

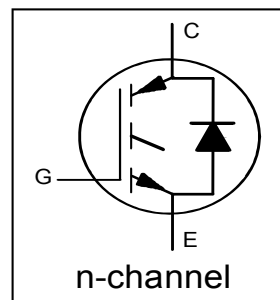
**INSULATED GATE BIPOLAR TRANSISTOR WITH ULTRA-FAST
SOFT RECOVERY DIODE**

Features

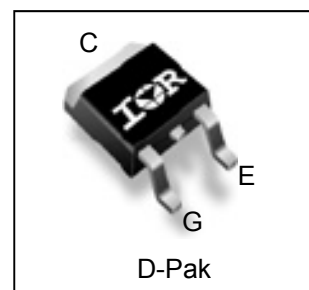
- Low $V_{CE(ON)}$ Non Punch Through IGBT technology
- Low Diode V_F
- 10 μ s Short Circuit Capability
- Square RBSOA
- Ultra-soft Diode Reverse Recovery Characteristics
- Positive $V_{CE(ON)}$ temperature co-efficient
- Lead-free

Benefits

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



$V_{CES} = 600V$
 $I_C = 3.7A, T_C = 100^\circ C$
 $T_{J(MAX)} = 150^\circ C$
 $V_{CE(ON)} \text{ typ.} = 1.95V$



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
$I_C @ T_C = 25^\circ C$	Continuous Collector Current	6.3	A
$I_C @ T_C = 100^\circ C$	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	
$I_F @ T_C = 25^\circ C$	Diode Continuous Forward Current	6.3	
$I_F @ T_C = 100^\circ C$	Diode Continuous Forward Current	3.7	
I_{FM}	Diode Maximum Forward Current ②	8.0	V
V_{GE}	Continuous Gate-to-Emitter Voltage	± 20	
$P_D @ T_C = 25^\circ C$	Maximum Power Dissipation	35	W
$P_D @ T_C = 100^\circ C$	Maximum Power Dissipation	14	
T_J T_{STG}	Operating Junction and Storage Temperature Range	-55 to +150	$^\circ C$
	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	$^\circ C/W$
$R_{\theta JC}$ (Diode)	Junction-to-Case (Diode) ④	—	—	7.70	
$R_{\theta JA}$	Junction-to-Ambient (PCB Mount) ⑥	—	—	50	

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

	Parameter	Min.	Typ.	Max.	Units	Conditions
$V_{(BR)CES}$	Collector-to-Emitter Breakdown Voltage	600	—	—	V	$V_{GE} = 0V, I_C = 500\mu A$ 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	$I_C = 2.0A, V_{GE} = 15V, T_J = 25^\circ\text{C}$
		—	2.28	—		$I_C = 2.0A, V_{GE} = 15V, T_J = 150^\circ\text{C}$
$V_{GE(th)}$	Gate Threshold Voltage	4.0	—	6.0	V	$V_{CE} = V_{GE}, I_C = 250\mu A$
g_{fe}	Forward Transconductance	—	1.2	—	S	$V_{CE} = 50V, I_C = 2.0A, PW = 20\mu s$
I_{CES}	Collector-to-Emitter Leakage Current	—	0.5	25	μA	$V_{GE} = 0V, V_{CE} = 600V$
		—	23	—		$V_{GE} = 0V, V_{CE} = 600V, T_J = 150^\circ\text{C}$
V_{FM}	Diode Forward Voltage Drop	—	1.3	1.6	V	$I_F = 2.0A$
		—	1.1	—		$I_F = 2.0A, T_J = 150^\circ\text{C}$
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
Q_g	Total Gate Charge (turn-on)	—	8.0	12	nC	$I_C = 2.0A$ $V_{GE} = 15V$ $V_{CC} = 400V$
Q_{ge}	Gate-to-Emitter Charge (turn-on)	—	1.3	2.0		
Q_{gc}	Gate-to-Collector Charge (turn-on)	—	4.0	6.0		
E_{on}	Turn-On Switching Loss	—	74	160	μJ	$I_C = 2.0A, V_{CC} = 400V, V_{GE} = 15V$ $R_G = 100\Omega, L = 7.1mH, T_J = 25^\circ\text{C}$ Energy losses include tail & diode reverse recovery
E_{off}	Turn-Off Switching Loss	—	39	120		
E_{tot}	Total Switching Loss	—	113	280		
$t_{d(on)}$	Turn-On delay time	—	11	30	ns	Energy losses include tail & diode reverse recovery
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	$I_C = 2.0A, V_{CC} = 400V, V_{GE} = 15V$ $R_G = 100\Omega, L = 7.1mH, T_J = 150^\circ\text{C}$ Energy losses include tail & diode reverse recovery
E_{off}	Turn-Off Switching Loss	—	68	—		
E_{tot}	Total Switching Loss	—	188	—		
$t_{d(on)}$	Turn-On delay time	—	13	—	ns	Energy losses include tail & diode reverse recovery
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	$V_{GE} = 0V$ $V_{CC} = 30V$ $f = 1.0MHz$
C_{oes}	Output Capacitance	—	17	—		
C_{res}	Reverse Transfer Capacitance	—	4.0	—		
RBSOA	Reverse Bias Safe Operating Area	FULL SQUARE				$T_J = 150^\circ\text{C}, I_C = 8.0A$ $V_{CC} = 480V, V_p \leq 600V$ $R_g = 100\Omega, V_{GE} = +20V$ to 0V
SCSOA	Short Circuit Safe Operating Area	10	—	—	μs	$T_J = 150^\circ\text{C}, V_p \leq 600V, R_g = 330\Omega$ $V_{CC} = 360V, V_{GE} = +15V$ to 0V
E_{rec}	Reverse Recovery Energy of the Diode	—	19	30	μJ	$T_J = 150^\circ\text{C}$
t_{rr}	Diode Reverse Recovery Time	—	45	68	ns	$V_{CC} = 400V, I_F = 2.0A, L = 7.1mH$
I_{rr}	Diode Peak Reverse Recovery Current	—	5.8	8.7	A	$V_{GE} = 15V, R_g = 100\Omega$

Notes:

- ① $V_{CC} = 80\% (V_{CES}), V_{GE} = 20V, L = 200\mu H, R_G = 100\Omega$.
- 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.

