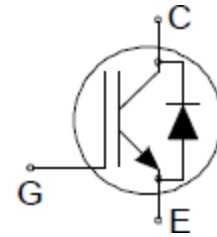




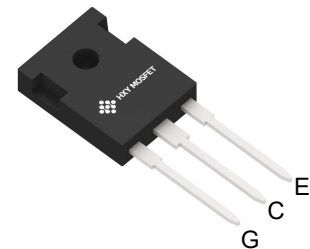
1. Description

FGH60N60SFDTU is obtained by advanced Trench and Field Stop (T-FS) technology which reduces the conduction loss, improves switching performance and enhances the avalanche energy.



Device Per Unit

Package Type	Unit	Quantity
TO-247	Tube	30



TO-247

Key Characteristics

Parameter	Value	Unit
V_{CES}	650	V
I_C	60	A
$V_{CE(sat).typ}$	1.65	V

Features

- Positive temperature coefficient
- Fast Switching
- Low $V_{CE(sat)}$
- Reliable and Rugged
- Halogen Free and Green Devices Available
- (RoHS Compliant)

Applications

- UPS
- Motor drives
- Boost
- Portable power station



2. Absolute Ratings

Symbol	Parameter	Values	Units
V_{CES}	Collector-Emitter Voltage	650	V
I_C	Collector Current @ $T_C=25^{\circ}\text{C}$	100	A
	Collector Current @ $T_C=100^{\circ}\text{C}$	60	A
I_{CM}	Pulsed Collector Current, tp limited by T_{Jmax}	200	A
I_F	Diode Continuous Forward Current @ $T_C=25^{\circ}\text{C}$	100	A
	Diode Continuous Forward Current @ $T_C=100^{\circ}\text{C}$	60	A
I_{FM}	Diode Maximum Forward Current, limited by T_{Jmax}	200	A
V_{GES}	Gate-Emitter Voltage	± 30	V
t_{SC}	Short circuit withstand time $V_{GE}=15\text{V}$, $V_{CC}\leq 400\text{V}$, allowed number of short circuits < 1000, times between short circuits $\geq 1.0\text{s}$, $T_J\leq 175^{\circ}\text{C}$	8	μs
P_D	Power Dissipation @ $T_C=25^{\circ}\text{C}$	250	W
T_{Jmax} , T_{stg}	Operating Junction and Storage Temperature Range	-55 to 175	$^{\circ}\text{C}$
T_L	Maximum Temperature for Soldering	260	$^{\circ}\text{C}$

3. Therman Characteristics

Symbol	Parameter	Values	Units
$R_{\theta JC}$	Junction-to-Case (IGBT)	0.60	$^{\circ}\text{C/W}$
$R_{\theta JC}$	Junction-to-Case (Diode)	0.55	$^{\circ}\text{C/W}$
$R_{\theta JA}$	Junction-to-Ambient	40	$^{\circ}\text{C/W}$

4. Electrical Characteristics (at $T_C = 25^{\circ}\text{C}$, unless otherwise specified)

Static Characteristics

Symbol	Parameter	Test Conditions	Values			Units
			Min.	Typ.	Max.	
V_{CES}	Collector-Emitter Breakdown Voltage	$V_{GE}=0\text{V}$ $I_C=1\text{mA}$	650	--	--	V
$V_{CE(sat)}$	Collector-Emitter Saturation Voltage	$V_{GE}=15\text{V}$ $I_C=60\text{A}$ $T_J=25^{\circ}\text{C}$	--	1.65	2.00	V
		$T_J=125^{\circ}\text{C}$	--	1.85	--	
		$T_J=175^{\circ}\text{C}$	--	2.00	--	
			--	--	--	



$V_{GE(TH)}$	Gate Threshold Voltage	$V_{CE}=V_{GE}, I_C=1mA$	4.3	5.3	6.3	V
V_F	Diode Forward Voltage	$I_F=50A$ $T_J=25^{\circ}C$ $T_J=125^{\circ}C$ $T_J=175^{\circ}C$	-- -- --	1.65 1.57 1.47	2.05 -- --	V
I_{CES}	Collector-Emitter Leakage Current	$V_{CE}=650V$ $V_{GE}=0V$	--	--	10	μA
$I_{GES(F)}$	Gate-Emitter Forward Leakage Current	$V_{GE}=+20V$	--	--	200	nA
$I_{GES(R)}$	Gate-Emitter Reverse Leakage Current	$V_{GE}=-20V$	--	--	-200	nA
Pulse width $tp \leq 300\mu s$, $\delta \leq 2\%$						

Dynamic Characteristics

Symbol	Parameter	Test Conditions	Values			Units
			Min.	Typ.	Max.	
C_{ies}	Input Capacitance	$V_{GE}=0V$ $V_{CE}=25V$ $f=1.0MHz$	--	3356	--	pF
C_{oes}	Output Capacitance		--	179	--	
C_{res}	Reverse Transfer Capacitance		--	93	--	
Q_g	Gate charge	$V_{CC}=520V$ $I_{CE}=60A$ $V_{GE}=15V$	--	183	--	nC
Q_{ge}	Gate-emitter charge		--	26	--	
Q_{gc}	Gate-collector charge		--	83	--	

IGBT Switching Characteristics, at $T_J=25^{\circ}C$

Symbol	Parameter	Test Conditions	Values			Units
			Min.	Typ.	Max.	
$t_{d(on)}$	Turn-on Delay Time	$I_C=60A$ $V_{CC}=400V$ $V_{GE}=15V$ $R_g=5\Omega$ Inductive Load	--	24	--	ns
t_r	Rise Time		--	88	--	
$t_{d(off)}$	Turn-Off Delay Time		--	124	--	
t_f	Fall Time		--	73	--	
E_{on}	Turn-On Switching Loss		--	1.40	--	mJ
E_{off}	Turn-Off Switching Loss		--	1.20	--	
E_{ts}	Total Switching Loss		--	2.60	--	



