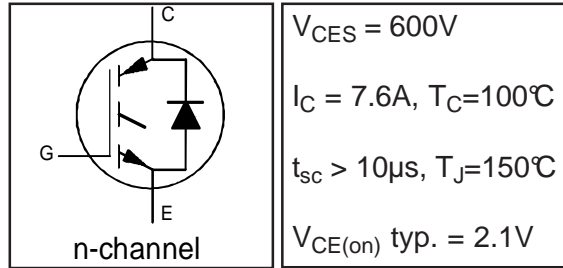


INSULATED GATE BIPOLAR TRANSISTOR WITH
ULTRAFAST SOFT RECOVERY DIODE

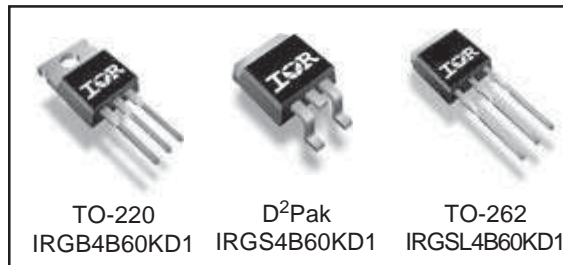
Features

- Low VCE (on) Non Punch Through IGBT Technology.
- 10µs Short Circuit Capability.
- Square RBSOA.
- Positive VCE (on) Temperature Coefficient.
- Maximum Junction Temperature rated at 175°C.



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	11	A
$I_C @ T_C = 100^\circ C$	Continuous Collector Current	7.6	
I_{CM}	Pulse Collector Current (Ref.Fig.C.T.5)	22	
I_{LM}	Clamped Inductive Load current ①	22	
$I_F @ T_C = 25^\circ C$	Diode Continuous Forward Current	11	
$I_F @ T_C = 100^\circ C$	Diode Continuous Forward Current	6.7	
I_{FM}	Diode Maximum Forward Current	22	V
V_{GE}	Gate-to-Emitter Voltage	±20	
$P_D @ T_C = 25^\circ C$	Maximum Power Dissipation	63	W
$P_D @ T_C = 100^\circ C$	Maximum Power Dissipation	31	
T_J	Operating Junction and	-55 to +175	°C
T_{STG}	Storage Temperature Range		
	Storage Temperature Range, for 10 sec.	300 (0.063 in. (1.6mm) from case)	

Thermal / Mechanical Characteristics

	Parameter	Min.	Typ.	Max.	Units
$R_{\theta JC}$	Junction-to-Case- IGBT	—	—	2.4	°C/W
$R_{\theta JC}$	Junction-to-Case- Diode	—	—	6.1	
$R_{\theta CS}$	Case-to-Sink, flat, greased surface	—	0.50	—	
$R_{\theta JA}$	Junction-to-Ambient	—	—	62	
$R_{\theta JA}$	Junction-to-Ambient (PCB Mount, steady state)②	—	—	40	
Wt	Weight	—	1.44	—	

IRGB/S/SL4B60KD1

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	—	0.28	—	V/°C	$V_{GE} = 0V, I_C = 1mA (25^\circ\text{C}-150^\circ\text{C})$	
$V_{CE(on)}$	Collector-to-Emitter Voltage	—	2.1	2.5	V	$I_C = 4.0A, V_{GE} = 15V, T_J = 25^\circ\text{C}$	5,6,7
		—	2.5	2.8		$I_C = 4.0A, V_{GE} = 15V, T_J = 150^\circ\text{C}$	9,10,11
		—	2.6	2.9		$I_C = 4.0A, V_{GE} = 15V, T_J = 175^\circ\text{C}$	
$V_{GE(th)}$	Gate Threshold Voltage	3.5	4.5	5.5	V	$V_{CE} = V_{GE}, I_C = 250\mu A$	9,10,11
$\Delta V_{GE(th)}/\Delta T_J$	Threshold Voltage temp. coefficient	—	-8.1	—	mV/°C	$V_{CE} = V_{GE}, I_C = 1mA (25^\circ\text{C}-150^\circ\text{C})$	12
g_{fe}	Forward Transconductance	—	1.7	—	S	$V_{CE} = 50V, I_C = 4.0A, PW = 80\mu s$	
I_{CES}	Zero Gate Voltage Collector Current	—	1.0	150	μA	$V_{GE} = 0V, V_{CE} = 600V$	
		—	136	600		$V_{GE} = 0V, V_{CE} = 600V, T_J = 150^\circ\text{C}$	
		—	722	2400		$V_{GE} = 0V, V_{CE} = 600V, T_J = 175^\circ\text{C}$	
V_{FM}	Diode Forward Voltage Drop	—	1.4	2.0	V	$I_F = 4.0A$	8
		—	1.3	1.8		$I_F = 4.0A, T_J = 150^\circ\text{C}$	
		—	1.2	1.7		$I_F = 4.0A, T_J = 175^\circ\text{C}$	
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.	
Q_g	Total Gate Charge (turn-on)	—	12	—	nC	$I_C = 4.0A$	23	
Q_{ge}	Gate-to-Emitter Charge (turn-on)	—	1.7	—		$V_{CC} = 400V$	CT1	
Q_{gc}	Gate-to-Collector Charge (turn-on)	—	6.5	—		$V_{GE} = 15V$		
E_{on}	Turn-On Switching Loss	—	73	80	μJ	$I_C = 4.0A, V_{CC} = 400V$	CT4	
E_{off}	Turn-Off Switching Loss	—	47	53		$V_{GE} = 15V, R_G = 100\Omega, L = 2.5mH$		
E_{tot}	Total Switching Loss	—	120	130		$T_J = 25^\circ\text{C}$ ③		
$t_{d(on)}$	Turn-On delay time	—	22	28	ns	$I_C = 4.0A, V_{CC} = 400V$	CT4	
t_r	Rise time	—	18	23		$V_{GE} = 15V, R_G = 100\Omega, L = 2.5mH$		
$t_{d(off)}$	Turn-Off delay time	—	100	110		$T_J = 25^\circ\text{C}$		
t_f	Fall time	—	66	80				
E_{on}	Turn-On Switching Loss	—	130	150	μJ	$I_C = 4.0A, V_{CC} = 400V$	CT4	
E_{off}	Turn-Off Switching Loss	—	83	140		$V_{GE} = 15V, R_G = 100\Omega, L = 2.5mH$		13,15
E_{tot}	Total Switching Loss	—	220	280		$T_J = 150^\circ\text{C}$ ③		WF1,WF2
$t_{d(on)}$	Turn-On delay time	—	22	27	ns	$I_C = 4.0A, V_{CC} = 400V$	14,16	
t_r	Rise time	—	18	22		$V_{GE} = 15V, R_G = 100\Omega, L = 2.5mH$		CT4
$t_{d(off)}$	Turn-Off delay time	—	120	130		$T_J = 150^\circ\text{C}$		WF1
t_f	Fall time	—	79	89				WF2
C_{ies}	Input Capacitance	—	190	—	pF	$V_{GE} = 0V$	22	
C_{oes}	Output Capacitance	—	25	—		$V_{CC} = 30V$		
C_{res}	Reverse Transfer Capacitance	—	6.2	—		$f = 1.0MHz$		
RBSOA	Reverse Bias Safe Operating Area	FULL SQUARE				$T_J = 150^\circ\text{C}, I_C = 22A, V_p = 600V$ $V_{CC}=500V, V_{GE} = +15V \text{ to } 0V, R_G = 100\Omega$	4 CT2	
SCSOA	Short Circuit Safe Operating Area	10	—	—	μs	$T_J = 150^\circ\text{C}, V_p = 600V, R_G = 100\Omega$ $V_{CC}=360V, V_{GE} = +15V \text{ to } 0V$	CT3 WF4	
E_{rec}	Reverse Recovery Energy of the Diode	—	81	100	μJ	$T_J = 150^\circ\text{C}$	17,18,19	
t_{rr}	Diode Reverse Recovery Time	—	93	—	ns	$V_{CC} = 400V, I_F = 4.0A, L = 2.5mH$	20,21	
I_{rr}	Peak Reverse Recovery Current	—	6.3	7.9	A	$V_{GE} = 15V, R_G = 100\Omega$	CT4,WF3	

