International
IOR Rectifier

PD-90882

IRHF9130
IRHF93130
JANSR2N7389
JANSF2N7389

[REF: MIL-PRF-19500/630]

P-CHANNEL

RAD HARD

REPETITIVE AVALANCHE AND dv/dt RATED

HEXFET® TRANSISTOR

-100 Volt, 0.30W, RAD HARD HEXFET

International Rectifier's P-Channel RAD HARD technology HEXFETs demonstrate excellent threshold voltage stability and breakdown voltage stability at total radiation doses as high as 3 X 10^5 Rads (Si). Under **identical** pre- and post-radiation test conditions, International Rectifier's P-Channel RAD HARD HEXFETs retain **identical** electrical specifications up to 1 x 10^5 Rads (Si) total dose. No compensation in gate drive circuitry is required. These devices are also 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 P-Channel RAD HARD HEXFETs has demonstrated virtual immunity to SEE failure. Since the P-Channel RAD HARD process utilizes International Rectifier's patented HEXFET technology, the user can expect the highest quality and reliability in the industry.

P-Channel 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
IRHF9130	-100V	0.30W	-6.5A
IRHF93130	-100V	0.30W	-6.5A

Features:

- Radiation Hardened up to 3 x 10^5 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

Absolute Maximum Ratings

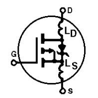
Pre-Irradiation

	Parameter	IRHF9130, IRHF93130	Units
I_D @ V_{GS} = -12V, T_C = 25°C	Continuous Drain Current	-6.5	A
I_D @ V_{GS} = -12V, T_C = 100°C	Continuous Drain Current	-4.1	
I_{DM}	Pulsed Drain Current ①	-26	
P_D @ T_C = 25°C	Max. Power Dissipation	25	W
	Linear Derating Factor	0.2	W/°C
V_{GS}	Gate-to-Source Voltage	± 20	V
E_{AS}	Single Pulse Avalanche Energy ②	165	mJ
I_{AR}	Avalanche Current ①	-6.5	A
E_{AR}	Repetitive Avalanche Energy ①	2.5	mJ
dv/dt	Peak Diode Recovery dv/dt ③	-22	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)	
	Weight	0.98 (typical)	g

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

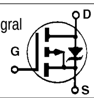
	Parameter	Min	Typ	Max	Units	Test Conditions
BV_{DSS}	Drain-to-Source Breakdown Voltage	-100	—	—	V	V_{GS} =0 V, I_D = -1.0mA
DBV_{DSS}/DT_J	Temperature Coefficient of Breakdown Voltage	—	-0.112	—	V/°C	Reference to 25°C, I_D = -1.0mA
$R_{DS(on)}$	Static Drain-to-Source On-State Resistance	—	—	0.30	W	V_{GS} = -12V, I_D = -4.1A ④
		—	—	0.35		V_{GS} = -12V, I_D = -6.5A
$V_{GS(th)}$	Gate Threshold Voltage	-2.0	—	-4.0	V	V_{DS} = V_{GS}, I_D = -1.0mA
g_{fs}	Forward Transconductance	2.5	—	—	S (M)	V_{DS} > -15V, I_{DS} = -4.1A ④
I_{DSS}	Zero Gate Voltage Drain Current	—	—	-25	mA	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	—	—	45	nC	V_{GS} = -12V, I_D = -6.5A V_{DS} = Max Rating x 0.5
Q_{gs}	Gate-to-Source Charge	—	—	10		
Q_{gd}	Gate-to-Drain ('Miller') Charge	—	—	25		
$t_{d(on)}$	Turn-On Delay Time	—	—	30	ns	V_{DD} = -50V, I_D = -6.5A, R_G = 7.5W
t_r	Rise Time	—	—	50		
$t_{d(off)}$	Turn-Off Delay Time	—	—	70		
t_f	Fall Time	—	—	70		
L_D	Internal Drain Inductance	—	5.0	—	nH	Measured from drain lead, 6mm (0.25 in) from package to center of die.
L_S	Internal Source Inductance	—	13	—		Measured from source lead, 6mm (0.25 in) from package to source bonding pad.
C_{iss}	Input Capacitance	—	1200	—	pF	V_{GS} = 0V, V_{DS} = -25V f = 1.0MHz
C_{oss}	Output Capacitance	—	290	—		
C_{rss}	Reverse Transfer Capacitance	—	76	—		

Modified MOSFET symbol showing the internal inductances.



