flowSOL 1 BI

600V/50A

**Features**
- Low inductive 12mm flow1 package
- Booster:
  - Dual boost topology
  - High-speed IGBT + ultrafast FWD
- Inverter:
  - H-bridge topology
  - High-speed IGBT + ultrafast FWD
- Integrated DC-capacitors
- Temperature sensor

**Target Applications**
- Solar Inverter:
  - Transformer-less solar inverter with bipolar modulation with high efficiency/cost ratio
  - Primary of a transformer based solar inverter with resonant switching

**Types**
- 10-FY06BIA050SG-M523E18

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**Maximum Ratings**

\[ T_J = 25°C, \text{ unless otherwise specified} \]

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Symbol</th>
<th>Condition</th>
<th>Value</th>
<th>Unit</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bypass Diode</td>
<td>Repetitive peak reverse voltage</td>
<td>( V_{RRM} )</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Forward current per diode</td>
<td>( I_{FAX} )</td>
<td>DC current ( T_J = 80°C ) ( T_C = 80°C )</td>
<td>39</td>
<td>A</td>
</tr>
<tr>
<td>Surge forward current</td>
<td>( I_{FSM} )</td>
<td>( t_S = 10\text{ms} ) ( T_J = 25°C )</td>
<td>370</td>
<td>A</td>
</tr>
<tr>
<td>I2r-value</td>
<td>( I_{2r} )</td>
<td></td>
<td>370</td>
<td>A²s</td>
</tr>
<tr>
<td>Power dissipation per Diode</td>
<td>( P_{DI} )</td>
<td>( T_J = T_{J\max} ) ( T_J = 80°C ) ( T_C = 80°C )</td>
<td>46</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>
<tr>
<td>Input Boost IGBT</td>
<td>Collector-emitter break down voltage</td>
<td>( V_{CE} )</td>
<td></td>
<td>600</td>
</tr>
<tr>
<td>DC collector current</td>
<td>( I_C )</td>
<td>( T_J = T_{J\max} ) ( T_J = 80°C ) ( T_C = 80°C )</td>
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<tr>
<td>Repetitive peak collector current</td>
<td>( I_{2PC} )</td>
<td>( I_S ) limited by ( T_{J\max} )</td>
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<td>A</td>
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<td>Power dissipation per IGBT</td>
<td>( P_{Di} )</td>
<td>( T_J = T_{J\max} ) ( T_J = 80°C ) ( T_C = 80°C )</td>
<td>83</td>
<td>W</td>
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<tr>
<td>Gate-emitter peak voltage</td>
<td>( V_{GE} )</td>
<td></td>
<td>( \pm 20 )</td>
<td>V</td>
</tr>
<tr>
<td>Short circuit ratings</td>
<td>( I_{SC} )</td>
<td>( V_{CE} = 15\text{V} ) ( T_J = 150°C )</td>
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<td>( \mu \text{A} )</td>
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<tr>
<td>Maximum Junction Temperature</td>
<td>( T_{J\max} )</td>
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<td>175</td>
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### Maximum Ratings

