### VINcoMNPC X4

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

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

**Types**
- 70-W212NMA600NB02-M200P62

### Maximum Ratings

\( T_j = 25°C, \) 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><strong>Half bridge IGBT ( T1 , T4 )</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Collector-emitter breakdown 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_{max} ) ( T_h=80°C )</td>
<td>517</td>
<td>A</td>
</tr>
<tr>
<td>Repetitive peak collector current</td>
<td>( I_{CPUL} )</td>
<td>( t_p ) limited by ( T_j\max )</td>
<td>1200</td>
<td>A</td>
</tr>
<tr>
<td>Power dissipation</td>
<td>( P_{tot} )</td>
<td>( T_j=T_{max} ) ( T_h=80°C )</td>
<td>1051</td>
<td>W</td>
</tr>
<tr>
<td>Gate-emitter peak voltage</td>
<td>( V_{GE} )</td>
<td></td>
<td>( \pm 20 )</td>
<td>V</td>
</tr>
<tr>
<td>Short circuit ratings</td>
<td>( t_{SC} )</td>
<td>( T_j \leq 150°C ) ( V_{CE}=15V )</td>
<td>10</td>
<td>µs</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>850</td>
<td>V</td>
</tr>
<tr>
<td>Maximum Junction Temperature</td>
<td>( T_{max} )</td>
<td></td>
<td>175</td>
<td>°C</td>
</tr>
</tbody>
</table>

| **Neutral point FWD ( D2 , D3 )** | | | | |
| Peak Repetitive Reverse Voltage | \( V_{RRM} \) | | 650 | V |
| DC forward current | \( I_F \) | \( T_j=T_{max} \) \( T_h=80°C \) | 254 | A |
| Repetitive peak forward current | \( I_{FPRM} \) | \( t_p = 1 \) ms \( T_{eq} < 150°C \) | 800 | A |
| Power dissipation | \( P_{tot} \) | \( T_j=T_{max} \) \( T_h=80°C \) | 354 | W |
| Maximum Junction Temperature | \( T_{max} \) | | 175 | °C |
### Maximum Ratings

* TJ = 25°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>Neutral point IGBT ( T2 , T3 )</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Collector-emitter breakdown voltage</td>
<td>$V_{CE}$</td>
<td></td>
<td>650</td>
<td>V</td>
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<tr>
<td>DC collector current</td>
<td>$I_C$</td>
<td>$T_J=T_{J,max}$</td>
<td>344</td>
<td>A</td>
</tr>
<tr>
<td>Repetitive peak collector current</td>
<td>$I_{PSM}$</td>
<td>$t_p$ limited by $T_{J,max}$</td>
<td>1200</td>
<td>A</td>
</tr>
<tr>
<td>Power dissipation</td>
<td>$P_{tot}$</td>
<td>$T_J=T_{J,max}$</td>
<td>629</td>
<td>W</td>
</tr>
<tr>
<td>Gate-emitter peak voltage</td>
<td>$V_{CE}$</td>
<td></td>
<td>±20</td>
<td>V</td>
</tr>
<tr>
<td>Short circuit ratings</td>
<td>$t_{SC}$</td>
<td>$T_J=150°C$</td>
<td>10</td>
<td>µs</td>
</tr>
<tr>
<td></td>
<td>$V_{CC}$</td>
<td>$V_{CE}=15V$</td>
<td>360</td>
<td></td>
</tr>
<tr>
<td>Turn off safe operating area (RB SOA)</td>
<td>$I_{max}$</td>
<td>$V_{CE max} = 1200V$</td>
<td>800</td>
<td>A</td>
</tr>
<tr>
<td></td>
<td></td>
<td>$T_{J,max} = 150°C$</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Maximum Junction Temperature</td>
<td>$T_{J,max}$</td>
<td></td>
<td>175</td>
<td>°C</td>
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<tr>
<td>Half bridge FWD ( D1 , D4 )</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Peak Repetitive Reverse Voltage</td>
<td>$V_{ESM}$</td>
<td></td>
<td>1200</td>
<td>V</td>
</tr>
<tr>
<td>DC forward current</td>
<td>$I_F$</td>
<td>$T_J=T_{J,max}$</td>
<td>272</td>
<td>A</td>
</tr>
<tr>
<td>Surge forward current</td>
<td>$I_{SM}$</td>
<td>$t_p=10ms, sin 180°$</td>
<td>1100</td>
<td>A</td>
</tr>
<tr>
<td></td>
<td>$t_p$</td>
<td>$T_J=150°C$</td>
<td></td>
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</tr>
<tr>
<td>I2t-value</td>
<td>$I_{T}$</td>
<td></td>
<td>3026</td>
<td>A²s</td>
</tr>
<tr>
<td>Repetitive peak forward current</td>
<td>$I_{PSM}$</td>
<td>$t_p$ limited by $T_{J,max}$</td>
<td>1200</td>
<td>A</td>
</tr>
<tr>
<td>Power dissipation</td>
<td>$P_{tot}$</td>
<td>$T_J=T_{J,max}$</td>
<td>596</td>
<td>W</td>
</tr>
<tr>
<td>Maximum Junction Temperature</td>
<td>$T_{J,max}$</td>
<td></td>
<td>175</td>
<td>°C</td>
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### Maximum Ratings

