

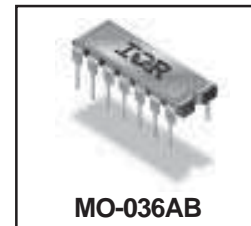
International  
**IR** Rectifier  
**RADIATION HARDENED  
 POWER MOSFET  
 THRU-HOLE (MO-036AB)**

PD - 93819B

**IRHG9110**  
**100V, QUAD P-CHANNEL**  
**RAD-Hard™ HEXFET®**  
**MOSFET TECHNOLOGY**

**Product Summary**

Part Number	Radiation Level	RDS(on)	Id
IRHG9110	100K Rads (Si)	1.1Ω	-0.75A
IRHG93110	300K Rads (Si)	1.1Ω	-0.75A



**MO-036AB**

International Rectifier's RAD-Hard™ HEXFET® MOSFET Technology provides high performance power MOSFETs for space applications. This technology has over a decade of proven performance and reliability in satellite applications. These devices have been characterized for both Total Dose and Single Event Effects (SEE). 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
- Low RDS(on)
- Low Total Gate Charge
- Proton Tolerant
- Simple Drive Requirements
- Ease of Paralleling
- Hermetically Sealed
- Ceramic Package
- Light Weight

**Absolute Maximum Ratings (Per Die)**

**Pre-Irradiation**

	Parameter		Units
Id @ VGS = 12V, TC = 25°C	Continuous Drain Current	-0.75	A
Id @ VGS = 12V, TC = 100°C	Continuous Drain Current	-0.5	
IdM	Pulsed Drain Current ①	-3.0	
PD @ TC = 25°C	Max. Power Dissipation	1.4	W
	Linear Derating Factor	0.011	W/°C
VGS	Gate-to-Source Voltage	±20	V
EAS	Single Pulse Avalanche Energy ②	75	mJ
IAR	Avalanche Current ①	-0.75	A
EAR	Repetitive Avalanche Energy ①	0.14	mJ
dv/dt	Peak Diode Recovery dv/dt	2.4 ③	V/ns
TJ	Operating Junction	-55 to 150	°C
TSTG	Storage Temperature Range		
	Lead Temperature	300 (0.63in./1.6mm from case for 10s)	
	Weight	1.3 (Typical)	g

For footnotes refer to the last page

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

	Parameter	Min	Typ	Max	Units	Test Conditions
BVDSS	Drain-to-Source Breakdown Voltage	-100	—	—	V	V <sub>GS</sub> = 0V, I <sub>D</sub> = -1.0mA
ΔBVDSS/ΔT <sub>J</sub>	Temperature Coefficient of Breakdown Voltage	—	-0.11	—	V/°C	Reference to 25°C, I <sub>D</sub> = -1.0mA
RDS(on)	Static Drain-to-Source On-State Resistance	—	—	1.2	Ω	V <sub>GS</sub> = -12V, I <sub>D</sub> = -0.75A <sup>④</sup>
		—	—	1.1		V <sub>GS</sub> = -12V, I <sub>D</sub> = -0.5A
VGS(th)	Gate Threshold Voltage	-2.0	—	-4.0	V	V <sub>DS</sub> = V <sub>GS</sub> , I <sub>D</sub> = -1.0mA
gfs	Forward Transconductance	0.6	—	—	S (Ω)	V <sub>DS</sub> > -15V, I <sub>DS</sub> = -0.5A <sup>④</sup>
I <sub>DSS</sub>	Zero Gate Voltage Drain Current	—	—	-25	μA	V <sub>DS</sub> = -80V, V <sub>GS</sub> = 0V
		—	—	-250		V <sub>DS</sub> = -80V, 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	—	—	15	nC	V <sub>GS</sub> = -12V, I <sub>D</sub> = -0.75A, V <sub>DS</sub> = -50V
Q <sub>gs</sub>	Gate-to-Source Charge	—	—	4.0		
Q <sub>gd</sub>	Gate-to-Drain ('Miller') Charge	—	—	4.3		
t <sub>d(on)</sub>	Turn-On Delay Time	—	—	22	ns	V <sub>DD</sub> = -50V, I <sub>D</sub> = -0.75A, V <sub>GS</sub> = -12V, R <sub>G</sub> = 24Ω
t <sub>r</sub>	Rise Time	—	—	19		
t <sub>d(off)</sub>	Turn-Off Delay Time	—	—	66		
t <sub>f</sub>	Fall Time	—	—	51		
LS + LD	Total Inductance	—	10	—	nH	Measured from Drain lead (6mm /0.25in. from package) to Source lead (6mm /0.25in from package) with Source wires internally bonded from Source Pin to Drain Pad
C <sub>iss</sub>	Input Capacitance	—	335	—	pF	V <sub>GS</sub> = 0V, V <sub>DS</sub> = 25V f = 1.0MHz
C <sub>oss</sub>	Output Capacitance	—	100	—		
C <sub>rss</sub>	Reverse Transfer Capacitance	—	22	—		

