

# IGBT - Field Stop

600 V, 60 A

## FGH60N60SMD

### Description

Using novel field stop IGBT technology, onsemi's new series of field stop 2<sup>nd</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.

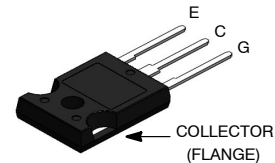
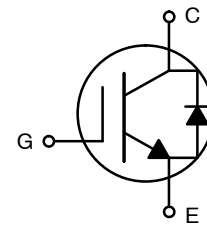
### Features

- Maximum Junction Temperature:  $T_J = 175^{\circ}\text{C}$
- Positive Temperature Co-efficient for easy Parallel Operating
- High Current Capability
- Low Saturation Voltage:  $V_{CE(sat)} = 1.9\text{ V (Typ.) @ } I_C = 60\text{ A}$
- High Input Impedance
- Fast Switching:  $E_{OFF} = 7.5\text{ uJ/A}$
- Tightened Parameter Distribution
- This Device is Pb-Free and is RoHS Compliant

### Applications

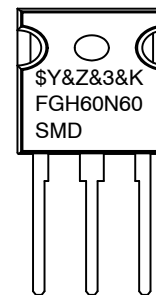
- Solar Inverter, UPS, Welder, PFC, Telecom, ESS

| $V_{CES}$ | $I_C$ |
|-----------|-------|
| 600 V     | 60 A  |



TO-247-3LD  
CASE 340CK

### MARKING DIAGRAM



|             |                        |
|-------------|------------------------|
| \$Y         | = onsemi Logo          |
| &Z          | = Assembly Plant Code  |
| &3          | = Numeric Date Code    |
| &K          | = Lot Code             |
| FGH60N60SMD | = Specific Device Code |

### ORDERING INFORMATION

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

# FGH60N60SMD

## ABSOLUTE MAXIMUM RATINGS

| Symbol            | Description                                                             | Ratings                   | Unit             |
|-------------------|-------------------------------------------------------------------------|---------------------------|------------------|
| $V_{CES}$         | Collector to Emitter Voltage                                            | 600                       | V                |
| $V_{GES}$         | Gate to Emitter Voltage                                                 | $\pm 20$                  | V                |
|                   | Transient Gate to Emitter Voltage                                       | $\pm 30$                  | V                |
| $I_C$             | Collector Current                                                       | $T_C = 25^\circ\text{C}$  | A                |
|                   |                                                                         | $T_C = 100^\circ\text{C}$ | A                |
| $I_{CM}$ (Note 1) | Pulsed Collector Current                                                | 180                       | A                |
| $I_F$             | Diode Forward Current                                                   | $T_C = 25^\circ\text{C}$  | A                |
|                   |                                                                         | $T_C = 100^\circ\text{C}$ | A                |
| $I_{FM}$ (Note 1) | Pulsed Diode Maximum Forward Current                                    | 180                       | A                |
| $P_D$             | Maximum Power Dissipation                                               | $T_C = 25^\circ\text{C}$  | W                |
|                   |                                                                         | $T_C = 100^\circ\text{C}$ | W                |
| $T_J$             | Operating Junction Temperature                                          | -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, 1/8" from Case for 5 Seconds | 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. Repetitive rating: Pulse width limited by max. junction temperature.

## THERMAL CHARACTERISTICS

| Symbol                  | Parameter                               | Typ. | Max. | Unit               |
|-------------------------|-----------------------------------------|------|------|--------------------|
| $R_{\theta JC}$ (IGBT)  | Thermal Resistance, Junction to Case    | –    | 0.25 | $^\circ\text{C/W}$ |
| $R_{\theta JC}$ (Diode) | Thermal Resistance, Junction to Case    | –    | 1.1  | $^\circ\text{C/W}$ |
| $R_{\theta JA}$         | Thermal Resistance, Junction to Ambient | –    | 40   | $^\circ\text{C/W}$ |

## PACKAGE MARKING AND ORDERING INFORMATION

| Part Number | Top Mark    | Package | Packing Method | Reel Size | Tape Width | Qty per Tube |
|-------------|-------------|---------|----------------|-----------|------------|--------------|
| FGH60N60SMD | FGH60N60SMD | TO-247  | Tube           | N/A       | N/A        | 30           |



# FGH60N60SMD

## 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       | $V_{GE} = 0\text{ V}, I_C = 250\text{ }\mu\text{A}$ | 600 | –   | –         | V                   |
| $\Delta BV_{CES} / \Delta T_J$ | Temperature Coefficient of Breakdown Voltage | $V_{GE} = 0\text{ V}, I_C = 250\text{ }\mu\text{A}$ | –   | 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                   | $I_C = 250\text{ }\mu\text{A}, V_{CE} = V_{GE}$                         | 3.5 | 4.5 | 6.0 | V |
| $V_{CE(sat)}$ | Collector to Emitter Saturation Voltage | $I_C = 60\text{ A}, V_{GE} = 15\text{ V},$                              | –   | 1.9 | 2.5 | V |
|               |                                         | $I_C = 60\text{ A}, V_{GE} = 15\text{ V},$<br>$T_C = 175^\circ\text{C}$ | –   | 2.1 | –   | V |

