## *flow* PIM 0 — 600V/10A

### Features

- Clip-in housing
- Trench Fieldstop IGBT's for low saturation losses
- Optional w/o BRC

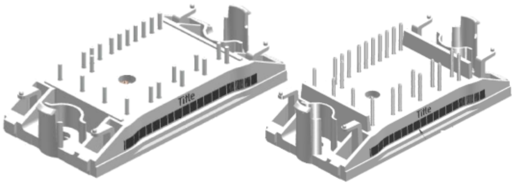
### Target Applications

- Industrial drives
- Embedded drives

### Types

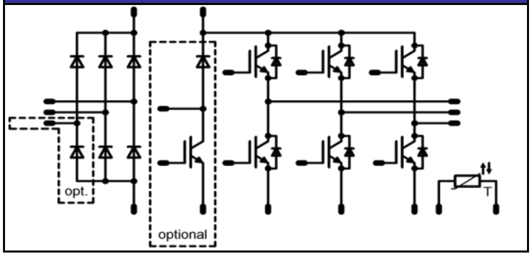
- V23990-P543-A28-PM
- V23990-P543-A29-PM
- V23990-P543-C28-PM
- V23990-P543-C29-PM

### *flow* PIM 0



12mm housing    17mm housing

### Schematic




# Maximum Ratings

$T_j$=25°C, unless otherwise specified

| Parameter | Symbol | Condition | | Value | Unit |
|---|---|---|---|---|---|
| **Input Rectifier Diode** | | | | | |
| Repetitive peak reverse voltage | $V_{RRM}$ | | | 1600 | V |
| DC forward current | $I_{FAV}$ | $T_j$=$T_j$max | $T_h$=80°C<br>$T_c$=80°C | 28<br>37 | A |
| Surge forward current | $I_{FSM}$ | $t_p$=10ms<br>50 Hz half sine wave | $T_j$=25°C | 200 | A |
| I2t-value | $I^2t$ | | | 200 | $A^2s$ |
| Power dissipation per Diode | $P_{tot}$ | $T_j$=$T_j$max | $T_h$=80°C<br>$T_c$=80°C | 33<br>50 | W |
| Maximum Junction Temperature | $T_j$max | | | 150 | °C |
| **Inverter Transistor** | | | | | |
| Collector-emitter break down voltage | $V_{CE}$ | | | 600 | V |
| DC collector current | $I_C$ | $T_j$=$T_j$max | $T_h$=80°C<br>$T_c$=80°C | 16<br>20 | A |
| Repetitive peak collector current | $I_{Cpulse}$ | $t_p$ limited by $T_j$max | | 30 | A |
| Turn off safe operating area | | VCE ≤ 1200V, Tj ≤ Top max | | 30 | A |
| Power dissipation per IGBT | $P_{tot}$ | $T_j$=$T_j$max | $T_h$=80°C<br>$T_c$=80°C | 39<br>60 | W |
| Gate-emitter peak voltage | $V_{GE}$ | | | ±20 | V |
| Short circuit ratings | $t_{SC}$<br>$V_{CC}$ | $T_j$≤150°C<br>$V_{GE}$=15V | | 6<br>360 | μs<br>V |
| Maximum Junction Temperature | $T_j$max | | | 175 | °C |

# Maximum Ratings

$T_j$=25℃, unless otherwise specified

| Parameter | Symbol | Condition | | Value | Unit |
|---|---|---|---|---|---|
| **Inverter Diode** | | | | | |
| Peak Repetitive Reverse Voltage | $V_{RRM}$ | | | 600 | V |
| DC forward current | $I_F$ | $T_j$=$T_j$max | $T_h$=80℃<br>$T_c$=80℃ | 25<br>25 | A |
| Repetitive peak forward current | $I_{FRM}$ | $t_p$ limited by $T_j$max | | 20 | A |
| Power dissipation per Diode | $P_{tot}$ | $T_j$=$T_j$max | $T_h$=80℃<br>$T_c$=80℃ | 22<br>32 | W |
| Maximum Junction Temperature | $T_j$max | | | 175 | ℃ |
| **Brake Transistor** | | | | | |
| Collector-emitter break down voltage | $V_{CE}$ | | | 600 | V |
| DC collector current | $I_C$ | $T_j$=$T_j$max | $T_h$=80℃<br>$T_c$=80℃ | 11<br>14 | A |
| Repetitive peak collector current | $I_{Cpuls}$ | $t_p$ limited by $T_j$max | | 18 | A |
| Turn off safe operating area | | VCE ≤ 1200V, Tj ≤ Top max | | 18 | A |
| Power dissipation per IGBT | $P_{tot}$ | $T_j$=$T_j$max | $T_h$=80℃<br>$T_c$=80℃ | 31<br>47 | W |
| Gate-emitter peak voltage | $V_{GE}$ | | | ±20 | V |
| Short circuit ratings | $t_{SC}$<br>$V_{CC}$ | $T_j$≤150℃<br>$V_{GE}$=15V | | 6<br>360 | μs<br>V |
| Maximum Junction Temperature | $T_j$max | | | 175 | ℃ |
| **Brake Diode** | | | | | |
| Peak Repetitive Reverse Voltage | $V_{RRM}$ | | | 600 | V |
| DC forward current | $I_F$ | $T_j$=$T_j$max | $T_h$=80℃<br>$T_c$=80℃ | 10<br>10 | A |
| Repetitive peak forward current | $I_{FRM}$ | $t_p$ limited by $T_j$max | | 12 | A |
| Power dissipation per Diode | $P_{tot}$ | $T_j$=$T_j$max | $T_h$=80℃<br>$T_c$=80℃ | 22<br>34 | W |
| Maximum Junction Temperature | $T_j$max | | | 175 | ℃ |
| **Thermal Properties** | | | | | |
| Storage temperature | $T_{stg}$ | | | -40…+125 | ℃ |
| Operation temperature under switching condition | $T_{op}$ | | | -40…+(Tjmax - 25) | ℃ |
| **Insulation Properties** | | | | | |
| Insulation voltage | $V_{is}$ | t=2s | DC voltage | 4000 | V |
| Creepage distance | | | | min 12,7 | mm |
| Clearance | | | | min 12,7 | mm |
| Comparative tracking index | CTI | | | >200 | |

## Characteristic Values

| Parameter | Symbol | Conditions | $V_{GE}$ [V] or $V_{GS}$ [V] | $V_r$ [V] or $V_{CE}$ [V] or $V_{DS}$ [V] | $I_C$ [A] or $I_F$ [A] or $I_D$ [A] | $T_j$ | Min | Typ | Max | Unit |
|---|---|---|---|---|---|---|---|---|---|---|
| **Input Rectifier Diode** | | | | | | | | | | |
| Forward voltage | $V_F$ | | | | 30 | Tj=25°C<br>Tj=125°C | 0,8 | 1,26<br>1,24 | 1,45 | V |
| Threshold voltage (for power loss calc. only) | $V_{to}$ | | | | 30 | Tj=25°C<br>Tj=125°C | | 0,92<br>0,82 | | V |
| Slope resistance (for power loss calc. only) | $r_t$ | | | | 30 | Tj=25°C<br>Tj=125°C | | 11<br>14 | | mΩ |
| Reverse current | $I_r$ | | | 1500 | | Tj=25°C<br>Tj=145°C | | | 1,1 | mA |
| Thermal resistance chip to heatsink per chip | $R_{thJH}$ | Thermal grease thickness≤50µm λ = 1 W/mK | | | | | | 2,10 | | K/W |
| **Inverter Transistor** | | | | | | | | | | |
| Gate emitter threshold voltage | $V_{GE(th)}$ | $V_{CE}=V_{GE}$ | | | 0,00015 | Tj=25°C<br>Tj=150°C | 5 | 5,8 | 6,5 | V |
| Collector-emitter saturation voltage | $V_{CE(sat)}$ | | 15 | | 10 | Tj=25°C<br>Tj=150°C | 1 | 1,59<br>1,78 | 2,2 | V |
| Collector-emitter cut-off current incl. Diode | $I_{CES}$ | | 0 | 600 | | Tj=25°C<br>Tj=150°C | | | 0,08 | mA |
| Gate-emitter leakage current | $I_{GES}$ | | 20 | 0 | | Tj=25°C<br>Tj=150°C | | | 350 | nA |
| Integrated Gate resistor | $R_{gint}$ | | | | | | | none | | Ω |
| Turn-on delay time | $t_{d(on)}$ | Rgoff=16 Ω<br>Rgon=32 Ω | ±15 | 300 | 10 | Tj=25°C<br>Tj=150°C | | 15<br>14 | | ns |
| Rise time | $t_r$ | | | | | Tj=25°C<br>Tj=150°C | | 11<br>14 | | ns |
| Turn-off delay time | $t_{d(off)}$ | | | | | Tj=25°C<br>Tj=150°C | | 155<br>170 | | ns |
| Fall time | $t_f$ | | | | | Tj=25°C<br>Tj=150°C | | 89<br>98 | | ns |
| Turn-on energy loss per pulse | $E_{on}$ | | | | | Tj=25°C<br>Tj=150°C | | 0,16<br>0,22 | | mWs |
| Turn-off energy loss per pulse | $E_{off}$ | | | | | Tj=25°C<br>Tj=150°C | | 0,24<br>0,29 | | mWs |
| Input capacitance | $C_{ies}$ | f=1MHz | 0 | 25 | | Tj=25°C | | 551 | | pF |
| Output capacitance | $C_{oss}$ | | | | | | | 40 | | pF |
| Reverse transfer capacitance | $C_{rss}$ | | | | | | | 17 | | pF |
| Gate charge | $Q_{Gate}$ | | ±15 | 480 | 10 | Tj=25°C | | 62 | | nC |
| Thermal resistance chip to heatsink per chip | $R_{thJH}$ | Thermal grease thickness≤50µm λ = 1 W/mK | | | | | | 2,41 | | K/W |
| **Inverter Diode** | | | | | | | | | | |
| Diode forward voltage | $V_F$ | | | | 10 | Tj=25°C<br>Tj=150°C | 1 | 1,61<br>1,51 | 2,25 | V |
| Peak reverse recovery current | $I_{RRM}$ | Rgon=32 Ω | ±15 | 300 | 10 | Tj=25°C<br>Tj=150°C | | 10<br>11 | | A |
| Reverse recovery time | $t_{rr}$ | | | | | Tj=25°C<br>Tj=150°C | | 142<br>219 | | ns |
| Reverse recovered charge | $Q_{rr}$ | | | | | Tj=25°C<br>Tj=150°C | | 0,46<br>0,80 | | µC |
| Peak rate of fall of recovery current | di(rec)max /dt | | | | | Tj=25°C<br>Tj=150°C | | 703<br>397 | | A/µs |
| Reverse recovered energy | Erec | | | | | Tj=25°C<br>Tj=150°C | | 0,09<br>0,17 | | mWs |
| Thermal resistance chip to heatsink per chip | $R_{thJH}$ | Thermal grease thickness≤50µm λ = 1 W/mK | | | | | | 3,33 | | K/W |

