

**RADIATION HARDENED  
 POWER MOSFET  
 THRU-HOLE (TO-39)**

**IRHF597230  
 200V, P-CHANNEL  
 **TECHNOLOGY****

**Product Summary**

Part Number	Radiation Level	RDS(on)	ID
IRHF597230	100K Rads (Si)	0.54Ω	-4.5A
IRHF593230	300K Rads (Si)	0.54Ω	-4.5A



International Rectifier's R5™ technology provides high performance power MOSFETs for space applications. These devices have been characterized for Single Event Effects (SEE) with useful performance up to an LET of 80 (MeV/(mg/cm<sup>2</sup>)). The combination of low RDS(on) and low gate charge reduces the power losses in switching applications such as DC to DC converters and motor control. These devices retain all of the well established advantages of MOSFETs such as voltage control, fast switching, ease of paralleling and temperature stability of electrical parameters.

**Features:**

- Single Event Effect (SEE) Hardened
- Ultra Low RDS(on)
- Low Total Gate Charge
- Proton Tolerant
- Simple Drive Requirements
- Ease of Paralleling
- Hermetically Sealed
- Ceramic Package
- Light Weight

**Absolute Maximum Ratings**

**Pre-Irradiation**

	Parameter		Units
ID @ VGS = -12V, TC = 25°C	Continuous Drain Current	-4.5	A
ID @ VGS = -12V, TC = 100°C	Continuous Drain Current	-3.0	
IDM	Pulsed Drain Current ①	-18	
PD @ TC = 25°C	Max. Power Dissipation	25	W
	Linear Derating Factor	0.2	W/°C
VGS	Gate-to-Source Voltage	±20	V
EAS	Single Pulse Avalanche Energy ②	157	mJ
IAR	Avalanche Current ①	-4.5	A
EAR	Repetitive Avalanche Energy ①	2.5	mJ
dv/dt	Peak Diode Recovery dv/dt ③	-25	V/ns
TJ	Operating Junction	-55 to 150	°C
TSTG	Storage Temperature Range		
	Lead Temperature	300 (0.063in/1.6mm from case for 10s )	
	Weight	0.98 ( Typical )	g

For footnotes refer to the last page

**Electrical Characteristics @ T<sub>j</sub> = 25°C (Unless Otherwise Specified)**

	Parameter	Min	Typ	Max	Units	Test Conditions
BV <sub>DSS</sub>	Drain-to-Source Breakdown Voltage	-200	—	—	V	V <sub>GS</sub> = 0V, I <sub>D</sub> = -1.0mA
ΔBV <sub>DSS</sub> /ΔT <sub>J</sub>	Temperature Coefficient of Breakdown Voltage	—	-0.21	—	V/°C	Reference to 25°C, I <sub>D</sub> = -1.0mA
R <sub>DS(on)</sub>	Static Drain-to-Source On-State Resistance	—	—	0.54	Ω	V <sub>GS</sub> = -12V, I <sub>D</sub> = -3.0A ④
V <sub>GS(th)</sub>	Gate Threshold Voltage	-2.0	—	-4.0	V	V <sub>DS</sub> = V <sub>GS</sub> , I <sub>D</sub> = -1.0mA
g <sub>fs</sub>	Forward Transconductance	3.6	—	—	S (τ)	V <sub>DS</sub> ≥ -15V, I <sub>DS</sub> = -3.0A ④
I <sub>DSS</sub>	Zero Gate Voltage Drain Current	—	—	-10	μA	V <sub>DS</sub> = -160V, V <sub>GS</sub> = 0V
		—	—	-25		V <sub>DS</sub> = -160V, V <sub>GS</sub> = 0V, T <sub>J</sub> = 125°C
I <sub>GSS</sub>	Gate-to-Source Leakage Forward	—	—	-100	nA	V <sub>GS</sub> = -20V
I <sub>GSS</sub>	Gate-to-Source Leakage Reverse	—	—	100		V <sub>GS</sub> = 20V
Q <sub>g</sub>	Total Gate Charge	—	—	40	nC	V <sub>GS</sub> = -12V, I <sub>D</sub> = -4.5A
Q <sub>gs</sub>	Gate-to-Source Charge	—	—	8.5		V <sub>DS</sub> = -100V
Q <sub>gd</sub>	Gate-to-Drain ('Miller') Charge	—	—	15		
t <sub>d(on)</sub>	Turn-On Delay Time	—	—	25	ns	V <sub>DD</sub> = -100V, I <sub>D</sub> = -4.5A, V <sub>GS</sub> = -12V, R <sub>G</sub> = 7.5Ω
t <sub>r</sub>	Rise Time	—	—	30		
t <sub>d(off)</sub>	Turn-Off Delay Time	—	—	50		
t <sub>f</sub>	Fall Time	—	—	120		
L <sub>S</sub> + L <sub>D</sub>	Total Inductance	—	7.0	—	nH	Measured from Drain lead (6mm /0.25in from package) to Source lead(6mm/0.25in from package)with Source wire internally bonded from Source pin to Drain pad
C <sub>iss</sub>	Input Capacitance	—	1340	—	pF	V <sub>GS</sub> = 0V, V <sub>DS</sub> = -25V f = 1.0MHz
C <sub>oss</sub>	Output Capacitance	—	190	—		
C <sub>rss</sub>	Reverse Transfer Capacitance	—	20	—		

