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-W212NMA600SC-M200P

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>Collector-emitter breakdown voltage</td>
<td>Vce</td>
<td></td>
<td>1200</td>
<td>V</td>
</tr>
<tr>
<td>DC collector current</td>
<td>Ic</td>
<td>Tj=T_max</td>
<td>498</td>
<td>A</td>
</tr>
<tr>
<td>Repetitive peak collector current</td>
<td>Icp</td>
<td>t_p limited by Tj_max</td>
<td>1800</td>
<td>A</td>
</tr>
<tr>
<td>Power dissipation</td>
<td>Ptot</td>
<td>Tj=T_max</td>
<td>1188</td>
<td>W</td>
</tr>
<tr>
<td>Gate-emitter peak voltage</td>
<td>Vce</td>
<td></td>
<td>±20</td>
<td>V</td>
</tr>
<tr>
<td>Short circuit ratings</td>
<td>tsc</td>
<td>Tj≤150°C</td>
<td>10</td>
<td>µs</td>
</tr>
<tr>
<td>Turn off safe operating area (RBSOA)</td>
<td>I_FRM</td>
<td>Vce max = 1200V</td>
<td>1200</td>
<td>A</td>
</tr>
<tr>
<td>Maximum Junction Temperature</td>
<td>Tj_max</td>
<td></td>
<td>175</td>
<td>°C</td>
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</table>

Buck Switch (T1, T4)

Buck Diode (D2, D3)

Power dissipation per FWD

Ptot

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Symbol</th>
<th>Condition</th>
<th>Value</th>
<th>Unit</th>
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</thead>
<tbody>
<tr>
<td>Peak Repetitive Reverse Voltage</td>
<td>V_rms</td>
<td>Tj=25°C</td>
<td>600</td>
<td>V</td>
</tr>
<tr>
<td>DC forward current</td>
<td>IR</td>
<td>Tj=T_max</td>
<td>288</td>
<td>A</td>
</tr>
<tr>
<td>Surge forward current</td>
<td>I_rms</td>
<td>t_p = 10 ms, sine halfwave</td>
<td>1250</td>
<td>A</td>
</tr>
<tr>
<td>I2t-value</td>
<td>I^t</td>
<td>Tj &lt; 150°C</td>
<td>7800</td>
<td>A²s</td>
</tr>
<tr>
<td>Repetitive peak forward current</td>
<td>I_FRM</td>
<td>t_p = 1 ms</td>
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<td>A</td>
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<tr>
<td>Power dissipation per FWD</td>
<td>Ptot</td>
<td>Tj=T_max</td>
<td>365</td>
<td>W</td>
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<tr>
<td>Maximum Junction Temperature</td>
<td>Tj_max</td>
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## Maximum Ratings

### Boost Switch (T2, T3)

<table>
<thead>
<tr>
<th>Parameter</th>
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<th>Unit</th>
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<tbody>
<tr>
<td>Collector-emitter breakdown voltage</td>
<td>$V_{CE}$</td>
<td>$T_j=T_{j,max}$</td>
<td>600</td>
<td>V</td>
</tr>
<tr>
<td>DC collector current</td>
<td>$I_C$</td>
<td>$T_i=T_{i,max}$</td>
<td>388</td>
<td>A</td>
</tr>
<tr>
<td>Repetitive peak collector current</td>
<td>$I_{FWM}$</td>
<td>$t_p$ limited by $T_{j,max}$</td>
<td>1800</td>
<td>A</td>
</tr>
<tr>
<td>Power dissipation</td>
<td>$P_{tot}$</td>
<td>$T_j=T_{j,max}$</td>
<td>594 900</td>
<td>W</td>
</tr>
<tr>
<td>Gate-emitter peak voltage</td>
<td>$V_{GE}$</td>
<td>$T_{j}=T_{j,max}$</td>
<td>±20</td>
<td>V</td>
</tr>
<tr>
<td>Short circuit ratings</td>
<td>$I_{SC}$</td>
<td>$T_{i}=150{,}^\circ C$</td>
<td>6</td>
<td>µs</td>
</tr>
<tr>
<td>Turn off safe operating area (RBSOA)</td>
<td>$I_{CSW}$</td>
<td>$V_{GE}=15V$</td>
<td>360 V</td>
<td>µs</td>
</tr>
<tr>
<td>Maximum Junction Temperature</td>
<td>$T_{j,max}$</td>
<td>$V_{ce} \leq 1200V$</td>
<td>1200</td>
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### Boost Diode (D1, D4)

