

## SKiiP 2414 GB17E4-4DUW V2



SKiiP® 4

## 2-pack-integrated intelligent Power System

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## Features\*

- Intelligent Power Module
- Integrated current and temperature measurement
- Integrated DC-link measurement
- Solder free power section
- IGBT4 and CAL4F technology
- Safety isolated switching and sensor signals
- Digital signal transmission
- CAN Interface
- 100% tested IPM
- RoHS compliant
- UL file no. E242581

## Typical Applications

- Renewable energies
- Traction
- Elevators
- Industrial drives

## Remarks

For further information please refer to SKiiP®4 Technical Explanation

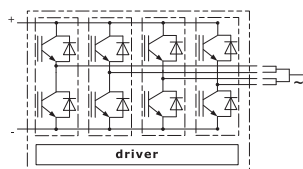
## Footnotes

<sup>1)</sup>With assembly of suitable MKP capacitor per terminal

<sup>2)</sup>The specified maximum operation junction temperature  $T_{jop}$  can be  $> 150^{\circ}\text{C}$  for a max. of 1000cum. Operations hours

| Absolute Maximum Ratings      |                                                           |                        |                      |                   |
|-------------------------------|-----------------------------------------------------------|------------------------|----------------------|-------------------|
| Symbol                        | Conditions                                                |                        | Values               | Unit              |
| System                        |                                                           |                        |                      |                   |
| V <sub>CC</sub> <sup>1)</sup> | Operating DC link voltage                                 |                        | 1300                 | V                 |
| V <sub>isol</sub>             | DC, t = 1 s, each polarity                                |                        | 5600                 | V                 |
| I <sub>t(RMS)</sub>           | per AC terminal, rms, sinusoidal current                  |                        | 500                  | A                 |
| I <sub>max (peak)</sub>       | max. peak current of power section                        |                        | 3600                 | A                 |
| I <sub>FSM</sub>              | T <sub>j</sub> = 175 °C, t <sub>p</sub> = 10 ms, sin 180° |                        | 15885                | A                 |
| I <sup>2</sup> t              | T <sub>j</sub> = 175 °C, t <sub>p</sub> = 10 ms, diode    |                        | 1262                 | kA <sup>2</sup> s |
| f <sub>out</sub>              | fundamental output frequency (sinusoidal)                 |                        | 1                    | kHz               |
| T <sub>stg</sub>              | storage temperature                                       |                        | -40 ... 85           | °C                |
| IGBT                          |                                                           |                        |                      |                   |
| V <sub>CES</sub>              | T <sub>j</sub> = 25 °C                                    |                        | 1700                 | V                 |
| I <sub>C</sub>                | T <sub>j</sub> = 175 °C                                   | T <sub>s</sub> = 25 °C | 3385                 | A                 |
|                               |                                                           | T <sub>s</sub> = 70 °C | 2723                 | A                 |
| I <sub>Cnom</sub>             |                                                           |                        | 2400                 | A                 |
| T <sub>j</sub> <sup>2)</sup>  | junction temperature                                      |                        | -40 ... 175          | °C                |
| Diode                         |                                                           |                        |                      |                   |
| V <sub>RRM</sub>              | T <sub>j</sub> = 25 °C                                    |                        | 1700                 | V                 |
| I <sub>F</sub>                | T <sub>j</sub> = 175 °C                                   | T <sub>s</sub> = 25 °C | 2362                 | A                 |
|                               |                                                           | T <sub>s</sub> = 70 °C | 1869                 | A                 |
| I <sub>Fnom</sub>             |                                                           |                        | 2400                 | A                 |
| T <sub>j</sub> <sup>2)</sup>  | junction temperature                                      |                        | -40 ... 175          | °C                |
| Driver                        |                                                           |                        |                      |                   |
| V <sub>s</sub>                | power supply                                              |                        | 19.2 ... 28.8        | V                 |
| V <sub>iH</sub>               | input signal voltage (high)                               |                        | V <sub>s</sub> + 0.3 | V                 |
| dv/dt                         | secondary to primary side                                 |                        | 75                   | kV/μs             |
| f <sub>sw</sub>               | switching frequency                                       |                        | 10                   | kHz               |

