SKAI 90 A2 GD06-2050WCI

HV SKAI 2

Three-phase IGBT inverter

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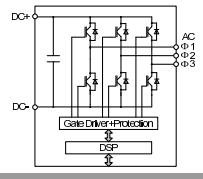
Features

- Optimized for HEV and EV
- High power density
- High overload capability
- Compact integration in IP67 enclosure:
  V, I, T sensors
  Integrated controller
  Gate driver with protection features
  IGBT's + CAL Diodes
  Fully programmable digital signalprocessor
  Resolver interface
  Active DC-link discharge unit
  12V/24V tolerant power supply
  EMI filters
  Liquid cooling
  DC-link capacitor
  Suitable environmental conditions in accordance to ISO 16750-(B,F)-N-K-D-Z-IP(6K7;6K9K)

Typical Applications*

- Commercial application vehicle
- Hybrid vehicle
- Battery driven vehicles (not suitable for mains applications)

No. 14282050



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Characteristics					
Symbol	**Conditions**	**min.**	**typ.**	**max.**	**Unit**
Electrical Data					
V_{isol}	DC, t = 1 s, (routine test acc. EN 50178)		3000		V
	DC, t = 1 min, (type test, acc. ISO 6469-3)		3000		V
V_{CC}	DC supply voltage	0	350	450	V
I_{nom}	rms @ nominal conditions: dV/dt = 10l/min, 50% Glykol/ 50% H_20, f_{sw} = 6kHz, V_{CC} = 350V, V_{out} = 150Vrms, f_{out} = 50Hz, cos(phi) = 0.85, $T_{coolant}$ = 60 °C, T_{air} = 65 °C		300		A
f_{sw}	Switching frequency	1		12	kHz
C_{DC}	DC-link capacitance	0.9		1.25	mF
C_y	EMI capacitor; DC to enclosure		0.66		µF
R_F	DC+ to enclosure, DC- to enclosure		6		MΩ
R_{BL}	DC+ to DC-		0.13		MΩ
Mechanical Data					
Weight			13.9		kg
Height			109		mm
Width			244		mm
Length			475		mm
M_t	AC / DC terminals (M8 screw)	13	14	15	Nm
M_c	Cover of terminal box (M5x16 flat-head-screw)	3.5	4	4.5	Nm
M_{cg}	AC / DC cable glands (at 7mm length of thread engagement)			20	Nm
M_e	Assembly of enclosure; thread (l): > 15mm — M8 screw			20	Nm
	Assembly of enclosure; thread (l): > 15mm — M6 screw			14	Nm
	Mounting torque of HVIL sheet screw (M4x8)	1.5		1.75	Nm
M_{gnd}	Ground connection	13	14	15	Nm
Hydraulical Data					
dp	Pressure drop@ 10l/min, $T_{coolant}$ = 25°C		100		mbar
p	Operating pressure			2	bar
$V_{Coolant}$	Coolant quantity of integrated cooling circuit		300		cm^3
P	Power dissipation to coolant; nominal conditions		2.1		kW
Environmental Data					
T_{stg}	Storage temperature	-40		85	°C
T_{no}	Non operating temperature range	-40		105	°C
T_{air}	Operating range, derating for T_{air} > 65°C with -3A / °C	-40		105	°C
$T_{coolant}$	Operating range, derating for $T_{coolant}$ > 60°C	-40		75	°C
IP	Enclosure protection level		IP67		
	With external connector protection		IP6K9K		
Altitude	V_{CC} = 450V			5000	m
Active Discharge Unit					
t_d	Discharge time to V_{CC} < 60V			5	s
R_{dis}	PTC discharge resistor (at 25°C)	245	350	455	Ω

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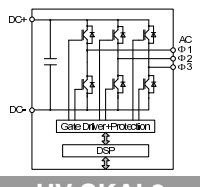

