### Features
- Mixed voltage NPC topology
- Reactive power capability
- Low inductance layout
- High speed IGBT and split output
- Common collector neutral connection

### Target Applications
- Solar inverter
- UPS
- Active frontend

### Types
- 30-FT12NMA200SH-M660F08
- 30-PT12NMA200SH-M660F08Y

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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>Repetitive peak reverse voltage</td>
<td>( V_{RRM} )</td>
<td>( T_j = T_{jmax} ) ( T_r = 80 , ^\circ C )</td>
<td>1200</td>
<td>V</td>
</tr>
<tr>
<td>DC forward current</td>
<td>( I_F )</td>
<td>( T_j = T_{jmax} ) ( T_r = 80 , ^\circ C )</td>
<td>25</td>
<td>A</td>
</tr>
<tr>
<td>Maximum repetitive forward current</td>
<td>( I_{FRM} )</td>
<td>( T_j = 10 , \mu s )</td>
<td>30</td>
<td>A</td>
</tr>
<tr>
<td>Power dissipation</td>
<td>( P_{tot} )</td>
<td>( T_j = 80 , ^\circ C )</td>
<td>52</td>
<td>W</td>
</tr>
</tbody>
</table>

### Half Bridge Switch

<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>( V_{CE} )</td>
<td>( T_j = T_{jmax} ) ( T_r = 80 , ^\circ C )</td>
<td>1200</td>
<td>V</td>
</tr>
<tr>
<td>DC collector current</td>
<td>( I_C )</td>
<td>( T_j = T_{jmax} ) ( T_r = 80 , ^\circ C )</td>
<td>171</td>
<td>A</td>
</tr>
<tr>
<td>Repetitive peak collector current</td>
<td>( I_{CPM} )</td>
<td>( T_j = T_{jmax} ), limited by ( T_{max} )</td>
<td>600</td>
<td>A</td>
</tr>
<tr>
<td>Turn off safe operation area</td>
<td>( V_{CE}, T = 1200V, T_{jmax} \leq 150^\circ C )</td>
<td>400</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Power dissipation</td>
<td>( P_{tot} )</td>
<td>( T_j = T_{jmax} ) ( T_r = 80 , ^\circ C )</td>
<td>434</td>
<td>W</td>
</tr>
<tr>
<td>Gate-emitter peak voltage</td>
<td>( V_{GE} )</td>
<td>( T_j = T_{jmax} ) ( T_r = 80 , ^\circ C )</td>
<td>( \pm 20 )</td>
<td>V</td>
</tr>
<tr>
<td>Short circuit ratings</td>
<td>( t_{SC} )</td>
<td>( T_j = 150 , ^\circ C ) ( V_{BE} = 15 , V )</td>
<td>10</td>
<td>( \mu s )</td>
</tr>
<tr>
<td>Maximum Junction Temperature</td>
<td>( T_{jmax} )</td>
<td></td>
<td>175</td>
<td>( ^\circ C )</td>
</tr>
</tbody>
</table>
## Maximum Ratings