| Characteristics                    |                                                    |                          |      |      |        |      |
|------------------------------------|----------------------------------------------------|--------------------------|------|------|--------|------|
| Symbol                             | Conditions                                         |                          | min. | typ. | max.   | Unit |
| IGBT                               |                                                    |                          |      |      |        |      |
| V <sub>CE(sat)</sub>               | I <sub>C</sub> = 2400 A<br>at terminal             | T <sub>j</sub> = 25 °C   |      | 2.12 | 2.43   | V    |
|                                    |                                                    | T <sub>j</sub> = 150 °C  |      | 2.53 | 2.79   | V    |
| V <sub>CE0</sub>                   |                                                    | T <sub>j</sub> = 25 °C   |      | 1.10 | 1.20   | V    |
|                                    |                                                    | T <sub>j</sub> = 150 °C  |      | 1.00 | 1.10   | V    |
| r <sub>CE</sub>                    | at terminal                                        | T <sub>j</sub> = 25 °C   |      | 0.42 | 0.51   | mΩ   |
|                                    |                                                    | T <sub>j</sub> = 150 °C  |      | 0.64 | 0.70   | mΩ   |
| E <sub>on</sub> + E <sub>off</sub> | I <sub>C</sub> = 2400 A<br>T <sub>j</sub> = 150 °C | V <sub>CC</sub> = 900 V  |      | 1780 |        | mJ   |
|                                    |                                                    | V <sub>CC</sub> = 1300 V |      | 2840 |        | mJ   |
| R <sub>th(j-s)</sub>               | per IGBT switch                                    |                          |      |      | 0.0138 | K/W  |
| R <sub>th(j-r)</sub>               | per IGBT switch                                    |                          |      |      | 0.01   | K/W  |



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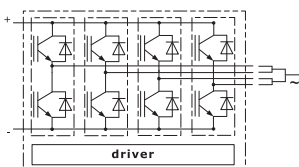
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<sup>2)</sup>The specified maximum operation junction temperature  $T_{vjop}$  can be  $> 150^{\circ}\text{C}$  for a max. of 1000cum. Operations hours

