International Rectifier

PD-97200B

# 2N7628M1

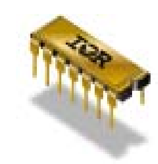
# RADIATION HARDENED LOGIC LEVEL POWER MOSFET THRU-HOLE (MO-036AB)

# IRHLG7970Z4 60V, Quad P-CHANNEL

R7™ TECHNOLOGY

## Product Summary

| Part Number | Radiation Level | $R_{DS(on)}$ | $I_D$ |
|---|---|---|---|
| IRHLG7970Z4 | 100K Rads (Si) | 1.25Ω | -0.71A |
| IRHLG7930Z4 | 300K Rads (Si) | 1.25Ω | -0.71A |



MO-036AB

International Rectifier's R7™ Logic Level Power MOSFETs provide simple solution to interfacing CMOS and TTL control circuits to power devices in space and other radiation environments. The threshold voltage remains within acceptable operating limits over the full operating temperature and post radiation. This is achieved while maintaining single event gate rupture and single event burnout immunity.

These devices are used in applications such as current boost low signal source in PWM, voltage comparator and operational amplifiers.

## Features:

- 5V CMOS and TTL Compatible
- Fast Switching
- Single Event Effect (SEE) Hardened
- Low Total Gate Charge
- Simple Drive Requirements
- Ease of Paralleling
- Hermetically Sealed
- Ceramic Package
- Light Weight
- Complimentary N-Channel Available - IRHLG770Z4

## Absolute Maximum Ratings (Per Die) — Pre-Irradiation

| | Parameter | | Units |
|---|---|---|---|
| $I_D$ @ $V_{GS}$ = -4.5V, $T_C$=25°C | Continuous Drain Current | -0.71 | A |
| $I_D$ @ $V_{GS}$ = -4.5V, $T_C$=100°C | Continuous Drain Current | -0.45 | |
| $I_{DM}$ | Pulsed Drain Current ① | -2.84 | |
| $P_D$ @ $T_C$ = 25°C | Max. Power Dissipation | 1.0 | W |
| | Linear Derating Factor | 0.01 | W/°C |
| $V_{GS}$ | Gate-to-Source Voltage | ±10 | V |
| $E_{AS}$ | Single Pulse Avalanche Energy ② | 21 | mJ |
| $I_{AR}$ | Avalanche Current ① | -0.71 | A |
| $E_{AR}$ | Repetitive Avalanche Energy ① | 0.1 | mJ |
| dv/dt | Peak Diode Recovery dv/dt ③ | -14 | V/ns |
| $T_J$<br>$T_{STG}$ | Operating Junction<br>Storage Temperature Range | -55 to 150 | °C |
| | Lead Temperature | 300 (0.63 in./1.6 mm from case for 10s) | |
| | Weight | 1.3 (Typical) | g |

For footnotes refer to the last page



04/01/08

## Electrical Characteristics For Each P-Channel Device @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, $I_D$ = -250μA |
| $\Delta BV_{DSS}/\Delta T_J$ | Temperature Coefficient of Breakdown Voltage | — | -0.08 | — | V/°C | Reference to 25°C, $I_D$ = -1.0mA |
| $R_{DS(on)}$ | Static Drain-to-Source On-State Resistance | — | — | 1.25 | Ω | $V_{GS}$ = -4.5V, $I_D$ = -0.45A ④ |
| $V_{GS(th)}$ | Gate Threshold Voltage | -1.0 | — | -2.0 | V | $V_{DS} = V_{GS}$, $I_D$ = -250μA |
| $\Delta V_{GS(th)}/\Delta T_J$ | Gate Threshold Voltage Coefficient | — | 3.07 | — | mV/°C | |
| $g_{fs}$ | Forward Transconductance | 0.9 | — | — | S | $V_{DS}$ = -10V, $I_{DS}$ = -0.45A ④ |
| $I_{DSS}$ | Zero Gate Voltage Drain Current | — | — | -1.0 | μA | $V_{DS}$= -48V ,$V_{GS}$= 0V |
| | | — | — | -10 | | $V_{DS}$ = -48V, $V_{GS}$ = 0V, $T_J$ =125°C |
| $I_{GSS}$ | Gate-to-Source Leakage Forward | — | — | -100 | nA | $V_{GS}$ = -10V |
| $I_{GSS}$ | Gate-to-Source Leakage Reverse | — | — | 100 | | $V_{GS}$ = 10V |
| $Q_g$ | Total Gate Charge | — | — | 2.8 | nC | $V_{GS}$ = -4.5V, $I_D$ = -0.71A |
| $Q_{gs}$ | Gate-to-Source Charge | — | — | 1.7 | | $V_{DS}$ = -30V |
| $Q_{gd}$ | Gate-to-Drain ('Miller') Charge | — | — | 0.8 | | |
| $t_{d(on)}$ | Turn-On Delay Time | — | — | 17 | ns | $V_{DD}$ = -30V, $I_D$ = -0.71A, |
| $t_r$ | Rise Time | — | — | 20 | | $V_{GS}$ = -5.0V, $R_G$ = 24Ω |
| $t_{d(off)}$ | Turn-Off Delay Time | — | — | 27 | | |
| $t_f$ | Fall Time | — | — | 23 | | |
| $L_S + L_D$ | Total Inductance | — | 10 | — | nH | Measured from Drain lead (6mm /0.25in from pack.) to Source lead (6mm/0.25in from pack.)with Source wire internally bonded from Source pin to Drain pad |
| $C_{iss}$ | Input Capacitance | — | 138 | — | pF | $V_{GS}$ = 0V, $V_{DS}$ = -25V |
| $C_{oss}$ | Output Capacitance | — | 39 | — | | f = 1.0MHz |
| $C_{rss}$ | Reverse Transfer Capacitance | — | 6.7 | — | | |
| $R_g$ | Gate Resistance | — | 52.4 | — | Ω | f = 1.0MHz, open drain |

