Vincotech

# 70-W212NMA600SC-M200P
datasheet

**VINcoMNPC X4** **1200 V / 600 A**

### Features

- Mixed-voltage NPC
- Low inductive
- High power screw interface
- Integrated DC-snubber capacitors

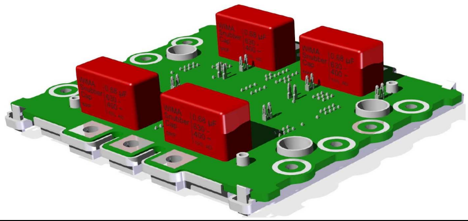
### Target Applications

- Solar inverter
- UPS
- High speed motor drive

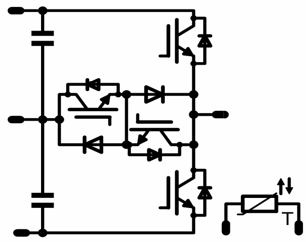
### Types

- 70-W212NMA600SC-M200P

### VINco X4 housing



### *Schematic*




## Maximum Ratings

Tj=25°C, unless otherwise specified

| Parameter | Symbol | Condition | | Value | Unit |
|---|---|---|---|---|---|
| **Buck Switch ( T1 , T4 )** | | | | | |
| Collector-emitter breakdown voltage | $V_{CE}$ | | | 1200 | V |
| DC collector current | $I_C$ | $T_j$=$T_j$max | $T_h$=80°C<br>$T_c$=80°C | 498<br>637 | A |
| Repetitive peak collector current | $I_{Cpulse}$ | $t_p$ limited by $T_j$max | | 1800 | A |
| Power dissipation | $P_{tot}$ | $T_j$=$T_j$max | $T_h$=80°C<br>$T_c$=80°C | 1188<br>1799 | 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 |
| Turn off safe operating area (RBSOA) | $I_{cmax}$ | $V_{CE\ max}$ = 1200V<br>$T_{vj\ max}$= 150°C | | 1200 | A |
| Maximum Junction Temperature | $T_j$max | | | 175 | °C |
| **Boost Diode ( D2 , D3 )** | | | | | |
| Peak Repetitive Reverse Voltage | $V_{RRM}$ | $T_j$=25°C | | 600 | V |
| DC forward current | $I_F$ | $T_j$=$T_j$max | $T_h$=80°C<br>$T_c$=80°C | 288<br>384 | A |
| Surge forward current | $I_{FSM}$ | $t_p$ = 10 ms, sine halfwave | $T_{vj}$ < 150°C | 1250 | A |
| I2t-value | $I^2t$ | | | 7800 | $A^2s$ |
| Repetitive peak forward current | $I_{FRM}$ | $t_P$ = 1 ms | $T_{vj}$ < 150°C | 1200 | A |
| Power dissipation per FWD | $P_{tot}$ | $T_j$=$T_j$max | $T_h$=80°C<br>$T_c$=80°C | 365<br>554 | W |
| Maximum Junction Temperature | $T_j$max | | | 175 | °C |

# Maximum Ratings

Tj=25°C, unless otherwise specified

| Parameter | Symbol | Condition | | Value | Unit |
|---|---|---|---|---|---|
| **Boost Switch ( T2 , T3 )** | | | | | |
| Collector-emitter breakdown voltage | $V_{CE}$ | | | 600 | V |
| DC collector current | $I_C$ | $T_j=T_j max$ | $T_h=80°C$<br>$T_c=80°C$ | 388<br>510 | A |
| Repetitive peak collector current | $I_{Cpuls}$ | $t_p$ limited by $T_j max$ | | 1800 | A |
| Power dissipation | $P_{tot}$ | $T_j=T_j max$ | $T_h=80°C$<br>$T_c=80°C$ | 594<br>900 | 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 |
| Turn off safe operating area (RBSOA) | $I_{cmax}$ | $V_{CE\ max}$ = 1200V<br>$T_{vj\ max}$= 150°C | | 1200 | A |
| Maximum Junction Temperature | $T_j max$ | | | 175 | °C |
| **Buck Diode ( D1 , D4 )** | | | | | |
| Peak Repetitive Reverse Voltage | $V_{RRM}$ | $T_j=25°C$ | | 1200 | V |
| DC forward current | $I_F$ | $T_j=T_j max$ | $T_h=80°C$<br>$T_c=80°C$ | 355<br>470 | A |
| Surge forward current | $I_{FSM}$ | $t_p$=10ms , sin 180° | $T_j=150°C$ | 3600 | A |
| I2t-value | $I^2t$ | | | 16200 | $A^2s$ |
| Repetitive peak forward current | $I_{FRM}$ | $t_p$ limited by $T_j max$ | | 1800 | A |
| Power dissipation per FWD | $P_{tot}$ | $T_j=T_j max$ | $T_h=80°C$<br>$T_c=80°C$ | 633<br>960 | W |
| Maximum Junction Temperature | $T_j max$ | | | 175 | °C |

# Maximum Ratings

Tj=25°C, unless otherwise specified

| Parameter | Symbol | Condition | Value | Unit |
|---|---|---|---|---|
| **DC link Capacitor** | | | | |
| Max.DC voltage | $V_{MAX}$ | | 630 | V |
| Operation Temperature | $T_{OP}$ | | -40…+105 | °C |
| RMS Current | $I_{RMS}$ | | 10 | A |
| **General Module Properties** | | | | |
| Material of module baseplate | | | Cu | |
| Material of internal isulation | | | Al2O3 | |
| **Thermal Properties** | | | | |
| Storage temperature | $T_{stg}$ | | -40…+125 | °C |
| Operation temperature under switching condition | $T_{op}$ | for power part | -40…+(Tjmax - 25) | °C |
| **Isolation Properties** | | | | |
| Isolation 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 | |
| **Buck Switch ( T1 , T4 )** | | | | | | | | | | |
| Gate emitter threshold voltage | $V_{GE(th)}$ | $V_{CE}=V_{GE}$ | | | 0,024 | Tj=25°C<br>Tj=125°C | 5 | 5,8 | 6,5 | V |
| Collector-emitter saturation voltage | $V_{CE(sat)}$ | | 15 | | 600 | Tj=25°C<br>Tj=125°C | 1 | 2,16<br>2,42 | 2,4 | V |
| Collector-emitter cut-off current incl. | $I_{CES}$ | | 0 | 1200 | | Tj=25°C<br>Tj=125°C | | | 0,6 | mA |
| Gate-emitter leakage current | $I_{GES}$ | | 20 | 0 | | Tj=25°C<br>Tj=125°C | | | 3000 | nA |
| Integrated Gate resistor | $R_{gint}$ | | | | | | | 1,25 | | Ω |
| Turn-on delay time | $t_{d(on)}$ | Rgoff=1 Ω<br>Rgon=1 Ω | ±15 | 350 | 600 | Tj=25°C<br>Tj=125°C | | 296<br>310 | | ns |
| Rise time | $t_r$ | | | | | Tj=25°C<br>Tj=125°C | | 57<br>64 | | |
| Turn-off delay time | $t_{d(off)}$ | | | | | Tj=25°C<br>Tj=125°C | | 350<br>410 | | |
| Fall time | $t_f$ | | | | | Tj=25°C<br>Tj=125°C | | 62<br>83 | | |
| Turn-on energy loss | $E_{on}$ | | | | | Tj=25°C<br>Tj=125°C | | 12<br>17 | | mWs |
| Turn-off energy loss | $E_{off}$ | | | | | Tj=25°C<br>Tj=125°C | | 20<br>31 | | |
| Input capacitance | $C_{ies}$ | f=1MHz | 0 | 25 | | Tj=25°C | | 37200 | | pF |
| Output capacitance | $C_{oss}$ | | | | | | | 2320 | | |
| Reverse transfer capacitance | $C_{rss}$ | | | | | | | 2040 | | |
| Gate charge | $Q_{Gate}$ | | ±15 | 600 | 600 | Tj=25°C | | 4800 | | nC |
| Thermal resistance junction to sink | $R_{th(j-s)}$ | phase-change material ʎ=3,4W/mK | | | | | | 0,08 | | K/W |
| Thermal resistance junction to case | $R_{th(j-c)}$ | | | | | | | 0,06 | | |
| **Boost Diode ( D2 , D3 )** | | | | | | | | | | |
| FWD forward voltage | $V_F$ | | | | 600 | Tj=25°C<br>Tj=125°C | 1,2 | 1,67<br>1,65 | 2,3 | V |
| Peak reverse recovery current | $I_{RRM}$ | Rgon=1 Ω | ±15 | 350 | 600 | Tj=25°C<br>Tj=125°C | | 339<br>399 | | A |
| Reverse recovery time | $t_{rr}$ | | | | | Tj=25°C<br>Tj=125°C | | 132<br>257 | | ns |
| Reverse recovered charge | $Q_{rr}$ | | | | | Tj=25°C<br>Tj=125°C | | 23<br>44 | | μC |
| Peak rate of fall of recovery current | di(rec)max /dt | | | | | Tj=25°C<br>Tj=125°C | | 4888<br>3314 | | A/μs |
| Reverse recovered energy | Erec | | | | | Tj=25°C<br>Tj=125°C | | 5<br>9 | | mWs |
| Thermal resistance junction to sink | $R_{th(j-s)}$ | phase-change material ʎ=3,4W/mK | | | | | | 0,26 | | K/W |
| Thermal resistance junction to case | $R_{th(j-c)}$ | | | | | | | 0,17 | | |
| **Boost Switch ( T2 , T3 )** | | | | | | | | | | |
| Gate emitter threshold voltage | $V_{GE(th)}$ | $V_{CE}=V_{GE}$ | | | 0,0096 | Tj=25°C<br>Tj=125°C | 5 | 5,8 | 6,5 | V |
| Collector-emitter saturation voltage | $V_{CE(sat)}$ | | 15 | | 600 | Tj=25°C<br>Tj=125°C | 1 | 1,57<br>1,80 | 2,3 | V |
| Collector-emitter cut-off incl. | $I_{CES}$ | | 0 | 600 | | Tj=25°C<br>Tj=125°C | | | 0,1 | mA |
| Gate-emitter leakage current | $I_{GES}$ | | 20 | 0 | | Tj=25°C<br>Tj=125°C | | | 3000 | nA |
| Integrated Gate resistor | $R_{gint}$ | | | | | | | 0,5 | | Ω |
| Turn-on delay time | $t_{d(on)}$ | Rgoff=1 Ω<br>Rgon=1 Ω | ±15 | 350 | 600 | Tj=25°C<br>Tj=125°C | | 244<br>250 | | ns |
| Rise time | $t_r$ | | | | | Tj=25°C<br>Tj=125°C | | 49<br>53 | | |
| Turn-off delay time | $t_{d(off)}$ | | | | | Tj=25°C<br>Tj=125°C | | 306<br>325 | | |
| Fall time | $t_f$ | | | | | Tj=25°C<br>Tj=125°C | | 48<br>67 | | |
| Turn-on energy loss | $E_{on}$ | | | | | Tj=25°C<br>Tj=125°C | | 8<br>13 | | mWs |
| Turn-off energy loss | $E_{off}$ | | | | | Tj=25°C<br>Tj=125°C | | 15<br>22 | | |
| Input capacitance | $C_{ies}$ | f=1MHz | 0 | 25 | | Tj=25°C | | 36960 | | pF |
| Output capacitance | $C_{oss}$ | | | | | | | 2304 | | |
| Reverse transfer capacitance | $C_{rss}$ | | | | | | | 1096 | | |
| Gate charge | $Q_{Gate}$ | | ±15 | 300 | 600 | Tj=25°C | | 6400 | | nC |
| Thermal resistance junction to sink | $R_{th(j-s)}$ | phase-change material ʎ=3,4W/mK | | | | | | 0,16 | | K/W |
| Thermal resistance junction to case | $R_{th(j-c)}$ | | | | | | | 0,11 | | |

copyright Vincotech

## 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 | |
| **Buck Diode ( D1 , D4 )** | | | | | | | | | | |
| FWD forward voltage | $V_F$ | | | | 600 | Tj=25°C<br>Tj=125°C | 1 | 2,23<br>2,31 | 3 | V |
| Reverse leakage current | $I_r$ | | | 1200 | | Tj=25°C<br>Tj=125°C | | | 720 | µA |
| Peak reverse recovery current | $I_{RRM}$ | Rgon=1 Ω | ±15 | 350 | 600 | Tj=25°C<br>Tj=125°C | | 422<br>568 | | A |
| Reverse recovery time | $t_{rr}$ | | | | | Tj=25°C<br>Tj=125°C | | 76<br>290 | | ns |
| Reverse recovered charge | $Q_{rr}$ | | | | | Tj=25°C<br>Tj=125°C | | 20<br>61 | | µC |
| Peak rate of fall of recovery current | di(rec)max /dt | | | | | Tj=25°C<br>Tj=125°C | | 14692<br>12189 | | A/µs |
| Reverse recovery energy | $E_{rec}$ | | | | | Tj=25°C<br>Tj=125°C | | 4<br>14 | | mWs |
| Thermal resistance junction to sink | $R_{th(j-s)}$ | phase-change material ʎ=3,4W/mK | | | | | | 0,15 | | K/W |
| Thermal resistance junction to case | $R_{th(j-c)}$ | | | | | | | 0,10 | | |
| **DC link Capacitor** | | | | | | | | | | |
| Capacitance | C | | | | | | | 1360 | | nF |
| Tolerance | | | | | | | -10 | | +10 | % |
| Dissipation factor | | | | | | $T_j$=20ºC | | | 0,0004 | mΩ |
| Climatic category | | | | | | | | 40/105/56 | | |
| **Thermistor** | | | | | | | | | | |
| Rated resistance | R | | | | | Tj=25°C | | 22000 | | Ω |
| Deviation of $R_{100}$ | ΔR/R | R100=1486 Ω | | | | Tj=100°C | -12 | | +12 | % |
| Power dissipation | P | | | | | Tj=25°C | | 200 | | mW |
| Power dissipation constant | | | | | | Tj=25°C | | 2 | | mW/K |
| B-value | $B_{(25/50)}$ | Tol. ±3% | | | | Tj=25°C | | 3950 | | K |
| B-value | $B_{(25/100)}$ | Tol. ±3% | | | | Tj=25°C | | 3998 | | K |
| Vincotech NTC Reference | | | | | | Tj=25°C | | | B | |
| **Module Properties** | | | | | | | | | | |
| Module inductance (from chips to PCB) | $L_{sCE}$ | | | | | | | 5 | | nH |
| Module inductance (from PCB to PCB using Intercon board) | $L_{sCE}$ | | | | | | | 3 | | nH |
| Resistance of Intercon boards (from PCB to PCB using Intercon board) | $Rcc_{1+EE'}$ | Tc=25°C, per switch | | | | | | 1,5 | | mΩ |
| Mounting torque | M | Screw M4 - mounting according to valid application note VINcoX-*-HI | | | | | 2 | | 2,2 | Nm |
| Mounting torque | M | Screw M5 - mounting according to valid application note VINcoX-*-HI | | | | | 4 | | 6 | Nm |
| Terminal connection torque | M | Screw M6 - mounting according to valid application note VINcoX-*-HI | | | | | 2,5 | | 5 | Nm |
| Weight | G | | | | | | | | 710 | g |

