flowPIM E1

Features
- IGBT M7 with low $V_{CES}$ and improved EMC behavior
- Standard industrial housing
- Optimized $R_{th(j-s)}$ with Phase Change Material
- Built-in NTC

flow E1 12 mm housing

Press-fit pin
Solder pin

Target applications
- Industrial Drives

Types
- 10-EZ12PMA010M7-L927A78T
- 10-E112PMA010M7-L927A78Z

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><strong>Inverter Switch</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Collector-emitter voltage</td>
<td>$V_{CES}$</td>
<td>$T_j = T_{jmax}$, $T_i = 80 , ^\circ C$</td>
<td>1200</td>
<td>V</td>
</tr>
<tr>
<td>Collector current</td>
<td>$I_C$</td>
<td>$T_j = T_{jmax}$</td>
<td>14</td>
<td>A</td>
</tr>
<tr>
<td>Repetitive peak collector current</td>
<td>$I_{CEmax}$</td>
<td>$I_C$, limited by $T_{jmax}$</td>
<td>20</td>
<td>A</td>
</tr>
<tr>
<td>Total power dissipation</td>
<td>$P_{tot}$</td>
<td>$T_j = T_{jmax}$, $T_i = 80 , ^\circ C$</td>
<td>56</td>
<td>W</td>
</tr>
<tr>
<td>Gate-emitter voltage</td>
<td>$V_{GES}$</td>
<td>$T_j = T_{jmax}$</td>
<td>±20</td>
<td>V</td>
</tr>
<tr>
<td>Maximum junction temperature</td>
<td>$T_{jmax}$</td>
<td></td>
<td>175</td>
<td>°C</td>
</tr>
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Maximum Ratings

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<tr>
<td><strong>Inverter Diode</strong></td>
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<td></td>
</tr>
<tr>
<td>Peak repetitive reverse voltage</td>
<td>( V_{RRM} )</td>
<td></td>
<td>1200</td>
<td>V</td>
</tr>
<tr>
<td>Continuous (direct) forward current</td>
<td>( I_{F} )</td>
<td>( T_j = T_{j\text{max}} ) ( T_s = 80 , ^\circ C )</td>
<td>14</td>
<td>A</td>
</tr>
<tr>
<td>Repetitive peak forward current</td>
<td>( I_{FRM} )</td>
<td>( T_j ), limited by ( T_{j\text{max}} )</td>
<td>20</td>
<td>A</td>
</tr>
<tr>
<td>Total power dissipation</td>
<td>( P_{tot} )</td>
<td>( T_j = T_{j\text{max}} ) ( T_s = 80 , ^\circ C )</td>
<td>43</td>
<td>W</td>
</tr>
<tr>
<td>Maximum junction temperature</td>
<td>( T_{j\text{max}} )</td>
<td></td>
<td>175</td>
<td>°C</td>
</tr>
<tr>
<td><strong>Brake Switch</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Collector-emitter voltage</td>
<td>( V_{CES} )</td>
<td></td>
<td>1200</td>
<td>V</td>
</tr>
<tr>
<td>Collector current</td>
<td>( I_{C} )</td>
<td>( T_j = T_{j\text{max}} ) ( T_s = 80 , ^\circ C )</td>
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<td>A</td>
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<td>Repetitive peak collector current</td>
<td>( I_{CRM} )</td>
<td>( I_p ), limited by ( T_{j\text{max}} )</td>
<td>20</td>
<td>A</td>
</tr>
<tr>
<td>Total power dissipation</td>
<td>( P_{tot} )</td>
<td>( T_j = T_{j\text{max}} ) ( T_s = 80 , ^\circ C )</td>
<td>56</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_{j\text{max}} )</td>
<td></td>
<td>175</td>
<td>°C</td>
</tr>
<tr>
<td><strong>Brake Diode</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Peak repetitive reverse voltage</td>
<td>( V_{RRM} )</td>
<td></td>
<td>1200</td>
<td>V</td>
</tr>
<tr>
<td>Continuous (direct) forward current</td>
<td>( I_{F} )</td>
<td>( T_j = T_{j\text{max}} ) ( T_s = 80 , ^\circ C )</td>
<td>14</td>
<td>A</td>
</tr>
<tr>
<td>Repetitive peak forward current</td>
<td>( I_{FRM} )</td>
<td>( T_j ), limited by ( T_{j\text{max}} )</td>
<td>20</td>
<td>A</td>
</tr>
<tr>
<td>Total power dissipation</td>
<td>( P_{tot} )</td>
<td>( T_j = T_{j\text{max}} ) ( T_s = 80 , ^\circ C )</td>
<td>43</td>
<td>W</td>
</tr>
<tr>
<td>Maximum junction temperature</td>
<td>( T_{j\text{max}} )</td>
<td></td>
<td>175</td>
<td>°C</td>
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<tr>
<td><strong>Rectifier 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>1600</td>
<td>V</td>
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<tr>
<td>Continuous (direct) forward current</td>
<td>( I_{F} )</td>
<td>( T_j = T_{j\text{max}} ) ( T_s = 80 , ^\circ C )</td>
<td>47</td>
<td>A</td>
</tr>
<tr>
<td>Surge (non-repetitive) forward current</td>
<td>( I_{SM} )</td>
<td>50 Hz Single Half Sine Wave ( t_p = 10 , \text{ms} ) ( T_j = 150 , ^\circ C )</td>
<td>270</td>
<td>A</td>
</tr>
<tr>
<td>Surge current capability</td>
<td>( P_{t} )</td>
<td></td>
<td>370</td>
<td>A^2\text{s}</td>
</tr>
<tr>
<td>Total power dissipation</td>
<td>( P_{tot} )</td>
<td>( T_j = T_{j\text{max}} ) ( T_s = 80 , ^\circ C )</td>
<td>58</td>
<td>W</td>
</tr>
<tr>
<td>Maximum junction temperature</td>
<td>( T_{j\text{max}} )</td>
<td></td>
<td>150</td>
<td>°C</td>
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</table>
Maximum Ratings

