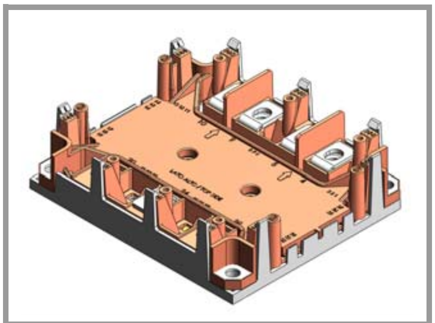


SKiM® 4

## Trench IGBT Modules

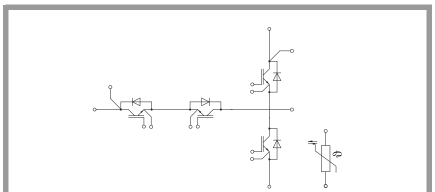
**SKiM601TMLI12E4B**

### Features

- IGBT 4 Trench Gate Technology
- Solder technology
- $V_{CE(sat)}$ with positive temperature coefficient
- Low inductance case
- Insulated by $Al_2O_3$ DCB (Direct Copper Bonded) ceramic substrate
- Pressure contact technology for thermal contacts
- Spring contact system to attach driver PCB to the control terminals
- High short circuit capability, self limiting to 6 x $I_C$
- Integrated temperature sensor

### Remarks*

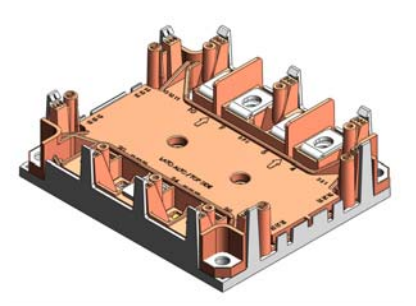
- Case temperature limited to $T_s$ = 125°C max; $T_c$ = $T_s$ (for baseplateless modules)
- Recommended $T_{op}$ = -40 ...+150°C
- IGBT1: outer IGBTs T1 & T4
- IGBT2: inner IGBTs T2 & T3
- Diode1: outer diodes D1 & D4
- Diode2: inner diodes D2 & D3



TMLI

**Absolute Maximum Ratings**

| Symbol | Conditions | | Values | Unit |
|---|---|---|---|---|
| **IGBT1** | | | | |
| $V_{CES}$ | $T_j$ = 25 °C | | 1200 | V |
| $I_C$ | $\lambda_{paste}$=0.8 W/(mK) | $T_s$ = 25 °C | 529 | A |
| | $T_j$ = 175 °C | $T_s$ = 70 °C | 425 | A |
| $I_C$ | $\lambda_{paste}$=2.5 W/(mK) | $T_s$ = 25 °C | 699 | A |
| | $T_j$ = 175 °C | $T_s$ = 70 °C | 567 | A |
| $I_{Cnom}$ | | | 600 | A |
| $I_{CRM}$ | $I_{CRM}$ = 3 x $I_{Cnom}$ | | 1800 | A |
| $V_{GES}$ | | | -20 ... 20 | V |
| $t_{psc}$ | $V_{CC}$ = 800 V, $V_{GE} \leq$ 15 V, $T_j$ = 150 °C, $V_{CES} \leq$ 1200 V | | 10 | µs |
| $T_j$ | | | -40 ... 175 | °C |
| **IGBT2** | | | | |
| $V_{CES}$ | $T_j$ = 25 °C | | 650 | V |
| $I_C$ | $\lambda_{paste}$=0.8 W/(mK) | $T_s$ = 25 °C | 433 | A |
| | $T_j$ = 175 °C | $T_s$ = 70 °C | 340 | A |
| $I_C$ | $\lambda_{paste}$=2.5 W/(mK) | $T_s$ = 25 °C | 545 | A |
| | $T_j$ = 175 °C | $T_s$ = 70 °C | 433 | A |
| $I_{Cnom}$ | | | 600 | A |
| $I_{CRM}$ | $I_{CRM}$ = 3 x $I_{Cnom}$ | | 1800 | A |
| $V_{GES}$ | | | -20 ... 20 | V |
| $t_{psc}$ | $V_{CC}$ = 360 V, $V_{GE} \leq$ 15 V, $T_j$ = 150 °C, $V_{CES} \leq$ 650 V | | 10 | µs |
| $T_j$ | | | -40 ... 175 | °C |
| **Diode1** | | | | |
| $V_{RRM}$ | $T_j$ = 25 °C | | 1200 | V |
| $I_F$ | $\lambda_{paste}$=0.8 W/(mK) | $T_s$ = 25 °C | 495 | A |
| | $T_j$ = 175 °C | $T_s$ = 70 °C | 389 | A |
| $I_F$ | $\lambda_{paste}$=2.5 W/(mK) | $T_s$ = 25 °C | 606 | A |
| | $T_j$ = 175 °C | $T_s$ = 70 °C | 480 | A |
| $I_{Fnom}$ | | | 600 | A |
| $I_{FRM}$ | $I_{FRM}$ = 2 x $I_{Fnom}$ | | 1200 | A |
| $I_{FSM}$ | 10 ms, sin 180°, $T_j$ = 25 °C | | 3240 | A |
| $T_j$ | | | -40 ... 175 | °C |
| **Diode2** | | | | |
| $V_{RRM}$ | $T_j$ = 25 °C | | 650 | V |
| $I_F$ | $\lambda_{paste}$=0.8 W/(mK) | $T_s$ = 25 °C | 527 | A |
| | $T_j$ = 175 °C | $T_s$ = 70 °C | 406 | A |
| $I_F$ | $\lambda_{paste}$=2.5 W/(mK) | $T_s$ = 25 °C | 655 | A |
| | $T_j$ = 175 °C | $T_s$ = 70 °C | 509 | A |
| $I_{Fnom}$ | | | 600 | A |
| $I_{FRM}$ | $I_{FRM}$ = 2 x $I_{Fnom}$ | | 1200 | A |
| $I_{FSM}$ | 10 ms, sin 180°, $T_j$ = 25 °C | | 3969 | A |
| $T_j$ | | | -40 ... 175 | °C |
| **Module** | | | | |
| $I_{t(RMS)}$ | | | 400 | A |
| $T_{stg}$ | | | -40 ... 125 | °C |
| $V_{isol}$ | AC sinus 50 Hz, t = 1 min | | 2500 | V |



