### Flow 2 MNPC

**Features**
- Mixed voltage NPC topology
- Reactive power capability
- Low inductance layout
- Split output
- Common collector neutral connection

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

**Types**
- 30-FT12NMA160SH02-M669F28
- 30-PT12NMA160SH02-M669F28Y

### Maximum Ratings

\[ T_j = 25 \, ^\circ C, \text{ unless otherwise specified} \]

<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_{RPM} )</td>
<td>( T_j = T_{jmax} ) ( T_s = 80 , ^\circ C )</td>
<td>1200</td>
<td>V</td>
</tr>
<tr>
<td>DC forward current</td>
<td>( I_s )</td>
<td>( T_j = T_{jmax} ) ( T_s = 80 , ^\circ C )</td>
<td>17</td>
<td>A</td>
</tr>
<tr>
<td>Maximum repetitive forward current</td>
<td>( I_{FPM} )</td>
<td>( T_s = 10 , \mu s )</td>
<td>14</td>
<td>A</td>
</tr>
<tr>
<td>I't-value</td>
<td>( I' )</td>
<td>( T_j = T_{jmax} )</td>
<td>40</td>
<td>A's</td>
</tr>
<tr>
<td>Power dissipation</td>
<td>( P_{tot} )</td>
<td>( T_s = 80 , ^\circ C )</td>
<td>40</td>
<td>W</td>
</tr>
<tr>
<td>Maximum Junction Temperature</td>
<td>( T_{jmax} )</td>
<td></td>
<td>150</td>
<td>°C</td>
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</table>

### Buck Inverse Diode

<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></td>
<td>1200</td>
<td>V</td>
</tr>
<tr>
<td>DC collector current</td>
<td>( I_C )</td>
<td>( T_j = T_{jmax} ) ( T_s = 80 , ^\circ C )</td>
<td>156</td>
<td>A</td>
</tr>
<tr>
<td>Repetitive peak collector current</td>
<td>( I_{CPM} )</td>
<td>( T_s ) limited by ( T_{jmax} )</td>
<td>480</td>
<td>A</td>
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<tr>
<td>Turn off safe operating area</td>
<td>( V_{CE(max)} = 1200 , V, T_s \leq 150 , ^\circ C )</td>
<td></td>
<td>320</td>
<td>A</td>
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<tr>
<td>Power dissipation</td>
<td>( P_{tot} )</td>
<td>( T_s = 80 , ^\circ C )</td>
<td>398</td>
<td>W</td>
</tr>
<tr>
<td>Gate-emitter peak voltage</td>
<td>( V_{GE} )</td>
<td></td>
<td>±20</td>
<td>V</td>
</tr>
<tr>
<td>Short circuit ratings</td>
<td>( I_{SC} )</td>
<td>( T_\theta \leq 150 , ^\circ C ) ( V_{ES} = 15 , V )</td>
<td>10</td>
<td>µs</td>
</tr>
<tr>
<td>Maximum Junction Temperature</td>
<td>( T_{jmax} )</td>
<td></td>
<td>175</td>
<td>°C</td>
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</table>
## Maximum Ratings

### Buck Diode

<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>$V_{RRM}$</td>
<td>$T_i = T_{j \text{max}}$</td>
<td>650</td>
<td>V</td>
</tr>
<tr>
<td>DC forward current</td>
<td>$I_F$</td>
<td>$T_i = T_{j \text{max}}$</td>
<td>96</td>
<td>A</td>
</tr>
<tr>
<td>Power dissipation</td>
<td>$P_{tot}$</td>
<td>$T_i = T_{j \text{max}}$</td>
<td>129</td>
<td>W</td>
</tr>
<tr>
<td>Maximum Junction Temperature</td>
<td>$T_{j \text{max}}$</td>
<td></td>
<td>175</td>
<td>°C</td>
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### Boost Switch

