for electronic input side)	6	GND
7	VDD (+15V for electronic input side)	8	GND
9	SO2 (Status output channel 2)	10	GND
11	InB (Input B)	12	GND
13	SO1 (Status output channel 1)	14	GND
15	InA (Input A)	16	GND
17	Input Mod (mode selection)	18	GND
19	ResetQ	20	GND

#### Recommended Interface Circuitry

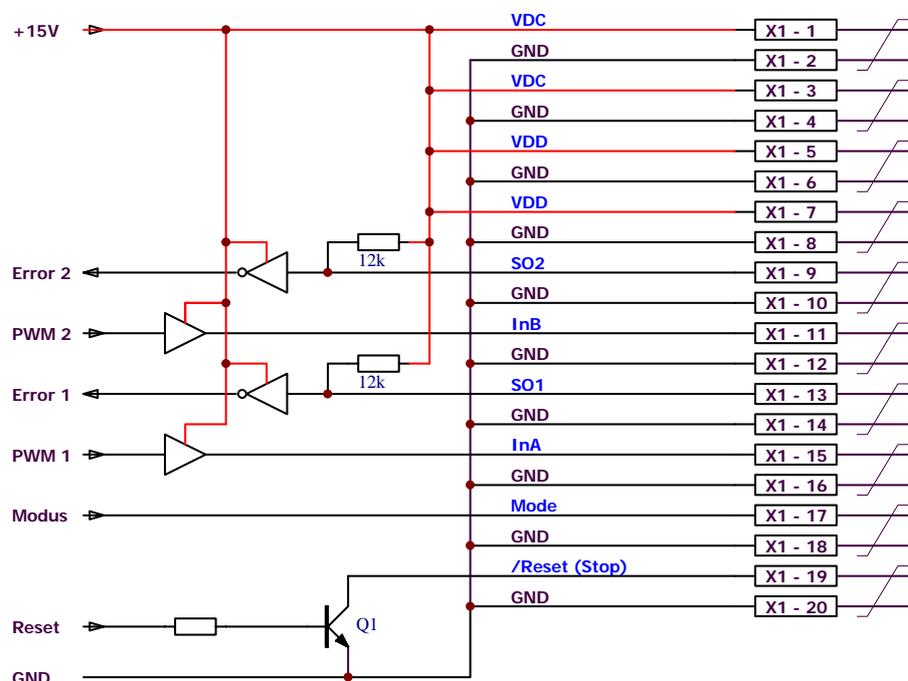


Fig. 3 Recommended user interface of 2SD316EI drivers for EconoDual modules

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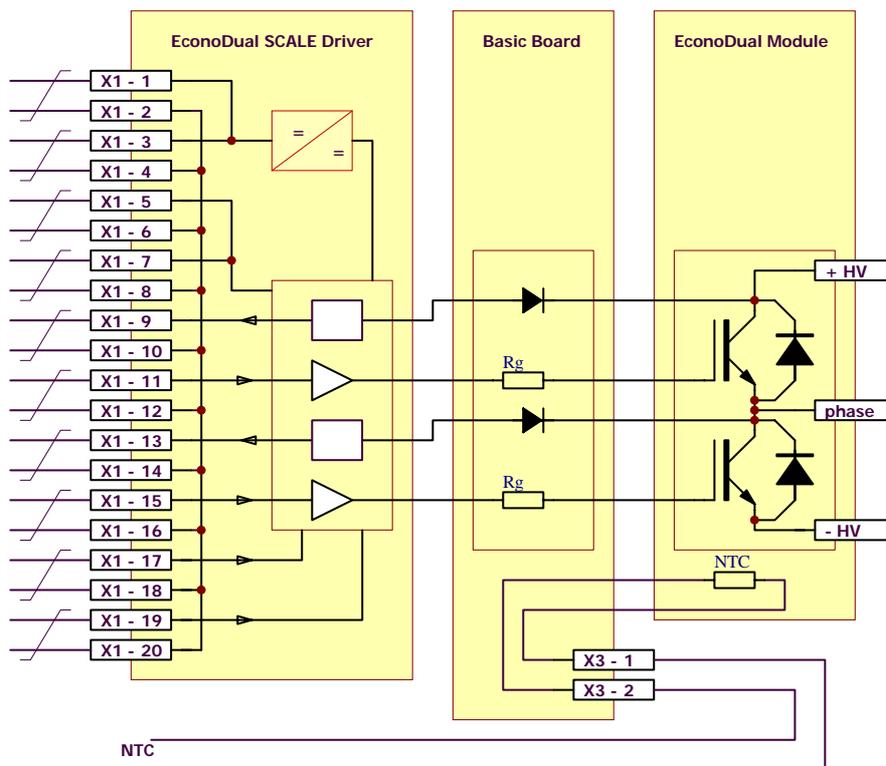


