

# IRHLMS797064

PD-95860B

## Radiation Hardened Logic Level Power MOSFET Thru-Hole (TO-254AA) 60V, 56A, P-channel, R7 Technology

### Features

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

### Potential Applications

- DC-DC converter
- Motor drives

### Product Validation

Qualified according to MIL-PRF-19500 for space applications

### Description

IR HiRel R7 Logic Level Power MOSFETs provide simple solution to interfacing CMOS and TTL control circuits to power devices in space and other radiation environments. The threshold voltage remains within acceptable operating limits over the full operating temperature and post radiation. This is achieved while maintaining single event gate rupture and single event burnout immunity.

The device is ideal when used to interface directly with most logic gates, linear IC's, micro-controllers, and other device types that operate from a 3.3-5V source. It may also be used to increase the output current of a PWM, voltage comparator or an operational amplifier where the logic level drive signal is available.

### Ordering Information

**Table 1** Ordering options

| Part number     | Package            | Screening Level | TID Level    |
|-----------------|--------------------|-----------------|--------------|
| IRHLMS797064    | Low ohmic TO-254AA | COTS            | 100 krad(Si) |
| IRHLMS797064SCS | Low ohmic TO-254AA | S-Level         | 100 krad(Si) |
| IRHLMS793064    | Low ohmic TO-254AA | COTS            | 300 krad(Si) |
| IRHLMS793064SCS | Low ohmic TO-254AA | S-Level         | 300 krad(Si) |

### Product Summary

- **Part number:** IRHLMS797064, IRHLMS793064
- **Radiation level:** 100 krad(Si), 300 krad(Si)
- **$R_{DS(on),max}$ :** 18m $\Omega$
- **$I_D$ :** -45A



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## Absolute Maximum Ratings

## 1 Absolute Maximum Ratings

Table 2 Absolute Maximum Ratings (Pre-Irradiation)

| Symbol                                        | Parameter                                           | Value                                     | Unit |
|-----------------------------------------------|-----------------------------------------------------|-------------------------------------------|------|
| $I_{D1} @ V_{GS} = -4.5V, T_C = 25^{\circ}C$  | Continuous Drain Current                            | -45*                                      | A    |
| $I_{D2} @ V_{GS} = -4.5V, T_C = 100^{\circ}C$ | Continuous Drain Current                            | -45*                                      | A    |
| $I_{DM} @ T_C = 25^{\circ}C$                  | Pulsed Drain Current <sup>1</sup>                   | -180                                      | A    |
| $P_D @ T_C = 25^{\circ}C$                     | Maximum Power Dissipation                           | 208                                       | W    |
|                                               | Linear Derating Factor                              | 1.67                                      | W/°C |
| $V_{GS}$                                      | Gate-to-Source Voltage                              | $\pm 10$                                  | V    |
| $E_{AS}$                                      | Single Pulse Avalanche Energy <sup>2</sup>          | 935                                       | mJ   |
| $I_{AR}$                                      | Avalanche Current <sup>1</sup>                      | -45                                       | A    |
| $E_{AR}$                                      | Repetitive Avalanche Energy <sup>1</sup>            | 20.8                                      | mJ   |
| $dv/dt$                                       | Peak Diode Reverse Recovery <sup>3</sup>            | -6.3                                      | V/ns |
| $T_J$<br>$T_{STG}$                            | Operating Junction and<br>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

<sup>1</sup> Repetitive Rating; Pulse width limited by maximum junction temperature.<sup>2</sup>  $V_{DD} = -50V$ , starting  $T_J = 25^{\circ}C$ ,  $L = 0.92mH$ , Peak  $I_L = -45A$ ,  $V_{GS} = -10V$ <sup>3</sup>  $I_{SD} \leq -45A$ ,  $di/dt \leq -790A/\mu s$ ,  $V_{DD} \leq -60V$ ,  $T_J \leq 150^{\circ}C$

## 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          | -60  | —     | —    | V                    | $V_{GS} = 0V, I_D = -250\mu A$                                                                 |
| $\Delta BV_{DSS}/\Delta T_j$   | Breakdown Voltage Temp. Coefficient        | —    | -0.06 | —    | 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 | —    | —     | 18   | m $\Omega$           | $V_{GS} = -4.5V, I_{D2} = -45A^1$                                                              |
| $V_{GS(th)}$                   | Gate Threshold Voltage                     | -1.0 | —     | -2.0 | V                    | $V_{DS} = V_{GS}, I_D = -250\mu A$                                                             |
| $\Delta V_{GS(th)}/\Delta T_j$ | Gate Threshold Voltage Temp. Coefficient   | —    | 5.5   | —    | mV/ $^\circ\text{C}$ |                                                                                                |
| $G_{fs}$                       | Forward Transconductance                   | 52   | —     | —    | S                    | $V_{DS} = -10V, I_{D2} = -45A^1$                                                               |
| $I_{DSS}$                      | Zero Gate Voltage Drain Current            | —    | —     | -1.0 | $\mu A$              | $V_{DS} = -48V, V_{GS} = 0V$                                                                   |
|                                |                                            | —    | —     | -25  |                      | $V_{DS} = -48V, V_{GS} = 0V, T_j = 125^\circ\text{C}$                                          |
| $I_{GSS}$                      | Gate-to-Source Leakage Forward             | —    | —     | -100 | nA                   | $V_{GS} = -10V$                                                                                |
|                                | Gate-to-Source Leakage Reverse             | —    | —     | 100  |                      | $V_{GS} = 10V$                                                                                 |
| $Q_G$                          | Total Gate Charge                          | —    | —     | 123  | nC                   | $I_{D1} = -45A$                                                                                |
| $Q_{GS}$                       | Gate-to-Source Charge                      | —    | —     | 62   |                      | $V_{DS} = -30V$                                                                                |
| $Q_{GD}$                       | Gate-to-Drain ('Miller') Charge            | —    | —     | 50   |                      | $V_{GS} = -4.5V$                                                                               |
| $t_{d(on)}$                    | Turn-On Delay Time                         | —    | —     | 54   | ns                   | $I_{D1} = -45A^{**}$<br>$V_{DD} = -30V$<br>$R_G = 2.35\Omega$<br>$V_{GS} = -5.0V$              |
| $t_r$                          | Rise Time                                  | —    | —     | 400  |                      |                                                                                                |
| $t_{d(off)}$                   | Turn-Off Delay Time                        | —    | —     | 120  |                      |                                                                                                |
| $t_f$                          | Fall Time                                  | —    | —     | 138  |                      |                                                                                                |
| $L_s + L_D$                    | Total Inductance                           | —    | 6.8   | —    | nH                   | Measured from Drain lead (6mm/ 0.25 in from package) to Source lead (6mm/0.25 in from package) |
| $C_{iss}$                      | Input Capacitance                          | —    | 7540  | —    | pF                   | $V_{GS} = 0V$                                                                                  |
| $C_{oss}$                      | Output Capacitance                         | —    | 2760  | —    |                      | $V_{DS} = -25V$                                                                                |
| $C_{rss}$                      | Reverse Transfer Capacitance               | —    | 350   | —    |                      | $f = 1.0\text{MHz}$                                                                            |
| $R_G$                          | Gate Resistance                            | —    | 2.4   | —    | $\Omega$             | $f = 1.0\text{MHz}$ , open drain                                                               |

