International IOR Rectifier

Provisional Data Sheet PD 9.679C

IRHN7250
IRHN8250

REPETITIVE AVALANCHE AND dv/dt RATED
HEXFET® TRANSISTOR

N-CHANNEL
MEGA RAD HARD

200 Volt, 0.10Ω, MEGA RAD HARD HEXFET

International Rectifier's MEGA RAD HARD technology HEXFET power MOSFETs demonstrate excellent threshold voltage stability and breakdown voltage stability at total radiation doses as high as 1 x 10^6 Rads (Si). Under **identical** pre- and post-radiation test conditions, International Rectifier's RAD HARD HEXFETs retain **identical** electrical specifications up to 1 x 10^5 Rads (Si) total dose. At 1 x 10^6 Rads (Si) total dose, under the same pre-dose conditions, only minor shifts in the electrical specifications are observed and are so specified in table 1. No compensation in gate drive circuitry is required. In addition, these devices are capable of surviving transient ionization pulses as high as 1 x 10^{12} Rads (Si)/Sec, and return to normal operation within a few microseconds. Single Event Effect (SEE) testing of International Rectifier RAD HARD HEXFETs has demonstrated virtual immunity to SEE failure. Since the MEGA RAD HARD process utilizes International Rectifier's patented HEXFET technology, the user can expect the highest quality and reliability in the industry.

RAD HARD HEXFET transistors also feature all of the well-established advantages of MOSFETs, such as voltage control, very fast switching, ease of paralleling and temperature stability of the electrical parameters.

They are well-suited for applications such as switching power supplies, motor controls, inverters, choppers, audio amplifiers and high-energy pulse circuits in space and weapons environments.

Product Summary

Part Number	BV_{DSS}	$R_{DS(on)}$	I_D
IRHN7250	200V	0.10Ω	26A
IRHN8250	200V	0.10Ω	26A

Features:

- Radiation Hardened up to 1 x 10^6 Rads (Si)
- Single Event Burnout (SEB) Hardened
- Single Event Gate Rupture (SEGR) Hardened
- Gamma Dot (Flash X-Ray) Hardened
- Neutron Tolerant
- Identical Pre- and Post-Electrical Test Conditions
- Repetitive Avalanche Rating
- Dynamic dv/dt Rating
- Simple Drive Requirements
- Ease of Paralleling
- Hermetically Sealed
- Surface Mount
- Light-weight

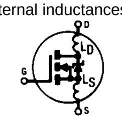
Absolute Maximum Ratings

Pre-Radiation

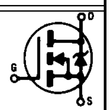
	Parameter	IRHN7250, IRHN8250	Units
I_D @ V_{GS} = 12V, T_C = 25°C	Continuous Drain Current	26	A
I_D @ V_{GS} = 12V, T_C = 100°C	Continuous Drain Current	16	
I_{DM}	Pulsed Drain Current ①	104	
P_D @ T_C = 25°C	Max. Power Dissipation	150	W
	Linear Derating Factor	1.2	W/K ⑤
V_{GS}	Gate-to-Source Voltage	±20	V
E_{AS}	Single Pulse Avalanche Energy ②	500	mJ
I_{AR}	Avalanche Current ①	26	A
E_{AR}	Repetitive Avalanche Energy ①	15	mJ
dv/dt	Peak Diode Recovery dv/dt ③	5.0	V/ns
T_J T_{STG}	Operating Junction Storage Temperature Range	-55 to 150	°C
	Package Mounting Surface Temperature	300 (for 5 sec.)	
	Weight	2.6 (typical)	g

Pre-Radiation

Electrical Characteristics @ Tj = 25°C (Unless Otherwise Specified)

	Parameter	Min.	Typ.	Max.	Units	Test Conditions
BV_{DSS}	Drain-to-Source Breakdown Voltage	200	—	—	V	V_{GS} = 0V, I_D = 1.0 mA
$\Delta BV_{DSS}/\Delta T_J$	Temperature Coefficient of Breakdown Voltage	—	0.28	—	V/°C	Reference to 25°C, I_D = 1.0 mA
$R_{DS(on)}$	Static Drain-to-Source On-State Resistance	—	—	0.10	Ω	V_{GS} = 12V, I_D = 16A ④
		—	—	0.11		V_{GS} = 12V, I_D = 26A ④
$V_{GS(th)}$	Gate Threshold Voltage	2.0	—	4.0	V	V_{DS} = V_{GS}, I_D = 1.0 mA
g_{fs}	Forward Transconductance	8.0	—	—	S (℧)	V_{DS} > 15V, I_{DS} = 16A ④
I_{DSS}	Zero Gate Voltage Drain Current	—	—	25	µA	V_{DS} = 0.8 x Max Rating, V_{GS} = 0V
		—	—	250		V_{DS} = 0.8 x Max Rating V_{GS} = 0V, T_J = 125°C
I_{GSS}	Gate-to-Source Leakage Forward	—	—	100	nA	V_{GS} = 20V
I_{GSS}	Gate-to-Source Leakage Reverse	—	—	-100		V_{GS} = -20V
Q_g	Total Gate Charge	—	—	170	nC	V_{GS} =12V, I_D = 26A
Q_{gs}	Gate-to-Source Charge	—	—	30		V_{DS} = Max. Rating x 0.5
Q_{gd}	Gate-to-Drain ('Miller') Charge	—	—	60		(see figures 23 and 31)
$t_{d(on)}$	Turn-On Delay Time	—	—	33	ns	V_{DD} = 100V, I_D = 26A,
t_r	Rise Time	—	—	140		R_G = 2.35Ω
$t_{d(off)}$	Turn-Off Delay Time	—	—	140		(see figure 22)
t_f	Fall Time	—	—	140		
L_D	Internal Drain Inductance	—	2.0	—	nH	Measured from the drain lead, 6mm (0.25 in.) from package to center of die. Modified MOSFET symbol showing the internal inductances. 
L_S	Internal Source Inductance	—	4.1	—		Measured from the source lead, 6mm (0.25 in.) from package to source bonding pad.
C_{iss}	Input Capacitance	—	4700	—	pF	V_{GS} = 0V, V_{DS} = 25V
C_{oss}	Output Capacitance	—	850	—		f = 1.0 MHz
C_{rss}	Reverse Transfer Capacitance	—	210	—		(see figure 22)

Source-Drain Diode Ratings and Characteristics

	Parameter	Min.	Typ.	Max.	Units	Test Conditions
I_S	Continuous Source Current (Body Diode)	—	—	26	A	Modified MOSFET symbol showing the integral reverse p-n junction rectifier. 
I_{SM}	Pulse Source Current (Body Diode) ①	—	—	104		
V_{SD}	Diode Forward Voltage	—	—	1.9	V	T_j = 25°C, I_S = 26A, V_{GS} = 0V ④
t_{rr}	Reverse Recovery Time		—	820	ns	T_j = 25°C, I_F = 26A, di/dt ≤ 100A/µs
Q_{RR}	Reverse Recovery Charge		—	12	µC	V_{DD} ≤ 50V ④
t_{on}	Forward Turn-On Time	Intrinsic turn-on time is negligible. Turn-on speed is substantially controlled by L_S + L_D.				

