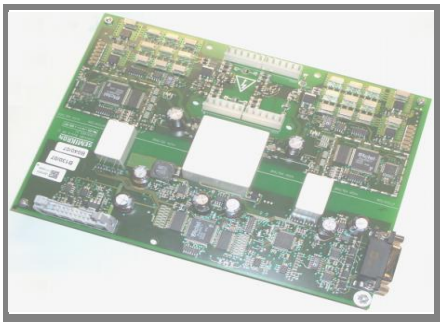
SEMIKUBE Board GB 11 ...



SEMIKUBE^{TM} Board

IGBT Driver Board

SEMIKUBE Board GB 11

Preliminary Data

Features

- Dual driver
- Potential free power supply
- Under voltage protection
- Drive interlock top / bottom
- Short circuit protection
- Integrated circuitry to sense current via external current sensors, heat sink temperature via external temperature sensor, DC-link voltage
- Over current protection (ext. CT)
- Over temperature protection
- Failure management
- Soft turn-off
- IEC 60068-1 (climate) 40/085/56, no condensation and no dripping water permitted, non-corrosive, climate class 3K3 acc. EN60721
- Coated with varnish

Typical Applications

- Driver for IGBT modules in bridge circuits
- DC bus voltage up to 1200V

1) please refer to maximum limit of switching frequency curves

2) the isolation test is not performed as a series test and must be performed by the user

3) according to VDE 0110-20

Operating temperature is real ambient temperature around the board

Isolation coordination in compliance with EN50178 PD2

Degree of protection: IP00

Absolute Maximum Ratings T_a = 25 °C, unless otherwise specified

Symbol	Conditions	Values	Units
V_S	Supply voltage primary	27	V
V_{iH}	Input signal voltage (High)	V_S + 0,3	V
V_{iL}	Input signal voltage (Low)	GND - 0,3	V
$Iout_{PEAK}$	Output peak current	30	A
$Iout_{AVmax}$	Output average current	300	mA
f_{max}	max. switching frequency 1)	50	kHz
V_{CE}	Collector emitter voltage sense across the IGBT	1700	V
dv/dt	Rate of rise and fall of voltage secondary to primary side	50	kV/µs
V_{isolIO}	Isolation test voltage input - output (AC, rms, 2s) 2)	4000	V
V_{isolPD}	Partial discharge extinction voltage, rms, $Q_{PD} \leq 10pC$ 3)	1500	V
V_{isol12}	Isolation test voltage output 1 - output 2 (AC, rms, 2s) 2)	1500	V
R_{Gonmin}	Minimum rating for external R_{Gon}	0,6	Ω
$R_{Goffmin}$	Minimum rating for external R_{Goff}	0,6	Ω
$Q_{out/pulse}$	Max. rating for output charge per pulse	30	µC
T_{op}	Operating temperature	- 20 ... + 70	°C
T_{stg}	Storage temperature	- 40 ... + 85	°C

Characteristics T_a = 25 °C, unless otherwise specified

Symbol	Conditions	min.	typ.	max.	Units
V_S	Supply voltage primary side	21,6	24	26,4	V
I_{SO}	Supply current primary side (no load)		270		mA
	Supply current primary side (max.) without external current sensors			1200	mA
V_i	Input signal voltage on / off		V_S / 0		V
V_{iT+}	Input threshold voltage (High)			0,7 * V_S	V
V_{iT-}	Input threshold voltage (Low)	0,3 * V_S			V
R_{in}	Input resistance (switching signals)		10		kΩ
$V_{G(on)}$	Turn on gate voltage output		+ 15		V
$V_{G(off)}$	Turn off gate voltage output		- 15		V
$t_{d(on)IO}$	Input-output turn-on propagation time		1,3		µs
$t_{d(off)IO}$	Input-output turn-off propagation time		1,3		µs
$t_{d(err)SCP}$	Error secondary - primary side propagation time		0,5		µs
$t_{d(err)HALT}$	Error primary - secondary side propagation time		1,0		µs
t_{TD}	Top-Bot Interlock Dead Time		4		µs
V_{CEstat}	Collector emitter threshold static monitoring voltage		4,1		V
t_{bl}	V_{CEstat} blanking time		5		µs
I_{TRIPSC}	Over current trip level with CT LEM HAFS 600-S/SP1		3600		A
T_{tp}	Over temperature protection level with temperature sensor KTY81-210		100		°C
C_{ps}	Coupling capacitance primary secondary		35		pF
w	weight		290		g
FIT	Failure in time @ T_a=40°C, max. load		6300		10^{-9}/h

This technical information specifies semiconductor devices but promises no characteristics. No warranty or guarantee expressed or implied is made regarding delivery, performance or suitability.

Technical Explanations

Revision 04
Status: ***preliminary***
Prepared by: Markus Hermwille

This Technical Explanation is valid for the following parts:		*Related Documents:*	
part number:	*L5041401*	*title:*	*Data Sheet SEMIKUBE Board GB 11*
date code (YYWW):	*≥ 0738*		

SEMIKUBE™ Board GB 11

Content

Please note:
Unless otherwise specified, all values in this technical explanation are typical values. Typical values are the average values expected in large quantities and are provided for information purposes only. These values can and do vary in different applications. All operating parameters should be validated by user's technical experts for each application.

Application and Handling Instructions

- Please provide for static discharge protection during handling. As long as the driver board is not completely assembled, the input terminals have to be short-circuited. Persons working with devices have to wear a grounded bracelet. Any synthetic floor coverings must not be statically chargeable. Even during transportation the input terminals have to be short-circuited using, for example, conductive rubber. Worktables have to be grounded. The same safety requirements apply to MOSFET- and IGBT-modules.
- Any parasitic inductances within the DC-link have to be minimised. Over-voltages may be absorbed by C- or RCD-snubbers between main terminals for PLUS and MINUS of the power module.
- When first operating a newly developed circuit, SEMIKRON recommends to apply low collector voltage and load current in the beginning and to increase these values gradually, observing the turn-off behaviour of the free-wheeling diode and the turn-off voltage spikes generated across the IGBT. An oscillographic control will be necessary. Additionally, the case temperature of the module has to be monitored. When the circuit works correctly under rated operation conditions, short-circuit testing may be done, starting again with low collector voltage.
- It is important to feed any errors back to the control circuit and to switch off the device immediately in failure events. Repeated turn-on of the IGBT into a short circuit with a high frequency may destroy the device.
- The inputs of the driver boards are sensitive to over-voltage. Voltages higher than V_S +0,3V or below -0,3V may destroy these inputs. Therefore, control signal over-voltages exceeding the above values have to be avoided.
- The connecting leads between driver board and the power module should be as short as possible (max. 20cm), the driver leads should be twisted.