<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>Peak Repetitive Reverse Voltage</td>
<td>$V_{REX}$</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>$T_j=T_{j,max}$</td>
<td>355</td>
<td>A</td>
</tr>
<tr>
<td>Surge forward current</td>
<td>$I_{SOE}$</td>
<td>$t_p=10{,}ms \text{, sin } 180^\circ$</td>
<td>3600</td>
<td>A</td>
</tr>
<tr>
<td>12t-value</td>
<td>$f_{t}$</td>
<td>$T_j=150{,}^\circ C$</td>
<td>16200</td>
<td>A·s</td>
</tr>
<tr>
<td>Repetitive peak forward current</td>
<td>$I_{PEM}$</td>
<td>$t_p$ limited by $T_{j,max}$</td>
<td>1800</td>
<td>A</td>
</tr>
<tr>
<td>Power dissipation per FWD</td>
<td>$P_{tot}$</td>
<td>$T_j=T_{j,max}$</td>
<td>633 960</td>
<td>W</td>
</tr>
<tr>
<td>Maximum Junction Temperature</td>
<td>$T_{j,max}$</td>
<td></td>
<td>175</td>
<td>°C</td>
</tr>
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Maximum Ratings

<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></td>
<td>630</td>
<td>V</td>
</tr>
<tr>
<td>Operation Temperature</td>
<td>( T_{\text{OP}} )</td>
<td></td>
<td>-40...+105</td>
<td>°C</td>
</tr>
<tr>
<td>RMS Current</td>
<td>( I_{\text{RMS}} )</td>
<td></td>
<td>10</td>
<td>A</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{REG}} )</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>for power part</td>
<td>-40...+(( T_{\text{JMAX}} - 25 ))</td>
<td>°C</td>
</tr>
<tr>
<td>Isolation Properties</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Isolation voltage</td>
<td>( V_{\text{u}} )</td>
<td>( \text{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>
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## 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>Buck Switch (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_{GE} = V_{CE} )</td>
<td>0,0006</td>
<td>V</td>
</tr>
<tr>
<td>Collector-emitter saturation voltage</td>
<td>( V_{CEO} )</td>
<td></td>
<td>1500</td>
<td>V</td>
</tr>
<tr>
<td>Collector-emitter cut-off incl.</td>
<td>( I_{CBO} )</td>
<td></td>
<td>0,24</td>
<td>V/A</td>
</tr>
<tr>
<td>Gate-emitter leakage current</td>
<td>( I_{GE} )</td>
<td></td>
<td>20</td>
<td>mA</td>
</tr>
<tr>
<td>Integrated Gate resistor</td>
<td>( R_{G} )</td>
<td></td>
<td>2,3</td>
<td>Ω</td>
</tr>
<tr>
<td>Turn-on delay time</td>
<td>( t_{on} )</td>
<td></td>
<td>±15</td>
<td>ns</td>
</tr>
<tr>
<td>Rise time</td>
<td>( t_{r} )</td>
<td></td>
<td>350</td>
<td>ns</td>
</tr>
<tr>
<td>Turn-off delay time</td>
<td>( t_{off} )</td>
<td>Rgoff=1Ω</td>
<td>600</td>
<td>μs</td>
</tr>
<tr>
<td>Fall time</td>
<td>( t_{f} )</td>
<td></td>
<td>1,5</td>
<td>ns</td>
</tr>
<tr>
<td>Turn-on energy loss</td>
<td>( E_{on} )</td>
<td></td>
<td>1,5</td>
<td>mJ</td>
</tr>
<tr>
<td>Turn-off energy loss</td>
<td>( E_{off} )</td>
<td></td>
<td>0,5</td>
<td>mJ</td>
</tr>
<tr>
<td>Input capacitance</td>
<td>( C_{in} )</td>
<td>f=1MHz</td>
<td>0</td>
<td>nF</td>
</tr>
<tr>
<td>Output capacitance</td>
<td>( C_{out} )</td>
<td></td>
<td>25</td>
<td>nF</td>
</tr>
<tr>
<td>Reverse transfer capacitance</td>
<td>( C_{g} )</td>
<td></td>
<td>3700</td>
<td>pF</td>
</tr>
<tr>
<td>Gate charge</td>
<td>( Q_{G} )</td>
<td></td>
<td>±15</td>
<td>nC</td>
</tr>
<tr>
<td>Thermal resistance junction to sink</td>
<td>( R_{th(j-s)} )</td>
<td>phase-change material</td>
