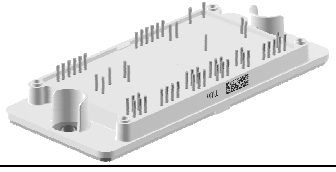
## flow2 MNPC 1200V/160A

### Features

- mixed voltage NPC topology
- reactive power capability
- low inductance layout
- Split output
- Common collector neutral connection

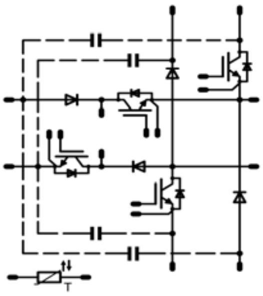
### flow2 13mm housing



### Target Applications

- solar inverter
- UPS
- Active frontend

### Schematic



### Types

- 30-FT12NMA160SH-M669F08

## Maximum Ratings

$T_j$=25℃, unless otherwise specified

| Parameter | Symbol | Condition | | Value | Unit |
|---|---|---|---|---|---|
| **Half Bridge IGBT Inverse Diode** | | | | | |
| Repetitive peak reverse voltage | $V_{RRM}$ | | | 1200 | V |
| DC forward current | $I_F$ | $T_j=T_j$max | $T_h$=80℃<br>$T_c$=80℃ | 17<br>22 | A |
| Maximum repetitive forward current | $I_{FRM}$ | tp=10ms | | 14 | A |
| $I^2t$-value | $I^2t$ | $T_j=T_j$max | | 40 | $A^2s$ |
| Power dissipation per Diode | $P_{tot}$ | | $T_h$=80℃<br>$T_c$=80℃ | 40<br>60 | W |
| Maximum Junction Temperature | $T_{jmax}$ | | | 150 | ℃ |
| **Half Bridge IGBT** | | | | | |
| Collector-emitter break down voltage | $V_{CE}$ | | | 1200 | V |
| DC collector current | $I_C$ | $T_j=T_j$max | $T_h$=80℃<br>$T_c$=80℃ | 157<br>202 | A |
| Pulsed collector current | $I_{Cpulse}$ | $t_p$ limited by $T_j$max | | 480 | A |
| Turn off safe operating area | | $V_{CEmax}$ = 1200V, $T_{vj}$ ≤ 150℃ | | 320 | A |
| Power dissipation per IGBT | $P_{tot}$ | $T_j=T_j$max | $T_h$=80℃<br>$T_c$=80℃ | 398<br>604 | W |
| Gate-emitter peak voltage | $V_{GE}$ | | | ±20 | V |
| Short circuit ratings | $t_{SC}$<br>$V_{CC}$ | $T_j$≤150℃<br>$V_{GE}$=15V | | 10<br>800 | µs<br>V |
| Maximum Junction Temperature | $T_j$max | | | 175 | ℃ |

# Maximum Ratings

$T_j$=25℃, unless otherwise specified

| Parameter | Symbol | Condition | Value | Unit |
|---|---|---|---|---|
| **Neutral Point FWD** | | | | |
| 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℃ | 96<br>129 | A |
| Non-repetitive Peak Surge Current | $I_{FSM}$ | $t_p$ limited by $T_j$max | 1200 | A |
| Power dissipation per Diode | $P_{tot}$ | $T_j$=$T_j$max $T_h$=80℃<br>$T_c$=80℃ | 110<br>166 | W |
| Maximum Junction Temperature | $T_j$max | | 150 | ℃ |
| **Neutral Point IGBT** | | | | |
| 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℃ | 91<br>121 | A |
| Pulsed collector current | $I_{cpulse}$ | $t_p$ limited by $T_j$max | 300 | A |
| Turn off safe operating area | | $V_{CE} \leq 600$V, $T_j \leq 175$℃ | 300 | A |
| Power dissipation per IGBT | $P_{tot}$ | $T_j$=$T_j$max $T_h$=80℃<br>$T_c$=80℃ | 174<br>264 | 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 | ℃ |
| **Neutral Point Inverse 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℃ | 38<br>51 | A |
| Maximum repetitive forward current | $I_{FRM}$ | $t_p$ limited by $T_j$max | 60 | A |
| Power dissipation per Diode | $P_{tot}$ | $T_j$=$T_j$max $T_h$=80℃<br>$T_c$=80℃ | 65<br>99 | W |
| Maximum Junction Temperature | $T_j$max | | 175 | ℃ |
| **Half Bridge FWD** | | | | |
| Peak Repetitive Reverse Voltage | $V_{RRM}$ | | 1200 | V |
| DC forward current | $I_F$ | $T_j$=$T_j$max $T_h$=80℃<br>$T_c$=80℃ | 50<br>66 | A |
| Nonrepetitive peak surge current | $I_{FRM}$ | $t_p$ limited by $T_j$max (Halfwave 1 Phase 60Hz) | 650 | A |
| Power dissipation per Diode | $P_{tot}$ | $T_j$=$T_j$max $T_h$=80℃<br>$T_c$=80℃ | 94<br>143 | W |
| Maximum Junction Temperature | $T_j$max | | 150 | ℃ |

# Maximum Ratings

Tj=25℃, unless otherwise specified

| Parameter | Symbol | Condition | | Value | Unit |
|---|---|---|---|---|---|
| **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 | | | | | 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 | |
| **Half Bridge IGBT Inverse Diode** | | | | | | | | | | |
| Forward voltage | $V_f$ | | | | 7 | Tj=25℃<br>Tj=125℃ | 1 | 1,97<br>1,65 | 3,4 | V |
| Threshold voltage (for power loss calc. only) | $V_{to}$ | | | | 7 | Tj=25℃<br>Tj=125℃ | | 1,33<br>1,01 | | V |
| Slope resistance (for power loss calc. only) | $r_t$ | | | | 7 | Tj=25℃<br>Tj=125℃ | | 91<br>91 | | mΩ |
| Reverse current | $I_r$ | | | 1200 | | Tj=25℃<br>Tj=125℃ | | | 0,25 | mA |
| Thermal resistance chip to heatsink per chip | $R_{thJH}$ | Thermal grease thickness≤50um λ = 1 W/mK | | | | | | 1,77 | | K/W |
| Thermal resistance chip to case per chip | $R_{thJC}$ | | | | | | | 1,17 | | |
| **Halfbridge IGBT** | | | | | | | | | | |
| Gate emitter threshold voltage | $V_{GE(th)}$ | $V_{CE}=V_{GE}$ | | | 0,006 | Tj=25℃<br>Tj=125℃ | 5,2 | 5,8 | 6,5 | V |
| Collector-emitter saturation voltage | $V_{CE(sat)}$ | | 15 | | 160 | Tj=25℃<br>Tj=125℃ | 2 | 2,02<br>2,37 | 2,4 | V |
| Collector-emitter cut-off current incl. Diode | $I_{CES}$ | | 0 | 1200 | | Tj=25℃<br>Tj=125℃ | | | 0,02 | mA |
| Gate-emitter leakage current | $I_{GES}$ | | 20 | 0 | | Tj=25℃<br>Tj=125℃ | | | 480 | nA |
| Integrated Gate resistor | $R_{gint}$ | | | | | | | none | | Ω |
| Turn-on delay time | $t_{d(ON)}$ | Rgoff=4 Ω<br>Rgon=4 Ω | ±15 | 350 | 100 | Tj=25℃<br>Tj=125℃ | | 133<br>135 | | ns |
| Rise time | $t_r$ | | | | | Tj=25℃<br>Tj=125℃ | | 20<br>23 | | |
| Turn-off delay time | $t_{d(OFF)}$ | | | | | Tj=25℃<br>Tj=125℃ | | 225<br>276 | | |
| Fall time | $t_f$ | | | | | Tj=25℃<br>Tj=125℃ | | 38<br>64 | | |
| Turn-on energy loss per pulse | $E_{on}$ | | | | | Tj=25℃<br>Tj=125℃ | | 1,80<br>3,18 | | mWs |
| Turn-off energy loss per pulse | $E_{off}$ | | | | | Tj=25℃<br>Tj=125℃ | | 2,52<br>4,03 | | |
| Input capacitance | $C_{ies}$ | f=1MHz | 0 | 25 | | Tj=25℃ | | 9200 | | pF |
| Output capacitance | $C_{oss}$ | | | | | | | 920 | | |
| Reverse transfer capacitance | $C_{rss}$ | | | | | | | 540 | | |
| Gate charge | $Q_{Gate}$ | | 15 | 960 | 160 | | | 740 | | nC |
| Thermal resistance chip to heatsink per chip | $R_{thJH}$ | Thermal grease thickness≤50um λ = 1 W/mK | | | | | | 0,24 | | K/W |
| Thermal resistance chip to case per chip | $R_{thJC}$ | | | | | | | 0,16 | | |
| **Neutral Point FWD** | | | | | | | | | | |
| Diode forward voltage | $V_F$ | | | | 120 | Tj=25℃<br>Tj=125℃ | | 1,47<br>1,29 | 1,7 | V |
| Peak reverse recovery current | $I_{RRM}$ | Rgon=4 Ω | ±15 | 350 | 100 | Tj=25℃<br>Tj=125℃ | | 127<br>151 | | A |
| Reverse recovery time | $t_{rr}$ | | | | | Tj=25℃<br>Tj=125℃ | | 40<br>81 | | ns |
| Reverse recovered charge | $Q_{rr}$ | | | | | Tj=25℃<br>Tj=125℃ | | 3,02<br>7,13 | | µC |
| Peak rate of fall of recovery current | di(rec)max /dt | | | | | Tj=25℃<br>Tj=125℃ | | 12386<br>3767 | | A/µs |
| Reverse recovered energy | Erec | | | | | Tj=25℃<br>Tj=125℃ | | 0,31<br>1,01 | | mWs |
| Thermal resistance chip to heatsink per chip | $R_{thJH}$ | Thermal grease thickness≤50um λ = 1 W/mK | | | | | | 0,64 | | K/W |
| Thermal resistance chip to case per chip | $R_{thJC}$ | | | | | | | 0,42 | | |
| **Neutral Point IGBT** | | | | | | | | | | |
| Gate emitter threshold voltage | $V_{GE(th)}$ | $V_{CE}=V_{GE}$ | | | 0,0016 | Tj=25℃<br>Tj=125℃ | 5 | 5,8 | 6,5 | V |
| Collector-emitter saturation voltage | $V_{CE(sat)}$ | | 15 | | 100 | Tj=25℃<br>Tj=125℃ | 1,05 | 1,58<br>1,8 | 1,85 | V |
| Collector-emitter cut-off incl diode | $I_{CES}$ | | 0 | 600 | | Tj=25℃<br>Tj=125℃ | | | 0,0052 | mA |
| Gate-emitter leakage current | $I_{GES}$ | | 20 | 0 | | Tj=25℃<br>Tj=125℃ | | | 1200 | nA |
| Integrated Gate resistor | $R_{gint}$ | | | | | | | none | | Ω |
| Turn-on delay time | $t_{d(on)}$ | Rgoff=4 Ω<br>Rgon=4 Ω | ±15 | 350 | 100 | Tj=25℃<br>Tj=125℃ | | 103<br>103 | | ns |
| Rise time | $t_r$ | | | | | Tj=25℃<br>Tj=125℃ | | 17<br>19 | | |
| Turn-off delay time | $t_{d(off)}$ | | | | | Tj=25℃<br>Tj=125℃ | | 158<br>179 | | |
| Fall time | $t_f$ | | | | | Tj=25℃<br>Tj=125℃ | | 44<br>64 | | |
| Turn-on energy loss per pulse | $E_{on}$ | | | | | Tj=25℃<br>Tj=125℃ | | 1,06<br>1,52 | | µWs |
| Turn-off energy loss per pulse | $E_{off}$ | | | | | Tj=25℃<br>Tj=125℃ | | 2,48<br>3,32 | | |
| Input capacitance | $C_{ies}$ | f=1MHz | 0 | 25 | | Tj=25℃ | | 6280 | | pF |
| Output capacitance | $C_{oss}$ | | | | | | | 400 | | |
| Reverse transfer capacitance | $C_{rss}$ | | | | | | | 186 | | |
| Gate charge | $Q_{Gate}$ | | 15 | 480 | 100 | | | 620 | | nC |
| Thermal resistance chip to heatsink per chip | $R_{thJH}$ | Thermal grease thickness≤50um λ = 1 W/mK | | | | | | 0,54 | | K/W |
| Thermal resistance chip to case per chip | $R_{thJC}$ | | | | | | | 0,36 | | |

## Characteristic Values

| Parameter | Symbol | Conditions | | | | | Value | | | Unit |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | $V_{GE}$ [V] or<br>$V_{GS}$ [V] | $V_r$ [V] or<br>$V_{CE}$ [V] or<br>$V_{DS}$ [V] | $I_C$ [A] or<br>$I_F$ [A] or<br>$I_D$ [A] | $T_j$ | Min | Typ | Max | |
| **Neutral Point Inverse Diode** | | | | | | | | | | |
| Diode forward voltage | $V_F$ | | | | 30 | Tj=25℃<br>Tj=125℃ | 1,00 | 1,64<br>1,55 | 1,95 | V |
| Thermal resistance chip to heatsink per chip | $R_{thJH}$ | Thermal grease thickness≤50um λ = 1 W/mK | | | | | | 1,45 | | K/W |
| Coupled thermal resistance inverter transistor-diode | $R_{thJC}$ | | | | | | | 0,96 | | |
| **Half Bridge FWD** | | | | | | | | | | |
| Diode forward voltage | $V_F$ | | | | 60 | Tj=25℃<br>Tj=125℃ | 1,50 | 2,47<br>2,11 | 3,30 | V |
| Reverse leakage current | $I_r$ | | | 1200 | | Tj=25℃<br>Tj=125℃ | | | 200 | µA |
| Peak reverse recovery current | $I_{RRM}$ | Rgon=4 Ω | ±15 | 350 | 100 | Tj=25℃<br>Tj=125℃ | | 107<br>142 | | A |
| Reverse recovery time | $t_{rr}$ | | | | | Tj=25℃<br>Tj=125℃ | | 51<br>69 | | ns |
| Reverse recovered charge | $Q_{rr}$ | | | | | Tj=25℃<br>Tj=125℃ | | 6<br>13 | | µC |
| Peak rate of fall of recovery current | di(rec)max /dt | | | | | Tj=25℃<br>Tj=125℃ | | 5985<br>2890 | | A/µs |
| Reverse recovery energy | $E_{rec}$ | | | | | Tj=25℃<br>Tj=125℃ | | 1,71<br>3,61 | | mWs |
| Thermal resistance chip to heatsink per chip | $R_{thJH}$ | Thermal grease thickness≤50um λ = 1 W/mK | | | | | | 0,74 | | K/W |
| Thermal resistance chip to case per chip | $R_{thJC}$ | | | | | | | 0,49 | | |
| **Thermistor** | | | | | | | | | | |
| Rated resistance | R | | | | | Tj=25℃ | | 22000 | | Ω |
| Deviation of R25 | ΔR/R | R100=1486 Ω | | | | Tj=100℃ | -5 | | +5 | % |
| Power dissipation | P | | | | | Tj=25℃ | | 200 | | mW |
| Power dissipation constant | | | | | | Tj=25℃ | | 2 | | mW/K |
| B-value | $B_{(25/50)}$ | Tol. ±3% | | | | Tj=25℃ | | 3950 | | K |
| B-value | $B_{(25/100)}$ | Tol. ±3% | | | | Tj=25℃ | | 3998 | | K |
| Vincotech NTC Reference | | | | | | | | | B | |