Further application support

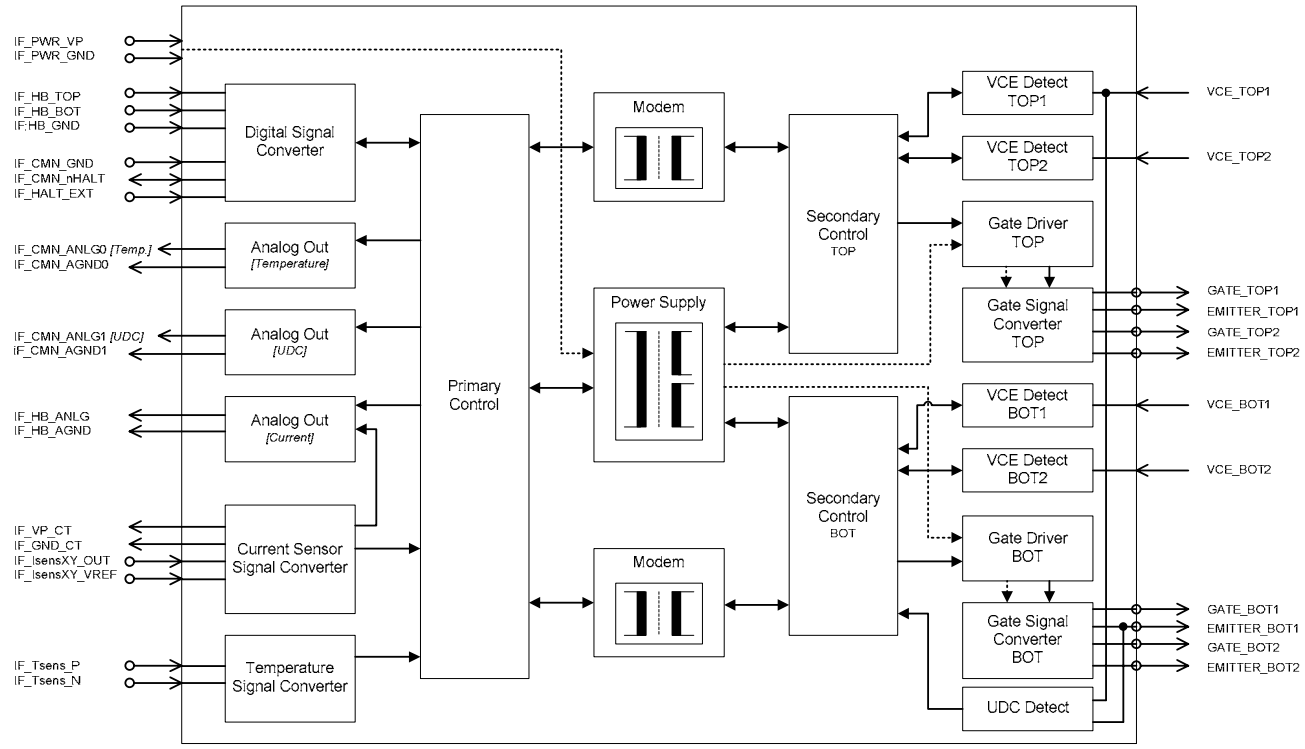
For design support please read the SEMIKRON Application Manual Power Modules available at www.SEMIKRON.com.

General Description

The SEMIKUBE Board GB 11 constitutes an interface between IGBT modules and the controller. This driver board is a power half bridge driver with two output connectors for paralleling IGBT modules. Functions for driving, potential separation and protection are integrated in the driver. Thus it can be used to build up a driver solution for IGBT modules e.g. SEMITRANS™, SEMiX®.

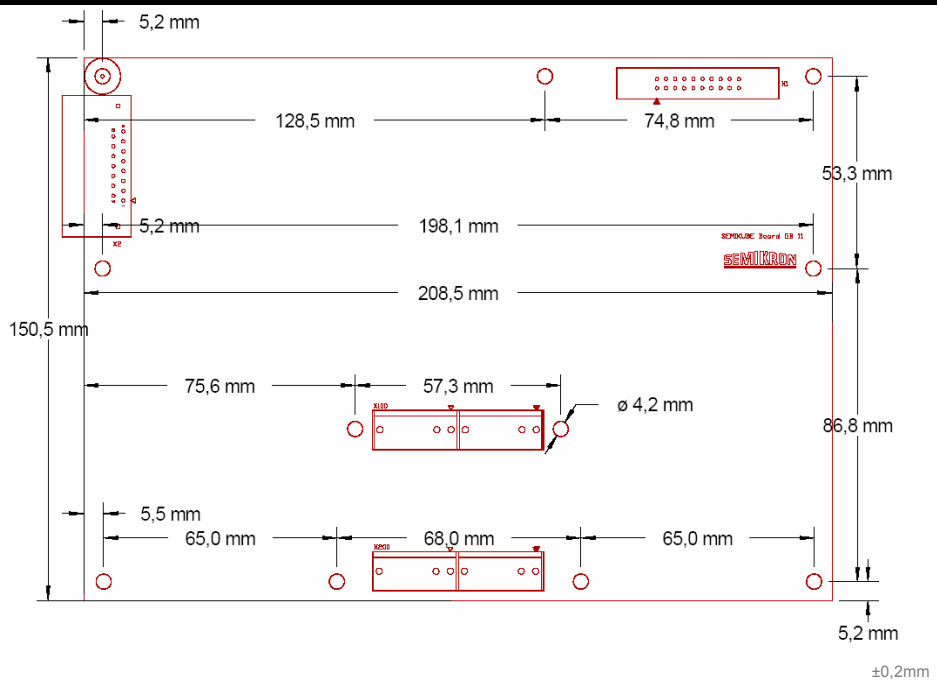
Block Diagram

SEMIKUBE Board GB 11

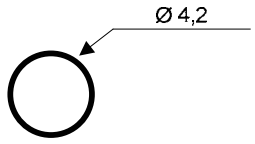


Dimensions & Drill Sizes

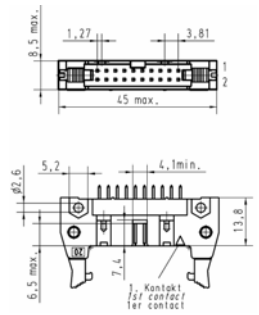
Dimensions in mm



Drill Size in mm

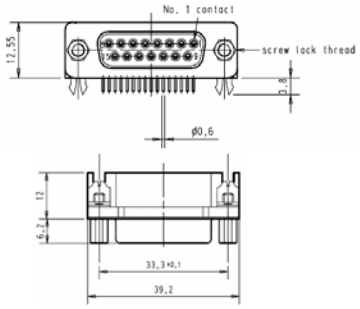
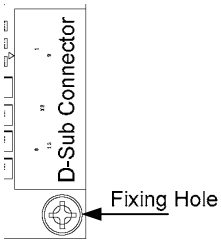


PIN Array X1 (not SKiiP® 2 / 3 compatible)

Connector X1 (Flat cable connector e.g. Harting 09 18 520 7 904)	
	Product information of suitable female connectors and distributor contact information is available at e.g. http://www.harting.com (part number 09 18 520 7 813 – female connector with strain relief clamp).

PIN	Signal	Function	Specification
X1:01	IF_PWR_VP	Power supply	Supply voltage +24V_{DC} (±10%) IN
X1:02	IF_PWR_GND	GND for IF_PWR_VP	
X1:03	IF_PWR_VP	Power supply	Supply voltage +24V_{DC} (±10%) IN
X1:04	IF_PWR_GND	GND for IF_PWR_VP	
X1:05	IF_PWR_VP	Power supply	Supply voltage +24V_{DC} (±10%) IN
X1:06	IF_PWR_GND	GND for IF_PWR_VP	
X1:07	IF_CMN_rsrvd	Reserved *[dominant recessive]*	
X1:08	IF_CMN_GND	GND for IF_CMN_nHALT, IF_CMNrsrvd	
X1:09	IF_CMN_nHALT	Status signal (bidirectional signal with dominant recessive behaviour) *[dominant recessive]*	Digital IF_PWR_VP logic LOW (dominant) = not ready to operate HIGH (recessive) = ready to operate
X1:10	IF_CMN_GPIO	General purpose IO *[dominant recessive]*	Inverted IF_CMN_nHALT signal Signal propagation time to IF_CMN_nHALT signal: 100µs (typ.)
X1:11	IF_CMN_ANLG0	Temperature analog out *[analog signal]*	Max. output current: 5mA Turns ratio: 100mV/°C Max. voltage range: +15V Nominal voltage range: 0 … 10V
X1:12	IF_CMN_AGND0	GND for IF_CMN_ANLG0	
X1:13	IF_CMN_ANLG1	U_{DC} analog out *[analog]*	Max. output current: 5mA Turns ratio: 10mV/V Max. voltage range: +15V Nominal voltage range: 0 … 10V
X1:14	IF_CMN_AGND1	GND for IF_CMN_ANLG1	
X1:15	IF_HB1_TOP	Switching signal input (HB1 TOP switch) *[push pull]*	Digital IF_PWR_VP logic LOW = TOP switch off HIGH = TOP switch on
X1:16	IF_HB1_BOT	Switching signal input (HB1 BOT switch) *[push pull]*	Digital IF_PWR_VP logic LOW = BOT switch off HIGH = BOT switch on
X1:17	IF_HB1_rsrvd	Reserved *[dominant recessive]*	
X1:18	IF_HB1_GND	GND for IF_HB1_TOP, IF_HB1_BOT, IF_HB1_rsrvd	
X1:19	IF_HB1_ANLG	I analog out HB1 *[analog]*	Max. output current: 5mA Turns ratio: 3mV/A Max. voltage range: ±15V Nominal voltage range: -10 … 10V
X1:20	IF_HB1_AGND	GND for IF_HB1_ANLG	

