**Features**
- Cree™ Silicon Carbide Power MOSFET
- Cree™ Silicon Carbide Power Schottky Diode
- MNPC Topology with Splitled Output
- Ultra Low Inductance with Integrated DC-capacitors
- Extremely Fast Switching with No "Tail" Current
- Unsensitivit for Cross Through Conduction
- Solderless Press-fit Mounting Technology
- Temperature sensor

**Maximum Ratings**

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Symbol</th>
<th>Condition</th>
<th>Value</th>
<th>Unit</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Half Bridge MOSFET (T1, T4)</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Drain-source break down voltage</td>
<td>$V_{oss}$</td>
<td>$T_j=T_{j,\text{max}}$; $T_a=80^\circ \text{C}$</td>
<td>1200</td>
<td>V</td>
</tr>
<tr>
<td>DC drain current</td>
<td>$I_D$</td>
<td>$I_0$ limited by $T_j, T_{j,\text{max}}$</td>
<td>49</td>
<td>A</td>
</tr>
<tr>
<td>Repetitive peak drain current</td>
<td>$I_{\text{opulse}}$</td>
<td>$T_a=80^\circ \text{C}$</td>
<td>180</td>
<td>A</td>
</tr>
<tr>
<td>Power dissipation</td>
<td>$P_{\text{tot}}$</td>
<td>$T_j=T_{j,\text{max}}$; $T_a=80^\circ \text{C}$</td>
<td>98</td>
<td>W</td>
</tr>
<tr>
<td>Gate-source peak voltage</td>
<td>$V_{GS}$</td>
<td>$T_j=T_{j,\text{max}}$; $T_a=80^\circ \text{C}$</td>
<td>-10/+25</td>
<td>V</td>
</tr>
<tr>
<td>Operation temperature</td>
<td>$T_{op}$</td>
<td>$T_j=T_{j,\text{max}}$; $T_a=80^\circ \text{C}$</td>
<td>135</td>
<td>°C</td>
</tr>
<tr>
<td>Maximum Junction Temperature</td>
<td>$T_{j,\text{max}}$</td>
<td></td>
<td>150</td>
<td>°C</td>
</tr>
<tr>
<td><strong>Neutral Point FWD (D7, D8)</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Peak Repetitive Reverse Voltage</td>
<td>$V_{\text{max}}$</td>
<td>$T_j=25^\circ \text{C}$</td>
<td>650</td>
<td>V</td>
</tr>
<tr>
<td>DC forward current</td>
<td>$I_F$</td>
<td>$I_0$ limited by $T_j, T_{j,\text{max}}$</td>
<td>27</td>
<td>A</td>
</tr>
<tr>
<td>Repetitive peak forward current</td>
<td>$I_{\text{pmax}}$</td>
<td>$T_j=T_{j,\text{max}}$</td>
<td>171</td>
<td>A</td>
</tr>
<tr>
<td>Power dissipation</td>
<td>$P_{\text{tot}}$</td>
<td>$T_j=T_{j,\text{max}}$; $T_a=80^\circ \text{C}$</td>
<td>58</td>
<td>W</td>
</tr>
<tr>
<td>Operation temperature</td>
<td>$T_{op}$</td>
<td>$T_j=T_{j,\text{max}}$; $T_a=80^\circ \text{C}$</td>
<td>150</td>
<td>°C</td>
</tr>
<tr>
<td>Maximum Junction Temperature</td>
<td>$T_{j,\text{max}}$</td>
<td></td>
<td>175</td>
<td>°C</td>
</tr>
</tbody>
</table>
### 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>Neutral Point IGBT ( T2, T3 )</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Collector-emitter break down voltage</td>
<td>$V_{CE}$</td>
<td>$T_j=T_{j,\text{max}}$</td>
<td>650</td>
<td>V</td>
</tr>
<tr>
<td>DC collector current</td>
<td>$I_C$</td>
<td>$T_j=T_{j,\text{max}}$</td>
<td>60</td>
<td>A</td>
</tr>
<tr>
<td>Repetitive peak collector current</td>
<td>$I_{D_{\text{PKP}}}$</td>
<td>$T_j$ limited by $T_{j,\text{max}}$</td>
<td>240</td>
<td>A</td>
</tr>
<tr>
<td>Power dissipation</td>
<td>$P_{	ext{int}}$</td>
<td>$T_j=T_{j,\text{max}}$</td>
<td>99</td>
<td>W</td>
</tr>
<tr>
<td>Gate-emitter peak voltage</td>
<td>$V_{GE}$</td>
<td>$T_j=T_{j,\text{max}}$</td>
<td>±20</td>
<td>V</td>
</tr>
<tr>
<td>Operation temperature</td>
<td>$T_{\text{op}}$</td>
<td>$T_j=T_{j,\text{max}}$</td>
<td>150</td>
<td>°C</td>
</tr>
<tr>
<td>Maximum Junction Temperature</td>
<td>$T_{j,\text{max}}$</td>
<td>$T_j$</td>
<td>175</td>
<td>°C</td>
</tr>
<tr>
<td><strong>Neutral Point Inv. Diode ( D2, D3 )</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Peak Repetitive Reverse Voltage</td>
<td>$V_{R_{\text{PKP}}}$</td>
<td>$T_j=25°C$</td>
<td>650</td>
<td>V</td>
</tr>
<tr>
<td>DC forward current</td>
<td>$I_F$</td>
<td>$T_j=T_{j,\text{max}}$</td>
<td>13</td>
<td>A</td>
</tr>
<tr>
<td>Repetitive peak forward current</td>
<td>$I_{R_{\text{PKP}}}$</td>
<td>$T_j$ limited by $T_{j,\text{max}}$</td>
<td>12</td>
<td>A</td>
</tr>
<tr>
<td>Power dissipation</td>
<td>$P_{	ext{int}}$</td>
