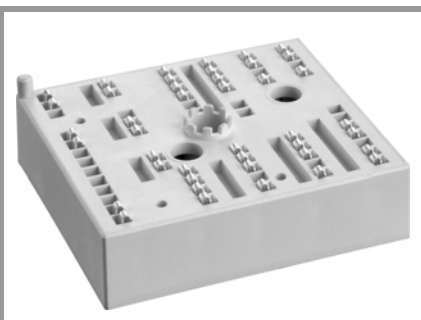


# SKiIP 28TMLI12F4V1



MiniSKiIP® 2

## 3-Level TNPC IGBT-Module

### SKiIP 28TMLI12F4V1

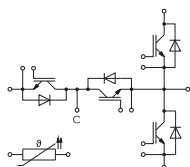
#### Features\*

- Fast Trench 4 IGBTs
- Trench IGBTs
- Robust and soft diodes in CAL technology
- Highly reliable spring contacts for electrical connections
- UL recognised: File no. E63532

#### Remarks\*

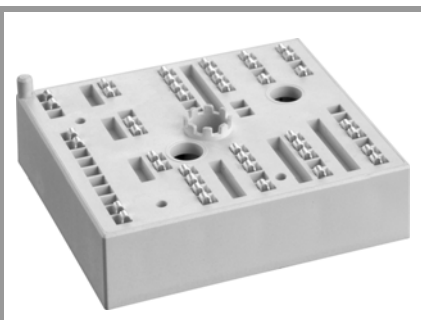
- Case temperature limited to  $T_C=125^\circ\text{C}$  max.;  $T_C = T_S$  (for baseplateless modules)
- Product reliability results valid for  $T_j \leq 150^\circ\text{C}$  (recommended  $T_{jop} = -40 \dots +150^\circ\text{C}$ )
- IGBT 1: outer IGBTs T1&T4
- IGBT 2: inner IGBTs T2&T3
- Diode 1: outer diodes D1&D4
- Diode 2: inner diodes D2&D3

| Absolute Maximum Ratings |   |                          |                  |   |
|--------------------------|---|--------------------------|------------------|---|
| Symbol                   | Conditions  | Values                   | Unit             |   |
| <b>IGBT1</b>             |   |                          |                  |   |
| $V_{CES}$                | $T_j = 25^\circ\text{C}$  | 1200                     | V                |   |
| $I_C$                    | $T_j = 175^\circ\text{C}$   | $T_s = 25^\circ\text{C}$ | 93               | A |
|                          |   | $T_s = 70^\circ\text{C}$ | 76               | A |
| $I_{Cnom}$               |   | 80                       | A                |   |
| $I_{CRM}$                |   | 240                      | A                |   |
| $V_{GES}$                |   | -20 ... 20               | V                |   |
| $t_{psc}$                | $V_{CC} = 800\text{ V}, V_{GE} \leq 15\text{ V}, T_j = 150^\circ\text{C}, V_{CES} \leq 1200\text{ V}$ | 10                       | $\mu\text{s}$    |   |
| $T_j$                    |   | -40 ... 175              | $^\circ\text{C}$ |   |
| <b>IGBT2</b>             |   |                          |                  |   |
| $V_{CES}$                | $T_j = 25^\circ\text{C}$  | 650                      | V                |   |
| $I_C$                    | $T_j = 175^\circ\text{C}$   | $T_s = 25^\circ\text{C}$ | 77               | A |
|                          |   | $T_s = 70^\circ\text{C}$ | 61               | A |
| $I_{Cnom}$               |   | 75                       | A                |   |
| $I_{CRM}$                |   | 225                      | A                |   |
| $V_{GES}$                |   | -20 ... 20               | V                |   |
| $t_{psc}$                | $V_{CC} = 360\text{ V}, V_{GE} \leq 15\text{ V}, T_j = 150^\circ\text{C}, V_{CES} \leq 650\text{ V}$  | 6                        | $\mu\text{s}$    |   |
| $T_j$                    |   | -40 ... 175              | $^\circ\text{C}$ |   |
| <b>Diode1</b>            |   |                          |                  |   |
| $V_{RRM}$                | $T_j = 25^\circ\text{C}$  | 1200                     | V                |   |
| $I_F$                    | $T_j = 175^\circ\text{C}$   | $T_s = 25^\circ\text{C}$ | 76               | A |
|                          |   | $T_s = 70^\circ\text{C}$ | 61               | A |
| $I_{FRM}$                |   | 150                      | A                |   |
| $I_{FSM}$                | 10 ms, sin 180°, $T_j = 25^\circ\text{C}$   | 430                      | A                |   |
| $T_j$                    |   | -40 ... 175              | $^\circ\text{C}$ |   |
| <b>Diode2</b>            |   |                          |                  |   |
| $V_{RRM}$                | $T_j = 25^\circ\text{C}$  | 650                      | V                |   |
| $I_F$                    | $T_j = 175^\circ\text{C}$   | $T_s = 25^\circ\text{C}$ | 65               | A |
|                          |   | $T_s = 70^\circ\text{C}$ | 51               | A |
| $I_{FRM}$                |   | 100                      | A                |   |
| $I_{FSM}$                | 10 ms, sin 180°, $T_j = 25^\circ\text{C}$   | 550                      | A                |   |
| $T_j$                    |   | -40 ... 175              | $^\circ\text{C}$ |   |
| <b>Module</b>            |   |                          |                  |   |
| $I_{t(RMS)}$             | 20 A per spring   | 80                       | A                |   |
| $T_{stg}$                | module without TIM  | -40 ... 125              | $^\circ\text{C}$ |   |
| $V_{isol}$               | AC sinus 50 Hz, $t = 1\text{ min}$  | 2500                     | V                |   |



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# SKiIP 28TMLI12F4V1



MiniSKiIP® 2

## 3-Level TNPC IGBT-Module

### SKiIP 28TMLI12F4V1

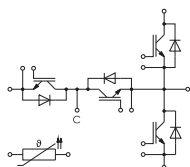
#### Features\*

- Fast Trench 4 IGBTs
- Trench IGBTs
- Robust and soft diodes in CAL technology
- Highly reliable spring contacts for electrical connections
- UL recognised: File no. E63532

