

# Field Stop Trench IGBT

**650 V, 40 A**

## FGA40T65SHD

### General Description

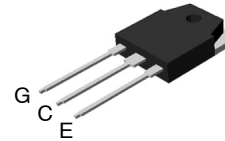
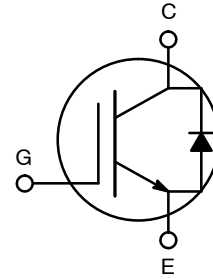
Using novel field stop IGBT technology, **onsemi**'s new series of field stop 3<sup>rd</sup> generation IGBTs offer the optimum performance for solar inverter, UPS, welder, telecom, ESS and PFC applications where low conduction and switching losses are essential.

### Features

- Maximum Junction Temperature:  $T_J = 175^\circ\text{C}$
- Positive Temperature Co-efficient for Easy Parallel Operating
- High Current Capability
- Low Saturation Voltage:  $V_{CE(sat)} = 1.6\text{ V (Typ.) @ } I_C = 40\text{ A}$
- 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



**TO-3P-3LD  
CASE 340BZ**

### MARKING DIAGRAM



FGA40T65SHD = Specific Device Code  
 A = Assembly Location  
 YWW = Date Code (Year & Week)  
 ZZ = Assembly Lot

### ORDERING INFORMATION

| Device      | Package                              | Shipping         |
|-------------|--------------------------------------|------------------|
| FGA40T65SHD | TO-3P-3LD<br>(Pb-Free / Halide Free) | 450 Units / Tube |

# FGA40T65SHD

## ABSOLUTE MAXIMUM RATINGS (T<sub>C</sub> = 25°C unless otherwise noted)

| Symbol                   | Description   | Value                    | Unit        |
|--------------------------|---|--------------------------|-------------|
| V <sub>CES</sub>         | Collector to Emitter Voltage  | 650                      | V           |
| V <sub>GES</sub>         | Gate to Emitter Voltage   | ±20                      | A           |
|                          | Transient Gate to Emitter Voltage                                       | ±30                      | A           |
| I <sub>C</sub>           | Collector Current   | @ T <sub>C</sub> = 25°C  | 80          |
|                          | Collector Current   | @ T <sub>C</sub> = 10°C  | 40          |
| I <sub>LM</sub> (Note 1) | Pulsed Collector Current  | @ T <sub>C</sub> = 25°C  | 120         |
| I <sub>CM</sub> (Note 2) | Pulsed Collector Current  |                          | 120         |
| I <sub>F</sub>           | Diode Forward Current   | @ T <sub>C</sub> = 25°C  | 40          |
|                          | Diode Forward Current   | @ T <sub>C</sub> = 100°C | 20          |
| I <sub>FM</sub> (Note 2) | Pulsed Diode Maximum Forward Current                                    |                          | 120         |
| P <sub>D</sub>           | Maximum Power Dissipation   | @ T <sub>C</sub> = 25°C  | 268         |
|                          | Maximum Power Dissipation   | @ T <sub>C</sub> = 10°C  | 134         |
| T <sub>J</sub>           | Operating Junction Temperature  |                          | -55 to +175 |
| T <sub>stg</sub>         | Storage Temperature Range   |                          | -55 to +175 |
| T <sub>L</sub>           | Maximum Lead Temp. for soldering Purposes, 1/8" from case for 5 seconds |                          | 300         |

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.

- V<sub>CC</sub> = 400 V, V<sub>GE</sub> = 15 V, I<sub>C</sub> = 120 A, R<sub>G</sub> = 30 Ω, Inductive Load.
- Repetitive rating: Pulse width limited by max. junction temperature.

