

## REPETITIVE AVALANCHE AND $dv/dt$ RATED HEXFET® TRANSISTOR

## IRHF7330SE

### N-CHANNEL SINGLE EVENT EFFECT (SEE) RAD HARD

#### 400Volt, 1.2Ω, SEE RAD HARD HEXFET

International Rectifier's SEE RAD HARD technology HEXFETs demonstrate immunity to SEE failure. Additionally, under **identical** pre- and post-irradiation test conditions, International Rectifier's RAD HARD HEXFETs retain **identical** electrical specifications up to  $1 \times 10^5$  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  $1 \times 10^{12}$  Rads (Si)/Sec, and return to normal operation within a few microseconds. Since the SEE 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 <sub>DSS</sub>	R <sub>DS(on)</sub>	I <sub>D</sub>
IRHF7330SE	400V	1.2Ω	3.0A

#### Features:

- Radiation Hardened up to  $1 \times 10^5$  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

#### Absolute Maximum Ratings

#### Pre-Irradiation

	Parameter	IRHF7330SE	Units
I <sub>D</sub> @ V <sub>GS</sub> = 12V, T <sub>C</sub> = 25°C	Continuous Drain Current	3.0	A
I <sub>D</sub> @ V <sub>GS</sub> = 12V, T <sub>C</sub> = 100°C	Continuous Drain Current	1.9	
I <sub>DM</sub>	Pulsed Drain Current ①	12	
P <sub>D</sub> @ T <sub>C</sub> = 25°C	Max. Power Dissipation	25	W
	Linear Derating Factor	0.2	W/°C
V <sub>GS</sub>	Gate-to-Source Voltage	±20	V
EAS	Single Pulse Avalanche Energy ②	140	mJ
I <sub>AR</sub>	Avalanche Current ①	3.0	A
EAR	Repetitive Avalanche Energy ①	2.5	mJ
dv/dt	Peak Diode Recovery dv/dt ③	6.7	V/ns
T <sub>J</sub>	Operating Junction	-55 to 150	°C
T <sub>STG</sub>	Storage Temperature Range		
	Lead Temperature	300 (0.063 in. (1.6mm) from case for 10 sec.)	
	Weight	0.98 (typical)	

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

	Parameter	Min	Typ	Max	Units	Test Conditions
BVDSS	Drain-to-Source Breakdown Voltage	400	—	—	V	VGS = 0V, ID = 1.0mA
ΔBVDSS/ΔTj	Temperature Coefficient of Breakdown Voltage	—	0.50	—	V/°C	Reference to 25°C, ID = 1.0mA
RDS(on)	Static Drain-to-Source On-State Resistance	—	—	1.2	Ω	VGS = 12V, ID = 1.9A ④
VGS(th)	Gate Threshold Voltage	2.5	—	4.5	V	VDS = VGS, ID = 1.0mA
gfs	Forward Transconductance	1.3	—	—	S (τ)	VDS > 15V, IDS = 1.9A ④
IDSS	Zero Gate Voltage Drain Current	—	—	50	μA	VDS = 0.8 x Max Rating, VGS = 0V
		—	—	250		VDS = 0.8 x Max Rating VGS = 0V, Tj = 125°C
IGSS	Gate-to-Source Leakage Forward	—	—	100	nA	VGS = 20V
IGSS	Gate-to-Source Leakage Reverse	—	—	-100		VGS = -20V
Qg	Total Gate Charge	—	—	41	nC	VGS = 12V, ID = 3.0A VDS = Max Rating x 0.5
Qgs	Gate-to-Source Charge	—	—	7.0		
Qgd	Gate-to-Drain ('Miller') Charge	—	—	20		
td(on)	Turn-On Delay Time	—	—	35	ns	VDD = 200V, ID = 3.0A, RG = 7.5Ω
tr	Rise Time	—	—	62		
td(off)	Turn-Off Delay Time	—	—	58		
tf	Fall Time	—	—	58		
LD	Internal Drain Inductance	—	5.0	—	nH	Measured from drain lead, 6mm (0.25 in) from package to center of die.
LS	Internal Source Inductance	—	15	—		Measured from source lead, 6mm (0.25 in) from package to source bonding pad.
Ciss	Input Capacitance	—	555	—	pF	VGS = 0V, VDS = 25V f = 1.0MHz
Coss	Output Capacitance	—	160	—		
Crss	Reverse Transfer Capacitance	—	60	—		

