

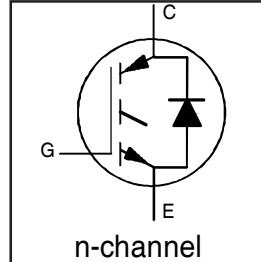
**INSULATED GATE BIPOLAR TRANSISTOR WITH
ULTRAFAST SOFT RECOVERY DIODE**

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.
- Maximum Junction Temperature Rated at 175°C
- Lead-Free
- UL Certified

Benefits

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



n-channel

$$V_{CES} = 600V$$

$$I_C = 10A, T_C = 100^\circ C$$

$$t_{sc} > 10\mu s, T_J = 150^\circ C$$

$$V_{CE(on)} \text{ typ.} = 1.7V$$



TO-220 Full-Pak

Base part number	Package Type	Standard Pack		Orderable Part Number
		Form	Quantity	
IRGIB10B60KD1P	TO-220AB Full- Pak	Tube	50	IRGIB10B60KD1P

Absolute Maximum Ratings

	Parameter	Max.	Units
V_{CES}	Collector-to-Emitter Voltage	600	V
$I_C @ T_C = 25^\circ C$	Continuous Collector Current	16	A
$I_C @ T_C = 100^\circ C$	Continuous Collector Current	10	
I_{CM}	Pulse Collector Current (Ref.Fig.C.T.5)	32	
I_{LM}	Clamped Inductive Load current ①	32	
$I_F @ T_C = 25^\circ C$	Diode Continuous Forward Current	16	
$I_F @ T_C = 100^\circ C$	Diode Continuous Forward Current	10	
I_{FM}	Diode Maximum Forward Current	32	V
V_{ISOL}	RMS Isolation Voltage, Terminal to Case, $t = 1 \text{ min}$	2500	
V_{GE}	Gate-to-Emitter Voltage	± 20	
$P_D @ T_C = 25^\circ C$	Maximum Power Dissipation	44	W
$P_D @ T_C = 100^\circ C$	Maximum Power Dissipation	22	
T_J	Operating Junction and	-55 to +175	$^\circ C$
T_{STG}	Storage Temperature Range		
	Soldering Temperature for 10 sec.		
	Mounting Torque, 6-32 or M3 Screw	300 (0.063 in. (1.6mm) from case) 10 lbf.in (1.1N.m)	

Thermal / Mechanical Characteristics

	Parameter	Min.	Typ.	Max.	Units
$R_{\theta JC}$	Junction-to-Case- IGBT	—	—	3.4	$^\circ C/W$
$R_{\theta JC}$	Junction-to-Case- Diode	—	—	5.3	
$R_{\theta CS}$	Case-to-Sink, flat, greased surface	—	0.50	—	
$R_{\theta JA}$	Junction-to-Ambient, typical socket mount	—	—	62	
Wt	Weight	—	2.0	—	g

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

	Parameter	Min.	Typ.	Max.	Units	Conditions
$V_{(BR)CES}$	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	—	0.99	—	V/ $^\circ\text{C}$	$V_{GE} = 0V, I_C = 1mA (25^\circ\text{C}-150^\circ\text{C})$
$V_{CE(on)}$	Collector-to-Emitter Voltage	1.50	1.70	2.10	V	$I_C = 10A, V_{GE} = 15V, T_J = 25^\circ\text{C}$
		—	2.05	2.35		$I_C = 10A, V_{GE} = 15V, T_J = 150^\circ\text{C}$
		—	2.06	2.35		$I_C = 10A, V_{GE} = 15V, T_J = 175^\circ\text{C}$
$V_{GE(th)}$	Gate Threshold Voltage	3.5	4.5	5.5	V	$V_{CE} = V_{GE}, I_C = 250\mu A$
$\Delta V_{GE(th)}/\Delta T_J$	Threshold Voltage temp. coefficient	—	-10	—	mV/ $^\circ\text{C}$	$V_{CE} = V_{GE}, I_C = 1mA (25^\circ\text{C}-150^\circ\text{C})$
gfe	Forward Transconductance	—	5.0	—	S	$V_{CE} = 50V, I_C = 10A, PW = 80\mu s$
I_{CES}	Zero Gate Voltage Collector Current	—	1.0	150	μA	$V_{GE} = 0V, V_{CE} = 600V$
		—	90	250		$V_{GE} = 0V, V_{CE} = 600V, T_J = 150^\circ\text{C}$
		—	150	400		$V_{GE} = 0V, V_{CE} = 600V, T_J = 175^\circ\text{C}$
V_{FM}	Diode Forward Voltage Drop	—	1.80	2.40	V	$I_F = 5.0A, V_{GE} = 0V$
		—	1.32	1.74		$I_F = 5.0A, V_{GE} = 0V, T_J = 150^\circ\text{C}$
		—	1.23	1.62		$I_F = 5.0A, V_{GE} = 0V, T_J = 175^\circ\text{C}$
I_{GES}	Gate-to-Emitter Leakage Current	—	—	± 100	nA	$V_{GE} = \pm 20V, V_{CE} = 0V$

