# Preliminary Datasheet for FZ06NPA070FP01

## Features
- "PS: 70A parallel switch (60A PT and 99mΩ)
- neutral point clamped inverter
- reactive power capability
- low inductance layout

## Target Applications
- solar inverter
- UPS

## Types
- FZ06NPA070FP01

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## Maximum Ratings

Tj=25°C, unless otherwise specified

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Symbol</th>
<th>Condition</th>
<th>Value</th>
<th>Unit</th>
</tr>
</thead>
<tbody>
<tr>
<td>Collector-emitter break down voltage</td>
<td>V_{CE}</td>
<td>Tj=T_{max}</td>
<td>600</td>
<td>V</td>
</tr>
<tr>
<td>DC collector current</td>
<td>I_{c}</td>
<td>Tj=T_{max}</td>
<td>44</td>
<td>A</td>
</tr>
<tr>
<td>Repetitive peak collector current</td>
<td>I_{pul}</td>
<td>I_{p} limited by T_{max}</td>
<td>240</td>
<td>A</td>
</tr>
<tr>
<td>Power dissipation per IGBT</td>
<td>P_{tot}</td>
<td>Tj=T_{max}</td>
<td>71</td>
<td>W</td>
</tr>
<tr>
<td>Gate-emitter peak voltage</td>
<td>V_{GE}</td>
<td>Tj=T_{max}</td>
<td>±20</td>
<td>V</td>
</tr>
<tr>
<td>Short circuit ratings</td>
<td>t_{sc}</td>
<td>V_{GE}=15V</td>
<td>5</td>
<td>μs</td>
</tr>
<tr>
<td>Maximum Junction Temperature</td>
<td>T_{jmax}</td>
<td></td>
<td>150</td>
<td>°C</td>
</tr>
</tbody>
</table>

## Buck IGBT

- Collector-emitter break down voltage: V_{CE}, 600 V
- DC collector current: I_{c}, 44 A
- Repetitive peak collector current: I_{pul}, 240 A
- Power dissipation per IGBT: P_{tot}, 71 W
- Gate-emitter peak voltage: V_{GE}, ±20 V
- Short circuit ratings: t_{sc}, 5 μs
- Maximum Junction Temperature: T_{jmax}, 150 °C

## Buck Diode

- Peak Repetitive Reverse Voltage: V_{max}, 600 V
- DC forward current: I_{f}, 21 A
- Repetitive peak forward current: I_{pul}, 120 A
- Power dissipation per Diode: P_{tot}, 41 W
- Maximum Junction Temperature: T_{jmax}, 150 °C

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Revision: 3
### Maximum Ratings

**Buck MOSFET**

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Symbol</th>
<th>Condition</th>
<th>Value</th>
<th>Unit</th>
</tr>
</thead>
<tbody>
<tr>
<td>Drain to source breakdown voltage</td>
<td>$V_{DS}$</td>
<td>$T_{J}=T_{max}$</td>
<td>600</td>
<td>V</td>
</tr>
<tr>
<td>DC drain current</td>
<td>$I_D$</td>
<td>$T_{r}=80°C$</td>
<td>16</td>
<td>A</td>
</tr>
<tr>
<td></td>
<td></td>
<td>$T_{c}=80°C$</td>
<td>21</td>
<td>A</td>
</tr>
<tr>
<td>Pulsed drain current</td>
<td>$I_{pulsa}$</td>
<td>$I_L$ limited by $T_{J,max}$</td>
<td>93</td>
<td>A</td>
</tr>
<tr>
<td>Power dissipation</td>
<td>$P_{tot}$</td>
<td>$T_{J}=T_{max}$</td>
<td>54</td>
<td>W</td>
</tr>
<tr>
<td></td>
<td></td>
<td>$T_{r}=80°C$</td>
<td>97</td>
<td>W</td>
</tr>
<tr>
<td>Gate-source peak voltage</td>
<td>$V_{gs}$</td>
<td></td>
<td>±20</td>
<td>V</td>
</tr>
<tr>
<td>Maximum Junction Temperature</td>
<td>$T_{J,max}$</td>
<td></td>
<td>150</td>
<td>°C</td>
</tr>
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</table>