Note ① to ③ are on page 16

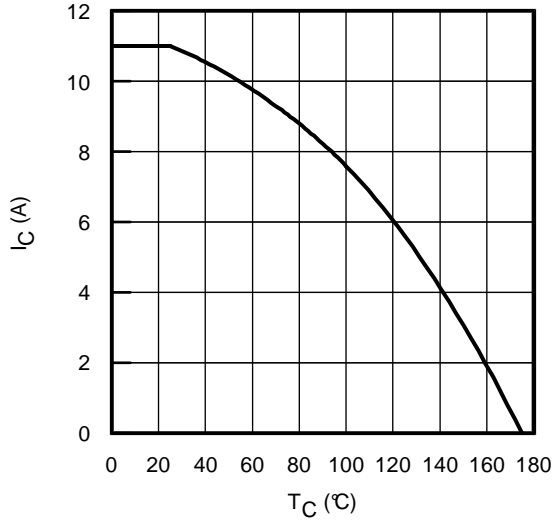


Fig. 1 - Maximum DC Collector Current vs. Case Temperature

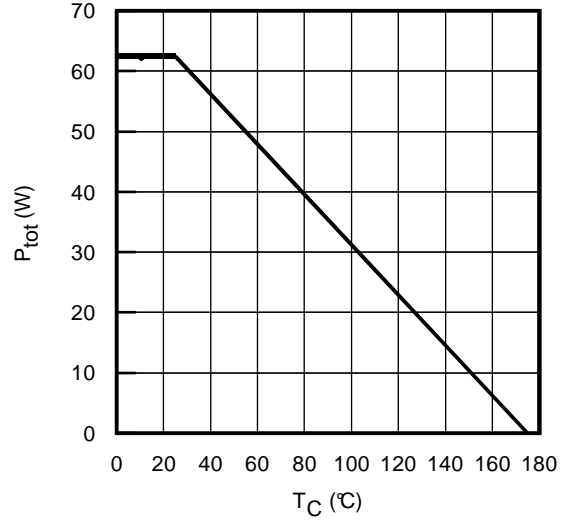


Fig. 2 - Power Dissipation vs. Case Temperature

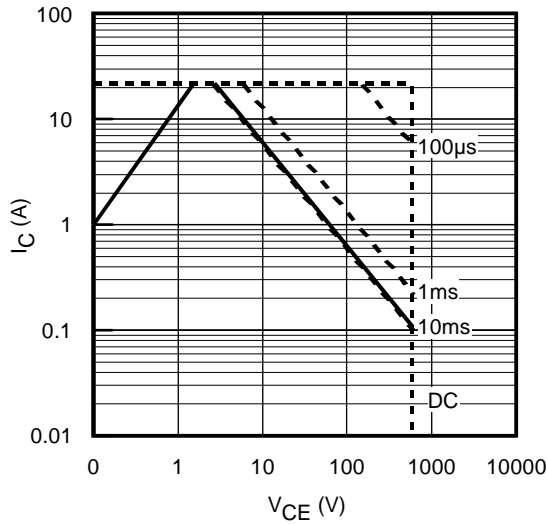


Fig. 3 - Forward SOA
 $T_C = 25^\circ\text{C}$; $T_J \leq 150^\circ\text{C}$

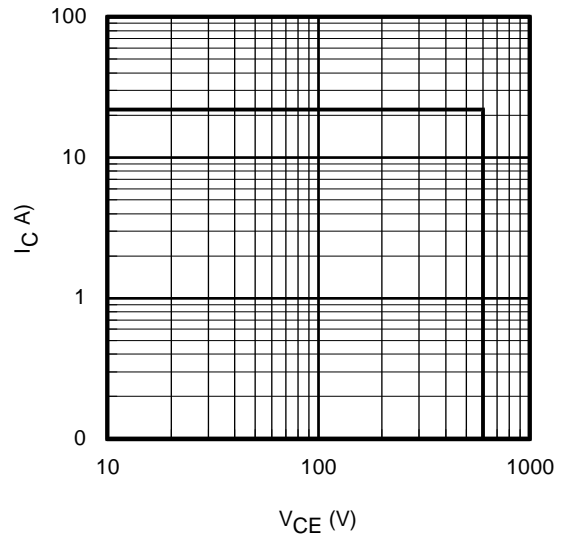


Fig. 4 - Reverse Bias SOA
 $T_J = 150^\circ\text{C}$; $V_{GE} = 15\text{V}$

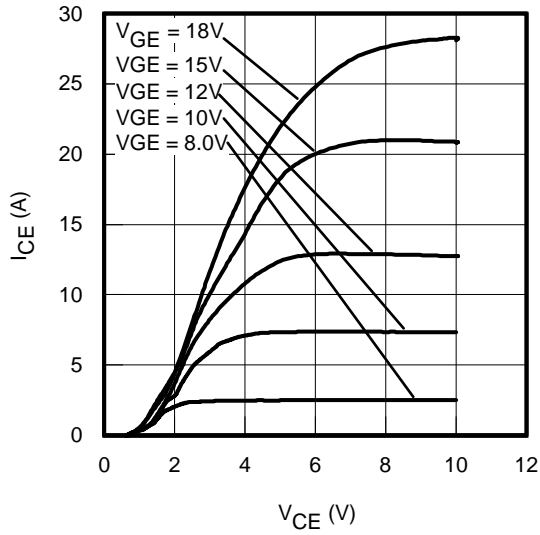


Fig. 5 - Typ. IGBT Output Characteristics
 $T_J = -40^\circ\text{C}$; $t_p = 80\mu\text{s}$

