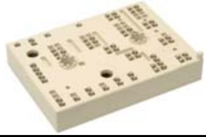
## MiniSKiiP® 3 PIM — 1200V/100A

### Features

- Solderless interconnection
- Trench Fieldstop IGBT4 technology

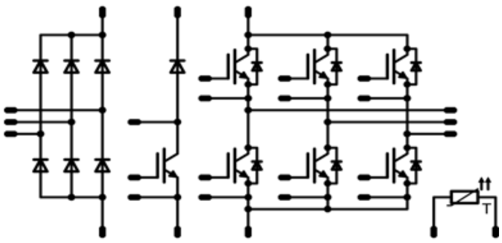
### MiniSKiiP® 3 housing



### Target Applications

- Industrial Motor Drives

### Schematic



### Types

- V23990-K420-A40-PM

# 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 | $I_{FAV}$ | DC current | $T_h$=80°C | 74 | A |
| Surge forward current | $I_{FSM}$ | $t_p$=10ms | $T_j$=25°C | 500 | A |
| I2t-value | $I^2t$ | $t_p$=10ms | $T_j$=25°C | 1250 | $A^2s$ |
| Power dissipation per Diode | $P_{tot}$ | $T_j=T_j$max | $T_h$=80°C | 75 | W |
| Maximum Junction Temperature | $T_j$max | | | 150 | °C |
| **Inverter Transistor** | | | | | |
| Collector-emitter break down voltage | $V_{CE}$ | | | 1200 | V |
| DC collector current | $I_C$ | $T_j=T_j$max | $T_h$=80°C | 67 | A |
| Repetitive peak collector current | $I_{Cpulse}$ | $t_p$ limited by $T_j$max | | 300 | A |
| Power dissipation per IGBT | $P_{tot}$ | $T_j=T_j$max | $T_h$=80°C | 127 | 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 | | 10<br>800 | μs<br>V |
| Maximum Junction Temperature | $T_j$max | | | 175 | °C |

# Maximum Ratings

$T_j$=25°C, unless otherwise specified

| Parameter | Symbol | Condition | | Value | Unit |
|---|---|---|---|---|---|
| **Inverter Diode** | | | | | |
| Repetitive peak reverse voltage | $V_{RRM}$ | | | 1200 | V |
| DC forward current | $I_F$ | $T_j=T_j$max | $T_h$=80°C | 51 | A |
| Repetitive peak forward current | $I_{FRM}$ | $t_p$ limited by $T_j$max | | 300 | A |
| Power dissipation per Diode | $P_{tot}$ | $T_j=T_j$max | $T_h$=80°C | 90 | W |
| Maximum Junction Temperature | $T_j$max | | | 175 | °C |
| **Brake Transistor** | | | | | |
| Collector-emitter break down voltage | $V_{CE}$ | | | 1200 | V |
| DC collector current | $I_C$ | $T_j=T_j$max | $T_h$=80°C | 66 | A |
| Repetitive peak collector current | $I_{Cpuls}$ | $t_p$ limited by $T_j$max | | 300 | A |
| Power dissipation per IGBT | $P_{tot}$ | $T_j=T_j$max | $T_h$=80°C | 127 | 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 | | 10<br>800 | μs<br>V |
| Maximum Junction Temperature | $T_j$max | | | 175 | °C |
| **Brake Diode** | | | | | |
| Repetitive peak reverse voltage | $V_{RRM}$ | | | 1200 | V |
| DC forward current | $I_F$ | $T_j=T_j$max | $T_h$=80°C | 51 | A |
| Repetitive peak forward current | $I_{FRM}$ | $t_p$ limited by $T_j$max | | 300 | A |
| Power dissipation per Diode | $P_{tot}$ | $T_j=T_j$max | $T_h$=80°C | 90 | W |
| Maximum Junction Temperature | $T_j$max | | | 175 | °C |
| **Thermal Properties** | | | | | |
| Storage temperature | $T_{stg}$ | | | -40…+125 | °C |
| Operation temperature under switching condition | $T_{op}$ | | | -40…+(Tjmax - 25) | °C |
| **Insulation Properties** | | | | | |
| Insulation voltage | $V_{is}$ | t=2s | DC voltage | 4000 | V |
| Creepage distance | | | | min 12.7 | mm |
| Clearance | | | | min 12.7 | mm |

## Characteristic Values

| Parameter | Symbol | Conditions | | | | | Value | | | Unit |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | $V_{GE}$ [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 | |
| **Input Rectifier Diode** | | | | | | | | | | |
| Forward voltage | $V_F$ | | | | 35 | Tj=25°C<br>Tj=125°C | 0.8 | 0.97<br>0.88 | 1.35 | V |
| Threshold voltage (for power loss calc. only) | $V_{to}$ | | | | | Tj=25°C<br>Tj=125°C | | 0.85<br>0.71 | | V |
| Slope resistance (for power loss calc. only) | $r_t$ | | | | | Tj=25°C<br>Tj=125°C | | 0.0035<br>0.0047 | | Ω |
| Reverse current | $I_r$ | | | 1500 | | Tj=25°C<br>Tj=125°C | | | 0.1<br>1.1 | mA |
| Thermal resistance chip to heatsink per chip | $R_{thJH}$ | Thermal grease thickness≤50μm λ=1W/mK | | | | | | 0.93 | | K/W |
| Thermal resistance chip to case per chip | $R_{thJC}$ | | | | | | | N/A | | |
| **Inverter Transistor** | | | | | | | | | | |
| Gate emitter threshold voltage | $V_{GE(th)}$ | $V_{CE}=V_{GE}$ | | | 0.0038 | Tj=25°C<br>Tj=150°C | 5 | 5.8 | 6.5 | V |
| Collector-emitter saturation voltage | $V_{CE(sat)}$ | | 15 | | 100 | Tj=25°C<br>Tj=150°C | 1.6 | 1.92<br>2.33 | 2.2 | V |
| Collector-emitter cut-off current incl. Diode | $I_{CES}$ | | 0 | 1200 | | Tj=25°C<br>Tj=150°C | | | 0.12 | mA |
| Gate-emitter leakage current | $I_{GES}$ | | 20 | 0 | | Tj=25°C<br>Tj=150°C | | | 600 | nA |
| Integrated Gate resistor | $R_{gint}$ | | | | | | | 7.5 | | Ω |
| Turn-on delay time | $t_{d(on)}$ | Rgoff=4Ω<br>Rgon=4Ω | ±15 | 600 | 100 | Tj=25°C<br>Tj=150°C | | 204<br>216 | | ns |
| Rise time | $t_r$ | | | | | Tj=25°C<br>Tj=150°C | | 35<br>42 | | |
| Turn-off delay time | $t_{d(off)}$ | | | | | Tj=25°C<br>Tj=150°C | | 296<br>384 | | |
| Fall time | $t_f$ | | | | | Tj=25°C<br>Tj=150°C | | 78<br>112 | | |
| Turn-on energy loss per pulse | $E_{on}$ | | | | | Tj=25°C<br>Tj=150°C | | 7.83<br>12.12 | | mWs |
| Turn-off energy loss per pulse | $E_{off}$ | | | | | Tj=25°C<br>Tj=150°C | | 5.72<br>9.25 | | |
| Input capacitance | $C_{ies}$ | f=1MHz | 0 | 25 | | Tj=25°C | | 6150 | | pF |
| Output capacitance | $C_{oss}$ | | | | | | | 405 | | |
| Reverse transfer capacitance | $C_{rss}$ | | | | | | | 345 | | |
| Gate charge | $Q_{Gate}$ | | ±15 | | | Tj=25°C | | 800 | | nC |
| Thermal resistance chip to heatsink per chip | $R_{thJH}$ | Thermal grease thickness≤50μm λ=1W/mK | | | | | | 0.75 | | K/W |
| Thermal resistance chip to case per chip | $R_{thJC}$ | | | | | | | N/A | | |
| **Inverter Diode** | | | | | | | | | | |
| Diode forward voltage | $V_F$ | | | | 100 | Tj=25°C<br>Tj=150°C | 1.5 | 2.47<br>2.46 | 2.7 | V |
| Peak reverse recovery current | $I_{RRM}$ | Rgon=4Ω | ±15 | 600 | 100 | Tj=25°C<br>Tj=150°C | | 68.3<br>91.3 | | A |
| Reverse recovery time | $t_{rr}$ | | | | | Tj=25°C<br>Tj=150°C | | 267<br>455 | | ns |
| Reverse recovered charge | $Q_{rr}$ | | | | | Tj=25°C<br>Tj=150°C | | 5.69<br>15.08 | | μC |
| Peak rate of fall of recovery current | di(rec)max /dt | | | | | Tj=25°C<br>Tj=150°C | | 2761<br>977 | | A/μs |
| Reverse recovered energy | Erec | | | | | Tj=25°C<br>Tj=150°C | | 1.87<br>5.42 | | mWs |
| Thermal resistance chip to heatsink per chip | $R_{thJH}$ | Thermal grease thickness≤50μm λ=1W/mK | | | | | | 1.05 | | K/W |
| Thermal resistance chip to case per chip | $R_{thJC}$ | | | | | | | N/A | | |

