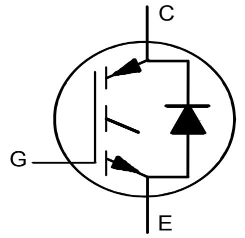
International
IOR Rectifier

IRGR2B60KDPbF

INSULATED GATE BIPOLAR TRANSISTOR WITH ULTRA-FAST SOFT RECOVERY DIODE



n-channel

V_{CES} = 600V

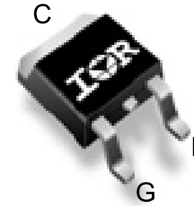
I_C = 3.7A, T_C = 100°C

$T_{J(MAX)}$ = 150°C

$V_{CE(ON)}$ typ. = 1.95V

Features
- Low $V_{CE\ (ON)}$ Non Punch Through IGBT technology
- Low Diode V_F
- 10µs Short Circuit Capability
- Square RBSOA
- Ultra-soft Diode Reverse Recovery Characteristics
- Positive $V_{CE\ (ON)}$ temperature co-efficient
- Lead-free

Benefits
- Benchmark Efficiency for Motor Control
- Rugged transient performance for increased reliability
- Excellent current sharing in parallel operation
- Low EMI



D-Pak

G	C	E
Gate	Collector	Emitter

Base part number	Package Type	Standard Pack		Orderable Part Number
		Form	Quantity	
IRGR2B60KDPbF	D-Pak	Tube	75	IRGR2B60KDPbF
		Tape and Reel	2000	IRGR2B60KDTRPbF
		Tape and Reel Left	3000	IRGR2B60KDTRLPbF
		Tape and Reel Right	3000	IRGR2B60KDTRRPbF

Absolute Maximum Ratings

	Parameter	Max.	Units
V_{CES}	Collector-to-Emitter Voltage	600	V
I_C @ T_C = 25°C	Continuous Collector Current	6.3	A
I_C @ T_C = 100°C	Continuous Collector Current	3.7	
I_{CM}	Pulse Collector Current, V_{GE} = 15V ②⑤	8.0	
I_{LM}	Clamped Inductive Load Current, V_{GE} = 20V ①	8.0	
I_F @ T_C = 25°C	Diode Continuous Forward Current	6.3	
I_F @ T_C = 100°C	Diode Continuous Forward Current	3.7	
I_{FM}	Diode Maximum Forward Current ②	8.0	
V_{GE}	Continuous Gate-to-Emitter Voltage	±20	V
P_D @ T_C = 25°C	Maximum Power Dissipation	35	W
P_D @ T_C = 100°C	Maximum Power Dissipation	14	
T_J T_{STG}	Operating Junction and Storage Temperature Range	-55 to +150	°C
	Soldering Temperature, for 10 sec.	300 (0.063 in.(1.6mm) from case)	

Thermal Resistance

	Parameter	Min.	Typ.	Max.	Units
$R_{\theta JC}$ (IGBT)	Junction-to-Case (IGBT) ④	——	——	3.56	°C/W
$R_{\theta JC}$ (Diode)	Junction-to-Case (Diode) ④	——	——	7.70	
$R_{\theta JA}$	Junction-to-Ambient (PCB Mount) ⑥	——	——	50	

Electrical Characteristics @ T_J = 25°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 = 500μA ③
$\Delta V_{(BR)CES}/\Delta T_J$	Temperature Coeff. of Breakdown Voltage	—	0.49	—	V/°C	V_{GE} = 0V, I_C = 1mA (25°C-150°C)
$V_{CE(on)}$	Collector-to-Emitter Saturation Voltage	—	1.95	2.25	V	I_C = 2.0A, V_{GE} = 15V, T_J = 25°C
		—	2.28	—		I_C = 2.0A, V_{GE} = 15V, T_J = 150°C
$V_{GE(th)}$	Gate Threshold Voltage	4.0	—	6.0	V	V_{CE} = V_{GE}, I_C = 250μA
gfe	Forward Transconductance	—	1.2	—	S	V_{CE} = 50V, I_C = 2.0A, PW = 20μs
I_{CES}	Collector-to-Emitter Leakage Current	—	0.5	25	μA	V_{GE} = 0V, V_{CE} = 600V
		—	23	—		V_{GE} = 0V, V_{CE} = 600V, T_J = 150°C
V_{FM}	Diode Forward Voltage Drop	—	1.3	1.6	V	I_F = 2.0A
		—	1.1	—		I_F = 2.0A, T_J = 150°C
I_{GES}	Gate-to-Emitter Leakage Current	—	—	±100	nA	V_{GE} = ±20V

Switching Characteristics @ T_J = 25°C (unless otherwise specified)

	Parameter	Min.	Typ.	Max.	Units	Conditions
Q_g	Total Gate Charge (turn-on)	—	8.0	12	nC	I_C = 2.0A
Q_{ge}	Gate-to-Emitter Charge (turn-on)	—	1.3	2.0		V_{GE} = 15V
Q_{gc}	Gate-to-Collector Charge (turn-on)	—	4.0	6.0		V_{CC} = 400V
E_{on}	Turn-On Switching Loss	—	74	160	μJ	I_C = 2.0A, V_{CC} = 400V, V_{GE} = 15V
E_{off}	Turn-Off Switching Loss	—	39	120		R_G = 100Ω, L = 7.1mH, T_J = 25°C
E_{tot}	Total Switching Loss	—	113	280		Energy losses include tail & diode reverse recovery
$t_{d(on)}$	Turn-On delay time	—	11	30	ns	
t_r	Rise time	—	8.7	25		
$t_{d(off)}$	Turn-Off delay time	—	150	170		
t_f	Fall time	—	56	75		
E_{on}	Turn-On Switching Loss	—	120	—	μJ	I_C = 2.0A, V_{CC} =400V, V_{GE}=15V
E_{off}	Turn-Off Switching Loss	—	68	—		R_G = 100Ω, L = 7.1mH, T_J = 150°C
E_{tot}	Total Switching Loss	—	188	—		Energy losses include tail & diode reverse recovery
$t_{d(on)}$	Turn-On delay time	—	13	—	ns	
t_r	Rise time	—	6.8	—		
$t_{d(off)}$	Turn-Off delay time	—	170	—		
t_f	Fall time	—	110	—		
C_{ies}	Input Capacitance	—	110	—	pF	V_{GE} = 0V
C_{oes}	Output Capacitance	—	17	—		V_{CC} = 30V
C_{res}	Reverse Transfer Capacitance	—	4.0	—		f = 1.0Mhz
RBSOA	Reverse Bias Safe Operating Area	FULL SQUARE				T_J = 150°C, I_C = 8.0A V_{CC} = 480V, Vp ≤ 600V Rg = 100Ω, V_{GE} = +20V to 0V
SCSOA	Short Circuit Safe Operating Area	10	—	—	μs	T_J = 150°C, Vp ≤ 600V, Rg=330Ω V_{CC} = 360V, V_{GE} = +15V to 0V
Erec	Reverse Recovery Energy of the Diode	—	19	30	μJ	T_J = 150°C
trr	Diode Reverse Recovery Time	—	45	68	ns	V_{CC} = 400V, I_F = 2.0A, L = 7.1mH
Irr	Diode Peak Reverse Recovery Current	—	5.8	8.7	A	V_{GE} = 15V, Rg = 100Ω

Notes:

① V_{CC} = 80% (V_{CES}), V_{GE} = 20V, L = 200μH, R_G = 100Ω.
② Pulse width limited by max. junction temperature.
③ Refer to AN-1086 for guidelines for measuring $V_{(BR)CES}$ safely.
④ R_θ is measured at T_J of approximately 90°C.
⑤ FBSOA operating conditions only.
⑥ When mounted on 1" square PCB (FR-4 or G-10 Material). For recommended footprint and soldering techniques refer to application note #AN-994.