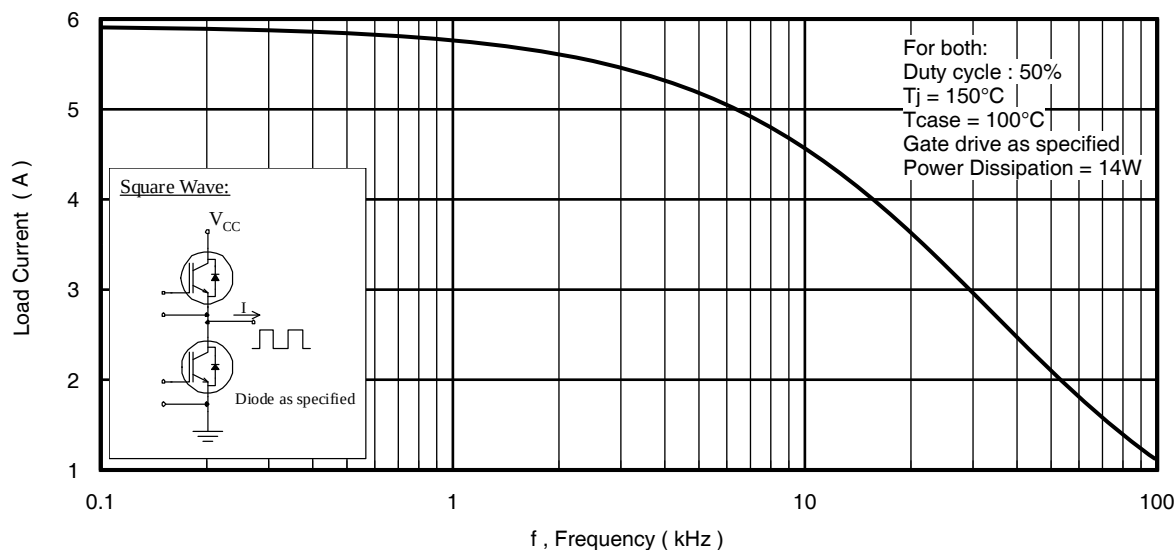


Fig. 1 - Typical Load Current vs. Frequency
(Load Current = I_{RMS} of fundamental)

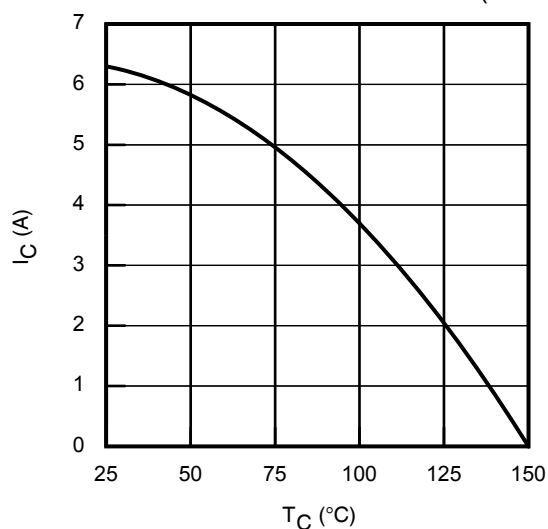


Fig. 2 - Maximum DC Collector Current vs. Case Temperature

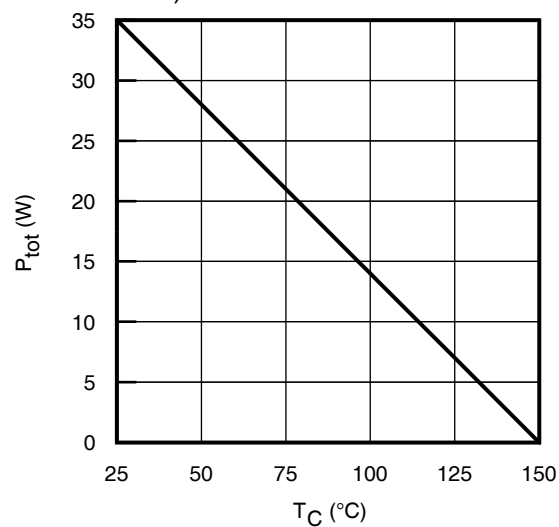


Fig. 3 - Power Dissipation vs. Case Temperature

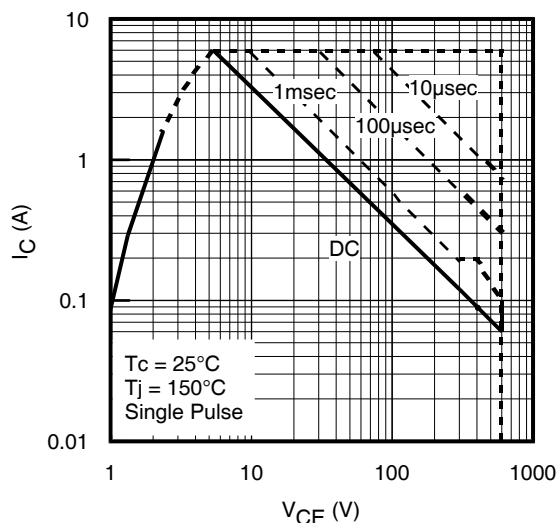


Fig. 4 - Forward SOA
 $T_c = 25^{\circ}\text{C}$; $T_j \leq 150^{\circ}\text{C}$; $V_{\text{GE}} = 15\text{V}$

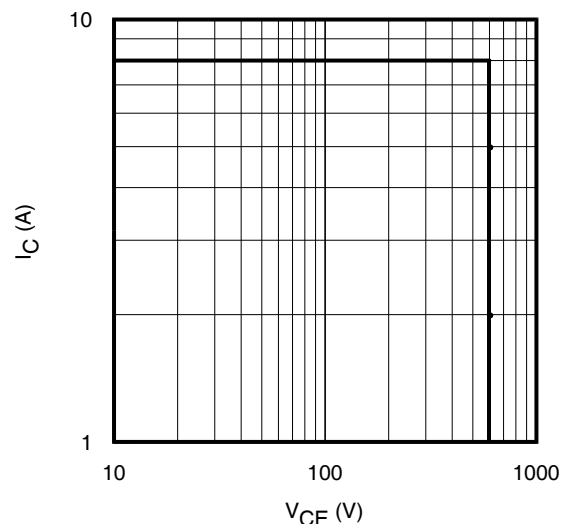


Fig. 5 - Reverse Bias SOA
 $T_j = 150^{\circ}\text{C}$; $V_{\text{GE}} = 20\text{V}$

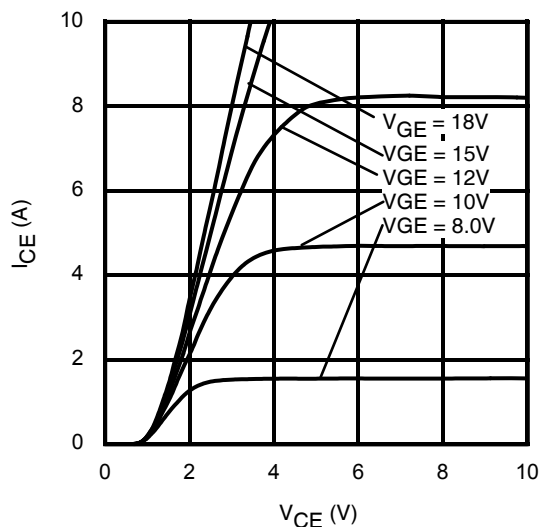


Fig. 6 - Typ. IGBT Output Characteristics
 $T_J = -40^{\circ}\text{C}$; $t_p = 20\mu\text{s}$

