

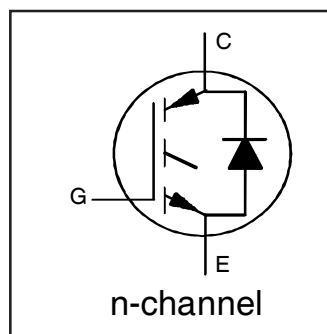
INSULATED GATE BIPOLAR TRANSISTOR WITH ULTRAFAST SOFT RECOVERY DIODE

Features

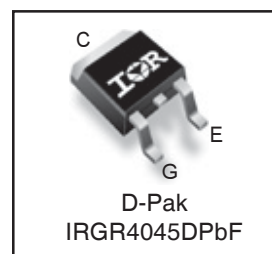
- Low $V_{CE(on)}$ Trench IGBT Technology
- Low Switching Losses
- Maximum Junction temperature 175 °C
- 5μs SCSOA
- Square RBSOA
- 100% of the parts tested for I_{LM} ①
- Positive $V_{CE(on)}$ Temperature Coefficient.
- Ultra Fast Soft Recovery Co-pak Diode
- Tighter Distribution of Parameters
- Lead-Free,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

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



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



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	—	—	1.9	$^\circ C/W$
$R_{\theta JC}$	Junction-to-Case - Diode ③	—	—	6.8	
$R_{\theta JA}$	Junction-to-Ambient (PCB Mount) ⑤	—	—	50	
$R_{\theta JA}$	Junction-to-Ambient	—	—	110	

*Qualification standards can be found at <http://www.irf.com/>

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	CT 6
$\Delta V_{(BR)CES}/\Delta T_J$	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	3.5	—	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. ⑥	Units	Conditions	Ref. Fig
Q_g	Total Gate Charge (turn-on)	—	13	19.5	nC	$I_C = 6.0A$	24 CT 1
Q_{ge}	Gate-to-Emitter Charge (turn-on)	—	3.1	4.65		$V_{CC} = 400V$	
Q_{gc}	Gate-to-Collector Charge (turn-on)	—	6.4	9.6		$V_{GE} = 15V$	
E_{on}	Turn-On Switching Loss	—	56	86	μJ	$I_C = 6.0A, V_{CC} = 400V, V_{GE} = 15V$	CT 4
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	$I_C = 6.0A, V_{CC} = 400V$	CT 4
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	μJ	$I_C = 6.0A, V_{CC} = 400V, V_{GE} = 15V$	13,15 CT 4 WF 1,WF 2
E_{on}	Turn-On Switching Loss	—	140	—		$R_G = 47\Omega, L = 1mH, L_S = 150nH, T_J = 175^\circ\text{C}$	
E_{off}	Turn-Off Switching Loss	—	189	—		Energy losses include tail and diode reverse recovery	
E_{total}	Total Switching Loss	—	329	—	ns	$I_C = 6.0A, V_{CC} = 400V$	14,16 CT 4 WF 1,WF 2
$t_{d(on)}$	Turn-On delay time	—	26	—		$R_G = 47\Omega, L = 1mH, L_S = 150nH$	
t_r	Rise time	—	12	—		$T_J = 175^\circ\text{C}$	
$t_{d(off)}$	Turn-Off delay time	—	95	—	pF	$V_{GE} = 0V$	23
t_f	Fall time	—	32	—		$V_{CC} = 30V$	
C_{ies}	Input Capacitance	—	350	—		$f = 1Mhz$	
C_{oes}	Output Capacitance	—	29	—	pF	$T_J = 175^\circ\text{C}, I_C = 24A$	4 CT 2
C_{res}	Reverse Transfer Capacitance	—	10	—		$V_{CC} = 500V, V_p = 600V$	
						$R_G = 100\Omega, V_{GE} = +20V \text{ to } 0V$	
RBSOA	Reverse Bias Safe Operating Area	FULL SQUARE				$V_{CC} = 400V, V_p = 600V$	22 CT 3, WF 4
SCSOA	Short Circuit Safe Operating Area	—	5	—	μs	$R_G = 100\Omega, V_{GE} = +15V \text{ to } 0V$	
E_{rec}	Reverse recovery energy of the diode	—	178	—	μJ	$T_J = 175^\circ\text{C}$	17,18,19 20,21
t_{rr}	Diode Reverse recovery time	—	74	—	ns	$V_{CC} = 400V, I_F = 6.0A$	
I_{rr}	Peak Reverse Recovery Current	—	12	—	A	$V_{GE} = 15V, R_G = 47\Omega, L = 1mH, L_S = 150nH$	WF 3

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.
- ⑤ When mounted on 1" square PCB (FR-4 or G-10 Material). For recommended footprint and soldering techniques refer to application note #AN-994.
- ⑥ Maximum limits are based on statistical sample size characterization.

