



**SEMITRANS®3**

## Fast IGBT4 Modules

SKM400GAL12T4

### Features

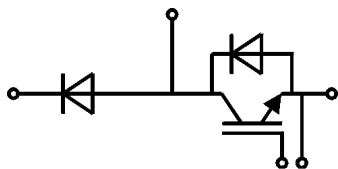
- $V_{CE(sat)}$  with positive temperature coefficient
- High short circuit capability, self limiting to  $6 \times I_{Cnom}$
- Fast & soft inverse CAL diodes
- Large clearance (10 mm) and creepage distances (20 mm)
- Isolated copper baseplate using DBC Technology (Direct Copper Bonding)

### Typical Applications

- DC/DC – converter
- Brake chopper
- Switched reluctance motor
- DC – motor

### Remarks

- Case temperature limited to  $T_c = 125^\circ\text{C}$  max, recomm.  
 $T_{op} = -40 \dots +150^\circ\text{C}$ , product rel. results valid for  $T_j = 150^\circ$



GAL

| Absolute Maximum Ratings |                                                                                |                         |             |      |
|--------------------------|--------------------------------------------------------------------------------|-------------------------|-------------|------|
| Symbol                   | Conditions                                                                     |                         | Values      | Unit |
| IGBT                     |                                                                                |                         |             |      |
| V <sub>CES</sub>         |                                                                                |                         | 1200        | V    |
| I <sub>C</sub>           | T <sub>j</sub> = 175 °C                                                        | T <sub>c</sub> = 25 °C  | 618         | A    |
|                          |                                                                                | T <sub>c</sub> = 80 °C  | 475         | A    |
| I <sub>Cnom</sub>        |                                                                                |                         | 400         | A    |
| I <sub>CRM</sub>         | I <sub>CRM</sub> = 3xI <sub>Cnom</sub>                                         |                         | 1200        | A    |
| V <sub>GES</sub>         |                                                                                |                         | -20 ... 20  | V    |
| t <sub>psc</sub>         | V <sub>CC</sub> = 800 V<br>V <sub>GE</sub> ≤ 15 V<br>V <sub>CES</sub> ≤ 1200 V | T <sub>j</sub> = 150 °C | 10          | μs   |
| T <sub>j</sub>           |                                                                                |                         | -40 ... 175 | °C   |
| Inverse diode            |                                                                                |                         |             |      |
| I <sub>F</sub>           | T <sub>j</sub> = 175 °C                                                        | T <sub>c</sub> = 25 °C  | 440         | A    |
|                          |                                                                                | T <sub>c</sub> = 80 °C  | 329         | A    |
| I <sub>Fnom</sub>        |                                                                                |                         | 400         | A    |
| I <sub>FRM</sub>         | I <sub>FRM</sub> = 3xI <sub>Fnom</sub>                                         |                         | 1200        | A    |
| I <sub>FSM</sub>         | t <sub>p</sub> = 10 ms, sin 180°, T <sub>j</sub> = 25 °C                       |                         | 1980        | A    |
| T <sub>j</sub>           |                                                                                |                         | -40 ... 175 | °C   |
| Freewheeling diode       |                                                                                |                         |             |      |
| I <sub>F</sub>           | T <sub>j</sub> = 175 °C                                                        | T <sub>c</sub> = 25 °C  | 440         | A    |
|                          |                                                                                | T <sub>c</sub> = 80 °C  | 329         | A    |
| I <sub>Fnom</sub>        |                                                                                |                         | 400         | A    |
| I <sub>FRM</sub>         | I <sub>FRM</sub> = 3xI <sub>Fnom</sub>                                         |                         | 1200        | A    |
| I <sub>FSM</sub>         | t <sub>p</sub> = 10 ms, sin 180°, T <sub>j</sub> = 25 °C                       |                         | 1980        | A    |
| T <sub>j</sub>           |                                                                                |                         | -40 ... 175 | °C   |
| Module                   |                                                                                |                         |             |      |
| I <sub>t(RMS)</sub>      |                                                                                |                         | 500         | A    |
| T <sub>stg</sub>         |                                                                                |                         | -40 ... 125 | °C   |
| V <sub>isol</sub>        | AC sinus 50Hz, t = 1 min                                                       |                         | 4000        | V    |

