

International IR Rectifier

INSULATED GATE BIPOLAR TRANSISTOR WITH
ULTRAFAST SOFT RECOVERY DIODE

PD - 94381E

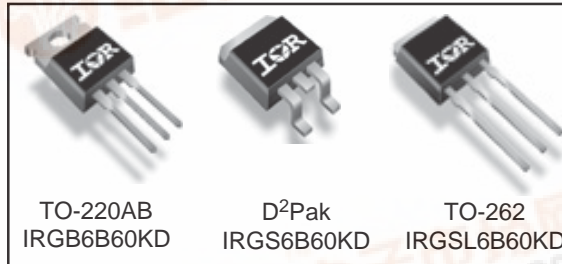
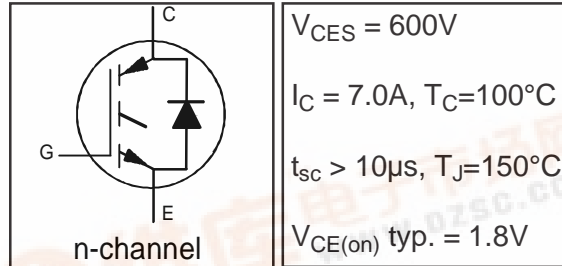
IRGB6B60KD
IRGS6B60KD
IRGSL6B60KD

Features

- Low VCE (on) Non Punch Through IGBT Technology.
- Low Diode VF.
- 10µs Short Circuit Capability.
- Square RBSOA.
- Ultrasoft Diode Reverse Recovery Characteristics.
- Positive VCE (on) Temperature Coefficient.

Benefits

- Benchmark Efficiency for Motor Control.
- Rugged Transient Performance.
- Low EMI.
- Excellent Current Sharing in Parallel Operation.



Absolute Maximum Ratings

Parameter	Max.	Units
V_{CES}	600	V
$I_C @ T_C = 25^\circ C$	13	A
$I_C @ T_C = 100^\circ C$	7.0	
I_{CM}	26	
I_{LM}	26	
$I_F @ T_C = 25^\circ C$	13	
$I_F @ T_C = 100^\circ C$	7.0	
I_{FM}	26	V
V_{GE}	± 20	
$P_D @ T_C = 25^\circ C$	90	W
$P_D @ T_C = 100^\circ C$	36	
T_J	-55 to +150	$^\circ C$
T_{STG}		
	300 (0.063 in. (1.6mm) from case)	

Thermal Resistance

Parameter	Min.	Typ.	Max.	Units
$R_{\theta JC}$	—	—	1.4	$^\circ C/W$
$R_{\theta JC}$	—	—	4.4	
$R_{\theta CS}$	—	0.50	—	
$R_{\theta JA}$	—	—	62	
$R_{\theta JA}$	—	—	40	
Wt	—	1.44	—	g



Electrical Characteristics @ T_J = 25°C (unless otherwise specified)

	Parameter	Min.	Typ.	Max.	Units	Conditions	Ref.Fig.
V _{(BR)CES}	Collector-to-Emitter Breakdown Voltage	600	—	—	V	V _{GE} = 0V, I _C = 500μA	
ΔV _{(BR)CES/ΔT_J}	Temperature Coeff. of Breakdown Voltage	—	0.3	—	V/°C	V _{GE} = 0V, I _C = 1.0mA, (25°C-150°C)	
V _{CE(on)}	Collector-to-Emitter Saturation Voltage	1.5	1.80	2.20	V	I _C = 5.0A, V _{GE} = 15V	5, 6,7
		—	2.20	2.50		I _C = 5.0A, V _{GE} = 15V, T _J = 150°C	9,10,11
V _{GE(th)}	Gate Threshold Voltage	3.5	4.5	5.5	V	V _{CE} = V _{GE} , I _C = 250μA	9,10,11
ΔV _{GE(th)/ΔT_J}	Temperature Coeff. of Threshold Voltage	—	-10	—	mV/°C	V _{CE} = V _{GE} , I _C = 1.0mA, (25°C-150°C)	12
g _{fe}	Forward Transconductance	—	3.0	—	S	V _{CE} = 50V, I _C = 5.0A, PW=80μs	
I _{CES}	Zero Gate Voltage Collector Current	—	1.0	150	μA	V _{GE} = 0V, V _{CE} = 600V	
		—	200	500		V _{GE} = 0V, V _{CE} = 600V, T _J = 150°C	
V _{FM}	Diode Forward Voltage Drop	—	1.25	1.45	V	I _C = 5.0A	8
		—	1.20	1.40		I _C = 5.0A T _J = 150°C	
I _{GES}	Gate-to-Emitter Leakage Current	—	—	±100	nA	V _{GE} = ±20V	

Switching Characteristics @ T_J = 25°C (unless otherwise specified)

	Parameter	Min.	Typ.	Max.	Units	Conditions	Ref.Fig.
Q _g	Total Gate Charge (turn-on)	—	18.2	—	nC	I _C = 5.0A	CT1
Q _{ge}	Gate - Emitter Charge (turn-on)	—	1.9	—		V _{CC} = 400V	
Q _{gc}	Gate - Collector Charge (turn-on)	—	9.2	—		V _{GE} = 15V	
E _{on}	Turn-On Switching Loss	—	110	210	μJ	I _C = 5.0A, V _{CC} = 400V	CT4
E _{off}	Turn-Off Switching Loss	—	135	245		V _{GE} = 15V, R _G = 100Ω, L = 1.4mH	
E _{tot}	Total Switching Loss	—	245	455		L _s = 150nH T _J = 25°C ③	
t _{d(on)}	Turn-On Delay Time	—	25	34	ns	I _C = 5.0A, V _{CC} = 400V	CT4
t _r	Rise Time	—	17	26		V _{GE} = 15V, R _G = 100Ω L = 1.4mH	
t _{d(off)}	Turn-Off Delay Time	—	215	230		L _s = 150nH, T _J = 25°C	
t _f	Fall Time	—	13.2	22			
E _{on}	Turn-On Switching Loss	—	150	260	μJ	I _C = 5.0A, V _{CC} = 400V	CT4
E _{off}	Turn-Off Switching Loss	—	190	300		V _{GE} = 15V, R _G = 100Ω, L = 1.4mH	
E _{tot}	Total Switching Loss	—	340	560		L _s = 150nH T _J = 150°C ③	
t _{d(on)}	Turn-On Delay Time	—	28	37	ns	I _C = 5.0A, V _{CC} = 400V	14, 16
t _r	Rise Time	—	17	26		V _{GE} = 15V, R _G = 100Ω L = 1.4mH	
t _{d(off)}	Turn-Off Delay Time	—	240	255		L _s = 150nH, T _J = 150°C	
t _f	Fall Time	—	18	27			
C _{ies}	Input Capacitance	—	290	—	pF	V _{GE} = 0V	
C _{oes}	Output Capacitance	—	34	—		V _{CC} = 30V	
C _{res}	Reverse Transfer Capacitance	—	10	—		f = 1.0MHz	
RBSOA	Reverse Bias Safe Operating Area	FULL SQUARE				T _J = 150°C, I _C = 26A, V _p = 600V V _{CC} = 500V, V _{GE} = +15V to 0V, R _G = 100Ω	4 CT2
SCSOA	Short Circuit Safe Operating Area	10	—	—	μs	T _J = 150°C, V _p = 600V, R _G = 100Ω V _{CC} = 360V, V _{GE} = +15V to 0V	CT3 WF4
E _{rec}	Reverse Recovery energy of the diode	—	90	175	μJ	T _J = 150°C	17,18,19
t _{rr}	Diode Reverse Recovery time	—	70	80	ns	V _{CC} = 400V, I _F = 5.0A, L = 1.4mH	20, 21
I _{rr}	Diode Peak Reverse Recovery Current	—	10	14	A	V _{GE} = 15V, R _G = 100Ω, L _s = 150nH	CT4, WF3