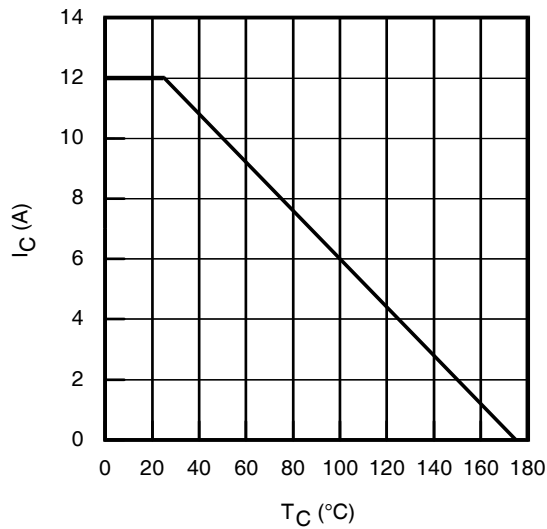


Fig. 1 - Maximum DC Collector Current vs. Case Temperature

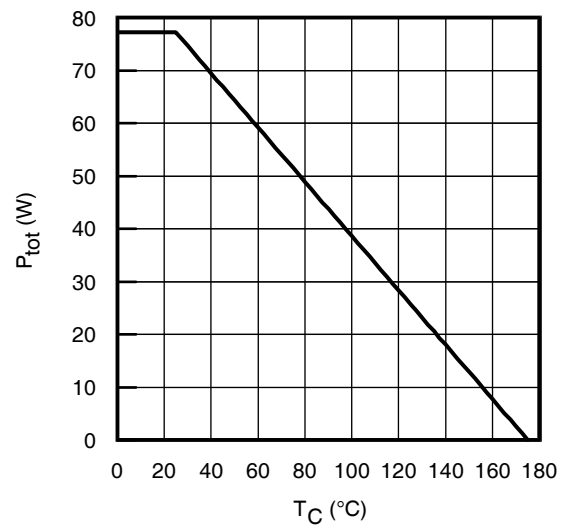


Fig. 2 - Power Dissipation vs. Case Temperature

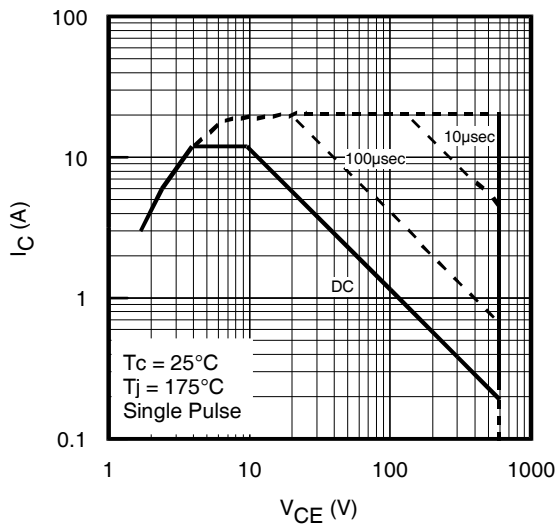


Fig. 3 - Forward SOA,
 $T_C = 25^\circ\text{C}$, $T_J \leq 175^\circ\text{C}$, $V_{GE} = 15\text{V}$

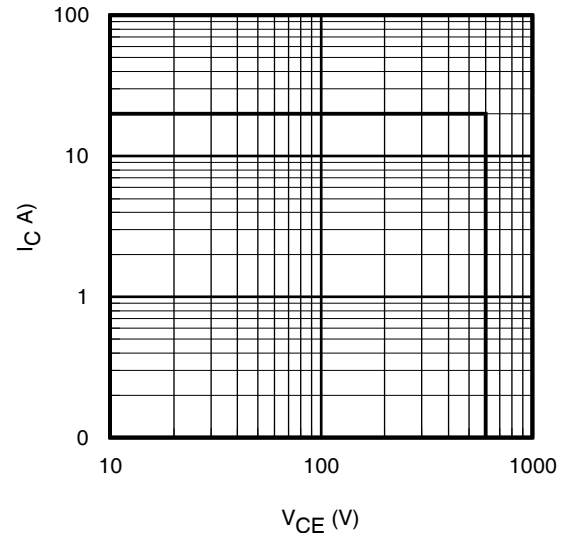


Fig. 4 - Reverse Bias SOA
 $T_J = 175^\circ\text{C}$, $V_{GE} = 20\text{V}$

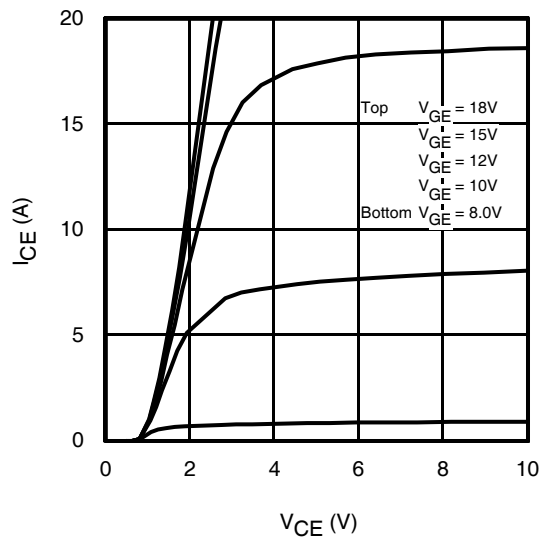


Fig. 5 - Typ. IGBT Output Characteristics
 $T_J = -40^\circ\text{C}$; $t_p = 80\mu\text{s}$

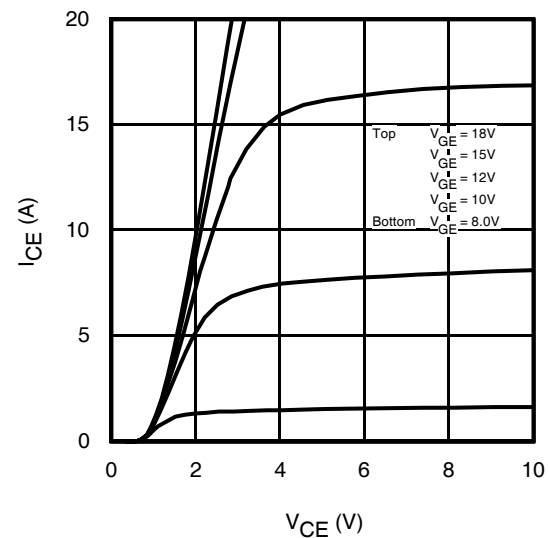


Fig. 6 - Typ. IGBT Output Characteristics
 $T_J = 25^\circ\text{C}$; $t_p = 80\mu\text{s}$

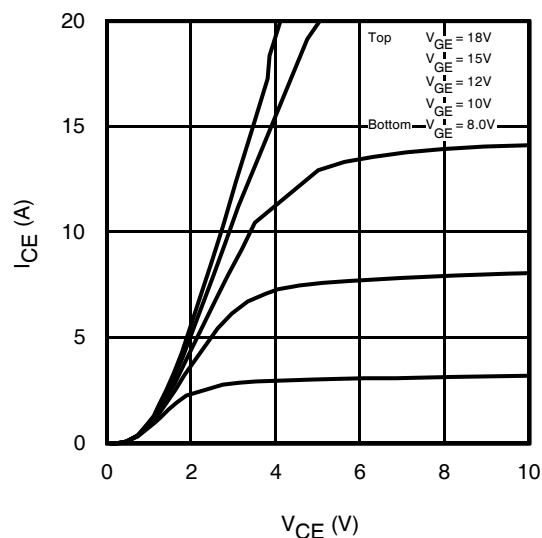


Fig. 7 - Typ. IGBT Output Characteristics
 $T_J = 175^\circ\text{C}$; $t_p = 80\mu\text{s}$