## Characteristic Values

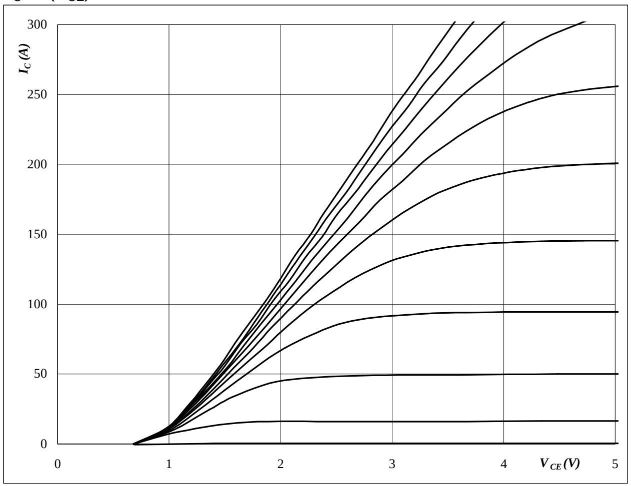
| Parameter | Symbol | Conditions | | | | | Value | | | Unit |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | $V_{GE}$ [V] or $V_{GS}$ [V] | $V_r$ [V] or $V_{CE}$ [V] or $V_{DS}$ [V] | $I_C$ [A] or $I_F$ [A] or $I_D$ [A] | $T_j$ | Min | Typ | Max | |
| **Brake Transistor** | | | | | | | | | | |
| Gate emitter threshold voltage | $V_{GE(th)}$ | $V_{CE}=V_{GE}$ | | | 0.0038 | Tj=25°C<br>Tj=150°C | 5 | 5.8 | 6.5 | V |
| Collector-emitter saturation voltage | $V_{CE(sat)}$ | | 15 | | 100 | Tj=25°C<br>Tj=150°C | 1.6 | 1.92<br>2.33 | 2.2 | V |
| Collector-emitter cut-off incl diode | $I_{CES}$ | | 0 | 1200 | | Tj=25°C<br>Tj=150°C | | | 0.12 | mA |
| Gate-emitter leakage current | $I_{GES}$ | | 20 | 0 | | Tj=25°C<br>Tj=150°C | | | 600 | nA |
| Integrated Gate resistor | $R_{gint}$ | | | | | | | 7.5 | | Ω |
| Turn-on delay time | $t_{d(on)}$ | Rgoff=4Ω<br>Rgon=4Ω | ±15 | 600 | 100 | Tj=25°C<br>Tj=150°C | | 198<br>215 | | ns |
| Rise time | $t_r$ | | | | | Tj=25°C<br>Tj=150°C | | 44<br>54 | | |
| Turn-off delay time | $t_{d(off)}$ | | | | | Tj=25°C<br>Tj=150°C | | 292<br>378 | | |
| Fall time | $t_f$ | | | | | Tj=25°C<br>Tj=150°C | | 73.5<br>113.4 | | |
| Turn-on energy loss per pulse | $E_{on}$ | | | | | Tj=25°C<br>Tj=150°C | | 10.3<br>15.2 | | mWs |
| Turn-off energy loss per pulse | $E_{off}$ | | | | | Tj=25°C<br>Tj=150°C | | 5.67<br>8.97 | | |
| Input capacitance | $C_{ies}$ | f=1MHz | 0 | 25 | | Tj=25°C | | 6150 | | pF |
| Output capacitance | $C_{oss}$ | | | | | | | 405 | | |
| Reverse transfer capacitance | $C_{rss}$ | | | | | | | 345 | | |
| Gate charge | $Q_{Gate}$ | | ±15 | | | Tj=25°C | | 800 | | nC |
| Thermal resistance chip to heatsink per chip | $R_{thJH}$ | Thermal grease thickness≤50µm λ=1W/mK | | | | | | 0.75 | | K/W |
| Thermal resistance chip to case per chip | $R_{thJC}$ | | | | | | | N/A | | |
| **Brake Diode** | | | | | | | | | | |
| Diode forward voltage | $V_F$ | | | | 100 | Tj=25°C<br>Tj=150°C | 1.5 | 2.47<br>2.45 | 2.7 | V |
| Reverse leakage current | $I_r$ | | | 1200 | | Tj=25°C<br>Tj=150°C | | | 120<br>10500 | µA |
| Peak reverse recovery current | $I_{RRM}$ | Rgon=4Ω | ±15 | 600 | 100 | Tj=25°C<br>Tj=150°C | | 37.8<br>53.3 | | A |
| Reverse recovery time | $t_{rr}$ | | | | | Tj=25°C<br>Tj=150°C | | 304<br>599 | | ns |
| Reverse recovered charge | $Q_{rr}$ | | | | | Tj=25°C<br>Tj=150°C | | 5.01<br>14.17 | | µC |
| Peak rate of fall of recovery current | di(rec)max/dt | | | | | Tj=25°C<br>Tj=150°C | | 477<br>93 | | A/µs |
| Reverse recovery energy | $E_{rec}$ | | | | | Tj=25°C<br>Tj=150°C | | 1.56<br>4.92 | | mWs |
| Thermal resistance chip to heatsink per chip | $R_{thJH}$ | Thermal grease thickness≤50µm λ=1W/mK | | | | | | 1.05 | | K/W |
| Thermal resistance chip to case per chip | $R_{thJC}$ | | | | | | | N/A | | |
| **Thermistor** | | | | | | | | | | |
| Rated resistance | R | | | | | Tj=25°C<br>Tj=150°C | 0.97 | 1<br>2.23 | 1.03 | kΩ |
| Temperature coefficient | a | | | | | Tj=25°C | | 0.76 | | %/K |
| Recommended measuring current | I | | | | | Tj=25°C | | 1 | 3 | mA |

# Output Inverter

**Figure 1** Output inverter IGBT

**Typical output characteristics**

$I_C = f(V_{CE})$



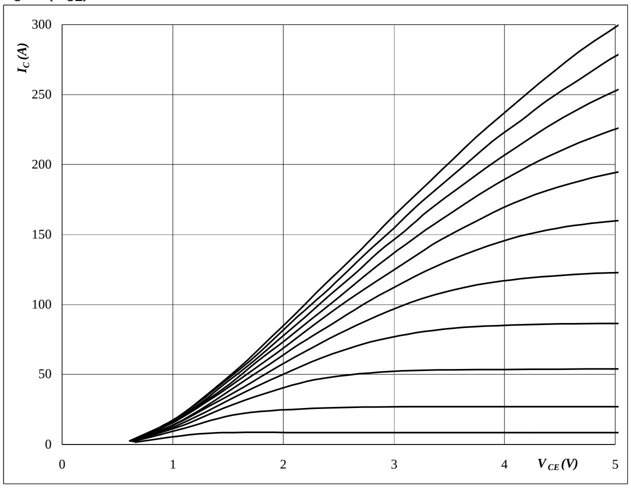

**At**

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

**Figure 2** Output inverter IGBT

**Typical output characteristics**

$I_C = f(V_{CE})$



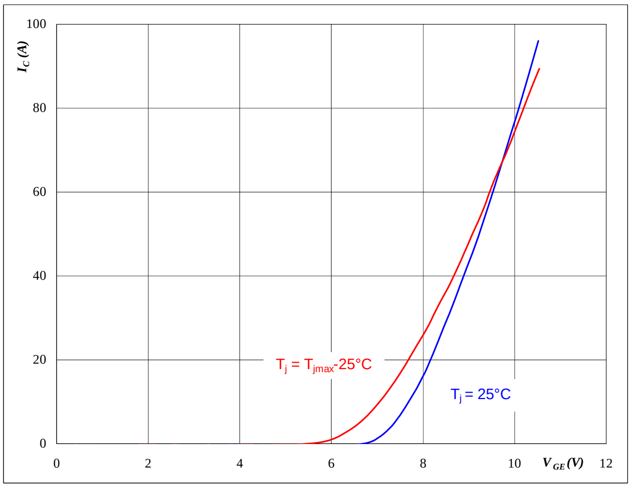

**At**

| | | |
|---|---|---|
| $t_p$ = | 250 | μs |
| $T_j$ = | 150 | °C |
| $V_{GE}$ from | 7 V to 17 V in steps of 1 V | |

**Figure 3** Output inverter IGBT

**Typical transfer characteristics**

$I_C = f(V_{GE})$



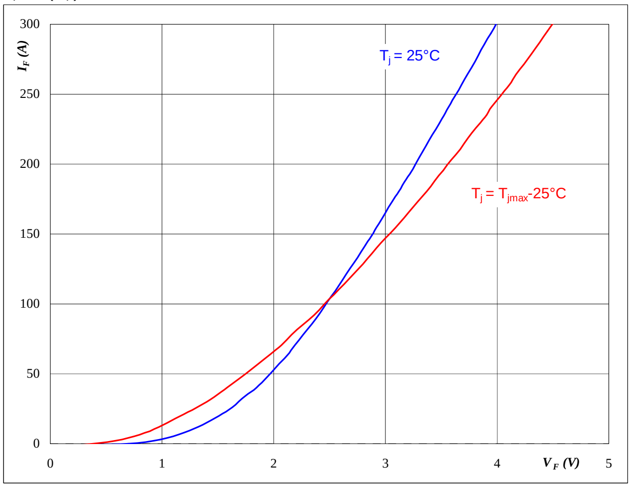

**At**

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

**Figure 4** Output inverter FRED

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

$I_F = f(V_F)$




**At**

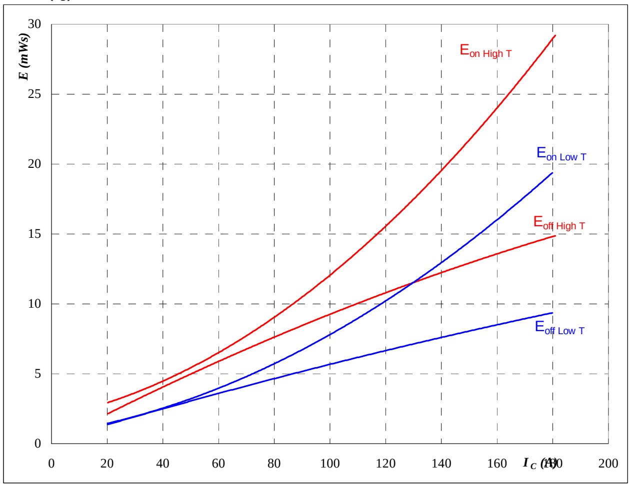
| | | |
|---|---|---|
| $t_p$ = | 250 | μs |

# Output Inverter

**Figure 5** Output inverter IGBT

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

$E = f(I_C)$



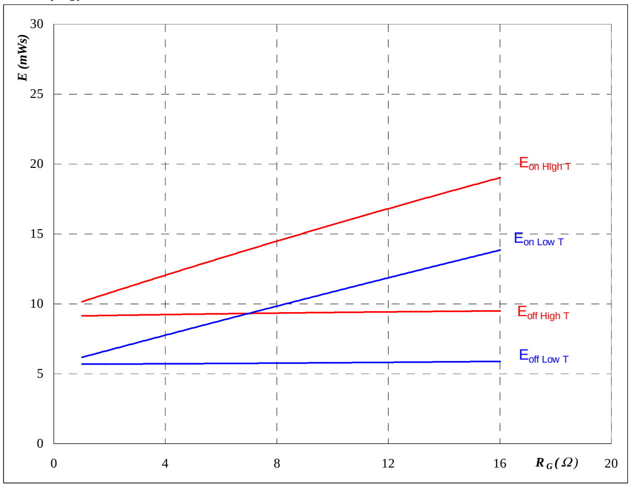

With an inductive load at

| | | |
|---|---|---|
| $T_j$ = | 25/150 | °C |
| $V_{CE}$ = | 600 | V |
| $V_{GE}$ = | ±15 | V |
| $R_{gon}$ = | 4 | Ω |
| $R_{goff}$ = | 4 | Ω |

**Figure 6** Output inverter IGBT

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

$E = f(R_G)$



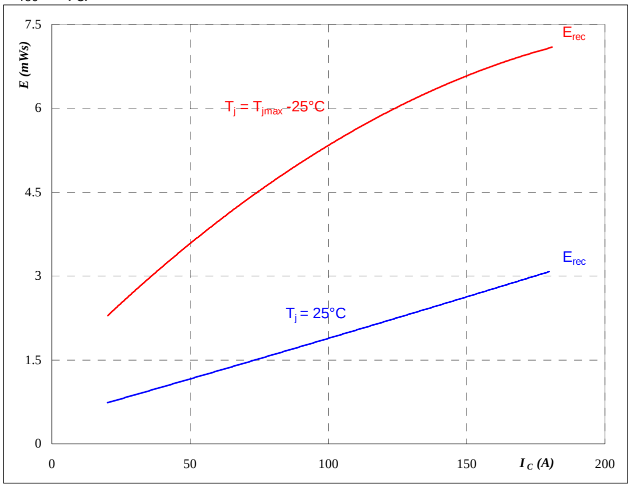

With an inductive load at

| | | |
|---|---|---|
| $T_j$ = | 25/150 | °C |
| $V_{CE}$ = | 600 | V |
| $V_{GE}$ = | ±15 | V |
| $I_C$ = | 100 | A |

**Figure 7** Output inverter IGBT

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

$E_{rec} = f(I_C)$



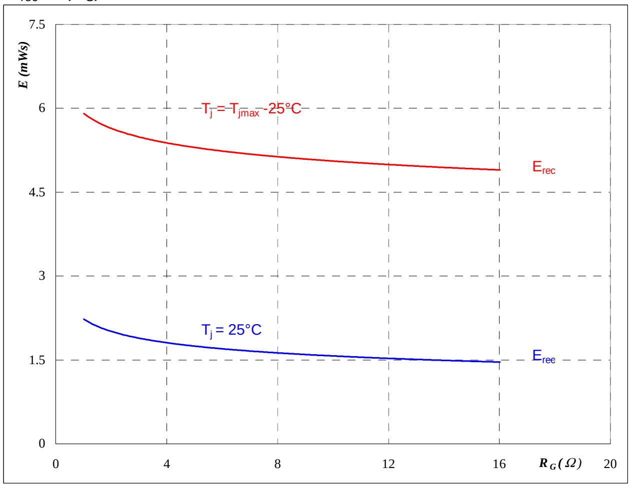

With an inductive load at

| | | |
|---|---|---|
| $T_j$ = | 25/150 | °C |
| $V_{CE}$ = | 600 | V |
| $V_{GE}$ = | ±15 | V |
| $R_{gon}$ = | 4 | Ω |

