VINcoMNPC X4

**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-W212NMA300SC-M208P

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**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><strong>Buck Switch (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>$T_j = T_{j\max}$, $T_s = 80 , ^\circ C$</td>
<td>270</td>
<td>A</td>
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<tr>
<td>Repetitive peak collector current</td>
<td>$I_{PSM}$</td>
<td>$I_s$ limited by $T_{j\max}$</td>
<td>900</td>
<td>A</td>
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<tr>
<td>Power dissipation</td>
<td>$P_{tot}$</td>
<td>$T_j = T_{j\max}$, $T_s = 80 , ^\circ C$</td>
<td>646</td>
<td>W</td>
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<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>$T_j \leq 150 , ^\circ C$, $V_{DC} = 15 , V$</td>
<td>10</td>
<td>µs</td>
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<tr>
<td></td>
<td>$V_{CE}$</td>
<td></td>
<td>800</td>
<td>V</td>
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<tr>
<td>Turn off safe operating area (RBSOA)</td>
<td>$I_{olim}$</td>
<td>$V_{CE, \text{max}} = 1200 , V$, $T_j, T_{j\max} = 150 , ^\circ C$</td>
<td>600</td>
<td>A</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><strong>Boost Diode (D2, D3)</strong></td>
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<tr>
<td>Peak Repetitive Reverse Voltage</td>
<td>$V_{RSM}$</td>
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<td>600</td>
<td>V</td>
</tr>
<tr>
<td>DC forward current</td>
<td>$I_F$</td>
<td>$T_j = T_{j\max}$, $T_s = 80 , ^\circ C$</td>
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<td>A</td>
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<td>Surge forward current</td>
<td>$I_{FSM}$</td>
<td>$I_s = 10 , ms$, sine halfwave</td>
<td>698</td>
<td>A</td>
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<td>T²-value</td>
<td>$t^2$</td>
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<td>2440</td>
<td>A²s</td>
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<td>Repetitive peak forward current</td>
<td>$I_{PFM}$</td>
<td>$I_p = 1 , ms$, $T_j &lt; 150 , ^\circ C$</td>
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<td>A</td>
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<tr>
<td>Power dissipation per FWD</td>
<td>$P_{tot}$</td>
<td>$T_j = T_{j\max}$, $T_s = 80 , ^\circ C$</td>
<td>357</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>
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<th>Condition</th>
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<tbody>
<tr>
<td><strong>Boost Switch (T2, T3)</strong></td>
<td></td>
<td></td>
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<td></td>
</tr>
<tr>
<td>Collector-emitter breakdown voltage</td>
<td>VCE</td>
<td>Tj = Tjmax</td>
<td>600</td>
<td>V</td>
</tr>
<tr>
<td>DC collector current</td>
<td>ICC</td>
<td>TJ = Tjmax</td>
<td>252</td>
<td>A</td>
</tr>
<tr>
<td>Repetitive peak collector current</td>
<td>ICCRPM</td>
<td>TJ limited by Tjmax</td>
<td>900</td>
<td>A</td>
</tr>
<tr>
<td>Power dissipation</td>
<td>Ptot</td>
<td>TJ = Tjmax</td>
<td>476</td>
<td>W</td>
</tr>
<tr>
<td>Gate-emitter peak voltage</td>
<td>VGE</td>
<td>TJ ≤ 150 °C</td>
<td>±20</td>
<td>V</td>
</tr>
<tr>
<td>Short circuit ratings</td>
<td>EDC</td>
<td>TJ ≤ 150 °C</td>
<td>6</td>
<td>µs</td>
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<tr>
<td>Turn off safe operating area (RBSDA)</td>
<td>IDSS</td>
<td>VGS = 15 V</td>
<td>360</td>
<td>V</td>
</tr>
<tr>
<td>Maximum Junction Temperature</td>
<td>Tjmax</td>
<td></td>
<td>175</td>
<td>°C</td>
</tr>
</tbody>
</table>

| **Buck Diode (D1, D4)** | | | | |
| Peak Repetitive Reverse Voltage | VBRM | TJ = Tjmax | 1200 | V |
| DC forward current | IF | TJ = Tjmax | 222 | A |
| Surge forward current | IFSM | TJ = 10ms, sin 180° | 1720 | A |
| T²-value | J²t | Tj = 150°C | 3700 | A²s |
| Repetitive peak forward current | IFDM | TJ limited by Tjmax | 900 | A |
| Power dissipation per PWD | Ptot | TJ = Tjmax | 476 | W |
| Maximum Junction Temperature | Tjmax | | 175 | °C |

