10-FZ12NMA080SH01-M260F
10-PZ12NMA080SH01-M260FY
datasheet

**Features**
- mixed voltage component topology
- neutral point clamped inverter
- reactive power capability
- low inductance layout

**Target Applications**
- solar inverter
- UPS

**Types**
- 10-FZ12NMA080SH01-M260F
- 10-PZ12NMA080SH01-M260FY

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### Maximum Ratings

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

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Symbol</th>
<th>Condition</th>
<th>Value</th>
<th>Unit</th>
</tr>
</thead>
<tbody>
<tr>
<td>Collector-emitter break down 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>$T_j=T_{j\max}$</td>
<td>69</td>
<td>A</td>
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<td>DC collector current</td>
<td>$I_C$</td>
<td>$T_j=T_{j\max}$</td>
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<td>A</td>
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<td>Repetitive peak collector current</td>
<td>$I_{CEM}$</td>
<td>$t_p$, limited by $T_{j\max}$</td>
<td>240</td>
<td>A</td>
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<tr>
<td>Power dissipation</td>
<td>$P_{tot}$</td>
<td>$T_j=T_{j\max}$</td>
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<td>W</td>
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<td></td>
<td>$P_{tot}$</td>
<td>$T_j=T_{j\max}$</td>
<td>239</td>
<td>W</td>
</tr>
<tr>
<td>Gate-emitter peak voltage</td>
<td>$V_{CE}$</td>
<td></td>
<td>±20</td>
<td>V</td>
</tr>
<tr>
<td>Short circuit ratings</td>
<td>$t_{SC}$</td>
<td>$V_{GE}=15V$</td>
<td>10</td>
<td>µs</td>
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<tr>
<td></td>
<td>$V_{CE}$</td>
<td>$V_{CE}=15V$</td>
<td>800</td>
<td>µs</td>
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<td>Turn off safe operating area (RBSOA)</td>
<td>$I_{FSM}$</td>
<td>$V_{CE \max} = 1200V$</td>
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<td>Maximum Junction Temperature</td>
<td>$T_{j\max}$</td>
<td></td>
<td>175</td>
<td>°C</td>
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---

### Half Bridge IGBT

- Collector-emitter break down voltage
- DC collector current
- Repetitive peak collector current
- Power dissipation
- Gate-emitter peak voltage
- Short circuit ratings
- Turn off safe operating area (RBSOA)
- Maximum Junction Temperature

### Neutral Point FWD

- Peak Repetitive Reverse Voltage
- DC forward current
- Surge forward current
- I2t-value
- Repetitive peak forward current
- Power dissipation
- Maximum Junction Temperature
### Maximum Ratings

**Neutral Point IGBT**

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Symbol</th>
<th>Condition</th>
<th>Value</th>
<th>Unit</th>
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<tr>
<td>Collector-emitter break down voltage</td>
<td>$V_{ce}$</td>
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<td>600</td>
<td>V</td>
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<tr>
<td>DC collector-emitter peak voltage</td>
<td>$i_c$</td>
<td>$T_j=T_{jmax}$</td>
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<td>Repetitive peak collector current</td>
<td>$I_{FPM}$</td>
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<td>Power dissipation</td>
<td>$P_{tot}$</td>
<td>$T_j=T_{jmax}$</td>
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<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>
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<td>$V_{CC}$</td>
<td>$V_{GE}=15$V</td>
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<td>Maximum Junction Temperature</td>
<td>$T_{jmax}$</td>
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**Half Bridge FWD**

<table>
<thead>
<tr>
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<th>Symbol</th>
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<th>Unit</th>
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<td>Peak Repetitive Reverse Voltage</td>
<td>$V_{zedm}$</td>
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<td>V</td>
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<td>DC forward current</td>
<td>$i_f$</td>
<td>$T_j=T_{jmax}$</td>
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<td>Surge forward current</td>
<td>$I_{ZDM}$</td>
<td>$t_{p}=10$ms, $sin 180^\circ$</td>
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<td>12t-value</td>
<td>$i_{t}^{12}$</td>
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<td>560</td>
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<td>$t_{p}$ limited by $T_{jmax}$</td>
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<td>Power dissipation</td>
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<td>$T_j=T_{jmax}$</td>
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<td>W</td>
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<tr>
<td>Maximum Junction Temperature</td>
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**Thermal Properties**

