

International IOR Rectifier

INSULATED GATE BIPOLAR TRANSISTOR WITH
ULTRAFAST SOFT RECOVERY DIODE

PD - 94383C

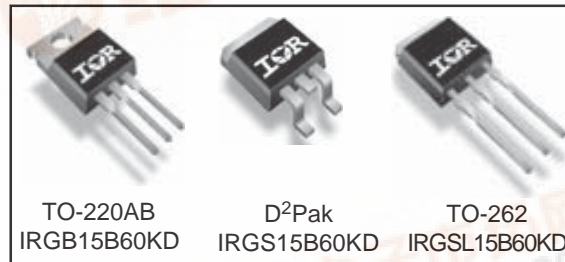
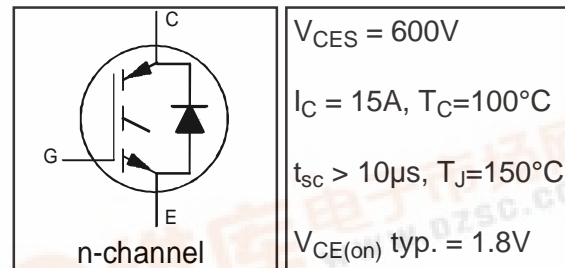
IRGB15B60KD
IRGS15B60KD
IRGSL15B60KD

Features

- Low $V_{CE(on)}$ Non Punch Through IGBT Technology.
- Low Diode VF.
- 10 μ s 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}	Collector-to-Emitter Voltage	600	V
$I_C @ T_C = 25^\circ C$	Continuous Collector Current	31	A
$I_C @ T_C = 100^\circ C$	Continuous Collector Current	15	
I_{CM}	Pulsed Collector Current	62	
I_{LM}	Clamped Inductive Load Current	62	
$I_F @ T_C = 25^\circ C$	Diode Continuous Forward Current	31	
$I_F @ T_C = 100^\circ C$	Diode Continuous Forward Current	15	V
I_{FM}	Diode Maximum Forward Current	64	
V_{GE}	Gate-to-Emitter Voltage	± 20	
$P_D @ T_C = 25^\circ C$	Maximum Power Dissipation	208	W
$P_D @ T_C = 100^\circ C$	Maximum Power Dissipation	83	
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	—	—	0.6	$^\circ C/W$
$R_{\theta JC}$	Junction-to-Case - Diode	—	—	2.1	
$R_{\theta CS}$	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



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Electrical Characteristics @ $T_J = 25^\circ\text{C}$ (unless otherwise specified)

	Parameter	Min.	Typ.	Max.	Units	Conditions	Ref.Fig.
$V_{(BR)CES}$	Collector-to-Emitter Breakdown Voltage	600	—	—	V	$V_{GE} = 0V, I_C = 500\mu A$	
$\Delta V_{(BR)CES}/\Delta T_J$	Temperature Coeff. of Breakdown Voltage	—	0.3	—	$V/^\circ\text{C}$	$V_{GE} = 0V, I_C = 1.0mA, (25^\circ\text{C}-150^\circ\text{C})$	
$V_{CE(on)}$	Collector-to-Emitter Saturation Voltage	1.5	1.80	2.20	V	$I_C = 15A, V_{GE} = 15V$	5, 6, 7
		—	2.05	2.50		$I_C = 15A, V_{GE} = 15V, T_J = 125^\circ\text{C}$	9, 10, 11
		—	2.10	2.60		$I_C = 15A, V_{GE} = 15V, T_J = 150^\circ\text{C}$	
$V_{GE(th)}$	Gate Threshold Voltage	3.5	4.5	5.5	V	$V_{CE} = V_{GE}, I_C = 250\mu A$	9, 10, 11
$\Delta V_{GE(th)}/\Delta T_J$	Temperature Coeff. of Threshold Voltage	—	-10	—	$mV/^\circ\text{C}$	$V_{CE} = V_{GE}, I_C = 1.0mA, (25^\circ\text{C}-150^\circ\text{C})$	12
g_{fe}	Forward Transconductance	—	10.6	—	S	$V_{CE} = 50V, I_C = 20A, PW=80\mu s$	
I_{CES}	Zero Gate Voltage Collector Current	—	5.0	150	μA	$V_{GE} = 0V, V_{CE} = 600V$	
		—	500	1000		$V_{GE} = 0V, V_{CE} = 600V, T_J = 150^\circ\text{C}$	
V_{FM}	Diode Forward Voltage Drop	—	1.20	1.45	V	$I_C = 15A$	8
		—	1.20	1.45		$I_C = 15A, T_J = 150^\circ\text{C}$	
I_{GES}	Gate-to-Emitter Leakage Current	—	—	± 100	nA	$V_{GE} = \pm 20V$	

Switching Characteristics @ $T_J = 25^\circ\text{C}$ (unless otherwise specified)

	Parameter	Min.	Typ.	Max.	Units	Conditions	Ref.Fig.
Qg	Total Gate Charge (turn-on)	—	56	84	nC	I _C = 15A	CT1
Qge	Gate - Emitter Charge (turn-on)	—	7.0	10		V _{CC} = 400V	
Qgc	Gate - Collector Charge (turn-on)	—	26	39		V _{GE} = 15V	
E _{on}	Turn-On Switching Loss	—	220	330	μJ	I _C = 15A, V _{CC} = 400V	CT4
E _{off}	Turn-Off Switching Loss	—	340	455		V _{GE} = 15V, R _G = 22Ω, L = 200μH	
E _{tot}	Total Switching Loss	—	560	785		L _s = 150nH T _J = 25°C ③	
t _{d(on)}	Turn-On Delay Time	—	34	44	ns	I _C = 15A, V _{CC} = 400V	CT4
t _r	Rise Time	—	16	22		V _{GE} = 15V, R _G = 22Ω, L = 200μH	
t _{d(off)}	Turn-Off Delay Time	—	184	200		L _s = 150nH, T _J = 25°C	
t _f	Fall Time	—	20	26	μJ	I _C = 15A, V _{CC} = 400V	CT4 13,15 WF1WF2
E _{on}	Turn-On Switching Loss	—	355	470		V _{GE} = 15V, R _G = 22Ω, L = 200μH	
E _{off}	Turn-Off Switching Loss	—	490	600		L _s = 150nH T _J = 150°C ③	
E _{tot}	Total Switching Loss	—	835	1070	ns	I _C = 15A, V _{CC} = 400V	14, 16 CT4 WF1 WF2
t _{d(on)}	Turn-On Delay Time	—	34	44		V _{GE} = 15V, R _G = 22Ω, L = 200μH	
t _r	Rise Time	—	18	25		L _s = 150nH, T _J = 150°C	
t _{d(off)}	Turn-Off Delay Time	—	203	226	pF	V _{GE} = 0V	
t _f	Fall Time	—	28	36		V _{CC} = 30V	
C _{ies}	Input Capacitance	—	850	—		f = 1.0MHz	
C _{oes}	Output Capacitance	—	75	—			
C _{res}	Reverse Transfer Capacitance	—	35	—			
RBSOA	Reverse Bias Safe Operating Area	FULL SQUARE				T _J = 150°C, I _C = 62A, V _p =600V V _{CC} = 500V, V _{GE} = +15V to 0V, R _G = 22Ω	4 CT2
SCSOA	Short Circuit Safe Operating Area	10	—	—	μs	T _J = 150°C, V _p =600V, R _G = 22Ω V _{CC} = 360V, V _{GE} = +15V to 0V	CT3 WF4
E _{rec}	Reverse Recovery energy of the diode	—	540	720	μJ	T _J = 150°C	17,18,19
t _{rr}	Diode Reverse Recovery time	—	92	111	ns	V _{CC} = 400V, I _F = 15A, L = 200μH	20,21
I _{rr}	Diode Peak Reverse Recovery Current	—	29	33	A	V _{GE} = 15V, R _G = 22Ω, L _s = 150nH	CT4,WF3