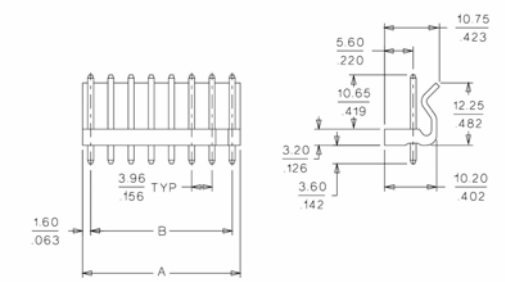
PIN Array X2

Connector X2 (D-Sub - S PCB connector e.g. Harting 09 68 253 761 3)	
	Shield of D-Sub connector is electrically connected to copper trace around the fixing hole of printed circuit board.  It is mandatory to use for the fixing hole next to the D-Sub connector a metal screw for assembling to enable grounding. Product information of suitable female connectors and distributor contact information is available at e.g. www.harting.com

PIN	Signal	Function	Specification
X2:01	IF_Tsens_P	Temperature sensor positive input	PTC Output current: 1mA for R_{load} < 6kOhm Specified for use of PTC with 2kOhm
X2:02	IF_Tsens_N	Temperature sensor negative input	
X2:03	IF_VP_CT	Power supply CT	+5V, max. 120mA [1)]
X2:04	IF_GND_CT	GND for IF_VP_CT	
X2:05	IF_Isens1_OUT	Output CT phase U	0 - 5V (max.)
X2:06	IF_Isens1_VREF	Reference for CT phase U	0 - 5V (max.)
X2:07	IF_Isens2_OUT	Output CT phase V	0 - 5V (max.)
X2:08	IF_Isens2_VREF	Reference for CT phase V	0 - 5V (max.)
X2:09	IF_VP_CT	Power supply CT	+5V, max. 120mA [1)]
X2:10	IF_GND_CT	GND for IF_VP_CT	
X2:11	IF_Isens3_OUT	Output CT phase W	0 - 5V (max.)
X2:12	IF_Isens3_VREF	Reference for CT phase W	0 - 5V (max.)
X2:13	IF_Isens4_OUT	Output CT phase W	0 - 5V (max.)
X2:14	IF_Isens4_VREF	Reference for CT phase W	0 - 5V (max.)
X2:15	IF_HALT_EXT	External system halt signal	Digital input. Only input signal. No reading of HALT status possible. LOW (external switch to GND) = HALT / disable driver board HIGH (open) = enable driver board

[1)] Max. 120mA in total and not per pin X2:03 and X2:09

PIN Array X100, X200

Connectors X100, X200 (Wire-to-Board Connector e.g. Molex 09-65-2068)	
	Position of Pin 01 is marked with an arrow on the printed circuit board. Product information of suitable female connectors and distributor contact information is available at e.g. www.molex.com (part number 09-50-1061 – crimp terminal housing).

PIN	Signal	Function	Specification
X100:01	EMITTER_BOT1	Emitter output BOT IGBT 1	
X100:02	GATE_BOT1	Gate output BOT IGBT 1	
X100:03	reserved		
X100:04	reserved		
X100:05	reserved		
X100:06	VCE_BOT1	Collector output BOT IGBT 1	
X100:07	EMITTER_TOP1	Emitter output TOP IGBT 1	
X100:08	GATE_TOP1	Gate output TOP IGBT 1	
X100:09	reserved		
X100:10	reserved		
X100:11	reserved		
X100:12	VCE_TOP1	Collector output TOP IGBT 1	
X200:01	EMITTER_BOT2	Emitter output BOT IGBT 2	
X200:02	GATE_BOT2	Gate output BOT IGBT 2	
X200:03	reserved		
X200:04	reserved		
X200:05	reserved		
X200:06	VCE_BOT2	Collector output BOT IGBT 2	
X200:07	EMITTER_TOP2	Emitter output TOP IGBT 2	
X200:08	GATE_TOP2	Gate output TOP IGBT 2	
X200:09	reserved		
X200:10	reserved		
X200:11	reserved		
X200:12	VCE_TOP2	Collector output TOP IGBT 2	

Driver Performance

The driver is designed for application with half bridges or single modules and a maximum gate charge per pulse < 30µC. The charge necessary to switch the IGBT is mainly depending on the IGBT's chip size, the DC-link voltage and the gate voltage. This correlation is shown in module datasheets. It should, however, be considered that the driver is turned on at +15V and turned off at -15V. Therefore, the gate voltage will change by 30V during each switching procedure. Unfortunately, many datasheets do not show negative gate voltages. In order to determine the required charge, the upper leg of the charge curve may be prolonged to +30V for determination of approximate charge per switch.
The medium output current of the driver is determined by the switching frequency and the gate charge. The maximum switching frequency may be calculated with the shown equations and is limited by the average current of the driver power supply and the power dissipation of driver components.

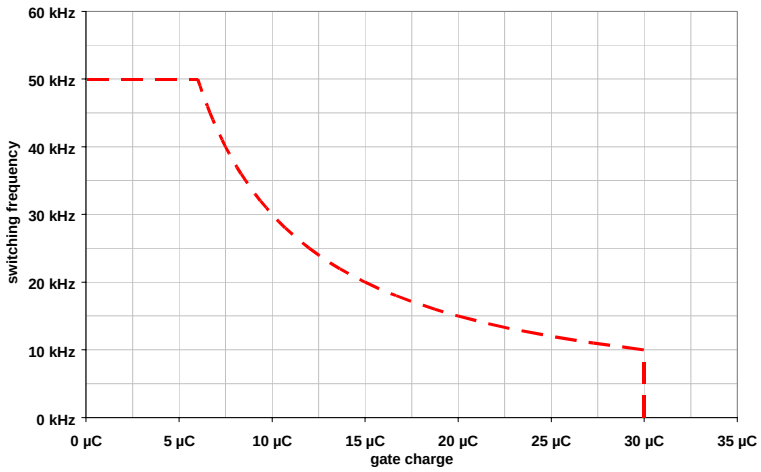
Calculation Switching Frequency

$$f_{max} = \frac{Iout_{AVmax}}{Q_{GE}}$$

f_{max}: Maximum switching frequency *
$Iout_{AVmax}$: Maximum output average current
Q_{GE}: Gate charge of the driven IGBT

*@ T_{amb}=25°C

Maximum Switching Frequency @ different Gate Charges @ T_{amb}=25°C

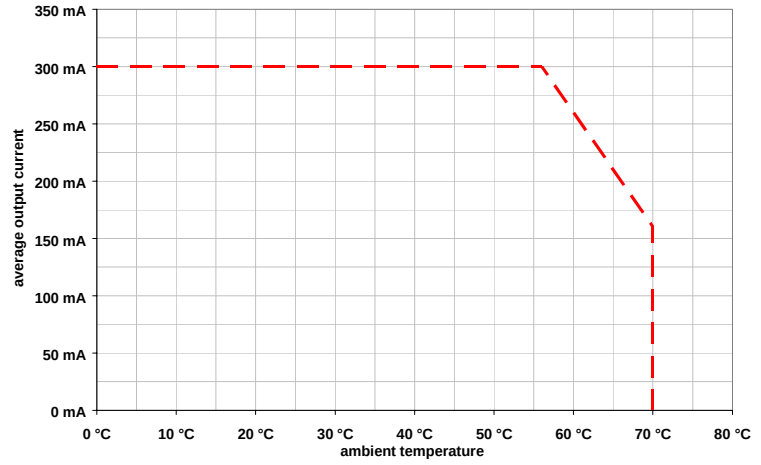


Calculation Average Output Current

$$Iout_{AV} = f_{sw} \times Q_{GE}$$

$Iout_{AV}$: Average output current
f_{sw}: Switching frequency
Q_{GE}: Gate charge of the driven IGBT

Total Average Output Current as a Function of the Ambient Temperature



Please note:
The average output current per output connector is 150mA. The maximum value of the switching frequency is limited to 50kHz due to switching reasons.

Insulation

Magnetic transformers are used for insulation between gate driver primary and secondary side. The transformer set consists of pulse transformers which are used for turn-on and turn-off signals of the IGBT and the error feedback between secondary and primary side, and a DC/DC converter. This converter provides a potential separation (galvanic separation) and power supply for the two secondary (TOP and BOT) sides of the driver. Thus, external transformers for power supply are not required.

