V23990-P589-*4*-PM datasheet

flow PIM 1
1200 V / 25 A

Features
- Three-phase rectifier, optional BRC, Inverter, NTC
- Very compact housing, easy to route
- IGBT4 / EmCon4 technology for low saturation losses and improved EMC behaviour

Target Applications
- Industrial drives
- Embedded Drives

Types
- V23990-P589-A41-PM
- V23990-P589-A41Y-PM
- V23990-P589-A418-PM
- V23990-P589-A418Y-PM
- V23990-P589-C41-PM
- V23990-P589-C418-PM

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>Repetitive peak reverse voltage</td>
<td>V_{RRM}</td>
<td></td>
<td>1600</td>
<td>V</td>
</tr>
<tr>
<td>DC forward current</td>
<td>I_{FSD}</td>
<td></td>
<td>35</td>
<td>A</td>
</tr>
<tr>
<td>Surge (non-repetitive) forward current</td>
<td>I_{FSM}</td>
<td>f_{FSM} = 10 ms, T_{j} = 150°C</td>
<td>280</td>
<td>A</td>
</tr>
<tr>
<td>1st-value</td>
<td>I_{1st}</td>
<td>half sine wave</td>
<td>390</td>
<td>A/s</td>
</tr>
<tr>
<td>Power dissipation</td>
<td>P_{pwm}</td>
<td>T_{j} = T_{j max}, T_{s} = 80 °C</td>
<td>56</td>
<td>W</td>
</tr>
<tr>
<td>Maximum Junction Temperature</td>
<td>T_{j max}</td>
<td></td>
<td>150</td>
<td>°C</td>
</tr>
</tbody>
</table>

Inverter Switch

<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 breakdown voltage</td>
<td>V_{CE}</td>
<td></td>
<td>1200</td>
<td>V</td>
</tr>
<tr>
<td>DC collector current</td>
<td>I_{C}</td>
<td>T_{j} = T_{j max}, T_{s} = 80 °C</td>
<td>32</td>
<td>A</td>
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<tr>
<td>Repetitive peak collector current</td>
<td>I_{CRM}</td>
<td>T_{j} limited by T_{j max}</td>
<td>75</td>
<td>A</td>
</tr>
<tr>
<td>Turn off safe operating area</td>
<td>V_{CE}</td>
<td>V_{CE} ≤ 1200V, T_{j} ≤ T_{j max}</td>
<td>50</td>
<td>A</td>
</tr>
<tr>
<td>Power dissipation</td>
<td>P_{pwm}</td>
<td>T_{j} = T_{j max}, T_{s} = 80 °C</td>
<td>94</td>
<td>W</td>
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<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} ≤ 150 °C</td>
<td>10</td>
<td>µs</td>
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<tr>
<td>Maximum Junction Temperature</td>
<td>T_{j max}</td>
<td>V_{GE} = 15 V</td>
<td>800</td>
<td>V</td>
</tr>
</tbody>
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11 Jul. 2018 / Revision 5
## Maximum Ratings

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

### Inverter Diode

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Symbol</th>
<th>Condition</th>
<th>Value</th>
<th>Unit</th>
</tr>
</thead>
<tbody>
<tr>
<td>Peak Repetitive Reverse Voltage</td>
<td>$V_{RRM}$</td>
<td></td>
<td>1200</td>
<td>V</td>
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<tr>
<td>DC forward current</td>
<td>$I_D$</td>
<td>$T_j = T_{jmax}$, $T_s = 80, ^\circ C$</td>
<td>29</td>
<td>A</td>
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<tr>
<td>Repetitive peak forward current</td>
<td>$I_{P dissociation}$</td>
<td>$I_j$ limited by $T_{jmax}$</td>
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<td>A</td>
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<tr>
<td>Power dissipation</td>
<td>$P_{dissociation}$</td>
<td>$T_j = T_{jmax}$, $T_s = 80, ^\circ C$</td>
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<td>W</td>
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<tr>
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<td>$T_{jmax}$</td>
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<td>°C</td>
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### Brake Switch

