flow 3xMNPC 1

1200 V / 25 A

datasheet

Features

- 3 phase mixed voltage component topology
- neutral point clamped inverter
- reactive power capability
- low inductance layout

Target Applications

- solar inverter
- UPS

Types

- 10-FY12M3A025SH-M746F08
- 10-P112M3A025SH-M746F08Y
- 10-F112M3A025SH-M746F09
- 10-P112M3A025SH-M746F09Y

Maximum Ratings

$T_j = 25 \degree C$, 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>Collector-emitter break down voltage</td>
<td>$V_{CES}$</td>
<td>$T_j = T_{jmax}$</td>
<td>1200</td>
<td>V</td>
</tr>
<tr>
<td>DC collector current</td>
<td>$I_C$</td>
<td>$T_j = T_{jmax}$, $T_s = 80 \degree C$</td>
<td>23</td>
<td>A</td>
</tr>
<tr>
<td>Pulsed collector current</td>
<td>$I_{DSM}$</td>
<td>$I_s$ limited by $T_{jmax}$</td>
<td>75</td>
<td>A</td>
</tr>
<tr>
<td>Turn off safe operating area</td>
<td>$I_{FRR}$</td>
<td>$T_j \leq 150 \degree C$, $V_{CES} = V_{RRM}$</td>
<td>75</td>
<td>A</td>
</tr>
<tr>
<td>Power dissipation per IGBT</td>
<td>$P_{tot}$</td>
<td>$T_j = T_{jmax}$</td>
<td>58</td>
<td>W</td>
</tr>
<tr>
<td>Gate-emitter peak voltage</td>
<td>$V_{GE}$</td>
<td></td>
<td>±20</td>
<td>V</td>
</tr>
<tr>
<td>Short circuit ratings</td>
<td>$I_{SC}$</td>
<td>$T_j \leq 150 \degree C$, $V_{CC} = 15 , V$</td>
<td>10</td>
<td>A</td>
</tr>
<tr>
<td>Maximum Junction Temperature</td>
<td>$T_{jmax}$</td>
<td></td>
<td>175</td>
<td>°C</td>
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</table>

Neutral P. FWD

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Symbol</th>
<th>Condition</th>
<th>Value</th>
<th>Unit</th>
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<tbody>
<tr>
<td>Peak Repetitive Reverse Voltage</td>
<td>$V_{DSM}$</td>
<td></td>
<td>600</td>
<td>V</td>
</tr>
<tr>
<td>DC forward current</td>
<td>$I_D$</td>
<td>$T_j = T_{jmax}$, $T_s = 80 \degree C$</td>
<td>17</td>
<td>A</td>
</tr>
<tr>
<td>Surge forward current</td>
<td>$I_{FSM}$</td>
<td>$I_s$ limited by $T_{jmax}$, $T_j = 100 \degree C$</td>
<td>150</td>
<td>A</td>
</tr>
<tr>
<td>Power dissipation per Diode</td>
<td>$P_{tot}$</td>
<td>$T_j = T_{jmax}$, $T_s = 80 \degree C$</td>
<td>28</td>
<td>W</td>
</tr>
<tr>
<td>Maximum Junction Temperature</td>
<td>$T_{jmax}$</td>
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<td>150</td>
<td>°C</td>
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### 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>Collector-emitter break down voltage</td>
<td>( V_{CES} )</td>
<td>( T_j = 25 , ^\circ C )</td>
<td>600</td>
<td>V</td>
</tr>
<tr>
<td>DC collector current</td>
<td>( I_{C} )</td>
<td>( T_j = T_{	ext{max}} ), ( T_s = 80 , ^\circ C )</td>
<td>18</td>
<td>A</td>
</tr>
<tr>
<td>Pulsed collector current</td>
<td>( I_{\text{pul}} )</td>
<td>( T_j \leq 150 , ^\circ C )</td>
<td>60</td>
<td>A</td>
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<tr>
<td>Turn off safe operating area</td>
<td>( \tau ), limited by ( T_{\text{max}} )</td>
<td>( V_{\text{GE}} = 15 , V )</td>
<td>6</td>
<td>( \mu s )</td>
</tr>
<tr>
<td>Power dissipation per IGBT</td>
<td>( P_{\text{tot}} )</td>
<td>( T_j = T_{\text{max}} ), ( T_s = 80 , ^\circ C )</td>
<td>31</td>
<td>W</td>
</tr>
<tr>
<td>Gate-emitter peak voltage</td>
<td>( V_{\text{GE}} )</td>
<td>( T_j \leq 150 , ^\circ C )</td>
<td>6</td>
<td>V</td>
</tr>
<tr>
<td>Short circuit ratings</td>
<td>( t_{\text{DC}} )</td>
<td>( V_{\text{CE}} = 15 , V )</td>
<td>360</td>
<td>MS</td>
</tr>
<tr>
<td>Maximum Junction Temperature</td>
<td>( T_{\text{max}} )</td>
<td>( T_j = T_{\text{max}} ), ( T_s = 80 , ^\circ C )</td>
<td>175</td>
<td>°C</td>
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### Half Bridge FWD