**Source-Drain Diode Ratings and Characteristics (Per Die)**

	Parameter	Min	Typ	Max	Units	Test Conditions
I <sub>S</sub>	Continuous Source Current (Body Diode)	—	—	-0.75	A	
I <sub>SM</sub>	Pulse Source Current (Body Diode) <sup>①</sup>	—	—	-3.0		
V <sub>SD</sub>	Diode Forward Voltage	—	—	-2.5	V	T <sub>J</sub> = 25°C, I <sub>S</sub> = -0.75A, V <sub>GS</sub> = 0V <sup>④</sup>
t <sub>rr</sub>	Reverse Recovery Time	—	—	90	nS	T <sub>J</sub> = 25°C, I <sub>F</sub> = -0.75A, di/dt ≥ -100A/μs
Q <sub>RR</sub>	Reverse Recovery Charge	—	—	257	nC	V <sub>DD</sub> ≤ -25V <sup>④</sup>
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 (Per Die)**

	Parameter	Min	Typ	Max	Units	Test Conditions
R <sub>thJC</sub>	Junction-to-Case	—	—	17	°C/W	Typical socket mount
R <sub>thJA</sub>	Junction-to-Ambient	—	—	90		

For footnotes refer to the last page

## Radiation Characteristics

IRHG9110

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-39 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 (Per Die)**

	Parameter	100KRads(Si) <sup>1</sup>		300K Rads (Si) <sup>2</sup>		Units	Test Conditions
		Min	Max	Min	Max		
BV <sub>DSS</sub>	Drain-to-Source Breakdown Voltage	-100	—	-100	—	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>DSS</sub> , I <sub>D</sub> = -1.0mA
I <sub>GS</sub>	Gate-to-Source Leakage Forward	—	-100	—	-100	nA	V <sub>GS</sub> = -20V
I <sub>GS</sub>	Gate-to-Source Leakage Reverse	—	100	—	100		V <sub>GS</sub> = 20 V
I <sub>DSS</sub>	Zero Gate Voltage Drain Current	—	-25	—	-25	μA	V <sub>DSS</sub> =-80V, V <sub>GS</sub> =0V
R <sub>DS(on)</sub>	Static Drain-to-Source <sup>④</sup> On-State Resistance (TO-39)	—	1.06	—	1.06	Ω	V <sub>GS</sub> = -12V, I <sub>D</sub> =-0.5A
R <sub>DS(on)</sub>	Static Drain-to-Source <sup>④</sup> On-State Resistance (MO-036AB)	—	1.1	—	1.1	Ω	V <sub>GS</sub> = -12V, I <sub>D</sub> =-0.5A
V <sub>SD</sub>	Diode Forward Voltage <sup>④</sup>	—	-2.5	—	-2.5	V	V <sub>GS</sub> = 0V, I <sub>S</sub> = -0.75A