| Characteristics      |                                                             |                         |      |      |      |      |
|----------------------|-------------------------------------------------------------|-------------------------|------|------|------|------|
| Symbol               | Conditions                                                  |                         | min. | typ. | max. | Unit |
| IGBT                 |                                                             |                         |      |      |      |      |
| V <sub>CE(sat)</sub> | I <sub>C</sub> = 400 A                                      | T <sub>J</sub> = 25 °C  |      | 1.8  | 2.05 | V    |
|                      | V <sub>GE</sub> = 15 V<br>chiplevel                         | T <sub>J</sub> = 150 °C |      | 2.2  | 2.4  | V    |
| V <sub>CE0</sub>     |                                                             | T <sub>J</sub> = 25 °C  |      | 0.8  | 0.9  | V    |
|                      |                                                             | T <sub>J</sub> = 150 °C |      | 0.7  | 0.8  | V    |
| r <sub>CE</sub>      | V <sub>GE</sub> = 15 V                                      | T <sub>J</sub> = 25 °C  |      | 2.5  | 2.9  | mΩ   |
|                      |                                                             | T <sub>J</sub> = 150 °C |      | 3.8  | 4.0  | mΩ   |
| V <sub>GE(th)</sub>  | V <sub>GE</sub> =V <sub>CE</sub> , I <sub>C</sub> = 15.2 mA |                         | 5    | 5.8  | 6.5  | V    |
| I <sub>CES</sub>     | V <sub>GE</sub> = 0 V                                       | T <sub>J</sub> = 25 °C  |      | 0.1  | 0.3  | mA   |
|                      | V <sub>CE</sub> = 1200 V                                    | T <sub>J</sub> = 150 °C |      |      |      | mA   |
| C <sub>ies</sub>     | V <sub>CE</sub> = 25 V<br>V <sub>GE</sub> = 0 V             | f = 1 MHz               |      | 24.6 |      | nF   |
| C <sub>oes</sub>     |                                                             | f = 1 MHz               |      | 1.62 |      | nF   |
| C <sub>res</sub>     |                                                             | f = 1 MHz               |      | 1.38 |      | nF   |
| Q <sub>G</sub>       | V <sub>GE</sub> = - 8 V...+ 15 V                            |                         |      | 2260 |      | nC   |
| R <sub>Gint</sub>    | T <sub>J</sub> = 25 °C                                      |                         |      | 1.9  |      | Ω    |



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- Fast & soft inverse CAL diodes
- Large clearance (10 mm) and creepage distances (20 mm)
- Isolated copper baseplate using DBC Technology (Direct Copper Bonding)

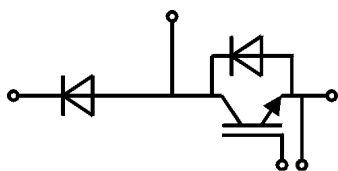
### Typical Applications

- DC/DC – converter
- Brake chopper
- Switched reluctance motor
- DC – motor

### Remarks

- Case temperature limited to  $T_c = 125^\circ\text{C}$  max, recomm.  
 $T_{op} = -40 \dots +150^\circ\text{C}$ , product rel. results valid for  $T_j = 150^\circ$