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

<table>
<thead>
<tr>
<th>Parameter</th>
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<th>Unit</th>
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<tbody>
<tr>
<td><strong>Module Properties</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Thermal Properties</strong></td>
<td></td>
<td></td>
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<td></td>
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<tr>
<td>Storage temperature</td>
<td>$T_{stg}$</td>
<td>-40...+125</td>
<td>°C</td>
<td></td>
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<tr>
<td>Operation temperature under</td>
<td>$T_{op}$</td>
<td>-40...($T_{max}$ - 25)</td>
<td>°C</td>
<td></td>
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<tr>
<td>switching condition</td>
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<tr>
<td><strong>Isolation Properties</strong></td>
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<tr>
<td>Isolation voltage</td>
<td>$V_{isol}$</td>
<td>DC Test Voltage* $t_p = 2 \text{ s}$</td>
<td>6000</td>
<td>V</td>
</tr>
<tr>
<td></td>
<td></td>
<td>AC Voltage $t_p = 1 \text{ min}$</td>
<td>2500</td>
<td>V</td>
</tr>
<tr>
<td>Creepage distance</td>
<td></td>
<td>min. 12,7</td>
<td>mm</td>
<td></td>
</tr>
<tr>
<td>Clearance</td>
<td></td>
<td>min. 12,7</td>
<td>mm</td>
<td></td>
</tr>
<tr>
<td>Comparative Tracking Index</td>
<td>CTI</td>
<td></td>
<td>$\geq 600$</td>
<td></td>
</tr>
</tbody>
</table>

*100 % tested in production
# 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&lt;sub&gt;GE&lt;/sub&gt;</td>
<td>[V]</td>
<td>10</td>
<td>0.001</td>
<td>25</td>
</tr>
<tr>
<td>V&lt;sub&gt;GS&lt;/sub&gt;</td>
<td>[V]</td>
<td>15</td>
<td>10</td>
<td>25</td>
</tr>
<tr>
<td>V&lt;sub&gt;CE&lt;/sub&gt;</td>
<td>[V]</td>
<td>0</td>
<td>1200</td>
<td>25</td>
</tr>
<tr>
<td>V&lt;sub&gt;DS&lt;/sub&gt;</td>
<td>[V]</td>
<td>20</td>
<td>0</td>
<td>25</td>
</tr>
<tr>
<td>Internal gate resistance</td>
<td>r&lt;sub&gt;g&lt;/sub&gt;</td>
<td>none</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Input capacitance</td>
<td>C&lt;sub&gt;ies&lt;/sub&gt;</td>
<td>0</td>
<td>10</td>
<td>25</td>
</tr>
<tr>
<td>Output capacitance</td>
<td>C&lt;sub&gt;oes&lt;/sub&gt;</td>
<td>0</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Reverse transfer capacitance</td>
<td>C&lt;sub&gt;res&lt;/sub&gt;</td>
<td>0</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Gate charge</td>
<td>Q&lt;sub&gt;g&lt;/sub&gt;</td>
<td>15</td>
<td>600</td>
<td>10</td>
</tr>
</tbody>
</table>