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

	Parameter	Min.	Typ.	Max.	Units	Conditions
Q_g	Total Gate Charge (turn-on)	—	41	62	nC	$I_C = 10A$
Q_{ge}	Gate-to-Emitter Charge (turn-on)	—	4.6	6.9		$V_{CC} = 400V$
Q_{gc}	Gate-to-Collector Charge (turn-on)	—	19	29		$V_{GE} = 15V$
E_{on}	Turn-On Switching Loss	—	156	264	μJ	$I_C = 10A, V_{CC} = 400V$
E_{off}	Turn-Off Switching Loss	—	165	273		$V_{GE} = 15V, R_G = 50\Omega, L = 1.07mH$
E_{tot}	Total Switching Loss	—	321	434		$L_s = 150nH, T_J = 25^\circ\text{C} \text{ ①}$
$t_{d(on)}$	Turn-On delay time	—	25	33	ns	$I_C = 10A, V_{CC} = 400V$
t_r	Rise time	—	24	34		$V_{GE} = 15V, R_G = 50\Omega, L = 1.1mH$
$t_{d(off)}$	Turn-Off delay time	—	180	250		$L_s = 150nH, T_J = 25^\circ\text{C}$
t_f	Fall time	—	62	87	μJ	$I_C = 10A, V_{CC} = 400V$
E_{on}	Turn-On Switching Loss	—	261	372		$V_{GE} = 15V, R_G = 50\Omega, L = 1.07mH$
E_{off}	Turn-Off Switching Loss	—	313	425		$L_s = 150nH, T_J = 150^\circ\text{C} \text{ ②}$
E_{tot}	Total Switching Loss	—	574	694	ns	$I_C = 8.0A, V_{CC} = 400V$
$t_{d(on)}$	Turn-On delay time	—	22	31		$V_{GE} = 15V, R_G = 50\Omega, L = 1.07mH$
t_r	Rise time	—	24	34		$L_s = 150nH, T_J = 150^\circ\text{C}$
$t_{d(off)}$	Turn-Off delay time	—	240	340	nH	$I_C = 8.0A, V_{CC} = 400V$
t_f	Fall time	—	48	67		$V_{GE} = 15V, R_G = 50\Omega, L = 1.07mH$
L_E	Internal Emitter Inductance	—	7.5	—		$L_s = 150nH, T_J = 150^\circ\text{C}$
C_{ies}	Input Capacitance	—	610	915	pF	Measured 5 mm from package
C_{oes}	Output Capacitance	—	66	99		$V_{GE} = 0V$
C_{res}	Reverse Transfer Capacitance	—	23	35		$V_{CC} = 30V$
RBSOA	Reverse Bias Safe Operating Area	FULL SQUARE				$f = 1.0MHz$
SCSOA	Short Circuit Safe Operating Area	10	—	—	μs	$T_J = 150^\circ\text{C}, I_C = 32A, V_p = 600V$ $V_{CC}=500V, V_{GE} = +15V \text{ to } 0V, R_G = 50\Omega$
$I_{SC(PEAK)}$	Peak Short Circuit Collector Current	—	100	—	A	$T_J = 150^\circ\text{C}, V_p = 600V, R_G = 50\Omega$
E_{rec}	Reverse Recovery Energy of the Diode	—	99	128	μJ	$V_{CC}=360V, V_{GE} = +15V \text{ to } 0V$
t_{rr}	Diode Reverse Recovery Time	—	79	103	ns	$T_J = 150^\circ\text{C}$
I_{rr}	Peak Reverse Recovery Current	—	14	18	A	$V_{CC} = 400V, I_F = 10A, L = 1.07mH$
Q_{rr}	Diode Reverse Recovery Charge	—	553	719	nC	$V_{GE} = 15V, R_G = 50\Omega$ $di/dt = 500A/\mu s$

① $V_{CC}=80\% (V_{CES}), V_{GE} = 20V, L=100\mu H, R_G = 50\Omega$.

② Energy losses include "tail" and diode reverse recovery.

