flowNPC 0

Features
- neutral point clamped inverter
- reactive power capability
- low inductance layout

Target Applications
- solar inverter
- UPS

Types
- 10-FZ06NRA041FS03-P965F78
- 10-PZ06NRA041FS03-P965F78Y

flow 0 12mm housing

Schematic

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>
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<tbody>
<tr>
<td>Boost Inv. Diode</td>
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<tr>
<td>Repetitive peak reverse voltage</td>
<td>V_{RRM}</td>
<td></td>
<td>600</td>
<td>V</td>
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<tr>
<td>Forward current per diode</td>
<td>I_{FAV}</td>
<td>DC current</td>
<td>17</td>
<td>A</td>
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<tr>
<td>Maximum repetitive forward current</td>
<td>I_{FRM}</td>
<td>Tj=80°C Tc=80°C</td>
<td>17</td>
<td>A</td>
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<tr>
<td>I2t-value</td>
<td>I_{t}</td>
<td>t=10ms</td>
<td>9.5</td>
<td>A²s</td>
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<td>Power dissipation per Diode</td>
<td>P_{mr}</td>
<td>Tj,Tj=25°C Tc=80°C</td>
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<td>W</td>
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<td>Maximum Junction Temperature</td>
<td>Tj=max</td>
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<td>175</td>
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### Maximum Ratings

**Tj=25°C, unless otherwise specified**

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Symbol</th>
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<th>Value</th>
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<tbody>
<tr>
<td><strong>Buck Diode</strong></td>
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</tr>
<tr>
<td>Peak Repetitive Reverse Voltage</td>
<td>( V_{\text{max}} )</td>
<td></td>
<td>600</td>
<td>V</td>
</tr>
<tr>
<td>DC forward current</td>
<td>( I_f )</td>
<td>( T_r=T_{\text{max}} ) ( T_c=80°C ) ( T_r=80°C )</td>
<td>25</td>
<td>35</td>
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<tr>
<td>Non repetitive peack surge current</td>
<td>( I_{\text{RSM}} )</td>
<td>( I_r ) limited by ( T_{\text{max}} ) ( 60\text{Hz Single Half-Sine Wave} ) ( T_c=25°C )</td>
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<td>Power dissipation per Diode</td>
<td>( P_{\text{tot}} )</td>
<td>( T_r=T_{\text{max}} )</td>
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<td>61</td>
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<td>Maximum Junction Temperature</td>
<td>( T_{\text{max}} )</td>
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<td>150</td>
<td>°C</td>
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<td><strong>Buck MOSFET</strong></td>
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<tr>
<td>Drain to source breakdown voltage</td>
<td>( V_{\text{DS}} )</td>
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<td>V</td>
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<td>DC drain current</td>
<td>( I_d )</td>
<td>( T_r=T_{\text{max}} ) ( T_c=80°C ) ( T_r=80°C )</td>
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<td>Pulsed drain current</td>
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<td>( T_r=T_{\text{max}} )</td>
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<td>Gate-source peak voltage</td>
<td>( V_{\text{gs}} )</td>
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<td>±20</td>
<td>V</td>
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<tr>
<td>Maximum Junction Temperature</td>
<td>( T_{\text{max}} )</td>
<td></td>
<td>150</td>
<td>°C</td>
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<td><strong>Boost IGBT</strong></td>
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<tr>
<td>Collector-emitter break down voltage</td>
<td>( V_{\text{CE}} )</td>
<td></td>
<td>600</td>
<td>V</td>
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<tr>
<td>DC collector current</td>
<td>( I_c )</td>
<td>( T_r=T_{\text{max}} ) ( T_c=80°C ) ( T_r=80°C )</td>
<td>58</td>
<td>77</td>
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<td>Pulsed collector current</td>
<td>( I_{\text{puls}} )</td>
<td>( I_r ) limited by ( T_{\text{max}} )</td>
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<td>Turn off safe operating area</td>
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<td>( T_{\text{r}} \leq 175°C ) ( V_{\text{CE}}=V_{\text{CES}} )</td>
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<td>Power dissipation per IGBT</td>
<td>( P_{\text{tot}} )</td>
<td>( T_r=T_{\text{max}} ) ( T_c=80°C ) ( T_r=80°C )</td>
<td>93</td>
<td>141</td>
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<tr>
<td>Gate-emitter peak voltage</td>
<td>( V_{\text{GE}} )</td>
<td></td>
<td>±20</td>
<td>V</td>
</tr>
<tr>
<td>Short circuit ratings</td>
<td>( I_{\text{SC}} ) ( V_{\text{CC}} ) ( T_{\text{r}} \leq 150°C ) ( V_{\text{CC}}=15\text{V} )</td>
<td>6</td>
<td>360</td>
<td>μs</td>
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<tr>
<td>Maximum Junction Temperature</td>
<td>( T_{\text{max}} )</td>
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<td>175</td>
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### Maximum Ratings

