

IRGB4045DPbF

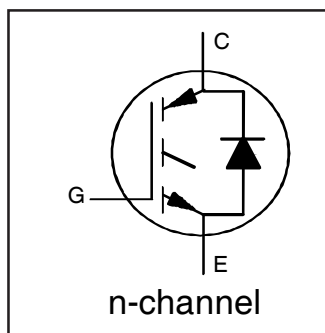
INSULATED GATE BIPOLAR TRANSISTOR WITH ULTRAFAST SOFT RECOVERY DIODE

Features

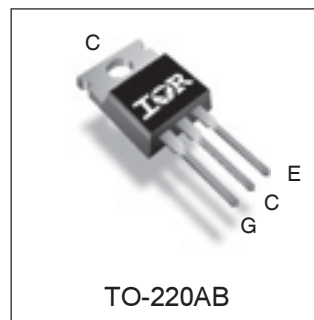
- Low $V_{CE(on)}$ Trench IGBT Technology
- Low Switching Losses
- Maximum Junction temperature 175 °C
- 5μs SCSOA
- Square RBSOA
- 100% of the parts tested for I_{LM} ①
- Positive $V_{CE(on)}$ Temperature Coefficient.
- Ultra Fast Soft Recovery Co-pak Diode
- Tighter Distribution of Parameters
- Lead-Free Package

Benefits

- High Efficiency in a Wide Range of Applications
- Suitable for a Wide Range of Switching Frequencies due to Low $V_{CE(ON)}$ and Low Switching Losses
- Rugged Transient Performance for Increased Reliability
- Excellent Current Sharing in Parallel Operation
- Low EMI



$V_{CES} = 600V$
 $I_C = 6.0A, T_C = 100^\circ C$
 $t_{sc} > 5\mu s, T_{jmax} = 175^\circ C$
 $V_{CE(on) typ.} = 1.7V$



G	C	E
Gate	Collector	Emitter

Absolute Maximum Ratings

	Parameter	Max.	Units
V _{CES}	Collector-to-Emitter Breakdown Voltage	600	V
I _C @ T _C = 25°C	Continuous Collector Current	12	A
I _C @ T _C = 100°C	Continuous Collector Current	6.0	
I _{CM}	Pulsed Collector Current, V _{GE} = 15V	18	
I _{LM}	Clamped Inductive Load Current, V _{GE} = 20V ①	24	
I _F @T _C =25°C	Diode Continuous Forward Current	8.0	
I _F @T _C =100°C	Diode Continuous Forward Current	4.0	
I _{FM}	Diode Maximum Forward Current ②	24	
V _{GE}	Continuous Gate-to-Emitter Voltage	± 20	V
	Transient Gate-to-Emitter Voltage	± 30	
P _D @ T _C =25°	Maximum Power Dissipation	77	W
P _D @ T _C =100°	Maximum Power Dissipation	39	
T _J	Operating Junction and	-55 to + 175	°C
T _{STG}	Storage Temperature Range		
	Soldering Temperature, for 10 seconds	300 (0.063 in. (1.6mm) from case)	

Thermal Resistance

	Parameter	Min.	Typ.	Max.	Units
$R_{\theta JC}$	Junction-to-Case - IGBT ③	—	—	1.94	°C/W
$R_{\theta JC}$	Junction-to-Case - Diode ③	—	—	6.30	
$R_{\theta CS}$	Case-to-Sink, flat, greased surface	—	0.5	—	
$R_{\theta JA}$	Junction-to-Ambient, typical socket mount ③	—	—	62	

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	$V_{GE} = 0V, I_C = 100\mu A$ ④	CT6
$\Delta V_{(BR)CES}/\Delta T_J$	Temperature Coeff. of Breakdown Voltage	—	0.36	—	V/°C	$V_{GE} = 0V, I_C = 250\mu A$ (25 -175 °C) ④	
$V_{CE(on)}$	Collector-to-Emitter Saturation Voltage	—	1.7	2.0	V	$I_C = 6.0A, V_{GE} = 15V, T_J = 25^\circ\text{C}$	5,6,7,9, 10,11
		—	2.07	—		$I_C = 6.0A, V_{GE} = 15V, T_J = 150^\circ\text{C}$	
		—	2.14	—		$I_C = 6.0A, V_{GE} = 15V, T_J = 175^\circ\text{C}$	
$V_{GE(th)}$	Gate Threshold Voltage	4.0	—	6.5	V	$V_{CE} = V_{GE}, I_C = 150\mu A$	9,10,11,12
$\Delta V_{GE(th)}/\Delta T_J$	Threshold Voltage temp. coefficient	—	-13	—	mV/°C	$V_{CE} = V_{GE}, I_C = 250\mu A$ (25 -175 °C)	
g_{fe}	Forward Transconductance	—	5.8	—	S	$V_{CE} = 25V, I_C = 6.0A, PW = 80\mu s$	
I_{CES}	Collector-to-Emitter Leakage Current	—	—	25	μA	$V_{GE} = 0V, V_{CE} = 600V$	8
		—	—	250		$V_{GE} = 0V, V_{CE} = 600V, T_J = 175^\circ\text{C}$	
V_{FM}	Diode Forward Voltage Drop	—	1.60	2.30	V	$I_F = 6.0A$	
		—	1.30	—		$I_F = 6.0A, T_J = 175^\circ\text{C}$	
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)	—	13	19.5	nC	$I_C = 6.0A$	24
Q_{ge}	Gate-to-Emitter Charge (turn-on)	—	3.1	4.65		$V_{CC} = 400V$	CT1
Q_{gc}	Gate-to-Collector Charge (turn-on)	—	6.4	9.6		$V_{GE} = 15V$	
E_{on}	Turn-On Switching Loss	—	56	86	μJ	$I_C = 6.0A, V_{CC} = 400V, V_{GE} = 15V$	CT4
E_{off}	Turn-Off Switching Loss	—	122	143		$R_G = 47\Omega, L = 1mH, L_S = 150nH, T_J = 25^\circ\text{C}$	
E_{total}	Total Switching Loss	—	178	229		Energy losses include tail and diode reverse recovery	
$t_{d(on)}$	Turn-On delay time	—	27	35	ns	$I_C = 6.0A, V_{CC} = 400V$	CT4
t_r	Rise time	—	11	15		$R_G = 47\Omega, L = 1mH, L_S = 150nH$	
$t_{d(off)}$	Turn-Off delay time	—	75	93		$T_J = 25^\circ\text{C}$	
t_f	Fall time	—	17	22			
E_{on}	Turn-On Switching Loss	—	140	—	μJ	$I_C = 6.0A, V_{CC} = 400V, V_{GE} = 15V$	13,15
E_{off}	Turn-Off Switching Loss	—	189	—		$R_G = 47\Omega, L = 1mH, L_S = 150nH, T_J = 175^\circ\text{C}$	CT4
E_{total}	Total Switching Loss	—	329	—		Energy losses include tail and diode reverse recovery	WF1,WF2
$t_{d(on)}$	Turn-On delay time	—	26	—	ns	$I_C = 6.0A, V_{CC} = 400V$	14,16
t_r	Rise time	—	12	—		$R_G = 47\Omega, L = 1mH, L_S = 150nH$	CT4
$t_{d(off)}$	Turn-Off delay time	—	95	—		$T_J = 175^\circ\text{C}$	WF1,WF2
t_f	Fall time	—	32	—			
C_{ies}	Input Capacitance	—	350	—	pF	$V_{GE} = 0V$	23
C_{oes}	Output Capacitance	—	29	—		$V_{CC} = 30V$	
C_{res}	Reverse Transfer Capacitance	—	10	—		$f = 1Mhz$	
RBSOA	Reverse Bias Safe Operating Area	FULL SQUARE				$T_J = 175^\circ\text{C}, I_C = 24A$ $V_{CC} = 500V, V_p = 600V$ $R_G = 100\Omega, V_{GE} = +20V$ to 0V	4 CT2
SCSOA	Short Circuit Safe Operating Area	5	—	—	μs	$V_{CC} = 400V, V_p = 600V$ $R_G = 100\Omega, V_{GE} = +15V$ to 0V	22, CT3 WF4
E_{rec}	Reverse recovery energy of the diode	—	178	—	μJ	$T_J = 175^\circ\text{C}$	17,18,19
t_{rr}	Diode Reverse recovery time	—	74	—	ns	$V_{CC} = 400V, I_F = 6.0A$	20,21
I_{rr}	Peak Reverse Recovery Current	—	12	—	A	$V_{GE} = 15V, R_G = 47\Omega, L = 1mH, L_S = 150nH$	WF3

