

# IGBT - Field Stop, Trench

## 650 V, 50 A

### Product Preview

## FGHL50T65SQDT

Using novel field stop IGBT technology, ON Semiconductor's new series of field stop 4th 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:  $V_{CE(Sat)} = 1.47\text{ V (Typ.) @ } I_C = 50\text{ A}$
- 100% of the Parts tested for  $I_{LM}(1)$
- High Input Impedance
- Fast Switching
- Tighten Parameter Distribution
- This Device is Pb-Free and is RoHS Compliant

#### Typical Applications

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

Table 1. MAXIMUM RATING

| Symbol         | Rating                                                                                  | Value                | Unit               |
|----------------|-----------------------------------------------------------------------------------------|----------------------|--------------------|
| $V_{CES}$      | Collector to Emitter Voltage                                                            | 650                  | V                  |
| $V_{GES}$      | Gate to Emitter Voltage<br>Transient Gate to Emitter Voltage                            | $\pm 20$<br>$\pm 30$ | V                  |
| $I_C$          | Collector Current<br>@ $T_C = 25^{\circ}\text{C}$<br>@ $T_C = 100^{\circ}\text{C}$      | 100<br>50            | A                  |
| $I_{LM}$       | Pulsed Collector Current (Note 1)                                                       | 200                  | A                  |
| $I_{CM}$       | Pulsed Collector Current (Note 2)                                                       | 200                  | A                  |
| $I_F$          | Diode Forward Current<br>@ $T_C = 25^{\circ}\text{C}$<br>@ $T_C = 100^{\circ}\text{C}$  | 75<br>50             | A                  |
| $I_{FM}$       | Pulsed Diode Maximum Forward Current                                                    | 300                  | A                  |
| $P_D$          | Maximum Power Dissipation @ $T_C = 25^{\circ}\text{C}$<br>@ $T_C = 100^{\circ}\text{C}$ | 268<br>134           | W                  |
| $T_J, T_{STG}$ | Operating Junction / Storage Temperature Range                                          | $-55$ to $+175$      | $^{\circ}\text{C}$ |
| $T_L$          | Maximum Lead Temp. for Soldering<br>Purposes, 1/8" from case for 5 seconds              | 265                  | $^{\circ}\text{C}$ |

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.  $V_{CC} = 400\text{ V}$ ,  $V_{GE} = 15\text{ V}$ ,  $I_C = 200\text{ A}$ ,  $R_G = 3\ \Omega$ , Inductive Load, 100% Tested
2. Repetitive rating: pulse width limited by max. Junction temperature

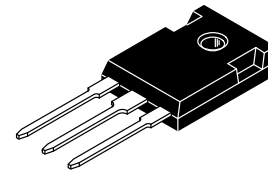
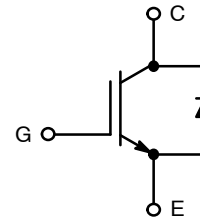
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50 A, 650 V  
 $V_{CE(Sat)} = 1.47\text{ V (Typ.)}$



TO-247-3LD  
CASE 340CX

#### MARKING DIAGRAM



FGHL50T65SQDT = Specific Device Code  
A = Assembly Location  
Y = Year  
WW = Work Week  
ZZ = Assembly Lot Number

#### ORDERING INFORMATION

| Device        | Package   | Shipping        |
|---------------|-----------|-----------------|
| FGHL50T65SQDT | TO-247-3L | 30 Units / Rail |

# FGHL50T65SQDT

## THERMAL CHARACTERISTICS

| Symbol          | Rating                                              | Value | Unit |
|-----------------|-----------------------------------------------------|-------|------|
| $R_{\theta JC}$ | Thermal Resistance, Junction to Case, for IGBT      | 0.56  | °C/W |
| $R_{\theta JC}$ | Thermal Resistance, Junction to Case, Max for Diode | 0.65  | °C/W |
| $R_{\theta JA}$ | Thermal Resistance, Junction to Ambient, Max        | 40    | °C/W |

## ELECTRICAL CHARACTERISTICS ( $T_J = 25^\circ\text{C}$ unless otherwise noted)

| Symbol | Parameter | Test Condition | Min | Typ | Max | Unit |
|--------|-----------|----------------|-----|-----|-----|------|
|--------|-----------|----------------|-----|-----|-----|------|

