### Features
- Mixed NPC three-level topology
- High speed components
- Integrated NTC

### Target applications
- UPS

### Types
- 10-FZ12NMA080SM01UL740F58

### Maximum Ratings

$T_i = 25 \, ^\circ C$, 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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</thead>
<tbody>
<tr>
<td><strong>Boost Switch</strong></td>
<td></td>
<td></td>
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</tr>
<tr>
<td>Collector-emitter voltage</td>
<td>$V_{GES}$</td>
<td></td>
<td>650</td>
<td>V</td>
</tr>
<tr>
<td>Collector current</td>
<td>$I_{C}$</td>
<td>$T_i = T_{j\text{max}}$ $T_i = 80 , ^\circ C$</td>
<td>79</td>
<td>A</td>
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<tr>
<td>Repetitive peak collector current</td>
<td>$I_{C_{\text{pk}}}$</td>
<td>$I_{C}$ limited by $T_{j\text{max}}$</td>
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<tr>
<td>Total power dissipation</td>
<td>$P_{tot}$</td>
<td>$T_i = T_{j\text{max}}$ $T_i = 80 , ^\circ C$</td>
<td>133</td>
<td>W</td>
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<tr>
<td>Gate-emitter voltage</td>
<td>$V_{GES}$</td>
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<td>4.20</td>
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<tr>
<td>Maximum Junction Temperature</td>
<td>$T_{j\text{max}}$</td>
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<td>175</td>
<td>°C</td>
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Maximum Ratings

\( T_i = 25 \, ^\circ\text{C} \), unless otherwise specified

<table>
<thead>
<tr>
<th>Parameter</th>
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<tr>
<td><strong>Boost Diode</strong></td>
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<tr>
<td>Peak repetitive reverse voltage</td>
<td>( V_{\text{RRM}} )</td>
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<td>1200</td>
<td>V</td>
</tr>
<tr>
<td>Continuous (direct) forward current</td>
<td>( I_F )</td>
<td>( T_i = T_{\text{max}} ), ( T_s = 80 , ^\circ\text{C} )</td>
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<td>Total power dissipation</td>
<td>( P_{\text{tot}} )</td>
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<td>Maximum junction temperature</td>
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<td>(^\circ\text{C})</td>
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<td><strong>Buck Switch</strong></td>
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<tr>
<td>Collector-emitter voltage</td>
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<td>V</td>
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<tr>
<td>Collector current</td>
<td>( I_C )</td>
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<td>( T_{\text{max}} )</td>
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<td>(^\circ\text{C})</td>
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<td><strong>Buck Diode</strong></td>
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<td>Peak Repetitive Reverse Voltage</td>
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<td>Repetitive peak forward current</td>
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<td><strong>Capacitor</strong></td>
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<td>Maximum DC voltage</td>
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<tr>
<td>Operation Temperature</td>
<td>( T_{\text{op}} )</td>
<td></td>
<td>-55...+125</td>
<td>(^\circ\text{C})</td>
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# Maximum Ratings

$T_i = 25 \, ^\circ\text{C}$, unless otherwise specified

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Symbol</th>
<th>Condition</th>
<th>Value</th>
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<td><strong>Module Properties</strong></td>
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<td><strong>Thermal Properties</strong></td>
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<td>Storage temperature</td>
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<td>Operation temperature under switching condition</td>
<td>$T_{jop}$</td>
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<td>-40...($T_{jmax} - 25$)</td>
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<tr>
<td><strong>Isolation Properties</strong></td>
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<td>AC Voltage $t_p = 1 , \text{min}$</td>
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<tr>
<td>Creepage distance</td>
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<tr>
<td>Clearance</td>
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<td>Comparative Tracking Index</td>
<td>CTI</td>
<td></td>
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*100 % tested in production
### Characteristic Values

