

# SK 150 MLI 07F3 TD1p



**SEMITOP® 4 Press-Fit**

## 3-Level NPC Inverter

### SK 150 MLI 07F3 TD1p

#### Features

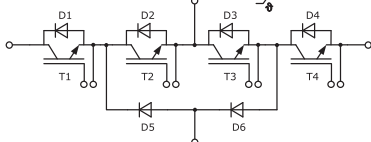
- One screw mounting module
- Solder free mounting with Press-Fit terminals
- Fully compatible with other SEMITOP® Press-Fit types
- Improved thermal performances by aluminium oxide substrate
- 650V Trench IGBT technology
- CAL4F technology FWD
- Rapid switching clamping diode technology
- Integrated NTC temperature sensor
- UL recognized, file no. E 63 532

#### Remarks\*

- 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.



**MLI-T**

| Absolute Maximum Ratings |                                                                                                    |                        |             |      |
|--------------------------|----------------------------------------------------------------------------------------------------|------------------------|-------------|------|
| Symbol                   |                                                                                                    | Conditions             | Values      | Unit |
| IGBT1                    |                                                                                                    |                        |             |      |
| V <sub>CES</sub>         | T <sub>j</sub> = 25 °C                                                                             |                        | 650         | V    |
| I <sub>C</sub>           | T <sub>j</sub> = 175 °C                                                                            | T <sub>s</sub> = 25 °C | 151         | A    |
|                          |                                                                                                    | T <sub>s</sub> = 70 °C | 120         | A    |
| I <sub>Cnom</sub>        |                                                                                                    |                        | 150         | A    |
| I <sub>CRM</sub>         | I <sub>CRM</sub> = 3 x I <sub>Cnom</sub>                                                           |                        | 450         | A    |
| V <sub>GES</sub>         |                                                                                                    |                        | -20 ... 20  | V    |
| t <sub>psc</sub>         | V <sub>CC</sub> = 400 V, V <sub>GE</sub> ≤ 15 V, T <sub>j</sub> = 150 °C, V <sub>CES</sub> ≤ 650 V |                        | 5           | μs   |
| T <sub>j</sub>           |                                                                                                    |                        | -40 ... 175 | °C   |
| IGBT2                    |                                                                                                    |                        |             |      |
| V <sub>CES</sub>         | T <sub>j</sub> = 25 °C                                                                             |                        | 650         | V    |
| I <sub>C</sub>           | T <sub>j</sub> = 175 °C                                                                            | T <sub>s</sub> = 25 °C | 178         | A    |
|                          |                                                                                                    | T <sub>s</sub> = 70 °C | 143         | A    |
| I <sub>Cnom</sub>        |                                                                                                    |                        | 150         | A    |
| I <sub>CRM</sub>         | I <sub>CRM</sub> = 3 x I <sub>Cnom</sub>                                                           |                        | 450         | A    |
| V <sub>GES</sub>         |                                                                                                    |                        | -20 ... 20  | V    |
| t <sub>psc</sub>         | V <sub>CC</sub> = 360 V, V <sub>GE</sub> ≤ 15 V, T <sub>j</sub> = 150 °C, V <sub>CES</sub> ≤ 650 V |                        | 6           | μs   |
| T <sub>j</sub>           |                                                                                                    |                        | -40 ... 175 | °C   |
| Diode1                   |                                                                                                    |                        |             |      |
| V <sub>RRM</sub>         | T <sub>j</sub> = 25 °C                                                                             |                        | 650         | V    |
| I <sub>F</sub>           | T <sub>j</sub> = 175 °C                                                                            | T <sub>s</sub> = 25 °C | 137         | A    |
|                          |                                                                                                    | T <sub>s</sub> = 70 °C | 107         | A    |
| I <sub>Fnom</sub>        |                                                                                                    |                        | 100         | A    |
| I <sub>FRM</sub>         | I <sub>FRM</sub> = 2 x I <sub>Fnom</sub>                                                           |                        | 200         | A    |
| I <sub>FSM</sub>         | 10 ms, sin 180°, T <sub>j</sub> = 25 °C                                                            |                        | 990         | A    |
| T <sub>j</sub>           |                                                                                                    |                        | -40 ... 175 | °C   |
| Diode2                   |                                                                                                    |                        |             |      |
| V <sub>RRM</sub>         | T <sub>j</sub> = 25 °C                                                                             |                        | 650         | V    |
| I <sub>F</sub>           | T <sub>j</sub> = 175 °C                                                                            | T <sub>s</sub> = 25 °C | 137         | A    |
|                          |                                                                                                    | T <sub>s</sub> = 70 °C | 107         | A    |
| I <sub>Fnom</sub>        |                                                                                                    |                        | 100         | A    |
| I <sub>FRM</sub>         | I <sub>FRM</sub> = 2 x I <sub>Fnom</sub>                                                           |                        | 200         | A    |
| I <sub>FSM</sub>         | 10 ms, sin 180°, T <sub>j</sub> = 25 °C                                                            |                        | 990         | A    |
| T <sub>j</sub>           |                                                                                                    |                        | -40 ... 175 | °C   |
| Diode5                   |                                                                                                    |                        |             |      |
| V <sub>RRM</sub>         | T <sub>j</sub> = 25 °C                                                                             |                        | 650         | V    |
| I <sub>F</sub>           | T <sub>j</sub> = 175 °C                                                                            | T <sub>s</sub> = 25 °C | 134         | A    |
|                          |                                                                                                    | T <sub>s</sub> = 70 °C | 105         | A    |
| I <sub>Fnom</sub>        |                                                                                                    |                        | 150         | A    |
| I <sub>FRM</sub>         | I <sub>FRM</sub> = 2 x I <sub>Fnom</sub>                                                           |                        | 300         | A    |
| I <sub>FSM</sub>         | 10 ms, sin 180°, T <sub>j</sub> = 25 °C                                                            |                        | 810         | A    |
| T <sub>j</sub>           |                                                                                                    |                        | -40 ... 175 | °C   |
| Module                   |                                                                                                    |                        |             |      |
| I <sub>t(RMS)</sub>      | T <sub>terminal</sub> = 100 °C, T <sub>S</sub> = 60°C, per pin                                     |                        | 40          | A    |
| T <sub>stg</sub>         |                                                                                                    |                        | -40 ... 125 | °C   |
| V <sub>isol</sub>        | AC, sinusoidal, t = 1 min                                                                          |                        | 2500        | V    |

