flowMNPC 1

1200 V / 160 A

Features
- mixed voltage NPC topology
- reactive power capability
- low inductance layout
- Split output
- Common collector neutral connection

Target Applications
- solar inverter
- UPS
- Active frontendl

Types
- 10-FY12NMA160SH-M420F
- 10-PY12NMA160SH-M420FY

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>Halfbridge IGBT Inverse Diode (D1, D4)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Repetitive peak reverse voltage</td>
<td>V_{RRM}</td>
<td></td>
<td>1200</td>
<td>V</td>
</tr>
<tr>
<td>DC forward current</td>
<td>I_T</td>
<td>Tj=T_{max}</td>
<td>T_j=80°C</td>
<td>14</td>
</tr>
<tr>
<td></td>
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<td>T_j=80°C</td>
<td>19</td>
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<tr>
<td>Repetitive peak forward current</td>
<td>I_{fRMS}</td>
<td>tp=10ms</td>
<td>14</td>
<td>A</td>
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<tr>
<td>Power dissipation per Diode</td>
<td>P_{tot}</td>
<td>T_j=80°C</td>
<td>31</td>
<td>W</td>
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<tr>
<td></td>
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<td>T_j=80°C</td>
<td>47</td>
<td>W</td>
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<tr>
<td>Maximum Junction Temperature</td>
<td>T_{jmax}</td>
<td></td>
<td>150</td>
<td>°C</td>
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</table>

| Halfbridge IGBT (T1, T4) | | | |
| Collector-emitter break down voltage | \( V_{CE} \) | | 1200 | V |
| DC collector current | I_C | Tj=T_{max} | T_j=80°C | 116 | A |
| | | | T_j=80°C | 156 | A |
| Repetitive peak collector current | I_{pulser} | I_p limited by T_{jmax} | 640 | A |
| Power dissipation per IGBT | P_{tot} | Tj=T_{max} | T_j=80°C | 260 | W |
| | | | T_j=80°C | 394 | W |
| Gate-emitter peak voltage | V_{GE} | | ±20 | V |
| Short circuit ratings | I_{SC} | V_{GE}=15V | T_j=150°C | 10 | µs |
| | | | V | 600 | V |
| Maximum Junction Temperature | T_{jmax} | | 175 | °C |
### Maximum Ratings