Creepage and Clearance Distance in mm	
Primary to secondary	Min. 17,0

Isolation Test Voltage

The isolation test voltage represents a measure of immunity to transient voltages. The maximum test voltage and time applied once between input and output, and once between output 1 and output 2 are indicated in the absolute maximum ratings. The high-voltage isolation tests and repeated tests of an isolation barrier can degrade isolation capability due to partial discharge. Repeated isolation voltage tests should be performed with reduced voltage. The test voltage must be reduced by 20% for each repeated test.
The isolation of the isolation barrier (transformer) is checked in the part. With exception of the isolation barrier, no active parts, which could break through are used. An isolation test is not performed as a series test. Therefore, the user can perform once the isolation test with voltage and time indicated in the absolute maximum ratings.

Please note:
An isolation test is not performed at SEMIKRON as a series test.

Auxiliary Power Supply

A few basic rules should be followed when dimensioning the user side power supply for the driver board. The following table shows the required features of an appropriate power supply.

Requirements of the auxiliary power supply	
Power supply	+24V ±10%
Maximum rise time of auxiliary power supply	50ms
Minimum peak current of auxiliary supply	1,5A
Power on reset completed after (typ.)	700ms

Please note:
Do not apply switching signals during power on reset.

The supplying switched mode power supply may not be turned-off for a short time as consequence of its current limitation. Its output characteristic needs to be considered. Switched mode power supplies with fold-back characteristic or hiccup-mode can create problems if no sufficient over current margin is available. The voltage has to rise continuously and without any plateau formation.
If the power supply is able to provide a higher current, a peak current will flow in the first instant to charge up the input capacitances on the driver. Its peak current value will be limited by the power supply and the effective impedances (e.g. distribution lines), only.
It is recommended to avoid the paralleling of several customer side power supply units. Their different set current limitations may lead to dips in the supply voltage.
The driver board is ready for operation typically 700ms after turning on the supply voltage. The driver error signal IF_CMN_nHALT is operational after this time. Without any error present, the IF_CMN_nHALT signal will be reset.
To assure a high level of system safety the TOP and BOT signal inputs should stay in a defined state (OFF state, LOW) during driver turn-on time. Only after the end of the power-on-reset, IGBT switching operation shall be permitted.

Under Voltage Protection (UVP) primary

The internally detected supply voltage of the driver board has an under voltage protection. The table below gives an overview of the trip level.

Signal Characteristics	typ.
Under voltage protection trip level	19V
Threshold level for reset after failure event	20V

If the internally detected supply voltage of the driver board falls below this level, the IGBTs will be switched off (IGBT driving signals set to LOW). The input side switching signals of the driver board will be ignored and the status signal IF_CMN_nHALT changes to the LOW state. LED 0 (V1) flashes red. The system restarts after 10 seconds and, if the supply voltage is higher than threshold level for reset after failure event.

Under Voltage Protection secondary

This function monitors the rectified voltage on the secondary side. If the voltage drops, the IGBTs will be switched off (IGBT driving signal set to LOW). The input side switching signals of the driver will be ignored.

Signal Characteristics	typ.
Under voltage protection trip level +15V	12V
Threshold level for reset after failure event +15V	13V
Under voltage protection trip level -15V	-12V
Threshold level for reset after failure event -15V	-13V

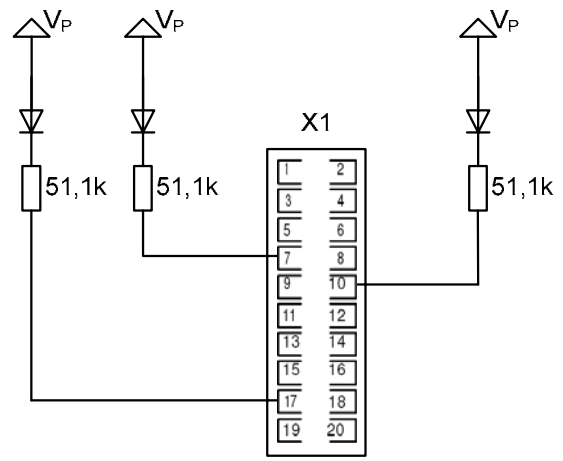
User Interface

Signals of the interface, which are specified as reserved or are not used by the user, must be connected as shown in the following table.

Connection of reserved signals and not used signals

Signal	Connection (required on user side)
[dominant recessive]	Pull up resistor (50k) to IF_PWR_VP
[push pull]	Pull down (direct) GND
[analog]	Pull down resistor (10k) to GND

Connection of IF_XY_rsrvd Signals



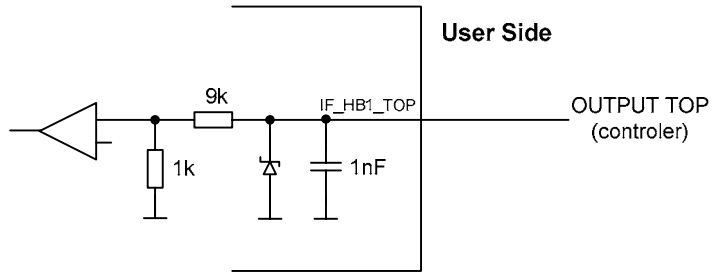
The ground potentials on the driver board are equal and all physically connected with each other on the printed circuit board. Because of the voltage drop on the power supply cable, the potential of power supply ground at the user side is different to the ground potential on the driver board. If the potential of the analog signals are only referred to the user ground potential, the measurement is failing. To eliminate this failure different signal for ground potential are used. The analog ground signal can be used to sense the ground potential of the driver board for a differential measurement.
It is mandatory on the user side to differ between analog ground (IF_xy_AGND) and IF_PWR_GND to avoid faulty analog values. It is allowed to short-circuit the IF_PWR_GND, the IF_CMN_GND and the ground pin of the half bridge (IF_HB1_GND) on the user side. But all analog signals have to be measured differential referred to the corresponding ground signal at the user interface. It is not allowed to short-circuit the analog ground signal with the IF_PWR_GND signal on user side.

Please note:
Do not remove the plug with applied voltage of the power supply. This can lead to unspecified voltage levels at the output stages of the driver board with the risk of destructions.

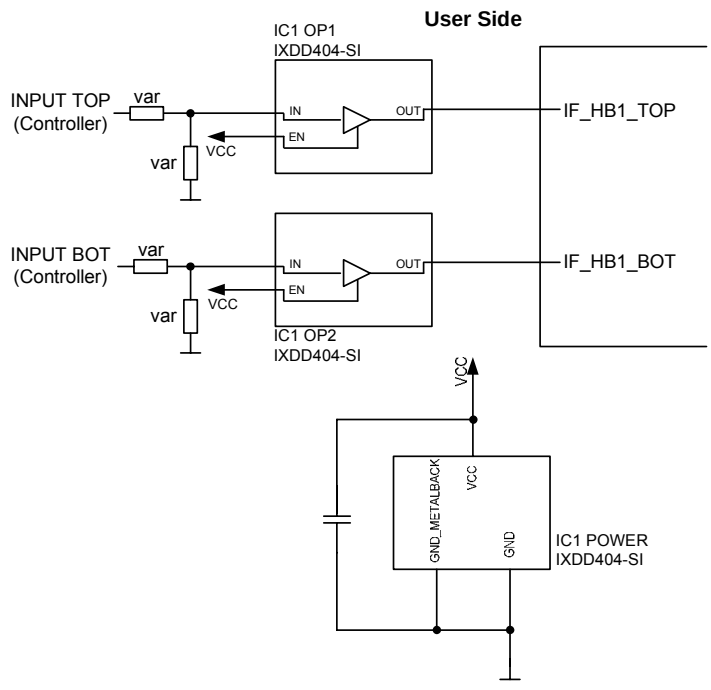
Digital Input Signals

The two input signals for the TOP and BOT signals of each phase have a digital positive / active high logic (input HIGH = IGBT on; input LOW = IGBT off).
It is mandatory to use circuits which switch active to V_S and 0V. Pull up and open collector output stages must not be used for TOP / BOT control signals. It is recommended choosing the line drivers according to the demanded length of the signal wires.

Please note:
It is not permitted to apply switching pulses shorter than 1µs. A non connected input will be considered like a LOW signal.

