Vincotech

**flow MNPC 4w**

1200 V / 600 A

### Features
- Mixed voltage NPC
- Low inductive
- High power screw interface

### Target Applications
- Solar inverter
- UPS
- High speed motor drive

### Types
- 70-W212NMC600SH01-M700P

---

**Schematic**

---

**Maximum Ratings**

*\( T_j = 25^\circ C, \) unless otherwise specified*

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Symbol</th>
<th>Condition</th>
<th>Value</th>
<th>Unit</th>
</tr>
</thead>
<tbody>
<tr>
<td>Collector-emitter break down voltage</td>
<td>( V_{CE} )</td>
<td></td>
<td>1200</td>
<td>V</td>
</tr>
<tr>
<td>DC collector current</td>
<td>( I_c )</td>
<td>( T_j=T_{j\text{max}} ), ( T_a=80^\circ C ), ( T_c=80^\circ C )</td>
<td>457</td>
<td>A</td>
</tr>
<tr>
<td>Repetitive peak collector current</td>
<td>( I_{CRM} )</td>
<td>( t_p ) limited by ( T_j\text{max} )</td>
<td>1800</td>
<td>A</td>
</tr>
<tr>
<td>Power dissipation</td>
<td>( P_{tot} )</td>
<td>( T_j=T_{j\text{max}} ), ( T_a=80^\circ C ), ( T_c=80^\circ C )</td>
<td>1105</td>
<td>W</td>
</tr>
<tr>
<td>Gate-emitter peak voltage</td>
<td>( V_{CE} )</td>
<td></td>
<td>( \leq 20 )</td>
<td>V</td>
</tr>
<tr>
<td>Short circuit ratings</td>
<td>( \tau_{SC} )</td>
<td>( T_j \leq 150^\circ C )</td>
<td>10</td>
<td>( \mu s )</td>
</tr>
<tr>
<td>Peak Repetitive Reverse Voltage</td>
<td>( V_{RRM} )</td>
<td>( T_j=25^\circ C )</td>
<td>600</td>
<td>V</td>
</tr>
<tr>
<td>DC forward current</td>
<td>( I_F )</td>
<td>( T_j=T_{j\text{max}} ), ( T_a=80^\circ C ), ( T_c=80^\circ C )</td>
<td>318</td>
<td>A</td>
</tr>
<tr>
<td>Repetitive peak forward current</td>
<td>( I_{FPM} )</td>
<td>( t_p = 1 \text{ ms} )</td>
<td>1800</td>
<td>A</td>
</tr>
<tr>
<td>Power dissipation per FWD</td>
<td>( P_{tot} )</td>
<td>( T_j=T_{j\text{max}} ), ( T_a=80^\circ C ), ( T_c=80^\circ C )</td>
<td>389</td>
<td>W</td>
</tr>
<tr>
<td>Maximum Junction Temperature</td>
<td>( T_{j\text{max}} )</td>
<td></td>
<td>175</td>
<td>( ^\circ C )</td>
</tr>
</tbody>
</table>

---

**Schematic**

---

**Target Applications**

- Solar inverter
- UPS
- High speed motor drive

---

**Types**

- 70-W212NMC600SH01-M700P

---

**Maximum Ratings**

*\( T_j = 25^\circ C, \) unless otherwise specified*

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Symbol</th>
<th>Condition</th>
<th>Value</th>
<th>Unit</th>
</tr>
</thead>
<tbody>
<tr>
<td>Collector-emitter break down voltage</td>
<td>( V_{CE} )</td>
<td></td>
<td>1200</td>
<td>V</td>
</tr>
<tr>
<td>DC collector current</td>
<td>( I_c )</td>
<td>( T_j=T_{j\text{max}} ), ( T_a=80^\circ C ), ( T_c=80^\circ C )</td>
<td>457</td>
<td>A</td>
</tr>
<tr>
<td>Repetitive peak collector current</td>
<td>( I_{CRM} )</td>
<td>( t_p ) limited by ( T_j\text{max} )</td>
<td>1800</td>
<td>A</td>
</tr>
<tr>
<td>Power dissipation</td>
<td>( P_{tot} )</td>
<td>( T_j=T_{j\text{max}} ), ( T_a=80^\circ C ), ( T_c=80^\circ C )</td>
<td>1105</td>
<td>W</td>
</tr>
<tr>
<td>Gate-emitter peak voltage</td>
<td>( V_{CE} )</td>
<td></td>
<td>( \leq 20 )</td>
<td>V</td>
</tr>
<tr>
<td>Short circuit ratings</td>
<td>( \tau_{SC} )</td>
<td>( T_j \leq 150^\circ C )</td>
<td>10</td>
<td>( \mu s )</td>
</tr>
<tr>
<td>Peak Repetitive Reverse Voltage</td>
<td>( V_{RRM} )</td>
<td>( T_j=25^\circ C )</td>
<td>600</td>
<td>V</td>
</tr>
<tr>
<td>DC forward current</td>
<td>( I_F )</td>
<td>( T_j=T_{j\text{max}} ), ( T_a=80^\circ C ), ( T_c=80^\circ C )</td>
<td>318</td>
<td>A</td>
</tr>
<tr>
<td>Repetitive peak forward current</td>
<td>( I_{FPM} )</td>
<td>( t_p = 1 \text{ ms} )</td>
<td>1800</td>
<td>A</td>
</tr>
<tr>
<td>Power dissipation per FWD</td>
<td>( P_{tot} )</td>
<td>( T_j=T_{j\text{max}} ), ( T_a=80^\circ C ), ( T_c=80^\circ C )</td>
<td>389</td>
<td>W</td>
</tr>
<tr>
<td>Maximum Junction Temperature</td>
<td>( T_{j\text{max}} )</td>
<td></td>
<td>175</td>
<td>( ^\circ C )</td>
</tr>
</tbody>
</table>

---

**Schematic**

---

**Target Applications**

- Solar inverter
- UPS
- High speed motor drive

---

**Types**

- 70-W212NMC600SH01-M700P
## Maximum Ratings

\( T_j = 25^\circ C, \text{ unless otherwise specified} \)