**Tj=25°C, unless otherwise specified**

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<th>Value</th>
<th>Unit</th>
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<td><strong>Boost Diode</strong></td>
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<td>Peak Repetitive Reverse Voltage</td>
<td>$V_{\text{RM}}$</td>
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<tr>
<td>DC forward current</td>
<td>$I_f$</td>
<td>$T_j=T_{\text{max}}$</td>
<td>$T_j=80^\circ \text{C}$</td>
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<td>$T_c=80^\circ \text{C}$</td>
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<td>$T_c=80^\circ \text{C}$</td>
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<td><strong>Thermal Properties</strong></td>
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<tr>
<td>Storage temperature</td>
<td>$T_{\text{stg}}$</td>
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<td>-40…+125</td>
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<td>Operation temperature under switching condition</td>
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<td>-40…+($T_{\text{max}} - 25$)</td>
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<td>$t=2s$</td>
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<td>Clearance</td>
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<td>min 12.7</td>
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### Characteristic Values

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<td><strong>Boost Inv. Diode</strong></td>
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<td>Forward voltage</td>
<td>( V_F )</td>
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<td>Tj=25°C</td>
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<td>10</td>
<td>Tj=125°C</td>
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<td>Threshold voltage (for power loss calc. only)</td>
<td>( V_{th} )</td>
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<td>Slope resistance (for power loss calc. only)</td>
<td>( I_{DR} )</td>
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<td>( I_R )</td>
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<td>Reverse resistance chip to heatsink per chip</td>
<td>( R_{thJH} )</td>
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<td>2.17</td>
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<tr>
<td><strong>Buck Diode</strong></td>
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<tr>
<td>Diode forward voltage</td>
<td>( V_F )</td>
<td>30</td>
<td>Tj=25°C</td>
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<tr>
<td>Reverse leakage current</td>
<td>( I_{Th} )</td>
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<td>Tj=25°C</td>
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<td>Peak reverse recovery current</td>
<td>( I_{Ph} )</td>
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<td>Tj=25°C</td>
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<td>Reverse recovery time</td>
<td>( t_{rr} )</td>
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<td>Reverse recovered charge</td>
<td>( Q_{rr} )</td>
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<td>Tj=25°C</td>
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<td>Peak rate of fall of recovery current</td>
<td>( di/reverse )</td>
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<td>Tj=25°C</td>
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<td>Reverse recovered energy</td>
<td>( E_{rec} )</td>
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<td>Thermal resistance chip to heatsink per chip</td>
<td>( R_{thJH} )</td>
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<td>1.74</td>
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<td><strong>Buck MOSFET</strong></td>
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<td>Static drain to source ON resistance</td>
<td>( R_{dson} )</td>
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<td>Tj=25°C</td>
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<td>Gate to Source Leakage Current</td>
<td>( I_{gs} )</td>
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<td>Zero Gate Voltage Drain Current</td>
<td>( I_{bs} )</td>
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<td>Turn On Delay Time</td>
<td>( t_{on} )</td>
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<td>Tj=25°C</td>
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<td>Rise Time</td>
<td>( t_{r} )</td>
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<td>Turn-off delay time</td>
<td>( t_{off} )</td>
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<td>Fall time</td>
<td>( t_{f} )</td>
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<td>Tj=25°C</td>
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<td>Turn-on energy loss per pulse</td>
<td>( E_{on} )</td>
<td>0</td>
<td>Tj=25°C</td>
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<td>Turn-off energy loss per pulse</td>
<td>( E_{off} )</td>
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<td>Total gate charge</td>
<td>( Q_{g} )</td>
<td>480</td>
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<td>Gate to drain charge</td>
<td>( Q_{gd} )</td>
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<td>Input capacitance</td>
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<td>Output capacitance</td>
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<td>Gate resistor</td>
<td>( R_{g} )</td>
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<td>0.90</td>
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<td>Thermal resistance chip to heatsink per chip</td>
<td>( R_{thJH} )</td>
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## Characteristic Values

