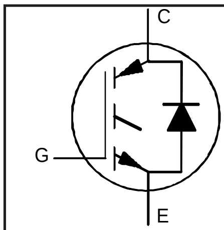
International
IOR Rectifier

PD - 94601A

IRGR3B60KD2

INSULATED GATE BIPOLAR TRANSISTOR WITH ULTRAFAST SOFT RECOVERY DIODE



n-channel

V_{CES} = 600V

I_C = 4.2A, T_C=100°C

t_{sc} > 10µs, T_J=150°C

$V_{CE(on)}$ typ. = 1.9V

Features
- Low VCE (on) Non Punch Through IGBT Technology.
- Low Diode VF.
- 10µs Short Circuit Capability.
- Square RBSOA.
- Ultrasoft Diode Reverse Recovery Characteristics.
- Positive VCE (on) Temperature Coefficient.

Benefits
- Benchmark Efficiency for Motor Control.
- Rugged Transient Performance.
- Low EMI.
- Excellent Current Sharing in Parallel Operation.


D-Pak

Absolute Maximum Ratings

	Parameter	Max.	Units
V_{CES}	Collector-to-Emitter Voltage	600	V
I_C @ T_C = 25°C	Continuous Collector Current	7.8	A
I_C @ T_C = 100°C	Continuous Collector Current	4.2	
I_{CM}	Pulse Collector Current (Ref.Fig.C.T.5)	15.6	
I_{LM}	Clamped Inductive Load current ①	15.6	
I_F @ Tc = 25°C	Diode Continous Forward Current	6.0	
I_F @ Tc = 100°C	Diode Continuous Forward Current	3.2	
I_{FM}	Diode Maximum Forward Current	15.6	
V_{GE}	Gate-to-Emitter Voltage	±20	V
P_D @ T_C = 25°C	Maximum Power Dissipation	52	W
P_D @ T_C = 100°C	Maximum Power Dissipation	21	
T_J T_{STG}	Operating Junction and Storage Temperature Range	-55 to +150	°C
	Soldering Temperature Range, for 10 sec.	300 (0.063 in. (1.6mm) from case)	

Thermal / Mechanical Characteristics

	Parameter	Min.	Typ.	Max.	Units
$R_{\theta JC}$	Junction-to-Case- IGBT	—	—	2.4	°C/W
$R_{\theta JC}$	Junction-to-Case- Diode	—	—	8.8	
$R_{\theta JA}$	Junction-to-Ambient, (PCB Mount) ②	—	—	50	
Wt	Weight	—	0.3	—	g

03/24/03

Electrical Characteristics @ T_J = 25℃ (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 = 500µA	
$\Delta V_{(BR)CES}/\Delta T_J$	Temperature Coeff. of Breakdown Voltage	—	0.32	—	V/℃	V_{GE} = 0V, I_C = 1mA (25℃-150℃)	
$V_{CE(on)}$	Collector-to-Emitter Voltage	—	1.9	2.4	V	I_C = 3.0A, V_{GE} = 15V	5,6,7
		—	2.2	2.6		I_C = 3.0A, V_{GE} = 15V, T_J = 150℃	9,10,11
$V_{GE(th)}$	Gate Threshold Voltage	3.5	4.5	5.5		V_{CE} = V_{GE}, I_C = 250µA	9,10,11
$\Delta V_{GE(th)}/\Delta T_J$	Threshold Voltage temp. coefficient	—	-8.5	—	mV/°C	V_{CE} = V_{GE}, I_C = 1mA (25℃-150℃)	12
gfe	Forward Transconductance	—	1.9	—	S	V_{CE} = 50V, I_C = 3.0A, PW = 80µs	
I_{CES}	Zero Gate Voltage Collector Current	—	1.0	150	µA	V_{GE} = 0V, V_{CE} = 600V	
		—	200	500		V_{GE} = 0V, V_{CE} = 600V, T_J = 150℃	
V_{FM}	Diode Forward Voltage Drop	—	1.5	1.8	V	I_F = 3.0A, V_{GE} = 0V	8
		—	1.5	1.8		I_F = 3.0A, V_{GE} = 0V, T_J = 150℃	
I_{GES}	Gate-to-Emitter Leakage Current	—	—	±100	nA	V_{GE} = ±20V, V_{CE} = 0V	

Switching Characteristics @ T_J = 25℃ (unless otherwise specified)

	Parameter	Min.	Typ.	Max.	Units	Conditions	Ref.Fig.
Q_g	Total Gate Charge (turn-on)	—	13	20	nC	I_C = 3.0A	23
Q_{ge}	Gate-to-Emitter Charge (turn-on)	—	1.5	2.3		V_{CC} = 400V	CT1
Q_{gc}	Gate-to-Collector Charge (turn-on)	—	6.6	9.9		V_{GE} = 15V	
E_{on}	Turn-On Switching Loss	—	62	75	µJ	I_C = 3.0A, V_{CC} = 400V	CT4
E_{off}	Turn-Off Switching Loss	—	39	50		V_{GE} = 15V, R_G = 100Ω, L = 2.5mH	
E_{tot}	Total Switching Loss	—	100	120		T_J = 25℃ ③	
$t_{d(on)}$	Turn-On delay time	—	18	22	ns	I_C = 3.0A, V_{CC} = 400V	
t_r	Rise time	—	15	21		V_{GE} = 15V, R_G = 100Ω, L = 2.5mH	CT4
$t_{d(off)}$	Turn-Off delay time	—	110	120		T_J = 25℃	
t_f	Fall time	—	68	80			
E_{on}	Turn-On Switching Loss	—	91	100	µJ	I_C = 3.0A, V_{CC} = 400V	CT4
E_{off}	Turn-Off Switching Loss	—	98	140		V_{GE} = 15V, R_G = 100Ω, L = 2.5mH	13,15
E_{tot}	Total Switching Loss	—	190	230		T_J = 150℃ ③	WF1,WF2
$t_{d(on)}$	Turn-On delay time	—	18	22	ns	I_C = 3.0A, V_{CC} = 400V	14,16
t_r	Rise time	—	17	22		V_{GE} = 15V, R_G = 100Ω, L = 2.5mH	CT4
$t_{d(off)}$	Turn-Off delay time	—	120	140		T_J = 150℃	WF1
t_f	Fall time	—	91	105			WF2
C_{ies}	Input Capacitance	—	190	—	pF	V_{GE} = 0V	
C_{oes}	Output Capacitance	—	23	—		V_{CC} = 30V	22
C_{res}	Reverse Transfer Capacitance	—	6.6	—		f = 1.0MHz	
RBSOA	Reverse Bias Safe Operating Area	FULL SQUARE				T_J = 150℃, I_C = 15.6A, Vp = 600V	4
						V_{CC}=500V,V_{GE}=+15V to 0V,R_G = 100Ω	CT2
SCSOA	Short Circuit Safe Operating Area	10	—	—	µs	T_J = 150℃, Vp = 600V, R_G = 100Ω	CT3
						V_{CC}=360V,V_{GE} = +15V to 0V	WF4
Erec	Reverse Recovery Energy of the Diode	—	38	44	µJ	T_J = 150℃	17,18,19
t_{rr}	Diode Reverse Recovery Time	—	77	84	ns	V_{CC} = 400V, I_F = 3.0A, L = 2.5mH	20,21
I_{rr}	Diode Peak Reverse Recovery Current	—	4.8	5.3	A	V_{GE} = 15V, R_G = 100Ω	CT4,WF3

