10-FY07ZAA050SM-L514B28 datasheet

Maximum Ratings

$T_j = 25 \, ^\circ C$, 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>Rectifier Diode</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Peak repetitive reverse voltage</td>
<td>$V_{RRM}$</td>
<td></td>
<td>1600</td>
<td>V</td>
</tr>
<tr>
<td>Continuous (direct) forward current</td>
<td>$I_F$</td>
<td></td>
<td>50</td>
<td>A</td>
</tr>
<tr>
<td>Surge (non-repetitive) forward current</td>
<td>$I_{FSM}$</td>
<td>50 Hz Single Half Sine Wave $6\text{~ms}$ $T_j = 150 , ^\circ C$</td>
<td>490</td>
<td>A</td>
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<tr>
<td>Surge current capability</td>
<td>$I_{2t}$</td>
<td>$t_p = 10 , \text{ms}$</td>
<td>1200</td>
<td>A$^2$</td>
</tr>
<tr>
<td>Total power dissipation</td>
<td>$P_{tot}$</td>
<td>$T_j = T_{j\text{max}}$ $T_i = 80 , ^\circ C$</td>
<td>78</td>
<td>W</td>
</tr>
<tr>
<td>Maximum junction temperature</td>
<td>$T_{j\text{max}}$</td>
<td></td>
<td>150</td>
<td>$^\circ C$</td>
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## Maximum Ratings

\( T_j = 25 ^\circ C \), unless otherwise specified

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<tbody>
<tr>
<td><strong>PFC Switch</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Collector-emitter voltage</td>
<td>( V_{CEO} )</td>
<td></td>
<td>650</td>
<td>V</td>
</tr>
<tr>
<td>Collector current</td>
<td>( I_c )</td>
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<td>30</td>
<td>A</td>
</tr>
<tr>
<td>Repetitive peak collector current</td>
<td>( I_{CMR} ), limited by ( T_{jmax} )</td>
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<td>90</td>
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<tr>
<td>Total power dissipation</td>
<td></td>
<td>( T_i = T_{jmax} ), ( T_s = 80 ^\circ C )</td>
<td>60</td>
<td>W</td>
</tr>
<tr>
<td>Gate-emitter voltage</td>
<td>( V_{GES} )</td>
<td></td>
<td>±20</td>
<td>V</td>
</tr>
<tr>
<td>Maximum junction temperature</td>
<td>( T_{jmax} )</td>
<td></td>
<td>175</td>
<td>(^\circ C)</td>
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<tr>
<td><strong>PFC Diode</strong></td>
<td></td>
<td></td>
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<td></td>
</tr>
<tr>
<td>Peak repetitive reverse voltage</td>
<td>( V_{RRM} )</td>
<td></td>
<td>650</td>
<td>V</td>
</tr>
<tr>
<td>Continuous (direct) forward current</td>
<td>( I_{F} ), ( T_i = T_{jmax} ), ( T_s = 80 ^\circ C )</td>
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<td>29</td>
<td>A</td>
</tr>
<tr>
<td>Repetitive peak forward current</td>
<td>( I_{FRM} )</td>
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<td>180</td>
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<td>Total power dissipation</td>
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<td>( T_i = T_{jmax} ), ( T_s = 80 ^\circ C )</td>
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<td>Maximum junction temperature</td>
<td>( T_{jmax} )</td>
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<td>175</td>
<td>(^\circ C)</td>
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<tr>
<td><strong>H-Bridge Switch</strong></td>
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<tr>
<td>Collector-emitter voltage</td>
<td>( V_{CEO} )</td>
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<td>650</td>
<td>V</td>
</tr>
<tr>
<td>Collector current</td>
<td>( I_c ), limited by ( T_{jmax} ), ( T_s = 80 ^\circ C )</td>
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<td>Repetitive peak collector current</td>
<td>( I_{CMR} ), limited by ( T_{jmax} )</td>
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<td>Turn off safe operating area</td>
<td></td>
<td>( T_j \leq 175 ^\circ C ), ( V_{CE} \leq 650 ) V</td>
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<tr>
<td>Total power dissipation</td>
<td></td>
<td>( T_i = T_{jmax} ), ( T_s = 80 ^\circ C )</td>
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<td>W</td>
</tr>
<tr>
<td>Gate-emitter voltage</td>
<td>( V_{GES} )</td>
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<td>±20</td>
<td>V</td>
</tr>
<tr>
<td>Maximum junction temperature</td>
<td>( T_{jmax} )</td>
<td></td>
<td>175</td>
<td>(^\circ C)</td>
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<tr>
<td><strong>H-Bridge Diode</strong></td>
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<td></td>
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<tr>
<td>Peak repetitive reverse voltage</td>
<td>( V_{RRM} )</td>
<td></td>
<td>650</td>
<td>V</td>
</tr>
<tr>
<td>Continuous (direct) forward current</td>
<td>( I_{F} )</td>
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<td>40</td>
<td>A</td>
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<tr>
<td>Repetitive peak forward current</td>
<td>( I_{FRM} )</td>
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<td>80</td>
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<td>Total power dissipation</td>
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<td>( T_i = T_{jmax} ), ( T_s = 80 ^\circ C )</td>
<td>58</td>
<td>W</td>
</tr>
<tr>
<td>Maximum junction temperature</td>
<td>( T_{jmax} )</td>
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<td>175</td>
<td>(^\circ C)</td>
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### Maximum Ratings