**Figure 8** Output inverter IGBT

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

$E_{rec} = f(R_G)$




With an inductive load at

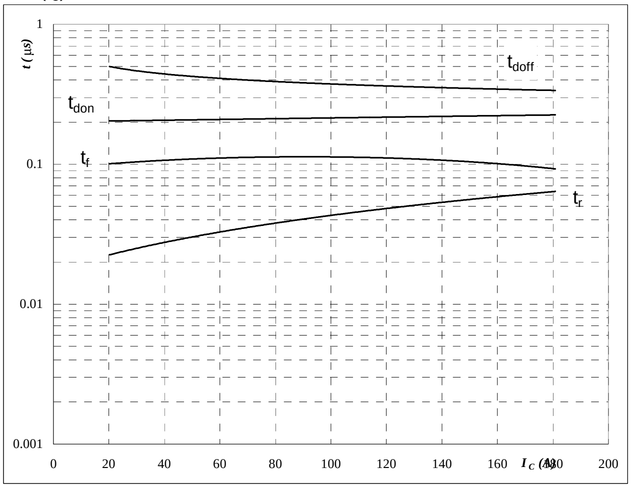
| | | |
|---|---|---|
| $T_j$ = | 25/150 | °C |
| $V_{CE}$ = | 600 | V |
| $V_{GE}$ = | ±15 | V |
| $I_C$ = | 100 | A |

# Output Inverter

**Figure 9** Output inverter IGBT

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

t = f($I_C$)



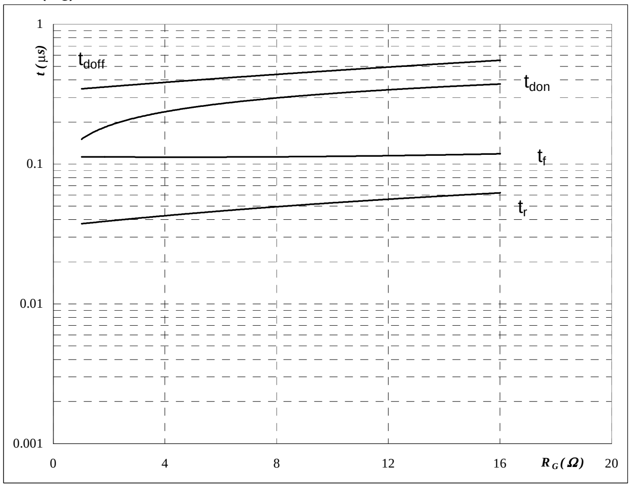

With an inductive load at

| | | |
|---|---|---|
| $T_j$ = | 150 | °C |
| $V_{CE}$ = | 600 | V |
| $V_{GE}$ = | ±15 | V |
| $R_{gon}$ = | 4 | Ω |
| $R_{goff}$ = | 4 | Ω |

**Figure 10** Output inverter IGBT

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

t = f($R_G$)



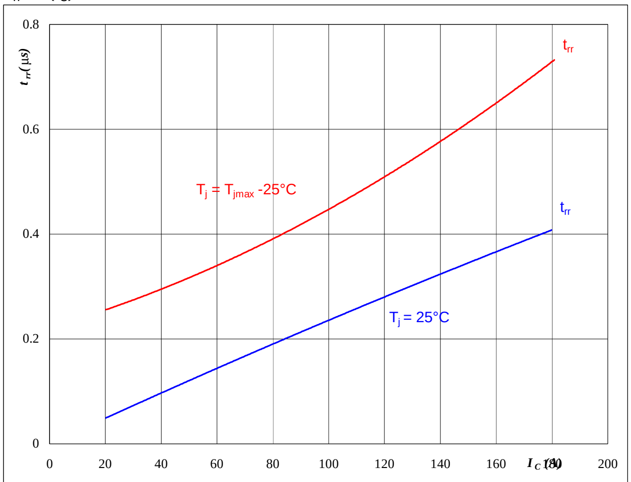

With an inductive load at

| | | |
|---|---|---|
| $T_j$ = | 150 | °C |
| $V_{CE}$ = | 600 | V |
| $V_{GE}$ = | ±15 | V |
| $I_C$ = | 100 | A |

**Figure 11** Output inverter FRED

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

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



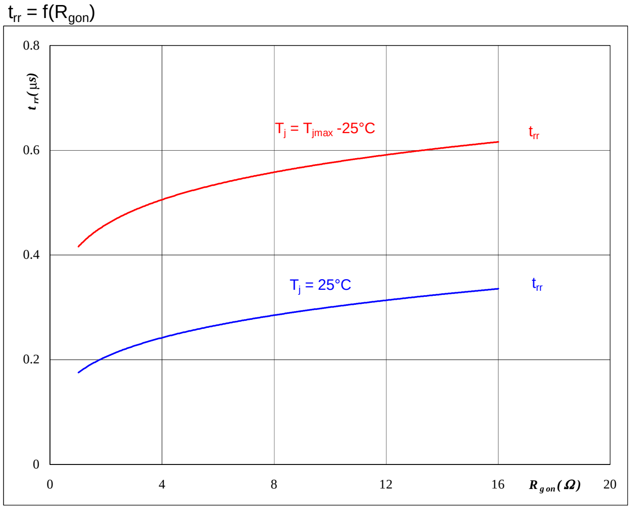

**At**

| | | |
|---|---|---|
| $T_j$ = | 25/150 | °C |
| $V_{CE}$ = | 600 | V |
| $V_{GE}$ = | ±15 | V |
| $R_{gon}$ = | 4 | Ω |

**Figure 12** Output inverter FRED

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

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




**At**

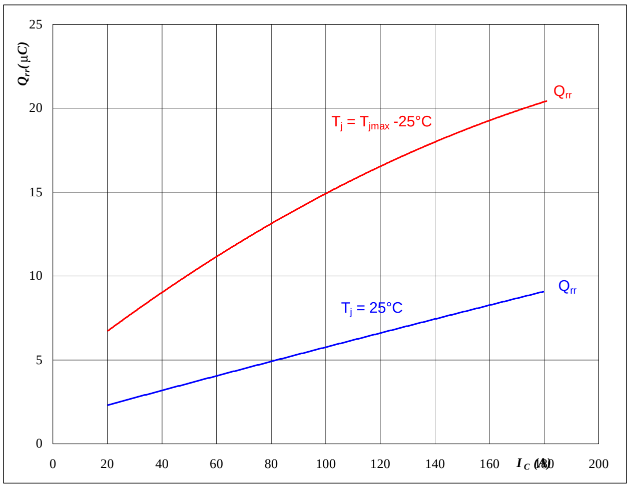
| | | |
|---|---|---|
| $T_j$ = | 25/150 | °C |
| $V_R$ = | 600 | V |
| $I_F$ = | 100 | A |
| $V_{GE}$ = | ±15 | V |

# Output Inverter

**Figure 13** Output inverter FRED

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

$Q_{rr} = f(I_C)$



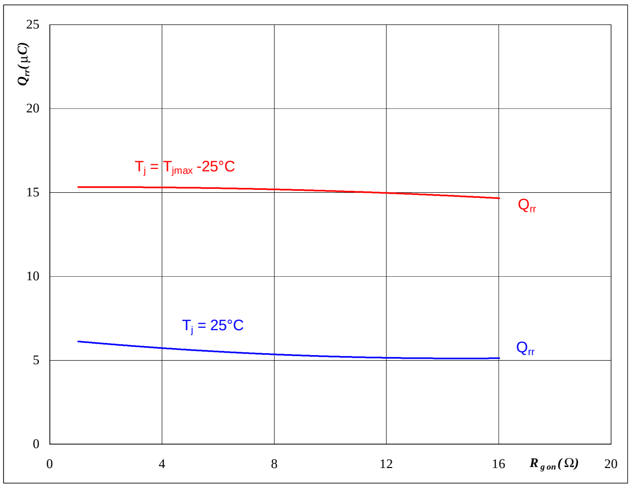

At

| | | |
|---|---|---|
| $T_j$ = | 25/150 | °C |
| $V_{CE}$ = | 600 | V |
| $V_{GE}$ = | ±15 | V |
| $R_{gon}$ = | 4 | Ω |

**Figure 14** Output inverter FRED

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

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



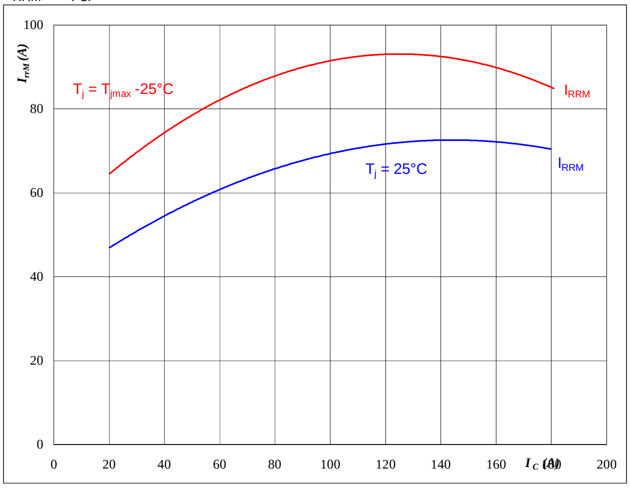

At

| | | |
|---|---|---|
| $T_j$ = | 25/150 | °C |
| $V_R$ = | 600 | V |
| $I_F$ = | 100 | A |
| $V_{GE}$ = | ±15 | V |

**Figure 15** Output inverter FRED

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

$I_{RRM} = f(I_C)$



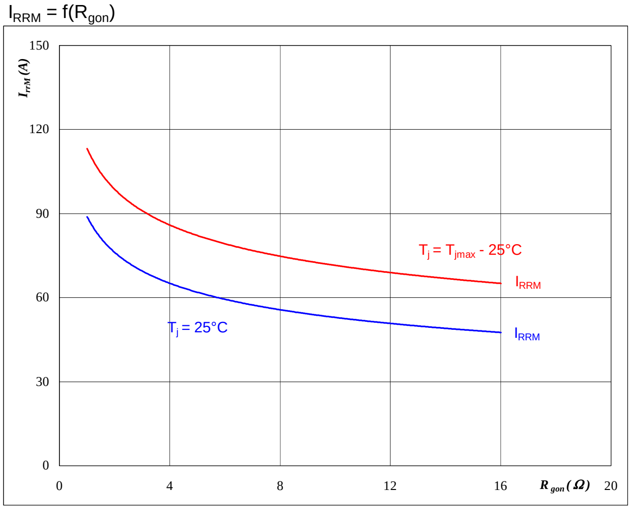

At

| | | |
|---|---|---|
| $T_j$ = | 25/150 | °C |
| $V_{CE}$ = | 600 | V |
| $V_{GE}$ = | ±15 | V |
| $R_{gon}$ = | 4 | Ω |

