

SKAI 90 A2 GD06-W12CI



HV SKAI 2

Three-phase IGBT inverter

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Target Data

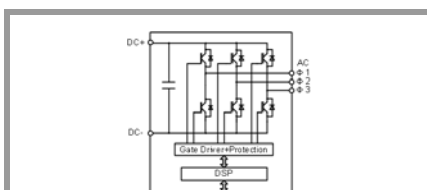
Features

- 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
EMI filters
Liquid cooling
DC link capacitor

Typical Applications*

- commercial application vehicle
- hybrid vehicle
- battery driven vehicle

No. 14282006



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| Characteristics | | | | | |
|---------------------------|--|----------|--------|------|------------------|
| Symbol | Conditions | min. | typ. | max. | Unit |
| Electrical Data | | | | | |
| V_{isol} | DC, $t = 1\text{ s}$ | | 3000 | | V |
| V_{CC} | DC supply voltage | | 350 | 450 | V |
| I_{nom} | rms @ rated conditions: $dV/dt = 10l/min$, 50% Glykol/50% H_2O , $f_{sw} = 4kHz$, $V_{CC} = 350V$, $V_{out} = 200V$, $f_{out} = 50\text{ Hz}$, $\cos(\phi) = 0.85$, $M = 0.93$, $T_{coolant} = 65\text{ }^\circ\text{C}$, $T_{air} = 65\text{ }^\circ\text{C}$ | | 300 | | A |
| f_{sw} | Switching frequency | 1 | | 15 | kHz |
| C_{DC} | DC Bus Capacitance | 0.9 | | 1.25 | mF |
| C_y | EMI Capacitor; DC to enclosure | | 0.66 | | μF |
| R_F | DC+ to enclosure, DC- to enclosure | | 1.13 | | $\text{M}\Omega$ |
| R_{BL} | DC+ to DC- | | 1 | | $\text{M}\Omega$ |
| Mechanical Data | | | | | |
| Weight | | | 15 | | 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 (recommended) | | 10 | | Nm |
| M_e | Assembly of enclosure; thread (l): > 15mm | M8 screw | | 20 | Nm |
| | | M6 screw | | 14 | Nm |
| M_{gnd} | Ground connection | 13 | 14 | 15 | Nm |
| Hydraulic Data | | | | | |
| dp | Pressure drop@ 10l/min, $T_{coolant} = 25\text{ }^\circ\text{C}$ | | 100 | | mbar |
| p | Operating pressure | | | 2 | bar |
| P | Power dissipation to coolant; rated conditions | | 1.9 | | kW |
| Environmental Data | | | | | |
| T_{stg} | storage temperature | -40 | | 85 | $^\circ\text{C}$ |
| T_{no} | Non operating temperature range | -40 | | 105 | $^\circ\text{C}$ |
| T_{air} | Operating range, derating for $T_{air} > 85\text{ }^\circ\text{C}$ | -40 | | 105 | $^\circ\text{C}$ |
| $T_{coolant}$ | Operating range, derating for $T_{coolant} > 65\text{ }^\circ\text{C}$ | -40 | | 75 | $^\circ\text{C}$ |
| IP | Enclosure protection level | | IP67 | | |
| | With external connector protection | | IP6K9K | | |
| Altitude | $V_{CC} = 450\text{ V}$ | | | 5000 | m |