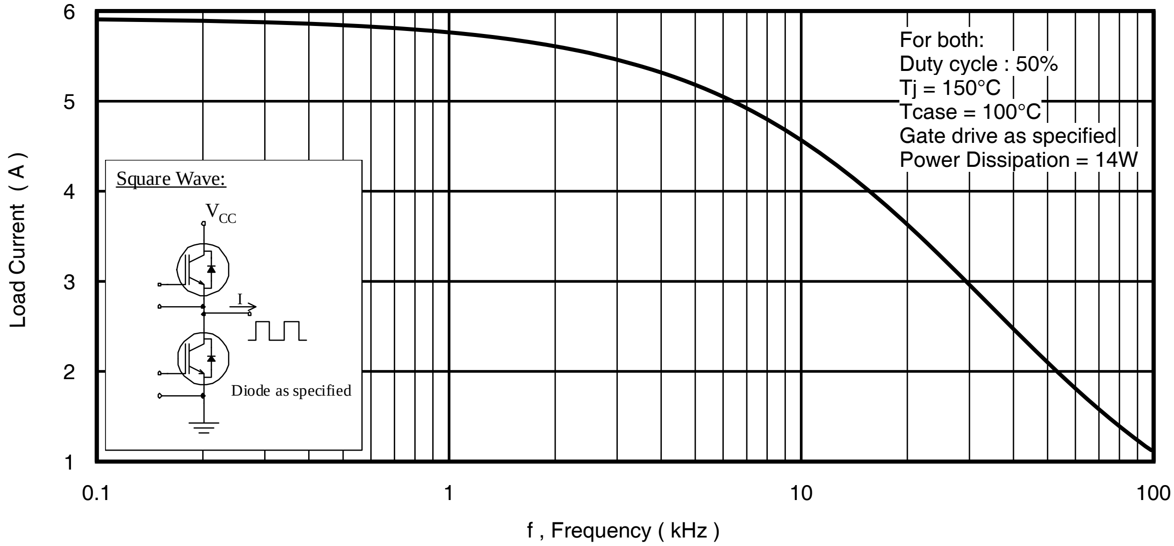


Fig. 1 - Typical Load Current vs. Frequency
(Load Current = I_{RMS} of fundamental)

