

# IRHYS6S7130CM

PD-97863A

## Radiation Hardened Power MOSFET Thru-Hole (Low-Ohmic TO-257AA) 100V, 20A, N-channel, R6 Technology

### Features

- Low  $R_{DS(on)}$
- Fast switching
- Single event effect (SEE) hardened
- Low total gate charge
- Simple drive requirements
- Hermetically sealed
- Electrically isolated
- Ceramic eyelets
- Light weight
- ESD rating: Class 2 per MIL-STD-750, Method 1020

### Potential Applications

- Isolated DC-DC converters
- Motor drives
- Electric propulsion
- Thermal management

### Product Validation

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

### Description

IR HiRel R6 S- line technology provides high performance power MOSFETs for space applications. These devices have been characterized for both Total Dose and Single Event Effect (SEE) with useful performance up to LET of 60 (MeV·cm<sup>2</sup>/mg). The combination of low  $R_{DS(on)}$  and low gate charge reduces the power losses in switching applications such as DC-DC converters and motor controllers. 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    |
|------------------|--------------------|-----------------|--------------|
| IRHYS6S7130CM    | Low-Ohmic TO-257AA | COTS            | 100 krad(Si) |
| IRHYS6S7130CMSCS | Low-Ohmic TO-257AA | S-Level         | 100 krad(Si) |
| IRHYS6S3130CM    | Low-Ohmic TO-257AA | COTS            | 300 krad(Si) |
| IRHYS6S3130CMSCS | Low-Ohmic TO-257AA | S-Level         | 300 krad(Si) |

### Product Summary

- $BV_{DSS}$ : 100V
- $I_D$ : 20A\*
- $R_{DS(on), max}$ : 42mΩ
- $Q_G, max$ : 50nC



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## Radiation Hardened Power MOSFET Thru-Hole (Low-Ohmic TO-257AA)

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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                            | 20*                                       | A              |
| $I_{D2} @ V_{GS} = 12V, T_C = 100^{\circ}C$ | Continuous Drain Current                            | 19                                        | A              |
| $I_{DM} @ T_C = 25^{\circ}C$                | Pulsed Drain Current <sup>1</sup>                   | 80                                        | A              |
| $P_D @ T_C = 25^{\circ}C$                   | Maximum Power Dissipation                           | 75                                        | W              |
|                                             | Linear Derating Factor                              | 0.6                                       | W/ $^{\circ}C$ |
| $V_{GS}$                                    | Gate-to-Source Voltage                              | $\pm 20$                                  | V              |
| $E_{AS}$                                    | Single Pulse Avalanche Energy <sup>2</sup>          | 107                                       | mJ             |
| $I_{AR}$                                    | Avalanche Current <sup>1</sup>                      | 20                                        | A              |
| $E_{AR}$                                    | Repetitive Avalanche Energy <sup>1</sup>            | 7.5                                       | mJ             |
| $dv/dt$                                     | Peak Diode Reverse Recovery <sup>3</sup>            | 5.5                                       | V/ns           |
| $T_J$<br>$T_{STG}$                          | Operating Junction and<br>Storage Temperature Range | -55 to +150                               | $^{\circ}C$    |
|                                             | Lead Temperature                                    | 300 (0.063 in. /1.6 mm from case for 10s) |                |
|                                             | Weight                                              | 4.3 (Typical)                             |                |

\* Current is limited by package

<sup>1</sup> Repetitive Rating; Pulse width limited by maximum junction temperature.<sup>2</sup>  $V_{DD} = 25V$ , starting  $T_J = 25^{\circ}C$ ,  $L = 0.54mH$ , Peak  $I_L = 20A$ ,  $V_{GS} = 12V$ <sup>3</sup>  $I_{SD} \leq 20A$ ,  $di/dt \leq 575A/\mu s$ ,  $V_{DD} \leq 100V$ ,  $T_J \leq 150^{\circ}C$