## THERMAL CHARACTERISTICS

| Symbol                   | Parameter                                     | Value | Unit |
|--------------------------|---|-------|------|
| R <sub>θJC</sub> (IGBT)  | Thermal Resistance, Junction to Case, Max.    | 0.56  | °C/W |
| R <sub>θJC</sub> (Diode) | Thermal Resistance, Junction to Case, Max.    | 1.71  | °C/W |
| R <sub>θJA</sub>         | Thermal Resistance, Junction to Ambient, Max. | 40    | °C/W |

## ELECTRICAL CHARACTERISTICS OF THE DIODE (T<sub>C</sub> = 25°C unless otherwise noted)

| Symbol           | Parameter                     | Test Conditions  | Min.                   | Typ. | Max. | Unit |
|------------------|-------------------------------|--|------------------------|------|------|------|
| V <sub>FM</sub>  | Diode Forward Voltage         | I <sub>F</sub> = 20 A                                    | T <sub>C</sub> = 25°C  | -    | 2.2  | 2.8  |
|                  |                               |  | T <sub>C</sub> = 175°C | -    | 1.94 | -    |
| E <sub>rec</sub> | Reverse Recovery Energy       | I <sub>F</sub> = 20 A,<br>dI <sub>F</sub> /dt = 200 A/μs | T <sub>C</sub> = 175°C | -    | 50   | μJ   |
| t <sub>rr</sub>  | Diode Reverse Recovery Time   |  | T <sub>C</sub> = 25°C  | -    | 31.8 | -    |
|                  |                               |  | T <sub>C</sub> = 175°C | -    | 192  | -    |
| Q <sub>rr</sub>  | Diode Reverse Recovery Charge |  | T <sub>C</sub> = 25°C  | -    | 50.6 | -    |
|                  |                               | T <sub>C</sub> = 175°C                                   | -                      | 699  | -    |      |

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.

# FGA40T65SHD

## ELECTRICAL CHARACTERISTICS OF THE IGBT ( $T_C = 25^\circ\text{C}$ unless otherwise noted)

| Symbol | Parameter | Test Conditions | Min. | Typ. | Max. | Unit |
|--------|-----------|-----------------|------|------|------|------|
|--------|-----------|-----------------|------|------|------|------|

### OFF CHARACTERISTICS

|                                |  |   |     |     |           |                     |
|--------------------------------|--|---|-----|-----|-----------|---------------------|
| $BV_{CES}$                     | Collector to Emitter Breakdown Voltage       | $V_{GE} = 0\text{ V}, I_C = 1\text{ mA}$              | 650 | –   | –         | V                   |
| $\Delta BV_{CES} / \Delta T_J$ | Temperature Coefficient of Breakdown Voltage | $I_C = 1\text{ mA}$ , Reference to $25^\circ\text{C}$ | –   | 0.6 | –         | V/ $^\circ\text{C}$ |
| $I_{CES}$                      | Collector Cut-Off Current                    | $V_{CE} = V_{CES}, V_{GE} = 0\text{ V}$               | –   | –   | 250       | $\mu\text{A}$       |
| $I_{GES}$                      | G–E Leakage Current                          | $V_{GE} = V_{GES}, V_{CE} = 0\text{ V}$               | –   | –   | $\pm 400$ | nA                  |

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

### DYNAMIC CHARACTERISTICS

|           |                              |   |   |      |   |    |
|-----------|------------------------------|---|---|------|---|----|
| $C_{ies}$ | Input Capacitance            | $V_{CE} = 30\text{ V}, V_{GE} = 0\text{ V}, f = 1\text{ MHz}$ | – | 1995 | – | pF |
| $C_{oes}$ | Output Capacitance           |   | – | 70   | – | pF |
| $C_{res}$ | Reverse Transfer Capacitance |   | – | 23   | – | pF |