**Boost IGBT**

<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 break down 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>$T_{J}=T_{max}$</td>
<td>57</td>
<td>A</td>
</tr>
<tr>
<td></td>
<td></td>
<td>$T_{r}=80°C$</td>
<td>75</td>
<td>A</td>
</tr>
<tr>
<td>Repetitive peak collector current</td>
<td>$I_{CPULS}$</td>
<td>$I_L$ limited by $T_{J,max}$</td>
<td>225</td>
<td>A</td>
</tr>
<tr>
<td>Power dissipation per IGBT</td>
<td>$P_{tot}$</td>
<td>$T_{J}=T_{max}$</td>
<td>85</td>
<td>W</td>
</tr>
<tr>
<td></td>
<td></td>
<td>$T_{r}=80°C$</td>
<td>129</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>$t_{SC}$</td>
<td>$T_{J}=150°C$</td>
<td>6</td>
<td>μs</td>
</tr>
<tr>
<td></td>
<td>$V_{CC}$</td>
<td>$V_{GE}=15V$</td>
<td>360</td>
<td>V</td>
</tr>
<tr>
<td>Maximum Junction Temperature</td>
<td>$T_{J,max}$</td>
<td></td>
<td>175</td>
<td>°C</td>
</tr>
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</table>

**Boost 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>Peak Repetitive Reverse Voltage</td>
<td>$V_{RRM}$</td>
<td>$T_{J}=25°C$</td>
<td>600</td>
<td>V</td>
</tr>
<tr>
<td>DC forward current</td>
<td>$I_F$</td>
<td>$T_{J}=T_{max}$</td>
<td>2</td>
<td>A</td>
</tr>
<tr>
<td></td>
<td></td>
<td>$T_{r}=80°C$</td>
<td>28</td>
<td>A</td>
</tr>
<tr>
<td>Power dissipation per Diode</td>
<td>$P_{tot}$</td>
<td>$T_{J}=T_{max}$</td>
<td>21</td>
<td>W</td>
</tr>
<tr>
<td></td>
<td></td>
<td>$T_{r}=80°C$</td>
<td>52</td>
<td>W</td>
</tr>
<tr>
<td>Maximum Junction Temperature</td>
<td>$T_{J,max}$</td>
<td></td>
<td>150</td>
<td>°C</td>
</tr>
</tbody>
</table>

**Boost Diode**

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Symbol</th>
<th>Condition</th>
<th>Value</th>
<th>Unit</th>
</tr>
</thead>
<tbody>
<tr>
<td>Peak Repetitive Reverse Voltage</td>
<td>$V_{RRM}$</td>
<td>$T_{J}=25°C$</td>
<td>1200</td>
<td>V</td>
</tr>
<tr>
<td>DC forward current</td>
<td>$I_F$</td>
<td>$T_{J}=T_{max}$</td>
<td>20</td>
<td>A</td>
</tr>
<tr>
<td></td>
<td></td>
<td>$T_{r}=80°C$</td>
<td>28</td>
<td>A</td>
</tr>
<tr>
<td>Repetitive peak forward current</td>
<td>$I_{RMS}$</td>
<td>$I_L$ limited by $T_{J,max}$</td>
<td>70</td>
<td>A</td>
</tr>
<tr>
<td>Power dissipation per Diode</td>
<td>$P_{tot}$</td>
<td>$T_{J}=T_{max}$</td>
<td>34</td>
<td>W</td>
</tr>
<tr>
<td></td>
<td></td>
<td>$T_{r}=80°C$</td>
<td>52</td>
<td>W</td>
</tr>
<tr>
<td>Maximum Junction Temperature</td>
<td>$T_{J,max}$</td>
<td></td>
<td>150</td>
<td>°C</td>
</tr>
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### Maximum Ratings

T<sub>j</sub>=25°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>Thermal Properties</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Storage temperature</td>
<td>T&lt;sub&gt;stg&lt;/sub&gt;</td>
<td></td>
<td>-40...+125</td>
<td>°C</td>
</tr>
<tr>
<td>Operation temperature under switching condition</td>
<td>T&lt;sub&gt;op&lt;/sub&gt;</td>
<td></td>
<td>-40...+(T&lt;sub&gt;jmax&lt;/sub&gt; - 25)</td>
<td>°C</td>
</tr>
<tr>
<td><strong>Insulation Properties</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Insulation voltage</td>
<td>V&lt;sub&gt;in&lt;/sub&gt;</td>
<td>t=2s</td>
<td>DC voltage</td>
<td>4000</td>
</tr>
<tr>
<td>Creepage distance</td>
<td></td>
<td></td>
<td></td>
<td>min 12.7</td>
</tr>
<tr>
<td>Clearance</td>
<td></td>
<td></td>
<td></td>
<td>min 12.7</td>
</tr>
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### Characteristic Values