IGBT Switching Characteristics, at $T_J=175^{\circ}\text{C}$

Symbol	Parameter	Test Conditions	Values			Units
			Min.	Typ.	Max.	
$t_{d(on)}$	Turn-on Delay Time	$I_C=60\text{A}$ $V_{CC}=400\text{V}$ $V_{GE}=15\text{V}$ $R_g=5\Omega$ Inductive Load	--	30	--	ns
t_r	Rise Time		--	95	--	
$t_{d(off)}$	Turn-Off Delay Time		--	152	--	
t_f	Fall Time		--	67	--	
E_{on}	Turn-On Switching Loss		--	1.62	--	mJ
E_{off}	Turn-Off Switching Loss		--	1.50	--	
E_{ts}	Total Switching Loss		--	3.12	--	

Diode Characteristics, at $T_J=25^{\circ}\text{C}$

Symbol	Parameter	Test Conditions	Values			Units
			Min.	Typ.	Max.	
T_{rr}	Reverse Recovery Time	$I_F=60\text{A}$ $V_{CC}=400\text{V}$ $di/dt=200\text{A}/\mu\text{s}$	--	136	-	ns
Q_{rr}	Reverse Recovery Charge		--	350	-	nC
I_{rrm}	Reverse Recovery Current		--	6.9	-	A

Diode Characteristics, at $T_J=175^{\circ}\text{C}$

Symbol	Parameter	Test Conditions	Values			Units
			Min.	Typ.	Max.	
T_{rr}	Reverse Recovery Time	$I_F=60\text{A}$ $V_{CC}=400\text{V}$ $di/dt=200\text{A}/\mu\text{s}$	--	183	-	ns
Q_{rr}	Reverse Recovery Charge		--	560	-	nC
I_{rrm}	Reverse Recovery Current		--	7.8	-	A