## Inverter Switch

### Static

**Gate-emitter threshold voltage**

| V<sub>GE(th)</sub> | [V] | 10 | 0.001 | 25 | 5.4 | 6.0 | 6.6 | V |

**Collector-emitter saturation voltage**

| V<sub>CEsat</sub> | [V] | 15 | 10 | 25 | 125 | 150 | 1.66 | 1.90 | 1.96 | V |

**Collector-emitter cut-off current**

| I<sub>oss</sub> | [µA] | 0 | 1200 | 25 | 35 | µA |

**Gate-emitter leakage current**

| I<sub>ges</sub> | [nA] | 20 | 0 | 25 | 500 | nA |

**Internal gate resistance**

| r<sub>g</sub> | none | | | | | | | | Ω |

**Input capacitance**

| C<sub>ies</sub> | 0 | 10 | 25 | 2000 | pF |

**Output capacitance**

| C<sub>oes</sub> | 0 | | | 86 | pF |

**Reverse transfer capacitance**

| C<sub>res</sub> | 0 | | | 23 | |

**Gate charge**

| Q<sub>g</sub> | 15 | 600 | 10 | 25 | 80 | nC |

### Thermal

**Thermal resistance junction to sink**

| R<sub>th(js)</sub> | λ<sub>paste</sub> = 3.4 W/mK (PSX) | 1.69 | K/W |

### Dynamic

**Turn-on delay time**

| t<sub>on</sub> | [ns] | 25 | 125 | 150 | 128 | 126 | 123 | ns |

**Rise time**

| t<sub>r</sub> | R<sub>on</sub> = 32 Ω | R<sub>off</sub> = 32 Ω | 25 | 125 | 150 | 29 | 32 | 34 |

**Turn-off delay time**

| t<sub>off</sub> | [ns] | 25 | 125 | 150 | 145 | 179 | 182 | ns |

**Fall time**

| t<sub>f</sub> | [ns] | 25 | 125 | 150 | 98 | 108 | 117 | ns |

**Turn-on energy (per pulse)**

| E<sub>on</sub> | Q<sub>FWD</sub> = 1.1 µC | Q<sub>FWD</sub> = 1.7 µC | Q<sub>FWD</sub> = 1.8 µC | 25 | 125 | 150 | 0.883 | 1.13 | 1.19 | mWs |

**Turn-off energy (per pulse)**

| E<sub>off</sub> | [mWs] | 25 | 125 | 150 | 0.656 | 0.860 | 0.908 | mWs |

* L<sub>s</sub> = 14 nH
### Characteristic Values

<table>
<thead>
<tr>
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<th>Unit</th>
</tr>
</thead>
<tbody>
<tr>
<td>Forward voltage</td>
<td>( V_{fs} )</td>
<td>10</td>
<td>1,61</td>
<td>( V )</td>
</tr>
<tr>
<td></td>
<td></td>
<td>25, 125, 150</td>
<td>1,69, 1,69</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Min</td>
<td>2,1</td>
<td></td>
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</tbody>
</table>

### Inverter Diode

#### Static

<table>
<thead>
<tr>
<th>Parameter</th>
<th>( I_{F} )</th>
<th>1200</th>
<th>25</th>
<th>25</th>
<th>( \mu A )</th>
</tr>
</thead>
<tbody>
<tr>
<td>Forward voltage</td>
<td>( V_F )</td>
<td>10</td>
<td>25</td>
<td>125</td>
<td>150</td>
</tr>
<tr>
<td>Reverse leakage current</td>
<td>( I_R )</td>
<td>25</td>
<td>25</td>
<td>125</td>
<td>409</td>
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</table>

#### Thermal

<table>
<thead>
<tr>
<th>Parameter</th>
<th>( R_{th(j-s)} )</th>
<th>2,19</th>
<th>K/W</th>
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</thead>
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#### Dynamic

<table>
<thead>
<tr>
<th>Parameter</th>
<th>( I_{peak} )</th>
<th>25</th>
<th>9</th>
<th>9</th>
<th>A</th>
</tr>
</thead>
<tbody>
<tr>
<td>Peak recovery current</td>
<td>( I_{RRM} )</td>
<td>25</td>
<td>125</td>
<td>150</td>
<td></td>
</tr>
<tr>
<td>Reverse recovery time</td>
<td>( t_{rr} )</td>
<td>25</td>
<td>373</td>
<td>409</td>
<td>ns</td>
</tr>
<tr>
<td>Recovered charge</td>
<td>( Q_{rec} )</td>
<td>25</td>
<td>150</td>
<td>125</td>
<td>( \mu C )</td>
</tr>
<tr>
<td>Reverse recovered energy</td>
<td>( E_{rec} )</td>
<td>25</td>
<td>0,374</td>
<td>0,620</td>
<td>mWs</td>
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<tr>
<td>Peak rate of fall of recovery current</td>
<td>( (di/dt)_{max} )</td>
<td>25</td>
<td>85</td>
<td>49</td>
<td>( A/\mu s )</td>
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Copyright Vincotech
## Characteristic Values