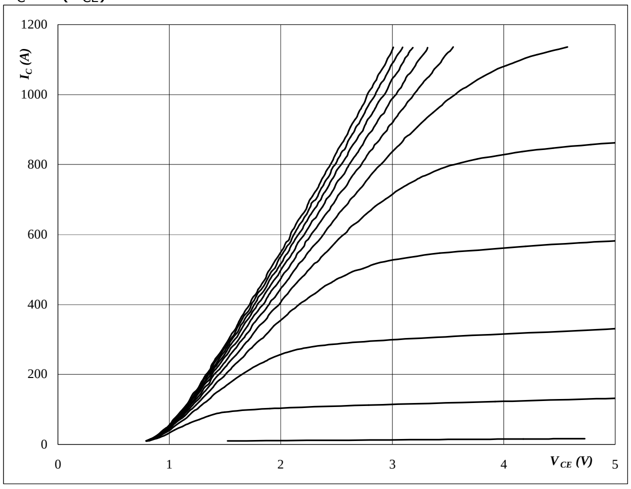
# Buck

**Half bridge IGBT and Neutral point FWD**

**Figure 1** IGBT

**Typical output characteristics**

$I_C = f(V_{CE})$



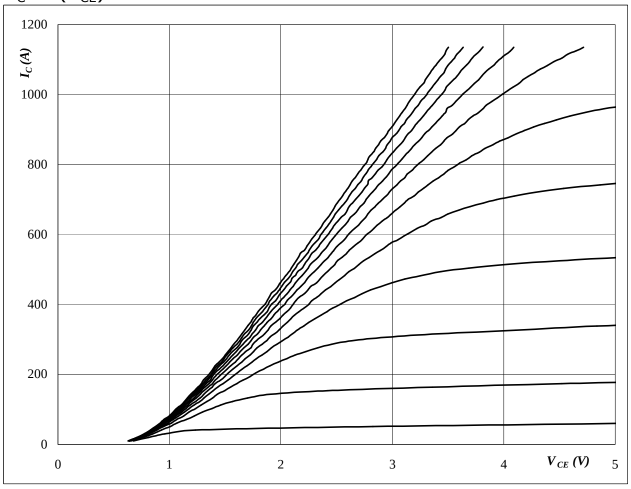

**At**

| | | |
|---|---|---|
| $t_p$ = | 350 | µs |
| $T_j$ = | 25 | °C |
| $V_{GE}$ from | 7 V to 17 V in steps of 1 V | |

**Figure 2** IGBT

**Typical output characteristics**

$I_C = f(V_{CE})$



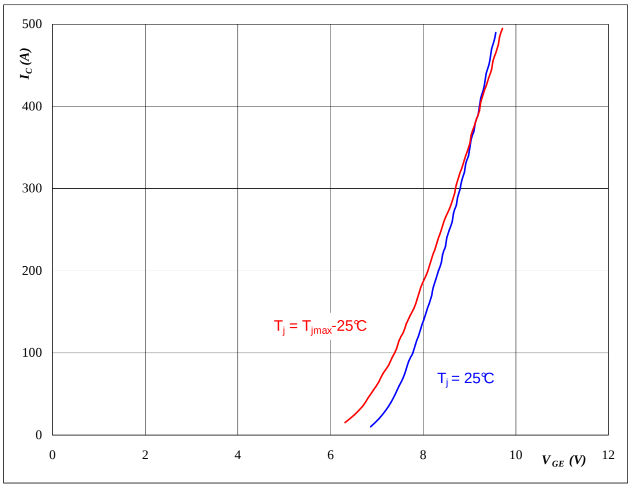

**At**

| | | |
|---|---|---|
| $t_p$ = | 350 | µs |
| $T_j$ = | 125 | °C |
| $V_{GE}$ from | 7 V to 17 V in steps of 1 V | |

**Figure 3** IGBT

**Typical transfer characteristics**

$I_C = f(V_{GE})$



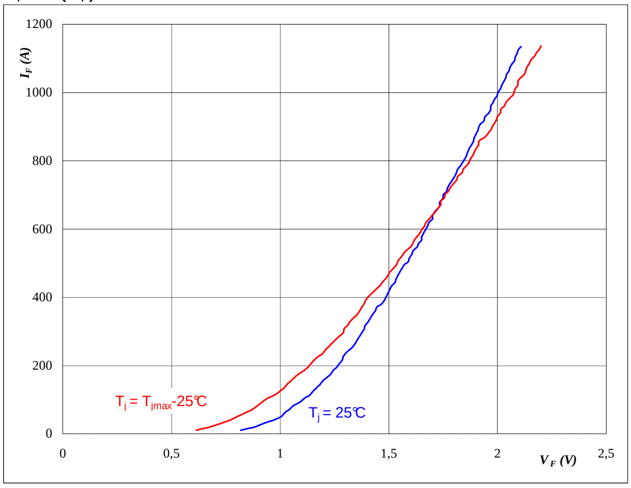

**At**

| | | |
|---|---|---|
| $t_p$ = | 350 | µs |
| $V_{CE}$ = | 10 | V |

**Figure 4** FWD

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

$I_F = f(V_F)$




**At**

| | | |
|---|---|---|
| $t_p$ = | 350 | µs |

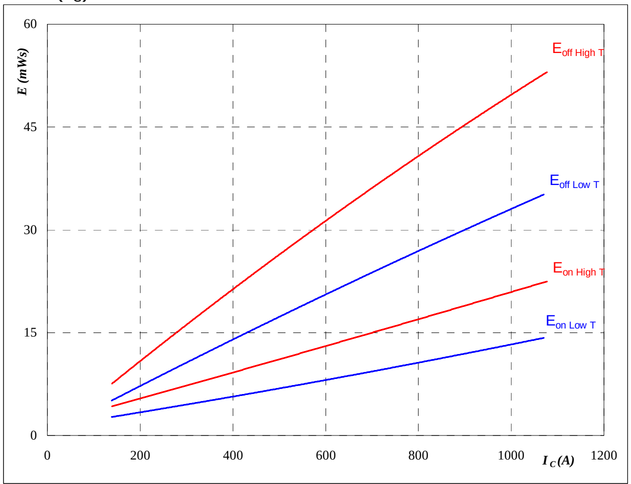
# Buck

**Half bridge IGBT and Neutral point FWD**

**Figure 5** IGBT

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

$E = f(I_C)$



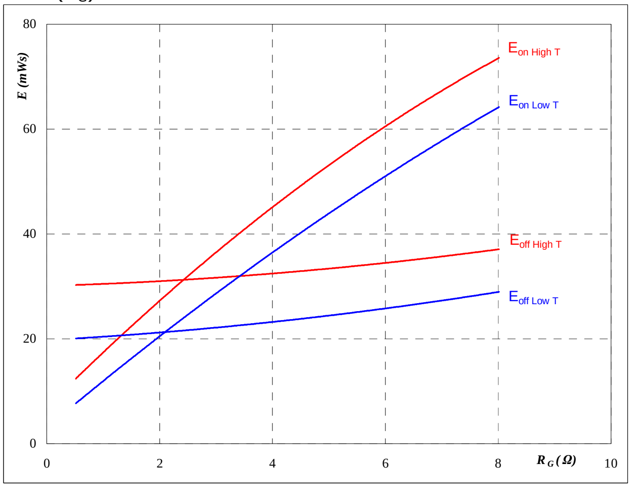

With an inductive load at

| | | |
|---|---|---|
| $T_j$ = | 25/125 | °C |
| $V_{CE}$ = | 350 | V |
| $V_{GE}$ = | ±15 | V |
| $R_{gon}$ = | 1 | Ω |
| $R_{goff}$ = | 1 | Ω |

**Figure 6** IGBT

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

$E = f(R_G)$



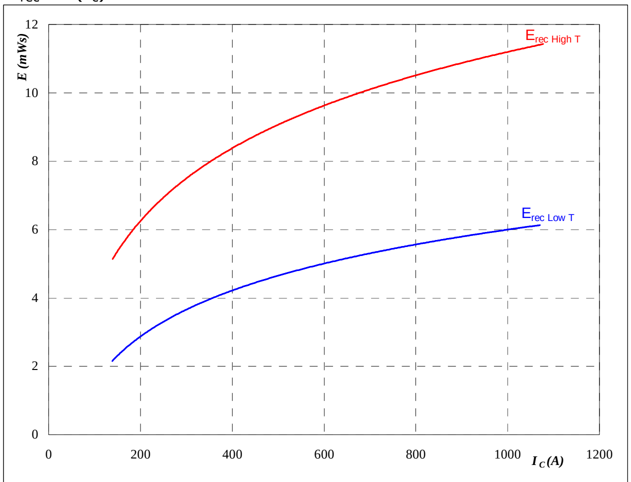

With an inductive load at

| | | |
|---|---|---|
| $T_j$ = | 25/125 | °C |
| $V_{CE}$ = | 350 | V |
| $V_{GE}$ = | ±15 | V |
| $I_C$ = | 596 | A |

**Figure 7** FWD

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

$E_{rec} = f(I_c)$



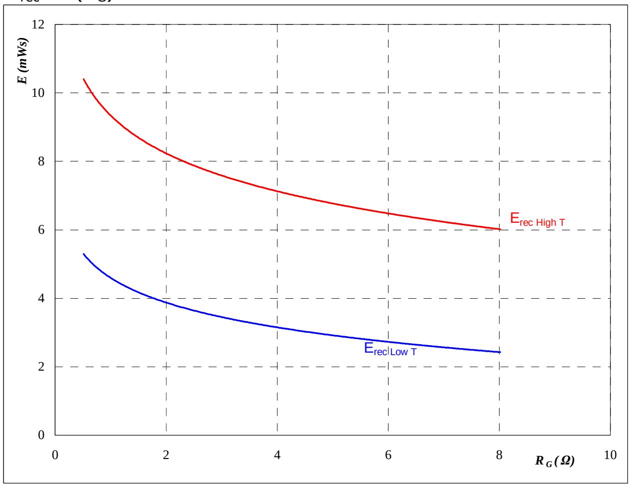

With an inductive load at

| | | |
|---|---|---|
| $T_j$ = | 25/125 | °C |
| $V_{CE}$ = | 350 | V |
| $V_{GE}$ = | ±15 | V |
| $R_{gon}$ = | 1 | 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 | °C |
| $V_{CE}$ = | 350 | V |
| $V_{GE}$ = | ±15 | V |
| $I_C$ = | 596 | A |

copyright Vincotech

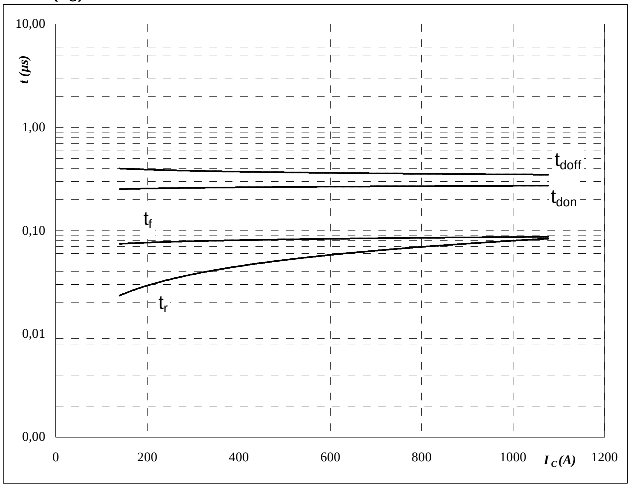
# Buck

**Half bridge IGBT and Neutral point FWD**

| Figure 9 | IGBT |
|---|---|

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

$t = f(I_C)$



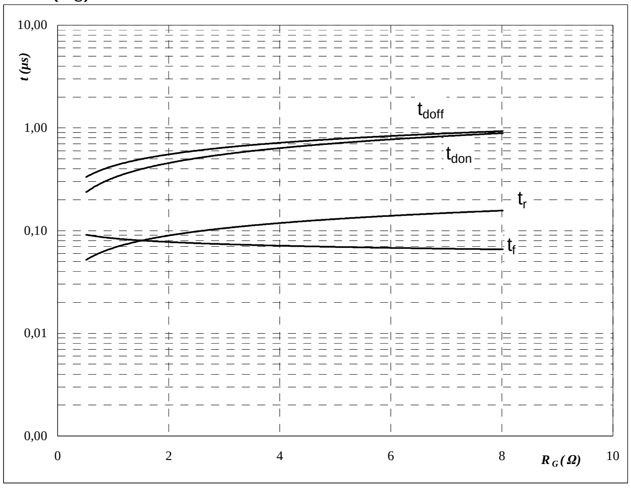

With an inductive load at

| | | |
|---|---|---|
| $T_j$ = | 125 | °C |
| $V_{CE}$ = | 350 | V |
| $V_{GE}$ = | ±15 | V |
| $R_{gon}$ = | 1 | Ω |
| $R_{goff}$ = | 1 | Ω |

| Figure 10 | IGBT |
|---|---|

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

$t = f(R_G)$



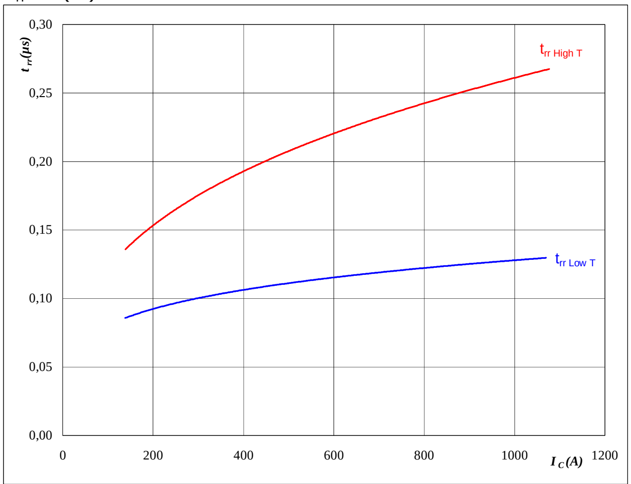

With an inductive load at

| | | |
|---|---|---|
| $T_j$ = | 125 | °C |
| $V_{CE}$ = | 350 | V |
| $V_{GE}$ = | ±15 | V |
| $I_C$ = | 596 | A |

| Figure 11 | FWD |
|---|---|

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

$t_{rr} = f(Ic)$



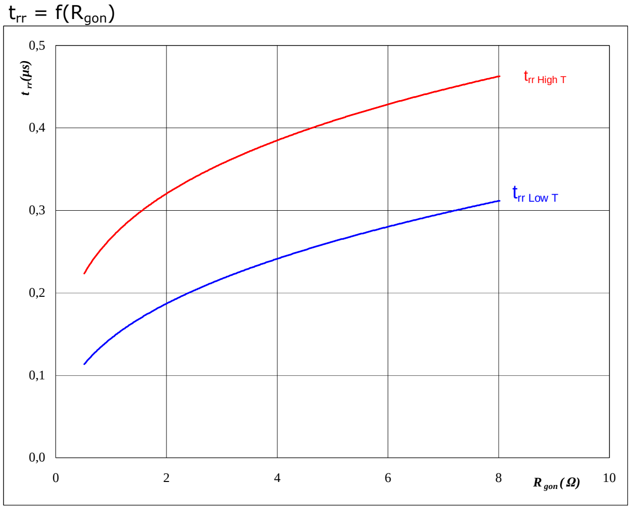

**At**

| | | |
|---|---|---|
| $T_j$ = | 25/125 | °C |
| $V_{CE}$ = | 350 | V |
| $V_{GE}$ = | ±15 | V |
| $R_{gon}$ = | 1 | 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 | °C |
| $V_R$ = | 350 | V |
| $I_F$ = | 596 | A |
| $V_{GE}$ = | ±15 | V |