**Source-Drain Diode Ratings and Characteristics**

	Parameter	Min	Typ	Max	Units	Test Conditions
I <sub>S</sub>	Continuous Source Current (Body Diode)	—	—	-4.5	A	
I <sub>SM</sub>	Pulse Source Current (Body Diode) ①	—	—	-18		
V <sub>SD</sub>	Diode Forward Voltage	—	—	-5.0	V	T <sub>j</sub> = 25°C, I <sub>S</sub> = -4.5A, V <sub>GS</sub> = 0V ④
t <sub>rr</sub>	Reverse Recovery Time	—	—	200	ns	T <sub>j</sub> = 25°C, I <sub>F</sub> = -4.5A, di/dt ≤ -100A/μs
Q <sub>RR</sub>	Reverse Recovery Charge	—	—	1.2	μC	V <sub>DD</sub> ≤ -25V ④
t <sub>on</sub>	Forward Turn-On Time	Intrinsic turn-on time is negligible. Turn-on speed is substantially controlled by L <sub>S</sub> + L <sub>D</sub> .				

**Thermal Resistance**

	Parameter	Min	Typ	Max	Units	Test Conditions
R <sub>thJC</sub>	Junction-to-Case	—	—	5.0	°C/W	Typical Socket Mount
R <sub>thJA</sub>	Junction-to-Ambient	—	—	175		

Note: Corresponding Spice and Saber models are available on the G&S Website.

For footnotes refer to the last page

## Radiation Characteristics

IRHF597230

International Rectifier Radiation Hardened MOSFETs are tested to verify their radiation hardness capability. The hardness assurance program at International Rectifier is comprised of two radiation environments. Every manufacturing lot is tested for total ionizing dose (per notes 5 and 6) using the TO-3 package. 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.

**Table 1. Electrical Characteristics @ Tj = 25°C, Post Total Dose Irradiation ⑤⑥**

	Parameter	100K Rads(Si) <sup>1</sup>		300KRads(Si) <sup>2</sup>		Units	Test Conditions
		Min	Max	Min	Max		
BV <sub>DSS</sub>	Drain-to-Source Breakdown Voltage	-200	—	-200	—	V	V <sub>GS</sub> = 0V, I <sub>D</sub> = -1.0mA
V <sub>GS(th)</sub>	Gate Threshold Voltage	-2.0	-4.0	-2.0	-5.0		V <sub>GS</sub> = V <sub>DS</sub> , I <sub>D</sub> = -1.0mA
I <sub>GSS</sub>	Gate-to-Source Leakage Forward	—	-100	—	-100	nA	V <sub>GS</sub> = -20V
I <sub>GSS</sub>	Gate-to-Source Leakage Reverse	—	100	—	100		V <sub>GS</sub> = 20 V
I <sub>DSS</sub>	Zero Gate Voltage Drain Current	—	-10	—	-10	μA	V <sub>DS</sub> = -160V, V <sub>GS</sub> = 0V
R <sub>DS(on)</sub>	Static Drain-to-Source ④ On-State Resistance (TO-3)	—	0.505	—	0.505	Ω	V <sub>GS</sub> = -12V, I <sub>D</sub> = -3.0A
R <sub>DS(on)</sub>	Static Drain-to-Source ④ On-State Resistance (TO-39)	—	0.54	—	0.54	Ω	V <sub>GS</sub> = -12V, I <sub>D</sub> = -3.0A
V <sub>SD</sub>	Diode Forward Voltage ④	—	-5.0	—	-5.0	V	V <sub>GS</sub> = 0V, I <sub>S</sub> = -4.5A