**Figure 16** Output inverter FRED

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

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




At

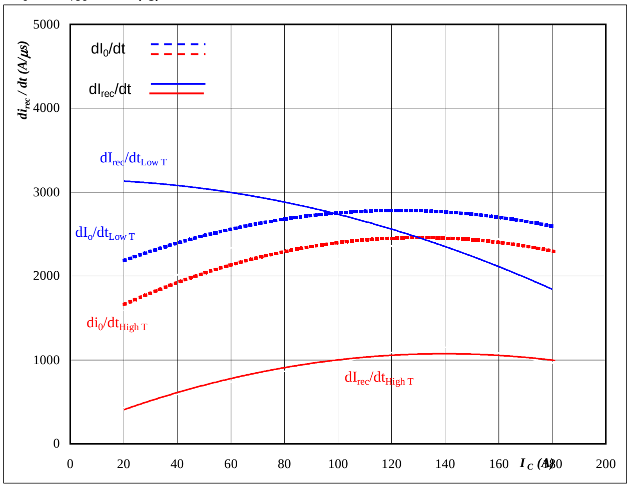
| | | |
|---|---|---|
| $T_j$ = | 25/150 | °C |
| $V_R$ = | 600 | V |
| $I_F$ = | 100 | A |
| $V_{GE}$ = | ±15 | V |

# Output Inverter

**Figure 17** Output inverter FRED

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

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



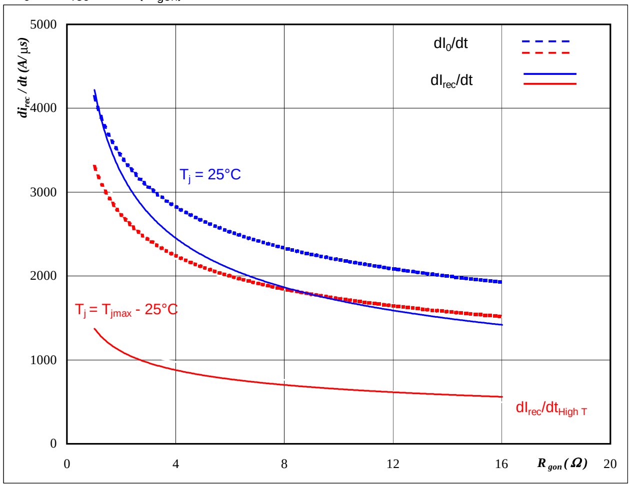

At

| | | |
|---|---|---|
| $T_j$ = | 25/150 | °C |
| $V_{CE}$ = | 600 | V |
| $V_{GE}$ = | ±15 | V |
| $R_{gon}$ = | 4 | Ω |

**Figure 18** Output inverter FRED

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

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



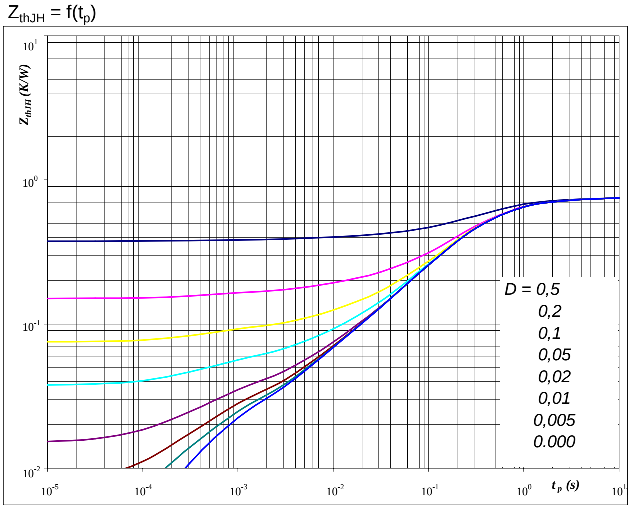

At

| | | |
|---|---|---|
| $T_j$ = | 25/150 | °C |
| $V_R$ = | 600 | V |
| $I_F$ = | 100 | 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 | |
| $R_{thJH}$ = | 0.75 | K/W |

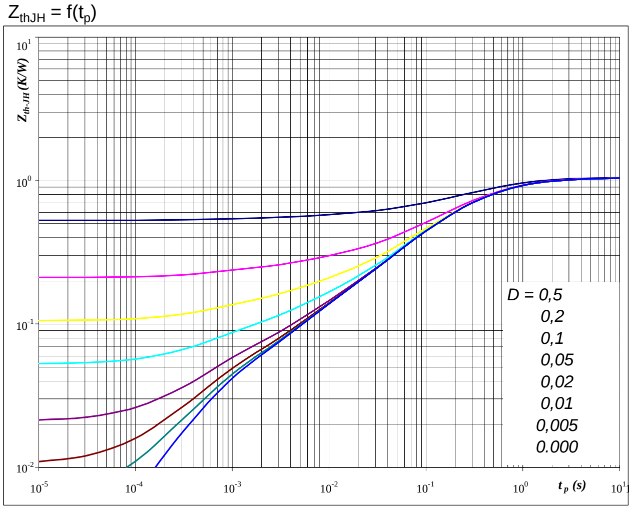
IGBT thermal model values

| R (C/W) | Tau (s) |
|---|---|
| 0.11 | 2.2E+00 |
| 0.42 | 3.8E-01 |
| 0.16 | 1.0E-01 |
| 0.04 | 9.2E-03 |
| 0.02 | 4.7E-04 |

**Figure 20** Output inverter FRED

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

$Z_{thJH} = f(t_p)$




At

| | | |
|---|---|---|
| D = | $t_p$ / T | |
| $R_{thJH}$ = | 1.05 | K/W |

FRED thermal model values

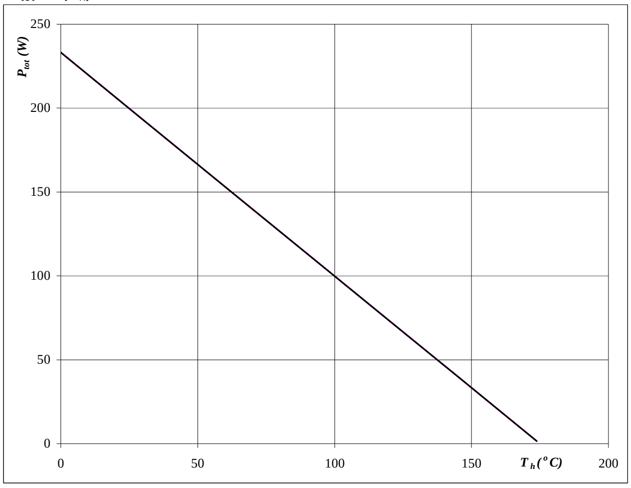
| R (C/W) | Tau (s) |
|---|---|
| 0.04 | 9.3E+00 |
| 0.21 | 1.1E+00 |
| 0.52 | 2.5E-01 |
| 0.19 | 5.4E-02 |
| 0.06 | 6.3E-03 |
| 0.03 | 6.4E-04 |