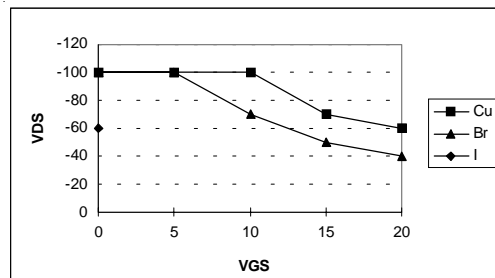
1. Part number IRHG9110

2. Part number IRHG93110

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 (Per Die)**

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
Cu	28.0	285	43.0	-100	-100	-100	-70	-60
Br	36.8	305	39.0	-100	-100	-70	-50	-40
I	59.8	343	32.6	-60	—	—	—	—



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

For footnotes refer to the last page

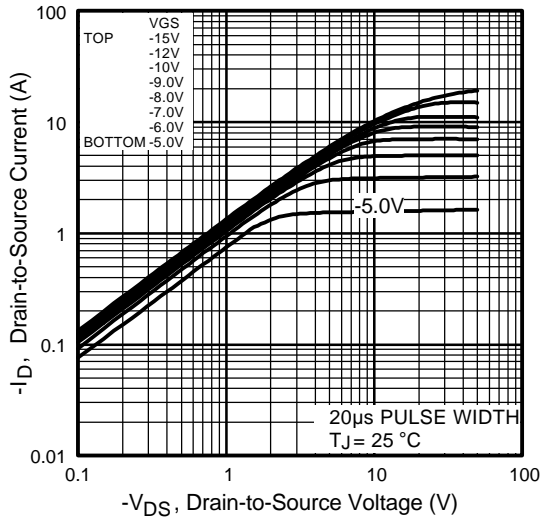


Fig 1. Typical Output Characteristics

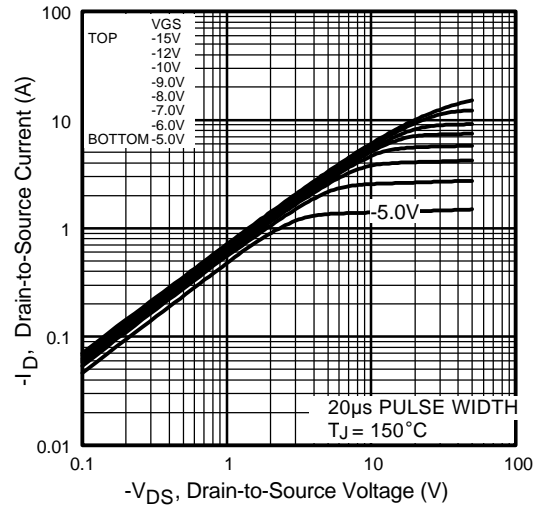


Fig 2. Typical Output Characteristics