### SWITCHING CHARACTERISTICS

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

TYPICAL PERFORMANCE CHARACTERISTICS

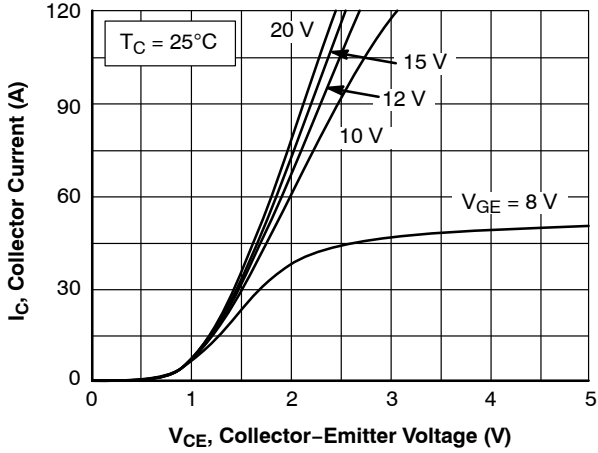


Figure 1. Typical Output Characteristics

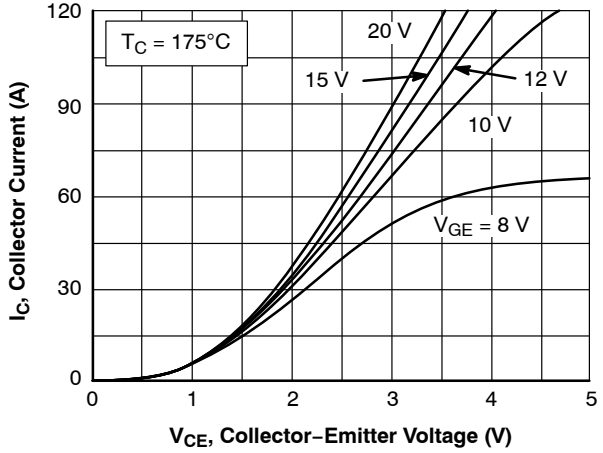


Figure 2. Typical Output Characteristics

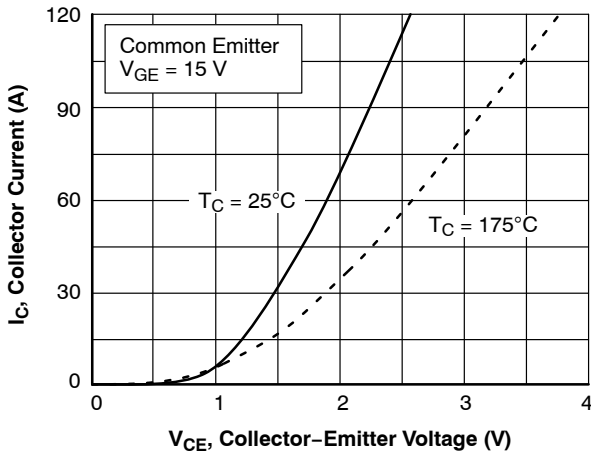