### OFF CHARACTERISTICS

|                                      |                                                                   |                                          |     |     |      |      |
|--------------------------------------|-------------------------------------------------------------------|------------------------------------------|-----|-----|------|------|
| $BV_{CES}$                           | Collector-emitter breakdown voltage, gate-emitter short-circuited | $V_{GE} = 0\text{ V}, I_C = 1\text{ mA}$ | 650 | –   | –    | V    |
| $\frac{\Delta BV_{CES}}{\Delta T_J}$ | Temperature Coefficient of Breakdown Voltage                      | $V_{GE} = 0\text{ V}, I_C = 1\text{ mA}$ | –   | 0.6 | –    | V/°C |
| $I_{CES}$                            | Collector-emitter cut-off current, gate-emitter short-circuited   | $V_{GE} = 0\text{ V}, V_{CE} = V_{CES}$  | –   | –   | 250  | μA   |
| $I_{GES}$                            | Gate leakage current, collector-emitter short-circuited           | $V_{GE} = V_{GES}, V_{CE} = 0\text{ V}$  | –   | –   | ±400 | nA   |

### ON CHARACTERISTICS

|               |                                      |                                                                                                                 |        |             |          |   |
|---------------|--------------------------------------|-----------------------------------------------------------------------------------------------------------------|--------|-------------|----------|---|
| $V_{GE(th)}$  | Gate-emitter threshold voltage       | $V_{GE} = V_{CE}, I_C = 50\text{ mA}$                                                                           | 2.6    | 4.5         | 6.4      | V |
| $V_{CE(sat)}$ | Collector-emitter saturation voltage | $V_{GE} = 15\text{ V}, I_C = 50\text{ A}$<br>$V_{GE} = 15\text{ V}, I_C = 50\text{ A}, T_c = 175^\circ\text{C}$ | –<br>– | 1.47<br>1.7 | 2.1<br>– | V |

### DYNAMIC CHARACTERISTICS

|           |                              |                                                               |   |      |   |    |
|-----------|------------------------------|---------------------------------------------------------------|---|------|---|----|
| $C_{ies}$ | Input capacitance            | $V_{CE} = 30\text{ V}, V_{GE} = 0\text{ V}, f = 1\text{ MHz}$ | – | 3081 | – | pF |
| $C_{oes}$ | Output capacitance           |                                                               | – | 136  | – |    |
| $C_{res}$ | Reverse transfer capacitance |                                                               | – | 10.8 | – |    |

### SWITCHING CHARACTERISTICS, INDUCTIVE LOAD

|              |                         |                                                                                                                                             |   |        |   |    |
|--------------|-------------------------|---------------------------------------------------------------------------------------------------------------------------------------------|---|--------|---|----|
| $t_{d(on)}$  | Turn-on delay time      | $T_C = 25^\circ\text{C}$<br>$V_{CC} = 400\text{ V}, I_C = 12.5\text{ A}$<br>$R_g = 4.7\ \Omega$<br>$V_{GE} = 15\text{ V}$<br>Inductive Load | – | 22.8   | – | ns |
| $t_r$        | Rise time               |                                                                                                                                             | – | 5.20   | – |    |
| $t_{d(off)}$ | Turn-off delay time     |                                                                                                                                             | – | 70     | – |    |
| $t_f$        | Fall time               |                                                                                                                                             | – | 27.20  | – |    |
| $E_{on}$     | Turn-on switching loss  |                                                                                                                                             | – | 223    | – | μJ |
| $E_{off}$    | Turn-off switching loss |                                                                                                                                             | – | 91.13  | – |    |
| $E_{ts}$     | Total switching loss    |                                                                                                                                             | – | 314.13 | – |    |
| $t_{d(on)}$  | Turn-on delay time      | $T_C = 25^\circ\text{C}$<br>$V_{CC} = 400\text{ V}, I_C = 25\text{ A}$<br>$R_g = 4.7\ \Omega$<br>$V_{GE} = 15\text{ V}$<br>Inductive Load   | – | 23.60  | – | ns |
| $t_r$        | Rise time               |                                                                                                                                             | – | 10.40  | – |    |
| $t_{d(off)}$ | Turn-off delay time     |                                                                                                                                             | – | 66.40  | – |    |
| $t_f$        | Fall time               |                                                                                                                                             | – | 10.20  | – |    |
| $E_{on}$     | Turn-on switching loss  |                                                                                                                                             | – | 515.60 | – | μJ |
| $E_{off}$    | Turn-off switching loss |                                                                                                                                             | – | 133    | – |    |
| $E_{ts}$     | Total switching loss    |                                                                                                                                             | – | 648.60 | – |    |