T<sub>j</sub>=25°C, unless otherwise specified

<table>
<thead>
<tr>
<th>Parameter</th>
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<th>Condition</th>
<th>Value</th>
<th>Unit</th>
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<tbody>
<tr>
<td><strong>NP Diode (D7, D8)</strong></td>
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<tr>
<td>Peak Repetitive Reverse Voltage</td>
<td>V&lt;sub&gt;RRM&lt;/sub&gt;</td>
<td>T&lt;sub&gt;j&lt;/sub&gt;=25°C</td>
<td>600</td>
<td>V</td>
</tr>
<tr>
<td>DC forward current</td>
<td>I&lt;sub&gt;F&lt;/sub&gt;</td>
<td>T&lt;sub&gt;j&lt;/sub&gt;=T&lt;sub&gt;max&lt;/sub&gt;</td>
<td>66</td>
<td>A</td>
</tr>
<tr>
<td>Repetitive peak forward current</td>
<td>I&lt;sub&gt;PRM&lt;/sub&gt;</td>
<td>I&lt;sub&gt;p&lt;/sub&gt; limited by T&lt;sub&gt;j&lt;/sub&gt;=T&lt;sub&gt;max&lt;/sub&gt;</td>
<td>240</td>
<td>A</td>
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<td>Power dissipation per Diode</td>
<td>P&lt;sub&gt;tot&lt;/sub&gt;</td>
<td>T&lt;sub&gt;j&lt;/sub&gt;=T&lt;sub&gt;max&lt;/sub&gt;</td>
<td>67</td>
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<td>Maximum Junction Temperature</td>
<td>T&lt;sub&gt;j&lt;/sub&gt;=T&lt;sub&gt;max&lt;/sub&gt;</td>
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<td>°C</td>
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<tr>
<td><strong>NP IGBT (T2, T3)</strong></td>
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<tr>
<td>Collector-emitter break down voltage</td>
<td>V&lt;sub&gt;C&lt;/sub&gt;E</td>
<td></td>
<td>600</td>
<td>V</td>
</tr>
<tr>
<td>DC collector current</td>
<td>I&lt;sub&gt;C&lt;/sub&gt;</td>
<td>T&lt;sub&gt;j&lt;/sub&gt;=T&lt;sub&gt;max&lt;/sub&gt;</td>
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<td>A</td>
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<tr>
<td>Repetitive peak collector current</td>
<td>I&lt;sub&gt;PRM&lt;/sub&gt;</td>
<td>I&lt;sub&gt;p&lt;/sub&gt; limited by T&lt;sub&gt;j&lt;/sub&gt;=T&lt;sub&gt;max&lt;/sub&gt;</td>
<td>300</td>
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<tr>
<td>Power dissipation per IGBT</td>
<td>P&lt;sub&gt;tot&lt;/sub&gt;</td>
<td>T&lt;sub&gt;j&lt;/sub&gt;=T&lt;sub&gt;max&lt;/sub&gt;</td>
<td>94</td>
<td>W</td>
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<tr>
<td>Gate-emitter peak voltage</td>
<td>V&lt;sub&gt;GE&lt;/sub&gt;</td>
<td></td>
<td>≤20</td>
<td>V</td>
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<tr>
<td>Short circuit ratings</td>
<td>t&lt;sub&gt;SC&lt;/sub&gt;</td>
<td>T≤150°C</td>
<td>6</td>
<td>µs</td>
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<tr>
<td>Maximum Junction Temperature</td>
<td>V&lt;sub&gt;C&lt;/sub&gt;C</td>
<td>V&lt;sub&gt;C&lt;/sub&gt;E=15V</td>
<td>360</td>
<td>V</td>
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<td><strong>NP Inverse Diode (D2, D3)</strong></td>
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<tr>
<td>Peak Repetitive Reverse Voltage</td>
<td>V&lt;sub&gt;RRM&lt;/sub&gt;</td>
<td>T&lt;sub&gt;j&lt;/sub&gt;=25°C</td>
<td>600</td>
<td>V</td>
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<tr>
<td>DC forward current</td>
<td>I&lt;sub&gt;F&lt;/sub&gt;</td>
<td>T&lt;sub&gt;j&lt;/sub&gt;=T&lt;sub&gt;max&lt;/sub&gt;</td>
<td>13</td>
<td>A</td>
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<tr>
<td>Repetitive peak forward current</td>
<td>I&lt;sub&gt;PRM&lt;/sub&gt;</td>
<td>I&lt;sub&gt;p&lt;/sub&gt; limited by T&lt;sub&gt;j&lt;/sub&gt;=T&lt;sub&gt;max&lt;/sub&gt;</td>
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<tr>
<td>Power dissipation per Diode</td>
<td>P&lt;sub&gt;tot&lt;/sub&gt;</td>
<td>T&lt;sub&gt;j&lt;/sub&gt;=T&lt;sub&gt;max&lt;/sub&gt;</td>
<td>20</td>
<td>W</td>
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<tr>
<td>Maximum Junction Temperature</td>
<td>T&lt;sub&gt;j&lt;/sub&gt;=T&lt;sub&gt;max&lt;/sub&gt;</td>
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<td>°C</td>
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<td><strong>Halfbridge Diode (D5, D6)</strong></td>
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<td>Peak Repetitive Reverse Voltage</td>
<td>V&lt;sub&gt;RRM&lt;/sub&gt;</td>
<td>T&lt;sub&gt;j&lt;/sub&gt;=25°C</td>
<td>1200</td>
<td>V</td>
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<tr>
<td>DC forward current</td>
<td>I&lt;sub&gt;F&lt;/sub&gt;</td>
<td>T&lt;sub&gt;j&lt;/sub&gt;=T&lt;sub&gt;max&lt;/sub&gt;</td>
<td>36</td>
<td>A</td>
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<tr>
<td>Repetitive peak forward current</td>
<td>I&lt;sub&gt;PRM&lt;/sub&gt;</td>
<td>I&lt;sub&gt;p&lt;/sub&gt; limited by T&lt;sub&gt;j&lt;/sub&gt;=T&lt;sub&gt;max&lt;/sub&gt;</td>
<td>120</td>
<td>A</td>
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<tr>
<td>Power dissipation per Diode</td>
<td>P&lt;sub&gt;tot&lt;/sub&gt;</td>
<td>T&lt;sub&gt;j&lt;/sub&gt;=T&lt;sub&gt;max&lt;/sub&gt;</td>
<td>61</td>
<td>W</td>
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<tr>
<td>Maximum Junction Temperature</td>
<td>T&lt;sub&gt;j&lt;/sub&gt;=T&lt;sub&gt;max&lt;/sub&gt;</td>
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<td>150</td>
<td>°C</td>
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<tr>
<td><strong>DC link Capacitor (C1, C2)</strong></td>
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<tr>
<td>Max.DC voltage</td>
<td>V&lt;sub&gt;MAX&lt;/sub&gt;</td>
<td>T&lt;sub&gt;o&lt;/sub&gt;=25°C</td>
<td>630</td>
<td>V</td>
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## Maximum Ratings

