

# SKM1200MLI12TE4



SEMITRANS® 10

## IGBT4 Modules

### SKM1200MLI12TE4

#### Features\*

- High efficient MLI topology
- Symmetrical current sharing
- Low-inductive module design
- High mechanical robustness
- UL recognized, file no. E63532

#### Typical Applications

- 1500V Solar inverters

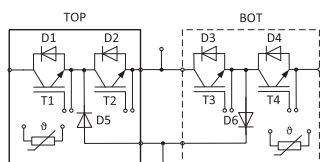
#### Remarks\*

- TOP-Switch
- Recommended  $T_{jop} = -40 \dots 150^\circ\text{C}$
- IGBT1 : outer IGBTs T1 & T4
- IGBT2 : inner IGBTs T2 & T3
- Diode1 : outer diodes D1 & D4
- Diode2 : inner diodes D2 & D3
- Diode5 : clamping diodes D5 & D6

#### Footnotes

<sup>1)</sup>Please find further technical information on the SEMIKRON website.

| Absolute Maximum Ratings |                                                                                                     |                         |             |      |
|--------------------------|-----------------------------------------------------------------------------------------------------|-------------------------|-------------|------|
| Symbol                   | Conditions                                                                                          |                         | Values      | Unit |
| IGBT1                    |                                                                                                     |                         |             |      |
| V <sub>CES</sub>         | T <sub>J</sub> = 25 °C                                                                              |                         | 1200        | V    |
| I <sub>C</sub>           | T <sub>J</sub> = 175 °C                                                                             | T <sub>c</sub> = 25 °C  | 2078        | A    |
|                          |                                                                                                     | T <sub>c</sub> = 100 °C | 1383        | A    |
| I <sub>Cnom</sub>        |                                                                                                     |                         | 1200        | A    |
| I <sub>CRM</sub>         |                                                                                                     |                         | 2400        | A    |
| V <sub>GES</sub>         |                                                                                                     |                         | -20 ... 20  | V    |
| t <sub>psc</sub>         | V <sub>CC</sub> = 800 V, V <sub>GE</sub> ≤ 15 V, T <sub>J</sub> = 150 °C, V <sub>CES</sub> ≤ 1200 V |                         | 10          | μs   |
| T <sub>J</sub>           |                                                                                                     |                         | -40 ... 175 | °C   |
| IGBT2                    |                                                                                                     |                         |             |      |
| V <sub>CES</sub>         | T <sub>J</sub> = 25 °C                                                                              |                         | 1200        | V    |
| I <sub>C</sub>           | T <sub>J</sub> = 175 °C                                                                             | T <sub>c</sub> = 25 °C  | 2078        | A    |
|                          |                                                                                                     | T <sub>c</sub> = 100 °C | 1383        | A    |
| I <sub>Cnom</sub>        |                                                                                                     |                         | 1200        | A    |
| I <sub>CRM</sub>         |                                                                                                     |                         | 2400        | A    |
| V <sub>GES</sub>         |                                                                                                     |                         | -20 ... 20  | V    |
| t <sub>psc</sub>         | V <sub>CC</sub> = 800 V, V <sub>GE</sub> ≤ 15 V, T <sub>J</sub> = 150 °C, V <sub>CES</sub> ≤ 1200 V |                         | 10          | μs   |
| T <sub>J</sub>           |                                                                                                     |                         | -40 ... 175 | °C   |
| Diode1                   |                                                                                                     |                         |             |      |
| V <sub>RRM</sub>         | T <sub>J</sub> = 25 °C                                                                              |                         | 1200        | V    |
| I <sub>F</sub>           | T <sub>J</sub> = 175 °C                                                                             | T <sub>c</sub> = 25 °C  | 1057        | A    |
|                          |                                                                                                     | T <sub>c</sub> = 100 °C | 676         | A    |
| I <sub>FRM</sub>         |                                                                                                     |                         | 1800        | A    |
| I <sub>FSM</sub>         | t <sub>p</sub> = 10 ms, sin 180°, T <sub>J</sub> = 25 °C                                            |                         | 4128        | A    |
| T <sub>J</sub>           |                                                                                                     |                         | -40 ... 175 | °C   |
| Diode2                   |                                                                                                     |                         |             |      |
| V <sub>RRM</sub>         | T <sub>J</sub> = 25 °C                                                                              |                         | 1200        | V    |
| I <sub>F</sub>           | T <sub>J</sub> = 175 °C                                                                             | T <sub>c</sub> = 25 °C  | 1057        | A    |
|                          |                                                                                                     | T <sub>c</sub> = 100 °C | 676         | A    |
| I <sub>FRM</sub>         |                                                                                                     |                         | 1800        | A    |
| I <sub>FSM</sub>         | t <sub>p</sub> = 10 ms, sin 180°, T <sub>J</sub> = 25 °C                                            |                         | 4128        | A    |
| T <sub>J</sub>           |                                                                                                     |                         | -40 ... 175 | °C   |
| Diode5                   |                                                                                                     |                         |             |      |
| V <sub>RRM</sub>         | T <sub>J</sub> = 25 °C                                                                              |                         | 1200        | V    |
| I <sub>F</sub>           | T <sub>J</sub> = 175 °C                                                                             | T <sub>c</sub> = 25 °C  | 1328        | A    |
|                          |                                                                                                     | T <sub>c</sub> = 100 °C | 848         | A    |
| I <sub>FRM</sub>         |                                                                                                     |                         | 2400        | A    |
| I <sub>FSM</sub>         | t <sub>p</sub> = 10 ms, sin 180°, T <sub>J</sub> = 25 °C                                            |                         | 5280        | A    |
| T <sub>J</sub>           |                                                                                                     |                         | -40 ... 175 | °C   |
| Module                   |                                                                                                     |                         |             |      |
| T <sub>stg</sub>         | module without TIM                                                                                  |                         | -40 ... 150 | °C   |
| V <sub>isol</sub>        | AC sinus 50 Hz, t = 1 min                                                                           |                         | 4000        | V    |



MLI TOP-Switch



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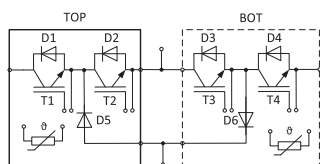
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#### Footnotes