SKiM® 4

## Trench IGBT Modules

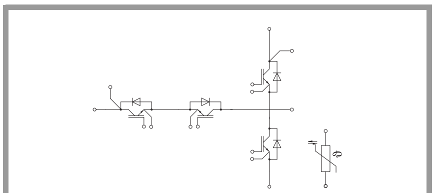
**SKiM601TMLI12E4B**

### Features

- IGBT 4 Trench Gate Technology
- Solder technology
- $V_{CE(sat)}$ with positive temperature coefficient
- Low inductance case
- Insulated by $Al_2O_3$ DCB (Direct Copper Bonded) ceramic substrate
- Pressure contact technology for thermal contacts
- Spring contact system to attach driver PCB to the control terminals
- High short circuit capability, self limiting to 6 x $I_C$
- Integrated temperature sensor

### Remarks*

- Case temperature limited to $T_s$ = 125°C max; $T_c$ = $T_s$ (for baseplateless modules)
- Recommended $T_{op}$ = -40 ...+150°C
- IGBT1: outer IGBTs T1 & T4
- IGBT2: inner IGBTs T2 & T3
- Diode1: outer diodes D1 & D4
- Diode2: inner diodes D2 & D3



TMLI

**Characteristics**

| Symbol | Conditions | | min. | typ. | max. | Unit |
|---|---|---|---|---|---|---|
| **IGBT1** | | | | | | |
| $V_{CE(sat)}$ | $I_C$ = 600 A, $V_{GE}$ = 15 V, chiplevel | $T_j$ = 25 °C | | 1.80 | 2.05 | V |
| | | $T_j$ = 150 °C | | 2.20 | 2.40 | V |
| $V_{CE0}$ | chiplevel | $T_j$ = 25 °C | | 0.80 | 0.90 | V |
| | | $T_j$ = 150 °C | | 0.70 | 0.80 | V |
| $r_{CE}$ | $V_{GE}$ = 15 V, chiplevel | $T_j$ = 25 °C | | 1.67 | 1.92 | mΩ |
| | | $T_j$ = 150 °C | | 2.5 | 2.7 | mΩ |
| $V_{GE(th)}$ | $V_{GE}$ = $V_{CE}$, $I_C$ = 24 mA | | 5 | 5.8 | 6.5 | V |
| $I_{CES}$ | $V_{GE}$ = 0 V, $V_{CE}$ = 1200 V, $T_j$ = 25 °C | | | | 5 | mA |
| $C_{ies}$ | $V_{CE}$ = 25 V, $V_{GE}$ = 0 V | f = 1 MHz | | 37.2 | | nF |
| $C_{oes}$ | | f = 1 MHz | | 2.32 | | nF |
| $C_{res}$ | | f = 1 MHz | | 2.04 | | nF |
| $Q_G$ | $V_{GE}$ = - 15 V...+ 15 V | | | 3750 | | nC |
| $R_{Gint}$ | $T_j$ = 25 °C | | | 1.3 | | Ω |
| $t_{d(on)}$ | $V_{CE}$ = 300 V, $I_C$ = 600 A, $V_{GE}$ = +15/-15 V, $R_{G\,on}$ = 2 Ω, $R_{G\,off}$ = 2 Ω, $di/dt_{on}$ = 2584 A/µs, $di/dt_{off}$ = 2673 A/µs | $T_j$ = 150 °C | | 261 | | ns |
| $t_r$ | | $T_j$ = 150 °C | | 231 | | ns |
| $E_{on}$ | | $T_j$ = 150 °C | | 11.44 | | mJ |
| $t_{d(off)}$ | | $T_j$ = 150 °C | | 585 | | ns |
| $t_f$ | | $T_j$ = 150 °C | | 182 | | ns |
| $E_{off}$ | | $T_j$ = 150 °C | | 44.88 | | mJ |
| $R_{th(j-s)}$ | per IGBT, $\lambda_{paste}$=0.8 W/(mK) | | | 0.125 | | K/W |
| $R_{th(j-s)}$ | per IGBT, $\lambda_{paste}$=2.5 W/(mK) | | | 0.078 | | K/W |
| **IGBT2** | | | | | | |
| $V_{CE(sat)}$ | $I_C$ = 600 A, $V_{GE}$ = 15 V, chiplevel | $T_j$ = 25 °C | | 1.55 | 1.95 | V |
| | | $T_j$ = 150 °C | | 1.75 | 2.15 | V |
| $V_{CE0}$ | chiplevel | $T_j$ = 25 °C | | 0.90 | 1.00 | V |
| | | $T_j$ = 150 °C | | 0.82 | 0.90 | V |
| $r_{CE}$ | $V_{GE}$ = 15 V, chiplevel | $T_j$ = 25 °C | | 1.08 | 1.58 | mΩ |
| | | $T_j$ = 150 °C | | 1.55 | 2.1 | mΩ |
| $V_{GE(th)}$ | $V_{GE}$ = $V_{CE}$, $I_C$ = 12 mA | | 5.1 | 5.8 | 6.4 | V |
| $I_{CES}$ | $V_{GE}$ = 0 V, $V_{CE}$ = 650 V, $T_j$ = 25 °C | | | | 1.4 | mA |
| $C_{ies}$ | $V_{CE}$ = 25 V, $V_{GE}$ = 0 V | f = 1 MHz | | 37.005 | | nF |
| $C_{oes}$ | | f = 1 MHz | | 2.307 | | nF |
| $C_{res}$ | | f = 1 MHz | | 1.098 | | nF |
| $Q_G$ | $V_{GE}$ = - 15 V...+ 15 V | | | 5002.2 | | nC |
| $R_{Gint}$ | $T_j$ = 25 °C | | | 0.7 | | Ω |
| $t_{d(on)}$ | $V_{CE}$ = 300 V, $I_C$ = 600 A, $V_{GE}$ = +15/-15 V, $R_{G\,on}$ = 2 Ω, $R_{G\,off}$ = 2 Ω, $di/dt_{on}$ = 2648 A/µs, $di/dt_{off}$ = 3097 A/µs | $T_j$ = 150 °C | | 121 | | ns |
| $t_r$ | | $T_j$ = 150 °C | | 232 | | ns |
| $E_{on}$ | | $T_j$ = 150 °C | | 6.05 | | mJ |
| $t_{d(off)}$ | | $T_j$ = 150 °C | | 599 | | ns |
| $t_f$ | | $T_j$ = 150 °C | | 156 | | ns |
| $E_{off}$ | | $T_j$ = 150 °C | | 44 | | mJ |
| $R_{th(j-s)}$ | per IGBT, $\lambda_{paste}$=0.8 W/(mK) | | | 0.19 | | K/W |
| $R_{th(j-s)}$ | per IGBT, $\lambda_{paste}$=2.5 W/(mK) | | | 0.133 | | K/W |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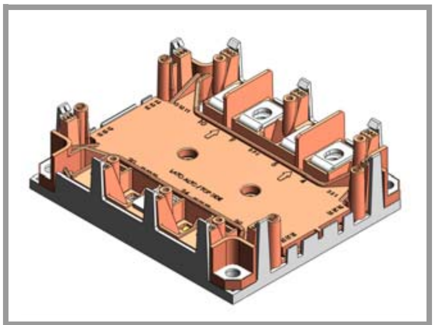


