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INTERNATIONAL RECTIFIER

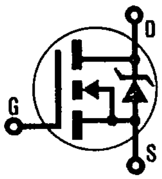
Preliminary Data Sheet No. PD-9.478A

T-39-13

INTERNATIONAL RECTIFIER IOR

HEXFET® TRANSISTORS

IRH150



N-CHANNEL

RAD HARD

100 Volt, 0.055Ω, Rad Hard HEXFET

International Rectifier's RAD HARD HEXFETs demonstrate excellent threshold voltage stability and breakdown voltage stability at total radiation doses as high as 1 megarad. 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 Upset (SEU) testing of International Rectifier RAD HARD HEXFETs has demonstrated virtual immunity to SEU failure. Since RAD HARD HEXFETs use International Rectifier's HEXFET technology, the user can expect the highest quality and reliability in the industry.

The 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.

Product Summary

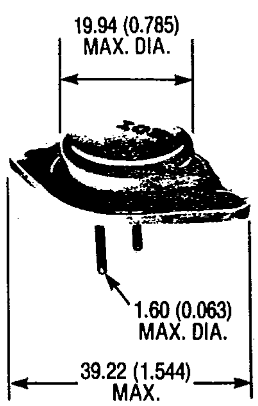
Part Number	BV_{DSS}	$R_{DS(on)}$	I_D
IRH150	100V	0.055Ω	38A

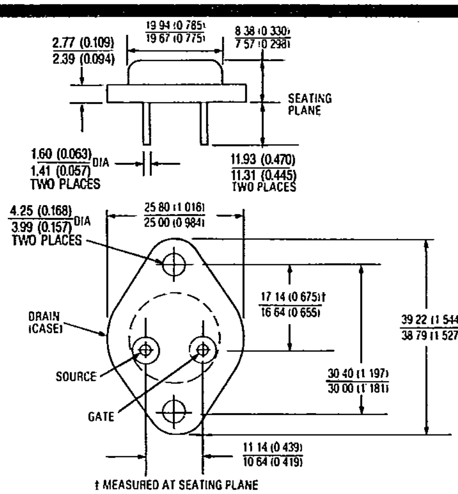
FEATURES:

- Radiation Hard
- Repetitive Avalanche Ratings
- Dynamic dv/dt Rating
- Simple Drive Requirements
- Ease of Paralleling

RAD HARD

CASE STYLE AND DIMENSIONS





Conforms to JEDEC Outline TO-204AE (Modified TO-3)
Dimensions in Millimeters and (Inches)

IRH150 Device **Pre-Radiation ①**

T-39-13

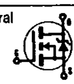
Pre-Radiation Absolute Maximum Ratings

	Parameter	IRH150	Units
I_D @ T_C = 25°C	Continuous Drain Current	38	A
I_D @ T_C = 100°C	Continuous Drain Current	24	A
I_{DM}	Pulsed Drain Current ②	150	A
P_D @ T_C = 25°C	Max. Power Dissipation	150	W
	Linear Derating Factor	1.2	W/K
V_{GS}	Gate-to-Source Voltage	±20	V
E_{AS}	Single Pulse Avalanche Energy ③	1500 (See Fig. 26)	mJ
I_{AR}	Repetitive Avalanche Current ②	38 (See Energy Limitations)	A
E_{AR}	Repetitive Avalanche Energy ②	15 (See Current Limitations)	mJ
dV/dt	Peak Commutating dv/dt ④	5.5 (See Fig. 29)	V/ns
T_J T_{STG}	Operating Junction Storage Temperature Range	−55 to 150	°C
	Lead Temperature	300 (0.063 in. (1.6mm) from case for 10s)	°C

Pre-Radiation Electrical Characteristics @ T_J = 25°C (Unless Otherwise Specified)

	Parameter	Min.	Typ.	Max.	Units	Test Conditions	
BV_{DSS}	Drain-to-Source Breakdown Voltage	100	—	—	V	V_{GS} = 0V, I_D = 1 mA	
$R_{DS(on)}$	Static Drain-to-Source On-State Resistance ⑤	—	0.040	0.055	Ω	V_{GS} = 12V, I_D = 20A	
$I_{D(on)}$	On-State Drain Current ⑤	38	—	—	A	V_{DS} > $I_{D(on)}$ x $R_{DS(on)}$ Max. V_{GS} = 12V	
$V_{GS(th)}$	Gate Threshold Voltage	2.0	—	5.0	V	V_{DS} = V_{GS}, I_D = 1 mA	
g_{fs}	Forward Transconductance ⑤	5.3	8	—	S (℧)	V_{DS} = 10V, I_{DS} = 20A	
I_{DSS}	Zero Gate Voltage Drain Current	—	—	1	mA	V_{DS} = 100V, V_{GS} = 0V	
		—	—	1		V_{DS} = 100V V_{GS} = 0V, T_C = 125°C	
I_{GSS}	Gate-to-Source Leakage Forward	—	—	100	nA	V_{GS} = 20V	
I_{GSS}	Gate-to-Source Leakage Reverse	—	—	−100	nA	V_{GS} = −20V	
Q_g	Total Gate Charge	—	110	170	nC	V_{GS} = 12V, I_D = 38A	
Q_{gs}	Gate-to-Source Charge	—	22	32	nC	V_{DS} = 80V See Fig. 28	
Q_{gd}	Gate-to-Drain ("Miller") Charge	—	48	72	nC	(Independent of operating temperature)	
$t_{d(on)}$	Turn-On Delay Time	—	21	32	ns	V_{DD} = 50V, I_D ≈ 38A, R_G = 6.2Ω	
t_r	Rise Time	—	180	—	ns	R_D = 6.2Ω	
$t_{d(off)}$	Turn-Off Delay Time	—	60	—	ns	See Fig. 27	
t_f	Fall Time	—	86	—	ns	(Independent of operating temperature)	
L_D	Internal Drain Inductance	—	5.0	—	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	—	13	—	nH	Measured from the source lead, 6mm (0.25 in.) from package to source bonding pad.	
C_{iss}	Input Capacitance	—	3300	—	pF	V_{GS} = 0V, V_{DS} = 25V	
C_{oss}	Output Capacitance	—	1000	—	pF	f = 1.0 MHz	
C_{rss}	Reverse Transfer Capacitance	—	170	—	pF	See Fig. 22	