| Characteristics                  |                                                                                                                        |                         |                    |                                                                                    |                    |                   |
|----------------------------------|------------------------------------------------------------------------------------------------------------------------|-------------------------|--------------------|------------------------------------------------------------------------------------|--------------------|-------------------|
| Symbol                           | Conditions                                                                                                             |                         | min.               | typ.                                                                               | max.               | Unit              |
| Diode                            |                                                                                                                        |                         |                    |                                                                                    |                    |                   |
| V <sub>F</sub> = V <sub>EC</sub> | I <sub>F</sub> = 2400 A<br>at terminal                                                                                 | T <sub>j</sub> = 25 °C  |                    | 2.02                                                                               | 2.34               | V                 |
|                                  |                                                                                                                        | T <sub>j</sub> = 150 °C |                    | 2.27                                                                               | 2.62               | V                 |
| V <sub>F0</sub>                  | at terminal                                                                                                            | T <sub>j</sub> = 25 °C  |                    | 1.21                                                                               | 1.36               | V                 |
|                                  |                                                                                                                        | T <sub>j</sub> = 150 °C |                    | 0.99                                                                               | 1.12               | V                 |
| r <sub>F</sub>                   |                                                                                                                        | T <sub>j</sub> = 25 °C  |                    | 0.34                                                                               | 0.41               | mΩ                |
|                                  |                                                                                                                        | T <sub>j</sub> = 150 °C |                    | 0.53                                                                               | 0.63               | mΩ                |
| E <sub>rr</sub>                  | I <sub>F</sub> = 2400 A<br>T <sub>j</sub> = 150 °C                                                                     | V <sub>R</sub> = 900 V  |                    | 412                                                                                |                    | mJ                |
|                                  |                                                                                                                        | V <sub>R</sub> = 1300 V |                    | 664                                                                                |                    | mJ                |
| R <sub>th(j-s)</sub>             | per diode switch                                                                                                       |                         |                    |                                                                                    | 0.0281             | K/W               |
| R <sub>th(j-r)</sub>             | per diode switch                                                                                                       |                         |                    |                                                                                    | 0.0241             | K/W               |
| Driver                           |                                                                                                                        |                         |                    |                                                                                    |                    |                   |
| V <sub>s</sub>                   | supply voltage non stabilized                                                                                          |                         | 19.2               | 24                                                                                 | 28.8               | V                 |
| I <sub>S0</sub>                  | bias current @V <sub>s</sub> = 24V, f <sub>sw</sub> = 0, I <sub>AC</sub> = 0                                           |                         |                    | 260                                                                                |                    | mA                |
| I <sub>s</sub>                   | k <sub>1</sub> = 46 mA/kHz, k <sub>2</sub> = 0,00015 mA/A <sup>2</sup> ,<br>f <sub>out</sub> =50Hz, sinusoidal current |                         | = 260              | + k <sub>1</sub> * f <sub>sw</sub> + k <sub>2</sub> * I <sub>AC</sub> <sup>2</sup> |                    | mA                |
| V <sub>IT+</sub>                 | input threshold voltage (HIGH)                                                                                         |                         | 0,7*V <sub>s</sub> |                                                                                    |                    | V                 |
| V <sub>IT-</sub>                 | input threshold voltage (LOW)                                                                                          |                         | 0,3*V <sub>s</sub> |                                                                                    |                    | V                 |
| R <sub>IN</sub>                  | input resistance                                                                                                       |                         |                    | 13                                                                                 |                    | kΩ                |
| C <sub>IN</sub>                  | input capacitance                                                                                                      |                         |                    | 1                                                                                  |                    | nF                |
| t <sub>pRESET</sub>              | error memory reset time                                                                                                |                         |                    | 500                                                                                |                    | ms                |
| t <sub>pReset(OCP)</sub>         | Over current reset time, FRT-function<br>can be activated via CAN interface                                            |                         |                    |                                                                                    |                    | μs                |
| t <sub>TD</sub>                  | top / bottom switch interlock time                                                                                     |                         |                    | 3                                                                                  |                    | μs                |
| t <sub>jitter</sub>              | jitter clock time                                                                                                      |                         |                    | 50                                                                                 | 58                 | ns                |
| t <sub>SIS</sub>                 | short pulse suppression time                                                                                           |                         |                    | 0.6                                                                                |                    | μs                |
| t <sub>POR</sub>                 | Power-On-Reset completed                                                                                               |                         |                    |                                                                                    | 1                  | s                 |
| I <sub>digiout</sub>             | digital output sink current<br>(HALT-signal)                                                                           |                         |                    |                                                                                    | 16                 | mA                |
| V <sub>it+ HALT</sub>            | input threshold voltage HIGH HALT<br>(Low -->High)                                                                     |                         | 0,6*V <sub>s</sub> |                                                                                    |                    | V                 |
| V <sub>it-HALT</sub>             | input threshold voltage LOW HALT<br>(High --> Low)                                                                     |                         |                    |                                                                                    | 0.4*V <sub>s</sub> | V                 |
| t <sub>d(terr)</sub>             | Error delay time (from detection to<br>HALT), (depends on kind of error)                                               |                         | 3                  |                                                                                    | 370                | μs                |
| I <sub>TRIPSC</sub>              | over current trip level                                                                                                |                         | 3600               |                                                                                    |                    | A <sub>PEAK</sub> |
| I <sub>LL</sub>                  |                                                                                                                        |                         |                    | n.a.                                                                               |                    | A <sub>PEAK</sub> |
| T <sub>trip</sub>                | over temperature trip level                                                                                            |                         | 128                | 135                                                                                | 142                | °C                |
| T <sub>DriverTrip</sub>          | over temperature PCB trip level                                                                                        |                         | 113                | 120                                                                                | 124                | °C                |
| V <sub>bCtrip</sub>              | over voltage trip level,                                                                                               |                         | 1300               | 1340                                                                               | 1380               | V                 |
| V <sub>bCtripLL</sub>            |                                                                                                                        |                         |                    | n.a.                                                                               |                    | V                 |