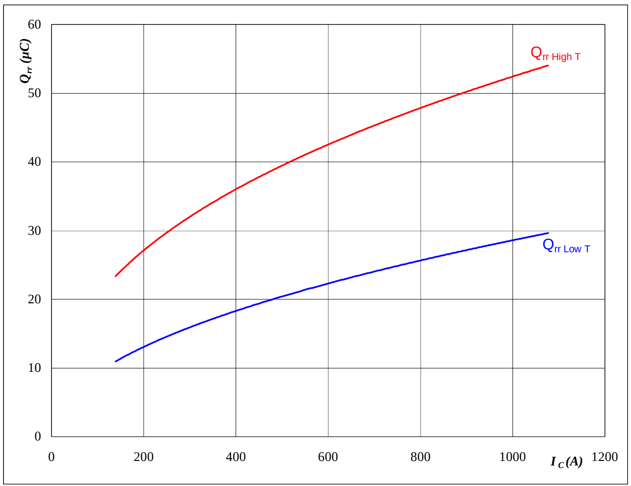
# Buck

**Half bridge IGBT and Neutral point FWD**

**Figure 13** FWD

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

$Q_{rr} = f(I_C)$



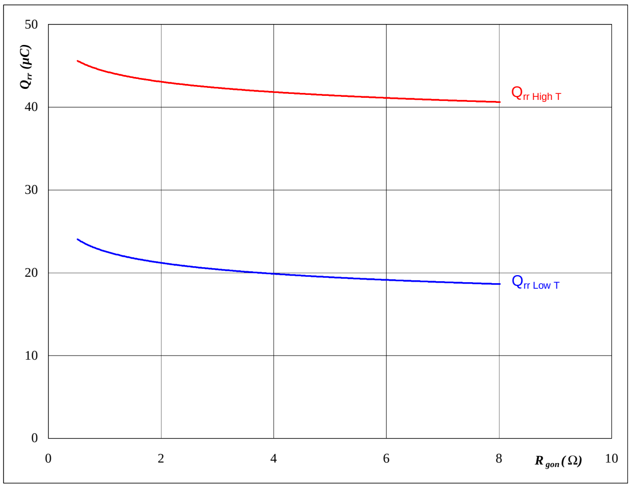

**At**

| | | |
|---|---|---|
| $T_j$ = | 25/125 | °C |
| $V_{CE}$ = | 350 | V |
| $V_{GE}$ = | ±15 | V |
| $R_{gon}$ = | 1 | Ω |

**Figure 14** FWD

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

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



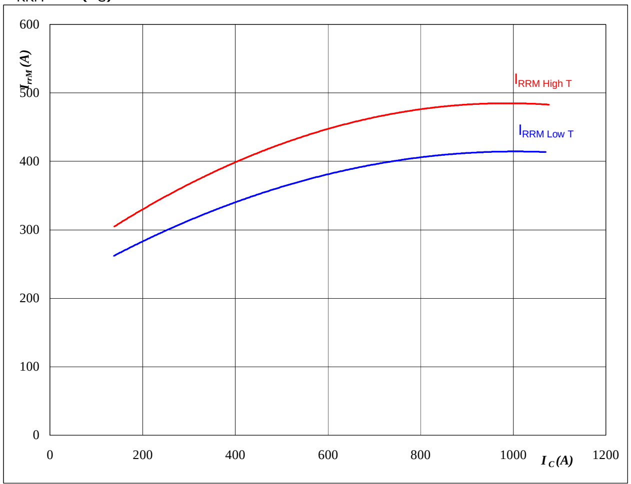

**At**

| | | |
|---|---|---|
| $T_j$ = | 25/125 | °C |
| $V_R$ = | 350 | V |
| $I_F$ = | 596 | A |
| $V_{GE}$ = | ±15 | V |

**Figure 15** FWD

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

$I_{RRM} = f(I_C)$



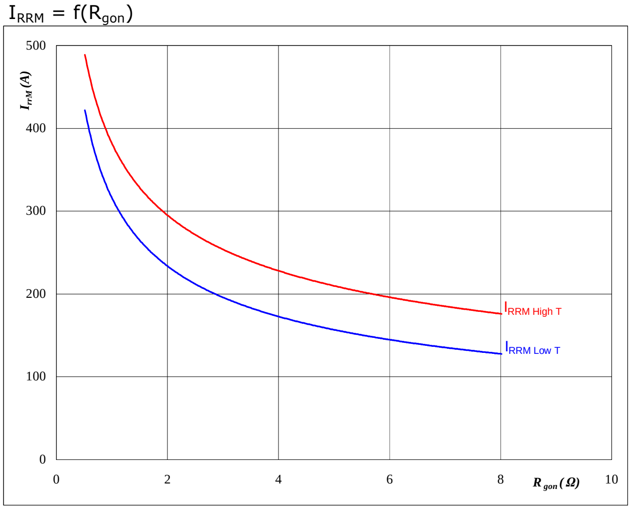

**At**

| | | |
|---|---|---|
| $T_j$ = | 25/125 | °C |
| $V_{CE}$ = | 350 | V |
| $V_{GE}$ = | ±15 | V |
| $R_{gon}$ = | 1 | 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 | °C |
| $V_R$ = | 350 | V |
| $I_F$ = | 596 | A |
| $V_{GE}$ = | ±15 | V |

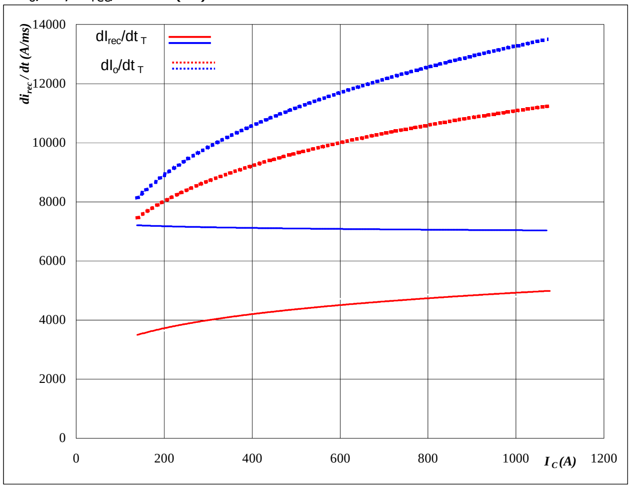
# Buck

**Half bridge IGBT and Neutral point FWD**

**Figure 17** FWD

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

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



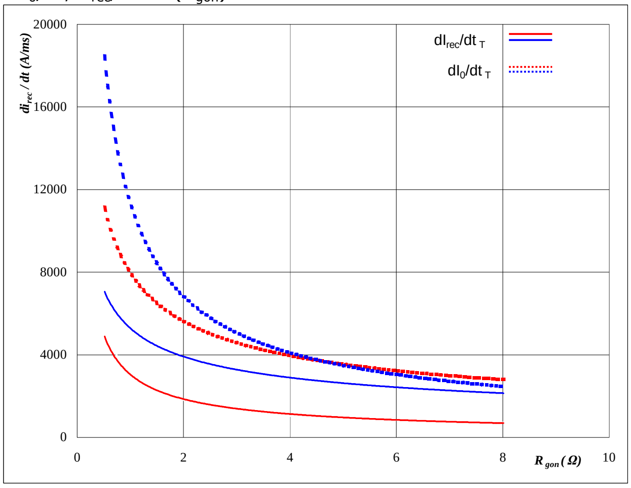

At

| | | |
|---|---|---|
| $T_j$ = | 25/125 | °C |
| $V_{CE}$ = | 350 | V |
| $V_{GE}$ = | ±15 | V |
| $R_{gon}$ = | 1 | Ω |

**Figure 18** FWD

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

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



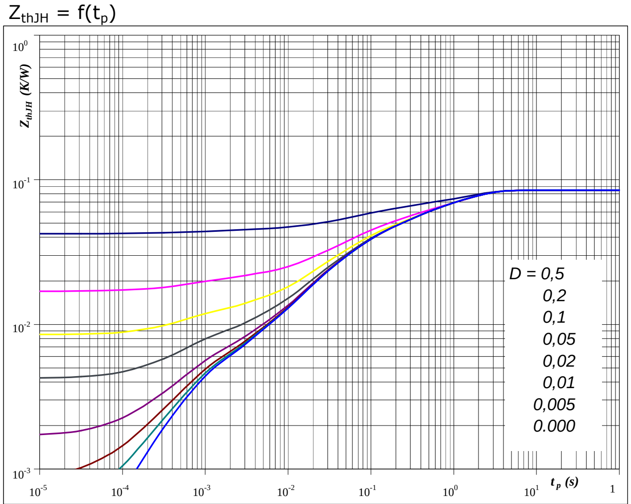

At

| | | |
|---|---|---|
| $T_j$ = | 25/125 | °C |
| $V_R$ = | 350 | V |
| $I_F$ = | 596 | 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 | |
| $R_{thJH}$ = | 0,08 | K/W |

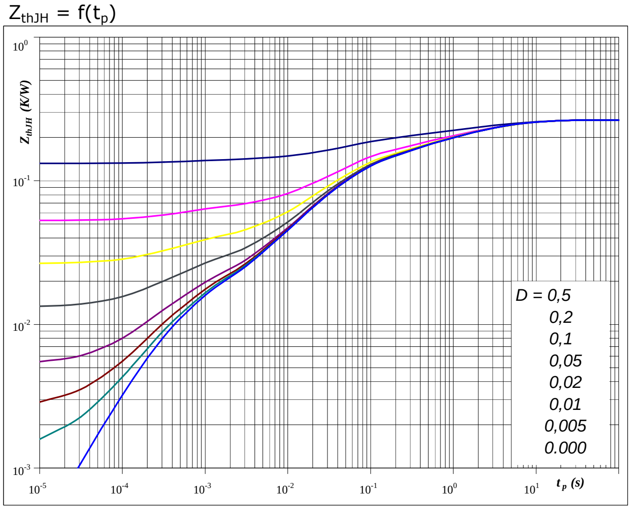
IGBT thermal model values

| R (C/W) | Tau (s) |
|---|---|
| 0,035 | 1,2E+00 |
| 0,021 | 1,8E-01 |
| 0,022 | 3,6E-02 |
| 0,003 | 8,0E-03 |
| 0,004 | 6,8E-04 |

**Figure 20** FWD

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

$Z_{thJH} = f(t_p)$




At

| | | |
|---|---|---|
| D = | $t_p$ / T | |
| $R_{thJH}$ = | 0,26 | K/W |

FWD thermal model values

| R (C/W) | Tau (s) |
|---|---|
| 0,049 | 5,4E+00 |
| 0,057 | 1,1E+00 |
| 0,041 | 2,6E-01 |
| 0,075 | 5,0E-02 |
| 0,024 | 1,7E-02 |
| 0,006 | 3,4E-03 |
| 0,012 | 4,0E-04 |