<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>Collector-emitter breakdown voltage</td>
<td>$V_{CE}$</td>
<td>$T_i \leq 150 °C$</td>
<td>650</td>
<td>V</td>
</tr>
<tr>
<td>DC collector current</td>
<td>$I_C$</td>
<td>$T_i \leq 150 °C$</td>
<td>94</td>
<td>A</td>
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<tr>
<td>Repetitive peak collector current</td>
<td>$I_{DSM}$</td>
<td>$T_i \leq 150 °C$</td>
<td>300</td>
<td>A</td>
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<tr>
<td>Turn off safe operating area</td>
<td>$V_{DS}$</td>
<td>$V_{DS} \leq 600 V$, $T_i \leq 175 °C$</td>
<td>300</td>
<td>A</td>
</tr>
<tr>
<td>Power dissipation</td>
<td>$P_{tot}$</td>
<td>$T_i = T_{j \text{max}}$</td>
<td>174</td>
<td>W</td>
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<tr>
<td>Gate-emitter peak voltage</td>
<td>$V_{GE}$</td>
<td>$T_i \leq 150 °C$</td>
<td>±20</td>
<td>V</td>
</tr>
<tr>
<td>Short circuit ratings</td>
<td>$t_{pc}$</td>
<td>$V_{RG} = 15 V$</td>
<td>6</td>
<td>μs</td>
</tr>
<tr>
<td>Maximum Junction Temperature</td>
<td>$T_{j \text{max}}$</td>
<td></td>
<td>175</td>
<td>°C</td>
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### Boost Inverse Diode

<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>$V_{RRM}$</td>
<td>$T_i = T_{j \text{max}}$</td>
<td>650</td>
<td>V</td>
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<tr>
<td>DC forward current</td>
<td>$I_F$</td>
<td>$T_i = T_{j \text{max}}$</td>
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<td>A</td>
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<tr>
<td>Maximum repetitive forward current</td>
<td>$I_{CRM}$</td>
<td>$T_i \leq 150 °C$</td>
<td>60</td>
<td>A</td>
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<tr>
<td>Power dissipation</td>
<td>$P_{tot}$</td>
<td>$T_i = T_{j \text{max}}$</td>
<td>65</td>
<td>W</td>
</tr>
<tr>
<td>Maximum Junction Temperature</td>
<td>$T_{j \text{max}}$</td>
<td></td>
<td>175</td>
<td>°C</td>
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</table>

### Boost Diode

<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>$V_{RRM}$</td>
<td>$T_i = T_{j \text{max}}$</td>
<td>1200</td>
<td>V</td>
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<tr>
<td>DC forward current</td>
<td>$I_F$</td>
<td>$T_i = T_{j \text{max}}$</td>
<td>65</td>
<td>A</td>
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<tr>
<td>Nonrepetitive peak surge current</td>
<td>$I_{FSM}$</td>
<td>$t_p \leq 8,3 ms$</td>
<td>650</td>
<td>A</td>
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<tr>
<td>Power dissipation</td>
<td>$P_{tot}$</td>
<td>$T_i = T_{j \text{max}}$</td>
<td>128</td>
<td>W</td>
</tr>
<tr>
<td>Maximum Junction Temperature</td>
<td>$T_{j \text{max}}$</td>
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<td>175</td>
<td>°C</td>
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### Thermal Properties

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<th>Unit</th>
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<tbody>
<tr>
<td>Storage temperature</td>
<td>$T_{stg}$</td>
<td></td>
<td>-40...+125</td>
<td>°C</td>
</tr>
<tr>
<td>Operation temperature under switching condition</td>
<td>$T_{op}$</td>
<td></td>
<td>-40...+(T_{j \text{max}} - 25)</td>
<td>°C</td>
</tr>
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</table>

### Isolation Properties

<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>Isolation voltage</td>
<td>$V_u$</td>
<td>$t_p = 2 s$</td>
<td>4000</td>
<td>V</td>
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<tr>
<td>AC Voltage</td>
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<td>$t_p = 1 min$</td>
<td>2500</td>
<td>V</td>
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<td>Creepage distance</td>
<td></td>
<td></td>
<td>min 12,7</td>
<td>mm</td>
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<tr>
<td>Clearance</td>
<td></td>
<td></td>
<td>min 12,7</td>
<td>mm</td>
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<tr>
<td>Comparative tracking index</td>
<td>CTI</td>
<td></td>
<td>&gt;200</td>
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* 100 % Tested in production
### Characteristic Values