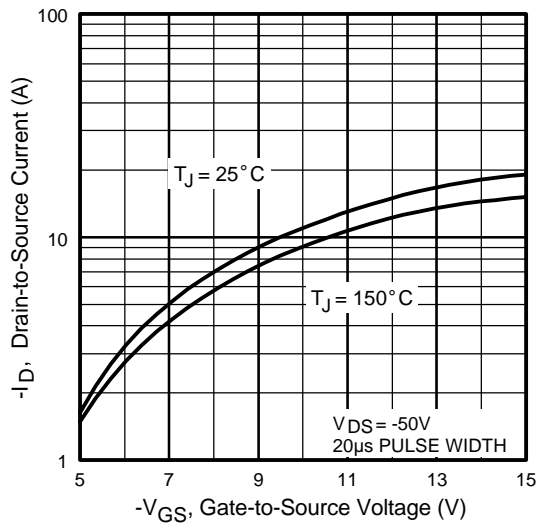


Fig 3. Typical Transfer Characteristics

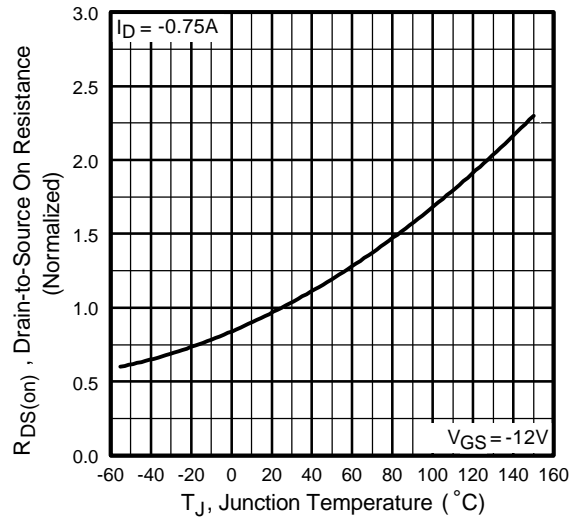


Fig 4. Normalized On-Resistance Vs. Temperature

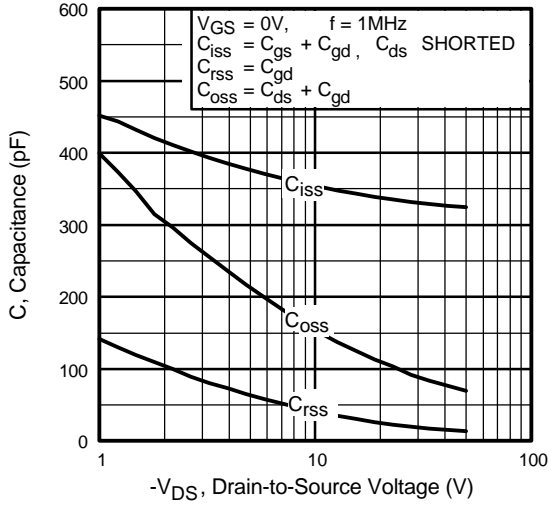


Fig 5. Typical Capacitance Vs. Drain-to-Source Voltage

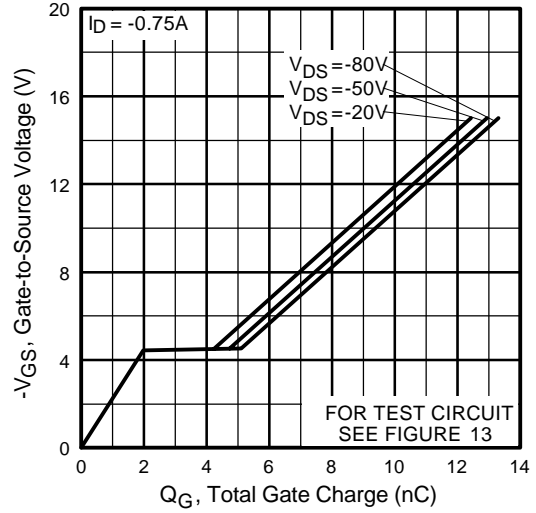


Fig 6. Typical Gate Charge Vs. Gate-to-Source Voltage

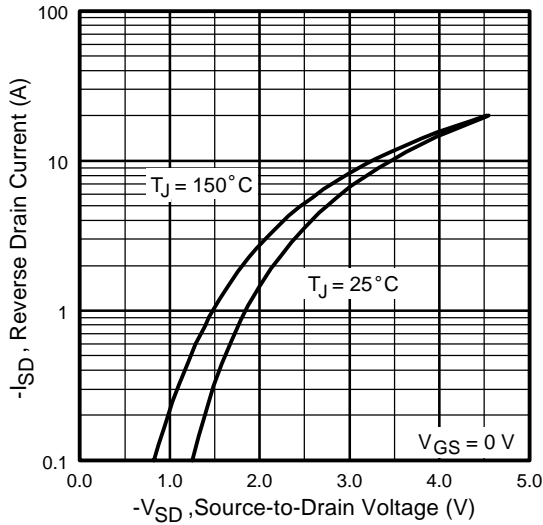


Fig 7. Typical Source-Drain Diode Forward Voltage

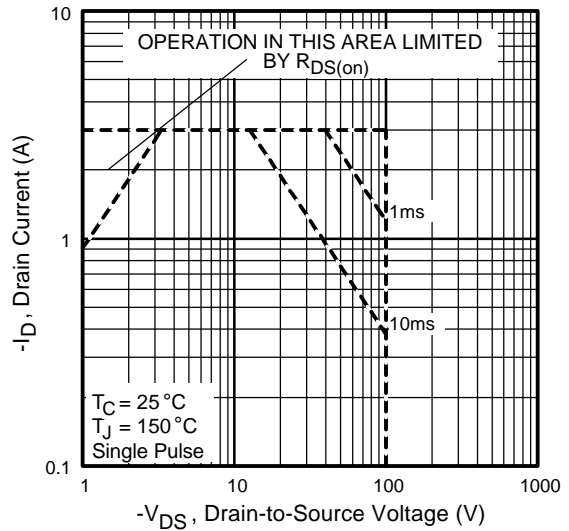


Fig 8. Maximum Safe Operating Area

