STGW39NC60VD

40 A - 600 V - very fast IGBT

Features
- Low $C_{RES} / C_{IES}$ ratio (no cross conduction susceptibility)
- IGBT co-packaged with ultra fast free-wheeling diode

Applications
- High frequency inverters
- UPS
- Motor drivers
- Induction heating

Description
This IGBT utilizes the advanced PowerMESH™ process resulting in an excellent trade-off between switching performance and low on-state behavior.

Table 1. Device summary

<table>
<thead>
<tr>
<th>Order code</th>
<th>Marking</th>
<th>Package</th>
<th>Packaging</th>
</tr>
</thead>
<tbody>
<tr>
<td>STGW39NC60VD</td>
<td>GW39NC60VD</td>
<td>TO-247</td>
<td>Tube</td>
</tr>
</tbody>
</table>

Figure 1. Internal schematic diagram
Contents

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1 Electrical ratings

Table 2. Absolute maximum ratings

<table>
<thead>
<tr>
<th>Symbol</th>
<th>Parameter</th>
<th>Value</th>
<th>Unit</th>
</tr>
</thead>
<tbody>
<tr>
<td>$V_{CES}$</td>
<td>Collector-emitter voltage ($V_{GE} = 0$)</td>
<td>600</td>
<td>V</td>
</tr>
<tr>
<td>$I_{C}^{(1)}$</td>
<td>Collector current (continuous) at 25 °C</td>
<td>80</td>
<td>A</td>
</tr>
<tr>
<td>$I_{C}^{(1)}$</td>
<td>Collector current (continuous) at 100 °C</td>
<td>40</td>
<td>A</td>
</tr>
<tr>
<td>$I_{CL}^{(2)}$</td>
<td>Turn-off latching current</td>
<td>220</td>
<td>A</td>
</tr>
<tr>
<td>$I_{CP}^{(3)}$</td>
<td>Pulsed collector current</td>
<td>220</td>
<td>A</td>
</tr>
<tr>
<td>$V_{GE}$</td>
<td>Gate-emitter voltage</td>
<td>± 20</td>
<td>V</td>
</tr>
<tr>
<td>$I_{F}$</td>
<td>Diode RMS forward current at $T_C = 25$ °C</td>
<td>30</td>
<td>A</td>
</tr>
<tr>
<td>$I_{FSM}$</td>
<td>Surge non repetitive forward current ($t_p=10$ ms sinusoidal)</td>
<td>120</td>
<td>A</td>
</tr>
<tr>
<td>$P_{TOT}$</td>
<td>Total dissipation at $T_C = 25$ °C</td>
<td>250</td>
<td>W</td>
</tr>
<tr>
<td>$T_J$</td>
<td>Operating junction temperature</td>
<td>– 55 to 150</td>
<td>°C</td>
</tr>
</tbody>
</table>

1. Calculated according to the iterative formula:
   
   $I_C(T_C) = \frac{T_{J MAX} - T_C}{R_{THJ - C} \times V_{CESAT MAX} \times I_C}$

2. $V_{clamp} = 80\% (V_{CES})$, $T_J = 150$ °C, $R_G = 10$ Ω, $V_{GE} = 15$ V

3. Pulse width limited by max. junction temperature allowed

Table 3. Thermal resistance

<table>
<thead>
<tr>
<th>Symbol</th>
<th>Parameter</th>
<th>Value</th>
<th>Unit</th>
</tr>
</thead>
<tbody>
<tr>
<td>$R_{thj-case}$</td>
<td>Thermal resistance junction-case (IGBT) max</td>
<td>0.5</td>
<td>°C/W</td>
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<tr>
<td>$R_{thj-case}$</td>
<td>Thermal resistance junction-case (diode) max</td>
<td>1.5</td>
<td>°C/W</td>
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<tr>
<td>$R_{thj-amb}$</td>
<td>Thermal resistance junction-ambient max</td>
<td>50</td>
<td>°C/W</td>
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</tbody>
</table>
# Electrical characteristics

(TCASE=25 °C unless otherwise specified)

