## 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-FT12NMA160SH-M669F08

## 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></td>
<td>1200</td>
<td>V</td>
</tr>
<tr>
<td>DC forward current</td>
<td>$I_F$</td>
<td>$T_j = T_{jmax}$, $T_s = 80, ^\circ C$</td>
<td>7</td>
<td>A</td>
</tr>
<tr>
<td>Maximum repetitive forward current</td>
<td>$I_{FSM}$</td>
<td>$T_s = 10, \mu s$</td>
<td>14</td>
<td>A</td>
</tr>
<tr>
<td>$I^2t$-value</td>
<td>$I^2t$</td>
<td>$T_j = T_{jmax}$</td>
<td>40</td>
<td>A$^2$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>
</tr>
</tbody>
</table>

### Buck 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>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>157</td>
<td>A</td>
</tr>
<tr>
<td>Repetitive peak collector current</td>
<td>$I_{CEM}$</td>
<td>$T_j = T_{jmax}$</td>
<td>480</td>
<td>A</td>
</tr>
<tr>
<td>Turn off safe operating area</td>
<td>$V_{CE(max)} = 1200, V$, $T_j = 150, ^\circ C$</td>
<td>320</td>
<td>A</td>
<td></td>
</tr>
<tr>
<td>Power dissipation</td>
<td>$P_{tot}$</td>
<td>$T_j = T_{jmax}$, $T_s = 80, ^\circ C$</td>
<td>398</td>
<td>W</td>
</tr>
<tr>
<td>Gate-emitter peak voltage</td>
<td>$V_{GE}$</td>
<td></td>
<td>4.20</td>
<td>V</td>
</tr>
<tr>
<td>Short circuit ratings</td>
<td>$\tau_{SC}$</td>
<td>$T_j \leq 150, ^\circ C$, $V_{CE} = 15, V$</td>
<td>10</td>
<td>μs</td>
</tr>
<tr>
<td></td>
<td>$V_{CE}$</td>
<td>$V_{CE} = 15, V$</td>
<td>800</td>
<td>μs</td>
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<tr>
<td>Maximum Junction Temperature</td>
<td>$T_{jmax}$</td>
<td></td>
<td>175</td>
<td>°C</td>
</tr>
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</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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<tbody>
<tr>
<td><strong>Buck Diode</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Peak Repetitive Reverse Voltage</td>
<td>$V_{RRM}$</td>
<td></td>
<td>600</td>
<td>V</td>
</tr>
<tr>
<td>DC forward current</td>
<td>$I_{f}$</td>
<td>$T_j = T_{jmax}$</td>
<td>96</td>
<td>A</td>
</tr>
<tr>
<td>Non-repetitive Peak Surge Current</td>
<td>$I_{FSM}$</td>
<td>$r_s$ limited by $T_{jmax}$</td>
<td>1200</td>
<td>A</td>
</tr>
<tr>
<td>Power dissipation</td>
<td>$P_{tot}$</td>
<td>$T_j = T_{jmax}$</td>
<td>110</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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<tr>
<td><strong>Boost Switch</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Collector-emitter breakdown voltage</td>
<td>$V_{CE}$</td>
<td></td>
<td>600</td>
<td>V</td>
</tr>
<tr>
<td>DC collector current</td>
<td>$I_{C}$</td>
<td>$T_j = T_{jmax}$</td>
<td>91</td>
<td>A</td>
</tr>
<tr>
<td>Repetitive peak collector current</td>
<td>$I_{CEM}$</td>
<td>$r_s$ limited by $T_{jmax}$</td>
<td>300</td>
<td>A</td>
</tr>
<tr>
<td>Turn off safe operating area</td>
<td>$V_{CE} \leq 600 \mathrm{V}$, $r_s \geq 175 \mathrm{^\circ C}$</td>
<td></td>
<td>300</td>
<td>A</td>
</tr>
<tr>
<td>Power dissipation</td>
<td>$P_{tot}$</td>
<td>$T_j = T_{jmax}$</td>
<td>174</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>
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<tr>
<td>Short circuit ratings</td>
<td>$t_p$</td>
<td>$T_j \leq 150 , ^\circ C$</td>
<td>6</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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<tr>
<td><strong>Boost Inverse Diode</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Peak Repetitive Reverse Voltage</td>
<td>$V_{RRM}$</td>
<td></td>
<td>600</td>
<td>V</td>
</tr>
<tr>
<td>DC forward current</td>
<td>$I_{f}$</td>
<td>$T_j = T_{jmax}$</td>
<td>38</td>
<td>A</td>
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<tr>
<td>Maximum repetitive forward current</td>
<td>$I_{CEM}$</td>
<td>$r_s$ limited by $T_{jmax}$</td>
<td>60</td>
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</tr>
<tr>
<td>Power dissipation</td>
<td>$P_{tot}$</td>
<td>$T_j = T_{jmax}$</td>
<td>65</td>
<td>W</td>
</tr>
<tr>
<td>Maximum Junction Temperature</td>
<td>$T_{jmax}$</td>
<td></td>
<td>175</td>
<td>°C</td>
</tr>
<tr>
<td><strong>Boost Diode</strong></td>
<td></td>
<td></td>
<td></td>
<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>$T_j = T_{jmax}$</td>
<td>50</td>
<td>A</td>
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<tr>
<td>Nonrepetitive peak surge current</td>
<td>$I_{FSM}$</td>
<td>$r_s$ limited by $T_{jmax}$ (Halfwave 1 Phase 60Hz)</td>
<td>650</td>
<td>A</td>
</tr>
<tr>
<td>Power dissipation</td>
<td>$P_{tot}$</td>
<td>$T_j = T_{jmax}$</td>
<td>94</td>
<td>W</td>
</tr>
<tr>
<td>Maximum Junction Temperature</td>
<td>$T_{jmax}$</td>
<td></td>
<td>150</td>
<td>°C</td>
</tr>
<tr>
<td><strong>Thermal Properties</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<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>$-40...+(T_{jmax} - 25)$</td>
<td>°C</td>
<td></td>
</tr>
<tr>
<td><strong>Isolation Properties</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>Isolation voltage</td>
<td>$V_{isol}$</td>
<td>DC voltage* $t_s = 2 , s$</td>
<td>4000</td>
<td>V</td>
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<tr>
<td></td>
<td></td>
<td>AC voltage $t_s = 1 , min$</td>
<td>2500</td>
<td>V</td>
</tr>
<tr>
<td>Creepage distance</td>
<td></td>
<td>min 12.7</td>
<td>mm</td>
<td></td>
</tr>
<tr>
<td>Clearance</td>
<td></td>
<td>min 12.7</td>
<td>mm</td>
<td></td>
</tr>
<tr>
<td>Comparative Tracking Index</td>
<td>CTI</td>
<td>&gt;200</td>
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* 100 % tested in production
## Characteristic Values