* TJ=25°C, unless otherwise specified *

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Symbol</th>
<th>Condition</th>
<th>Value</th>
<th>Unit</th>
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<tbody>
<tr>
<td><strong>General Module Properties</strong></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><strong>Thermal Properties</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Storage temperature</td>
<td>T_{eq}</td>
<td></td>
<td>-40...+125</td>
<td>°C</td>
</tr>
<tr>
<td>Operation temperature under switching condition</td>
<td>T_{op}</td>
<td></td>
<td>-40...+(T_{jmax} - 25)</td>
<td>°C</td>
</tr>
<tr>
<td><strong>Isolation Properties</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Isolation voltage</td>
<td>V_{is}</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>
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</tbody>
</table>
## Characteristic Values

### Half bridge IGBT (T1, T4)

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Symbol</th>
<th>Value</th>
<th>Unit</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gate emitter threshold voltage</td>
<td>( V_{ces} )</td>
<td>( V_{ces} = V_{ce} )</td>
<td>0.03</td>
</tr>
<tr>
<td>Collector-emitter saturation voltage</td>
<td>( V_{ces} )</td>
<td>15</td>
<td>600</td>
</tr>
<tr>
<td>Collector-emitter cut-off current incl. FWD</td>
<td>( I_{ces} )</td>
<td>0</td>
<td>1200</td>
</tr>
<tr>
<td>Gate-emitter leakage current</td>
<td>( I_{ce} )</td>
<td>20</td>
<td>0</td>
</tr>
<tr>
<td>Integrated Gate resistor</td>
<td>( R_{gst} )</td>
<td>0.03</td>
<td>6</td>
</tr>
<tr>
<td>Turn-off delay time</td>
<td>( t_{off} )</td>
<td>9.4</td>
<td>2.11</td>
</tr>
<tr>
<td>Thermal resistance junction to sink</td>
<td>( R_{ies} )</td>
<td>0.0032</td>
<td>0.15</td>
</tr>
<tr>
<td>Turn-on energy loss</td>
<td>( E_{on} )</td>
<td>0</td>
<td>1500</td>
</tr>
<tr>
<td>Reverse transfer capacitance</td>
<td>( C_{e} )</td>
<td>0.09</td>
<td>0.11</td>
</tr>
</tbody>
</table>

### Neutral point FWD (D2, D3)

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Symbol</th>
<th>Value</th>
<th>Unit</th>
</tr>
</thead>
<tbody>
<tr>
<td>Forward voltage</td>
<td>( V_{f} )</td>
<td>400</td>
<td>( V )</td>
</tr>
<tr>
<td>Peak reverse recovery current</td>
<td>( i_{f} )</td>
<td>6,4</td>
<td>( mA )</td>
</tr>
<tr>
<td>Reverse recovery time</td>
<td>( t_{f} )</td>
<td>9</td>
<td>( ns )</td>
</tr>
<tr>
<td>Reverse recovered charge</td>
<td>( Q_{f} )</td>
<td>18</td>
<td>( \mu C )</td>
</tr>
<tr>
<td>Peak rate of fall of recovery current</td>
<td>( dV/dt )</td>
<td>2050</td>
<td>1027</td>
</tr>
<tr>
<td>Reverse recovered energy</td>
<td>( E_{rec} )</td>
<td>7</td>
<td>7</td>
</tr>
<tr>
<td>Thermal resistance junction to sink</td>
<td>( R_{ies} )</td>
<td>0.27</td>
<td>( K/W )</td>
</tr>
<tr>
<td>Reverse transfer capacitance</td>
<td>( C_{e} )</td>
<td>0.31</td>
<td>( K/W )</td>
</tr>
</tbody>
</table>