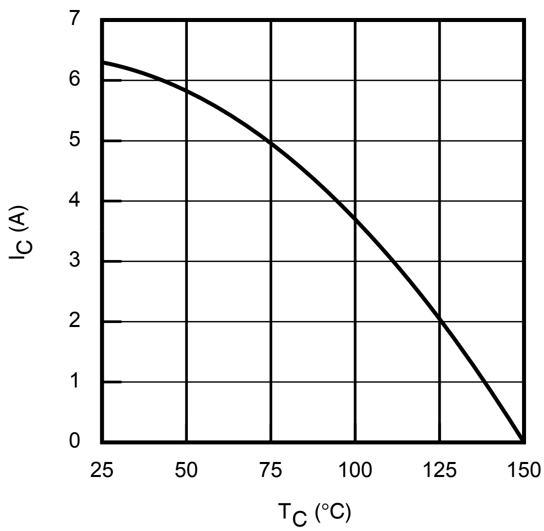


Fig. 2 - Maximum DC Collector Current vs. Case Temperature

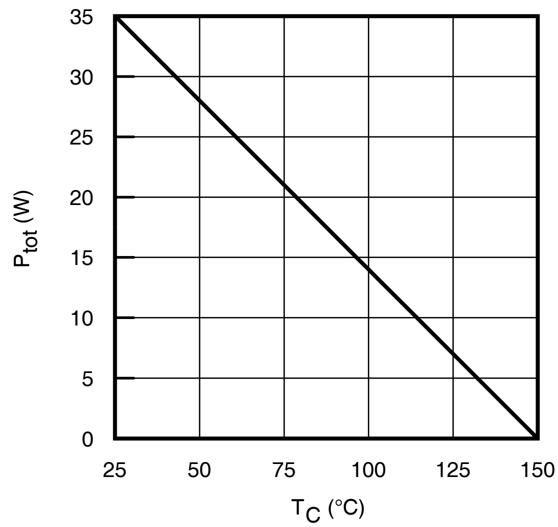


Fig. 3 - Power Dissipation vs. Case Temperature

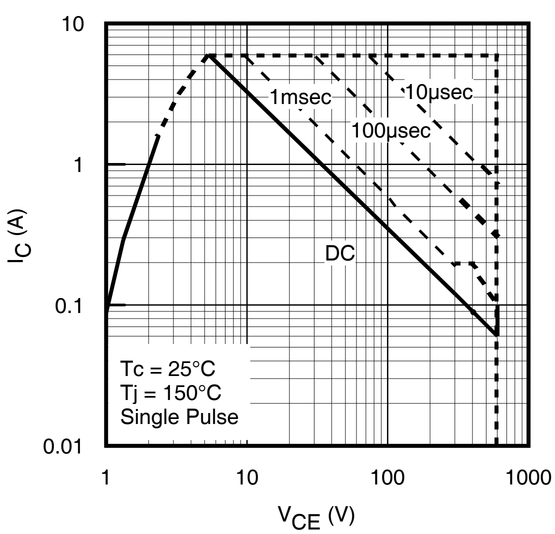


Fig. 4 - Forward SOA
T_C = 25°C; T_J ≤ 150°C; V_{GE} = 15V

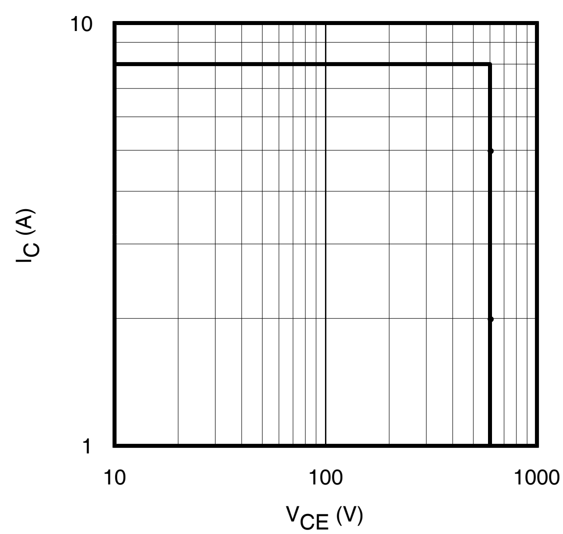


Fig. 5 - Reverse Bias SOA
T_J = 150°C; V_{GE} = 20V

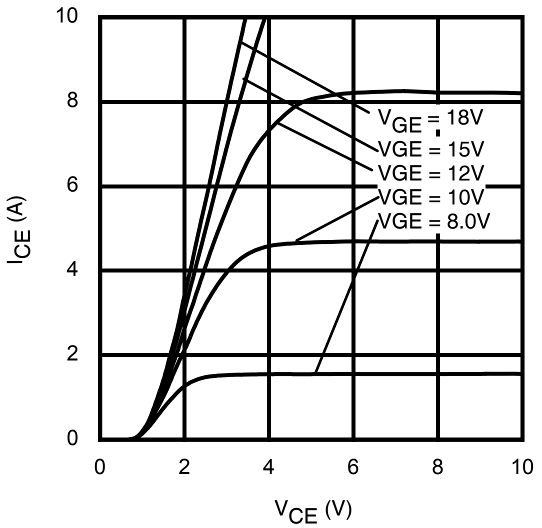


Fig. 6 - Typ. IGBT Output Characteristics
T_J = -40°C; tp = 20µs

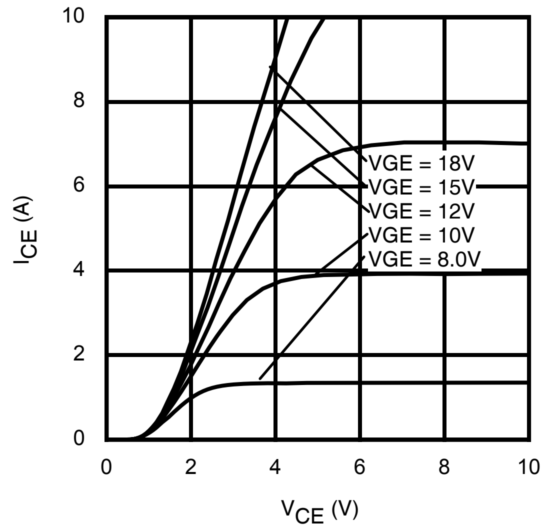


Fig. 7 - Typ. IGBT Output Characteristics
T_J = 25°C; tp = 20µs

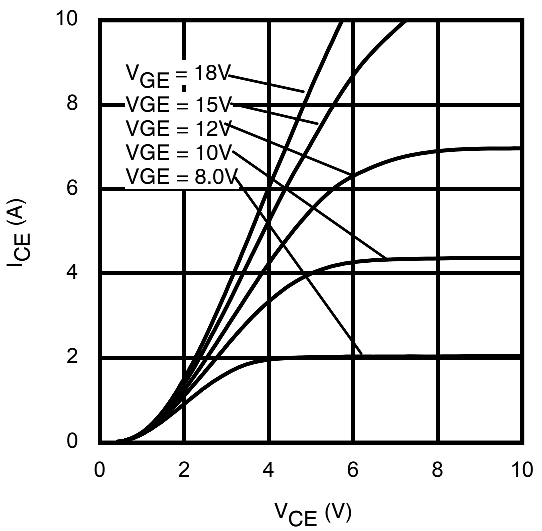


Fig. 8 - Typ. IGBT Output Characteristics
T_J = 150°C; tp = 20µs

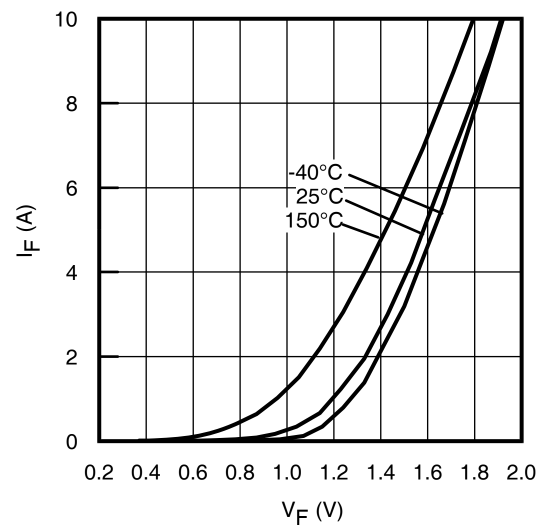


Fig. 9 - Typ. Diode Forward Voltage Drop Characteristics

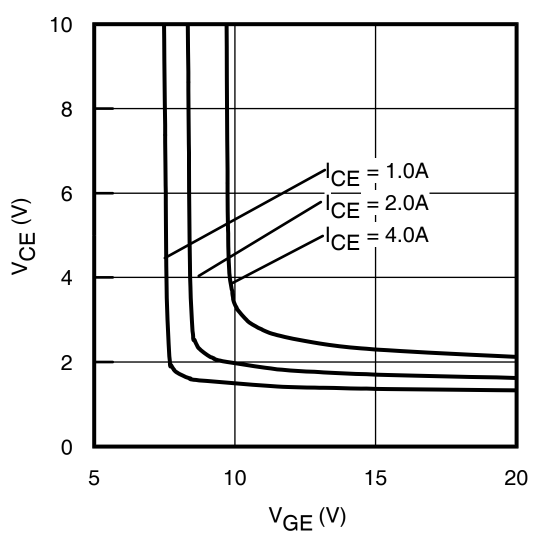


Fig. 10 - Typical V_{CE} vs. V_{GE}