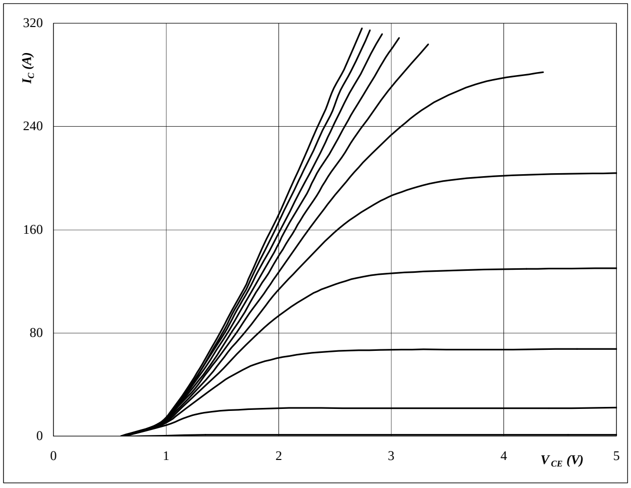
# Half Bridge

## Half Bridge IGBT and Neutral Point FWD

**Figure 1** IGBT

**Typical output characteristics**

$I_C = f(V_{CE})$



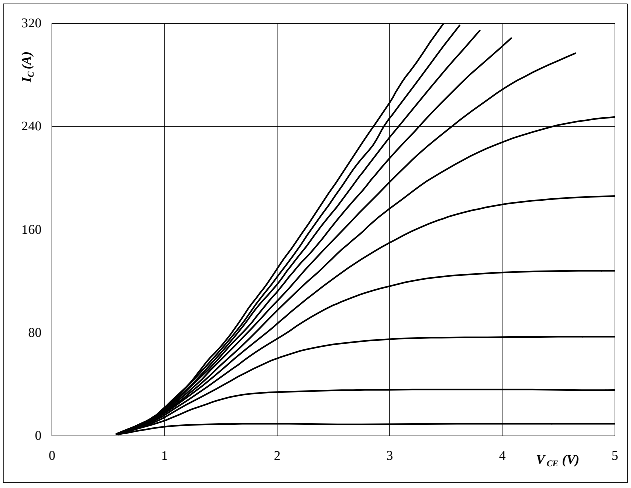
**At**

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

**Figure 2** IGBT

**Typical output characteristics**

$I_C = f(V_{CE})$



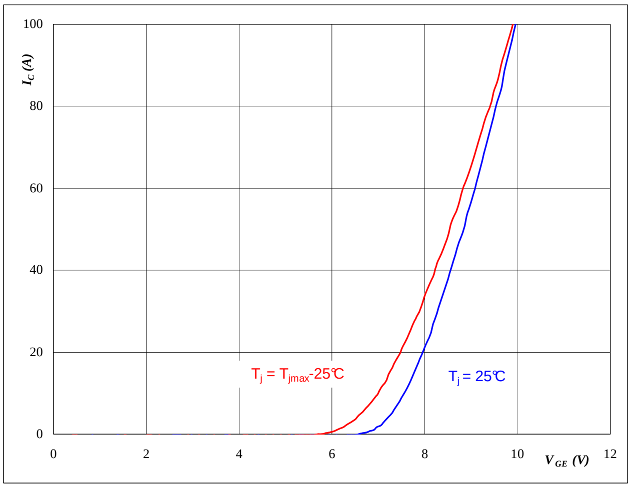
**At**

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

**Figure 3** IGBT

**Typical transfer characteristics**

$I_C = f(V_{GE})$



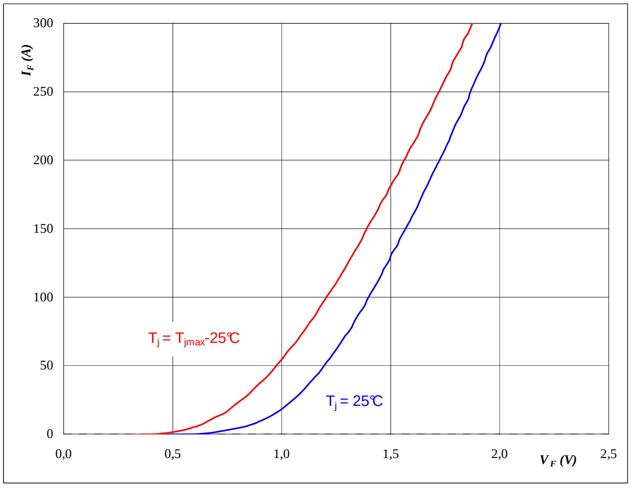
**At**

| | | |
|---|---|---|
| $t_p$ = | 250 | µs |
| $V_{CE}$ = | 10 | V |
| $T_j$ = | 25/150 | ℃ |

**Figure 4** NP FWD

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

$I_F = f(V_F)$



**At**

| | | |
|---|---|---|
| $t_p$ = | 250 | µs |
| $T_j$ = | 25/150 | ℃ |

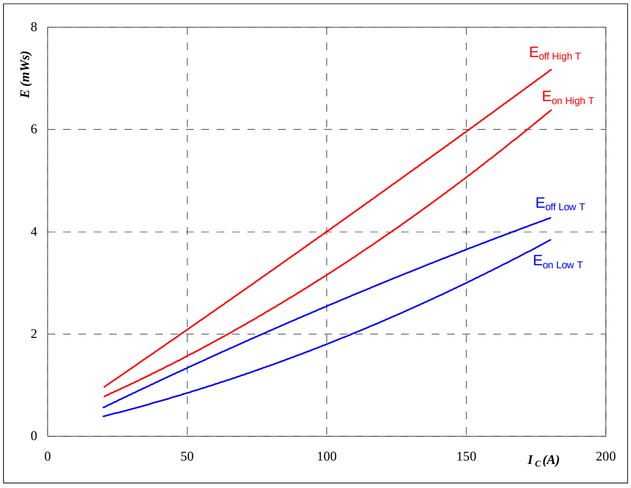
# Half Bridge

## Half Bridge IGBT and Neutral Point FWD

**Figure 5** IGBT

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

$E = f(I_C)$



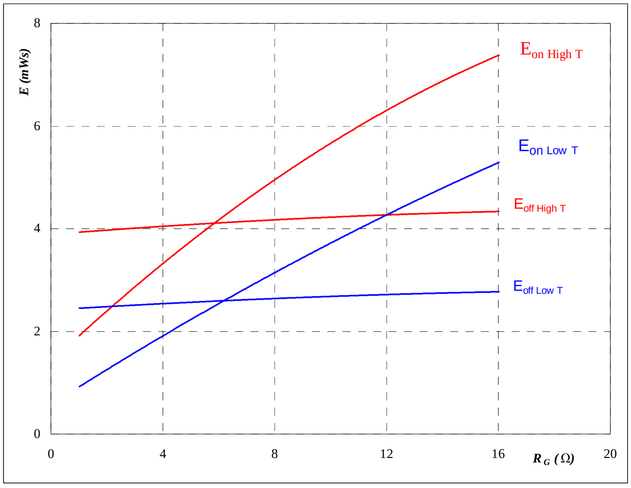
With an inductive load at

$T_j$ = 25/125 ℃
$V_{CE}$ = 350 V
$V_{GE}$ = ±15 V
$R_{gon}$ = 4 Ω
$R_{goff}$ = 4 Ω

**Figure 6** IGBT

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

$E = f(R_G)$



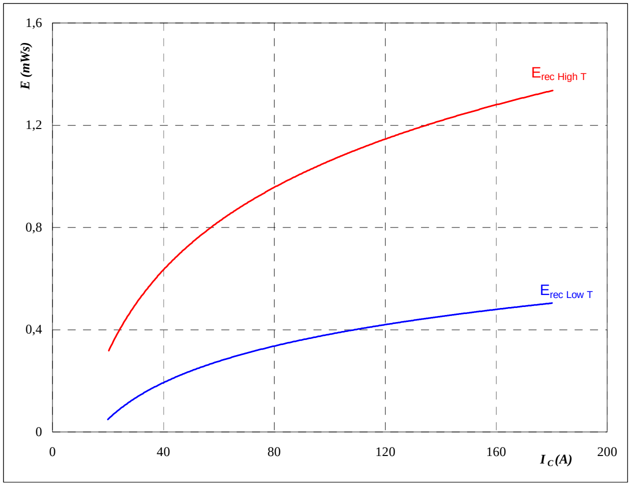
With an inductive load at

$T_j$ = 25/125 ℃
$V_{CE}$ = 350 V
$V_{GE}$ = ±15 V
$I_C$ = 100 A

**Figure 7** NP FWD

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

$E_{rec} = f(I_c)$



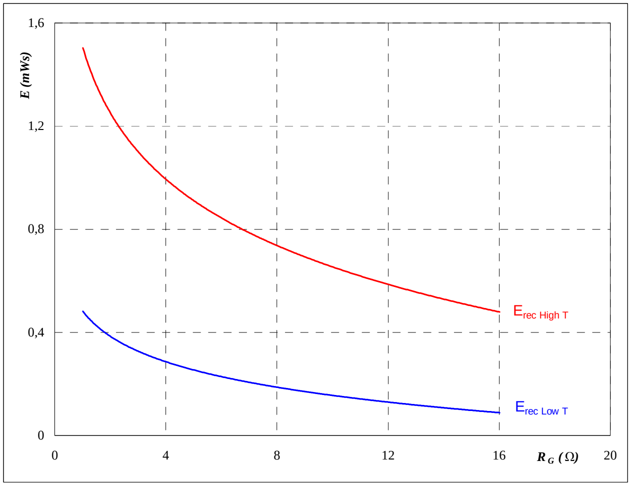
With an inductive load at

$T_j$ = 25/125 ℃
$V_{CE}$ = 350 V
$V_{GE}$ = ±15 V
$R_{gon}$ = 4 Ω

**Figure 8** NP 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 ℃
$V_{CE}$ = 350 V
$V_{GE}$ = ±15 V
$I_C$ = 100 A

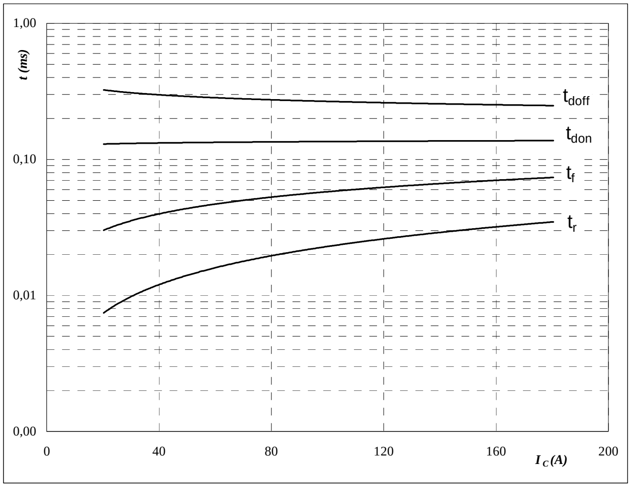
# Half Bridge

**Half Bridge IGBT and Neutral Point FWD**

**Figure 9** IGBT

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

t = f($I_C$)



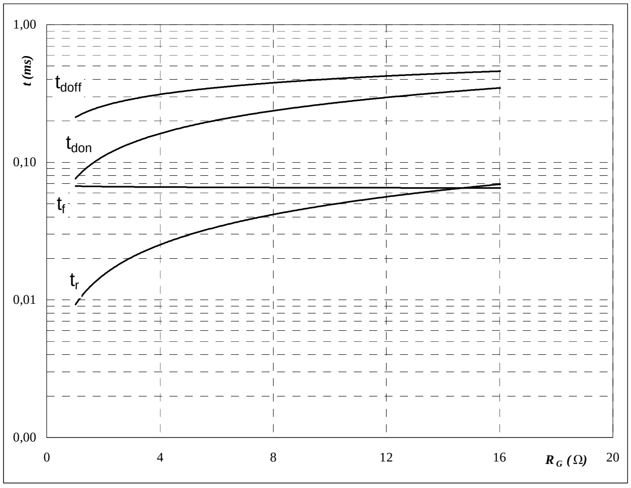
With an inductive load at

$T_j$ = 125 ℃
$V_{CE}$ = 350 V
$V_{GE}$ = ±15 V
$R_{gon}$ = 4 Ω
$R_{goff}$ = 4 Ω

**Figure 10** IGBT

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

t = f($R_G$)



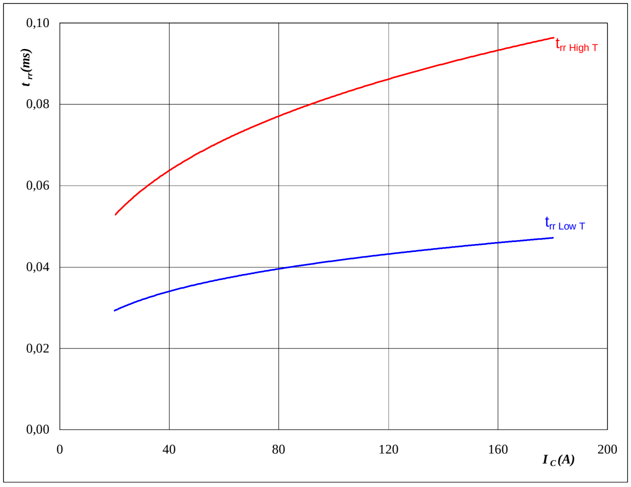
With an inductive load at

$T_j$ = 125 ℃
$V_{CE}$ = 350 V
$V_{GE}$ = ±15 V
$I_C$ = 100 A

**Figure 11** NP FWD

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

$t_{rr}$ = f(Ic)