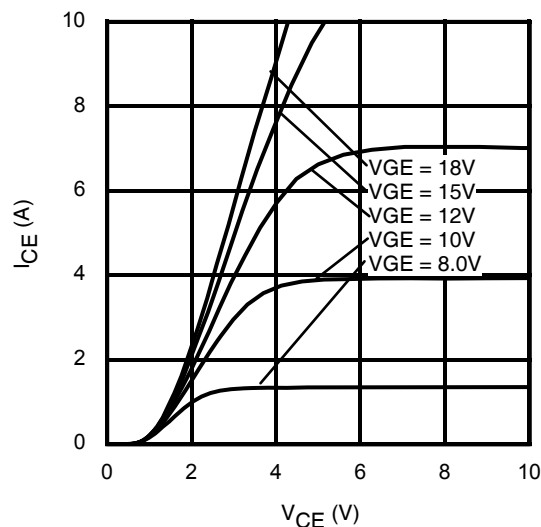


Fig. 7 - Typ. IGBT Output Characteristics
 $T_J = 25^{\circ}\text{C}$; $t_p = 20\mu\text{s}$

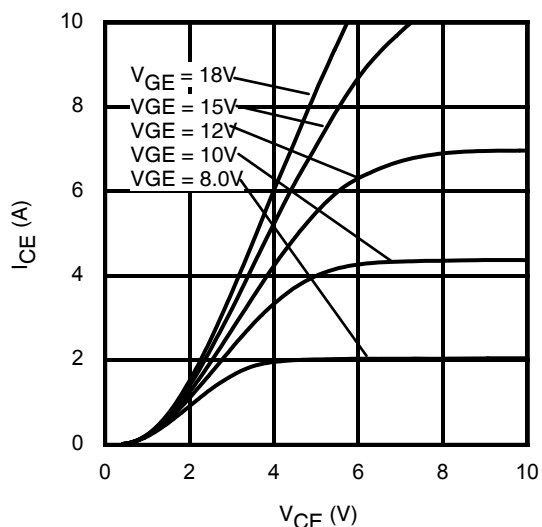


Fig. 8 - Typ. IGBT Output Characteristics
 $T_J = 150^{\circ}\text{C}$; $t_p = 20\mu\text{s}$

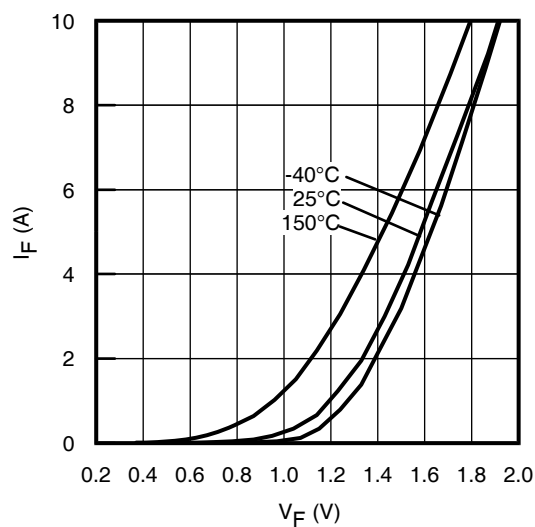


Fig. 9 - Typ. Diode Forward Voltage Drop Characteristics

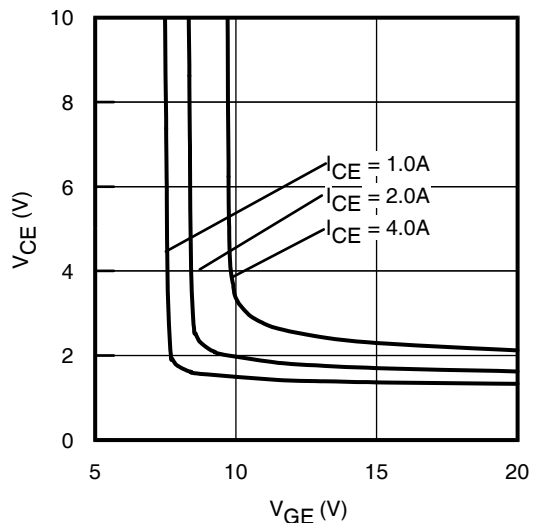


Fig. 10 - Typical V_{CE} vs. V_{GE}
 $T_J = -40^{\circ}\text{C}$

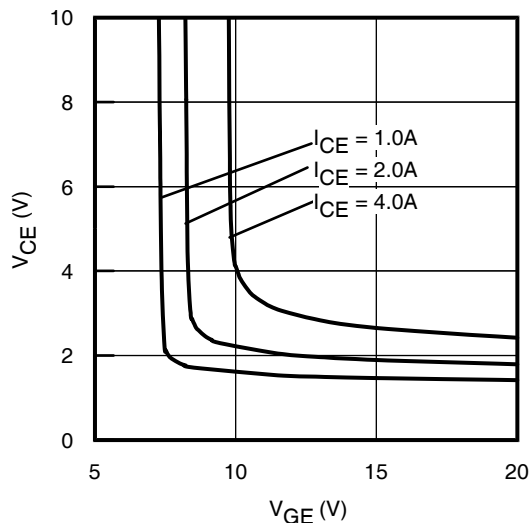


Fig. 11 - Typical V_{CE} vs. V_{GE}
 $T_J = 25^{\circ}\text{C}$

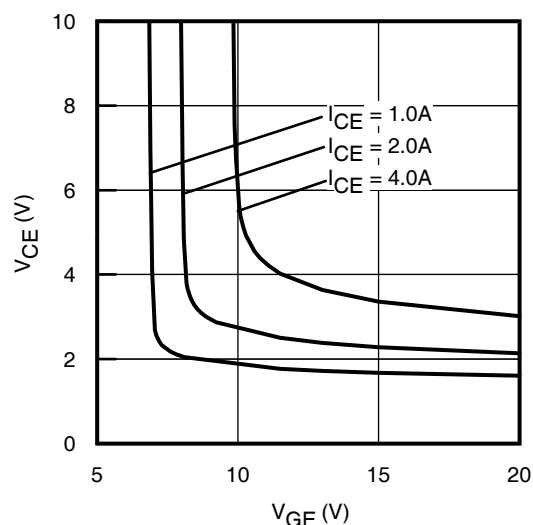


Fig. 12 - Typical V_{CE} vs. V_{GE}
 $T_J = 150^\circ\text{C}$

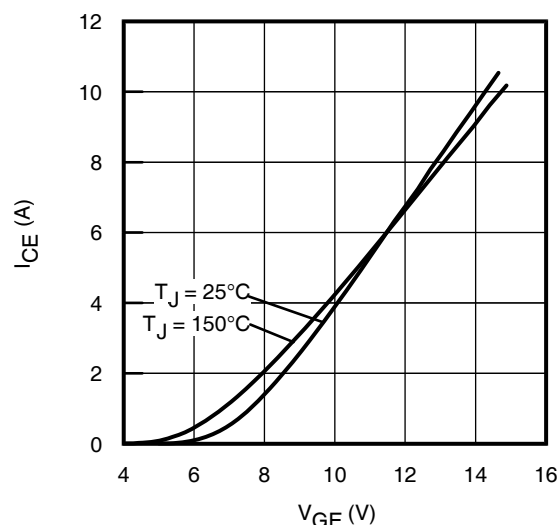


Fig. 13 - Typ. Transfer Characteristics
 $V_{CE} = 50\text{V}$; $t_p = 20\mu\text{s}$