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| Characteristics      |                                                                                               |                         |      |        |       |      |
|----------------------|-----------------------------------------------------------------------------------------------|-------------------------|------|--------|-------|------|
| Symbol               | Conditions                                                                                    |                         | min. | typ.   | max.  | Unit |
| IGBT1                |                                                                                               |                         |      |        |       |      |
| V <sub>CE(sat)</sub> | I <sub>C</sub> = 1200 A                                                                       | T <sub>j</sub> = 25 °C  |      | 1.80   | 2.05  | V    |
|                      | V <sub>GE</sub> = 15 V<br>chiplevel                                                           | T <sub>j</sub> = 150 °C |      | 2.05   | 2.30  | V    |
| V <sub>CE0</sub>     | chiplevel                                                                                     | T <sub>j</sub> = 25 °C  |      | 0.87   | 1.01  | V    |
|                      |                                                                                               | T <sub>j</sub> = 150 °C |      | 0.77   | 0.90  | V    |
| r <sub>CE</sub>      | V <sub>GE</sub> = 15 V                                                                        | T <sub>j</sub> = 25 °C  |      | 0.78   | 0.87  | mΩ   |
|                      | chiplevel                                                                                     | T <sub>j</sub> = 150 °C |      | 1.07   | 1.17  | mΩ   |
| V <sub>GE(th)</sub>  | V <sub>GE</sub> = V <sub>CE</sub> , I <sub>C</sub> = 44.4 mA                                  |                         | 5.1  | 5.8    | 6.3   | V    |
| I <sub>CES</sub>     | V <sub>GE</sub> = 0 V, V <sub>CE</sub> = 1200 V, T <sub>j</sub> = 25 °C                       |                         |      |        | 5     | mA   |
| C <sub>ies</sub>     | V <sub>CE</sub> = 25 V<br>V <sub>GE</sub> = 0 V                                               | f = 1 MHz               |      | 75.0   |       | nF   |
| C <sub>oes</sub>     |                                                                                               | f = 1 MHz               |      | 7      |       | nF   |
| C <sub>res</sub>     |                                                                                               | f = 1 MHz               |      | 4.08   |       | nF   |
| Q <sub>G</sub>       | V <sub>GE</sub> = - 8 V...+ 15 V                                                              |                         |      | 6900   |       | nC   |
| R <sub>Gint</sub>    | T <sub>j</sub> = 25 °C                                                                        |                         |      | 0.9    |       | Ω    |
| t <sub>d(on)</sub>   | V <sub>CC</sub> = 600 V                                                                       | T <sub>j</sub> = 150 °C |      | 249    |       | ns   |
| t <sub>r</sub>       | I <sub>C</sub> = 1200 A                                                                       | T <sub>j</sub> = 150 °C |      | 83     |       | ns   |
| E <sub>on</sub>      | V <sub>GE</sub> = +15/-15 V                                                                   | T <sub>j</sub> = 150 °C |      | 108    |       | mJ   |
| t <sub>d(off)</sub>  | R <sub>G on</sub> = 1 Ω                                                                       | T <sub>j</sub> = 150 °C |      | 887    |       | ns   |
| t <sub>f</sub>       | R <sub>G off</sub> = 2 Ω                                                                      | T <sub>j</sub> = 150 °C |      | 130    |       | ns   |
| E <sub>off</sub>     | di/dt <sub>on</sub> = 15500 A/<br>μs<br>di/dt <sub>off</sub> = 7500 A/μs<br>dv/dt = 3300 V/μs | T <sub>j</sub> = 150 °C |      | 189    |       | mJ   |
| R <sub>th(j-c)</sub> | per IGBT                                                                                      |                         |      |        | 0.021 | K/W  |
| R <sub>th(c-s)</sub> | per IGBT (λgrease= 0.81 W/(m*K))                                                              |                         |      | 0.0137 |       | K/W  |
| R <sub>th(c-s)</sub> | per IGBT, pre-applied phase change material                                                   |                         |      | -      |       | K/W  |
| IGBT2                |                                                                                               |                         |      |        |       |      |
| V <sub>CE(sat)</sub> | I <sub>C</sub> = 1200 A                                                                       | T <sub>j</sub> = 25 °C  |      | 1.80   | 2.05  | V    |
|                      | V <sub>GE</sub> = 15 V<br>chiplevel                                                           | T <sub>j</sub> = 150 °C |      | 2.05   | 2.30  | V    |
| V <sub>CE0</sub>     | chiplevel                                                                                     | T <sub>j</sub> = 25 °C  |      | 0.87   | 1.01  | V    |
|                      |                                                                                               | T <sub>j</sub> = 150 °C |      | 0.77   | 0.90  | V    |
| r <sub>CE</sub>      | V <sub>GE</sub> = 15 V                                                                        | T <sub>j</sub> = 25 °C  |      | 0.78   | 0.87  | mΩ   |
|                      | chiplevel                                                                                     | T <sub>j</sub> = 150 °C |      | 1.07   | 1.17  | mΩ   |
| V <sub>GE(th)</sub>  | V <sub>GE</sub> = V <sub>CE</sub> , I <sub>C</sub> = 44.4 mA                                  |                         | 5.1  | 5.8    | 6.3   | V    |
| I <sub>CES</sub>     | V <sub>GE</sub> = 0 V, V <sub>CE</sub> = 1200 V, T <sub>j</sub> = 25 °C                       |                         |      |        | 5     | mA   |
| C <sub>ies</sub>     | V <sub>CE</sub> = 25 V<br>V <sub>GE</sub> = 0 V                                               | f = 1 MHz               |      | 75.0   |       | nF   |
| C <sub>oes</sub>     |                                                                                               | f = 1 MHz               |      | 7      |       | nF   |
| C <sub>res</sub>     |                                                                                               | f = 1 MHz               |      | 4.08   |       | nF   |
| Q <sub>G</sub>       | V <sub>GE</sub> = - 8 V...+ 15 V                                                              |                         |      | 6900   |       | nC   |
| R <sub>Gint</sub>    | T <sub>j</sub> = 25 °C                                                                        |                         |      | 0.9    |       | Ω    |
| t <sub>d(on)</sub>   | V <sub>CC</sub> = 600 V                                                                       | T <sub>j</sub> = 150 °C |      | 422    |       | ns   |
| t <sub>r</sub>       | I <sub>C</sub> = 1200 A                                                                       | T <sub>j</sub> = 150 °C |      | 162    |       | ns   |
| E <sub>on</sub>      | V <sub>GE</sub> = +15/-15 V                                                                   | T <sub>j</sub> = 150 °C |      | 101    |       | mJ   |
| t <sub>d(off)</sub>  | R <sub>G on</sub> = 1 Ω                                                                       | T <sub>j</sub> = 150 °C |      | 1544   |       | ns   |
| t <sub>f</sub>       | R <sub>G off</sub> = 5.1 Ω                                                                    | T <sub>j</sub> = 150 °C |      | 155    |       | ns   |
| E <sub>off</sub>     | di/dt <sub>on</sub> = 6400 A/μs<br>di/dt <sub>off</sub> = 7600 A/μs<br>dv/dt = 2000 V/μs      | T <sub>j</sub> = 150 °C |      | 238    |       | mJ   |
| R <sub>th(j-c)</sub> | per IGBT                                                                                      |                         |      |        | 0.021 | K/W  |
| R <sub>th(c-s)</sub> | per IGBT (λgrease= 0.81 W/(m*K))                                                              |                         |      | 0.0137 |       | K/W  |
| R <sub>th(c-s)</sub> | per IGBT, pre-applied phase change material                                                   |                         |      | -      |       | K/W  |