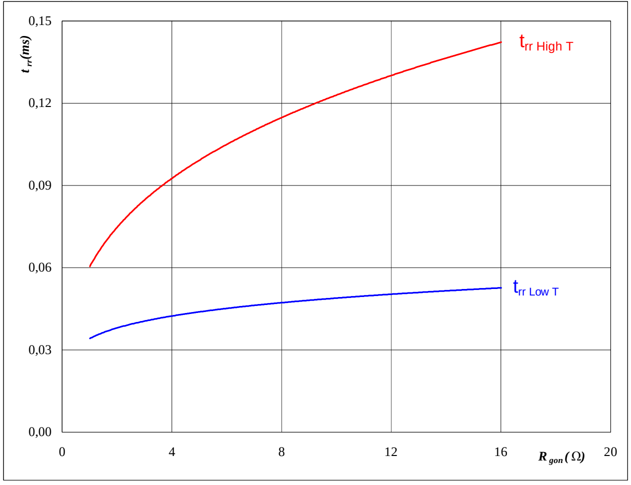
**At**

$T_j$ = 25/125 ℃
$V_{CE}$ = 350 V
$V_{GE}$ = ±15 V
$R_{gon}$ = 4 Ω

**Figure 12** NP FWD

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

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



**At**

$T_j$ = 25/125 ℃
$V_R$ = 350 V
$I_F$ = 100 A
$V_{GE}$ = ±15 V

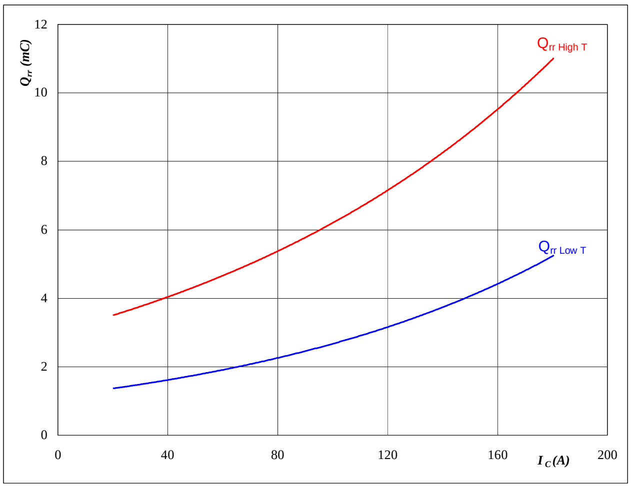
# Half Bridge

## Half Bridge IGBT and Neutral Point FWD

**Figure 13** NP FWD

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

$Q_{rr} = f(I_C)$



**At**

$T_j$ = 25/125 ℃

$V_{CE}$ = 350 V

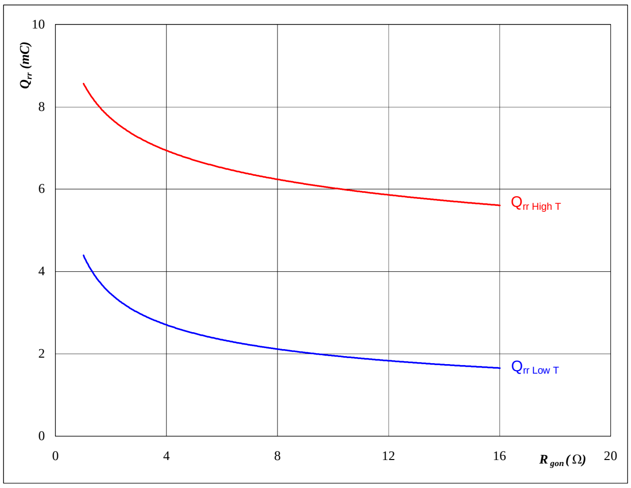
$V_{GE}$ = ±15 V

$R_{gon}$ = 4 Ω

**Figure 14** NP FWD

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

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



**At**

$T_j$ = 25/125 ℃

$V_R$ = 350 V

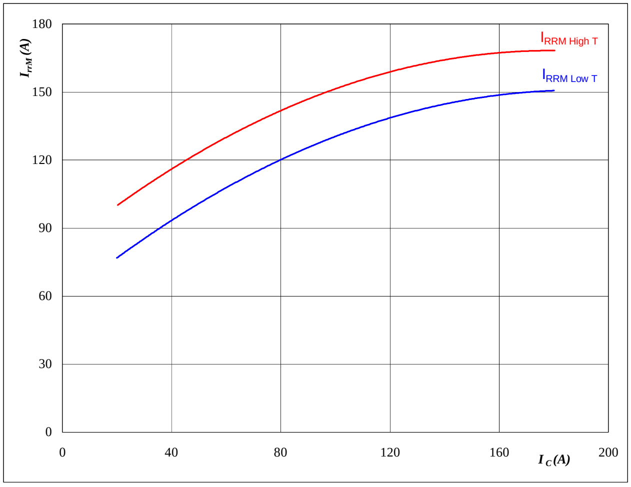
$I_F$ = 100 A

$V_{GE}$ = ±15 V

**Figure 15** NP FWD

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

$I_{RRM} = f(I_C)$



**At**

$T_j$ = 25/125 ℃

$V_{CE}$ = 350 V

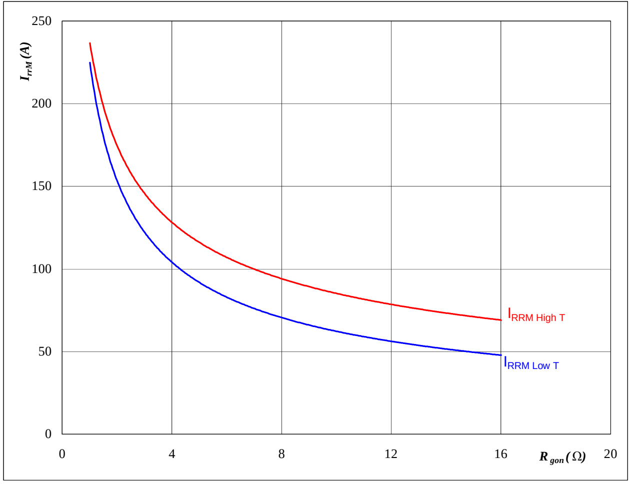
$V_{GE}$ = ±15 V

$R_{gon}$ = 4 Ω

**Figure 16** NP FWD

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

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



**At**

$T_j$ = 25/125 ℃

$V_R$ = 350 V

$I_F$ = 100 A

$V_{GE}$ = ±15 V

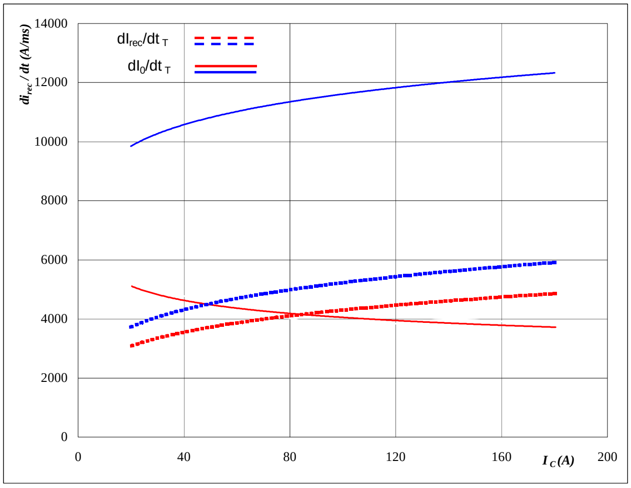
# Half Bridge

## Half Bridge IGBT and Neutral Point FWD

**Figure 17** NP FWD

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

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



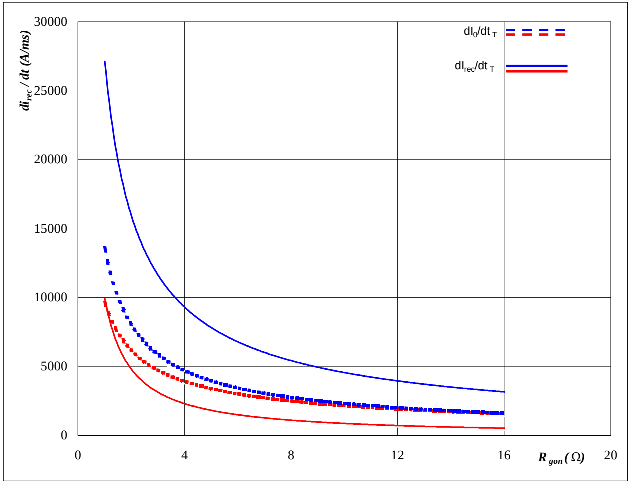
**At**

| | | |
|---|---|---|
| $T_j$ = | 25/125 | ℃ |
| $V_{CE}$ = | 350 | V |
| $V_{GE}$ = | ±15 | V |
| $R_{gon}$ = | 4 | Ω |

**Figure 18** NP FWD

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

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



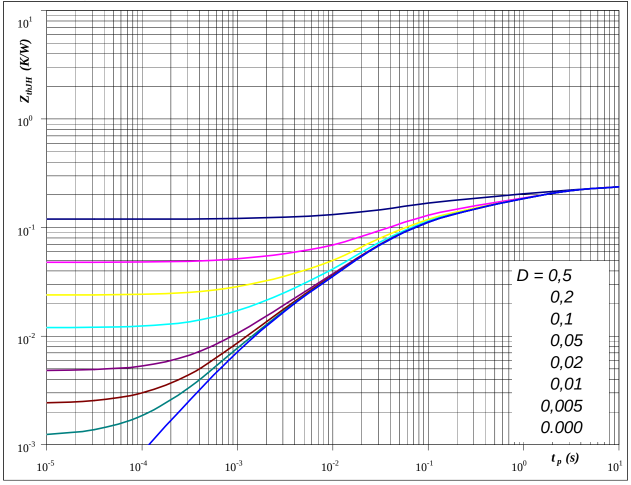
**At**

| | | |
|---|---|---|
| $T_j$ = | 25/125 | ℃ |
| $V_R$ = | 350 | V |
| $I_F$ = | 100 | A |
| $V_{GE}$ = | ±15 | V |

**Figure 19** IGBT

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

$Z_{thJH} = f(t_p)$



**At**

| | | |
|---|---|---|
| D = | $t_p$ / T | |
| $R_{thJH}$ = | 0,24 | K/W |

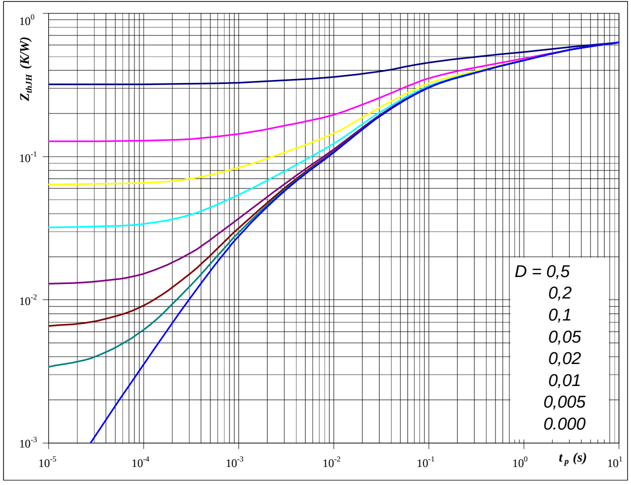
IGBT thermal model values

| R (C/W) | Tau (s) |
|---|---|
| 0,08 | 2,26 |
| 0,06 | 0,29 |
| 0,07 | 0,05 |
| 0,02 | 0,01 |
| 0,01 | 0,002 |

**Figure 20** NP FWD

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

$Z_{thJH} = f(t_p)$



**At**

| | | |
|---|---|---|
| D = | $t_p$ / T | |
| $R_{thJH}$ = | 0,64 | K/W |

FWD thermal model values

| R (C/W) | Tau (s) |
|---|---|
| 0,17 | 3,90 |
| 0,11 | 0,85 |
| 0,08 | 0,18 |
| 0,20 | 0,04 |
| 0,04 | 0,01 |
| 0,03 | 0,001 |

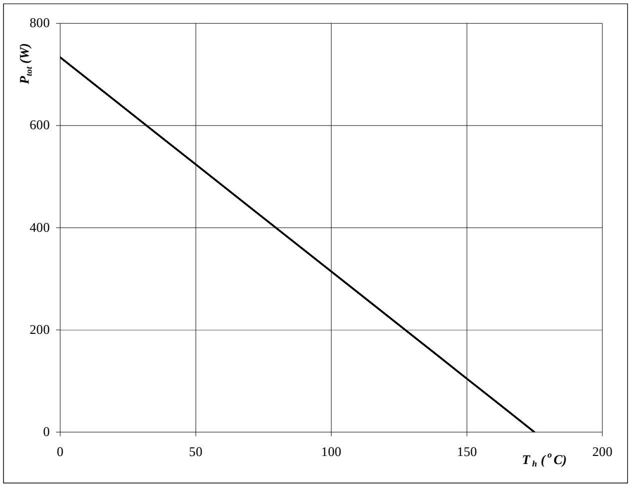
# Half Bridge

## Half Bridge IGBT and Neutral Point FWD

**Figure 21** IGBT

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

$P_{tot} = f(T_h)$



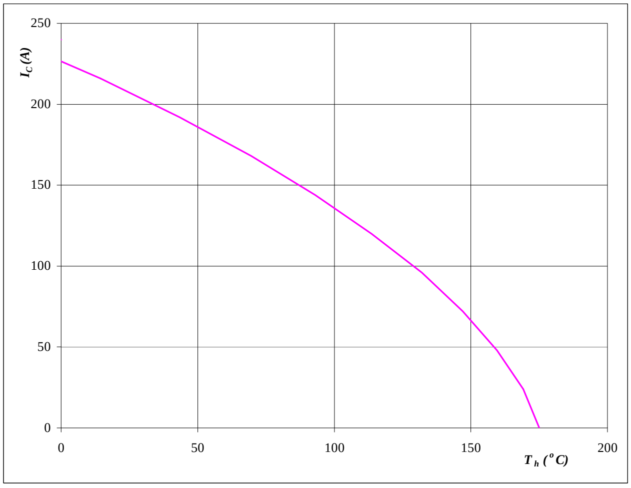
**At**

$T_j$ = 175 ℃

**Figure 22** IGBT

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

$I_C = f(T_h)$



**At**

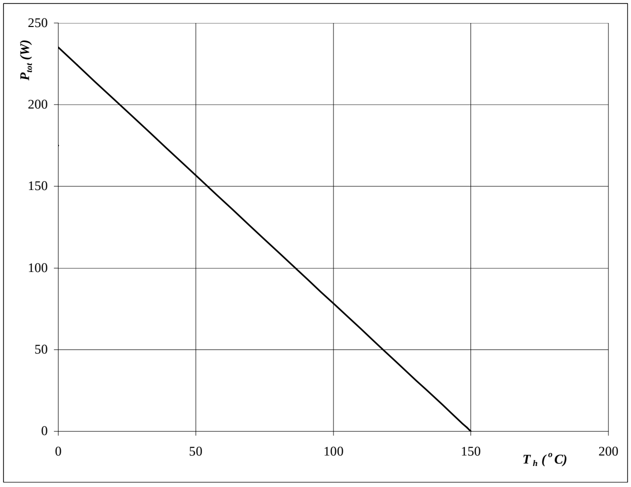
$T_j$ = 175 ℃

$V_{GE}$ = 15 V

**Figure 23** NP FWD

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

$P_{tot} = f(T_h)$



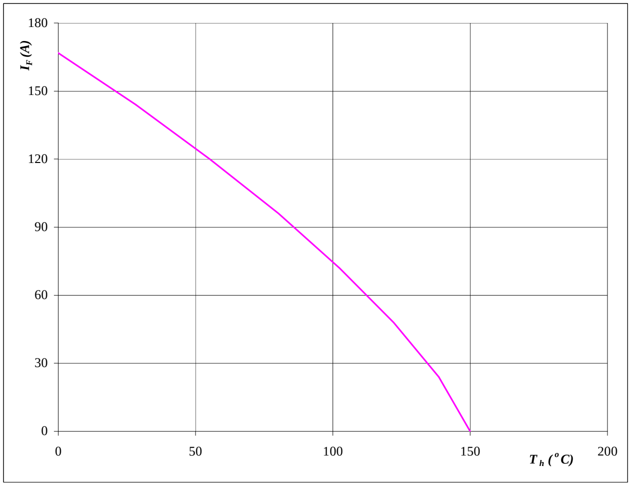
**At**

$T_j$ = 150 ℃

**Figure 24** NP FWD

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

$I_F = f(T_h)$



**At**

$T_j$ = 150 ℃

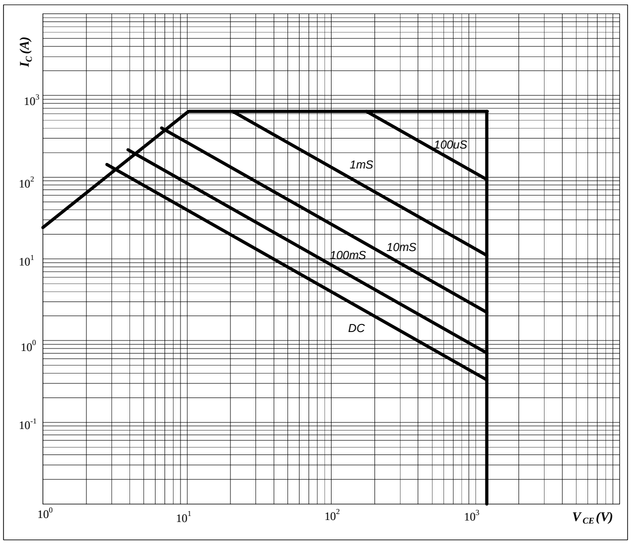
# Half Bridge

**Half Bridge IGBT and Neutral Point FWD**

**Figure 25** IGBT

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

$I_C = f(V_{CE})$



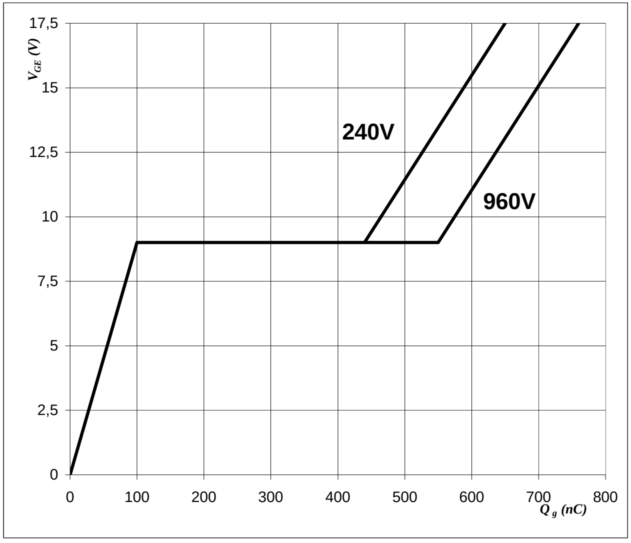
**At**

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

**Figure 26** IGBT

**Gate voltage vs Gate charge**

$V_{GE} = f(Q_g)$



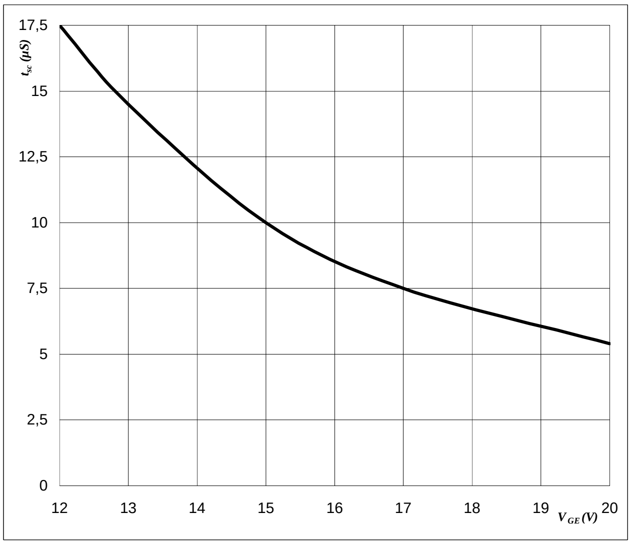
**At**

| | | |
|---|---|---|
| $I_D$ = | 160 | A |
| $T_j$= | 25 | ºC |

**Figure 27** Output inverter IGBT

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

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



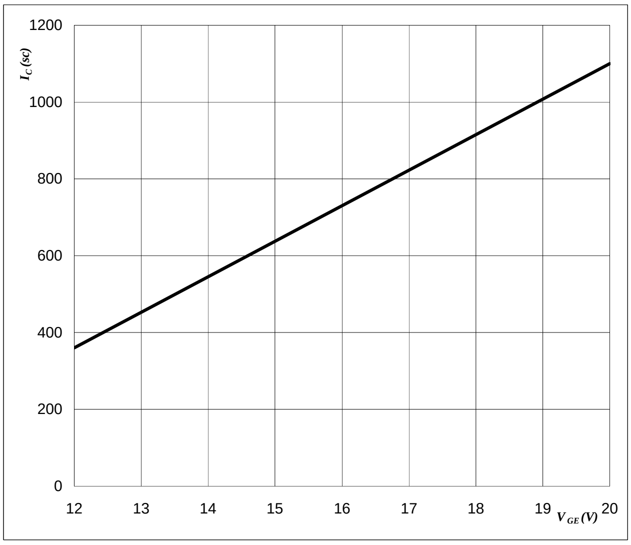
**At**

| | | |
|---|---|---|
| $V_{CE}$ = | 1200 | V |
| $T_j$ ≤ | 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**