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<td>-40...+125</td>
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<tr>
<td>Operation temperature under switching condition</td>
<td>$T_{op}$</td>
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<td>-40...+(T_{jmax} - 25)</td>
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**Insulation Properties**

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<th>Parameter</th>
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<th>t=2s</th>
<th>DC voltage</th>
<th>Value</th>
<th>Unit</th>
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<td>Insulation voltage</td>
<td>$V_a$</td>
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<td>4000</td>
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<td>Creepage distance</td>
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<td>min 12,7</td>
<td>mm</td>
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<tr>
<td>Clearance</td>
<td></td>
<td></td>
<td>8,95</td>
<td>mm</td>
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## Characteristic Values

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Symbol</th>
<th>Conditions</th>
<th>Value</th>
<th>Unit</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Half Bridge IGBT</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Gate emitter threshold voltage</td>
<td>$V_{GE(th)}$</td>
<td>$V_{CE} = V_{CE}$</td>
<td>0,003</td>
<td>$T_j=25^\circ C$</td>
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<tr>
<td>Collector-emitter saturation voltage</td>
<td>$V_{CEsat}$</td>
<td>$I_C$ or $I_F$ A or $I_D$ A</td>
<td>15</td>
<td>$T_j=25^\circ C$</td>
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<td>Collector-emitter cut-off current incl. Diode</td>
<td>$I_{CES}$</td>
<td>$T_j=25^\circ C$</td>
<td>0</td>
<td>$T_j=25^\circ C$</td>
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<td>Gate-emitter leakage current</td>
<td>$I_{GES}$</td>
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<td>$T_j=25^\circ C$</td>
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<td>Integrated Gate resistor</td>
<td>$R_{gint}$</td>
<td>none</td>
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<td></td>
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<tr>
<td>Turn-on delay time</td>
<td>$t_{f1}$</td>
<td>$R_{gon}=4 \Omega$</td>
<td>±15</td>
<td>$T_j=25^\circ C$</td>
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<tr>
<td>Rise time</td>
<td>$t_r$</td>
<td>$R_{goff}=4 \Omega$</td>
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<tr>
<td>Turn-off delay time</td>
<td>$t_{off}$</td>
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<td></td>
</tr>
<tr>
<td>Fall time</td>
<td>$t_f$</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Turn-on energy loss</td>
<td>$E_{on}$</td>
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<td></td>
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<tr>
<td>Turn-off energy loss</td>
<td>$E_{off}$</td>
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<tr>
<td>Input capacitance</td>
<td>$C_{iss}$</td>
<td>$f=1MHz$</td>
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<td>$T_j=25^\circ C$</td>
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<td>Output capacitance</td>
<td>$C_{oss}$</td>
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<tr>
<td>Reverse transfer capacitance</td>
<td>$C_{rss}$</td>
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<td></td>
<td></td>
</tr>
<tr>
<td>Gate charge</td>
<td>$Q_G$</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Thermal resistance chip to heatsink</td>
<td>$R_{th(j-s)}$</td>
<td>Thermal grease thickness ≤ 50um</td>
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<tr>
<td><strong>Neutral Point FWD</strong></td>
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<tr>
<td>Diode forward voltage</td>
<td>$V_D$</td>
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<td>15</td>
<td>$T_j=25^\circ C$</td>
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<tr>
<td>Peak reverse recovery current</td>
<td>$I_{r}$</td>
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<td>600</td>
<td>$T_j=25^\circ C$</td>
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<tr>
<td>Reverse recovery time</td>
<td>$t_{rr}$</td>
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<tr>
<td>Reverse recovered charge</td>
<td>$Q_{rr}$</td>
<td>$R_{gon}=4 \Omega$</td>
<td>±15</td>
<td>$T_j=25^\circ C$</td>
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<tr>
<td>Peak rate of fall of recovery current</td>
<td>$I_{(dr/dt)}_{max}$</td>
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<tr>
<td>Reverse recovered energy</td>
<td>$E_{ne}$</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Thermal resistance chip to heatsink</td>
<td>$R_{th(j-s)}$</td>
<td>Thermal grease thickness ≤ 50um</td>
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</tr>
</tbody>
</table>
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<tr>
<td><strong>Neutral Point IGBT</strong></td>
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<tr>
<td>Gate emitter threshold voltage</td>
<td>$V_{GE(th)}$</td>
<td>$V_{CE}=V_{CE}$</td>
<td>0,0012</td>
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<td>Collector-emitter saturation voltage</td>
<td>$V_{CEsat}$</td>
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<tr>
<td>Collector-emitter cut-off incl diode</td>
<td>$t_{off}$</td>
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<td>0</td>
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<tr>
<td>Gate-emitter leakage current</td>
<td>$I_{ges}$</td>
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<td>20</td>
<td>0</td>
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<tr>
<td>Integrated Gate resistor</td>
<td>$R_{gint}$</td>
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<td>none</td>
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</tr>
<tr>
<td>Turn-on delay time</td>
<td>$t_{d(on)}$</td>
<td>$R_{goff}=4 , \Omega$</td>
<td>$\pm 15$</td>
<td>350</td>
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<td>Rise time</td>
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<td>$R_{gon}=4 , \Omega$</td>
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<tr>
<td>Turn-off delay time</td>
<td>$t_{d(off)}$</td>
<td>$R_{goff}=4 , \Omega$</td>
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<td>480</td>
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<td>Fall time</td>
<td>$t_{f}$</td>
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<tr>
<td>Turn-on energy loss</td>
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<td>$T_j=25^\circ C$</td>
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<tr>
<td>Turn-off energy loss</td>
<td>$E_{off}$</td>
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<td>Input capacitance</td>
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<td>Output capacitance</td>
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<td>Reverse transfer capacitance</td>
<td>$C_{rss}$</td>
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<td>Gate charge</td>
<td>$Q_{G}$</td>
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<td>75</td>
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<td>Thermal resistance chip to heatsink</td>
<td>$R_{th(j-s)}$</td>
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<tr>
<td><strong>Half Bridge FWD</strong></td>
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<tr>
<td>Diode forward voltage</td>
<td>$V_{f}$</td>
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<td>Reverse leakage current</td>
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<td>Peak reverse recovery current</td>
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<td>$\pm 15$</td>
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<tr>
<td>Reverse recovery time</td>
<td>$t_{rr}$</td>
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<tr>
<td>Reverse recovered charge</td>
<td>$Q_{rr}$</td>
<td></td>
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<tr>
<td>Peak rate of fall of recovery current</td>
<td>$\theta_{f}(\Delta I_{rr})$</td>
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<td>Reverse recovery energy</td>
<td>$E_{rec}$</td>
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<td>1,55</td>
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<td>Thermal resistance chip to heatsink</td>
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<td><strong>Rated resistance</strong></td>
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<td>Rated resistance</td>
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<td>Deviation of R100</td>
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<tr>
<td>B-value</td>
<td>$B_{(100^\circ C)}$</td>
<td>Tol. ±3%</td>
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**Half Bridge**

