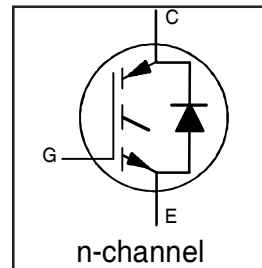


INSULATED GATE BIPOLAR TRANSISTOR WITH
ULTRAFAST SOFT RECOVERY DIODE

IRGB6B60KDPbF
IRGS6B60KDPbF
IRGSL6B60KDPbF

Features

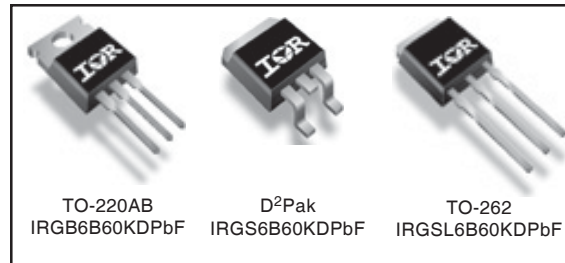
- Low VCE (on) Non Punch Through IGBT Technology.
- Low Diode VF.
- 10µs Short Circuit Capability.
- Square RBSOA.
- Ultrasoft Diode Reverse Recovery Characteristics.
- Positive VCE (on) Temperature Coefficient.
- Lead-Free



$V_{CES} = 600V$
 $I_C = 10A, T_C = 100^\circ C$
 $t_{sc} > 10\mu s, T_J = 150^\circ C$
 $V_{CE(on)} \text{ typ.} = 1.8V$

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}	Collector-to-Emitter Voltage	600	V
$I_C @ T_C = 25^\circ C$	Continuous Collector Current	18	A
$I_C @ T_C = 100^\circ C$	Continuous Collector Current	10	
I_{CM}	Pulsed Collector Current	26	
I_{LM}	Clamped Inductive Load Current④	26	
$I_F @ T_C = 25^\circ C$	Diode Continuous Forward Current	18	
$I_F @ T_C = 100^\circ C$	Diode Continuous Forward Current	10	V
I_{FM}	Diode Maximum Forward Current	26	
V_{GE}	Gate-to-Emitter Voltage	± 20	
$P_D @ T_C = 25^\circ C$	Maximum Power Dissipation	90	W
$P_D @ T_C = 100^\circ C$	Maximum Power Dissipation	36	
T_J	Operating Junction and	-55 to +150	$^\circ C$
T_{STG}	Storage Temperature Range		
	Soldering Temperature, for 10 sec.	300 (0.063 in. (1.6mm) from case)	

Thermal Resistance

	Parameter	Min.	Typ.	Max.	Units
$R_{\theta JC}$	Junction-to-Case - IGBT	—	—	1.4	$^\circ C/W$
$R_{\theta JC}$	Junction-to-Case - Diode	—	—	4.4	
$R_{\theta CS}$	Case-to-Sink, flat, greased surface	—	0.50	—	
$R_{\theta JA}$	Junction-to-Ambient, typical socket mount①	—	—	62	
$R_{\theta JA}$	Junction-to-Ambient (PCB Mount, steady state)②	—	—	40	
Wt	Weight	—	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		I _C = 5.0A	8
		—	1.20	1.40	V	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	—		I _C = 5.0A	
Q _{ge}	Gate - Emitter Charge (turn-on)	—	1.9	—	nC	V _{CC} = 400V	CT1
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		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	ns	L _s = 150nH, T _J = 25°C	
t _f	Fall Time	—	13.2	22			
E _{on}	Turn-On Switching Loss	—	150	260		I _C = 5.0A, V _{CC} = 400V	CT4
E _{off}	Turn-Off Switching Loss	—	190	300	μJ	V _{GE} = 15V, R _G = 100Ω, L = 1.4mH	13, 15
E _{tot}	Total Switching Loss	—	340	560		L _s = 150nH, T _J = 150°C ③	WF1WF2
t _{d(on)}	Turn-On Delay Time	—	28	37		I _C = 5.0A, V _{CC} = 400V	14, 16
t _r	Rise Time	—	17	26		V _{GE} = 15V, R _G = 100Ω, L = 1.4mH	CT4
t _{d(off)}	Turn-Off Delay Time	—	240	255	ns	L _s = 150nH, T _J = 150°C	WF1
t _f	Fall Time	—	18	27			WF2
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