### Buck Inverse Diode

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Conditions</th>
<th>Value</th>
<th>Unit</th>
</tr>
</thead>
<tbody>
<tr>
<td>Forward voltage</td>
<td>$V_G$</td>
<td>25</td>
<td>1</td>
</tr>
<tr>
<td>Threshold voltage (for power loss calc. only)</td>
<td>$V_T$</td>
<td>125</td>
<td>1,45</td>
</tr>
<tr>
<td>Slope resistance (for power loss calc. only)</td>
<td>$r_s$</td>
<td>25</td>
<td>0,91</td>
</tr>
<tr>
<td>Reverse current</td>
<td>$I_r$</td>
<td>1200</td>
<td>0,25</td>
</tr>
<tr>
<td>Thermal resistance junction to sink</td>
<td>$R_{th(j-s)}$</td>
<td>none</td>
<td></td>
</tr>
</tbody>
</table>

### Buck Switch

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Conditions</th>
<th>Value</th>
<th>Unit</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gate-emitter threshold voltage</td>
<td>$V_{GE(th)}$</td>
<td>0,006</td>
<td>5,2</td>
</tr>
<tr>
<td>Collector-emitter saturation voltage</td>
<td>$V_{CES}$</td>
<td>15</td>
<td>2</td>
</tr>
<tr>
<td>Collector-emitter cut-off current incl. Diode</td>
<td>$I_{ces}$</td>
<td>1200</td>
<td>25</td>
</tr>
<tr>
<td>Gate-emitter leakage current</td>
<td>$I_{ges}$</td>
<td>20</td>
<td>480</td>
</tr>
<tr>
<td>Integrated Gate resistor</td>
<td>$R_{int}$</td>
<td>none</td>
<td></td>
</tr>
<tr>
<td>Turn-on delay time</td>
<td>$t_{on}$</td>
<td>25</td>
<td>133</td>
</tr>
<tr>
<td>Rise time</td>
<td>$t_{rise}$</td>
<td>25</td>
<td>20</td>
</tr>
<tr>
<td>Turn-off delay time</td>
<td>$t_{off}$</td>
<td>25</td>
<td>225</td>
</tr>
<tr>
<td>Fall time</td>
<td>$t_{fall}$</td>
<td>25</td>
<td>276</td>
</tr>
<tr>
<td>Turn-on energy loss</td>
<td>$E_{on}$</td>
<td>15</td>
<td>20</td>
</tr>
<tr>
<td>Turn-off energy loss</td>
<td>$E_{off}$</td>
<td>125</td>
<td>64</td>
</tr>
<tr>
<td>Input capacitance</td>
<td>$C_{in}$</td>
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<td>920</td>
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<tr>
<td>Output capacitance</td>
<td>$C_{out}$</td>
<td>0</td>
<td>920</td>
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<tr>
<td>Reverse transfer capacitance</td>
<td>$C_{in}$</td>
<td>25</td>
<td>540</td>
</tr>
<tr>
<td>Gate charge</td>
<td>$Q_s$</td>
<td>15</td>
<td>740</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></td>
</tr>
</tbody>
</table>

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13 Apr. 2018 / Revision 6
### Characteristic Values

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Symbol</th>
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<th>Value</th>
<th>Unit</th>
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</thead>
<tbody>
<tr>
<td><strong>Buck Diode</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Diode forward voltage</td>
<td>$V_F$</td>
<td></td>
<td>120</td>
<td>V</td>
</tr>
<tr>
<td>Peak reverse recovery current</td>
<td>$I_{RM}$</td>
<td></td>
<td></td>
<td>A</td>
</tr>
<tr>
<td>Reverse recovery time</td>
<td>$t_{rr}$</td>
<td>±15</td>
<td>350</td>
<td>ns</td>
</tr>
<tr>
<td>Reverse recovered charge</td>