**Figure 1**

**Typical output characteristics**

$I_C = f(V_{CE})$

At

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

**Figure 2**

**Typical output characteristics**

$I_C = f(V_{CE})$

At

- $\tau_p = 250 \mu s$
- $T_J = 125 ^\circ C$
- $V_{CE}$ from 7 V to 17 V in steps of 1 V

**Figure 3**

**Typical transfer characteristics**

$I_C = f(V_{CE})$

At

- $\tau_p = 250 \mu s$
- $V_{CE} = 10 V$

**Figure 4**

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

$I_F = f(V_F)$

At

- $\tau_p = 250 \mu s$

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Typical switching energy losses as a function of collector current

\[ E = f(I_C) \]

With an inductive load at

- \( T_J = 25/125 \, ^\circ C \)
- \( V_{CE} = 350 \, V \)
- \( V_{GE} = \pm 15 \, V \)
- \( R_{gon} = 4 \, \Omega \)
- \( R_{goff} = 4 \, \Omega \)

Typical reverse recovery energy loss as a function of collector current

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

With an inductive load at

- \( T_J = 25/125 \, ^\circ C \)
- \( V_{CE} = 350 \, V \)
- \( V_{GE} = \pm 15 \, V \)
- \( R_{gon} = 4 \, \Omega \)
- \( I_C = 56 \, A \)
### Half Bridge

#### Typical switching times as a function of collector current

\[ t = f(I_C) \]

