# IRH7054

PD-90883D

## Radiation Hardened Power MOSFET
## Thru-Hole (TO-204AE)
## 60V, 45A, 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
- Ceramic package
- ESD rating: Class 3A per MIL-STD-750, Method 1020

### Product Summary

- **$BV_{DSS}$:** 60V
- **$I_D$:** 45A
- **$R_{DS(on),max}$:** 25mΩ(100 krad(Si))
- **$Q_{G,max}$:** 200nC

**TO-204AE**

### Potential Applications

- DC-DC converter
- Motor drives

### Product Validation

Qualified 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 |
|---|---|---|---|
| IRH7054 | TO-204AE | COTS | 100 krad(Si) |
| IRH7054SCV | TO-204AE | JANTXV-equivalent | 100 krad(Si) |
| IRH3054 | TO-204AE | COTS | 300 krad(Si) |
| IRH4054 | TO-204AE | COTS | 500 krad(Si) |

# Table of contents

# 1 Absolute Maximum Ratings

**Table 2 Absolute Maximum Ratings (Pre-Irradiation)**

| Symbol | Parameter | Value | Unit |
|---|---|---|---|
| $I_{D1}$ @ $V_{GS}$ = 12V, $T_C$ = 25°C | Continuous Drain Current | 45* | A |
| $I_{D2}$ @ $V_{GS}$ = 12V, $T_C$ = 100°C | Continuous Drain Current | 32 | A |
| $I_{DM}$ @ $T_C$ = 25°C | Pulsed Drain Current [1] | 210 | A |
| $P_D$ @ $T_C$ = 25°C | Maximum 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] | 35 | A |
| $E_{AR}$ | Repetitive Avalanche Energy [1] | 15 | mJ |
| dv/dt | Peak Diode Reverse Recovery [3] | 3.5 | V/ns |
| $T_J$<br>$T_{STG}$ | Operating Junction and Storage Temperature Range | -55 to +150 | °C |
| | Lead Temperature | 300 (0.063 in. /1.6 mm from case for 10s) | |
| | Weight | 11.5 (Typical) | g |

* Current is limited by package

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

[2] $V_{DD}$ = 25V, starting $T_J$ = 25°C, L = 0.49mH, Peak $I_L$ = 35A, $V_{GS}$ = 12V

[3] $I_{SD} \leq$ 35A, di/dt ≤ 150A/µs, $V_{DD} \leq$ 60V, $T_J \leq$ 150°C

# 2 Device Characteristics

## 2.1 Electrical Characteristics (Pre-Irradiation)

**Table 3 Static and Dynamic Electrical Characteristics @ $T_j$ = 25°C (Unless Otherwise Specified)**

| Symbol | Parameter | Min. | Typ. | Max. | Unit | Test Conditions |
|---|---|---|---|---|---|---|
| $BV_{DSS}$ | Drain-to-Source Breakdown Voltage | 60 | — | — | V | $V_{GS}$ = 0V, $I_D$ = 1.0mA |
| $\Delta BV_{DSS}/\Delta T_J$ | Breakdown Voltage Temp. Coefficient | — | 0.053 | — | V/°C | Reference to 25°C, $I_D$ = 1.0mA |
| $R_{DS(on)}$ | Static Drain-to-Source On-State Resistance | — | — | 25 | mΩ | $V_{GS}$ = 12V, $I_{D2}$ = 32A [1] |
| | | — | — | 28 | | $V_{GS}$ = 12V, $I_{D1}$ = 45A [1] |
| $V_{GS(th)}$ | Gate Threshold Voltage | 2.0 | — | 4.0 | V | $V_{DS}$ = $V_{GS}$, $I_D$ = 1mA |
| Gfs | Forward Transconductance | 12 | — | — | S | $V_{DS}$ = 15V, $I_D$ = 35A [1] |
| $I_{DSS}$ | Zero Gate Voltage Drain Current | — | — | 25 | μA | $V_{DS}$ = 48V, $V_{GS}$ = 0V |
| | | — | — | 250 | | $V_{DS}$ = 48V, $V_{GS}$ = 0V, $T_J$ = 125°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 | — | — | 200 | nC | $I_D$ = 35A<br>$V_{DS}$ = 30V<br>$V_{GS}$ = 12V |
| $Q_{GS}$ | Gate-to-Source Charge | — | — | 60 | | |
| $Q_{GD}$ | Gate-to-Drain (‘Miller’) Charge | — | — | 75 | | |
| $t_{d(on)}$ | Turn-On Delay Time | — | — | 27 | ns | $I_D$ = 35A **<br>$V_{DD}$ = 30V<br>$R_G$ = 2.35Ω<br>$V_{GS}$ = 12V |
| $t_r$ | Rise Time | — | — | 100 | | |
| $t_{d(off)}$ | Turn-Off Delay Time | — | — | 75 | | |
| $t_f$ | Fall Time | — | — | 75 | | |
| $L_s$ +$L_D$ | Total Inductance | — | 10 | — | 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 pin |
| $C_{iss}$ | Input Capacitance | — | 4100 | — | pF | $V_{GS}$ = 0V<br>$V_{DS}$ = 25V<br>$f$ = 1.0MHz |
| $C_{oss}$ | Output Capacitance | — | 2000 | — | | |
| $C_{rss}$ | Reverse Transfer Capacitance | — | 560 | — | | |