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

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<th>Parameter</th>
<th>Symbol</th>
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<tr>
<td><strong>Current Transformer Protection Diode</strong></td>
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<tr>
<td>Peak repetitive reverse voltage</td>
<td>$V_{RRM}$</td>
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<td>650</td>
<td>V</td>
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<tr>
<td>Continuous (direct) forward current</td>
<td>$I_{F}$</td>
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<tr>
<td>Repetitive peak forward current</td>
<td>$I_{PFA}$</td>
<td>$T_j = T_{jimax}$</td>
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<td>Total power dissipation</td>
<td>$P_{tot}$</td>
<td>$T_j = T_{jimax}$, $T_i = 80 , ^\circ\text{C}$</td>
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<td>W</td>
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<td>Maximum junction temperature</td>
<td>$T_{jmax}$</td>
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<td>°C</td>
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<td><strong>PFC Sw. Protection Diode</strong></td>
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<tr>
<td>Peak repetitive reverse voltage</td>
<td>$V_{RRM}$</td>
<td></td>
<td>650</td>
<td>V</td>
</tr>
<tr>
<td>Continuous (direct) forward current</td>
<td>$I_{F}$</td>
<td></td>
<td>10</td>
<td>A</td>
</tr>
<tr>
<td>Repetitive peak forward current</td>
<td>$I_{PFA}$</td>
<td>$T_j = T_{jimax}$</td>
<td>20</td>
<td>A</td>
</tr>
<tr>
<td>Total power dissipation</td>
<td>$P_{tot}$</td>
<td>$T_j = T_{jimax}$, $T_i = 80 , ^\circ\text{C}$</td>
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<td>W</td>
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<tr>
<td>Maximum junction temperature</td>
<td>$T_{jmax}$</td>
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<td>°C</td>
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<td><strong>Capacitor (DC)</strong></td>
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<td>Maximum DC voltage</td>
<td>$V_{MAX}$</td>
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<td>630</td>
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<td>Operation Temperature</td>
<td>$T_{op}$</td>
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<td>-55...+125</td>
<td>°C</td>
</tr>
<tr>
<td><strong>Module Properties</strong></td>
<td></td>
<td></td>
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<td><strong>Thermal Properties</strong></td>
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<tr>
<td>Storage temperature</td>
<td>$T_{stg}$</td>
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<td>-40...+125</td>
<td>°C</td>
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<tr>
<td>Operation temperature under switching condition</td>
<td>$T_{jop}$</td>
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<td>-40...($T_{jmax}$ - 25)</td>
<td>°C</td>
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<td><strong>Isolation Properties</strong></td>
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<td>Isolation voltage</td>
<td>$V_{isol}$</td>
<td>DC Test Voltage* $t_p = 2 , s$</td>
<td>4000</td>
<td>V</td>
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<td>AC Voltage $t_p = 1 , min$</td>
<td>2500</td>
<td>V</td>
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<tr>
<td>Creepage distance</td>
<td></td>
<td></td>
<td>min. 12,7</td>
<td>mm</td>
</tr>
<tr>
<td>Clearance</td>
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<td>7,58</td>
<td>mm</td>
</tr>
<tr>
<td>Comparative Tracking Index</td>
<td>CTI</td>
<td></td>
<td>&gt; 200</td>
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*100 % tested in production
### Characteristic Values

