Absolute Maximum Ratings T_a = 25 °C

Symbol	Term	Value	Units
V_S	Supply Voltage primary	15,6	V
V_{IH}	Input signal Voltage High (5 V input level)	6.5	V
V_{CE}	Collector-Emitter-Voltage	1200	V
dv/dt	Rate of rise and fall of voltage (secondary to primary side)	15	kV/µs
$V_{isol\ IO}$	Isolation test voltage IN-OUT (1 min)	2.5	kV_{AC}
T_{op} / T_{stg}	Operation Temp.	0 ... + 70 [1)]	°C
	Storage Temp.	0 ... + 70 [1)]	°C
Sixpack Circuit			
$I_{OUT\ peak}$	Output peak current	1,5	A
I_{OUTAV}	Output average current (max)	15	mA
f_{sw}	Switching frequency (max) [4)]	20	kHz
R_{IN}	Input resistance	500	Ω
R_{gmin}	Minimum gate resistor	18 [9)]	Ω
$Q_{OUT/pulse}$	Charge per pulse	0.750	µC
Brake Chopper Circuit			
$I_{OUT\ peak}$	Output peak current	1	A
I_{OUTAV}	Output average	8,4	mA
R_{IN}	Input resistance	500	Ω
f_{sw}	Switching frequency	20	kHz
R_{gmin}	Minimum gate resistor	15	Ω
$Q_{OUT/pulse}$	Charge per pulse	0.42	µC
$T_{TRIPBRC}$ [2)]	Triplevel temp.-monitoring	115 ± 5 [3)]	°C

Electrical Characteristics T_a = 25 °C

Symbol	Term	min	typ	max	Units	remark
V_S	Supply voltage primary	14.4	15.0	15.6	V	Pin 11
I_S	Supply current max		0.43 / 0,70 [8)]		A	
I_{SO}	Supply current primary standby		0,165 / 0,27 [8)]		A	
V_{iH5V} [4)]	Input voltage 5 V input level		5		V	
V_{iH15V} [4)]	Input voltage 15 V input level		15		V	Rv=1kΩ
$V_{iInhibit\ off}$	Inhibit voltage off		< 5		V	
Sixpack Circuit						
$V_{G(on)}$	Turn-on gate voltage		+ 15		V	
$V_{G(off)}$	Turn-off gate voltage		– 8		V	
$t_{d(on)\ IO}$	Input-Output turn-on propagation time		0.3		µs	
$t_{d(off)\ IO}$	Input-Output turn-off propagation time		0.3		µs	
Brake Chopper Circuit						
$V_{G(on)}$	Turn-on gate voltage		+ 15		V	
$V_{G(off)}$	Turn-off gate voltage		0		V	
V_{GESTAT}	Reference voltage for V_{CE}-monitoring		5,3		V	
V_{OL} [5)]	logic low output voltage		500		mV	10 mA
V_{OH} [5)]	logic high output voltage		30		V	10 mA
$t_{d(on)\ IO}$	Input-Output turn-on propagation time		3.9		µs	
$t_{d(off)\ IO}$	Input-Output turn-off propagation time		6.4		µs	
$t_{d(err)\ Gate}$ [6)]	Error input-output propagation time		3.2		µs	V_{CEBRC}
$t_{d(err)\ ovr}$ [7)]	Error input-output propagation time		6.7		µs	

SEMIDRIVER®
IGBT Driver kit
SKHIBS 01 / 02

Preliminary Data

General Features

- driver for sixpack and sevenpack up to V_{CES} = 1200 V
- used together with the transformer → minimal configuration for operation
- Inhibiting signal
- ERROR output (open collector transistor)

Sixpack circuit

- input signals transferred via opto couplers
- turn on voltage + 15 V / turn off voltage – 8 V
- separate, insulated supply voltage for the 3 TOP switches
- common, insulated supply voltage for the 3 BOT switches

brake chopper circuit

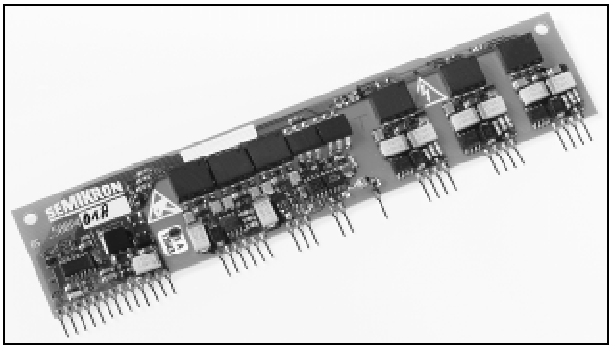
- driver for BRC - IGBT
- V_{CE} monitoring for brake chopper IGBT
- temperature monitoring (external adjustable) for BRC - IGBT
- turn on voltage + 15 V / turn off voltage 0 V
- isolation via opto couplers

1) – 25 °C ... + 85 °C on request
2) If temperature monitoring in use Trip level can be adjusted with an external resistor
3) factory adjusted
4) R_{in} = 500 Ω
5) open collector output, external pull-up resistor
6) time for shut off the gates when failure occur
7) time between failure occur and information available at output $\overline{\text{ERROR}}$ (Pin 8)
8) Supply current SKHIBS 02
9) at 20 kHz switching frequency

SEMIDRIVER ®
SKHIBS Driver kit
Subprints for soldering into a printed circuit board

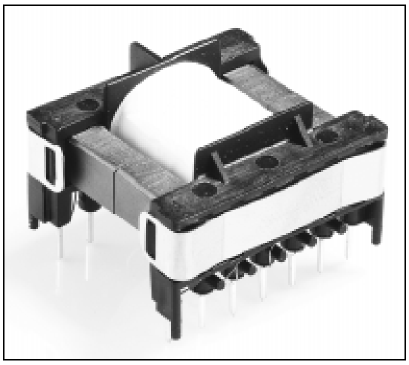
Preliminary Data

subprint 1



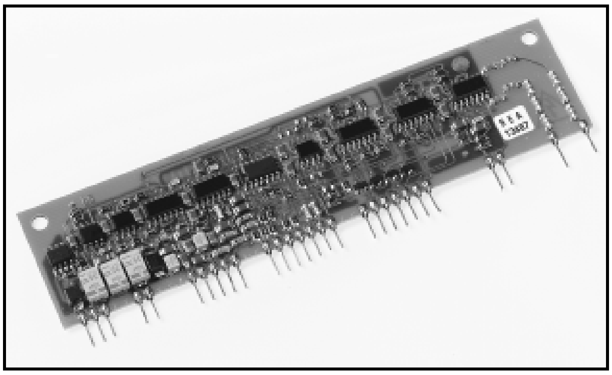
Sixpack circuit
+ brake chopper circuit

transformer



SKHIBS 01

subprint 2



supervisory
+ monitoring circuits

SKHIBS 02

Overview SEMIKRON driver kit SKHIBS 01 / 02

The SEMIKRON driver kit SKHIBS consists in max. configuration of 2 subprints and 1 transformer, which have to be soldered into a printed circuit board (PCB).

Subprint 1 together with the transformer represents the minimal configuration, SKHIBS 01, which can be used for driving max. 7 IGBTs, e.g. a sixpack or a sixpack with brake chopper.