### DYNAMIC CHARACTERISTICS

|           |                              |                                                                    |   |      |   |    |
|-----------|------------------------------|--------------------------------------------------------------------|---|------|---|----|
| $C_{ies}$ | Input Capacitance            | $V_{CE} = 30\text{ V}, V_{GE} = 0\text{ V},$<br>$f = 1\text{ MHz}$ | – | 2915 | – | pF |
| $C_{oes}$ | Output Capacitance           |                                                                    | – | 270  | – | pF |
| $C_{res}$ | Reverse Transfer Capacitance |                                                                    | – | 85   | – | pF |

### SWITCHING CHARACTERISTICS

|              |                          |                                                                                                                                            |   |      |      |    |
|--------------|--------------------------|--------------------------------------------------------------------------------------------------------------------------------------------|---|------|------|----|
| $T_{d(on)}$  | Turn-On Delay Time       | $V_{CC} = 400\text{ V}, I_C = 60\text{ A},$<br>$R_G = 3\text{ }\Omega, V_{GE} = 15\text{ V},$<br>Inductive Load, $T_C = 25^\circ\text{C}$  | – | 18   | 27   | ns |
| $T_r$        | Rise Time                |                                                                                                                                            | – | 47   | 70   | ns |
| $T_{d(off)}$ | Turn-Off Delay Time      |                                                                                                                                            | – | 104  | 146  | ns |
| $T_f$        | Fall Time                |                                                                                                                                            | – | 50   | 68   | ns |
| $E_{on}$     | Turn-On Switching Loss   |                                                                                                                                            | – | 1.26 | 1.94 | mJ |
| $E_{off}$    | Turn-Off Switching Loss  |                                                                                                                                            | – | 0.45 | 0.6  | mJ |
| $E_{ts}$     | Total Switching Loss     |                                                                                                                                            | – | 1.71 | 2.54 | mJ |
| $T_{d(on)}$  | Turn-On Delay Time       | $V_{CC} = 400\text{ V}, I_C = 60\text{ A},$<br>$R_G = 3\text{ }\Omega, V_{GE} = 15\text{ V},$<br>Inductive Load, $T_C = 175^\circ\text{C}$ | – | 18   | –    | ns |
| $T_r$        | Rise Time                |                                                                                                                                            | – | 41   | –    | ns |
| $T_{d(off)}$ | Turn-Off Delay Time      |                                                                                                                                            | – | 115  | –    | ns |
| $T_f$        | Fall Time                |                                                                                                                                            | – | 48   | –    | ns |
| $E_{on}$     | Turn-On Switching Loss   |                                                                                                                                            | – | 2.1  | –    | mJ |
| $E_{off}$    | Turn-Off Switching Loss  |                                                                                                                                            | – | 0.78 | –    | mJ |
| $E_{ts}$     | Total Switching Loss     |                                                                                                                                            | – | 2.88 | –    | mJ |
| $Q_g$        | Total Gate Charge        | $V_{CE} = 400\text{ V}, I_C = 60\text{ A},$<br>$V_{GE} = 15\text{ V}$                                                                      | – | 189  | 284  | nC |
| $Q_{ge}$     | Gate to Emitter Charge   |                                                                                                                                            | – | 20   | 30   | nC |
| $Q_{gc}$     | Gate to Collector Charge |                                                                                                                                            | – | 91   | 137  | 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.



# FGH60N60SMD

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

| Symbol           | Parameter                     | Test Conditions                                          |                        | Min | Typ | Max | Unit |
|------------------|-------------------------------|----------------------------------------------------------|------------------------|-----|-----|-----|------|
| V <sub>FM</sub>  | Diode Forward Voltage         | I <sub>F</sub> = 30 A                                    | T <sub>C</sub> = 25°C  | –   | 2.1 | 2.7 | V    |
|                  |                               |                                                          | T <sub>C</sub> = 175°C | –   | 1.7 | –   |      |
| E <sub>rec</sub> | Reverse Recovery Energy       | I <sub>F</sub> = 30 A,<br>di <sub>F</sub> /dt = 200 A/μs | T <sub>C</sub> = 175°C | –   | 79  | –   | μJ   |
| T <sub>rr</sub>  | Diode Reverse Recovery Time   |                                                          | T <sub>C</sub> = 25°C  | –   | 30  | 39  | ns   |
|                  |                               |                                                          | T <sub>C</sub> = 175°C | –   | 72  | –   |      |
| Q <sub>rr</sub>  | Diode Reverse Recovery Charge |                                                          | T <sub>C</sub> = 25°C  | –   | 44  | 62  | nC   |
|                  |                               |                                                          | T <sub>C</sub> = 175°C | –   | 238 | –   |      |