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Symbol</th>
<th>Condition</th>
<th>Value</th>
<th>Unit</th>
</tr>
</thead>
<tbody>
<tr>
<td>Collector-emitter break down voltage</td>
<td>( V_{CE} )</td>
<td>( T_j = T_{j,\text{max}} )</td>
<td>600</td>
<td>V</td>
</tr>
<tr>
<td>DC collector current</td>
<td>( I_C )</td>
<td>( T_j = T_{j,\text{max}} ) ( T_e = 80^\circ C ) ( T_i = 80^\circ C )</td>
<td>420</td>
<td>A</td>
</tr>
<tr>
<td></td>
<td></td>
<td>( T_e = 80^\circ C )</td>
<td>550</td>
<td>A</td>
</tr>
<tr>
<td>Repetitive peak collector current</td>
<td>( I_{C,RMS} )</td>
<td>( t_s ) limited by ( T_{j,\text{max}} )</td>
<td>1800</td>
<td>A</td>
</tr>
<tr>
<td>Power dissipation</td>
<td>( P_{tot} )</td>
<td>( T_j = T_{j,\text{max}} ) ( T_e = 80^\circ C )</td>
<td>645</td>
<td>W</td>
</tr>
<tr>
<td></td>
<td></td>
<td>( T_e = 80^\circ C )</td>
<td>977</td>
<td>W</td>
</tr>
<tr>
<td>Gate-emitter peak voltage</td>
<td>( V_{CE} )</td>
<td></td>
<td>( \pm 20 )</td>
<td>V</td>
</tr>
<tr>
<td>Short circuit ratings</td>
<td>( t_{SC} )</td>
<td>( V_{CC} ) ( V_{CE} = 15V ) ( T_j \leq 150^\circ C )</td>
<td>6</td>
<td>( \mu s )</td>
</tr>
<tr>
<td></td>
<td></td>
<td>( V_{CE} = 15V )</td>
<td>360</td>
<td>( \mu s )</td>
</tr>
<tr>
<td>Turn off safe operating area (RBSOA)</td>
<td>( I_{\text{FSM}} )</td>
<td>( V_{CE} ) ( V_{CE} \leq 1200V ) ( T_{j,max} = 150^\circ C )</td>
<td>1200</td>
<td>A</td>
</tr>
<tr>
<td>Maximum Junction Temperature</td>
<td>( T_{j,max} )</td>
<td></td>
<td>175</td>
<td>( ^\circ C )</td>
</tr>
<tr>
<td>Peak Repetitive Reverse Voltage</td>
<td>( V_{\text{BSM}} )</td>
<td>( T_j = 25^\circ C )</td>
<td>1200</td>
<td>V</td>
</tr>
<tr>
<td>DC forward current</td>
<td>( I_F )</td>
<td>( T_j = T_{j,\text{max}} ) ( T_e = 80^\circ C ) ( T_i = 80^\circ C )</td>
<td>239</td>
<td>A</td>
</tr>
<tr>
<td></td>
<td></td>
<td>( T_e = 80^\circ C )</td>
<td>316</td>
<td>A</td>
</tr>
<tr>
<td>Surge forward current</td>
<td>( I_{VOM} )</td>
<td>( t_s = 10ms, \text{ sin } 180^\circ ) ( T_j = 150^\circ C )</td>
<td>1800</td>
<td>A</td>
</tr>
<tr>
<td>I2t-value</td>
<td>( I^2t )</td>
<td>( t_s = 10ms, \text{ sin } 180^\circ ) ( T_j = 150^\circ C )</td>
<td>8100</td>
<td>( A^2s )</td>
</tr>
<tr>
<td>Power dissipation per FWD</td>
<td>( P_{tot} )</td>
<td>( T_j = T_{j,\text{max}} ) ( T_e = 80^\circ C ) ( T_i = 80^\circ C )</td>
<td>468</td>
<td>W</td>
</tr>
<tr>
<td></td>
<td></td>
<td>( T_e = 80^\circ C )</td>
<td>709</td>
<td>W</td>
</tr>
<tr>
<td>Maximum Junction Temperature</td>
<td>( T_{j,max} )</td>
<td></td>
<td>175</td>
<td>( ^\circ C )</td>
</tr>
</tbody>
</table>
### Maximum Ratings

$T_j = 25^\circ C$, unless otherwise specified

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Symbol</th>
<th>Condition</th>
<th>Value</th>
<th>Unit</th>
</tr>
</thead>
<tbody>
<tr>
<td>DC link Capacitor</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Max.DC voltage</td>
<td>$V_{\text{MAX}}$</td>
<td>$T_{\text{cmax}}=100^\circ C$</td>
<td>630</td>
<td>V</td>
</tr>
<tr>
<td>General Module Properties</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Material of module baseplate</td>
<td></td>
<td></td>
<td>Cu</td>
<td></td>
</tr>
<tr>
<td>Material of internal isolation</td>
<td></td>
<td></td>
<td>Al2O3</td>
<td></td>
</tr>
<tr>
<td>Thermal Properties</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Storage temperature</td>
<td>$T_{\text{stg}}$</td>
<td></td>
<td>-40...+125</td>
<td>°C</td>
</tr>
<tr>
<td>Operation temperature under switching condition</td>
<td>$T_{\text{op}}$</td>
<td></td>
<td>-40...+(Tjmax - 25)</td>
<td>°C</td>
</tr>
<tr>
<td>Insulation Properties</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Insulation voltage</td>
<td>$V_{\text{a}}$</td>
<td>t=2s DC voltage</td>
<td>4000</td>
<td>V</td>
</tr>
<tr>
<td>Creepage distance</td>
<td></td>
<td></td>
<td>min 12,7</td>
<td>mm</td>
</tr>
<tr>
<td>Clearance</td>
<td></td>
<td></td>
<td>min 12,7</td>
<td>mm</td>
</tr>
<tr>
<td>Comparative tracking index</td>
<td>CTI</td>
<td></td>
<td>&gt;200</td>
<td></td>
</tr>
</tbody>
</table>

