flowNPC1

**Features**
- neutral point clamped inverter
- reactive power capability
- SiC buck diode
- clip-in pcb mounting
- low inductance layout

**Target Applications**
- solar inverter
- UPS

**Types**
- 10-PY06NRA021FS-M410FY

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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>Out Boost MOSFET</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Drain to source breakdown voltage</td>
<td>V_{DS}</td>
<td>Tj=25°C</td>
<td>600</td>
<td>V</td>
</tr>
<tr>
<td>DC drain current</td>
<td>I_{D}</td>
<td>Tj=Tj,max</td>
<td>47</td>
<td>A</td>
</tr>
<tr>
<td>Pulsed drain current</td>
<td>I_{Pulse}</td>
<td>I_{p} limited by Tj,max</td>
<td>544</td>
<td>A</td>
</tr>
<tr>
<td>Power dissipation</td>
<td>P_{tot}</td>
<td>Tj=Tj,max</td>
<td>108</td>
<td>W</td>
</tr>
<tr>
<td>Gate-source peak voltage</td>
<td>V_{GS}</td>
<td>static/AC (f&gt;1 Hz)</td>
<td>±20±30</td>
<td>V</td>
</tr>
<tr>
<td>Maximum Junction Temperature</td>
<td>Tj=max</td>
<td></td>
<td>150</td>
<td>°C</td>
</tr>
</tbody>
</table>

| Out Boost FWD                    |        |                   |       |      |
| Peak Repetitive Reverse Voltage  | V_{RRM} | Tj=25°C           | 1200  | V    |
| DC forward current               | I_{f}  | Tj=Tj,max         | 24    | A    |
| Surge Peak Forward Current       | I_{FSM} | 10 ms sin 180°   | 170   | A    |
| Power dissipation                | P_{tot} | Tj=Tj,max         | 58    | W    |
| Maximum Junction Temperature     | Tj=max |                   | 175   | °C   |
### 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><strong>Buck FWD</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Peak Repetitive Reverse Voltage</td>
<td>$V_{max}$</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>$T_c=80°C$</td>
<td>24</td>
</tr>
<tr>
<td>Repetitive peak forward current</td>
<td>$I_{f_{RMS}}$</td>
<td>$T_j=10$ ms, Half Sine Wave, $D=0.3$</td>
<td>$T_c=25°C$</td>
<td>201</td>
</tr>
<tr>
<td>Power dissipation per Diode</td>
<td>$P_{tot}$</td>
<td>$T_j=T_{max}$</td>
<td></td>
<td>39</td>
</tr>
<tr>
<td>Maximum Junction Temperature</td>
<td>$T_{j_{max}}$</td>
<td></td>
<td></td>
<td>175</td>
</tr>
</tbody>
</table>

| **Buck MOSFET** |         |             |       |      |
| Drain to source breakdown voltage | $V_{DS}$ | |       | 600  | V    |
| DC drain current | $I_D$ | $T_j=T_{max}$ | $T_c=80°C$ | 47   | A    |
| Pulsed drain current | $I_{pulse}$ | $I_D$ limited by $T_{j_{max}}$ | $T_c=25°C$ | 544  | A    |
| Power dissipation | $P_{tot}$ | $T_j=T_{max}$ | $T_c=80°C$ | 108  | W    |
| Gate-source peak voltage | $V_{gs}$ | static/AC ($f>1$ Hz) | | ±20/±30 | V |
| Maximum Junction Temperature | $T_{j_{max}}$ | | | 150  | °C   |

**Thermal Properties**

| Storage temperature | $T_{stg}$ | -40...+125 | °C |
| Operation temperature under switching condition | $T_{op}$ | -40...$(T_{j_{max}} - 25)$ | °C |

**Insulation Properties**

| Insulation voltage | $V_{in}$ | $t=2s$ | DC voltage | 4000  | V |
| Creepage distance | | | | min 12.7 | mm |
| Clearance | | | | min 12.7 | mm |
### Characteristic Values