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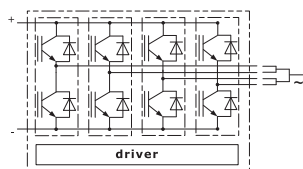
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| Characteristics    |                                                                                      |      |                                       |        |                         |
|--------------------|--------------------------------------------------------------------------------------|------|---------------------------------------|--------|-------------------------|
| Symbol             | Conditions                                                                           | min. | typ.                                  | max.   | Unit                    |
| <b>System</b>      |                                                                                      |      |                                       |        |                         |
| $t_{d(on)IO}$      | $V_{CC} = 1300\text{ V}$<br>$I_C = 2400\text{ A}$<br>$T_j = 25^{\circ}\text{C}$      |      | turn on<br>propagation delay<br>time  | 2.8    | $\mu\text{s}$           |
| $t_{d(off)IO}$     |                                                                                      |      | turn off<br>propagation delay<br>time | 2.6    | $\mu\text{s}$           |
| $dV_{CE}/dt_{on}$  | $T_j = 25^{\circ}\text{C}$<br>$V_{CC} = 1300\text{ V}$                               |      | $I_C = 0\text{ A}$                    | 14     | $\text{kV}/\mu\text{s}$ |
|                    |                                                                                      |      | $I_C = 2400\text{ A}$                 | 3      | $\text{kV}/\mu\text{s}$ |
| $dV_{CE}/dt_{off}$ |                                                                                      |      | $I_C = 2400\text{ A}$                 | 10     | $\text{kV}/\mu\text{s}$ |
| $R_{th(s-a)}$      | flow rate = 15 l/min, $T_{Fluid}=40^{\circ}\text{C}$ ,<br>water/glycol ratio 50%:50% |      |                                       | 0.0065 | K/W                     |
| $R_{CC'+EE'}$      | measured per switch, $T_s = 25^{\circ}\text{C}$                                      |      | 0.0675                                |        | $\text{m}\Omega$        |
| $L_{CE}$           | commutation inductance                                                               |      | 4.5                                   |        | nH                      |
| $C_{CHC}$          | coupling capacitance secondary to<br>heat sink                                       |      | 6                                     |        | nF                      |
| $C_{ps}$           | coupling capacitance primary to<br>secondary                                         |      | 0.08                                  |        | nF                      |
| $I_{CES} + I_{RD}$ | $V_{GE} = 0\text{ V}$ , $V_{CE} = 1700\text{ V}$ , $T_j = 25^{\circ}\text{C}$        |      | 0.199                                 |        | mA                      |
| $M_{dc}$           | DC terminals                                                                         | 6    |                                       | 8      | Nm                      |
| $M_{ac}$           | AC terminals                                                                         | 13   |                                       | 15     | Nm                      |
| w                  | SKiiP System w/o heat sink                                                           |      | 3.22                                  |        | kg                      |
| $w_h$              | heat sink                                                                            |      | 4.25                                  |        | kg                      |



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## Isolation coordination acc. to EN 50178 and IEC 61800-5-1

|                                                                                             |                                       |
|---------------------------------------------------------------------------------------------|---------------------------------------|
| Maximum grid RMS voltage, line-to-line, grounded delta mains                                | 690V+20%                              |
| Installation altitude for maximum grid RMS voltage, line-to-line, grounded delta mains      | 2000m                                 |
| Maximum grid RMS voltage, line-to-line, star point grounded mains                           | 690V+20%                              |
| Installation altitude for maximum grid RMS voltage, line-to-line, star point grounded mains | 4000m                                 |
| Maximum transient peak voltage between low voltage circuit and mains                        | 1900V                                 |
| Pollution degree acc. to IEC 60664-1 outside the moulded power section                      | 2                                     |
| Overvoltage cat. acc. to IEC 60664-1 for mains                                              | III                                   |
| Overvoltage cat. acc. to UL 840 within mains                                                | I                                     |
| Overvoltage cat. acc. to UL 840 between mains and ground                                    | III                                   |
| Overvoltage cat. acc. to UL 840 between mains and low voltage circuit                       | III                                   |
| Basic isolation                                                                             | between heat sink and mains           |
| Reinforced isolation                                                                        | between low voltage circuit and mains |
| Protection level acc. to IEC 60529                                                          | IP00                                  |