Figure 3. Typical Saturation Voltage Characteristics

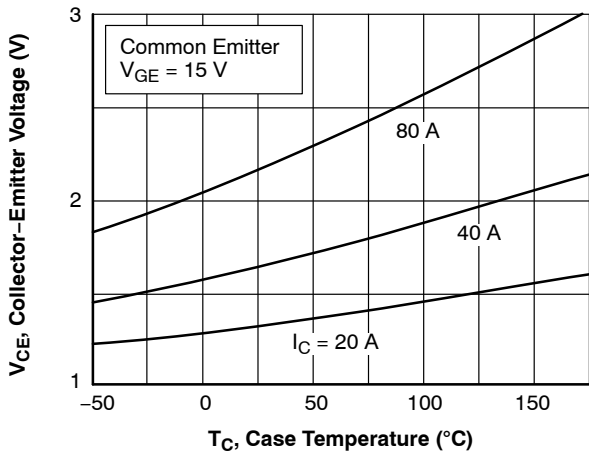


Figure 4. Saturation Voltage vs. Case Temperature at Variant Current Level

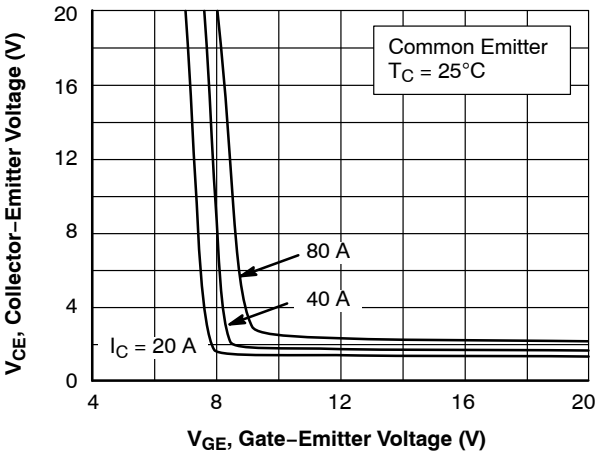


Figure 5. Saturation Voltage vs. VGE

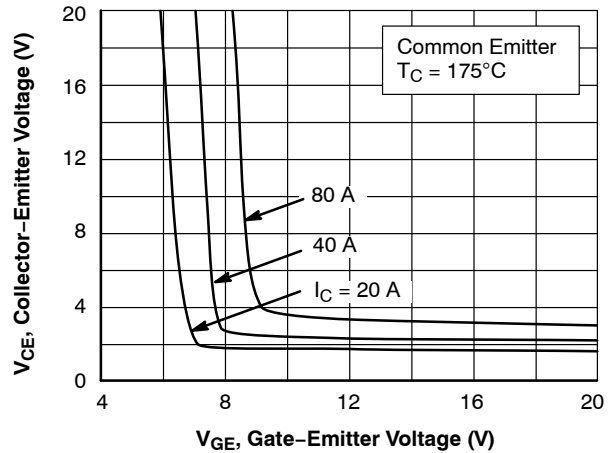


Figure 6. Saturation Voltage vs. VGE

TYPICAL PERFORMANCE CHARACTERISTICS (continued)