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Characteristics					
Symbol	**Conditions**	**min.**	**typ.**	**max.**	**Unit**
Interface Parameters					
V_s	Auxiliary supply voltage primary side	8		32	V
I_{S0}	Auxiliary supply current primary side if power converter is not activated (ELX X1:02 lower than threshold voltage or not connected (n.c.))			0.5	mA
I_s	Auxiliary supply current primary side with activated power converter: Supply current @ Vs = 12V		2900	3900	mA
I_S	Auxiliary supply current primary side with activated power converter: Supply current @ Vs = 24V		1500	2000	mA
$t_{POR-DSP}$	Power-on reset completed (DSP section only)			0.5	s
t_{POR}	Power-on reset completed (gate driver primary & secondary side)			0.92	s
Controller Switching Parameters					
$t_{d(on)IO}$	Input-output turn-on propagation time		0.5	0.8	µs
$t_{d(off)IO}$	Input-output turn-off propagation time		0.5	0.8	µs
t_{jitter}	Signal transfer prim - sec (total jitter)			50	ns
t_{SIS}	Short pulse suppression time	0.026		0.052	µs
t_{et}	Input impulse extension time	0.9	1	1.1	µs
$t_{d(err)DSCP}$	Error input-output propagation time for DSCP error	0.2		2	µs
$t_{d(err)OCP}$	Error input-output propagation time for OCP error		4	20	µs
$t_{d(err)TMP}$	Error input-output propagation time for temperature error			50	ms
t_{TD}	Top-Bot interlock dead time		4.0	4.1	µs
t_{bl}	V_{CE} monitoring blanking time		5	5.1	µs
Protection Functions					
$T_{PCBtrip}$	Over temp. protection trip level on PCB	100	103		°C
$T_{DCBtrip}$	Over temperature protection trip level on DCB	105	110		°C
$m_{PCBsens}$	Gradient of PCB Temperature measurement (16bit value, accuracy ±0.5°C), SPI-adress: 0x05, 0x0D		0.0078		°C/ digit
f_S	Max. sample rate of temperature read-out PCB and DCB	100			s^{-1}
V_{DCtrip}	Trip level of DC-link voltage monitoring	450			V
V_{VStrip}	Under voltage protection trip level of board primary side			8	V
V_{VSrst}	Threshold voltage level for driver reset after failure event	8			V
I_{TRIPSC}	Overcurrent trip level	850			A_{PEAK}
$I_{outsens}$	AC sensing range	-924		924	A
$m_{Ioutsens}$	Gradient of output current sensing		2.22		digits/ A
$OS_{Ioutsens}$	Offset of AC current sensing		2048		digits
$BW_{Ioutsens}$	Bandwidth (-3dB) of I_{AC} sensing		43		kHz
V_{DCsens}	Measurable DC-link voltage	0		600	V
$m_{VDCsens}$	Gradient of DC-link voltage sensing		6.83		digits/ V
$BW_{VDCsens}$	Bandwidth (-3dB) Vcc voltage sensing		90		kHz

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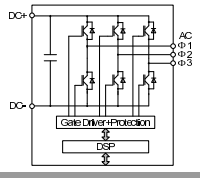
Resolver Characteristics					
V_{out}	Resolver excitation voltage (rms), two output voltages (1) / (2) selectable		4.0V / 5.0V		V_{AC}
f_{out}	Resolver excitation output frequency (frequency selectable in 256 steps)	2		20	kHz
	Default setting		10		kHz
r_v	Resolver transformation ratio (1) (max. input voltage sin/cos track: 4Vpp)	0.252	0.286	0.319	
	Resolver transformation ratio (2) (max. input voltage sin/cos track: 4Vpp)	0.212	0.23	0.248	
R_L	Resolver excitation load	60			Ω
$BW_{resolver}$	Bandwidth (-3dB) resolver channel		20		kHz
Motor Temperature Sensing					
R_{ts}	Measurable range 1 (e.g. for NTC) [Default]	0		33100	Ω
	Measurable range 2 (e.g. for KTY81)	0		4415	Ω
	Measurable range 3 (e.g. for PT1000)	0		1835	Ω
	Measurable range 4 (e.g. for PT100)	0		1345	Ω
Miscellaneous Functions					
m_{MP_AI}	Gradient of multipurpose analog input voltage sensing (0-5V, single-ended)	802.3	819.0	837.3	digits/ V
	Gradient of multipurpose analog input voltage sensing (0-10V, differential)	396.2	409.5	423.7	digits/ V



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Signal Connector

PIN	Signal	Function	Specifications
X1:01	PWR_VP	INPUT Auxiliary power supply / battery "+"	Supply voltage V_s
X1:02	ELX	INPUT Turn on / turn off signal of power converter	Input voltage range = 0V … +50V (V_{max}); Trip level ($V_{triplevel}$) for boot loader configuration change = +32.5V…+38V; Threshold voltage ON = 5.5V (±2V), Threshold voltage OFF = 4.5V (±2V); Input impedance ≥ 2kΩ;
X1:03	reserved	reserved	do not connect
X1:04	reserved	reserved	do not connect
X1:05	PS_PWR_GND	GND	Ground of speed/position sensor power supply.
X1:06	PS_PWR	OUTPUT	Speed/position sensor power supply; Two output voltage modes selectable: (1) Output voltage = +12V (Resolver mode disabled) (2) Output voltage = +14.5V (Resolver mode enabled) Default setting: Output switched off (high impedance), Output current limit I_{out} = 250mA (permanent, at room temperature), (no over-current protection, output can only work as a source, output must not be used as a current sink) Ground of X1:06 (PS_PWR) → X1:05.
X1:07	PS_DI_AP	OUTPUT Resolver excitation output E+	Resolver functionality is disabled at power-up. For transmission of the absolute position to EQEP-init of DSP during resolver enable, the following sequence is necessary: 1. Setting of DSP EQEP configuration registers. 2. Reset of EQEP position register 3. Appropriate setting of motor sensor interface configuration register.
X1:08	PS_DI_BP	INPUT Resolver input Sinus track (-)	Refer to pin X1:07
X1:09	PS_DI_NP	INPUT Resolver input Cosinus track (-)	Refer to pin X1:07