5. Characteristics Curves

Figure 1: Power Dissipation

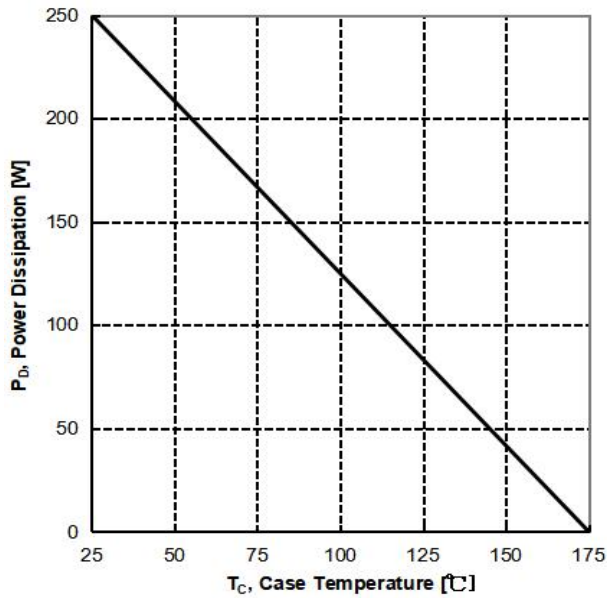


Figure 2: Collector Current vs. Case Temperature

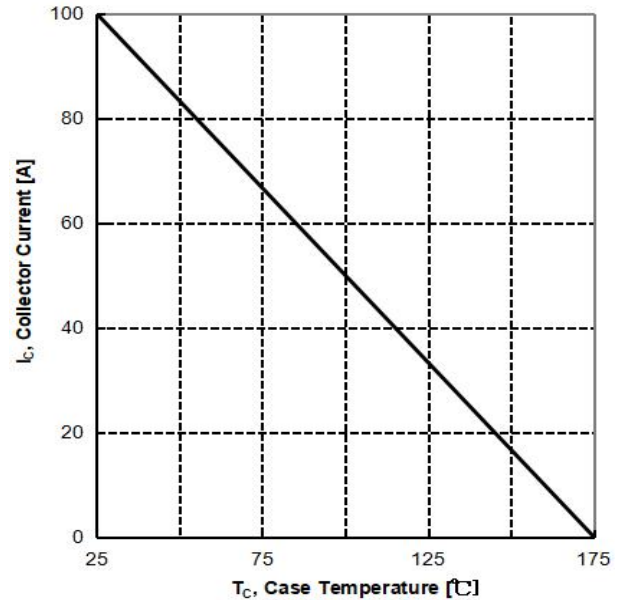


Figure 3: Safe Operation Area

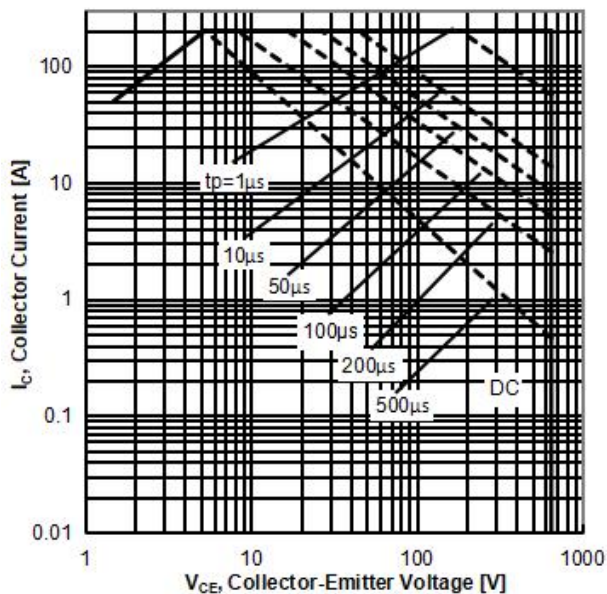


Figure 4: Typical Transfer Characteristics

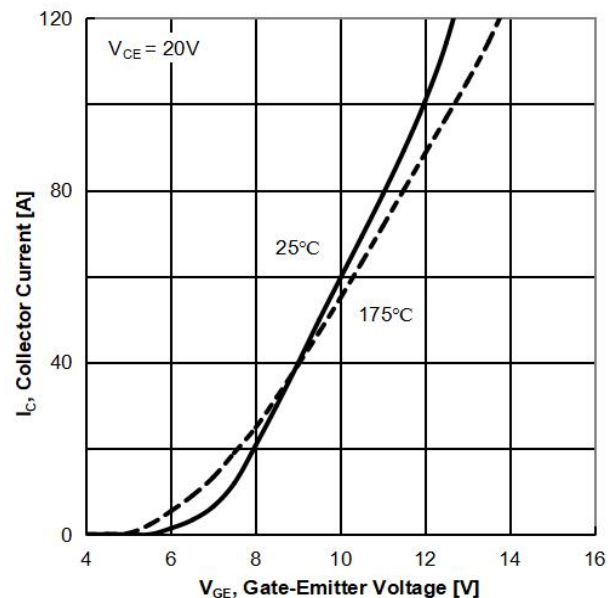




Figure 5: Typical Output Characteristics

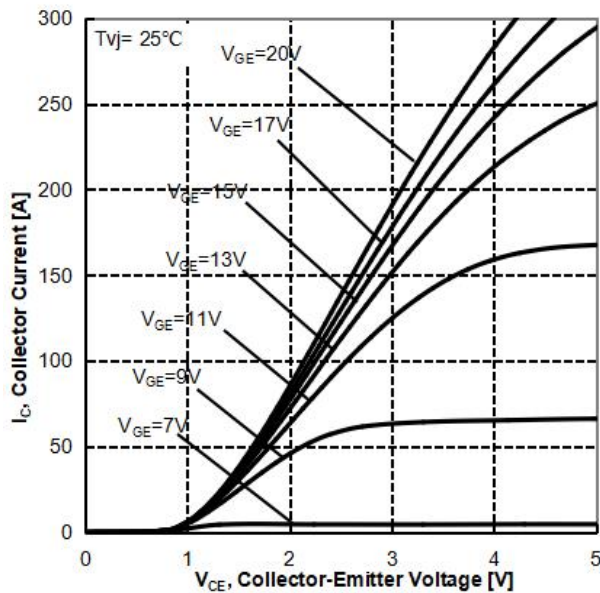


Figure 6: Typical Output Characteristics

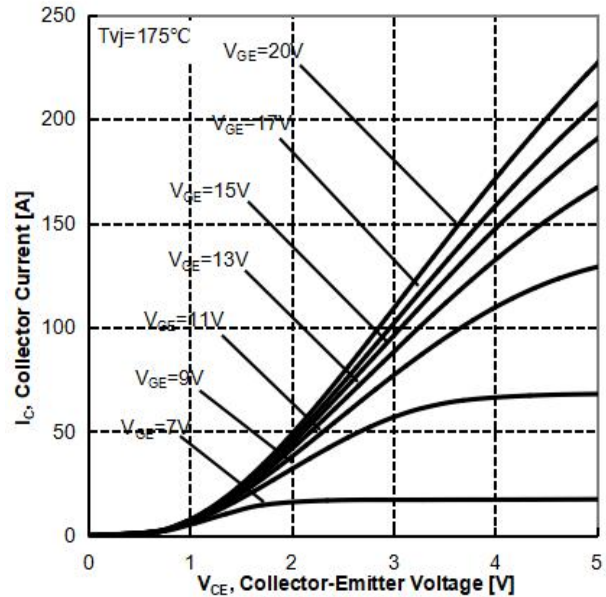


Figure 7: Typical Collector-Emitter Saturation Voltage vs. Junction Temperature

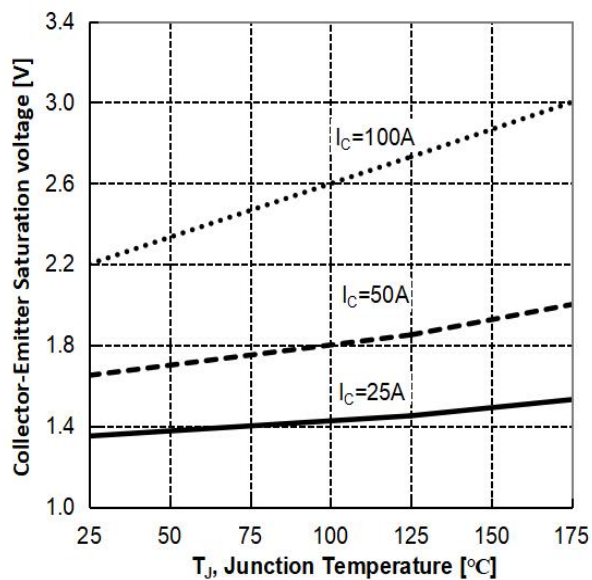


Figure 8: Typical Gate-Emitter Threshold Voltage vs. Junction Temperature

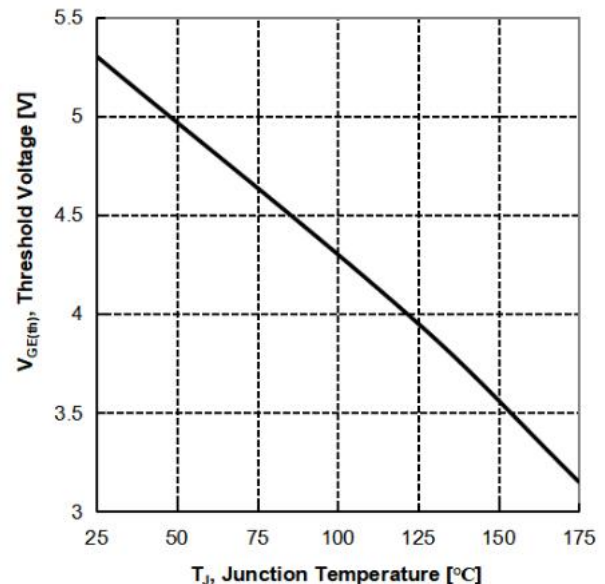




Figure 9: Typical Switching Times vs.
Gate Resistor ($T_J=25^\circ\text{C}$, $V_{CE}=400\text{V}$,
 $V_{GE}=15\text{V}$, $I_C=60\text{A}$)