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

<sup>1</sup> Pulse width  $\leq 300\mu s$ ; Duty Cycle  $\leq 2\%$

## 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 <sub>S</sub>  | Continuous Source Current (Body Diode)          | —                                                                                              | —    | -45  | A    |                                                                                                       |
| I <sub>SM</sub> | Pulsed Source Current (Body Diode) <sup>1</sup> | —                                                                                              | —    | -180 | A    |                                                                                                       |
| V <sub>SD</sub> | Diode Forward Voltage                           | —                                                                                              | —    | -5.0 | V    | T <sub>J</sub> = 25°C, I <sub>S</sub> = -45A, V <sub>GS</sub> = 0V <sup>2</sup>                       |
| t <sub>rr</sub> | Reverse Recovery Time                           | —                                                                                              | —    | 120  | ns   | T <sub>J</sub> = 25°C, I <sub>F</sub> = -45A, V <sub>DD</sub> ≤ -25V<br>di/dt = -100A/μs <sup>2</sup> |
| Q <sub>rr</sub> | Reverse Recovery Charge                         | —                                                                                              | —    | 375  | nC   |                                                                                                       |
| t <sub>on</sub> | Forward Turn-On Time                            | Intrinsic turn-on time is negligible (turn-on is dominated by L <sub>S</sub> +L <sub>D</sub> ) |      |      |      |                                                                                                       |

## 2.3 Thermal Characteristics

Table 5 Thermal Resistance

| Symbol          | Parameter                                  | Min. | Typ. | Max. | Unit                      |
|-----------------|--------------------------------------------|------|------|------|---------------------------|
| $R_{\theta JC}$ | Junction-to-Case                           | —    | —    | 0.60 | $^\circ\text{C}/\text{W}$ |
| $R_{\theta CS}$ | Case-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 <sup>3, 4</sup>

| Symbol       | Parameter                                                          | Up to 300 krad (Si) <sup>5</sup> |      | Unit             | Test Conditions                                  |
|--------------|--------------------------------------------------------------------|----------------------------------|------|------------------|--------------------------------------------------|
|              |                                                                    | Min.                             | Max. |                  |                                                  |
| $BV_{DSS}$   | Drain-to-Source Breakdown Voltage                                  | -60                              | —    | V                | $V_{GS} = 0\text{V}$ , $I_D = -250\mu\text{A}$   |
| $V_{GS(th)}$ | Gate Threshold Voltage                                             | -1.0                             | -2.0 | V                | $V_{DS} = V_{GS}$ , $I_D = -250\mu\text{A}$      |
| $I_{GSS}$    | Gate-to-Source Leakage Forward                                     | —                                | -100 | nA               | $V_{GS} = -10\text{V}$                           |
|              | Gate-to-Source Leakage Reverse                                     | —                                | 100  |                  | $V_{GS} = 10\text{V}$                            |
| $I_{DSS}$    | Zero Gate Voltage Drain Current                                    | —                                | -10  | $\mu\text{A}$    | $V_{DS} = -48\text{V}$ , $V_{GS} = 0\text{V}$    |
| $R_{DS(on)}$ | Static Drain-to-Source On-State Resistance (TO-3) <sup>2</sup>     | —                                | 19   | $\text{m}\Omega$ | $V_{GS} = -4.5\text{V}$ , $I_{D2} = -45\text{A}$ |
| $R_{DS(on)}$ | Static Drain-to-Source On-State Resistance (TO-254AA) <sup>2</sup> | —                                | 18   | $\text{m}\Omega$ | $V_{GS} = -4.5\text{V}$ , $I_{D2} = -45\text{A}$ |
| $V_{SD}$     | Diode Forward Voltage                                              | —                                | -5.0 | V                | $V_{GS} = 0\text{V}$ , $I_F = -45\text{A}$       |

<sup>1</sup> Repetitive Rating; Pulse width limited by maximum junction temperature.

<sup>2</sup> Pulse width  $\leq 300\mu\text{s}$ ; Duty Cycle  $\leq 2\%$ 
<sup>3</sup> 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.

<sup>4</sup> Total Dose Irradiation with  $V_{DS}$  Bias.  $V_{DS} = -48\text{V}$  applied and  $V_{GS} = 0$  during irradiation per MIL-STD-750, Method 1019, condition A.