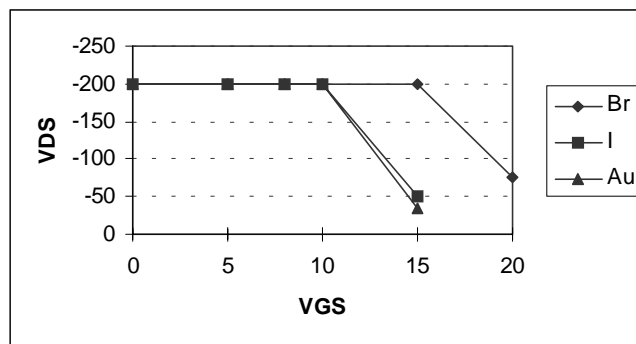
1. Part number IRHF597230

2. Part number IRHF593230

International Rectifier radiation hardened MOSFETs have been characterized in heavy ion environment for Single Event Effects (SEE). Single Event Effects characterization is illustrated in Fig. a and Table 2.

**Table 2. Single Event Effect Safe Operating Area**

Ion	LET (MeV/(mg/cm <sup>2</sup> ))	Energy (MeV)	Range (μm)	V <sub>DS</sub> (V)				
				@ V <sub>GS</sub> =0V	@ V <sub>GS</sub> =5V	@ V <sub>GS</sub> =10V	@ V <sub>GS</sub> =15V	@ V <sub>GS</sub> =20V
Br	37.3	285	36.8	- 200	- 200	- 200	- 200	-75
I	59.9	345	32.7	- 200	- 200	- 200	- 50	—
Au	82.3	357	28.5	- 200	- 200	- 200	- 35	—