# Output Inverter

**Figure 21** Output inverter IGBT

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

$P_{tot} = f(T_h)$




At

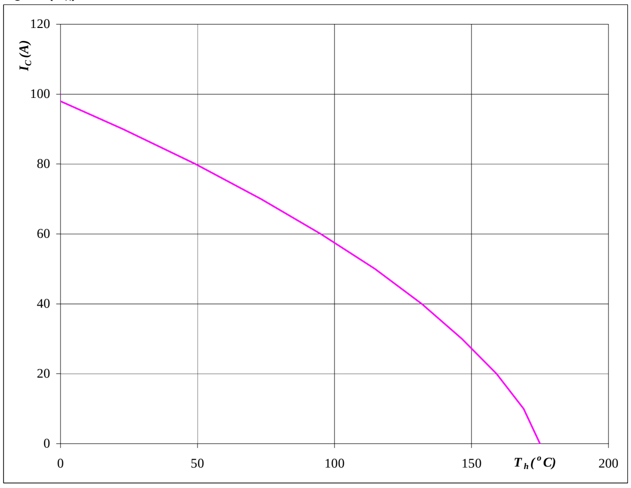
$T_j$ = 175 °C

single heating
overall heating

**Figure 22** Output inverter IGBT

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

$I_C = f(T_h)$




At

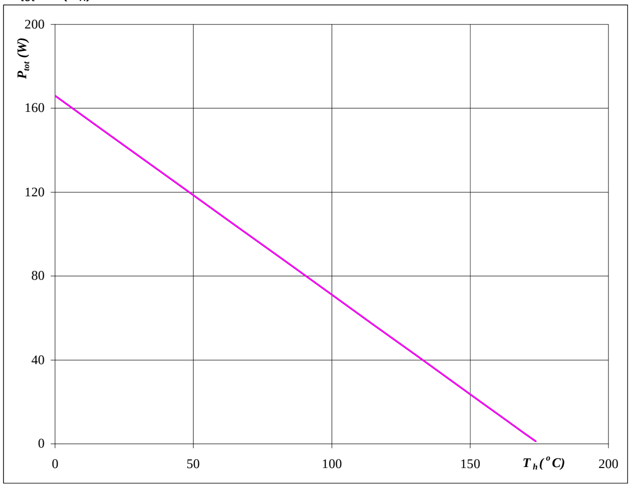
$T_j$ = 175 °C

$V_{GE}$ = 15 V

**Figure 23** Output inverter FRED

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

$P_{tot} = f(T_h)$




At

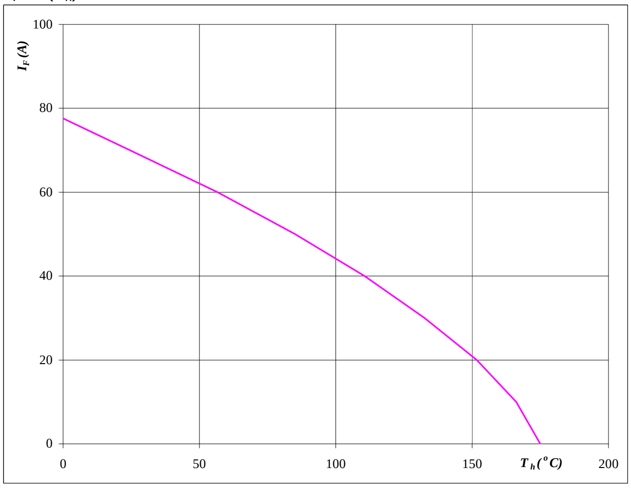
$T_j$ = 175 °C

single heating
overall heating

**Figure 24** Output inverter FRED

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

$I_F = f(T_h)$




At

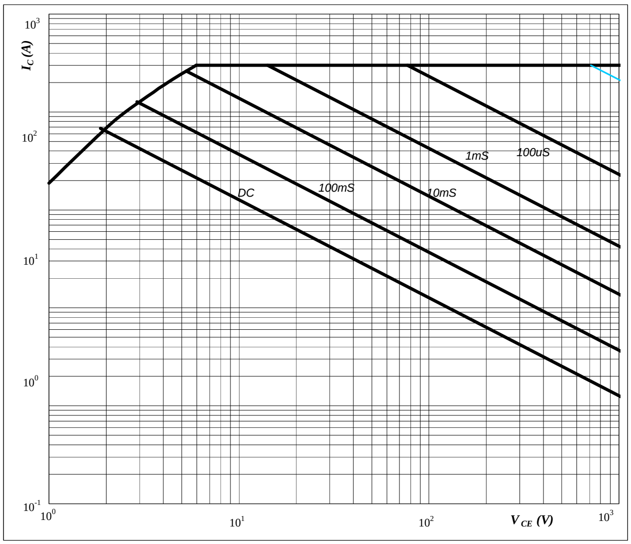
$T_j$ = 175 °C

# Output Inverter

**Figure 25** Output inverter IGBT

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

$I_C = f(V_{CE})$



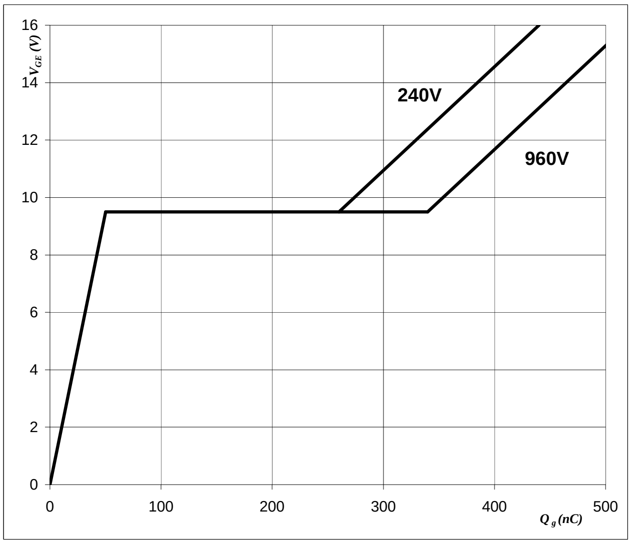

**At**

| | | |
|---|---|---|
| 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**

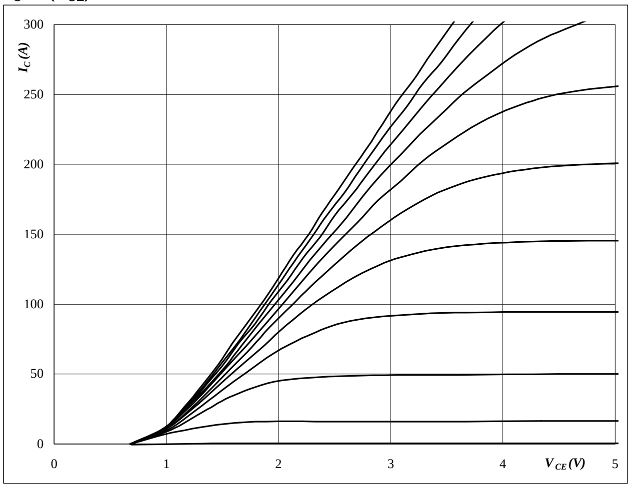
| | | |
|---|---|---|
| $I_C$ = | 100 | A |

# Brake

**Figure 1** Brake IGBT

**Typical output characteristics**

$I_C = f(V_{CE})$




**At**

$t_p$ = 250 µs

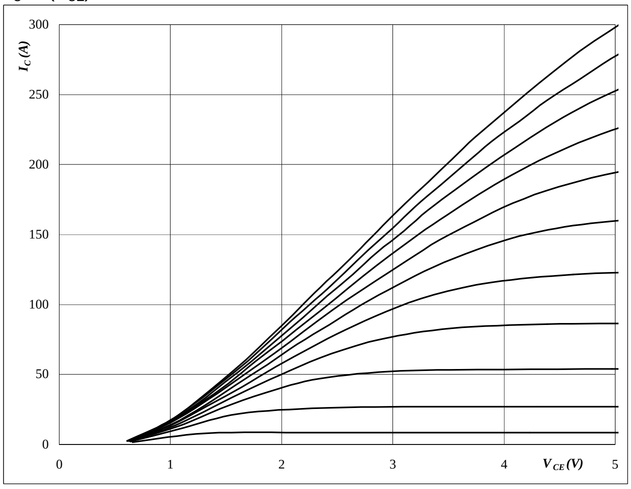
$T_j$ = 25 °C

$V_{GE}$ 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

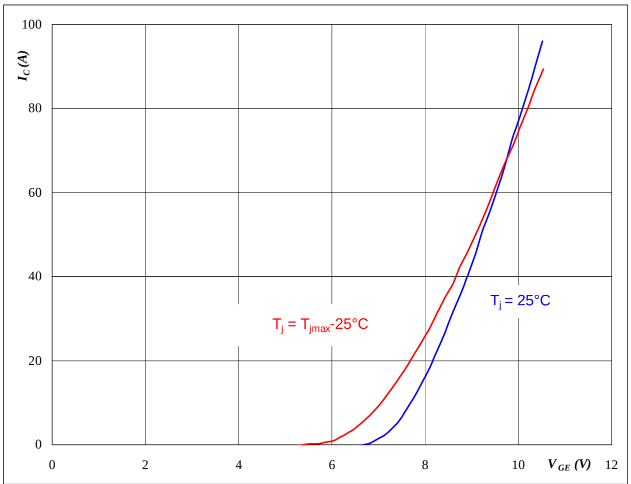
$T_j$ = 150 °C

$V_{GE}$ from 7 V to 17 V in steps of 1 V

**Figure 3** Brake IGBT

**Typical transfer characteristics**

$I_C = f(V_{GE})$




**At**

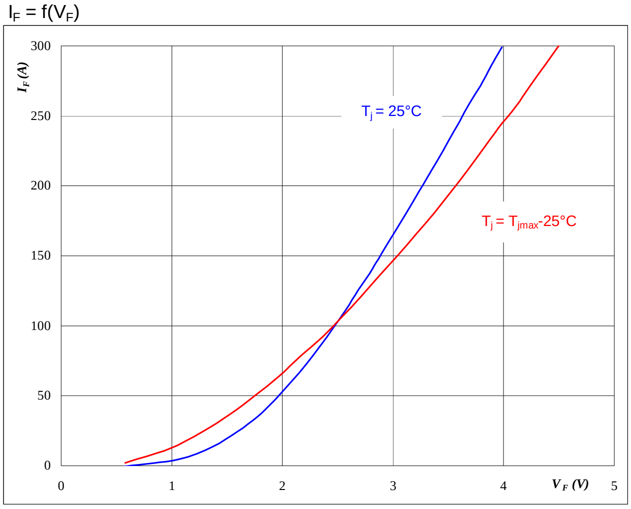
$t_p$ = 250 µs

$V_{CE}$ = 10 V

**Figure 4** Brake FRED

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

$I_F = f(V_F)$




**At**

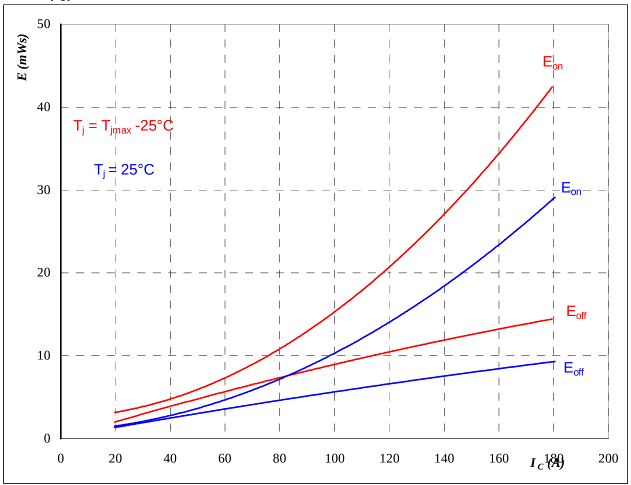
$t_p$ = 250 µs

# Brake

**Figure 5** Brake IGBT

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

$E = f(I_C)$



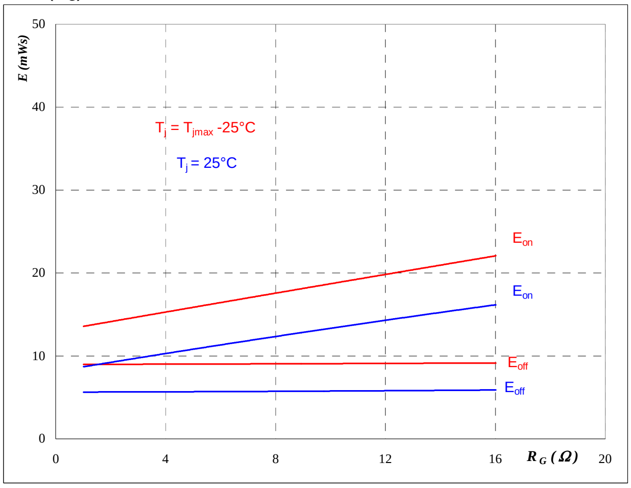

With an inductive load at

| | | |
|---|---|---|
| $T_j$ = | 25/150 | °C |
| $V_{CE}$ = | 600 | V |
| $V_{GE}$ = | ±15 | V |
| $R_{gon}$ = | 4 | Ω |
| $R_{goff}$ = | 4 | Ω |

**Figure 6** Brake IGBT

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

$E = f(R_G)$



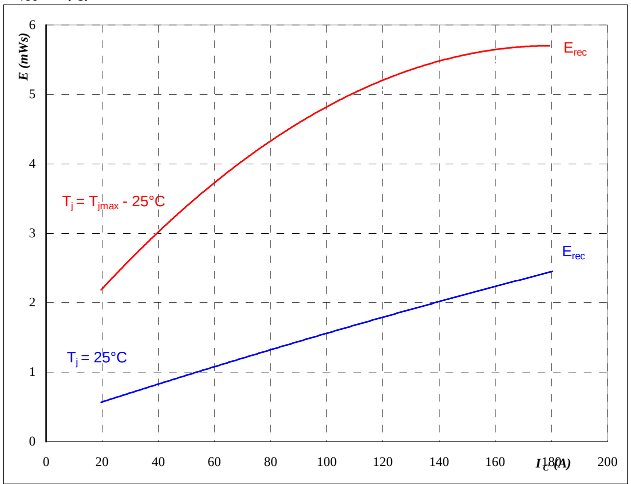

With an inductive load at

| | | |
|---|---|---|
| $T_j$ = | 25/150 | °C |
| $V_{CE}$ = | 600 | V |
| $V_{GE}$ = | ±15 | V |
| $I_C$ = | 100 | A |

**Figure 7** Brake IGBT

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

$E_{rec} = f(I_C)$



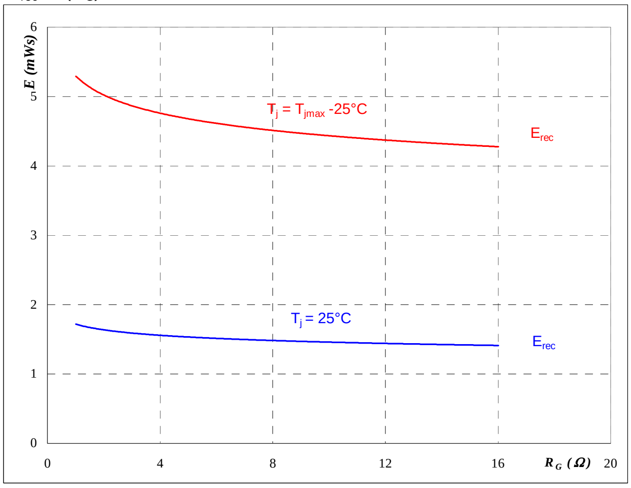

With an inductive load at

| | | |
|---|---|---|
| $T_j$ = | 25/150 | °C |
| $V_{CE}$ = | 600 | V |
| $V_{GE}$ = | ±15 | V |
| $R_{gon}$ = | 4 | Ω |

**Figure 8** Brake IGBT

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

$E_{rec} = f(R_G)$




With an inductive load at

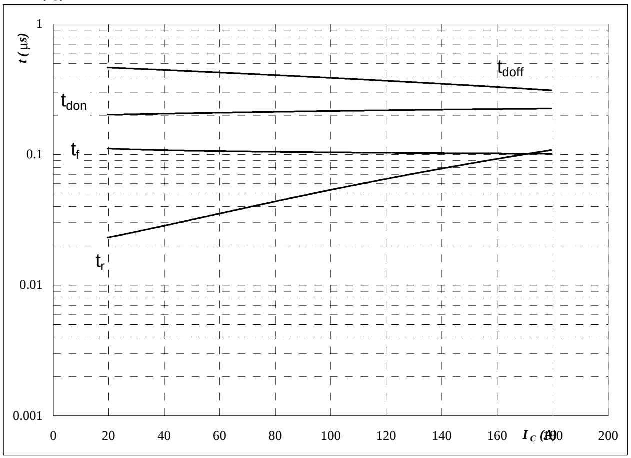
| | | |
|---|---|---|
| $T_j$ = | 25/150 | °C |
| $V_{CE}$ = | 600 | V |
| $V_{GE}$ = | ±15 | V |
| $I_C$ = | 100 | A |