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<tr>
<td><strong>Static</strong></td>
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</tr>
<tr>
<td>Gate-emitter threshold voltage</td>
<td>$V_{GE\text{th}}$</td>
<td>10</td>
<td>0,001</td>
<td>25</td>
</tr>
<tr>
<td>Collector-emitter saturation voltage</td>
<td>$V_{CE\text{sat}}$</td>
<td>15</td>
<td>10</td>
<td>25</td>
</tr>
<tr>
<td>Collector-emitter cut-off current</td>
<td>$I_{CE\text{S}}$</td>
<td>0</td>
<td>1200</td>
<td>25</td>
</tr>
<tr>
<td>Gate-emitter leakage current</td>
<td>$I_{GES}$</td>
<td>20</td>
<td>0</td>
<td>25</td>
</tr>
<tr>
<td>Internal gate resistance</td>
<td>$r_{g}$</td>
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<td></td>
</tr>
<tr>
<td>Input capacitance</td>
<td>$C_{gs}$</td>
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<tr>
<td>Output capacitance</td>
<td>$C_{os}$</td>
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<td>25</td>
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<tr>
<td>Reverse transfer capacitance</td>
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<td>23</td>
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<tr>
<td>Gate charge</td>
<td>$Q_{g}$</td>
<td>15</td>
<td>600</td>
<td>10</td>
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<tr>
<td><strong>Thermal</strong></td>
<td></td>
<td></td>
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<td></td>
</tr>
<tr>
<td>Thermal resistance junction to sink</td>
<td>$R_{th(j-s)}$</td>
<td>$λ_{paste} = 3,4 W/mK$ (PSX)</td>
<td></td>
<td>1,69</td>
</tr>
<tr>
<td><strong>Dynamic</strong></td>
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<td></td>
<td></td>
</tr>
<tr>
<td>Turn-on delay time</td>
<td>$t_{(on)}$</td>
<td>0 / 15</td>
<td>600</td>
<td>10</td>
</tr>
<tr>
<td>Rise time</td>
<td>$t_{r}$</td>
<td>$R_{ps} = 32 \Omega$</td>
<td>0 / 15</td>
<td>600</td>
</tr>
<tr>
<td>Turn-off delay time</td>
<td>$t_{(off)}$</td>
<td>$R_{ps} = 32 \Omega$</td>
<td>0 / 15</td>
<td>600</td>
</tr>
<tr>
<td>Fall time</td>
<td>$t_{f}$</td>
<td>$R_{gs} = 32 \Omega$</td>
<td>0 / 15</td>
<td>600</td>
</tr>
<tr>
<td>Turn-on energy (per pulse)</td>
<td>$E_{on}$</td>
<td>$Q_{on\text{H}} = 1 \mu C$</td>
<td>0 / 15</td>
<td>600</td>
</tr>
<tr>
<td>Turn-off energy (per pulse)</td>
<td>$E_{off}$</td>
<td>$Q_{off\text{H}} = 1,6 \mu C$</td>
<td>0 / 15</td>
<td>600</td>
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</tbody>
</table>
### Characteristic Values

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<th>Unit</th>
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<tbody>
<tr>
<td></td>
<td></td>
<td>$V_{ge}$ [V]</td>
<td>10</td>
<td>1.61</td>
</tr>
<tr>
<td></td>
<td></td>
<td>$V_{gs}$ [V]</td>
<td>125</td>
<td>1.69</td>
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<tr>
<td></td>
<td></td>
<td>$I_{f}$ [A]</td>
<td>150</td>
<td>2.1</td>
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<tr>
<td></td>
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<td>$T_{j}$ [°C]</td>
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<tr>
<td></td>
<td></td>
<td>Min</td>
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<tr>
<td></td>
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<td>Typ</td>
<td>125</td>
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<tr>
<td></td>
<td></td>
<td>Max</td>
<td>150</td>
<td></td>
</tr>
</tbody>
</table>

### Brake Diode

#### Static

- **Forward voltage**  
  - $V_{f}$  
  - Conditions:  
    - 10  
    - 125  
    - 150  
  - Value:  
    - 1.61  
    - 1.69  
    - 2.1  
  - Unit: V

- **Reverse leakage current**  
  - $I_{r}$  
  - Conditions:  
    - 1200  
    - 25  
  - Value:  
    - 25  
  - Unit: μA

#### Thermal

- **Thermal resistance junction to sink**  
  - $R_{th(j-s)}$  
  - Value:  
    - 2.19  
  - Unit: K/W

### Dynamic

- **Peak recovery current**  
  - $I_{prm}$  
  - Conditions:  
    - 25  
    - 125  
    - 150  
  - Value:  
    - 7  
    - 8  
    - 8  
  - Unit: A

- **Reverse recovery time**  
  - $t_{rr}$  
  - Conditions:  
    - 25  
    - 125  
    - 150  
  - Value:  
    - 2647  
    - 3964  
    - 4475  
  - Unit: ns

- **Recovered charge**  
  - $Q_{r}$  
  - Conditions:  
    - $di/dt = 165$ A/μs  
    - $di/dt = 148$ A/μs  
    - $di/dt = 153$ A/μs  
  - Value:  
    - 0.989  
    - 1.57  
    - 1.77  
  - Unit: μC