<td>$Q_{rr}$</td>
<td>4 Ω</td>
<td></td>
<td>µC</td>
</tr>
<tr>
<td>Peak rate of fall of recovery current</td>
<td>$(\mathrm{d}V/\mathrm{d}t)_{\mathrm{RM}}$</td>
<td>125</td>
<td>mAs</td>
<td></td>
</tr>
<tr>
<td>Reverse recovered energy</td>
<td>$E_{rec}$</td>
<td></td>
<td></td>
<td>mA</td>
</tr>
<tr>
<td>Thermal resistance junction to sink</td>
<td>$R_{th(j-s)}$</td>
<td>Thermal grease, thickness≤50um, $\lambda = 1 , \text{W/mK}$</td>
<td>0.04</td>
<td>K/W</td>
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<tr>
<td><strong>Boost Switch</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Gate-emitter threshold voltage</td>
<td>$V_{GEM}$</td>
<td>$V_{GE} = V_{CE}$</td>
<td>0.0016</td>
<td>V</td>
</tr>
<tr>
<td>Collector-emitter saturation voltage</td>
<td>$V_{Cem}$</td>
<td>$V_{CE}$</td>
<td>25</td>
<td>5</td>
</tr>
<tr>
<td>Collector-emitter cut-off incl diode</td>
<td>$t_{off}$</td>
<td></td>
<td>0</td>
<td>100</td>
</tr>
<tr>
<td>Gate-emitter leakage current</td>
<td>$I_{on}$</td>
<td></td>
<td>20</td>
<td>0</td>
</tr>
<tr>
<td>Integrated Gate resistor</td>
<td>$R_{gint}$</td>
<td></td>
<td>none</td>
<td>Ω</td>
</tr>
<tr>
<td>Turn-on delay time</td>
<td>$t_{on}$</td>
<td></td>
<td>45</td>
<td>100</td>
</tr>
<tr>
<td>Rise time</td>
<td>$t_{r}$</td>
<td>±15</td>
<td>100</td>
<td>25</td>
</tr>
<tr>
<td>Turn-off delay time</td>
<td>$t_{off}$</td>
<td>$R_{goff} = 4 , \Omega$</td>
<td>45</td>
<td>125</td>
</tr>
<tr>
<td>Fall time</td>
<td>$t_{f}$</td>
<td></td>
<td>100</td>
<td>25</td>
</tr>
<tr>
<td>Turn-on energy loss</td>
<td>$E_{on}$</td>
<td></td>
<td>25</td>
<td>5</td>
</tr>
<tr>
<td>Turn-off energy loss</td>
<td>$E_{off}$</td>
<td></td>
<td>25</td>
<td>125</td>
</tr>
<tr>
<td>Input capacitance</td>
<td>$C_{iss}$</td>
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<td>6280</td>
<td>pF</td>
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<tr>
<td>Output capacitance</td>
<td>$C_{oss}$</td>
<td>$f = 1 , \text{MHz}$</td>
<td>0</td>
<td>25</td>
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<td>Reverse transfer capacitance</td>
<td>$C_{rss}$</td>
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<td>186</td>
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<td>Gate charge</td>
<td>$Q_{g}$</td>
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<td>620</td>
<td></td>
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<tr>
<td>Thermal resistance junction to sink</td>
<td>$R_{th(j-s)}$</td>
<td>Thermal grease, thickness≤50um, $\lambda = 1 , \text{W/mK}$</td>
<td>0.54</td>
<td>K/W</td>
</tr>
<tr>
<td><strong>Boost Inverse Diode</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Diode forward voltage</td>
<td>$V_F$</td>
<td></td>
<td>30</td>
<td>V</td>
</tr>
<tr>
<td>Thermal resistance junction to sink</td>
<td>$R_{th(j-s)}$</td>
<td>Thermal grease, thickness≤50um, $\lambda = 1 , \text{W/mK}$</td>
<td>1.45</td>
<td>K/W</td>
</tr>
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### Characteristic Values

