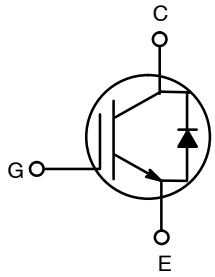
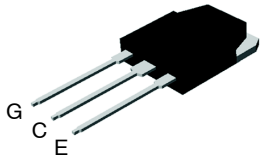
# IGBT – Field Stop

## 650 V, 60 A

# FGA60N65SMD




**TO−3P−3LD / EIAJ SC−65, ISOLATED CASE 340BZ**

### General Description

Using Novel Field Stop IGBT Technology, **onsemi**'s new series of Field Stop IGBTs offer the optimum performance for Solar Inverter, UPS, SMPS, Welder and PFC applications where low conduction and switching losses are essential.

### Features

- Maximum Junction Temperature: $T_J$ = 175°C
- Positive Temperature Co−efficient for Easy Parallel Operating
- High Current Capability
- Low Saturation Voltage: $V_{CE(sat)}$ = 1.9 V(Typ.) @ $I_C$ = 60 A
- Fast Switching: $E_{OFF}$ = 7.5 μJ/A
- Tighten Parameter Distribution
- This Device is Pb−Free and is RoHS Compliant

### Applications

- Solar Inverter, UPS, SMPS, Welder, PFC

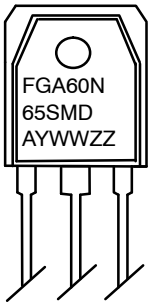
### ABSOLUTE MAXIMUM RATINGS

| Symbol | Rating | | Value | Unit |
|---|---|---|---|---|
| $V_{CES}$ | Collector to Emitter Voltage | | 650 | V |
| $V_{GES}$ | Gate to Emitter Voltage | | ±20 | V |
| | Transient Gate to Emitter Voltage | | ±30 | V |
| $I_C$ | Collector Current | $T_C$ = 25°C | 120 | A |
| | | $T_C$ = 100°C | 60 | A |
| $I_{CM}$ | Pulsed Collector Current (Note 1) | | 180 | A |
| $I_F$ | Diode Forward Current | $T_C$ = 25°C | 60 | A |
| | | $T_C$ = 100°C | 30 | A |
| $I_{FM}$ | Pulsed Diode Maximum Forward Current (Note 1) | | 180 | A |
| $P_D$ | Maximum Power Dissipation | $T_C$ = 25°C | 600 | W |
| | | $T_C$ = 100°C | 300 | W |
| $T_J$ | Operating Junction Temperature | | −55 to +175 | °C |
| $T_{stg}$ | Storage Temperature Range | | −55 to +175 | °C |
| $T_L$ | Maximum Lead Temp. for Soldering Purposes, 1/8" from Case for 5 Seconds | | 300 | °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

### MARKING DIAGRAM




FGA60N65SMD = Specific Device Code
A = Assembly Location
YWW = Date Code (Year & Work Week)
ZZ = Lot Code

### ORDERING INFORMATION

| Device | Package | Shipping |
|---|---|---|
| FGA60N65SMD | TO−3P−3L | 450 / Box |

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## THERMAL CHARACTERISTICS

| Symbol | Characteristic | Value | Unit |
|---|---|---|---|
| $R_{\theta JC}$(IGBT) | Thermal Resistance, Junction to Case | 0.25 | °C/W |
| $R_{\theta JC}$(Diode) | Thermal Resistance, Junction to Case | 1.1 | °C/W |
| $R_{\theta JA}$ | Thermal Resistance, Junction to Ambient | 40 | °C/W |