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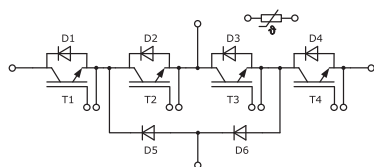
#### Remarks\*

- 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.

| Characteristics      |                                                                        |                         |      |       |      |      |
|----------------------|------------------------------------------------------------------------|-------------------------|------|-------|------|------|
| Symbol               | Conditions                                                             |                         | min. | typ.  | max. | Unit |
| IGBT1                |                                                                        |                         |      |       |      |      |
| V <sub>CE(sat)</sub> | I <sub>C</sub> = 150 A                                                 | T <sub>j</sub> = 25 °C  |      | 1.85  | 2.22 | V    |
|                      | V <sub>GE</sub> = 15 V<br>chiplevel                                    | T <sub>j</sub> = 150 °C |      | 2.18  | 2.55 | V    |
| V <sub>CE0</sub>     | chiplevel                                                              | 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>      | V <sub>GE</sub> = 15 V                                                 | T <sub>j</sub> = 25 °C  |      | 5.0   | 6.8  | mΩ   |
|                      | chiplevel                                                              | T <sub>j</sub> = 150 °C |      | 7.9   | 9.7  | mΩ   |
| V <sub>GE(th)</sub>  | V <sub>GE</sub> = V <sub>CE</sub> , I <sub>C</sub> = 2.4 mA            |                         | 4.2  | 5.1   | 5.6  | V    |
| I <sub>CES</sub>     | V <sub>GE</sub> = 0 V, V <sub>CE</sub> = 650 V, T <sub>j</sub> = 25 °C |                         |      |       | 0.4  | mA   |
| C <sub>ies</sub>     | V <sub>CE</sub> = 25 V<br>V <sub>GE</sub> = 0 V                        | f = 1 MHz               |      | 9.24  |      | nF   |
| C <sub>oes</sub>     |                                                                        | f = 1 MHz               |      | 480   |      | nF   |
| C <sub>res</sub>     |                                                                        | f = 1 MHz               |      | 0.274 |      | nF   |
| Q <sub>G</sub>       | V <sub>GE</sub> = -15V ... +15 V                                       |                         |      | 1500  |      | nC   |
| R <sub>Gint</sub>    | T <sub>j</sub> = 25 °C                                                 |                         |      | 2.4   |      | Ω    |
| t <sub>d(on)</sub>   | V <sub>CE</sub> = 300 V                                                | T <sub>j</sub> = 150 °C |      | 194   |      | ns   |
| t <sub>r</sub>       | I <sub>C</sub> = 150 A                                                 | T <sub>j</sub> = 150 °C |      | 80    |      | ns   |
| E <sub>on</sub>      | V <sub>GE</sub> = +15/-15 V<br>R <sub>G on</sub> = 1.8 Ω               | T <sub>j</sub> = 150 °C |      | 9.07  |      | mJ   |
| t <sub>d(off)</sub>  | R <sub>G off</sub> = 1.8 Ω                                             | T <sub>j</sub> = 150 °C |      | 374   |      | ns   |
| t <sub>f</sub>       | di/dt <sub>on</sub> = 1650 A/μs<br>di/dt <sub>off</sub> = 5083 A/μs    | T <sub>j</sub> = 150 °C |      | 27    |      | ns   |
| E <sub>off</sub>     |                                                                        | T <sub>j</sub> = 150 °C |      | 1.3   |      | mJ   |
| R <sub>th(j-s)</sub> | per IGBT, λ <sub>paste</sub> =0.8 W/(mK)                               |                         |      | 0.38  |      | K/W  |
| IGBT2                |                                                                        |                         |      |       |      |      |
| V <sub>CE(sat)</sub> | I <sub>C</sub> = 150 A                                                 | T <sub>j</sub> = 25 °C  |      | 1.45  | 1.77 | V    |
|                      | V <sub>GE</sub> = 15 V<br>chiplevel                                    | T <sub>j</sub> = 150 °C |      | 1.70  | 2.10 | V    |
| V <sub>CE0</sub>     | chiplevel                                                              | T <sub>j</sub> = 25 °C  |      | 0.90  | 1.00 | V    |
|                      |                                                                        | T <sub>j</sub> = 150 °C |      | 0.82  | 0.90 | V    |
| r <sub>CE</sub>      | V <sub>GE</sub> = 15 V                                                 | T <sub>j</sub> = 25 °C  |      | 3.7   | 5.1  | mΩ   |
|                      | chiplevel                                                              | T <sub>j</sub> = 150 °C |      | 5.9   | 8.0  | mΩ   |
| V <sub>GE(th)</sub>  | V <sub>GE</sub> = V <sub>CE</sub> , I <sub>C</sub> = 2.4 mA            |                         | 5.1  | 5.8   | 6.4  | V    |
| I <sub>CES</sub>     | V <sub>GE</sub> = 0 V, V <sub>CE</sub> = 650 V, T <sub>j</sub> = 25 °C |                         |      |       | 0.4  | mA   |
| C <sub>ies</sub>     | V <sub>CE</sub> = 25 V<br>V <sub>GE</sub> = 0 V                        | f = 1 MHz               |      | 9.24  |      | nF   |
| C <sub>oes</sub>     |                                                                        | f = 1 MHz               |      | 0.6   |      | nF   |
| C <sub>res</sub>     |                                                                        | f = 1 MHz               |      | 0.274 |      | nF   |
| Q <sub>G</sub>       | V <sub>GE</sub> = -15V ... +15 V                                       |                         |      | 1360  |      | nC   |
| R <sub>Gint</sub>    | T <sub>j</sub> = 25 °C                                                 |                         |      | 2.0   |      | Ω    |
| t <sub>d(on)</sub>   | V <sub>CE</sub> = 300 V                                                | T <sub>j</sub> = 150 °C |      | 69    |      | ns   |
| t <sub>r</sub>       | I <sub>C</sub> = 150 A                                                 | T <sub>j</sub> = 150 °C |      | 47    |      | ns   |
| E <sub>on</sub>      | V <sub>GE</sub> = +15/-15 V<br>R <sub>G on</sub> = 3 Ω                 | T <sub>j</sub> = 150 °C |      | 3.47  |      | mJ   |
| t <sub>d(off)</sub>  | R <sub>G off</sub> = 3 Ω                                               | T <sub>j</sub> = 150 °C |      | 288   |      | ns   |
| t <sub>f</sub>       | di/dt <sub>on</sub> = 3460 A/μs<br>di/dt <sub>off</sub> = 2011 A/μs    | T <sub>j</sub> = 150 °C |      | 43    |      | ns   |
| E <sub>off</sub>     |                                                                        | T <sub>j</sub> = 150 °C |      | 3.98  |      | mJ   |
| R <sub>th(j-s)</sub> | per IGBT, λ <sub>paste</sub> =0.8 W/(mK)                               |                         |      | 0.35  |      | K/W  |