**Source-Drain Diode Ratings and Characteristics**

	Parameter	Min	Typ	Max	Units	Test Conditions
IS	Continuous Source Current (Body Diode)	—	—	3.0	A	Modified MOSFET symbol showing the integral reverse-pn junction rectifier.
ISM	Pulse Source Current (Body Diode) ①	—	—	12		
VSD	Diode Forward Voltage	—	—	1.4	V	Tj = 25°C, IS = 3.0A, VGS = 0V ④
t <sub>rr</sub>	Reverse Recovery Time	—	—	516	ns	Tj = 25°C, IF = 3.0A, di/dt ≤ 100A/μs
QRR	Reverse Recovery Charge	—	—	3.0	μC	VDD ≤ 50V ④
t <sub>on</sub>	Forward Turn-On Time	Intrinsic turn-on time is negligible. Turn-on speed is substantially controlled by LS + LD.				

**Thermal Resistance**

	Parameter	Min	Typ	Max	Units	Test Conditions
RthJC	Junction-to-Case	—	—	5.0	°C/W	Typical socket mount
RthJA	Junction-to-Ambient	—	—	175		

**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 5 and a  $V_{DS}$  bias condition equal to 80% of the device rated voltage per note 6. Post-irradiation limits of the devices irradiated to  $1 \times 10^5$  Rads (Si) are presented in Table 1, column 1, IRHF7330SE. 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  $1 \times 10^5$  Rads (Si) the only parameter limit change is  $V_{GS_{Th}}$  minimum.

High dose rate testing may be done on a special request basis using a dose rate up to  $1 \times 10^{12}$  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** ⑤ ⑥

		IRHF7330SE		Units	Test Conditions ⑧
Parameter		100K Rads (Si)			
		Min	Max		
$BV_{DSS}$	Drain-to-Source Breakdown Voltage	400	—	V	$V_{GS} = 0V, I_D = 1.0mA$
$V_{GS(th)}$	Gate Threshold Voltage ④	2.0	4.5		$V_{GS} = V_{DS}, I_D = 1.0mA$
$I_{GSS}$	Gate-to-Source Leakage Forward	—	100	nA	$V_{GS} = 20V$
$I_{GSS}$	Gate-to-Source Leakage Reverse	—	-100		$V_{GS} = -20V$
$I_{DSS}$	Zero Gate Voltage Drain Current	—	50	$\mu A$	$V_{DS}=0.8 \times \text{Max Rating}, V_{GS}=0V$
$R_{DS(on)1}$	Static Drain-to-Source ④ On-State Resistance One	—	1.2	$\Omega$	$V_{GS} = 12V, I_D = 1.9A$
$V_{SD}$	Diode Forward Voltage ④	—	1.4	V	$T_C = 25^\circ C, I_S = 3.0A, V_{GS} = 0V$

**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	—	—	320	—	—	320	V	Applied drain-to-source voltage during gamma-dot
$I_{PP}$		—	3	—	—	3	—	A	Peak radiation induced photo-current
$di/dt$		—	15	—	—	3	—	A/ $\mu sec$	Rate of rise of photo-current
$L_1$		—	27	—	—	133	—	$\mu H$	Circuit inductance required to limit di/dt

**Table 3. Single Event Effects**

Ion	LET (Si) (MeV/mg/cm <sup>2</sup> )	Fluence (ions/cm <sup>2</sup> )	Range ( $\mu m$ )	$V_{DS}$ Bias (V)	$V_{GS}$ Bias (V)
Cu	28	$3 \times 10^5$	~43	400	-5