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Symbol</th>
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<th>Value</th>
<th>Unit</th>
</tr>
</thead>
<tbody>
<tr>
<td>Peak Repetitive Reverse Voltage</td>
<td>( V_{\text{RSM}} )</td>
<td>( T_j = T_{\text{max}} ), ( T_s = 80 , ^\circ C )</td>
<td>1200</td>
<td>V</td>
</tr>
<tr>
<td>DC forward current</td>
<td>( I_{F} )</td>
<td>( T_j = T_{\text{max}} ), ( T_s = 80 , ^\circ C )</td>
<td>10</td>
<td>A</td>
</tr>
<tr>
<td>Surge forward current</td>
<td>( I_{\text{FM}} )</td>
<td>( T_j = T_{\text{max}} ), ( T_s = 80 , ^\circ C )</td>
<td>36</td>
<td>A</td>
</tr>
<tr>
<td>Power dissipation per Diode</td>
<td>( P_{\text{tot}} )</td>
<td>( T_j = T_{\text{max}} ), ( T_s = 80 , ^\circ C )</td>
<td>26</td>
<td>W</td>
</tr>
<tr>
<td>Maximum Junction Temperature</td>
<td>( T_{\text{max}} )</td>
<td>( T_j = T_{\text{max}} ), ( T_s = 80 , ^\circ C )</td>
<td>175</td>
<td>°C</td>
</tr>
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</table>

### Thermal Properties

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Symbol</th>
<th>Condition</th>
<th>Value</th>
<th>Unit</th>
</tr>
</thead>
<tbody>
<tr>
<td>Storage temperature</td>
<td>( T_{\text{Stg}} )</td>
<td></td>
<td>-40...+125</td>
<td>°C</td>
</tr>
<tr>
<td>Operation temperature under switching condition</td>
<td>( T_{\text{op}} )</td>
<td></td>
<td>-40...+(( T_{\text{max}} - 25 ))</td>
<td>°C</td>
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### Insulation Properties

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Symbol</th>
<th>Condition</th>
<th>Value</th>
<th>Unit</th>
</tr>
</thead>
<tbody>
<tr>
<td>Insulation voltage</td>
<td>( V_u )</td>
<td>( t = 2 , s )</td>
<td>6000</td>
<td>V</td>
</tr>
<tr>
<td></td>
<td></td>
<td>( t = 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>12 mm Solder pin</td>
<td>8,19</td>
<td>mm</td>
</tr>
<tr>
<td></td>
<td></td>
<td>12 mm Press-fit pin</td>
<td>7,89</td>
<td>mm</td>
</tr>
<tr>
<td></td>
<td></td>
<td>17 mm Solder pin</td>
<td>min 12,7</td>
<td>mm</td>
</tr>
<tr>
<td></td>
<td></td>
<td>17 mm Press-fit pin</td>
<td>12,65</td>
<td>mm</td>
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</tbody>
</table>

