

IRHM7160 (JANSR2N7432)

PD-91331G

Radiation Hardened Power MOSFET Thru-Hole (TO-254AA) 100V, 35A, N-channel, Rad Hard HEXFET™ Technology

Features

- Single event effect (SEE) hardened
- Low $R_{DS(on)}$
- Low total gate charge
- Simple drive requirements
- Hermetically sealed
- Electrically isolated
- Ceramic eyelets
- ESD rating: Class 3B per MIL-STD-750, Method 1020

Potential Applications

- DC-DC converter
- Motor drives

Product Validation

Qualified to JANS screening flow according to MIL-PRF-19500 for space applications

Description

IR HiRel rad hard HEXFET 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 $R_{DS(on)}$ 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 and temperature stability of electrical parameters.

Ordering Information

Table 1 Ordering options

| Part number | Package | Screening Level | TID Level |
|-------------|----------|-----------------|--------------|
| IRHM7160 | TO-254AA | COTS | 100 krad(Si) |
| JANSR2N7432 | TO-254AA | JANS | 100 krad(Si) |
| IRHM3160 | TO-254AA | COTS | 300 krad(Si) |
| JANSF2N7432 | TO-254AA | JANS | 300 krad(Si) |
| IRHM4160 | TO-254AA | COTS | 500 krad(Si) |
| JANSG2N7432 | TO-254AA | JANS | 500 krad(Si) |

Product Summary

- BV_{DSS} : 100V
- I_D : 35A
- $R_{DS(on),max}$: 45m Ω (100 krad(Si))
- $Q_{G,max}$: 310nC
- REF: MIL-PRF-19500/663

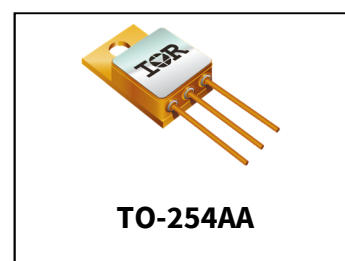


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1 Absolute Maximum Ratings

Table 2 Absolute Maximum Ratings (Pre-Irradiation)

| Symbol | Parameter | Value | Unit |
|--|---|---|------|
| $I_{D1} @ V_{GS} = 12V, T_C = 25^\circ C$ | Continuous Drain Current | 35* | A |
| $I_{D2} @ V_{GS} = 12V, T_C = 100^\circ C$ | Continuous Drain Current | 32 | A |
| $I_{DM} @ T_C = 25^\circ C$ | Pulsed Drain Current ¹ | 140 | A |
| $P_D @ T_C = 25^\circ C$ | Maximum Power Dissipation | 250 | W |
| | Linear Derating Factor | 2.0 | W/°C |
| V_{GS} | Gate-to-Source Voltage | ± 20 | V |
| E_{AS} | Single Pulse Avalanche Energy ² | 500 | mJ |
| I_{AR} | Avalanche Current ¹ | 35 | A |
| E_{AR} | Repetitive Avalanche Energy ¹ | 25 | mJ |
| dv/dt | Peak Diode Reverse Recovery ³ | 7.3 | V/ns |
| T_J T_{STG} | Operating Junction and Storage Temperature Range | -55 to +150 | °C |
| | Lead Temperature | 300 (0.063 in. /1.6 mm from case for 10s) | |
| | Weight | 9.3 (Typical) | |

* Current is limited by package

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

² $V_{DD} = 25V$, starting $T_J = 25^\circ C$, $L = 0.82mH$, Peak $I_L = 35A$, $V_{GS} = 12V$

³ $I_{SD} \leq 35A$, $di/dt \leq 100A/\mu s$, $V_{DD} \leq 100V$, $T_J \leq 150^\circ C$

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2 Device Characteristics

2.1 Electrical Characteristics (Pre-Irradiation)

Table 3 Static and Dynamic Electrical Characteristics @ $T_j = 25^\circ\text{C}$ (Unless Otherwise Specified)

| Symbol | Parameter | Min. | Typ. | Max. | Unit | Test Conditions |
|------------------------------|--|------|-------|------|---------------------|--|
| BV_{DSS} | Drain-to-Source Breakdown Voltage | 100 | — | — | V | $V_{GS} = 0V, I_D = 1.0\text{mA}$ |
| $\Delta BV_{DSS}/\Delta T_J$ | Breakdown Voltage Temp. Coefficient | — | 0.107 | — | V/ $^\circ\text{C}$ | Reference to $25^\circ\text{C}, I_D = 1.0\text{mA}$ |
| $R_{DS(on)}$ | Static Drain-to-Source On-State Resistance | — | — | 45 | m Ω | $V_{GS} = 12V, I_{D2} = 32A^1$ |
| $V_{GS(th)}$ | Gate Threshold Voltage | 2.0 | — | 4.0 | V | $V_{DS} = V_{GS}, I_D = 1\text{mA}$ |
| Gfs | Forward Transconductance | 16 | — | — | S | $V_{DS} = 15V, I_{D2} = 32A^1$ |
| I_{DSS} | Zero Gate Voltage Drain Current | — | — | 25 | μA | $V_{DS} = 80V, V_{GS} = 0V$ |
| | | — | — | 250 | | $V_{DS} = 80V, V_{GS} = 0V, T_J = 125^\circ\text{C}$ |
| I_{GSS} | Gate-to-Source Leakage Forward | — | — | 100 | nA | $V_{GS} = 20V$ |
| | Gate-to-Source Leakage Reverse | — | — | -100 | | $V_{GS} = -20V$ |
| Q_G | Total Gate Charge | — | — | 310 | nC | $I_{D1} = 35A$ $V_{DS} = 50V$ $V_{GS} = 12V$ |
| Q_{GS} | Gate-to-Source Charge | — | — | 53 | | |
| Q_{GD} | Gate-to-Drain ('Miller') Charge | — | — | 110 | | |
| $t_{d(on)}$ | Turn-On Delay Time | — | — | 35 | ns | $I_{D1} = 35A^{**}$ $V_{DD} = 50V$ $R_G = 2.35\Omega$ $V_{GS} = 12V$ |
| t_r | Rise Time | — | — | 150 | | |
| $t_{d(off)}$ | Turn-Off Delay Time | — | — | 150 | | |
| t_f | Fall Time | — | — | 130 | | |
| $L_s + L_D$ | Total Inductance | — | 6.8 | — | nH | Measured from Drain lead (6mm / 0.25 in from package) to Source lead (6mm/ 0.25 in from package) with Source wire internally bonded from Source pin to Drain pad |
| C_{iss} | Input Capacitance | — | 5300 | — | pF | $V_{GS} = 0V$ $V_{DS} = 25V$ $f = 1.0\text{MHz}$ |
| C_{oss} | Output Capacitance | — | 1600 | — | | |
| C_{rss} | Reverse Transfer Capacitance | — | 350 | — | | |

