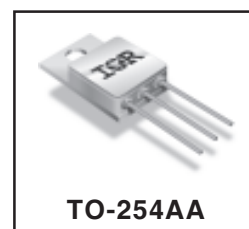


**RADIATION HARDENED  
POWER MOSFET  
THRU-HOLE (TO-254AA)**

**IRHM7360SE  
JANSR2N7391  
400V, N-CHANNEL  
REF:MIL-PRF-19500/661  
RAD Hard™ HEXFET® TECHNOLOGY**

**Product Summary**

| Part Number | Radiation Level | R <sub>DS(on)</sub> | I <sub>D</sub> | QPL Part Number |
|-------------|-----------------|---------------------|----------------|-----------------|
| IRHM7360SE  | 100K Rads (Si)  | 0.20Ω               | 22A            | JANSR2N7391     |



International Rectifier's RADHard™ 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 R<sub>DS(on)</sub> 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 R<sub>DS(on)</sub>
- Low Total Gate Charge
- Proton Tolerant
- Simple Drive Requirements
- Ease of Paralleling
- Hermetically Sealed
- Light Weight
- ESD Rating: Class 3B per MIL-STD-750, Method 1020

**Absolute Maximum Ratings**

**Pre-Irradiation**

|                                                                | Parameter                       |                                               | Units |
|----------------------------------------------------------------|---------------------------------|-----------------------------------------------|-------|
| I <sub>D</sub> @ V <sub>GS</sub> = 12V, T <sub>C</sub> = 25°C  | Continuous Drain Current        | 22                                            | A     |
| I <sub>D</sub> @ V <sub>GS</sub> = 12V, T <sub>C</sub> = 100°C | Continuous Drain Current        | 14                                            |       |
| I <sub>DM</sub>                                                | Pulsed Drain Current ①          | 88                                            |       |
| P <sub>D</sub> @ T <sub>C</sub> = 25°C                         | Max. Power Dissipation          | 250                                           | W     |
|                                                                | Linear Derating Factor          | 2.0                                           | W/°C  |
| V <sub>GS</sub>                                                | Gate-to-Source Voltage          | ±20                                           | V     |
| E <sub>AS</sub>                                                | Single Pulse Avalanche Energy ② | 500                                           | mJ    |
| I <sub>AR</sub>                                                | Avalanche Current ①             | 22                                            | A     |
| E <sub>AR</sub>                                                | Repetitive Avalanche Energy ①   | 25                                            | mJ    |
| dv/dt                                                          | Peak Diode Recovery dv/dt ③     | 3.0                                           | 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                          | 9.3 (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            | 400 | —    | —            | 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 | —   | 0.51 | —            | V/°C  | Reference to 25°C, I <sub>D</sub> = 1.0mA                                                                            |
| R <sub>DS(on)</sub>                 | Static Drain-to-Source On-State Resistance   | —   | —    | 0.20<br>0.21 | Ω     | V <sub>GS</sub> = 12V, I <sub>D</sub> = 14A ④<br>V <sub>GS</sub> = 12V, I <sub>D</sub> = 22A                         |
| V <sub>GS(th)</sub>                 | Gate Threshold Voltage                       | 2.5 | —    | 4.5          | V     | V <sub>DS</sub> = V <sub>GS</sub> , I <sub>D</sub> = 1.0mA                                                           |
| g <sub>fs</sub>                     | Forward Transconductance                     | 6.0 | —    | —            | S     | V <sub>DS</sub> = 15V, I <sub>DS</sub> = 14A ④                                                                       |
| I <sub>DSS</sub>                    | Zero Gate Voltage Drain Current              | —   | —    | 50<br>250    | μA    | V <sub>DS</sub> = 320V, V <sub>GS</sub> = 0V<br>V <sub>DS</sub> = 320V, 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         | nA    | V <sub>GS</sub> = -20V                                                                                               |
| Q <sub>g</sub>                      | Total Gate Charge                            | —   | —    | 185          | nC    | V <sub>GS</sub> = 12V, I <sub>D</sub> = 22A<br>V <sub>DS</sub> = 200V                                                |
| Q <sub>gs</sub>                     | Gate-to-Source Charge                        | —   | —    | 35           | nC    |                                                                                                                      |
| Q <sub>gd</sub>                     | Gate-to-Drain ('Miller') Charge              | —   | —    | 100          | nC    |                                                                                                                      |
| t <sub>d(on)</sub>                  | Turn-On Delay Time                           | —   | —    | 28           | ns    | V <sub>DD</sub> = 200V, I <sub>D</sub> = 22A,<br>V <sub>GS</sub> = 12V, R <sub>G</sub> = 2.35Ω                       |
| t <sub>r</sub>                      | Rise Time                                    | —   | —    | 97           |       |                                                                                                                      |
| t <sub>d(off)</sub>                 | Turn-Off Delay Time                          | —   | —    | 120          |       |                                                                                                                      |
| t <sub>f</sub>                      | Fall Time                                    | —   | —    | 72           |       |                                                                                                                      |
| L <sub>S</sub> + L <sub>D</sub>     | Total Inductance                             | —   | 6.8  | —            | nH    | Measured from drain lead (6mm/0.25in. from package) to source lead (6mm/0.25in. from package)                        |
| C <sub>iss</sub>                    | Input Capacitance                            | —   | 4000 | —            | pF    | V <sub>GS</sub> = 0V, V <sub>DS</sub> = 25V<br>f = 1.0MHz                                                            |
| C <sub>oss</sub>                    | Output Capacitance                           | —   | 1000 | —            |       |                                                                                                                      |
| C <sub>rss</sub>                    | Reverse Transfer Capacitance                 | —   | 460  | —            |       |                                                                                                                      |

