

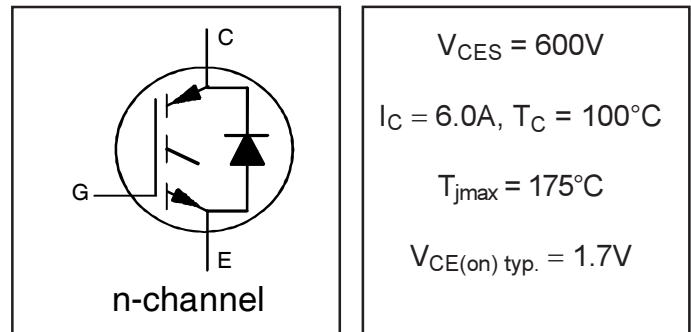
INSULATED GATE BIPOLAR TRANSISTOR WITH ULTRAFAST SOFT RECOVERY DIODE

Features

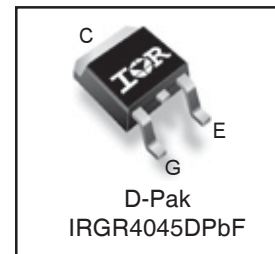
- Low $V_{CE(on)}$ Trench IGBT Technology
- Low Switching Losses
- Maximum Junction temperature 175 °C
- 5µs SCSOA
- Square RBSOA
- 100% of the parts tested for I_{LM} ①
- Positive $V_{CE(on)}$ Temperature Coefficient.
- Ultra Fast Soft Recovery Co-pak Diode
- Tighter Distribution of Parameters
- Lead-Free, 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
$I_C @ T_C = 25^\circ C$	Continuous Collector Current	12	A
$I_C @ T_C = 100^\circ C$	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	
$I_F @ T_C = 25^\circ C$	Diode Continuous Forward Current	8.0	
$I_F @ T_C = 100^\circ C$	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	
$P_D @ T_C = 25^\circ$	Maximum Power Dissipation	77	W
		$P_D @ T_C = 100^\circ$	
T_J T_{STG}	Operating Junction and Storage Temperature Range	-55 to + 175	$^\circ C$
	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°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 μA ④	CT 6
ΔV _{(BR)CES} /ΔT _J	Temperature Coeff. of Breakdown Voltage	—	0.36	—	V/°C	V _{GE} = 0V, I _C = 250 μA (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°C	5,6,7,9, 10,11
		—	2.07	—		I _C = 6.0A, V _{GE} = 15V, T _J = 150°C	
		—	2.14	—		I _C = 6.0A, V _{GE} = 15V, T _J = 175°C	
V _{GE(th)}	Gate Threshold Voltage	3.5	—	6.5	V	V _{CE} = V _{GE} , I _C = 150 μA	9,10,11,12
ΔV _{GE(th)} /ΔT _J	Threshold Voltage temp. coefficient	—	-13	—	mV/°C	V _{CE} = V _{GE} , I _C = 250 μA (25 - 175 °C)	
g _{fe}	Forward Transconductance	—	5.8	—	S	V _{CE} = 25V, I _C = 6.0A, PW = 80 μs	
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°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°C	
I _{GES}	Gate-to-Emitter Leakage Current	—	—	±100	nA	V _{GE} = ± 20 V	

Switching Characteristics @ T_J = 25°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
Q _{ge}	Gate-to-Emitter Charge (turn-on)	—	3.1	4.65		V _{CC} = 400V	CT 1
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 = 47Ω, L=1mH, L _S = 150nH, T _J = 25°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 = 47Ω, L=1mH, L _S = 150nH	
t _{d(off)}	Turn-Off delay time	—	75	93		T _J = 25°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 = 47Ω, L=1mH, L _S = 150nH, T _J = 175°C	CT 4
E _{total}	Total Switching Loss	—	329	—		Energy losses include tail and diode reverse recovery	WF 1,WF 2
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 = 47Ω, L=1mH, L _S = 150nH	CT 4
t _{d(off)}	Turn-Off delay time	—	95	—		T _J = 175°C	WF 1,WF 2
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°C, I _C = 24A V _{CC} = 500V, V _p = 600V R _G = 100Ω, V _{GE} = +20V to 0V	4 CT 2
SCSOA	Short Circuit Safe Operating Area	—	5	—	μs	V _{CC} = 400V, V _p = 600V R _G = 100Ω, V _{GE} = +15V to 0V	22 CT 3, WF 4
E _{rec}	Reverse recovery energy of the diode	—	178	—	μJ	T _J = 175°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 = 47Ω, L=1mH, L _S =150nH	WF 3

Notes:

- ① V_{CC} = 80% (V_{CES}), V_{GE} = 15V, L = 1.0mH, R_G = 47Ω.
- 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.

