SKYPER® 42 LJ R

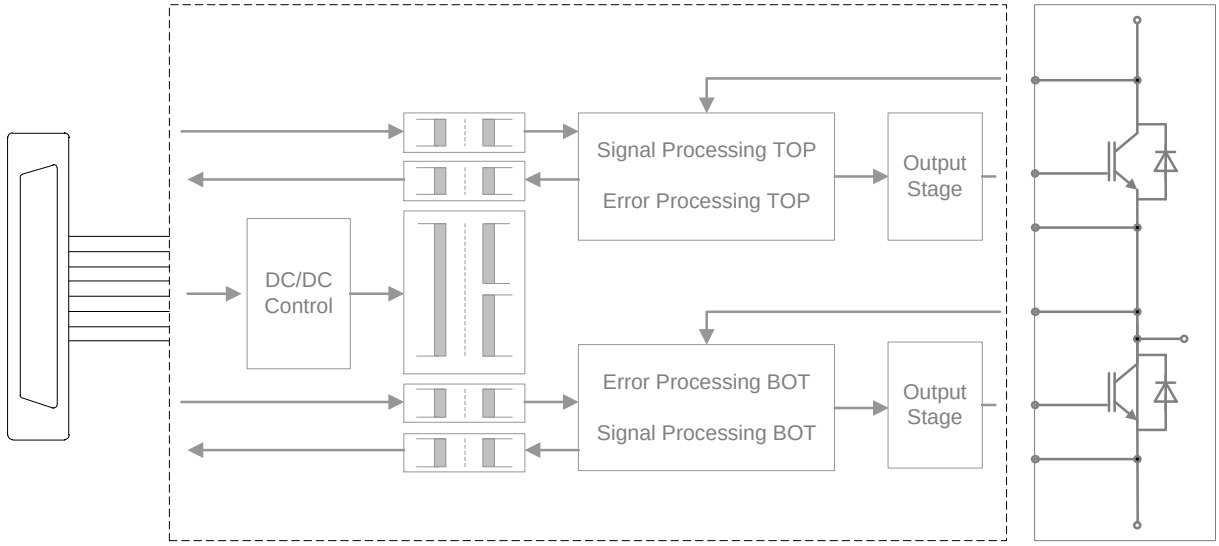
1. Introduction

The SKYPER 42 LJ core constitutes an interface between IGBT modules and the controller. This core is a half bridge driver. Driving, insulation and protection functions are integrated in the driver. SKYPER 42 LJ R is developed for systems up to 300kW.

- Two output channels
- Safe and fast failure signals thanks to separated signal/error transformers
- Robust rectangle signal transmission
- Configurable failure management for use in two /three-level inverters
- Adjustable failure and filter management
- Low jitter +/- 1,25ns
- Highest noise immunity with short pulse suppression, EMC cage and robust interface
- Under voltage protection (UVP)
- Dynamic Short Circuit Protection (DSCP) by V_{CE} monitoring and direct switch off
- Secondary failure input (SDI) for over temperature shot down
- Expandable by external boost capacitors (BC)
- Integrated isolated power supply for the secondary side
- DC bus voltage up to 1200V
- 3W output power per channel
- Up to 25 µC gate charge
- **MTBF rate > 6 Million hours**

SKYPER® 42 LJ R

Block diagram of SKYPER® 42 LJ R



2. Preliminary Data Sheet

Symbol	Conditions	min	typ	max	Unit
U_{VP}	Supply voltage primary side	14,4	15	15,6	V
$I_{VP,Load}$	Supply current primary side (max.)		400		mA
$I_{VP,Idle}$	Supply current primary (no load)	30		120	mA
$t_{Powerup}$	Power up time		150		ms
$U_{IN(HIGH)}$	Input voltage HIGH	11	15	U_{VP}+0,3	V
$U_{VP\ trip}$	Undervoltage protection		13,5		V
$U_{IN(LOW)}$	Input voltage LOW	-0,3V	0	4	V
$U_{ISO(PRIM-SEC)}$	Isolation test voltage input – output (AC, rms, 2s)		4		kV
$U_{ISO(SEK-SEC)}$	Isolation test voltage output 1 – output 2 (AC, rms, 2s)		2		kV
$S_{LS(PRIM-SEC)}$	Clearance prim sec		12,2		mm
$S_{KS(PRIM-SEC)}$	Creepage prim sec		12,2		mm
$S_{LS(SEC-SEC)}$	Clearance sec sec		8		mm
$S_{KS(SEC-SEC)}$	Creepage sec sec		8		mm
Q_{GATE}	Max. rating for output charge per pulse			25	µC
U_{GATE_ON}	Turn on output voltage, stabilized		15		V
U_{GATE_OFF}	Turn off output voltage, stabilized		-8		V
$I_{Gate,Peak}$	Output peak current			20	A
$I_{Gate,On}$=$I_{Gate,Off}$	Output average current			80	mA
f_{sw}	Max. switching frequency			100	kHz
$U_{CE(SAT)}$	Collector emitter threshold voltage	2		10	V
$t_{U(CE)}$	VCEstat blanking time	2		10	µs
t_d	Input-output turn-on/off propagation delay time		0,5		µs
t_{dERROR}	Error delay time		-		µs
t_{Pmin}	Minimum pulse length	1			µs
U_{DCLink}	DC Link voltage			1200	V
t_{Jitter}	Signal jitter		+/- 1,25		ns
du/dt	du/dt- robustness		100		KV/µs
MTBF	Mean time between failures		6		10^6h