## 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          | 100  | —     | —    | V                    | $V_{GS} = 0V, I_D = 1.0mA$                                                                                                                                       |
| $\Delta BV_{DSS}/\Delta T_J$   | Breakdown Voltage Temp. Coefficient        | —    | 0.12  | —    | V/ $^\circ\text{C}$  | Reference to $25^\circ\text{C}$ , $I_D = 1.0mA$                                                                                                                  |
| $R_{DS(on)}$                   | Static Drain-to-Source On-State Resistance | —    | —     | 42   | m $\Omega$           | $V_{GS} = 12V, I_{D2} = 19A^1$                                                                                                                                   |
| $V_{GS(th)}$                   | Gate Threshold Voltage                     | 2.0  | —     | 4.0  | V                    | $V_{DS} = V_{GS}, I_D = 1mA$                                                                                                                                     |
| $\Delta V_{GS(th)}/\Delta T_J$ | Gate Threshold Voltage Coefficient         | —    | -8.72 | —    | mV/ $^\circ\text{C}$ |                                                                                                                                                                  |
| $G_{fs}$                       | Forward Transconductance                   | 14   | —     | —    | S                    | $V_{DS} = 15V, I_{D2} = 19A^1$                                                                                                                                   |
| $I_{DSS}$                      | Zero Gate Voltage Drain Current            | —    | —     | 10   | $\mu A$              | $V_{DS} = 80V, V_{GS} = 0V$                                                                                                                                      |
|                                |                                            | —    | —     | 25   |                      | $V_{DS} = 80V, V_{GS} = 0V, T_J = 125^\circ\text{C}$                                                                                                             |
| $I_{GSS}$                      | Gate-to-Source Leakage Forward             | —    | —     | 100  | nA                   | $V_{GS} = 20V$                                                                                                                                                   |
|                                | Gate-to-Source Leakage Reverse             | —    | —     | -100 |                      | $V_{GS} = -20V$                                                                                                                                                  |
| $Q_G$                          | Total Gate Charge                          | —    | —     | 50   | nC                   | $I_{D1} = 20A$<br>$V_{DS} = 50V$<br>$V_{GS} = 12V$                                                                                                               |
| $Q_{GS}$                       | Gate-to-Source Charge                      | —    | —     | 15   |                      |                                                                                                                                                                  |
| $Q_{GD}$                       | Gate-to-Drain ('Miller') Charge            | —    | —     | 12   |                      |                                                                                                                                                                  |
| $t_{d(on)}$                    | Turn-On Delay Time                         | —    | —     | 20   | ns                   | $I_{D1} = 20A^{**}$<br>$V_{DD} = 50V$<br>$R_G = 7.5\Omega$<br>$V_{GS} = 12V$                                                                                     |
| $t_r$                          | Rise Time                                  | —    | —     | 50   |                      |                                                                                                                                                                  |
| $t_{d(off)}$                   | Turn-Off Delay Time                        | —    | —     | 35   |                      |                                                                                                                                                                  |
| $t_f$                          | Fall Time                                  | —    | —     | 15   |                      |                                                                                                                                                                  |
| $L_s + L_D$                    | 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                          | —    | 1710  | —    | pF                   | $V_{GS} = 0V$<br>$V_{DS} = 25V$<br>$f = 1.0MHz$                                                                                                                  |
| $C_{oss}$                      | Output Capacitance                         | —    | 343   | —    |                      |                                                                                                                                                                  |
| $C_{rss}$                      | Reverse Transfer Capacitance               | —    | 6.5   | —    |                      |                                                                                                                                                                  |
| $R_G$                          | Gate Resistance                            | —    | 1.1   | —    | $\Omega$             | $f = 1.0MHz$ , 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)          | —                                                                                              | —    | 20   | A    |                                                                                       |
| I <sub>SM</sub> | Pulsed Source Current (Body Diode) <sup>1</sup> | —                                                                                              | —    | 80   | A    |                                                                                       |
| V <sub>SD</sub> | Diode Forward Voltage                           | —                                                                                              | —    | 1.2  | V    | T <sub>J</sub> = 25°C, I <sub>S</sub> = 20A, V <sub>GS</sub> = 0V <sup>2</sup>        |
| t <sub>rr</sub> | Reverse Recovery Time                           | —                                                                                              | —    | 250  | ns   | T <sub>J</sub> = 25°C, I <sub>F</sub> = 20A, V <sub>DD</sub> ≤ 25V<br>di/dt = 100A/μs |
| Q <sub>rr</sub> | Reverse Recovery Charge                         | —                                                                                              | 1.81 | —    | μC   |                                                                                       |
| 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                            | —    | —    | 1.67 | $^\circ\text{C}/\text{W}$ |
| $R_{\theta JA}$ | Junction-to- Ambient (Typical socket mount) | —    | —    | 80   |                           |

## 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                                  | 100                              | —    | V                | $V_{GS} = 0\text{V}$ , $I_D = 1.0\text{mA}$   |
| $V_{GS(th)}$ | Gate Threshold Voltage                                             | 2.0                              | 4.0  | 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   | $\mu\text{A}$    | $V_{DS} = 80\text{V}$ , $V_{GS} = 0\text{V}$  |
| $R_{DS(on)}$ | Static Drain-to-Source On-State Resistance (TO-3) <sup>2</sup>     | —                                | 45   | $\text{m}\Omega$ | $V_{GS} = 12\text{V}$ , $I_{D2} = 19\text{A}$ |
| $R_{DS(on)}$ | Static Drain-to-Source On-State Resistance (TO-257AA) <sup>2</sup> | —                                | 42   | $\text{m}\Omega$ | $V_{GS} = 12\text{V}$ , $I_{D2} = 19\text{A}$ |
| $V_{SD}$     | Diode Forward Voltage                                              | —                                | 1.2  | V                | $V_{GS} = 0\text{V}$ , $I_F = 20\text{A}$     |

<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.  $V_{DS} = 80\text{V}$  applied and  $V_{GS} = 0$  during irradiation per MIL-STD-750, Method 1019, condition A.