<td>$T_j=T_{j,\text{max}}$</td>
<td>27</td>
<td>W</td>
</tr>
<tr>
<td>Operation temperature</td>
<td>$T_{\text{op}}$</td>
<td>$T_j=T_{j,\text{max}}$</td>
<td>150</td>
<td>°C</td>
</tr>
<tr>
<td>Maximum Junction Temperature</td>
<td>$T_{j,\text{max}}$</td>
<td>$T_j$</td>
<td>175</td>
<td>°C</td>
</tr>
<tr>
<td><strong>Half Bridge FWD ( D5, D6 )</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Peak Repetitive Reverse Voltage</td>
<td>$V_{R_{\text{PKP}}}$</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>$T_j=T_{j,\text{max}}$</td>
<td>16</td>
<td>A</td>
</tr>
<tr>
<td>Repetitive peak forward current</td>
<td>$I_{R_{\text{PKP}}}$</td>
<td>$T_j$ limited by $T_{j,\text{max}}$</td>
<td>47</td>
<td>A</td>
</tr>
<tr>
<td>Power dissipation</td>
<td>$P_{	ext{int}}$</td>
<td>$T_j=T_{j,\text{max}}$</td>
<td>40</td>
<td>W</td>
</tr>
<tr>
<td>Operation temperature</td>
<td>$T_{\text{op}}$</td>
<td>$T_j=T_{j,\text{max}}$</td>
<td>150</td>
<td>°C</td>
</tr>
<tr>
<td>Maximum Junction Temperature</td>
<td>$T_{j,\text{max}}$</td>
<td>$T_j$</td>
<td>175</td>
<td>°C</td>
</tr>
</tbody>
</table>
## 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>DC link Capacitor (C1, C2)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Max. DC voltage</td>
<td>V_{\text{MAX}}</td>
<td>Tc=25°C</td>
<td>500</td>
<td>V</td>
</tr>
<tr>
<td>Thermal Properties</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Storage temperature</td>
<td>T_{\text{stg}}</td>
<td></td>
<td>-40...+125</td>
<td>°C</td>
</tr>
<tr>
<td>Insulation Properties</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Insulation voltage</td>
<td>V_{\text{i}}</td>
<td>t=2s, DC voltage</td>
<td>4000</td>
<td>V</td>
</tr>
<tr>
<td>Creepage distance</td>
<td></td>
<td></td>
<td>min 12,7</td>
<td>mm</td>
</tr>
<tr>
<td>Clearance</td>
<td></td>
<td></td>
<td>min 9,17</td>
<td>mm</td>
</tr>
<tr>
<td>Comparative tracking index</td>
<td>CTI</td>
<td></td>
<td>&gt;200</td>
<td></td>
</tr>
</tbody>
</table>
### 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>Half Bridge MOSFET (T1, T4)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
| Drain-source on-state resistance               | R\(_{\text{DS(on)}}\) | 16         | 60    | 27   | m\(
| Gate threshold voltage                         | V\(_{\text{GS(th)}}\) | 0,003      |       | 1,62 | V    |
| Total Gate Reverse Leakage                     | I\(_{\text{oss}}\)   | 20         | 0     | 0,75 | \(\mu\)A |
| Zero Gate Voltage Drain Current                | I\(_{\text{oss}}\)   | 0          | 1200  | 300  | 750 \(\mu\)A |
| Turn-on delay time                             | t\(_{\text{(on)}}\)  | 16/5       |       | 24   | ns   |
| Rise time                                      | t\(_{r}\)           | 0          | 1200  | 7    | ns   |
| Turn-off delay time                            | t\(_{\text{off}}\)   | Rgoff=4 \(\Omega\) | 44 | 63   | ns   |
| Fall time                                      | t\(_{f}\)           | Rgon=4 \(\Omega\) | 350 | 68   | ns   |
| Turn-on energy loss per pulse                  | E\(_{\text{on}}\)    |            |       | 17   | mWs  |
| Turn-off energy loss per pulse                 | E\(_{\text{off}}\)   |            |       | 0,13 | mWs  |
| Total gate charge *                            | Q\(_{d}\)           | 0/20       | 800   | 148  | pF   |
| Gate to source charge                          | Q\(_{gs}\)          |            |       | 32   | pF   |
| Gate to drain charge                           | Q\(_{gd}\)          |            |       | 54   | pF   |
| Input capacitance *                            | C\(_{\text{in}}\)    |            |       | 2850 | pF   |
| Output capacitance                             | C\(_{\text{out}}\)   | f=1MHz     | 0     | 240  | pF   |
| Reverse transfer capacitance                   | C\(_{\text{fr}}\)    |            |       | 19,5 |      |
| Thermal resistance chip to heatsink            | R\(_{\text{th}}\)    | Phase-Change Material | 0,71 | K/W  |

