

# FGHL40S65UQ

## Product Preview

### Field Stop Trench IGBT 40 A, 650 V

Using the novel field stop generation IGBT technology, ON Semiconductor's new series of field stop 4<sup>th</sup> generation of RC IGBTs offer superior conduction and switching performance and easy parallel operation. This device is well suited for the resonant or soft switching application such as induction heating and microwave oven.

#### Features

- Maximum Junction Temperature:  $T_J = 175^{\circ}\text{C}$
- Positive Temperature Co-efficient for Easy Parallel Operating
- High Current Capability
- Low Saturation Voltage:  $V_{CE(sat)} = 1.36\text{ V (Typ.)}$  @  $I_C = 40\text{ A}$
- 100% of the Parts tested for  $I_{LM}$  (Note 1)
- High Input Impedance
- Fast Switching
- Tighten Parameter Distribution
- RoHS Compliant
- IGBT with Monolithic Reverse Conducting Diode

#### Typical Applications

- Induction Heating
- Microwave Oven
- Soft Switching Application

#### MAXIMUM RATINGS

| Rating                                                                                     | Symbol         | Value                | Unit               |
|--------------------------------------------------------------------------------------------|----------------|----------------------|--------------------|
| Collector to Emitter Voltage                                                               | $V_{CES}$      | 650                  | V                  |
| Gate to Emitter Voltage<br>Transient Gate to Emitter Voltage                               | $V_{GES}$      | $\pm 20$<br>$\pm 30$ | V                  |
| Collector Current @ $T_C = 25^{\circ}\text{C}$<br>@ $T_C = 100^{\circ}\text{C}$            | $I_C$          | 80<br>40             | A                  |
| Pulsed Collector Current (Note 1)                                                          | $I_{LM}$       | 120                  | A                  |
| Pulsed Collector Current (Note 2)                                                          | $I_{CM}$       | 120                  | A                  |
| Diode Forward Current @ $T_C = 25^{\circ}\text{C}$<br>@ $T_C = 100^{\circ}\text{C}$        | $I_F$          | 40<br>20             | A                  |
| Pulsed Diode Maximum Forward Current                                                       | $I_{FM}$       | 120                  | A                  |
| Maximum Power Dissipation<br>@ $T_C = 25^{\circ}\text{C}$<br>@ $T_C = 100^{\circ}\text{C}$ | $P_D$          | 231<br>115           | W                  |
| Operating Junction<br>/ Storage Temperature Range                                          | $T_J, T_{STG}$ | $-55$ to<br>$+175$   | $^{\circ}\text{C}$ |
| Maximum Lead Temp. for Soldering<br>Purposes, 1/8" from case for 5 seconds                 | $T_L$          | 260                  | $^{\circ}\text{C}$ |

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.

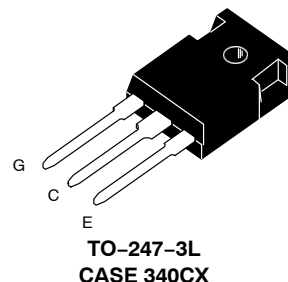
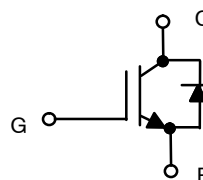
1.  $V_{CC} = 400\text{ V}$ ,  $V_{GE} = 15\text{ V}$ ,  $I_C = 120\text{ A}$ ,  $R_G = 7\ \Omega$ , Inductive Load, 100% Tested.
2. Repetitive rating; pulse width limited by max. Junction temperature.



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40 A, 650 V  
 $V_{CE(sat)} = 1.36\text{ V (Typ.)}$



#### MARKING DIAGRAM



&Y = ON Semiconductor Logo  
&Z = Assembly Plant Code  
&3 = 3-Digit Data Code  
&K = 2-Digit Lot Traceability Code  
FGHL40S65UQ = Specific Device Code

#### ORDERING INFORMATION

| Device      | Package   | Shipping        |
|-------------|-----------|-----------------|
| FGHL40S65UQ | TO-247-3L | 30 Units / Rail |

This document contains information on a product under development. ON Semiconductor reserves the right to change or discontinue this product without notice.