Subprint 2 (supervisory and monitoring functions) completes the driver kit, and can be used optional together with Subprint 1 and the transformer. This subprint is special made for using with SEMIKRON protection principle OCP (Over Current Protection) using closed loop current sensors for protecting the driver against overcurrent, short circuit and ground fault condition.

SEMIKRON devices MiniSKiiP 8 with integrated current sensors, as well as MiniSKiiP 3 or SEMITRANS 6 or 7 with external current sensors, soldered into the printed board, can be used together with this complete driver kit SKHIBS 02.

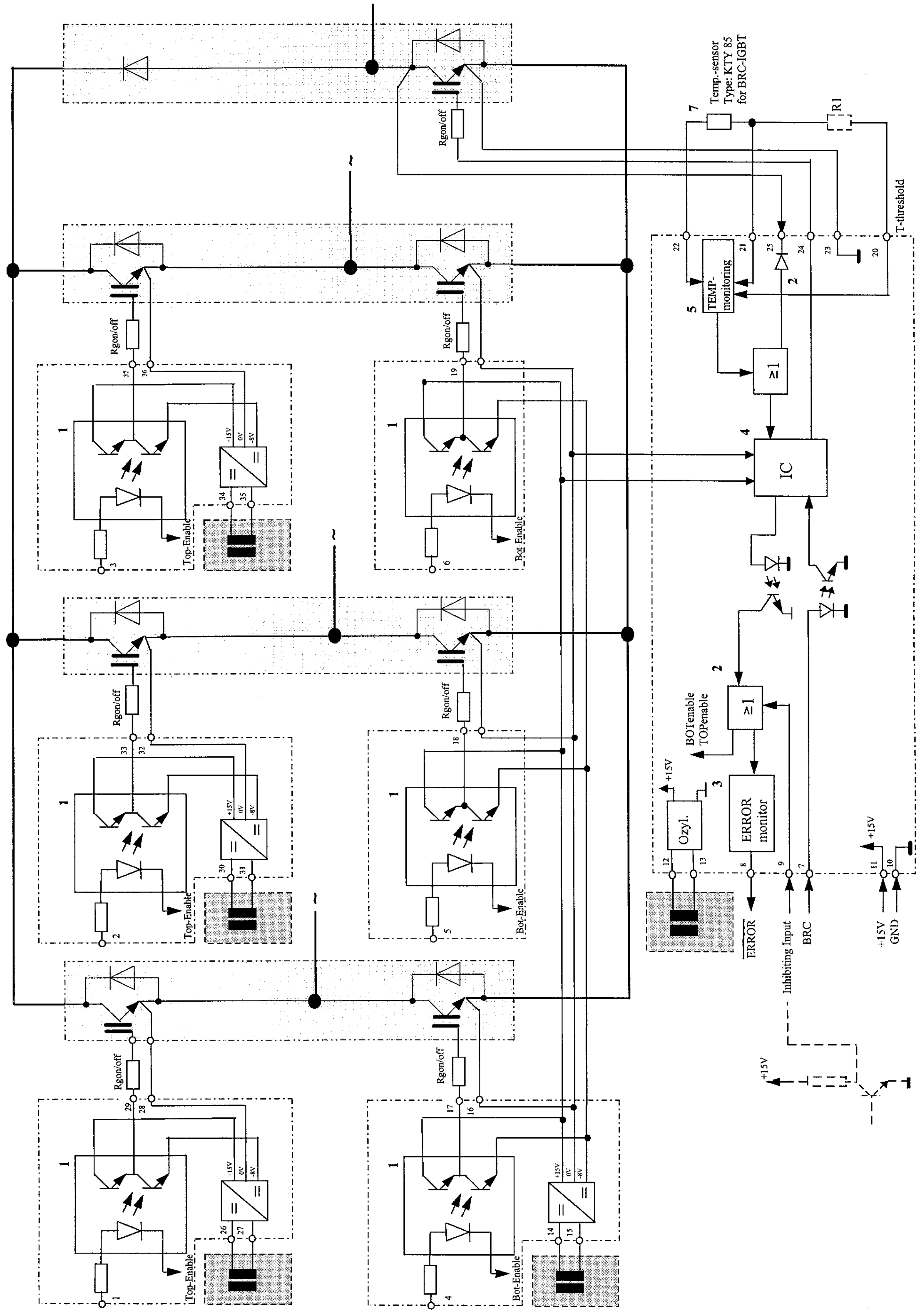
SKHIBS drives IGBTs up to V_{CES} =1200 V. The output capability was designed to drive 120 A IGBTs up to 20 kHz.

The power supply for the driver kit may be the same used for the control board (15 V ± 0.6 V), without the requirements of insulation. The signals (inverter) between primary side and secondary side are transmitted via opto couplers (also used for insulation) with a dv/dt > 15 kV/µsec.

Operation (storage) temperature is from 0 °C to + 70 °C, (– 25 °C to + 85 °C on request).

To protect the subprints against moisture and dust they are coated with varnish.

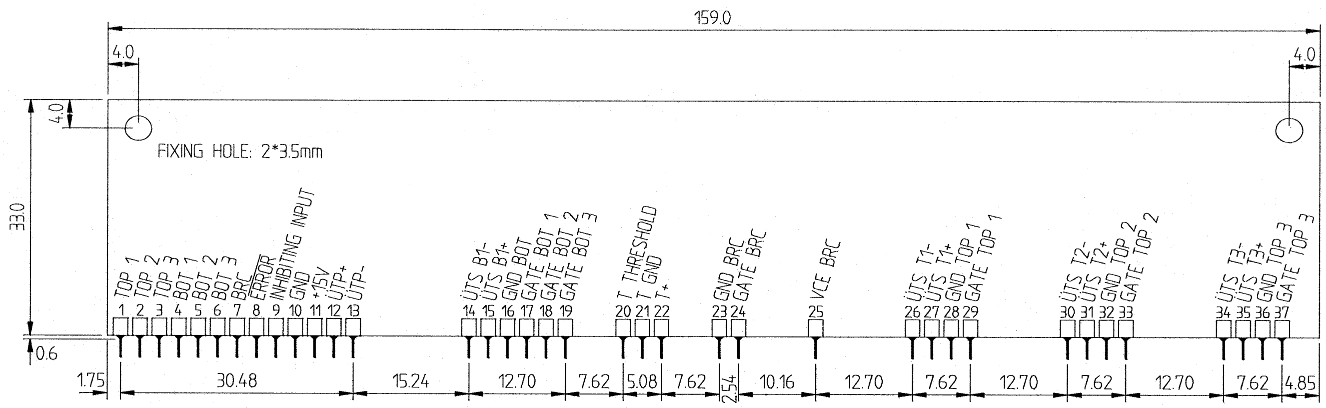
SKHIBS 01 Block Diagram



Description of the circuit block diagram SKHIBS 01
insulated
The circuit shows the minimal configuration for driving 6 inverter IGBTs and 1 brake chopper IGBTs.
The transformer delivers the insulated supply voltage for driving the IGBTs.
The regulation of these voltages is made on subprint 1.
For each TOP IGBT + 15 V is used for switching on the IGBT,
– 8 V is used for switching off the IGBT.
The BOT IGBTs are supplied with one common power supply, + 15 V is used for switching on and – 8 V is used for switching off. The brake chopper IGBT is supplied due to the power supply used for the BOT switches.
For switching off the brake chopper IGBT 0 V is used. Switching on is made with + 15 V.

