

# Field Stop Trench IGBT, 20 A, 650 V

## FGAF20S65AQ

Using novel field stop IGBT technology, ON Semiconductor's new series of field stop 4<sup>th</sup> generation of RC IGBTs offer the optimum performance for PFC applications and welder 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:  $V_{CE(\text{Sat})} = 1.4\text{ V (Typ.)}$  @  $I_C = 20\text{ A}$
- 100% of the Parts Tested for  $I_{LM}$  (Note 1)
- High Input Impedance
- Fast Switching
- Tighten Parameter Distribution
- IGBT with Monolithic Reverse Conducting Diode
- This Device is Pb-Free and is RoHS Compliant

### Typical Applications

- PFC, Welder

### 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<br>@ $T_C = 25^{\circ}\text{C}$<br>@ $T_C = 100^{\circ}\text{C}$      | $I_C$          | 40<br>20             | A                  |
| Pulsed Collector Current (Note 1)                                                       | $I_{LM}$       | 60                   | A                  |
| Pulsed Collector Current (Note 2)                                                       | $I_{CM}$       | 60                   | A                  |
| Diode Forward Current<br>@ $T_C = 25^{\circ}\text{C}$<br>@ $T_C = 100^{\circ}\text{C}$  | $I_F$          | 20<br>10             | A                  |
| Pulsed Diode Maximum Forward Current                                                    | $I_{FM}$       | 60                   | A                  |
| Maximum Power Dissipation @ $T_C = 25^{\circ}\text{C}$<br>@ $T_C = 100^{\circ}\text{C}$ | $P_D$          | 75<br>37             | W                  |
| Operating Junction / Storage Temperature Range                                          | $T_J, T_{STG}$ | $-55$ to $+175$      | $^{\circ}\text{C}$ |
| Maximum Lead Temp. for Soldering 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.

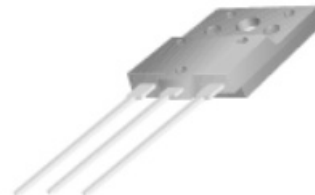
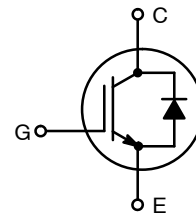
1.  $V_{CC} = 400\text{ V}$ ,  $V_{GE} = 15\text{ V}$ ,  $I_C = 60\text{ A}$ ,  $R_G = 23\ \Omega$ , Inductive Load, 100% Tested
2. Repetitive rating: pulse width limited by max. Junction temperature



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**20 A, 650 V**  
 **$V_{CE(\text{sat})} = 1.4\text{ V (Typ.)}$**



TO-3PF  
CASE 340AH

### MARKING DIAGRAM



&Y = ON Semiconductor Logo  
&E = Designate space on marking  
&3 = 3-Digit Data Code  
&K = 2-Digit Lot Traceability Code  
FGAF20S65AQ = Specific Device Code

### ORDERING INFORMATION

| Device      | Package   | Shipping        |
|-------------|-----------|-----------------|
| FGAF20S65AQ | TO-3PF-3L | 30 Units / Rail |

# FGAF20S65AQ

**Table 1. THERMAL CHARACTERISTICS**

| Parameter                                       | Symbol          | Value | Unit |
|-------------------------------------------------|-----------------|-------|------|
| Thermal Resistance, Junction-to-Case, for IGBT  | $R_{\theta JC}$ | 2     | °C/W |
| Thermal Resistance, Junction-to-Case, for Diode | $R_{\theta JC}$ | 3.6   | °C/W |
| Thermal Resistance, Junction-to-Ambient         | $R_{\theta JA}$ | 40    | °C/W |

**Table 2. 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       | $V_{GE} = V_{CE}, I_C = 20\text{ mA}$                                                                           | $V_{GE(th)}$  | 2.6 | 5.3        | 6.6      | V |
| Collector-emitter saturation voltage | $V_{GE} = 15\text{ V}, I_C = 20\text{ A}$<br>$V_{GE} = 15\text{ V}, I_C = 20\text{ A}, T_J = 175^\circ\text{C}$ | $V_{CE(sat)}$ | –   | 1.4<br>1.7 | 2.1<br>– | V |

**DYNAMIC CHARACTERISTIC**

|                              |                                                                  |           |   |      |   |    |
|------------------------------|------------------------------------------------------------------|-----------|---|------|---|----|
| Input capacitance            | $V_{CE} = 30\text{ V}, V_{GE} = 0\text{ V}, f = 1\text{ MHz}$    | $C_{ies}$ | – | 1319 | – | pF |
| Output capacitance           |                                                                  | $C_{oes}$ | – | 21   | – |    |
| Reverse transfer capacitance |                                                                  | $C_{res}$ | – | 6    | – |    |
| Gate charge total            | $V_{CE} = 400\text{ V}, I_C = 20\text{ A}, V_{GE} = 15\text{ V}$ | $Q_g$     | – | 38   | – | nC |
| Gate to emitter charge       |                                                                  | $Q_{ge}$  | – | 9    | – |    |
| Gate to collector charge     |                                                                  | $Q_{gc}$  | – | 11   | – |    |

