

# IGBT - Field Stop, Trench

## 650 V, 60 A

### FGH60T65SQD-F155

#### Description

Using novel field stop IGBT technology, ON Semiconductor's new series of field stop 4<sup>th</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

- Max Junction Temperature 175°C
- Positive Temperature Co-efficient for Easy Parallel Operating
- High Current Capability
- Low Saturation Voltage:  $V_{CE(sat)} = 1.6 \text{ V (Typ.) @ } I_C = 60 \text{ A}$
- 100% of the Parts Tested for ILM(1)
- High Input Impedance
- Fast Switching
- Tighten Parameter Distribution
- This Device is Pb-Free and is RoHS Compliant

#### Applications

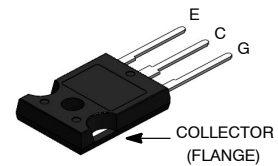
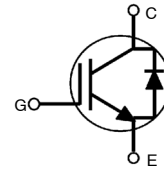
- Solar Inverter, UPS, Welder, Telecom, ESS, PFC



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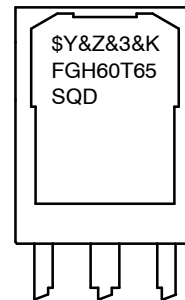
[www.onsemi.com](http://www.onsemi.com)

|           |       |
|-----------|-------|
| $V_{CES}$ | $I_C$ |
| 650 V     | 60 A  |



TO-247-3LD  
CASE 340CH

#### MARKING DIAGRAM



|             |                         |
|-------------|-------------------------|
| \$Y         | = ON Semiconductor Logo |
| &Z          | = Assembly Plant Code   |
| &3          | = Numeric Date Code     |
| &K          | = Lot Code              |
| FGH60T65SQD | = Specific Device Code  |

#### ORDERING INFORMATION

See detailed ordering and shipping information on page 2 of this data sheet.

# FGH60T65SQD-F155

## ABSOLUTE MAXIMUM RATINGS

| Symbol               | Description  | FGH60T65SQD-F155            | Unit             |
|----------------------|--|-----------------------------|------------------|
| $V_{CES}$            | Collector to Emitter Voltage                                       | 650                         | V                |
| $V_{GES}$            | Gate to Emitter Voltage  | $\pm 20$                    | V                |
|                      | Transient Gate to Emitter Voltage                                  | $\pm 30$                    | V                |
| $I_C$                | Collector Current  | @ $T_c < 25^\circ\text{C}$  | 120              |
|                      |  | @ $T_c < 100^\circ\text{C}$ | 60               |
| $I_{LM}$<br>(Note 1) | Pulsed Collector Current   | @ $T_c < 25^\circ\text{C}$  | 240              |
| $I_{CM}$<br>(Note 2) | Pulsed Collector Current   |                             | 240              |
| $I_F$                | Diode Forward Current  | @ $T_c < 25^\circ\text{C}$  | 60               |
|                      | Diode Forward Current  | @ $T_c < 100^\circ\text{C}$ | 30               |
| $I_{FM}$<br>(Note 2) | Repetitive Forward Surge Current                                   |                             | 240              |
| $P_D$                | Maximum Power Dissipation  | @ $T_c < 25^\circ\text{C}$  | 333              |
|                      |  | @ $T_c < 100^\circ\text{C}$ | 167              |
| $T_J$                | Operating Junction Temperature Range                               | -55 to +175                 | $^\circ\text{C}$ |
| $T_{STG}$            | Storage Temperature Range  | -55 to +175                 | $^\circ\text{C}$ |
| $T_L$                | Maximum Lead Temp. For soldering Purposes, 18" from case for 5 sec | 300                         | $^\circ\text{C}$ |

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.  $V_{CC} = 400\text{ V}$ ,  $V_{GE} = 15\text{ V}$ ,  $I_C = 240\text{ A}$ ,  $R_G = 21\ \Omega$ , Inductive Load.
2. Repetitive rating: Pulse width limited by max. junction temperature.

## THERMAL CHARACTERISTICS

| Symbol                  | Parameter                                     | FGH60T65SQD-F155 | Unit                      |
|-------------------------|---|------------------|---------------------------|
| $R_{\theta JC}$ (IGBT)  | Thermal Resistance, Junction to Case, Max.    | 0.45             | $^\circ\text{C}/\text{W}$ |
| $R_{\theta JC}$ (Diode) | Thermal Resistance, Junction to Case, Max.    | 1.25             | $^\circ\text{C}/\text{W}$ |
| $R_{\theta JA}$         | Thermal Resistance, Junction to Ambient, Max. | 40               | $^\circ\text{C}/\text{W}$ |