## Environmental conditions acc. to IEC 60721

|                                                        | Storage            | Transportation     | Operation stationary use at weather protected locations | Operating ground vehicle installations | Operating ship environment |
|--------------------------------------------------------|--------------------|--------------------|---------------------------------------------------------|----------------------------------------|----------------------------|
| Climatic conditions                                    | 1K2 <sub>(1)</sub> | 2K2 <sub>(1)</sub> | 3K3 <sub>(1)</sub>                                      | 5K1 <sub>(1)</sub>                     | 6K1 <sub>(1)</sub>         |
| Biological conditions                                  | 1B1                | 2B1                | 3B1                                                     | 5B1                                    | 6B1                        |
| Chemically active substances<br>(excluded: salt spray) | 1C2                | 2C1                | 3C2                                                     | 5C2                                    | 6C2                        |
| Mechanically active substances                         | 1S1                | 2S1                | 3S1                                                     | 5S1                                    | 6S1                        |
| Mechanical conditions                                  | 1M3                | (4)                | 3M6 <sub>(2)</sub>                                      | 5M3 <sub>(3)</sub>                     | 6M3                        |
| Contaminating fluids                                   | ---                | ---                | ---                                                     | 5F1                                    | ---                        |

(1) expanded temperature range: -40°C / +85°C. Please note: by operation near 85°C the life time of product is reduced.

(2) 3M7 possible, but due to the mechanic load capacity of external components like DC-Link capacitors limited to 3M6

