

IRHNM57214SE, IRHNMC57214SE

PD-97818D

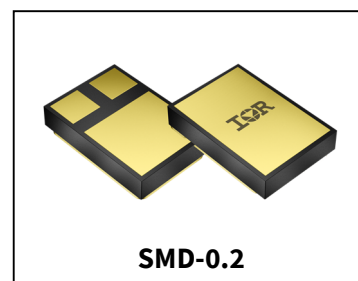
Radiation Hardened Power MOSFET Surface Mount (SMD-0.2) 250V, 3.7A, N-channel, R5 Technology

Features

- Single event effect (SEE) hardened
- Low $R_{DS(on)}$
- Low total gate charge
- Simple drive requirements
- Low total gate charge
- Hermetically sealed
- Surface mount
- Ceramic package
- Light weight
- ESD rating: Class 1B per MIL-STD-750, Method 1020

Product Summary

- BV_{DSS} : 250V
- I_D : 3.7A
- $R_{DS(on), max}$: 1.7Ω
- $Q_{G, max}$: 9.1nC



Potential Applications

- DC-DC converter
- Motor drives

Product Validation

Qualified to IR HiRel's S-level screening flow which is equivalent to MIL-PRF-19500

Description

IR HiRel R5 technology provides high performance power MOSFETs for space applications. These devices have been characterized for Single Event Effects (SEE) with useful performance up to an LET of $80\text{MeV}\cdot\text{cm}^2/\text{mg}$. 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, ease of paralleling and temperature stability of electrical parameters switching and temperature stability of electrical parameters.

Ordering Information

Table 1 Ordering options

| Part number | Package | Screening Level | TID Level |
|------------------|---------------------|-----------------|--------------|
| IRHNM57214SE | SMD-0.2 | COTS | 100 krad(Si) |
| IRHNM57214SESCS | SMD-0.2 | S-level | 100 krad(Si) |
| IRHNMC57214SE | SMD-0.2 ceramic lid | COTS | 100 krad(Si) |
| IRHNMC57214SESCS | SMD-0.2 ceramic lid | S-level | 100 krad(Si) |

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Absolute Maximum Ratings

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 | 3.7 | A |
| $I_{D2} @ V_{GS} = 12V, T_C = 100^\circ C$ | Continuous Drain Current | 2.4 | A |
| $I_{DM} @ T_C = 25^\circ C$ | Pulsed Drain Current ¹ | 14.8 | A |
| $P_D @ T_C = 25^\circ C$ | Maximum Power Dissipation | 40 | W |
| | Linear Derating Factor | 0.32 | W/°C |
| V_{GS} | Gate-to-Source Voltage | ± 20 | V |
| E_{AS} | Single Pulse Avalanche Energy ² | 34 | mJ |
| I_{AR} | Avalanche Current ¹ | 3.7 | A |
| E_{AR} | Repetitive Avalanche Energy ¹ | 4.0 | mJ |
| dv/dt | Peak Diode Reverse Recovery ³ | 3.7 | V/ns |
| T_J T_{STG} | Operating Junction and Storage Temperature Range | -55 to +150 | °C |
| | Lead Temperature | 300 (for 5s) | |
| | Weight | 0.25 (Typical) | |

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

² $V_{DD} = 50V$, starting $T_J = 25^\circ C$, $L = 5.0mH$, Peak $I_L = 3.7A$, $V_{GS} = 12V$

³ $I_{SD} \leq 3.7A$, $di/dt \leq 1018A/\mu s$, $V_{DD} \leq 250V$, $T_J \leq 150^\circ C$

Device Characteristics

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 | 250 | — | — | V | $V_{GS} = 0V, I_D = 1.0mA$ |
| $\Delta BV_{DSS}/\Delta T_J$ | Breakdown Voltage Temp. Coefficient | — | 0.27 | — | V/ $^\circ\text{C}$ | Reference to $25^\circ\text{C}, I_D = 1mA$ |
| $R_{DS(on)}$ | Static Drain-to-Source On-State Resistance | — | — | 1.7 | Ω | $V_{GS} = 12V, I_{D2} = 2.4A^1$ |
| $V_{GS(th)}$ | Gate Threshold Voltage | 2.5 | — | 4.5 | V | $V_{DS} = V_{GS}, I_D = 1.0mA$ |
| $\Delta V_{GS(th)}/\Delta T_J$ | Gate Threshold Voltage Coefficient | — | -9.1 | — | mV/ $^\circ\text{C}$ | |
| Gfs | Forward Transconductance | 2.0 | — | — | S | $V_{DS} = 15V, I_{D2} = 2.4A^1$ |
| I_{DSS} | Zero Gate Voltage Drain Current | — | — | 10 | μA | $V_{DS} = 200V, V_{GS} = 0V$ |
| | | — | — | 25 | | $V_{DS} = 200V, V_{GS} = 0V, T_J = 125^\circ\text{C}$ |
| 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 | — | — | 9.1 | nC | $I_{D1} = 3.7A$ |
| Q_{GS} | Gate-to-Source Charge | — | — | 2.9 | | $V_{DS} = 125V$ |
| Q_{GD} | Gate-to-Drain ('Miller') Charge | — | — | 4.3 | | $V_{GS} = 12V$ |
| $t_{d(on)}$ | Turn-On Delay Time | — | — | 7.5 | ns | $I_{D1} = 3.7A^{**}$ $V_{DD} = 125V$ $R_G = 7.5\Omega$ $V_{GS} = 12V$ |
| t_r | Rise Time | — | — | 6.6 | | |
| $t_{d(off)}$ | Turn-Off Delay Time | — | — | 16.8 | | |
| t_f | Fall Time | — | — | 14 | | |
| $L_s + L_D$ | Total Inductance | — | 6.8 | — | nH | Measured from center of Drain pad to center of Source pad |
| C_{iss} | Input Capacitance | — | 308 | — | pF | $V_{GS} = 0V$ |
| C_{oss} | Output Capacitance | — | 51 | — | | $V_{DS} = 20V$ |
| C_{rSS} | Reverse Transfer Capacitance | — | 1.2 | — | | $f = 1.0MHz$ |
| R_G | Gate Resistance | — | 6.6 | — | Ω | $f = 1.0MHz, \text{open drain}$ |

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

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

Radiation Hardened Power MOSFET Surface-Mount (SMD-0.2)