| | | |
|---|---|---|
| $V_{CE}$ ≤ | 1200 | V |
| $T_j$ = | 175 | ºC |

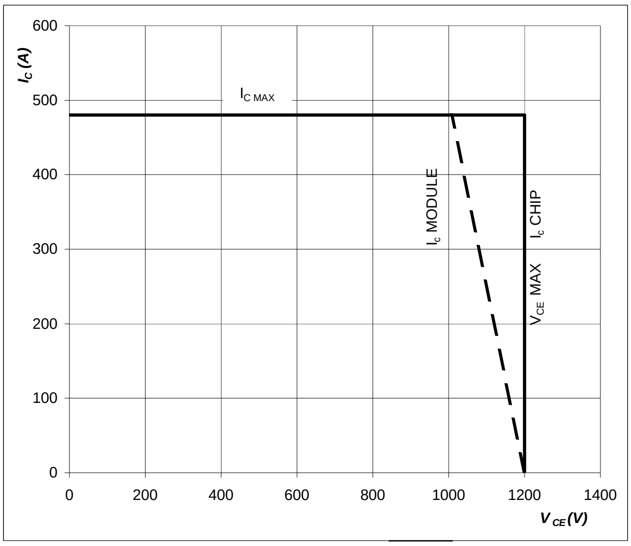
# Half Bridge

### Half Bridge IGBT and Neutral Point FWD

**Figure 27** 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

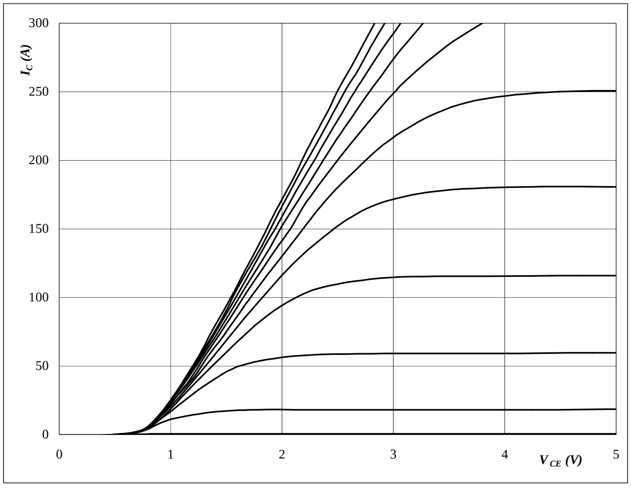
# Neutral Point IGBT

## Neutral Point IGBT and Half Bridge FWD

**Figure 1** NP IGBT

**Typical output characteristics**

$I_C = f(V_{CE})$



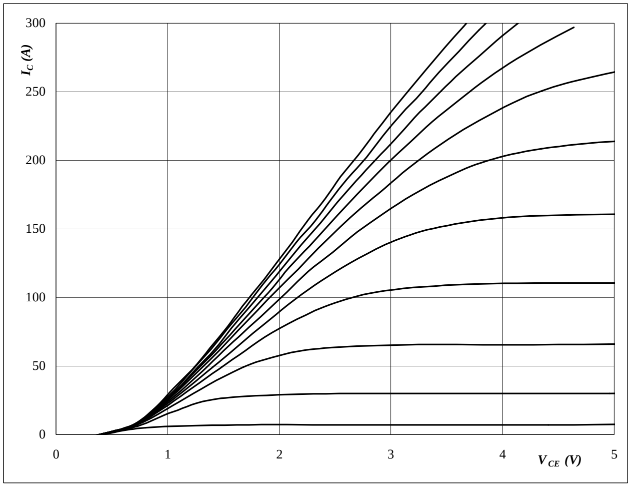
**At**

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

**Figure 2** NP IGBT

**Typical output characteristics**

$I_C = f(V_{CE})$



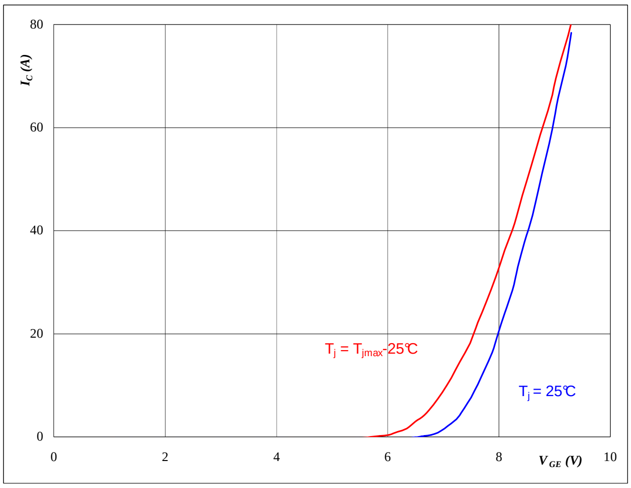
**At**

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

**Figure 3** NP IGBT

**Typical transfer characteristics**

$I_C = f(V_{GE})$



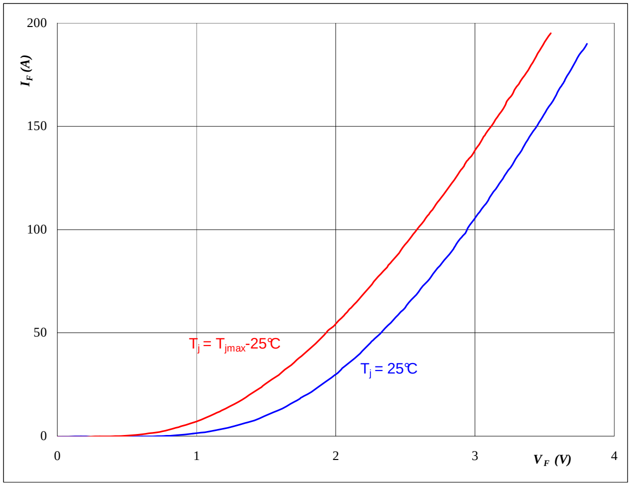
**At**

$t_p$ = 250 µs
$V_{CE}$ = 10 V
$T_j$ = 25/150 ℃

**Figure 4** FWD

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

$I_F = f(V_F)$



**At**

$t_p$ = 250 µs
$T_j$ = 25/150 ℃

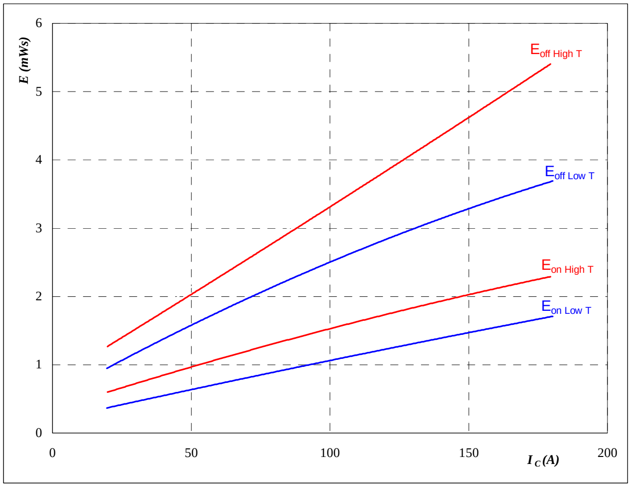
# Neutral Point IGBT

**Neutral Point IGBT and Half Bridge FWD**

**Figure 5** NP IGBT

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

E = f($I_C$)



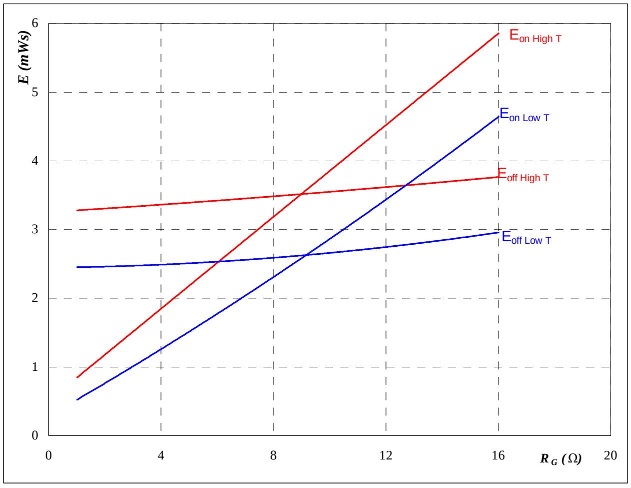
With an inductive load at

$T_j$ = 25/125 ℃
$V_{CE}$ = 350 V
$V_{GE}$ = ±15 V
$R_{gon}$ = 4 Ω
$R_{goff}$ = 4 Ω

**Figure 6** NP IGBT

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

E = f($R_G$)



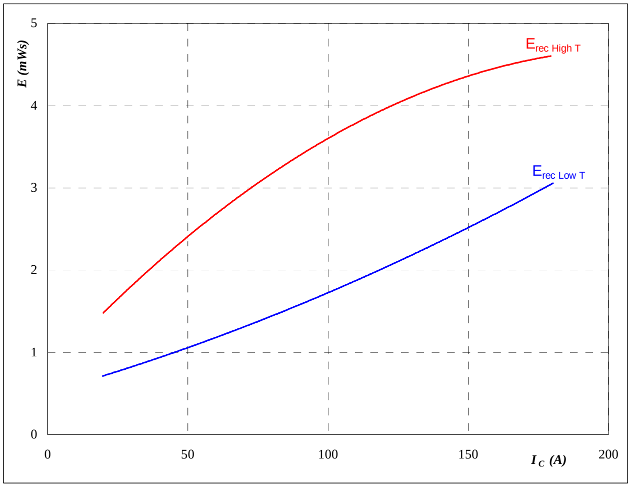
With an inductive load at

$T_j$ = 25/125 ℃
$V_{CE}$ = 350 V
$V_{GE}$ = ±15 V
$I_C$ = 100 A

**Figure 7** FWD

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

$E_{rec}$ = f($I_c$)



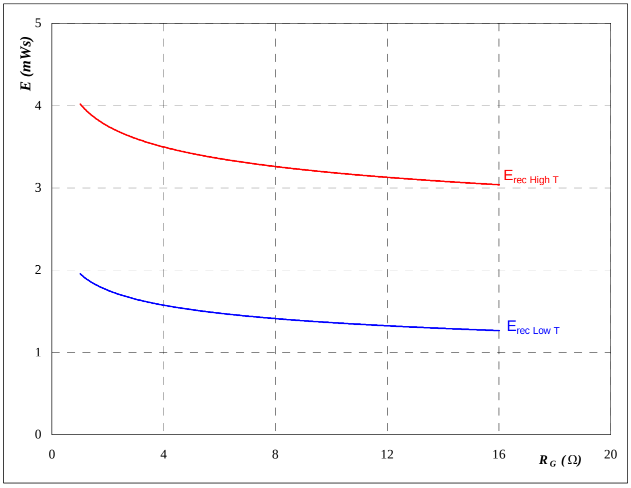
With an inductive load at

$T_j$ = 25/125 ℃
$V_{CE}$ = 350 V
$V_{GE}$ = ±15 V
$R_{gon}$ = 4 Ω

**Figure 8** 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 ℃
$V_{CE}$ = 350 V
$V_{GE}$ = ±15 V
$I_C$ = 100 A

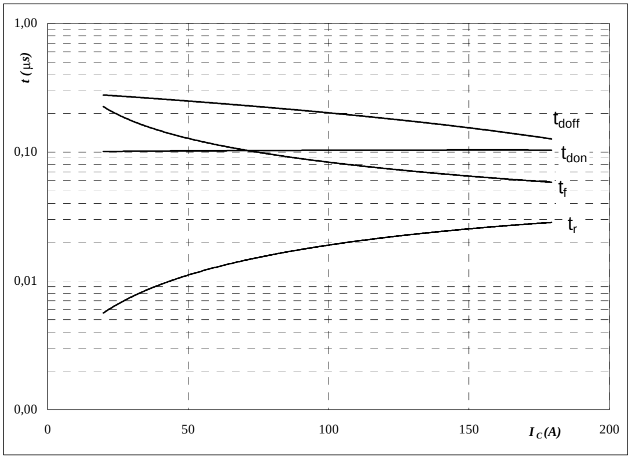
# Neutral Point IGBT

**Neutral Point IGBT and Half Bridge FWD**

**Figure 9** NP IGBT

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

t = f($I_C$)



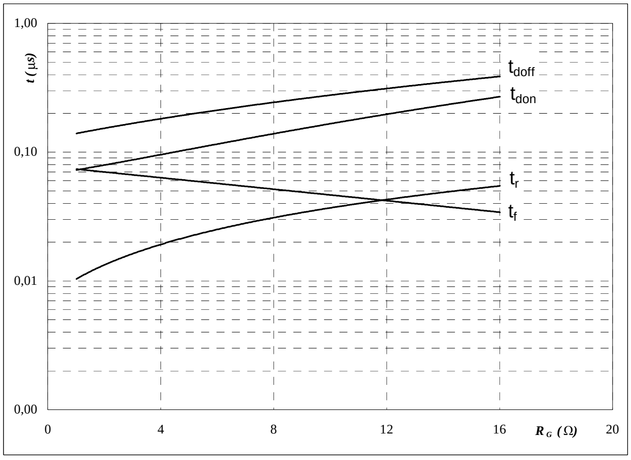
With an inductive load at

| | | |
|---|---|---|
| $T_j$ = | 125 | ℃ |
| $V_{CE}$ = | 350 | V |
| $V_{GE}$ = | ±15 | V |
| $R_{gon}$ = | 4 | Ω |
| $R_{goff}$ = | 4 | Ω |

**Figure 10** NP IGBT

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

t = f($R_G$)



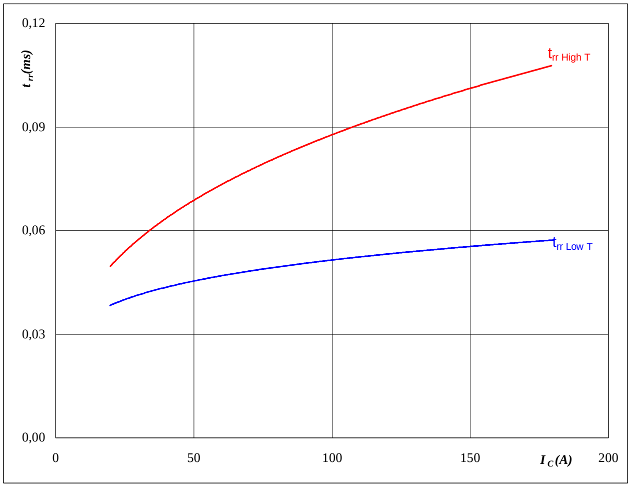
With an inductive load at

| | | |
|---|---|---|
| $T_j$ = | 125 | ℃ |
| $V_{CE}$ = | 350 | V |
| $V_{GE}$ = | ±15 | V |
| $I_C$ = | 100 | A |

**Figure 11** FWD

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

$t_{rr}$ = f(Ic)



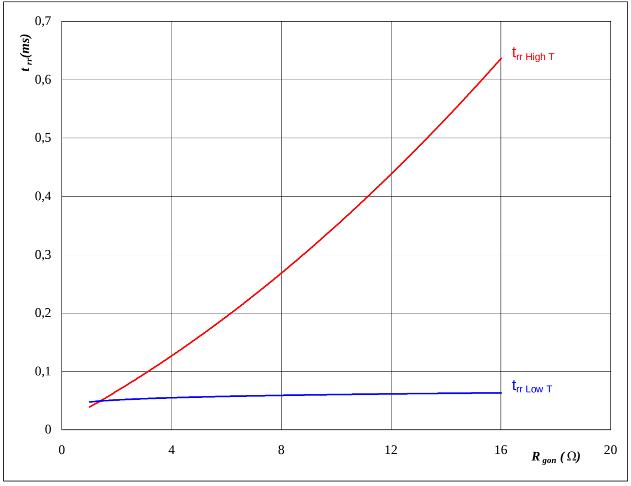
**At**

| | | |
|---|---|---|
| $T_j$ = | 25/125 | ℃ |
| $V_{CE}$ = | 350 | V |
| $V_{GE}$ = | ±15 | V |
| $R_{gon}$ = | 4,0 | Ω |