## PACKAGE MARKING AND ORDERING INFORMATION

| Part Number      | Top Mark    | Package    | Packing Method | Reel Size | Tape Width | Quantity |
|------------------|-------------|------------|----------------|-----------|------------|----------|
| FGH60T65SQD-F155 | FGH60T65SQD | TO-247-3LD | Tube           | -         | -          | 30       |

# FGH60T65SQD-F155

## 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 | -         | $\text{V}/^\circ\text{C}$ |
| $I_{CES}$                      | 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                   | $I_C = 60\text{ mA}, V_{CE} = V_{GE}$                              | 2.6 | 4.5  | 6.4 | V |
| $V_{CE(sat)}$ | Collector to Emitter Saturation Voltage | $I_C = 60\text{ A}, V_{GE} = 15\text{ V}$                          | -   | 1.6  | 2.1 | V |
|               |   | $I_C = 60\text{ A}, V_{GE} = 15\text{ V}, T_C = 175^\circ\text{C}$ | -   | 1.92 | -   | V |

### DYNAMIC CHARACTERISTICS

|           |                              |   |   |      |   |    |
|-----------|------------------------------|---|---|------|---|----|
| $C_{ies}$ | Input Capacitance            | $V_{CE} = 30\text{ V}, V_{GE} = 0\text{ V}, f = 1\text{ MHz}$ | - | 3813 | - | pF |
| $C_{oes}$ | Output Capacitance           |   | - | 90   | - | pF |
| $C_{res}$ | Reverse Transfer Capacitance |   | - | 13   | - | pF |

### SWITCHING CHARACTERISTICS

|              |                         |   |   |      |   |               |
|--------------|-------------------------|---|---|------|---|---------------|
| $t_{d(on)}$  | Turn-On Delay Time      | $V_{CC} = 400\text{ V}, I_C = 15\text{ A}, R_G = 4.7\ \Omega, V_{GE} = 15\text{ V},$<br>Inductive Load, $T_C = 25^\circ\text{C}$  | - | 20.8 | - | ns            |
| $t_r$        | Rise Time               |   | - | 8    | - | ns            |
| $t_{d(off)}$ | Turn-Off Delay Time     |   | - | 102  | - | ns            |
| $t_f$        | Fall Time               |   | - | 11.2 | - | ns            |
| $E_{on}$     | Turn-On Switching Loss  |   | - | 227  | - | $\mu\text{J}$ |
| $E_{off}$    | Turn-Off Switching Loss |   | - | 100  | - | $\mu\text{J}$ |
| $E_{ts}$     | Total Switching Loss    |   | - | 327  | - | $\mu\text{J}$ |
| $t_{d(on)}$  | Turn-On Delay Time      | $V_{CC} = 400\text{ V}, I_C = 30\text{ A}, R_G = 4.7\ \Omega, V_{GE} = 15\text{ V},$<br>Inductive Load, $T_C = 25^\circ\text{C}$  | - | 21.6 | - | ns            |
| $t_r$        | Rise Time               |   | - | 14.4 | - | ns            |
| $t_{d(off)}$ | Turn-Off Delay Time     |   | - | 97.6 | - | ns            |
| $t_f$        | Fall Time               |   | - | 4.8  | - | ns            |
| $E_{on}$     | Turn-On Switching Loss  |   | - | 585  | - | $\mu\text{J}$ |
| $E_{off}$    | Turn-Off Switching Loss |   | - | 167  | - | $\mu\text{J}$ |
| $E_{ts}$     | Total Switching Loss    |   | - | 752  | - | $\mu\text{J}$ |
| $T_{d(on)}$  | Turn-On Delay Time      | $V_{CC} = 400\text{ V}, I_C = 15\text{ A}, R_G = 4.7\ \Omega, V_{GE} = 15\text{ V},$<br>Inductive Load, $T_C = 175^\circ\text{C}$ | - | 19.2 | - | ns            |
| $T_r$        | Rise Time               |   | - | 9.6  | - | ns            |
| $T_{d(off)}$ | Turn-Off Delay Time     |   | - | 115  | - | ns            |
| $T_f$        | Fall Time               |   | - | 11.2 | - | ns            |
| $E_{on}$     | Turn-On Switching Loss  |   | - | 448  | - | $\mu\text{J}$ |
| $E_{off}$    | Turn-Off Switching Loss |   | - | 199  | - | $\mu\text{J}$ |
| $E_{ts}$     | Total Switching Loss    |   | - | 647  | - | $\mu\text{J}$ |