Thermal Resistance

	Parameter	Min.	Typ.	Max.	Units	Test Conditions
R_{thJC}	Junction-to-Case	—	—	0.83	K/W⑤	
R_{thJPCB}	Junction-to-PC board	—	TBD	—		soldered to a copper-clad PC board

Radiation Performance of Mega Rad Hard HEXFETs

Post-Radiation Characteristics

International Rectifier Radiation Hardened HEX-FETs are tested to verify their hardness capability. The hardness assurance program at International Rectifier uses two radiation environments.

Every manufacturing lot is tested in a low dose rate (total dose) environment per MIL-STD-750, test method 1019. International Rectifier has imposed a standard gate voltage of 12 volts per note 6 and figure 8a and a V_{DSS} bias condition equal to 80% of the device rated voltage per note 7 and figure 8b. Pre- and post-radiation limits of the devices irradiated to 1 x 10^5 Rads (Si) are identical and are presented in Table 1, column 1, IRHN7250. Device performance limits at a post radiation level of 1 x 10^6 Rads (Si) are presented in Table 1, column 2, IRHN8250. The values in Table 1 will be met for either of the two low dose rate test circuits that are used. Typical delta curves showing radiation response appear in figures 1 through 5. Typical post-radiation curves appear in figures 10 through 17.

Both pre- and post-radiation performance are tested and specified using the same drive circuitry and test conditions in order to provide a direct comparison. It should be noted that at a radiation level of 1 x 10^5 Rads (Si), no change in limits are specified in DC parameters. At a radiation level of 1 x10^6 Rads (Si), leakage remains low and the device is usable with no change in drive circuitry required.

High dose rate testing may be done on a special request basis, using a dose rate up to 1 x 10^{12} Rads (Si)/Sec. Photocurrent and transient voltage waveforms are shown in figure 7, and the recommended test circuit to be used is shown in figure 9.

International Rectifier radiation hardened HEXFETs have been characterized in neutron and heavy ion Single Event Effects (SEE) environments. The effects on bulk silicon of the type used by International Rectifier on RAD HARD HEXFETs are shown in figure 6. Single Event Effects characterization is shown in Table 3.

Table 1. Low Dose Rate ⑥ ⑦

Parameter		IRHN7250 100K Rads (Si) min.	IRHN7250 100K Rads (Si) max.	IRHN8250 1000K Rads (Si) min.	IRHN8250 1000K Rads (Si) max.	Units	Test Conditions ⑩
BV_{DSS}	Drain-to-Source Breakdown Voltage	200	—	200	—	V	V_{GS} = 0V, I_D = 1.0 mA
$V_{GS(th)}$	Gate Threshold Voltage ④	2.0	4.0	1.25	4.5	V	V_{GS} = V_{DS}, I_D = 1.0 mA
I_{GSS}	Gate-to-Source Leakage Forward	—	100	—	100	nA	V_{GS} = +20V
I_{GSS}	Gate-to-Source Leakage Reverse	—	-100	—	-100	nA	V_{GS} = -20V
I_{DSS}	Zero Gate Voltage Drain Current	—	25	—	50	µA	V_{DS} = 0.8 x Max Rating, V_{GS} = 0
$R_{DS(on)1}$	Static Drain-to-Source ④ On-State Resistance One	—	0.10	—	0.150	Ω	V_{GS} = 12V, I_D = 16A
V_{SD}	Diode Forward Voltage ④	—	1.9	—	1.9	V	T_C = 25°C, I_S = 26A,V_{GS} = 0V

Table 2. High Dose Rate ⑧

Parameter		10^{11} Rads (Si)/sec Min.	Typ	Max.	10^{12} Rads (Si)/sec Min.	Typ.	Max.	Units	Test Conditions
V_{DSS}	Drain-to-Source Voltage	—	—	160	—	—	160	V	Applied drain-to-source voltage during gamma-dot
I_{PP}		—	15	—	—	15	—	A	Peak radiation induced photo-current
di/dt		—	—	160	—	—	8.0	A/µsec	Rate of rise of photo-current
L_1		1.0	—	—	20	—	—	µH	Circuit inductance required to limit di/dt

Table 3. Single Event Effects ⑨

Parameter	Typ.	Units	Ion	LET (Si) (MeV/mg/cm²)	Fluence (ions/cm²)	Range (µm)	V_{DS} Bias (V)	V_{GS} Bias (V)
BV_{DSS}	200	V	Ni	28	1 x 10^5	~41	160	-5