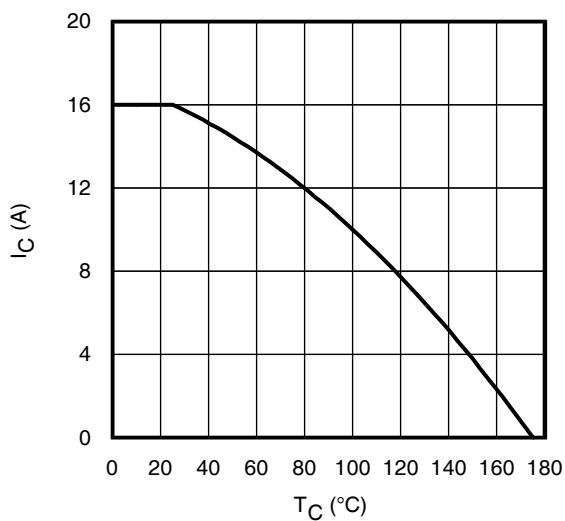


Fig. 1 - Maximum DC Collector Current vs. Case Temperature

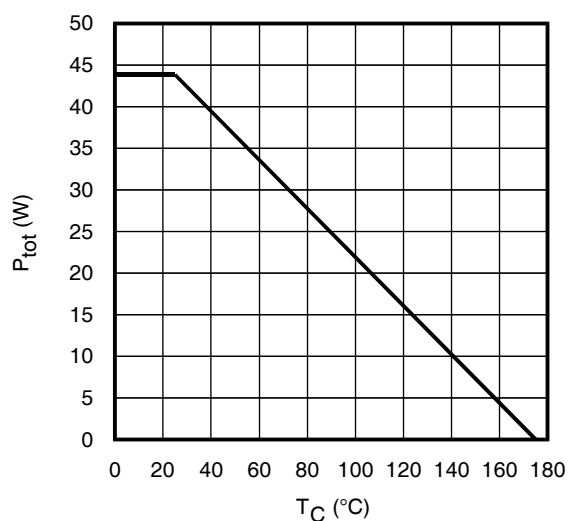


Fig. 2 - Power Dissipation vs. Case Temperature

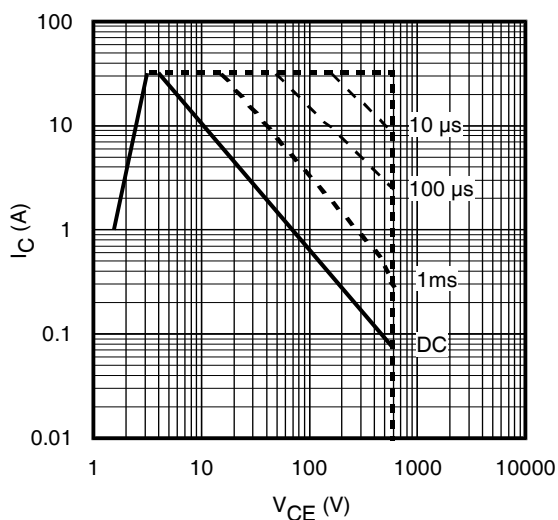


Fig. 3 - Forward SOA
 $T_C = 25^\circ\text{C}$; $T_J \leq 175^\circ\text{C}$

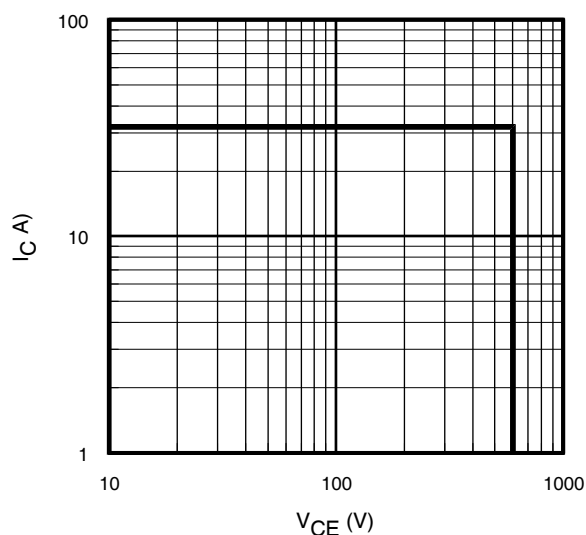


Fig. 4 - Reverse Bias SOA
 $T_J = 150^\circ\text{C}$; $V_{GE} = 15\text{V}$

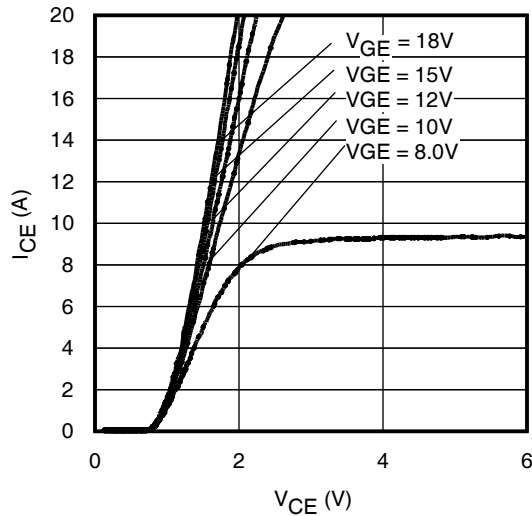


Fig. 5 - Typ. IGBT Output Characteristics
 $T_J = -40^{\circ}\text{C}$; $t_p = 80\mu\text{s}$

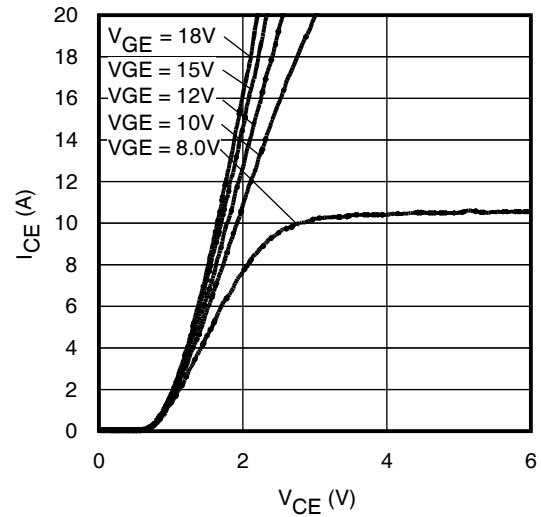


Fig. 6 - Typ. IGBT Output Characteristics
 $T_J = 25^{\circ}\text{C}$; $t_p = 80\mu\text{s}$

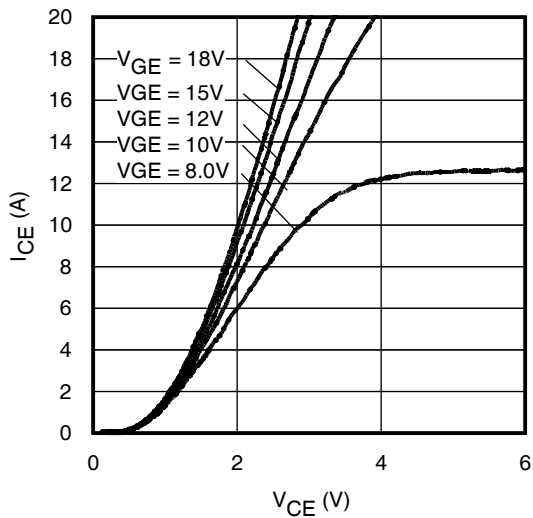


Fig. 7 - Typ. IGBT Output Characteristics
 $T_J = 150^{\circ}\text{C}$; $t_p = 80\mu\text{s}$