Source-Drain Diode Ratings and Characteristics

	Parameter	Min	Typ	Max	Units	Test Conditions
I_S	Continuous Source Current (Body Diode)	—	—	-6.5	A	Modified MOSFET symbol showing the integral reverse p-n junction rectifier.
I_{SM}	Pulse Source Current (Body Diode) ①	—	—	-26		
V_{SD}	Diode Forward Voltage	—	—	-3.0	V	T_j = 25°C, I_S = -6.5A, V_{GS} = 0V ④
t_{rr}	Reverse Recovery Time	—	—	250	ns	T_j = 25°C, I_F = -6.5A, di/dt £ -100A/ms V_{DD} £ -50V ④
Q_{RR}	Reverse Recovery Charge	—	—	0.74	mC	
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	—	—	5.0	°C/W	
R_{thJA}	Junction-to-Ambient	—	175	—		Typical socket mount

Radiation Performance of P-Channel Rad Hard HEXFETs

International Rectifier Radiation Hardened HEXFETs are tested to verify their hardness capability. The hardness assurance program at International Rectifier comprises three radiation environments.

Every manufacturing lot is tested in a low dose rate (total dose) environment per MIL-STD-750, test method 1019 condition A. International Rectifier has imposed a standard gate condition of -12 volts per note 5 and a V_{DS} bias condition equal to 80% of the device rated voltage per note 6. Pre- and post- irradiation limits of the devices irradiated to 1 x 10^5 Rads (Si) are identical and are presented in Table 1, column 1, IRHF9130. Post-irradiation limits of the devices irradiated to 3 x 10^5 Rads (Si) are presented in Table 1, column 2, IRHF93130. The values in Table 1 will be met for either of the two low dose rate test circuits that are used. Both pre- and post-irradiation 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 3 x 10^5 Rads (Si) the only parametric limit change is $V_{GS(th)}$ maximum.

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 (See Table 2).

International Rectifier radiation hardened P-Channel HEXFETs are considered to be neutron-tolerant, as stated in MIL-PRF-19500 Group D. International Rectifier radiation hardened P-Channel HEXFETs have been characterized in heavy ion Single Event Effects (SEE) environments. Single Event Effects characterization is shown in Table 3.

Table 1. Low Dose Rate ⑤ ⑥

	Parameter	IRHF9130 100K Rads (Si)		IRHF93130 300K Rads (Si)		Units	Test Conditions ⑧
		MIN	MAX	MIN	MAX		
BV_{DSS}	Drain-to-Source Breakdown Voltage	-100	—	-100	—	V	V_{GS} = 0V, I_D = -1.0mA
$V_{GS(th)}$	Gate Threshold Voltage ④	-2.0	-4.0	-2.0	-5.0		V_{GS} = V_{DS}, I_D = -1.0mA
I_{GSS}	Gate-to-Source Leakage Forward	—	-100	—	-100	nA	V_{GS} = -20V
I_{GSS}	Gate-to-Source Leakage Reverse	—	100	—	100		V_{GS} = 20V
I_{DSS}	Zero Gate Voltage Drain Current	—	-25	—	-25	µA	V_{DS}=0.8 x Max Rating, V_{GS}=0V
$R_{DS(on)1}$	Static Drain-to-Source ④ On-State Resistance One	—	0.30	—	0.30	W	V_{GS} = -12V, I_D =-4.1A
V_{SD}	Diode Forward Voltage ④	—	-3.0	—	-3.0	V	T_C = 25°C, I_S = -6.5A,V_{GS} = 0V