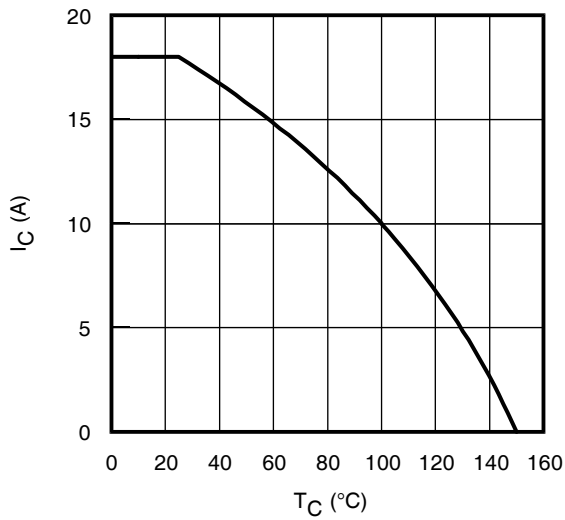


Fig. 1 - Maximum DC Collector Current vs. Case Temperature

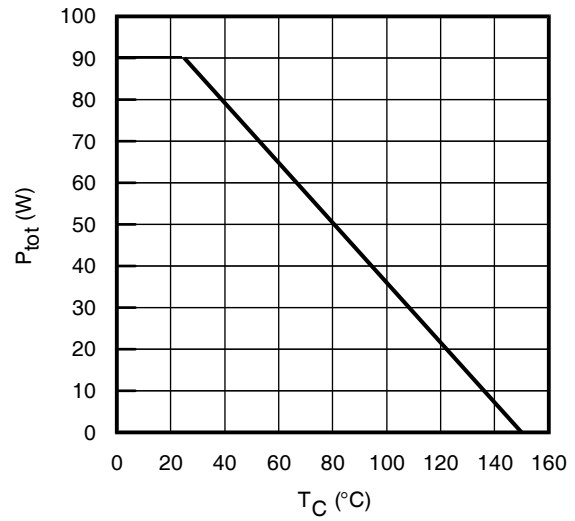


Fig. 2 - Power Dissipation vs. Case Temperature

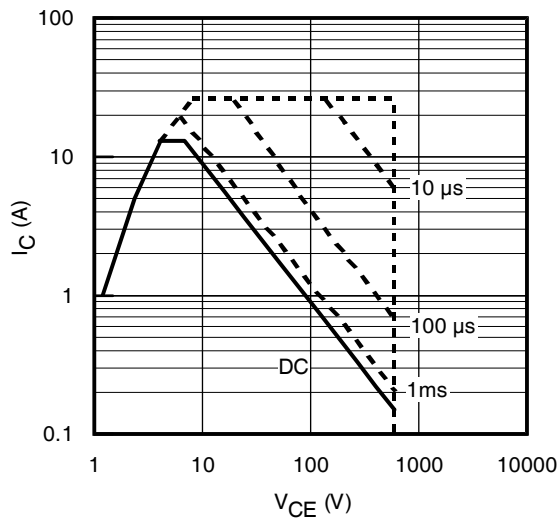


Fig. 3 - Forward SOA
 $T_C = 25^\circ\text{C}$; $T_J \leq 150^\circ\text{C}$

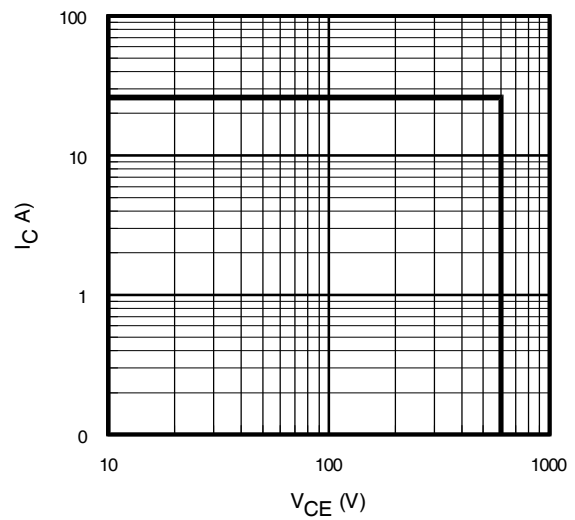


Fig. 4 - Reverse Bias SOA
 $T_J = 150^\circ\text{C}$; $V_{GE} = 15\text{V}$

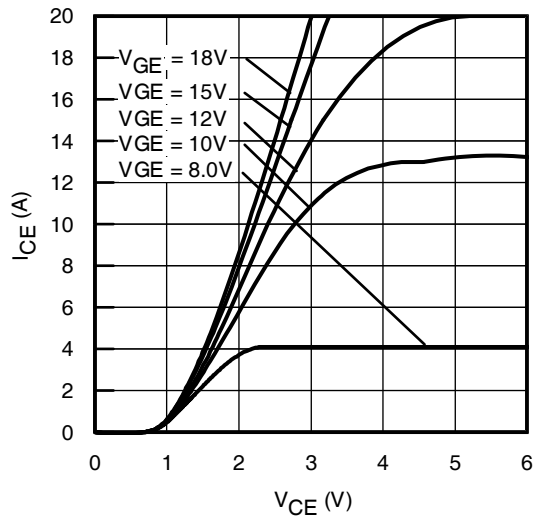


Fig. 5 - Typ. IGBT Output Characteristics
T_J = -40°C; t_p = 80μs

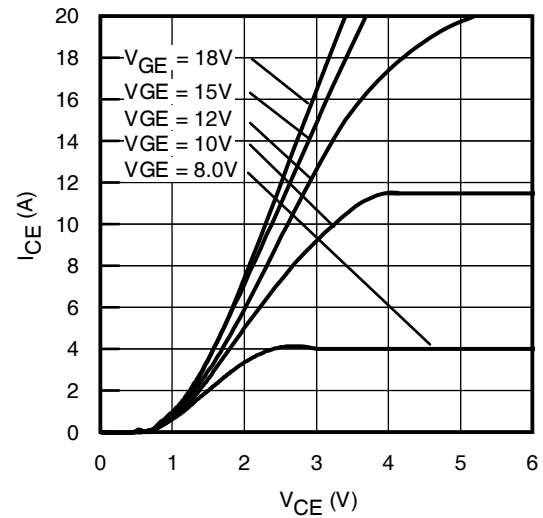


Fig. 6 - Typ. IGBT Output Characteristics
T_J = 25°C; t_p = 80μs

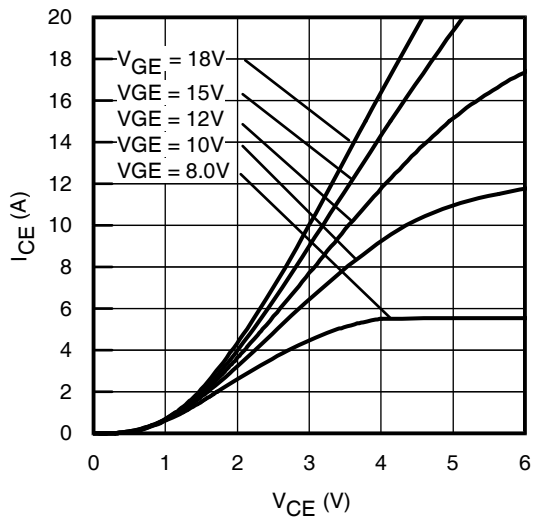


Fig. 7 - Typ. IGBT Output Characteristics
T_J = 150°C; t_p = 80μs

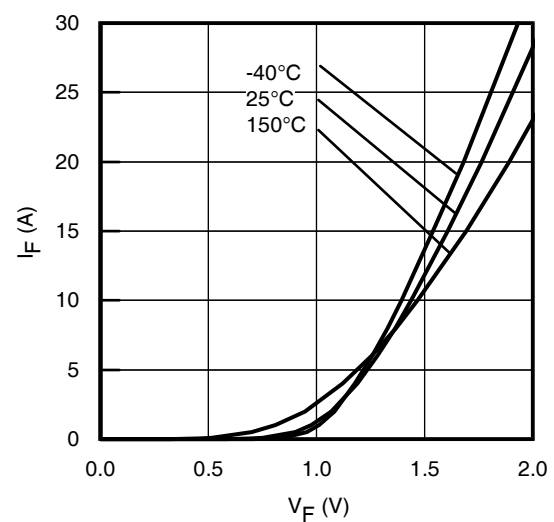


Fig. 8 - Typ. Diode Forward Characteristics