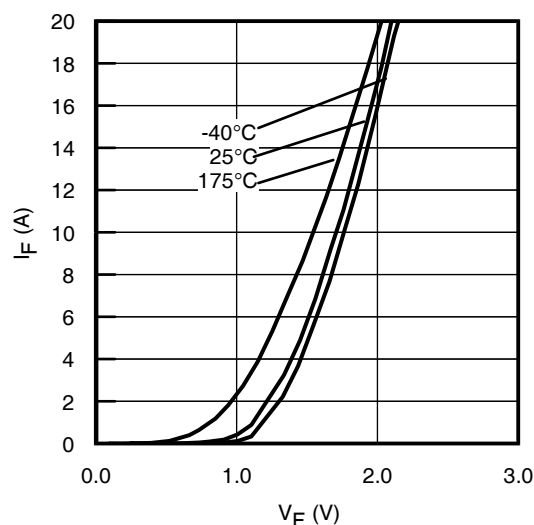


Fig. 8 - Typ. Diode Forward Characteristics
 $t_p = 80\mu\text{s}$

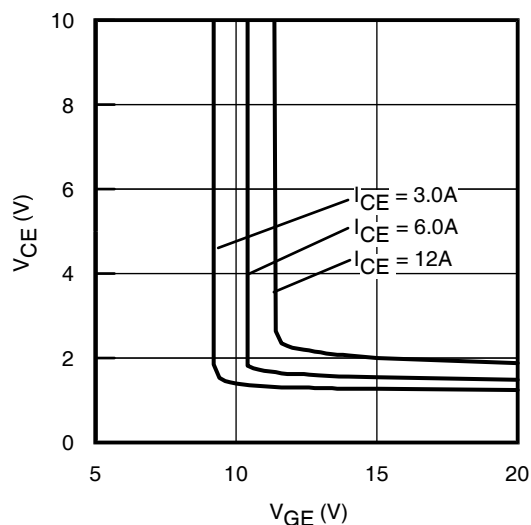


Fig. 9 - Typical V_{CE} vs. V_{GE}
 $T_J = -40^\circ\text{C}$

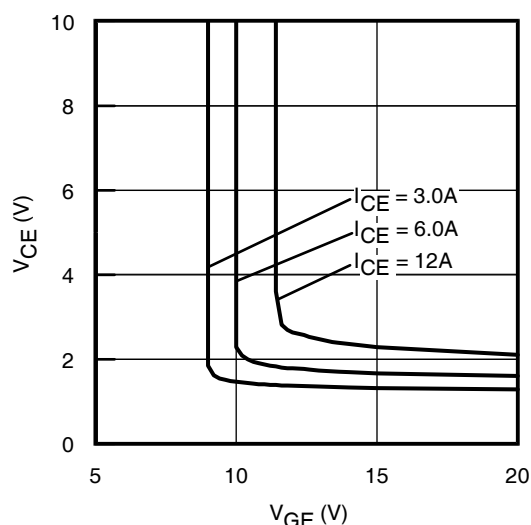


Fig. 10 - Typical V_{CE} vs. V_{GE}
 $T_J = 25^\circ\text{C}$

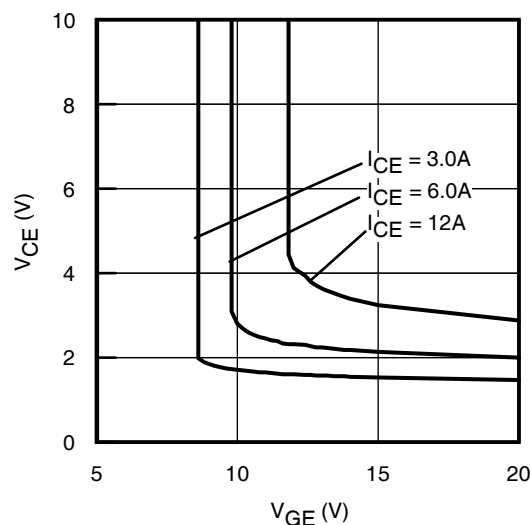


Fig. 11 - Typical V_{CE} vs. V_{GE}
 $T_J = 175^\circ\text{C}$

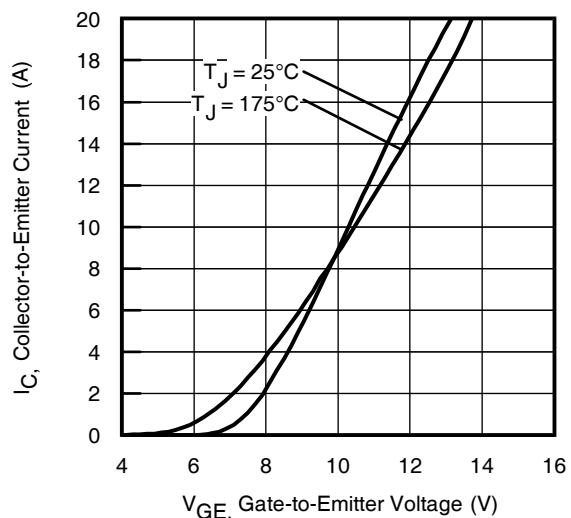


Fig. 12 - Typ. Transfer Characteristics
 $V_{CE} = 50\text{V}$; $t_p = 10\mu\text{s}$

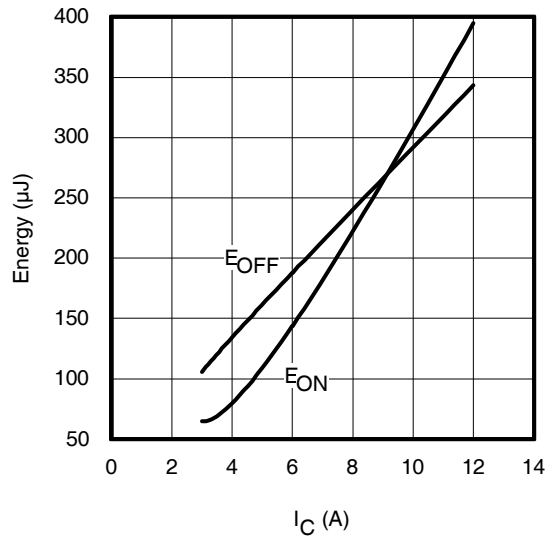


Fig. 13 - Typ. Energy Loss vs. I_C
 $T_J = 175^\circ\text{C}$; $L = 1\text{mH}$; $V_{CE} = 400\text{V}$; $R_G = 47\Omega$; $V_{GE} = 15\text{V}$.

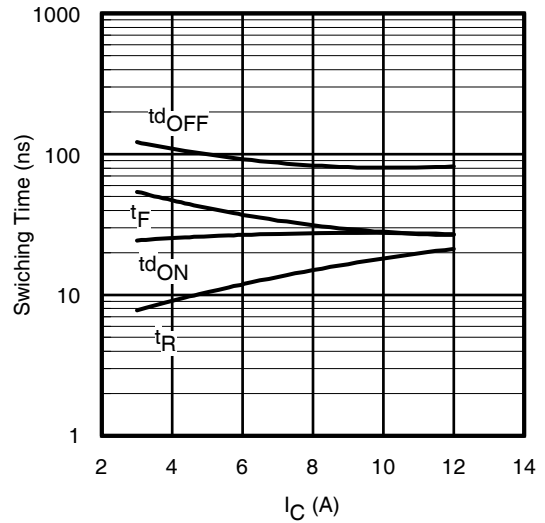


Fig. 14 - Typ. Switching Time vs. I_C
 $T_J = 175^\circ\text{C}$; $L = 1\text{mH}$; $V_{CE} = 400\text{V}$
 $R_G = 47\Omega$; $V_{GE} = 15\text{V}$