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<th>Value</th>
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<tr>
<td><strong>Boost IGBT</strong></td>
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<tr>
<td>Gate emitter threshold voltage</td>
<td>(V_{GE} \text{ or } V_{GCE} )</td>
<td>(V)</td>
<td>0,0012</td>
<td>(V)</td>
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<td>Collector-emitter saturation voltage</td>
<td>(V_{CES} \text{ or } V_{CE} )</td>
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<td>1,05</td>
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<td>Collector-emitter cut-off incl diode</td>
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<td>(mA)</td>
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<td>Gate-emitter leakage current</td>
<td>(I_{GES} \text{ or } I_{GE} )</td>
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<td>Rise time</td>
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<td>Turn-off delay time</td>
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<td>Fall time</td>
<td>(t_{f} )</td>
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<td>Turn-on energy loss per pulse</td>
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<td>(mWs)</td>
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<td>Output capacitance</td>
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<td>Reverse transfer capacitance</td>
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<td>Gate charge</td>
<td>(Q_{gain} )</td>
<td>(nC)</td>
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<td>Thermal resistance chip to heatsink per chip</td>
<td>(R_{thJH} )</td>
<td>(K/W)</td>
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<td><strong>Boost Diode</strong></td>
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<td>Diode forward voltage</td>
<td>(V_{F} )</td>
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<td>Reverse leakage current</td>
<td>(I_{r} )</td>
<td>(\mu A)</td>
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<td>Peak reverse recovery current</td>
<td>(I_{rms} )</td>
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<td>Reverse recovery time</td>
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<td>(Q_{re} )</td>
<td>(nC)</td>
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<td>(di/\text{rec})</td>
<td>(A/\mu s)</td>
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<td>(K/W)</td>
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<td><strong>Thermistor</strong></td>
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<td>Rated resistance</td>
<td>(R )</td>
<td>(\Omega)</td>
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<td>Deviation of R25</td>
<td>(\Delta R/R )</td>
<td>(\Omega)</td>
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<td>B-value</td>
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**Vincotech NTC Reference** | | | | |

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Buck

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

- At 
  \[ t_p = 250 \ \mu s \]
  \[ T_j = 25 \ \degree C \]
  \[ V_{CE} \text{ from } 0 \text{ V to } 20 \text{ V in steps of } 2 \text{ V} \]

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

- At 
  \[ t_p = 250 \ \mu s \]
  \[ T_j = 125 \ \degree C \]
  \[ V_{CE} \text{ from } 0 \text{ V to } 20 \text{ V in steps of } 2 \text{ V} \]

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

**Figure 4**
Typical diode forward current as a function of forward voltage
\[ I_F = f(V_F) \]

- At 
  \[ t_p = 250 \ \mu s \]
  \[ V_{CE} = 10 \text{ V} \]

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MOSFET

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
- \( V_{GE} = 10 \) V
- \( R_{on} = 2 \) Ω
- \( R_{off} = 2 \) Ω

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

With an inductive load at
- \( T_j = 25/125 \) °C
- \( V_{CE} = 350 \) V
- \( V_{GE} = 10 \) V
- \( I_c = 30 \) A