**SKiM® 4**

## Trench IGBT Modules

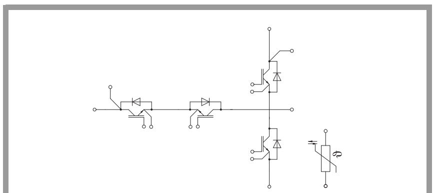
**SKiM601TMLI12E4B**

### Features

- IGBT 4 Trench Gate Technology
- Solder technology
- $V_{CE(sat)}$ with positive temperature coefficient
- Low inductance case
- Insulated by $Al_2O_3$ DCB (Direct Copper Bonded) ceramic substrate
- Pressure contact technology for thermal contacts
- Spring contact system to attach driver PCB to the control terminals
- High short circuit capability, self limiting to 6 x $I_C$
- Integrated temperature sensor

### Remarks*

- Case temperature limited to $T_s$ = 125°C max; $T_c$ = $T_s$ (for baseplateless modules)
- Recommended $T_{op}$ = -40 ...+150°C
- IGBT1: outer IGBTs T1 & T4
- IGBT2: inner IGBTs T2 & T3
- Diode1: outer diodes D1 & D4
- Diode2: inner diodes D2 & D3



**TMLI**

| **Characteristics** | | | | | | |
|---|---|---|---|---|---|---|
| **Symbol** | **Conditions** | | **min.** | **typ.** | **max.** | **Unit** |
| **Diode1** | | | | | | |
| $V_F = V_{EC}$ | $I_F$ = 600 A | $T_j$ = 25 °C | | 2.14 | 2.46 | V |
| | chiplevel | $T_j$ = 150 °C | | 2.07 | 2.38 | V |
| $V_{F0}$ | chiplevel | $T_j$ = 25 °C | | 1.30 | 1.50 | V |
| | | $T_j$ = 150 °C | | 0.90 | 1.10 | V |
| $r_F$ | chiplevel | $T_j$ = 25 °C | | 1.40 | 1.60 | mΩ |
| | | $T_j$ = 150 °C | | 1.95 | 2.1 | mΩ |
| $I_{RRM}$ | $I_F$ = 600 A | $T_j$ = 150 °C | | 251 | | A |
| $Q_{rr}$ | $V_R$ = 300 V | $T_j$ = 150 °C | | 21.9 | | µC |
| $E_{rr}$ | $V_{GE}$ = +15/-15 V | $T_j$ = 150 °C | | 4.37 | | mJ |
| $R_{th(j-s)}$ | per Diode, $\lambda_{paste}$=0.8 W/(mK) | | | 0.15 | | K/W |
| $R_{th(j-s)}$ | per Diode, $\lambda_{paste}$=2.5 W/(mK) | | | 0.11 | | K/W |