Device Characteristics

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) | — | — | 3.7 | A | |
| I_{SM} | Pulsed Source Current (Body Diode) ¹ | — | — | 14.8 | A | |
| V_{SD} | Diode Forward Voltage | — | — | 1.0 | V | $T_J = 25^\circ\text{C}$, $I_S = 3.7\text{A}$, $V_{GS} = 0\text{V}$ ² |
| t_{rr} | Reverse Recovery Time | — | — | 145 | ns | $T_J = 25^\circ\text{C}$, $I_F = 3.7\text{A}$, $V_{DD} \leq 25\text{V}$ |
| Q_{rr} | Reverse Recovery Charge | — | — | 857 | nC | $di/dt = 100\text{A}/\mu\text{s}$ 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 | — | — | 3.12 | $^\circ\text{C}/\text{W}$ |

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 | Up to 100 krad (Si) | | Unit | Test Conditions |
|--------------|---|---------------------|------|---------------|--|
| | | Min. | Max. | | |
| BV_{DSS} | Drain-to-Source Breakdown Voltage | 250 | — | V | $V_{GS} = 0\text{V}$, $I_D = 1.0\text{mA}$ |
| $V_{GS(th)}$ | Gate Threshold Voltage | 2.0 | 4.5 | V | $V_{DS} = V_{GS}$, $I_D = 1.0\text{mA}$ |
| I_{GSS} | Gate-to-Source Leakage Forward | — | 100 | nA | $V_{GS} = 20\text{V}$ |
| | Gate-to-Source Leakage Reverse | — | -100 | | $V_{GS} = -20\text{V}$ |
| I_{DSS} | Zero Gate Voltage Drain Current | — | 10 | μA | $V_{DS} = 200\text{V}$, $V_{GS} = 0\text{V}$ |
| $R_{DS(on)}$ | Static Drain-to-Source On-State Resistance (TO-3) ² | — | 1.7 | Ω | $V_{GS} = 12\text{V}$, $I_{D2} = 2.4\text{A}$ |
| $R_{DS(on)}$ | Static Drain-to-Source On-State Resistance (SMD-0.2) ² | — | 1.7 | Ω | $V_{GS} = 12\text{V}$, $I_{D2} = 2.4\text{A}$ |
| V_{SD} | Diode Forward Voltage | — | 1.0 | V | $V_{GS} = 0\text{V}$, $I_F = 3.7\text{A}$ |

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. $V_{DS} = 200\text{V}$ applied and $V_{GS} = 0$ during irradiation per MIL-STD-750, Method 1019, condition A.

Radiation Hardened Power MOSFET Surface-Mount (SMD-0.2)

Device Characteristics

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 Worst Case 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 |
| Br | 36.7 | 309 | 39.5 | 250 | 250 | 250 | 250 | 250 |
| I | 59.8 | 341 | 32.5 | 250 | 250 | 250 | 250 | 240 |
| Au | 82.3 | 350 | 28.4 | 250 | 250 | 225 | 175 | 50 |