PIN	Signal	Function	Specifications
X1:10	MP_AI_C1P	INPUT Configurable multipurpose analog input channel 1 Complementary signal MP_AI_C1N (pin X1:22)	Input voltage range = 0V … +10V; Input impedance to Analog_GND (X1:24) = 20kΩ (±10%); Accuracy of analog signal = ±2.5% (analog circuit only); Bandwidth (-3dB) = 10kHz;
X1:11	PS_AI_C1	INPUT Analog position/speed sensor input channel 1	Input voltage range = 0V … +5V; Input impedance = 5.5kΩ (±10%); Accuracy of analog signal = ±2.5% (analog circuit only); Bandwidth (-3dB) = 10kHz;
X1:12	PS_AI_C2	INPUT Analog position/speed sensor input channel 2	Input voltage range = 0V … +5V; Input impedance = 5.5kΩ (±10%); Accuracy of analog signal = ±2.5% (analog circuit only); Bandwidth (-3dB) = 10kHz;
X1:13	PWR_GND	Auxiliary power supply ground	Ground of auxiliary power supply
X1:14	CANA_H	INPUT/OUTPUT CAN interface channel A HIGH line	Specification: Fully compatible to ISO11898 standard; connected via capacitor (100pF) and CAN bus ESD protection diode to GND. Termination resistor selectable, refer also to Pin X1:26 (CANA_TERM).
X1:15	CANA_L	INPUT/OUTPUT CAN interface channel A LOW line	Specification: See pin X1:14.
X1:16	CANB_H	INPUT/OUTPUT CAN interface channel B HIGH line	Specification: Fully compliant to ISO11898-2 standard; connected via capacitor (100pF) and CAN bus ESD protection diode to GND. Termination resistor selectable, refer also to Pin X1:28 (CANB_TERM).
X1:17	CANB_L	INPUT/OUTPUT CAN interface channel B LOW line	Specification: See pin X1:16.
X1:18	MP_DO_C1	OUTPUT Multipurpose digital output channel 1	The unit provides multipurpose digital output with overcurrent protection. The output is switched to PWR_VP voltage by a high side switch. The ground for the digital output is PWR_GND (X1:13). Average output current per output: 1.0A; Output current limit I_{out} = 5A … 14A (overtemperature range); $R_{DS(on)} \leq 300m\Omega$; Max. bandwidth (-3dB): 2kHz;
X1:19	PS_DI_AN	OUTPUT Resolver excitation output E-	Refer to pin X1:07
X1:20	PS_DI_BN	INPUT Resolver input Sinus track (+)	Refer to pin X1:07

PIN	Signal	Function	Specifications
X1:21	PS_DI_NN	INPUT Resolver input Cosinus track (+)	Refer to pin X1:07
X1:22	MP_AI_C1N	INPUT Configurable multipurpose analog input channel 1 Complementary signal to MP_AI_C1P (pin X1:10)	See pin X1:10 specifications
X1:23	TS_AI_MOT	INPUT Motor temperature sensor analog input channel	Four selectable temperature sensor measurement ranges. Temperature sensors e.g.: Range 1: NTC Range 2: KTY81 Range 3: PT1000 Range 4: PT100 Bandwidth of temperature sensing (-3dB): 140Hz. Please refer also to Figure „Motor temperature measurement scaling" and Technical explanations for further details and calculation example(s).
X1:24	Analog GND	Analog ground	Ground of TS_AI_MOT / PS_AI_Cx
X1:25	RS232_RX	INPUT RS232 RX	RS232 interface, External connected 3.3V-RS232 transceiver necessary.
X1:26	CANA_TERM	CAN termination channel A	The CAN interface A is extended by a termination Pin CANA_Term (X1:26). A termination of the CAN channel A with a termination resistor of 121Ω can be realized by connection of the termination Pin to the CANA_L pin at the cable harness. The selection of the termination has to be done by the customer.
X1:27	RS232_TX	OUTPUT RS232 TX	RS232 interface, External connected 3.3V-RS232 transceiver necessary, output voltage level limited to 2.6 – 2.9V by protection diode.
X1:28	CANB_TERM	CAN termination channel B	The CAN interface B is extended by a termination Pin CANB_Term (X1:28). A termination of the CAN channel B with a termination resistor of 121Ω can be realized by connection of the termination Pin to the CANB_L pin at the cable harness. The selection of the termination has to be done by the customer.
X1:29	MP_AI_C2P	INPUT Configurable multipurpose analog input channel 2 Complementary signal to MP_AI_C2N (pin X1:30)	Input voltage range = 0V … +10V; Input impedance to Analog_GND (X1:24) = 20kΩ (±10%); Accuracy of analog signal = ±2.5%; Bandwidth (-3dB) = 10kHz;