<sup>5</sup> Part numbers IRHLMS797064 and IRHLMS793064

# IRHLS797064

## Radiation Hardened Power MOSFET Thru-Hole (TO-254AA)

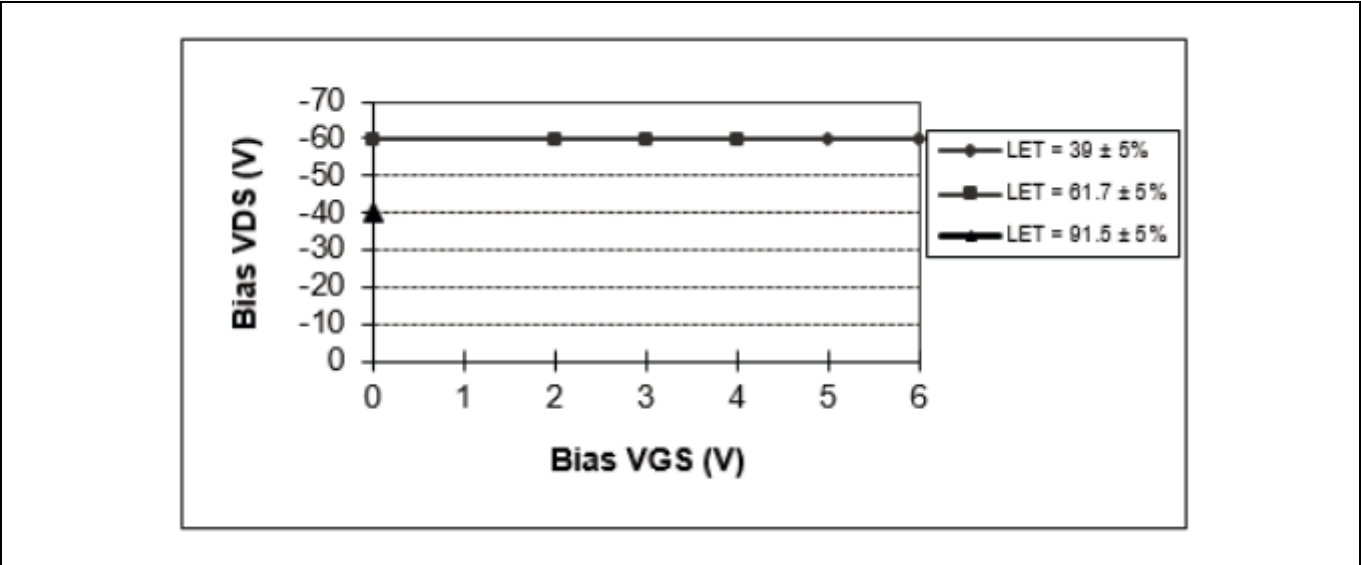
### Device Characteristics

#### 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 Typical Single Event Effects Safe Operating Area**

| LET<br>(MeV·cm <sup>2</sup> /mg) | Energy<br>(MeV) | Range<br>(μm) | V <sub>DS</sub> (V)  |                      |                      |                      |                      |                      |
|----------------------------------|-----------------|---------------|----------------------|----------------------|----------------------|----------------------|----------------------|----------------------|
|                                  |                 |               | V <sub>GS</sub> = 0V | V <sub>GS</sub> = 2V | V <sub>GS</sub> = 3V | V <sub>GS</sub> = 4V | V <sub>GS</sub> = 5V | V <sub>GS</sub> = 6V |
| 39.0 ± 5%                        | 312 ± 7.5%      | 38.6 ± 7.5%   | -60                  | -60                  | -60                  | -60                  | -60                  | -60                  |
| 61.7 ± 5%                        | 584 ± 7.5%      | 48.7 ± 7.5%   | -60                  | -60                  | -60                  | -60                  | —                    | —                    |
| 91.5 ± 5%                        | 1262 ± 7.5%     | 70.1 ± 7.5%   | -40                  | —                    | —                    | —                    | —                    | —                    |