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

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Symbol</th>
<th>Condition</th>
<th>Value</th>
<th>Unit</th>
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</thead>
<tbody>
<tr>
<td><strong>Neutral Point FWD</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Peak Repetitive Reverse Voltage</td>
<td>$V_{RRM}$</td>
<td>$T_i = T_{pwm}$, $T_s = 80 , ^\circ C$</td>
<td>700</td>
<td>V</td>
</tr>
<tr>
<td>DC forward current</td>
<td>$I_{FDM}$</td>
<td>$T_i = T_{pwm}$, $T_s = 80 , ^\circ C$</td>
<td>87</td>
<td>A</td>
</tr>
<tr>
<td>Diode maximum forward current</td>
<td>$I_{FDM}$</td>
<td>$r_s$ limited by $T_{pwm}$</td>
<td>300</td>
<td>A</td>
</tr>
<tr>
<td>Power dissipation</td>
<td>$P_{tot}$</td>
<td>$T_i = T_{pwm}$, $T_s = 80 , ^\circ C$</td>
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<td>W</td>
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<tr>
<td>Maximum Junction Temperature</td>
<td>$T_{jmax}$</td>
<td></td>
<td>150</td>
<td>^\circ C</td>
</tr>
<tr>
<td><strong>Neutral Point Switch</strong></td>
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<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Collector-emitter breakdown voltage</td>
<td>$V_{CE}$</td>
<td></td>
<td>600</td>
<td>V</td>
</tr>
<tr>
<td>DC collector current</td>
<td>$I_{C}$</td>
<td>$T_i = T_{pwm}$, $T_s = 80 , ^\circ C$</td>
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<td>A</td>
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<tr>
<td>Repetitive peak collector current</td>
<td>$I_{CEM}$</td>
<td>$r_s$ limited by $T_{pwm}$</td>
<td>450</td>
<td>A</td>
</tr>
<tr>
<td>Turn off safe operation area</td>
<td></td>
<td>$V_{CE} \leq 600V$, $T_i \leq 175, ^\circ C$</td>
<td>450</td>
<td>A</td>
</tr>
<tr>
<td>Power dissipation</td>
<td>$P_{tot}$</td>
<td>$T_i = T_{pwm}$, $T_s = 80 , ^\circ C$</td>
<td>198</td>
<td>W</td>
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<tr>
<td>Gate–emitter peak voltage</td>
<td>$V_{CE}$</td>
<td></td>
<td>420</td>
<td>V</td>
</tr>
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<td>Short circuit ratings</td>
<td>$I_{CC}$</td>
<td>$T_i \leq 150 , ^\circ C$</td>
<td>6</td>
<td>A</td>
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<tr>
<td></td>
<td>$V_{CE}$</td>
<td>$V_{CE} = 15 , V$</td>
<td>360</td>
<td>ms</td>
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<tr>
<td>Maximum Junction Temperature</td>
<td>$T_{jmax}$</td>
<td></td>
<td>175</td>
<td>^\circ C</td>
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<tr>
<td><strong>Neutral Point Sw. Protection Diode</strong></td>
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<td></td>
<td></td>
</tr>
<tr>
<td>Peak Repetitive Reverse Voltage</td>
<td>$V_{RRM}$</td>
<td>$T_i = T_{pwm}$</td>
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<td>V</td>
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<td>DC forward current</td>
<td>$I_{F}$</td>
<td>$T_i = T_{pwm}$, $T_s = 80 , ^\circ C$</td>
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<td>A</td>
</tr>
<tr>
<td>Maximum repetitive forward current</td>
<td>$I_{FDM}$</td>
<td>$r_s$ limited by $T_{pwm}$</td>
<td>100</td>
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</tr>
<tr>
<td>Power dissipation</td>
<td>$P_{tot}$</td>
<td>$T_i = T_{pwm}$, $T_s = 80 , ^\circ C$</td>
<td>82</td>
<td>W</td>
</tr>
<tr>
<td>Maximum Junction Temperature</td>
<td>$T_{jmax}$</td>
<td></td>
<td>175</td>
<td>^\circ C</td>
</tr>
<tr>
<td><strong>Half Bridge FWD</strong></td>
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<td></td>
</tr>
<tr>
<td>Peak Repetitive Reverse Voltage</td>
<td>$V_{RRM}$</td>
<td></td>
<td>1200</td>
<td>V</td>
</tr>
<tr>
<td>DC forward current</td>
<td>$I_{F}$</td>
<td>$T_i = T_{pwm}$, $T_s = 80 , ^\circ C$</td>
<td>84</td>
<td>A</td>
</tr>
<tr>
<td>Nonrepetitive peak surge current</td>
<td>$I_{FSM}$</td>
<td>$r_s$ limited by $T_{pwm}$</td>
<td>540</td>
<td>A</td>
</tr>
<tr>
<td>Power dissipation</td>
<td>$P_{tot}$</td>
<td>$T_i = T_{pwm}$, $T_s = 80 , ^\circ C$</td>
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<td>W</td>
</tr>
<tr>
<td>Maximum Junction Temperature</td>
<td>$T_{jmax}$</td>
<td></td>
<td>175</td>
<td>^\circ C</td>
</tr>
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</table>
### Maximum Ratings

$T_\text{r} = 25 \, ^\circ\text{C}$, unless otherwise specified

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<tr>
<th>Parameter</th>
<th>Symbol</th>
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</tr>
</thead>
<tbody>
<tr>
<td><strong>Thermal Properties</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Storage temperature</td>
<td>$T_{\text{stg}}$</td>
<td></td>
<td>-40...+125°C</td>
<td>ºC</td>
</tr>
<tr>
<td>Operation temperature under switching condition</td>
<td>$T_{\text{op}}$</td>
<td></td>
<td>-40...$(T_{\text{max}} - 25)$</td>
<td>ºC</td>
</tr>
<tr>
<td><strong>Isolation Properties</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Isolation voltage</td>
<td>$V_{\text{is}}$</td>
<td>$t = 2 , \text{s}$</td>
<td>DC Test Voltage</td>
<td>4000</td>
</tr>
<tr>
<td>Creepage distance</td>
<td></td>
<td></td>
<td>min 12,7 mm</td>
<td>mm</td>
</tr>
<tr>
<td>Clearance</td>
<td></td>
<td></td>
<td>min 12,7 mm</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>
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</tr>
</thead>
<tbody>
<tr>
<td><strong>Half Bridge Sw. Protection Diode</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Forward voltage</td>
<td>$V_{F}$</td>
<td></td>
<td>1,6</td>
<td>V</td>
</tr>
<tr>
<td>Thermal resistance junction to sink</td>
<td>$R_{th(j-s)}$</td>
<td>Thermal grease thickness ≤ 50um λ = 1 W/mK</td>
<td>1,35</td>
<td>K/W</td>
</tr>
<tr>
<td><strong>Half Bridge Switch</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Gate emitter threshold voltage</td>
<td>$V_{th}$</td>
<td></td>
<td>0,068</td>
<td>V</td>
</tr>
<tr>
<td>Collector-emitter saturation voltage</td>
<td>$V_{CE(sat)}$</td>
<td></td>
<td>25</td>
<td>V</td>
</tr>
<tr>
<td>Collector-emitter cut-off current incl. Diode</td>
<td>$I_{CES}$</td>
<td></td>
<td>125</td>
<td>mA</td>
</tr>
<tr>
<td>Gate-emitter leakage current</td>
<td>$I_{GE}$</td>
<td></td>
<td>25</td>
<td>nA</td>
</tr>
<tr>
<td>Integrated Gate resistor</td>
<td>$R_{gin}$</td>
<td></td>
<td>1</td>
<td>Ω</td>
</tr>
<tr>
<td>Turn-on delay time</td>
<td>$t_{d(on)}$</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>$t_{f}$</td>
<td></td>
<td>200</td>
<td>ns</td>
</tr>
<tr>
<td>Fall time</td>
<td>$t_{f}$</td>
<td></td>
<td>200</td>
<td>ns</td>
</tr>
<tr>
<td>Turn-on energy loss</td>
<td>$E_{on}$</td>
<td></td>
<td>25</td>
<td>mWs</td>
</tr>
<tr>
<td>Turn-off energy loss</td>
<td>$E_{off}$</td>
<td></td>
<td>25</td>
<td>mWs</td>
</tr>
<tr>
<td>Input capacitance</td>
<td>$C_{iss}$</td>
<td></td>
<td>25</td>
<td>pF</td>
</tr>
<tr>
<td>Output capacitance</td>
<td>$C_{oss}$</td>
<td></td>
<td>25</td>
<td>pF</td>
</tr>
<tr>
<td>Reverse transfer capacitance</td>
<td>$C_{rss}$</td>
<td></td>
<td>25</td>
<td>pF</td>
</tr>
<tr>
<td>Gate charge</td>
<td>$Q_{g}$</td>
<td></td>
<td>960</td>
<td>nC</td>
</tr>
<tr>
<td>Thermal resistance junction to sink</td>
<td>$R_{th(j-s)}$</td>
<td>Thermal grease thickness ≤ 50um λ = 1 W/mK</td>
<td>0,22</td>
<td>K/W</td>
</tr>
</tbody>
</table>