t_p = 80μs

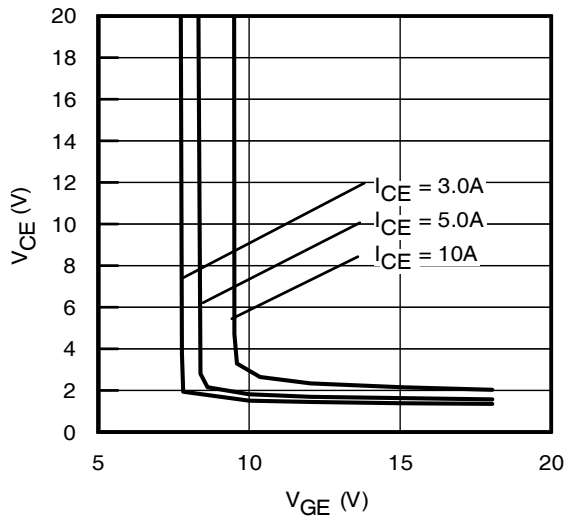


Fig. 9 - Typical V_{CE} vs. V_{GE}
 $T_J = -40^{\circ}\text{C}$

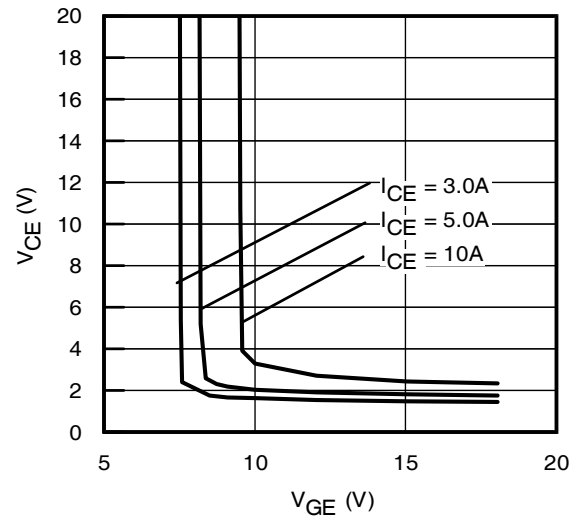


Fig. 10 - Typical V_{CE} vs. V_{GE}
 $T_J = 25^{\circ}\text{C}$

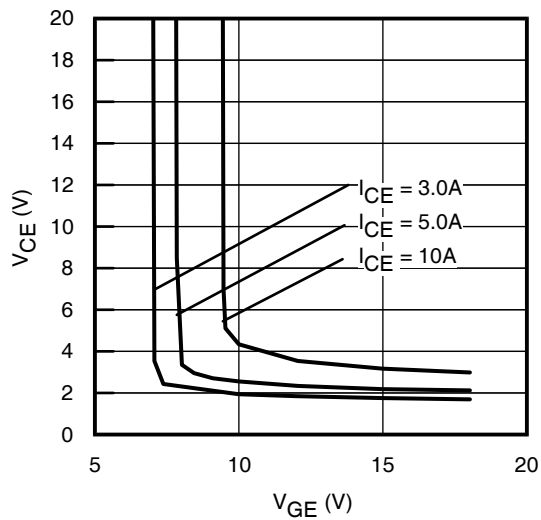


Fig. 11 - Typical V_{CE} vs. V_{GE}
 $T_J = 150^{\circ}\text{C}$

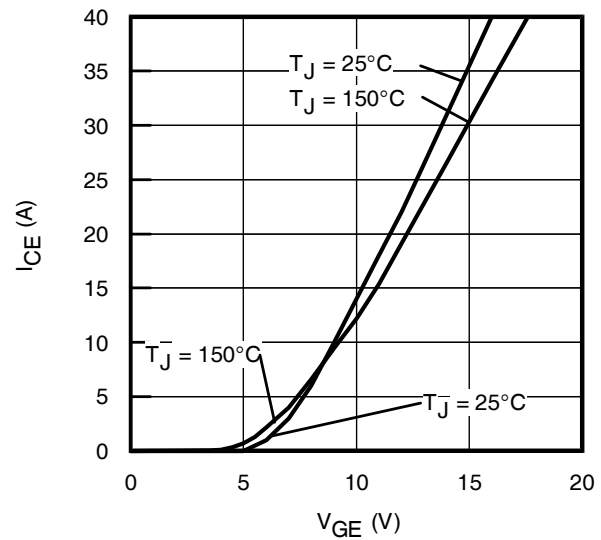


Fig. 12 - Typ. Transfer Characteristics
 $V_{CE} = 50\text{V}$; $t_p = 10\mu\text{s}$

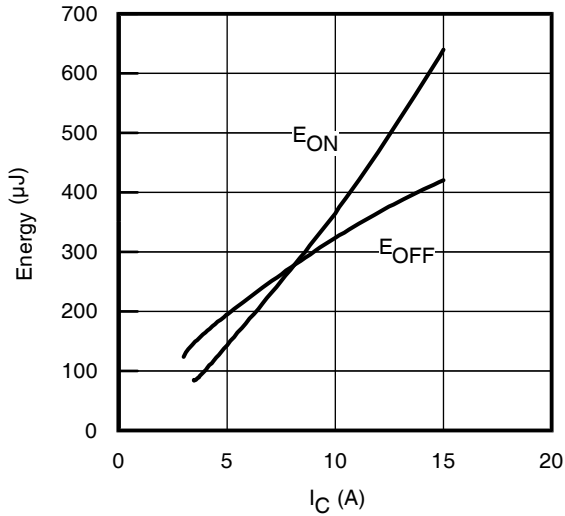


Fig. 13 - Typ. Energy Loss vs. I_C
 $T_J = 150^\circ\text{C}$; $L = 1.4\text{mH}$; $V_{CE} = 400\text{V}$
 $R_G = 100\Omega$; $V_{GE} = 15\text{V}$

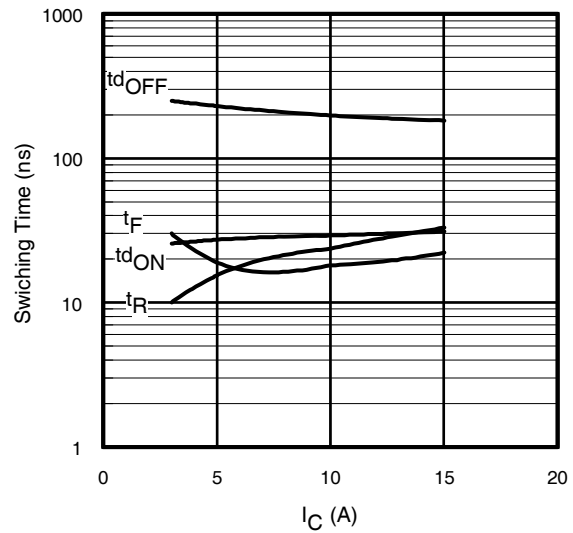


Fig. 14 - Typ. Switching Time vs. I_C
 $T_J = 150^\circ\text{C}$; $L = 1.4\text{mH}$; $V_{CE} = 400\text{V}$
 $R_G = 100\Omega$; $V_{GE} = 15\text{V}$