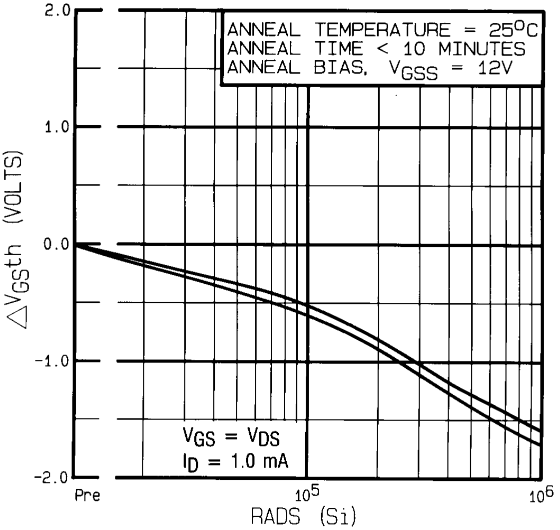


Figure 1. – Typical Response of Gate Threshold Voltage Vs. Total Dose Exposure

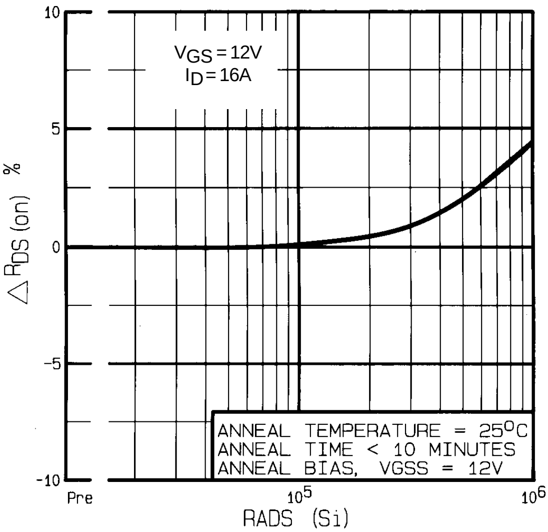


Figure 2. – Typical Response of On-State Resistance Vs. Total Dose Exposure

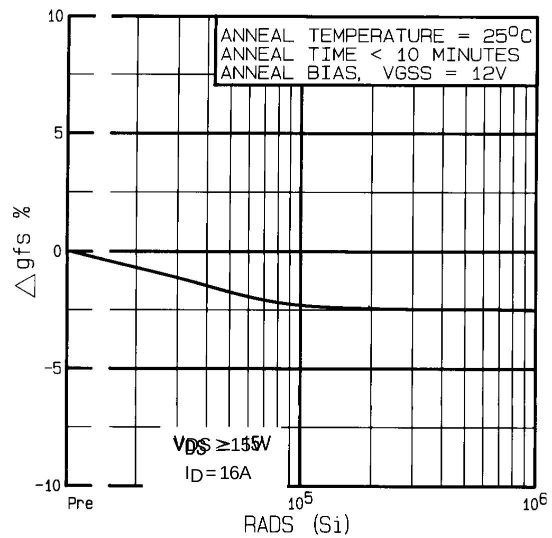


Figure 3. – Typical Response of Transconductance Vs. Total Dose Exposure

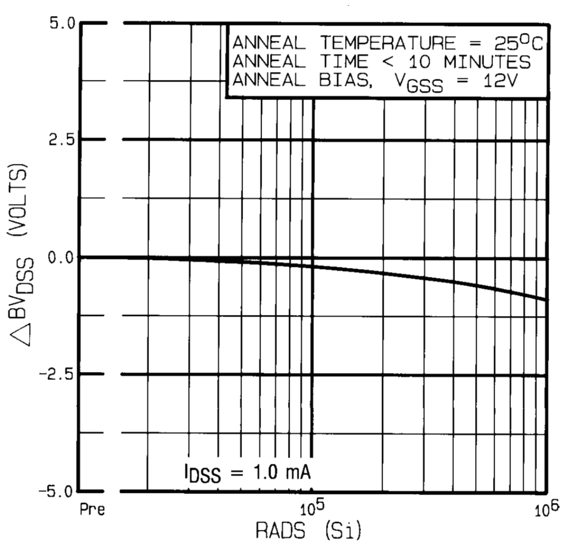


Figure 4. – Typical Response of Drain-to-Source Breakdown Vs. Total Dose Exposure

Post-Radiation

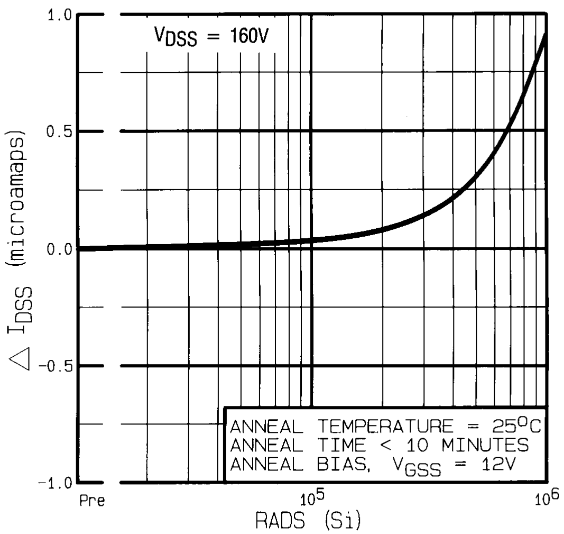


Figure 5. – Typical Zero Gate Voltage Drain Current Vs. Total Dose Exposure

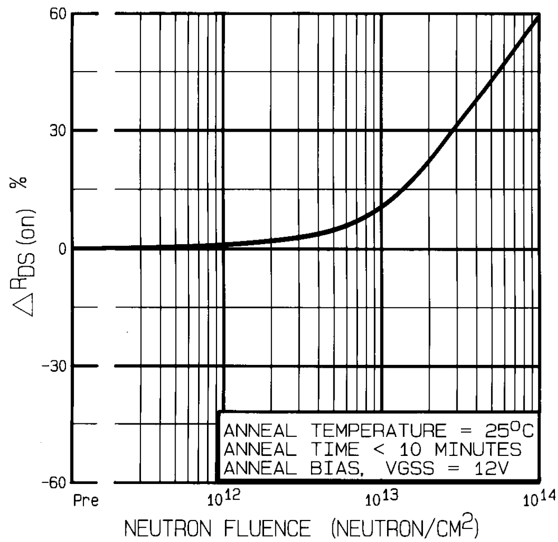


Figure 6. – Typical On-State Resistance Vs. Neutron Fluence Level

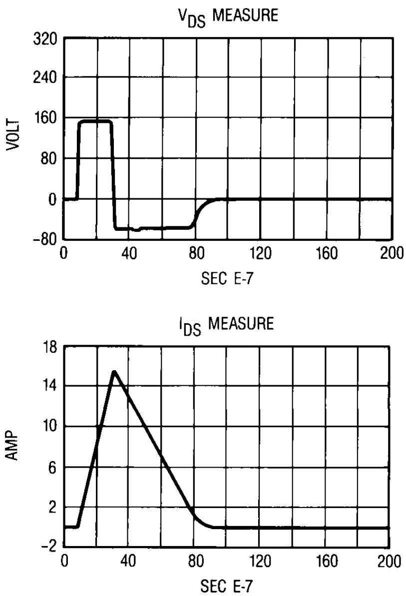


Figure 7. – Typical Transient Response of Rad Hard HEXFET During 1 x10[12] Rad (Si)/Sec Exposure

