Field Stop IGBT
650 V, 40 A
FGA40N65SMD

General Description
Using novel field stop IGBT technology, onsemi’s new series of field stop 2nd generation IGBTs offer the optimum performance for solar inverter, UPS, welder, induction heating, telecom, ESS and PFC applications where low conduction and switching losses are essential.

Features
• Maximum Junction Temperature: $T_J = 175°C$
• Positive Temperature Co–efficient for Easy Parallel Operating
• High Current Capability
• Low Saturation Voltage: $V_{CE(sat)} = 1.9$ V (Typ.) @ $I_C = 40$ A
• Fast Switching: $E_{OFF} = 6.5 \mu$J/A
• Tighten Parameter Distribution
• These Devices are Pb–Free and are RoHS Compliant

Applications
• Solar Inverter, UPS, Welder, Induction Heating
• Telecom, ESS

MARKING DIAGRAM

ORDERING INFORMATION

<table>
<thead>
<tr>
<th>Device</th>
<th>Package</th>
<th>Shipping</th>
</tr>
</thead>
<tbody>
<tr>
<td>FGA40N65SMD</td>
<td>TO–3P–3LD</td>
<td>450 Units / Tube</td>
</tr>
<tr>
<td></td>
<td>(Pb–Free)</td>
<td></td>
</tr>
</tbody>
</table>

FGA40N65SMD = Specific Device Code
A = Assembly Location
YWY = Date Code (Year & Week)
Z = Assembly Lot
# ABSOLUTE MAXIMUM RATINGS

<table>
<thead>
<tr>
<th>Symbol</th>
<th>Description</th>
<th>Value</th>
<th>Unit</th>
</tr>
</thead>
<tbody>
<tr>
<td>$V_{CES}$</td>
<td>Collector to Emitter Voltage</td>
<td>650</td>
<td>V</td>
</tr>
<tr>
<td>$V_{GES}$</td>
<td>Gate to Emitter Voltage</td>
<td>–20</td>
<td>A</td>
</tr>
<tr>
<td></td>
<td>Transient Gate to Emitter Voltage</td>
<td>–30</td>
<td>A</td>
</tr>
<tr>
<td>$I_C$</td>
<td>Collector Current @ $T_C = 25^\circ C$</td>
<td>80</td>
<td>A</td>
</tr>
<tr>
<td></td>
<td>Collector Current @ $T_C = 100^\circ C$</td>
<td>40</td>
<td>A</td>
</tr>
<tr>
<td>$I_{CM}$</td>
<td>Pulsed Collector Current</td>
<td>120</td>
<td>A</td>
</tr>
<tr>
<td>$I_F$</td>
<td>Diode Forward Current @ $T_C = 25^\circ C$</td>
<td>40</td>
<td>A</td>
</tr>
<tr>
<td></td>
<td>Diode Forward Current @ $T_C = 100^\circ C$</td>
<td>20</td>
<td>A</td>
</tr>
<tr>
<td>$I_{FM}$</td>
<td>Pulsed Diode Maximum Forward Current</td>
<td>120</td>
<td>A</td>
</tr>
<tr>
<td>$P_D$</td>
<td>Maximum Power Dissipation @ $T_C = 25^\circ C$</td>
<td>349</td>
<td>W</td>
</tr>
<tr>
<td></td>
<td>Maximum Power Dissipation @ $T_C = 100^\circ C$</td>
<td>174</td>
<td>W</td>
</tr>
<tr>
<td>$T_J$</td>
<td>Operating Junction Temperature</td>
<td>–55 to +175</td>
<td>°C</td>
</tr>
<tr>
<td>$T_{stg}$</td>
<td>Storage Temperature Range</td>
<td>–55 to +175</td>
<td>°C</td>
</tr>
<tr>
<td>$T_L$</td>
<td>Maximum Lead Temp. for Soldering Purposes, 1/8” from case for 5 seconds</td>
<td>300</td>
<td>°C</td>
</tr>
</tbody>
</table>

Stresses exceeding those listed in the Maximum Ratings table may damage the device. If any of these limits are exceeded, device functionality should not be assumed, damage may occur and reliability may be affected.