### Table 4. Static

<table>
<thead>
<tr>
<th>Symbol</th>
<th>Parameter</th>
<th>Test conditions</th>
<th>Min.</th>
<th>Typ.</th>
<th>Max.</th>
<th>Unit</th>
</tr>
</thead>
<tbody>
<tr>
<td>V(BR)CES</td>
<td>Collector-emitter breakdown voltage (VGE = 0)</td>
<td>IC = 1 mA</td>
<td></td>
<td>600</td>
<td></td>
<td>V</td>
</tr>
<tr>
<td>VCE(sat)</td>
<td>Collector-emitter saturation voltage</td>
<td>VGE = 15 V, IC = 30 A</td>
<td></td>
<td>1.8</td>
<td>2.4</td>
<td>V</td>
</tr>
<tr>
<td></td>
<td></td>
<td>VGE = 15 V, IC = 30 A, TC=125 °C</td>
<td></td>
<td>1.7</td>
<td></td>
<td>V</td>
</tr>
<tr>
<td>VGE(th)</td>
<td>Gate threshold voltage</td>
<td>VCE= VGE, IC=1 mA</td>
<td>3.75</td>
<td>5.75</td>
<td></td>
<td>V</td>
</tr>
<tr>
<td>ICES</td>
<td>Collector cut-off current (VGE = 0)</td>
<td>VCE = 600 V</td>
<td>500</td>
<td>5</td>
<td></td>
<td>µA</td>
</tr>
<tr>
<td></td>
<td></td>
<td>VCE = 600 V, TC = 125 °C</td>
<td></td>
<td></td>
<td>5</td>
<td>mA</td>
</tr>
<tr>
<td>IGES</td>
<td>Gate-emitter leakage current (VCE = 0)</td>
<td>VGE = ± 20 V</td>
<td>±100</td>
<td></td>
<td></td>
<td>nA</td>
</tr>
<tr>
<td>gfs (1)</td>
<td>Forward transconductance</td>
<td>VCE = 15 V, IC= 30 A</td>
<td>20</td>
<td></td>
<td></td>
<td>S</td>
</tr>
</tbody>
</table>

1. Pulsed: pulse duration = 300 µs, duty cycle 1.5%

### Table 5. Dynamic

<table>
<thead>
<tr>
<th>Symbol</th>
<th>Parameter</th>
<th>Test conditions</th>
<th>Min.</th>
<th>Typ.</th>
<th>Max.</th>
<th>Unit</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cies</td>
<td>Input capacitance</td>
<td>VCE = 25 V, f = 1 MHz, VGE= 0</td>
<td>2900</td>
<td>298</td>
<td>59</td>
<td>pF</td>
</tr>
<tr>
<td>Coes</td>
<td>Output capacitance</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>pF</td>
</tr>
<tr>
<td>Cres</td>
<td>Reverse transfer capacitance</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>pF</td>
</tr>
<tr>
<td>Qg</td>
<td>Total gate charge</td>
<td>VCE = 390 V, IC = 30 A, VGE = 15 V</td>
<td>126</td>
<td>16</td>
<td>46</td>
<td>nC</td>
</tr>
<tr>
<td>Qge</td>
<td>Gate-emitter charge</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>nC</td>
</tr>
<tr>
<td>Qgc</td>
<td>Gate-collector charge</td>
<td>(see Figure 19)</td>
<td></td>
<td></td>
<td></td>
<td>nC</td>
</tr>
</tbody>
</table>
Table 6. Switching on/off (inductive load)

<table>
<thead>
<tr>
<th>Symbol</th>
<th>Parameter</th>
<th>Test conditions</th>
<th>Min.</th>
<th>Typ.</th>
<th>Max.</th>
<th>Unit</th>
</tr>
</thead>
<tbody>
<tr>
<td>( t_{\text{d(on)}} )</td>
<td>Turn-on delay time</td>
<td>( V_{CC} = 390 \text{ V}, I_C = 30 \text{ A}, R_G = 10 \text{ \Omega}, V_{GE} = 15 \text{ V} ) (see Figure 18)</td>
<td></td>
<td></td>
<td>33</td>
<td>ns</td>
</tr>
<tr>
<td>( t_r )</td>
<td>Current rise time</td>
<td></td>
<td>13</td>
<td></td>
<td>2500</td>
<td>ns</td>
</tr>
<tr>
<td>( (\text{di/dt})_{\text{on}} )</td>
<td>Turn-on current slope</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>A/\mu s</td>
</tr>
<tr>
<td>( t_{\text{d(on)}} )</td>
<td>Turn-on delay time</td>
<td>( V_{CC} = 390 \text{ V}, I_C = 30 \text{ A}, R_G = 10 \text{ \Omega}, V_{GE} = 15 \text{ V} ) (see Figure 18)</td>
<td>32</td>
<td></td>
<td>14</td>
<td>ns</td>
</tr>
<tr>
<td>( t_r )</td>
<td>Current rise time</td>
<td></td>
<td>14</td>
<td></td>
<td>2280</td>
<td>ns</td>
</tr>
<tr>
<td>( (\text{di/dt})_{\text{on}} )</td>
<td>Turn-on current slope</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>A/\mu s</td>
</tr>
<tr>
<td>( t_{\text{r(Voff)}} )</td>
<td>Off voltage rise time</td>
<td>( V_{CC} = 390 \text{ V}, I_C = 30 \text{ A}, R_G = 10 \text{ \Omega}, V_{GE} = 15 \text{ V} ) (see Figure 18)</td>
<td>33</td>
<td></td>
<td>178</td>
<td>ns</td>
</tr>
<tr>
<td>( t_{\text{d(off)}} )</td>
<td>Turn-off delay time</td>
<td></td>
<td>178</td>
<td></td>
<td>65</td>
<td>ns</td>
</tr>
<tr>
<td>( t_f )</td>
<td>Current fall time</td>
<td></td>
<td>65</td>
<td></td>
<td></td>
<td>ns</td>
</tr>
<tr>
<td>( t_{\text{r(Voff)}} )</td>
<td>Off voltage rise time</td>
<td>( V_{CC} = 390 \text{ V}, I_C = 30 \text{ A}, R_G = 10 \text{ \Omega}, V_{GE} = 15 \text{ V} ) (see Figure 18)</td>
<td>68</td>
<td></td>
<td>238</td>
<td>ns</td>
</tr>
<tr>
<td>( t_{\text{d(off)}} )</td>
<td>Turn-off delay time</td>
<td></td>
<td>238</td>
<td></td>
<td>128</td>
<td>ns</td>
</tr>
<tr>
<td>( t_f )</td>
<td>Current fall time</td>
<td></td>
<td>128</td>
<td></td>
<td></td>
<td>ns</td>
</tr>
</tbody>
</table>