Note ① to ③ are on page 15

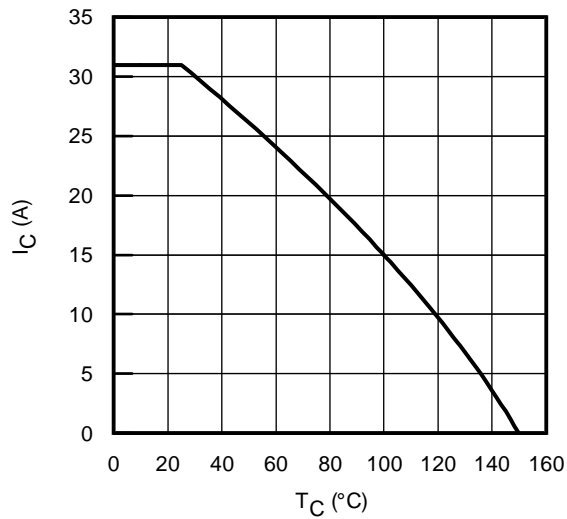


Fig. 1 - Maximum DC Collector Current vs. Case Temperature

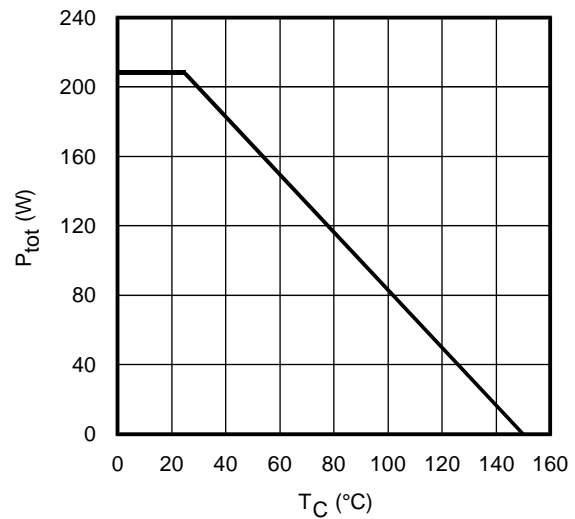


Fig. 2 - Power Dissipation vs. Case Temperature

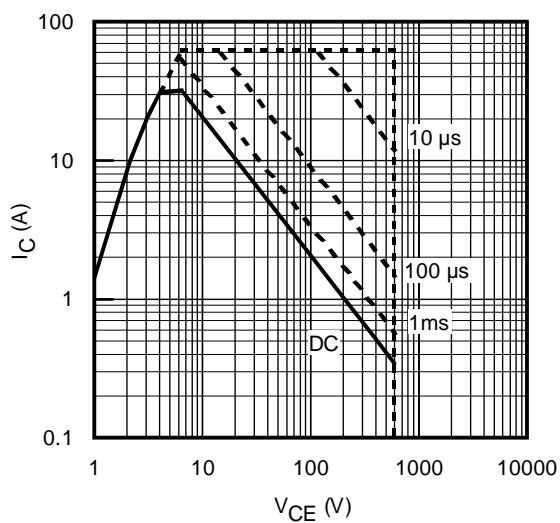


Fig. 3 - Forward SOA
 $T_C = 25^{\circ}\text{C}$; $T_J \leq 150^{\circ}\text{C}$

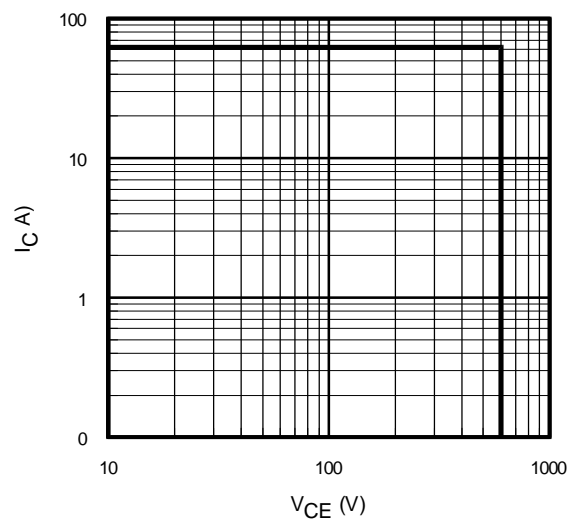


Fig. 4 - Reverse Bias SOA
 $T_J = 150^{\circ}\text{C}$; $V_{GE} = 15\text{V}$

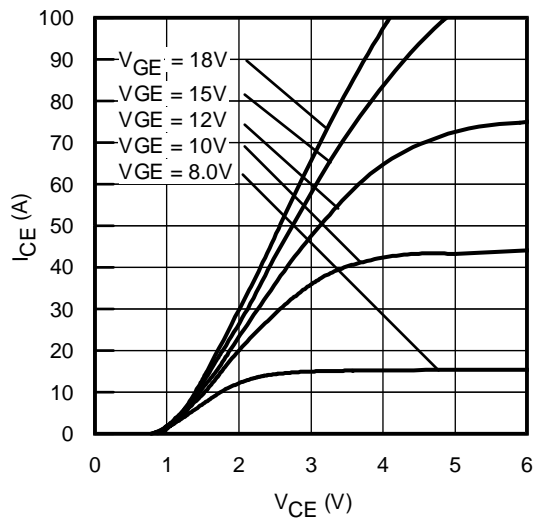


Fig. 5 - Typ. IGBT Output Characteristics
T_J = -40°C; tp = 300μs

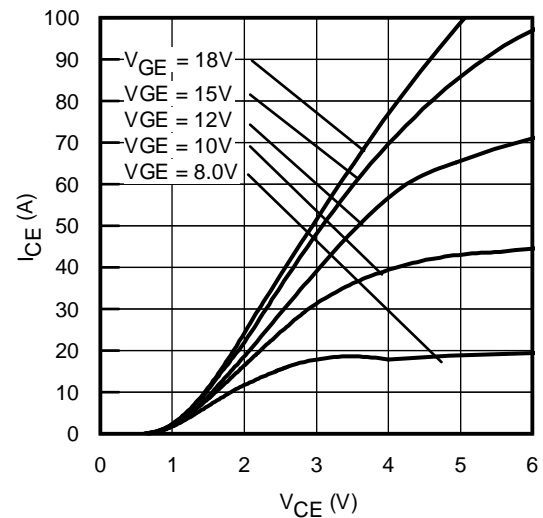


Fig. 6 - Typ. IGBT Output Characteristics