#### Remarks\*

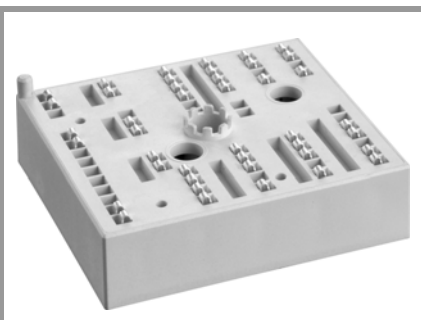
- Case temperature limited to  $T_C=125^\circ\text{C}$  max.;  $T_C = T_S$  (for baseplateless modules)
- Product reliability results valid for  $T_j \leq 150^\circ\text{C}$  (recommended  $T_{jop} = -40 \dots +150^\circ\text{C}$ )
- IGBT 1: outer IGBTs T1&T4
- IGBT 2: inner IGBTs T2&T3
- Diode 1: outer diodes D1&D4
- Diode 2: inner diodes D2&D3

| Characteristics |   |                           |      |      |      |            |
|-----------------|---|---------------------------|------|------|------|------------|
| Symbol          | Conditions  |                           | min. | typ. | max. | Unit       |
| <b>IGBT1</b>    |   |                           |      |      |      |            |
| $V_{CE(sat)}$   | $I_C = 80 \text{ A}$<br>$V_{GE} = 15 \text{ V}$<br>chipelevel                           | $T_j = 25^\circ\text{C}$  |      | 2.05 | 2.40 | V          |
|                 |   | $T_j = 150^\circ\text{C}$ |      | 2.59 | 2.85 | V          |
| $V_{CE0}$       | chipelevel  | $T_j = 25^\circ\text{C}$  |      | 0.80 | 0.90 | V          |
|                 |   | $T_j = 150^\circ\text{C}$ |      | 0.70 | 0.80 | V          |
| $r_{CE}$        | $V_{GE} = 15 \text{ V}$<br>chipelevel   | $T_j = 25^\circ\text{C}$  |      | 16   | 19   | m $\Omega$ |
|                 |   | $T_j = 150^\circ\text{C}$ |      | 24   | 26   | m $\Omega$ |
| $V_{GE(th)}$    | $V_{GE} = V_{CE}, I_C = 1 \text{ mA}$   |                           | 5.2  | 5.8  | 6.4  | V          |
| $I_{CES}$       | $V_{GE} = 0 \text{ V}, V_{CE} = 1200 \text{ V}, T_j = 25^\circ\text{C}$                 |                           |      |      | 1    | mA         |
| $C_{ies}$       | $V_{CE} = 25 \text{ V}$<br>$V_{GE} = 0 \text{ V}$                                       | $f = 1 \text{ MHz}$       |      | 4.60 |      | nF         |
| $C_{oes}$       |   | $f = 1 \text{ MHz}$       |      | 0.37 |      | nF         |
| $C_{res}$       |   | $f = 1 \text{ MHz}$       |      | 0.27 |      | nF         |
| $Q_G$           | $V_{GE} = -8 \text{ V} \dots +15 \text{ V}$   |                           |      | 454  |      | nC         |
| $R_{Gint}$      | $T_j = 25^\circ\text{C}$  |                           |      | 4.0  |      | $\Omega$   |
| $t_{d(on)}$     | $V_{CE} = 300 \text{ V}$  | $T_j = 150^\circ\text{C}$ |      | 168  |      | ns         |
| $t_r$           | $I_C = 80 \text{ A}$  | $T_j = 150^\circ\text{C}$ |      | 54   |      | ns         |
| $E_{on}$        | $V_{GE} = +15/-15 \text{ V}$  | $T_j = 150^\circ\text{C}$ |      | 3.4  |      | mJ         |
| $t_{d(off)}$    | $R_{G on} = 1.6 \Omega$   | $T_j = 150^\circ\text{C}$ |      | 285  |      | ns         |
| $t_f$           | $R_{G off} = 1.6 \Omega$  | $T_j = 150^\circ\text{C}$ |      | 58   |      | ns         |
| $E_{off}$       | $di/dt_{on} = 1330 \text{ A}/\mu\text{s}$<br>$di/dt_{off} = 1220 \text{ A}/\mu\text{s}$ | $T_j = 150^\circ\text{C}$ |      | 2.2  |      | mJ         |
| $R_{th(j-s)}$   | per IGBT, $\lambda_{paste}=0.8 \text{ W}/(\text{K}^*\text{m})$                          |                           |      | 0.49 |      | K/W        |
| <b>IGBT2</b>    |   |                           |      |      |      |            |
| $V_{CE(sat)}$   | $I_C = 75 \text{ A}$<br>$V_{GE} = 15 \text{ V}$<br>chipelevel                           | $T_j = 25^\circ\text{C}$  |      | 1.45 | 1.77 | V          |
|                 |   | $T_j = 150^\circ\text{C}$ |      | 1.70 | 2.10 | V          |
| $V_{CE0}$       | chipelevel  | $T_j = 25^\circ\text{C}$  |      | 0.90 | 1.00 | V          |
|                 |   | $T_j = 150^\circ\text{C}$ |      | 0.82 | 0.90 | V          |
| $r_{CE}$        | $V_{GE} = 15 \text{ V}$<br>chipelevel   | $T_j = 25^\circ\text{C}$  |      | 7.3  | 10   | m $\Omega$ |
|                 |   | $T_j = 150^\circ\text{C}$ |      | 12   | 16   | m $\Omega$ |
| $V_{GE(th)}$    | $V_{GE} = V_{CE}, I_C = 1.2 \text{ mA}$   |                           | 5.1  | 5.8  | 6.4  | V          |
| $I_{CES}$       | $V_{GE} = 0 \text{ V}, V_{CE} = 650 \text{ V}, T_j = 25^\circ\text{C}$                  |                           |      |      | 1    | mA         |
| $C_{ies}$       | $V_{CE} = 25 \text{ V}$<br>$V_{GE} = 0 \text{ V}$                                       | $f = 1 \text{ MHz}$       |      | 4.62 |      | nF         |
| $C_{oes}$       |   | $f = 1 \text{ MHz}$       |      | 0.30 |      | nF         |
| $C_{res}$       |   | $f = 1 \text{ MHz}$       |      | 0.14 |      | nF         |
| $Q_G$           | $V_{GE} = -8 \text{ V} \dots +15 \text{ V}$   |                           |      | 680  |      | nC         |
| $R_{Gint}$      | $T_j = 25^\circ\text{C}$  |                           |      | 4.0  |      | $\Omega$   |
| $t_{d(on)}$     | $V_{CE} = 300 \text{ V}$  | $T_j = 150^\circ\text{C}$ |      | 84   |      | ns         |
| $t_r$           | $I_C = 75 \text{ A}$  | $T_j = 150^\circ\text{C}$ |      | 33   |      | ns         |
| $E_{on}$        | $V_{GE} = +15/-15 \text{ V}$  | $T_j = 150^\circ\text{C}$ |      | 1.6  |      | mJ         |
| $t_{d(off)}$    | $R_{G on} = 1.6 \Omega$   | $T_j = 150^\circ\text{C}$ |      | 212  |      | ns         |
| $t_f$           | $R_{G off} = 1.6 \Omega$  | $T_j = 150^\circ\text{C}$ |      | 65   |      | ns         |
| $E_{off}$       | $di/dt_{on} = 2600 \text{ A}/\mu\text{s}$<br>$di/dt_{off} = 1000 \text{ A}/\mu\text{s}$ | $T_j = 150^\circ\text{C}$ |      | 1.9  |      | mJ         |
| $R_{th(j-s)}$   | per IGBT, $\lambda_{paste}=0.8 \text{ W}/(\text{K}^*\text{m})$                          |                           |      | 0.89 |      | K/W        |