<table>
<thead>
<tr>
<th>Parameter</th>
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<th>Value</th>
<th>Unit</th>
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</thead>
<tbody>
<tr>
<td><strong>Buck Inverse Diode</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Forward voltage</td>
<td>$V_F$</td>
<td></td>
<td>$0,006$</td>
<td>$25$</td>
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<tr>
<td>Threshold voltage (for power loss calc. only)</td>
<td>$V_{th}$</td>
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<tr>
<td>Slope resistance (for power loss calc. only)</td>
<td>$r_t$</td>
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<td></td>
<td></td>
</tr>
<tr>
<td>Reverse current</td>
<td>$I_r$</td>
<td>$1200$</td>
<td>$25$</td>
<td>$1,57$</td>
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<tr>
<td>Thermal resistance junction to sink</td>
<td>$R_{th(j-s)}$</td>
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<td></td>
<td></td>
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<tr>
<td><strong>Buck Switch</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Gate-emitter threshold voltage</td>
<td>$V_{th}$</td>
<td>$R_{th}=4 \Omega$</td>
<td>$150$</td>
<td>$25$</td>
</tr>
<tr>
<td>Collector-emitter saturation voltage</td>
<td>$V_{ce}$</td>
<td>$R_{th}=4 \Omega$</td>
<td>$150$</td>
<td>$25$</td>
</tr>
<tr>
<td>Collector-emitter cut-off current incl. Diode</td>
<td>$I_{CC}$</td>
<td>$0$</td>
<td>$1200$</td>
<td>$25$</td>
</tr>
<tr>
<td>Gate-emitter leakage current</td>
<td>$I_{ge}$</td>
<td>$20$</td>
<td>$0$</td>
<td>$25$</td>
</tr>
<tr>
<td>Integrated Gate resistor</td>
<td>$R_{gin}$</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>Turn-on delay time</td>
<td>$t_{on}$</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>Rise time</td>
<td>$t_{r}$</td>
<td>$\pm 15$</td>
<td>$150$</td>
<td>$25$</td>
</tr>
<tr>
<td>Turn-off delay time</td>
<td>$t_{off}$</td>
<td>$R_{on}=4 \Omega$</td>
<td>$150$</td>
<td>$25$</td>
</tr>
<tr>
<td>Fall time</td>
<td>$t_{f}$</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Turn-on energy loss</td>
<td>$E_{on}$</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>Turn-off energy loss</td>
<td>$E_{off}$</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Input capacitance</td>
<td>$C_{iss}$</td>
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<td></td>
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<tr>
<td>Output capacitance</td>
<td>$C_{oss}$</td>
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<td></td>
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<tr>
<td>Reverse transfer capacitance</td>
<td>$C_{rss}$</td>
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<td></td>
<td></td>
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<tr>
<td>Gate charge</td>
<td>$Q_g$</td>
<td>$15$</td>
<td>$960$</td>
<td>$160$</td>
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<tr>
<td>Thermal resistance junction to sink</td>
<td>$R_{th(j-s)}$</td>
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<tr>
<td><strong>Diode</strong></td>
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<tr>
<td>Diode forward voltage</td>
<td>$V_F$</td>
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<td>$100$</td>
<td>$25$</td>
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<tr>
<td>Peak reverse recovery current</td>
<td>$I_{RRM}$</td>
<td>$R_{on}=4 \Omega$</td>
<td>$150$</td>
<td>$25$</td>
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<td>Reverse recovery time</td>
<td>$t_{rr}$</td>
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<tr>
<td>Reverse recovered charge</td>
<td>$Q_{rr}$</td>
<td>$R_{on}=4 \Omega$</td>
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<tr>
<td>Peak rate of fall of recovery current</td>
<td>$\frac{\Delta I}{\Delta t}_{\text{max}}$</td>
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<tr>
<td>Reverse recovered energy</td>
<td>$E_{rec}$</td>
<td>$R_{on}=4 \Omega$</td>
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<td></td>
</tr>
<tr>
<td>Thermal resistance junction to sink</td>
<td>$R_{th(j-s)}$</td>
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### Characteristic Values