<td>0,08</td>
<td>K/W</td>
</tr>
<tr>
<td>Thermal resistance junction to case</td>
<td>( R_{th(j-c)} )</td>
<td>phase-change material</td>
<td>0,06</td>
<td>K/W</td>
</tr>
<tr>
<td>Buck Diode (D2, D3)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>PWD forward voltage</td>
<td>( V_{f} )</td>
<td></td>
<td>600</td>
<td>V</td>
</tr>
<tr>
<td>Peak reverse recovery current</td>
<td>( I_{so} )</td>
<td></td>
<td>190</td>
<td>A</td>
</tr>
<tr>
<td>Reverse recovery time</td>
<td>( t_{rr} )</td>
<td>( R_{G} = 1 \Omega )</td>
<td>1,3</td>
<td>ns</td>
</tr>
<tr>
<td>Reverse recovered charge</td>
<td>( Q_{rr} )</td>
<td>( R_{G} = 1 \Omega )</td>
<td>21</td>
<td>μC</td>
</tr>
<tr>
<td>Peak rate of fall of recovery current</td>
<td>( \frac{E_{off}}{I_{off}} )</td>
<td></td>
<td>4890</td>
<td>A/μs</td>
</tr>
<tr>
<td>Reverse recovered energy</td>
<td>( E_{off} )</td>
<td></td>
<td>5</td>
<td>mJ</td>
</tr>
<tr>
<td>Thermal resistance junction to sink</td>
<td>( R_{th(j-s)} )</td>
<td>phase-change material</td>
<td>0,26</td>
<td>K/W</td>
</tr>
<tr>
<td>Thermal resistance junction to case</td>
<td>( R_{th(j-c)} )</td>
<td>phase-change material</td>
<td>0,17</td>
<td>K/W</td>
</tr>
<tr>
<td>Boost Switch (T2, T3)</td>
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<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Gate emitter threshold voltage</td>
<td>( V_{GE(th)} )</td>
<td>( V_{GE} = V_{CE} )</td>
<td>0,0006</td>
<td>V</td>
</tr>
<tr>
<td>Collector-emitter saturation voltage</td>
<td>( V_{CEO} )</td>
<td></td>
<td>1500</td>
<td>V</td>
</tr>
<tr>
<td>Collector-emitter cut-off incl.</td>
<td>( I_{CBO} )</td>
<td></td>
<td>0,24</td>
<td>V/A</td>
</tr>
<tr>
<td>Gate-emitter leakage current</td>
<td>( I_{GE} )</td>
<td></td>
<td>20</td>
<td>mA</td>
</tr>
<tr>
<td>Integrated Gate resistor</td>
<td>( R_{G} )</td>
<td></td>
<td>2,3</td>
<td>Ω</td>
</tr>
<tr>
<td>Turn-on delay time</td>
<td>( t_{on} )</td>
<td></td>
<td>±15</td>
<td>ns</td>
</tr>
<tr>
<td>Rise time</td>
<td>( t_{r} )</td>
<td></td>
<td>350</td>
<td>ns</td>
</tr>
<tr>
<td>Turn-off delay time</td>
<td>( t_{off} )</td>
<td>Rgoff=1Ω</td>
<td>600</td>
<td>μs</td>
</tr>
<tr>
<td>Fall time</td>
<td>( t_{f} )</td>
<td></td>
<td>1,5</td>
<td>ns</td>
</tr>
<tr>
<td>Turn-on energy loss</td>
<td>( E_{on} )</td>
<td></td>
<td>1,5</td>
<td>mJ</td>
</tr>
<tr>
<td>Turn-off energy loss</td>
<td>( E_{off} )</td>
<td></td>
<td>0,5</td>
<td>mJ</td>
</tr>
<tr>
<td>Input capacitance</td>
<td>( C_{in} )</td>
<td>f=1MHz</td>
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<td>nF</td>
</tr>
<tr>
<td>Output capacitance</td>
<td>( C_{out} )</td>
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<td>25</td>
<td>nF</td>
</tr>
<tr>
<td>Reverse transfer capacitance</td>
<td>( C_{g} )</td>
<td></td>
<td>36960</td>
<td>pF</td>
</tr>
<tr>
<td>Gate charge</td>
<td>( Q_{G} )</td>
<td></td>
<td>±15</td>
<td>nC</td>
</tr>
<tr>
<td>Thermal resistance junction to sink</td>
<td>( R_{th(j-s)} )</td>
<td>phase-change material</td>
<td>0,16</td>
<td>K/W</td>
</tr>
<tr>
<td>Thermal resistance junction to case</td>
<td>( R_{th(j-c)} )</td>
<td>phase-change material</td>
<td>0,11</td>
<td>K/W</td>
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### Characteristic Values