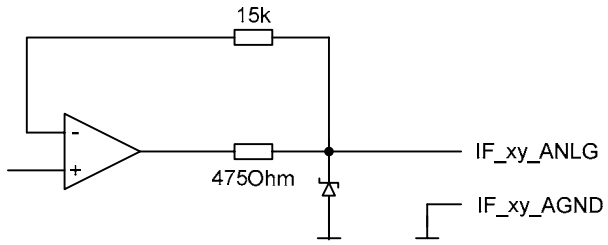
TOP / BOT Input	
	A capacitor is connected to the input to obtain high noise immunity. This capacitor can cause for current limited line drivers a little delay of few ns, which can be neglected.

In the following an example is given for a circuit on the controller board of the user.

Application Example - Connection µC with User Interface	
	The circuit is based on a Dual Low-Side Ultrafast MOSFET Driver IXDD404SI. Please read the data sheet of the MOSFET Driver before using the component in your application. Control signals from the controller (e.g. 3,3V, 5V) are shifted to Digital IF_PWR_VP logic.

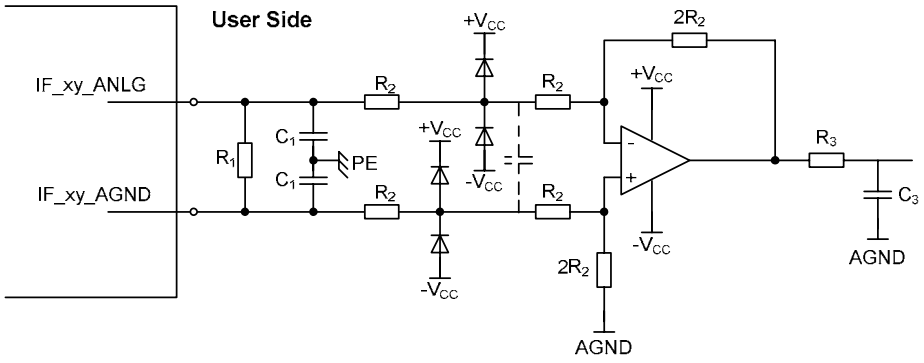
Analog Output Signals

The following schematic shows the analog output lines of the driver board.

Analog Output	Application Hints
	The 475 Ω resistor in series with the voltage follower does avoid damages caused by a temporary short circuit at user side. Please ensure that the maximum driven current by the output operational amplifier does not exceed 5 mA. For a trouble-free interaction of the driver board and user side control it is necessary to adapt the user input to the driver board outputs. For that reason the corresponding analog signal ground (IF_xy_AGND) shall be used when analog signals are measured. The analog signal ground is on the driver board on the same potential as the ground of the power supply (IF_PWR_GND). The difference is that the analog signal ground line is not used for supply currents and for that reason no voltage drop due to supply current will be caused.

In the following a schematic and a description is given for an analog input circuit on the controller board of the user.

Application Example – Symmetric Wired Differential Amplifier



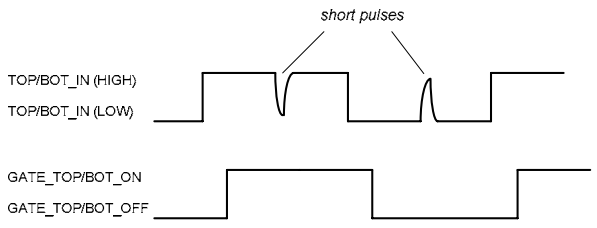
The circuit is a symmetrical wired differential amplifier.

- At the input is a 10kΩ resistor (R1). The interference sensitivity of the over all circuit (user control, driver) is reduced by a continuous current flow through this resistor.
- C_1 leaks differential and common mode high-frequency interference currents. This capacitor should not be larger than 100pF to ensure that there is no additional time delay in the system.
- The symmetrical wiring of the amplifier is as follows. Please note that no capacitor is in parallel to the feedback resistor and also to the resistor of the non-inverting input to ground ($2R_2$). These capacitors have often higher tolerances, so the common-mode rejection of the circuitry is reduced by this effect.
- The input resistor should be split up and installed between the clamping-diodes. The current in the diodes is limited by this resistor. A diode with a low reverse current should be selected e.g. 1N4148.
- If a low pass filtering shall be implemented in the input circuit, this should be done with a capacitor between the input resistors (see dotted lines). In most cases this capacitor is not necessary and the smoothing can be realised by a simple R-C network (R_3, C_3) at the end of the operational amplifier.

Short Pulse Suppression (SPS)

This circuit suppresses short turn-on and off-pulses of incoming signals. This way the IGBTs are protected against spurious noise as they can occur due to bursts on the signal lines. Pulses shorter than 620ns (typ.) are suppressed.

Pulse pattern – SPS



Failure Management

A failure caused by under voltage protection (primary and secondary), short circuit protection, over current protection or temperature protection will force IF_CMN_nHALT into LOW state (not ready to operate) and set the error latch. The IGBTs will be switched off (IGBT driving signals set to LOW) and switching pulses from the controller will be not transferred to the output stage. At the same time an internal timer with a time constant of 3s is started. If no failure is present anymore, a time of minimum 3s after failure detection is passed or in case of over temperature protection, the measured temperature has fallen below 70°C, the driver board is ready to operate and switching signals are transferred to the output stage again.

System Diagnostic Indication by LED

The system status during system power on, normal operation or failure event are illuminated by three tri-colours LEDs (LED 0 (V1) on primary side, LED 2 (V151) on secondary side TOP, LED 3 (V128) on secondary side BOT) on the driver board. The LEDs indicate the following conditions.

Diagnostic Code – System Start

LED 0 (V1)	Description
green, flashes	System is starting and checking supply voltages.
red, flashes	Supply voltage < V_s min.
yellow, flashes	Failure during system start. Automatic restart after 10 seconds and V_s > threshold level for reset.

LED 2 (V151), LED 3 (V128)	Description
yellow, flashes	System is starting and waiting for configuration of secondary side.

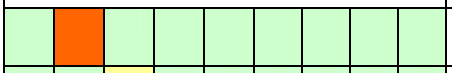
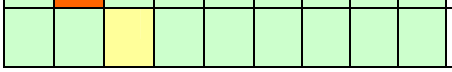
Diagnostic Code – Normal Operation

LED 0 (V1)	Description
green, steady on	System is working. No system failures occur since last system start.

LED 2 (V151), LED 3 (V128)	Description
green, steady on	System is working. No system failures occur since last system start.

Diagnostic Code – Failure Type Indication after Failure Event on Primary Side

LED 0 (V1) is illuminating ten flashes with a frequency of 1Hz. After no illumination for three seconds, the flashing sequence is repeated. The failure indication is illuminated until the driver is rebooted (turn-off of internal power supply).

Examples for LED 0 (V1):	
Flashing sequence	Description
	Failure caused by over current at CT 2 is present.
	Failure caused by over current at CT 3 happened, but is not present anymore.

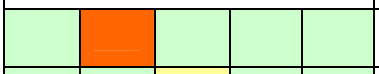
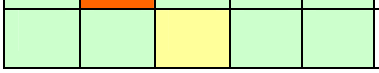
LED 0 (V1)				
flash 1	flash 2	flash 3	flash 4	flash 5
status over current CT 1	status over current CT 2	status over current CT 3	status over current CT 4	status over temperature
flash 6	flash 7	flash 8	flash 9	flash 10
status failure secondary side	status under voltage	status input signal error [1)]	status internal error	status HALT signal

LED 0 (V1) (colour of the flash)	**Description**
green	OK. No failure.
yellow	Failure was occurred, but failure is not present anymore.
red	Failure is present.

[1)] Input signal oscillation > 55kHz

Diagnostic Code – Failure Type Indication after Failure Event on Secondary Side

LED 2 (V151) and LED 3 (V128) are illuminating five flashes with a frequency of 2Hz. After no illumination for three seconds, the flashing sequence is repeated. The failure indication is illuminated until reconfiguration of the secondary side (turn-off of internal power supply).

Examples for LED 2 (V151), LED 3 (V128):	
Flashing sequence	Description
	Failure caused by under voltage +15V is present.
	Failure caused by under voltage -15V happened, but is not present anymore.