① V_{CC} = 80% (V_{CES}), V_{GE} = 15V, L = 100µH, R_G = 100Ω.

② When mounted on 1" square PCB (FR-4 or G-10 Material). For recommended footprint and soldering techniques refer to application note #AN-994.

③ Energy losses include "tail" and diode reverse recovery.

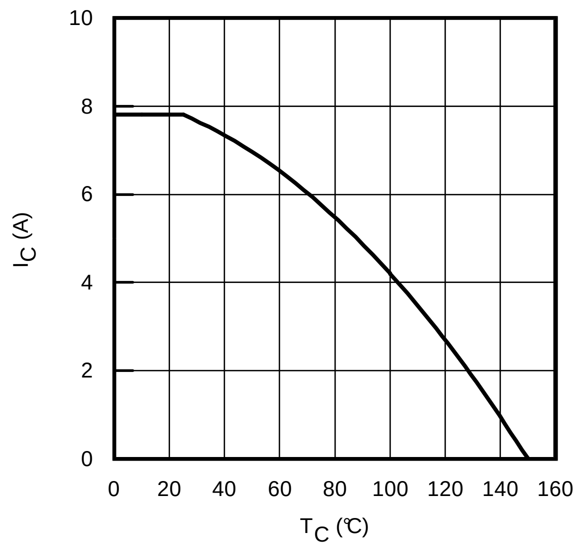


Fig. 1 - Maximum DC Collector Current vs. Case Temperature

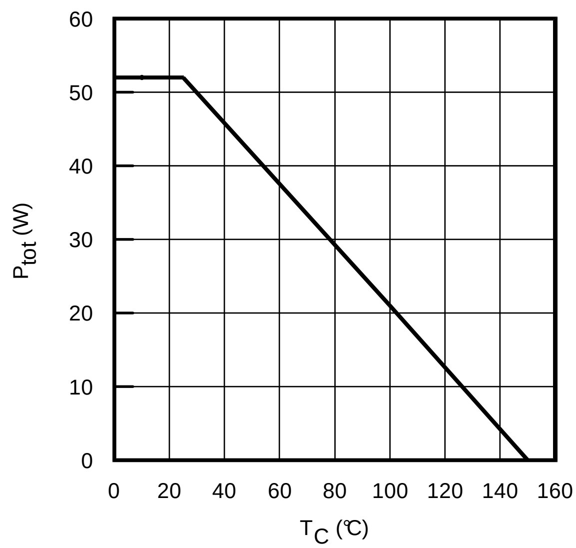


Fig. 2 - Power Dissipation vs. Case Temperature

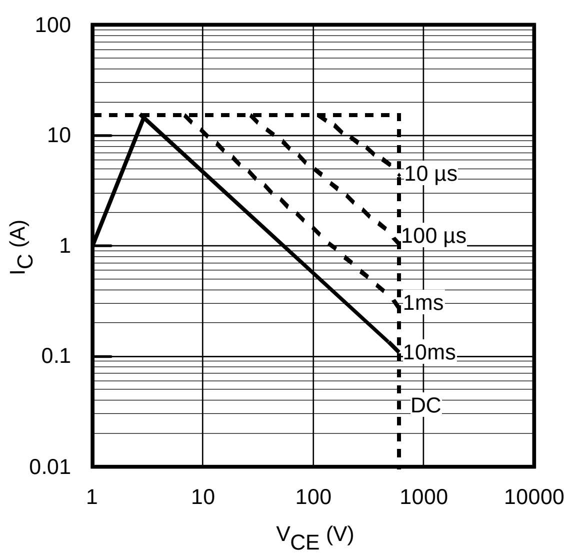


Fig. 3 - Forward SOA
T_C = 25℃; $T_J \leq$ 150℃

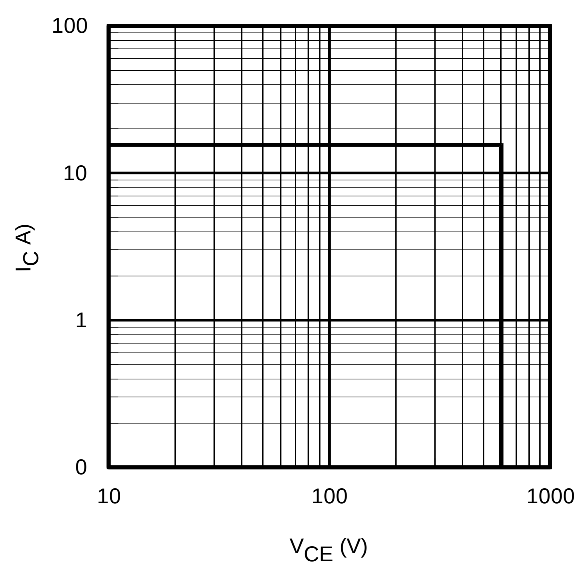


Fig. 4 - Reverse Bias SOA
T_J = 150℃; V_{GE} =15V

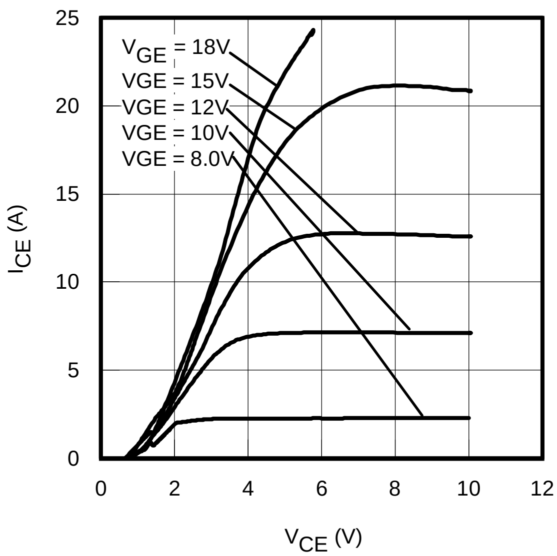