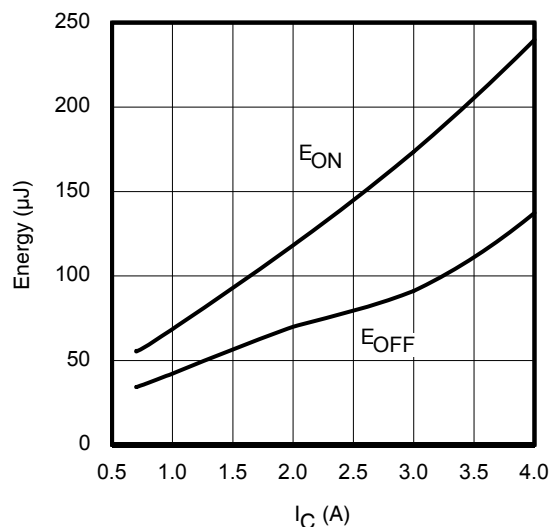


Fig. 14 - Typ. Energy Loss vs. I_C
 $T_J = 150^\circ\text{C}$; $L = 7.1\text{mH}$; $V_{CE} = 400\text{V}$; $R_G = 100\Omega$; $V_{GE} = 15\text{V}$

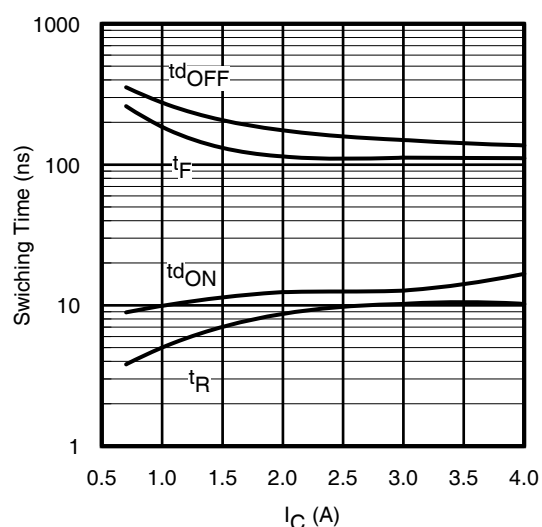


Fig. 15 - Typ. Switching Time vs. I_C
 $T_J = 150^\circ\text{C}$; $L = 7.1\text{mH}$; $V_{CE} = 400\text{V}$; $R_G = 100\Omega$; $V_{GE} = 15\text{V}$

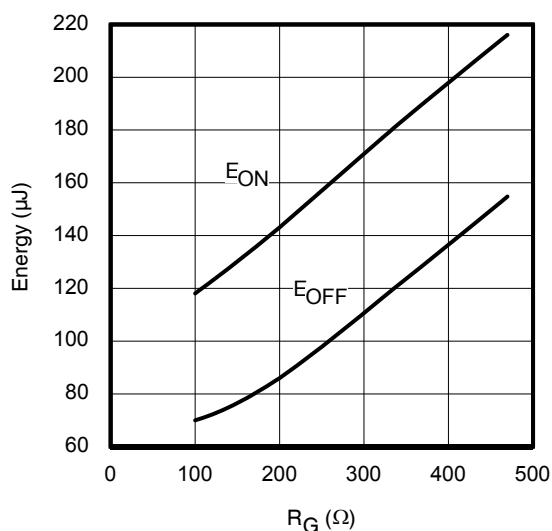


Fig. 16 - Typ. Energy Loss vs. R_G
 $T_J = 150^\circ\text{C}$; $L = 7.1\text{mH}$; $V_{CE} = 400\text{V}$; $I_{CE} = 2.0\text{A}$; $V_{GE} = 15\text{V}$

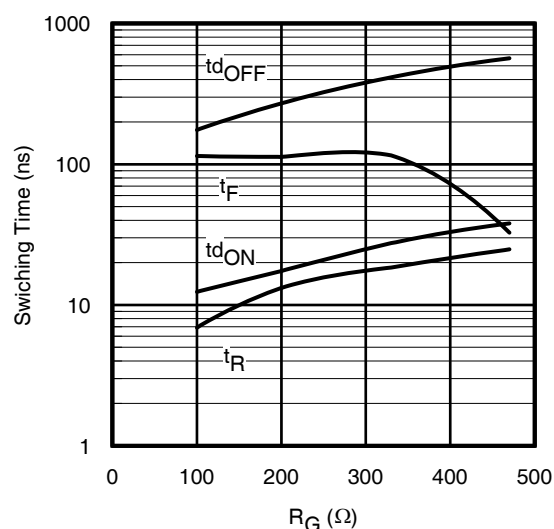


Fig. 17 - Typ. Switching Time vs. R_G
 $T_J = 150^\circ\text{C}$; $L = 7.1\text{mH}$; $V_{CE} = 400\text{V}$; $I_{CE} = 2.0\text{A}$; $V_{GE} = 15\text{V}$

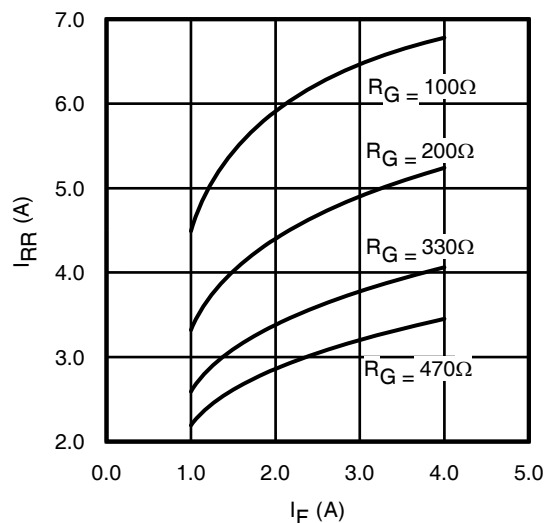


Fig. 18 - Typical Diode I_{RR} vs. I_F
 $T_J = 150^\circ\text{C}$

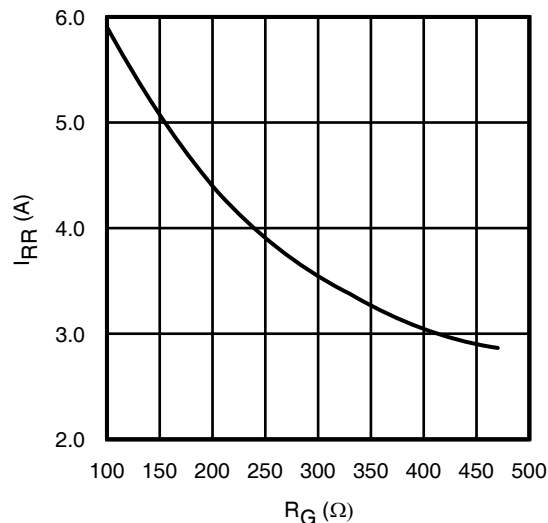


Fig. 19 - Typical Diode I_{RR} vs. R_G
 $T_J = 150^\circ\text{C}; I_F = 2.0\text{A}$