**MLI-T**

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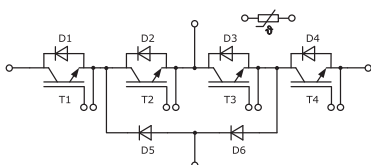
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#### Footnotes

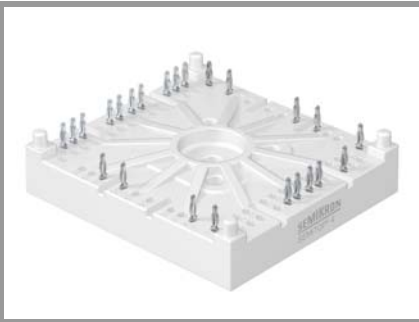
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| Characteristics                  |                                                            |                         |      |      |      |      |
|----------------------------------|------------------------------------------------------------|-------------------------|------|------|------|------|
| Symbol                           | Conditions                                                 |                         | min. | typ. | max. | Unit |
| Diode1                           |                                                            |                         |      |      |      |      |
| V <sub>F</sub> = V <sub>EC</sub> | I <sub>F</sub> = 100 A                                     | T <sub>j</sub> = 25 °C  |      | 1.37 | 1.73 | V    |
|                                  | chiplevel                                                  | T <sub>j</sub> = 150 °C |      | 1.35 | 1.72 | V    |
| V <sub>F0</sub>                  | chiplevel                                                  | T <sub>j</sub> = 25 °C  |      | 1.04 | 1.24 | V    |
|                                  |                                                            | T <sub>j</sub> = 150 °C |      | 0.85 | 0.99 | V    |
| r <sub>F</sub>                   | chiplevel                                                  | T <sub>j</sub> = 25 °C  |      | 3.3  | 4.9  | mΩ   |
|                                  |                                                            | T <sub>j</sub> = 150 °C |      | 5.0  | 7.3  | mΩ   |
| I <sub>RRM</sub>                 | I <sub>F</sub> = 150 A                                     | T <sub>j</sub> = 150 °C |      | 135  |      | A    |
| Q <sub>rr</sub>                  | di/dt <sub>off</sub> = 3460 A/μs<br>V <sub>R</sub> = 300 V | T <sub>j</sub> = 150 °C |      | 13.8 |      | μC   |
| E <sub>rr</sub>                  | V <sub>GE</sub> = +15/-15 V                                | T <sub>j</sub> = 150 °C |      | 1.76 |      | mJ   |
| R <sub>th(j-s)</sub>             | per Diode, λ <sub>paste</sub> =0.8 W/(mK)                  |                         |      | 0.58 |      | K/W  |
| Diode2                           |                                                            |                         |      |      |      |      |
| V <sub>F</sub> = V <sub>EC</sub> | I <sub>F</sub> = 100 A                                     | T <sub>j</sub> = 25 °C  |      | 1.37 | 1.73 | V    |
|                                  | chiplevel                                                  | T <sub>j</sub> = 150 °C |      | 1.35 | 1.72 | V    |
| V <sub>F0</sub>                  | chiplevel                                                  | T <sub>j</sub> = 25 °C  |      | 1.04 | 1.24 | V    |
|                                  |                                                            | T <sub>j</sub> = 150 °C |      | 0.85 | 0.99 | V    |
| r <sub>F</sub>                   | chiplevel                                                  | T <sub>j</sub> = 25 °C  |      | 3.3  | 4.9  | mΩ   |
|                                  |                                                            | T <sub>j</sub> = 150 °C |      | 5.0  | 7.3  | mΩ   |
| I <sub>RRM</sub>                 | I <sub>F</sub> = 100 A                                     | T <sub>j</sub> = 150 °C |      | -    |      | A    |
| Q <sub>rr</sub>                  | V <sub>R</sub> = 300 V                                     | T <sub>j</sub> = 150 °C |      | -    |      | μC   |
| E <sub>rr</sub> 1)               | V <sub>GE</sub> = +15/-15 V                                | T <sub>j</sub> = 150 °C |      | -    |      | mJ   |
| R <sub>th(j-s)</sub>             | per Diode, λ <sub>paste</sub> =0.8 W/(mK)                  |                         |      | 0.58 |      | K/W  |
| Diode5                           |                                                            |                         |      |      |      |      |
| V <sub>F</sub> = V <sub>EC</sub> | I <sub>F</sub> = 150 A                                     | T <sub>j</sub> = 25 °C  |      | 1.35 | 1.92 | V    |
|                                  | chiplevel                                                  | T <sub>j</sub> = 150 °C |      | 1.30 | 1.89 | V    |
| V <sub>F0</sub>                  | chiplevel                                                  | T <sub>j</sub> = 25 °C  |      | 0.90 | 1.10 | V    |
|                                  |                                                            | T <sub>j</sub> = 150 °C |      | 0.71 | 0.94 | V    |
| r <sub>F</sub>                   | chiplevel                                                  | T <sub>j</sub> = 25 °C  |      | 3.0  | 5.5  | mΩ   |
|                                  |                                                            | T <sub>j</sub> = 150 °C |      | 3.9  | 6.3  | mΩ   |
| I <sub>RRM</sub>                 | I <sub>F</sub> = 150 A                                     | T <sub>j</sub> = 150 °C |      | 55   |      | A    |
| Q <sub>rr</sub>                  | di/dt <sub>off</sub> = 1650 A/μs<br>V <sub>R</sub> = 300 V | T <sub>j</sub> = 150 °C |      | 9.7  |      | μC   |
| E <sub>rr</sub>                  | V <sub>GE</sub> = +15/-15 V                                | T <sub>j</sub> = 150 °C |      | 1.39 |      | mJ   |
| R <sub>th(j-s)</sub>             | per Diode, λ <sub>paste</sub> =0.8 W/(mK)                  |                         |      | 0.63 |      | K/W  |