Fig. 5 - Typ. IGBT Output Characteristics
T_J = -40°C; tp = 80µs

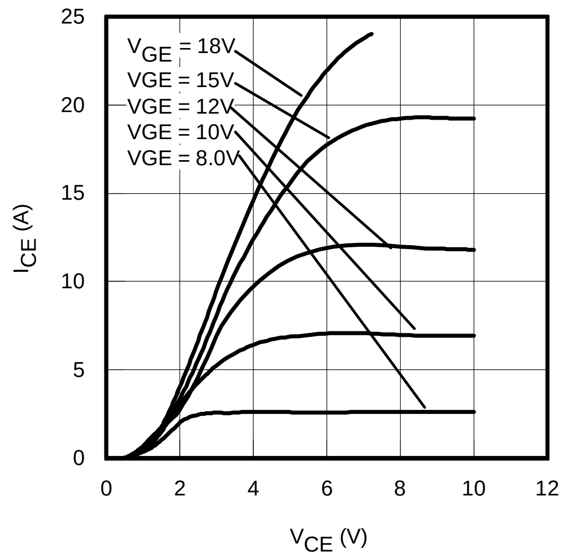


Fig. 6 - Typ. IGBT Output Characteristics
T_J = 25°C; tp = 80µs

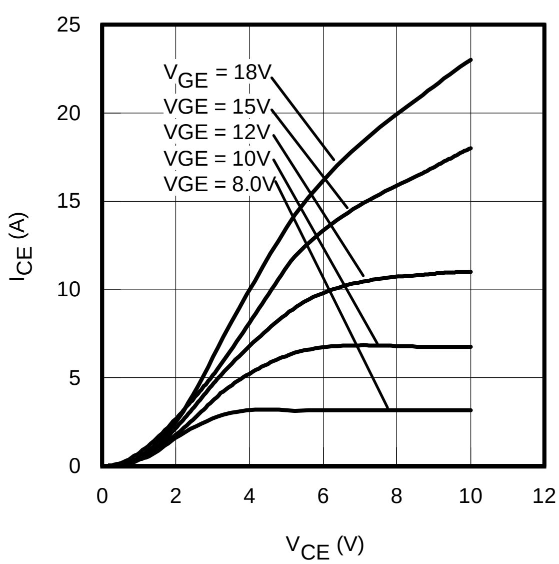


Fig. 7 - Typ. IGBT Output Characteristics
T_J = 150°C; tp = 80µs

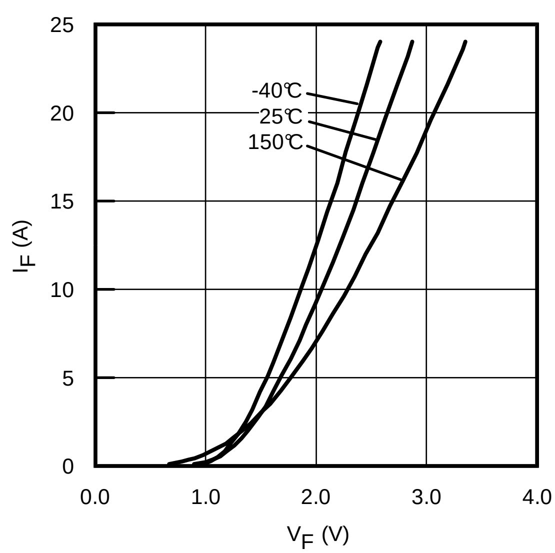


Fig. 8 - Typ. Diode Forward Characteristics
tp = 80µs

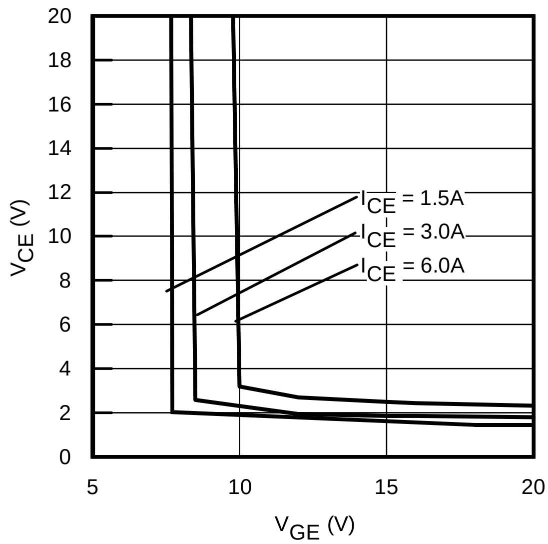


Fig. 9 - Typical V_{CE} vs. V_{GE}
T_J = -40°C

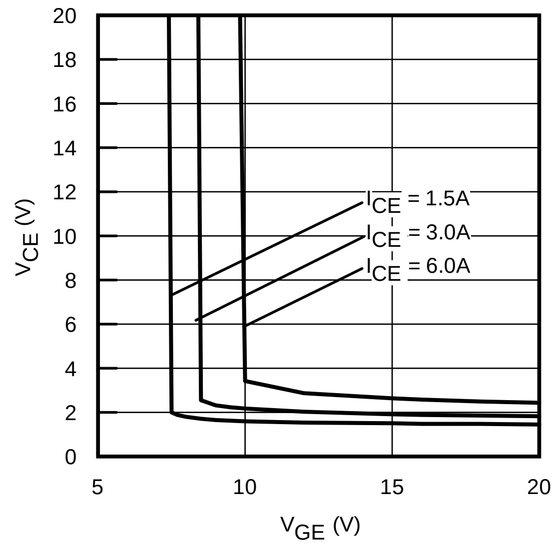


Fig. 10 - Typical V_{CE} vs. V_{GE}
T_J = 25°C

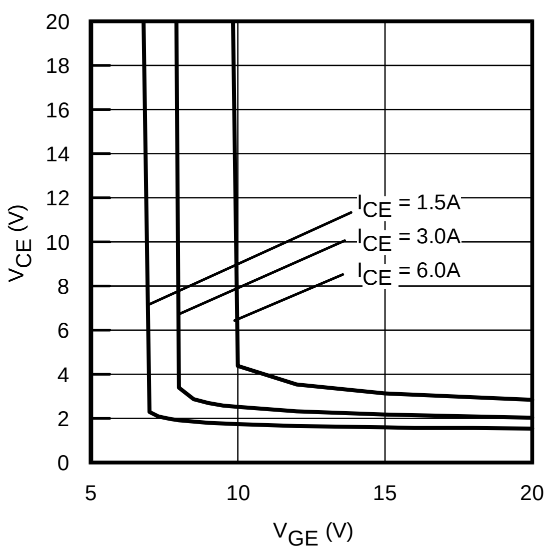


Fig. 11 - Typical V_{CE} vs. V_{GE}
T_J = 150°C