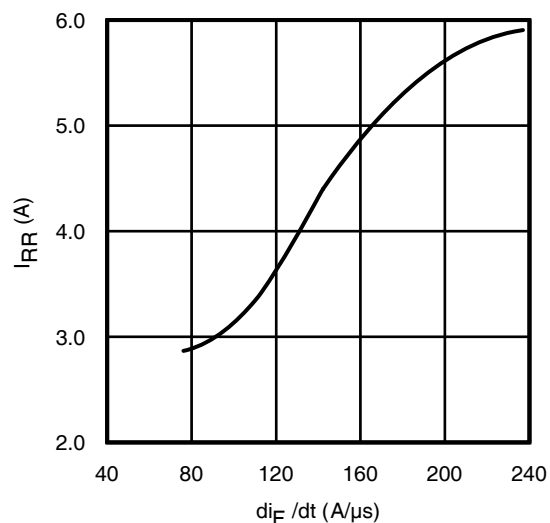


Fig. 20 - Typical Diode I_{RR} vs. di_F/dt
 $V_{CC} = 400\text{V}; V_{GE} = 15\text{V}; I_F = 2.0\text{A}; T_J = 150^\circ\text{C}$

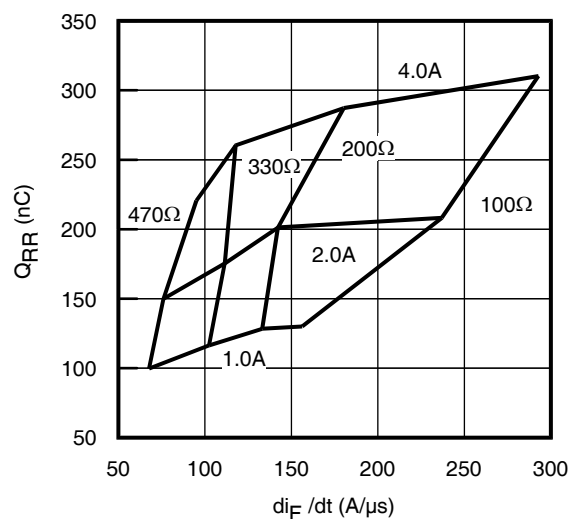


Fig. 21 - Typical Diode Q_{RR}
 $V_{CC} = 400\text{V}; V_{GE} = 15\text{V}; T_J = 150^\circ\text{C}$