**SWITCHING CHARACTERISTIC, INDUCTIVE LOAD**

|                         |                                                                                                                                          |              |   |     |   |    |
|-------------------------|------------------------------------------------------------------------------------------------------------------------------------------|--------------|---|-----|---|----|
| Turn-on delay time      | $T_J = 25^\circ\text{C}$<br>$V_{CC} = 400\text{ V}, I_C = 5\text{ A}$<br>$R_g = 23\ \Omega$<br>$V_{GE} = 15\text{ V}$<br>Inductive Load  | $t_{d(on)}$  | – | 16  | – | ns |
| Rise time               |                                                                                                                                          | $t_r$        | – | 6.4 | – |    |
| Turn-off delay time     |                                                                                                                                          | $t_{d(off)}$ | – | 109 | – |    |
| Fall time               |                                                                                                                                          | $t_f$        | – | 27  | – |    |
| Turn-on switching loss  |                                                                                                                                          | $E_{on}$     | – | 200 | – | μJ |
| Turn-off switching loss |                                                                                                                                          | $E_{off}$    | – | 56  | – |    |
| Total switching loss    |                                                                                                                                          | $E_{ts}$     | – | 256 | – |    |
| Turn-on delay time      | $T_J = 25^\circ\text{C}$<br>$V_{CC} = 400\text{ V}, I_C = 10\text{ A}$<br>$R_g = 23\ \Omega$<br>$V_{GE} = 15\text{ V}$<br>Inductive Load | $t_{d(on)}$  | – | 18  | – | ns |
| Rise time               |                                                                                                                                          | $t_r$        | – | 11  | – |    |
| Turn-off delay time     |                                                                                                                                          | $t_{d(off)}$ | – | 102 | – |    |
| Fall time               |                                                                                                                                          | $t_f$        | – | 21  | – |    |
| Turn-on switching loss  |                                                                                                                                          | $E_{on}$     | – | 345 | – | μJ |
| Turn-off switching loss |                                                                                                                                          | $E_{off}$    | – | 95  | – |    |
| Total switching loss    |                                                                                                                                          | $E_{ts}$     | – | 440 | – |    |

# FGAF20S65AQ

**Table 2. ELECTRICAL CHARACTERISTICS** ( $T_J = 25^\circ\text{C}$  unless otherwise specified)

| Parameter                                | Test Conditions                                                                                                                               | Symbol              | Min    | Typ         | Max      | Unit          |
|------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------|---------------------|--------|-------------|----------|---------------|
| SWITCHING CHARACTERISTIC, INDUCTIVE LOAD |                                                                                                                                               |                     |        |             |          |               |
| Turn-on delay time                       | $T_J = 175^{\circ}\text{C}$<br>$V_{CC} = 400\text{ V}, I_C = 5\text{ A}$<br>$R_g = 23\ \Omega$<br>$V_{GE} = 15\text{ V}$<br>Inductive Load    | $t_{d(\text{on})}$  | –      | 14.4        | –        | ns            |
| Rise time                                |                                                                                                                                               | $t_r$               | –      | 6.4         | –        |               |
| Turn-off delay time                      |                                                                                                                                               | $t_{d(\text{off})}$ | –      | 118         | –        |               |
| Fall time                                |                                                                                                                                               | $t_f$               | –      | 51          | –        |               |
| Turn-on switching loss                   |                                                                                                                                               | $E_{\text{on}}$     | –      | 301         | –        | $\mu\text{J}$ |
| Turn-off switching loss                  |                                                                                                                                               | $E_{\text{off}}$    | –      | 94          | –        |               |
| Total switching loss                     |                                                                                                                                               | $E_{\text{ts}}$     | –      | 395         | –        |               |
| Turn-on delay time                       | $T_J = 175^{\circ}\text{C}$<br>$V_{CC} = 400\text{ V}, I_C = 10\text{ A}$<br>$R_g = 23\ \Omega$<br>$V_{GE} = 15\text{ V}$<br>Inductive Load   | $t_{d(\text{on})}$  | –      | 16          | –        | ns            |
| Rise time                                |                                                                                                                                               | $t_r$               | –      | 12          | –        |               |
| Turn-off delay time                      |                                                                                                                                               | $t_{d(\text{off})}$ | –      | 114         | –        |               |
| Fall time                                |                                                                                                                                               | $t_f$               | –      | 46          | –        |               |
| Turn-on switching loss                   |                                                                                                                                               | $E_{\text{on}}$     | –      | 466         | –        | $\mu\text{J}$ |
| Turn-off switching loss                  |                                                                                                                                               | $E_{\text{off}}$    | –      | 177         | –        |               |
| Total switching loss                     |                                                                                                                                               | $E_{\text{ts}}$     | –      | 643         | –        |               |
| DIODE CHARACTERISTIC                     |                                                                                                                                               |                     |        |             |          |               |
| Forward Voltage                          | $I_F = 10\text{ A}$<br>$I_F = 10\text{ A}, T_J = 175^{\circ}\text{C}$                                                                         | $V_F$               | –<br>– | 1.3<br>1.3  | 1.6<br>– | V             |
| Reverse Recovery Energy                  | $I_F = 10\text{ A}, di_F/dt = 200\text{ A}/\mu\text{s}$                                                                                       | $E_{\text{rec}}$    | –      | 179         | –        | $\mu\text{J}$ |
| Diode Reverse Recovery Time              | $I_F = 10\text{ A}, di_F/dt = 200\text{ A}/\mu\text{s}$<br>$I_F = 10\text{ A}, di_F/dt = 200\text{ A}/\mu\text{s}, T_J = 175^{\circ}\text{C}$ | $T_{\text{rr}}$     | –      | 235<br>302  | –        | nS            |
| Diode Reverse Recovery Charge            | $I_F = 10\text{ A}, di_F/dt = 200\text{ A}/\mu\text{s}$<br>$I_F = 10\text{ A}, di_F/dt = 200\text{ A}/\mu\text{s}, T_J = 175^{\circ}\text{C}$ | $Q_{\text{rr}}$     | –      | 802<br>1286 | –        | 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

