### Features
- Mixed voltage NPC topology
- Reactive power capability
- Low inductance layout
- Split output
- Enhanced LVRT capability

### Target Applications
- Solar inverter
- UPS
- Active frontend

### Types
- 10-FY12NMA160SH01-M820F18
- 10-PY12NMA160SH01-M820F18Y

### 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>$V_{RSM}$</td>
<td></td>
<td>1200</td>
<td>V</td>
</tr>
<tr>
<td>Forward current</td>
<td>$I_{FAd}$</td>
<td>DC current</td>
<td>14</td>
<td>A</td>
</tr>
<tr>
<td>Repetitive peak forward current</td>
<td>$I_{FPM}$</td>
<td>$t_p=10\text{ms}$</td>
<td>14</td>
<td>A</td>
</tr>
<tr>
<td>Power dissipation</td>
<td>$P_{tot}$</td>
<td>$T_j=T_{j,max}$</td>
<td>31</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>

#### Halfbridge IGBT Inverse Diode

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Symbol</th>
<th>Condition</th>
<th>Value</th>
<th>Unit</th>
</tr>
</thead>
<tbody>
<tr>
<td>Collector-emitter break down voltage</td>
<td>$V_{CES}$</td>
<td></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>117</td>
<td>A</td>
</tr>
<tr>
<td>Pulsed collector current</td>
<td>$I_{CRM}$</td>
<td>$t_p\text{ limited by }T_j{max}$</td>
<td>480</td>
<td>A</td>
</tr>
<tr>
<td>Turn off safe operating area</td>
<td></td>
<td>$T_j\leq150\text{°C}$</td>
<td>480</td>
<td>A</td>
</tr>
<tr>
<td>Power dissipation</td>
<td>$P_{tot}$</td>
<td>$T_j=T_{j,max}$</td>
<td>260</td>
<td>W</td>
</tr>
<tr>
<td>Gate-emitter peak voltage</td>
<td>$V_{GE}$</td>
<td></td>
<td>±20</td>
<td>V</td>
</tr>
<tr>
<td>Short circuit ratings</td>
<td>$t_{SC}$</td>
<td>$T_j\leq150\text{°C}$</td>
<td>10</td>
<td>μs</td>
</tr>
<tr>
<td></td>
<td>$V_{CC}$</td>
<td>$V_{GE}=15\text{V}$</td>
<td>800</td>
<td>V</td>
</tr>
<tr>
<td>Maximum Junction Temperature</td>
<td>$T_{j,max}$</td>
<td></td>
<td>175</td>
<td>°C</td>
</tr>
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</table>
## Maximum Ratings