** Switching speed maximum limits are based on manufacturing test equipment and capability.

¹ Pulse width $\leq 300 \mu\text{s}$; Duty Cycle $\leq 2\%$

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2.2 Source-Drain Diode Ratings and Characteristics (Pre-Irradiation)

Table 4 Source-Drain Diode Characteristics

| Symbol | Parameter | Min. | Typ. | Max. | Unit | Test Conditions |
|----------|---|---|------|------|---------------|---|
| I_S | Continuous Source Current (Body Diode) | — | — | 35 | A | |
| I_{SM} | Pulsed Source Current (Body Diode) ¹ | — | — | 140 | A | |
| V_{SD} | Diode Forward Voltage | — | — | 1.8 | V | $T_J = 25^\circ\text{C}$, $I_S = 35\text{A}$, $V_{GS} = 0\text{V}$ ² |
| t_{rr} | Reverse Recovery Time | — | — | 570 | ns | $T_J = 25^\circ\text{C}$, $I_F = 35\text{A}$, $V_{DD} \leq 50\text{V}$ |
| Q_{rr} | Reverse Recovery Charge | — | — | 6.1 | μC | $di/dt = 100\text{A}/\mu\text{s}$ ² |
| t_{on} | Forward Turn-On Time | Intrinsic turn-on time is negligible (turn-on is dominated by $L_S + L_D$) | | | | |

2.3 Thermal Characteristics

Table 5 Thermal Resistance

| Symbol | Parameter | Min. | Typ. | Max. | Unit |
|-----------------|---|------|------|------|---------------------------|
| $R_{\theta JC}$ | Junction-to-Case | — | — | 0.50 | $^\circ\text{C}/\text{W}$ |
| $R_{\theta CS}$ | Junction-to-Sink | — | 0.21 | — | |
| $R_{\theta JA}$ | Junction-to- Ambient (Typical socket mount) | — | — | 48 | |

2.4 Radiation Characteristics

IR HiRel radiation hardened MOSFETs are tested to verify their radiation hardness capability. The hardness assurance program at IR HiRel is comprised of two radiation environments. Every manufacturing lot is tested for total ionizing dose (per notes 3 and 4) 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.

2.4.1 Electrical Characteristics — Post Total Dose Irradiation

Table 6 Electrical Characteristics @ $T_J = 25^\circ\text{C}$, Post Total Dose Irradiation^{3, 4}

| Symbol | Parameter | 100 krad (Si) ⁵ | | Up to 500 krad (Si) ⁶ | | Unit | Test Conditions |
|--------------|--|----------------------------|------|----------------------------------|------|------------------|---|
| | | Min. | Max. | Min. | Max. | | |
| BV_{DSS} | Drain-to-Source Breakdown Voltage | 100 | — | 100 | — | V | $V_{GS} = 0\text{V}$, $I_D = 1.0\text{mA}$ |
| $V_{GS(th)}$ | Gate Threshold Voltage | 2.0 | 4.0 | 1.25 | 4.5 | V | $V_{DS} = V_{GS}$, $I_D = 1.0\text{mA}$ |
| I_{GSS} | Gate-to-Source Leakage Forward | — | 100 | — | 100 | nA | $V_{GS} = 20\text{V}$ |
| | Gate-to-Source Leakage Reverse | — | -100 | — | -100 | | $V_{GS} = -20\text{V}$ |
| I_{DSS} | Zero Gate Voltage Drain Current | — | 25 | — | 25 | μA | $V_{DS} = 80\text{V}$, $V_{GS} = 0\text{V}$ |
| $R_{DS(on)}$ | Static Drain-to-Source On-State Resistance (TO-3) ² | — | 45 | — | 62 | $\text{m}\Omega$ | $V_{GS} = 12\text{V}$, $I_{D2} = 32\text{A}$ |
| $R_{DS(on)}$ | Static Drain-to-Source On-State Resistance (TO-254AA) ² | — | 45 | — | 62 | $\text{m}\Omega$ | $V_{GS} = 12\text{V}$, $I_{D2} = 32\text{A}$ |
| V_{SD} | Diode Forward Voltage | — | 1.8 | — | 1.8 | V | $V_{GS} = 0\text{V}$, $I_F = 35\text{A}$ |

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

² Pulse width $\leq 300 \mu\text{s}$; Duty Cycle $\leq 2\%$

³ Total Dose Irradiation with V_{GS} Bias. $V_{GS} = 12\text{V}$ applied and $V_{DS} = 0$ during irradiation per MIL-STD-750, Method 1019, condition A.

⁴ Total Dose Irradiation with V_{DS} Bias. $V_{DS} = 80\text{V}$ applied and $V_{GS} = 0$ during irradiation per MIL-STD-750, Method 1019, condition A.