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Symbol</th>
<th>Conditions</th>
<th>Value</th>
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</tr>
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<tbody>
<tr>
<td>Boost Switch</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Gate emitter threshold voltage</td>
<td>$V_{GE(th)}$</td>
<td>$V_{ES} = V_{CE}$</td>
<td>0,0016</td>
<td>25</td>
</tr>
<tr>
<td>Collector-emitter saturation voltage</td>
<td>$V_{ces}$</td>
<td>15</td>
<td>100</td>
<td>25</td>
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<tr>
<td>Collector-emitter cut-off diode</td>
<td>$I_{CES}$</td>
<td>0</td>
<td>650</td>
<td>25</td>
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<tr>
<td>Gate-emitter leakage current</td>
<td>$I_{ss}$</td>
<td>20</td>
<td>0</td>
<td>25</td>
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<td>Integrated Gate resistor</td>
<td>$R_{gg}$</td>
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<tr>
<td>Turn-on delay time</td>
<td>$t_{on}$</td>
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<td>Rise time</td>
<td>$t_{r}$</td>
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<td>100</td>
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<td>Turn-off delay time</td>
<td>$t_{off}$</td>
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<td>100</td>
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<td>Fall time</td>
<td>$t_{f}$</td>
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<td>Turn-on energy loss</td>
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<tr>
<td>Turn-off energy loss</td>
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<td>Output capacitance</td>
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<td>Gate charge</td>
<td>$Q_{CE}$</td>
<td>phase-change material</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Thermal resistance junction to sink</td>
<td>$R_{th(j-s)}$</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

| Boost Inverse Diode | | | | |
| Diode forward voltage | $V_{F}$ | 30 | 25 | 1,23 | 1,64 | 1,87 | V |
| Thermal resistance junction to sink | $R_{th(j-s)}$ | phase-change material | | | | K/W |

| Boost Diode | | | | |
| Diode forward voltage | $V_{F}$ | 60 | 25 | 1,50 | 2,47 | 3,30 | V |
| Reverse leakage current | $I_{F}$ | 1200 | | | | µA |
| Peak reverse recovery current | $I_{REX}$ | | | | | A |
| Reverse recovery time | $t_{r}$ | | | | | ms |
| Reverse recovered charge | $Q_{R}$ | | | | | µC |
| Peak rate of fall of recovery current | $(\frac{di}{dt})_{MAX}$ | | | | | A/µs |
| Reverse recovery energy | $E_{RE}$ | | | | | mJ |
| Thermal resistance junction to sink | $R_{th(j-s)}$ | phase-change material | | | | K/W |

| Thermistor | | | | |
| Rated resistance | $R$ | | 25 | 22000 | Ω |
| Deviation of $R_{th}$ | $\Delta R_{th}$ | $R_{th} = 1486 \Omega$ | 100 | -12 | +12 | % |
| Power dissipation | $P$ | | 25 | 200 | | mW |
| Power dissipation constant | | | 25 | 2 | | mW/K |
| B-value | $B_{(25/50)}$ | Tol. ±3% | 25 | 3950 | | K |
| B-value | $B_{(25/120)}$ | Tol. ±3% | 25 | 3998 | | K |
| Vincotech NTC Reference | | | | | | B |

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Buck Characteristics

**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

\[ I_c = f(V_{ge}) \]

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

\[ I_f = f(V_f) \]

At

- \( T_j = 25/125 \ ^\circ C \)
- \( t_p = 250 \ \mu s \)
- \( V_{ce} = 10 \ \text{V} \)
- \( T_j = 25/125 \ ^\circ C \)
Buck Characteristics

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

With an inductive load at
- \( T_J = 25/125 \) °C
- \( V_{CE} = 350 \) V
- \( V_{GE} = \pm 15 \) V
- \( R_{gon} = 4 \) Ω
- \( I_C = 150 \) A