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<th>Parameter</th>
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<tr>
<td><strong>Static</strong></td>
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<td>Gate-emitter threshold voltage</td>
<td>$V_{GE\text{th}}$</td>
<td>$V_{GE} = V_{CE}$</td>
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<td>Collector-emitter cut-off current</td>
<td>$I_{CBO}$</td>
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<td>Gate-emitter leakage current</td>
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<td>nA</td>
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<td>Internal gate resistance</td>
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<td>Reverse transfer capacitance</td>
<td>$C_{res}$</td>
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<td>Gate charge</td>
<td>$Q_g$</td>
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<td>Thermal resistance junction to sink</td>
<td>$R_{j-s}$</td>
<td>phase-change material $\lambda = 3.4$ W/mK</td>
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<td>K/W</td>
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<tr>
<td>Turn-on delay time</td>
<td>$t_{on}$</td>
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<td>±15</td>
<td>ns</td>
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<tr>
<td>Rise time</td>
<td>$\tau$</td>
<td>$R_{on} = 4$ Ω $R_{off} = 4$ Ω</td>
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<td>ns</td>
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<td>Turn-off delay time</td>
<td>$t_{off}$</td>
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<td>Fall time</td>
<td>$\tau$</td>
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<td>81</td>
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<tr>
<td>Turn-on energy (per pulse)</td>
<td>$E_{on}$</td>
<td>$Q_{on} = 3.3$ µC $Q_{on} = 7.8$ µC</td>
<td>25</td>
<td>mWs</td>
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<td>Turn-off energy (per pulse)</td>
<td>$E_{off}$</td>
<td>$Q_{off} = 9.5$ µC</td>
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## Characteristic Values

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<td>2,21</td>
<td>2,31</td>
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<td>Forward voltage</td>
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<td>Reverse leakage current</td>
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<td>Reverse recovery time</td>
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<td>Recovered charge</td>
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<td>$di/dt = 8288$ A/µs</td>
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<td>11172 9951 9159</td>
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<tr>
<td>Gate-emitter threshold voltage</td>
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<td>V</td>
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<td>Collector-emitter saturation</td>
<td>$V_{CE}$</td>
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<td>Collector-emitter cut-off current</td>
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<tr>
<td>Gate-emitter leakage current</td>
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<tr>
<td>Internal gate resistance</td>
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<tr>
<td>Input capacitance</td>
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<td>Thermal resistance junction to</td>
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<td>Turn-on delay time</td>
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<td>Rise time</td>
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<td>Turn-on energy (per pulse)</td>
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<td>Turn-off energy (per pulse)</td>
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<td>Gate-emitter threshold voltage</td>
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<td>V</td>
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<td>Collector-emitter saturation</td>
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<td>Rise time</td>
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### Table:

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<td>Gate-emitter threshold voltage</td>
<td>$V_{GE}$</td>
<td>0,08</td>
<td>V</td>
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<tr>
<td>Collector-emitter saturation</td>
<td>$V_{CE}$</td>
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<td>25</td>
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<td>$Q_{g}$</td>
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<td>K/W</td>
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<td>Turn-on delay time</td>
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<td>±15</td>
<td>350</td>
</tr>
<tr>
<td>Rise time</td>
<td>$t_{r}$</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Turn-off delay time</td>
<td>$t_{off}$</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Fall time</td>
<td>$t_{f}$</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Turn-on energy (per pulse)</td>
<td>$E_{on}$</td>
<td>25</td>
<td>144</td>
</tr>
<tr>
<td>Turn-off energy (per pulse)</td>
<td>$E_{off}$</td>
<td>25</td>
<td>1,590</td>
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</table>
### Characteristic Values

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Symbol</th>
<th>Conditions</th>
<th>Value</th>
<th>Unit</th>
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<tbody>
<tr>
<td>$V_{GE}$</td>
<td>[V]</td>
<td>100</td>
<td>1,61</td>
<td>1,77</td>
</tr>
<tr>
<td>$V_{GS}$</td>
<td>[V]</td>
<td>125, 150</td>
<td>1,58</td>
<td>1,57</td>
</tr>
<tr>
<td>$V_{CE}$</td>
<td>[V]</td>
<td></td>
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</tr>
<tr>
<td>$V_{DS}$</td>
<td>[V]</td>
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<tr>
<td>$V_{F}$</td>
<td>[V]</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>$I_{C}$</td>
<td>[A]</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>$I_{D}$</td>
<td>[A]</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>$I_{F}$</td>
<td>[A]</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>$T_j$</td>
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<td>25</td>
<td></td>
</tr>
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<td></td>
<td></td>
<td>Typ</td>
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</tr>
<tr>
<td></td>
<td></td>
<td>Max</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