# FGHL50T65SQDT

## ELECTRICAL CHARACTERISTICS (T<sub>J</sub> = 25°C unless otherwise noted) (continued)

| Symbol                                           | Parameter                | Test Condition                                                                                                                                   | Min | Typ    | Max | Unit |
|--------------------------------------------------|--------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------|-----|--------|-----|------|
| <b>SWITCHING CHARACTERISTICS, INDUCTIVE LOAD</b> |                          |                                                                                                                                                  |     |        |     |      |
| t <sub>d(on)</sub>                               | Turn-on delay time       | T <sub>C</sub> = 175°C<br>V <sub>CC</sub> = 400 V, I <sub>C</sub> = 12.5 A<br>R <sub>g</sub> = 4.7 Ω<br>V <sub>GE</sub> = 15 V<br>Inductive Load | –   | 23.60  | –   | ns   |
| t <sub>r</sub>                                   | Rise time                |                                                                                                                                                  | –   | 7.20   | –   |      |
| t <sub>d(off)</sub>                              | Turn-off delay time      |                                                                                                                                                  | –   | 87     | –   |      |
| t <sub>f</sub>                                   | Fall time                |                                                                                                                                                  | –   | 72     | –   |      |
| E <sub>on</sub>                                  | Turn-on switching loss   |                                                                                                                                                  | –   | 259.20 | –   | μJ   |
| E <sub>off</sub>                                 | Turn-off switching loss  |                                                                                                                                                  | –   | 221    | –   |      |
| E <sub>ts</sub>                                  | Total switching loss     |                                                                                                                                                  | –   | 480.20 | –   |      |
| t <sub>d(on)</sub>                               | Turn-on delay time       | T <sub>C</sub> = 175°C<br>V <sub>CC</sub> = 400 V, I <sub>C</sub> = 25 A<br>R <sub>g</sub> = 4.7 Ω<br>V <sub>GE</sub> = 15 V<br>Inductive Load   | –   | 25.60  | –   | ns   |
| t <sub>r</sub>                                   | Rise time                |                                                                                                                                                  | –   | 14.80  | –   |      |
| t <sub>d(off)</sub>                              | Turn-off delay time      |                                                                                                                                                  | –   | 78     | –   |      |
| t <sub>f</sub>                                   | Fall time                |                                                                                                                                                  | –   | 42     | –   |      |
| E <sub>on</sub>                                  | Turn-on switching loss   |                                                                                                                                                  | –   | 578.90 | –   | μJ   |
| E <sub>off</sub>                                 | Turn-off switching loss  |                                                                                                                                                  | –   | 406.80 | –   |      |
| E <sub>ts</sub>                                  | Total switching loss     |                                                                                                                                                  | –   | 985.70 | –   |      |
| Q <sub>g</sub>                                   | Total Gate Charge        | V <sub>CE</sub> = 400 V, I <sub>C</sub> = 50 A,<br>V <sub>GE</sub> = 15 V                                                                        | –   | 99.7   | –   | nC   |
| Q <sub>ge</sub>                                  | Gate to Emitter Charge   |                                                                                                                                                  | –   | 18.3   | –   | nC   |
| Q <sub>gc</sub>                                  | Gate to collector Charge |                                                                                                                                                  | –   | 25.90  | –   | nC   |

## DIODE CHARACTERISTICS

|                  |                               |                                                                                                                                           |        |                  |          |    |
|------------------|-------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------|--------|------------------|----------|----|
| V <sub>F</sub>   | Forward voltage               | I <sub>F</sub> = 50 A, T <sub>C</sub> = 25°C<br>I <sub>F</sub> = 50 A, T <sub>C</sub> = 175°C                                             | –<br>– | 2<br>1.6         | 2.6<br>– | V  |
| E <sub>rec</sub> | Reverse Recovery Energy       | I <sub>F</sub> = 50 A, dI <sub>F</sub> /dt = 200 A/μs,<br>T <sub>C</sub> = 175°C                                                          | –      | 80.14            | –        | μJ |
| T <sub>rr</sub>  | Diode Reverse Recovery Time   | I <sub>F</sub> = 50 A, dI <sub>F</sub> /dt = 200 A/μs<br>I <sub>F</sub> = 50 A, dI <sub>F</sub> /dt = 200 A/μs,<br>T <sub>C</sub> = 175°C | –      | 35.60<br>201     | –        | nS |
| Q <sub>rr</sub>  | Diode Reverse Recovery Charge | I <sub>F</sub> = 50 A, dI <sub>F</sub> /dt = 200 A/μs<br>I <sub>F</sub> = 50 A, dI <sub>F</sub> /dt = 200 A/μs,<br>T <sub>C</sub> = 175°C | –      | 66.22<br>1135.65 | –        | 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 CHARACTERISTICS