**Figure 12** FWD

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

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



**At**

| | | |
|---|---|---|
| $T_j$ = | 25/125 | ℃ |
| $V_R$ = | 350 | V |
| $I_F$ = | 100 | A |
| $V_{GE}$ = | ±15 | V |

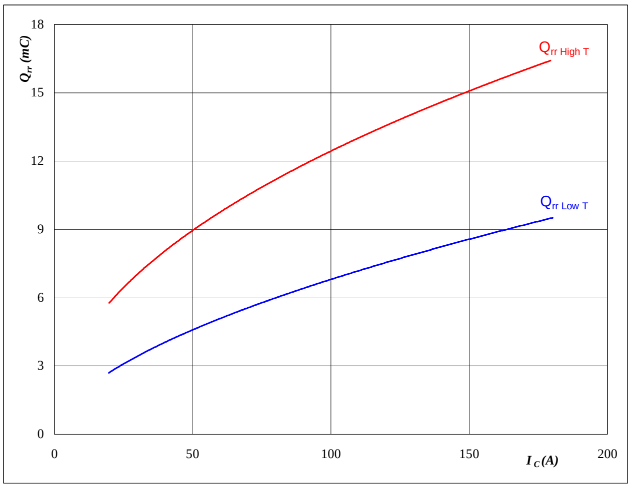
# Neutral Point IGBT

**Neutral Point IGBT and Half Bridge FWD**

**Figure 13** FWD

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

$Q_{rr} = f(I_C)$



**At**

$T_j$ = 25/125 ℃

$V_{CE}$ = 350 V

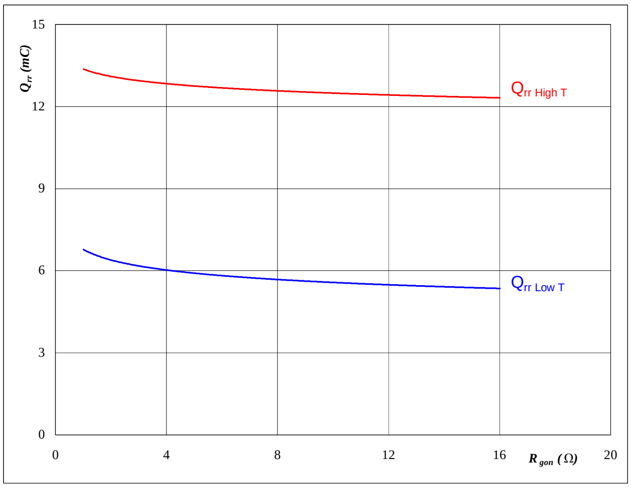
$V_{GE}$ = ±15 V

$R_{gon}$ = 4 Ω

**Figure 14** FWD

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

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



**At**

$T_j$ = 25/125 ℃

$V_R$ = 350 V

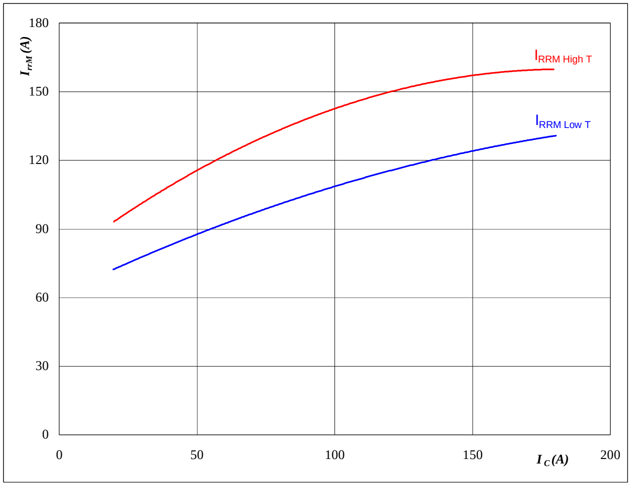
$I_F$ = 100 A

$V_{GE}$ = ±15 V

**Figure 15** FWD

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

$I_{RRM} = f(I_C)$



**At**

$T_j$ = 25/125 ℃

$V_{CE}$ = 350 V

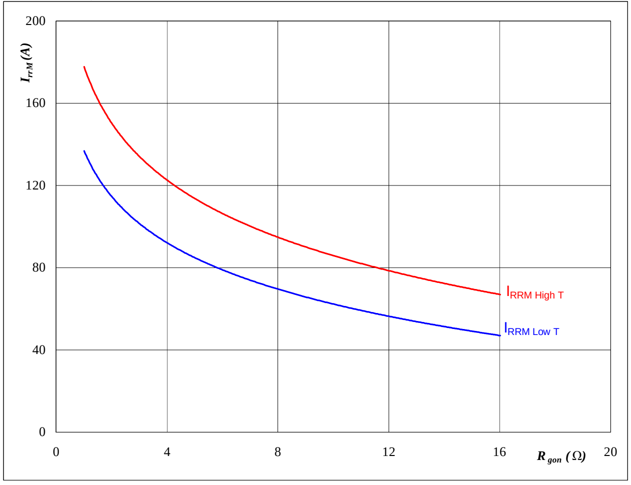
$V_{GE}$ = ±15 V

$R_{gon}$ = 4 Ω

**Figure 16** FWD

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

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



**At**

$T_j$ = 25/125 ℃

$V_R$ = 350 V

$I_F$ = 100 A

$V_{GE}$ = ±15 V

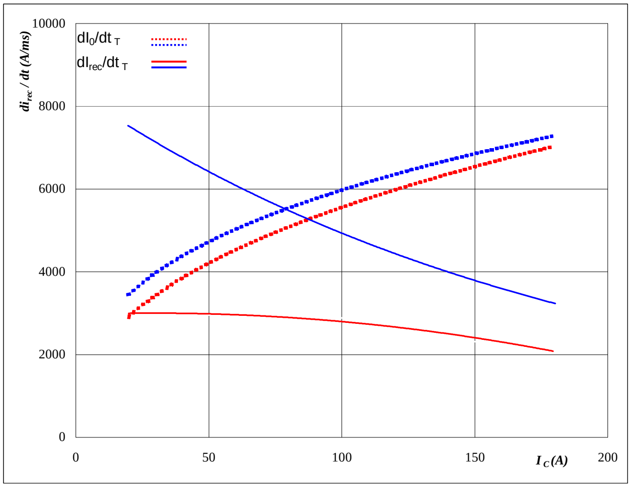
# Neutral Point IGBT

**Neutral Point IGBT and Half Bridge FWD**

**Figure 17** 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 ℃

$V_{CE}$ = 350 V

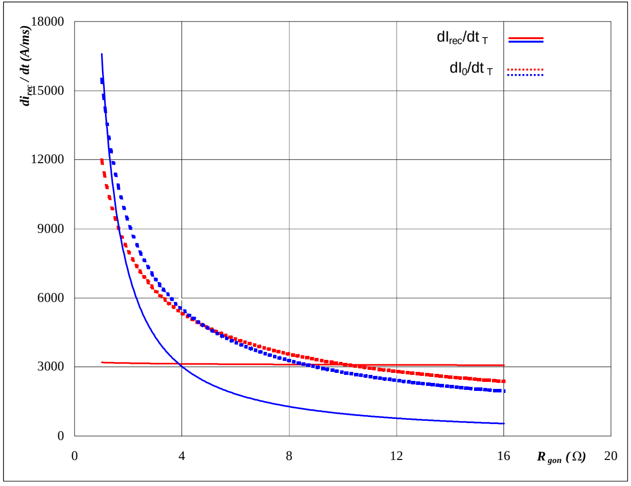
$V_{GE}$ = ±15 V

$R_{gon}$ = 4 Ω

**Figure 18** 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 ℃

$V_R$ = 350 V

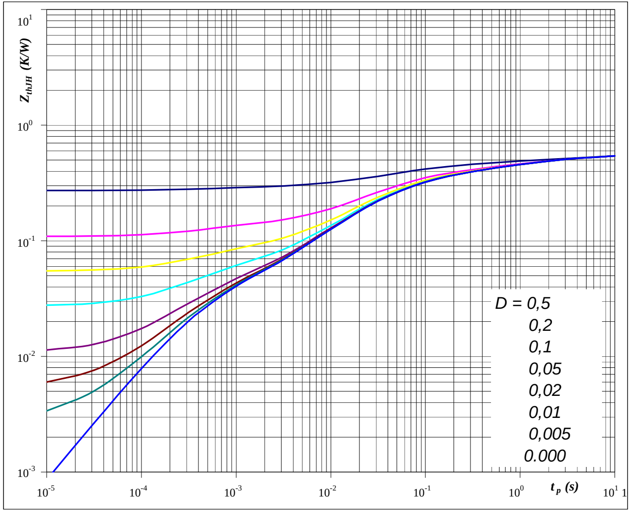
$I_F$ = 100 A

$V_{GE}$ = ±15 V

**Figure 19** NP IGBT

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

$Z_{thJH} = f(t_p)$



**At**

D = tp / T

$R_{thJH}$ = 0,54 K/W

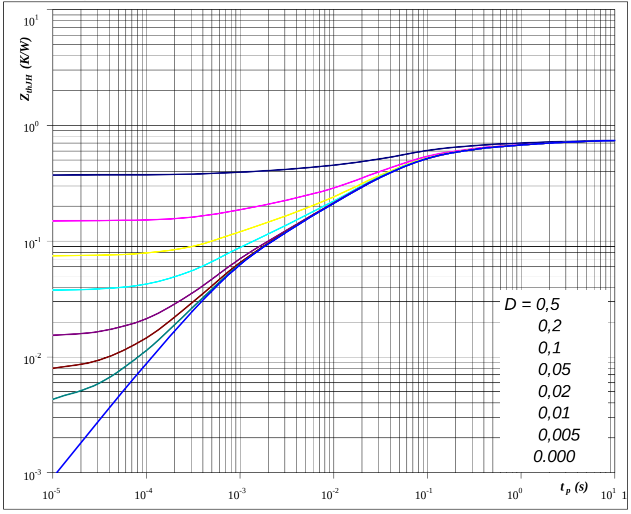
IGBT thermal model values

| R (C/W) | Tau (s) |
|---|---|
| 0,11 | 2,87 |
| 0,09 | 0,46 |
| 0,12 | 0,10 |
| 0,17 | 0,02 |
| 0,03 | 0,004 |

**Figure 20** FWD

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

$Z_{thJH} = f(t_p)$



**At**

D = tp / T

$R_{thJH}$ = 0,74 K/W

FWD thermal model values

| R (C/W) | Tau (s) |
|---|---|
| 0,07 | 3,67 |
| 0,10 | 0,54 |
| 0,20 | 0,10 |
| 0,26 | 0,03 |
| 0,07 | 0,005 |