Note: ① to ④ are on page 15

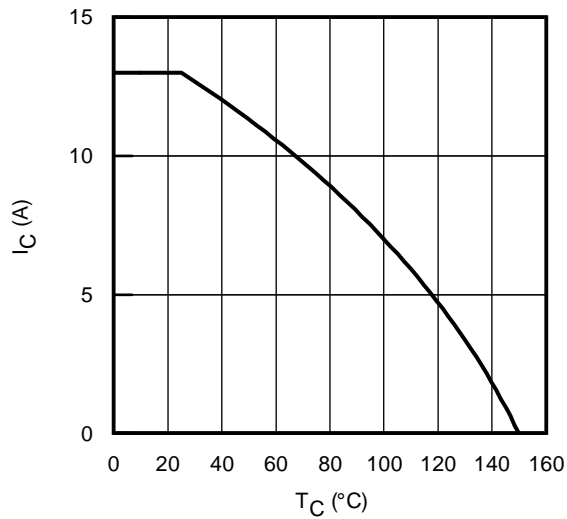


Fig. 1 - Maximum DC Collector Current vs. Case Temperature

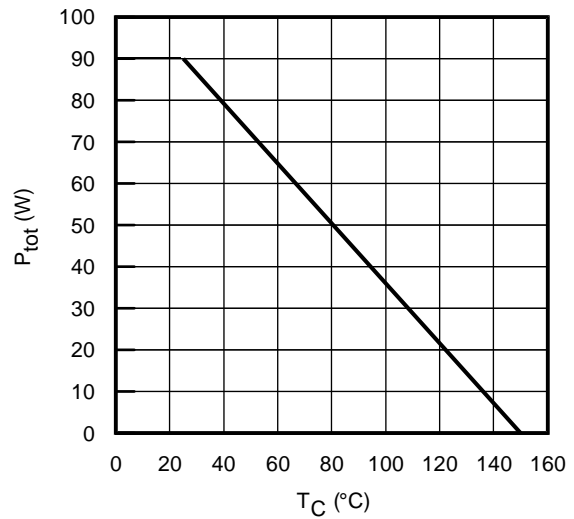


Fig. 2 - Power Dissipation vs. Case Temperature

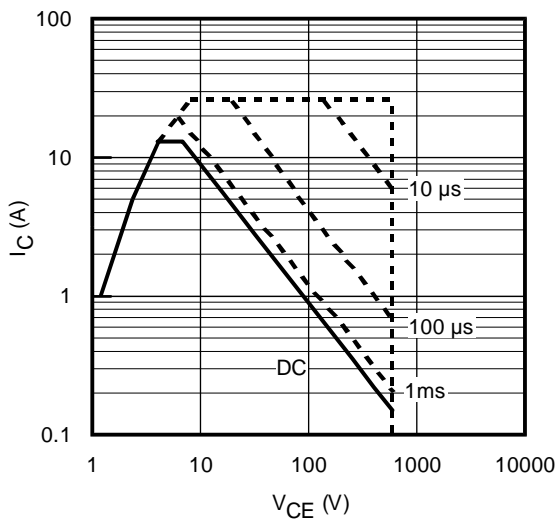


Fig. 3 - Forward SOA
 $T_C = 25^{\circ}C$; $T_J \leq 150^{\circ}C$

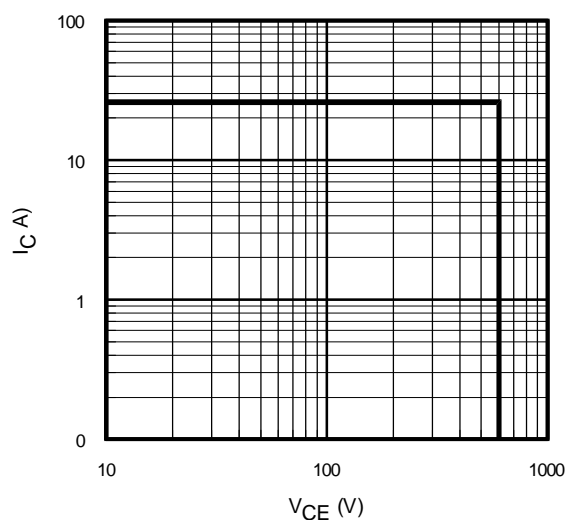


Fig. 4 - Reverse Bias SOA
 $T_J = 150^{\circ}C$; $V_{GE} = 15V$

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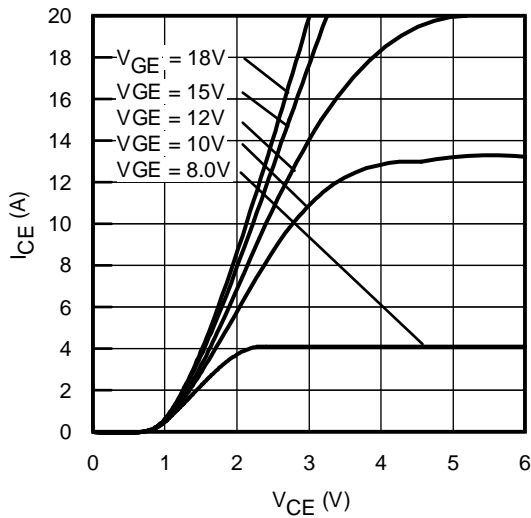


Fig. 5 - Typ. IGBT Output Characteristics
 $T_J = -40^\circ\text{C}$; $t_p = 80\mu\text{s}$

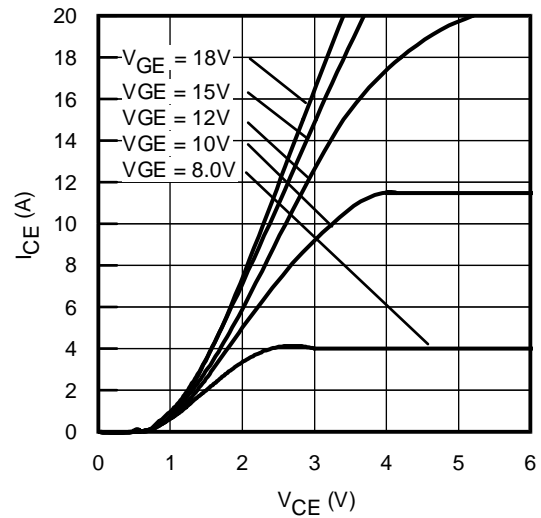


Fig. 6 - Typ. IGBT Output Characteristics
 $T_J = 25^\circ\text{C}$; $t_p = 80\mu\text{s}$

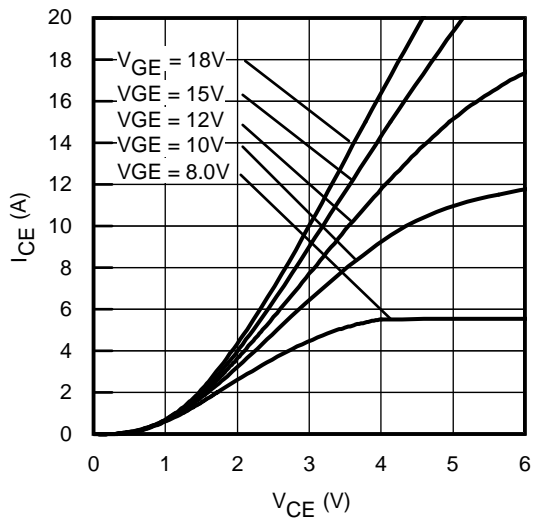


Fig. 7 - Typ. IGBT Output Characteristics
 $T_J = 150^\circ\text{C}$; $t_p = 80\mu\text{s}$