## Characteristic Values

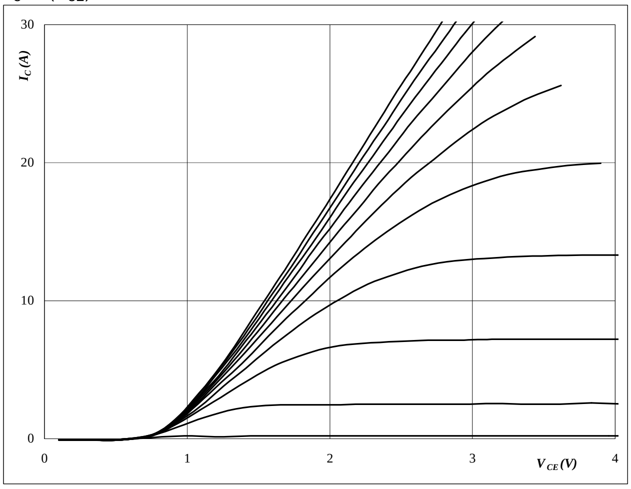
| Parameter | Symbol | Conditions | $V_{GE}$ [V] or $V_{GS}$ [V] | $V_r$ [V] or $V_{CE}$ [V] or $V_{DS}$ [V] | $I_C$ [A] or $I_F$ [A] or $I_D$ [A] | $T_j$ | Min | Typ | Max | Unit |
|---|---|---|---|---|---|---|---|---|---|---|
| **Brake Transistor** | | | | | | | | | | |
| Gate emitter threshold voltage | $V_{GE(th)}$ | $V_{CE}=V_{GE}$ | | | 0,00043 | Tj=25℃<br>Tj=150℃ | 5 | 5,8 | 6,5 | V |
| Collector-emitter saturation voltage | $V_{CE(sat)}$ | | 15 | | 6 | Tj=25℃<br>Tj=150℃ | 1 | 1,55<br>1,72 | 2,1 | V |
| Collector-emitter cut-off incl diode | $I_{CES}$ | | 0 | 600 | | Tj=25℃<br>Tj=150℃ | | | 0,06 | mA |
| Gate-emitter leakage current | $I_{GES}$ | | 20 | 0 | | Tj=25℃<br>Tj=150℃ | | | 350 | nA |
| Integrated Gate resistor | $R_{gint}$ | | | | | | | none | | Ω |
| Turn-on delay time | $t_{d(on)}$ | Rgoff=16 Ω<br>Rgon=32 Ω | ±15 | 300 | 6 | Tj=25℃<br>Tj=150℃ | | 11<br>10 | | ns |
| Rise time | $t_r$ | | | | | Tj=25℃<br>Tj=150℃ | | 8<br>10 | | |
| Turn-off delay time | $t_{d(off)}$ | | | | | Tj=25℃<br>Tj=150℃ | | 118<br>130 | | |
| Fall time | $t_f$ | | | | | Tj=25℃<br>Tj=150℃ | | 93<br>117 | | |
| Turn-on energy loss per pulse | $E_{on}$ | | | | | Tj=25℃<br>Tj=150℃ | | 0,07<br>0,10 | | mWs |
| Turn-off energy loss per pulse | $E_{off}$ | | | | | Tj=25℃<br>Tj=150℃ | | 0,15<br>0,18 | | |
| Input capacitance | $C_{ies}$ | f=1MHz | 0 | 25 | | Tj=25℃ | | 368 | | pF |
| Output capacitance | $C_{oss}$ | | | | | | | 28 | | |
| Reverse transfer capacitance | $C_{rss}$ | | | | | | | 11 | | |
| Gate charge | $Q_{Gate}$ | | | | | Tj=25℃ | | 42 | | nC |
| Thermal resistance chip to heatsink per chip | $R_{thJH}$ | Thermal grease thickness≤50µm<br>λ = 1 W/mK | | | | | | 3,07 | | K/W |
| **Brake Diode** | | | | | | | | | | |
| Diode forward voltage | $V_F$ | | | | 6 | Tj=25℃<br>Tj=150℃ | 1 | 1,69<br>1,61 | 2,5 | V |
| Reverse leakage current | $I_r$ | Rgon=32 Ω | | 600 | | Tj=25℃<br>Tj=150℃ | | | 60 | µA |
| Peak reverse recovery current | $I_{RRM}$ | Rgon=32 Ω | ±15 | 300 | 6 | Tj=25℃<br>Tj=150℃ | | 7<br>8 | | A |
| Reverse recovery time | $t_{rr}$ | | | | | Tj=25℃<br>Tj=150℃ | | 97<br>151 | | ns |
| Reverse recovered charge | $Q_{rr}$ | | | | | Tj=25℃<br>Tj=150℃ | | 0,23<br>0,23 | | µC |
| Peak rate of fall of recovery current | di(rec)max<br>/dt | | | | | Tj=25℃<br>Tj=150℃ | | 522<br>321 | | A/µs |
| Reverse recovery energy | $E_{rec}$ | | | | | Tj=25℃<br>Tj=150℃ | | 0,05<br>0,09 | | mWs |
| Thermal resistance chip to heatsink per chip | $R_{thJH}$ | Thermal grease thickness≤50µm<br>λ = 1 W/mK | | | | | | 4,29 | | K/W |
| **Thermistor** | | | | | | | | | | |
| Rated resistance | R | | | | | Tj=25℃ | | 22000 | | Ω |
| Deviation of R100 | ΔR/R | R100=1486 Ω | | | | Tc=100℃ | -5 | | 5 | % |
| Power dissipation | P | | | | | Tc=100℃ | | 210 | | mW |
| Power dissipation constant | | | | | | Tj=25℃ | | 3,5 | | mW/K |
| B-value | $B_{(25/50)}$ | Tol. ±3% | | | | Tj=25℃ | | | | K |
| B-value | $B_{(25/100)}$ | Tol. ±3% | | | | Tj=25℃ | | 4000 | | K |
| Vincotech NTC Reference | | | | | | Tj=25℃ | | | A | |

# Output Inverter

**Figure 1** Output inverter IGBT

**Typical output characteristics**

$I_C = f(V_{CE})$



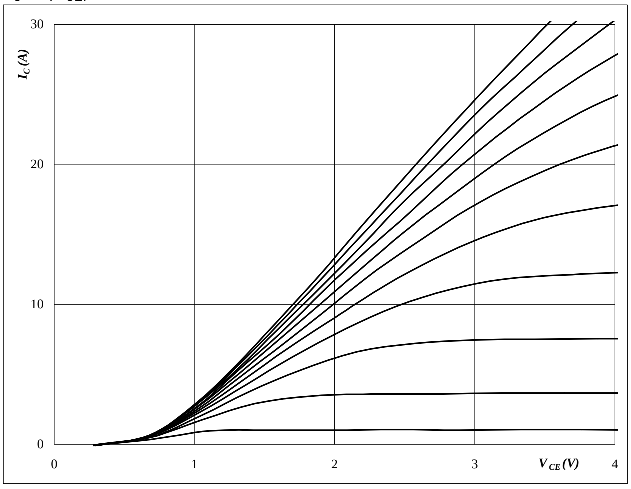

**At**

| | | |
|---|---|---|
| $t_p$ = | 250 | µs |
| $T_j$ = | 25 | ℃ |
| $V_{GE}$ from | 7 V to 17 V in steps of 1 V | |

**Figure 2** Output inverter IGBT

**Typical output characteristics**

$I_C = f(V_{CE})$



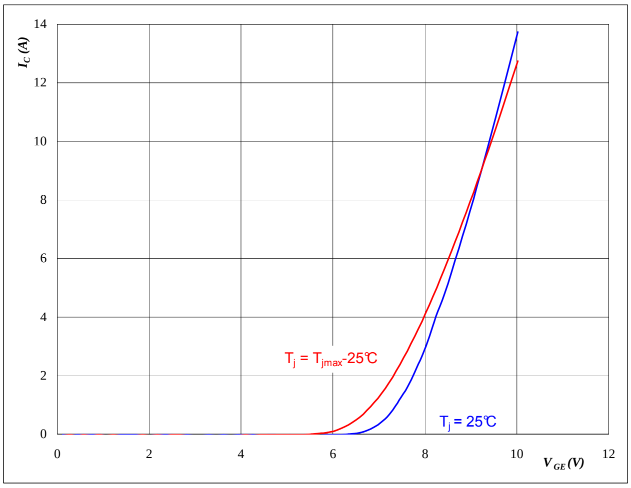

**At**

| | | |
|---|---|---|
| $t_p$ = | 250 | µs |
| $T_j$ = | 125 | ℃ |
| $V_{GE}$ from | 7 V to 17 V in steps of 1 V | |

**Figure 3** Output inverter IGBT

**Typical transfer characteristics**

$I_C = f(V_{GE})$



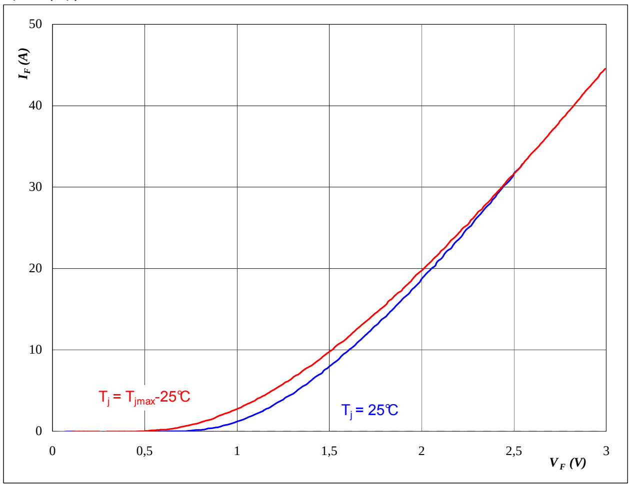

**At**

| | | |
|---|---|---|
| $t_p$ = | 250 | µs |
| $V_{CE}$ = | 10 | V |

**Figure 4** Output inverter FWD

**Typical diode forward current as a function of forward voltage**

$I_F = f(V_F)$




**At**

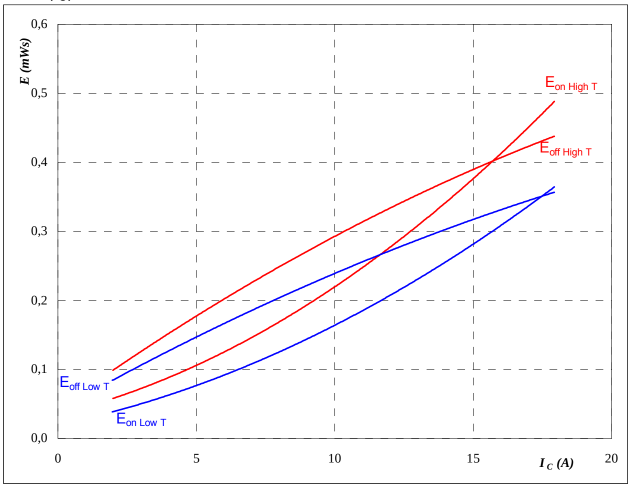
| | | |
|---|---|---|
| $t_p$ = | 250 | µs |

# Output Inverter

**Figure 5** Output inverter IGBT

**Typical switching energy losses as a function of collector current**

$E = f(I_C)$



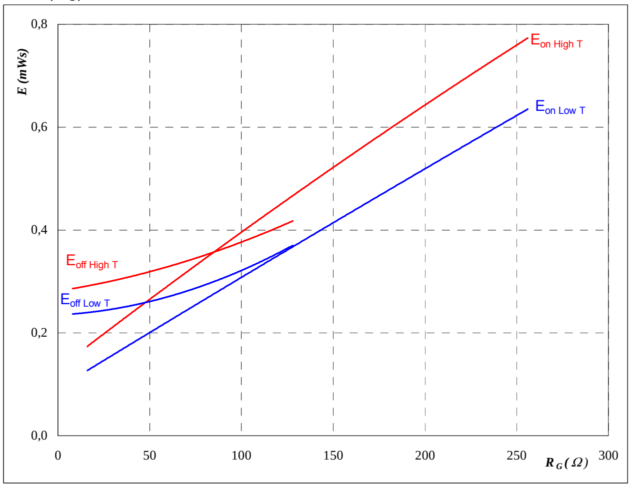

With an inductive load at

| | | |
|---|---|---|
| $T_j$ = | 25/125 | °C |
| $V_{CE}$ = | 300 | V |
| $V_{GE}$ = | 15 | V |
| $R_{gon}$ = | 32 | Ω |
| $R_{goff}$ = | 16 | Ω |

**Figure 6** Output inverter IGBT

**Typical switching energy losses as a function of gate resistor**

$E = f(R_G)$



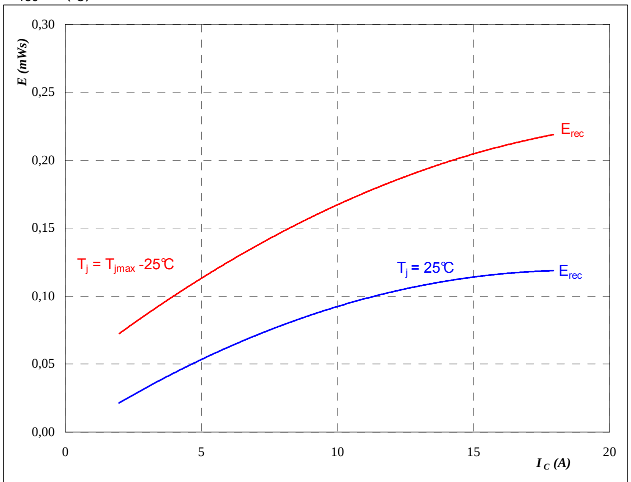

With an inductive load at

| | | |
|---|---|---|
| $T_j$ = | 25/125 | °C |
| $V_{CE}$ = | 300 | V |
| $V_{GE}$ = | 15 | V |
| $I_C$ = | 10 | A |

**Figure 7** Output inverter FWD

**Typical reverse recovery energy loss as a function of collector current**

$E_{rec} = f(I_C)$



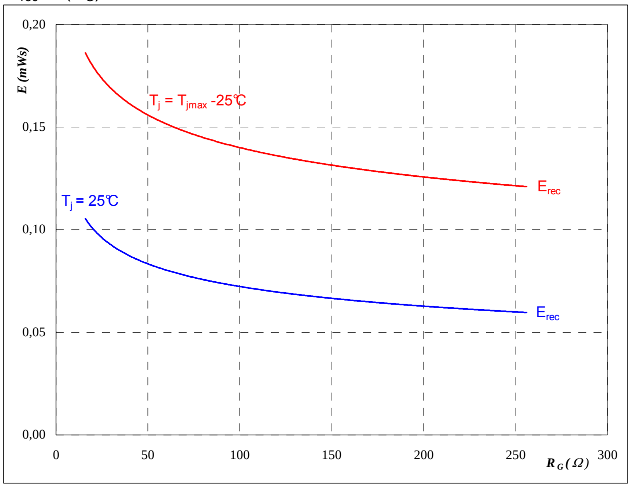

With an inductive load at

| | | |
|---|---|---|
| $T_j$ = | 25/125 | °C |
| $V_{CE}$ = | 300 | V |
| $V_{GE}$ = | 15 | V |
| $R_{gon}$ = | 32 | Ω |