# Brake

**Figure 9** Brake IGBT

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

$t = f(I_C)$



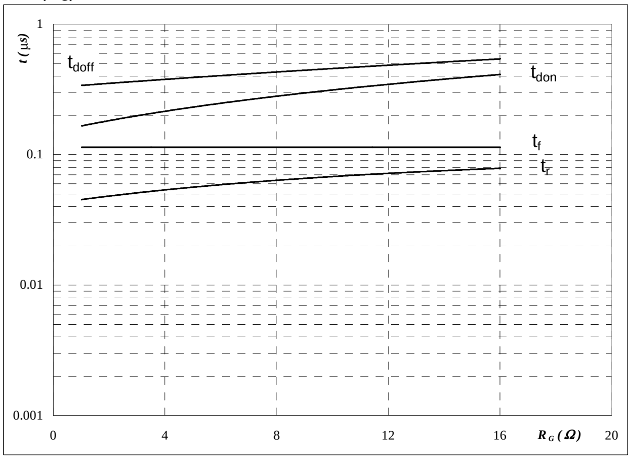

With an inductive load at

| | | |
|---|---|---|
| $T_j$ = | 25/150 | °C |
| $V_{CE}$ = | 600 | V |
| $V_{GE}$ = | ±15 | V |
| $R_{gon}$ = | 4 | Ω |
| $R_{goff}$ = | 4 | Ω |

**Figure 10** Brake IGBT

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

$t = f(R_G)$



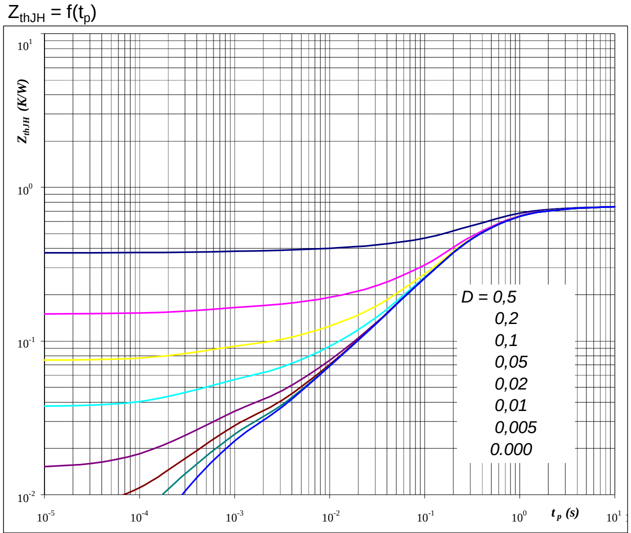

With an inductive load at

| | | |
|---|---|---|
| $T_j$ = | 25/150 | °C |
| $V_{CE}$ = | 600 | V |
| $V_{GE}$ = | ±15 | V |
| $I_C$ = | 100 | A |

**Figure 11** Brake IGBT

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

$Z_{thJH} = f(t_p)$



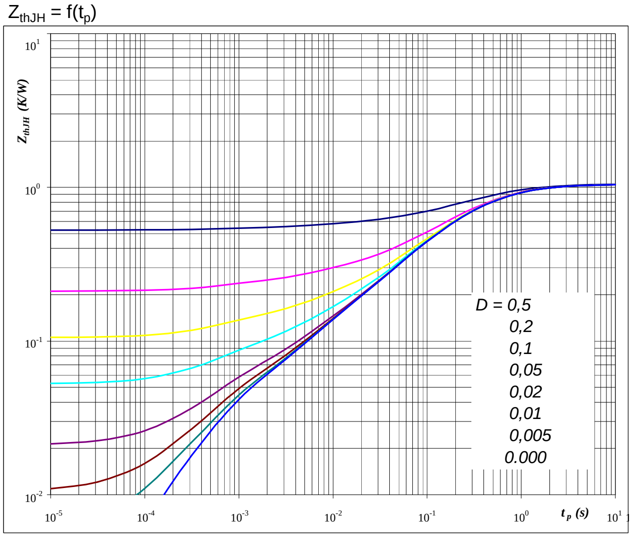

At

| | | |
|---|---|---|
| D = | tp / T | |
| $R_{thJH}$ = | 0.75 | K/W |

**Figure 12** Brake FRED

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

$Z_{thJH} = f(t_p)$




At

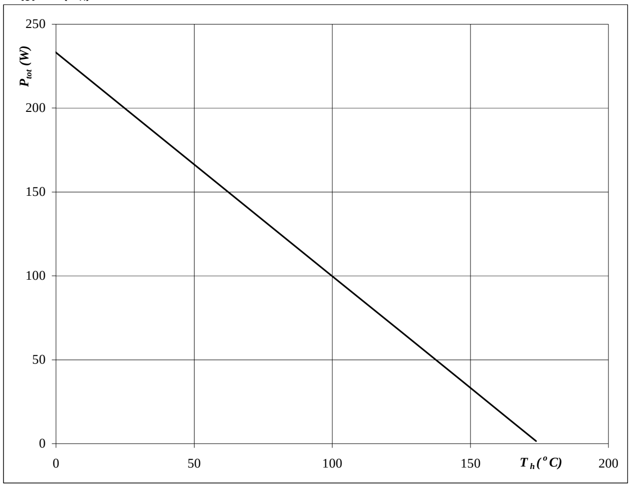
| | | |
|---|---|---|
| D = | tp / T | |
| $R_{thJH}$ = | 1.05 | K/W |