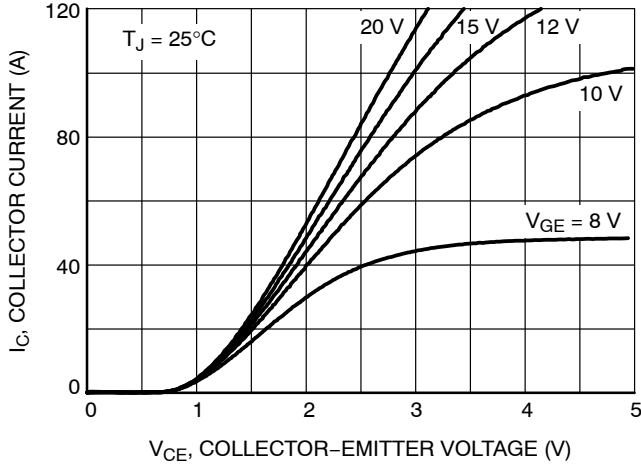


Figure 1. Typical Output Characteristics

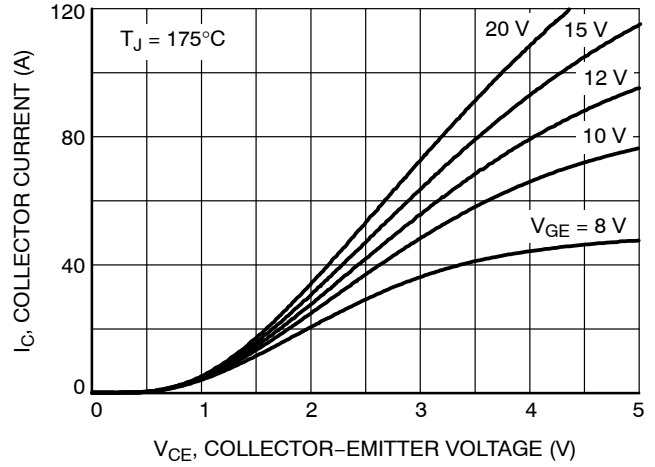


Figure 2. Typical Output Characteristics

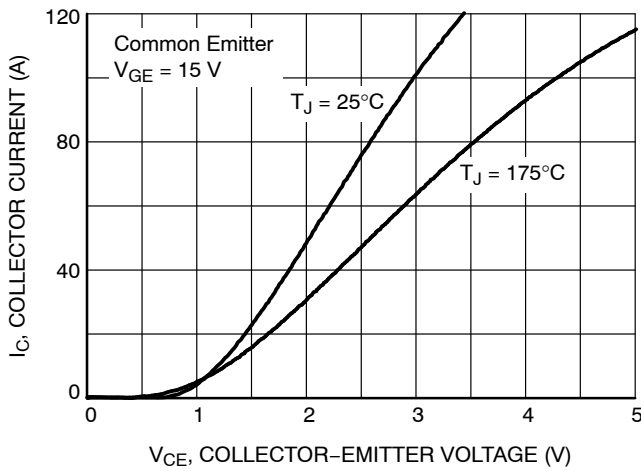


Figure 3. Typical Saturation Voltage Characteristics

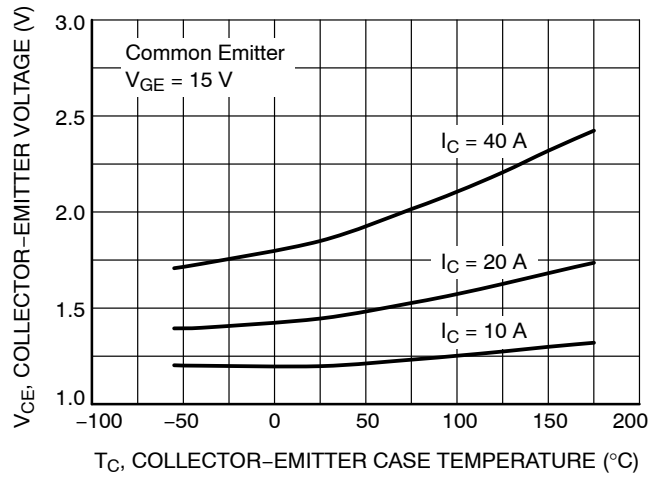


Figure 4. Saturation Voltage vs. Case Temperature at Variant Current Level

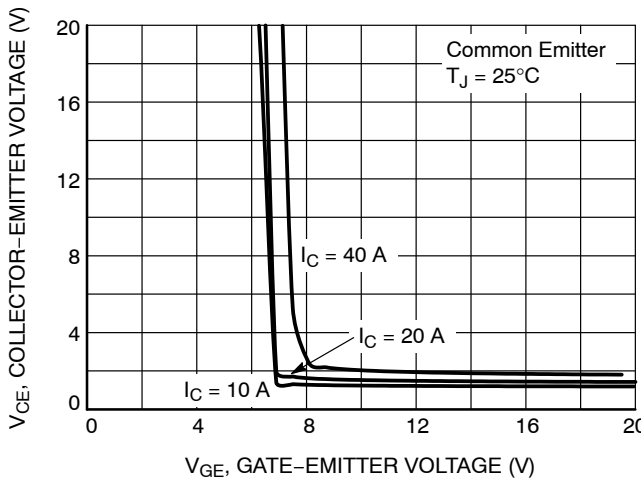


Figure 5. Saturation Voltage vs.  $V_{GE}$

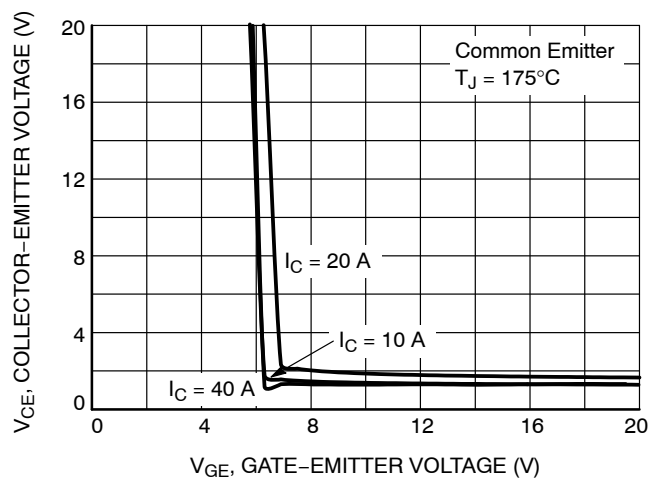