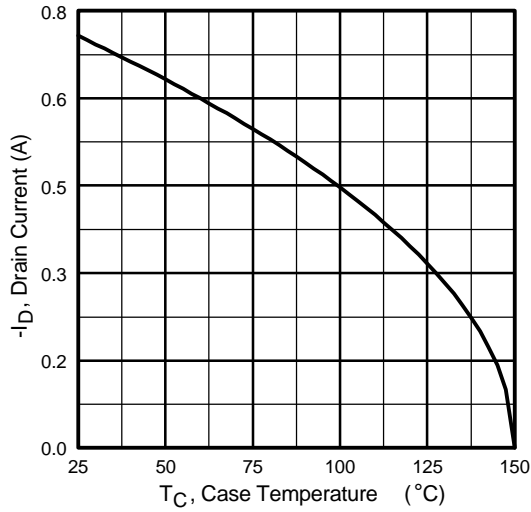


Fig 9. Maximum Drain Current Vs. Case Temperature

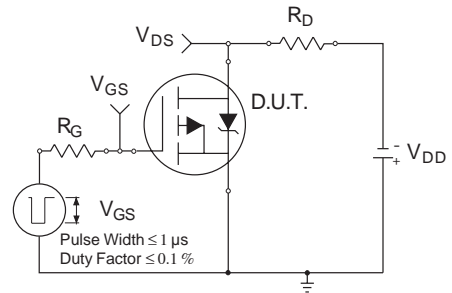


Fig 10a. Switching Time Test Circuit

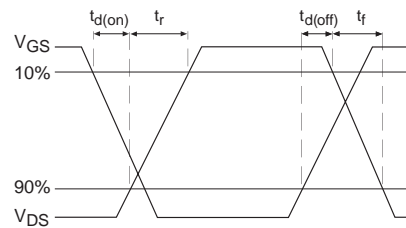


Fig 10b. Switching Time Waveforms

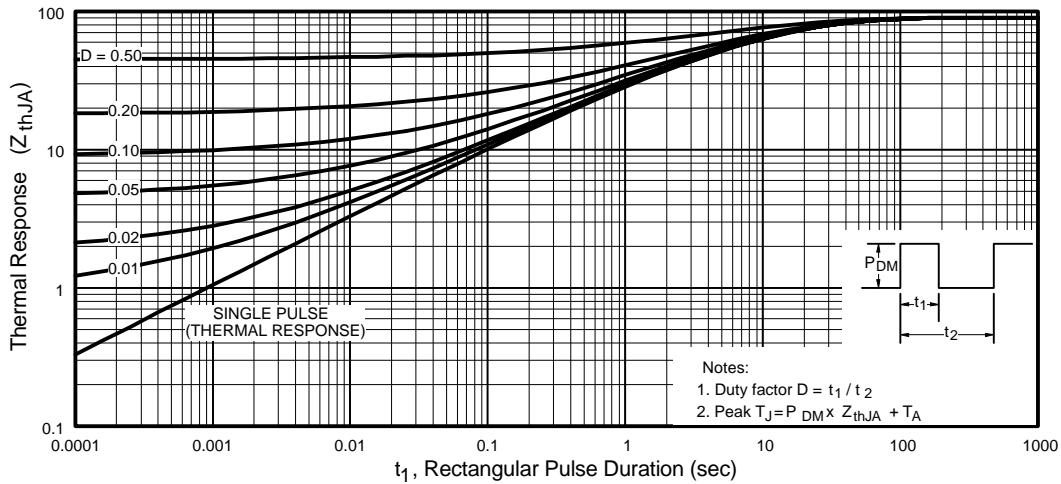


Fig 11. Maximum Effective Transient Thermal Impedance, Junction-to-Ambient

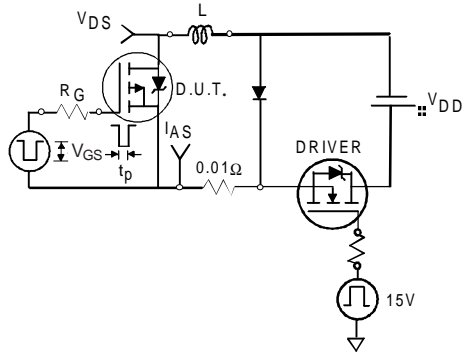


Fig 12a. Unclamped Inductive Test Circuit

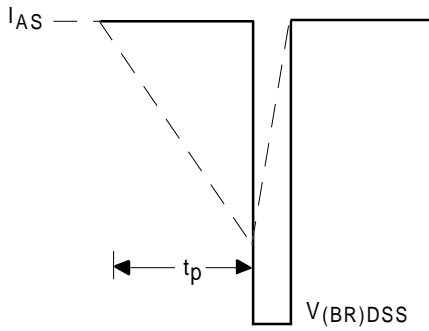


Fig 12b. Unclamped Inductive Waveforms

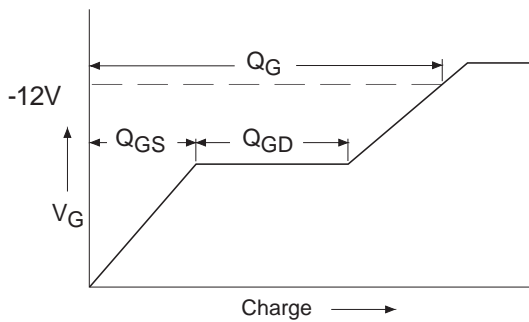