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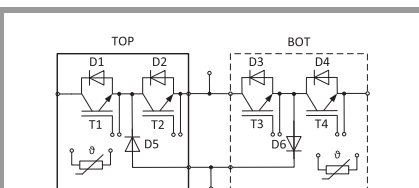
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#### Footnotes

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| Characteristics                  |                                                        |                         |      |        |      |      |
|----------------------------------|--------------------------------------------------------|-------------------------|------|--------|------|------|
| Symbol                           | Conditions                                             |                         | min. | typ.   | max. | Unit |
| Diode1                           |                                                        |                         |      |        |      |      |
| V <sub>F</sub> = V <sub>EC</sub> | I <sub>F</sub> = 1200 A                                | T <sub>j</sub> = 25 °C  |      | 2.46   | 2.82 | V    |
|                                  | V <sub>GE</sub> = 0 V<br>chiplevel                     | T <sub>j</sub> = 150 °C |      | 2.51   | 2.86 | V    |
| V <sub>F0</sub>                  | chiplevel                                              | T <sub>j</sub> = 25 °C  |      | 1.30   | 1.50 | V    |
|                                  |                                                        | T <sub>j</sub> = 150 °C |      | 0.90   | 1.10 | V    |
| r <sub>F</sub>                   | chiplevel                                              | T <sub>j</sub> = 25 °C  |      | 0.97   | 1.10 | mΩ   |
|                                  |                                                        | T <sub>j</sub> = 150 °C |      | 1.34   | 1.47 | mΩ   |
| I <sub>RRM</sub>                 | I <sub>F</sub> = 1200 A                                | T <sub>j</sub> = 150 °C |      | 595    |      | A    |
| Q <sub>rr</sub>                  | di/dt <sub>off</sub> = 6400 A/μs                       | T <sub>j</sub> = 150 °C |      | 127    |      | μC   |
| E <sub>rr</sub>                  | V <sub>CC</sub> = 600 V<br>V <sub>GE</sub> = +15/-15 V | T <sub>j</sub> = 150 °C |      | 76     |      | mJ   |
| R <sub>th(j-c)</sub>             | per diode                                              |                         |      | 0.057  |      | K/W  |
| R <sub>th(c-s)</sub>             | per Diode (λgrease= 0.81 W/(m*K))                      |                         |      | 0.0178 |      | K/W  |
| R <sub>th(c-s)</sub>             | per Diode, pre-applied phase change material           |                         |      | -      |      | K/W  |
| Diode2                           |                                                        |                         |      |        |      |      |
| V <sub>F</sub> = V <sub>EC</sub> | I <sub>F</sub> = 1200 A                                | T <sub>j</sub> = 25 °C  |      | 2.46   | 2.82 | V    |
|                                  | V <sub>GE</sub> = 0 V<br>chiplevel                     | T <sub>j</sub> = 150 °C |      | 2.51   | 2.86 | V    |
| V <sub>F0</sub>                  | chiplevel                                              | T <sub>j</sub> = 25 °C  |      | 1.30   | 1.50 | V    |
|                                  |                                                        | T <sub>j</sub> = 150 °C |      | 0.90   | 1.10 | V    |
| r <sub>F</sub>                   | chiplevel                                              | T <sub>j</sub> = 25 °C  |      | 0.97   | 1.10 | mΩ   |
|                                  |                                                        | T <sub>j</sub> = 150 °C |      | 1.34   | 1.47 | mΩ   |
| I <sub>RRM</sub>                 | I <sub>F</sub> = 1200 A                                | T <sub>j</sub> = 150 °C |      | 595    |      | A    |
| Q <sub>rr</sub>                  | di/dt <sub>off</sub> = 6400 A/μs                       | T <sub>j</sub> = 150 °C |      | 127    |      | μC   |
| E <sub>rr</sub> 1)               | V <sub>R</sub> = 600 V<br>V <sub>GE</sub> = +15/-15 V  | T <sub>j</sub> = 150 °C |      | -      |      | mJ   |
| R <sub>th(j-c)</sub>             | per diode                                              |                         |      | 0.057  |      | K/W  |
| R <sub>th(c-s)</sub>             | per Diode (λgrease= 0.81 W/(m*K))                      |                         |      | 0.0178 |      | K/W  |
| R <sub>th(c-s)</sub>             | per Diode, pre-applied phase change material           |                         |      | -      |      | K/W  |
| Diode5                           |                                                        |                         |      |        |      |      |
| V <sub>F</sub> = V <sub>EC</sub> | I <sub>F</sub> = 1200 A                                | T <sub>j</sub> = 25 °C  |      | 2.20   | 2.52 | V    |
|                                  | chiplevel                                              | T <sub>j</sub> = 150 °C |      | 2.15   | 2.47 | V    |
| V <sub>F0</sub>                  |                                                        | T <sub>j</sub> = 25 °C  |      | 1.30   | 1.50 | V    |
|                                  | chiplevel                                              | T <sub>j</sub> = 150 °C |      | 0.90   | 1.10 | V    |
| r <sub>F</sub>                   | chiplevel                                              | T <sub>j</sub> = 25 °C  |      | 0.75   | 0.85 | mΩ   |
|                                  |                                                        | T <sub>j</sub> = 150 °C |      | 1.04   | 1.14 | mΩ   |
| I <sub>RRM</sub>                 | I <sub>F</sub> = 1200 A                                | T <sub>j</sub> = 150 °C |      | 1022   |      | A    |
| Q <sub>rr</sub>                  | di/dt <sub>off</sub> = 15500 A/μs                      | T <sub>j</sub> = 150 °C |      | 194    |      | μC   |
| E <sub>rr</sub>                  | V <sub>R</sub> = 600 V<br>V <sub>GE</sub> = +15/-15 V  | T <sub>j</sub> = 150 °C |      | 96     |      | mJ   |
| R <sub>th(j-c)</sub>             | per diode                                              |                         |      | 0.046  |      | K/W  |
| R <sub>th(c-s)</sub>             | per Diode (λgrease= 0.81 W/(m*K))                      |                         |      | 0.0164 |      | K/W  |
| R <sub>th(c-s)</sub>             | per Diode, pre-applied phase change material           |                         |      | -      |      | K/W  |