(3) 5M3 without impact of foreign bodies, stones

(4) no declaration due to customer-specific packing

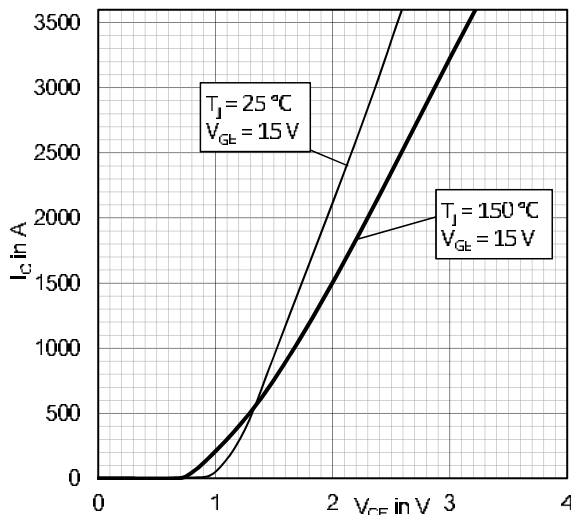


Fig. 1: Typical IGBT output characteristics

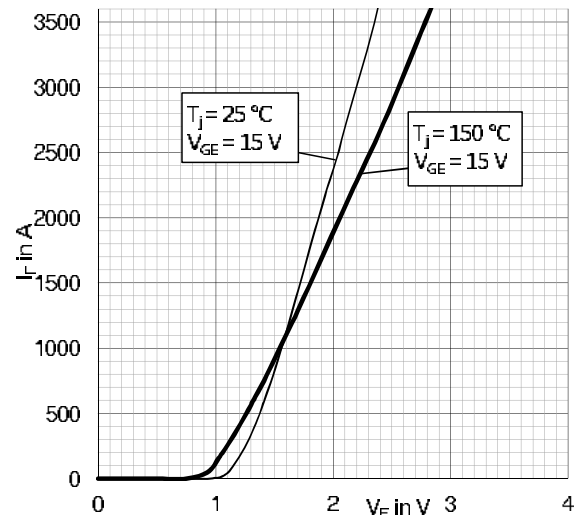


Fig. 2: Typical diode output characteristics

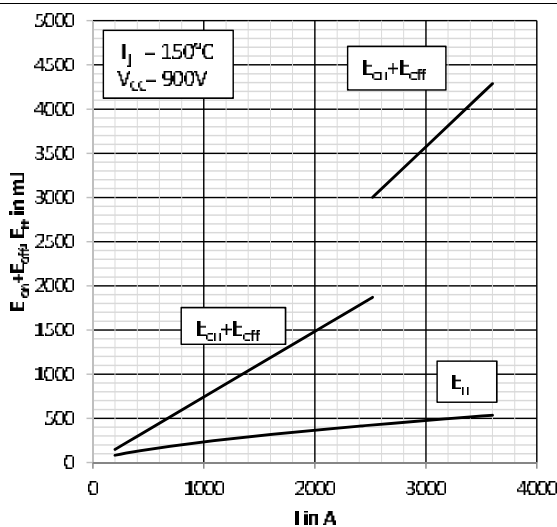


Fig. 3: Typical switching energy  $E = f(I_C)$

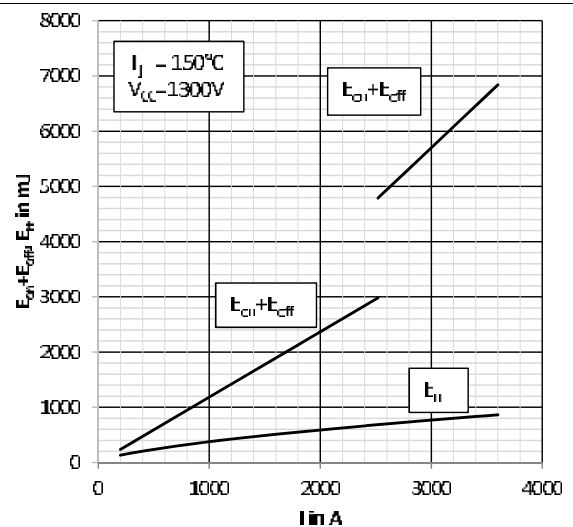


Fig. 4: Typical switching energy  $E = f(I_C)$

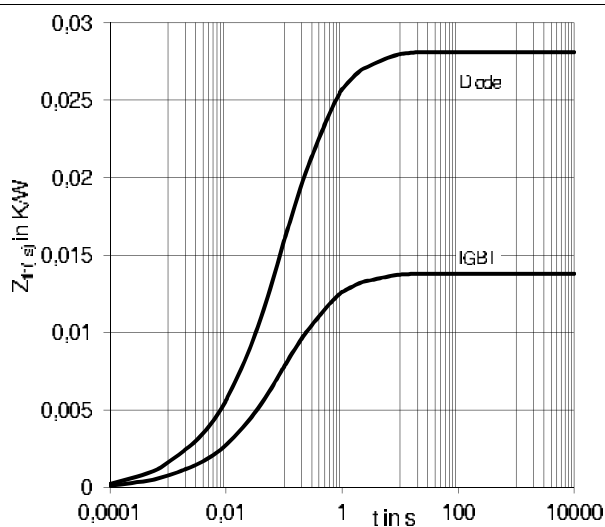


Fig. 5: Transient thermal impedance  $Z_{th}(j-s)$

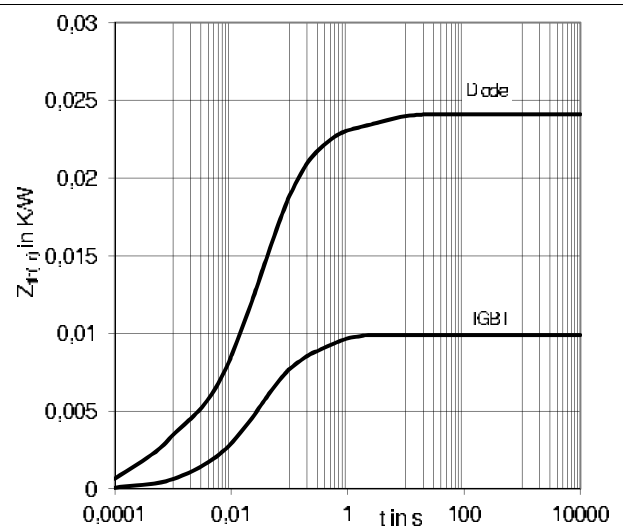


Fig. 6: Transient thermal impedance  $Z_{th}(j-r)$

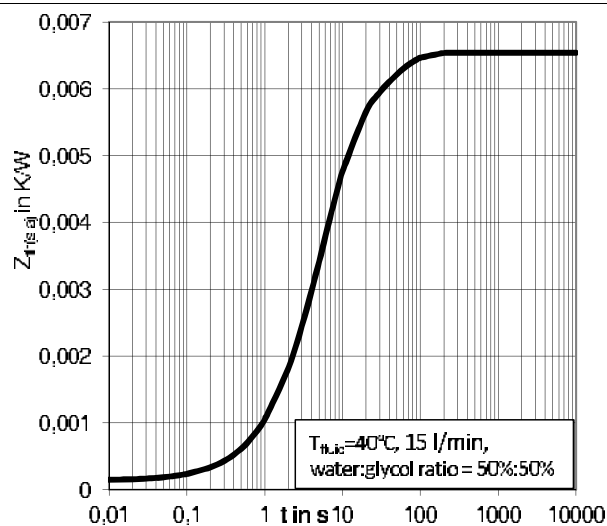


Fig. 7: Transient thermal impedance  $Z_{th}(s-a)$

|                 | $R_{th} [K/W]$ |        |        |        |        |
|-----------------|----------------|--------|--------|--------|--------|
|                 | 1              | 2      | 3      | 4      | 5      |