## ELECTRICAL CHARACTERISTICS OF THE IGBT ($T_C$ = 25°C unless otherwise noted)

| Symbol | Parameter | Test Condition | Min. | Typ. | Max. | Unit |
|---|---|---|---|---|---|---|
| **OFF CHARACTERISTICS** | | | | | | |
| $BV_{CES}$ | Collector to Emitter Breakdown Voltage | $V_{GE}$ = 0 V, $I_C$ = 250 μA | 650 | – | – | V |
| $\frac{\Delta BV_{CES}}{\Delta T_J}$ | Temperature Coefficient of Breakdown Voltage | $V_{GE}$ = 0 V, $I_C$ = 250 μA | – | 0.6 | – | V/°C |
| $I_{CES}$ | Collector Cut−Off Current | $V_{CE}$ = $V_{CES}$, $V_{GE}$ = 0 V | – | – | 250 | μA |
| $I_{GES}$ | G−E Leakage Current | $V_{GE}$ = $V_{GES}$, $V_{CE}$ = 0 V | – | – | ±400 | nA |
| **ON CHARACTERISTICS** | | | | | | |
| $V_{GE(th)}$ | G−E Threshold Voltage | $I_C$ = 250 μA, $V_{CE}$ = $V_{GE}$ | 3.5 | 4.5 | 6.0 | V |
| $V_{CE(sat)}$ | Collector to Emitter Saturation Voltage | $I_C$ = 60 A, $V_{GE}$ = 15 V | – | 1.9 | 2.5 | V |
| | | $I_C$ = 60 A, $V_{GE}$ = 15 V, $T_C$ = 175°C | – | 2.1 | – | V |
| **DYNAMIC CHARACTERISTICS** | | | | | | |
| $C_{ies}$ | Input Capacitance | $V_{CE}$ = 30 V, $V_{GE}$ = 0 V, f = 1 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 V, $I_C$ = 60 A, $V_{GE}$ = 15 V, $R_G$ = 3 Ω, Inductive Load, $T_C$ = 25°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 | | – | 1.54 | 2.31 | mJ |
| $E_{off}$ | Turn−Off Switching Loss | | – | 0.45 | 0.60 | mJ |
| $E_{ts}$ | Total Switching Loss | | – | 1.99 | 2.91 | mJ |
| $t_{d(on)}$ | Turn-On Delay Time | $V_{CC}$ = 400 V, $I_C$ = 60 A, $V_{GE}$ = 15 V, $R_G$ = 3 Ω, Inductive Load, $T_C$ = 175°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 | | – | 2.08 | – | mJ |
| $E_{off}$ | Turn−Off Switching Loss | | – | 0.78 | – | mJ |
| $E_{ts}$ | Total Switching Loss | | – | 2.86 | – | mJ |
| $Q_g$ | Total Gate Charge | $V_{CE}$ = 400 V, $I_C$ = 60 A, $V_{GE}$ = 15 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.

**ELECTRICAL CHARACTERISTICS OF THE DIODE** ($T_C$ = 25°C unless otherwise noted)

| Symbol | Parameter | Test Condition | | Min. | Typ. | Max. | Unit |
|---|---|---|---|---|---|---|---|
| $V_{FM}$ | Diode Forward Voltage | $I_F$ = 30 A | $T_C$ = 25°C | – | 2.1 | 2.6 | V |
| | | | $T_C$ = 175°C | – | 1.7 | – | |
| $E_{rec}$ | Reverse Recovery Energy | $I_F$ = 30 A, $dI_F/dt$ = 200 A/μs | $T_C$ = 175°C | – | 127 | – | μJ |
| $t_{rr}$ | Diode Reverse Recovery Time | | $T_C$ = 25°C | – | 47 | – | ns |
| | | | $T_C$ = 175°C | – | 212 | – | |
| $Q_{rr}$ | Diode Reverse Recovery Charge | | $T_C$ = 25°C | – | 87 | – | nC |
| | | | $T_C$ = 175°C | – | 933 | – | |