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

3 Electrical Characteristics Curves (Pre-irradiation)

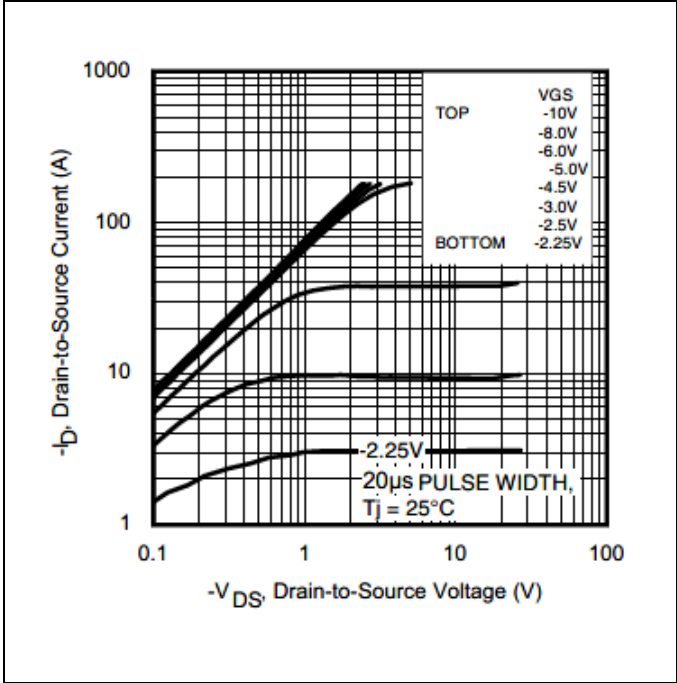


Figure 2 Typical Output Characteristics

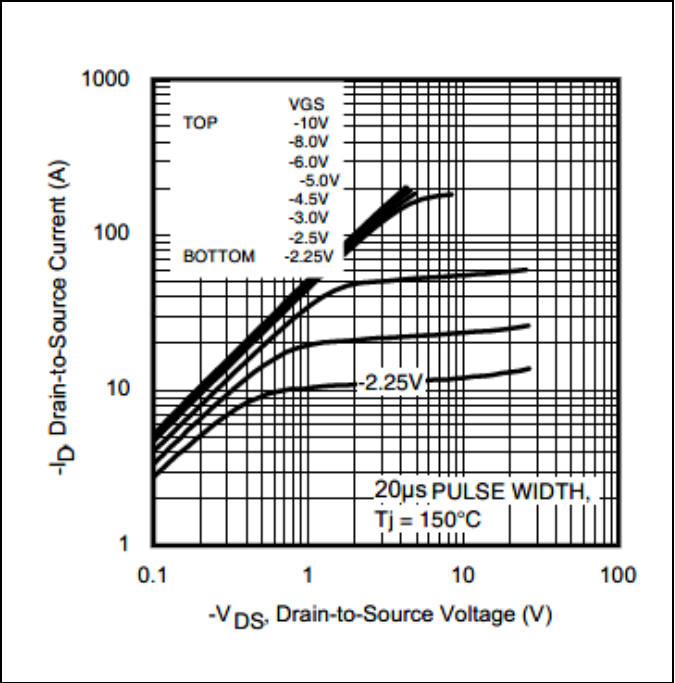


Figure 3 Typical Output Characteristics

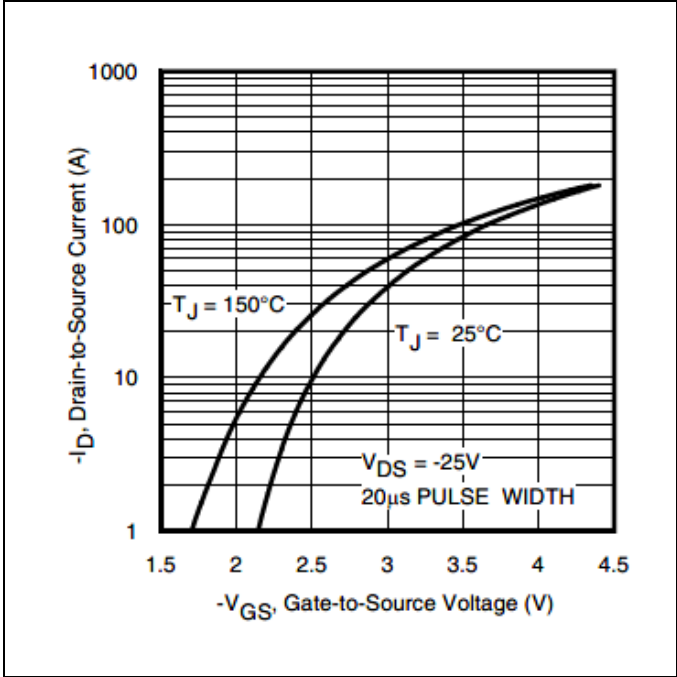


Figure 4 Typical Transfer Characteristics

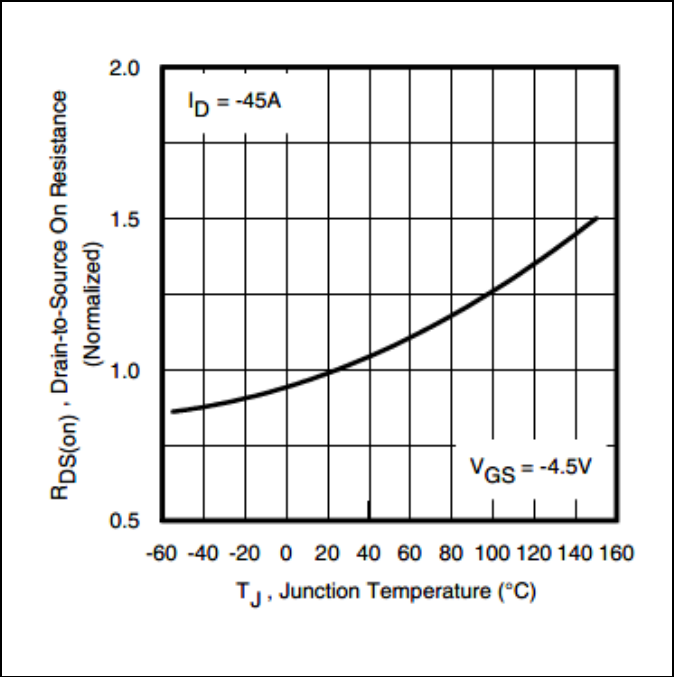


Figure 5 Normalized On-Resistance Vs. Temperature