*additional value stands for built-in capacitor

### Neutral Point FWD

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Symbol</th>
<th>Conditions</th>
<th>Value</th>
<th>Unit</th>
</tr>
</thead>
<tbody>
<tr>
<td>Diode forward voltage</td>
<td>$V_{F}$</td>
<td></td>
<td>150</td>
<td>V</td>
</tr>
<tr>
<td>Peak reverse recovery current</td>
<td>$I_{RRM}$</td>
<td></td>
<td>1,3</td>
<td>A</td>
</tr>
<tr>
<td>Reverse recovery time</td>
<td>$t_{r}$</td>
<td></td>
<td>1,4</td>
<td>ns</td>
</tr>
<tr>
<td>Reverse recovered charge</td>
<td>$Q_{r}$</td>
<td></td>
<td>1</td>
<td>μC</td>
</tr>
<tr>
<td>Peak rate of fall of recovery current</td>
<td>$d(V_{F}/d	au)_{max}$</td>
<td></td>
<td>25</td>
<td>A/μs</td>
</tr>
<tr>
<td>Reverse recovered energy</td>
<td>$E_{rec}$</td>
<td></td>
<td>25</td>
<td>mWs</td>
</tr>
<tr>
<td>Thermal resistance junction to sink</td>
<td>$R_{th(j-s)}$</td>
<td>Thermal grease thickness ≤ 50um λ = 1 W/mK</td>
<td>0,64</td>
<td>K/W</td>
</tr>
</tbody>
</table>
### Characteristic Values

<table>
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<tr>
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<th>Conditions</th>
<th>Value</th>
<th>Unit</th>
</tr>
</thead>
<tbody>
<tr>
<td>Collector-emitter saturation voltage</td>
<td>$V_{CE}$</td>
<td>$V_{CE} = V_{CS}$</td>
<td>0,024</td>
<td>V</td>
</tr>
<tr>
<td>Collector-emitter cut-off diode</td>
<td>$I_{CES}$</td>
<td>0</td>
<td>600</td>
<td>µA</td>
</tr>
<tr>
<td>Gate-emitter leakage current</td>
<td>$I_{GEC}$</td>
<td>20</td>
<td>0</td>
<td>25</td>
</tr>
<tr>
<td>Integrated Gate resistor</td>
<td>$R_{on}$</td>
<td>none</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Turn-on delay time</td>
<td>$t_{on}$</td>
<td>15</td>
<td>150</td>
<td>25</td>
</tr>
<tr>
<td>Rise time</td>
<td>$r_{on}$</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>$r_{off}$</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Turn-on energy loss</td>
<td>$E_{on}$</td>
<td>25</td>
<td>150</td>
<td>1,10</td>
</tr>
<tr>
<td>Turn-off energy loss</td>
<td>$E_{off}$</td>
<td>25</td>
<td>150</td>
<td>1,59</td>
</tr>
<tr>
<td>Input capacitance</td>
<td>$C_{in}$</td>
<td>25</td>
<td>150</td>
<td>9240</td>
</tr>
<tr>
<td>Output capacitance</td>
<td>$C_{out}$</td>
<td>25</td>
<td>150</td>
<td>576</td>
</tr>
<tr>
<td>Reverse transfer capacitance</td>
<td>$C_{rs}$</td>
<td>274</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Gate charge</td>
<td>$Q_{G}$</td>
<td>25</td>
<td>150</td>
<td>940</td>
</tr>
<tr>
<td>Thermal resistance junction to sink</td>
<td>$R_{th(j-s)}$</td>
<td>Thermal grease thickness ≤ 50um</td>
<td>25</td>
<td>1,16</td>
</tr>
</tbody>
</table>