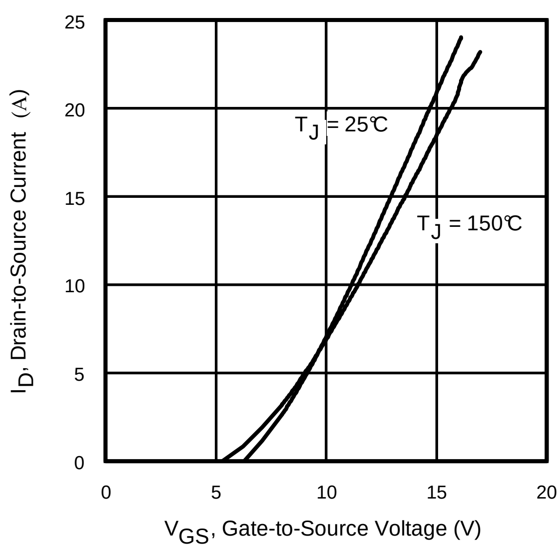


Fig. 12 - Typ. Transfer Characteristics
V_{CE} = 50V; tp = 10µs

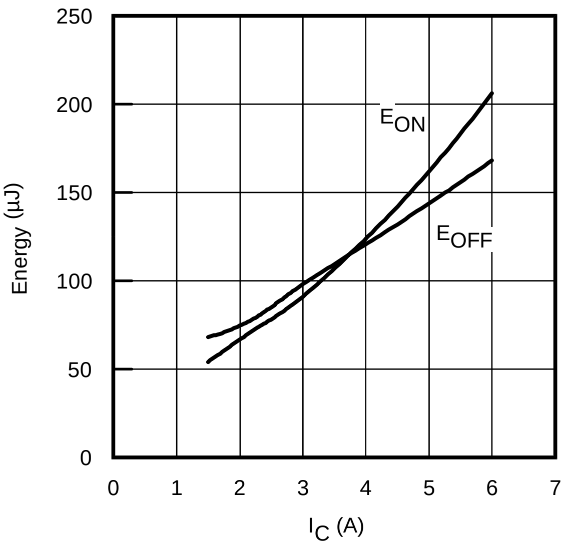


Fig. 13 - Typ. Energy Loss vs. I_C
T_J = 150°C; L=2.5mH; V_{CE}= 400V
R_G= 100Ω; V_{GE}= 15V

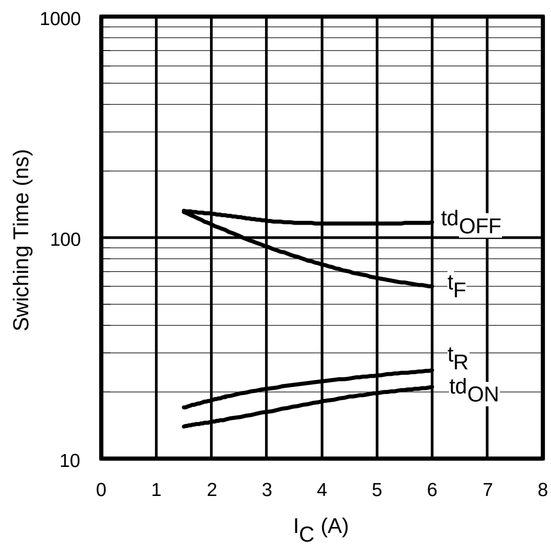


Fig. 14 - Typ. Switching Time vs. I_C
T_J = 150°C; L=2.5mH; V_{CE}= 400V
R_G= 100Ω; V_{GE}= 15V

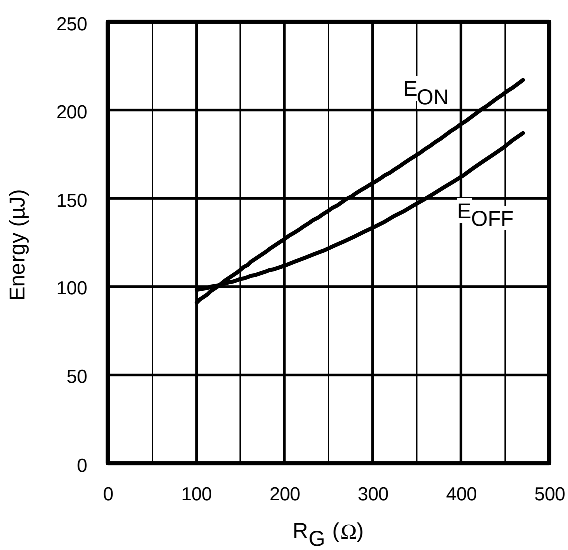


Fig. 15 - Typ. Energy Loss vs. R_G
T_J = 150°C; L=2.5mH; V_{CE}= 400V
I_{CE}= 3.0A; V_{GE}= 15V

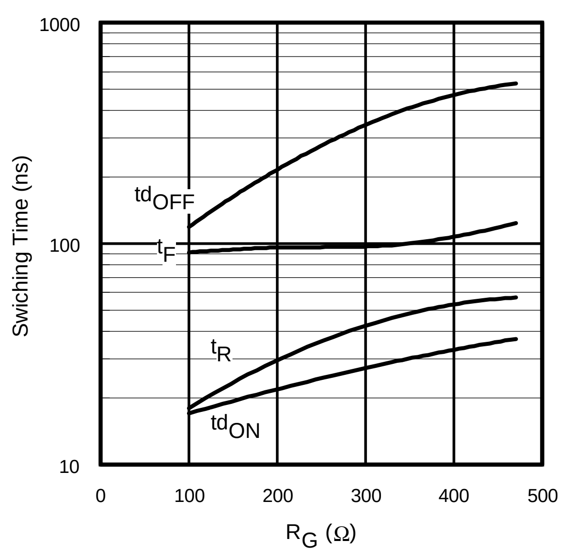


Fig. 16 - Typ. Switching Time vs. R_G
T_J = 150°C; L=2.5mH; V_{CE}= 400V
I_{CE}= 3.0A; V_{GE}= 15V