\( T_j=25^\circ C \), unless otherwise specified

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Symbol</th>
<th>Condition</th>
<th>Value</th>
<th>Unit</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>NP Diode</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Peak Repetitive Reverse Voltage</td>
<td>( V_{RRM} )</td>
<td></td>
<td>700</td>
<td>V</td>
</tr>
<tr>
<td>DC forward current</td>
<td>( I_F )</td>
<td>( T_j=T_{j\max} ) ( T_h=80^\circ C )</td>
<td>53</td>
<td>A</td>
</tr>
<tr>
<td>Power dissipation</td>
<td>( P_{tot} )</td>
<td>( T_j=T_{j\max} ) ( T_h=80^\circ C ) ( T_c=80^\circ C )</td>
<td>63</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><strong>NP IGBT</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Collector-emitter break down voltage</td>
<td>( V_{CES} )</td>
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<td>650</td>
<td>V</td>
</tr>
<tr>
<td>DC collector current</td>
<td>( I_C )</td>
<td>( T_j=T_{j\max} ) ( T_h=80^\circ C ) ( T_c=80^\circ C )</td>
<td>76</td>
<td>A</td>
</tr>
<tr>
<td>Pulsed collector current</td>
<td>( I_{CRM} )</td>
<td>( t_p ) limited by ( T_{j\max} )</td>
<td>450</td>
<td>A</td>
</tr>
<tr>
<td>Turn off safe operating area</td>
<td>( P_{tot} )</td>
<td>( T_j=T_{j\max} ) ( T_h=80^\circ C ) ( T_c=80^\circ C )</td>
<td>96</td>
<td>W</td>
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<tr>
<td>Power dissipation</td>
<td>( P_{tot} )</td>
<td>( V_{CE}=15V )</td>
<td>145</td>
<td>W</td>
</tr>
<tr>
<td>Gate-emitter peak voltage</td>
<td>( V_{GE} )</td>
<td></td>
<td>±20</td>
<td>V</td>
</tr>
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<td>Short circuit ratings</td>
<td>( t_{SC} )</td>
<td>( T_j\leq150^\circ C ) ( V_{CE}=15V )</td>
<td>6</td>
<td>μs</td>
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<tr>
<td></td>
<td>( V_{CC} )</td>
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<td>360</td>
<td>V</td>
</tr>
<tr>
<td>Maximum Junction Temperature</td>
<td>( T_{j\max} )</td>
<td></td>
<td>175</td>
<td>°C</td>
</tr>
<tr>
<td><strong>NP Inverse Diode</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Peak Repetitive Reverse Voltage</td>
<td>( V_{RRM} )</td>
<td></td>
<td>650</td>
<td>V</td>
</tr>
<tr>
<td>DC forward current</td>
<td>( I_F )</td>
<td>( T_j=T_{j\max} ) ( T_h=80^\circ C ) ( T_c=80^\circ C )</td>
<td>15</td>
<td>A</td>
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<td>Repetitive peak forward current</td>
<td>( I_{CRM} )</td>
<td>( t_p ) limited by ( T_{j\max} )</td>
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<td>A</td>
</tr>
<tr>
<td>Power dissipation</td>
<td>( P_{tot} )</td>
<td>( T_j=T_{j\max} ) ( T_h=80^\circ C ) ( T_c=80^\circ C )</td>
<td>28</td>
<td>W</td>
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<tr>
<td>Maximum Junction Temperature</td>
<td>( T_{j\max} )</td>
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<td>175</td>
<td>°C</td>
</tr>
<tr>
<td><strong>Halfbridge Diode</strong></td>
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</tr>
<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_F )</td>
<td>( T_j=T_{j\max} ) ( T_h=80^\circ C ) ( T_c=80^\circ C )</td>
<td>31</td>
<td>A</td>
</tr>
<tr>
<td>Repetitive peak forward current</td>
<td>( I_{CRM} )</td>
<td>( t_p ) limited by ( T_{j\max} )</td>
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<td>A</td>
</tr>
<tr>
<td>Power dissipation</td>
<td>( P_{tot} )</td>
<td>( T_j=T_{j\max} ) ( T_h=80^\circ C ) ( T_c=80^\circ C )</td>
<td>61</td>
<td>W</td>
</tr>
<tr>
<td>Maximum Junction Temperature</td>
<td>( T_{j\max} )</td>
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<td>150</td>
<td>°C</td>
</tr>
</tbody>
</table>
$T_j=25{^\circ}C$, unless otherwise specified

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Symbol</th>
<th>Condition</th>
<th>Value</th>
<th>Unit</th>
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<tbody>
<tr>
<td>DC link Capacitor</td>
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<td></td>
<td></td>
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<tr>
<td>Max. DC voltage</td>
<td>$V_{\text{MAX}}$</td>
<td>$T_c=25{^\circ}C$</td>
<td>630</td>
<td>V</td>
</tr>
<tr>
<td>Thermal Properties</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Storage temperature</td>
<td>$T_{\text{stg}}$</td>
<td></td>
<td>-40...+125</td>
<td>°C</td>
</tr>
<tr>
<td>Operation temperature under switching condition</td>
<td>$T_{\text{op}}$</td>
<td></td>
<td>-40...+(T_{\text{max}} - 25)</td>
<td>°C</td>
</tr>
<tr>
<td>Insulation Properties</td>
<td></td>
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<td></td>
</tr>
<tr>
<td>Insulation voltage</td>
<td>$V_{\text{IS}}$</td>
<td>$t=2s$</td>
<td>DC voltage</td>
<td>4000</td>
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<tr>
<td>Creepage distance</td>
<td></td>
<td></td>
<td></td>
<td>min 12,7</td>
</tr>
<tr>
<td>Clearance</td>
<td></td>
<td></td>
<td></td>
<td>min 8,06</td>
</tr>
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</table>
### 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>Forward voltage</strong></td>
<td>$V_{ds}$</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Reverse current</strong></td>
<td>$I_{r}$</td>
<td>1200</td>
<td>7</td>
<td>$T_j=25^\circ\text{C}$</td>
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<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>$T_j=125^\circ\text{C}$</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>$T_j=125^\circ\text{C}$</td>
</tr>
<tr>
<td><strong>Thermal resistance chip to heatsink</strong></td>
<td>$R_{th(j-s)}$</td>
<td>Thermal grease thickness≤50um $\lambda = 1 \text{ W/mK}$</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