**Figure 8** Output inverter FWD

**Typical reverse recovery energy loss as a function of gate resistor**

$E_{rec} = f(R_G)$




With an inductive load at

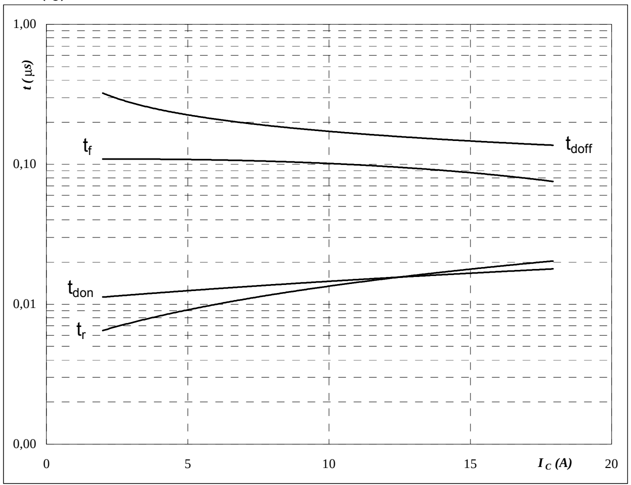
| | | |
|---|---|---|
| $T_j$ = | 25/125 | °C |
| $V_{CE}$ = | 300 | V |
| $V_{GE}$ = | 15 | V |
| $I_C$ = | 10 | A |

# Output Inverter

**Figure 9** Output inverter IGBT

**Typical switching times as a function of collector current**

t = f($I_C$)



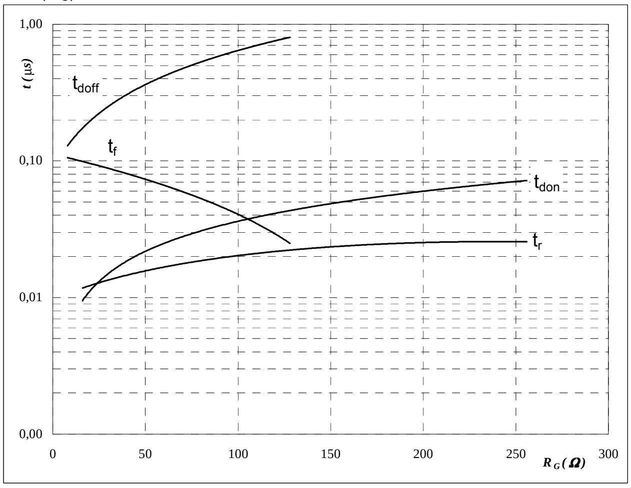

With an inductive load at

| | | |
|---|---|---|
| $T_j$ = | 125 | °C |
| $V_{CE}$ = | 300 | V |
| $V_{GE}$ = | 15 | V |
| $R_{gon}$ = | 32 | Ω |
| $R_{goff}$ = | 16 | Ω |

**Figure 10** Output inverter IGBT

**Typical switching times as a function of gate resistor**

t = f($R_G$)



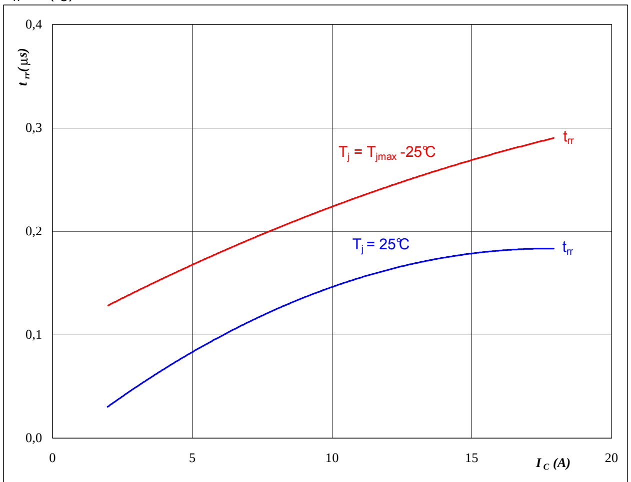

With an inductive load at

| | | |
|---|---|---|
| $T_j$ = | 125 | °C |
| $V_{CE}$ = | 300 | V |
| $V_{GE}$ = | 15 | V |
| $I_C$ = | 10 | A |

**Figure 11** Output inverter FWD

**Typical reverse recovery time as a function of collector current**

$t_{rr}$ = f($I_C$)



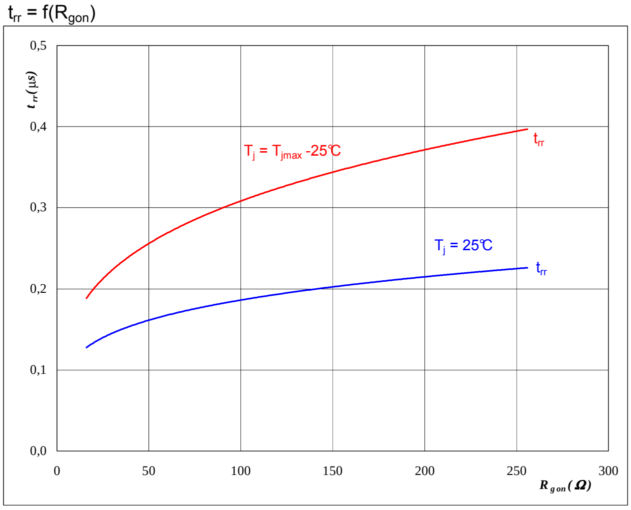

At

| | | |
|---|---|---|
| $T_j$ = | 25/125 | °C |
| $V_{CE}$ = | 300 | V |
| $V_{GE}$ = | 15 | V |
| $R_{gon}$ = | 32 | Ω |

**Figure 12** Output inverter FWD

**Typical reverse recovery time as a function of IGBT turn on gate resistor**

$t_{rr}$ = f($R_{gon}$)




At

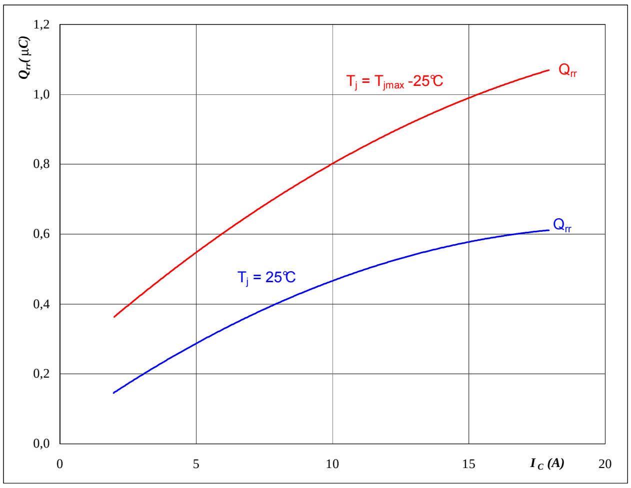
| | | |
|---|---|---|
| $T_j$ = | 25/125 | °C |
| $V_R$ = | 300 | V |
| $I_F$ = | 10 | A |
| $V_{GE}$ = | 15 | V |

# Output Inverter

**Figure 13** Output inverter FWD

**Typical reverse recovery charge as a function of collector current**

$Q_{rr} = f(I_C)$



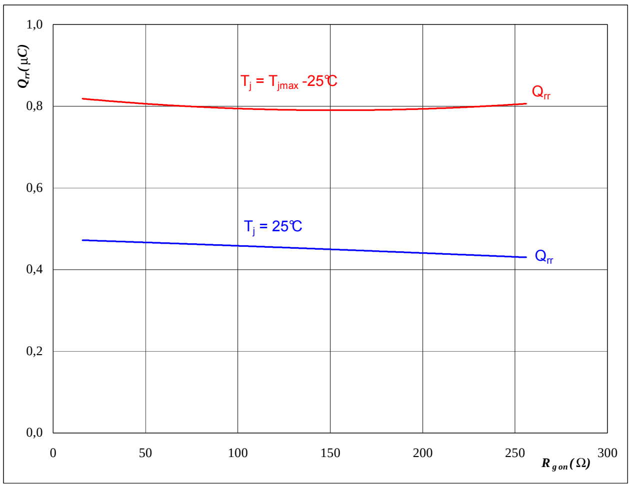

At

| | | |
|---|---|---|
| $T_j$ = | 25/125 | ℃ |
| $V_{CE}$ = | 300 | V |
| $V_{GE}$ = | 15 | V |
| $R_{gon}$ = | 32 | Ω |

**Figure 14** Output inverter FWD

**Typical reverse recovery charge as a function of IGBT turn on gate resistor**

$Q_{rr} = f(R_{gon})$



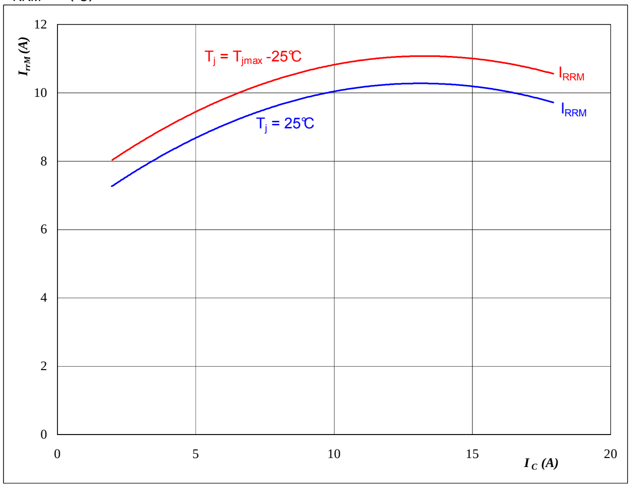

At

| | | |
|---|---|---|
| $T_j$ = | 25/125 | ℃ |
| $V_R$ = | 300 | V |
| $I_F$ = | 10 | A |
| $V_{GE}$ = | 15 | V |

**Figure 15** Output inverter FWD

**Typical reverse recovery current as a function of collector current**

$I_{RRM} = f(I_C)$



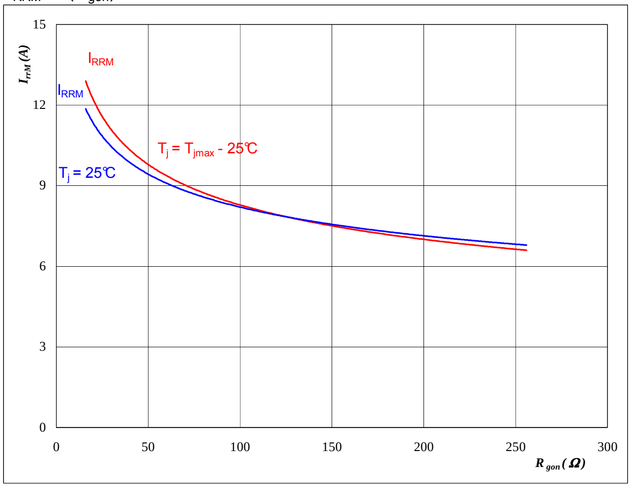

At

| | | |
|---|---|---|
| $T_j$ = | 25/125 | ℃ |
| $V_{CE}$ = | 300 | V |
| $V_{GE}$ = | 15 | V |
| $R_{gon}$ = | 32 | Ω |

**Figure 16** Output inverter FWD

**Typical reverse recovery current as a function of IGBT turn on gate resistor**

$I_{RRM} = f(R_{gon})$




At

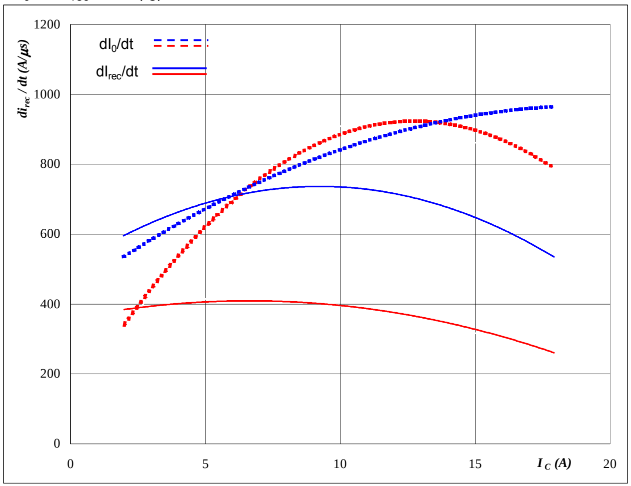
| | | |
|---|---|---|
| $T_j$ = | 25/125 | ℃ |
| $V_R$ = | 300 | V |
| $I_F$ = | 10 | A |
| $V_{GE}$ = | 15 | V |