| **Diode2** | | | | | | |
| $V_F = V_{EC}$ | $I_F$ = 600 A | $T_j$ = 25 °C | | 1.39 | 1.75 | V |
| | chiplevel | $T_j$ = 150 °C | | 1.38 | 1.76 | V |
| $V_{F0}$ | chiplevel | $T_j$ = 25 °C | | 1.04 | 1.24 | V |
| | | $T_j$ = 150 °C | | 0.85 | 0.99 | V |
| $r_F$ | chiplevel | $T_j$ = 25 °C | | 0.59 | 0.86 | mΩ |
| | | $T_j$ = 150 °C | | 0.88 | 1.28 | mΩ |
| $I_{RRM}$ | $I_F$ = 600 A | $T_j$ = 150 °C | | 247 | | A |
| $Q_{rr}$ | $V_R$ = 300 V | $T_j$ = 150 °C | | 25.2 | | µC |
| $E_{rr}$ | $V_{GE}$ = +15/-15 V | $T_j$ = 150 °C | | 2.64 | | mJ |
| $R_{th(j-s)}$ | per Diode, $\lambda_{paste}$=0.8 W/(mK) | | | 0.18 | | K/W |
| $R_{th(j-s)}$ | per Diode, $\lambda_{paste}$=2.5 W/(mK) | | | 0.132 | | K/W |
| **Module** | | | | | | |
| $L_{sCE1}$ | | | | 29 | | nH |
| $L_{CE}$ | | | | 40 | | nH |
| $R_{CC'+EE'}$ | measured betw. | $T_s$ = 25 °C | | 0.4 | | mΩ |
| | terminal 4 and 24 | $T_s$ = 125 °C | | 0.6 | | mΩ |
| $M_s$ | to heat sink (M5) | | 2 | | 3 | Nm |
| $M_t$ | | to terminals M6 | 4 | | 5 | Nm |
| | | | | | | Nm |
| w | | | | 317 | | g |
| **Temperature Sensor** | | | | | | |
| $R_{100}$ | $T_c$=100°C ($R_{25}$=5 kΩ) | | | 493 ± 5% | | Ω |
| $B_{100/125}$ | $R_{(T)}=R_{100}\exp[B_{100/125}(1/T-1/T_{100})]$; T[K]; | | | 3550 ±2% | | K |

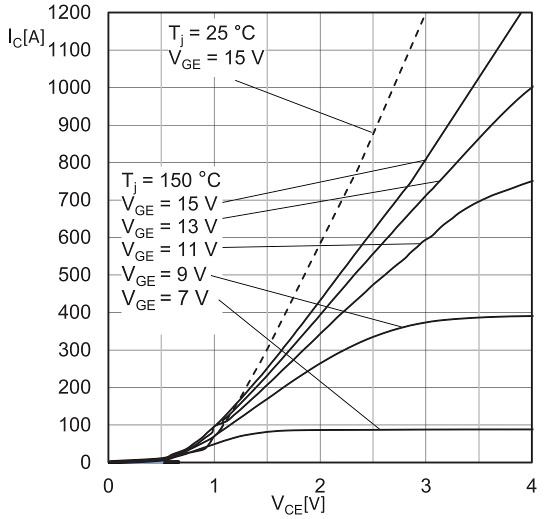



Fig. 1: Typ. IGBT1 output characteristic, incl. $R_{CC'+ EE'}$

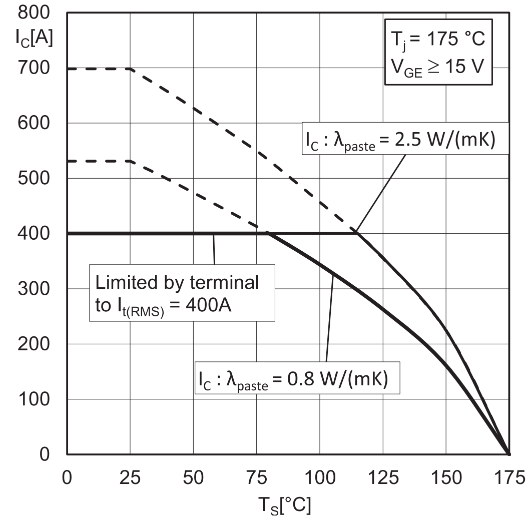



Fig. 2: IGBT1 rated current vs. Temperature $I_c=f(T_s)$

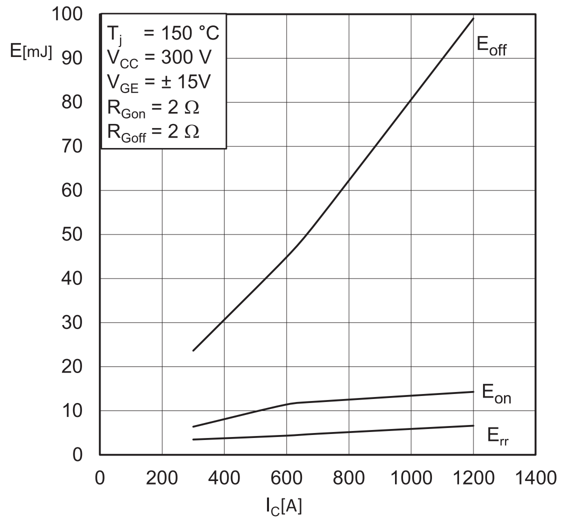



Fig. 3: Typ. IGBT1 & Diode2 turn-on /-off energy = f ($I_C$)