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

With an inductive load at
- \( T_J = 25/125 \) °C
- \( V_{CE} = 350 \) V
- \( V_{GE} = \pm 15 \) V
- \( I_C = 150 \) 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
- \( T_J = 25/125 \) °C
- \( V_{CE} = 350 \) V
- \( V_{GE} = \pm 15 \) V
- \( R_{gon} = 4 \) Ω

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

With an inductive load at
- \( T_J = 25/125 \) °C
- \( V_{CE} = 350 \) V
- \( V_{GE} = \pm 15 \) V
- \( I_C = 150 \) A
Buck Characteristics

**figure 9.** IGBT
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

**figure 10.** IGBT
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
- \( V_{GE} = \pm 15 \) V
- \( I_C = 150 \) A

**figure 11.** FWD
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 12.** FWD
Typical reverse recovery time as a function of IGBT turn on gate resistor
\[ t_{rr} = f(R_{gon}) \]

At
- \( T_J = 25/125 \) °C
- \( V_k = 350 \) V
- \( I_F = 150 \) A
- \( V_{GE} = \pm 15 \) V
Buck Characteristics

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

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

At

\[ T_j = \frac{25}{125} \, ^\circ\text{C} \]
\[ V_{CE} = 350 \, \text{V} \]
\[ V_{GE} = \pm 15 \, \text{V} \]
\[ R_{gon} = 4 \, \Omega \]

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

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

At

\[ T_j = \frac{25}{125} \, ^\circ\text{C} \]
\[ V_s = 350 \, \text{V} \]
\[ I_f = 150 \, \text{A} \]
\[ V_{GE} = \pm 15 \, \text{V} \]

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

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

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

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

At

\[ T_j = \frac{25}{125} \, ^\circ\text{C} \]
\[ V_s = 350 \, \text{V} \]
\[ I_f = 150 \, \text{A} \]
\[ V_{GE} = \pm 15 \, \text{V} \]
Buck Characteristics

**figure 17.** 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

- \( T_j = 25/125 \degree C \)
- \( V_{CE} = 350 \text{ V} \)
- \( I_F = 150 \text{ A} \)
- \( V_{GE} = \pm 15 \text{ V} \)
- \( R_{gon} = 4 \Omega \)

**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

- \( T_j = 25/125 \degree C \)
- \( V_{CE} = 350 \text{ V} \)
- \( I_F = 150 \text{ A} \)
- \( V_{GE} = \pm 15 \text{ V} \)

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

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

At

- \( D = 0.5 \)
- \( R_{th(j-s)} = 0.22 \text{ K/W} \)

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

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

At

- \( D = 0.5 \)
- \( R_{th(j-s)} = 0.73 \text{ K/W} \)

IGBT thermal model values

- \( R \text{(K/W)} \)
- \( \text{Tau (s)} \)
- \( 8.1E-02, 2.3E+00 \)
- \( 5.7E-02, 2.9E-01 \)
- \( 7.2E-02, 4.6E-02 \)
- \( 2.1E-02, 1.3E-02 \)
- \( 8.0E-03, 1.5E-03 \)

FWD thermal model values

- \( R \text{(K/W)} \)
- \( \text{Tau (s)} \)
- \( 6.7E-02, 4.1E+00 \)
- \( 7.9E-02, 9.3E-01 \)
- \( 1.9E-01, 1.4E-01 \)
- \( 2.8E-01, 3.5E-02 \)
- \( 6.1E-02, 6.8E-03 \)
- \( 5.6E-02, 1.2E-03 \)
Buck Characteristics

**figure 21. IGBT**
Power dissipation as a function of heatsink temperature

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

At

\[ T_j = 175 \degree C \]

**figure 22. IGBT**
Collector current as a function of heatsink temperature

\[ I_C = f(T_s) \]

At

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

**figure 23. FWD**
Power dissipation as a function of heatsink temperature

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

At

\[ T_j = 175 \degree C \]

**figure 24. FWD**
Forward current as a function of heatsink temperature

\[ I_F = f(T_s) \]

At

\[ T_j = 175 \degree C \]
Buck Characteristics

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

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

**figure 26.**
Gate voltage vs Gate charge

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

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

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

**figure 28.**
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
- \( V_{CE} = \pm 15 \) V
- \( T_j = T_{j\text{max}} \)