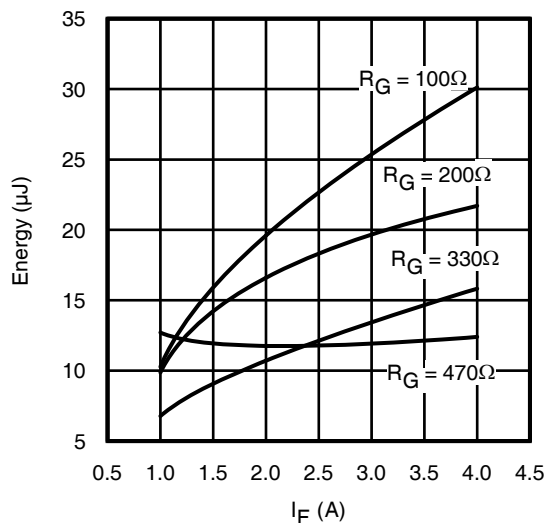


Fig. 22 - Typ. Diode E_{RR} vs. I_F
 $T_J = 150^\circ\text{C}$

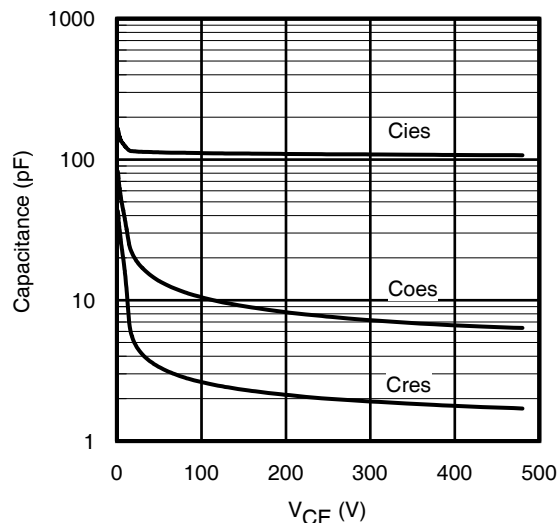


Fig. 23 - Typ. Capacitance vs. V_{CE}
 $V_{GE} = 0\text{V}; f = 1\text{MHz}$

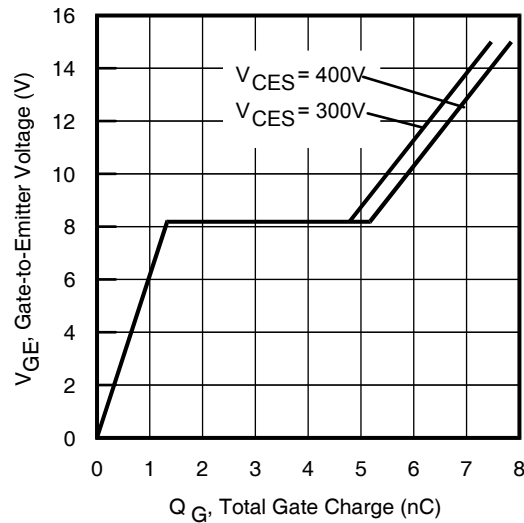


Fig. 23 - Typical Gate Charge vs. V_{GE}
 $I_{CE} = 2.0A$

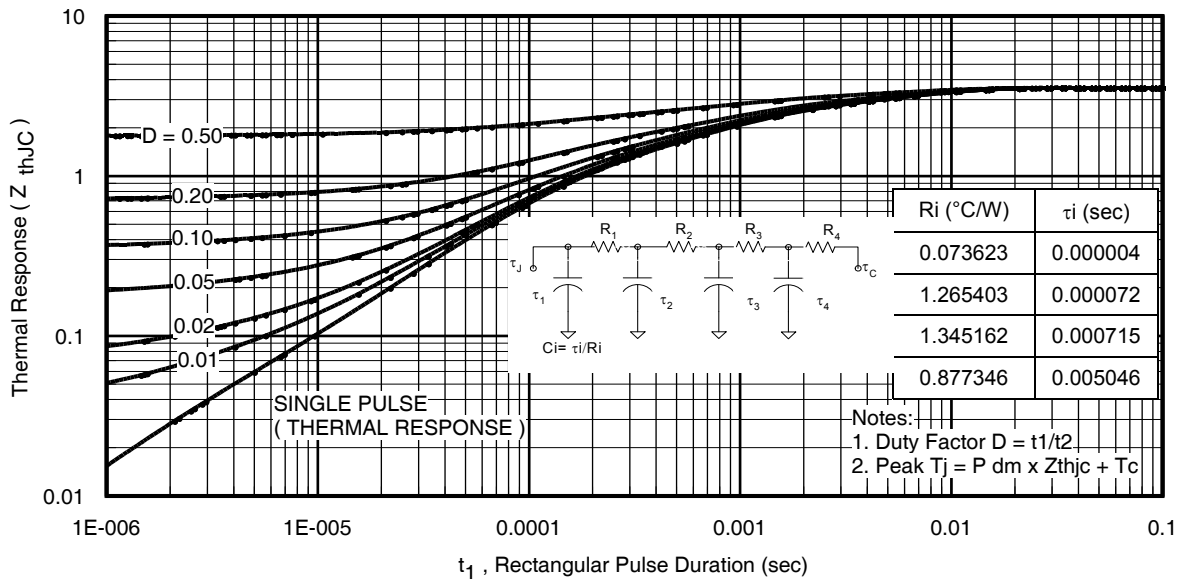


Fig. 24 - Maximum Transient Thermal Impedance, Junction-to-Case (IGBT)

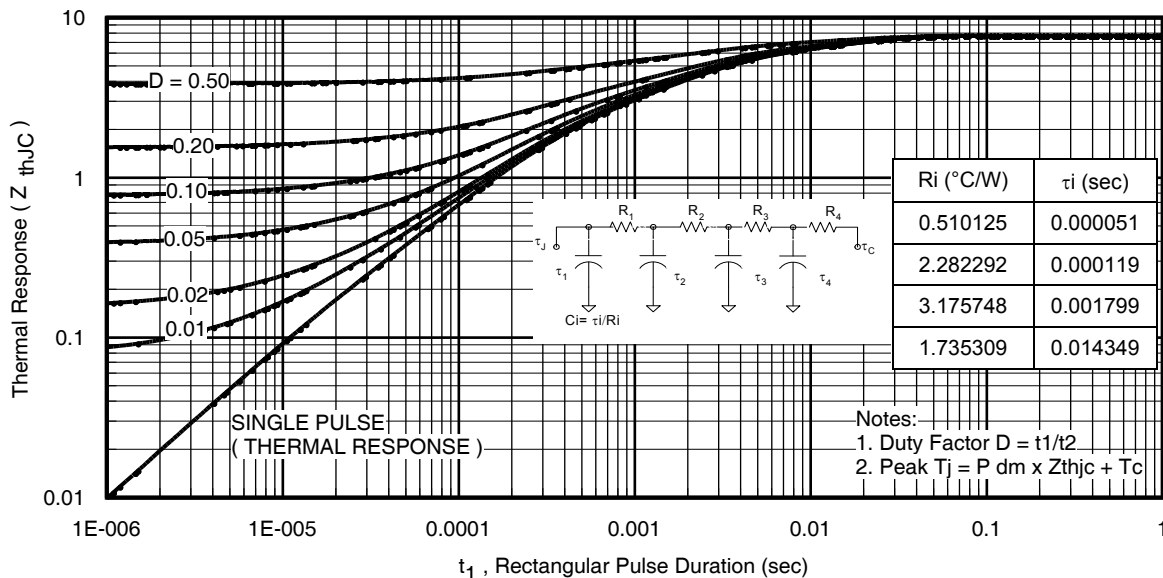


Fig. 25 - Maximum Transient Thermal Impedance, Junction-to-Case (DIODE)

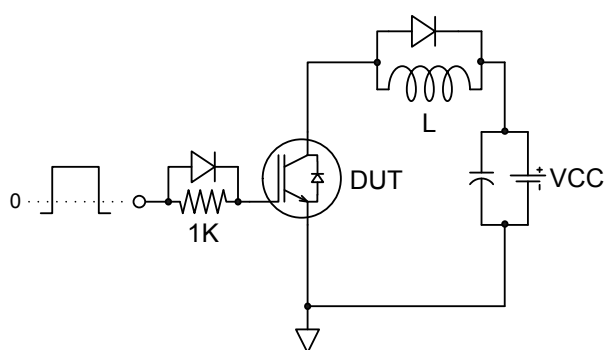


Fig.C.T.1 - Gate Charge Circuit (turn-off)