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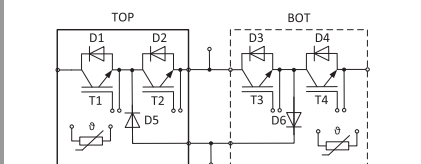
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| Characteristics       |                                                                                                  |                         |      |          |      |      |
|-----------------------|--------------------------------------------------------------------------------------------------|-------------------------|------|----------|------|------|
| Symbol                | Conditions                                                                                       |                         | min. | typ.     | max. | Unit |
| Module                |                                                                                                  |                         |      |          |      |      |
| L <sub>sCE1</sub>     |                                                                                                  |                         |      | 10       |      | nH   |
| L <sub>sCE2</sub>     |                                                                                                  |                         |      | 50       |      | nH   |
| R <sub>CC'+EE'</sub>  | measured per switch                                                                              | T <sub>C</sub> = 25 °C  |      | 0.1      |      | mΩ   |
|                       |                                                                                                  | T <sub>C</sub> = 125 °C |      | 0.15     |      | mΩ   |
| R <sub>th(c-s)1</sub> | calculated without thermal coupling (λ <sub>grease</sub> =0.81 W/(m*K))                          |                         |      | 0.0031   |      | K/W  |
| R <sub>th(c-s)2</sub> | including thermal coupling, T <sub>s</sub> underneath module (λ <sub>grease</sub> =0.81 W/(m*K)) |                         |      | 0.005    |      | K/W  |
| R <sub>th(c-s)2</sub> | including thermal coupling, T <sub>s</sub> underneath module, pre-applied phase change material  |                         |      | -        |      | K/W  |
| M <sub>s</sub>        | to heat sink M5                                                                                  |                         | 4    |          | 6    | Nm   |
| M <sub>t</sub>        |                                                                                                  | to terminals M8         | 8    |          | 10   | Nm   |
|                       |                                                                                                  | to terminals M4         | 1.8  |          | 2.1  | Nm   |
| w                     |                                                                                                  |                         |      |          | 1250 | g    |
| Temperature Sensor    |                                                                                                  |                         |      |          |      |      |
| R <sub>100</sub>      | T <sub>C</sub> =100°C (R <sub>25</sub> =5 kΩ)                                                    |                         |      | 493 ± 5% |      | Ω    |
| B <sub>100/125</sub>  | R(T)=R <sub>100</sub> exp[B <sub>100/125</sub> (1/T-1/T <sub>100</sub> )]; T[K];                 |                         |      | 3550 ±2% |      | K    |



**MLI TOP-Switch**

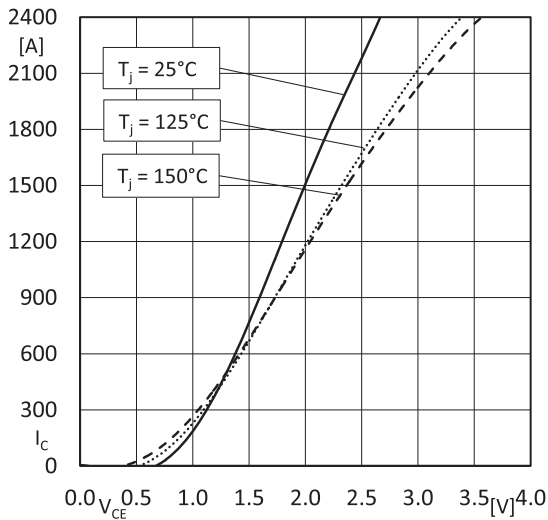


Fig. 1: Typ. IGBT1 output characteristics  $I_C=f(V_{CE})$ ,  $V_{GE}=15V$  (chipelevel)

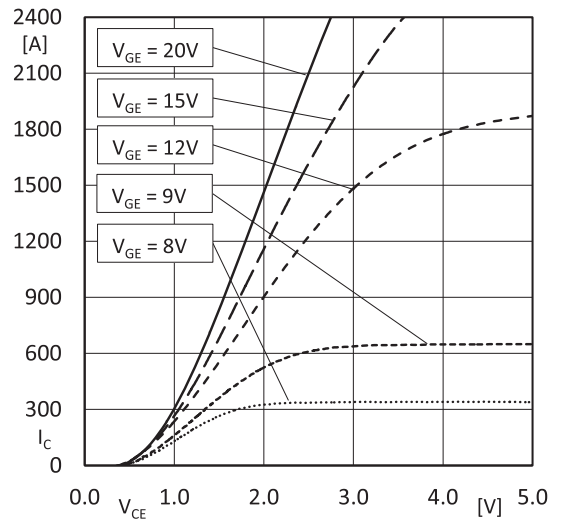


Fig. 2: Typ. IGBT1 output characteristics  $I_C=f(V_{CE})$ ,  $T_j=150^\circ C$  (chipelevel)

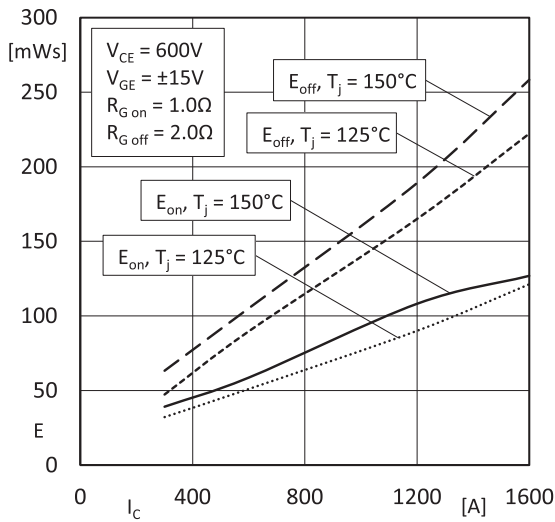


Fig. 3: Typ. IGBT1 switching losses  $E=f(I_C)$

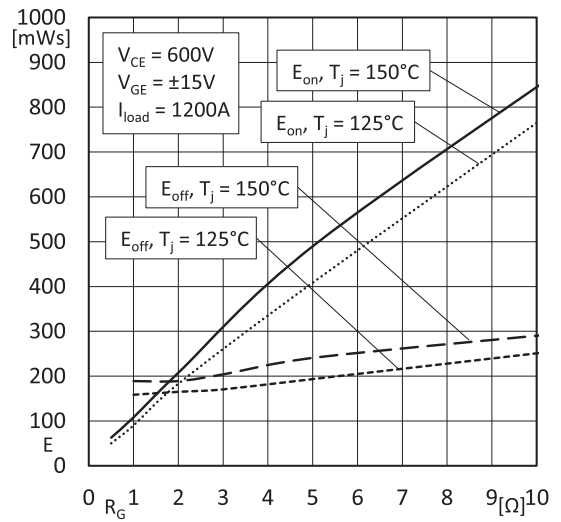


Fig. 4: Typ. IGBT1 switching losses  $E=f(R_G)$

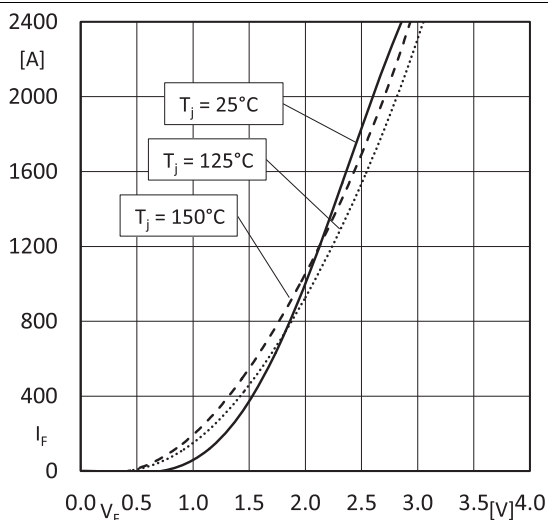


Fig. 5: Typ. Diode5 forward characteristics  $I_F=f(V_F)$  (chipelevel)