<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>$R_{dS(on)}$</td>
<td>$10 \leq V_{GS} \leq V_{GS}$</td>
<td>$20.8 \leq 2V_{GS}$</td>
<td>mΩ</td>
</tr>
<tr>
<td>Gate threshold voltage</td>
<td>$V_{GS(th)}$</td>
<td>$V_{GS}(25\degree C)$</td>
<td>$41.2 \leq 3V_{GS}$</td>
<td>V</td>
</tr>
<tr>
<td>Gate to Source Leakage Current</td>
<td>$I_{GS}$</td>
<td>$20 \leq 0V_{GS}$</td>
<td>$200 \leq 0$</td>
<td>nA</td>
</tr>
<tr>
<td>Zero Gate Voltage Drain Current</td>
<td>$I_{DS}$</td>
<td>$0 \leq I_{DS}$</td>
<td>$10 \leq 0$</td>
<td>µA</td>
</tr>
<tr>
<td>Turn On Delay Time</td>
<td>$t_{ON}$</td>
<td>$10 \leq 400$</td>
<td>$30 \leq 400$</td>
<td>ns</td>
</tr>
<tr>
<td>Rise Time</td>
<td>$t_{r}$</td>
<td>$R_{g(on)}=2 \Omega$</td>
<td>$10 \leq 400$</td>
<td>A</td>
</tr>
<tr>
<td>Fall time</td>
<td>$t_{f}$</td>
<td>$R_{g(on)}=2 \Omega$</td>
<td>$30 \leq 400$</td>
<td>µs</td>
</tr>
<tr>
<td>Turn-on energy loss per pulse</td>
<td>$E_{on}$</td>
<td>$0 \leq 0$</td>
<td>$72 \leq 0$</td>
<td>pF</td>
</tr>
<tr>
<td>Turn-off energy loss per pulse</td>
<td>$E_{off}$</td>
<td>$0 \leq 0$</td>
<td>$300 \leq 0$</td>
<td>µC</td>
</tr>
<tr>
<td>Total gate charge</td>
<td>$Q_{g}$</td>
<td>$0 \leq 0$</td>
<td>$100 \leq 0$</td>
<td>µC</td>
</tr>
<tr>
<td>Gate to source charge</td>
<td>$Q_{iss}$</td>
<td>$0 \leq 0$</td>
<td>$2 \leq 0$</td>
<td>µC</td>
</tr>
<tr>
<td>Gate to drain charge</td>
<td>$Q_{gs}$</td>
<td>$0 \leq 0$</td>
<td>$300 \leq 0$</td>
<td>µC</td>
</tr>
<tr>
<td>Input capacitance</td>
<td>$C_{iss}$</td>
<td>$f=1\text{MHz}$</td>
<td>$13060 \leq 1$</td>
<td>pF</td>
</tr>
<tr>
<td>Output capacitance</td>
<td>$C_{gs}$</td>
<td>$f=1\text{MHz}$</td>
<td>$720 \leq 1$</td>
<td>pF</td>
</tr>
<tr>
<td>Gate resistor</td>
<td>$f_{o}$</td>
<td>$10 \leq 100$</td>
<td>$25\degree C$</td>
<td>nC</td>
</tr>
<tr>
<td>Thermal resistance chip to heatsink per chip</td>
<td>$R_{JH}$</td>
<td>Thermal grease thickness</td>
<td>$50\mu m$</td>
<td>K/W</td>
</tr>
<tr>
<td>Thermal resistance chip to case per chip</td>
<td>$R_{JC}$</td>
<td>Thermal grease thickness</td>
<td>$50\mu m$</td>
<td>K/W</td>
</tr>
</tbody>
</table>

### Out Boost FWD

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Symbol</th>
<th>Conditions</th>
<th>Value</th>
<th>Unit</th>
</tr>
</thead>
<tbody>
<tr>
<td>Forward voltage</td>
<td>$V_{F}$</td>
<td>$35 \leq 35$</td>
<td>$2.51 \leq 2.68$</td>
<td>V</td>
</tr>
<tr>
<td>Reverse leakage current</td>
<td>$I_{F}$</td>
<td>$1200 \leq 1200$</td>
<td>$60 \leq 5500$</td>
<td>µA</td>
</tr>
<tr>
<td>Peak recovery current</td>
<td>$I_{RRM}$</td>
<td>$10 \leq 400$</td>
<td>$24 \leq 21$</td>
<td>A</td>
</tr>
<tr>
<td>Reverse recovery time</td>
<td>$t_{rr}$</td>
<td>$R_{on}=2 \Omega$</td>
<td>$25\degree C$</td>
<td>ns</td>
</tr>
<tr>
<td>Reverse recovery charge</td>
<td>$Q_{rr}$</td>
<td>$R_{on}=2 \Omega$</td>
<td>$25\degree C$</td>
<td>µC</td>
</tr>
<tr>
<td>Reverse recovered energy</td>
<td>$E_{rec}$</td>
<td>$0 \leq 0$</td>
<td>$1.65 \leq 1.09$</td>
<td>K/W</td>
</tr>
</tbody>
</table>