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Symbol</th>
<th>Conditions</th>
<th>Value</th>
<th>Unit</th>
</tr>
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<tbody>
<tr>
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</tr>
<tr>
<td>Parameter</td>
<td>Symbol</td>
<td>Conditions</td>
<td>Value</td>
<td>Unit</td>
</tr>
</tbody>
</table>

#### Buck IGBT *

<table>
<thead>
<tr>
<th>Parameter</th>
<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(th)</td>
<td>V_C=E=G</td>
<td>0.00025</td>
<td>4.5</td>
</tr>
<tr>
<td>Collector-emitter saturation voltage</td>
<td>V_CE(sat)</td>
<td>15</td>
<td>70</td>
<td>1.45</td>
</tr>
<tr>
<td>Collector-emitter cut-off current incl. Diode</td>
<td>I_CES</td>
<td>0</td>
<td>600</td>
<td>250</td>
</tr>
<tr>
<td>Gate-emitter leakage current</td>
<td>I_GES</td>
<td>±20</td>
<td>0</td>
<td>300</td>
</tr>
<tr>
<td>Integrated Gate resistor</td>
<td>R_PRT</td>
<td>none</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Input capacitance **</td>
<td>C_Ciss</td>
<td></td>
<td></td>
<td>4+4,7</td>
</tr>
<tr>
<td>Output capacitance</td>
<td>C_Ciss</td>
<td></td>
<td></td>
<td>400</td>
</tr>
<tr>
<td>Reverse transfer capacitance</td>
<td>C_Ciss</td>
<td></td>
<td></td>
<td>200</td>
</tr>
<tr>
<td>Gate charge **</td>
<td>Q_G</td>
<td>±15</td>
<td>Tj=25°C</td>
<td>225+70</td>
</tr>
<tr>
<td>Thermal resistance chip to heatsink per chip</td>
<td>RthJH</td>
<td>Thermal grease thickness50um</td>
<td>A=1 W/mK</td>
<td>0.99</td>
</tr>
</tbody>
</table>

* see dynamic characteristic at Buck MOSFET

**additional value stands for built-in capacitor

#### Buck Diode

<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_D</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Peak reverse recovery current</td>
<td>I_RRM</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Reverse recovery time</td>
<td>t_{rr}</td>
<td>Rgon=8 Ω</td>
<td>350</td>
<td>40</td>
</tr>
<tr>
<td>Reverse recovered charge</td>
<td>Q_{rr}</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Peak rate of fall of recovery current</td>
<td>dV/dt</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Reverse recovered energy</td>
<td>E_{re}</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Thermal resistance chip to heatsink per chip</td>
<td>RthJH</td>
<td>Thermal grease thickness50um</td>
<td>A=1 W/mK</td>
<td>1.72</td>
</tr>
</tbody>
</table>

#### Buck MOSFET

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Symbol</th>
<th>Conditions</th>
<th>Value</th>
<th>Unit</th>
</tr>
</thead>
<tbody>
<tr>
<td>Static drain to source ON resistance</td>
<td>R_{dss}</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Gate threshold voltage</td>
<td>V_{GES(th)}</td>
<td>V_C=E=G</td>
<td>0.001</td>
<td>2.1</td>
</tr>
<tr>
<td>Gate to Source Leakage Current</td>
<td>I_{gs}</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Zero Gate Voltage Drain Current</td>
<td>I_{gs}</td>
<td>0</td>
<td>800</td>
<td></td>
</tr>
<tr>
<td>Turn On Delay Time</td>
<td>t_{ON}</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Rise Time</td>
<td>t_{R}</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Turn off delay time</td>
<td>t_{OFF}</td>
<td>Rgon=8 Ω **</td>
<td>350</td>
<td>40</td>
</tr>
<tr>
<td>Fall time</td>
<td>t_{F}</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Turn-on energy loss per pulse</td>
<td>E_{on}</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Turn-off energy loss per pulse</td>
<td>E_{off}</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total gate charge</td>
<td>Q_{g}</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Gate to source charge</td>
<td>Q_{gs}</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Gate to drain charge</td>
<td>Q_{gd}</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Input capacitance</td>
<td>C_{iss}</td>
<td>f=1MHz</td>
<td>0</td>
<td>100</td>
</tr>
<tr>
<td>Output capacitance</td>
<td>C_{oss}</td>
<td></td>
<td></td>
<td>2800</td>
</tr>
<tr>
<td>Thermal resistance chip to heatsink per chip</td>
<td>RthJH</td>
<td>Thermal grease thickness50um</td>
<td>A=1 W/mK</td>
<td>1.29</td>
</tr>
</tbody>
</table>