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

| | Parameter | Min | Typ | Max | Units | Test Conditions |
|---|---|---|---|---|---|---|
| $I_S$ | Continuous Source Current (Body Diode) | — | — | -0.71 | A | |
| $I_{SM}$ | Pulse Source Current (Body Diode) ① | — | — | -2.84 | | |
| $V_{SD}$ | Diode Forward Voltage | — | — | -5.0 | V | $T_j$ = 25°C, $I_S$ = -0.71A, $V_{GS}$ = 0V ④ |
| $t_{rr}$ | Reverse Recovery Time | — | — | 30 | ns | $T_j$ = 25°C, $I_F$ = -0.71A, di/dt ≤–100A/μs |
| $Q_{RR}$ | Reverse Recovery Charge | — | — | 11 | nC | $V_{DD}$ ≤ -25V ④ |
| $t_{on}$ | Forward Turn-On Time | Intrinsic turn-on time is negligible. Turn-on speed is substantially controlled by $L_S + L_D$. | | | | |

## Thermal Resistance (Per Die)

| | Parameter | Min | Typ | Max | Units | Test Conditions |
|---|---|---|---|---|---|---|
| $R_{thJA}$ | Junction-to-Ambient | — | — | 125 | °C/W | Typical socket mount |

**Note: Corresponding Spice and Saber models are available International Rectifier Website.**

For footnotes refer to the last page

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 For Each P-Channel Device @Tj = 25°C, Post Total Dose Irradiation ⑤⑥**

| | Parameter | Up to 300K Rads (Si)[1] | | Units | Test Conditions |
|---|---|---|---|---|---|
| | | Min | Max | | |
| $BV_{DSS}$ | Drain-to-Source Breakdown Voltage | -60 | — | V | $V_{GS}$ = 0V, $I_D$ = -250µA |
| $V_{GS(th)}$ | Gate Threshold Voltage | -1.0 | -2.0 | | $V_{GS}$ = $V_{DS}$, $I_D$ = -250µA |
| $I_{GSS}$ | Gate-to-Source Leakage Forward | — | -100 | nA | $V_{GS}$ = -10V |
| $I_{GSS}$ | Gate-to-Source Leakage Reverse | — | 100 | | $V_{GS}$ = 10V |
| $I_{DSS}$ | Zero Gate Voltage Drain Current | — | -1.0 | µA | $V_{DS}$= -48V, $V_{GS}$= 0V |
| $R_{DS(on)}$ | Static Drain-to-Source ④ On-State Resistance (TO-39) | — | 1.20 | Ω | $V_{GS}$ = -4.5V, $I_D$ = -0.45A |
| $R_{DS(on)}$ | Static Drain-to-Source On-state ④ Resistance (MO-036) | — | 1.25 | Ω | $V_{GS}$ = -4.5V, $I_D$ = -0.45A |
| $V_{SD}$ | Diode Forward Voltage ④ | — | -5.0 | V | $V_{GS}$ = 0V, $I_D$ = -0.71A |