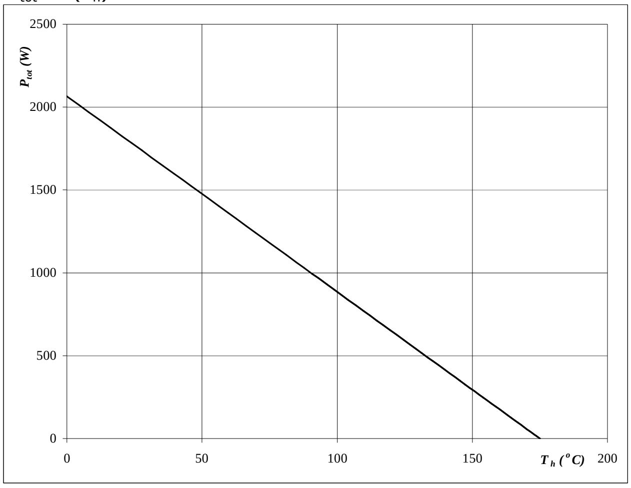
# Buck

**Half bridge IGBT and Neutral point FWD**

**Figure 21** IGBT

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

$P_{tot} = f(T_h)$



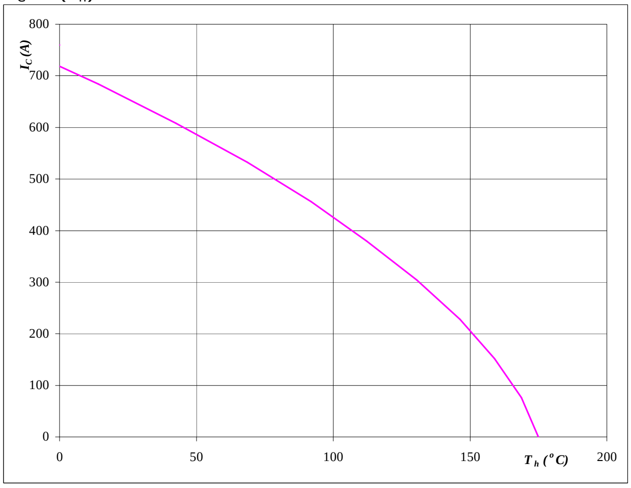

**At**

$T_j$ = 175 °C

**Figure 22** IGBT

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

$I_C = f(T_h)$




**At**

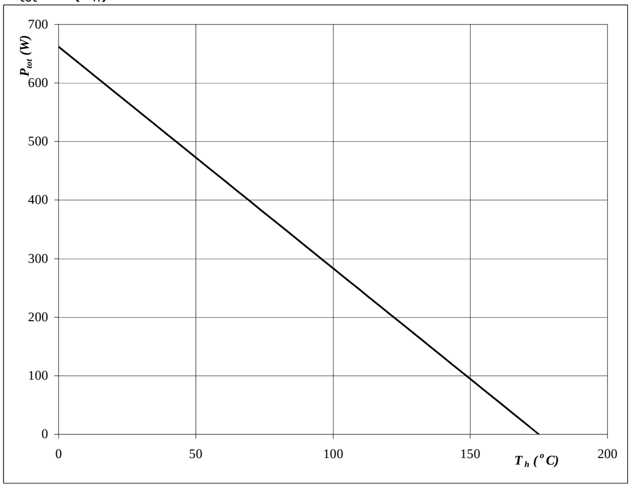
$T_j$ = 175 °C

$V_{GE}$ = 15 V

**Figure 23** FWD

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

$P_{tot} = f(T_h)$



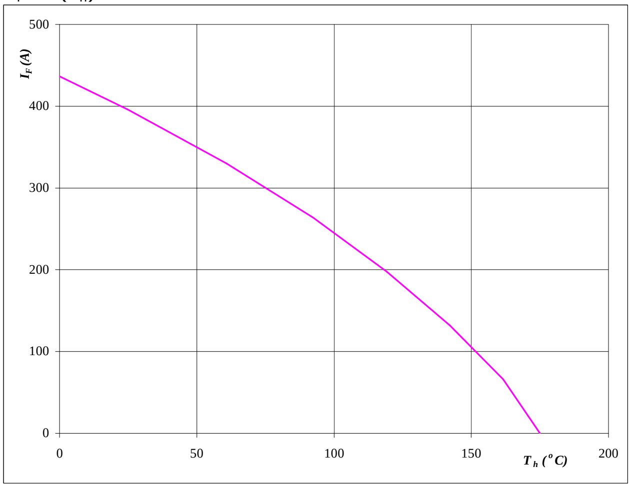

**At**

$T_j$ = 175 °C

**Figure 24** FWD

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

$I_F = f(T_h)$




**At**

$T_j$ = 175 °C

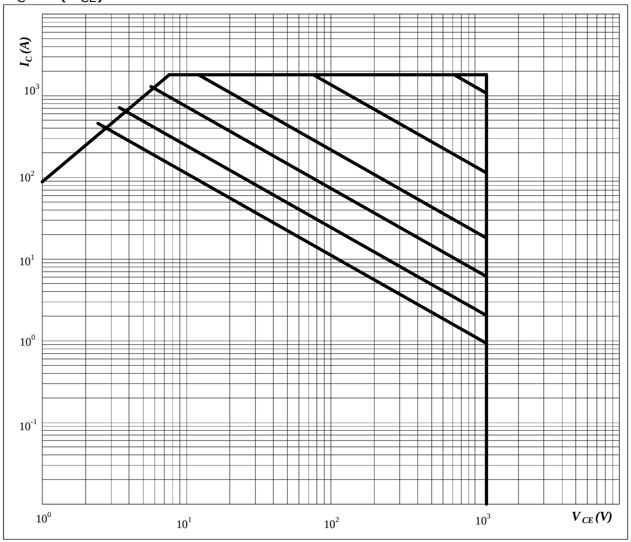
# Buck

**Half bridge IGBT and Neutral point FWD**

**Figure 25** IGBT

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

$I_C = f(V_{CE})$



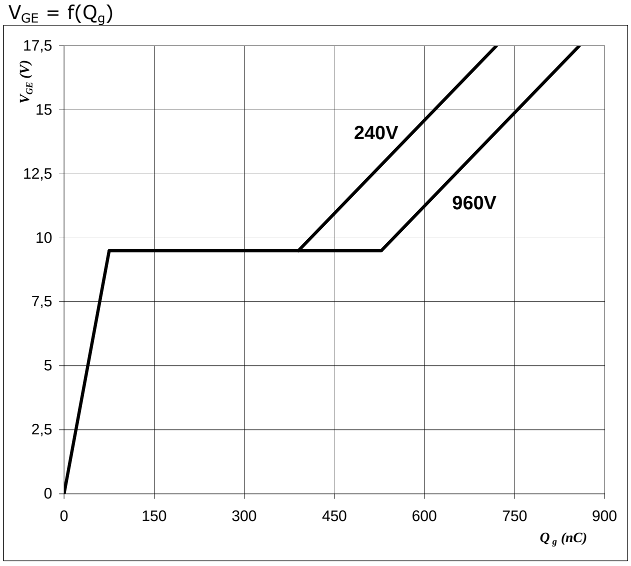

**At**

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

**Figure 26** IGBT

**Gate voltage vs Gate charge**

$V_{GE} = f(Q_g)$



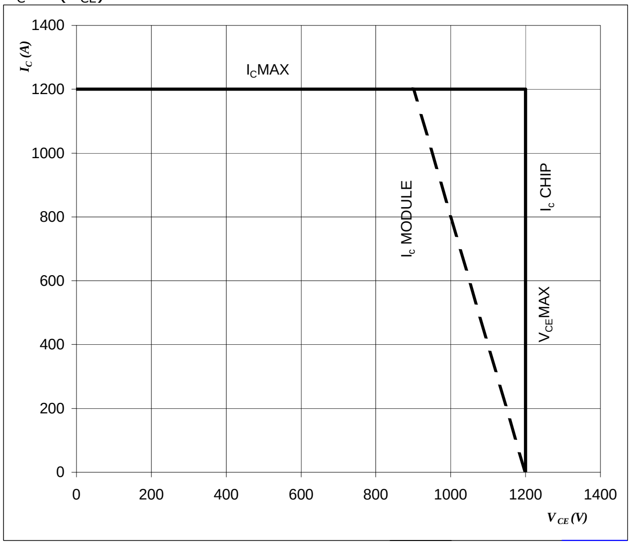

**At**

| | | |
|---|---|---|
| $I_C$ = | 600 | A |

**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 | |

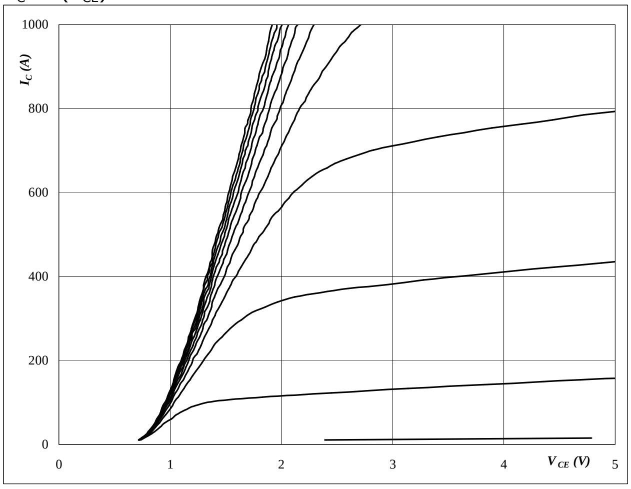
# Boost

**Neutral point IGBT and Half bridge FWD**

**Figure 1** IGBT

**Typical output characteristics**

$I_C = f(V_{CE})$




**At**

$t_p$ = 350 µs

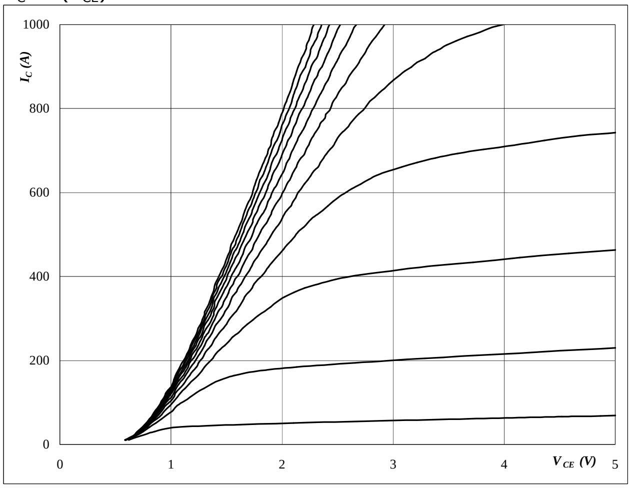
$T_j$ = 25 °C

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

**Figure 2** IGBT

**Typical output characteristics**

$I_C = f(V_{CE})$




**At**

$t_p$ = 350 µs

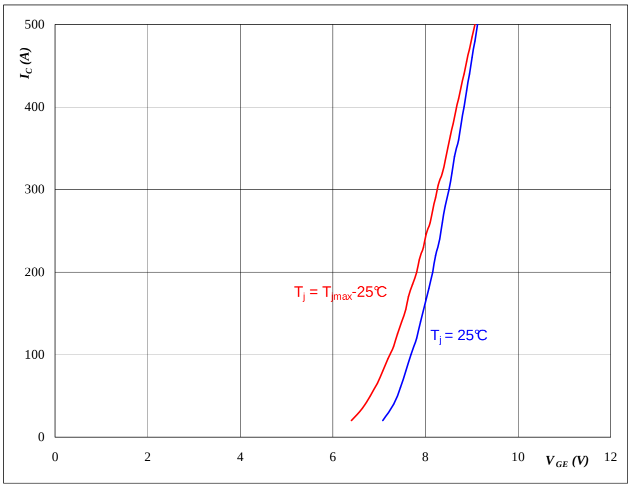
$T_j$ = 125 °C

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

**Figure 3** IGBT

**Typical transfer characteristics**

$I_C = f(V_{GE})$




**At**

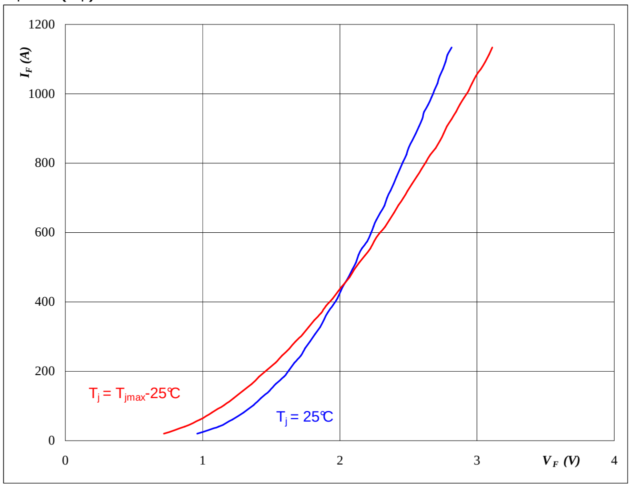
$t_p$ = 350 µs

$V_{CE}$ = 0 V

**Figure 4** FWD

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

$I_F = f(V_F)$




**At**

$t_p$ = 350 µs

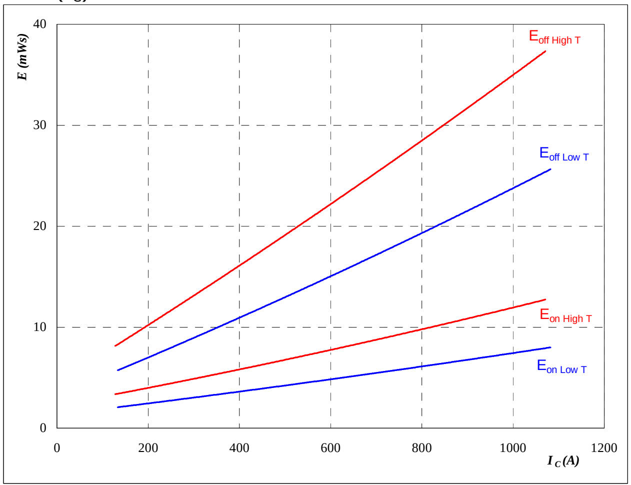
# Boost

**Neutral point IGBT and Half bridge FWD**

**Figure 5** IGBT

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

$E = f(I_C)$



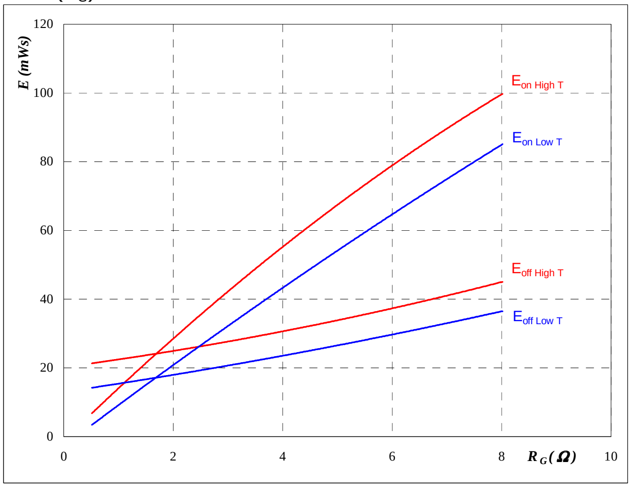

With an inductive load at

| | | |
|---|---|---|
| $T_j$ = | 25/125 | °C |
| $V_{CE}$ = | 350 | V |
| $V_{GE}$ = | ±15 | V |
| $R_{gon}$ = | 1 | Ω |
| $R_{goff}$ = | 1 | Ω |

**Figure 6** IGBT

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

$E = f(R_G)$



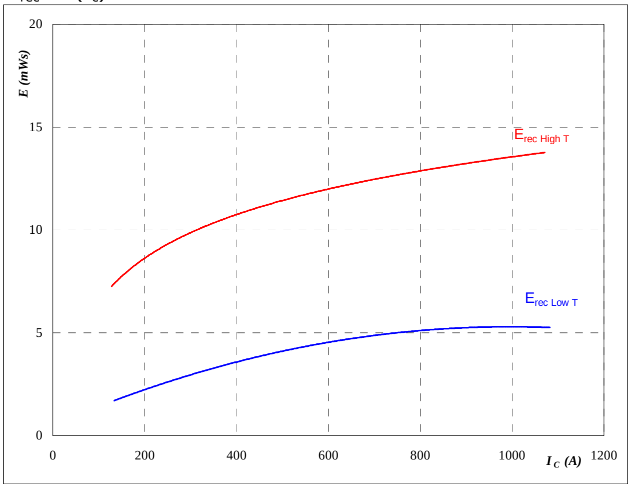

With an inductive load at

| | | |
|---|---|---|
| $T_j$ = | 25/125 | °C |
| $V_{CE}$ = | 350 | V |
| $V_{GE}$ = | ±15 | V |
| $I_C$ = | 600 | A |

**Figure 7** FWD

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

$E_{rec} = f(I_c)$



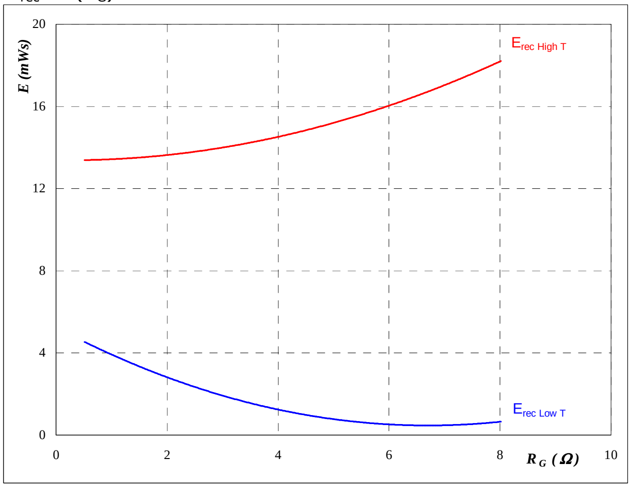

With an inductive load at

| | | |
|---|---|---|
| $T_j$ = | 25/125 | °C |
| $V_{CE}$ = | 350 | V |
| $V_{GE}$ = | ±15 | V |
| $R_{gon}$ = | 1 | 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 | °C |
| $V_{CE}$ = | 350 | V |
| $V_{GE}$ = | ±15 | V |
| $I_C$ = | 600 | A |

