International
IOR Rectifier

IRHM9064
IRHM 93064
JANSR2N7424

REPETITIVE AVALANCHE AND dv/dt RATED
HEXFET® TRANSISTOR

P-CHANNEL
RAD HARD

-60 Volt, 0.05Ω, 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 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
IRHM9064	-60V	0.05Ω	-35A
IRHM93064	-60V	0.05Ω	-35A

Features:

- Radiation Hardened up to 1 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
- Electrically Isolated
- Ceramic Eyelets

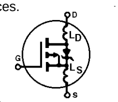
Absolute Maximum Ratings

Pre-Irradiation

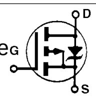
	Parameter	IRHM9064/IRHM93064	Units
I_D @ V_{GS} = -12V, T_C = 25°C	Continuous Drain Current	-35	A
I_D @ V_{GS} = -12V, T_C = 100°C	Continuous Drain Current	-30	
I_{DM}	Pulsed Drain Current ①	-192	
P_D @ T_C = 25°C	Max. Power Dissipation	250	W
	Linear Derating Factor	2.0	W/°C
V_{GS}	Gate-to-Source Voltage	±20	V
E_{AS}	Single Pulse Avalanche Energy ②	500	mJ
I_{AR}	Avalanche Current ①	-35	A
E_{AR}	Repetitive Avalanche Energy ①	25	mJ
dv/dt	Peak Diode Recovery dv/dt ③	-5.5	V/ns
T_J T_{STG}	Operating Junction Storage Temperature Range	-55 to 150	°C
	Package Mounting Surface Temperature	300 (for 5 Sec.)	
	Weight	9.3 (typical)	g

7/6/98

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

	Parameter	Min	Typ	Max	Units	Test Conditions
BV_{DSS}	Drain-to-Source Breakdown Voltage	-60	—	—	V	V_{GS} = 0V, I_D = -1.0mA
$\Delta BV_{DSS}/\Delta T_J$	Temperature Coefficient of Breakdown Voltage	—	-0.056	—	V/°C	Reference to 25°C, I_D = -1.0mA
$R_{DS(on)}$	Static Drain-to-Source On-State Resistance	—	—	0.050	Ω	V_{GS} = -12V, I_D =-30A ④
		—	—	0.053		V_{GS} = -12V, I_D = -35A
$V_{GS(th)}$	Gate Threshold Voltage	-2.0	—	-4.0	V	V_{DS} = V_{GS}, I_D = -1.0mA
g_{fs}	Forward Transconductance	18	—	—	S (℧)	V_{DS} > -15V, I_{DS} = -30A 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	—	—	300	nC	V_{GS} =-12V, I_D = -35A V_{DS} = Max Rating x 0.5
Q_{gs}	Gate-to-Source Charge	—	—	70		
Q_{gd}	Gate-to-Drain ('Miller') Charge	—	—	91		
$t_{d(on)}$	Turn-On Delay Time	—	—	35	ns	V_{DD} = -30V, I_D = -35A, R_G = 2.35Ω
t_r	Rise Time	—	—	150		
$t_{d(off)}$	Turn-Off Delay Time	—	—	200		
t_f	Fall Time	—	—	200		
L_D	Internal Drain Inductance	—	8.7	—	nH	Measured from drain lead, 6mm (0.25 in) from package to center of die. Modified MOSFET symbol showing the internal inductances. 
L_S	Internal Source Inductance	—	8.7	—		Measured from source lead, 6mm (0.25 in) from package to source bonding pad.
C_{iss}	Input Capacitance	—	6700	—	pF	V_{GS} = 0V, V_{DS} = -25V f = 1.0MHz
C_{oss}	Output Capacitance	—	2800	—		
C_{rss}	Reverse Transfer Capacitance	—	920	—		

Source-Drain Diode Ratings and Characteristics

	Parameter	Min	Typ	Max	Units	Test Conditions
I_S	Continuous Source Current (Body Diode)	—	—	-35	A	Modified MOSFET symbol showing the integral reverse p-n junction rectifier. 
I_{SM}	Pulse Source Current (Body Diode) ①	—	—	-192		
V_{SD}	Diode Forward Voltage	—	—	-3.0	V	T_j = 25°C, I_S = -35A, V_{GS} = 0V ④
t_{rr}	Reverse Recovery Time	—	—	270	ns	T_j = 25°C, I_F = -35A, di/dt ≤ -100A/µs V_{DD} ≤ -50V ④
Q_{RR}	Reverse Recovery Charge	—	—	2.5	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