The driver kit SKHIBS 01 is able to drive SEMIKRON IGBTs up to I_C = 120 A specified at 25 °C.

Outline subprint 1



PIN-array subprint 1

Characteristics			
PIN	**symbol**	**term**	**remark**
1	TOP 1	input TOP 1	5 V / 10 mA (using 15 V input voltage; additional Rv = 1 kΩ necessary
2	TOP 2	input TOP 2	5 V / 10 mA (using 15 V input voltage; additional Rv = 1 kΩ necessary
3	TOP 3	input TOP 3	5 V / 10 mA (using 15 V input voltage; additional Rv = 1 kΩ necessary
4	BOT 1	input BOTTOM 1	5 V / 10 mA (using 15 V input voltage; additional Rv = 1 kΩ necessary
5	BOT 2	input BOTTOM 2	5 V / 10 mA (using 15 V input voltage; additional Rv = 1 kΩ necessary
6	BOT 3	input BOTTOM 3	5 V / 10 mA (using 15 V input voltage; additional Rv = 1 kΩ necessary
7	BRC	input brake chopper	5 V / 10 mA (connected to Pin 16 of SKHIBS 03 when in use)
8	$\overline{\text{ERROR}}$	output ERROR	open collector transistor (30 V / 10 mA)
9	Inhibiting Input	Inhibit signal	connected to open collector (max. 15 V) or connected to Pin 17 (of SKHIBS 03 when in use)
10	GND	GND power supply	controlled power supply
11	+ 15 V	+ 15 V power supply	controlled power supply (15 V+ / –0.6 V)
12	ÜTP +	input voltage DC/DC converter	connected to PIN 1 SKHIBS 02 short distance for connection to SKHIBS 02 required
13	ÜTP -	input voltage DC/DC converter	connected to PIN 2 SKHIBS 02 short distance for connection to SKHIBS 02 required
14	ÜTS B1-	input voltage BOT DC/DC converter	connected to PIN 8 SKHIBS 02 short distance for connection to SKHIBS 02 required
15	ÜTS B1+	input voltage BOT DC/DC converter	connected to PIN 7 SKHIBS 02 short distance for connection to SKHIBS 02 required
16	GND BOT	GND BOT 1 - 3	
17	Gate BOT 1	output gate BOT 1	turn on + 15 V, turn off – 8 V
18	Gate BOT 2	output gate BOT 2	turn on + 15 V, turn off – 8 V
19	Gate BOT 3	output gate BOT 3	turn on + 15 V, turn off – 8 V
20	T THRESHOLD	input threshold voltage T_{BRC}	adjustable due to external resistor R1
21	T GND	GND for PIN 20 and 22	
22	T +	input temperature sensor	connected to BRC-Temp. sensor used in SEMIKRON devices MiniSKiiP 8
23	GND BRC	GND BRC	
24	Gate BRC	output gate BRC	turn on + 15 V, turn off 0 V
25	VCE BRC	VCE monitoring BRC	connected to collector BRC- IGBT
26	ÜTS T1-	input voltage TOP 1 DC/DC converter	connected to PIN 10 SKHIBS 02 short distance for connection to SKHIBS 02 required
27	ÜTS T1+	input voltage TOP 1 DC/DC converter	connected to PIN 9 SKHIBS 02 short distance for connection to SKHIBS 02 required
28	GND TOP 1	GND TOP 1	
29	Gate TOP 1	output gate TOP 1	turn on + 15 V, turn off – 8 V
30	ÜTS T2-	input voltage TOP 2 DC/DC converter	connected to PIN 12 SKHIBS 02 short distance for connection to SKHIBS 02 required
31	ÜTS T2+	input voltage TOP 2 DC/DC converter	connected to PIN 11 SKHIBS 02 short distance for connection to SKHIBS 02 required
32	GND TOP 2	GND TOP 2	
33	Gate TOP 2	output gate TOP 2	turn on + 15 V, turn off – 8 V
34	ÜTS T3-	input voltage TOP 3 DC/DC converter	connected to PIN 14 SKHIBS 02 short distance for connection to SKHIBS 02 required
35	ÜTS T3+	input voltage TOP 3 DC/DC converter	connected to PIN 13 SKHIBS 02 short distance for connection to SKHIBS 02 required
36	GND TOP 3	GND TOP 3	
37	Gate TOP 3	output gate TOP 3	turn on + 15 V, turn off – 8 V

Features of subprint 1

1. Introduction

Before giving detailed informations about SKHIBS 01 a short description is given about the using of the subprint 1 and the transformer.

a) Subprint 1 together with the transformer describes the minimal configuration for driving 6 IGBT switches and 1 brake chopper IGBT. 6 Opto couplers are used for driving the IGBTs of the inverter circuit.
Driving of the brake chopper IGBT is made with an integrated circuit, which allows the short circuit protection of this brake chopper IGBT due to V_{CE}-monitoring. The protection of the brake chopper against overtemperature, e.g. using the temperature sensor e.g. in MiniSKiiP 8 devices, can also be made.
Insulation of the inputsignal PIN 7 „BRC“ and the Error feedback PIN 8 „$\overline{\text{ERROR}}$“ is made via opto-couplers.

b) The transformer supplies the insulated supply voltage. The 6 IGBT for the inverter are supplied with regulated + 15 V for switching on and -8V for switching off the IGBTs.
The 3 TOP-IGBTs have separate supply voltages. The 3 BOT-IGBTs have a common supply voltage.
This voltage is also used for driving the brake chopper IGBT, if in use.
Circuits on subprint 1 provide the regulated voltages for switching the IGBTs.

c) Using only SKHIBS 01, there will be no feature to protect the IGBTs against short circuit. But with the input PIN 9 „INHIBITING INPUT“ all inverter IGBTs can be made inactive, when the customers evaluation electronic delivers a fault signal, e.g. in short circuit condition.

Together with the subprint 2 the protection of the inverter IGBTs can be made with the SEMIKRON driver principle „OCP“. OCP stands for **O**ver **C**urrent **P**rotection. The closed loop current sensors, integrated e.g. in MiniSKiiP 8 (inverter device) are used to protect the system against short circuit, earth fault and overload condition.

d) The brake chopper IGBT of the subprint 1 has a separate input PIN 7 „BRC“ for externally controlling of this IGBT in chopper mode. Using the SKHIBS 02 a brake chopper control circuit is realised on subprint 2. This will be explained in chapter B2.

2. Input circuit for inverter

The signal transfer to each IGBT is made with opto-couplers, used for switching on and switching off the IGBT. When using 5 V inputsignal (TTL-logic), no additional resistor in series to the input is necessary.

Using positive 15 V input voltage an additional resistor R_v = 1 kΩ have to be connected in series to the inputs.

Because no interlock of TOP and BOT switch in each halfbridge is made on the subprint, the controller have to provide this interlock. Deadtime of interlock should be t_{TD} > 3 µsec.

Please observe: No interlock will destroy the IGBT when switching.