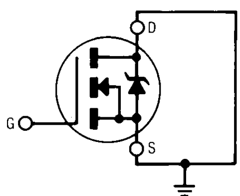


Figure 8a. – During Radiation Gate Stress of V_{GSS} = 12V

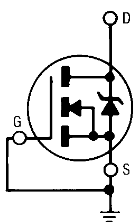


Figure 8b. – During Radiation V_{DSS} Stress = 80% of B_{VDSS}

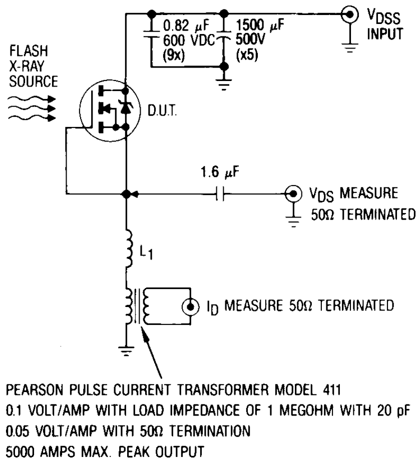


Figure 9. – High Dose Rate (Gamma Dot) Test Circuit

Radiation Characteristics

Note: Bias Conditions during radiation; V_{GS} = 12 V_{dc}, V_{DS} = 0 V_{dc}

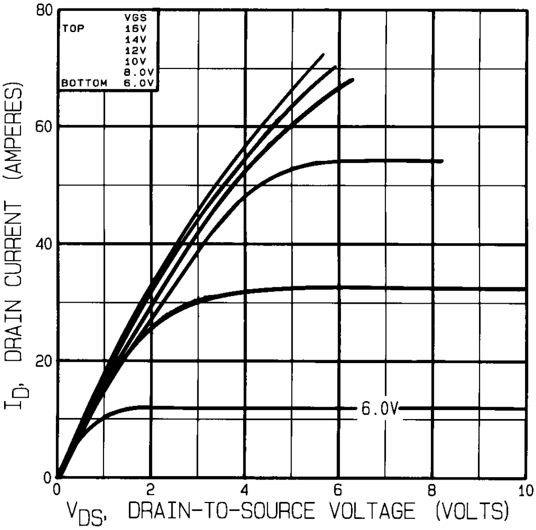


Figure 10. – Typical Output Characteristics Pre-Radiation

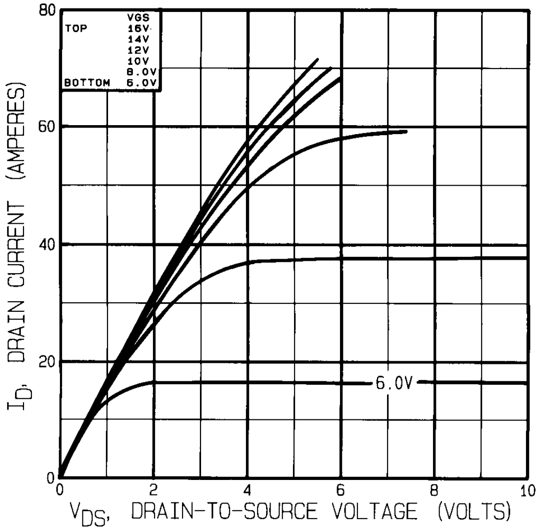


Figure 11. – Typical Output Characteristics Post-Radiation 100K Rads (Si)

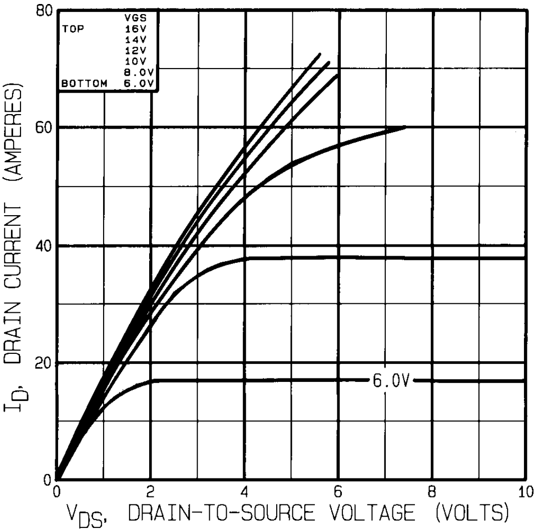


Figure 12. – Typical Output Characteristics Post-Radiation 300K Rads (Si)

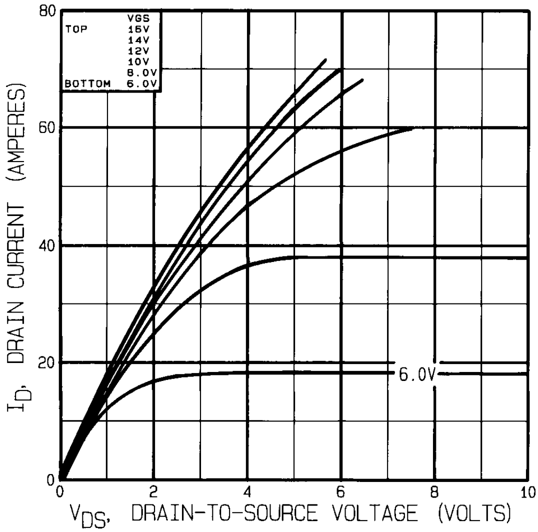


Figure 13. – Typical Output Characteristics Post-Radiation 1 Mega Rads (Si)

Radiation Characteristics

Note: Bias Conditions during radiation; V_{GS} = 0 V_{dc}, V_{DS} = 160 V_{dc}

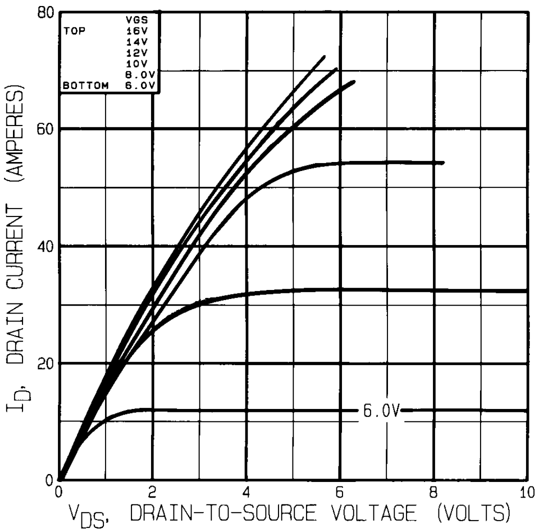


Figure 14. – Typical Output Characteristics Pre-Radiation

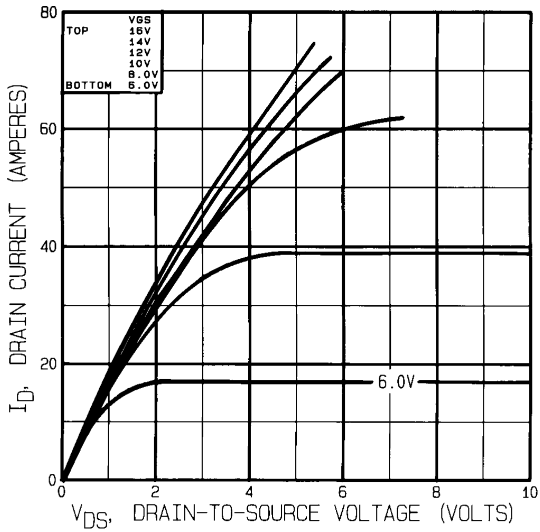


Figure 15. – Typical Output Characteristics Post-Radiation 100K Rads (Si)