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Symbol</th>
<th>Units</th>
<th>Conditions</th>
<th>Value</th>
<th>Tj=25°C</th>
<th>Tj=125°C</th>
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<tr>
<td>FWD forward voltage</td>
<td>Vf</td>
<td>V</td>
<td></td>
<td>600</td>
<td>223</td>
<td>3</td>
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<tr>
<td>Reverse leakage current</td>
<td>Il</td>
<td>µA</td>
<td></td>
<td>1200</td>
<td></td>
<td>720</td>
</tr>
<tr>
<td>Peak reverse recovery current</td>
<td>IRR</td>
<td>A</td>
<td></td>
<td>422</td>
<td>568</td>
<td>78</td>
</tr>
<tr>
<td>Reverse recovery time</td>
<td>tr</td>
<td>ms</td>
<td></td>
<td>290</td>
<td>60</td>
<td></td>
</tr>
<tr>
<td>Reverse recovered charge</td>
<td>Qrr</td>
<td>µC</td>
<td></td>
<td>61</td>
<td>0.61</td>
<td></td>
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<td>Peak rate of fall of recovery current</td>
<td>dv/dt</td>
<td>A/µs</td>
<td></td>
<td>14592</td>
<td>12180</td>
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<td>Reverse recovery energy</td>
<td>Em</td>
<td>mW</td>
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<td></td>
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<tr>
<td>Thermal resistance junction to sink</td>
<td>Rth(j-s)</td>
<td>K/W</td>
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<td>0.15</td>
<td></td>
<td></td>
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<td>Thermal resistance junction to case</td>
<td>Rth(j-c)</td>
<td>K/W</td>
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<td>0.10</td>
<td></td>
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### DC link Capacitor

<table>
<thead>
<tr>
<th>Capacitance</th>
<th>C</th>
<th>nf</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tolerance</td>
<td>±10</td>
<td></td>
</tr>
<tr>
<td>Dissipation factor</td>
<td>0.0004</td>
<td>mW</td>
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### Thermistor

<table>
<thead>
<tr>
<th>Rated resistance</th>
<th>Rth(25°C)</th>
<th>Ω</th>
</tr>
</thead>
<tbody>
<tr>
<td>Deviation of Rth</td>
<td>±5%</td>
<td></td>
</tr>
<tr>
<td>Power dissipation</td>
<td>5</td>
<td>mW</td>
</tr>
<tr>
<td>Power dissipation constant</td>
<td>1,5</td>
<td>mW/K</td>
</tr>
<tr>
<td>B-value</td>
<td>3962</td>
<td>K</td>
</tr>
<tr>
<td>B-value</td>
<td>4000</td>
<td>K</td>
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### Module Properties