- **Reverse recovered energy**  
  - $E_{rec}$  
  - Conditions:  
    - 25  
    - 125  
    - 150  
  - Value:  
    - 0.337  
    - 0.577  
    - 0.666  
  - Unit: mWs

- **Peak rate of fall of recovery current**  
  - $(di/dt)_{max}$  
  - Conditions:  
    - 25  
    - 125  
    - 150  
  - Value:  
    - 6  
    - 4  
    - 4  
  - Unit: A/μs

### Rectifier Diode

#### Static

- **Forward voltage**  
  - $V_{f}$  
  - Conditions:  
    - 35  
    - 25  
    - 125  
  - Value:  
    - 1.17  
    - 1.13  
  - Unit: V

- **Reverse leakage current**  
  - $I_{r}$  
  - Conditions:  
    - 1600  
    - 25  
  - Value:  
    - 50  
  - Unit: μA

#### Thermal

- **Thermal resistance junction to sink**  
  - $R_{th(j-s)}$  
  - Value:  
    - 1.20  
  - Unit: K/W
### Characteristic Values

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Symbol</th>
<th>Conditions</th>
<th>Value</th>
<th>Unit</th>
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<tr>
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<td>3437</td>
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<td>Vincotech NTC Reference</td>
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Inverter Switch Characteristics

**Figure 1.** Typical output characteristics

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

- \( t_p = 250 \mu s \)
- \( V_{CE} = 15 \text{ V} \)
- \( T_j: 25 ^\circ C \) (solid line)
- \( 125 ^\circ C \) (dotted line)
- \( 150 ^\circ C \) (dashed line)

**Figure 2.** Typical output characteristics

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

- \( t_p = 250 \mu s \)
- \( V_{CE} = 10 \text{ V} \)
- \( T_j: 25 ^\circ C \) (solid line)
- \( 125 ^\circ C \) (dotted line)
- \( 150 ^\circ C \) (dashed line)

**Figure 3.** Typical transfer characteristics

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

- \( t_p = 100 \mu s \)
- \( V_{GE} = 10 \text{ V} \)
- \( T_j: 25 ^\circ C \) (solid line)
- \( 125 ^\circ C \) (dotted line)
- \( 150 ^\circ C \) (dashed line)

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

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

- \( D = t_p / T \)
- \( R_{th(j-s)} = 1,69 \text{ K/W} \)

**IGBT thermal model values**

- \( R (\text{K/W}) \)
- \( \tau (\text{s}) \)
- \( 8,19E-02 \)
- \( 2,69E+00 \)
- \( 1,67E-01 \)
- \( 3,26E-01 \)
- \( 5,87E-01 \)
- \( 5,94E-02 \)
- \( 4,55E-01 \)
- \( 1,53E-02 \)
- \( 2,18E-01 \)
- \( 3,12E-03 \)
- \( 1,79E-01 \)
- \( 4,83E-04 \)
Inverter Switch Characteristics

Figure 5. IGBT
Gate voltage vs gate charge
Safe operating area
$V_G = f(Q_G)$
$I_C = f(V_{CE})$

- $I_C = 10$ A
- $D =$ single pulse
- $T_s = 80$ °C
- $V_{IN} = \pm 15$ V
- $T_j =$ $T_{j,max}$

$V_{CE} = 0$ V
$V_{CE} \leq 0$ V
$T_j \leq 0$ °C

Short circuit duration as a function of $V_G$
Typical short circuit current as a function of $V_G$
$t_{p,SC} = f(V_G)$
$I_{SC} = f(V_G)$
Inverter 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 °C
  - 125 °C
  - 150 °C

**FWD thermal model values**

<table>
<thead>
<tr>
<th>( R_{th(j-s)} ) (K/W)</th>
<th>( \tau ) (s)</th>
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<td>8,09E-02</td>
<td>3,20E+00</td>
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<tr>
<td>2,08E-01</td>
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<tr>
<td>6,85E-01</td>
<td>4,41E-02</td>
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<tr>
<td>5,92E-01</td>
<td>1,02E-02</td>
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<tr>
<td>3,27E-01</td>
<td>2,02E-03</td>
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<tr>
<td>2,95E-01</td>
<td>3,64E-04</td>
</tr>
</tbody>
</table>

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

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30 May, 2019 / Revision 4
Brake Switch Characteristics

**Figure 1.**
Typical output characteristics

$I_C = f(V_{CE})$

**Figure 2.**
Typical output characteristics

$I_C = f(V_{GE})$

**Figure 3.**
Typical transfer characteristics

$I_C = f(V_{GE})$

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

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

- $t_p = 250 \, \mu s$
- $t_p = 100 \, \mu s$
- $V_{CE} = 10 \, V$
- $V_{CE} = 15 \, V$
- $T_j: 25^\circ C$
- $T_j: 125^\circ C$
- $T_j: 150^\circ C$

**IGBT thermal model values**

- $R_{th(j-s)} = 1.69 \, K/W$
- $D = t_p / T$
- $R_{th} (\mu s) = 1.69, 2.69E+00, 3.26E+01, 5.94E+02, 1.53E+02, 3.12E+03, 4.83E+04$