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

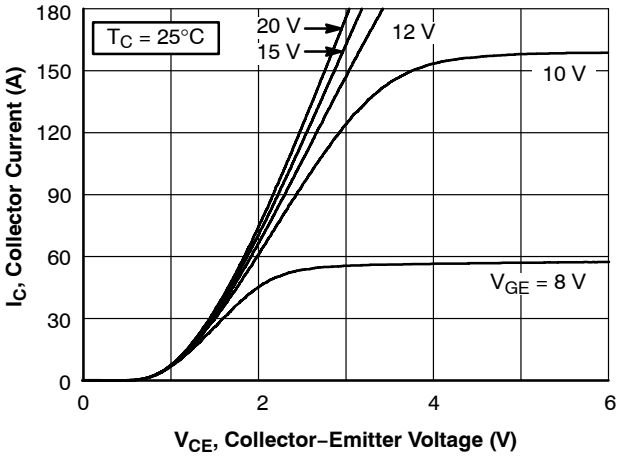


**Figure 1. Typical Output Characteristics**

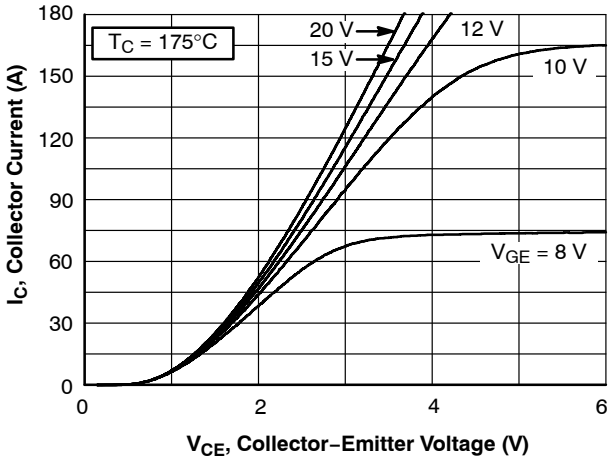


**Figure 2. Typical Output Characteristics**

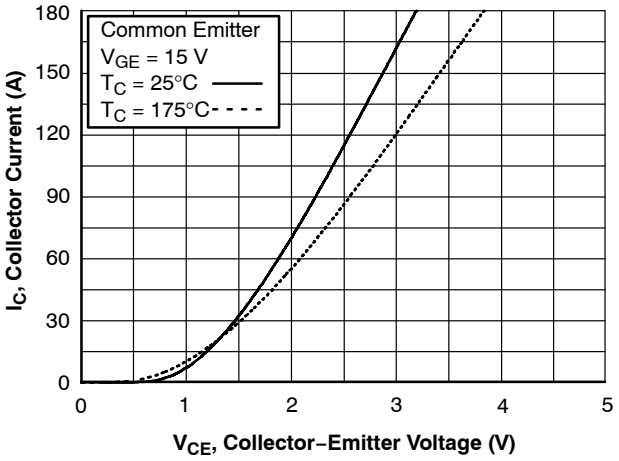


**Figure 3. Typical Saturation Voltage Characteristics**

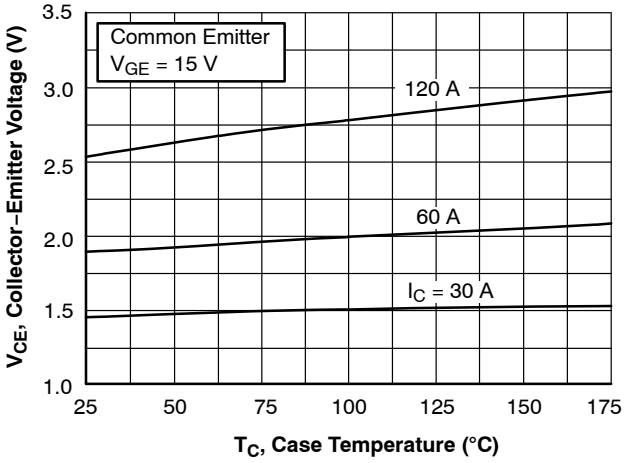