T_J = 25°C; tp = 300μs

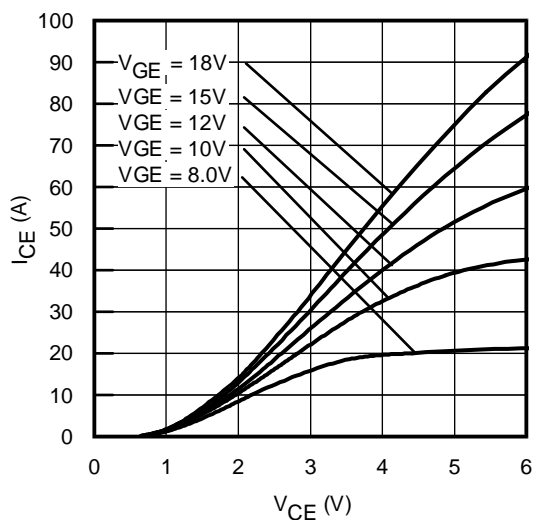


Fig. 7 - Typ. IGBT Output Characteristics
T_J = 150°C; tp = 300μs

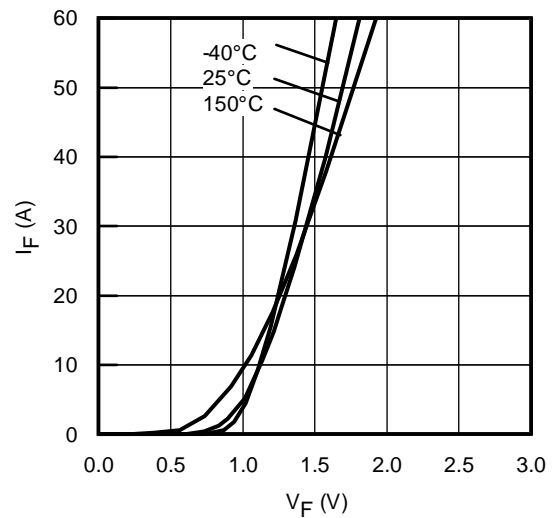


Fig. 8 - Typ. Diode Forward Characteristics
tp = 80μs

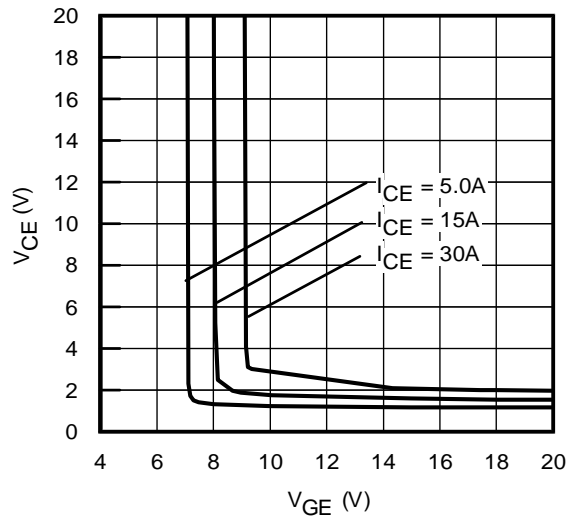


Fig. 9 - Typical V_{CE} vs. V_{GE}
 $T_J = -40^{\circ}\text{C}$

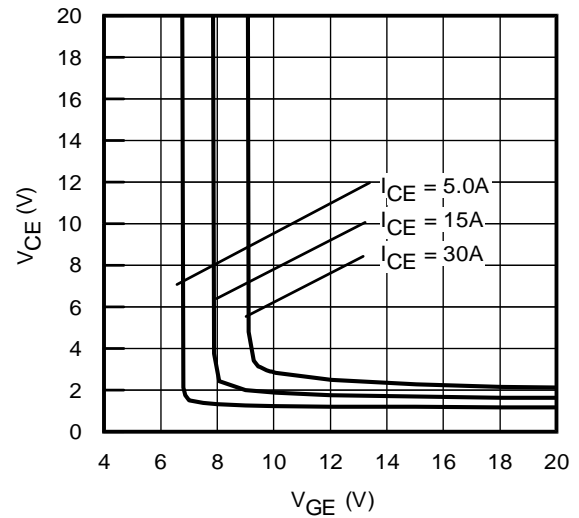


Fig. 10 - Typical V_{CE} vs. V_{GE}
 $T_J = 25^{\circ}\text{C}$

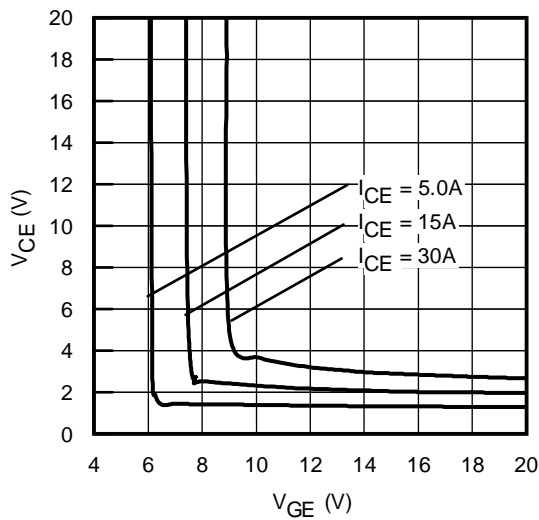


Fig. 11 - Typical V_{CE} vs. V_{GE}
 $T_J = 150^{\circ}\text{C}$

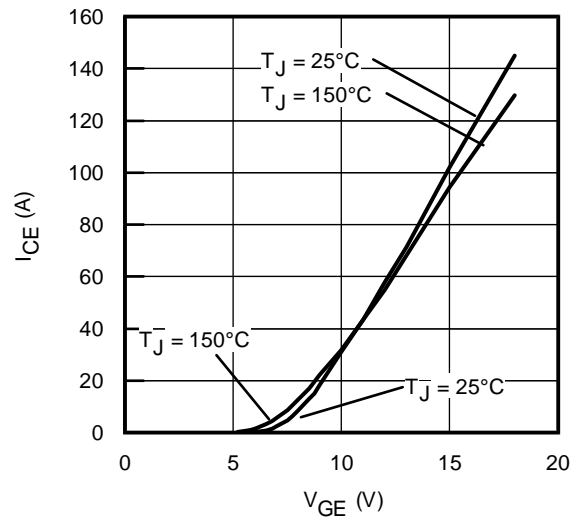


Fig. 12 - Typ. Transfer Characteristics
 $V_{CE} = 50\text{V}$; $t_p = 10\mu\text{s}$