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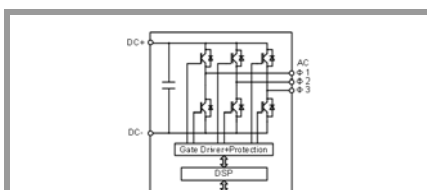
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 - Gate driver with protection features
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|--|--|-------|-------|-------|--------------|
| Symbol | Conditions | min. | typ. | max. | Unit |
| Interface parameters | | | | | |
| V_s | | 8 | 12 | 16 | V |
| I_{so} | 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 at 12V (without additional power consumption at Pins MP_DO_Cx; PS_PWRx, depending on f_{sw}), power converter activated (ELX higher than threshold voltage) | | 2900 | 3900 | mA |
| t_{POR} | Power-on reset completed | | 0.1 | 0.9 | s |
| Controller switching parameters | | | | | |
| $t_{d(on)IO}$ | Input-output turn-on propagation time | | 0.5 | 0.6 | μ s |
| $t_{d(off)IO}$ | Input-output turn-off propagation time | | 0.5 | 0.6 | μ s |
| t_{jitter} | Signal transfer prim - sec (total jitter) | | | 50 | ns |
| t_{SIS} | Short pulse suppression time | 0.026 | | 0.052 | μ s |
| t_{et} | Input impulse extension time | 0.9 | 1 | 1.1 | μ s |
| $t_{d(err)DSCP}$ | Error input-output propagation time for DSCP error | 0.2 | | 1 | μ s |
| $t_{d(err)OCP}$ | Error input-output propagation time for OCP error | | 4 | 10 | μ s |
| $t_{d(err)TMP}$ | Error input-output propagation time for temperature error | | | 50 | ms |
| t_{TD} | Top-Bot interlock dead time | | 4 | 4.1 | μ s |
| t_{bl} | VCE monitoring blanking time | | 5 | 5.1 | μ s |
| Protection functions | | | | | |
| $T_{PCBtrip}$ | Over temperature protection trip level (PCB) | 100 | | | $^{\circ}$ C |
| T_{CStrip} | Over temperature protection trip level on ceramic-substrate | 120 | | | $^{\circ}$ C |
| BW_{TBsens} | Bandwidth of temperature sensing on driver board | 100 | | | Hz |
| V_{DCtrip} | Trip level of DC-link voltage monitoring | 450 | | | V |
| V_{VStrip} | Under voltage protection trip level of board primary side | | | 8.8 | V |
| V_{VSrst} | Threshold voltage level for driver reset after failure event | 8.8 | | | V |
| I_{TRIPSC} | Overcurrent trip level | 850 | | | A_{PEAK} |
| $I_{outsens}$ | AC sensing range | -924 | | 924 | A |
| $m_{Ioutsens}$ | Gradient of output current sensing | | 2.216 | | digits/A |
| $OS_{Ioutsens}$ | Offset of AC current sensing | | 2048 | | digits |
| $BW_{Ioutsens}$ | Bandwidth (3 dB) of AC current sensing | | 16 | | kHz |
| V_{DCsens} | Measurable DC-link-voltage | 0 | | 600 | V |
| $m_{VDCsens}$ | Gradient of DC-link voltage sensing | | 6.825 | | digits/V |
| $BW_{VDCsens}$ | Bandwidth (3 dB) of DC-link voltage sensing | | 8 | | kHz |
| Miscellaneous functions | | | | | |
| V_{pre_charge} | Pre-charge voltage | | 200 | | V |

Signal Connector

| PIN | Signal | Function | Specifications |
|-------|-------------|--|---|
| X1:01 | PWR_VP | INPUT Auxiliary power supply / battery “+” | Supply voltage Vs |
| X1:02 | ELX | INPUT Turn on / turn off signal of power converter | Input voltage range = 0V ... +18V; Trip level for boot loader configuration change = +16V; Threshold voltage = 6.0V (±2V); Input impedance ≥ 2kΩ; |
| X1:03 | PS_PWR1_GND | GND | Ground of speed/position sensor power supply 1 |
| X1:04 | PS_PWR1 | OUTPUT | Speed/position sensor power supply 1; Output voltage range = +11.0V ... 13.0V; Output current limit I _{out,limit} = 100mA (no over current protection); |
| X1:05 | PS_PWR2_GND | GND | Ground of speed/position sensor power supply 2 |
| X1:06 | PS_PWR2 | OUTPUT | Speed/position sensor power supply 2; Output voltage range = +4.75V ... +5.25V; Output current limit I _{out,limit} = 250mA (no over current protection) |
| X1:07 | PS_DI_AP | INPUT/OUTPUT Digital position/speed sensor Track A Complementary signal to PS_DI_AN (pin 19) | Input voltage range = 0V ... +5.25V; Input voltage in case of open line = 2.0V(±0.25V); Input impedance (signal to GND) = 2.3kΩ (±15%); Input filter time constant = 200ns; Threshold voltage HIGH = PS_DI_AP - PS_DI_AN ! +200mV; Threshold voltage LOW = PS_DI_AP - PS_DI_AN " -200mV; |
| X1:08 | PS_DI_BP | INPUT/OUTPUT Digital position/speed sensor Track B Complementary signal to PS_DI_BN (pin 20) | Input voltage range = 0V ... +5.25V; Input voltage in case of open line = 2.0V (±0.25); Input impedance (signal to GND) = 2.3kΩ (±15%); Input filter time constant = 200ns; Threshold voltage HIGH = PS_DI_BP - PS_DI_BN ≥+200mV; Threshold voltage LOW = PS_DI_BP - PS_DI_BN ≤-200mV; |