Source-Drain Diode Ratings and Characteristics

	Parameter	Min.	Typ.	Max.	Units	Test Conditions
I_S	Continuous Source Current (Body Diode)	—	—	38	A	Modified MOSFET symbol showing the integral Reverse p-n junction rectifier. 
I_{SM}	Pulse Source Current (Body Diode) ④	—	—	150	A	
V_{SD}	Diode Forward Voltage ⑤	—	—	2.5	V	T_C = 25°C, I_S = 38A, V_{GS} = 0V
t_{rr}	Reverse Recovery Time	—	270	570	ns	T_J = 25°C, I_F = 38A, dI_F/dt = 100A/µs
Q_{RR}	Reverse Recovery Charge	—	3.2	6.8	µC	
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

R_{thJC}	Junction-to-Case	—	—	0.83	K/W	
R_{thCS}	Case-to-Sink	—	0.12	—	K/W	Mounting surface flat, smooth, and greased
R_{thJA}	Junction-to-Ambient	—	—	30	K/W	Typical socket mount

Post-Radiation

IRH150 Device

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Radiation Performance of Rad Hard HEXFETs

International Rectifier Radiation Hard (Rad Hard) HEXFETs are tested to verify their hardness capability. The hardness assurance program at International Rectifier uses two radiation environments. Every manufacturing lot is tested in low dose rate ("total dose") and high dose rate ("gamma dot") environments.

Low dose rate testing is performed following MIL-STD-750C, test method 1019. Refer to notes ⑥ and ⑦. The lot is evaluated with two different test circuits. Device performance is presented in table 1. The values in table 1 will be met for either of the two low dose rate test circuits that are used. In addition, Rad Hard HEXFETs have been characterized for their post radiation response. Typical curves showing radiation response as well as post radiation response appear in figures 1 through 8.

The two test circuits used during low dose rate exposures are shown in figure 11. The first test circuit biases the gate electrode at 12 volts with respect to the drain and source electrodes (see fig. 11a). In general, a 12 volt V_{GSS} steady state bias is a worst case condition for the "on-state" parameters of the device (eg. $V_{GS(th)}$, $R_{DS(on)}$, g_{fs}, etc.). The second test circuit biases the drain electrode with respect to the source and gate electrodes at 80% of the rated BV_{DSS} (pre-radiation) (fig. 11b). The steady state V_{DSS} bias equal to 80% of the rated BV_{DSS} (pre-radiation) is considered a worst case test condition for BV_{DSS} (post-radiation).

High dose rate (gamma-dot) testing is done using a dose rate set at 1.5-2.0 x 10^{12} rads (Si)/sec. The device is exposed to this rate with its full rated breakdown voltage applied. Photocurrent and transient voltage waveforms are shown in Figure 10. With the rated breakdown voltage applied the device will survive the maximum rated di/dt. The device performance is presented in table 2. The test circuit used for this test is shown in figure 12.

In addition to these tests, Radiation Hard HEXFETs have been characterized in neutron and heavy ion SEU environments (see fig 9 and table 3 respectively).

Table 1. Low Dose Rate

Parameter ⑥ ⑦		100K Rads (Si) Min.	100K Rads (Si) Max.	250K Rads (Si)	500K Rads (Si)	1000K Rads (Si)	Units	Test Conditions
V_{GS}	Gate Threshold Voltage	1	6	See Fig. 1 & 6			V	$V_{GS} = V_{DS}$, I_D = 1 mA
$R_{DS(on)}$	Static Drain-to-Source ⑤ On State Resistance	—	.075	⑪			Ω	V_{GS} = 12V, I_D = 20A
g_{fs}	Forward Transconductance ⑤	4.85	—	See Fig. 2			S(Ʊ)	V_{DS} = 10V, I_D = 20A
$I_{D(on)}$	On-State Drain Current ⑤	30 Min @ T_C = 25°C 20 Min. @ T_C = 100°C		See Fig. 3 & 7			A	V_{GS} = 12V, $V_{DS} = V_{GS}$
BV_{DSS}	Drain-to-Source Breakdown Voltage	100 Min.		See Fig. 4			V	V_{GS} = 0V, I_D = 1 mA
I_{DSS}	Zero Gate Voltage Drain Current	1 Max.		See Fig. 5 & 8			mA	V_{DS} = 100V, V_{GS} = 0V
I_{GSS}	Gate-to-Source Leakage Forward	100 Max.		100 Max.			nA	V_{GS} = ±20
V_{SD}	Diode Forward Voltage ⑤	2.5 Max.		2.5 Max.			V	T_C = 25°C, I_S = 30A, V_{GS} = 0V

Table 2. High Dose Rate

Parameter ⑧		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	—	—	100	—	—	100	V	Applied drain-to-source voltage during gamma-dot
I_{PP}		—	150	—	—	150	—	A	Peak radiation induced photo-current
di/dt		—	—	1000	—	—	200	A/μsec	Rate of rise of photo-current
L_1		0.1	—	—	0.5	—	—	μH	Circuit inductance required to limit di/dt

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Table 3. Single Event Upset

Parameter	Typ.	Units	Test Conditions: Ion	LET (Si) (MeV/mg/cm²)	Range (μm)
V_{DS} ⑨	100	V	Copper	30	~40
V_{DS} ⑩	100	V	Cf-252	40 — 45	~15

① See Figures 13 through 29 for pre-radiation curves.