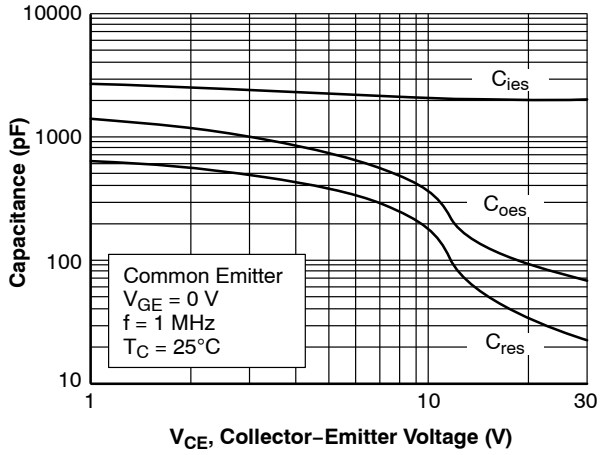


Figure 7. Capacitance Characteristics

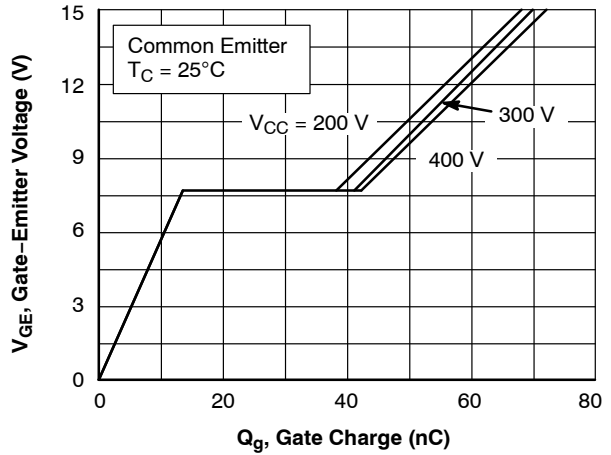


Figure 8. Gate Charge Characteristics

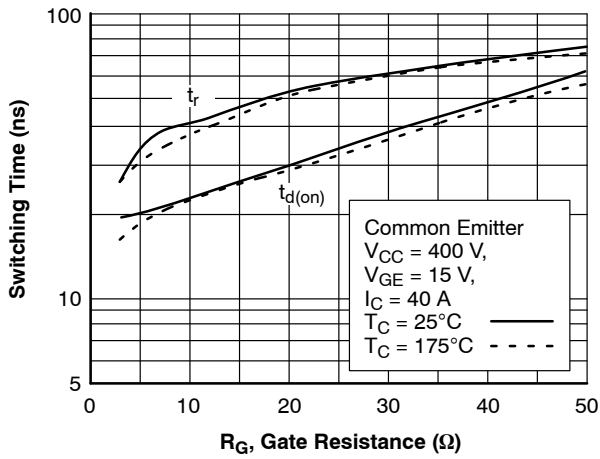


Figure 9. Turn-on Characteristics vs. Gate Resistance

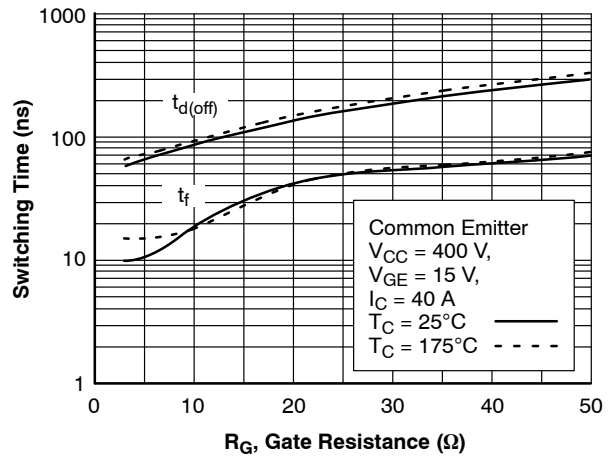


Figure 10. Turn-off Characteristics vs. Gate Resistance

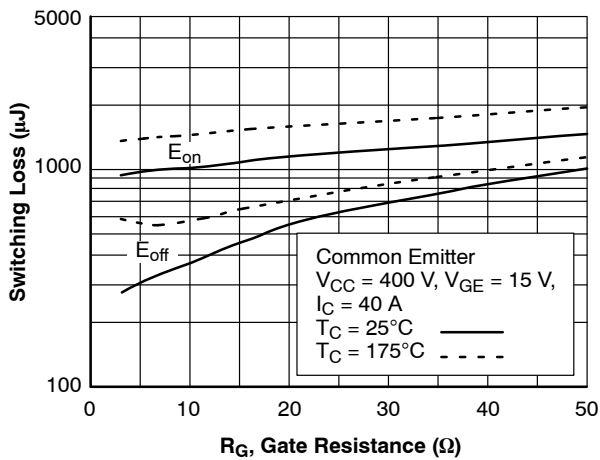


Figure 11. Switching Loss vs. Gate Resistance

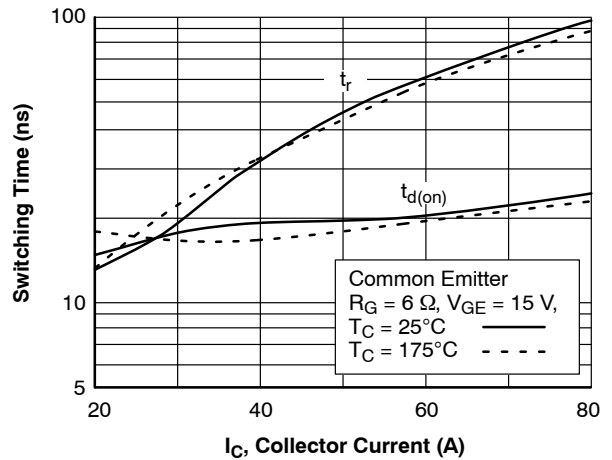


Figure 12. Turn-on Characteristics vs. Collector Current

TYPICAL PERFORMANCE CHARACTERISTICS (continued)