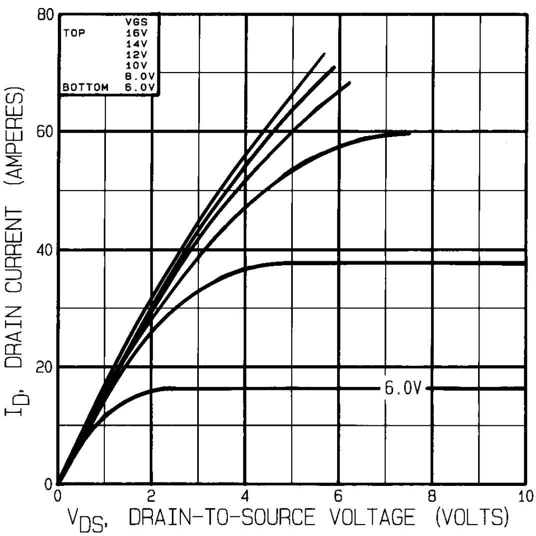


Figure 16. – Typical Output Characteristics Post-Radiation 300K Rads (Si)

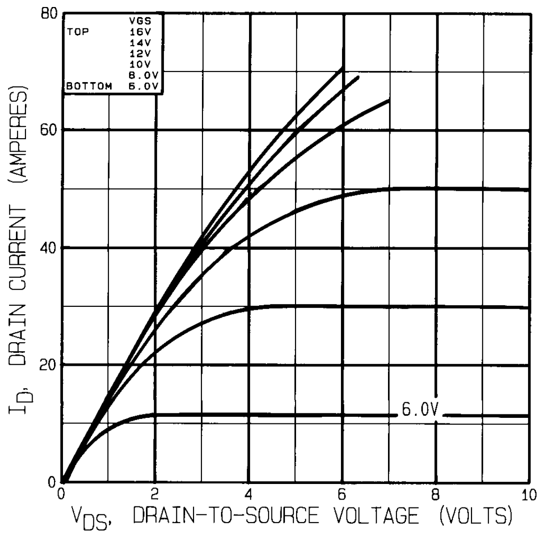


Figure 17. – Typical Output Characteristics Post-Radiation 1 Mega Rads (Si)