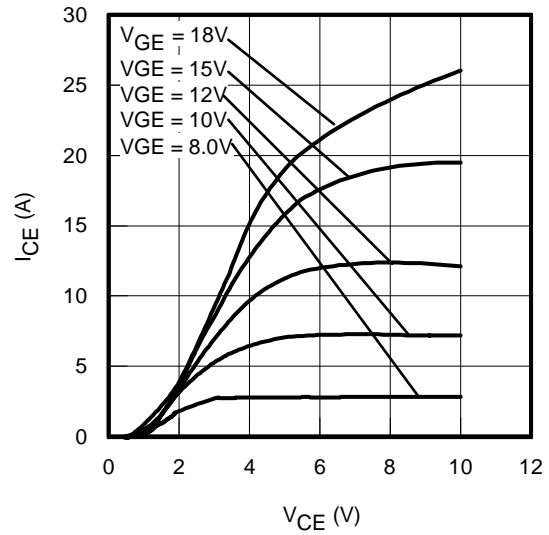


Fig. 6 - Typ. IGBT Output Characteristics
 $T_J = 25^\circ\text{C}$; $t_p = 80\mu\text{s}$

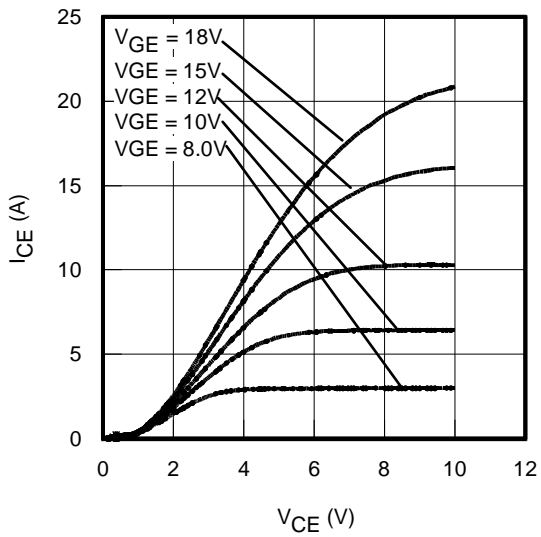


Fig. 7 - Typ. IGBT Output Characteristics
 $T_J = 150^\circ\text{C}$; $t_p = 80\mu\text{s}$

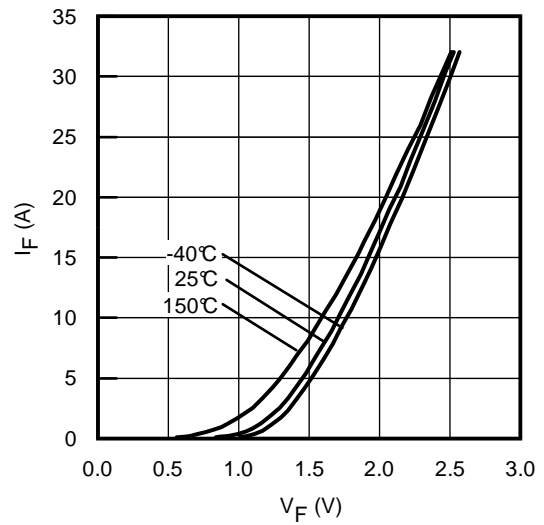


Fig. 8 - Typ. Diode Forward Characteristics
 $t_p = 80\mu\text{s}$

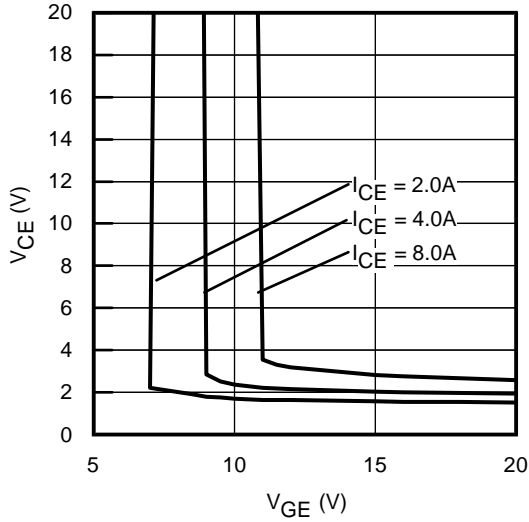


Fig. 9 - Typical V_{CE} vs. V_{GE}
 $T_J = -40^\circ\text{C}$

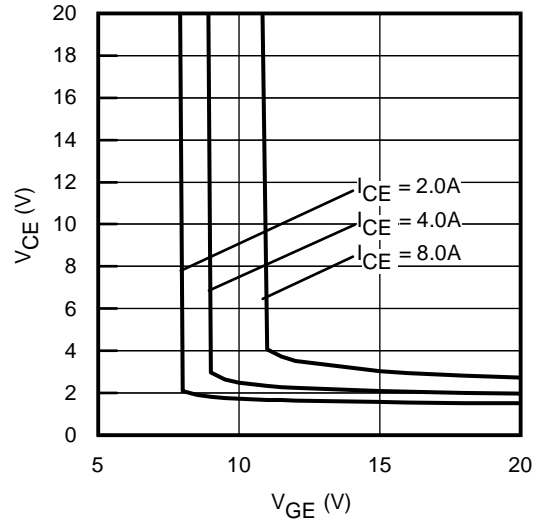


Fig. 10 - Typical V_{CE} vs. V_{GE}
 $T_J = 25^\circ\text{C}$

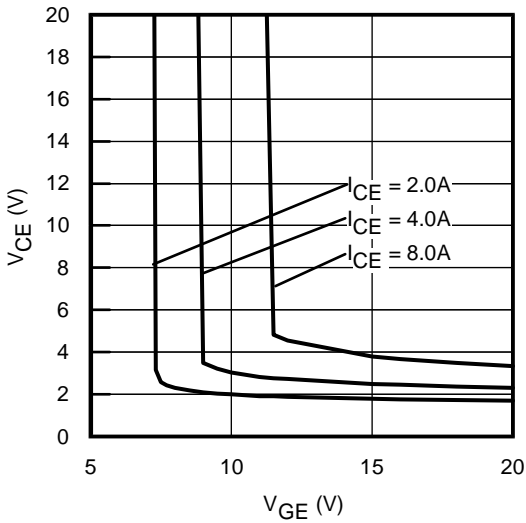


Fig. 11 - Typical V_{CE} vs. V_{GE}
 $T_J = 150^\circ\text{C}$

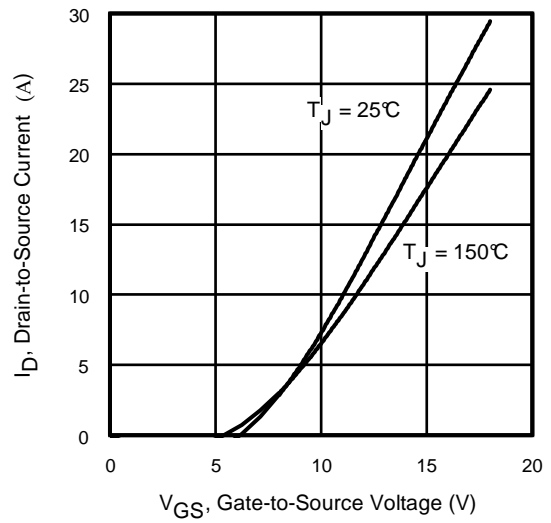


Fig. 12 - Typ. Transfer Characteristics
 $V_{CE} = 360\text{V}$; $t_p = 10\mu\text{s}$