### Halfbridge IGBT

<table>
<thead>
<tr>
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<th>Symbol</th>
<th>Conditions</th>
<th>Value</th>
<th>Unit</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Gate emitter threshold voltage</strong></td>
<td>$V_{GE(th)}$</td>
<td>$V_{CE}=V_{GE}$</td>
<td>0,006</td>
<td>5</td>
</tr>
<tr>
<td></td>
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<td>$T_j=125^\circ\text{C}$</td>
</tr>
<tr>
<td><strong>Collector-emitter saturation voltage</strong></td>
<td>$V_{ces}$</td>
<td>15</td>
<td>160</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>$T_j=125^\circ\text{C}$</td>
</tr>
<tr>
<td><strong>Collector-emitter cut-off incl. Diode</strong></td>
<td>$I_{ces}$</td>
<td>0</td>
<td>1200</td>
<td>1</td>
</tr>
<tr>
<td><strong>Gate-emitter leakage current</strong></td>
<td>$I_{ge}$</td>
<td>20</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td><strong>Integrated Gate resistor</strong></td>
<td>$R_{gan}$</td>
<td>none</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Turn-on delay time</strong></td>
<td>$t_{d(on)}$</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Rise time</strong></td>
<td>$t_r$</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Turn-off delay time</strong></td>
<td>$t_{d(off)}$</td>
<td>Roff=4 Ω</td>
<td>45</td>
<td>15</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Rgon=4 Ω</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Fall time</strong></td>
<td>$t_f$</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Turn-on energy loss per pulse</strong></td>
<td>$E_{on}$</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Turn-off energy loss per pulse</strong></td>
<td>$E_{off}$</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Input capacitance</strong></td>
<td>$C_{iss}$</td>
<td>$f=1\text{MHz}$</td>
<td>0</td>
<td>25</td>
</tr>
<tr>
<td><strong>Output capacitance</strong></td>
<td>$C_{oss}$</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Reverse transfer capacitance</strong></td>
<td>$C_{ies}$</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Gate charge</strong></td>
<td>$Q_{g}$</td>
<td>$\pm 15$</td>
<td>960</td>
<td>160</td>
</tr>
<tr>
<td><strong>Thermal resistance chip to heatsink</strong></td>
<td>$R_{th(j-s)}$</td>
<td>Thermal grease thickness≤50um $\lambda = 1 \text{ W/mK}$</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

### NP Diode

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Symbol</th>
<th>Conditions</th>
<th>Value</th>
<th>Unit</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Diode forward voltage</strong></td>
<td>$V_s$</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Reverse leakage current</strong></td>
<td>$I_{r}$</td>
<td>700</td>
<td>1</td>
<td>$T_j=25^\circ\text{C}$</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>$T_j=125^\circ\text{C}$</td>
</tr>
<tr>
<td><strong>Peak reverse recovery current</strong></td>
<td>$I_{rr}$</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Reverse recovery time</strong></td>
<td>$t_{rr}$</td>
<td>Rgon=4 Ω</td>
<td>86</td>
<td>15</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>$T_j=125^\circ\text{C}$</td>
</tr>
<tr>
<td><strong>Reverse recovered charge</strong></td>
<td>$Q_{rr}$</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Peak rate of fall of recovery current</strong></td>
<td>$(dV_{ds}/dt)_{max}$</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Reverse recovered energy</strong></td>
<td>$E_{rec}$</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Thermal resistance chip to heatsink</strong></td>
<td>$R_{th(j-s)}$</td>
<td>Thermal grease thickness≤50um $\lambda = 1 \text{ W/mK}$</td>
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<td></td>
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</table>
## Characteristic Values