Notes:

- ① $V_{CC} = 80\% (V_{CES}), V_{GE} = 15V, L = 1.0mH, R_G = 47\Omega$.
- ② Pulse width limited by max. junction temperature.
- ③ R_θ is measured at T_J approximately 90°C .
- ④ Refer to AN-1086 for guidelines for measuring $V_{(BR)CES}$ safely.

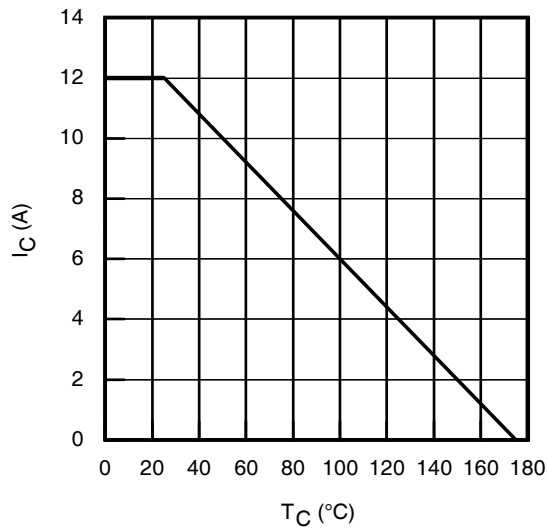


Fig. 1 - Maximum DC Collector Current vs. Case Temperature

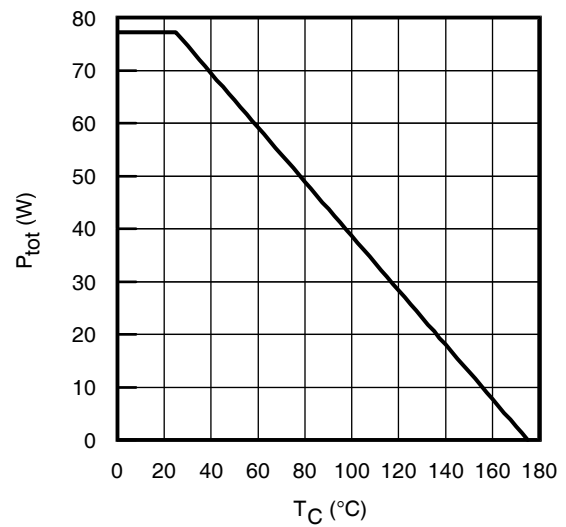


Fig. 2 - Power Dissipation vs. Case Temperature

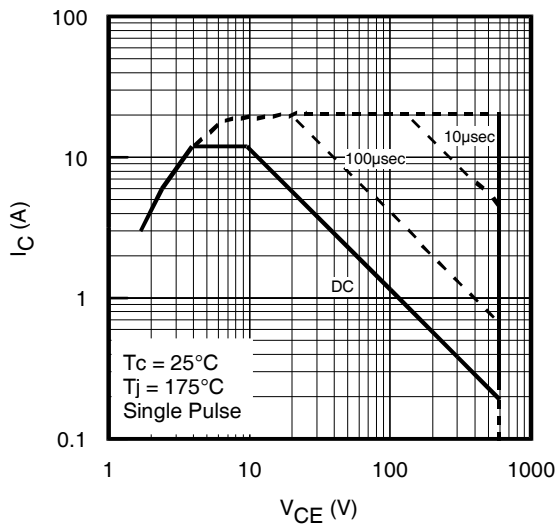


Fig. 3 - Forward SOA,
 $T_C = 25^\circ\text{C}$, $T_J \leq 175^\circ\text{C}$, $V_{GE} = 15\text{V}$

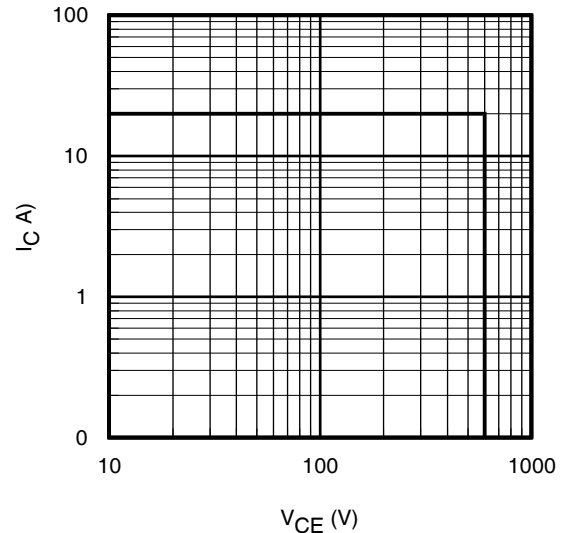


Fig. 4 - Reverse Bias SOA
 $T_J = 175^\circ\text{C}$, $V_{GE} = 20\text{V}$

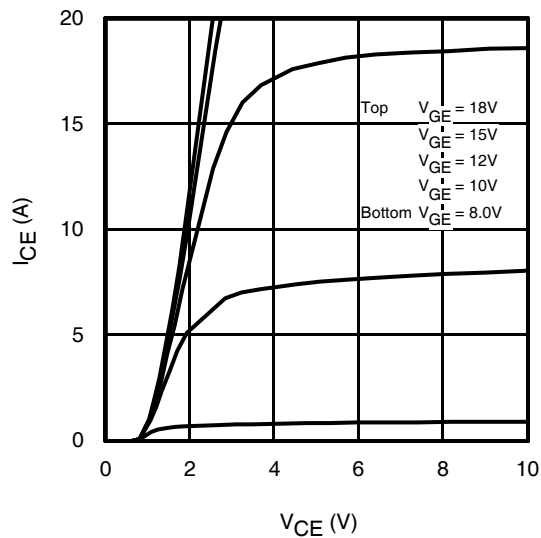


Fig. 5 - Typ. IGBT Output Characteristics
 $T_J = -40^\circ\text{C}$; $t_p = 80\mu\text{s}$