**Figure 9**

With an inductive load at

- \( T_J = 125 \, ^\circ C \)
- \( V_{CE} = 350 \, V \)
- \( V_{GE} = \pm 15 \, V \)
- \( R_{gon} = 4 \, \Omega \)
- \( R_{goff} = 4 \, \Omega \)

**Figure 10**

With an inductive load at

- \( T_J = 125 \, ^\circ C \)
- \( V_{CE} = 350 \, V \)
- \( V_{GE} = \pm 15 \, V \)
- \( I_C = 56 \, A \)

### Typical reverse recovery time as a function of collector current

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

**Figure 11**

**Figure 12**

At

- \( T_J = 25/125 \, ^\circ C \)
- \( V_{CE} = 350 \, V \)
- \( V_{GE} = \pm 15 \, V \)
- \( R_{gon} = 4 \, \Omega \)

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**Half Bridge**

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

At  
\[ T_j = 25/125 \ ^\circ \text{C} \]  
\[ V_{CE} = 350 \ \text{V} \]  
\[ V_{GE} = \pm 15 \ \text{V} \]  
\[ R_{gon} = 4 \ \Omega \]

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

At  
\[ T_j = 25/125 \ ^\circ \text{C} \]  
\[ V_R = 350 \ \text{V} \]  
\[ I_F = 56 \ \text{A} \]  
\[ V_{GE} = \pm 15 \ \text{V} \]

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

At  
\[ T_j = 25/125 \ ^\circ \text{C} \]  
\[ V_{CE} = 350 \ \text{V} \]  
\[ V_{GE} = \pm 15 \ \text{V} \]  
\[ R_{gon} = 4 \ \Omega \]

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

At  
\[ T_j = 25/125 \ ^\circ \text{C} \]  
\[ V_R = 350 \ \text{V} \]  
\[ I_F = 56 \ \text{A} \]  
\[ V_{GE} = \pm 15 \ \text{V} \]
Half Bridge
Half Bridge IGBT and Neutral Point FWD

Figure 17
Typical rate of fall of forward and reverse recovery current as a function of collector current
\( \frac{dI}{dt}, \frac{dI_{\text{rec}}}{dt} = f(I_C) \)

\[ \frac{dI_0}{dt}, \frac{dI_{\text{rec}}}{dt} = f(R_{\text{gon}}) \]

At
- \( T_j = 25/125 \ ^\circ\text{C} \)
- \( V_{CE} = 350 \ \text{V} \)
- \( V_{GE} = \pm 15 \ \text{V} \)
- \( R_{\text{gon}} = 4 \ \Omega \)

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

At
- \( T_j = 25/125 \ ^\circ\text{C} \)
- \( V_R = 350 \ \text{V} \)
- \( I_F = 56 \ \text{A} \)
- \( V_{GE} = \pm 15 \ \text{V} \)

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

At
- \( D = \frac{t_p}{T} \)
- \( R_{\text{thJH}} = 0,60 \ \text{K/W} \)

IGBT thermal model values

<table>
<thead>
<tr>
<th>( R ) (K/W)</th>
<th>( \text{Tau (s)} )</th>
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<tbody>
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</tbody>
</table>

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

At
- \( D = \frac{t_p}{T} \)
- \( R_{\text{thJH}} = 1,63 \ \text{K/W} \)

FWD thermal model values

<table>
<thead>
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<th>( R ) (K/W)</th>
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<td>0,11</td>
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</tbody>
</table>
### Half Bridge

**Figure 21**  
Half Bridge IGBT and Neutral Point FWD

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

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

**Figure 22**  
IGBT

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

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

**Figure 23**  
FWD

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

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

**Figure 24**  
FWD

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

At  
\[ T_j = 175 \, ^\circ C \]
Figure 25
Safe operating area as a function of collector-emitter voltage

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

At
\( D = \) single pulse
\( T_a = 80 \) °C
\( V_{GE} = \pm 15 \) V
\( T_j = T_{J\max} \) °C

Figure 26
Gate voltage vs Gate charge

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

At
\( I_C = 80 \) A

Figure 27
Reverse bias safe operating area

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

At
\( T_j = T_{J\max} - 25 \) °C
DC link \( V_{CE\max} = \) DC link plus
Switching mode : 3 level switching
Neutral point

Neutral Point IGBT and Half Bridge FWD

**Figure 1**
Neutral Point 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**
Neutral Point 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**
Neutral Point IGBT