### Neutral Point Switch

<table>
<thead>
<tr>
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<th>Symbol</th>
<th>Conditions</th>
<th>Value</th>
<th>Unit</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gate-emitter threshold voltage</td>
<td>$V_{GE}$</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Collector-emitter saturation voltage</td>
<td>$V_{CE}$</td>
<td>$V_{CE} = V_{CS}$</td>
<td>15</td>
<td>150</td>
</tr>
<tr>
<td>Collector-emitter cut-off diode</td>
<td>$I_{CES}$</td>
<td>0</td>
<td>600</td>
<td>25</td>
</tr>
<tr>
<td>Gate-emitter leakage current</td>
<td>$I_{GEC}$</td>
<td>20</td>
<td>0</td>
<td>25</td>
</tr>
<tr>
<td>Integrated Gate resistor</td>
<td>$R_{on}$</td>
<td>none</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Turn-on delay time</td>
<td>$t_{on}$</td>
<td>15</td>
<td>150</td>
<td>25</td>
</tr>
<tr>
<td>Rise time</td>
<td>$r_{on}$</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>$r_{off}$</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Turn-on energy loss</td>
<td>$E_{on}$</td>
<td>25</td>
<td>150</td>
<td>1,10</td>
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<tr>
<td>Turn-off energy loss</td>
<td>$E_{off}$</td>
<td>25</td>
<td>150</td>
<td>1,59</td>
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<tr>
<td>Input capacitance</td>
<td>$C_{in}$</td>
<td>25</td>
<td>150</td>
<td>9240</td>
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<tr>
<td>Output capacitance</td>
<td>$C_{out}$</td>
<td>25</td>
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<td>Reverse transfer capacitance</td>
<td>$C_{rs}$</td>
<td>274</td>
<td></td>
<td></td>
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<tr>
<td>Gate charge</td>
<td>$Q_{G}$</td>
<td>25</td>
<td>150</td>
<td>940</td>
</tr>
<tr>
<td>Thermal resistance junction to sink</td>
<td>$R_{th(j-s)}$</td>
<td>Thermal grease thickness ≤ 50um</td>
<td>25</td>
<td>1,16</td>
</tr>
</tbody>
</table>

### Diode forward voltage

<table>
<thead>
<tr>
<th>Parameter</th>
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<th>Conditions</th>
<th>Value</th>
<th>Unit</th>
</tr>
</thead>
<tbody>
<tr>
<td>Collector-emitter saturation voltage</td>
<td>$V_{CE}$</td>
<td>$V_{CE} = V_{CS}$</td>
<td>50</td>
<td>25</td>
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### Half Bridge FWD

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<th>Unit</th>
</tr>
</thead>
<tbody>
<tr>
<td>Collector-emitter saturation voltage</td>
<td>$V_{CE}$</td>
<td>$V_{CE} = V_{CS}$</td>
<td>100</td>
<td>25</td>
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</table>

### Thermistor

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Symbol</th>
<th>Conditions</th>
<th>Value</th>
<th>Unit</th>
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</thead>
<tbody>
<tr>
<td>Rated resistance</td>
<td>$R$</td>
<td></td>
<td>25</td>
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<tr>
<td>Deviation of $R_{TH}$</td>
<td>$ΔR_{TH}$</td>
<td>$R_{TH} = 1486 Ω$</td>
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<td>-5</td>
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<td>Power dissipation</td>
<td>$P$</td>
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<td>Power dissipation constant</td>
<td>$P$</td>
<td></td>
<td>25</td>
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<tr>
<td>B-value</td>
<td>$B_{(25/50)}$</td>
<td>Tol. ±3%</td>
<td>25</td>
<td>3950</td>
</tr>
<tr>
<td>B-value</td>
<td>$B_{(25/100)}$</td>
<td>Tol. ±3%</td>
<td>25</td>
<td>3998</td>
</tr>
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</table>

Vincotech NTC Reference |

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Half Bridge
Half Bridge IGBT and Neutral Point FWD

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

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

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

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

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

At
- \( t_p = 250 \ \mu s \)
- \( T_j = T_{j_{max}} - 25 \ ^\circ C \)
- \( V_{CE} = 10 \ V \)

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

At
- \( t_p = 250 \ \mu s \)
- \( T_j = 25/150 \ ^\circ C \)
**Half Bridge**

**Figure 5.**

**Typical switching energy losses as a function of collector current**

\[ E = f(I_C) \]

![Graph showing typical switching energy losses](image)

With an inductive load at:
- \( T_J = 25/125 \, ^\circ\text{C} \)
- \( V_{CE} = 350 \, \text{V} \)
- \( V_{GE} = \pm 15 \, \text{V} \)
- \( R_{gon} = 2 \, \Omega \)
- \( R_{goff} = 2 \, \Omega \)

**Figure 6.**

**Typical switching energy losses as a function of gate resistor**

\[ E = f(R_G) \]

![Graph showing typical switching energy losses](image)

With an inductive load at:
- \( T_J = 25/125 \, ^\circ\text{C} \)
- \( V_{CE} = 350 \, \text{V} \)
- \( V_{GE} = \pm 15 \, \text{V} \)
- \( I_C = 198 \, \text{A} \)

**Figure 7.**

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

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

![Graph showing typical reverse recovery energy loss](image)

With an inductive load at:
- \( T_J = 25/125 \, ^\circ\text{C} \)
- \( V_{CE} = 350 \, \text{V} \)
- \( V_{GE} = \pm 15 \, \text{V} \)
- \( R_{gon} = 2 \, \Omega \)

**Figure 8.**

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

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

![Graph showing typical reverse recovery energy loss](image)