**Source-Drain Diode Ratings and Characteristics**

|                 | Parameter                              | Min                                                                                                                  | Typ | Max | Units | Test Conditions                                                                         |
|-----------------|----------------------------------------|----------------------------------------------------------------------------------------------------------------------|-----|-----|-------|-----------------------------------------------------------------------------------------|
| I <sub>S</sub>  | Continuous Source Current (Body Diode) | —                                                                                                                    | —   | 22  | A     |                                                                                         |
| I <sub>SM</sub> | Pulse Source Current (Body Diode) ①    | —                                                                                                                    | —   | 88  |       |                                                                                         |
| V <sub>SD</sub> | Diode Forward Voltage                  | —                                                                                                                    | —   | 1.4 | V     | T <sub>J</sub> = 25°C, I <sub>S</sub> = 22A, V <sub>GS</sub> = 0V ④                     |
| t <sub>rr</sub> | Reverse Recovery Time                  | —                                                                                                                    | —   | 720 | ns    | T <sub>J</sub> = 25°C, I <sub>F</sub> = 22A, di/dt ≤ 100A/μs<br>V <sub>DD</sub> ≤ 50V ④ |
| Q <sub>RR</sub> | Reverse Recovery Charge                | —                                                                                                                    | —   | 14  | μC    |                                                                                         |
| 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    | —   | —    | 0.50 | °C/W  | Typical socket mount |
| R <sub>thCS</sub> | Case-to-Sink        | —   | 0.21 | —    |       |                      |
| R <sub>thJA</sub> | Junction-to-Ambient | —   | —    | 48   |       |                      |

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

For footnotes refer to the last page

## Pre-Irradiation

## IRHM7360SE, JANSR2N7391

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.

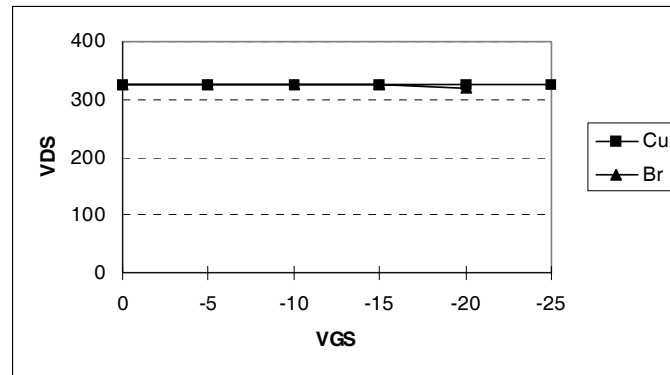
**Table 1. Electrical Characteristics @  $T_j = 25^\circ\text{C}$ , Post Total Dose Irradiation ⑤⑥**