copyright Vincotech
## Characteristic Values

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Symbol</th>
<th>Conditions</th>
<th>Value</th>
<th>Unit</th>
</tr>
</thead>
<tbody>
<tr>
<td>half bridge IGBT (T1, T4)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Gate emitter threshold voltage</td>
<td>$V_{GE(th)}$</td>
<td>$V_{GS}=V_{DS}$</td>
<td>$0,0208$</td>
<td>$5 \pm 0,8 \pm 6,5$</td>
</tr>
<tr>
<td>Collector-emitter saturation voltage</td>
<td>$V_{CES}$</td>
<td>$V_{CE}$</td>
<td>$15 \pm 0,4$</td>
<td>$1,4 \pm 2,2 \pm 2,4$</td>
</tr>
<tr>
<td>Collector-emitter cut-off current incl. FWD</td>
<td>$I_{fso}$</td>
<td>$0 \pm 0,2$</td>
<td>$1,200$</td>
<td>$10 \pm 0,08$</td>
</tr>
<tr>
<td>Gate-emitter leakage current</td>
<td>$I_{fsl}$</td>
<td>$20 \pm 0$</td>
<td>$0 \pm 0$</td>
<td>$960 \pm 0$</td>
</tr>
<tr>
<td>Integrated Gate resistor</td>
<td>$R_{gint}$</td>
<td></td>
<td></td>
<td>$1,25 \pm 0$</td>
</tr>
<tr>
<td>Turn-on delay time</td>
<td>$t_{on}$</td>
<td></td>
<td>$\pm 15$</td>
<td>$350 \pm 600$</td>
</tr>
<tr>
<td>Rise time</td>
<td>$t_{r}$</td>
<td>$R_{goff}=0,5 \Omega$</td>
<td>$\pm 15$</td>
<td>$350 \pm 600$</td>
</tr>
<tr>
<td>Fall time</td>
<td>$t_{f}$</td>
<td>$R_{goff}=0,5 \Omega$</td>
<td>$\pm 15$</td>
<td>$350 \pm 600$</td>
</tr>
<tr>
<td>Input capacitance</td>
<td>$C_{iss}$</td>
<td>$f=1MHz$</td>
<td>$0 \pm 25$</td>
<td>$T_{j}=25^\circ C$</td>
</tr>
<tr>
<td>Output capacitance</td>
<td>$C_{oss}$</td>
<td>$f=1MHz$</td>
<td>$0 \pm 25$</td>
<td>$T_{j}=25^\circ C$</td>
</tr>
<tr>
<td>Reverse transfer capacitance</td>
<td>$C_{rss}$</td>
<td></td>
<td></td>
<td>$1880 \pm 0$</td>
</tr>
<tr>
<td>Collector reverse voltage</td>
<td>$V_{CE}$</td>
<td>$T_{j}=25^\circ C$</td>
<td>$0,37 \pm 0,06$</td>
<td>$0,09 \pm 0,06$</td>
</tr>
<tr>
<td>Thermal resistance chip to heatsink</td>
<td>$r_{th(j-c)}$</td>
<td>$T_{j}=25^\circ C$</td>
<td>$0,37 \pm 0,06$</td>
<td>$0,09 \pm 0,06$</td>
</tr>
<tr>
<td>Thermal resistance chip to case</td>
<td>$r_{th(j-s)}$</td>
<td>$T_{j}=25^\circ C$</td>
<td>$0,37 \pm 0,06$</td>
<td>$0,09 \pm 0,06$</td>
</tr>
<tr>
<td>neutral point FWD (D2, D3)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>FWD forward voltage</td>
<td>$V_{DS}$</td>
<td>$600 \pm 0,5 \Omega$</td>
<td>$\pm 15$</td>
<td>$350 \pm 600$</td>
</tr>
<tr>
<td>Peak reverse recovery current</td>
<td>$I_{rr}$</td>
<td>$R_{gon}=0,5 \Omega$</td>
<td>$\pm 15$</td>
<td>$350 \pm 600$</td>
</tr>
<tr>
<td>Reverse recovery time</td>
<td>$t_{rr}$</td>
<td>$R_{gon}=0,5 \Omega$</td>
<td>$\pm 15$</td>
<td>$350 \pm 600$</td>
</tr>
<tr>
<td>Reverse recovered charge</td>
<td>$0 \pm 0$</td>
<td>$R_{gon}=0,5 \Omega$</td>
<td>$\pm 15$</td>
<td>$350 \pm 600$</td>
</tr>
<tr>
<td>Peak rate of fall of recovery current</td>
<td>$V_{ds(f)}$</td>
<td>$R_{gon}=0,5 \Omega$</td>
<td>$\pm 15$</td>
<td>$350 \pm 600$</td>
</tr>
<tr>
<td>Reverse recovered energy</td>
<td>$E_{rr}$</td>
<td>$R_{gon}=0,5 \Omega$</td>
<td>$\pm 15$</td>
<td>$350 \pm 600$</td>
</tr>
<tr>
<td>Thermal resistance chip to heatsink</td>
<td>$r_{th(j-c)}$</td>
<td>$T_{j}=25^\circ C$</td>
<td>$0,37 \pm 0,06$</td>
<td>$0,09 \pm 0,06$</td>
</tr>
<tr>
<td>Thermal resistance chip to case</td>
<td>$r_{th(j-s)}$</td>
<td>$T_{j}=25^\circ C$</td>
<td>$0,37 \pm 0,06$</td>
<td>$0,09 \pm 0,06$</td>
</tr>
<tr>
<td>neutral point IGBT (T2, T3)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Gate emitter threshold voltage</td>
<td>$V_{GE(th)}$</td>
<td>$V_{GS}=V_{DS}$</td>
<td>$0,0096$</td>
<td>$5 \pm 0,8 \pm 6,5$</td>
</tr>
<tr>
<td>Collector-emitter saturation voltage</td>
<td>$V_{CES}$</td>
<td>$V_{CE}$</td>
<td>$15 \pm 0,4$</td>
<td>$1,05 \pm 1,8 \pm 1,85$</td>
</tr>
<tr>
<td>Collector-emitter cut-off current incl. FWD</td>
<td>$I_{fso}$</td>
<td>$0 \pm 0,2$</td>
<td>$600 \pm 0$</td>
<td>$0,0304$</td>
</tr>
<tr>
<td>Gate-emitter leakage current</td>
<td>$I_{fsl}$</td>
<td>$20 \pm 0$</td>
<td>$0 \pm 0$</td>
<td>$2400 \pm 0$</td>
</tr>
<tr>
<td>Integrated Gate resistor</td>
<td>$R_{gint}$</td>
<td></td>
<td></td>
<td>$0,5 \pm 0$</td>
</tr>
<tr>
<td>Turn-on delay time</td>
<td>$t_{on}$</td>
<td></td>
<td>$\pm 15$</td>
<td>$350 \pm 600$</td>
</tr>
<tr>
<td>Rise time</td>
<td>$t_{r}$</td>
<td>$R_{goff}=1 \Omega$</td>
<td>$\pm 15$</td>
<td>$350 \pm 600$</td>
</tr>
<tr>
<td>Fall time</td>
<td>$t_{f}$</td>
<td>$R_{goff}=1 \Omega$</td>
<td>$\pm 15$</td>
<td>$350 \pm 600$</td>
</tr>
<tr>
<td>Input capacitance</td>
<td>$C_{iss}$</td>
<td>$f=1MHz$</td>
<td>$0 \pm 25$</td>
<td>$T_{j}=25^\circ C$</td>
</tr>
<tr>
<td>Output capacitance</td>
<td>$C_{oss}$</td>
<td>$f=1MHz$</td>
<td>$0 \pm 25$</td>
<td>$T_{j}=25^\circ C$</td>
</tr>
<tr>
<td>Reverse transfer capacitance</td>
<td>$C_{rss}$</td>
<td></td>
<td></td>
<td>$1096 \pm 0$</td>
</tr>
<tr>
<td>Collector reverse voltage</td>
<td>$V_{CE}$</td>
<td>$T_{j}=25^\circ C$</td>
<td>$0,37 \pm 0,06$</td>
<td>$0,15 \pm 0,10$</td>
</tr>
<tr>
<td>Thermal resistance chip to heatsink</td>
<td>$r_{th(j-c)}$</td>
<td>$T_{j}=25^\circ C$</td>
<td>$0,37 \pm 0,06$</td>
<td>$0,15 \pm 0,10$</td>
</tr>
<tr>
<td>Thermal resistance chip to case</td>
<td>$r_{th(j-s)}$</td>
<td>$T_{j}=25^\circ C$</td>
<td>$0,37 \pm 0,06$</td>
<td>$0,15 \pm 0,10$</td>
</tr>
</tbody>
</table>
### Characteristic Values

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Symbol</th>
<th>Conditions</th>
<th>Value</th>
<th>Unit</th>
</tr>
</thead>
<tbody>
<tr>
<td>FWD forward voltage</td>
<td>V_{fs}</td>
<td>600</td>
<td>1</td>
<td>1.15</td>
</tr>
<tr>
<td>Reverse leakage current</td>
<td>I_{rs}</td>
<td>1200</td>
<td>1</td>
<td>1.15</td>
</tr>
<tr>
<td>Peak reverse recovery current</td>
<td>I_{rm}</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Reverse recovery time</td>
<td>t_{rr}</td>
<td></td>
<td>350</td>
<td>600</td>
</tr>
<tr>
<td>Reverse recovered charge</td>
<td>Q_{on}</td>
<td>R_{gon}=1 Ω</td>
<td>±15</td>
<td></td>
</tr>
<tr>
<td>Thermal resistance chip to heatsink</td>
<td>R_{hc}</td>
<td></td>
<td>0.20</td>
<td></td>
</tr>
<tr>
<td>Thermal resistance chip to case</td>
<td>R_{hc}</td>
<td></td>
<td>0.13</td>
<td></td>
</tr>
<tr>
<td>DC link Capacitor</td>
<td>C</td>
<td></td>
<td>2* 0.68</td>
<td>µF</td>
</tr>
<tr>
<td>Thermistor</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Rated resistance</td>
<td>R</td>
<td>T=25°C</td>
<td>22000</td>
<td></td>
</tr>
<tr>
<td>Deviation of R_{ch}</td>
<td>Δ_Rch</td>
<td>R_{ch}=1486 Ω</td>
<td>T=100°C</td>
<td>-12</td>
</tr>
<tr>
<td>Power dissipation</td>
<td>P</td>
<td>T=25°C</td>
<td>200</td>
<td></td>
</tr>
<tr>
<td>Power dissipation constant</td>
<td></td>
<td>T=25°C</td>
<td>2</td>
<td></td>
</tr>
<tr>
<td>B-value</td>
<td>P_{(250)}</td>
<td>Tol. ±3%</td>
<td>T=25°C</td>
<td>3950</td>
</tr>
<tr>
<td>B-value</td>
<td>P_{(250)}</td>
<td>Tol. ±3%</td>
<td>T=25°C</td>
<td>3996</td>
</tr>
<tr>
<td>Vincotech NTC Reference</td>
<td></td>
<td>T=25°C</td>
<td>B</td>
<td></td>
</tr>
<tr>
<td>Module Properties</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Module inductance (from chips to PCB)</td>
<td>L_{ch}</td>
<td></td>
<td>10</td>
<td></td>
</tr>
<tr>
<td>Mounting torque</td>
<td>M</td>
<td></td>
<td>2</td>
<td>2.2</td>
</tr>
<tr>
<td>Mounting torque</td>
<td>M</td>
<td>4</td>
<td>6</td>
<td>Nm</td>
</tr>
<tr>
<td>Terminal connection torque</td>
<td>M</td>
<td></td>
<td>2,5</td>
<td>5</td>
</tr>
<tr>
<td>Weight</td>
<td>G</td>
<td></td>
<td>1300</td>
<td>g</td>
</tr>
</tbody>
</table>