1. Part numbers IRHLG7970Z4, IRHLG7930Z4

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. Typical Single Event Effect Safe Operating Area (Per Die)**

| Ion | LET | Energy | Range | VDS (V) | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | (MeV/(mg/cm$^2$)) | (MeV) | (µm) | @VGS= 0V | @VGS= 2V | @VGS= 4V | @VGS= 5V | @VGS= 6V | @VGS= 7V | @VGS= 8V | @VGS= 10V |
| Br | 37 | 305 | 39 | -60 | -60 | -60 | -60 | -60 | -50 | -35 | -25 |
| I | 60 | 370 | 34 | -60 | -60 | -60 | -60 | -60 | -20 | - | - |
| Au | 84 | 390 | 30 | -60 | -60 | -60 | -60 | - | - | - | - |

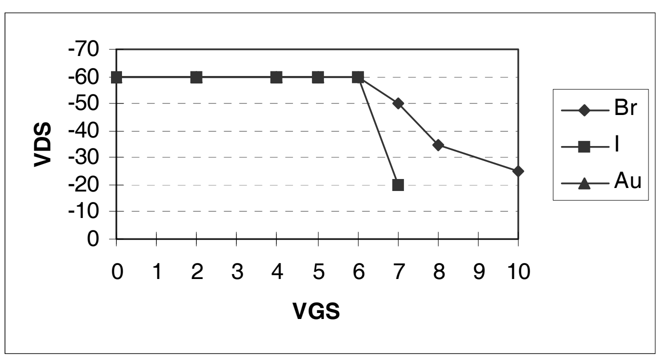



**Fig a.** Typical Single Event Effect, Safe Operating Area

For footnotes refer to the last page

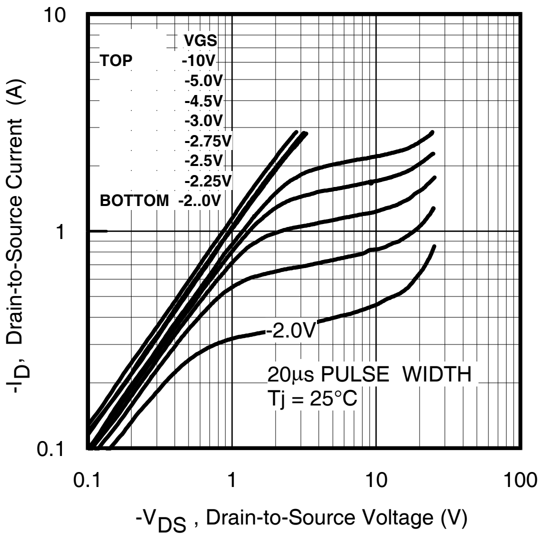



**Fig 1.** Typical Output Characteristics

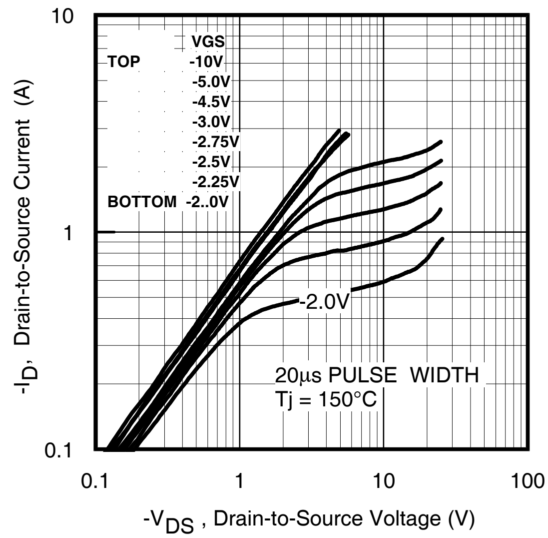



**Fig 2.** Typical Output Characteristics

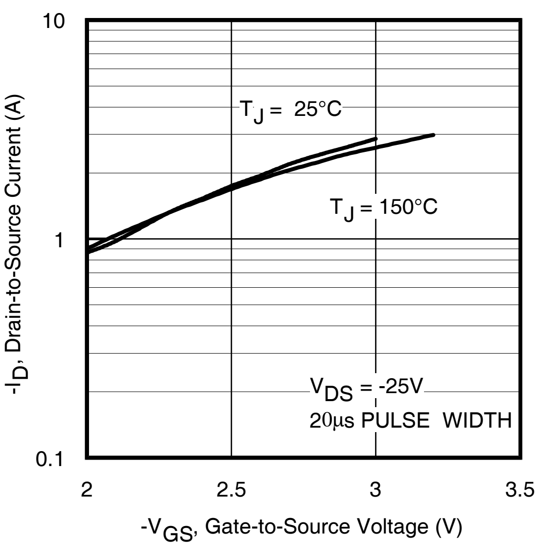



**Fig 3.** Typical Transfer Characteristics

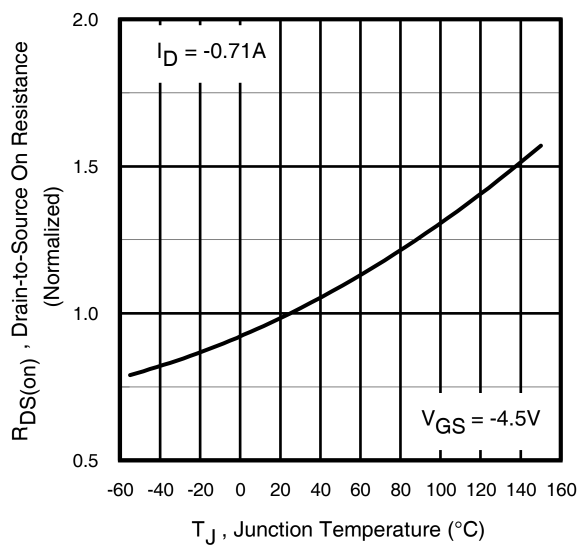



**Fig 4.** Normalized On-Resistance Vs. Temperature

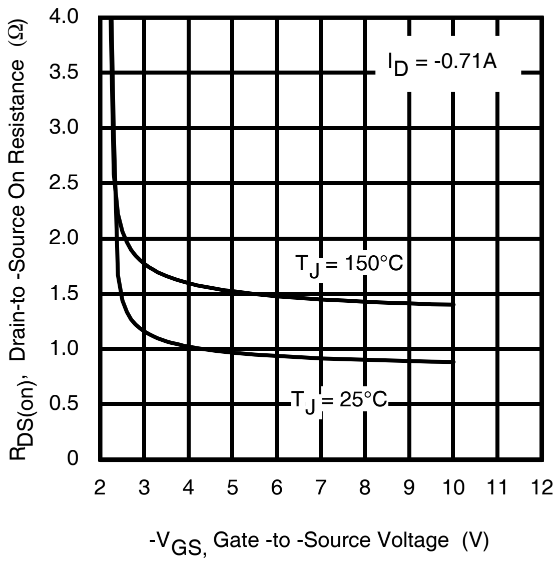



**Fig 5.** Typical On-Resistance Vs Gate Voltage

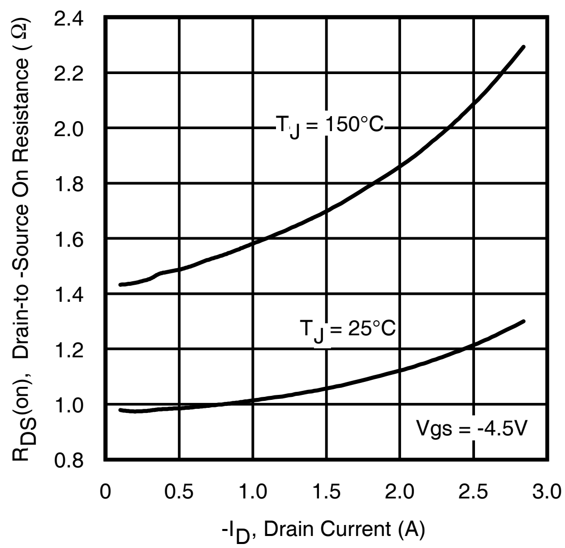