| **DC link Capacitor** | | | | |
| Max. DC voltage | VMAX | TJ = 25°C | 630 | V |

| **General Module Properties** | | | | |
| Material of module baseplate | | | Cu |
| Material of internal isolation | | | A203 |

| **Thermal Properties** | | | | |
| Storage temperature | TS | | -40...+125 | °C |
| Operation temperature under switching condition | TOP | | -40...+(Tjmax - 25) | °C |

| **Isolation Properties** | | | | |
| Isolation voltage | VISO | DC Test Voltage* | 6000 | V |
| AC Voltage | | | 2500 | V |
| Creepage distance | | | min 12,7 | mm |
| Clearance | | | min 12,7 | mm |
| Comparative Tracking Index | CTI | | >200 |

*100% tested in production
### 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><strong>Buck Switch (T1, T4)</strong></td>
<td></td>
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<td></td>
</tr>
<tr>
<td>Gate-emitter threshold voltage</td>
<td>V (_{GE(th)})</td>
<td>V (<em>{GE} = V (</em>{CE} )</td>
<td>0,012</td>
<td>25</td>
</tr>
<tr>
<td>Collector-emitter saturation voltage</td>
<td>V (_{CEsat} )</td>
<td>V (<em>{CE} = V (</em>{CE} )</td>
<td>0,012</td>
<td>25</td>
</tr>
<tr>
<td>Collector-emitter cut-off incl.</td>
<td>I (_{CES} )</td>
<td></td>
<td>0</td>
<td>1200</td>
</tr>
<tr>
<td>Gate-emitter leakage current</td>
<td>I (_{GEm} )</td>
<td></td>
<td>20</td>
<td>0</td>
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<tr>
<td>Integrated Gate resistor</td>
<td>R (_{gon} )</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Turn-on delay time</td>
<td>t (_{on} )</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Rise time</td>
<td>t (_{r} )</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Turn-off delay time</td>
<td>t (_{off} )</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Fall time</td>
<td>t (_{f} )</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Turn-on energy loss</td>
<td>E (_{on} )</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Turn-off energy loss</td>
<td>E (_{off} )</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Input capacitance</td>
<td>C (_{iss} )</td>
<td>V (_{CEO} = 1 ) MHz</td>
<td>0</td>
<td>25</td>
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<tr>
<td>Output capacitance</td>
<td>C (_{oss} )</td>
<td>V (_{CEO} = 1 ) MHz</td>
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<td>25</td>
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<tr>
<td>Gate charge</td>
<td>Q (_{G} )</td>
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<td>15</td>
<td>560</td>
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<td>Thermal resistance junction to sink</td>
<td>R (_{th(j-s)} )</td>
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<tr>
<td><strong>Boost Diode (D2, D3)</strong></td>
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<tr>
<td>FWD forward voltage</td>
<td>V (_{F} )</td>
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<tr>
<td>Peak reverse recovery current</td>
<td>I (_{br} )</td>
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<tr>
<td>Reverse recovery time</td>
<td>t (_{rr} )</td>
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<tr>
<td>Reverse recovered charge</td>
<td>Q (_{RRM} )</td>
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<td></td>
<td></td>
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<tr>
<td>Peak rate of fall of recovery current</td>
<td>(dI/dt) (_{br} )</td>
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<tr>
<td>Reverse recovered energy</td>
<td>E (_{br} )</td>
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<tr>
<td>Thermal resistance junction to sink</td>
<td>R (_{th(j-s)} )</td>
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<tr>
<td>Gate-emitter threshold voltage</td>
<td>V (_{GE(th)})</td>
<td>V (<em>{GE} = V (</em>{CE} )</td>
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<td>Collector-emitter saturation voltage</td>
<td>V (_{CEsat} )</td>
<td>V (<em>{CE} = V (</em>{CE} )</td>
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<td>Collector-emitter cut-off incl.</td>
<td>I (_{CES} )</td>
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<td>0</td>
<td>600</td>
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<td>Gate-emitter leakage current</td>
<td>I (_{GEm} )</td>