Copyright Vincotech
**Buck operation**

half bridge IGBT (T1,T4) and neutral point FWD (D2,D3)

**Figure 1**
Typical output characteristics $V_{ge}=15V$
$I_{C} = f(V_{ce})$

![Graph of I_C vs V_{ce}]

- $t_{p} = 350 \text{µs}$
- $T_{j} = 25/125/150 \degree C$
- $V_{ce}$ from 7 V to 17 V in steps of 1 V

**Figure 2**
Typical output characteristics $I_{C} = f(V_{ce})$

![Graph of I_C vs V_{ce}]

At

**Figure 3**
Typical transfer characteristics $I_{C} = f(V_{ce})$

![Graph of I_C vs V_{ce}]

At

**Figure 4**
Typical FWD forward current as a function of forward voltage $I_{F} = f(V_{F})$

![Graph of I_F vs V_F]

At

copyright Vincotech
**Buck operation**

half bridge IGBT (T1,T4) and neutral point FWD (D2,D3)

**Figure 5**

Typical switching energy losses as a function of collector current

\[ E = f(I_C) \]

With an inductive load at

- \( T_I = 25/125/150 \, ^\circ C \)
- \( V_{CE} = 350 \, V \)
- \( V_{CE} = \pm 15 \, V \)
- \( R_{gon} = 0.5 \, \Omega \)
- \( R_{goff} = 0.5 \, \Omega \)

**Figure 6**

Typical switching energy losses as a function of gate resistor

\[ E = f(R_G) \]

With an inductive load at

- \( T_I = 25/125/150 \, ^\circ C \)
- \( V_{CE} = 350 \, V \)
- \( V_{CE} = \pm 15 \, V \)
- \( I_C = 600 \, A \)

**Figure 7**

Typical reverse recovery energy loss as a function of collector current

\[ E_{rec} = f(I_C) \]

With an inductive load at

- \( T_I = 25/125/150 \, ^\circ C \)
- \( V_{CE} = 350 \, V \)
- \( V_{CE} = \pm 15 \, V \)
- \( R_{gon} = 0.5 \, \Omega \)

**Figure 8**

Typical reverse recovery energy loss as a function of gate resistor

\[ E_{rec} = f(R_G) \]

With an inductive load at

- \( T_I = 25/125/150 \, ^\circ C \)
- \( V_{CE} = 350 \, V \)
- \( V_{CE} = \pm 15 \, V \)
- \( I_C = 600 \, A \)
**Buck operation**

Half bridge IGBT (T1,T4) and neutral point FWD (D2,D3)

---

**Figure 9**

Typical switching times as a function of collector current

\[ t = f(I_C) \]

With an inductive load at

- \( T_J = 125 \ \degree C \)
- \( V_{CE} = 350 \ \text{V} \)
- \( V_{GS} = \pm 15 \ \text{V} \)
- \( R_{gon} = 0.5 \ \Omega \)
- \( R_{goff} = 0.5 \ \Omega \)

---

**Figure 10**

Typical switching times as a function of gate resistor

\[ t = f(R_G) \]

With an inductive load at

- \( T_J = 125 \ \degree C \)
- \( V_{CE} = 350 \ \text{V} \)
- \( V_{GS} = \pm 15 \ \text{V} \)
- \( I_C = 600 \ \text{A} \)

---

**Figure 11**

Typical reverse recovery time as a function of collector current

\[ t_{rr} = f(I_C) \]

At

- \( T_J = 25/125/150 \ \degree C \)
- \( V_{CE} = 350 \ \text{V} \)
- \( V_{GS} = \pm 15 \ \text{V} \)
- \( R_{gon} = 0.5 \ \Omega \)

---

**Figure 12**

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

\[ t_{rr} = f(R_{gon}) \]

At

- \( T_J = 25/125/150 \ \degree C \)
- \( V_{CE} = 350 \ \text{V} \)
- \( I_F = 600 \ \text{A} \)
- \( V_{GS} = \pm 15 \ \text{V} \)
Buck operation
half bridge IGBT (T1,T4) and neutral point FWD (D2,D3)

**Figure 13**
Typical reverse recovery charge as a function of collector current
\[ Q_{rr} = f(I_C) \]

**Figure 14**
Typical reverse recovery charge as a function of IGBT turn on gate resistor
\[ Q_{rr} = f(R_{gon}) \]

At
- \( T_j = 25/125/150 \) °C
- \( V_{CE} = 350 \) V
- \( V_{GE} = \pm 15 \) V
- \( R_{gon} = 0.5 \) Ω

**Figure 15**
Typical reverse recovery current as a function of collector current
\[ I_{RRM} = f(I_C) \]

**Figure 16**
Typical reverse recovery current as a function of IGBT turn on gate resistor
\[ I_{RRM} = f(R_{gon}) \]

At
- \( T_j = 25/125/150 \) °C
- \( V_{CE} = 350 \) V
- \( I_F = 600 \) A
- \( V_{GE} = \pm 15 \) V
Buck operation
half bridge IGBT (T1,T4) and neutral point FWD (D2,D3)

**Figure 17**
Typical rate of fall of forward and reverse recovery current as a function of collector current
\[
\frac{di}{dt}, \frac{dI_{rec}}{dt} = f(I_c)
\]

At
\[
T_j = \frac{25}{125} \degree C
\]
\[
V_{CE} = 350 \ V
\]
\[
V_{GE} = \pm 15 \ V
\]
\[
I_F = 600 \ A
\]
\[
R_{gon} = 0.5 \ \Omega
\]

**Figure 18**
Typical rate of fall of forward and reverse recovery current as a function of IGBT turn on gate resistor
\[
\frac{di}{dt}, \frac{dI_{rec}}{dt} = f(R_{gon})
\]

At
\[
T_j = \frac{25}{125} \degree C
\]
\[
V_{CE} = 350 \ V
\]
\[
l_F = 600 \ A
\]
\[
V_{GE} = \pm 15 \ V
\]

**Figure 19**
IGBT transient thermal impedance as a function of pulse width
\[
Z_{thJH} = f(t_p)
\]

At
\[
D = \frac{t_p}{T}
\]
\[
R_{inf} = 0.086 \ K/W
\]

**Figure 20**
FWD transient thermal impedance as a function of pulse width
\[
Z_{thJH} = f(t_p)
\]

At
\[
D = \frac{t_p}{T}
\]
\[
R_{inf} = 0.244 \ K/W
\]

IGBT thermal model values

<table>
<thead>
<tr>
<th>( R ) (K/W)</th>
<th>Tau (s)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0,037</td>
<td>1.555</td>
</tr>
<tr>
<td>0,019</td>
<td>0,210</td>
</tr>
<tr>
<td>0,023</td>
<td>0,031</td>
</tr>
<tr>
<td>0,003</td>
<td>0,002</td>
</tr>
<tr>
<td>0,005</td>
<td>0,0003</td>
</tr>
</tbody>
</table>

FWD thermal model values

<table>
<thead>
<tr>
<th>( R ) (K/W)</th>
<th>Tau (s)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0,046</td>
<td>5,114</td>
</tr>
<tr>
<td>0,048</td>
<td>1,051</td>
</tr>
<tr>
<td>0,046</td>
<td>0,196</td>
</tr>
<tr>
<td>0,074</td>
<td>0,043</td>
</tr>
<tr>
<td>0,018</td>
<td>0,014</td>
</tr>
</tbody>
</table>
Buck operation
half bridge IGBT (T1,T4) and neutral point FWD (D2,D3)

**Figure 21**
Power dissipation as a function of heatsink temperature
\[ P_{\text{tot}} = f(T_h) \]

At
\[ T_j = 175 \, ^\circ C \]