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# SKiIP 28TMLI12F4V1



MiniSKiIP® 2

## 3-Level TNPC IGBT-Module

### SKiIP 28TMLI12F4V1

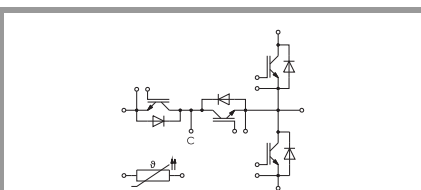
#### Features\*

- Fast Trench 4 IGBTs
- Trench IGBTs
- Robust and soft diodes in CAL technology
- Highly reliable spring contacts for electrical connections
- UL recognised: File no. E63532

#### Remarks\*

- Case temperature limited to  $T_C=125^\circ\text{C}$  max.;  $T_C = T_S$  (for baseplateless modules)
- Product reliability results valid for  $T_j \leq 150^\circ\text{C}$  (recommended  $T_{jop} = -40 \dots +150^\circ\text{C}$ )
- IGBT 1: outer IGBTs T1&T4
- IGBT 2: inner IGBTs T2&T3
- Diode 1: outer diodes D1&D4
- Diode 2: inner diodes D2&D3

| Characteristics           |   |                           | min.                      | typ.             | max. | Unit          |
|---------------------------|---|---------------------------|---------------------------|------------------|------|---------------|
| Symbol                    | Conditions  |                           |                           |                  |      |               |
| <b>Diode1</b>             |   |                           |                           |                  |      |               |
| $V_F = V_{EC}$            | $I_F = 75 \text{ A}$<br>$V_{GE} = 0 \text{ V}$<br>chipelevel  | $T_j = 25^\circ\text{C}$  |                           | 2.17             | 2.49 | V             |
|                           |   | $T_j = 150^\circ\text{C}$ |                           | 2.11             | 2.42 | V             |
| $V_{F0}$                  | chipelevel  | $T_j = 25^\circ\text{C}$  |                           | 1.30             | 1.50 | V             |
|                           |   | $T_j = 150^\circ\text{C}$ |                           | 0.90             | 1.10 | V             |
| $r_F$                     | chipelevel  | $T_j = 25^\circ\text{C}$  |                           | 12               | 13   | m $\Omega$    |
|                           |   | $T_j = 150^\circ\text{C}$ |                           | 16               | 18   | m $\Omega$    |
| $I_{RRM}$                 | $I_F = 75 \text{ A}$  | $T_j = 150^\circ\text{C}$ |                           | 115              |      | A             |
| $Q_{rr}$                  | $di/dt_{off} = 2360 \text{ A}/\mu\text{s}$<br>$V_R = 300 \text{ V}$   | $T_j = 150^\circ\text{C}$ |                           | 8.9              |      | $\mu\text{C}$ |
| $E_{rr}$                  | $V_{GE} = +15/-15 \text{ V}$  | $T_j = 150^\circ\text{C}$ |                           | 1.7              |      | mJ            |
| $R_{th(j-s)}$             | per Diode, $\lambda_{paste}=0.8 \text{ W}/(\text{K}\cdot\text{m})$  |                           |                           | 0.86             |      | K/W           |
| <b>Diode2</b>             |   |                           |                           |                  |      |               |
| $V_F = V_{EC}$            | $I_F = 50 \text{ A}$<br>$V_{GE} = 0 \text{ V}$<br>chipelevel  | $T_j = 25^\circ\text{C}$  |                           | 1.37             | 1.73 | V             |
|                           |   | $T_j = 150^\circ\text{C}$ |                           | 1.35             | 1.72 | V             |
| $V_{F0}$                  | chipelevel  | $T_j = 25^\circ\text{C}$  |                           | 1.04             | 1.24 | V             |
|                           |   | $T_j = 150^\circ\text{C}$ |                           | 0.85             | 0.99 | V             |
| $r_F$                     | chipelevel  | $T_j = 25^\circ\text{C}$  |                           | 6.7              | 9.8  | m $\Omega$    |
|                           |   | $T_j = 150^\circ\text{C}$ |                           | 10               | 15   | m $\Omega$    |
| $I_{RRM}$                 | $I_F = 50 \text{ A}$  | $T_j = 125^\circ\text{C}$ |                           | 48.7             |      | A             |
| $Q_{rr}$                  | $di/dt_{off} = 1250 \text{ A}/\mu\text{s}$<br>$V_R = 300 \text{ V}$   | $T_j = 125^\circ\text{C}$ |                           | 5                |      | $\mu\text{C}$ |
| $E_{rr}$                  | $V_{GE} = +15/-15 \text{ V}$  | $T_j = 125^\circ\text{C}$ |                           | 0.7              |      | mJ            |
| $R_{th(j-s)}$             | per Diode, $\lambda_{paste}=0.8 \text{ W}/(\text{mK})$  |                           |                           | 1.25             |      | K/W           |
| <b>Module</b>             |   |                           |                           |                  |      |               |
| $L_{sCE1}$                |   |                           |                           | -                |      | nH            |
| $L_{CE}$                  |   |                           |                           | -                |      | nH            |
| $R_{CC+EE}$               |   |                           | $T_s = 25^\circ\text{C}$  |                  | -    | m $\Omega$    |
|                           |   |                           | $T_s = 125^\circ\text{C}$ |                  | -    | m $\Omega$    |
| $M_s$                     | to heat sink  |                           | 2                         |                  | 2.5  | Nm            |
| $w$                       |   |                           |                           | 55               |      | g             |
| <b>Temperature Sensor</b> |   |                           |                           |                  |      |               |
| $R_{100}$                 | $T_r=100^\circ\text{C}$ ( $R_{25}=1000\Omega$ )   |                           |                           | 1670 $\pm$<br>3% |      | $\Omega$      |
| $R_{(T)}$                 | $R_{(T)}=1000\Omega[1+A(T-25^\circ\text{C})+B(T-25^\circ\text{C})^2]$<br>$A = 7.635 \cdot 10^{-3} \text{ }^\circ\text{C}^{-1}$<br>$B = 1.731 \cdot 10^{-5} \text{ }^\circ\text{C}^{-2}$ |                           |                           |                  |      |               |



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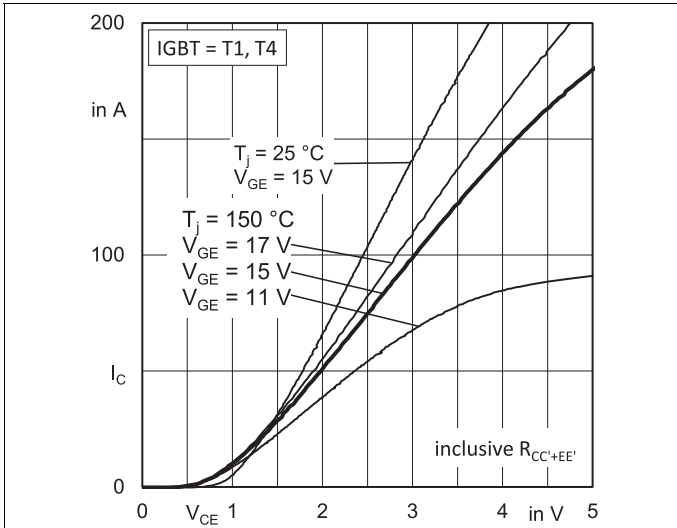