### Neutral Point FWD (D7, D8)

<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></td>
<td>24</td>
<td>1,52</td>
</tr>
<tr>
<td>Peak reverse recovery current</td>
<td>I(_{\text{D(on)}})</td>
<td>16/5</td>
<td></td>
<td>40</td>
</tr>
<tr>
<td>Reverse recovery time</td>
<td>t(_{r})</td>
<td>Rgoff=4 (\Omega)</td>
<td>44</td>
<td>12</td>
</tr>
<tr>
<td>Reverse recovered charge</td>
<td>Q(_{r})</td>
<td>Rgon=4 (\Omega)</td>
<td>350</td>
<td>0,20</td>
</tr>
<tr>
<td>Peak rate of fall of recovery current</td>
<td>t(_{(\text{rec})})</td>
<td>16/5</td>
<td></td>
<td>10399</td>
</tr>
<tr>
<td>Reverse recovered energy</td>
<td>E(_{\text{rec}})</td>
<td></td>
<td></td>
<td>0,03</td>
</tr>
<tr>
<td>Thermal resistance chip to heatsink</td>
<td>R(_{\text{th}})</td>
<td>Phase-Change Material</td>
<td>1,63</td>
<td>K/W</td>
</tr>
</tbody>
</table>
**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><strong>Gate</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Gate-emitter threshold voltage</td>
<td>( V_{GE} )</td>
<td>( V_{GE} ) or ( V_{CE} )</td>
<td>0.0008</td>
<td>V</td>
</tr>
<tr>
<td>Collector-emitter saturation voltage</td>
<td>( V_{CE} )</td>
<td>15</td>
<td>80</td>
<td>V</td>
</tr>
<tr>
<td>Collector-emitter cut-off diode</td>
<td>( t_{CES} )</td>
<td>0</td>
<td>600</td>
<td>mA</td>
</tr>
<tr>
<td>Gate-emitter leakage current</td>
<td>( I_{GES} )</td>
<td>20</td>
<td>0</td>
<td>nA</td>
</tr>
<tr>
<td>Integrated Gate resistor</td>
<td>( R_{ges} )</td>
<td></td>
<td>none</td>
<td></td>
</tr>
<tr>
<td>Turn-on delay time</td>
<td>( t_{th(U)} )</td>
<td>( R_{goff}=2 \ \Omega )</td>
<td>15</td>
<td>ns</td>
</tr>
<tr>
<td>Rise time</td>
<td>( t_r )</td>
<td>( R_{gon}=2 \ \Omega )</td>
<td>350</td>
<td></td>
</tr>
<tr>
<td>Fall time</td>
<td>( t_f )</td>
<td>( R_{off} )</td>
<td>44</td>
<td></td>
</tr>
<tr>
<td>Turn-on energy loss per pulse</td>
<td>( E_{on} )</td>
<td>( T_j=25^\circ C )</td>
<td>43</td>
<td>mWs</td>
</tr>
<tr>
<td>Turn-off energy loss per pulse</td>
<td>( E_{off} )</td>
<td>( T_j=25^\circ C )</td>
<td>45</td>
<td></td>
</tr>
<tr>
<td>Input capacitance</td>
<td>( C_{iss} )</td>
<td>( f=1 \text{MHz} )</td>
<td>0</td>
<td>nF</td>
</tr>
<tr>
<td>Output capacitance</td>
<td>( C_{iss} )</td>
<td>( f=1 \text{MHz} )</td>
<td>25</td>
<td></td>
</tr>
<tr>
<td>Reverse transfer capacitance</td>
<td>( C_{iss} )</td>
<td>( f=1 \text{MHz} )</td>
<td>80</td>
<td></td>
</tr>
<tr>
<td>Gate charge</td>
<td>( Q_{G} )</td>
<td>15</td>
<td>520</td>
<td>nC</td>
</tr>
<tr>
<td>Thermal resistance chip to heatsink</td>
<td>( R_{th(G)} )</td>
<td>Phase-Change</td>
<td>0.96</td>
<td>K/W</td>
</tr>
</tbody>
</table>

**Neutral Point IGBT (T2, T3)**

<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>6</td>
<td>1,2</td>
<td>1.58</td>
</tr>
<tr>
<td>Thermal resistance chip to heatsink</td>
<td>( R_{th(G)} )</td>
<td>Phase-Change Material</td>
<td>3.52</td>
<td>K/W</td>
</tr>
</tbody>
</table>