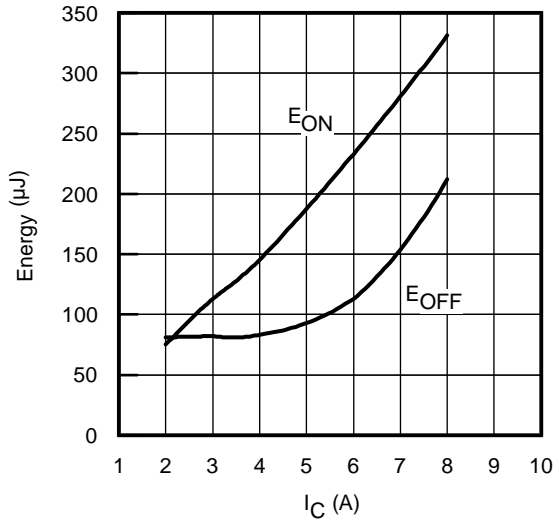


Fig. 13 - Typ. Energy Loss vs. I_C
 $T_J = 150^\circ\text{C}$; $L=2.5\text{mH}$; $V_{CE}= 400\text{V}$,
 $R_G= 100\Omega$; $V_{GE}= 15\text{V}$

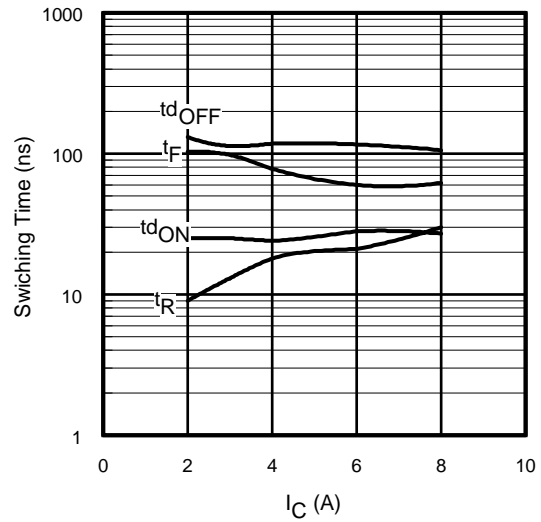


Fig. 14 - Typ. Switching Time vs. I_C
 $T_J = 150^\circ\text{C}$; $L=2.5\text{mH}$; $V_{CE}= 400\text{V}$
 $R_G= 100\Omega$; $V_{GE}= 15\text{V}$

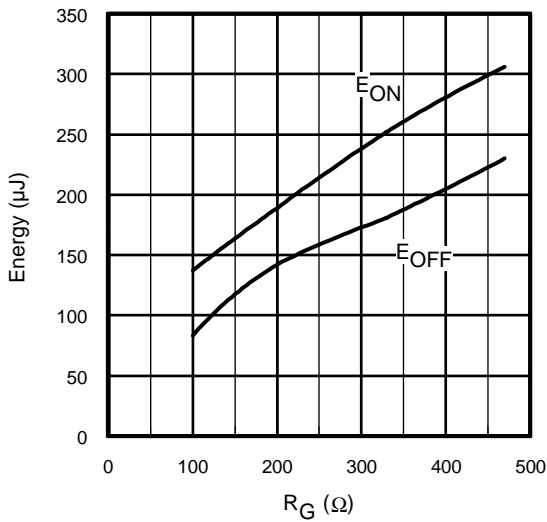


Fig. 15 - Typ. Energy Loss vs. R_G
 $T_J = 150^\circ\text{C}$; $L=2.5\text{mH}$; $V_{CE}= 400\text{V}$
 $I_{CE}= 4.0\text{A}$; $V_{GE}= 15\text{V}$

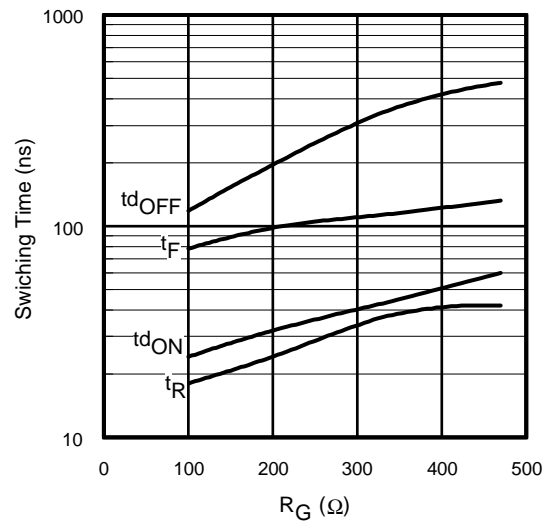


Fig. 16 - Typ. Switching Time vs. R_G
 $T_J = 150^\circ\text{C}$; $L=2.5\text{mH}$; $V_{CE}= 400\text{V}$
 $I_{CE}= 4.0\text{A}$; $V_{GE}= 15\text{V}$

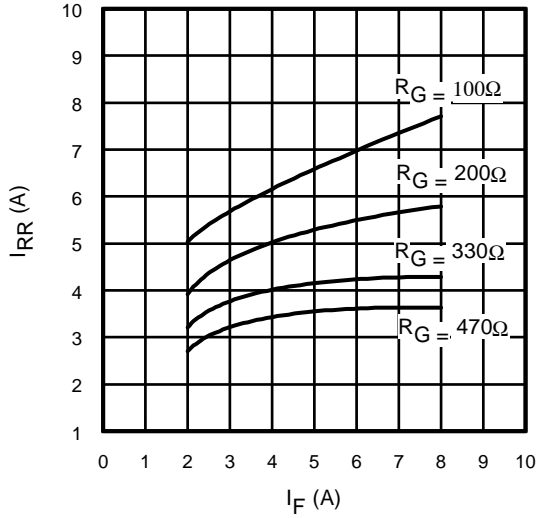


Fig. 17 - Typical Diode I_{RR} vs. I_F
 $T_J = 150^\circ\text{C}$

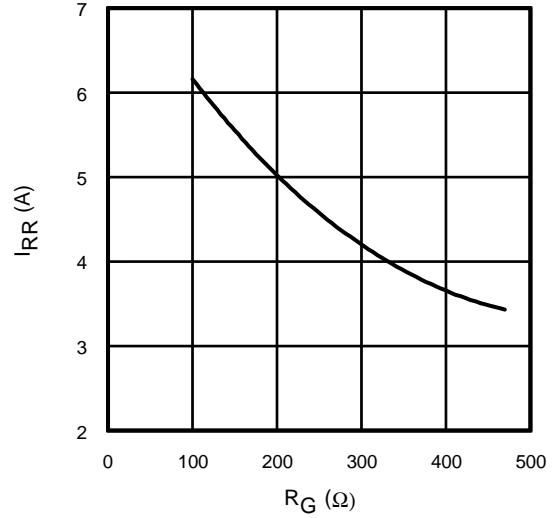


Fig. 18 - Typical Diode I_{RR} vs. R_G
 $T_J = 150^\circ\text{C}$; $I_F = 4.0\text{A}$