Fig. 4 Block diagram covering SCALE driver, basic board and IGBT module

## Description of Interface X1

### General

The interface of the 2SD316EI driver is very simple and easy to use.

The driver has the following terminals:

- 2 x PWM inputs (drive signals)
- 2 x status outputs (failure returns)
- 4 x power-supply terminals (but only one 15V power supply is needed)
- 1 x reset input
- 1 x mode selection (half-bridge mode / direct mode)

The driver 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 SCALE driver and should also be connected on the control-board side. This arrangement produces a very low-inductance connection with high immunity against interference.

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For improved noise immunity, the driver's input signals have 15V levels. (The 5V operating mode of the SCALE chipset is not available for this driver.)

All inputs have Schmitt-trigger characteristics and are ESD-protected by diodes.

### VDC terminals

The driver has two *VDC* terminals on the interface connector. In normal operation, these terminals are connected together to the common +15V voltage supply.

### VDD terminals

The driver has two *VDD* terminals on the interface connector. In normal operation, these terminals are connected together to the common +15V voltage supply.

*VDD* and *VDC* terminals can be connected to a single +15V power supply.

### Mod (input, mode selection)

The *Mod* input allows the operating mode to be selected.

### Half-bridge mode

If input *Mod* is low (connected to GND), half-bridge mode is selected, see Fig. 5. In this mode, the inputs *InA* and *InB* have the following functions: *InA* is the PWM signal input while *InB* acts as the enable input.