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Symbol</th>
<th>Condition</th>
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<th>Unit</th>
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<tbody>
<tr>
<td>Collector-emitter breakdown voltage</td>
<td>$V_{ce}$</td>
<td></td>
<td>1200</td>
<td>V</td>
</tr>
<tr>
<td>DC collector current</td>
<td>$I_{C}$</td>
<td>$T_j = T_{jmax}$, $T_s = 80, ^\circ C$</td>
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<td>$I_{CPEAK}$</td>
<td>$I_j$ limited by $T_{jmax}$</td>
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<td>Turn off safe operating area</td>
<td>$V_{CE}$</td>
<td>$V_{CE} \leq 1200, V$, $T_j \leq T_{jmax}$</td>
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<td>A</td>
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<td>$P_{dissociation}$</td>
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<td>Gate–emitter peak voltage</td>
<td>$V_{GE}$</td>
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<td>240</td>
<td>V</td>
</tr>
<tr>
<td>Short circuit ratings</td>
<td>$V_{CC}$</td>
<td>$V_{CC} = 15, V$</td>
<td>10</td>
<td>µs</td>
</tr>
<tr>
<td>Maximum Junction Temperature</td>
<td>$T_{jmax}$</td>
<td></td>
<td>175</td>
<td>°C</td>
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### Brake Diode

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<tr>
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<th>Symbol</th>
<th>Condition</th>
<th>Value</th>
<th>Unit</th>
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</thead>
<tbody>
<tr>
<td>Peak Repetitive Reverse Voltage</td>
<td>$V_{RRM}$</td>
<td></td>
<td>1200</td>
<td>V</td>
</tr>
<tr>
<td>DC forward current</td>
<td>$I_D$</td>
<td>$T_j = T_{jmax}$, $T_s = 80, ^\circ C$</td>
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<td>A</td>
</tr>
<tr>
<td>Repetitive peak forward current</td>
<td>$I_{P dissociation}$</td>
<td>$I_j$ limited by $T_{jmax}$</td>
<td>20</td>
<td>A</td>
</tr>
<tr>
<td>Power dissipation</td>
<td>$P_{dissociation}$</td>
<td>$T_j = T_{jmax}$, $T_s = 80, ^\circ C$</td>
<td>46</td>
<td>W</td>
</tr>
<tr>
<td>Maximum Junction Temperature</td>
<td>$T_{jmax}$</td>
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<td>°C</td>
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### Thermal Properties

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<tr>
<th>Parameter</th>
<th>Symbol</th>
<th>Condition</th>
<th>Value</th>
<th>Unit</th>
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</thead>
<tbody>
<tr>
<td>Storage temperature</td>
<td>$T_{stg}$</td>
<td></td>
<td>-40…+125</td>
<td>°C</td>
</tr>
<tr>
<td>Operation temperature under switching condition</td>
<td>$T_{op}$</td>
<td></td>
<td>-40…+(T_{jmax} - 25)</td>
<td>°C</td>
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### Isolation Properties

<table>
<thead>
<tr>
<th>Parameter</th>
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<th>Condition</th>
<th>Value</th>
<th>Unit</th>
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</thead>
<tbody>
<tr>
<td>Isolation voltage</td>
<td>$V_{is}$</td>
<td>$t = 2, s$</td>
<td>4000</td>
<td>V</td>
</tr>
<tr>
<td>Creepage distance</td>
<td></td>
<td></td>
<td>min 12,7</td>
<td>mm</td>
</tr>
<tr>
<td>Clearance</td>
<td></td>
<td>12mm housing</td>
<td>8,06</td>
<td>mm</td>
</tr>
<tr>
<td></td>
<td></td>
<td>17mm housing</td>
<td>min 12,7</td>
<td>mm</td>
</tr>
<tr>
<td>Comparative tracking index</td>
<td>CTI</td>
<td></td>
<td>&gt;200</td>
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## Characteristic Values

### Rectifier Diode

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Symbol</th>
<th>Value</th>
<th>Unit</th>
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<tbody>
<tr>
<td>Forward voltage</td>
<td>$V_{FS}$</td>
<td>30</td>
<td>1.6</td>
</tr>
<tr>
<td>Threshold voltage (for power loss calc. only)</td>
<td>$V_{FM}$</td>
<td>30</td>
<td>0.78</td>
</tr>
<tr>
<td>Slope resistance (for power loss calc. only)</td>
<td>$r_s$</td>
<td>30</td>
<td>8</td>
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<tr>
<td>Reverse current</td>
<td>$I_{rr}$</td>
<td>1600</td>
<td>2</td>
</tr>
<tr>
<td>Thermal resistance junction to sink</td>
<td>$R_{th(j-s)}$</td>
<td>1.65</td>
<td>K/W</td>
</tr>
</tbody>
</table>