* 100 % tested in production
## Characteristic Values

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<thead>
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<th>Symbol</th>
<th>Conditions</th>
<th>Value</th>
<th>Unit</th>
</tr>
</thead>
<tbody>
<tr>
<td>Collector-emitter saturation voltage</td>
<td>V_{CE}</td>
<td>25</td>
<td>0,0085</td>
<td>V</td>
</tr>
<tr>
<td>Collector-emitter cut-off current</td>
<td>I_{CES}</td>
<td>25</td>
<td>0,0024</td>
<td>mA</td>
</tr>
<tr>
<td>Integrated Gate resistor</td>
<td>R_{gint}</td>
<td></td>
<td>none</td>
<td>Ω</td>
</tr>
<tr>
<td>Rise time</td>
<td>t_{r}</td>
<td>25</td>
<td>1,71</td>
<td>ns</td>
</tr>
<tr>
<td>Fall time</td>
<td>t_{f}</td>
<td>25</td>
<td>2,42</td>
<td>ns</td>
</tr>
<tr>
<td>Turn-off delay time</td>
<td>t_{off}</td>
<td>25</td>
<td>116</td>
<td>µs</td>
</tr>
<tr>
<td>Turn-on energy loss per pulse</td>
<td>E_{on}</td>
<td>25</td>
<td>0,38</td>
<td>mWs</td>
</tr>
<tr>
<td>Input capacitance</td>
<td>C_{in}</td>
<td>25</td>
<td>0,14</td>
<td>pF</td>
</tr>
<tr>
<td>Fall time</td>
<td>t_{f}</td>
<td>25</td>
<td>116</td>
<td>µs</td>
</tr>
<tr>
<td>FALL time</td>
<td>t_{f}</td>
<td>25</td>
<td>116</td>
<td>µs</td>
</tr>
<tr>
<td>Reverse recovered charge</td>
<td>Q_{rr}</td>
<td>25</td>
<td>0,05</td>
<td>mWs</td>
</tr>
<tr>
<td>Thermal resistance chip to heatsink per chip</td>
<td>R_{th(j-s)}</td>
<td>Thermal grease thickness ≤ 50um λ = 3 W/mK</td>
<td>1,64</td>
<td>K/W</td>
</tr>
<tr>
<td>Gate charge</td>
<td>Q_{G}</td>
<td>25</td>
<td>155</td>
<td>nC</td>
</tr>
<tr>
<td>Gate charge</td>
<td>Q_{G}</td>
<td>25</td>
<td>155</td>
<td>nC</td>
</tr>
<tr>
<td>Collector-emitter cut-off current</td>
<td>I_{COM}</td>
<td>25</td>
<td>120</td>
<td>nA</td>
</tr>
<tr>
<td>Gate-emitter leakage current</td>
<td>I_{G}</td>
<td>25</td>
<td>120</td>
<td>nA</td>
</tr>
<tr>
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<td>I_{G}</td>
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<td>25</td>
<td>2,42</td>
<td>ns</td>
</tr>
<tr>
<td>Reverse recovery current</td>
<td>I_{RRM}</td>
<td>25</td>
<td>0,38</td>
<td>mWs</td>
</tr>
<tr>
<td>Reverse recovery time</td>
<td>t_{rr}</td>
<td>25</td>
<td>0,05</td>
<td>mWs</td>
</tr>
<tr>
<td>Reverse leakage current</td>
<td>I_{L}</td>
<td>25</td>
<td>10</td>
<td>µA</td>
</tr>
<tr>
<td>Reverse recovery time</td>
<td>t_{rr}</td>
<td>25</td>
<td>0,05</td>
<td>mWs</td>
</tr>
<tr>
<td>Reverse recovered charge</td>
<td>Q_{rr}</td>
<td>25</td>
<td>0,05</td>
<td>mWs</td>
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<td>Peak reverse recovery current</td>
<td>I_{RRM}</td>
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<td>0,38</td>
<td>mWs</td>
</tr>
<tr>
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<td>t_{rr}</td>
<td>25</td>
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<tr>
<td>Gate charge</td>
<td>Q_{G}</td>
<td>25</td>
<td>155</td>
<td>nC</td>
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<td>Q_{G}</td>
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<td>155</td>
<td>nC</td>
</tr>
<tr>
<td>Collector-emitter cut-off current</td>
<td>I_{COM}</td>
<td>25</td>
<td>120</td>
<td>nA</td>
</tr>
<tr>
<td>Gate-emitter leakage current</td>
<td>I_{G}</td>
<td>25</td>
<td>120</td>
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<td>120</td>
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</tr>
<tr>
<td>Rise time</td>
<td>t_{r}</td>
<td>25</td>
<td>1,71</td>
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</tr>
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<tr>
<td>Reverse recovered charge</td>
<td>Q_{rr}</td>
<td>25</td>
<td>0,05</td>
<td>mWs</td>
</tr>
<tr>
<td>Thermal resistance chip to heatsink per chip</td>
<td>R_{th(j-s)}</td>
<td>Thermal grease thickness ≤ 50um λ = 3 W/mK</td>
<td>1,64</td>
<td>K/W</td>
</tr>
</tbody>
</table>

### Neutral P. FWD

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Symbol</th>
<th>Conditions</th>
<th>Value</th>
<th>Unit</th>
</tr>
</thead>
<tbody>
<tr>
<td>Reverse leakage current</td>
<td>I_{L}</td>
<td>25</td>
<td>10</td>
<td>µA</td>
</tr>
<tr>
<td>Peak reverse recovery current</td>
<td>I_{RRM}</td>
<td>25</td>
<td>0,38</td>
<td>mWs</td>
</tr>
<tr>
<td>Reverse recovery time</td>
<td>t_{rr}</td>
<td>25</td>
<td>0,05</td>
<td>mWs</td>
</tr>
<tr>
<td>Reverse recovered charge</td>
<td>Q_{rr}</td>
<td>25</td>
<td>0,05</td>
<td>mWs</td>
</tr>
<tr>
<td>Peak rate of fall of recovery current</td>
<td>(di/dt)_{max}</td>
<td>25</td>
<td>0,44</td>
<td>µC</td>
</tr>
<tr>
<td>Reverse recovered charge</td>
<td>Q_{rr}</td>
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<td>0,05</td>
<td>mWs</td>
</tr>
<tr>
<td>Thermal resistance chip to heatsink per chip</td>
<td>R_{th(j-s)}</td>
<td>Thermal grease thickness ≤ 50um λ = 3 W/mK</td>
<td>1,64</td>
<td>K/W</td>
</tr>
</tbody>
</table>
# Characteristic Values