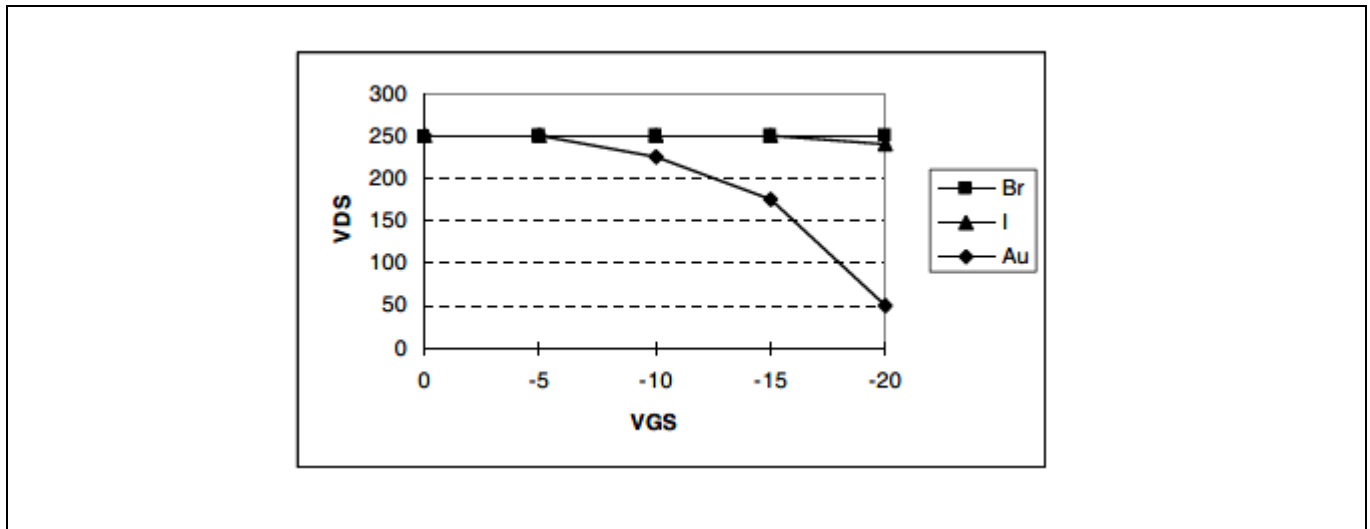


Figure 1 Worst Case Single Event Effect, Safe Operating Area

3 Electrical Characteristics Curves (Pre-irradiation)

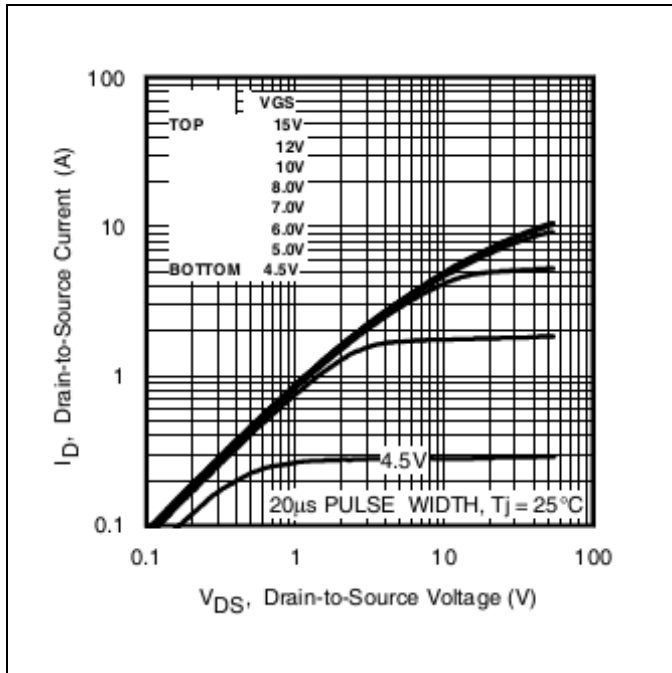


Figure 2 Typical Output Characteristics

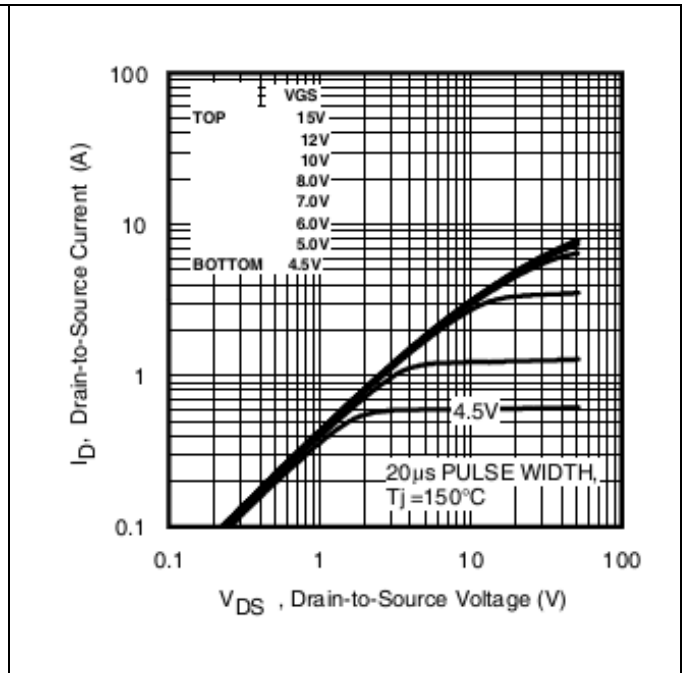


Figure 3 Typical Output Characteristics

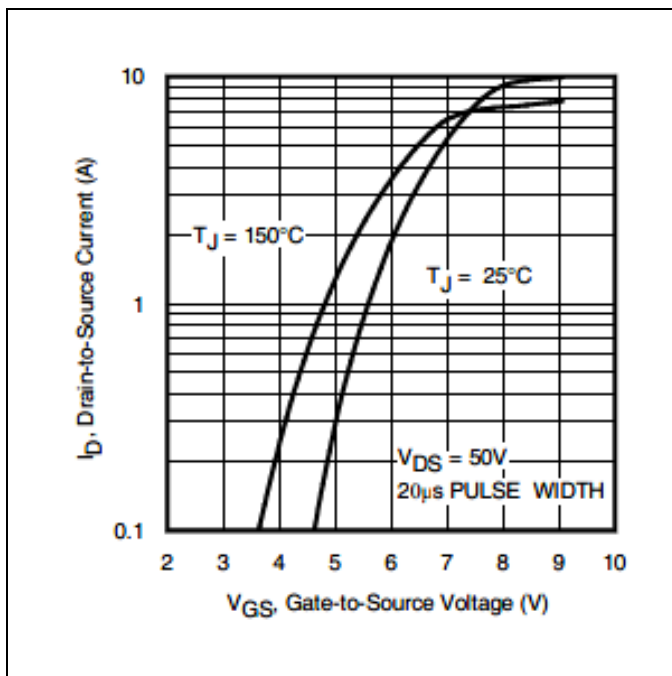


Figure 4 Typical Transfer Characteristics

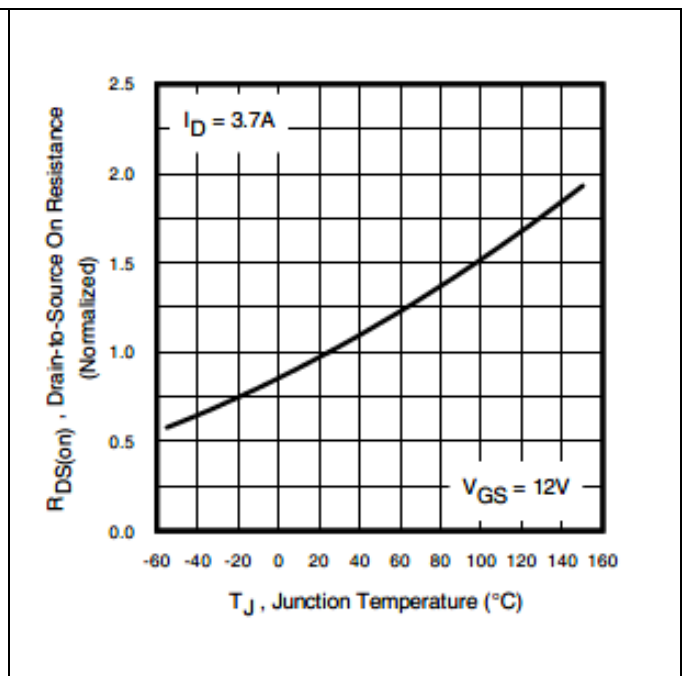


Figure 5 Normalized On-Resistance Vs. Temperature

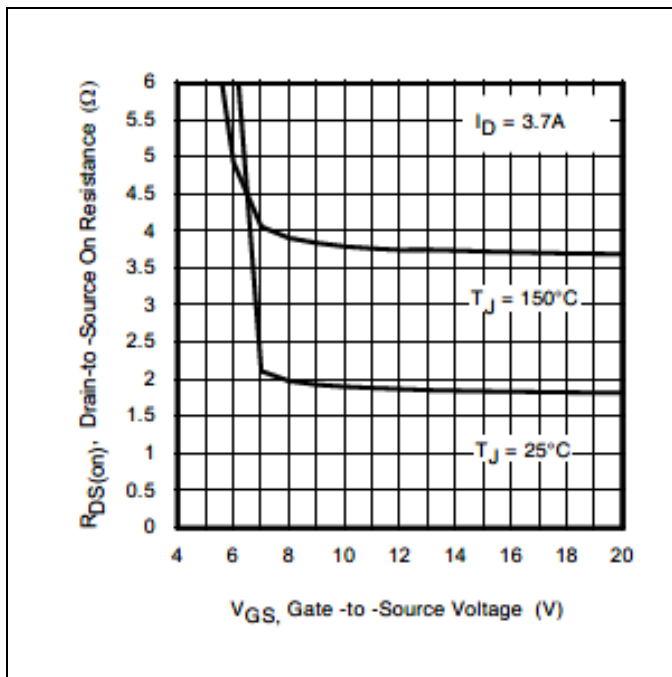