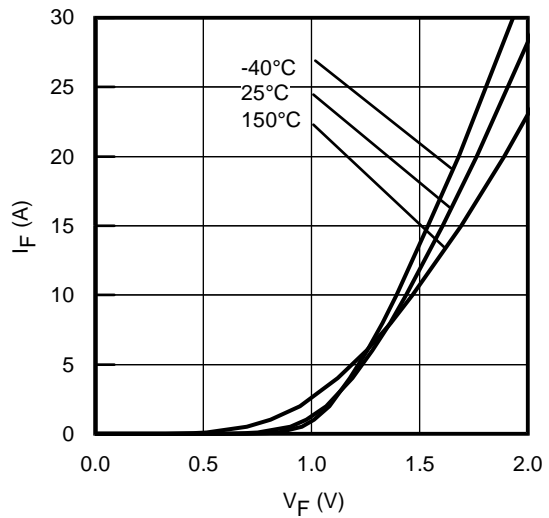


Fig. 8 - Typ. Diode Forward Characteristics
 $t_p = 80\mu\text{s}$

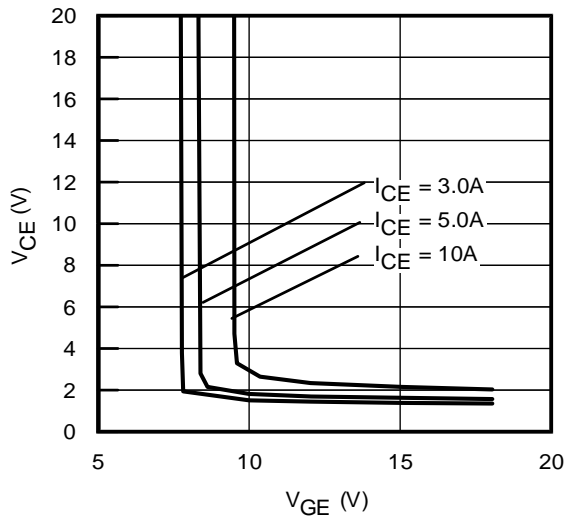


Fig. 9 - Typical V_{CE} vs. V_{GE}
 $T_J = -40^\circ\text{C}$

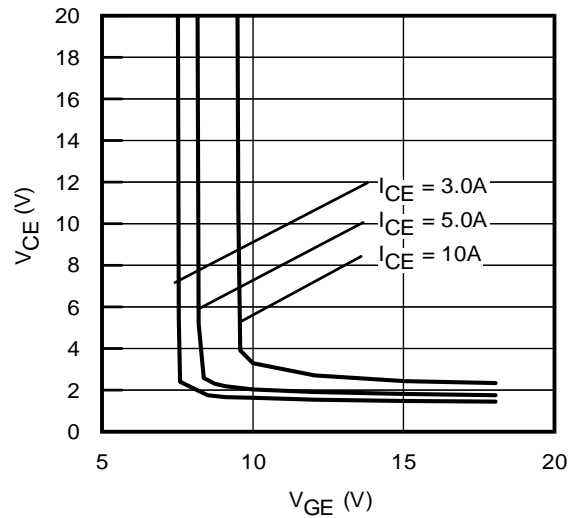


Fig. 10 - Typical V_{CE} vs. V_{GE}
 $T_J = 25^\circ\text{C}$

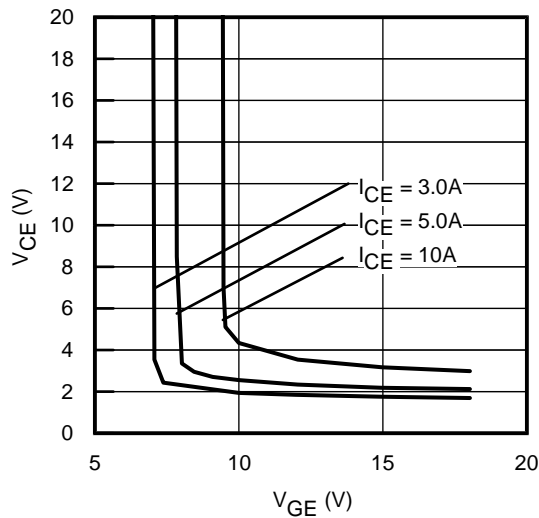


Fig. 11 - Typical V_{CE} vs. V_{GE}
 $T_J = 150^\circ\text{C}$

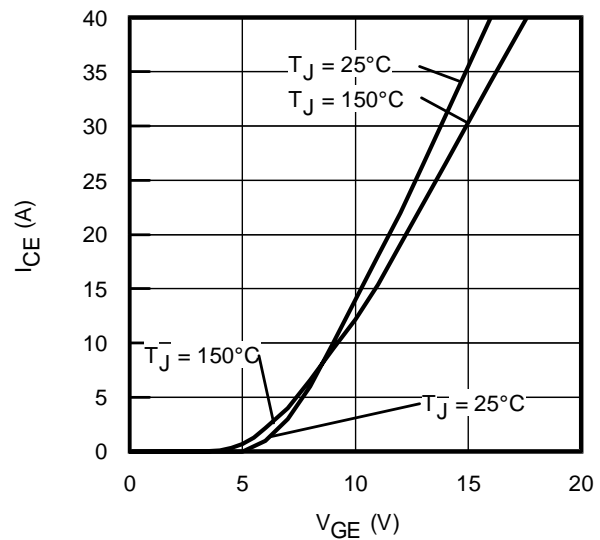


Fig. 12 - Typ. Transfer Characteristics
 $V_{CE} = 50\text{V}$; $t_p = 10\mu\text{s}$

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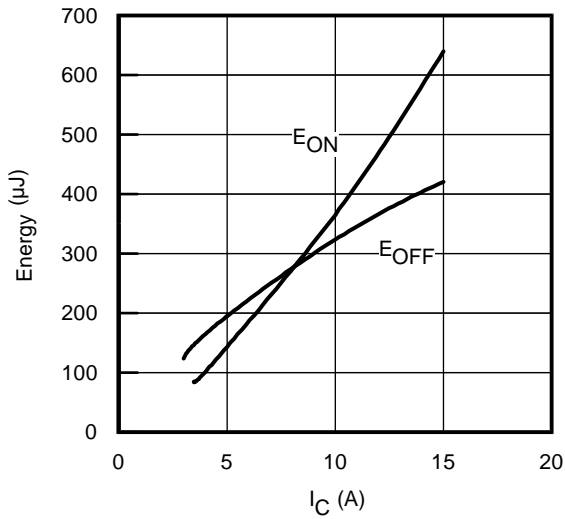


Fig. 13 - Typ. Energy Loss vs. I_C
 $T_J = 150^\circ\text{C}$; $L=1.4\text{mH}$; $V_{CE}= 400\text{V}$
 $R_G= 100\Omega$; $V_{GE}= 15\text{V}$