T<sub>j</sub>=25°C, unless otherwise specified

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<tbody>
<tr>
<td><strong>Thermal Properties</strong></td>
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<tr>
<td>Storage temperature</td>
<td>T&lt;sub&gt;stg&lt;/sub&gt;</td>
<td></td>
<td>-40…+125</td>
<td>°C</td>
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<tr>
<td>Operation temperature under switching condition</td>
<td>T&lt;sub&gt;op&lt;/sub&gt;</td>
<td></td>
<td>-40…+(T&lt;sub&gt;jmax&lt;/sub&gt; - 25)</td>
<td>°C</td>
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<tr>
<td><strong>Insulation Properties</strong></td>
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<td></td>
</tr>
<tr>
<td>Insulation voltage</td>
<td>V&lt;sub&gt;is&lt;/sub&gt;</td>
<td>t=2s DC voltage</td>
<td>4000</td>
<td>V</td>
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<tr>
<td>Creepage distance</td>
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<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>
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<td>&gt;200</td>
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### Characteristic Values

<table>
<thead>
<tr>
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<tr>
<td><strong>Halftide IGBT Inverse Diode (D1, D4)</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Forward voltage</td>
<td>VGE</td>
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<td>1.97</td>
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<tr>
<td>Thermal resistance chip to heatsink per chip</td>
<td>RthJH</td>
<td></td>
<td>1</td>
<td>0.65</td>
</tr>
<tr>
<td>Thermal resistance chip to case per chip</td>
<td>RthJC</td>
<td></td>
<td>1</td>
<td>1.48</td>
</tr>
</tbody>
</table>

| | | | | |
| **Halftide IGBT (T1, T4)** | | | | |
| Gate emitter threshold voltage | VGE(th) | | 5 | 5.8 | 6.5 | V |
| Collector-emitter saturation voltage | VCE(sat) | | 1 | 2.04 | 2.5 | V |
| Collector-emitter cut-off current incl. Diode | IQSS | | 1 | 1 | mA |
| Gate-emitter leakage current | IGE | | 20 | 30 | 480 | nA |
| Integrated Gate resistor | Rint | | | none | | |
| Turn-on delay time | t(ON) | | | 133 | | ns |
| Rise time | tR | | | 136 | | ns |
| Turn-off delay time | t(OFF) | | | 23 | | ns |
| Fall time | tF | | | 225 | | ns |
| Turn-on energy loss per pulse | Eon | | | 276 | | mWs |
| Turn-off energy loss per pulse | Eoff | | | 64 | | mWs |
| Input capacitance | Ciss | | | 60 | | pF |
| Reverse recovery time | tdi(ON) | | | 9030 | | |
| Output capacitance | Coss | | | 520 | | |
| Gate charge | QG | | | 15 | 960 | 160 | Tj=25°C | 740 | nC |
| Thermal resistance chip to heatsink per chip | RthJH | | | 0.37 | | K/W |
| Thermal resistance chip to case per chip | RthJC | | | 0.24 | | |
| *additional value stands for built-in capacitor* |

| | | | | |
| **NP Diode (D7, D8)** | | | | |
| Diode forward voltage | VF | | 120 | 1.4 | 1.47 | 2 | V |
| Peak reverse recovery current | Qrr | | | 127 | | A |
| Reverse recovery time | trr | | | 151 | | ns |
| Reverse recovered charge | QL | | | 81 | | µC |
| Peak rate of fall of recovery current | dV/dt | | | 9.00 | | A/μs |
| Reverse recovered energy | Erec | | | 7.13 | | mWs |
| Thermal resistance chip to heatsink per chip | RthJH | | | 10388 | | A/μs |
| Thermal resistance chip to case per chip | RthJC | | | 137 | | |