**Figure 4. Saturation Voltage vs. Case Temperature at Variant Current Level**

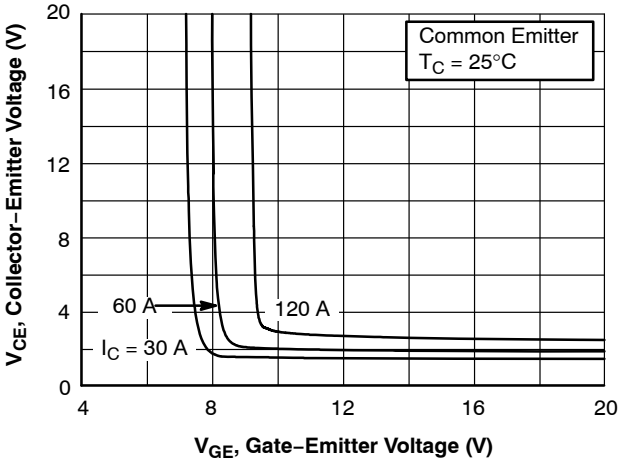


**Figure 5. Saturation Voltage vs. $V_{GE}$**

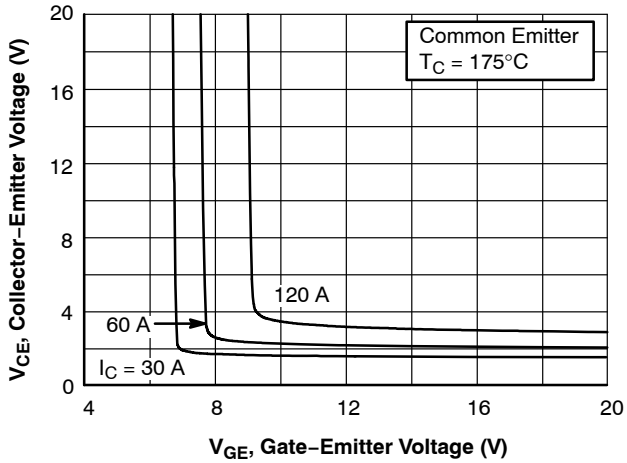


**Figure 6. Saturation Voltage vs. $V_{GE}$**

## TYPICAL PERFORMANCE CHARACTERISTICS (continued)

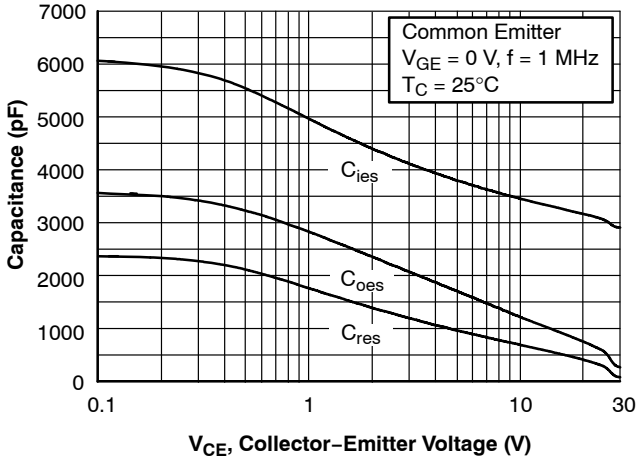


Figure 7. Capacitance Characteristics

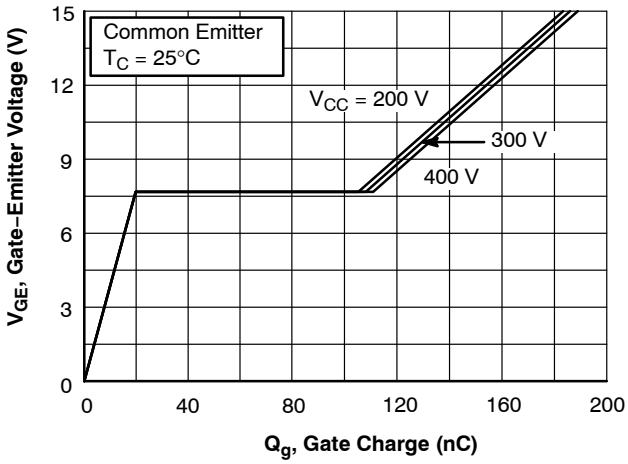


Figure 8. Gate Charge Characteristics