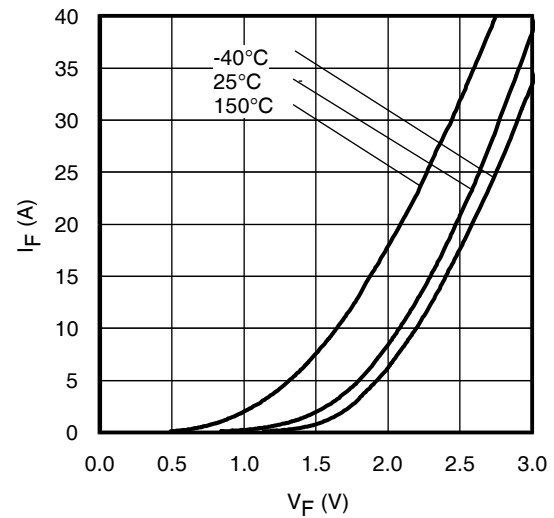


Fig. 8 - Typ. Diode Forward Characteristics
 $t_p = 80\mu\text{s}$

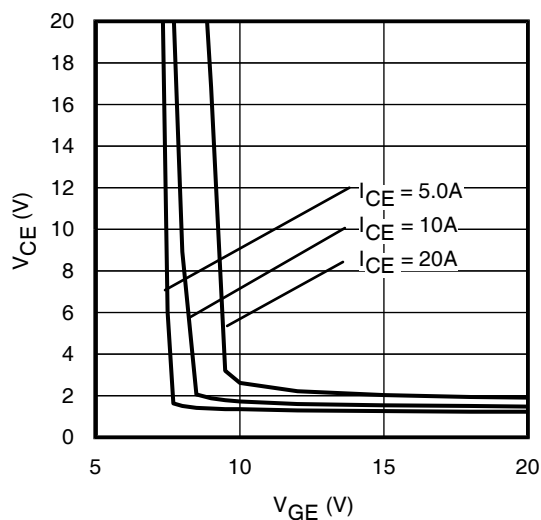


Fig. 9 - Typical V_{CE} vs. V_{GE}
 $T_J = -40^{\circ}\text{C}$

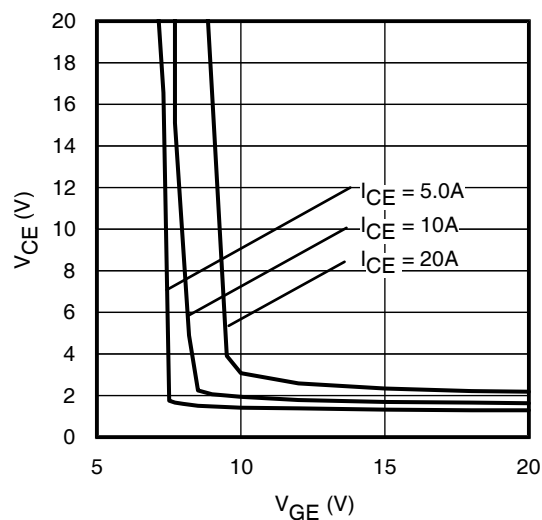


Fig. 10 - Typical V_{CE} vs. V_{GE}
 $T_J = 25^{\circ}\text{C}$

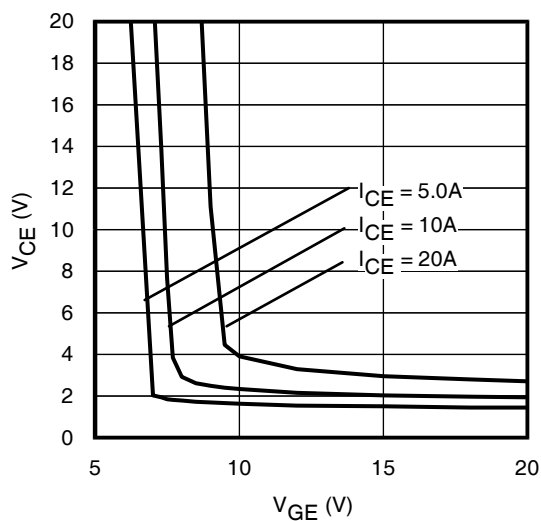


Fig. 11 - Typical V_{CE} vs. V_{GE}
 $T_J = 150^{\circ}\text{C}$

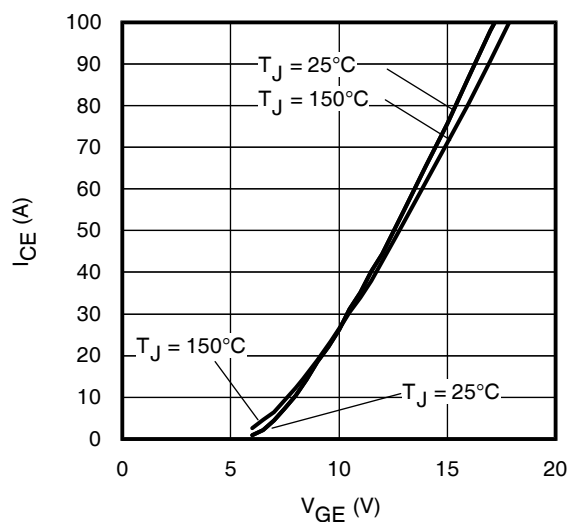


Fig. 12 - Typ. Transfer Characteristics
 $V_{CE} = 50\text{V}$; $t_p = 10\mu\text{s}$

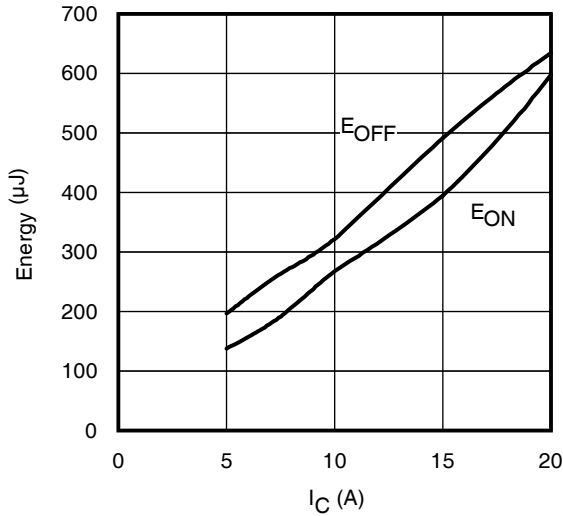


Fig. 13 - Typ. Energy Loss vs. I_C
 $T_J = 150^\circ\text{C}$; $L = 1.07\text{mH}$; $V_{CE} = 400\text{V}$
 $R_G = 50\Omega$; $V_{GE} = 15\text{V}$

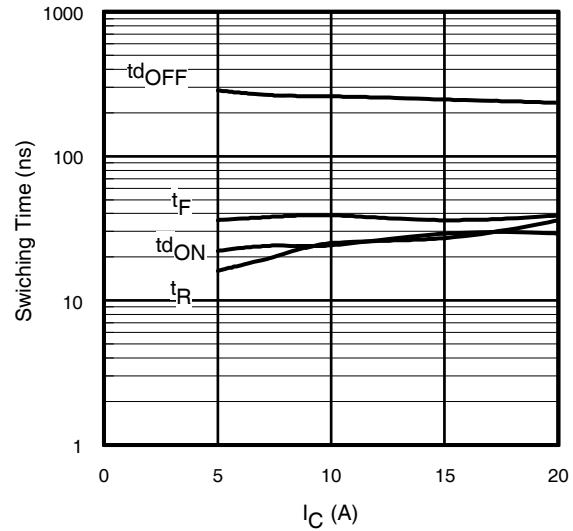


Fig. 14 - Typ. Switching Time vs. I_C
 $T_J = 150^\circ\text{C}$; $L = 1.07\text{mH}$; $V_{CE} = 400\text{V}$
 $R_G = 50\Omega$; $V_{GE} = 15\text{V}$

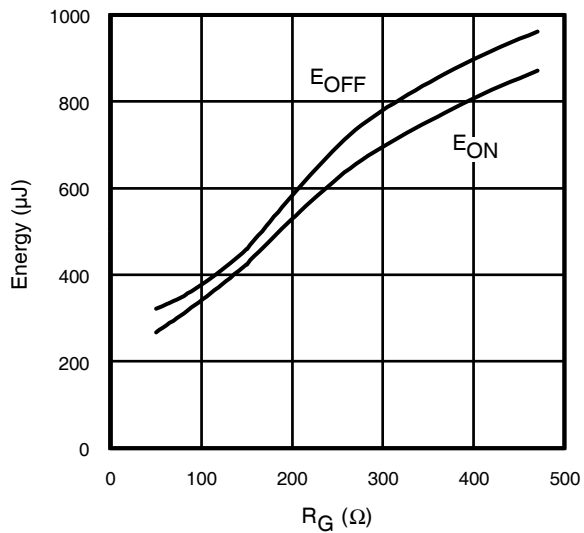


Fig. 15 - Typ. Energy Loss vs. R_G
 $T_J = 150^\circ\text{C}$; $L = 1.07\text{mH}$; $V_{CE} = 400\text{V}$
 $I_{CE} = 10\text{A}$; $V_{GE} = 15\text{V}$

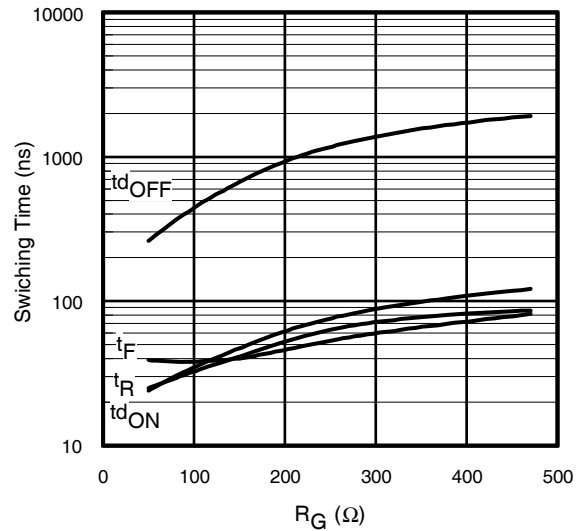


Fig. 16 - Typ. Switching Time vs. R_G
 $T_J = 150^\circ\text{C}$; $L = 1.07\text{mH}$; $V_{CE} = 400\text{V}$
 $I_{CE} = 10\text{A}$; $V_{GE} = 15\text{V}$