Table 2. High Dose Rate ⑦

	Parameter	10^{11} Rads (Si)/sec			10^{12} Rads (Si)/sec			Units	Test Conditions
		Min	Typ	Max	Min	Typ	Max		
V_{DSS}	Drain-to-Source Voltage	—	—	-80	—	—	-80	V	Applied drain-to-source voltage during gamma-dot
I_{PP}		—	-60	—	—	-60	—	A	Peak radiation induced photo-current
di/dt		—	—	-800	—	—	-160	A/µsec	Rate of rise of photo-current
L_1		0.1	—	—	0.5	—	—	µH	Circuit inductance required to limit di/dt

Table 3. Single Event Effects

Ion	LET (Si) (MeV/mg/cm²)	Fluence (ions/cm²)	Range (µm)	V_{DS}Bias (V)	V_{GS} Bias (V)
Cu	28	3x 10^5	~43	-100	5

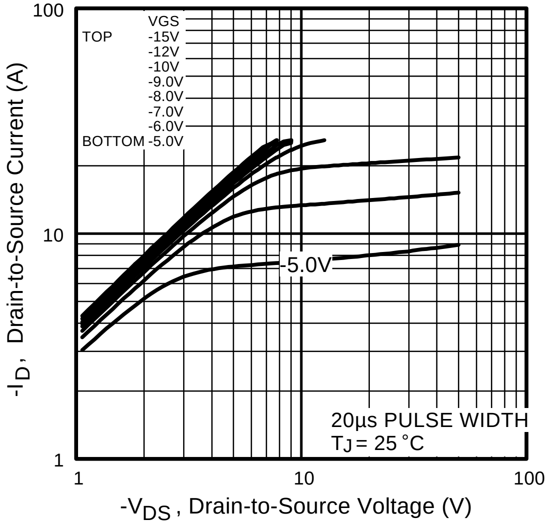


