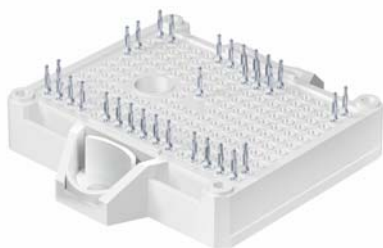


# SK200TMLI12F4TE2



SEMITOP®E2

## 3-Level TNPC

### SK200TMLI12F4TE2

#### Features\*

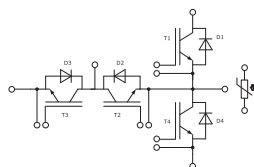
- Optimized design for superior thermal performances
- Low inductive design
- Press-Fit contact technology
- 1200V Trench IGBT4 Fast (F4)
- 650V Trench IGBT3 (E3)
- Robust and soft switching CAL4F diode technology
- Integrated NTC temperature sensor
- UL recognized file no. E 63 532

#### Typical Applications

- UPS
- Solar

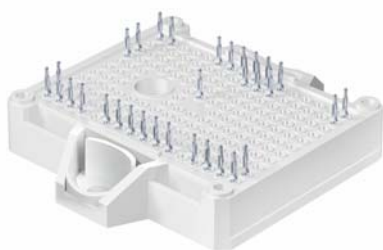
#### Remarks\*

- 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



TMLI-T

| Absolute Maximum Ratings |                                                                                                     |                        |             |      |
|--------------------------|-----------------------------------------------------------------------------------------------------|------------------------|-------------|------|
| Symbol                   | Conditions                                                                                          |                        | Values      | Unit |
| IGBT1                    |                                                                                                     |                        |             |      |
| V <sub>CES</sub>         | T <sub>j</sub> = 25 °C                                                                              |                        | 1200        | V    |
| I <sub>C</sub>           | λ <sub>paste</sub> =0.8 W/(mK)                                                                      | T <sub>s</sub> = 25 °C | 169         | A    |
|                          | T <sub>j</sub> = 175 °C                                                                             | T <sub>s</sub> = 70 °C | 135         | A    |
| I <sub>C</sub>           | λ <sub>paste</sub> =2.5 W/(mK)                                                                      | T <sub>s</sub> = 25 °C | 248         | A    |
|                          | T <sub>j</sub> = 175 °C                                                                             | T <sub>s</sub> = 70 °C | 200         | A    |
| I <sub>Cnom</sub>        |                                                                                                     |                        | 200         | A    |
| I <sub>CRM</sub>         |                                                                                                     |                        | 600         | 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 |                        | 6           | 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>           | λ <sub>paste</sub> =0.8 W/(mK)                                                                      | T <sub>s</sub> = 25 °C | 102         | A    |
|                          | T <sub>j</sub> = 175 °C                                                                             | T <sub>s</sub> = 70 °C | 81          | A    |
| I <sub>C</sub>           | λ <sub>paste</sub> =2.5 W/(mK)                                                                      | T <sub>s</sub> = 25 °C | 123         | A    |
|                          | T <sub>j</sub> = 175 °C                                                                             | T <sub>s</sub> = 70 °C | 99          | A    |
| I <sub>Cnom</sub>        |                                                                                                     |                        | 100         | A    |
| I <sub>CRM</sub>         |                                                                                                     |                        | 300         | 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                                                                              |                        | 1200        | V    |
| I <sub>F</sub>           | λ <sub>paste</sub> =0.8 W/(mK)                                                                      | T <sub>s</sub> = 25 °C | 69          | A    |
|                          | T <sub>j</sub> = 175 °C                                                                             | T <sub>s</sub> = 70 °C | 55          | A    |
| I <sub>F</sub>           | λ <sub>paste</sub> =2.5 W/(mK)                                                                      | T <sub>s</sub> = 25 °C | 101         | A    |
|                          | T <sub>j</sub> = 175 °C                                                                             | T <sub>s</sub> = 70 °C | 81          | A    |
| I <sub>FRM</sub>         |                                                                                                     |                        | 150         | A    |
| I <sub>FSM</sub>         | 10 ms, sin 180°, T <sub>j</sub> = 25 °C                                                             |                        | 430         | 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>           | λ <sub>paste</sub> =0.8 W/(mK)                                                                      | T <sub>s</sub> = 25 °C | 98          | A    |
|                          | T <sub>j</sub> = 175 °C                                                                             | T <sub>s</sub> = 70 °C | 76          | A    |
| I <sub>F</sub>           | λ <sub>paste</sub> =2.5 W/(mK)                                                                      | T <sub>s</sub> = 25 °C | 132         | A    |
|                          | T <sub>j</sub> = 175 °C                                                                             | T <sub>s</sub> = 70 °C | 104         | A    |
| I <sub>FRM</sub>         |                                                                                                     |                        | 200         | A    |
| I <sub>FSM</sub>         | 10 ms, sin 180°, T <sub>j</sub> = 25 °C                                                             |                        | 820         | A    |
| T <sub>j</sub>           |                                                                                                     |                        | -40 ... 175 | °C   |
| Module                   |                                                                                                     |                        |             |      |
| I <sub>t(RMS)</sub>      |                                                                                                     |                        | 30          | A    |
| T <sub>stg</sub>         |                                                                                                     |                        | -40 ... 125 | °C   |
| V <sub>isol</sub>        | AC, sinusoidal, t = 1 min                                                                           |                        | 2500        | V    |



SEMITOP®E2

## 3-Level TNPC

### SK200TMLI12F4TE2

#### Features\*

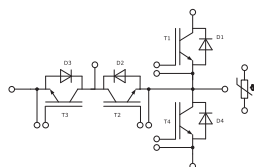
- Optimized design for superior thermal performances
- Low inductive design
- Press-Fit contact technology
- 1200V Trench IGBT4 Fast (F4)
- 650V Trench IGBT3 (E3)
- Robust and soft switching CAL4F diode technology
- Integrated NTC temperature sensor
- UL recognized file no. E 63 532