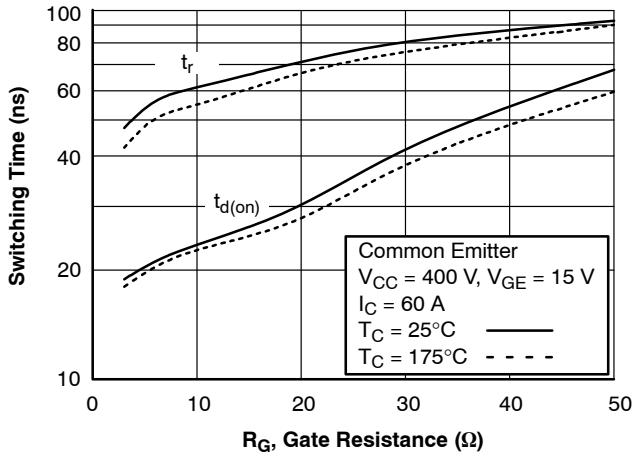


Figure 9. Turn−on Characteristics vs. Gate Resistance

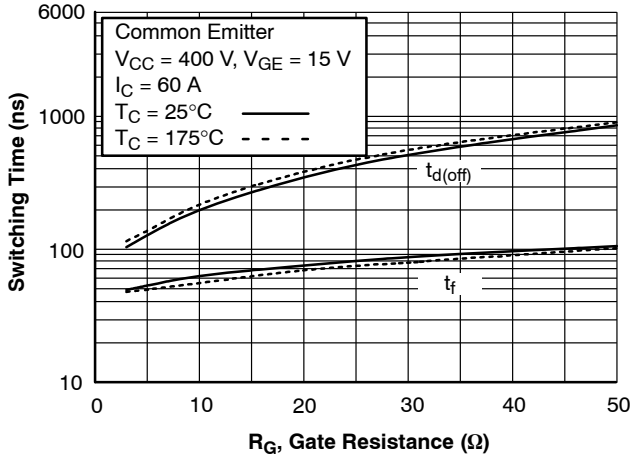


Figure 10. Turn−off Characteristics vs. Gate Resistance

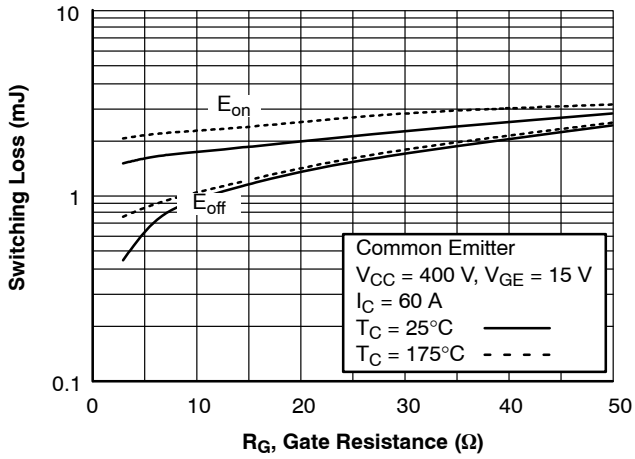


Figure 11. Switching Loss vs. Gate Resistance

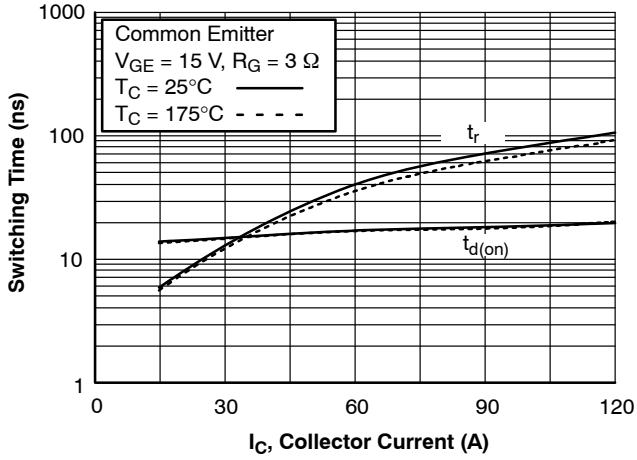


Figure 12. Turn−on Characteristics vs. Collector Current

## TYPICAL PERFORMANCE CHARACTERISTICS (continued)

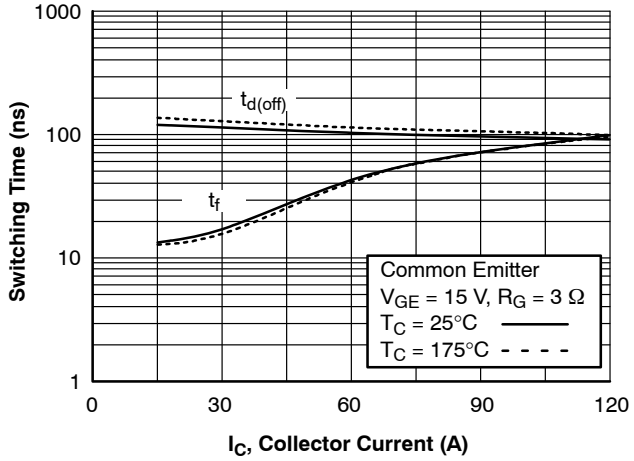