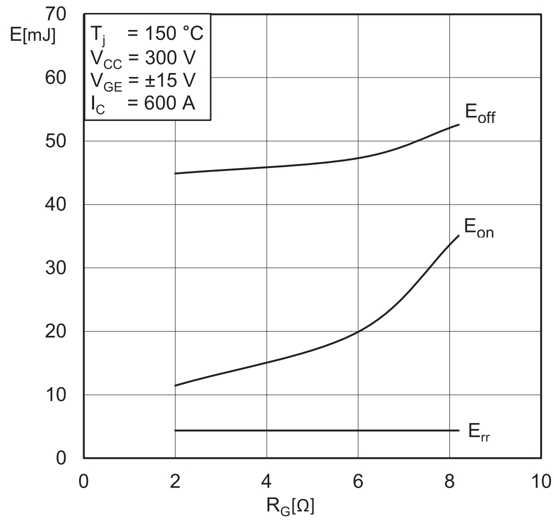



Fig. 4: Typ. IGBT1 & Diode2 turn-on /-off energy = f($R_G$)

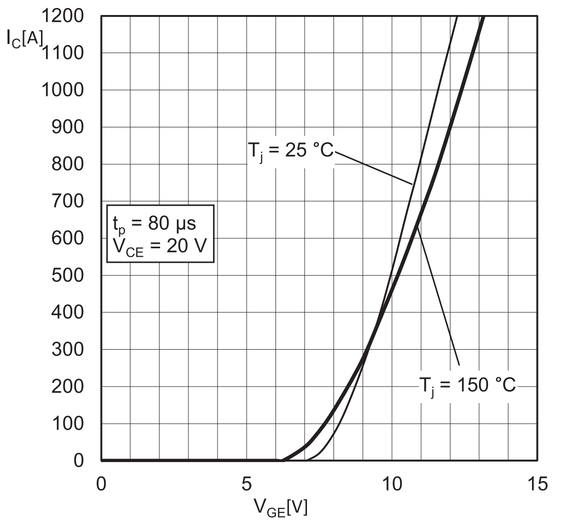



Fig. 5: Typ. IGBT1 transfer characteristic

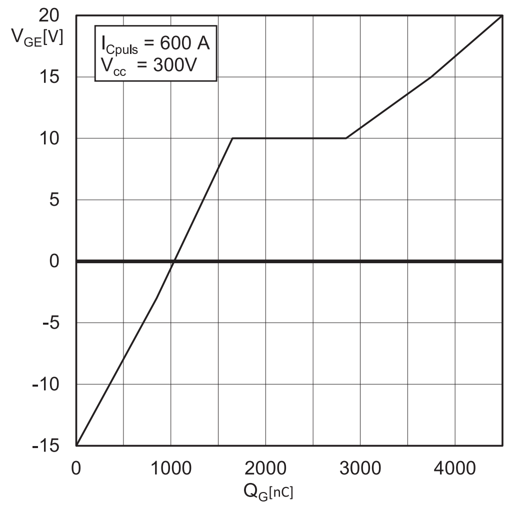



Fig. 6: Typ. IGBT1 gate charge characteristic

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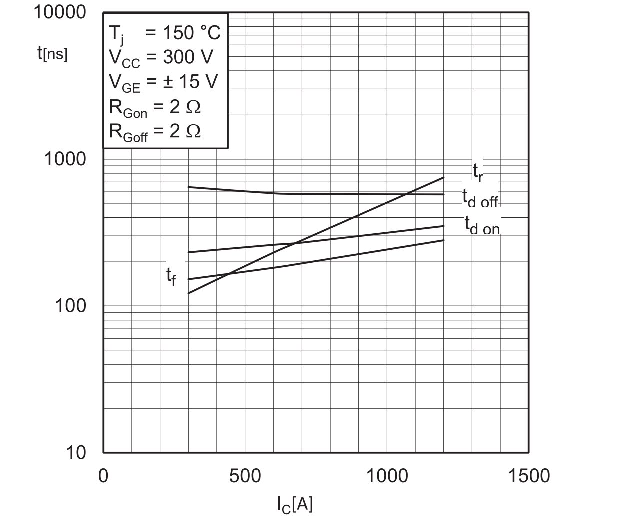