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Brake Switch Characteristics

Figure 5. IGBT

Soft operating area

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

\[ I_c = 10 \, \text{A} \]

D = single pulse

\[ V_T = 80 \, \text{°C} \]

\[ V_{GE} = \pm 15 \, \text{V} \]

\[ T_j = T_{j_{max}} \]
Brake Diode Characteristics

**Figure 1.** Typical forward characteristics
\[ I_F = f(V_F) \]

**Figure 2.** Transient thermal impedance as a function of pulse width
\[ Z_{th(j-s)} = f(t_p) \]

- \( t_p = 250 \, \mu s \)
- \( T_j: 25 \, ^\circ C \)
- \( 125 \, ^\circ C \)
- \( 150 \, ^\circ C \)

- \( D = \frac{t_p}{T} \)
- \( R_{th(j-s)} = 2.19 \, K/W \)

<table>
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<tr>
<th>( R_{th(j-s)} ) (K/W)</th>
<th>( \tau ) (s)</th>
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**Rectifier 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

\[ R = f(T) \]

- NTC-typical temperature characteristic
- \( R \) (Ω)
- \( T \) (°C)

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Inverter Switching Characteristics

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

\[ E = f(I_C) \]

With an inductive load at
- \( V_{CE} = 600 \) V
- \( T_j = 25 \) °C
- \( V_{CE} = \pm 15 \) V
- \( R_{g(on)} = 32 \) Ω
- \( I_C = 10 \) A

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

\[ E = f(R_g) \]

With an inductive load at
- \( V_{CE} = 600 \) V
- \( T_j = 25 \) °C
- \( V_{CE} = \pm 15 \) V
- \( I_C = 10 \) 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
- \( V_{CE} = 600 \) V
- \( T_j = 25 \) °C
- \( V_{CE} = \pm 15 \) V
- \( R_{g(on)} = 32 \) 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
- \( V_{CE} = 600 \) V
- \( T_j = 25 \) °C
- \( V_{CE} = \pm 15 \) V
- \( I_C = 10 \) A
Inverter Switching Characteristics

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

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

With an inductive load at:
- \( T_J = 150 \, ^\circ C \)
- \( V_{CE} = 600 \, V \)
- \( V_{DS} = \pm 15 \, V \)
- \( R_{gon} = 32 \, \Omega \)

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

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

With an inductive load at:
- \( T_J = 150 \, ^\circ C \)
- \( V_{CE} = 600 \, V \)
- \( V_{DS} = \pm 15 \, V \)
- \( I_C = 10 \, A \)

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

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

- \( V_{CE} = 600 \, V \)
- \( V_{DS} = \pm 15 \, V \)
- \( R_{gon} = 32 \, \Omega \)

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

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

- \( V_{CE} = 600 \, V \)
- \( V_{DS} = \pm 15 \, V \)
- \( I_C = 10 \, A \)
Inverter Switching Characteristics

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

\[ Q_r = f(I_C) \]

At
- \( V_{GS} = 600 \) V
- \( V_{DS} = \pm 15 \) V
- \( T_j = 25 \) °C
- \( R_{on} = 32 \) Ω

\[ Q_r \] vs \( I_C \)

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

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

At
- \( V_{GS} = 600 \) V
- \( V_{DS} = \pm 15 \) V
- \( T_j = 25 \) °C
- \( I_C = 10 \) A

\[ Q_r \] vs \( R_{on} \)

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

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

At
- \( V_{GS} = 600 \) V
- \( V_{DS} = \pm 15 \) V
- \( T_j = 25 \) °C
- \( R_{on} = 32 \) Ω

\[ I_{RM} \] vs \( I_C \)

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

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

At
- \( V_{GS} = 600 \) V
- \( V_{DS} = \pm 15 \) V
- \( T_j = 25 \) °C
- \( I_C = 10 \) A

\[ I_{RM} \] vs \( R_{on} \)
**Inverter 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
- \( V_{CE} = 600 \) V
- \( V_{GS} = +15 \) V
- \( T_J = 25 \) °C
- \( R_{gs} = 32 \) Ω

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

At
- \( V_{CE} = 600 \) V
- \( V_{GS} = +15 \) V
- \( T_J = 25 \) °C
- \( I_C = 10 \) A

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

At
- \( T_J = 175 \) °C
- \( R_{gs} = 32 \) Ω
- \( R_{pot} = 32 \) Ω

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Inverter Switching Definitions