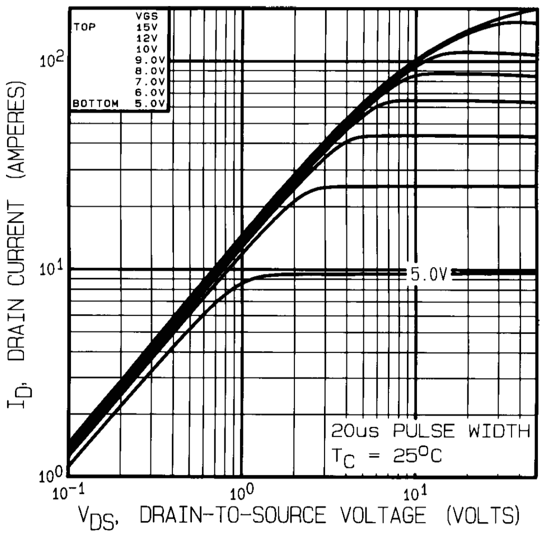


Figure 18. – Typical Output Characteristics, T_C = 25°C

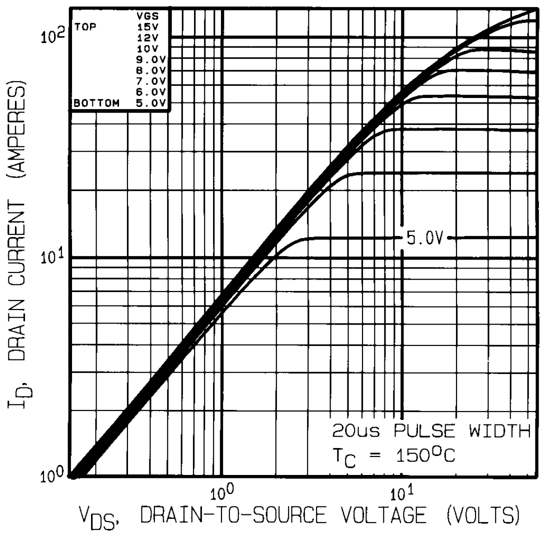


Figure 19. – Typical Output Characteristics, T_C = 150°C

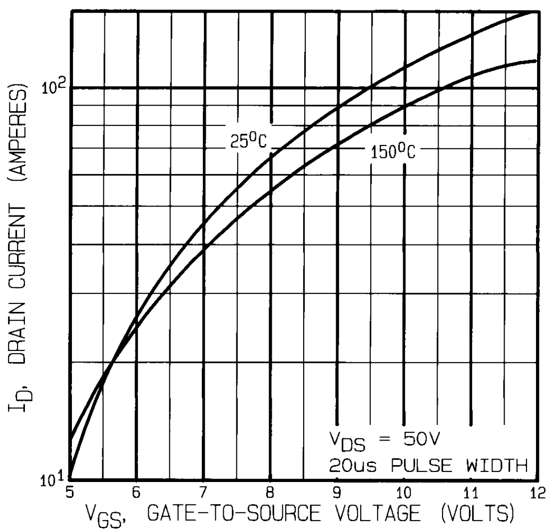


Figure 20. – Typical Transfer Characteristics

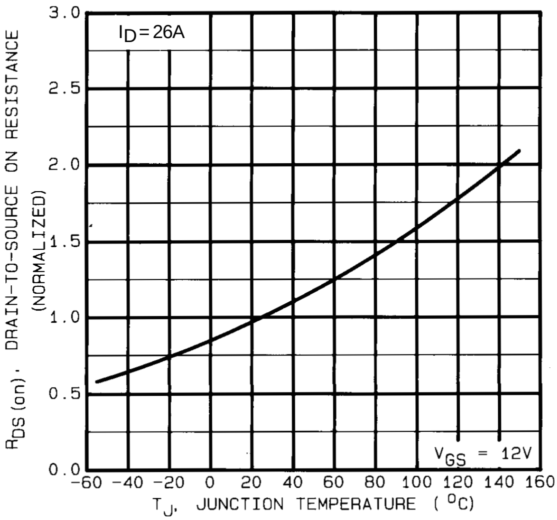


Figure 21. – Normalized On-Resistance Vs. Temperature

Pre-Radiation

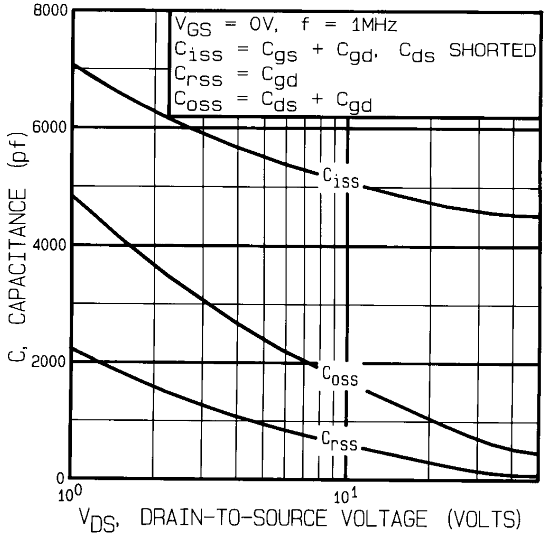


Figure 22. – Typical Capacitance Vs. Drain-to-Source Voltage

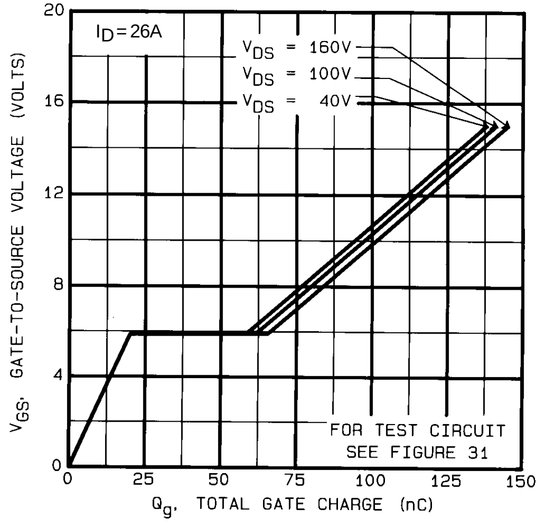


Figure 23. – Typical Gate Charge Vs. Gate-to-Source Voltage

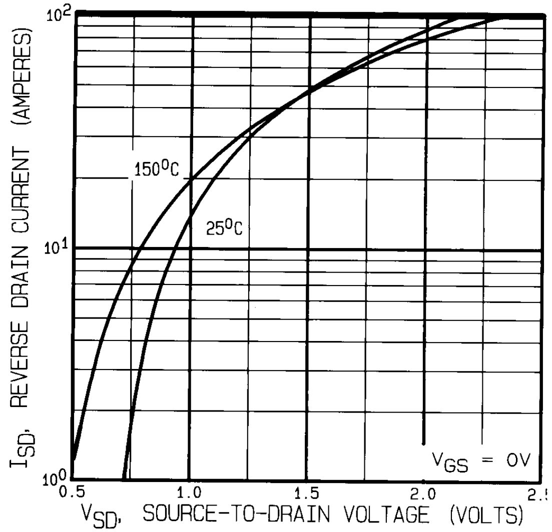


Figure 24. – Typical Source-Drain Diode Forward Voltage

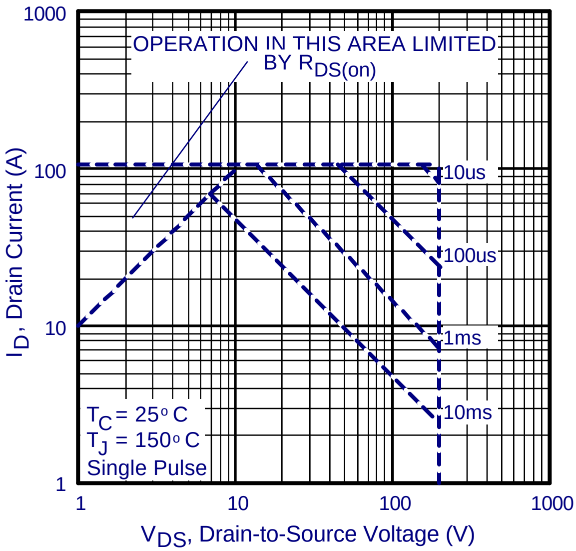


Figure 25. – Maximum Safe Operating Area

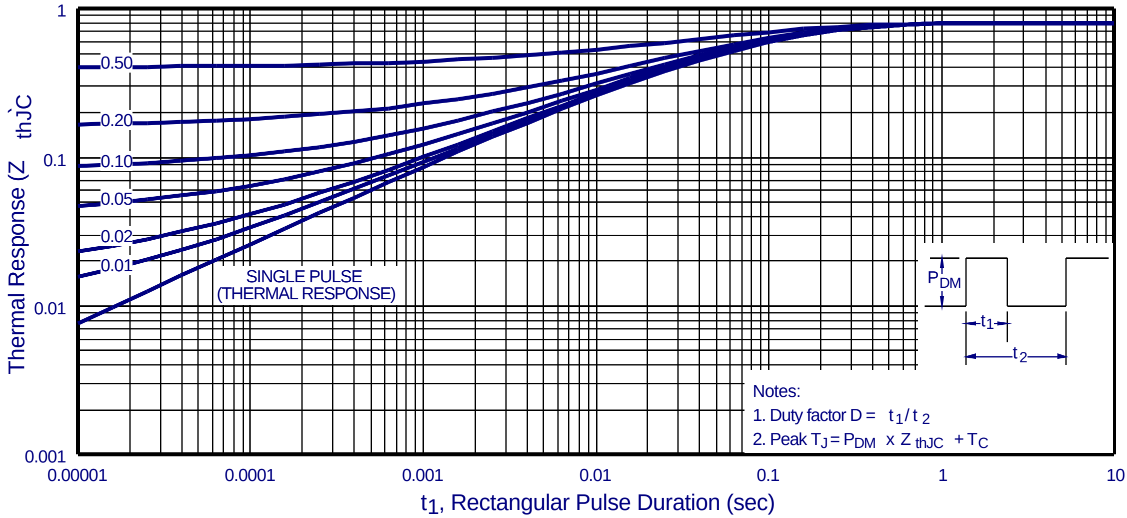


Figure 26. – Maximum Effective Transient Thermal Impedance, Junction-to-Case Vs. Pulse Duration