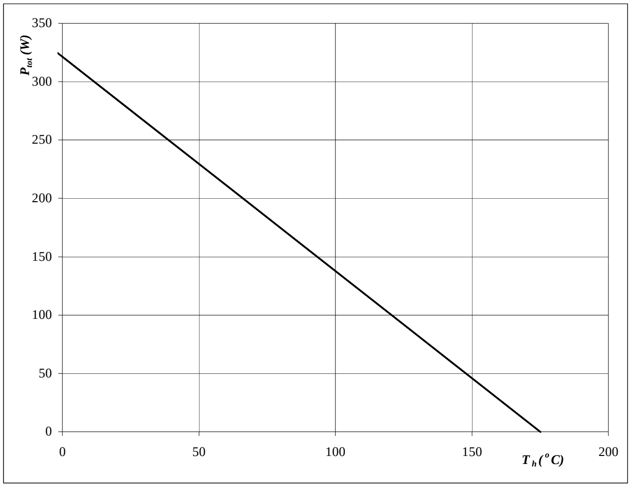
# Neutral Point IGBT

## Neutral Point IGBT and Half Bridge FWD

**Figure 21** NP IGBT

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

$P_{tot} = f(T_h)$



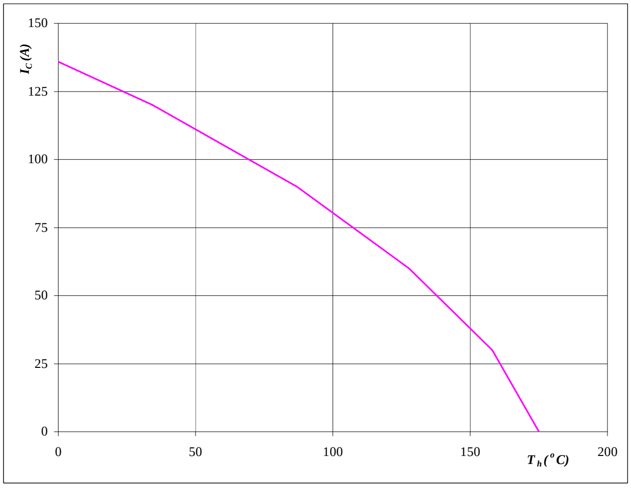
**At**

$T_j$ = 175 ºC

**Figure 22** NP IGBT

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

$I_C = f(T_h)$



**At**

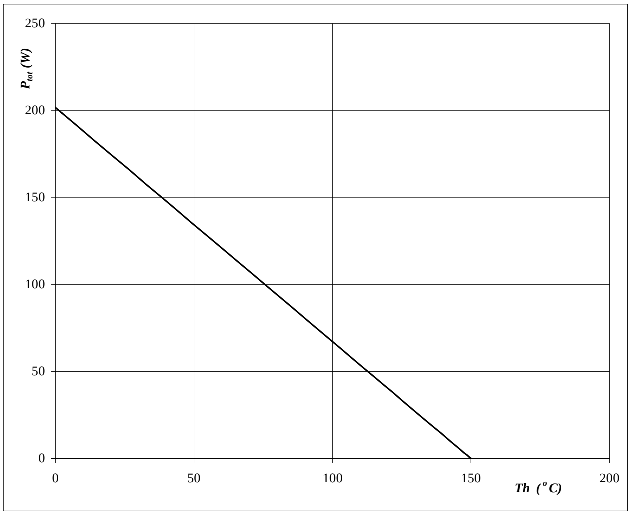
$T_j$ = 175 ºC

$V_{GE}$ = 15 V

**Figure 23** FWD

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

$P_{tot} = f(T_h)$



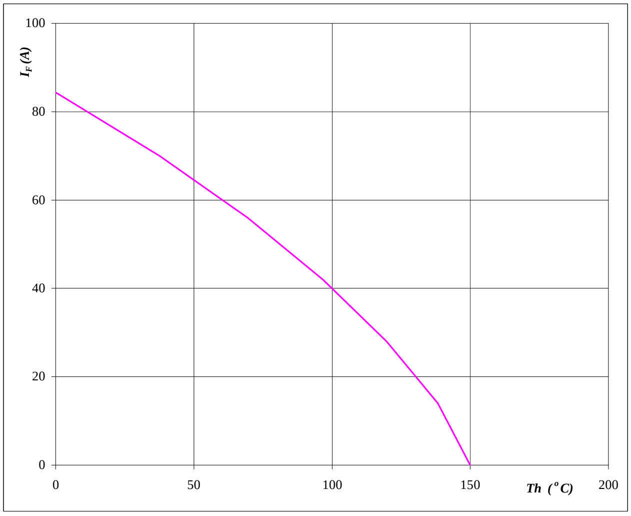
**At**

$T_j$ = 150 ºC

**Figure 24** FWD

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

$I_F = f(T_h)$



**At**

$T_j$ = 150 ºC

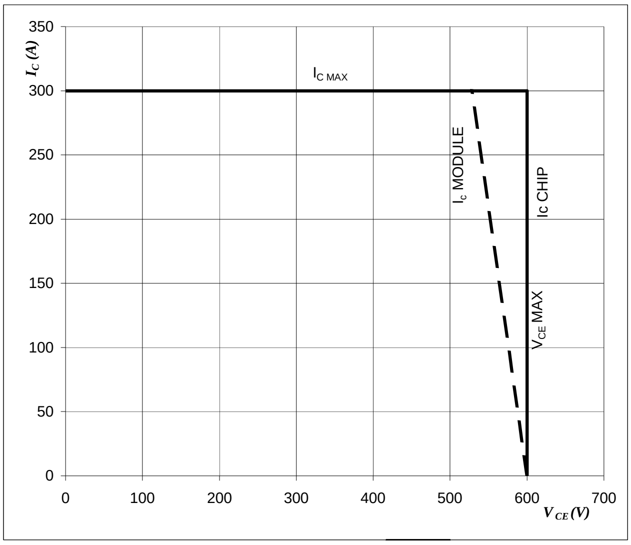
# Neutral Point IGBT

**Neutral Point IGBT**

**Figure 25** NP IGBT

**Reverse bias safe operating area**

$I_C = f(V_{CE})$



**At**

$T_j$ = $T_{jmax}$-25 ºC

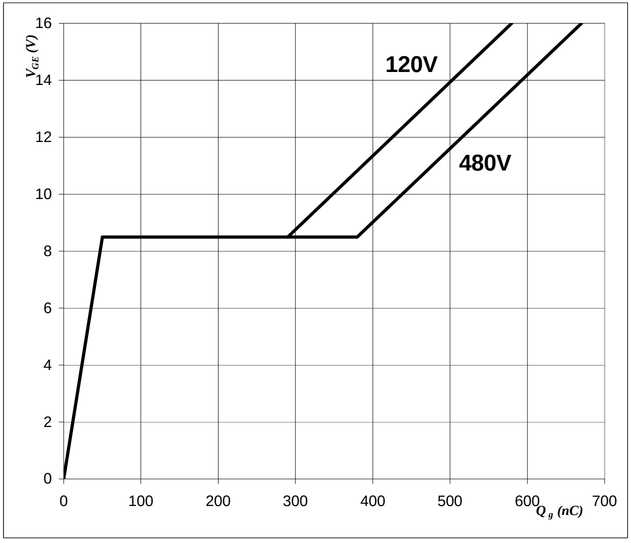
$U_{ccminus}$=$U_{ccplus}$

Switching mode : 3 level switching

**Figure 26** NP IGBT

**Gate voltage vs Gate charge**

$V_{GE} = f(Q_g)$



**At**

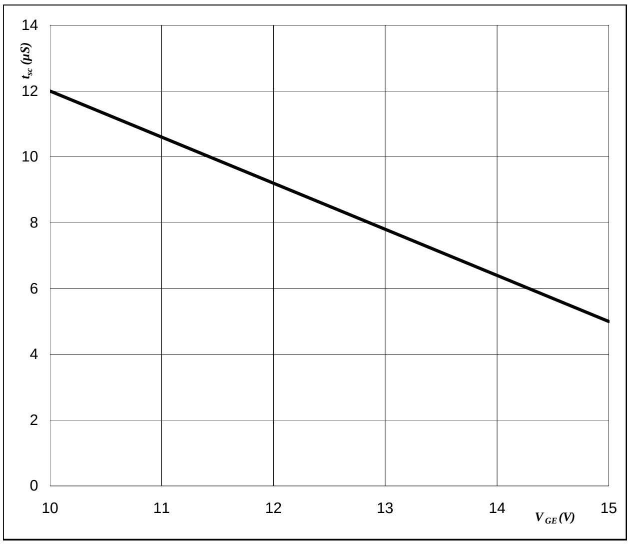
$I_D$ = 100 A

$T_j$= 25 ºC

**Figure 27** Output inverter IGBT

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

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



**At**

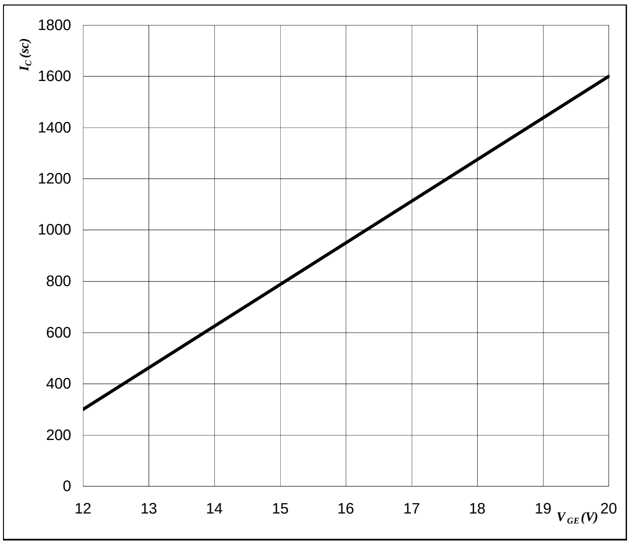
$V_{CE}$ = 600 V

$T_j$ ≤ 150 ºC

**Figure 28** Output inverter IGBT

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

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



**At**

$V_{CE}$ ≤ 400 V

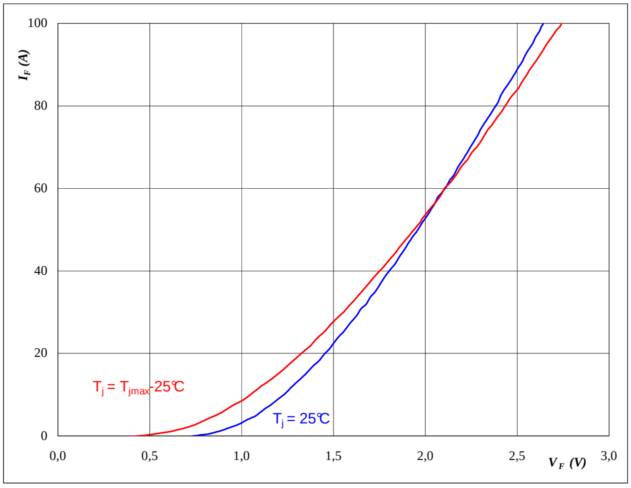
$T_j$ = 125 ºC

# NP IGBT Inverse Diode

**Figure 25** NP Inverse Diode

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

$I_F = f(V_F)$



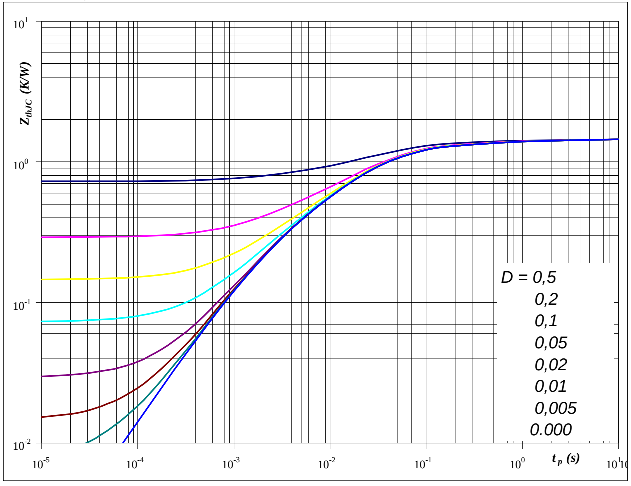
**At**

$t_p$ = 250 µs

**Figure 26** NP Inverse Diode

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

$Z_{thJH} = f(t_p)$



**At**

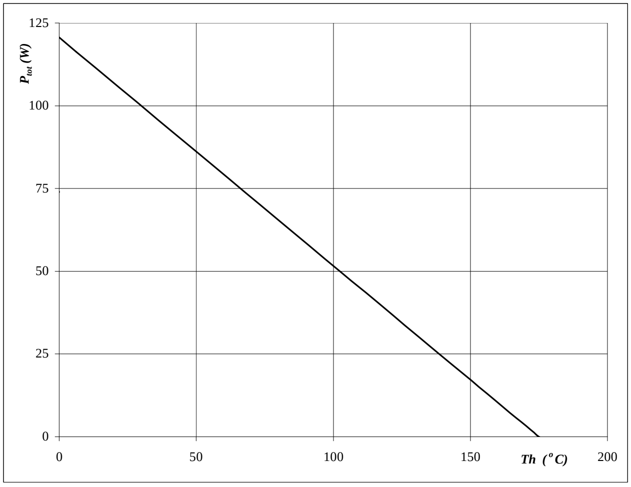
D = tp / T

$R_{thJH}$ = 1,45 K/W

**Figure 27** NP Inverse Diode

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

$P_{tot} = f(T_h)$



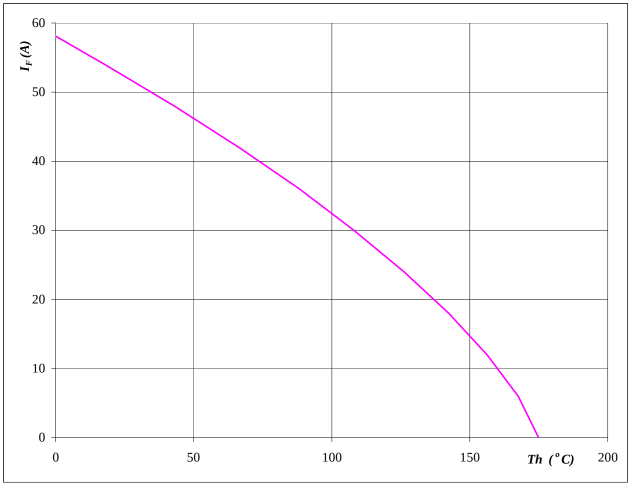
**At**

$T_j$ = 175 ºC

**Figure 28** NP Inverse Diode

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

$I_F = f(T_h)$



**At**

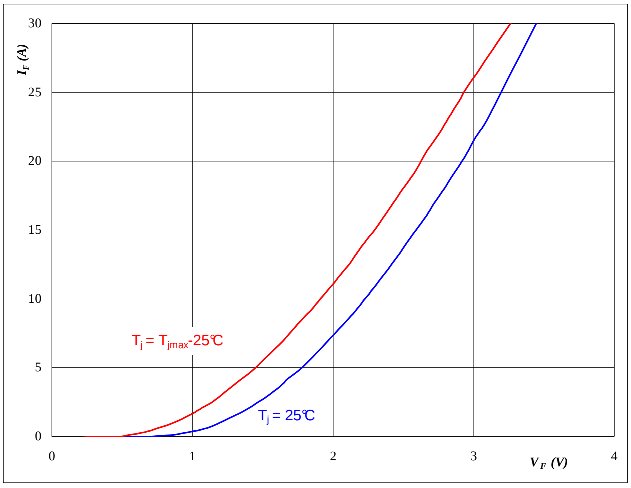
$T_j$ = 175 ºC

# Half Bridge Inverse Diode

**Figure 1** Halfbridge IGBT Inverse Diode

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

$I_F = f(V_F)$



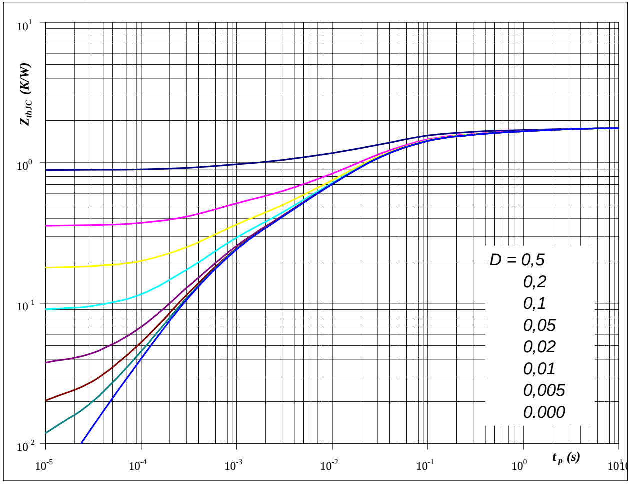
**At**

$t_p$ = 250 µs

**Figure 2** Halfbridge IGBT Inverse Diode

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

$Z_{thJH} = f(t_p)$



**At**

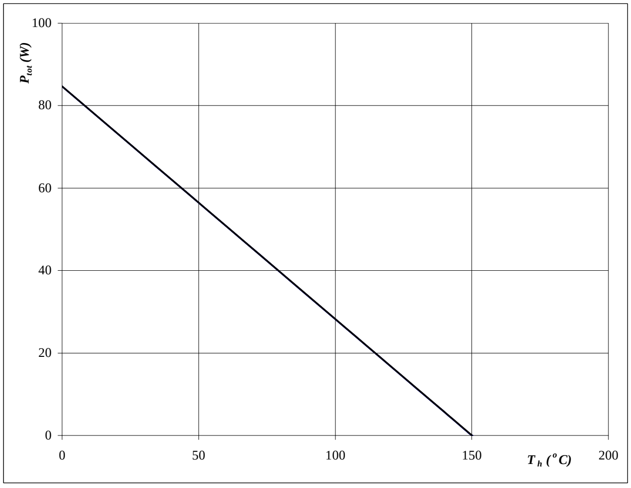
D = $t_p$ / T

$R_{thJH}$ = 1,77 K/W

**Figure 3** Halfbridge IGBT Inverse Diode

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

$P_{tot} = f(T_h)$



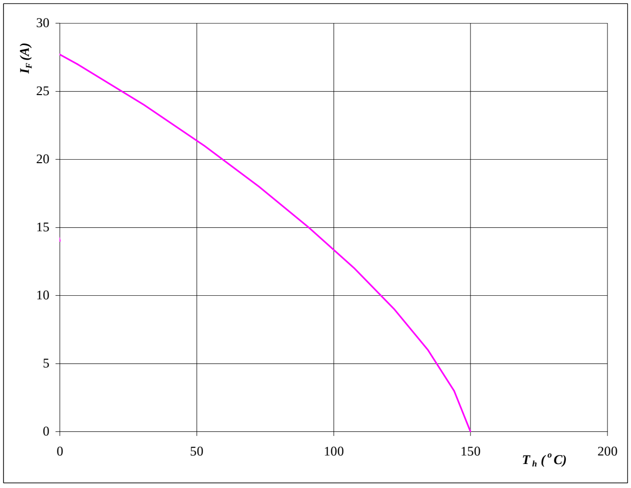
**At**

$T_j$ = 150 ºC

**Figure 4** Halfbridge IGBT Inverse Diode

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

$I_F = f(T_h)$



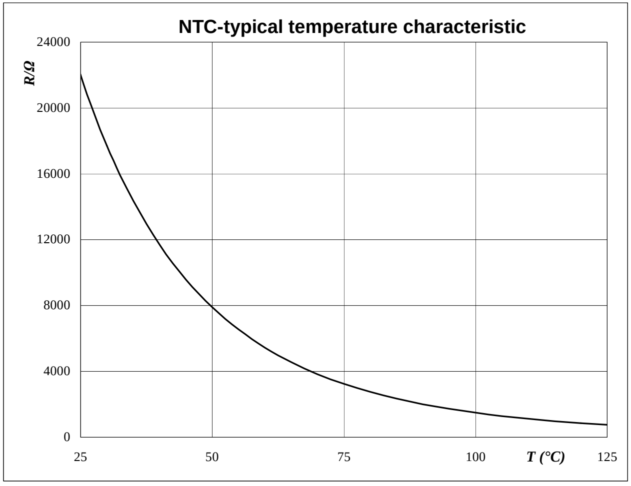
**At**

$T_j$ = 150 ºC

# Thermistor

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

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



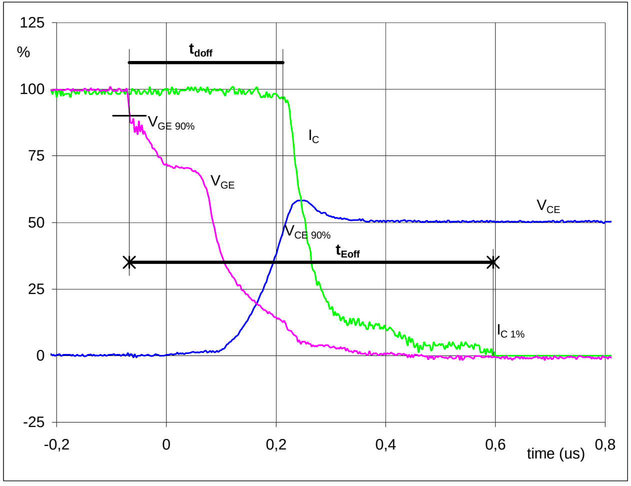
# Switching Definitions Half Bridge

**General conditions**

| | | |
|---|---|---|
| $T_j$ | = | 125 °C |
| $R_{gon}$ | = | 4 Ω |
| $R_{goff}$ | = | 4 Ω |