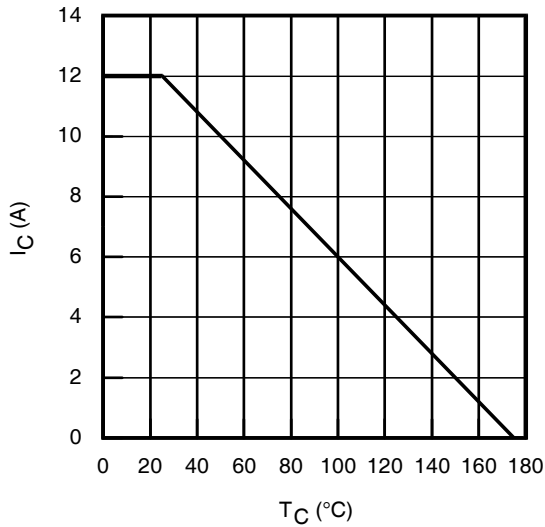


Fig. 1 - Maximum DC Collector Current vs. Case Temperature

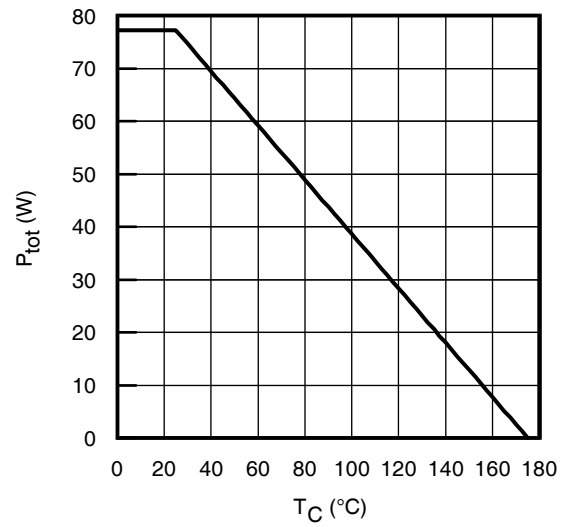


Fig. 2 - Power Dissipation vs. Case Temperature

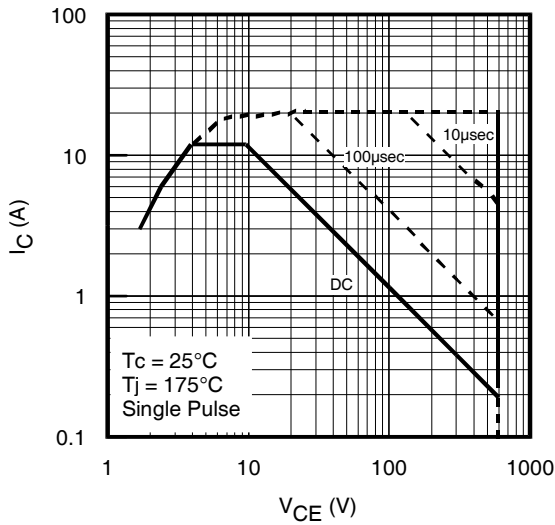


Fig. 3 - Forward SOA,
 $T_C = 25^\circ\text{C}$, $T_J \leq 175^\circ\text{C}$, $V_{GE} = 15\text{V}$

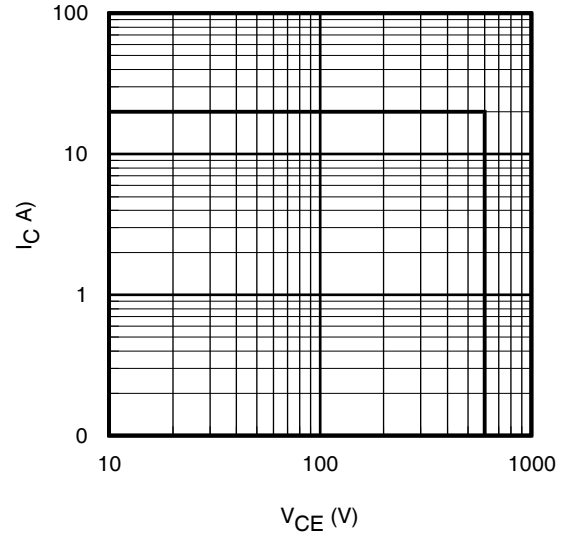


Fig. 4 - Reverse Bias SOA
 $T_J = 175^\circ\text{C}$, $V_{GE} = 20\text{V}$

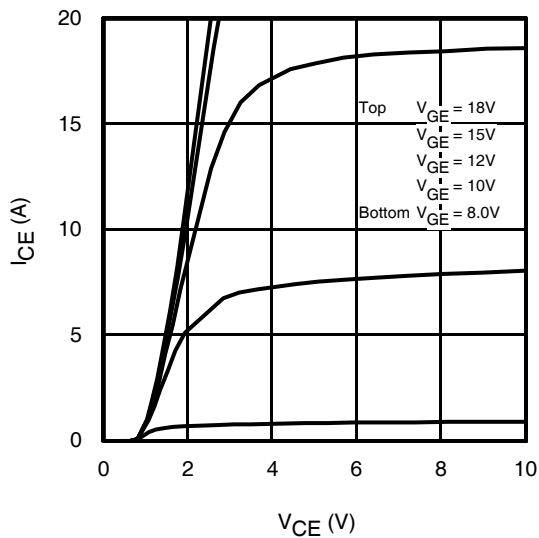


Fig. 5 - Typ. IGBT Output Characteristics
 $T_J = -40^\circ\text{C}$; $t_p = 80\mu\text{s}$

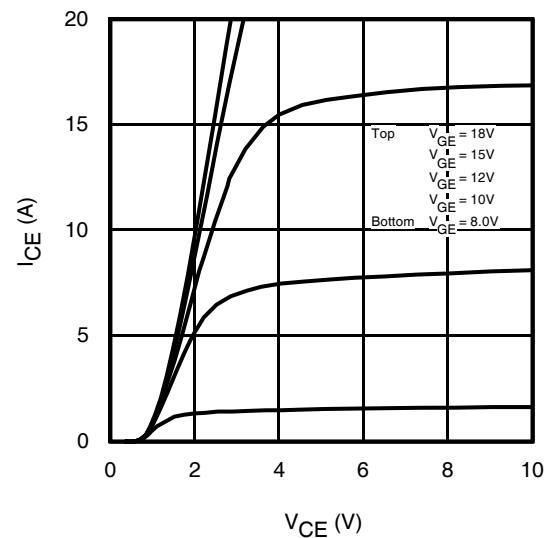


Fig. 6 - Typ. IGBT Output Characteristics
 $T_J = 25^\circ\text{C}$; $t_p = 80\mu\text{s}$

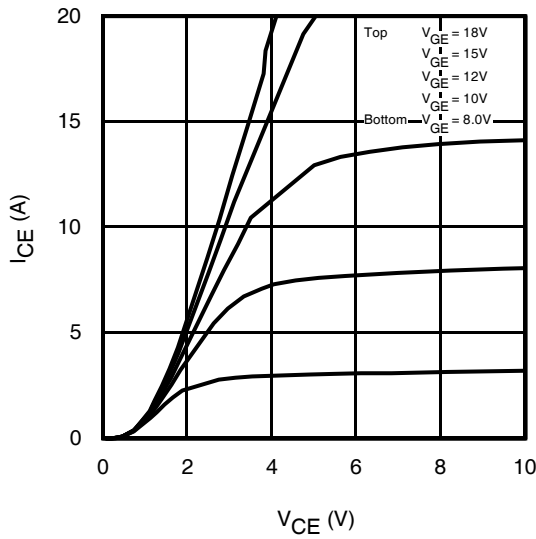


Fig. 7 - Typ. IGBT Output Characteristics
 $T_J = 175^\circ\text{C}$; $t_p = 80\mu\text{s}$