<table>
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<tr>
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<th>Value</th>
<th>Unit</th>
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<tbody>
<tr>
<td>Neutral P. IGBT</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Gate-emitter threshold voltage</td>
<td>$V_{GE(th)}$</td>
<td>$V_{EE} = V_{CE}$</td>
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<td>V</td>
</tr>
<tr>
<td>Collector-emitter saturation voltage</td>
<td>$V_{CEsat}$</td>
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<td>15</td>
<td>V</td>
</tr>
<tr>
<td>Collector-emitter cut-off</td>
<td>$I_{CEC}$</td>
<td></td>
<td>0, 600</td>
<td>mA</td>
</tr>
<tr>
<td>Gate-emitter leakage current</td>
<td>$I_{leg}$</td>
<td></td>
<td>20</td>
<td>nA</td>
</tr>
<tr>
<td>Integrated Gate resistor</td>
<td>$R_{gint}$</td>
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<td>none</td>
<td>Ω</td>
</tr>
<tr>
<td>Turn-on delay time</td>
<td>$t_{on}$</td>
<td>$R_{pm} = 16 , \Omega$</td>
<td>±15</td>
<td>ns</td>
</tr>
<tr>
<td>Rise time</td>
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<td>$R_{pm} = 16 , \Omega$</td>
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<tr>
<td>Turn-off delay time</td>
<td>$t_{off}$</td>
<td></td>
<td>15</td>
<td>ns</td>
</tr>
<tr>
<td>Fall time</td>
<td>$t_{f}$</td>
<td></td>
<td>15</td>
<td>ns</td>
</tr>
<tr>
<td>Turn-on energy loss per pulse</td>
<td>$E_{on}$</td>
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<td>72</td>
<td>mW</td>
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<tr>
<td>Turn-off energy loss per pulse</td>
<td>$E_{off}$</td>
<td></td>
<td>14</td>
<td>mW</td>
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<tr>
<td>Input capacitance</td>
<td>$C_{iss}$</td>
<td>$f = 1 , MHz$</td>
<td>71</td>
<td>pF</td>
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<tr>
<td>Gate charge</td>
<td>$Q_{gs}$</td>
<td></td>
<td>15</td>
<td>nC</td>
</tr>
<tr>
<td>Thermal resistance chip to heatsink per chip</td>
<td>$R_{th(j-s)}$</td>
<td>Thermal grease thickness ≤ 50um $\lambda = 1 , W/mK$</td>
<td>3,09</td>
<td>K/W</td>
</tr>
<tr>
<td>Half Bridge FWD</td>
<td></td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>Diode forward voltage</td>
<td>$V_{F}$</td>
<td></td>
<td>8</td>
<td>V</td>
</tr>
<tr>
<td>Reverse leakage current</td>
<td>$I_{R}$</td>
<td></td>
<td>1,2</td>
<td>µA</td>
</tr>
<tr>
<td>Peak reverse recovery current</td>
<td>$I_{rrm}$</td>
<td>$R_{pm} = 16 , \Omega$</td>
<td>±15</td>
<td>µA</td>
</tr>
<tr>
<td>Reverse recovery time</td>
<td>$t_{rr}$</td>
<td>$R_{pm} = 16 , \Omega$</td>
<td>150</td>
<td>ns</td>
</tr>
<tr>
<td>Reverse recovered charge</td>
<td>$Q_{e}$</td>
<td></td>
<td>24</td>
<td>µC</td>
</tr>
<tr>
<td>Peak rate of fall of recovery current</td>
<td>$\left</td>
<td>(d I/d t)_{max}\right</td>
<td>$</td>
<td></td>
</tr>
<tr>
<td>Reverse recovery energy</td>
<td>$E_{rr}$</td>
<td></td>
<td>0,14</td>
<td>mJ</td>
</tr>
<tr>
<td>Thermal resistance chip to heatsink per chip</td>
<td>$R_{th(j-s)}$</td>
<td>Thermal grease thickness ≤ 50um $\lambda = 1 , W/mK$</td>
<td>3,65</td>
<td>K/W</td>
</tr>
<tr>
<td>Thermistor</td>
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<td></td>
</tr>
<tr>
<td>Rated resistance</td>
<td>$R$</td>
<td></td>
<td>25</td>
<td>Ω</td>
</tr>
<tr>
<td>Deviation of $R_{on}$</td>
<td>$\Delta R_{on}$</td>
<td>$R_{on} = 1486 , \Omega$</td>
<td>100</td>
<td>%</td>
</tr>
<tr>
<td>Power dissipation</td>
<td>$P$</td>
<td></td>
<td>25</td>
<td>mW</td>
</tr>
<tr>
<td>Power dissipation constant</td>
<td></td>
<td></td>
<td>3,5</td>
<td>mW/K</td>
</tr>
<tr>
<td>B-value</td>
<td>$B(25/55)$</td>
<td></td>
<td>25</td>
<td>K</td>
</tr>
<tr>
<td>B-value</td>
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Half Bridge

Half Bridge IGBT & Neutral Point FWD

**figure 1.** IGBT

Typical output characteristics

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

At

- \( t_p = 250 \ \mu s \)
- \( T_j = 25 \ ^\circ C \)
- \( V_{CE} \) from 7 V to 17 V in steps of 1 V

**figure 2.** IGBT

Typical output characteristics

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

At

- \( t_p = 250 \ \mu s \)
- \( T_j = 125 \ ^\circ C \)
- \( V_{CE} \) from 7 V to 17 V in steps of 1 V

**figure 3.** IGBT

Typical transfer characteristics

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

\[ I_F = f(V_F) \]

At

- \( t_p = 250 \ \mu s \)
- \( T_j = 25 \ ^\circ C \)
- \( T_j = T_j\text{max} - 25 \ ^\circ C \)
- \( V_{CE} = 10 \ V \)
- \( V_{GE} \) from 7 V to 17 V in steps of 1 V