<sup>5</sup> Part numbers IRHYS6S7130CM, IRHYS6S3130CM

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Radiation Hardened Power MOSFET Thru-Hole (Low-Ohmic TO-257AA)

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> = -5V | V <sub>GS</sub> = -10V | V <sub>GS</sub> = -15V | V <sub>GS</sub> = -19V | V <sub>GS</sub> = -20V |
| 37.6 ± 5%                        | 391 ± 5%        | 47.6 ± 5%     | 100                  | 100                   | 100                    | 100                    | 100                    | 100                    |
| 60.3 ± 5%                        | 711 ± 5%        | 57.7 ± 7.5%   | 100                  | 100                   | 100                    | 30                     | —                      | —                      |

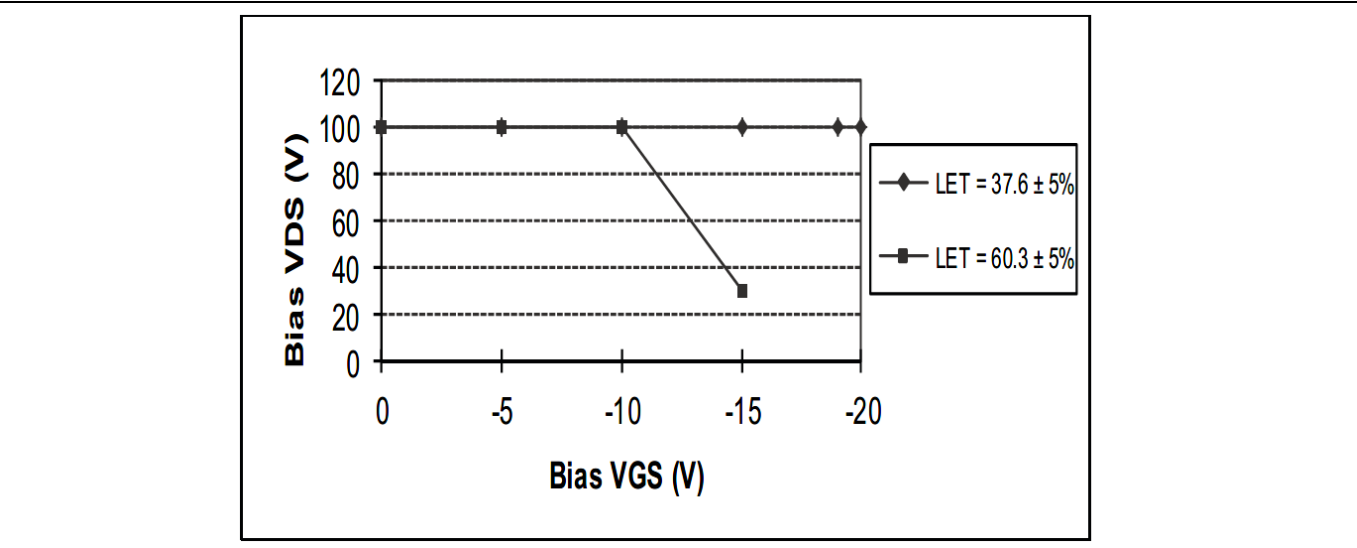


Figure 1 Typical Single Event Effect, Safe Operating Area

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## Radiation Hardened Power MOSFET Thru-Hole (Low-Ohmic TO-257AA)