# Output Inverter

| Figure 17 | Output inverter FWD |
|---|---|

**Typical rate of fall of forward and reverse recovery current as a function of collector current**

$dI_0/dt, dI_{rec}/dt = f(I_C)$



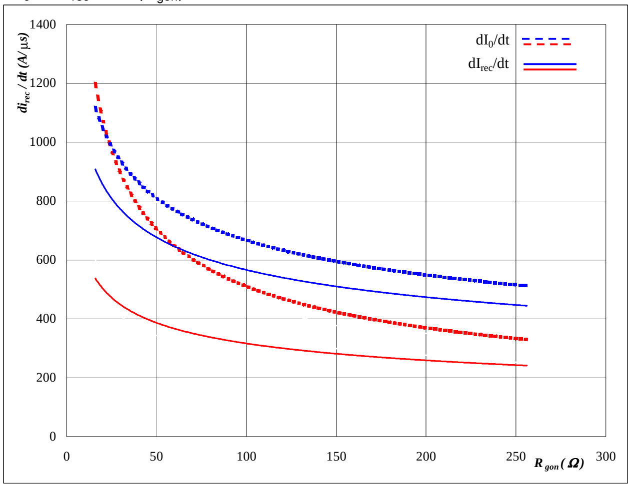

**At**

| | | |
|---|---|---|
| $T_j$ = | 25/125 | ℃ |
| $V_{CE}$ = | 300 | V |
| $V_{GE}$ = | 15 | V |
| $R_{gon}$ = | 32 | Ω |

| Figure 18 | Output inverter FWD |
|---|---|

**Typical rate of fall of forward and reverse recovery current as a function of IGBT turn on gate resistor**

$dI_0/dt, dI_{rec}/dt = f(R_{gon})$



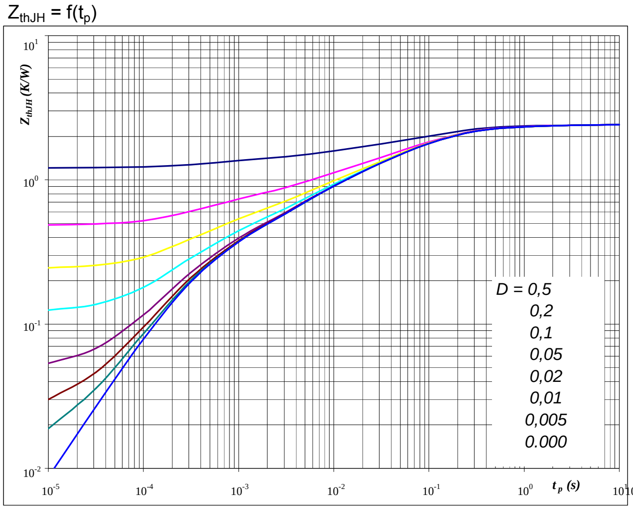

**At**

| | | |
|---|---|---|
| $T_j$ = | 25/125 | ℃ |
| $V_R$ = | 300 | V |
| $I_F$ = | 10 | A |
| $V_{GE}$ = | 15 | V |

| Figure 19 | Output inverter IGBT |
|---|---|

**IGBT transient thermal impedance as a function of pulse width**

$Z_{thJH} = f(t_p)$



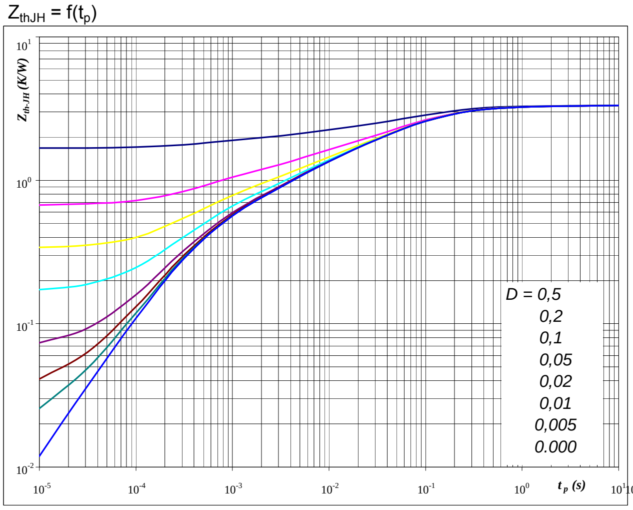

**At**

| | | |
|---|---|---|
| D = | $t_p$ / T | |
| $R_{thJH}$ = | 2,41 | K/W |

| Figure 20 | Output inverter FWD |
|---|---|

**FWD transient thermal impedance as a function of pulse width**

$Z_{thJH} = f(t_p)$




**At**

| | | |
|---|---|---|
| D = | $t_p$ / T | |
| $R_{thJH}$ = | 3,33 | K/W |

IGBT thermal model values

| Thermal grease | | Phase change interface | |
|---|---|---|---|
| R (C/W) | Tau (s) | R (C/W) | Tau (s) |
| 0,06 | 5,2E+00 | 0,05 | 4,2E+00 |
| 0,26 | 5,0E-01 | 0,21 | 4,1E-01 |
| 0,97 | 1,0E-01 | 0,78 | 8,1E-02 |
| 0,52 | 1,9E-02 | 0,42 | 1,5E-02 |
| 0,35 | 3,4E-03 | 0,28 | 2,8E-03 |
| 0,26 | 3,5E-04 | 0,21 | 2,8E-04 |

FWD thermal model values

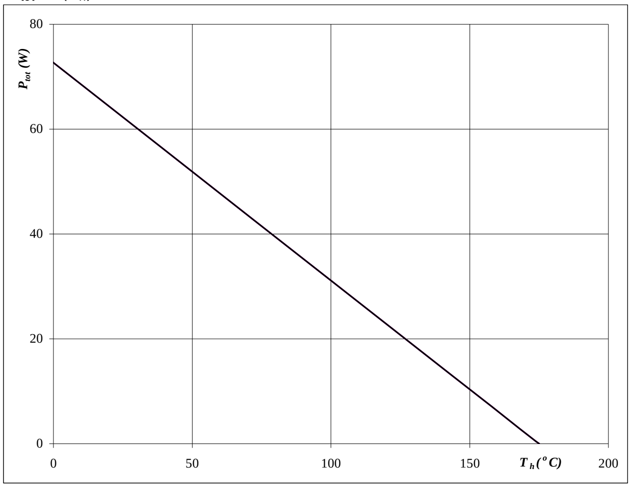
| Thermal grease | | Phase change interface | |
|---|---|---|---|
| R (C/W) | Tau (s) | R (C/W) | Tau (s) |
| 0,07 | 8,2E+00 | 0,05 | 6,6E+00 |
| 0,31 | 5,2E-01 | 0,25 | 4,3E-01 |
| 1,25 | 9,3E-02 | 1,01 | 7,6E-02 |
| 0,78 | 2,0E-02 | 0,63 | 1,6E-02 |
| 0,54 | 3,2E-03 | 0,43 | 2,6E-03 |
| 0,40 | 4,1E-04 | 0,33 | 3,3E-04 |

# Output Inverter

**Figure 21** Output inverter IGBT

**Power dissipation as a function of heatsink temperature**

$P_{tot} = f(T_h)$



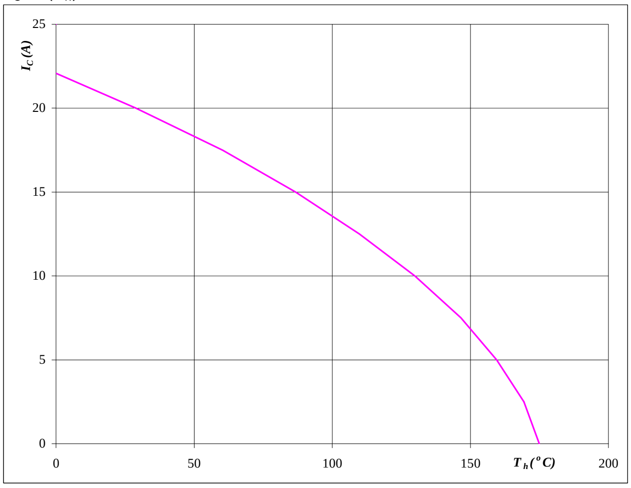

**At**

$T_j$ = 175 ℃

**Figure 22** Output inverter IGBT

**Collector current as a function of heatsink temperature**

$I_C = f(T_h)$




**At**

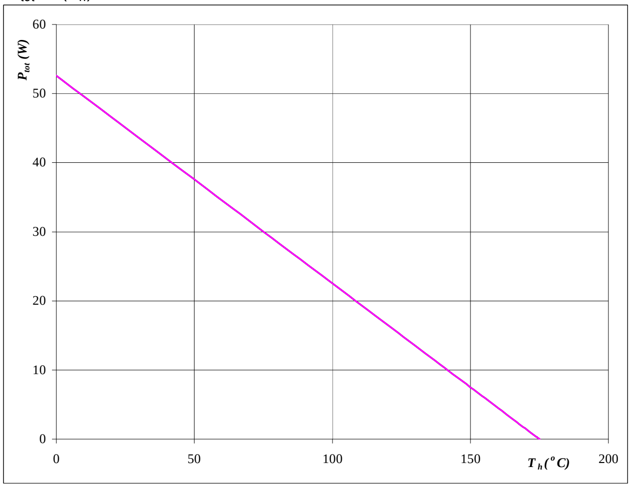
$T_j$ = 175 ℃

$V_{GE}$ = 15 V

**Figure 23** Output inverter FWD

**Power dissipation as a function of heatsink temperature**

$P_{tot} = f(T_h)$



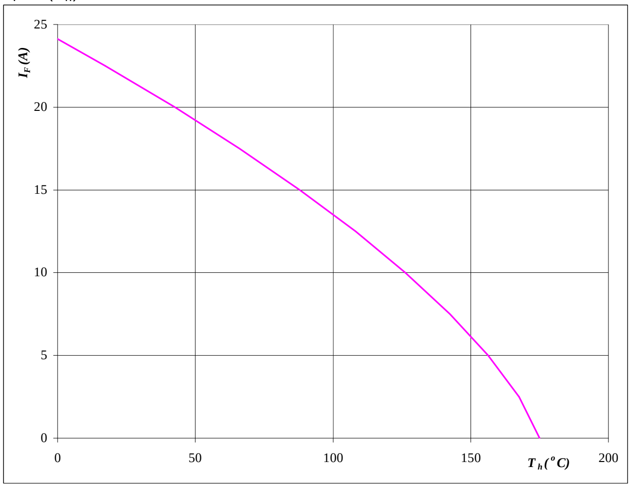

**At**

$T_j$ = 175 ℃

**Figure 24** Output inverter FWD

**Forward current as a function of heatsink temperature**

$I_F = f(T_h)$




**At**

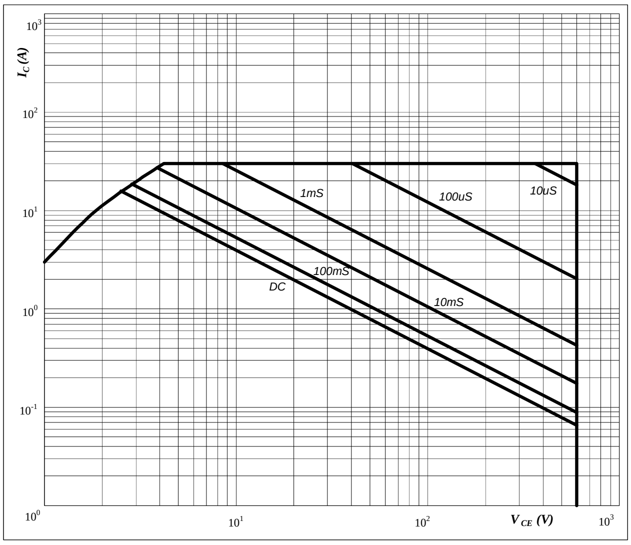
$T_j$ = 175 ℃

# Output Inverter

**Figure 25** Output inverter IGBT

**Safe operating area as a function of collector-emitter voltage**

$I_C = f(V_{CE})$



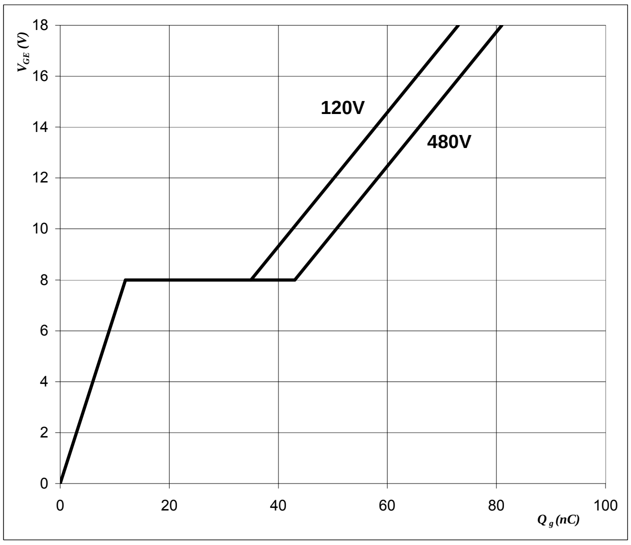

**At**

| | | |
|---|---|---|
| D = | single pulse | |
| $T_h$ = | 80 | ºC |
| $V_{GE}$ = | 15 | V |
| $T_j$ = | $T_{jmax}$ | ºC |

