International
IOR Rectifier

# IRHN9150
# IRHN93150
# JANSR2N7244U
# JANSF2N7422U
**(REF:MIL-PRF-19500/662)**
P-CHANNEL
**RAD HARD**

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

## -100 Volt, 0.073Ω, 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 virtual 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 | $BV_{DSS}$ | $R_{DS(on)}$ | $I_D$ |
|---|---|---|---|
| IRHN9150 | -100V | 0.080Ω | -22A |
| IRHN93150 | -100V | 0.080Ω | -22A |

## Features:

- Radiation Hardened up to 3 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
- Surface Mount
- Lightweight

## Absolute Maximum Ratings

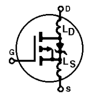
**Pre-Irradiation**

| | Parameter | IRHN9150, IRHN93150 | Units |
|---|---|---|---|
| $I_D$ @ $V_{GS}$ = -12V, $T_C$ = 25°C | Continuous Drain Current | -22 | A |
| $I_D$ @ $V_{GS}$ = -12V, $T_C$ = 100°C | Continuous Drain Current | -14 | |
| $I_{DM}$ | Pulsed Drain Current ① | - 88 | |
| $P_D$ @ $T_C$ = 25°C | Max. Power Dissipation | 150 | W |
| | Linear Derating Factor | 1.2 | W/°C |
| $V_{GS}$ | Gate-to-Source Voltage | ± 20 | V |
| $E_{AS}$ | Single Pulse Avalanche Energy ② | 500 | mJ |
| $I_{AR}$ | Avalanche Current ① | -22 | A |
| $E_{AR}$ | Repetitive Avalanche Energy ① | 15 | mJ |
| dv/dt | Peak Diode Recovery dv/dt ③ | -23 | V/ns |
| $T_J$<br>$T_{STG}$ | Operating Junction<br>Storage Temperature Range | -55 to 150 | |
| | Lead Temperature | 300 (0.063 in. (1.6mm) from case for 10s | °C |
| | Weight | 2.6 (typical) | g |

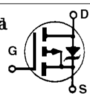


1/6/99

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

| | Parameter | Min | Typ | Max | Units | Test Conditions |
|---|---|---|---|---|---|---|
| $BV_{DSS}$ | Drain-to-Source Breakdown Voltage | -100 | — | — | V | $V_{GS}$ = 0V, $I_D$ = -1.0mA |
| $\Delta BV_{DSS}/\Delta T_J$ | Temperature Coefficient of Breakdown Voltage | — | -0.093 | — | V/°C | Reference to 25°C, $I_D$ = -1.0mA |
| $R_{DS(on)}$ | Static Drain-to-Source On-State Resistance | — | — | 0.080 | Ω | $V_{GS}$ = -12V, $I_D$ = -14A ④ |
| | | — | — | 0.085 | | $V_{GS}$ = -12V, $I_D$ = -22A |
| $V_{GS(th)}$ | Gate Threshold Voltage | -2.0 | — | -4.0 | V | $V_{DS}$ = $V_{GS}$, $I_D$ = -1.0mA |
| $g_{fs}$ | Forward Transconductance | 11 | — | — | S (℧) | $V_{DS}$ > -15V, $I_{DS}$ = -14A 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<br>$V_{GS}$ = 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 | — | — | 200 | nC | $V_{GS}$ =-12V, $I_D$ = -22A<br>$V_{DS}$ = Max Rating x 0.5 |
| $Q_{gs}$ | Gate-to-Source Charge | — | — | 35 | | |
| $Q_{gd}$ | Gate-to-Drain ('Miller') Charge | — | — | 48 | | |
| $t_{d(on)}$ | Turn-On Delay Time | — | — | 40 | ns | $V_{DD}$ = -50V, $I_D$ =-22A,<br>$R_G$ = 2.35Ω |
| $t_r$ | Rise Time | — | — | 170 | | |
| $t_{d(off)}$ | Turn-Off Delay Time | — | — | 190 | | |
| $t_f$ | Fall Time | — | — | 190 | | |
| $L_D$ | Internal Drain Inductance | — | 2.0 | — | 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 | — | 4.1 | — | | Measured from source lead, 6mm (0.25 in) from package to source bonding pad. |
| $C_{iss}$ | Input Capacitance | — | 4300 | — | pF | $V_{GS}$ = 0V, $V_{DS}$ = -25V<br>f = 1.0MHz |
| $C_{oss}$ | Output Capacitance | — | 1100 | — | | |
| $C_{rss}$ | Reverse Transfer Capacitance | — | 310 | — | | |