Figure 6. Saturation Voltage vs.  $V_{GE}$

TYPICAL CHARACTERISTICS

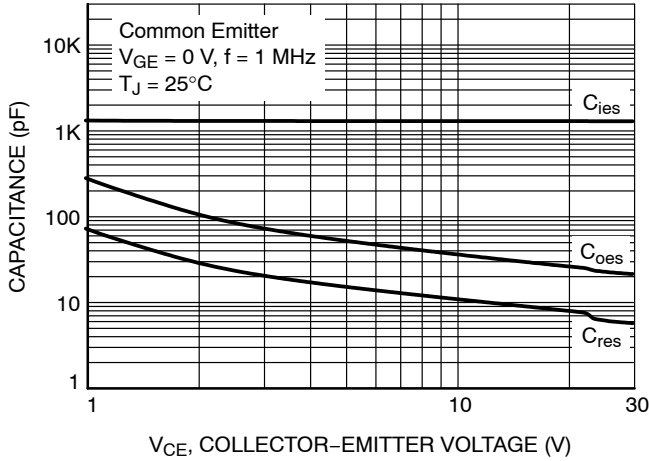


Figure 7. Capacitance Characteristics

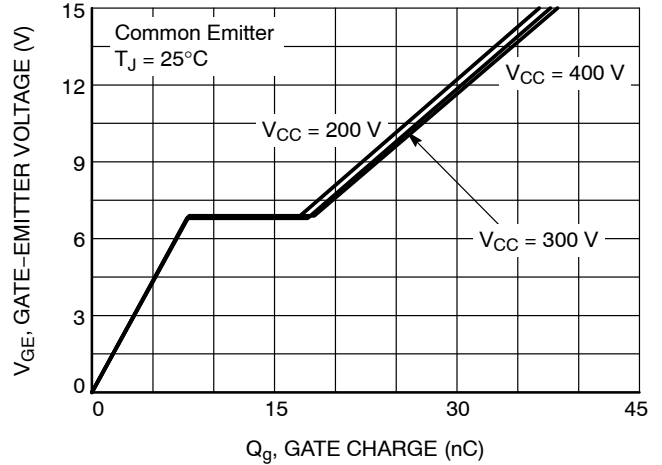


Figure 8. Gate Charge

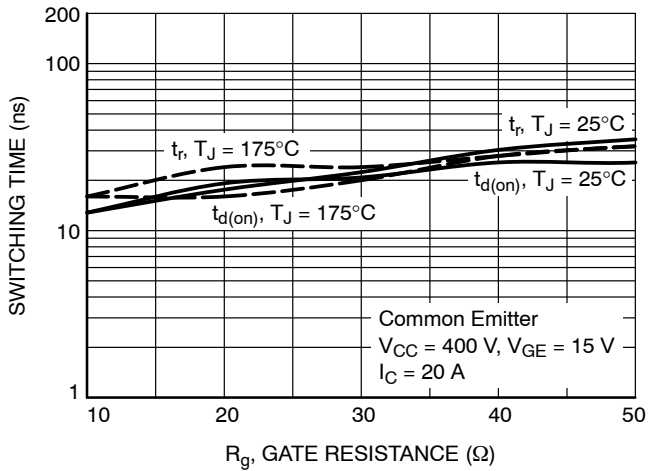


Figure 9. Turn-On Characteristics vs. Gate Resistance

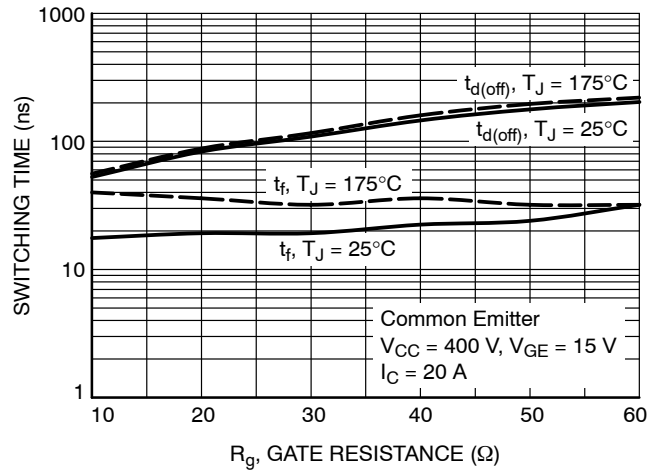


Figure 10. Turn-Off Characteristics vs. Gate Resistance

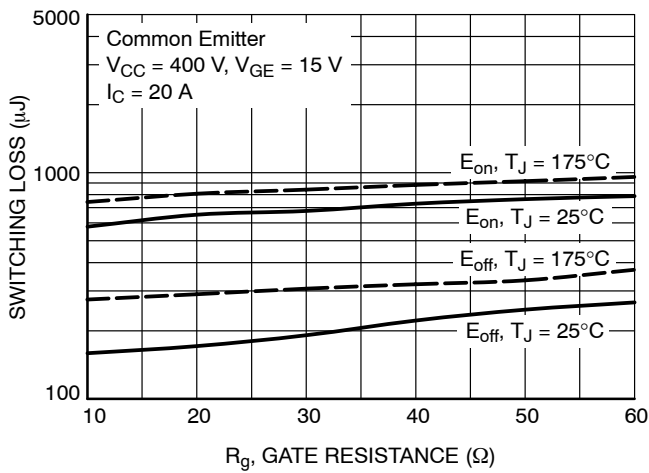


Figure 11. Switching Loss vs. Gate Resistance