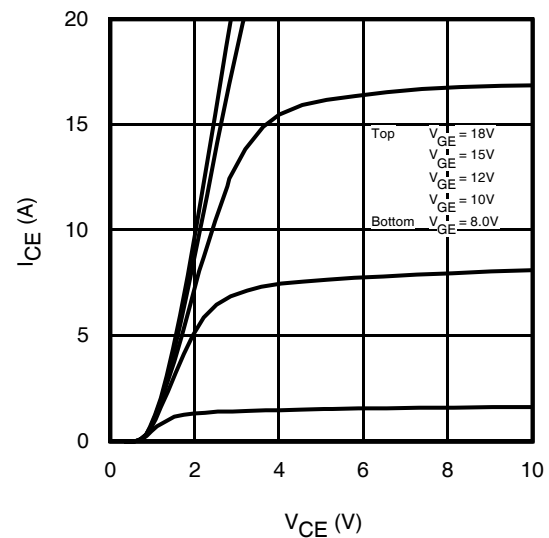


Fig. 6 - Typ. IGBT Output Characteristics
 $T_J = 25^\circ\text{C}$; $t_p = 80\mu\text{s}$

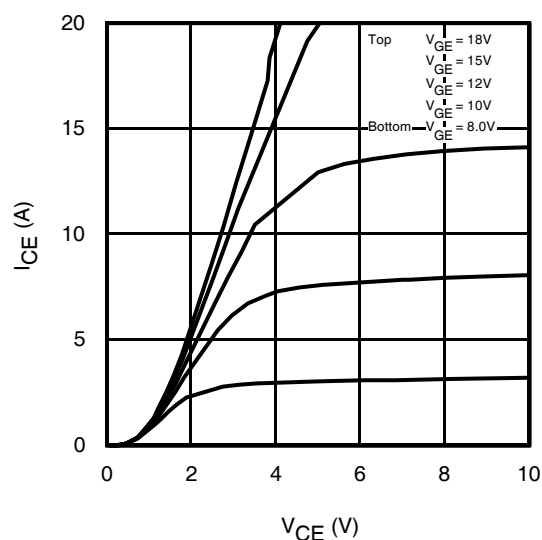


Fig. 7 - Typ. IGBT Output Characteristics
 $T_J = 175^\circ\text{C}$; $t_p = 80\mu\text{s}$