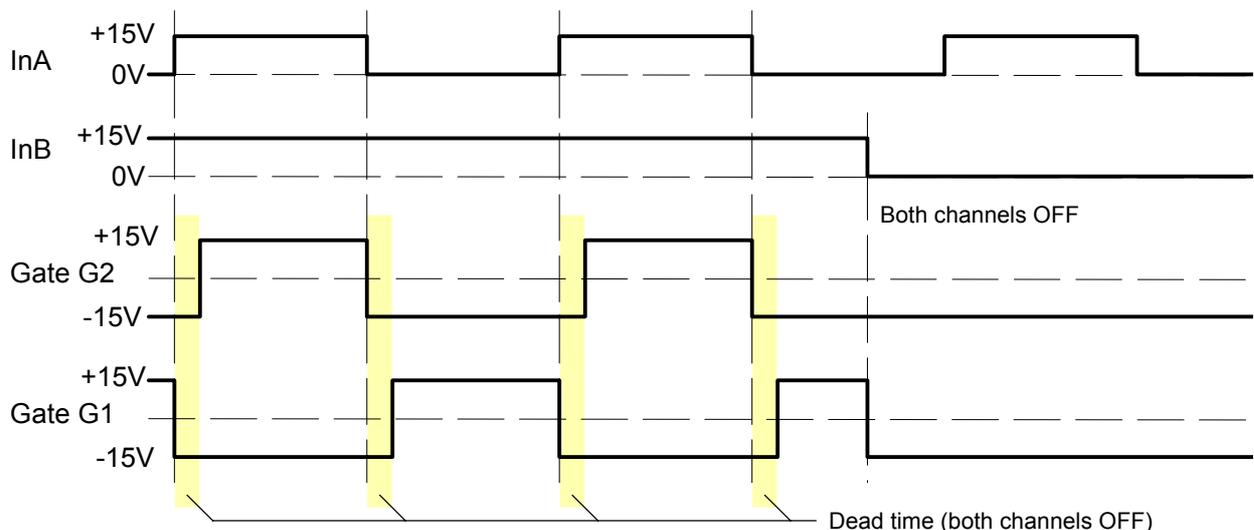


Fig. 5 Signals in half-bridge mode

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When input *InB* is low, both channels of the half-bridge 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 1 turns off immediately and channel 2 turns on after a dead time. The dead times are set by RC networks on the SCALE driver.

### Direct mode

If input *Mod* is high (connected to VDD), direct mode is selected. In this mode, there is no interdependence between the two channels. Input *InA* directly influences channel 1 (low-side IGBT) while *InB* influences channel 2 (high-side IGBT). High 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. In this mode, both channels can be driven either synchronously or with overlapping timing (i.e. for parallel resonance converters).

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

The input *Mod* has a built-in 4k7 pull-up resistor and Schmitt-trigger characteristics.

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### *ResetQ* (input)

The terminal *ResetQ* has a built-in 4k7 pull-up resistor and Schmitt-trigger characteristics. If not used, it can be either left open or connected via an additional pull-up resistor to VDD.

If the terminal *ResetQ* is pulled down (by transistor Q1) to GND, then:

- a) The error memory of the driver (in the interface chip LDI 001) is reset, assuming that it had been set earlier
- b) Both driver channels are blocked (both IGBTs are turned off)

The error memories are initially set when the SCALE driver starts up. They can be reset by temporarily connecting the input *ResetQ* to GND (after start-up, controlled by a power-up signal). An automatic reset is then applied at the first edge of the drive signals provided that the blocking time has already elapsed (on both channels). So it is recommended to wait approx. 2 seconds after connecting the supply voltage (VDD and VDC) to the driver before applying signals to the inputs *InA* or *InB*.

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### *InA*, *InB* (drive inputs, e.g. PWM)

These are basically PWM inputs, but their function depends on the *Mod* input (see above). These inputs only accept 15V logic (designed for high noise immunity). They have built-in 4k7 pull-down resistors and Schmitt-trigger characteristics.

**SOx (status outputs)**

The outputs *SOx* have open-collector transistors (see Fig. 6). When an error condition is detected in channel “x”, the output goes to low (connected to GND). Otherwise, the output has high impedance.

Both *SOx* outputs can be connected together to provide a common error signal. However, it is recommended to evaluate the status signals individually to allow a fast and precise failure diagnosis.

The outputs *SOx* can be connected to the +5V...+15V power supply via a pull-up resistor (the voltage at *SOx* must not exceed the VDD level). The outputs *SOx* can handle a maximum current of 1.5 mA. To ensure a clean logic signal, it is recommended to apply a filter and a Schmitt trigger gate to *SOx*.