Table 7. Switching energy (inductive load)

<table>
<thead>
<tr>
<th>Symbol</th>
<th>Parameter</th>
<th>Test conditions</th>
<th>Min.</th>
<th>Typ.</th>
<th>Max.</th>
<th>Unit</th>
</tr>
</thead>
<tbody>
<tr>
<td>( E_{\text{on}} ) (1)</td>
<td>Turn-on switching losses</td>
<td>( V_{CC} = 390 \text{ V}, I_C = 30 \text{ A}, R_G = 10 \text{ \Omega}, V_{GE} = 15 \text{ V} ) (see Figure 20)</td>
<td>333</td>
<td>537</td>
<td>870</td>
<td>\mu J</td>
</tr>
<tr>
<td>( E_{\text{off}} ) (2)</td>
<td>Turn-off switching losses</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>\mu J</td>
</tr>
<tr>
<td>( E_{\text{ts}} )</td>
<td>Total switching losses</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>\mu J</td>
</tr>
<tr>
<td>( E_{\text{on}} ) (1)</td>
<td>Turn-on switching losses</td>
<td>( V_{CC} = 390 \text{ V}, I_C = 30 \text{ A}, R_G = 10 \text{ \Omega}, V_{GE} = 15 \text{ V} ) (see Figure 20)</td>
<td>618</td>
<td>1125</td>
<td>1743</td>
<td>\mu J</td>
</tr>
<tr>
<td>( E_{\text{off}} ) (2)</td>
<td>Turn-off switching losses</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>\mu J</td>
</tr>
<tr>
<td>( E_{\text{ts}} )</td>
<td>Total switching losses</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>\mu J</td>
</tr>
</tbody>
</table>

1. \( E_{\text{on}} \) is the turn-on losses when a typical diode is used in the test circuit in figure 2. \( E_{\text{on}} \) include diode recovery energy. If the IGBT is offered in a package with a co-pak diode, the co-pack diode is used as external diode. IGBTs & Diode are at the same temperature (25°C and 125°C).

2. Turn-off losses include also the tail of the collector current.
## Table 8. Collector-emitter diode

<table>
<thead>
<tr>
<th>Symbol</th>
<th>Parameter</th>
<th>Test conditions</th>
<th>Min.</th>
<th>Typ.</th>
<th>Max.</th>
<th>Unit</th>
</tr>
</thead>
</table>
| $V_F$  | Forward on-voltage | $I_F = 30$ A  
$I_F = 30$ A, $T_C = 125$ °C | 2.4 | 1.8 |  | V  |
| $t_{rr}$ | Reverse recovery time | $I_F = 30$ A, $V_R = 50$ V,  
$\frac{di}{dt} = 100$ A/µs (see Figure 21) | 45 | 56 | 2.55 | ns nC A |
| $Q_{rr}$ | Reverse recovery charge | $I_F = 30$ A, $V_R = 50$ V,  
$\frac{di}{dt} = 100$ A/µs (see Figure 21) | 100 | 290 | 5.8 | ns nC A |
2.1 Electrical characteristics (curves)