**Figure 13. Turn−off Characteristics vs. Collector Current**

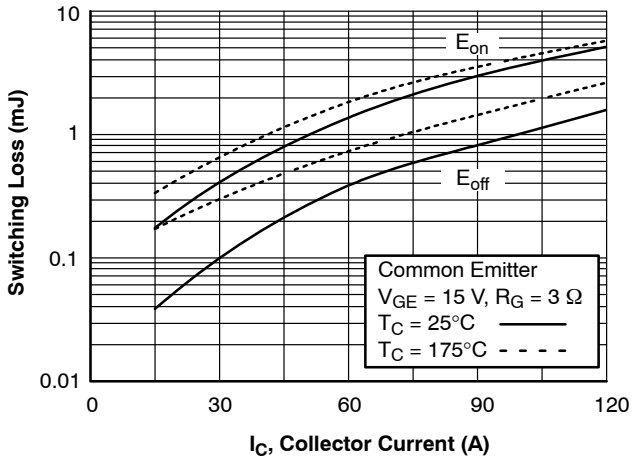


**Figure 14. Switching Loss vs. Collector Current**

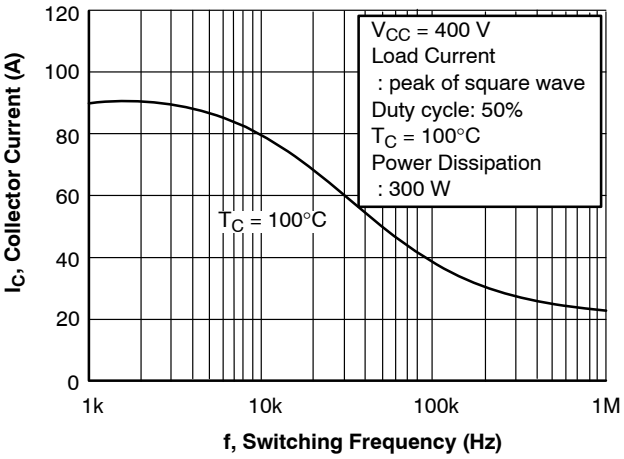


**Figure 15. Load Current vs. Frequency**

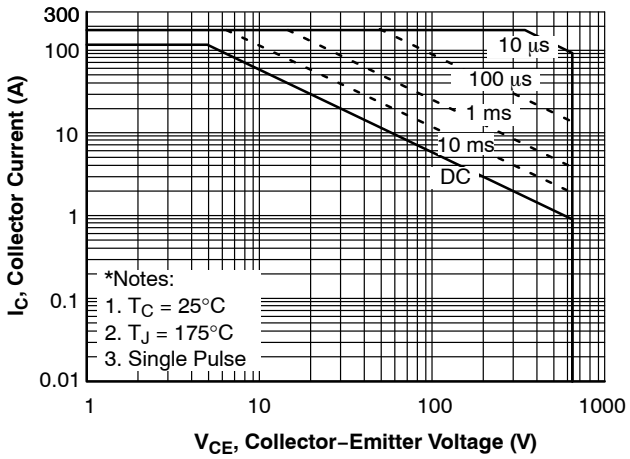


**Figure 16. SOA Characteristics**

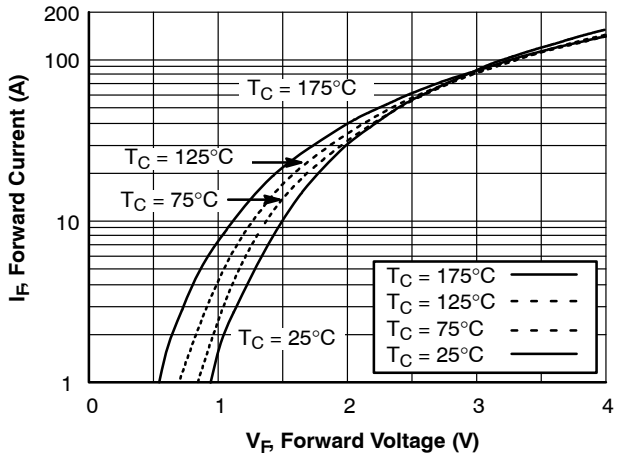