⁵ Part numbers IRHM7160 (JANSR2N7432)

⁶ Part numbers IRHM3160 (JANSF2N7432) and IRHM4160 (JANSR2N7432)

2.4.2 Single Event Effects — Safe Operating Area

IR HiRel radiation hardened MOSFETs have been characterized in heavy ion environment for Single Event Effects (SEE). Single Event Effects characterization is illustrated in Fig. 1 and Table 7.

Table 7 Typical Single Event Effects Safe Operating Area

| Ion | LET (MeV·cm ² /mg) | Energy (MeV) | Range (μm) | V _{DS} (V) | | | | |
|-----|----------------------------------|-----------------|---------------|----------------------|-----------------------|------------------------|------------------------|------------------------|
| | | | | V _{GS} = 0V | V _{GS} = -5V | V _{GS} = -10V | V _{GS} = -15V | V _{GS} = -20V |
| Cu | 28 | 285 | 43 | 100 | 100 | 100 | 80 | 60 |
| Br | 36.8 | 305 | 39 | 100 | 90 | 70 | 50 | — |

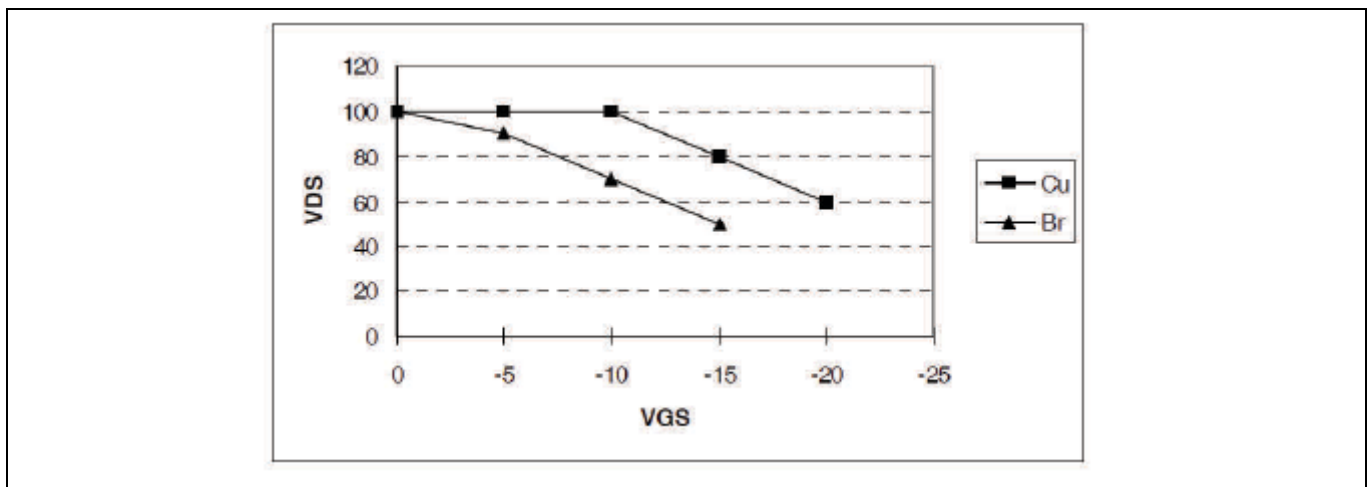


Figure 1 Typical Single Event Effect, Safe Operating Area

3 Electrical Characteristics Curves (Pre-irradiation)

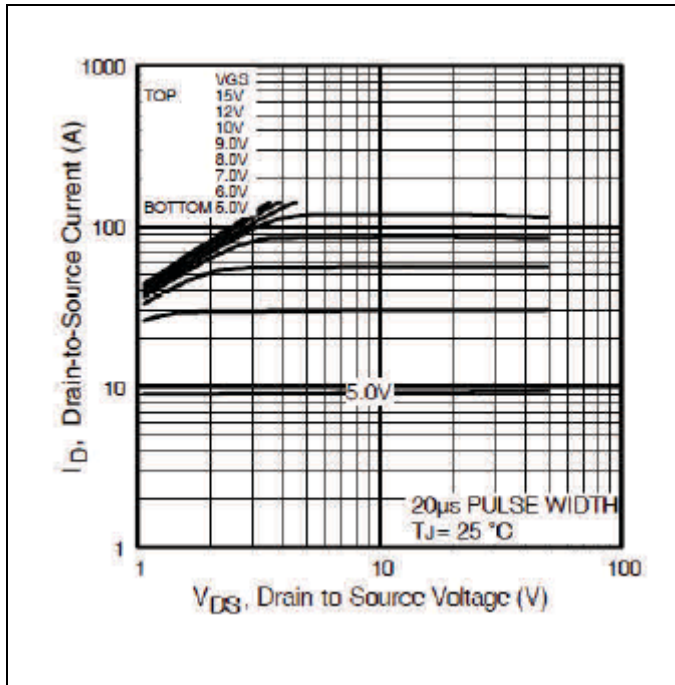


Figure 2 Typical Output Characteristics

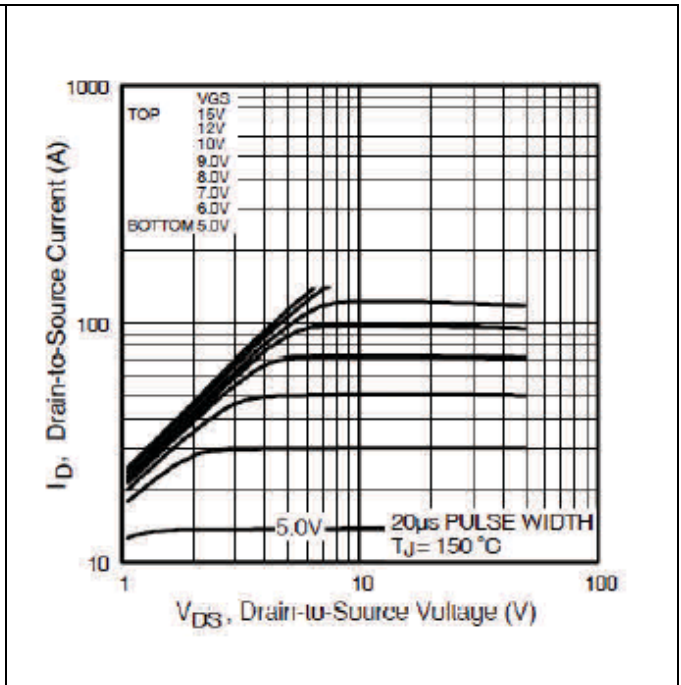