# IRHLS797064

## Radiation Hardened Power MOSFET Thru-Hole (TO-254AA)

### Electrical Characteristics Curves (Pre-irradiation)

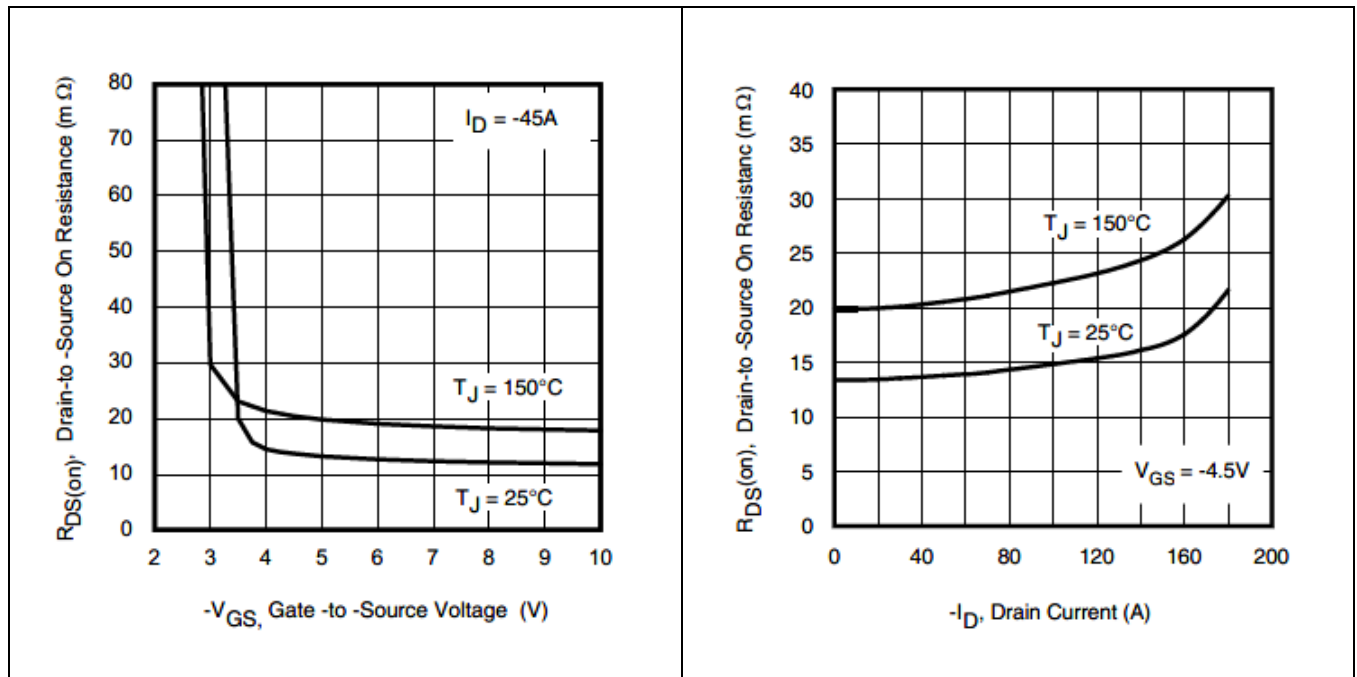


Figure 6 Typical On-Resistance Vs Gate Voltage

Figure 7 Typical On-Resistance Vs Drain Current

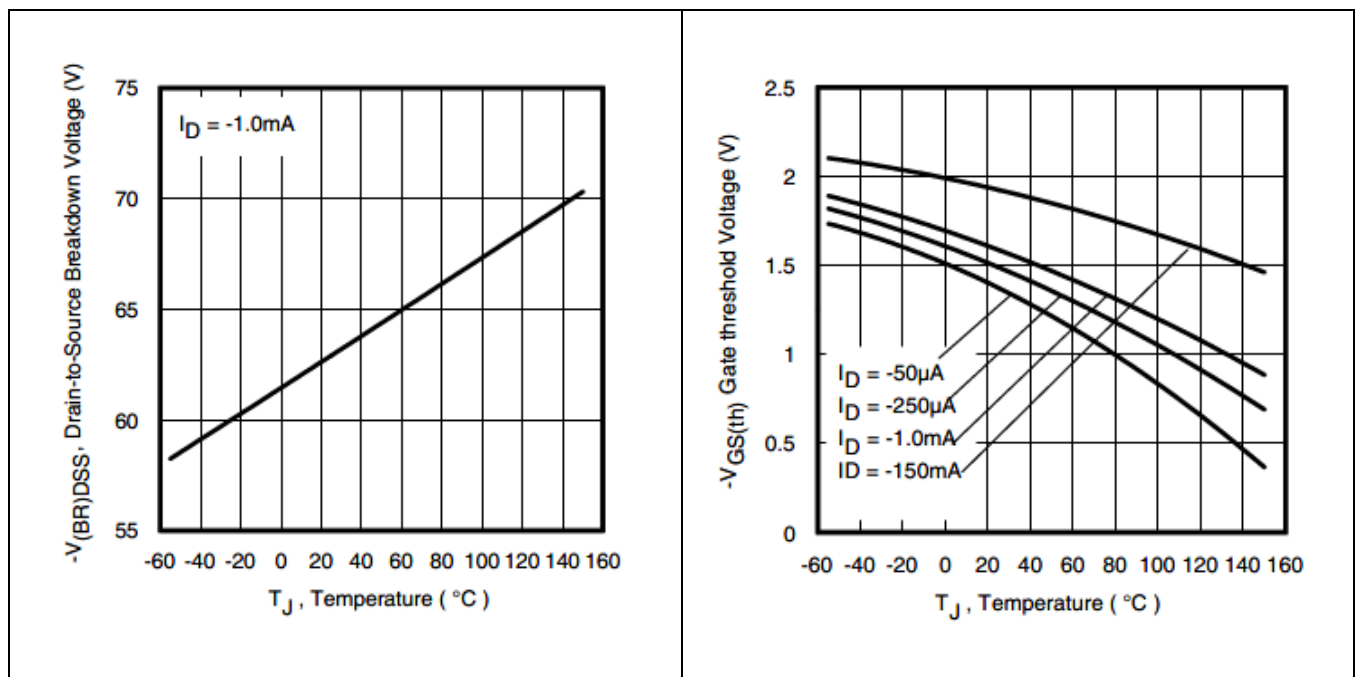


Figure 8 Typical Drain-to-Source Breakdown Voltage Vs Temperature

Figure 9 Typical Threshold Voltage Vs Temperature



## Radiation Hardened Power MOSFET Thru-Hole (TO-254AA)

## Electrical Characteristics Curves (Pre-irradiation)

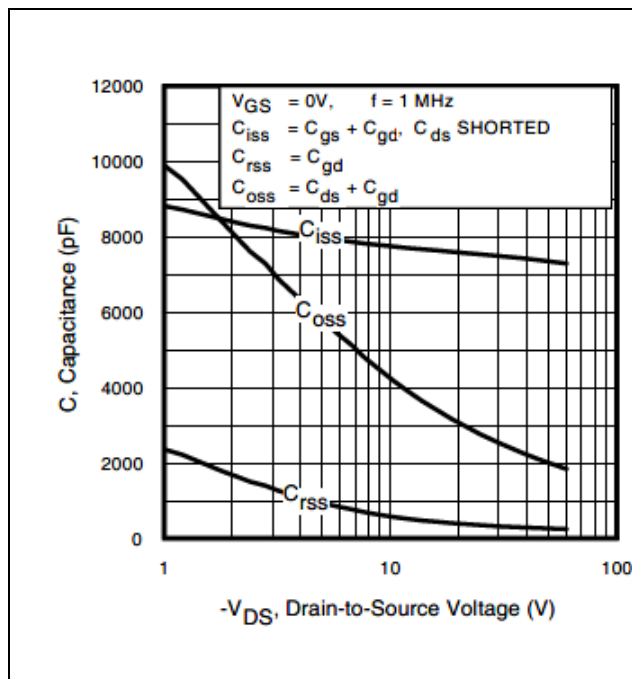