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

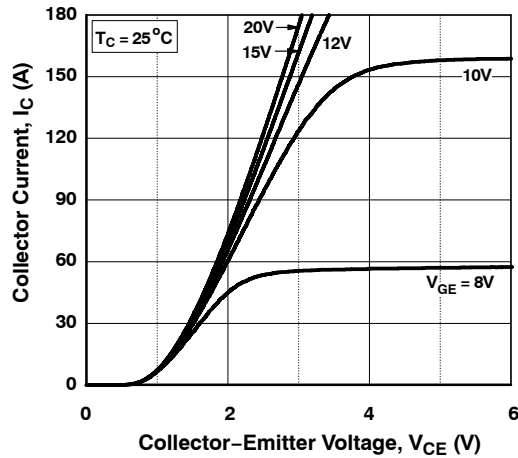


Figure 1. Typical Output Characteristics

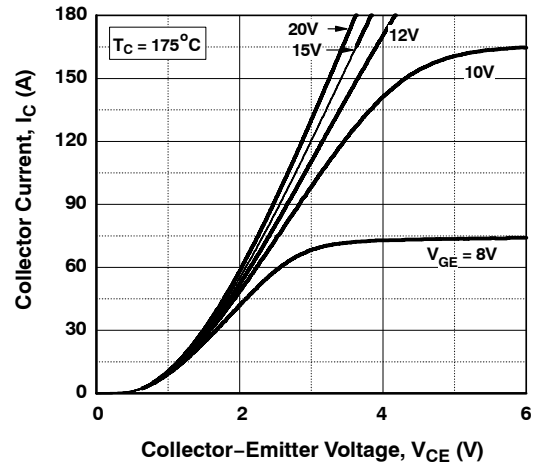


Figure 2. Typical Output Characteristics

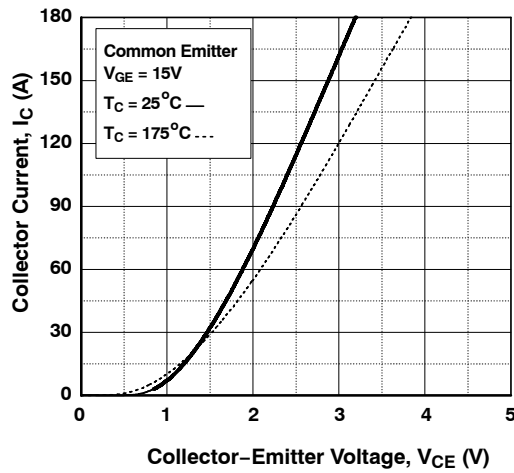


Figure 3. Typical Saturation Voltage Characteristics

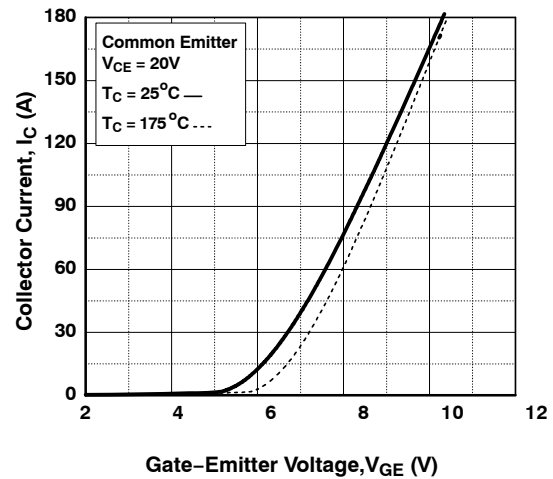


Figure 4. Transfer Characteristics

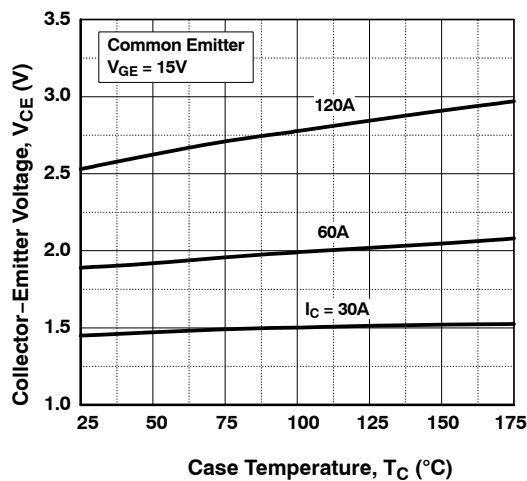


Figure 5. Saturation Voltage vs. Case Temperature at Variant Current Level

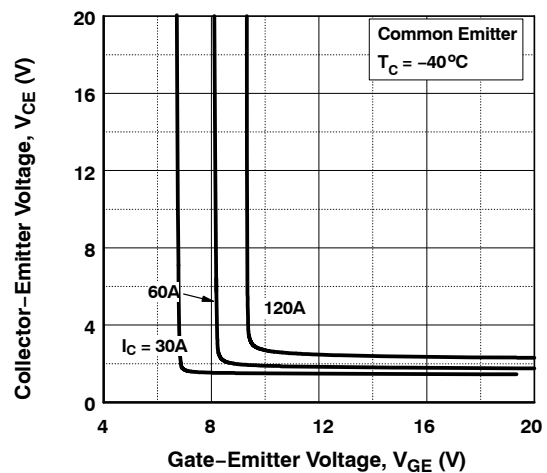


Figure 6. Saturation Voltage vs.  $V_{GE}$