<table>
<thead>
<tr>
<th>Parameter</th>
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<th>Unit</th>
</tr>
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<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>Min</td>
<td>Typ</td>
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<tr>
<td></td>
<td></td>
<td></td>
<td>V&lt;sub&gt;GE&lt;/sub&gt; [V]</td>
<td>V&lt;sub&gt;GS&lt;/sub&gt; [V]</td>
</tr>
<tr>
<td>Rectifier Diode</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Static</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Forward voltage</td>
<td>V&lt;sub&gt;F&lt;/sub&gt;</td>
<td>50</td>
<td>25</td>
<td>1,14</td>
</tr>
<tr>
<td>Reverse leakage current</td>
<td>I&lt;sub&gt;R&lt;/sub&gt;</td>
<td>1600</td>
<td>25</td>
<td>50</td>
</tr>
<tr>
<td>Thermal</td>
<td>R&lt;sub&gt;th(j-s)&lt;/sub&gt;</td>
<td>λ&lt;sub&gt;paste&lt;/sub&gt; = 3,4 W/mK (PSX)</td>
<td>0,90</td>
<td>K/W</td>
</tr>
<tr>
<td>PFC Switch</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Static</td>
<td></td>
<td></td>
<td></td>
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</tr>
<tr>
<td>Gate-emitter threshold voltage</td>
<td>V&lt;sub&gt;GE(th)&lt;/sub&gt;</td>
<td>V&lt;sub&gt;GE&lt;/sub&gt; = V&lt;sub&gt;CE&lt;/sub&gt;</td>
<td>0,0003</td>
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</tr>
<tr>
<td>Collector-emitter saturation voltage</td>
<td>V&lt;sub&gt;CEsat&lt;/sub&gt;</td>
<td>15</td>
<td>30</td>
<td>25</td>
</tr>
<tr>
<td>Collector-emitter cut-off current</td>
<td>I&lt;sub&gt;CES&lt;/sub&gt;</td>
<td>20</td>
<td>0</td>
<td>25</td>
</tr>
<tr>
<td>Gate-emitter leakage current</td>
<td>I&lt;sub&gt;GES&lt;/sub&gt;</td>
<td>15</td>
<td>520</td>
<td>30</td>
</tr>
<tr>
<td>Internal gate resistance</td>
<td>r&lt;sub&gt;g&lt;/sub&gt;</td>
<td>none</td>
<td>Ω</td>
<td></td>
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<tr>
<td>Input capacitance</td>
<td>C&lt;sub&gt;in&lt;/sub&gt;</td>
<td>f= 1 Mhz</td>
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<td>25</td>
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<tr>
<td>Reverse transfer capacitance</td>
<td>C&lt;sub&gt;res&lt;/sub&gt;</td>
<td>7,7</td>
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<td></td>
</tr>
<tr>
<td>Dynamic</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Turn-on delay time</td>
<td>t&lt;sub&gt;d(on)&lt;/sub&gt;</td>
<td>0 / 15</td>
<td>400</td>
<td>30</td>
</tr>
<tr>
<td>Rise time</td>
<td>τ&lt;sub&gt;d&lt;/sub&gt;</td>
<td>25</td>
<td>125</td>
<td>4</td>
</tr>
<tr>
<td>Turn-off delay time</td>
<td>t&lt;sub&gt;d(off)&lt;/sub&gt;</td>
<td>25</td>
<td>125</td>
<td>99</td>
</tr>
<tr>
<td>Fall time</td>
<td>τ&lt;sub&gt;f&lt;/sub&gt;</td>
<td>25</td>
<td>125</td>
<td>4</td>
</tr>
<tr>
<td>Turn-on energy (per pulse)</td>
<td>E&lt;sub&gt;on&lt;/sub&gt;</td>
<td>Q&lt;sub&gt;on-LED&lt;/sub&gt; = 0,3 µC</td>
<td>25</td>
<td>125</td>
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<tr>
<td>Turn-off energy (per pulse)</td>
<td>E&lt;sub&gt;off&lt;/sub&gt;</td>
<td>Q&lt;sub&gt;off-LED&lt;/sub&gt; = 1,1 µC</td>
<td>25</td>
<td>125</td>
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## Characteristic Values

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<th>Unit</th>
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<td><strong>Parameter</strong></td>
<td></td>
<td></td>
<td>Min</td>
<td>Typ</td>
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<tr>
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<tr>
<td>Forward voltage</td>
<td>$V_A$</td>
<td>30</td>
<td>25</td>
<td>2,46</td>
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<tr>
<td>Reverse leakage current</td>
<td>$I_R$</td>
<td>650</td>
<td>25</td>
<td>10</td>
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<tr>
<td><strong>Thermal</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Thermal resistance junction to sink</td>
<td>$R_{th(j-s)}$</td>
<td>λ = 3,4 W/mK (PSX)</td>
<td>1,83</td>
<td>K/W</td>
</tr>
<tr>
<td><strong>Dynamic</strong></td>
<td></td>
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</tr>
<tr>
<td>Peak recovery current</td>
<td>$I_{RRM}$</td>
<td>0 / 15</td>
<td>25</td>
<td>38</td>
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<tr>
<td>Reverse recovery time</td>
<td>$t_{rr}$</td>
<td>0 / 15</td>
<td>25</td>
<td>46</td>
</tr>
<tr>
<td>Recovered charge</td>
<td>$Q_r$</td>
<td>0 / 15</td>
<td>25</td>
<td>0,342</td>
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<tr>
<td>Reverse recovered energy</td>
<td>$E_{rec}$</td>
<td>0 / 15</td>
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<td>0,042</td>
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<tr>
<td>Peak rate of fall of recovery current</td>
<td>$\left(\frac{di}{dt}\right)_{max}$</td>
<td>0 / 15</td>
<td>25</td>
<td>1007</td>
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<tbody>
<tr>
<td>Gate-emitter threshold voltage</td>
<td>$V_{GE}$</td>
<td>$V_{CE} = V_{CE}$</td>
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<tr>
<td>Collector-emitter saturation voltage</td>
<td>$V_{CEsat}$</td>
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<td>25</td>
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<tr>
<td>Collector-emitter cut-off current</td>
<td>$I_{CE}$</td>
<td></td>
<td>0</td>
<td>650</td>
</tr>
<tr>
<td>Gate-emitter leakage current</td>
<td>$I_{GE}$</td>
<td></td>
<td>20</td>
<td>0</td>
</tr>
<tr>
<td>Input capacitance</td>
<td>$C_{isc}$</td>
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<td>25</td>
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<tr>
<td>Output capacitance</td>
<td>$C_{oes}$</td>
<td>$f = 1$ Mhz</td>
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<td>Reverse transfer capacitance</td>
<td>$C_{res}$</td>
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<td></td>
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<tr>
<td>Gate charge</td>
<td>$Q_{g}$</td>
<td></td>
<td>15</td>
<td>520</td>
</tr>
<tr>
<td>Thermal resistance junction to sink</td>
<td>$R_{th(j-s)}$</td>
<td>$λ_{PSX} = 3,4 \text{ W/mK}$</td>
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<td></td>
</tr>
<tr>
<td>Turn-on delay time</td>
<td>$t_{on}$</td>
<td></td>
<td>25</td>
<td>125</td>
</tr>
<tr>
<td>Rise time</td>
<td>$t_{r}$</td>
<td>$R_{on} = 8$ Ω</td>
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<td></td>
</tr>
<tr>
<td>Turn-off delay time</td>
<td>$t_{off}$</td>
<td></td>
<td>25</td>
<td>125</td>
</tr>
<tr>
<td>Fall time</td>
<td>$t_{f}$</td>
<td>$R_{off} = 8$ Ω</td>
<td></td>
<td></td>
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<tr>
<td>Turn-on energy (per pulse)</td>
<td>$E_{on}$</td>
<td>$Q_{on} = 1,3 \mu$C</td>
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<tr>
<td>Turn-off energy (per pulse)</td>
<td>$E_{off}$</td>
<td>$Q_{off} = 2,7 \mu$C</td>
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### H-Bridge Diode