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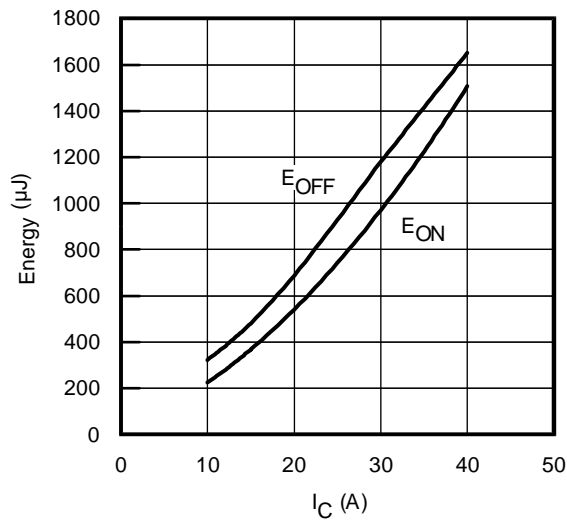


Fig. 13 - Typ. Energy Loss vs. I_C
 $T_J = 150^\circ\text{C}$; $L=200\mu\text{H}$; $V_{CE}=400\text{V}$
 $R_G=22\Omega$; $V_{GE}=15\text{V}$

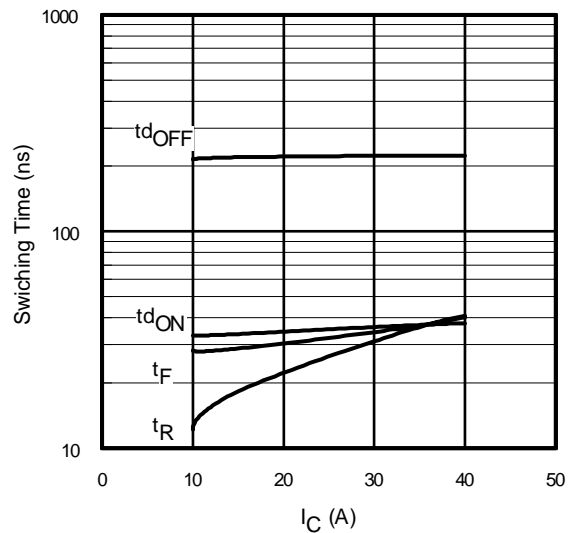


Fig. 14 - Typ. Switching Time vs. I_C
 $T_J = 150^\circ\text{C}$; $L=200\mu\text{H}$; $V_{CE}=400\text{V}$
 $R_G=22\Omega$; $V_{GE}=15\text{V}$

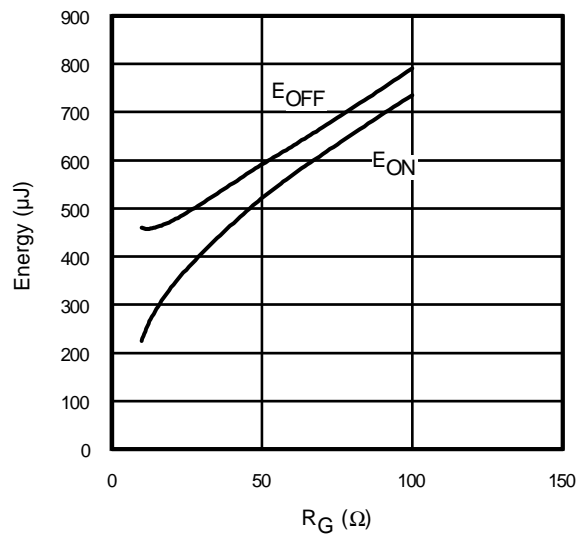


Fig. 15 - Typ. Energy Loss vs. R_G
 $T_J = 150^\circ\text{C}$; $L=200\mu\text{H}$; $V_{CE}=400\text{V}$
 $I_{CE}=15\text{A}$; $V_{GE}=15\text{V}$

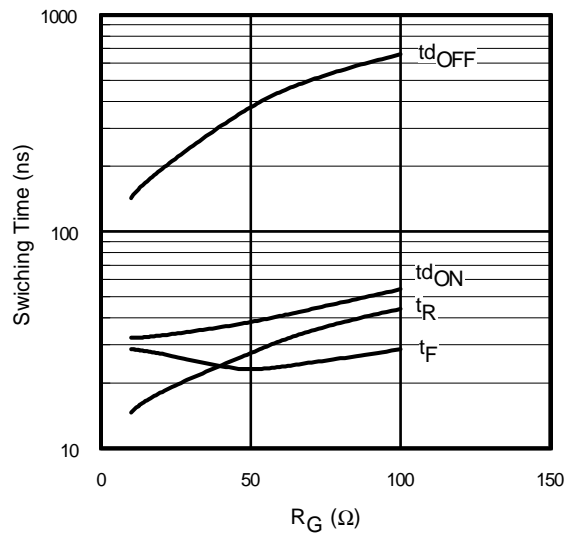


Fig. 16- Typ. Switching Time vs. R_G
 $T_J = 150^\circ\text{C}$; $L=200\mu\text{H}$; $V_{CE}=600\text{V}$
 $I_{CE}=15\text{A}$; $V_{GE}=15\text{V}$

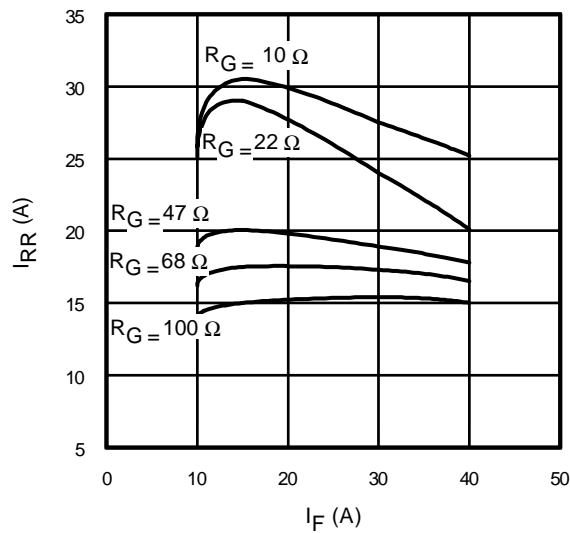


Fig. 17 - Typical Diode I_{RR} vs. I_F
 $T_J = 150^\circ\text{C}$

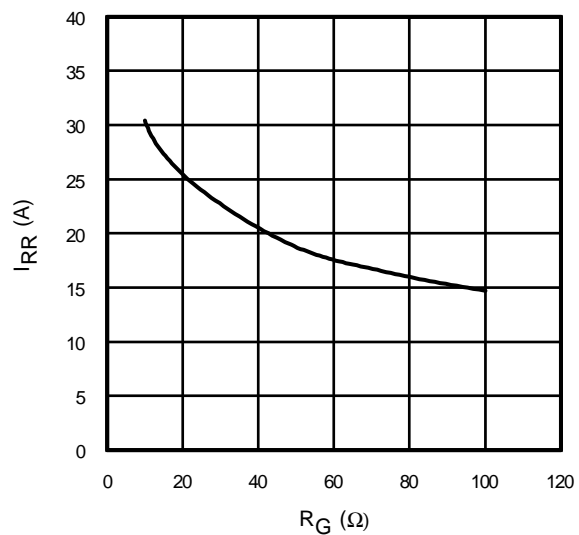


Fig. 18 - Typical Diode I_{RR} vs. R_G
 $T_J = 150^\circ\text{C}; I_F = 15\text{A}$