	Parameter	Min	Typ	Max	Units	Test Conditions
R_{thJC}	Junction-to-Case	—	—	0.50	W/°C	
R_{thCS}	Case-to-Sink	—	0.21	—		
R_{thJA}	Junction-to-Ambient	—	—	48		Typical socket mount

* Current is limited by pin diameter (Die current is 48A , see fig. 4 & 9)

Radiation Performance of Rad Hard HEXFETs

International Rectifier Radiation Hardened HEXFETs are tested to verify their hardness capability. The hardness assurance program at International Rectifier comprises 3 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 6 and a V_{DS} bias condition equal to 80% of the device rated voltage per note 7. 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, IRHM9064. Post-irradiation limits of devices irradiated to 3 x 10^5 Rads(Si) are presented in Table 1, column 2, IRHM93064. 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 after an irradiation level of 1 x 10^5 Rads (Si) no changes in limits are specified in DC parameters. After an irradiation of 3 x 10^5 only the $V_{GS(th)}$ max is affected.

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 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 ⑤⑥

	Parameter	IRHM9064 100K Rads (Si) Min	IRHM9064 100K Rads (Si) Max	IRHM93064 300K Rads (Si) Min	IRHM93064 300K Rads (Si) Max	Units	Test Conditions ⑧
BV_{DSS}	Drain-to-Source Breakdown Voltage	-60	—	-60	—	V	V_{GS} = 0V, I_D = -1.0mA
$V_{GS(th)}$	Gate Threshold Voltage ④	-2.0	-4.0	-2.0	-5.0	V	$V_{GS} = V_{DS}$, 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	nA	V_{GS} = 20 V
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	—	0.05	—	0.05	Ω	V_{GS} = -12V, I_D =-30A
V_{SD}	Diode Forward Voltage ④	—	-3.0	—	-3.0	V	T_C = 25°C, I_S = -35A, V_{GS} = 0V

Table 2. High Dose Rate ⑦

	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	—	—	-48	—	—	-48	V	Applied drain-to-source voltage during gamma-dot
I_{PP}		—	-100	—	—	-100	—	A	Peak radiation induced photo-current
di/dt		—	-800	—	—	-160	—	A/µsec	Rate of rise of photo-current
L_1		0.1	—	—	0.8	—	—	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	-60	5