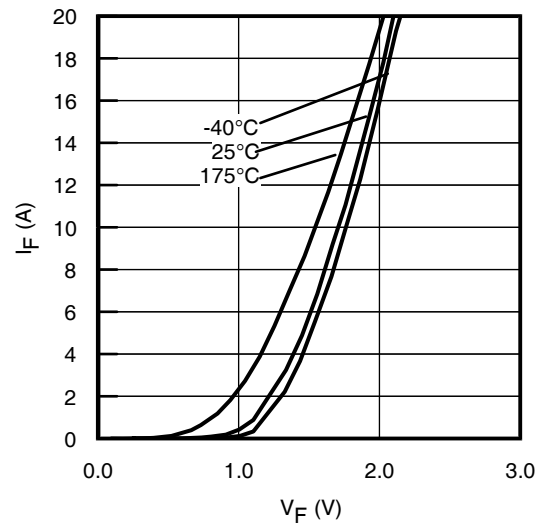


Fig. 8 - Typ. Diode Forward Characteristics
 $t_p = 80\mu\text{s}$

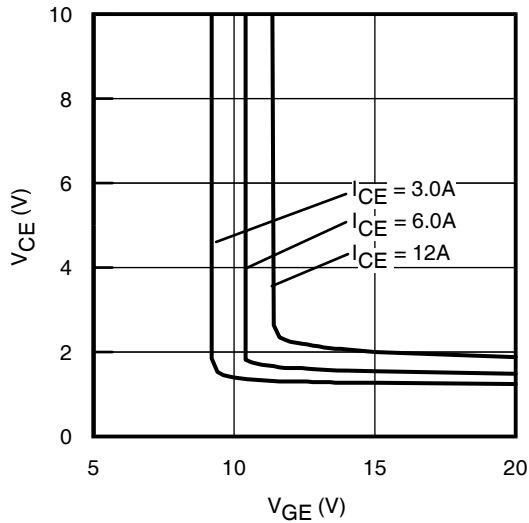


Fig. 9 - Typical V_{CE} vs. V_{GE}
 $T_J = -40^\circ\text{C}$

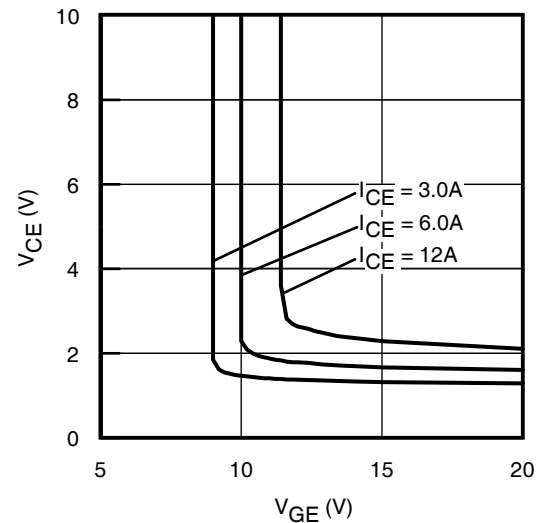


Fig. 10 - Typical V_{CE} vs. V_{GE}
 $T_J = 25^\circ\text{C}$

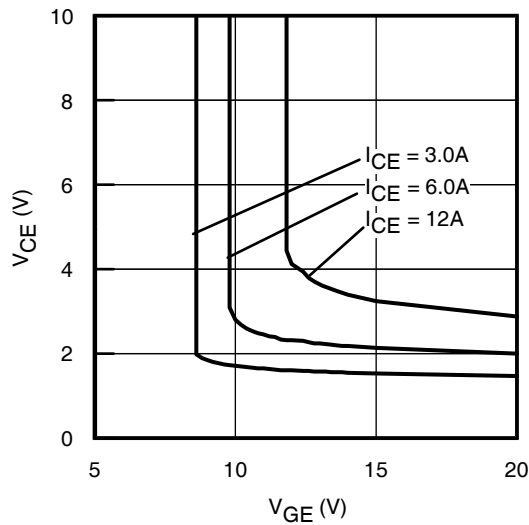


Fig. 11 - Typical V_{CE} vs. V_{GE}
 $T_J = 175^\circ\text{C}$

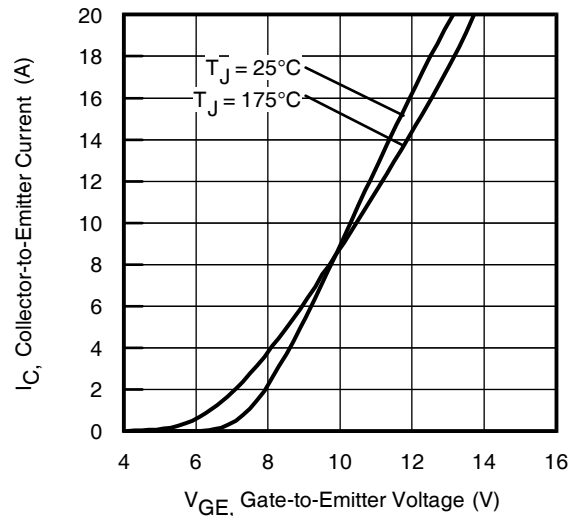


Fig. 12 - Typ. Transfer Characteristics
 $V_{CE} = 50\text{V}$; $t_p = 10\mu\text{s}$

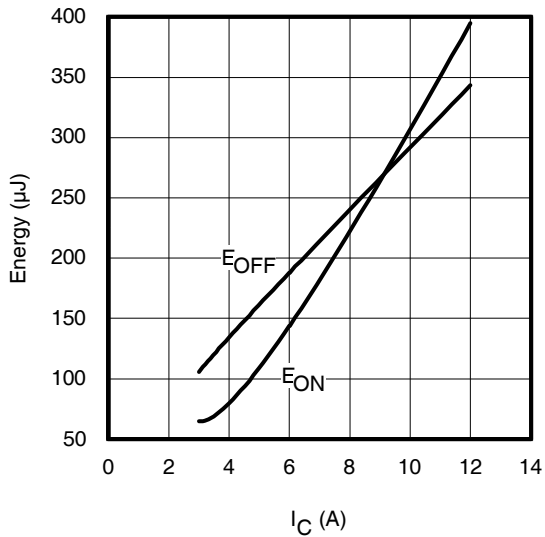


Fig. 13 - Typ. Energy Loss vs. I_C

$T_J = 175^\circ\text{C}$; $L = 1\text{mH}$; $V_{CE} = 400\text{V}$; $R_G = 47\Omega$; $V_{GE} = 15\text{V}$.