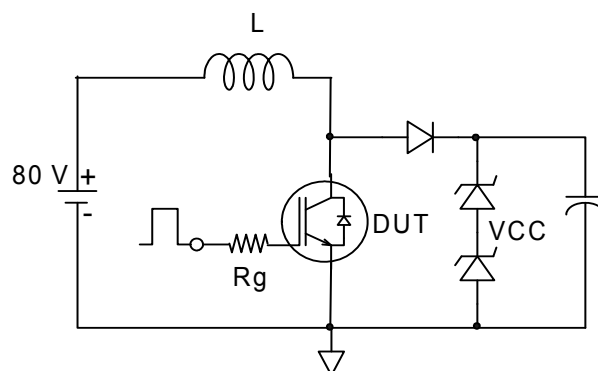


Fig.C.T.2 - RBSOA Circuit

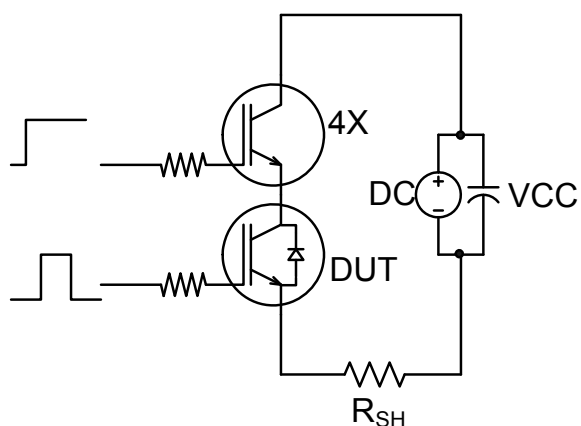


Fig.C.T.3 - S.C. SOA Circuit

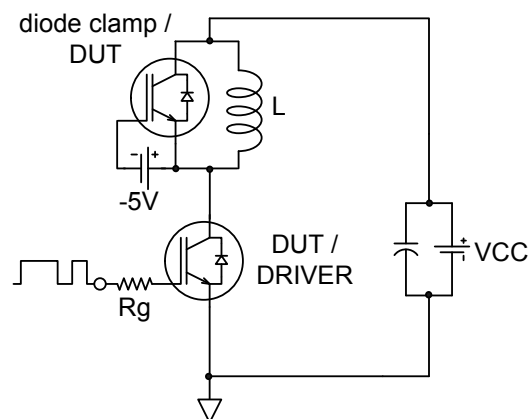


Fig.C.T.4 - Switching Loss Circuit

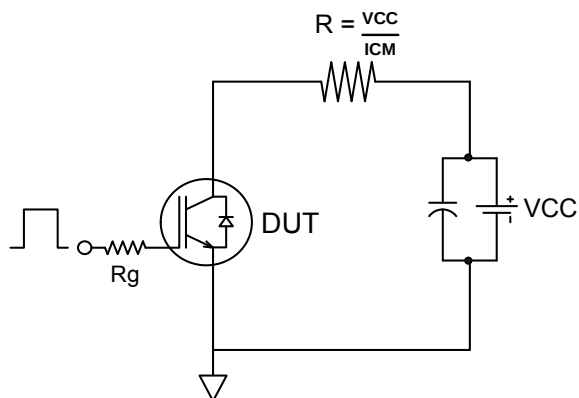


Fig. C.T.5 - Resistive Load Circuit

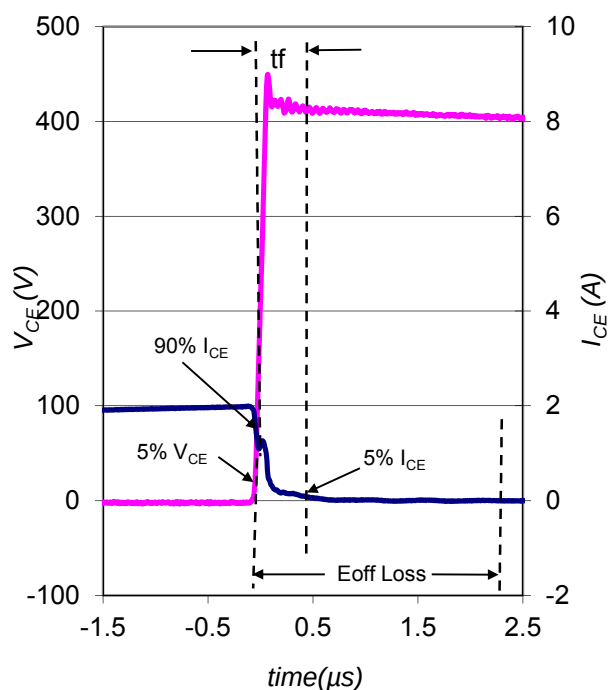


Fig. WF1 - Typ. Turn-off Loss Waveform
@ $T_J = 150^{\circ}\text{C}$ using Fig. CT.4

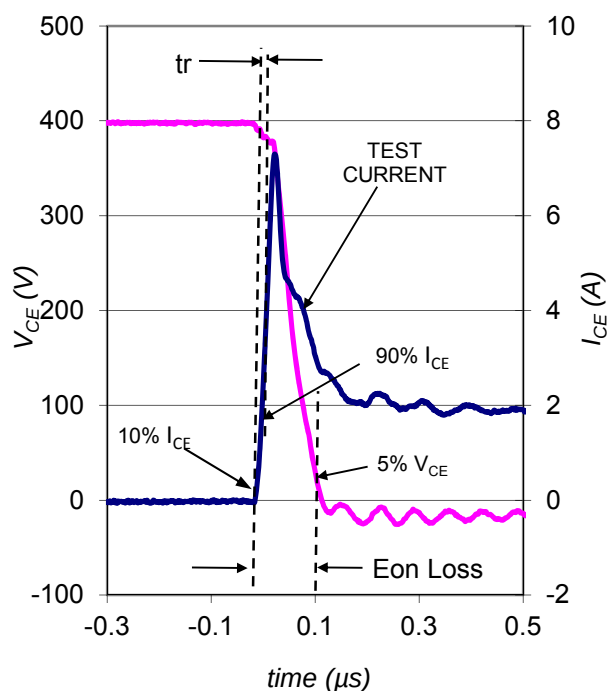


Fig. WF2 - Typ. Turn-on Loss Waveform
@ $T_J = 150^{\circ}\text{C}$ using Fig. CT.4

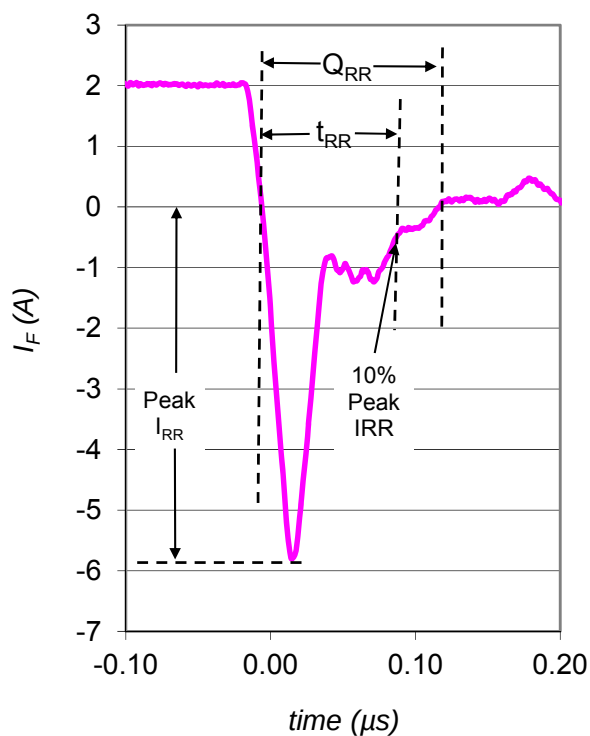


Fig. WF3 - Typ. Diode Recovery Waveform
@ $T_J = 150^{\circ}\text{C}$ using Fig. CT.4

