



ON Semiconductor®

January 2018

# FGH60T65SQD

## 650 V, 60 A Field Stop Trench IGBT

### Features

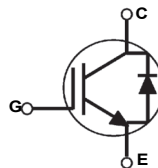
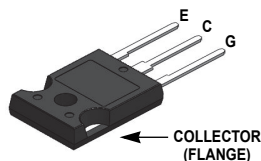
- Maximum Junction Temperature:  $T_J = 175^{\circ}\text{C}$
- Positive Temperature Co-efficient for Easy Parallel Operating
- High Current Capability
- Low Saturation Voltage:  $V_{CE(sat)} = 1.6\text{ V (Typ.) @ } I_C = 60\text{ A}$
- 100% of the Parts tested for  $I_{LM}(1)$
- High Input Impedance
- Fast Switching
- Tighten Parameter Distribution
- RoHS Compliant

### General Description

Using novel field stop IGBT technology, ON semiconductor's new series of field stop 4<sup>th</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.

### Applications

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



### Absolute Maximum Ratings

Symbol	Description	FGH60T65SQD-F155	Unit
$V_{CES}$	Collector to Emitter Voltage	650	V
$V_{GES}$	Gate to Emitter Voltage	$\pm 20$	V
	Transient Gate to Emitter Voltage	$\pm 30$	V
$I_C$	Collector Current @ $T_C = 25^{\circ}\text{C}$	120	A
	Collector Current @ $T_C = 100^{\circ}\text{C}$	60	A
$I_{LM}(1)$	Pulsed Collector Current @ $T_C = 25^{\circ}\text{C}$	240	A
$I_{CM}(2)$	Pulsed Collector Current	240	A
$I_F$	Diode Forward Current @ $T_C = 25^{\circ}\text{C}$	60	A
	Diode Forward Current @ $T_C = 100^{\circ}\text{C}$	30	A
$I_{FM}(2)$	Pulsed Diode Maximum Forward Current	240	A
$P_D$	Maximum Power Dissipation @ $T_C = 25^{\circ}\text{C}$	333	W
	Maximum Power Dissipation @ $T_C = 100^{\circ}\text{C}$	167	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	$^{\circ}\text{C}$

#### Notes:

1.  $V_{CC} = 400\text{ V}$ ,  $V_{GE} = 15\text{ V}$ ,  $I_C = 240\text{ A}$ ,  $R_G = 21\ \Omega$ , Inductive Load
2. Repetitive rating: Pulse width limited by max. junction temperature

## Thermal Characteristics

Symbol	Parameter	FGH60T65SQD-F155	Unit
$R_{\theta JC}(IGBT)$	Thermal Resistance, Junction to Case, Max.	0.45	$^{\circ}\text{C}/\text{W}$
$R_{\theta JC}(\text{Diode})$	Thermal Resistance, Junction to Case, Max.	1.25	$^{\circ}\text{C}/\text{W}$
$R_{\theta JA}$	Thermal Resistance, Junction to Ambient, Max.	40	$^{\circ}\text{C}/\text{W}$

## Package Marking and Ordering Information

Part Number	Top Mark	Package	Packing Method	Reel Size	Tape Width	Quantity
FGH60T65SQD-F155	FGH60T65SQD	TO-247 G03	Tube	-	-	30