Figure 6 Typical On-Resistance Vs. Gate Voltage

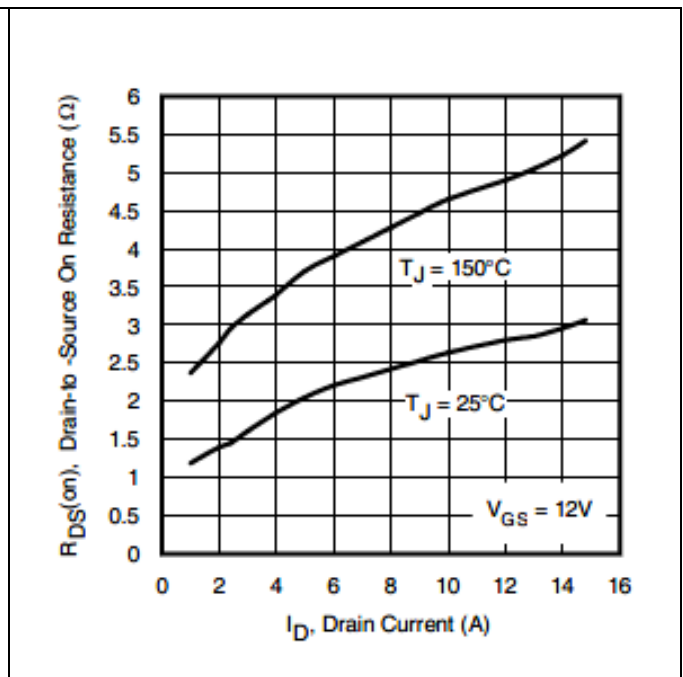


Figure 7 Typical On-Resistance Vs. Drain Current

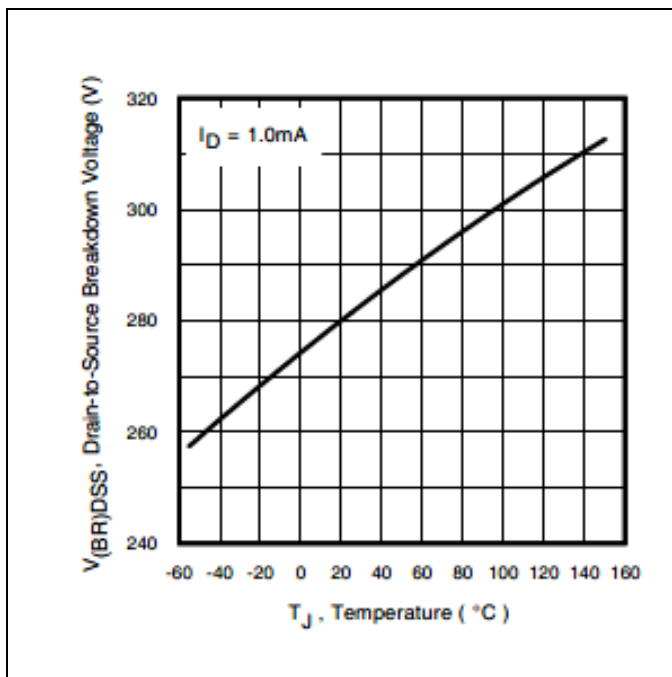


Figure 8 Typical Drain-to-Source Breakdown Voltage Vs. Temperature

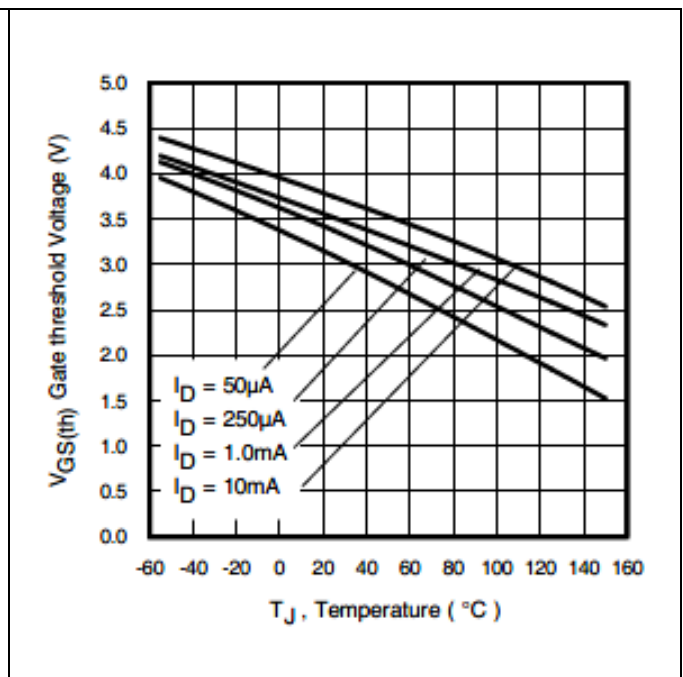


Figure 9 Typical Threshold Voltage Vs. Temperature

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Radiation Hardened Power MOSFET Surface-Mount (SMD-0.2)

Electrical Characteristics Curves (Pre-irradiation)