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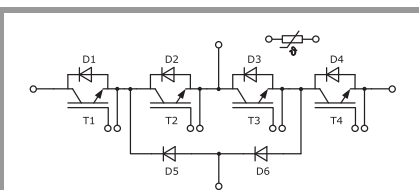
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#### Footnotes

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

| Characteristics           |                                                             |      |                |      |                                 |
|---------------------------|-------------------------------------------------------------|------|----------------|------|---------------------------------|
| Symbol                    | Conditions                                                  | min. | typ.           | max. | Unit                            |
| <b>Module</b>             |                                                             |      |                |      |                                 |
| $L_{sCE1}$                |                                                             |      | -              |      | nH                              |
| $L_{sCE2}$                |                                                             |      | -              |      | nH                              |
| $R_{CC'+EE'}$             |                                                             |      | -              |      | $T_s = 25^\circ\text{C}$<br>mΩ  |
|                           |                                                             |      |                |      | $T_s = 125^\circ\text{C}$<br>mΩ |
| $M_s$                     | to heatsink                                                 | 2.5  |                | 2.75 | Nm                              |
| $M_t$                     |                                                             |      | -              |      | Nm                              |
|                           |                                                             |      | -              |      | Nm                              |
| w                         |                                                             |      | 60             |      | g                               |
| <b>Temperature Sensor</b> |                                                             |      |                |      |                                 |
| $R_{100}$                 | $T_c = 100^\circ\text{C}$ ( $R_{25} = 5 \text{ k}\Omega$ )  |      | $493 \pm 5\%$  |      | Ω                               |
| $B_{100/125}$             | $R(T) = R_{100} \exp[B_{100/125}(1/T - 1/T_{100})]$ ; T[K]; |      | $3550 \pm 2\%$ |      | K                               |