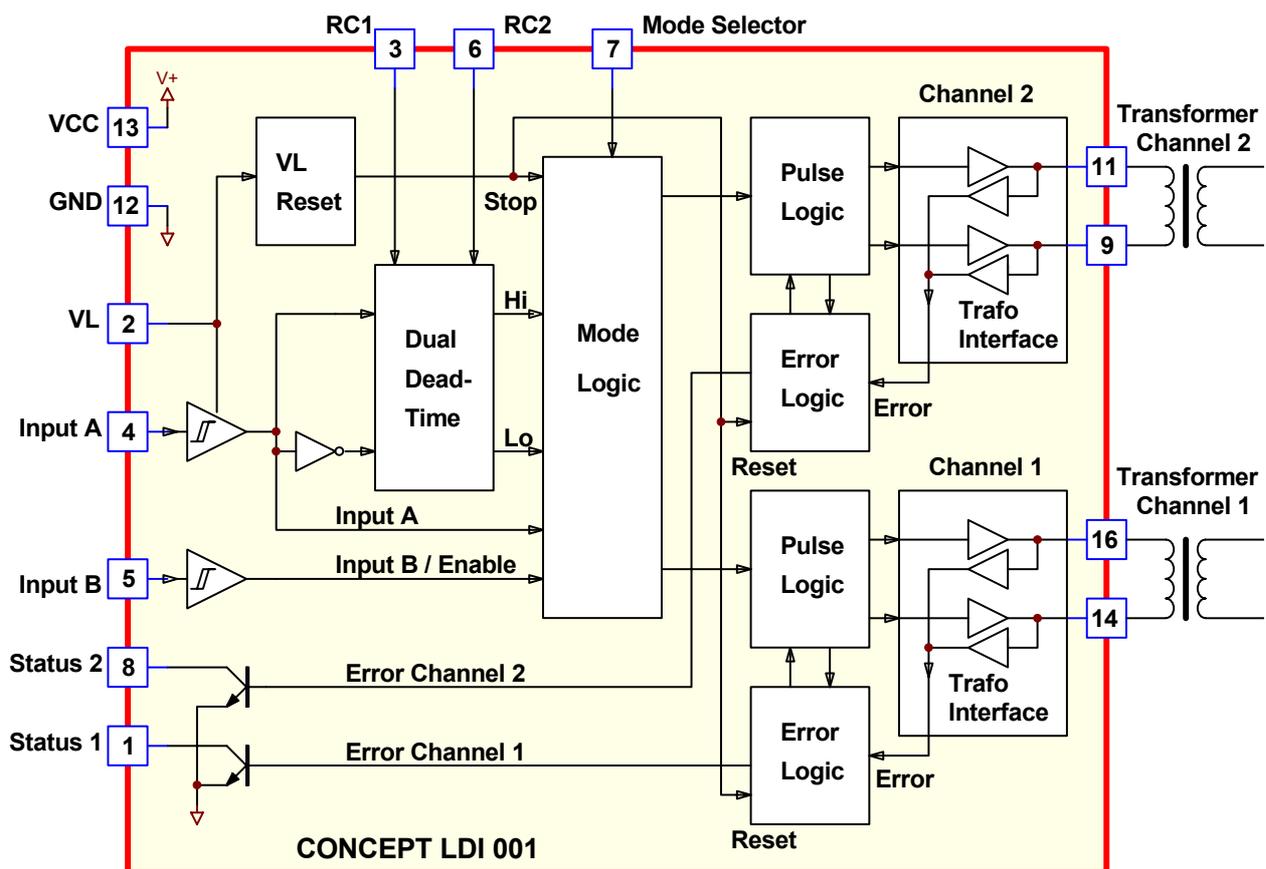


Fig. 6 Block diagram of the LDI 001

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### How the status information is processed

Each transition in a drive signal leads to:

- a) An error-memory reset of LDI 001
- b) Transfer of status information from IGD 001 to LDI 001
- c) If a failure is detected by IGD 001 (during the blocking time), the error memory in LDI 001 is set.

### External reset

The error memory may also be reset by temporarily connecting the input *ResetQ* to GND. Under a failure condition, the error memory is set with the next transition of the input signal.

### LED-Status Indicators (channel-status indicators)

To facilitate verification, the driver is equipped with green status LEDs (for each of both channels). They are located on the SCALE driver close to the output connectors (refer to Fig. 1) and light up under normal operation. A turned-off LED means that the respective channel is either inactive or is not supplied with VDC voltage. Moreover, under failure conditions, the driver is blocked for approx. 1 second, thus switching the LEDs to their off-state for the same period.