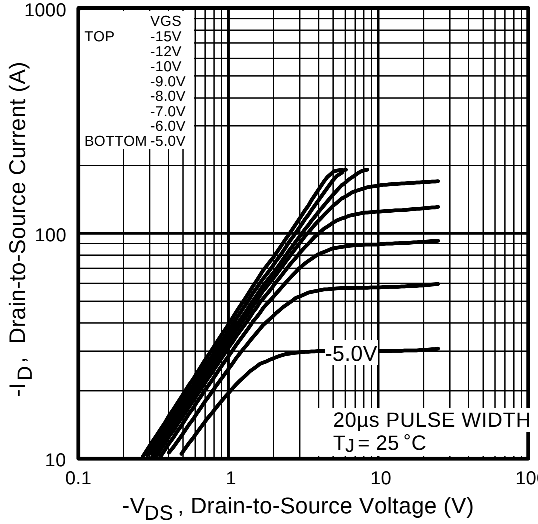


Fig 1. Typical Output Characteristics

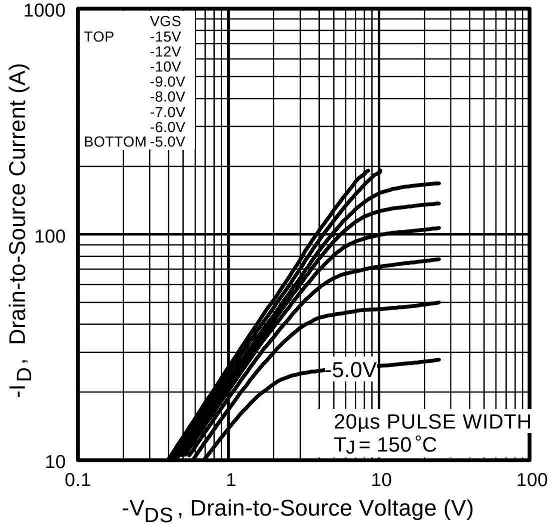


Fig 2. Typical Output Characteristics

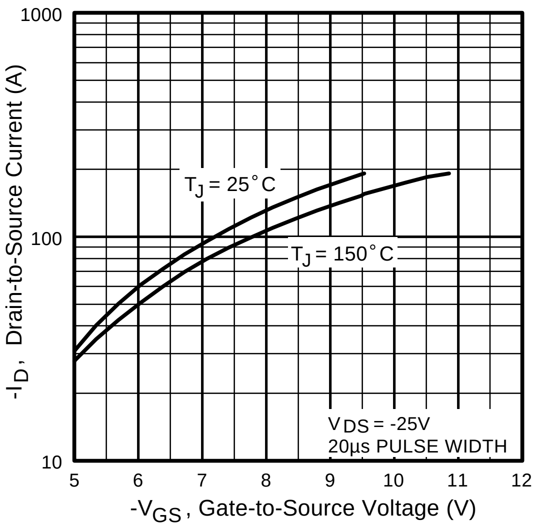


Fig 3. Typical Transfer Characteristics

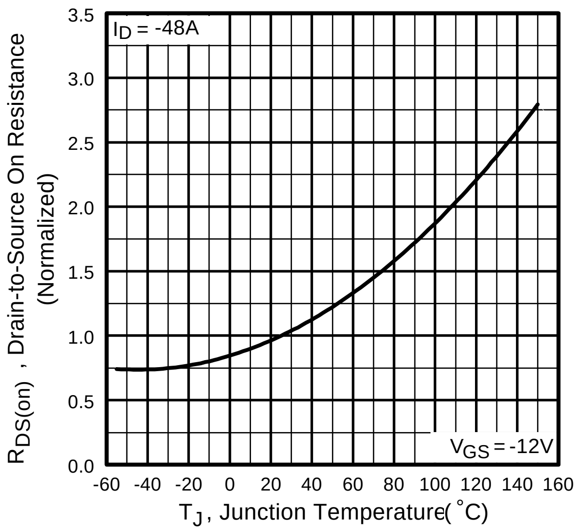


Fig 4. Normalized On-Resistance Vs. Temperature

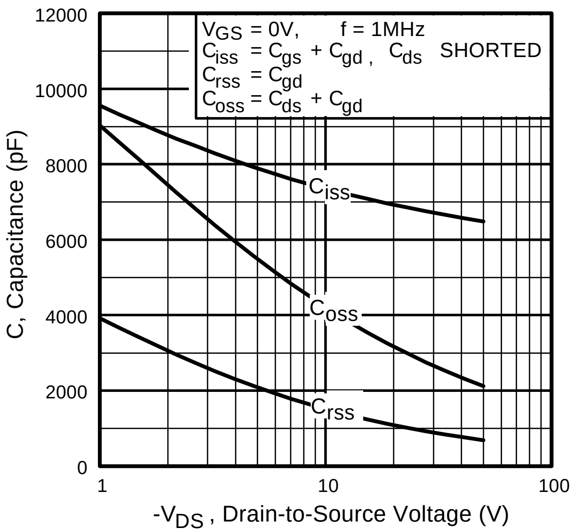


Fig 5. Typical Capacitance Vs. Drain-to-Source Voltage

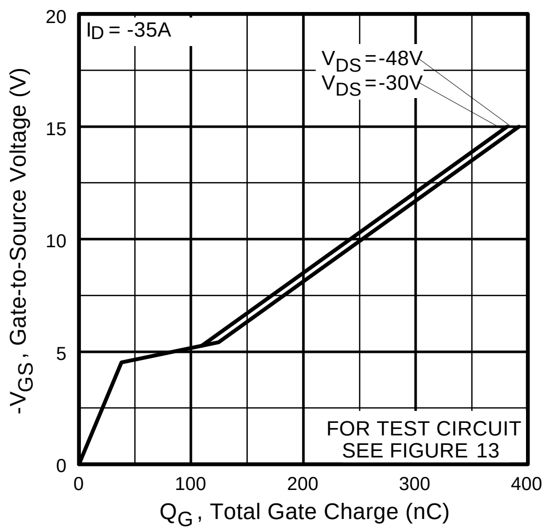


Fig 6. Typical Gate Charge Vs. Gate-to-Source Voltage

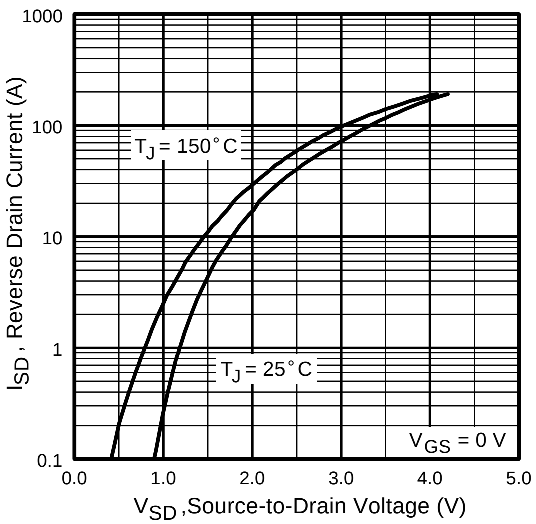


Fig 7. Typical Source-Drain Diode Forward Voltage

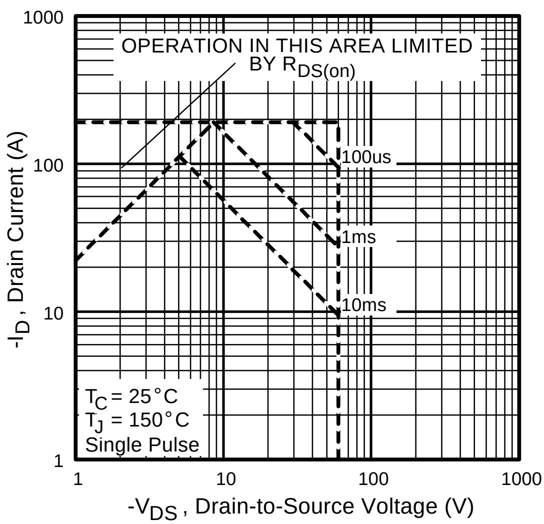


Fig 8. Maximum Safe Operating Area

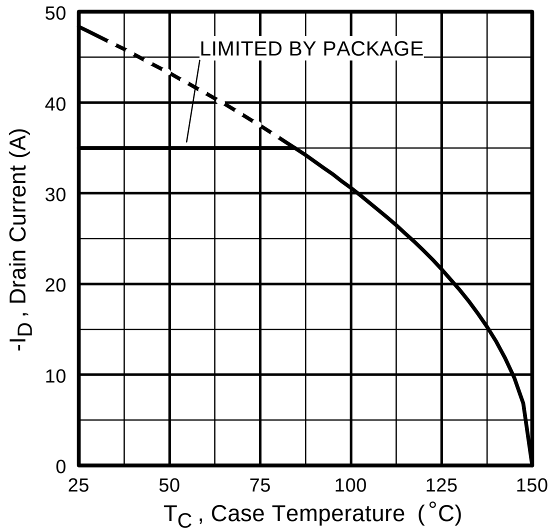


Fig 9. Maximum Drain Current Vs. Case Temperature