* see schematic of the Gate-complex at characteristic figures

** see schematic of the Gate-complex at characteristic figures

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## Characteristic Values

### Boost IGBT

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Symbol</th>
<th>Conditions</th>
<th>Value</th>
<th>Unit</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gate emitter threshold voltage</td>
<td>$V_{GE(th)}$</td>
<td>$V_{CE(th)} V_{GE}$</td>
<td>0.0012</td>
<td>V</td>
</tr>
<tr>
<td>Collector-emitter saturation voltage</td>
<td>$V_{CE(sat)}$</td>
<td>$V_{GS(th)} V_{CE}$</td>
<td>15</td>
<td>mA</td>
</tr>
<tr>
<td>Collector-emitter cut-off incl diode</td>
<td>$I_{CES}$</td>
<td></td>
<td>70</td>
<td>mA</td>
</tr>
<tr>
<td>Gate-emitter leakage current</td>
<td>$I_{GES}$</td>
<td></td>
<td></td>
<td>mA</td>
</tr>
<tr>
<td>Integrated Gate resistor</td>
<td>$R_{gint}$</td>
<td></td>
<td></td>
<td>Ω</td>
</tr>
<tr>
<td>Turn-on delay time</td>
<td>$t_{(on)}$</td>
<td></td>
<td></td>
<td>ns</td>
</tr>
<tr>
<td>Rise time</td>
<td>$t_{R}$</td>
<td>$R_{g(on)}=8 \Omega$</td>
<td>≤15</td>
<td>ns</td>
</tr>
<tr>
<td>Turn-off delay time</td>
<td>$t_{(off)}$</td>
<td>$R_{g(off)}=8 \Omega$</td>
<td>350</td>
<td>ns</td>
</tr>
<tr>
<td>Fall time</td>
<td>$t_{f}$</td>
<td></td>
<td>60</td>
<td>ns</td>
</tr>
<tr>
<td>Turn-on energy loss per pulse</td>
<td>$E_{on}$</td>
<td></td>
<td></td>
<td>mWs</td>
</tr>
<tr>
<td>Turn-off energy loss per pulse</td>
<td>$E_{off}$</td>
<td></td>
<td></td>
<td>mWs</td>
</tr>
<tr>
<td>Input capacitance</td>
<td>$C_{in}$</td>
<td></td>
<td></td>
<td>pF</td>
</tr>
<tr>
<td>Output capacitance</td>
<td>$C_{out}$</td>
<td>R=1MHz</td>
<td>0</td>
<td>pF</td>
</tr>
<tr>
<td>Reverse transfer capacitance</td>
<td>$C_{rmin}$</td>
<td></td>
<td></td>
<td>pF</td>
</tr>
<tr>
<td>Gate charge</td>
<td>$Q_{gmin}$</td>
<td></td>
<td>15</td>
<td>nC</td>
</tr>
<tr>
<td>Thermal resistance chip to heatsink per chip</td>
<td>$R_{thJH}$</td>
<td>Thermal grease thickness=50um $\lambda=1$ W/mK</td>
<td>1.11</td>
<td>KW</td>
</tr>
</tbody>
</table>

### Boost Inverse Diode

<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>$V_{D}$</td>
<td></td>
<td>20</td>
<td>V</td>
</tr>
<tr>
<td>Thermal resistance chip to heatsink per chip</td>
<td>$R_{thJH}$</td>
<td>Thermal grease thickness=50um $\lambda=1$ W/mK</td>
<td>4.36</td>
<td>KW</td>
</tr>
</tbody>
</table>