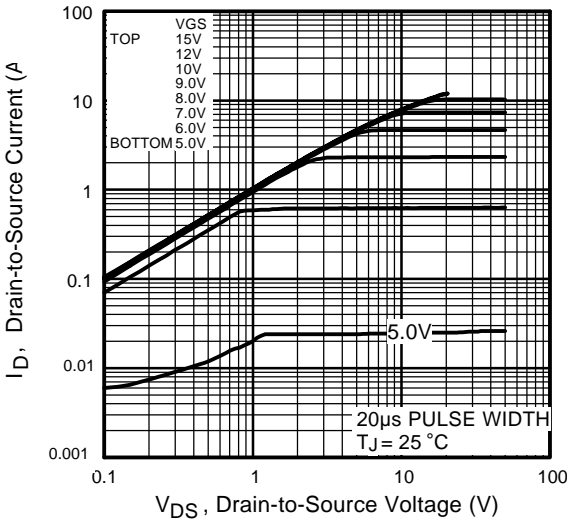


Fig 1. Typical Output Characteristics

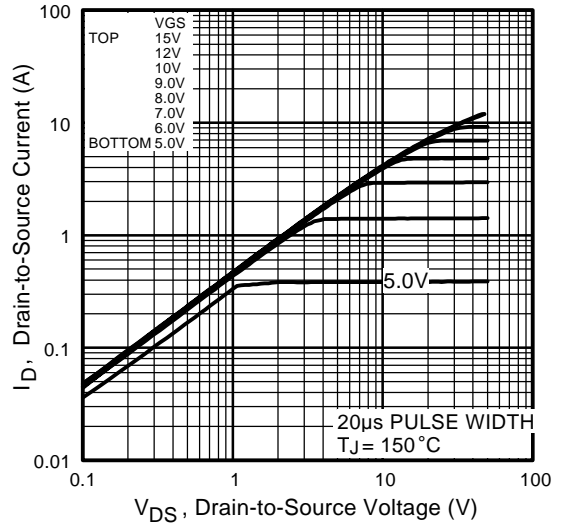


Fig 2. Typical Output Characteristics

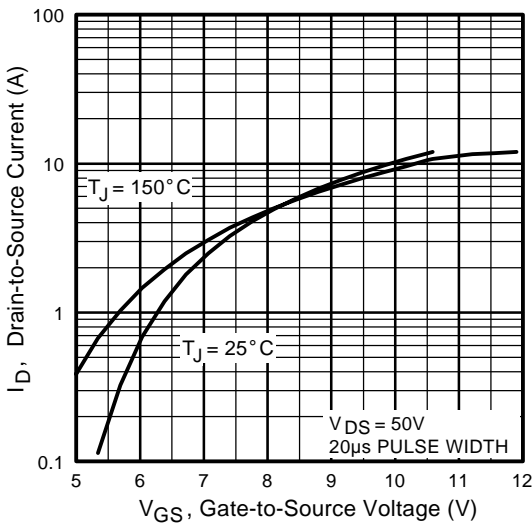


Fig 3. Typical Transfer Characteristics

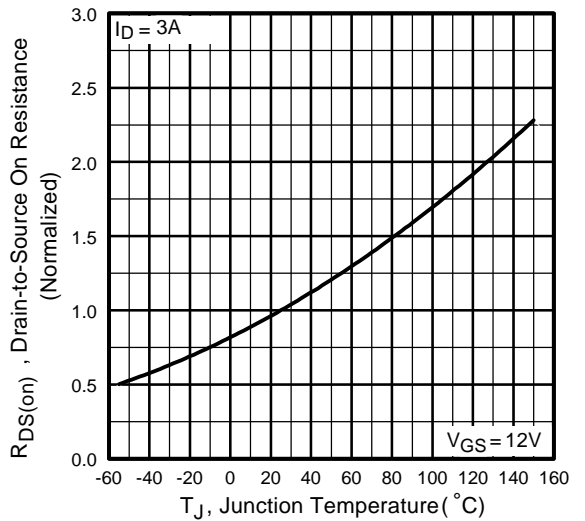
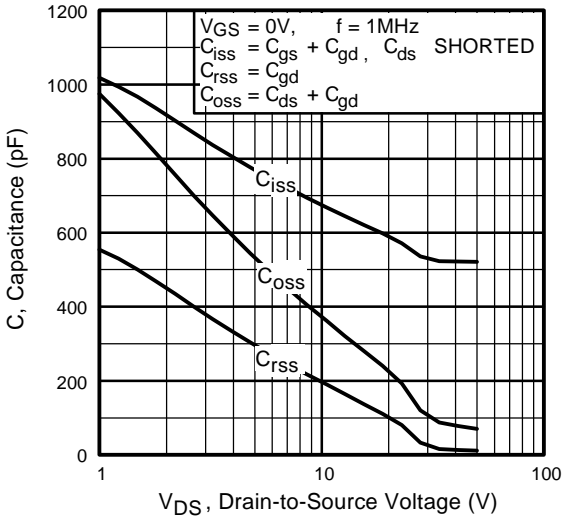
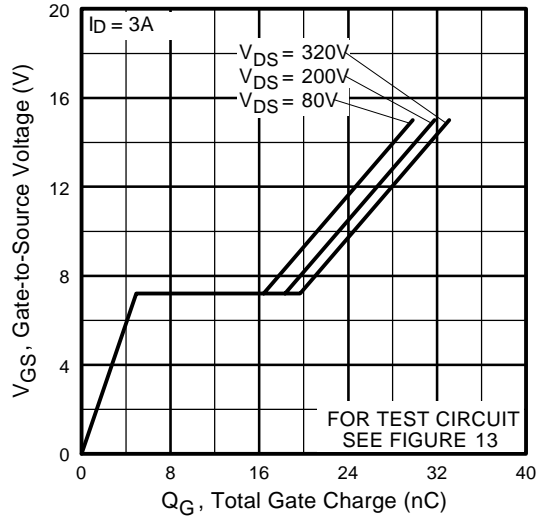