#### Typical Applications

- UPS
- Solar

#### Remarks\*

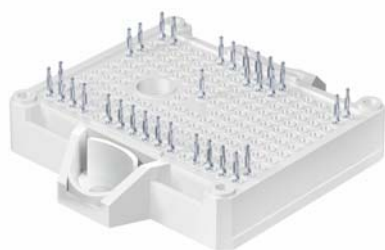
- Recommended  $T_{jop} = -40 \dots +150^{\circ}\text{C}$
- IGBT1: outer IGBTs T1 & T4
- IGBT2: inner IGBTs T2 & T3
- Diode1: outer diodes D1 & D4
- Diode2: inner diodes D2 & D3



TMLI-T

| Characteristics      |                                                                         |                         |      |       |      |      |
|----------------------|-------------------------------------------------------------------------|-------------------------|------|-------|------|------|
| Symbol               | Conditions                                                              |                         | min. | typ.  | max. | Unit |
| IGBT1                |                                                                         |                         |      |       |      |      |
| V <sub>CE(sat)</sub> | I <sub>C</sub> = 200 A                                                  | T <sub>j</sub> = 25 °C  |      | 2.05  | 2.42 | V    |
|                      | V <sub>GE</sub> = 15 V<br>chipllevel                                    | T <sub>j</sub> = 150 °C |      | 2.59  | 2.96 | V    |
| V <sub>CE0</sub>     | chipllevel                                                              | T <sub>j</sub> = 25 °C  |      | 1.10  | 1.28 | V    |
|                      |                                                                         | T <sub>j</sub> = 150 °C |      | 0.95  | 1.13 | V    |
| r <sub>CE</sub>      | V <sub>GE</sub> = 15 V<br>chipllevel                                    | T <sub>j</sub> = 25 °C  |      | 4.8   | 5.7  | mΩ   |
|                      |                                                                         | T <sub>j</sub> = 150 °C |      | 8.2   | 9.2  | mΩ   |
| V <sub>GE(th)</sub>  | V <sub>GE</sub> = V <sub>CE</sub> , I <sub>C</sub> = 7.6 mA             |                         | 5.2  | 5.8   | 6.4  | V    |
| I <sub>CES</sub>     | V <sub>GE</sub> = 0 V, V <sub>CE</sub> = 1200 V, T <sub>j</sub> = 25 °C |                         |      |       | 2.67 | mA   |
| C <sub>ies</sub>     | V <sub>CE</sub> = 25 V<br>V <sub>GE</sub> = 0 V                         | f = 1 MHz               |      | 12.3  |      | nF   |
| C <sub>oes</sub>     |                                                                         | f = 1 MHz               |      | 0.81  |      | nF   |
| C <sub>res</sub>     |                                                                         | f = 1 MHz               |      | 0.69  |      | nF   |
| Q <sub>G</sub>       | V <sub>GE</sub> = - 15 V...+ 15 V                                       |                         |      | 1400  |      | nC   |
| R <sub>Gint</sub>    | T <sub>j</sub> = 25 °C                                                  |                         |      | 3.8   |      | Ω    |
| t <sub>d(on)</sub>   | V <sub>CE</sub> = 400 V                                                 | T <sub>j</sub> = 150 °C |      | 164   |      | ns   |
| t <sub>r</sub>       | I <sub>C</sub> = 100 A                                                  | T <sub>j</sub> = 150 °C |      | 30    |      | ns   |
| E <sub>on</sub>      | V <sub>GE</sub> = +15/-15 V                                             | T <sub>j</sub> = 150 °C |      | 4.44  |      | mJ   |
| t <sub>d(off)</sub>  | R <sub>G on</sub> = 1.1 Ω                                               | T <sub>j</sub> = 150 °C |      | 404   |      | ns   |
| t <sub>f</sub>       | R <sub>G off</sub> = 1.1 Ω                                              | T <sub>j</sub> = 150 °C |      | 58    |      | ns   |
| E <sub>off</sub>     | di/dt <sub>on</sub> = 4708 A/μs                                         | T <sub>j</sub> = 150 °C |      | 5.4   |      | mJ   |
| R <sub>th(j-s)</sub> | per IGBT, λ <sub>paste</sub> =0.8 W/(mK)                                |                         |      | 0.32  |      | K/W  |
| R <sub>th(j-s)</sub> | per IGBT, λ <sub>paste</sub> =2.5 W/(mK)                                |                         |      | 0.17  |      | K/W  |
| IGBT2                |                                                                         |                         |      |       |      |      |
| V <sub>CE(sat)</sub> | I <sub>C</sub> = 100 A                                                  | T <sub>j</sub> = 25 °C  |      | 1.45  | 1.85 | V    |
|                      | V <sub>GE</sub> = 15 V<br>chipllevel                                    | T <sub>j</sub> = 150 °C |      | 1.70  | 2.10 | V    |
| V <sub>CE0</sub>     | chipllevel                                                              | 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<br>chipllevel                                    | T <sub>j</sub> = 25 °C  |      | 5.5   | 8.5  | mΩ   |
|                      |                                                                         | T <sub>j</sub> = 150 °C |      | 8.8   | 12   | mΩ   |
| V <sub>GE(th)</sub>  | V <sub>GE</sub> = V <sub>CE</sub> , I <sub>C</sub> = 1.6 mA             |                         | 5    | 5.8   | 6.5  | V    |
| I <sub>CES</sub>     | V <sub>GE</sub> = 0 V, V <sub>CE</sub> = 650 V, T <sub>j</sub> = 25 °C  |                         |      |       | 0.29 | mA   |
| C <sub>ies</sub>     | V <sub>CE</sub> = 25 V<br>V <sub>GE</sub> = 0 V                         | f = 1 MHz               |      | 6.16  |      | nF   |
| C <sub>oes</sub>     |                                                                         | f = 1 MHz               |      | 0.384 |      | nF   |
| C <sub>res</sub>     |                                                                         | f = 1 MHz               |      | 0.183 |      | nF   |
| Q <sub>G</sub>       | V <sub>GE</sub> = - 15 V...+ 15 V                                       |                         |      | 1000  |      | nC   |
| R <sub>Gint</sub>    | T <sub>j</sub> = 25 °C                                                  |                         |      | 2.0   |      | Ω    |
| t <sub>d(on)</sub>   | V <sub>CE</sub> = 400 V                                                 | T <sub>j</sub> = 150 °C |      | 78    |      | ns   |
| t <sub>r</sub>       | I <sub>C</sub> = 100 A                                                  | T <sub>j</sub> = 150 °C |      | 31    |      | ns   |
| E <sub>on</sub>      | V <sub>GE</sub> = +15/-15 V                                             | T <sub>j</sub> = 150 °C |      | 4.3   |      | mJ   |
| t <sub>d(off)</sub>  | R <sub>G on</sub> = 3.3 Ω                                               | T <sub>j</sub> = 150 °C |      | 262   |      | ns   |
| t <sub>f</sub>       | R <sub>G off</sub> = 3.3 Ω                                              | T <sub>j</sub> = 150 °C |      | 52    |      | ns   |
| E <sub>off</sub>     | di/dt <sub>on</sub> = 3800 A/μs                                         | T <sub>j</sub> = 150 °C |      | 4.5   |      | mJ   |
| R <sub>th(j-s)</sub> | per IGBT, λ <sub>paste</sub> =0.8 W/(mK)                                |                         |      | 0.67  |      | K/W  |
| R <sub>th(j-s)</sub> | per IGBT, λ <sub>paste</sub> =2.5 W/(mK)                                |                         |      | 0.49  |      | K/W  |