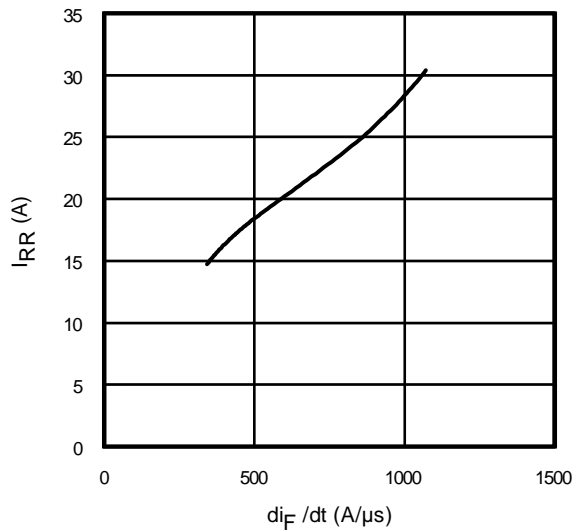


Fig. 19 - Typical Diode I_{RR} vs. di_F/dt
 $V_{CC} = 400\text{V}; V_{GE} = 15\text{V};$
 $I_{CE} = 15\text{A}; T_J = 150^\circ\text{C}$

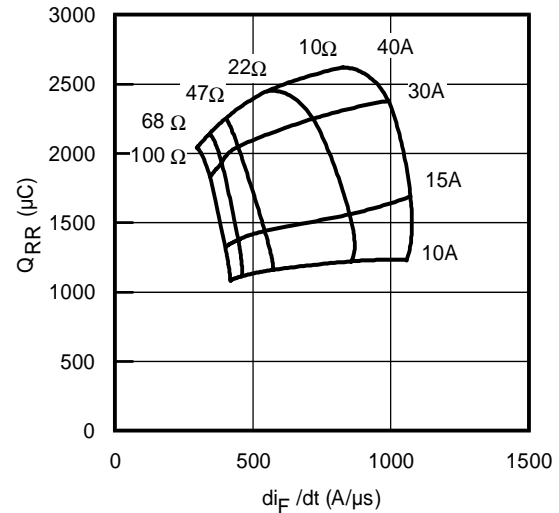


Fig. 20 - Typical Diode Q_{RR}
 $V_{CC} = 400\text{V}; V_{GE} = 15\text{V}; T_J = 150^\circ\text{C}$

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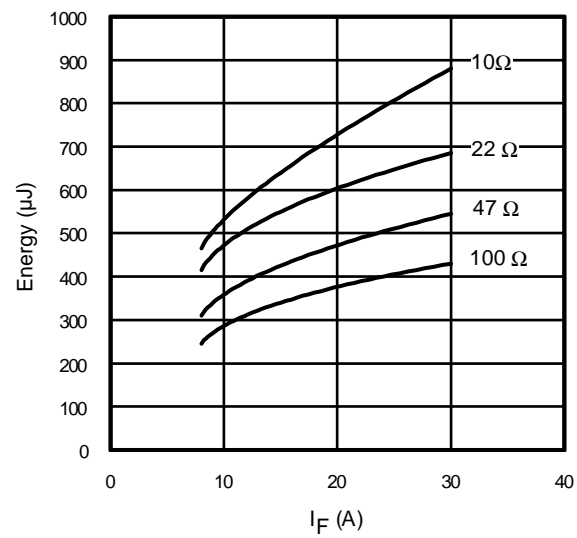


Fig. 21 - Typical Diode E_{RR} vs. I_F
 $T_J = 150^\circ\text{C}$

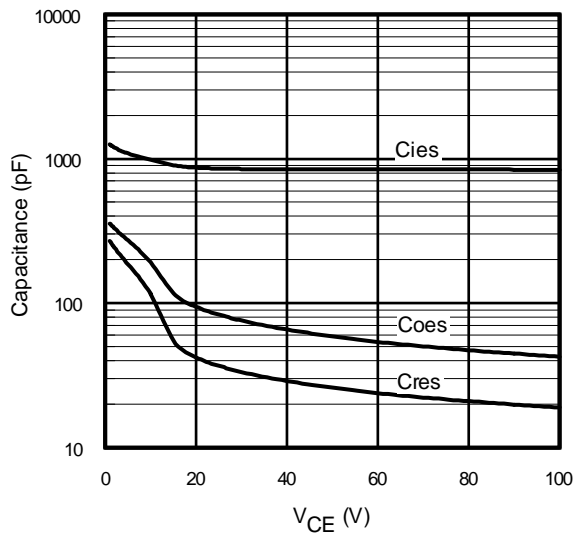


Fig. 22- Typ. Capacitance vs. V_{CE}
 $V_{GE} = 0\text{V}$; $f = 1\text{MHz}$

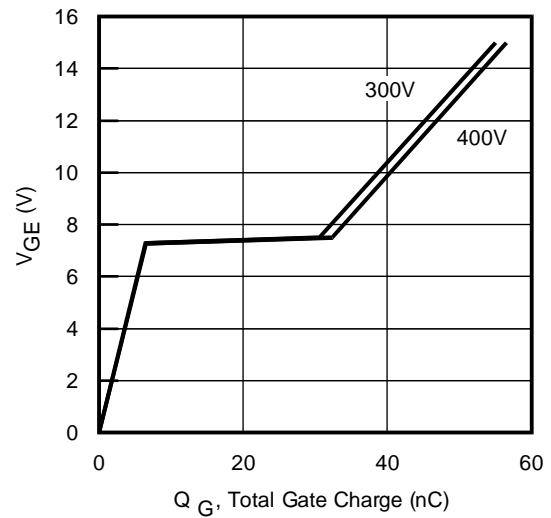


Fig. 23 - Typical Gate Charge vs. V_{GE}
 $I_{CE} = 15\text{A}$; $L = 600\mu\text{H}$