# Brake

**Figure 13** Brake IGBT

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

$P_{tot} = f(T_h)$



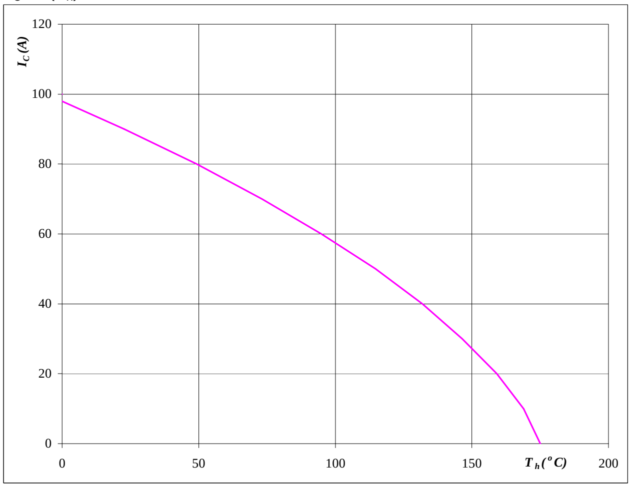

**At**

$T_j$ = 175 ºC

**Figure 14** Brake IGBT

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

$I_C = f(T_h)$




**At**

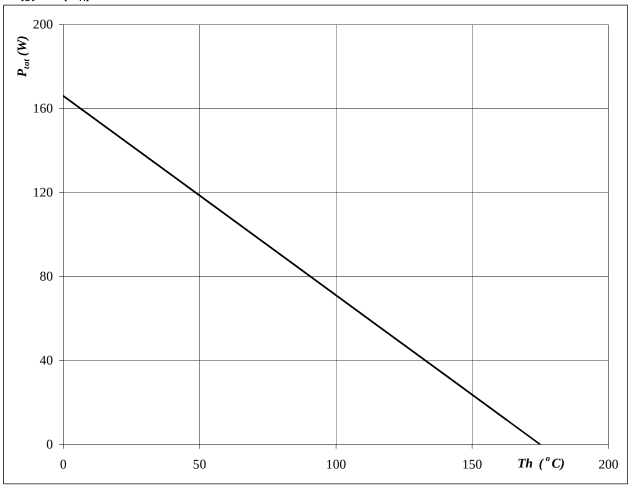
$T_j$ = 175 ºC

$V_{GE}$ = 15 V

**Figure 15** Brake FRED

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

$P_{tot} = f(T_h)$



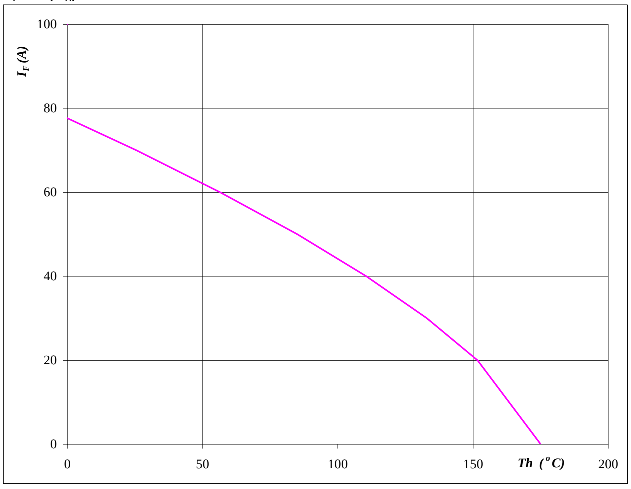

**At**

$T_j$ = 175 ºC

**Figure 16** Brake FRED

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

$I_F = f(T_h)$




**At**

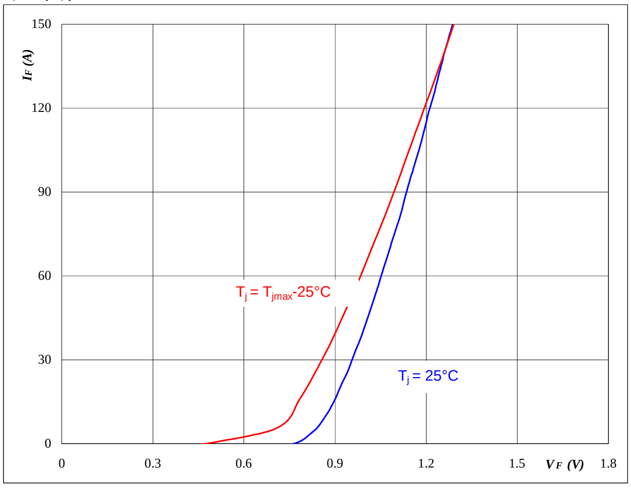
$T_j$ = 175 ºC

# Input Rectifier Bridge

**Figure 1** Rectifier diode

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

$I_F = f(V_F)$



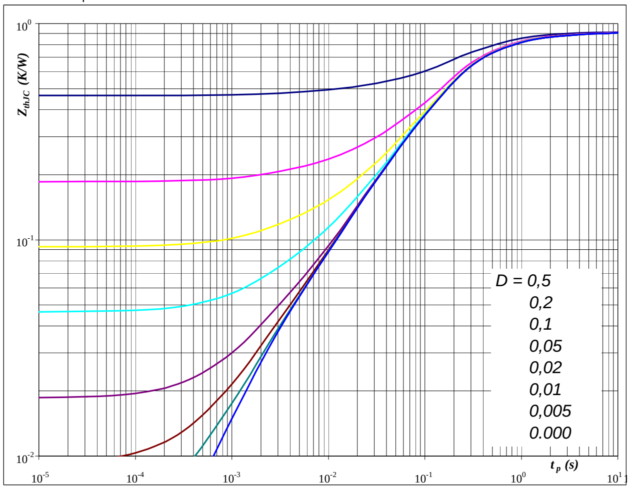

**At**

$t_p$ = 250 µs

**Figure 2** Rectifier diode

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

$Z_{thJH} = f(t_p)$




**At**

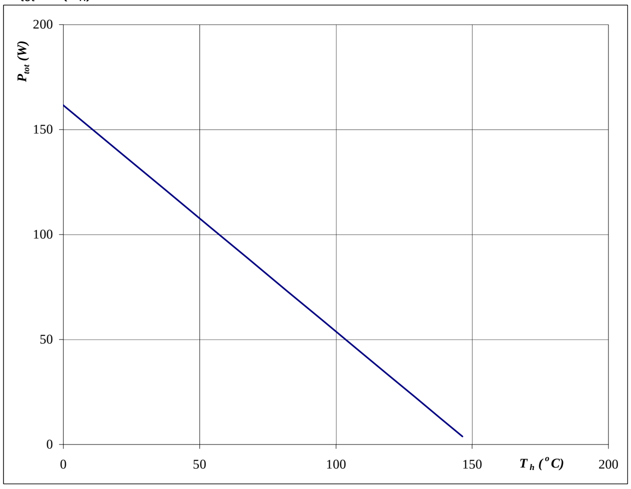
D = $t_p$ / T

$R_{thJH}$ = 0.928 K/W

**Figure 3** Rectifier diode

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

$P_{tot} = f(T_h)$



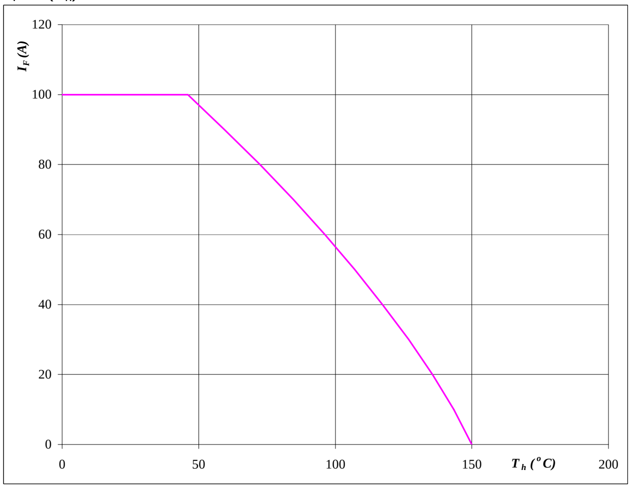

**At**

$T_j$ = 150 ºC

**Figure 4** Rectifier diode

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

$I_F = f(T_h)$



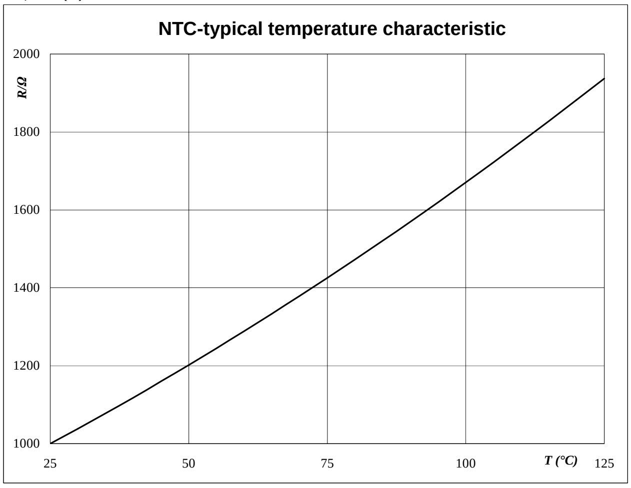

**At**

$T_j$ = 150 ºC

# Thermistor

| Figure 1 | Thermistor |
| --- | --- |

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



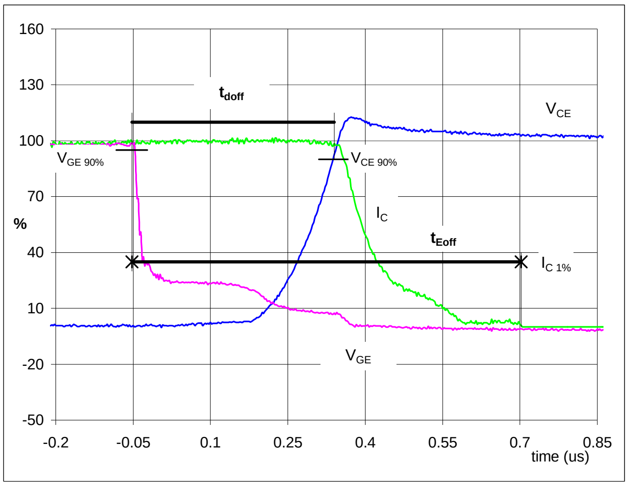
# Switching Definitions Output Inverter

**General conditions**

| | | |
|---|---|---|
| $T_j$ | = | 150 °C |
| $R_{gon}$ | = | 4 Ω |
| $R_{goff}$ | = | 4 Ω |

**Figure 1** Output inverter IGBT

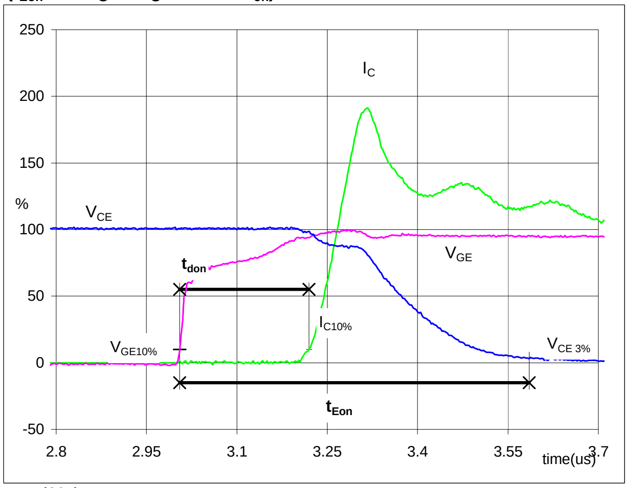
**Turn-off Switching Waveforms & definition of $t_{doff}$, $t_{Eoff}$**
**($t_{Eoff}$ = integrating time for $E_{off}$)**




| | | |
|---|---|---|
| $V_{GE}$ (0%) = | -15 | V |
| $V_{GE}$ (100%) = | 15 | V |
| $V_C$ (100%) = | 600 | V |
| $I_C$ (100%) = | 100 | A |
| $t_{doff}$ = | 0.38 | μs |
| $t_{Eoff}$ = | 0.75 | μs |

**Figure 2** Output inverter IGBT

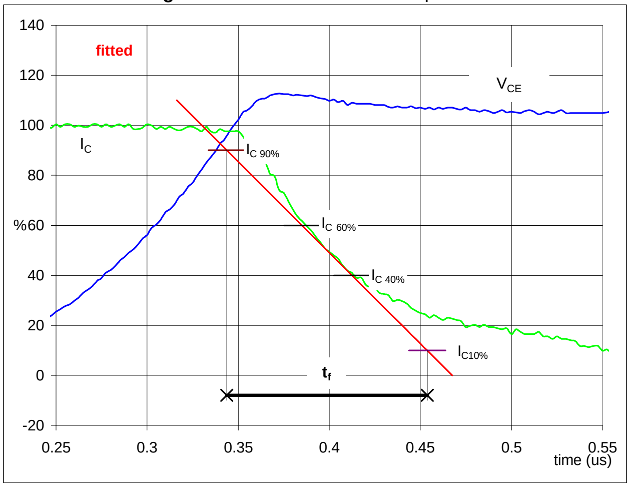
**Turn-on Switching Waveforms & definition of tdon, $t_{Eon}$**
**($t_{Eon}$ = integrating time for $E_{on}$)**




| | | |
|---|---|---|
| $V_{GE}$ (0%) = | -15 | V |
| $V_{GE}$ (100%) = | 15 | V |
| $V_C$ (100%) = | 600 | V |
| $I_C$ (100%) = | 100 | A |
| $t_{don}$ = | 0.22 | μs |
| $t_{Eon}$ = | 0.58 | μs |

**Figure 3** Output inverter IGBT

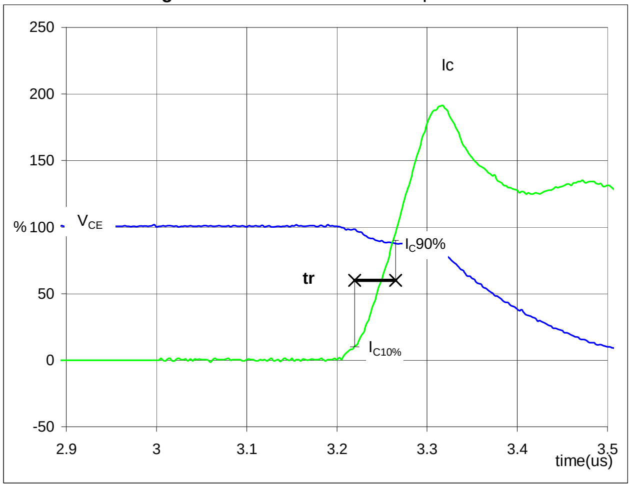
**Turn-off Switching Waveforms & definition of $t_f$**




| | | |
|---|---|---|
| $V_C$ (100%) = | 600 | V |
| $I_C$ (100%) = | 100 | A |
| $t_f$ = | 0.11 | μs |

**Figure 4** Output inverter IGBT

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

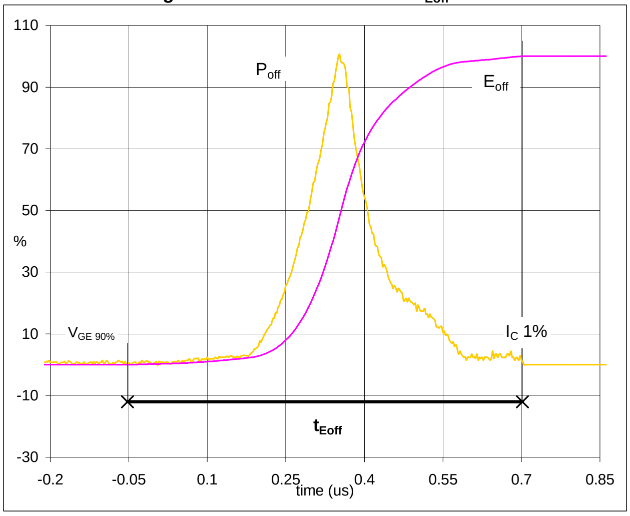



| | | |
|---|---|---|
| $V_C$ (100%) = | 600 | V |
| $I_C$ (100%) = | 100 | A |
| $t_r$ = | 0.04 | μs |

# Switching Definitions Output Inverter

**Figure 5** Output inverter IGBT

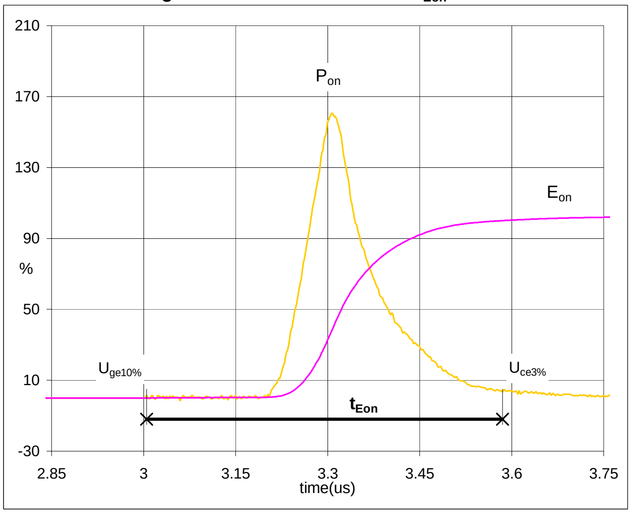
**Turn-off Switching Waveforms & definition of $t_{Eoff}$**




| | | |
|---|---|---|
| $P_{off}$ (100%) = | 60.10 | kW |
| $E_{off}$ (100%) = | 9.25 | mJ |
| $t_{Eoff}$ = | 0.75 | μs |