FWD

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
- \( V_{GE} = 10 \) V
- \( R_{on} = 2 \) 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
- \( V_{GE} = 10 \) V
- \( I_c = 30 \) A
**Figure 9**

Typical switching times as a function of collector current

\[ t = f(I_C) \]

With an inductive load at

- \( T_j = 125 \) °C
- \( V_{CE} = 350 \) V
- \( V_{GE} = 10 \) V
- \( R_{gOn} = 2 \) Ω
- \( R_{gOff} = 2 \) Ω

**Figure 10**

Typical switching times as a function of gate resistor

\[ t = f(R_G) \]

With an inductive load at

- \( T_j = 125 \) °C
- \( V_{CE} = 350 \) V
- \( V_{GE} = 10 \) V
- \( I_c = 30 \) A

**Figure 11**

Typical reverse recovery time as a function of collector current

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

At

- \( T_j = 25/125 \) °C
- \( V_{CE} = 350 \) V
- \( V_{GE} = 10 \) V
- \( R_{gOn} = 2 \) Ω

**Figure 12**

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

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

At

- \( T_j = 25/125 \) °C
- \( V_{GE} = 350 \) V
- \( I_c = 30 \) A
- \( V_{GE} = 10 \) V

*copyright Vincotech*
Typical reverse recovery charge as a function of collector current

$$Q_{rr} = f(I_C)$$

At

- $T_J = 25/125 \degree C$
- $V_{CE} = 350 \ V$
- $V_{GE} = 10 \ V$
- $R_{gon} = 2 \ \Omega$

Typical reverse recovery current as a function of collector current

$$I_{RRM} = f(I_C)$$

At

- $T_J = 25/125 \degree C$
- $V_{CE} = 350 \ V$
- $V_{GE} = 10 \ V$
- $R_{gon} = 2 \ \Omega$
**Figure 17**  
Typical rate of fall of forward and reverse recovery current as a function of collector current  
\( \frac{dI_o}{dt}, \frac{dI_{rec}}{dt} = f(I_c) \)

At  
- \( T_j = 25/125 \) °C  
- \( V_{CE} = 350 \) V  
- \( V_{GE} = 10 \) V  
- \( R_{gon} = 2 \) Ω

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

At  
- \( T_j = 25/125 \) °C  
- \( V_{GE} = 10 \) V  
- \( t_F = 30 \) A  
- \( V_{CE} = 350 \) V

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

At  
- \( D = 0.5 \)  
- \( R_{thJH} = 0.90, 1.74 \) K/W  

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

At  
- \( D = 0.5 \)  
- \( R_{thJH} = 3.4, 5.1, 1.0, 2.5, 4.5, 8.6 \) K/W  

**Table:**  
<table>
<thead>
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<th>( D )</th>
<th>( R_{thJH} ) (K/W)</th>
<th>( \tau ) (s)</th>
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<td>4.5E-03</td>
<td>0.05</td>
</tr>
<tr>
<td>0.11</td>
<td>8.6E-04</td>
<td>0.05</td>
</tr>
</tbody>
</table>
Power dissipation as a function of heatsink temperature

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

At

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

Forward current as a function of heatsink temperature

\[ I_F = f(T_h) \]

At

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

\[ V_{GE} = 15 \, V \]
Figure 25: Safe operating area as a function of collector-emitter voltage
\( I_C = f(V_{CE}) \)

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

At
- \( D = \) single pulse
- \( T_h = 80 \) °C
- \( V_{GE} = 15 \) V
- \( T_j = T_{j_{\max}} \) °C