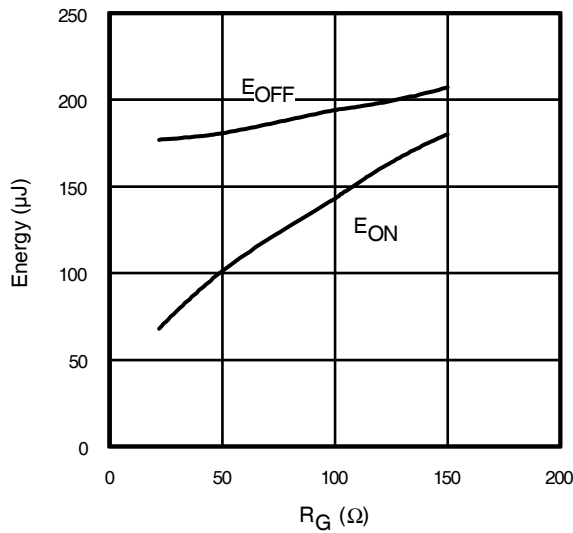


Fig. 15 - Typ. Energy Loss vs. R_G
 $T_J = 150^\circ\text{C}$; $L = 1.4\text{mH}$; $V_{CE} = 400\text{V}$
 $I_{CE} = 5.0\text{A}$; $V_{GE} = 15\text{V}$

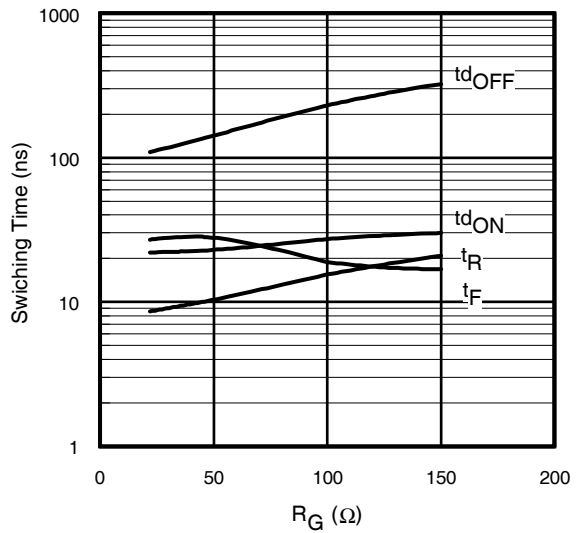


Fig. 16 - Typ. Switching Time vs. R_G
 $T_J = 150^\circ\text{C}$; $L = 1.4\text{mH}$; $V_{CE} = 400\text{V}$
 $I_{CE} = 5.0\text{A}$; $V_{GE} = 15\text{V}$

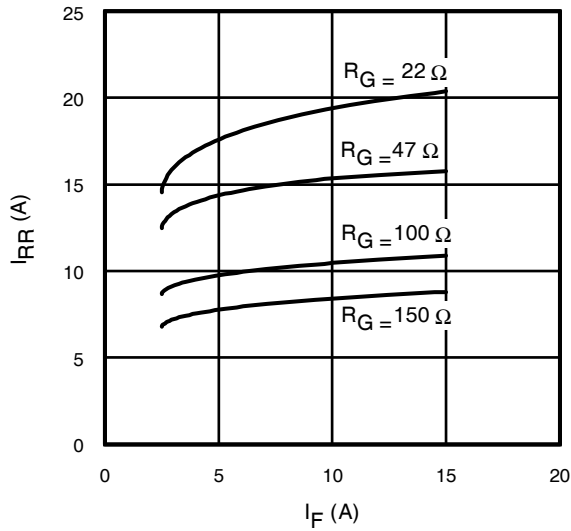


Fig. 17 - Typical Diode I_{RR} vs. I_F
 $T_J = 150^\circ\text{C}$

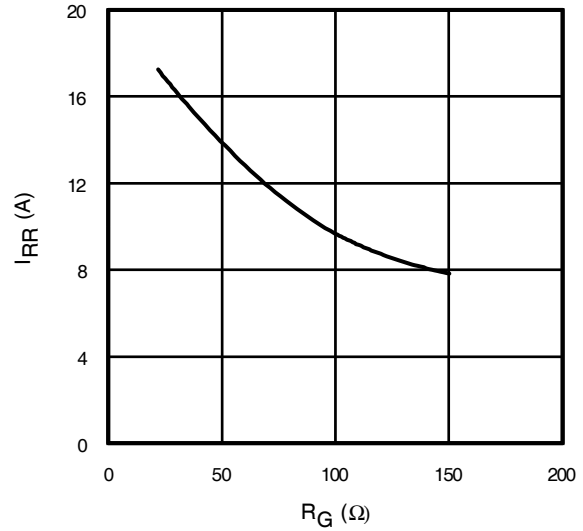


Fig. 18 - Typical Diode I_{RR} vs. R_G
 $T_J = 150^\circ\text{C}$; $I_F = 5.0\text{A}$

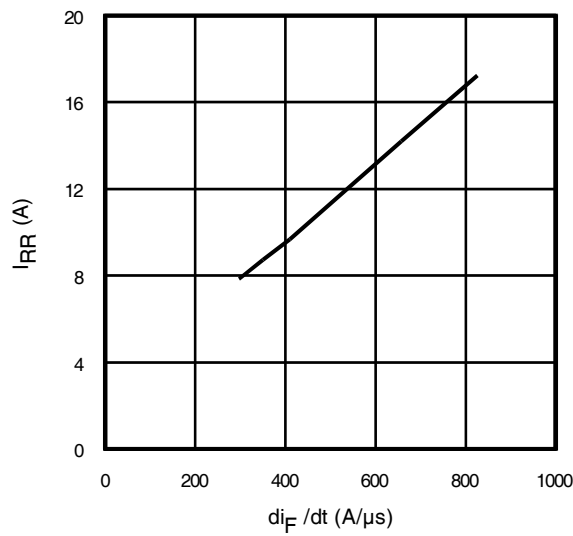


Fig. 19- Typical Diode I_{RR} vs. di_F/dt
 $V_{CC} = 400\text{V}$; $V_{GE} = 15\text{V}$;
 $I_{CE} = 5.0\text{A}$; $T_J = 150^\circ\text{C}$