## Source-Drain Diode Ratings and Characteristics

| | Parameter | Min | Typ | Max | Units | Test Conditions |
|---|---|---|---|---|---|---|
| $I_S$ | Continuous Source Current (Body Diode) | — | — | -22 | A | Modified MOSFET symbol showing the integral reverse p-n junction rectifier.  |
| $I_{SM}$ | Pulse Source Current (Body Diode) ① | — | — | -88 | | |
| $V_{SD}$ | Diode Forward Voltage | — | — | -3.0 | V | $T_j$ = 25°C, $I_S$ = -22A, $V_{GS}$ = 0V ④ |
| $t_{rr}$ | Reverse Recovery Time | — | — | 300 | ns | $T_j$ = 25°C, $I_F$ = -22A, di/dt ≤ -100A/µs<br>$V_{DD}$ ≤ -50V ④ |
| $Q_{RR}$ | Reverse Recovery Charge | — | — | 1.5 | 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 | — | — | 0.83 | °C/W | |
| $R_{thJ-PCB}$ | Junction-to-PC board | — | 6.6 | — | | soldered to a 1" square copper-clad board |

## 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 com prises three 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. Pre- and post- irradiation limits of the devices irradiated to 1 x $10^5$ Rads (Si) are identical and are presented in Table1, column1, IRHN9150. Post-irradiation limits of the devices irradiated to 3 x $10^5$ Rads (Si) are presented in Table 1, column 2, IRHN93150. 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 3 x $10^5$ Rads (Si) the only parametric limit change is $V_{GS(th)}$ maximum.

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 P-Channel HEXFETs are considered to be neutron-tolerant, as stated in MIL-PRF-19500 Group D.

International Rectifier radiation hardened P-Channel 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

| | Parameter | IRHN9150 100K Rads (Si) | | IRHN93150 300K Rads (Si) | | Units | Test Conditions ⑧ |
|---|---|---|---|---|---|---|---|
| | | Min | Max | Min | Max | | |
| $BV_{DSS}$ | Drain-to-Source Breakdown Voltage | -100 | — | -100 | — | V | $V_{GS}$ = 0V, $I_D$ = -1.0mA |
| $V_{GS(th)}$ | Gate Threshold Voltage ④ | -2.0 | -4.0 | -2.0 | -5.0 | | $V_{GS}$ = $V_{DS}$, $I_D$ = -1.0mA |
| $I_{GSS}$ | Gate-to-Source Leakage Forward | — | -100 | — | -100 | nA | $V_{GS}$ = -20V |
| $I_{GSS}$ | Gate-to-Source Leakage Reverse | — | 100 | — | 100 | | $V_{GS}$ = 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 | — | 0.080 | — | 0.080 | Ω | $V_{GS}$ = -12V, $I_D$ = -14A |
| $V_{SD}$ | Diode Forward Voltage ④ | — | -3.0 | — | -3.0 | V | $T_C$ = 25°C, $I_S$ = -22A,$V_{GS}$ = 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 | — | — | -80 | — | — | -80 | 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 | — | — | 0.5 | — | — | µH | Circuit inductance required to limit di/dt |

### Table 3. Single Event Effects

| Ion | LET (Si) (MeV/mg/cm$^2$) | Fluence (ions/cm$^2$) | Range (µm) | $V_{DS}$Bias (V) | $V_{GS}$ Bias (V) |
|---|---|---|---|---|---|
| Ni | 28 | 1x $10^5$ | ~41 | -100 | 5 |