### Neutral point IGBT (T2, T3)

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Symbol</th>
<th>Value</th>
<th>Unit</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gate emittor threshold voltage</td>
<td>( V_{ces} )</td>
<td>( V_{ces} = V_{ce} )</td>
<td>0.0032</td>
</tr>
<tr>
<td>Collector-emitter saturation voltage</td>
<td>( V_{ces} )</td>
<td>15</td>
<td>400</td>
</tr>
<tr>
<td>Collector-emitter cut-off inc FWD</td>
<td>( I_{ces} )</td>
<td>0</td>
<td>650</td>
</tr>
<tr>
<td>Gate-emitter leakage current</td>
<td>( I_{ce} )</td>
<td>20</td>
<td>0</td>
</tr>
<tr>
<td>Integrated Gate resistor</td>
<td>( R_{gst} )</td>
<td>1</td>
<td>( \Omega )</td>
</tr>
<tr>
<td>Turn-on delay time</td>
<td>( t_{on} )</td>
<td>9.4</td>
<td>2.11</td>
</tr>
<tr>
<td>Rise time</td>
<td>( t_{r} )</td>
<td>44</td>
<td>49</td>
</tr>
<tr>
<td>Turn-off delay time</td>
<td>( t_{off} )</td>
<td>9.4</td>
<td>2.11</td>
</tr>
<tr>
<td>Fall time</td>
<td>( t_{f} )</td>
<td>9</td>
<td>( \mu s )</td>
</tr>
<tr>
<td>Input capacitance</td>
<td>( C_{e} )</td>
<td>24640</td>
<td>( mW )</td>
</tr>
<tr>
<td>Output capacitance</td>
<td>( C_{e} )</td>
<td>1536</td>
<td>( pF )</td>
</tr>
<tr>
<td>Gate charge</td>
<td>( Q_{d} )</td>
<td>0.15</td>
<td>( K/W )</td>
</tr>
<tr>
<td>Reverse transfer capacitance</td>
<td>( C_{e} )</td>
<td>0.17</td>
<td>( K/W )</td>
</tr>
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</table>
## Characteristic Values

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Symbol</th>
<th>Conditions</th>
<th>Value</th>
<th>Unit</th>
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</thead>
<tbody>
<tr>
<td>Half bridge FWD (D1, D4)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>FWD forward voltage</td>
<td>$V_{GE}$</td>
<td>$T_J=25^\circ C$, $T_J=125^\circ C$</td>
<td>2.19, 2.47</td>
<td>V</td>
</tr>
<tr>
<td>Reverse leakage current</td>
<td>$I_L$</td>
<td>$T_J=25^\circ C$, $T_J=125^\circ C$</td>
<td>48</td>
<td>$\mu A$</td>
</tr>
<tr>
<td>Peak reverse recovery current</td>
<td>$I_{RRM}$</td>
<td>$T_J=25^\circ C$, $T_J=125^\circ C$</td>
<td>448, 568</td>
<td>A</td>
</tr>
<tr>
<td>Reverse recovery time</td>
<td>$t_{RR}$</td>
<td>$T_J=25^\circ C$, $T_J=125^\circ C$</td>
<td>70, 138</td>
<td>ns</td>
</tr>
<tr>
<td>Reverse recovered charge</td>
<td>$Q_{rec}$</td>
<td>$T_J=25^\circ C$, $T_J=125^\circ C$</td>
<td>1.9, 63</td>
<td>$\mu C$</td>
</tr>
<tr>
<td>Peak rate of fall of recovery current</td>
<td>$R_{MIN} \times 350$</td>
<td>$T_J=25^\circ C$, $T_J=125^\circ C$</td>
<td>20142, 14965</td>
<td>A/µs</td>
</tr>
<tr>
<td>Reverse recovery energy</td>
<td>$E_{rec}$</td>
<td>$T_J=25^\circ C$, $T_J=125^\circ C$</td>
<td>6, 13</td>
<td>mWs</td>
</tr>
<tr>
<td>Thermal resistance junction to sink</td>
<td>$R_{thJH}$</td>
<td>100µm preapplied PCM</td>
<td>0.16</td>
<td>K/W</td>
</tr>
<tr>
<td>Thermal resistance junction to case</td>
<td>$R_{thJH}$</td>
<td>100µm grease 1W/mK</td>
<td>0.18</td>
<td>K/W</td>
</tr>
<tr>
<td>Thermistor</td>
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<td>$T_J=25^\circ C$, $T_J=100^\circ C$</td>
<td>22000</td>
<td>Ω</td>
</tr>
<tr>
<td>Rated resistance</td>
<td>$R$</td>
<td>$T_J=25^\circ C$</td>
<td>1486</td>
<td>Ω</td>
</tr>
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<td>Deviation of $R_{thJH}$</td>
<td>$\Delta R/R$</td>
<td>$T_J=100^\circ C$</td>
<td>-12, +14</td>
<td>%</td>
</tr>
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<td>Power dissipation</td>
<td>$P$</td>
<td>$T_J=25^\circ C$</td>
<td>200</td>
<td>mW</td>
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<tr>
<td>Power dissipation constant</td>
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<td>$T_J=25^\circ C$</td>
<td>2</td>
<td>mW/K</td>
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<tr>
<td>B-value</td>
<td>$R_{100}=1486$</td>
<td>$T_J=25^\circ C$</td>
<td>1.0</td>
<td>K</td>
</tr>
<tr>
<td>Vincotech NTC Reference</td>
<td></td>
<td>$T_J=25^\circ C$</td>
<td>0.16</td>
<td>K/W</td>
</tr>
<tr>
<td>Module Properties</td>
<td></td>
<td>$T_J=25^\circ C$, per switch</td>
<td>1.5</td>
<td>mΩ</td>
</tr>
<tr>
<td>Module inductance (from chips to PCB)</td>
<td>$L_{sCE,PCB}$</td>
<td>$T_J=25^\circ C$, per switch</td>
<td>5</td>
<td>nH</td>
</tr>
<tr>
<td>Module inductance (from PCB to PCB using Intercon board)</td>
<td>$L_{sCE,PCB,IN}$</td>
<td>$T_J=25^\circ C$, per switch</td>
<td>3</td>
<td>nH</td>
</tr>
<tr>
<td>Resistance of Intercon boards (from PCB to PCB using Intercon board)</td>
<td>$R_{0IN,MIN}$</td>
<td>$T_J=25^\circ C$, per switch</td>
<td>1.5</td>
<td>mΩ</td>
</tr>
<tr>
<td>Mounting torque</td>
<td>$M$</td>
<td>Screw M4 - mounting according to valid application note VINcoX-* HH</td>
<td>2, 2.2</td>
<td>Nm</td>
</tr>
<tr>
<td>Mounting torque</td>
<td>$M$</td>
<td>Screw M5 - mounting according to valid application note VINcoX-* HH</td>
<td>4, 6</td>
<td>Nm</td>
</tr>
<tr>
<td>Terminal connection torque</td>
<td>$M$</td>
<td>Screw M6 - mounting according to valid application note VINcoX-* HH</td>
<td>2.5, 5</td>
<td>Nm</td>
</tr>
<tr>
<td>Weight</td>
<td>$G$</td>
<td></td>
<td>710</td>
<td>g</td>
</tr>
</tbody>
</table>
Buck operation
Half Bridge IGBT (T1,T4) and Neutral Point FWD (D2,D3)