## TYPICAL PERFORMANCE CHARACTERISTICS (Continued)

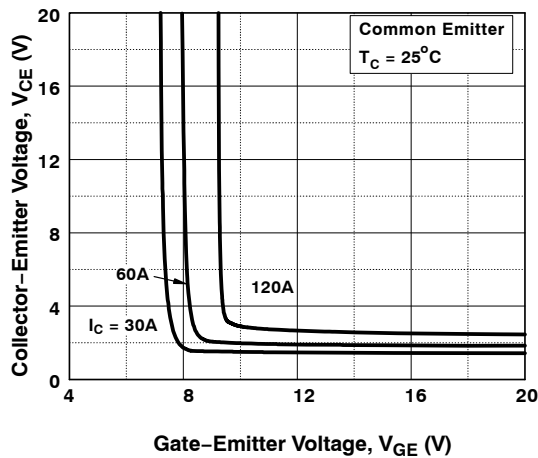


Figure 7. Saturation Voltage vs.  $V_{GE}$

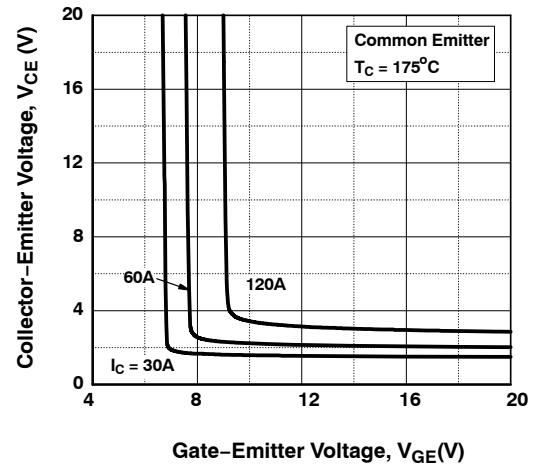


Figure 8. Saturation Voltage vs.  $V_{GE}$

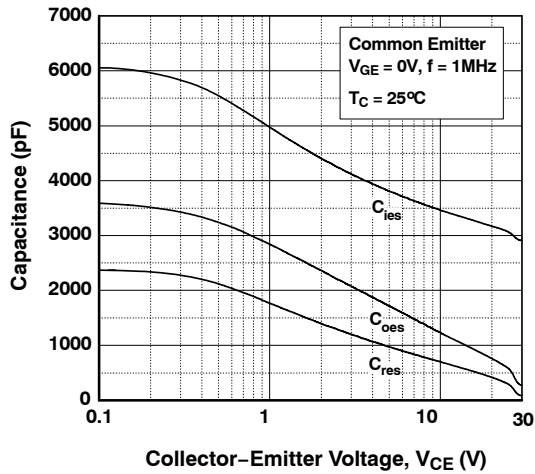


Figure 9. Capacitance Characteristics

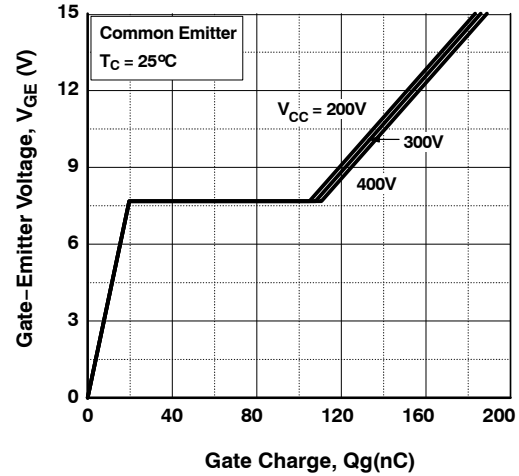


Figure 10. Gate Charge Characteristics

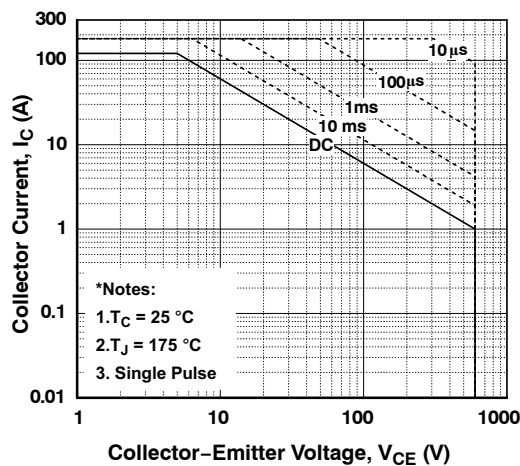


Figure 11. SOA Characteristics

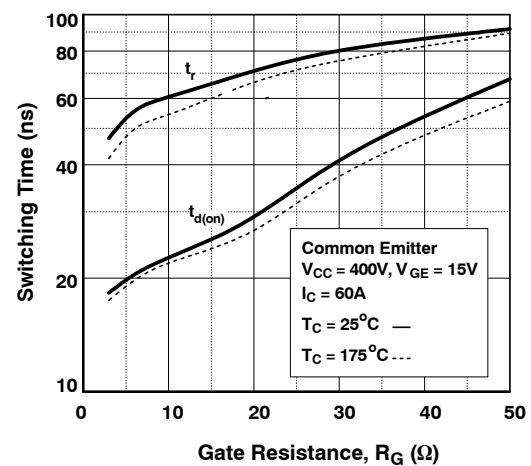


Figure 12. Turn-on Characteristics vs. Gate Resistance

TYPICAL PERFORMANCE CHARACTERISTICS (Continued)