| Characteristics    |                                           |                           |      |      |                |
|--------------------|-------------------------------------------|---------------------------|------|------|----------------|
| Symbol             | Conditions                                |                           | min. | typ. | max. Unit      |
| $t_{d(on)}$        | $V_{CC} = 600\text{ V}$                   | $T_j = 150^\circ\text{C}$ |      | 220  | ns             |
| $t_r$              | $I_C = 400\text{ A}$                      | $T_j = 150^\circ\text{C}$ |      | 47   | ns             |
| $E_{on}$           | $V_{GE} = \pm 15\text{ V}$                | $T_j = 150^\circ\text{C}$ |      | 33   | mJ             |
| $t_{d(off)}$       | $R_{G\ on} = 1\ \Omega$                   | $T_j = 150^\circ\text{C}$ |      | 505  | ns             |
| $t_f$              | $R_{G\ off} = 1\ \Omega$                  | $T_j = 150^\circ\text{C}$ |      | 78   | ns             |
| $E_{off}$          | $di/dt_{on} = 9700\text{ A}/\mu\text{s}$  | $T_j = 150^\circ\text{C}$ |      | 42   | mJ             |
| $R_{th(j-c)}$      | $di/dt_{off} = 4300\text{ A}/\mu\text{s}$ | $T_j = 150^\circ\text{C}$ |      |      | 0.072 K/W      |
|                    | per IGBT                                  |                           |      |      |                |
| Inverse diode      |                                           |                           |      |      |                |
| $V_F = V_{EC}$     | $I_F = 400\text{ A}$                      | $T_j = 25^\circ\text{C}$  |      | 2.2  | 2.52 V         |
|                    | $V_{GE} = 0\text{ V}$                     | $T_j = 150^\circ\text{C}$ |      | 2.15 | 2.47 V         |
|                    | chip                                      |                           |      |      |                |
| $V_{F0}$           |                                           | $T_j = 25^\circ\text{C}$  |      | 1.3  | 1.5 V          |
|                    |                                           | $T_j = 150^\circ\text{C}$ |      | 0.9  | 1.1 V          |
| $r_F$              |                                           | $T_j = 25^\circ\text{C}$  |      | 2.3  | 2.5 m $\Omega$ |
|                    |                                           | $T_j = 150^\circ\text{C}$ |      | 3.1  | 3.4 m $\Omega$ |
| $I_{RRM}$          | $I_F = 400\text{ A}$                      | $T_j = 150^\circ\text{C}$ |      | 450  | A              |
| $Q_{rr}$           | $di/dt_{off} = 8800\text{ A}/\mu\text{s}$ | $T_j = 150^\circ\text{C}$ |      | 68   | $\mu\text{C}$  |
| $E_{rr}$           | $V_{GE} = \pm 15\text{ V}$                | $T_j = 150^\circ\text{C}$ |      | 30.5 | mJ             |
|                    | $V_{CC} = 600\text{ V}$                   | $T_j = 150^\circ\text{C}$ |      |      |                |
| $R_{th(j-c)}$      | per diode                                 |                           |      | 0.14 | K/W            |
| Freewheeling diode |                                           |                           |      |      |                |
| $V_F = V_{EC}$     | $I_F = 400\text{ A}$                      | $T_j = 25^\circ\text{C}$  |      | 2.2  | 2.52 V         |
|                    | $V_{GE} = 0\text{ V}$                     | $T_j = 150^\circ\text{C}$ |      | 2.15 | 2.47 V         |
|                    | chip                                      |                           |      |      |                |
| $V_{F0}$           |                                           | $T_j = 25^\circ\text{C}$  |      | 1.3  | 1.5 V          |
|                    |                                           | $T_j = 150^\circ\text{C}$ |      | 0.9  | 1.1 V          |
| $r_F$              |                                           | $T_j = 25^\circ\text{C}$  |      | 2.3  | 2.5 m $\Omega$ |
|                    |                                           | $T_j = 150^\circ\text{C}$ |      | 3.1  | 3.4 m $\Omega$ |
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|                    | $V_{CC} = 600\text{ V}$                   | $T_j = 150^\circ\text{C}$ |      |      |                |
| $R_{th(j-c)}$      | per Diode                                 |                           |      | 0.14 | K/W            |
| Module             |                                           |                           |      |      |                |
| $L_{CE}$           |                                           |                           |      | 15   | 20 nH          |
| $R_{CC'+EE'}$      | terminal-chip                             | $T_c = 25^\circ\text{C}$  |      | 0.25 | m $\Omega$     |
|                    |                                           | $T_c = 125^\circ\text{C}$ |      | 0.5  | m $\Omega$     |
| $R_{th(c-s)}$      | per module                                |                           |      | 0.02 | 0.038 K/W      |
| $M_s$              | to heat sink M6                           |                           | 3    | 5    | Nm             |
| $M_t$              |                                           | to terminals M6           | 2.5  | 5    | Nm             |
|                    |                                           |                           |      |      | Nm             |
| w                  |                                           |                           |      | 325  | g              |