<table>
<thead>
<tr>
<th>Module inductance (from chips to PCB)</th>
<th>L</th>
<th>µH</th>
</tr>
</thead>
<tbody>
<tr>
<td>Module inductance (from PCB to PCB using Intercon board)</td>
<td>L</td>
<td>µH</td>
</tr>
<tr>
<td>Resistance of Intercon boards (from PCB to PCB using Intercon board)</td>
<td>R</td>
<td>mΩ</td>
</tr>
<tr>
<td>Mounting torque</td>
<td>M</td>
<td>6 Nm</td>
</tr>
<tr>
<td>Terminal connection torque</td>
<td>M</td>
<td>710 g</td>
</tr>
</tbody>
</table>
Figure 1
Typical output characteristics
$I_C = f(V_{CE})$

At
$t_p = 350 \mu s$
$T_j = 25 \degree C$
$V_{GE}$ from 7 V to 17 V in steps of 1 V

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

At
$t_p = 350 \mu s$
$T_j = 125 \degree C$
$V_{GE}$ from 7 V to 17 V in steps of 1 V

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

At
$t_p = 350 \mu s$
$V_{CE} = 10 V$

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

At
$t_p = 350 \mu s$
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
\[ T_j = 25/125 \degree C \]
\[ V_{CE} = 350 \text{ V} \]
\[ V_{GE} = \pm 15 \text{ V} \]
\[ R_{on} = 1 \Omega \]
\[ R_{off} = 1 \Omega \]

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

With an inductive load at
\[ T_j = 25/125 \degree C \]
\[ V_{CE} = 350 \text{ V} \]
\[ V_{GE} = \pm 15 \text{ V} \]
\[ I_C = 596 \text{ A} \]

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

With an inductive load at
\[ T_j = 25/125 \degree C \]
\[ V_{CE} = 350 \text{ V} \]
\[ V_{GE} = \pm 15 \text{ V} \]
\[ R_{on} = 1 \Omega \]

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

With an inductive load at
\[ T_j = 25/125 \degree C \]
\[ V_{CE} = 350 \text{ V} \]
\[ V_{GE} = \pm 15 \text{ V} \]
\[ I_C = 596 \text{ A} \]
**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
- \( I_c = 596 \) A

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

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

**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
- \( R_{gon} = 1 \) Ω

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

At
\[ T_J = 25/125 °C \]
\[ V_{CE} = 350 \text{ V} \]
\[ V_{GE} = \pm 15 \text{ V} \]
\[ R_{gon} = 1 \Omega \]

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

At
\[ T_J = 25/125 °C \]
\[ V_{CE} = 350 \text{ V} \]
\[ I_F = 596 \text{ A} \]
\[ V_{GE} = \pm 15 \text{ V} \]

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

At
\[ T_J = 25/125 °C \]
\[ V_{CE} = 350 \text{ V} \]
\[ V_{GE} = \pm 15 \text{ V} \]
\[ R_{gon} = 1 \Omega \]

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

At
\[ T_J = 25/125 °C \]
\[ V_{CE} = 350 \text{ V} \]
\[ I_F = 596 \text{ A} \]
\[ V_{GE} = \pm 15 \text{ V} \]
Typical rate of fall of forward and reverse recovery current as a function of collector current
di0/dt, direc/dt = f(Ic)

At
Tj = 25/125 °C
VCE = 350 V
VGE = ±15 V
IF = 596 A
Rgon = 1 Ω

IGBT transient thermal impedance as a function of pulse width
ZthJH = f(tp)

At
D = tp / T
RthJH = 0,08 K/W

IGBT thermal model values
R (C/W)  Tau (s)
3,54E-02  1,20E+00
2,06E-02  1,85E-01
2,16E-02  3,61E-02
2,86E-03  8,04E-03
4,30E-03  6,80E-04

FWD transient thermal impedance as a function of pulse width
ZthJH = f(tp)

At
D = tp / T
RthJH = 0,26 K/W

FWD thermal model values
R (C/W)  Tau (s)
4,86E-02  5,38E+00
5,69E-02  1,12E+00
4,08E-02  2,59E-01
7,52E-02  4,95E-02
2,43E-02  1,67E-02
6,46E-03  3,42E-03
1,22E-02  3,99E-04

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Buck
Half bridge IGBT and Neutral point FWD