There are no gate resistors Rgon/off provided on the subprint 1.
The max. output peak current IOUTpeak < 1,5 A have to considered, when fixing the gate resistors.
The minimum permissible gate resistor is Rg = 18 Ω. 18 kHz < f_{sw} < 20 kHz
15 Ω. 16 kHz < f_{sw} < 18 kHz
12 Ω < 16 kHz switching frequency

3. INHIBITING signal

Therefore the SKHIBS 01 has no protection against short circuit it will be possible to disconnect the low voltage side from high voltage side in case of a fault condition due to the input PIN 9 „INHIBITING INPUT". In case of fault condition the INHIBITING INPUT signal have to be turned to LOW signal (set to GND).
When the INHIBITING signal is short in time, an internal circuit extent a short pulse to 1 ms.
The INHIBITING signal sets the $\overline{\text{ERROR}}$ output PIN 8 from LOW to HIGH level.

The power supply for the inverter IGBTs as well as the brake chopper IGBT, will also be disconnected, when the brake chopper IGBT driver circuit creates an $\overline{\text{ERROR}}$ signal caused either due to VCE-monitoring or overtemperature monitoring of the brake chopper IGBT.

4. $\overline{\text{ERROR}}$ monitoring

The Error output PIN 8 „$\overline{\text{ERROR}}$" is an open collector transistor (max. 30 V / 10 mA).
In case of an $\overline{\text{ERROR}}$ (either external fault information via the input PIN 9 „INHIBITING INPUT" or because of an internal fault information (created on subprint 1) the $\overline{\text{ERROR}}$ output PIN 8 is set to HIGH level.
When there is a fault condition, transferred due to the INHIBITING INPUT signal, the $\overline{\text{ERROR}}$ output is active until the INHIBITING INPUT is > 5 V (Umax. = + 15 V).
When PIN 8 „$\overline{\text{ERROR}}$" is active due to the V_{CE}-monitoring or overtemperature sensing of the brake chopper, the $\overline{\text{ERROR}}$ output is active until the input signal PIN 7 „BRC" is set to LOW level (OV) for t > 1msec.

5. brake chopper driver

The brake chopper driver IC transfers the on and off signals to the brake chopper IGBT.
Switching on of the IGBT is made with + 15 V, switching off is made with 0 V.
This IC also monitors the V_{CE}-voltage of the brake chopper. If there is a short circuit, the V_{CE}-monitoring delivers a error signal at PIN 8 "$\overline{\text{ERROR}}$" when the voltage exceed typ. 5.3 V.
When the brake chopper is not in use, input PIN 7 „BRC" have to be set to „GND" (PIN 10).
Also the input on secondary side PIN 25 „V_{CE} BRC" have to be connected to „GND" (PIN 23).

Temperature monitoring (Brake chopper only)

Also an $\overline{\text{ERROR}}$ signal will be transferred to the $\overline{\text{ERROR}}$ output PIN 8 „$\overline{\text{ERROR}}$", when the temperature exceeded a value, fixed by the customer (factory adjusted: max. T_{TRIP} = 115 °C + / – 5 °C).
This circuit evaluates the overtemperature of a thermal resistor type KTY 85 (Philips), which is soldered on the DCB ceramic of SEMIKRON MiniSKiiP 8 devices.
When this temperature is not in use, input PIN 21 „T GND“ have be connected to PIN 22 „T+“.

Factory adjusted the overtemperature detection is fixed to 115 °C heatsink temperature.
Due to the paralleling of the external resistor R1 between PIN 20 „T THRESHOLD“ and PIN 21 „GND“ the threshold level can be adjusted, according to the following table.

Ttrip heatsink	calculated resistor R1	recommended resistor R1 (E96)
50 °C	3.54 kΩ	3.57 kΩ
60 °C	4.41 kΩ	4.42 kΩ
70 °C	5.69 kΩ	5.62 kΩ
80 °C	7.70 kΩ	7.68 kΩ
85 °C	9.22 kΩ	9.31 kΩ
90 °C	11.38 kΩ	11.30 kΩ
95 °C	14.66 kΩ	14.70 kΩ
100 °C	20.26 kΩ	20.50 kΩ
105 °C	31.98 kΩ	31.60 kΩ
110 °C	70.19 kΩ	69.80 kΩ