### Boost Diode

<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>$V_{D}$</td>
<td></td>
<td>30</td>
<td>V</td>
</tr>
<tr>
<td>Reverse leakage current</td>
<td>$I_{r}$</td>
<td></td>
<td>1200</td>
<td>mA</td>
</tr>
<tr>
<td>Peak reverse recovery current</td>
<td>$I_{(peak)}$</td>
<td></td>
<td></td>
<td>mA</td>
</tr>
<tr>
<td>Reverse recovery time</td>
<td>$t_{(r)}$</td>
<td></td>
<td>350</td>
<td>ns</td>
</tr>
<tr>
<td>Reverse recovered charge</td>
<td>$Q_{r}$</td>
<td>$R_{g(on)}=8 \Omega$</td>
<td>40</td>
<td>μC</td>
</tr>
<tr>
<td>Peak rate of fall of recovery current</td>
<td>$di/dt,(max)$</td>
<td></td>
<td></td>
<td>A/μs</td>
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<tr>
<td>Reverse recovery energy</td>
<td>$E_{rec}$</td>
<td></td>
<td></td>
<td>mWs</td>
</tr>
<tr>
<td>Thermal resistance chip to heatsink per chip</td>
<td>$R_{thJH}$</td>
<td>Thermal grease thickness=50um $\lambda=1$ W/mK</td>
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<td>KW</td>
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### Thermistor

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<th>Value</th>
<th>Unit</th>
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<td>Rated resistance*</td>
<td>$R_{th}$</td>
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<tr>
<td>Power dissipation</td>
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<td></td>
<td></td>
<td>mW</td>
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<tr>
<td>B-value</td>
<td>$B_{(25/100)}$</td>
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<td></td>
<td>K</td>
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* See details on Thermistor charts on Figure 2.
Buck

Figure 1: MOSFET
Typical output characteristics
$\text{IC} = f(\text{VCE})$

At
$\tau_p = 250 \ \mu\text{s}$
$\text{Tj} = 25 ^\circ\text{C}$
$\text{VGE from 3 V to 19 V in steps of 2 V}$

Figure 2: MOSFET
Typical output characteristics
$\text{IC} = f(\text{VCE})$

At
$\tau_p = 250 \ \mu\text{s}$
$\text{Tj} = 125 ^\circ\text{C}$
$\text{VGE from 3 V to 19 V in steps of 2 V}$

Figure 3: MOSFET
Typical transfer characteristics
$\text{IC} = f(\text{VGE})$

At
$\tau_p = 250 \ \mu\text{s}$
$\text{Tj} = \text{Tjmax-25 ^\circ\text{C}}$

Figure 4: FRED
Typical diode forward current as a function of forward voltage
$\text{IF} = f(\text{VF})$

At
$\tau_p = 250 \ \mu\text{s}$
$\text{Tj} = \text{Tjmax-25 ^\circ\text{C}}$
Typical switching energy losses
as a function of collector current
\[ E = f(I_C) \]

With an inductive load at
\[ T_j = 25/125 \, ^\circ \text{C} \]
\[ V_{CE} = 350 \, \text{V} \]
\[ V_{GE} = \pm 15 \, \text{V} \]
\[ R_{gon} = 8 \, \Omega \]
\[ R_{goff} = 8 \, \Omega \]

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

With an inductive load at
\[ T_j = 25/125 \, ^\circ \text{C} \]
\[ V_{CE} = 350 \, \text{V} \]
\[ V_{GE} = \pm 15 \, \text{V} \]
\[ R_{gon} = 8 \, \Omega \]

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Figure 9 MOSFET
Typical switching times as a function of collector current
\( t = f(I_C) \)

With an inductive load at
- \( T_j = 125 \, ^\circ \text{C} \)
- \( V_{CE} = 350 \, \text{V} \)
- \( V_{GE} = \pm 15 \, \text{V} \)
- \( R_{g(on)} = 8 \, \Omega \)
- \( R_{g(off)} = 8 \, \Omega \)

Figure 10 MOSFET
Typical switching times as a function of gate resistor
\( t = f(R_g) \)

With an inductive load at
- \( T_j = 125 \, ^\circ \text{C} \)
- \( V_{CE} = 350 \, \text{V} \)
- \( V_{GE} = \pm 15 \, \text{V} \)
- \( I_c = 40 \, \text{A} \)

Figure 11 FRED
Typical reverse recovery time as a function of collector current
\( t_{rr} = f(I_c) \)

At
- \( T_j = 25/125 \, ^\circ \text{C} \)
- \( V_{CE} = 350 \, \text{V} \)
- \( V_{GE} = \pm 15 \, \text{V} \)
- \( R_{g(on)} = 8 \, \Omega \)

Figure 12 FRED
Typical reverse recovery time as a function of IGBT turn on gate resistor
\( t_{rr} = f(R_{g(on)}) \)