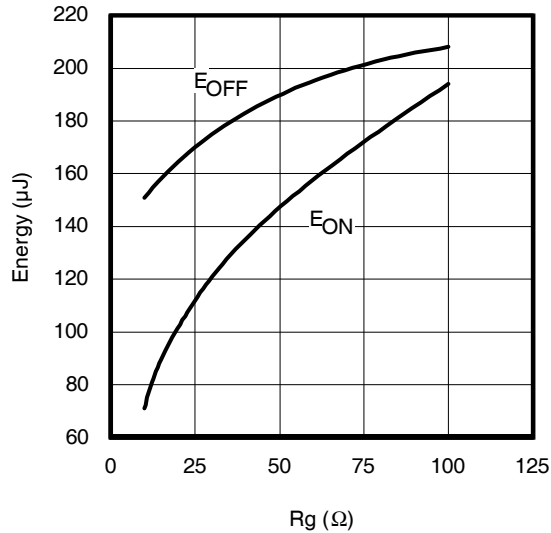


Fig. 15 - Typ. Energy Loss vs. R_G
 $T_J = 175^\circ\text{C}$; $L = 1\text{mH}$; $V_{CE} = 400\text{V}$; $I_{CE} = 6.0\text{A}$; $V_{GE} = 15\text{V}$

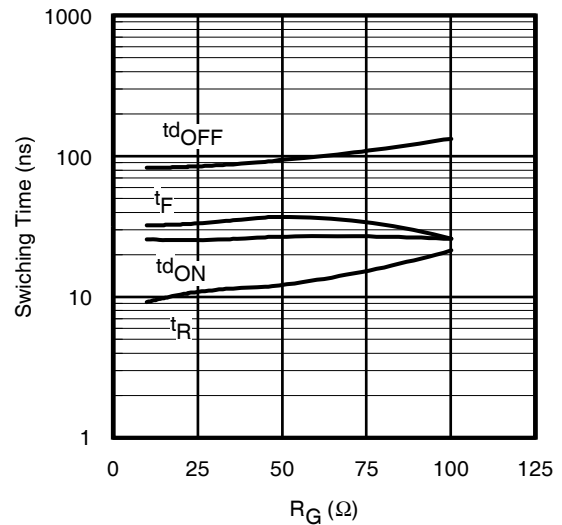


Fig. 16 - Typ. Switching Time vs. R_G
 $T_J = 175^\circ\text{C}$; $L = 1\text{mH}$; $V_{CE} = 400\text{V}$
 $I_{CE} = 6.0\text{A}$; $V_{GE} = 15\text{V}$

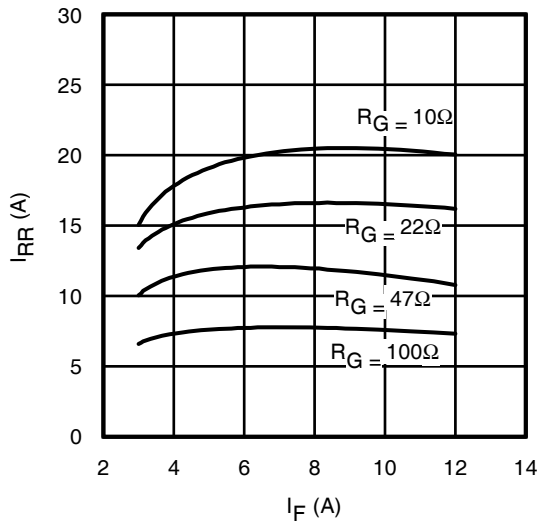


Fig. 17 - Typical Diode I_{RR} vs. I_F
 $T_J = 175^\circ\text{C}$

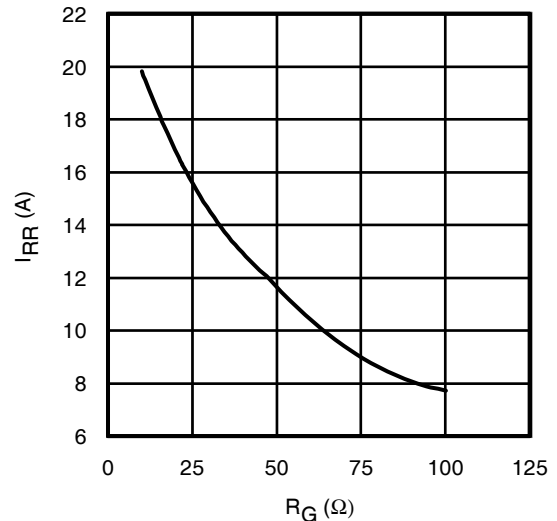


Fig. 18 - Typical Diode I_{RR} vs. R_G
 $T_J = 175^\circ\text{C}$; $I_F = 6.0\text{A}$

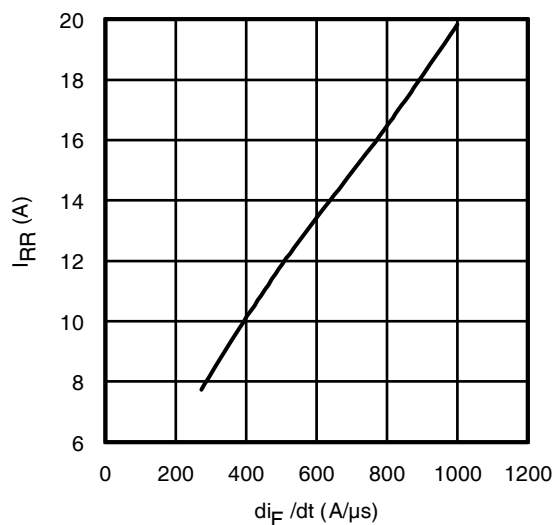


Fig. 19 - Typical Diode I_{RR} vs. di_F/dt
 $V_{CC} = 400V$; $V_{GE} = 15V$;
 $I_{CE} = 6.0A$; $T_J = 175^\circ C$

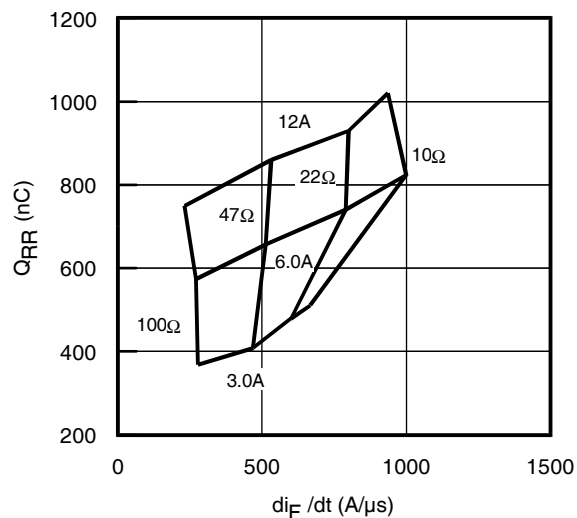


Fig. 20 - Typical Diode Q_{RR}
 $V_{CC} = 400V$; $V_{GE} = 15V$; $T_J = 175^\circ C$