### Inverter Switch

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Symbol</th>
<th>Value</th>
<th>Unit</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gate-emitter leakage current</td>
<td>$I_{GSS}$</td>
<td>20</td>
<td>nA</td>
</tr>
<tr>
<td>Integrated Gate resistor</td>
<td>$R_{gon}$</td>
<td>32</td>
<td>Ω</td>
</tr>
<tr>
<td>Turn-on delay time</td>
<td>$t_{on}$</td>
<td>±15</td>
<td>ns</td>
</tr>
<tr>
<td>Rise time</td>
<td>$t_r$</td>
<td>600</td>
<td>128</td>
</tr>
<tr>
<td>Turn-off delay time</td>
<td>$t_{off}$</td>
<td>25</td>
<td>128</td>
</tr>
<tr>
<td>Fall time</td>
<td>$t_f$</td>
<td>25</td>
<td>128</td>
</tr>
<tr>
<td>Turn-on energy loss</td>
<td>$E_{on}$</td>
<td>25</td>
<td>4.4</td>
</tr>
<tr>
<td>Turn-off energy loss</td>
<td>$E_{off}$</td>
<td>25</td>
<td>1.4</td>
</tr>
<tr>
<td>Input capacitance</td>
<td>$C_{in}$</td>
<td>25</td>
<td>1400</td>
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<tr>
<td>Output capacitance</td>
<td>$C_{out}$</td>
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<td>115</td>
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<tr>
<td>Reverse transfer capacitance</td>
<td>$C_{rr}$</td>
<td>0</td>
<td>85</td>
</tr>
<tr>
<td>Thermal resistance junction to sink</td>
<td>$R_{th(j-s)}$</td>
<td>phase-change material $= 3.4$ W/mK</td>
<td>K/W</td>
</tr>
</tbody>
</table>