**Tj=25°C, unless otherwise specified**

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Symbol</th>
<th>Condition</th>
<th>Value</th>
<th>Unit</th>
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<tbody>
<tr>
<td><strong>Input Boost Inverse Diode</strong></td>
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<tr>
<td>Peak Repetitive Reverse Voltage</td>
<td>V_{RMS}</td>
<td>T_j=25°C</td>
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<tr>
<td>DC forward current</td>
<td>I_f</td>
<td>T_j=T_{max}</td>
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<td></td>
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<td>T_c=80°C</td>
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<td>W</td>
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<td>Maximum Junction Temperature</td>
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<td><strong>Input Boost Diode</strong></td>
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<tr>
<td>Peak Repetitive Reverse Voltage</td>
<td>V_{RMS}</td>
<td>T_j=25°C</td>
<td>600</td>
<td>V</td>
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<tr>
<td>DC forward current</td>
<td>I_f</td>
<td>T_j=T_{max}</td>
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<td>A</td>
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<tr>
<td></td>
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<td>T_c=80°C</td>
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<td>Repetitive peak forward current</td>
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<td>Power dissipation</td>
<td>P_{IR}</td>
<td>T_j=T_{max}</td>
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<td></td>
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<td>T_c=80°C</td>
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<td>W</td>
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<td>Maximum Junction Temperature</td>
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<tr>
<td><strong>H-Bridge IGBT</strong></td>
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<tr>
<td>Collector-emitter break down voltage</td>
<td>V_{CE}</td>
<td>T_j=25°C</td>
<td>600</td>
<td>V</td>
</tr>
<tr>
<td>DC collector current</td>
<td>I_c</td>
<td>T_j=T_{max}</td>
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<td>A</td>
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<td></td>
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<td>T_c=80°C</td>
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<td>Repetitive peak collector current</td>
<td>I_{CPulse}</td>
<td>I_{p} limited by T_{max}</td>
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<td>Power dissipation per IGBT</td>
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<td>T_j=T_{max}</td>
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<td>W</td>
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<td></td>
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<td>T_c=80°C</td>
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<td>Gate-emitter peak voltage</td>
<td>V_{GE}</td>
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<td>≤20</td>
<td>V</td>
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<td>Short circuit ratings</td>
<td>I_{SC}</td>
<td>T_j≤150°C</td>
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<td>μs</td>
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<tr>
<td></td>
<td>V_{CC}</td>
<td>V_{CC}=15V</td>
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<td>V</td>
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<td>Maximum Junction Temperature</td>
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<td>°C</td>
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<tr>
<td><strong>H-Bridge Diode</strong></td>
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<tr>
<td>Peak Repetitive Reverse Voltage</td>
<td>V_{RMS}</td>
<td>T_j=25°C</td>
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<td>V</td>
</tr>
<tr>
<td>DC forward current</td>
<td>I_f</td>
<td>T_j=T_{max}</td>
<td>23</td>
<td>A</td>
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<td></td>
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<td>T_c=80°C</td>
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<tr>
<td>Repetitive peak forward current</td>
<td>I_{FRM}</td>
<td>I_f limited by T_{max}</td>
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<td>A</td>
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<tr>
<td>Power dissipation per Diode</td>
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<td>T_j=T_{max}</td>
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<td>W</td>
</tr>
<tr>
<td></td>
<td></td>
<td>T_c=80°C</td>
<td>60</td>
<td>W</td>
</tr>
<tr>
<td>Maximum Junction Temperature</td>
<td>T_{jmax}</td>
<td></td>
<td>150</td>
<td>°C</td>
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<tr>
<td><strong>DC link Capacitor</strong></td>
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<tr>
<td>Max.DC voltage</td>
<td>V_{MAX}</td>
<td>T_c=25°C</td>
<td>630</td>
<td>V</td>
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</table>

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**Revision: 1**
### Maximum Ratings

*Tj=25°C, unless otherwise specified*

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<tbody>
<tr>
<td><strong>Thermal Properties</strong></td>
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<td></td>
<td></td>
</tr>
<tr>
<td>Storage temperature</td>
<td>$T_{stg}$</td>
<td></td>
<td>-40…+125°C</td>
<td>°C</td>
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<tr>
<td>Operation temperature under switching condition</td>
<td>$T_{op}$</td>
<td></td>
<td>-40…+(Tjmax - 25) °C</td>
<td>°C</td>
</tr>
<tr>
<td><strong>Insulation Properties</strong></td>
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<td></td>
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<tr>
<td>Insulation voltage</td>
<td>$V_{in}$</td>
<td>$t=2s$ DC voltage</td>
<td>4000</td>
<td>V</td>
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<tr>
<td>Creepage distance</td>
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<td></td>
<td>min 12.7</td>
<td>mm</td>
</tr>
<tr>
<td>Clearance</td>
<td></td>
<td></td>
<td>min 12.7</td>
<td>mm</td>
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</table>
### Characteristic Values

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<tr>
<td>Bypass Diode</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Forward voltage</td>
<td>$V_F$</td>
<td>$V_D$=15 V</td>
<td>9.89</td>
<td>V</td>
</tr>
<tr>
<td>Threshold voltage</td>
<td>$V_T$</td>
<td>$V_D$=15 V</td>
<td>9.89</td>
<td>V</td>
</tr>
<tr>
<td>Slope resistance</td>
<td>$r_s$</td>
<td>$V_D$=15 V</td>
<td>9.89</td>
<td>V</td>
</tr>
<tr>
<td>Reverse current</td>
<td>$I_R$</td>
<td>$V_D$=15 V</td>
<td>9.89</td>
<td>mA</td>
</tr>
<tr>
<td>Thermal resistance</td>
<td>$R_{th}$</td>
<td>Thermal grease thickness=50um $k=1 \text{ W/mK}$</td>
<td>1.53</td>
<td>K/W</td>
</tr>
</tbody>
</table>