## FGH60T65SQD-F155

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

| Symbol                           | Parameter                | Test Conditions  | Min | Typ  | Max | Unit          |
|----------------------------------|--------------------------|--|-----|------|-----|---------------|
| <b>SWITCHING CHARACTERISTICS</b> |                          |  |     |      |     |               |
| $T_{d(on)}$                      | Turn-On Delay Time       | $V_{CC} = 400\text{ V}$ , $I_C = 30\text{ A}$ ,<br>$R_G = 4.7\ \Omega$ , $V_{GE} = 15\text{ V}$ ,<br>Inductive Load, $T_C = 175^\circ\text{C}$ | -   | 20.8 | -   | ns            |
| $T_r$                            | Rise Time                |  | -   | 16   | -   | ns            |
| $T_{d(off)}$                     | Turn-Off Delay Time      |  | -   | 106  | -   | ns            |
| $T_f$                            | Fall Time                |  | -   | 8.8  | -   | ns            |
| $E_{on}$                         | Turn-On Switching Loss   |  | -   | 942  | -   | $\mu\text{J}$ |
| $E_{off}$                        | Turn-Off Switching Loss  |  | -   | 386  | -   | $\mu\text{J}$ |
| $E_{ts}$                         | Total Switching Loss     |  | -   | 1328 | -   | $\mu\text{J}$ |
| $Q_g$                            | Total Gate Charge        | $V_{CE} = 400\text{ V}$ , $I_C = 60\text{ A}$ ,<br>$V_{GE} = 15\text{ V}$  | -   | 79   | -   | nC            |
| $Q_{ge}$                         | Gate to Emitter Charge   |  | -   | 22   | -   | nC            |
| $Q_{gc}$                         | Gate to Collector Charge |  | -   | 27   | -   | 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.

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

| Symbol    | Parameter                     | Test Conditions   | Min                       | Typ | Max  | Unit |               |
|-----------|-------------------------------|---|---------------------------|-----|------|------|---------------|
| $V_{FM}$  | Diode Forward Voltage         | $I_F = 30\text{ A}$   | $T_C = 25^\circ\text{C}$  | -   | 2.3  | 2.7  | V             |
|           |                               |   | $T_C = 175^\circ\text{C}$ | -   | 1.9  | -    |               |
| $E_{rec}$ | Reverse Recovery Energy       | $I_F = 30\text{ A}$ ,<br>$di_F/dt = 200\text{ A}/\mu\text{s}$ | $T_C = 175^\circ\text{C}$ | -   | 50   | -    | $\mu\text{J}$ |
| $T_{rr}$  | Diode Reverse Recovery Time   |   | $T_C = 25^\circ\text{C}$  | -   | 34.6 | -    | ns            |
|           |                               |   | $T_C = 175^\circ\text{C}$ | -   | 197  | -    |               |
| $Q_{rr}$  | Diode Reverse Recovery Charge |   | $T_C = 25^\circ\text{C}$  | -   | 58.6 | -    | nC            |
|           |                               | $T_C = 175^\circ\text{C}$                                     | -                         | 810 | -    |      |               |