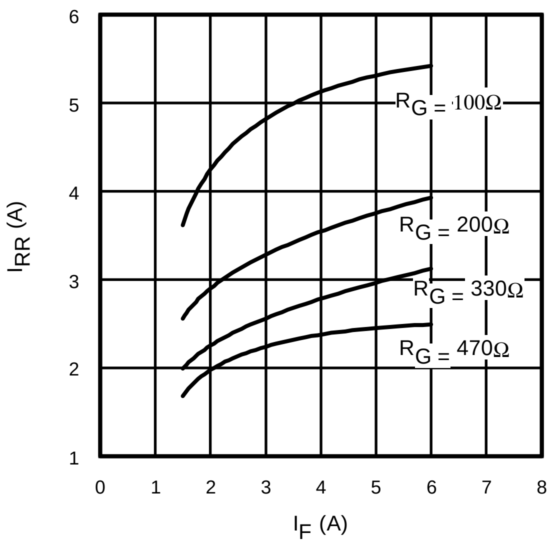


Fig. 17 - Typical Diode I_{RR} vs. I_F
T_J = 150℃

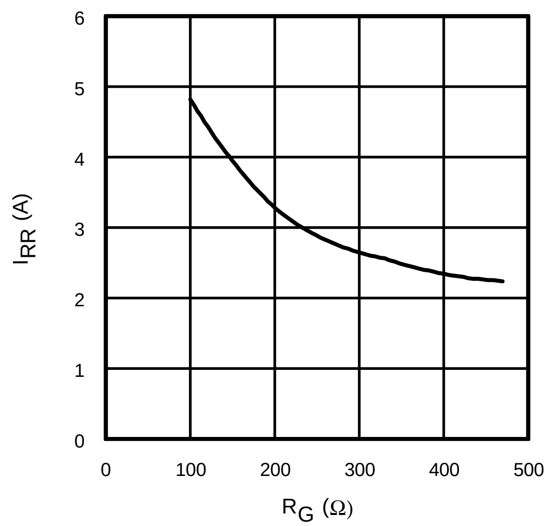


Fig. 18 - Typical Diode I_{RR} vs. R_G
T_J = 150℃; I_F = 3.0A

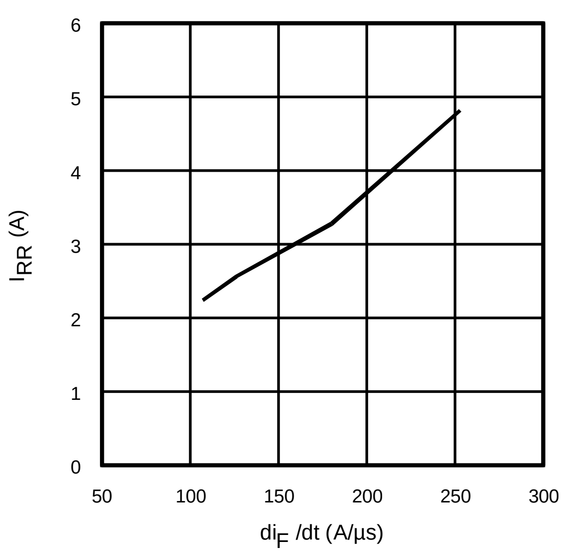


Fig. 19- Typical Diode I_{RR} vs. di_F/dt
V_{CC}= 400V; V_{GE}= 15V;
I_F = 3.0A; T_J = 150℃