# SK200TMLI12F4TE2



SEMITOP®E2

## 3-Level TNPC

### SK200TMLI12F4TE2

#### Features\*

- Optimized design for superior thermal performances
- Low inductive design
- Press-Fit contact technology
- 1200V Trench IGBT4 Fast (F4)
- 650V Trench IGBT3 (E3)
- Robust and soft switching CAL4F diode technology
- Integrated NTC temperature sensor
- UL recognized file no. E 63 532

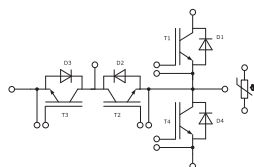
#### Typical Applications

- UPS
- Solar

#### 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

| Characteristics                  |                                                                                               |                         |      |          |      |      |
|----------------------------------|-----------------------------------------------------------------------------------------------|-------------------------|------|----------|------|------|
| Symbol                           | Conditions                                                                                    |                         | min. | typ.     | max. | Unit |
| Diode1                           |                                                                                               |                         |      |          |      |      |
| V <sub>F</sub> = V <sub>EC</sub> | I <sub>F</sub> = 75 A                                                                         | T <sub>j</sub> = 25 °C  |      | 2.17     | 2.49 | V    |
|                                  | chiplevel                                                                                     | T <sub>j</sub> = 150 °C |      | 2.11     | 2.42 | 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  |      | 12       | 13   | mΩ   |
|                                  |                                                                                               | T <sub>j</sub> = 150 °C |      | 16       | 18   | mΩ   |
| I <sub>RRM</sub>                 | I <sub>F</sub> = 100 A                                                                        | T <sub>j</sub> = 150 °C |      | 120      |      | A    |
| Q <sub>rr</sub>                  | di/dt <sub>off</sub> = 3800 A/μs                                                              | T <sub>j</sub> = 150 °C |      | 12.3     |      | μC   |
| E <sub>rr</sub>                  | V <sub>R</sub> = 400 V<br>V <sub>GE</sub> = +15/-15 V                                         | T <sub>j</sub> = 150 °C |      | 3.2      |      | mJ   |
| R <sub>th(j-s)</sub>             | per Diode, λ <sub>paste</sub> =0.8 W/(mK)                                                     |                         |      | 1.01     |      | K/W  |
| R <sub>th(j-s)</sub>             | per Diode, λ <sub>paste</sub> =2.5 W/(mK)                                                     |                         |      | 0.55     |      | K/W  |
| Diode2                           |                                                                                               |                         |      |          |      |      |
| V <sub>F</sub> = V <sub>EC</sub> | I <sub>F</sub> = 100 A                                                                        | T <sub>j</sub> = 25 °C  |      | 1.40     | 1.76 | V    |
|                                  | chiplevel                                                                                     | T <sub>j</sub> = 150 °C |      | 1.38     | 1.77 | 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  |      | 3.6      | 5.3  | mΩ   |
|                                  |                                                                                               | T <sub>j</sub> = 150 °C |      | 5.3      | 7.8  | mΩ   |
| I <sub>RRM</sub>                 | I <sub>F</sub> = 100 A                                                                        | T <sub>j</sub> = 150 °C |      | 151      |      | A    |
| Q <sub>rr</sub>                  | di/dt <sub>off</sub> = 4823 A/μs                                                              | T <sub>j</sub> = 150 °C |      | 12.2     |      | μC   |
| E <sub>rr</sub>                  | V <sub>R</sub> = 400 V<br>V <sub>GE</sub> = +15/-15 V                                         | T <sub>j</sub> = 150 °C |      | 3.14     |      | mJ   |
| R <sub>th(j-s)</sub>             | per Diode, λ <sub>paste</sub> =0.8 W/(mK)                                                     |                         |      | 0.91     |      | K/W  |
| R <sub>th(j-s)</sub>             | per Diode, λ <sub>paste</sub> =2.5 W/(mK)                                                     |                         |      | 0.59     |      | K/W  |
| Module                           |                                                                                               |                         |      |          |      |      |
| L <sub>sCE1</sub>                |                                                                                               |                         |      | 14       |      | nH   |
| L <sub>CE</sub>                  |                                                                                               |                         |      | -        |      | nH   |
| R <sub>CC'+EE'</sub>             | per switch                                                                                    | T <sub>s</sub> = 25 °C  |      | -        |      | mΩ   |
|                                  |                                                                                               | T <sub>s</sub> = 150 °C |      | -        |      | mΩ   |
| M <sub>s</sub>                   | to heatsink                                                                                   |                         | 1.6  |          | 2.3  | Nm   |
| M <sub>t</sub>                   |                                                                                               |                         |      | -        |      | Nm   |
|                                  |                                                                                               |                         |      |          |      | Nm   |
| w                                |                                                                                               |                         |      | 35       |      | 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 <sub>(T)</sub> =R <sub>100</sub> exp[B <sub>100/125</sub> (1/T-1/T <sub>100</sub> )]; T[K]; |                         |      | 3550 ±2% |      | K    |