# FGHL40S65UQ

## THERMAL CHARACTERISTICS

| Rating                                         | Symbol          | Value | Unit |
|------------------------------------------------|-----------------|-------|------|
| Thermal resistance junction-to-case, for IGBT  | $R_{\theta JC}$ | 0.65  | °C/W |
| Thermal resistance junction-to-case, for Diode | $R_{\theta JC}$ | 1.69  | °C/W |
| Thermal resistance junction-to-ambient         | $R_{\theta JA}$ | 40    | °C/W |

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

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

### OFF CHARACTERISTIC

|                                                                   |                                              |                                |     |     |      |      |
|-------------------------------------------------------------------|----------------------------------------------|--------------------------------|-----|-----|------|------|
| Collector-emitter breakdown voltage, gate-emitter short-circuited | $V_{GE} = 0\text{ V}, I_C = 1\text{ mA}$     | $BV_{CES}$                     | 650 | —   | —    | V    |
| Temperature Coefficient of Breakdown Voltage                      | $V_{GE} = 0\text{ V}, I_C = 1\text{ mA}$     | $\Delta BV_{CES} / \Delta T_J$ | —   | 0.5 | —    | V/°C |
| Collector-emitter cut-off current, gate-emitter short-circuited   | $V_{GE} = 0\text{ V}, V_{CE} = 650\text{ V}$ | $I_{CES}$                      | —   | —   | 250  | μA   |
| Gate leakage current, collector-emitter short-circuited           | $V_{GE} = 20\text{ V}, V_{CE} = 0\text{ V}$  | $I_{GES}$                      | —   | —   | ±400 | nA   |

### ON CHARACTERISTIC

|                                      |                                                                                                                 |               |     |             |          |   |
|--------------------------------------|-----------------------------------------------------------------------------------------------------------------|---------------|-----|-------------|----------|---|
| Gate-emitter threshold voltage       | $V_{GE} = V_{CE}, I_C = 40\text{ mA}$                                                                           | $V_{GE(th)}$  | 2.5 | 4.7         | 6.5      | V |
| Collector-emitter saturation voltage | $V_{GE} = 15\text{ V}, I_C = 40\text{ A}$<br>$V_{GE} = 15\text{ V}, I_C = 40\text{ A}, T_J = 175^\circ\text{C}$ | $V_{CE(sat)}$ | —   | 1.36<br>1.6 | 1.7<br>— | V |

### DYNAMIC CHARACTERISTIC

|                              |                                                                       |           |   |      |   |    |
|------------------------------|-----------------------------------------------------------------------|-----------|---|------|---|----|
| Input capacitance            | $V_{CE} = 30\text{ V}, V_{GE} = 0\text{ V}, f = 1\text{ MHz}$         | $C_{ies}$ | — | 6054 | — | pF |
| Output capacitance           |                                                                       | $C_{oes}$ | — | 36   | — |    |
| Reverse transfer capacitance |                                                                       | $C_{res}$ | — | 30   | — |    |
| Gate charge total            | $V_{CE} = 400\text{ V}, I_C = 40\text{ A},$<br>$V_{GE} = 15\text{ V}$ | $Q_g$     | — | 306  | — | nC |
| Gate to emitter charge       |                                                                       | $Q_{ge}$  | — | 30   | — |    |
| Gate to collector charge     |                                                                       | $Q_{gc}$  | — | 99   | — |    |

### SWITCHING CHARACTERISTIC, INDUCTIVE LOAD

|                         |                                                                                                                                           |              |   |      |   |    |
|-------------------------|-------------------------------------------------------------------------------------------------------------------------------------------|--------------|---|------|---|----|
| Turn-on delay time      | $T_J = 25^\circ\text{C}$<br>$V_{CC} = 400\text{ V}, I_C = 40\text{ A},$<br>$R_G = 6\ \Omega$<br>$V_{GE} = 15\text{ V}$<br>Inductive Load  | $t_{d(on)}$  | — | 32   | — | ns |
| Rise time               |                                                                                                                                           | $t_r$        | — | 20   | — |    |
| Turn-off delay time     |                                                                                                                                           | $t_{d(off)}$ | — | 260  | — |    |
| Fall time               |                                                                                                                                           | $t_f$        | — | 13   | — |    |
| Turn-on switching loss  |                                                                                                                                           | $E_{ON}$     | — | 1760 | — | μJ |
| Turn-off switching loss |                                                                                                                                           | $E_{OFF}$    | — | 362  | — |    |
| Total switching loss    |                                                                                                                                           | $E_{TS}$     | — | 2122 | — |    |
| Turn-on delay time      | $T_J = 175^\circ\text{C}$<br>$V_{CC} = 400\text{ V}, I_C = 40\text{ A},$<br>$R_G = 6\ \Omega$<br>$V_{GE} = 15\text{ V}$<br>Inductive Load | $t_{d(on)}$  | — | 30   | — | ns |
| Rise time               |                                                                                                                                           | $t_r$        | — | 28   | — |    |
| Turn-off delay time     |                                                                                                                                           | $t_{d(off)}$ | — | 284  | — |    |
| Fall time               |                                                                                                                                           | $t_f$        | — | 56   | — |    |
| Turn-on switching loss  |                                                                                                                                           | $E_{ON}$     | — | 2050 | — | μJ |
| Turn-off switching loss |                                                                                                                                           | $E_{OFF}$    | — | 590  | — |    |
| Total switching loss    |                                                                                                                                           | $E_{TS}$     | — | 2640 | — |    |