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<tr>
<th>Parameter</th>
<th>Symbol</th>
<th>Conditions</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Parameter</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Voltage</td>
<td>( V )</td>
<td>(</td>
<td>V</td>
</tr>
<tr>
<td>Current</td>
<td>( I )</td>
<td>(</td>
<td>I</td>
</tr>
<tr>
<td>Temperature</td>
<td>( T )</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

### NP IGBT

- **Gate emitter threshold voltage**
  - \( V_{GE(th)} \)
  - Conditions: \( T=25°C \) or \( T=125°C \)
  - Value: \( 5 \), \( 8 \), \( 6.5 \) \( V \)
- **Collector-emitter saturation voltage**
  - \( V_{CEO} \)
  - Conditions: \( T=25°C \) or \( T=125°C \)
  - Value: \( 1.05 \), \( 1.48 \), \( 1.85 \) \( V \)
- **Collector-emitter cut-off incl diode**
  - \( I_{CES} \)
  - Conditions: \( T=25°C \) or \( T=125°C \)
  - Value: 0.05 \( mA \)
- **Gate-emitter leakage current**
  - \( I_{GE} \)
  - Conditions: \( T=25°C \) or \( T=125°C \)
  - Value: 700 \( nA \)
- **Integrated Gate resistor**
  - \( R_{gm} \)
  - Value: none \( \Omega \)
- **Turn-on delay time**
  - \( t_{(on)} \)
  - Conditions: \( T=25°C \) or \( T=125°C \)
  - Value: \( 0.008 \) \( ms \)
- **Rise time**
  - \( t_{r} \)
  - Conditions: \( T=25°C \) or \( T=125°C \)
  - Value: \( 0.15 \) \( ns \)
- **Turn-off delay time**
  - \( t_{(off)} \)
  - Conditions: \( T=25°C \) or \( T=125°C \)
  - Value: \( 350 \) \( ns \)
- **Fall time**
  - \( t_{f} \)
  - Conditions: \( T=25°C \) or \( T=125°C \)
  - Value: \( 100 \) \( ns \)
- **Turn-on energy loss per pulse**
  - \( E_{on} \)
  - Conditions: \( T=25°C \) or \( T=125°C \)
  - Value: \( 1.23 \) \( mW \)
- **Turn-off energy loss per pulse**
  - \( E_{off} \)
  - Conditions: \( T=25°C \) or \( T=125°C \)
  - Value: \( 1.99 \) \( mW \)
- **Input capacitance**
  - \( C_{sc} \)
  - Conditions: \( f=1MHz \)
  - Value: \( 0.276 \) \( pF \)
- **Output capacitance**
  - \( C_{so} \)
  - Conditions: \( T=25°C \)
  - Value: \( 0.274 \) \( pF \)
- **Reverse transfer capacitance**
  - \( C_{rss} \)
  - Conditions: \( T=100°C \)
  - Value: \( 0.033 \) \( pF \)
- **Thermal resistance chip to heatsink**
  - \( R_{(j-Q)} \)
  - Conditions: Thermal grease thickness 50um \( \lambda = 1 \) \( W/mK \)
  - Value: \( 0.99 \) \( K/W \)

### NP Inverse Diode

- **Diode forward voltage**
  - \( V_{F} \)
  - Conditions: \( T=25°C \) or \( T=125°C \)
  - Value: \( 1.23 \) \( V \)
- **Thermal resistance chip to heatsink**
  - \( R_{(j-Q)} \)
  - Conditions: Thermal grease thickness 50um \( \lambda = 1 \) \( W/mK \)
  - Value: \( 3.43 \) \( K/W \)