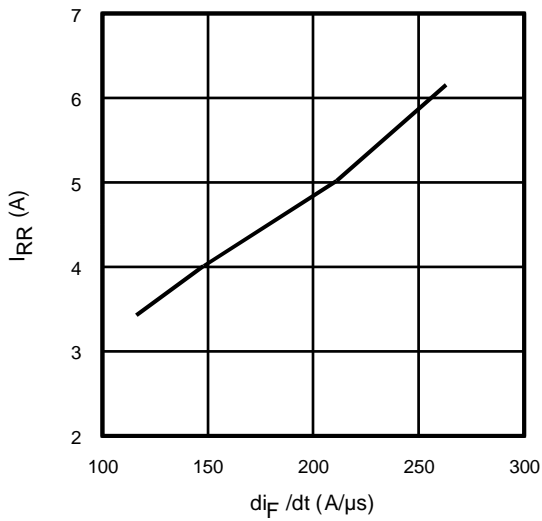


Fig. 19 - Typical Diode I_{RR} vs. di_F/dt
 $V_{CC} = 400\text{V}$; $V_{GE} = 15\text{V}$;
 $I_F = 4.0\text{A}$; $T_J = 150^\circ\text{C}$

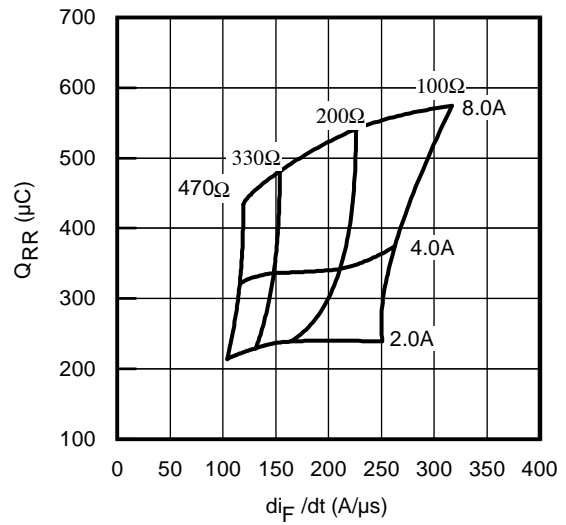


Fig. 20 - Typical Diode Q_{RR}
 $V_{CC} = 400\text{V}$; $V_{GE} = 15\text{V}$; $T_J = 150^\circ\text{C}$

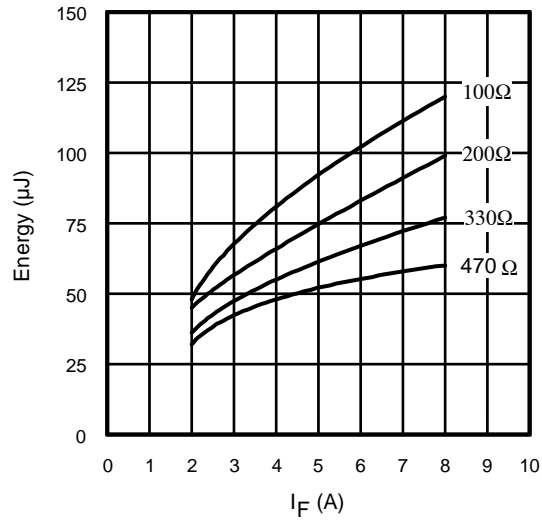


Fig. 21 - Typical Diode E_{RR} vs. I_F
 $T_J = 150^\circ\text{C}$

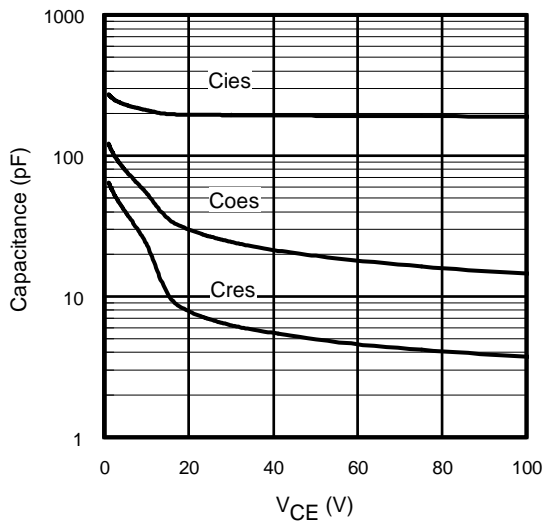


Fig. 22- Typ. Capacitance vs. V_{CE}
 $V_{GE} = 0\text{V}$; $f = 1\text{MHz}$

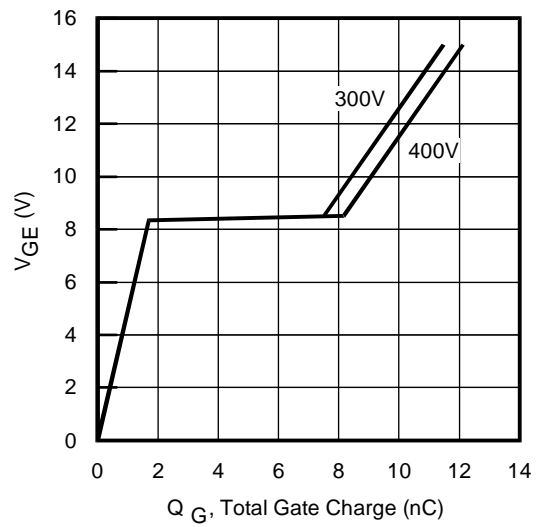


Fig. 23 - Typical Gate Charge vs. V_{GE}
 $I_{CE} = 4.0\text{A}$; $L = 3150\mu\text{H}$

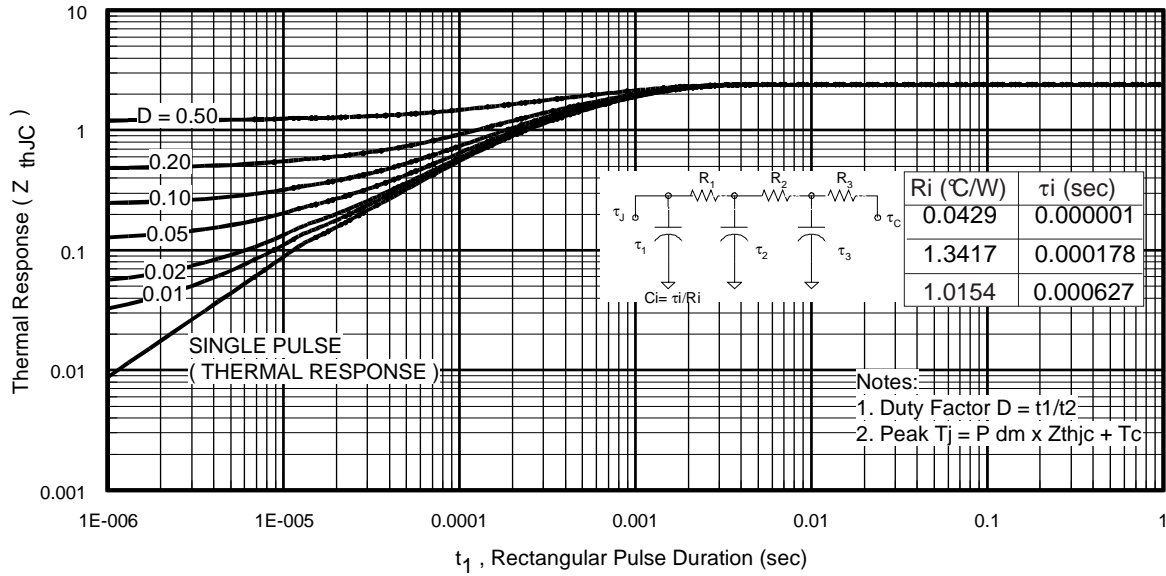


Fig 24. Maximum Transient Thermal Impedance, Junction-to-Case (IGBT)