|              | Parameter                                                | 100KRads (Si) |      | Units    | Test Conditions                |
|--------------|----------------------------------------------------------|---------------|------|----------|--------------------------------|
|              |                                                          | Min           | Max  |          |                                |
| $BV_{DSS}$   | Drain-to-Source Breakdown Voltage                        | 400           | —    | V        | $V_{GS} = 0V, I_D = 1.0mA$     |
| $V_{GS(th)}$ | Gate Threshold Voltage                                   | 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   | $\mu A$  | $V_{DS} = 320V, V_{GS} = 0V$   |
| $R_{DS(on)}$ | Static Drain-to-Source ④<br>On-State Resistance (TO-3)   | —             | 0.20 | $\Omega$ | $V_{GS} = 12V, I_D = 14A$      |
| $R_{DS(on)}$ | Static Drain-to-Source ④<br>On-State Resistance (TO-254) | —             | 0.20 | $\Omega$ | $V_{GS} = 12V, I_D = 14A$      |
| $V_{SD}$     | Diode Forward Voltage ④                                  | —             | 1.4  | V        | $V_{GS} = 0V, I_D = 22A$       |

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.

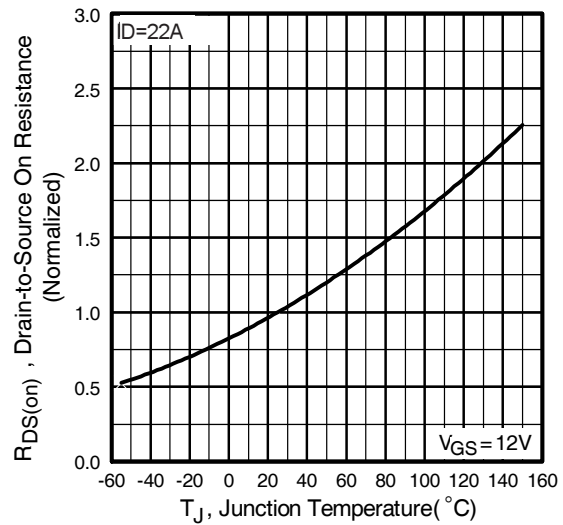
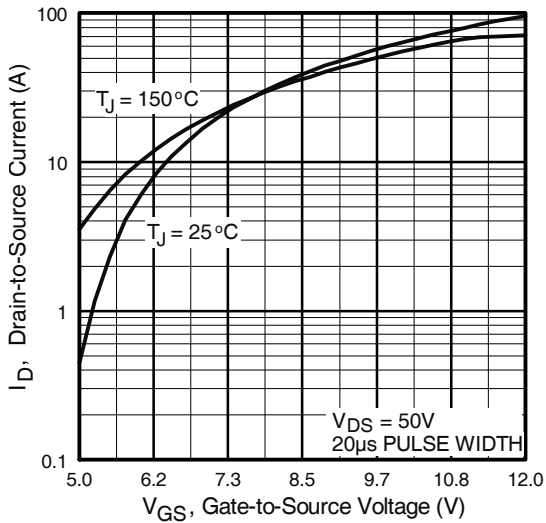
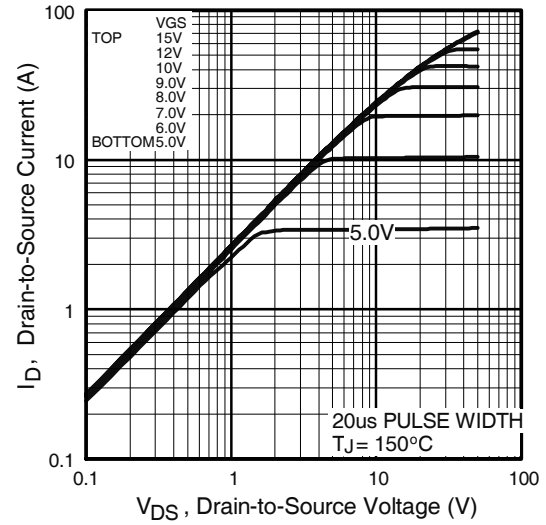
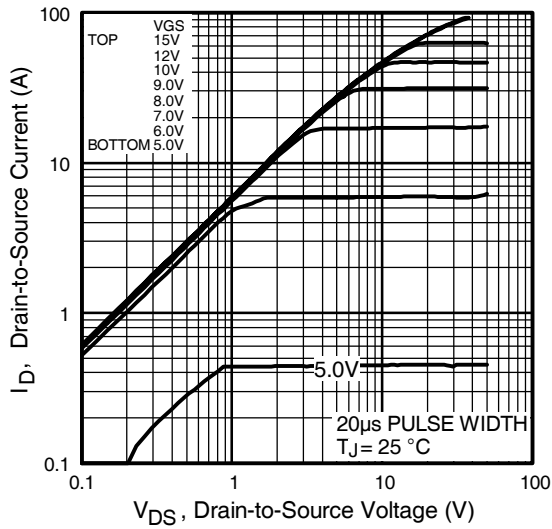
**Table 2. Typical Single Event Effect Safe Operating Area**