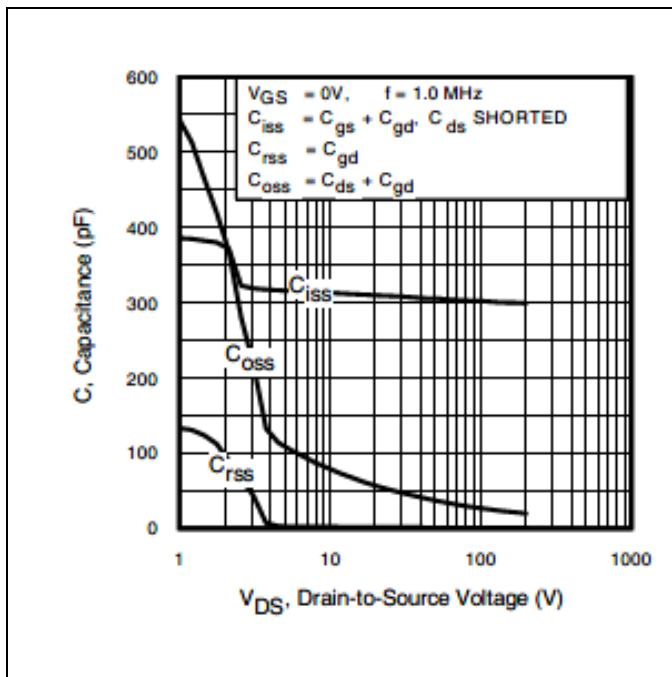


Figure 10 Typical Capacitance Vs. Drain-to-Source Voltage

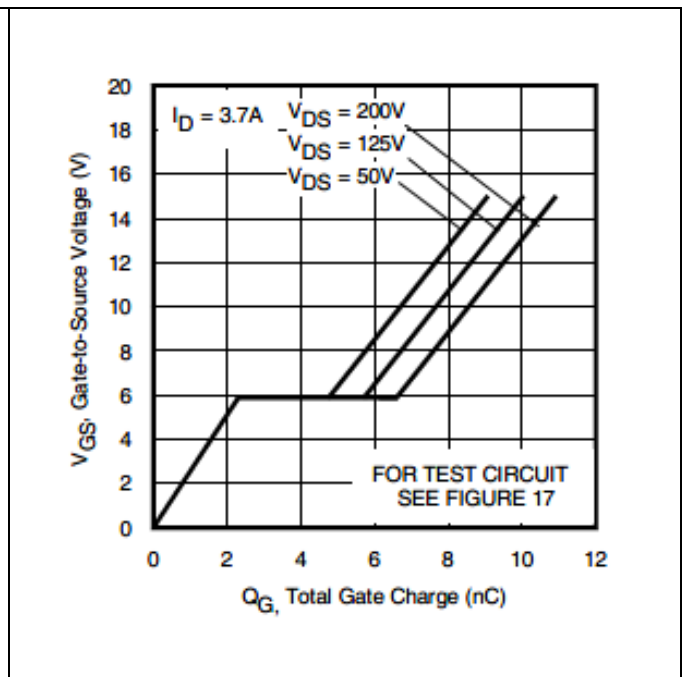


Figure 11 Gate-to-Source Voltage Vs. Typical Gate Charge

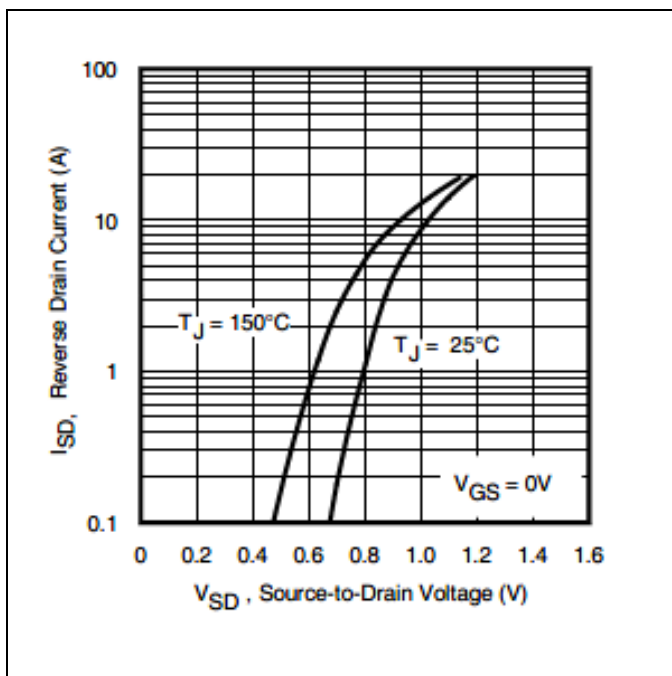


Figure 12 Typical Source-Drain Current Vs. Diode Forward Voltage

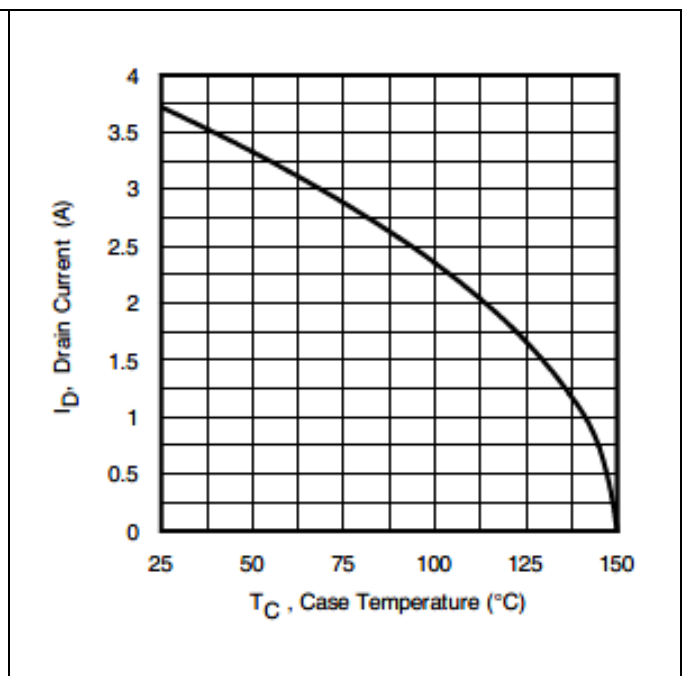


Figure 13 Maximum Drain Current Vs. Case Temperature

IRHNM57214SE, IRHNC57214SE

Radiation Hardened Power MOSFET Surface-Mount (SMD-0.2)

Electrical Characteristics Curves (Pre-irradiation)