#### Input Boost IGBT

<table>
<thead>
<tr>
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<th>Value</th>
<th>Unit</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gate-emitter threshold voltage</td>
<td>$V_{GE(th)}$</td>
<td>$f=1\text{MHz}$</td>
<td>50</td>
<td>V</td>
</tr>
<tr>
<td>Collector-emitter saturation voltage</td>
<td>$V_{CE(sat)}$</td>
<td>$f=1\text{MHz}$</td>
<td>50</td>
<td>V</td>
</tr>
<tr>
<td>Collector-emitter cut-off</td>
<td>$I_{COS}$</td>
<td>$f=1\text{MHz}$</td>
<td>50</td>
<td>mA</td>
</tr>
<tr>
<td>Gate-emitter leakage current</td>
<td>$I_{GSS}$</td>
<td>$f=1\text{MHz}$</td>
<td>50</td>
<td>nA</td>
</tr>
<tr>
<td>Integrated Gate resistor</td>
<td>$R_{gin}$</td>
<td>none</td>
<td>50</td>
<td>pF</td>
</tr>
<tr>
<td>Turn-on delay time</td>
<td>$t_{on}$</td>
<td>$f=1\text{MHz}$</td>
<td>50</td>
<td>ns</td>
</tr>
<tr>
<td>Rise time</td>
<td>$t_r$</td>
<td>$f=1\text{MHz}$</td>
<td>50</td>
<td>ns</td>
</tr>
<tr>
<td>Turn-off delay time</td>
<td>$t_{off}$</td>
<td>$f=1\text{MHz}$</td>
<td>50</td>
<td>ns</td>
</tr>
<tr>
<td>Fall time</td>
<td>$t_f$</td>
<td>$f=1\text{MHz}$</td>
<td>50</td>
<td>ns</td>
</tr>
<tr>
<td>Turn-on energy loss per pulse</td>
<td>$E_{on}$</td>
<td>$f=1\text{MHz}$</td>
<td>50</td>
<td>mWs</td>
</tr>
<tr>
<td>Turn-off energy loss per pulse</td>
<td>$E_{off}$</td>
<td>$f=1\text{MHz}$</td>
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<td>mWs</td>
</tr>
<tr>
<td>Input capacitance</td>
<td>$C_{iss}$</td>
<td>$f=1\text{MHz}$</td>
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<td>pF</td>
</tr>
<tr>
<td>Output capacitance</td>
<td>$C_{iss}$</td>
<td>$f=1\text{MHz}$</td>
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<td>pF</td>
</tr>
<tr>
<td>Reverse transfer capacitance</td>
<td>$C_{iss}$</td>
<td>$f=1\text{MHz}$</td>
<td>50</td>
<td>pF</td>
</tr>
<tr>
<td>Gate charge</td>
<td>$Q_{GSS}$</td>
<td>$f=1\text{MHz}$</td>
<td>50</td>
<td>nC</td>
</tr>
<tr>
<td>Thermal resistance chip to heatsink per chip</td>
<td>$R_{th}$</td>
<td>Thermal grease thickness=50um $k=1 \text{ W/mK}$</td>
<td>1.15</td>
<td>K/W</td>
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#### Input Boost Inverse Diode

<table>
<thead>
<tr>
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<th>Value</th>
<th>Unit</th>
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<tbody>
<tr>
<td>Diode forward voltage</td>
<td>$V_F$</td>
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<td>Thermal resistance chip to heatsink per chip</td>
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<td>Thermal grease thickness=50um $k=1 \text{ W/mK}$</td>
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#### Input Boost Diode