# FGHL40S65UQ

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

| Parameter                     | Test Conditions                                                                                                                                                          | Symbol           | Min    | Typ          | Max      | Unit          |
|-------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------|--------|--------------|----------|---------------|
| <b>DIODE CHARACTERISTIC</b>   |                                                                                                                                                                          |                  |        |              |          |               |
| Forward voltage               | $I_F = 20\text{ A}$<br>$I_F = 20\text{ A}, T_J = 175^\circ\text{C}$                                                                                                      | $V_F$            | —<br>— | 1.24<br>1.24 | 1.6<br>— | V             |
| Reverse Recovery Energy       | $I_F = 20\text{ A}, \Delta I_F/\Delta t = 200\text{ A}/\mu\text{s}$                                                                                                      | $E_{\text{REC}}$ | —      | 359          | —        | $\mu\text{J}$ |
| Diode Reverse Recovery Time   | $I_F = 20\text{ A}, \Delta I_F/\Delta t = 200\text{ A}/\mu\text{s}$<br>$I_F = 20\text{ A}, \Delta I_F/\Delta t = 200\text{ A}/\mu\text{s},$<br>$T_J = 175^\circ\text{C}$ | $T_{\text{RR}}$  | —      | 319<br>430   | —        | nS            |
| Diode Reverse Recovery Charge | $I_F = 20\text{ A}, \Delta I_F/\Delta t = 200\text{ A}/\mu\text{s}$<br>$I_F = 20\text{ A}, \Delta I_F/\Delta t = 200\text{ A}/\mu\text{s},$<br>$T_J = 175^\circ\text{C}$ | $Q_{\text{RR}}$  | —      | 1853<br>3007 | —        | nC            |