Note that verification, in particular of sporadic malfunctions, is impaired when the status outputs are connected together. It is therefore recommended to check both *SOx* signals individually and to use the information supplied by the respective status LEDs.

### Basic Board: The Plug-and-Play Adapter Board

The basic board contains all gate resistors, gate-clamping and active-clamping diodes (overvoltage protection) as well as the diodes for the collector-sense function (and short-circuit protection). Moreover, it also includes components for setting the turn-off trip level and the response time.

When applying 2SD316EI drivers for EconoDual modules, you should note that the basic boards are adapted to a particular type of IGBT module. The type designation of the basic board consequently also includes the type designation of the corresponding IGBT module.

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**These basic boards are valid only for the specified IGBT modules. Neglect of this warning may lead to failure.**

The driver is adapted to EconoDual IGBT modules. Its plug-and-play capability means that it is ready to operate immediately after mounting. The user need not invest any effort in designing or adjusting the driver to a specific application. The basic board contains only the usual through-hole components and can therefore be easily adjusted by the user to fit any special needs and applications.

The basic boards are assembled with the smallest possible gate resistor in order to minimize switching losses.

### Protection Concept

Only a brief overview will now be given of the functions of the SCALE driver chipset used here. For further information about the chipset, refer to /1/.

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### Power-supply monitoring

An under-voltage monitoring circuit blocks the driver if the supply voltage drops below about 10...11V. In this case, the IGBT is driven with a negative gate voltage to keep it in the off-state. A failure condition is transmitted.

The monitoring is performed locally on each channel (integrated in the IGD 001).

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### Short-circuit and overcurrent protection

Each channel of a SCALE driver is equipped with a  $V_{ce}$ -monitoring circuit. The circuit is inactive during the response time applied to ensure that the IGBT is fully turned on (see Fig. 7).