TMLI-T

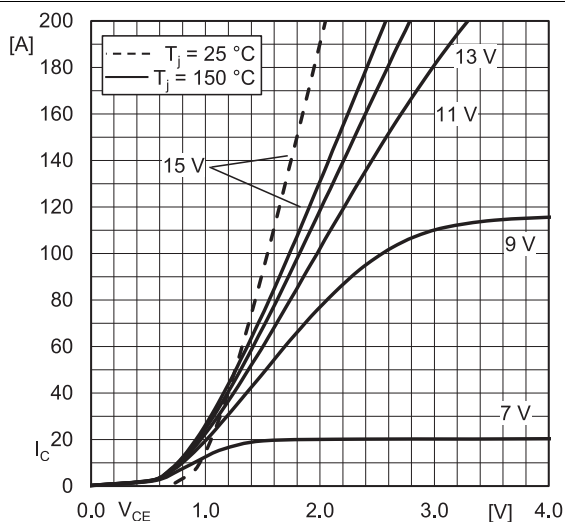


Fig. 1: Typ. IGBT1 output characteristic, incl.  $R_{CC'+EE'}$

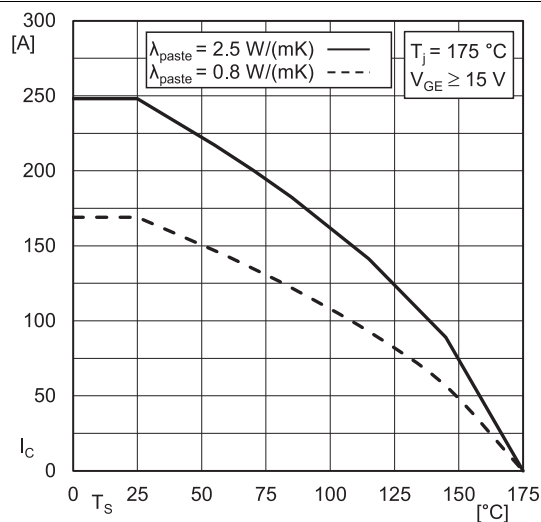


Fig. 2: IGBT1 rated current vs. Temperature  $I_C=f(T_s)$

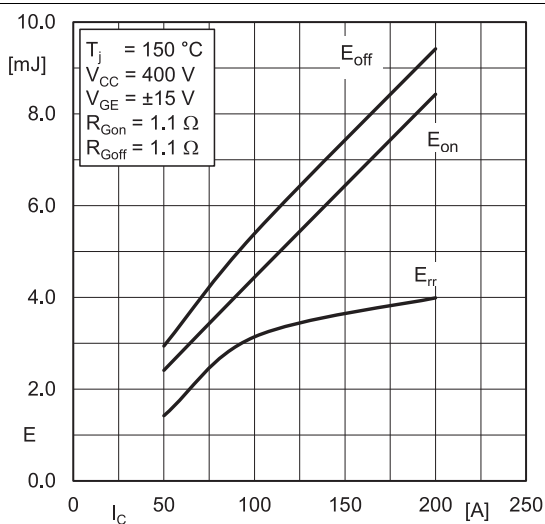


Fig. 3: Typ. IGBT1 & Diode2 turn-on /-off energy =  $f(I_C)$

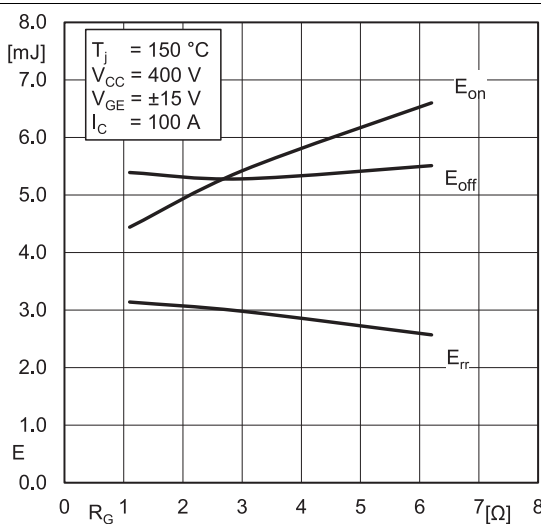


Fig. 4: Typ. IGBT1 & Diode2 turn-on /-off energy =  $f(R_G)$