**figure 4.** FWD

Typical diode forward current as a function of forward voltage

\[ I_F = f(V_F) \]

\[ I_F = f(V_F) \]

At

- \( t_p = 250 \ \mu s \)
Half Bridge

IGBT

Typical switching energy losses as a function of collector current

$$E = f(I_C)$$

![Graph showing typical switching energy losses as a function of collector current](image)

With an inductive load at:

- $$T_J = 25/125 \, ^\circ C$$
- $$V_{CE} = 350 \, V$$
- $$V_{GE} = \pm 15 \, V$$
- $$R_{gon} = 16 \, \Omega$$
- $$R_{goff} = 16 \, \Omega$$

IGBT

Typical switching energy losses as a function of gate resistor

$$E = f(R_G)$$

![Graph showing typical switching energy losses as a function of gate resistor](image)

With an inductive load at:

- $$T_J = 25/125 \, ^\circ C$$
- $$V_{CE} = 350 \, V$$
- $$V_{GE} = \pm 15 \, V$$
- $$I_C = 15 \, A$$

FWD

Typical reverse recovery energy loss as a function of collector current

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

![Graph showing typical reverse recovery energy loss as a function of collector current](image)

With an inductive load at:

- $$T_J = 25/125 \, ^\circ C$$
- $$V_{CE} = 350 \, V$$
- $$V_{GE} = \pm 15 \, V$$
- $$R_{gon} = 16 \, \Omega$$

FWD

Typical reverse recovery energy loss as a function of gate resistor

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

![Graph showing typical reverse recovery energy loss as a function of gate resistor](image)

With an inductive load at:

- $$T_J = 25/125 \, ^\circ C$$
- $$V_{CE} = 350 \, V$$
- $$V_{GE} = \pm 15 \, V$$
- $$I_C = 15 \, A$$
**Half Bridge**

**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.](image)

With an inductive load at

$T_J = 125 \, ^{\circ}\text{C}$

$V_{CE} = 350 \, \text{V}$

$V_{GE} = \pm 15 \, \text{V}$

$R_{gon} = 16 \, \Omega$

$R_{goff} = 16 \, \Omega$

**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.](image)

With an inductive load at

$T_J = 125 \, ^{\circ}\text{C}$

$V_{CE} = 350 \, \text{V}$

$V_{GE} = \pm 15 \, \text{V}$

$I_C = 15 \, \text{A}$

**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.](image)

At

$T_J = 25/125 \, ^{\circ}\text{C}$

$V_{CE} = 350 \, \text{V}$

$V_{GE} = \pm 15 \, \text{V}$

$R_{gon} = 16 \, \Omega$

**FWD**

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

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

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

At

$T_J = 25/125 \, ^{\circ}\text{C}$

$V_B = 350 \, \text{V}$

$I_F = 15 \, \text{A}$

$V_{GE} = \pm 15 \, \text{V}$

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**Half Bridge**

**Half Bridge IGBT & Neutral Point FWD**

**figure 13.** FWD

Typical reverse recovery charge as a function of collector current

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

\[ Q_{rr \text{ High T}} \]

\[ Q_{rr \text{ Low T}} \]

At

- \( T_J = 25/125 \ ^\circ C \)
- \( V_{CE} = 350 \ V \)
- \( V_{GE} = \pm 15 \ V \)
- \( R_{gon} = 16 \ \Omega \)

**figure 14.** FWD

Typical reverse recovery charge as a function of IGBT turn on gate resistor

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

\[ Q_{rr \text{ High T}} \]

\[ Q_{rr \text{ Low T}} \]

At

- \( T_J = 25/125 \ ^\circ C \)
- \( V_R = 350 \ V \)
- \( I_F = 15 \ A \)
- \( V_{GE} = \pm 15 \ V \)

**figure 15.** FWD

Typical reverse recovery current as a function of collector current

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

\[ I_{RRM \text{ High T}} \]

\[ I_{RRM \text{ Low T}} \]

At

- \( T_J = 25/125 \ ^\circ C \)
- \( V_{CE} = 350 \ V \)
- \( V_{GE} = \pm 15 \ V \)
- \( I_F = 15 \ A \)
- \( R_{gon} = 16 \ \Omega \)

**figure 16.** FWD

Typical reverse recovery current as a function of IGBT turn on gate resistor

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

\[ I_{RRM \text{ High T}} \]

\[ I_{RRM \text{ Low T}} \]

At

- \( T_J = 25/125 \ ^\circ C \)
- \( V_R = 350 \ V \)
- \( I_F = 15 \ A \)
- \( V_{GE} = \pm 15 \ V \)

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## Half Bridge

**Half Bridge IGBT & Neutral Point FWD**

### figure 17. FWD

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

\[
\frac{dI_{0}}{dt}, \frac{dI_{\text{rec}}}{dt} = f(I_{c})
\]

- \( I_{c} \) (A)
- \( \frac{dI_{0}}{dt} \) (A/ms)
- \( \frac{dI_{\text{rec}}}{dt} \) (A/ms)