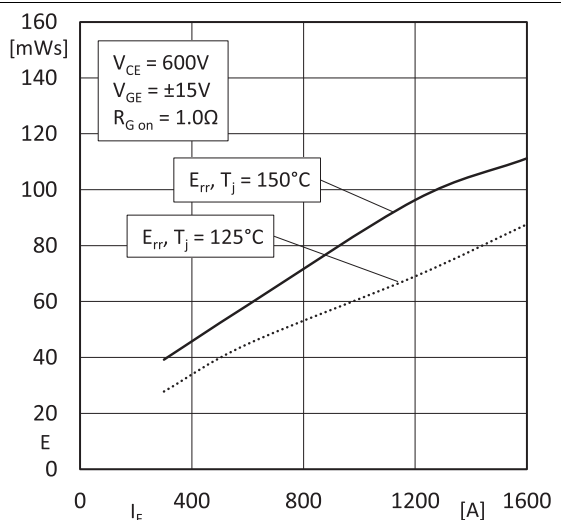


Fig. 6: Typ. Diode5 switching losses  $E=f(I_F)$

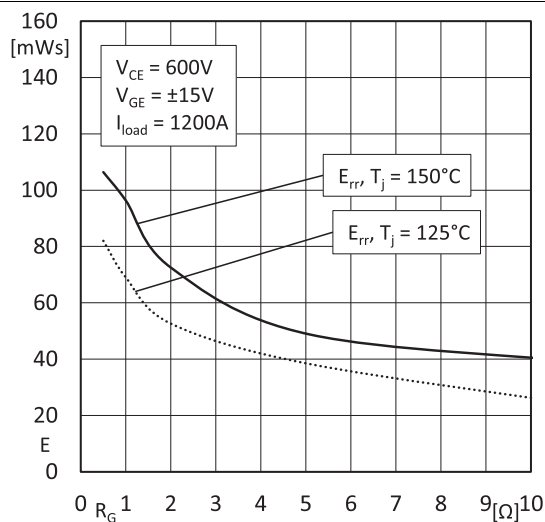


Fig. 7: Typ. Diode5 switching losses  $E=f(R_G)$

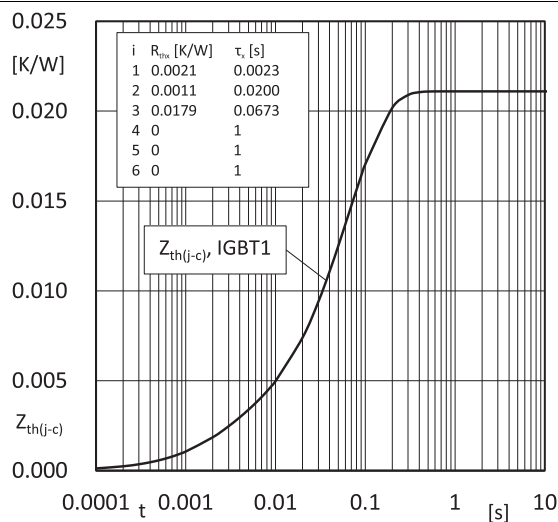


Fig. 8: IGBT1 transient thermal impedance

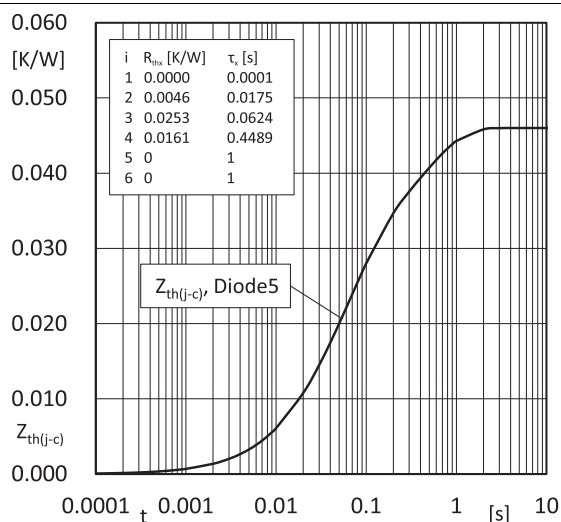


Fig. 9: Diode5 transient thermal impedance

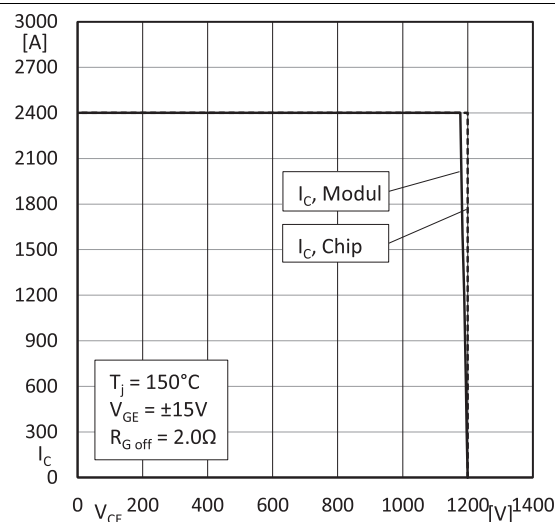


Fig. 10: RBSOA IGBT1

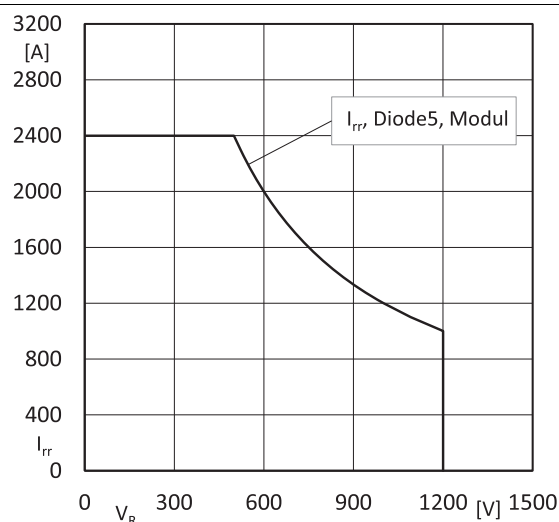


Fig. 11: RBSOA Diode5

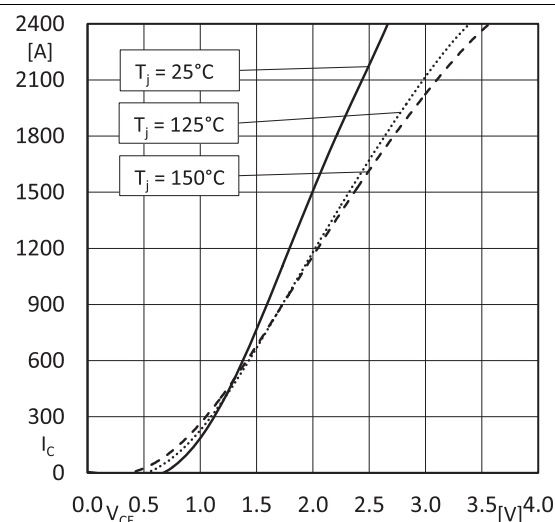


Fig. 12: Typ. IGBT2 output characteristics  $I_C=f(V_{CE})$ ,  $V_{GE}=15V$  (chipelevel)