TYPICAL CHARACTERISTICS

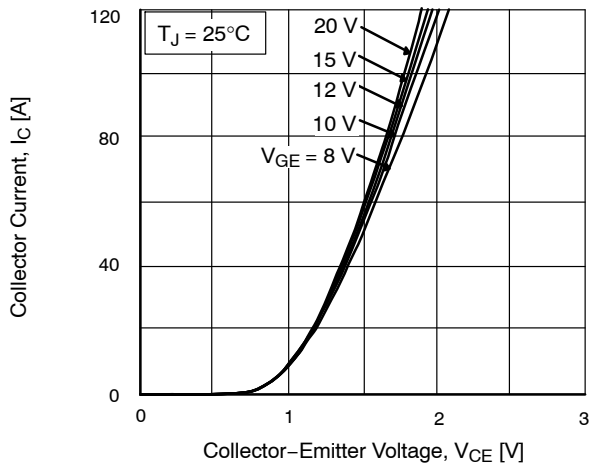


Figure 1. Typical Output Characteristics

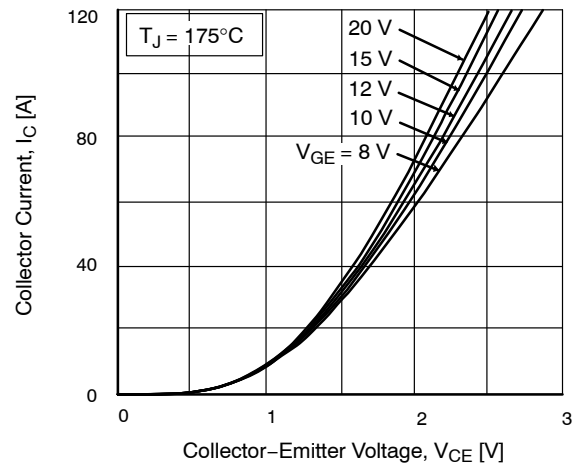


Figure 2. Typical Output Characteristics

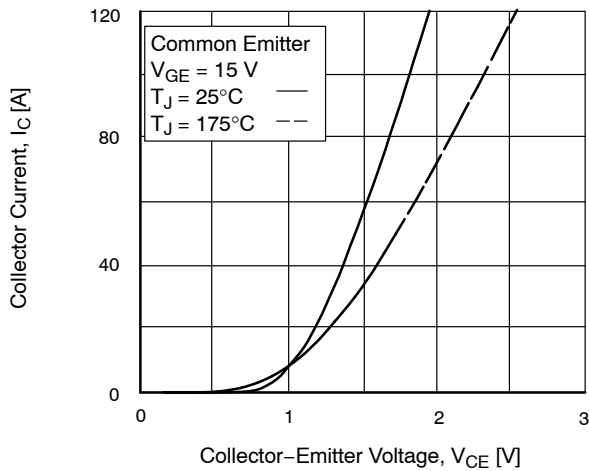


Figure 3. Typical Saturation Voltage Characteristics

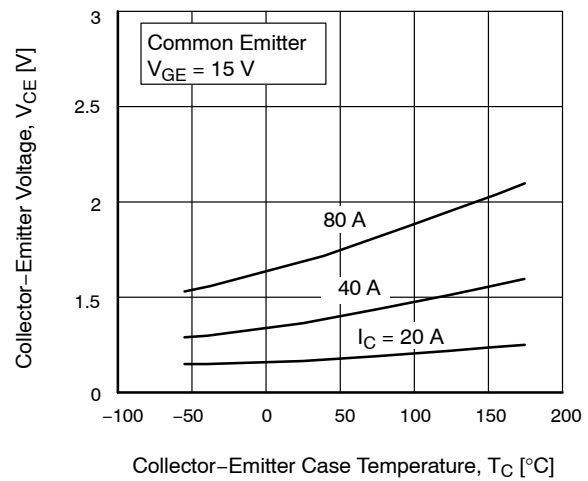


Figure 4. Saturation Voltage vs. Case Temperature at Variant Current Level

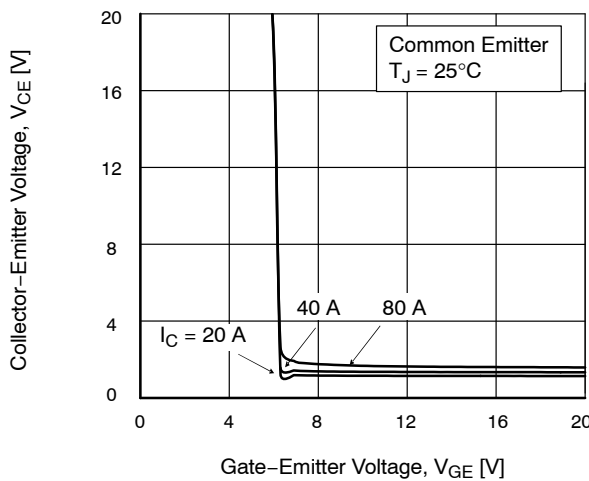


Figure 5. Saturation Voltage vs  $V_{GE}$

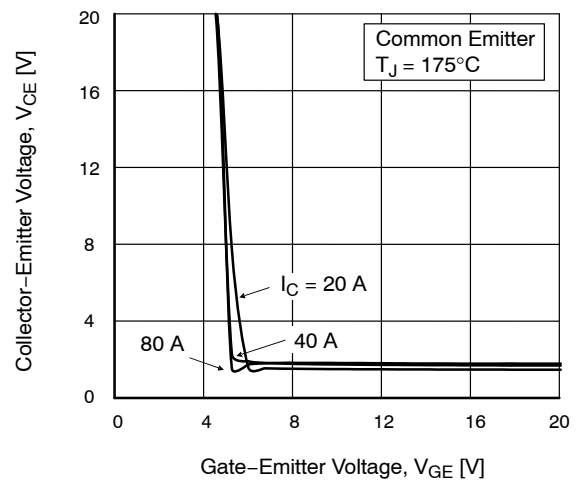


Figure 6. Saturation Voltage vs  $V_{GE}$

TYPICAL CHARACTERISTICS (continued)