### Halfbridge Diode

- **Diode forward voltage**
  - \( V_{F} \)
  - Conditions: \( T=25°C \) or \( T=125°C \)
  - Value: \( 1.23 \) \( V \)
- **Reverse leakage current**
  - \( I_{r} \)
  - Conditions: \( T=25°C \) or \( T=125°C \)
  - Value: \( 200 \) \( mA \)
- **Peak reverse recovery current**
  - \( I_{(off)} \)
  - Conditions: \( T=25°C \) or \( T=125°C \)
  - Value: \( 3.5 \) \( mA \)
- **Reverse recovery time**
  - \( t_{r} \)
  - Conditions: \( T=25°C \) or \( T=125°C \)
  - Value: \( 3.3 \) \( ms \)
- **Reverse recovered charge**
  - \( Q_{sc} \)
  - Conditions: \( T=25°C \) or \( T=125°C \)
  - Value: \( 6.17 \) \( \mu C \)
- **Peak rate of fall of recovery current**
  - \( (d_{i}/dt)_{max} \)
  - Conditions: \( T=25°C \) or \( T=125°C \)
  - Value: \( 2952 \) \( A/\mu s \)
- **Reverse recovery energy**
  - \( E_{sc} \)
  - Conditions: \( T=25°C \) or \( T=125°C \)
  - Value: \( 1.66 \) \( mWs \)
- **Thermal resistance chip to heatsink**
  - \( R_{(j-Q)} \)
  - Conditions: Thermal grease thickness 50um \( \lambda = 1 \) \( W/mK \)
  - Value: \( 1.15 \) \( K/W \)

### DC link Capacitor

- **C value**
  - \( C \)
  - Conditions: \( 80 \), \( 100 \), \( 120 \) \( nF \)

### Thermistor

- **Rated resistance**
  - \( R \)
  - Conditions: \( T=25°C \)
  - Value: \( 21511 \) \( \Omega \)
- **Deviation of R100**
  - \( A_{\pm 100} \)
  - Conditions: \( R100=1486 \) \( \Omega \)
  - Value: \( -4.5 \) to \( +4.5 \) \%)
- **Power dissipation**
  - \( P \)
  - Conditions: \( T=25°C \)
  - Value: \( 210 \) \( mW \)
- **Power dissipation constant**
  - \( B \)
  - Conditions: \( T=25°C \)
  - Value: \( 3.5 \) \( mW/K \)
- **B-value**
  - \( B \)
  - Conditions: \( T=25°C \)
  - Value: \( 3964 \) \( K \)

---

10-FY12NMA160SH01-M820F18
10-PY12NMA160SH01-M820F18Y
 datasheet

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Half Bridge

Half Bridge IGBT and Neutral Point FWD

**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

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

**Figure 3**
Typical transfer characteristics

$I_C = f(V_{CE})$

At

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

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

$I_F = f(V_F)$

At

- $t_P = 250 \ \mu s$

$T_j = T_{jmax} - 25 ^\circ C$

$V_{CE}$ = 10 V

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**Figure 5**

Typical switching energy losses as a function of collector current

\[ E = f(I_C) \]

With an inductive load at

\[ T_j = 25/125 \degree C \]
\[ V_{CE} = 350 \text{ V} \]
\[ V_{GE} = \pm 15 \text{ V} \]
\[ R_{gon} = 4 \Omega \]
\[ I_C = 100 \text{ A} \]

**Figure 6**

Typical switching energy losses as a function of gate resistor

\[ E = f(R_G) \]

With an inductive load at

\[ T_j = 25/125 \degree C \]
\[ V_{CE} = 350 \text{ V} \]
\[ V_{GE} = \pm 15 \text{ V} \]
\[ R_{gon} = 4 \Omega \]
\[ I_C = 100 \text{ A} \]

**Figure 7**

Typical reverse recovery energy loss as a function of collector current

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

With an inductive load at

\[ T_j = 25/125 \degree C \]
\[ V_{CE} = 350 \text{ V} \]
\[ V_{GE} = \pm 15 \text{ V} \]
\[ R_{goff} = 4 \Omega \]