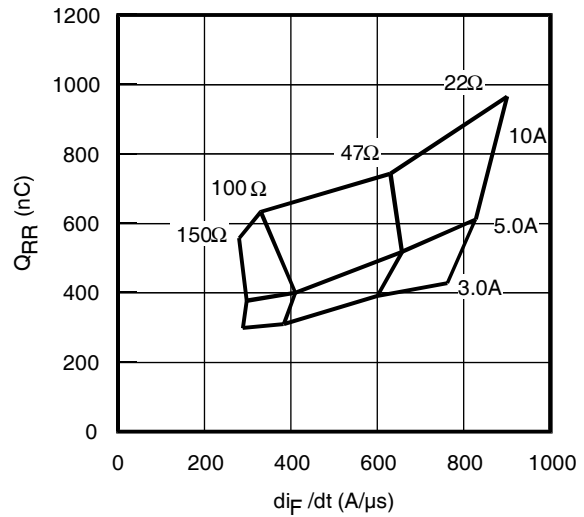


Fig. 20 - Typical Diode Q_{RR}
 $V_{CC} = 400\text{V}$; $V_{GE} = 15\text{V}$; $T_J = 150^\circ\text{C}$

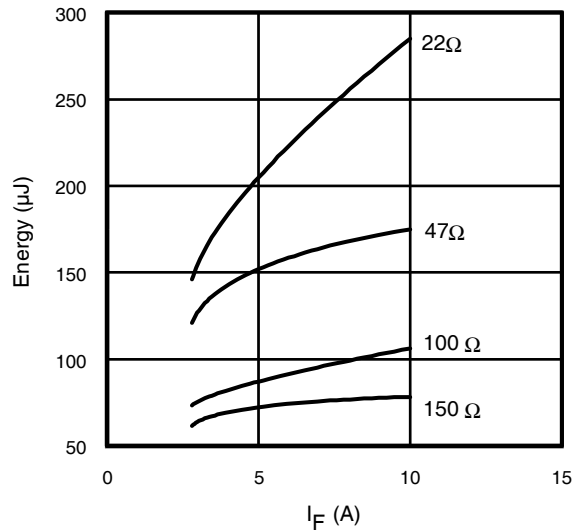


Fig. 21 - Typical Diode E_{RR} vs. I_F
 $T_J = 150^\circ\text{C}$

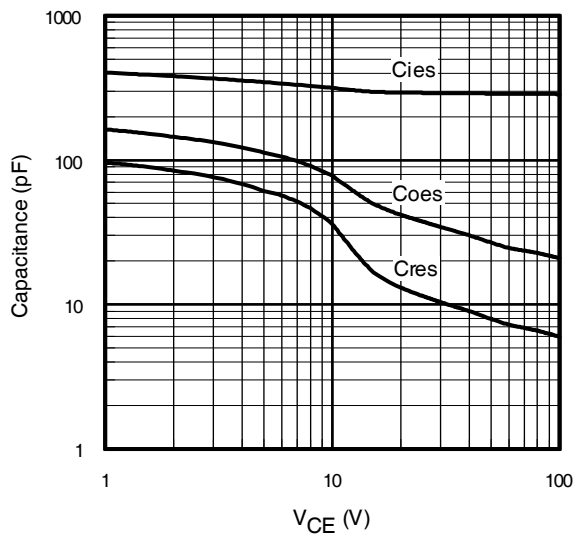


Fig. 22- Typ. Capacitance vs. V_{CE}
 $V_{GE} = 0\text{V}$; $f = 1\text{MHz}$

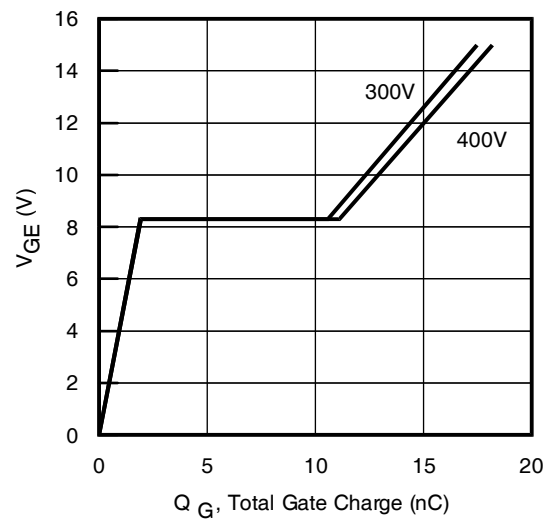


Fig. 23 - Typical Gate Charge vs. V_{GE}
 $I_{CE} = 5.0\text{A}$; $L = 600\mu\text{H}$

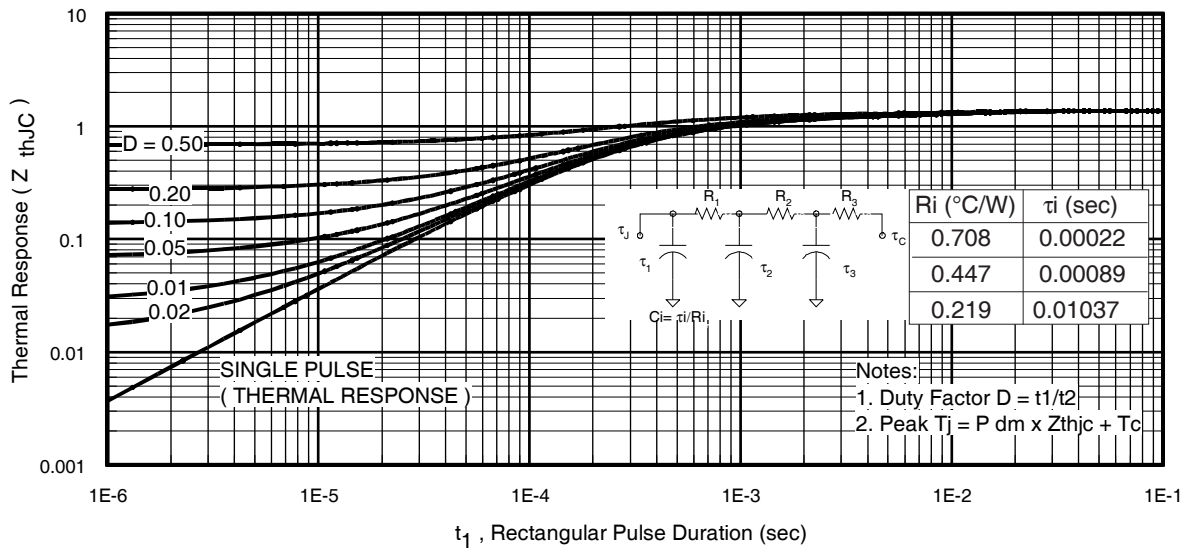


Fig 24. Maximum Transient Thermal Impedance, Junction-to-Case (IGBT)