### Buck Diode

#### Static

- **Forward voltage** $V_F$
  - 100 V: 1,61 V, 1,77 V

- **Reverse leakage current** $I_r$
  - 650 µA

#### Thermal

- **Thermal resistance junction to sink** $R_{th(j-s)}$
  - 0,90 K/W

### Dynamic

- **Peak recovery current** $I_{RRM}$
  - ±15 A: 34 A, 42 A

- **Reverse recovery time** $t_{rr}$
  - 25 ns, 100 ns, 148 ns

- **Recovered charge** $Q_r$
  - 25 µC

- **Reverse recovered energy** $E_{rec}$
  - 25 mWs

- **Peak rate of fall of recovery current** $(di/dt)_{max}$
  - 25 A/µs

### Capacitor

- **Capacitance** $C$
  - 150 nF

- **Dissipation factor** $f = 1$ kHz
  - 25 %

### Thermistor

- **Rated resistance** $R$
  - 25 kΩ

- **Deviation of $R_{NC}$** $\Delta R/R_{NC}$
  - 100 %, -12 %, +14 %

- **Power dissipation** $P$
  - 25 mW

- **Power dissipation constant** $P$
  - 25 mW/K

- **B-value** $B_{25/100}$
  - 25 K

- **Vincotech NTC Reference**
  - B
Boost Switch Characteristics

**figure 1.** IGBT

*Typical output characteristics*

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

- \( t_p = 250 \, \mu s \)
- \( V_{CE} = 15 \, V \)
- \( T_J = 25 \, ^\circ C \)

**figure 2.** IGBT

*Typical output characteristics*

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

- \( t_p = 250 \, \mu s \)
- \( V_{CE} = 10 \, V \)
- \( T_J = 125 \, ^\circ C \)

**figure 3.** IGBT

*Typical transfer characteristics*

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

- \( t_p = 100 \, \mu s \)
- \( V_{CE} = 10 \, V \)
- \( T_J = 25 \, ^\circ C \)

**figure 4.** IGBT

*Transient Thermal Impedance as function of Pulse duration*

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

- \( D = \frac{t_p}{T} \)
- \( R_{th} = 0.72 \, K/W \)

**IGBT thermal model values**

<table>
<thead>
<tr>
<th>( R ) (K/W)</th>
<th>( t ) (s)</th>
</tr>
</thead>
<tbody>
<tr>
<td>7.52E-02</td>
<td>1.73E-00</td>
</tr>
<tr>
<td>1.31E-01</td>
<td>2.44E-01</td>
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<td>3.01E-01</td>
<td>6.32E-02</td>
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<tr>
<td>4.30E-02</td>
<td>3.50E-03</td>
</tr>
<tr>
<td>4.35E-02</td>
<td>3.33E-04</td>
</tr>
</tbody>
</table>
Boost Switch Characteristics

**Figure 5.** Gate voltage vs Gate charge

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

**Figure 6.** Safe operating area

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

At

- \( I_c = 100 \) A
- \( V_G = \pm 15 \) V
- \( T_j = T_{j\text{max}} \)
- \( D = \) single pulse
- \( T_s = 80 \) °C
- \( V_{CE} = \pm 15 \) V
- \( T_j = T_{j\text{max}} \)
Boost Diode Characteristics

**Figure 1.** FWD
Typical forward characteristics

\[ I_F = f(V_F) \]

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

\[ t_p = 250 \, \mu s \]

\[ T : 25 \, ^\circ C \]

\[ 125 \, ^\circ C \]

\[ 150 \, ^\circ C \]

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

\[ R_{th(j-s)} = 1,02 \, \text{K/W} \]