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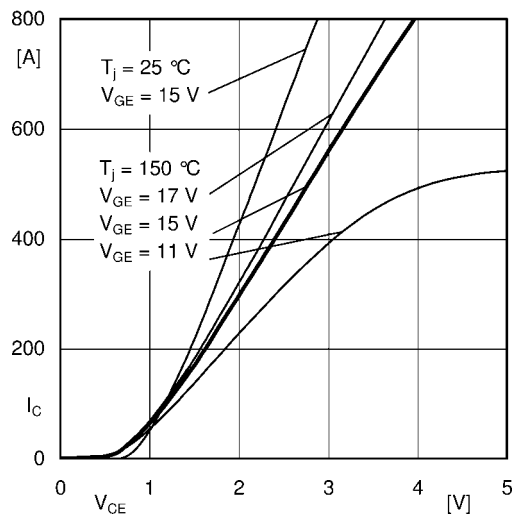


Fig. 1: Typ. output characteristic, inclusive  $R_{CC'} + E_{E'}$

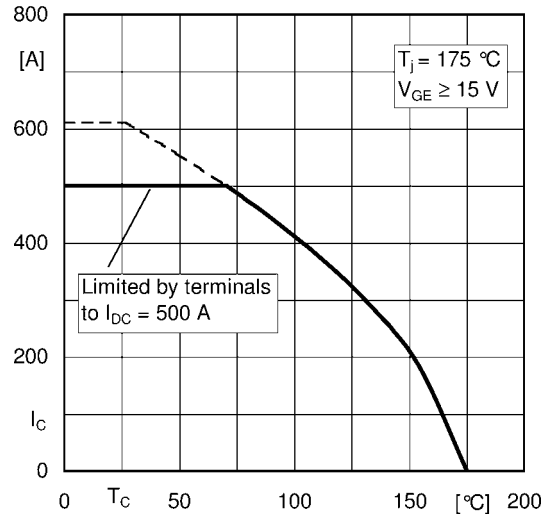


Fig. 2: Rated current vs. temperature  $I_C = f(T_C)$

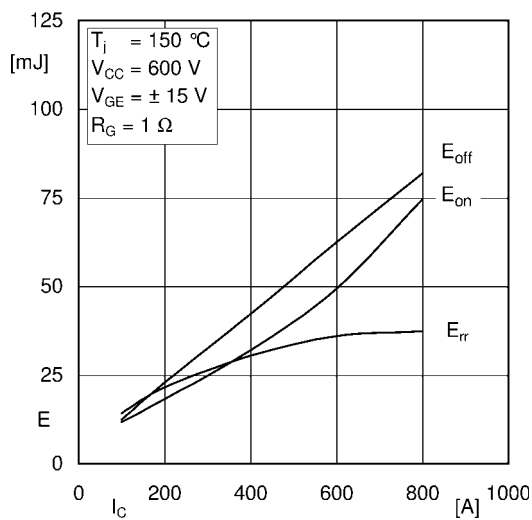


Fig. 3: Typ. turn-on /-off energy =  $f(I_C)$