**Figure 17. Forward Characteristics**

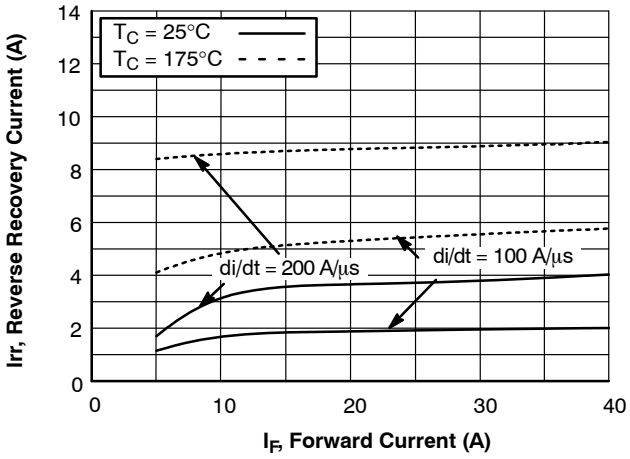


**Figure 18. Reverse Recovery Current**

## TYPICAL PERFORMANCE CHARACTERISTICS (continued)

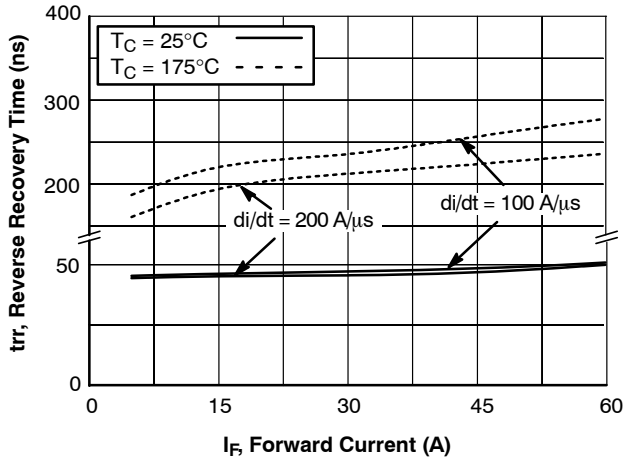


Figure 19. Reverse Recovery Time

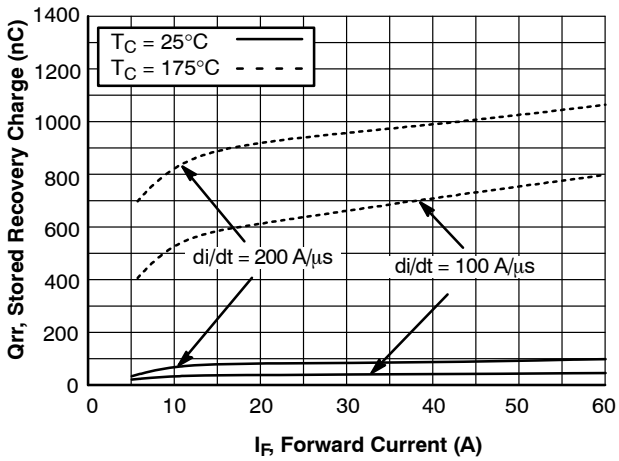


Figure 20. Stored Charge

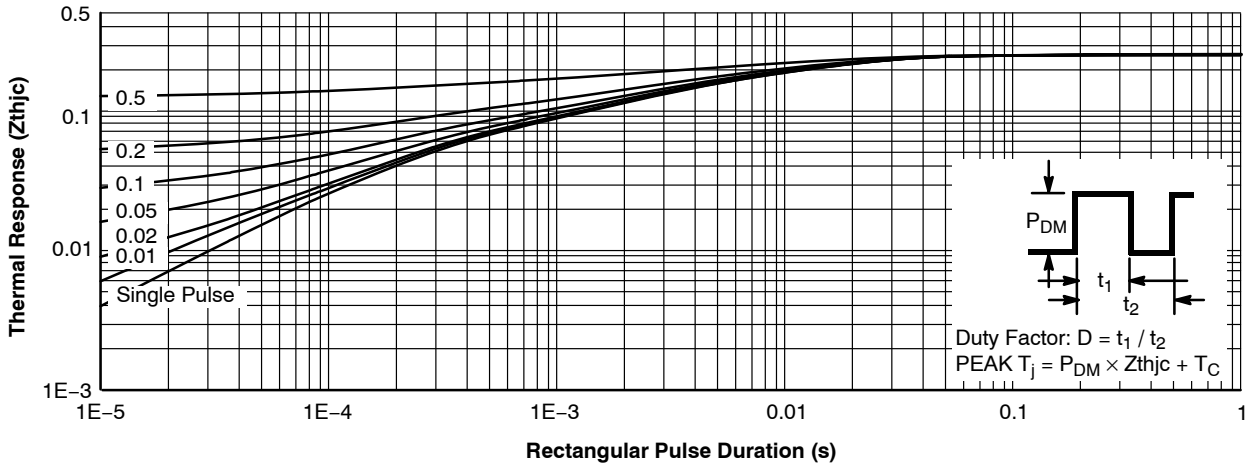


Figure 21. Transient Thermal Impedance of IGBT

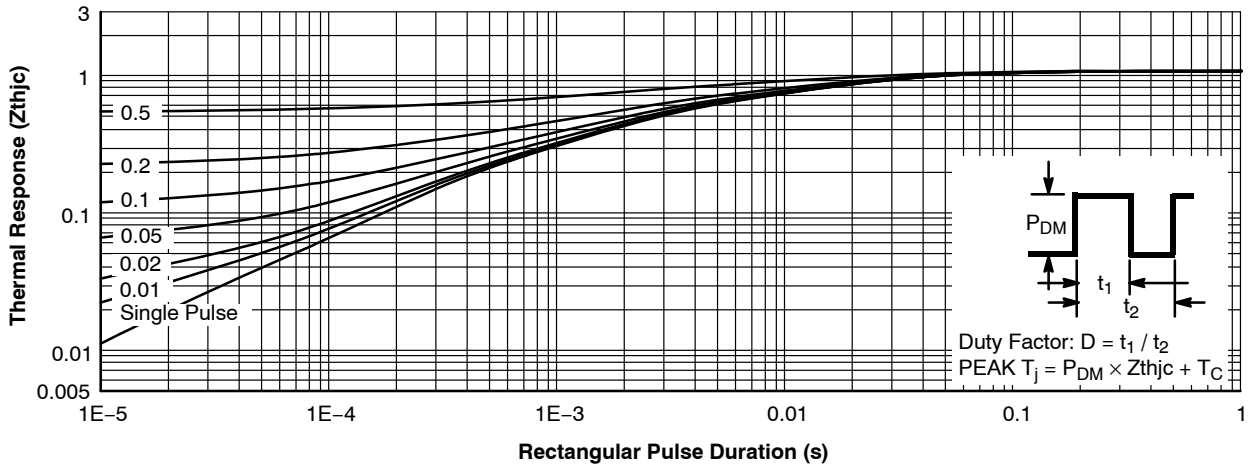