<table>
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<tr>
<td>Forward voltage</td>
<td>$V_F$</td>
<td>$f=1\text{MHz}$</td>
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<td>V</td>
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<td>Reverse leakage current</td>
<td>$I_r$</td>
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<td>pA</td>
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<td>Peak recovery current</td>
<td>$I_{peak}$</td>
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<td>Reverse recovery time</td>
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<td>ns</td>
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<td>Reverse recovery charge</td>
<td>$Q_r$</td>
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<td>Reverse recovered energy</td>
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<td>Thermal resistance chip to heatsink per chip</td>
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<td>Thermal grease thickness=50um $k=1 \text{ W/mK}$</td>
<td>1.76</td>
<td>K/W</td>
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## Characteristic Values

### H-Bridge IGBT

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Symbol</th>
<th>Conditions</th>
<th>Value</th>
<th>Unit</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gate-emitter threshold voltage</td>
<td>$V_{GE(th)}$</td>
<td>$V_{GE}=V_{CE}$</td>
<td>0,008</td>
<td>V</td>
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<tr>
<td>Collector-emitter saturation voltage</td>
<td>$V_{CBO}$</td>
<td>15 0 50</td>
<td>$T_j=25{}^\circ{}C$</td>
<td>1,94</td>
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<td>Collector-emitter cut-off incl diode</td>
<td>$I_{DSS}$</td>
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<td>Gate-emitter leakage current</td>
<td>$I_{DSS}$</td>
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<td>100</td>
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<td>Integrated Gate resistor</td>
<td>$R_{gint}$</td>
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<tr>
<td>Turn-on delay time</td>
<td>$t_{d(on)}$</td>
<td>±15 400 50</td>
<td>$T_j=25{}^\circ{}C$</td>
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<td>$t_r$</td>
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<td>Fall time</td>
<td>$t_f$</td>
<td>±15</td>
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<td>Turn-off delay time</td>
<td>$t_{d(off)}$</td>
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<tr>
<td>Turn-on energy loss per pulse</td>
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<td>Turn-off energy loss per pulse</td>
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<td>$T_j=25{}^\circ{}C$</td>
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<tr>
<td>Input capacitance</td>
<td>$C_{ins}$</td>
<td>f=1MHz</td>
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<td>Output capacitance</td>
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<tr>
<td>Reverse transfer capacitance</td>
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<td></td>
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<td>Gate charge</td>
<td>$Q_{gate}$</td>
<td>±15 480 50</td>
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<td>Thermal resistance chip to heatsink per chip</td>
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<td>Thermal grease thickness 50um $k=1\ W/\text{mK}$</td>
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<td>1,15</td>
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</tbody>
</table>

### H-Bridge Diode

<table>
<thead>
<tr>
<th>Parameter</th>
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<th>Value</th>
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<td>Diode forward voltage</td>
<td>$V_D$</td>
<td>50</td>
<td>$T_j=25{}^\circ{}C$</td>
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<tr>
<td>Peak reverse recovery current</td>
<td>$I_{RRM}$</td>
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<td>Reverse recovery time</td>
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<td>Reverse recovered charge</td>
<td>$Q_{r}$</td>
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<td>Peak rate of fall of recovery current</td>
<td>$E_{rec}$</td>
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<td>$T_j=25{}^\circ{}C$</td>
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<td>Reverse recovery energy</td>
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<td>Thermal resistance chip to heatsink per chip</td>
<td>$R_{thJH}$</td>
<td>Thermal grease thickness 50um $k=1\ W/\text{mK}$</td>
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### DC link Capacitor

<table>
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<th>Unit</th>
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### Thermistor

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<th>Unit</th>
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<td>Deviation of R25</td>
<td>$\Delta R/R$</td>
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<td>mW/K</td>
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<td>B-value</td>
<td>$B_{25/50}$</td>
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<td>B-value</td>
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<td>Tol. ±3%</td>
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<td>Vincotech NTC Reference</td>
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</tbody>
</table>

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**H-Bridge**

**Figure 1**
Typical output characteristics
\[ I_C = f(V_{CE}) \]

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

**Figure 2**
Typical output characteristics
\[ I_C = f(V_{CE}) \]

At
\[ t_p = 250 \ \mu s \]
\[ T_J = 125 \ ^\circ C \]
\[ V_{GE} \text{ from 7 V to 17 V in steps of 1 V} \]

**Figure 3**
Typical transfer characteristics
\[ I_C = f(V_{GE}) \]

**Figure 4**
Typical diode forward current as a function of forward voltage
\[ I_F = f(V_F) \]

At
\[ t_p = 250 \ \mu s \]
\[ V_{CE} = 10 \ \text{V} \]