## 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 <sub>CES</sub>	Collector to Emitter Breakdown Voltage	V <sub>GE</sub> = 0V, I <sub>C</sub> = 1 mA	650	-	-	V
ΔBV <sub>CES</sub> / ΔT <sub>J</sub>	Temperature Coefficient of Breakdown Voltage	I <sub>C</sub> = 1 mA, Reference to 25°C	-	0.6	-	V/°C
I <sub>CES</sub>	Collector Cut-Off Current	V <sub>CE</sub> = V <sub>CES</sub> , V <sub>GE</sub> = 0 V	-	-	250	μA
I <sub>GES</sub>	G-E Leakage Current	V <sub>GE</sub> = V <sub>GES</sub> , V <sub>CE</sub> = 0 V	-	-	±400	nA
On Characteristics						
V <sub>GE(th)</sub>	G-E Threshold Voltage	I <sub>C</sub> = 60 mA, V <sub>CE</sub> = V <sub>GE</sub>	2.6	4.5	6.4	V
V <sub>CE(sat)</sub>	Collector to Emitter Saturation Voltage	I <sub>C</sub> = 60 A, V <sub>GE</sub> = 15 V	-	1.6	2.1	V
		I <sub>C</sub> = 60 A, V <sub>GE</sub> = 15 V, T <sub>C</sub> = 175°C	-	1.92	-	V
Dynamic Characteristics						
C <sub>ies</sub>	Input Capacitance	V <sub>CE</sub> = 30 V, V <sub>GE</sub> = 0 V, f = 1MHz	-	3813	-	pF
C <sub>oes</sub>	Output Capacitance		-	90	-	pF
C <sub>res</sub>	Reverse Transfer Capacitance		-	13	-	pF
Switching Characteristics						
t <sub>d(on)</sub>	Turn-On Delay Time	V <sub>CC</sub> = 400 V, I <sub>C</sub> = 15 A, R <sub>G</sub> = 4.7 Ω, V <sub>GE</sub> = 15 V, Inductive Load, T <sub>C</sub> = 25°C	-	20.8	-	ns
t <sub>r</sub>	Rise Time		-	8	-	ns
t <sub>d(off)</sub>	Turn-Off Delay Time		-	102	-	ns
t <sub>f</sub>	Fall Time		-	11.2	-	ns
E <sub>on</sub>	Turn-On Switching Loss		-	227	-	μJ
E <sub>off</sub>	Turn-Off Switching Loss		-	100	-	μJ
E <sub>ts</sub>	Total Switching Loss		-	327	-	μJ
t <sub>d(on)</sub>	Turn-On Delay Time	V <sub>CC</sub> = 400 V, I <sub>C</sub> = 30 A, R <sub>G</sub> = 4.7 Ω, V <sub>GE</sub> = 15 V, Inductive Load, T <sub>C</sub> = 25°C	-	21.6	-	ns
t <sub>r</sub>	Rise Time		-	14.4	-	ns
t <sub>d(off)</sub>	Turn-Off Delay Time		-	97.6	-	ns
t <sub>f</sub>	Fall Time		-	4.8	-	ns
E <sub>on</sub>	Turn-On Switching Loss		-	585	-	μJ
E <sub>off</sub>	Turn-Off Switching Loss		-	167	-	μJ
E <sub>ts</sub>	Total Switching Loss		-	752	-	μJ

**Electrical Characteristics of the IGBT** (Continued)

Symbol	Parameter	Test Conditions	Min.	Typ.	Max.	Unit
$T_{d(on)}$	Turn-On Delay Time	$V_{CC} = 400\text{ V}$ , $I_C = 15\text{ A}$ , $R_G = 4.7\ \Omega$ , $V_{GE} = 15\text{ V}$ , Inductive Load, $T_C = 175^\circ\text{C}$	-	19.2	-	ns
$T_r$	Rise Time		-	9.6	-	ns
$T_{d(off)}$	Turn-Off Delay Time		-	115	-	ns
$T_f$	Fall Time		-	11.2	-	ns
$E_{on}$	Turn-On Switching Loss		-	448	-	$\mu\text{J}$
$E_{off}$	Turn-Off Switching Loss		-	199	-	$\mu\text{J}$
$E_{ts}$	Total Switching Loss		-	647	-	$\mu\text{J}$
$T_{d(on)}$	Turn-On Delay Time	$V_{CC} = 400\text{ V}$ , $I_C = 30\text{ A}$ , $R_G = 4.7\ \Omega$ , $V_{GE} = 15\text{ V}$ , Inductive Load, $T_C = 175^\circ\text{C}$	-	20.8	-	ns
$T_r$	Rise Time		-	16	-	ns
$T_{d(off)}$	Turn-Off Delay Time		-	106	-	ns
$T_f$	Fall Time		-	8.8	-	ns
$E_{on}$	Turn-On Switching Loss		-	942	-	$\mu\text{J}$
$E_{off}$	Turn-Off Switching Loss		-	386	-	$\mu\text{J}$
$E_{ts}$	Total Switching Loss		-	1328	-	$\mu\text{J}$
$Q_g$	Total Gate Charge	$V_{CE} = 400\text{ V}$ , $I_C = 60\text{ A}$ , $V_{GE} = 15\text{ V}$	-	79	-	nC
$Q_{ge}$	Gate to Emitter Charge		-	22	-	nC
$Q_{gc}$	Gate to Collector Charge		-	27	-	nC