**Fig a. Single Event Effect, Safe Operating Area**

For footnotes refer to the last page

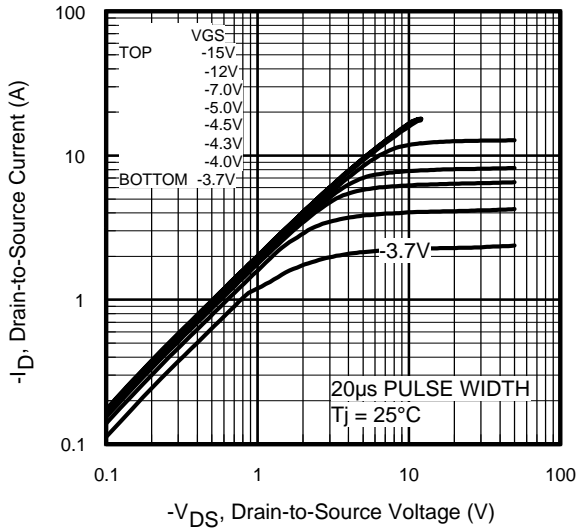


Fig 1. Typical Output Characteristics

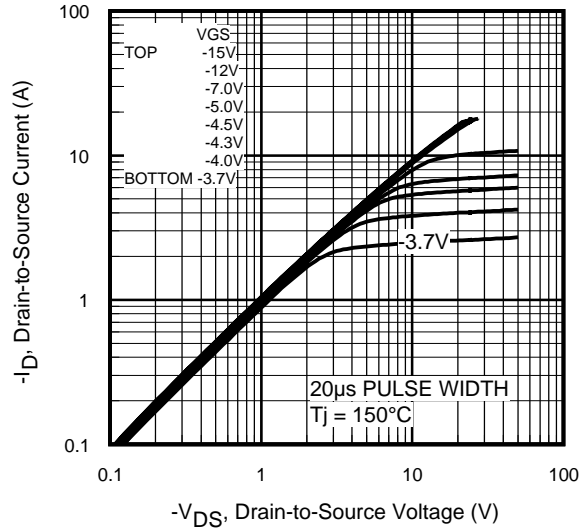


Fig 2. Typical Output Characteristics

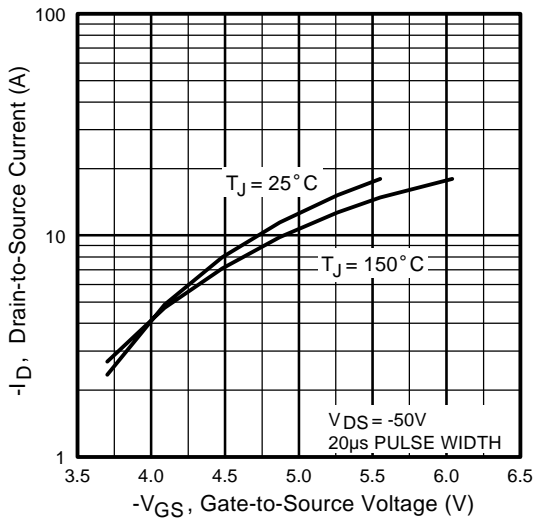


Fig 3. Typical Transfer Characteristics

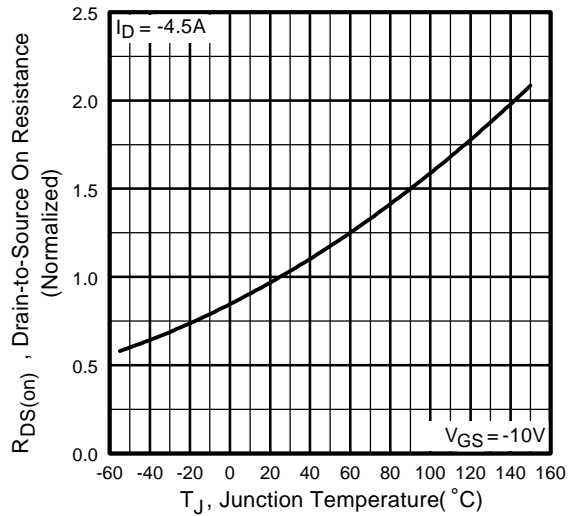
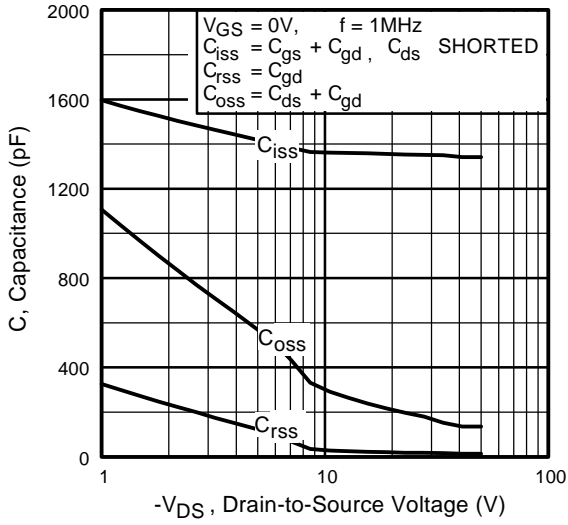
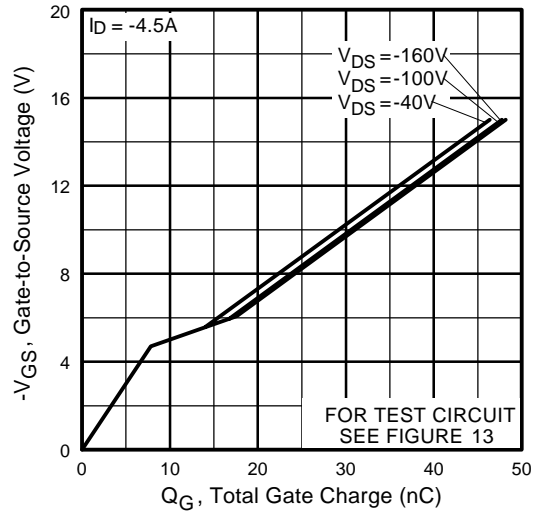