*additional value stands for built-in capacitor*
### Characteristic Values

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<tr>
<td><strong>HP IGBT (T2, T3)</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Gate emitter threshold voltage</td>
<td>( V_{GE} )</td>
<td>( I=25°C )</td>
<td>5000V</td>
<td>mV</td>
</tr>
<tr>
<td>Collector-emitter saturation voltage</td>
<td>( V_{CE} )</td>
<td>( I=25°C )</td>
<td>4.5</td>
<td>V</td>
</tr>
<tr>
<td>Collector-emitter cut-off incl diode</td>
<td>( I_{off} )</td>
<td>( I=25°C )</td>
<td>600</td>
<td>mA</td>
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<tr>
<td>Gate-emitter leakage current</td>
<td>( I_{leak} )</td>
<td>( I=25°C )</td>
<td>1200</td>
<td>nA</td>
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<tr>
<td>Integrated Gate resistor</td>
<td>( R_{int} )</td>
<td>none</td>
<td>D</td>
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<tr>
<td>Turn-on delay time</td>
<td>( t_{on} )</td>
<td>( I=25°C )</td>
<td>103</td>
<td>ns</td>
</tr>
<tr>
<td>Rise time</td>
<td>( t_{r} )</td>
<td>( I=25°C )</td>
<td>168</td>
<td>ns</td>
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<tr>
<td>Turn-off delay time</td>
<td>( t_{off} )</td>
<td>( I=25°C )</td>
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<tr>
<td>Fall time</td>
<td>( t_{f} )</td>
<td>( I=25°C )</td>
<td>64</td>
<td>ns</td>
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<tr>
<td>Turn-on energy loss per pulse</td>
<td>( E_{on} )</td>
<td>( I=25°C )</td>
<td>1.62</td>
<td>µWs</td>
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<td>Turn-off energy loss per pulse</td>
<td>( E_{off} )</td>
<td>( I=25°C )</td>
<td>2.48</td>
<td>µWs</td>
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<tr>
<td>Input capacitance</td>
<td>( C_{in} )</td>
<td>( f=1MHz )</td>
<td>6280</td>
<td>pF</td>
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<tr>
<td>Output capacitance</td>
<td>( C_{out} )</td>
<td>( f=1MHz )</td>
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<td>Reverse transfer capacitance</td>
<td>( C_{t} )</td>
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<td>186</td>
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<tr>
<td>Gate charge</td>
<td>( Q_{g} )</td>
<td>( I=25°C )</td>
<td>520</td>
<td>nC</td>
</tr>
<tr>
<td>Thermal resistance chip to heatsink per chip</td>
<td>( R_{thjc} )</td>
<td>Thermal grease thickness ≤ 50um ( \lambda = 1 \text{ W/mK} )</td>
<td>1.01</td>
<td>K/W</td>
</tr>
<tr>
<td>Thermal resistance chip to power source per chip</td>
<td>( R_{thjc} )</td>
<td>Thermal grease thickness ≤ 50um ( \lambda = 1 \text{ W/mK} )</td>
<td>0.67</td>
<td>K/W</td>
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<tr>
<td><strong>HP Inverse Diode (D2, D3)</strong></td>
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</tr>
<tr>
<td>Diode forward voltage</td>
<td>( V_{f} )</td>
<td>( I=25°C )</td>
<td>1.00</td>
<td>V</td>
</tr>
<tr>
<td>Thermal resistance chip to power source per chip</td>
<td>( R_{thjc} )</td>
<td>Thermal grease thickness ≤ 50um ( \lambda = 1 \text{ W/mK} )</td>
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<td>K/W</td>
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<td>Coupled thermal resistance inverter transistor-diode</td>
<td>( R_{thjc} )</td>
<td>Thermal grease thickness ≤ 50um ( \lambda = 1 \text{ W/mK} )</td>
<td>2.27</td>
<td>K/W</td>
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<td>( \mathbf{D} )</td>
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<td>Diode forward voltage</td>
<td>( V_{f} )</td>
<td>( I=25°C )</td>
<td>1.50</td>
<td>V</td>
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<tr>
<td>Reverse leakage current</td>
<td>( I_{rev} )</td>
<td>( I=25°C )</td>
<td>200</td>
<td>µA</td>
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<tr>
<td>Peak reverse recovery current</td>
<td>( I_{rev} )</td>
<td>( I=25°C )</td>
<td>107</td>
<td>A</td>
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<tr>
<td>Reverse recovery time</td>
<td>( t_{rr} )</td>
<td>( I=25°C )</td>
<td>51</td>
<td>ns</td>
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<tr>
<td>Reverse recovered charge</td>
<td>( Q_{rr} )</td>
<td>( I=25°C )</td>
<td>6.24</td>
<td>µC</td>
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<tr>
<td>Peak rate of fall of recovery current</td>
<td>( i_{df} )</td>
<td>( I=25°C )</td>
<td>3885</td>
<td>A/µs</td>
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<tr>
<td>Reverse recovery energy</td>
<td>( E_{rec} )</td>
<td>( I=25°C )</td>
<td>1.71</td>
<td>mWs</td>
</tr>
<tr>
<td>Thermal resistance chip to heatsink per chip</td>
<td>( R_{thjc} )</td>
<td>Thermal grease thickness ≤ 50um ( \lambda = 1 \text{ W/mK} )</td>
<td>1.15</td>
<td>K/W</td>
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<td>Thermal resistance chip to power source per chip</td>
<td>( R_{thjc} )</td>
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<td>0.76</td>
<td>K/W</td>
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<tr>
<td>( \mathbf{D} )</td>
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<tr>
<td>DC link Capacitor (C1, C2)</td>
<td>C</td>
<td>( \text{DC} ) to Neutral and DC- to Neutral</td>
<td>100</td>
<td>nF</td>
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<tr>
<td><strong>Thermistor</strong></td>
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<tr>
<td>Rated resistance</td>
<td>( R )</td>
<td>( I=25°C )</td>
<td>2200</td>
<td>Ω</td>
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<tr>
<td>Deviation of R25</td>
<td>( \Delta R / R )</td>
<td>( I=25°C )</td>
<td>±5</td>
<td>%</td>
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<tr>
<td>Power dissipation</td>
<td>( P )</td>
<td>( I=25°C )</td>
<td>200</td>
<td>mW</td>
</tr>
<tr>
<td>Power dissipation constant</td>
<td>( P )</td>
<td>( I=25°C )</td>
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<td>mW/K</td>
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<tr>
<td>B-value</td>
<td>( B_{(25/100)} )</td>
<td>Td = ±3%</td>
<td>3595</td>
<td>K</td>
</tr>
<tr>
<td>B-value</td>
<td>( B_{(25/100)} )</td>
<td>Td = ±3%</td>
<td>3596</td>
<td>K</td>
</tr>
<tr>
<td><strong>Module Properties</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Thermal resistance, case to heatsink</td>
<td>( R_{thch} )</td>
<td>per module</td>
<td>1.05</td>
<td>K/W</td>
</tr>
<tr>
<td>Module stray inductance</td>
<td>( L_{CE} )</td>
<td>( I=25°C )</td>
<td>5</td>
<td>nH</td>
</tr>
<tr>
<td>Chip module lead resistance, terminals -chip</td>
<td>( R_{on} )</td>
<td>( I=25°C )</td>
<td>2</td>
<td>mΩ</td>
</tr>
<tr>
<td>Mounting torque</td>
<td>M</td>
<td></td>
<td>2</td>
<td>Nm</td>
</tr>
<tr>
<td>Weight</td>
<td>G</td>
<td></td>
<td>42.28</td>
<td>g</td>
</tr>
</tbody>
</table>
Half bridge (T1, T4 / D7, D8)