② Repetitive Rating; Pulse width limited by maximum junction temperature (see figure 17)

③ @ V_{DD} = 50V, Starting T_J = 25°C, L = 1.6 mH, R_G = 25Ω, Peak I_L = 38A.

④ I_{SD} ≤ 38A, di/dt ≤ 200 A/μs, $V_{DD} \leq BV_{DSS}$, Suggested R_G = 6.2Ω

⑤ Pulse width ≤ 300 μs; Duty Cycle ≤ 2%

⑥ **High Total Dose Irradiation with V_{GS} Bias.** +12 volt V_{GS} applied and V_{DS} = 0 during irradiation per MIL-STD-750C, method 1019. (See figure 11a)

⑦ **High Total Dose Irradiation with V_{DS} Bias.** V_{DS} = 0.8 rated BV_{DSS} (pre-radiation) applied and V_{GS} = 0 during irradiation per MIL-STD-750C, method 1019. (See figure 11b)

⑧ This test is performed using a flash x-ray source operated in the e-beam mode (energy ~2.5 Mev). See figure 12.

⑨ Study sponsored by NASA

⑩ Study sponsored by Rockwell International

⑪ To be determined

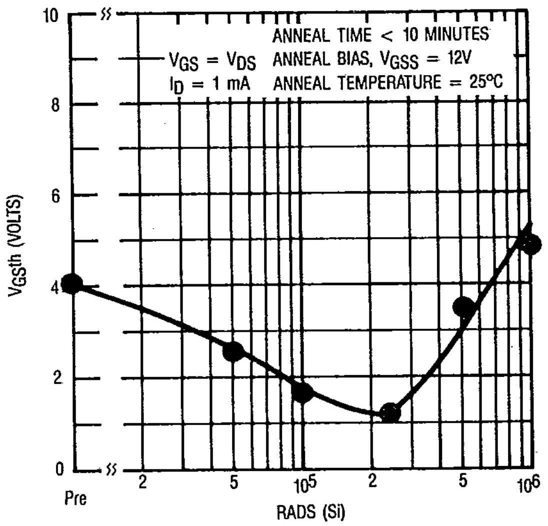

Fig. 1 — Typical Response of Gate Threshold Voltage Vs. Total Dose Exposure⑤

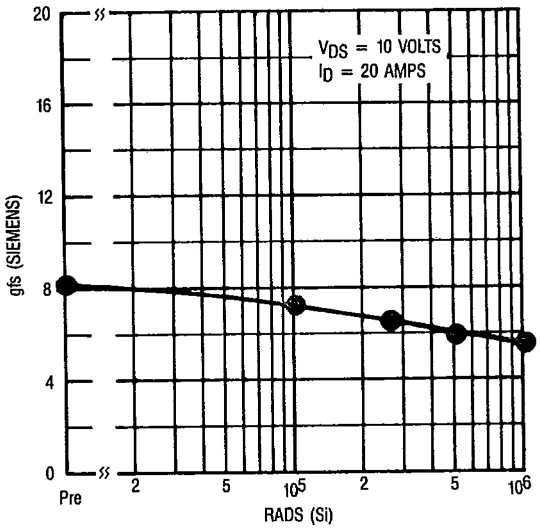

Fig. 2 — Typical Response of Transconductance Vs. Total Dose Exposure⑤