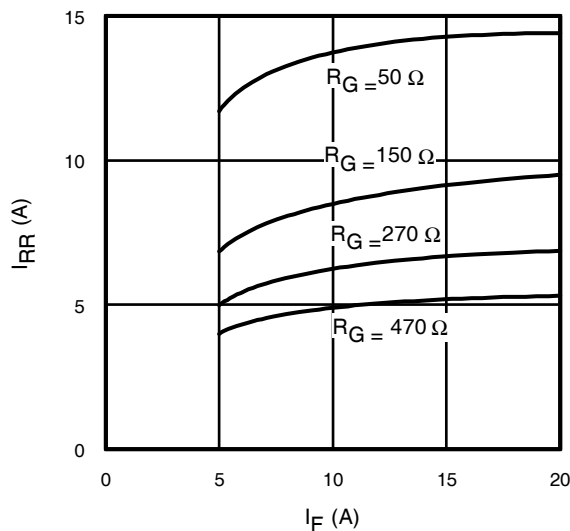


Fig. 17 - Typical Diode I_{RR} vs. I_F
 $T_J = 150^\circ\text{C}$

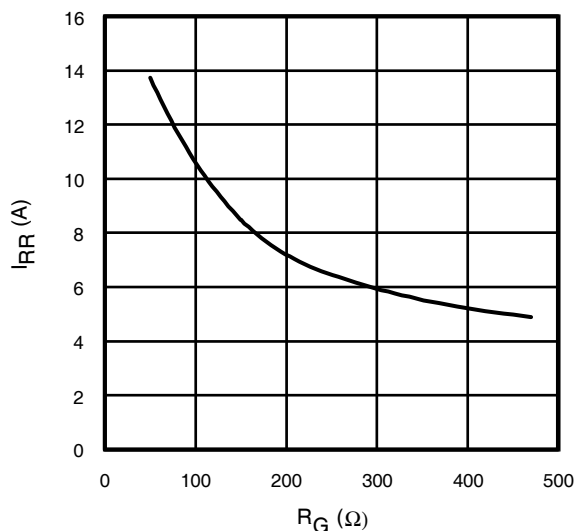


Fig. 18 - Typical Diode I_{RR} vs. R_G
 $T_J = 150^\circ\text{C}$; $I_F = 10\text{A}$

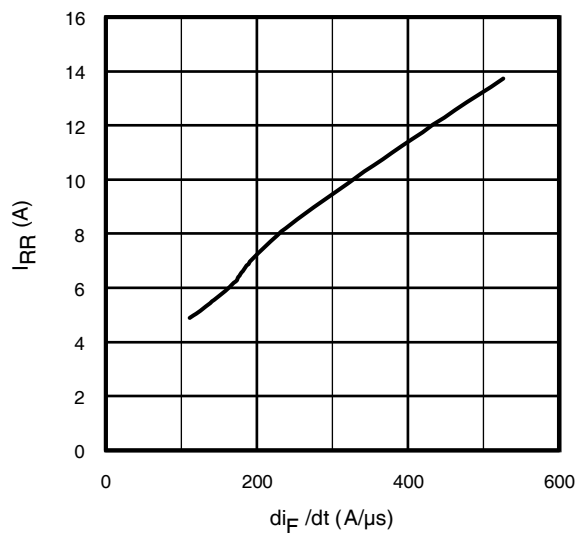


Fig. 19- Typical Diode I_{RR} vs. di_F/dt
 $V_{CC} = 400\text{V}$; $V_{GE} = 15\text{V}$;
 $I_{CE} = 10\text{A}$; $T_J = 150^\circ\text{C}$

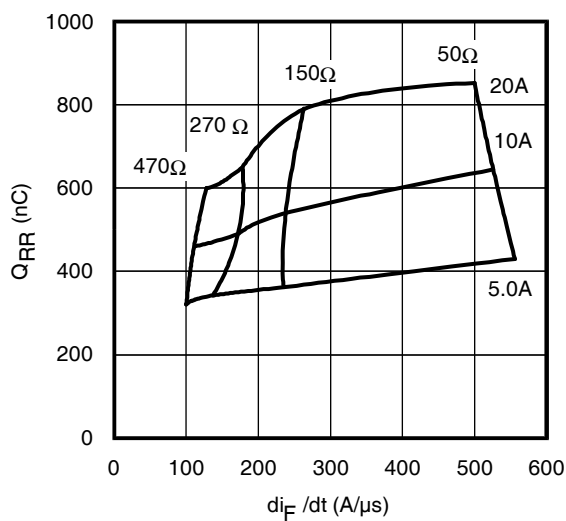


Fig. 20 - Typical Diode Q_{RR}
 $V_{CC} = 400\text{V}$; $V_{GE} = 15\text{V}$; $T_J = 150^\circ\text{C}$