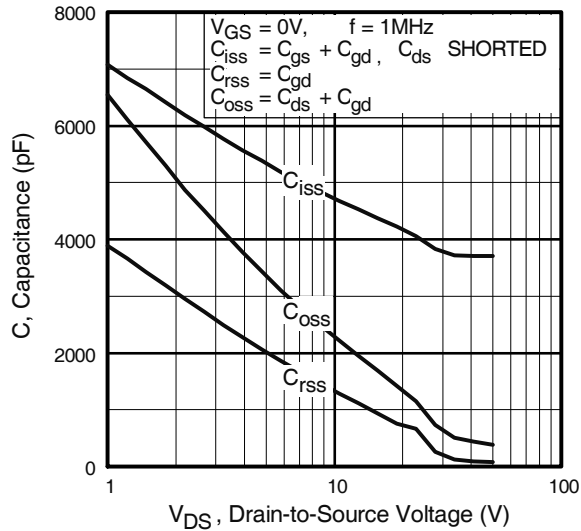
| Ion | LET<br>MeV/(mg/cm <sup>2</sup> ) | Energy<br>(MeV) | Range<br>( $\mu m$ ) | $V_{DS}$ (V)  |                |                 |                 |                 |                 |
|-----|----------------------------------|-----------------|----------------------|---------------|----------------|-----------------|-----------------|-----------------|-----------------|
|     |                                  |                 |                      | @ $V_{GS}=0V$ | @ $V_{GS}=-5V$ | @ $V_{GS}=-10V$ | @ $V_{GS}=-15V$ | @ $V_{GS}=-20V$ | @ $V_{GS}=-25V$ |
| Cu  | 28                               | 285             | 43                   | 325           | 325            | 325             | 325             | 325             | 325             |
| Br  | 36.8                             | 305             | 39                   | 325           | 325            | 325             | 325             | 320             | —               |



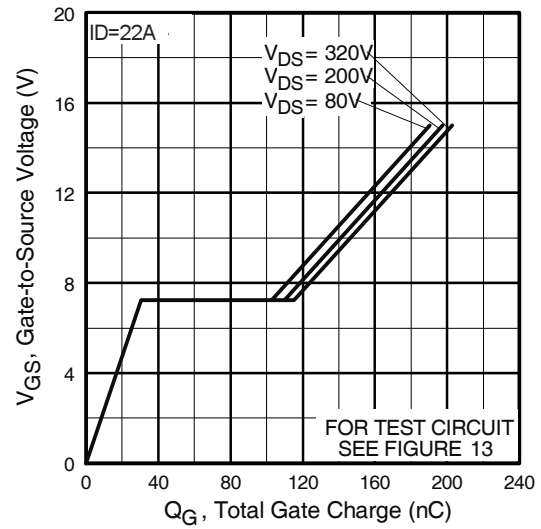
**Fig a. Typical Single Event Effect, Safe Operating Area**