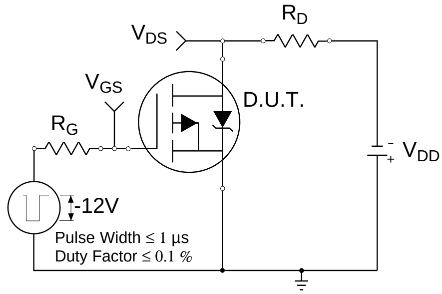


Fig 10a. Switching Time Test Circuit

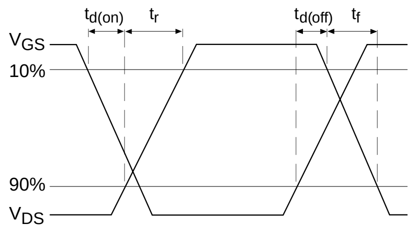


Fig 10b. Switching Time Waveforms

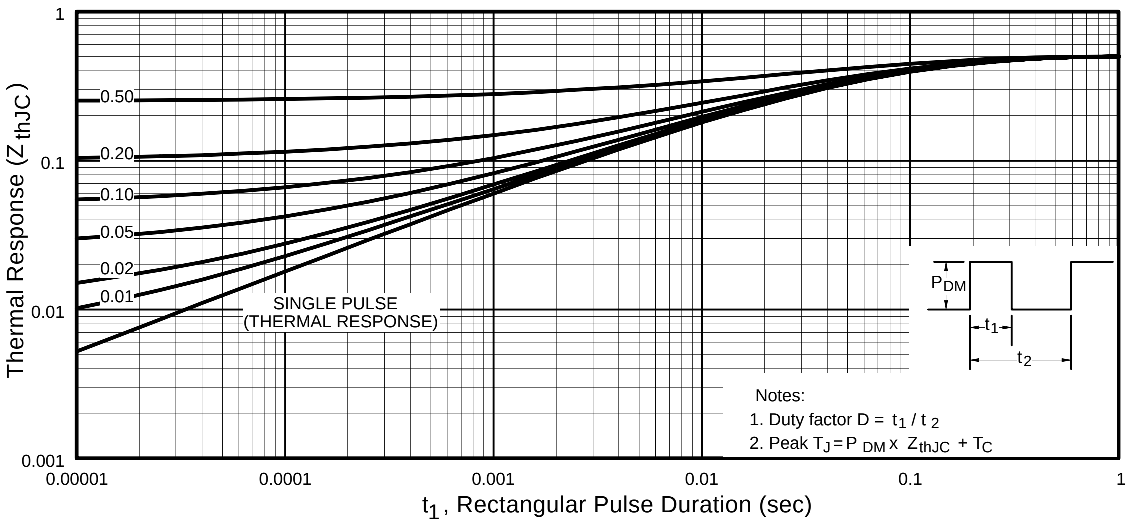


Fig 11. Maximum Effective Transient Thermal Impedance, Junction-to-Case

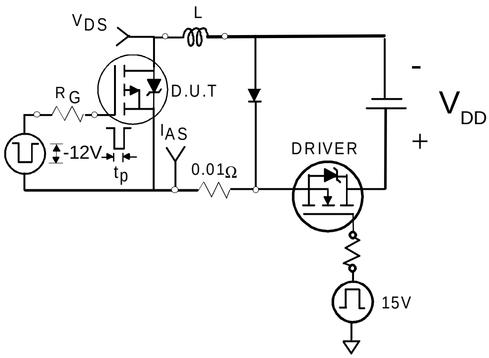


Fig 12a. Unclamped Inductive Test Circuit

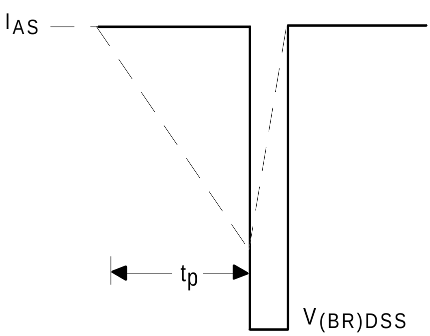


Fig 12b. Unclamped Inductive Waveforms

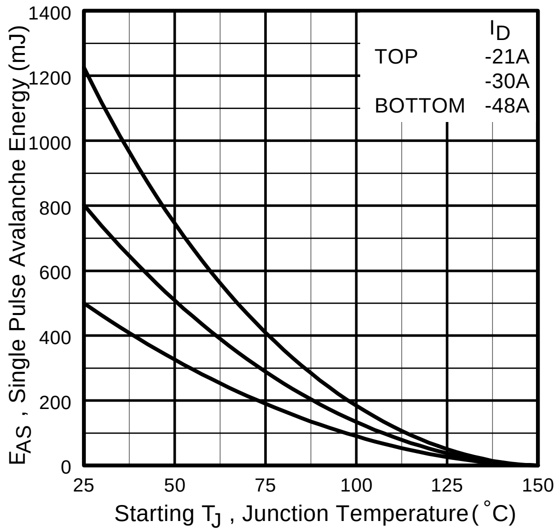


Fig 12c. Maximum Avalanche Energy Vs. Drain Current

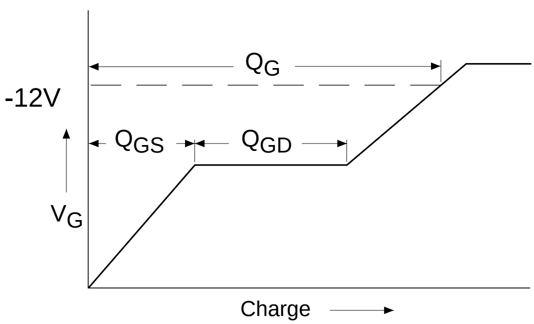


Fig 13a. Basic Gate Charge Waveform

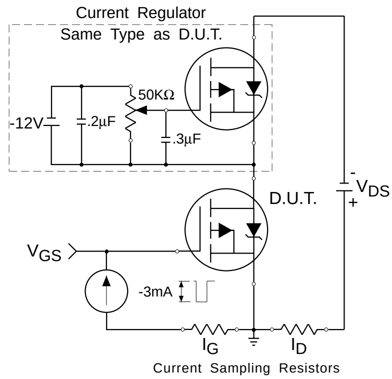


Fig 13b. Gate Charge Test Circuit

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 = -35A, V_{GS} = -12V, $25 \leq R_G \leq 200\Omega$