### Electrical Characteristics Curves (Pre-irradiation)

### 3 Electrical Characteristics Curves (Pre-irradiation)

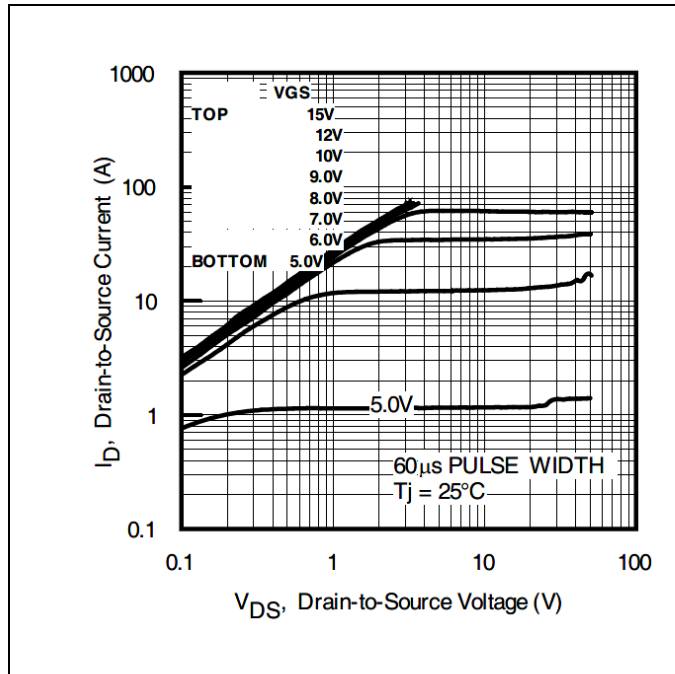


Figure 2 Typical Output Characteristics

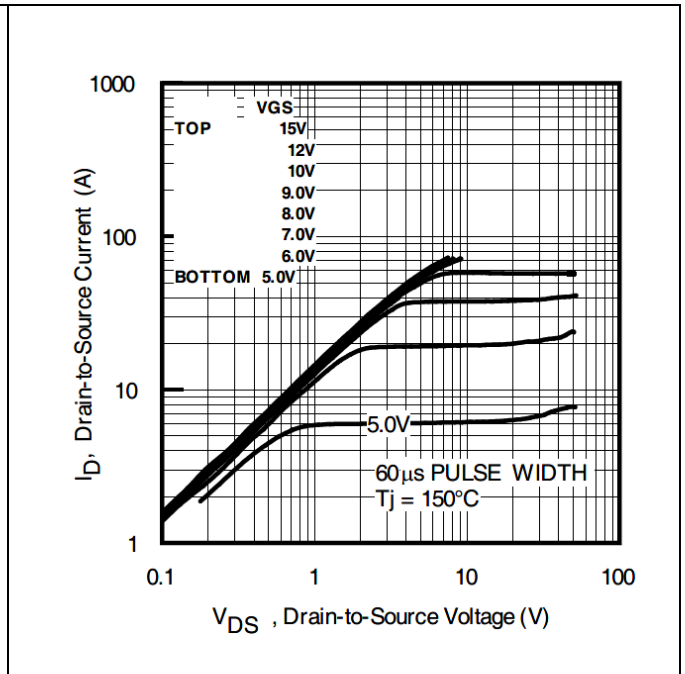


Figure 3 Typical Output Characteristics

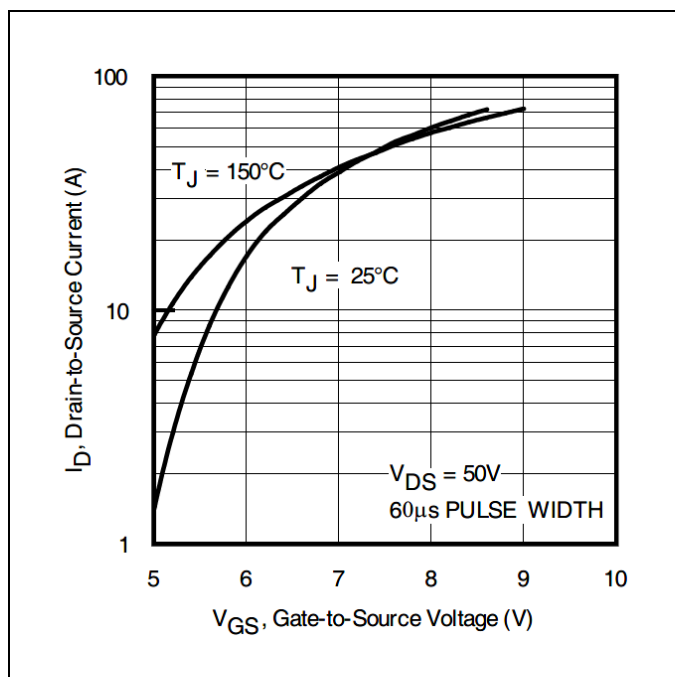


Figure 4 Typical Transfer Characteristics

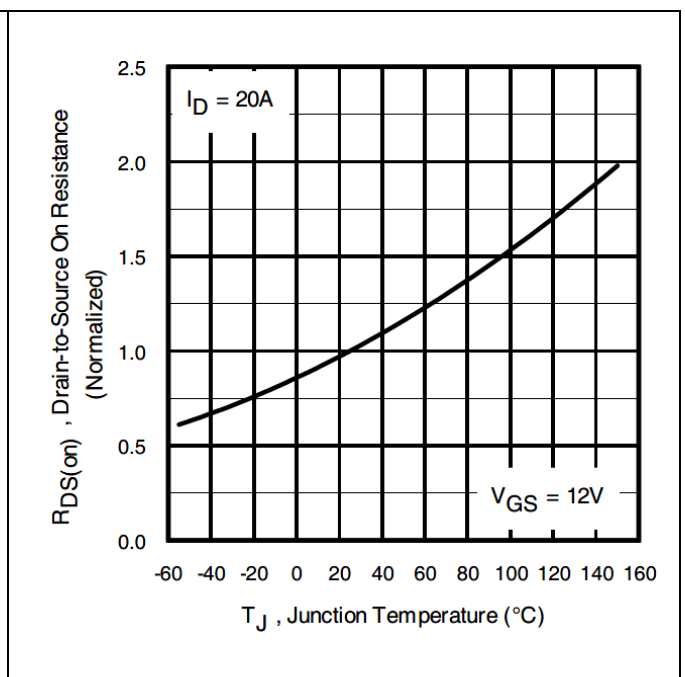
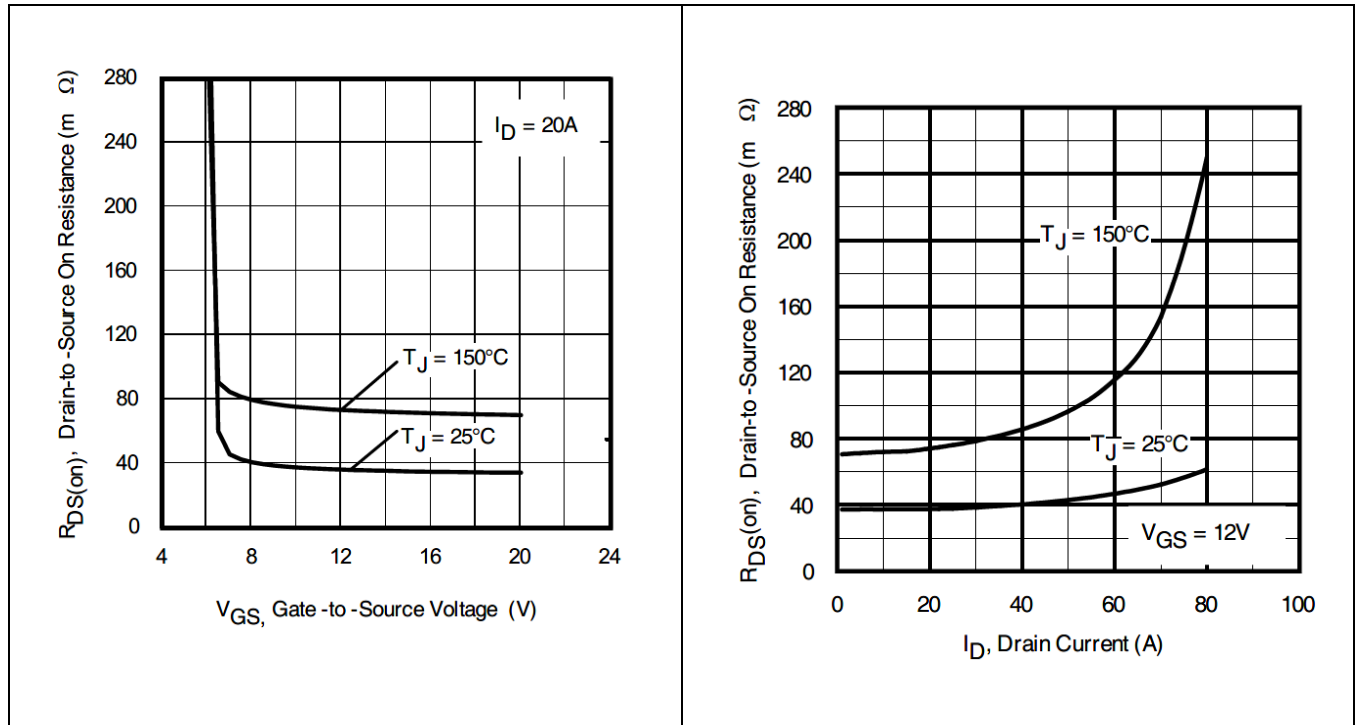