Fig 1. Typical Output Characteristics

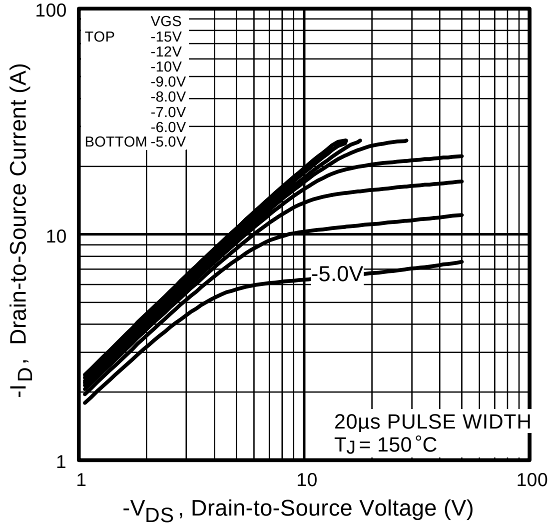


Fig 2. Typical Output Characteristics

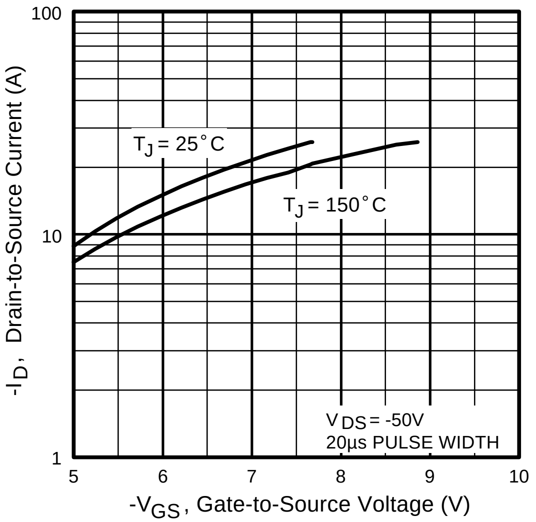


Fig 3. Typical Transfer Characteristics

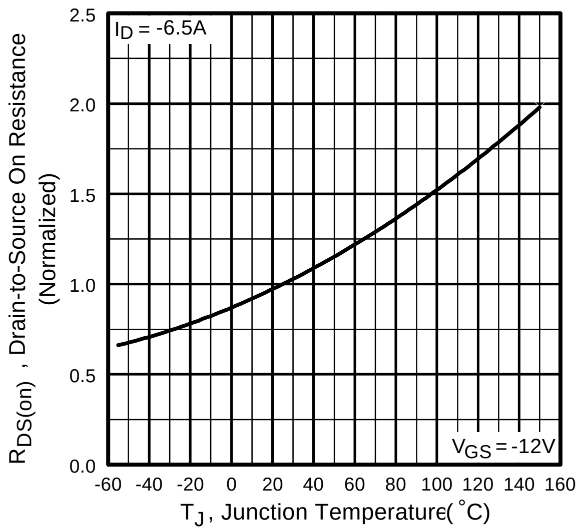


Fig 4. Normalized On-Resistance Vs. Temperature

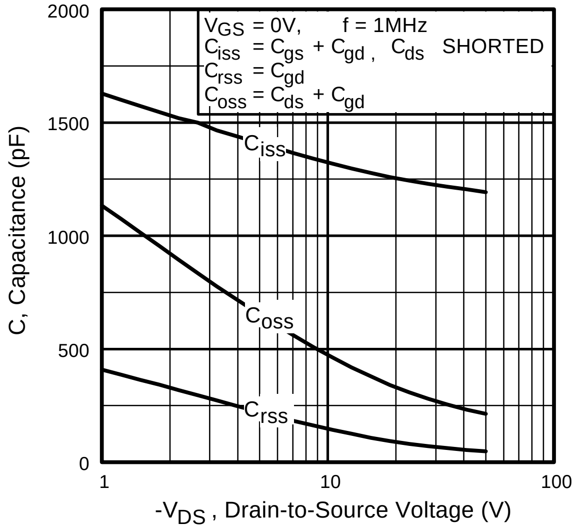


Fig 5. Typical Capacitance Vs. Drain-to-Source Voltage

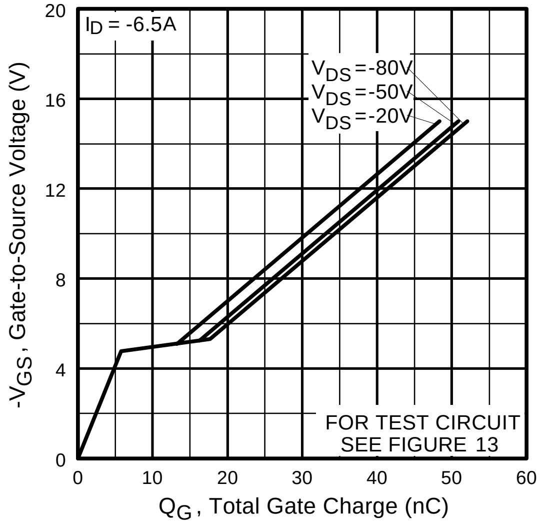


Fig 6. Typical Gate Charge Vs. Gate-to-Source Voltage

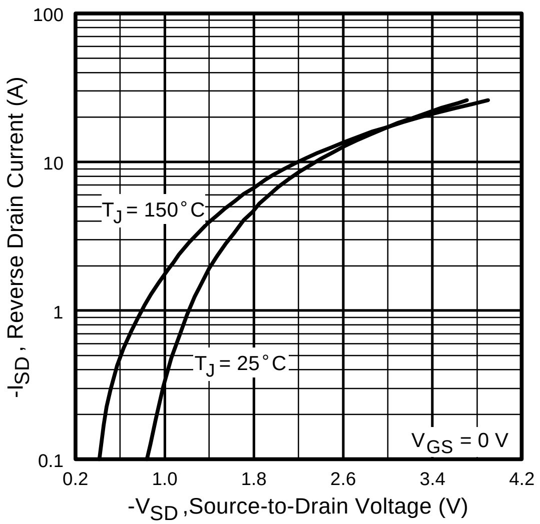


Fig 7. Typical Source-Drain Diode Forward Voltage