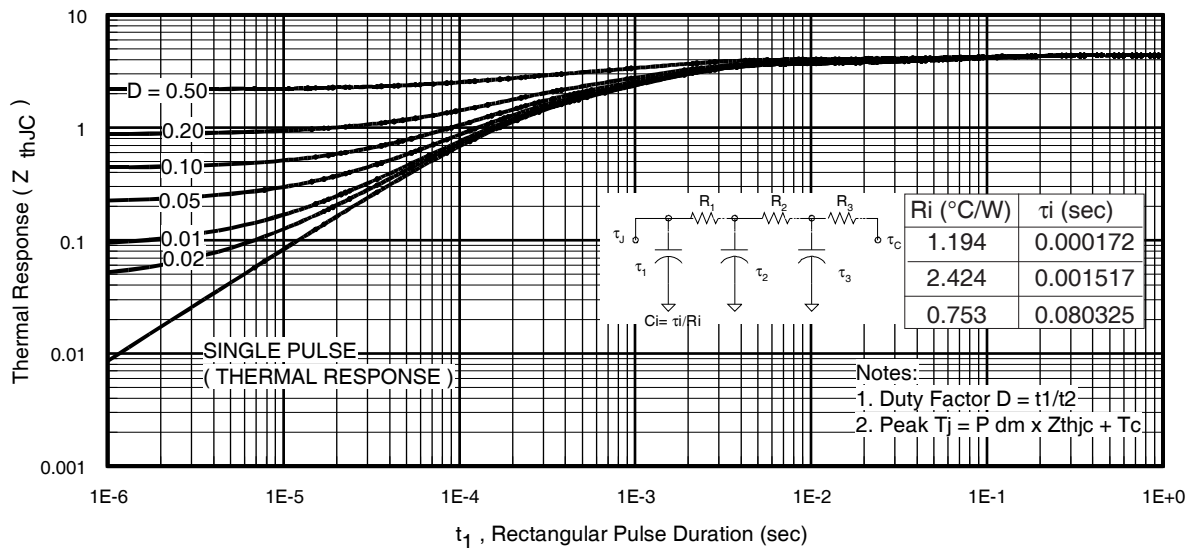


Fig 25. Maximum Transient Thermal Impedance, Junction-to-Case (DIODE)

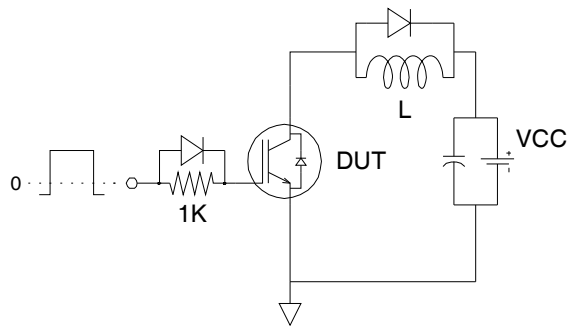


Fig.C.T.1 - Gate Charge Circuit (turn-off)

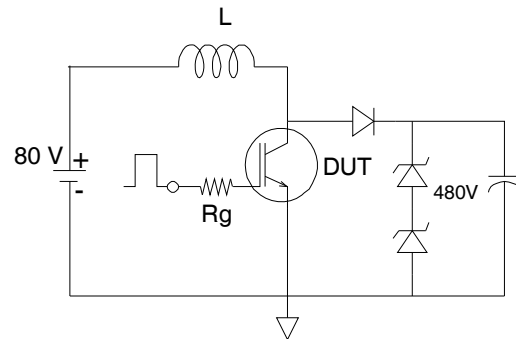


Fig.C.T.2 - RBSOA Circuit

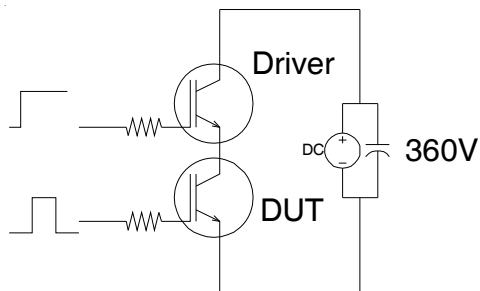


Fig.C.T.3 - S.C.SOA Circuit

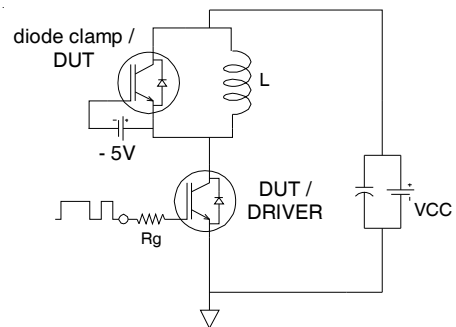


Fig.C.T.4 - Switching Loss Circuit

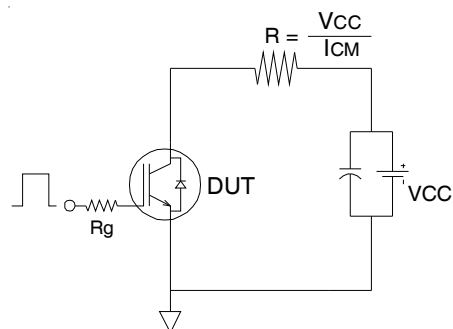


Fig.C.T.5 - Resistive Load Circuit

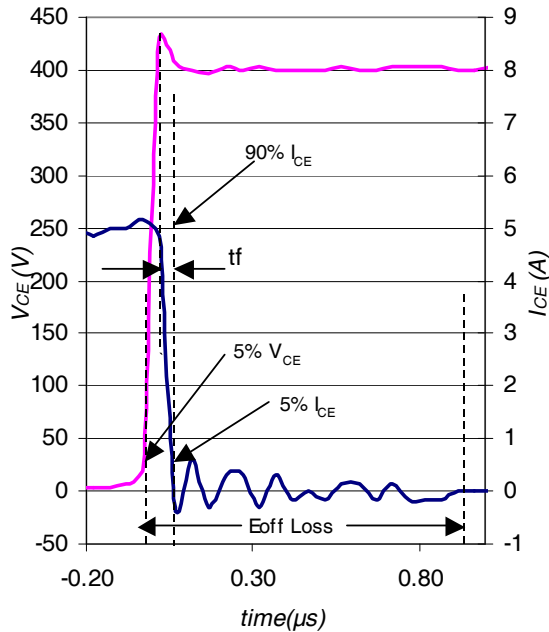


Fig. WF1- Typ. Turn-off Loss Waveform
@ $T_J = 150^\circ\text{C}$ using Fig. CT.4