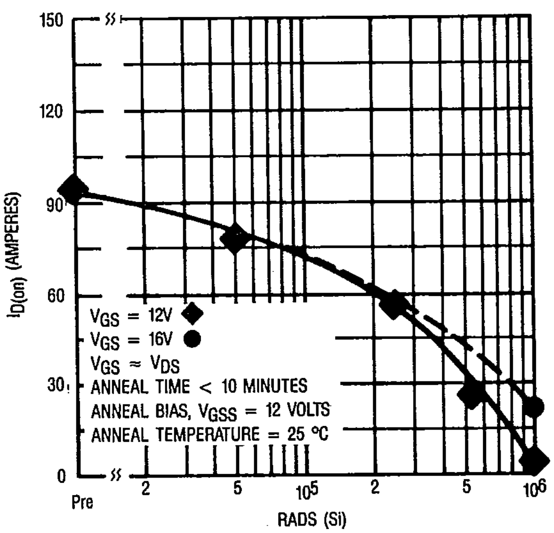

Fig. 3 — Typical Response of On-State Drain Current Vs. Total Dose Exposure⑤

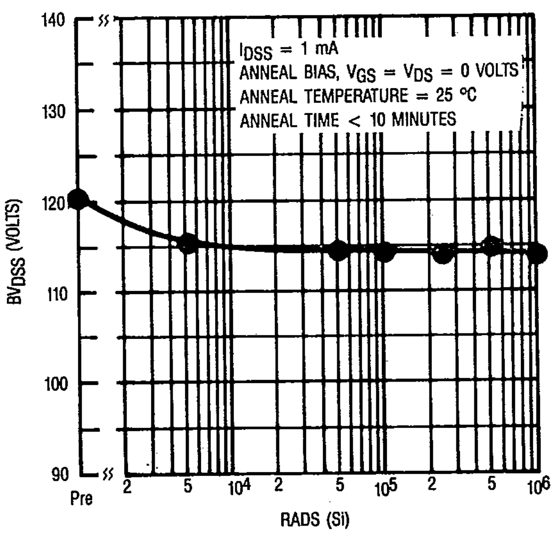

Fig. 4 — Typical Response of Drain-to-Source Breakdown Vs. Total Dose Exposure⑥

Post-Radiation

IRH150 Device

T-39-13

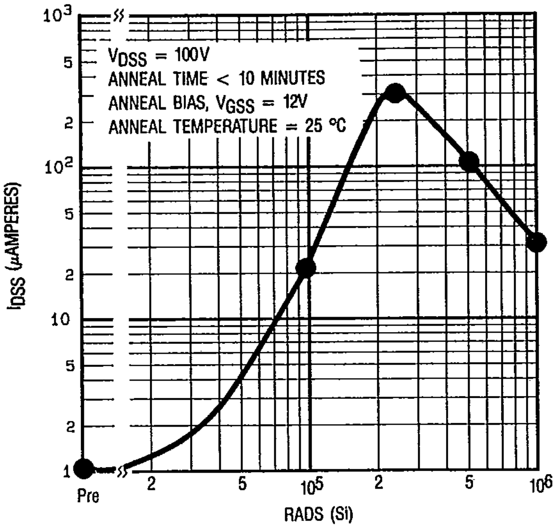

Fig. 5 — Typical Zero Gate Voltage Drain Current Vs. Total Dose Exposure ⑤

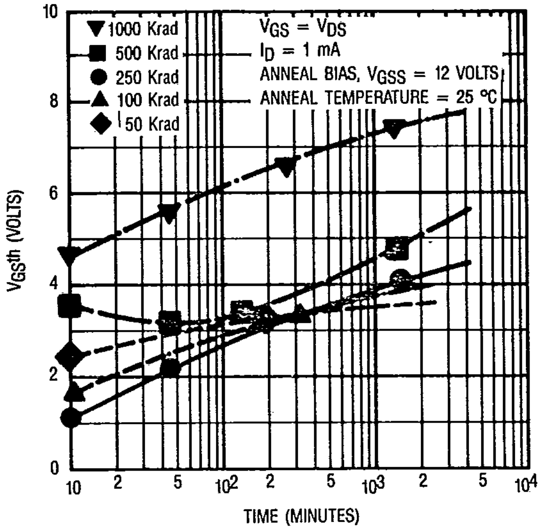

Fig. 6 — Typical Post Radiation Annealing Response of Gate Threshold Voltage Vs. Time ⑤

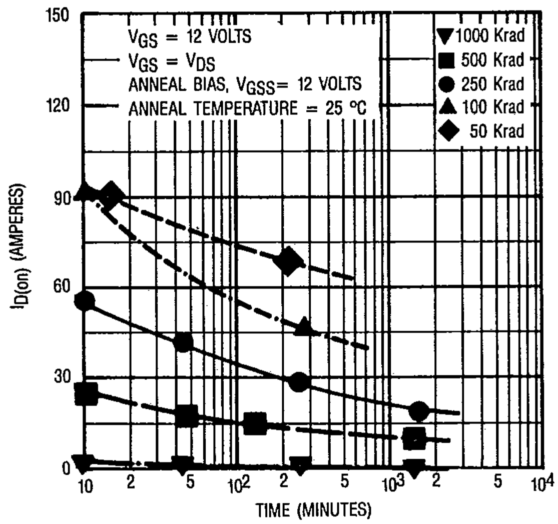

Fig. 7 — Typical Post Radiation Annealing Response of On-State Drain Current Vs. Time ⑤

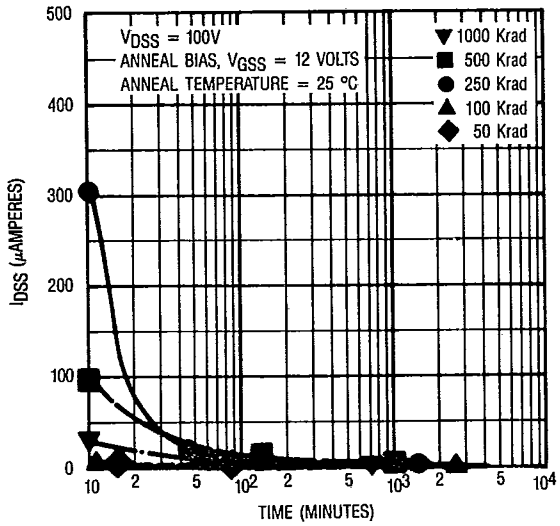

Fig. 8 — Typical Post Radiation Annealing Response of Zero Gate Voltage Drain Current Vs. Time ⑤

RAD HARD

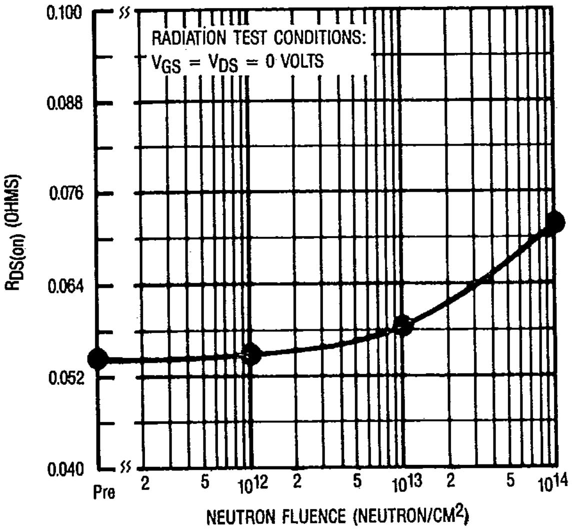

Fig. 9 — On Resistance Vs. Neutron Fluence Level

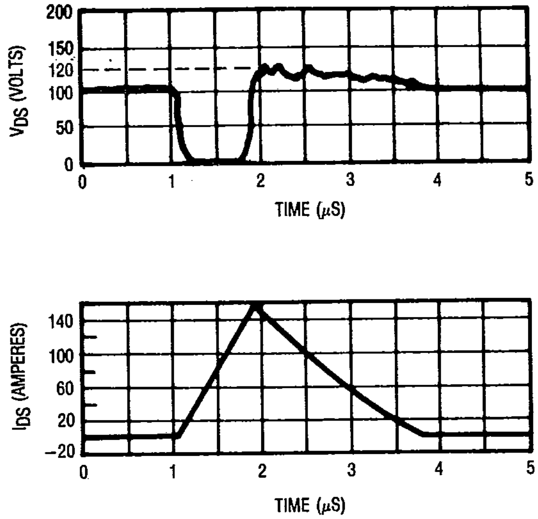

Fig. 10 — Typical Transient Response of Rad Hard HEXFET During 1 x 10^{12} Rad (Si)/Sec Exposure