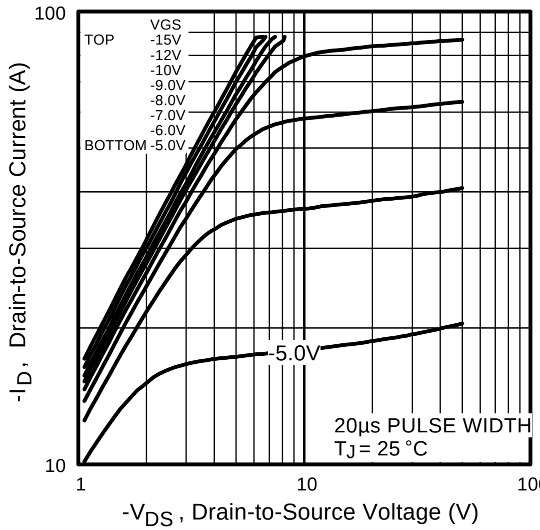



**Fig 1.** Typical Output Characteristics

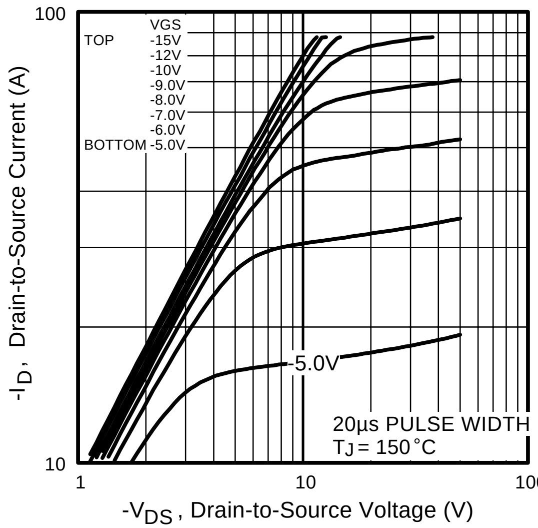



**Fig 2.** Typical Output Characteristics

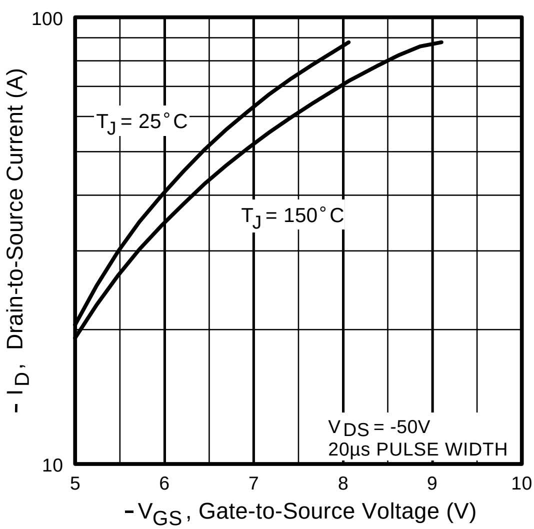



**Fig 3.** Typical Transfer Characteristics

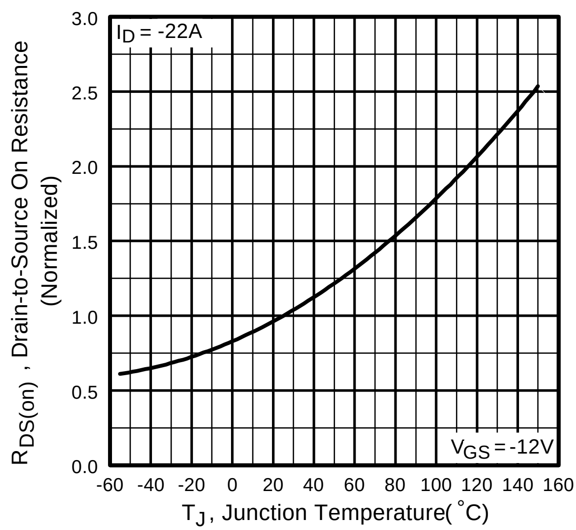



**Fig 4.** Normalized On-Resistance Vs. Temperature

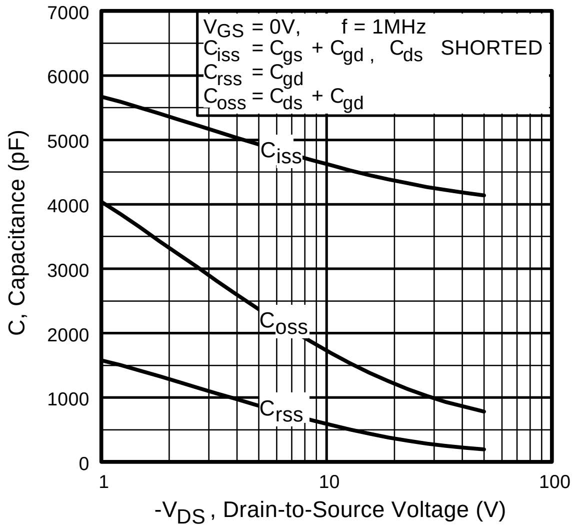



**Fig 5.** Typical Capacitance Vs. Drain-to-Source Voltage

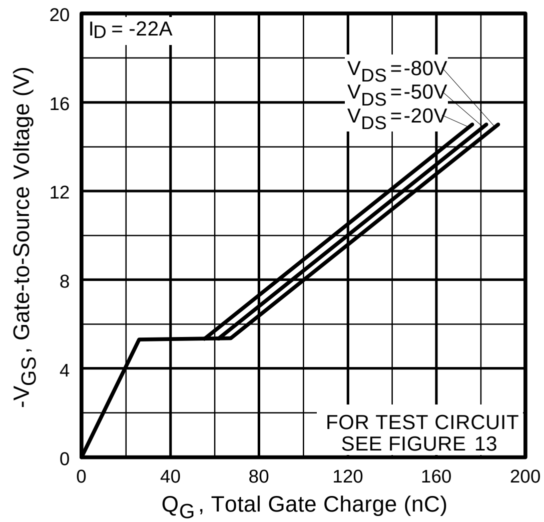



**Fig 6.** Typical Gate Charge Vs. Gate-to-Source Voltage

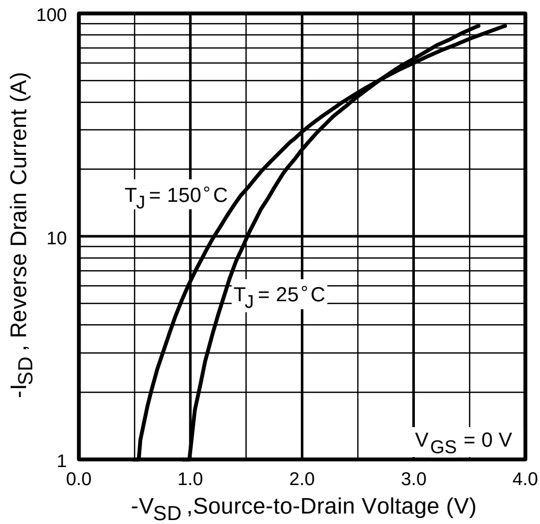



**Fig 7.** Typical Source-Drain Diode Forward Voltage

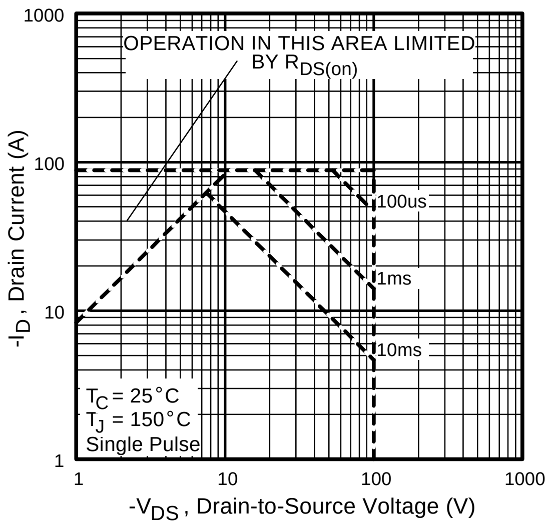