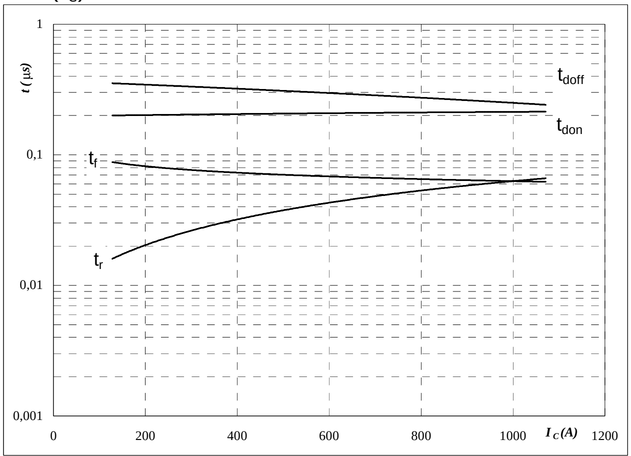
# Boost

**Neutral point IGBT and Half bridge FWD**

| **Figure 9** | IGBT |
|---|---|

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

$t = f(I_C)$



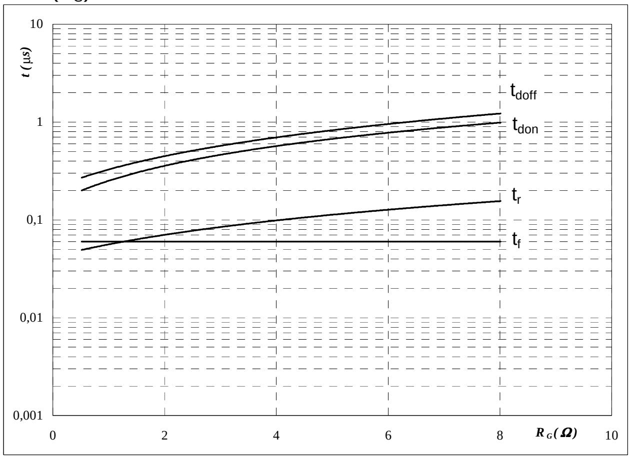

With an inductive load at

| | | |
|---|---|---|
| $T_j$ = | 125 | °C |
| $V_{CE}$ = | 350 | V |
| $V_{GE}$ = | ±15 | V |
| $R_{gon}$ = | 1 | Ω |
| $R_{goff}$ = | 1 | Ω |

| **Figure 10** | IGBT |
|---|---|

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

$t = f(R_G)$



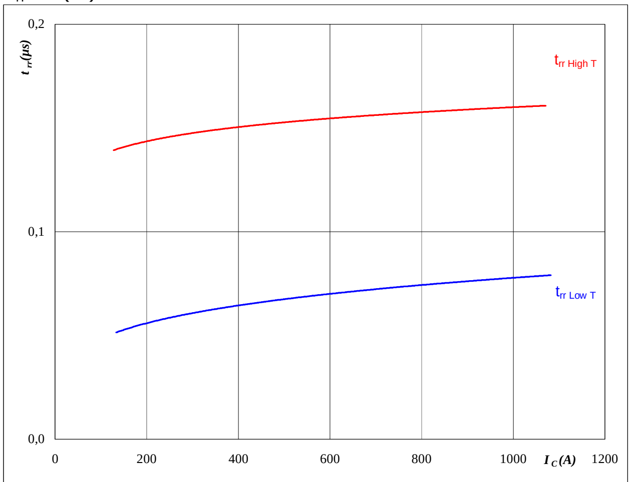

With an inductive load at

| | | |
|---|---|---|
| $T_j$ = | 125 | °C |
| $V_{CE}$ = | 350 | V |
| $V_{GE}$ = | ±15 | V |
| $I_C$ = | 600 | A |

| **Figure 11** | FWD |
|---|---|

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

$t_{rr} = f(Ic)$



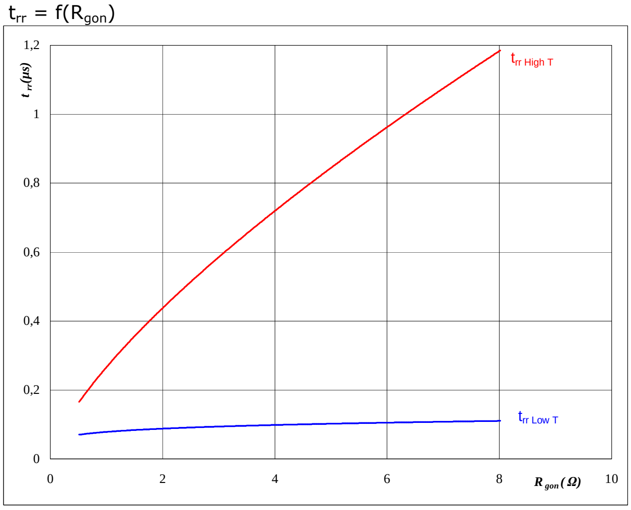

**At**

| | | |
|---|---|---|
| $T_j$ = | 25/125 | °C |
| $V_{CE}$ = | 350 | V |
| $V_{GE}$ = | ±15 | V |
| $R_{gon}$ = | 1 | 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 | °C |
| $V_R$ = | 350 | V |
| $I_F$ = | 600 | A |
| $V_{GE}$ = | ±15 | V |

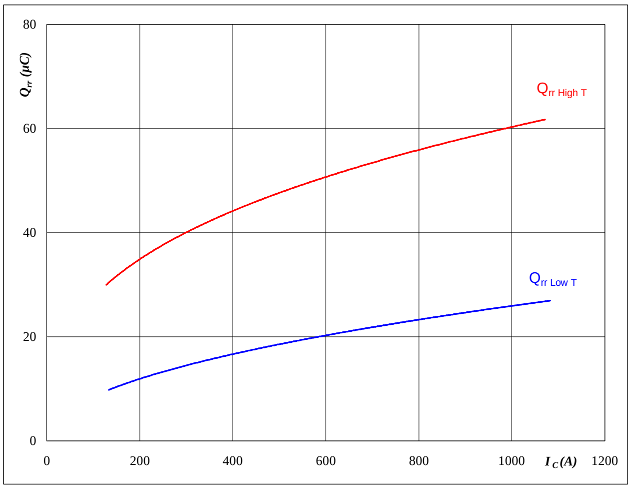
# Boost

**Neutral point IGBT and Half bridge FWD**

**Figure 13** FWD

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

$Q_{rr} = f(I_C)$



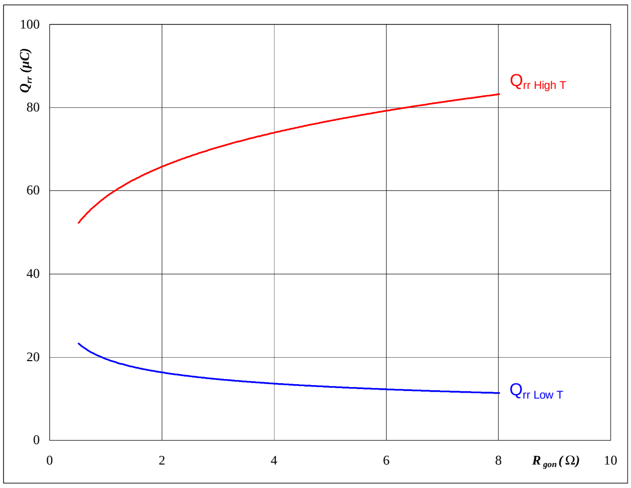

**At**

| | | |
|---|---|---|
| $T_j$ = | 25/125 | °C |
| $V_{CE}$ = | 350 | V |
| $V_{GE}$ = | ±15 | V |
| $R_{gon}$ = | 1 | Ω |

**Figure 14** FWD

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

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



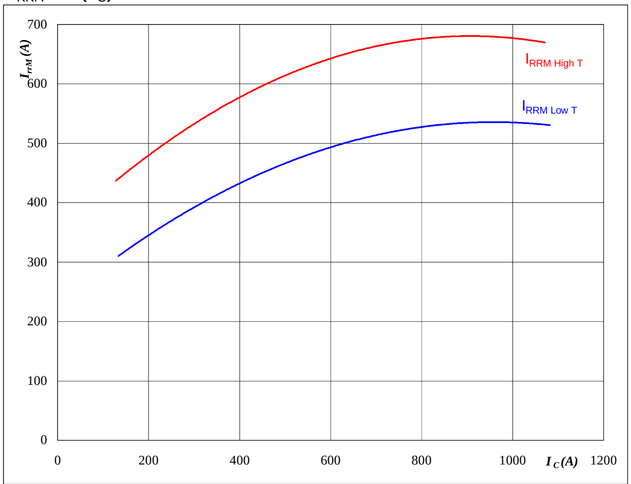

**At**

| | | |
|---|---|---|
| $T_j$ = | 25/125 | °C |
| $V_R$ = | 350 | V |
| $I_F$ = | 600 | A |
| $V_{GE}$ = | ±15 | V |

**Figure 15** FWD

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

$I_{RRM} = f(I_C)$



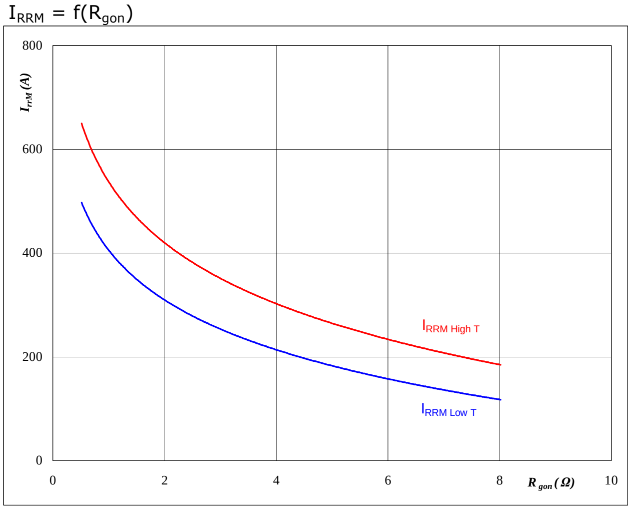

**At**

| | | |
|---|---|---|
| $T_j$ = | 25/125 | °C |
| $V_{CE}$ = | 350 | V |
| $V_{GE}$ = | ±15 | V |
| $R_{gon}$ = | 1 | 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 | °C |
| $V_R$ = | 350 | V |
| $I_F$ = | 600 | A |
| $V_{GE}$ = | ±15 | V |

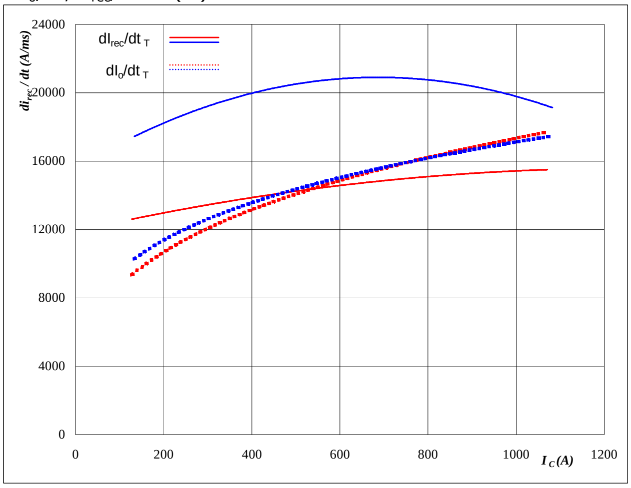
# Boost

**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**

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



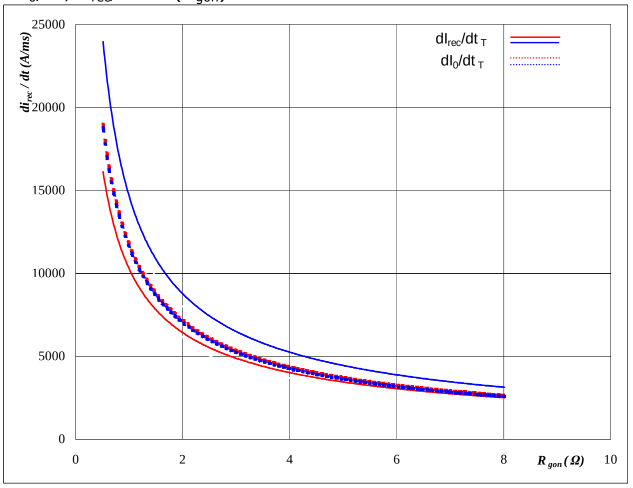

**At**

| | | |
|---|---|---|
| $T_j$ = | 25/125 | °C |
| $V_{CE}$ = | 350 | V |
| $V_{GE}$ = | ±15 | V |
| $R_{gon}$ = | 1 | Ω |

**Figure 18** FWD

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

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



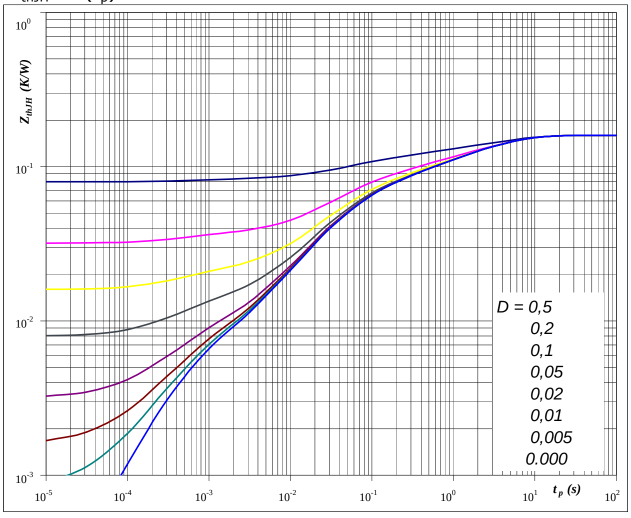

**At**

| | | |
|---|---|---|
| $T_j$ = | 25/125 | °C |
| $V_R$ = | 350 | V |
| $I_F$ = | 600 | 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 = | tp / T | |
| $R_{thJH}$ = | 0,16 | K/W |

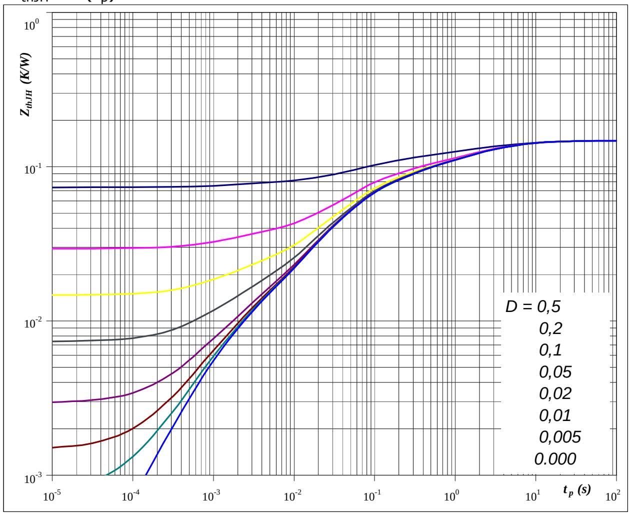
IGBT thermal model values

| R (K/W) | Tau (s) |
|---|---|
| 0,05 | 4,40 |
| 0,03 | 1,10 |
| 0,03 | 0,24 |
| 0,04 | 0,05 |
| 0,01 | 0,02 |
| 0,002 | 0,003 |
| 0,005 | 0,0005 |

**Figure 20** FWD

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

$Z_{thJH} = f(t_p)$




**At**

| | | |
|---|---|---|
| D = | tp / T | |
| $R_{thJH}$ = | 0,15 | K/W |

FWD thermal model values

| R (K/W) | Tau (s) |
|---|---|
| 0,02 | 6,05 |
| 0,04 | 1,29 |
| 0,03 | 0,22 |
| 0,04 | 0,05 |
| 0,01 | 0,01 |
| 0,01 | 0,001 |