③ $I_{SD} \leq$ -35A, di/dt ≤ 150A/µs, $V_{DD} \leq BV_{DSS}$, $T_J \leq$ 150°C Suggested RG = 2.35Ω

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

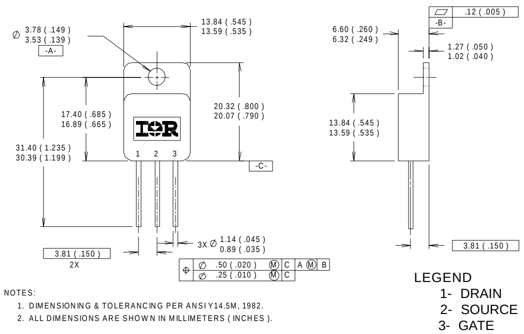
⑤ **Total Dose Irradiation with V_{GS} Bias.** -12 volt V_{GS} applied and V_{DS} = 0 during irradiation per MIL-STD-750, method 1019, condition A.

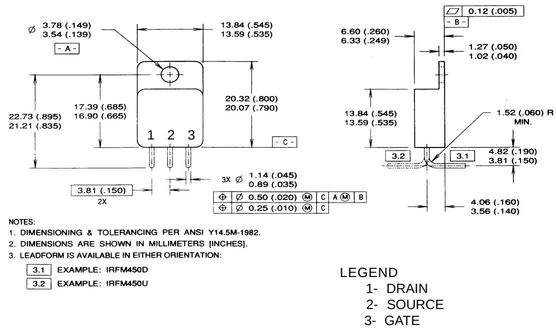
⑥ **Total Dose Irradiation with V_{DS} Bias.** V_{DS} = 0.8 rated BV_{DSS} (pre-irradiation) applied and V_{GS} = 0 during irradiation per MIL-STD -750, method 1019, condition A.

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-Irradiation and Post-Irradiation test conditions are **identical** to facilitate direct comparison for circuit applications.

Case Outline and Dimensions — TO-254AA





Conforms to JEDEC Outline TO-254AA
Dimensions in Millimeters and (Inches)

CAUTION

BERYLLIA WARNING PER MIL-PRF-19500

Package containing beryllia shall not be ground, sandblasted, machined, or have other operations performed on them which will produce beryllia or beryllium dust. Furthermore, beryllium oxide packages shall not be placed in acids that will produce fumes containing beryllium.

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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: K&H Bldg., 2F, 30-4 Nishi-Ikebukuro 3-Chome, Toshima-Ku, Tokyo Japan 171 Tel: 81 3 3983 0086
IR SOUTHEAST ASIA: 315 Outram Road, #10-02 Tan Boon Liat Building, Singapore 0316 Tel: 65 221 8371
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