**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	-	2.3	2.7	V
			T <sub>C</sub> = 175°C	-	1.9	-	
E <sub>rec</sub>	Reverse Recovery Energy	I <sub>F</sub> = 30 A, dI <sub>F</sub> /dt = 200 A/μs	T <sub>C</sub> = 175°C	-	50	-	μJ
T <sub>rr</sub>	Diode Reverse Recovery Time		T <sub>C</sub> = 25°C	-	34.6	-	ns
			T <sub>C</sub> = 175°C	-	197	-	
Q <sub>rr</sub>	Diode Reverse Recovery Charge		T <sub>C</sub> = 25°C	-	58.6	-	nC
			T <sub>C</sub> = 175°C	-	810	-	

## Typical Performance Characteristics

Figure 1. Typical Output Characteristics

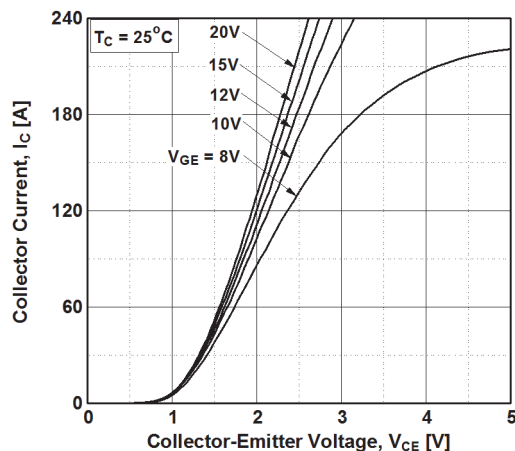


Figure 2. Typical Output Characteristics

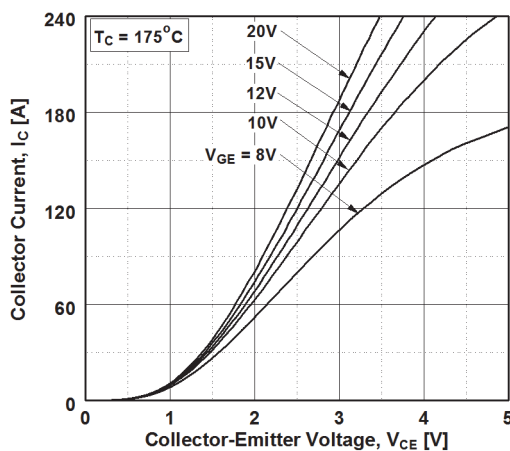


Figure 3. Typical Saturation Voltage Characteristics

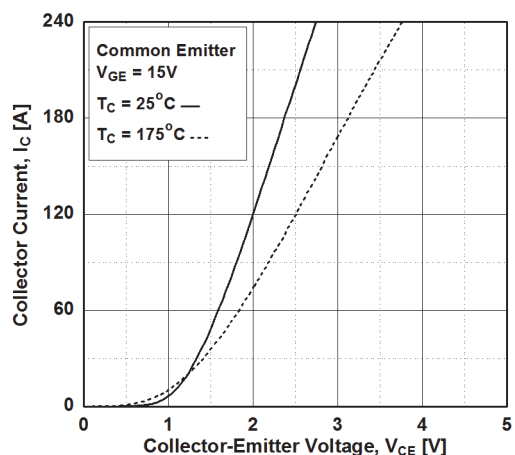


Figure 4. Saturation Voltage vs. Case Temperature at Variant Current Level

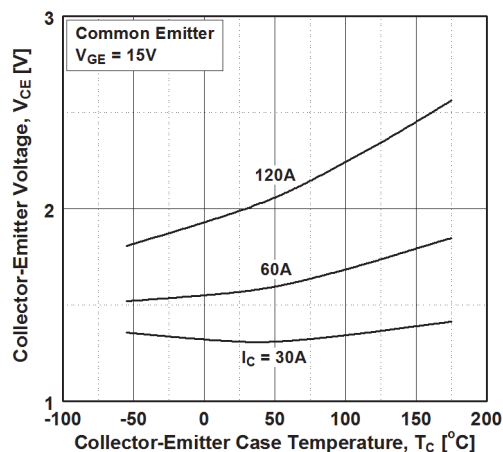


Figure 5. Saturation Voltage vs.  $V_{GE}$

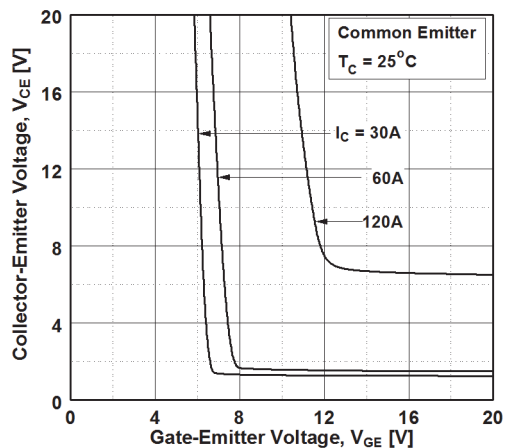
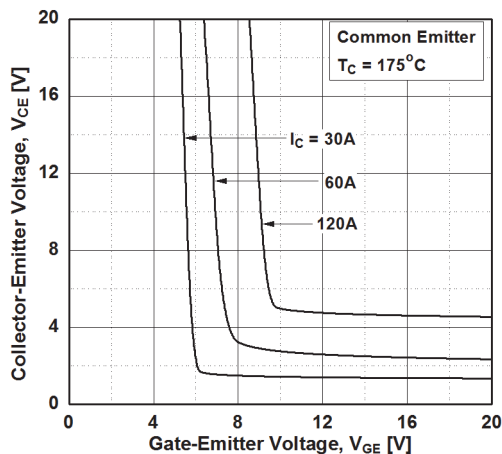