**Half Bridge FWD (D5, D6)**

<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>10</td>
<td>1,49</td>
<td>1.78</td>
</tr>
<tr>
<td>Reverse leakage current</td>
<td>( I_{L} )</td>
<td>1200</td>
<td>34</td>
<td></td>
</tr>
<tr>
<td>Peak reverse recovery current</td>
<td>( I_{r} )</td>
<td>( R_{goff}=2 \ \Omega )</td>
<td>44</td>
<td></td>
</tr>
<tr>
<td>Reverse recovery time</td>
<td>( t_{r} )</td>
<td>( R_{gon}=2 \ \Omega )</td>
<td>21</td>
<td></td>
</tr>
<tr>
<td>Reverse recovered charge</td>
<td>( Q_{r} )</td>
<td>( R_{off} )</td>
<td>0.41</td>
<td></td>
</tr>
<tr>
<td>Peak rate of fall of recovery current</td>
<td>( r(mA/V) )</td>
<td>( R_{off} )</td>
<td>910</td>
<td></td>
</tr>
<tr>
<td>Reverse recovery energy</td>
<td>( E_{rec} )</td>
<td>( r(mA/V) )</td>
<td>0.07</td>
<td></td>
</tr>
<tr>
<td>Thermal resistance chip to heatsink</td>
<td>( R_{th(G)} )</td>
<td>Phase-Change Material</td>
<td>2.39</td>
<td>K/W</td>
</tr>
</tbody>
</table>
### 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>DC link Capacitor (C1, C2)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>C value</td>
<td>C</td>
<td></td>
<td>270</td>
<td>nF</td>
</tr>
<tr>
<td>Thermistor</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Rated resistance</td>
<td>R</td>
<td></td>
<td></td>
<td>Ω</td>
</tr>
<tr>
<td>Deviation of R100</td>
<td>ΔR/R</td>
<td></td>
<td>Tj=25°C</td>
<td>22000</td>
</tr>
<tr>
<td>Power dissipation</td>
<td>P</td>
<td></td>
<td>Tj=25°C</td>
<td>200</td>
</tr>
<tr>
<td>Power dissipation constant</td>
<td></td>
<td></td>
<td>Tj=25°C</td>
<td>2</td>
</tr>
<tr>
<td>B-value</td>
<td>B_{25/50}</td>
<td>Tol. ±3%</td>
<td>Tj=25°C</td>
<td>3950</td>
</tr>
<tr>
<td>B-value</td>
<td>B_{25/100}</td>
<td>Tol. ±3%</td>
<td>Tj=25°C</td>
<td>3996</td>
</tr>
<tr>
<td>Vincotech NTC Reference</td>
<td></td>
<td></td>
<td></td>
<td>B</td>
</tr>
</tbody>
</table>
Half Bridge
half bridge MOSFET and neutral point FWD

**Figure 1**

Typical output characteristics
\[ I_D = f(V_{DS}) \]

At
- \( t_p = 250 \ \mu s \)
- \( T_J = 25 \ \degree C \)
- \( V_{DS} \) from -6 V to 20 V in steps of 2 V

**Figure 2**

Typical output characteristics
\[ I_D = f(V_{DS}) \]

At
- \( t_p = 250 \ \mu s \)
- \( T_J = 125 \ \degree C \)
- \( V_{DS} \) from -6 V to 20 V in steps of 2 V

**Figure 3**

Typical transfer characteristics
\[ I_D = f(V_{GS}) \]

At
- \( t_p = 250 \ \mu s \)
- \( V_{DS} = 10 \ \text{V} \)

**Figure 4**

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

At
- \( t_p = 250 \ \mu s \)

- \( T_J = T_{case} = 25 \degree C \)
- \( T_J = T_{case} = 25 \degree C \)
Half Bridge

half bridge MOSFET and neutral point FWD

**Figure 5** MOSFET

Typical switching energy losses as a function of drain current

\[ E = f(I_d) \]

With an inductive load at

- \( T_j = 25/125 \) °C
- \( V_{GS} = 350 \) V
- \( V_{DS} = +16/-5 \) V
- \( R_{	ext{on}} = 4 \) Ω
- \( R_{	ext{off}} = 4 \) Ω

**Figure 6** MOSFET

Typical switching energy losses as a function of gate resistor

\[ E = f(R_g) \]

With an inductive load at

- \( T_j = 25/125 \) °C
- \( V_{GS} = 350 \) V
- \( V_{DS} = +16/-5 \) V
- \( I_0 = 44 \) A

**Figure 7** FWD

Typical reverse recovery energy loss as a function of drain current

\[ E_{	ext{rec}} = f(I_d) \]

With an inductive load at

- \( T_j = 25/125 \) °C
- \( V_{GS} = 350 \) V
- \( V_{DS} = +16/-5 \) V
- \( R_{	ext{on}} = 4 \) Ω

**Figure 8** FWD

Typical reverse recovery energy loss as a function of gate resistor

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

With an inductive load at

- \( T_j = 25/125 \) °C
- \( V_{GS} = 350 \) V
- \( V_{DS} = +16/-5 \) V
- \( I_0 = 44 \) A
Half Bridge

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

With an inductive load at
- \( T_j = 125 \) °C
- \( V_{GS} = 350 \) V
- \( V_{DS} = +16/-5 \) V
- \( R_{on} = 4 \) Ω
- \( R_{off} = 4 \) Ω

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

With an inductive load at
- \( T_j = 125 \) °C
- \( V_{GS} = 350 \) V
- \( V_{DS} = +16/-5 \) V
- \( I_o = 44 \) A

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

At
- \( T_j = 25/125 \) °C
- \( V_{GS} = 350 \) V
- \( V_{DS} = +16/-5 \) V
- \( R_{on} = 4 \) Ω