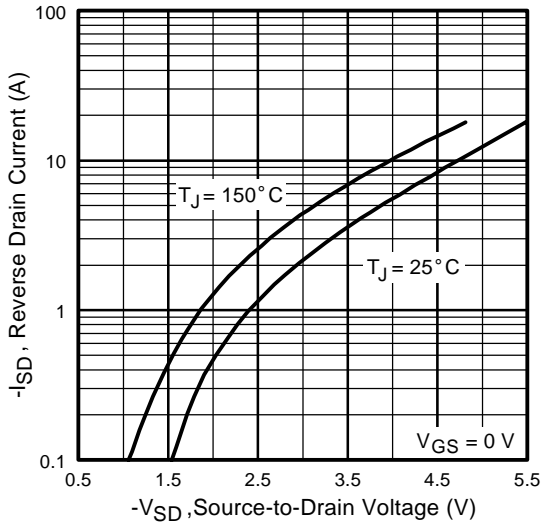
Fig 4. Normalized On-Resistance Vs. Temperature



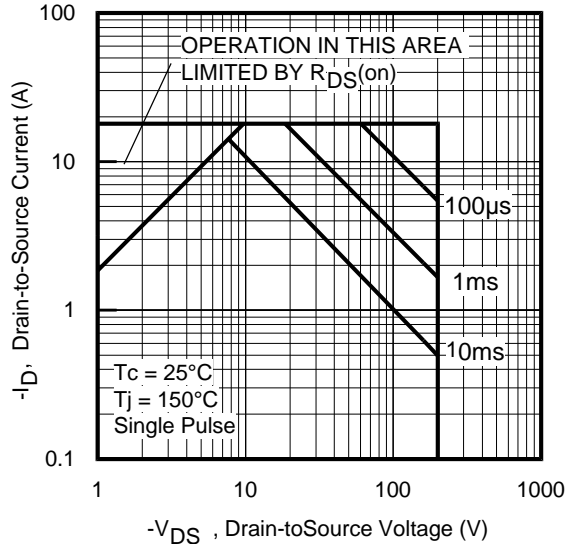
**Fig 5.** Typical Capacitance Vs. Drain-to-Source Voltage



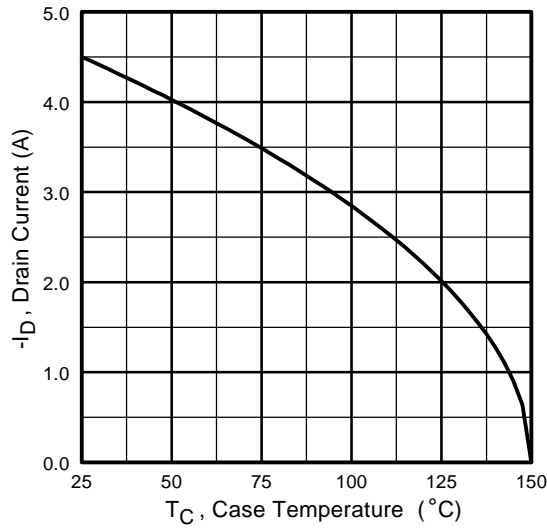
**Fig 6.** Typical Gate Charge Vs. Gate-to-Source Voltage



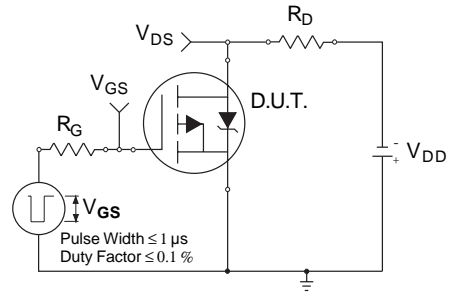
**Fig 7.** Typical Source-Drain Diode Forward Voltage