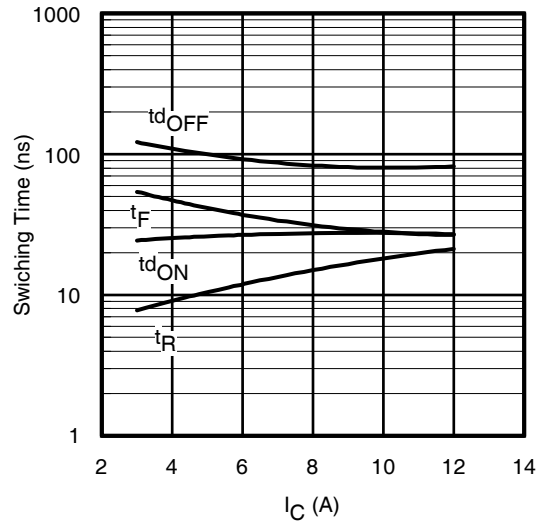


Fig. 14 - Typ. Switching Time vs. I_C

$T_J = 175^\circ\text{C}$; $L = 1\text{mH}$; $V_{CE} = 400\text{V}$
 $R_G = 47\Omega$; $V_{GE} = 15\text{V}$

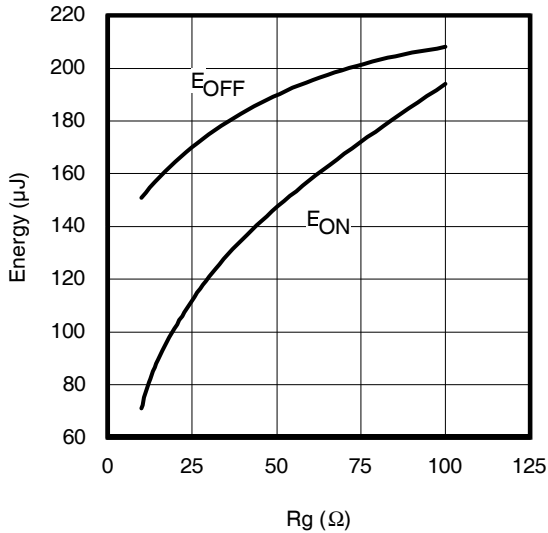


Fig. 15 - Typ. Energy Loss vs. R_G

$T_J = 175^\circ\text{C}$; $L = 1\text{mH}$; $V_{CE} = 400\text{V}$; $I_{CE} = 6.0\text{A}$; $V_{GE} = 15\text{V}$

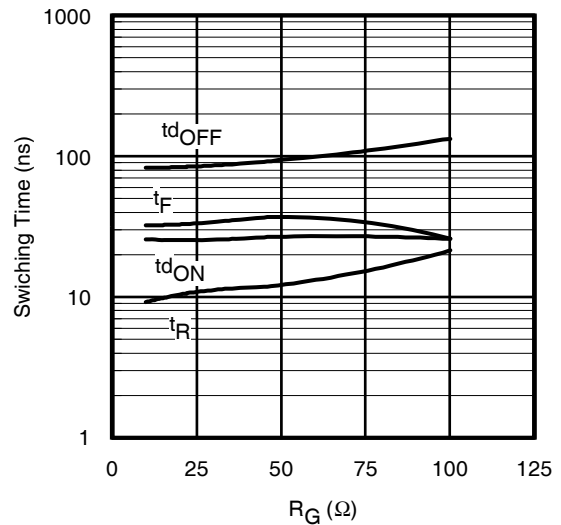


Fig. 16 - Typ. Switching Time vs. R_G

$T_J = 175^\circ\text{C}$; $L = 1\text{mH}$; $V_{CE} = 400\text{V}$
 $I_{CE} = 6.0\text{A}$; $V_{GE} = 15\text{V}$

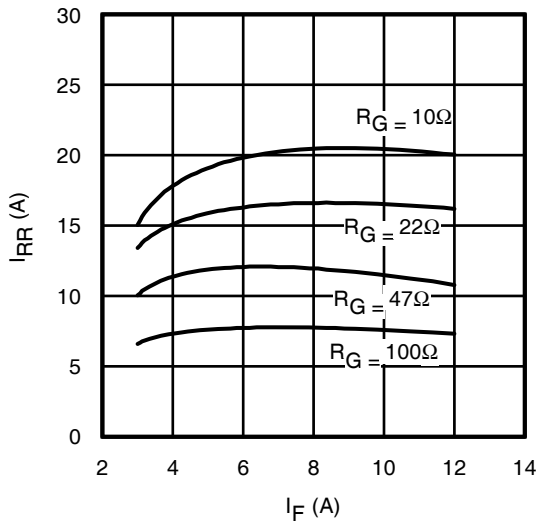


Fig. 17 - Typical Diode I_{RR} vs. I_F

$T_J = 175^\circ\text{C}$

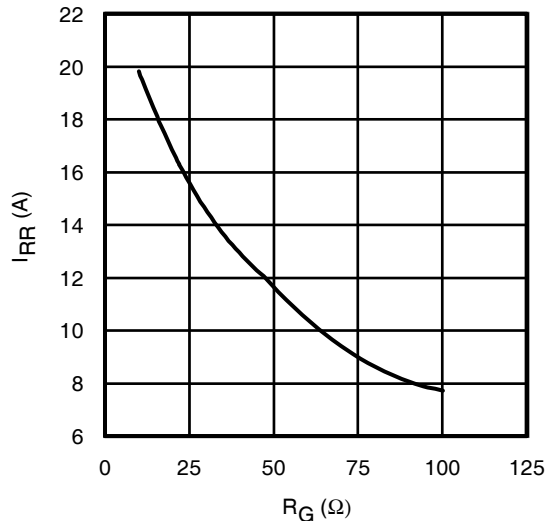


Fig. 18 - Typical Diode I_{RR} vs. R_G

$T_J = 175^\circ\text{C}$; $I_F = 6.0\text{A}$

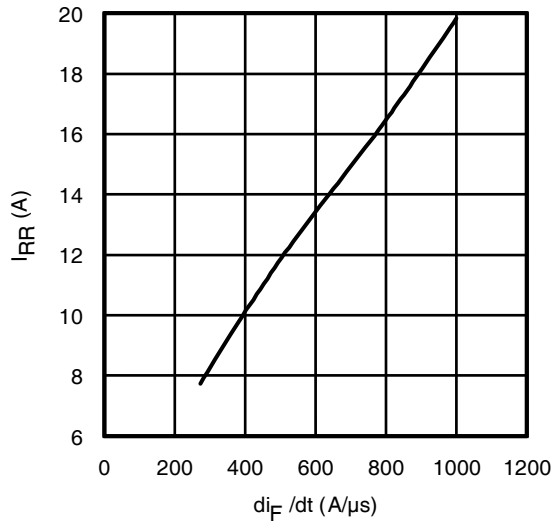


Fig. 19- Typical Diode I_{RR} vs. di_F/dt
 $V_{CC}=400V$; $V_{GE}=15V$;
 $I_{CE}=6.0A$; $T_J=175^{\circ}C$