| PIN | Signal | Function | Specifications |
|-------|-----------|--|---|
| X1:09 | PS_DI_NP | INPUT/OUTPUT Digital Position/Speed sensor index Track N Complementary signal to PS_DI_NN (pin 21) | Input voltage range = 0V ... +5.25V; Input voltage in case of open line = 2.0V (±0.25); Input impedance (signal to GND) = 2.3kΩ (±15%); Input filter time constant = 200ns; Threshold voltage HIGH = PS_DI_NP - PS_DI_NN ≥ +200mV; Threshold voltage LOW = PS_DI_NP - PS_DI_NN ≤ -200mV; |
| X1:10 | MP_AI_C1P | INPUT Configurable multipurpose analog input channel 1 Complementary signal MP_AI_C1N (pin 22) | Input voltage range = 0V ... +10V; Input impedance = 20kΩ (±10%); Accuracy of analog signal = ±2.5%; Bandwidth = 10kHz; |
| X1:11 | PS_AI_C1 | INPUT Analog position/speed sensor input channel 1 | Input voltage range = 0V ... +10V; Input impedance = 5.5kΩ (±10%); Accuracy of analog signal = ±2.5%; Bandwidth = 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%; Bandwidth = 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 | No termination resistors populated; Specification: ISO 11783 (2.5V, 250kbit/sec minimum, quad twisted cable) or J1939/11 (250kbit/sec minimum, twisted shielded pair); |
| X1:15 | CANA_L | INPUT/OUTPUT CAN interface channel A LOW line | No termination resistors populated; Specification: ISO 11783 (2.5V, 250kbit/sec minimum, quad twisted cable) or J1939/11 (250kbit/sec minimum, twisted shielded pair); |
| X1:16 | CANB_H | INPUT/OUTPUT CAN interface channel B HIGH line | No termination resistors populated; Specification: ISO 11783 (2.5V, 250kbit/sec minimum, quad twisted cable) or J1939/11 (250kbit/sec minimum, twisted shielded pair); |
| X1:17 | CANB_L | INPUT/OUTPUT CAN interface channel B LOW line | No termination resistors populated; Specification: ISO 11783 (2.5V, 250kbit/sec minimum, quad twisted cable) or J1939/11 (250kbit/sec minimum, twisted shielded pair); |