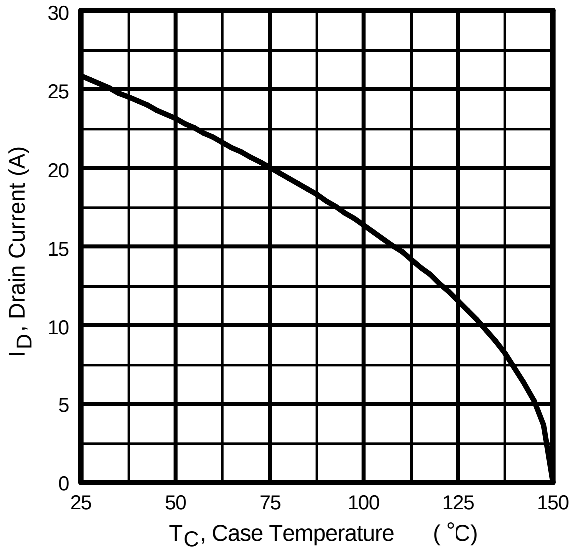


Figure 27. – Maximum Drain Current Vs. Case Temperature

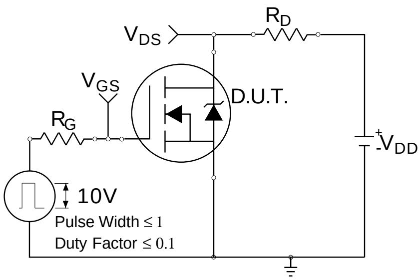


Figure 28a. – Switching Time Test Circuit

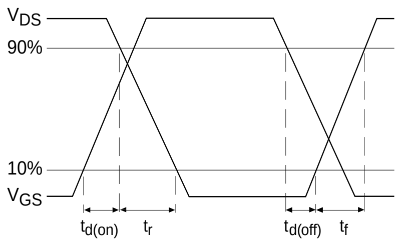


Figure 28b. – Switching Time Waveforms

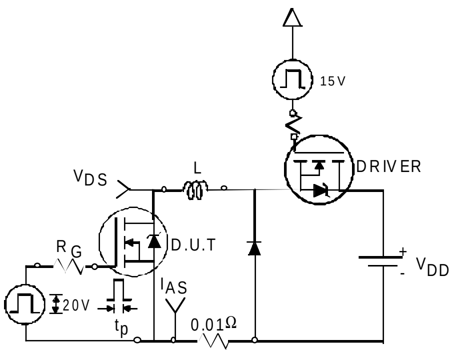


Figure 29a. – Unclamped Inductive Test Curcuit

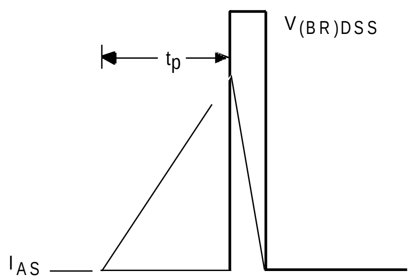


Figure 29b. – Unclamped Inductive Waveforms

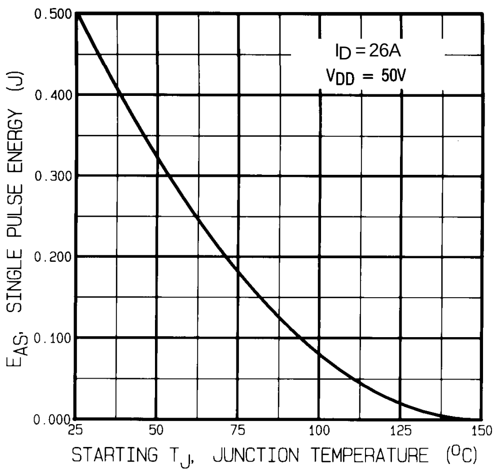


Figure 29c. – Maximum Avalanche Energy Vs. Starting Junction Temperature

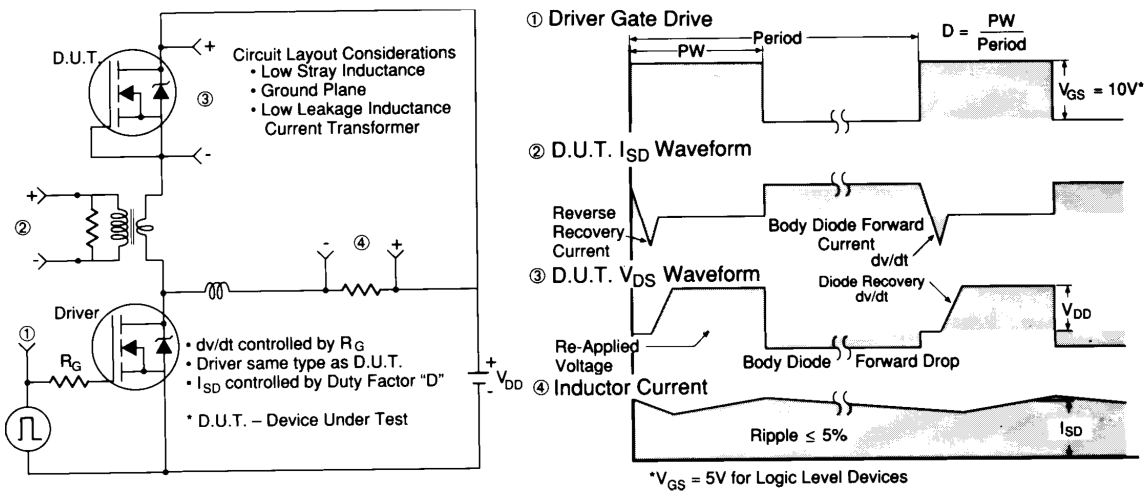


Figure 30. – Peak Diode Recovery dv/dt Test Circuit

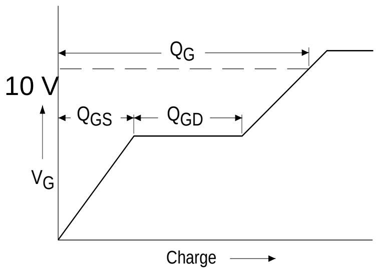


Figure 31a. – Basic Gate Charge Waveform

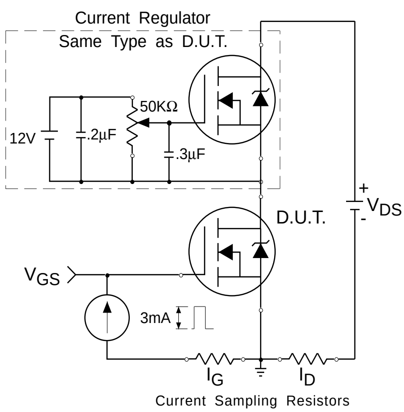


Figure 31b. – Gate Charge Test Circuit

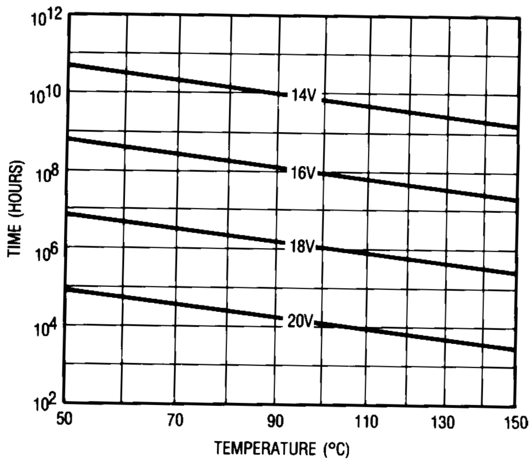


Figure 32 – Typical Time to Accumulated 1% Failure

① Repetitive Rating; Pulse width limited by maximum junction temperature. (figure 26) Refer to current HEXFET reliability report.

② @ V_{DD} = 50V, Starting T_J = 25°C,
E_{AS} = [0.5 * L * (I_L^2) * [BV_{DSS}/(BV_{DSS}-V_{DD})]
Peak I_L = 26A, 25 ≤ R_G ≤ 200Ω

③ I_{SD} ≤ 26A, di/dt ≤ 190 A/µs,
V_{DD} ≤ BV_{DSS}, T_J ≤ 150°C
Suggested RG = 2.35Ω

④ Pulse width ≤ 300 µs; Duty Cycle ≤ 2%

⑤ K/W = °C/W
W/K = W/°C

⑥ **Total Dose Irradiation with V_{GS} Bias.**
+12 volt V_{GS} applied and V_{DS} = 0 during irradiation per MIL-STD-750, method 1019. (figure 8a)