PIN	Signal	Function	Specifications
X1:30	MP_AI_C2N	INPUT Configurable multipurpose analog input channel 2 Complementary signal to MP_AI_C2P (pin X1:29)	See pin X1:29 specifications.
X1:31	MP_DI_C1	INPUT Isolated multipurpose digital port input channel 1	Input voltage range = 0V … +10V; Threshold voltage = 5V (±1.0V); Input filter time constant = 200ns; Isolation between input and logic ground = 100 VDC; For input impedance refer to Technical Explanations.
X1:32	MP_DI_C2	INPUT Isolated multipurpose digital port input channel 2	Input voltage range = 0V … +10V; Threshold voltage = 5V (±1.0V); Input filter time constant = 200ns; Isolation between input and logic ground = 100 VDC; For input impedance refer to Technical Explanations.
X1:33	MP_DI_GND	Digital ground	Ground of multipurpose digital port input channels.
X1:34	MP_DO_C2	OUTPUT Multipurpose digital port output channel 2	The unit provides multipurpose digital output with overcurrent protection. The output is switched to PWR_VP voltage by a high side switch. The ground for the digital output is PWR_GND (X1:13). Average output current per output: 1.0A; Output current limit I_{out} = 5A … 14A (overtemperature range); $R_{DS(on)} \leq 300m\Omega$; Max. bandwidth (-3dB): 2kHz;
X1:35	ENCLOSURE	INPUT/OUTPUT	Connected to inverter enclosure.

Power Connectors

Terminal	Function	cable harness Ø Cu/mm²	V rated terminal [1)]	I rated terminal
DC +	HVDC Bus "+"	@ 50	600V DC	300A rms
DC -	HVDC Bus "-"	@ 50	600V DC	300A rms
L1	Phase L1	@ 50	600V DC	300A rms
L2	Phase L2	@ 50	600V DC	300A rms
L3	Phase L3	@ 50	600V DC	300A rms

[1)] terminal – terminal, terminal - enclosure

Coolant Fittings

Terminal	Function
IN	Coolant Inlet
OUT	Coolant Outlet

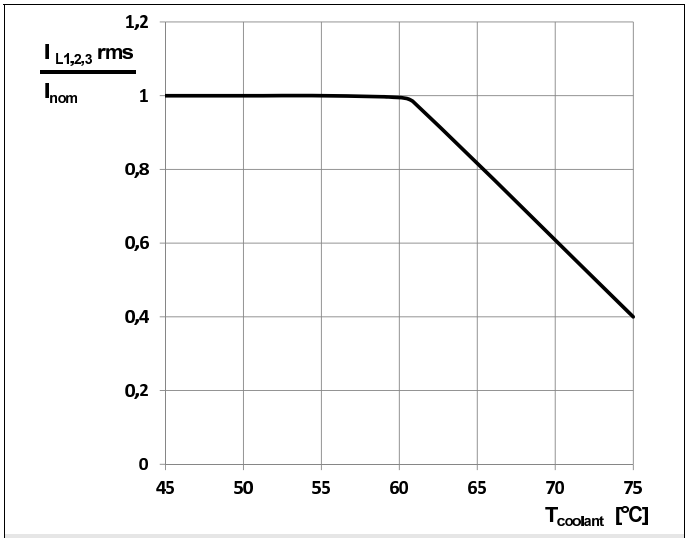


Fig. 1: Normalized output current vs. coolant temperature (temperature at coolant inlet "IN")

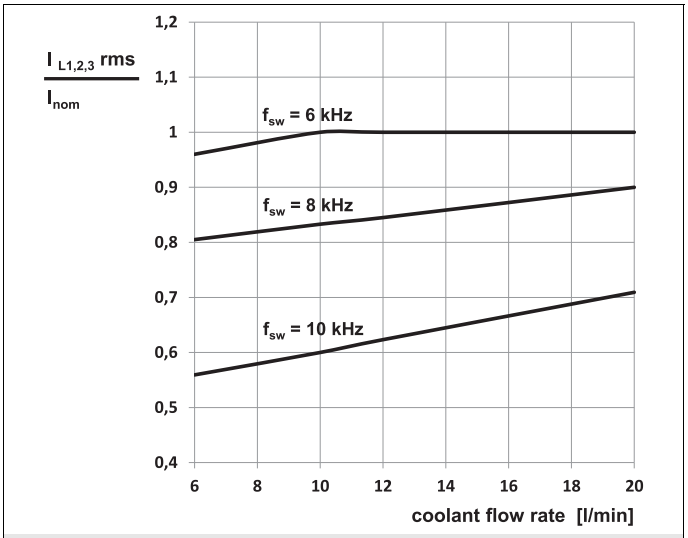


Fig. 2. Normalized output current vs. coolant flow

Nominal Operating Point:

(if not specified otherwise)

f_{sw}	switching frequency	6	kHz
I_{nom}	nominal current	300	A rms
$T_{coolant}$ *	coolant temperature	60	°C
$T_{ambient}$	ambient temperature	65	°C
dV/dt *	coolant flow rate	10	l/min
V_{CC}	DC link supply voltage	350	V
V_{OUT}	output voltage	150	V rms
f_{OUT}	output frequency	50	Hz
cos (ϕ)	power factor	0.85	