**FWD thermal model values**

<table>
<thead>
<tr>
<th>( R ) (K/W)</th>
<th>( \tau ) (s)</th>
</tr>
</thead>
<tbody>
<tr>
<td>5,56E-02</td>
<td>3,42E+00</td>
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<tr>
<td>1,14E-01</td>
<td>5,52E-01</td>
</tr>
<tr>
<td>4,09E-01</td>
<td>9,76E-02</td>
</tr>
<tr>
<td>2,64E-01</td>
<td>3,22E-02</td>
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<tr>
<td>9,94E-02</td>
<td>6,42E-03</td>
</tr>
<tr>
<td>7,49E-02</td>
<td>9,84E-04</td>
</tr>
</tbody>
</table>

**Figure 2.** FWD
Transient thermal impedance as a function of pulse width

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

\[ t_p \] (s)
Buck Switch Characteristics

**figure 1.** IGBT

Typical output characteristics

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

\[
t_p = 250 \ \mu s \quad V_{CE} = 15 \ \text{V} \quad T_J = 125 \ ^\circ\text{C}
\]

\[
t_p = 250 \ \mu s \quad V_{CE} = 15 \ \text{V} \quad T_J = 150 \ ^\circ\text{C}
\]

**figure 2.** IGBT

Typical output characteristics

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

\[
t_p = 250 \ \mu s \quad V_{GE} = 15 \ \text{V} \quad T_J = 125 \ ^\circ\text{C}
\]

\[
t_p = 250 \ \mu s \quad V_{GE} = 15 \ \text{V} \quad T_J = 150 \ ^\circ\text{C}
\]

**figure 3.** IGBT

Typical transfer characteristics

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

\[
t_p = 100 \ \mu s \quad V_{GE} = 10 \ \text{V} \quad T_J = 125 \ ^\circ\text{C}
\]

\[
t_p = 100 \ \mu s \quad V_{GE} = 10 \ \text{V} \quad T_J = 150 \ ^\circ\text{C}
\]

**figure 4.** IGBT

Transient thermal impedance as function of pulse duration

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

\[
D = \frac{t_p}{T} \quad R_{th(j-s)} = 0.43 \ \text{K/W}
\]

**IGBT thermal model values**

\[
R \ (\text{K/W}) \quad t \ (\text{s})
\]

<table>
<thead>
<tr>
<th>R</th>
<th>t</th>
</tr>
</thead>
<tbody>
<tr>
<td>5.91E-02</td>
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<tr>
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<td>2.08E-02</td>
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<tr>
<td>1.78E-02</td>
<td>4.96E-04</td>
</tr>
</tbody>
</table>

Copyright Vincotech
Buck Switch Characteristics

**Figure 5.** Gate voltage vs gate charge

V_{GE} = f(Q_{G})

- \( I_{C} = 80 \) A
- \( T_s = 80 \) °C
- \( V_{GE} = \pm 15 \) V
- \( T_j = T_{j\text{max}} \) °C

**Figure 6.** Safe operating area

\( I_{C} = f(V_{CE}) \)

- \( D = \) single pulse
- \( V_{CE} = 200\) V
- \( V_{CE} = 400\) V
- \( V_{CE} = 800\) V
- \( V_{CE} = 1000\) V

- \( I_{C} = 0,01 \) to 1000 A
- \( V_{CE} = 100 \) to 10000 V
Buck Diode Characteristics

**Typical forward characteristics**

\[ I_F = f(V_F) \]

- \( I_F = 250 \, \mu s \)
- \( T_J = 25 \, ^\circ C \)
- \( T_J = 125 \, ^\circ C \)
- \( T_J = 150 \, ^\circ C \)

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

- \( D = 0.5 \)
- \( D = 0.2 \)
- \( D = 0.1 \)
- \( D = 0.05 \)
- \( D = 0.02 \)
- \( D = 0.01 \)
- \( D = 0.005 \)
- \( D = 0.000 \)