Fig. 1: Typ. IGBT1 output characteristic, incl.  $R_{CC'+EE'}$

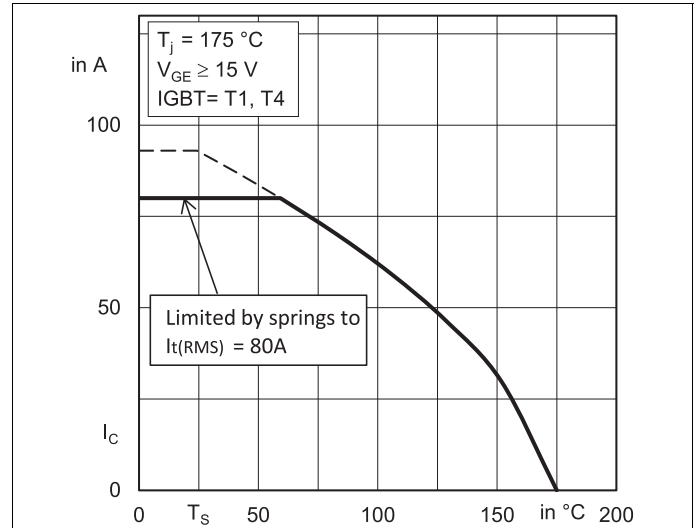


Fig. 2: IGBT1 rated current vs. Temperature  $I_c=f(T_s)$

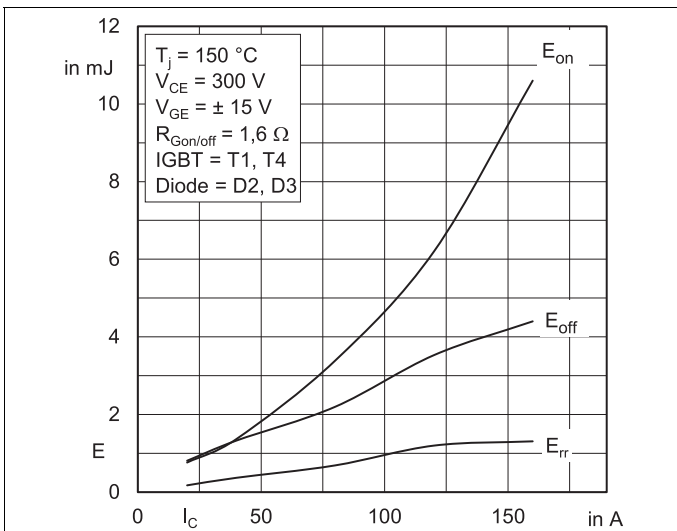


Fig. 3: Typ. IGBT1 & Diode2 turn-on /-off energy =  $f(I_c)$

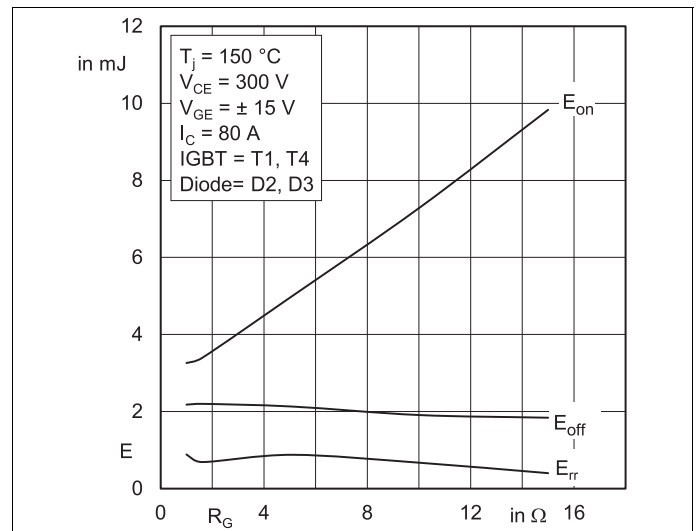


Fig. 4: Typ. IGBT1 & Diode2 turn-on /-off energy =  $f(R_G)$

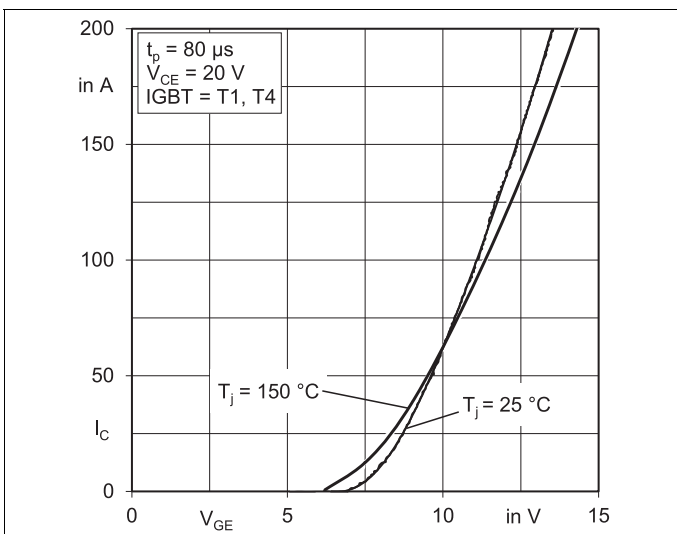


Fig. 5: Typ. IGBT1 transfer characteristic

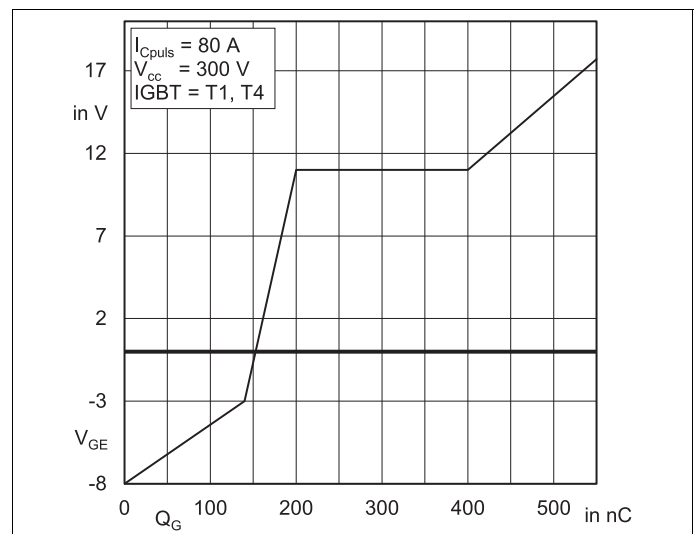


Fig. 6: Typ. IGBT1 gate charge characteristic

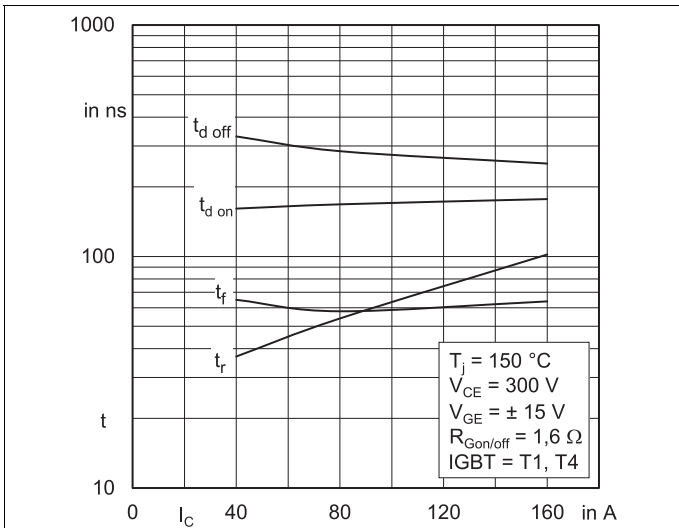


Fig. 7: Typ. IGBT1 switching times vs.  $I_C$

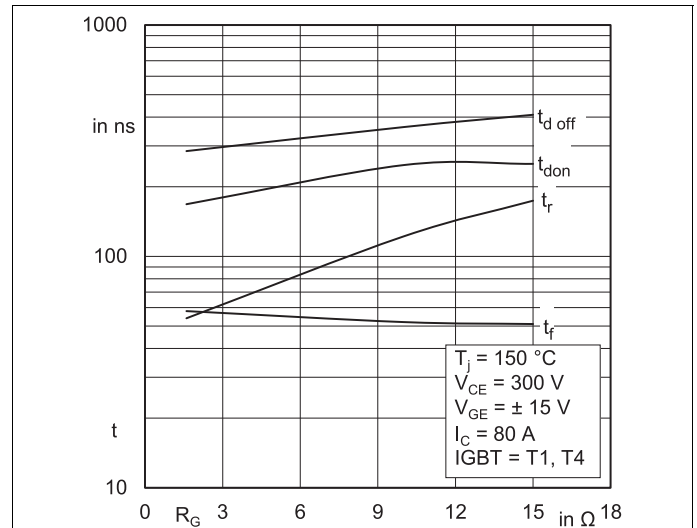


Fig. 8: Typ. IGBT1 switching times vs. gate resistor  $R_G$

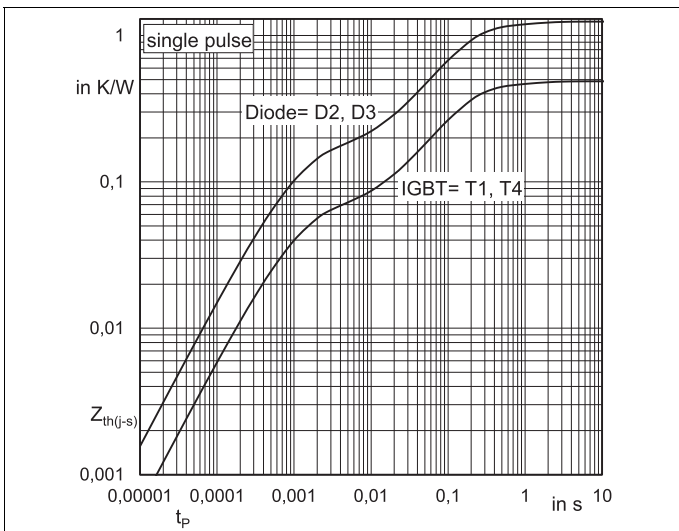


Fig. 9: Typ. Transient thermal impedance of IGBT1 & Diode2

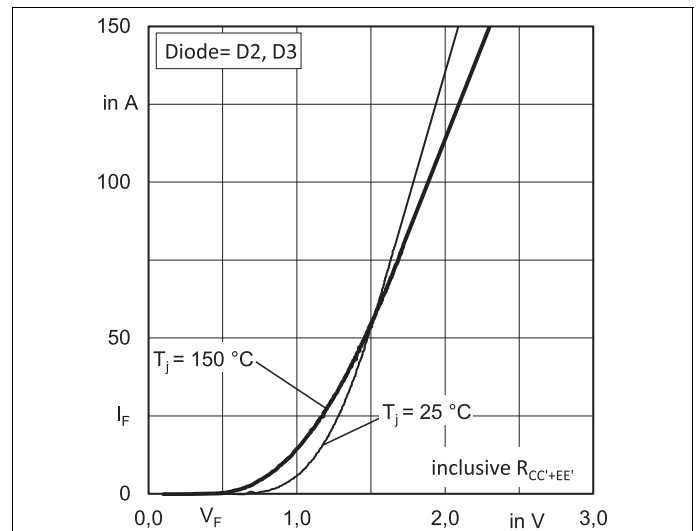


Fig. 10: Typ. Diode2 forward characteristic, incl.  $R_{CC+EE'}$

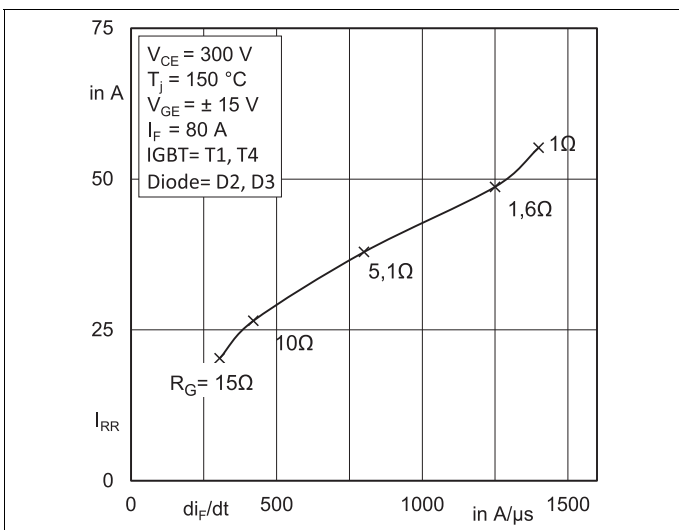


Fig. 11: Typ. Diode2 peak reverse recovery current