**Figure 1** Half Bridge IGBT

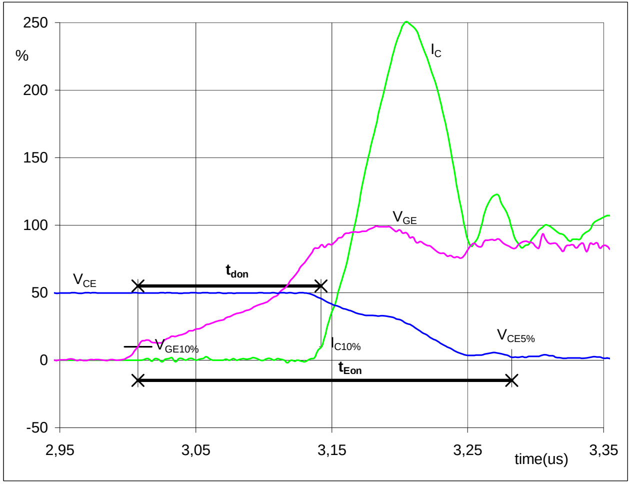
**Turn-off Switching Waveforms & definition of $t_{doff}$, $t_{Eoff}$**
**($t_{Eoff}$ = integrating time for $E_{off}$)**



| | | |
|---|---|---|
| $V_{GE}$ (0%) = | -15 | V |
| $V_{GE}$ (100%) = | 15 | V |
| $V_C$ (100%) = | 700 | V |
| $I_C$ (100%) = | 100 | A |
| $t_{doff}$ = | 0,28 | μs |
| $t_{Eoff}$ = | 0,66 | μs |

**Figure 2** Half Bridge IGBT

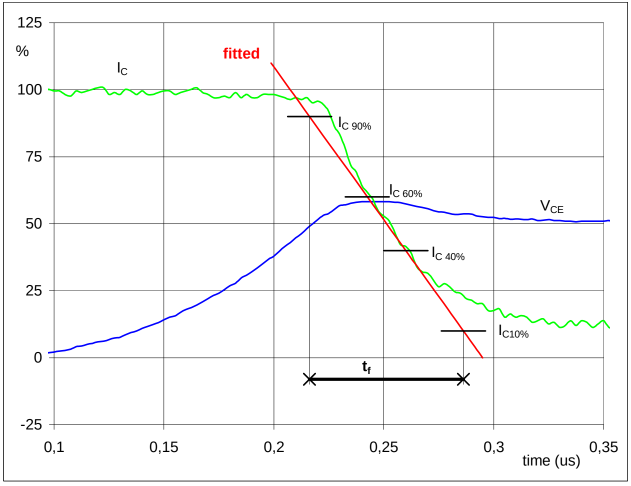
**Turn-on Switching Waveforms & definition of $t_{don}$, $t_{Eon}$**
**($t_{Eon}$ = integrating time for $E_{on}$)**



| | | |
|---|---|---|
| $V_{GE}$ (0%) = | -15 | V |
| $V_{GE}$ (100%) = | 15 | V |
| $V_C$ (100%) = | 700 | V |
| $I_C$ (100%) = | 100 | A |
| $t_{don}$ = | 0,14 | μs |
| $t_{Eon}$ = | 0,27 | μs |

**Figure 3** Half Bridge IGBT

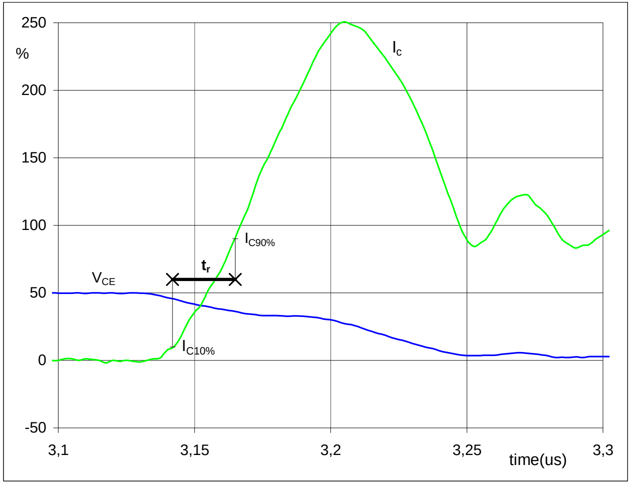
**Turn-off Switching Waveforms & definition of $t_f$**



| | | |
|---|---|---|
| $V_C$ (100%) = | 700 | V |
| $I_C$ (100%) = | 100 | A |
| $t_f$ = | 0,06 | μs |

**Figure 4** Half Bridge IGBT

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

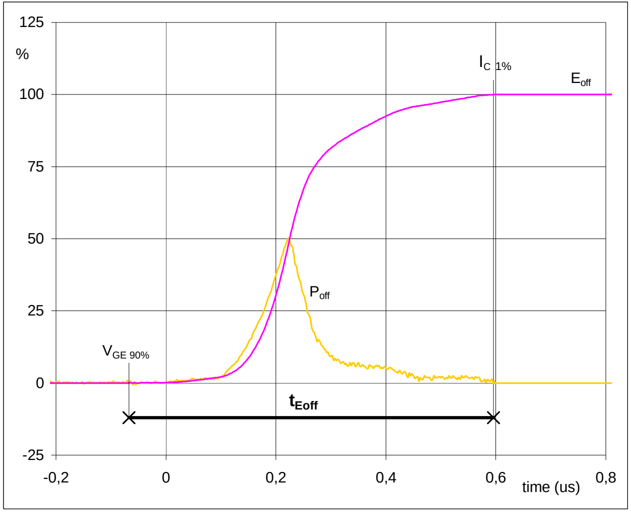


| | | |
|---|---|---|
| $V_C$ (100%) = | 700 | V |
| $I_C$ (100%) = | 100 | A |
| $t_r$ = | 0,02 | μs |

# Switching Definitions Half Bridge

**Figure 5** Half Bridge IGBT

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



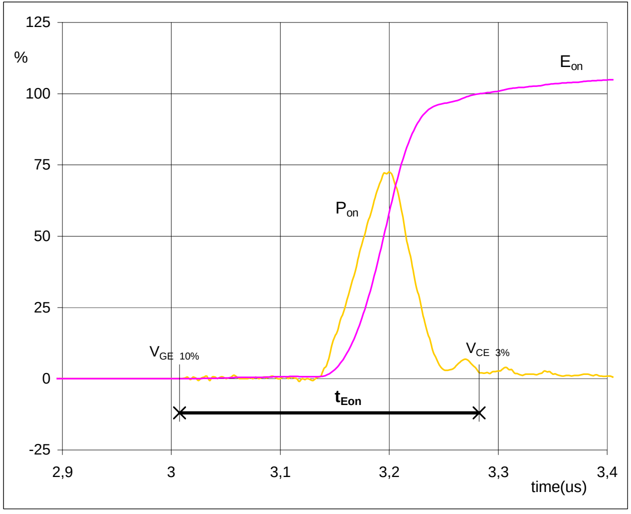
$P_{off}$ (100%) = 70,22 kW

$E_{off}$ (100%) = 4,03 mJ

$t_{Eoff}$ = 0,66 µs

**Figure 6** Half Bridge IGBT

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



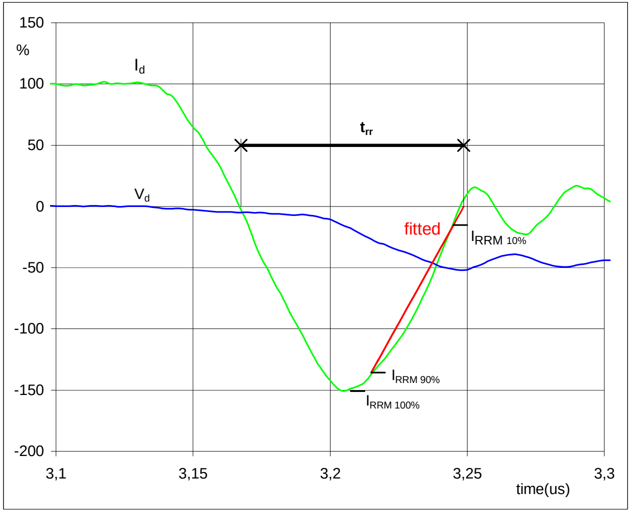
$P_{on}$ (100%) = 70,22 kW

$E_{on}$ (100%) = 3,18 mJ

$t_{Eon}$ = 0,27 µs

**Figure 7** Neutral Point FWD

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



$V_d$ (100%) = 700 V

$I_d$ (100%) = 100 A

$I_{RRM}$ (100%) = -151 A

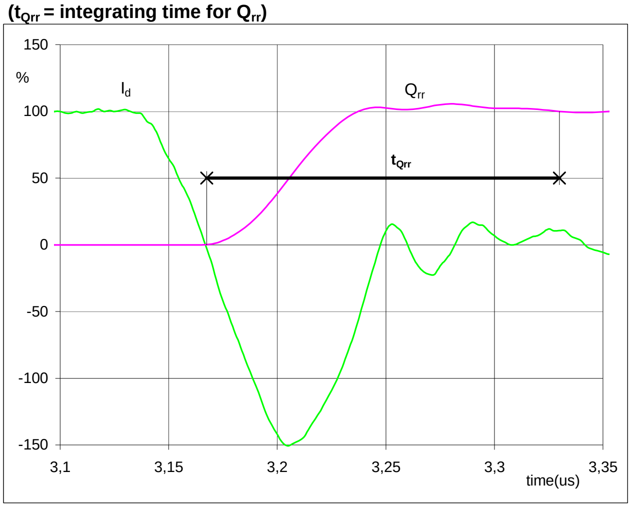
$t_{rr}$ = 0,08 µs

# Switching Definitions Half Bridge

**Figure 8** Neutral Point FWD

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

**($t_{Qrr}$= integrating time for $Q_{rr}$)**



$I_d$ (100%) = 100 A

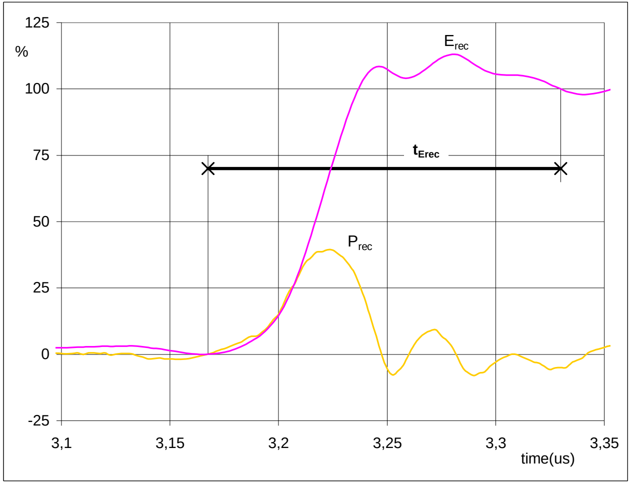
$Q_{rr}$ (100%) = 7,13 µC

$t_{Qrr}$ = 0,16 µs

**Figure 9** Neutral Point FWD

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

**($t_{Erec}$= integrating time for $E_{rec}$)**



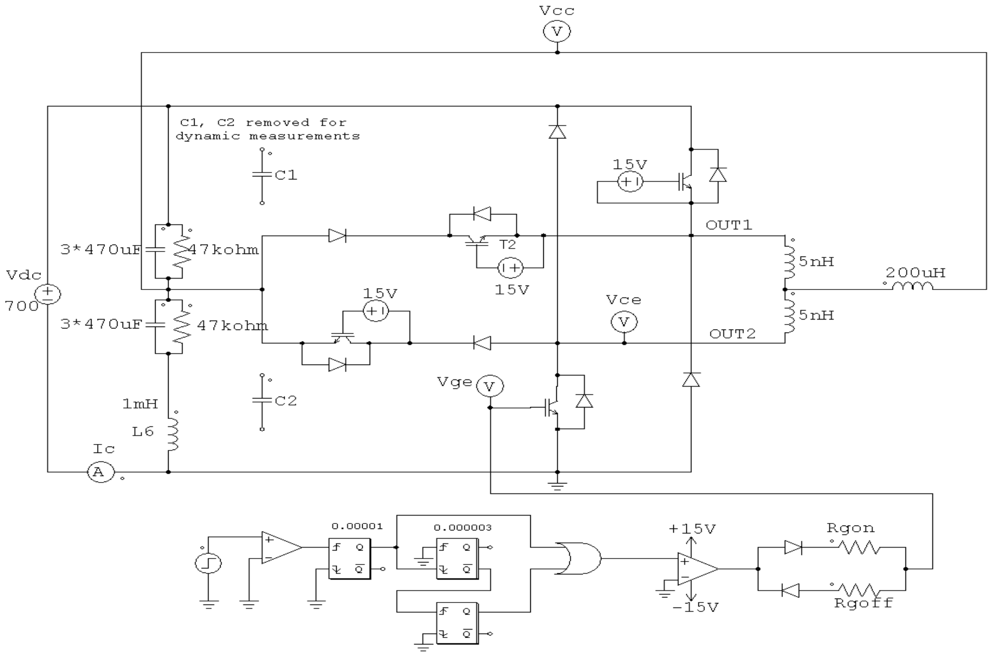
$P_{rec}$ (100%) = 70,22 kW

$E_{rec}$ (100%) = 1,01 mJ

$t_{Erec}$ = 0,16 µs

# half bridge switching measurement circuit

**Figure 10** Half Bridge IGBT



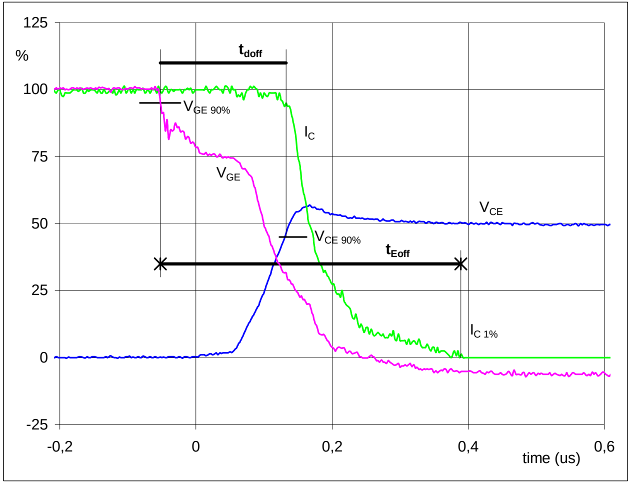
# Switching Definitions Neutral Point IGBT

**General conditions**

| | | |
|---|---|---|
| **$T_j$** | **=** | **125 °C** |
| **$R_{gon}$** | **=** | **4 Ω** |
| **$R_{goff}$** | **=** | **4 Ω** |

**Figure 1** neutral point IGBT

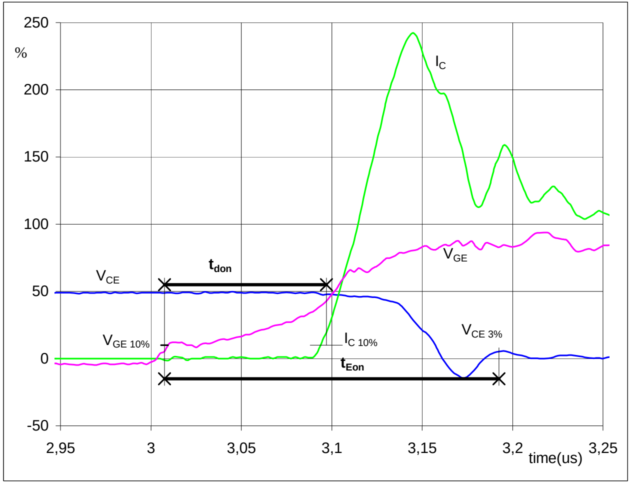
**Turn-off Switching Waveforms & definition of $t_{doff}$, $t_{Eoff}$**
**($t_{Eoff}$ = integrating time for $E_{off}$)**



$V_{GE}$ (0%) = -15 V
$V_{GE}$ (100%) = 15 V
$V_C$ (100%) = 700 V
$I_C$ (100%) = 100 A
$t_{doff}$ = 0,18 µs
$t_{Eoff}$ = 0,44 µs

**Figure 2** neutral point IGBT

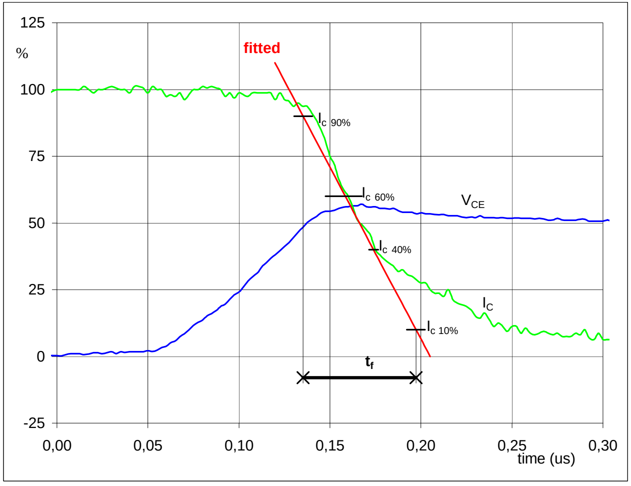
**Turn-on Switching Waveforms & definition of $t_{don}$, $t_{Eon}$**
**($t_{Eon}$ = integrating time for $E_{on}$)**