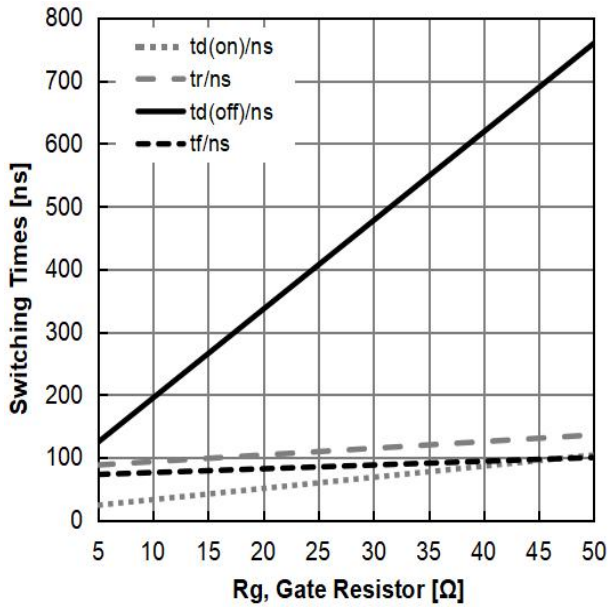


Figure 10: Typical Switching Energy vs.
Gate Resistor ($T_J=25^\circ\text{C}$, $V_{CE}=400\text{V}$,
 $V_{GE}=15\text{V}$, $I_C=60\text{A}$)

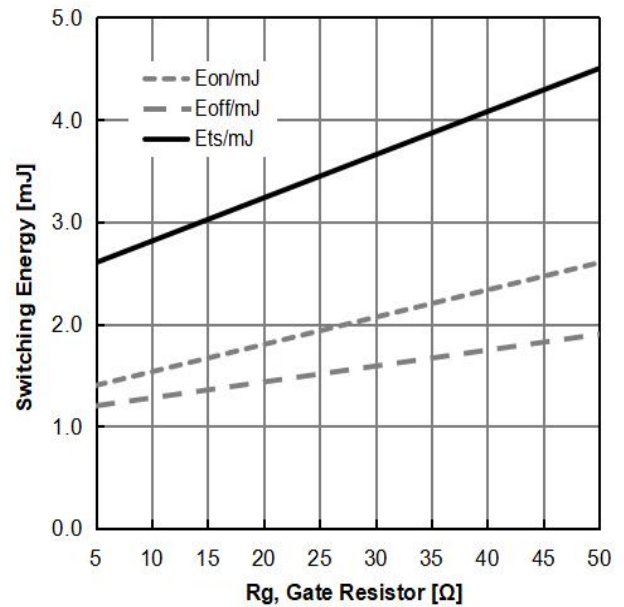


Figure 11: Typical Switching Times vs.
Junction Temperature ($V_{CE}=400\text{V}$,
 $V_{GE}=15\text{V}$, $I_C=60\text{A}$, $R_g=5\Omega$)

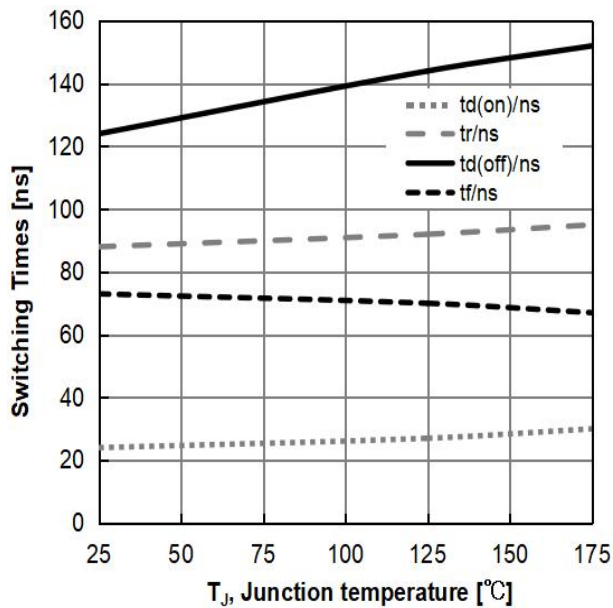


Figure 12: Typical Switching Energy vs.
Junction Temperature ($V_{CE}=400\text{V}$,
 $V_{GE}=15\text{V}$, $I_C=60\text{A}$, $R_g=5\Omega$)

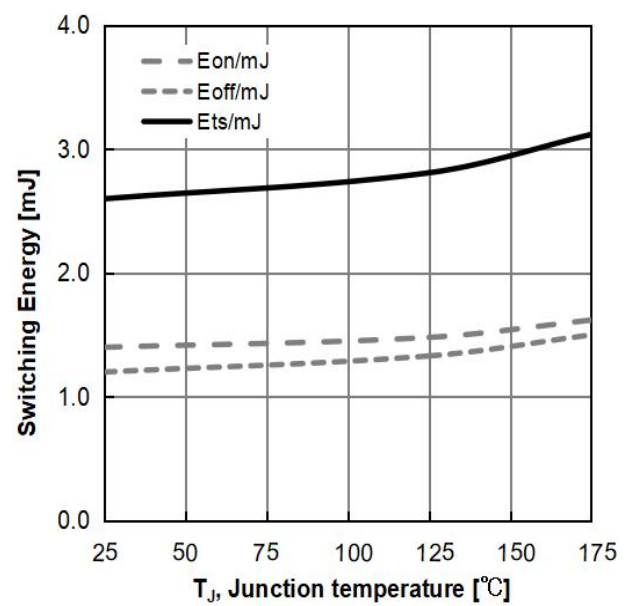




Figure 13: Typical Switching Times vs.
Collector Current ($T_J=25^{\circ}\text{C}$, $V_{CE}=400\text{V}$,
 $V_{GE}=15\text{V}$, $R_g=5\Omega$)