# FGH60T65SQD-F155

## TYPICAL CHARACTERISTICS

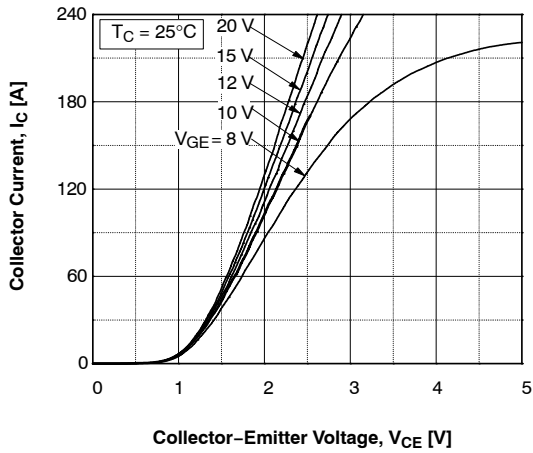


Figure 1. Typical Output Characteristics

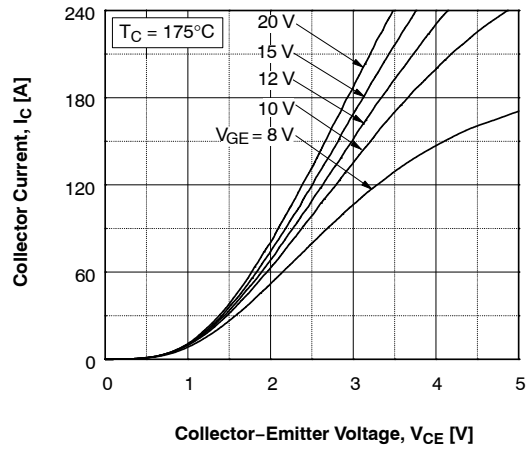


Figure 2. Typical Output Characteristics

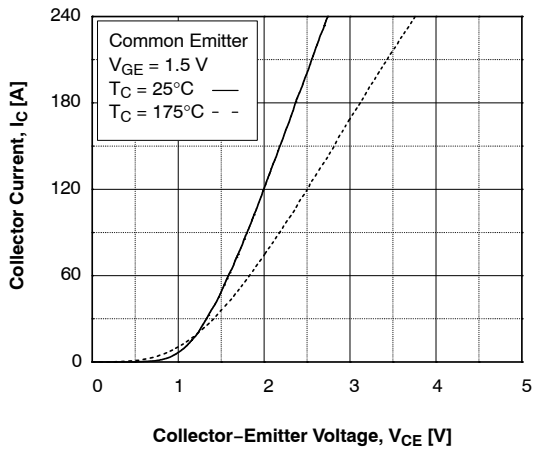


Figure 3. Typical Saturation Voltage Characteristics

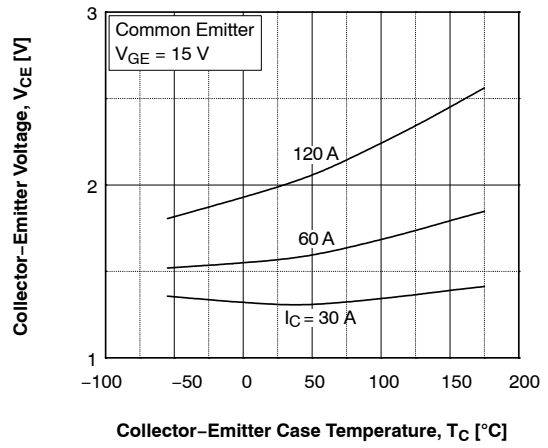


Figure 4. Saturation Voltage vs. Case Temperature at Variant Current Level

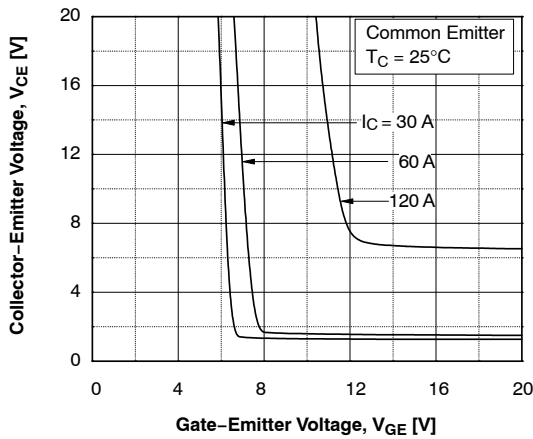


Figure 5. Saturation Voltage vs.  $V_{GE}$

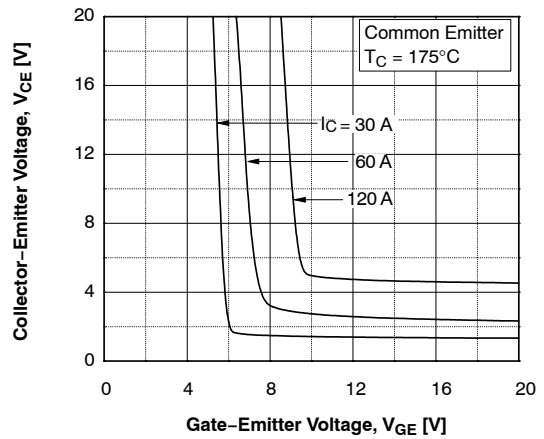


Figure 6. Saturation Voltage vs.  $V_{GE}$

TYPICAL CHARACTERISTICS (Continued)