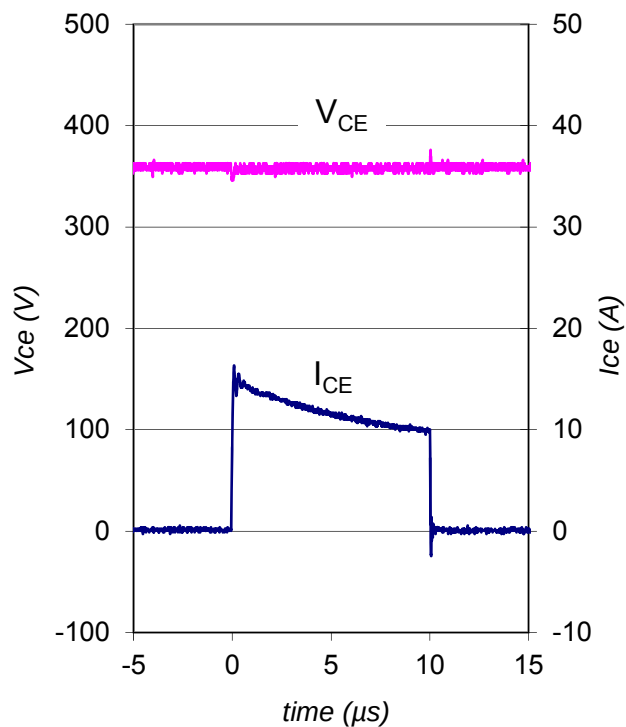
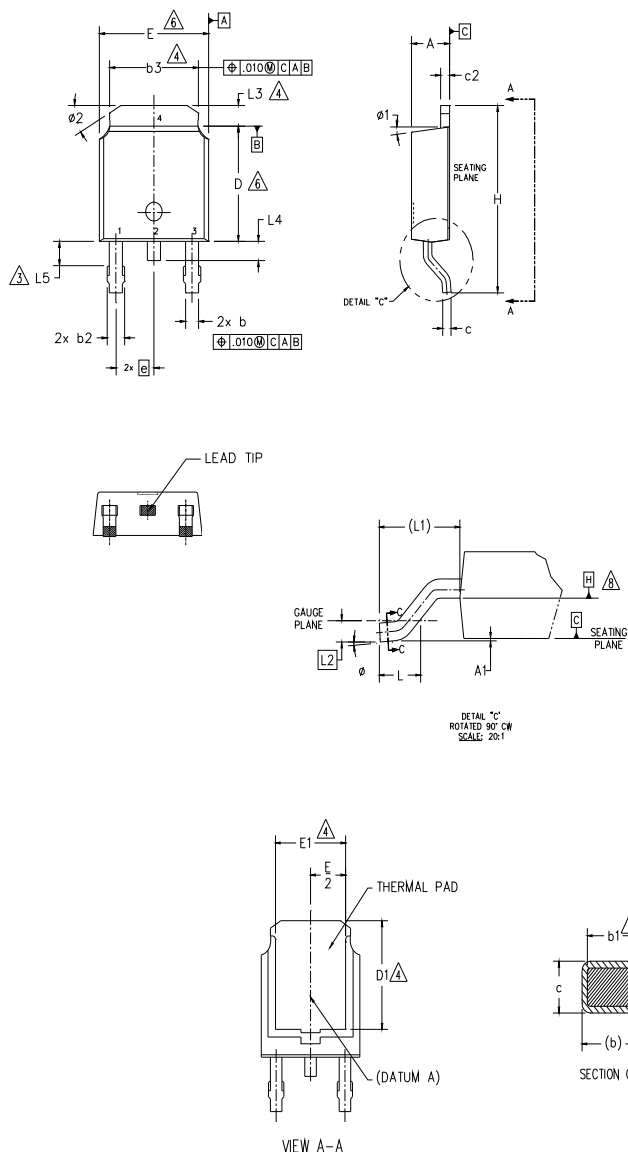


Fig. WF4 - Typ. S.C. Waveform
@ $T_J = 150^{\circ}\text{C}$ using Fig. CT.3

D-Pak (TO-252AA) Package Outline

Dimensions are shown in millimeters (inches)



NOTES:

- 1.- DIMENSIONING AND TOLERANCING PER ASME Y14.5M-1994
- 2.- 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	7
A1	—	0.13	—	.005	
b	0.64	0.89	.025	.035	
b1	0.65	0.79	.025	.031	4
b2	0.76	1.14	.030	.045	
b3	4.95	5.46	.195	.215	
c	0.46	0.61	.018	.024	7
c1	0.41	0.56	.016	.022	
c2	0.46	0.89	.018	.035	
D	5.97	6.22	.235	.245	6
D1	5.21	—	.205	—	
E	6.35	6.73	.250	.265	4
E1	4.32	—	.170	—	
e	2.29 BSC		.090 BSC		4
H	9.40	10.41	.370	.410	
L	1.40	1.78	.055	.070	
L1	2.74 BSC		.108 REF.		3
L2	0.51 BSC		.020 BSC		
L3	0.89	1.27	.035	.050	
L4	—	1.02	—	.040	3
L5	1.14	1.52	.045	.060	
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'

INTERNATIONAL
RECTIFIER
LOGO

ASSEMBLY
LOT CODE



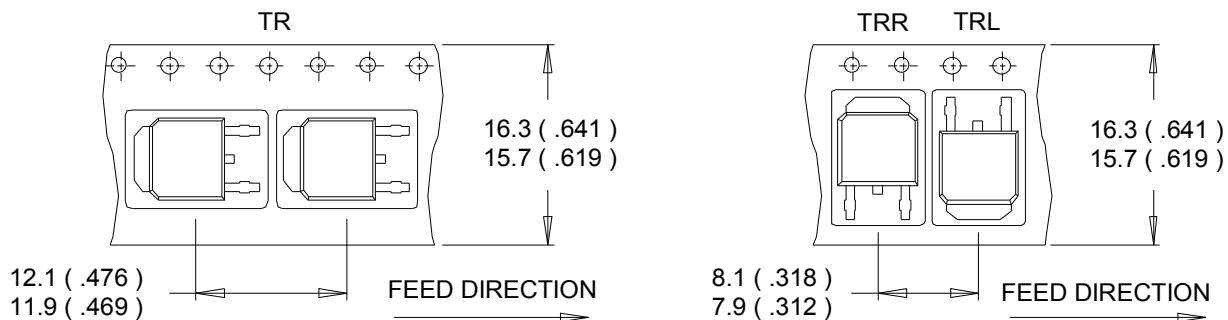
PART NUMBER

DATE CODE
YEAR 9 = 1999
WEEK 16
LINE A

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

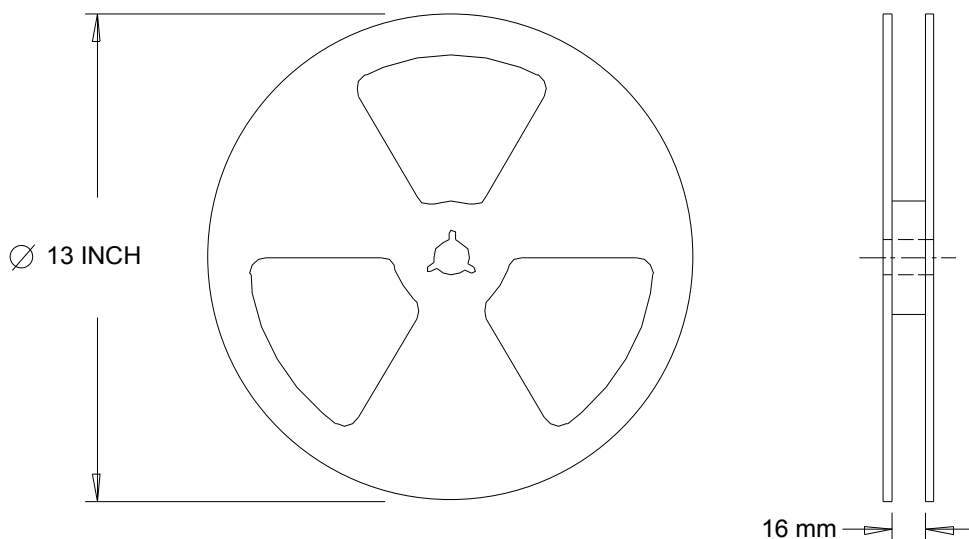
D-Pak (TO-252AA) Tape and Reel Information

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/>

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