With an inductive load at:
- \( T_J = 25/125 \, ^\circ\text{C} \)
- \( V_{CE} = 350 \, \text{V} \)
- \( V_{GE} = \pm 15 \, \text{V} \)
- \( I_C = 198 \, \text{A} \)
**Half Bridge**

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

\[ t = f(I_C) \]

With an inductive load at

\[ T_J = 125 \, ^\circ C \]
\[ V_{CE} = 350 \, V \]
\[ V_{GE} = \pm 15 \, V \]
\[ R_{gon} = 2 \, \Omega \]
\[ R_{goff} = 2 \, \Omega \]

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

\[ t = f(R_G) \]

With an inductive load at

\[ T_J = 125 \, ^\circ C \]
\[ V_{CE} = 350 \, V \]
\[ V_{GE} = \pm 15 \, V \]
\[ I_C = 198 \, A \]

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

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

At

\[ T_J = 25/125 \, ^\circ C \]
\[ V_{CE} = 350 \, V \]
\[ V_{GE} = \pm 15 \, V \]
\[ R_{gon} = 2 \, \Omega \]

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

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

At

\[ T_J = 25/125 \, ^\circ C \]
\[ V_B = 350 \, V \]
\[ I_F = 198 \, A \]
\[ V_{GE} = \pm 15 \, V \]
### Half Bridge IGBT and Neutral Point FWD

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

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

At
- \( T_J = 25/125 \) °C
- \( V_{CE} = 350 \) V
- \( V_{GE} = \pm 15 \) V
- \( R_{gon} = 2 \) Ω

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

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

At
- \( T_J = 25/125 \) °C
- \( V_{R} = 350 \) V
- \( I_F = 198 \) A
- \( V_{GE} = \pm 15 \) V

#### Figure 15.
Typical reverse recovery current as a function of collector current

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

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

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

At
- \( T_J = 25/125 \) °C
- \( V_{R} = 350 \) V
- \( I_F = 198 \) A
- \( V_{GE} = \pm 15 \) V
Half Bridge
Half Bridge IGBT and Neutral Point FWD

**Figure 17.**
Typical rate of fall of forward and reverse recovery current as a function of collector current

\[ \frac{di_0}{dt}, \frac{di_{rec}}{dt} = f(I_{cc}) \]

At
- \( T_j = 25/125\, ^\circ C \)
- \( V_{CE} = 350\, V \)
- \( V_{GE} = \pm 15\, V \)
- \( R_{gon} = 2\, \Omega \)

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

\[ \frac{di_0}{dt}, \frac{di_{rec}}{dt} = f(R_{gon}) \]

At
- \( T_j = 25/125\, ^\circ C \)
- \( V_R = 350\, V \)
- \( I_F = 198\, A \)
- \( V_{GE} = \pm 15\, V \)

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

\[ Z_{th_{(J,s)}} = f(t_p) \]

At
- \( D = \frac{t_p}{T} \)
- \( R_{th_{(J,s)}} = 0.22\, K/W \)

**Figure 20.**
FWD transient thermal impedance as a function of pulse width

\[ Z_{th_{(J,s)}} = f(t_p) \]

At
- \( D = \frac{t_p}{T} \)
- \( R_{th_{(J,s)}} = 0.64\, K/W \)

IGBT thermal model values

\[
\begin{align*}
R_{(K/W)} & \quad \text{Tau (s)} \\
0.04 & \quad 4,0E+00 \\
0.05 & \quad 9,4E-01 \\
0.04 & \quad 2,3E-01 \\
0.07 & \quad 5,4E-02 \\
0.02 & \quad 1,6E-02 \\
0.01 & \quad 2,8E-03 \\
\end{align*}
\]

FWD thermal model values

\[
\begin{align*}
R_{(K/W)} & \quad \text{Tau (s)} \\
0.09 & \quad 4,6E+00 \\
0.11 & \quad 1,2E+00 \\
0.16 & \quad 1,8E-01 \\
0.23 & \quad 3,8E-02 \\
0.03 & \quad 5,8E-03 \\
0.03 & \quad 7,4E-04 \\
\end{align*}
\]
Half Bridge
Half Bridge IGBT and Neutral Point FWD

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

![Graph showing power dissipation as a function of heatsink temperature for IGBT.]

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

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

![Graph showing collector current as a function of heatsink temperature for IGBT.]

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

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

![Graph showing power dissipation as a function of heatsink temperature for FWD.]

At
\[ T_j = 150 \ ^\circ\text{C} \]

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

![Graph showing forward current as a function of heatsink temperature for FWD.]

At
\[ T_j = 150 \ ^\circ\text{C} \]
**Half Bridge**

**Half Bridge IGBT and Neutral Point FWD**

**Figure 25.** IGBT

Safe operating area as a function of collector-emitter voltage

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

**Figure 26.** IGBT

Gate voltage vs Gate charge

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

**Figure 27.** IGBT

Short circuit withstand time as a function of gate-emitter voltage

\[ t_{sc} = f(V_{GE}) \]

**Figure 28.** IGBT

Typical short circuit collector current as a function of gate-emitter voltage

\[ I_{C(sc)} = f(V_{GE}) \]