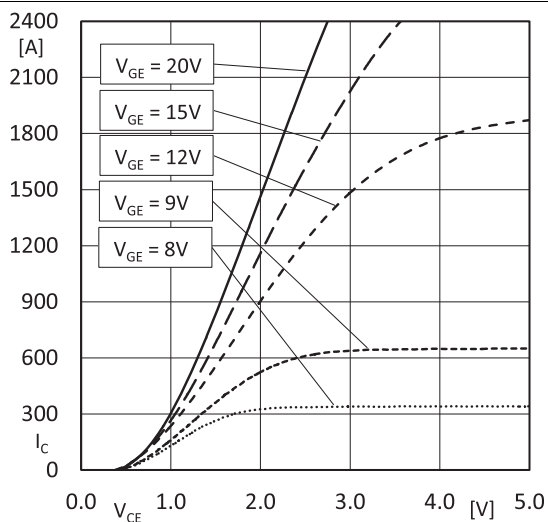


Fig. 13: Typ. IGBT2 output characteristics  $I_C=f(V_{CE})$ ,  $T_J=150^\circ\text{C}$  (chipelevel)

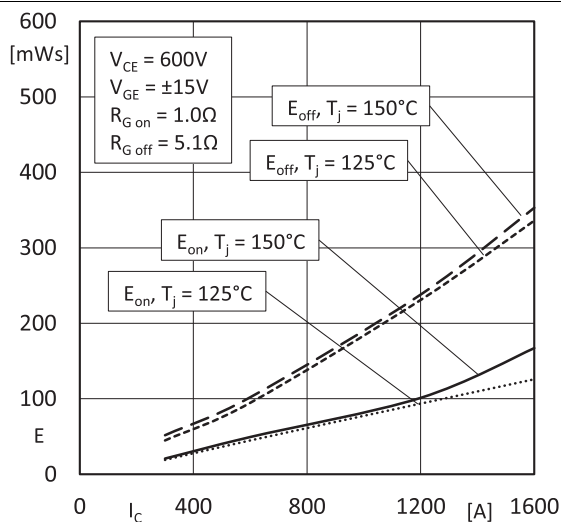


Fig. 14: Typ. IGBT2 switching losses  $E=f(I_C)$

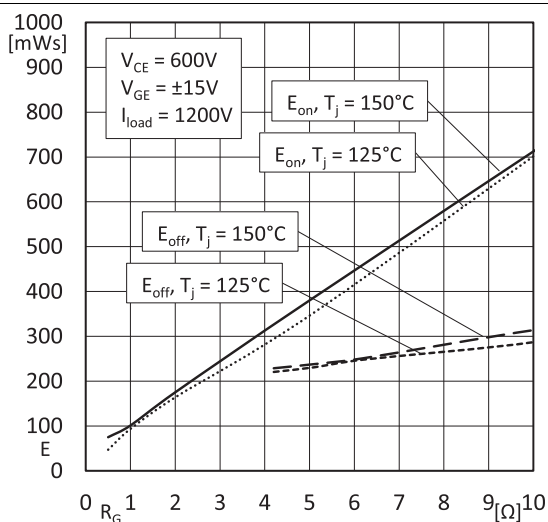


Fig. 15: Typ. IGBT2 switching losses  $E=f(R_G)$

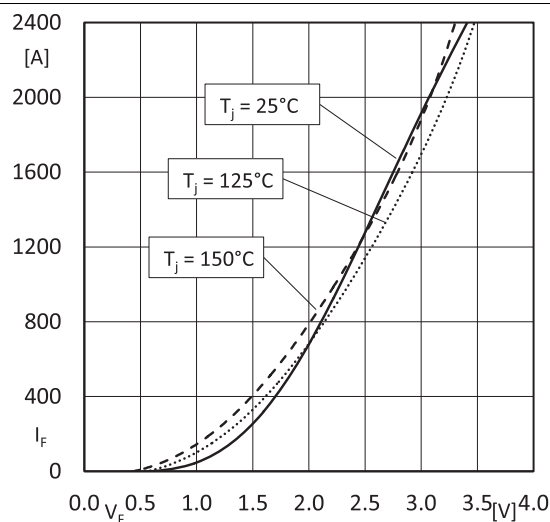


Fig. 16: Typ. Diode1 forward characteristics  $I_F=f(V_F)$  (chipelevel)