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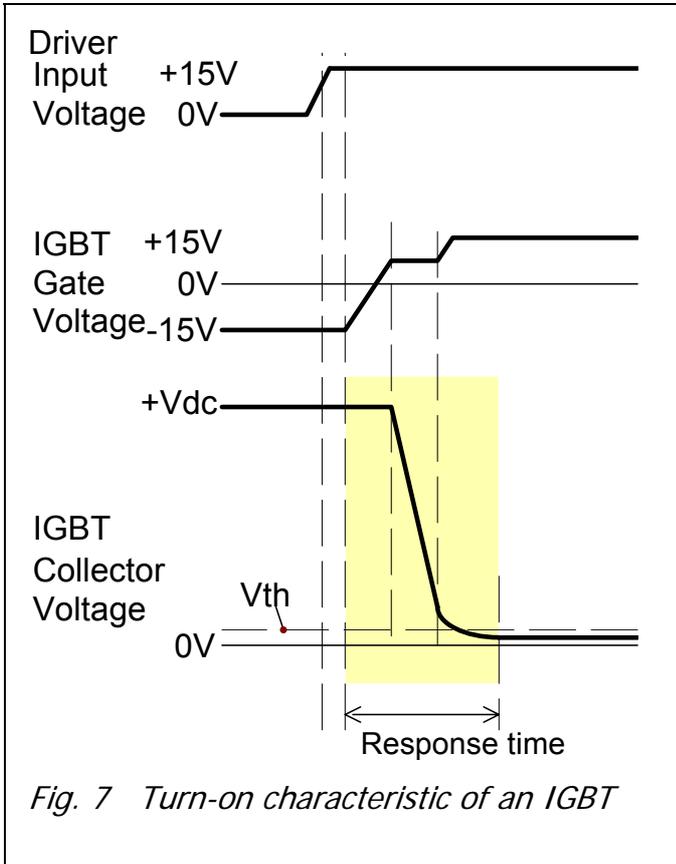
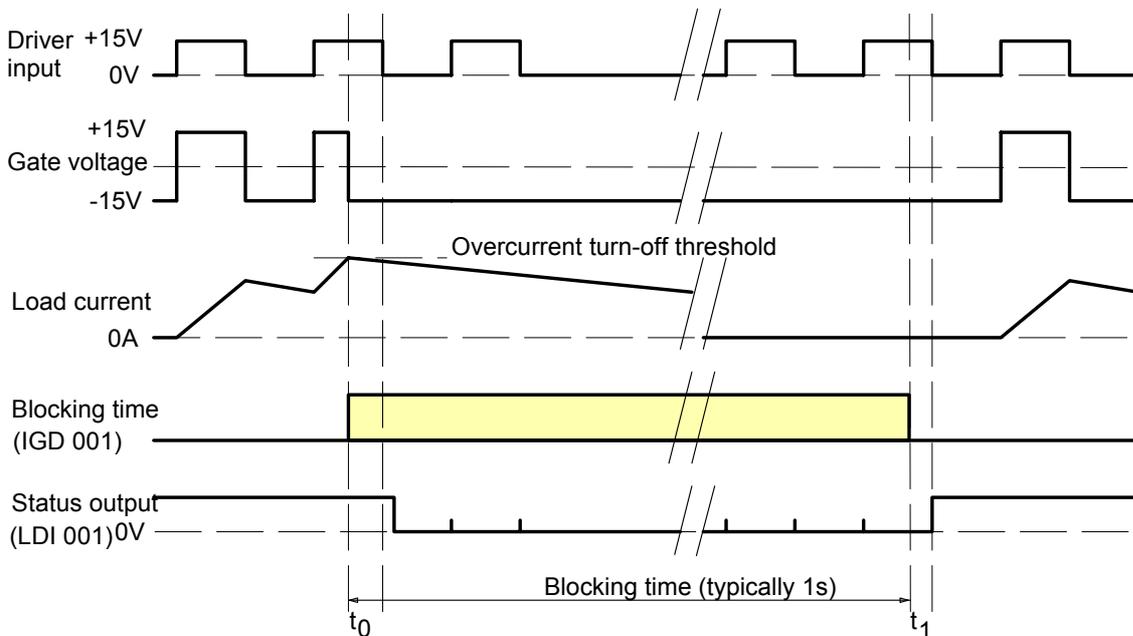


Fig. 7 Turn-on characteristic of an IGBT

In the event of failure due to  $V_{ce}$  monitoring or power-supply under-voltage lock-out, the IGBT is kept in the off-state for a blocking time during which all drive signals are ignored. The blocking time is applied independently to each channel by IGD 001. It starts when  $V_{ce}$  exceeds the threshold of the  $V_{ce}$ -monitoring circuit. With the next transition of the drive signal, the "error" information is transferred for storage to the LDI 001, whose respective status output  $SOx$  goes to low. The driver then ignores any drive signal. The error information is reset only at a first transition in the drive signal after expiry of the blocking time. This automatic reset is shown in Fig. 8. The error memories can also be reset by temporarily pulling the *ResetQ* terminal to GND.



$t_0$  = Power-transistor turn-off in case of overcurrent  $t_0 - t_1$  = Blocking time (all input signals are ignored)

Fig. 8 Short-circuit and overcurrent protection. Automatic reset of the failure condition after expiry of the blocking time

## Active clamping

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Simple gate driving leads to the typical turn-off transition shown in Fig. 9. Turn-off with a specified minimum gate resistance is critical, particularly for trench-gate IGBT chips (such as those used in EconoDual modules), due to the high rate of decrease of the collector current. To minimize turn-off losses, therefore, the 2SD316EI features an active clamping function. This technique is designed to turn the IGBT on partially whenever the collector-emitter voltage exceeds a predefined threshold. The IGBT is then kept in linear operation. The basic circuitry is shown in Fig. 10.