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<td>20</td>
<td>0</td>
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<td>Integrated Gate resistor</td>
<td>R (_{gon} )</td>
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<td>t (_{on} )</td>
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<td></td>
<td></td>
</tr>
<tr>
<td>Rise time</td>
<td>t (_{r} )</td>
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<td></td>
<td></td>
</tr>
<tr>
<td>Turn-off delay time</td>
<td>t (_{off} )</td>
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<td></td>
<td></td>
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<tr>
<td>Fall time</td>
<td>t (_{f} )</td>
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<tr>
<td>Turn-on energy loss</td>
<td>E (_{on} )</td>
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<tr>
<td>Turn-off energy loss</td>
<td>E (_{off} )</td>
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<tr>
<td>Input capacitance</td>
<td>C (_{iss} )</td>
<td>V (_{CEO} = 1 ) MHz</td>
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<tr>
<td>Output capacitance</td>
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<td>Gate charge</td>
<td>Q (_{G} )</td>
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<td>Thermal resistance junction to sink</td>
<td>R (_{th(j-s)} )</td>
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<td>Forward voltage</td>
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<td>Reverse leakage current</td>
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<td>Peak reverse recovery current</td>
<td>$I_{p}$</td>
<td>$R_{pn} = 1 \Omega$</td>
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<td>125</td>
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<td>Reverse recovered charge</td>
<td>$Q_{r}$</td>
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<td>125</td>
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<td>Peak rate of fall of recovery current</td>
<td>$(di/dt)_{pmax}$</td>
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<td>Reverse recovery energy</td>
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<td>125</td>
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<td>Cap value</td>
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<td>Stray inductance of on board capacitors</td>
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<td>nH</td>
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<td>mΩ</td>
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<td>Rated resistance</td>
<td>$R$</td>
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<td>Power dissipation constant</td>
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<td>B-value</td>
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<td>3950</td>
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<td>B-value</td>
<td>$B_{25/50}$</td>
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<td>Vincotech NTC Reference</td>
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<td>Module Properties</td>
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<td>Module inductance (from chips to PCB)</td>
<td>$L_{core}$</td>
<td></td>
<td>5</td>
<td>nH</td>
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<td>Module inductance (from PCB to PCB using Intercon)</td>
<td>$L_{core}$</td>
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<td>3</td>
<td>nH</td>
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<td>Resistance of Intercon boards (from PCB to PCB using Intercon)</td>
<td>$R_{OCEX}$</td>
<td>$Tc=25^\circ\text{C}$, per switch</td>
<td>1.5</td>
<td>mΩ</td>
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<td>Mounting torque</td>
<td>$M$</td>
<td>Screw M4 - mounting according to valid application note ($V_{In(A)X=H}$)</td>
<td>2</td>
<td>2.2</td>
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<tr>
<td>Mounting torque</td>
<td>$M$</td>
<td>Screw M5 - mounting according to valid application note ($V_{In(A)X=H}$)</td>
<td>4</td>
<td>6</td>
</tr>
<tr>
<td>Terminal connection torque</td>
<td>$M$</td>
<td>Screw M5 - mounting according to valid application note ($V_{In(A)X=H}$)</td>
<td>2.5</td>
<td>5</td>
</tr>
<tr>
<td>Weight</td>
<td>$G$</td>
<td></td>
<td>710</td>
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</tr>
</tbody>
</table>