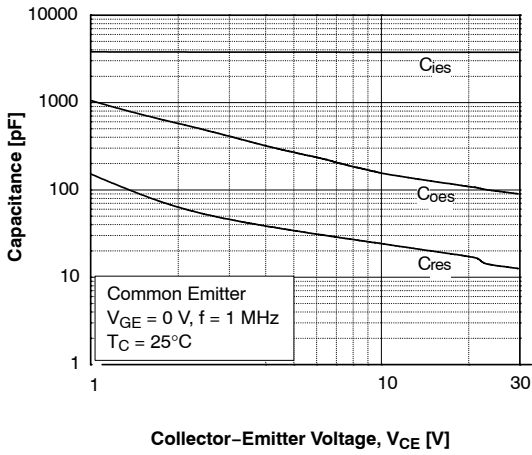


Figure 7. Capacitance Characteristics

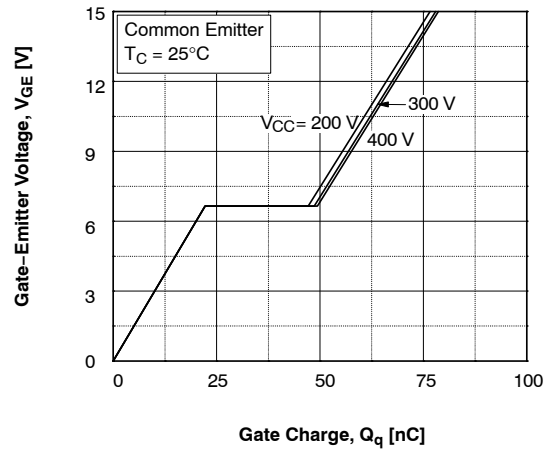


Figure 8. Gate Charge Characteristics

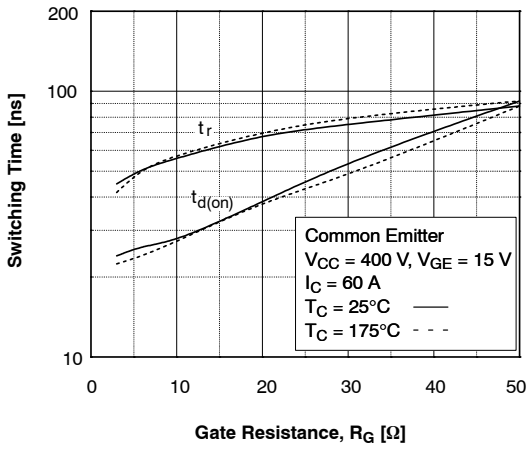


Figure 9. Turn-on Characteristics vs. Gate Resistance

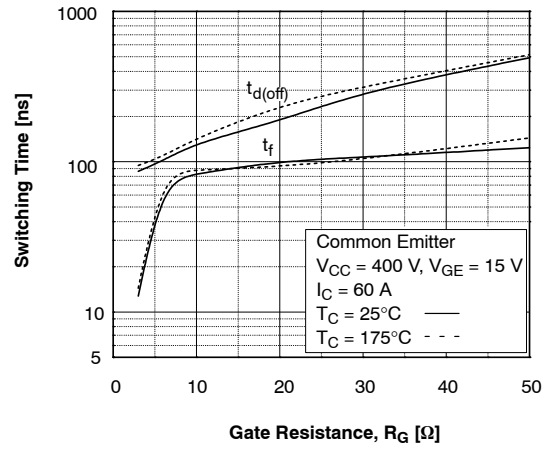


Figure 10. Turn-off Characteristics vs. Gate Resistance

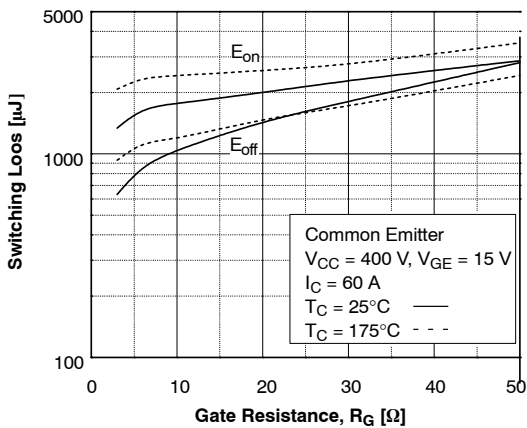


Figure 11. Switching Loops vs. Gate Resistance

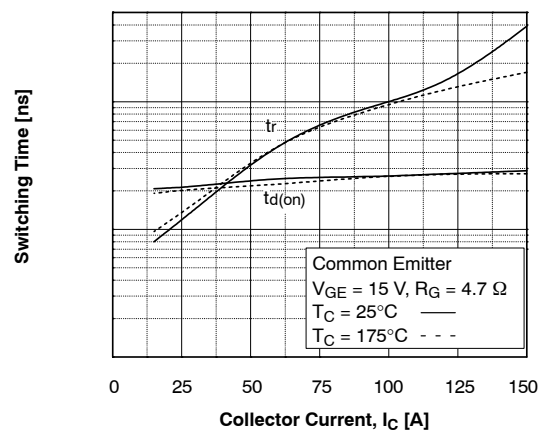


Figure 12. Turn-on Characteristics vs. Collector Current

TYPICAL CHARACTERISTICS (Continued)