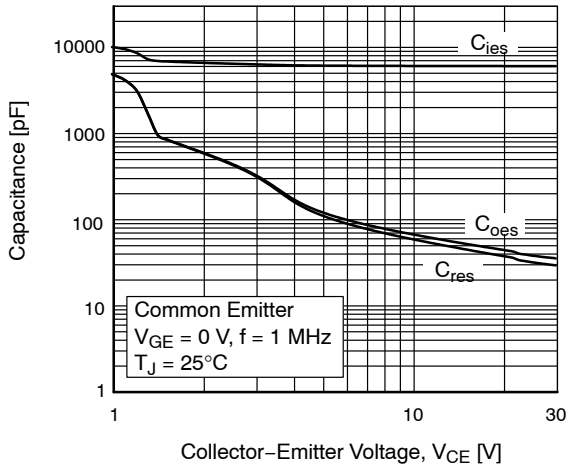


Figure 7. Capacitance Characteristics

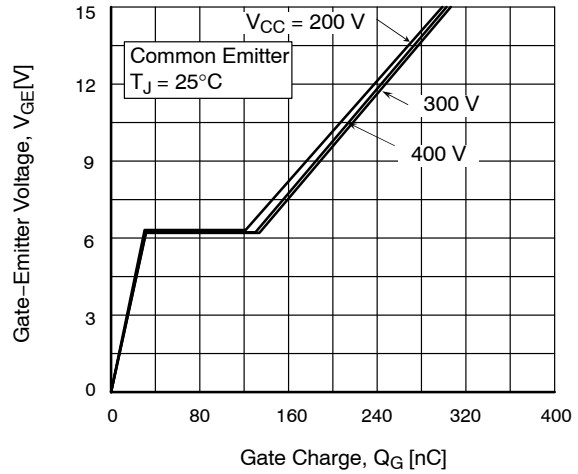


Figure 8. Gate Charge Characteristics

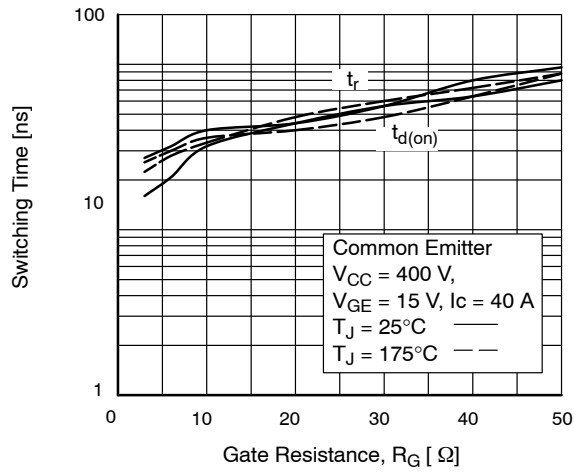


Figure 9. Turn-on Characteristics vs. Gate Resistance

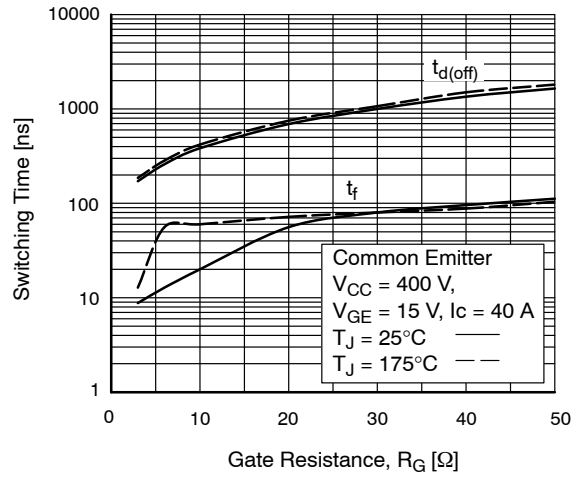


Figure 10. Turn-Off Characteristics vs. Gate Resistance

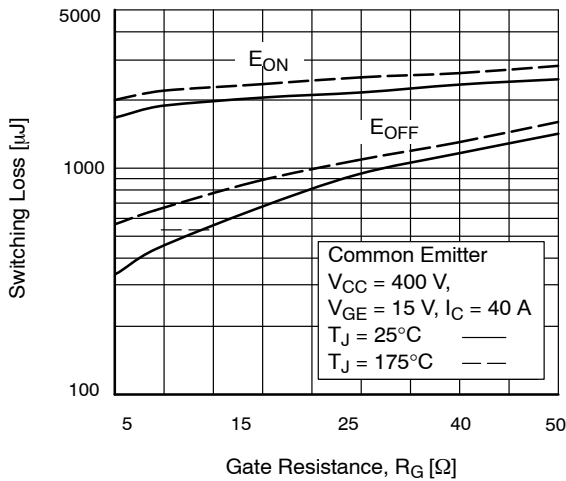


Figure 11. Switching Loss vs Gate Resistance

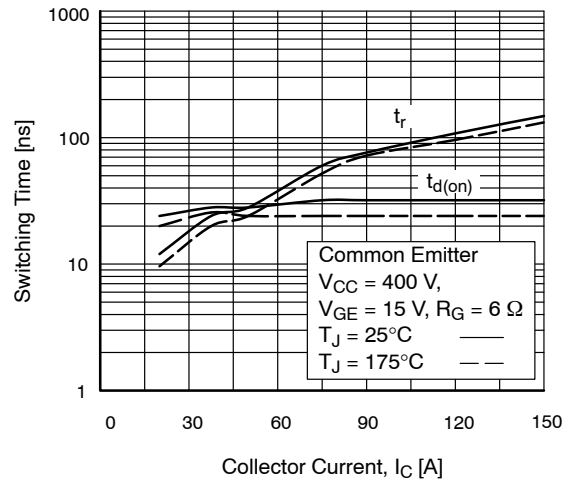


Figure 12. Turn-On Characteristics vs. Collector Current

TYPICAL CHARACTERISTICS (continued)