| PIN | Signal | Function | Specifications |
|-------|-----------|---|---|
| X1:18 | MP_DO_C1 | OUTPUT Multipurpose digital port 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. Output voltage range MP_DO_Cx = 0V ... PWR_VP, the ground for the digital output is PWR_GND (X1:13). Average output current per output I _{Average,out} = 1.0A; Output current limit I _{out,limit} = 5A ... 14A (overtemperature range); On-state resistance ≤ 300mΩ; |
| X1:19 | PS_DI_AN | INPUT/OUTPUT Digital position/speed sensor Track A Complementary signal to PS_DI_AP (pin 7) | See pin 7 specifications; Input impedance = 3.4 kΩ (±15%); Input voltage (open line) = 3.0V (±0.25V); Input filter time constant = 200ns; |
| X1:20 | PS_DI_BN | INPUT/OUTPUT Digital position/speed sensor Track B Complementary signal to PS_DI_BP (pin 8) | See pin 8 specifications; Input impedance = 3.4 kΩ (±15%); Input voltage (open line) = 3.0V (±0.25V); Input filter time constant = 200ns; |
| X1:21 | PS_DI_NN | INPUT/OUTPUT Digital Position/Speed sensor index Track N Complementary signal to PS_DI_NP (pin 9) | See pin 9 specifications; Input impedance = 3.4 kΩ (±15%); Input voltage (open line) = 3.0V (±0.25V); Input filter time constant = 200ns; |
| X1:22 | MP_AI_C1N | INPUT Configurable multipurpose analog input channel 1 Complementary signal to MP_AI_C1P (pin 10) | See pin 10 specifications |
| X1:23 | TS_AI_MOT | INPUT Motor temperature sensor analog input channel 1 | Temperature sensor range = 50Ω ... 210kΩ; |
| X1:24 | AI_GND | Analog ground | Ground of TS_AI_MOT |
| X1:25 | CANA_PWR | RESERVED / NOT CONNECTED | CAN bus power supply channel A |
| X1:26 | CANA_GND | OUTPUT | Return of CAN bus power supply channel A connected to PWR_GND |
| X1:27 | CANB_PWR | RESERVED / NOT CONNECTED | CAN bus power supply channel B |
| X1:28 | CANB_GND | OUTPUT | Return of CAN bus power supply channel B connected to PWR_GND |
| X1:29 | MP_AI_C2P | INPUT Configurable multipurpose analog input channel 2 Complementary signal to MP_AI_C2N (pin 30) | Input voltage range = 0V ... +10V; Input impedance = 20kΩ (±10%); Accuracy of analog signal = ±2.5%; Bandwidth = 10kHz; |
| X1:30 | MP_AI_C2N | INPUT Configurable multipurpose analog input channel 2 Complementary signal to MP_AI_C2P (pin 29) | See pin 29 specifications |

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| PIN | Signal | Function | Specifications |
|-------|-----------|---|---|
| X1:31 | MP_DI_C1 | INPUT Isolated multipurpose digital port input channel 1 | Input voltage range = 0V ... +10V; Threshold voltage = 5V (± 1.0); Input impedance = 820Ω ($\pm 20\%$); Input filter time constant = 200ns; Isolation between input and logic ground = 100 VDC; |
| X1:32 | MP_DI_C2 | INPUT Isolated multipurpose digital port input channel 2 | Input voltage range = 0V ... +10V; Threshold voltage = 5V (± 1.0); Input impedance = 820Ω ($\pm 20\%$); Input filter time constant = 200ns; Isolation between input and logic ground = 100 VDC; |
| 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. Output voltage range MP_DO_Cx = 0V ... PWR_VP, the ground for the digital output is PWR_GND (X1:13). Average output current per output $I_{Average,out} = 1.0A$; Output current limit $I_{out,limit} = 5A \dots 14A$ (overtemperature range); On-state resistance $\leq 300m\Omega$; |
| X1:35 | ENCLOSURE | INPUT/OUTPUT | Connected to the inverter enclosure by gore EMI pads |

Power Connectors

| Terminal | Function | cable harness cross section Cu / mm ² |
|----------|--------------|--|
| DC+ | HVDC Bus "+" | ≤ 70 |
| DC- | HVDC Bus "-" | ≤ 70 |
| | | |
| L1 | Phase L1 | ≤ 70 |
| L2 | Phase L2 | ≤ 70 |
| L3 | Phase L3 | ≤ 70 |

Coolant fittings

| Terminal | Function |
|----------|----------------|
| IN | Coolant Inlet |
| OUT | Coolant Outlet |