**At**

- \( I_C = 160 \) A
- \( T_j = 25 \) °C

---

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figure 29. IGBT
Reverse bias safe operating area

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

At
\[ T_j = T_{jmax} - 25^\circ C \]
\[ V_{ccminus} = V_{ccplus} \]

Switching mode: 3 level switching
Boost Characteristics

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

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

At
- \( T_j = 25/150 \ ^\circ C \)
- \( t_p = 250 \ \mu s \)
- \( V_{CE} = 10 \) V

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

At
- \( T_j = 25/150 \ ^\circ C \)
- \( t_p = 250 \ \mu s \)
Boost Characteristics

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

\[ E = f(I_C) \]

![IGBT Energy Loss vs Collector Current](image1)

With an inductive load at
- \( T_j = 25/125 \) °C
- \( V_{CE} = 350 \) V
- \( V_{GE} = \pm 15 \) V
- \( R_{gon} = 4 \) Ω
- \( I_C = 100 \) A

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

\[ E = f(R_G) \]

![IGBT Energy Loss vs Gate Resistor](image2)

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

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

![FWD Energy Loss vs Collector Current](image3)

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

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

![FWD Energy Loss vs Gate Resistor](image4)

With an inductive load at
- \( T_j = 25/125 \) °C
- \( V_{CE} = 350 \) V
- \( V_{GE} = \pm 15 \) V
- \( I_C = 100 \) A
**Boost Characteristics**

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

\[ t = f(I_C) \]

**IGBT**

With an inductive load at:
- \( T_J = 125 \) °C
- \( V_{CE} = 350 \) V
- \( V_{GE} = \pm 15 \) V
- \( R_{gon} = 4 \) Ω
- \( I_C = 100 \) A

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

\[ t = f(R_G) \]

**IGBT**

With an inductive load at:
- \( T_J = 125 \) °C
- \( V_{CE} = 350 \) V
- \( V_{GE} = \pm 15 \) V
- \( I_C = 100 \) A

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

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

**FWD**

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

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

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

**FWD**

At:
- \( T_J = 25/125 \) °C
- \( V_A = 350 \) V
- \( I_F = 100 \) A
- \( V_{GE} = \pm 15 \) V
Boost Characteristics

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

At
\[ T_j = 25/125 \, ^\circ C \]
\[ V_{CE} = 350 \, V \]
\[ V_{GE} = \pm 15 \, V \]
\[ R_{gon} = 4 \, \Omega \]

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

At
\[ T_j = 25/125 \, ^\circ C \]
\[ V_x = 350 \, V \]
\[ I_F = 100 \, A \]
\[ V_{GE} = \pm 15 \, V \]

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

At
\[ T_j = 25/125 \, ^\circ C \]
\[ V_{CE} = 350 \, V \]
\[ V_{GE} = \pm 15 \, V \]
\[ I_F = 100 \, A \]
\[ V_{GE} = \pm 15 \, V \]
Boost Characteristics

**figure 17.**
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
- \(T_j = 25/125 \, ^\circ C\)
- \(V_{CE} = 350 \, V\)
- \(V_{GE} = \pm 15 \, V\)
- \(R_{gon} = 4 \, \Omega\)

**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
- \(T_j = 25/125 \, ^\circ C\)
- \(V_{GE} = \pm 15 \, V\)
- \(I_F = 100 \, A\)
- \(V_{CE} = 350 \, V\)

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

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

At
- \(D = 0.5\)
- \(t_p / T\)
- \(R_{th(j-s)} = 0.48 \, K/W\)

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

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

At
- \(D = 0.5\)
- \(t_p / T\)
- \(R_{th(j-s)} = 0.68 \, K/W\)
Boost Characteristics

**figure 21.**
Power dissipation as a function of heatsink temperature

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

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

**figure 22.**
Collector current as a function of heatsink temperature

\[ I_C = f(T_s) \]

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

**figure 23.**
Power dissipation as a function of heatsink temperature

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

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

**figure 24.**
Forward current as a function of heatsink temperature

\[ I_F = f(T_s) \]