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

With an inductive load at
\[ T_J = 25/125 \degree C \]
\[ V_{CE} = 400 \text{ V} \]
\[ V_{GF} = 15 \text{ V} \]
\[ R_{on} = 4 \text{ } \Omega \]
\[ R_{off} = 4 \text{ } \Omega \]

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

With an inductive load at
\[ T_J = 25/125 \degree C \]
\[ V_{CE} = 400 \text{ V} \]
\[ V_{GF} = 15 \text{ V} \]
\[ I_C = 50 \text{ A} \]

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

With an inductive load at
\[ T_J = 25/125 \degree C \]
\[ V_{CE} = 400 \text{ V} \]
\[ V_{GF} = 15 \text{ V} \]
\[ R_{on} = 4 \text{ } \Omega \]

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

With an inductive load at
\[ T_J = 25/125 \degree C \]
\[ V_{CE} = 400 \text{ V} \]
\[ V_{GF} = 15 \text{ V} \]
\[ I_C = 50 \text{ A} \]
H-Bridge

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

With an inductive load at
- \( T_J = 125 \, ^\circ \text{C} \)
- \( V_{CE} = 400 \, \text{V} \)
- \( V_{GE} = 15 \, \text{V} \)
- \( R_{gon} = 4 \, \Omega \)
- \( R_{goff} = 4 \, \Omega \)

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

With an inductive load at
- \( T_J = 125 \, ^\circ \text{C} \)
- \( V_{CE} = 400 \, \text{V} \)
- \( V_{GE} = 15 \, \text{V} \)
- \( I_C = 50 \, \text{A} \)

**Figure 11**
Typical reverse recovery time as a function of collector current
\( t_r = f(I_C) \)

At
- \( T_J = 25/125 \, ^\circ \text{C} \)
- \( V_{CE} = 400 \, \text{V} \)
- \( V_{GE} = 15 \, \text{V} \)
- \( R_{gon} = 4 \, \Omega \)

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

At
- \( T_J = 25/125 \, ^\circ \text{C} \)
- \( V_{CE} = 400 \, \text{V} \)
- \( I_C = 50 \, \text{A} \)
- \( V_{GE} = 15 \, \text{V} \)
H-Bridge

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
\[ T_J = 25/125 \, ^\circ C \]
\[ V_{CE} = 400 \, V \]
\[ V_{GE} = 15 \, V \]
\[ R_{gon} = 4 \, \Omega \]

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
\[ T_J = 25/125 \, ^\circ C \]
\[ V_{GE} = 15 \, V \]
\[ I_F = 50 \, A \]
\[ V_{GE} = 15 \, V \]

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
\[ T_J = 25/125 \, ^\circ C \]
\[ V_{CE} = 400 \, V \]
\[ V_{GE} = 15 \, V \]
\[ R_{gon} = 4 \, \Omega \]

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
\[ T_J = 25/125 \, ^\circ C \]
\[ V_{GE} = 15 \, V \]
\[ I_F = 50 \, A \]
\[ V_{GE} = 15 \, V \]
H-Bridge

**Figure 17**
Typical rate of fall of forward and reverse recovery current as a function of collector current
\[
\frac{dI_0}{dt}, \frac{dI_{rec}}{dt} = f(I_c)
\]

- **At**
  - \(T_j = 25/125 \, ^\circ C\)
  - \(V_{CE} = 400 \, V\)
  - \(V_{GE} = 15 \, V\)
  - \(R_{gon} = 4 \, \Omega\)

**Figure 18**
Typical rate of fall of forward and reverse recovery current as a function of IGBT turn on gate resistor
\[
\frac{dI_0}{dt}, \frac{dI_{rec}}{dt} = f(R_{gon})
\]

- **At**
  - \(T_j = 25/125 \, ^\circ C\)
  - \(V_{CE} = 400 \, V\)
  - \(I_F = 50 \, A\)
  - \(V_{GE} = 15 \, V\)

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

- **At**
  - \(D = \frac{t_p}{T}\)
  - \(R_{thJH} = 1.15 \, K/W\)

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

- **At**
  - \(D = \frac{t_p}{T}\)
  - \(R_{thJH} = 1.76 \, K/W\)