### Buck FWD

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Symbol</th>
<th>Conditions</th>
<th>Value</th>
<th>Unit</th>
</tr>
</thead>
<tbody>
<tr>
<td>Diode forward voltage</td>
<td>$V_{F}$</td>
<td>$30 \leq 30$</td>
<td>$1.43 \leq 1.59$</td>
<td>V</td>
</tr>
<tr>
<td>Peak reverse recovery current</td>
<td>$I_{RRM}$</td>
<td>$10 \leq 400$</td>
<td>$24 \leq 21$</td>
<td>A</td>
</tr>
<tr>
<td>Reverse recovery time</td>
<td>$t_{rr}$</td>
<td>$R_{on}=2 \Omega$</td>
<td>$25\degree C$</td>
<td>ns</td>
</tr>
<tr>
<td>Reverse recovered charge</td>
<td>$Q_{rr}$</td>
<td>$R_{on}=2 \Omega$</td>
<td>$25\degree C$</td>
<td>µC</td>
</tr>
<tr>
<td>Peak rate of fall of recovery current</td>
<td>$d_{rec}$/max</td>
<td>$10 \leq 400$</td>
<td>$6880 \leq 4288$</td>
<td>Aµs</td>
</tr>
<tr>
<td>Reverse recovered energy</td>
<td>$E_{rec}$</td>
<td>$10 \leq 400$</td>
<td>$4.044 \leq 2.64$</td>
<td>K/W</td>
</tr>
<tr>
<td>Thermal resistance chip to heatsink per chip</td>
<td>$R_{JH}$</td>
<td>Thermal grease thickness</td>
<td>$50\mu m$</td>
<td>K/W</td>
</tr>
<tr>
<td>Thermal resistance chip to case per chip</td>
<td>$R_{JC}$</td>
<td>Thermal grease thickness</td>
<td>$50\mu m$</td>
<td>K/W</td>
</tr>
</tbody>
</table>
### Characteristic Values

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<tr>
<th>Parameter</th>
<th>Symbol</th>
<th>Conditions</th>
</tr>
</thead>
<tbody>
<tr>
<td>Static drain to source ON resistance</td>
<td>( R_{\text{on}} )</td>
<td>10 60</td>
</tr>
<tr>
<td>Gate threshold voltage</td>
<td>( V_{\text{GS(th)}} )</td>
<td>( V_{\text{GS(th)}} )</td>
</tr>
<tr>
<td>Gate to Source Leakage Current</td>
<td>( I_{\text{GS}} )</td>
<td>20 0</td>
</tr>
<tr>
<td>Zero Gate Voltage Drain Current</td>
<td>( I_{\text{DS}} )</td>
<td>0 600</td>
</tr>
<tr>
<td>Turn On Delay Time</td>
<td>( t_{\text{ON}} )</td>
<td>10 400 30</td>
</tr>
<tr>
<td>Rise Time</td>
<td>( t_r )</td>
<td></td>
</tr>
<tr>
<td>Turn off delay time</td>
<td>( t_{\text{OFF}} )</td>
<td>( R_{\text{g/off}}=2 \Omega )</td>
</tr>
<tr>
<td>Fall time</td>
<td>( t_f )</td>
<td></td>
</tr>
<tr>
<td>Turn-on energy loss per pulse</td>
<td>( E_{\text{on}} )</td>
<td></td>
</tr>
<tr>
<td>Turn-off energy loss per pulse</td>
<td>( E_{\text{off}} )</td>
<td></td>
</tr>
<tr>
<td>Total gate charge</td>
<td>( Q_{\text{g}} )</td>
<td></td>
</tr>
<tr>
<td>Gate to source charge</td>
<td>( Q_{\text{ds}} )</td>
<td></td>
</tr>
<tr>
<td>Gate to drain charge</td>
<td>( Q_{\text{ds}} )</td>
<td></td>
</tr>
<tr>
<td>Input capacitance</td>
<td>( C_{\text{inc}} )</td>
<td>( f=1\text{MHz} )</td>
</tr>
<tr>
<td>Output capacitance</td>
<td>( C_{\text{out}} )</td>
<td>( f=1\text{MHz} )</td>
</tr>
<tr>
<td>Gate resistor</td>
<td>( C_{\text{g}} )</td>
<td></td>
</tr>
<tr>
<td>Thermal resistance chip to heatsink per chip</td>
<td>( R_{\text{hi}} )</td>
<td>Thermal grease thickness 550um ( k = 1 \text{W/mK} )</td>
</tr>
<tr>
<td>Thermal resistance chip to case per chip</td>
<td>( R_{\text{hc}} )</td>
<td></td>
</tr>
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</table>