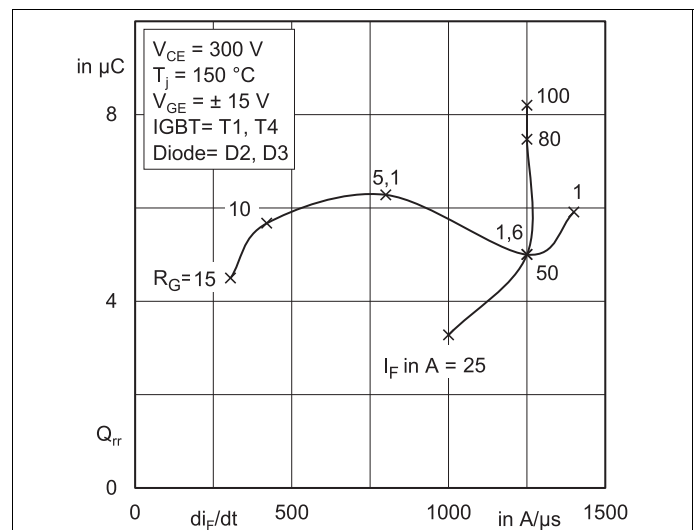


Fig. 12: Typ. Diode2 recovery charge

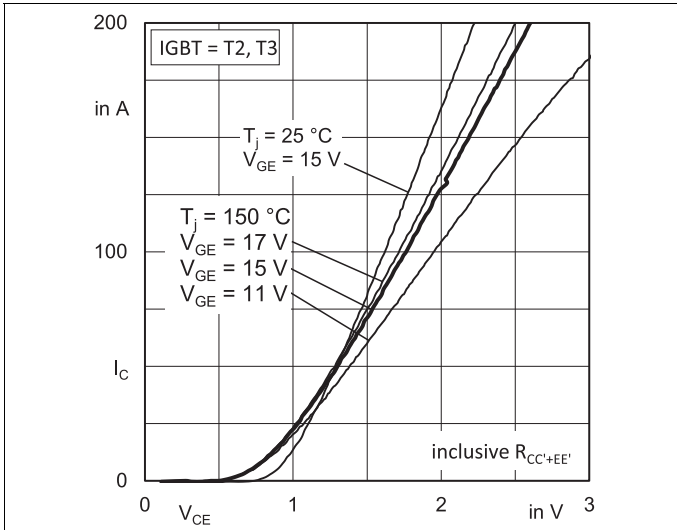


Fig. 13: Typ. IGBT2 output characteristic, incl.  $R_{CC'+EE'}$

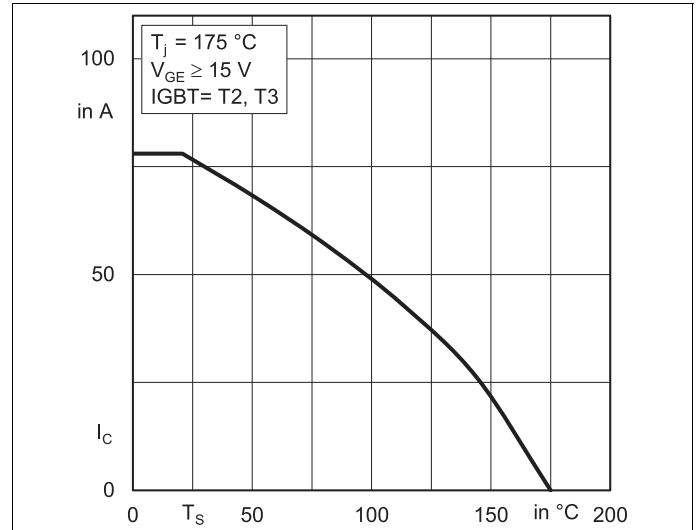


Fig. 14: IGBT2 Rated current vs. Temperature  $I_C = f(T_s)$

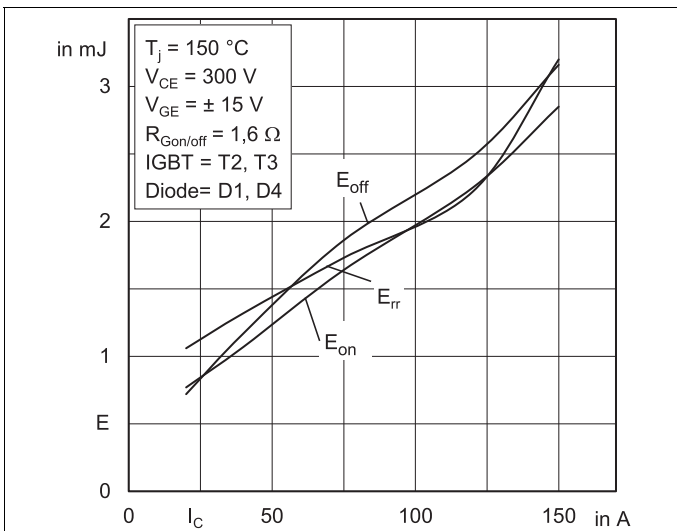


Fig. 15: Typ. IGBT2 & Diode1 turn-on /-off energy =  $f(I_C)$

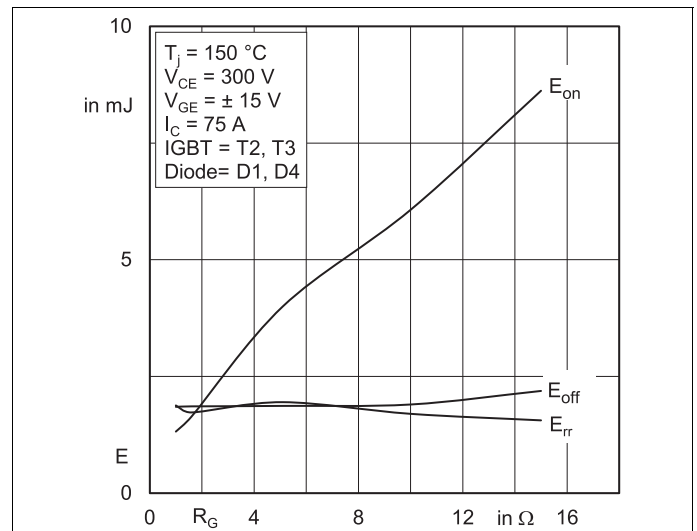


Fig. 16: Typ. IGBT2 & Diode1 turn-on /-off energy =  $f(R_G)$

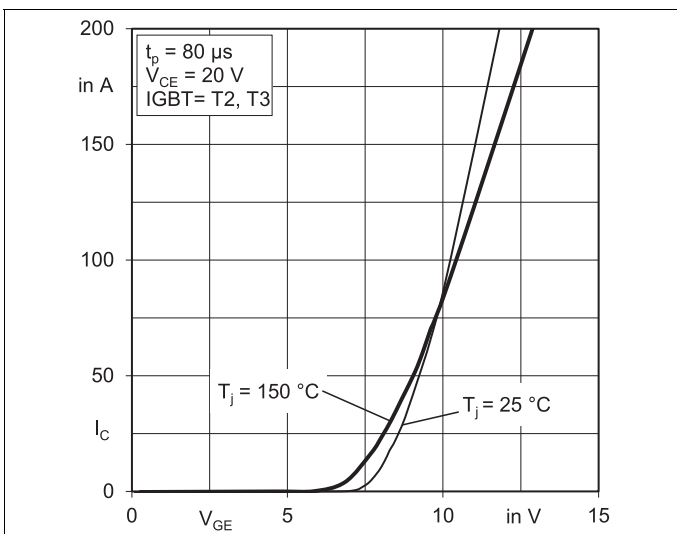


Fig. 17: Typ. IGBT2 transfer characteristic

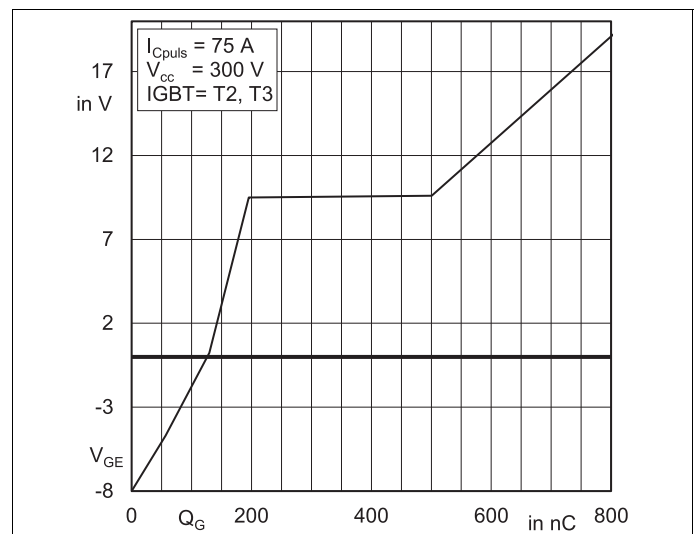


Fig. 18: Typ. IGBT2 gate charge characteristic

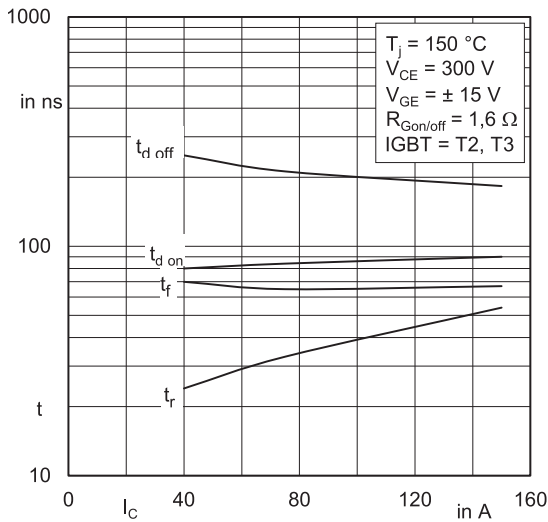


Fig. 19: Typ. IGBT2 switching times vs.  $I_C$

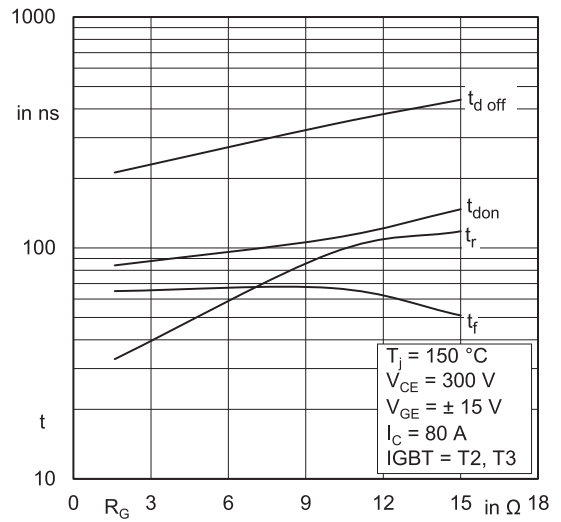


Fig. 20: Typ. IGBT2 switching times vs. gate resistor  $R_G$

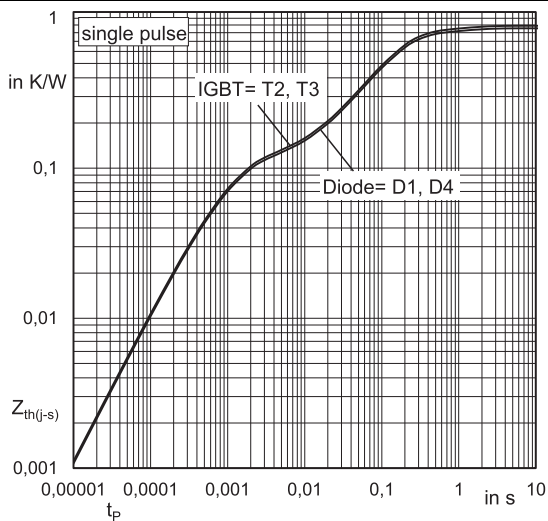


Fig. 21: Transient thermal impedance of IGBT2 & Diode1

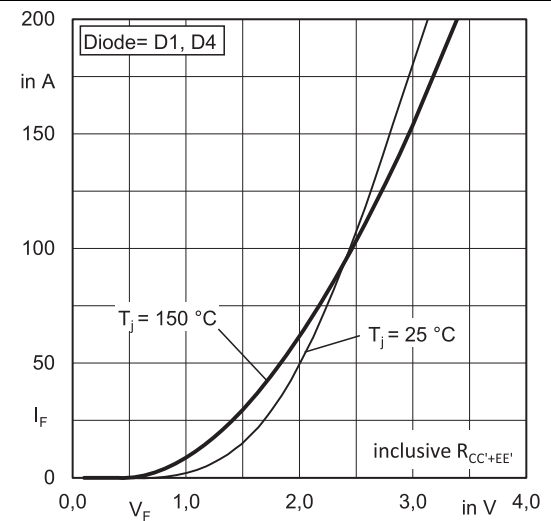


Fig. 22: Typ. Diode1 forward characteristic, incl.  $R_{CC+EE'}$