FWD thermal model values

<table>
<thead>
<tr>
<th>( R ) (K/W)</th>
<th>( \tau ) (s)</th>
</tr>
</thead>
<tbody>
<tr>
<td>7.42E-02</td>
<td>3.64E+00</td>
</tr>
<tr>
<td>1.41E-01</td>
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<td>3.41E-01</td>
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<td>1.94E-01</td>
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<tr>
<td>9.09E-02</td>
<td>6.04E-03</td>
</tr>
<tr>
<td>5.85E-02</td>
<td>5.72E-04</td>
</tr>
</tbody>
</table>
Thermistor Characteristics

Typical NTC characteristic as a function of temperature

\[ R = R(T) \]

![NTC-typical temperature characteristic graph](image-url)
Boost Switching Characteristics

**Figure 1.** IGBT
Typical switching energy losses as a function of collector current

\[ E = f(I_C) \]

With an inductive load at 25 °C
- \( V_{in} = 350 \) V
- \( V_{in} = \pm 15 \) V
- \( R_{gon} = 4 \) Ω

\( I_C = 81 \) A

**Figure 2.** IGBT
Typical switching energy losses as a function of gate resistor

\[ E = f(R_g) \]

With an inductive load at 25 °C
- \( V_{in} = 350 \) V
- \( V_{in} = \pm 15 \) V
- \( I_C = 81 \) A

**Figure 3.** FWD
Typical reverse recovered energy loss as a function of collector current

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

With an inductive load at 25 °C
- \( V_{in} = 350 \) V
- \( V_{in} = \pm 15 \) V
- \( R_{gon} = 4 \) Ω

**Figure 4.** FWD
Typical reverse recovered energy loss as a function of gate resistor

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

With an inductive load at 25 °C
- \( V_{in} = 350 \) V
- \( V_{in} = \pm 15 \) V
- \( I_C = 81 \) A
Boost Switching Characteristics

**Figure 5.** IGBT
Typical switching times as a function of collector current

$t_d(on) = f(I_C)$

$t_d(off) = f(I_C)$

With an inductive load at
$T_J = 150 \, ^\circ C$
$V_{CE} = 350 \, V$
$V_{GE} = \pm 15 \, V$
$R_{son} = 4 \, \Omega$

**Figure 6.** IGBT
Typical switching times as a function of gate resistor

$t_d(on) = f(R_{g})$

$t_d(off) = f(R_{g})$

With an inductive load at
$T_J = 150 \, ^\circ C$
$V_{CE} = 350 \, V$
$V_{GE} = \pm 15 \, V$
$R_{gon} = 4 \, \Omega$

**Figure 7.** FWD
Typical reverse recovery time as a function of collector current

$t_{rr} = f(I_C)$

At
$V_{CE} = 350 \, V$
$V_{GE} = \pm 15 \, V$
$R_{off} = 4 \, \Omega$

$T_J = 25 \, ^\circ C$

$T_J = 125 \, ^\circ C$

$T_J = 150 \, ^\circ C$

**Figure 8.** FWD
Typical reverse recovery time as a function of IGBT turn on gate resistor

$t_{rr} = f(R_{gon})$

At
$V_{CE} = 350 \, V$
$V_{GE} = \pm 15 \, V$

$T_J = 25 \, ^\circ C$

$T_J = 125 \, ^\circ C$

$T_J = 150 \, ^\circ C$

Sample data:

- Collector current ($I_C$)
- Gate voltage ($V_{GE}$)
- Collector voltage ($V_{CE}$)
- Gate resistor ($R_{g}$)
- On-state resistance ($R_{son}$)
- Off-state resistance ($R_{off}$)
- Reverse recovery time ($t_{rr}$)
Boost Switching Characteristics

**Figure 9.** Typical recovered charge as a function of collector current

\[ Q_r = f(I_C) \]

**Figure 10.** Typical recovered charge as a function of IGBT turn-on gate resistor

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

**Figure 11.** Typical peak reverse recovery current as a function of collector current

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

**Figure 12.** Typical peak reverse recovery current as a function of IGBT turn-on gate resistor

\[ I_{RM} = f(R_{gon}) \]
Boost Switching Characteristics

Figure 13.
Typical rate of fall of forward and reverse recovery current as a function of collector current
\[
\frac{di_F}{dt}, \frac{di_{rr}}{dt} = f(I_C)
\]