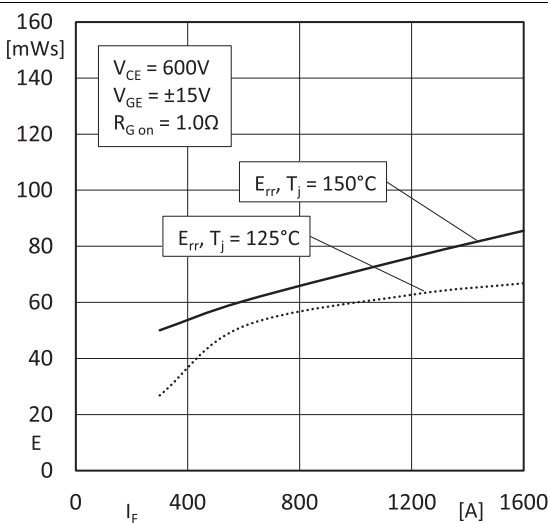


Fig. 17: Typ. Diode1 switching losses  $E=f(I_F)$

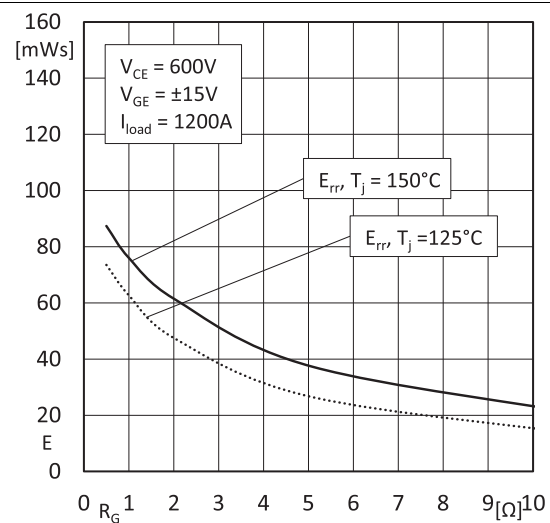


Fig. 18: Typ. Diode1 switching losses  $E=f(R_G)$

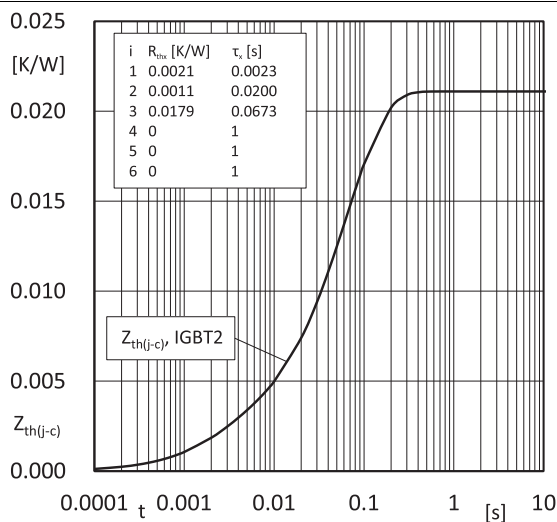


Fig. 19: IGBT2 transient thermal impedance

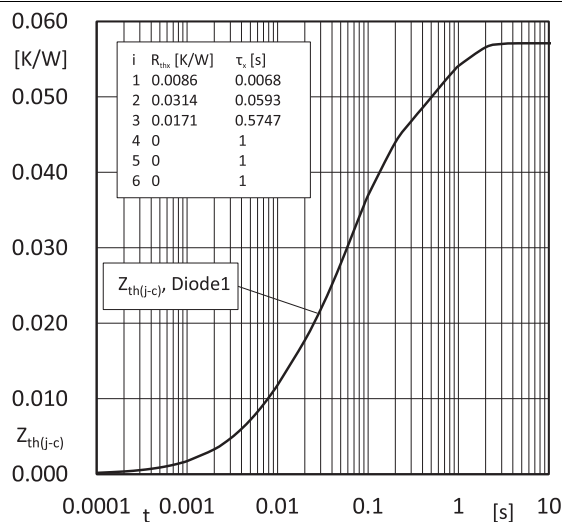


Fig. 20: Diode1 transient thermal impedance

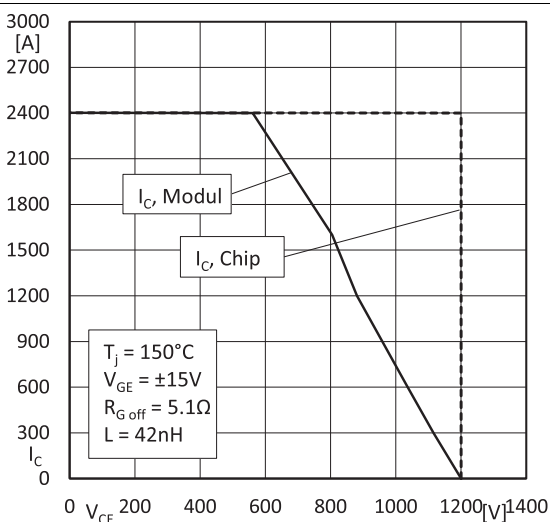


Fig. 21: RBSOA IGBT2

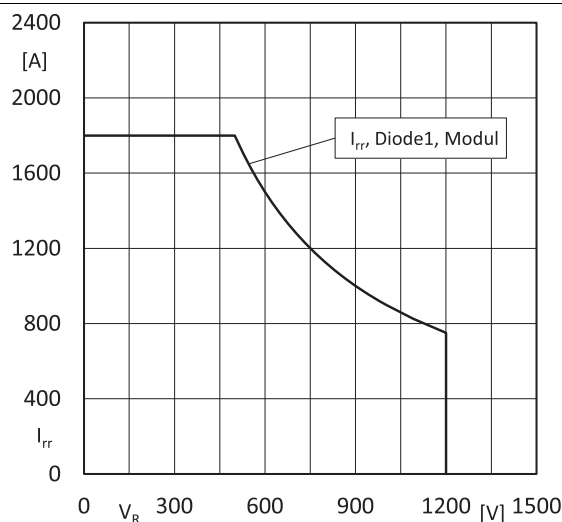


Fig. 22: RBSOA Diode1

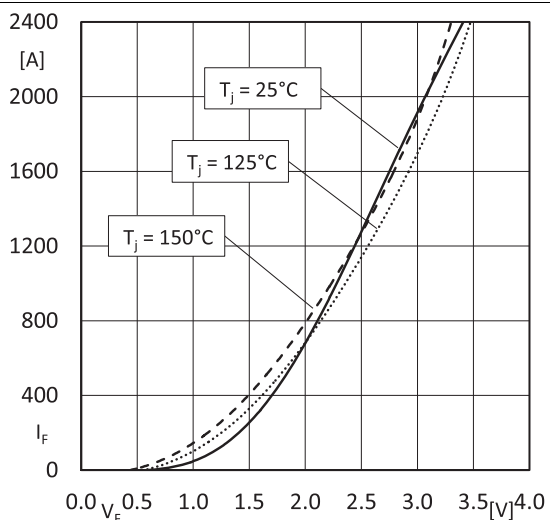


Fig. 23: Typ. Diode2 forward characteristics  $I_F=f(V_F)$  (chiplevel)