### Thermistor

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Symbol</th>
<th>Conditions</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rated resistance</td>
<td>( R )</td>
<td>( T_j=25°C )</td>
</tr>
<tr>
<td>Deviation of ( R_{100} ) ( \Delta R/R )</td>
<td>( R_{100} = 1486 \Omega )</td>
<td>( T_c=100°C )</td>
</tr>
<tr>
<td>Power dissipation</td>
<td>( P )</td>
<td>( T_j=25°C )</td>
</tr>
<tr>
<td>Power dissipation constant</td>
<td>( T_j=25°C )</td>
<td>2</td>
</tr>
<tr>
<td>B-value</td>
<td>( B_{25/50} )</td>
<td>Tol. ±3%</td>
</tr>
<tr>
<td>B-value</td>
<td>( B_{25/100} )</td>
<td>Tol. ±3%</td>
</tr>
<tr>
<td>Vincotech NTC Reference</td>
<td></td>
<td>( T_j=25°C )</td>
</tr>
</tbody>
</table>

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

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

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

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

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

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

At
\[ t_p = 250 \mu s \]
\[ V_{CE} = 10 \text{ V} \]
\[ T_j = T_{jmax} - 25 \degree C \]
\[ T_j = 25 \degree C \]
\[ T_j = T_{jmax} - 25 \degree C \]
**Figure 5**
Typical switching energy losses as a function of collector current

\[ E = f(I_C) \]

With an inductive load at

- \( T_j = 25/125 \, ^\circ C \)
- \( V_{CE} = 400 \, V \)
- \( V_{GE} = 10 \, V \)
- \( R_{gon} = 2 \, \Omega \)
- \( R_{goff} = 2 \, \Omega \)

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

\[ E = f(R_G) \]

With an inductive load at

- \( T_j = 25/125 \, ^\circ C \)
- \( V_{CE} = 400 \, V \)
- \( V_{GE} = 10 \, V \)
- \( I_C = 30 \, A \)

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

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

With an inductive load at

- \( T_j = 25/125 \, ^\circ C \)
- \( V_{CE} = 400 \, V \)
- \( V_{GE} = 10 \, V \)
- \( R_{gon} = 2 \, \Omega \)

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

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

With an inductive load at

- \( T_j = 25/125 \, ^\circ C \)
- \( V_{CE} = 400 \, V \)
- \( V_{GE} = 10 \, V \)
- \( I_C = 30 \, A \)
Figure 9
Typical switching times as a function of collector current
\[ t = f(I_C) \]

With an inductive load at
\[ T_j = 125 \, ^\circ C \]
\[ V_{CE} = 400 \, V \]
\[ V_{GS} = 10 \, V \]
\[ R_{gon} = 2 \, \Omega \]
\[ R_{goff} = 2 \, \Omega \]

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

With an inductive load at
\[ T_j = 125 \, ^\circ C \]
\[ V_{CE} = 400 \, V \]
\[ V_{GS} = 10 \, V \]
\[ I_C = 30 \, A \]

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

At
\[ T_j = 25/125 \, ^\circ C \]
\[ V_{CE} = 400 \, V \]
\[ V_{GS} = 10 \, V \]
\[ R_{gon} = 2 \, \Omega \]