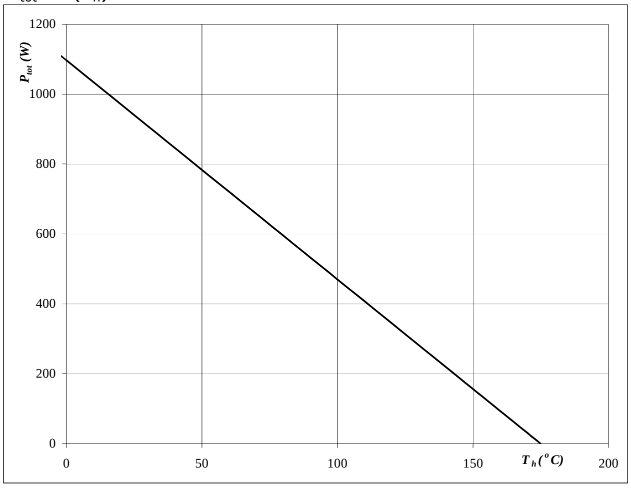
# Boost

**Neutral point IGBT and Half bridge FWD**

**Figure 21** IGBT

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

$P_{tot} = f(T_h)$



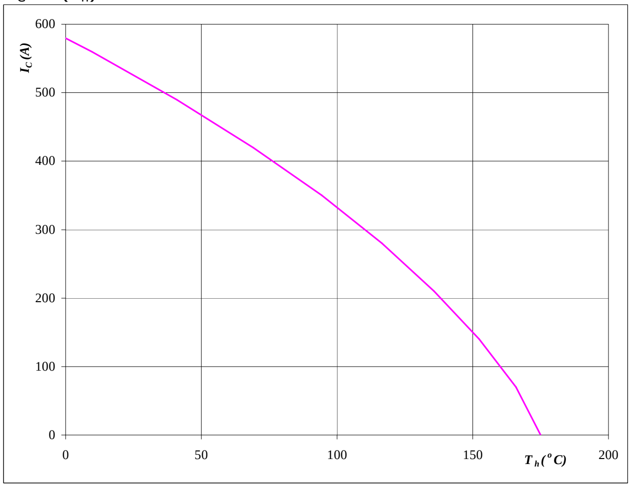

**At**

$T_j$ = 175 ºC

**Figure 22** IGBT

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

$I_C = f(T_h)$




**At**

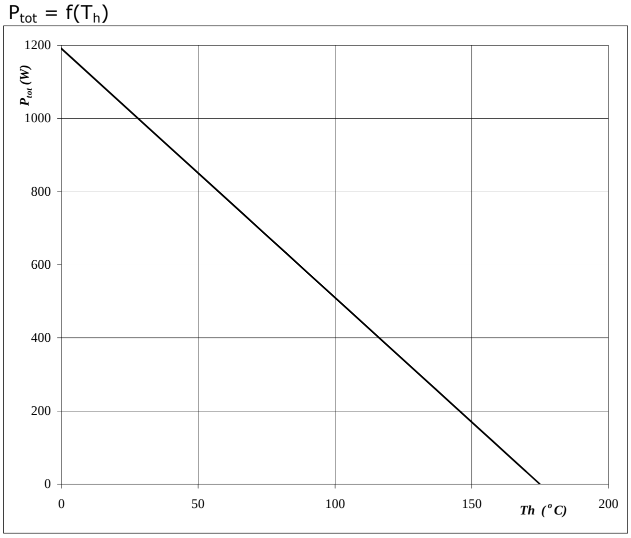
$T_j$ = 175 ºC

$V_{GE}$ = 15 V

**Figure 23** FWD

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

$P_{tot} = f(T_h)$



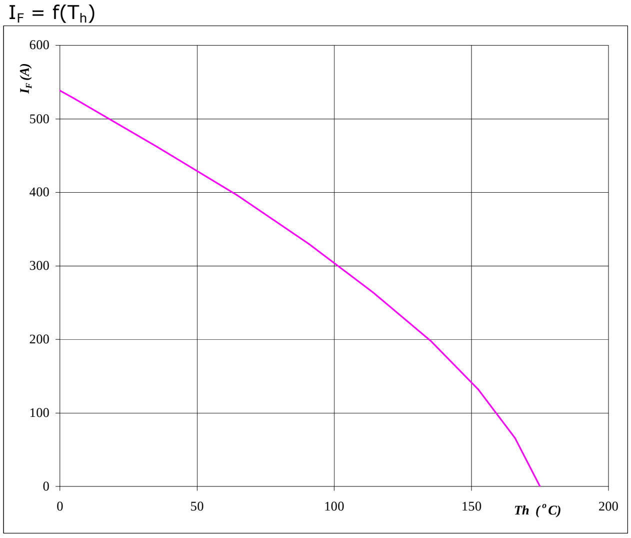

**At**

$T_j$ = 175 ºC

**Figure 24** FWD

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

$I_F = f(T_h)$




**At**

$T_j$ = 175 ºC

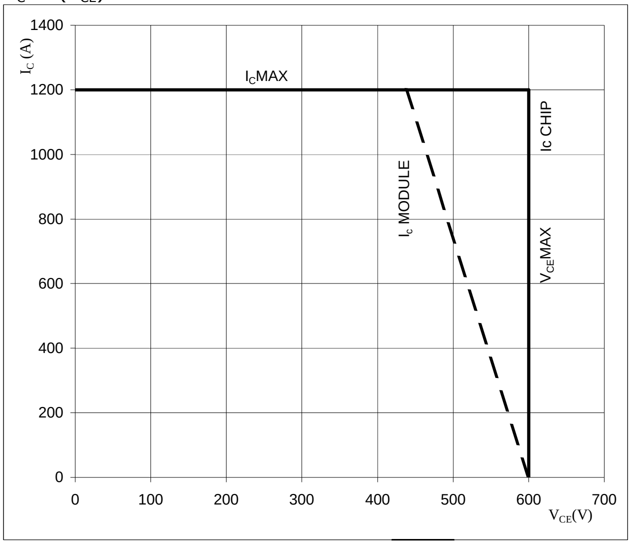
# Boost

**Neutral point IGBT**

**Figure 25** IGBT

**Reverse bias safe operating area**

$I_C = f(V_{CE})$




**At**

$T_j$ = $T_{jmax}$-25 ºC

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

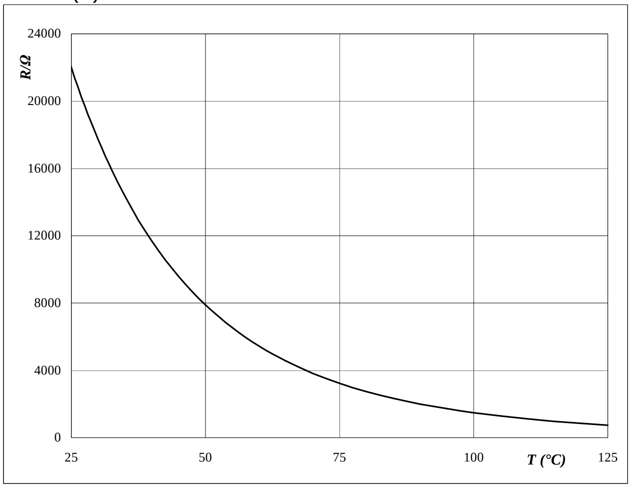
Switching mode : 3 level switching

# Thermistor

**Figure 26** Thermistor

**Typical NTC characteristic as a function of temperature**

$R_T = f(T)$



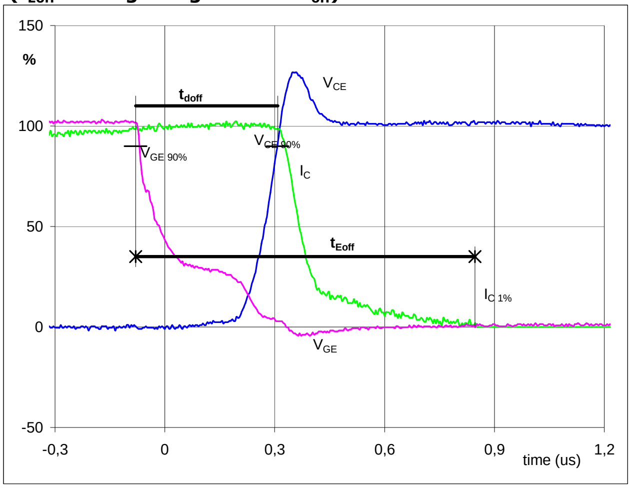
# Switching Definitions Half bridge IGBT

**General conditions**

| | | |
|---|---|---|
| $T_j$ | = | 125 °C |
| $R_{gon}$ | = | 2 Ω |
| $R_{goff}$ | = | 2 Ω |

**Figure 1** Half bridge IGBT

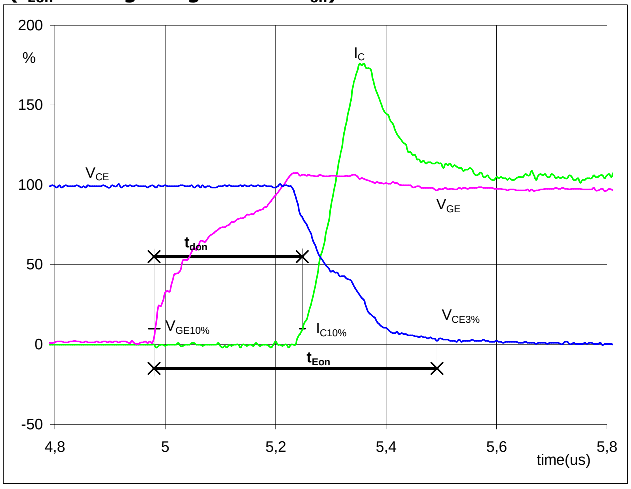
**Turn-off Switching Waveforms & definition of $t_{doff}$, $t_{Eoff}$**
**($t_{Eoff}$ = integrating time for $E_{off}$)**




| | | |
|---|---|---|
| $V_{GE}$ (0%) = | -15 | V |
| $V_{GE}$ (100%) = | 15 | V |
| $V_C$ (100%) = | 350 | V |
| $I_C$ (100%) = | 591 | A |
| $t_{doff}$ = | 0,37 | μs |
| $t_{Eoff}$ = | 0,93 | μs |

**Figure 2** Half bridge IGBT

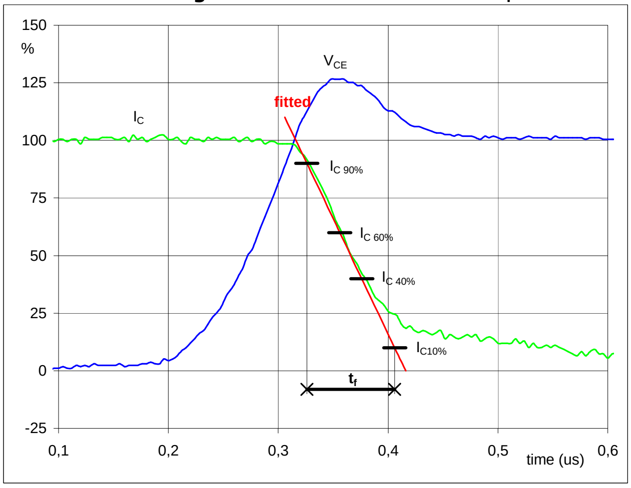
**Turn-on Switching Waveforms & definition of $t_{don}$, $t_{Eon}$**
**($t_{Eon}$ = integrating time for $E_{on}$)**




| | | |
|---|---|---|
| $V_{GE}$ (0%) = | -15 | V |
| $V_{GE}$ (100%) = | 15 | V |
| $V_C$ (100%) = | 350 | V |
| $I_C$ (100%) = | 591 | A |
| $t_{don}$ = | 0,26 | μs |
| $t_{Eon}$ = | 0,51 | μs |

**Figure 3** Half bridge IGBT

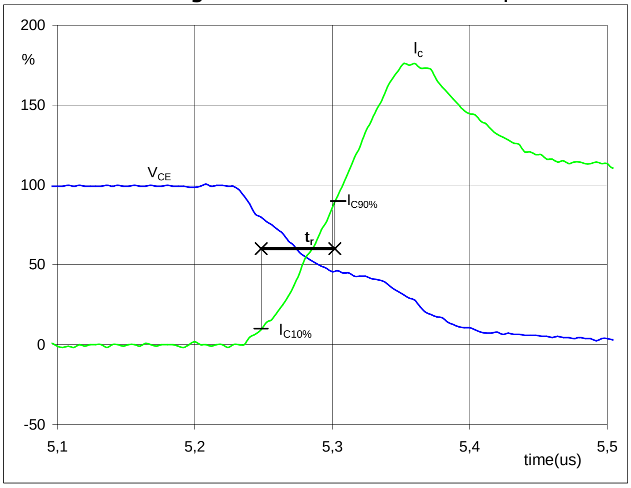
**Turn-off Switching Waveforms & definition of $t_f$**




| | | |
|---|---|---|
| $V_C$ (100%) = | 350 | V |
| $I_C$ (100%) = | 591 | A |
| $t_f$ = | 0,08 | μs |

**Figure 4** Half bridge IGBT

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

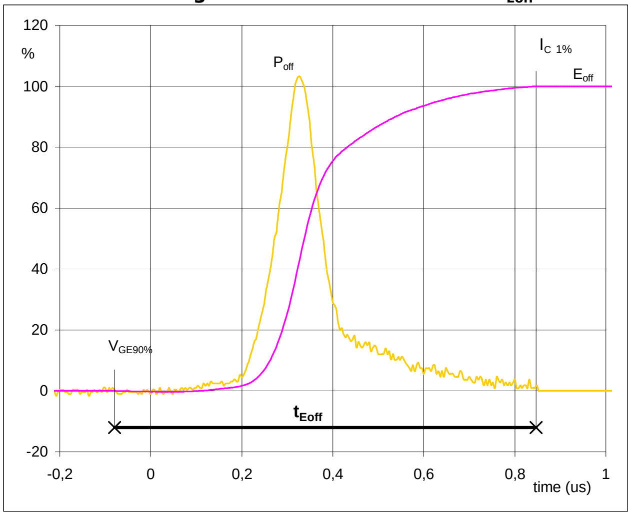



| | | |
|---|---|---|
| $V_C$ (100%) = | 350 | V |
| $I_C$ (100%) = | 591 | A |
| $t_r$ = | 0,06 | μs |

# Switching Definitions half bridge IGBT

**Figure 5** Half bridge IGBT

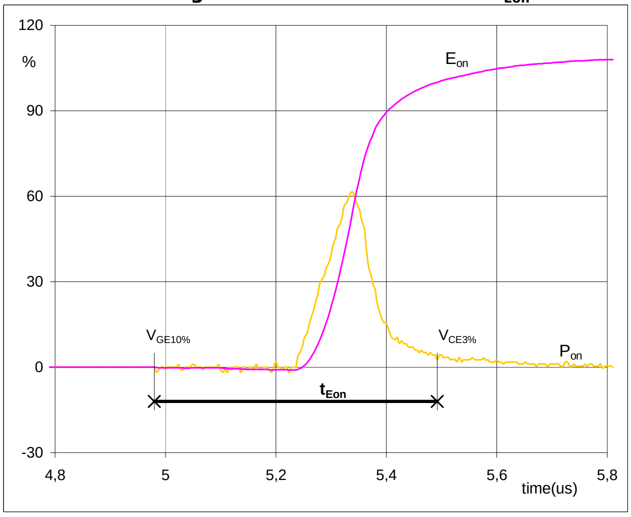
**Turn-off Switching Waveforms & definition of $t_{Eoff}$**




| | | |
|---|---|---|
| $P_{off}$ (100%) = | 206,68 | kW |
| $E_{off}$ (100%) = | 30,27 | mJ |
| $t_{Eoff}$ = | 0,93 | µs |