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Buck
half bridge IGBT and neutral point FWD

**Figure 1.** IGBT Typical output characteristics

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

At

\[ t_p = 350 \ \mu s \]
\[ T_j = 25 \ ^\circ C \]
\[ V_{CE} \text{ from } 7 \ \text{V} \text{ to } 17 \ \text{V} \text{ in steps of } 1 \ \text{V} \]

**Figure 2.** IGBT Typical output characteristics

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

At

\[ t_p = 350 \ \mu s \]
\[ T_j = 125 \ ^\circ C \]
\[ V_{CE} \text{ from } 7 \ \text{V} \text{ to } 17 \ \text{V} \text{ in steps of } 1 \ \text{V} \]

**Figure 3.** IGBT Typical transfer characteristics

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

At

\[ t_p = 350 \ \mu s \]
\[ T_j = 25 \ ^\circ C \]
\[ T_j = T_{j\max} - 25 \ ^\circ C \]

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

\[ I_F = f(V_F) \]

At

\[ t_p = 350 \ \mu s \]
\[ V_{CE} = 10 \ \text{V} \]
\[ T_j = 25 \ ^\circ C \]
\[ T_j = T_{j\max} - 25 \ ^\circ C \]
**Buck**

half bridge IGBT and neutral point FWD

**figure 5.**
Typical switching energy losses as a function of collector current

\[ E = f(I_c) \]

With an inductive load at

- \( T_j = 25/125 \) °C
- \( V_{CE} = 350 \) V
- \( V_{CE} = \pm 15 \) V
- \( R_{gss} = 1 \) Ω
- \( R_{goff} = 1 \) Ω

**figure 6.**
Typical switching energy losses as a function of gate resistor

\[ E = f(R_g) \]

With an inductive load at

- \( T_j = 25/125 \) °C
- \( V_{CE} = 350 \) V
- \( V_{CE} = \pm 15 \) V
- \( I_C = 300 \) A

**figure 7.**
Typical reverse recovery energy loss as a function of collector current

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

With an inductive load at

- \( T_j = 25/125 \) °C
- \( V_{CE} = 350 \) V
- \( V_{CE} = \pm 15 \) V
- \( R_{gss} = 1 \) Ω

**figure 8.**
Typical reverse recovery energy loss as a function of gate resistor

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

With an inductive load at

- \( T_j = 25/125 \) °C
- \( V_{CE} = 350 \) V
- \( V_{CE} = \pm 15 \) V
- \( I_C = 300 \) A
**Buck**

half bridge IGBT and neutral point FWD

**figure 9.**

Typical switching times as a function of collector current

\[ t = f(I_C) \]

With an inductive load at

- \( T_j = 125 \degree C \)
- \( V_{CE} = 350 \) V
- \( V_{GE} = \pm 15 \) V
- \( R_{gon} = 1 \) Ω
- \( R_{goff} = 1 \) Ω

**figure 10.**

Typical switching times as a function of gate resistor

\[ t = f(R_g) \]

With an inductive load at

- \( T_j = 125 \degree C \)
- \( V_{CE} = 350 \) V
- \( V_{GE} = \pm 15 \) V
- \( I_C = 300 \) A

**figure 11.**

Typical reverse recovery time as a function of collector current

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

At

- \( T_j = 25/125 \degree C \)
- \( V_{CE} = 350 \) V
- \( V_{GE} = \pm 15 \) V
- \( R_{gon} = 1 \) Ω

**figure 12.**

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

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

At

- \( T_j = 25/125 \degree C \)
- \( V_{CE} = 350 \) V
- \( V_{GE} = \pm 15 \) 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
- \( V_{GE} = \pm 15 \) 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
- \( V_s = 350 \) V
- \( I_f = 300 \) A
- \( V_{GE} = \pm 15 \) 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
- \( V_{GE} = \pm 15 \) V
- \( I_f = 300 \) A
- \( R_{gon} = 1 \) 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
- \( V_s = 350 \) V
- \( I_f = 300 \) A
- \( V_{GE} = \pm 15 \) 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
\[
dI_o/dt, dI_{rec}/dt = f(I_C)
\]

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
\[
T_j = 25/125 °C
V_{CE} = 350 V
V_{GE} = ±15 V
I_F = 300 A
R_{gon} = 1 Ω
\]

**figure 19.** IGBT
IGBT transient thermal impedance as a function of pulse width
\[
Z_{th(j-s)} = f(t_p)
\]

At
\[
D = t_p / T
R_{th(j-s)} = 0,15 K/W
\]

IGBT thermal model values
\[
R (K/W) \quad \text{Tau (s)}
\begin{align*}
4,1E-02 & \quad 3,0E+00 \\
3,4E-02 & \quad 4,9E-01 \\
4,4E-02 & \quad 5,7E-02 \\
1,8E-02 & \quad 1,4E-02 \\
9,1E-03 & \quad 5,7E-04
\end{align*}
\]

**figure 20.** FWD
FWD transient thermal impedance as a function of pulse width
\[
Z_{th(j-s)} = f(t_p)
\]

At
\[
D = t_p / T
R_{th(j-s)} = 0,27 K/W
\]