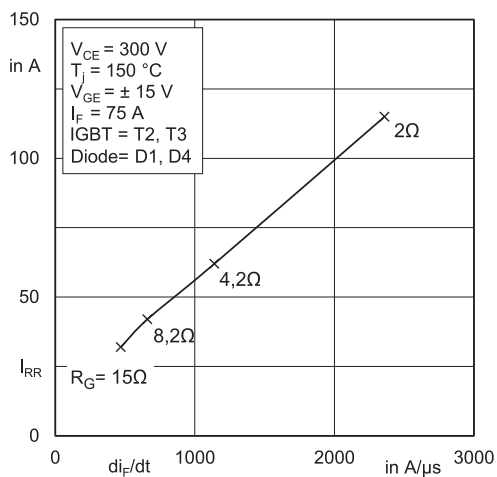


Fig. 23: Typ. Diode1 peak reverse recovery current

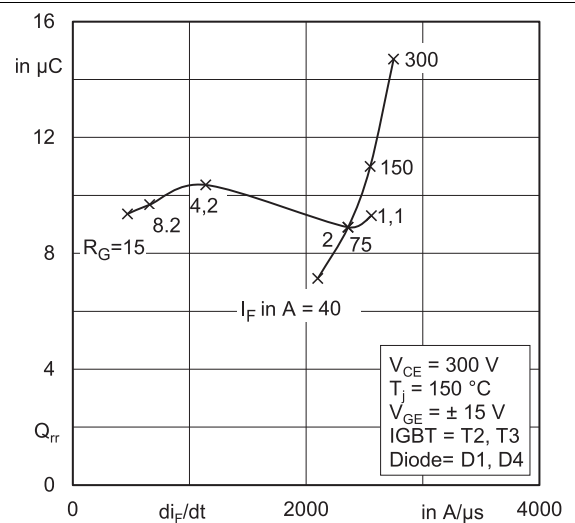
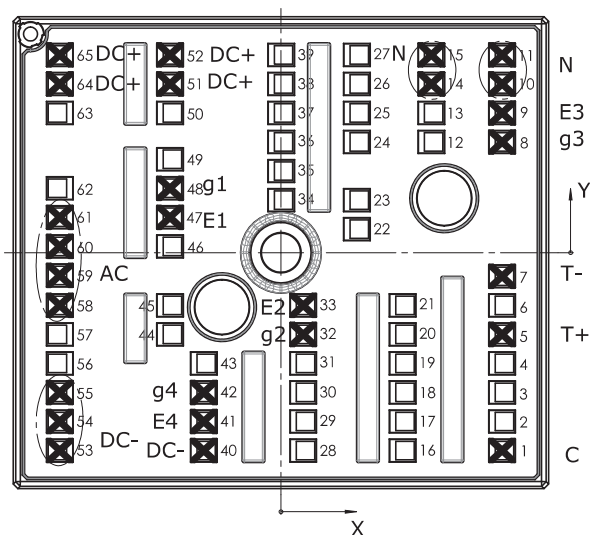


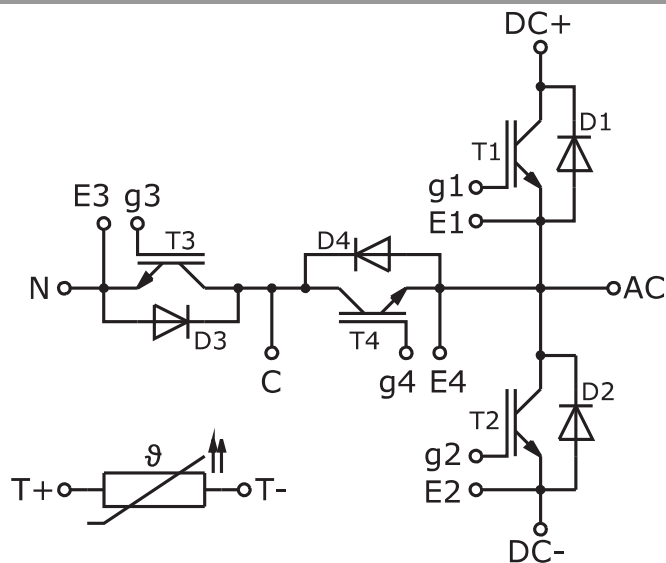
Fig. 24: Typ. Diode1 recovery charge

| Pin out |       |        |          |     |        |        |          |     |        |        |          |
|---------|-------|--------|----------|-----|--------|--------|----------|-----|--------|--------|----------|
| Pin     | X     | Y      | Function | Pin | X      | Y      | Function | Pin | X      | Y      | Function |
| 1       | 24,38 | -21,80 | C        | 23  | 8,38   | 5,80   |          | 45  | -12,23 | -5,80  |          |
| 2       | 24,38 | -18,60 |          | 24  | 8,38   | 12,20  |          | 46  | -12,23 | 0,70   |          |
| 3       | 24,38 | -15,40 |          | 25  | 8,38   | 15,40  |          | 47  | -12,23 | 3,90   | E1       |
| 4       | 24,38 | -12,20 |          | 26  | 8,38   | 18,60  |          | 48  | -12,23 | 7,10   | g1       |