**Fig 6.** Typical On-Resistance Vs Drain Current

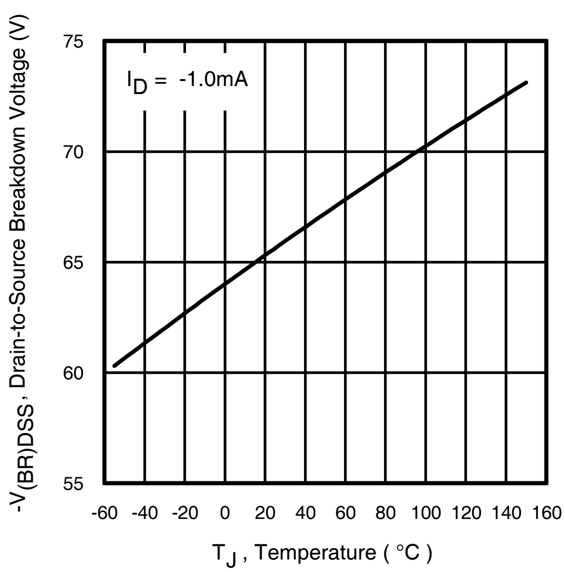



**Fig 7**. Typical Drain-to-Source Breakdown Voltage Vs Temperature

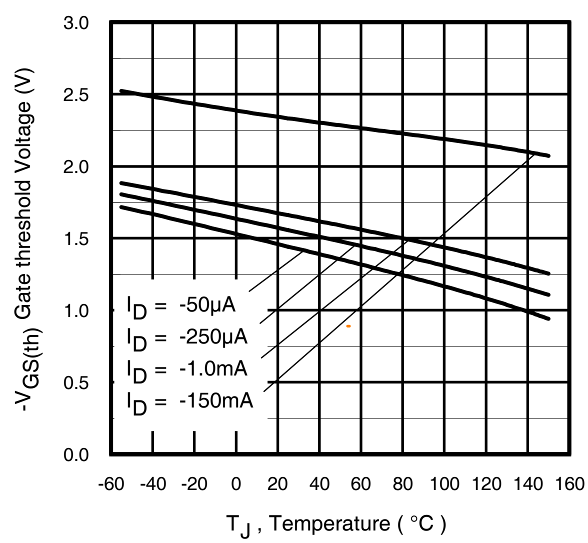



**Fig 8.** Typical Threshold Voltage Vs Temperature

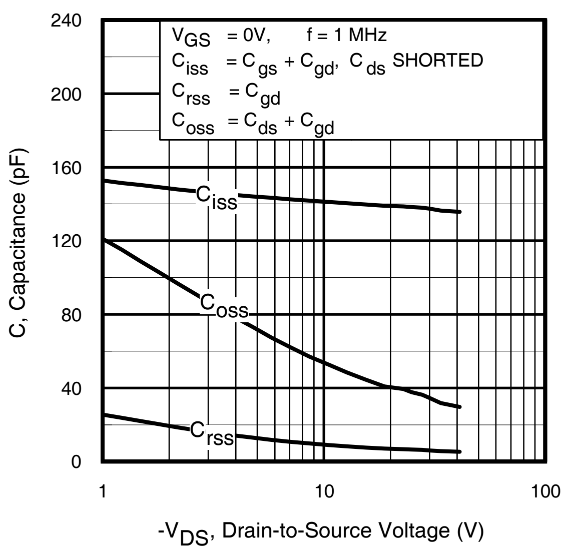



**Fig 9.** Typical Capacitance Vs.Drain-to-Source Voltage

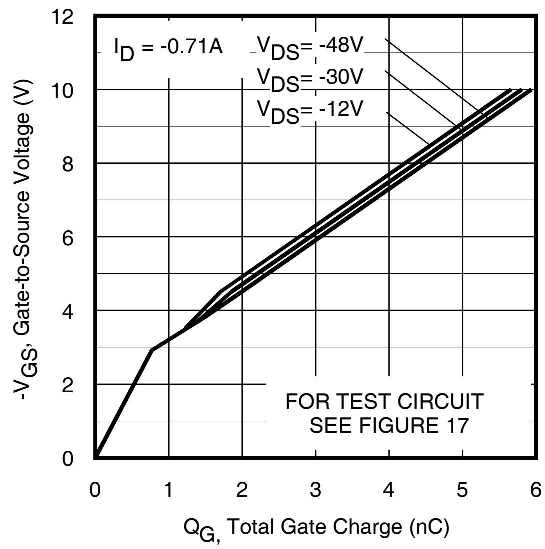



**Fig 10.** Typical Gate Charge Vs. Gate-to-Source Voltage

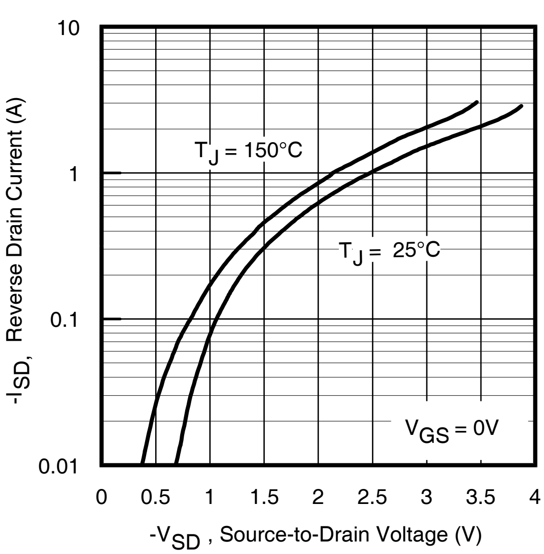



**Fig 11.** Typical Source-Drain Diode Forward Voltage

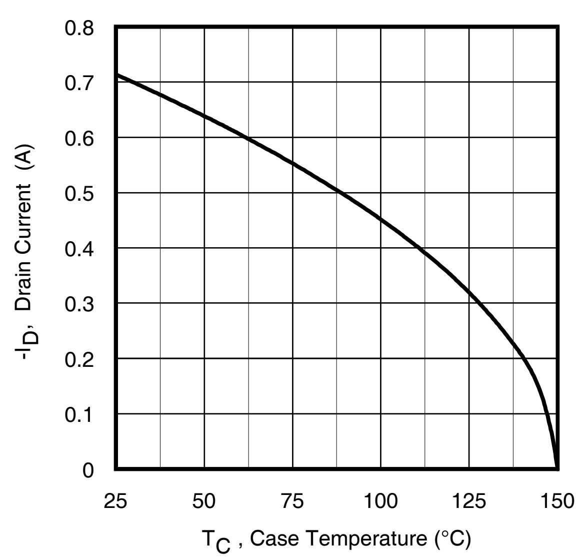