#### Static

<table>
<thead>
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<th>Parameter</th>
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<th>Conditions</th>
<th>Value</th>
<th>Unit</th>
</tr>
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<tbody>
<tr>
<td>Forward voltage</td>
<td>$V_F$</td>
<td></td>
<td>40</td>
<td>$1.52$</td>
</tr>
<tr>
<td>Reverse leakage current</td>
<td>$I_R$</td>
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<td>650</td>
<td>$2.1$</td>
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#### Thermal

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Symbol</th>
<th>Value</th>
<th>Unit</th>
</tr>
</thead>
<tbody>
<tr>
<td>Thermal resistance junction to sink</td>
<td>$R_{th(j-s)}$</td>
<td>$3.4$</td>
<td>W/mK</td>
</tr>
</tbody>
</table>

#### Dynamic

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Symbol</th>
<th>Conditions</th>
<th>Value</th>
<th>Unit</th>
</tr>
</thead>
<tbody>
<tr>
<td>Peak recovery current</td>
<td>$I_{BRM}$</td>
<td></td>
<td>$25$</td>
<td>$23$</td>
</tr>
<tr>
<td>Reverse recovery time</td>
<td>$t_{RR}$</td>
<td></td>
<td>$25$</td>
<td>$90$</td>
</tr>
<tr>
<td>Recovered charge</td>
<td>$Q_r$</td>
<td>$350$</td>
<td>$1,330$</td>
<td>$3,090$</td>
</tr>
<tr>
<td>Reverse recovered energy</td>
<td>$E_{rec}$</td>
<td>$25$</td>
<td>$0.305$</td>
<td>$0.570$</td>
</tr>
<tr>
<td>Peak rate of fall of recovery current</td>
<td>$\left(\frac{di}{dt}\right)_{max}$</td>
<td>$25$</td>
<td>$1064$</td>
<td>$460$</td>
</tr>
</tbody>
</table>

### Current Transformer Protection Diode

#### Static

<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></td>
<td>$10$</td>
<td>$1.67$</td>
</tr>
<tr>
<td>Reverse leakage current</td>
<td>$I_R$</td>
<td></td>
<td>$650$</td>
<td>$0.14$</td>
</tr>
</tbody>
</table>

#### Thermal

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Symbol</th>
<th>Value</th>
<th>Unit</th>
</tr>
</thead>
<tbody>
<tr>
<td>Thermal resistance junction to sink</td>
<td>$R_{th(j-s)}$</td>
<td>$3.4$</td>
<td>W/mK</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>$V_{GE}$</td>
<td>[V]</td>
<td>$V_{GS}$</td>
<td>10</td>
<td>1,67</td>
</tr>
<tr>
<td>$V_{CE}$</td>
<td>[V]</td>
<td>$I_{1}$</td>
<td>Typ</td>
<td>V</td>
</tr>
<tr>
<td>$V_{DS}$</td>
<td>[V]</td>
<td>$I_{2}$</td>
<td>Max</td>
<td>V</td>
</tr>
<tr>
<td>$V_{F}$</td>
<td>[V]</td>
<td>$I_{3}$</td>
<td>Min</td>
<td>V</td>
</tr>
<tr>
<td>$T_{j}$</td>
<td>[°C]</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

### PFC Sw. Protection Diode

#### Static

- **Forward voltage**
  - $V_F$
  - 10
  - 25
  - 125
  - 1,67
  - 1,87
  - V

- **Reverse leakage current**
  - $I_R$
  - 650
  - 25
  - 0,14
  - μA

#### Thermal

- **Thermal resistance junction to sink**
  - $R_{th(j-s)}$
  - $I_{sink} = 3,4 \text{ W/mK (PSX)}$
  - 2,87
  - K/W

#### Capacitor (DC)

- **Capacitance**
  - $C$
  - 100
  - nF

- **Tolerance**
  - -10
  - +10
  - %

- **Dissipation factor**
  - $f = 1 \text{ kHz}$
  - 25
  - 2,5
  - %

#### Thermistor

- **Rated resistance**
  - $R$
  - 25
  - 22
  - kΩ

- **Deviation of $R_{tot}$**
  - $R_{tot} = 1484 \Omega$
  - 100
  - -5
  - 5
  - %

- **Power dissipation**
  - $P$
  - 25
  - 5
  - mW

- **Power dissipation constant**
  - 25
  - 1,5
  - mW/K

- **B-value**
  - $B_{25(50)}$
  - Tol. ±1 %
  - 25
  - 3962
  - K

- **B-value**
  - $B_{25(100)}$
  - Tol. ±1 %
  - 25
  - 4000
  - K

Vincotech NTC Reference

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10-FY07ZAA050SM-L514B28 datasheet