**MLI-T**

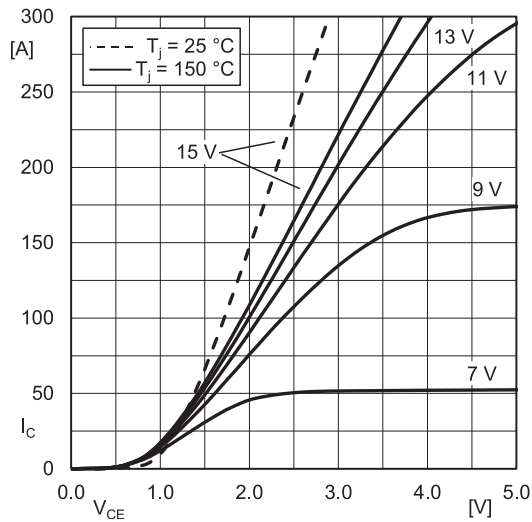


Fig. 1: Typ. IGBT1 output characteristic, incl.  $R_{CC'+EE'}$

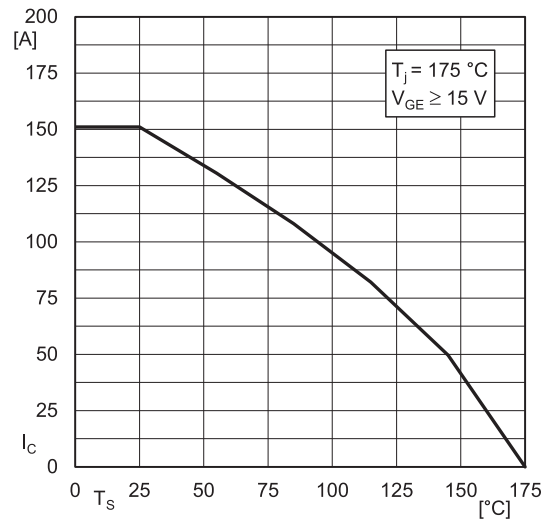


Fig. 2: IGBT1 rated current vs. Temperature  $I_C=f(T_s)$

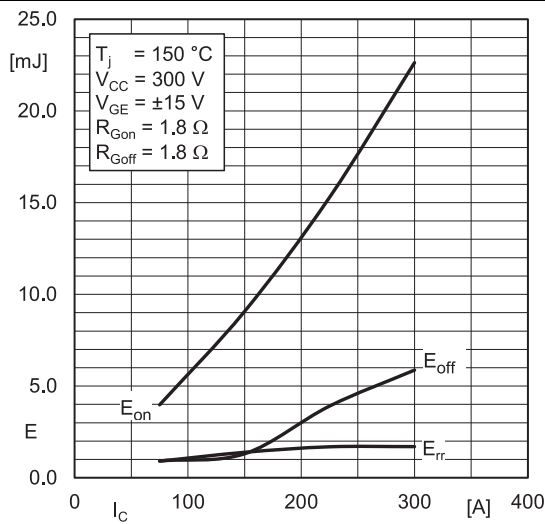


Fig. 3: Typ. IGBT1 & Diode5 turn-on /-off energy =  $f(I_C)$

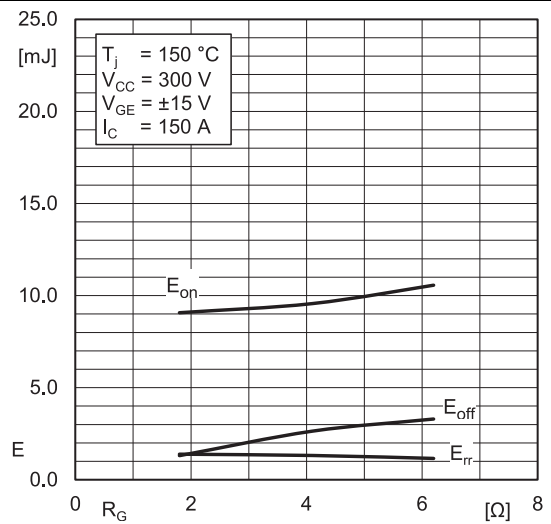


Fig. 4: Typ. IGBT1 & Diode5 turn-on /-off energy =  $f(R_G)$

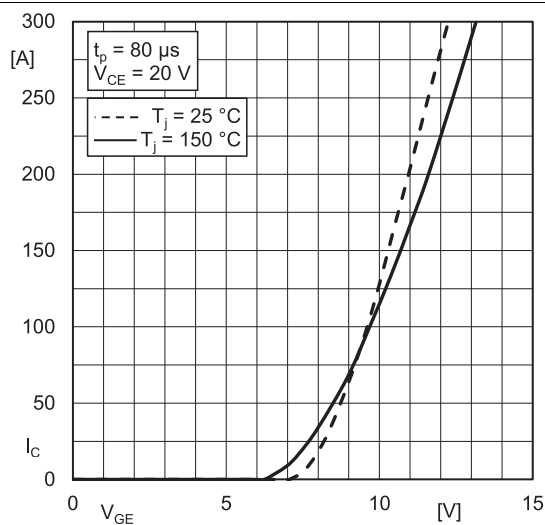


Fig. 5: Typ. IGBT1 transfer characteristic

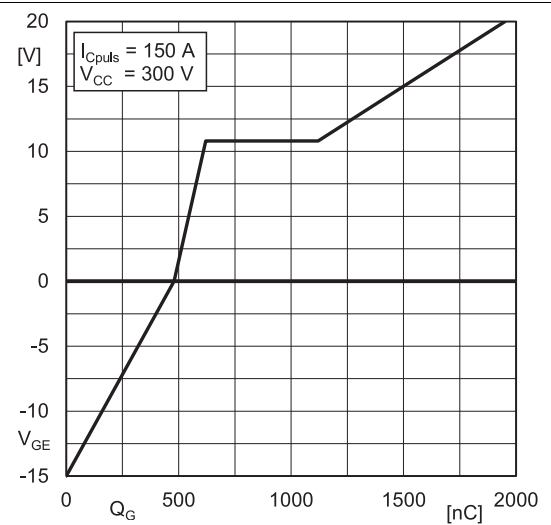


Fig. 6: Typ. IGBT1 gate charge characteristic

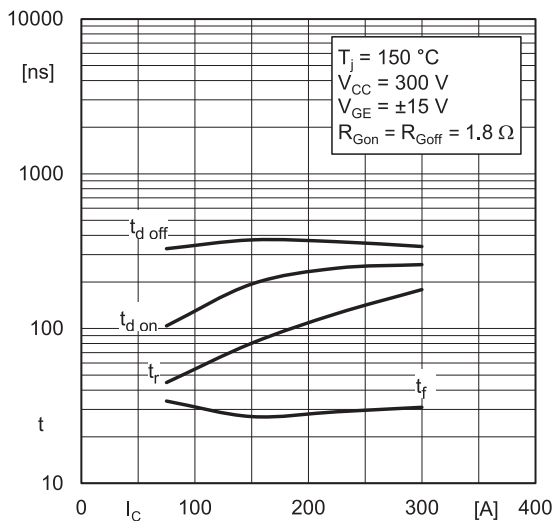