**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 $T_j = 175 \, ^\circ C$  
$V_{ge} = 15 \, V$

**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
Half bridge IGBT and Neutral point FWD

**Figure 25**
Safe operating area as a function of collector-emitter voltage

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

<table>
<thead>
<tr>
<th>( V_{CE} ) (V)</th>
<th>( I_C ) (A)</th>
</tr>
</thead>
<tbody>
<tr>
<td>240</td>
<td>0</td>
</tr>
<tr>
<td>960</td>
<td>15</td>
</tr>
</tbody>
</table>

At

\[ D = \text{single pulse} \]
\[ T_h = 80 \, ^\circ\text{C} \]
\[ V_{GE} = \pm 15 \, \text{V} \]
\[ T_J = T_{j\text{max}} \, ^\circ\text{C} \]

**Figure 26**
Gate voltage vs Gate charge

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

\[ V_{GE} = 240 \, \text{V} \]
\[ V_{GE} = 960 \, \text{V} \]

At

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

**Figure 27**
Reverse bias safe operating area

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

Switching mode: 3 level switching
**Boost**

Neutral point IGBT and Half bridge FWD

**Figure 1**
Typical output characteristics

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

At

- \( t_p = 350 \ \mu s \)
- \( T_j = 25 \ ^\circ C \)
- \( V_{GE} \) from 7 V to 17 V in steps of 1 V

**Figure 2**
Typical output characteristics

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

At

- \( t_p = 350 \ \mu s \)
- \( T_j = 125 \ ^\circ C \)
- \( V_{GE} \) from 7 V to 17 V in steps of 1 V

**Figure 3**
Typical transfer characteristics

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

At

- \( t_p = 350 \ \mu s \)
- \( V_{CE} = 0 \ \text{V} \)
- \( T_j = T_{j\text{max}} - 25 \ ^\circ C \)

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

\[ I_F = f(V_F) \]

At

- \( t_p = 350 \ \mu s \)
Figure 5: IGBT
Typical switching energy losses as a function of collector current
\[ E = f(I_C) \]
With an inductive load at
\[ T_j = 25/125 \, ^\circ C \]
\[ V_{CE} = 350 \, V \]
\[ V_{GE} = \pm 15 \, V \]
\[ R_{g_{on}} = 1 \, \Omega \]
\[ R_{g_{off}} = 1 \, \Omega \]

Figure 6: IGBT
Typical switching energy losses as a function of gate resistor
\[ E = f(R_G) \]
With an inductive load at
\[ T_j = 25/125 \, ^\circ C \]
\[ V_{CE} = 350 \, V \]
\[ V_{GE} = \pm 15 \, V \]
\[ I_C = 600 \, A \]

Figure 7: FWD
Typical reverse recovery energy loss as a function of collector current
\[ E_{rec} = f(I_C) \]
With an inductive load at
\[ T_j = 25/125 \, ^\circ C \]
\[ V_{CE} = 350 \, V \]
\[ V_{GE} = \pm 15 \, V \]
\[ R_{g_{on}} = 1 \, \Omega \]

Figure 8: FWD
Typical reverse recovery energy loss as a function of gate resistor
\[ E_{rec} = f(R_G) \]
With an inductive load at
\[ T_j = 25/125 \, ^\circ C \]
\[ V_{CE} = 350 \, V \]
\[ V_{GE} = \pm 15 \, V \]
\[ I_C = 600 \, A \]
Typical switching times as a function of collector current

\[ t = f(I_C) \]

With an inductive load at

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

Typical reverse recovery time as a function of collector current

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

At

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

**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  
- \( T_j = 25/125 \degree C \)
- \( V_A = 350 \) V
- \( I_F = 600 \) A
- \( V_{GE} = \pm 15 \) V

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

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

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

**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  
- \( T_j = 25/125 \degree C \)
- \( V_A = 350 \) V
- \( I_F = 600 \) A
- \( V_{GE} = \pm 15 \) V
Figure 17
Neutral point IGBT and Half bridge FWD

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
- \( T_j = 25/125 \ ^\circ C \)
- \( V_{ce} = 350 \ V \)
- \( V_{ds} = \pm 15 \ V \)
- \( R_{gon} = 1 \ \Omega \)

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

At
\( D = \frac{t_p}{T} \)
\( R_{thJH} = 0.16 \ K/W \)