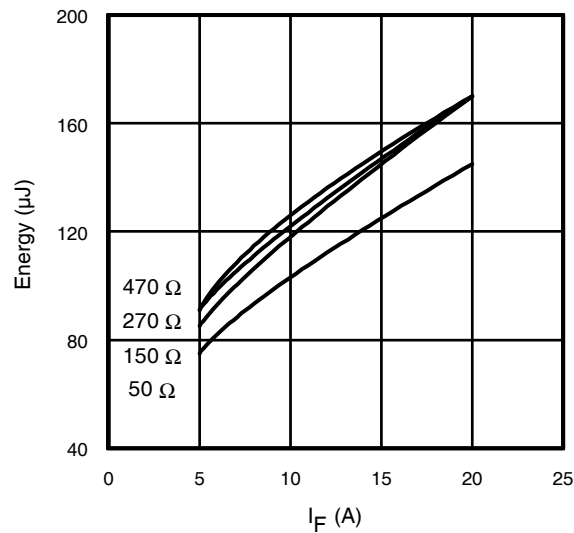


Fig. 21 - Typical Diode E_{RR} vs. I_F
 $T_J = 150^\circ\text{C}$

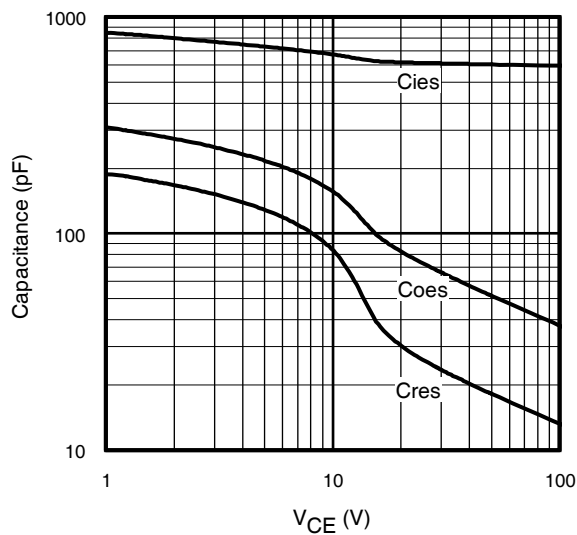


Fig. 22- Typ. Capacitance vs. V_{CE}
 $V_{GE} = 0\text{V}$; $f = 1\text{MHz}$

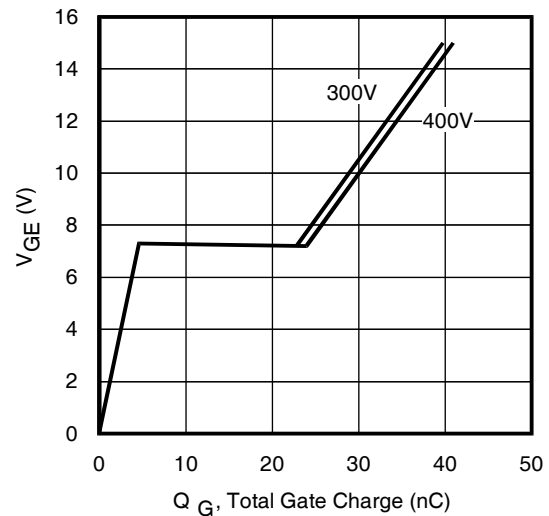


Fig. 23 - Typical Gate Charge vs. V_{GE}
 $I_{CE} = 10\text{A}$; $L = 2500\mu\text{H}$

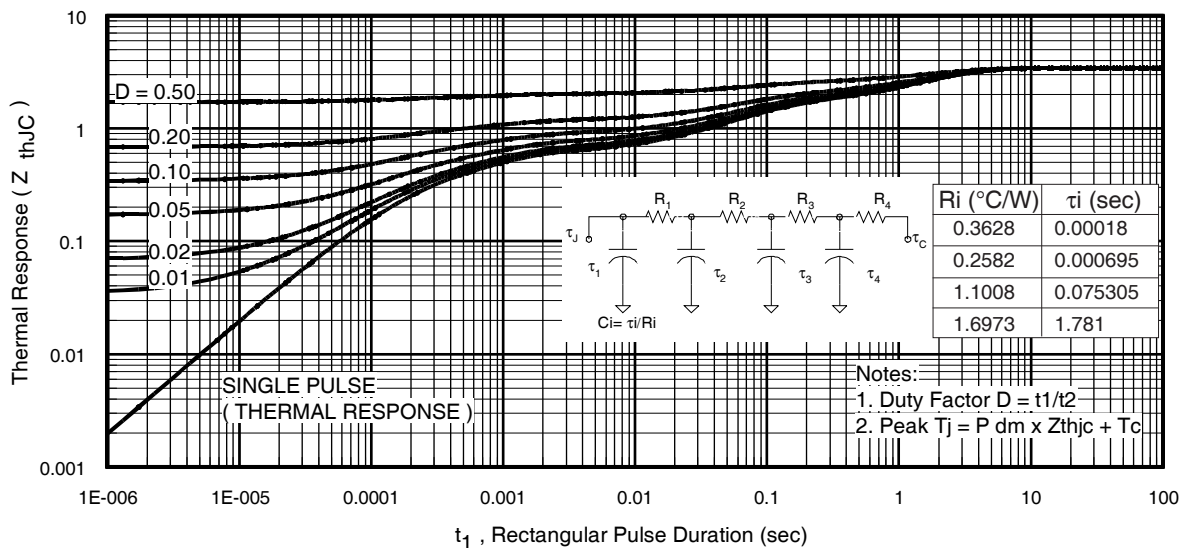


Fig 24. Maximum Transient Thermal Impedance, Junction-to-Case (IGBT)

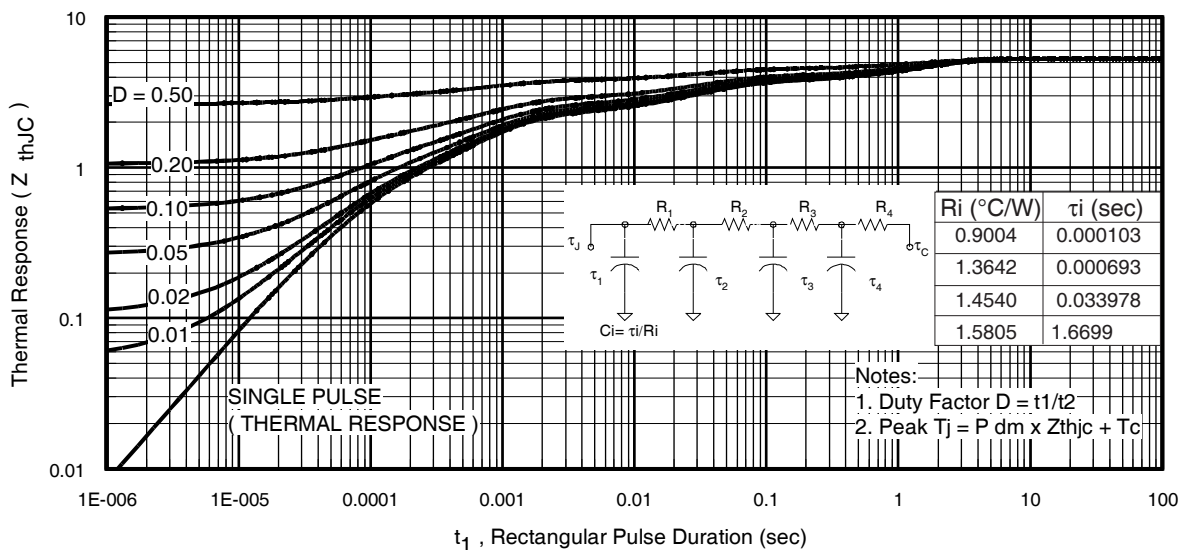


Fig 25. Maximum Transient Thermal Impedance, Junction-to-Case (DIODE)