Fig. 7: Typ. IGBT1 switching times vs.  $I_C$

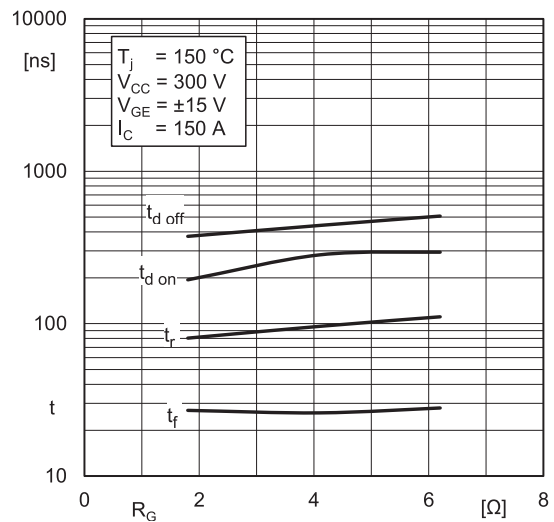


Fig. 8: Typ. IGBT1 switching times vs. gate resistor  $R_G$

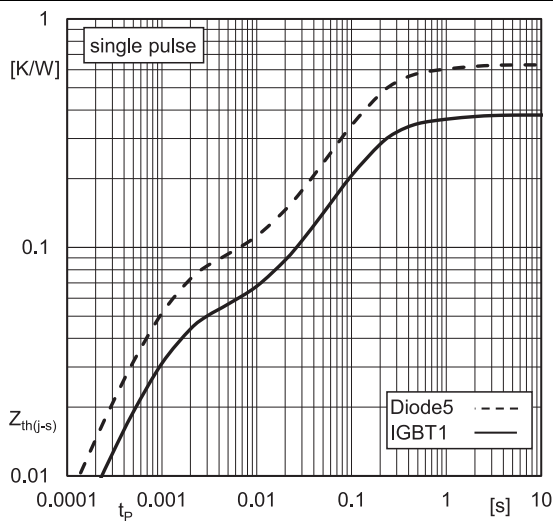


Fig. 9: Transient thermal impedance of IGBT1 & Diode5

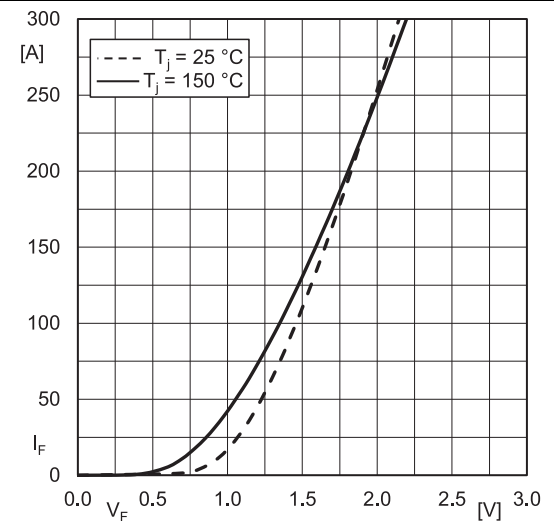


Fig. 10: Typ. Diode5 forward characteristic, incl.  $R_{CC'+EE'}$

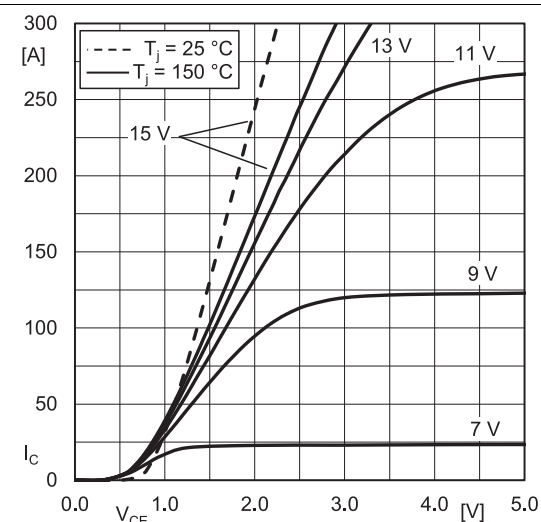


Fig. 13: Typ. IGBT2 output characteristic, incl.  $R_{CC'+EE'}$

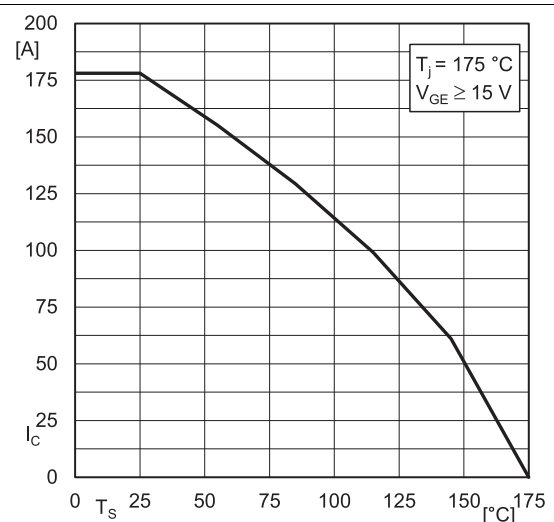


Fig. 14: IGBT2 Rated current vs. Temperature  $I_C = f(T_s)$

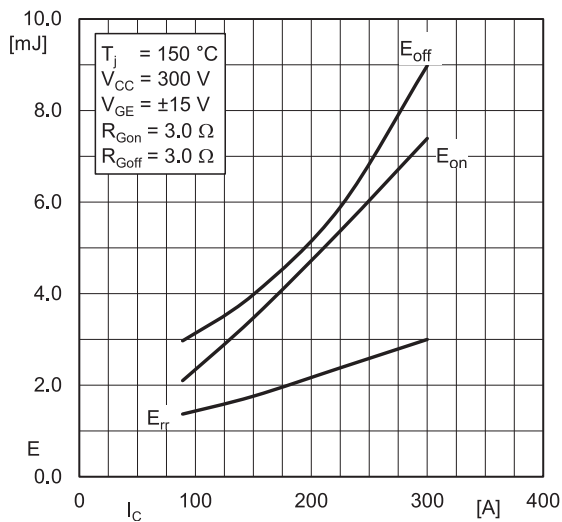