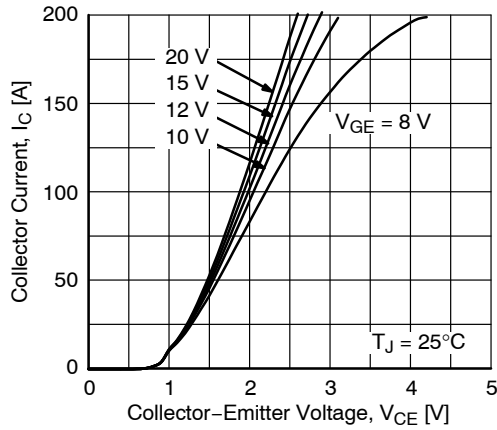


Figure 1. Typical Output Characteristics  
( $T_J = 25^\circ\text{C}$ )

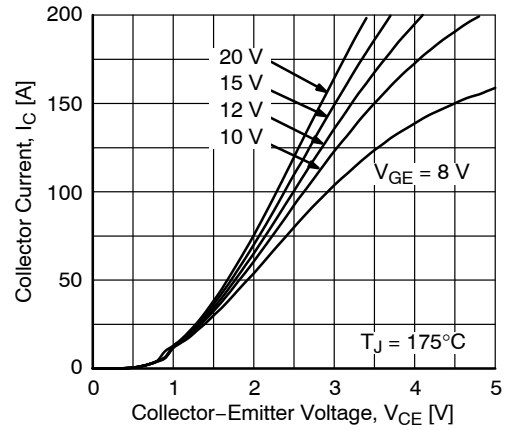


Figure 2. Typical Output Characteristics  
( $T_J = 175^\circ\text{C}$ )

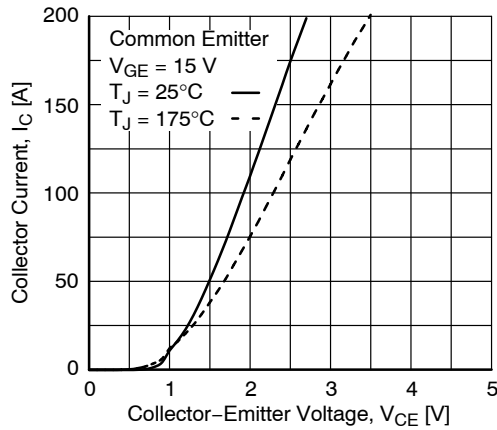


Figure 3. Typical Saturation Voltage  
Characteristics

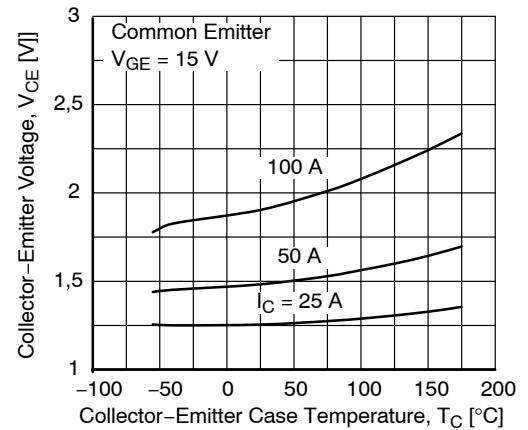


Figure 4. Saturation Voltage vs. Case  
Temperature at Variant Current Level

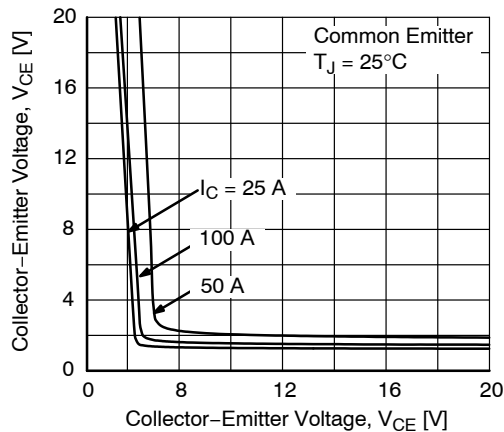


Figure 5. Saturation Voltage vs.  $V_{GE}$   
( $T_J = 25^\circ\text{C}$ )

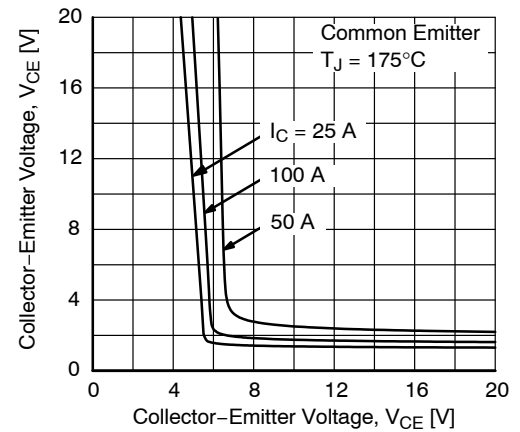


Figure 6. Saturation Voltage vs.  $V_{GE}$   
( $T_J = 175^\circ\text{C}$ )