**Figure 1**
Typical output characteristics Vge=15V
\[ I_C = f(V_{CE}) \]

At
- \( t_p = 350 \ \mu s \)
- \( T_J = 25/125/150 \ ^\circ C \)
- \( V_{GE} = 15 \ \text{V} \)

**Figure 2**
Typical output characteristics
\[ I_C = f(V_{CE}) \]

At
- \( t_p = 350 \ \mu s \)
- \( T_J = 150 \ ^\circ C \)
- \( V_{CE} \) from 7 V to 17 V in steps of 1 V

**Figure 3**
Typical transfer characteristics
\[ I_C = f(V_{GE}) \]

**Figure 4**
Typical FWD forward current as a function of forward voltage
\[ I_F = f(V_F) \]

At
- \( t_p = 350 \ \mu s \)
- \( V_{CE} = 350 \ \text{V} \)
- \( T_J = 25/125/150 \ ^\circ C \)
**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

\[ E = f(I_C) \]

![Figure 5 Plot](image)

With an inductive load at:

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

**Figure 6**

Typical switching energy losses as a function of gate resistor

\[ E = f(R_G) \]

![Figure 6 Plot](image)

With an inductive load at:

- \( T_J = 25/125/150 \) °C
- \( V_{CE} = 350 \) V
- \( V_{GE} = \pm 15 \) V
- \( I_C = 601 \) A

**Figure 7**

Typical reverse recovery energy loss as a function of collector current

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

![Figure 7 Plot](image)

With an inductive load at:

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

**Figure 8**

Typical reverse recovery energy loss as a function of gate resistor

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

![Figure 8 Plot](image)

With an inductive load at:

- \( T_J = 25/125/150 \) °C
- \( V_{CE} = 350 \) V
- \( V_{GE} = \pm 15 \) V
- \( I_C = 601 \) 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
- \( T_J = 125 \text{ °C} \)
- \( V_{CE} = 350 \text{ V} \)
- \( V_{GE} = \pm 15 \text{ V} \)
- \( R_{gon} = 0.5 \text{ Ω} \)
- \( R_{goff} = 0.5 \text{ Ω} \)

**Figure 10**
Typical switching times as a function of gate resistor
\[ t = f(R_G) \]

With an inductive load at
- \( T_J = 125 \text{ °C} \)
- \( V_{CE} = 350 \text{ V} \)
- \( V_{GE} = \pm 15 \text{ V} \)
- \( I_C = 601 \text{ A} \)