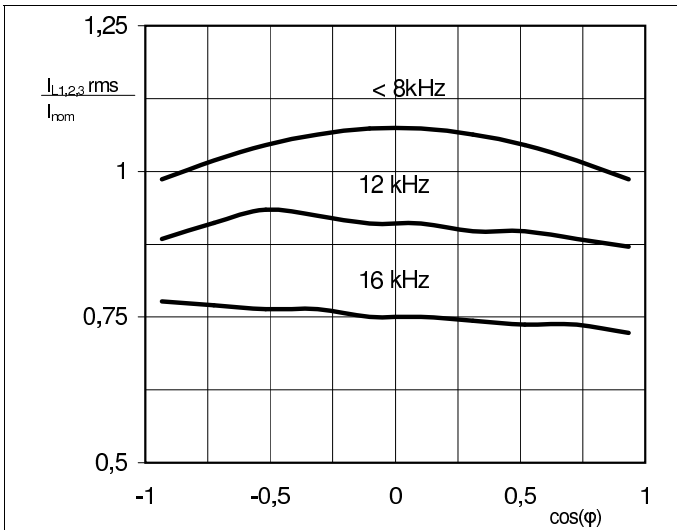


Fig. 1: Normalized output current vs. $\cos(\varphi)$

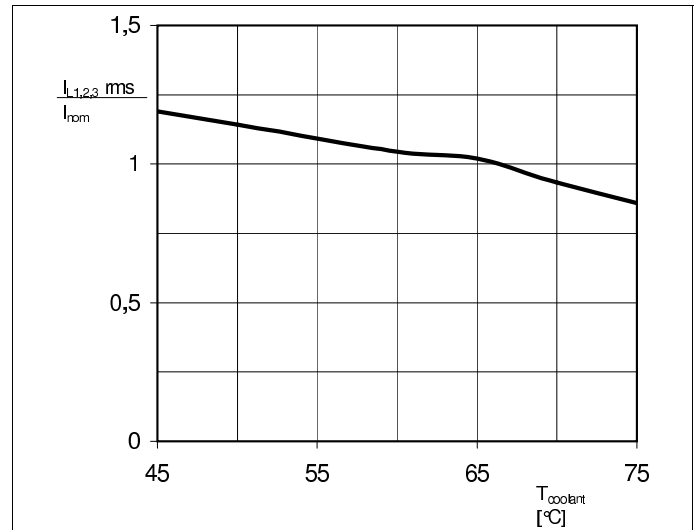


Fig. 2: Normalized output current vs. coolant temperature

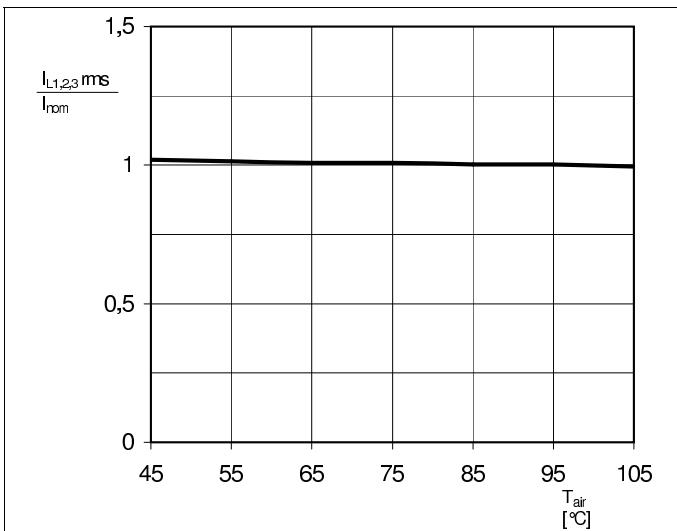


Fig. 3: Normalized output current vs. ambient temperature

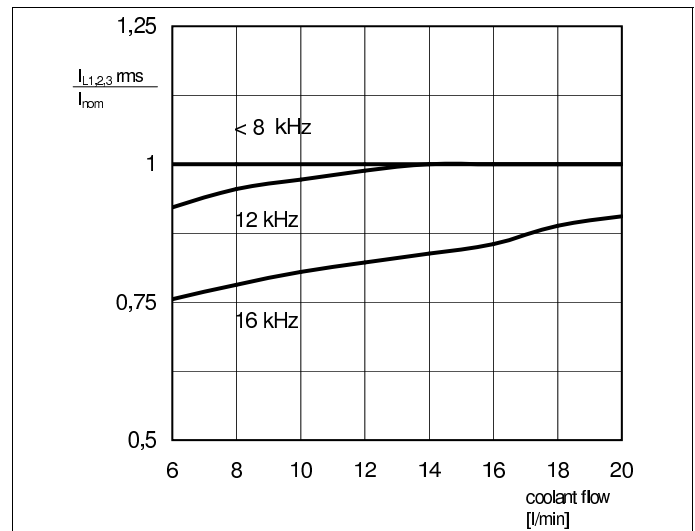


Fig. 4: Normalized output current vs. coolant flow

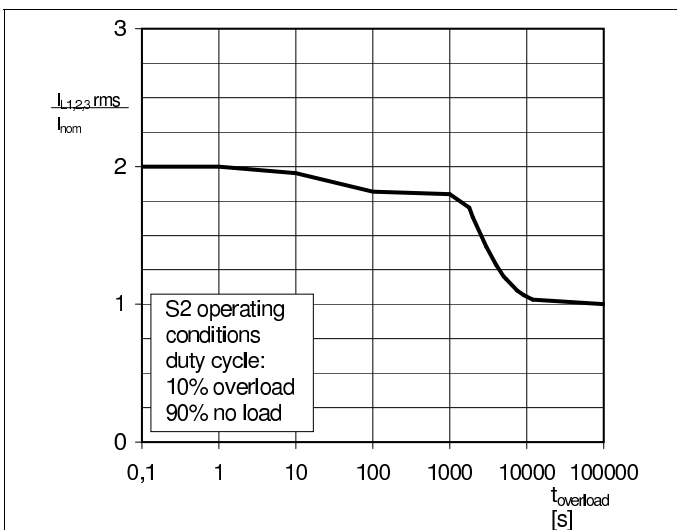


Fig. 5: Overload capability

Operating point:
if not specified otherwise

| | | | |
|----------------------|---------------------|------|--------------------|
| T_{coolant} | | 65 | $^{\circ}\text{C}$ |
| T_{air} | | 65 | $^{\circ}\text{C}$ |
| dV/dt | coolant flow | 10 | l/min |
| f_{sw} | switching frequency | 4 | kHz |
| V_{CC} | DC supply voltage | 350 | V |
| V_{OUT} | output voltage | 200 | V |
| f_{out} | output frequency | 50 | Hz |
| $\cos(\varphi)$ | | 0,85 | |
| I_{norm} | normalized current | 300 | A |
| M | modulation factor | 0,93 | |