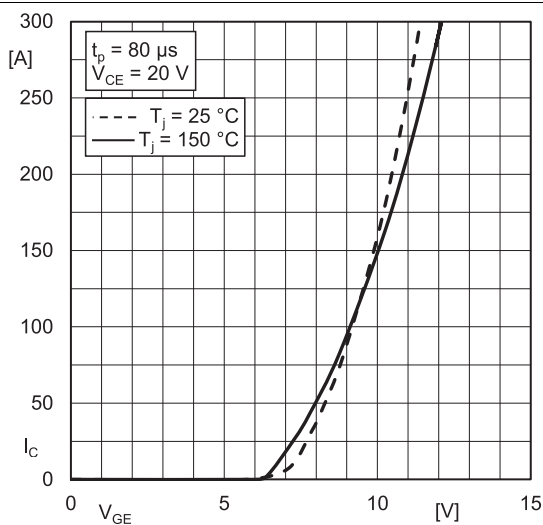


Fig. 5: Typ. IGBT1 transfer characteristic

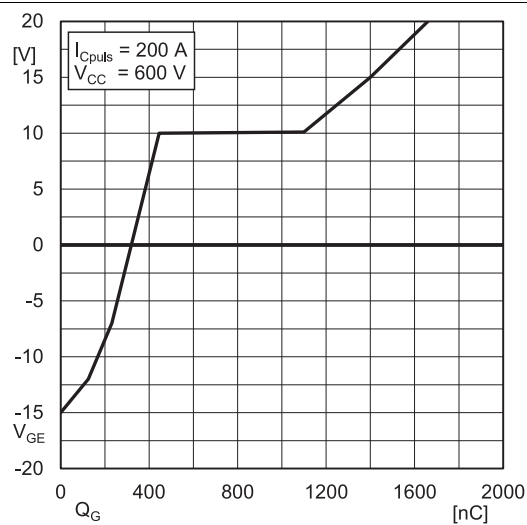
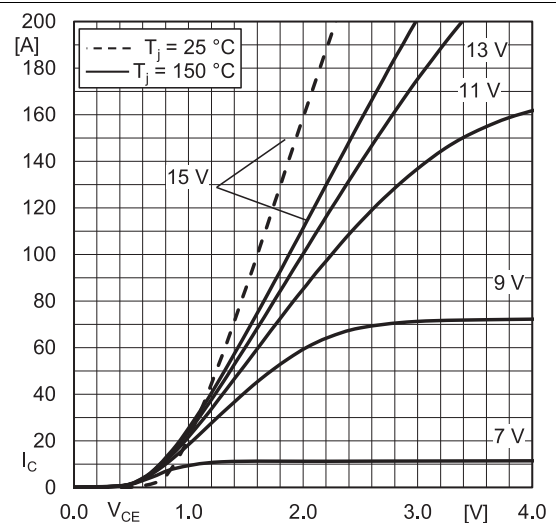
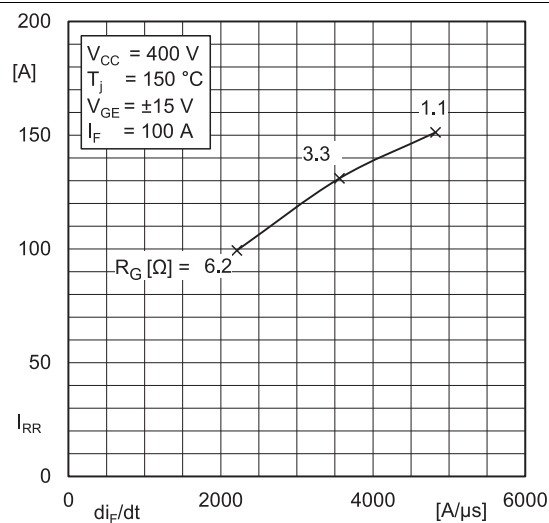
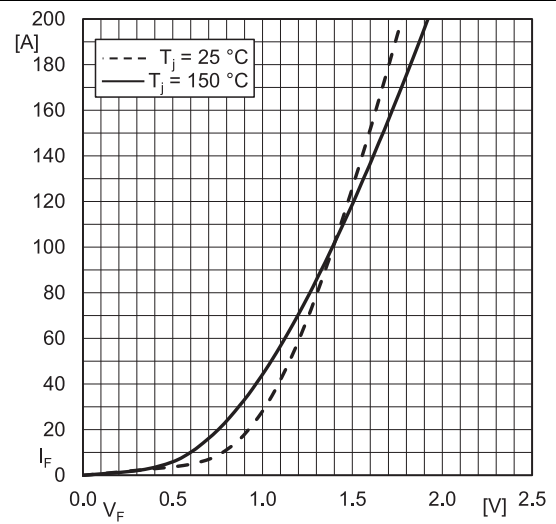
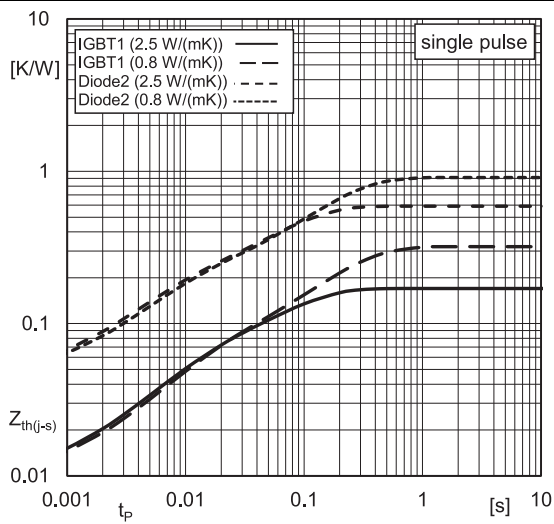
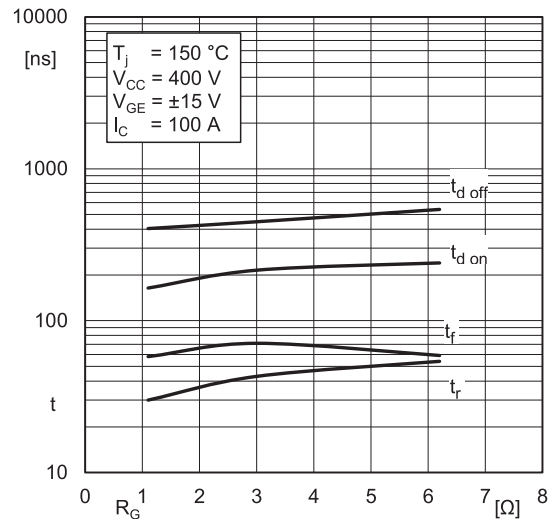
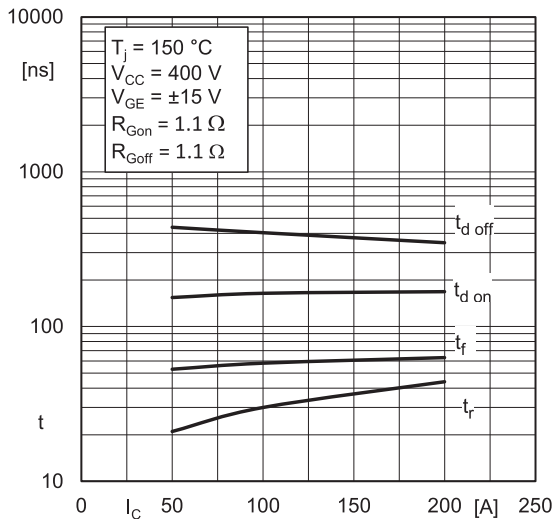