**At**

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

**At**

- \( I_D = 160 \) A
- \( T_J = 25 \) °C

**At**

- \( V_{CE} = 1200 \) V
- \( T_J \leq 175 \) °C

**At**

- \( V_{CE} \leq 1200 \) V
- \( T_J = 175 \) °C
**Half Bridge**

Half Bridge IGBT and Neutral Point FWD

**figure 27.**

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
Neutral Point

Neutral Point IGBT and Half Bridge FWD

**figure 1.** IGBT

Typical output characteristics

$I_C = f(V_{CE})$

<table>
<thead>
<tr>
<th>$V_{CE}$ (V)</th>
<th>$I_C$ (A)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>1</td>
<td>5</td>
</tr>
<tr>
<td>2</td>
<td>10</td>
</tr>
<tr>
<td>3</td>
<td>15</td>
</tr>
<tr>
<td>4</td>
<td>20</td>
</tr>
<tr>
<td>5</td>
<td>25</td>
</tr>
</tbody>
</table>

At
- $t_p = 250 \ \mu s$
- $T_j = 25 \ ^\circ C$
- $V_{CE}$ from 7 V to 17 V in steps of 1 V

**figure 2.** IGBT

Typical output characteristics

$I_C = f(V_{CE})$

<table>
<thead>
<tr>
<th>$V_{CE}$ (V)</th>
<th>$I_C$ (A)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>1</td>
<td>5</td>
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<tr>
<td>2</td>
<td>10</td>
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<td>3</td>
<td>15</td>
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<td>4</td>
<td>20</td>
</tr>
<tr>
<td>5</td>
<td>25</td>
</tr>
</tbody>
</table>

At
- $t_p = 250 \ \mu s$
- $T_j = 150 \ ^\circ C$
- $V_{CE}$ from 7 V to 17 V in steps of 1 V

**figure 3.** IGBT

Typical transfer characteristics

$I_C = f(V_{GE})$

<table>
<thead>
<tr>
<th>$V_{GE}$ (V)</th>
<th>$I_C$ (A)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>0</td>
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<tr>
<td>1</td>
<td>5</td>
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<td>2</td>
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<td>4</td>
<td>20</td>
</tr>
<tr>
<td>5</td>
<td>25</td>
</tr>
</tbody>
</table>

At
- $t_p = 250 \ \mu s$
- $V_{CE} = 0 \ \text{V}$
- $T_j = 25/150 \ ^\circ C$

**figure 4.** FWD

Typical FWD forward current as a function of forward voltage

$I_F = f(V_F)$

<table>
<thead>
<tr>
<th>$V_F$ (V)</th>
<th>$I_F$ (A)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>1</td>
<td>5</td>
</tr>
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<td>2</td>
<td>10</td>
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<td>3</td>
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<tr>
<td>4</td>
<td>20</td>
</tr>
<tr>
<td>5</td>
<td>25</td>
</tr>
</tbody>
</table>

At
- $t_p = 250 \ \mu s$
- $T_j = 25/150 \ ^\circ C$
Neutral Point
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
- \( T_j = 25/126 \) °C
- \( V_{CE} = 350 \) V
- \( V_{GE} = \pm 15 \) V
- \( R_{gon} = 2 \) Ω
- \( R_{goff} = 2 \) Ω

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

\[ E = f(R_G) \]

With an inductive load at
- \( T_j = 25/126 \) °C
- \( V_{CE} = 350 \) V
- \( V_{GE} = \pm 15 \) V
- \( I_C = 151 \) A

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

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

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

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

With an inductive load at
- \( T_j = 25/126 \) °C
- \( V_{CE} = 350 \) V
- \( V_{GE} = \pm 15 \) V
- \( I_C = 151 \) A
Neutral Point
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
\[ T_j = 126 \, ^\circ\text{C} \]
\[ V_{CE} = 350 \, \text{V} \]
\[ V_{GE} = \pm 15 \, \text{V} \]
\[ R_{gon} = 2 \, \Omega \]
\[ R_{goff} = 2 \, \Omega \]

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

With an inductive load at
\[ T_j = 126 \, ^\circ\text{C} \]
\[ V_{CE} = 350 \, \text{V} \]
\[ V_{GE} = \pm 15 \, \text{V} \]
\[ I_C = 151 \, \text{A} \]

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

At
\[ T_j = 25/126 \, ^\circ\text{C} \]
\[ V_{CE} = 350 \, \text{V} \]
\[ V_{GE} = \pm 15 \, \text{V} \]
\[ R_{gon} = 2 \, \Omega \]

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

At
\[ T_j = 25/126 \, ^\circ\text{C} \]
\[ V_R = 350 \, \text{V} \]
\[ I_F = 151 \, \text{A} \]
\[ V_{GE} = \pm 15 \, \text{V} \]
Neutral Point
Neutral Point IGBT and Half Bridge FWD

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

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

- At
  - \( T_J = 25/126 \, ^{\circ}\text{C} \)
  - \( V_{CE} = 350 \, \text{V} \)
  - \( V_{GE} = \pm 15 \, \text{V} \)
  - \( R_{gon} = 2 \, \Omega \)

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

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

- At
  - \( T_J = 25/126 \, ^{\circ}\text{C} \)
  - \( V_{CE} = 350 \, \text{V} \)
  - \( I_F = 151 \, \text{A} \)
  - \( V_{GE} = \pm 15 \, \text{V} \)

**figure 15.**
Typical reverse recovery current as a function of collector current

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

- At
  - \( T_J = 25/126 \, ^{\circ}\text{C} \)
  - \( V_{CE} = 350 \, \text{V} \)
  - \( V_{GE} = \pm 15 \, \text{V} \)
  - \( R_{gon} = 2 \, \Omega \)