### At

- \( T_{j} = 25/125 \) °C
- \( V_{CE} = 350 \) V
- \( V_{GE} = \pm 15 \) V
- \( R_{\text{gon}} = 16 \) Ω

### figure 18. FWD

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

\[
\frac{dI_{0}}{dt}, \frac{dI_{\text{rec}}}{dt} = f(R_{\text{gon}})
\]

- \( R_{\text{gon}} \) (Ω)
- \( \frac{dI_{0}}{dt} \) (A/ms)
- \( \frac{dI_{\text{rec}}}{dt} \) (A/ms)

### At

- \( T_{j} = 25/125 \) °C
- \( V_{R} = 350 \) V
- \( I_{F} = 15 \) A
- \( V_{GE} = \pm 15 \) V

### figure 19. IGBT

IGBT transient thermal impedance as a function of pulse width

\[
Z_{\text{th}(j-s)} = f(t_{p})
\]

- \( t_{p} \) (s)
- \( Z_{\text{th}(j-s)} \) (K/W)

### At

- \( D = \frac{t_{p}}{T} \)
- \( R_{\text{th}(j-s)} = 1.64 \) K/W

### IGBT thermal model values

- \( R \) (K/W)  
  - 2.04E-01 7.24E-01
  - 6.14E-01 1.26E-01
  - 5.32E-01 4.64E-02
  - 2.06E-01 9.84E-03
  - 8.53E-02 1.28E-03

### figure 20. FWD

FWD transient thermal impedance as a function of pulse width

\[
Z_{\text{th}(j-s)} = f(t_{p})
\]

- \( t_{p} \) (s)
- \( Z_{\text{th}(j-s)} \) (K/W)

### At

- \( D = \frac{t_{p}}{T} \)
- \( R_{\text{th}(j-s)} = 2.48 \) K/W

### FWD thermal model values

- \( R \) (K/W)  
  - 7.74E-02 4.05E+00
  - 1.56E-01 5.69E-01
  - 1.07E+00 7.94E-02
  - 6.06E-01 1.99E-02
  - 3.14E-01 4.66E-03
  - 2.53E-01 9.24E-04
Half Bridge
Half Bridge IGBT & Neutral Point FWD

**Figure 21.**
Power dissipation as a function of heatsink temperature

\[ P_{tot} = f(T_s) \]

At

\[ T_j = 175 \degree C \]

**Figure 22.**
Collector current as a function of heatsink temperature

\[ I_C = f(T_s) \]

At

\[ T_j = 175 \degree C \]

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

**Figure 23.**
Power dissipation as a function of heatsink temperature

\[ P_{tot} = f(T_s) \]

At

\[ T_j = 150 \degree C \]

**Figure 24.**
Forward current as a function of heatsink temperature

\[ I_F = f(T_s) \]

At

\[ T_j = 150 \degree C \]
Figure 25. IGBT
Safe operating area as a function of collector-emitter voltage
\( I_C = f(V_{CE}) \)

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

At
\( D = \) single pulse
\( T_s = 80 \degree C \)
\( V_{GE} = \pm 15 \) V
\( T_j = T_{j\text{max}} \) °C

At
\( I_C = 0 \) A
Neutral Point
Neutral Point IGBT & Half Bridge FWD

**figure 1.** IGBT
Typical output characteristics
$I_C = f(V_{CE})$

![Graph 1](image1.png)

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

**figure 2.** IGBT
Typical output characteristics
$I_C = f(V_{CE})$

![Graph 2](image2.png)

At
$t_p = 250 \ \mu s$
$T_J = 126 \ ^\circ C$
$V_{CE}$ from 7 V to 17 V in steps of 1 V

**figure 3.** IGBT
Typical transfer characteristics
$I_C = f(V_{GE})$

![Graph 3](image3.png)

At
$t_p = 250 \ \mu s$
$V_{CE} = 10 \ \text{V}$
$T_J = T_{Jmax} - 25 \ ^\circ C$

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

![Graph 4](image4.png)

At
$t_p = 250 \ \mu s$
Neutral Point
Neutral Point IGBT & Half Bridge FWD

**figure 5.**
Typical switching energy losses as a function of collector current

\[ E = f(I_C) \]

With an inductive load at

- \( T_J = 25/126 \, ^\circ C \)
- \( V_{CE} = 350 \, V \)
- \( V_{GE} = \pm 15 \, V \)
- \( R_{gon} = 16 \, \Omega \)
- \( I_C = 15 \, A \)

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

\[ E = f(R_G) \]

With an inductive load at

- \( T_J = 25/126 \, ^\circ C \)
- \( V_{CE} = 350 \, V \)
- \( V_{GE} = \pm 15 \, V \)
- \( I_C = 15 \, A \)

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

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

With an inductive load at

- \( T_J = 25/126 \, ^\circ C \)
- \( V_{CE} = 350 \, V \)
- \( V_{GE} = \pm 15 \, V \)
- \( R_{gon} = 16 \, \Omega \)

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

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

With an inductive load at

- \( T_J = 25/126 \, ^\circ C \)
- \( V_{CE} = 350 \, V \)
- \( V_{GE} = \pm 15 \, V \)
- \( I_C = 15 \, A \)
Neutral Point
Neutral Point IGBT & Half Bridge FWD