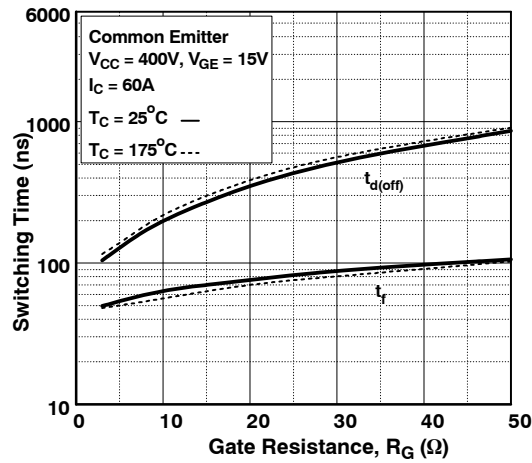


Figure 13. Turn-off Characteristics vs. Gate Resistance

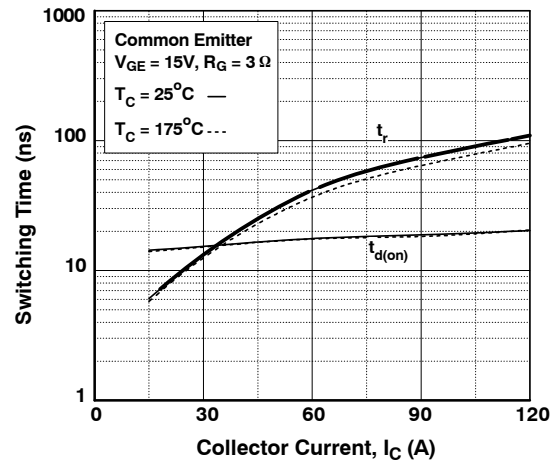


Figure 14. Turn-on Characteristics vs. Collector Current

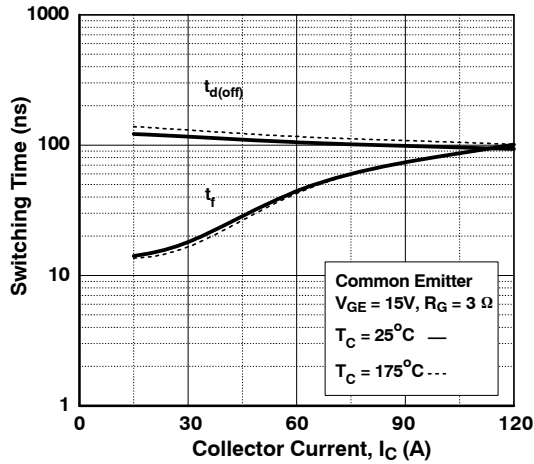


Figure 15. Turn-off Characteristics vs. Collector Current

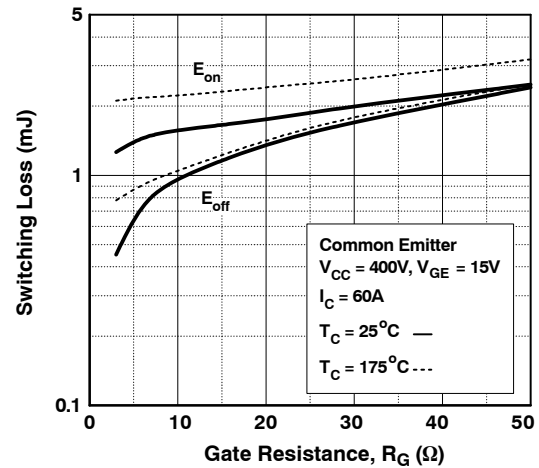


Figure 16. Switching Loss vs. Gate Resistance

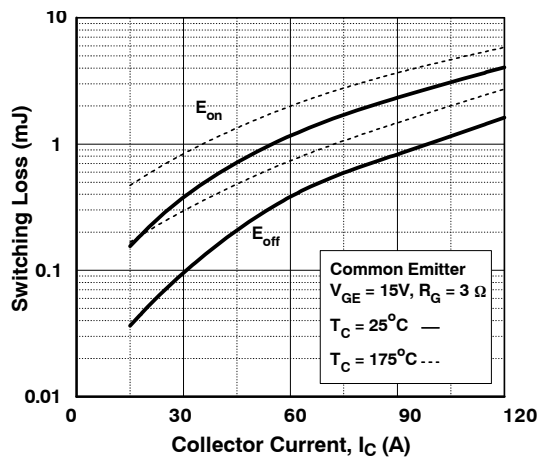


Figure 17. Switching Loss vs. Collector Current

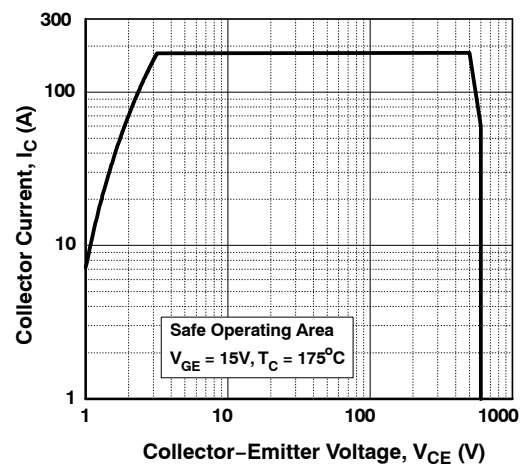


Figure 18. Turn Off Switching SOA Characteristics

TYPICAL PERFORMANCE CHARACTERISTICS (Continued)