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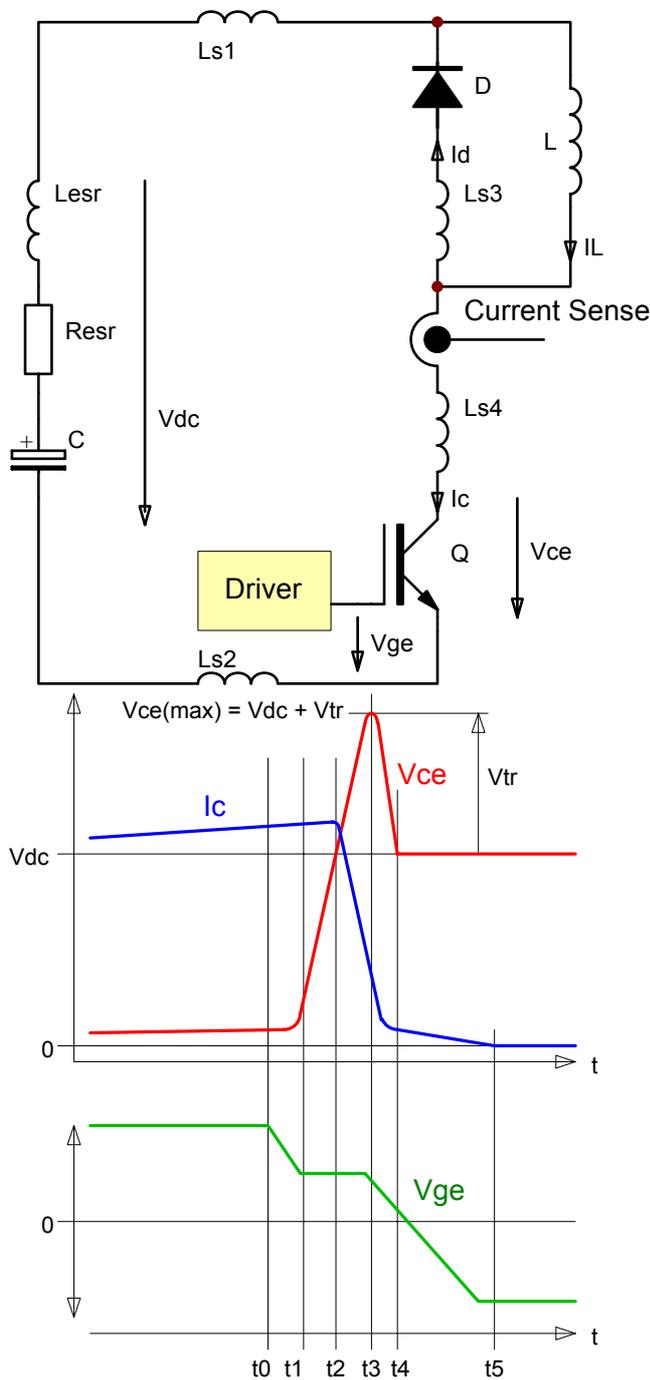


Fig. 9 Test circuit (left) and typical switching characteristics (right)

Legend to Fig. 9

- $t_0$  = Initiation of the turn-off process
- $t_1$  = Start of collector-emitter voltage rise
- $t_2$  = Start of collector current drop
- $t_3$  = Maximum collector-emitter voltage

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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 thus reducing switching losses. Furthermore, active clamping manages the over-voltage under changed operating conditions.

The active clamping function should not lead the user to forget about the inductances of the power stack.