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Rectifier Diode Characteristics

**figure 1.** Typical forward characteristics

$I_F = f(V_F)$

\[ I_F = f(V_F) \]

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

$Z_{th(j-s)} = f(t_p)$

$D = \frac{t_p}{T}$

$R_{th(j-s)} = 0.90 \text{ K/W}$

Diode thermal model values

<table>
<thead>
<tr>
<th>$r$ (K/W)</th>
<th>$\tau$ (s)</th>
</tr>
</thead>
<tbody>
<tr>
<td>3.53E-02</td>
<td>1.46E+01</td>
</tr>
<tr>
<td>8.25E-02</td>
<td>1.44E+00</td>
</tr>
<tr>
<td>2.22E-01</td>
<td>2.31E-01</td>
</tr>
<tr>
<td>4.39E-01</td>
<td>7.58E-02</td>
</tr>
<tr>
<td>8.14E-02</td>
<td>1.11E-02</td>
</tr>
<tr>
<td>3.58E-02</td>
<td>1.56E-03</td>
</tr>
</tbody>
</table>
PFC Switch Characteristics

Figure 1. IGBT Typical output characteristics

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

Figure 2. IGBT Typical output characteristics

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

Figure 3. IGBT Typical transfer characteristics

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

Figure 4. IGBT Transient thermal impedance as function of pulse duration

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

Experiment conditions:
- \(t_p = 250 \mu s\)
- \(V_{CE} = 15 \text{ V}\)
- \(T_j = 125 \text{ °C}\)
- \(150 \text{ °C}\)
- \(V_{GE}\) from 7 V to 17 V in steps of 1 V

transistor thermal model values

\[
V_{CE} = 10 \text{ V}
\]

\[
R_{th(j-s)} = 1,57 \text{ K/W}
\]

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PFC Switch Characteristics

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

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

- \( V_{GE} \) = 130 V
- \( V_{GE} \) = 520 V
- \( Q_G \) (nC)
- \( I_C \) = 30 A

**figure 6.**
Safe operating area

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

- \( I_C \) (A)
- \( V_{CE} \) (V)
- \( D = \) single pulse
- \( T_J = 80 \) °C
- \( V_{DSS} = \pm 15 \) V
- \( T_J = T_{J\text{max}} \)
PFC Diode Characteristics

**Figure 1.**
Typical forward characteristics

\[ I_F = f(V_F) \]

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

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

- \( t_p = 250 \, \mu s \)
- \( T_j = 25 \, ^\circ C \)
- \( D = \frac{t_p}{T} \)
- \( T_j = 125 \, ^\circ C \)
- \( R_{th(j-s)} = 1.83 \, K/W \)

**FWD thermal model values**

<table>
<thead>
<tr>
<th>( R ) (K/W)</th>
<th>( \tau ) (s)</th>
</tr>
</thead>
<tbody>
<tr>
<td>6.05E-02</td>
<td>3.63E+00</td>
</tr>
<tr>
<td>1.50E-01</td>
<td>6.48E-01</td>
</tr>
<tr>
<td>8.27E-01</td>
<td>7.70E-02</td>
</tr>
<tr>
<td>4.06E-01</td>
<td>1.51E-02</td>
</tr>
<tr>
<td>2.16E-01</td>
<td>3.45E-03</td>
</tr>
<tr>
<td>1.73E-01</td>
<td>7.36E-04</td>
</tr>
</tbody>
</table>

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H-Bridge Switch Characteristics

**figure 1.**
Typical output characteristics

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

\[ t_p = 250 \, \mu s \]
\[ V_{CE} = 15 \, V \]
\[ T_J = 25 \, ^\circ C \]

**figure 2.**
Typical output characteristics

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

\[ t_p = 250 \, \mu s \]
\[ V_{CE} \text{ from 5 V to 19 V in steps of 1 V} \]

**figure 3.**
Typical transfer characteristics

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

\[ t_p = 100 \, \mu s \]
\[ V_{CE} = 10 \, V \]
\[ T_J = 25 \, ^\circ C \]

**figure 4.**
Transient thermal impedance as function of pulse duration

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

\[ D = \frac{t_p}{T} \]
\[ R_{eq(s)} = 1.22 \, \text{K/W} \]

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>1,2E-01</td>
<td>8,75E-01</td>
</tr>
<tr>
<td>4,4E-01</td>
<td>1,12E-01</td>
</tr>
<tr>
<td>3,96E-01</td>
<td>3,56E-02</td>
</tr>
<tr>
<td>1,75E-01</td>
<td>7,55E-03</td>
</tr>
<tr>
<td>3,44E-02</td>
<td>1,97E-03</td>
</tr>
<tr>
<td>4,80E-02</td>
<td>4,33E-04</td>
</tr>
</tbody>
</table>
H-Bridge Switch Characteristics

**Figure 5.** IGBT
Gate voltage vs gate charge
\[ V_{GE} = f(Q_G) \]

**Figure 6.** IGBT
Safe operating area
\[ I_C = f(V_{CE}) \]

- \( I_C = 50 \) A
- \( V_{GE} = \pm 15 \) V
- \( T_j = T_{jmax} \)
- \( D = \) single pulse
- \( T_s = 80 \) °C
- \( V_{CE} = \pm 15 \) V
- \( T_j = T_{jmax} \)
**H-Bridge Diode Characteristics**