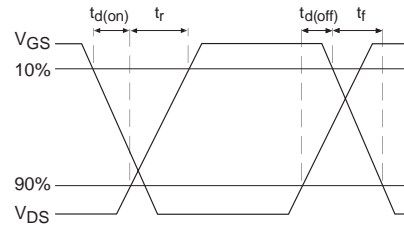
**Fig 8.** Maximum Safe Operating Area



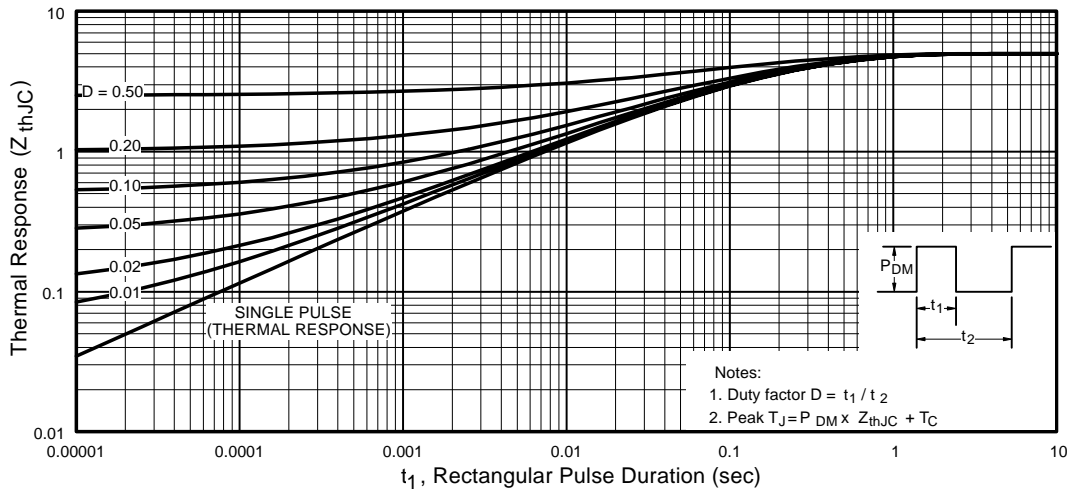
**Fig 9.** Maximum Drain Current Vs. Case Temperature