**Fig 8.** Maximum Safe Operating Area

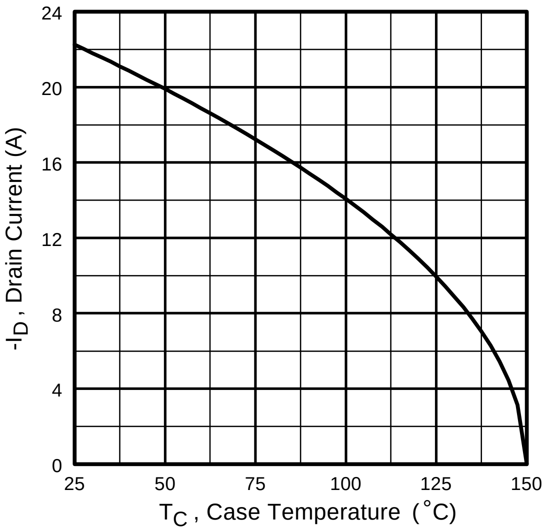



**Fig 9.** Maximum Drain Current Vs. Case Temperature

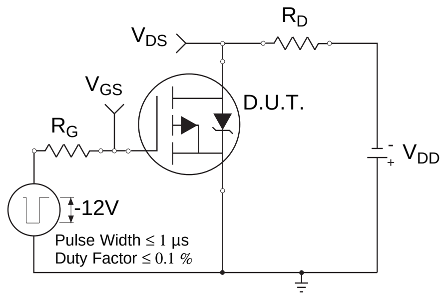



**Fig 10a.** Switching Time Test Circuit

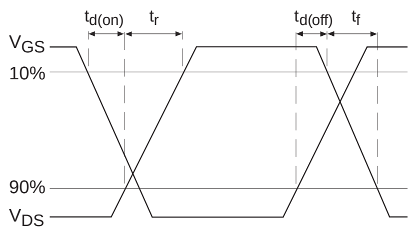



**Fig 10b.** Switching Time Waveforms

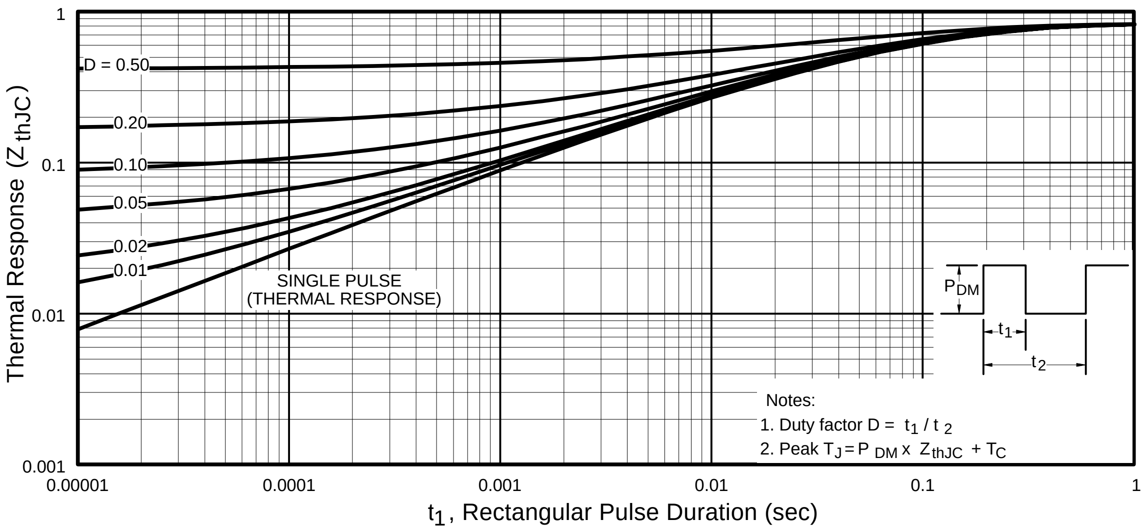



**Fig 11.** Maximum Effective Transient Thermal Impedance, Junction-to-Case

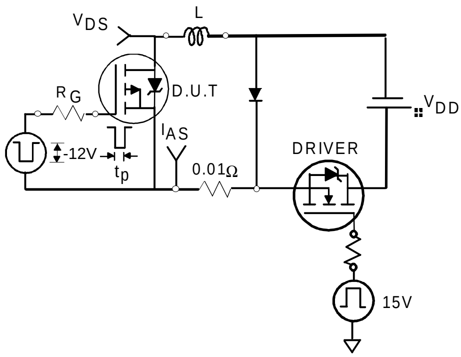



**Fig 12a.** Unclamped Inductive Test Circuit

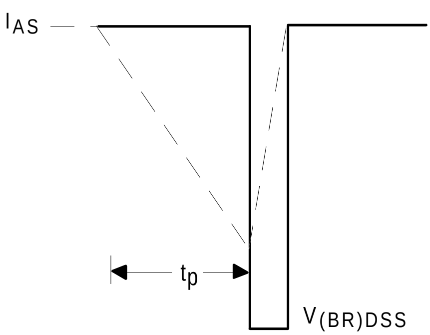



**Fig 12b.** Unclamped Inductive Waveforms

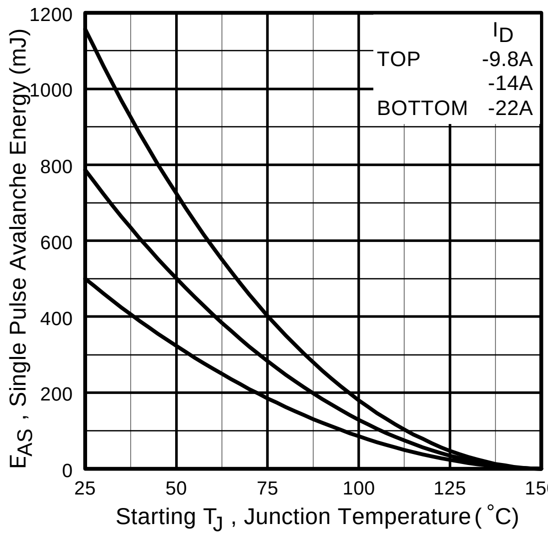