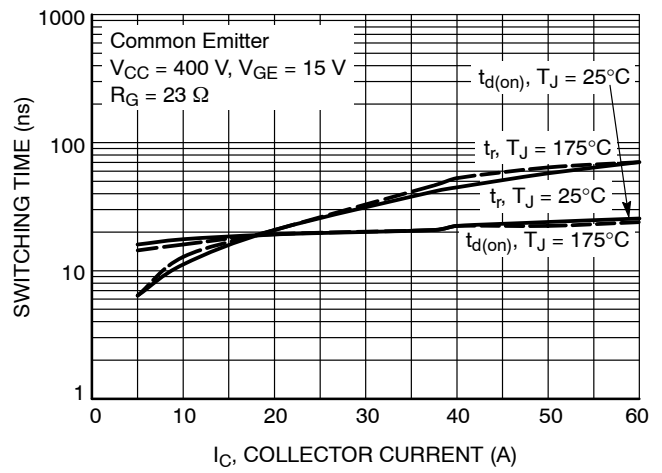


Figure 12. Turn-On Characteristics vs. Collector Current

TYPICAL CHARACTERISTICS

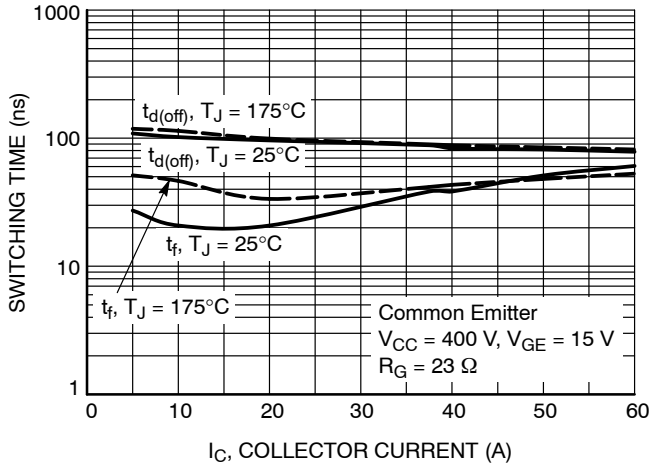


Figure 13. Turn-Off Characteristics vs. Collector Current

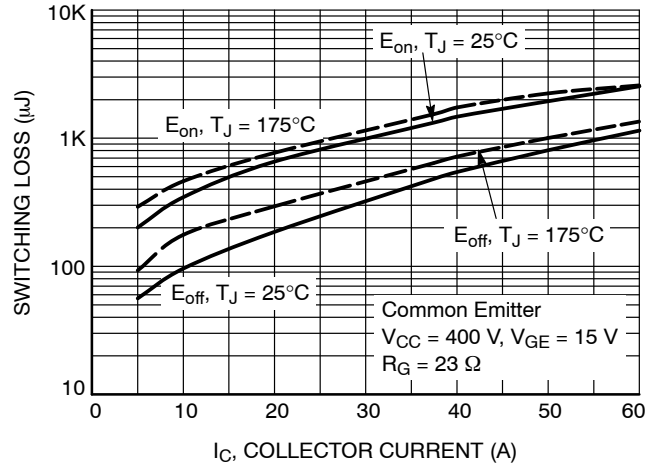


Figure 14. Switching Loss vs. Collector Current

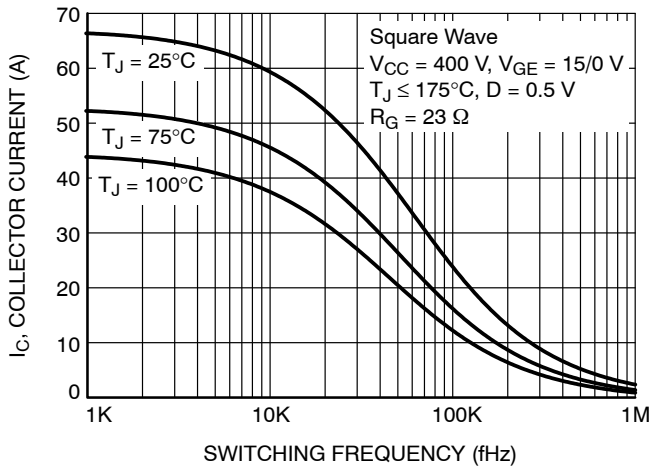


Figure 15. Load Current vs. Frequency

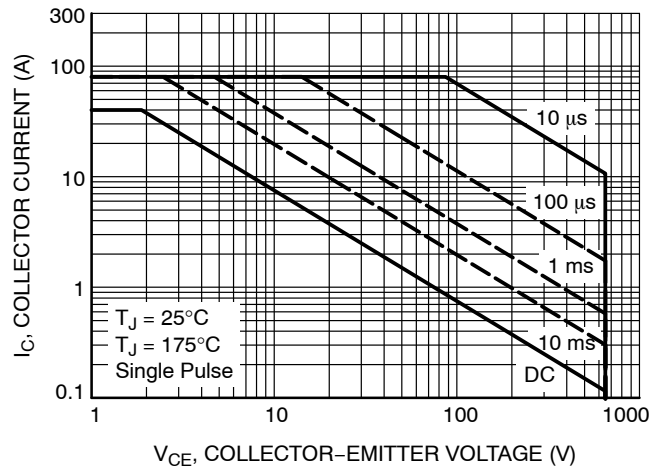


Figure 16. SOA Characteristics (FBSOA)