FWD thermal model values
\[
R (K/W) \quad \text{Tau (s)}
\begin{align*}
2,5E-02 & \quad 9,7E+00 \\
5,8E-02 & \quad 1,8E+00 \\
4,0E-02 & \quad 3,0E-01 \\
8,5E-02 & \quad 4,3E-02 \\
3,8E-02 & \quad 9,8E-03 \\
1,9E-02 & \quad 5,4E-04
\end{align*}
\]
Buck
half bridge IGBT and neutral point FWD

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

\[ \begin{align*}
\text{At} & \quad T_j = 175 \degree C \\
\end{align*} \]

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

\[ \begin{align*}
\text{At} & \quad T_j = 175 \degree C \\
V_{GE} & = 15 \ \text{V} \\
\end{align*} \]

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

\[ \begin{align*}
\text{At} & \quad T_j = 175 \degree C \\
\end{align*} \]

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

\[ \begin{align*}
\text{At} & \quad T_j = 175 \degree C \\
\end{align*} \]
**Buck**

half bridge IGBT and neutral point FWD

**figure 25.**

Safe operating area as a function of collector-emitter voltage

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

**figure 26.**

Gate voltage vs Gate charge

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

At

- \( D = \) single pulse
- \( T_s = 80 \) °C
- \( V_{GE} = \pm 15 \) V
- \( T_j = T_{j\text{max}} \)

**figure 27.**

Reverse bias safe operating area

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

At

- \( I_C = 300 \) A

\( T_j = T_{j\text{max}}-25 \) °C

\( U_{\text{continuous}} = U_{\text{clamped}} \)

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
\[ t_p = 350 \ \mu s \]
\[ T_j = 25 \ ^\circ C \]
\[ V_{CE} \text{ from } 7 \text{ V to } 17 \text{ V in steps of } 1 \text{ V} \]

Figure 2. IGBT
Typical output characteristics

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

At
\[ t_p = 350 \ \mu s \]
\[ T_j = 125 \ ^\circ C \]
\[ V_{CE} \text{ from } 7 \text{ V to } 17 \text{ V in steps of } 1 \text{ V} \]

Figure 3. IGBT
Typical transfer characteristics

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

At
\[ t_p = 350 \ \mu s \]
\[ T_j = 25 \ ^\circ C \]
\[ T_j = T_{j\text{max}} - 25 \ ^\circ C \]

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

\[ I_F = f(V_F) \]

At
\[ t_p = 350 \ \mu s \]
Boost
neutral point IGBT and half bridge FWD

**figure 5.**
Typical switching energy losses
as a function of collector current
\[ E = \text{f}(I_C) \]

With an inductive load at
- \( T_j = 25/125 \) °C
- \( V_{CE} = 350 \) V
- \( V_{CE} = \pm 15 \) V
- \( R_{gon} = 1 \) Ω
- \( I_C = 300 \) A

**figure 6.**
Typical switching energy losses
as a function of gate resistor
\[ E = \text{f}(R_G) \]

With an inductive load at
- \( T_j = 25/125 \) °C
- \( V_{CE} = 350 \) V
- \( V_{CE} = \pm 15 \) V
- \( I_C = 300 \) A

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

With an inductive load at
- \( T_j = 25/125 \) °C
- \( V_{CE} = 350 \) V
- \( V_{CE} = \pm 15 \) V
- \( R_{gon} = 1 \) Ω

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

With an inductive load at
- \( T_j = 25/125 \) °C
- \( V_{CE} = 350 \) V
- \( V_{CE} = \pm 15 \) V
- \( I_C = 300 \) 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
\[ T_j = 125 \, ^\circ C \]
\[ V_{CE} = 350 \, V \]
\[ V_{GE} = \pm 15 \, V \]
\[ R_{gon} = 1 \, \Omega \]
\[ R_{goff} = 1 \, \Omega \]

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

With an inductive load at
\[ T_j = 125 \, ^\circ C \]
\[ V_{CE} = 350 \, V \]
\[ V_{GE} = \pm 15 \, V \]
\[ I_C = 300 \, A \]

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

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

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

At
\[ T_j = 25/125 \, ^\circ C \]
\[ V_A = 350 \, V \]
\[ I_f = 300 \, A \]
\[ V_{GE} = \pm 15 \, V \]
Boost
neutral point IGBT and half bridge FWD

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

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

At
- \( T_j = 25/125 \) °C
- \( V_{CE} = 350 \) V
- \( V_{GE} = \pm 15 \) V
- \( R_{g(on)} = 1 \) Ω