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

At
\[ T_j = 25/125 \, ^\circ C \]
\[ V_{CE} = 400 \, V \]
\[ I_T = 30 \, A \]
\[ V_{GE} = 10 \, V \]
Typical reverse recovery charge as a function of collector current
\[ Q_{rr} = f(I_C) \]

At
\[ T_j = 25/125 \, ^\circ C \]
\[ V_{CE} = 400 \, V \]
\[ V_{GE} = 10 \, V \]
\[ R_{gon} = 2 \, \Omega \]

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

At
\[ T_j = 25/125 \, ^\circ C \]
\[ V_{CE} = 400 \, V \]
\[ V_{GE} = 10 \, V \]
\[ I_F = 30 \, A \]
\[ V_{GE} = 10 \, V \]
Figure 17
Typical rate of fall of forward and reverse recovery current as a function of collector current
\[ \frac{dI_c}{dt}, \frac{dI_{rec}}{dt} = f(I_c) \]

At
- \( T_j = 25/125 \) °C
- \( V_{CE} = 400 \) 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
\[ \frac{dI_c}{dt}, \frac{dI_{rec}}{dt} = f(R_{gon}) \]

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

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

<table>
<thead>
<tr>
<th>MOSFET thermal model values</th>
<th>Thermal grease</th>
<th>Phase change interface</th>
</tr>
</thead>
<tbody>
<tr>
<td>R (C/W)</td>
<td>Tau (s)</td>
<td>R (C/W)</td>
</tr>
<tr>
<td>0.12</td>
<td>2.641</td>
<td>0.10</td>
</tr>
<tr>
<td>0.20</td>
<td>0.608</td>
<td>0.17</td>
</tr>
<tr>
<td>0.28</td>
<td>0.200</td>
<td>0.23</td>
</tr>
<tr>
<td>0.05</td>
<td>0.027</td>
<td>0.04</td>
</tr>
<tr>
<td>0.01</td>
<td>0.004</td>
<td>0.01</td>
</tr>
</tbody>
</table>

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

<table>
<thead>
<tr>
<th>FWD thermal model values</th>
<th>Thermal grease</th>
<th>Phase change interface</th>
</tr>
</thead>
<tbody>
<tr>
<td>R (C/W)</td>
<td>Tau (s)</td>
<td>R (C/W)</td>
</tr>
<tr>
<td>0.31</td>
<td>0.946</td>
<td>0.27</td>
</tr>
<tr>
<td>0.96</td>
<td>0.184</td>
<td>0.82</td>
</tr>
<tr>
<td>0.44</td>
<td>0.063</td>
<td>0.38</td>
</tr>
<tr>
<td>0.37</td>
<td>0.013</td>
<td>0.32</td>
</tr>
<tr>
<td>0.28</td>
<td>0.003</td>
<td>0.24</td>
</tr>
<tr>
<td>0.10</td>
<td>0.001</td>
<td>0.08</td>
</tr>
</tbody>
</table>
Power dissipation as a function of heatsink temperature:

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

Collector current as a function of heatsink temperature:

\[ I_c = f(T_h) \]

At

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

Forward current as a function of heatsink temperature:

\[ I_F = f(T_h) \]

At

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

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Figure 25 MOSFET
Safe operating area as a function of collector-emitter voltage
$I_C = f(V_{CE})$

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

At
$D =$ single pulse
$Th =$ 80 °C
$V_{GE} =$ 10 V
$Tj =$ $T_{max}$ °C

BUCK

At
$I_C =$ 89 A pulsed
OUTPUT BOOST

Figure 1: Typical output characteristics

- $I_D = f(V_{DS})$
- $V_{GS}$ from 0 V to 20 V in steps of 2 V
- $V_{DS}$ = 12 V
- $T_J = 25\,^\circ\,C$
- $t_{sp} = 250\,\mu s$
- $T_J = T_{J\,max} - 25\,^\circ\,C$

Figure 2: Typical output characteristics

- $I_D = f(V_{GS})$
- $V_{GS}$ from 0 V to 20 V in steps of 2 V
- $V_{GS}$ from 0 V to 20 V in steps of 2 V
- $T_J = 126\,^\circ\,C$
- $t_{sp} = 250\,\mu s$