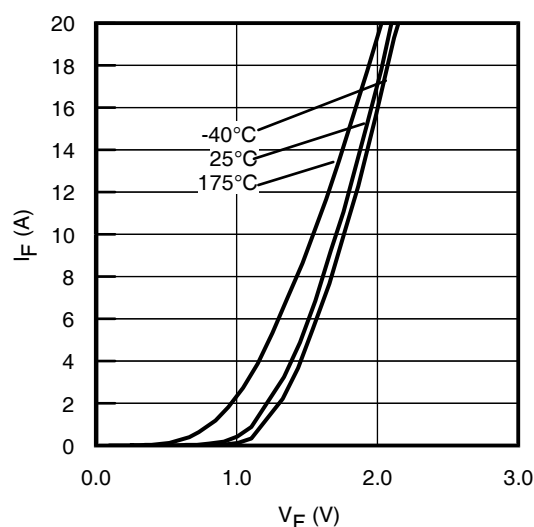


Fig. 8 - Typ. Diode Forward Characteristics
 $t_p = 80\mu\text{s}$

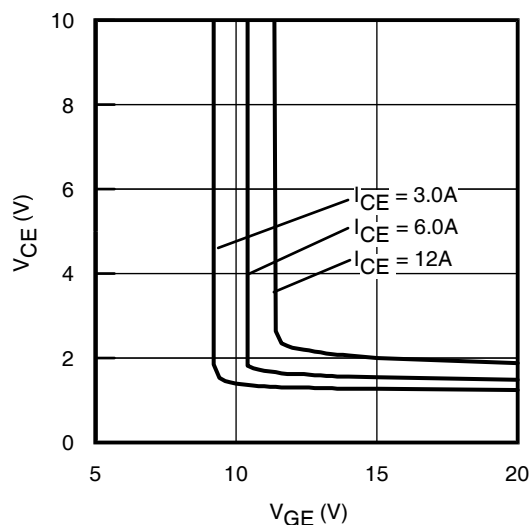


Fig. 9 - Typical V_{CE} vs. V_{GE}
 $T_J = -40^\circ\text{C}$

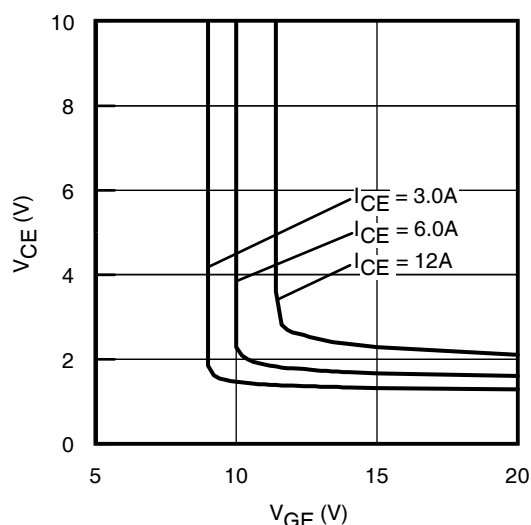


Fig. 10 - Typical V_{CE} vs. V_{GE}
 $T_J = 25^\circ\text{C}$

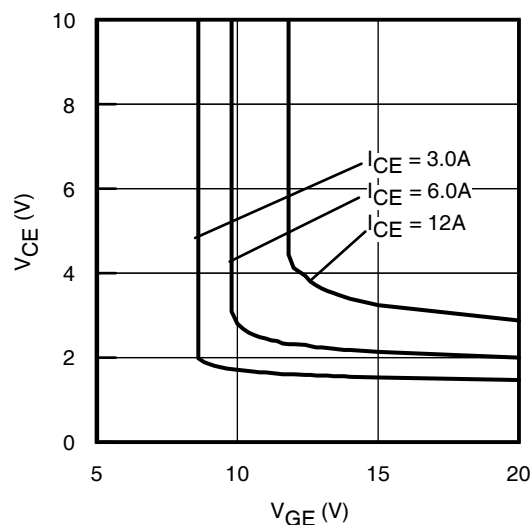


Fig. 11 - Typical V_{CE} vs. V_{GE}
 $T_J = 175^\circ\text{C}$

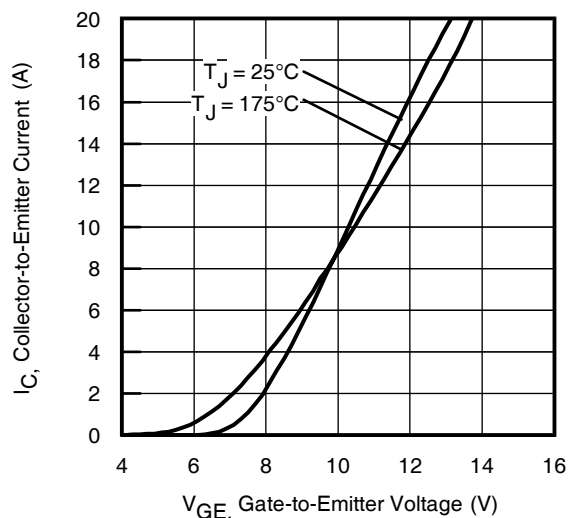


Fig. 12 - Typ. Transfer Characteristics
 $V_{CE} = 50\text{V}$; $t_p = 10\mu\text{s}$

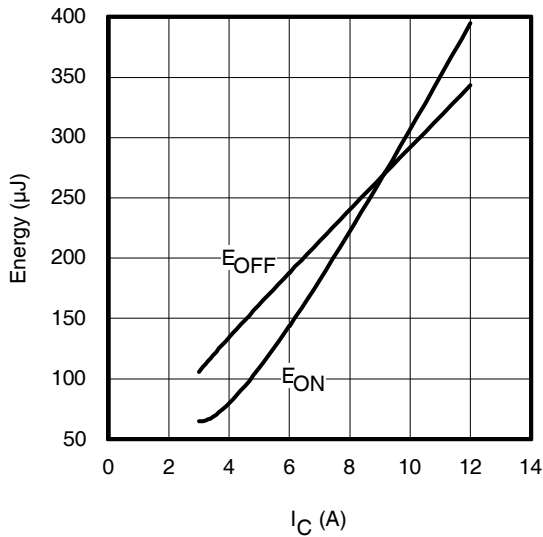


Fig. 13 - Typ. Energy Loss vs. I_C
 $T_J = 175^\circ\text{C}$; $L = 1\text{mH}$; $V_{CE} = 400\text{V}$; $R_G = 47\Omega$; $V_{GE} = 15\text{V}$.

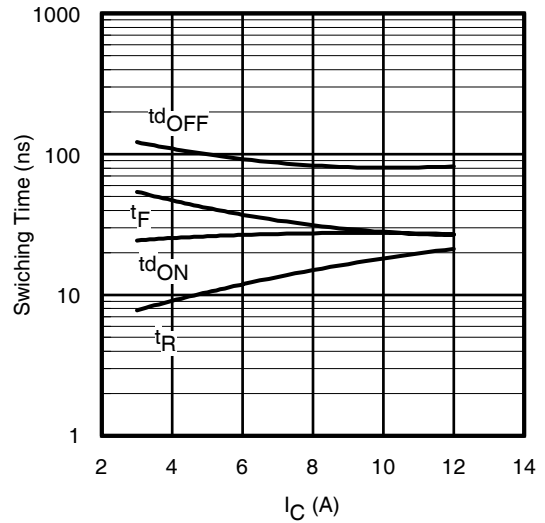


Fig. 14 - Typ. Switching Time vs. I_C
 $T_J = 175^\circ\text{C}$; $L = 1\text{mH}$; $V_{CE} = 400\text{V}$
 $R_G = 47\Omega$; $V_{GE} = 15\text{V}$

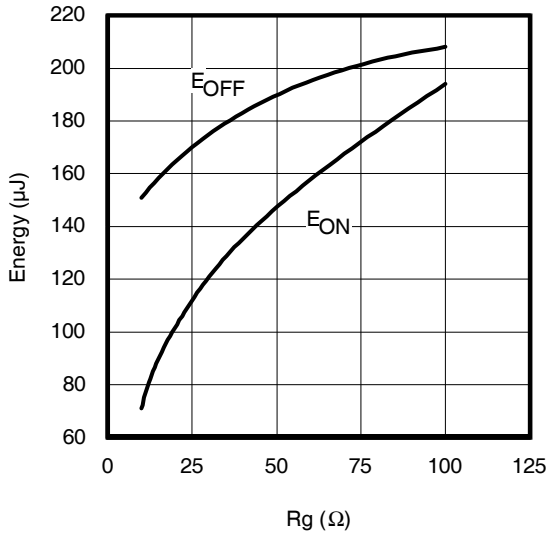


Fig. 15 - Typ. Energy Loss vs. R_G
 $T_J = 175^\circ\text{C}$; $L = 1\text{mH}$; $V_{CE} = 400\text{V}$; $I_{CE} = 6.0\text{A}$; $V_{GE} = 15\text{V}$

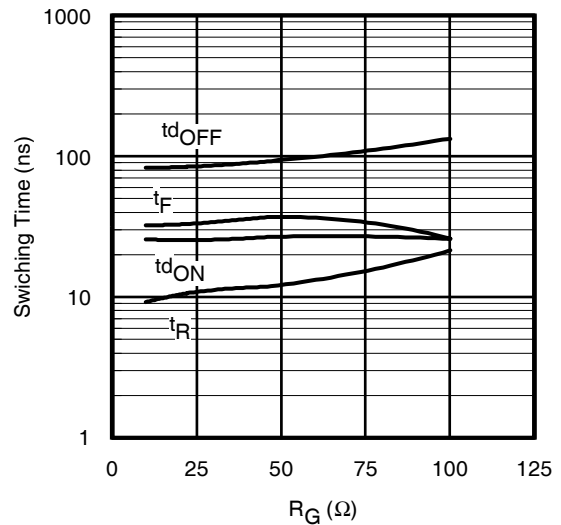


Fig. 16 - Typ. Switching Time vs. R_G
 $T_J = 175^\circ\text{C}$; $L = 1\text{mH}$; $V_{CE} = 400\text{V}$
 $I_{CE} = 6.0\text{A}$; $V_{GE} = 15\text{V}$