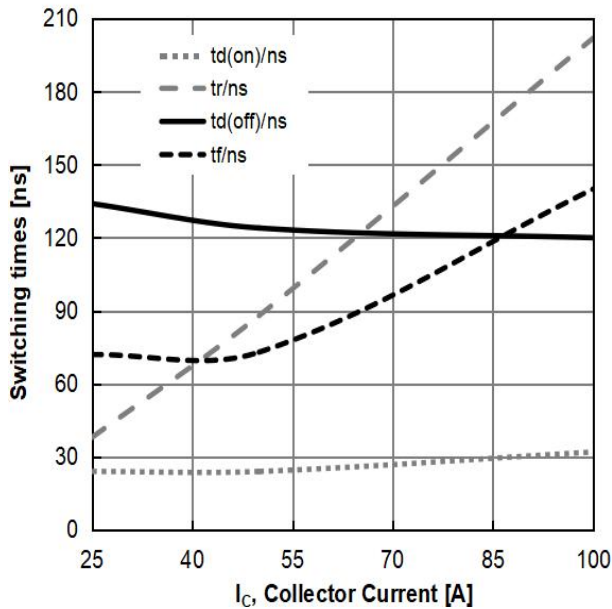


Figure 14: Typical Switching Energy vs.
Collector Current ($T_J=25^{\circ}\text{C}$, $V_{CE}=400\text{V}$,
 $V_{GE}=15\text{V}$, $R_g=5\Omega$)

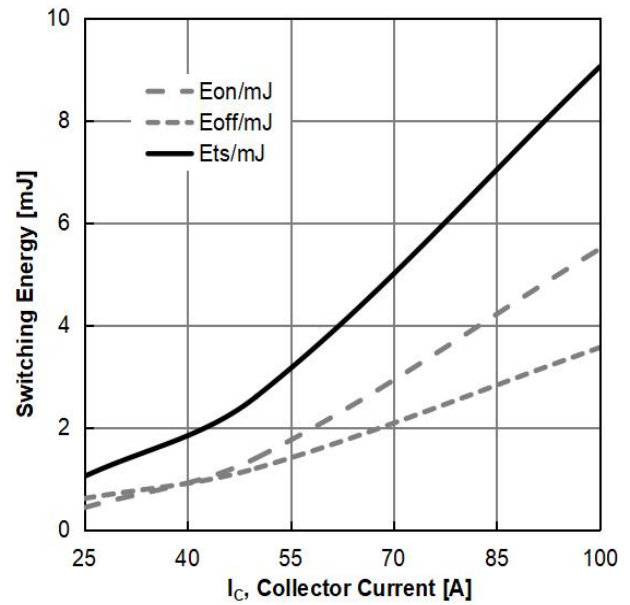


Figure 15: Typical Switching Times vs.
 V_{CE} ($T_J=25^{\circ}\text{C}$, $V_{GE}=15\text{V}$, $I_C=60\text{A}$, $R_g=5\Omega$)

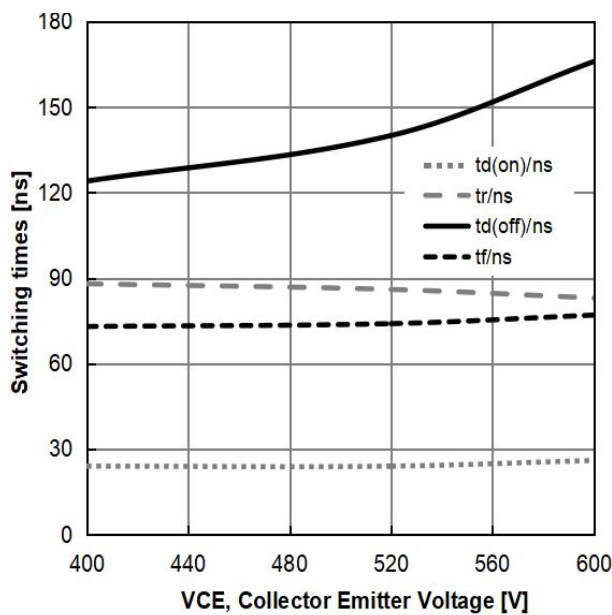


Figure 16: Typical Switching Energy vs.
 V_{CE} ($T_J=25^{\circ}\text{C}$, $V_{GE}=15\text{V}$, $I_C=60\text{A}$, $R_g=5\Omega$)