1. Repetitive rating: Pulse width limited by max. junction temperature.

# THERMAL CHARACTERISTICS

<table>
<thead>
<tr>
<th>Symbol</th>
<th>Parameter</th>
<th>Value</th>
<th>Unit</th>
</tr>
</thead>
<tbody>
<tr>
<td>$R_{J,JC}$(GBT)</td>
<td>Thermal Resistance, Junction to Case, Max.</td>
<td>0.43</td>
<td>°C/W</td>
</tr>
<tr>
<td>$R_{J,JC}$(Diode)</td>
<td>Thermal Resistance, Junction to Case, Max.</td>
<td>1.5</td>
<td>°C/W</td>
</tr>
<tr>
<td>$R_{J,UA}$</td>
<td>Thermal Resistance, Junction to Ambient, Max.</td>
<td>40</td>
<td>°C/W</td>
</tr>
</tbody>
</table>

# ELECTRICAL CHARACTERISTICS OF THE DIODE ($T_C = 25^\circ C$ unless otherwise noted)

<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>$V_{FM}$</td>
<td>Diode Forward Voltage</td>
<td>$I_F = 20\ A$</td>
<td>$T_C = 25^\circ C$</td>
<td>–</td>
<td>2.1</td>
<td>2.6</td>
</tr>
<tr>
<td></td>
<td></td>
<td>$T_C = 175^\circ C$</td>
<td>–</td>
<td>1.7</td>
<td>–</td>
<td></td>
</tr>
<tr>
<td>$E_{rec}$</td>
<td>Reverse Recovery Energy</td>
<td>$I_F = 20\ A$, $dI_F/dt = 200\ A/\mu s$</td>
<td>$T_C = 175^\circ C$</td>
<td>–</td>
<td>96</td>
<td>–</td>
</tr>
<tr>
<td>$t_{rr}$</td>
<td>Diode Reverse Recovery Time</td>
<td></td>
<td>$T_C = 25^\circ C$</td>
<td>–</td>
<td>42</td>
<td>–</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>$T_C = 175^\circ C$</td>
<td>–</td>
<td>200</td>
<td>–</td>
</tr>
<tr>
<td>$I_{rr}$</td>
<td>Diode Peak Reverse Recovery Current</td>
<td></td>
<td>$T_C = 25^\circ C$</td>
<td>–</td>
<td>3.6</td>
<td>–</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>$T_C = 175^\circ C$</td>
<td>–</td>
<td>8.0</td>
<td>–</td>
</tr>
<tr>
<td>$Q_{rr}$</td>
<td>Diode Reverse Recovery Charge</td>
<td></td>
<td>$T_C = 25^\circ C$</td>
<td>–</td>
<td>76</td>
<td>–</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>$T_C = 175^\circ C$</td>
<td>–</td>
<td>800</td>
<td>–</td>
</tr>
</tbody>
</table>

Product parametric performance is indicated in the Electrical Characteristics for the listed test conditions, unless otherwise noted. Product performance may not be indicated by the Electrical Characteristics if operated under different conditions.
## ELECTRICAL CHARACTERISTICS OF THE IGBT

(T<sub>C</sub> = 25°C unless otherwise noted)