<table>
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<tr>
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</tr>
</thead>
<tbody>
<tr>
<td>Boost Diode</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Diode forward voltage</td>
<td>( V_{f} )</td>
<td>25</td>
<td>1,50</td>
<td>V</td>
</tr>
<tr>
<td></td>
<td></td>
<td>125</td>
<td>2,47</td>
<td></td>
</tr>
<tr>
<td>Reverse leakage current</td>
<td>( I_{r} )</td>
<td>25</td>
<td>3,30</td>
<td>V</td>
</tr>
<tr>
<td></td>
<td></td>
<td>125</td>
<td>2,11</td>
<td></td>
</tr>
<tr>
<td>Peak reverse recovery current</td>
<td>( I_{t_{\text{rm}}} )</td>
<td>25</td>
<td>2,11</td>
<td>µA</td>
</tr>
<tr>
<td>Reverse recovery time</td>
<td>( t_{r} )</td>
<td>25</td>
<td>142</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>125</td>
<td>51</td>
<td></td>
</tr>
<tr>
<td>Reverse recovered charge</td>
<td>( Q_{\text{rec}} )</td>
<td>25</td>
<td>6,6</td>
<td>μC</td>
</tr>
<tr>
<td>Peak rate of fall of recovery current</td>
<td>( \left( \frac{dI_{f}}{dt} \right)_{\text{max}} )</td>
<td>25</td>
<td>2890</td>
<td>A/μs</td>
</tr>
<tr>
<td>Reverse recovery energy</td>
<td>( E_{\text{rec}} )</td>
<td>25</td>
<td>1,71</td>
<td>mWs</td>
</tr>
<tr>
<td>Thermal resistance junction to sink</td>
<td>( R_{\text{j-s}} )</td>
<td></td>
<td>0,74</td>
<td>K/W</td>
</tr>
</tbody>
</table>

| Thermistor | | | | |
| Rated resistance | \( R \) | 25 | 22000 | Ω |
| Deviation of \( R_{\text{rm}} \) | \( \Delta R_{\text{rm}} \) | 100 | 5 | % |
| Power dissipation | \( P \) | 25 | 200 | mW |
| Power dissipation constant | | 25 | 2 | mW/K |
| B-value | \( B_{(25/100)} \) | 25 | 3950 | K |
| B-value | \( B_{(25/50)} \) | 25 | 3998 | K |