**IGBT thermal model values**

<table>
<thead>
<tr>
<th>R (C/W)</th>
<th>Tau (s)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.09</td>
<td>2,0E+00</td>
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<tr>
<td>0.33</td>
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<tr>
<td>0.05</td>
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</table>

**FWD thermal model values**

<table>
<thead>
<tr>
<th>R (C/W)</th>
<th>Tau (s)</th>
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<tbody>
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<td>0.12</td>
<td>1,6E-03</td>
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</tbody>
</table>
H-Bridge

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

At
\[ T_j = 175 \degree C \]

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

At
\[ T_j = 175 \degree C \]
\[ V_{GE} = 15 \text{ V} \]

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

At
\[ T_j = 150 \degree C \]

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

At
\[ T_j = 150 \degree C \]
H-Bridge

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

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

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

120V
480V

At
\[ I_C = 50 \text{ A} \]


**Figure 1**

Typical output characteristics

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

At

\[ t_p = 250 \ \text{ms} \]

\[ T_j = 25 \ ^\circ \text{C} \]

\[ V_{GS} \text{ from 7 V to 17 V in steps of 1 V} \]

**Figure 2**

Typical output characteristics

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

At

\[ t_p = 250 \ \text{ms} \]

\[ T_j = 125 \ ^\circ \text{C} \]

\[ V_{GS} \text{ from 7 V to 17 V in steps of 1 V} \]

**Figure 3**

Typical transfer characteristics

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

At

\[ t_p = 250 \ \text{ms} \]

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

**Figure 4**

Typical diode forward current as a function of forward voltage

\[ I_F = f(V_F) \]

At

\[ t_p = 250 \ \text{ms} \]
Figure 5  
**Typical switching energy losses**  
as a function of collector current  
\[ E = f(I_c) \]

With an inductive load at  
- \( T_j = 25/125 \) °C  
- \( V_{DS} = 400 \) V  
- \( V_{GS} = 15 \) V  
- \( R_{gon} = 4 \, \Omega \)  
- \( R_{goff} = 4 \, \Omega \)

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

With an inductive load at  
- \( T_j = 25/125 \) °C  
- \( V_{DS} = 400 \) V  
- \( V_{GS} = 15 \) V  
- \( I_b = 50 \) A

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

With an inductive load at  
- \( T_j = 25/125 \) °C  
- \( V_{DS} = 400 \) V  
- \( V_{GS} = 15 \) V  
- \( R_{gon} = 4 \, \Omega \)  
- \( R_{goff} = 4 \, \Omega \)

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

With an inductive load at  
- \( T_j = 25/125 \) °C  
- \( V_{DS} = 400 \) V  
- \( V_{GS} = 15 \) V  
- \( I_b = 50 \) A
**INPUT BOOST**

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

With an inductive load at
\[ T_j = 125 \, ^\circ C \]
\[ V_{DS} = 400 \, V \]
\[ V_{GS} = 15 \, V \]
\[ R_{gon} = 4 \, \Omega \]
\[ R_{goff} = 4 \, \Omega \]

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

With an inductive load at
\[ T_j = 125 \, ^\circ C \]
\[ V_{DS} = 400 \, V \]
\[ V_{GS} = 15 \, V \]
\[ I_C = 50 \, A \]

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

At
\[ T_j = 25/125 \, ^\circ C \]
\[ V_{DS} = 400 \, V \]
\[ V_{GS} = 15 \, V \]
\[ R_{gon} = 4 \, \Omega \]

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

At
\[ T_j = 25/125 \, ^\circ C \]
\[ V_D = 400 \, V \]
\[ I_C = 50 \, A \]
\[ V_{GS} = 15 \, V \]

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Typical reverse recovery charge as a function of collector current

$Q_{rr} = f(I_C)$

At

$T_j = 25/125 \degree C$

$V_{CE} = 400 \, V$

$V_{GS} = 15 \, V$

$R_{gon} = 4 \, \Omega$

Typical reverse recovery current as a function of collector current

$I_{RRM} = f(I_C)$

At

$T_j = 25/125 \degree C$

$V_{CE} = 400 \, V$

$V_{GS} = 15 \, V$

$R_{gon} = 4 \, \Omega$
Figure 17
Typical rate of fall of forward and reverse recovery current as a function of collector current
\( \frac{dI_0}{dt}, \frac{dI_{rec}}{dt} = f(I_c) \)