Fig. 6: Typ. IGBT1 gate charge characteristic



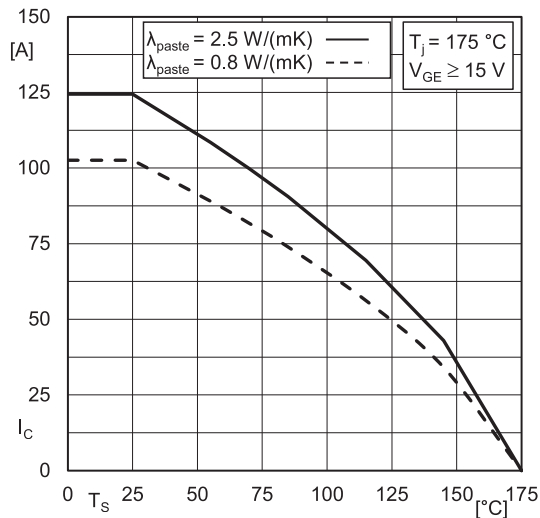


Fig. 14: IGBT2 Rated current vs. Temperature  $I_C = f(T_s)$

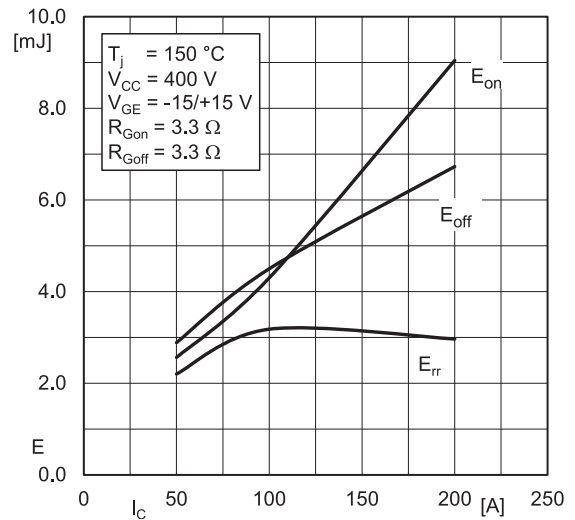


Fig. 15: Typ. IGBT2 & Diode1 turn-on /-off energy =  $f(I_C)$

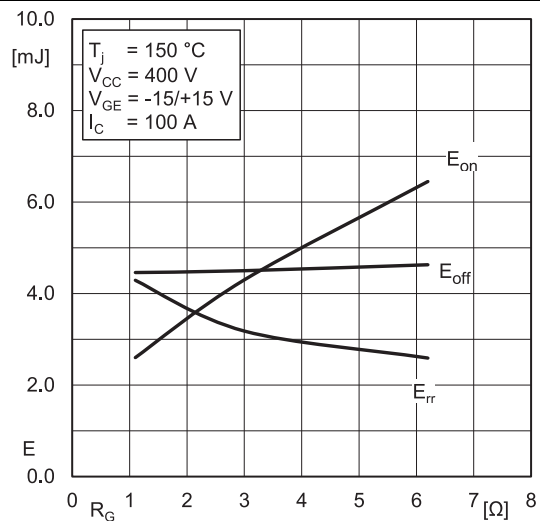


Fig. 16: Typ. IGBT2 & Diode1 turn-on /-off energy =  $f(R_G)$

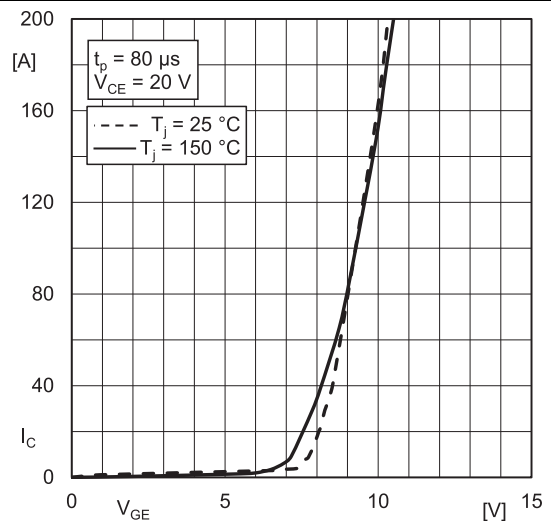


Fig. 17: Typ. IGBT2 transfer characteristic

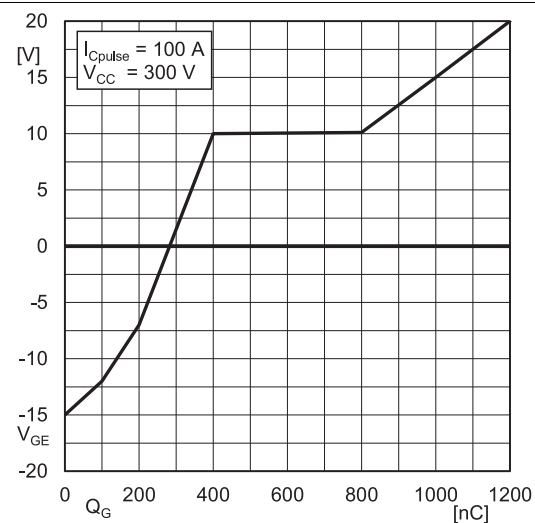


Fig. 18: Typ. IGBT2 gate charge characteristic

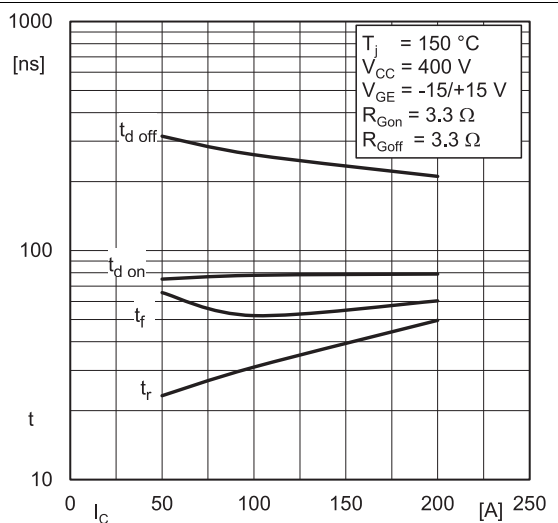


Fig. 19: Typ. IGBT2 switching times vs.  $I_C$