Figure 2. Output characteristics

Figure 3. Transfer characteristics

Figure 4. Transconductance

Figure 5. Collector-emitter on voltage vs temperature

Figure 6. Collector-emitter on voltage vs collector current

Figure 7. Normalized gate threshold vs temperature
Electrical characteristics

STGW39NC60VD

Figure 8. Normalized breakdown voltage vs temperature

Figure 9. Gate charge vs gate-emitter voltage

Figure 10. Capacitance variations

Figure 11. Switching losses vs temperature

Figure 12. Switching losses vs gate resistance

Figure 13. Switching losses vs collector current
2.2 Frequency applications

For a fast IGBT suitable for high frequency applications, the typical collector current vs. maximum operating frequency curve is reported. That frequency is defined as follows:

\[ f_{\text{MAX}} = \frac{(P_D - P_C)}{(E_{\text{ON}} + E_{\text{OFF}})} \]

- The maximum power dissipation is limited by maximum junction to case thermal resistance:

Equation 1

\[ P_D = \frac{\Delta T}{R_{\text{THJ-C}}} \]

considering \( \Delta T = T_J - T_C = 125 \, ^{\circ}\text{C} - 75 \, ^{\circ}\text{C} = 50 \, ^{\circ}\text{C} \)

- The conduction losses are:
Equation 2

\[ P_C = I_C \cdot V_{CE(SAT)} \cdot \delta \]

with 50% of duty cycle, \( V_{CESAT} \) typical value @125 °C.

● Power dissipation during ON & OFF commutations is due to the switching frequency:

Equation 3

\[ P_{SW} = (E_{ON} + E_{OFF}) \cdot freq. \]

Typical values @ 125 °C for switching losses are used (test conditions: \( V_{CE} = 390 \) V, \( V_{GE} = 15 \) V, \( R_G = 10 \) Ω). Furthermore, diode recovery energy is included in the \( E_{ON} \) (see note 2), while the tail of the collector current is included in the \( E_{OFF} \) measurements (see note 3).
3 Test circuit

Figure 18. Test circuit for inductive load switching

Figure 19. Gate charge test circuit

Figure 20. Switching waveforms

Figure 21. Diode recovery times waveform
4 Package mechanical data

In order to meet environmental requirements, ST offers these devices in ECOPACK® packages. These packages have a lead-free second level interconnect. The category of second level interconnect is marked on the package and on the inner box label, in compliance with JEDEC Standard JESD97. The maximum ratings related to soldering conditions are also marked on the inner box label. ECOPACK is an ST trademark. ECOPACK specifications are available at: www.st.com
### TO-247 mechanical data

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<thead>
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<th>Dim.</th>
<th>mm.</th>
<th>Min.</th>
<th>Typ</th>
<th>Max.</th>
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</thead>
<tbody>
<tr>
<td>A</td>
<td>4.85</td>
<td>5.15</td>
<td></td>
<td></td>
</tr>
<tr>
<td>A1</td>
<td>2.20</td>
<td>2.60</td>
<td></td>
<td></td>
</tr>
<tr>
<td>b</td>
<td>1.0</td>
<td>1.40</td>
<td></td>
<td></td>
</tr>
<tr>
<td>b1</td>
<td>2.0</td>
<td>2.40</td>
<td></td>
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<tr>
<td>b2</td>
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<td>c</td>
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<td>D</td>
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<tr>
<td>S</td>
<td>5.50</td>
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5 Revision history

Table 9. Document revision history

<table>
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<tr>
<th>Date</th>
<th>Revision</th>
<th>Changes</th>
</tr>
</thead>
<tbody>
<tr>
<td>17-Nov-2005</td>
<td>1</td>
<td>First release</td>
</tr>
<tr>
<td>05-May-2006</td>
<td>2</td>
<td>Inserted curves</td>
</tr>
<tr>
<td>10-Jul-2006</td>
<td>3</td>
<td>Modified value on Absolute maximum ratings</td>
</tr>
<tr>
<td>01-Dec-2006</td>
<td>4</td>
<td>Modified value on Dynamic</td>
</tr>
<tr>
<td>16-May-2007</td>
<td>5</td>
<td>New curves updated: Figure 5 and Figure 6</td>
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<tr>
<td>22-Aug-2007</td>
<td>6</td>
<td>Added new Figure 17 and new section 2.2: Frequency applications</td>
</tr>
<tr>
<td>31-Jan-2008</td>
<td>7</td>
<td>Modified: Table 8: Collector-emitter diode</td>
</tr>
<tr>
<td>29-Jul-2008</td>
<td>8</td>
<td>Updated $V_{CE(sat)}$ on Table 4</td>
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