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

At
- \( T_j = 25/125 \) °C
- \( V_{GS} = 350 \) V
- \( I_o = 44 \) A
- \( V_{DS} = +16/-5 \) V
Half Bridge
half bridge MOSFET and neutral point FWD

**Figure 13**
Typical reverse recovery charge as a function of drain current
$Q_{rr} = f(I_D)$

![Graph showing $Q_{rr}$ as a function of $I_D$](image)

**At**
- $T_J = 25/125$ °C
- $V_{DS} = 350$ V
- $V_{GS} = +16/-5$ V
- $R_{GON} = 4$ Ω

**Figure 14**
Typical reverse recovery charge as a function of MOSFET turn on gate resistor
$Q_{rr} = f(R_{GON})$

![Graph showing $Q_{rr}$ as a function of $R_{GON}$](image)

**At**
- $T_J = 25/125$ °C
- $V_D = 350$ V
- $I_D = 44$ A
- $V_{GS} = +16/-5$ V

**Figure 15**
Typical reverse recovery current as a function of drain current
$I_{RRM} = f(I_D)$

![Graph showing $I_{RRM}$ as a function of $I_D$](image)

**At**
- $T_J = 25/125$ °C
- $V_{DS} = 350$ V
- $V_{GS} = +16/-5$ V
- $R_{GON} = 4$ Ω

**Figure 16**
Typical reverse recovery current as a function of MOSFET turn on gate resistor
$I_{RRM} = f(R_{GON})$

![Graph showing $I_{RRM}$ as a function of $R_{GON}$](image)

**At**
- $T_J = 25/125$ °C
- $V_D = 350$ V
- $I_D = 44$ A
- $V_{GS} = +16/-5$ V
**Half Bridge**

half bridge MOSFET and neutral point FWD

---

**Figure 17**

Typical rate of fall of forward and reverse recovery current as a function of drain current

\[
dL/dt, dL_\text{rev}/dt = f(I_d)
\]

---

**Figure 18**

Typical rate of fall of forward and reverse recovery current as a function of MOSFET turn on gate resistor

\[
dL/dt, dL_\text{rev}/dt = f(R_{\text{on}})
\]

---

**Figure 19**

MOSFET transient thermal impedance as a function of pulse width

\[
Z_{\text{th,FW}} = f(D)
\]

---

**Figure 20**

FWD transient thermal impedance as a function of pulse width

\[
Z_{\text{th,FW}} = f(D)
\]

---

MOSFET thermal model values

<table>
<thead>
<tr>
<th>R (K/W)</th>
<th>Tau (s)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0,02</td>
<td>9,2E-01</td>
</tr>
<tr>
<td>0,36</td>
<td>1,3E-01</td>
</tr>
<tr>
<td>0,09</td>
<td>4,4E-02</td>
</tr>
<tr>
<td>0,06</td>
<td>6,1E-03</td>
</tr>
<tr>
<td>0,08</td>
<td>7,1E-04</td>
</tr>
</tbody>
</table>

FWD thermal model values

<table>
<thead>
<tr>
<th>R (K/W)</th>
<th>Tau (s)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0,08</td>
<td>3,0E+00</td>
</tr>
<tr>
<td>0,18</td>
<td>5,1E-01</td>
</tr>
<tr>
<td>0,85</td>
<td>8,5E-02</td>
</tr>
<tr>
<td>0,29</td>
<td>2,6E-02</td>
</tr>
<tr>
<td>0,17</td>
<td>3,9E-03</td>
</tr>
<tr>
<td>0,06</td>
<td>8,3E-04</td>
</tr>
</tbody>
</table>
Half Bridge
half bridge MOSFET and neutral point FWD

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

**Figure 22**
Drain current as a function of heatsink temperature
\[ I_D = f(T_s) \]

At
- \( T_J = 150 \) °C

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

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

At
- \( T_J = 175 \) °C
- \( V_{DS} = 15 \) V
**Half Bridge**

Half bridge MOSFET and neutral point FWD

**Figure 25**

Safe operating area as a function of drain-source voltage

\[ I_D = f(V_{DS}) \]

At

\[ D = \text{single pulse} \]

\[ T_h = 80 \text{ °C} \]

\[ V_{DS} = 15 \text{ V} \]

\[ T_J = T_{J_{max}} \text{ °C} \]

**Figure 27**

Reverse bias safe operating area

\[ I_D = f(V_{DS}) \]

At

\[ T_J = T_{J_{max}} - 25 \text{ °C} \]

\[ V_{DS} = V_{DS_{max}} \]

Switching mode: 3 level switching
Neutral Point
neutral point IGBT and half bridge FWD

**Figure 1**
Typical output characteristics
$I_C = f(V_{ce})$

![Graph showing typical output characteristics]

At
$\tau_p = 250 \ \mu s$
$T_J = 25 \ ^\circ C$
$V_{CE}$ from 7 V to 17 V in steps of 1 V

**Figure 2**
Typical output characteristics
$I_C = f(V_{ce})$

![Graph showing typical output characteristics]

At
$\tau_p = 250 \ \mu s$
$T_J = 125 \ ^\circ C$
$V_{CE}$ from 7 V to 17 V in steps of 1 V

**Figure 3**
Typical transfer characteristics
$I_C = f(V_{ce})$

![Graph showing typical transfer characteristics]