**Figure 22**
Collector current as a function of heatsink temperature
\[ I_C = f(T_h) \]

At
\[ T_j = 175 \, ^\circ C \]
\[ V_{\text{GE}} = 15 \, V \]

**Figure 23**
Power dissipation as a function of heatsink temperature
\[ P_{\text{tot}} = f(T_h) \]

At
\[ T_j = 175 \, ^\circ C \]

**Figure 24**
Forward current as a function of heatsink temperature
\[ I_F = f(T_h) \]

At
\[ T_j = 175 \, ^\circ C \]
Buck operation
half bridge IGBT (T1,T4) and neutral point FWD (D2,D3)

**Figure 25**
Reverse bias safe operating area

\[ I_C = f(V_{CE}) \]

**Figure 26**
Gate voltage vs Gate charge

\[ V_{GE} = f(Q_g) \]

At
\[ T_J = 150 \, ^\circ C \]
\[ U_{DCM} = \frac{U_{CC}}{2} \]
\[ V_{CE} = \pm 15 \, V \]
\[ R_{ON} = 0.5 \, \Omega \]
Switching mode: 3 level

At
\[ I_C = 600 \, A \]

Vcc=240V
Vcc=960V
**Boost operation**
neutral point IGBT (T2,T3) and half bridge FWD (D1,D2)

**Figure 1**
Typical output characteristics Vge=15V

\[ I_C = f(V_{ce}) \]

![Image 1](image1.png)

\[ t_p = 350 \mu s \]
\[ T_j = 25/125/150 \degree C \]
\[ V_{CE} = 10 \ V \]

**Figure 2**
Typical output characteristics

\[ I_C = f(V_{ce}) \]

![Image 2](image2.png)

\[ t_p = 350 \mu s \]
\[ T_j = 150 \degree C \]
\[ V_{CE} \text{ from 7 V to 17 V in steps of 1 V} \]

**Figure 3**
Typical transfer characteristics

\[ I_C = f(V_{ce}) \]

![Image 3](image3.png)

\[ t_p = 350 \mu s \]
\[ V_{CE} = 10 \ V \]
\[ T_j = 25/125/150 \degree C \]

**Figure 4**
Typical FWD forward current as a function of forward voltage

\[ I_F = f(V_F) \]

![Image 4](image4.png)

\[ t_p = 350 \mu s \]
\[ T_j = 25/125/150 \degree C \]
Boost operation
neutral point IGBT (T2,T3) and half bridge FWD (D1,D2)

Figure 5
Typical switching energy losses
as a function of collector current
\[ E = f(I_C) \]

With an inductive load at
\[ T_J = 25/125/150 \, ^\circ C \]
\[ V_{CE} = 350 \, V \]
\[ V_{Gt} = \pm 15 \, V \]
\[ R_{gon} = 1 \, \Omega \]
\[ R_{goff} = 1 \, \Omega \]

Figure 6
Typical switching energy losses
as a function of gate resistor
\[ E = f(R_G) \]

With an inductive load at
\[ T_J = 25/125/150 \, ^\circ C \]
\[ V_{CE} = 350 \, V \]
\[ V_{Gt} = \pm 15 \, V \]
\[ I_C = 600 \, A \]

Figure 7
Typical reverse recovery energy loss
as a function of collector current
\[ E_{rec} = f(I_C) \]

With an inductive load at
\[ T_J = 25/125/150 \, ^\circ C \]
\[ V_{CE} = 350 \, V \]
\[ V_{Gt} = \pm 15 \, V \]
\[ R_{gon} = 1 \, \Omega \]

Figure 8
Typical reverse recovery energy loss
as a function of gate resistor
\[ E_{rec} = f(R_G) \]

With an inductive load at
\[ T_J = 25/125/150 \, ^\circ C \]
\[ V_{CE} = 350 \, V \]
\[ V_{Gt} = \pm 15 \, V \]
\[ I_C = 600 \, A \]
**Boost operation**

neutral point IGBT (T2,T3) and half bridge FWD (D1,D2)

**Figure 9**
Typical switching times as a function of collector current

\[ t = f(I_C) \]

With an inductive load at

- \( T_j = 125 \, ^\circ \text{C} \)
- \( V_{CE} = 350 \, \text{V} \)
- \( V_{SS} = \pm 15 \, \text{V} \)
- \( R_{gon} = 1 \, \Omega \)
- \( R_{goff} = 1 \, \Omega \)

**Figure 10**
Typical switching times as a function of gate resistor

\[ t = f(R_g) \]

With an inductive load at

- \( T_j = 125 \, ^\circ \text{C} \)
- \( V_{CE} = 350 \, \text{V} \)
- \( V_{SS} = \pm 15 \, \text{V} \)
- \( I_C = 600 \, \text{A} \)

**Figure 11**
Typical reverse recovery time as a function of collector current

\[ t_{rr} = f(I_C) \]

At

- \( T_j = \frac{25}{125/150} \, ^\circ \text{C} \)
- \( V_{CE} = 350 \, \text{V} \)
- \( V_{SS} = \pm 15 \, \text{V} \)
- \( R_{gon} = 1 \, \Omega \)

**Figure 12**
Typical reverse recovery time as a function of IGBT turn on gate resistor

\[ t_{rr} = f(R_{gon}) \]

At

- \( T_j = \frac{25}{125/150} \, ^\circ \text{C} \)
- \( V_{CE} = 350 \, \text{V} \)
- \( I_C = 600 \, \text{A} \)
- \( V_{SS} = \pm 15 \, \text{V} \)
Boost operation
neutral point IGBT (T2,T3) and half bridge FWD (D1,D2)

**Figure 13**
Typical reverse recovery charge as a function of collector current
\[ Q_{rr} = f(I_C) \]

\[ Q_{rr} \] as a function of \( I_C \)

- **At**
  - \( T_J = 25/125/150 \) °C
  - \( V_CE = 350 \) V
  - \( V_GE = \pm 15 \) V
  - \( R_{gon} = 1 \) Ω

**Figure 14**
Typical reverse recovery charge as a function of IGBT turn on gate resistor
\[ Q_{rr} = f(R_{gon}) \]

\[ Q_{rr} \] as a function of \( R_{gon} \)

- **At**
  - \( T_J = 25/125/150 \) °C
  - \( V_R = 350 \) V
  - \( I_F = 600 \) A
  - \( V_{GE} = \pm 15 \) V

**Figure 15**
Typical reverse recovery current as a function of collector current
\[ I_{RRM} = f(I_C) \]

\[ I_{RRM} \] as a function of \( I_C \)

- **At**
  - \( T_J = 25/125/150 \) °C
  - \( V_CE = 350 \) V
  - \( V_{CE} = \pm 15 \) V
  - \( I_F = 600 \) A
  - \( V_{GE} = \pm 15 \) V

**Figure 16**
Typical reverse recovery current as a function of IGBT turn on gate resistor
\[ I_{RRM} = f(R_{gon}) \]

\[ I_{RRM} \] as a function of \( R_{gon} \)

- **At**
  - \( T_J = 25/125/150 \) °C
  - \( V_R = 350 \) V
  - \( I_F = 600 \) A
  - \( V_{GE} = \pm 15 \) V
Boost operation
neutral point IGBT (T2,T3) and half bridge FWD (D1,D2)

**Figure 17**
Typical rate of fall of forward and reverse recovery current as a function of collector current
\[ \frac{dI_0}{dt}, \frac{dI_{rec}}{dt} = f(I_c) \]

At
- \( T_j = 25/125/150 \) °C
- \( V_{CE} = 350 \) V
- \( V_{GE} = \pm 15 \) V
- \( I_F = 600 \) A
- \( R_{gon} = 1 \) Ω

**Figure 18**
Typical rate of fall of forward and reverse recovery current as a function of IGBT turn on gate resistor
\[ \frac{dI_0}{dt}, \frac{dI_{rec}}{dt} = f(R_{gon}) \]