Fig. 15: Typ. IGBT2 & Diode1 turn-on /-off energy =  $f(I_C)$

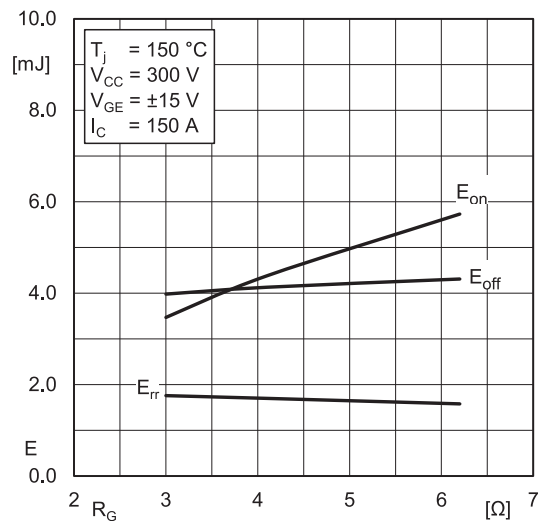


Fig. 16: Typ. IGBT2 & Diode1 turn-on /-off energy =  $f(R_G)$

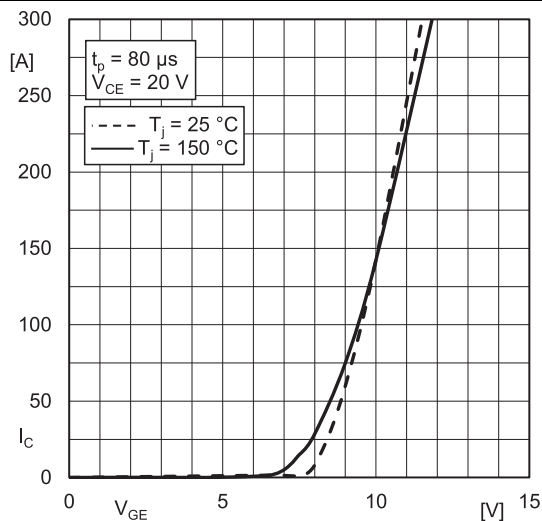


Fig. 17: Typ. IGBT2 transfer characteristic

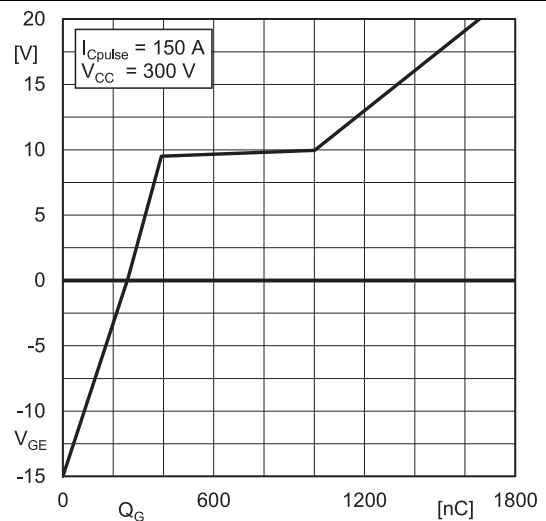


Fig. 18: Typ. IGBT2 gate charge characteristic

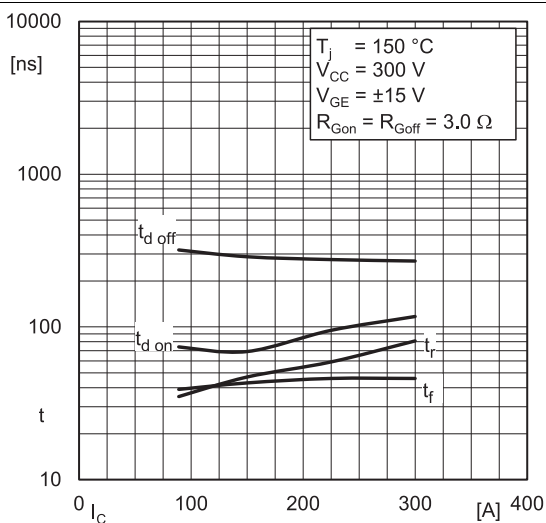


Fig. 19: Typ. IGBT2 switching times vs.  $I_C$

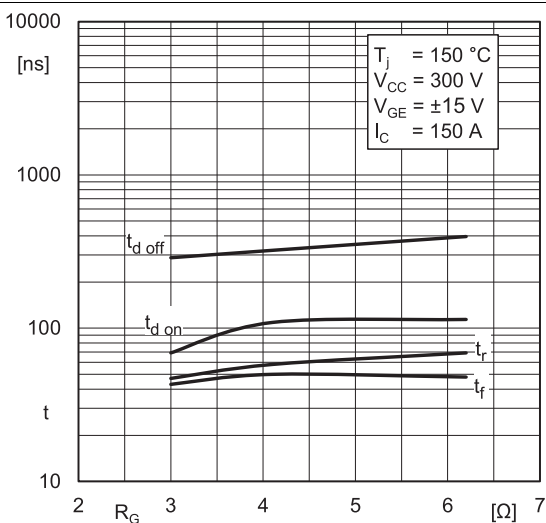


Fig. 20: Typ. IGBT2 switching times vs. gate resistor  $R_G$

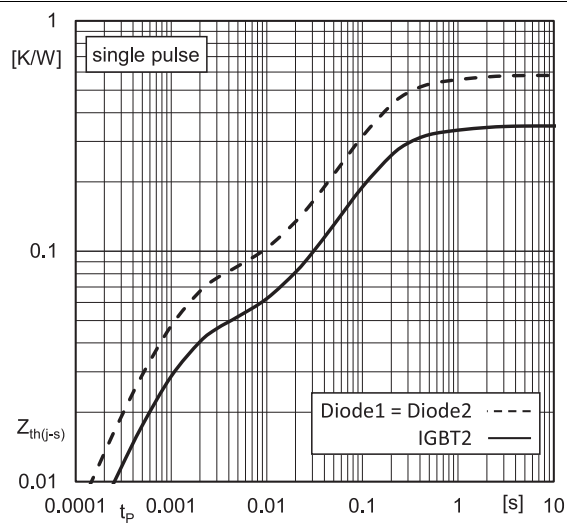


Fig. 21: Transient thermal impedance of IGBT2, Diode1 & Diode2