Fig. 6: Legend

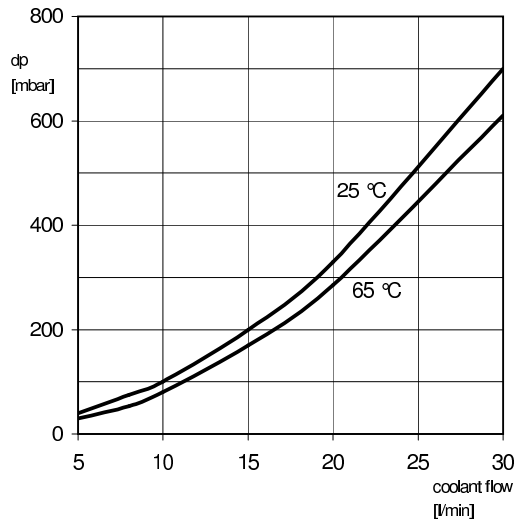


Fig. 7: Pressure drop characteristic

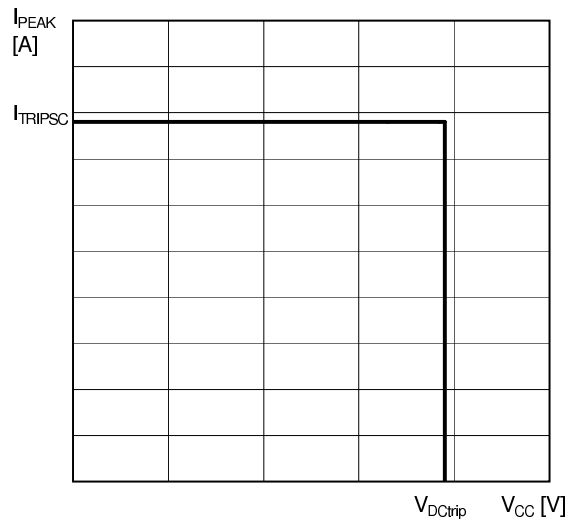


Fig. 8: Safe operating area

| DCB Temperature [°C] | ADC _{OUT} [digit] | | |
|----------------------|----------------------------|------|------|
| | min. | typ. | max. |
| -40 | 3959 | 4084 | 4208 |
| -30 | 3948 | 4072 | 4197 |
| -20 | 3927 | 4053 | 4179 |
| -10 | 3895 | 4022 | 4148 |
| 0 | 3844 | 3972 | 4099 |
| 10 | 3767 | 3896 | 4024 |
| 20 | 3657 | 3786 | 3915 |
| 30 | 3504 | 3635 | 3766 |
| 40 | 3300 | 3437 | 3572 |
| 50 | 3047 | 3191 | 3332 |
| 60 | 2753 | 2903 | 3050 |
| 70 | 2433 | 2586 | 2736 |
| 80 | 2105 | 2258 | 2407 |
| 90 | 1788 | 1935 | 2080 |
| 100 | 1494 | 1634 | 1772 |
| 110 | 1241 | 1363 | 1490 |
| 120 | 1018 | 1131 | 1241 |
| 130 | 835 | 934 | 1030 |
| 140 | 683 | 768 | 850 |
| 150 | 561 | 631 | 702 |

Fig. 9: DCB temperature measurement scaling

| PCB Temperature [°C] | ADC _{OUT} [digit] | | |
|----------------------|----------------------------|------|------|
| | min. | typ. | max. |
| -40 | 3893 | 4026 | 4156 |
| -30 | 3835 | 3972 | 4106 |
| -20 | 3745 | 3887 | 4025 |
| -10 | 3613 | 3759 | 3901 |
| 0 | 3431 | 3578 | 3722 |
| 5 | 3319 | 3485 | 3609 |
| 10 | 3193 | 3337 | 3480 |
| 15 | 3054 | 3195 | 3335 |
| 20 | 2904 | 3040 | 3175 |
| 25 | 2744 | 2873 | 3002 |
| 30 | 2564 | 2698 | 2830 |
| 35 | 2380 | 2516 | 2652 |
| 40 | 2193 | 2332 | 2470 |
| 45 | 2009 | 2149 | 2288 |
| 50 | 1828 | 1969 | 2108 |
| 55 | 1655 | 1794 | 1932 |
| 60 | 1491 | 1628 | 1764 |
| 65 | 1338 | 1472 | 1604 |
| 70 | 1198 | 1326 | 1454 |
| 75 | 1069 | 1192 | 1315 |
| 80 | 952 | 1069 | 1186 |
| 85 | 847 | 957 | 1068 |
| 90 | 752 | 856 | 961 |
| 95 | 663 | 766 | 864 |
| 100 | 594 | 685 | 777 |
| 105 | 528 | 612 | 698 |

