Field Stop Trench IGBT
650 V, 40 A
FGA40T65SHD

General Description
Using novel field stop IGBT technology, onsemi’s new series of field stop 3rd generation IGBTs offer the optimum performance for solar inverter, UPS, welder, telecom, ESS and PFC applications where low conduction and switching losses are essential.

Features
- Maximum Junction Temperature: $T_J = 175^\circ$C
- Positive Temperature Co–efficient for Easy Parallel Operating
- High Current Capability
- Low Saturation Voltage: $V_{CE(sat)} = 1.6$ V (Typ.) @ $I_C = 40$ A
- 100% of the Parts Tested for $I_{LM}(1)$
- High Input Impedance
- Fast Switching
- Tighten Parameter Distribution
- These Devices are Pb–Free, Halogen Free/BFR Free and are RoHS Compliant

Applications
- Solar Inverter, UPS, Welder, Telecom, ESS, PFC

MARKING DIAGRAM
FGA40T65SHD

Device Package Shipping

<table>
<thead>
<tr>
<th>Device</th>
<th>Package</th>
<th>Shipping</th>
</tr>
</thead>
<tbody>
<tr>
<td>FGA40T65SHD</td>
<td>TO–3P–3LD</td>
<td>450 Units / Tube</td>
</tr>
<tr>
<td></td>
<td>(Pb–Free / Halide Free)</td>
<td></td>
</tr>
</tbody>
</table>

FGA40T65SHD AYWWZZ

FGA40T
65SHD
AYWWZZ

GCE

Device Package Shipping
ABSOLUTE MAXIMUM RATINGS  \((T_C = 25^\circ C\) unless otherwise noted)

<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</td>
<td>@ (T_C = 25^\circ C)</td>
<td>80</td>
</tr>
<tr>
<td></td>
<td>Collector Current</td>
<td>@ (T_C = 10^\circ C)</td>
<td>40</td>
</tr>
<tr>
<td>(I_{LM}) (Note 1)</td>
<td>Pulsed Collector Current</td>
<td>@ (T_C = 25^\circ C)</td>
<td>120</td>
</tr>
<tr>
<td>(I_{CM}) (Note 2)</td>
<td>Pulsed Collector Current</td>
<td></td>
<td>120</td>
</tr>
<tr>
<td>(I_F)</td>
<td>Diode Forward Current</td>
<td>@ (T_C = 25^\circ C)</td>
<td>40</td>
</tr>
<tr>
<td></td>
<td>Diode Forward Current</td>
<td>@ (T_C = 100^\circ C)</td>
<td>20</td>
</tr>
<tr>
<td>(I_{FM}) (Note 2)</td>
<td>Pulsed Diode Maximum Forward Current</td>
<td></td>
<td>120</td>
</tr>
<tr>
<td>(P_D)</td>
<td>Maximum Power Dissipation</td>
<td>@ (T_C = 25^\circ C)</td>
<td>268</td>
</tr>
<tr>
<td></td>
<td>Maximum Power Dissipation</td>
<td>@ (T_C = 10^\circ C)</td>
<td>134</td>
</tr>
<tr>
<td>(T_J)</td>
<td>Operating Junction Temperature</td>
<td></td>
<td>−55 to +175</td>
</tr>
<tr>
<td>(T_{stg})</td>
<td>Storage Temperature Range</td>
<td></td>
<td>−55 to +175</td>
</tr>
<tr>
<td>(T_L)</td>
<td>Maximum Lead Temp. for soldering Purposes, 1/8” from case for 5 seconds</td>
<td></td>
<td>300</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. \(V_{CC} = 400\) V, \(V_{GE} = 15\) V, \(I_C = 120\) A, \(R_G = 30\) Ω, Inductive Load.
2. 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_{JUC(IGBT)})</td>
<td>Thermal Resistance, Junction to Case, Max.</td>
<td>0.56</td>
<td>°C/W</td>
</tr>
<tr>
<td>(R_{JUC(Diode)})</td>
<td>Thermal Resistance, Junction to Case, Max.</td>
<td>1.71</td>
<td>°C/W</td>
</tr>
<tr>
<td>(R_{JUA})</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>2.2</td>
<td>2.8</td>
<td>V</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>(T_C = 100^\circ C)</td>
<td></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>50</td>
<td></td>
<td>µJ</td>
</tr>
<tr>
<td>(t_{rr})</td>
<td>Diode Reverse Recovery Time</td>
<td>(I_F = 20) A, (dI_F/dt = 200) A/(\mu)s</td>
<td>(T_C = 25^\circ C)</td>
<td>31.8</td>
<td></td>
<td>ns</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>(T_C = 175^\circ C)</td>
<td>192</td>
<td></td>
<td></td>
</tr>
<tr>
<td>(Q_{rr})</td>
<td>Diode Reverse Recovery Charge</td>
<td>(I_F = 20) A, (dI_F/dt = 200) A/(\mu)s</td>
<td>(T_C = 25^\circ C)</td>
<td>50.6</td>
<td></td>
<td>nC</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>(T_C = 175^\circ C)</td>
<td>699</td>
<td></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 \( (T_C = 25^\circ C \text{ unless otherwise noted}) \)