Figure 10 Typical Capacitance Vs. Drain-to-Source Voltage

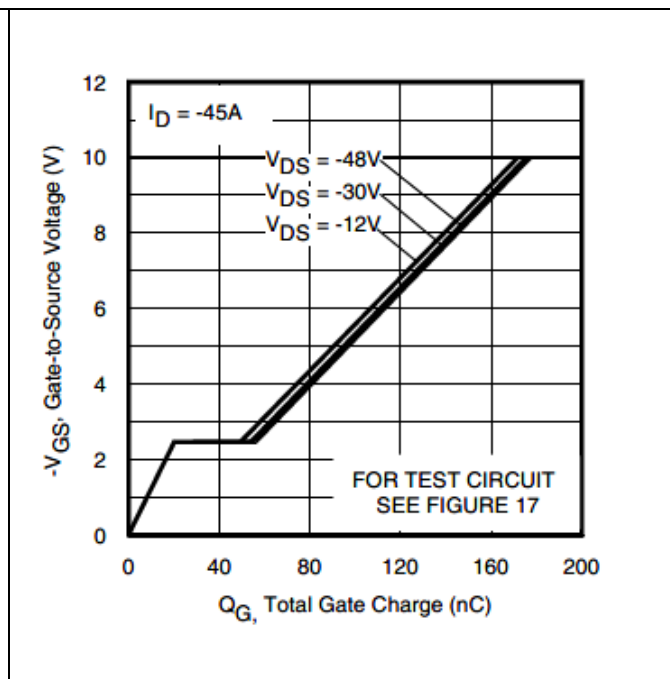


Figure 11 Typical Gate-to-Source Voltage Vs. Typical Gate Charge

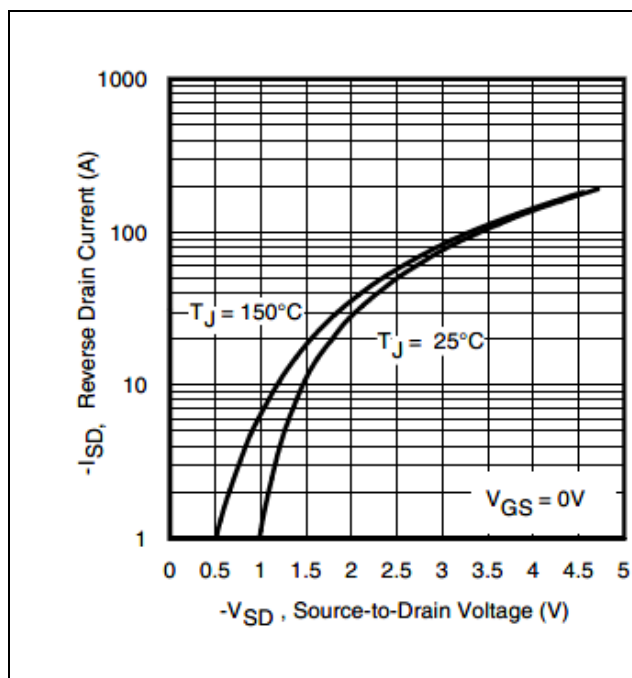


Figure 12 Typical Source-Drain Current Vs. Diode Forward Voltage

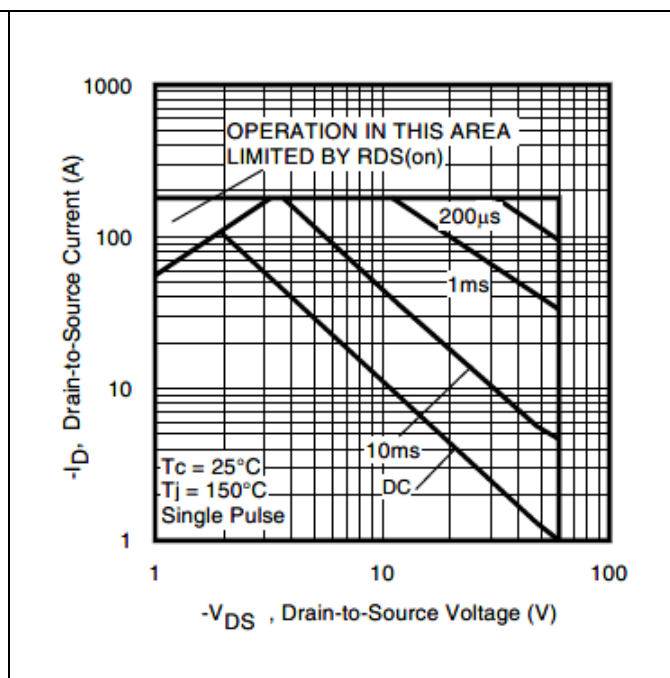


Figure 13 Maximum Safe Operating Area

# IRHLS797064

## Radiation Hardened Power MOSFET Thru-Hole (TO-254AA)

### Electrical Characteristics Curves (Pre-irradiation)

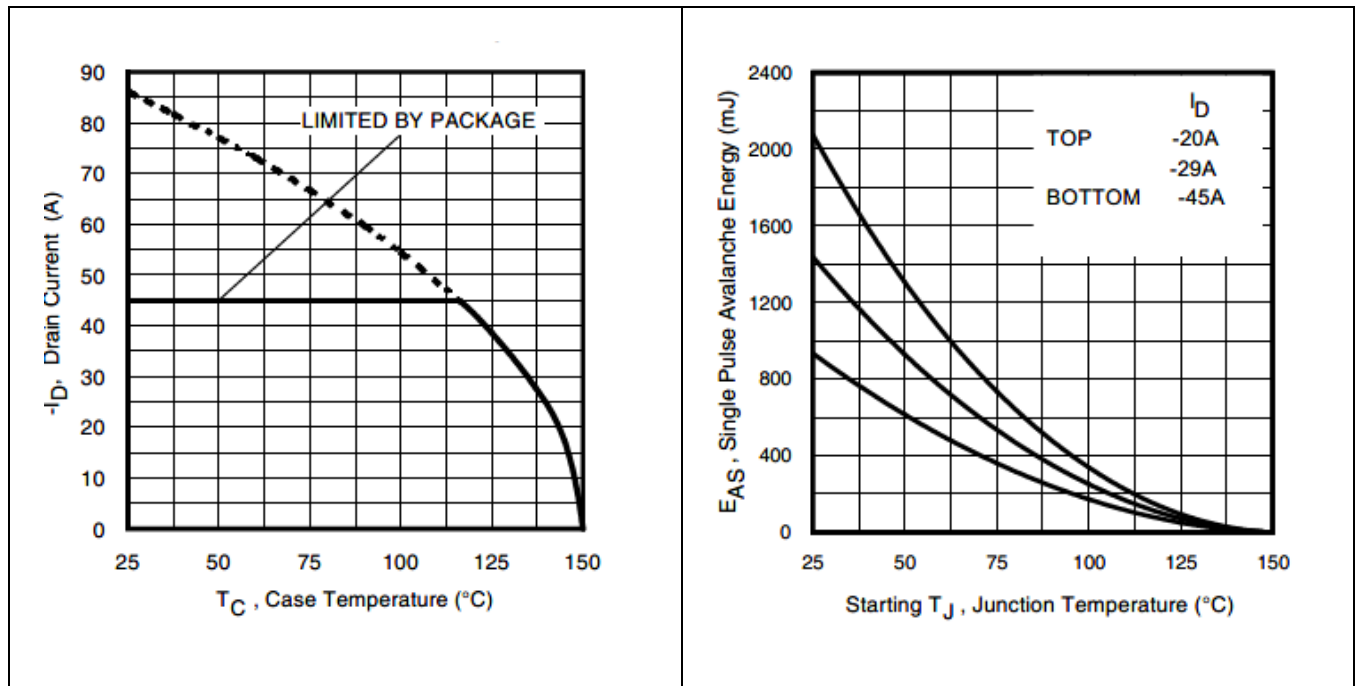