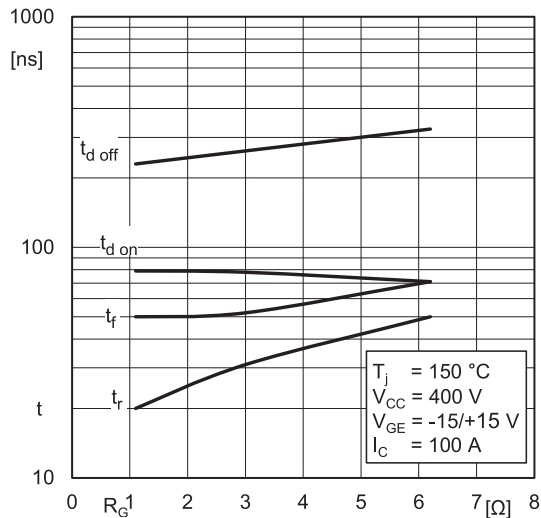


Fig. 20: Typ. IGBT2 switching times vs. gate resistor  $R_G$

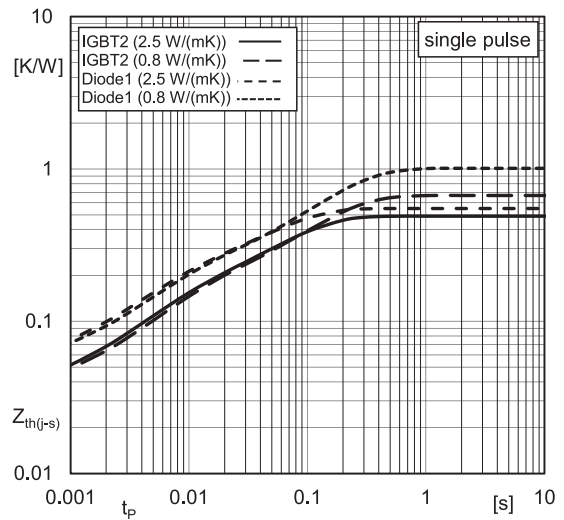


Fig. 21: Transient thermal impedance of IGBT2 & Diode1

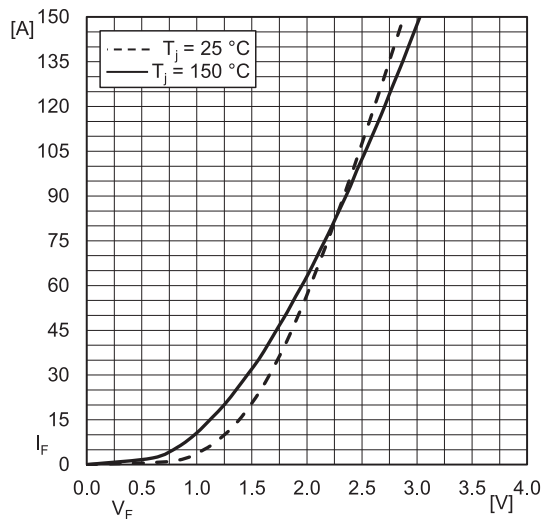


Fig. 22: Typ. Diode1 forward characteristic, incl.  $R_{CC'+EE'}$

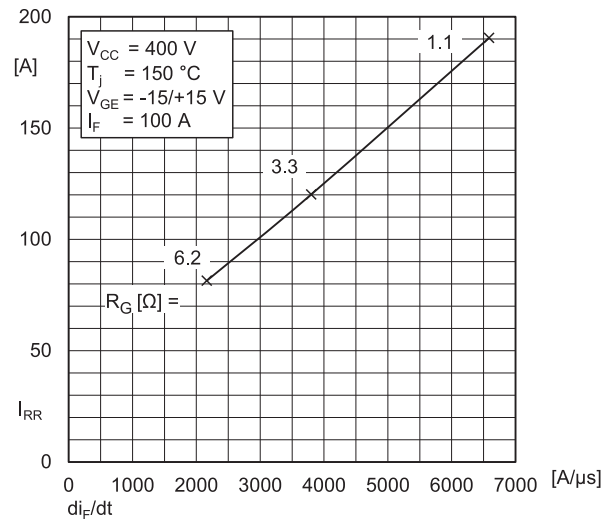


Fig. 23: Typ. Diode1 peak reverse recovery current

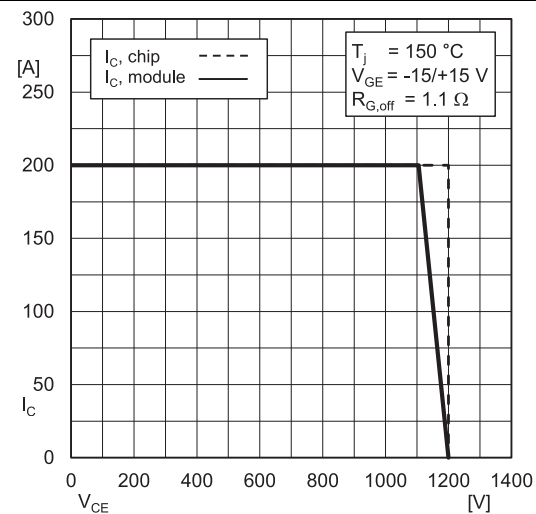


Fig. 25: RBSOA IGBT1

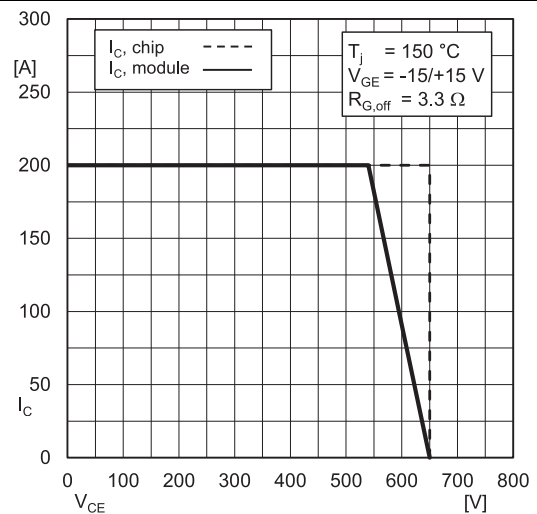
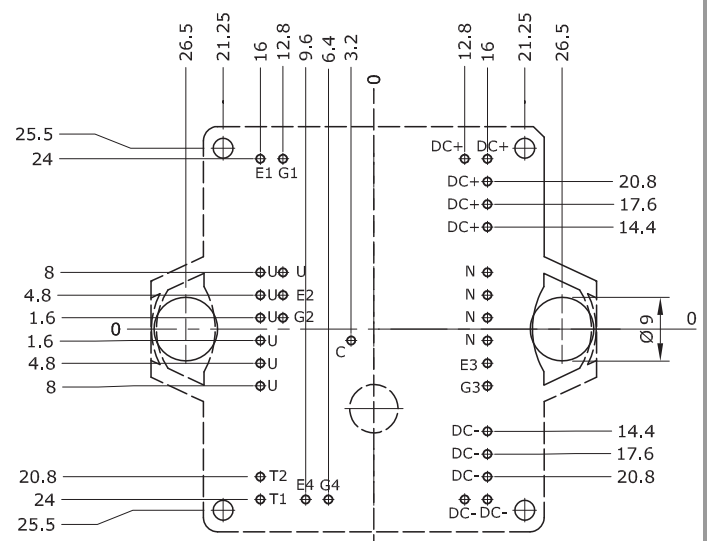
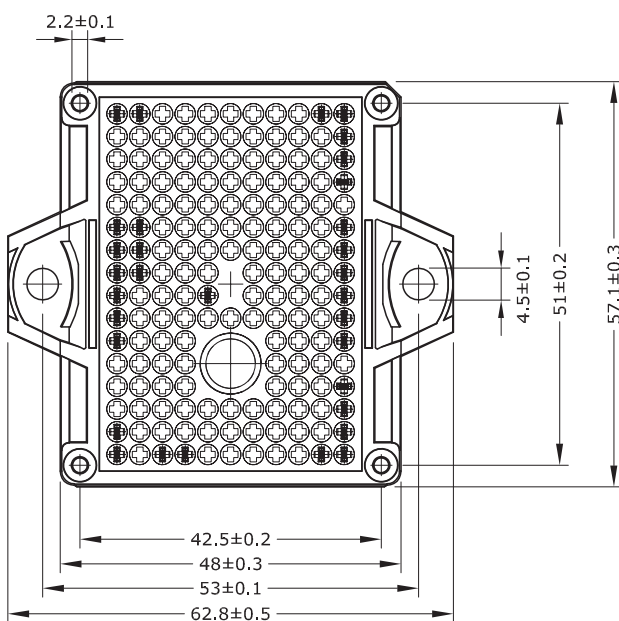
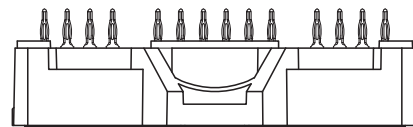
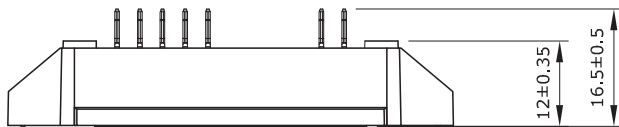
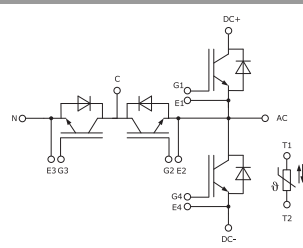


Fig. 26: RBSOA IGBT2



- Pin-Grid 3.2 mm
- Tolerance of PCB hole pattern  $\boxed{\oplus \mid \varnothing 0.1}$
- Diameters of drill  $\varnothing 1.15\text{mm}$
- Copper thickness in hole 25 - 50  $\mu\text{m}$
- Hole specification for contacts:  
refer to SEMITOP E1/E2 Mounting Instruction

SEMITOP®E2



TMLI-T

This is an electrostatic discharge sensitive device (ESDS) due to international standard IEC 61340.

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

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