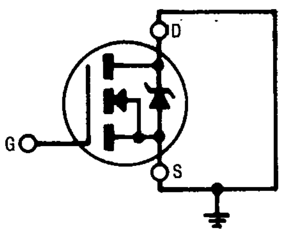

Fig. 11a — Gate Stress of V_{GSS} Equals 12 Volts During Radiation

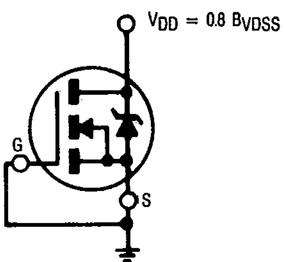

Fig. 11b — V_{DSS} Stress Equals 80% of B_{VDSS} During Radiation

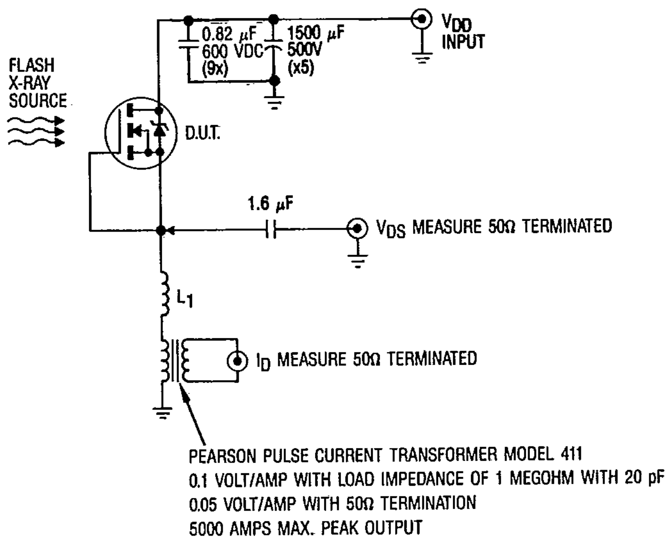

Fig. 12 — High Dose Rate (Gamma Dot) Test Circuit

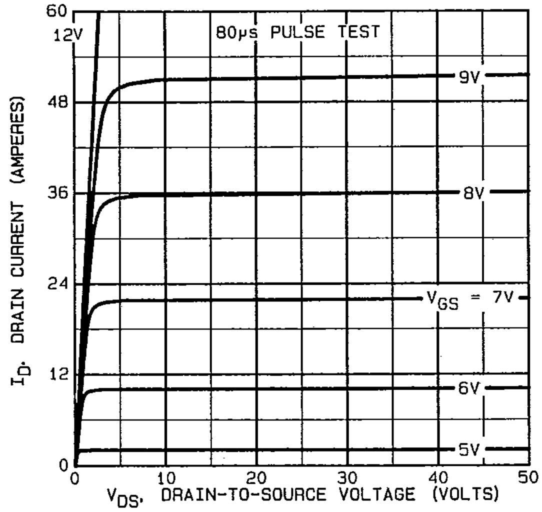

Fig. 13 — Typical Output Characteristics

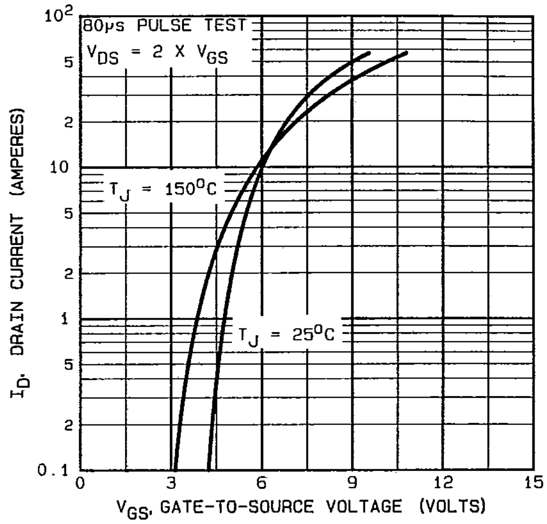

Fig. 14 — Typical Transfer Characteristics

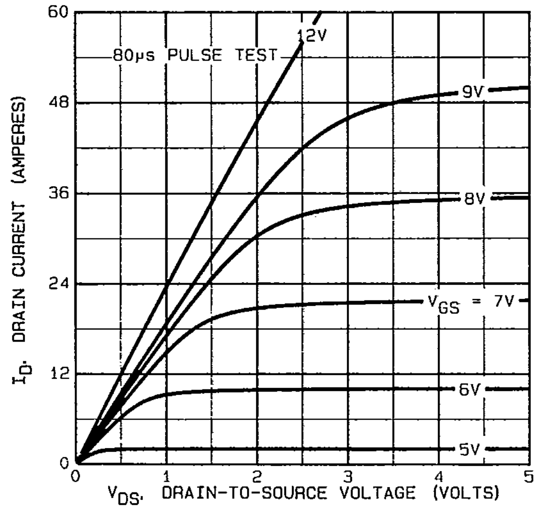

Fig. 15 — Typical Saturation Characteristics

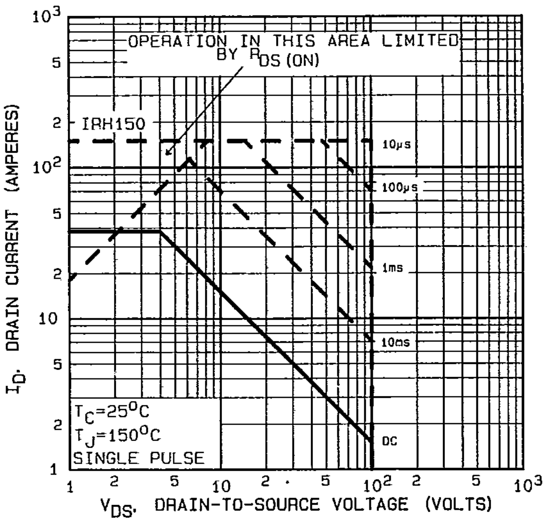

Fig. 16 — Maximum Safe Operating Area

RAD HARD

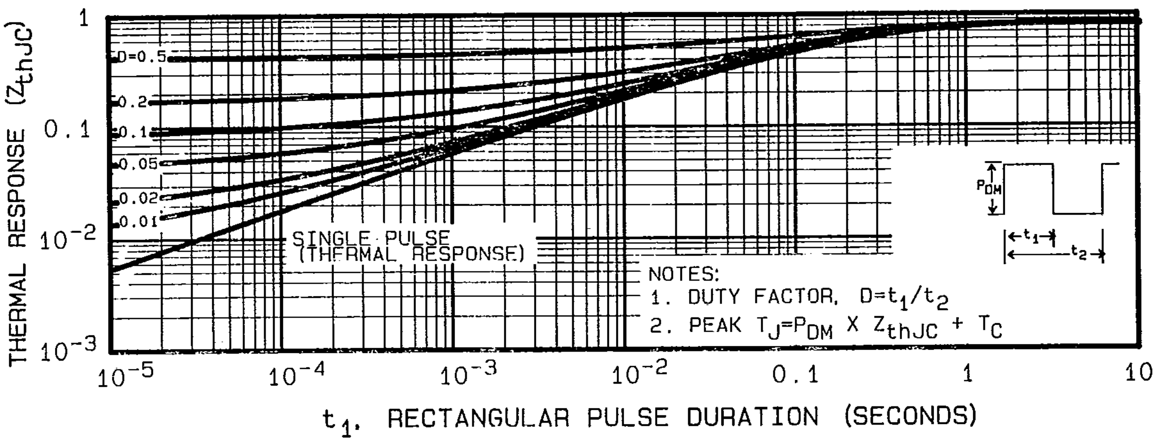

Fig. 17 — Maximum Effective Transient Thermal Impedance, Junction-to-Case Vs. Pulse Duration