At
- \( T_j = 25/125 \) °C
- \( V_{CE} = 400 \) V
- \( V_{GE} = 15 \) V
- \( R_{gon} = 4 \) Ω

Figure 18
Typical rate of fall of forward and reverse recovery current as a function of IGBT turn on gate resistor
\( \frac{dI_0}{dt}, \frac{dI_{rec}}{dt} = f(R_{gon}) \)

At
- \( T_j = 25/125 \) °C
- \( V_{CE} = 400 \) V
- \( I_F = 50 \) A
- \( V_{GS} = 15 \) V

Figure 19
IGBT/MOSFET transient thermal impedance as a function of pulse width
\( Z_{thJH} = f(t_p) \)

At
- \( D = t_p / T \)
- \( R_{thJH} = 1.15 \) K/W

IGBT thermal model values

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<thead>
<tr>
<th>R (C/W)</th>
<th>Tau (s)</th>
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<tbody>
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<td>0.00E+00</td>
<td>0.00E+00</td>
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</tbody>
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Figure 20
FWD transient thermal impedance as a function of pulse width
\( Z_{thJH} = f(t_p) \)

At
- \( D = t_p / T \)
- \( R_{thJH} = 1.76 \) K/W

FWD thermal model values

<table>
<thead>
<tr>
<th>R (C/W)</th>
<th>Tau (s)</th>
</tr>
</thead>
<tbody>
<tr>
<td>5.96E-02</td>
<td>4.76E+00</td>
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<td>1.23E-01</td>
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</tbody>
</table>
Figure 21  
BOOST IGBT  
Power dissipation as a function of heatsink temperature  
\[ P_{\text{tot}} = f(T_h) \]

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

Figure 22  
BOOST IGBT  
Collector/Drain current as a function of heatsink temperature  
\[ I_{C} = f(T_h) \]

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

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

At  
\[ T_j = 150 \, ^\circ C \]

Figure 24  
BOOST FWD  
Forward current as a function of heatsink temperature  
\[ I_{F} = f(T_h) \]

At  
\[ T_j = 150 \, ^\circ C \]
Figure 25
Safe operating area as a function of drain-source voltage

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

\[ V_{GS} = f(Q_g) \]

At
- single pulse
- \( T_S = 80 \) °C
- \( V_{GS} = 15 \) V
- \( T_J = T_{JMAX} \) °C

Figure 26
Gate voltage vs Gate charge

\[ V_{GS} = f(Q_g) \]

At
- \( I_D = 50 \) A

120V
480V
Bypass Diode

**Figure 1**
Typical diode forward current as a function of forward voltage
$I_F = f(V_F)$

**Figure 2**
Diode transient thermal impedance as a function of pulse width
$Z_{thJH} = f(t_p)$

**Figure 3**
Power dissipation as a function of heatsink temperature
$P_{tot} = f(T_h)$

**Figure 4**
Forward current as a function of heatsink temperature
$I_F = f(T_h)$

- At $t_p = 250$ µs
- At $D = \frac{t_p}{T}$
  - $R_{thJH} = 1.528$ K/W
- At $T_j = 150$ °C
INP. BOOST INVERSE DIODE

**Figure 1**
Typical thyristor forward current as a function of forward voltage
\( I_F = f(V_F) \)

At
\[ T_j = 250 \text{ °C}, T_j = 25 \text{ °C} \]

**Figure 2**
Thyristor transient thermal impedance as a function of pulse width
\( Z_{TH} = f(t_p) \)

At
\[ D = 0.5, 0.2, 0.1, 0.05, 0.02, 0.01, 0.005, 0.000 \]
\[ R_{TH} = 2.44 \text{ K/W} \]

**Figure 3**
Power dissipation as a function of heatsink temperature
\( P_{TH} = f(T_{jH}) \)

At
\[ T_j = 175 \text{ °C} \]