**Figure 11**
Typical reverse recovery time as a function of collector current
\[ t_{rr} = f(I_C) \]

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

**Figure 12**
Typical reverse recovery time as a function of IGBT turn on gate resistor
\[ t_{rr} = f(R_{gon}) \]

At
- \( T_J = 25/125/150 \text{ °C} \)
- \( V_A = 350 \text{ V} \)
- \( I_F = 601 \text{ A} \)
- \( V_{GE} = \pm 15 \text{ V} \)
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

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

![Graph showing typical reverse recovery charge as a function of collector current.](image)

**At**
- \( T_J = 25/125/150 \, ^\circ C \)
- \( V_{CE} = 350 \, V \)
- \( V_{GE} = \pm 15 \, V \)
- \( R_{gon} = 0,5 \, \Omega \)

**Figure 14**
Typical reverse recovery charge as a function of IGBT turn on gate resistor

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

![Graph showing typical reverse recovery charge as a function of gate resistor.](image)

**At**
- \( T_J = 25/125/150 \, ^\circ C \)
- \( V_R = 350 \, V \)
- \( I_F = 601 \, A \)
- \( V_{GE} = \pm 15 \, V \)

**Figure 15**
Typical reverse recovery current as a function of collector current

\[ I_{RRM} = f(I_C) \]

![Graph showing typical reverse recovery current as a function of collector current.](image)

**At**
- \( T_J = 25/125/150 \, ^\circ C \)
- \( V_{CE} = 350 \, V \)
- \( V_{GE} = \pm 15 \, V \)
- \( R_{gon} = 0,5 \, \Omega \)

**Figure 16**
Typical reverse recovery current as a function of IGBT turn on gate resistor

\[ I_{RRM} = f(R_{gon}) \]

![Graph showing typical reverse recovery current as a function of gate resistor.](image)

**At**
- \( T_J = 25/125/150 \, ^\circ C \)
- \( V_R = 350 \, V \)
- \( I_F = 601 \, A \)
- \( V_{GE} = \pm 15 \, V \)
**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

\[ \frac{dI}{dt}, \frac{dI_{\text{rec}}}{dt} = f(I_c) \]

**Figure 18**

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

\[ \frac{dI}{dt}, \frac{dI_{\text{rec}}}{dt} = f(R_{\text{gon}}) \]

- **At**
  - \( T_j = 25/125/150 \, ^\circ\text{C} \)
  - \( V_{CE} = 350 \, \text{V} \)
  - \( V_{GE} = \pm 15 \, \text{V} \)
  - \( R_{\text{gon}} = 1.0 \, \Omega \)

**Figure 19**

IGBT transient thermal impedance as a function of pulse width

\[ Z_{\text{thJH}} = f(t_p) \]

**Figure 20**

FWD transient thermal impedance as a function of pulse width

\[ Z_{\text{thJH}} = f(t_p) \]

- **At**
  - \( T_j = 25/125/150 \, ^\circ\text{C} \)
  - \( V_{CE} = 350 \, \text{V} \)
  - \( I_F = 601 \, \text{A} \)
  - \( V_{GE} = \pm 15 \, \text{V} \)

---

**Table:**

<table>
<thead>
<tr>
<th>Preapplied PCM</th>
<th>Thermal grease</th>
<th>FWD thermal model values</th>
</tr>
</thead>
<tbody>
<tr>
<td>100um prepai</td>
<td>0.09 K/W</td>
<td>0.27 K/W</td>
</tr>
<tr>
<td>lled PCM</td>
<td>R (K/W) Tau (s)</td>
<td>R (K/W) Tau (s)</td>
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<td>4,16E-02</td>
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<tr>
<td>1,69E-03</td>
<td>5,94E-03</td>
<td>2,06E-03</td>
</tr>
</tbody>
</table>

---

Copyright Vincotech
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

\[ T_j = 175 \, ^\circ\text{C} \]

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

\[ I_C = f(T_h) \]

At

\[ T_j = 175 \, ^\circ\text{C} \]

\[ V_{GE} = 15 \, \text{V} \]

**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

\[ T_j = 175 \, ^\circ\text{C} \]
**Buck operation**

Half Bridge IGBT (T1,T4) and Neutral Point FWD (D2,D3)

**Figure 21**

IGBT

Reverse bias safe operating area

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

At

\[T_j = 25, 150 \, ^\circ C\]

\[U_{ominus} = U_{oplus} = U_{oc}/2\]

\[V_{GE} = \pm 15 \, V\]

\[R_{gon} = 1 \, \Omega\]

Switching mode: 3 level cont, 2 level dashed
Boost operation
Neutral point IGBT (T2,T3) and Half bridge FWD (D1,D4)

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

At
- $t_p = 350 \ \mu s$
- $T_j = 25/125/150 \ ^\circ C$
- $V_{ce}= 15 \ \text{V}$