### Inverter Diode

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Symbol</th>
<th>Value</th>
<th>Unit</th>
</tr>
</thead>
<tbody>
<tr>
<td>Diode forward voltage</td>
<td>$V_{F}$</td>
<td>25</td>
<td>1.6</td>
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<tr>
<td>Peak reverse recovery current</td>
<td>$I_{RRM}$</td>
<td>25</td>
<td>0.0024</td>
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<tr>
<td>Reverse recovery time</td>
<td>$t_{rr}$</td>
<td>25</td>
<td>128</td>
</tr>
<tr>
<td>Reverse recovered charge</td>
<td>$Q_{rr}$</td>
<td>25</td>
<td>1.6</td>
</tr>
<tr>
<td>Peak rate of fall of recovery current</td>
<td>$I_{di/dt}^{(100)}$</td>
<td>25</td>
<td>1722</td>
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<td>4.81</td>
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<td>$R_{th(j-s)}$</td>
<td>phase-change material $= 3.4$ W/mK</td>
<td>K/W</td>
</tr>
<tr>
<td>Parameter</td>
<td>Symbol</td>
<td>Unit</td>
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<tr>
<td>-----------</td>
<td>--------</td>
<td>------</td>
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<tr>
<td>Collector-emitter voltage</td>
<td>$V_{ce}$</td>
<td>[V]</td>
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<td>Collector-emitter saturation voltage</td>
<td>$V_{cesat}$</td>
<td>[V]</td>
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<tr>
<td>Collector-emitter cut-off voltage</td>
<td>$V_{ces}$</td>
<td>[V]</td>
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<tr>
<td>Gate-emitter voltage</td>
<td>$V_{ge}$</td>
<td>[V]</td>
<td></td>
</tr>
<tr>
<td>Gate-emitter leakage current</td>
<td>$I_{ge}$</td>
<td>[A]</td>
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<tr>
<td>Gate charge</td>
<td>$Q_{g}$</td>
<td>[nC]</td>
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<tr>
<td>Input capacitance</td>
<td>$C_{in}$</td>
<td>[pF]</td>
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<tr>
<td>Output capacitance</td>
<td>$C_{out}$</td>
<td>[pF]</td>
<td></td>
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<tr>
<td>Reverse transfer capacitance</td>
<td>$C_{ies}$</td>
<td>[pF]</td>
<td></td>
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<tr>
<td>Rise time</td>
<td>$t_{r}$</td>
<td>[ns]</td>
<td></td>
</tr>
<tr>
<td>Fall time</td>
<td>$t_{f}$</td>
<td>[ns]</td>
<td></td>
</tr>
<tr>
<td>Turn-on delay time</td>
<td>$t_{on}$</td>
<td>[ns]</td>
<td></td>
</tr>
<tr>
<td>Turn-off delay time</td>
<td>$t_{off}$</td>
<td>[ns]</td>
<td></td>
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<tr>
<td>Integrated Gate resistor</td>
<td>$R_{gint}$</td>
<td>[Ω]</td>
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</tr>
<tr>
<td>Reverse recovery time</td>
<td>$t_{rr}$</td>
<td>[ns]</td>
<td></td>
</tr>
<tr>
<td>Reverse recovered charge</td>
<td>$Q_{r}$</td>
<td>[nC]</td>
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<td>Peak rate of fall of recovery current</td>
<td>$dI_{rr}/dt$</td>
<td>[mA/μs]</td>
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<tr>
<td>Reverse recovery energy</td>
<td>$E_{rec}$</td>
<td>[mJ]</td>
<td></td>
</tr>
<tr>
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<td>$t_{rr}$</td>
<td>[ns]</td>
<td></td>
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<tr>
<td>Reversal current</td>
<td>$I_{r}$</td>
<td>[μA]</td>
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<tr>
<td>Peak reverse recovery current</td>
<td>$I_{rr}$</td>
<td>[μA]</td>
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<tr>
<td>Gate-emitter leakage current</td>
<td>$I_{ge}$</td>
<td>[μA]</td>
<td></td>
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<tr>
<td>Gate charge</td>
<td>$Q_{g}$</td>
<td>[nC]</td>
<td></td>
</tr>
<tr>
<td>Input capacitance</td>
<td>$C_{in}$</td>
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</tr>
<tr>
<td>Output capacitance</td>
<td>$C_{out}$</td>
<td>[pF]</td>
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<tr>
<td>Reverse transfer capacitance</td>
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<td>[pF]</td>
<td></td>
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<tr>
<td>Rise time</td>
<td>$t_{r}$</td>
<td>[ns]</td>
<td></td>
</tr>
<tr>
<td>Fall time</td>
<td>$t_{f}$</td>
<td>[ns]</td>
<td></td>
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<tr>
<td>Turn-on delay time</td>
<td>$t_{on}$</td>
<td>[ns]</td>
<td></td>
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<tr>
<td>Turn-off delay time</td>
<td>$t_{off}$</td>
<td>[ns]</td>
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<tr>
<td>Integrated Gate resistor</td>
<td>$R_{gint}$</td>
<td>[Ω]</td>
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<td>Reverse recovery time</td>
<td>$t_{rr}$</td>
<td>[ns]</td>
<td></td>
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<tr>
<td>Reverse recovered charge</td>
<td>$Q_{r}$</td>
<td>[nC]</td>
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<td>Peak rate of fall of recovery current</td>
<td>$dI_{rr}/dt$</td>
<td>[mA/μs]</td>
<td></td>
</tr>
<tr>
<td>Reverse recovery energy</td>
<td>$E_{rec}$</td>
<td>[mJ]</td>
<td></td>
</tr>
<tr>
<td>Thermal resistance junction to sink</td>
<td>$R_{j-s}$</td>
<td>[°C/W]</td>
<td></td>
</tr>
<tr>
<td>Thermistor</td>
<td></td>
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<td></td>
</tr>
<tr>
<td>Rated resistance</td>
<td>$R$</td>
<td>[Ω]</td>
<td></td>
</tr>
<tr>
<td>Deviation of $R_{on}$</td>
<td>$A_{4K}$</td>
<td>-5 %</td>
<td></td>
</tr>
<tr>
<td>Power dissipation</td>
<td>$P$</td>
<td>[mW]</td>
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</tr>
<tr>
<td>Power dissipation constant</td>
<td>$P_{on}$</td>
<td>[mW/K]</td>
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</tr>
<tr>
<td>B-value</td>
<td>$B_{4K}$</td>
<td>0.63 %</td>
<td></td>
</tr>
<tr>
<td>B-value</td>
<td>$B_{25}$</td>
<td>0.63 %</td>
<td></td>
</tr>
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</table>