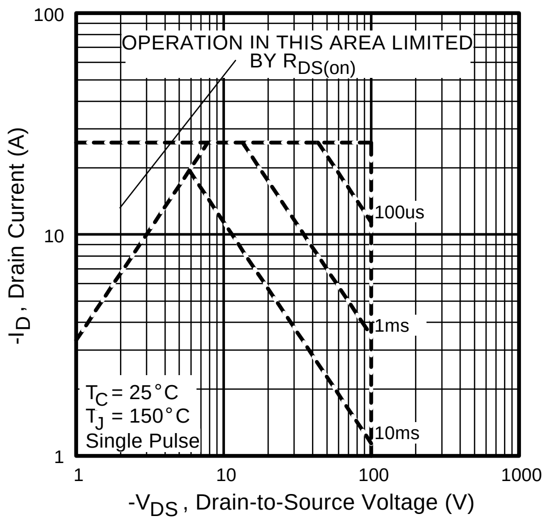


Fig 8. Maximum Safe Operating Area

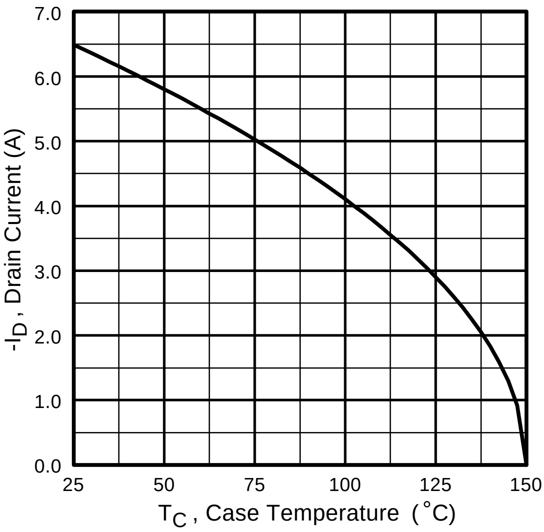


Fig 9. Maximum Drain Current Vs. Case Temperature

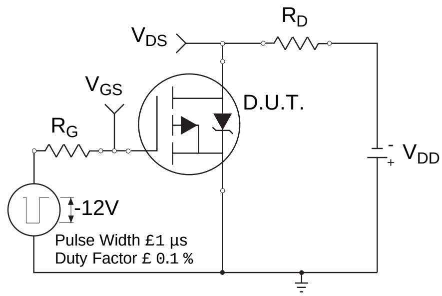


Fig 10a. Switching Time Test Circuit

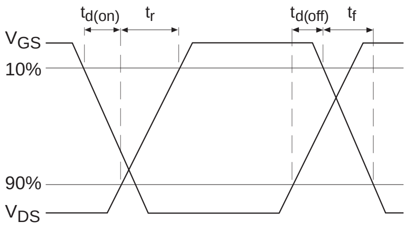


Fig 10b. Switching Time Waveforms

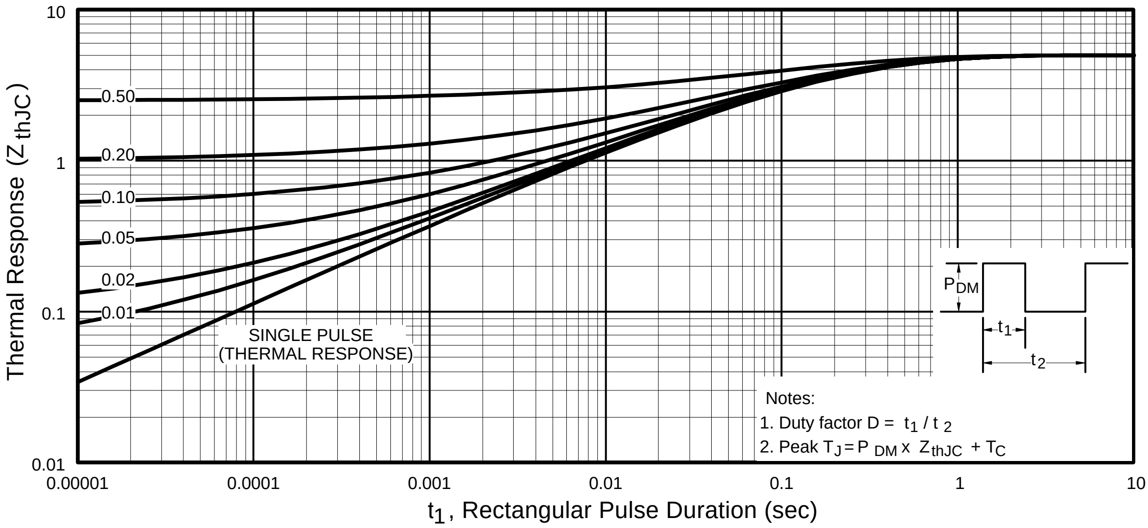


Fig 11. Maximum Effective Transient Thermal Impedance, Junction-to-Case

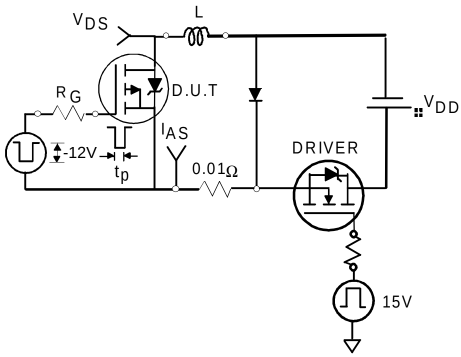


Fig 12a. Unclamped Inductive Test Circuit

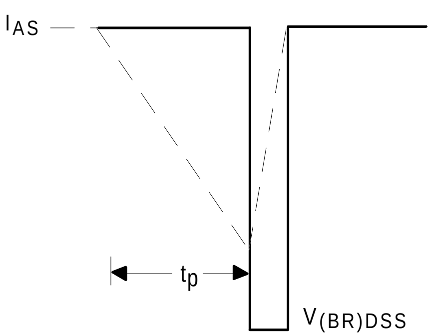


Fig 12b. Unclamped Inductive Waveforms