Table 2: trip level for temperature protection; accuracy = + / – 5 °C

Transformer

Preliminary Data

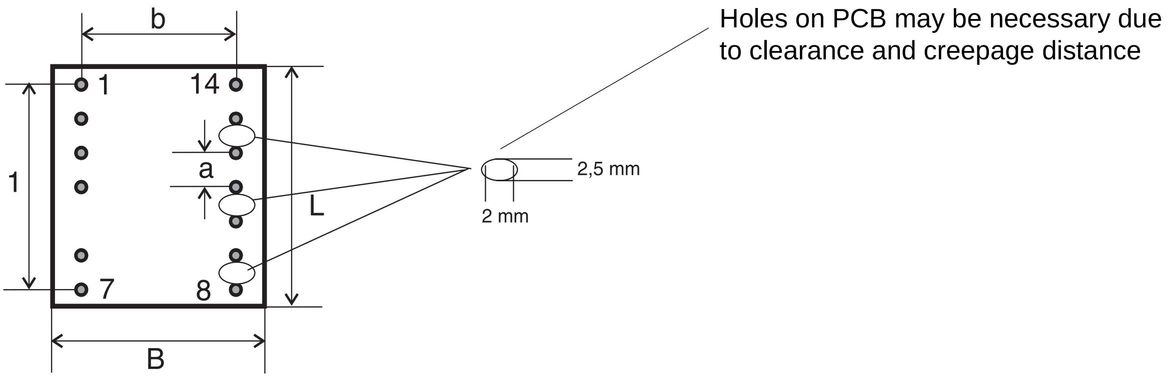


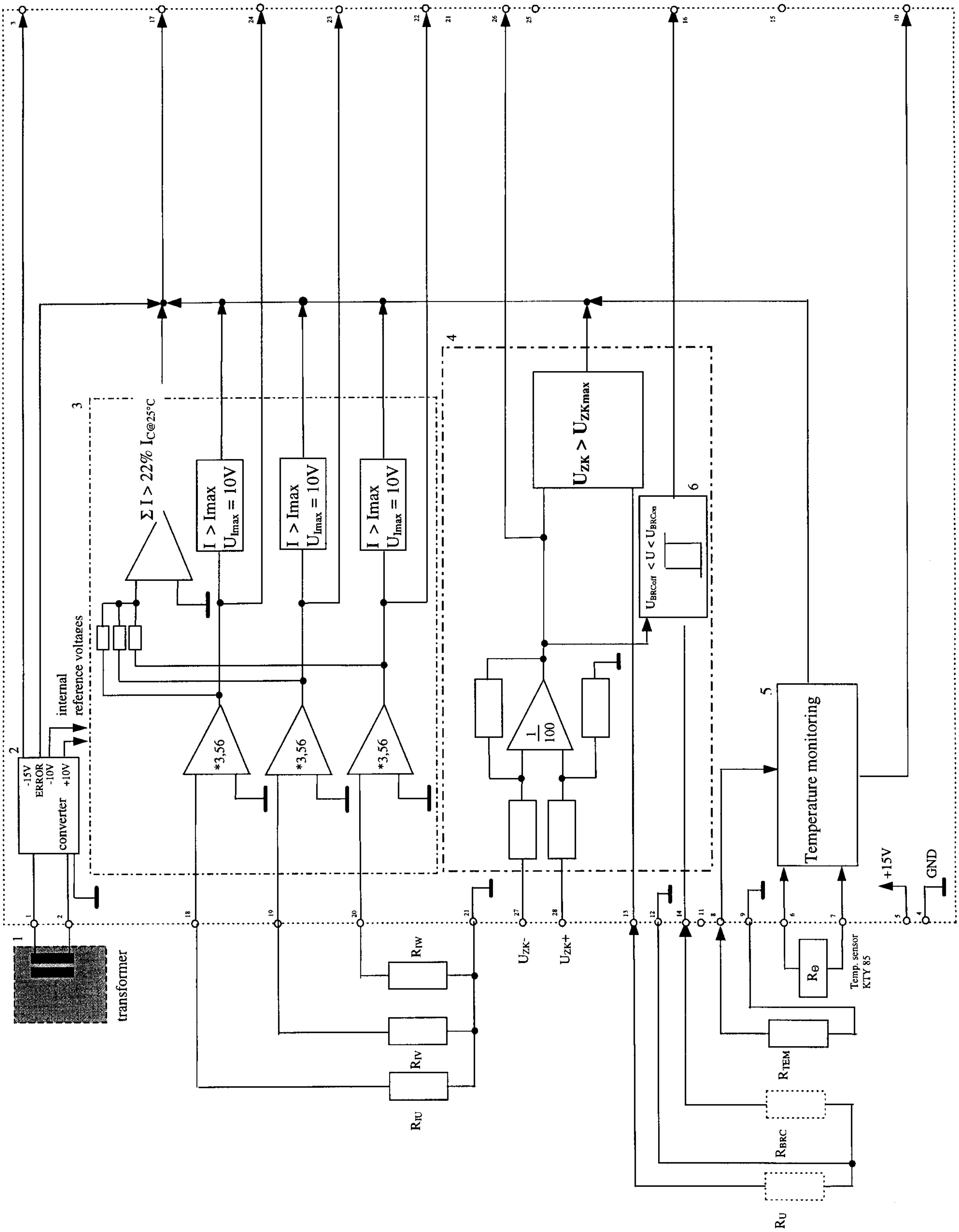
Fig. 3 Outline transformer

Dimensions			
term		**value**	**unit**
PIN dimension		QU. 0.7	mm
length	L	35.4	
width	B	31.4	
height	H	< 25	
distance between pins	a	5.08	
distance between pins lines	b	22.86	
distance between pins 1 to 7 and pins 8 to 14	i	30.48	

PIN array

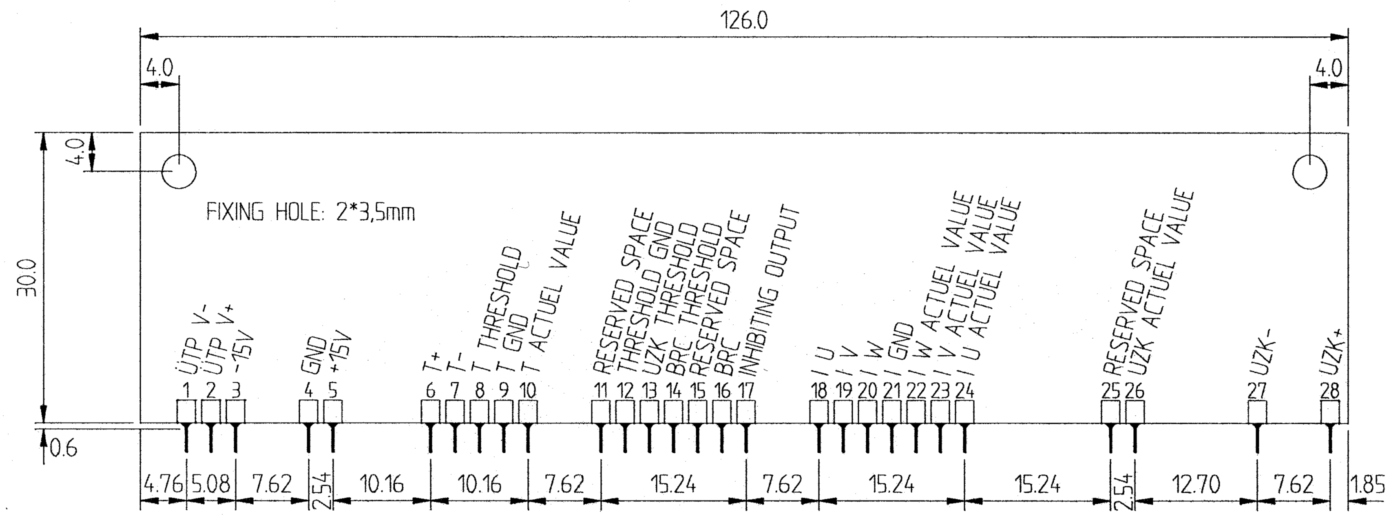
PIN number	term	remark
1	supply voltage (+ 15 V / 0 V)	connected to PIN 12 subprint 1 (short distance for connection required)
2	supply voltage (+ 15 V / 0 V)	connected to PIN 13 subprint 1 (short distance for connection required)
3	output voltage VI (used for – 15 V)	connected to PIN 2 subprint 2 (short distance for connection required)
4	output voltage VI (used for – 15 V)	connected to PIN 1 subprint 2 (short distance for connection required)
7	output voltage II (used for supply of BOT switches)	connected to PIN 15 subprint 1 (short distance for connection required)
8	output voltage II (used for supply of BOT switches)	connected to PIN 14 subprint 1 (short distance for connection required)
9	output voltage III (used for supply of TOP 1)	connected to PIN 27 subprint 1 (short distance for connection required)
10	output voltage III (used for supply of TOP 1)	connected to PIN 26 subprint 1 (short distance for connection required)
11	output voltage IV (used for supply of TOP 2)	connected to PIN 31 subprint 1 (short distance for connection required)
12	output voltage IV (used for supply of TOP 2)	connected to PIN 30 subprint 1 (short distance for connection required)
13	output voltage V (used for supply of TOP 3)	connected to PIN 35 subprint 1 (short distance for connection required)
14	output voltage V (used for supply of TOP 3)	connected to PIN 34 subprint 1 (short distance for connection required)