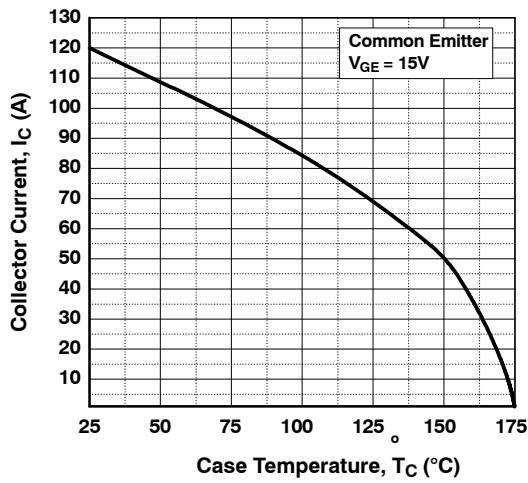


Figure 19. Current Derating

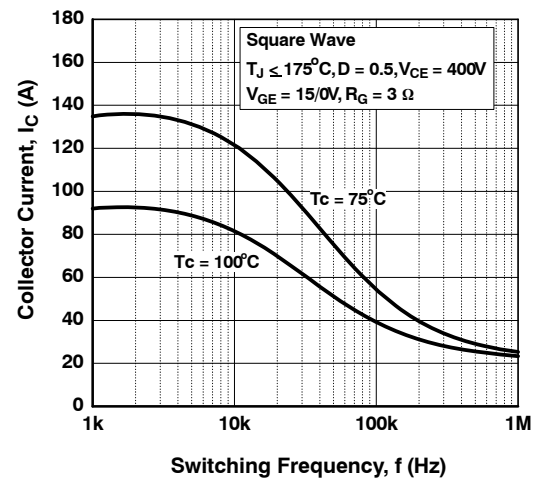


Figure 20. Load Current vs. Frequency

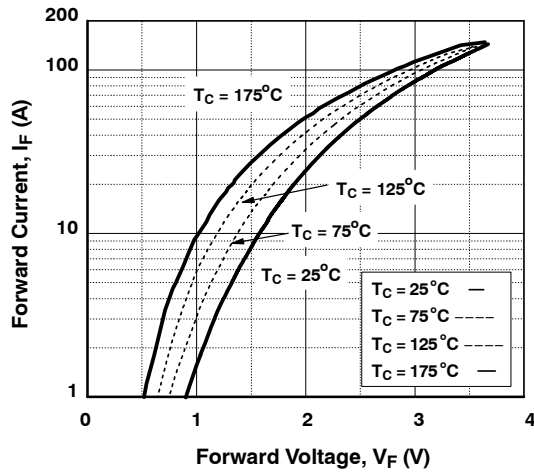


Figure 21. Forward Characteristics

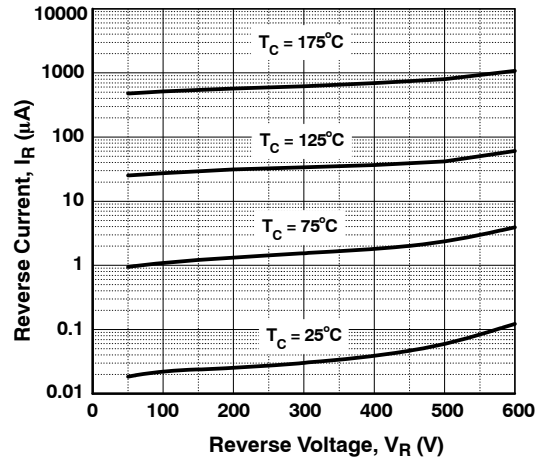


Figure 22. Reverse Current

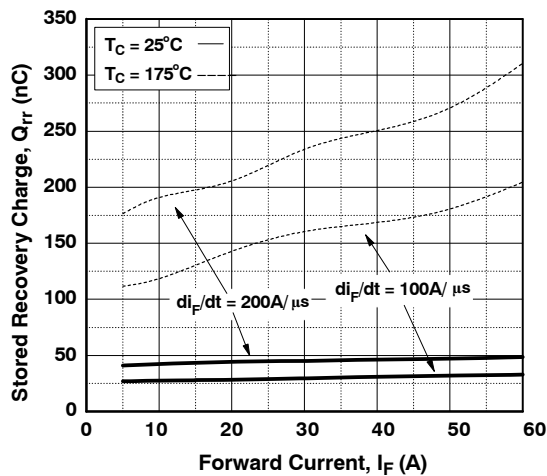


Figure 23. Stored Charge

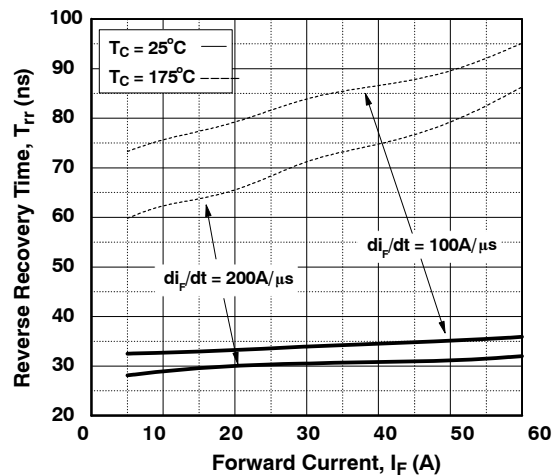


Figure 24. Reverse Recovery Time

FGH60N60SMD

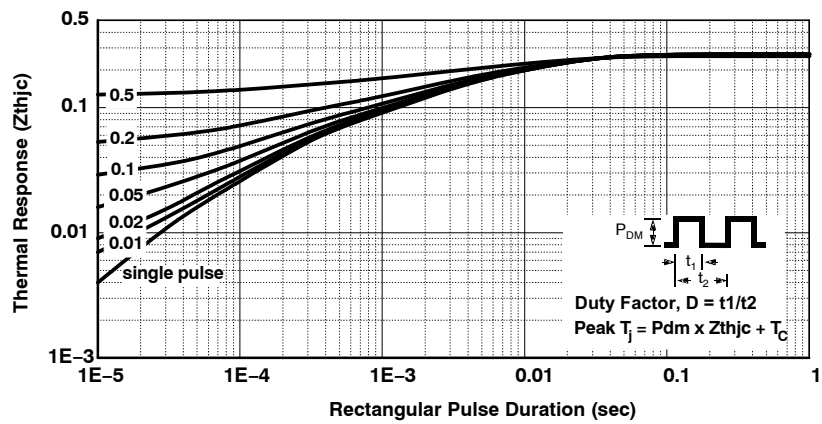


Figure 25. Transient Thermal Impedance of IGBT

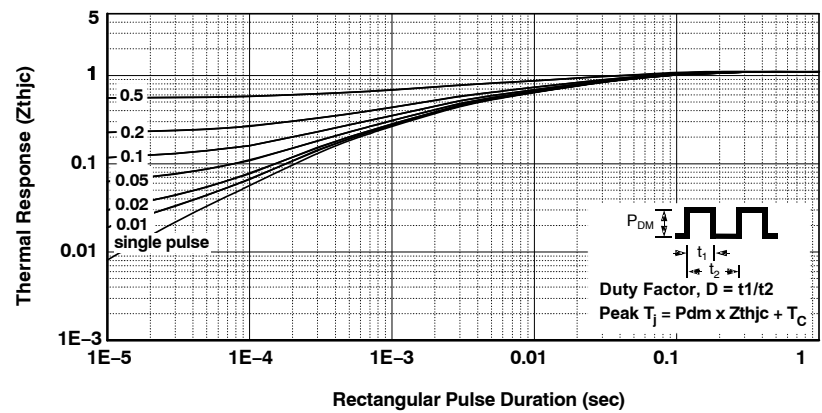
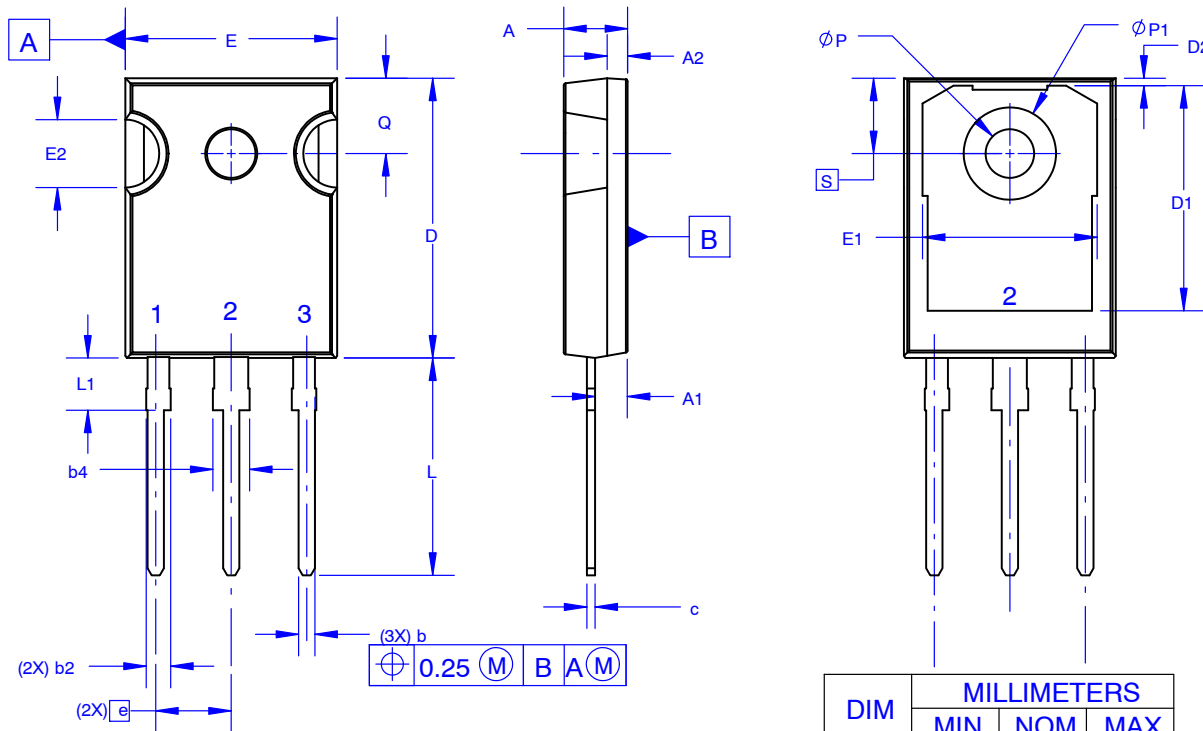


Figure 26. Transient Thermal Impedance of Diode

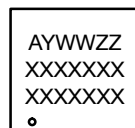
**TO-247-3LD SHORT LEAD**  
**CASE 340CK**  
**ISSUE A**

DATE 31 JAN 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  
ZZ = Assembly Lot Code

\*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        | 2.20        | 2.40  | 2.60  |
| A2        | 1.40        | 1.50  | 1.60  |
| 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  |
| D         | 20.32       | 20.57 | 20.82 |
| D1        | 13.08       | ~     | ~     |
| D2        | 0.51        | 0.93  | 1.35  |
| E         | 15.37       | 15.62 | 15.87 |
| E1        | 12.81       | ~     | ~     |
| E2        | 4.96        | 5.08  | 5.20  |
| e         | ~           | 5.56  | ~     |
| L         | 15.75       | 16.00 | 16.25 |
| L1        | 3.69        | 3.81  | 3.93  |
| $\phi P$  | 3.51        | 3.58  | 3.65  |
| $\phi P1$ | 6.60        | 6.80  | 7.00  |
| Q         | 5.34        | 5.46  | 5.58  |
| S         | 5.34        | 5.46  | 5.58  |

|                         |                              |                                                                                                                                                                                  |
|-------------------------|------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
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