IGBT thermal model values
<table>
<thead>
<tr>
<th>R (K/W)</th>
<th>Tau (s)</th>
</tr>
</thead>
<tbody>
<tr>
<td>4,60E-02</td>
<td>4,40E+00</td>
</tr>
<tr>
<td>2,82E-02</td>
<td>1,10E+00</td>
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<tr>
<td>2,81E-02</td>
<td>2,36E-01</td>
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<tr>
<td>3,54E-02</td>
<td>5,04E-02</td>
</tr>
<tr>
<td>1,47E-02</td>
<td>1,71E-02</td>
</tr>
<tr>
<td>2,19E-03</td>
<td>2,97E-03</td>
</tr>
<tr>
<td>4,85E-03</td>
<td>4,64E-04</td>
</tr>
</tbody>
</table>

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
\( T_j = 25/125 \ ^\circ C \)
\( V_{ce} = 350 \ V \)
\( I_F = 600 \ A \)
\( V_{ds} = \pm 15 \ V \)

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

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

FWD thermal model values
<table>
<thead>
<tr>
<th>R (K/W)</th>
<th>Tau (s)</th>
</tr>
</thead>
<tbody>
<tr>
<td>2,30E-02</td>
<td>6,05E+00</td>
</tr>
<tr>
<td>3,53E-02</td>
<td>1,29E+00</td>
</tr>
<tr>
<td>2,90E-02</td>
<td>2,22E-01</td>
</tr>
<tr>
<td>4,43E-02</td>
<td>4,71E-02</td>
</tr>
<tr>
<td>8,50E-03</td>
<td>1,13E-02</td>
</tr>
<tr>
<td>6,93E-03</td>
<td>1,30E-03</td>
</tr>
</tbody>
</table>
Boost
Neutral point IGBT and Half bridge FWD

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

![Graph](image1)

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

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

![Graph](image2)

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

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

![Graph](image3)

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

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

![Graph](image4)

At
\[ T_j = 175 \, ^\circ\text{C} \]
Figure 25
IGBT
Reverse bias safe operating area

$I_C = f(V_{CE})$

At
$T_J = T_{jmax} - 25 \, ^{\circ}C$

$U_{ccminus} = U_{ccplus}$

Switching mode : 3 level switching
Figure 26
Thermistor
Typical NTC characteristic
as a function of temperature
\[ R_T = f(T) \]
Switching Definitions Half bridge IGBT

**General conditions**

- $T_J = 125 \, ^\circ\text{C}$
- $R_{\text{on}} = 2 \, \Omega$
- $R_{\text{off}} = 2 \, \Omega$

**Figure 1**

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

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

**Figure 2**

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

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

**VGE (0%)**
- $-15 \, \text{V}$

**VGE (100%)**
- $15 \, \text{V}$

**VCE (100%)**
- $350 \, \text{V}$

**Ic (100%)**
- $591 \, \text{A}$

**$t_{\text{doff}}$$= 0,37 \, \mu\text{s}$**

**$t_{\text{Eoff}}$$= 0,93 \, \mu\text{s}$**

**Figure 3**

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

**Vc (100%)**
- $350 \, \text{V}$

**Ic (100%)**
- $591 \, \text{A}$

**$t_r$$ = 0,08 \, \mu\text{s}$**

**Figure 4**

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

**Vc (100%)**
- $350 \, \text{V}$

**Ic (100%)**
- $591 \, \text{A}$

**$t_f$$ = 0,06 \, \mu\text{s}$**

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Switching Definitions half bridge IGBT

Figure 5
Turn-off Switching Waveforms & definition of \( t_{\text{Eoff}} \)

- \( P_{\text{off}} \) (100%) = 206.68 kW
- \( E_{\text{off}} \) (100%) = 30.27 mJ
- \( t_{\text{Eoff}} \) = 0.93 μs

Figure 6
Turn-on Switching Waveforms & definition of \( t_{\text{Eon}} \)

- \( P_{\text{on}} \) (100%) = 206.68 kW
- \( E_{\text{on}} \) (100%) = 12.81 mJ
- \( t_{\text{Eon}} \) = 0.51 μs