Vincotech NTC Reference | B | | | |
Buck Switch

Buck IGBT and Buck FWD

**figure 1. IGBT**

**Typical output characteristics**

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

- \( t_p = 250 \ \mu s \)
- \( T_j = 25 \ ^\circ C \)
- \( V_{CE} \) 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

**figure 2. IGBT**

**Typical output characteristics**

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

**figure 3. IGBT**

**Typical transfer characteristics**

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

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

**At**

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

**figure 4. FWD**

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

\[ I_F = f(V_F) \]

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

**Buck IGBT and Buck FWD**

---

**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
- \( I_C = 100 \) 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
- \( I_C = 100 \) 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
- \( I_C = 100 \) A
Typical switching times as a function of collector current

\[ t = f(I_C) \]

With an inductive load at

- \( T_j = 125 \, ^\circ\text{C} \)
- \( V_{CE} = 350 \, \text{V} \)
- \( V_{GE} = \pm 15 \, \text{V} \)
- \( R_{gon} = 4 \, \Omega \)
- \( R_{goff} = 4 \, \Omega \)

At

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

With an inductive load at

- \( T_j = 125 \, ^\circ\text{C} \)
- \( V_{CE} = 350 \, \text{V} \)
- \( V_{GE} = \pm 15 \, \text{V} \)
- \( I_C = 100 \, \text{A} \)

Typical reverse recovery time as a function of collector current

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

At

- \( T_j = 25/125 \, ^\circ\text{C} \)
- \( V_{CE} = 350 \, \text{V} \)
- \( V_{GE} = \pm 15 \, \text{V} \)
- \( R_{gon} = 4 \, \Omega \)
**figure 13.** FWD
Typical reverse recovery charge as a function of collector current

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

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

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

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

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

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

\[ I_{\text{rrM}} = f(I_C) \]

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

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

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

At
\[ T_J = 25/125 \, ^\circ\text{C} \]
\[ V_{CE} = 350 \, \text{V} \]
\[ I_F = 100 \, \text{A} \]
\[ V_{GE} = \pm 15 \, \text{V} \]
**Buck Switch**

**Buck IGBT and Buck FWD**

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

\[ \frac{dI_F}{dt}, \frac{dI_{rec}}{dt} = f(I_{C}) \]

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

\[ \frac{dI_F}{dt}, \frac{dI_{rec}}{dt} = f(R_{gon}) \]

**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**

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

**IGBT thermal model values**

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<tr>
<th>( R ) (K/W)</th>
<th>Tau (s)</th>
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**FWD thermal model values**

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<td>3,49E-02</td>
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</table>
Buck Switch
Buck IGBT and Buck FWD

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

At
\[ T_j = 175 \, ^\circ C \]

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

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

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

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

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

At
\[ T_j = 150 \, ^\circ C \]
**Buck Switch**

**Buck IGBT and Buck FWD**

---

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

---

**Figure 26.** IGBT

Gate voltage vs Gate charge

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

At

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

---

**Figure 27.** IGBT

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

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

At

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

---

**Figure 28.** IGBT

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

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

At

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

---

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Buck Switch

Buck IGBT and Buck FWD

**Reverse bias safe operating area**

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

At

\[ T_j = T_{jmax} - 25 \degree C \]

\[ U_{ccminus} = U_{ccplus} \]

Switching mode: 3 level switching
Boost Switch
Boost IGBT and Boost FWD

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

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

- At
  - \( t_p = 250 \ \mu s \)
  - \( V_{CE} = 10 \ V \)
  - \( T_j = 25/150 \ ^\circ C \)
  - \( T_j = T_{j\text{max}} - 25 \ ^\circ C \)
Boost Switch
Boost IGBT and Boost FWD

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

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

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
\[ E = f(R_G) \]

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

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

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

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

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

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

**figure 9. IGBT**

Typical switching times as a function of collector current

\[ t = f(I_C) \]

With an inductive load at:

- \( T_j = 125 \, ^\circ\text{C} \)
- \( V_{CE} = 350 \, \text{V} \)
- \( V_{GE} = \pm 15 \, \text{V} \)
- \( R_{gon} = 4 \, \Omega \)
- \( I_C = 100 \, \text{A} \)

**figure 10. IGBT**

Typical switching times as a function of gate resistor

\[ t = f(R_G) \]

With an inductive load at:

- \( T_j = 125 \, ^\circ\text{C} \)
- \( V_{CE} = 350 \, \text{V} \)
- \( V_{GE} = \pm 15 \, \text{V} \)
- \( I_C = 100 \, \text{A} \)

**figure 11. FWD**

Typical reverse recovery time as a function of collector current

\[ t_t = f(I_C) \]

At:

- \( T_j = 25/125 \, ^\circ\text{C} \)
- \( V_{CE} = 350 \, \text{V} \)
- \( V_{GE} = \pm 15 \, \text{V} \)
- \( R_{gon} = 4,0 \, \Omega \)

**figure 12. FWD**

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

\[ t_t = f(R_{gon}) \]

At:

- \( T_j = 25/125 \, ^\circ\text{C} \)
- \( V_{CE} = 350 \, \text{V} \)
- \( V_{GE} = \pm 15 \, \text{V} \)
- \( I_F = 100 \, \text{A} \)
Boost Switch
Boost IGBT and Boost FWD

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

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

[Graph showing typical reverse recovery charge as a function of collector current.

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

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

[Graph showing typical reverse recovery charge as a function of IGBT turn on gate resistor.

At

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

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

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

[Graph showing typical reverse recovery current as a function of collector current.

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

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

[Graph showing typical reverse recovery current as a function of IGBT turn on gate resistor.

At

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

Copyright Vincotech
figure 17. FWD
Typical rate of fall of forward and reverse recovery current as a function of collector current
\[ \frac{dI}{dt}, \frac{di_{rec}}{dt} = f(I_c) \]

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

figure 18. FWD
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
- \( T_j = 25/125 \) °C
- \( V_{BE} = 350 \) V
- \( I_f = 100 \) A
- \( V_{GE} = \pm 15 \) V

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

At
- \( D = t_p / T \)
- \( R_{(j-s)} = 0.54 \) K/W

IGBT thermal model values

<table>
<thead>
<tr>
<th>( R ) (K/W)</th>
<th>Tau (s)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1,12E-01</td>
<td>2,87E+00</td>
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<td>3,03E-02</td>
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</tbody>
</table>

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

At
- \( D = t_p / T \)
- \( R_{(j-s)} = 0.74 \) K/W

FWD thermal model values

<table>
<thead>
<tr>
<th>( R ) (K/W)</th>
<th>Tau (s)</th>
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<tbody>
<tr>
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<td>2,84E-02</td>
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<tr>
<td>6,83E-02</td>
<td>4,90E-03</td>
</tr>
</tbody>
</table>
Boost Switch
Boost IGBT and Boost FWD

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

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

\[ I_C = f(T_s) \]

At
\[ T_j = 175 \degree C \]

**Figure 22.**
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.**
Power dissipation as a function of heatsink temperature

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

At
\[ T_j = 150 \degree C \]

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

\[ I_F = f(T_s) \]

At
\[ T_j = 150 \degree C \]
Boost IGBT

Reverse bias safe operating area

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

Gate voltage vs Gate charge

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

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

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

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

\[ I_{c(max)} = f(V_{CE}) \]

At

- \[ T_j = T_{j,\text{max}} - 25 \degree C \]
- \[ U_{\text{com}} = U_{\text{peak}} \]

Switching mode: 3 level switching

At

- \[ I_D = 100 \ A \]
- \[ T_j = 25 \degree C \]

At

- \[ V_{CE} = 600 \ V \]
- \[ T_j \leq 150 \degree C \]

At

- \[ V_{CE} \leq 400 \ V \]
- \[ T_j = 125 \degree C \]
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

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

\[ D = \frac{t_p}{T_{R_{th(j-s)}}} = 1.45 \text{ K/W} \]

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

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

\[ T_j = 175 ^\circ C \]

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

\[ I_F = f(T_h) \]

\[ T_j = 175 ^\circ C \]
Buck Inverse Diode

**Figure 1.** Buck Inverse Diode

Typical FWD forward current as a function of forward voltage

\[ I_F = f(V_F) \]

Power dissipation as a function of heatsink temperature

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

**Figure 2.** Buck Inverse Diode

FWD transient thermal impedance as a function of pulse width

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

\[ D = \frac{t_p}{T} \]

\[ R_{th(j-s)} = 1,77 \text{ K/W} \]

**Figure 3.** Buck Inverse Diode

Forward current as a function of heatsink temperature

\[ I_F = f(T_j) \]

\[ T_j = 150 \text{ °C} \]