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

At
- $t_p = 350 \ \mu s$
- $T_j = 151 \ ^\circ C$
- $V_{ce}$ from 7 V to 17 V in steps of 1 V

**Figure 3**
Typical transfer characteristics $I_C = f(V_{ge})$

At
- $t_p = 350 \ \mu s$
- $V_{ce} = 350 \ \text{V}$
- $T_j = 25/125/150 \ ^\circ C$

**Figure 4**
Typical FWD forward current as a function of forward voltage $I_F = f(V_F)$

At
- $t_p = 350 \ \mu s$
- $T_j = 25/125/150 \ ^\circ C$
Boost operation
Neutral point IGBT (T2,T3) and Half bridge FWD (D1,D4)

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

With an inductive load at
\[ T_J = 25/125/150 \, ^\circ C \]
\[ V_{CE} = 350 \, V \]
\[ V_{GE} = \pm 15 \, V \]
\[ R_{gon} = 1,0 \, \Omega \]
\[ R_{goff} = 1 \, \Omega \]

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

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

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

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

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

With an inductive load at
\[ T_J = 25/125/150 \, ^\circ C \]
\[ V_{CE} = 350 \, V \]
\[ V_{GE} = \pm 15 \, V \]
\[ I_C = 600 \, A \]
Boost operation
Neutral point IGBT (T2,T3) and Half bridge FWD (D1,D4)

**Figure 9** IGBT
Typical switching times as a function of collector current
\[ t = f(I_C) \]

With an inductive load at
- \( T_j = 126 \, ^\circ C \)
- \( V_{CE} = 350 \, V \)
- \( V_{GE} = \pm 15 \, V \)
- \( R_{gon} = 1 \, \Omega \)
- \( R_{goff} = 1 \, \Omega \)

**Figure 10** IGBT
Typical switching times as a function of gate resistor
\[ t = f(R_G) \]

With an inductive load at
- \( T_j = 126 \, ^\circ C \)
- \( V_{CE} = 350 \, V \)
- \( V_{GE} = \pm 15 \, V \)
- \( I_C = 600 \, A \)

**Figure 11** FWD
Typical reverse recovery time as a function of collector current
\[ t_{rr} = f(I_C) \]

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

**Figure 12** FWD
Typical reverse recovery time as a function of IGBT turn on gate resistor
\[ t_{rr} = f(R_{gon}) \]

At
- \( T_j = 25/125/150 \, ^\circ C \)
- \( V_R = 350 \, V \)
- \( I_F = 600 \, A \)
- \( V_{GE} = \pm 15 \, V \)
Boost operation
Neutral point IGBT (T2,T3) and Half bridge FWD (D1,D4)

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

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

- 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
\[ I_{RRM} = f(I_C) \]

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
  - \( V_R = 350 \) V
  - \( I_F = 600 \) A
  - \( V_{GE} = \pm 15 \) V
Figure 17
Typical rate of fall of forward and reverse recovery current as a function of collector current

\[
dI_o/dt, dI_{rec}/dt = f(I_{C})
\]

At

\[
T_j = 25/125/150 \ ^\circ C
\]
\[
V_{CE} = 350 \ V
\]
\[
V_{GE} = \pm 15 \ V
\]
\[
R_{gon} = 1 \ \Omega
\]

Figure 18
Typical rate of fall of forward and reverse recovery current as a function of IGBT turn on gate resistor

\[
dI_o/dt, dI_{rec}/dt = f(R_{gon})
\]

At

\[
T_j = 25/125/150 \ ^\circ C
\]
\[
V_R = 350 \ V
\]
\[
I_F = 600 \ A
\]
\[
V_{GE} = \pm 15 \ V
\]

Figure 19
IGBT transient thermal impedance as a function of pulse width

\[
Z_{thJH} = f(t_p)
\]

At

\[
D = tp / T
\]

Preapplied PCM

\[
R_{thJH} = 0,15 \ K/W \quad R_{thKH} = 0,17 \ K/W
\]

100um preapplied PCM

<table>
<thead>
<tr>
<th>R (K/W)</th>
<th>Tau (s)</th>
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<tbody>
<tr>
<td>1,46E-02</td>
<td>5,01E+00</td>
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<tr>
<td>2,63E-02</td>
<td>1,17E+00</td>
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<td>3,34E-02</td>
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<td>2,23E-02</td>
<td>1,51E-02</td>
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<tr>
<td>1,07E-02</td>
<td>1,59E-03</td>
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</tbody>
</table>

100um grease 1W/mK (P12)