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

Vincotech
Boost Characteristics

figure 25. IGBT Safe operating area as a function of collector-emitter voltage

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

At

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

**Figure 25.** IGBT

Reverse bias safe operating area

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

- \( T_J = T_{j(max) - 25 \, ^\circ C} \)
- \( V_{CE(max)} = V_{CEO} \)

Switching mode: 3 level switching

**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

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

- \( V_{CE} = 600 \, V \)
- \( T_J \leq 150 \, ^\circ C \)

**Figure 28.** IGBT

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

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

- \( V_{CE} \leq 400 \, V \)
- \( T_J = 125 \, ^\circ C \)
Boost 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

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

**figure 27.**
Power dissipation as a function of heatsink temperature

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

- \( T_j = 175 \ ^\circ C \)

**figure 28.**
Forward current as a function of heatsink temperature

\[ I_F = f(T_s) \]

At

- \( T_j = 175 \ ^\circ C \)
Buck Inverse Diode

**figure 1.** Typical FWD forward current as a function of forward voltage

\[ I_F = f(V_F) \]

![Graph showing forward current vs forward voltage](image1)

At

- \( T_j = 25/125 \) °C
- \( t_p = 250 \) µs

**figure 2.** FWD transient thermal impedance as a function of pulse width

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

![Graph showing thermal impedance vs pulse width](image2)

At

- \( D = \frac{t_p}{T} \)
- \( Z_{th(0)} = 1.57 \) K/W

**figure 3.** Power dissipation as a function of heatsink temperature

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

![Graph showing power dissipation vs heatsink temperature](image3)

At

- \( T_j = 150 \) °C

**figure 4.** Forward current as a function of heatsink temperature

\[ I_F = f(T_s) \]

![Graph showing forward current vs heatsink temperature](image4)

At

- \( T_j = 150 \) °C
**Thermistor**

![Thermistor Typical NTC characteristic as a function of temperature](image)

\[ R = f(T) \]
Buck Switching Characteristics

General conditions

\[
\begin{align*}
T_J &= 125 \, ^\circ \text{C} \\
R_{	ext{on}} &= 4 \, \Omega \\
R_{	ext{off}} &= 4 \, \Omega
\end{align*}
\]

Figure 1. IGBT
Turn-off Switching Waveforms & definition of \( t_{\text{doff}}, t_{\text{Eoff}} \)

\( t_{\text{doff}} = 0,25 \, \mu\text{s} \)
\( t_{\text{Eoff}} = 0,62 \, \mu\text{s} \)

\( V_{\text{CE}} (0\%) = -15 \, \text{V} \)
\( V_{\text{CE}} (100\%) = 350 \, \text{V} \)
\( I_{\text{C}} (100\%) = 149 \, \text{A} \)

Figure 2. IGBT
Turn-on Switching Waveforms & definition of \( t_{\text{don}}, t_{\text{Eon}} \)

\( t_{\text{don}} = 0,13 \, \mu\text{s} \)
\( t_{\text{Eon}} = 0,37 \, \mu\text{s} \)

\( V_{\text{CE}} (0\%) = -15 \, \text{V} \)
\( V_{\text{CE}} (100\%) = 350 \, \text{V} \)
\( I_{\text{C}} (100\%) = 149 \, \text{A} \)

Figure 3. IGBT
Turn-off Switching Waveforms & definition of \( t_{f} \)

\( V_{\text{CE}} (100\%) = 350 \, \text{V} \)
\( I_{\text{C}} (100\%) = 149 \, \text{A} \)
\( t_{f} = 0,06 \, \mu\text{s} \)

Figure 4. IGBT
Turn-on Switching Waveforms & definition of \( t_{r} \)

\( V_{\text{CE}} (100\%) = 350 \, \text{V} \)
\( I_{\text{C}} (100\%) = 149 \, \text{A} \)
\( t_{r} = 0,03 \, \mu\text{s} \)
Buck Switching Characteristics

**figure 5. IGBT**
Turn-off Switching Waveforms & definition of $t_{Eoff}$

- $P_{off} (100\%) = 52.08$ kW
- $E_{off} (100\%) = 5.81$ mJ
- $t_{Eoff} = 0.62$ µs