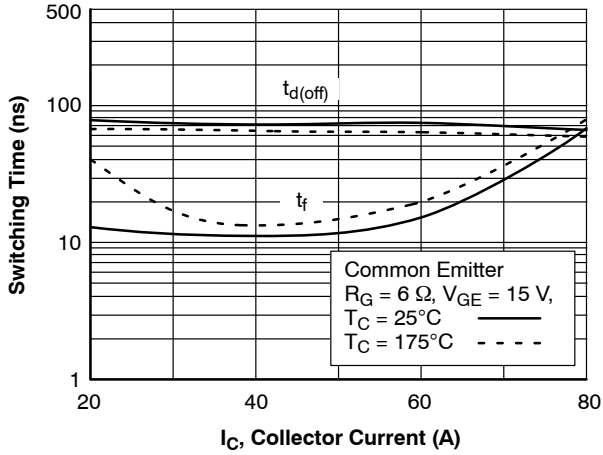


Figure 13. Turn-off Characteristics vs. Collector Current

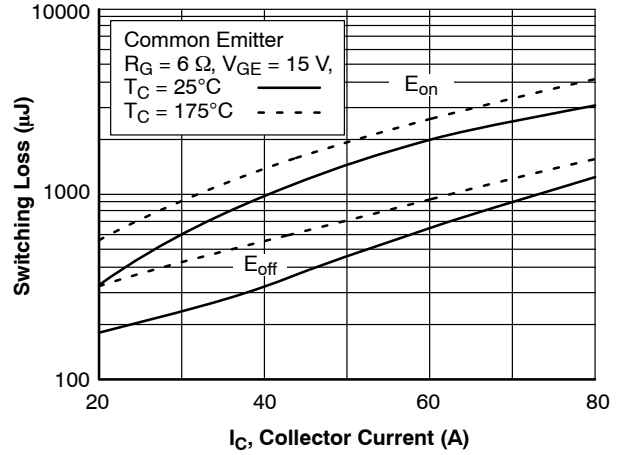


Figure 14. Switching Loss vs. Collector Current

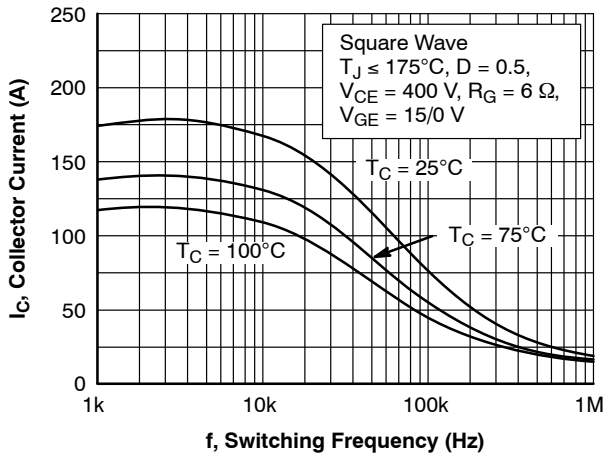


Figure 15. Load Current Vs. Frequency

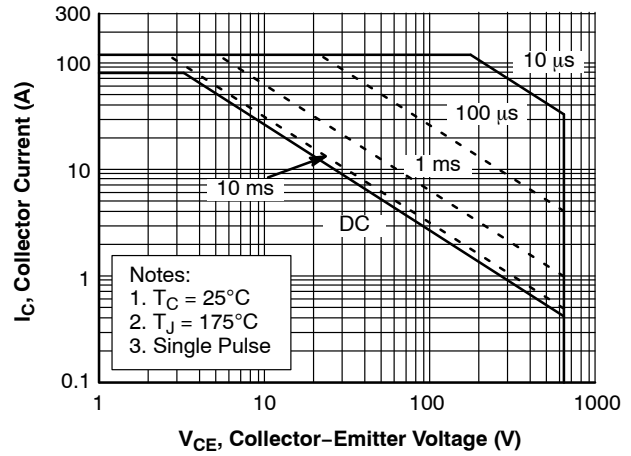