Fig. 7: Typ. IGBT1 switching times vs. $I_C$

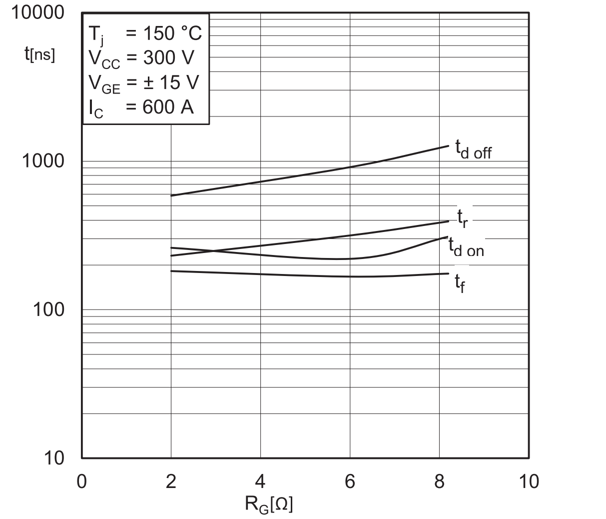



Fig. 8: Typ. IGBT1 switching times vs. gate resistor $R_G$

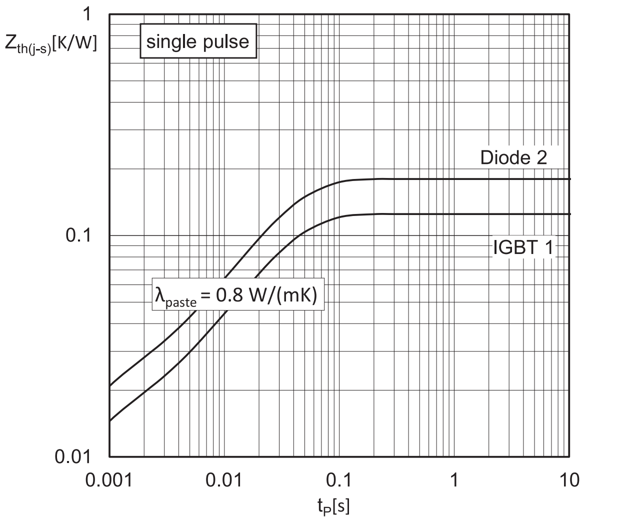



Fig. 9: Transient thermal impedance of IGBT1 & Diode2

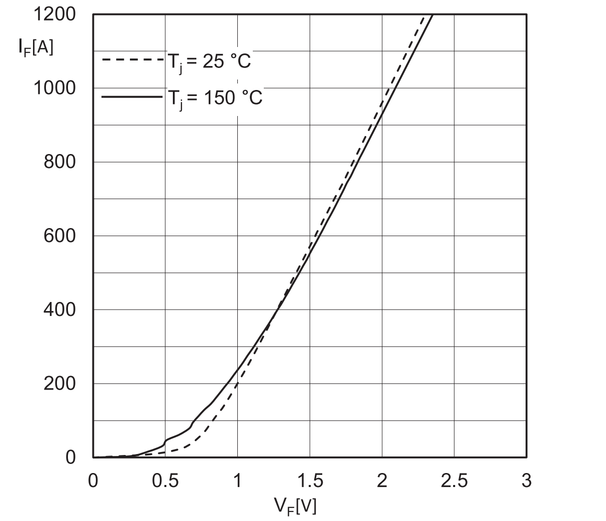



Fig. 10: Typ. Diode2 forward characteristic, incl. $R_{CC'+EE'}$

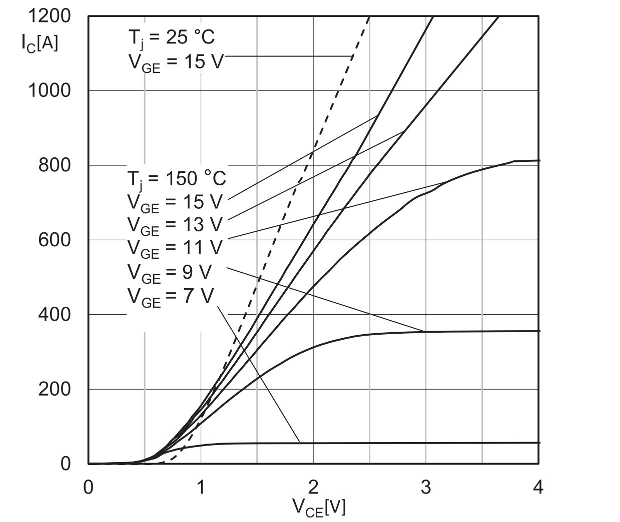



Fig. 13: Typ. IGBT2 output characteristic, incl. $R_{CC'+EE'}$

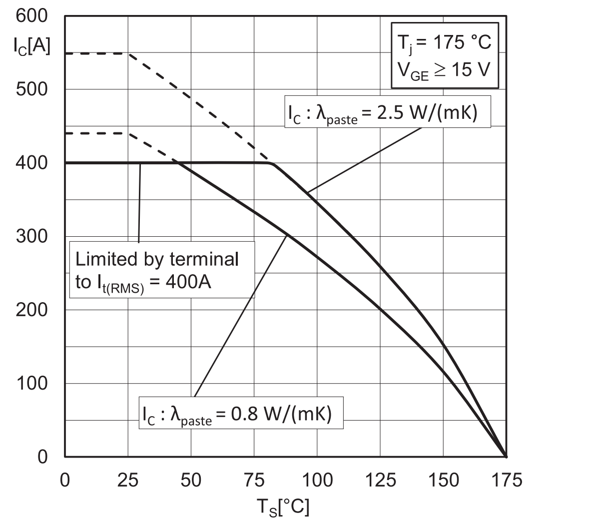



Fig. 14: IGBT2 Rated current vs. Temperature $I_c$= f ($T_s$)

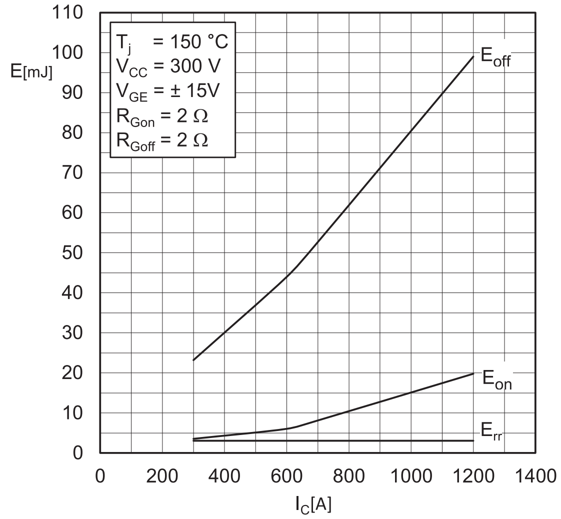



Fig. 15: Typ. IGBT2 & Diode1 turn-on /-off energy = f ($I_C$)