Figure 6. Saturation Voltage vs.  $V_{GE}$



## Typical Performance Characteristics

Figure 7. Capacitance Characteristics

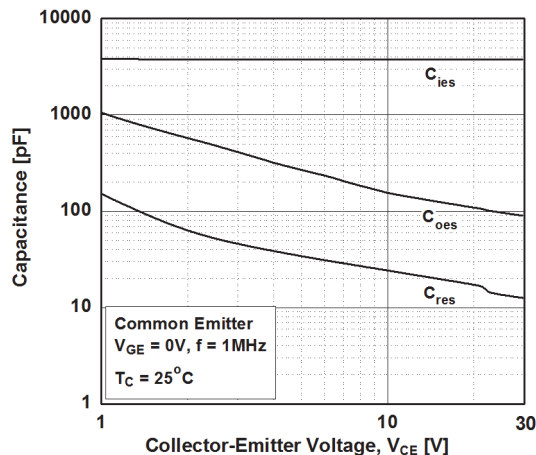


Figure 8. Gate charge Characteristics

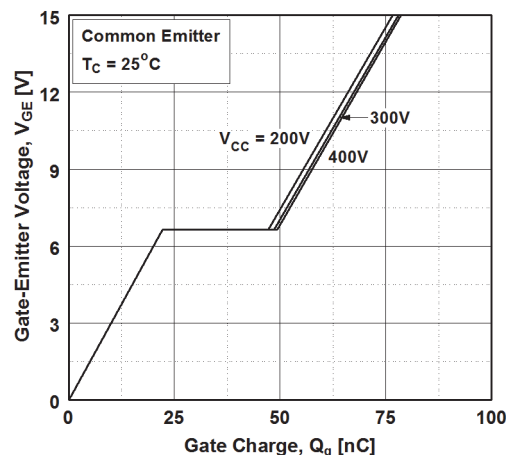


Figure 9. Turn-on Characteristics vs. Gate Resistance

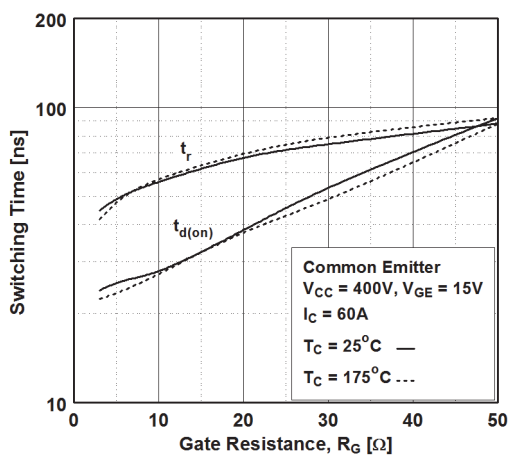


Figure 10. Turn-off Characteristics vs. Gate Resistance

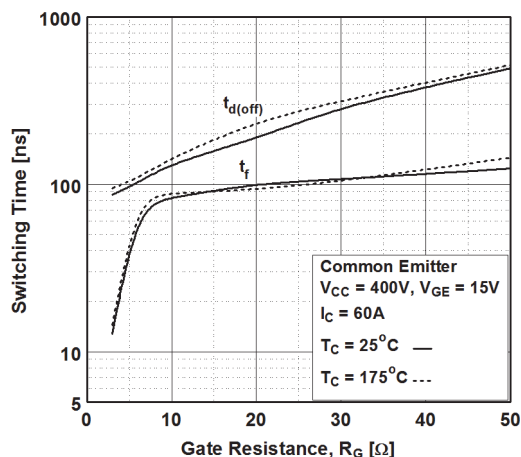


Figure 11. Switching Loss vs. Gate Resistance

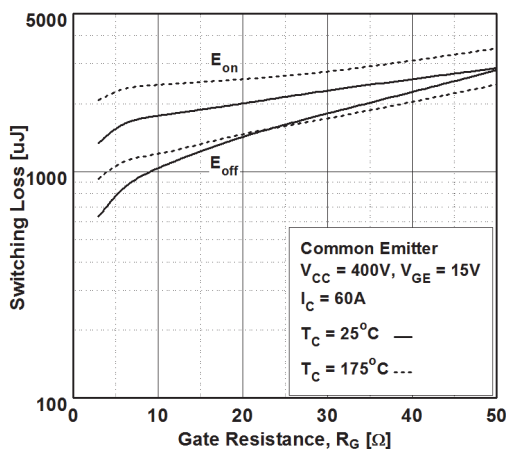
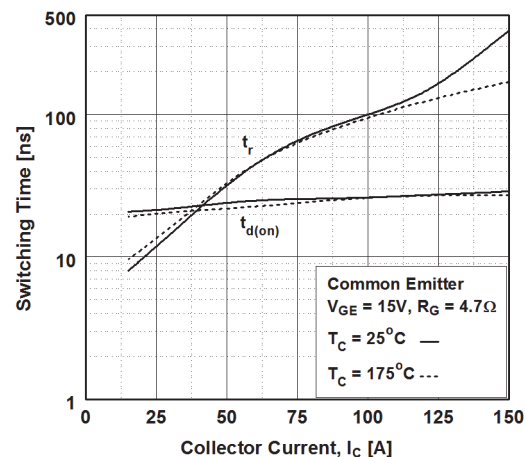