Thermistor

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Symbol</th>
<th>Unit</th>
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<tbody>
<tr>
<td>Rated resistance</td>
<td>$R$</td>
<td>[Ω]</td>
</tr>
<tr>
<td>Deviation of $R_{on}$</td>
<td>$A_{4K}$</td>
<td>-5 %</td>
</tr>
<tr>
<td>Power dissipation</td>
<td>$P$</td>
<td>[mW]</td>
</tr>
<tr>
<td>Power dissipation constant</td>
<td>$P_{on}$</td>
<td>[mW/K]</td>
</tr>
<tr>
<td>B-value</td>
<td>$B_{4K}$</td>
<td>0.63 %</td>
</tr>
<tr>
<td>B-value</td>
<td>$B_{25}$</td>
<td>0.63 %</td>
</tr>
</tbody>
</table>

Thermistor

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<th>Unit</th>
</tr>
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<tbody>
<tr>
<td>Rated resistance</td>
<td>$R$</td>
<td>[°C/W]</td>
</tr>
<tr>
<td>Deviation of $R_{on}$</td>
<td>$A_{4K}$</td>
<td>-5 %</td>
</tr>
<tr>
<td>Power dissipation</td>
<td>$P$</td>
<td>[mW]</td>
</tr>
<tr>
<td>Power dissipation constant</td>
<td>$P_{on}$</td>
<td>[mW/K]</td>
</tr>
<tr>
<td>B-value</td>
<td>$B_{4K}$</td>
<td>0.63 %</td>
</tr>
<tr>
<td>B-value</td>
<td>$B_{25}$</td>
<td>0.63 %</td>
</tr>
</tbody>
</table>

Vincotech NTC Reference

B
Inverter Characteristics

**Figure 1**
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**
Typical output characteristics

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

At
- \( t_p = 250 \ \mu s \)
- \( T_j = 150 \ ^\circ C \)
- \( V_{CE} \) from 7 V to 17 V in steps of 1 V

**Figure 3**
Typical transfer characteristics

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

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

**Figure 4**
Typical diode forward current as a function of forward voltage

\[ I_F = f(V_F) \]

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

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

With an inductive load at
- \( T_j = 25/150 \) °C
- \( V_{CE} = 600 \) V
- \( V_{GE} = \pm 15 \) V
- \( R_{gon} = 32 \) Ω
- \( I_C = 25 \) A

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

With an inductive load at
- \( T_j = 25/150 \) °C
- \( V_{CE} = 600 \) V
- \( V_{GE} = \pm 15 \) V
- \( I_C = 25 \) A

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

With an inductive load at
- \( T_j = T_{jmax} - 25 \) °C
- \( V_{CE} = 600 \) V
- \( V_{GE} = \pm 15 \) V
- \( R_{goff} = 32 \) Ω

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

With an inductive load at
- \( T_j = T_{jmax} - 25 \) °C
- \( V_{CE} = 600 \) V
- \( V_{GE} = \pm 15 \) V
- \( I_C = 25 \) A
Inverter Characteristics

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

With an inductive load at  
$T_J = 150 \, ^\circ C$  
$V_{CE} = 600 \, V$  
$V_{GE} = \pm 15 \, V$  
$R_{gon} = 32 \, \Omega$

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

With an inductive load at  
$T_J = 150 \, ^\circ C$  
$V_{CE} = 600 \, V$  
$V_{GE} = \pm 15 \, V$  
$I_C = 25 \, A$

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

At  
$T_J = 25/150 \, ^\circ C$  
$V_{CE} = 600 \, V$  
$V_{GE} = \pm 15 \, V$  
$R_{gon} = 32 \, \Omega$

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

At  
$T_J = 25/150 \, ^\circ C$  
$V_s = 600 \, V$  
$I_f = 25 \, A$  
$V_{GE} = \pm 15 \, V$
Inverter Characteristics

Figure 13  
Typical reverse recovery charge as a function of collector current  
\[ Q_{rr} = f(I_C) \]

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

At  
- \( T_j = 25/150 \) °C  
- \( V_{CE} = 600 \) V  
- \( V_{GE} = \pm15 \) V  
- \( R_{gon} = 32 \) Ω