**figure 9.**
Typical switching times as a function of collector current
\[ t = f(I_C) \]

With an inductive load at:
- \( T_j = 126 \) °C
- \( V_{CE} = 350 \) V
- \( V_{GE} = \pm 15 \) V
- \( R_{gon} = 16 \) Ω
- \( R_{goff} = 16 \) Ω

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

With an inductive load at:
- \( T_j = 126 \) °C
- \( V_{CE} = 350 \) V
- \( V_{GE} = \pm 15 \) V
- \( I_C = 15 \) A

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

At
- \( T_j = 25/126 \) °C
- \( V_{CE} = 350 \) V
- \( V_{GE} = \pm 15 \) V
- \( R_{gon} = 16 \) Ω

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

At
- \( T_j = 25/126 \) °C
- \( V_R = 350 \) V
- \( I_F = 15 \) A
- \( V_{GE} = \pm 15 \) V
Neural Point
Neutral Point IGBT & Half Bridge FWD

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

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

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

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

- **At**
  - \( T_j = 25/126 \) °C
  - \( V_{CE} = 350 \) V
  - \( V_{GE} = \pm 15 \) V
  - \( R_{gon} = 16 \) Ω

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

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

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

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

- **At**
  - \( T_j = 25/126 \) °C
  - \( V_R = 350 \) V
  - \( I_F = 15 \) A
  - \( V_{GE} = \pm 15 \) V

---
**Neutral Point**

Neutral Point IGBT & Half Bridge FWD

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

**At**
- \( T_j = 25/126 \) °C
- \( V_{CE} = 350 \) V
- \( V_{GE} = \pm 15 \) V
- \( R_{gon} = 16 \) Ω

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

**At**
- \( T_j = 25/126 \) °C
- \( V_R = 350 \) V
- \( I_F = 15 \) A
- \( V_{GE} = \pm 15 \) V

**figure 19.**
IGBT transient thermal impedance as a function of pulse width
\[
Z_{th(jCs)} = f(t_p)
\]

**At**
- \( D = \frac{t_p}{T} \)
- \( R_{th(jCs)} = 3,09 \) K/W

**IGBT thermal model values**
- \( R \) (K/W) \( Tau \) (s)
  - 9,31E-02 1,78E+00
  - 3,67E-01 2,71E-01
  - 1,74E+00 6,94E-02
  - 3,64E-01 1,36E-02
  - 2,46E-01 3,45E-03
  - 2,37E-01 4,12E-04

**figure 20.**
FWD transient thermal impedance as a function of pulse width
\[
Z_{th(jCs)} = f(t_p)
\]

**At**
- \( D = \frac{t_p}{T} \)
- \( R_{th(jCs)} = 3,65 \) K/W

**FWD thermal model values**
- \( R \) (K/W) \( Tau \) (s)
  - 1,54E-01 1,23E+00
  - 5,83E-01 1,75E-01
  - 1,42E+00 4,78E-02
  - 7,75E-01 8,99E-03
  - 7,22E-01 1,81E-03

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Neutral Point IGBT & Half Bridge FWD

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

**figure 22.**
Collector current as a function of heatsink temperature
\[ I_C = f(T_s) \]

At
\[ T_j = 175 \, ^\circ C \]

**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
\[ T_j = 175 \, ^\circ C \]

\[ V_{\text{gel}} = 15 \, V \]
figure 1. Thermistor
Typical NTC characteristic as a function of temperature
\[ R_T = f(T) \]
Switching Definitions Half Bridge

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>$R_{gon}$</td>
<td>16 Ω</td>
</tr>
<tr>
<td>$R_{goff}$</td>
<td>16 Ω</td>
</tr>
</tbody>
</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 V
- $V_{CE}$ (100%) = 15 V
- $V_C$ (100%) = 350 V
- $I_C$ (100%) = 15 A
- $t_{doff}$ = 0.22 µs
- $t_{Eoff}$ = 0.69 µs

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

- $V_{CE}$ (0%) = -15 V
- $V_{CE}$ (100%) = 15 V
- $V_C$ (100%) = 350 V
- $I_C$ (100%) = 15 A
- $t_{don}$ = 0.07 µs
- $t_{Eon}$ = 0.20 µs

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

- $V_C$ (100%) = 350 V
- $I_C$ (100%) = 15 A
- $t_f$ = 0.12 µs

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

- $V_C$ (100%) = 350 V
- $I_C$ (100%) = 15 A
- $t_r$ = 0.02 µs
Switching Definitions Half Bridge

**figure 5.** IGBT
Turn-off Switching Waveforms & definition of \( t_{\text{off}} \)

- \( P_{\text{off}} \) (100%) = 5,28 kW
- \( E_{\text{off}} \) (100%) = 0,63 mJ
- \( t_{\text{Eoff}} \) = 0,69 µs

**figure 6.** IGBT
Turn-on Switching Waveforms & definition of \( t_{\text{on}} \)

- \( P_{\text{on}} \) (100%) = 5,28 kW
- \( E_{\text{on}} \) (100%) = 0,30 mJ
- \( t_{\text{Eon}} \) = 0,20 µs