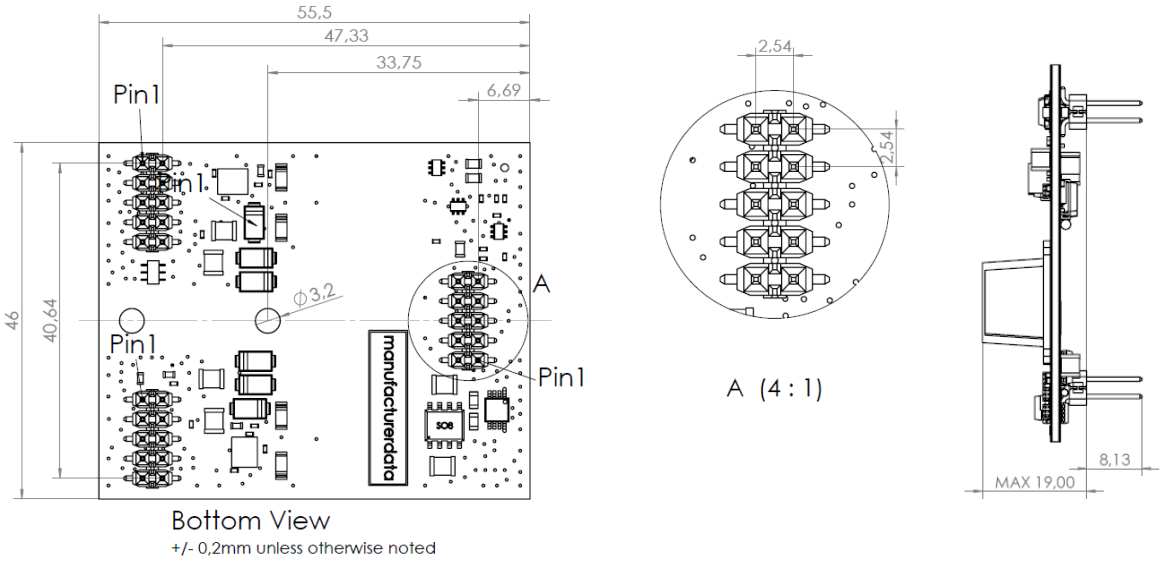
3. Content

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.

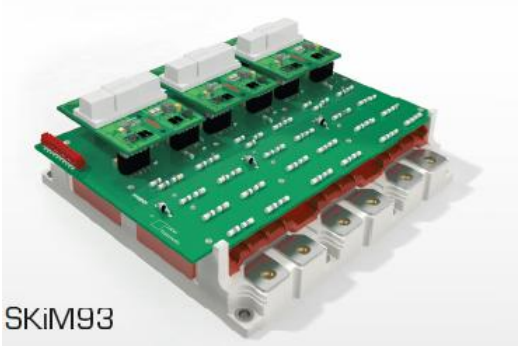
4. Application and Handling Instructions

4.1. Mechanical Instructions

Dimensions – 69 x 80 x 19 + Holes – bottom view



- For integrating the SKYPER 42 LJ R driver core into an inverter system an adaptor board has to be built. The adapter board builds the interface between the driver core and the IGBT module. The driver can be soldered on the adapter board or plugged into connectors.
- SEMIKRON offers adaptor boards for SKiM 63/93 modules. For customer specific adaptor boards please contact your responsible sales for further information.

Adapter board with DC link measurement and temperature shutdown feature. The adapter board connects three SKYPER 42 LJ R with one SKiM63/93 GD module. The SEMIKRON adapter boards are sent out without gate resistors nor V_{CE} components. These can be modified according to application requirements. For higher volumes SEMIKRON offers a standard population service of these components.	

SKiM 63 GD adapter board: L5063201
SKiM 93 GD adapter board: L5063901

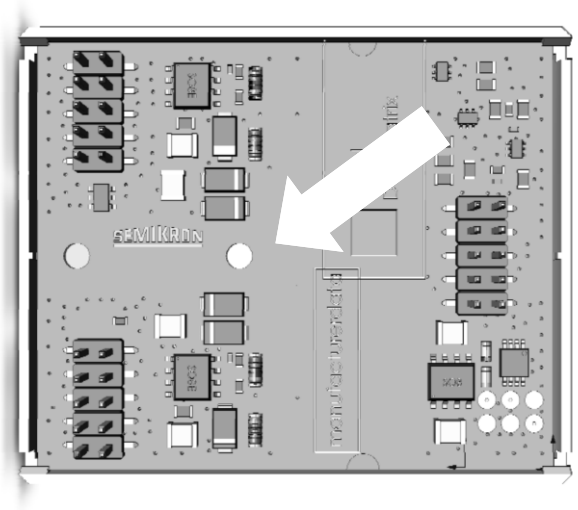
For details please refer to the adapter boards' data sheets.