At
\begin{align*}
V_{GS} &= 350 \text{ V} \\
V_{RES} &= \pm 15 \text{ V} \\
R_{Gon} &= 4 \text{ } \Omega
\end{align*}

At
\begin{align*}
T_j &= 25 \text{ °C} \\
T_j &= 125 \text{ °C} \\
T_j &= 150 \text{ °C}
\end{align*}

Figure 14.
Typical rate of fall of forward and reverse recovery current as a function of IGBT turn on gate resistor
\[
\frac{di_F}{dt}, \frac{di_{rr}}{dt} = f(R_{Gon})
\]

At
\begin{align*}
V_{GS} &= 350 \text{ V} \\
V_{RES} &= \pm 15 \text{ V} \\
R_{Gon} &= 4 \text{ } \Omega
\end{align*}

At
\begin{align*}
I_C &= 81 \text{ A} \\
I_C &= 150 \text{ °C}
\end{align*}

Figure 15.
IGBT
Reverse bias safe operating area
\[
I_C = f(V_{CE})
\]

At
\begin{align*}
T_j &= 175 \text{ °C} \\
R_{Gon} &= 4 \text{ } \Omega \\
R_{Goff} &= 4 \text{ } \Omega
\end{align*}
Boost Switching Definitions

General conditions

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>$T_j$</td>
<td>125 °C</td>
</tr>
<tr>
<td>$R_{DS(on)}$</td>
<td>4 Ω</td>
</tr>
<tr>
<td>$R_{DS(off)}$</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 $Eoff$)

$V_{GE}(0\%) = -15 \text{ V}$

$V_{CE}(0\%) = 15 \text{ V}$

$I_{C}(100\%) = 350 \text{ V}$

$I_{C}(10\%) = 81 \text{ A}$

$t_{off} = 0.088 \mu s$

$t_{Eoff} = 0.103 \mu s$

Figure 2. Turn-on Switching Waveforms & definition of $t_{on}$, $t_{Eon}$ ($t_{Eon}$ = integrating time for $Eon$)

$V_{CE}(10\%) = 15 \text{ V}$

$V_{CE}(100\%) = 350 \text{ V}$

$I_{C}(10\%) = 81 \text{ A}$

$I_{C}(100\%) = 81 \text{ A}$

$t_{on} = 0.066 \mu s$

$t_{Eon} = 0.115 \mu s$

Figure 3. Turn-off Switching Waveforms & definition of $t_f$

$V_{CE}(10\%) = 350 \text{ V}$

$I_{C}(10\%) = 81 \text{ A}$

$t_{f} = 0.010 \mu s$

Figure 4. Turn-on Switching Waveforms & definition of $t_r$

$V_{CE}(10\%) = 350 \text{ V}$

$I_{C}(10\%) = 81 \text{ A}$

$t_{r} = 0.008 \mu s$
Boost Switching Characteristics

**Figure 5.** IGBT

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

- $P_{off}(100\%) = 28.49$ kW
- $E_{off}(100\%) = 0.60$ mJ
- $t_{Eoff} = 0.10 \mu s$

**Figure 6.** IGBT

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

- $P_{on}(100\%) = 28.49$ kW
- $E_{on}(100\%) = 1.40$ mJ
- $t_{Eon} = 0.11 \mu s$

**Figure 7.** FWD

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

- $V_F(100\%) = 350$ V
- $I_F(100\%) = 81$ A
- $I_{rr}(100\%) = -147$ A
- $t_{rr} = 0.048 \mu s$
Boost Switching Characteristics

Figure 8. FWD

Turn-on Switching Waveforms & definition of $t_{Qr}$ ($t_{Qr}$ = integrating time for $Q_r$)

\[ I_F(100\%) = 81\ A \]
\[ Q_r(100\%) = 7,85\ \mu C \]
\[ t_{Qr} = 1,00\ \mu s \]