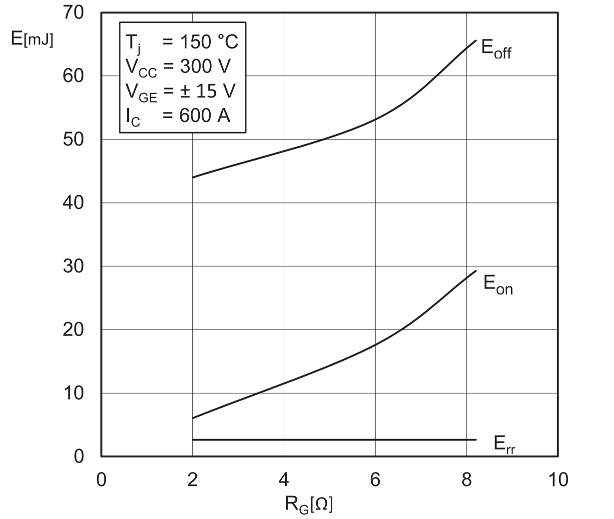



Fig. 16: Typ. IGBT2 & Diode1 turn-on / -off energy = f($R_G$)

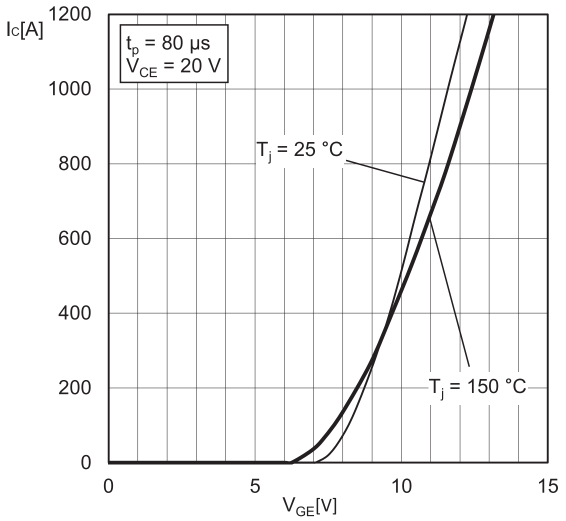



Fig. 17: Typ. IGBT2 transfer characteristic

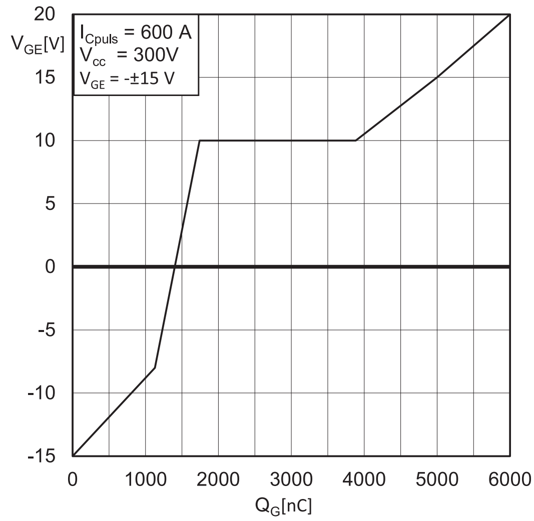



Fig. 18: Typ. IGBT2 gate charge characteristic

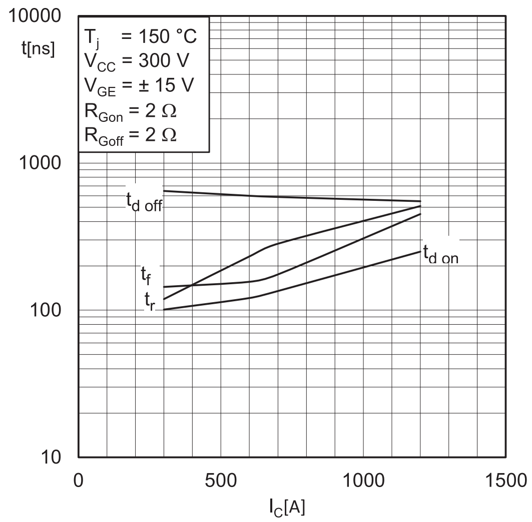



Fig. 19: Typ. IGBT2 switching times vs. $I_C$

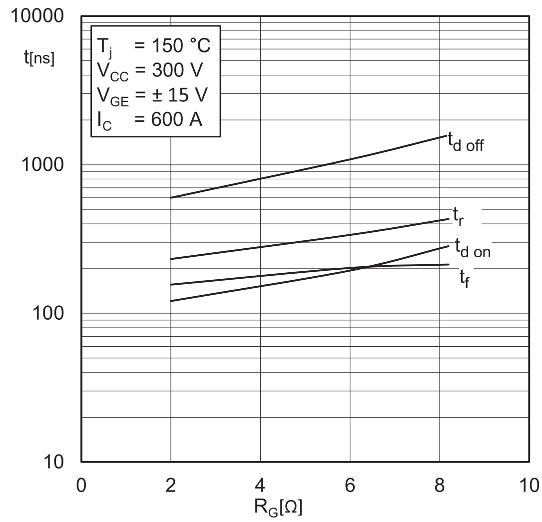