4.2. Plug in connection

Using plug connectors for SKYPER 42 LJ R means optimized board layout for spring contacted modules. As there is no need for through-hole components the high voltage on bottom side of the adapter board can be kept separate from the low voltage top side. SEMIKRON recommends using following components:

Description	Shape	Manufacturer	Art. no.
(female) RM2.54 10p	SMD 2ROW	Suyin	254100GA

When using plug connector the driver core has to be fixed by a support post. These support posts ensure the robustness against shock and vibration condition.



Hole for support post

Describtion	Shape	Manufacturer	Art. no.
Nylon support post	Dual lock	Richcho	DLMSOM-8-01

4.3. Solder connection

SKYPER 42 R can easily be soldered on an adaptor board without additional support posts. The new housing of SKYPER 42LJ ensures the optimized distance for soldering without additional support posts.

Soldering Hints
▪ The temperature of the solder must not exceed 260°C, and solder time must not exceed 10 seconds. ▪ The ambient temperature must not exceed the specified maximum storage temperature of the driver. ▪ The solder joints should be in accordance to IPC A 610 Revision D (or later) - Class 3 (Acceptability of Electronic Assemblies) to ensure an optimal connection between driver core and printed circuit board. ▪ The driver is not suited for hot air reflow or infrared reflow processes.

5. Start-up

1. Adapter board modification
   (details in adapter board documentation)

- Population of gate resistors
- Population of short circuit detection components
- Modification of over temperature shutdown level

2. Choosing the right power supply

- Stabilised 15V +/- 4%
- I.e. Traco Power TBL/ 15W

3. Setting PWM

- Input impedance 10kΩ / 15V
- For EMC: Filter with 1nF cap to ground

4. Failure management

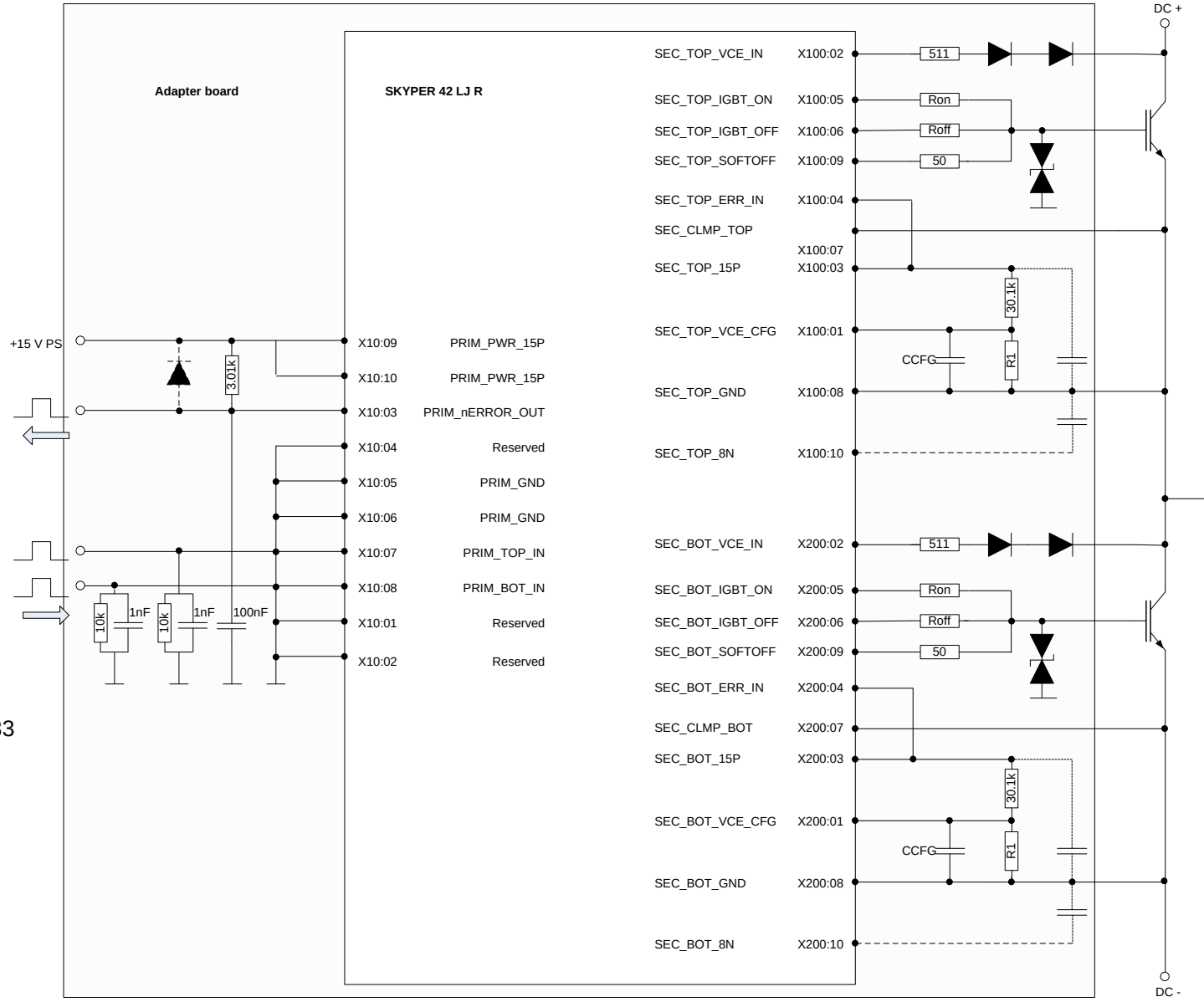
- Low active pulse
- Open drain output (20V/30mA)
- For EMC: Filter with 1nF cap to ground
- Against overvoltages due to cable inductance:
  freewheeling diode to VP