half bridge IGBT and Neutral Point FWD

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

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

**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**
- \[ t_p = 250 \, \mu s \]
- \[ T_j = 25 \, ^\circ C \]
- \( V_{CE} \) from 7 V to 17 V in steps of 1 V

**At**
- \[ t_p = 250 \, \mu s \]
- \[ T_j = 125 \, ^\circ C \]
- \( V_{CE} \) from 7 V to 17 V in steps of 1 V

---

**At**
- \[ t_p = 250 \, \mu s \]
- \[ V_{CE} = 10 \, V \]
- \[ T_j = 25/150 \, ^\circ C \]

---

**At**
- \[ t_p = 250 \, \mu s \]
- \[ T_j = 25/150 \, ^\circ C \]
Half bridge (T1, T4 / D7, D8)

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
- \( V_{GE} = \pm 15 \) V
- \( R_{gon} = 4 \) Ω
- \( R_{goff} = 4 \) 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
- \( V_{GE} = \pm 15 \) V
- \( I_C = 100 \) 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
- \( V_{GE} = \pm 15 \) V
- \( R_{gon} = 4 \) 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
- \( V_{GE} = \pm 15 \) V
- \( I_C = 100 \) A
Typical switching times as a function of collector current
\( t = f(I_C) \)

With an inductive load at:
- \( T_j = 125 \) °C
- \( V_{CE} = 350 \) V
- \( V_{GE} = \pm 15 \) V
- \( R_{gon} = 4 \) Ω
- \( R_{goff} = 4 \) Ω

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

At:
- \( T_j = 25/125 \) °C
- \( V_{CE} = 350 \) V
- \( V_{GE} = \pm 15 \) V
- \( R_{gon} = 4 \) Ω
Figure 13  
Typical reverse recovery charge as a function of collector current  
\[ Q_{rr} = f(I_C) \]

![Graph showing typical reverse recovery charge](image1)

At  
- \( T_J = 25/125 \) °C  
- \( V_{CE} = 350 \) V  
- \( V_{GE} = \pm 15 \) V  
- \( R_{gon} = 4 \) Ω

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

![Graph showing typical reverse recovery charge](image2)

At  
- \( T_J = 25/125 \) °C  
- \( V_{BE} = 350 \) V  
- \( I_B = 100 \) 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](image3)

At  
- \( T_J = 25/125 \) °C  
- \( V_{CE} = 350 \) V  
- \( V_{GE} = \pm 15 \) V  
- \( R_{gon} = 4 \) Ω

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

![Graph showing typical reverse recovery current](image4)

At  
- \( T_J = 25/125 \) °C  
- \( V_{BE} = 350 \) V  
- \( I_B = 100 \) A  
- \( V_{GE} = \pm 15 \) V
Typical rate of fall of forward and reverse recovery current as a function of collector current:

\[
d\frac{dI}{dt}, d\frac{dI}{dt} = f(I_c)
\]

\[
d\frac{dI}{dt}, d\frac{dI}{dt} = f(R_{gon})
\]

IGBT transient thermal impedance as a function of pulse width:

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

FWD transient thermal impedance as a function of pulse width:

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

IGBT thermal model values:

<table>
<thead>
<tr>
<th>R (C/W)</th>
<th>Tau (s)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.06</td>
<td>2.4E-00</td>
</tr>
<tr>
<td>0.15</td>
<td>4.0E-01</td>
</tr>
<tr>
<td>0.12</td>
<td>1.0E-01</td>
</tr>
<tr>
<td>0.03</td>
<td>1.3E-02</td>
</tr>
<tr>
<td>0.01</td>
<td>8.4E-04</td>
</tr>
</tbody>
</table>

FWD thermal model values:

<table>
<thead>
<tr>
<th>R (C/W)</th>
<th>Tau (s)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.05</td>
<td>7.4E+00</td>
</tr>
<tr>
<td>0.27</td>
<td>1.3E+00</td>
</tr>
<tr>
<td>0.55</td>
<td>2.7E-01</td>
</tr>
<tr>
<td>0.11</td>
<td>4.0E-02</td>
</tr>
<tr>
<td>0.04</td>
<td>5.1E-03</td>
</tr>
<tr>
<td>0.03</td>
<td>6.0E-04</td>
</tr>
</tbody>
</table>
Power dissipation as a function of heatsink temperature

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

Collector current as a function of heatsink temperature

\[ I_C = f(T_h) \]

Power dissipation as a forward current as a function of heatsink temperature

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

Forward current as a function of heatsink temperature

\[ I_F = f(T_h) \]
Half bridge (T1, T4 / D7, D8)

**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
- \( T_h = 80 \, ^\circ\text{C} \)
- \( V_{GE} = 0 \, \text{V} \)
- \( T_j = T_{\text{max}} \, ^\circ\text{C} \)

**Figure 27**
Reverse bias safe operating area

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

**At**
- \( T_j = T_{\text{max}} - 25 \, ^\circ\text{C} \)
- \( U_{\text{continuous}} = U_{\text{peak}} \)

Switching mode: 3 level switching
Neutral Point IGBT (T2, T3 / D5, D6)
neutral point IGBT and half bridge FWD

Figure 1 NP IGBT
Typical output characteristics
$I_C = f(V_{CE})$

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

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

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

At
$t_P = 250 \mu s
T_j = 25/150 \degree C
V_{CE} \text{ from 7 V to 17 V in steps of 1 V}$

At
$t_P = 250 \mu s
T_j = 150 \degree C
V_{CE} \text{ from 7 V to 17 V in steps of 1 V}$

At
$t_P = 250 \mu s
V_{CE} = 10 \text{ V}
T_j = 25/150 \degree C$

At
$t_P = 250 \mu s
T_j = 25/150 \degree C$
Neutral Point IGBT (T2, T3 / D5, D6)
neutral point IGBT and half bridge 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
- \( V_{GE} = \pm 15 \) V
- \( R_{gon} = 4 \) Ω
- \( R_{goff} = 4 \) 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
- \( V_{GE} = \pm 15 \) V
- \( I_C = 60 \) 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
- \( V_{GE} = \pm 15 \) V
- \( R_{gon} = 4 \) 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
- \( V_{GE} = \pm 15 \) V
- \( I_C = 60 \) A
Neutral Point IGBT (T2, T3 / D5, D6)
neutral point IGBT and half bridge FWD

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

$t = f(I_C)$

With an inductive load at

$T_j = 125$ °C  
$V_{CE} = 350$ V  
$V_{CE} = \pm 15$ V  
$R_{gon} = 4$ Ω  
$R_{goff} = 4$ Ω

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

$t = f(R_g)$

With an inductive load at

$T_j = 125$ °C  
$V_{CE} = 350$ V  
$V_{CE} = \pm 15$ V  
$I_C = 60$ A

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

$t_{rr} = f(I_C)$

At

$T_j = 25/125$ °C  
$V_{CE} = 350$ V  
$V_{CE} = \pm 15$ V  
$R_{gon} = 4.0$ Ω

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

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

At

$T_j = 25/125$ °C  
$V_{CE} = 350$ V  
$I_C = 60$ A  
$V_{CE} = \pm 15$ V

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Neutral Point IGBT (T2, T3 / D5, D6)

Neutral point IGBT and half bridge FWD

**Figure 13**
Typical reverse recovery charge as a function of collector current

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

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

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

**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

\[ I_{RRM} = f(R_{gon}) \]
Neutral Point IGBT (T2, T3 / D5, D6)
neutral point IGBT and half bridge FWD

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

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

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

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

<table>
<thead>
<tr>
<th>D</th>
<th>t_p / T</th>
<th>R_{thJH}</th>
<th>Tau (s)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0,05</td>
<td>6,49</td>
<td>1,01</td>
<td>1,01</td>
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<tr>
<td>0,16</td>
<td>1,27</td>
<td>1,15</td>
<td>1,15</td>
</tr>
<tr>
<td>0,52</td>
<td>0,25</td>
<td>0,005</td>
<td>0,005</td>
</tr>
<tr>
<td>0,18</td>
<td>0,07</td>
<td>0,005</td>
<td>0,005</td>
</tr>
<tr>
<td>0,07</td>
<td>0,01</td>
<td>0,005</td>
<td>0,005</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>R (C/W)</th>
<th>Tau (s)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0,05</td>
<td>4,90</td>
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<tr>
<td>0,13</td>
<td>0,82</td>
</tr>
<tr>
<td>0,59</td>
<td>0,18</td>
</tr>
<tr>
<td>0,22</td>
<td>0,05</td>
</tr>
<tr>
<td>0,10</td>
<td>0,01</td>
</tr>
</tbody>
</table>