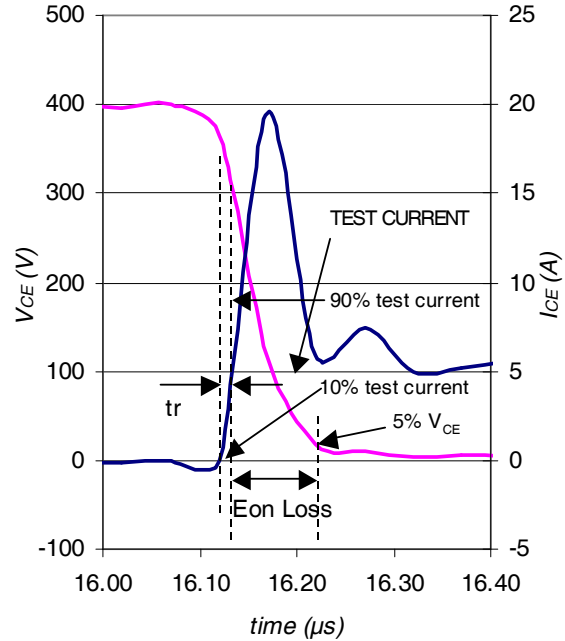


Fig. WF2- Typ. Turn-on Loss Waveform
@ $T_J = 150^\circ\text{C}$ using Fig. CT.4

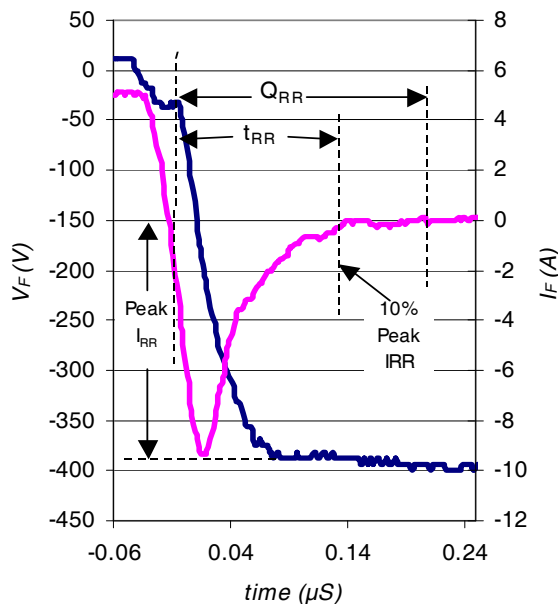


Fig. WF3- Typ. Diode Recovery Waveform
@ $T_J = 150^\circ\text{C}$ using Fig. CT.4

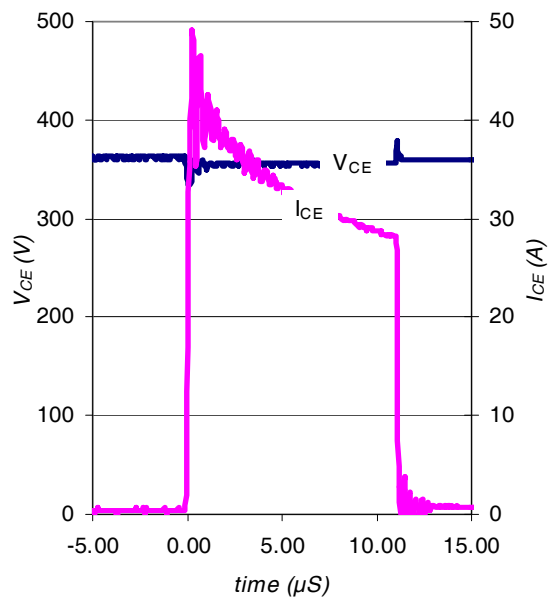
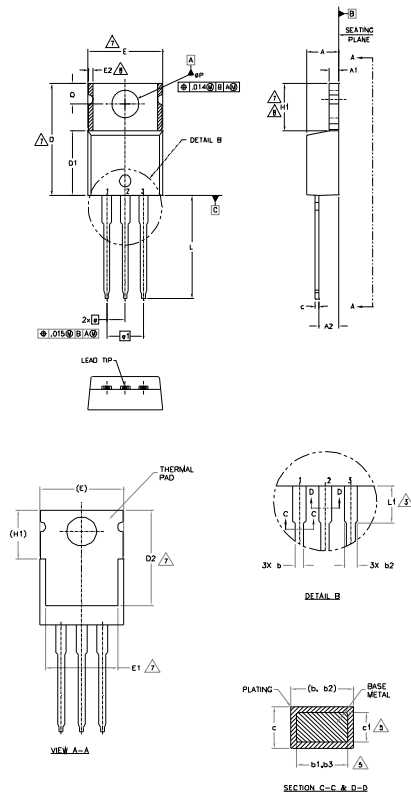


Fig. WF4- Typ. S.C Waveform
@ $T_J = 150^\circ\text{C}$ using Fig. CT.3

International
IOR Rectifier

Dimensions are shown in millimeters (inches)



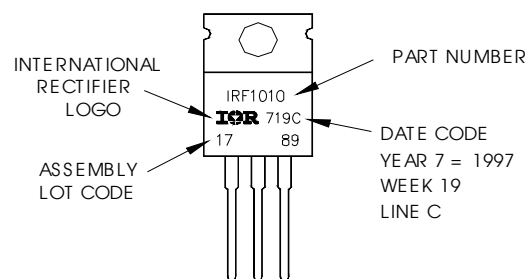
- 1.- DIMENSIONING AND TOLERANCING AS PER ASME Y14.5 M- 1994.
- 2.- DIMENSIONS ARE SHOWN IN INCHES [MILLIMETERS].
- 3.- LEAD DIMENSION AND FINISH UNCONTROLLED IN L1.
- 4.- DIMENSION D, D1 & E DO NOT INCLUDE MOLD FLASH. MOLD FLASH SHALL NOT EXCEED .005" (0.127) PER SIDE. THESE DIMENSIONS ARE MEASURED AT THE OUTERMOST EXTREMES OF THE PLASTIC BODY.
- 5.- DIMENSION b1, b3 & c1 APPLY TO BASE METAL ONLY.
- 6.- CONTROLLING DIMENSION: INCHES.
- 7.- THERMAL PAD CONTOUR OPTIONAL WITHIN DIMENSIONS E,H1,D2 & E1
- 8.- DIMENSION E2 X H1 DEFINE A ZONE WHERE STAMPING AND SINGULATION IRREGULARITIES ARE ALLOWED.
- 9.- OUTLINE CONFORMS TO JEDEC TO-220, EXCEPT A2 (max.) AND D2 (min.). WHERE DIMENSIONS ARE DERIVED FROM THE ACTUAL PACKAGE OUTLINE.