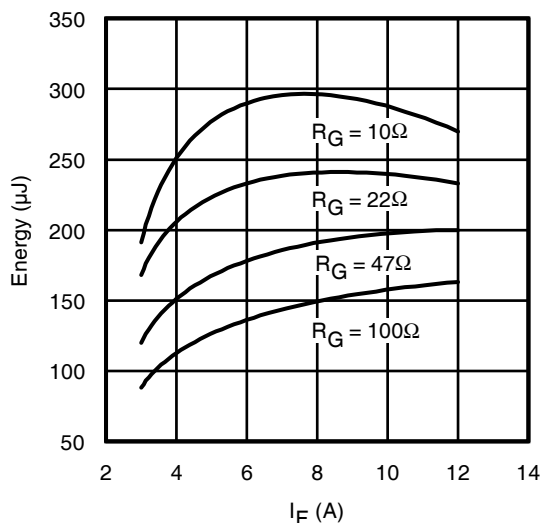


Fig. 21 - Typical Diode E_{RR} vs. I_F
 $T_J = 175^\circ C$

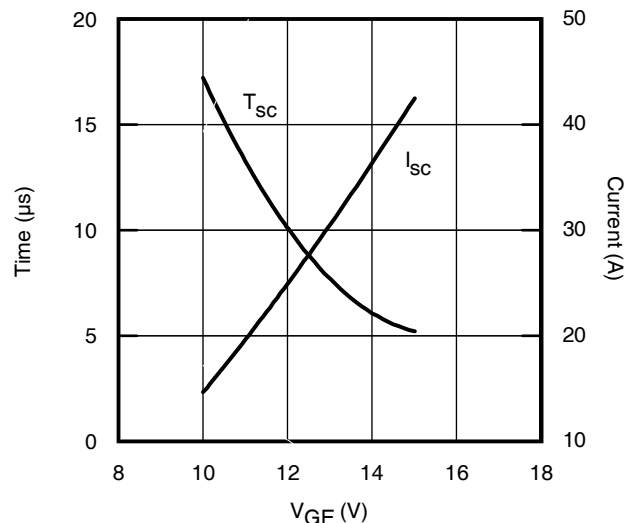


Fig. 22 - Typ. V_{GE} vs. Short Circuit Time
 $V_{CC} = 400V$, $T_C = 25^\circ C$

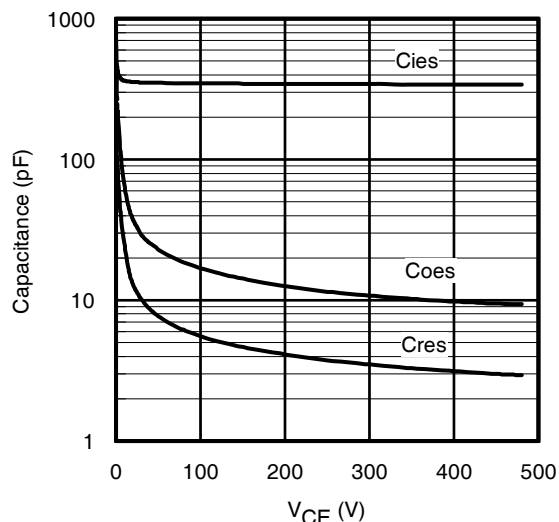


Fig. 23 - Typ. Capacitance vs. V_{CE}
 $V_{GE} = 0V$; $f = 1MHz$

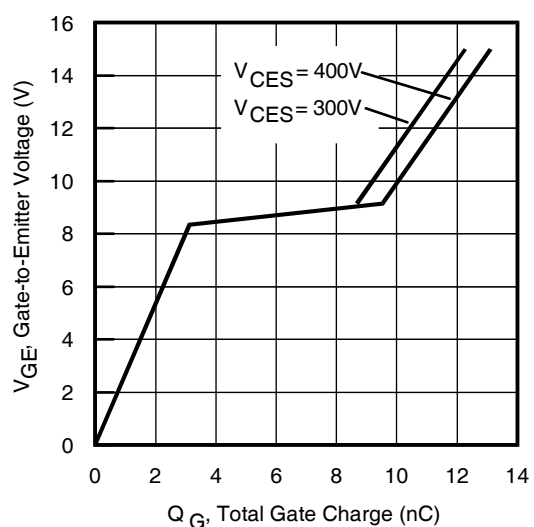


Fig. 24 - Typical Gate Charge vs. V_{GE}
 $I_{CE} = 6.0A$, $L = 600\mu H$

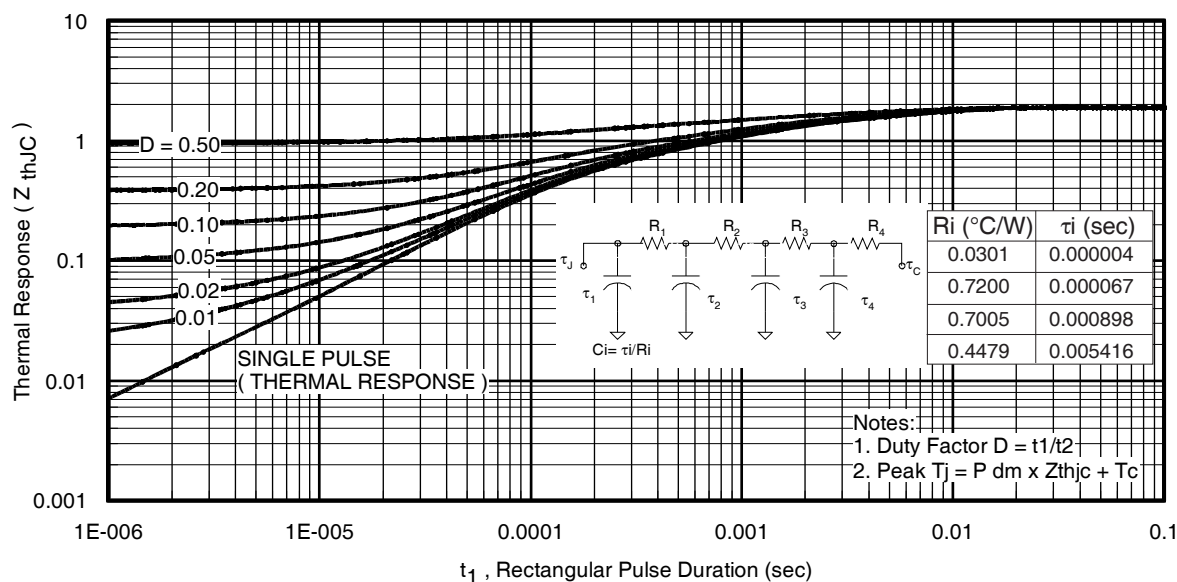


Fig 25. Maximum Transient Thermal Impedance, Junction-to-Case (IGBT)