Figure 22. Transient Thermal Impedance of Diode

**TO−3P−3LD / EIAJ SC−65, ISOLATED**
CASE 340BZ
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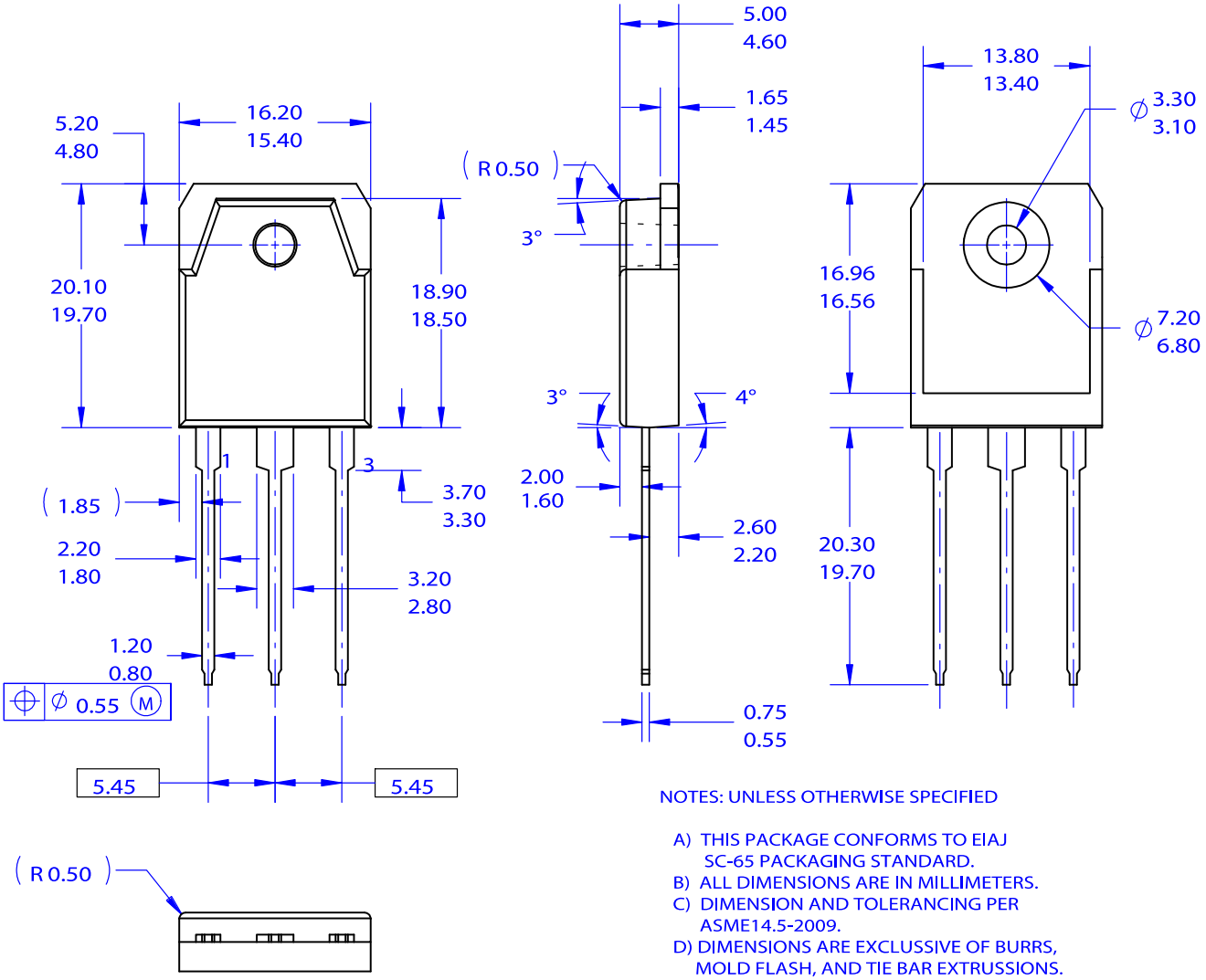
DATE 31 OCT 2016

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C) DIMENSION AND TOLERANCING PER ASME14.5-2009.
D) DIMENSIONS ARE EXCLUSSIVE OF BURRS, MOLD FLASH, AND TIE BAR EXTRUSSIONS.

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