Figure 3: Typical transfer characteristics

- $I_F = f(V_F)$
- $T_J = 25\,^\circ\,C$
- $V_{GS}$ = 12 V

Figure 4: Typical diode forward current as a function of forward voltage

- $I_D = f(V_F)$
- $T_J = 25\,^\circ\,C$
- $T_J = T_{J\,max} - 25\,^\circ\,C$
Figure 5  
**Typical switching energy losses**  
as a function of collector current  
\[ E = f(I_D) \]  

With an inductive load at  
\[ T_J = 25/125 \, ^\circ\text{C} \]  
\[ V_{DS} = 400 \, \text{V} \]  
\[ V_{GS} = 10 \, \text{V} \]  
\[ R_{gon} = 2 \, \Omega \]  
\[ R_{goff} = 2 \, \Omega \]  

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

With an inductive load at  
\[ T_J = 25/125 \, ^\circ\text{C} \]  
\[ V_{DS} = 400 \, \text{V} \]  
\[ V_{GS} = 10 \, \text{V} \]  
\[ I_B = 30 \, \text{A} \]

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

With an inductive load at  
\[ T_J = 25/125 \, ^\circ\text{C} \]  
\[ V_{DS} = 400 \, \text{V} \]  
\[ V_{GS} = 10 \, \text{V} \]  
\[ R_{gon} = 2 \, \Omega \]  
\[ R_{goff} = 2 \, \Omega \]  

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

With an inductive load at  
\[ T_J = 25/125 \, ^\circ\text{C} \]  
\[ V_{DS} = 400 \, \text{V} \]  
\[ V_{GS} = 10 \, \text{V} \]  
\[ I_B = 30 \, \text{A} \]
OUTPUT BOOST

**Figure 9**
**BOOST MOSFET**
Typical switching times as a function of collector current
\[ t = f(I_c) \]

With an inductive load at
- \( T_j = 125 \, ^\circ C \)
- \( V_{DS} = 400 \, V \)
- \( V_{GS} = 10 \, V \)
- \( R_{gon} = 2 \, \Omega \)
- \( R_{goff} = 2 \, \Omega \)

**Figure 10**
**BOOST MOSFET**
Typical switching times as a function of gate resistor
\[ t = f(R_G) \]

With an inductive load at
- \( T_j = 125 \, ^\circ C \)
- \( V_{DS} = 400 \, V \)
- \( V_{GS} = 10 \, V \)
- \( I_C = 30 \, A \)
- \( R_{gon} = 2 \, \Omega \)

**Figure 11**
**BOOST FWD**
Typical reverse recovery time as a function of collector current
\[ t_r = f(I_c) \]

At
- \( T_j = 25/125 \, ^\circ C \)
- \( V_{CE} = 400 \, V \)
- \( V_{GS} = 10 \, V \)
- \( R_{gon} = 2 \, \Omega \)

**Figure 12**
**BOOST FWD**
Typical reverse recovery time as a function of IGBT turn on gate resistor
\[ t_r = f(R_{gon}) \]

At
- \( T_j = 25/125 \, ^\circ C \)
- \( V_{DS} = 400 \, V \)
- \( I_V = 30 \, A \)
- \( V_{GS} = 10 \, V \)
**OUTPUT BOOST**

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

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

At

- \( T_J = 25/125 \, ^\circ C \)
- \( V_{CE} = 400 \, V \)
- \( V_{GS} = 10 \, V \)
- \( R_{gon} = 2 \, \Omega \)

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

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

At

- \( T_J = 25/125 \, ^\circ C \)
- \( V_{CE} = 400 \, V \)
- \( I_F = 30 \, A \)
- \( V_{GS} = 10 \, V \)

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

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

At

- \( T_J = 25/125 \, ^\circ C \)
- \( V_{CE} = 400 \, V \)
- \( V_{GS} = 10 \, V \)
- \( R_{gon} = 2 \, \Omega \)

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

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

At

- \( T_J = 25/125 \, ^\circ C \)
- \( V_{CE} = 400 \, V \)
- \( I_F = 30 \, A \)
- \( V_{GS} = 10 \, V \)
**OUTPUT BOOST**

**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 MOSFET turn on gate resistor

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

**Figure 19**

MOSFET transient thermal impedance as a function of pulse width

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

**Figure 20**

FWD transient thermal impedance as a function of pulse width

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

---

**MOSFET thermal model values**

<table>
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<tr>
<th>Thermal grease</th>
<th>Phase change interface</th>
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<td>R (C/W)</td>
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**FWD thermal model values**