At
- \( T_j = 25/125 \) °C
- \( V_{CE} = 350 \) V
- \( V_{GE} = \pm 15 \) V
- \( I_F = 60 \) A
- \( R_{gon} = 4,0 \) Ω

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

IGBT thermal model values
- \( R (C/W) \)
- \( \tau (s) \)

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Neutral Point IGBT (T2, T3 / D5, D6)
neutral point IGBT and half bridge FWD

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

At
\[ T_j = 175 \degree C \]

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

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

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

At
\[ T_j = 150 \degree C \]

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

At
\[ T_j = 150 \degree C \]
Neutral Point IGBT (T2, T3 / D5, D6)
neutral point IGBT

Figure 25
Reverse bias safe operating area

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

At
\[ T_j = T_{jmax} - 25 \text{ °C} \]
\[ U_{ccminus} = U_{ccplus} \]

Switching mode: 3 level switching
NP IGBT Inverse Diode (D2, D3)

**Figure 25**
Typical FWD forward current as a function of forward voltage
\[ I_F = f(V_F) \]

**Figure 26**
FWD transient thermal impedance as a function of pulse width
\[ Z_{thJH} = f(t_p) \]

At
\[ t_p = 250 \mu s \]

**Figure 27**
Power dissipation as a function of heatsink temperature
\[ P_{tot} = f(T_h) \]

At
\[ T_j = 150 ^\circ C \]

**Figure 28**
Forward current as a function of heatsink temperature
\[ I_F = f(T_h) \]

At
\[ T_j = 150 ^\circ C \]
**Figure 1** Halfbridge IGBT Inverse Diode

Typical FWD forward current as a function of forward voltage

\[ I_F = f(V_F) \]

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

\[ t_p = 250 \mu s \]

**Figure 2** Halfbridge IGBT Inverse Diode

FWD transient thermal impedance as a function of pulse width

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

\[ D = 0.5 \]

\[ 0.1 \]

\[ 0.05 \]

\[ 0.02 \]

\[ 0.01 \]

\[ 0.005 \]

\[ 0.001 \]

\[ 0.000 \]

\[ 2.235 \text{ K/W} \]

**Figure 3** Halfbridge IGBT Inverse Diode

Power dissipation as a function of heatsink temperature

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

\[ T_j = 150 ^\circ C \]

**Figure 4** Halfbridge IGBT Inverse Diode

Forward current as a function of heatsink temperature

\[ I_F = f(T_h) \]

\[ T_j = 150 ^\circ C \]
Thermistor

Figure 1

Typical NTC characteristic
as a function of temperature

\[ R_T = f(T) \]
Switching Definitions half bridge (T1, T4 / D7, D8)

**General conditions**

<table>
<thead>
<tr>
<th>Symbol</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>$T_J$</td>
<td>125 °C</td>
</tr>
<tr>
<td>$R_{son}$</td>
<td>4 Ω</td>
</tr>
<tr>
<td>$R_{off}$</td>
<td>4 Ω</td>
</tr>
</tbody>
</table>

**Figure 1**

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

- $t_{doff} = 0.28 \mu s$
- $t_{Eoff} = 0.66 \mu s$

**Figure 2**

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

- $t_{don} = 0.14 \mu s$
- $t_{Eon} = 0.27 \mu s$

**Figure 3**

Turn-off Switching Waveforms & definition of $t_t$

- $V_C(100\%) = 700 \text{ V}$
- $I_C(100\%) = 100 \text{ A}$
- $t_t = 0.06 \mu s$

**Figure 4**

Turn-on Switching Waveforms & definition of $t_t$

- $V_C(100\%) = 700 \text{ V}$
- $I_C(100\%) = 100 \text{ A}$
- $t_t = 0.02 \mu s$
Switching Definitions half bridge (T1, T4 / D7, D8)

**Figure 5**

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

![Graph showing turn-off switching waveforms with definitions of $E_{off}$, $t_{Eoff}$, $V_{GEoff}$, and $I_{C RRM}$.]

For $100\%$:
- $P_{off} = 70.22$ kW
- $E_{off} = 4.03$ mJ
- $t_{Eoff} = 0.66$ µs

**Figure 6**

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

![Graph showing turn-on switching waveforms with definitions of $E_{on}$, $t_{Eon}$, $V_{GEon}$, and $I_{C RRM}$.]