For footnotes refer to the last page

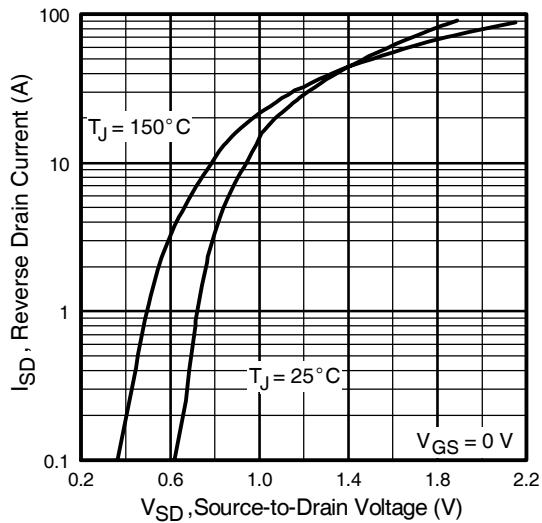




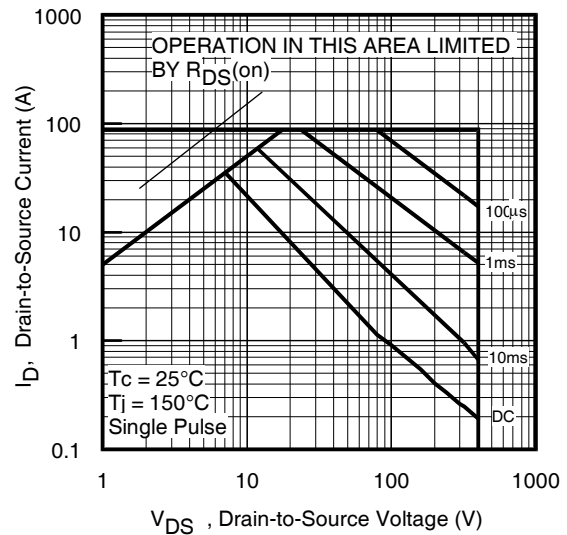
**Fig 5.** Typical Capacitance Vs. Drain-to-Source Voltage



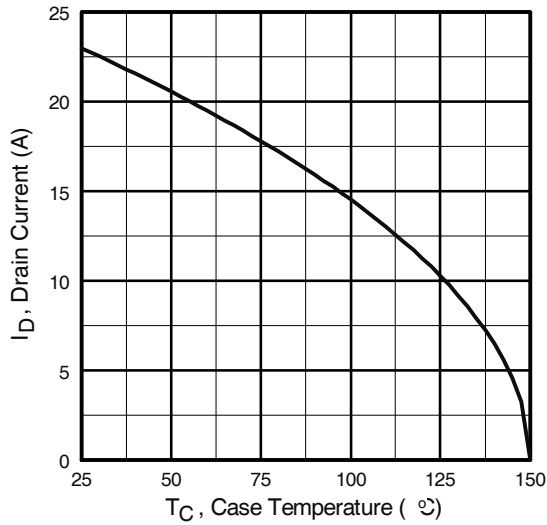
**Fig 6.** Typical Gate Charge Vs. Gate-to-Source Voltage



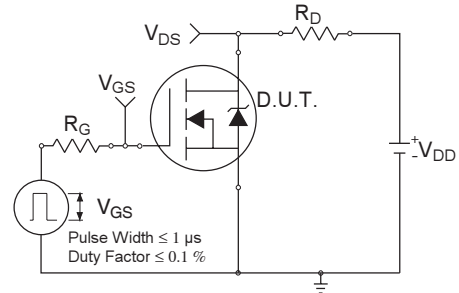
**Fig 7.** Typical Source-Drain Diode Forward Voltage