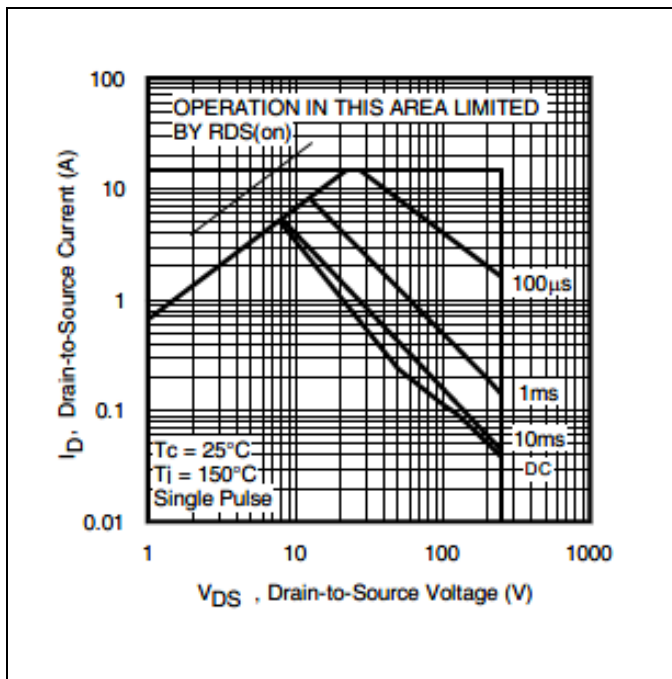


Figure 14 Maximum Safe Operating Area

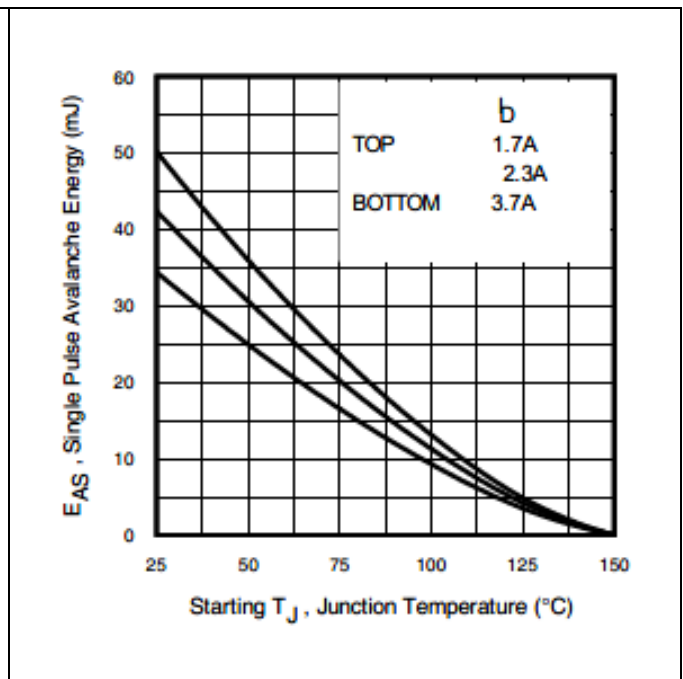


Figure 15 Maximum Avalanche Energy Vs. Junction Temperature

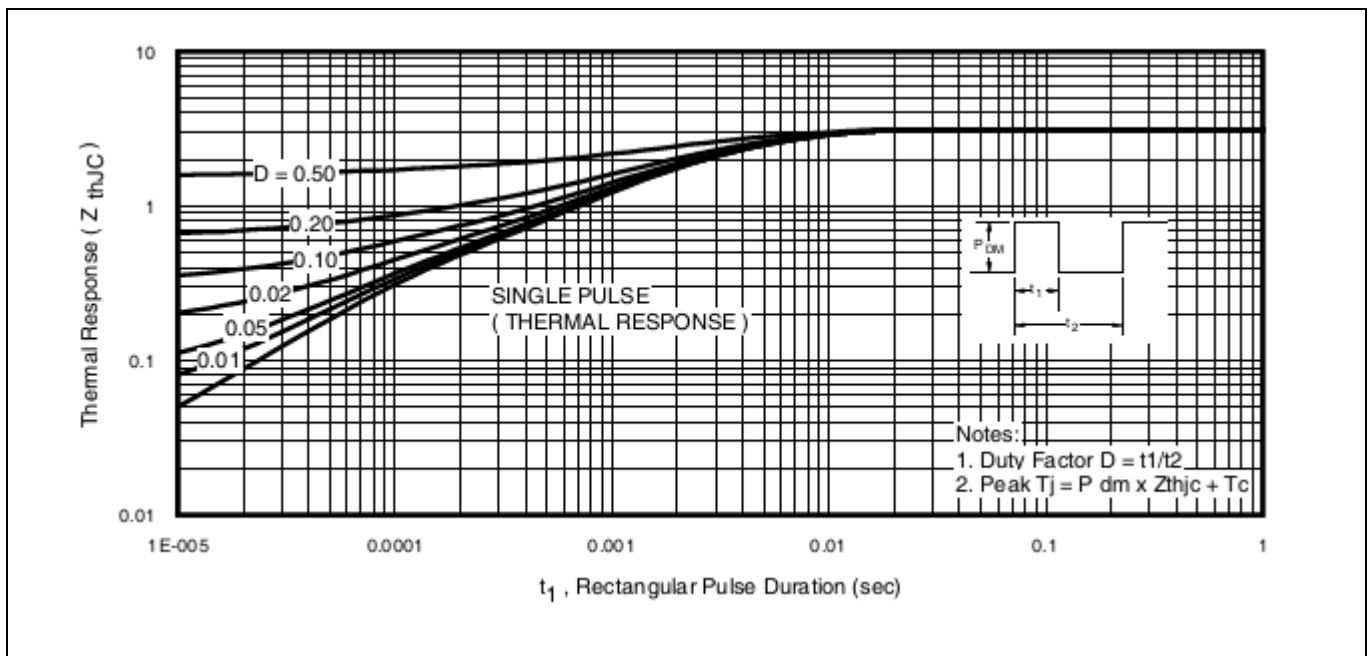


Figure 16 Maximum Effective Transient Thermal Impedance, Junction-to-Case

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Radiation Hardened Power MOSFET Surface-Mount (SMD-0.2)

Test Circuits (Pre-irradiation)