Figure 12. Turn-on Characteristics vs. Collector Current



## Typical Performance Characteristics

Figure 13. Turn-off Characteristics vs. Collector Current

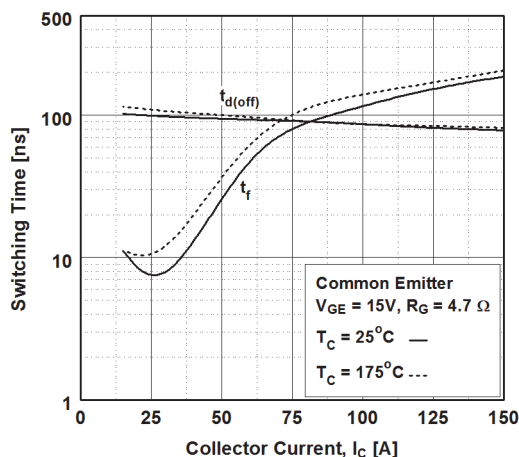


Figure 14. Switching Loss vs. Collector Current

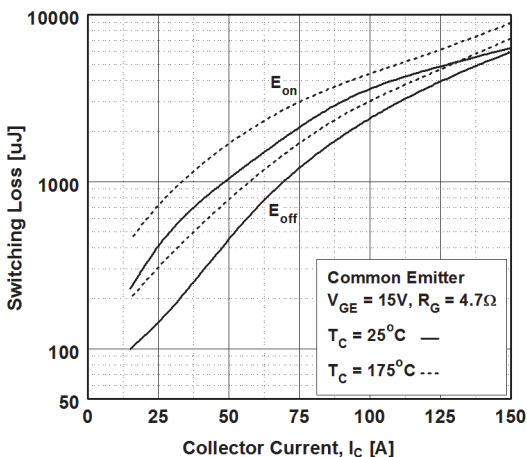


Figure 15. Load Current Vs. Frequency

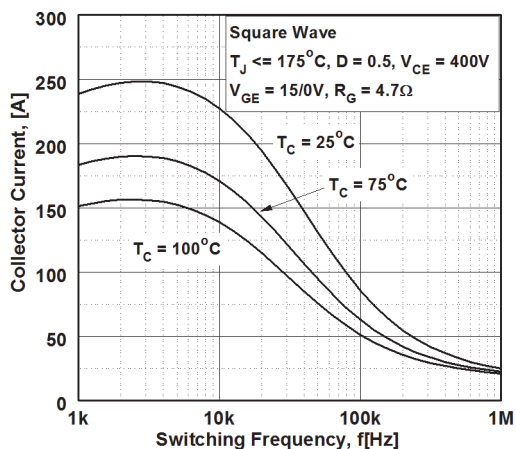


Figure 16. SOA Characteristics

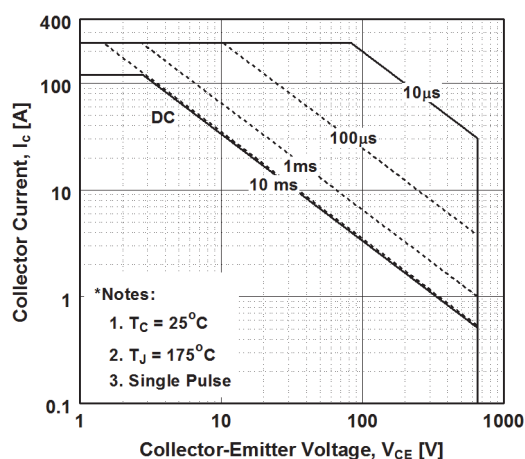


Figure 17. Forward Characteristics

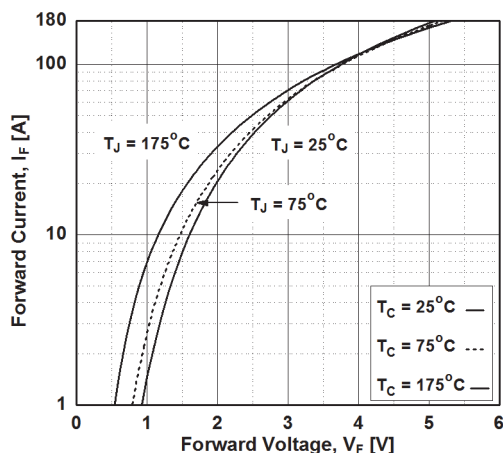
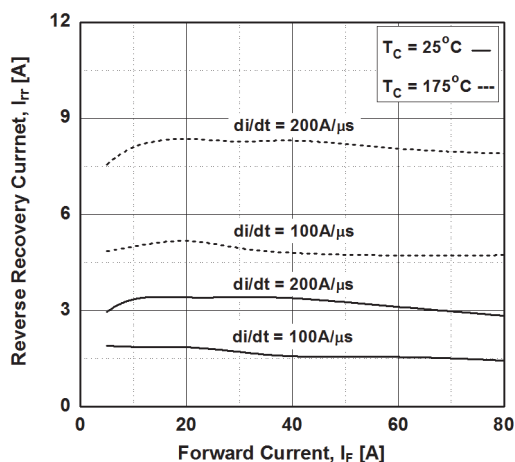