**Fig 12.** Maximum Drain Current Vs. Case Temperature

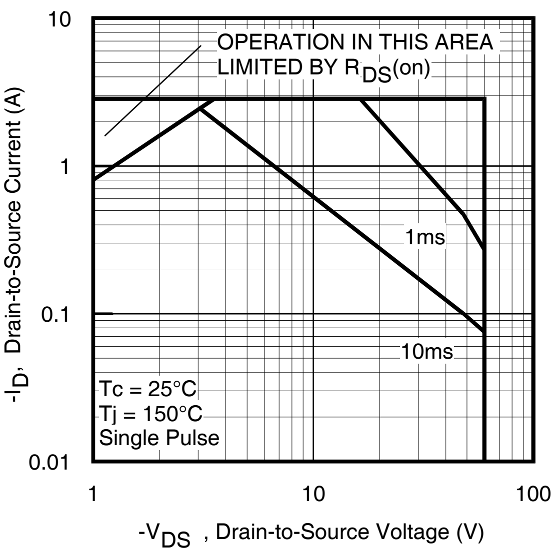



**Fig 13.** Maximum Safe Operating Area

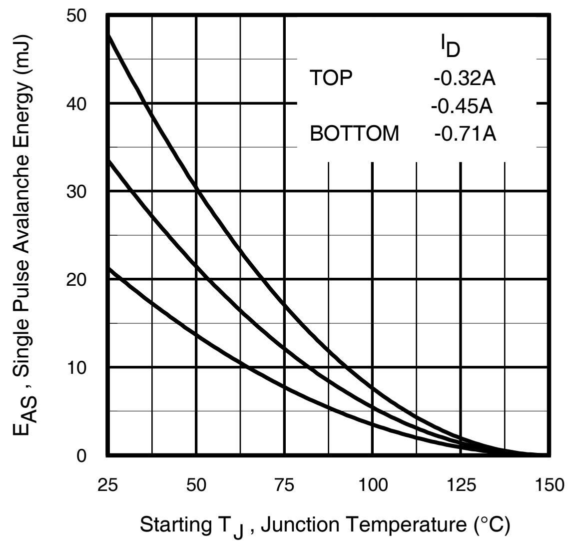



**Fig 14.** Maximum Avalanche Energy Vs. Drain Current

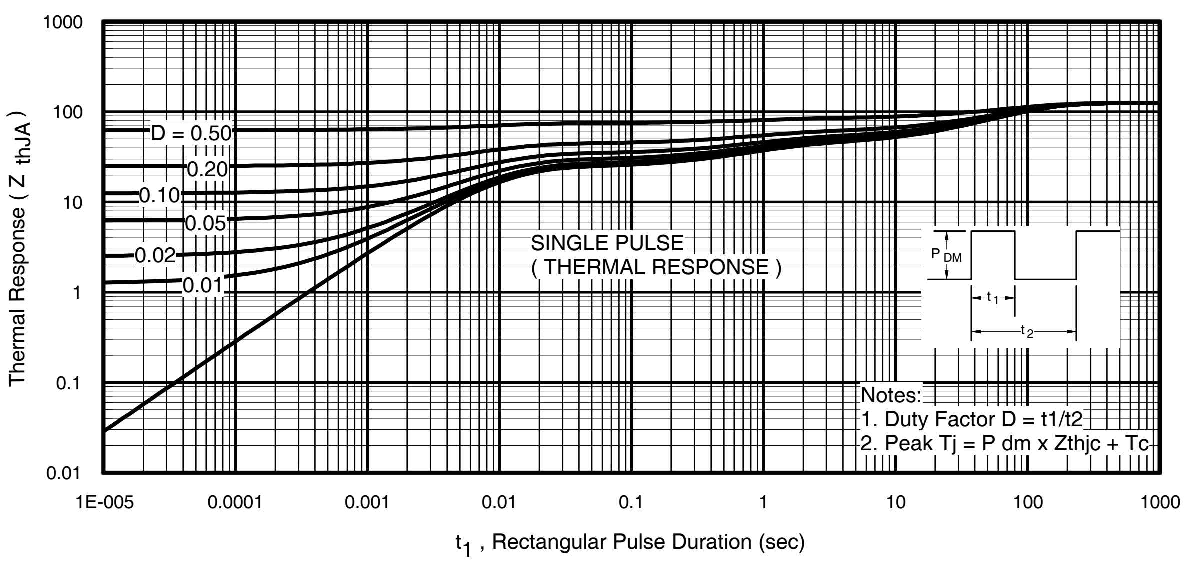



**Fig 15.** Maximum Effective Transient Thermal Impedance, Junction-to-Ambient

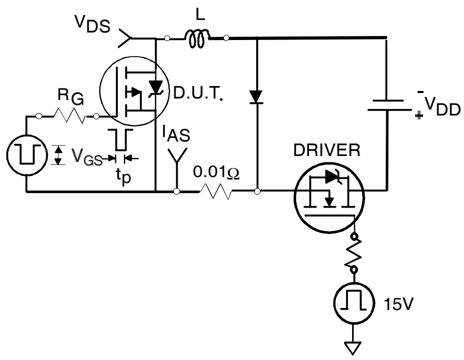



**Fig 16a.** Unclamped Inductive Test Circuit

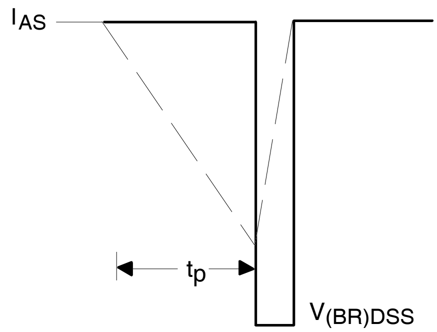



**Fig 16b.** Unclamped Inductive Waveforms

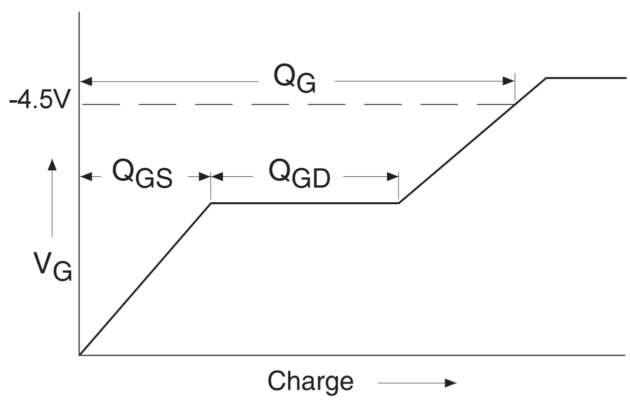