* coolant mixture: 50% glycol / 50% H_2O

Fig. 3: Legend

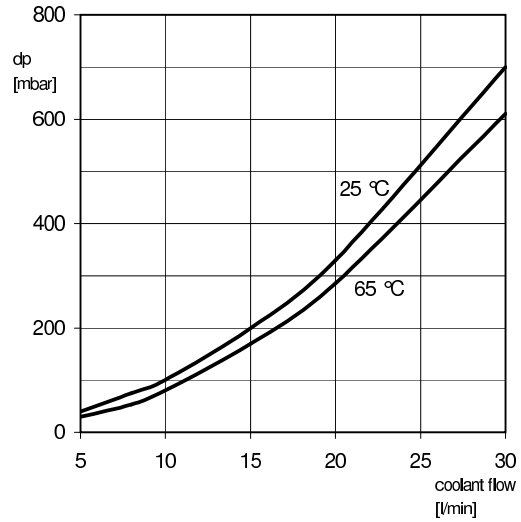


Fig. 4: Pressure drop characteristic
(for coolant mixture 50% glycol / 50% H_2O)

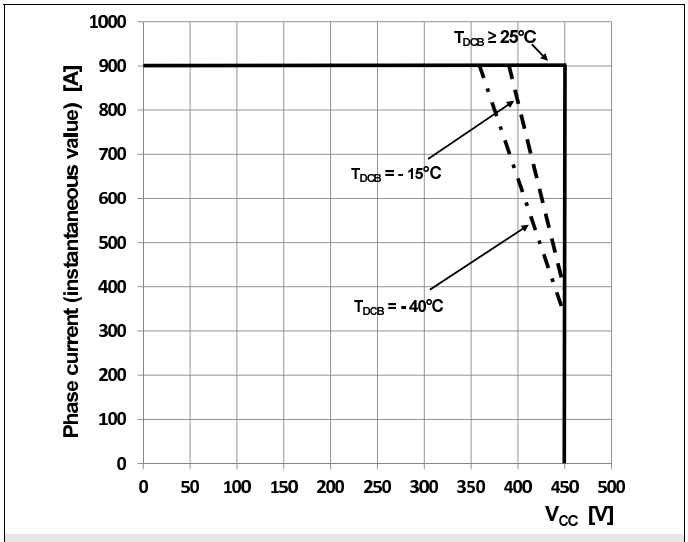


Fig. 5: Safe operating area

DCB temperature [°C]	ADC_{Out} [digit]			DCB temperature [°C]	ADC_{Out} [digit]		
	min.	typ.	max.		min.	typ.	max.
-40	4065	4072	4078	55	2378	2452	2523
-30	4042	4050	4058	60	2193	2270	2344
-20	4002	4013	4024	65	2009	2089	2166
-15	3974	3986	3999	70	1832	1913	1989
-10	3938	3953	3967	75	1662	1742	1820
-5	3893	3911	3927	80	1501	1580	1658
0	3839	3860	3879	85	1352	1428	1503
5	3773	3797	3819	90	1213	1287	1359
10	3694	3722	3748	95	1085	1156	1227
15	3602	3634	3663	100	972	1037	1103
20	3495	3531	3564	105	867	928	993
25	3373	3413	3451	110	774	832	892
30	3235	3281	3325	115	689	744	801
35	3083	3136	3185	120	615	666	718
40	2919	2977	3033	130	488	534	577
45	2744	2809	2870	140	391	429	467
50	2563	2633	2700	150	313	345	380

Fig. 6: DCB temperature measurement scaling

PCB temperature [°C]	ADC_{out} [digit]			PCB temperature [°C]	ADC_{out} [digit]		
	min.	typ.	max.		min.	typ.	max.
-40	3893	4026	4156	45	2009	2149	2288
-35	3868	4002	4134	50	1828	1969	2108
-30	3835	3972	4106	55	1655	1794	1932
-25	3795	3934	4070	60	1491	1628	1764
-20	3745	3887	4025	65	1338	1472	1604
-15	3685	3829	3969	70	1198	1326	1454
-10	3613	3759	3901	75	1069	1192	1315
-5	3529	3676	3819	80	952	1069	1186
0	3431	3578	3722	85	847	957	1068
5	3319	3465	3609	90	752	856	961
10	3193	3337	3480	95	668	766	864
15	3054	3195	3335	100	594	685	777
20	2904	3040	3175	105	528	612	698
25	2744	2873	3002	110	469	548	628
30	2564	2698	2830	115	418	491	565
35	2380	2516	2652	120	372	440	508
40	2193	2332	2470	125	333	394	458