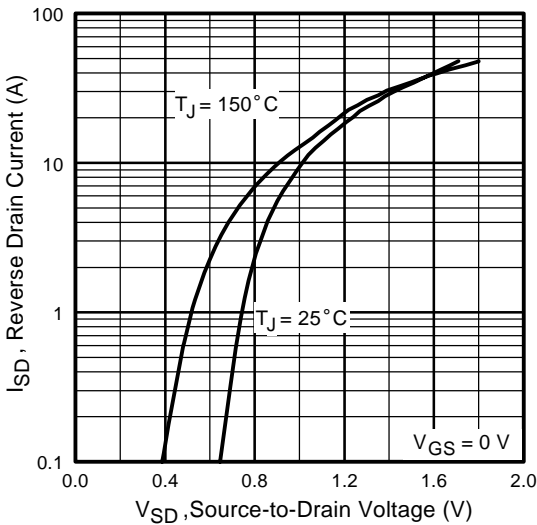
Fig 4. Normalized On-Resistance Vs. Temperature



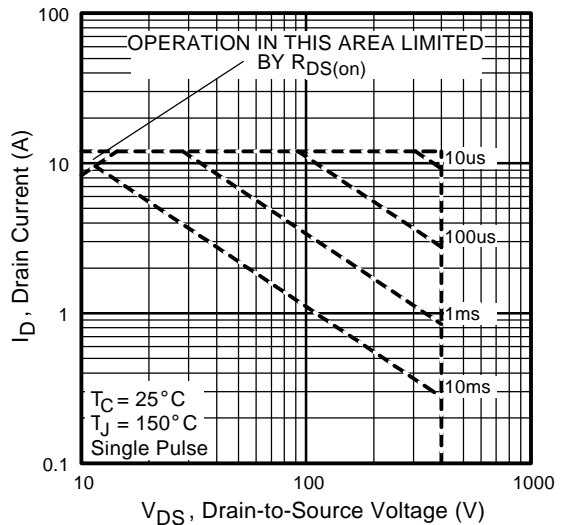
**Fig 5.** Typical Capacitance Vs. Drain-to-Source Voltage



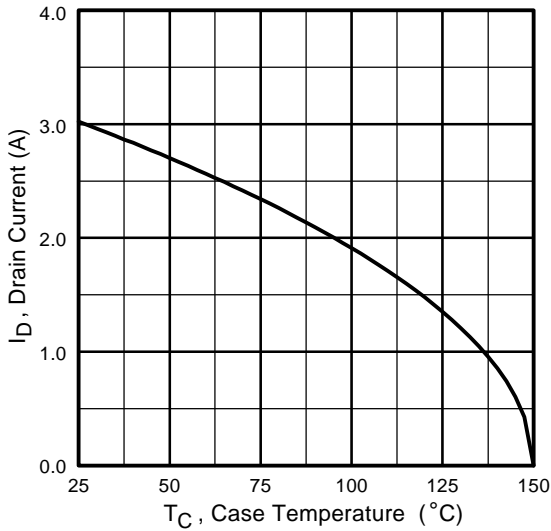
**Fig 6.** Typical Gate Charge Vs. Gate-to-Source Voltage



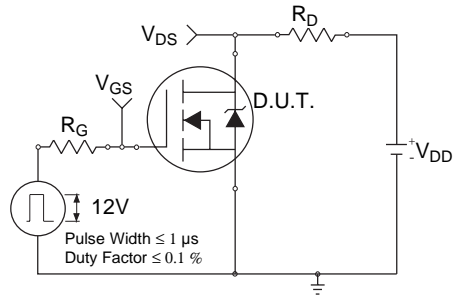
**Fig 7.** Typical Source-Drain Diode Forward Voltage