TYPICAL CHARACTERISTICS (continued)

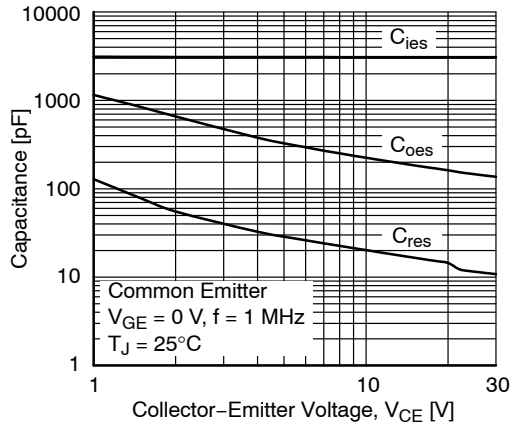


Figure 7. Capacitance Characteristics

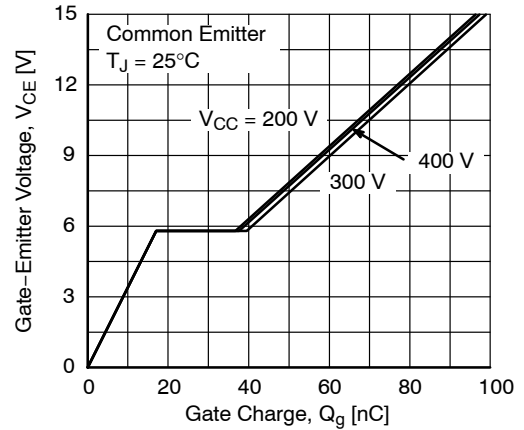


Figure 8. Gate Charge Characteristic

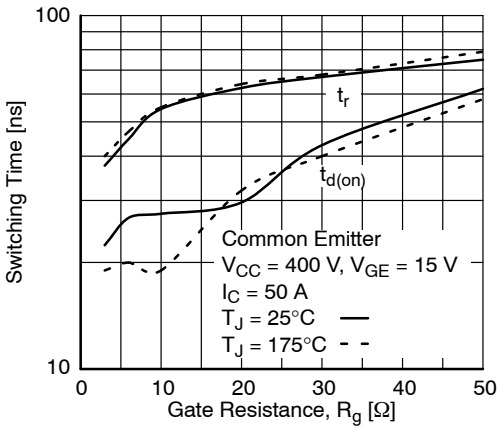


Figure 9. Turn-on Characteristics vs. Gate Resistance

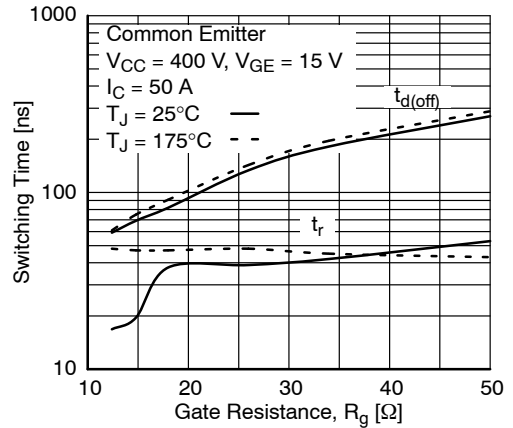


Figure 10. Turn-Off Characteristics vs. Gate Resistance

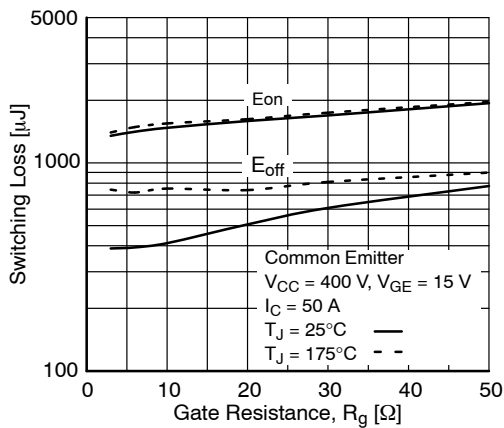


Figure 11. Switching Loss vs Gate Resistance

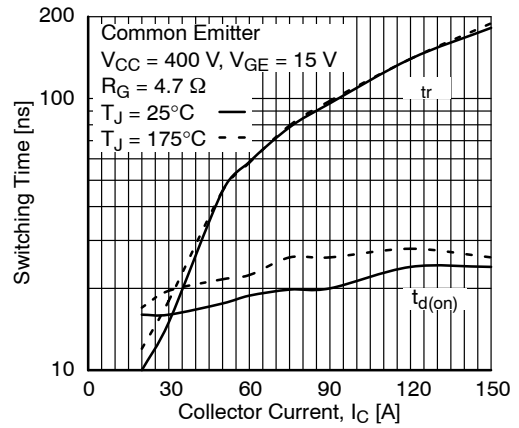


Figure 12. Turn-On Characteristics vs. Collector Current

TYPICAL CHARACTERISTICS (continued)