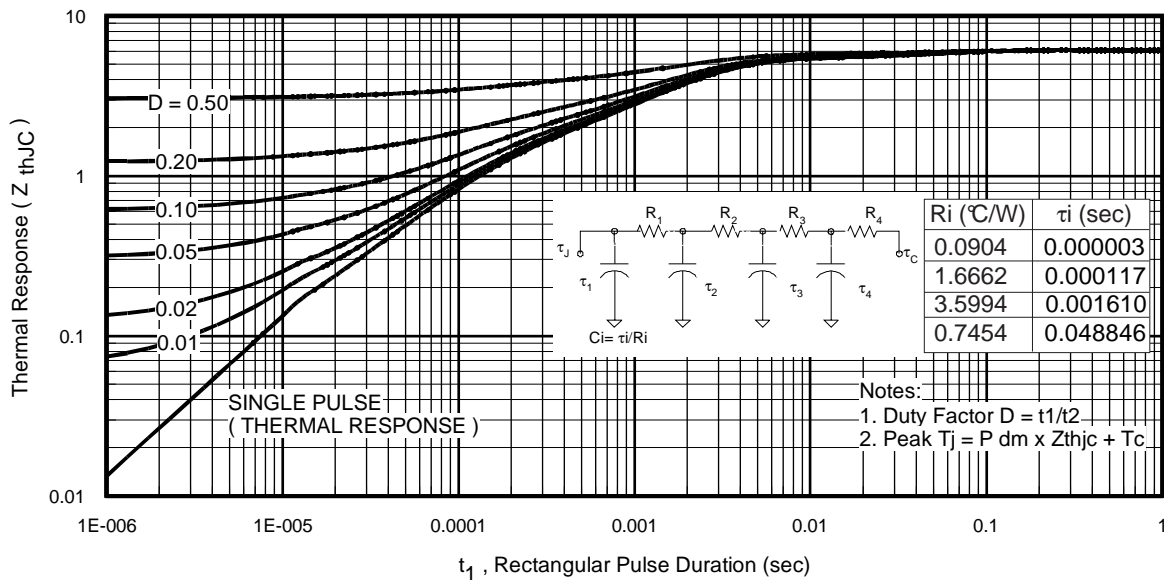


Fig 25. Maximum Transient Thermal Impedance, Junction-to-Case (DIODE)

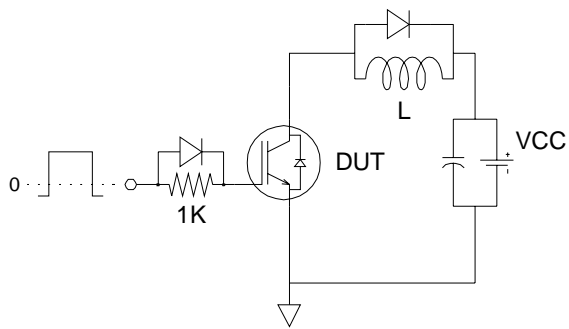


Fig.C.T.1 - Gate Charge Circuit (turn-off)

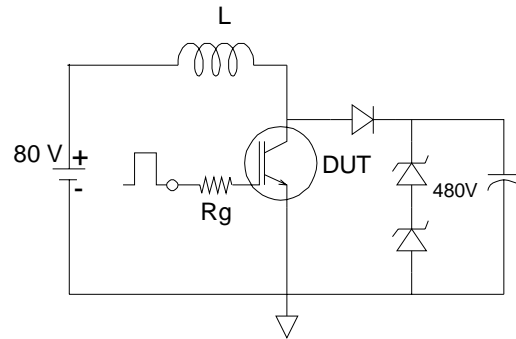


Fig.C.T.2 - RBSOA Circuit

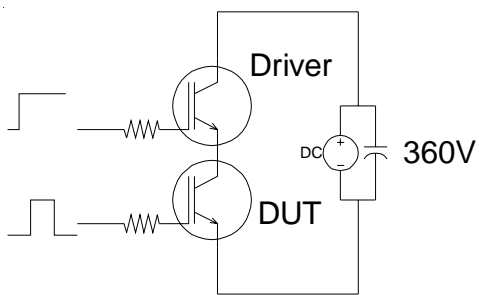


Fig.C.T.3 - S.C.SOA Circuit

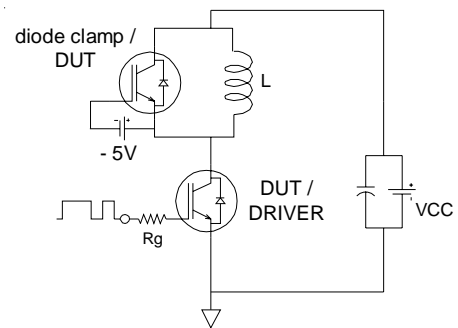


Fig.C.T.4 - Switching Loss Circuit

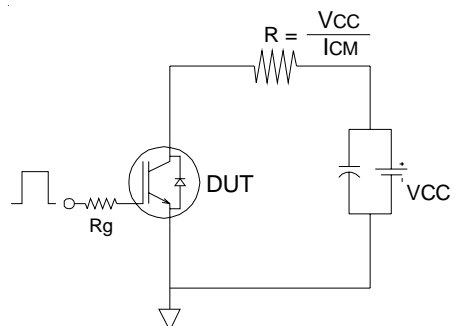


Fig.C.T.5 - Resistive Load Circuit

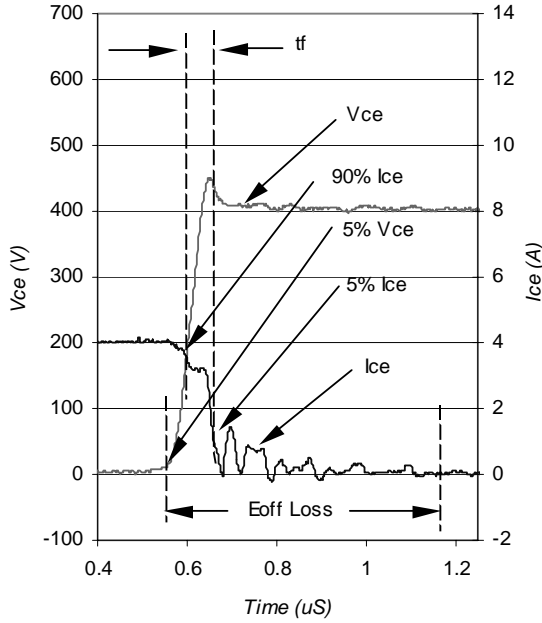


Fig. WF1- Typ. Turn-off Loss Waveform
 @ $T_J = 150^\circ\text{C}$ using Fig. CT.4