Fig. 7: PCB temperature measurement scaling

Motor temperature [°C] (ambient temperature of sensor)	ADC_{out} [digit]		Motor temperature [°C] (ambient temperature of sensor)	ADC_{out} [digit]	
	Range 3 PT1000	Range 4 PT100		Range 3 PT1000	Range 4 PT100
-40	2343	390	55	3086	537
-35	2386	398	60	3122	545
-30	2428	406	65	3156	553
-25	2470	414	70	3191	560
-20	2512	422	75	3225	568
-15	2553	430	80	3259	575
-10	2594	437	85	3293	582
-5	2634	445	90	3326	590
0	2674	453	95	3359	597
5	2713	461	100	3392	605
10	2752	469	105	3424	612
15	2791	476	110	3456	620
20	2829	484	120	3519	634
25	2867	492	125	3550	641
30	2905	499	130	3581	649
35	2942	507	135	3611	656
40	2978	515	140	3642	663
45	3015	522	145	3672	671
50	3051	530	150	3701	678
PT100-, PT1000-sensor according EN 60751:2008					

Fig. 8: Motor temperature measurement scaling

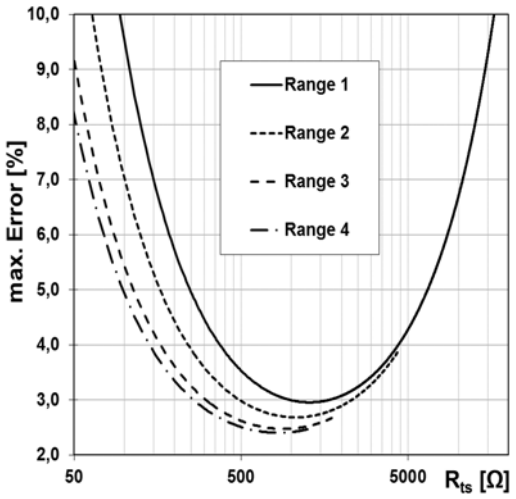


Fig. 9: Motor temperature sensing error

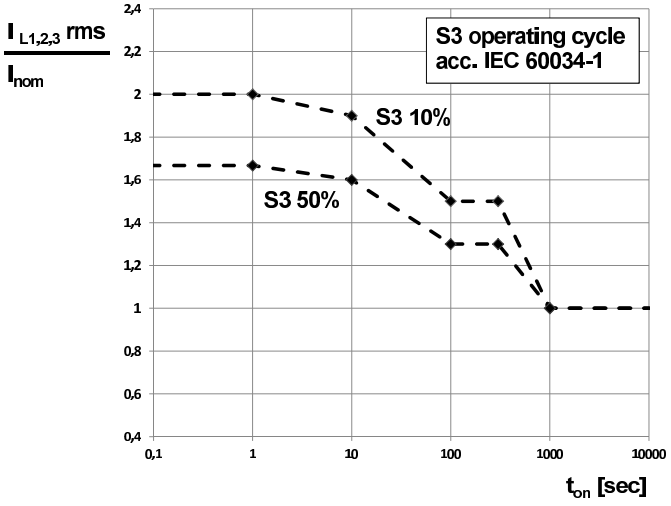


Fig. 10: Overload capability

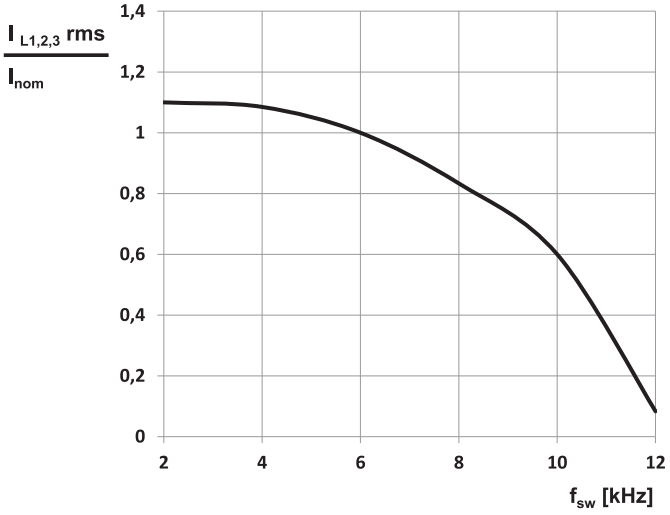


Fig. 11: Normalized output current vs. switching frequency f_{sw}

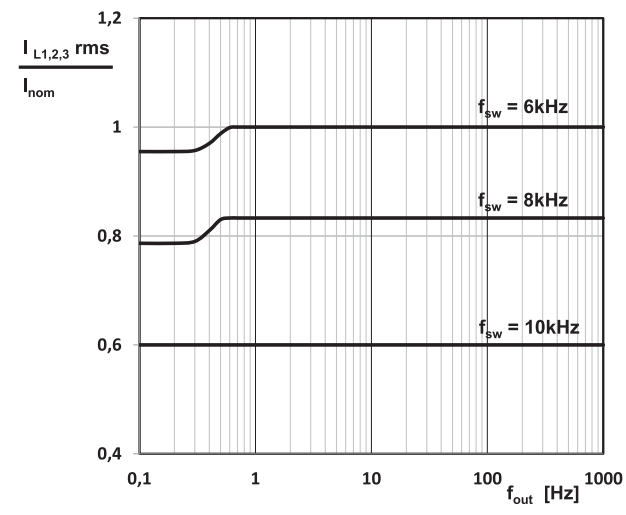
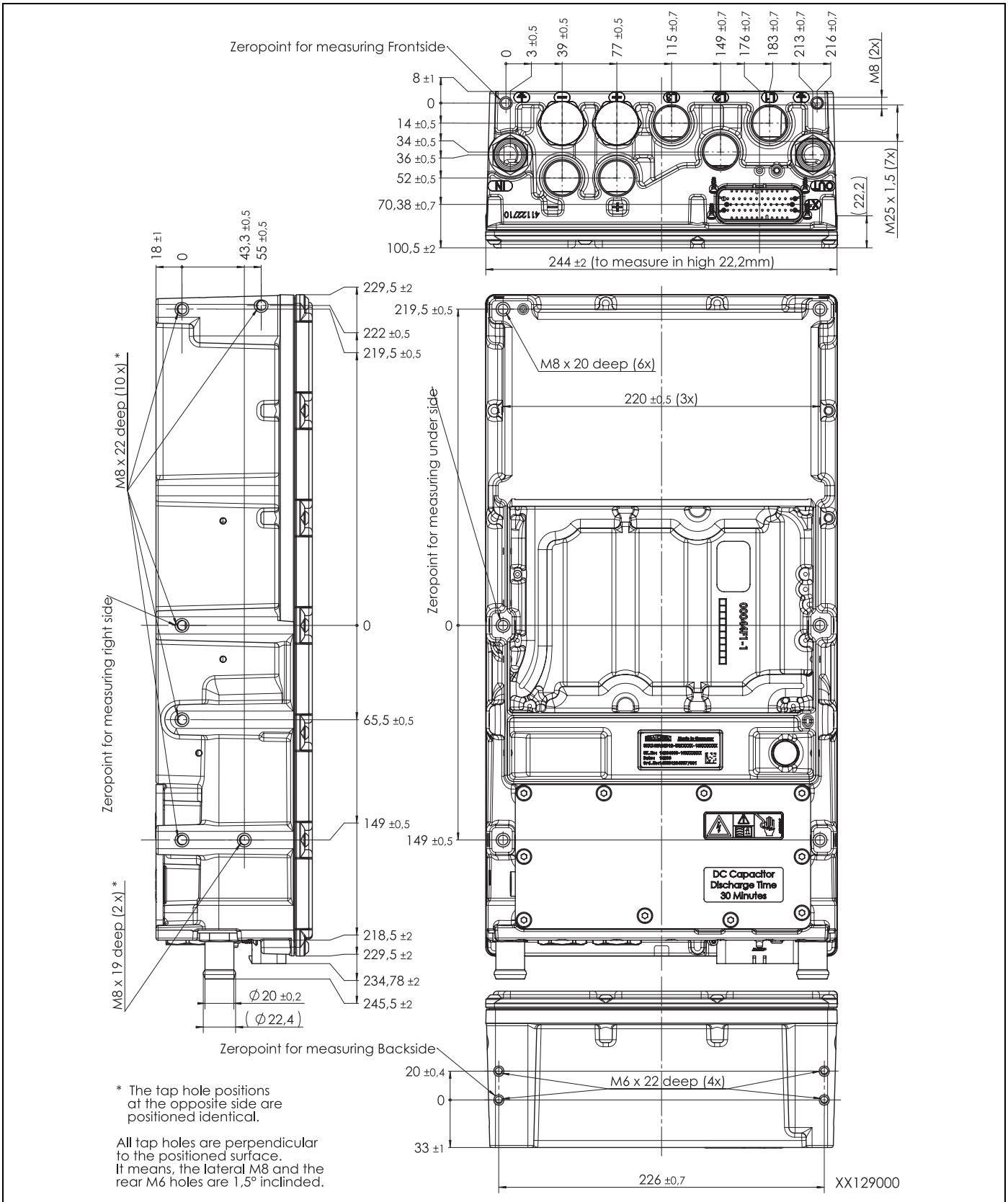
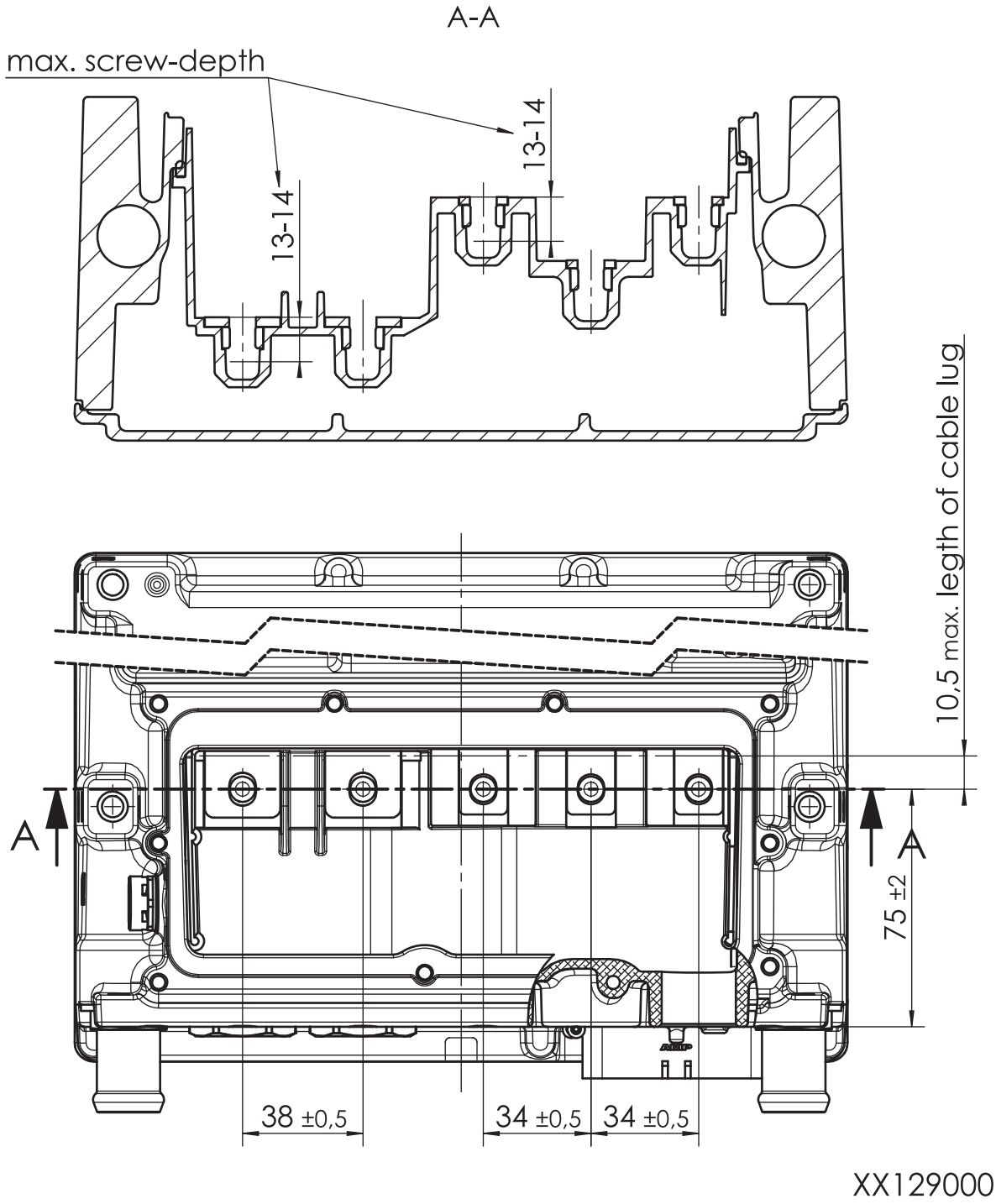