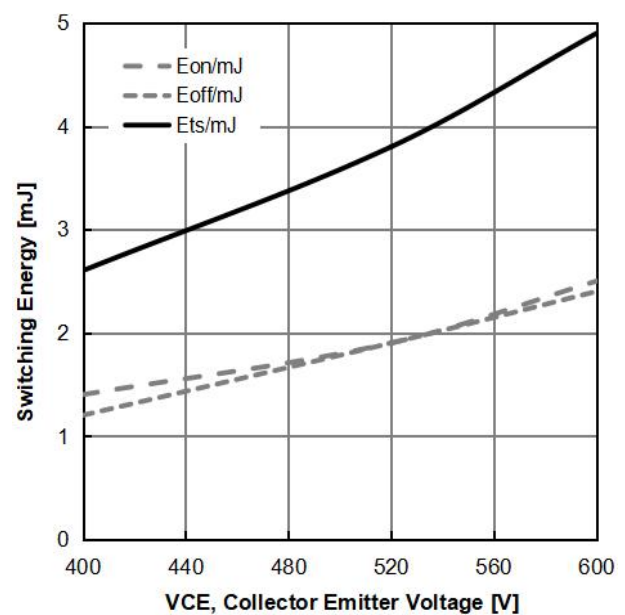




Figure 17: Typical Capacitance vs. Collector- Emitter Voltage

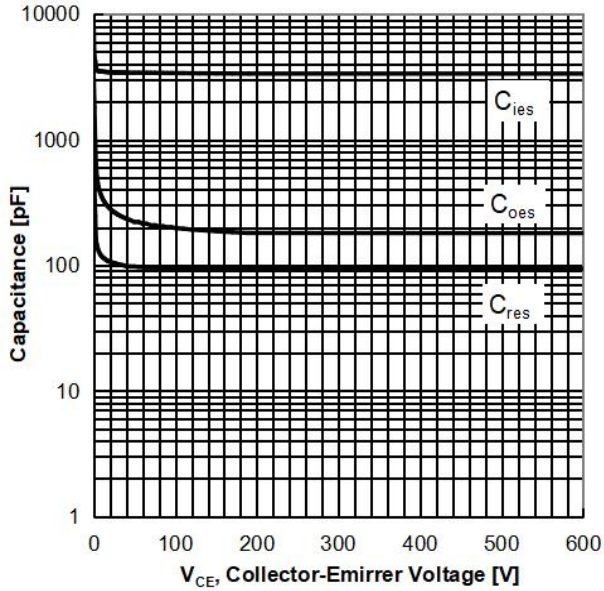


Figure 18: Typical Gate Charge

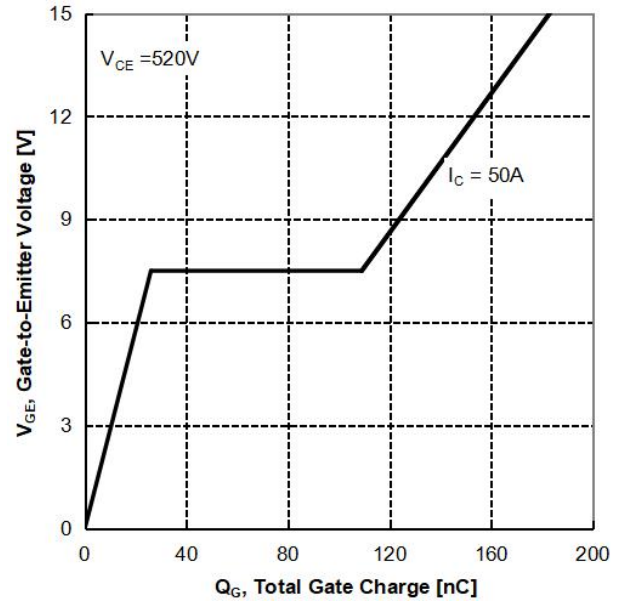


Figure 19: IGBT Transient Thermal Impedance vs. Pulse Width

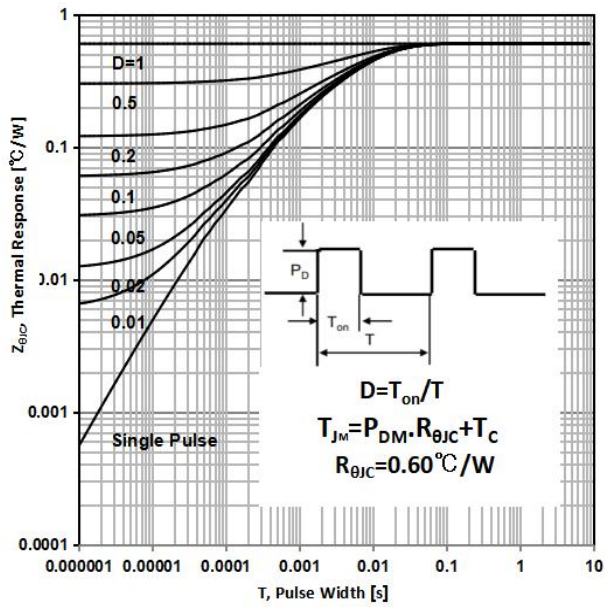


Figure 20: Diode Transient Thermal Impedance vs. Pulse Width

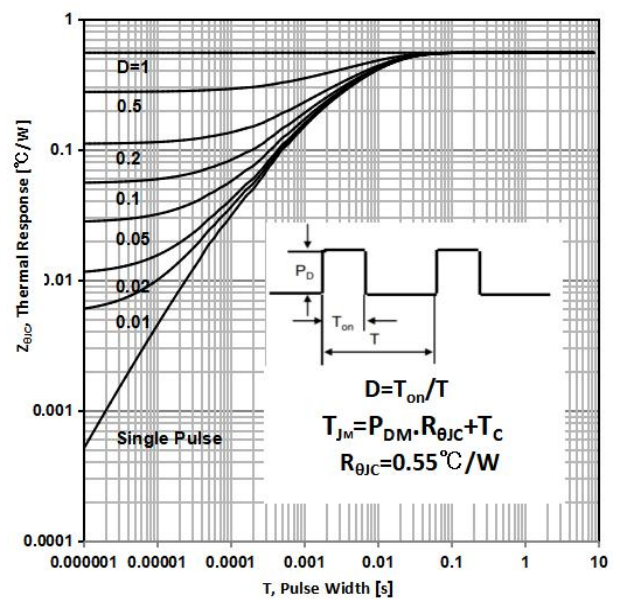
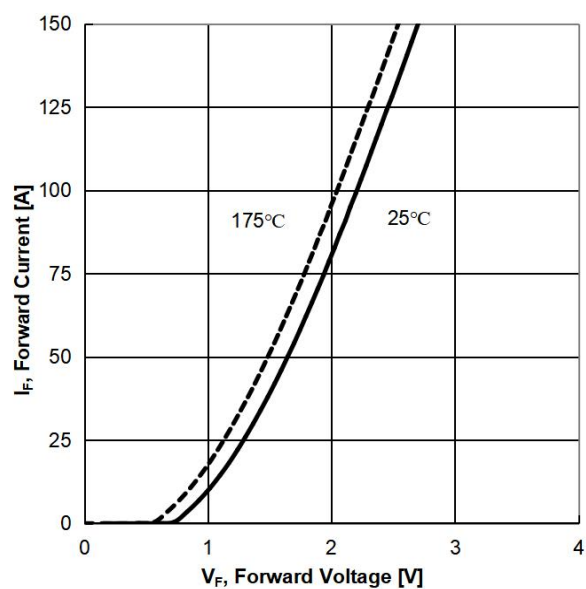