General conditions

<table>
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<th>Value</th>
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<tr>
<td>$R_{on}$</td>
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<tr>
<td>$R_{off}$</td>
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</table>

figure 1. IGBT

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

$V_{CE}(0\%) = -15 \text{ V}$
$V_{CE}(100\%) = 15 \text{ V}$
$I_{C}(100\%) = 600 \text{ V}$
$I_{C}(0\%) = 10 \text{ A}$
$t_{doff} = 179 \text{ ns}$

figure 2. IGBT

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

$V_{CE}(0\%) = -15 \text{ V}$
$V_{CE}(100\%) = 15 \text{ V}$
$I_{C}(100\%) = 600 \text{ V}$
$I_{C}(0\%) = 10 \text{ A}$
$t_{don} = 126 \text{ ns}$

figure 3. IGBT

Turn-off Switching Waveforms & definition of $t_f$

$V_{CE}(0\%) = 0 \text{ V}$
$V_{CE}(100\%) = 600 \text{ V}$
$I_{C} (10\%) = 10 \text{ A}$
$t_{f} = 108 \text{ ns}$

figure 4. IGBT

Turn-on Switching Waveforms & definition of $t_r$

$V_{CE}(0\%) = 0 \text{ V}$
$V_{CE}(100\%) = 600 \text{ V}$
$I_{C} (10\%) = 10 \text{ A}$
$t_{r} = 32 \text{ ns}$
Inverter Switching Characteristics

Figure 5. Turn-off Switching Waveforms & definition of \( t_{rr} \)

- \( V_f (100\%) = 600 \text{ V} \)
- \( I_f (100\%) = 10 \text{ A} \)
- \( I_{RMS} (100\%) = 9 \text{ A} \)
- \( t_{rr} = 373 \text{ ns} \)

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

- \( I_o (100\%) = 10 \text{ A} \)
- \( Q_r (100\%) = 1,66 \text{ µC} \)
Brake Switching Characteristics

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

\[ E = f(I_C) \]

With an inductive load at
- \( V_{CC} = 600 \, V \)
- \( 0 / 15 \, V \)
- \( R_{on} = 32 \, \Omega \)

\( T_j = 25 \, ^{\circ}C \)
\( 125 \, ^{\circ}C \)
\( 150 \, ^{\circ}C \)

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

\[ E = f(R_g) \]

With an inductive load at
- \( V_{CC} = 600 \, V \)
- \( 0 / 15 \, V \)
- \( I_C = 10 \, A \)

\( T_j = 25 \, ^{\circ}C \)
\( 125 \, ^{\circ}C \)
\( 150 \, ^{\circ}C \)

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

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

With an inductive load at
- \( V_{CC} = 600 \, V \)
- \( 0 / 15 \, V \)
- \( R_{on} = 32 \, \Omega \)

\( T_j = 25 \, ^{\circ}C \)
\( 125 \, ^{\circ}C \)
\( 150 \, ^{\circ}C \)

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

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

With an inductive load at
- \( V_{CC} = 600 \, V \)
- \( 0 / 15 \, V \)
- \( I_C = 10 \, A \)

\( T_j = 25 \, ^{\circ}C \)
\( 125 \, ^{\circ}C \)
\( 150 \, ^{\circ}C \)
Brake Switching Characteristics

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

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

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

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

With an inductive load at

\[ V_{CE} = 600 \text{ V} \]
\[ V_{GE} = 0 \text{ / } 15 \text{ V} \]
\[ R_{ges} = 32 \Omega \]
\[ I_{C} = 10 \text{ A} \]
\[ T_{j} = 150 \degree C \]

At

\[ V_{CE} = 600 \text{ V} \]
\[ V_{GE} = 0 \text{ / } 15 \text{ V} \]
\[ R_{ges} = 32 \Omega \]
\[ I_{C} = 10 \text{ A} \]
\[ T_{j} = 125 \degree C \]
**Brake 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

\[ Q_r = f(R_{go n}) \]

**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

\[ I_{RM} = f(R_{go n}) \]
Brake Switching Characteristics

**Figure 13.** FWD
Typical rate of fall of forward and reverse recovery current as a function of collector current \(\frac{d_i}{dt}, \frac{d_{ir}}{dt} = f(I_C)\)

At
- \(V_{CE} = 600\) V
- \(V_{GK} = 0 / 15\) V
- \(R_{on} = 32\) Ω
- \(T_J = 25^\circ C\)

**Figure 14.** FWD
Typical rate of fall of forward and reverse recovery current as a function of IGBT turn-on gate resistor \(\frac{d_i}{dt}, \frac{d_{ir}}{dt} = f(R_{gon})\)

At
- \(V_{CE} = 600\) V
- \(V_{GK} = 0 / 15\) V
- \(R_{on} = 32\) Ω
- \(I_C = 10\) A
- \(T_J = 150^\circ C\)

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

At
- \(V_{CE} = 175^\circ C\)
- \(R_{on} = 32\) Ω
- \(R_{off} = 32\) Ω

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Brake Switching Definitions

General conditions

\[\begin{align*}
T_j &= 125 °C \\
R_{gon} &= 32 \, \Omega \\
R_{goff} &= 32 \, \Omega
\end{align*}\]