4 Test Circuits (Pre-irradiation)

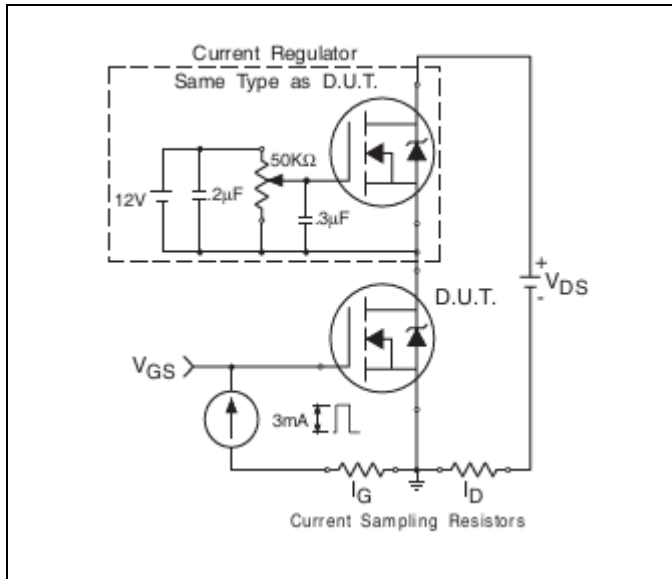


Figure 17 Gate Charge Test Circuit

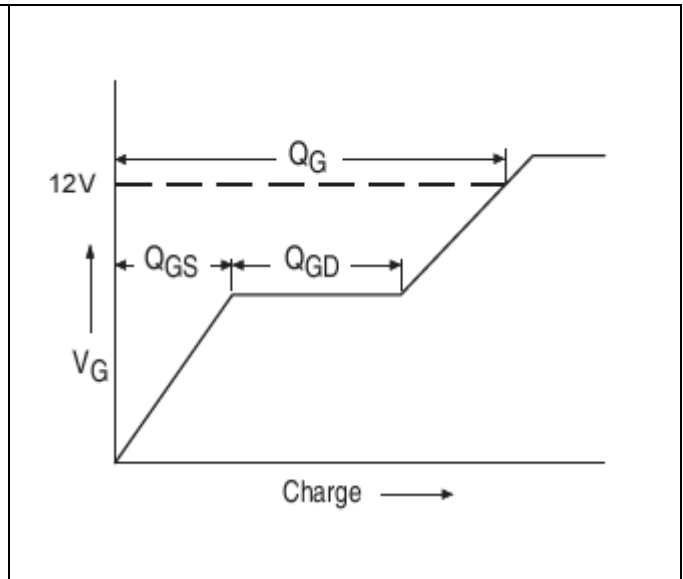


Figure 18 Gate Charge Waveform

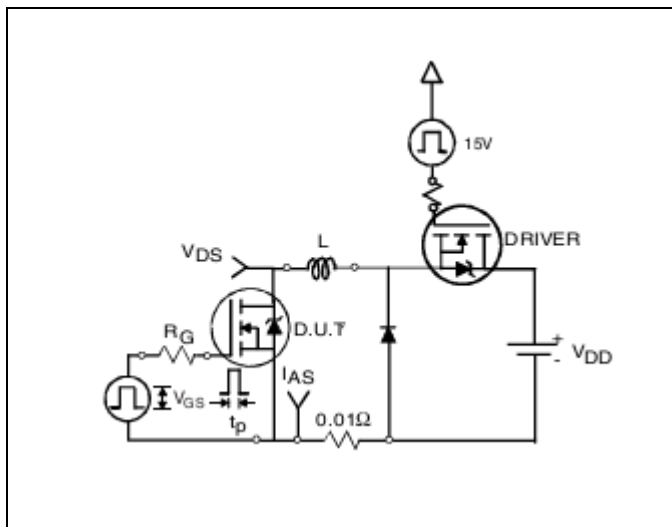


Figure 19 Unclamped Inductive Test Circuit

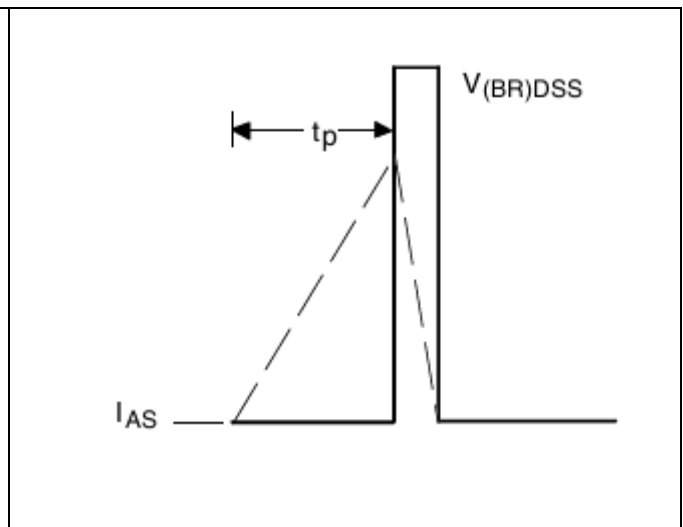


Figure 20 Unclamped Inductive Waveform

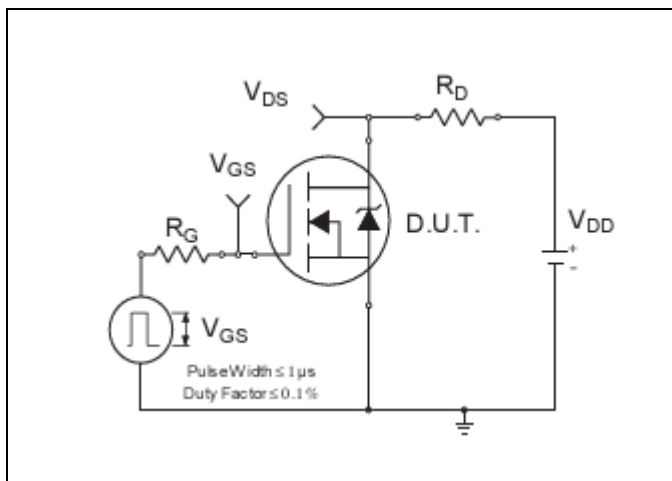


Figure 21 Switching Time Test Circuit

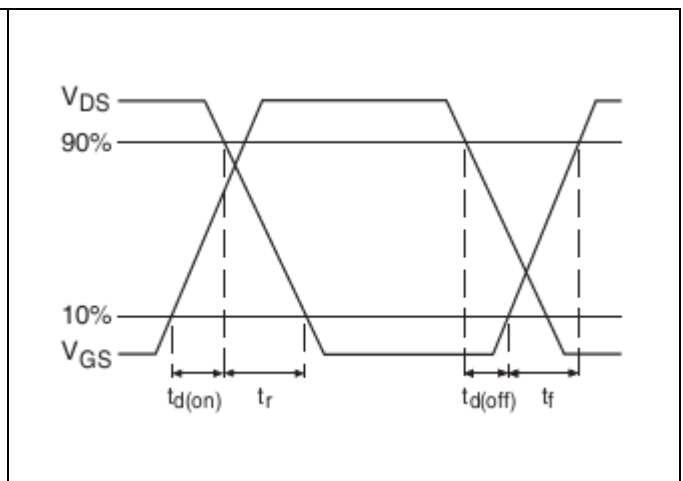
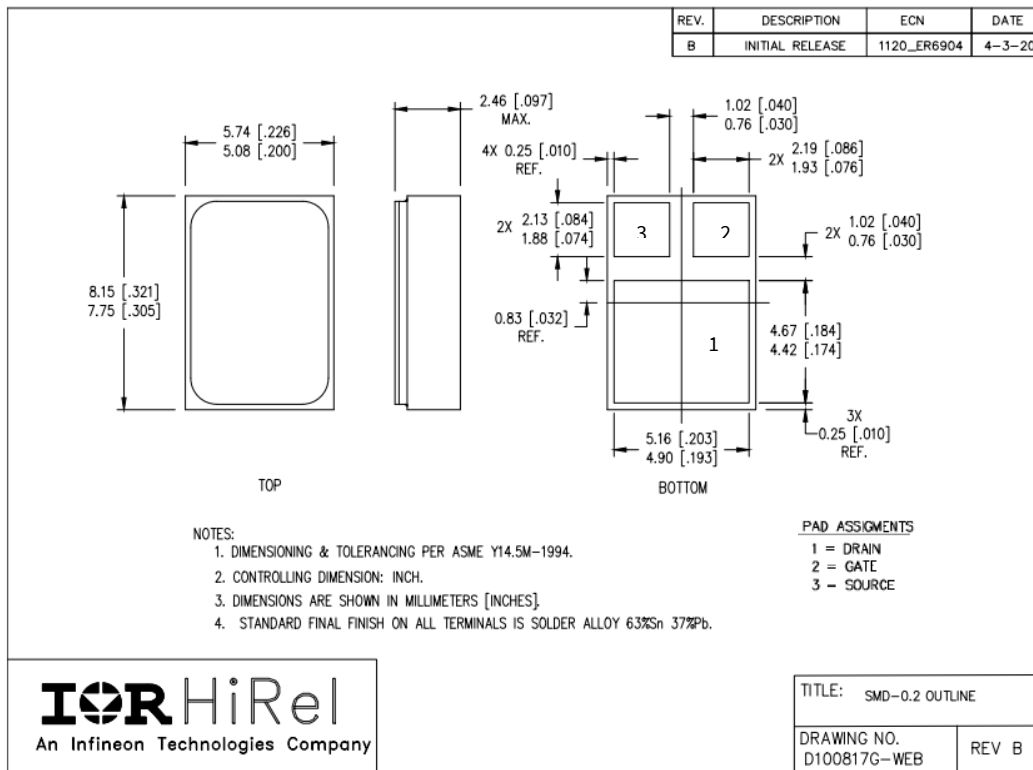


Figure 22 Switching Time Waveforms

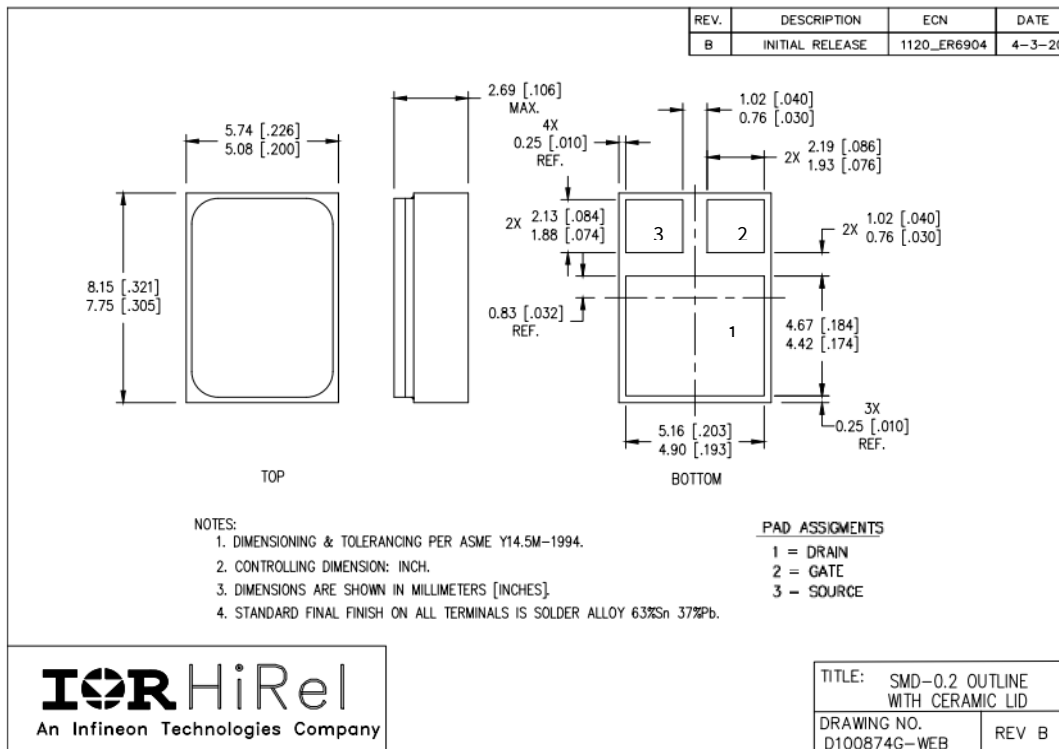
Package Outline

5 Package Outline

Note: For the most updated package outline, please see the website: [SMD-0.2 \(Metal Lid\)](#)



Note: For the most updated package outline, please see the website: [SMD-0.2 \(Ceramic Lid\)](#)



Revision history**Revision history**

| Document version | Date of release | Description of changes |
|-------------------------|------------------------|---------------------------------|
| | 02/12/2014 | Datasheet (PD-97818) |
| Rev A | 10/7/2016 | Updated based on ECN-1120_04671 |
| Rev B | 06/16/2017 | Updated based on ECN-1120_05233 |
| Rev C | 11/13/2019 | Updated based on ECN-1120_07618 |
| Rev D | 05/23/2022 | Updated based on ECN-1120_08905 |

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