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

[1] Pulse width ≤ 300 μs; Duty Cycle ≤ 2%

## 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) | — | — | 45 | A | |
| $I_{SM}$ | Pulsed Source Current (Body Diode) [1] | — | — | 210 | A | |
| $V_{SD}$ | Diode Forward Voltage | — | — | 1.4 | V | $T_J$ = 25°C, $I_S$ = 35A, $V_{GS}$ = 0V [2] |
| $t_{rr}$ | Reverse Recovery Time | — | — | 280 | ns | $T_J$ = 25°C, $I_F$ = 35A, $V_{DD}$ ≤ 50V |
| $Q_{rr}$ | Reverse Recovery Charge | — | — | 2.2 | µC | di/dt = 100A/µs [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 | — | — | 0.83 | °C/W |
| $R_{\theta JA}$ | Junction-to-Ambient (Typical Socket Mount) | — | — | 30 | |
| $R_{\theta JCS}$ | Junction-to-Sink | — | 0.12 | — | |

## 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°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 | 60 | — | 60 | — | V | $V_{GS}$ = 0V, $I_D$ = 1.0mA |
| $V_{GS(th)}$ | Gate Threshold Voltage | 2.0 | 4.0 | 1.25 | 4.5 | V | $V_{DS}$ = $V_{GS}$, $I_D$ = 1.0mA |
| $I_{GSS}$ | Gate-to-Source Leakage Forward | — | 100 | — | 100 | nA | $V_{GS}$ = 20V |
| | Gate-to-Source Leakage Reverse | — | -100 | — | -100 | | $V_{GS}$ = -20V |
| $I_{DSS}$ | Zero Gate Voltage Drain Current | — | 25 | — | 50 | µA | $V_{DS}$ = 48V, $V_{GS}$ = 0V |
| $R_{DS(on)}$ | Static Drain-to-Source On-State Resistance (TO-3) [2] | — | 25 | — | 27 | mΩ | $V_{GS}$ = 12V, $I_{D1}$ = 45 A |
| $R_{DS(on)}$ | Static Drain-to-Source On-State Resistance (TO-204AE) [2] | — | 25 | — | 27 | mΩ | $V_{GS}$ = 12V, $I_{D1}$ = 45A |
| $V_{SD}$ | Diode Forward Voltage | — | 1.4 | — | 1.4 | V | $V_{GS}$ = 0V, $I_F$ = 45A |

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

[2] Pulse width ≤ 300 µs; Duty Cycle ≤ 2%

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

[4] Total Dose Irradiation with $V_{DS}$ Bias. $V_{DS}$ = 48V applied and $V_{GS}$ = 0 during irradiation per MIL-STD-750, Method 1019, condition A.

[5] Part numbers IRH7054

[6] Part numbers IRH3054 and IRH4054

## 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·cm²/mg) | Energy (MeV) | Range (µm) | $V_{DS}$ (V) | | | | |
|---|---|---|---|---|---|---|---|---|
| | | | | $V_{GS}$ = 0V | $V_{GS}$ = -5V | $V_{GS}$ = -10V | $V_{GS}$ = -15V | $V_{GS}$ = -20V |
| Br | 36.8 | 305 | 39 | 60 | 60 | 45 | 40 | 30 |
| I | 59.9 | 345 | 32.8 | 40 | 35 | 30 | 25 | 20 |