Fig. 10: PCB temperature measurement scaling

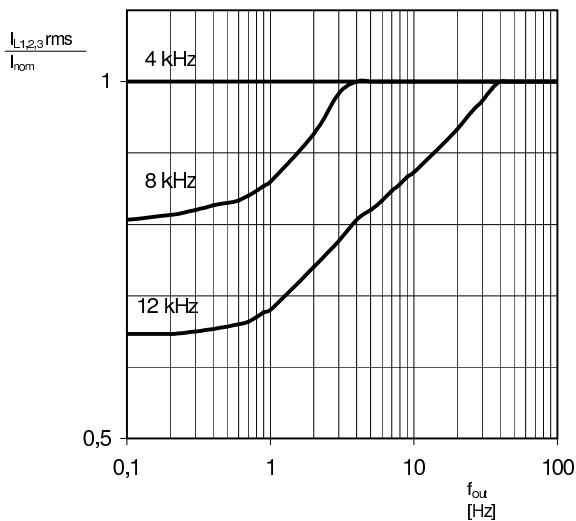
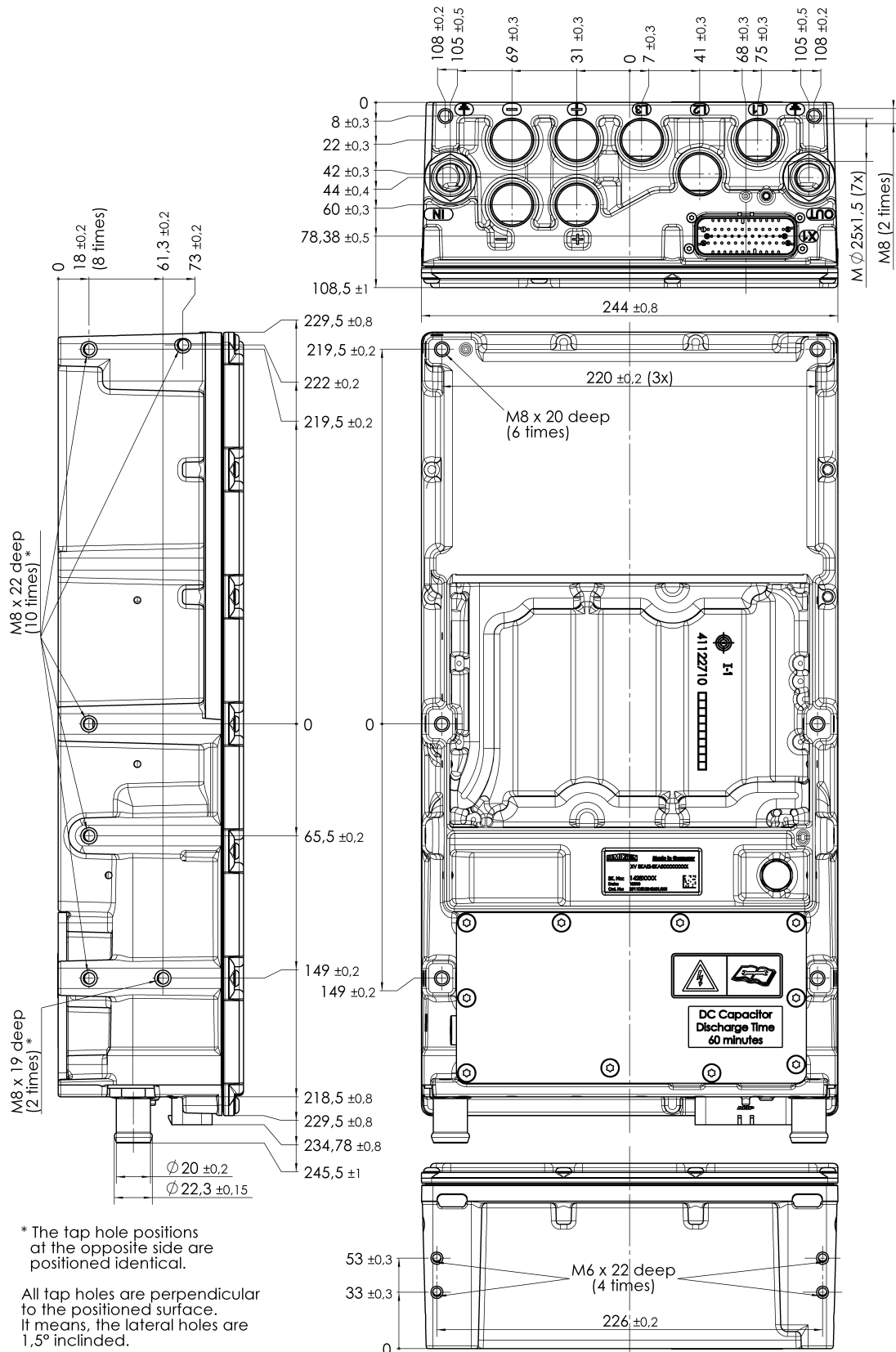


Fig. 11: Normalized output current vs. output frequency

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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.