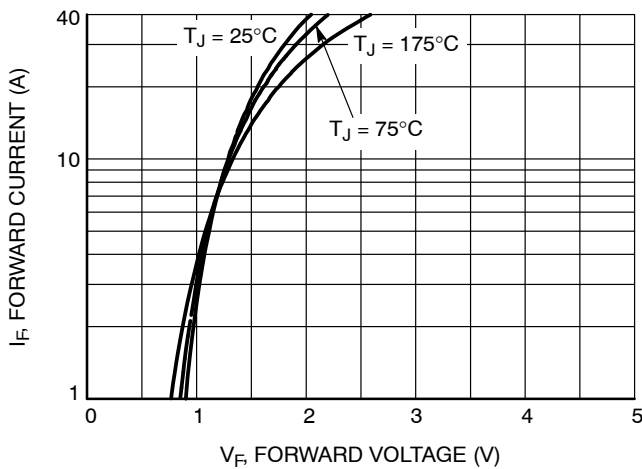


Figure 17. Forward Characteristics

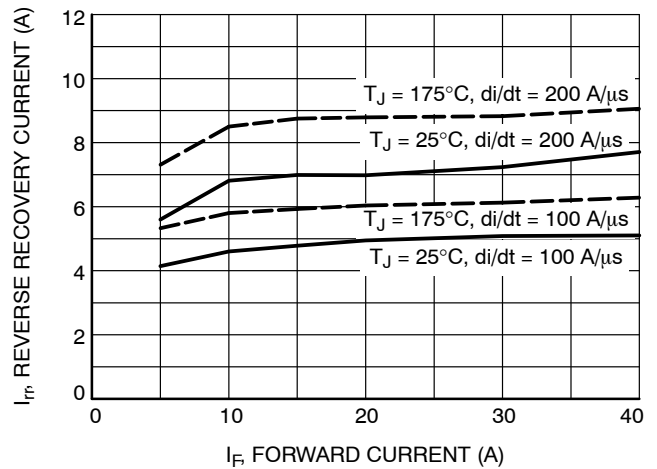


Figure 18. Reverse Recovery Current

TYPICAL CHARACTERISTICS

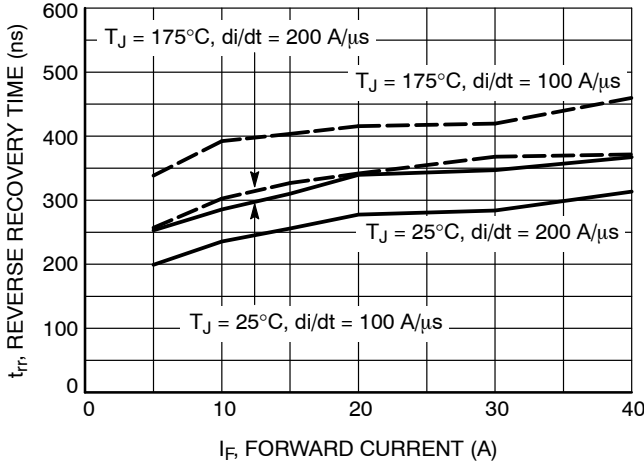


Figure 19. Reverse Recovery Time

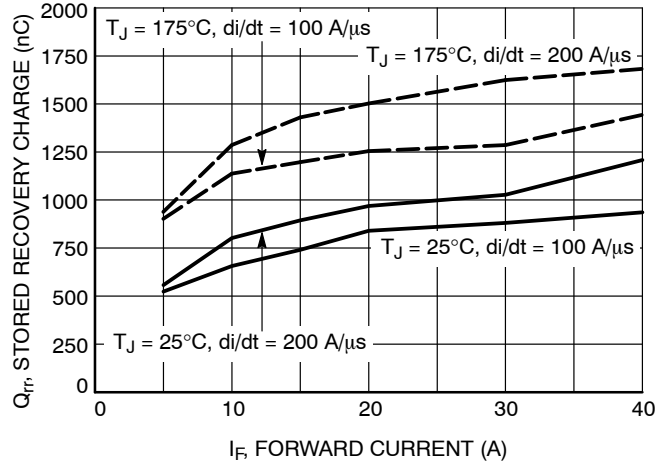


Figure 20. Stored Charge

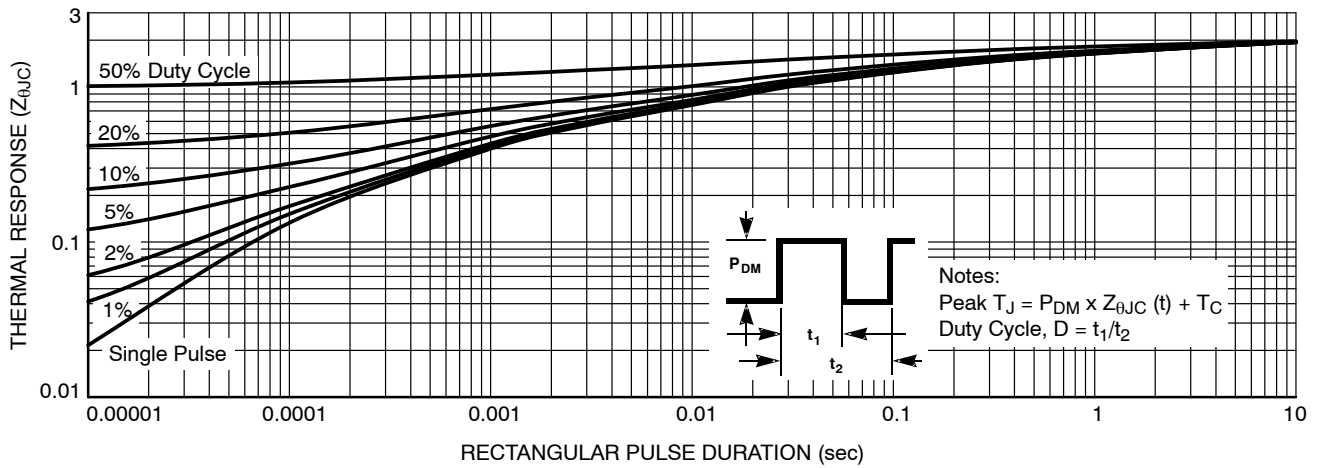


Figure 21. Transient Thermal Impedance of IGBT

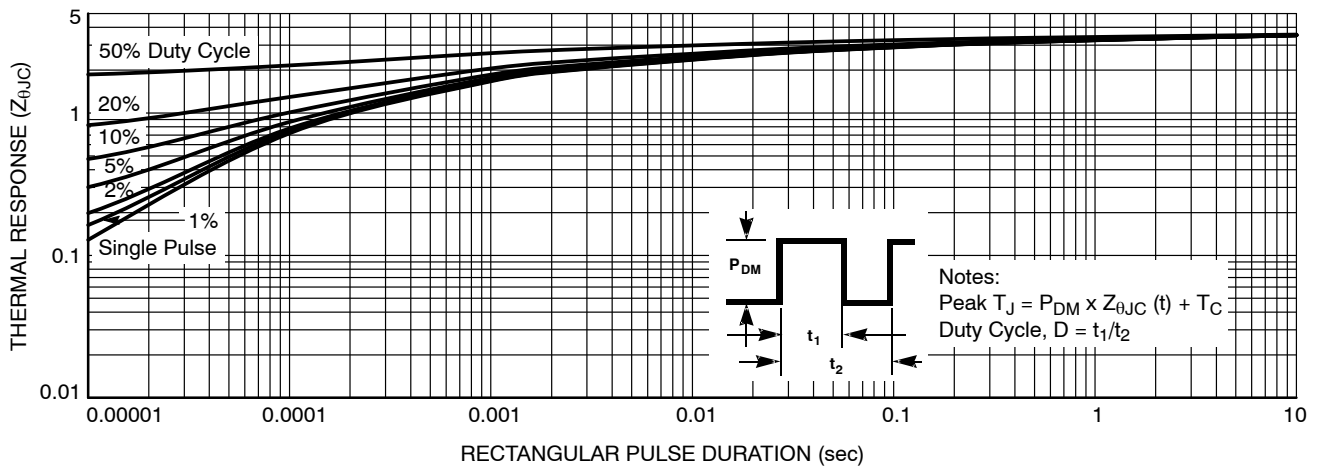
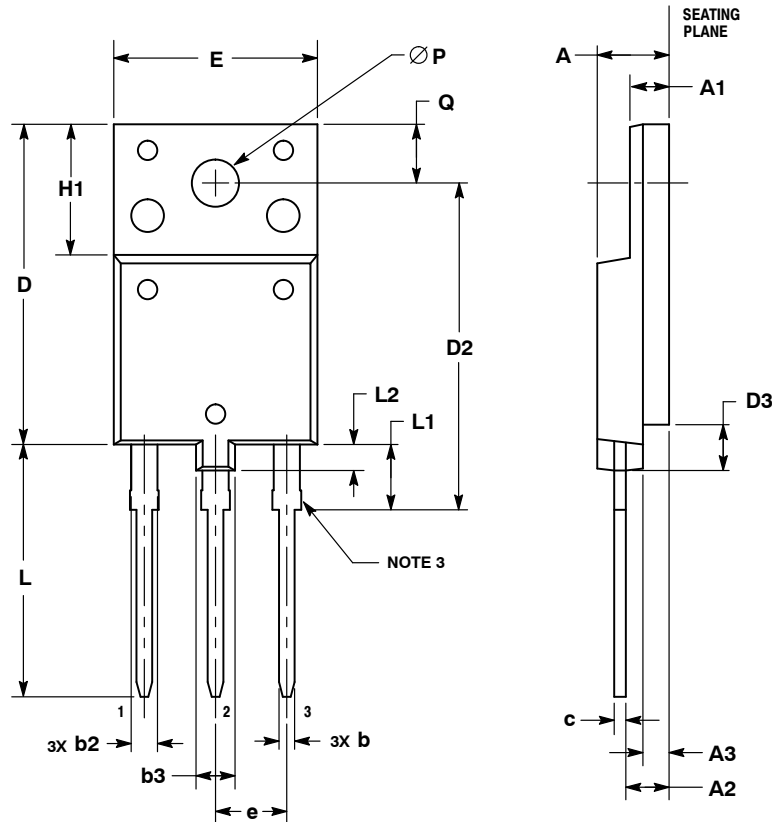


Figure 22. Transient Thermal Impedance of Diode

**TO-3PF-3L**  
**CASE 340AH**  
**ISSUE A**

DATE 09 JAN 2015