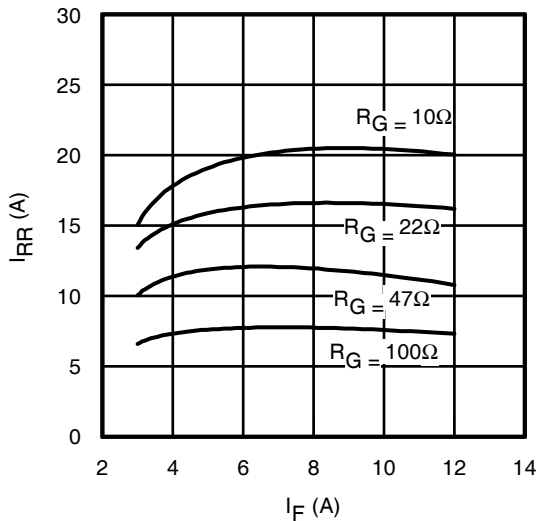


Fig. 17 - Typical Diode I_{RR} vs. I_F
 $T_J = 175^\circ\text{C}$

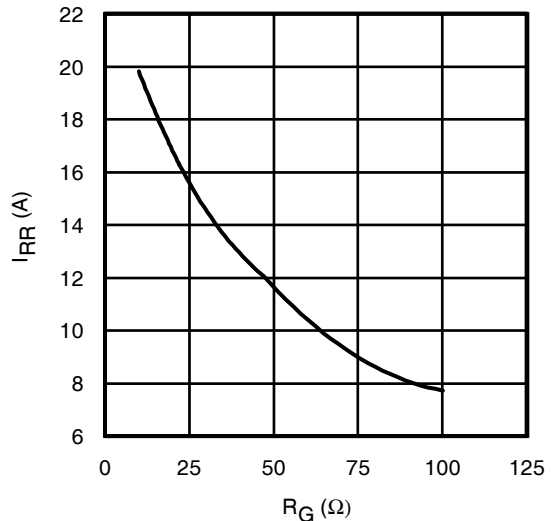


Fig. 18 - Typical Diode I_{RR} vs. R_G
 $T_J = 175^\circ\text{C}$; $I_F = 6.0\text{A}$

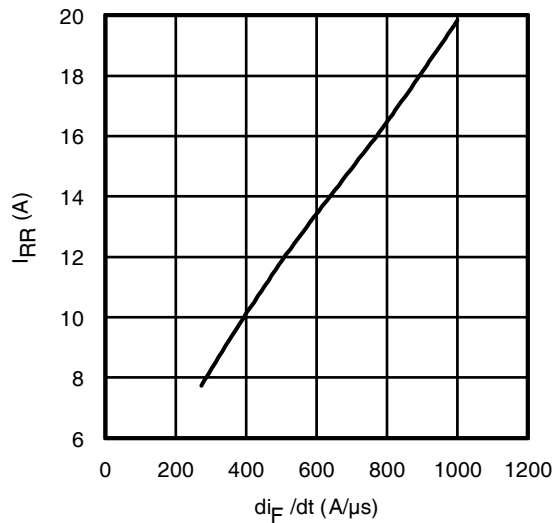


Fig. 19 - Typical Diode I_{RR} vs. di_F/dt
 $V_{CC} = 400V$; $V_{GE} = 15V$;
 $I_{CE} = 6.0A$; $T_J = 175^\circ C$

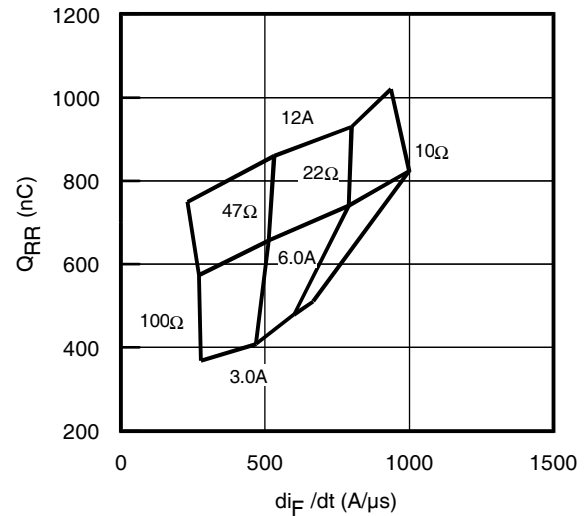


Fig. 20 - Typical Diode Q_{RR}
 $V_{CC} = 400V$; $V_{GE} = 15V$; $T_J = 175^\circ C$

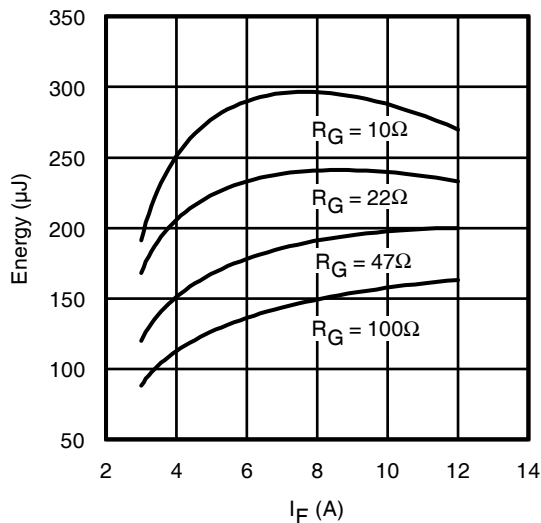


Fig. 21 - Typical Diode E_{RR} vs. I_F
 $T_J = 175^\circ C$

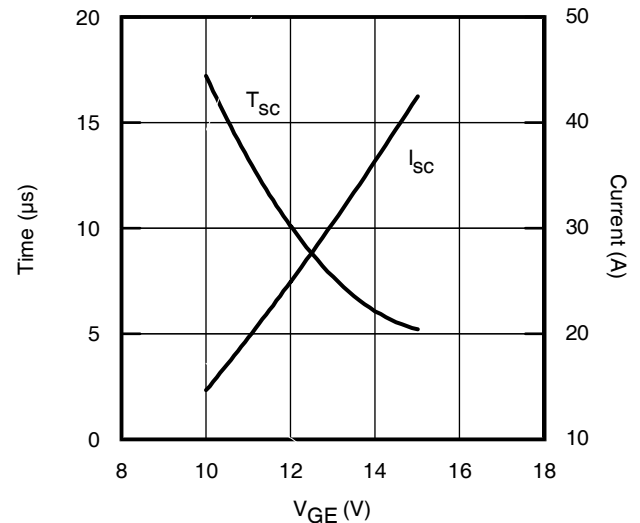


Fig. 22 - Typ. V_{GE} vs. Short Circuit Time
 $V_{CC} = 400V$, $T_C = 25^\circ C$