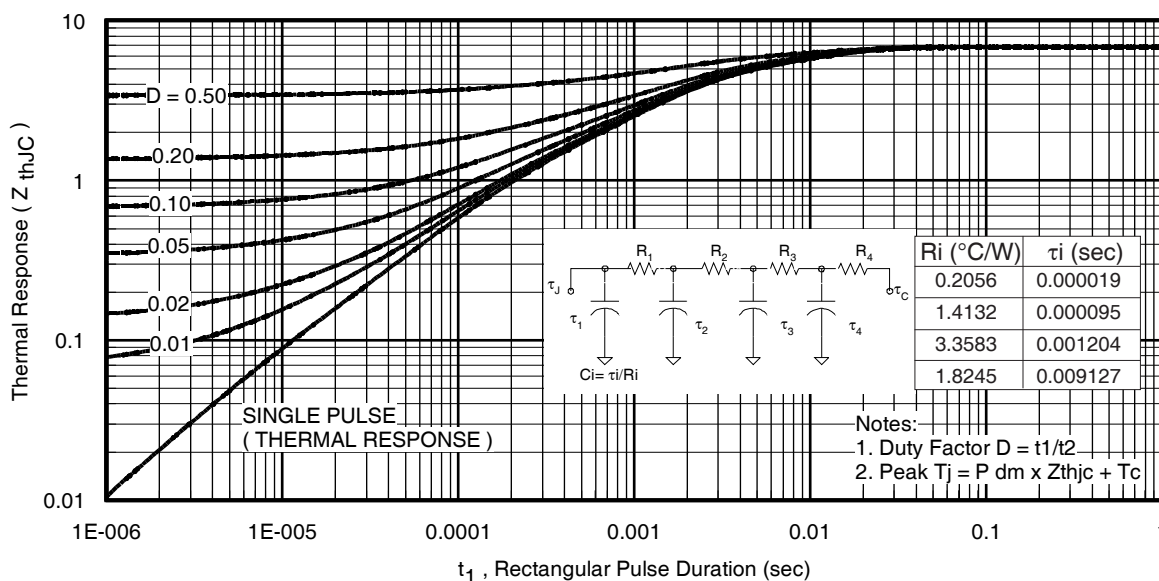


Fig. 26. Maximum Transient Thermal Impedance, Junction-to-Case (DIODE)

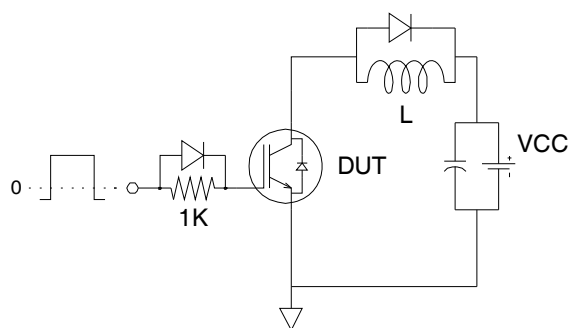


Fig.C.T.1 - Gate Charge Circuit (turn-off)

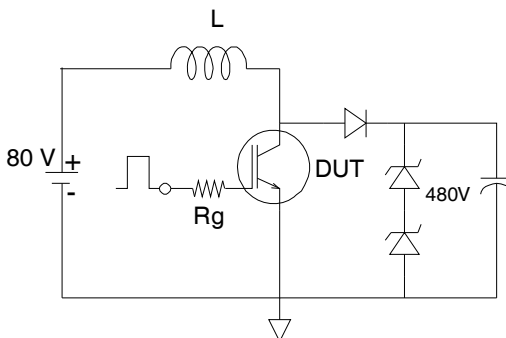


Fig.C.T.2 - RBSOA Circuit

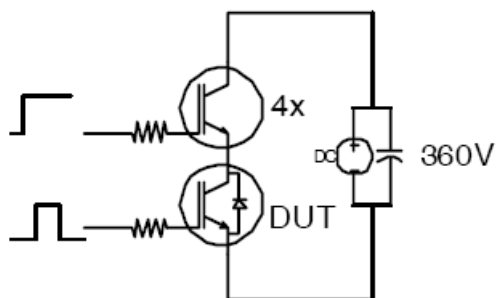


Fig.C.T.3 - S.C.SOA Circuit

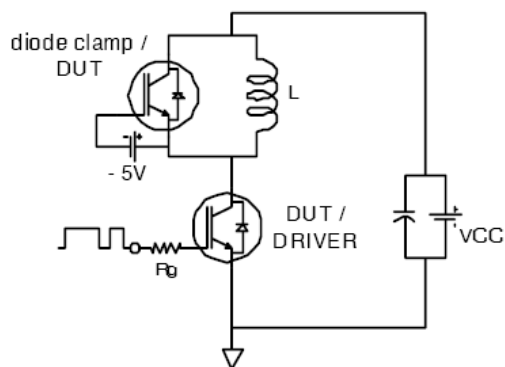


Fig.C.T.4 - Switching Loss Circuit

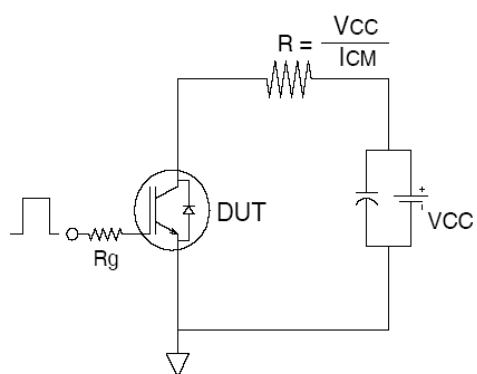


Fig.C.T.5 - Resistive Load Circuit

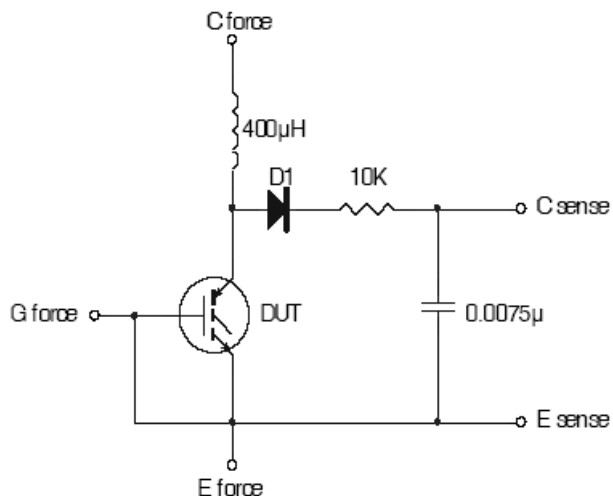


Fig.C.T.6 - Typical Filter Circuit for $V_{(BR)CES}$ Measurement

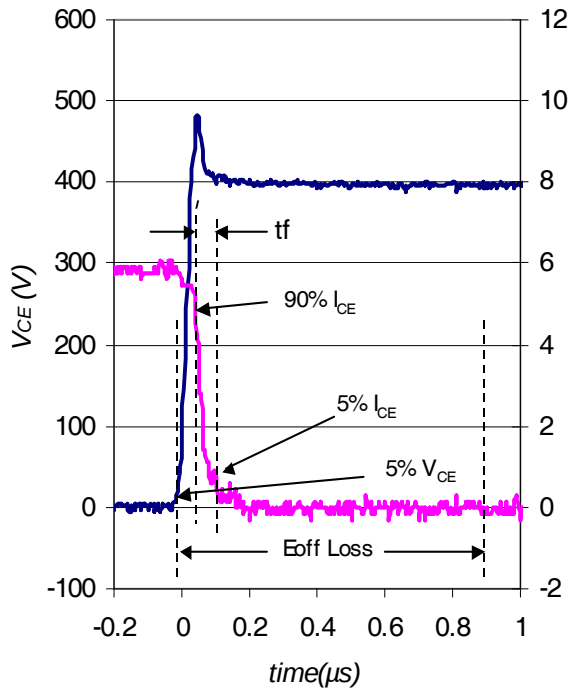


Fig. WF1 - Typ. Turn-off Loss Waveform
@ $T_J = 175^\circ\text{C}$ using Fig. CT.4