5. Connection to IGBT module

VCE monitoring
- High voltage diodes (2x) : SEMIKRON SA264 – 03897533
- Adjustment of threshold level by R1
- Adjustment of blanking time by CCFG

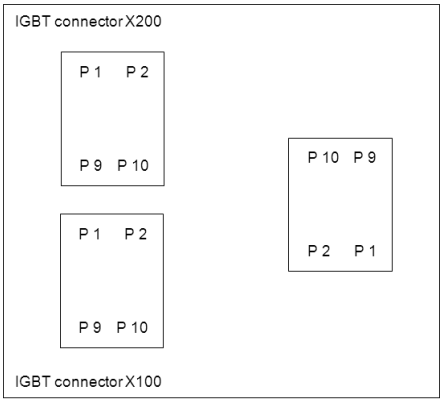
Gate resistors
- RON > ROFF value: Range between data sheet values
  and roughly twice this value
- SOFTOFF value: ~10 x RON/OFF

Protection
- Suppressor diodes against gate overvoltage
- Gate emitter resistor for safe gate locking



6. Driver Interface

Pinning of SKYPER 42 LJ Bottom View



6.1. Controller Interface – Primary Side Pinning

PIN	Signal	Function	Specification
X10:01	Reserved		To be connected to ground
X10:02	Reserved		To be connected to ground
X10:03	PRIM_nERROR_ OUT	ERROR output	LOW = ERROR; open collector output; max. 20V / 30mA Sample status: failure pulse typ = 15µs Series status: failure reset after 30µs (inputs low)
X10:04	Reserved	Interlock set up	To be connected to ground (interlock feature will be implemented in the series version)
X10:05	Reserved	Failure set up	To be connected to ground (adjustable failure management will be implemented in the series version)
X10:06	Reserved	Filter time set up	To be connected to ground (adjustable filter time will be implemented in the series version)
X10:07	PRIM_TOP_IN	Switching signal input (TOP switch)	Digital 15 V; 10 kOhm impedance; LOW = TOP switch off; HIGH = TOP switch on
X10:08	PRIM_BOT_IN	Switching signal input (BOTTOM switch)	Digital 15 V; 10 kOhm impedance; LOW = BOT switch off; HIGH = BOT switch on
X10:09	PRIM_PWR_15P	Drive core power supply	Stabilized +15V ±4%
X10:10	PRIM_PWR_15P	Drive core power supply	Stabilized +15V ±4%

6.2. Module interface – Secondary Side

PIN	Signal	Function	Specification
X100:01	SEC_TOP_VCE_CFG	Input reference voltage adjustment	IGBT OFF = pulled up to +15V
X100:02	SEC_TOP_VCE_IN	Input V_{CE} monitoring	
X100:03	SEC_TOP_15P	Output power supply	Stabilised +15V / max. 10mA. Factory setting of boost capacitors: 10µF
X100:04	SEC_TOP_ERR_IN	External error input	15V logic input; 6,6kOhm impedance; LOW = ERROR HIGH = NO ERROR
X100:05	SEC_TOP_IGBT_ON	Switch on signal TOP IGBT	
X100:06	SEC_TOP_IGBT_OFF	Switch off signal TOP IGBT	
X100:07	SEC_CLMP_TOP	Over voltage TOP	High=15V: active clamp Low=GND: deactivated active clamp
X100:08	SEC_TOP_GND	GND for power supply and GND for digital signals	Emitter Potential
X100:09	SEC_TOP_IGBT_SOFTOFF	Output of SoftOff output stage	Connection of $R_{SoftOff}$
X100:10	SEC_TOP_8N	Output power supply	Stabilised -8V / max. 10mA. Factory setting of boost capacitors: 10µF
X200:01	SEC_BOT_VCE_CFG	Input reference voltage adjustment	IGBT OFF = pulled up to +15V.
X200:02	SEC_BOT_VCE_IN	Input V_{CE} monitoring	
X200:03	SEC_ BOT_15P	Output power supply	Stabilised +15V / max. 10mA. Factory setting of boost capacitors: 10µF
X200:04	SEC_BOT_ERR_IN	External error input	15V logic input; 6,6kOhm impedance; LOW = ERROR HIGH = NO ERROR
X200:05	SEC_BOT_IGBT_ON	Switch on signal BOT IGBT	
X200:06	SEC_BOT_IGBT_OFF	Switch off signal BOT IGBT	
X200:07	SEC_CLMP_BOT	Over voltage BOT	High=15V: active clamp Low=GND: deactivated active clamp
X200:08	SEC_ BOT_GND	GND for power supply and GND for digital signals	Emitter Potential
X200:09	SEC_BOT_IGBT_SOFTOFF	Output of SoftOff output stage	Connection of $R_{SoftOff}$
X200:10	SEC_BOT_8N	Output power supply	Stabilised -8V / max. 10mA. Factory setting of boost capacitors: 10µF