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

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

At
- \( T_j = 25/125 \) °C
- \( V_{CE} = 350 \) V
- \( V_{GE} = \pm 15 \) V
- \( I_f = 300 \) A
- \( V_{GE} = \pm 15 \) V

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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
d
dI0/dt, dIrec/dt = f(Ic)

At
Tj = 25/125 °C
Vce = 350 V
Vce < ±15 V
Rgon = 1 Ω

**figure 18.** FWD
Typical rate of fall of forward and reverse recovery current as a function of IGBT turn on gate resistor
d
dI0/dt, dIrec/dt = f(Rgon)

At
Tj = 25/125 °C
Vce = 350 V
Ig = 300 A
Vce < ±15 V

**figure 19.** IGBT
IGBT transient thermal impedance as a function of pulse width
Zth(j-s) = f(tp)

At
D = tp / T
Rth(j-s) = 0,20 K/W

**figure 20.** FWD
FWD transient thermal impedance as a function of pulse width
Zth(j-s) = f(tp)

At
D = tp / T
Rth(j-s) = 0,20 K/W

IGBT thermal model values

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<th>R (K/W)</th>
<th>Tau (s)</th>
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<td>1,1E-02</td>
<td>4,7E-04</td>
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</table>

FWD thermal model values

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<td>8,9E-03</td>
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<td>1,3E-02</td>
<td>8,0E-04</td>
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</tbody>
</table>
Boost
neutral point IGBT and half bridge FWD

---

**figure 21.**

<table>
<thead>
<tr>
<th>Power dissipation as a function of heatsink temperature</th>
</tr>
</thead>
<tbody>
<tr>
<td>$P_{tot} = f(T_s)$</td>
</tr>
</tbody>
</table>

![Graph](image)

*At*

$T_j = 175 ^\circ C$

---

**figure 22.**

<table>
<thead>
<tr>
<th>Collector current as a function of heatsink temperature</th>
</tr>
</thead>
<tbody>
<tr>
<td>$I_C = f(T_s)$</td>
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</tbody>
</table>

![Graph](image)

*At*

$T_j = 175 ^\circ C$

---

**figure 23.**

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</table>

![Graph](image)

*At*

$T_j = 175 ^\circ C$

---

**figure 24.**

<table>
<thead>
<tr>
<th>Forward current as a function of heatsink temperature</th>
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</thead>
<tbody>
<tr>
<td>$I_F = f(T_s)$</td>
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</table>

![Graph](image)

*At*

$T_j = 175 ^\circ C$

---

**Vincotech**

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figure 25. IGBT
Reverse bias safe operating area

$I_C = f(V_{CE})$

At $T_j = T_{j,max} - 25 \degree C$
U_{cc,minus} = U_{cc,plus}
Switching mode : 3 level switching
Thermistor

figure 1. Thermistor
Typical NTC characteristic
as a function of temperature
$R = f(T)$
Switching Definitions Buck IGBT

General conditions

<table>
<thead>
<tr>
<th>$T_J$</th>
<th>$125 , ^\circ C$</th>
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<tbody>
<tr>
<td>$R_{on}$</td>
<td>$1 , \Omega$</td>
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<tr>
<td>$R_{off}$</td>
<td>$1 , \Omega$</td>
</tr>
</tbody>
</table>

**figure 1.** IGBT

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

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

- $V_{CE} (0\%) = -15 \, V$
- $V_{CE} (100\%) = 350 \, V$
- $I_C (100\%) = 400 \, A$
- $t_{doff} = 0.32 \, \mu s$
- $t_{Eoff} = 1.04 \, \mu s$

**figure 2.** IGBT

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

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

- $V_{CE} (0\%) = -15 \, V$
- $V_{CE} (100\%) = 350 \, V$
- $I_C (100\%) = 400 \, A$
- $t_{don} = 0.21 \, \mu s$
- $t_{Eon} = 0.54 \, \mu s$

**figure 3.** IGBT

Turn-off Switching Waveforms & definition of $t_f$

- $V_C (100\%) = 350 \, V$
- $I_C (100\%) = 400 \, A$
- $t_f = 0.08 \, \mu s$

**figure 4.** IGBT

Turn-on Switching Waveforms & definition of $t_r$

- $V_C (100\%) = 350 \, V$
- $I_C (100\%) = 400 \, A$
- $t_r = 0.05 \, \mu s$

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Switching Definitions Buck IGBT