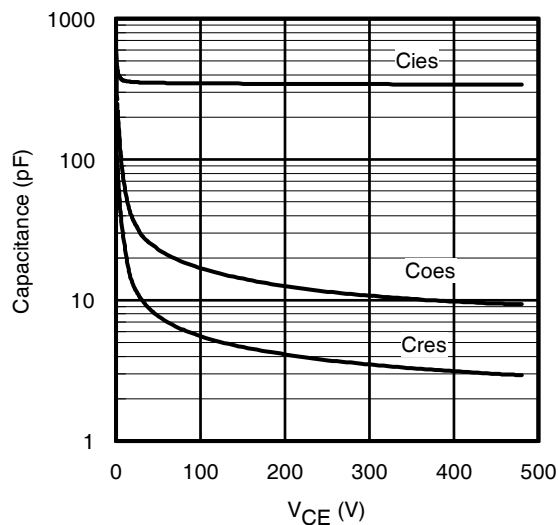


Fig. 23 - Typ. Capacitance vs. V_{CE}
 $V_{GE} = 0V$; $f = 1MHz$

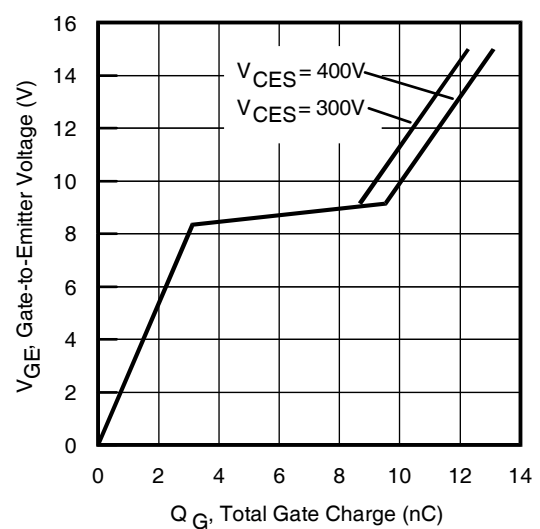


Fig. 24 - Typical Gate Charge vs. V_{GE}
 $I_{CE} = 6.0A$, $L = 600\mu H$

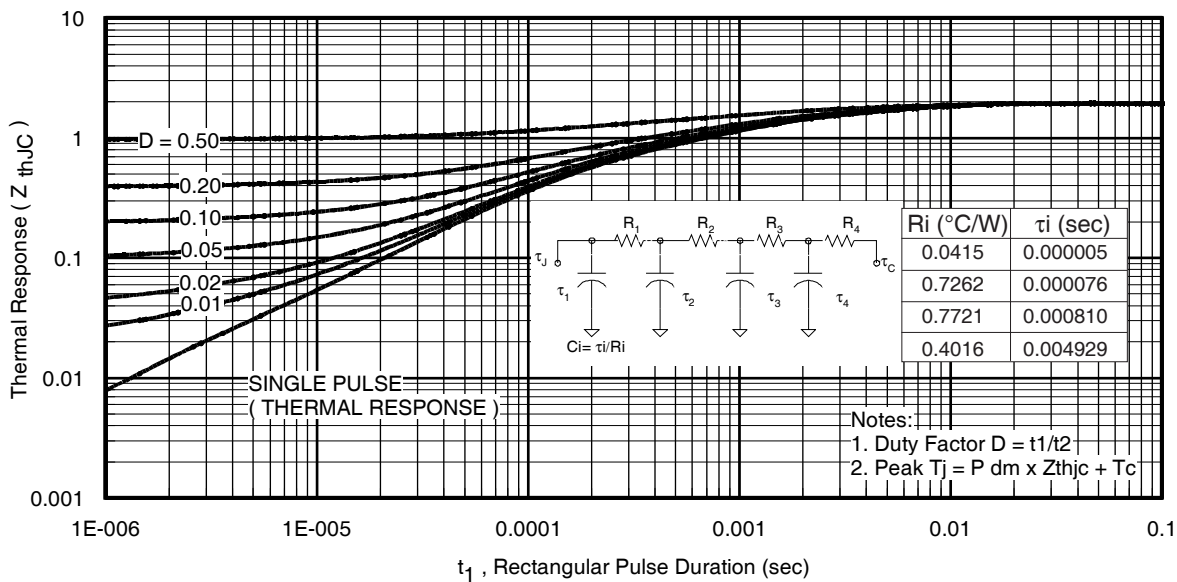


Fig 25. Maximum Transient Thermal Impedance, Junction-to-Case (IGBT)

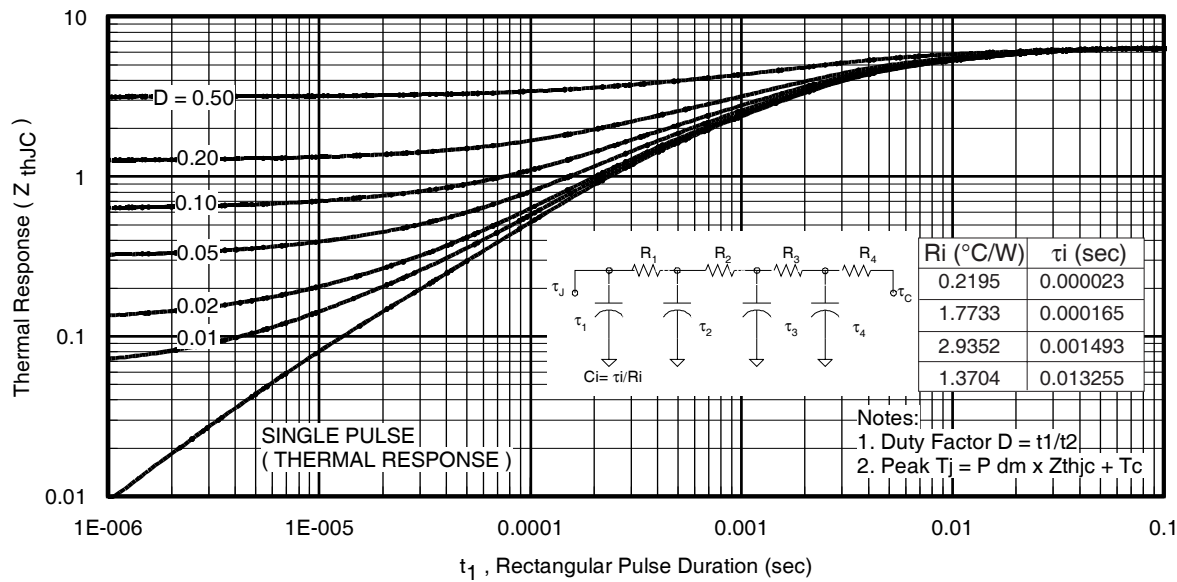


Fig. 26. Maximum Transient Thermal Impedance, Junction-to-Case (DIODE)