Figure 21: Typical Diode Forward Current
vs. Forward Voltage





6. Test Circuit and Waveform

Figure 22. Inductive Switching Test Circuit

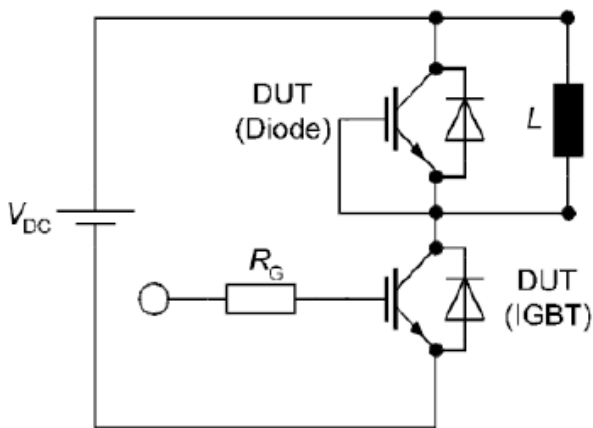


Figure 23. Definition of switching times

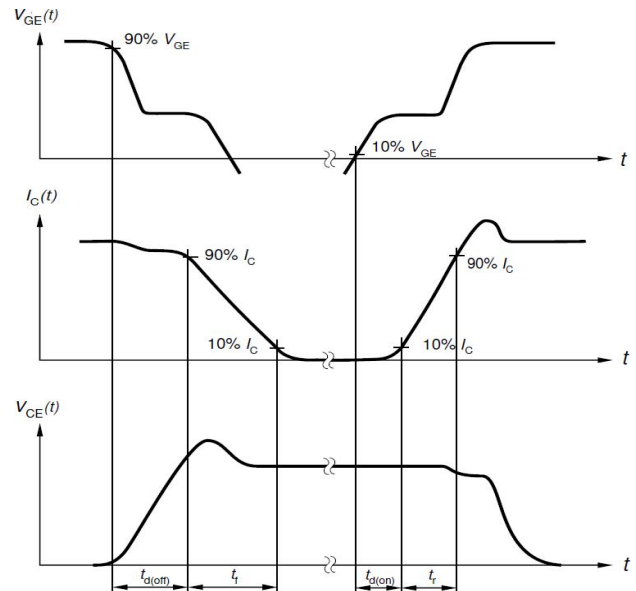


Figure 24. Definition of switching losses

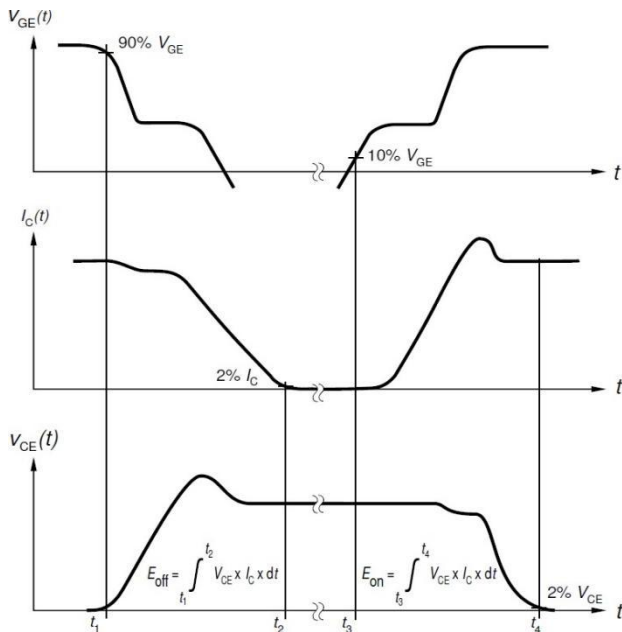
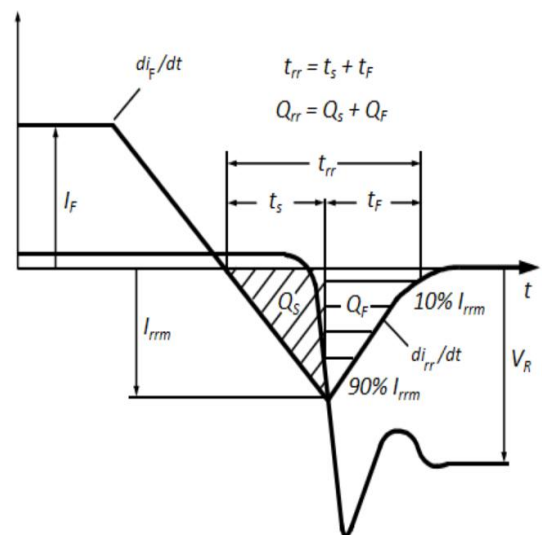


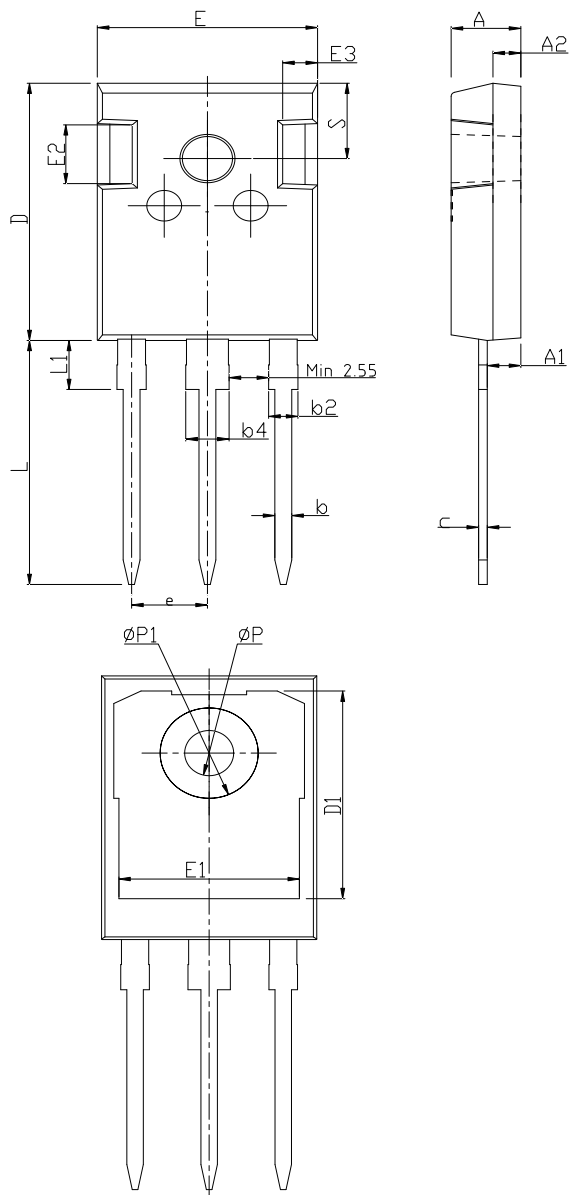
Figure 25. Definition of diode switching characteristics