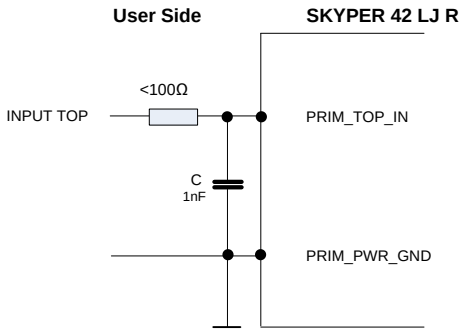
6.3. Power supply - Primary

Requirements of the auxiliary power supply	
Power rating of external power supply	10-15W

The same power supply can be used for SKYPER 32 and SKYPER 42. Do not apply switching signals during power on reset.

6.4. Gate driver signals – Primary

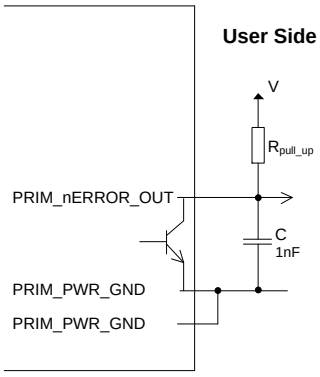
The inputs have a Schmitt Trigger characteristic and a positive / active high logic (input HIGH = IGBT on; input LOW = IGBT off).
It is mandatory to use circuits which switch active to +15V and 0V. The duty cycle of the driver can be adjusted between 0 – 100%. It is not permitted to apply switching pulses shorter than 1µs.

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. The capacitors have to be placed as close as possible to the driver interface. In addition one can add a series resistor for even higher robustness with the consequence of a longer delay time.	

6.5. Failure output – Primary

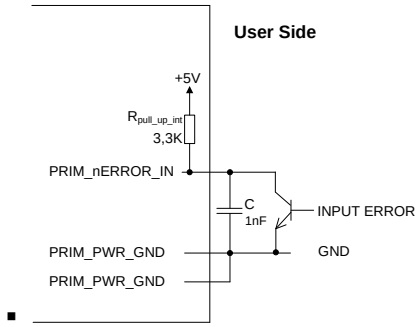
Any error detected will force PRIM_nERROR_OUT into low state (low active). Switching pulses from the controller will be ignored for 30µs. Connected and switched off IGBTs remain off.
The output PRIM_nERROR_OUT is an open collector output. For the error evaluation an external pull-up-resistor is necessary. The error output is not short circuit proof.

Please consider: During sampling phase the error logic is different. The driver gives out an error pulse for typ. 15µs. There is not reset implemented so the controller has to react immidiatly after failure detection. The reset feature after 30µs will be implemented in the series driver solution.

Open collector error transistor	Application hints
▪ The pull up resistor has to be in the range of V / I_{max} < R_{pull_up} < 10kΩ. ▪ Reset when TOP/BOT signals set to low for $t_{pERRRESET}$ > 30µs ▪ Internal voltage drop in failure case <200mV ▪ PRIM_nERROR_OUT can operate to maximum 20V and can switch a maximum of 30mA. ▪ Example: For V = +15V the resistor should be in the range R_{pull_up} = (15V/15mA) … 10kΩ ⇒ 1kΩ… 10kΩ.	

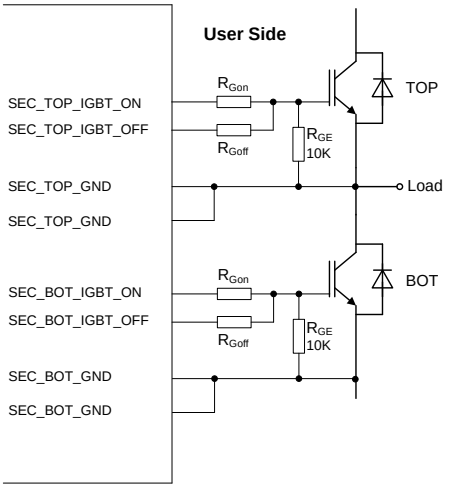
6.6. External Error Input (EEI) – Secondary

SKYPER 42 LJ R can transmit isolated failure signals from external circuits like over temperature or over current.

Connection SDI	Hints
▪ Input LOW = Error ▪ A LOW signal at PRIM_nERROR_IN will set the error latch and force the output PRIM_nERROR_OUT into low state. Switching pulses from the controller will be ignored. ▪ The EEI function can be disabled by connecting to 15V.	

6.7. Gate resistors - Secondary

The turn-on and turn-off speed of each IGBT can be set by the external resistors R_{Gon} and R_{Goff}.