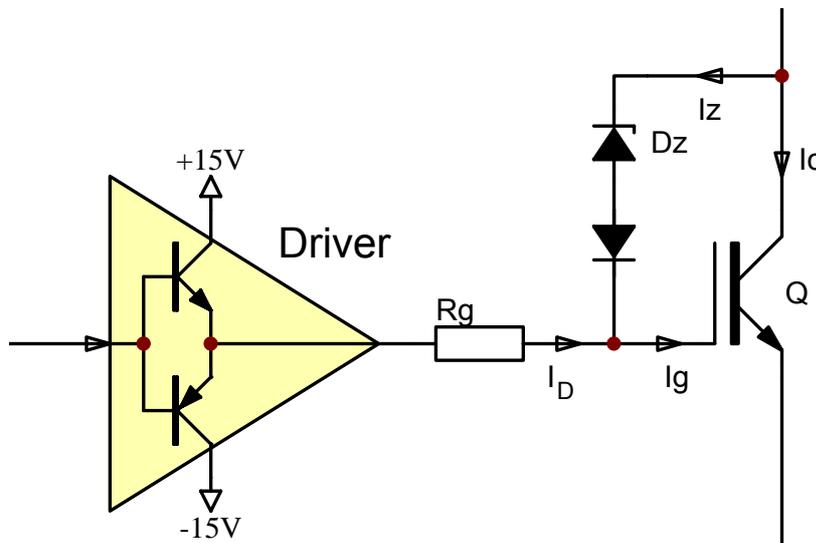


Fig. 10 Basic circuitry for active clamping

**Bibliography**

- /1/ Description and Application Manual for SCALE Drivers, CONCEPT
- /2/ The "SCALE" IGBT Driver, a new, scalable, compact, all purpose, low cost, easy-to-use driver for IGBTs, H. Rüedi & P. Köhli, PCIM 1998 Proceedings
- /3/ Modular SCALE Driver Solution for EconoPACK+, H. Rüedi, PCIM 2001 Proceedings
- /4/ Development of Modular High-Power IGBT Stacks, H. Rüedi & D.Tollik, PCIM 2001 Proceedings

**Note:** These papers are available on the Internet at [www.IGBT-Driver.com/go/papers](http://www.IGBT-Driver.com/go/papers)

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### **The Information Source: SCALE 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](http://www.IGBT-Driver.com)

### **Quite Special: Customized SCALE 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 engineers have more than 20 years experience in the development and manufacture of intelligent gate drivers for power MOSFETs and IGBTs and have already implemented a large number of customized solutions.

### **Evaluation Systems**

The evaluation systems used with EconoDual modules are designed particularly for development, verification, qualification and testing. They contain IGBTs, driver boards and DC-link capacitors, completely mounted and 100% tested. CONCEPT offers systems with various heat sinks or without coolers.

For details see: [www.IGBT-Driver.com/go/EconoDual](http://www.IGBT-Driver.com/go/EconoDual)

### **Customer-Specific Systems**

CONCEPT develops and produces complete power equipment and systems according to the customer's specifications.

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### Consulting and Training

CONCEPT provides consulting and training services to customers on optimal procedures in power control, ideal circuit topologies as well as general do's and don'ts in the development of power electronics.

### Technical Support

CONCEPT provides expert help with your questions and problems:

[www.IGBT-Driver.com/go/support](http://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 Technology Ltd. The quality management system covers all stages of product development and production up to delivery. The drivers of the SCALE series are manufactured according to the ISO9001:2000 quality standard.

### 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 Technology 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 Technology AG apply.

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**Ordering Information**

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

Related IGBT	CONCEPT Driver Type #
1200V EconoDual IGBTs	2SD316EI-12
1700V EconoDual IGBTs	2SD316EI-17

Connection	CONCEPT Modular Cable Type #
2SD316EI-xx to DB01-xxx (all types)	MIC01A (2 items per driver)

Related IGBT	CONCEPT Basic Board Type #
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See current list on [www.IGBT-Driver.com/go/EconoDual](http://www.IGBT-Driver.com/go/EconoDual)

**Information about Other Products**
**For drivers adapted to other high-voltage or high-power IGBT modules**

Direct link: [www.IGBT-Driver.com/go/plug-and-play](http://www.IGBT-Driver.com/go/plug-and-play)

**For other drivers and evaluation systems**

Please click: [www.IGBT-Driver.com](http://www.IGBT-Driver.com)

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