T_J = -40°C

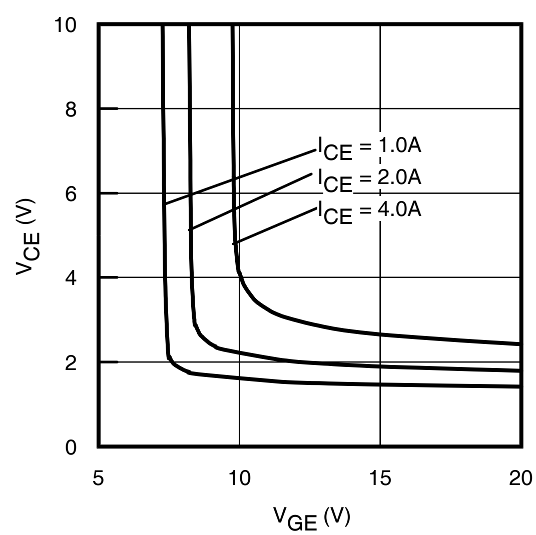


Fig. 11 - Typical V_{CE} vs. V_{GE}
T_J = 25°C

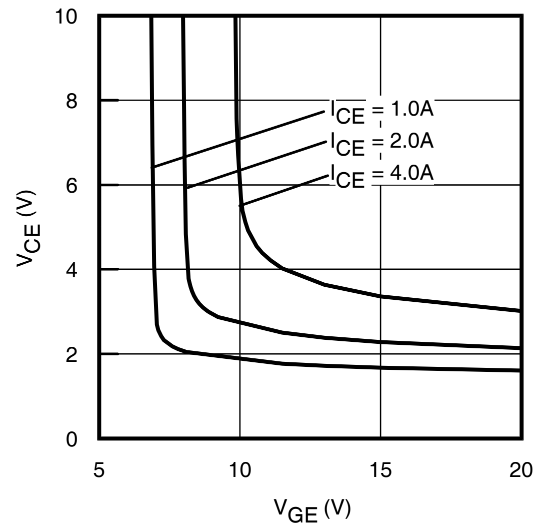


Fig. 12 - Typical V_{CE} vs. V_{GE}
T_J = 150°C

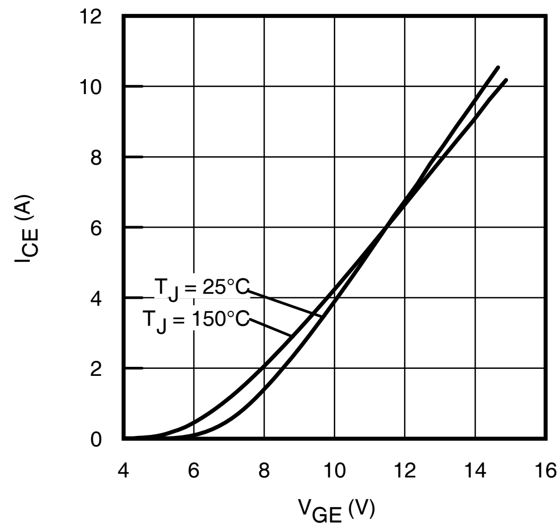


Fig. 13 - Typ. Transfer Characteristics
V_{CE} = 50V; tp = 20µs

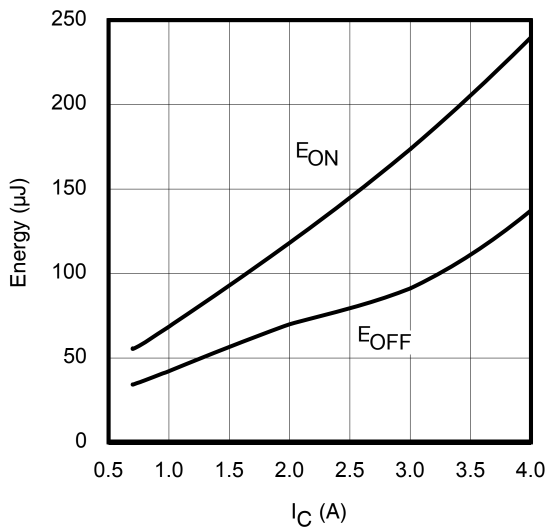


Fig. 14 - Typ. Energy Loss vs. I_C
T_J = 150°C; L = 7.1mH; V_{CE} = 400V, R_G = 100Ω; V_{GE} = 15V

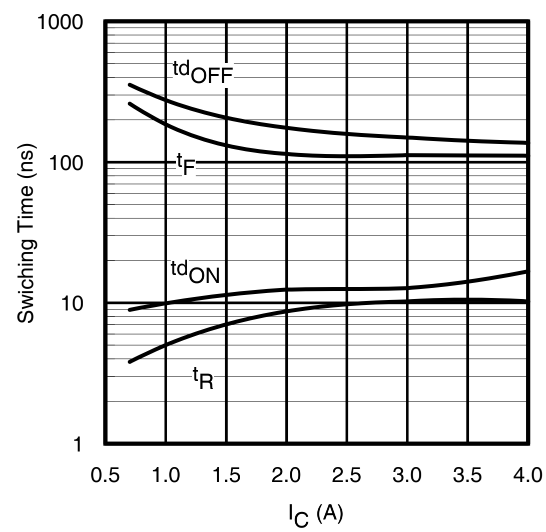


Fig. 15 - Typ. Switching Time vs. I_C
T_J = 150°C; L = 7.1mH; V_{CE} = 400V, R_G = 100Ω; V_{GE} = 15V

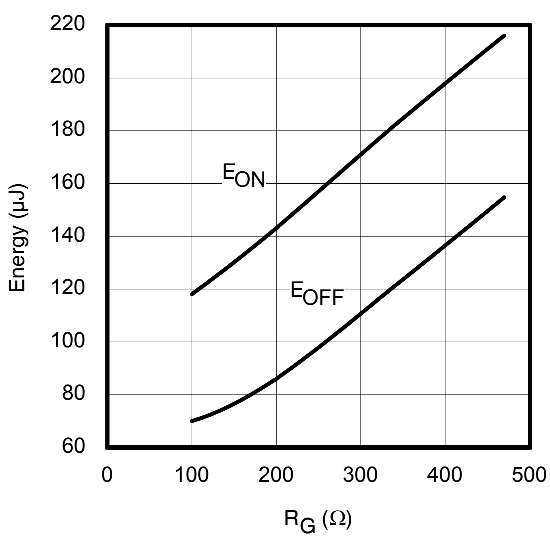


Fig. 16 - Typ. Energy Loss vs. R_G
T_J = 150°C; L = 7.1mH; V_{CE} = 400V, I_{CE} = 2.0A; V_{GE} = 15V

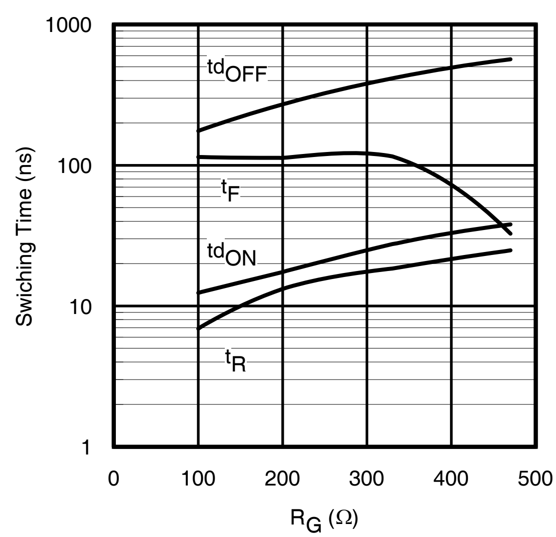


Fig. 17 - Typ. Switching Time vs. R_G
T_J = 150°C; L = 7.1mH; V_{CE} = 400V, I_{CE} = 2.0A; V_{GE} = 15V