<table>
<thead>
<tr>
<th>R (K/W)</th>
<th>Tau (s)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1,46E-02</td>
<td>5,01E+00</td>
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<tr>
<td>2,63E-02</td>
<td>1,17E+00</td>
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<td>3,34E-02</td>
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<td>5,42E-02</td>
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<tr>
<td>2,23E-02</td>
<td>1,51E-02</td>
</tr>
<tr>
<td>1,07E-02</td>
<td>1,59E-03</td>
</tr>
</tbody>
</table>

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Boost operation
Neutral point IGBT (T2,T3) and Half bridge FWD (D1,D4)

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

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

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

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

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

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

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

At
\[ T_j = 175 \, ^\circ C \]
Boost operation
Neutral point IGBT (T2,T3) and Half bridge FWD (D1,D4)

**Figure 25**
Reverse bias safe operating area

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

At
\[ T_j = \frac{25}{150} °C \]
\[ U_{ominus}=U_{oplus}+U_c/2 \]
\[ V_{GE} = \pm 15 \text{ V} \]
\[ R_{gon} = 1 \text{ Ω} \]

**Figure 22**
Gate voltage vs Gate charge

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

At
\[ I_c = 400 \text{ A} \]
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>TJ</th>
<th>125 °C</th>
</tr>
</thead>
<tbody>
<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 $t_{doff}$, $t_{Eoff}$

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

![Image](image1)

$V_{GE}(0\%) = -15 \text{ V}$
$V_{GE}(100\%) = 15 \text{ V}$
$V_{C}(100\%) = 350 \text{ V}$
$I_{C}(100\%) = 599 \text{ A}$
$t_{doff} = 0,27 \mu s$
$t_{Eoff} = 0,97 \mu s$

**Figure 2**

Half Bridge IGBT

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

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

![Image](image2)

$V_{GE}(0\%) = -15 \text{ V}$
$V_{GE}(100\%) = 15 \text{ V}$
$V_{C}(100\%) = 350 \text{ V}$
$I_{C}(100\%) = 599 \text{ A}$
$t_{don} = 0,34 \mu s$
$t_{Eon} = 0,80 \mu s$

**Figure 3**

Half Bridge IGBT

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

![Image](image3)

$V_{C}(100\%) = 350 \text{ V}$
$I_{C}(100\%) = 599 \text{ A}$
$t_{f} = 0,07 \mu s$

**Figure 4**

Half Bridge IGBT

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

![Image](image4)

$V_{C}(100\%) = 350 \text{ V}$
$I_{C}(100\%) = 599 \text{ A}$
$t_{r} = 0,09 \mu s$
Swiching Definitions Half Bridge

**Figure 5**
Half Bridge IGBT
Turn-off Switching Waveforms & definition of t\(_{\text{off}}\)

- \(P_{\text{off}}\) (100%) = 209,70 kW
- \(E_{\text{off}}\) (100%) = 26,34 mJ
- \(t_{\text{off}}\) = 0,97 μs

**Figure 6**
Half Bridge IGBT
Turn-on Switching Waveforms & definition of t\(_{\text{on}}\)

- \(P_{\text{on}}\) (100%) = 209,70 kW
- \(E_{\text{on}}\) (100%) = 33,64 mJ
- \(t_{\text{on}}\) = 0,80 μs

**Figure 7**
Half Bridge IGBT
Gate voltage vs Gate charge (measured)

- \(V_{\text{GEoff}}\) = -15 V
- \(V_{\text{GEon}}\) = 15 V
- \(V_{\text{CE3}}\) (100%) = 350 V
- \(I_{\text{C}}\) (100%) = 599 A
- \(Q_{g}\) = 2710,20 nC

**Figure 8**
Neutral Point FWD
Turn-off Switching Waveforms & definition of \(t_{\text{r}}\)

- \(V_{\text{G}}\) (100%) = 350 V
- \(I_{\text{d}}\) (100%) = 599 A
- \(I_{\text{RRM}}\) (100%) = -192 A
- \(t_{\text{r}}\) = 0,42 μs
Switching Definitions Half Bridge

**Figure 9** Neutral Point FWD
Turn-on Switching Waveforms & definition of $t_{Qrr}$
($t_{Qrr}$ = integrating time for $Q_{rr}$)

![Graph showing turn-on switching waveforms](image-url)

$I_d (100\%) = 599$ A  
$Q_{rr} (100\%) = 34,86$ μC  
$t_{Qrr} = 0,85$ μs

**Figure 10** Neutral Point FWD
Turn-on Switching Waveforms & definition of $t_{Erec}$
($t_{Erec}$ = integrating time for $E_{rec}$)

![Graph showing turn-on switching waveforms](image-url)

$P_{rec} (100\%) = 209,70$ kW  
$E_{rec} (100\%) = 6,58$ mJ  
$t_{Erec} = 0,85$ μs
Half Bridge switching measurement circuit