## NOTES:

1. DIMENSIONING AND TOLERANCING PER ASME Y14.5M, 2009.
2. CONTROLLING DIMENSION: MILLIMETERS.
3. CONTOUR UNCONTROLLED IN THIS AREA (6 PLACES).
4. DIMENSIONS D AND E DO NOT INCLUDE MOLD FLASH OR GATE PROTRUSIONS. MOLD FLASH AND GATE PROTRUSIONS NOT TO EXCEED 0.13 PER SIDE. THESE DIMENSIONS ARE TO BE MEASURED AT THE OUTERMOST EXTREME OF THE PLASTIC BODY.
5. DIMENSION b2 DOES NOT INCLUDE DAMBAR PROTRUSION. LEAD WIDTH INCLUDING PROTRUSION SHALL NOT EXCEED 2.20.

| DIM | MILLIMETERS |       |
|-----|-------------|-------|
|     | MIN         | MAX   |
| A   | 5.30        | 5.70  |
| A1  | 2.80        | 3.20  |
| A2  | 3.10        | 3.50  |
| A3  | 1.80        | 2.20  |
| b   | 0.65        | 0.95  |
| b2  | 1.90        | 2.15  |
| b3  | 3.80        | 4.20  |
| c   | 0.80        | 1.10  |
| D   | 24.30       | 24.70 |
| D2  | 24.70       | 25.30 |
| D3  | 3.30        | 3.70  |
| E   | 15.30       | 15.70 |
| e   | 5.35        | 5.55  |
| H1  | 9.80        | 10.20 |
| L   | 19.10       | 19.50 |
| L1  | 4.80        | 5.20  |
| L2  | 1.90        | 2.20  |
| P   | 3.40        | 3.80  |
| Q   | 4.30        | 4.70  |

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