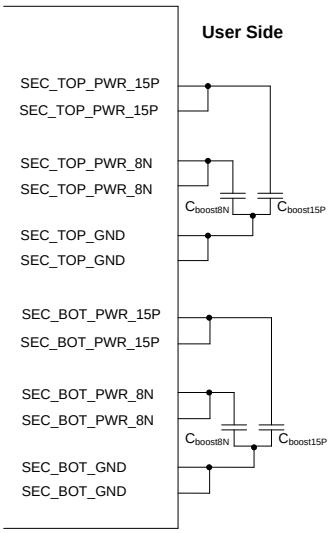
Connection R_{Gon}, R_{Goff}	Application Hints
▪ By increasing R_{Gon} the turn-on speed will decrease. The reverse peak current of the free-wheeling diode will diminish. ▪ By increasing R_{Goff} the turn-off speed of the IGBT will decrease. The inductive peak over voltage during turn-off will diminish. ▪ In order to ensure locking of the IGBT even when the driver supply voltage is turned off, a resistance (R_{GE}) has to be integrated. ▪ Tpically, IGBT modules with a large current rating will be driven with smaller gate resistors and vice versa. ▪ The value of gate resistors will be between the value indicated in the IGBT data sheet and roughly twice this value. ▪ Depending on the individual parameters, RG(off) can be roughly twice the RG(on) value.	

Gate resistors should be surge proof. SEMIKRON recommends taking MELF or Mini-MELF resistors to keep the long-time reliability.

Describtion	Shape	Manufacturer	Art. no.
MELF resistors	MELF / MiniMELF SMD	Vishay Beyschlag, Vishay Draloric, Vitrohm	PRO MELF resistors, SMM0207, SMM 0204, ZC series

6.8. External Boost Capacitors (BC) -Secondary

The rated gate charge of the driver can be increased by additional boost capacitors to drive IGBT with large gate capacitance.

Connection External Boost Capacitors	Dimensioning of C_{boost}
▪ SKYPER 42 LJ R has internal gate capacitors of 2.5 µC ▪ Using external capacitors: **4µF = 1µC** ▪ The boost capacitors on C15 and C-8 should be chosen with the same values ▪ Please consider the maximum rating for output power per pulse of the gate driver. The external boost capacitors should be connected as close as possible to the gate driver to have low inductance.	

7. Protection features

7.1. Failure management

The SKYPER 42 LJ detects under voltage situation, short circuits and failures from the external protection circuit like over temperature or over current. Any error detected will force the output PRIM_nERROR_OUT into low pulse for 30 µs and has to be reset by the controller. The IGBTs will be switched off (IGBT driving signals set to LOW). The input side switching signals of the driver will be ignored. The input signals have to be set to low status for 30µs for reset.

Following failures are indicated by the failure output

- Under supply voltage situation
- Short circuit in the IGBT bridge
- Generic failure input of the secondary side failure input: Over temperature, over current

The failure management of SKYPER 42 LJ R can be modified according to the application. One can choose between switch off by the driver or error to the controller without switch off. The modification procedure will be published in the next version of the technical explanation.

Please consider: During sampling phase the error logic is different. The driver gives out an error pulse for typ. 15µs. There is not reset implemented so the controller has to react immidiatly after failure detection. The communication between TOP and BOT channel has to be realised by the controller. I.e. a short circuit detected and switched off by the TOP channel of the driver is sending back a failure (PIM_nERROR_OUT=low) and the custer has to switch off the BOT channel. The reset feature after 30µs will be implemented in the series release. The failure management can not be adjusted during sampling phase. The driver is switching off directly all failures.

7.2. Dead time generation (Interlock TOP / BOT) adjustable (DT)

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. The highest dead time dominates. Example:

	Controller dead time	SKYPER dead time	Total dead time
Controller > driver	4µs	2µs	4µs
Controller < driver	2µs	4µs	4µs
Controller no dead time	No dead time	2µs	2µs
Driver without dead time	2µs	No dead time	2µs

It is possible to control the driver with one switching signal and its inverted signal. No error signal will be generated when signals are overlapped.

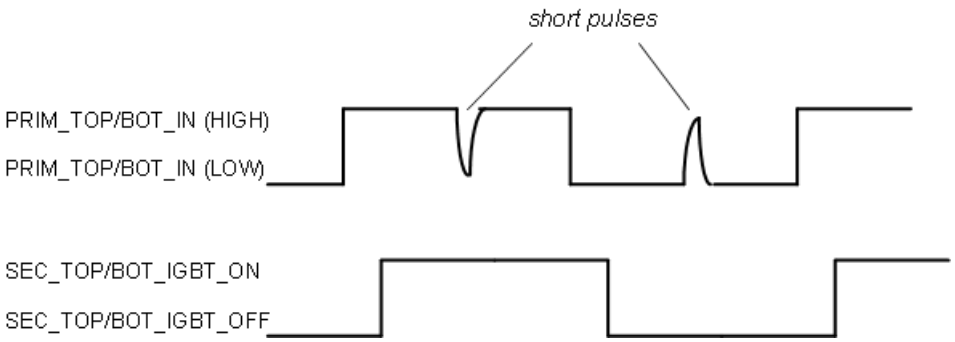
The dead time can be adjusted. The modification template will be added in the next version of the technical explanation.

Please consider: During sampling phase the interlock feature is deactivated. The driver does not have an own dead time. The dead time has to be implemented by the controller.

7.3. Short Pulse Suppression (SPS)

This driver 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. Short or high noise pulses doesn't affect the driver on the controller side. The filter time can be set up by the customer.