At
- \( T_j = 25/125 \, ^\circ \text{C} \)
- \( V_{CE} = 350 \, \text{V} \)
- \( V_{GE} = \pm 15 \, \text{V} \)
- \( I_g = 40 \, \text{A} \)
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
  - \( R_{gon} = 8 \) Ω

Typical reverse recovery current as a function of collector current

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

- **At**
  - \( T_j = 25/125 \) °C
  - \( V_{CE} = 350 \) V
  - \( V_{GE} = \pm 15 \) V
  - \( R_{gon} = 8 \) Ω
**Figure 17**
Typical rate of fall of forward and reverse recovery current as a function of collector current

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

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

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

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

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

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

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

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

\[ \begin{align*}
T_j &= 150 \degree C \\
\end{align*} \]

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

\[ \begin{align*}
T_j &= 150 \degree C \quad V_{GE} = 15 \ V
\end{align*} \]

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

\[ \begin{align*}
T_j &= 150 \degree C \\
\end{align*} \]

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

\[ \begin{align*}
T_j &= 150 \degree C \\
\end{align*} \]
Figure 25  
Safe operating area as a function of collector-emitter voltage  
$IC = f(V_{CE})$

At  
$D = \text{single pulse}$  
$Th = 80 \degree \text{C}$  
$V_{GE} = \pm 15 \text{ V}$  
$T_j = T_{j\max} \degree \text{C}$

Figure 26  
Gate voltage vs Gate charge  
$V_{GE} = f(Q_g)$

At  
$D = \text{single pulse}$  
$I_{GREF} = 1\text{mA}, R_L = 15\Omega$

Figure 27  
MOSFET transient thermal impedance as a function of pulse width  
$Z_{thJH} = f(tp)$

At  
$D = tp / T$  
$R_{thJH} = 1.29 \text{ K/W}$  
$IC = 18 \text{ A}$

MOSFET thermal model values  
<table>
<thead>
<tr>
<th>$R (C/W)$</th>
<th>$\tau$ (s)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.09</td>
<td>9.2E+00</td>
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<tr>
<td>0.27</td>
<td>1.3E+00</td>
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<td>0.05</td>
<td>4.7E-04</td>
</tr>
</tbody>
</table>
Boost

**Figure 1**
Typical output characteristics
$I_c = f(V_{CE})$

![IGBT Figure 1](image1)

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

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

![IGBT Figure 2](image2)

- $t_p = 250 \, \mu s$
- $T_j = 125 \, ^\circ C$
- $V_{CE}$ from 6 V to 16 V in steps of 1 V

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

![IGBT Figure 3](image3)

- $t_p = 250 \, \mu s$
- $T_j = T_{j\text{max}} - 25 \, ^\circ C$
- $V_{CE}$ = 10 V

**Figure 4**
Typical diode forward current as a function of forward voltage
$IF = f(V_F)$

![FRED Figure 4](image4)

- $t_p = 250 \, \mu s$
- $T_j = T_{j\text{max}} - 25 \, ^\circ C$
- $V_F$ from 0 V to 100 V in steps of 1 V
Figure 5  
Typical switching energy losses as a function of collector current  
\[ E = f(I_c) \]

With an inductive load at
- \( T_j = 25/125 \) °C
- \( V_{CE} = 350 \) V
- \( V_{GE} = 15 \) V
- \( R_{gon} = 8 \) Ω
- \( R_{goff} = 8 \) Ω

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

With an inductive load at
- \( T_j = 25/125 \) °C
- \( V_{CE} = 350 \) V
- \( V_{GE} = 15 \) V
- \( I_c = 40 \) A

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

With an inductive load at
- \( T_j = 25/125 \) °C
- \( V_{CE} = 350 \) V
- \( V_{GE} = 15 \) V
- \( R_{gon} = 8 \) Ω

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

With an inductive load at
- \( T_j = 25/125 \) °C
- \( V_{CE} = 350 \) V
- \( V_{GE} = 15 \) V
- \( I_c = 40 \) A
**Figure 9** IGBT
Typical switching times as a function of collector current
\( t = f(I_C) \)

With an inductive load at
- \( T_j = 125 \ ^\circ \text{C} \)
- \( V_{CE} = 350 \ \text{V} \)
- \( V_{GE} = 15 \ \text{V} \)
- \( R_{gon} = 8 \ \Omega \)
- \( R_{goff} = 8 \ \Omega \)