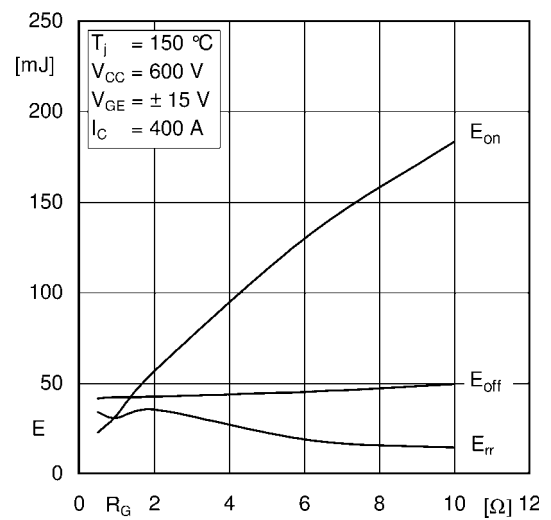


Fig. 4: Typ. turn-on /-off energy =  $f(R_G)$

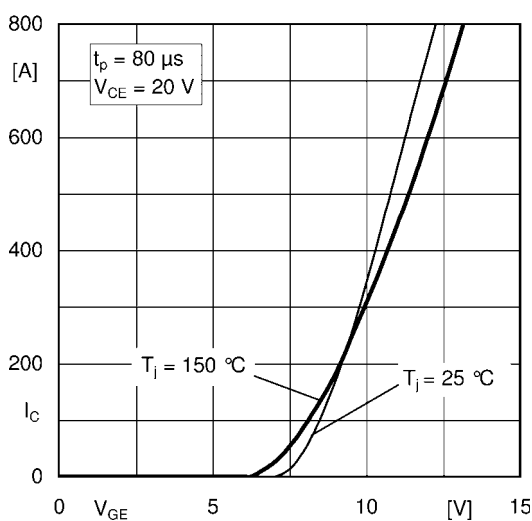


Fig. 5: Typ. transfer characteristic

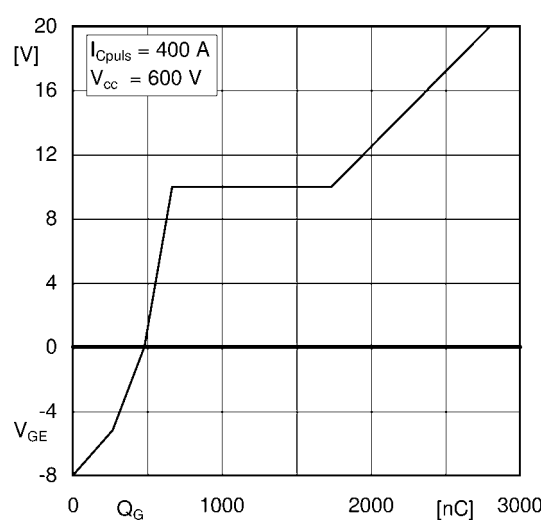


Fig. 6: Typ. gate charge characteristic

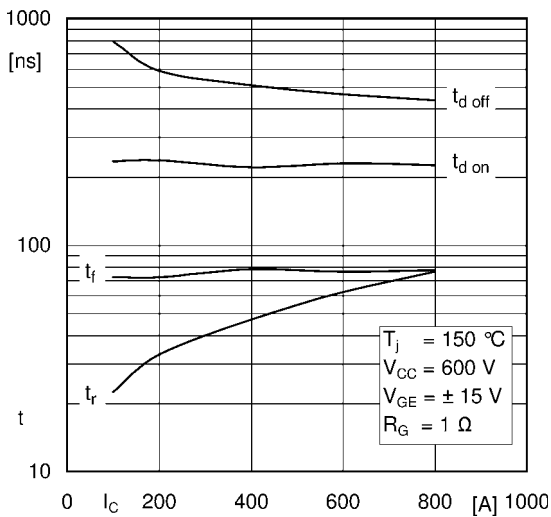