Pulse pattern – SPS

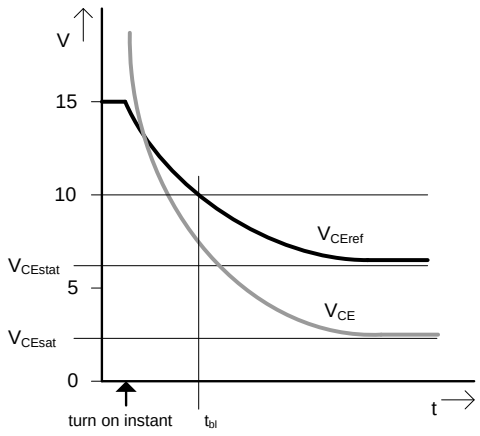


Please consider: During sampling phase the filter time is fixed and can not be modfied.

7.4. Dynamic Short Circuit Protection by VCEsat monitoring (DSCP)

The DSCP monitors the collector-emitter voltage V_{CE} of the IGBT during its on-state.
The reference voltage V_{CEref} may dynamically be adapted to the IGBTs switching behaviour. Immediately after turn-on of the IGBT, a higher value is effective than in steady state. V_{CEstat} is the steady-state value of V_{CEref} and is adjusted to the required maximum value for each IGBT by an external resistor R_{CE}. It may not exceed 10V. The time constant for the delay (exponential shape) of V_{CEref} may be controlled by an external capacitor $C_{CE.}$ It controls the blanking time t_{bl} which passes after turn-on of the IGBT before the V_{CEsat} monitoring is activated.

Reference Voltage (V_{CEref}) Characteristic



After t_{bl} has passed, the V_{CE} monitoring will be triggered as soon as $V_{CE} > V_{CEref}$ and will turn off the IGBT.

Short circuit modification

$$U_{TH}\ R_{Conf}, R_1, R_V = 15V \times \frac{R_{Conf}}{R_{Conf}+R_1} - R_V \times 1mA$$

$$t_{bl}\ R_{Conf}, R_1, C_{Conf} = 60 \times 10^{-9}s + \frac{R_1 \times R_{Conf}}{R_1+R_{Conf}} \times C_{Conf} \times \ln(3)$$

The voltage drop of the high voltage diode is not considered in the formula.

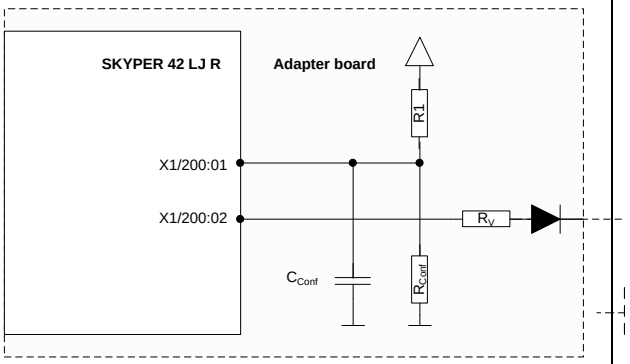
Application hints:

C_{Config}	<1nF
R_1+R_{CONF}	>10 kΩ

For disabling the DSCP SEC_TOP/BOT_VCE_IN must be connected with SEC_TOP/BOT_GND.

- Reverse blocking voltage of the diode shall be higher than the used IGBT.
- Reverse recovery time of the fast diode shall be lower than V_{CE} rising of the used IGBT.

Forward voltage of the diode: 1,5V @ 2mA forward current (T_j=25°C).



7.5. Soft Turn-Off (STO)

In the event of short circuit, the SoftOff feature increases the resistance in series with R_{Goff} and slows down the turn-off speed of the IGBT. The reduced di/dt reduces the voltage spike above the collector emitter in the short circuit case. The soft turn-off time can be adjusted by connection an external resistor $R_{SoftOff}$.

Connection SEC_TOP_IGBT_SOFTOFF

The SoftOff resistor should be calculated 10 times as high as the standard off resistor.

The soft turn-off time is limited to 10µs. After this time the output stage turn-off with used R_{Goff}.

7.6. Over voltage feedback

X100:07	SEC_CLMP_TOP	Over voltage TOP	High=15V: active clamp Low=GND: deactivated active clamp
X200:07	SEC_CLMP_BOT	Over voltage BOT	High=15V: active clamp Low=GND: deactivated active clamp

The SKYPER 42 LJ does offer an over voltage detection feature. The SKYPER 42 LJ blocks switch off signals from the controller as long as an overvoltage on the Zener circuit between collector and emitter is detected and transmitted to SEC_CLMP_TOP/BOT. The zener diode chain has to be designed by the customer according to the application.