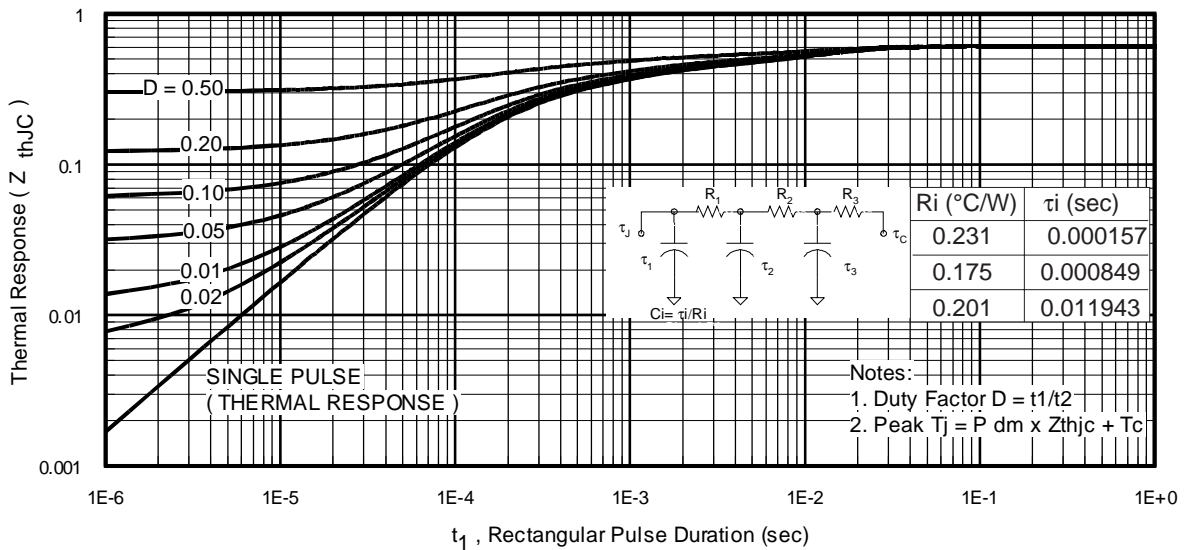


Fig 24. Maximum Transient Thermal Impedance, Junction-to-Case (IGBT)

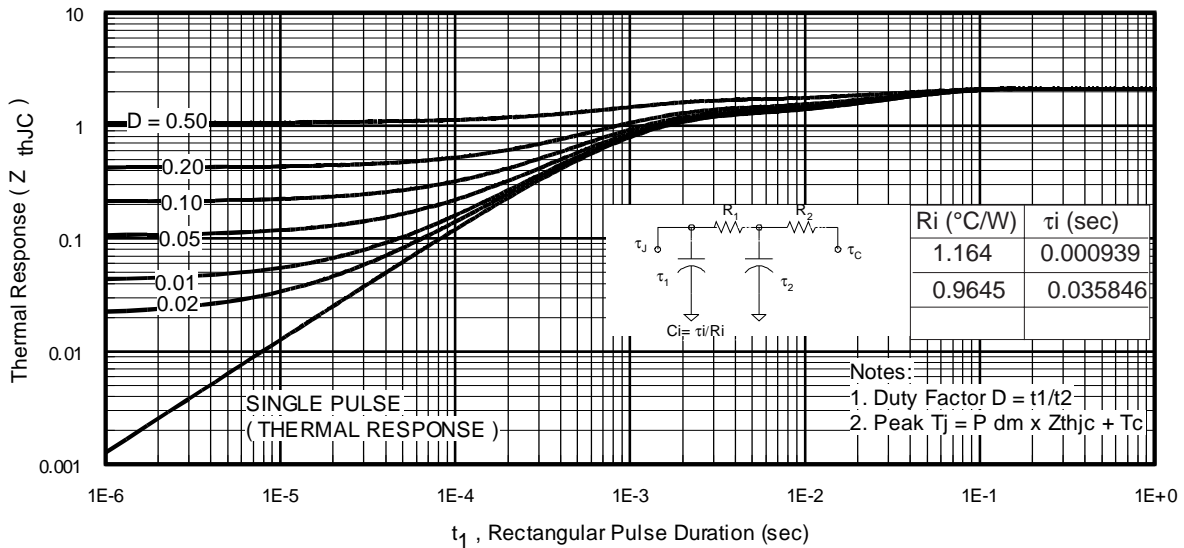


Fig 25. Maximum Transient Thermal Impedance, Junction-to-Case (DIODE)

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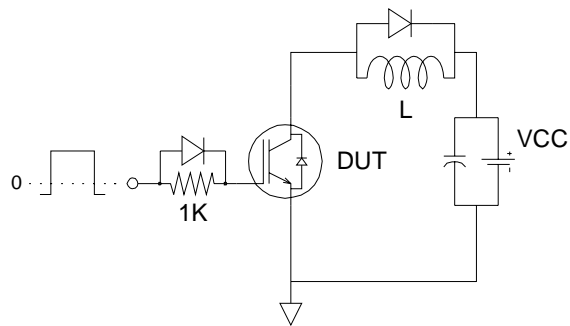


Fig.C.T.1 - Gate Charge Circuit (turn-off)