At
- \( T_j = 25/125/150 \) °C
- \( V_{CE} = 350 \) V
- \( I_F = 600 \) A
- \( V_{GE} = \pm 15 \) V

**Figure 19**
IGBT transient thermal impedance as a function of pulse width
\[ Z_{thJH} = f(t_p) \]

At
- \( D = \frac{t_p}{T} \)
- \( R_{thJH} = 0.15 \) K/W

IGBT thermal model values

<table>
<thead>
<tr>
<th>( R ) (K/W)</th>
<th>Tau (s)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.05</td>
<td>3.58</td>
</tr>
<tr>
<td>0.02</td>
<td>0.74</td>
</tr>
<tr>
<td>0.03</td>
<td>0.18</td>
</tr>
<tr>
<td>0.03</td>
<td>0.04</td>
</tr>
<tr>
<td>0.01</td>
<td>0.01</td>
</tr>
</tbody>
</table>

**Figure 20**
FWD transient thermal impedance as a function of pulse width
\[ Z_{thJH} = f(t_p) \]

At
- \( D = \frac{t_p}{T} \)
- \( R_{thJH} = 0.20 \) K/W

FWD thermal model values

<table>
<thead>
<tr>
<th>( R ) (K/W)</th>
<th>Tau (s)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.02</td>
<td>4.55</td>
</tr>
<tr>
<td>0.03</td>
<td>0.92</td>
</tr>
<tr>
<td>0.05</td>
<td>0.19</td>
</tr>
<tr>
<td>0.07</td>
<td>0.05</td>
</tr>
<tr>
<td>0.03</td>
<td>0.02</td>
</tr>
</tbody>
</table>
Boost operation
neutral point IGBT (T2,T3) and half bridge FWD (D1,D2)

**Figure 21**
Power dissipation as a function of heatsink temperature

\[ P_{\text{tot}} = f(T_h) \]

At \( T_j = 175 \, ^\circ\text{C} \)

**Figure 22**
Collector current as a function of heatsink temperature

\[ I_C = f(T_h) \]

At \( T_j = 175 \, ^\circ\text{C} \)

**Figure 23**
Power dissipation as a function of heatsink temperature

\[ P_{\text{tot}} = f(T_h) \]

At \( T_j = 175 \, ^\circ\text{C} \)

**Figure 24**
Forward current as a function of heatsink temperature

\[ I_F = f(T_h) \]

At \( T_j = 175 \, ^\circ\text{C} \)
**Boost operation**
neutral point IGBT (T2,T3) and half bridge FWD (D1,D2)

**Figure 25**
Reverse bias safe operating area

\[ I_C = f(V_{CE}) \]

\[ V_{GE} = f(Q_g) \]

At
\[ T_j = 25,150 \text{ °C} \]
\[ U_{comm} = U_{voltage}, U_C/2 \]
\[ V_{GE} = \pm 15 \text{ V} \]
\[ R_{gon} = 1 \text{ Ω} \]

**Figure 26**
Gate voltage vs Gate charge

At
\[ I_C = 600 \text{ A} \]

Vcc=120V
Vcc=480V
Thermistor

Figure 1

Typical NTC characteristic as a function of temperature

\[ R_T = f(T) \]
Switching Definitions Half Bridge

General conditions

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>$T_i$</td>
<td>125 °C</td>
</tr>
<tr>
<td>$R_{on}$</td>
<td>0,5 Ω</td>
</tr>
<tr>
<td>$R_{off}$</td>
<td>0,5 Ω</td>
</tr>
</tbody>
</table>

**Figure 1**

Half Bridge IGBT

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

$(t_{Eoff} = \text{integrating time for } E_{off})$

- $V_{CE}$ (0%) = -15 V
- $V_{CE}$ (100%) = 15 V
- $I_C$ (100%) = 594 A
- $t_{doff} = 0,349 \mu s$
- $t_{Eoff} = 0,767 \mu s$

**Figure 2**

Half Bridge IGBT

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

$(t_{Eon} = \text{integrating time for } E_{on})$

- $V_{CE}$ (0%) = -15 V
- $V_{CE}$ (100%) = 15 V
- $I_C$ (100%) = 700 V
- $I_C$ (100%) = 594 A
- $t_{don} = 0,256 \mu s$
- $t_{Eon} = 0,572 \mu s$

**Figure 3**

Half Bridge IGBT

Turn-off Switching Waveforms & definition of $t_f$

- $V_C$ (100%) = 700 V
- $I_C$ (100%) = 594 A
- $t_f = 0,057 \mu s$

**Figure 4**

Half Bridge IGBT

Turn-on Switching Waveforms & definition of $t_r$

- $V_C$ (100%) = 700 V
- $I_C$ (100%) = 594 A
- $t_r = 0,054 \mu s$
Switching Definitions Half Bridge

**Figure 5**  
Half Bridge IGBT  
Turn-off Switching Waveforms & definition of $t_{E_{off}}$

\[
\begin{align*}
P_{off} (100\%) &= 415.88 \text{ kW} \\
E_{off} (100\%) &= 24.11 \text{ mJ} \\
t_{E_{off}} &= 0.767 \text{ µs}
\end{align*}
\]

**Figure 6**  
Half Bridge IGBT  
Turn-on Switching Waveforms & definition of $t_{E_{on}}$

\[
\begin{align*}
P_{on} (100\%) &= 415.88 \text{ kW} \\
E_{on} (100\%) &= 17.53 \text{ mJ} \\
t_{E_{on}} &= 0.572 \text{ µs}
\end{align*}
\]

**Figure 7**  
Neutral Point FWD  
Turn-off Switching Waveforms & definition of $t_{rr}$

\[
\begin{align*}
V_{d} (100\%) &= 700 \text{ V} \\
I_{d} (100\%) &= 594 \text{ A} \\
I_{RMS} (100\%) &= -415 \text{ A} \\
t_{rr} &= 0.289 \text{ µs}
\end{align*}
\]
Switching Definitions Half Bridge

**Figure 8**  Neutral Point FWD

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

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

$I_d (100\%) = 594 \text{ A}$

$Q_{rr} (100\%) = 45,49 \text{ µC}$

$t_{Qrr} = 0,67 \text{ µs}$

**Figure 9**  Neutral Point FWD

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

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

$P_{rec} (100\%) = 415,88 \text{ kW}$

$E_{rec} (100\%) = 10,16 \text{ mJ}$

$t_{Erec} = 0,67 \text{ µs}$
Half Bridge switching measurement circuit

Figure 10

[Diagram of Half Bridge switching measurement circuit]
Switching Definitions Neutral Point

General conditions

\[
\begin{align*}
T_j &= 125 \, ^\circ\mathrm{C} \\
R_{\text{gen}} &= 1 \, \Omega \\
R_{\text{goff}} &= 1 \, \Omega
\end{align*}
\]

Figure 1 Neutral Point IGBT

Turn-off Switching Waveforms & definition of \( t_{\text{doff}} \), \( t_{\text{Eoff}} \)

\( (t_{\text{Eoff}} = \text{integrating time for } E_{\text{off}}) \)

\[
\begin{align*}
V_{\text{CE}} (0\%) &= -15 \, \text{V} \\
V_{\text{CE}} (100\%) &= 15 \, \text{V} \\
V_{\text{C}} (100\%) &= 350 \, \text{V} \\
I_{\text{C}} (100\%) &= 583 \, \text{A} \\
t_{\text{doff}} &= 0.23 \, \mu\text{s} \\
t_{\text{Eoff}} &= 0.58 \, \mu\text{s}
\end{align*}
\]

Figure 2 Neutral Point IGBT

Turn-on Switching Waveforms & definition of \( t_{\text{don}} \), \( t_{\text{Eon}} \)