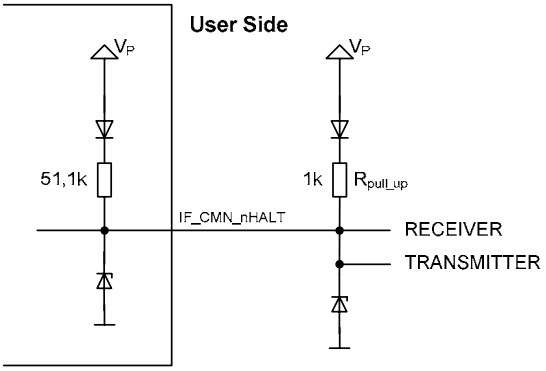
LED 2 (V151), LED 3 (V128)				
flash 1	flash 2	flash 3	flash 4	flash 5
status short circuit protection	status under voltage +15V	status under voltage -15V	status over temperature of power output stage	status internal error

LED 2 (V151), LED 3 (V128) (colour of the flash)	**Description**
green	OK. No failure.
yellow	Failure was occurred, but failure is not present anymore.
red	Failure is present.

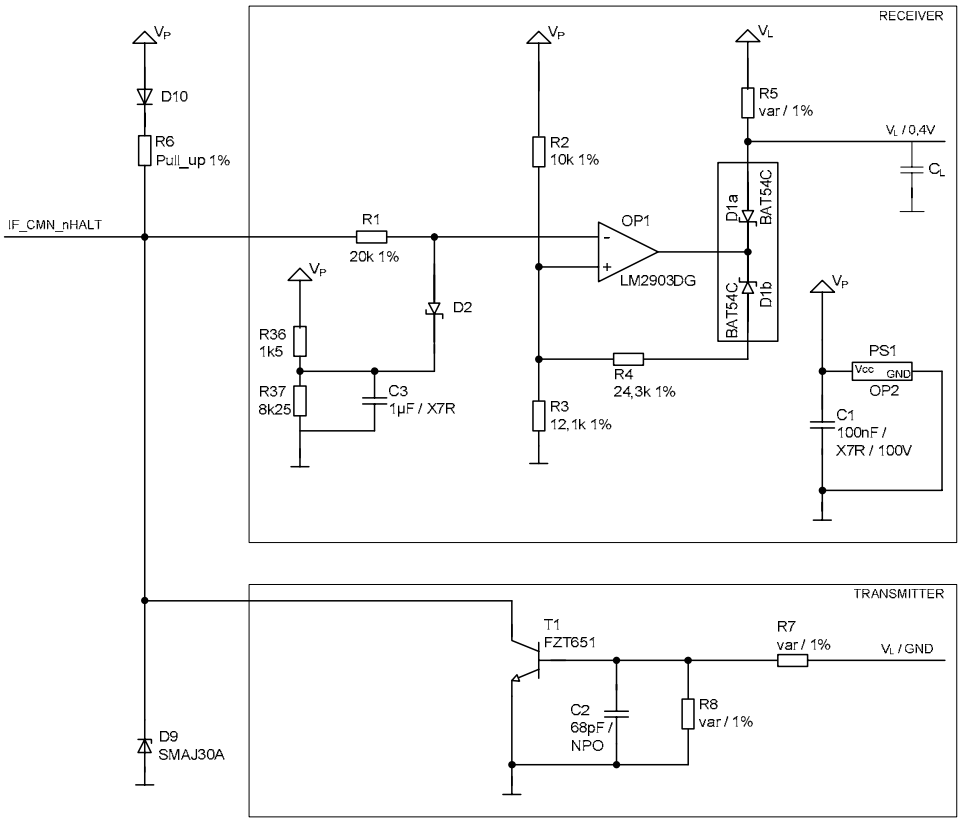
Halt Logic Signal (HLS)

The Halt Logic Signal IF_CMN_nHALT is a bidirectional signal with dominant recessive behaviour. It shows and controls the drive board status. When IF_CMN_nHALT is HIGH (recessive), the driver core is ready to operate. When IF_CMN_nHALT is LOW (dominant), the driver core is disabled / not ready to operate / HALT mode because of e. g. detected failure or system start of the driver board. With a LOW signal at IF_CMN_nHALT or IF_HALT_EXT the driver board can be hold in a safe state (e.g. during a start up of a system or gathered failure signal of other hardware) or a synchronous release of paralleled driver can be generated.

Please note:
IF_CMN_nHALT is not short circuit proof.

Connection IF_CMN_nHALT	Application Hints
	An external pull-up resistor of 1kΩ and a diode is required. IF_CMN_nHALT must operate with IF_PWR_VP logic. The receiver and transmitter circuit have to be high impedance to assure a recessive logic level higher than 0,9*V_P, independent of the number of connected circuits. Therefore, a circuit which uses direct pull-down resistor connected to IF_CMN_nHALT, does not fit to the specification. See the following application example for possible solution.

Application Example - Connection IF_CMN_nHALT with User Interface

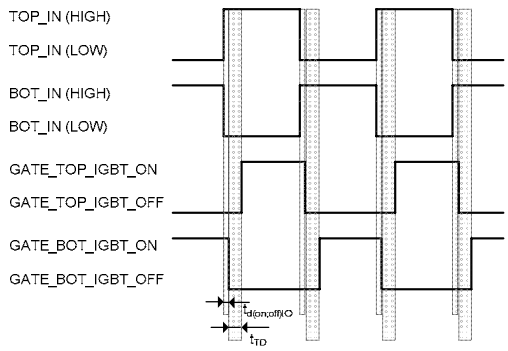


- The output of the stage is inverted.
- Propagation delay for on / off depends on C_L and R5. Due to the open collector output of the LM2903, the propagation delay time of the rising edge is smaller than the propagation delay time of the falling edge of the HALT signal.
- The current through the open collector of the comparator is limited by the resistor R5 and should not exceed 5mA in order to limit the voltage drop and the losses.
- The resistors R36 and R37 clamp the voltage for the input of the comparator. By this, the inverting input stays in the permissible common mode range.
- D2 should be a schottky diode with low voltage drop.
- The resistors R7 and R8 have to be selected according to the used logic level to drive the transistor T1. A base current of about 1mA is recommended.

Dead Time generation (Interlock TOP / BOT)

The DT circuit prevents, that TOP and BOT IGBT of one half bridge are switched on at the same time (shoot through). The dead time is not added to a dead time given by the controller. Thus the total dead time is the maximum of "built in dead time" and "controller dead time". It is possible to control the driver with one switching signal and its inverted signal.

Pulse pattern – DT



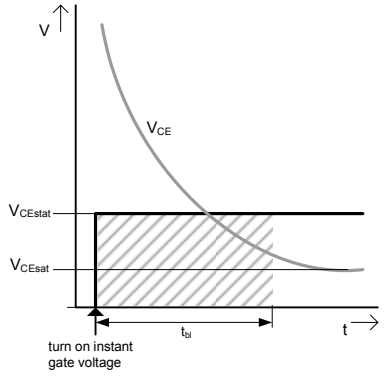
- The total propagation delay of the driver is the sum of interlock dead time (t_{TD}) and driver input output signal propagation delay ($t_{d(on;off)IO}$) as shown in the pulse pattern. Moreover the switching time of the IGBT chip has to be taken into account (not shown in the pulse pattern).
- In case both channel inputs (TOP_IN and BOT_IN) are at high level, the IGBTs will be turned off.
- If only one channel is switching, there will be no interlock dead time.

Please note:
No error message will be generated when overlap of switching signals occurs.

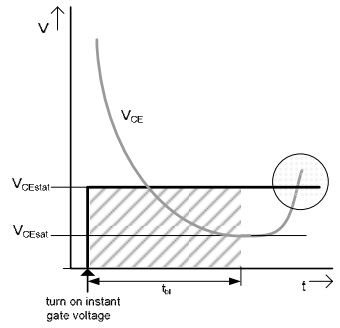
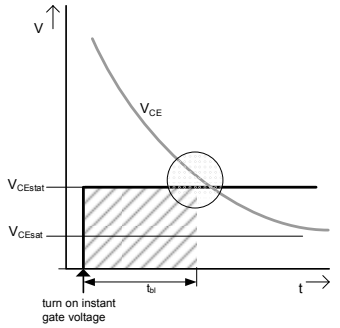
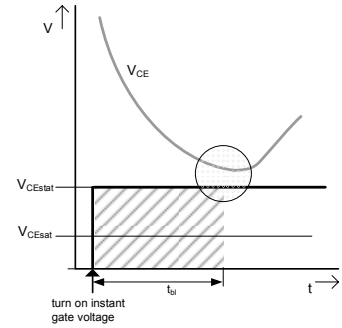
Short Circuit Protection by V_{CEsat} monitoring / de-saturation monitoring (SCP)

The SCP circuit is responsible for short circuit sensing. It monitors the collector-emitter voltage V_{CE} of the IGBT during its on-state. Due to the direct measurement of V_{CEsat} on the IGBT's collector, the SCP circuit switches off the IGBTs and an error is indicated.