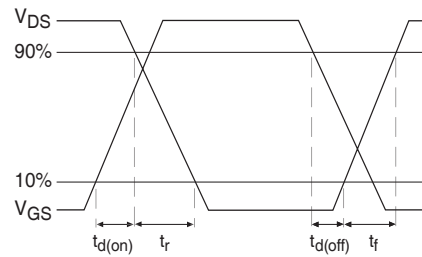
**Fig 8.** Maximum Safe Operating Area



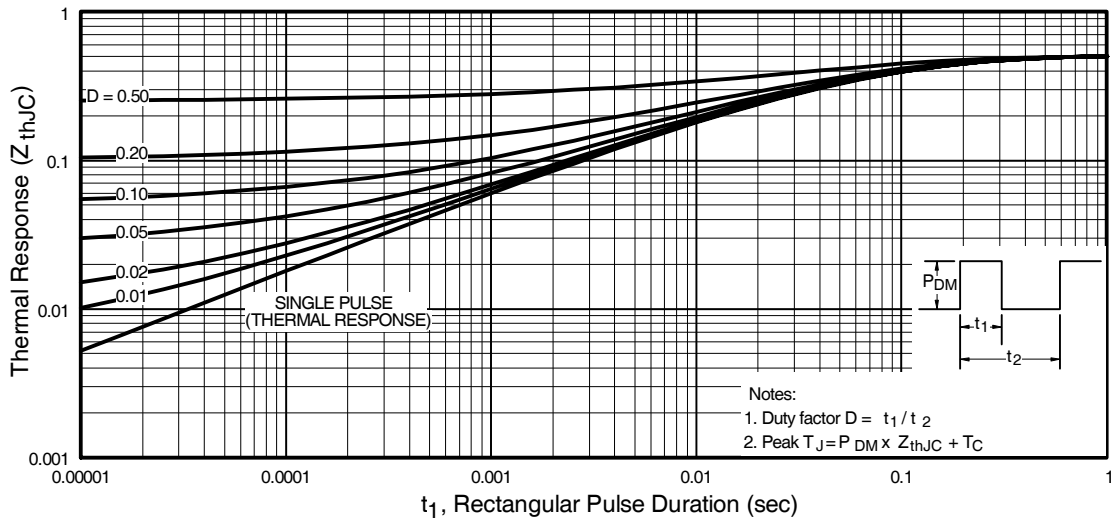
**Fig 9.** Maximum Drain Current Vs. Case Temperature