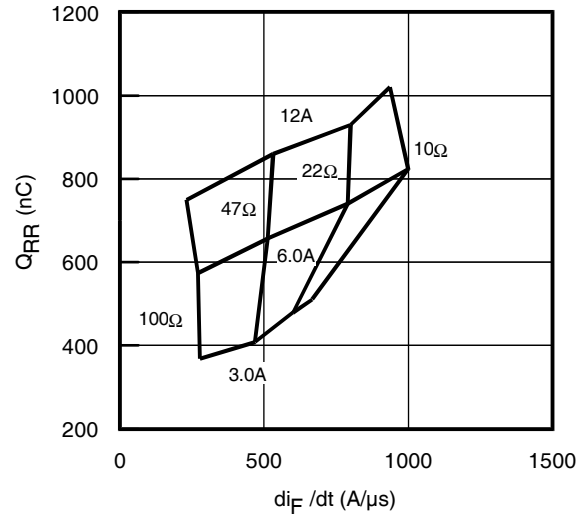


Fig. 20 - Typical Diode Q_{RR}
 $V_{CC}=400V$; $V_{GE}=15V$; $T_J=175^{\circ}C$

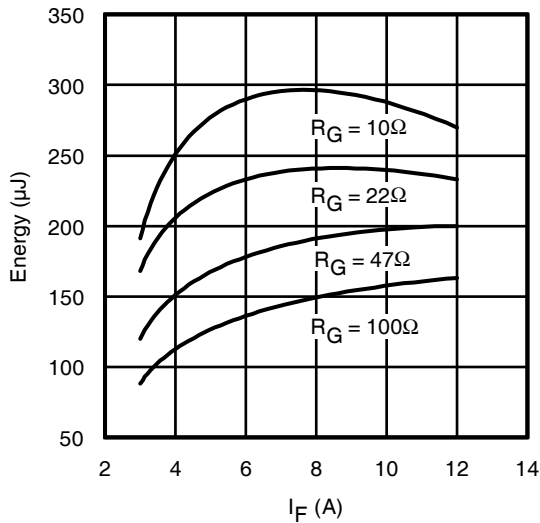


Fig. 21 - Typical Diode E_{RR} vs. I_F
 $T_J=175^{\circ}C$

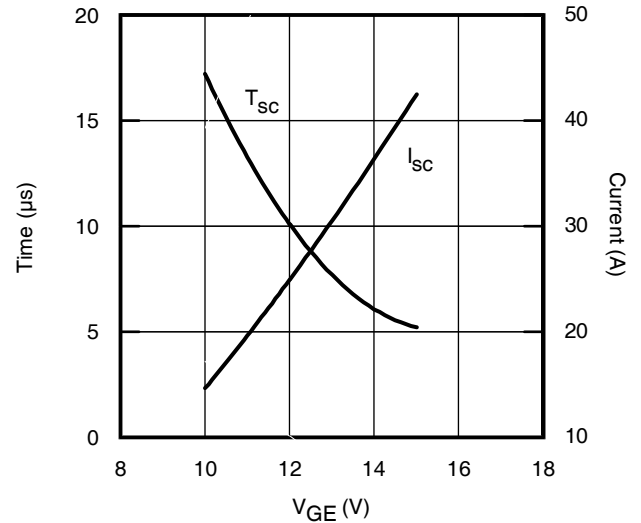


Fig. 22- Typ. V_{GE} vs. Short Circuit Time
 $V_{CC}=400V$, $T_C=25^{\circ}C$

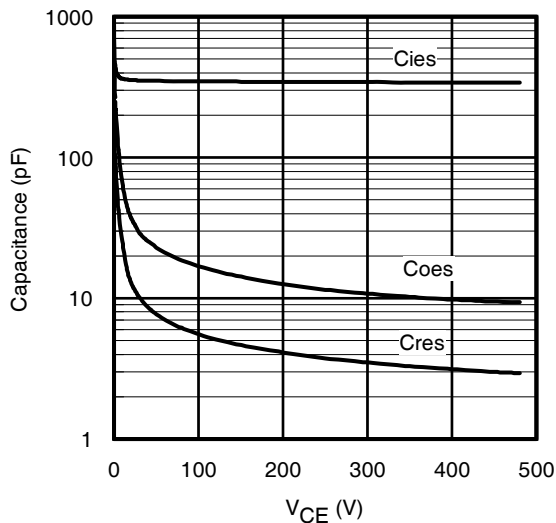


Fig. 23- Typ. Capacitance vs. V_{CE}