**figure 5.** Turn-off Switching Waveforms & definition of $t_{E\text{off}}$

- $P_{\text{off}}$ (100%) = 140 kW
- $E_{\text{off}}$ (100%) = 15.62 mJ
- $t_{E\text{off}}$ = 1.04 $\mu$s

**figure 6.** Turn-on Switching Waveforms & definition of $t_{E\text{on}}$

- $P_{\text{on}}$ (100%) = 140 kW
- $E_{\text{on}}$ (100%) = 11.38 mJ
- $t_{E\text{on}}$ = 0.54 $\mu$s

**figure 7.** FWD Turn-off Switching Waveforms & definition of $t_{rr}$

- $V_d$ (100%) = 350 V
- $I_d$ (100%) = 400 A
- $I_{\text{MAX}}$ (100%) = -217 A
- $t_{rr}$ = 0.27 $\mu$s
Switching Definitions Buck IGBT

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

- $I_d$ (100%) = 400 A
- $Q_{rr}$ (100%) = 25.32 μC
- $t_{Q_{rr}}$ = 0.58 μs

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

- $P_{rec}$ (100%) = 140 kW
- $E_{rec}$ (100%) = 5.33 mJ
- $t_{E_{rec}}$ = 0.58 μs

**Buck IGBT switching measurement circuit**

**figure 10.** Buck IGBT switching measurement circuit diagram.
Switching Definitions Boost IGBT

General conditions

### General Conditions

- **$T_J = 125 \, ^\circ C$**
- **$R_{ON} = 1 \, \Omega$**
- **$R_{OFF} = 1 \, \Omega$**

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

- **$V_{CE} (0\%) = -15 \, V$**
- **$V_{CE} (100\%) = 350 \, V$**
- **$I_C (100\%) = 302 \, A$**
- **$t_{doff} = 0.23 \, \mu s$**
- **$t_{Eoff} = 0.58 \, \mu s$**

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

- **$V_{CE} (0\%) = -15 \, V$**
- **$V_{CE} (100\%) = 350 \, V$**
- **$I_C (100\%) = 302 \, A$**
- **$t_{don} = 0.19 \, \mu s$**
- **$t_{Eon} = 0.38 \, \mu s$**
Switching Definitions Boost IGBT

**Figure 5.** IGBT
Turn-off Switching Waveforms & definition of \( t_{E_{\text{off}}} \)

\[
P_{\text{off}}(100\%) = 106 \, \text{kW}

E_{\text{off}}(100\%) = 11,52 \, \text{mJ}

\( t_{E_{\text{off}}} = 0,58 \, \mu\text{s} \)

**Figure 6.** IGBT
Turn-on Switching Waveforms & definition of \( t_{E_{\text{on}}} \)

\[
P_{\text{on}}(100\%) = 106 \, \text{kW}

E_{\text{on}}(100\%) = 13,39 \, \text{mJ}

\( t_{E_{\text{on}}} = 0,38 \, \mu\text{s} \)

**Figure 7.** FWD
Turn-off Switching Waveforms & definition of \( t_{rr} \)

\[
V_d(100\%) = 350 \, \text{V}

I_d(100\%) = 302 \, \text{A}

I_{\text{SOE}}(100\%) = -384 \, \text{A}

\( t_{rr} = 0,15 \, \mu\text{s} \)
Switching Definitions Boost IGBT

figure 8. Turn-on Switching Waveforms & definition of $t_{Qrr}$

$Q_{rr}$ (100%) = 35.60 μC
$t_{Qrr} = 0.33 \mu s$

$I_d (100\%) = 302\, \text{A}$

figure 9. Turn-on Switching Waveforms & definition of $t_{Erec}$

$E_{rec}$ (100%) = 8.89 mJ
$t_{Erec} = 0.33 \mu s$

$P_{rec} (100\%) = 106\, \text{kW}$

Boost IGBT switching measurement circuit

figure 10.
70-W212NMA300SC-M208P datasheet

Ordering Code & Marking

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Power interconnections

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**NOTE:** Driver pins for parallel devices are not connected inside the module!

Gx-1 to Gx-2 and Ex-1 to Ex-2 shall be connected on customer PCB!
Where x = 1 to 4
Packaging instruction

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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

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