Fig. 7: Typ. switching times vs.  $I_C$

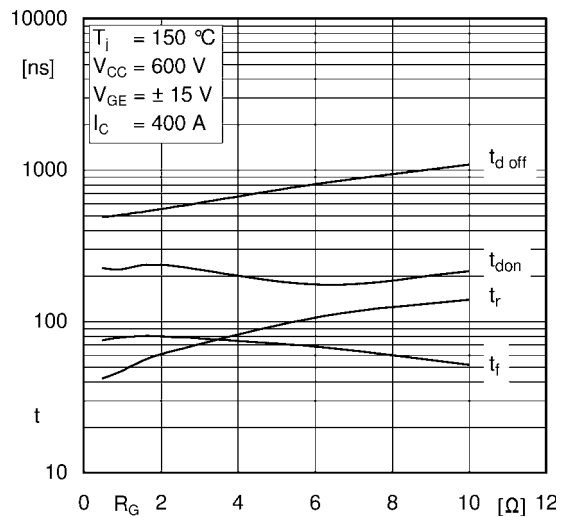


Fig. 8: Typ. switching times vs. gate resistor  $R_G$

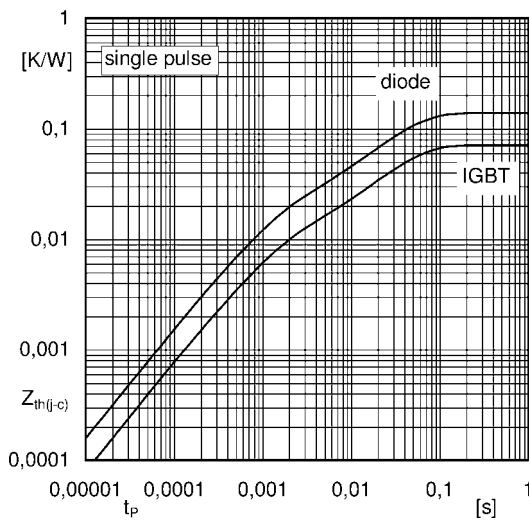


Fig. 9: Transient thermal impedance

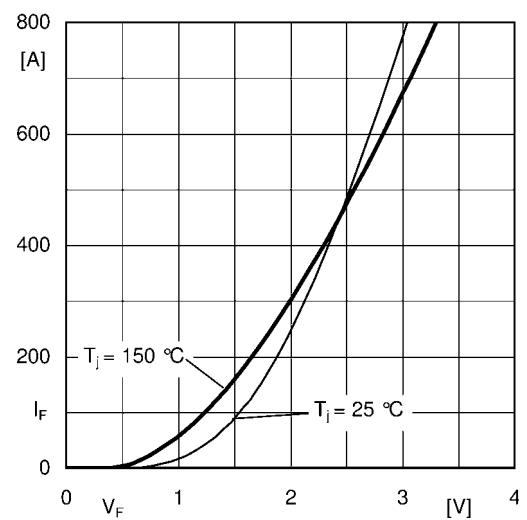


Fig. 10: CAL diode forward characteristic

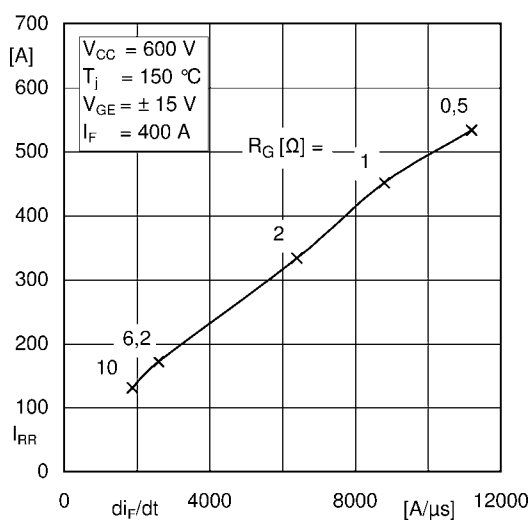