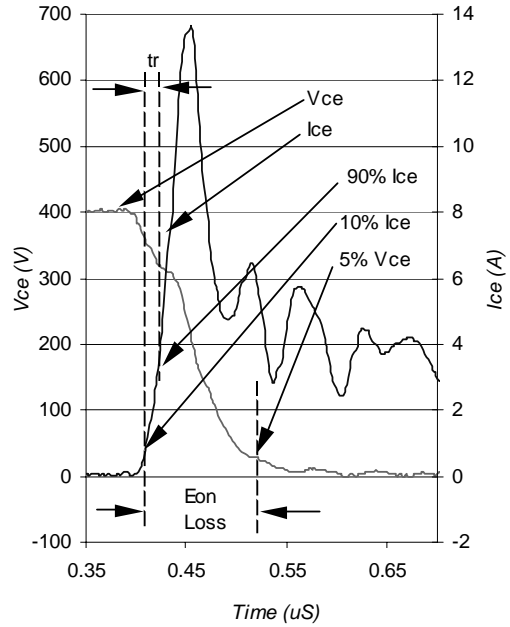


Fig. WF2- Typ. Turn-on Loss Waveform
 @ $T_J = 150^\circ\text{C}$ using Fig. CT.4

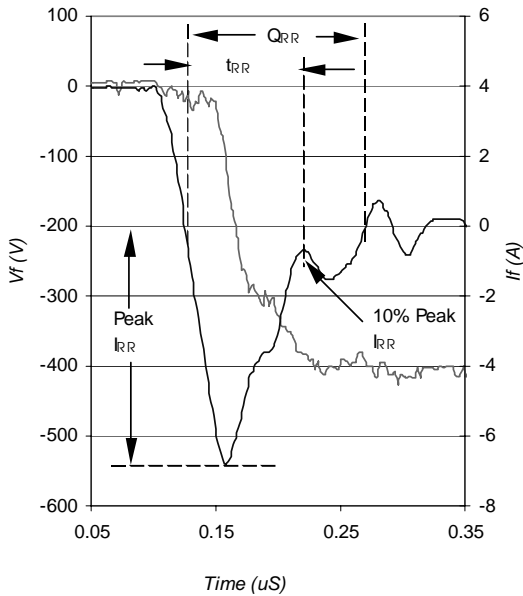


Fig. WF3- Typ. Diode Recovery Waveform
 @ $T_J = 150^\circ\text{C}$ using Fig. CT.4

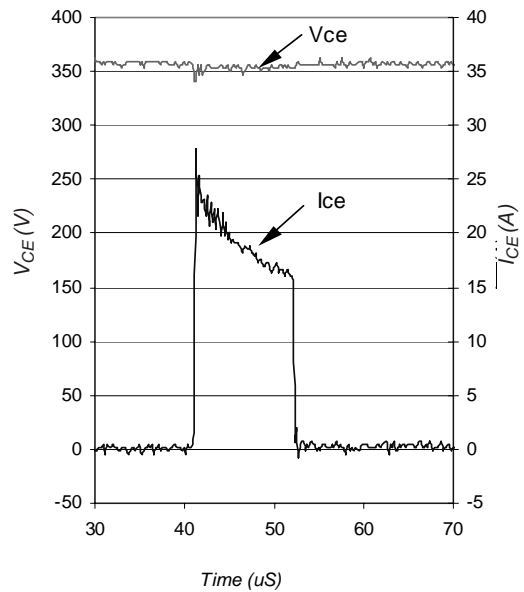
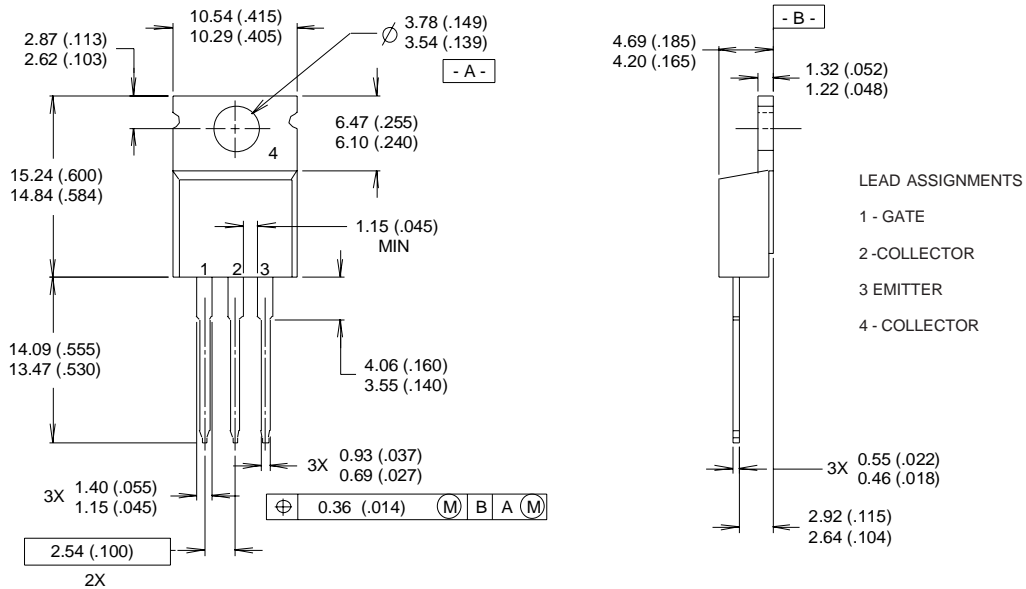


Fig. WF4- Typ. S.C Waveform
 @ $T_C = 150^\circ\text{C}$ using Fig. CT.3

IRGB/S/SL4B60KD1

TO-220AB Package Outline

Dimensions are shown in millimeters (inches)

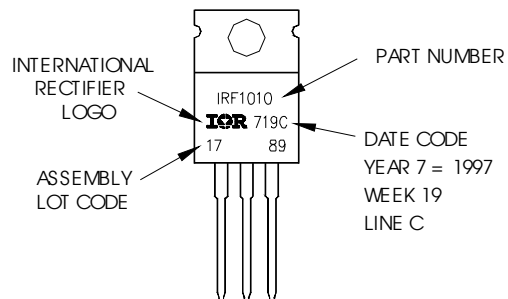


NOTES:

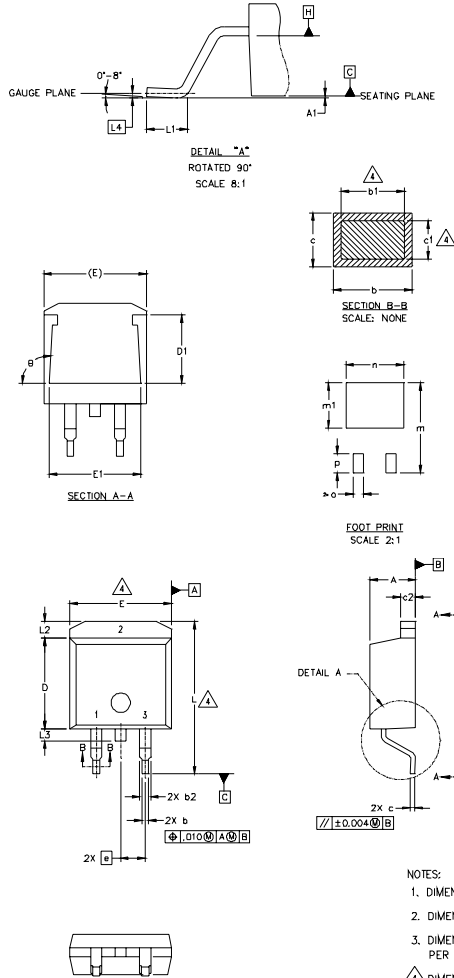
- 1 DIMENSIONING & TOLERANCING PER ANSI Y14.5M, 1982.
- 2 CONTROLLING DIMENSION : INCH
- 3 OUTLINE CONFORMS TO JEDEC OUTLINE TO-220AB.
- 4 HEATSINK & LEAD MEASUREMENTS DO NOT INCLUDE BURRS.

TO-220AB Part Marking Information

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



D²Pak Package Outline



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	
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		.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

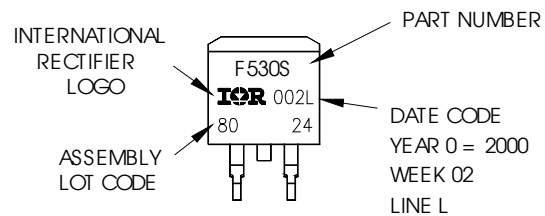
* PART DEPENDENT.

NOTES:

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.

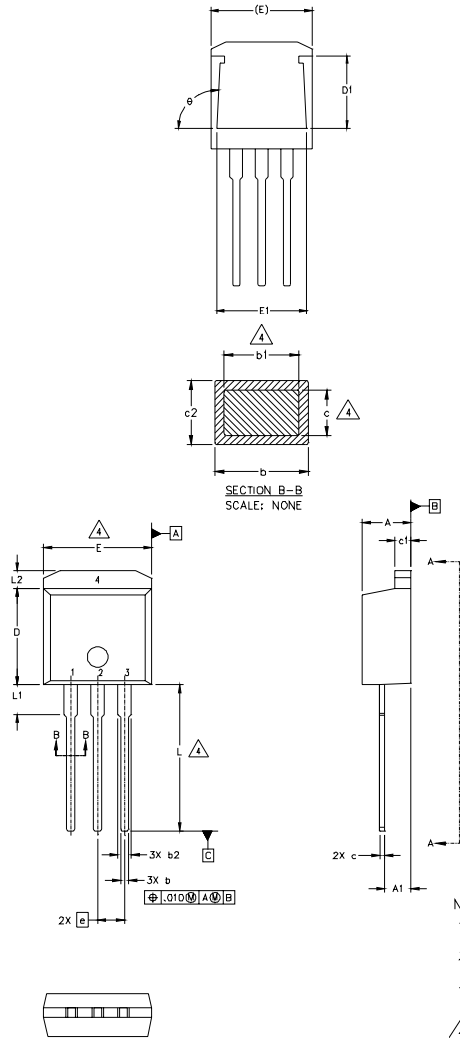
D²Pak Part Marking Information

EXAMPLE: THIS IS AN IRF530S WITH
LOT CODE 8024
ASSEMBLED ON WW 02, 2000
IN THE ASSEMBLY LINE "L"



IRGB/S/SL4B60KD1

TO-262 Package Outline



SYMBOL	DIMENSIONS				NOTES	
	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		
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			3
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		

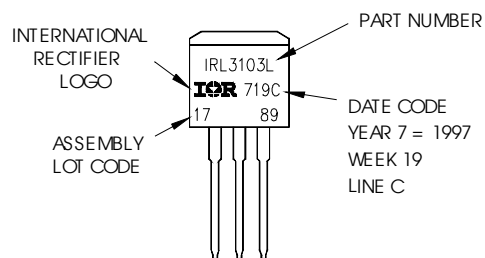
LEAD ASSIGNMENTS

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

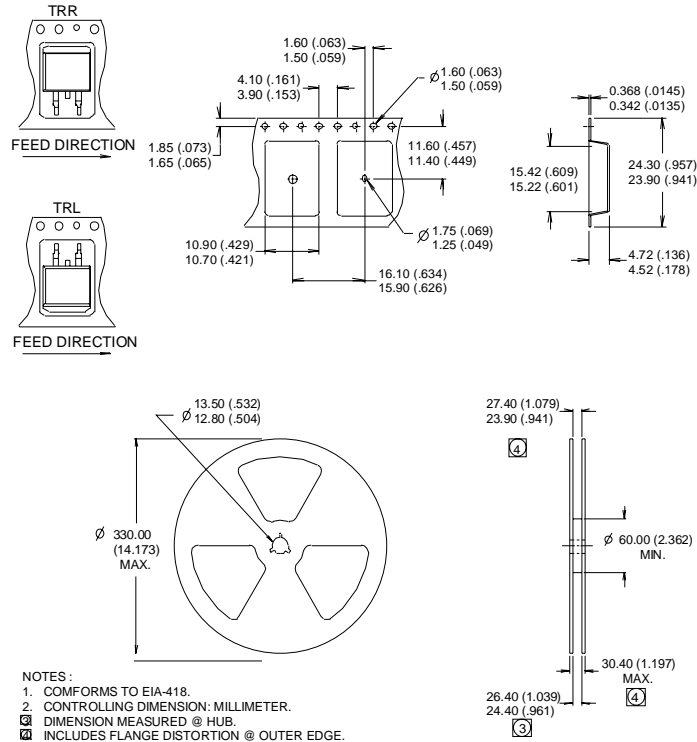
- NOTES:
1. DIMENSIONING AND TOLERANCING PER ASME Y14.5M-1994
 2. DIMENSIONS ARE SHOWN IN MILLIMETERS [INCHES]
 3. DIMENSION D & E DO NOT INCLUDE MOLD FLASH. MOLD FLASH SHALL NOT EXCEED 0.127 [0.005"] PER SIDE. THESE DIMENSIONS ARE MEASURED AT THE OUTMOST EXTREMES OF THE PLASTIC BODY.
 4. DIMENSION b1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



D²Pak Tape & Reel Information



Notes:

- ① $V_{CC} = 80\% (V_{CES})$, $V_{GE} = 15V$, $L = 100\mu H$, $R_G = 100\Omega$.
- ② 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, using Diode FD059H06A5.

TO-220AB 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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Visit us at www.irf.com for sales contact information. 05/03

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