Figure 7
Neutral point FWD
Turn-off Switching Waveforms & definition of \( t_{\text{rr}} \)

- \( V_{\text{f}} \) (100%) = 350 V
- \( I_{\text{d}} \) (100%) = 591 A
- \( I_{\text{RRM 10%}} \) = -457 A
- \( t_{\text{rr}} \) = 0.25 μs
Switching Definitions half bridge IGBT

Figure 8  Neutral point FWD
Turn-on Switching Waveforms & definition of $t_{Qrr}$
($t_{Qrr} =$ integrating time for $Q_{rr}$)

$\begin{align*}
I_d(100\%) & = 591 \ \text{A} \\
Q_{rr}(100\%) & = 47.04 \ \text{µC} \\
t_{Qrr} & = 0.55 \ \text{µs}
\end{align*}$

Figure 9  Neutral point FWD
Turn-on Switching Waveforms & definition of $t_{Erec}$
($t_{Erec} =$ integrating time for $E_{rec}$)

$\begin{align*}
P_{rec}(100\%) & = 206.68 \ \text{kW} \\
E_{rec}(100\%) & = 10.70 \ \text{mJ} \\
t_{Erec} & = 0.55 \ \text{µs}
\end{align*}$
half bridge IGBT switching measurement circuit

Figure 10
Switching Definitions neutral point IGBT

General conditions

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>$T_J$</td>
<td>125 °C</td>
</tr>
<tr>
<td>$R_{goff}$</td>
<td>2 Ω</td>
</tr>
<tr>
<td>$R_{gon}$</td>
<td>2 Ω</td>
</tr>
</tbody>
</table>

Figure 1
Neutral point IGBT

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

Figure 2
Neutral point IGBT

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

**Values:****

- $V_{GE}(0\%) = -15$ V
- $V_{GE}(100\%) = 15$ V
- $V_C (100\%) = 350$ V
- $I_C (100\%) = 592$ A
- $t_{doff} = 0,23 \mu s$
- $t_{Eoff} = 0,58 \mu s$
- $V_{GE}(0\%) = -15$ V
- $V_{GE}(100\%) = 15$ V
- $V_C (100\%) = 350$ V
- $I_C (100\%) = 592$ A
- $t_{don} = 0,25 \mu s$
- $t_{Eon} = 0,38 \mu s$
- $V_C (100\%) = 350$ V
- $I_C (100\%) = 592$ A
- $t_f = 0,067 \mu s$
- $t_r = 0,053 \mu s$
Switching Definitions neutral point IGBT

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

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

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

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

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

- $V_d(100\%) = 350$ V
- $I_d(100\%) = 592$ A
- $I_{\text{RDM}}(100\%) = -568$ A
- $t_{rr} = 0,29$ μs
Switching Definitions neutral point IGBT

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

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

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

- $P_{rec}(100\%) = 207,31$ kW
- $E_{rec}(100\%) = 14,30$ mJ
- $t_{Erec} = 0,33$ μs
neutral point IGBT switching measurement circuit
Ordering Code and Marking - Outline - Pinout

### Ordering Code & Marking

<table>
<thead>
<tr>
<th>Version</th>
<th>Ordering Code</th>
<th>in DataMatrix as</th>
<th>in packaging barcode as</th>
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</thead>
<tbody>
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<td>without PCM</td>
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<td>M200P</td>
<td>M200P</td>
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<tr>
<td>with PCM</td>
<td>70-W212NMA600SC-M200P-/3/</td>
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<td>M200P-/3/</td>
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</table>

### Outline

#### Driver pins

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<tr>
<th>Pin</th>
<th>X1</th>
<th>Y1</th>
<th>Function</th>
<th>Group</th>
<th>M4 screw</th>
<th>X3</th>
<th>Y3</th>
<th>Function</th>
<th>M6 screw</th>
<th>X2</th>
<th>Y2</th>
<th>Function</th>
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<tbody>
<tr>
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<td>78.7</td>
<td>G1-1</td>
<td>T1</td>
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<td>37</td>
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<td>0</td>
<td>Phase</td>
</tr>
<tr>
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<td>T1</td>
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<td>65.2</td>
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#### Low current connections

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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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