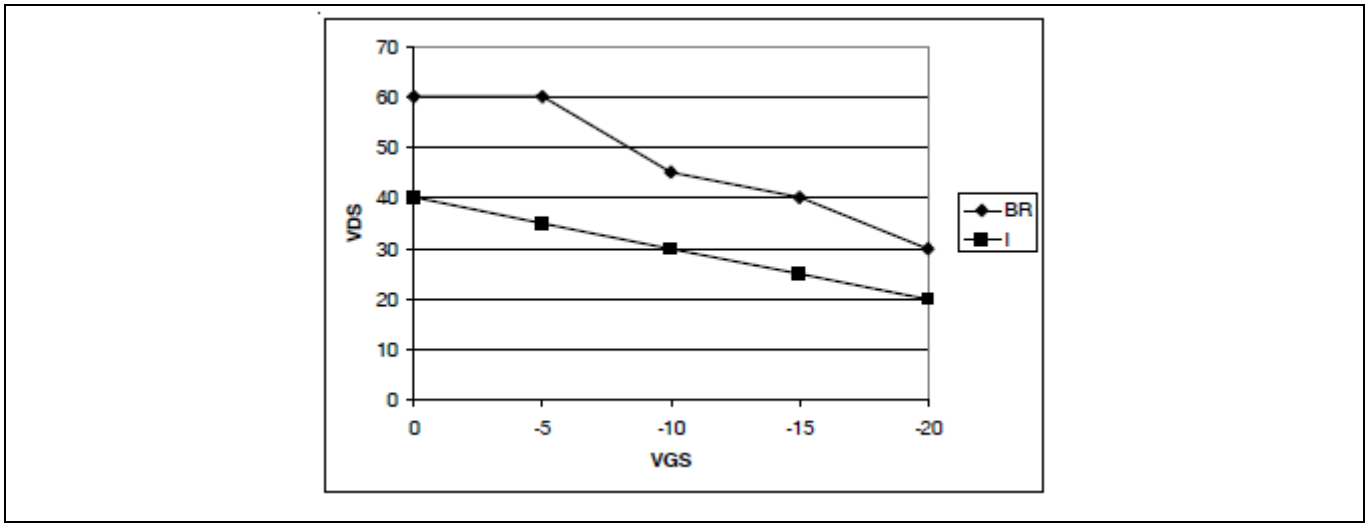



**Figure 1 Typical Single Event Effect, Safe Operating Area**

# 3 Electrical Characteristics Curves (Pre-irradiation)

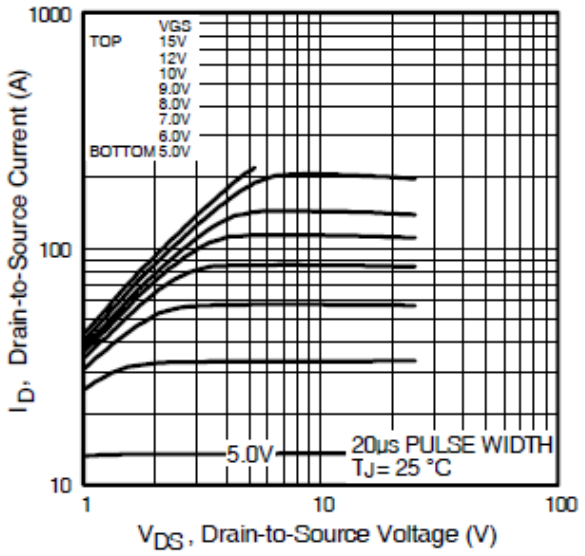



**Figure 2 Typical Output Characteristics**

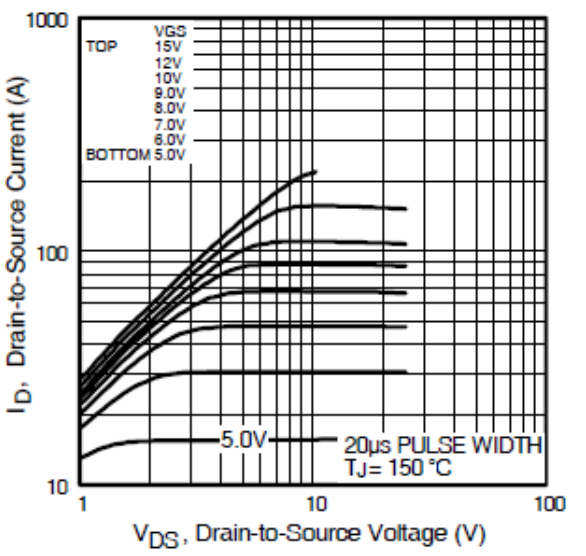



**Figure 3 Typical Output Characteristics**

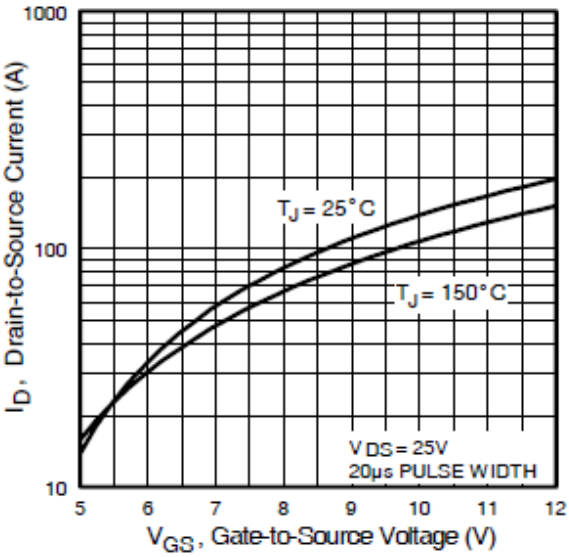