 $V_{GE}=0V$; $f=1MHz$

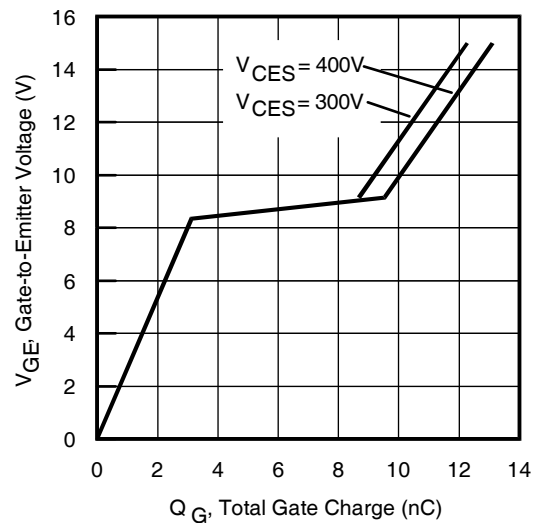


Fig. 24 - Typical Gate Charge vs. V_{GE}
 $I_{CE}=6.0A$, $L=600\mu H$

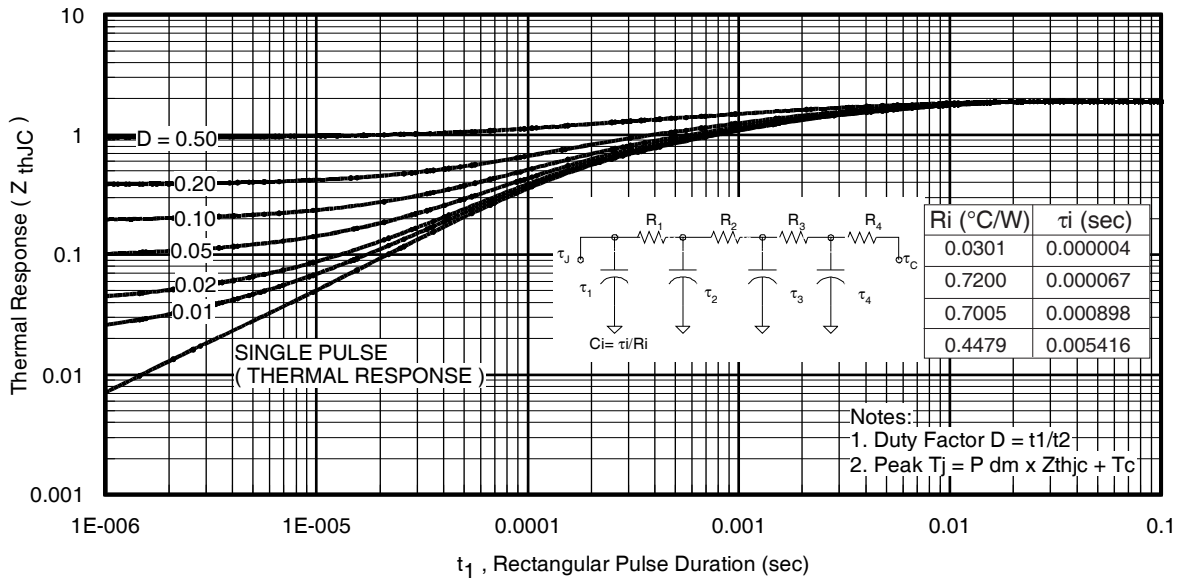


Fig 25. Maximum Transient Thermal Impedance, Junction-to-Case (IGBT)

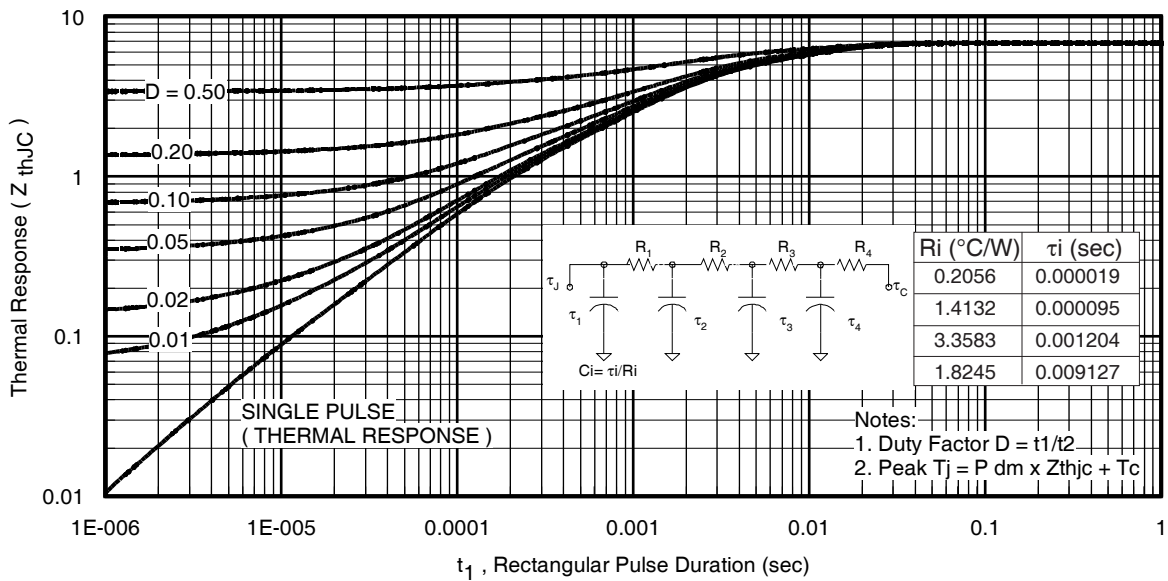


Fig. 26. Maximum Transient Thermal Impedance, Junction-to-Case (DIODE)

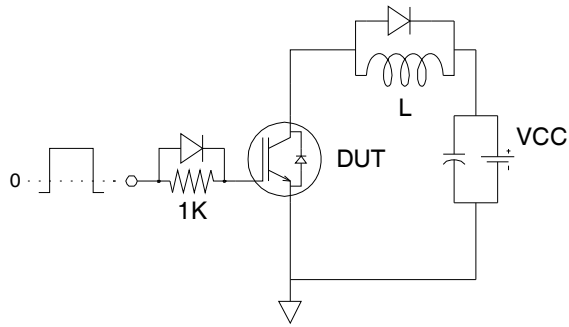


Fig.C.T.1 - Gate Charge Circuit (turn-off)