Block Diagram Subprint 2



R_U and R_{BRC} can be soldered on PCB
R_{TEM} must be soldered on PCB

Outline subprint 2



PIN-array subprint 2

Characteristics			
PIN	**symbol**	**term**	**remark**
1	ÜTP V-	input voltage for -15V	connected to PIN 4 of transformer (short distance for connection required)
2	ÜTP V+	input voltage for -15V	connected to PIN 3 of transformer (short distance connection required)
3	– 15 V	– 15 V output voltage	neg. supply voltage for evaluation electronic for the current sensors
4	GND	GND power supply	controlled power supply
5	+ 15 V	+ 15 V power supply	controlled power supply
6	T+	input temperature sensor	connected to temp. sensor
7	T-	input temperature sensor	connected to temp. sensor
8	T THRESHOLD	input threshold voltage T-sensoring	adjusted by external resistor, resistor **must** be soldered on PCB R_{TEM} = 0 Ω ⇒ Terr = 115 °C
9	T GND	GND for T-threshold	GND for PIN 8
10	T ACTUAL VALUE	T-sensoring actual value	analogue voltage signal (unipolar, max. 5 mA)
11	reserved		
12	THRESHOLD GND	GND for U-threshold and BRC threshold	GND for PINs 13 / 14
13	U THRESHOLD	input threshold voltage max. U_{DC} - link voltage	adjusted by external resistor RUresistor can be soldered on PCB
14	BRC THRESHOLD	input threshold voltage U_{BRC} - on/off voltage	adjusted by external resistor RBRCresistor can be soldered on PCB
15	reserved		
16	BRC	turn on/off signal	connected to PIN 7 SKHIBS01
17	Inhibiting output	inhibit signal	
18	IU	input current phase U	connected to evaluation electronic of current sensors, via load resistor R_{IU}
19	IV	input current phase V	connected to evaluation electronic of current sensors, via load resistor R_{IV}
20	IW	input current phase W	connected to evaluation electronic of current sensors, via load resistor R_{IW}
21	I GND	GND for IU, IV, IW	GND for PINs18/19/20
22	IW ACTUAL VALUE	output current phase U actual value	analog output signal (bipolar, I_{max}. 5 mA)
23	IV ACTUAL VALUE	output current phase V actual value	analog output signal (bipolar, I_{max}. 5 mA)
24	IU ACTUAL VALUE	output current phase W actual value	analog output signal (bipolar, I_{max}. 5 mA)
25	reserved		
26	UZK ACTUAL VALUE	output signal UZK	
27	UZK -	DC-link voltage - UZK	
28	UZK +	DC-link voltage + UZK	

Features of subprint 2

Subprint 2 has to be used with the subprint 1 and the transformer to form the complete driver kit SKHIBS 02.
The subprint 2 has several monitoring and supervising circuits integrated, which can be used also separately, if one of the functions is not used. The transformer supplies the supply voltage to provide the current sensor electronic with negative – 15 V. Regulation of the – 15 V voltage is done on the subprint 2.

The features of subprint 2 are listed:

1. current sensing

monitoring circuit for evaluation of 3 current sensors used e.g. in MiniSKiiP 8 (the evaluation electronic for the current sensors have also be soldered onto the PCB)

- short circuit protection (AC to AC and AC to DC terminals)
- earth fault protection
- normalized, analog voltage signal of the actual AC-current value for using in control system available

2. temperature sensing

monitoring circuit for temperature sensor type KTY 85 (Philips) used in SEMIKRON MiniSKiiP devices

- overtemperature protection (threshold level adjustable with external resistor RTEM)
- normalized, analog voltage signal of the actual heatsink temperature available

3. DC-link voltage sensing

DC-link voltage monitoring and evaluation of chopper switching signals for driving a brake chopper IGBT

- evaluation of brake chopper threshold voltages for self controlled switching of brake chopper IGBT (threshold levels adjustable with external resistor RBRC)
- overvoltage monitoring U_{ZKmax} (threshold levels adjustable with external resistor R_U)
- normalized, analog voltage signal of the actual DC-link voltage available

4. undervoltage monitoring of the supply voltage

Switch off below 14 V

Functional Description of subprint 2

The block diagram on page 10 is used for explaining the supervisory and protection functions of subprint 2.

BOX 1/2. Negative supply voltage, internal reference voltage

The transformer have to be connected to the subprint 2 at Pin 1 „ÜTP V-“ and Pin 2 „ÜTP V+“.
An integrated circuit provides the negative – 15 V for supplying the evaluation electronics of the current sensors.
The + 10 V and – 10 V reference voltages are generated on subprint 2.

BOX 3. Current sensing

Fig. 1 is showing the SEMIKRON OCP **(Over Current Protection)** driver principle. The actual current signal information, evaluated by the current sensors used for each phase e.g. closed loop current sensors integrated in SEMIKRON device MiniSKiiP 8 or when using current sensors for soldering into a printed circuit board, are used to protect the IGBTs against short circuit, overload and earth fault condition. No cost intensive V_{CE}-monitoring circuits have to be consider on the printed circuit board, PCB.

Due to this new SEMIKRON driver principle the safety and the reliability of the inverters will be increased.

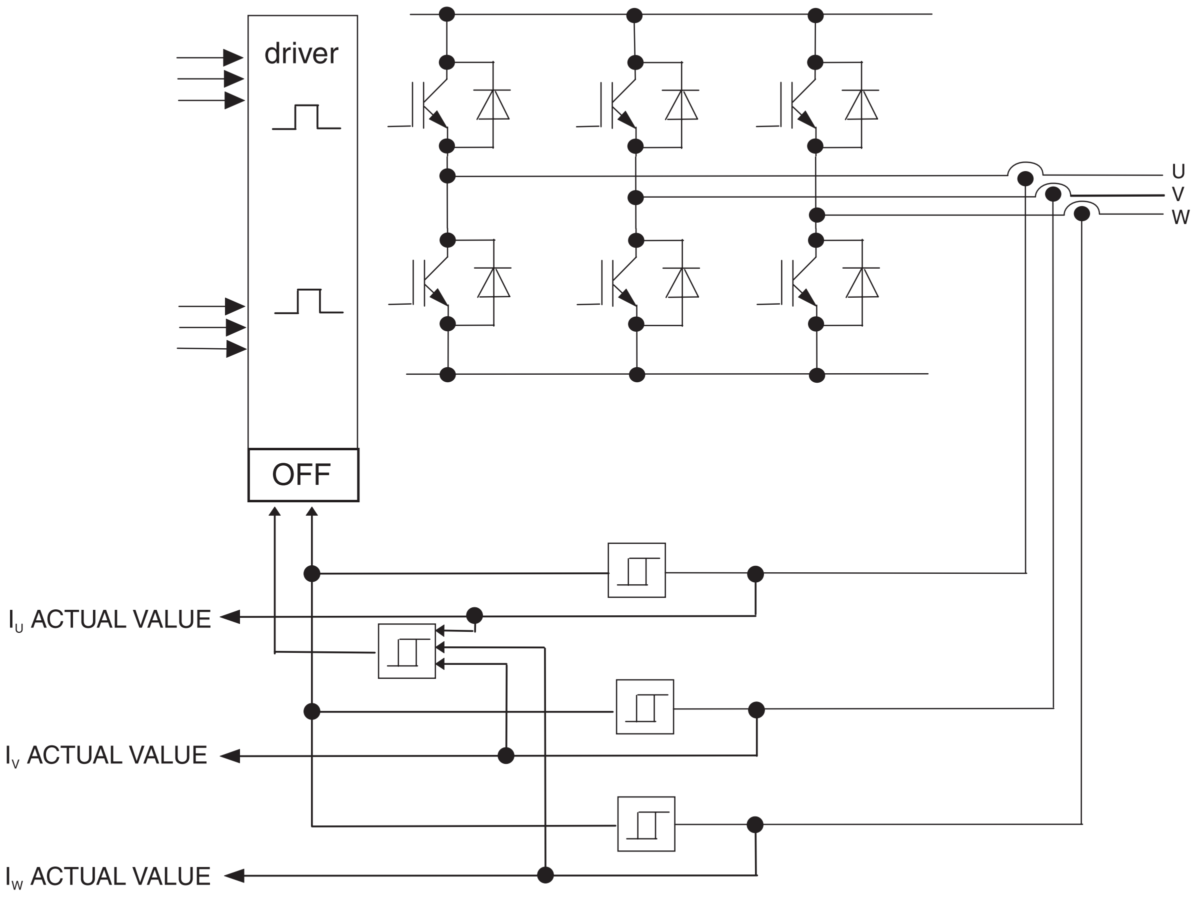


Fig. 1 OCP driver principle using current sensors for short circuit protection

This circuit is using the current sensor signals, provided by the evaluation electronic of the 3 current sensors, for short circuit protection. Also an analog voltage signal of the actual current value will be provided.
Short circuit protection is done by comparing the actual current (voltage across the load resistors of the current sensors R_{IU}, R_{IV} and R_{IW}) in each phase with a threshold voltage fixed on the subprint 2 (see Fig. 3).