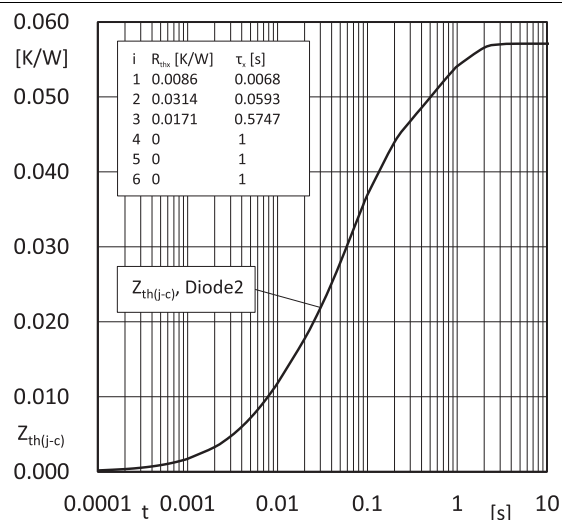


Fig. 24: Diode2 transient thermal impedance



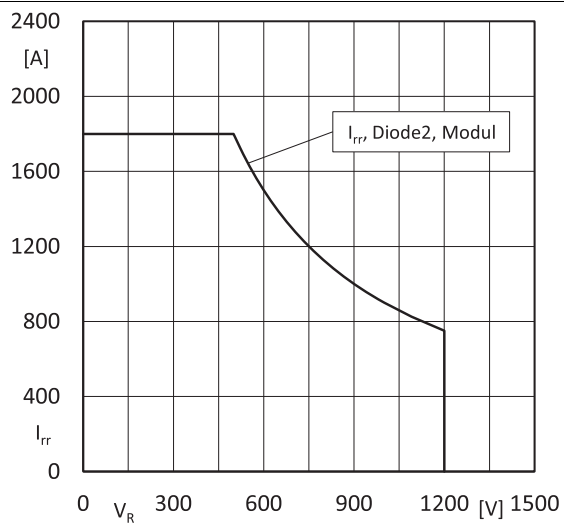


Fig. 25: RBSOA Diode2

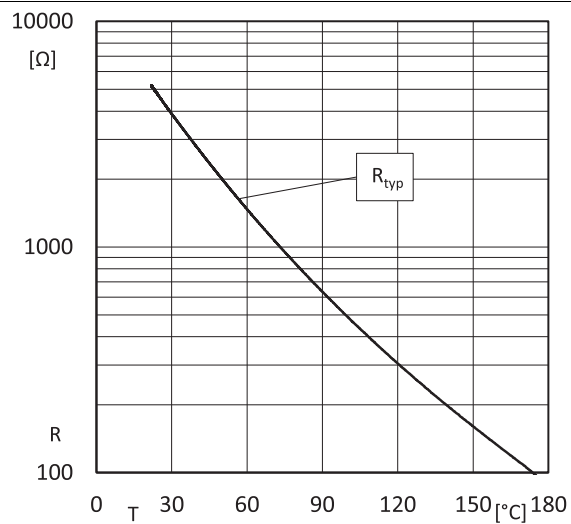
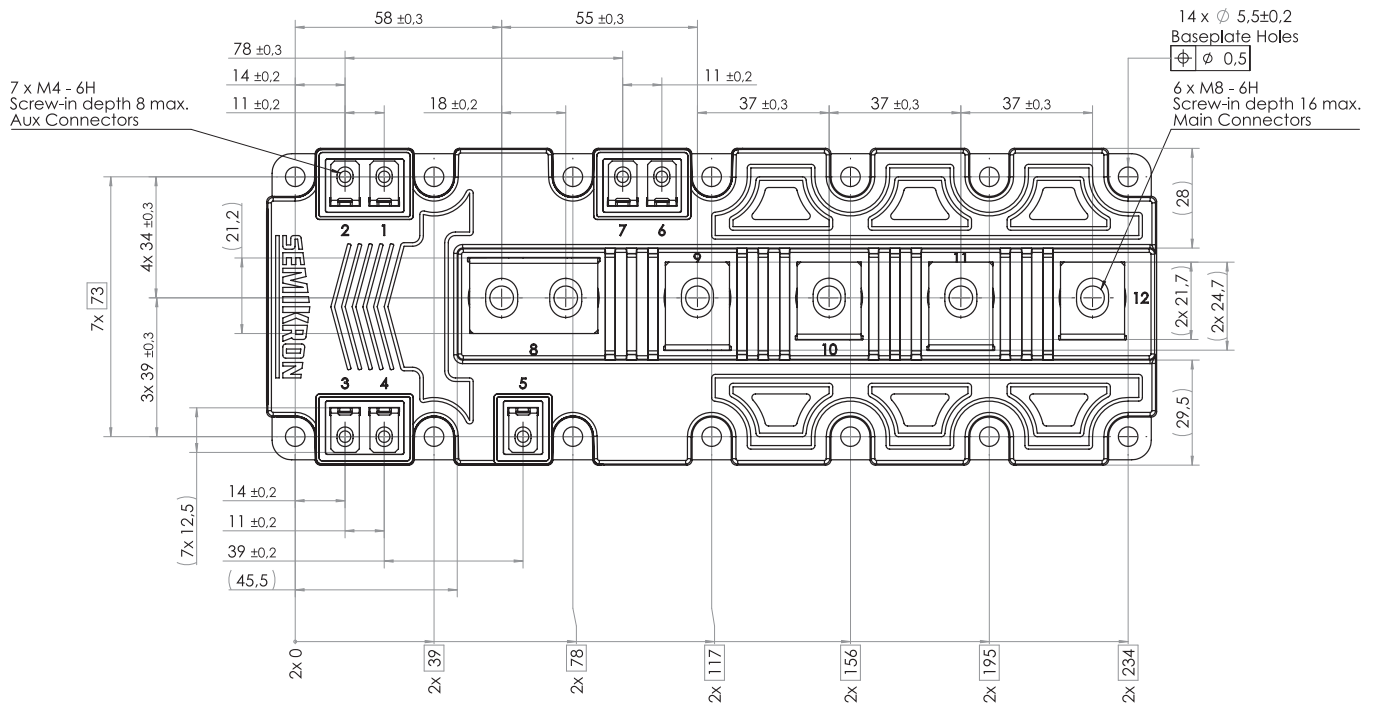
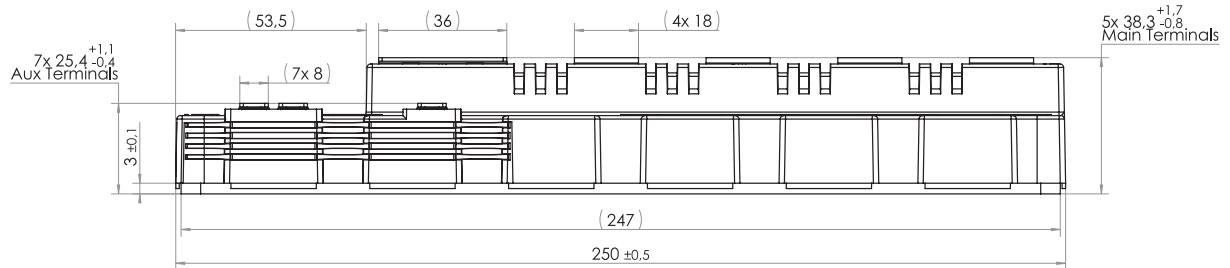
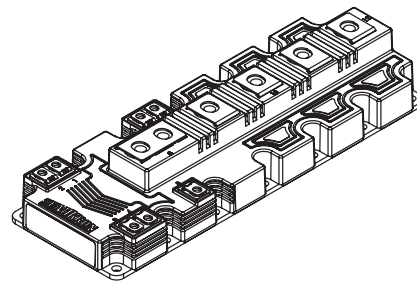
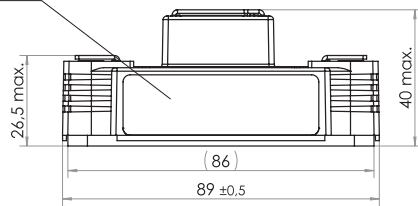


Fig. 26: Typ. NTC characteristics

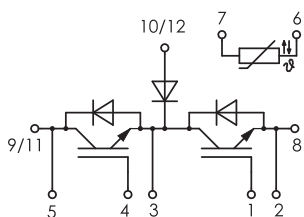
# SKM1200MLI12TE4

Module label



- Dimensions in mm
- General tolerances  $\pm 0.5$  mm

## SEMITRANS 10



## TOP MLI

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

## **\*IMPORTANT INFORMATION AND WARNINGS**

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