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



**Fig 10b.** Switching Time Waveforms



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

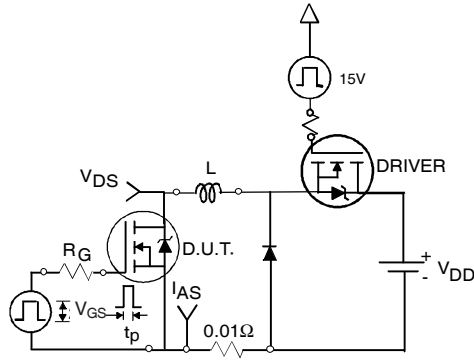


Fig 12a. Unclamped Inductive Test Circuit

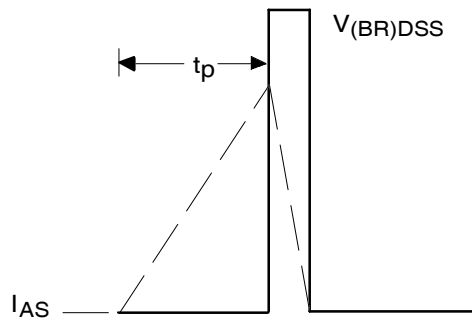


Fig 12b. Unclamped Inductive Waveforms

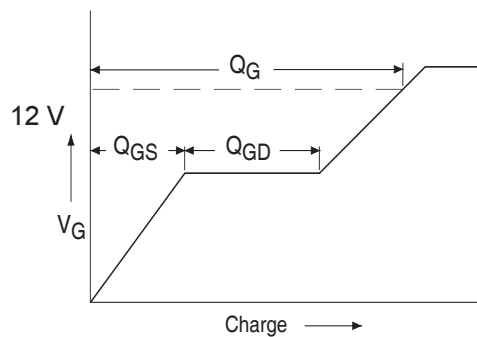


Fig 13a. Basic Gate Charge Waveform

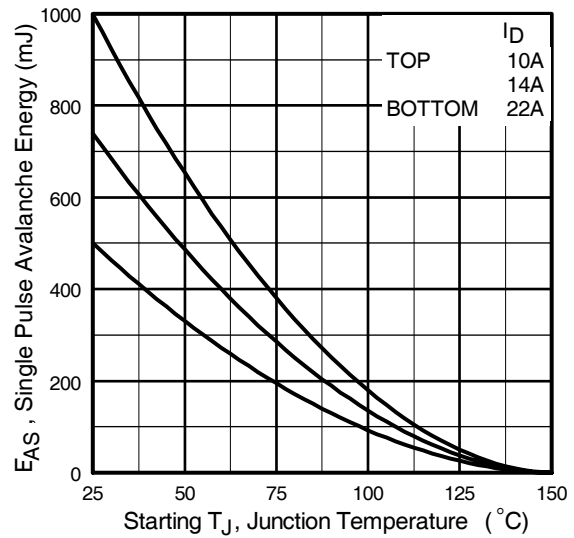


Fig 12c. Maximum Avalanche Energy Vs. Drain Current

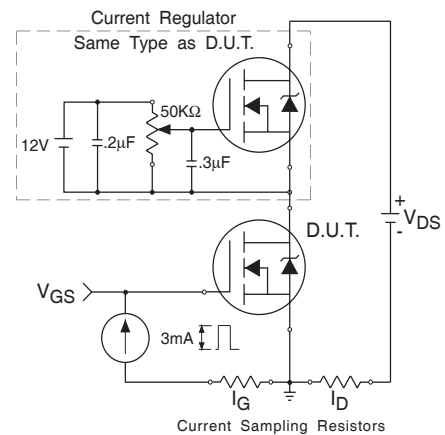
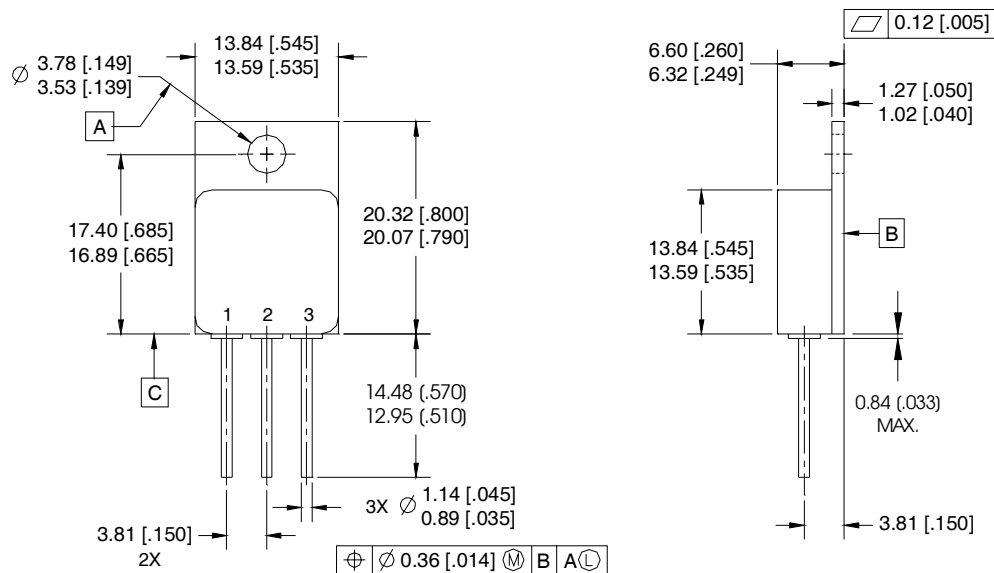


Fig 13b. Gate Charge Test Circuit

**Footnotes:**

- ① Repetitive Rating; Pulse width limited by maximum junction temperature.
- ②  $V_{DD} = 50V$ , starting  $T_J = 25^\circ C$ ,  $L = 2.0\text{ mH}$   
Peak  $I_L = 22A$ ,  $V_{GS} = 12V$
- ③  $I_{SD} \leq 22A$ ,  $di/dt \leq 120A/\mu s$ ,  
 $V_{DD} \leq 400V$ ,  $T_J \leq 150^\circ C$
- ④ Pulse width  $\leq 300\text{ }\mu s$ ; 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.**  
320 volt  $V_{DS}$  applied and  $V_{GS} = 0$  during irradiation per MIL-STD-750, method 1019, condition A.

**Case Outline and Dimensions —TO-254AA****NOTES:**

1. DIMENSIONING & TOLERANCING PER ASME Y14.5M-1994.
2. ALL DIMENSIONS ARE SHOWN IN MILLIMETERS [INCHES].
3. CONTROLLING DIMENSION: INCH.
4. CONFORMS TO JEDEC OUTLINE TO-254AA.

**PIN ASSIGNMENTS**

- 1 = DRAIN
- 2 = SOURCE
- 3 = GATE

**CAUTION****BERYLLIA WARNING PER MIL-PRF-19500**

Package containing beryllia shall not be ground, sandblasted, machined, or have other operations performed on them which will produce beryllia or beryllium dust. Furthermore, beryllium oxide packages shall not be placed in acids that will produce fumes containing beryllium.

International  
**IR** Rectifier

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**IR LEOMINSTER :** 205 Crawford St., Leominster, Massachusetts 01453, USA Tel: (978) 534-5776

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Visit us at [www.irf.com](http://www.irf.com) for sales contact information.

Data and specifications subject to change without notice. 06/2014