<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><strong>OFF CHARACTERISTICS</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>B&lt;sub&gt;VCES&lt;/sub&gt;</td>
<td>Collector to Emitter Breakdown Voltage</td>
<td>V&lt;sub&gt;GE&lt;/sub&gt; = 0 V, I&lt;sub&gt;C&lt;/sub&gt; = 250 μA</td>
<td>650</td>
<td>–</td>
<td>–</td>
<td>V</td>
</tr>
<tr>
<td>ΔB&lt;sub&gt;VCES&lt;/sub&gt; / ΔT&lt;sub&gt;J&lt;/sub&gt;</td>
<td>Temperature Coefficient of Breakdown Voltage</td>
<td>V&lt;sub&gt;GE&lt;/sub&gt; = 0 V, I&lt;sub&gt;C&lt;/sub&gt; = 250 μA</td>
<td>–</td>
<td>0.6</td>
<td>–</td>
<td>V/^°C</td>
</tr>
<tr>
<td>I&lt;sub&gt;CES&lt;/sub&gt;</td>
<td>Collector Cut–Off Current</td>
<td>V&lt;sub&gt;CES&lt;/sub&gt;= V&lt;sub&gt;CES&lt;/sub&gt;, V&lt;sub&gt;GE&lt;/sub&gt; = 0 V</td>
<td>–</td>
<td>–</td>
<td>250</td>
<td>μA</td>
</tr>
<tr>
<td>I&lt;sub&gt;GES&lt;/sub&gt;</td>
<td>G–E Leakage Current</td>
<td>V&lt;sub&gt;GE&lt;/sub&gt; = V&lt;sub&gt;GES&lt;/sub&gt;, V&lt;sub&gt;GE&lt;/sub&gt; = 0 V</td>
<td>–</td>
<td>–</td>
<td>±400</td>
<td>nA</td>
</tr>
<tr>
<td><strong>ON CHARACTERISTICS</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>V&lt;sub&gt;GE(th)&lt;/sub&gt;</td>
<td>G–E Threshold Voltage</td>
<td>I&lt;sub&gt;C&lt;/sub&gt; = 250 μA, V&lt;sub&gt;CES&lt;/sub&gt; = V&lt;sub&gt;GE&lt;/sub&gt;</td>
<td>3.5</td>
<td>4.5</td>
<td>6.0</td>
<td>V</td>
</tr>
<tr>
<td>V&lt;sub&gt;CE(sat)&lt;/sub&gt;</td>
<td>Collector to Emitter Saturation Voltage</td>
<td>I&lt;sub&gt;C&lt;/sub&gt; = 40 A, V&lt;sub&gt;GE&lt;/sub&gt; = 15 V</td>
<td>–</td>
<td>1.9</td>
<td>2.5</td>
<td>V</td>
</tr>
<tr>
<td></td>
<td></td>
<td>I&lt;sub&gt;C&lt;/sub&gt; = 40 A, V&lt;sub&gt;GE&lt;/sub&gt; = 15 V, T&lt;sub&gt;C&lt;/sub&gt; = 175°C</td>
<td>–</td>
<td>2.1</td>
<td>–</td>
<td>V</td>
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<tr>
<td><strong>DYNAMIC CHARACTERISTICS</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>C&lt;sub&gt;ies&lt;/sub&gt;</td>
<td>Input Capacitance</td>
<td>V&lt;sub&gt;Ce&lt;/sub&gt; = 30 V, V&lt;sub&gt;GE&lt;/sub&gt; = 0 V, f = 1 MHz</td>
<td>–</td>
<td>1880</td>
<td>–</td>
<td>pF</td>
</tr>
<tr>
<td>C&lt;sub&gt;oes&lt;/sub&gt;</td>
<td>Output Capacitance</td>
<td></td>
<td>–</td>
<td>180</td>
<td>–</td>
<td>pF</td>
</tr>
<tr>
<td>C&lt;sub&gt;res&lt;/sub&gt;</td>
<td>Reverse Transfer Capacitance</td>
<td></td>
<td>–</td>
<td>50</td>
<td>–</td>
<td>pF</td>
</tr>
<tr>
<td><strong>SWITCHING CHARACTERISTICS</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>t&lt;sub&gt;on&lt;/sub&gt;</td>
<td>Turn–On Delay Time</td>
<td>V&lt;sub&gt;CC&lt;/sub&gt; = 400 V, I&lt;sub&gt;C&lt;/sub&gt; = 40 A, R&lt;sub&gt;G&lt;/sub&gt; = 6 Ω, V&lt;sub&gt;GE&lt;/sub&gt; = 15 V, Inductive Load, T&lt;sub&gt;C&lt;/sub&gt; = 25°C</td>
<td>–</td>
<td>12</td>
<td>16</td>
<td>ns</td>
</tr>
<tr>
<td>t&lt;sub&gt;r&lt;/sub&gt;</td>
<td>Rise Time</td>
<td></td>
<td>–</td>
<td>20</td>
<td>28</td>
<td>ns</td>
</tr>
<tr>
<td>t&lt;sub&gt;off&lt;/sub&gt;</td>
<td>Turn–Off Delay Time</td>
<td></td>
<td>–</td>
<td>92</td>
<td>120</td>
<td>ns</td>
</tr>
<tr>
<td>t&lt;sub&gt;f&lt;/sub&gt;</td>
<td>Fall Time</td>
<td></td>
<td>–</td>
<td>13</td>
<td>17</td>
<td>ns</td>
</tr>
<tr>
<td>E&lt;sub&gt;on&lt;/sub&gt;</td>
<td>Turn–On Switching Loss</td>
<td></td>
<td>–</td>
<td>0.82</td>
<td>1.23</td>
<td>mJ</td>
</tr>
<tr>
<td>E&lt;sub&gt;off&lt;/sub&gt;</td>
<td>Turn–Off Switching Loss</td>
<td></td>
<td>–</td>
<td>0.26</td>
<td>0.34</td>
<td>mJ</td>
</tr>
<tr>
<td>E&lt;sub&gt;ls&lt;/sub&gt;</td>
<td>Total Switching Loss</td>
<td></td>
<td>–</td>
<td>1.08</td>
<td>1.57</td>
<td>mJ</td>
</tr>
<tr>
<td>t&lt;sub&gt;on&lt;/sub&gt;</td>
<td>Turn–On Delay Time</td>
<td>V&lt;sub&gt;CC&lt;/sub&gt; = 400 V, I&lt;sub&gt;C&lt;/sub&gt; = 40 A, R&lt;sub&gt;G&lt;/sub&gt; = 6 Ω, V&lt;sub&gt;GE&lt;/sub&gt; = 15 V, Inductive Load, T&lt;sub&gt;C&lt;/sub&gt; = 175°C</td>
<td>–</td>
<td>15</td>
<td>–</td>
<td>ns</td>
</tr>
<tr>
<td>t&lt;sub&gt;r&lt;/sub&gt;</td>
<td>Rise Time</td>
<td></td>
<td>–</td>
<td>22</td>
<td>–</td>
<td>ns</td>
</tr>
<tr>
<td>t&lt;sub&gt;off&lt;/sub&gt;</td>
<td>Turn–Off Delay Time</td>
<td></td>
<td>–</td>
<td>116</td>
<td>–</td>
<td>ns</td>
</tr>
<tr>
<td>t&lt;sub&gt;f&lt;/sub&gt;</td>
<td>Fall Time</td>
<td></td>
<td>–</td>
<td>16</td>
<td>–</td>
<td>ns</td>
</tr>
<tr>
<td>E&lt;sub&gt;on&lt;/sub&gt;</td>
<td>Turn–On Switching Loss</td>
<td></td>
<td>–</td>
<td>1.08</td>
<td>–</td>
<td>mJ</td>
</tr>
<tr>
<td>E&lt;sub&gt;off&lt;/sub&gt;</td>
<td>Turn–Off Switching Loss</td>
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<td>0.60</td>
<td>–</td>
<td>mJ</td>
</tr>
<tr>
<td>E&lt;sub&gt;ls&lt;/sub&gt;</td>
<td>Total Switching Loss</td>
<td></td>
<td>–</td>
<td>1.68</td>
<td>–</td>
<td>mJ</td>
</tr>
<tr>
<td>Q&lt;sub&gt;g&lt;/sub&gt;</td>
<td>Total Gate Charge</td>
<td>V&lt;sub&gt;Ce&lt;/sub&gt; = 400 V, I&lt;sub&gt;C&lt;/sub&gt; = 40 A, V&lt;sub&gt;GE&lt;/sub&gt; = 15 V</td>
<td>–</td>
<td>119</td>
<td>180</td>
<td>nC</td>
</tr>
<tr>
<td>Q&lt;sub&gt;ge&lt;/sub&gt;</td>
<td>Gate to Emitter Charge</td>
<td></td>
<td>–</td>
<td>13</td>
<td>20</td>
<td>nC</td>
</tr>
<tr>
<td>Q&lt;sub&gt;gc&lt;/sub&gt;</td>
<td>Gate to Collector Charge</td>
<td></td>
<td>–</td>
<td>58</td>
<td>90</td>
<td>nC</td>
</tr>
</tbody>
</table>