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<td>0.00</td>
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Figure 21. BOOST MOSFET
Power dissipation as a function of heatsink temperature
\[ P_{\text{tot}} = f(T_h) \]

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

Figure 22. BOOST MOSFET
Collector/Drain current as a function of heatsink temperature
\[ I_{\text{C}} = f(T_h) \]

At
\[ T_j = 150 \, ^\circ\text{C} \]
\[ V_{\text{GS}} = 10 \, \text{V} \]

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

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

Figure 24. BOOST FWD
Forward current as a function of heatsink temperature
\[ I_{\text{F}} = f(T_h) \]

At
\[ T_j = 175 \, ^\circ\text{C} \]
Figure 25  BOOST MOSFET
Safe operating area as a function of collector-emitter voltage
\( I_C = f(V_{CE}) \)

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

At
\( D = \) single pulse
\( T_h = 80 \) °C
\( V_{GE} = 10 \) V
\( T_j = T_{j_{\text{max}}} \) °C

At
\( I_C = 89 \) A pulsed
Thermistor

Figure 1
Typical NTC characteristic as a function of temperature

$R_T = f(T)$

![NTC-typical temperature characteristic graph](image)
Switching Definitions BUCK MOSFET

General conditions

<table>
<thead>
<tr>
<th>TJ</th>
<th>125 °C</th>
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<td>Rssn</td>
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<tr>
<td>Rgoff</td>
<td>2 Ω</td>
</tr>
</tbody>
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Figure 1 BUCK MOSFET
Turn-off Switching Waveforms & definition of \( t_{doff}, t_{Eoff} \)
(\( t_{Eoff} \) = integrating time for \( E_{off} \))

\[ V_{CE}(0\%) = 0 \text{ V} \]
\[ V_{CE}(100\%) = 10 \text{ V} \]
\[ I_{C}(100\%) = 30 \text{ A} \]
\[ t_{doff} = 0.25 \mu s \]
\[ t_{Eoff} = 0.26 \mu s \]

Figure 2 BUCK MOSFET
Turn-on Switching Waveforms & definition of \( t_{don}, t_{Eon} \)
(\( t_{Eon} \) = integrating time for \( E_{on} \))

\[ V_{CE}(0\%) = 0 \text{ V} \]
\[ V_{CE}(100\%) = 10 \text{ V} \]
\[ V_{C}(100\%) = 800 \text{ V} \]
\[ I_{C}(100\%) = 30 \text{ A} \]
\[ t_{don} = 0.03 \mu s \]
\[ t_{Eon} = 0.06 \mu s \]

Figure 3 BUCK MOSFET
Turn-off Switching Waveforms & definition of \( t_f \)

\[ V_{C}(100\%) = 800 \text{ V} \]
\[ I_{C}(100\%) = 30 \text{ A} \]
\[ t_f = 0.046 \mu s \]

Figure 4 BUCK MOSFET
Turn-on Switching Waveforms & definition of \( t_r \)

\[ V_{C}(100\%) = 800 \text{ V} \]
\[ I_{C}(100\%) = 30 \text{ A} \]
\[ t_r = 0.009 \mu s \]
Switching Definitions BUCK MOSFET

**Figure 5**
BUCK MOSFET

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

- $P_{\text{off}}$ (100%) = 24.06 kW
- $E_{\text{off}}$ (100%) = 0.16 mJ
- $t_{\text{off}}$ = 0.26 $\mu$s

**Figure 6**
BUCK MOSFET

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

- $P_{\text{on}}$ (100%) = 24.06 kW
- $E_{\text{on}}$ (100%) = 0.21 mJ
- $t_{\text{on}}$ = 0.06 $\mu$s

**Figure 7**
BUCK MOSFET

Gate voltage vs Gate charge (measured)

- $V_{\text{GEoff}}$ = 0 V
- $V_{\text{GEon}}$ = 10 V
- $V_C$ (100%) = 800 V
- $I_D$ (100%) = 30 A
- $Q_g$ = 347.26 nC