<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>( BV_{CES} )</td>
<td>Collector to Emitter Breakdown Voltage</td>
<td>( V_{GE} = 0 \text{ V}, I_C = 1 \text{ mA} )</td>
<td>650</td>
<td>–</td>
<td>–</td>
<td>V</td>
</tr>
<tr>
<td>( \Delta BV_{CES} / \Delta T_J )</td>
<td>Temperature Coefficient of Breakdown Voltage</td>
<td>( I_C = 1 \text{ mA, Reference to 25}^\circ C )</td>
<td>–</td>
<td>0.6</td>
<td>–</td>
<td>V/(^\circ C)</td>
</tr>
<tr>
<td>( I_{CES} )</td>
<td>Collector Cut–Off Current</td>
<td>( V_{CE} = V_{CES}, V_{GE} = 0 \text{ V} )</td>
<td>–</td>
<td>–</td>
<td>250</td>
<td>( \mu A )</td>
</tr>
<tr>
<td>( I_{GES} )</td>
<td>G–E Leakage Current</td>
<td>( V_{GE} = V_{GES}, V_{CE} = 0 \text{ V} )</td>
<td>–</td>
<td>–</td>
<td>±400</td>
<td>( nA )</td>
</tr>
</tbody>
</table>

**OFF CHARACTERISTICS**

**ON CHARACTERISTICS**

\( V_{GE(th)} \) | G–E Threshold Voltage                   | \( I_C = 40 \text{ mA, } V_{CE} = V_{GE} \) | 3.5  | 5.5  | 7.5  | V    |
\( V_{CE(sat)} \) | Collector to Emitter Saturation Voltage  | \( I_C = 40 \text{ A, } V_{GE} = 15 \text{ V} \) | 1.6  | 2.1  | –    | V    |

\( I_C = 40 \text{ A, } V_{GE} = 15 \text{ V, } T_C = 175^\circ C \) | \( I_C = 40 \text{ A, } V_{GE} = 15 \text{ V, } T_C = 175^\circ C \) | \( I_C = 40 \text{ A, } V_{GE} = 15 \text{ V, } T_C = 175^\circ C \) | \( 2.14 \) | –    | –    | V    |

**DYNAMIC CHARACTERISTICS**

\( C_{i(es)} \) | Input Capacitance                      | \( V_{CE} = 30 \text{ V, } V_{GE} = 0 \text{ V, } f = 1 \text{ MHz} \) | –    | 1995 | –    | pF   |
\( C_{o(es)} \) | Output Capacitance                     | \( V_{CE} = 30 \text{ V, } V_{GE} = 0 \text{ V, } f = 1 \text{ MHz} \) | 70   | –    | –    | pF   |
\( C_{r(es)} \) | Reverse Transfer Capacitance           | \( V_{CE} = 30 \text{ V, } V_{GE} = 0 \text{ V, } f = 1 \text{ MHz} \) | –    | 23   | –    | pF   |