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

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

- At
  - \( T_J = 25/126 \, ^{\circ}\text{C} \)
  - \( V_{CE} = 350 \, \text{V} \)
  - \( I_F = 151 \, \text{A} \)
  - \( V_{GE} = \pm 15 \, \text{V} \)
Neutral Point
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
\[
dI_0/dt, dI_{rec}/dt = f(I_c)
\]

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

At
\[
T_j = 25/126 \degree C
\]
\[
V_{CE} = 350 \text{ V}
\]
\[
V_{GE} = \pm 15 \text{ V}
\]
\[
R_{gon} = 2 \Omega
\]

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

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

At
\[
D = \frac{t_p}{T}
\]
\[
R_{th(j-s)} = 0.48 \text{ K/W}
\]

IGBT thermal model values
\[
R (\text{K/W}) \quad \text{Tau (s)}
\]
\[
0.09 \quad 4.40
\]
\[
0.11 \quad 0.76
\]
\[
0.10 \quad 0.13
\]
\[
0.15 \quad 0.03
\]
\[
0.02 \quad 0.01
\]

FWD thermal model values
\[
R (\text{K/W}) \quad \text{Tau (s)}
\]
\[
0.06 \quad 3.05
\]
\[
0.08 \quad 0.45
\]
\[
0.20 \quad 0.09
\]
\[
0.14 \quad 0.03
\]
\[
0.04 \quad 0.004
\]
Neutral Point
Neutral Point IGBT and Half Bridge FWD

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

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

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

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

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

At
\[ T_j = 175 \degree C \]
Neutral Point
neutral point IGBT

---

**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. IGBT**
Gate voltage vs Gate charge

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

At
\[ I_D = 150 \, A \]
\[ T_J = 25 \, ^\circ C \]

---

**Figure 27. IGBT**
Short circuit withstand time as a function of gate-emitter voltage

\[ t_{sc} = f(V_{GE}) \]

At
\[ V_{CE \leq 400 \, V} \]
\[ T_J \leq 150 \, ^\circ C \]

---

**Figure 28. IGBT**
Typical short circuit collector current as a function of gate-emitter voltage

\[ I_{SC} = f(V_{GE}) \]

At
\[ V_{CE \leq 400 \, V} \]
\[ T_J = 150 \, ^\circ C \]
Neutal Point IGBT Inverse Diode

**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
\[ Z_{th(j-s)} = f(t_p) \]

At
\[ t_p = 250 \mu s \]

At
\[ D = \frac{t_p}{T} \]
\[ R_{th(j-s)} = 1.16 \text{ K/W} \]

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

At
\[ T_j = 175 \degree C \]

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

At
\[ T_j = 175 \degree C \]
**Half Bridge Inverse Diode**

**Figure 1.** IGBT
Typical FWD forward current as a function of forward voltage
\[ I_F = f(V_F) \]

**Figure 2.** IGBT
FWD transient thermal impedance as a function of pulse width
\[ Z_{th(j-s)} = f(t_p) \]

**Figure 3.** IGBT
Power dissipation as a function of heatsink temperature
\[ P_{tot} = f(T_s) \]

**Figure 4.** IGBT
Forward current as a function of heatsink temperature
\[ I_F = f(T_J) \]

At
\[ t_p = 250 \ \mu s \]

At
\[ D = \frac{t_p}{T} \]
\[ R_{th(j-s)} = 1.35 \ \text{K/W} \]

At
\[ T_J = 150 \ ^\circ\text{C} \]

At
\[ T_J = 150 \ ^\circ\text{C} \]
figure 1. Thermistor

Typical NTC characteristic
as a function of temperature

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

**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>$R_{gon}$</td>
<td>2 Ω</td>
</tr>
<tr>
<td>$R_{goff}$</td>
<td>2 Ω</td>
</tr>
</tbody>
</table>

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

- $V_{CE} (0\%) = -15$ V
- $V_{CE} (100\%) = 15$ V
- $I_C (100\%) = 198$ A
- $t_{doff} = 0.23$ μs
- $t_{Eoff} = 0.61$ μs

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

- $V_{CE} (0\%) = -15$ V
- $V_{CE} (100\%) = 15$ V
- $I_C (100\%) = 700$ V
- $I_C (100\%) = 198$ A
- $t_{don} = 0.13$ μs
- $t_{Eon} = 0.30$ μs

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

- $V_C (100\%) = 700$ V
- $I_C (100\%) = 198$ A
- $t_f = 0.06$ μs

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

- $V_C (100\%) = 700$ V
- $I_C (100\%) = 198$ A
- $t_r = 0.03$ μs
Switching Definitions Half Bridge

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

![graph showing IGBT turn-off waveforms](image)

- \( P_{\text{off}}(100\%) = 138,85 \text{ kW} \)
- \( E_{\text{off}}(100\%) = 7,97 \text{ mJ} \)
- \( t_{\text{Qoff}} = 0,61 \text{ μs} \)

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

![graph showing IGBT turn-on waveforms](image)

- \( P_{\text{on}}(100\%) = 138,85 \text{ kW} \)
- \( E_{\text{on}}(100\%) = 4,20 \text{ mJ} \)
- \( t_{\text{Qon}} = 0,30 \text{ μs} \)

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

![graph showing FWD turn-off waveforms](image)

- \( V_d (100\%) = 700 \text{ V} \)
- \( I_d (100\%) = 198 \text{ A} \)
- \( I_{\text{RRM}} (100\%) = -169 \text{ A} \)
- \( t_{\text{rr}} = 0,12 \text{ μs} \)