8. Electrical Characteristic

Maximum switching frequency @ different gate charges @ Tamb=25°C

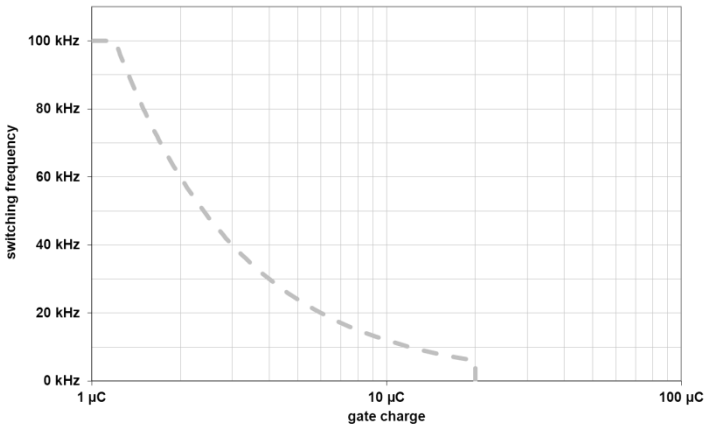
$$f_{\max} = \frac{Iout_{AV\,\max}}{Q_{GE}}$$

f_{max}: Maximum switching frequency *

$Iout_{AVmax}$: Maximum output average current

Q_{GE}: Gate charge of the driven IGBT

* @ T_{amb}=25°C



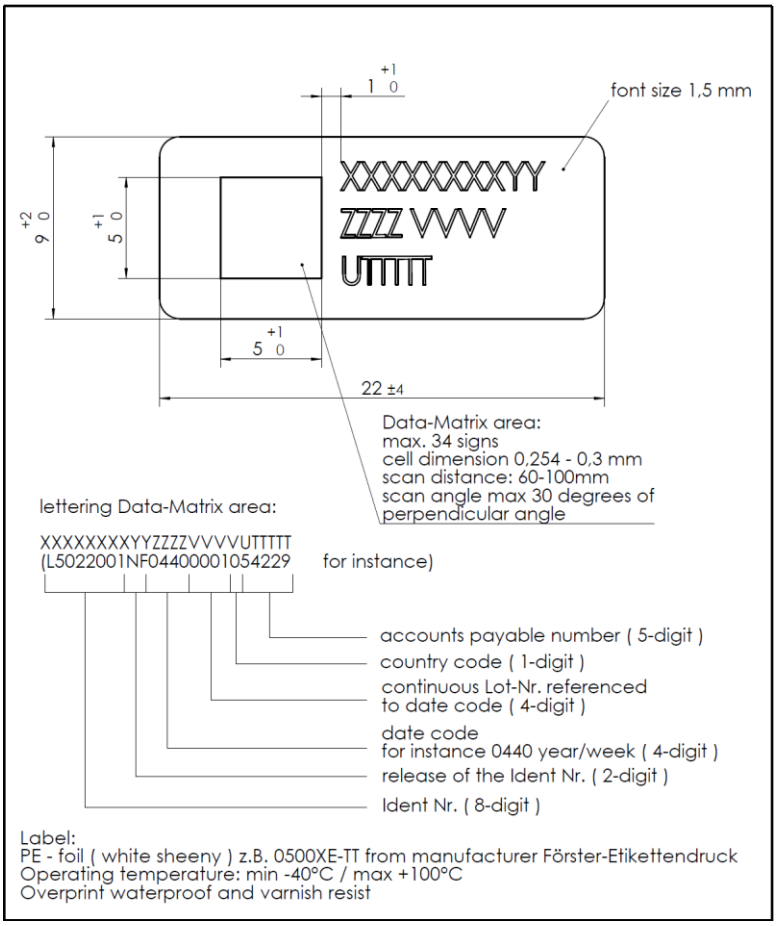
9. Environmental Conditions

Insulation parameters		**Rating**
Climatic Classification Pollution Degree (PD)		PD2
Maximum altitude (above sea level)		2000 meter above sea
Overvoltage category (according to EN50178)		OVC 3
Isolation resistance test, Prim-Sec		4000 VDC/AC, rms,2s
Rated insulation voltage (EN60664-1)		8 kV Cat. III
Environmental Condition	**Norm / Standard**	
Operating temperature		-40.. +85 °C
Storage temperature		-40.. +85 °C
High humidity	DIN 45930 CECC 50012	85 °C, 85%
Flammability	VDV 150 DIN 5510 prEN 100	Heavy flammable materials only
	RoHS / WEEE / China RoHS	
EMC Condition	**Norm / Standard**	**Parameter**
ESD	DIN EN 61000-4-2 DIN EN 61800-3	6 kV contact discharge / 8 kV air discharge

Burst	DIN EN 61000-4-4 DIN EN 61800-3	≥ 2kV on adaptor board for signal lines
Immunity against external interference	DIN EN 61000-4-3 DIN EN 61800-3	≥ 30V/m 30MHz – 1000 MHz
Immunity against conducted interference	DIN EN 61000-4-3 DIN EN 61800-3	≥ 20V 150kHz – 80MHz
Shock Vibration		
Vibration	Sinusoidal 20Hz … 500Hz, 5g, 2h per axis (x, y, z) Random 20Hz … 2000Hz, 5g, 2 h per axis (x, y, z)	
Shock	6000 Shocks (6 axis; +-x, +-y, +-z, 1000 shocks per axis), 30g, 18ms Connection between driver and PCB has to be reinforced by support post	

10. Marking

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



11. Document tracking and disclaimer

Revision	04
Status:	Target
By:	Johannes Krapp

This Technical Explanation is valid for the following parts:

part number:	L5063101	title:	Data Sheet SKYPER 42 LJ R
date code (YYWW):	>2012 CW30		

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