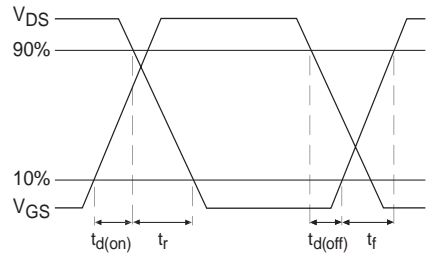
**Fig 8.** Maximum Safe Operating Area



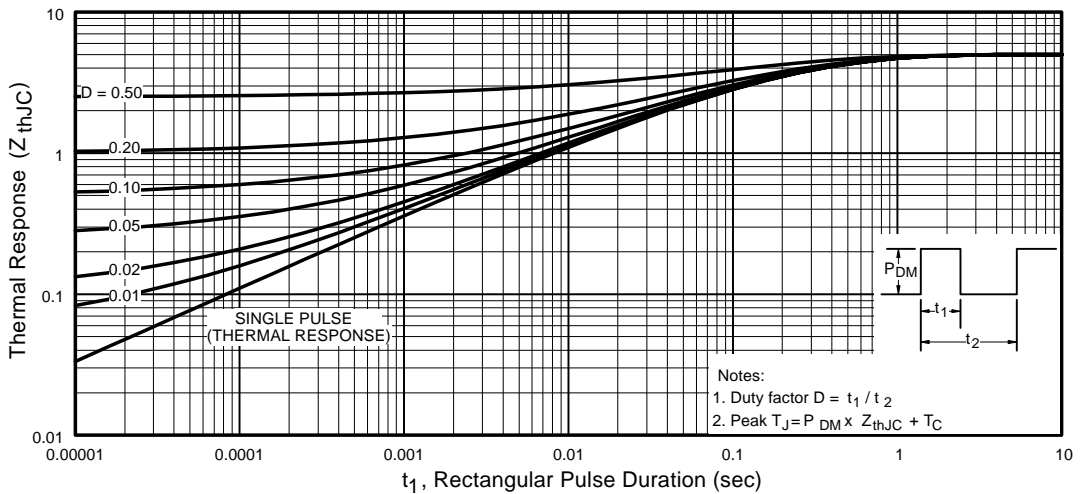
**Fig 9.** Maximum Drain Current Vs. Case Temperature