| $Z_{th(j-s)} I$ | 0,0010         | 0,0049 | 0,0055 | 0,0017 | 0,0007 |
| $Z_{th(j-s)} D$ | 0,0020         | 0,0100 | 0,0112 | 0,0034 | 0,0015 |
| $Z_{th(j-r)} I$ | 0,0020         | 0,0048 | 0,0023 | 0,0008 |        |
| $Z_{th(j-r)} D$ | 0,0012         | 0,0039 | 0,0104 | 0,0054 | 0,0032 |
| $Z_{th(s-a)}$   | 0,0014         | 0,0050 | 0,0001 |        |        |

|                 | $\tau [s]$ |        |        |        |        |
|-----------------|------------|--------|--------|--------|--------|
|                 | 1          | 2      | 3      | 4      | 5      |
| $Z_{th(j-s)} I$ | 3,6500     | 0,4100 | 0,0650 | 0,0090 | 0,0008 |
| $Z_{th(j-s)} D$ | 3,6500     | 0,4100 | 0,0650 | 0,0090 | 0,0008 |
| $Z_{th(j-r)} I$ | 0,4500     | 0,0475 | 0,0142 | 0,0016 |        |
| $Z_{th(j-r)} D$ | 4,1546     | 0,2644 | 0,0497 | 0,0107 | 0,0005 |
| $Z_{th(s-a)}$   | 34,2609    | 5,2284 | 0,0005 |        |        |