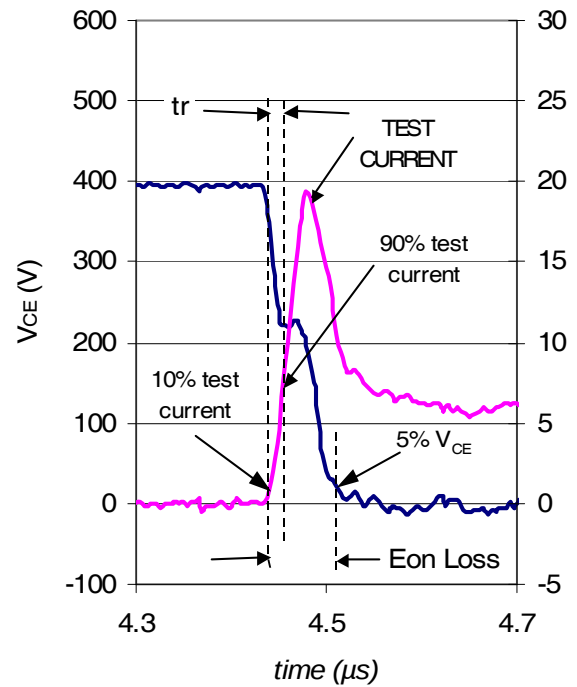
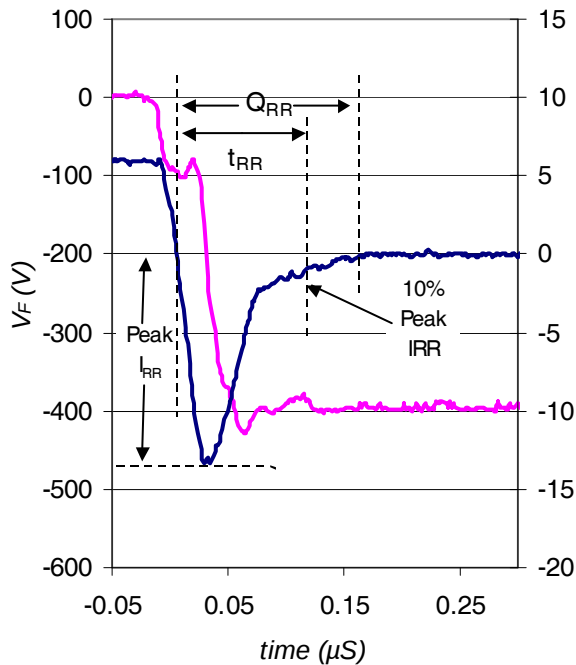
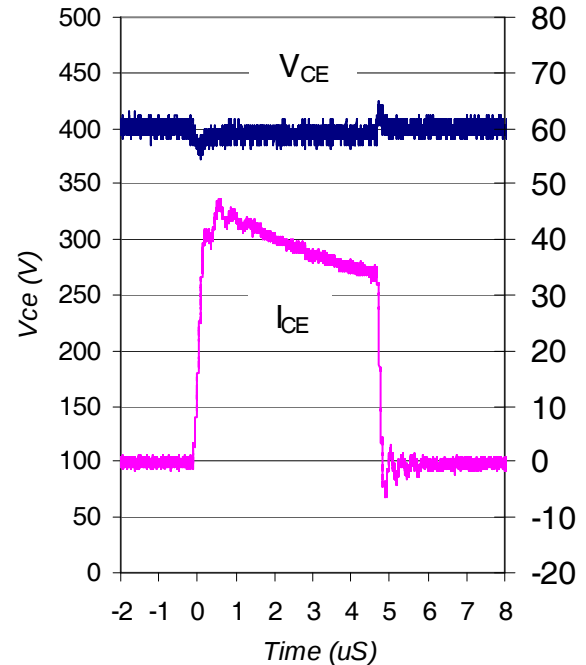


Fig. WF2 - Typ. Turn-on Loss Waveform
@ $T_J = 175^\circ\text{C}$ using Fig. CT.4



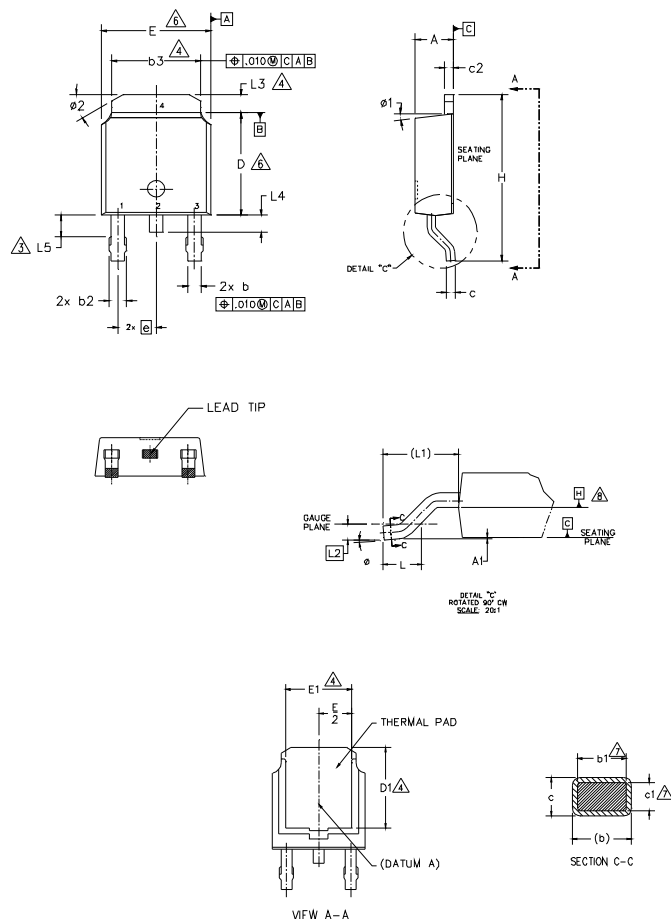
WF.3- Typ. Diode Recovery Waveform
@ $T_J = 175^\circ\text{C}$ using CT.4



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

D-Pak (TO-252AA) Package Outline

Dimensions are shown in millimeters (inches)