Product parametric performance is indicated in the Electrical Characteristics for the listed test conditions, unless otherwise noted. Product performance may not be indicated by the Electrical Characteristics if operated under different conditions.
TYPICAL PERFORMANCE CHARACTERISTICS

Figure 1. Typical Output Characteristics

Figure 2. Typical Output Characteristics

Figure 3. Typical Saturation Voltage Characteristics

Figure 4. Saturation Voltage vs. Case Temperature at Variant Current Level

Figure 5. Saturation Voltage vs. $V_{GE}$

Figure 6. Saturation Voltage vs. $V_{GE}$
Figure 7. Capacitance Characteristics

Figure 8. Gate Charge Characteristics

Figure 9. Turn–on Characteristics vs. Gate Resistance

Figure 10. Turn–off Characteristics vs. Gate Resistance

Figure 11. Switching Loss vs. Gate Resistance

Figure 12. Turn–on Characteristics vs. Collector Current
TYPICAL PERFORMANCE CHARACTERISTICS (continued)

Figure 13. Turn-off Characteristics vs. Collector Current

Figure 14. Switching Loss vs. Collector Current

Figure 15. Load Current Vs. Frequency

Figure 16. SOA Characteristics

Figure 17. Forward Characteristics

Figure 18. Reverse Recovery Current
TYPICAL PERFORMANCE CHARACTERISTICS (continued)

Figure 19. Reverse Recovery Time

Figure 20. Stored Charge

Figure 21. Transient Thermal Impedance of IGBT

Figure 22. Transient Thermal Impedance of Diode
MECHANICAL CASE OUTLINE
PACKAGE DIMENSIONS

TO-3P-3LD / EIAJ SC-65, ISOLATED
CASE 340BZ
ISSUE O

DATE 31 OCT 2016

NOTES: UNLESS OTHERWISE SPECIFIED
A) THIS PACKAGE CONFORMS TO EIAJ SC-65 PACKAGING STANDARD.
B) ALL DIMENSIONS ARE IN MILLIMETERS.
C) DIMENSION AND TOLERANCING PER ASME Y14.5-2009.
D) DIMENSIONS ARE EXCLUSIVE OF BURRS, MOLD FLASH, AND TIE BAR EXTRUSIONS.

DOCUMENT NUMBER: 98AON13862G
DESCRIPTION: TO-3P-3LD / EIAJ SC-65, ISOLATED

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