Buck

\[ V_{CE}(V) \]
\[ I_C(A) \]

\[ 10^3 \]
\[ 10^2 \]
\[ 10^1 \]
\[ 10^0 \]

\[ 10^{-1} \]
\[ 10^{-2} \]

\[ 100 \mu S \]
\[ 1 \mu S \]
\[ 10 \mu S \]
\[ 100 \mu S \]

\[ 0 \]
\[ 50 \]
\[ 100 \]
\[ 150 \]
\[ 200 \]
\[ 250 \]

\[ 0 \]
\[ 5 \]
\[ 10 \]
\[ 15 \]
\[ 20 \]
\[ 25 \]

\[ 0 \]
\[ 2 \]
\[ 4 \]
\[ 6 \]

\( DC \)

\[ 120V \]
\[ 480V \]
**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

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

**Figure 3**

**IGBT**

Typical transfer characteristics

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

At

- \( t_p = 250 \, \mu s \)
- \( V_{CE} = 10 \, V \)

**Figure 4**

**FWD**

Typical diode forward current as a function of forward voltage

\[ I_F = f(V_F) \]

At

- \( t_p = 250 \, \mu s \)
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
- \( V_{DS} = \pm 15 \) V
- \( R_{gon} = 4 \) Ω
- \( R_{goff} = 4 \) Ω

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
- \( V_{DS} = \pm 15 \) V
- \( I_c = 30 \) A
**Figure 9**

Typical switching times as a function of collector current

$t = f(I_C)$

With an inductive load at

- $T_J = 25/125 \degree C$
- $V_{CE} = 350 \, V$
- $V_{GE} = \pm 15 \, V$
- $R_{gon} = 4 \, \Omega$
- $R_{goff} = 4 \, \Omega$

**Figure 10**

Typical switching times as a function of gate resistor

$t = f(R_{G})$

With an inductive load at

- $T_J = 25/125 \degree C$
- $V_{CE} = 350 \, V$
- $V_{GE} = \pm 15 \, V$
- $I_C = 30 \, A$

**Figure 11**

Typical reverse recovery time as a function of collector current

$t_r = f(I_C)$

At

- $T_J = 25/125 \degree C$
- $V_{CE} = 350 \, V$
- $V_{GE} = \pm 15 \, V$
- $R_{gon} = 4 \, \Omega$

**Figure 12**

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

$t_r = f(R_{gon})$

At

- $T_J = 25/125 \degree C$
- $V_{TH} = 350 \, V$
- $I_C = 30 \, A$
- $V_{GE} = \pm 15 \, V$
Figure 13
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
Typical reverse recovery charge as a function of IGBT turn on gate resistor
\[ Q_{rr} = f(R_{gon}) \]

At
\[ T_J = 25/125 \, ^\circ C \]
\[ V_{BT} = 350 \, V \]
\[ I_F = 30 \, A \]
\[ V_{GE} = \pm 15 \, V \]

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

At
\[ T_J = 25/125 \, ^\circ C \]
\[ V_{GE} = \pm 15 \, V \]

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

At
\[ T_J = 25/125 \, ^\circ C \]
\[ V_{BT} = 350 \, V \]
\[ I_F = 30 \, A \]
\[ V_{GE} = \pm 15 \, V \]
Figure 17
Typical rate of fall of forward and reverse recovery current as a function of collector current
dI/dt, dI_{rec}/dt = f(I_c)

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

Figure 18
Typical rate of fall of forward and reverse recovery current as a function of pulse width

dI/dt, dI_{rec}/dt = f(\mu)

At
D = tp / T
R_{th,JH} = 1,02 K/W

IGBT thermal model values

<table>
<thead>
<tr>
<th>R (C/W)</th>
<th>Tau (s)</th>
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<td>0,08</td>
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<td>0,04</td>
<td>2,72E-04</td>
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</tbody>
</table>

Figure 19
IGBT transient thermal impedance as a function of pulse width
Z_{th,JH} = f(\mu)

At
D = 0.5
0,2
0,1
0,05
0,02
0,01
0,005
0,000

Figure 20
FWD transient thermal impedance as a function of pulse width
Z_{th,JH} = f(\mu)