**Figure 6** Half bridge IGBT

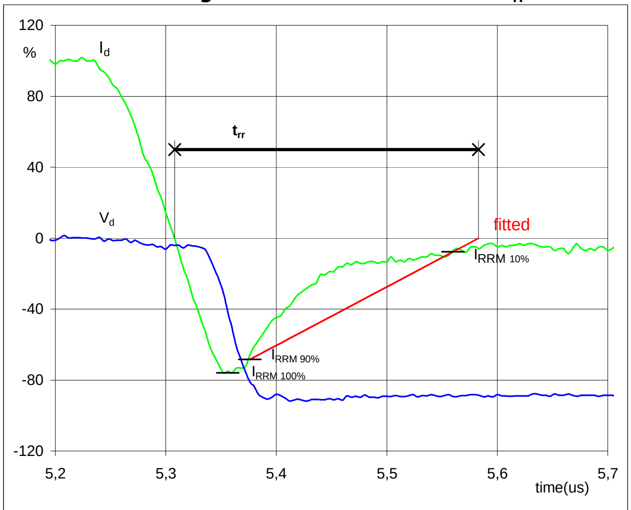
**Turn-on Switching Waveforms & definition of $t_{Eon}$**




| | | |
|---|---|---|
| $P_{on}$ (100%) = | 206,68 | kW |
| $E_{on}$ (100%) = | 12,81 | mJ |
| $t_{Eon}$ = | 0,51 | µs |

**Figure 7** Neutral point FWD

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

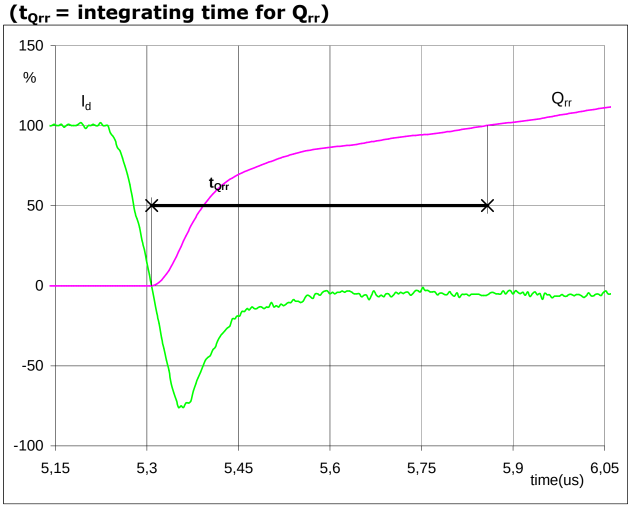



| | | |
|---|---|---|
| $V_d$ (100%) = | 350 | V |
| $I_d$ (100%) = | 591 | A |
| $I_{RRM}$ (100%) = | -457 | A |
| $t_{rr}$ = | 0,25 | µs |

# Switching Definitions half bridge IGBT

| Figure 8 | Neutral point FWD |
|---|---|

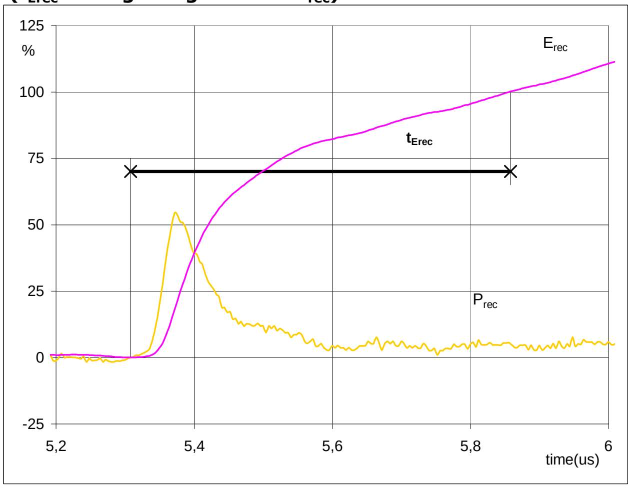
**Turn-on Switching Waveforms & definition of $t_{Qrr}$**
**($t_{Qrr}$ = integrating time for $Q_{rr}$)**




| | | |
|---|---|---|
| $I_d$ (100%) = | 591 | A |
| $Q_{rr}$ (100%) = | 47,04 | μC |
| $t_{Qrr}$ = | 0,55 | μs |

| Figure 9 | Neutral point FWD |
|---|---|

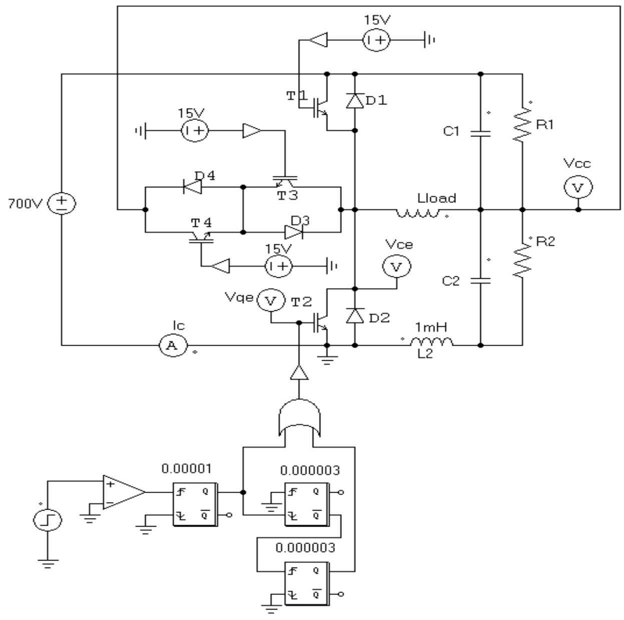
**Turn-on Switching Waveforms & definition of $t_{Erec}$**
**($t_{Erec}$= integrating time for $E_{rec}$)**




| | | |
|---|---|---|
| $P_{rec}$ (100%) = | 206,68 | kW |
| $E_{rec}$ (100%) = | 10,70 | mJ |
| $t_{Erec}$ = | 0,55 | μs |

# half bridge IGBT switching measurement circuit

**Figure 10**



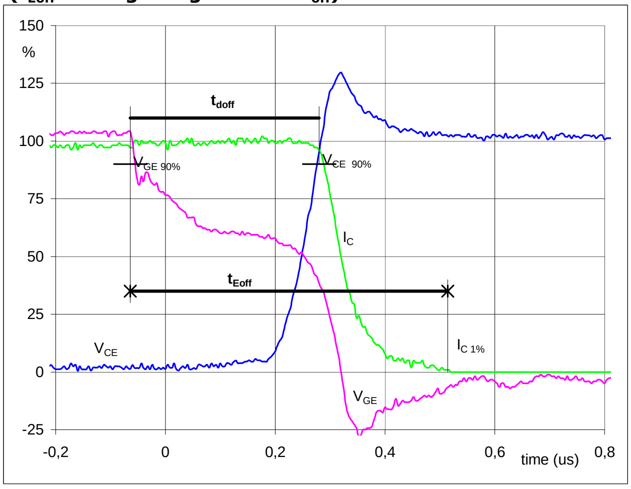
# Switching Definitions neutral point IGBT

**General conditions**

| | | |
|---|---|---|
| $T_j$ | = | 125 °C |
| $R_{gon}$ | = | 2 Ω |
| $R_{goff}$ | = | 2 Ω |

## Figure 1 — Neutral point IGBT

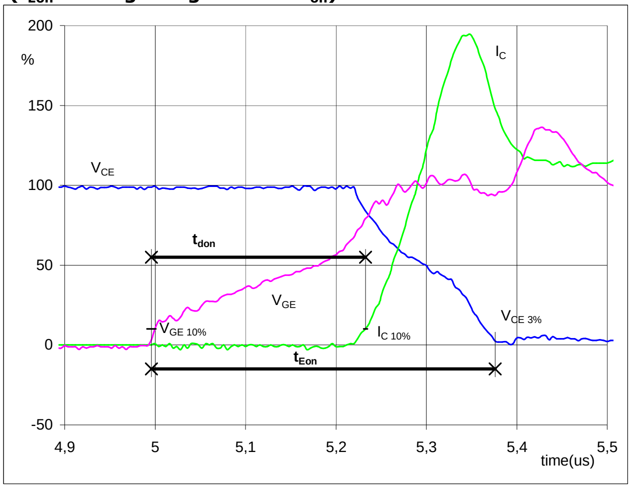
**Turn-off Switching Waveforms & definition of $t_{doff}$, $t_{Eoff}$ ($t_{Eoff}$ = integrating time for $E_{off}$)**




| | | |
|---|---|---|
| $V_{GE}$ (0%) = | -15 | V |
| $V_{GE}$ (100%) = | 15 | V |
| $V_C$ (100%) = | 350 | V |
| $I_C$ (100%) = | 592 | A |
| $t_{doff}$ = | 0,23 | μs |
| $t_{Eoff}$ = | 0,58 | μs |

## Figure 2 — Neutral point IGBT

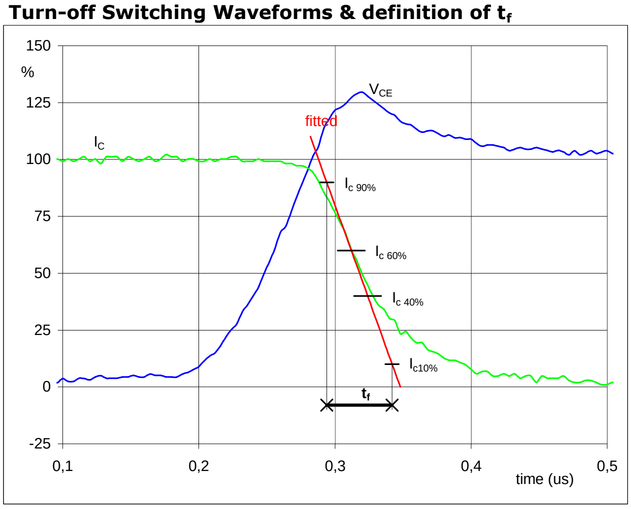
**Turn-on Switching Waveforms & definition of $t_{don}$, $t_{Eon}$ ($t_{Eon}$ = integrating time for $E_{on}$)**




| | | |
|---|---|---|
| $V_{GE}$ (0%) = | -15 | V |
| $V_{GE}$ (100%) = | 15 | V |
| $V_C$ (100%) = | 350 | V |
| $I_C$ (100%) = | 592 | A |
| $t_{don}$ = | 0,25 | μs |
| $t_{Eon}$ = | 0,38 | μs |

## Figure 3 — Neutral point IGBT

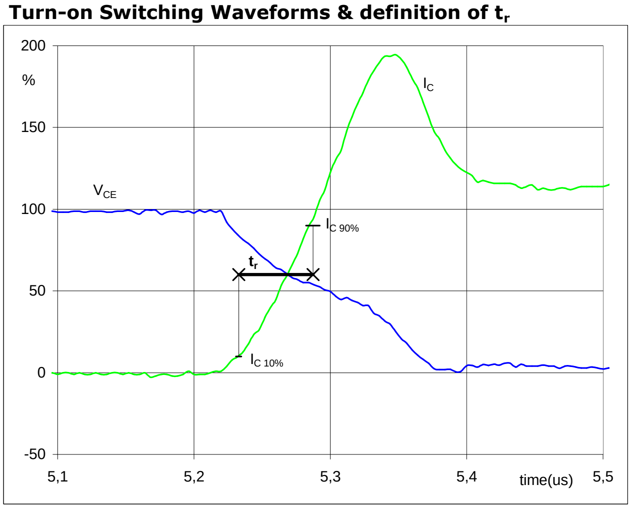
**Turn-off Switching Waveforms & definition of $t_f$**




| | | |
|---|---|---|
| $V_C$ (100%) = | 350 | V |
| $I_C$ (100%) = | 592 | A |
| $t_f$ = | 0,067 | μs |

## Figure 4 — Neutral point IGBT

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

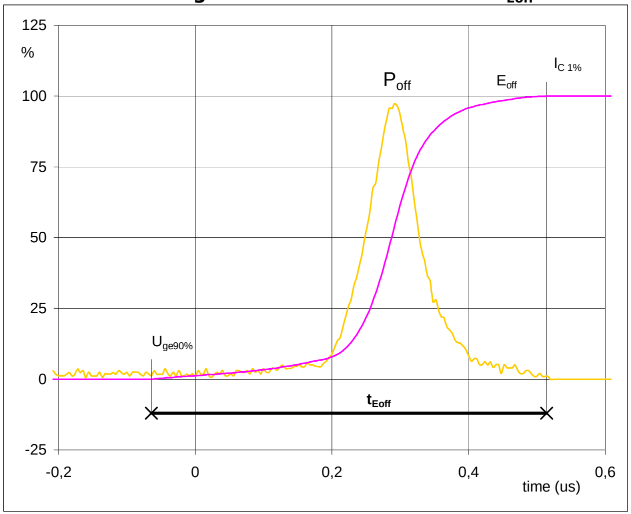



| | | |
|---|---|---|
| $V_C$ (100%) = | 350 | V |
| $I_C$ (100%) = | 592 | A |
| $t_r$ = | 0,053 | μs |

# Switching Definitions neutral point IGBT

| **Figure 5** | Neutral point IGBT |
|---|---|

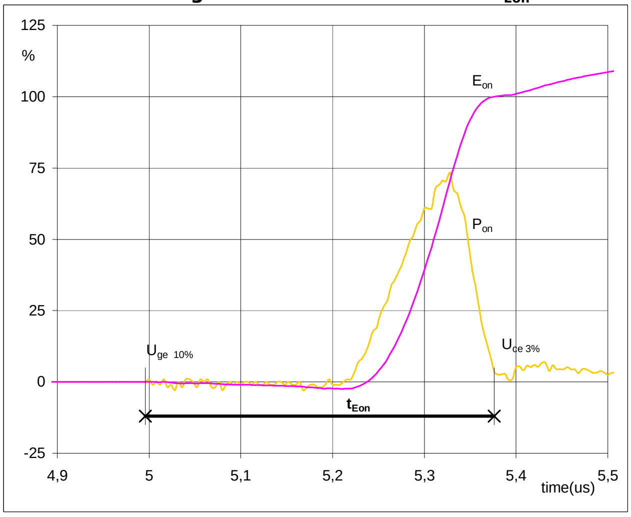
**Turn-off Switching Waveforms & definition of $t_{Eoff}$**




| | | |
|---|---|---|
| $P_{off}$ (100%) = | 207,31 | kW |
| $E_{off}$ (100%) = | 22,22 | mJ |
| $t_{Eoff}$ = | 0,58 | µs |

| **Figure 6** | Neutral point IGBT |
|---|---|

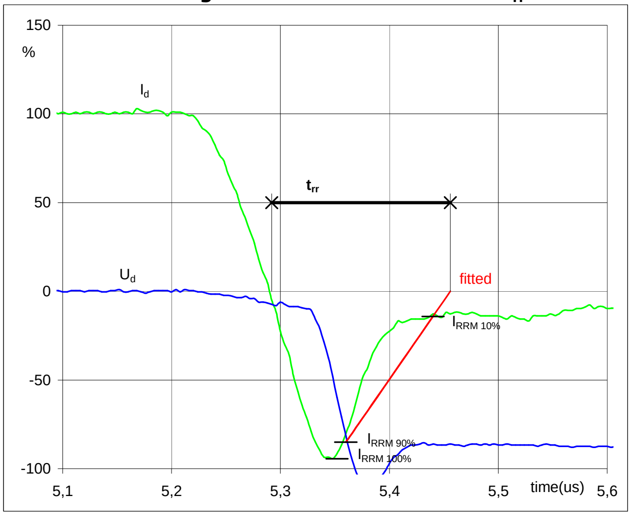
**Turn-on Switching Waveforms & definition of $t_{Eon}$**




| | | |
|---|---|---|
| $P_{on}$ (100%) = | 207,3054 | kW |
| $E_{on}$ (100%) = | 13,39 | mJ |
| $t_{Eon}$ = | 0,38 | µs |

| **Figure 7** | Half bridge FWD |
|---|---|

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

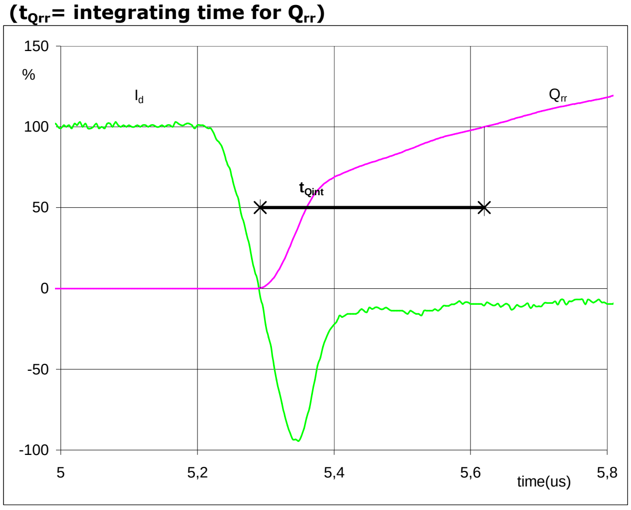



| | | |
|---|---|---|
| $V_d$ (100%) = | 350 | V |
| $I_d$ (100%) = | 592 | A |
| $I_{RRM}$ (100%) = | -568 | A |
| $t_{rr}$ = | 0,29 | µs |