SYMBOL	DIMENSIONS				NOTES
	MILLIMETERS		INCHES		
	MIN.	MAX.	MIN.	MAX.	
A	3.56	4.83	.140	.190	
A1	0.51	1.40	.020	.055	
A2	2.03	2.92	.080	.115	
b	0.38	1.01	.015	.040	
b1	0.38	0.97	.015	.038	5
b2	1.14	1.78	.045	.070	
b3	1.14	1.73	.045	.068	5
c	0.36	0.61	.014	.024	
c1	0.36	0.56	.014	.022	5
D	14.22	16.51	.560	.650	4
D1	8.38	9.02	.330	.355	
D2	11.68	12.88	.460	.507	7
E	9.65	10.67	.380	.420	4,7
E1	6.86	8.89	.270	.350	7
E2	-	0.76	-	.030	8
e	2.54 BSC		.100 BSC		
e1	5.08 BSC		.200 BSC		
H1	5.84	6.86	.230	.270	7,8
L	12.70	14.73	.500	.580	
L1	3.56	4.06	.140	.160	3
ØP	3.54	4.08	.139	.161	
Q	2.54	3.42	.100	.135	

- 1.- ANODE
- 2.- CATHODE
- 3.- ANODE

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"

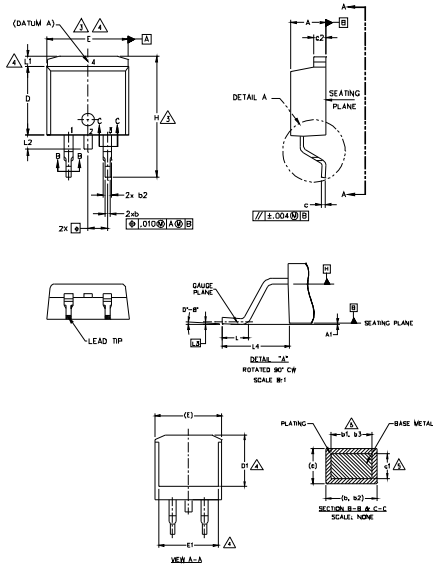


12

IRGB/S/SL6B60KDPbF

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	5
A1	0.00	0.254	.000	.010	
b	0.51	0.99	.020	.039	
b1	0.51	0.89	.020	.035	
b2	1.14	1.78	.045	.070	
b3	1.14	1.73	.045	.068	5
c	0.38	0.74	.015	.029	5
c1	0.38	0.58	.015	.023	
c2	1.14	1.65	.045	.065	
D	8.38	9.65	.330	.380	3
D1	6.86	—	.270		4
E	9.65	10.67	.380	.420	3,4
E1	6.22	—	.245		4
e	2.54 BSC		.100 BSC		4
H	14.61	15.88	.575	.625	
L	1.78	2.79	.070	.110	
L1	—	1.65	—	.066	
L2	—	1.78	—	.070	
L3	0.25 BSC		.010 BSC		4
L4	4.78	5.28	.188	.208	

NOTES

- NOTES:
1. DIMENSIONING AND TOLERANCING PER ASME Y14.2M-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. DIMENSIONS ARE MEASURED AT THE OUTMOST EXTREMES OF THE PLASTIC BODY AT DATUM H.
 4. THERMAL PAD CONTOUR OPTIONAL WITHIN DIMENSION E, L1, D1 & E1.
 5. DIMENSION b1 and c1 APPLY TO BASE METAL ONLY.
 6. DATUM A & B TO BE DETERMINED AT DATUM PLANE H.
 7. CONTROLLING DIMENSION: INCH.
 8. OUTLINE CONFORMS TO JEDEC OUTLINE TO-263AB.

LEAD ASSIGNMENTS

DIODES

- 1.- ANODE (TWO DIE) / OPEN (ONE DIE)
2. 4.- CATHODE
- 3.- ANODE

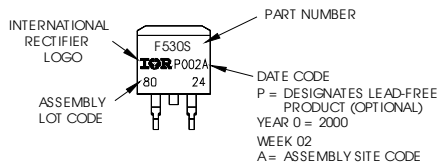
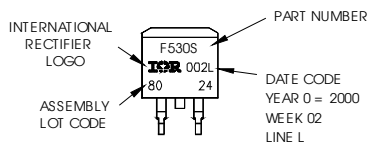
HEXFET

- | | |
|--------------|------------------|
| 1.- GATE | 1.- GATE |
| 2, 4.- DRAIN | 2, 4.- COLLECTOR |
| 3.- SOURCE | 3.- EMITTER |

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"

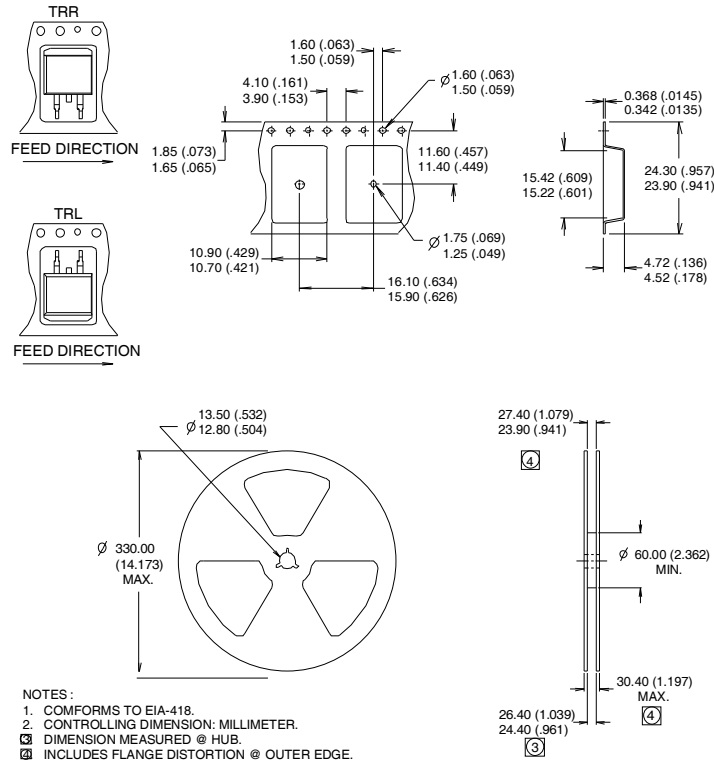


Note: For the most current drawing please refer to IR website at <http://www.irf.com/package/>

www.irf.com

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 $V_{CC} = 80\% (V_{CES})$, $V_{GE} = 20V$, $L = 100 \mu H$, $R_G = 100\Omega$.

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.