Typical transfer characteristics

$I_C = f(V_{CE})$

At

- $t_p = 250 \, \mu s$
- $V_{CE} = 10 \, V$

**Figure 4**
FWD

Typical diode forward current as a function of forward voltage

$I_F = f(V_F)$

At

- $t_p = 250 \, \mu s$
- $T_j = T_j_{max} - 25 \, ^\circ C$
Neutral point
Neutral Point IGBT and Half Bridge FWD

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

\[ E = f(I_C) \]

With an inductive load at
- \( T_J = 25/125 \) °C
- \( V_{CE} = 350 \) V
- \( V_{GE} = \pm 15 \) V
- \( R_{gon} = 4 \) Ω
- \( R_{goff} = 4 \) Ω

**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
- \( V_{CE} = 350 \) V
- \( V_{GE} = \pm 15 \) V
- \( I_C = 56 \) A

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

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

With an inductive load at
- \( T_J = 25/125 \) °C
- \( V_{CE} = 350 \) V
- \( V_{GE} = \pm 15 \) V
- \( R_{gon} = 4 \) Ω

**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
- \( V_{CE} = 350 \) V
- \( V_{GE} = \pm 15 \) V
- \( I_C = 56 \) A
Neutral point
Neutral Point IGBT and Half Bridge FWD

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

\[ t = f(I_C) \]

With an inductive load at

- \( T_J = 125 \, ^\circ\text{C} \)
- \( V_{CE} = 350 \, \text{V} \)
- \( V_{GE} = \pm 15 \, \text{V} \)
- \( R_{gon} = 4 \, \Omega \)
- \( R_{goff} = 4 \, \Omega \)

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

\[ t = f(R_G) \]

With an inductive load at

- \( T_J = 125 \, ^\circ\text{C} \)
- \( V_{CE} = 350 \, \text{V} \)
- \( V_{GE} = \pm 15 \, \text{V} \)
- \( I_C = 56 \, \text{A} \)

**Figure 11**
Typical reverse recovery time as a function of collector current

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

At

- \( T_J = 25/125 \, ^\circ\text{C} \)
- \( V_{CE} = 350 \, \text{V} \)
- \( V_{GE} = \pm 15 \, \text{V} \)
- \( R_{gon} = 4 \, \Omega \)

**Figure 12**
Typical reverse recovery time as a function of IGBT turn on gate resistor

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

At

- \( T_J = 25/125 \, ^\circ\text{C} \)
- \( V_{CE} = 350 \, \text{V} \)
- \( I_F = 56 \, \text{A} \)
- \( V_{GE} = \pm 15 \, \text{V} \)
Neutral point
Neutral Point IGBT and Half Bridge FWD

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

- **At**
  - \( T_j = 25/125 \) °C
  - \( V_{CE} = 350 \) V
  - \( V_{GE} = \pm 15 \) V
  - \( R_{gon} = 4 \) Ω

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

- **At**
  - \( T_j = 25/125 \) °C
  - \( V_R = 350 \) V
  - \( I_F = 56 \) A
  - \( V_{GE} = \pm 15 \) V

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

- **At**
  - \( T_j = 25/125 \) °C
  - \( V_{CE} = 350 \) V
  - \( V_{GE} = \pm 15 \) V
  - \( I_F = 56 \) A
  - \( R_{gon} = 4 \) Ω

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

- **At**
  - \( T_j = 25/125 \) °C
  - \( V_R = 350 \) V
  - \( I_F = 56 \) A
  - \( V_{GE} = \pm 15 \) V
Neutral point
Neutral Point IGBT and Half Bridge FWD

**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
- \( V_{CE} = 350 \) V
- \( V_{GE} = \pm 15 \) 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
- \( V_R = 350 \) V
- \( I_F = 56 \) A
- \( V_{GE} = \pm 15 \) V

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

At
- \( D = t_p / T \)
- \( R_{thJH} = 1.32 \) K/W

IGBT thermal model values

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<th>( \tau ) (s)</th>
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<td>8.5E-02</td>
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<tr>
<td>0.13</td>
<td>8.9E-03</td>
</tr>
</tbody>
</table>