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



**Fig 10b.** Switching Time Waveforms



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

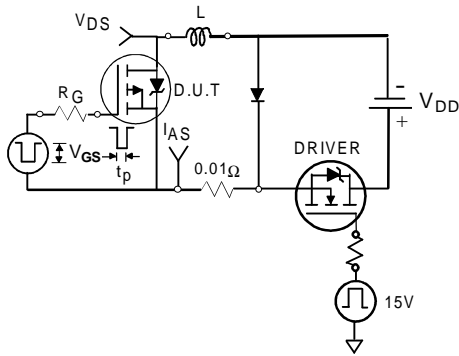


Fig 12a. Unclamped Inductive Test Circuit

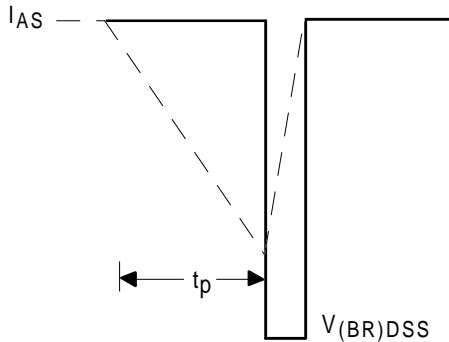


Fig 12b. Unclamped Inductive Waveforms

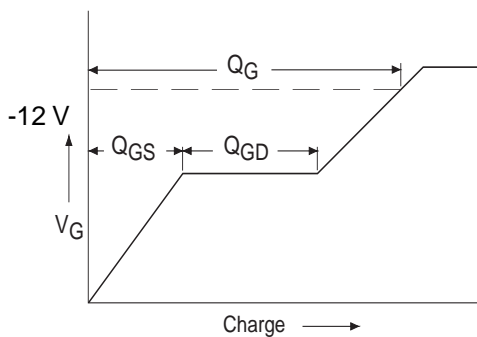


Fig 13a. Basic Gate Charge Waveform

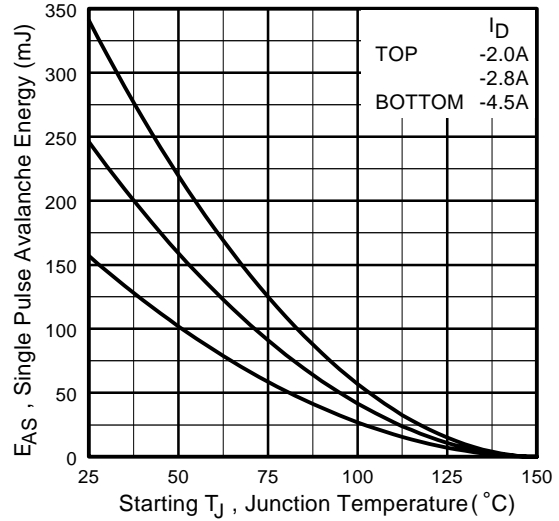


Fig 12c. Maximum Avalanche Energy Vs. Drain Current

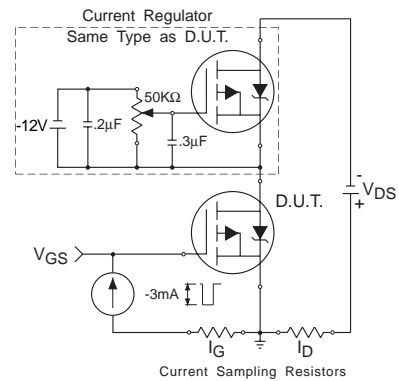
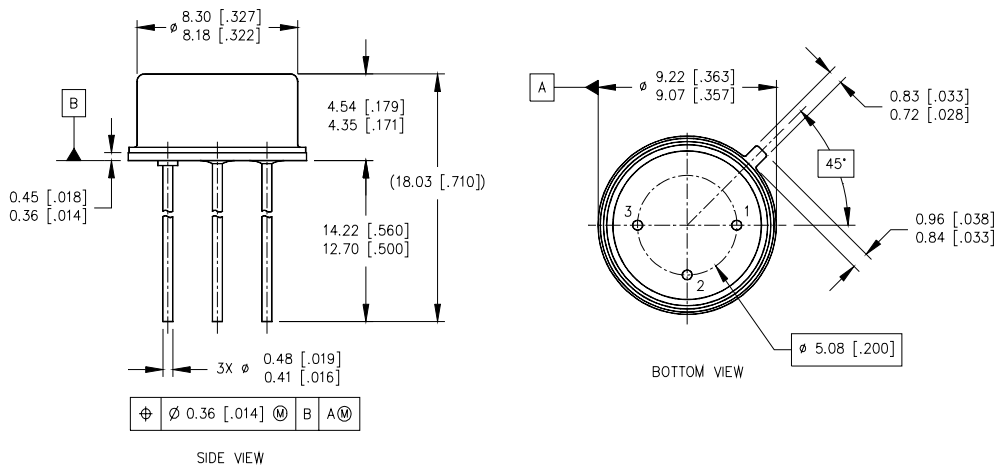


Fig 13b. Gate Charge Test Circuit

**Footnotes:**

- ① Repetitive Rating; Pulse width limited by maximum junction temperature.
- ②  $V_{DD} = -50V$ , starting  $T_J = 25^\circ C$ ,  $L=15.5\text{ mH}$   
Peak  $I_L = -4.5A$ ,  $V_{GS} = -12V$
- ③  $I_{SD} \leq -4.5A$ ,  $di/dt \leq -360A/\mu s$ ,  
 $V_{DD} \leq -200V$ ,  $T_J \leq 150^\circ C$
- ④ Pulse width  $\leq 300\ \mu s$ ; Duty Cycle  $\leq 2\%$
- 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.**  
-160 volt  $V_{DS}$  applied and  $V_{GS} = 0$  during irradiation per MIL-STD-750, method 1019, condition A.

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



NOTES:

- 1. DIMENSIONING AND TOLERANCING PER ASME 14.5M-1994.
- 2. DIMENSIONS ARE SHOWN IN MILLIMETERS [INCHES].
- 3. CONTROLLING DIMENSION: INCH.
- 4. CONFORMS TO JEDEC OUTLINE TO-205AF (TO-39).

- LEGEND
- 1-SOURCE
  - 2-GATE
  - 3-DRAIN

International  
**IR Rectifier**

IR WORLD HEADQUARTERS: 233 Kansas St., El Segundo, California 90245, USA Tel: (310) 252-7105  
TAC Fax: (310) 252-7903

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