# Switching Definitions neutral point IGBT

**Figure 8** Half bridge FWD

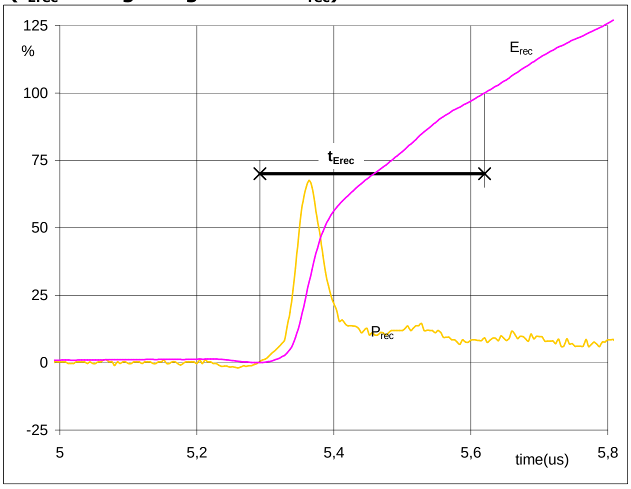
**Turn-on Switching Waveforms & definition of $t_{Qrr}$**
**($t_{Qrr}$= integrating time for $Q_{rr}$)**




| | | |
|---|---|---|
| $I_d$ (100%) = | 592 | A |
| $Q_{rr}$ (100%) = | 60,53 | µC |
| $t_{Qint}$ = | 0,33 | µs |

**Figure 9** Half bridge FWD

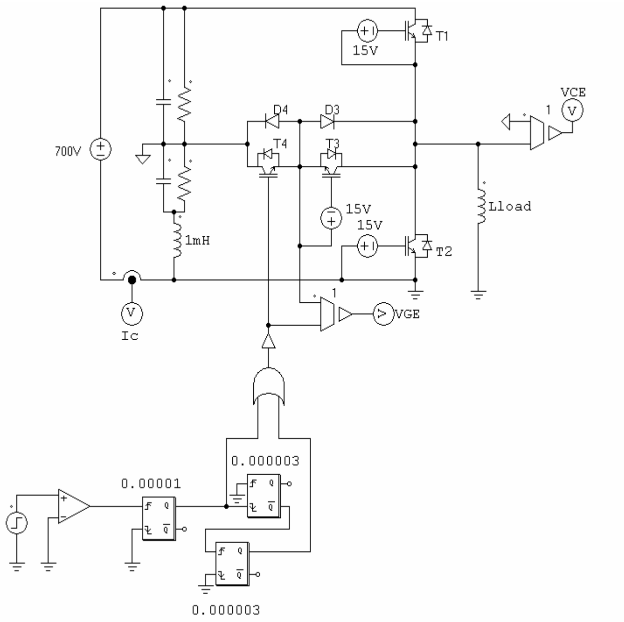
**Turn-on Switching Waveforms & definition of $t_{Erec}$**
**($t_{Erec}$= integrating time for $E_{rec}$)**




| | | |
|---|---|---|
| $P_{rec}$ (100%) = | 207,31 | kW |
| $E_{rec}$ (100%) = | 14,30 | mJ |
| $t_{Erec}$ = | 0,33 | µs |

# neutral point IGBT switching measurement circuit

**Figure 10**



# Ordering Code and Marking - Outline - Pinout

## Ordering Code & Marking

| Version | Ordering Code | in DataMatrix as | in packaging barcode as |
|---|---|---|---|
| without PCM | 70-W212NMA600SC-M200P | M200P | M200P |
| with PCM | 70-W212NMA600SC-M200P-/3/ | M200P | M200P-/3/ |

## Outline

Driver pins

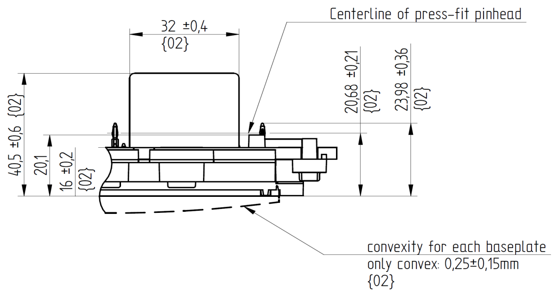
| Pin | X1 | Y1 | Function | Group |
|---|---|---|---|---|
| 1.1 | 4,5 | 78,7 | G1-1 | T1 |
| 1.2 | 4,5 | 81,6 | E1-1 | T1 |
| 1.3 | 39,5 | 78,7 | G1-2 | T1 |
| 1.4 | 39,5 | 81,6 | E1-2 | T1 |
| 1.5 | 1,95 | 68,4 | E2-1 | T2 |
| 1.6 | 4,85 | 68,4 | G2-1 | T2 |
| 1.7 | 39,2 | 68,4 | G2-2 | T2 |
| 1.8 | 42,1 | 68,4 | E2-2 | T2 |
| 1.9 | -2,2 | 46 | G3-1 | T3 |
| 1.10 | -2,2 | 48,9 | E3-1 | T3 |
| 1.11 | 46,2 | 46 | G3-2 | T3 |
| 1.12 | 46,2 | 48,9 | E3-2 | T3 |
| 1.13 | -6,75 | 29,2 | E4-1 | T4 |
| 1.14 | -6,75 | 32,1 | G4-1 | T4 |
| 1.15 | 50,8 | 29,2 | E4-2 | T4 |
| 1.16 | 50,8 | 32,1 | G4-2 | T4 |
| 1.17 | 19,5 | 30,2 | Desat-DC+ | |
| 1.18 | 24,6 | 30,2 | Desat-DC+ | |
| 1.19 | 19,5 | 44,7 | Desat-GND | |
| 1.20 | 24,6 | 44,7 | Desat-GND | |
| 1.21 | 67,7 | 86,7 | NTC | |
| 1.22 | 67,7 | 89,8 | NTC | |

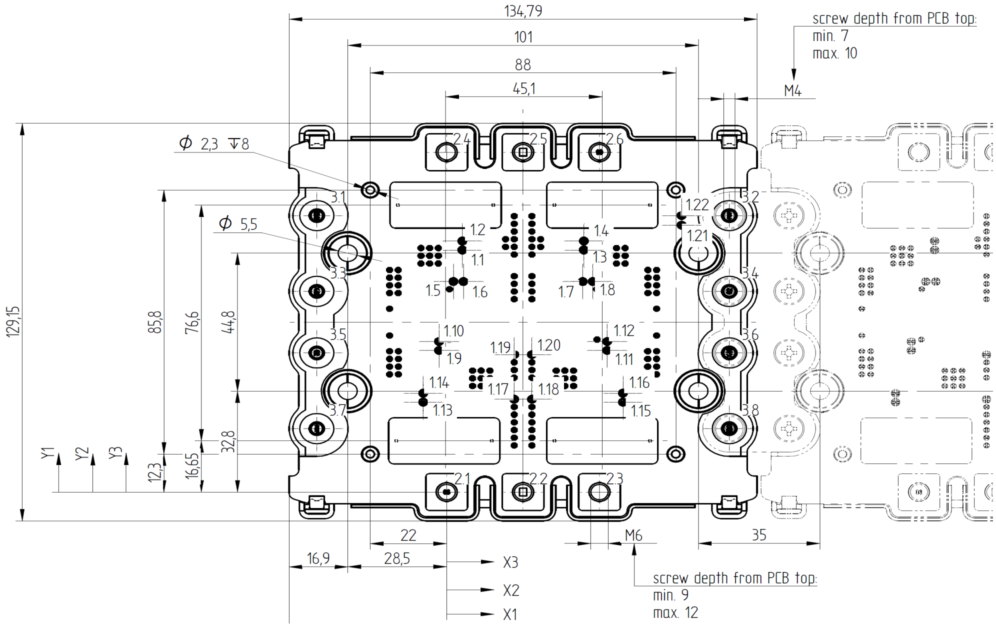
Low current connections

| M4 screw | X3 | Y3 | Function |
|---|---|---|---|
| 3.1 | -37 | 89,8 | DC+ |
| 3.2 | 81,4 | 89,8 | DC+ |
| 3.3 | -37 | 65,2 | CE |
| 3.4 | 81,4 | 65,2 | CE |
| 3.5 | -37 | 45,2 | Phase |
| 3.6 | 81,4 | 45,2 | Phase |
| 3.7 | -37 | 20,6 | DC- |
| 3.8 | 81,4 | 20,6 | DC- |

Power connections

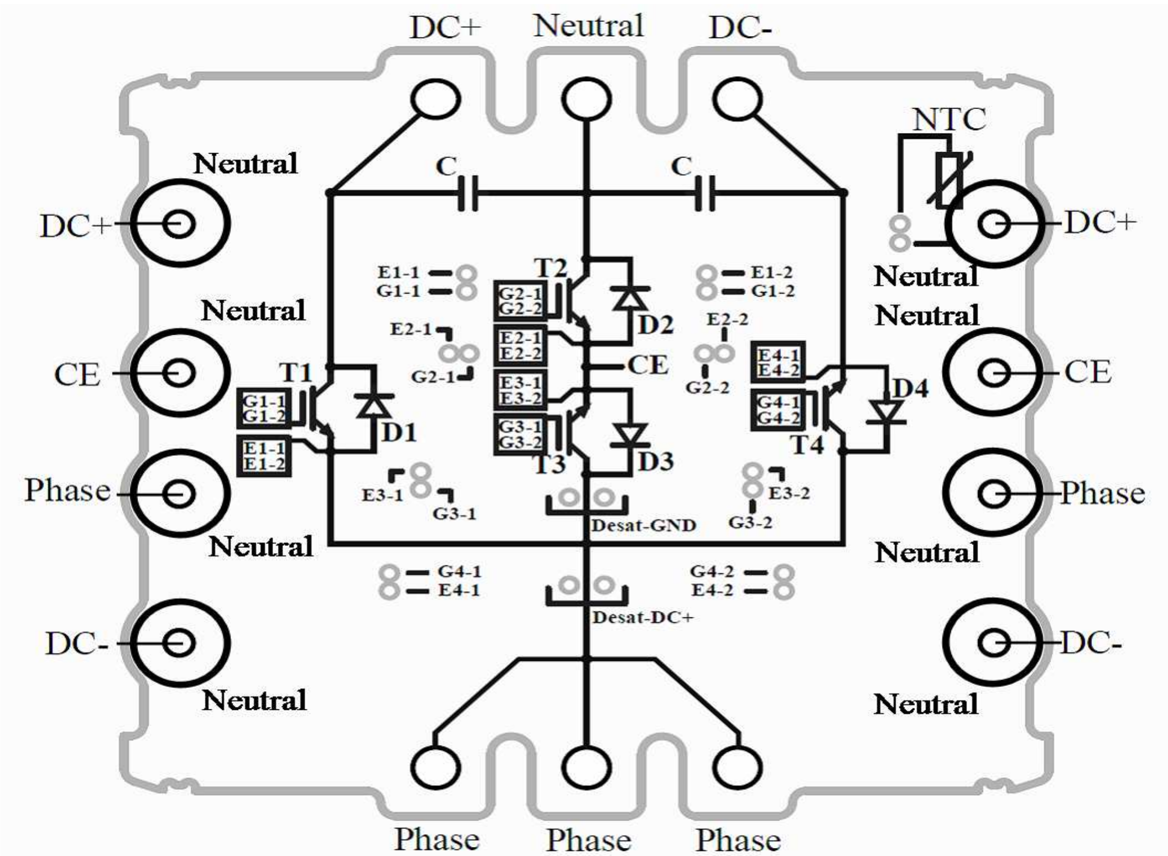
| M6 screw | X2 | Y2 | Function |
|---|---|---|---|
| 2.1 | 0 | 0 | Phase |
| 2.2 | 22 | 0 | Phase |
| 2.3 | 44 | 0 | Phase |
| 2.4 | 0 | 110,4 | DC+ |
| 2.5 | 22 | 110,4 | Neutral |
| 2.6 | 44 | 110,4 | DC- |



## Ordering Code and Marking - Outline - Pinout

### Pinout




**NOTE: Driver pins for parallel devices are not connected inside the module!**
**Gx-1 to Gx-2 and Ex-1 to Ex2 shall be connected on customer PCB!**
**Where x = 1 to 4**

### Identification

| ID | Component | Voltage | Current | Function | Comment |
|---|---|---|---|---|---|
| T1, T4 | IGBT | 1200 V | 600 A | Buck Switch | |
| T2, T3 | IGBT | 600 V | 600 A | Boost Switch | |
| D2, D3 | FWD | 600 V | 600 A | Buck Diode | |
| D1, D4 | FWD | 1200 V | 600 A | Boost Diode | |
| C | Capacitor | 630 V | | DC Link Capacitor | |
| NTC | NTC | | | Thermistor | |

| Packaging instruction | | | |
| --- | --- | --- | --- |
| Standard packaging quantity (SPQ) | **Variable*** | >SPQ Standard | <SPQ Sample |

| Handling instruction |
| --- |
| Handling instructions for VINco X4 packages see vincotech.com website. |

| Package data |
| --- |
| Package data for VINco X4 packages see vincotech.com website. |

| UL recognition and file number |
| --- |
| This device is certified according to UL 1557 standard, UL file number E192116. For more information see vincotech.com website. |

*10 without PCM
6 with PCM

| Document No.: | Date: | Modification: | Pages |
| --- | --- | --- | --- |
| 70-W212NMA600SC-M200P-D8-14 | 09 Jan. 2018 | | |

**DISCLAIMER**
The information, specifications, procedures, methods and recommendations herein (together "information") are presented by Vincotech to reader in good faith, are believed to be accurate and reliable, but may well be incomplete and/or not applicable to all conditions or situations that may exist or occur. Vincotech reserves the right to make any changes without further notice to any products to improve reliability, function or design. No representation, guarantee or warranty is made to reader as to the accuracy, reliability or completeness of said information or that the application or use of any of the same will avoid hazards, accidents, losses, damages or injury of any kind to persons or property or that the same will not infringe third parties rights or give desired results. It is reader's sole responsibility to test and determine the suitability of the information and the product for reader's intended use.

**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.