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

At
- \( D = t_p / T \)
- \( R_{thJH} = 1.21 \) K/W

FWD thermal model values

<table>
<thead>
<tr>
<th>( R ) (K/W)</th>
<th>( \tau ) (s)</th>
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</thead>
<tbody>
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<td>0.05</td>
<td>2.8E-03</td>
</tr>
</tbody>
</table>
Neutral point
Neutral Point IGBT and Half Bridge FWD

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

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

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

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

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

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

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

At
\[ T_j = 175 \, ^\circ C \]
Neutral Point
Neutral Point IGBT and Half Bridge FWD

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

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

At
\[ D = \text{single pulse} \]
\[ T_a = 80 \, ^\circ\text{C} \]
\[ V_{GE} = 15 \, \text{V} \]
\[ T_j = T_{j\text{max}} \, ^\circ\text{C} \]

Figure 26
Gate voltage vs Gate charge

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

At
\[ I_C = 75 \, \text{A} \]

Figure 27
Reverse bias safe operating area

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

At
\[ T_j = T_{j\text{max}}-25 \, ^\circ\text{C} \]
DC link \( V_{\text{DC}} = \text{DC link plus} \)
Switching mode : 3 level switching
Thermistor

Figure 1  Thermistor

Typical NTC characteristic
as a function of temperature

\[ R_\text{t} = f(T) \]
Switching Definitions Neutral point IGBT

General conditions

<table>
<thead>
<tr>
<th>Condition</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>$T_J$</td>
<td>125 °C</td>
</tr>
<tr>
<td>$R_{gon}$</td>
<td>4 Ω</td>
</tr>
<tr>
<td>$R_{goff}$</td>
<td>4 Ω</td>
</tr>
</tbody>
</table>

**Figure 1** Neutral point IGBT

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

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

- $V_{CG}(0\%) = -15$ V
- $V_{CG}(100\%) = 15$ V
- $V_{CE}(100\%) = 350$ V
- $I_C(100\%) = 56$ A
- $t_{doff} = 0.21 \mu s$
- $t_{Eoff} = 0.58 \mu s$

**Figure 2** Neutral point IGBT

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

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

- $V_{CG}(0\%) = -15$ V
- $V_{CG}(100\%) = 15$ V
- $V_{CE}(100\%) = 350$ V
- $I_C(100\%) = 56$ A
- $t_{don} = 0.09 \mu s$
- $t_{Eon} = 0.16 \mu s$

**Figure 3** Neutral point IGBT

Turn-off Switching Waveforms & definition of $t_r$

- $V_C(100\%) = 350$ V
- $I_C(100\%) = 56$ A
- $t_r = 0.11 \mu s$

**Figure 4** Neutral point IGBT

Turn-on Switching Waveforms & definition of $t_r$

- $V_C(100\%) = 350$ V
- $I_C(100\%) = 56$ A
- $t_r = 0.01 \mu s$
Switching Definitions Neutral point IGBT

Figure 5  Neutral point IGBT
Turn-off Switching Waveforms & definition of \( t_{\text{Eoff}} \)

\[ P_{\text{off}} (100\%) = 19.56 \text{ kW} \]
\[ E_{\text{off}} (100\%) = 2.50 \text{ mJ} \]
\[ t_{\text{Eoff}} = 0.58 \mu\text{s} \]

Figure 6  Neutral point IGBT
Turn-on Switching Waveforms & definition of \( t_{\text{Eon}} \)

\[ P_{\text{on}} (100\%) = 19.56 \text{ kW} \]
\[ E_{\text{on}} (100\%) = 0.75 \text{ mJ} \]
\[ t_{\text{Eon}} = 0.16 \mu\text{s} \]

Figure 7  Neutral point IGBT
Gate voltage vs Gate charge (measured)

\[ V_{GE\text{ off}} = -15 \text{ V} \]
\[ V_{GE\text{ on}} = 15 \text{ V} \]
\[ V_C (100\%) = 350 \text{ V} \]
\[ I_C (100\%) = 56 \text{ A} \]
\[ Q_g = 775.97 \text{ nC} \]

Figure 8  Neutral point FWD
Turn-off Switching Waveforms & definition of \( t_r \)

\[ V_d (100\%) = 350 \text{ V} \]
\[ I_d (100\%) = 56 \text{ A} \]
\[ I_{\text{RRM}} (100\%) = -118 \text{ A} \]
\[ t_r = 0.15 \mu\text{s} \]
Switching Definitions Neutral point IGBT