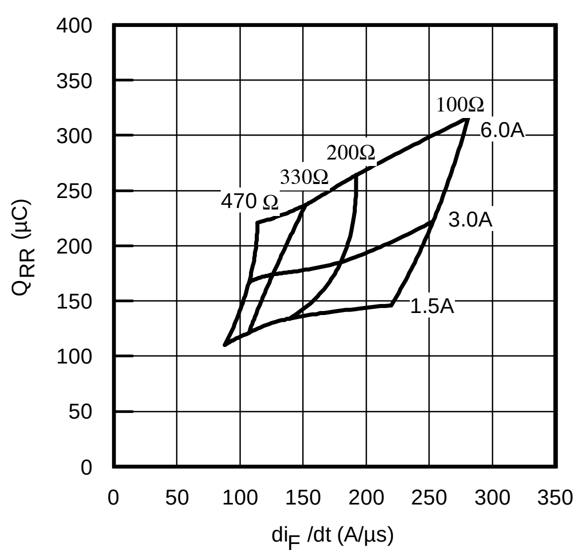


Fig. 20 - Typical Diode Q_{RR}
V_{CC}= 400V; V_{GE}= 15V;T_J = 150℃

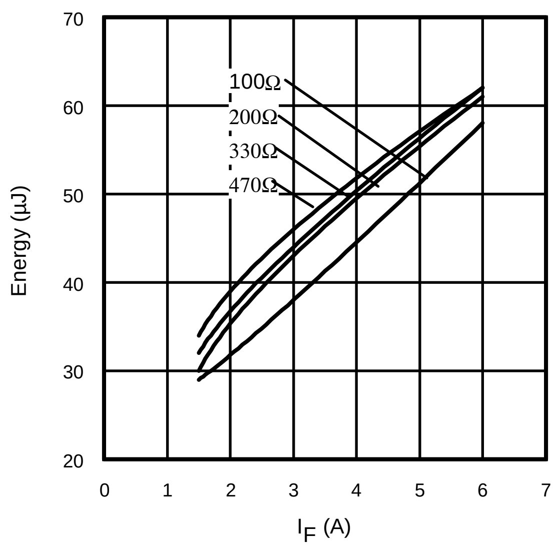


Fig. 21 - Typical Diode E_{RR} vs. I_F
T_J = 150°C

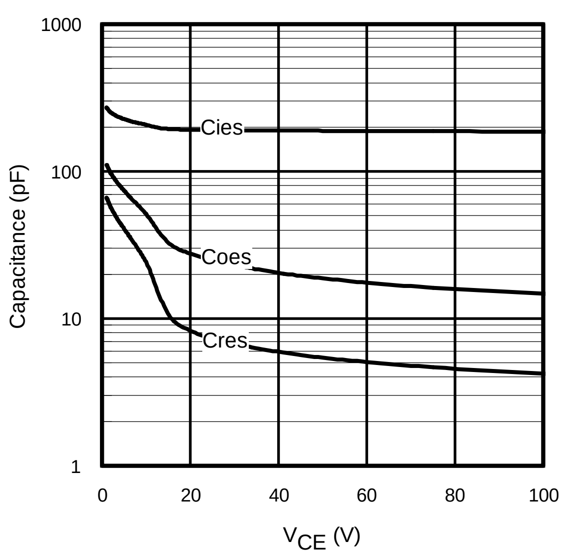


Fig. 22- Typ. Capacitance vs. V_{CE}
V_{GE}= 0V; f = 1MHz

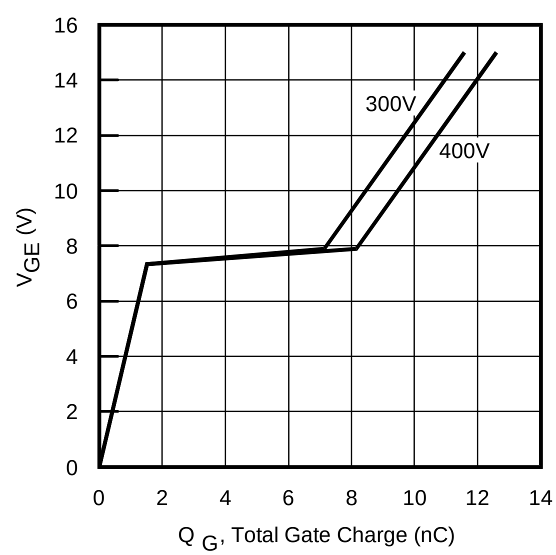


Fig. 23 - Typical Gate Charge vs. V_{GE}
I_{CE} = 3.0A; L = 600µH

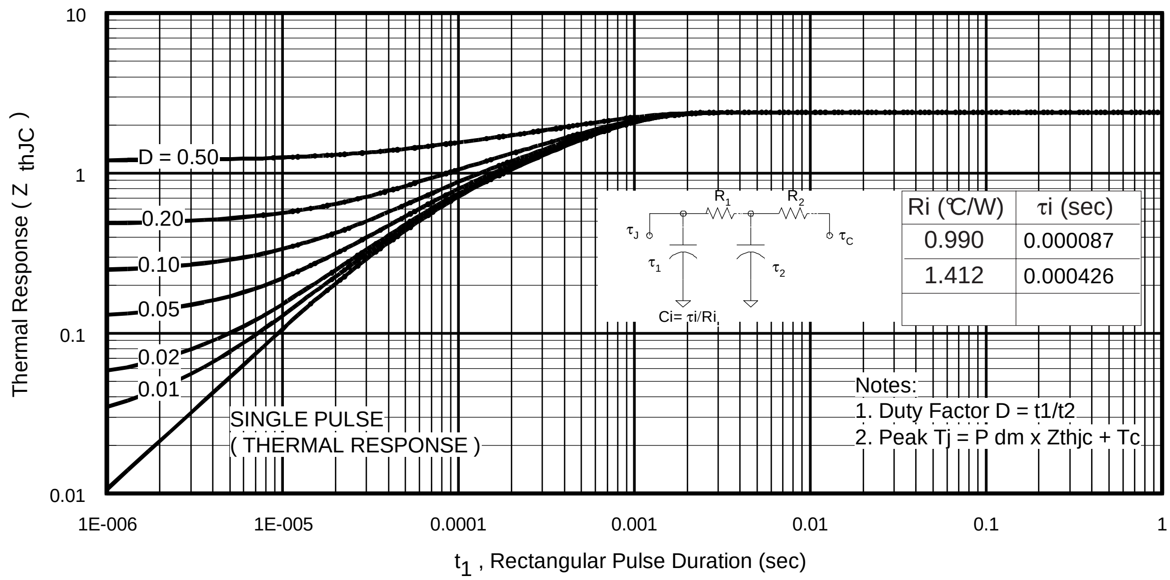


Fig 24. Maximum Transient Thermal Impedance, Junction-to-Case (IGBT)

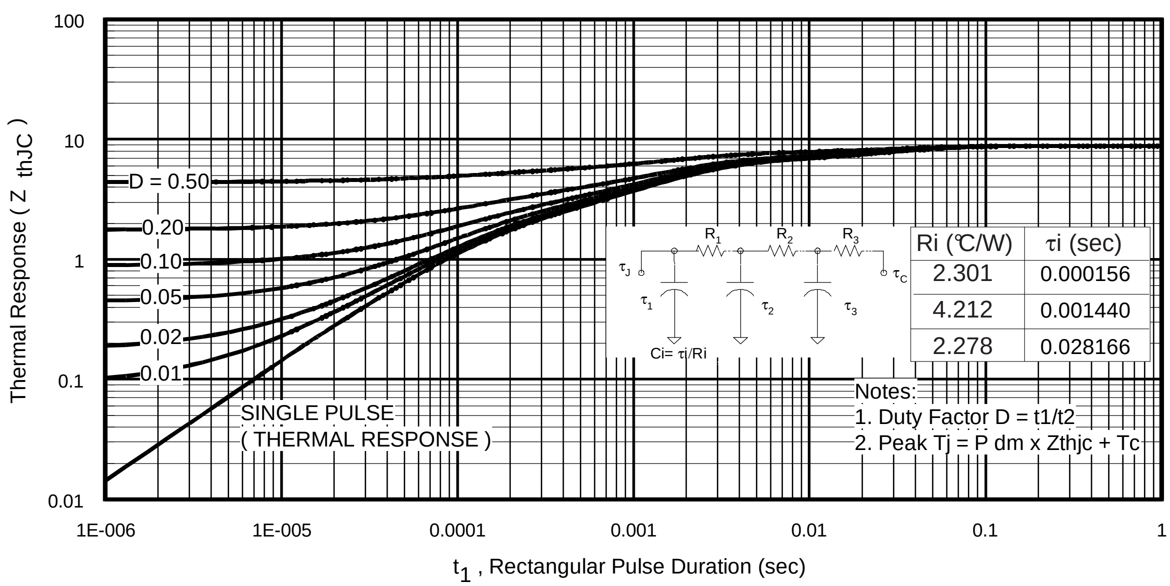


Fig 25. Maximum Transient Thermal Impedance, Junction-to-Case (DIODE)