Figure 5 Normalized On-Resistance Vs. Temperature

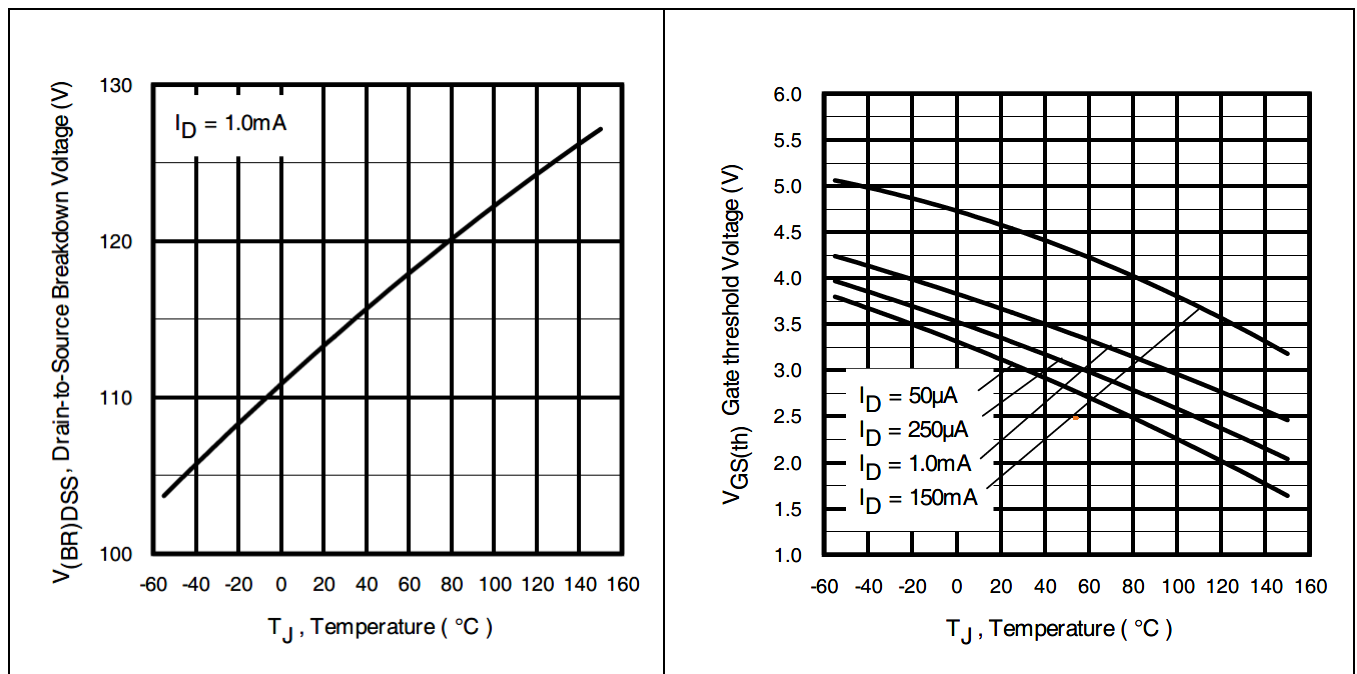
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## Radiation Hardened Power MOSFET Thru-Hole (Low-Ohmic TO-257AA)