**Fig 12c.** Maximum Avalanche Energy Vs. Drain Current

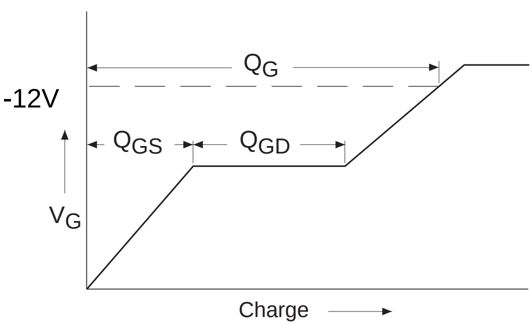



**Fig 13a.** Basic Gate Charge Waveform

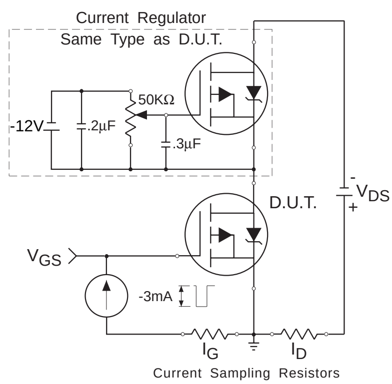



**Fig 13b.** Gate Charge Test Circuit

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 $I_L$ = -22A, $V_{GS}$ = -12V, $25 \le R_G \le 200\Omega$

③ $I_{SD} \le$ -22A, di/dt ≤ -450A/µs, $V_{DD} \le BV_{DSS}$, $T_J \le$ 150°C Suggested RG = 2.35Ω

④ Pulse width ≤ 300 µs; Duty Cycle ≤ 2% irradiation per MIL-STD-750, method 1019, condition A.

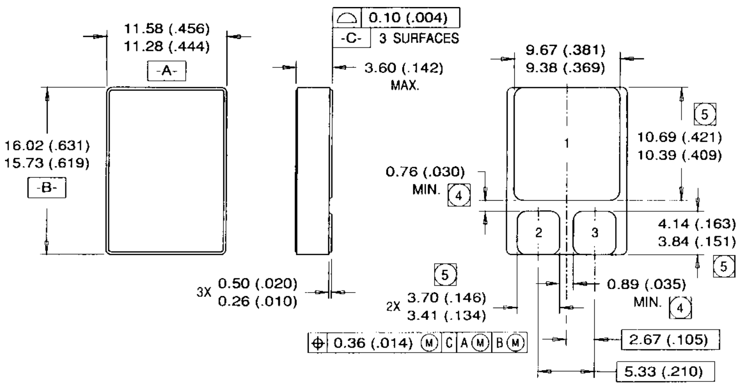
⑤ **Total Dose Irradiation with $V_{GS}$ Bias.** 12 volt $V_{GS}$ applied and $V_{DS}$ = 0 during irradiation per MIL-STD-750, method 1019, condition A.

⑥ **Total Dose Irradiation with $V_{DS}$ Bias.** $V_{DS}$ = 0.8 rated $BV_{DSS}$ (pre-Irrradiation) applied and $V_{GS}$ = 0 during irradiation per MlL-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 — SMD-1




NOTES:

1. DIMENSIONING & TOLERANCING PER ANSI Y14.5M-1982
2. CONTROLLING DIMENSION: INCH.
3. DIMENSIONS ARE SHOWN IN MILLIMETERS (INCHES).

4 DIMENSION INCLUDES METALLIZATION FLASH.

5 DIMENSION DOES NOT INCLUDE METALLIZATION FLASH.

LEAD ASSIGNMENTS

1 = DRAIN
2 = GATE
3 = SOURCE

**SMD-1**

International
IOR Rectifier

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