Figure 14 Maximum Drain Current Vs. Case Temperature

Figure 15 Maximum Avalanche Energy Vs. Junction Temperature

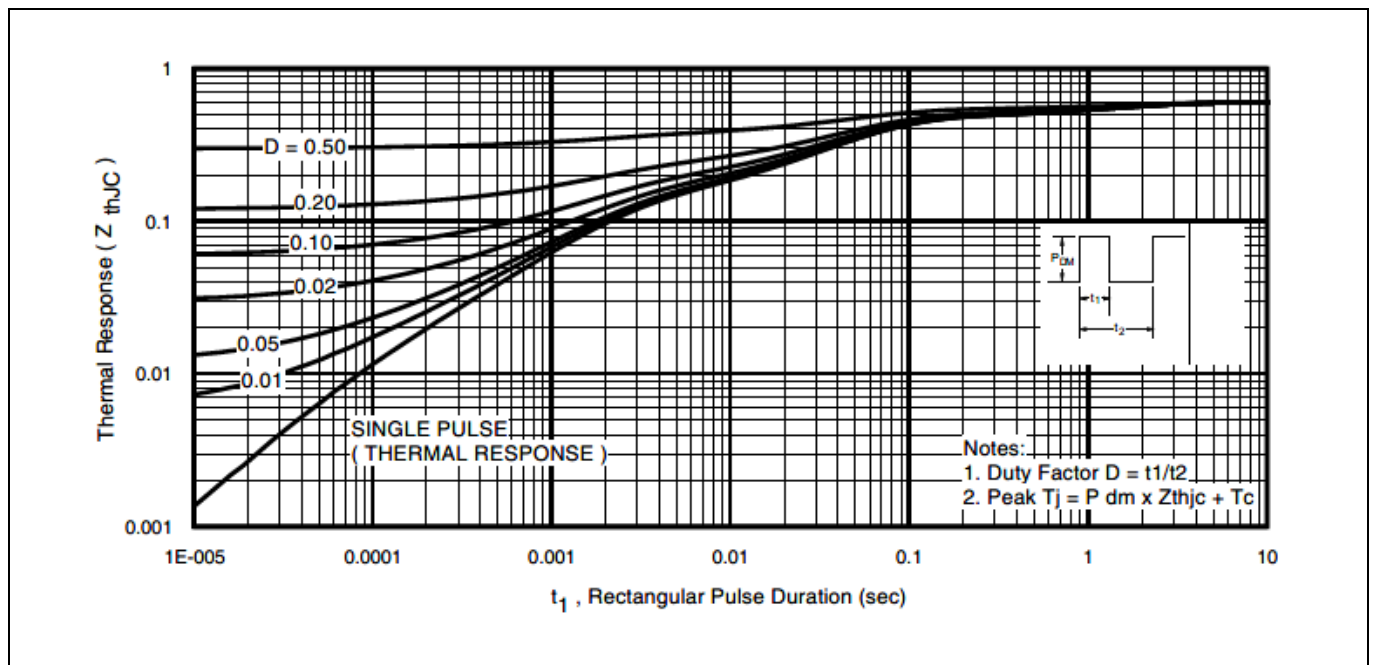


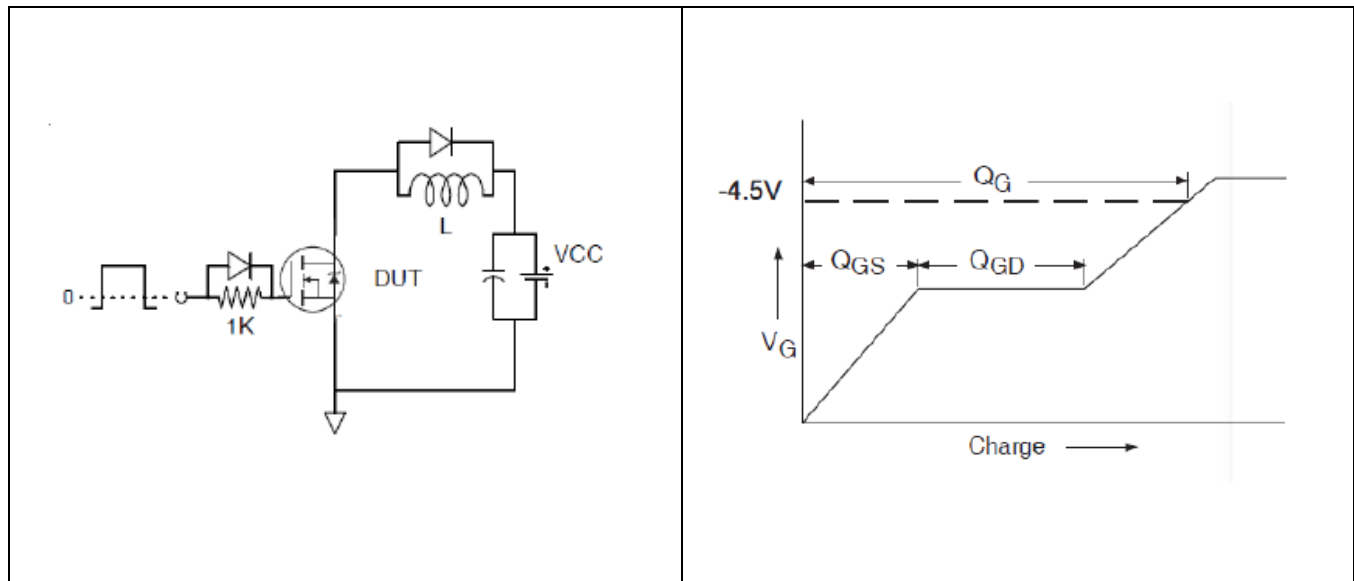
Figure 16 Maximum Effective Transient Thermal Impedance, Junction-to-Case

## IRHLS797064

### Radiation Hardened Power MOSFET Thru-Hole (TO-254AA)

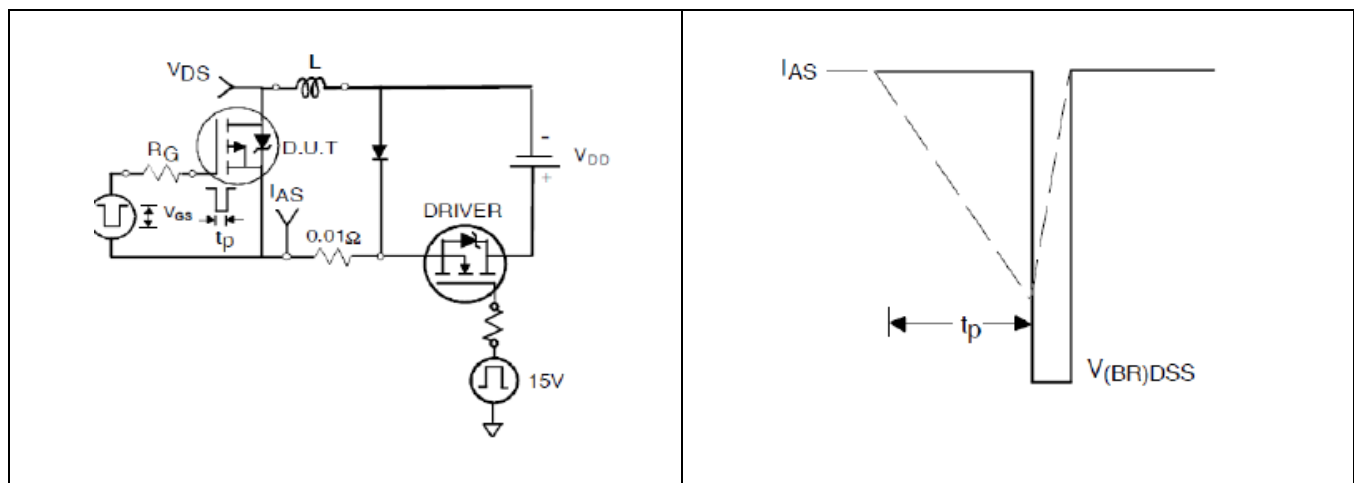
#### Test Circuits (Pre-irradiation)