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

![Switching Waveforms](image)

$I_d (100\%) = 56$ A  
$Q_{rr} (100\%) = 8,22$ µC  
$t_{Q_{rr}} = 1,00$ µs

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

![Switching Waveforms](image)

$P_{rec} (100\%) = 19,56$ kW  
$E_{rec} (100\%) = 2,42$ mJ  
$t_{E_{rec}} = 1,00$ µs

**Measurement circuits**

**Figure 11**
BOOST stage switching measurement circuit

![Diagram](image)
Switching Definitions Half Bridge IGBT

General conditions

<table>
<thead>
<tr>
<th>Symbol</th>
<th>Value</th>
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<tr>
<td>$T_J$</td>
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<tr>
<td>$R_{gon}$</td>
<td>4 Ω</td>
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<tr>
<td>$R_{goff}$</td>
<td>4 Ω</td>
</tr>
</tbody>
</table>

Figure 1

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

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

- $V_{GEO}(0\%) = -15$ V
- $V_{GEC}(100\%) = 15$ V
- $V_{CE}(100\%) = 700$ V
- $I_C(100\%) = 56$ A
- $t_{doff} = 0.23$ µs
- $t_{Eoff} = 0.60$ µs

Figure 2

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

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

- $V_{GEO}(0\%) = -15$ V
- $V_{GEC}(100\%) = 15$ V
- $V_{CE}(100\%) = 700$ V
- $I_C(100\%) = 56$ A
- $t_{don} = 0.08$ µs
- $t_{Eon} = 0.21$ µs

Figure 3

Turn-off Switching Waveforms & definition of $t_f$

- $V_{CE}(100\%) = 700$ V
- $I_C(100\%) = 56$ A
- $t_f = 0.07$ µs

Figure 4

Turn-on Switching Waveforms & definition of $t_r$

- $V_{CE}(100\%) = 700$ V
- $I_C(100\%) = 56$ A
- $t_r = 0.02$ µs
Switching Definitions Half Bridge IGBT

Figure 5: Turn-off Switching Waveforms & definition of $t_{\text{Eoff}}$

- $P_{\text{off}}$ (100%) = 39.44 kW
- $E_{\text{off}}$ (100%) = 2.24 mJ
- $t_{\text{Eoff}}$ = 0.60 µs

Figure 6: Turn-on Switching Waveforms & definition of $t_{\text{Eon}}$

- $P_{\text{on}}$ (100%) = 39.44 kW
- $E_{\text{on}}$ (100%) = 0.96 mJ
- $t_{\text{Eon}}$ = 0.21 µs

Figure 7: Gate voltage vs Gate charge (measured)

- $V_{\text{GE off}}$ = -15 V
- $V_{\text{GE on}}$ = 15 V
- $V_{\text{C}}$ (100%) = 700 V
- $I_{\text{C}}$ (100%) = 56 A
- $Q_{g}$ = 596.49 nC

Figure 8: Turn-off Switching Waveforms & definition of $t_{\text{rr}}$

- $V_{\text{d}}$ (100%) = 700 V
- $I_{\text{d}}$ (100%) = 56 A
- $I_{\text{RRM}}$ (100%) = -83 A
- $t_{\text{rr}}$ = 0.07 µs
Switching Definitions Half Bridge IGBT

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

Figure 10  
Half Bridge IGBT  
Turn-on Switching Waveforms & definition of $t_{E_{rec}}$  
($t_{E_{rec}} = \text{integrating time for } E_{rec}$)

$I_d (100\%) = 56 \text{ A}$
$Q_{rr} (100\%) = 2,74 \mu \text{C}$
$t_{Qrr} = 0,16 \mu \text{s}$

$P_{\text{rec}} (100\%) = 39,44 \text{ kW}$
$E_{\text{rec}} (100\%) = 0,53 \text{ mJ}$
$t_{E_{rec}} = 0,16 \mu \text{s}$

Measurement circuits

Figure 11  
BUCK stage switching measurement circuit
### Ordering Code & Marking

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### Pinout

- **+DC**: 15,16
- **GND**: 05, 14
- **-DC**: 03,04
- **Line**: 08, 09, 10, 11
- **G1**: 17
- **S1**: 18
- **G2**: 02
- **S2**: 01
- **NTC1**: 19
- **NTC2**: 20

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