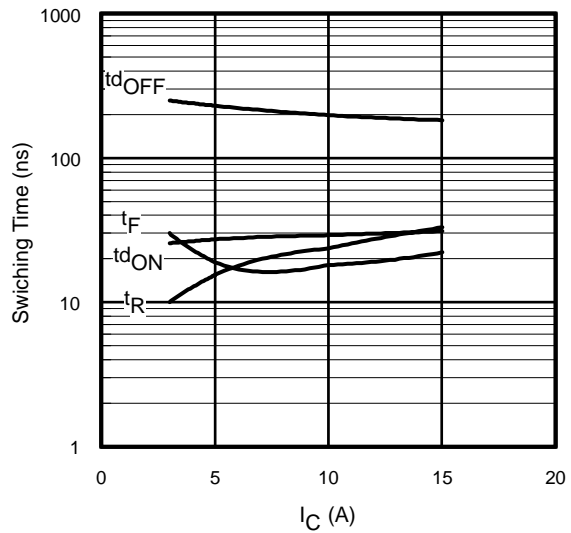


Fig. 14 - Typ. Switching Time vs. I_C
 $T_J = 150^\circ\text{C}$; $L=1.4\text{mH}$; $V_{CE}= 400\text{V}$
 $R_G= 100\Omega$; $V_{GE}= 15\text{V}$

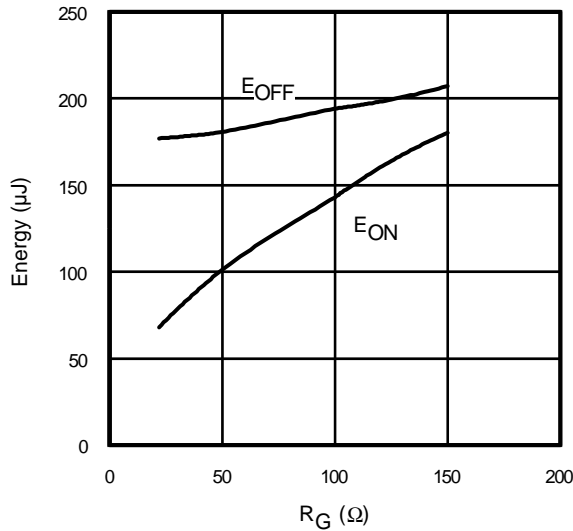


Fig. 15 - Typ. Energy Loss vs. R_G
 $T_J = 150^\circ\text{C}$; $L=1.4\text{mH}$; $V_{CE}= 400\text{V}$
 $I_{CE}= 5.0\text{A}$; $V_{GE}= 15\text{V}$

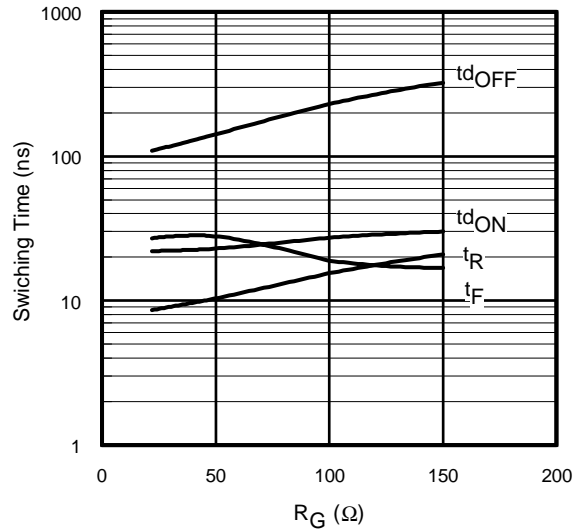


Fig. 16 - Typ. Switching Time vs. R_G
 $T_J = 150^\circ\text{C}$; $L=1.4\text{mH}$; $V_{CE}= 400\text{V}$
 $I_{CE}= 5.0\text{A}$; $V_{GE}= 15\text{V}$

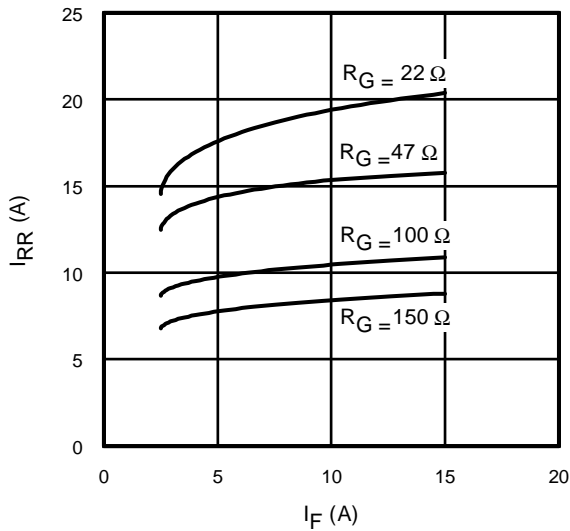


Fig. 17 - Typical Diode I_{RR} vs. I_F
 $T_J = 150^\circ\text{C}$

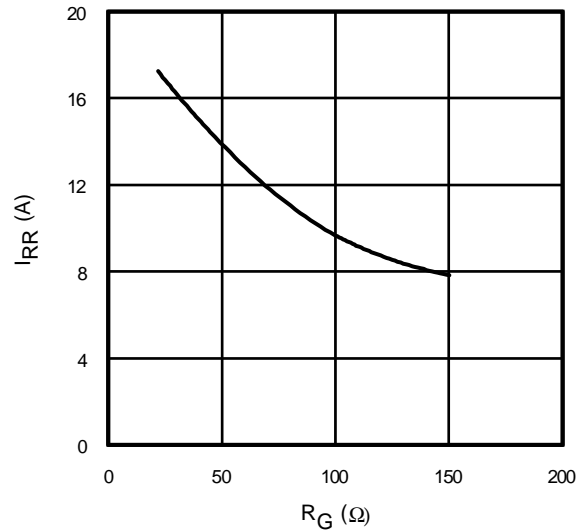


Fig. 18 - Typical Diode I_{RR} vs. R_G
 $T_J = 150^\circ\text{C}; I_F = 5.0\text{A}$

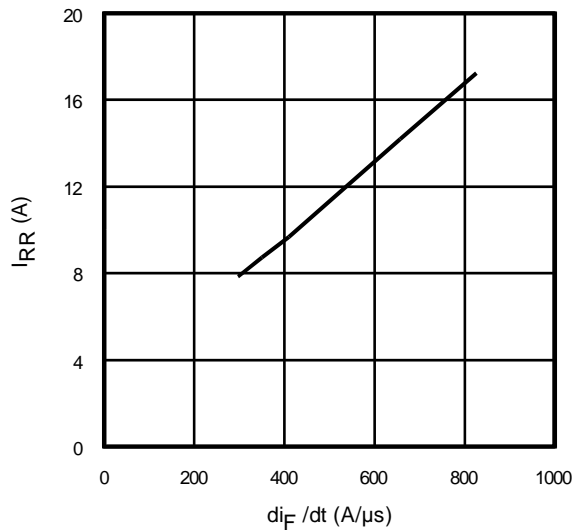


Fig. 19- Typical Diode I_{RR} vs. di_F/dt
 $V_{CC} = 400\text{V}; V_{GE} = 15\text{V};$
 $I_{CE} = 5.0\text{A}; T_J = 150^\circ\text{C}$