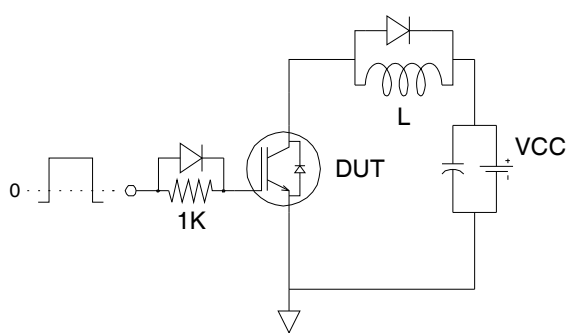


Fig.C.T.1 - Gate Charge Circuit (turn-off)

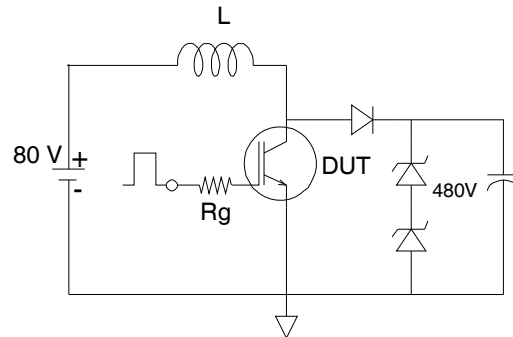


Fig.C.T.2 - RBSOA Circuit

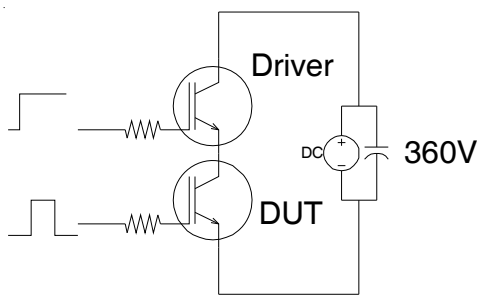


Fig.C.T.3 - S.C.SOA Circuit

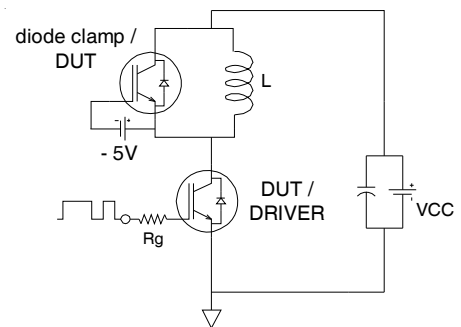


Fig.C.T.4 - Switching Loss Circuit

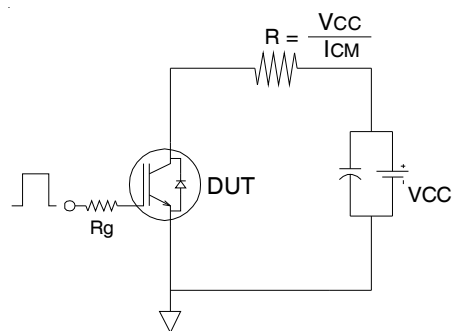


Fig.C.T.5 - Resistive Load Circuit

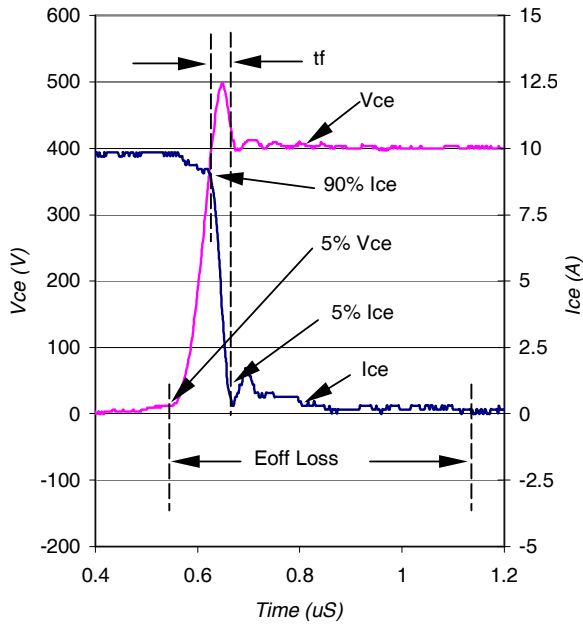


Fig. WF1- Typ. Turn-off Loss Waveform
@ $T_J = 150^{\circ}\text{C}$ using Fig. CT.4

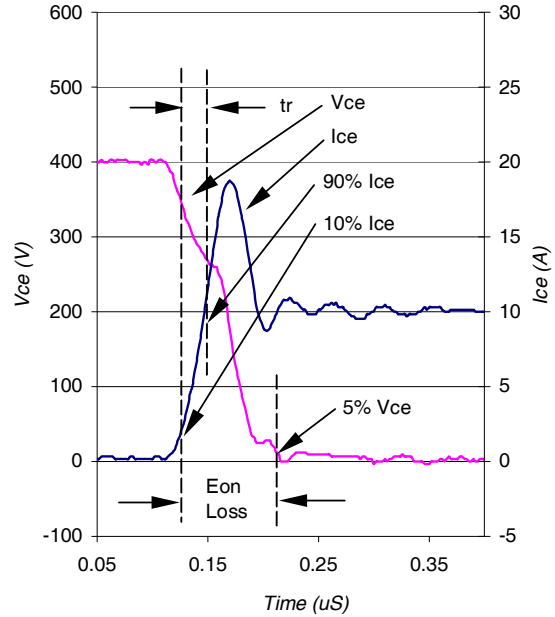


Fig. WF2- Typ. Turn-on Loss Waveform
@ $T_J = 150^{\circ}\text{C}$ using Fig. CT.4

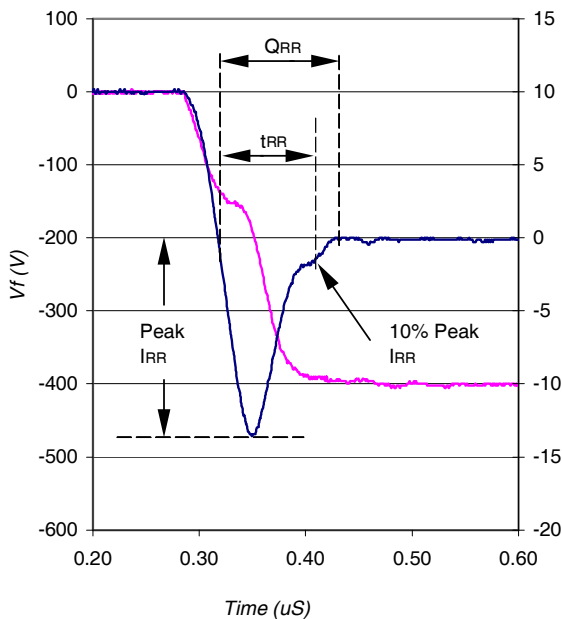


Fig. WF3- Typ. Diode Recovery Waveform
@ $T_J = 150^{\circ}\text{C}$ using Fig. CT.4