### Electrical Characteristics Curves (Pre-irradiation)



**Figure 6 Typical On-Resistance Vs. Gate Voltage** **Figure 7 Typical On-Resistance Vs. Drain Current**



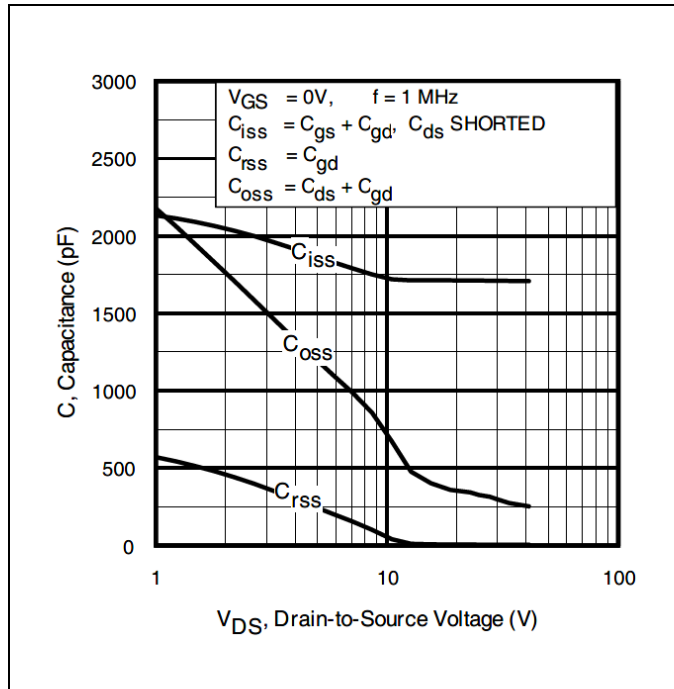
**Figure 8 Typical Drain-to-Source Breakdown Voltage vs. Temperature** **Figure 9 Typical Threshold Voltage vs. Temperature**



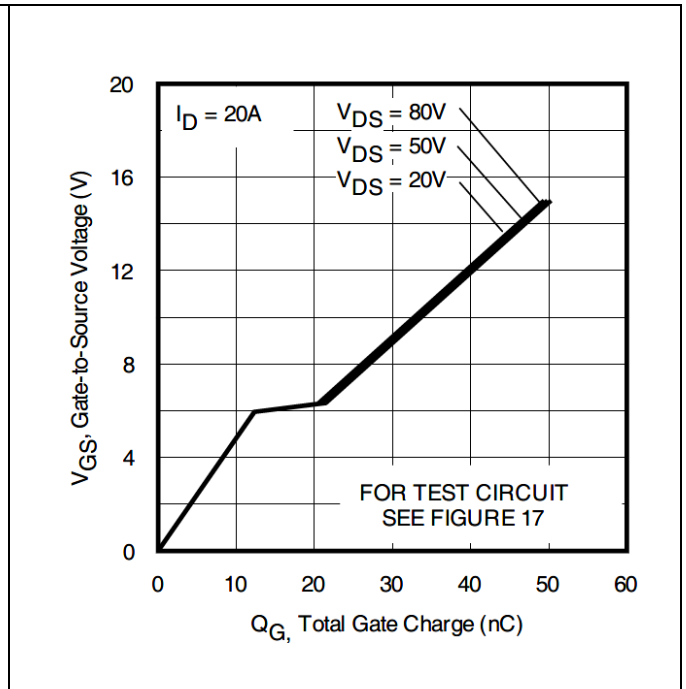
# IRHYS6S7130CM

## Radiation Hardened Power MOSFET Thru-Hole (Low-Ohmic TO-257AA)

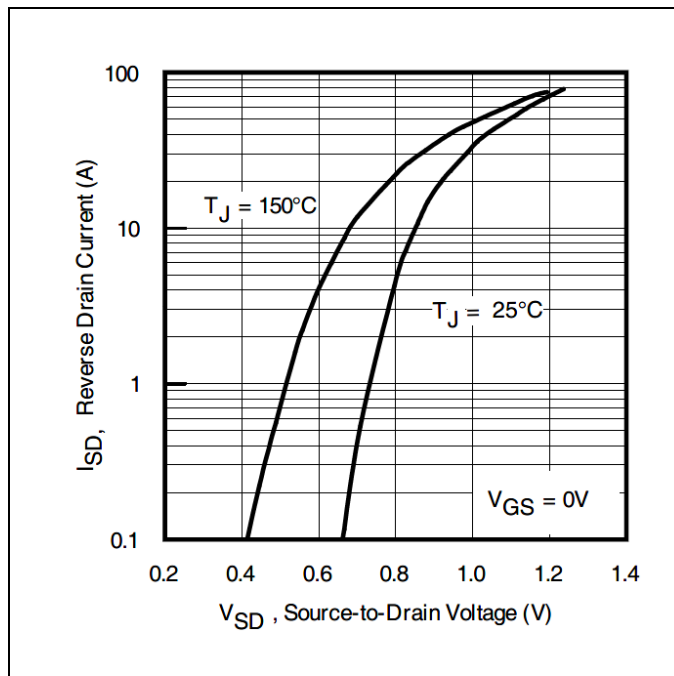
### Electrical Characteristics Curves (Pre-irradiation)