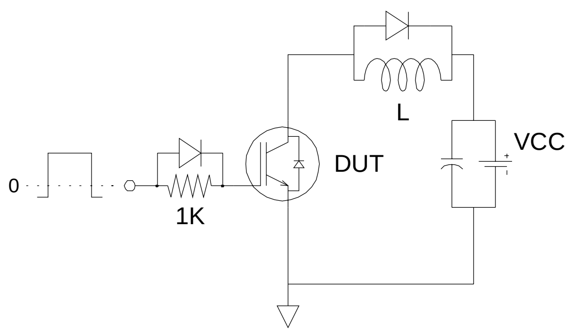


Fig.C.T.1 - Gate Charge Circuit (turn-off)

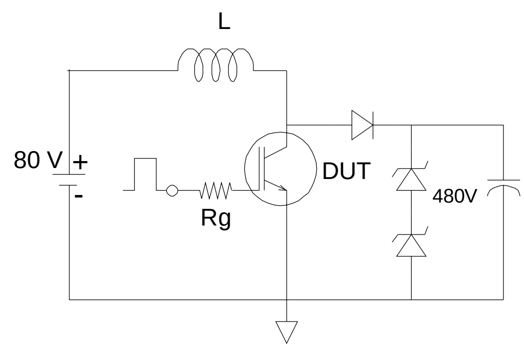


Fig.C.T.2 - RBSOA Circuit

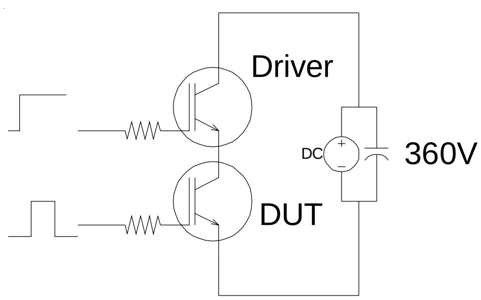


Fig.C.T.3 - S.C.SOA Circuit

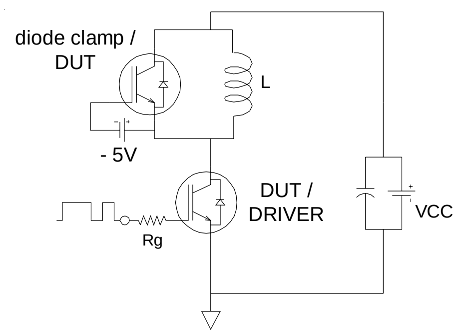


Fig.C.T.4 - Switching Loss Circuit

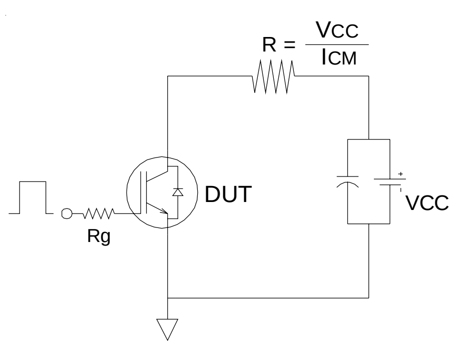


Fig.C.T.5 - Resistive Load Circuit

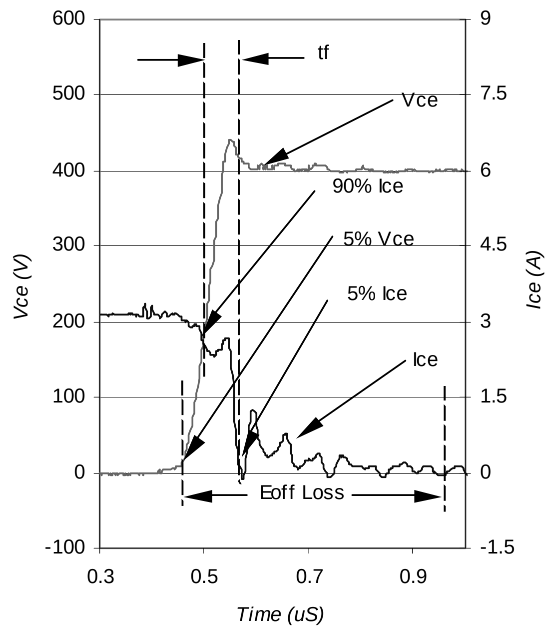


Fig. WF1- Typ. Turn-off Loss Waveform
@ T_J = 150°C using Fig. CT.4

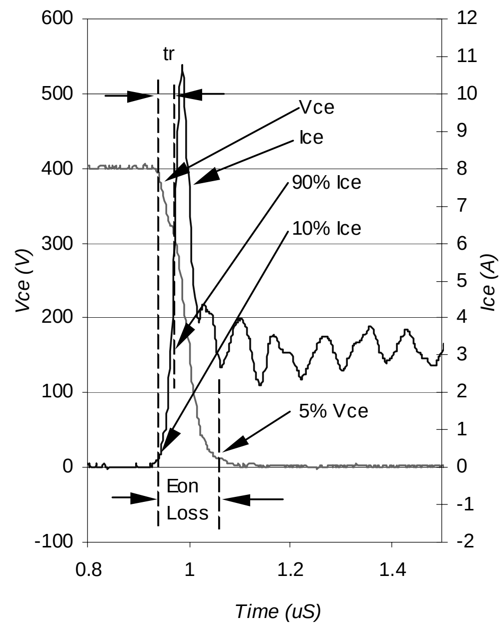


Fig. WF2- Typ. Turn-on Loss Waveform
@ T_J = 150°C using Fig. CT.4

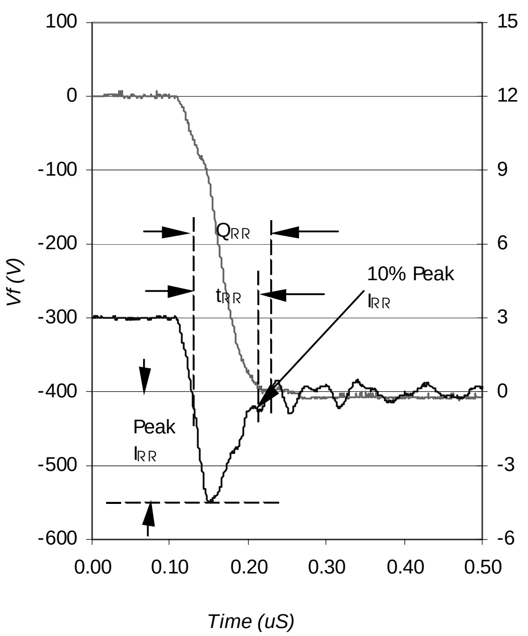


Fig. WF3- Typ. Diode Recovery Waveform
@ T_J = 150°C using Fig. CT.4

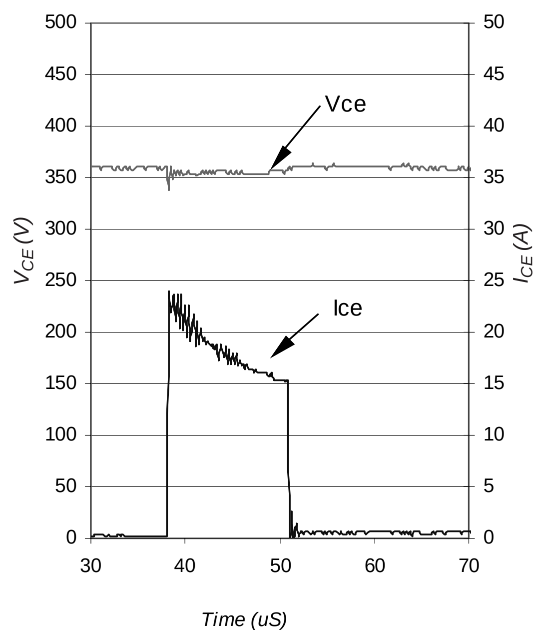
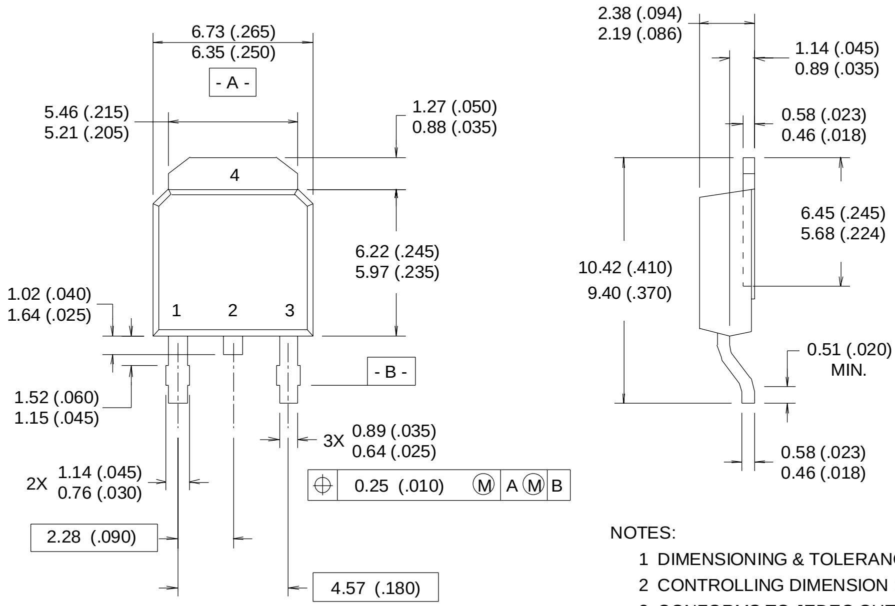


Fig. WF4- Typ. S.C Waveform
@ T_C = 150°C using Fig. CT.3

TO-252AA (D-Pak) Package Outline

Dimensions are shown in millimeters (inches)



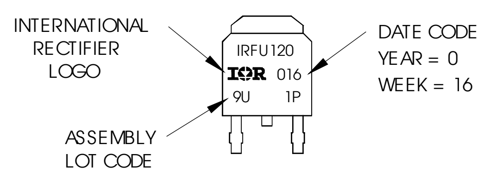
LEAD ASSIGNMENTS
1 - GATE
2 - DRAIN