**Figure 4 Typical Transfer Characteristics**

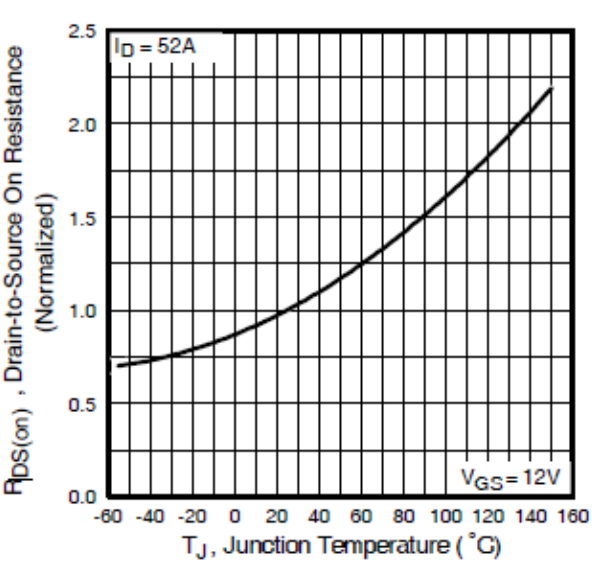



**Figure 5 Normalized On-Resistance Vs. Temperature**

## Electrical Characteristics Curves (Pre-irradiation)

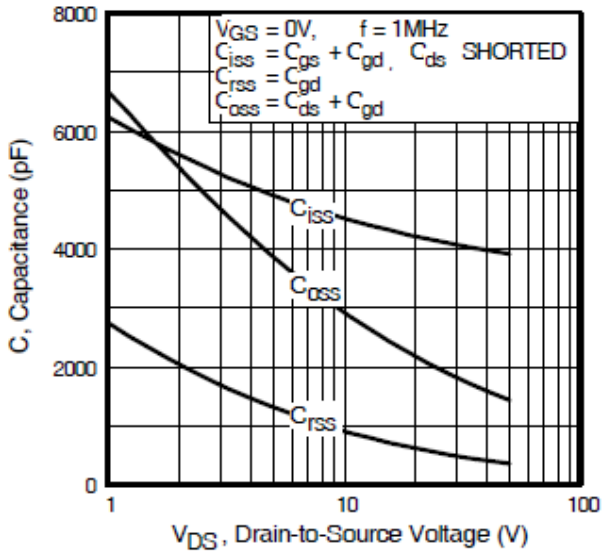



**Figure 6** **Typical Capacitance Vs. Drain-to-Source Voltage**

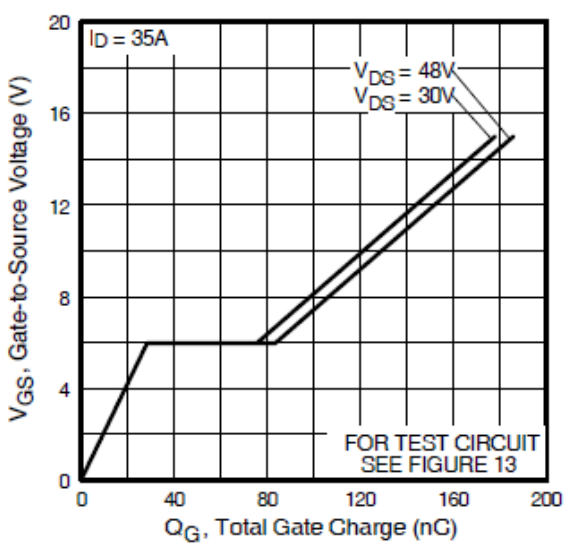



**Figure 7** **Typical Gate-to-Source Voltage Vs. Typical Gate Charge**

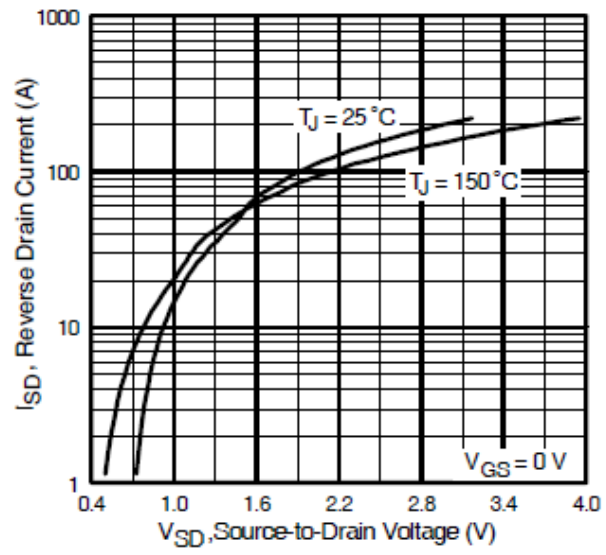