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

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

At  
- \( T_j = 25/150 \) °C  
- \( V_s = 600 \) V  
- \( I_f = 25 \) A  
- \( V_{GE} = \pm15 \) V

Figure 15  
Typical reverse recovery current as a function of collector current  
\[ I_{RRM} = f(I_C) \]

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

At  
- \( T_j = 25/150 \) °C  
- \( V_{CE} = 600 \) V  
- \( V_{GE} = \pm15 \) V  
- \( R_{gon} = 32 \) Ω

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

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

At  
- \( T_j = 25/150 \) °C  
- \( V_s = 600 \) V  
- \( I_f = 25 \) A  
- \( V_{GE} = \pm15 \) V
Inverter Characteristics

Figure 17  Inverter FWD
Typical rate of fall of forward and reverse recovery current as a function of collector current
\[ \frac{dI}{dt} = f(I) \]

At
\[ T_j = 25/150 \degree C \]
\[ V_{CE} = 600 \ V \]
\[ V_{GE} = \pm 15 \ V \]
\[ R_{gon} = 32 \ \Omega \]

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

At
\[ T_j = 25/150 \degree C \]
\[ V_{GS} = 600 \ V \]
\[ I_F = 25 \ A \]
\[ V_{GE} = \pm 15 \ V \]

Figure 19  Inverter IGBT
IGBT transient thermal impedance as a function of pulse width
\[ Z_{th(j-s)} = f(t_p) \]

At
\[ D = t_p / T \]
\[ R_{th(j-s)} = 1.01 \ K/W \]

Table: IGBT thermal model values

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<thead>
<tr>
<th>R (K/W)</th>
<th>Tau (s)</th>
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<td>1.66E-03</td>
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<td>3.85E-02</td>
<td>8.73E-04</td>
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</table>

Figure 20  Inverter FWD
FWD transient thermal impedance as a function of pulse width
\[ Z_{th(j-s)} = f(t_p) \]

At
\[ D = t_p / T \]
\[ R_{th(j-s)} = 1.59 \ K/W \]

Table: FWD thermal model values

<table>
<thead>
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<th>R (K/W)</th>
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<tr>
<td>1.35E-01</td>
<td>3.39E-04</td>
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</table>
Inverter Characteristics

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

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

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

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

\[ I_C = f(T_s) \]

At
\[ T_j = 175 \, ^\circ C \]
\[ V_{CE} = 15 \, V \]

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

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

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

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

\[ I_F = f(T_s) \]

At
\[ T_j = 175 \, ^\circ C \]
**Inverter Characteristics**

**Figure 25**
Safe operating area as a function of collector-emitter voltage

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

At
\[ D = \text{single pulse} \]
\[ T_n = 80 \degree C \]
\[ V_{GE} = \pm 15 \text{ V} \]
\[ T_j = T_{j_{max}} \]

**Figure 26**
Gate voltage vs Gate charge

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

At
\[ I_C = 25 \text{ A} \]

**Figure 27**
Short circuit withstand time as a function of gate-emitter voltage

\[ t_{sc} = f(V_{GE}) \]

At
\[ V_{CE} = 1200 \text{ V} \]
\[ T_j \leq 175 \degree C \]

**Figure 28**
Typical short circuit collector current as a function of gate-emitter voltage

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

At
\[ V_{CE} \leq 1200 \text{ V} \]
\[ T_j = 175 \degree C \]
Figure 29  Inverter IGBT
Reverse bias safe operating area

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

At
\[ T_j = T_{jmax} - 25 \, ^\circ C \]
Brake Characteristics

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

![Graph showing typical output characteristics with $I_C = f(V_{CE})$](image1)

**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**  
Brake IGBT  
Typical output characteristics  
$I_C = f(V_{CE})$

![Graph showing typical output characteristics with $I_C = f(V_{CE})$](image2)

**At**  
$t_p = 250 \ \mu s$  
$T_j = 150 ^\circ C$  
$V_{CE}$ from 7 V to 17 V in steps of 1 V

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

![Graph showing typical transfer characteristics with $I_C = f(V_{GE})$](image3)