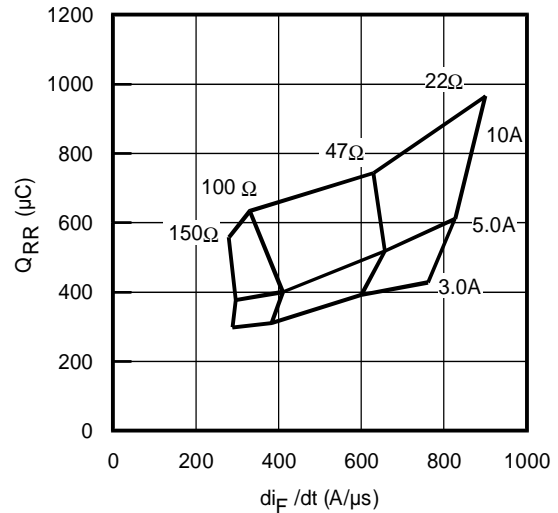


Fig. 20 - Typical Diode Q_{RR}
 $V_{CC} = 400\text{V}; V_{GE} = 15\text{V}; T_J = 150^\circ\text{C}$

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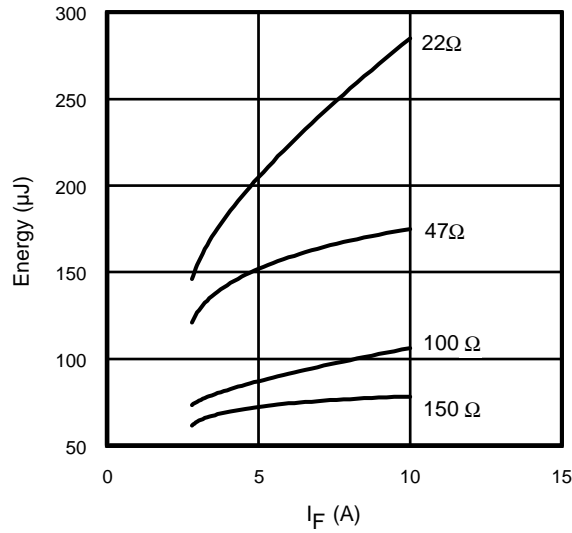


Fig. 21 - Typical Diode E_{RR} vs. I_F
 $T_J = 150^\circ\text{C}$

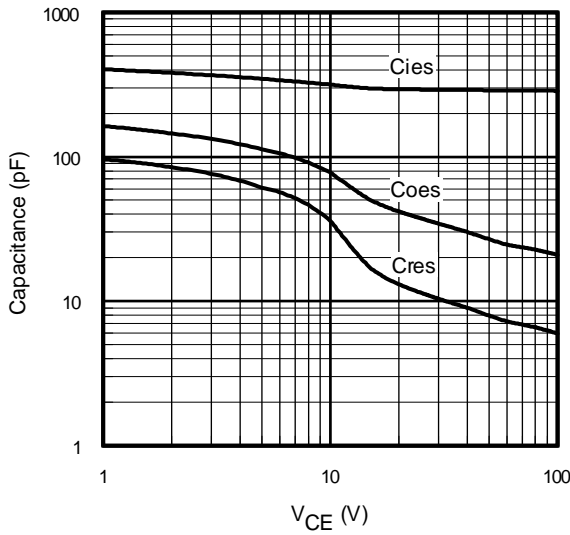


Fig. 22- Typ. Capacitance vs. V_{CE}
 $V_{GE} = 0\text{V}$; $f = 1\text{MHz}$

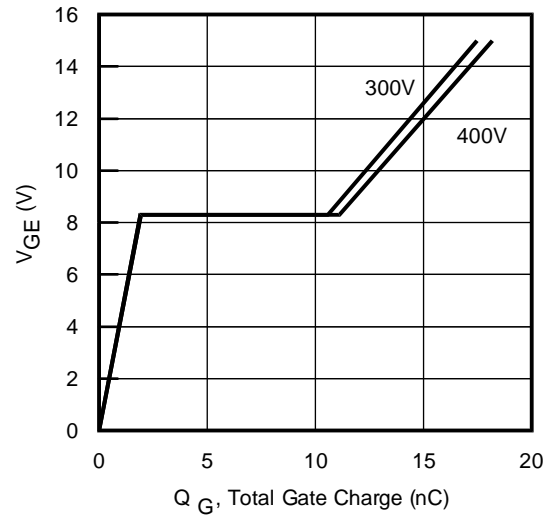


Fig. 23 - Typical Gate Charge vs. V_{GE}
 $I_{CE} = 5.0\text{A}$; $L = 600\mu\text{H}$

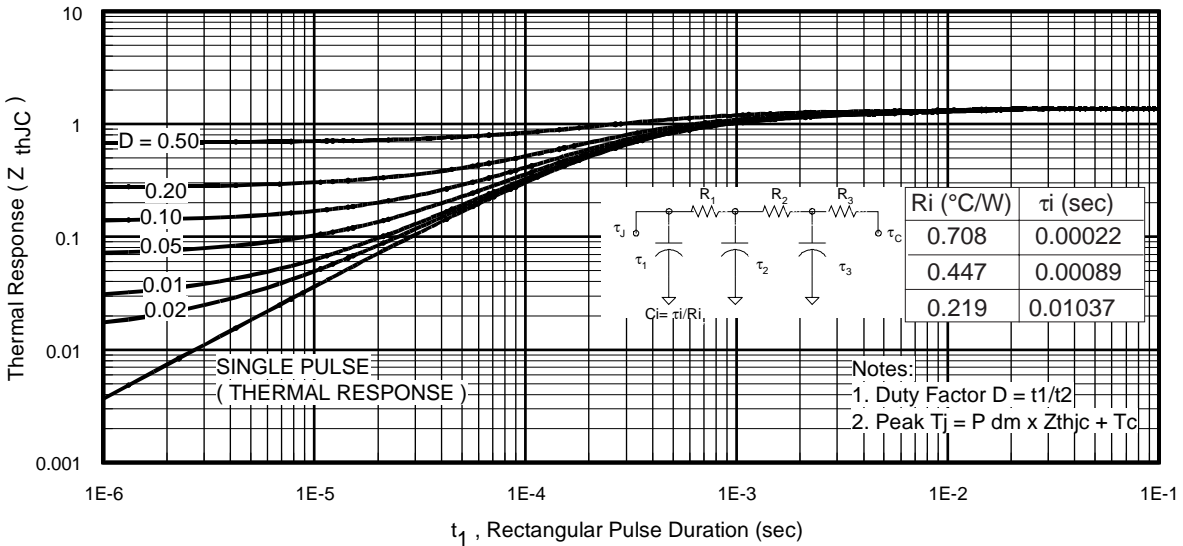


Fig 24. Maximum Transient Thermal Impedance, Junction-to-Case (IGBT)