**figure 6. IGBT**
Turn-on Switching Waveforms & definition of $t_{Eon}$

- $P_{on} (100\%) = 52.08$ kW
- $E_{on} (100\%) = 3.36$ mJ
- $t_{Eon} = 0.37$ µs

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

- $V_d (100\%) = 350$ V
- $I_d (100\%) = 149$ A
- $I_{src} (100\%) = -133$ A
- $t_{rr} = 0.11$ µs
Buck Switching Characteristics

**Turn-on Switching Waveforms & definition of \( t_{Qrr} \)**

\( t_{Qrr} \) = integrating time for \( Q_{rr} \)

- \( I_d \) (100%) = 149 A
- \( Q_{rr} \) (100%) = 6.41 µC
- \( t_{Qrr} \) = 0.23 µs

**Turn-on Switching Waveforms & definition of \( t_{Erec} \)**

\( t_{Erec} \) = integrating time for \( E_{rec} \)

- \( P_{rec} \) (100%) = 52.08 kW
- \( E_{rec} \) (100%) = 1.25 mJ
- \( t_{Erec} \) = 0.23 µs

Buck switching measurement circuit

**IGBT**

- \( V_{dc} \)
- \( V_{cc} \) = 15V
- \( R_{gon} \)
- \( R_{goff} \)
- \( R_{g} \)
- \( L \)
- \( D \)
- \( Q \)
Boost Switching Characteristics

General conditions

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<th>Parameter</th>
<th>Value</th>
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<td>$R_{on}$</td>
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<tr>
<td>$R_{off}$</td>
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</tbody>
</table>

**figure 1.** IGBT

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

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

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

**figure 2.** IGBT

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

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

- $V_{CE}(0\%) = -15$ V
- $V_{CE}(100\%) = 15$ V
- $I_C(100\%) = 100$ A
- $t_{don} = 0.10$ µs
- $t_{Eon} = 0.15$ µs

**figure 3.** IGBT

Turn-off Switching Waveforms & definition of $t_f$

- $V_C(100\%) = 350$ V
- $I_C(100\%) = 100$ A
- $t_f = 0.064$ µs

**figure 4.** IGBT

Turn-on Switching Waveforms & definition of $t_r$

- $V_C(100\%) = 350$ V
- $I_C(100\%) = 100$ A
- $t_r = 0.019$ µs

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Boost Switching Characteristics

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

- $P_{\text{off}} (100\%) = 34,96 \text{ kW}$
- $E_{\text{off}} (100\%) = 3,32 \text{ mJ}$
- $t_{\text{Eoff}} = 0,44 \text{ µs}$

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

- $P_{\text{on}} (100\%) = 34,964 \text{ kW}$
- $E_{\text{on}} (100\%) = 1,52 \text{ mJ}$
- $t_{\text{Eon}} = 0,15 \text{ µs}$

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

- $V_d (100\%) = 350 \text{ V}$
- $I_d (100\%) = 100 \text{ A}$
- $I_{\text{DDM}} (100\%) = -142 \text{ A}$
- $t_{\text{rr}} = 0,07 \text{ µs}$

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Boost Switching Characteristics

**figure 8.** FWD
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 9.** FWD
Turn-on Switching Waveforms & definition of $t_{Erec}$
($t_{Erec}$ = integrating time for $E_{rec}$)

- $P_{rec} (100\%) = 34.96$ kW
- $E_{rec} (100\%) = 3.61$ mJ
- $t_{Erec} = 1.00$ µs

Boost switching measurement circuit

**figure 10.**
IGBT
### Ordering Code & Marking

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### Outline
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Handling instruction
Handling instructions for flow 2 packages see vincotech.com website.

Package data
Package data for flow 2 packages see vincotech.com website.

UL recognition and file number
This device is certified according to UL 1557 standard, UL file number E192116. For more information see vincotech.com website.

Packaging instruction

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2. A critical component is any component of a life support device or system whose failure to perform can be reasonably expected to cause the failure of the life support device or system, or to affect its safety or effectiveness.