At
$\tau_p = 250 \ \mu s$
$V_{CE} = 0 \ \text{V}$

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

![Graph showing typical FWD forward current]

At
$\tau_p = 250 \ \mu s$
Neutral Point
neutral point IGBT and half bridge FWD

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

With an inductive load at
\[ T_1 = 25/125 \degree C \]
\[ V_{DC} = 350 \, V \]
\[ V_{GSS} = \pm 15 \, V \]
\[ R_{fsw} = 2 \, \Omega \]
\[ R_{gss} = 2 \, \Omega \]

Figure 6  IGBT
Typical switching energy losses as a function of gate resistor
\[ E = f(R_{G}) \]

With an inductive load at
\[ T_1 = 25/125 \degree C \]
\[ V_{DC} = 350 \, V \]
\[ V_{GSS} = \pm 15 \, V \]
\[ I_{C} = 44 \, A \]

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

With an inductive load at
\[ T_1 = 25/125 \degree C \]
\[ V_{DC} = 350 \, V \]
\[ V_{GSS} = \pm 15 \, V \]
\[ R_{fsw} = 2 \, \Omega \]

Figure 8  FWD
Typical reverse recovery energy loss as a function of gate resistor
\[ E_{rev} = f(R_{G}) \]

With an inductive load at
\[ T_1 = 25/125 \degree C \]
\[ V_{DC} = 350 \, V \]
\[ V_{GSS} = \pm 15 \, V \]
\[ I_{C} = 44 \, A \]
Neutral Point
neutral point IGBT and half bridge FWD

**Figure 9**
**IGBT**
Typical switching times as a function of collector current
$t = f(I_c)$

![Graph showing typical switching times as a function of collector current.]

With an inductive load at
- $T_J = 125 \text{ °C}$
- $V_{CE} = 350 \text{ V}$
- $V_{GE} = \pm 15 \text{ V}$
- $R_{gpm} = 2 \text{ Ω}$
- $R_{gff} = 2 \text{ Ω}$

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

![Graph showing typical switching times as a function of gate resistor.]

With an inductive load at
- $T_J = 125 \text{ °C}$
- $V_{CE} = 350 \text{ V}$
- $V_{GE} = \pm 15 \text{ V}$
- $I_c = 44 \text{ A}$

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

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

**At**
- $T_J = 25/125 \text{ °C}$
- $V_{CE} = 350 \text{ V}$
- $V_{GE} = \pm 15 \text{ V}$
- $R_{gpm} = 2 \text{ Ω}$

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

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

**At**
- $T_J = 25/125 \text{ °C}$
- $V_{S} = 350 \text{ V}$
- $I_r = 44 \text{ A}$
- $V_{GE} = \pm 15 \text{ V}$
Neutral Point
neutral point IGBT and half bridge FWD

Figure 13
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
- \( R_{gon} = 2 \) Ω

Figure 14
Typical reverse recovery charge as a function of IGBT turn on gate resistor
\( Q_{rr} = f(R_{gon}) \)

At
- \( T_j = 25/125 \) °C
- \( V_{CE} = 350 \) V
- \( I_r = 44 \) A
- \( V_{GE} = \pm 15 \) V

Figure 15
Typical reverse recovery current as a function of collector current
\( I_{RRH} = f(I_c) \)

At
- \( T_j = 25/125 \) °C
- \( V_{CE} = 350 \) V
- \( V_{GE} = \pm 15 \) V
- \( R_{gon} = 2 \) Ω

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

At
- \( T_j = 25/125 \) °C
- \( V_{CE} = 350 \) V
- \( I_r = 44 \) A
- \( V_{GE} = \pm 15 \) V
Neutral Point
neutral point IGBT and half bridge FWD

**Figure 17**
Typical rate of fall of forward and reverse recovery current as a function of collector current
\[ \frac{dI}{dt}, \frac{dI_{rev}}{dt} = f(I_c) \]

At
- \( T_j = 25/125 \) °C
- \( V_{C3} = 350 \) V
- \( V_{C3} = \pm15 \) V
- \( R_{g3} = 2 \) Ω

**Figure 18**
Typical rate of fall of forward and reverse recovery current as a function of IGBT turn on gate resistor
\[ \frac{dI}{dt}, \frac{dI_{rev}}{dt} = f(R_{on}) \]

At
- \( T_j = 25/125 \) °C
- \( V_{G3} = 350 \) V
- \( I_f = 44 \) A
- \( V_{C3} = \pm15 \) V

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

At
- \( D = \frac{t_p}{T} \)
- \( R_{thJT} = 0,96 \) K/W

IGBT thermal model values

<table>
<thead>
<tr>
<th>R (K/W)</th>
<th>Tau (s)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0,10</td>
<td>2,15</td>
</tr>
<tr>
<td>0,14</td>
<td>0,45</td>
</tr>
<tr>
<td>0,40</td>
<td>0,11</td>
</tr>
<tr>
<td>0,16</td>
<td>0,03</td>
</tr>
<tr>
<td>0,11</td>
<td>0,01</td>
</tr>
</tbody>
</table>