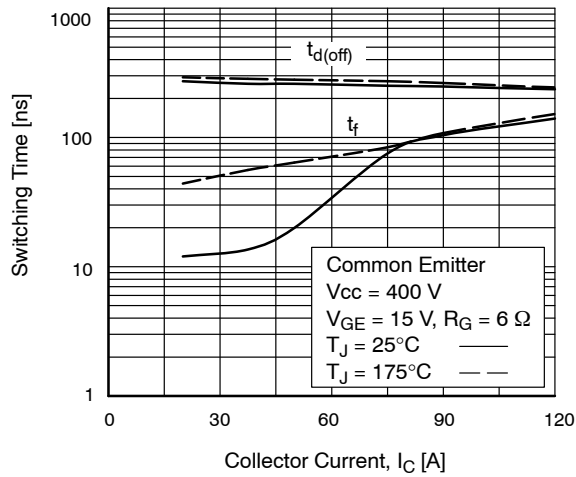


Figure 13. Turn-Off Characteristics vs. Collector Current

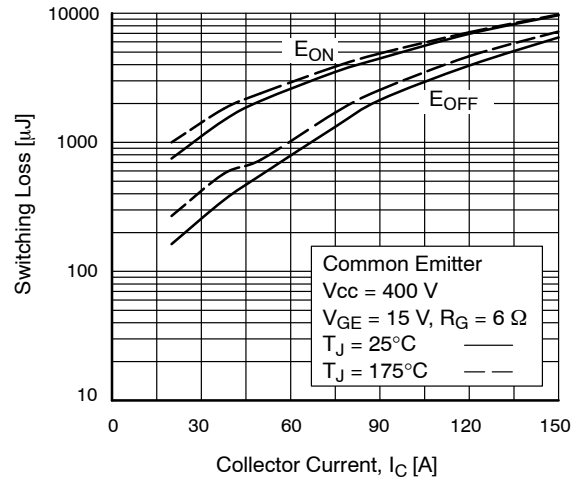


Figure 14. Switching Loss vs. Collector Current

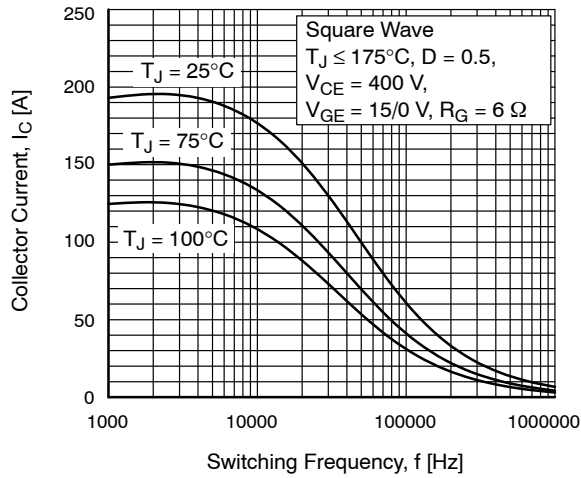


Figure 15. Load Current vs. Frequency

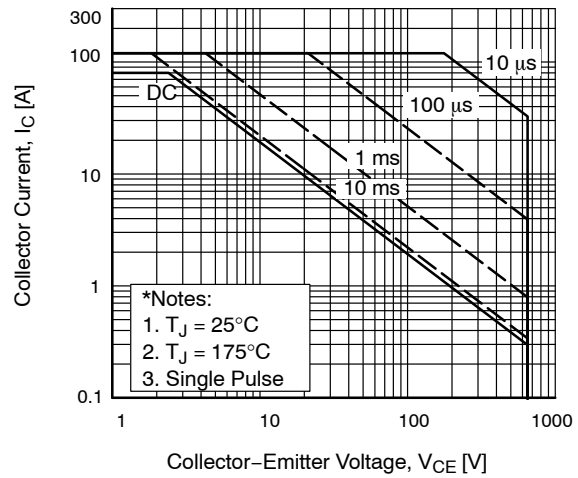


Figure 16. SOA Characteristics (FBSOA)