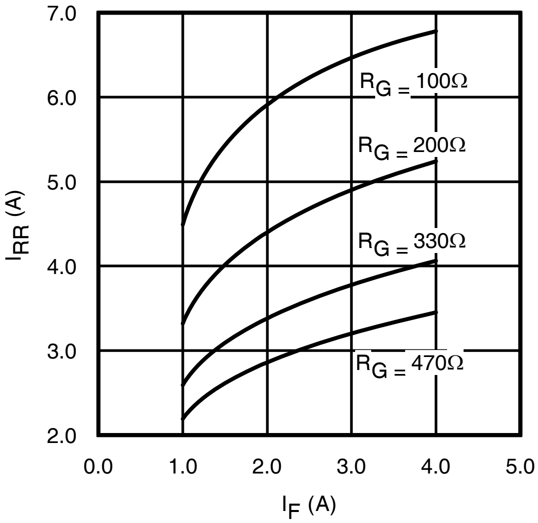


Fig. 18 - Typical Diode I_{RR} vs. I_F
T_J = 150°C

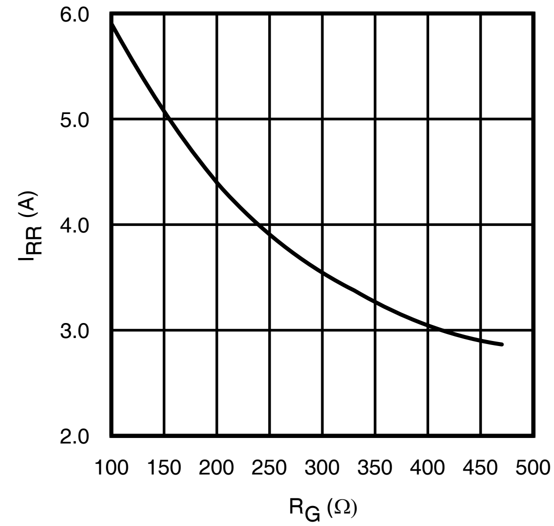


Fig. 19 - Typical Diode I_{RR} vs. R_G
T_J = 150°C; I_F = 2.0A

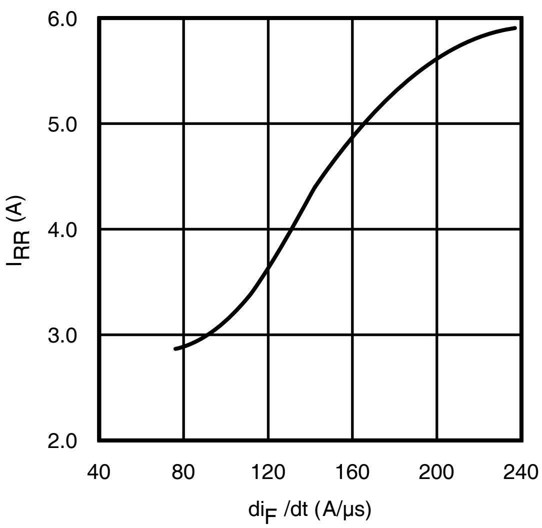


Fig. 20 - Typical Diode I_{RR} vs. di_F/dt
V_{CC} = 400V; V_{GE} = 15V; I_F = 2.0A; T_J = 150°C