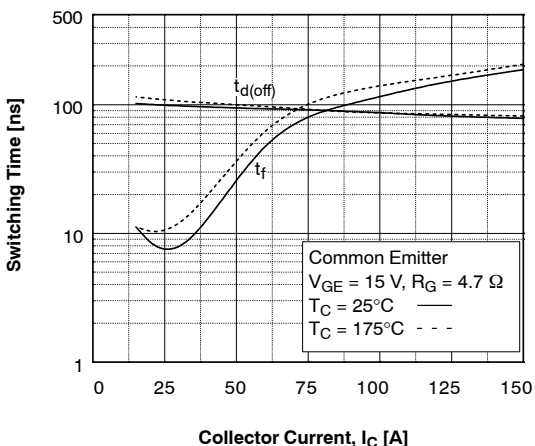


Figure 13. Turn-off Characteristics vs. Collector Current

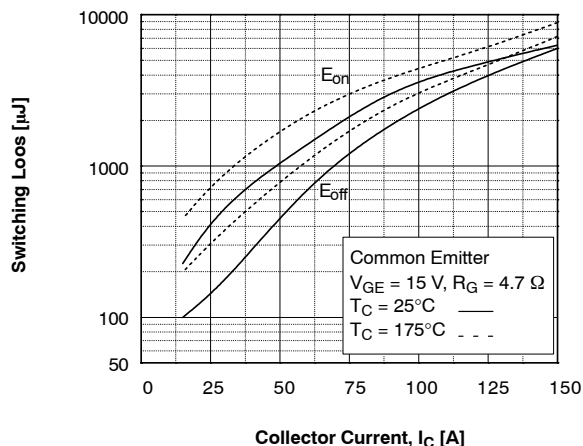


Figure 14. Switching Losses vs. Collector Current

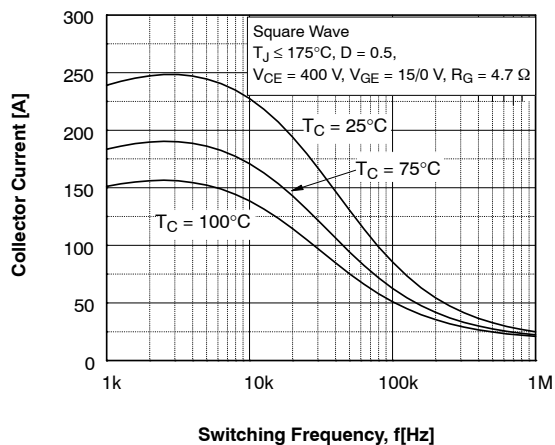


Figure 15. Load Current vs. Frequency

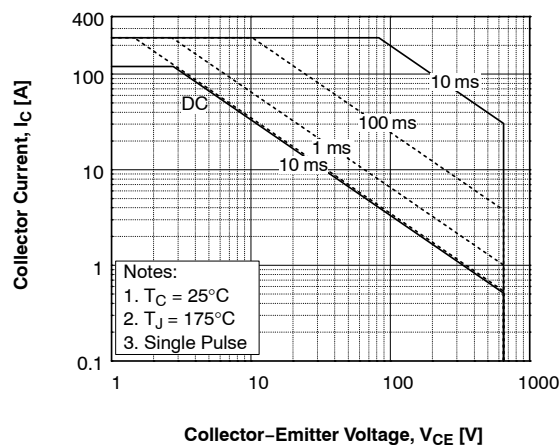


Figure 16. SOA Characteristics

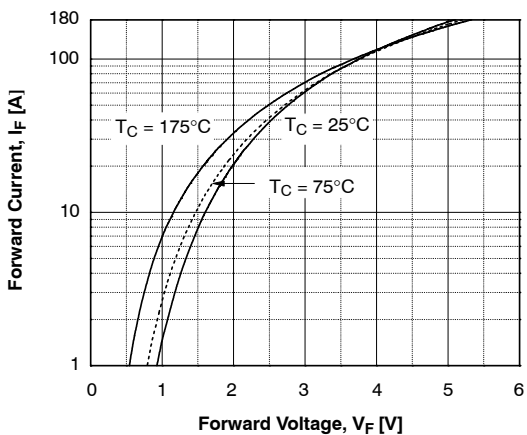


Figure 17. Forward Characteristics

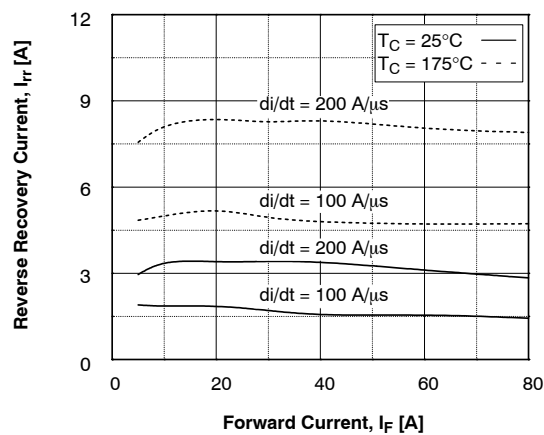


Figure 18. Reverse Recovery Current

# FGH60T65SQD-F155

## TYPICAL CHARACTERISTICS (Continued)

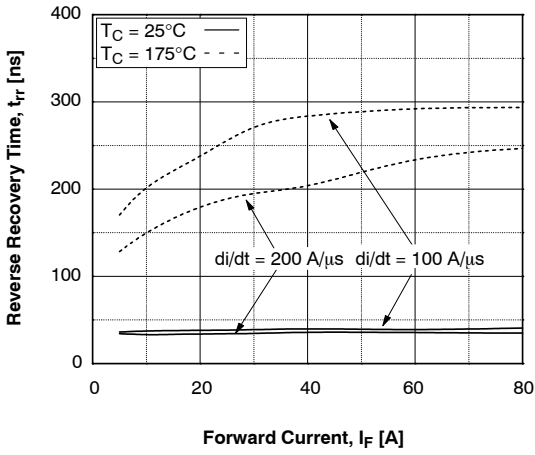


Figure 19. Reverse Recovery Time

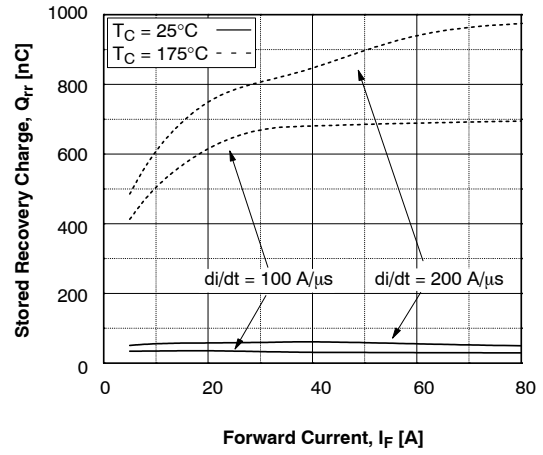


Figure 20. Stored Charge

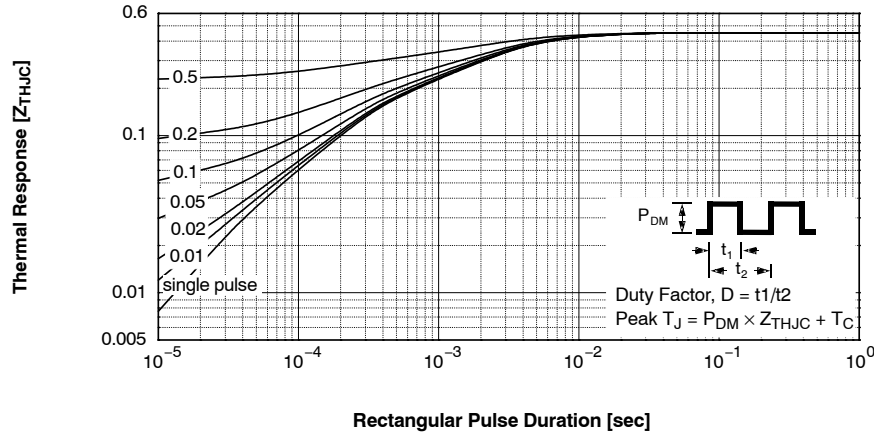


Figure 21. Transient Thermal Impedance of IGBT

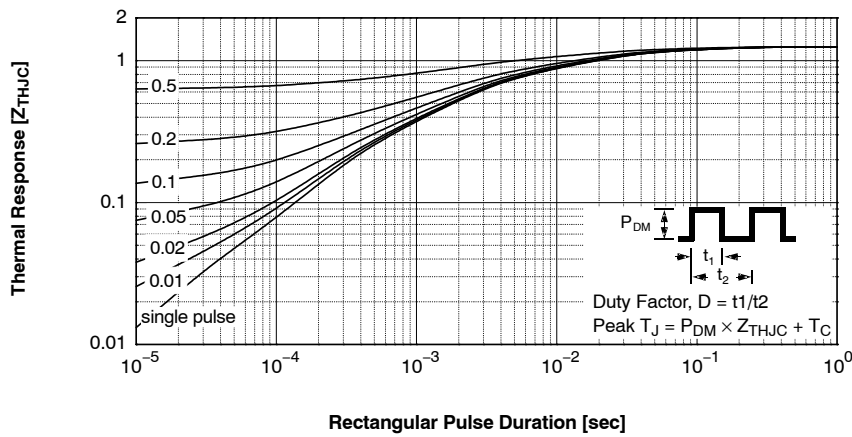


Figure 22. Transient Thermal Impedance of Diode



# MECHANICAL CASE OUTLINE

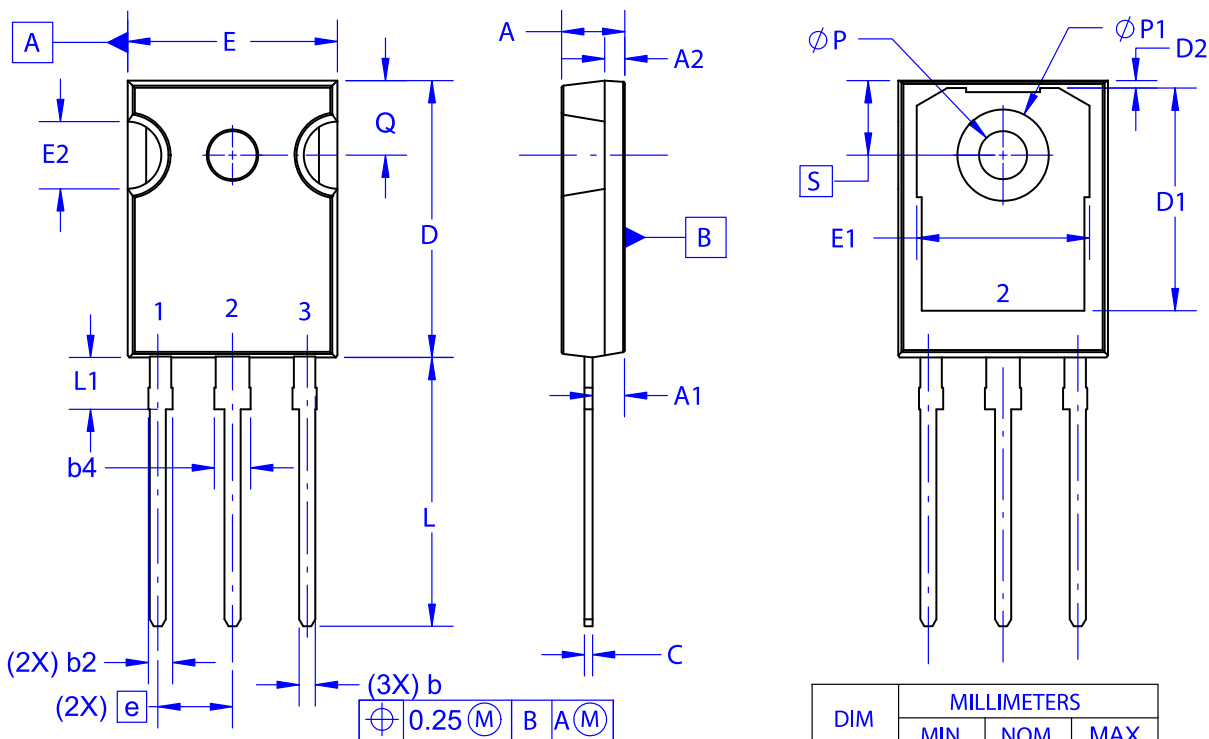