Figure 18. Reverse Recovery Current



## Typical Performance Characteristics

Figure 19. Reverse Recovery Time

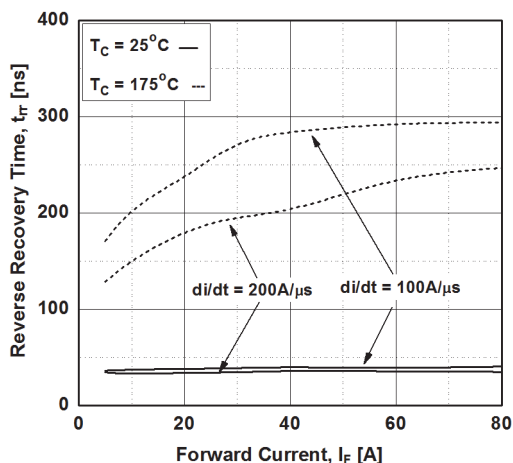


Figure 20. Stored Charge

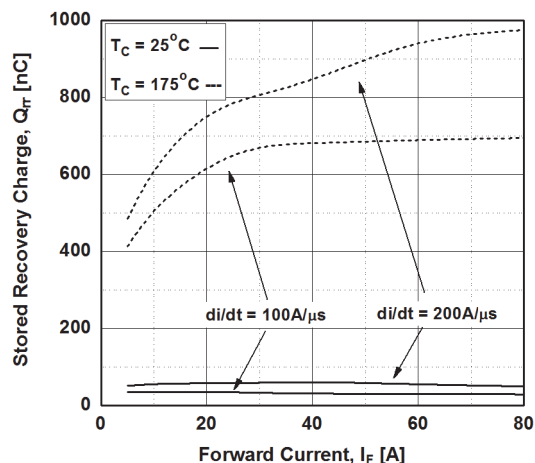


Figure 21. Transient Thermal Impedance of IGBT

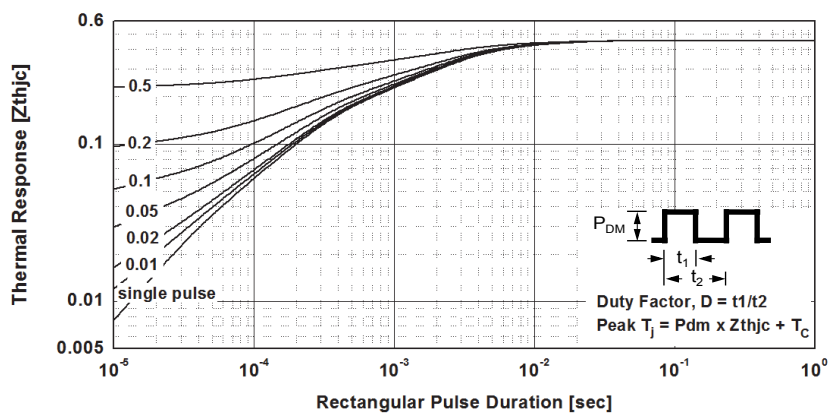
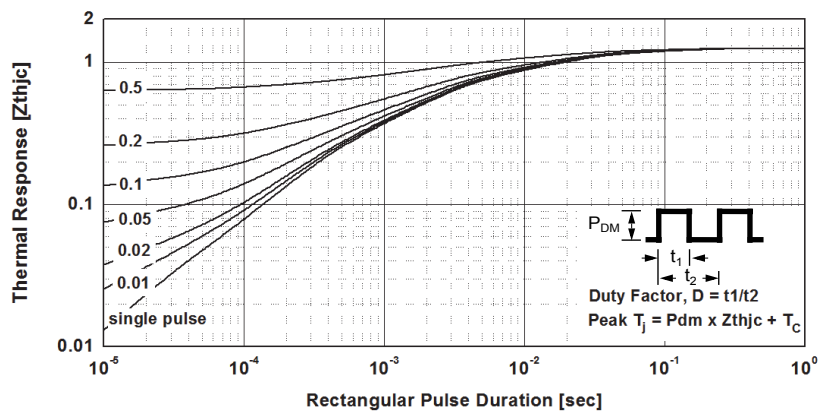
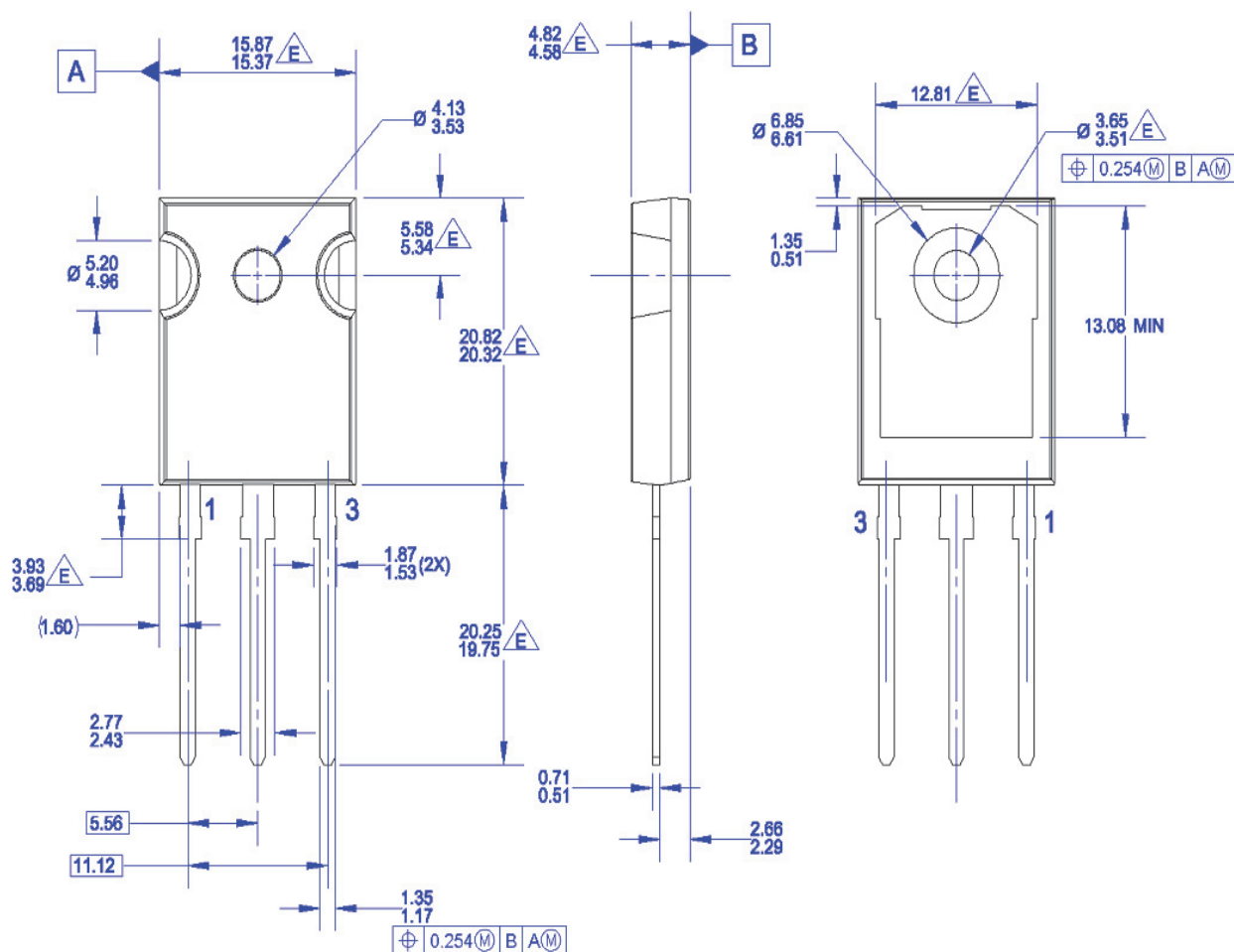


Figure 22. Transient Thermal Impedance of Diode



## Mechanical Dimensions




NOTES: UNLESS OTHERWISE SPECIFIED.

- A. PACKAGE REFERENCE: JEDEC TO-247, ISSUE E, VARIATION AB, DATED JUNE, 2004.
- B. DIMENSIONS ARE EXCLUSIVE OF BURRS, MOLD FLASH, AND TIE BAR EXTRUSIONS.
- C. ALL DIMENSIONS ARE IN MILLIMETERS.
- D. DRAWING CONFORMS TO ASME Y14.5 - 1994

E. DOES NOT COMPLY JEDEC STANDARD VALUE  
F. DRAWING FILENAME: MKT-TO247G03\_REV02



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