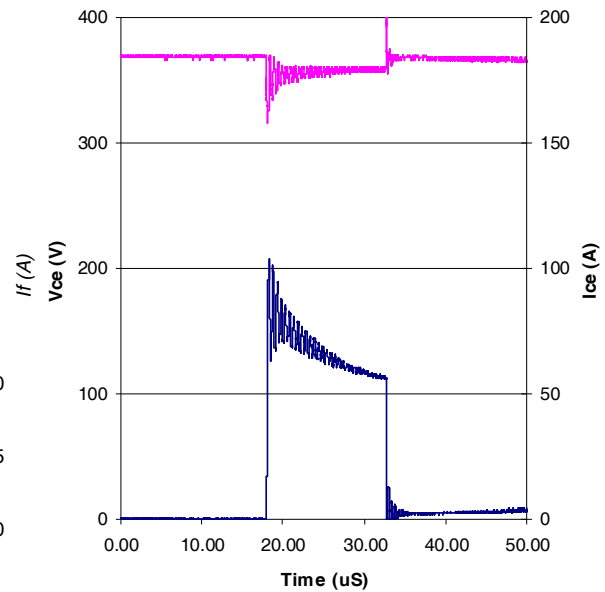
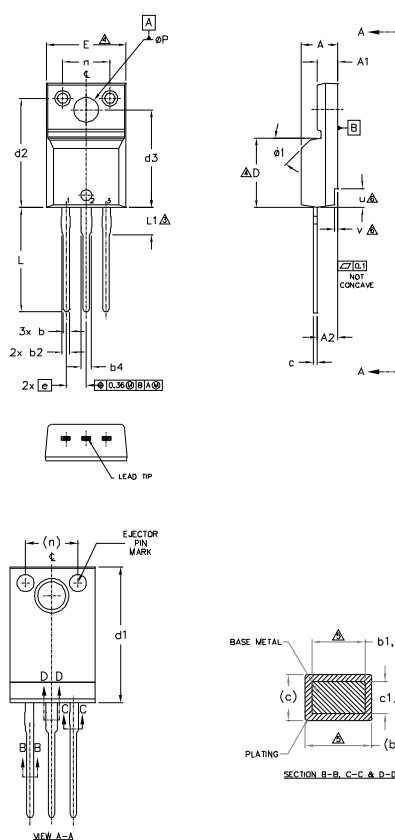


Fig. WF4- Typ. S.C Waveform
@ $T_C = 150^{\circ}\text{C}$ using Fig. CT.3

TO-220 Full-Pak Package Outline

Dimensions are shown in millimeters (inches)



NOTES
1.0 DIMENSIONING AND TOLERANCING AS PER ASME Y14.5 M-1994.
2.0 DIMENSIONS ARE SHOWN IN MILLIMETERS (INCHES)
3.0 LEAD DIMENSION AND FINISH UNCONTROLLED IN L1
4.0 DIMENSION D & C DO NOT INCLUDE WELD FLASH; WELD FLASH SHALL NOT EXCEED .005" (0.127) PER SIDE. THESE DIMENSIONS ARE MEASURED AT THE QUOTER MOST EXTREMES OF THE PLASTIC BODY.
5.0 DIMENSION V1, V2, V3 & V4 APPLY TO BASE METAL ONLY.
6.0 STEP OPTIONAL ON PLASTIC BODY DEFINED BY DIMENSIONS u & v.
7.0 CONTROLLING DIMENSION 1 INCHES.

LEAD ASSIGNMENTS

REJECT
1- GATE
2- DRAIN
3- SOURCE

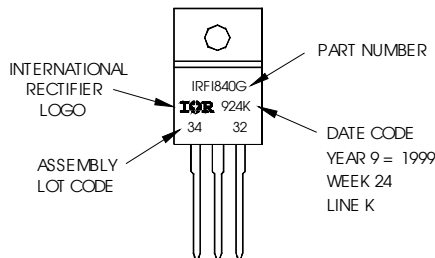
BASE METAL
1- GATE
2- COLLECTOR
3- EMITTER

SYMBOL	DIMENSIONS				NOTES
	MILLIMETERS		INCHES		
	MIN.	MAX.	MIN.	MAX.	
A	4.57	4.83	.180	.190	5
A1	2.57	2.82	.101	.111	
A2	2.51	2.92	.099	.115	
b	0.61	0.94	.024	.037	
b1	0.61	0.89	.024	.035	
b2	0.76	1.27	.030	.050	5
b3	0.76	1.22	.030	.048	
b4	1.02	1.52	.040	.060	
b5	1.02	1.47	.040	.058	5
c	0.33	0.63	.013	.025	5
c1	0.33	0.58	.013	.023	
D	8.66	9.80	.341	.386	
d1	15.80	16.13	.622	.635	4
d2	13.97	14.22	.550	.560	
d3	12.29	12.93	.484	.509	
E	9.63	10.74	.379	.423	4
e	2.54 BSC		.100 BSC		3
L	13.21	13.72	.520	.540	
L1	3.10	3.68	.122	.145	
n	6.05	6.60	.238	.260	
øP	3.05	3.45	.120	.136	
u	2.39	2.49	.094	.098	6
v	0.41	0.51	.016	.020	6
ø1	—	45°	—	45°	

TO-220 Full-Pak Part Marking Information

EXAMPLE: THIS IS AN IRF1840G
WITH ASSEMBLY
LOT CODE 3432
ASSEMBLED ON WW 24 1999
IN THE ASSEMBLY LINE "K"

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



TO-220 Full-Pak package is not recommended for Surface Mount Application

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

Qualification Information[†]

Qualification Level	Industrial (per JEDEC JESD47F) ^{††}	
Moisture Sensitivity Level	TO-220AB-Full-Pak	N/A
RoHS Compliant	Yes	

[†] Qualification standards can be found at International Rectifier's web site <http://www.irf.com/product-info/reliability>

^{††} Applicable version of JEDEC standard at the time of product release.

Revision History

Date	Comments
8/4/2015	• Updated data sheet with the new corporate template. • Added feature "UL Certified" on page 1. • Updated package outline on page 12. • Updated note ① from "$V_{GE} = 15V$" to "$V_{GE} = 20V$" on page 2.

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