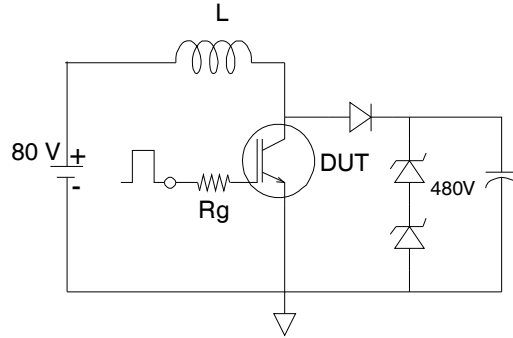


Fig.C.T.2 - RBSOA Circuit



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

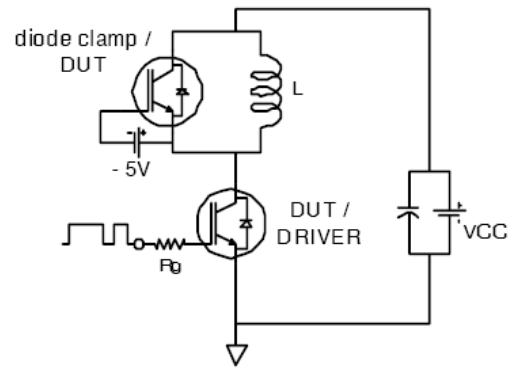


Fig.C.T.4 - Switching Loss Circuit

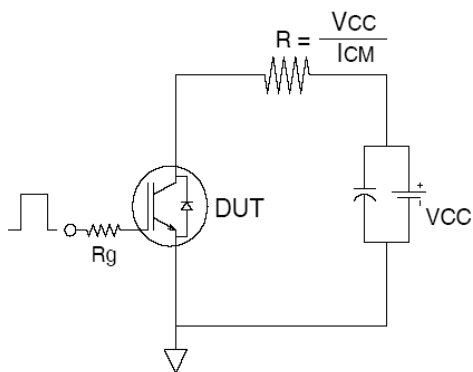


Fig.C.T.5 - Resistive Load Circuit

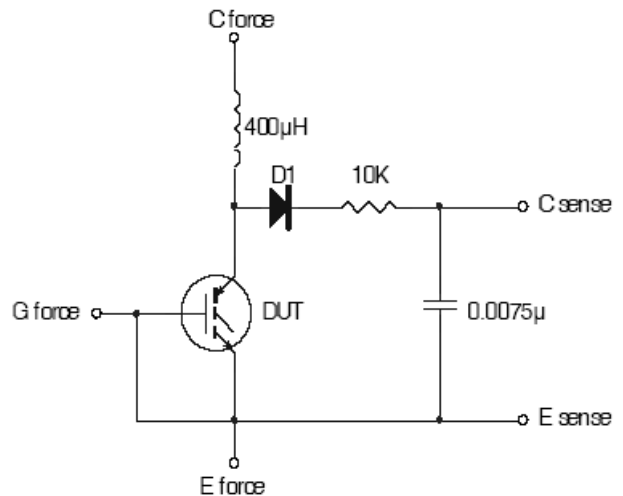


Fig.C.T.6 - Typical Filter Circuit for $V_{(BR)CES}$ Measurement

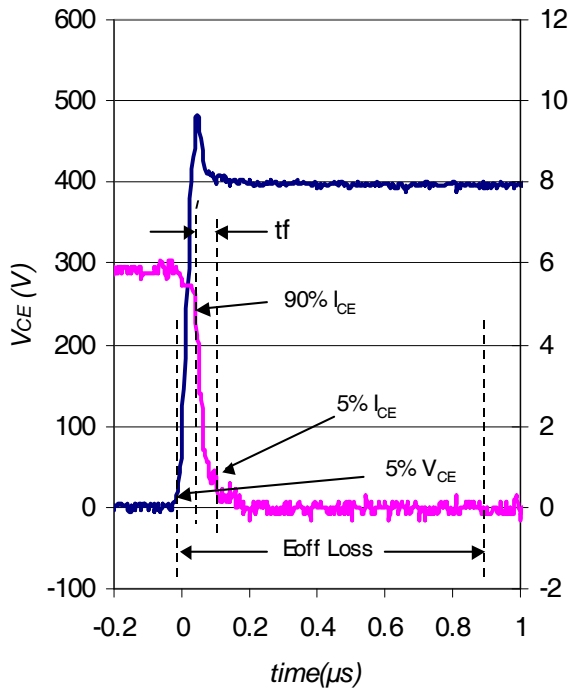


Fig. WF1 - Typ. Turn-off Loss Waveform
@ $T_J = 175^\circ\text{C}$ using Fig. CT.4

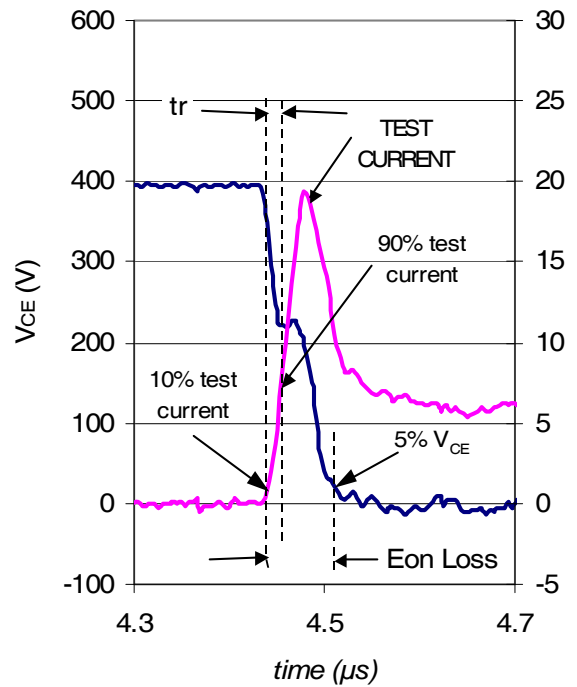
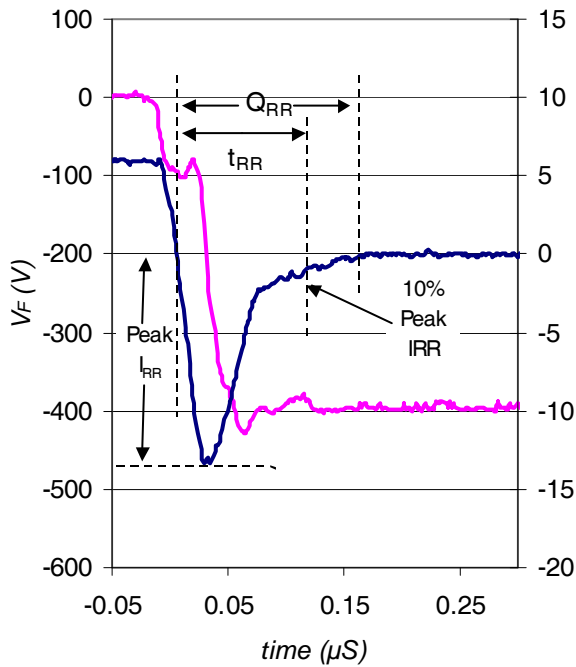
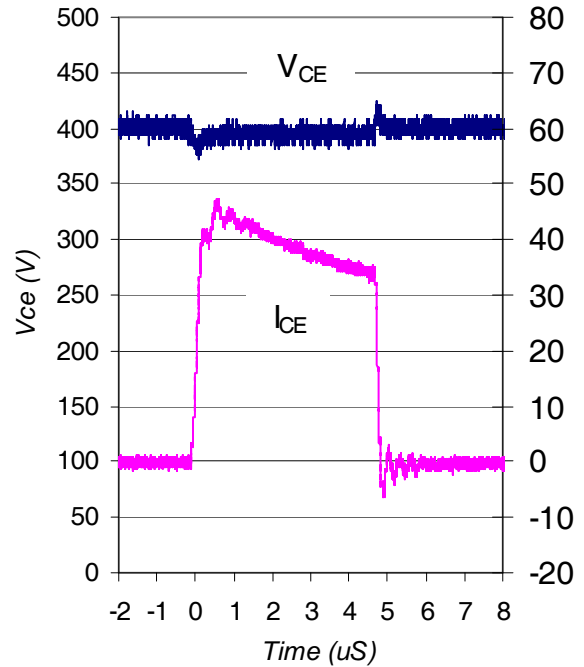