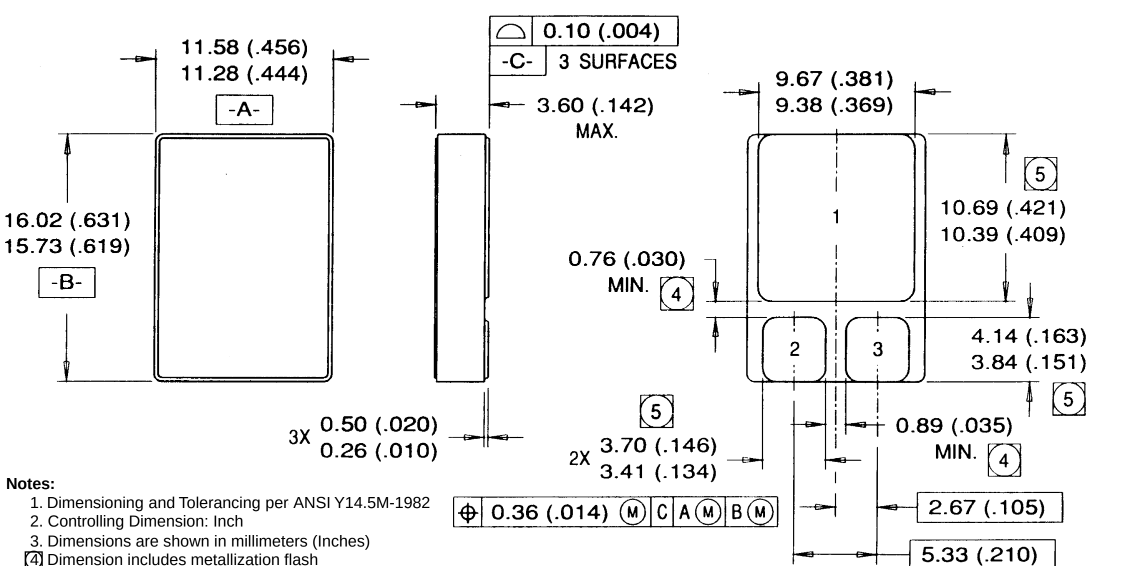
⑦ **Total Dose Irradiation with V_{DS} Bias.**
V_{DS} = 0.8 x rated BV_{DSS} (pre-radiation) applied and V_{GS} = 0 during irradiation per MIL-STD-750, method 1019. (figure 8b)

⑧ This test is performed using a flash x-ray source operated in the e-beam mode (energy ~2.5 MeV), 30 nsec pulse. (figure 9)

⑨ Study sponsored by NASA. Evaluation performed at Brookhaven National Labs.

⑩ All Pre-Radiation and Post-Radiation test conditions are **identical** to facilitate direct comparison for circuit applications.

Case Outline and Dimensions – SMD-1



Notes:
1. Dimensioning and Tolerancing per ANSI Y14.5M-1982
2. Controlling Dimension: Inch
3. Dimensions are shown in millimeters (Inches)
4 Dimension includes metallization flash
5 Dimension does not include metallization flash

International
IOR Rectifier

WORLD HEADQUARTERS: 233 Kansas St., El Segundo, California 90245, Tel: (310) 322 3331
EUROPEAN HEADQUARTERS: Hurst Green, Oxted, Surrey RH8 9BB, UK Tel: ++ 44 1883 732020
IR CANADA: 7321 Victoria Park Ave., Suite 201, Markham, Ontario L3R 2Z8, Tel: (905) 475 1897
IR GERMANY: Saalburgstrasse 157, 61350 Bad Homburg Tel: ++ 49 6172 96590
IR ITALY: Via Liguria 49, 10071 Borgaro, Torino Tel: ++ 39 11 451 0111
IR FAR EAST: 171 (K&H Bldg.) 30-4 Nishi-ikebukuro 3-Chome, Toshima-ku, Tokyo Japan Tel: 81 3 3983 0086
IR SOUTHEAST ASIA: 315 Outram Road, #10-02 Tan Boon Liat Building, Singapore 0316 Tel: 65 221 8371