**figure 7.** IGBT
Gate voltage vs Gate charge (measured)

- \( V_{\text{G(off)}} \) = -15 V
- \( V_{\text{G(on)}} \) = 15 V
- \( V_{\text{C}} \) (100%) = 350 V
- \( I_{\text{C}} \) (100%) = 15 A
- \( Q_{g} \) = 180,95 nC

**figure 8.** FWD
Turn-off Switching Waveforms & definition of \( t_{\tau} \)

- \( V_{\text{d}} \) (100%) = 350 V
- \( I_{\text{d}} \) (100%) = 15 A
- \( I_{\text{RRM}} \) (100%) = -22 A
- \( t_{\tau} \) = 0,03 µs
Switching Definitions Half Bridge

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

$I_d (100\%) = 15$ A  
$Q_{rr} (100\%) = 0.44$ µC  
$t_{Qrr} = 0.07$ µs

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

$P_{rec} (100\%) = 5.28$ kW  
$E_{rec} (100\%) = 0.05$ mJ  
$t_{Erec} = 0.07$ µs

**Half Bridge switching measurement circuit**

**Figure 11.** Half Bridge stage switching measurement circuit
Switching Definitions Neutral Point

General conditions

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value</th>
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</thead>
<tbody>
<tr>
<td>( T_j )</td>
<td>125 °C</td>
</tr>
<tr>
<td>( R_{\text{son}} )</td>
<td>16 Ω</td>
</tr>
<tr>
<td>( R_{\text{goff}} )</td>
<td>16 Ω</td>
</tr>
</tbody>
</table>

**figure 1.** Neutral Point IGBT

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

\( t_{\text{Eoff}} = \text{integrating time for } E_{\text{off}} \)

- \( V_C(0\%) = -15 \) V
- \( V_C(100\%) = 15 \) V
- \( I_C(100\%) = 15 \) A
- \( t_{\text{doff}} = 0.16 \) µs
- \( t_{\text{Eoff}} = 0.53 \) µs

**figure 2.** Neutral Point IGBT

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

\( t_{\text{Eon}} = \text{integrating time for } E_{\text{on}} \)

- \( V_C(0\%) = -15 \) V
- \( V_C(100\%) = 15 \) V
- \( I_C(100\%) = 15 \) A
- \( t_{\text{don}} = 0.07 \) µs
- \( t_{\text{Eon}} = 0.18 \) µs

**figure 3.** Neutral Point IGBT

Turn-off Switching Waveforms & definition of \( t_f \)

- \( V_C(100\%) = 350 \) V
- \( I_C(100\%) = 15 \) A
- \( t_f = 0.069 \) µs

**figure 4.** Neutral Point IGBT

Turn-on Switching Waveforms & definition of \( t_r \)

- \( V_C(100\%) = 350 \) V
- \( I_C(100\%) = 15 \) A
- \( t_r = 0.016 \) µs
Switching Definitions Neutral Point

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

- $P_{\text{off}}$ (100%) = 5.26 kW
- $E_{\text{off}}$ (100%) = 0.53 mJ
- $t_{E_{\text{off}}} = 0.53$ µs

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

- $P_{\text{on}}$ (100%) = 5.26 kW
- $E_{\text{on}}$ (100%) = 0.30 mJ
- $t_{E_{\text{on}}} = 0.18$ µs

**figure 8. Half Bridge FWD**
Turn-off Switching Waveforms & definition of $t_{\text{rr}}$

- $V_d$ (100%) = 350 V
- $I_d$ (100%) = 15 A
- $I_{\text{diss}}$ (100%) = -24 A
- $t_{\text{rr}} = 0.04$ µs
Switching Definitions Neutral Point

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

- $I_q (100\%) = 15 \text{ A}$
- $Q_{rr} (100\%) = 1.51 \mu\text{C}$
- $t_{Qint} = 1.00 \mu\text{s}$

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

- $P_{rec} (100\%) = 5.26 \text{ kW}$
- $E_{rec} (100\%) = 0.38 \text{ mJ}$
- $t_{Erec} = 1.00 \mu\text{s}$

**Neutral Point switching measurement circuit**

**Figure 11.**
Neutral Point stage switching measurement circuit
### Ordering Code & Marking

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<th>Version</th>
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**Datasheet for 10-x112M3A025SH-M746F09x**

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### Identification

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<th>Current</th>
<th>Function</th>
<th>Comment</th>
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<td>1200 V</td>
<td>25 A</td>
<td>Half Bridge IGBT</td>
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<tr>
<td>D1,D4,D5,D8,D9,D12</td>
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<td>1200 V</td>
<td>8 A</td>
<td>Half Bridge FWD</td>
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<td>600 V</td>
<td>20 A</td>
<td>Neutral P. IGBT</td>
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**Pinout**

**Identification**

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## Packaging instruction

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</table>

## Handling instruction

Handling instructions for flow 1 packages see vincotech.com website.

## Package data

Package data for flow 1 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.

### Document No.: 10-xY12M3A025SH-M746F0xx-D5-14  
### Date: 12 Jul. 2017  
### Modification: Added press-fit version  
### Pages All

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