**Figure 4**
Forward current as a function of heatsink temperature
\( I_F = f(T_{jH}) \)

At
\[ T_j = 175 \text{ °C} \]
Figure 1

Typical NTC characteristic
as a function of temperature

\( R_T = f(T) \)
**Switching Definitions H-Bridge IGBT**

**General conditions**

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

### Figure 1 H-Bridge IGBT

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

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

| $V_{GE}$ (0%) | 0 V |
| $V_{GE}$ (100%) | 15 V |
| $V_{CE}$ (100%) | 50 A |
| $t_{off}$ | 0.33 ms |
| $t_{on}$ | 0.39 ms |

### Figure 2 H-Bridge IGBT

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

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

| $V_{GE}$ (0%) | 0 V |
| $V_{GE}$ (100%) | 15 V |
| $V_{CE}$ (100%) | 50 A |
| $t_{on}$ | 0.03 ms |
| $t_{off}$ | 0.19 ms |

### Figure 3 H-Bridge IGBT

**Turn-off Switching Waveforms & definition of $t$**

| $V_{CE}$ (100%) | 400 V |
| $I_C$ (100%) | 50 A |
| $t$ | 0.01 ms |

### Figure 4 H-Bridge IGBT

**Turn-on Switching Waveforms & definition of $t$**

| $V_{CE}$ (100%) | 400 V |
| $I_C$ (100%) | 50 A |
| $t$ | 0.02 ms |
Switching Definitions H-Bridge IGBT

**Figure 5**

_H-Bridge IGBT_

**Turn-off Switching Waveforms & definition of t\textsubscript{Eoff}**

- \( P\textsubscript{off} (100\%) = 19.99 \text{ kW} \)
- \( E\textsubscript{off} (100\%) = 0.80 \text{ mJ} \)
- \( t\textsubscript{Eoff} = 0.39 \text{ \(\mu\)s} \)

**Figure 6**

_H-Bridge IGBT_

**Turn-on Switching Waveforms & definition of t\textsubscript{Eon}**

- \( P\textsubscript{on} (100\%) = 19.99 \text{ kW} \)
- \( E\textsubscript{on} (100\%) = 1.20 \text{ mJ} \)
- \( t\textsubscript{Eon} = 0.19 \text{ \(\mu\)s} \)

**Figure 7**

_H-Bridge IGBT_

**Gate voltage vs Gate charge (measured)**

- \( V\textsubscript{GE off} = 0 \text{ V} \)
- \( V\textsubscript{GE on} = 15 \text{ V} \)
- \( V\textsubscript{G} (100\%) = 400 \text{ V} \)
- \( I\textsubscript{d} (100\%) = 50 \text{ A} \)
- \( Q\textsubscript{g} = 270.72 \text{ nC} \)

**Figure 8**

_H-Bridge FWD_

**Turn-off Switching Waveforms & definition of \( t\textsubscript{rr} \)**

- \( V\textsubscript{d} (100\%) = 400 \text{ V} \)
- \( I\textsubscript{b} (100\%) = 50 \text{ A} \)
- \( I\textsubscript{tota} (100\%) = -56 \text{ A} \)
- \( t\textsubscript{rr} = 0.03 \text{ \(\mu\)s} \)
Switching Definitions H-Bridge IGBT

**Figure 9**

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

($t_{Qrr}$ = integrating time for $Q_{rr}$)

![Diagram](image)

$I_d$ (100%) = 50 A

$Q_{rr}$ (100%) = 1.16 %

$t_{Qrr}$ = 0.10 µs

**Figure 10**

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

($t_{Erec}$ = integrating time for $E_{rec}$)

![Diagram](image)

$P_{rec}$ (100%) = 19.99 kW

$E_{rec}$ (100%) = 0.13 mJ

$t_{Erec}$ = 0.10 µs
### Ordering Code & Marking

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<th>Ordering Code</th>
<th>in DataMatrix as</th>
<th>in packaging barcode as</th>
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<td>10-FY06BIA050SG-M523E18</td>
<td>M523E18</td>
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### Outline

- Pins 3, 4, 7, 14 are not connected.
- Pins 27 and 30 have to be connected together.
- Pins 31 and 34 have to be connected together.

### Pinout

- Tolerance of pin positions ±0.5mm at the end of pins.
- Dimension of coordinate axis is only offset without tolerance.
- PCB cutouts and holes see in handling instructions document.
### PRODUCT STATUS DEFINITIONS

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<th>Datasheet Status</th>
<th>Product Status</th>
<th>Definition</th>
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