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

At
- \( D = \frac{t_p}{T} \)
- \( R_{thJT} = 2,39 \) K/W

FWD thermal model values

<table>
<thead>
<tr>
<th>R (K/W)</th>
<th>Tau (s)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0,07</td>
<td>2,91</td>
</tr>
<tr>
<td>0,20</td>
<td>0,36</td>
</tr>
<tr>
<td>1,24</td>
<td>0,06</td>
</tr>
<tr>
<td>0,49</td>
<td>0,02</td>
</tr>
<tr>
<td>0,32</td>
<td>0,00</td>
</tr>
</tbody>
</table>
Neutral Point
neutral point IGBT and half bridge FWD

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

![Graph of power dissipation vs. heatsink temperature](image1)

At
\[ T_j = 175 \degree C \]

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

![Graph of collector current vs. heatsink temperature](image2)

At
\[ T_j = 175 \degree C \]

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

![Graph of power dissipation vs. heatsink temperature](image3)

At
\[ T_j = 175 \degree C \]

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

![Graph of forward current vs. heatsink temperature](image4)

At
\[ T_j = 175 \degree C \]
Neutral Point
neutral point IGBT

Figure 25
Reverse bias safe operating area

Ic = f(Vce)

At

Tj = Tjmax - 25 °C
Uce(max) = Uce(max)

Switching mode : 3 level switching
Neutral Point Inverse Diode

**Figure 25** Neutral Point Inverse Diode
Typical FWD forward current as a function of forward voltage
\[ I_F = f(V_F) \]

![Graph showing typical FWD forward current](image)

**Figure 26** Neutral Point Inverse Diode
FWD transient thermal impedance as a function of pulse width
\[ Z_{TH} = f(t_p) \]

**Figure 27** Neutral Point Inverse Diode
Power dissipation as a function of heatsink temperature
\[ P_{Diss} = f(T_h) \]

![Graph showing power dissipation](image)

**Figure 28** Neutral Point Inverse Diode
Forward current as a function of heatsink temperature
\[ I_F = f(T_h) \]

![Graph showing forward current](image)

At
\[ t_p = 250 \mu s \]

At
\[ D = \frac{t_p}{T} \]
\[ R_{TH} = 3.52 \Omega/K \]

At
\[ T_j = 175 \degree C \]
Figure 29
Thermistor

Typical NTC characteristic
as a function of temperature

\[ R_T = f(T) \]

![NTC-typical temperature characteristic](image)
Switching Definitions Half Bridge MOSFET

**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>$R_{DS}$</td>
<td>4 Ω</td>
</tr>
<tr>
<td>$R_{DSS}$</td>
<td>4 Ω</td>
</tr>
</tbody>
</table>

**Figure 1**

**Half bridge MOSFET**

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

($t_{on} = $ integrating time for $E_{on}$)

- $V_{GS}(0\%) = -5$ V
- $V_{GS}(100\%) = 16$ V
- $I_{D}(100\%) = 44$ A
- $t_{off} = 0.07$ μs
- $t_{on} = 0.07$ μs

**Figure 2**

**Half bridge MOSFET**

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

($t_{off} = $ integrating time for $E_{off}$)

- $V_{GS}(0\%) = -5$ V
- $V_{GS}(100\%) = 16$ V
- $V_{DS}(100\%) = 350$ V
- $I_{D}(100\%) = 44$ A
- $t_{on} = 0.02$ μs
- $t_{off} = 0.05$ μs

**Figure 3**

**Half bridge MOSFET**

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

- $V_{DS}(100\%) = 350$ V
- $I_{D}(100\%) = 44$ A
- $t_{f} = 0.013$ μs

**Figure 4**

**Half bridge MOSFET**

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

- $V_{DS}(100\%) = 350$ V
- $I_{D}(100\%) = 44$ A
- $t_{f} = 0.007$ μs
Switching Definitions Half Bridge MOSFET

**Figure 5**

Half bridge MOSFET
Turn-off Switching Waveforms & definition of \( t_{\text{on}} \)

\[
P_{\text{off}} (100\%) = 15,43 \text{ kW}
\]
\[
E_{\text{off}} (100\%) = 0,08 \text{ mJ}
\]

\( t_{\text{on}} = 0,07 \mu \text{s} \)

**Figure 6**

Half bridge MOSFET
Turn-on Switching Waveforms & definition of \( t_{\text{on}} \)

\[
P_{\text{on}} (100\%) = 15,43 \text{ kW}
\]
\[
E_{\text{on}} (100\%) = 0,11 \text{ mJ}
\]

\( t_{\text{on}} = 0,05 \mu \text{s} \)

**Figure 8**

Neutral point FWD
Turn-off Switching Waveforms & definition of \( t_{\text{on}} \)

\[
V_d (100\%) = 350 \text{ V}
\]
\[
I_d (100\%) = 44 \text{ A}
\]
\[
I_{\text{onset}} (100\%) = -44 \text{ A}
\]

\( t_{\text{on}} = 0,012 \mu \text{s} \)
Switching Definitions Half Bridge MOSFET

Figure 9: Turn-on Switching Waveforms & definition of \( t_{qr} \)

\( t_{qr} = \) integrating time for \( q_r \)