**Figure 4.** Buck Inverse Diode

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figure 1. Thermistor

Typical NTC characteristic as a function of temperature

\[ R_T = f(T) \]
Switching Definitions Buck

General conditions

\[ T_j = 125 \, ^\circ \text{C} \]
\[ R_{\text{on}} = 4 \, \Omega \]
\[ R_{\text{off}} = 4 \, \Omega \]

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

\( t_{\text{doff}} = 0,28 \, \mu\text{s} \)
\( t_{\text{Eoff}} = 0,66 \, \mu\text{s} \)

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

\( t_{\text{don}} = 0,14 \, \mu\text{s} \)
\( t_{\text{Eon}} = 0,31 \, \mu\text{s} \)

**figure 3.** Buck IGBT
Turn-off Switching Waveforms & definition of \( t_f \)

\( t_f = 0,06 \, \mu\text{s} \)

**figure 4.** Buck IGBT
Turn-on Switching Waveforms & definition of \( t_r \)

\( t_r = 0,02 \, \mu\text{s} \)
Switching Definitions Buck

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

\[ P_{\text{off}} (100\%) = 35.11 \text{ kW} \]
\[ E_{\text{off}} (100\%) = 4.03 \text{ mJ} \]
\[ t_{\text{Eoff}} = 0.66 \text{ µs} \]

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

\[ P_{\text{on}} (100\%) = 35.11 \text{ kW} \]
\[ E_{\text{on}} (100\%) = 3.18 \text{ mJ} \]
\[ t_{\text{Eon}} = 0.31 \text{ µs} \]

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

\[ V_d (100\%) = 350 \text{ V} \]
\[ I_d (100\%) = 100 \text{ A} \]
\[ I_{\text{RRM}} (100\%) = -151 \text{ A} \]
\[ t_{\text{rr}} = 0.08 \text{ µs} \]
Switching Definitions Buck

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

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

$I_d (100%) = 100$ A
$Q_{rr} (100%) = 7,13$ µC
$t_{Qrr} = 0,16$ µs

$P_{rec} (100%) = 35,11$ kW
$E_{rec} (100%) = 1,01$ mJ
$t_{Erec} = 0,16$ µs

Buck switching measurement circuit

**figure 10.**
Switching Definitions Boost

General conditions

<table>
<thead>
<tr>
<th>Symbol</th>
<th>Value</th>
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<tr>
<td>$R_{on}$</td>
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<tr>
<td>$R_{off}$</td>
<td>4 Ω</td>
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**Turn-off Switching Waveforms & definition of $t_{doff}$, $t_{Eoff}$**

$t_{doff} = 0,18 \mu s$

$t_{Eoff} = 0,44 \mu s$

- $V_{CE}(0\%) = -15$ V
- $V_{CE}(100\%) = 350$ V
- $I_C(100\%) = 100$ A
- $t_{doff} = 0,18 \mu s$
- $t_{Eoff} = 0,44 \mu s$

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

$t_{don} = 0,10 \mu s$

$t_{Eon} = 0,15 \mu s$

- $V_{CE}(0\%) = -15$ V
- $V_{CE}(100\%) = 15$ V
- $V_C(100\%) = 350$ V
- $I_C(100\%) = 100$ A
- $t_{don} = 0,10 \mu s$
- $t_{Eon} = 0,15 \mu s$

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

$t_f = 0,064 \mu s$

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

$t_r = 0,019 \mu s$
Switching Definitions Boost

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

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

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

$P_{\text{on}}$ (100%) = 34,964 kW  
$E_{\text{on}}$ (100%) = 1,52 mJ  
$t_{\text{Eon}} = 0,18 \, \mu s$

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

$V_d$ (100%) = 350 V  
$I_d$ (100%) = 100 A  
$I_{\text{RRM 10%}}$ (100%) = -142 A  
$t_{\text{rr}} = 0,07 \, \mu s$
Switching Definitions Boost

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

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

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

$P_{inc} (100\%) = 69.93$ kW
$E_{inc} (100\%) = 3.61$ mJ
$t_{Einc} = 1.00$ µs

Boost switching measurement circuit

**figure 10.**

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## Ordering Code & Marking

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13 Apr. 2018 / Revision 6
### Identification

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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.

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