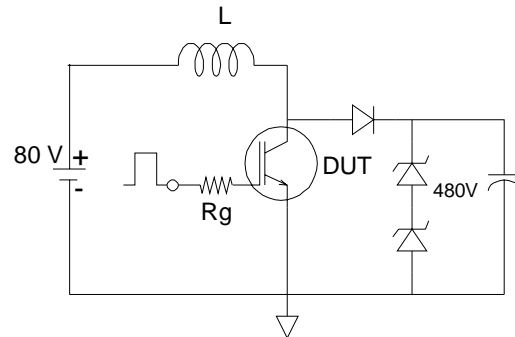


Fig.C.T.2 - RBSOA Circuit

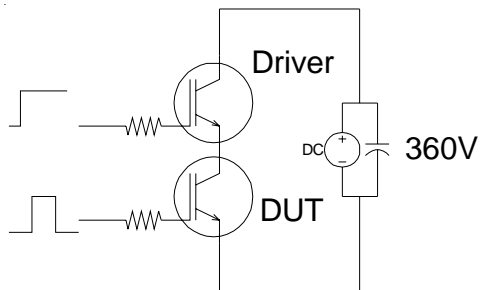


Fig.C.T.3 - S.C.SOA Circuit

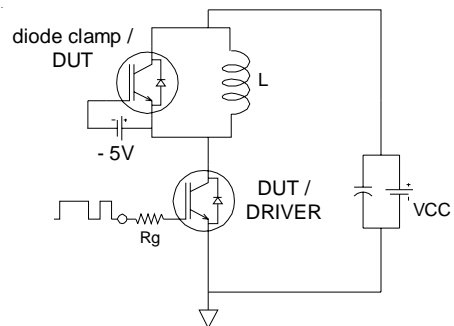


Fig.C.T.4 - Switching Loss Circuit

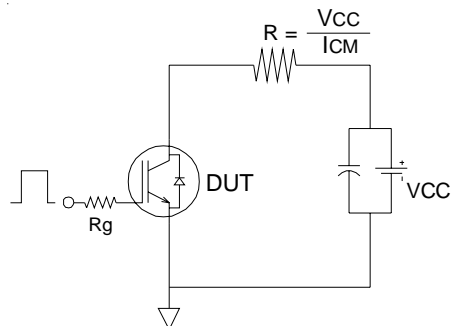
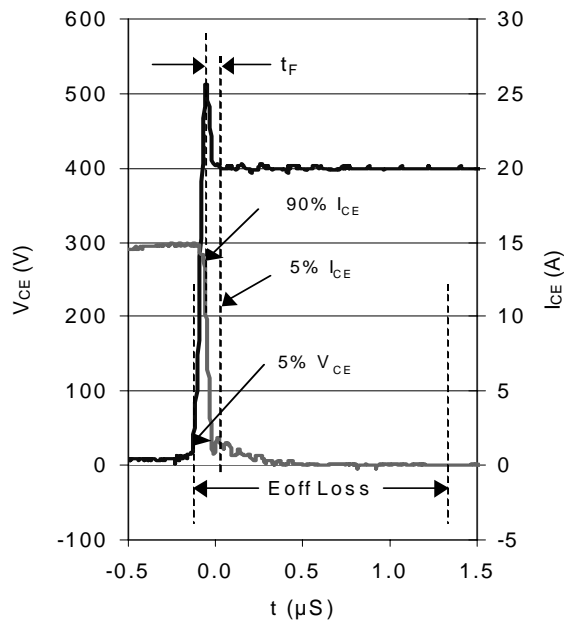
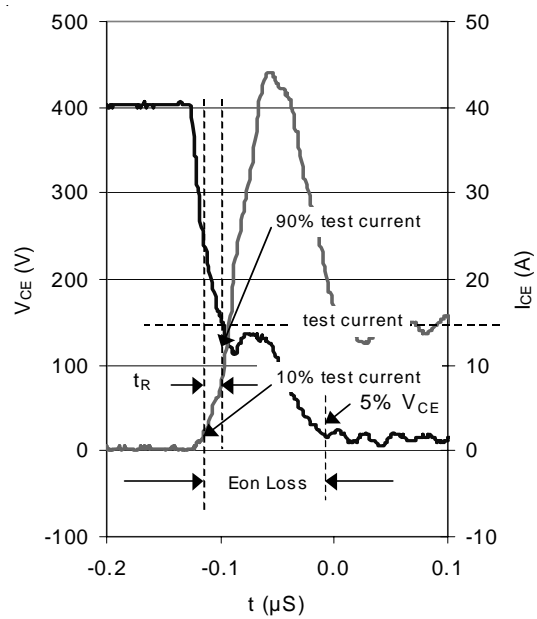


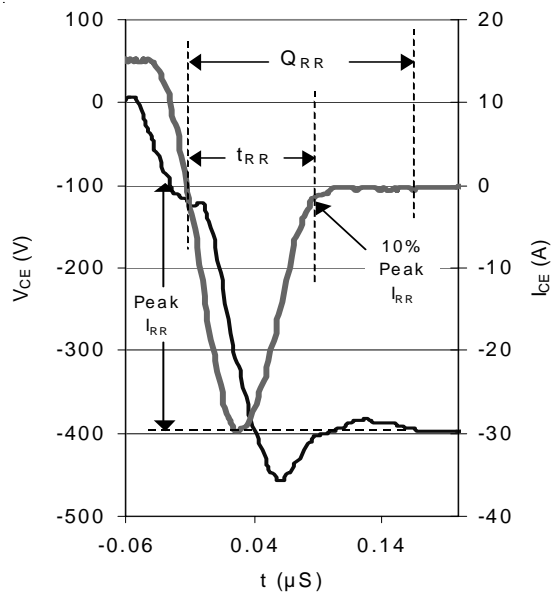
Fig.C.T.5 - Resistive Load Circuit



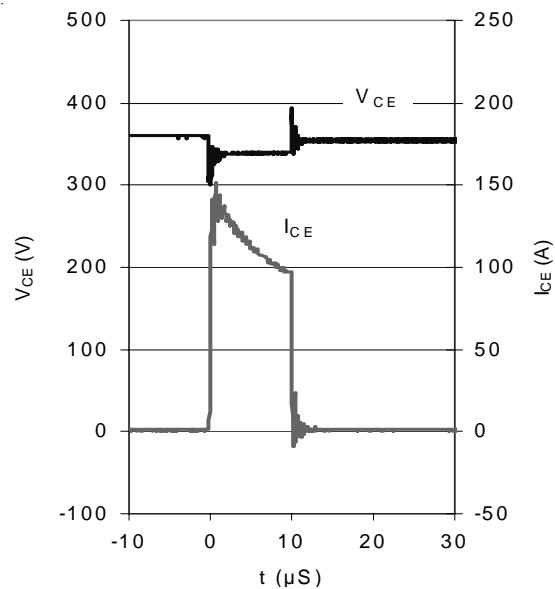
WF.1- Typ. Turn-off Loss
@ $T_J = 150^\circ\text{C}$ using CT.4



WF.2- Typ. Turn-on Loss
@ $T_J = 150^\circ\text{C}$ using Fig. CT.4



WF.3- Typ. Reverse Recovery
@ $T_J = 150^\circ\text{C}$ using CT.4



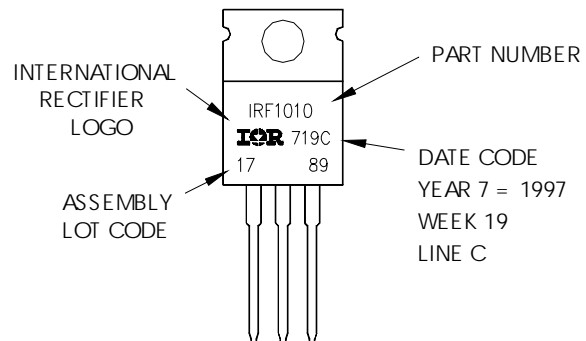
WF.4- Typ. Short Circuit
@ $T_J = 150^\circ\text{C}$ using CT.3

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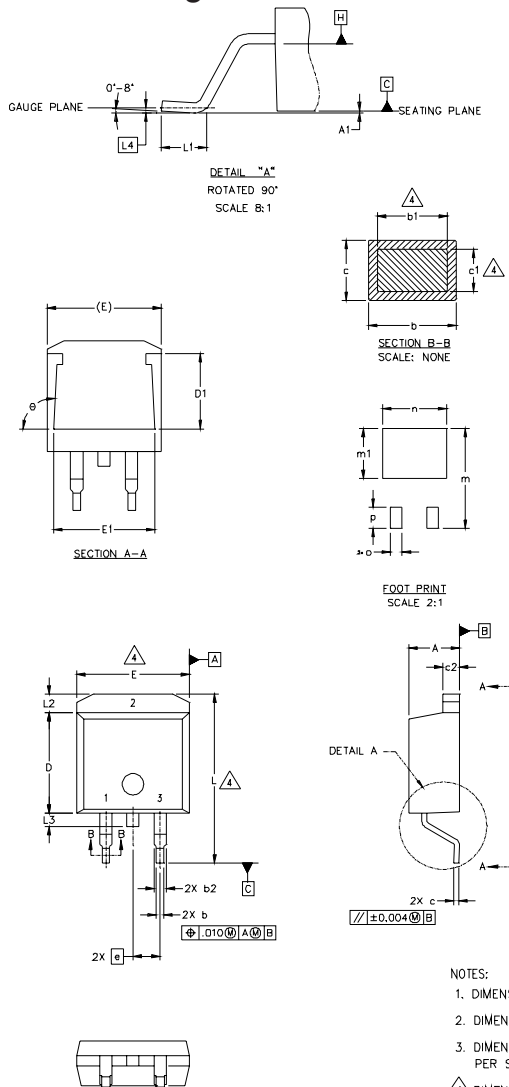
Dimensions are shown in millimeters (inches)