\( I_v(100\%) = 44 \) A

\( Q_v(100\%) = 0,18 \) \( \mu \)C

\( t_{qr} = 0,024 \) \( \mu \)s

Figure 10: Turn-on Switching Waveforms & definition of \( t_{rec} \)

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

\( P_{rec}(100\%) = 15,43 \) kW

\( E_{rec}(100\%) = 0,023 \) mJ

\( t_{rec} = 0,024 \) \( \mu \)s

Half Bridge MOSFET switching measurement circuit

Figure 11
Switching Definitions Neutral Point IGBT

General conditions

\[ T_J = 125 \, ^\circ C \]
\[ R_{on} = 2 \, \Omega \]
\[ R_{off} = 2 \, \Omega \]

Figure 1 Neutral Point IGBT
Turn-off Switching Waveforms & definition of \( t_{\text{doff}}, t_{\text{off}} \)
(\( t_{\text{onf}} = \) integrating time for \( E_{\text{off}} \))

\[
\begin{align*}
V_{\text{G}} (0\%) & = 0 \, V \\
V_{\text{G}} (100\%) & = 23 \, V \\
V_c (100\%) & = 700 \, V \\
l_c (100\%) & = 44 \, A \\
t_{\text{doff}} & = 0,10 \, \mu s \\
t_{\text{off}} & = 0,17 \, \mu s \\
\end{align*}
\]

Figure 2 Neutral Point IGBT
Turn-on Switching Waveforms & definition of \( t_{\text{don}}, t_{\text{on}} \)
(\( t_{\text{onf}} = \) integrating time for \( E_{\text{on}} \))

\[
\begin{align*}
V_{\text{G}} (0\%) & = 0 \, V \\
V_{\text{G}} (100\%) & = 23 \, V \\
V_c (100\%) & = 700 \, V \\
l_c (100\%) & = 44 \, A \\
t_{\text{don}} & = 0,05 \, \mu s \\
t_{\text{on}} & = 0,12 \, \mu s \\
\end{align*}
\]

Figure 3 Neutral Point IGBT
Turn-off Switching Waveforms & definition of \( t_r \)

\[
\begin{align*}
V_c (100\%) & = 700 \, V \\
l_c (100\%) & = 44 \, A \\
t_r & = 0,011 \, \mu s \\
\end{align*}
\]

Figure 4 Neutral Point IGBT
Turn-on Switching Waveforms & definition of \( t_r \)

\[
\begin{align*}
V_c (100\%) & = 700 \, V \\
l_c (100\%) & = 44 \, A \\
t_r & = 0,005 \, \mu s \\
\end{align*}
\]
Switching Definitions Neutral Point IGBT

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

![Waveform diagram showing $P_{\text{off}}$, $E_{\text{off}}$, $t_{\text{off}}$, and $I_{\text{on}}$.]

$P_{\text{off}}(100\%) = 30.83$ kW
$E_{\text{off}}(100\%) = 0.30$ mJ
$t_{\text{off}} = 0.17\ $μs

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

![Waveform diagram showing $P_{\text{on}}$, $E_{\text{on}}$, $t_{\text{on}}$, and $I_{\text{off}}$.]

$P_{\text{on}}(100\%) = 30.8259$ kW
$E_{\text{on}}(100\%) = 0.38$ mJ
$t_{\text{on}} = 0.12\ $μs

Figure 8 Half Bridge FWD
Turn-off Switching Waveforms & definition of $t_{\text{on}}$

![Waveform diagram showing $V_d$, $I_d$, $t_{\text{on}}$, and $I_{\text{on}}$.]

$V_d(100\%) = 700$ V
$I_d(100\%) = 44$ A
$I_{\text{on}}(100\%) = -44$ A
$t_{\text{on}} = 0.04\ $μs
Switching Definitions Neutral Point IGBT

Figure 9: Half Bridge FWD
Turn-on Switching Waveforms & definition of $t_{Qr}$
($t_{Qr}$ = integrating time for $Q_r$)

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

$I_q (100\%) = 44$ A
$Q_r (100\%) = 0,59$ $\mu$C
$t_{Qr} = 0,085$ $\mu$s

$P_{rec} (100\%) = 30,83$ kW
$E_{rec} (100\%) = 0,09$ mJ
$t_{Erec} = 0,09$ $\mu$s

Copyright Vincotech
Neutral Point IGBT switching measurement circuit

Figure 11
Ordering Code and Marking - Outline - Pinout

**Ordering Code & Marking**

<table>
<thead>
<tr>
<th>Version</th>
<th>Ordering Code</th>
<th>in DataMatrix as</th>
<th>in packaging barcode as</th>
</tr>
</thead>
<tbody>
<tr>
<td>without thermal paste 12mm housing</td>
<td>10-PZ12NMA027ME-M340F63Y</td>
<td>M340F63Y</td>
<td>M340F63Y</td>
</tr>
</tbody>
</table>

**Outline**

**Pinout**
**DISCLAIMER**
The information given in this datasheet describes the type of component and does not represent assured characteristics. For tested values please contact Vincotech. Vincotech reserves the right to make changes without further notice to any products herein to improve reliability, function or design. Vincotech does not assume any liability arising out of the application or use of any product or circuit described herein; neither does it convey any license under its patent rights, nor the rights of others.

**LIFE SUPPORT POLICY**
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.