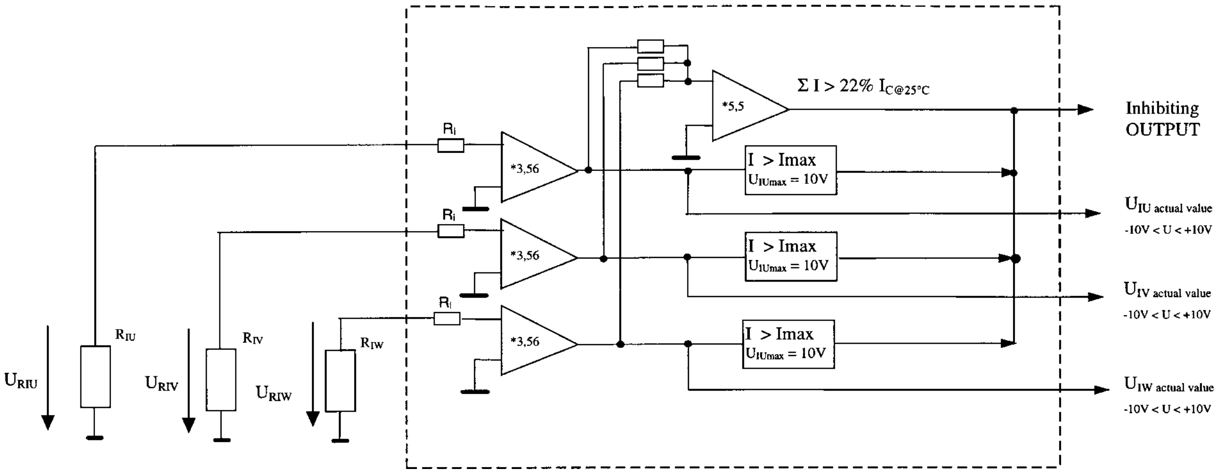


Fig. 3 current monitoring circuit

When the actual voltage value across the load resistors R_{IU}, R_{IV} or R_{IW} exceed 2.8 V, short circuit condition or overload condition will be noticed.

normalisation for short circuit protection:

$U_{IU,IV,IW\ ACTUAL\ VALUE}$: 10 V = U_{ISC} ⇒ $U_{RIU,RIV,RIW}$ = 2.8 V

normalisation for earth fault protection:

INHIBITING OUTPUT: I_{GL} > 22 % $I_{C\ @25°C}$ ⇒ Δ_{UR} = < 0.5 V

When these fault conditions occur, a signal (logic low level) is transferred via the output Pin 17 „INHIBITING OUTPUT“. This output have to be connected to Pin 9 „INHIBITING“ on subprint 1.
All Inverter IGBTs will be switched off, when Pin 9 „INHIBITING“ turns to LOW.

Table 1 is showing SEMIKRON’s recommendation using SEMIKRON IGBTs and current sensors from VAC (other current sensors can also be used, if specifications are comparable **- please observe data sheets of current sensors in use** -).

Short circuit trip level is here set to 125 % $I_{C\ @25\ °C}$ (recommended value by SEMIKRON).

SEMIKRON device	rated current $IC_{@25\ °C}$	recommendated trip level I_{TRIPSC} = 125 % $IC_{@25\ °C}$	calculated load resistors [3] R_{IU}, R_{IV}, R_{IW}	recommended load resistors R_{IU}, R_{IV}, R_{IW}	recommended current sensor [1]
SKiiP 30 NAB 06 [1]	30 A	> 37 A	151.9 Ω	150 Ω	type A
SKiiP 31 NAB 06 [1]	38 A	> 47 A	119.6 Ω	121 Ω	
SKiiP 30 NAB 12 [1]	33 A	> 41 A	137 Ω	137 Ω	
SKiiP 31 NAB 12 [1]	38 A	> 47 A	119.6 Ω	121 Ω	
SKiiP 32 NAB 12 [1]	65 A	> 81 A	69.4 Ω	69.8 Ω	
SKiiP 82 AC 06 I	60 A	> 75 A	74.9 Ω	75 Ω	integrated current sensor extra evalua-tion electronics
SKiiP 83 AC 06 I	100 A	> 119 A [2]	47.2 Ω	47.5 Ω	
SKiiP 81 AC 12 I	65 A	> 81 A	69.8 Ω	69.8 Ω	
SKiiP 82 AC 12 I	95 A	> 119 A	47.2 Ω	47.5 Ω	
SKM 22 GD 123 D (L)[1]	22 A	> 27 A	208.1 Ω	210 Ω	type A
SKM 40 GD 123 D (L)[1]	40 A	> 50 A	112.4 Ω	113 Ω	
SKM 75 GD 123 D (L) [1]	75 A	> 93 A	60.4 Ω	60.4 Ω	type B
SKM 22 GD 123 D (L) [1]	22 A	> 27 A	208.1 Ω	210 Ω	type A
SKM 40 GDL 123 D [1]	40 A	> 50 A	112.4 Ω	113 Ω	
SKM 75 GDL123 D [1]	75 A	> 93 A	60.4 Ω	60.4 Ω	type B
3 * SKM 50 GB 123 D [1]	50 A	> 62 A	90.6 Ω	90.9 Ω	
3 * SKM 75 GB 123 D [1]	75 A	> 93 A	60.4 Ω	60.4 Ω	

Table 1

1) external current sensors for soldering in PCB necessary (please see recommendation for current sensors below)

2) reduced value because of limitation of reproduction of sensor signals (see data sheets for current sensors)

3) $R_{IU}, R_{IV}, R_{IW} = \frac{U_{SC} * ü}{I_{SC}}$ with: ü = transformation ration of current sensor
U_{SC} = threshold voltage for short circuit detection
I_{SC} = actual short circuit current

$R_{IU}, R_{IV}, R_{IW} = \frac{2.8 * 2000}{I_{SC}}$ with: ü = 2000
U_{SC} = 2.8 V fixed on subprint 2

With the recommended values of the resistors given in table 1 the following normalisation is valid (but not valid for devices marked with 2) in table 1).

normalisation for analog output voltage signals:

$U_{IU\ ACTUAL\ VALUE}$: 8 V = $I_{C\ @25\ °C}$ ⇒ U_{RIU} = 2.25 V

$U_{IV\ ACTUAL\ VALUE}$: 8 V = $I_{C\ @25\ °C}$ ⇒ U_{RIV} = 2.25 V

$U_{IW\ ACTUAL\ VALUE}$: 8 V = $I_{C\ @25\ °C}$ ⇒ U_{RIW} = 2.25 V

normalisation for short circuit protection:

$U_{IU\ ACTUAL\ VALUE}$: 10 V = 125 % * $I_{C\ @25\ °C}$ ⇒ U_{RIU} = 2.8 V

$U_{IV\ ACTUAL\ VALUE}$: 10 V = 125 % * $I_{C\ @25\ °C}$ ⇒ U_{RIV} = 2.8 V

$U_{IW\ ACTUAL\ VALUE}$: 10 V = 125 % * $I_{C\ @25\ °C}$ ⇒ U_{RIW} = 2.8 V

If no current sensors are in use, the pins 22/23/24 have not to be connected to subprint 2 or not to be connected to the PCB.
Pin 18/19/20 have to be connected to pin 21 (GND)

Recommended current sensors for using with SKHIBS 02:

Overview of current sensor (from company VAC*)) and evaluation electronics recommended for SEMIKRON devices (see table 2)

type	VAC part-nb.	ratio	I_{NOM} [A]	$I_{maxprimary}$ [A]	$I_{maxsecondary}$ [mA]	dimension W'L'H (mm)	integrated electronic	busbar required
A	T60404-M4645-X021	1 : 2000	5 ... 80	120	60	39*30.5*16.5	no [1)]	no
B	T60404-N4644-X101	1 : 2000	50...100	150	75	40*18*25.4	yes	yes

Table 2

[1)] evaluation electronic type T60404-Q5790-X100 necessary

*) VAC VACUUMSCHMELZE GmbH
Postfach 2253
Grüner Weg 37
D-63450 Hanau

Tel.:++49 (0) 6181 38 0
Fax.:++49 (0) 6181 38 2645

BOX 4. DC-link voltage monitoring

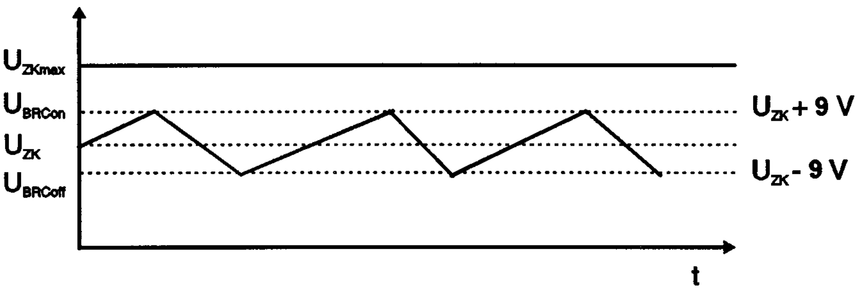
This circuit is using the DC-link voltage, connected to Pins 28 „UZK+“ and Pin 27 (UZK-) to evaluate the threshold voltages for the self-controlled brake chopper mode, when using the brake chopper IGBT.

Pin 16 „BRC“ of subprint 2 have to be connected to Pin 7 „BRC“ of subprint 1, when using the self-controlled brake chopper mode.

With the external resistor R_{BRC}, the switching on- and off levels can be adjusted. The hysteresis will be 18 V.

The following equation can be used to calculate the threshold R_{BRC}. This resistor have to be connected between Pin 14 „BRC THRESHOLD“ and PIN 12 „THRESHOLD GND“.

$$R_{BRC} = U_{ZK} / (100-U_{ZK}/9.01) - 1.1$$



When no external resistor R_{BRC} is soldered onto the PCB (factory adjusted) the switching on and off signals U_{BRCon} and U_{BRCoff} are fixed to the max. permissible DC-link voltage U_{ZK} < 900 V.

Please pay attention:

To adapt U_{BRCon} and U_{BRCoff} to the requirements of the application, R_{BRC} have to be fixed according the following table 3 (not all possibilities are shown).

U_{DC}	calculated R_{BRC}	recommended R_{BRC} (E96)	U_{BRCon}	U_{BRCoff}
300 V	3.4 kΩ	3.4 kΩ	308 V	292 V
600 V	16.86 kΩ	16.9 kΩ	608 V	592 V
750 V	43.65 kΩ	43.2 kΩ	758 V	742 V
850 V	149.07 kΩ	150 kΩ	858 V	842 V

Table 3

The same circuit detects the max DC-link voltage U_{ZKmax}, which can be adjust also by the external resistor R_U.
When $U_{ZK} > U_{ZKmax}$ a fault signal is transferred via the output PIN 17 „INHIBITING OUTPUT".
This output have to be connected to Pin 9 „INHIBITING" on subprint 1. All IGBTs will be switched off, when Pin 9 „INHIBITING" turns to LOW.

The threshold voltage Ru for switching off, because of overvoltage can be calculated with the following equation:

$$R_U = U_{ZKmax} / (100 - U_{ZKmax}/9.01) - 1.1$$

At PIN 26 „UZK ACTUAL VALUE" a normalized analog voltage signal of the actual DC-link voltage is available.

normalisation of the analog voltage signal:

$$U_{ZK\ ACTUAL\ VALUE} = \frac{1}{100} * U_{ZK}$$

$U_{ZK\ ACTUAL\ VALUE}$: 10 V = $U_{ZKmaxabsolute}$ = 1000 V

If the DC-link voltage circuit is not in use well as pin 27 and 28 have to be connected each other.

BOX 5. Temperature monitoring

This circuit evaluates the overtemperature of the thermal resistor type KTY 85 (Philips), which is soldered in SEMIKRON MiniSKiiP devices.
With an external resistor R_{TEM} the threshold voltage for overtemperature detection can be adjusted.

Please pay attention:
When this temperature circuit will be used, R_{TEM} have to be soldered between Pin 8 and Pin 9.

With R_{TEM} = 0 Ω the overtemperature detection (actual heatsink temperature) is adjusted to 115 °C with an accuracy of +/-5 °C.

Table 4 is showing the adjustment of the external resistors R_{TEM}.

Ttrip	recommended resistor R_{TEM} (E96) [1)]	calculated resistor R_{TEM}
50 °C	249 kΩ	251.86 kΩ
60 °C	48.7 kΩ	48.29 kΩ
70 °C	22.1 kΩ	22.22 kΩ
80 °C	12.1 kΩ	12.01 kΩ
85 °C	8.87 kΩ	8.93 kΩ
90 °C	6.49 kΩ	6.56 kΩ
95 °C	4.7 kΩ	4.70 kΩ
100 °C	3.16 kΩ	3.18 kΩ
105 °C	1.96 kΩ	1.94 kΩ
110 °C	0.887 kΩ	0.89 kΩ
115 °C	0.0 kΩ	0.0 kΩ

Table 4

[1)] resistors have to be soldered onto PCB

If the temperature sensor is not in use input PIN 6 „T+“ have to be connected to PIN 7 “T-” and PIN 8 “T-threshold” have to be connected to PIN 9 “T_{GND}”
At the output Pin 26 „$U_{ZK\ ACTUAL\ VALUE}$“ a normalized, analog voltage of the actual heatsink temperature will be available. The following diagram is showing the curve of the analog voltage vs. the actual heatsink temperature. The accuracy is +/-5 °C.