**Figure 8**
BUCK FWD

Turn-off Switching Waveforms & definition of $t_r$

- $V_d$ (100%) = 800 V
- $I_d$ (100%) = 30 A
- $t_{\text{max}}$ (100%) = -21 A
- $t_r$ = 0.013 $\mu$s
Switching Definitions BUCK MOSFET

**Figure 9**
Turn-on Switching Waveforms & definition of $t_{Qrr}$
($t_{Qrr}$ = integrating time for $Q_{rr}$)

- $I_d (100\%) = 30 \text{ A}$
- $Q_{rr} (100\%) = 0.22 \text{ \(\mu\)C}$
- $t_{Qrr} = 0.03 \text{ \(\mu\)s}$

**Figure 10**
Turn-on Switching Waveforms & definition of $t_{Erec}$
($t_{Erec} = $ integrating time for $E_{rec}$)

- $P_{rec} (100\%) = 24.06 \text{ kW}$
- $E_{rec} (100\%) = 0.04 \text{ mJ}$
- $t_{Erec} = 0.03 \text{ \(\mu\)s}$

---

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Switching Definitions BOOST MOSFET

General conditions

* TJ = 125 °C*

* R_(son) = 2 Ω*

* R_(off) = 2 Ω*

---

**Figure 1**

Turn-off Switching Waveforms & definition of t\(_{\text{doff}}\), t\(_{\text{Eoff}}\)

(t\(_{\text{Eoff}}\) = integrating time for E\(_{\text{off}}\))

---

**Figure 2**

Turn-on Switching Waveforms & definition of t\(_{\text{don}}\), t\(_{\text{Eon}}\)

(t\(_{\text{Eon}}\) = integrating time for E\(_{\text{on}}\))

---

**Figure 3**

Turn-off Switching Waveforms & definition of t\(_{\text{f}}\)

---

**Figure 4**

Turn-on Switching Waveforms & definition of t\(_{\text{r}}\)

---

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<tr>
<td>V(_{\text{CE}}) (100%)</td>
<td>800 V</td>
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<td>I(_{\text{C}}) (100%)</td>
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<tr>
<td>t(_{\text{Eoff}})</td>
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<tr>
<td>t(_{\text{Eon}})</td>
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Switching Definitions BOOST MOSFET

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

\[ \text{P}_{\text{off}} (100\%) = 23.95 \text{ kW} \]
\[ \text{E}_{\text{off}} (100\%) = 0.33 \text{ mJ} \]
\[ t_{\text{Eoff}} = 0.35 \mu\text{s} \]

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

\[ \text{P}_{\text{on}} (100\%) = 23.95 \text{ kW} \]
\[ \text{E}_{\text{on}} (100\%) = 0.48 \text{ mJ} \]
\[ t_{\text{Eon}} = 0.08 \mu\text{s} \]

Figure 7
Gate voltage vs Gate charge (measured)

\[ V_{\text{GEOff}} = 0 \text{ V} \]
\[ V_{\text{GEon}} = 10 \text{ V} \]
\[ V_{\text{G} (100\%)} = 800 \text{ V} \]
\[ I_{\text{D} (100\%)} = 30 \text{ A} \]
\[ Q_{\text{G}} = 373.03 \text{ nC} \]

Figure 8
Turn-off Switching Waveforms & definition of $t_{\text{rr}}$

\[ V_{\text{G}} (100\%) = 800 \text{ V} \]
\[ t_{\text{f}} (100\%) = 30 \text{ A} \]
\[ t_{\text{rr} (100\%)} = -94 \text{ A} \]
\[ t_{\text{rr}} = 0.09 \mu\text{s} \]
Switching Definitions BOOST MOSFET

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

$I_d$ (100%) = 30 A
$Q_{rr}$ (100%) = 4.73 μC
$t_{Qrr} = 1.00 \mu s$

Figure 10
Turn-on Switching Waveforms & definition of $t_{Erec}$
($t_{Erec}$ = integrating time for $E_{rec}$)

$P_{rec}$ (100%) = 23.95 kW
$E_{rec}$ (100%) = 1.58 mJ
$t_{Erec} = 1.00 \mu s$
Ordering Code and Marking - Outline - Pinout

Ordering Code & Marking

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<th>Ordering Code</th>
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<th>in packaging barcode as</th>
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Outline

Pinout

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