Figure 16. SOA Characteristics

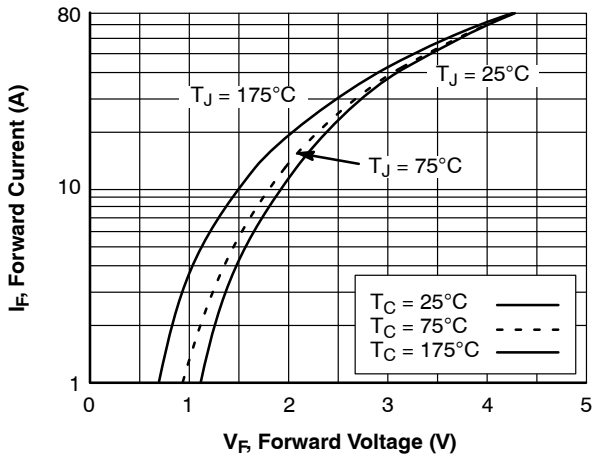


Figure 17. Forward Characteristics

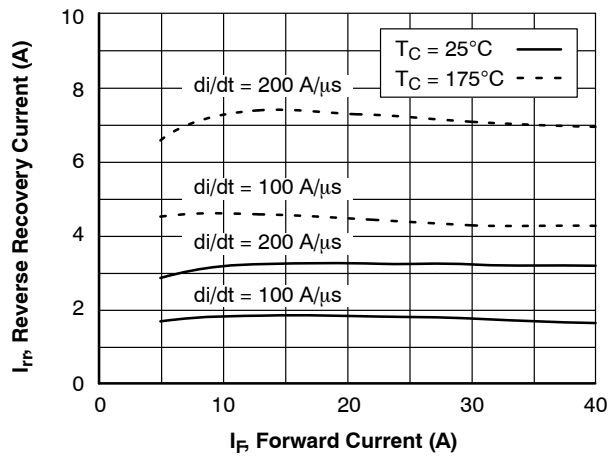


Figure 18. Reverse Recovery Current

# FGA40T65SHD

## TYPICAL PERFORMANCE CHARACTERISTICS (continued)

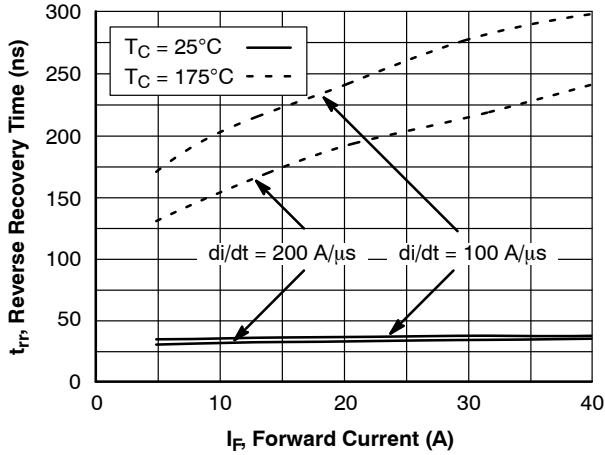


Figure 19. Reverse Recovery Time