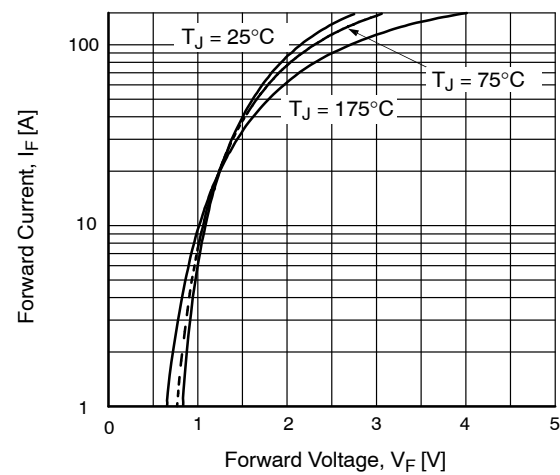


Figure 17. Forward Characteristics

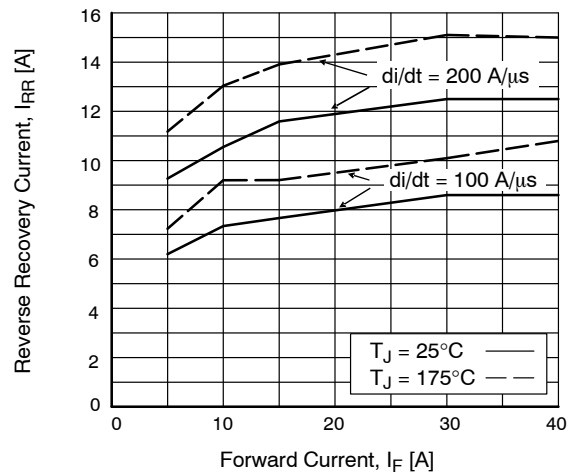


Figure 18. Reverse Recovery Current

TYPICAL CHARACTERISTICS (continued)