**Fig 10a.** Switching Time Test Circuit



**Fig 10b.** Switching Time Waveforms



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

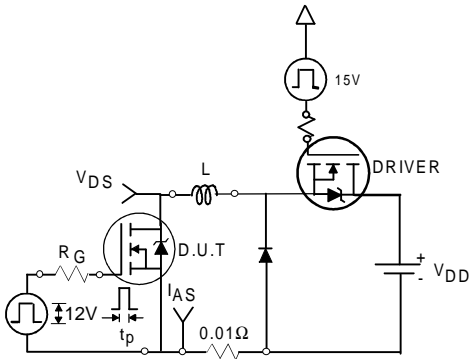


Fig 12a. Unclamped Inductive Test Circuit

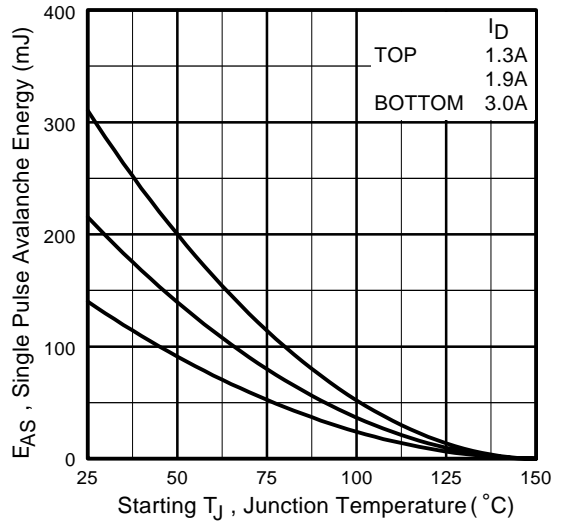


Fig 12c. Maximum Avalanche Energy Vs. Drain Current

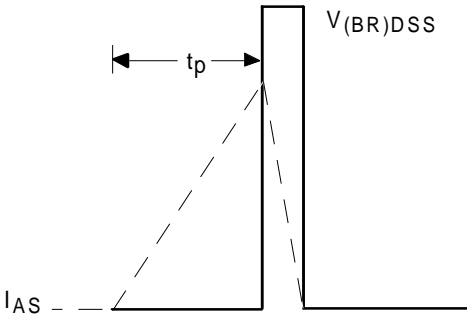


Fig 12b. Unclamped Inductive Waveforms

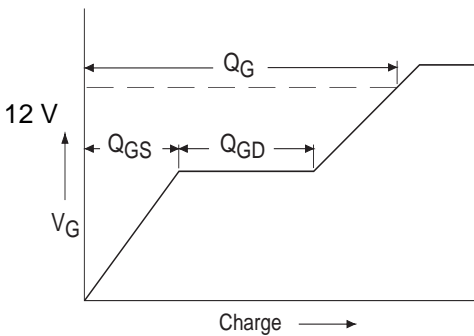


Fig 13a. Basic Gate Charge Waveform

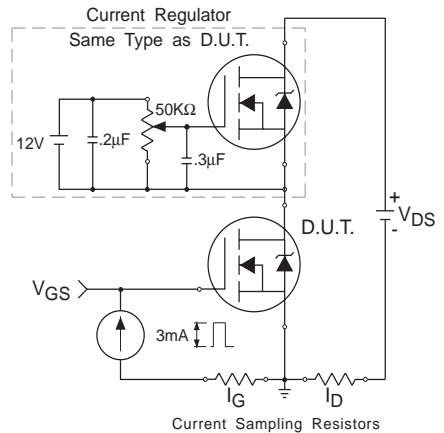
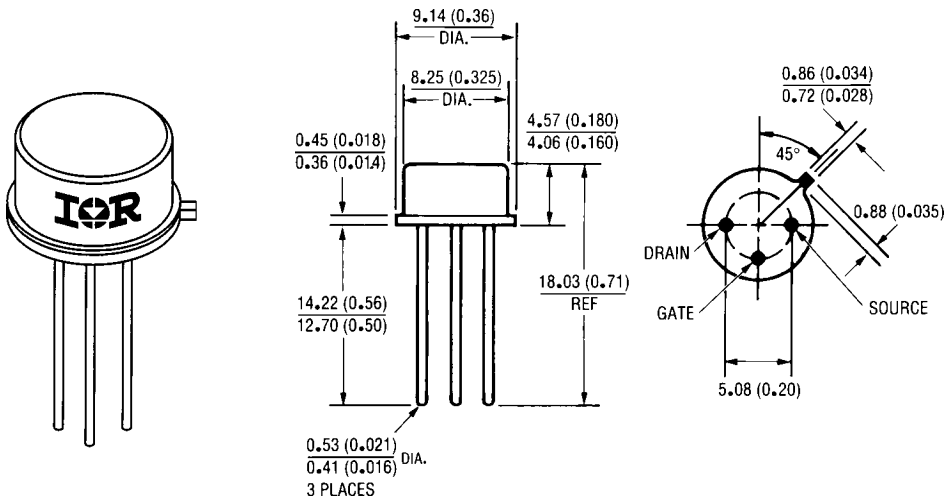


Fig 13b. Gate Charge Test Circuit

- ① Repetitive Rating; Pulse width limited by maximum junction temperature. Refer to current HEXFET reliability report.
- ② @ Starting  $T_J = 25^\circ\text{C}$ ,  
 $E_{AS} = [0.5 * L * (I_L^2)]$ ,  $V_{DD} = 50\text{V}$   
 Peak  $I_L = 3.0\text{A}$ ,  $V_{GS} = 12\text{V}$ ,  $25 \leq R_G \leq 200\Omega$
- ③  $I_{SD} \leq 3.0\text{A}$ ,  $di/dt \leq 400\text{A}/\mu\text{s}$ ,  
 $V_{DD} \leq BV_{DSS}$ ,  $T_J \leq 150^\circ\text{C}$   
 Suggested  $R_G = 7.5\Omega$
- ④ Pulse width  $\leq 300 \mu\text{s}$ ; Duty Cycle  $\leq 2\%$
- ⑤ **Total Dose Irradiation with VGS 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 VDS 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  $\sim 2.5 \text{ MeV}$ ), 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-205AF (Modified TO-39)**



All dimensions are shown millimeters (inches)

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**IOR** Rectifier

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