Figure 3 Typical Output Characteristics

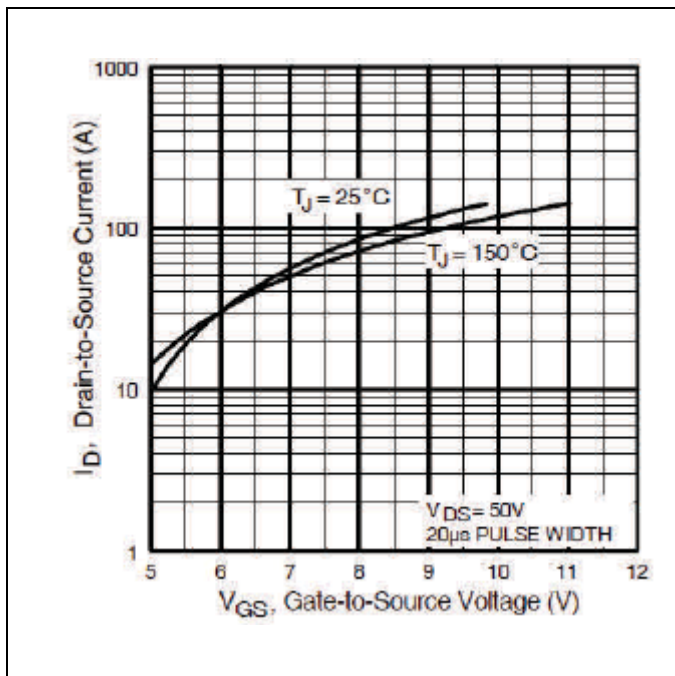


Figure 4 Typical Transfer Characteristics

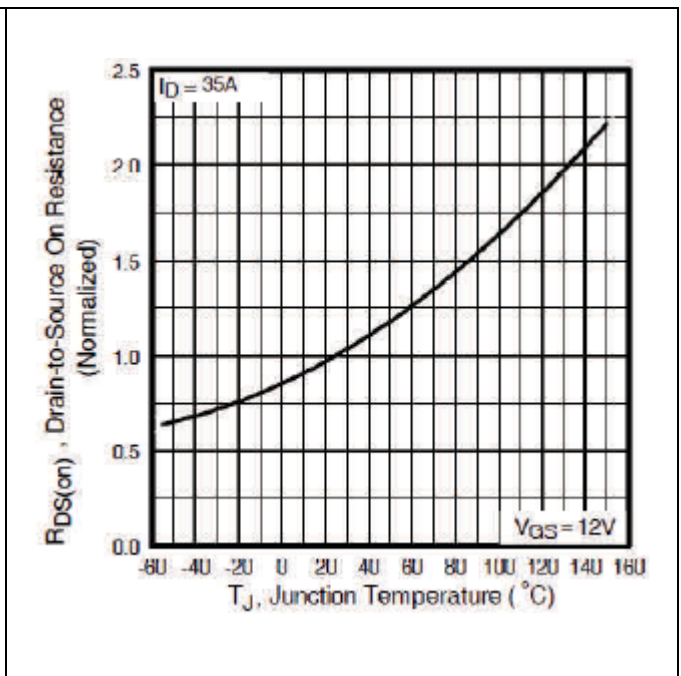


Figure 5 Normalized On-Resistance Vs. Temperature

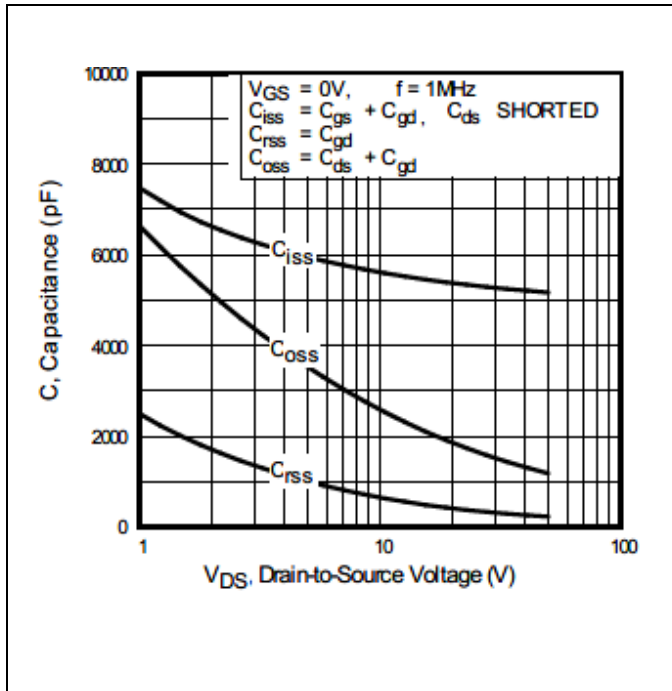


Figure 6 Typical Capacitance Vs. Drain-to-Source Voltage

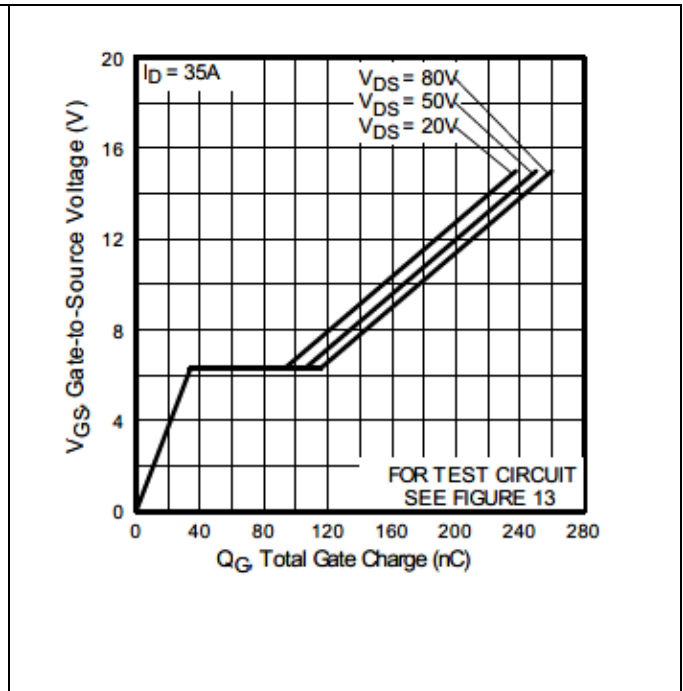


Figure 7 Typical Gate-to-Source Voltage Vs. Typical Gate Charge

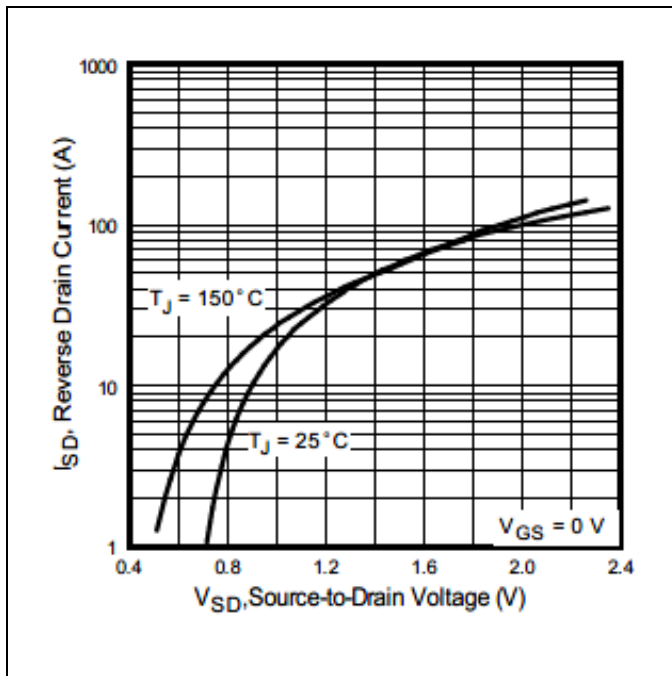


Figure 8 Typical Source-Drain Current Vs. Diode Forward Voltage