Fig. 8: Coefficients of thermal impedances

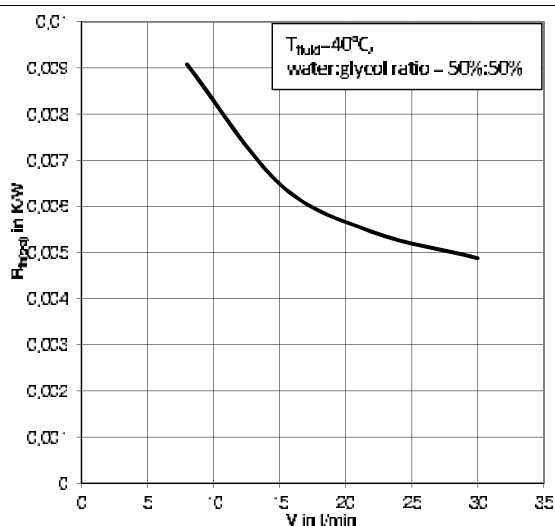


Fig. 9: Thermal resistance  $R_{th}(s-a)$  versus flow rate  $V$

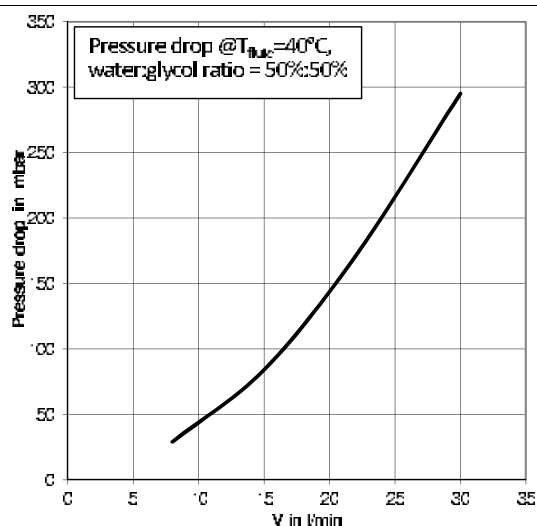
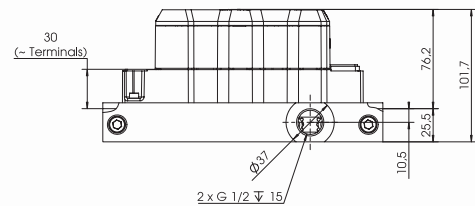
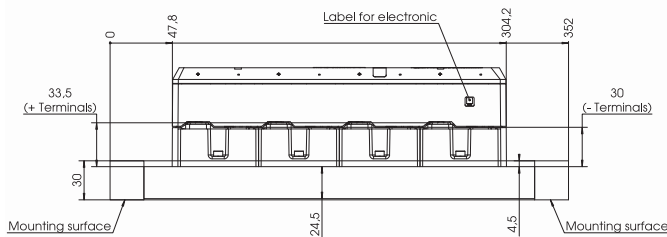
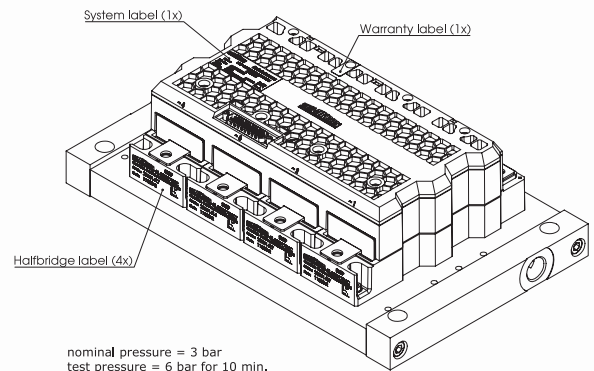
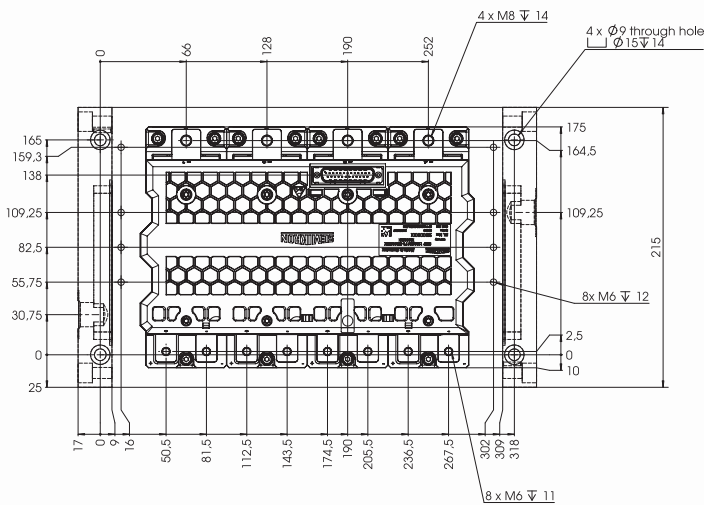


Fig. 10: Pressure drop  $\Delta p$  versus flow rate  $V$



All dimensions in mm!



nominal pressure = 3 bar  
test pressure = 6 bar for 10 min.  
coolant with percentage of glycol ≥ 10%

## System

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

### \*IMPORTANT INFORMATION AND WARNINGS

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