**At**  
$t_p = 250 \ \mu s$  
$V_{CE} = 10 \ \text{V}$

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

![Graph showing typical diode forward current as a function of forward voltage with $I_F = f(V_F)$](image4)

**At**  
$t_p = 250 \ \mu s$
Brake Characteristic

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

With an inductive load at
- \( T_J = 25/150 \) °C
- \( V_{CE} = 600 \) V
- \( V_{GE} = \pm 15 \) V
- \( R_{gon} = 32 \) Ω
- \( I_C = 15 \) A

**Figure 6** Brake IGBT
Typical switching energy losses as a function of gate resistor
\[ E = f(R_G) \]

With an inductive load at
- \( T_J = 25/150 \) °C
- \( V_{CE} = 600 \) V
- \( V_{GE} = \pm 15 \) V
- \( I_C = 15 \) A

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

With an inductive load at
- \( T_J = 25/150 \) °C
- \( V_{CE} = 600 \) V
- \( V_{GE} = \pm 15 \) V
- \( R_{gon} = 32 \) Ω

**Figure 8** Brake FWD
Typical reverse recovery energy loss as a function of gate resistor
\[ E_{rec} = f(R_G) \]

With an inductive load at
- \( T_J = 25/150 \) °C
- \( V_{CE} = 600 \) V
- \( V_{GE} = \pm 15 \) V
- \( I_C = 15 \) A
Brake Characteristics

**Figure 9**
Typical switching times as a function of collector current

\[ t = f(I_c) \]

With an inductive load at

- \( T_j = 25/150 \) °C
- \( V_{CE} = 600 \) V
- \( V_{CE} = \pm 15 \) V
- \( R_{gon} = 32 \) Ω
- \( R_{goff} = 32 \) Ω

**Figure 10**
Typical switching times as a function of gate resistor

\[ t = f(R_g) \]

With an inductive load at

- \( T_j = 25/150 \) °C
- \( V_{CE} = 600 \) V
- \( V_{CE} = \pm 15 \) V
- \( I_c = 15 \) A

**Figure 11**
IGBT transient thermal impedance as a function of pulse width

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

At

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

\[ R_{th(j-s)} = 1.35 \text{ K/W} \]

**Figure 12**
FWD transient thermal impedance as a function of pulse width

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

At

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

\[ R_{th(j-s)} = 2.07 \text{ K/W} \]
Brake Characteristics

**Figure 13** Brake IGBT  
Power dissipation as a function of heatsink temperature  
\[ P_{tot} = f(T_s) \]

![Graph showing power dissipation as a function of heatsink temperature](image)

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

**Figure 14** Brake IGBT  
Collector current as a function of heatsink temperature  
\[ I_C = f(T_s) \]

![Graph showing collector current as a function of heatsink temperature](image)

At  
\[ T_j = 175 \, ^\circ C \]
\[ V_{CE} = 15 \, V \]

**Figure 15** Brake FWD  
Power dissipation as a function of heatsink temperature  
\[ P_{tot} = f(T_s) \]

![Graph showing power dissipation as a function of heatsink temperature](image)

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

**Figure 16** Brake FWD  
Forward current as a function of heatsink temperature  
\[ I_F = f(T_s) \]

![Graph showing forward current as a function of heatsink temperature](image)

At  
\[ T_j = 175 \, ^\circ C \]
Rectifier Diode Characteristics

**Figure 1**
Typical diode forward current as a function of forward voltage

\[ I_F = f(V_F) \]

![Graph showing forward current (IF) as a function of forward voltage (VF).](image)

At
\[ t_p = 250 \mu s \]

**Figure 2**
Diode transient thermal impedance as a function of pulse width

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

![Graph showing transient thermal impedance (Zth) as a function of pulse width (tp).](image)

At
\[ D = \frac{t_p}{T} \quad R_{n(j-s)} = 1.25 \text{ K/W} \]

**Figure 3**
Power dissipation as a function of heatsink temperature

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

![Graph showing power dissipation (Ptot) as a function of heatsink temperature (Ts).](image)

At
\[ T_j = 150 \degree C \]

**Figure 4**
Forward current as a function of heatsink temperature

\[ I_F = f(T_s) \]

![Graph showing forward current (IF) as a function of heatsink temperature (Ts).](image)

At
\[ T_j = 150 \degree C \]
Thermistor Characteristics

Figure 1

Typical NTC characteristic as a function of temperature
\[ R_T = f(T) \]
### Switching Definitions Inverter