**Figure 8**

Typical reverse recovery energy loss as a function of gate resistor

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

With an inductive load at

\[ T_j = 25/125 \degree C \]
\[ V_{CE} = 350 \text{ V} \]
\[ V_{GE} = \pm 15 \text{ V} \]
\[ R_{goff} = 4 \Omega \]
\[ I_C = 100 \text{ A} \]
Half Bridge
Half Bridge IGBT and Neutral Point FWD

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

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

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

With an inductive load at
- \( T_j = 125 \) °C
- \( V_{CE} = 350 \) V
- \( V_{GE} = \pm 15 \) V
- \( I_C = 100 \) A

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

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

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

At
- \( T_j = 25/125 \) °C
- \( V_{CE} = 350 \) V
- \( I_F = 100 \) A
- \( V_{GE} = \pm 15 \) V
Half Bridge
Half Bridge IGBT and Neutral Point FWD

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

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

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

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

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

At
\[ T_J = 25/125 \ \degree C \]
\[ V_R = 350 \ \text{V} \]
\[ I_F = 100 \ \text{A} \]
\[ V_{GE} = \pm 15 \ \text{V} \]

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

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

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

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

At
\[ T_J = 25/125 \ \degree C \]
\[ V_R = 350 \ \text{V} \]
\[ I_F = 100 \ \text{A} \]
\[ V_{GE} = \pm 15 \ \text{V} \]
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 
\[ \frac{dI}{dt}, \frac{dI_{rec}}{dt} = f(I_c) \]

At
\[ T_j = 25/125 \, ^\circ C \]
\[ V_{CE} = 350 \, V \]
\[ V_{GE} = \pm 15 \, V \]
\[ I_F = 100 \, A \]
\[ R_{gon} = 4 \, \Omega \]

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

At
\[ T_j = 25/125 \, ^\circ C \]
\[ V_r = 350 \, V \]
\[ I_r = 100 \, A \]
\[ V_{GE} = \pm 15 \, V \]

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

At
\[ D = \frac{t_p}{T} \]
\[ R_{\infty} = 0.37 \, K/W \]

IGBT thermal model values

\[ R \, (K/W) \, \tau \, (s) \]
\[ 0.06, 2.4E+00 \]
\[ 0.15, 4.0E-01 \]
\[ 0.12, 1.0E-01 \]
\[ 0.03, 1.3E-02 \]
\[ 0.01, 8.4E-04 \]

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

At
\[ D = \frac{t_p}{T} \]
\[ R_{\infty} = 1.11 \, K/W \]

FWD thermal model values

\[ R \, (K/W) \, \tau \, (s) \]
\[ 0.07, 6.8E+00 \]
\[ 0.25, 1.2E+00 \]
\[ 0.57, 2.8E-01 \]
\[ 0.12, 6.0E-02 \]
\[ 0.06, 1.3E-02 \]
\[ 0.03, 1.1E-03 \]

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

At
\[ T_j = 175 \ \degree C \]

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

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

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

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

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

At
\[ T_j = 150 \ \degree C \]
Half Bridge
Half Bridge IGBT and Neutral Point FWD

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

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

At
- Single pulse
- \( T_J = 80 \) °C
- \( V_{GE} = \pm 15 \) V
- \( T_J = T_{JMAX} \) °C

At
- \( I_C = 160 \) A
Neutral Point
Neutral Point IGBT and Half Bridge FWD

**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

$t_p = 250 \mu s$

$T_j = 125 ^\circ C$

$V_{CE}$ from 7 V to 17 V in steps of 1 V

**Figure 3**
Typical transfer characteristics

$I_C = f(V_{GE})$

At

$t_p = 250 \mu s$

$V_{CE} = 10 V$

$T_j = T_{j_{max}} - 25 ^\circ C$

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

$I_F = f(V_F)$

At

$t_p = 250 \mu s$

$T_j = T_{j_{max}} - 25 ^\circ C$

$V_F$ from 0 V to 12 V
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

- \( T_j = 25/125 \, ^\circ\text{C} \)
- \( V_{CE} = 350 \, \text{V} \)
- \( V_{GE} = \pm 15 \, \text{V} \)
- \( R_{gon} = 4 \, \Omega \)
- \( I_C = 100 \, \text{A} \)