**Figure 1.**

Typical forward characteristics

\[ I_F = f(V_F) \]

- \( V_F \leq 2.5 \, \text{V} \)
- \( T_J = 25 \, ^\circ \text{C}, 125 \, ^\circ \text{C}, 150 \, ^\circ \text{C} \)
- \( f_{T_P} = 250 \, \mu \text{s} \)

**Figure 2.**

Transient thermal impedance as a function of pulse width

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

- \( t_p = 250 \, \mu \text{s} \)
- \( D = t_p / T \)
- \( R_{TH} = 1.63 \, \text{K/W} \)

FWD thermal model values

<table>
<thead>
<tr>
<th>( T_J ) (°C)</th>
<th>( t ) (s)</th>
<th>( R_{TH} ) (K/W)</th>
</tr>
</thead>
<tbody>
<tr>
<td>25</td>
<td>0.005</td>
<td>5.48E-02</td>
</tr>
<tr>
<td>25</td>
<td>0.01</td>
<td>1.35E-01</td>
</tr>
<tr>
<td>25</td>
<td>0.02</td>
<td>6.09E-01</td>
</tr>
<tr>
<td>25</td>
<td>0.05</td>
<td>4.79E-01</td>
</tr>
<tr>
<td>25</td>
<td>0.1</td>
<td>2.54E-01</td>
</tr>
<tr>
<td>25</td>
<td>0.2</td>
<td>1.02E-01</td>
</tr>
<tr>
<td>125</td>
<td>0.005</td>
<td>4.24E+00</td>
</tr>
<tr>
<td>125</td>
<td>0.01</td>
<td>6.38E-01</td>
</tr>
<tr>
<td>125</td>
<td>0.02</td>
<td>1.07E-01</td>
</tr>
<tr>
<td>125</td>
<td>0.05</td>
<td>3.28E-02</td>
</tr>
<tr>
<td>125</td>
<td>0.1</td>
<td>5.68E-03</td>
</tr>
<tr>
<td>125</td>
<td>0.2</td>
<td>6.59E-04</td>
</tr>
<tr>
<td>150</td>
<td>0.005</td>
<td>1.07E+00</td>
</tr>
<tr>
<td>150</td>
<td>0.01</td>
<td>1.07E-01</td>
</tr>
<tr>
<td>150</td>
<td>0.02</td>
<td>3.28E-02</td>
</tr>
<tr>
<td>150</td>
<td>0.05</td>
<td>5.68E-03</td>
</tr>
<tr>
<td>150</td>
<td>0.1</td>
<td>6.59E-04</td>
</tr>
</tbody>
</table>
Current Transformer Protection Diode Characteristics

Figure 1. Typical forward characteristics

\[ I_F = f(V_F) \]

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

\[ t_p = 250 \mu s \]

\[ T_0 = 25 \degree C \]

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

\[ R_{th(j-s)} = 2.87 \text{ K/W} \]

FWD thermal model values

<table>
<thead>
<tr>
<th>R (K/W)</th>
<th>τ (s)</th>
</tr>
</thead>
<tbody>
<tr>
<td>6.53E-02</td>
<td>3.94E+00</td>
</tr>
<tr>
<td>1.48E-01</td>
<td>4.48E-01</td>
</tr>
<tr>
<td>1.31E+00</td>
<td>5.96E-02</td>
</tr>
<tr>
<td>7.32E-01</td>
<td>1.36E-02</td>
</tr>
<tr>
<td>4.04E-01</td>
<td>2.79E-03</td>
</tr>
<tr>
<td>2.11E-01</td>
<td>5.37E-04</td>
</tr>
</tbody>
</table>
PFC Sw. Protection Diode Characteristics

**Figure 1.**

Typical forward characteristics

\[ I_F = f(V_F) \]

**Figure 2.**

Transient thermal impedance as a function of pulse width

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

- \( t_p = 250 \mu s \)
- \( 25 \, ^\circ C \)
- \( 125 \, ^\circ C \)

**Thermistor Characteristics**

**Figure 1.**

Typical NTC characteristic as a function of temperature

\[ R = f(T) \]
PFC Switching Characteristics

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

$$E = f(I_C)$$

With an inductive load at

\[V_{in} = 400 \text{ V} \quad T_j = 25 \text{ °C} \]

\[V_{in} = 0 / 15 \text{ V} \quad T_j = 125 \text{ °C} \]

\[R_{on} = 8 \quad \Omega \]

\[I_C = 30 \text{ A} \]

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

$$E = f(R_g)$$

With an inductive load at

\[V_{in} = 400 \text{ V} \quad T_j = 25 \text{ °C} \]

\[V_{in} = 0 / 15 \text{ V} \quad T_j = 125 \text{ °C} \]

\[I_C = 30 \text{ A} \]

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

$$E_{rec} = f(I_C)$$

With an inductive load at

\[V_{in} = 400 \text{ V} \quad T_j = 25 \text{ °C} \]

\[V_{in} = 0 / 15 \text{ V} \quad T_j = 125 \text{ °C} \]

\[R_{on} = 8 \quad \Omega \]

\[I_C = 30 \text{ A} \]