Fig. WF2 - Typ. Turn-on Loss Waveform
@ $T_J = 175^\circ\text{C}$ using Fig. CT.4



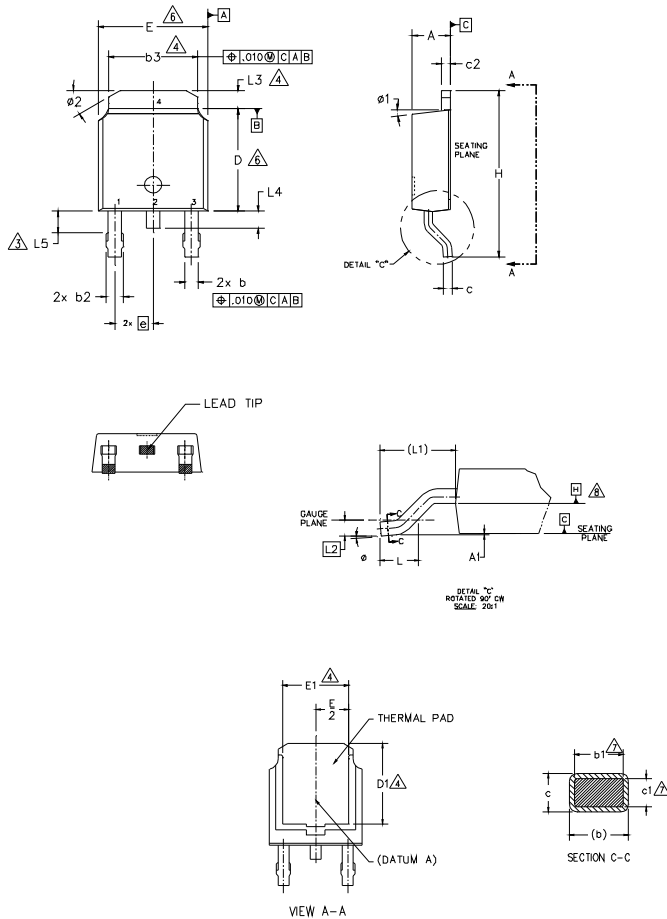
WF.3- Typ. Diode Recovery Waveform
@ $T_J = 175^\circ\text{C}$ using CT.4



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.- DIMENSION ARE SHOWN IN INCHES [MILLIMETERS]
- △- LEAD DIMENSION UNCONTROLLED IN L5.
- △- 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.
- △- 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.
- △- DIMENSION b1 & c1 APPLIED TO BASE METAL ONLY.
- △- 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
φ	0"	10"	0"	10"	
φ1	0"	15"	0"	15"	
φ2	25"	35"	25"	35"	

LEAD ASSIGNMENTS

HEXFET

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

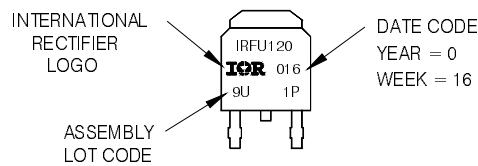
IGBT & CoPAK

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

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

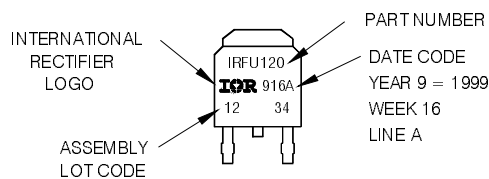
Notes: This part marking information applies to devices produced before 02/26/2001

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



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

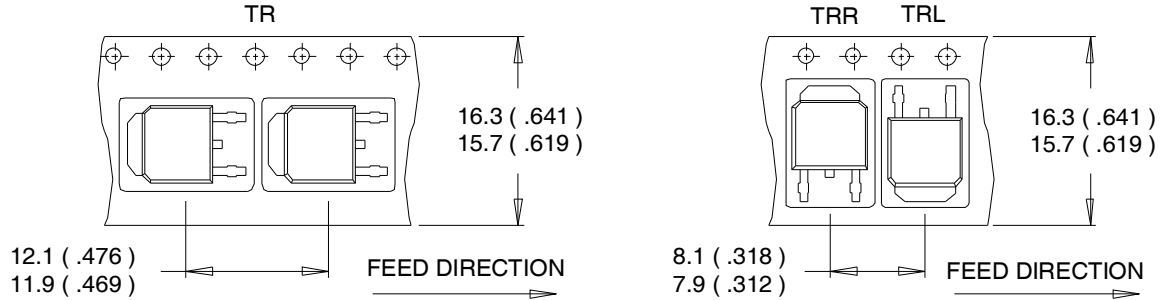
EXAMPLE: THIS IS AN IRFR120
WITH ASSEMBLY
LOT CODE 1234
ASSEMBLED ON WW 16, 1999
IN THE ASSEMBLY LINE 'A'



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

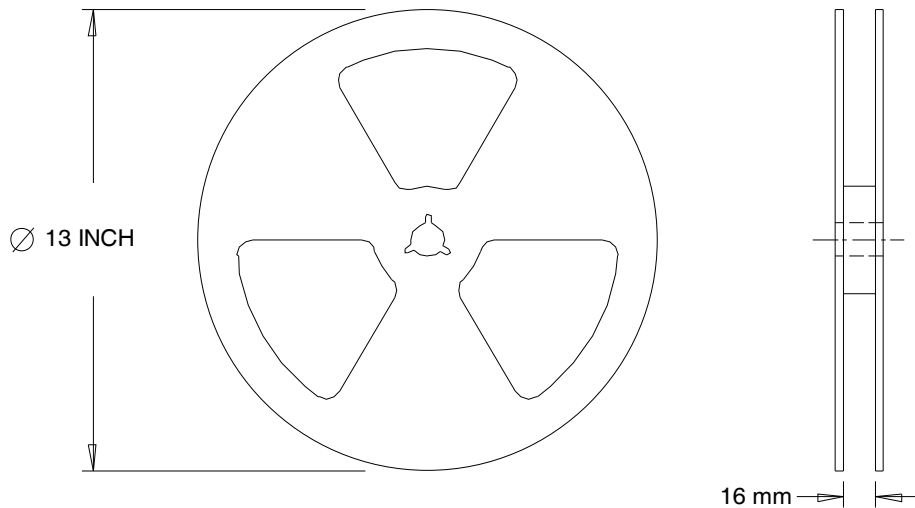
D-Pak (TO-252AA) Tape & Reel Information

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.