At
D = 0.5
0,2
0,1
0,05
0,02
0,01
0,005
0,000

FWD thermal model values

<table>
<thead>
<tr>
<th>R (C/W)</th>
<th>Tau (s)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0,04</td>
<td>6,53E+00</td>
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<td>5,77E-03</td>
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<tr>
<td>0,17</td>
<td>9,51E-04</td>
</tr>
</tbody>
</table>
**Figure 21**
Power dissipation as a function of heatsink temperature

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

At

\[ T_j = 175°C \]

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

\[ I_C = f(T_h) \]

At

\[ T_j = 175°C \]

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

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

At

\[ T_j = 150°C \]

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

\[ I_F = f(T_h) \]

At

\[ T_j = 150°C \]

\[ V_{GE} = 15V \]
Figure 25 IGBT Inverse Diode
Typical diode forward current as a function of forward voltage
I_F = f(V_F)

![Graph showing I_F vs V_F](image)

At
T_j = 250 µs

Figure 26 IGBT Inverse Diode
Diode transient thermal impedance as a function of pulse width
Z_θ_JH = f(t_p)

![Graph showing Z_θ_JH vs t_p](image)

At
D = t_p / T
R_θ_JH = 2.17 K/W

Figure 27 IGBT Inverse Diode
Power dissipation as a function of heatsink temperature
P_tot = f(T_h)

![Graph showing P_tot vs T_h](image)

At
T_j = T_jmax - 25°C

Figure 28 IGBT Inverse Diode
Forward current as a function of heatsink temperature
I_F = f(T_h)

![Graph showing I_F vs T_h](image)

At
T_j = 175 °C
Thermistor

Figure 1

Typical NTC characteristic
as a function of temperature

\[ R_T = f(T) \]
Switching Definitions BUCK MOSFET

General conditions

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value</th>
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</thead>
<tbody>
<tr>
<td>$T_i$</td>
<td>125 °C</td>
</tr>
<tr>
<td>$R_{DS(on)}$</td>
<td>2 Ω</td>
</tr>
<tr>
<td>$R_{Rug}IGBT$</td>
<td>2 Ω</td>
</tr>
</tbody>
</table>

Figure 1

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

$t_{doff} = 0,13 \, \mu s$
$t_{Eoff} = 0,15 \, \mu s$

$V_{GS}(0\%) = 0 \, V$
$V_{GS}(100\%) = 10 \, V$
$I_C(100\%) = 30 \, A$

Figure 2

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

$t_{don} = 0,02 \, \mu s$
$t_{Eon} = 0,05 \, \mu s$

$V_{GS}(0\%) = 0 \, V$
$V_{GS}(100\%) = 10 \, V$
$I_C(100\%) = 30 \, A$

Figure 3

Turn-off Switching Waveforms & definition of $t_f$

$t_f = 0,007 \, \mu s$

$V_C(100\%) = 700 \, V$
$I_C(100\%) = 30 \, A$

Figure 4

Turn-on Switching Waveforms & definition of $t_r$

$t_r = 0,006 \, \mu s$

$V_C(100\%) = 700 \, V$
$I_C(100\%) = 30 \, A$
Switching Definitions BUCK MOSFET

Figure 5
Turn-off Switching Waveforms & definition of t_{Eoff}

- \( P_{\text{off}} \) (100%) = 21.23 kW
- \( E_{\text{off}} \) (100%) = 0.070 mJ
- \( t_{\text{Eoff}} \) = 0.15 \( \mu \)s

Figure 6
Turn-on Switching Waveforms & definition of t_{Eon}

- \( P_{\text{on}} \) (100%) = 21.23 kW
- \( E_{\text{on}} \) (100%) = 0.28 mJ
- \( t_{\text{Eon}} \) = 0.05 \( \mu \)s

Figure 7
Turn-off Switching Waveforms & definition of \( t_r \)

- \( V_d \) (100%) = 700 V
- \( I_d \) (100%) = 30 A
- \( I_{\text{RMS}} \) (100%) = -75 A
- \( t_r \) = 0.02 \( \mu \)s