$V_{GE}$ (0%) = -15 V
$V_{GE}$ (100%) = 15 V
$V_C$ (100%) = 700 V
$I_C$ (100%) = 100 A
$t_{don}$ = 0,10 µs
$t_{Eon}$ = 0,18 µs

**Figure 3** neutral point IGBT

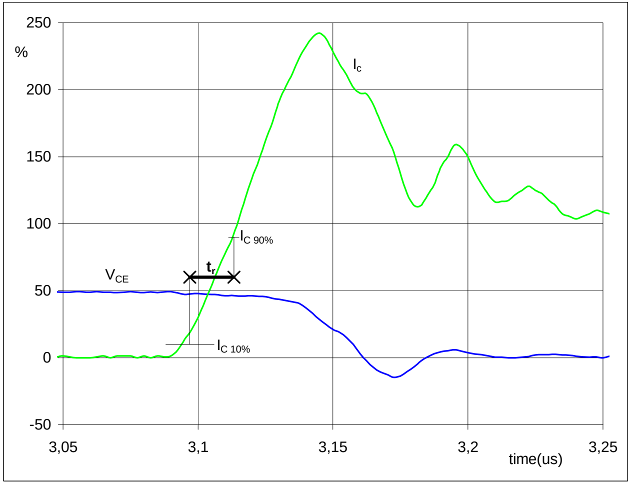
**Turn-off Switching Waveforms & definition of $t_f$**



$V_C$ (100%) = 700 V
$I_C$ (100%) = 100 A
$t_f$ = 0,064 µs

**Figure 4** neutral point IGBT

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

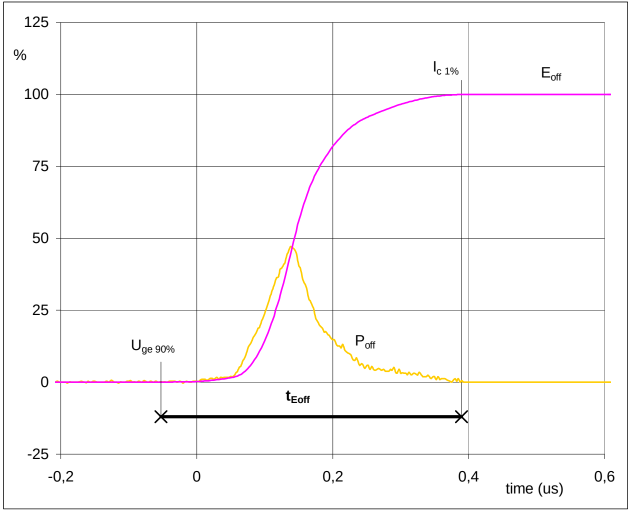


$V_C$ (100%) = 700 V
$I_C$ (100%) = 100 A
$t_r$ = 0,019 µs

# Switching Definitions Neutral Point IGBT

**Figure 5** neutral point IGBT

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



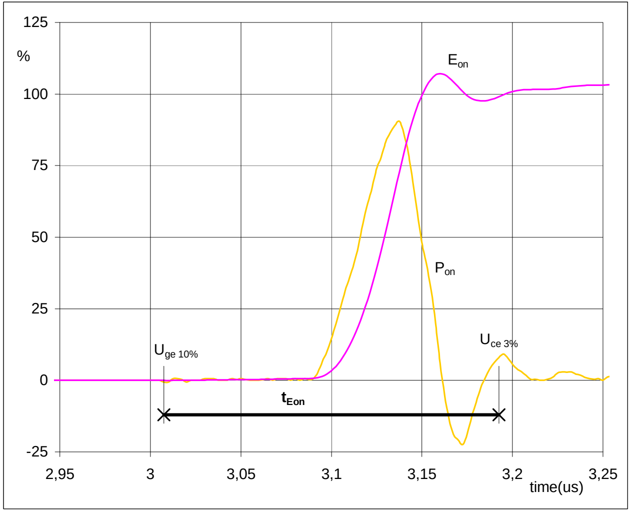
$P_{off}$ (100%) = 69,93 kW

$E_{off}$ (100%) = 3,32 mJ

$t_{Eoff}$ = 0,44 µs

**Figure 6** neutral point IGBT

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



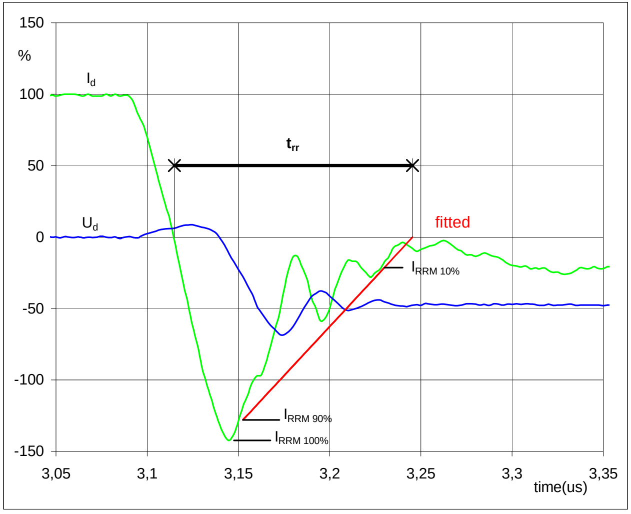
$P_{on}$ (100%) = 69,9279 kW

$E_{on}$ (100%) = 1,52 mJ

$t_{Eon}$ = 0,18 µs

**Figure 7** half bridge FWD

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



$V_d$ (100%) = 700 V

$I_d$ (100%) = 100 A

$I_{RRM}$ (100%) = -142 A

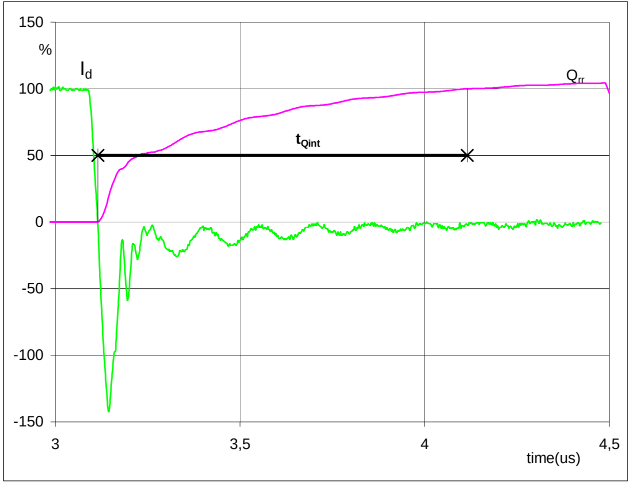
$t_{rr}$ = 0,07 µs

# Switching Definitions Neutral Point IGBT

**Figure 8** half bridge FWD

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

**($t_{Qrr}$= integrating time for $Q_{rr}$)**



$I_d$ (100%) = 100 A

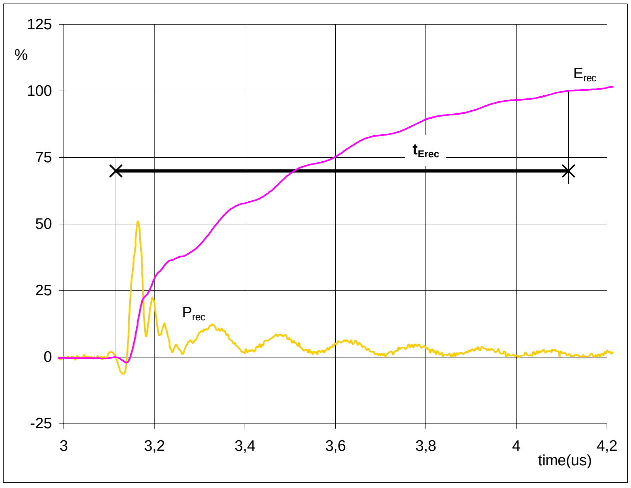
$Q_{rr}$ (100%) = 12,71 µC

$t_{Qint}$ = 1,00 µs

**Figure 9** half bridge FWD

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

**($t_{Erec}$= integrating time for $E_{rec}$)**



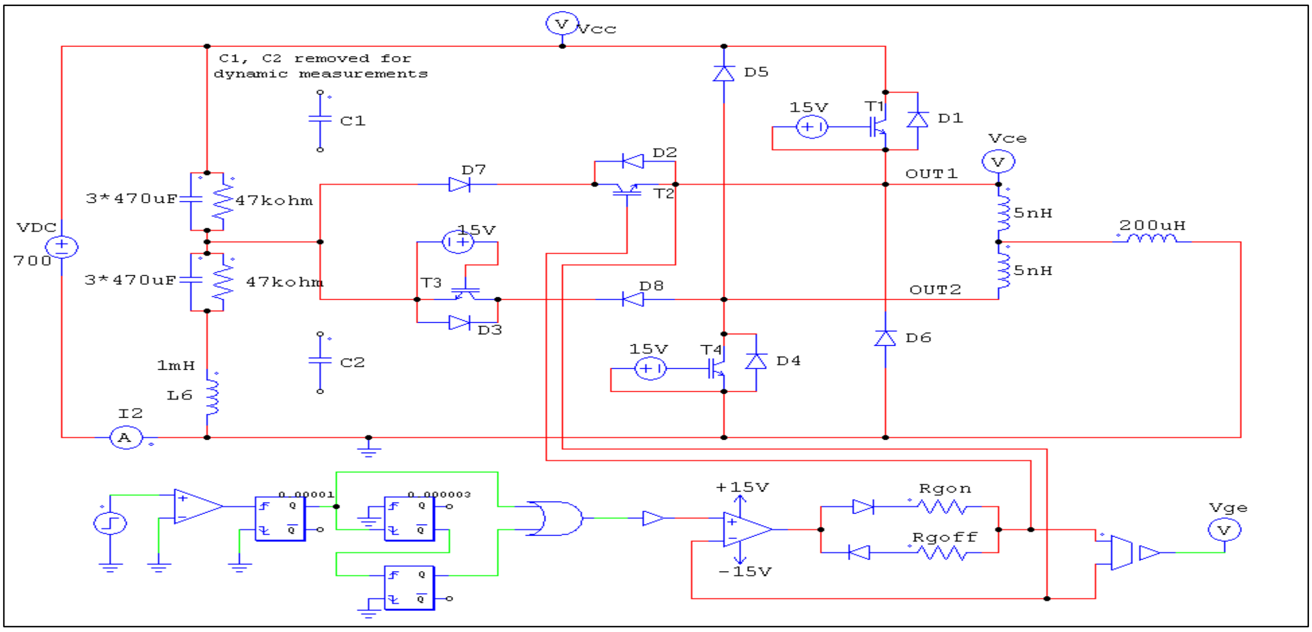
$P_{rec}$ (100%) = 69,93 kW

$E_{rec}$ (100%) = 3,61 mJ

$t_{Erec}$ = 1,00 µs

# Neutral Point IGBT switching measurement circuit

**Figure 10** neutral point IGBT

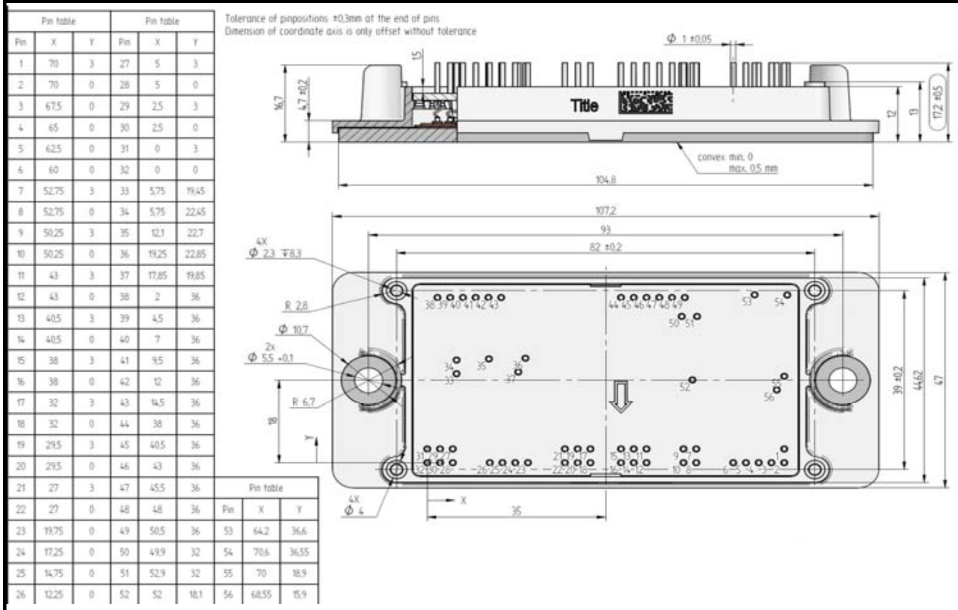


# Ordering Code and Marking - Outline - Pinout

## Ordering Code & Marking

| Version | Ordering Code | in DataMatrix as | in packaging barcode as |
|---|---|---|---|
| without thermal paste 13mm housing | 30-FT12NMA160SH-M669F08 | M669F08 | M669F08 |

## Outline

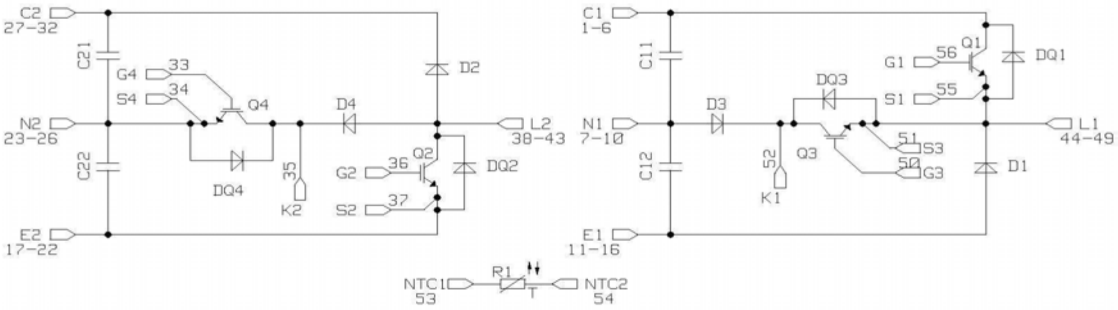


Tolerance of pinpositions ±0,3mm at the end of pins
Dimension of coordinate axis is only offset without tolerance

| Pin table | | | Pin table | | |
|---|---|---|---|---|---|
| Pin | X | Y | Pin | X | Y |
| 1 | 70 | 3 | 27 | 5 | 3 |
| 2 | 70 | 0 | 28 | 5 | 0 |
| 3 | 67,5 | 0 | 29 | 2,5 | 3 |
| 4 | 65 | 0 | 30 | 2,5 | 0 |
| 5 | 62,5 | 0 | 31 | 0 | 3 |
| 6 | 60 | 0 | 32 | 0 | 0 |
| 7 | 52,75 | 3 | 33 | 5,75 | 19,45 |
| 8 | 52,75 | 0 | 34 | 5,75 | 22,45 |
| 9 | 50,25 | 3 | 35 | 12,1 | 22,7 |
| 10 | 50,25 | 0 | 36 | 19,25 | 22,85 |
| 11 | 43 | 3 | 37 | 17,85 | 19,85 |
| 12 | 43 | 0 | 38 | 2 | 36 |
| 13 | 40,5 | 3 | 39 | 4,5 | 36 |
| 14 | 40,5 | 0 | 40 | 7 | 36 |
| 15 | 38 | 3 | 41 | 9,5 | 36 |
| 16 | 38 | 0 | 42 | 12 | 36 |
| 17 | 32 | 3 | 43 | 14,5 | 36 |
| 18 | 32 | 0 | 44 | 38 | 36 |
| 19 | 29,5 | 3 | 45 | 40,5 | 36 |
| 20 | 29,5 | 0 | 46 | 43 | 36 |
| 21 | 27 | 3 | 47 | 45,5 | 36 |
| 22 | 27 | 0 | 48 | 48 | 36 |
| 23 | 19,75 | 0 | 49 | 50,5 | 36 |
| 24 | 17,25 | 0 | 50 | 49,9 | 32 |
| 25 | 14,75 | 0 | 51 | 52,9 | 32 |
| 26 | 12,25 | 0 | 52 | 52 | 18,1 |

| Pin table | | |
|---|---|---|
| Pin | X | Y |
| 53 | 64,2 | 36,6 |
| 54 | 70,6 | 36,55 |
| 55 | 70 | 18,9 |
| 56 | 68,55 | 15,9 |

## 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.