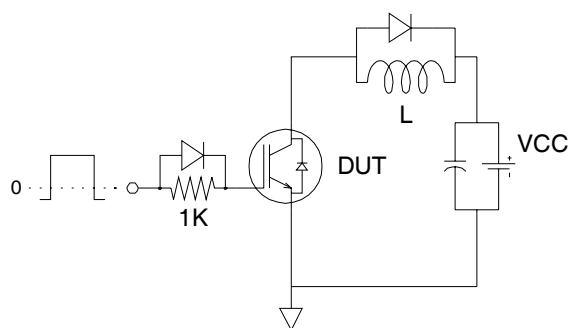


Fig.C.T.1 - Gate Charge Circuit (turn-off)

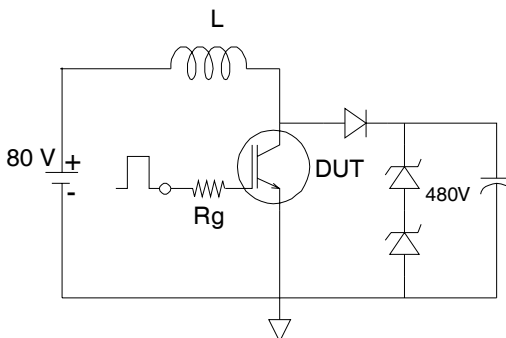


Fig.C.T.2 - RBSOA Circuit

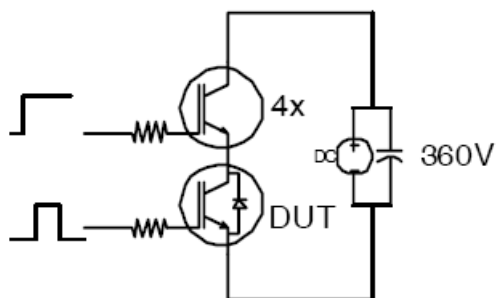


Fig.C.T.3 - S.C.SOA Circuit

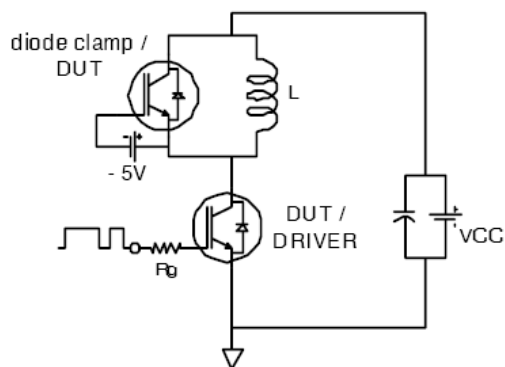


Fig.C.T.4 - Switching Loss Circuit

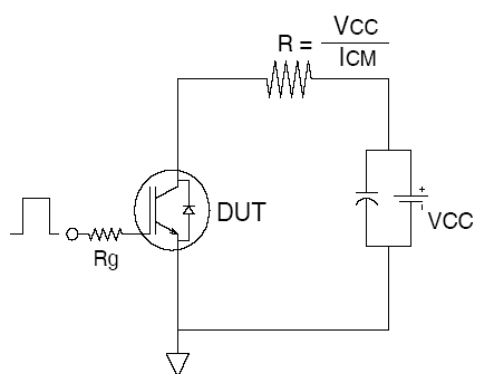


Fig.C.T.5 - Resistive Load Circuit

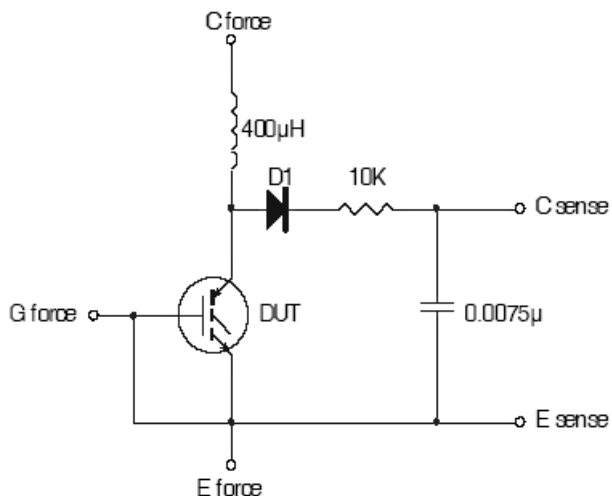


Fig.C.T.6 - Typical Filter Circuit for $V_{(BR)CES}$ Measurement

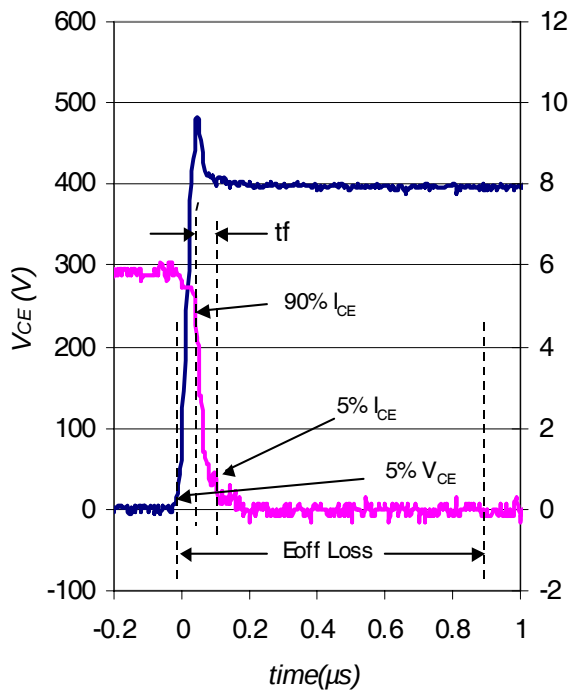


Fig. WF1 - Typ. Turn-off Loss Waveform
@ $T_J = 175^\circ\text{C}$ using Fig. CT.4