\( (t_{\text{Eon}} = \text{integrating time for } E_{\text{on}}) \)

\[
\begin{align*}
V_{\text{CE}} (0\%) &= -15 \, \text{V} \\
V_{\text{CE}} (100\%) &= 15 \, \text{V} \\
V_{\text{C}} (100\%) &= 350 \, \text{V} \\
I_{\text{C}} (100\%) &= 583 \, \text{A} \\
t_{\text{don}} &= 0.274 \, \mu\text{s} \\
t_{\text{Eon}} &= 0.38 \, \mu\text{s}
\end{align*}
\]

Figure 3 Neutral Point IGBT

Turn-off Switching Waveforms & definition of \( t_f \)

\[
\begin{align*}
V_{\text{C}} (100\%) &= 350 \, \text{V} \\
I_{\text{C}} (100\%) &= 583 \, \text{A} \\
t_f &= 0.07 \, \mu\text{s}
\end{align*}
\]

Figure 4 Neutral Point IGBT

Turn-on Switching Waveforms & definition of \( t_r \)

\[
\begin{align*}
V_{\text{C}} (100\%) &= 350 \, \text{V} \\
I_{\text{C}} (100\%) &= 583 \, \text{A} \\
t_r &= 0.045 \, \mu\text{s}
\end{align*}
\]
Switching Definitions Neutral Point

**Figure 5** Neutral Point IGBT
Turn-off Switching Waveforms & definition of $t_{Eoff}$

- $P_{off}$ (100%) = 203,90 kW
- $E_{off}$ (100%) = 23,39 mJ
- $t_{Eoff}$ = 0,58 µs

**Figure 6** Neutral Point IGBT
Turn-on Switching Waveforms & definition of $t_{Eon}$

- $P_{on}$ (100%) = 203,8995 kW
- $E_{on}$ (100%) = 13,39 mJ
- $t_{Eon}$ = 0,38 µs

**Figure 7** Half Bridge FWD
Turn-off Switching Waveforms & definition of $t_{rr}$

- $V_{e}$ (100%) = 350 V
- $I_{d}$ (100%) = 583 A
- $I_{RMS}$ (100%) = -545 A
- $t_{rr}$ = 0,09 µs
Switching Definitions Neutral Point

**Figure 8**  
Half Bridge FWD  
Turn-on Switching Waveforms & definition of $t_{Q_{rr}}$  
($t_{Q_{rr}}$ = integrating time for $Q_{rr}$)

**Figure 9**  
Half Bridge FWD  
Turn-on Switching Waveforms & definition of $t_{E_{rec}}$  
($t_{E_{rec}}$ = integrating time for $E_{rec}$)

$I_d (100\%) = 583$ A  
$Q_{rr} (100\%) = 31.59$ µC  
$t_{Q_{int}} = 0.33$ µs

$P_{rec} (100\%) = 203.90$ kW  
$E_{rec} (100\%) = 7.18$ mJ  
$t_{E_{rec}} = 0.33$ µs
Neutral Point switching measurement circuit
### Ordering Code and Marking - Outline - Pinout

#### Driver pins

<table>
<thead>
<tr>
<th>Pin</th>
<th>X1</th>
<th>Y1</th>
<th>Function</th>
<th>Group</th>
<th>M6 screw</th>
<th>X3</th>
<th>Y3</th>
<th>Function</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.1</td>
<td>3.2</td>
<td>81.6</td>
<td>G1-1</td>
<td>T1</td>
<td>3.1</td>
<td>-37</td>
<td>89.8</td>
<td>TR+</td>
</tr>
<tr>
<td>1.2</td>
<td>2.8</td>
<td>81.6</td>
<td>E1-1</td>
<td>T1</td>
<td>3.2</td>
<td>-37</td>
<td>89.8</td>
<td>DC+</td>
</tr>
<tr>
<td>1.3</td>
<td>41.2</td>
<td>81.6</td>
<td>E1-2</td>
<td>T1</td>
<td>3.3</td>
<td>-37</td>
<td>89.8</td>
<td>Neutral</td>
</tr>
<tr>
<td>1.4</td>
<td>4.85</td>
<td>68.5</td>
<td>E2-1</td>
<td>T2</td>
<td>3.4</td>
<td>81.4</td>
<td>89.8</td>
<td>TR+</td>
</tr>
<tr>
<td>1.5</td>
<td>44.2</td>
<td>67.5</td>
<td>G2-1</td>
<td>T2</td>
<td>3.5</td>
<td>81.4</td>
<td>89.8</td>
<td>DC+</td>
</tr>
<tr>
<td>1.6</td>
<td>1.85</td>
<td>68.5</td>
<td>G2-2</td>
<td>T2</td>
<td>3.6</td>
<td>81.4</td>
<td>89.8</td>
<td>Neutral</td>
</tr>
<tr>
<td>1.7</td>
<td>43.2</td>
<td>67.5</td>
<td>G2-3</td>
<td>T3</td>
<td>3.7</td>
<td>81.4</td>
<td>89.8</td>
<td>DC+</td>
</tr>
<tr>
<td>1.8</td>
<td>39.2</td>
<td>67.5</td>
<td>G2-4</td>
<td>T3</td>
<td>3.8</td>
<td>81.4</td>
<td>89.8</td>
<td>Neutral</td>
</tr>
<tr>
<td>1.9</td>
<td>95.4</td>
<td>46.6</td>
<td>G3-1</td>
<td>T3</td>
<td>3.9</td>
<td>81.4</td>
<td>89.8</td>
<td>CE</td>
</tr>
<tr>
<td>1.10</td>
<td>95.4</td>
<td>49.6</td>
<td>G3-2</td>
<td>T3</td>
<td>3.10</td>
<td>81.4</td>
<td>89.8</td>
<td>Neutral</td>
</tr>
<tr>
<td>1.11</td>
<td>49.4</td>
<td>46.6</td>
<td>G3-3</td>
<td>T4</td>
<td>3.11</td>
<td>81.4</td>
<td>89.8</td>
<td>Neutral</td>
</tr>
<tr>
<td>1.12</td>
<td>49.4</td>
<td>49.6</td>
<td>E4-1</td>
<td>T4</td>
<td>3.12</td>
<td>81.4</td>
<td>89.8</td>
<td>Phase</td>
</tr>
<tr>
<td>1.13</td>
<td>44.5</td>
<td>30.7</td>
<td>G4-1</td>
<td>T4</td>
<td>3.13</td>
<td>81.4</td>
<td>89.8</td>
<td>Phase</td>
</tr>
<tr>
<td>1.14</td>
<td>44.5</td>
<td>34.7</td>
<td>G4-2</td>
<td>T4</td>
<td>3.14</td>
<td>81.4</td>
<td>89.8</td>
<td>Neutral</td>
</tr>
<tr>
<td>1.15</td>
<td>4.45</td>
<td>30.7</td>
<td>G4-3</td>
<td>T4</td>
<td>3.15</td>
<td>81.4</td>
<td>89.8</td>
<td>Neutral</td>
</tr>
<tr>
<td>1.16</td>
<td>44.5</td>
<td>34.7</td>
<td>G4-4</td>
<td>T4</td>
<td>3.15</td>
<td>81.4</td>
<td>89.8</td>
<td>Neutral</td>
</tr>
<tr>
<td>1.17</td>
<td>19.5</td>
<td>16</td>
<td>Desat-DC+</td>
<td>T5</td>
<td>3.16</td>
<td>81.4</td>
<td>89.8</td>
<td>Neutral</td>
</tr>
<tr>
<td>1.18</td>
<td>24.6</td>
<td>16</td>
<td>Desat-DC+</td>
<td>T5</td>
<td>3.17</td>
<td>81.4</td>
<td>89.8</td>
<td>Neutral</td>
</tr>
<tr>
<td>1.19</td>
<td>19.5</td>
<td>50.8</td>
<td>Desat-GND</td>
<td>T5</td>
<td>3.18</td>
<td>81.4</td>
<td>89.8</td>
<td>Neutral</td>
</tr>
<tr>
<td>1.20</td>
<td>24.6</td>
<td>50.8</td>
<td>Desat-GND</td>
<td>T5</td>
<td>3.19</td>
<td>81.4</td>
<td>89.8</td>
<td>Neutral</td>
</tr>
<tr>
<td>1.21</td>
<td>67.7</td>
<td>86.7</td>
<td>NTC</td>
<td>T6</td>
<td>3.20</td>
<td>81.4</td>
<td>89.8</td>
<td>Neutral</td>
</tr>
<tr>
<td>1.22</td>
<td>67.7</td>
<td>89.9</td>
<td>NTC</td>
<td>T6</td>
<td>3.20</td>
<td>81.4</td>
<td>89.8</td>
<td>Neutral</td>
</tr>
</tbody>
</table>