For $100\%$:
- $P_{on} = 70.22$ kW
- $E_{on} = 3.18$ mJ
- $t_{Eon} = 0.27$ µs

**Figure 7**

Gate voltage vs Gate charge (measured)

![Graph showing gate voltage vs gate charge with definitions of $V_{GE90\%}$, $V_{GE10\%}$, $V_{CE3\%}$, and $V_{CE10\%}$.]

- $V_{GE90\%} = -15$ V
- $V_{GE10\%} = 15$ V
- $V_{CE3\%} = 700$ V
- $V_{CE10\%} = 100$ A
- $Q_g = 1140.19$ nC

**Figure 8**

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

![Graph showing turn-off switching waveforms with definitions of $V_s$, $I_{RRM}$, $I_{fitted}$, $I_{free10\%}$, and $I_{free100\%}$].

- $V_s(100\%) = 700$ V
- $I_{fitted}(100\%) = 100$ A
- $I_{free10\%}(100\%) = -151$ A
- $t_{rr} = 0.08$ µs

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Switching Definitions half bridge (T1, T4 / D7, D8)

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

- $I_d(100%) = 100\, A$
- $Q_{rr}(100%) = 7.13\, \mu C$
- $t_{Qrr} = 0.16\, \mu s$

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

- $P_{rec}(100%) = 70.22\, kW$
- $E_{rec}(100%) = 1.01\, mJ$
- $t_{Erec} = 0.16\, \mu s$

half bridge switching measurement circuit (T1, T4 / D7, D8)

Figure 11
half bridge IGBT
Switching Definitions neutral point IGBT (T2, T3 / D5, D6)

**General conditions**

<table>
<thead>
<tr>
<th>$T_J$</th>
<th>$125 , ^\circ\text{C}$</th>
</tr>
</thead>
<tbody>
<tr>
<td>$R_{\text{on}}$</td>
<td>$4 , \Omega$</td>
</tr>
<tr>
<td>$R_{\text{off}}$</td>
<td>$4 , \Omega$</td>
</tr>
</tbody>
</table>

**Figure 1**

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

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

- $V_{\text{CE}}(0\%) = -15 \, \text{V}$
- $V_{\text{CE}}(100\%) = 15 \, \text{V}$
- $I_C(100\%) = 100 \, \text{A}$
- $t_{\text{doff}} = 0.18 \, \mu\text{s}$
- $t_{\text{Eoff}} = 0.44 \, \mu\text{s}$

**Figure 2**

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

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

- $V_{\text{CE}}(0\%) = -15 \, \text{V}$
- $V_{\text{CE}}(100\%) = 15 \, \text{V}$
- $V_C(100\%) = 700 \, \text{V}$
- $I_C(100\%) = 100 \, \text{A}$
- $t_{\text{don}} = 0.10 \, \mu\text{s}$
- $t_{\text{Eon}} = 0.18 \, \mu\text{s}$

**Figure 3**

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

**Figure 4**

*Turn-on Switching Waveforms & definition of $t_r$*
Switching Definitions neutral point IGBT (T2, T3 / D5, D6)

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

- $P_{off}(100\%) = 69.93$ kW
- $E_{off}(100\%) = 3.32$ mJ
- $t_{Eoff} = 0.44$ μs

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

- $P_{on}(100\%) = 69.9279$ kW
- $E_{on}(100\%) = 1.52$ mJ
- $t_{Eon} = 0.18$ μs

**Figure 7** neutral point IGBT
Gate voltage vs Gate charge (measured)

- $V_{GEoff} = -15$ V
- $V_{GEon} = 15$ V
- $V_{d}(100\%) = 700$ V
- $I_{d}(100\%) = 100$ A
- $Q_g = 950.59$ nC

**Figure 8** half bridge FWD
Turn-off Switching Waveforms & definition of $t_{tr}$

- $V_d(100\%) = 700$ V
- $I_d(100\%) = 100$ A
- $I_{RRM}(100\%) = -142$ A
- $t_{tr} = 0.07$ μs
Switching Definitions neutral point IGBT (T2, T3 / D5, D6)

**Figure 9**

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

- $I_d(100\%) = 100$ A
- $Q_{rr}(100\%) = 12.71$ µC
- $t_{Qrr} = 1.00$ µs

**Figure 10**

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

- $P_{rec}(100\%) = 69.93$ kW
- $E_{rec}(100\%) = 3.61$ mJ
- $t_{Erec} = 1.00$ µs

**neutral point IGBT switching measurement circuit (T2, T3 / D5, D6)**

**Figure 11**

Diagram of the neutral point IGBT switching measurement circuit (T2, T3 / D5, D6)
### Ordering Code & Marking

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<td>10-PY12NMA160SH-M420FY/-3/</td>
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### Outline

![Outline Diagram]

### Pinout

![Pinout Diagram]
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