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

\[ E = f(R_G) \]

With an inductive load at

- \( T_j = 25/125 \, ^\circ\text{C} \)
- \( V_{CE} = 350 \, \text{V} \)
- \( V_{GE} = \pm 15 \, \text{V} \)
- \( I_C = 100 \, \text{A} \)

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

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

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

\[ E_{rec} = f(R_G) \]
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
- \( T_j = 125 ^\circ C \)
- \( V_{CE} = 350 \) V
- \( V_{sel} = \pm 15 \) 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
- \( T_j = 125 ^\circ C \)
- \( V_{CE} = 350 \) V
- \( V_{sel} = \pm 15 \) V
- \( I_C = 100 \) A

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

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

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

At
- \( T_j = 25/125 ^\circ C \)
- \( V_{CE} = 350 \) V
- \( I_f = 100 \) A
- \( V_{sel} = \pm 15 \) V
Neutral Point
Neutral Point IGBT and Half Bridge FWD

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

![Graph showing typical reverse recovery charge](image)

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

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

![Graph showing typical reverse recovery charge](image)

**At**
\[ T_j = 25/125 \, ^\circ\text{C} \]
\[ V_{R} = 350 \, \text{V} \]
\[ I_f = 100 \, \text{A} \]
\[ V_{GE} = \pm 15 \, \text{V} \]

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

![Graph showing typical reverse recovery current](image)

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

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

![Graph showing typical reverse recovery current](image)

**At**
\[ T_j = 25/125 \, ^\circ\text{C} \]
\[ V_{R} = 350 \, \text{V} \]
\[ I_f = 100 \, \text{A} \]
\[ V_{GE} = \pm 15 \, \text{V} \]
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
\[ \frac{dI_f}{dt}, \frac{dI_{rec}}{dt} = f(I_c) \]

At
- \( T_j = 25/125 \) °C
- \( V_{CE} = 350 \) V
- \( V_{GE} = \pm 15 \) V
- \( I_F = 100 \) A
- \( R_{gon} = 4 \) Ω

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

At
- \( T_j = 25/125 \) °C
- \( V_{CE} = 350 \) V
- \( I_F = 100 \) A
- \( V_{GE} = \pm 15 \) V

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

At
- \( D = t_p / T \)
- \( R_{thJH} = 0,99 \) K/W

IGBT 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>0,55</td>
<td>1,3E-02</td>
</tr>
<tr>
<td>0,02</td>
<td>1,2E-03</td>
</tr>
</tbody>
</table>

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

At
- \( D = t_p / T \)
- \( R_{thJH} = 1,15 \) K/W

FWD thermal model values

<table>
<thead>
<tr>
<th>( R ) (K/W)</th>
<th>Tau (s)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0,05</td>
<td>4,9E+00</td>
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<tr>
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<td>7,8E-03</td>
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<tr>
<td>0,07</td>
<td>9,8E-04</td>
</tr>
</tbody>
</table>
Neutral Point
Neutral Point IGBT and Half Bridge FWD

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

\[ P_{\text{tot}} = f(T_h) \]

At
\[ T_j = 175 \, ^\circ\text{C} \]

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

\[ I_C = f(T_h) \]

At
\[ T_j = 175 \, ^\circ\text{C} \]

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

\[ P_{\text{tot}} = f(T_h) \]

At
\[ T_j = 150 \, ^\circ\text{C} \]

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

\[ I_F = f(T_h) \]

At
\[ T_j = 150 \, ^\circ\text{C} \]
**NP IGBT Inverse Diode**

**Figure 25**  
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.](image)

At  
\[ t_p = 250 \ \mu s \]

**Figure 26**  
Diode transient thermal impedance as a function of pulse width  
\[ Z_{thJH} = f(t_p) \]

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

At  
\[ D = \frac{t_p}{T} \]
\[ R_{thH} = 3.43 \ \text{K/W} \]