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

![graph showing FWD turn-on waveforms](image)

- \( I_d (100\%) = 198 \text{ A} \)
- \( Q_{\text{rr}} (100\%) = 11,00 \text{ μC} \)
- \( t_{\text{Qrr}} = 0,24 \text{ μs} \)
Switching Definitions Half Bridge

**figure 9.**
FWD

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

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

\[
P_{rec} (100\%) = 138.85 \text{ kW}\\
E_{rec} (100\%) = 2.39 \text{ mJ}\\
t_{E_{rec}} = 0.24 \text{ μs}
\]

**Half Bridge switching measurement circuit**

**figure 11.**
IGBT

Cl, C2 removed for dynamic measurements

- $V_{cc}$
- 700V
- $V_{cc}$
- $V_{gen}$
- 4.7kohm
- 47kohm
- 1mH
- L6
- 3x470mF
- 470mF
- C1, C2
- OUT1
- 3x500mH
- 3x500mH
- 15V
- 15V
- 15V
- $V_{cc}$
- $V_{gen}$
- $V_{cc}$
- OUT2
- 5mH
- 5mH
- 300mH
Switching Definitions Neutral Point IGBT

General conditions

<table>
<thead>
<tr>
<th>Condition</th>
<th>Value</th>
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<tbody>
<tr>
<td>$T_J$</td>
<td>125 °C</td>
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<tr>
<td>$R_{gon}$</td>
<td>4 Ω</td>
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<tr>
<td>$R_{goff}$</td>
<td>4 Ω</td>
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</tbody>
</table>

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

- $V_C$ (0%) = -15 V
- $V_C$ (100%) = 700 V
- $I_C$ (100%) = 151 A
- $t_{doff}$ = 0.18 μs
- $t_{Eoff}$ = 0.46 μs

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

- $V_C$ (0%) = -15 V
- $V_C$ (100%) = 700 V
- $I_C$ (100%) = 151 A
- $t_{don}$ = 0.11 μs
- $t_{Eon}$ = 0.19 μs

**figure 3.** Neutral Point IGBT
Turn-off Switching Waveforms & definition of $t_f$

- $V_C$ (100%) = 700 V
- $I_C$ (100%) = 151 A
- $t_f$ = 0.064 μs

**figure 4.** Neutral Point IGBT
Turn-on Switching Waveforms & definition of $t_r$

- $V_C$ (100%) = 700 V
- $I_C$ (100%) = 151 A
- $t_r$ = 0.019 μs
Switching Definitions Neutral Point IGBT

**figure 5. Neutral Point IGBT**

**Turn-off Switching Waveforms & definition of t\text{Eoff}**

![Graph showing turn-off switching waveforms and definition of t\text{Eoff}]

\[ P_{\text{Eoff}} (100\%) = 69.93 \text{ kW} \]

\[ E_{\text{Eoff}} (100\%) = 3.32 \text{ mJ} \]

\[ t_{\text{Eoff}} = 0.44 \mu s \]

**figure 6. Neutral Point IGBT**

**Turn-on Switching Waveforms & definition of t\text{Eon}**

![Graph showing turn-on switching waveforms and definition of t\text{Eon}]

\[ P_{\text{Eon}} (100\%) = 69.93 \text{ kW} \]

\[ E_{\text{Eon}} (100\%) = 1.52 \text{ mJ} \]

\[ t_{\text{Eon}} = 0.18 \mu s \]

**figure 7. Half Bridge FWD**

**Turn-off Switching Waveforms & definition of t\text{rr}**

![Graph showing turn-off switching waveforms and definition of t\text{rr}]

\[ V_d (100\%) = 700 \text{ V} \]

\[ I_d (100\%) = 151 \text{ A} \]

\[ I_{\text{RRM}} (100\%) = -142 \text{ A} \]

\[ t_{\text{rr}} = 0.07 \mu s \]

**figure 8. Half Bridge FWD**

**Turn-on Switching Waveforms & definition of t\text{Qrr}**

![Graph showing turn-on switching waveforms and definition of t\text{Qrr}]

\[ I_d (100\%) = 151 \text{ A} \]

\[ Q_r (100\%) = 12.71 \mu C \]

\[ t_{\text{Qrr}} = 1.00 \mu s \]
Switching Definitions Neutral Point IGBT

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

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

**Neutral Point IGBT switching measurement circuit**

**figure 10.** Neutral Point IGBT
Ordering Code and Marking - Outline - Pinout

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<th>Version</th>
<th>Ordering Code</th>
<th>in DataMatrix as</th>
<th>in packaging barcode as</th>
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<td>without thermal paste with solder pins</td>
<td>30-FT12NMA200SH-M660F08</td>
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<td>with thermal paste and solder pins</td>
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<td>M660F08-/3/</td>
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<td>M660F08Y-/3/</td>
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</tbody>
</table>

Outline

![Outline Diagram](image)
### Pinout

#### Identification

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<tr>
<th>ID</th>
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<th>Current</th>
<th>Function</th>
<th>Comment</th>
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<td>200A</td>
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<td>15A</td>
<td>HB IGBT Inverse Diode</td>
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<td>150A</td>
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<td>IGBT</td>
<td>600V</td>
<td>150A</td>
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<td>100A</td>
<td>Half Bridge FWD</td>
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<td>50A</td>
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<td>Resistor</td>
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