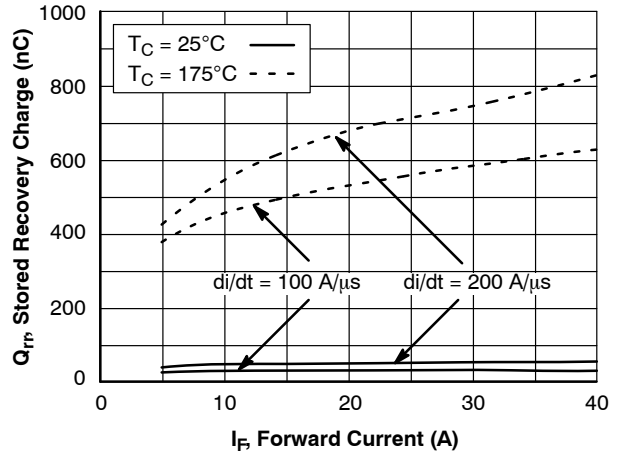


Figure 20. Stored Charge

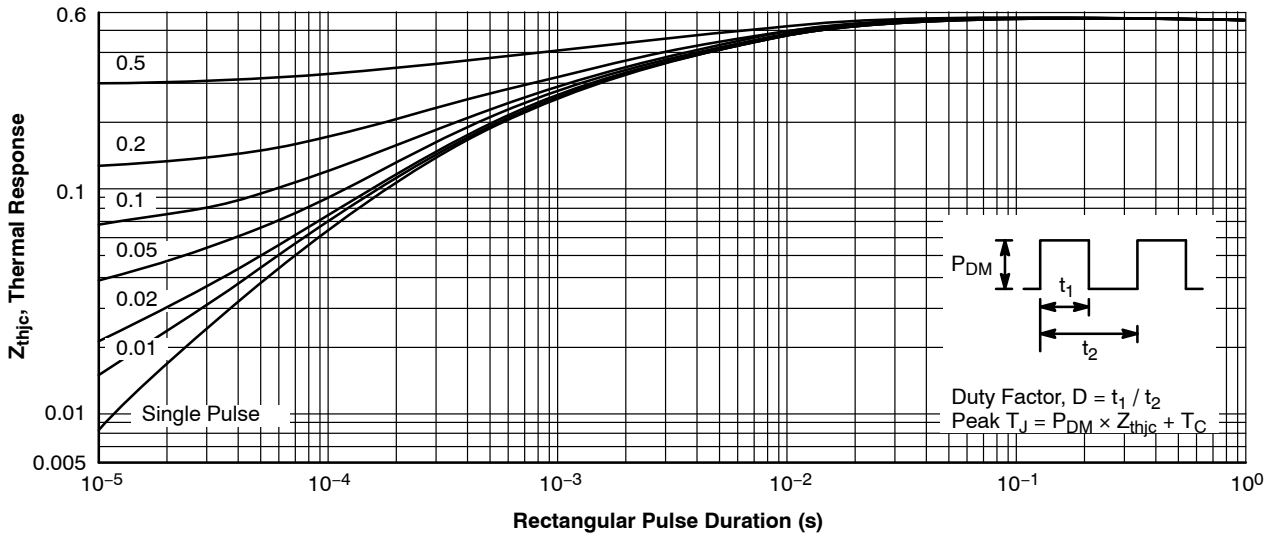


Figure 21. Transient Thermal Impedance of IGBT

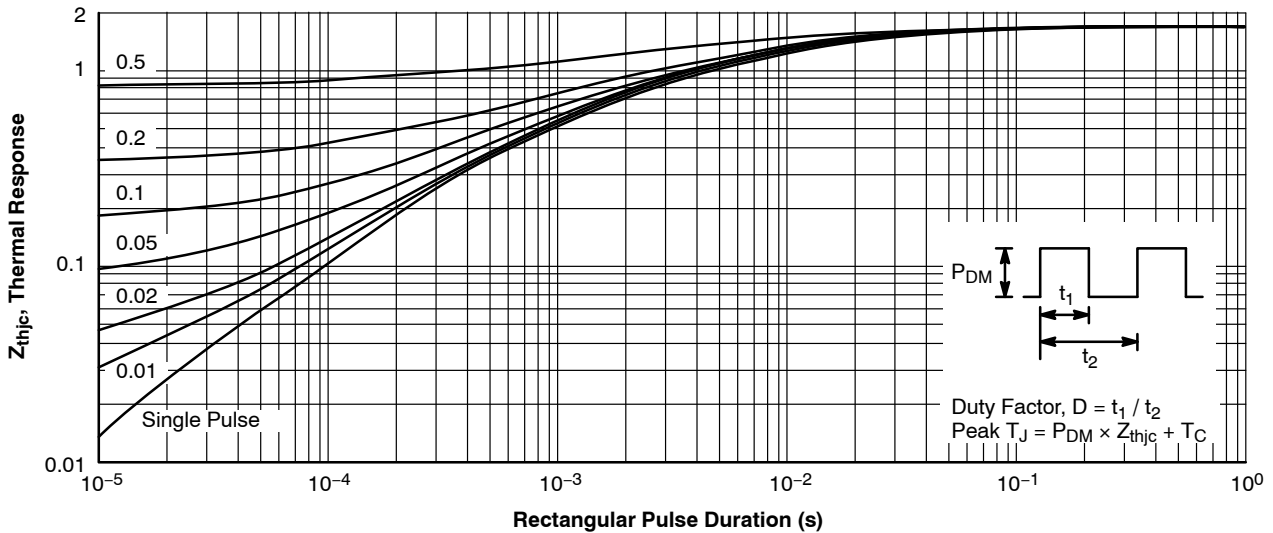


Figure 22. Transient Thermal Impedance of Diode



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