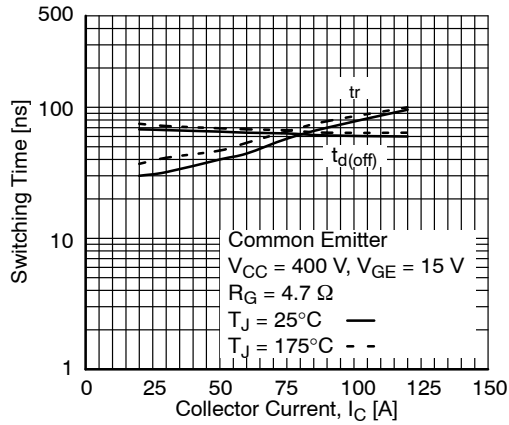


Figure 13. Turn-Off Characteristics vs. Collector Current

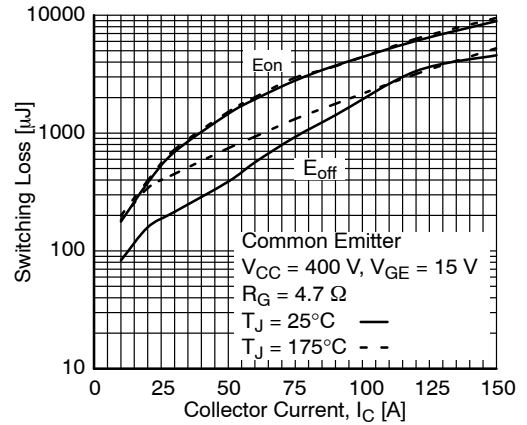


Figure 14. Switching Loss vs. Collector Current

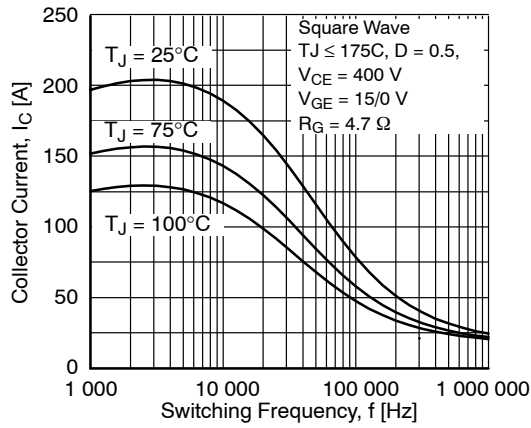


Figure 15. Load Current vs. Frequency

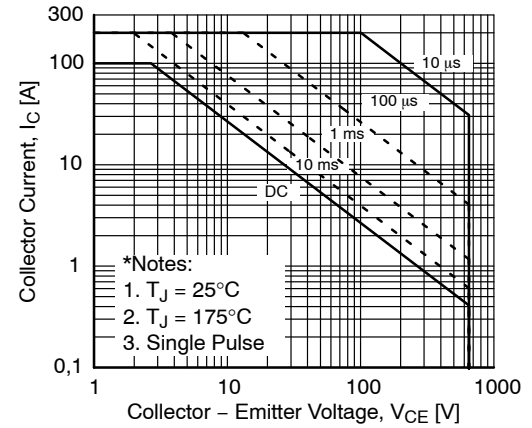


Figure 16. SOA Characteristics (FBSOA)