Fig. 12: Normalized output current vs. inverter output frequency


Zeropoint for measuring Frontside
0
3 ±0,5
39 ±0,5
77 ±0,5
115 ±0,7
149 ±0,7
176 ±0,7
183 ±0,7
213 ±0,7
216 ±0,7
M8 (2x)
8 ±1
0
14 ±0,5
34 ±0,5
36 ±0,5
52 ±0,5
70,38 ±0,7
100,5 ±2
(22,2)
M25 x 1,5 (7x)
244 ±2 (to measure in high 22,2mm)
18 ±1
0
43,3 ±0,5
55 ±0,5
229,5 ±2
222 ±0,5
219,5 ±0,5
M8 x 22 deep (10 x) *
Zeropoint for measuring right side
0
65,5 ±0,5
149 ±0,5
218,5 ±2
229,5 ±2
234,78 ±2
245,5 ±2
M8 x 19 deep (2 x) *
Ø20 ±0,2
(Ø22,4)
219,5 ±0,5
M8 x 20 deep (6x)
220 ±0,5 (3x)
Zeropoint for measuring under side
0
149 ±0,5
DC Capacitor
Discharge Time
30 Minutes
Zeropoint for measuring Backside
20 ±0,4
0
33 ±1
M6 x 22 deep (4x)
226 ±0,7
XX129000
* The tap hole positions at the opposite side are positioned identical.
All tap holes are perpendicular to the positioned surface.
It means, the lateral M8 and the rear M6 holes are 1,5° inclinded.

Case 7



Dimension of connecting box and screwing terminals

This is an electrostatic discharge sensitive device (ESDS), international standard IEC 60747-1, Chapter IX

* The specifications of our components may not be considered as an assurance of component characteristics. Components have to be tested for the respective application. Adjustments may be necessary. The use of SEMIKRON products in life support appliances and systems is subject to prior specification and written approval by SEMIKRON. We therefore strongly recommend prior consultation of our staff.