Collector-Emitter Threshold Static Monitoring Voltage (V_{CEstat}) and Blanking Time (t_{bl})



After t_{bl} has passed, the de-saturation monitoring will be triggered as soon as $V_{CE} > V_{CEstat}$ and will turn off the IGBT. The error memory will be set, and the output IF_CMN_nHALT changes to the LOW state. Possible failure modes are shows in the following pictures.

Short circuit during operation	Turn on of IGBT too slow *	Short circuit during turn on
		

* or adjusted blanking time too short

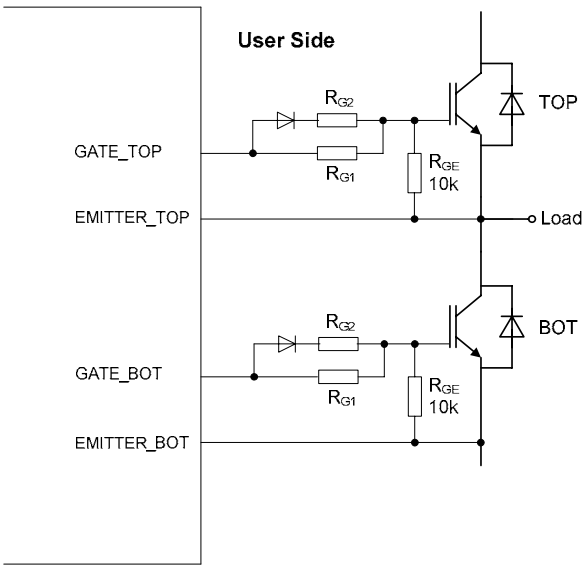
Application hints

If the SCP function is not used, for example during the experimental phase, VCE_TOP must be connected with EMITTER_TOP for disabling SCP @ TOP side and VCE_BOT must be connected with EMMITER_BOT for disabling SCP @ BOT side.

Gate resistors

The output transistors of the driver are MOSFETs. The setting of the turn-on and turn-off speed of each IGBT can be adjusted by the external resistors R_G. As an IGBT has input capacitance (varying during switching time) which must be charged and discharged, the resistors will dictate what time must be taken to do this. The final value of the resistance is difficult to predict, because it depends on many parameters as DC link voltage, stray inductance of the circuit, switching frequency and type of IGBT.

Connection R_{Gon}, R_{Goff}



Application Hints

The gate resistor influences the switching time, switching losses, dv/dt behaviour, etc. and has to be selected very carefully. Due to this influence a general value for the gate resistors cannot be recommended. The gate resistor has to be optimized according to switching behaviour and over voltage peaks within the specific circuitry.

In order to adjust the turn-on and turn-off behaviour individually, a second resistor R_{G2} and a series diode in parallel to the gate resistor R_{G1} can be placed.

By increasing R_{G1} the turn-off speed of the IGBT will decrease. The inductive peak over voltage during turn-off will diminish.

By increasing R_{G2} the turn-on speed will decrease. The reverse peak current of the free-wheeling diode will diminish.

In order to ensure locking of the IGBT even when the driver supply voltage is turned off, a gate clamping circuit is integrated on the driver board. Even if a clamping circuit is integrated, a resistance (R_{GE}) has to be installed.

Please Note:

- Low value internal R_{Gon} and R_{Goff} of 0,5Ohm per output (connector X100, X200) are inserted on the driver board to avoid short circuits on the outputs.
- **The external gate resistor (R_{G1}, R_{G2}) must be higher than 0,6Ohm.**
- The final value of the gate resistance is equal to gate resistor on the driver board + external gate resistor.

Soft Turn-Off (STO)

In case of short circuit, the STO circuit increases the resistance in series with an additional turn-off gate resistor (R_{Goff_SC}) and turns-off the IGBT at lower speed. This produces smaller voltage spike above the collector emitter of the IGBT by reducing the di/dt value. Because in short-circuit conditions the IGBT's peak current increases and some stray inductance is always present in power circuits, it must fall to zero in a longer time than at normal operation.

STO Characteristics	
R_{Goff_SC} on board per output (connector X100, X200)	10Ω
Max. soft-turn-off time. (After this time the output stage turns-off with the used $R_{Goff.}$)	7,0µs

Please note:
The soft turn-off function is no complete protection from induced over voltage in the event of short-circuit turn-off. Only the short-circuit protection leads to soft turn-off.

External Halt Signal (EHS)

The external halt signal IF_HALT_EXT can be used to place the gate driver into HALT mode. Disabling of this function can be achieved by no connection.

Current Sensing

The driver board can receive information from maximum four external current sensors. An evaluation circuit on the driver board provides a normalized, analog voltage signal of the received current information of all sensors.

Signal Characteristics	
Over current trip level	3.600A (900A per sensor input)
Turns ratio of the analog signal	3mV/A
Total accuracy of the over current trip level (without sensor)	4%
Total accuracy of analog signal (without sensor) @ trip level	4%
Filtering time constant	6,7µs

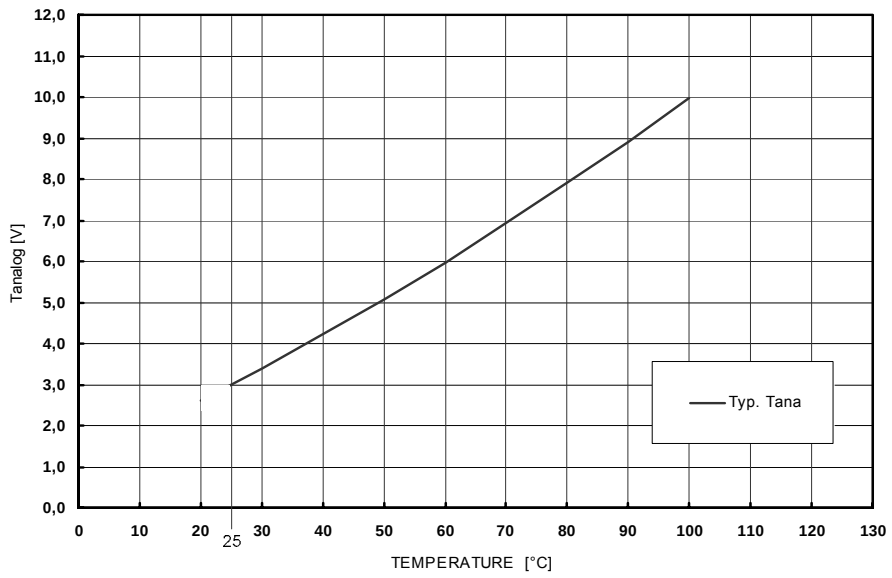
Please note:
The evaluation circuit is designed for current sensor LEM HAFS 600-S/SP1.
If no current sensor is used, IF_IsensX_OUT must be connected IF_IsensX_VREF. E.g. IF_Isens1_OUT must be connected with IF_Isens1_VREF, if no current sensor is used @ phase U.

Temperature Sensing

The driver board can receive information from an external temperature sensor (PTC). An evaluation circuit on the driver board provides a normalized, analog voltage signal of the received temperature information.

Signal Characteristics	
Over temperature trip level	100°C
Accuracy of the over temperature trip level incl. sensor	±4°C
Threshold level for reset after failure event	70°C
Minimum measurable temperature	25°C

Analog Temperature Signal with Temperature Sensor KTY81-210



Please note:

The evaluation circuit is designed for temperature sensor KTY81-210.

For most air cooled applications the over temperature trip threshold is sufficient to protect the system. But for water cooled systems or short time overloads the threshold might be too high. In this case there is a need for another protection trip level for what the user can evaluate the analog temperature output to protect the system.

If no temperature sensor is connected, the temperature sensing function must be disabled by connection a 2kOhm resistor between IF_Tsens_P and IF_Tsens_N.