NOTES:

- 1.- DIMENSIONING AND TOLERANCING PER ASME Y14.5M-1994
- 2.- DIMENSIONS ARE SHOWN IN INCHES [MILLIMETERS]
- 3.- LEAD DIMENSION UNCONTROLLED IN L5.
- 4.- DIMENSION D1, E1, L3 & b3 ESTABLISH A MINIMUM MOUNTING SURFACE FOR THERMAL PAD.
- 5.- SECTION C-C DIMENSIONS APPLY TO THE FLAT SECTION OF THE LEAD BETWEEN .005 AND 0.10 [0.13 AND 0.25] FROM THE LEAD TIP.
- 6.- DIMENSION D & E DO NOT INCLUDE MOLD FLASH. MOLD FLASH SHALL NOT EXCEED .005 [0.13] PER SIDE. THESE DIMENSIONS ARE MEASURED AT THE OUTMOST EXTREMES OF THE PLASTIC BODY.
- 7.- DIMENSION b1 & c1 APPLIED TO BASE METAL ONLY.
- 8.- DATUM A & B TO BE DETERMINED AT DATUM PLANE H.
- 9.- OUTLINE CONFORMS TO JEDEC OUTLINE TO-252AA.

SYMBOL	DIMENSIONS				NOTES
	MILLIMETERS		INCHES		
	MIN.	MAX.	MIN.	MAX.	
A	2.18	2.39	.086	.094	
A1	—	0.13	—	.005	
b	0.64	0.89	.025	.035	
b1	0.65	0.79	.025	.031	7
b2	0.76	1.14	.030	.045	
b3	4.95	5.46	.195	.215	4
c	0.46	0.61	.018	.024	
c1	0.41	0.56	.016	.022	7
c2	0.46	0.89	.018	.035	
D	5.97	6.22	.235	.245	6
D1	5.21	—	.205	—	4
E	6.35	6.73	.250	.265	6
E1	4.32	—	.170	—	4
e	2.29 BSC		.090 BSC		
H	9.40	10.41	.370	.410	
L	1.40	1.78	.055	.070	
L1	2.74 BSC		.108 REF.		
L2	0.51 BSC		.020 BSC		
L3	0.89	1.27	.035	.050	4
L4	—	1.02	—	.040	
L5	1.14	1.52	.045	.060	3
ø	0"	10"	0"	10"	
ø1	0"	15"	0"	15"	
ø2	25"	35"	25"	35"	

LEAD ASSIGNMENTS

HEXFET

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

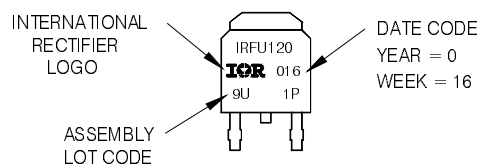
IGBT & CoPAK

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

D-Pak (TO-252AA) Part Marking Information

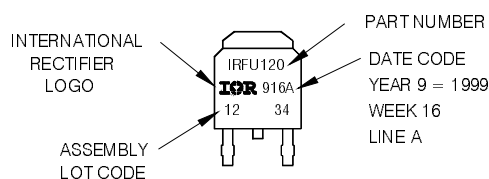
Notes: This part marking information applies to devices produced before 02/26/2001

EXAMPLE: THIS IS AN IRFR120
WITH ASSEMBLY
LOT CODE 9U1P



Notes: This part marking information applies to devices produced after 02/26/2001

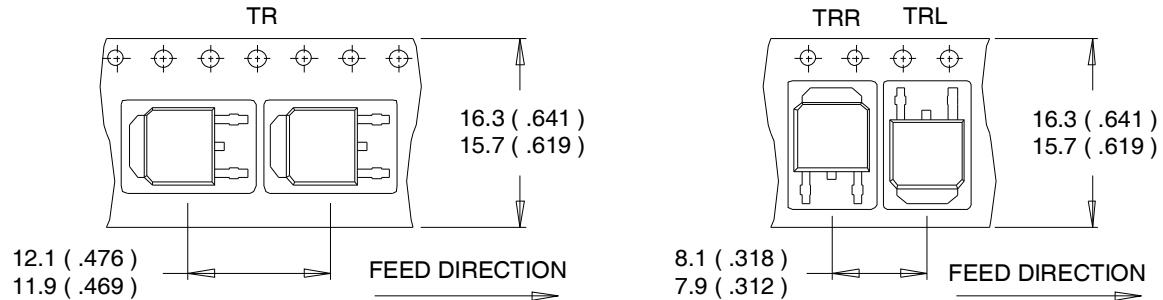
EXAMPLE: THIS IS AN IRFR120
WITH ASSEMBLY
LOT CODE 1234
ASSEMBLED ON WW 16, 1999
IN THE ASSEMBLY LINE 'A'



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

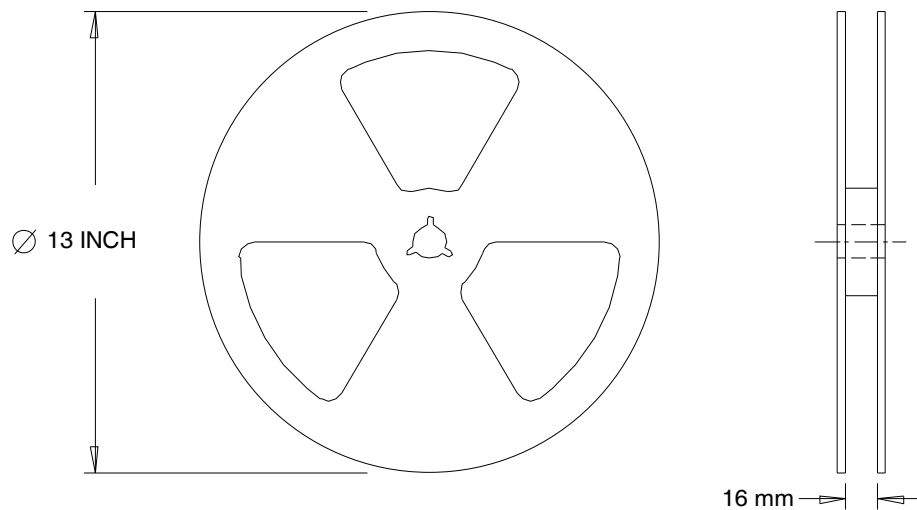
D-Pak (TO-252AA) Tape & Reel Information

Dimensions are shown in millimeters (inches)



NOTES :

1. CONTROLLING DIMENSION : MILLIMETER.
2. ALL DIMENSIONS ARE SHOWN IN MILLIMETERS (INCHES).
3. OUTLINE CONFORMS TO EIA-481 & EIA-541.



NOTES :

1. OUTLINE CONFORMS TO EIA-481.

Data and specifications subject to change without notice.
This product has been designed and qualified for the Industrial market.
Qualification Standards can be found on IR's Web site.

International
IR Rectifier

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