7. Package Information

TO-247

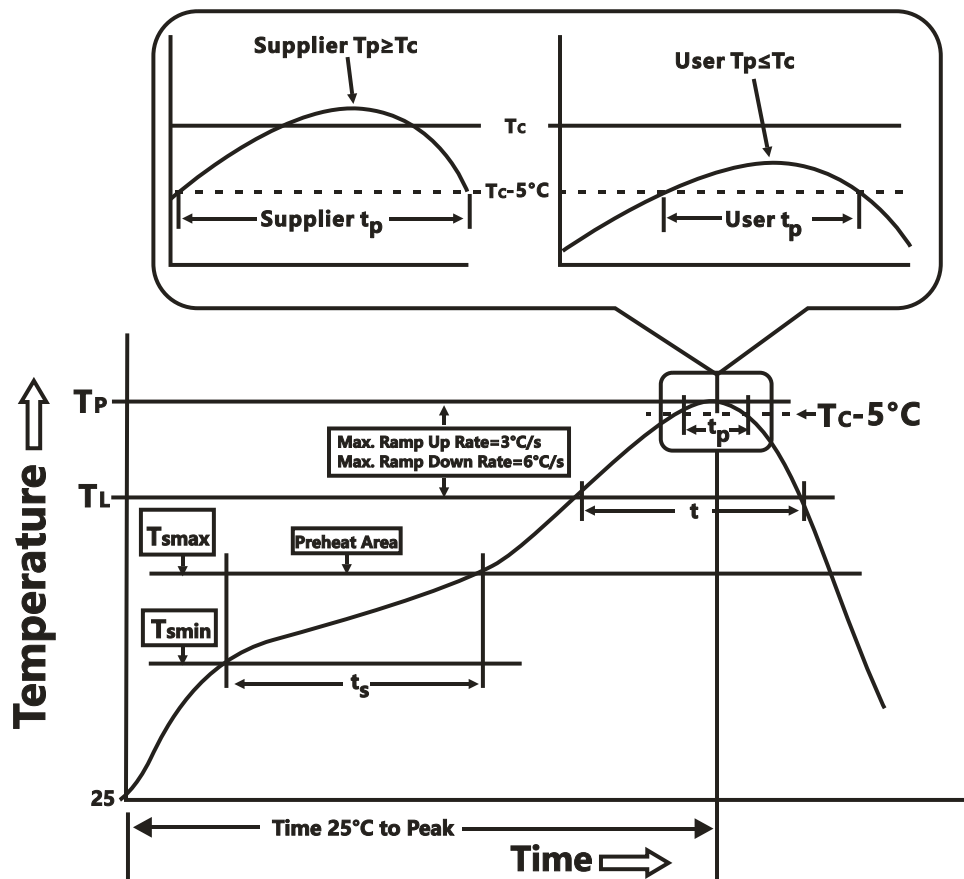


COMMON DIMENSIONS

SYMBOL	mm		
	MIN	NOM	MAX
A	4.80	5.00	5.20
A1	2.21	2.41	2.59
A2	1.85	2.00	2.15
b	1.11	1.21	1.36
b2	1.91	2.01	2.21
b4	2.91	3.01	3.21
c	0.51	0.61	0.75
D	20.70	21.00	21.30
D1	16.25	16.55	16.85
E	15.50	15.80	16.10
E1	13.00	13.30	13.60
E2	4.80	5.00	5.20
E3	2.30	2.50	2.70
e	5.44BSC		
L	19.62	19.92	20.22
L1	-	-	4.30
ΦP	3.40	3.60	3.80
ΦP1	-	-	7.30
S	6.15BSC		



8. Classification Profile



9. Classification Reflow Profiles

Profile Feature	Sn-Pb Eutectic Assembly	Pb-Free Assembly
Preheat & Soak		
Temperature min (T_{smin})	100 °C	150 °C
Temperature max (T_{smax})	150 °C	200 °C
Time (T_{smin} to T_{smax}) (T_s)	60-120 seconds	60-120 seconds
Average ramp-up rate (T_{smax} to T_p)	3 °C/second max.	3°C/second max.
Liquidous temperature (T_L)	183 °C	217 °C
Time at liquidous (t_L)	60-150 seconds	60-150 seconds



Peak package body temperature (T_p)*	See Classification Temp in table 1	See Classification Temp in table 2
Time (t_p)** within 5°C of the specified classification temperature (T_c)	20** seconds	30** seconds
Average ramp-down rate (T_p to T_{smax})	6 °C/second max.	6 °C/second max.
Time 25°C to peak temperature	6 minutes max.	8 minutes max.
*Tolerance for peak profile Temperature (T_p) is defined as a supplier minimum and a user maximum.		
** Tolerance for time at peak profile temperature (t_p) is defined as a supplier minimum and a user maximum.		

Table 1.Sn-Pb Eutectic Process – Classification Temperatures (T_c)

Package Thickness	Volume mm ³ <350	Volume mm ³ ≥350
<2.5 mm	235 °C	220 °C
≥2.5 mm	220 °C	220 °C

Table 2.Pb-free Process – Classification Temperatures (T_c)

Package Thickness	Volume mm ³ <350	Volume mm ³ 350-2000	Volume mm ³ ≥2000
<1.6 mm	260 °C	260 °C	260 °C
1.6 mm – 2.5 mm	260 °C	250 °C	245 °C
≥2.5 mm	250 °C	245 °C	245 °C

10. Reliability Test Program

Test item	Method	Description
HTRB	JESD-22, A108	168/500 Hrs, Bias @ 150°C
HTGB	JESD-22, A108	168 /500 Hrs, 100%V _{GE} @ 150°C
PCT	JESD-22, A102	96 Hrs, 100%RH, 2atm, 121°C
TCT	JESD-22, A104	250/500 Cycles, -55°C~150°C



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