**Figure 26** Output inverter IGBT

**Gate voltage vs Gate charge**

$V_{GE} = f(Q_{GE})$



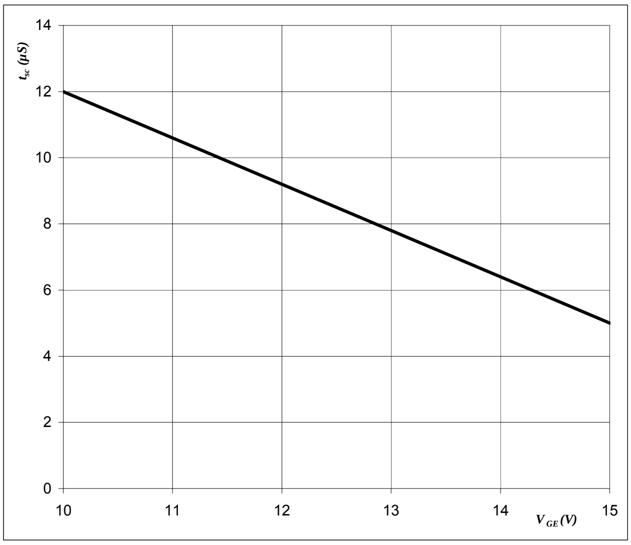

**At**

| | | |
|---|---|---|
| $I_C$ = | 10 | A |

**Figure 27** Output inverter IGBT

**Short circuit withstand time as a function of gate-emitter voltage**

$t_{sc} = f(V_{GE})$



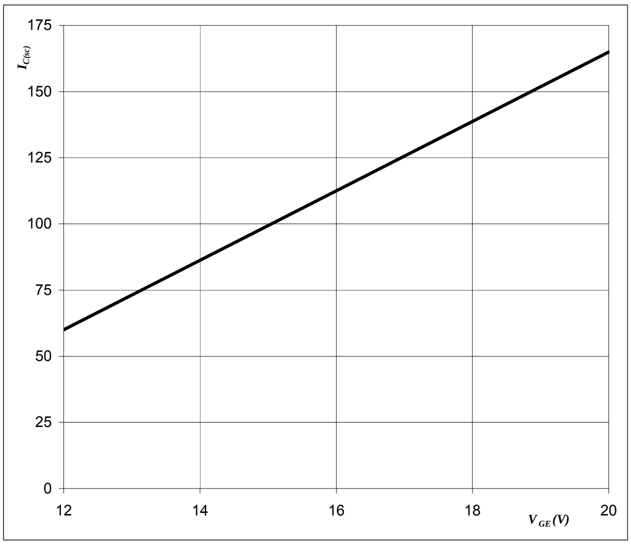

**At**

| | | |
|---|---|---|
| $V_{CE}$ = | 600 | V |
| $T_j \leq$ | 175 | ºC |

**Figure 28** Output inverter IGBT

**Typical short circuit collector current as a function of gate-emitter voltage**

$V_{GE} = f(Q_{GE})$



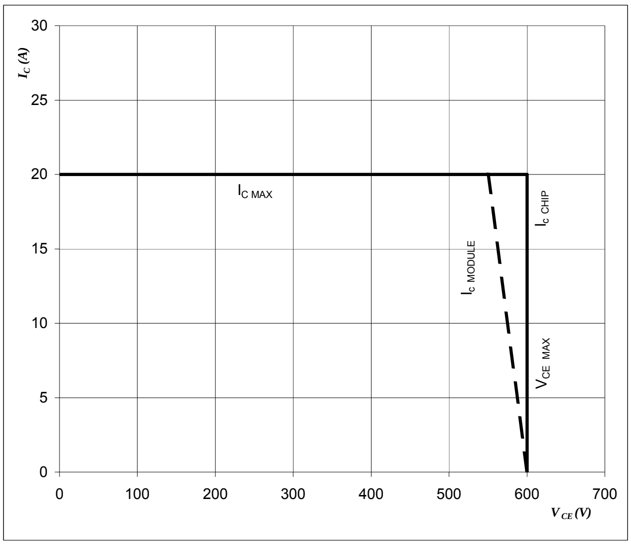

**At**

| | | |
|---|---|---|
| $V_{CE} \leq$ | 600 | V |
| $T_j$ = | 175 | ºC |

| Figure 29 | IGBT |
|---|---|

**Reverse bias safe operating area**

$I_C = f(V_{CE})$




**At**

$T_j$ = $T_{jmax}$-25 ºC

$U_{ccminus}$=$U_{ccplus}$

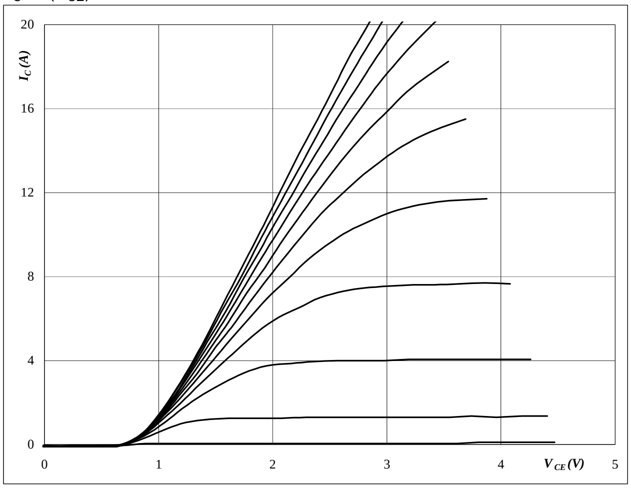
Switching mode : 3 level switching

# Brake

**Figure 1** Brake IGBT

**Typical output characteristics**

$I_C = f(V_{CE})$



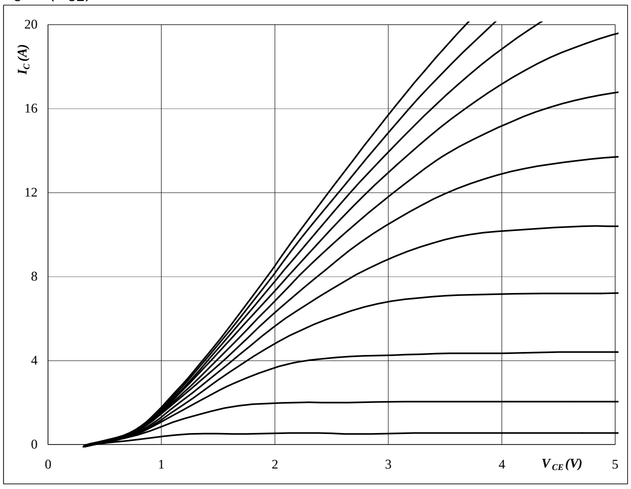

**At**

| | | |
|---|---|---|
| $t_p$ = | 250 | μs |
| $T_j$ = | 25 | ℃ |
| $V_{GE}$ from | 7 V to 17 V in steps of 1 V | |

**Figure 2** Brake IGBT

**Typical output characteristics**

$I_C = f(V_{CE})$



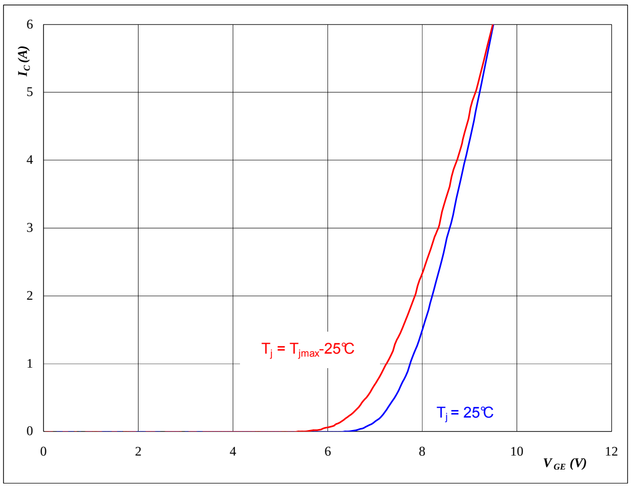

**At**

| | | |
|---|---|---|
| $t_p$ = | 250 | μs |
| $T_j$ = | 125 | ℃ |
| $V_{GE}$ from | 7 V to 17 V in steps of 1 V | |

**Figure 3** Brake IGBT

**Typical transfer characteristics**

$I_C = f(V_{GE})$



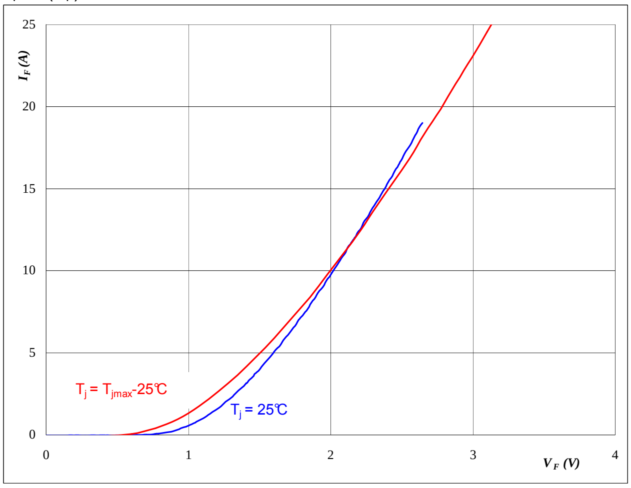

**At**

| | | |
|---|---|---|
| $t_p$ = | 250 | μs |
| $V_{CE}$ = | 10 | V |

**Figure 4** Brake FWD

**Typical diode forward current as a function of forward voltage**

$I_F = f(V_F)$




**At**

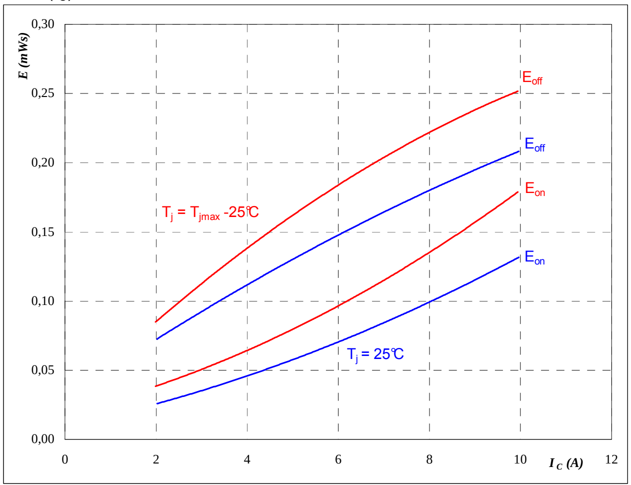
| | | |
|---|---|---|
| $t_p$ = | 250 | μs |

# Brake

**Figure 5** Brake IGBT

**Typical switching energy losses**
**as a function of collector current**

$E = f(I_C)$



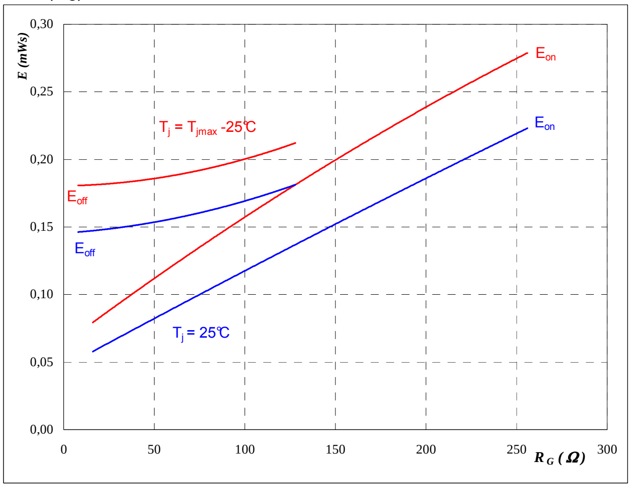

With an inductive load at

| | | |
|---|---|---|
| $T_j$ = | 25/125 | °C |
| $V_{CE}$ = | 300 | V |
| $V_{GE}$ = | 15 | V |
| $R_{gon}$ = | 32 | Ω |
| $R_{goff}$ = | 16 | Ω |

**Figure 6** Brake IGBT

**Typical switching energy losses**
**as a function of gate resistor**

$E = f(R_G)$



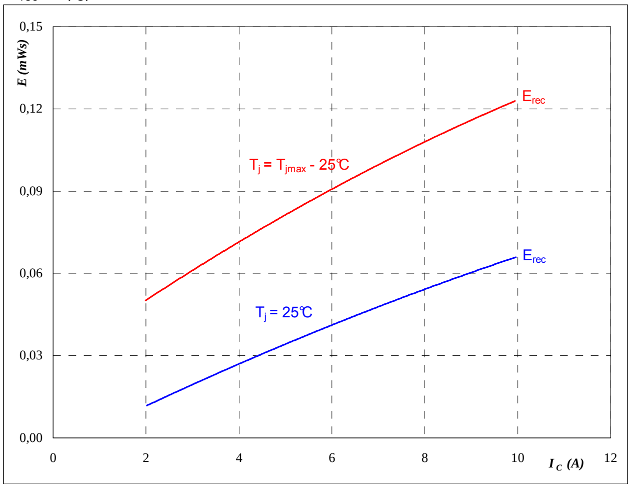

With an inductive load at

| | | |
|---|---|---|
| $T_j$ = | 25/125 | °C |
| $V_{CE}$ = | 300 | V |
| $V_{GE}$ = | 15 | V |
| $I_C$ = | 6 | A |

**Figure 7** Brake FWD

**Typical reverse recovery energy loss**
**as a function of collector current**

$E_{rec} = f(I_C)$



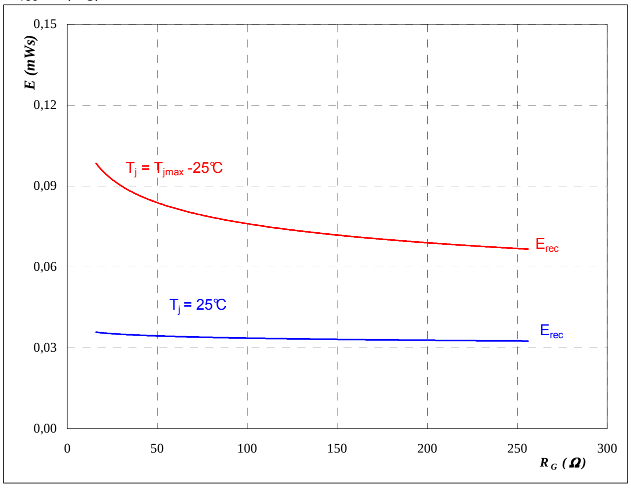

With an inductive load at

| | | |
|---|---|---|
| $T_j$ = | 25/125 | °C |
| $V_{CE}$ = | 300 | V |
| $V_{GE}$ = | 15 | V |
| $R_{gon}$ = | 32 | Ω |