#### Low current connections

<table>
<thead>
<tr>
<th>Pin</th>
<th>X1</th>
<th>Y1</th>
<th>Function</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.1</td>
<td>90</td>
<td>2</td>
<td>81.6</td>
</tr>
<tr>
<td>1.2</td>
<td>2.8</td>
<td>81.6</td>
<td>E1-1</td>
</tr>
<tr>
<td>1.3</td>
<td>41.2</td>
<td>81.6</td>
<td>G1-2</td>
</tr>
<tr>
<td>1.4</td>
<td>4.85</td>
<td>68.5</td>
<td>E2-1</td>
</tr>
<tr>
<td>1.5</td>
<td>44.2</td>
<td>67.5</td>
<td>G2-1</td>
</tr>
<tr>
<td>1.6</td>
<td>1.85</td>
<td>68.5</td>
<td>G2-2</td>
</tr>
<tr>
<td>1.7</td>
<td>43.2</td>
<td>67.5</td>
<td>G2-3</td>
</tr>
<tr>
<td>1.8</td>
<td>39.2</td>
<td>67.5</td>
<td>G2-4</td>
</tr>
<tr>
<td>1.9</td>
<td>95.4</td>
<td>46.6</td>
<td>G3-1</td>
</tr>
<tr>
<td>1.10</td>
<td>95.4</td>
<td>49.6</td>
<td>G3-2</td>
</tr>
<tr>
<td>1.11</td>
<td>49.4</td>
<td>46.6</td>
<td>G3-3</td>
</tr>
<tr>
<td>1.12</td>
<td>49.4</td>
<td>49.6</td>
<td>E4-1</td>
</tr>
<tr>
<td>1.13</td>
<td>44.5</td>
<td>30.7</td>
<td>G4-1</td>
</tr>
<tr>
<td>1.14</td>
<td>44.5</td>
<td>34.7</td>
<td>G4-2</td>
</tr>
<tr>
<td>1.15</td>
<td>4.45</td>
<td>30.7</td>
<td>G4-3</td>
</tr>
<tr>
<td>1.16</td>
<td>44.5</td>
<td>34.7</td>
<td>G4-4</td>
</tr>
<tr>
<td>1.17</td>
<td>19.5</td>
<td>16</td>
<td>Desat-DC+</td>
</tr>
<tr>
<td>1.18</td>
<td>24.6</td>
<td>16</td>
<td>Desat-DC+</td>
</tr>
<tr>
<td>1.19</td>
<td>19.5</td>
<td>50.8</td>
<td>Desat-GND</td>
</tr>
<tr>
<td>1.20</td>
<td>24.6</td>
<td>50.8</td>
<td>Desat-GND</td>
</tr>
<tr>
<td>1.21</td>
<td>67.7</td>
<td>86.7</td>
<td>NTC</td>
</tr>
<tr>
<td>1.22</td>
<td>67.7</td>
<td>89.9</td>
<td>NTC</td>
</tr>
</tbody>
</table>

#### Power connections

<table>
<thead>
<tr>
<th>Pin</th>
<th>X1</th>
<th>Y1</th>
<th>Function</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.1</td>
<td>2.8</td>
<td>81.6</td>
<td>G1-1</td>
</tr>
<tr>
<td>1.2</td>
<td>44.2</td>
<td>81.6</td>
<td>G1-2</td>
</tr>
<tr>
<td>1.3</td>
<td>41.2</td>
<td>81.6</td>
<td>E1-2</td>
</tr>
<tr>
<td>1.4</td>
<td>4.85</td>
<td>68.5</td>
<td>E2-1</td>
</tr>
<tr>
<td>1.5</td>
<td>44.2</td>
<td>67.5</td>
<td>G2-1</td>
</tr>
<tr>
<td>1.6</td>
<td>1.85</td>
<td>68.5</td>
<td>G2-2</td>
</tr>
<tr>
<td>1.7</td>
<td>43.2</td>
<td>67.5</td>
<td>G2-3</td>
</tr>
<tr>
<td>1.8</td>
<td>39.2</td>
<td>67.5</td>
<td>G2-4</td>
</tr>
<tr>
<td>1.9</td>
<td>95.4</td>
<td>46.6</td>
<td>G3-1</td>
</tr>
<tr>
<td>1.10</td>
<td>95.4</td>
<td>49.6</td>
<td>G3-2</td>
</tr>
<tr>
<td>1.11</td>
<td>49.4</td>
<td>46.6</td>
<td>G3-3</td>
</tr>
<tr>
<td>1.12</td>
<td>49.4</td>
<td>49.6</td>
<td>E4-1</td>
</tr>
<tr>
<td>1.13</td>
<td>44.5</td>
<td>30.7</td>
<td>G4-1</td>
</tr>
<tr>
<td>1.14</td>
<td>44.5</td>
<td>34.7</td>
<td>G4-2</td>
</tr>
<tr>
<td>1.15</td>
<td>4.45</td>
<td>30.7</td>
<td>G4-3</td>
</tr>
<tr>
<td>1.16</td>
<td>44.5</td>
<td>34.7</td>
<td>G4-4</td>
</tr>
<tr>
<td>1.17</td>
<td>19.5</td>
<td>16</td>
<td>Desat-DC+</td>
</tr>
<tr>
<td>1.18</td>
<td>24.6</td>
<td>16</td>
<td>Desat-DC+</td>
</tr>
<tr>
<td>1.19</td>
<td>19.5</td>
<td>50.8</td>
<td>Desat-GND</td>
</tr>
<tr>
<td>1.20</td>
<td>24.6</td>
<td>50.8</td>
<td>Desat-GND</td>
</tr>
<tr>
<td>1.21</td>
<td>67.7</td>
<td>86.7</td>
<td>NTC</td>
</tr>
<tr>
<td>1.22</td>
<td>67.7</td>
<td>89.9</td>
<td>NTC</td>
</tr>
</tbody>
</table>

#### Diagram

![Diagram of the pinout and outline](image-url)
## Ordering Code and Marking - Outline - Pinout

### Pinout

```
<table>
<thead>
<tr>
<th>DC+</th>
<th>Neutral</th>
<th>DC-</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
```

### Identification

<table>
<thead>
<tr>
<th>ID</th>
<th>Component</th>
<th>Voltage</th>
<th>Current</th>
<th>Function</th>
<th>Comment</th>
</tr>
</thead>
<tbody>
<tr>
<td>T1,T4</td>
<td>IGBT</td>
<td>1200V</td>
<td>600A</td>
<td>Half Bridge Switch</td>
<td></td>
</tr>
<tr>
<td>D1,D4</td>
<td>FWD</td>
<td>1200V</td>
<td>300A</td>
<td>Half Bridge Diode</td>
<td></td>
</tr>
<tr>
<td>T2,T3</td>
<td>IGBT</td>
<td>600V</td>
<td>600A</td>
<td>Neutral Point Switch</td>
<td></td>
</tr>
<tr>
<td>G2,G3</td>
<td>FWD</td>
<td>600V</td>
<td>600A</td>
<td>Neutral Point Diode</td>
<td></td>
</tr>
<tr>
<td>NTC</td>
<td>NTC</td>
<td>600V</td>
<td>600A</td>
<td>Thermistor</td>
<td></td>
</tr>
</tbody>
</table>
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.