| 5       | 24,38 | -9,00  | T+       | 27  | 8,38   | 21,80  |          | 49  | -12,23 | 10,30  |          |
| 6       | 24,38 | -5,80  |          | 28  | 2,46   | -21,80 |          | 50  | -12,23 | 15,40  |          |
| 7       | 24,38 | -2,60  | T-       | 29  | 2,46   | -18,60 |          | 51  | -12,23 | 18,60  | DC+      |
| 8       | 24,38 | 12,20  | g3       | 30  | 2,46   | -15,40 |          | 52  | -12,23 | 21,80  | DC+      |
| 9       | 24,38 | 15,40  | E3       | 31  | 2,46   | -12,20 |          | 53  | -24,38 | -21,80 | DC-      |
| 10      | 24,38 | 18,60  | N        | 32  | 2,46   | -9,00  | g2       | 54  | -24,38 | -18,60 | DC-      |
| 11      | 24,38 | 21,80  | N        | 33  | 2,46   | -5,80  | E2       | 55  | -24,38 | -15,40 | DC-      |
| 12      | 16,58 | 12,20  |          | 34  | 0,03   | 5,80   |          | 56  | -24,38 | -12,20 |          |
| 13      | 16,58 | 15,40  |          | 35  | 0,03   | 9,00   |          | 57  | -24,38 | -9,00  |          |
| 14      | 16,58 | 18,60  | N        | 36  | 0,03   | 12,20  |          | 58  | -24,38 | -5,80  | AC       |
| 15      | 16,58 | 21,80  | N        | 37  | 0,03   | 15,40  |          | 59  | -24,38 | -2,50  | AC       |
| 16      | 13,42 | -21,80 |          | 38  | 0,03   | 18,60  |          | 60  | -24,38 | 0,70   | AC       |
| 17      | 13,42 | -18,60 |          | 39  | 0,03   | 21,80  |          | 61  | -24,38 | 3,90   | AC       |
| 18      | 13,42 | -15,40 |          | 40  | -8,51  | -21,80 | DC-      | 62  | -24,38 | 7,10   |          |
| 19      | 13,42 | -12,20 |          | 41  | -8,51  | -18,60 | E4       | 63  | -24,38 | 15,40  |          |
| 20      | 13,42 | -9,00  |          | 42  | -8,51  | -15,40 | g4       | 64  | -24,38 | 18,60  | DC+      |
| 21      | 13,42 | -5,80  |          | 43  | -8,51  | -12,20 |          | 65  | -24,38 | 21,80  | DC+      |
| 22      | 8,38  | 2,60   |          | 44  | -12,23 | -9,00  |          |     |        |        |          |

all values in mm



Pinout and Dimensions



Pinout

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

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

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