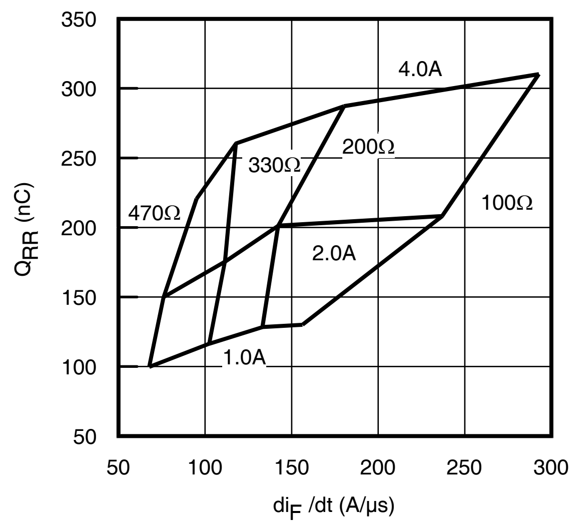


Fig. 21 - Typical Diode Q_{RR}
V_{CC} = 400V; V_{GE} = 15V; T_J = 150°C

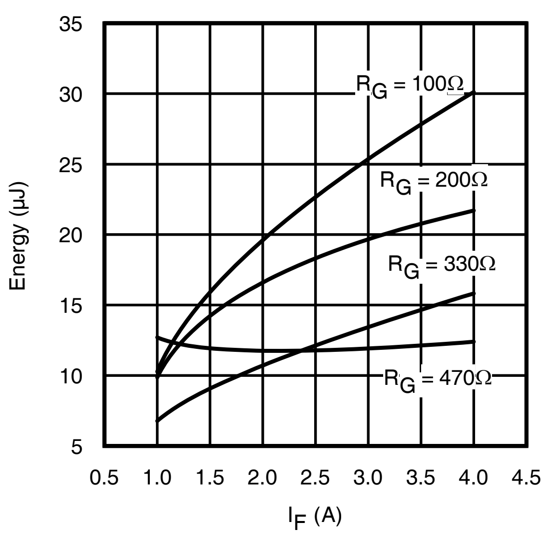


Fig. 22 - Typ. Diode E_{RR} vs. I_F
T_J = 150°C

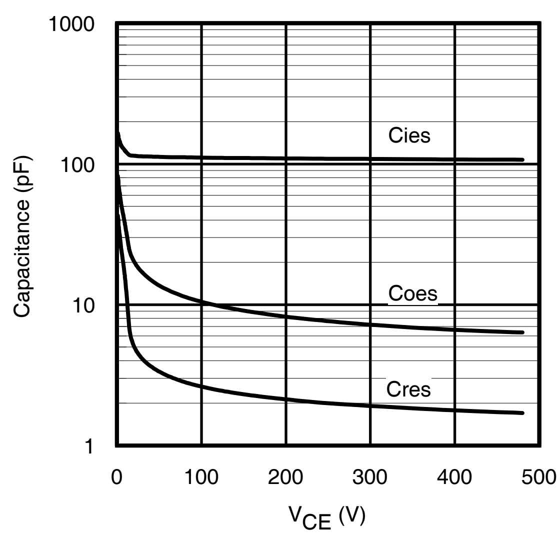


Fig. 23 - Typ. Capacitance vs. V_{CE}
V_{GE}= 0V; f = 1MHz

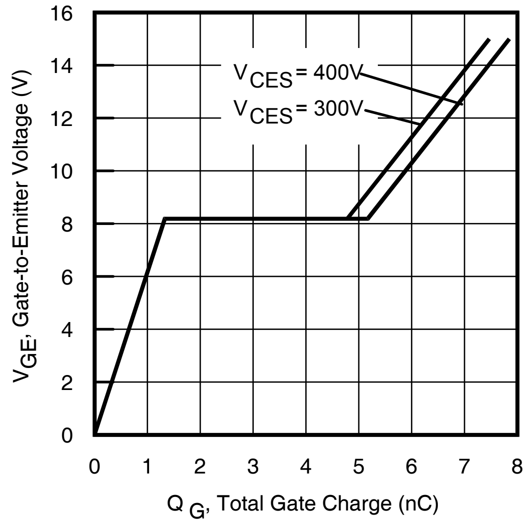


Fig. 23 - Typical Gate Charge vs. V_{GE}

I_{CE} = 2.0A

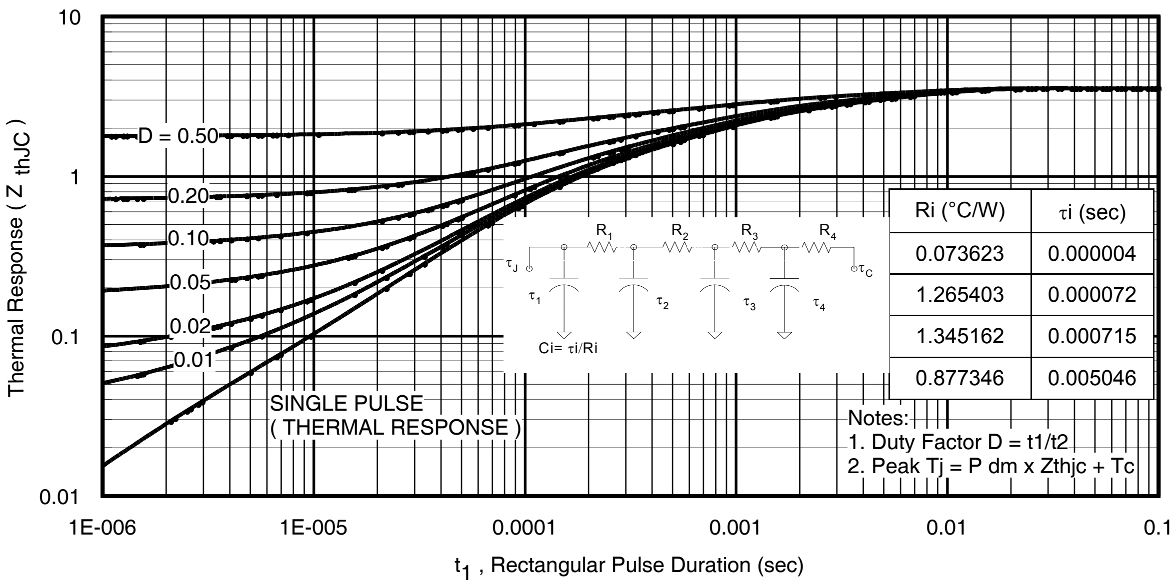


Fig. 24 - Maximum Transient Thermal Impedance, Junction-to-Case (IGBT)

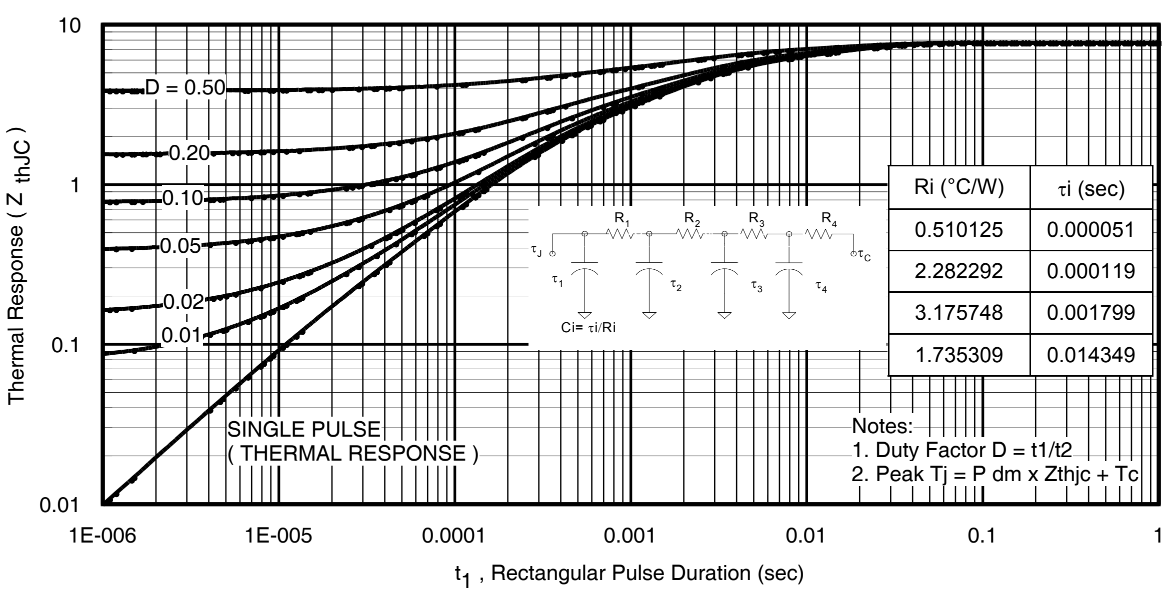


Fig. 25 - Maximum Transient Thermal Impedance, Junction-to-Case (DIODE)

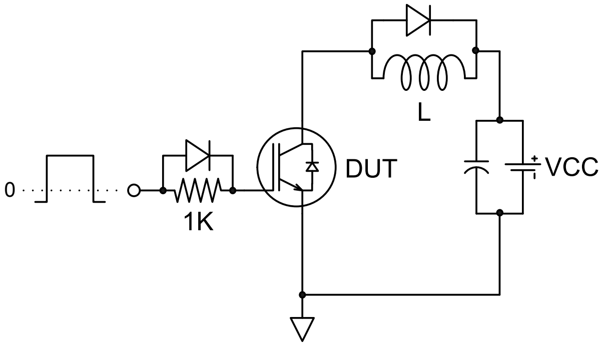


Fig.C.T.1 - Gate Charge Circuit (turn-off)