DC-Link-Voltage Sensing

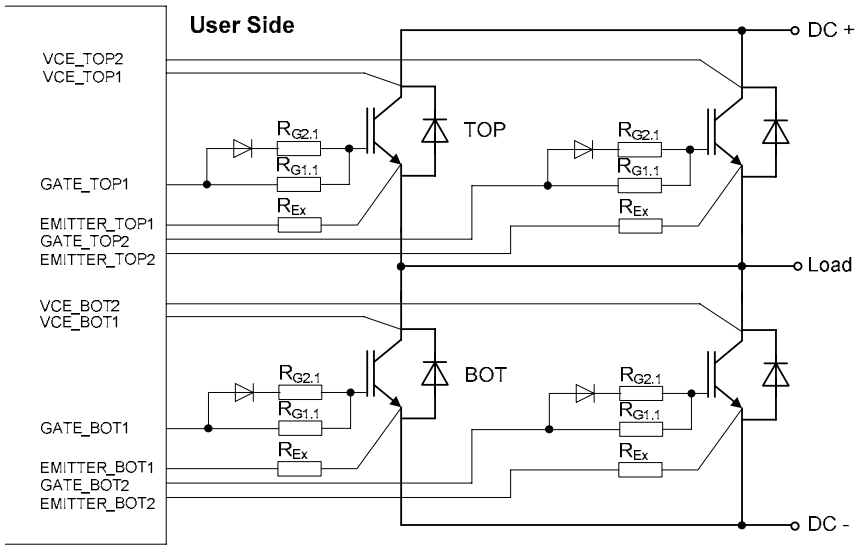
With the DC-link-voltage sensing feature, a normalized, analog voltage signal of the actual DC-link-voltage level is available at the connector X1 of the driver board.
Normalization of the actual DC-link-voltage signal and input impedances of the measurement circuit is shown in the table below.

Signal Characteristics	
Maximum V_{CES}	1200V
Maximum measurable DC-link-voltage	1000V
Turns ratio of the analog signal	100mV/V
Accuracy of analog signal @ 1000V	±4,5% @ T_a=25°C
Temperature coefficient	±0,03%/K
Filtering time constant	840µs
Update rate on primary side (typ.)	9ms

Connection Principle

The driver board has two output connectors for paralleling IGBT modules. The following schematic shows the connection principle.

Connection Principle for Paralleled Half Bridge IGBT Modules



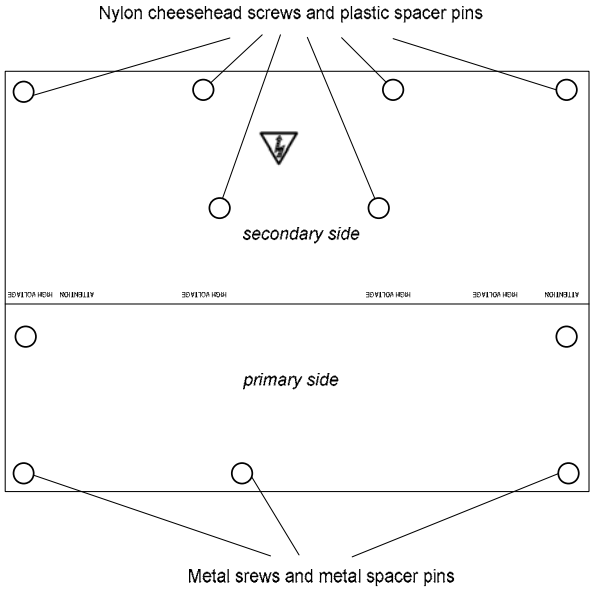
Application Hints

In parallel configuration, care must be considered to reach an optimised circuit and to obtain the total performance of the IGBT. The IGBTs must have independent values for R_G, and an auxiliary emitter resistor R_{Ex}.
The R_{Ex} assumes a value of 0,5Ohm and its function is to reduce the main current to circulate by the auxiliary emitter what could make the emitter voltage against ground unbalanced.
The external resistors should be mounted on an additional circuit board close to the paralleled modules.

All power and driver circuits within the parallel circuit have to be laid out with minimum loop inductance and strictly symmetrical wiring.

Please note:
Please read the Application Note AN-7002 "Conncection of Gate Drivers to IGBT and Controller" before using the driver baord. The application note is available on Driver Electronics product page at www.SEMIKRON.com.

Mounting Notes

Assembly of Driver Board	
	The driver board has drill holes for fixing the driver board. It is mandatory to fix the driver board with metal screws and metal spacer pins at the primary side and plastic screws and plastic spacer pins at the secondary side. It is mandatory to use all drill holes for fixing the driver board.

Environmental Conditions

The driver board is type tested under the environmental conditions below.

Conditions	Values (max.)
Thermal Cycling	- 100 cycle, $T_{stg(max)}$ - $T_{stg(min)}$, without operation - Tested acc. IEC 60068-2-14 Test Na
Vibration	Sinusoidal sweep 20Hz … 500Hz, 1g, 26 sweeps per axis (x, y, z) - Tested acc. IEC 68-2-6 - Driver board fixed at primary side with four steel cheesehead screws from Farnell (www.farnell.com), part number 8857717 (manufacturer Roebuck) and four brass spacer pins from Schaefer Elektromechanik (wwww.elektromechanik-schaefer.de), part number 6040-25. Driver board fixed at secondary side with four nylon cheesehead screws from Allthread (www.allthread.co.uk), part number 119040006 and four plastic spacer pins from Schaefer Elektromechanik (wwww.elektromechanik-schaefer.de), part number 8040-25.
Shock	Half-sinusoidal pulse 15g, shock width 18ms, 3 shocks in each direction (±x, ±y, ±z), 18 shocks in total - Tested acc. IEC 68-2-27 - Driver board fixed at primary side with four steel cheesehead screws from Farnell (www.farnell.com), part number 8857717 (manufacturer Roebuck) and four brass spacer pins from Schaefer Elektromechanik (wwww.elektromechanik-schaefer.de), part number 6040-25. Driver board fixed at secondary side with four nylon cheesehead screws from Allthread (www.allthread.co.uk), part number 119040006 and four plastic spacer pins from Schaefer Elektromechanik (wwww.elektromechanik-schaefer.de), part number 8040-25.
Temperature humidity	- 40/085/56 (+40°C, 85% RH, 56h) - Tested acc. IEC 60068-1 (climate) - Climate class 3K3
Fast transients (Burst)	- Power terminals: 4kV / 5kHz - Control terminals: 4kV / 5kHz - Tested acc. EN 61000-4-4
Electrostatic discharge (ESD)	- Contact discharge: 6kV - Air discharge: 8kV - Tested acc. EN 61000-4-2

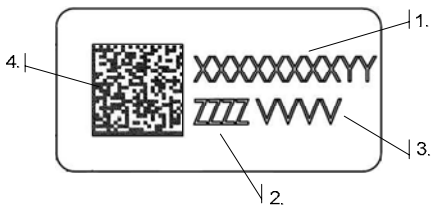
Radio Frequency Fields	- Electrical field: 7,5V/m - Polarisation: vertical + horizontal - Frequency: 80 MHz - 1000 MHz - Modulation: 80% AM, 1kHz - Tested acc. EN 61000-4-3
RF Conducted Disturbance	- Voltage: 10V EMF - Frequency: 150 kHz - 80 MHz - Modulation: 80 % AM, 1kHz - Tested acc. EN 61000-4-6

The characteristics and further environmental conditions are indicated in the data sheet.

Marking

Every driver board is marked. The marking contains the following items.

Part Marking Information



1. SEMIKRON part number (8 digits) + version number (2 digits)
2. Date code (4 digits): YYWW
3. Continuous number referred to date coce (4 digits)
4. Data matrix code

The Data Matrix Code is described as follows:

- Type: EEC 200
- Standard: ICO / IEC 16022
- Cell size: 0,254 - 0,3 mm
- Dimension: 5 × 5 mm
- The following data is coded:

❶ ❷ ❸ ❹ ❺
XXXXXXXXYY ZZZZ VVVV

❶	8 digits 2 digits	part number version number
❷	1 digit	blank
❸	4 digits	date code
❹	1 digit	blank
❺	4 digits	continuous number

www.SEMIKRON.com