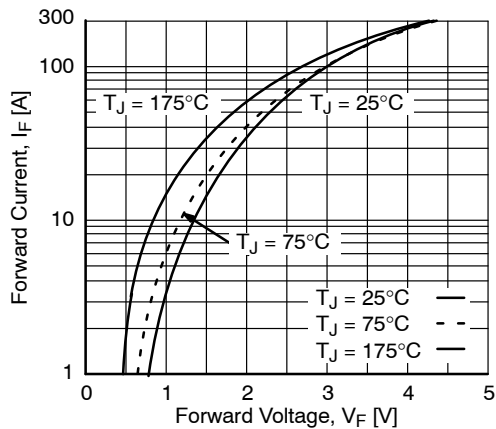


Figure 17. Forward Characteristics

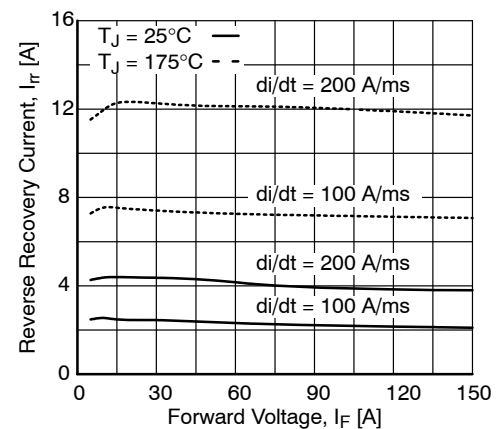


Figure 18. Reverse Recover Current

TYPICAL CHARACTERISTICS (continued)