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

\[\begin{align*}
V_{GE}(0\%) &= 0 \, V \\
V_{GE}(100\%) &= 15 \, V \\
V_{CE}(0\%) &= 600 \, V \\
I_{C}(0\%) &= 10 \, A \\
t_{doff} &= 251 \, \text{ns}
\end{align*}\]

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

\[\begin{align*}
V_{GE}(0\%) &= 0 \, V \\
V_{GE}(100\%) &= 15 \, V \\
V_{CE}(0\%) &= 600 \, V \\
I_{C}(0\%) &= 10 \, A \\
t_{don} &= 68 \, \text{ns}
\end{align*}\]

Figure 3. Turn-off Switching Waveforms & definition of \(t_{r}, t_{f}\)

\[\begin{align*}
I_{C}(0\%) &= 600 \, V \\
I_{C}(10\%) &= 10 \, A \\
t_{r} &= 111 \, \text{ns}
\end{align*}\]

Figure 4. Turn-on Switching Waveforms & definition of \(t_{r}, t_{f}\)

\[\begin{align*}
I_{C}(0\%) &= 600 \, V \\
I_{C}(10\%) &= 10 \, A \\
t_{r} &= 50 \, \text{ns}
\end{align*}\]
Brake Switching Characteristics

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

\begin{align*}
V_F (100\%) &= 600 \text{ V} \\
I_F (100\%) &= 10 \text{ A} \\
I_{RRM (100\%)} &= 8 \text{ A} \\
I_o &= 3964 \text{ ns}
\end{align*}

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

\begin{align*}
I_F (100\%) &= 10 \text{ A} \\
Q_r (100\%) &= 1,57 \mu\text{C}
\end{align*}
10-EZ12PMA010M7-L927A78T
10-E112PMA010M7-L927A78Z
datasheet

Ordering Code & Marking

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<td>10-EZ12PMA010M7-L927A78T</td>
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<td>10-E112PMA010M7-L927A78Z</td>
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<td>without thermal paste 12 mm housing with solder pins</td>
<td>10-E112PMA010M7-L927A78Z-/3/</td>
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<tr>
<td>with thermal paste 12 mm housing with solder pins</td>
<td>10-E112PMA010M7-L927A78Z-/3/</td>
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Pin table

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<th>Pin</th>
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<th>Function</th>
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<td>Br</td>
</tr>
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<td>0</td>
<td>DC-Br</td>
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<td>0</td>
<td>G27</td>
</tr>
<tr>
<td>4</td>
<td>19,2</td>
<td>0</td>
<td>DC-Rect</td>
</tr>
<tr>
<td>5</td>
<td>16</td>
<td>0</td>
<td>G15</td>
</tr>
<tr>
<td>6</td>
<td>12,8</td>
<td>0</td>
<td>DC-3</td>
</tr>
<tr>
<td>7</td>
<td>9,6</td>
<td>0</td>
<td>G13</td>
</tr>
<tr>
<td>8</td>
<td>6,4</td>
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<td>DC-2</td>
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<td>G11</td>
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<td>Ph3</td>
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<td>32</td>
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<td>Therm1</td>
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<tr>
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<td>16</td>
<td>16</td>
<td>Therm2</td>
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<td>23</td>
<td>25,6</td>
<td>6,4</td>
<td>DC+Rect</td>
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Outline

- Solder pin
- Press-fit pin

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### Identification

<table>
<thead>
<tr>
<th>ID</th>
<th>Component</th>
<th>Voltage</th>
<th>Current</th>
<th>Function</th>
<th>Comment</th>
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<tr>
<td>T11, T12, T13, T14, T15, T16</td>
<td>IGBT</td>
<td>1200 V</td>
<td>10 A</td>
<td>Inverter Switch</td>
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<tr>
<td>D11, D12, D13, D14, D15, D16</td>
<td>FWD</td>
<td>1200 V</td>
<td>10 A</td>
<td>Inverter Diode</td>
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<tr>
<td>T27</td>
<td>IGBT</td>
<td>1200 V</td>
<td>10 A</td>
<td>Brake Switch</td>
<td></td>
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<tr>
<td>D27</td>
<td>FWD</td>
<td>1200 V</td>
<td>10 A</td>
<td>Brake Diode</td>
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<tr>
<td>D31, D32, D33, D34, D35, D36</td>
<td>Rectifier</td>
<td>1600 V</td>
<td>35 A</td>
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<td>NTC</td>
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**Packaging instruction**

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<tr>
<th>Standard packaging quantity (SPQ)</th>
<th>&gt;SPQ Standard</th>
<th>&lt;SPQ Sample</th>
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</table>

**Handling instruction**

Handling instructions for flow E1 packages see vincotech.com website.

**Package data**

Package data for flow E1 packages see vincotech.com website.

**UL recognition and file number**

This device is certified according to UL 1557 standard, UL file number E192116. For more information see vincotech.com website.

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