**Figure 6** Output inverter IGBT

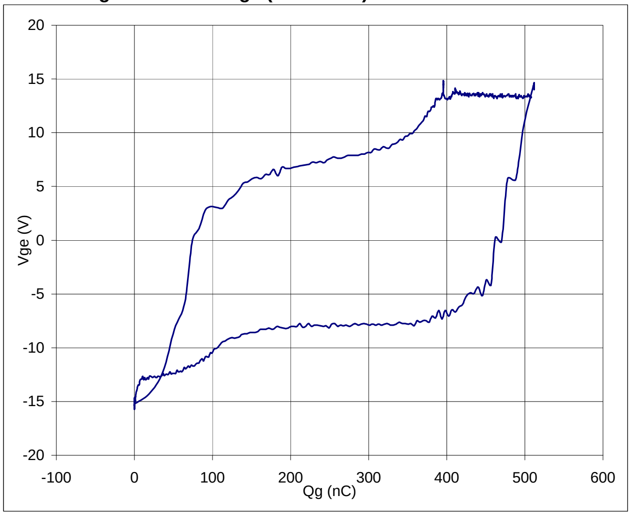
**Turn-on Switching Waveforms & definition of $t_{Eon}$**




| | | |
|---|---|---|
| $P_{on}$ (100%) = | 60.10 | kW |
| $E_{on}$ (100%) = | 12.12 | mJ |
| $t_{Eon}$ = | 0.58 | μs |

**Figure 7** Output inverter FRED

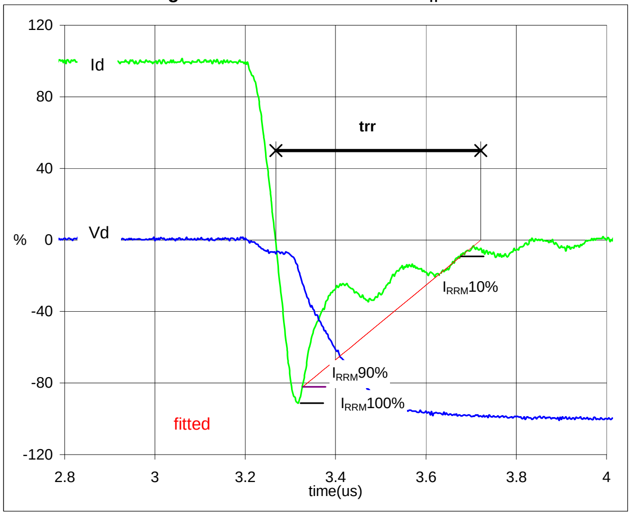
**Gate voltage vs Gate charge (measured)**




| | | |
|---|---|---|
| $V_{GEoff}$ = | -15 | V |
| $V_{GEon}$ = | 15 | V |
| $V_C$ (100%) = | 600 | V |
| $I_C$ (100%) = | 100 | A |
| $Q_g$ = | 597.46 | nC |

**Figure 8** Output inverter IGBT

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

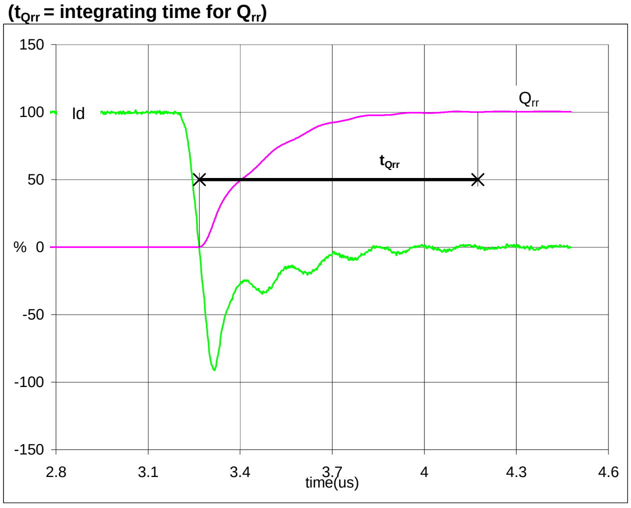



| | | |
|---|---|---|
| $V_d$ (100%) = | 600 | V |
| $I_d$ (100%) = | 100 | A |
| $I_{RRM}$ (100%) = | -91 | A |
| $t_{rr}$ = | 0.46 | μs |

# Switching Definitions Output Inverter

| **Figure 9** | Output inverter FRED |
|---|---|

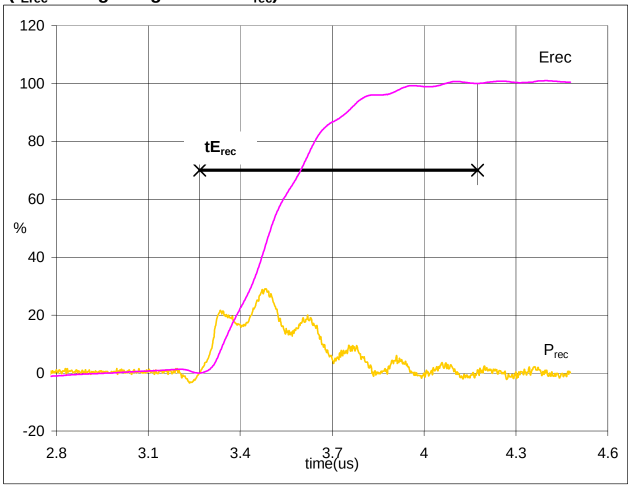
**Turn-on Switching Waveforms & definition of $t_{Qrr}$**
**($t_{Qrr}$ = integrating time for $Q_{rr}$)**




| | | |
|---|---|---|
| $I_d$ (100%) = | 100 | A |
| $Q_{rr}$ (100%) = | 15.08 | µC |
| $t_{Qrr}$ = | 0.91 | µs |

| **Figure 10** | Output inverter FRED |
|---|---|

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



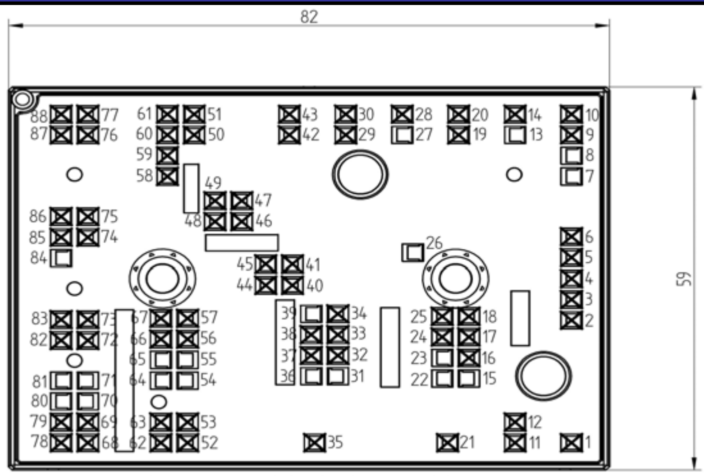

| | | |
|---|---|---|
| $P_{rec}$ (100%) = | 60.10 | kW |
| $E_{rec}$ (100%) = | 5.42 | mJ |
| $t_{Erec}$ = | 0.91 | µs |

# Ordering Code and Marking - Outline - Pinout

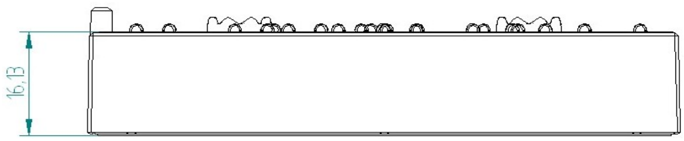
## Ordering Code & Marking

| Version | Ordering Code | in DataMatrix as | in packaging barcode as |
|---|---|---|---|
| with std lid (black V23990-K12-T-PM) | V23990-K420-A40-/0A/-PM | K420A40 | K420A40-/0A/ |
| with std lid (black V23990-K12-T-PM) and P12 | V23990-K420-A40-/1A/-PM | K420A40 | K420A40-/1A/ |
| with thin lid (white V23990-K13-T-PM) | V23990-K420-A40-/0B/-PM | K420A40 | K420A40-/0B/ |
| with thin lid (white V23990-K13-T-PM) and P12 | V23990-K420-A40-/1B/-PM | K420A40 | K420A40-/1B/ |

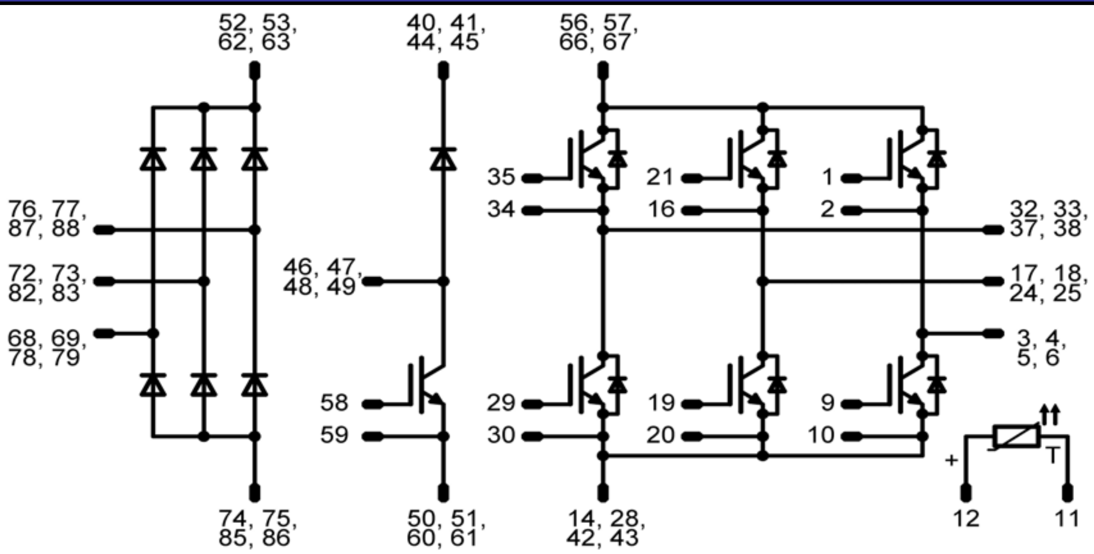
## Outline




X = assembled pin position




## Pinout



## PRODUCT STATUS DEFINITIONS

| Datasheet Status | Product Status | Definition |
|---|---|---|
| Target | Formative or In Design | This datasheet contains the design specifications for product development. Specifications may change in any manner without notice. The data contained is exclusively intended for technically trained staff. |
| Preliminary | First Production | This datasheet contains preliminary data, and supplementary data may be published at a later date. Vincotech reserves the right to make changes at any time without notice in order to improve design. The data contained is exclusively intended for technically trained staff. |
| Final | Full Production | This datasheet contains final specifications. Vincotech reserves the right to make changes at any time without notice in order to improve design. The data contained is exclusively intended for technically trained staff. |



**LIFE SUPPORT POLICY**

Vincotech products are not authorised for use as critical components in life support devices or systems without the express written approval of Vincotech.

As used herein:

1. Life support devices or systems are devices or systems which, (a) are intended for surgical implant into the body, or (b) support or sustain life, or (c) whose failure to perform when properly used in accordance with instructions for use provided in labelling can be reasonably expected to result in significant injury to the user.

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.