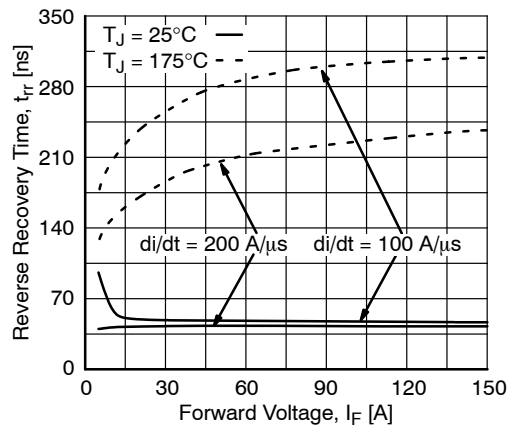


Figure 19. Reverse Recovery Time

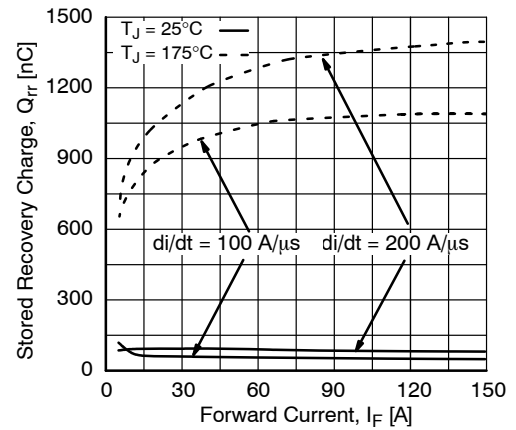


Figure 20. Stored Charge

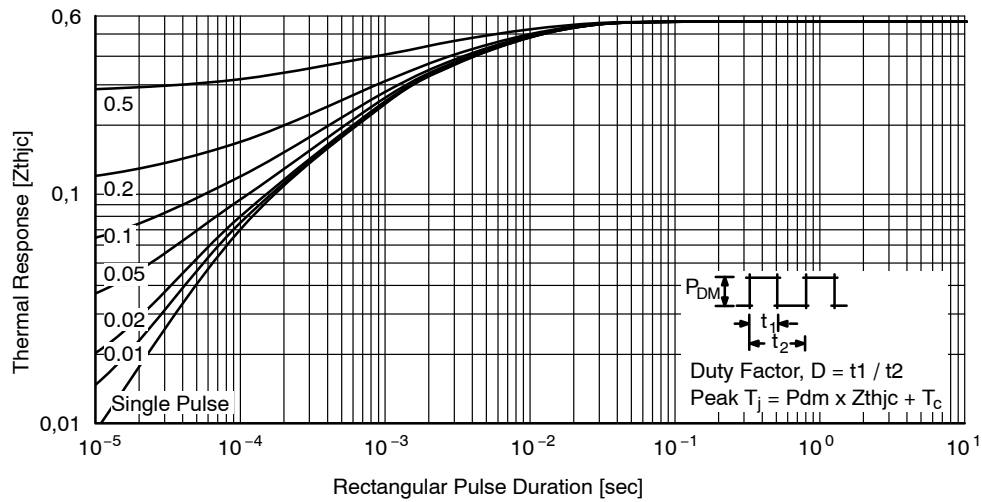


Figure 21. Transient Thermal Impedance of IGBT

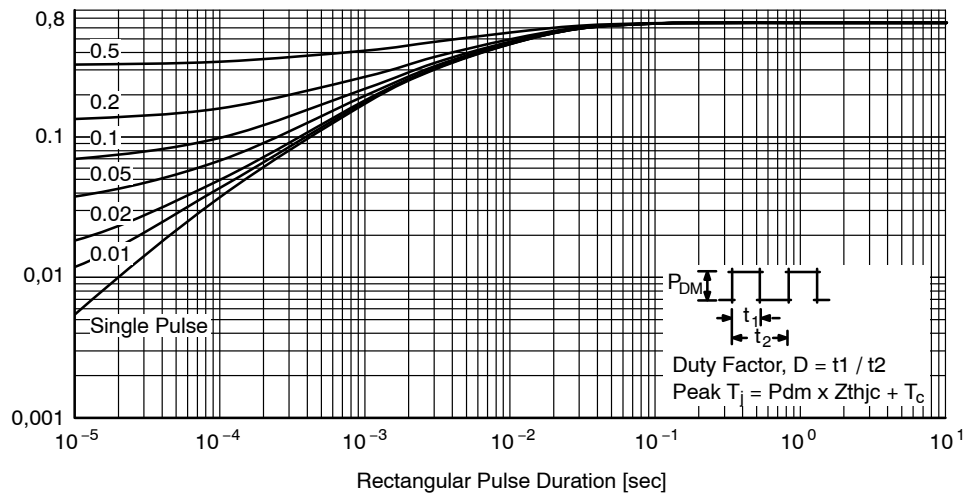
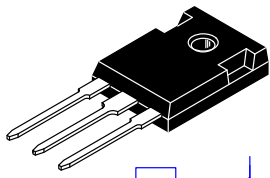


Figure 22. Transient Thermal Impedance of Diode

# MECHANICAL CASE OUTLINE

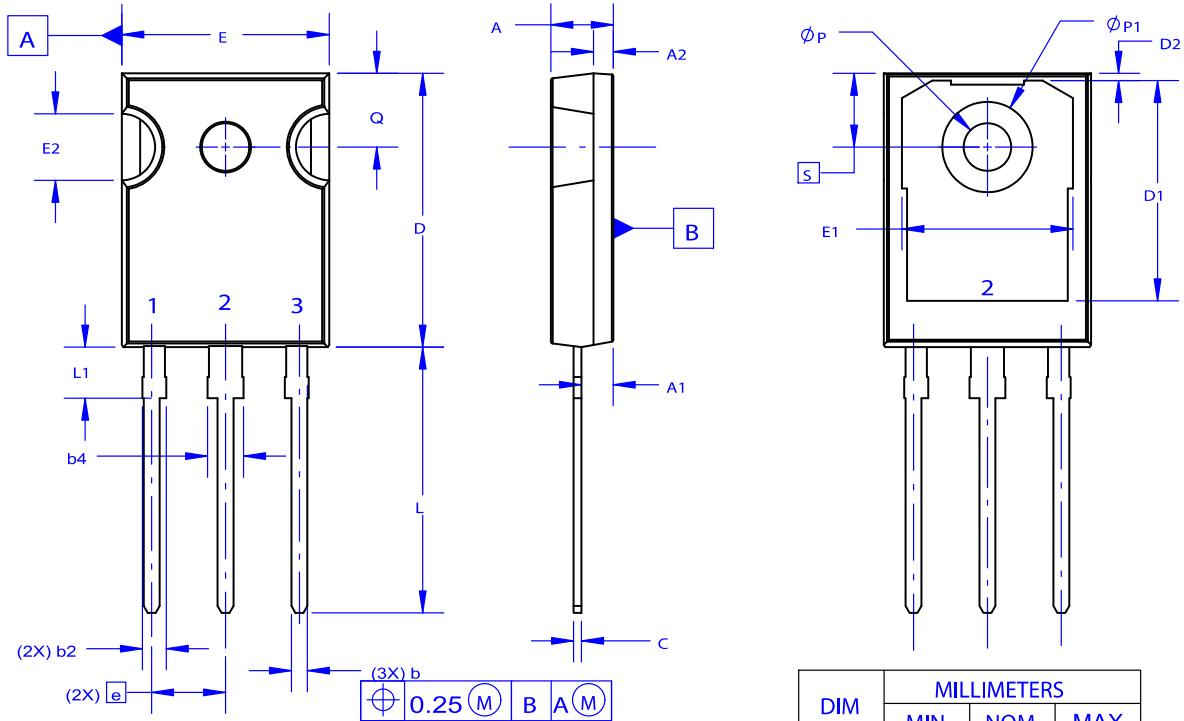
## PACKAGE DIMENSIONS

ON Semiconductor®



**TO-247-3LD**  
**CASE 340CX**  
**ISSUE O**

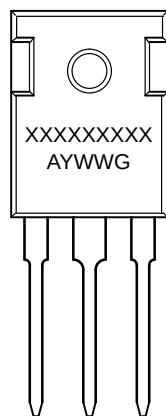
DATE 27 JUN 2018



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\*



XXXXXX = 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.

|                  |             |                                                                                                                                                                                  |
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