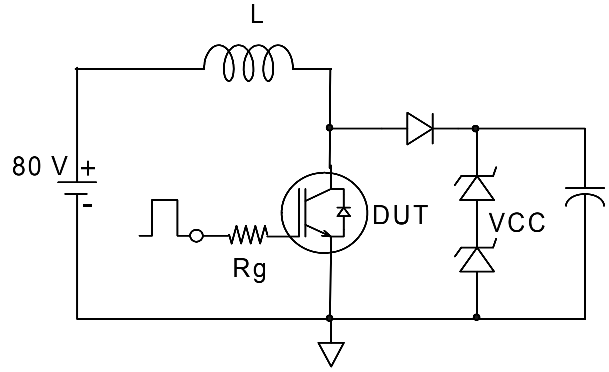


Fig.C.T.2 - RBSOA Circuit

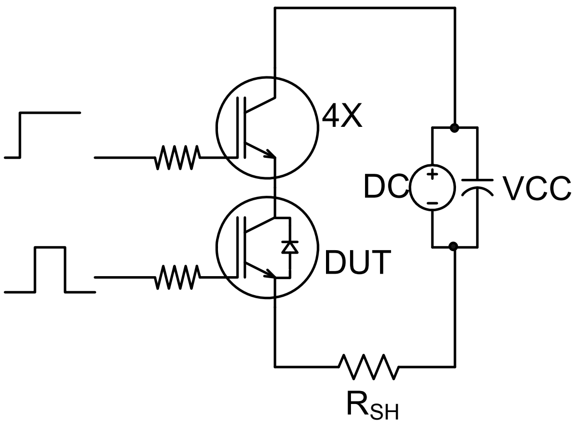


Fig.C.T.3 - S.C. SOA Circuit

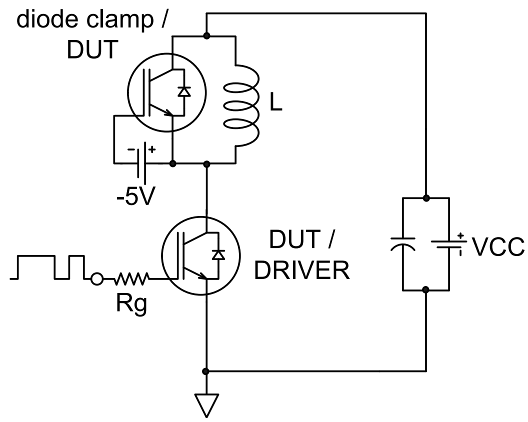


Fig.C.T.4 - Switching Loss Circuit

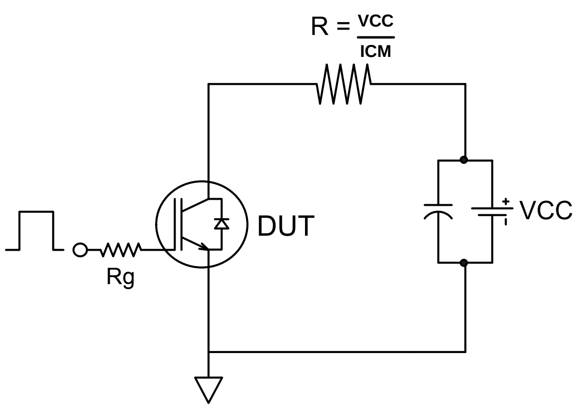


Fig. C.T.5 - Resistive Load Circuit

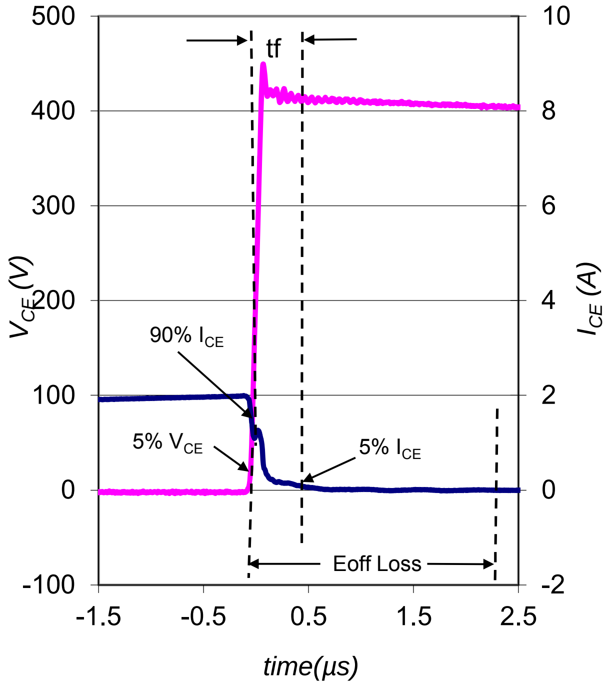


Fig. WF1 - Typ. Turn-off Loss Waveform
@ T_J = 150°C using Fig. CT.4

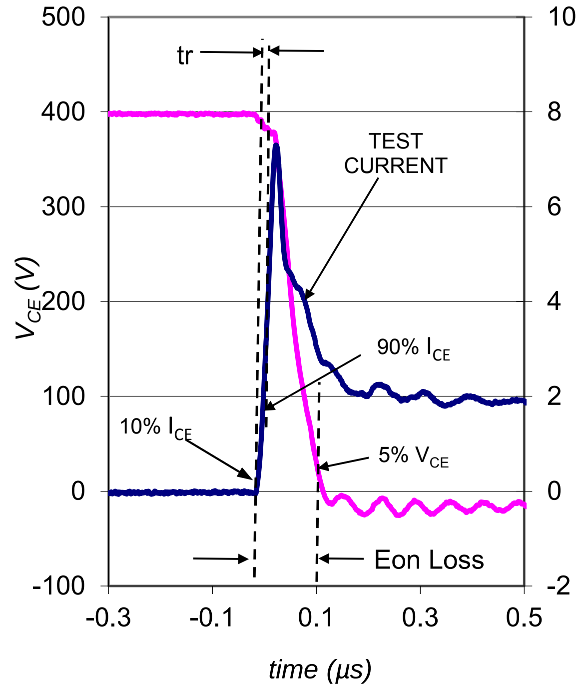


Fig. WF2 - Typ. Turn-on Loss Waveform
@ T_J = 150°C using Fig. CT.4

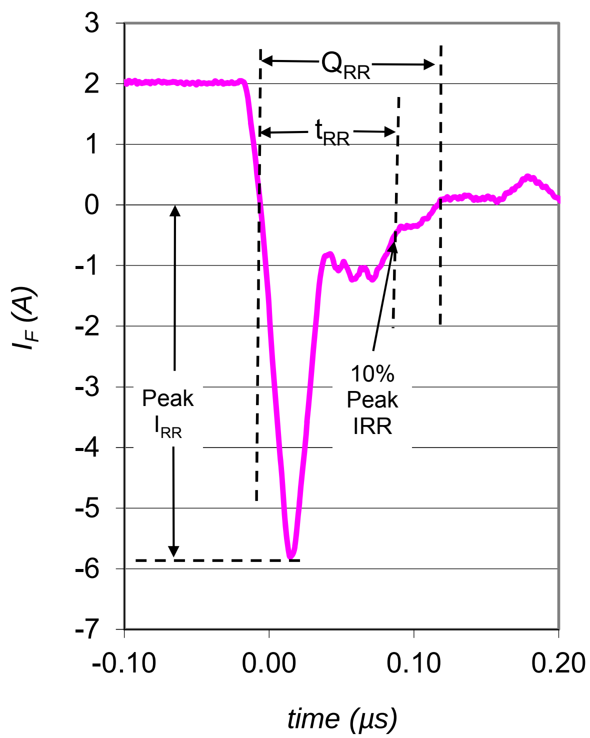


Fig. WF3 - Typ. Diode Recovery Waveform
@ T_J = 150°C using Fig. CT.4

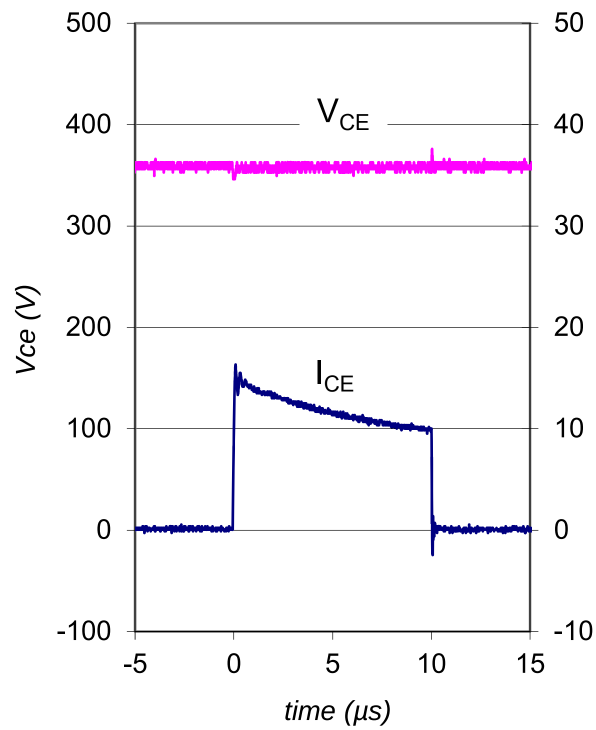
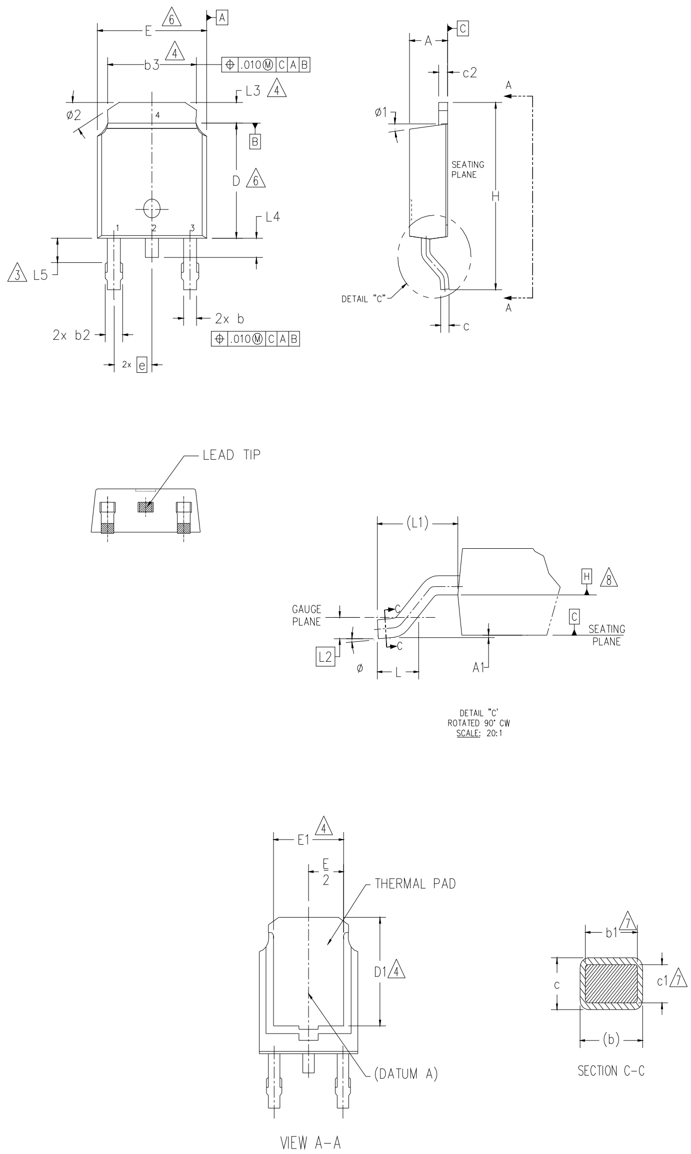


Fig. WF4 - Typ. S.C. Waveform
@ T_J = 150°C using Fig. CT.3

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].

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

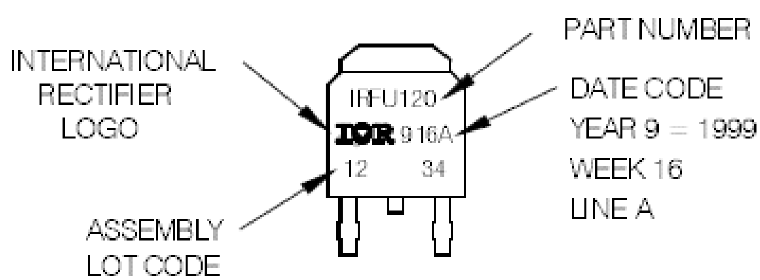