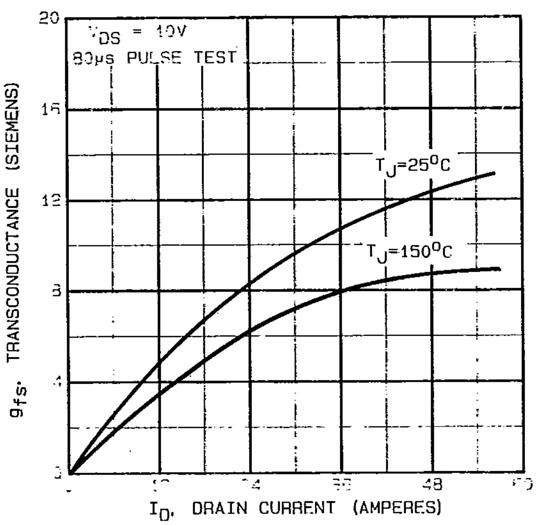

Fig. 18 — Typical Transconductance Vs. Drain Current

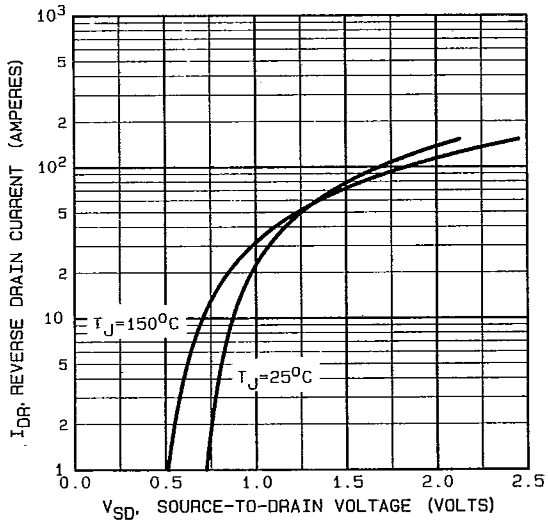

Fig. 19 — Typical Source-Drain Diode Forward Voltage

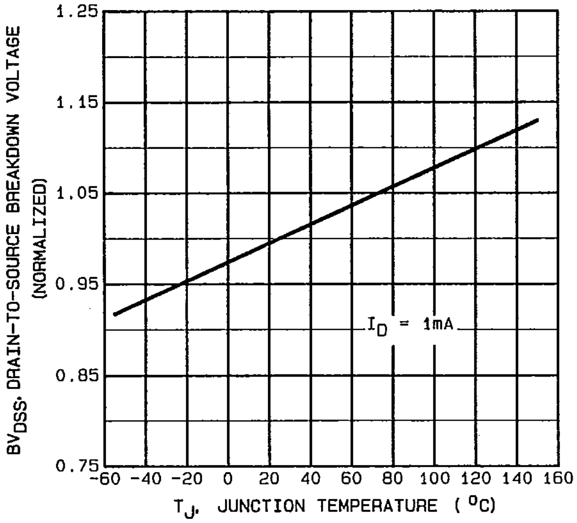

Fig. 20 — Breakdown Voltage Vs. Temperature

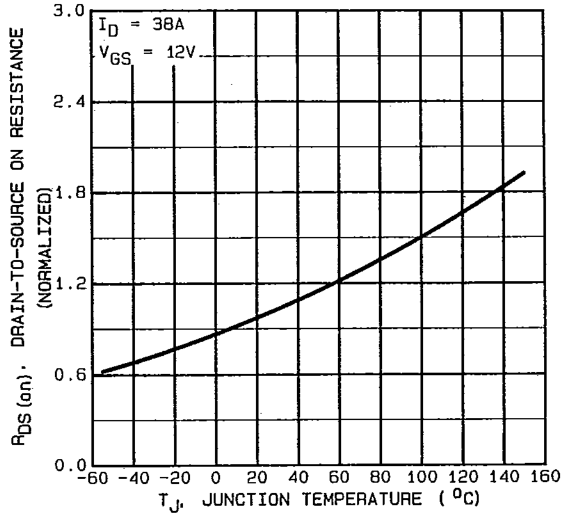

Fig. 21 — Normalized On-Resistance Vs. Temperature

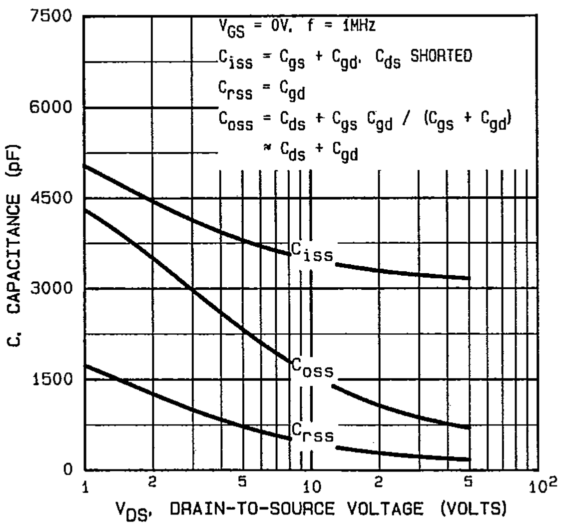

Fig. 22 — Typical Capacitance Vs. Drain-to-Source Voltage