**Figure 10** IGBT
Typical switching times as a function of gate resistor
\( t = f(R_G) \)

With an inductive load at
- \( T_j = 125 \ ^\circ \text{C} \)
- \( V_{CE} = 350 \ \text{V} \)
- \( V_{GE} = 15 \ \text{V} \)
- \( I_C = 40 \ \text{A} \)

**Figure 11** FRED
Typical reverse recovery time as a function of collector current
\( t_{rr} = f(I_C) \)

At
- \( T_j = 25/125 \ ^\circ \text{C} \)
- \( V_{CE} = 350 \ \text{V} \)
- \( V_{GE} = 15 \ \text{V} \)
- \( R_{gon} = 8 \ \Omega \)

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

At
- \( T_j = 25/125 \ ^\circ \text{C} \)
- \( V_{BE} = 350 \ \text{V} \)
- \( I_C = 40 \ \text{A} \)
- \( V_{GE} = 15 \ \text{V} \)
Typical reverse recovery charge as a function of collector current

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

**At**

\[ T_j = 25/125 \degree C \]
\[ V_{CE} = 350 \, V \]
\[ V_{GE} = 15 \, V \]
\[ R_{gon} = 8 \, \Omega \]

Typical reverse recovery current as a function of collector current

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

**At**

\[ T_j = 25/125 \degree C \]
\[ V_{CE} = 350 \, V \]
\[ V_{GE} = 15 \, V \]
\[ R_{gon} = 8 \, \Omega \]
Typical rate of fall of forward and reverse recovery current as a function of collector current

\[ \frac{dI_0}{dt}, \frac{dI_{rec}}{dt} = f(I_c) \]

At

- \( T_j = 25/125 \degree C \)
- \( V_{CE} = 350 \text{ V} \)
- \( V_{GE} = 15 \text{ V} \)
- \( I_F = 40 \text{ A} \)
- \( R_{gon} = 8 \text{ \Omega} \)

IGBT transient thermal impedance as a function of pulse width

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

At

- \( D = \frac{t_p}{T} \)
- \( R_{thJH} = 1.11 \text{ K/W} \)

IGBT thermal model values

<table>
<thead>
<tr>
<th>( R \text{ (C/W)} )</th>
<th>( \text{Tau (s)} )</th>
</tr>
</thead>
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FRED transient thermal impedance as a function of pulse width

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

At

- \( D = \frac{t_p}{T} \)
- \( R_{thJH} = 2.04 \text{ K/W} \)

FRED thermal model values

<table>
<thead>
<tr>
<th>( R \text{ (C/W)} )</th>
<th>( \text{Tau (s)} )</th>
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</tbody>
</table>
Boost

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

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

At

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

**Figure 22**
Collector current as a function of heatsink temperature

\[ I_C = f(T_h) \]

At

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

**Figure 23**
Power dissipation as a function of heatsink temperature

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

At

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

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

\[ I_F = f(T_h) \]

At

\[ T_j = 150 \, ^\circ C \]
Figure 25: Typical diode forward current as a function of forward voltage
\[ I_F = f(V_F) \]

At
\[ T_p = 250 \mu s \]

Figure 26: Diode transient thermal impedance as a function of pulse width
\[ Z_{th, JH} = f(T_p) \]

At
\[ D = \frac{T_p}{T}, R_{th, JH} = 4.36 \text{ K/W} \]

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

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

Figure 28: Forward current as a function of heatsink temperature
\[ I_F = f(T_{th}) \]

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

Figure 1
Typical NTC characteristic as a function of temperature

Figure 2
Typical NTC resistance values

\[ R(T) = R_{25} \cdot e^{\left( \frac{1}{T_{25}} \left( \frac{1}{T} - \frac{1}{T_{25}} \right) \right)} \] \[ [\Omega] \]

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Switching Definitions BUCK MOSFET

General conditions

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<th>Symbol</th>
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<td>$T_j$</td>
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<td>$R_{on,IGBT}$</td>
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<tr>
<td>$R_{on,MOSFET}$</td>
<td>0 Ω</td>
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<tr>
<td>$R_{off,IGBT}$</td>
<td>8 Ω</td>
</tr>
<tr>
<td>$R_{off,MOSFET}$</td>
<td>47 Ω</td>
</tr>
</tbody>
</table>