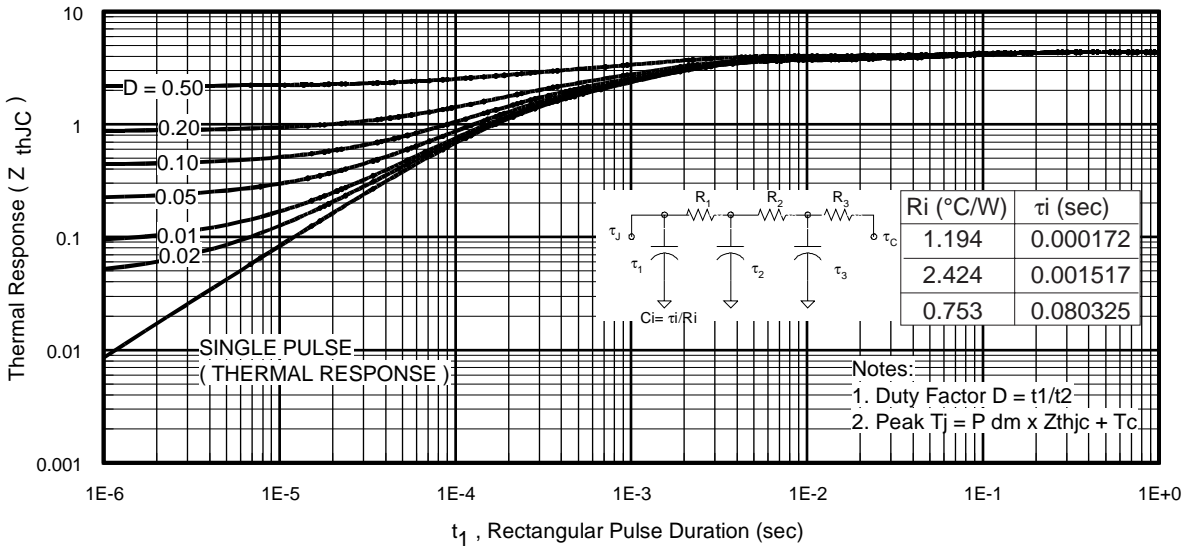


Fig 25. Maximum Transient Thermal Impedance, Junction-to-Case (DIODE)

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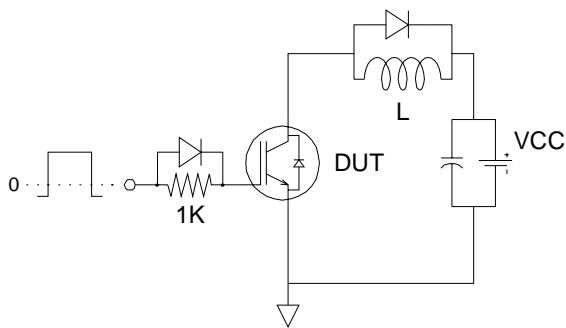


Fig.C.T.1 - Gate Charge Circuit (turn-off)

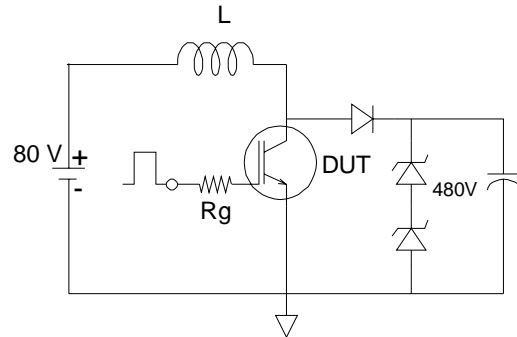


Fig.C.T.2 - RBSOA Circuit

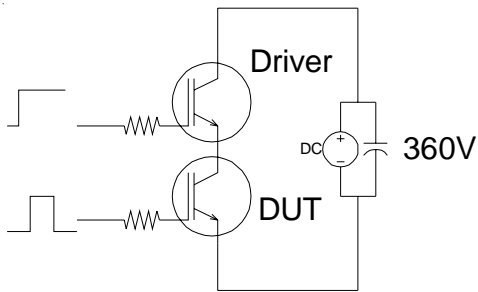


Fig.C.T.3 - S.C.SOA Circuit

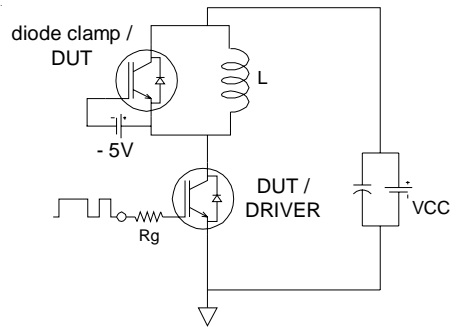


Fig.C.T.4 - Switching Loss Circuit

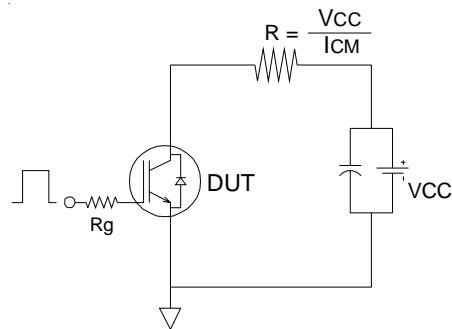


Fig.C.T.5 - Resistive Load Circuit

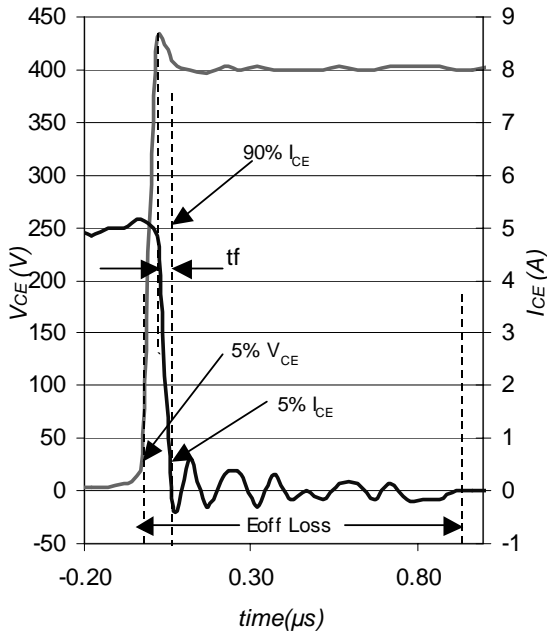


Fig. WF1- Typ. Turn-off Loss Waveform
@ $T_J = 150^\circ\text{C}$ using Fig. CT.4

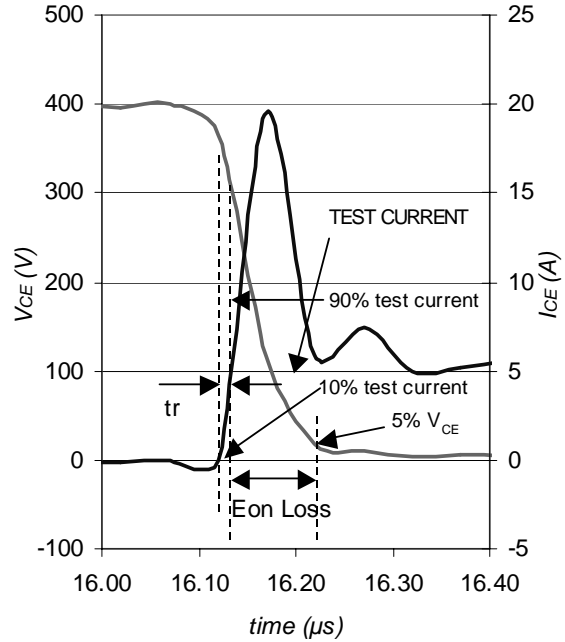


Fig. WF2- Typ. Turn-on Loss Waveform
@ $T_J = 150^\circ\text{C}$ using Fig. CT.4

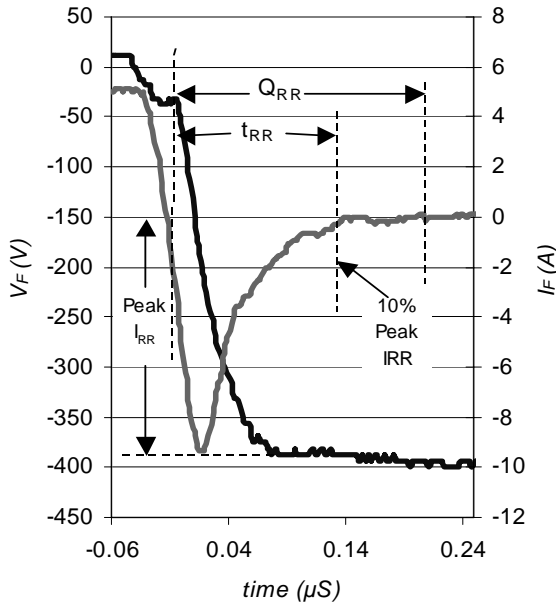


Fig. WF3- Typ. Diode Recovery Waveform
@ $T_J = 150^\circ\text{C}$ using Fig. CT.4