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

$$E_{rec} = f(R_g)$$

With an inductive load at

\[V_{in} = 400 \text{ V} \quad T_j = 25 \text{ °C} \]

\[V_{in} = 0 / 15 \text{ V} \quad T_j = 125 \text{ °C} \]

\[I_C = 30 \text{ A} \]
PFC Switching Characteristics

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

\[ t_{d(on)} = f(I_C) \]

With an inductive load at
- \( T_j = 125 \, ^\circ C \)
- \( V_{CE} = 400 \, V \)
- \( V_{GE} = 0 / 15 \, V \)
- \( R_{gon} = 8 \, \Omega \)

\[ t_{d(off)} = f(I_C) \]

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

\[ t_{d(on)} = f(R_g) \]

With an inductive load at
- \( T_j = 125 \, ^\circ C \)
- \( V_{CE} = 400 \, V \)
- \( V_{GE} = 0 / 15 \, V \)
- \( I_C = 30 \, A \)

\[ t_{d(off)} = f(R_g) \]

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

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

At
- \( V_{CE} = 400 \, V \)
- \( V_{GE} = 0 / 15 \, V \)
- \( T_j = 25 \, ^\circ C \)
- \( R_{pm} = 8 \, \Omega \)

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

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

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

At
- \( V_{CE} = 400 \, V \)
- \( V_{GE} = 0 / 15 \, V \)
- \( T_j = 125 \, ^\circ C \)
- \( I_C = 30 \, A \)
PFC Switching Characteristics

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

\[ Q_r = f(I_C) \]

At
- \( V_{CE} = 400 \) V
- \( V_{GE} = 0 / 15 \) V
- \( R_{gon} = 8 \) Ω

\( T_j = 25 \) °C

\( Q_r \) vs. \( I_C \)

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

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

At
- \( V_{CE} = 400 \) V
- \( V_{GE} = 0 / 15 \) V
- \( I_C = 30 \) A

\( T_j = 125 \) °C

\( Q_r \) vs. \( R_{gon} \)

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

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

At
- \( V_{CE} = 400 \) V
- \( V_{GE} = 0 / 15 \) V
- \( R_{gon} = 8 \) Ω

\( T_j = 25 \) °C

\( I_{RM} \) vs. \( I_C \)

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

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

At
- \( V_{CE} = 400 \) V
- \( V_{GE} = 0 / 15 \) V
- \( I_C = 30 \) A

\( T_j = 125 \) °C

\( I_{RM} \) vs. \( R_{gon} \)
PFC Switching Characteristics

Figure 13. FWD
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

- \( V_{CE} = 400 \text{ V} \)
- \( V_{GE} = 0 \text{ / } 15 \text{ V} \)
- \( T_j = 25 ^\circ \text{C} \)
- \( R_{gon} = 8 \Omega \)
- \( I_C = 30 \text{ A} \)

Figure 14. FWD
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

- \( V_{CE} = 400 \text{ V} \)
- \( V_{GE} = 0 \text{ / } 15 \text{ V} \)
- \( T_j = 150 ^\circ \text{C} \)
- \( J_C = 30 \text{ A} \)

Figure 15. IGBT
Reverse bias safe operating area

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

At

- \( T_j = 125 ^\circ \text{C} \)
- \( R_{on} = 8 \Omega \)
- \( R_{off} = 8 \Omega \)
PFC Switching Definitions

General conditions

<table>
<thead>
<tr>
<th>Condition</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>$T_j$</td>
<td>125 °C</td>
</tr>
<tr>
<td>$R_{g,on}$</td>
<td>8 Ω</td>
</tr>
<tr>
<td>$R_{g,off}$</td>
<td>8 Ω</td>
</tr>
</tbody>
</table>

**Figure 1.** Turn-off Switching Waveforms & definition of $t_{doff}$, $t_{Eoff}$ ($t_{Eoff}$ = integrating time for $E_{off}$)

- $V_{CE}(0%) = 0$ V
- $V_{CE}(100%) = 15$ V
- $I_C(100%) = 400$ V
- $I_C(100%) = 30$ A
- $t_{doff} = 115$ ns

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

- $V_{CE}(0%) = 0$ V
- $V_{CE}(100%) = 15$ V
- $I_C(100%) = 400$ V
- $I_C(100%) = 30$ A
- $t_{don} = 17$ ns

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

- $V_{CE}(100%) = 400$ V
- $I_C(10%) = 30$ A
- $t_f = 7$ ns

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

- $V_{CE}(100%) = 400$ V
- $I_C(10%) = 30$ A
- $t_r = 6$ ns
PFC Switching Characteristics

Figure 5. FWD
Turn-off Switching Waveforms & definition of $t_{rr}$

$V_F (100\%) = 400 \text{ V}$
$I_F (100\%) = 30 \text{ A}$
$I_{max} (100\%) = 46 \text{ A}$
$t_{rr} = 44 \text{ ns}$

Figure 6. FWD
Turn-on Switching Waveforms & definition of $t_{Qr}$ ($t_{Qr} = \text{ integrating time for } Q_r$)

$I_r (100\%) = 30 \text{ A}$
$I_{max} (100\%) = 1.06 \mu\text{C}$
H-Bridge 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

- \( V_{DD} = 350 \) V
- \( T_J = 125 \) °C
- \( R_{Gate} = 8 \) Ω

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

\[ E = f(R_g) \]

With an inductive load at 25 °C

- \( V_{DD} = 350 \) V
- \( T_J = 125 \) °C
- \( I_C = 50 \) 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