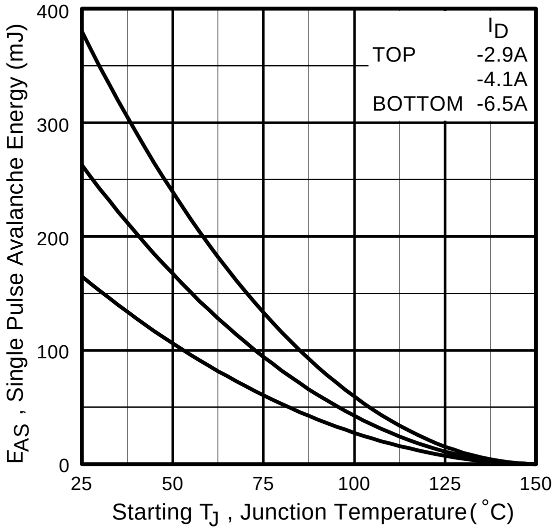


Fig 12c. Maximum Avalanche Energy Vs. Drain Current

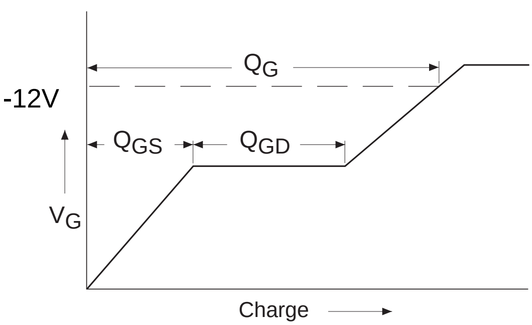


Fig 13a. Basic Gate Charge Waveform

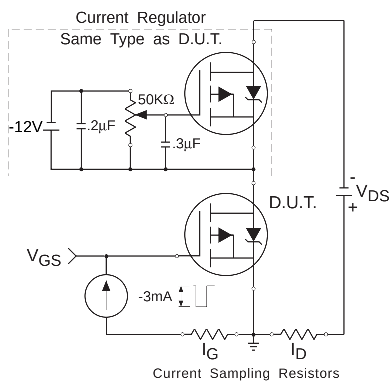


Fig 13b. Gate Charge Test Circuit

REVIEW ONLY

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

② @ V_{DD} = -25V, Starting T_J = 25°C, E_{AS} = [0.5 * L * (I_L^2)] Peak I_L = -6.5A, V_{GS} = -12V, 25 £ R_G £ 200W

③ I_{SD} £ -6.5A, di/dt £ -430A/ms, V_{DD} £ BV_{DSS}, T_J £ 150°C Suggested RG = 7.5W

④ Pulse width £ 300 ms; Duty Cycle £ 2%

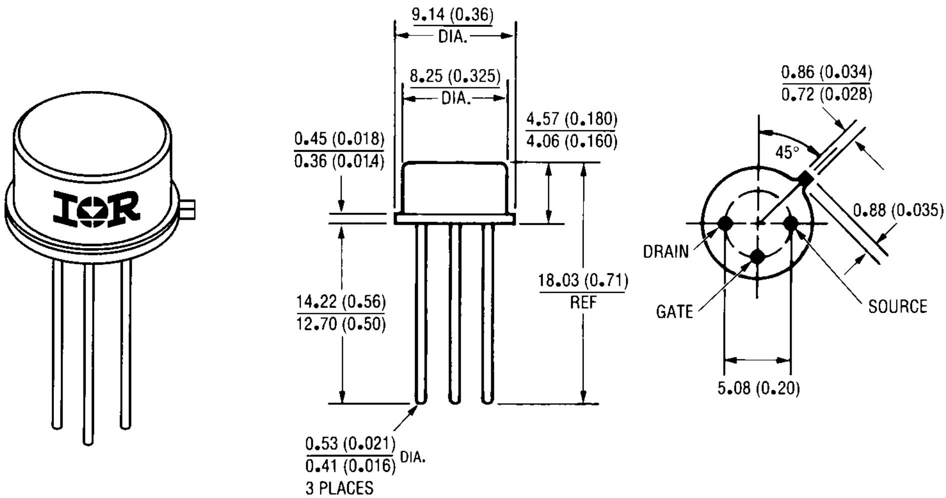
⑤ **Total Dose Irradiation with V_{GS} Bias.** -12 volt V_{GS} applied and V_{DS} = 0 during irradiation per MIL-STD-750, method 1019.

⑥ **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-750, method 1019.

⑦ This test is performed using a flash x-ray source operated in the e-beam mode (energy ~2.5 MeV), 30 nsec pulse.

⑧ All Pre-Radiation and Post-Radiation test conditions are **identical** to facilitate direct comparison for circuit applications.

Case Outline and Dimensions — TO-205AF (Modified TO-39)



All dimensions are shown millimeters (inches)

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