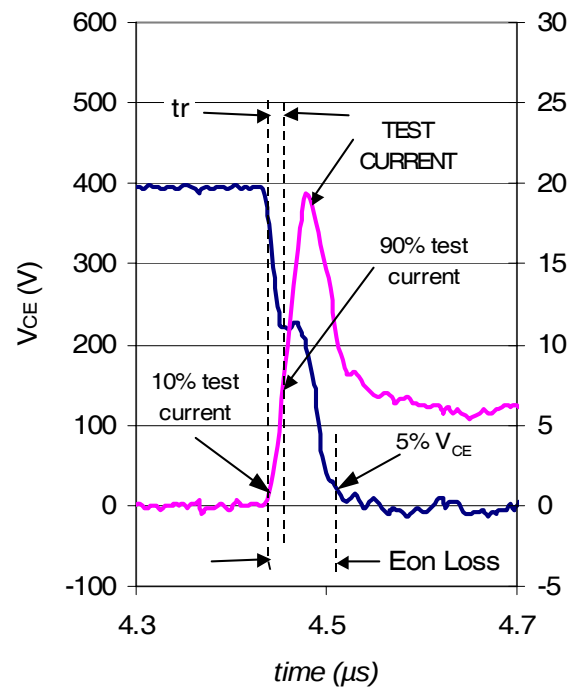
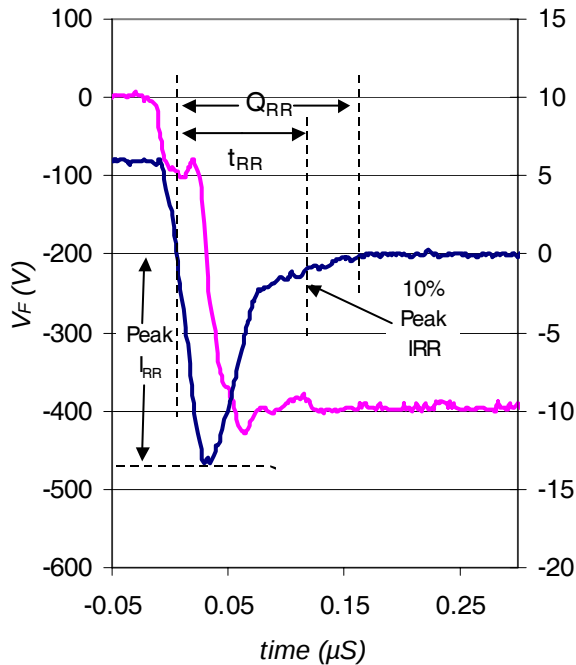
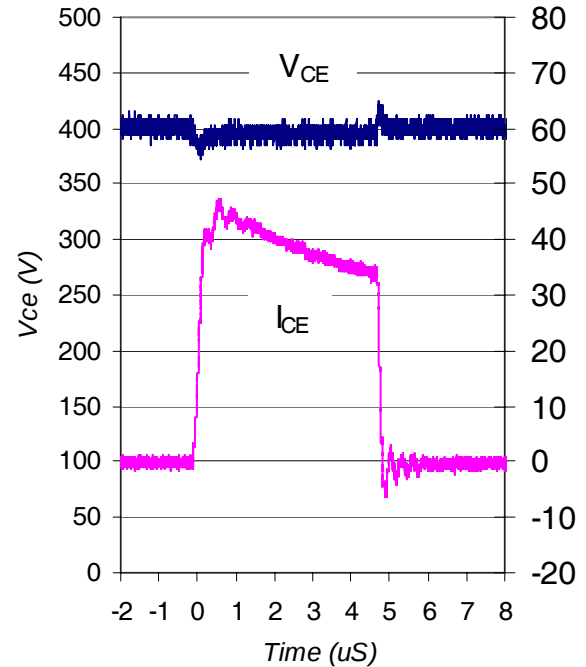


Fig. WF2 - Typ. Turn-on Loss Waveform
@ $T_J = 175^\circ\text{C}$ using Fig. CT.4

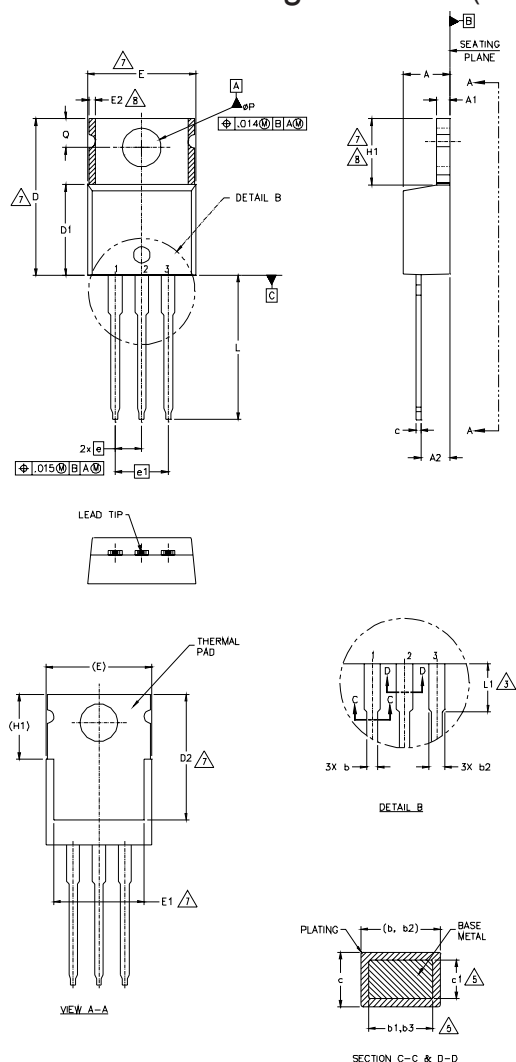


WF.3- Typ. Diode Recovery Waveform
@ $T_J = 175^\circ\text{C}$ using CT.4



WF.4- Typ. Short Circuit Waveform
@ $T_J = 25^\circ\text{C}$ using CT.3

TO-220AB Package Outline (Dimensions are shown in millimeters (inches))



NOTES:

- 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	5	
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		
b2	1.14	1.78	.045	.070	5	
b3	1.14	1.73	.045	.068		
c	0.36	0.61	.014	.024		
c1	0.36	0.56	.014	.022		
D	14.22	16.51	.560	.650		4
D1	8.38	9.02	.330	.355		
D2	11.68	12.88	.460	.507		
E	9.65	10.67	.380	.420		
E1	6.86	8.89	.270	.350	7	
E2	—	0.76	—	.030		
e	2.54 BSC		.100 BSC			8
e1	5.08 BSC		.200 BSC			
H1	5.84	6.86	.230	.270		
L	12.70	14.73	.500	.580	7,8	
L1	—	6.35	—	.250		
øP	3.54	4.08	.139	.161		
Q	2.54	3.42	.100	.135		

LEAD ASSIGNMENTS

HEXFET

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

IGBTs, CoPACK

- 1.- GATE
- 2.- COLLECTOR
- 3.- EMITTER

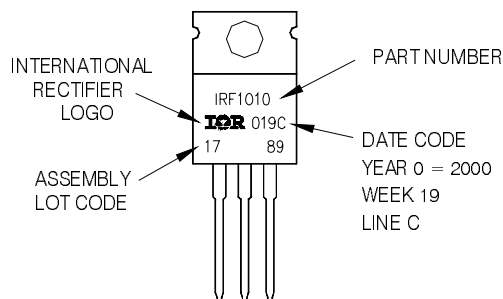
DIODES

- 1.- ANODE/OPEN
- 2.- CATHODE
- 3.- ANODE

TO-220AB Part Marking Information

EXAMPLE: THIS IS AN IRF1010
LOT CODE 1789
ASSEMBLED ON WW 19, 2000
IN THE ASSEMBLY LINE "C"

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



TO-220AB packages are not recommended for Surface Mount Application.

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

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.