- \( V_{DD} = 350 \) V
- \( T_J = 125 \) °C
- \( R_{Gate} = 8 \) 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

- \( V_{DD} = 350 \) V
- \( T_J = 125 \) °C
- \( I_C = 50 \) A
H-Bridge Switching Characteristics

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

$t_{d(on)} = f(I_C)$

With an inductive load at
$T_j = 150 \, ^\circ C$
$V_{CE} = 350 \, V$
$V_{GE} = \pm 15 \, V$
$R_{gon} = 8 \, \Omega$
$I_C = 50 \, A$

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

$t_{d(off)} = f(R_g)$

With an inductive load at
$T_j = 150 \, ^\circ C$
$V_{CE} = 350 \, V$
$V_{GE} = \pm 15 \, V$
$R_{goff} = 8 \, \Omega$

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

$t_{rr} = f(I_C)$

With an inductive load at
$T_j = 25 \, ^\circ C$
$V_{CE} = 350 \, V$
$T_j = 125 \, ^\circ C$
$V_{CE} = 150 \, ^\circ C$
$R_{gon} = 8 \, \Omega$

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

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

With an inductive load at
$T_j = 25 \, ^\circ C$
$V_{CE} = 350 \, V$
$R_{gon} = 50 \, A$
H-Bridge Switching Characteristics

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

\[ Q_{r} = f(I_{C}) \]

With an inductive load at
\[ V_{IN} = 350 \text{ V} \]
\[ I_{C} = 50 \text{ A} \]
\[ T_{j} = 25^\circ \text{C} \]

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

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

With an inductive load at
\[ V_{IN} = 350 \text{ V} \]
\[ I_{C} = 50 \text{ A} \]
\[ T_{j} = 150^\circ \text{C} \]

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

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

With an inductive load at
\[ V_{IN} = 350 \text{ V} \]
\[ I_{C} = 50 \text{ A} \]
\[ T_{j} = 25^\circ \text{C} \]

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

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

With an inductive load at
\[ V_{IN} = 350 \text{ V} \]
\[ I_{C} = 50 \text{ A} \]
\[ T_{j} = 150^\circ \text{C} \]
H-Bridge Switching Characteristics

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

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

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

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

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

At
- \( T_j = 125 \) °C
- \( R_{on} = 8 \) Ω
- \( R_{off} = 8 \) Ω

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H-Bridge Switching Definitions

General conditions

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>$T_1$</td>
<td>125 °C</td>
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<tr>
<td>$R_{GS}$</td>
<td>8 Ω</td>
</tr>
<tr>
<td>$R_{ON}$</td>
<td>8 Ω</td>
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**Figure 1:** Turn-off Switching Waveforms & definition of \( t_{Eoff} \) (\( t_{Eoff} \) = integrating time for \( E_{off} \))

- $V_{CE}(0\%) = -15 \text{ V}$
- $V_{CE}(100\%) = 15 \text{ V}$
- $I_{C}(100\%) = 350 \text{ V}$
- $I_{C}(10\%) = 50 \text{ A}$
- $t_{Eoff} = 99 \text{ ns}$

**Figure 2:** Turn-on Switching Waveforms & definition of \( t_{Eon} \) (\( t_{Eon} \) = integrating time for \( E_{on} \))

- $V_{CE}(0\%) = -15 \text{ V}$
- $V_{CE}(100\%) = 15 \text{ V}$
- $I_{C}(100\%) = 350 \text{ V}$
- $I_{C}(10\%) = 50 \text{ A}$
- $t_{Eon} = 133 \text{ ns}$

**Figure 3:** Turn-off Switching Waveforms & definition of \( I_{C10\%} \)

- $V_{CE}(10\%) = 350 \text{ V}$
- $I_{C}(10\%) = 50 \text{ A}$
- $t_{f} = 7 \text{ ns}$

**Figure 4:** Turn-on Switching Waveforms & definition of \( I_{C10\%} \)

- $V_{CE}(10\%) = 350 \text{ V}$
- $I_{C}(10\%) = 50 \text{ A}$
- $t_{r} = 35 \text{ ns}$
**H-Bridge Switching Characteristics**

**Figure 5.**

<table>
<thead>
<tr>
<th>Turn-off Switching Waveforms &amp; definition of $t_{Qr}$</th>
</tr>
</thead>
<tbody>
<tr>
<td>$V_F(100%) = 350$ V</td>
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<tr>
<td>$I_F(100%) = 50$ A</td>
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<tr>
<td>$I_{Fmax}(100%) = 35$ A</td>
</tr>
<tr>
<td>$t_{rr} = 120$ ns</td>
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**Figure 6.**

<table>
<thead>
<tr>
<th>Turn-on Switching Waveforms &amp; definition of $I_{Qr}$ ($I_{Qr} = \text{integrating time for } Q$)</th>
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</thead>
<tbody>
<tr>
<td>$I_{F}(100%) = 50$ A</td>
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<tr>
<td>$Q_r(100%) = 2.70$ μC</td>
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<td>ID</td>
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<tr>
<td>D31, D32, D33, D34</td>
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<tr>
<td>T25, T27</td>
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<tr>
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<tr>
<td>T11, T12, T13, T14</td>
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<td>D26, D28</td>
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<td>D45, D47</td>
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<tr>
<td>C1, C2</td>
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<tr>
<td>R2</td>
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