Figure 1: Output inverter IGBT

Turn-off Switching Waveforms & definition of $t_{\text{off}}$, $t_{\text{on}}$

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

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

$V_G$ (0%) = -15 V
$V_G$ (100%) = 15 V
$V_C$ (100%) = 350 V
$I_C$ (100%) = 40 A
$t_{\text{off}}$ = 0.23 μs
$t_{\text{on}}$ = 0.24 μs

Figure 2: Output inverter IGBT

Turn-on Switching Waveforms & definition of $t_{\text{on}}$, $t_{\text{off}}$

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

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

$V_G$ (0%) = -15 V
$V_G$ (100%) = 15 V
$V_C$ (100%) = 350 V
$I_C$ (100%) = 40 A
$t_{\text{on}}$ = 0.13 μs
$t_{\text{off}}$ = 0.16 μs

Figure 3: Output inverter IGBT

Turn-off Switching Waveforms & definition of $t_{\text{f}}$

$t_{\text{f}}$ = fitted

$V_C$ (100%) = 350 V
$I_C$ (100%) = 40 A
$t_{\text{f}}$ = 0.00 μs

Figure 4: Output inverter IGBT

Turn-on Switching Waveforms & definition of $t_{\text{r}}$

$t_{\text{r}}$ = fitted

$V_C$ (100%) = 350 V
$I_C$ (100%) = 40 A
$t_{\text{r}}$ = 0.01 μs
Switching Definitions BUCK MOSFET

Figure 5  Output inverter IGBT
Turn-off Switching Waveforms & definition of $t_{Eoff}$

$P_{off}(100\%) = 13.94$ kW
$E_{off}(100\%) = 0.20$ mJ
$t_{Eoff} = 0.24$ $\mu$s

Figure 6  Output inverter IGBT
Turn-on Switching Waveforms & definition of $t_{Eon}$

$P_{on}(100\%) = 13.94$ kW
$E_{on}(100\%) = 0.33$ mJ
$t_{Eon} = 0.16$ $\mu$s

Figure 7  Output inverter IGBT
Turn-off Switching Waveforms & definition of $t_{r}$

$V_d(100\%) = 350$ V
$I_d(100\%) = 40$ A
$t_{r_{10%}} = 4.1$ time (us)
$t_{r_{90%}} = 4.12$ time (us)
$t_{r_{100%}} = 4.14$ time (us)

Figure 8  Output inverter FRED
Turn-on Switching Waveforms & definition of $t_{Qr}$
($t_{Qrr}$ = integrating time for $Q_r$)

$I_r(100\%) = 40$ A
$Q_r(100\%) = 1.09$ $\mu$C
$t_{Qr} = 0.04$ $\mu$s
Switching Definitions BUCK MOSFET

Figure 9
Output inverter FRED

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

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

$P_{rec}$ (100%) = 13.94 kW

$E_{rec}$ (100%) = 0.16 mJ

$t_{Erec}$ = 0.04 $\mu$s

Figure 11
BUCK stage switching measurement circuit

Figure 12
BOOST stage switching measurement circuit

Cg is included in the module
Ordering Code and Marking - Outline - Pinout

Ordering Code & Marking

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<thead>
<tr>
<th>Version</th>
<th>Ordering Code</th>
<th>in DataMatrix as</th>
<th>in packaging barcode as</th>
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Outline

Pinout
PRODUCT STATUS DEFINITIONS

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<th>Datasheet Status</th>
<th>Product Status</th>
<th>Definition</th>
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<tr>
<td>Target</td>
<td>Formative or In Design</td>
<td>This datasheet contains the design specifications for product development. Specifications may change in any manner without notice. The data contained is exclusively intended for technically trained staff.</td>
</tr>
<tr>
<td>Preliminary</td>
<td>First Production</td>
<td>This datasheet contains preliminary data, and supplementary data may be published at a later date. Vincotech reserves the right to make changes at any time without notice in order to improve design. The data contained is exclusively intended for technically trained staff.</td>
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<tr>
<td>Final</td>
<td>Full Production</td>
<td>This datasheet contains final specifications. Vincotech reserves the right to make changes at any time without notice in order to improve design. The data contained is exclusively intended for technically trained staff.</td>
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</table>

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Vincotech products are not authorised for use as critical components in life support devices or systems without the express written approval of Vincotech.

As used herein:
1. Life support devices or systems are devices or systems which, (a) are intended for surgical implant into the body, or (b) support or sustain life, or (c) whose failure to perform when properly used in accordance with instructions for use provided in labelling can be reasonably expected to result in significant injury to the user.
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.