EXAMPLE: THIS IS AN IRF1010
LOT CODE 1789
ASSEMBLED ON WW 19, 1997
IN THE ASSEMBLY LINE "C"



D²Pak Package Outline



IRG/B/S/SL15B60KD

S Y M B O L	DIMENSIONS				N O T E S
	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	
c2	1.14	1.40	.045	.055	
D	8.51	9.65	.335	.380	3
D1	5.33		.210		3
E	9.65	10.67	.380	.420	
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	93°	.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 2.- DRAIN 3.- SOURCE	1.- GATE 2.- COLLECTOR 3.- EMITTER	1.- ANODE * 2.- CATHODE 3.- ANODE

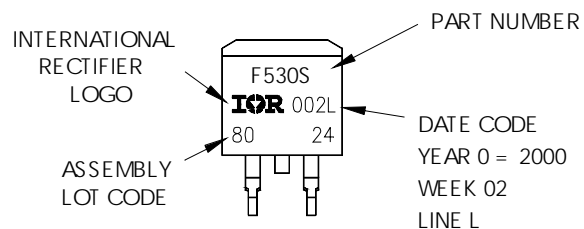
* PART DEPENDENT.

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.

D²Pak Part Marking Information

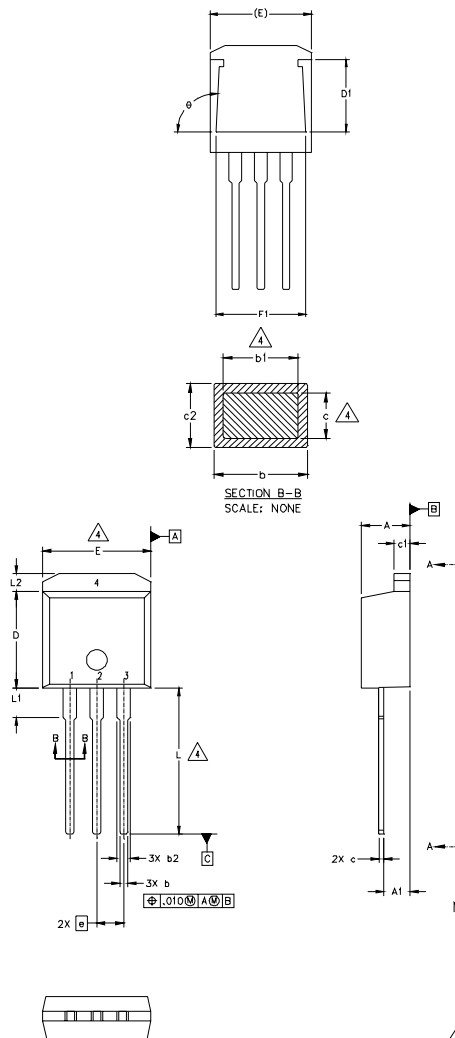
EXAMPLE: THIS IS AN IRF530S WITH
LOT CODE 8024
ASSEMBLED ON WW02, 2000
IN THE ASSEMBLY LINE "L"



IRG/B/S/SL15B60KD

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TO-262 Package Outline



S Y M B O L	DIMENSIONS				N O T E S
	MILLIMETERS		INCHES		
	MIN.	MAX.	MIN.	MAX.	
A	4.06	4.83	.160	.190	4
A1	2.03	2.92	.080	.115	
b	0.51	0.99	.020	.039	
b1	0.51	0.89	.020	.035	
b2	1.14	1.40	.045	.055	4
c	0.38	0.63	.015	.025	
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	
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

- 1.- GATE
- 2.- DRAIN
- 3.- SOURCE
- 4.- DRAIN

IGBT

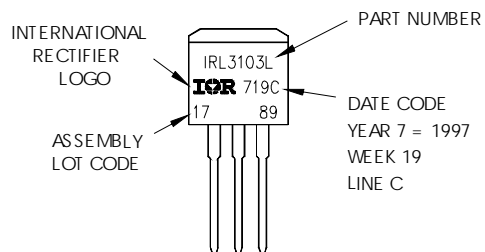
- 1- GATE
- 2- COLLECTOR
- 3- EMITTER
- 4- COLLECTOR

NOTES:

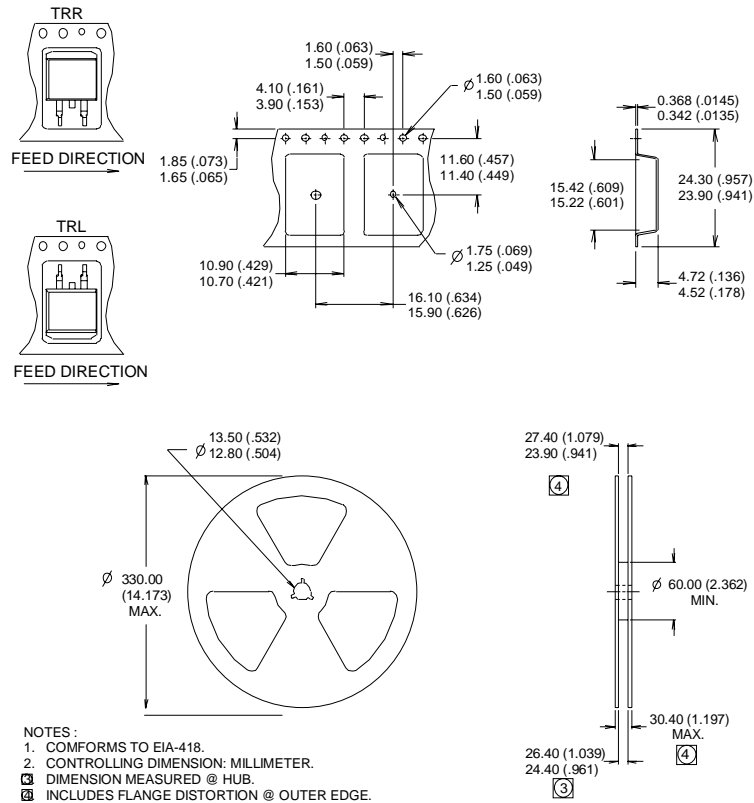
1. DIMENSIONING AND TOLERANCING PER ASME Y14.5M-1994
2. DIMENSIONS ARE SHOWN IN MILLIMETERS [INCHES].
3. DIMENSION D & E DO NOT INCLUDE MOLD FLASH. MOLD FLASH SHALL NOT EXCEED 0.127 [.005"] PER SIDE. THESE DIMENSIONS ARE MEASURED AT THE OUTMOST EXTREMES OF THE PLASTIC BODY.
4. DIMENSION b1 AND c1 APPLY 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"



D²Pak Tape & Reel Information



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.

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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TAC Fax: (310) 252-7903

Visit us at www.irf.com for sales contact information. 6/02

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