**Figure 8** **Typical Source-Drain Current Vs. Diode Forward Voltage**

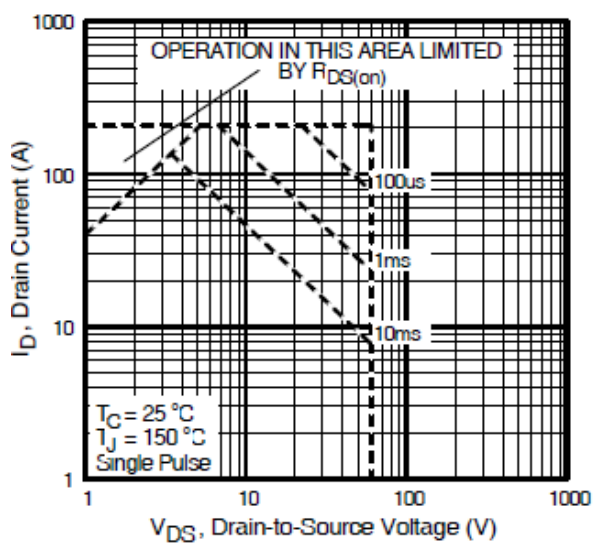



**Figure 9** **Maximum Safe Operating Area**

## Electrical Characteristics Curves (Pre-irradiation)

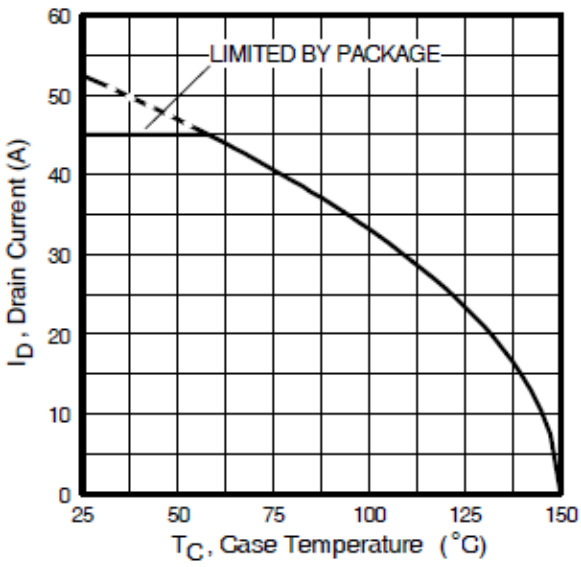



**Figure 10** Maximum Drain Current Vs. Case Temperature

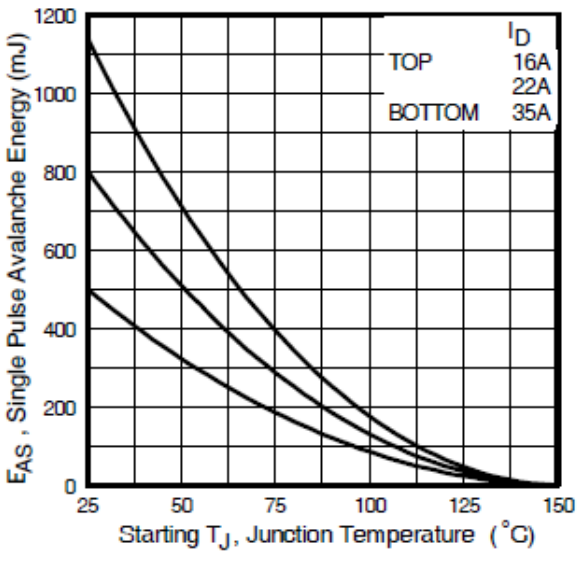