1.– GATE
2.– DRAIN
3.– SOURCE
4.– DRAIN

IGBT & CoPAK

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

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

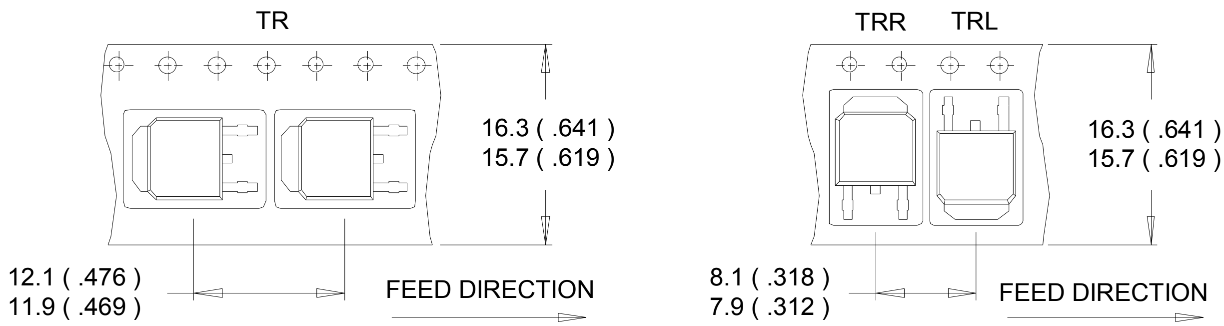
EXAMPLE: THIS IS AN IRFR120
WITH ASSEMBLY
LOT CODE 1234
ASSEMBLED ON WW 16, 1999
IN THE ASSEMBLY LINE 'A'



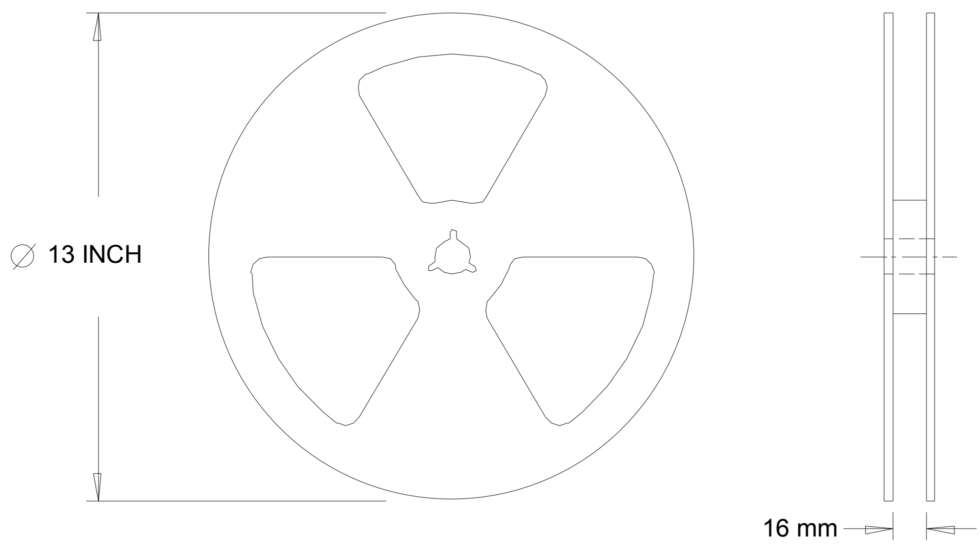
Note: For the most current drawing please refer to IR website at http://www.irf.com/package/

D-Pak (TO-252AA) Tape and 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.

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

Qualification Information†

Qualification Level	Industrial††	
Moisture Sensitivity Level	D-Pak	MSL1
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.

International Rectifier
IR WORLD HEADQUARTERS: 101 N. Sepulveda Blvd., El Segundo, California 90245, USA
To contact International Rectifier, please visit http://www.irf.com/whoto-call/