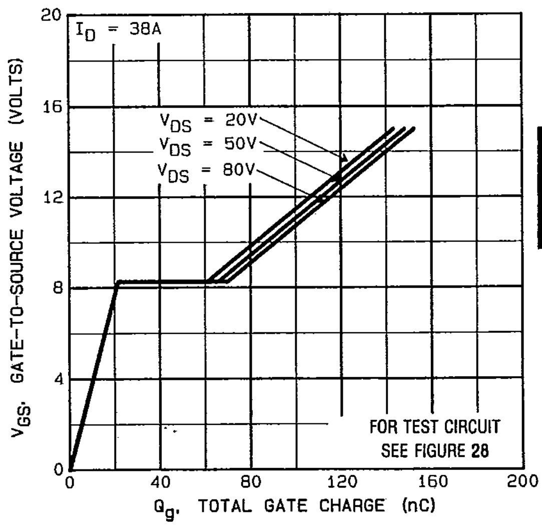

Fig. 23 — Typical Gate Charge Vs. Gate-to-Source Voltage

RAD HARD

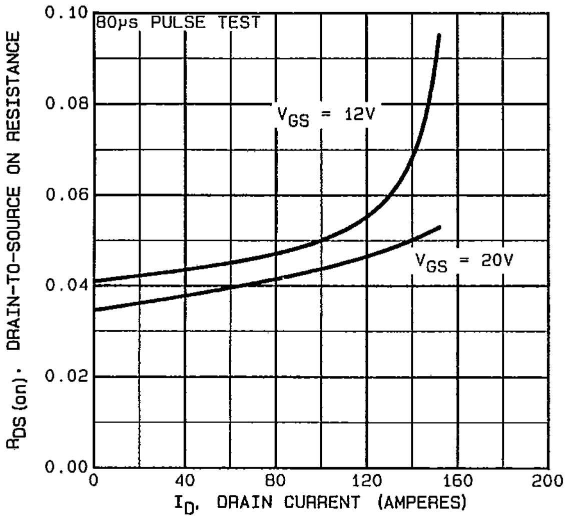

Fig. 24 — Typical On-Resistance Vs. Drain Current

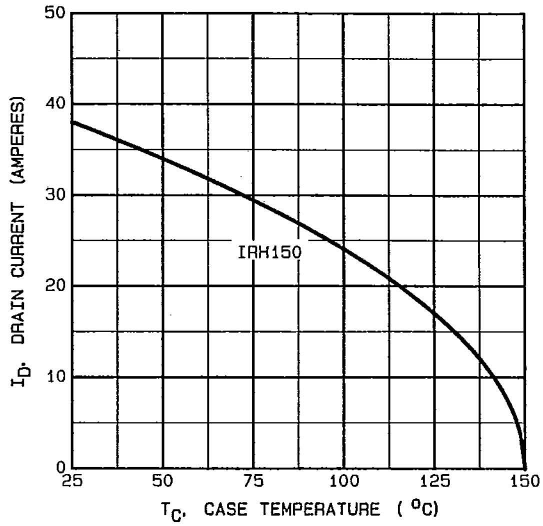

Fig. 25 — Maximum Drain Current Vs. Case Temperature

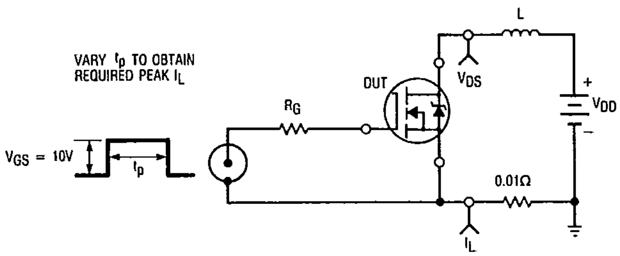

Fig. 26a — Avalanche Inductive Test Circuit

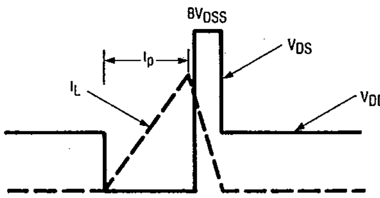

Fig. 26b — Avalanche Inductive Load Test Waveforms

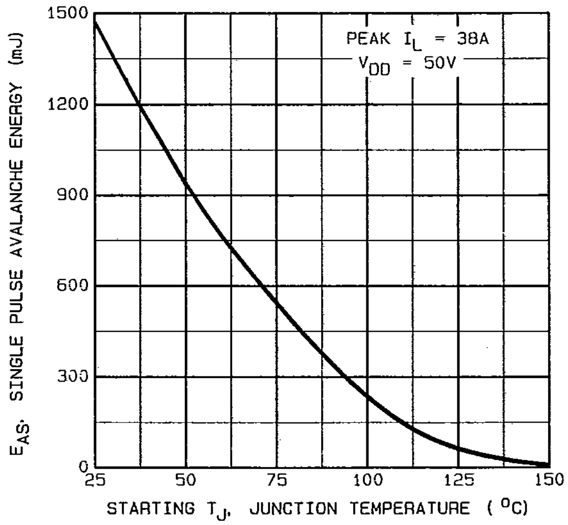