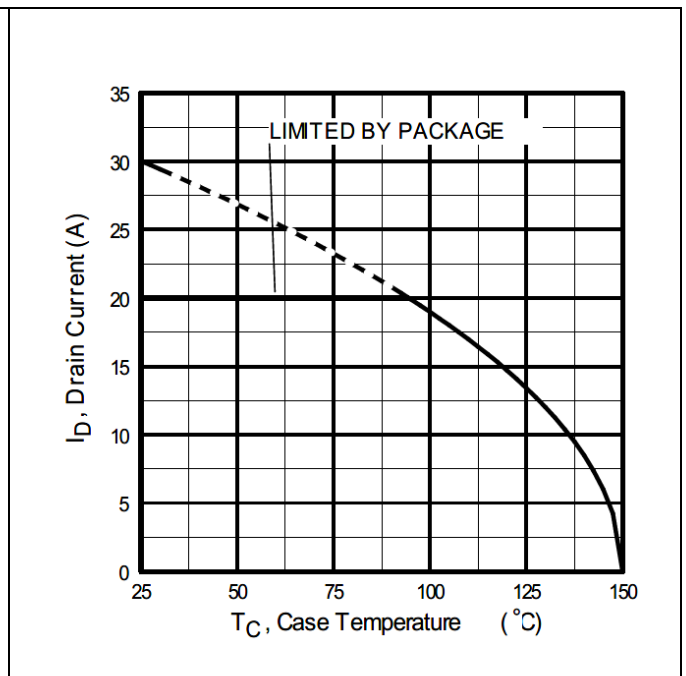
**Figure 10** Typical Capacitance Vs. Drain-to-Source Voltage