**Figure 11** Maximum Avalanche Energy Vs. Junction Temperature

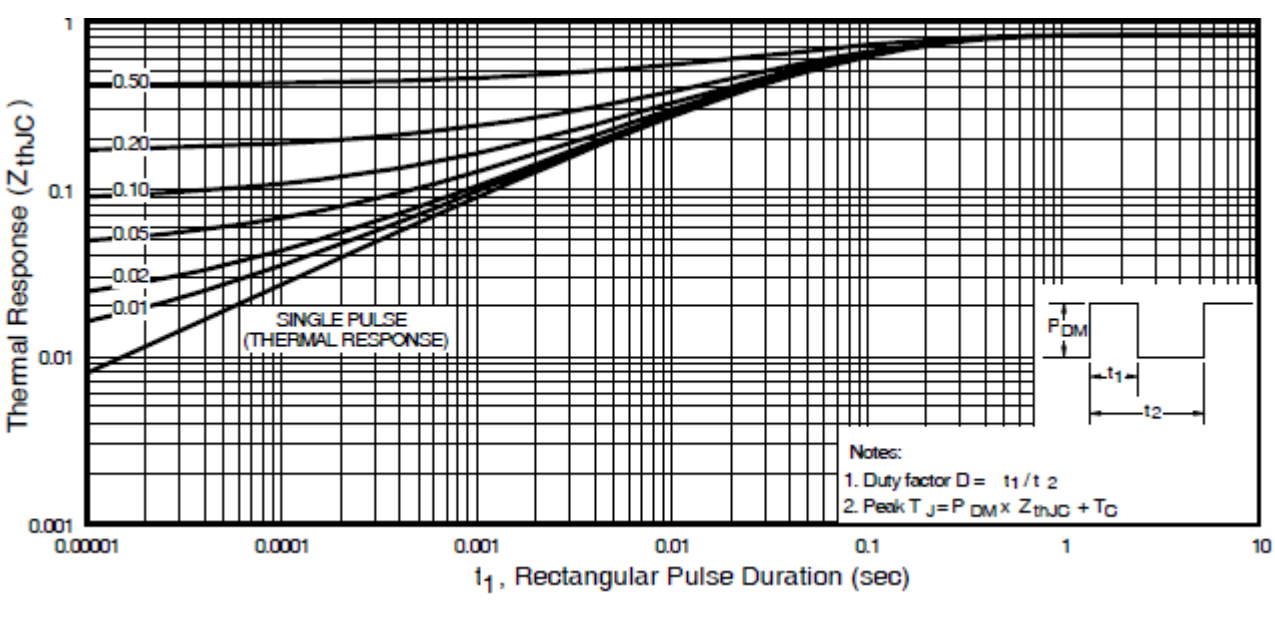



**Figure 12** Maximum Effective Transient Thermal Impedance, Junction-to-Case

# 4 Test Circuits (Pre-irradiation)

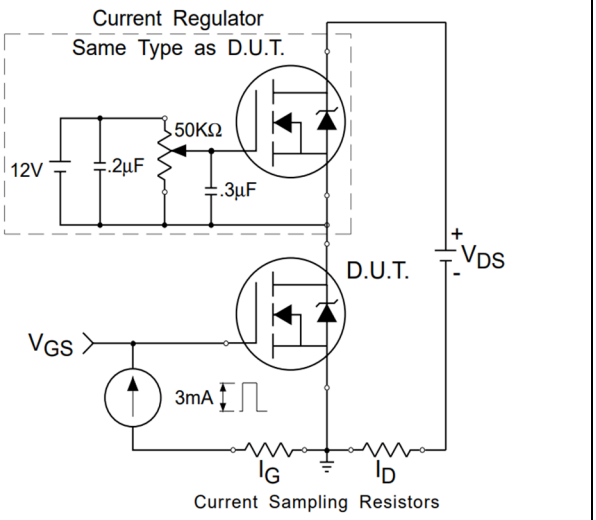



**Figure 13 Gate Charge Test Circuit**

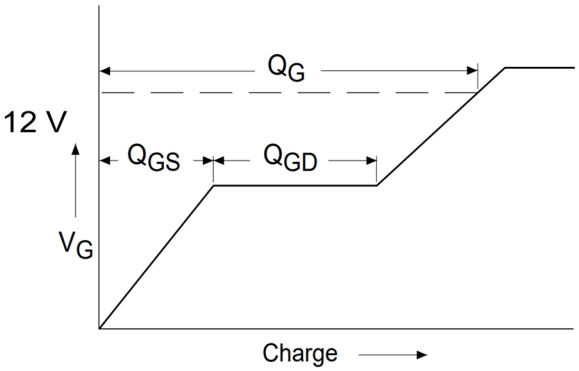



**Figure 14 Gate Charge Waveform**

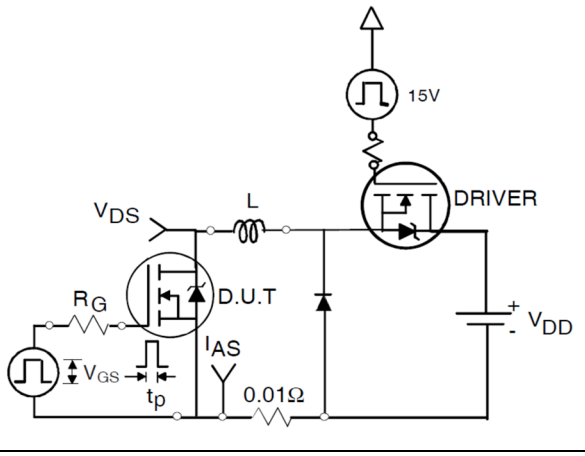