**Figure 8** Brake FWD

**Typical reverse recovery energy loss**
**as a function of gate resistor**

$E_{rec} = f(R_G)$




With an inductive load at

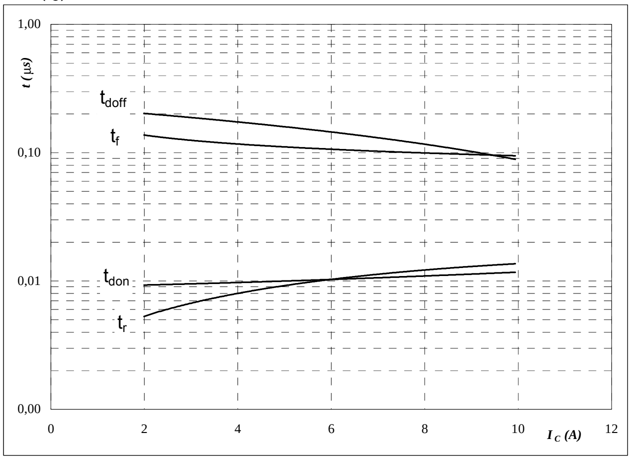
| | | |
|---|---|---|
| $T_j$ = | 25/125 | °C |
| $V_{CE}$ = | 300 | V |
| $V_{GE}$ = | 15 | V |
| $I_C$ = | 6 | A |

# Brake

**Figure 9** Brake IGBT

**Typical switching times as a function of collector current**

t = f($I_C$)



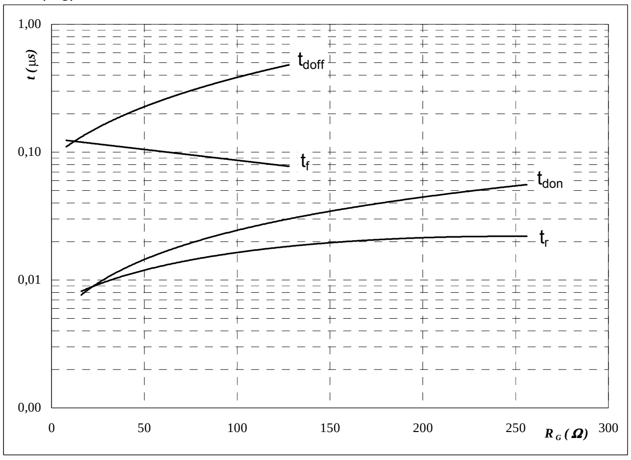

With an inductive load at

| | | |
|---|---|---|
| $T_j$ = | 125 | ℃ |
| $V_{CE}$ = | 300 | V |
| $V_{GE}$ = | 15 | V |
| $R_{gon}$ = | 32 | Ω |
| $R_{goff}$ = | 16 | Ω |

**Figure 10** Brake IGBT

**Typical switching times as a function of gate resistor**

t = f($R_G$)



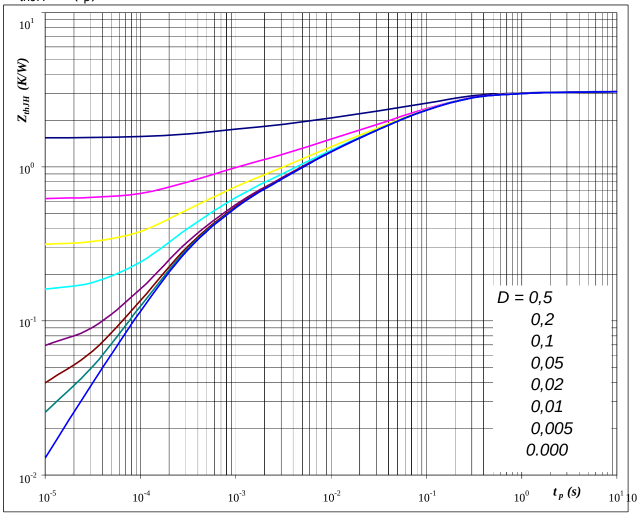

With an inductive load at

| | | |
|---|---|---|
| $T_j$ = | 125 | ℃ |
| $V_{CE}$ = | 300 | V |
| $V_{GE}$ = | 15 | V |
| $I_C$ = | 6 | A |

**Figure 11** Brake IGBT

**IGBT transient thermal impedance as a function of pulse width**

$Z_{thJH}$ = f($t_p$)

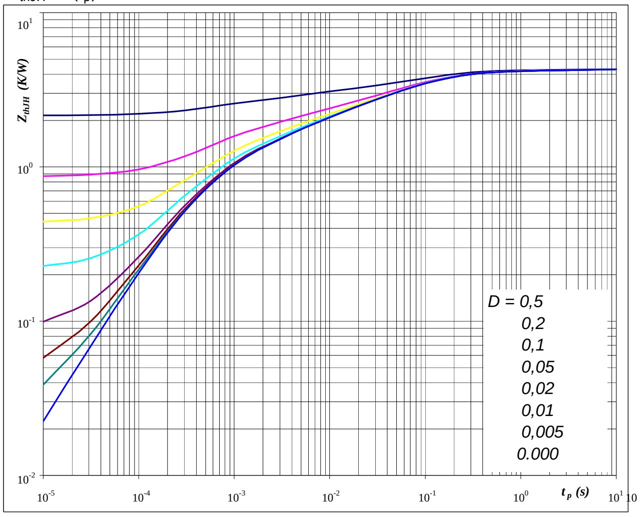



| | | | | |
|---|---|---|---|---|
| **At** | D = | tp / T | | |
| Thermal grease | | Phase change interface | | |
| $R_{thJH}$ = 3,07 | K/W | $R_{thJH}$ = | 0,60 | K/W |

**Figure 12** Brake FWD

**FWD transient thermal impedance as a function of pulse width**

$Z_{thJH}$ = f($t_p$)



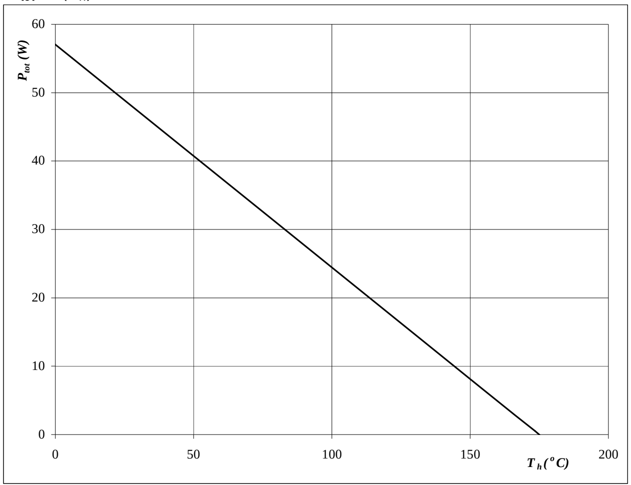

| | | | | |
|---|---|---|---|---|
| **At** | D = | tp / T | | |
| Thermal grease | | Phase change interface | | |
| $R_{thJH}$ = 4,29 | K/W | $R_{thJH}$ = | 1,27 | K/W |