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

- \( I_d \) (100%) = 30 A
- \( Q_{\text{rr}} \) (100%) = 0.95 \( \mu \)C
- \( t_{Qrr} \) = 0.05 \( \mu \)s
Switching Definitions BUCK MOSFET

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

- $P_{rec}(100\%) = 21.23$ kW
- $E_{rec}(100\%) = 0.14$ mJ
- $t_{E_{rec}} = 0.05$ µs

Measurement circuits

Figure 11
BUCK stage switching measurement circuit

Figure 12
BOOST stage switching measurement circuit
Swimming Definitions BOOST

General conditions

<table>
<thead>
<tr>
<th>Condition</th>
<th>Value</th>
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<tr>
<td>$T_J$</td>
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<tr>
<td>$R_{on-IGBT}$</td>
<td>4 Ω</td>
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<tr>
<td>$R_{off-IGBT}$</td>
<td>4 Ω</td>
</tr>
</tbody>
</table>

Figure 1

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

$t_{Eoff}$ = integrating time for $E_{off}$

$t_{off}$ = 0.24 μs
$t_{Eoff}$ = 0.52 μs

$V_{GE}(0\%)$ = -15 V
$V_{GE}(100\%)$ = 15 V
$I_C(100\%)$ = 30 A

Figure 2

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

$t_{Eon}$ = integrating time for $E_{on}$

$t_{on}$ = 0.08 μs
$t_{Eon}$ = 0.10 μs

$V_{GE}(0\%)$ = -15 V
$V_{GE}(100\%)$ = 15 V
$I_C(100\%)$ = 30 A

Figure 3

Turn-off Switching Waveforms & definition of $t_f$

$t_f$ = 0.09 μs

$V_C(100\%)$ = 350 V
$I_C(100\%)$ = 30 A

Figure 4

Turn-on Switching Waveforms & definition of $t_r$

$t_r$ = 0.01 μs

$V_C(100\%)$ = 350 V
$I_C(100\%)$ = 30 A
Switching Definitions BOOST

**Figure 5**

**BOOST IGBT**

Turn-off Switching Waveforms & definition of \( t_{\text{Eoff}} \)

\[
P_{\text{off}} (100\%) = 10.46 \text{ kW} \\
E_{\text{off}} (100\%) = 1.36 \text{ mJ} \\
t_{\text{Eoff}} = 0.52 \mu\text{s}
\]

**Figure 6**

**BOOST IGBT**

Turn-on Switching Waveforms & definition of \( t_{\text{Eon}} \)

\[
P_{\text{on}} (100\%) = 10.46 \text{ kW} \\
E_{\text{on}} (100\%) = 0.39 \text{ mJ} \\
t_{\text{Eon}} = 0.10 \mu\text{s}
\]

**Figure 7**

**BOOST IGBT**

Turn-off Switching Waveforms & definition of \( t_{\text{r}} \)

\[
V_{\text{d}} (100\%) = 350 \text{ V} \\
I_{\text{d}} (100\%) = 30 \text{ A} \\
I_{\text{RRM}} (100\%) = -67 \text{ A} \\
t_{\text{r}} = 0.10 \mu\text{s}
\]

**Figure 8**

**BOOST FWD**

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

\[
I_{\text{d}} (100\%) = 30 \text{ A} \\
Q_{\text{r}} (100\%) = 4.72 \mu\text{C} \\
t_{\text{Qrr}} = 1.00 \mu\text{s}
\]
Switching Definitions BOOST

Figure 9

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

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

- $P_{\text{rec}}$ (100%) = 10.46 kW
- $E_{\text{rec}}$ (100%) = 1.45 mJ
- $t_{E_{\text{rec}}}$ = 1.00 µs

Measurement circuits

Figure 11

BUCK stage switching measurement circuit

Figure 12

BOOST stage switching measurement circuit
Ordering Code and Marking

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<th>Ordering Code</th>
<th>in DataMatrix as</th>
<th>in packaging barcode as</th>
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Pinout

DC+ 15, 16

GND 0, 14

Line 5, 10, 11

pin 3 and 17 are NOT CONNECTED

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