## PACKAGE DIMENSIONS

ON Semiconductor®



TO-247-3LD  
CASE 340CH  
ISSUE A

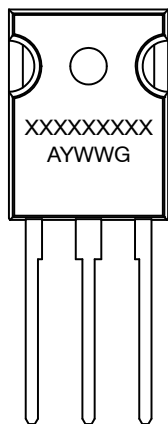
DATE 09 OCT 2019



NOTES: UNLESS OTHERWISE SPECIFIED.

- A. DIMENSIONS ARE EXCLUSIVE OF BURRS, MOLD FLASH, AND TIE BAR EXTRUSIONS.
- B. ALL DIMENSIONS ARE IN MILLIMETERS.
- C. DRAWING CONFORMS TO ASME Y14.5 - 2009.
- D. DIMENSION A1 TO BE MEASURED IN THE REGION DEFINED BY L1.
- E. LEAD FINISH IS UNCONTROLLED IN THE REGION DEFINED BY L1.

### GENERIC MARKING DIAGRAM\*



XXXX = Specific Device Code  
A = Assembly Location  
Y = Year  
WW = Work Week  
G = Pb-Free Package

\*This information is generic. Please refer to device data sheet for actual part marking. Pb-Free indicator, "G" or microdot "•", may or may not be present. Some products may not follow the Generic Marking.

| DIM | MILLIMETERS |       |       |
|-----|-------------|-------|-------|
|     | MIN         | NOM   | MAX   |
| A   | 4.58        | 4.70  | 4.82  |
| A1  | 2.29        | 2.475 | 2.66  |
| A2  | 1.40        | 1.50  | 1.60  |
| D   | 20.32       | 20.57 | 20.82 |
| E   | 15.37       | 15.62 | 15.87 |
| E2  | 4.96        | 5.08  | 5.20  |
| e   | ~           | 5.56  | ~     |
| L   | 19.75       | 20.00 | 20.25 |
| L1  | 3.69        | 3.81  | 3.93  |
| ØP  | 3.51        | 3.58  | 3.65  |
| Q   | 5.34        | 5.46  | 5.58  |
| S   | 5.34        | 5.46  | 5.58  |
| b   | 1.17        | 1.26  | 1.35  |
| b2  | 1.53        | 1.65  | 1.77  |
| b4  | 2.42        | 2.54  | 2.66  |
| c   | 0.51        | 0.61  | 0.71  |
| D1  | 13.08       | ~     | ~     |
| D2  | 0.51        | 0.93  | 1.35  |
| E1  | 12.81       | ~     | ~     |
| ØP1 | 6.61        | 6.73  | 6.85  |

|                  |             |  |
|------------------|-------------|--|
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| DESCRIPTION:     | TO-247-3LD  | PAGE 1 OF 1  |

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