Figure 9. FWD

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

\[ P_{rec}(100\%) = 28,49\ kW \]
\[ E_{rec}(100\%) = 2,08\ mJ \]
\[ t_{Erec} = 1,00\ \mu s \]
Buck Switching Characteristics

**Figure 1.** IGBT
Typical switching energy losses as a function of collector current

\[ E = f(I_C) \]

With an inductive load at 25 °C
- \( V_{DS} = 350 \) V
- \( V_{DS} = \pm 15 \) V
- \( R_g = 4 \) Ω
- \( I_C = 80 \) A

**Figure 2.** IGBT
Typical switching energy losses as a function of gate resistor

\[ E = f(R_g) \]

With an inductive load at 25 °C
- \( V_{DS} = 350 \) V
- \( V_{DS} = \pm 15 \) V
- \( I_C = 80 \) A

**Figure 3.** FWD
Typical reverse recovered energy loss as a function of collector current

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

With an inductive load at 25 °C
- \( V_{DS} = 350 \) V
- \( V_{DS} = \pm 15 \) V
- \( R_g = 4 \) Ω

**Figure 4.** FWD
Typical reverse recovered energy loss as a function of gate resistor

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

With an inductive load at 25 °C
- \( V_{DS} = 350 \) V
- \( V_{DS} = \pm 15 \) V
- \( I_C = 80 \) A
Buck Switching Characteristics

**Figure 5.** IGBT
Typical switching times as a function of collector current

$t = f(I_C)$

With an inductive load at

\[ T_j = 150 °C \]
\[ V_{CE} = 350 V \]
\[ V_{GE} = ±15 V \]
\[ R_{gon} = 4 \, Ω \]
\[ I_C = 80 A \]

**Figure 6.** IGBT
Typical switching times as a function of gate resistor

$t = f(R_{g})$

With an inductive load at

\[ T_j = 150 °C \]
\[ V_{CE} = 350 V \]
\[ V_{GE} = ±15 V \]
\[ I_C = 80 A \]

**Figure 7.** FWD
Typical reverse recovery time as a function of collector current

$t_{rr} = f(I_C)$

At

\[ V_{CE} = 350 V \]
\[ V_{GE} = ±15 V \]
\[ R_{goff} = 4 \, Ω \]

**Figure 8.** FWD
Typical reverse recovery time as a function of IGBT turn on gate resistor

$t_{rr} = f(R_{g(on)})$

At

\[ V_{CE} = 350 V \]
\[ V_{GE} = ±15 V \]
\[ T_j = 125 °C \]
\[ R_{g(on)} = 4 \, Ω \]
\[ I_C = 80 A \]
Buck Switching Characteristics

Figure 9. FWD
Typical recovered charge as a function of collector current

\[ Q_r = f(I_C) \]

Figure 10. FWD
Typical recovered charge as a function of IGBT turn-on gate resistor

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

Figure 11. FWD
Typical peak reverse recovery current as a function of collector current

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

Figure 12. FWD
Typical peak reverse recovery current as a function of IGBT turn-on gate resistor

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

At
\[ V_{CE} = 350 \text{ V} \]
\[ V_{GE} = \pm 15 \text{ V} \]
\[ T_j = 125 \text{ °C} \]
\[ I_C = 80 \text{ A} \]

At
\[ V_{CE} = 350 \text{ V} \]
\[ V_{GE} = \pm 15 \text{ V} \]
\[ T_j = 125 \text{ °C} \]
\[ I_C = 80 \text{ A} \]
Buck Switching Characteristics

**Figure 13.** FWD  
Typical rate of fall of forward and reverse recovery current as a function of collector current  
\[
di/dt, di_rr/dt = f(I_C)
\]

Graph showing di/dt and di_rr/dt as functions of I_C at different temperatures and voltages.

**Figure 14.** FWD  
Typical rate of fall of forward and reverse recovery current as a function of IGBT turn on gate resistor  
\[
di/dt, di_rr/dt = f(R_{gon})
\]

Graph showing di/dt and di_rr/dt as functions of R_{gon}.