## 4 Test Circuits (Pre-irradiation)



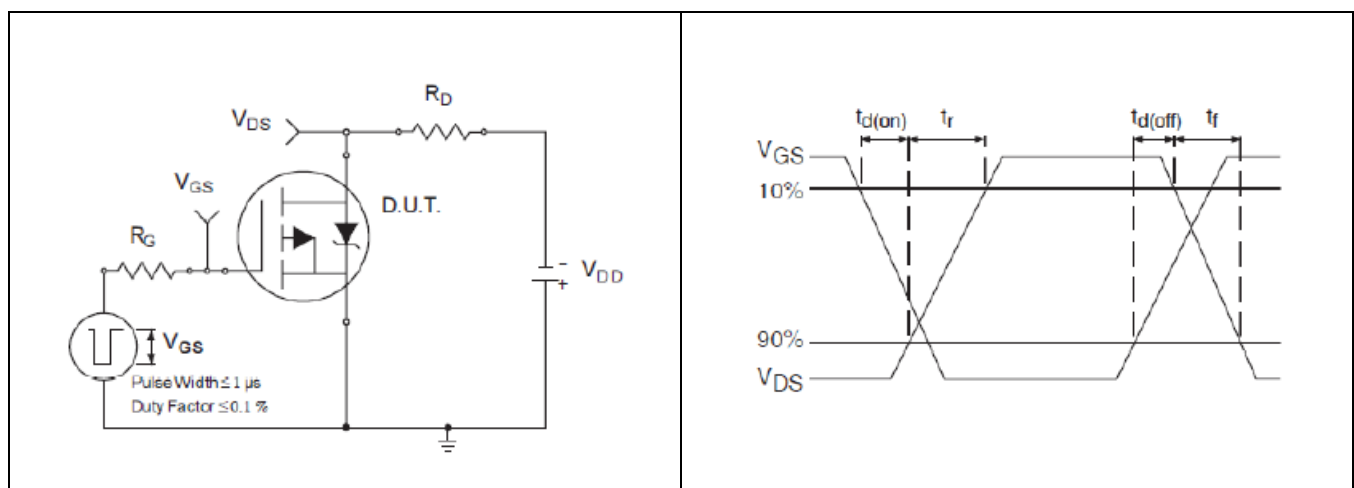
**Figure 17 Gate Charge Test Circuit**

**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**

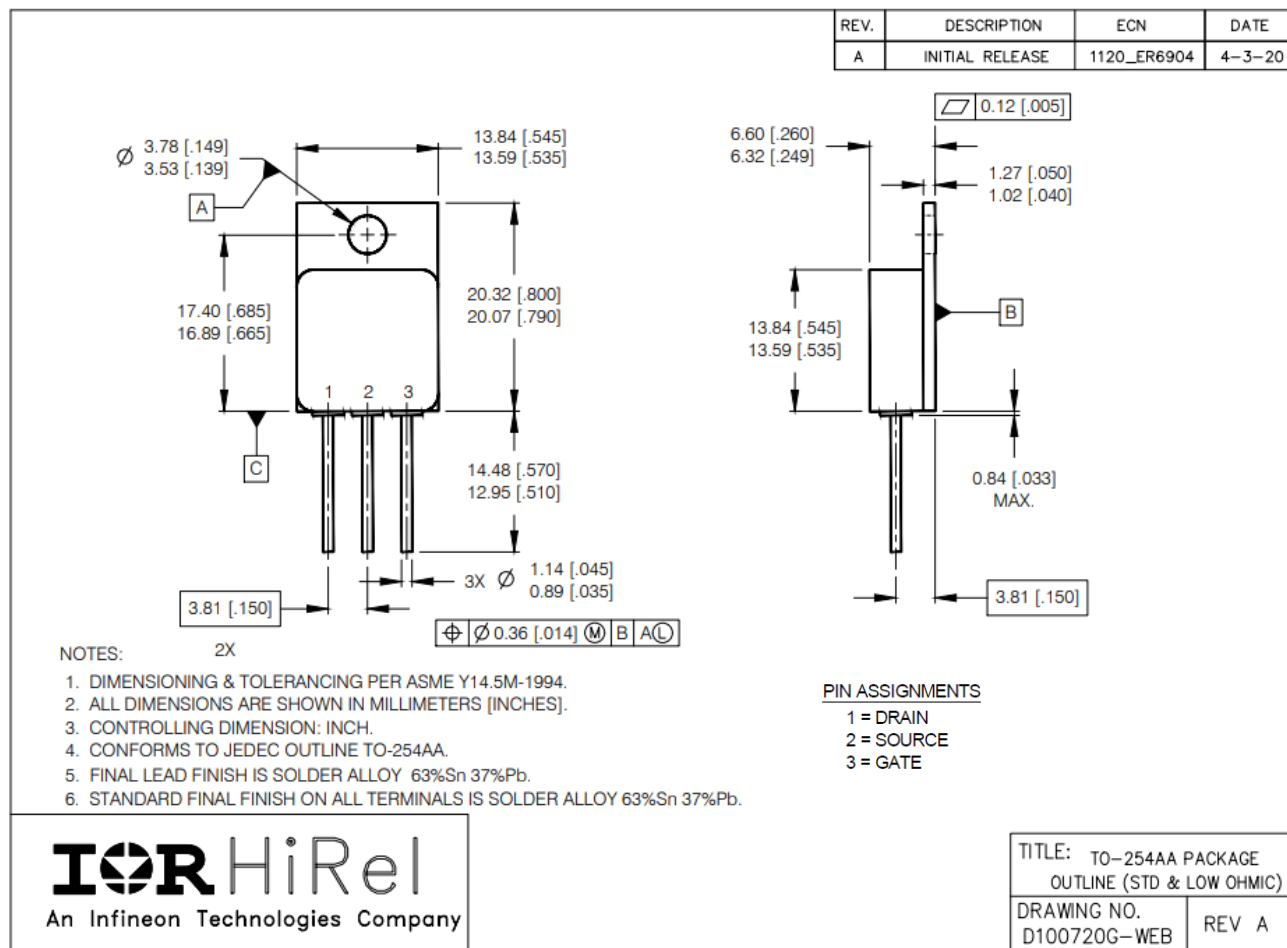
**IRHLS797064**

**Radiation Hardened Power MOSFET Thru-Hole (TO-254AA)**

## Package Outline

### 5 Package Outline

**Note:** For the most updated package outline, please see the website: [TO-254AA](http://www.infineon.com/toc-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          |
|------------------|-----------------|---------------------------------|
|                  | 06/16/2017      | Datasheet (PD-95860)            |
| Rev A            | 03/02/2020      | Updated based on ECN-1120_07827 |
| Rev B            | 04/25/2022      | Updated based on ECN-1120_09018 |

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