**SWITCHING CHARACTERISTICS**

\( t_{d(on)} \) | Turn–On Delay Time                     | \( V_{CC} = 400 \text{ V, } I_C = 40 \text{ A, } R_G = 6 \text{ } \Omega, V_{GE} = 15 \text{ V, Inductive Load, } T_C = 25^\circ C \) | –    | 19.2 | –    | ns   |
\( t_r \)     | Rise Time                              | \( V_{CC} = 400 \text{ V, } I_C = 40 \text{ A, } R_G = 6 \text{ } \Omega, V_{GE} = 15 \text{ V, Inductive Load, } T_C = 25^\circ C \) | –    | 34.4 | –    | ns   |
\( t_{d(off)} \) | Turn–Off Delay Time                    | \( V_{CC} = 400 \text{ V, } I_C = 40 \text{ A, } R_G = 6 \text{ } \Omega, V_{GE} = 15 \text{ V, Inductive Load, } T_C = 25^\circ C \) | –    | 65.6 | –    | ns   |
\( t_f \)     | Fall Time                              | \( V_{CC} = 400 \text{ V, } I_C = 40 \text{ A, } R_G = 6 \text{ } \Omega, V_{GE} = 15 \text{ V, Inductive Load, } T_C = 25^\circ C \) | –    | 9.6  | –    | ns   |
\( E_{on} \)  | Turn–On Switching Loss                | \( V_{CC} = 400 \text{ V, } I_C = 40 \text{ A, } R_G = 6 \text{ } \Omega, V_{GE} = 15 \text{ V, Inductive Load, } T_C = 25^\circ C \) | –    | 1010 | –    | \( \mu J \) |
\( E_{off} \) | Turn–Off Switching Loss               | \( V_{CC} = 400 \text{ V, } I_C = 40 \text{ A, } R_G = 6 \text{ } \Omega, V_{GE} = 15 \text{ V, Inductive Load, } T_C = 25^\circ C \) | –    | 297  | –    | \( \mu J \) |
\( E_{ts} \)  | Total Switching Loss                 | \( V_{CC} = 400 \text{ V, } I_C = 40 \text{ A, } R_G = 6 \text{ } \Omega, V_{GE} = 15 \text{ V, Inductive Load, } T_C = 25^\circ C \) | –    | 1307 | –    | \( \mu J \) |
\( t_{d(on)} \) | Turn–On Delay Time                     | \( V_{CC} = 400 \text{ V, } I_C = 40 \text{ A, } R_G = 6 \text{ } \Omega, V_{GE} = 15 \text{ V, Inductive Load, } T_C = 175^\circ C \) | –    | 18.4 | –    | ns   |
\( t_r \)     | Rise Time                              | \( V_{CC} = 400 \text{ V, } I_C = 40 \text{ A, } R_G = 6 \text{ } \Omega, V_{GE} = 15 \text{ V, Inductive Load, } T_C = 175^\circ C \) | –    | 32.8 | –    | ns   |
\( t_{d(off)} \) | Turn–Off Delay Time                    | \( V_{CC} = 400 \text{ V, } I_C = 40 \text{ A, } R_G = 6 \text{ } \Omega, V_{GE} = 15 \text{ V, Inductive Load, } T_C = 175^\circ C \) | –    | 71.2 | –    | ns   |
\( t_f \)     | Fall Time                              | \( V_{CC} = 400 \text{ V, } I_C = 40 \text{ A, } R_G = 6 \text{ } \Omega, V_{GE} = 15 \text{ V, Inductive Load, } T_C = 175^\circ C \) | –    | 14.4 | –    | ns   |
\( E_{on} \)  | Turn–On Switching Loss                | \( V_{CC} = 400 \text{ V, } I_C = 40 \text{ A, } R_G = 6 \text{ } \Omega, V_{GE} = 15 \text{ V, Inductive Load, } T_C = 175^\circ C \) | –    | 1390 | –    | \( \mu J \) |
\( E_{off} \) | Turn–Off Switching Loss               | \( V_{CC} = 400 \text{ V, } I_C = 40 \text{ A, } R_G = 6 \text{ } \Omega, V_{GE} = 15 \text{ V, Inductive Load, } T_C = 175^\circ C \) | –    | 541  | –    | \( \mu J \) |
\( E_{ts} \)  | Total Switching Loss                 | \( V_{CC} = 400 \text{ V, } I_C = 40 \text{ A, } R_G = 6 \text{ } \Omega, V_{GE} = 15 \text{ V, Inductive Load, } T_C = 175^\circ C \) | –    | 1931 | –    | \( \mu J \) |
\( Q_g \) | Total Gate Charge                     | \( V_{CE} = 400 \text{ V, } I_C = 40 \text{ A, } V_{GE} = 15 \text{ V} \) | –    | 72.2 | –    | nC   |
\( Q_{ge} \) | Gate to Emitter Charge                | \( V_{CE} = 400 \text{ V, } I_C = 40 \text{ A, } V_{GE} = 15 \text{ V} \) | –    | 13.5 | –    | nC   |
\( Q_{gc} \) | Gate to Collector Charge              | \( V_{CE} = 400 \text{ V, } I_C = 40 \text{ A, } V_{GE} = 15 \text{ V} \) | –    | 28.5 | –    | nC   |

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.
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. $V_{GE}$
TYPICAL PERFORMANCE CHARACTERISTICS (continued)

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

Notes:
1. TC = 25°C
2. TJ = 175°C
3. Single Pulse
TYPICAL PERFORMANCE CHARACTERISTICS (continued)

![Figure 19. Reverse Recovery Time](image1)

![Figure 20. Stored Charge](image2)

![Figure 21. Transient Thermal Impedance of IGBT](image3)

![Figure 22. Transient Thermal Impedance of Diode](image4)
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 ASME14.5-2009.
D) DIMENSIONS ARE EXCLUSIVE OF BURRS, MOLD FLASH, AND TIE BAR EXTRUSIONS.

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