**Figure 15.** IGBT  
Reverse bias safe operating area  
\[
I_C = f(V_{CE})
\]

Graph showing the safe operating area for I_C and V_{CE}.

At  
- \(V_{Bus} = 350\) V, \(V_{GE} = \pm 15\) V, \(R_{gon} = 4\) Ω, \(R_{goff} = 4\) Ω, \(I_C = 80\) A, \(T_j = 175\) °C.
Buck Switching Definitions

**General conditions**

<table>
<thead>
<tr>
<th>Symbol</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>$T_j$</td>
<td>125 °C</td>
</tr>
<tr>
<td>$R_{gum}$</td>
<td>4 Ω</td>
</tr>
<tr>
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**Figure 1. IGBT**

- Turn-off Switching Waveforms & definition of $t_{doff}$ ($t_{doff}$ = integrating time for $E_{off}$)

- $V_{CE}$
- $I_C$
- $V_G$
- $V_{CE}$

- $V_G(0%) = 15$ V
- $V_G(100%) = 350$ V
- $I_C(100%) = 80$ A
- $t_{doff} = 0.270$ µs
- $t_Eoff = 0.783$ µs

**Figure 3. IGBT**

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

- $V_{CE}$
- $I_C$
- $V_G$
- $V_{CE}$

- $V_G(0%) = -15$ V
- $V_G(100%) = 15$ V
- $I_C(100%) = 80$ A
- $t_{don} = 0.150$ µs
- $t_{Eon} = 0.461$ µs

**Figure 2. IGBT**

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

- $V_{CE}$
- $I_C$
- $V_G$
- $V_{CE}$

- $V_G(100%) = 350$ V
- $I_C(100%) = 80$ A
- $t_{f} = 0.073$ µs
- $t_{r} = 0.041$ µs

**Figure 4. IGBT**

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

- $V_{CE}$
- $I_C$
- $V_G$
- $V_{CE}$

- $V_G(100%) = 350$ V
- $I_C(100%) = 80$ A
- $t_{f} = 0.041$ µs

---

**Graphs and plots**

- Graph 1: Turn-off switching waveforms with definitions for $t_{doff}$, $t_{Eoff}$.
- Graph 2: Turn-on switching waveforms with definitions for $t_{don}$, $t_{Eon}$.
- Graph 3: Turn-off switching waveforms with definition of $t_f$.
- Graph 4: Turn-on switching waveforms with definition of $t_r$.
Buck Switching Characteristics

Figure 5. IGBT
Turn-off Switching Waveforms & definition of tEoff

- P_{off}(100%) = 28.03 kW
- E_{off}(100%) = 3.09 mJ
- t_{Eoff} = 0.78 µs

Figure 6. IGBT
Turn-on Switching Waveforms & definition of tEon

- P_{on}(100%) = 28.03 kW
- E_{on}(100%) = 4.66 mJ
- t_{Eon} = 0.46 µs

Figure 7. FWD
Turn-off Switching Waveforms & definition of trr

- V_{F}(100%) = 350 V
- I_{F}(100%) = 80 A
- J_{off}(100%) = -42 A
- t_{rr} = 0.148 µs
Buck Switching Characteristics

Figure 8. FWD
Turn-on Switching Waveforms & definition of $t_{Qr}$ ($t_{Qr}$ = integrating time for $Q_r$)

- $I_F$ (100%) = 80 A
- $Q_r$ (100%) = 4.72 μC
- $t_{Qr}$ = 0.30 μs

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

- $P_{rec}$ (100%) = 28.03 kW
- $E_{rec}$ (100%) = 0.58 mJ
- $t_{Erec}$ = 0.30 μs
### Ordering Code & Marking

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### Datamatrix

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### Outline

- Tolerance of pin positions: ±0.05mm at the end of pins
- Dimension of coordinate pins is only offset without tolerance
### Pinout

#### Identification

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<tr>
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<th>Current</th>
<th>Function</th>
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<td>Boost Switch</td>
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