# Brake

| Figure 13 | Brake IGBT |
|---|---|

**Power dissipation as a function of heatsink temperature**

$P_{tot} = f(T_h)$



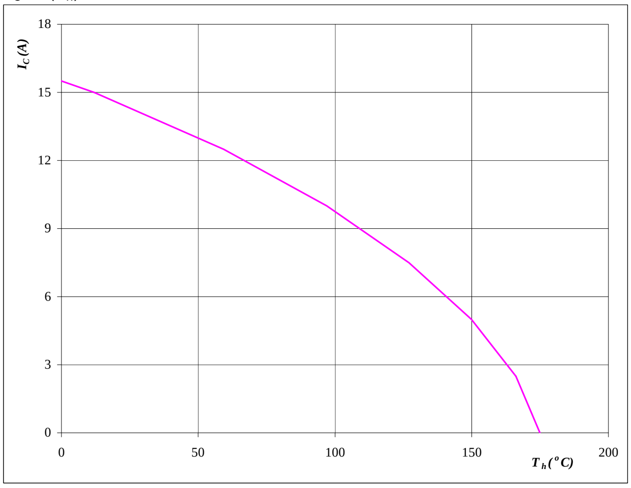

**At**

$T_j$ = 175 °C

| Figure 14 | Brake IGBT |
|---|---|

**Collector current as a function of heatsink temperature**

$I_C = f(T_h)$




**At**

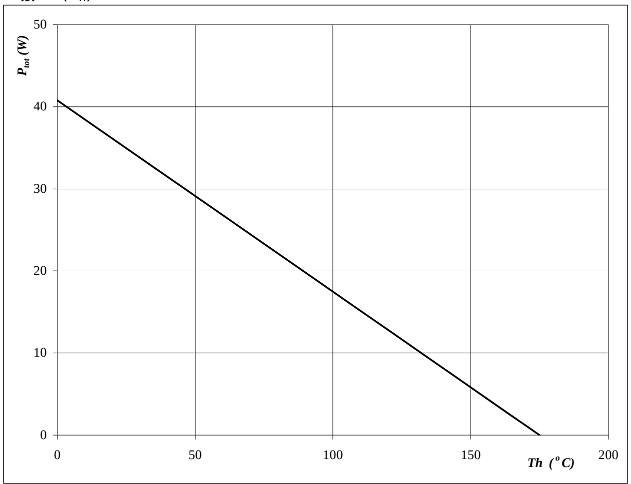
$T_j$ = 175 °C

$V_{GE}$ = 15 V

| Figure 15 | Brake FWD |
|---|---|

**Power dissipation as a function of heatsink temperature**

$P_{tot} = f(T_h)$



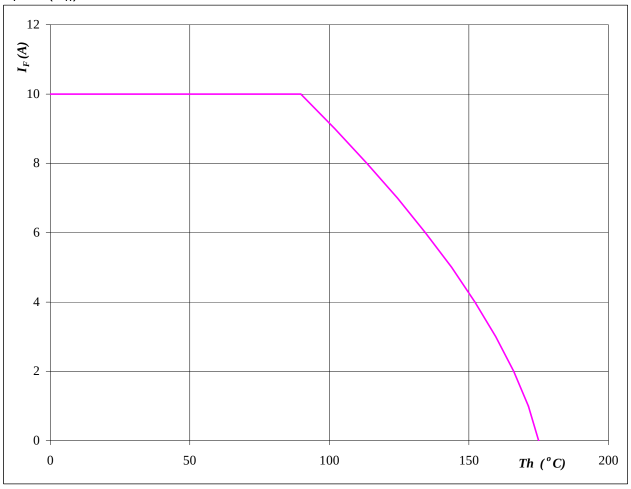

**At**

$T_j$ = 175 °C

| Figure 16 | Brake FWD |
|---|---|

**Forward current as a function of heatsink temperature**

$I_F = f(T_h)$




**At**

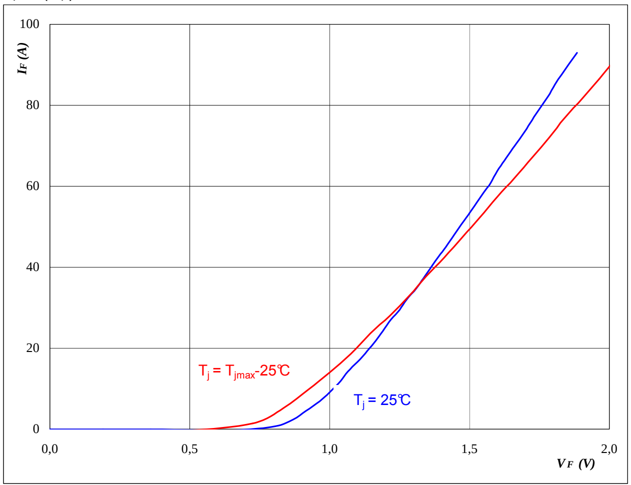
$T_j$ = 175 °C

# Input Rectifier Bridge

**Figure 1** Rectifier diode

**Typical diode forward current as a function of forward voltage**

$I_F = f(V_F)$



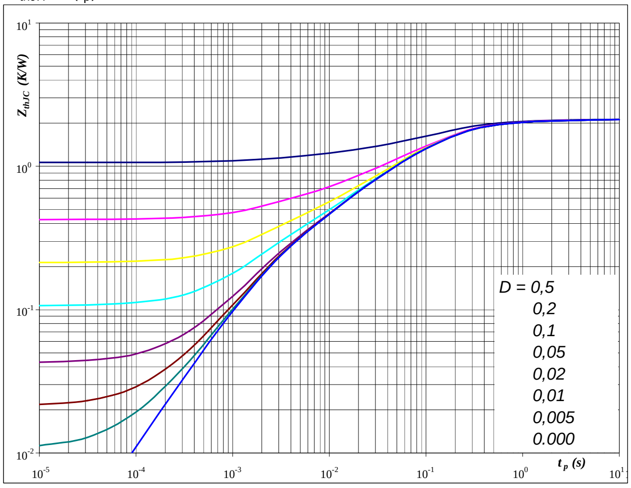

**At**

$t_p$ = 250 µs

**Figure 2** Rectifier diode

**Diode transient thermal impedance as a function of pulse width**

$Z_{thJH} = f(t_p)$




**At**

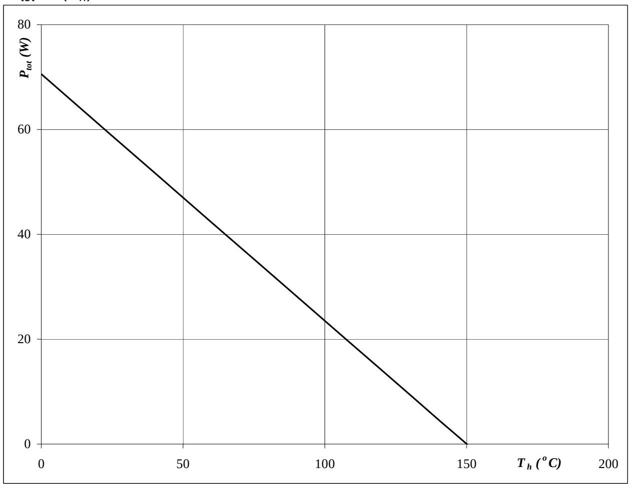
D = $t_p$ / T

$R_{thJH}$ = 2,1 K/W

**Figure 3** Rectifier diode

**Power dissipation as a function of heatsink temperature**

$P_{tot} = f(T_h)$



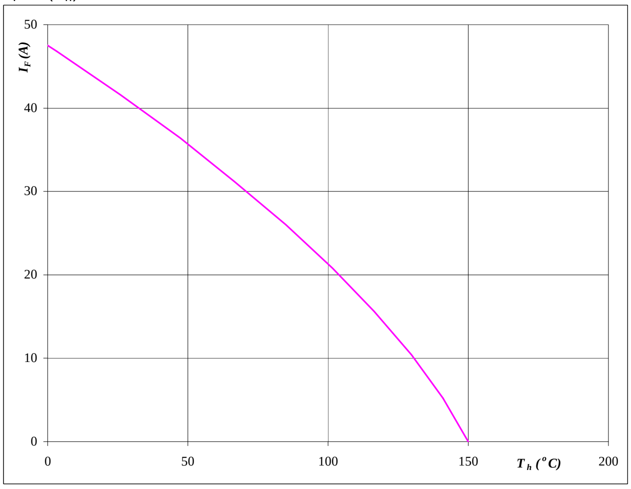

**At**

$T_j$ = 150 ºC

**Figure 4** Rectifier diode

**Forward current as a function of heatsink temperature**

$I_F = f(T_h)$




**At**

$T_j$ = 150 ºC

# Thermistor

**Figure 1** Thermistor

**Typical NTC characteristic**
**as a function of temperature**
$R_T = f(T)$

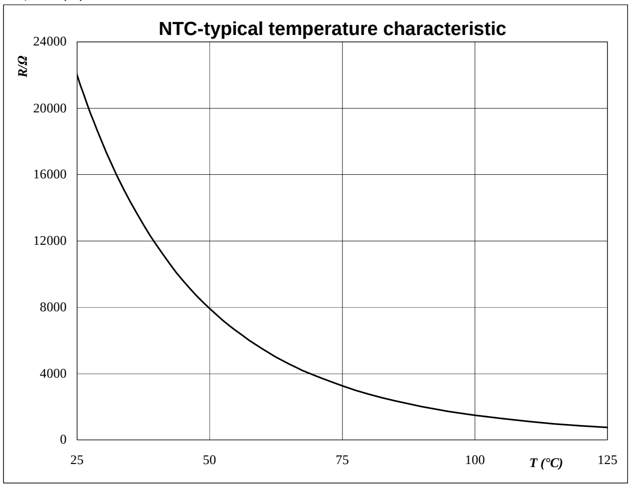



**Figure 2** Thermistor

**Typical NTC resistance values**

$$R(T) = R_{25} \cdot e^{\left(B_{25/100} \cdot \left(\frac{1}{T} - \frac{1}{T_{25}}\right)\right)} \quad [\Omega]$$

| T [°C] | $R_{nom}$ [Ω] | $R_{min}$ [Ω] | $R_{max}$ [Ω] | △R/R [±%] |
|---|---|---|---|---|
| -55 | 2089434,5 | 1506495,4 | 2672373,6 | 27,9 |
| 0 | 71804,2 | 59724,4 | 83884 | 16,8 |
| 10 | 43780,4 | 37094,4 | 50466,5 | 15,3 |
| 20 | 27484,6 | 23684,6 | 31284,7 | 13,8 |
| 25 | 22000 | 19109,3 | 24890,7 | 13,1 |
| 30 | 17723,3 | 15512,2 | 19934,4 | 12,5 |
| 60 | 5467,9 | 4980,6 | 5955,1 | 8,9 |
| 70 | 3848,6 | 3546 | 4151,1 | 7,9 |
| 80 | 2757,7 | 2568,2 | 2947,1 | 6,9 |
| 90 | 2008,9 | 1889,7 | 2128,2 | 5,9 |
| **100** | **1486,1** | **1411,8** | **1560,4** | **5** |
| 150 | 400,2 | 364,8 | 435,7 | 8,8 |

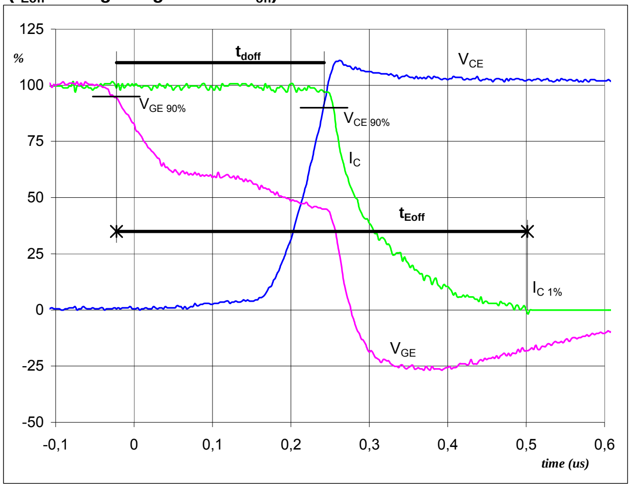
# Switching Definitions Output Inverter

**General conditions**

| | | |
|---|---|---|
| $T_j$ | = | 125 °C |
| $R_{gon}$ | = | 32 Ω |
| $R_{goff}$ | = | 16 Ω |

**Figure 1** Output inverter IGBT

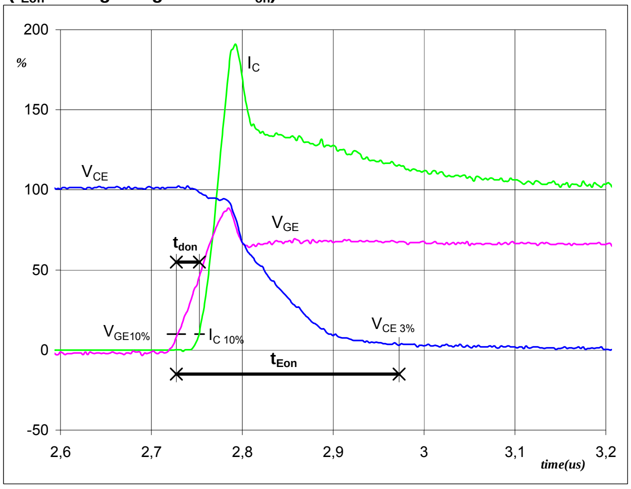
**Turn-off Switching Waveforms & definition of $t_{doff}$, $t_{Eoff}$**
**($t_{Eoff}$ = integrating time for $E_{off}$)**




| | | |
|---|---|---|
| $V_{GE}$ (0%) = | 0 | V |
| $V_{GE}$ (100%) = | 15 | V |
| $V_C$ (100%) = | 300 | V |
| $I_C$ (100%) = | 10 | A |
| $t_{doff}$ = | 0,26 | µs |
| $t_{Eoff}$ = | 0,52 | µs |

**Figure 2** Output inverter IGBT

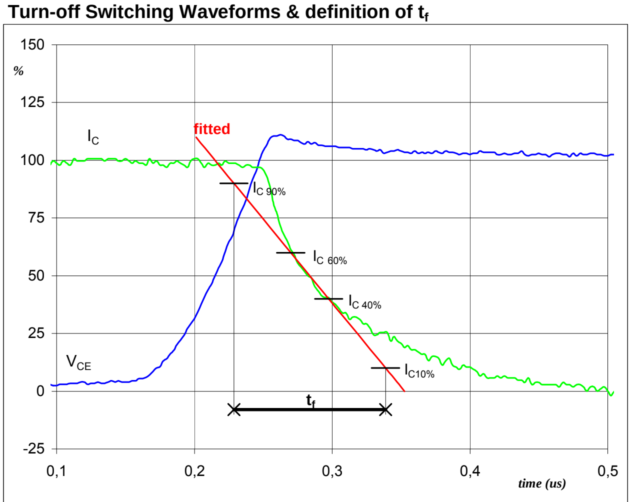
**Turn-on Switching Waveforms & definition of tdon, $t_{Eon}$**
**($t_{Eon}$ = integrating time for $E_{on}$)**




| | | |
|---|---|---|
| $V_{GE}$ (0%) = | 0 | V |
| $V_{GE}$ (100%) = | 15 | V |
| $V_C$ (100%) = | 300 | V |
| $I_C$ (100%) = | 10 | A |
| $t_{don}$ = | 0,02 | µs |
| $t_{Eon}$ = | 0,24 | µs |

**Figure 3** Output inverter IGBT

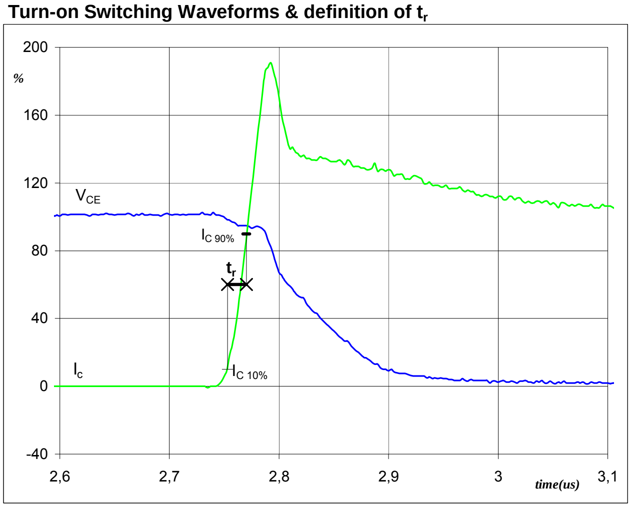
**Turn-off Switching Waveforms & definition of $t_f$**




| | | |
|---|---|---|
| $V_C$ (100%) = | 300 | V |
| $I_C$ (100%) = | 10 | A |
| $t_f$ = | 0,10 | µs |

**Figure 4** Output inverter IGBT

**Turn-on Switching Waveforms & definition of $t_r$**

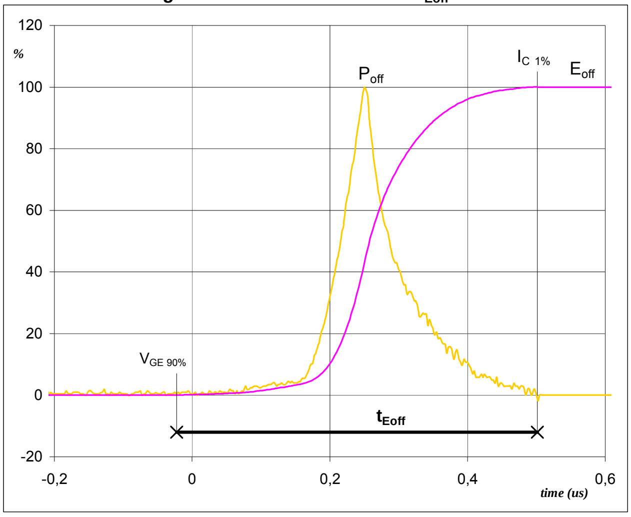



| | | |
|---|---|---|
| $V_C$ (100%) = | 300 | V |
| $I_C$ (100%) = | 10 | A |
| $t_r$ = | 0,02 | µs |