Fig. 11: CAL diode peak reverse recovery current

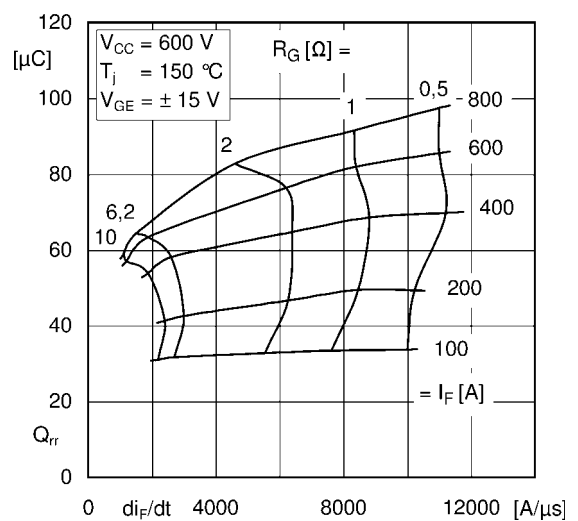
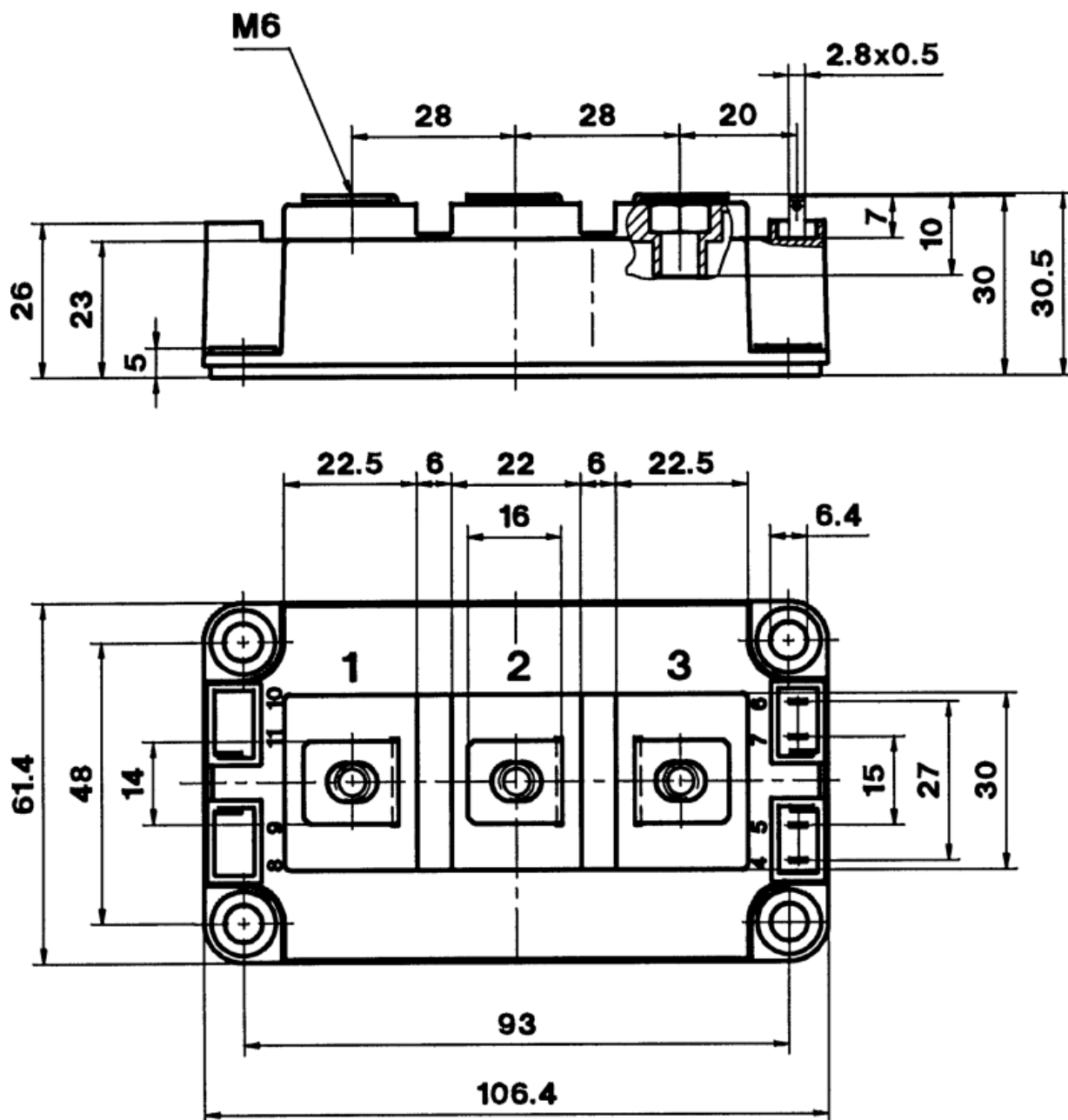
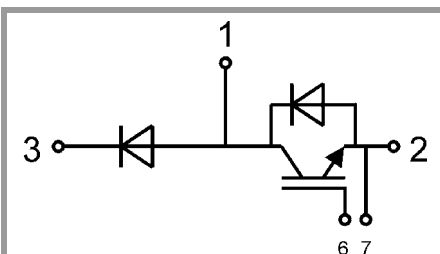


Fig. 12: Typ. CAL diode peak reverse recovery charge



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

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