Figure 11
Switching Definitions Neutral Point

General conditions

<table>
<thead>
<tr>
<th>$T_J$</th>
<th>125 °C</th>
</tr>
</thead>
<tbody>
<tr>
<td>$R_{on}$</td>
<td>1 Ω</td>
</tr>
<tr>
<td>$R_{off}$</td>
<td>1 Ω</td>
</tr>
</tbody>
</table>

**Figure 1**
Neutral Point IGBT
Turn-off Switching Waveforms & definition of $t_{off}$, $t_{on}$
($t_{off}$ = integrating time for $E_{off}$)

**Figure 2**
Neutral Point IGBT
Turn-on Switching Waveforms & definition of $t_{on}$, $t_{off}$
($t_{on}$ = integrating time for $E_{on}$)

**Figure 3**
Neutral Point IGBT
Turn-off Switching Waveforms & definition of $t_{f}$

**Figure 4**
Neutral Point IGBT
Turn-on Switching Waveforms & definition of $t_{r}$

---

$V_{CE} (0\%) = -15 \text{ V}$
$V_{CE} (100\%) = 15 \text{ V}$
$V_C (100\%) = 350 \text{ V}$
$I_C (100\%) = 601 \text{ A}$
$t_{off} = 0,23 \mu$ s
$t_{on} = 0,58 \mu$ s

$V_C (100\%) = 350 \text{ V}$
$I_C (100\%) = 601 \text{ A}$
$t_{f} = 0,106 \mu$ s

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Switching Definitions Neutral Point

**Figure 5** Neutral Point IGBT
Turn-off Switching Waveforms & definition of t\(_{\text{off}}\)

- \(P_{\text{off}}\) (100%) = 210,20 kW
- \(E_{\text{off}}\) (100%) = 27,94 mJ
- \(t_{\text{off}}\) = 0,58 \(\mu\)s

**Figure 6** Neutral Point IGBT
Turn-on Switching Waveforms & definition of t\(_{\text{on}}\)

- \(P_{\text{on}}\) (100%) = 210,204 kW
- \(E_{\text{on}}\) (100%) = 13,39 mJ
- \(t_{\text{on}}\) = 0,38 \(\mu\)s

**Figure 7** Neutral Point IGBT
Gate voltage vs Gate charge (measured)

- \(V_{\text{Goff}}\) = 15 V
- \(V_{\text{Gon}}\) = 15 V
- \(V_{\text{C}}\) (100%) = 350 V
- \(I_{\text{C}}\) (100%) = 601 A
- \(Q_{\text{G}}\) = 3441,54 nC

**Figure 8** Half Bridge FWD
Turn-off Switching Waveforms & definition of \(t_{\text{rr}}\)

- \(V_{\text{G(on)}}\) = 350 V
- \(I_{\text{d}}\) (100%) = 601 A
- \(I_{\text{RRM}}\) (100%) = 540 A
- \(t_{\text{rr}}\) = 0,14 \(\mu\)s
Switching Definitions Neutral Point

**Figure 9**
Half Bridge FWD
Turn-on Switching Waveforms & definition of $t_{Qrr}$
($t_{Qrr} = \text{integrating time for } Q_{rr}$)

$\begin{align*}
I_d (100\%) &= 601 \text{ A} \\
Q_{rr} (100\%) &= 51,60 \mu \text{C} \\
t_{Qint} &= 0,33 \mu \text{s}
\end{align*}$

**Figure 10**
Half Bridge FWD
Turn-on Switching Waveforms & definition of $t_{Erec}$
($t_{Erec} = \text{integrating time for } E_{rec}$)

$\begin{align*}
P_{rec} (100\%) &= 210,20 \text{ kW} \\
E_{rec} (100\%) &= 12,97 \text{ mJ} \\
t_{Erec} &= 0,33 \mu \text{s}
\end{align*}$
Neutral Point switching measurement circuit

Figure 11
### Component Voltage Current

<table>
<thead>
<tr>
<th>Component</th>
<th>Voltage</th>
<th>Current</th>
<th>Function</th>
<th>Comment</th>
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<td>1200 V</td>
<td>600 A</td>
<td>Buck Switch</td>
<td></td>
</tr>
<tr>
<td>IGBT 2</td>
<td>650 V</td>
<td>400 A</td>
<td>Boost Switch</td>
<td></td>
</tr>
<tr>
<td>FWD 3</td>
<td>650 V</td>
<td>400 A</td>
<td>Buck Diode</td>
<td></td>
</tr>
<tr>
<td>FWD 4</td>
<td>1200 V</td>
<td>400 A</td>
<td>Boost Diode</td>
<td></td>
</tr>
<tr>
<td>NTC</td>
<td></td>
<td></td>
<td>Thermistor</td>
<td></td>
</tr>
</tbody>
</table>

### Ordering Code and Marking - Outline - 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
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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.