# Switching Definitions Output Inverter

**Figure 5** Output inverter IGBT

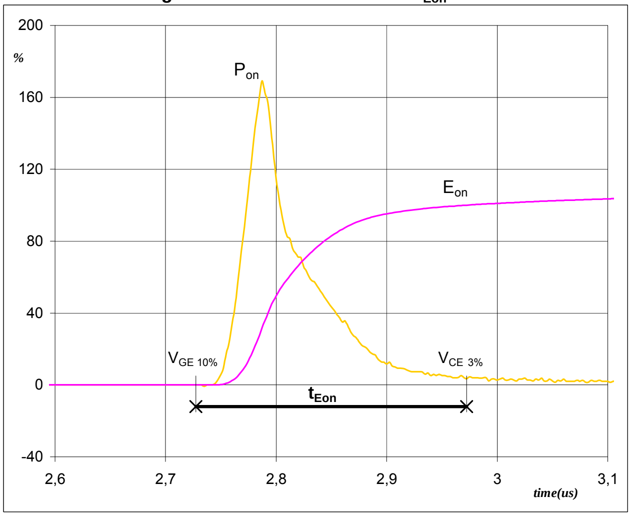
**Turn-off Switching Waveforms & definition of $t_{Eoff}$**




| | | |
|---|---|---|
| $P_{off}$ (100%) = | 2,99 | kW |
| $E_{off}$ (100%) = | 0,30 | mJ |
| $t_{Eoff}$ = | 0,52 | μs |

**Figure 6** Output inverter IGBT

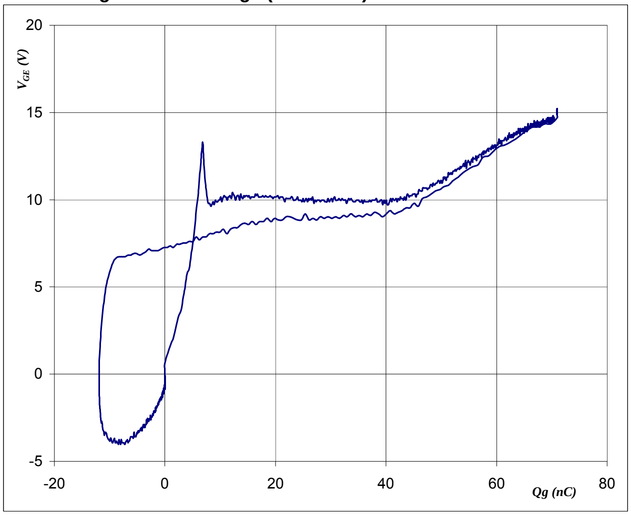
**Turn-on Switching Waveforms & definition of $t_{Eon}$**




| | | |
|---|---|---|
| $P_{on}$ (100%) = | 2,99 | kW |
| $E_{on}$ (100%) = | 0,31 | mJ |
| $t_{Eon}$ = | 0,24 | μs |

**Figure 7** Output inverter FWD

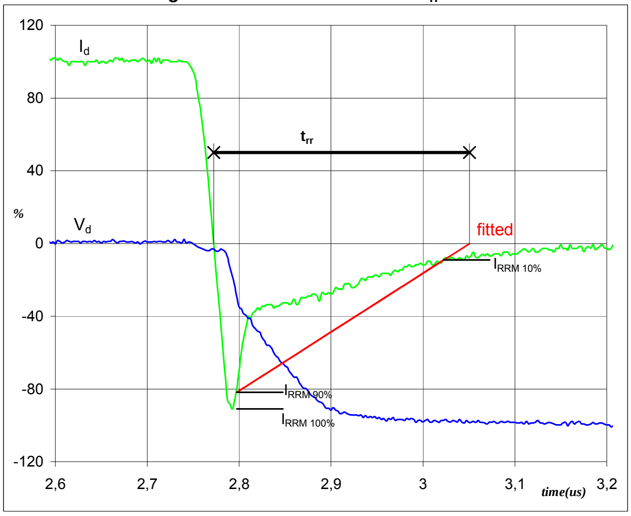
**Gate voltage vs Gate charge (measured)**




| | | |
|---|---|---|
| $V_{GEoff}$ = | 0 | V |
| $V_{GEon}$ = | 15 | V |
| $V_C$ (100%) = | 300 | V |
| $I_C$ (100%) = | 10 | A |
| $Q_g$ = | 70,94 | nC |

**Figure 8** Output inverter IGBT

**Turn-off Switching Waveforms & definition of $t_{rr}$**

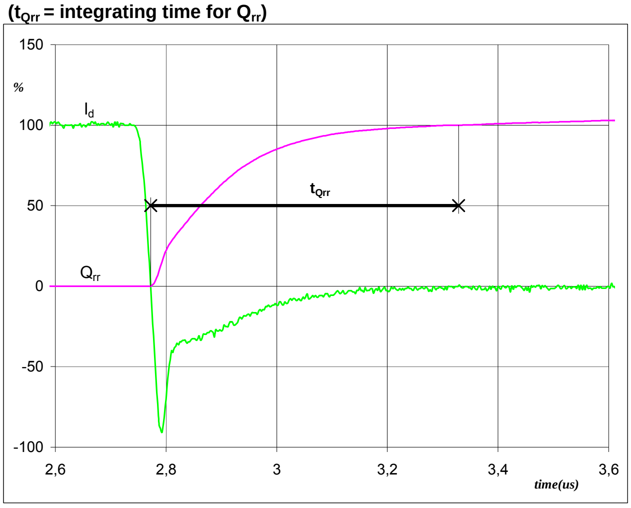



| | | |
|---|---|---|
| $V_d$ (100%) = | 300 | V |
| $I_d$ (100%) = | 10 | A |
| $I_{RRM}$ (100%) = | 9 | A |
| $t_{rr}$ = | 0,26 | μs |

# Switching Definitions Output Inverter

| **Figure 9** | Output inverter FWD |
|---|---|

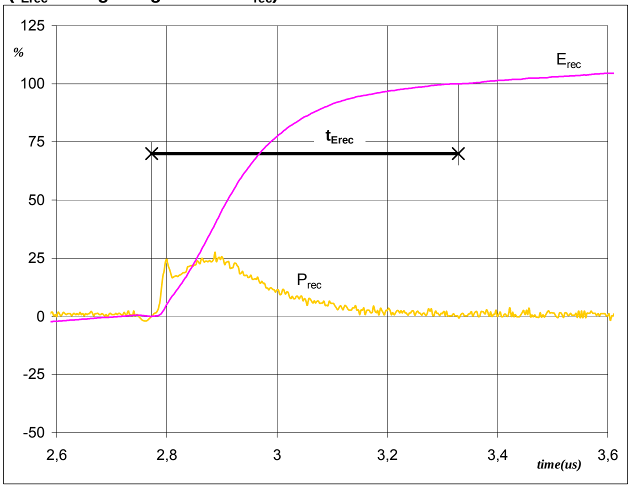
**Turn-on Switching Waveforms & definition of $t_{Qrr}$**
**($t_{Qrr}$ = integrating time for $Q_{rr}$)**




| | | |
|---|---|---|
| $I_d$ (100%) = | 10 | A |
| $Q_{rr}$ (100%) = | 0,82 | µC |
| $t_{Qrr}$ = | 0,56 | µs |

| **Figure 10** | Output inverter FWD |
|---|---|

**Turn-on Switching Waveforms & definition of $t_{Erec}$**
**($t_{Erec}$= integrating time for $E_{rec}$)**



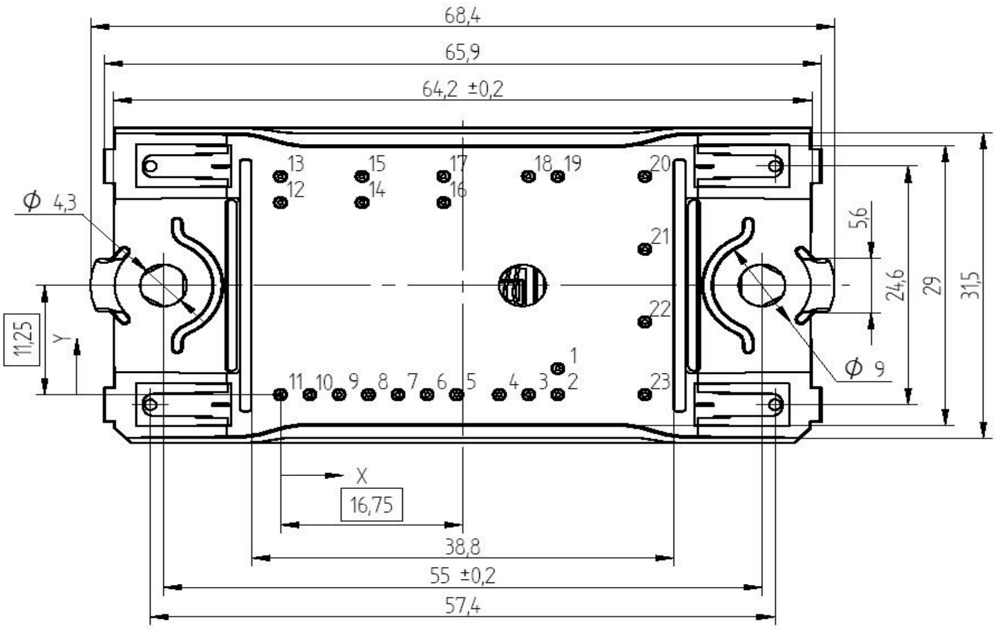

| | | |
|---|---|---|
| $P_{rec}$ (100%) = | 2,99 | kW |
| $E_{rec}$ (100%) = | 0,16 | mJ |
| $t_{Erec}$ = | 0,56 | µs |

# Ordering Code and Marking - Outline - Pinout

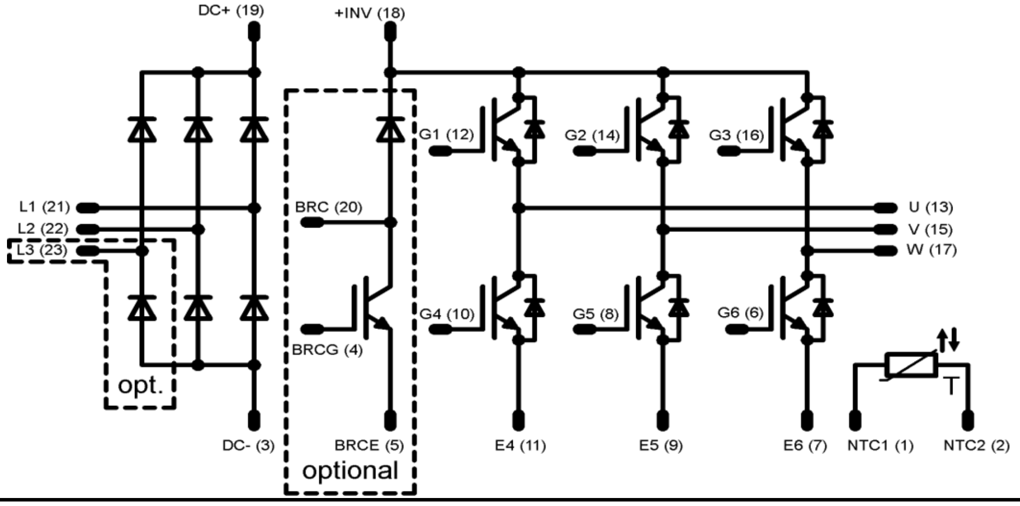
## Ordering Code & Marking

| Version | Ordering Code | in DataMatrix as | in packaging barcode as |
|---|---|---|---|
| without thermal paste 12mm 2clips housing | V23990-P543-A28-PM | P543-A28 | P543-A28 |
| without thermal paste 17mm 2clips housing | V23990-P543-A29-PM | P543-A29 | P543-A29 |
| without thermal paste 12mm 2clips housing | V23990-P543-C28-PM | P543-C28 | P543-C28 |
| without thermal paste 17mm 2clips housing | V23990-P543-C29-PM | P543-C29 | P543-C29 |

| Pin | X | Y |
|---|---|---|
| 1 | 25.5 | 2.7 |
| 2 | 25.5 | 0 |
| 3 | 22.8 | 0 |
| 4 | 20.1 | 0 |
| 5 | 16.2 | 0 |
| 6 | 13.5 | 0 |
| 7 | 10.8 | 0 |
| 8 | 8.1 | 0 |
| 9 | 5.4 | 0 |
| 10 | 2.7 | 0 |
| 11 | 0 | 0 |
| 12 | 0 | 19.8 |
| 13 | 0 | 22.5 |
| 14 | 7.5 | 19.8 |
| 15 | 7.5 | 22.5 |
| 16 | 15 | 19.8 |
| 17 | 15 | 22.5 |
| 18 | 22.8 | 22.5 |
| 19 | 25.5 | 22.5 |
| 20 | 33.5 | 22.5 |
| 21 | 33.5 | 15 |
| 22 | 33.5 | 7.5 |
| 23 | 33.5 | 0 |




## Pinout



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2. A critical component is any component of a life support device or system whose failure to perform can be reasonably expected to cause the failure of the life support device or system, or to affect its safety or effectiveness.