**Figure 15 Unclamped Inductive Test Circuit**

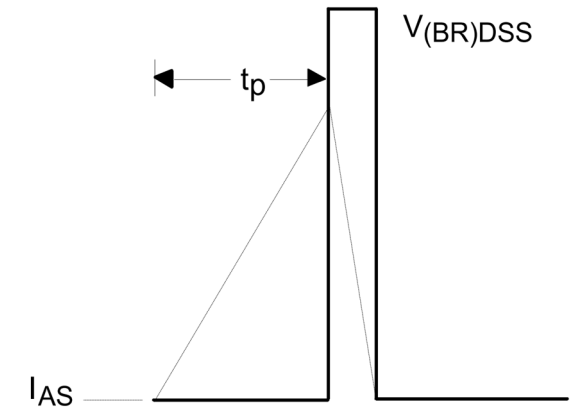



**Figure 16 Unclamped Inductive Waveform**

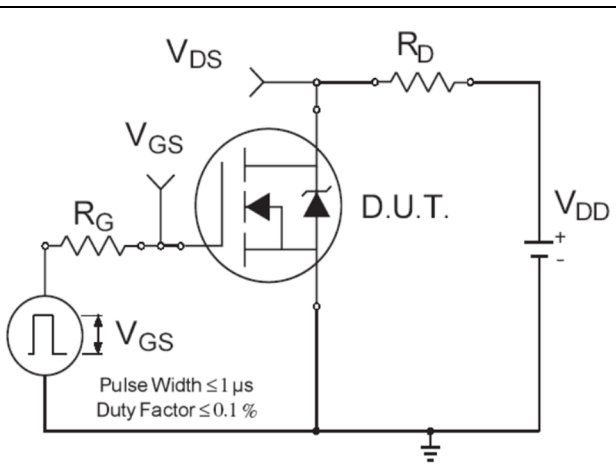



**Figure 17 Switching Time Test Circuit**

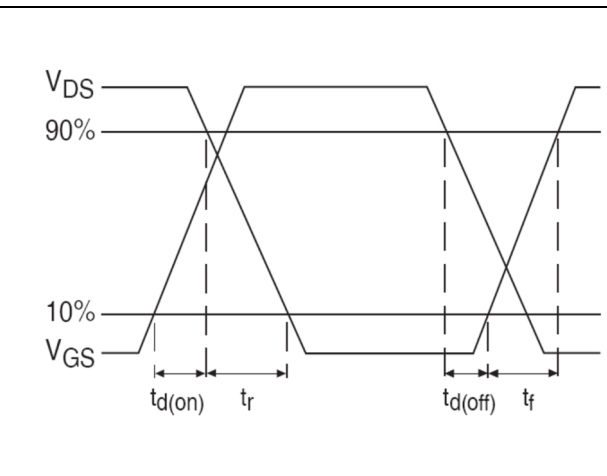
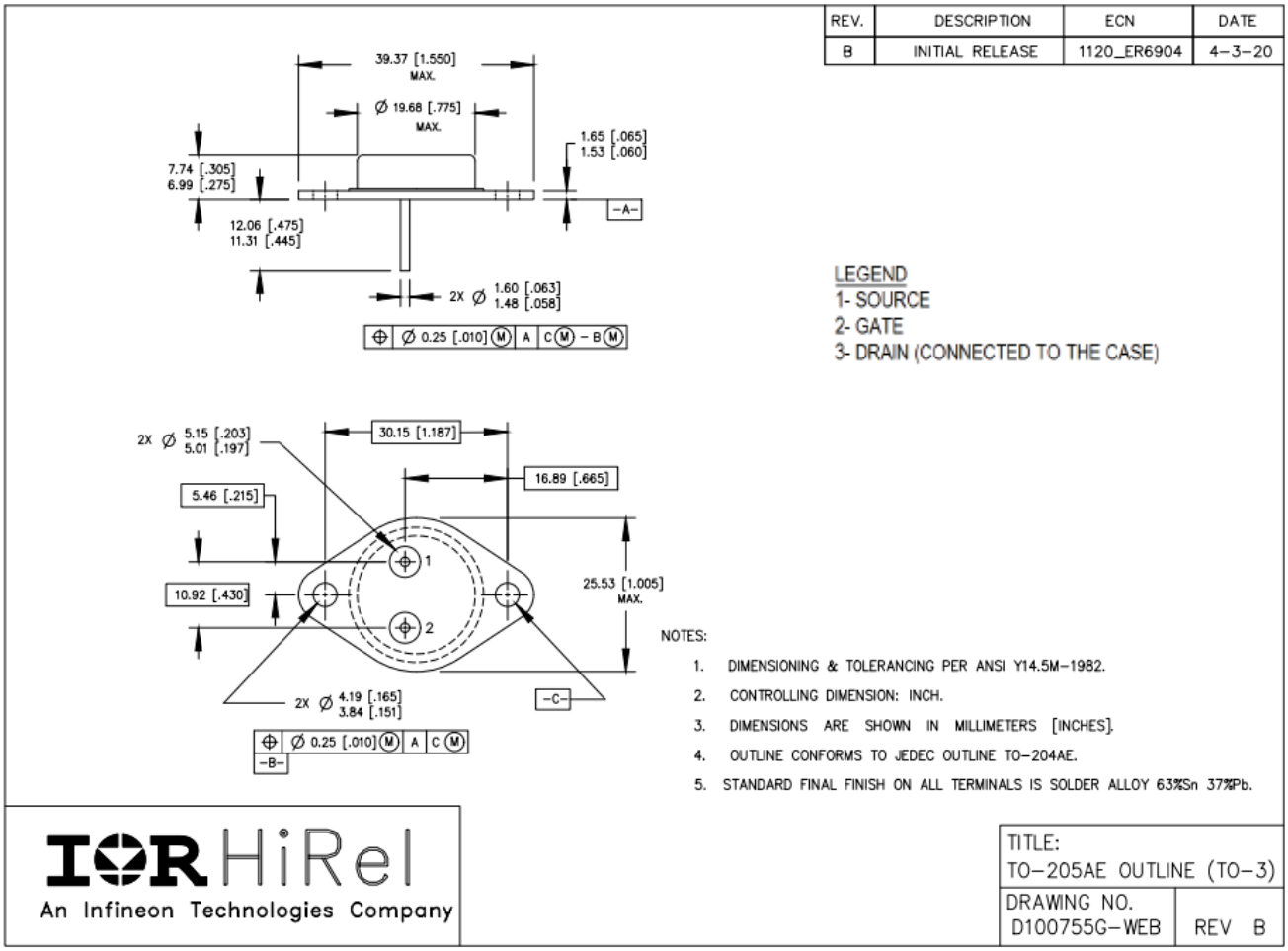



**Figure 18 Switching Time Waveforms**

# 5 Package Outline

**Note: For the most updated package outline, please see the website: TO-204AE**



# Revision history

| Document version | Date of release | Description of changes |
|---|---|---|
| | 10/02/1998 | Datasheet (PD-90883A) |
| Rev B | 06/04/2001 | Updated switch time test condition |
| Rev C | 10/14/2005 | Updated SEE table |
| Rev D | 05/24/2022 | Updated based on ECN-1120_09018 |

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