Fig. 20: Typ. IGBT2 switching times vs. gate resistor $R_G$

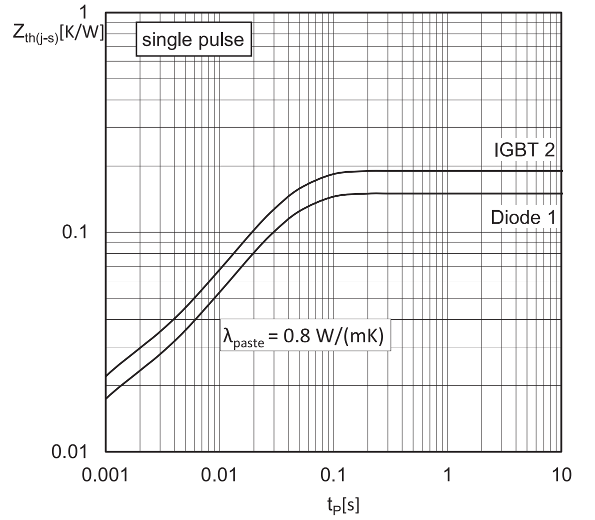



Fig. 21: Transient thermal impedance of IGBT2 & Diode1

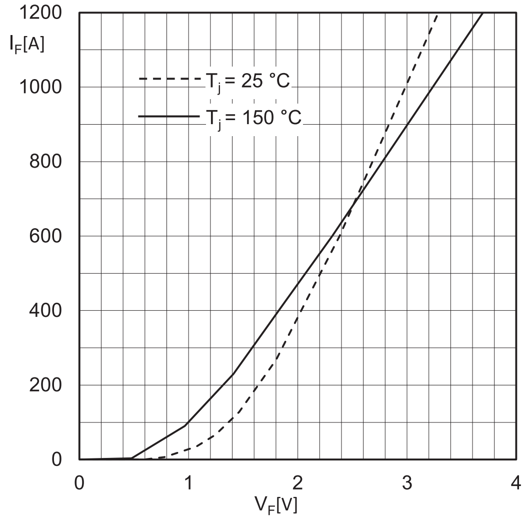
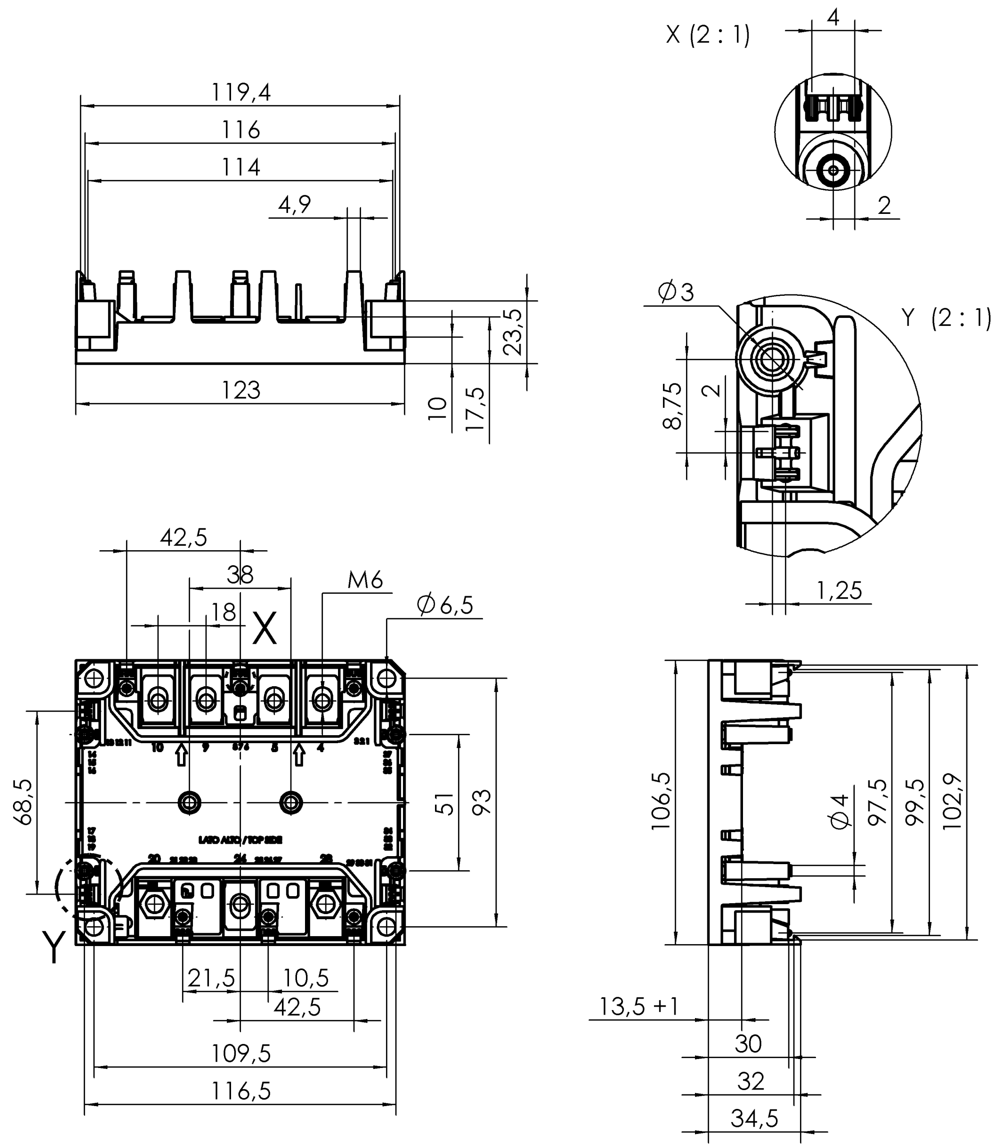
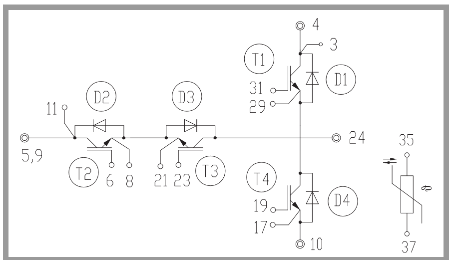



Fig. 22: Typ. Diode1 forward characteristic, incl. $R_{CC'+EE'}$




SKiM 4




TMLI

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

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