3 - SOURCE
4 - DRAIN

NOTES:
1 DIMENSIONING & TOLERANCING PER ANSI Y14.5M, 1982.
2 CONTROLLING DIMENSION : INCH.
3 CONFORMS TO JEDEC OUTLINE TO-252AA.
4 DIMENSIONS SHOWN ARE BEFORE SOLDER DIP, SOLDER DIP MAX. +0.16 (.006).

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

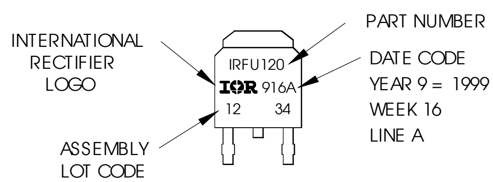
Notes: This part marking information applies to devices produced before 02/26/2001

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



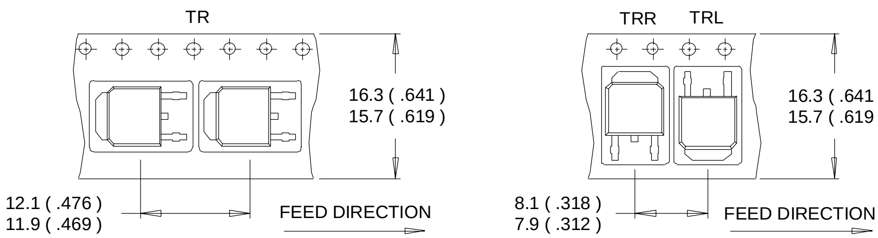
Notes: This part marking information applies to devices produced after 02/26/2001

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

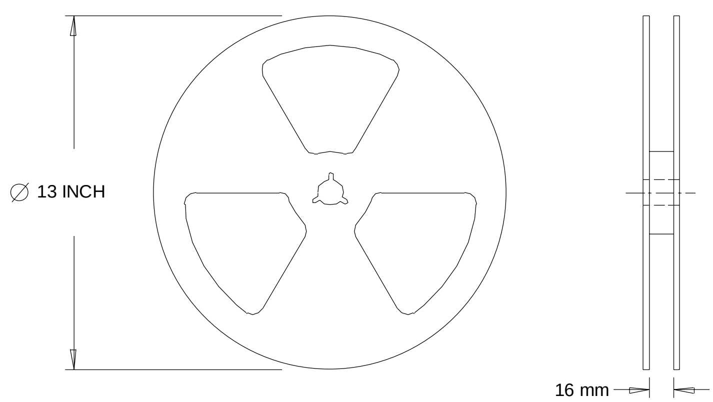


D-Pak (TO-252AA) Tape & Reel Information

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
IOR Rectifier

IR WORLD HEADQUARTERS: 233 Kansas St., El Segundo, California 90245, USA Tel: (310) 252-7105
TAC Fax: (310) 252-7903
Visit us at www.irf.com for sales contact information.03/03

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