Fig 13a. Basic Gate Charge Waveform

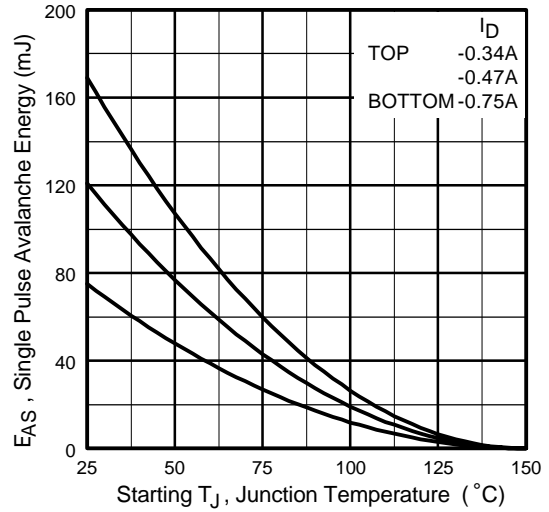


Fig 12c. Maximum Avalanche Energy Vs. Drain Current

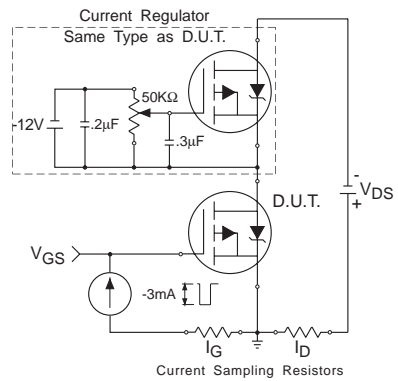
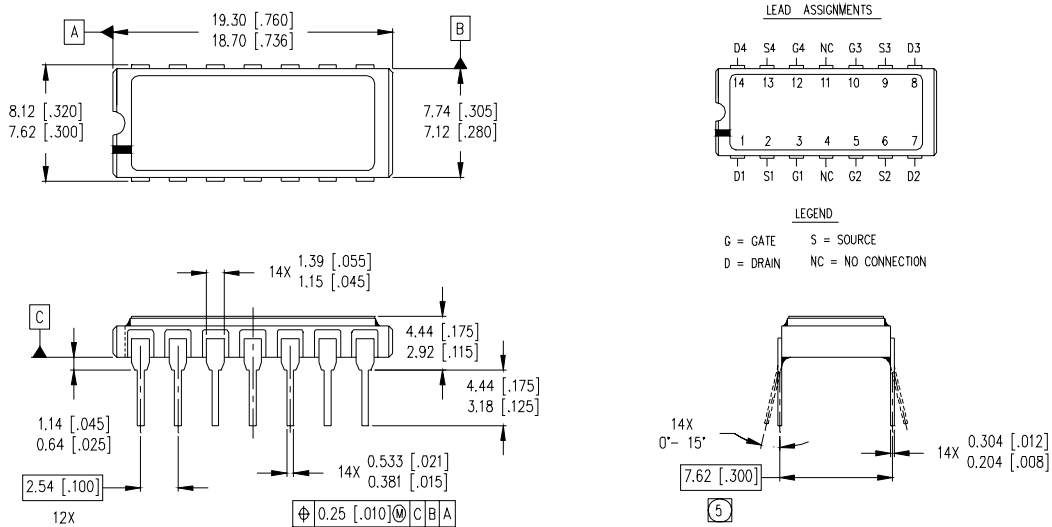


Fig 13b. Gate Charge Test Circuit

**Footnotes:**

- ① Repetitive Rating; Pulse width limited by maximum junction temperature.
- ②  $V_{DD} = -25V$ , starting  $T_J = 25^\circ C$ ,  $L = 267mH$ , Peak  $I_L = -0.75A$ ,  $V_{GS} = -12V$
- ③  $I_{SD} \leq -0.75A$ ,  $di/dt \leq -132A/\mu s$ ,  $V_{DD} \leq -100V$ ,  $T_J \leq 150^\circ C$
- 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.**  
-80 volt  $V_{DS}$  applied and  $V_{GS} = 0$  during irradiation per MIL-STD-750, method 1019, condition A

**Case Outline and Dimensions — MO-036AB**



NOTES:

- 1. DIMENSIONING & TOLERANCING PER ASME Y14.5M-1994.
- 2. CONTROLLING DIMENSION: INCH.
- 3. DIMENSIONS ARE SHOWN IN MILLIMETERS [INCHES].
- 4. OUTLINE CONFORMS TO JEDEC OUTLINE MO-036AB.
- ⑤ MEASURED WITH THE LEADS CONSTRAINED TO BE PERPENDICULAR TO DATUM PLANE C.

International  
**IR** Rectifier

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