**Figure 27**  
Power dissipation as a function of heatsink temperature  
\[ P_{tot} = f(T_h) \]

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

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

**Figure 28**  
Forward current as a function of heatsink temperature  
\[ I_F = f(T_h) \]

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

At  
\[ T_j = 175 \ ^\circ C \]
**Half Bridge Inverse Diode**

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

\[ I_F = f(V_F) \]

At
\[ t_p = 250 \mu s \]

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

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

At
\[ D = \frac{t_p}{T}, \quad R_{th} = 2.24 \text{ K/W} \]

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

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

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

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

\[ I_F = f(T_h) \]

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

Figure 1: Typical NTC characteristic as a function of temperature

\[ R_T = f(T) \]
Switching Definitions Half Bridge

General conditions

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

**Figure 1**
Turn-off Switching Waveforms & definition of $t_{doff}$, $t_{Eoff}$

$V_{CE}(0\%) = -15$ V
$V_{CE}(100\%) = 15$ V
$I_C(100\%) = 100$ A
$t_{doff} = 0.27$ µs
$t_{Eoff} = 0.64$ µs

**Figure 2**
Turn-on Switching Waveforms & definition of $t_{don}$, $t_{Eon}$

$V_{CE}(0\%) = -15$ V
$V_{CE}(100\%) = 15$ V
$I_C(100\%) = 700$ V
$I_C(100\%) = 100$ A
$t_{don} = 0.13$ µs
$t_{Eon} = 0.28$ µs

**Figure 3**
Turn-off Switching Waveforms & definition of $t_f$

$V_C (100\%) = 700$ V
$I_C (100\%) = 100$ A
$t_f = 0.06$ µs

**Figure 4**
Turn-on Switching Waveforms & definition of $t_r$

$V_C (100\%) = 700$ V
$I_C (100\%) = 100$ A
$t_r = 0.03$ µs
Switching Definitions Half Bridge

**Figure 5** Half Bridge IGBT
Turn-off Switching Waveforms & definition of $t_{E\text{off}}$

$P_{\text{off}} (100\%) = 70,11$ kW
$E_{\text{off}} (100\%) = 4,19$ mJ
$t_{E\text{off}} = 0,64$ µs

**Figure 6** Half Bridge IGBT
Turn-on Switching Waveforms & definition of $t_{E\text{on}}$

$P_{\text{on}} (100\%) = 70,11$ kW
$E_{\text{on}} (100\%) = 2,60$ mJ
$t_{E\text{on}} = 0,28$ µs

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

$V_d (100\%) = 700$ V
$I_d (100\%) = 100$ A
$I_{R\text{RM}} (100\%) = -113$ A
$t_{rr} = 0,11$ µs
Switching Definitions Half Bridge

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

- $I_d$ (100%) = 100 A
- $Q_{rr}$ (100%) = 7.16 μC
- $t_{Qrr}$ = 0.22 μs

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

- $P_{rec}$ (100%) = 70.11 kW
- $E_{rec}$ (100%) = 1.38 mJ
- $t_{Erec}$ = 0.22 μs

**Measurement circuits**

**Figure 10**
BUCK stage switching measurement circuit
Ordering Code and Marking - Outline - Pinout

### Ordering Code & Marking

<table>
<thead>
<tr>
<th>Version</th>
<th>Ordering Code</th>
<th>in DataMatrix as</th>
<th>in packaging barcode as</th>
</tr>
</thead>
<tbody>
<tr>
<td>without thermal paste with solder pins</td>
<td>10-FY12NMA160SH01-M820F18</td>
<td>M820F</td>
<td>M820-F</td>
</tr>
<tr>
<td>without thermal paste with pressfit pins</td>
<td>10-PY12NMA160SH01-M820F18Y</td>
<td>M820FY</td>
<td>M820-FY</td>
</tr>
</tbody>
</table>

### Outline

![Outline Diagram](image)

### Pinout

![Pinout Diagram](image)

**Low current connection**
**DISCLAIMER**

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2. A critical component is any component of a life support device or system whose failure to perform can be reasonably expected to cause the failure of the life support device or system, or to affect its safety or effectiveness.