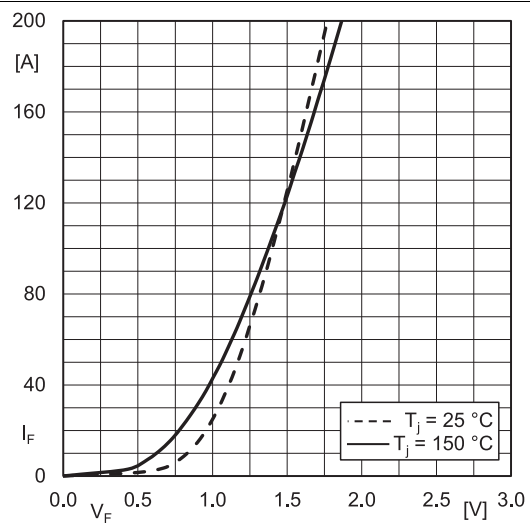
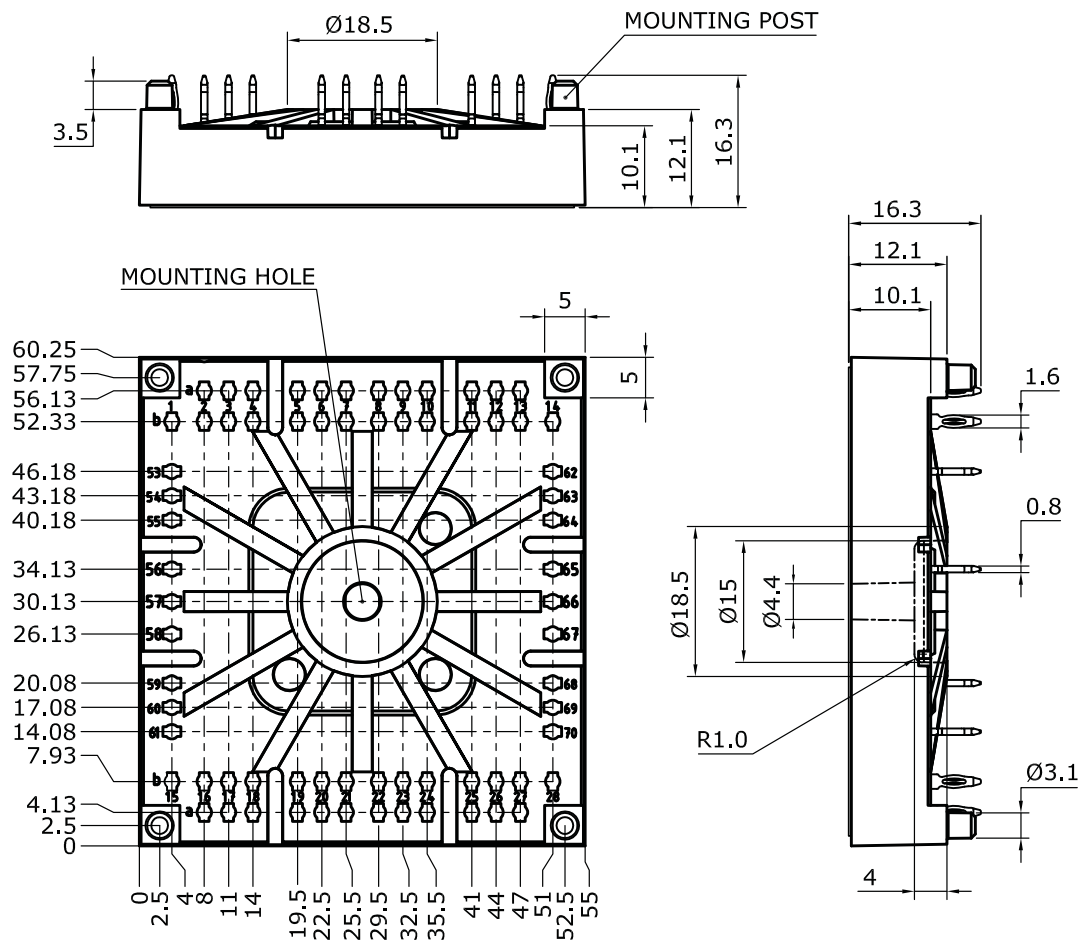


Fig. 22: Typ. Diode1 & Diode2 forward characteristic, incl.  $R_{CC'+EE'}$

Dimensions: mm

Tolerance system: ISO 2768-m



Suggested drilled hole diameter for terminal pins in the circuit board:

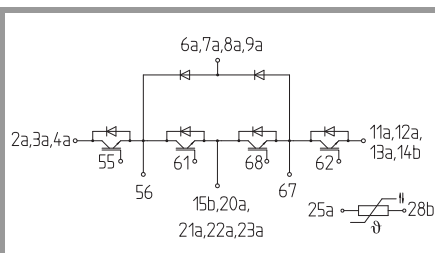
- minimum: 1.575 mm
- typical: 1.6 mm
- maximum: 1.625 mm

Suggested hole diameter for the mounting post in the circuit board:

- 3.6 mm

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SEMIPOT 4 Press-Fit



MLI-T

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

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