Fig. 26c — Typical Avalanche Vs. Starting Junction Temperature

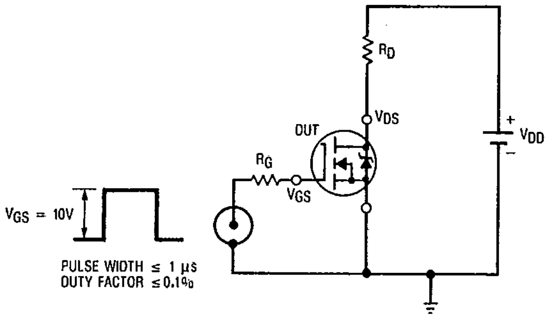

Fig. 27a — Switching Time Test Circuit

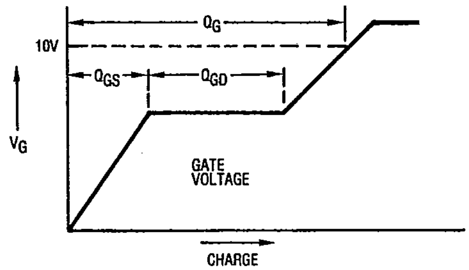

Fig. 28a — Basic Gate Charge Waveform

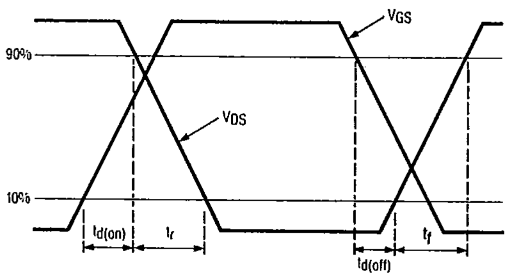

Fig. 27b — Switching Time Waveforms

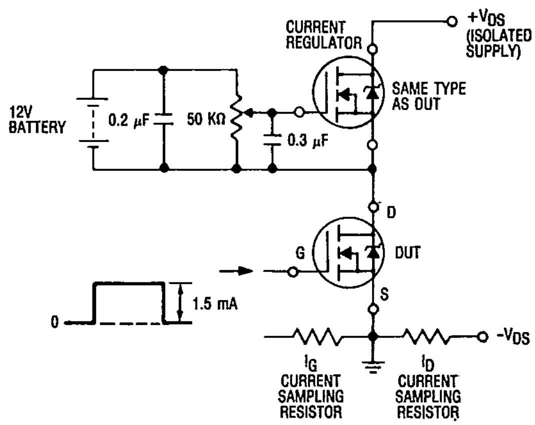

Fig. 28b — Gate Charge Test Circuit

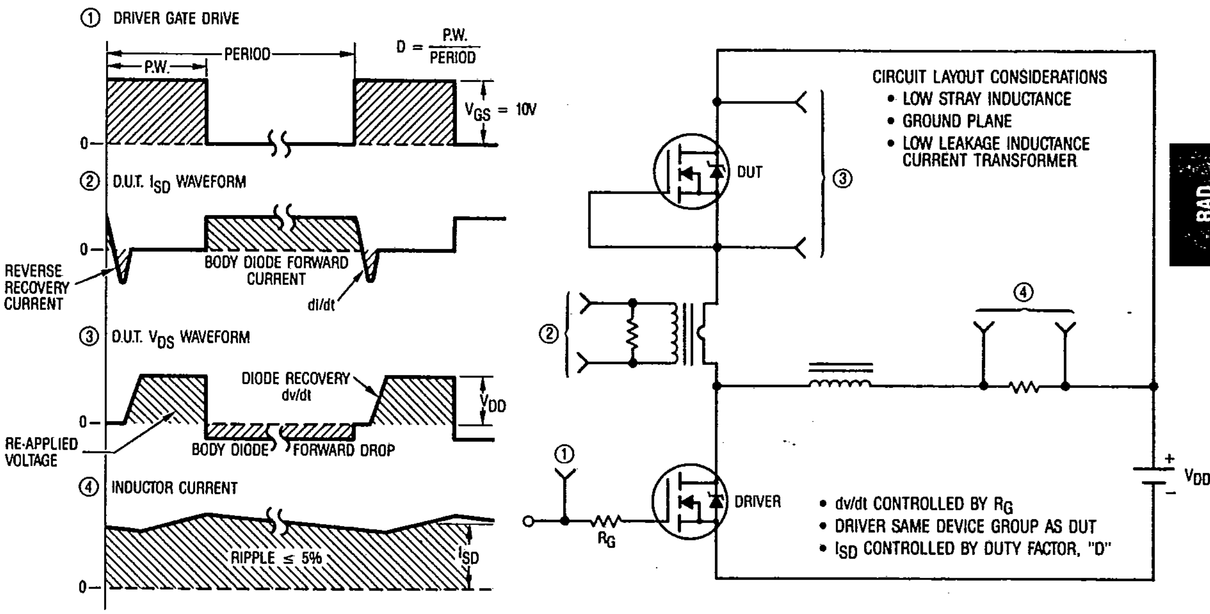

Fig. 29 — Peak Commutating dv/dt Test Circuit

RAD HARD