**Fig 17a.** Basic Gate Charge Waveform

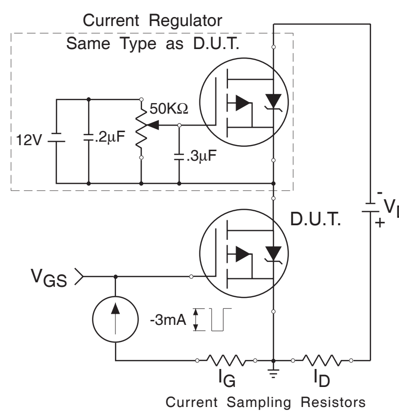



**Fig 17b.** Gate Charge Test Circuit

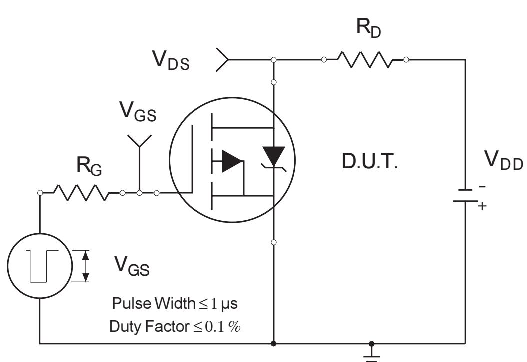



**Fig 18a.** Switching Time Test Circuit

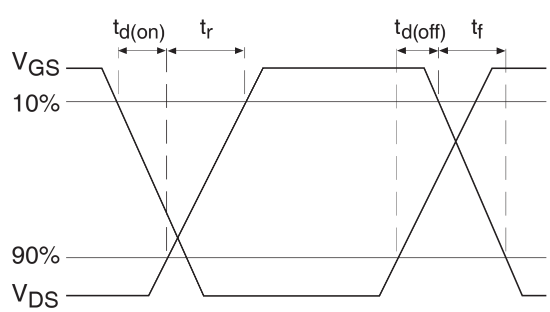



**Fig 18b.** Switching Time Waveforms

## Footnotes:

① Repetitive Rating; Pulse width limited by maximum junction temperature.

② $V_{DD}$ = -25V, starting $T_J$ = 25°C, L= 85mH Peak $I_L$ = -0.71A, $V_{GS}$ = -10V

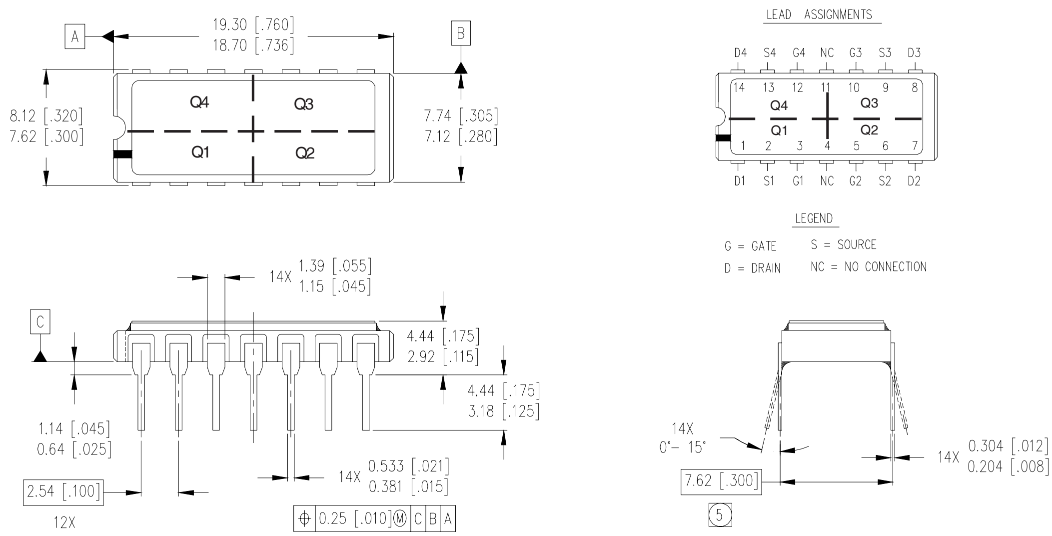
③ $I_{SD} \le$ -0.71A, di/dt $\le$ -164A/µs, $V_{DD} \le$ -60V, $T_J \le$ 150°C

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

⑤ **Total Dose Irradiation with $V_{GS}$ Bias.** -10 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.** -48 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 IOR Rectifier

**IR WORLD HEADQUARTERS:** 233 Kansas St., El Segundo, California 90245, USA Tel: (310) 252-7105
**IR LEOMINSTER :** 205 Crawford St., Leominster, Massachusetts 01453, USA Tel: (978) 534-5776
TAC Fax: (310) 252-7903
Visit us at www.irf.com for sales contact information.

*Data and specifications subject to change without notice. 04/2008*