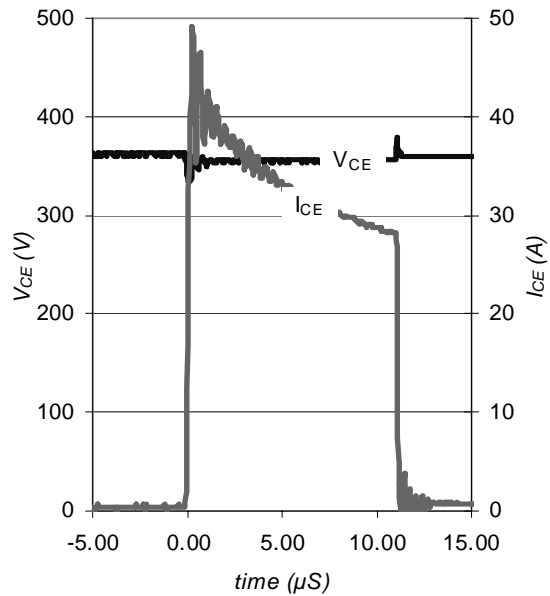


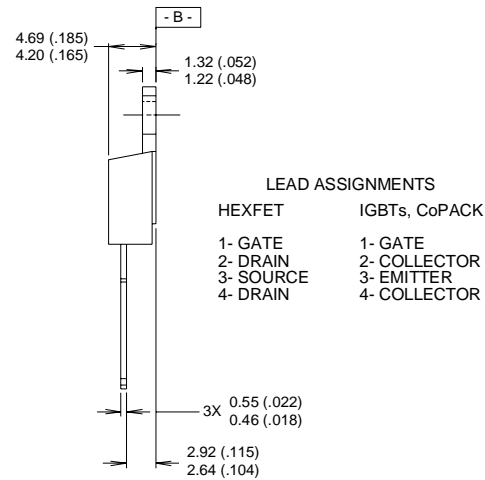
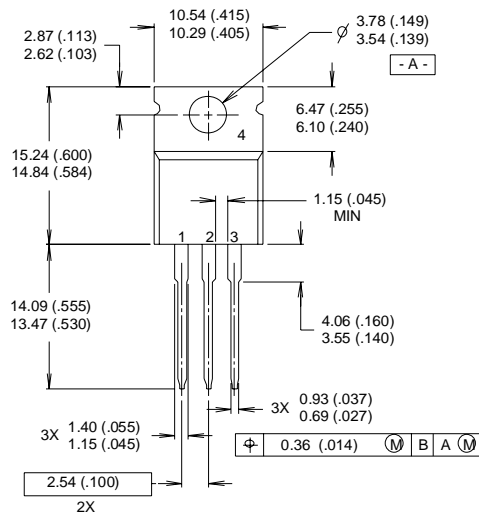
Fig. WF4- Typ. S.C Waveform
@ $T_J = 150^\circ\text{C}$ using Fig. CT.3

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TO-220AB Package Outline

Dimensions are shown in millimeters (inches)



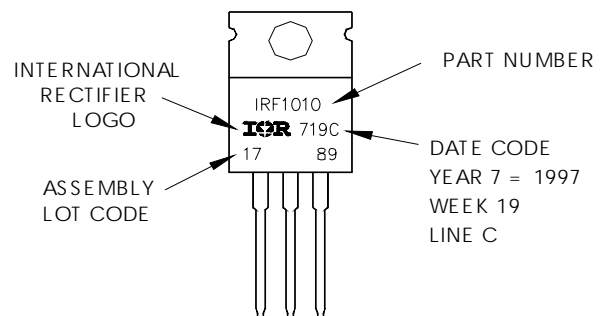
NOTES:

- 1 DIMENSIONING & TOLERANCING PER ANSI Y14.5M, 1982.
- 2 CONTROLLING DIMENSION : INCH

- 3 OUTLINE CONFORMS TO JEDEC OUTLINE TO-220AB.
- 4 HEATSINK & LEAD MEASUREMENTS DO NOT INCLUDE BURRS.

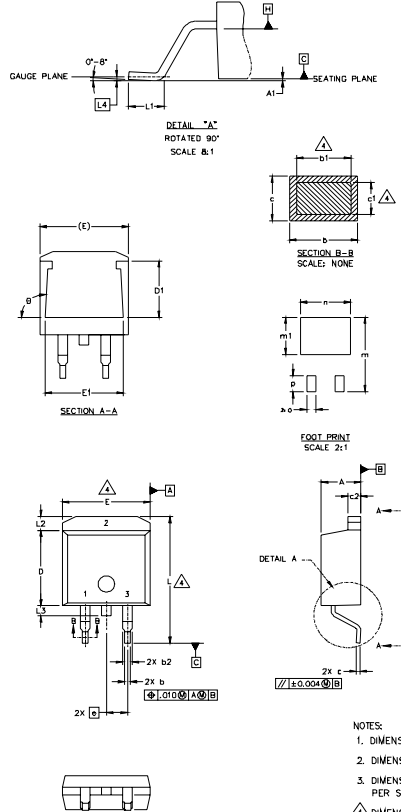
TO-220AB Part Marking Information

EXAMPLE: THIS IS AN IRF1010
 LOT CODE 1789
 ASSEMBLED ON WW 19, 1997
 IN THE ASSEMBLY LINE "C"
Note: "P" in assembly line
 position indicates "Lead-Free"



D²Pak Package Outline

Dimensions are shown in millimeters (inches)



SYMBOL	DIMENSIONS				NOTES
	MILLIMETERS		INCHES		
	MIN.	MAX.	MIN.	MAX.	
A	4.06	4.83	.160	.190	4
A1		0.127		.005	
b	0.51	0.99	.020	.039	
b1	0.51	0.89	.020	.035	
b2	1.14	1.40	.045	.055	4
c	0.43	0.63	.017	.025	
c1	0.38	0.74	.015	.029	3
c2	1.14	1.40	.045	.055	
D	8.51	9.65	.335	.380	3
D1	5.33		.210		
E	9.65	10.67	.380	.420	3
E1	6.22		.245		
e	2.54	BSC	.100	BSC	
L	14.61	15.88	.575	.625	
L1	1.78	2.79	.070	.110	
L2		1.65		.065	
L3	1.27	1.78	.050	.070	
L4		0.25	BSC	.010	BSC
m	17.78		.700		
m1	8.89		.350		
n	11.43		.450		
o	2.08		.082		
p	3.81		.150		
θ	90°	93°	90°	93°	

LEAD ASSIGNMENTS

HEXFET	IGBTs, CoPACK	DIODES
1.- GATE	1.- GATE	1.- ANODE *
2.- DRAIN	2.- COLLECTOR	2.- CATHODE
3.- SOURCE	3.- EMITTER	3.- ANODE

* PART DEPENDENT.