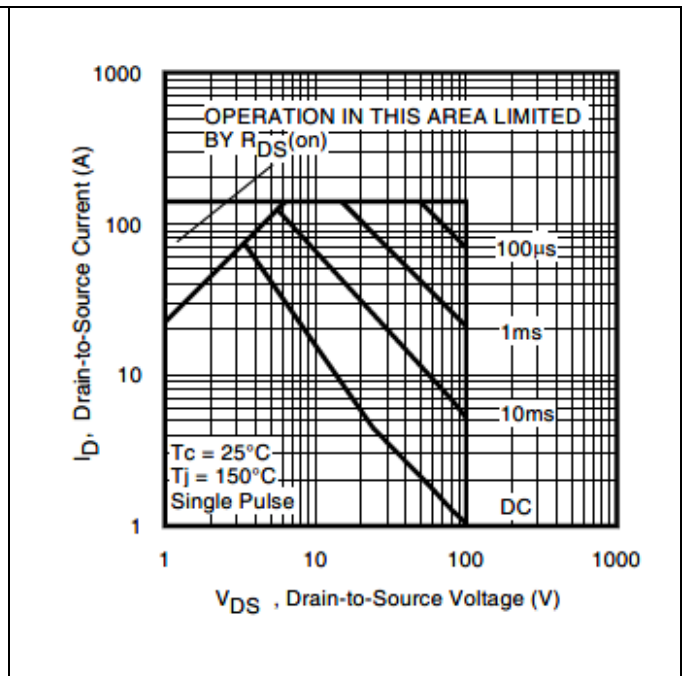


Figure 9 Maximum Safe Operating Area

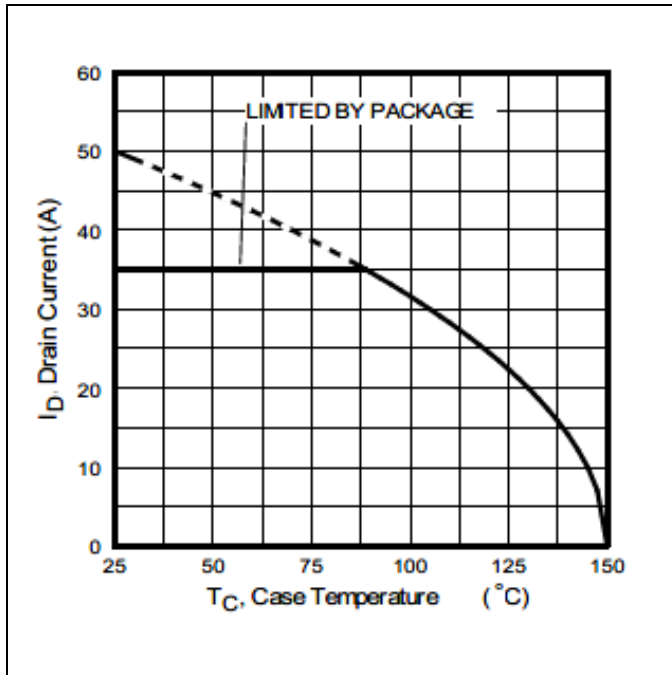


Figure 10 Maximum Drain Current Vs. Case Temperature

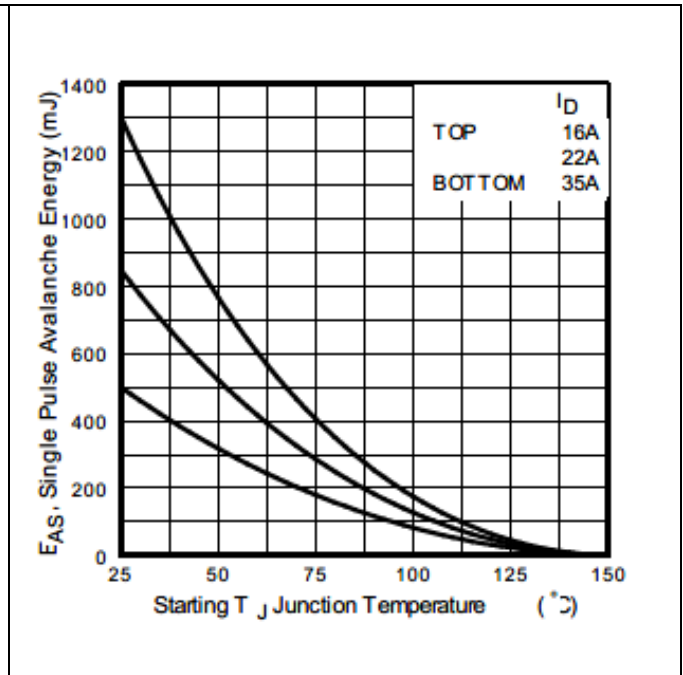


Figure 11 Maximum Avalanche Energy Vs. Junction Temperature

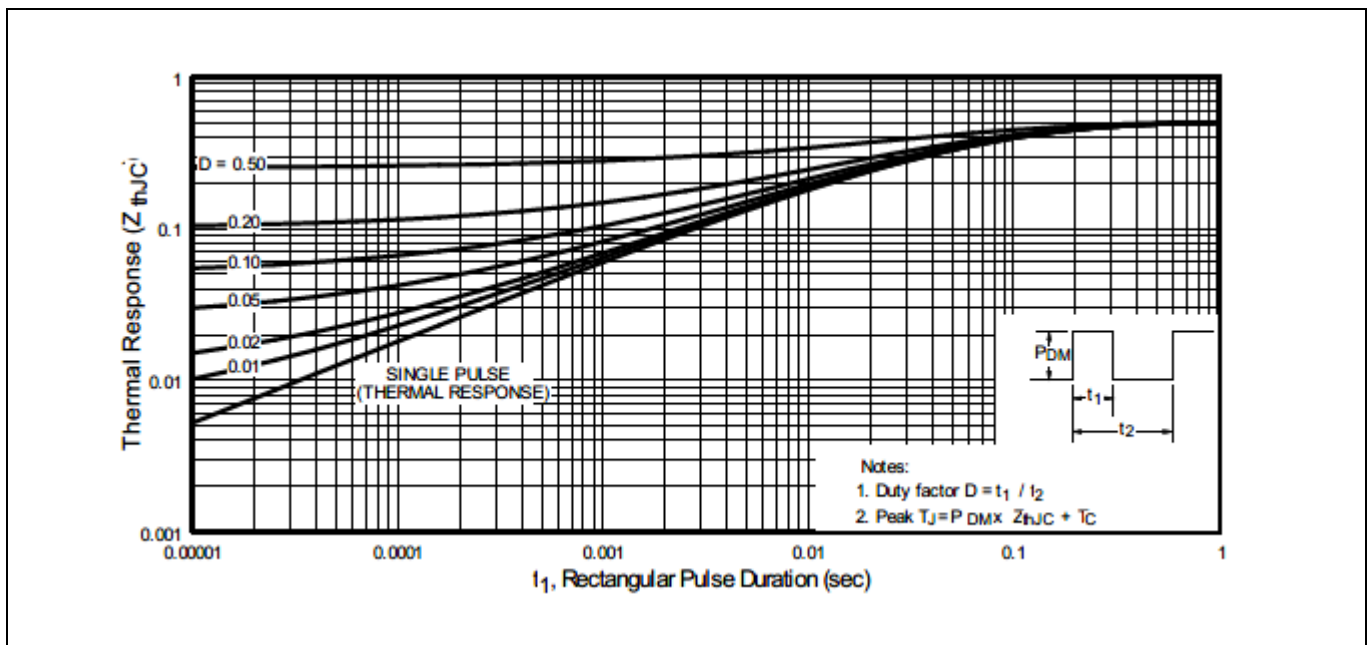


Figure 12 Maximum Effective Transient Thermal Impedance, Junction-to-Case

4 Test Circuits (Pre-irradiation)

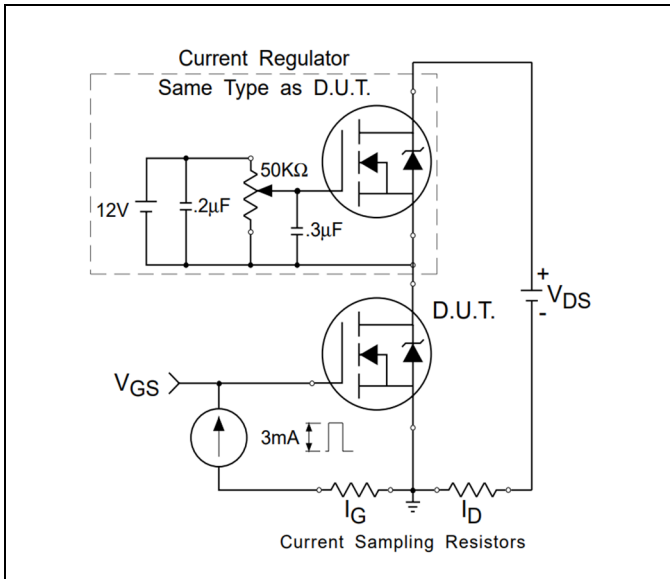


Figure 13 Gate Charge Test Circuit

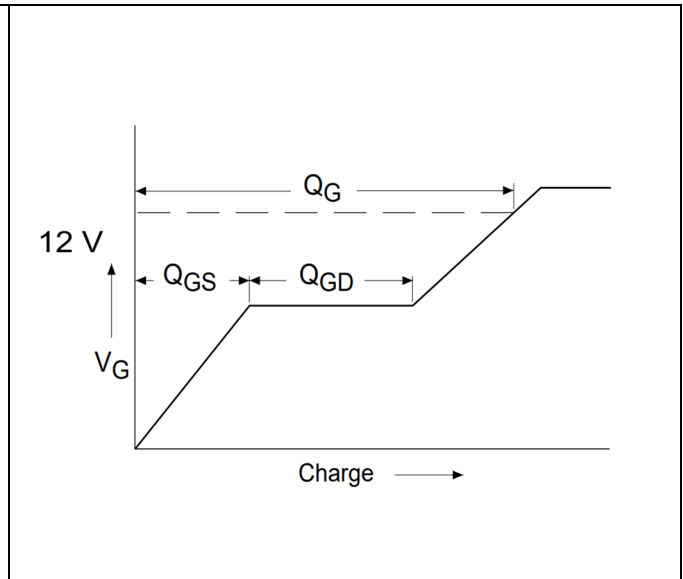


Figure 14 Gate Charge Waveform