**General conditions**

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value</th>
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<td>$T_J$</td>
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<tr>
<td>$R_{on}$</td>
<td>32 Ω</td>
</tr>
<tr>
<td>$R_{off}$</td>
<td>32 Ω</td>
</tr>
</tbody>
</table>

---

**Figure 1**

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

- $V_{GE}(0\%) = -15$ V
- $V_{GE}(100\%) = 15$ V
- $I_C(100\%) = 25$ A
- $t_{doff} = 0.28 \mu$s
- $t_{Eoff} = 0.66 \mu$s

---

**Figure 2**

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

- $V_{CE}(0\%) = -15$ V
- $V_{CE}(100\%) = 15$ V
- $I_C(100\%) = 25$ A
- $t_{don} = 0.13 \mu$s
- $t_{Eon} = 0.43 \mu$s

---

**Figure 3**

Turn-off Switching Waveforms & definition of $t_i$

- $V_C(100\%) = 600$ V
- $I_C(100\%) = 25$ A
- $t_i = 0.10 \mu$s

---

**Figure 4**

Turn-on Switching Waveforms & definition of $t_r$

- $V_C(100\%) = 600$ V
- $I_C(100\%) = 25$ A
- $t_r = 0.03 \mu$s
Switching Definitions Inverter

**Figure 5**
Inverter Switch
Turn-off Switching Waveforms & definition of $t_{Eoff}$

- $P_{off} (100\%) = 15.01$ kW
- $E_{off} (100\%) = 2.17$ mJ
- $t_{Eoff} = 0.66$ μs

**Figure 6**
Inverter Switch
Turn-on Switching Waveforms & definition of $t_{Eon}$

- $P_{on} (100\%) = 15.01$ kW
- $E_{on} (100\%) = 2.53$ mJ
- $t_{Eon} = 0.43$ μs

**Figure 7**
Inverter Switch
Turn-off Switching Waveforms & definition of $t_{rr}$

- $V_d (100\%) = 600$ V
- $I_d (100\%) = 25$ A
- $I_{RRM} (100\%) = 10$ A
- $t_{rr} = 0.10$ μs
Switching Definitions Inverter

**Figure 8**
Inverter FWD
Turn-on Switching Waveforms & definition of $t_{Qrr}$
($t_{Qrr}$ = integrating time for $Q_{rr}$)

![Waveform Chart](image)

$I_d (100\%) = 25 \text{ A}$
$Q_{rr} (100\%) = 4.81 \text{ μC}$
$t_{Qrr} = 1.00 \text{ μs}$

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

![Waveform Chart](image)

$P_{rec} (100\%) = 15.01 \text{ kW}$
$E_{rec} (100\%) = 1.94 \text{ mJ}$
$t_{Erec} = 1.00 \text{ μs}$
Ordering Code and Marking - Outline - Pinout

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<th>Version</th>
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<td>V23990-P589-A41-PM</td>
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<tr>
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<td>with thermal paste 17mm housing Press-fit pins</td>
<td>V23990-P589-A41V-PM</td>
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<td>V23990-P589-A41B-PM</td>
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Outline

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12mm housing, Press-fit pins

17mm housing, solder pins

17mm housing, Press-fit pins

Pin X Y Function
1 52,55 0 BrG
2 47,7 0 DC-
3 44,8 0 DC-
4 37,8 0 DC+
5 35 0 Inv+
6 35 2,8 Inv+
7 28 0 R1
8 25,2 0 R2
9 22,4 0 N6
10 19,6 0 G6
11 16,8 0 S6
12 14 0 N4
13 11,2 0 G4
14 8,4 0 S4
15 5,6 0 N2
16 2,8 0 G2
17 0 0 S2
18 0 28,5 U
19 2,8 28,5 G1
20 2,8 28,5 S1
21 14,5 28,5 V
22 17,2 28,5 G3
23 22 28,5 S3
24 29 28,5 W
25 31,8 28,5 G5
26 36,5 28,5 S5
27 43,5 28,5 L1
28 52,55 25 L2
29 52,55 16,9 L3
30 52,55 8,6 BrC
31 52,55 2,8 BrE
Ordering Code and Marking - Outline - Pinout

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<td>1200 V</td>
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