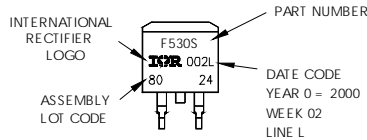
NOTES:

- DIMENSIONING AND TOLERANCING PER ASME Y14.5M-1994
- DIMENSIONS ARE SHOWN IN MILLIMETERS [INCHES].
- DIMENSION D & E DO NOT INCLUDE MOLD FLASH. MOLD FLASH SHALL NOT EXCEED 0.127 [0.005"] PER SIDE. THESE DIMENSIONS ARE MEASURED AT THE OUTMOST EXTREMES OF THE PLASTIC BODY.
- DIMENSION b1 AND c1 APPLY TO BASE METAL ONLY.
- CONTROLLING DIMENSION: INCH.

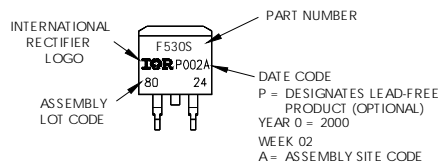
D²Pak Part Marking Information

EXAMPLE: THIS IS AN IRF530S WITH
LOT CODE 8024
ASSEMBLED ON WW02, 2000
IN THE ASSEMBLY LINE "L"

Note: "P" in assembly line
position indicates "Lead-Free"



OR

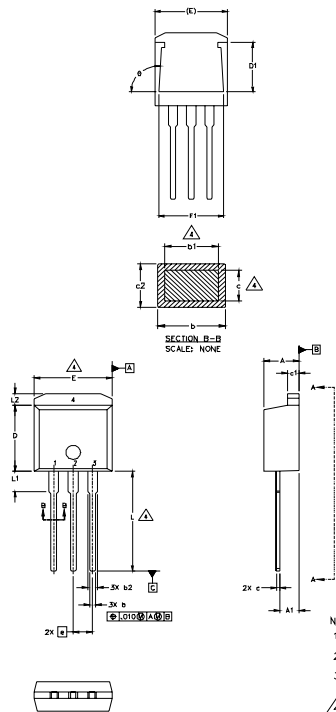


IRG/B/S/SL6B60KD

International
IRF Rectifier

TO-262 Package Outline

Dimensions are shown in millimeters (inches)



SYMBOL	DIMENSIONS				NOTES
	MILLIMETERS		INCHES		
	MIN.	MAX.	MIN.	MAX.	
A	4.06	4.83	.160	.190	
A1	2.03	2.92	.080	.115	
b	0.51	0.99	.020	.039	
b1	0.51	0.89	.020	.035	4
b2	1.14	1.40	.045	.055	
c	0.38	0.63	.015	.025	4
c1	1.14	1.40	.045	.055	
c2	0.43	.063	.017	.029	
D	8.51	9.65	.335	.380	3
D1	5.33		.210		
E	9.65	10.67	.380	.420	3
E1	6.22		.245		
e	2.54	BSC	.100	BSC	
L	13.46	14.09	.530	.555	
L1	3.56	3.71	.140	.146	
L2		1.65		.065	

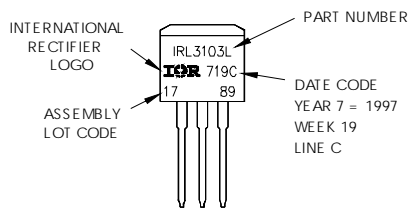
LEAD ASSIGNMENTS

HEXFET	IGBT
1.- GATE	1 - GATE
2.- DRAIN	2 - COLLECTOR
3.- SOURCE	3 - EMITTER
4.- DRAIN	

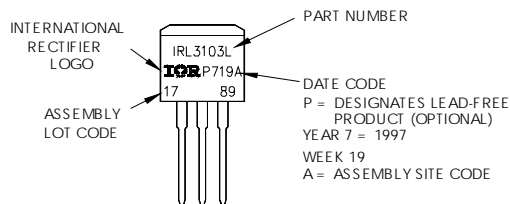
- NOTES:
1. DIMENSIONING AND TOLERANCING PER ASME Y14.5M-1994
 2. DIMENSIONS ARE SHOWN IN MILLIMETERS [INCHES]
 3. DIMENSION D & E DO NOT INCLUDE MOLD FLASH. MOLD FLASH SHALL NOT EXCEED 0.127 [0.005"] PER SIDE. THESE DIMENSIONS ARE MEASURED AT THE OUTMOST EXTREMES OF THE PLASTIC BODY.
 4. DIMENSION b1 AND c1 APPLY TO BASE METAL ONLY.
 5. CONTROLLING DIMENSION: INCH.

TO-262 Part Marking Information

EXAMPLE: THIS IS AN IRL3103L
 LOT CODE 1789
 ASSEMBLED ON WW 19, 1997
 IN THE ASSEMBLY LINE "C"
 Note: "P" in assembly line
 position indicates "Lead-Free"

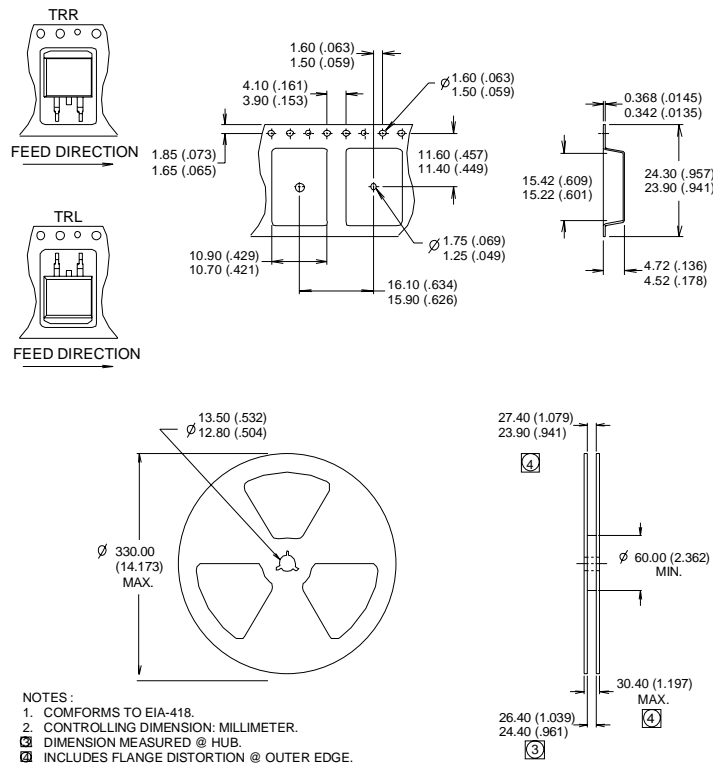


OR



D²Pak Tape & Reel Information

Dimensions are shown in millimeters (inches)



Notes:

- ① This is only applied to TO-220AB package
- ② This is applied to D²Pak, when mounted on 1" square PCB (FR-4 or G-10 Material).
For recommended footprint and soldering techniques refer to application note #AN-994.
- ③ Energy losses include "tail" and diode reverse recovery.
- ④ $V_{CC} = 80\% (V_{CES})$, $V_{GE} = 20V$, $L = 100 \mu H$, $R_G = 100\Omega$.

TO-220 package is not recommended for Surface Mount Application

Data and specifications subject to change without notice.
 This product has been designed and qualified for Industrial market.
 Qualification Standards can be found on IR's Web site.

International
IR Rectifier

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