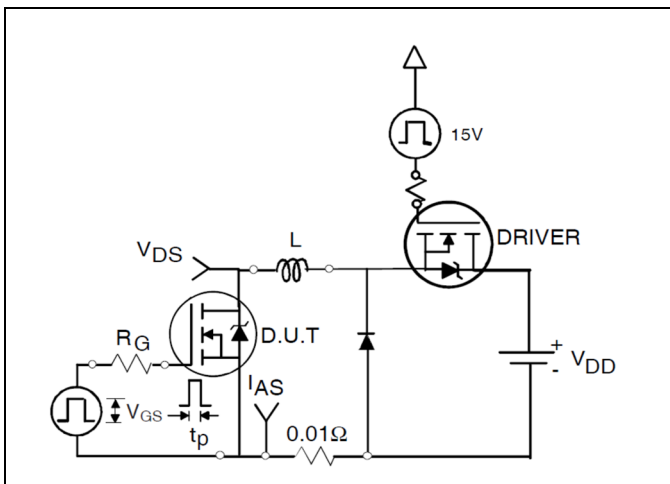


Figure 15 Unclamped Inductive Test Circuit

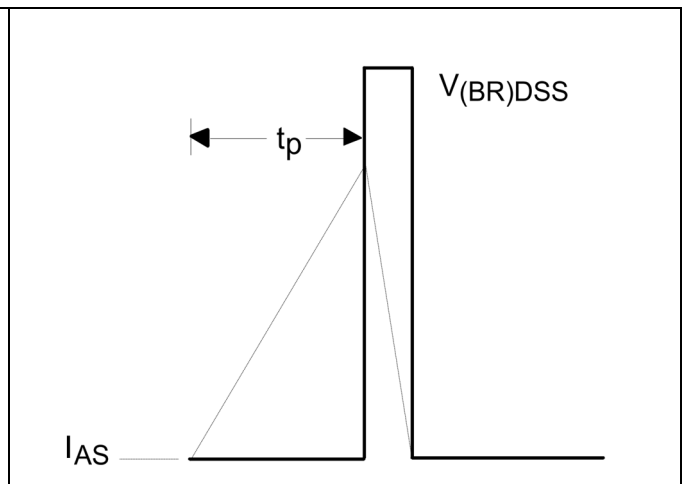


Figure 16 Unclamped Inductive Waveform

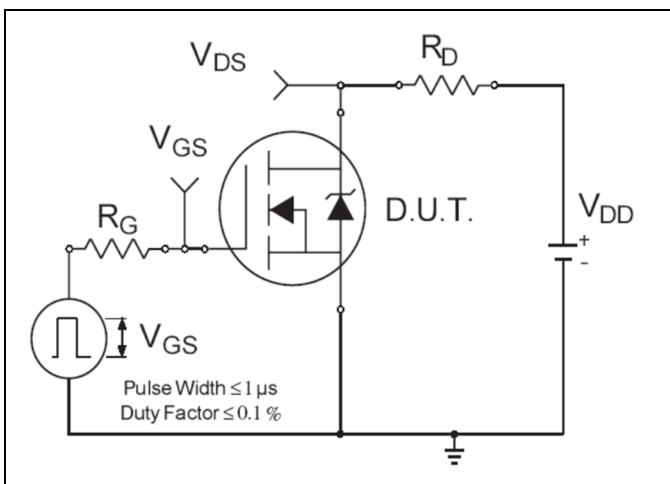


Figure 17 Switching Time Test Circuit

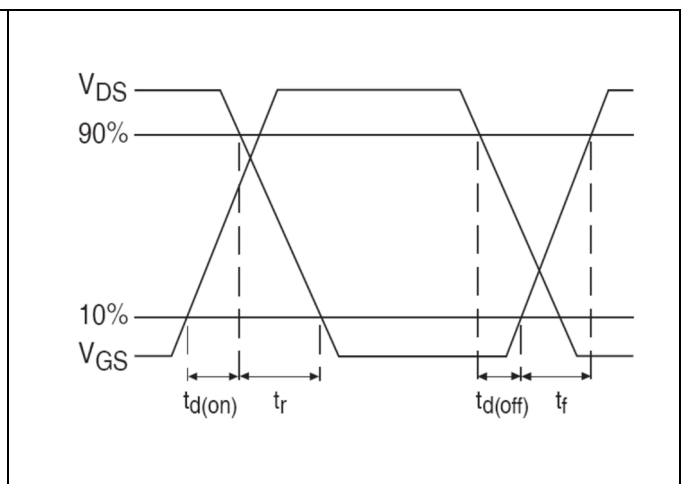
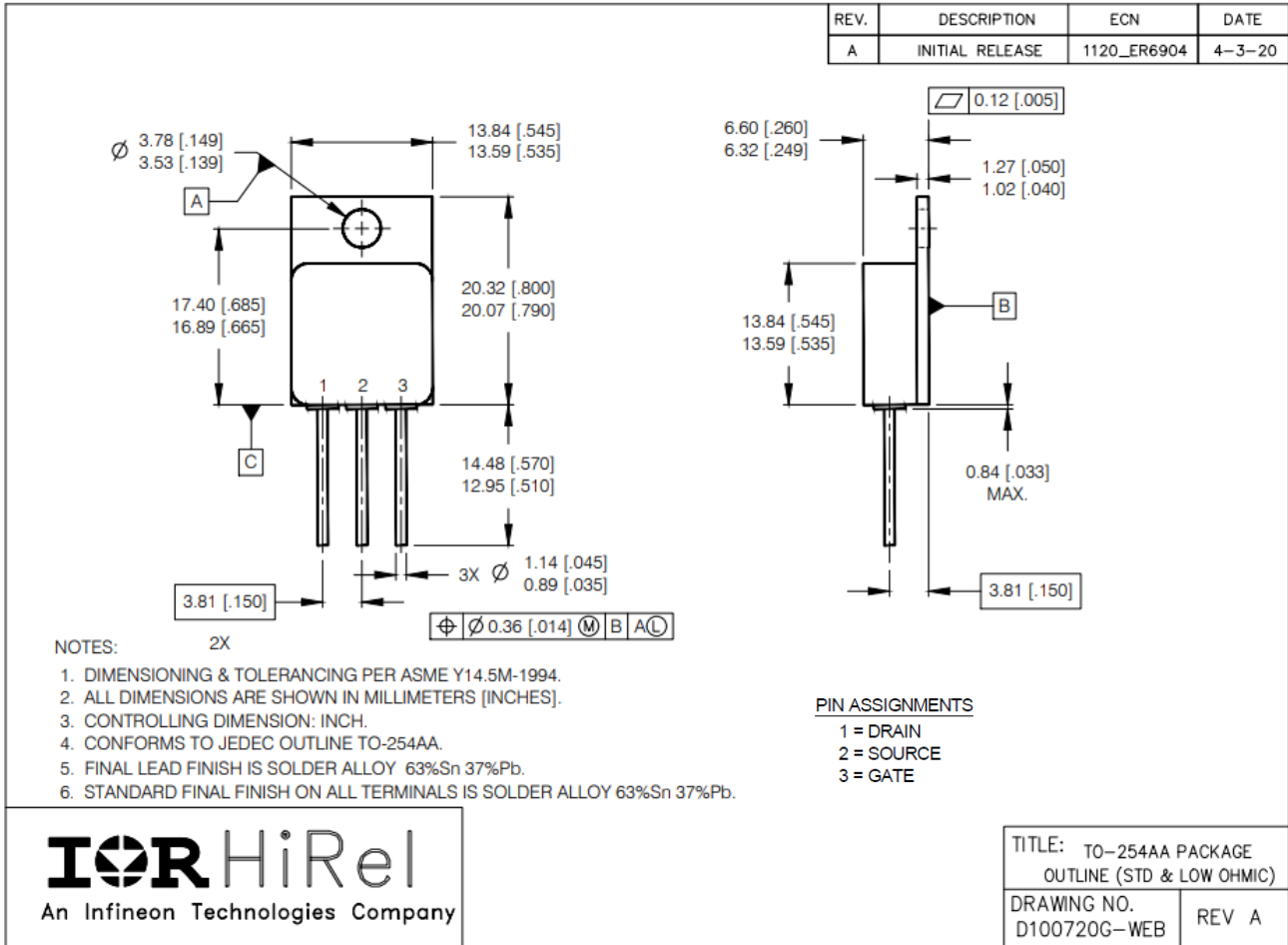


Figure 18 Switching Time Waveforms

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5 Package Outline

Note: For the most updated package outline, please see the website: TO-254AA



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.

Revision history**Revision history**

| Document version | Date of release | Description of changes |
|-------------------------|------------------------|------------------------------------|
| | 10/15/1998 | Datasheet (PD-91331B) |
| Rev C | 06/21/2001 | Updated switch time test condition |
| Rev D | 08/30/2004 | Updated 600kRad(si) to 500kRad(si) |
| Rev E | 08/10/2007 | Updated based on ECN-14880 |
| Rev F | 03/11/2019 | Updated based on ECN-1120_05732-1 |
| Rev G | 05/25/2022 | Updated based on ECN-1120_09018 |

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