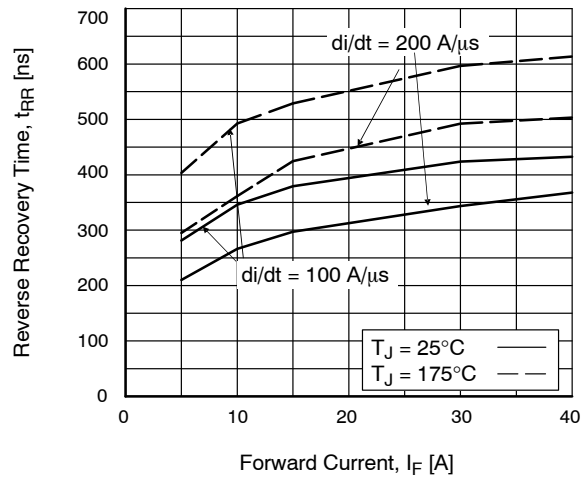


Figure 19. Reverse Recovery Time

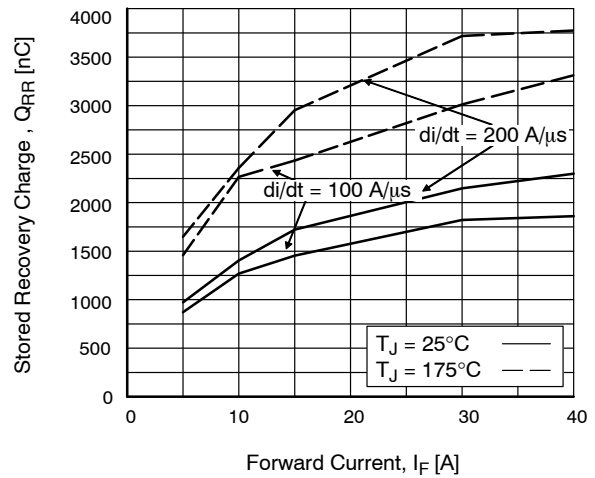


Figure 20. Stored Charge

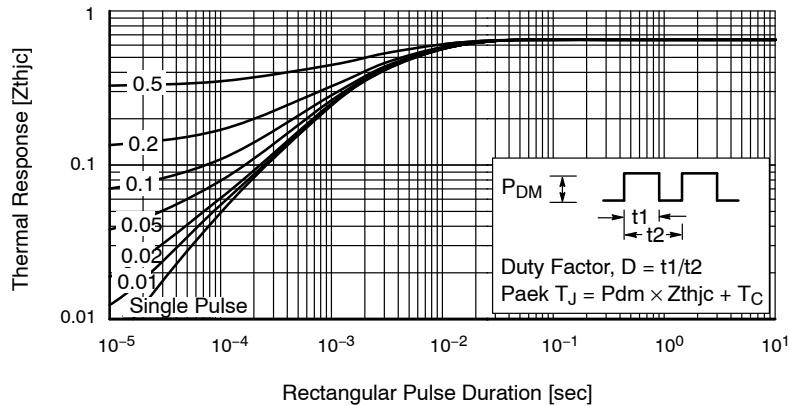


Figure 21. Transient Thermal Impedance of IGBT

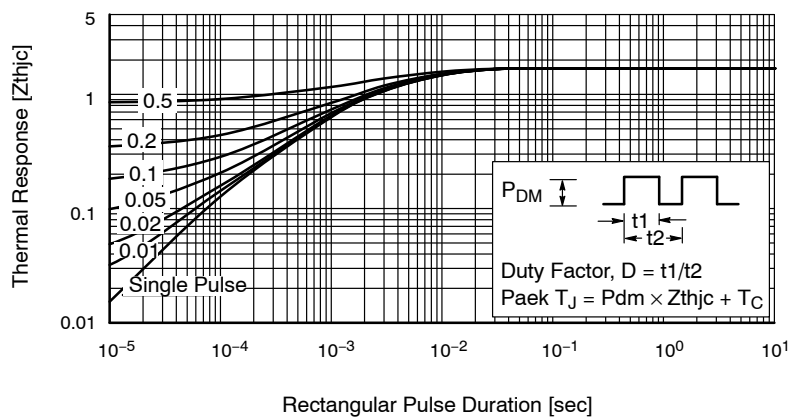
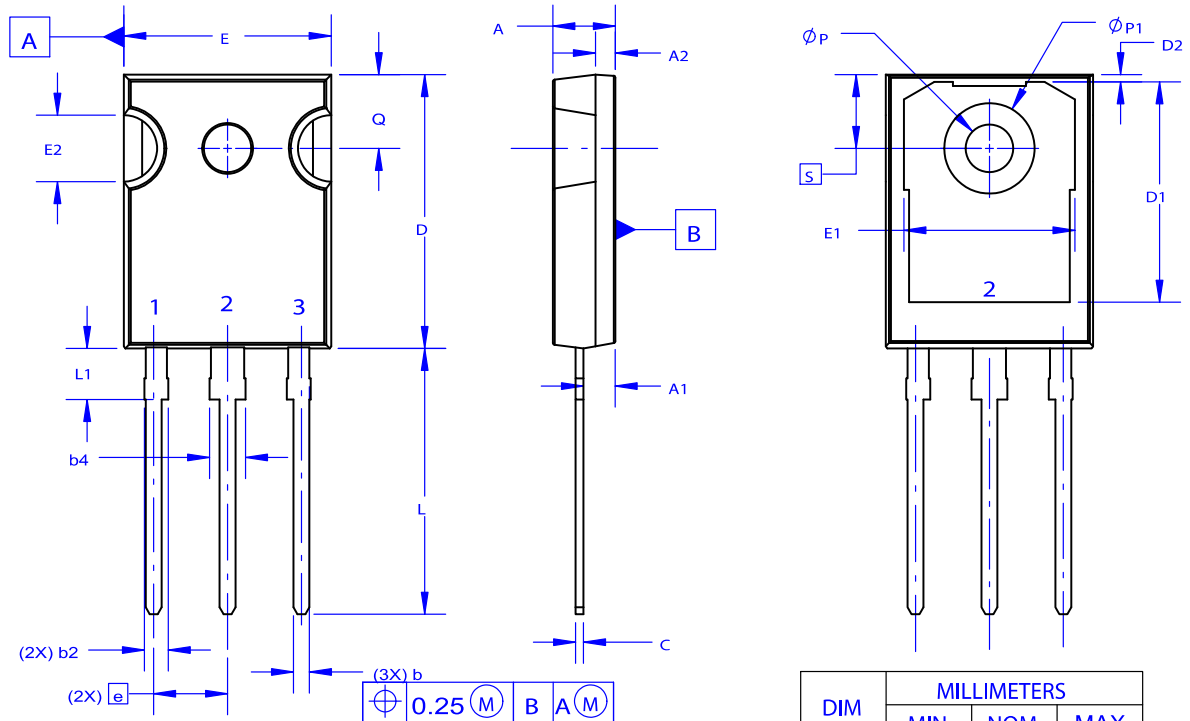


Figure 22. Transient Thermal Impedance of Diode

# FGHL40S65UQ

TO-247-3LD  
CASE 340CX  
ISSUE O



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.

| 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  |
| 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  |
| $\phi P$  | 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       | ~     | ~     |
| $\phi P1$ | 6.60        | 6.80  | 7.00  |



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