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



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

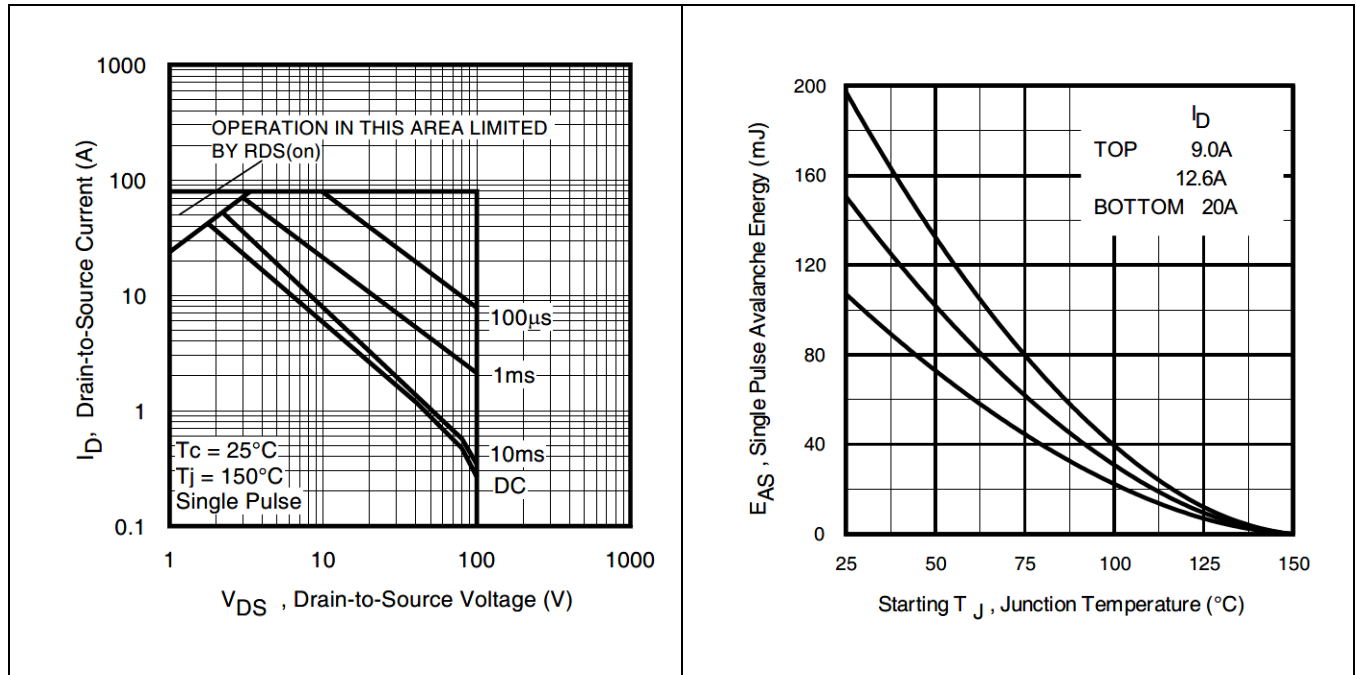


**Figure 13** Maximum Drain Current Vs. Case Temperature

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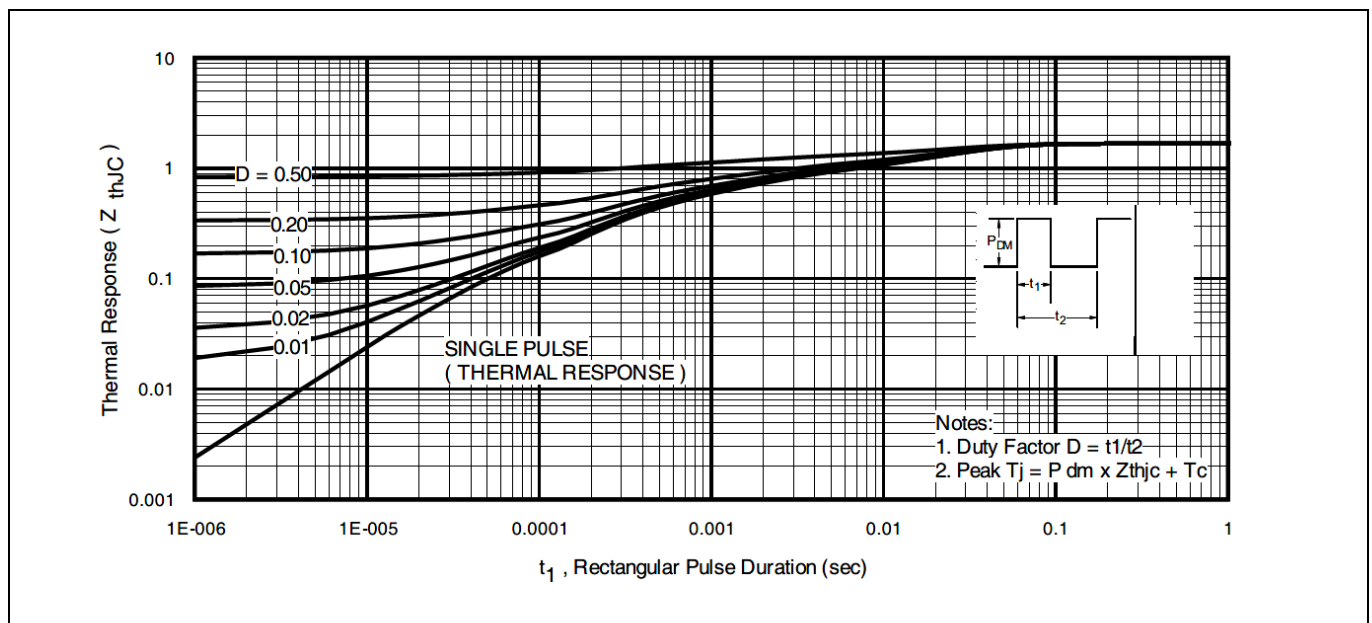
## Radiation Hardened Power MOSFET Thru-Hole (Low-Ohmic TO-257AA)

### Electrical Characteristics Curves (Pre-irradiation)



**Figure 14 Maximum Safe Operating Area**

**Figure 15 Maximum Avalanche Energy Vs. Junction Temperature**



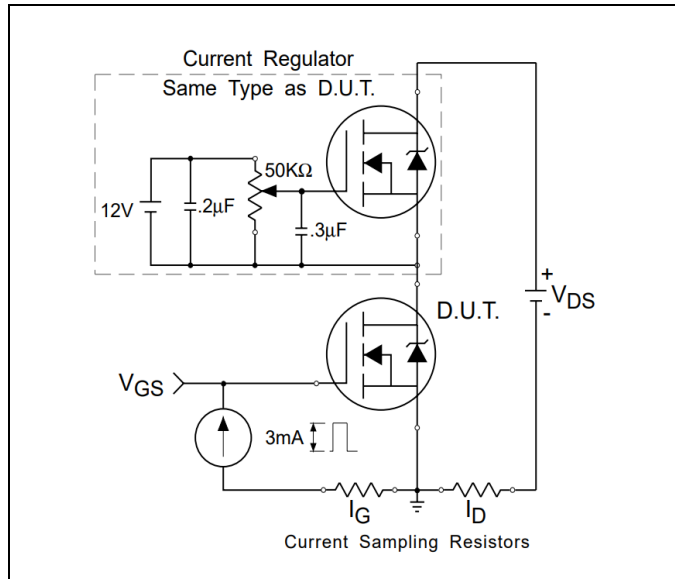
**Figure 16 Maximum Effective Transient Thermal Impedance, Junction-to-Case**

# IRHYS6S7130CM

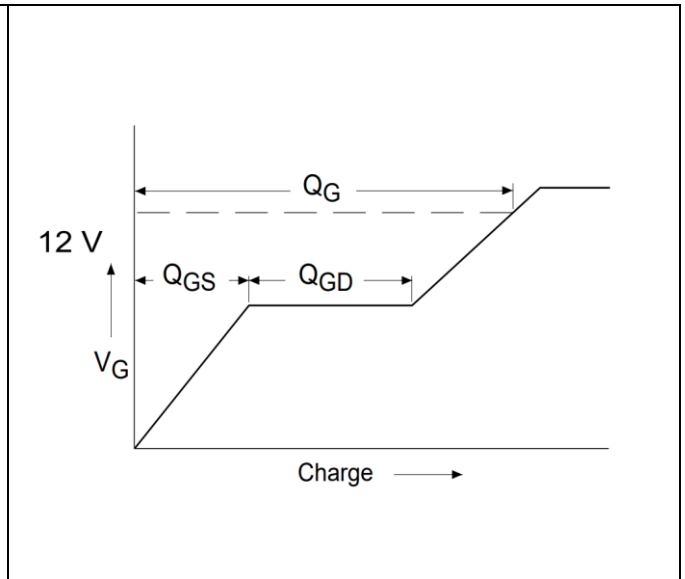
## Radiation Hardened Power MOSFET Thru-Hole (Low-Ohmic TO-257AA)

### Test Circuits (Pre-irradiation)

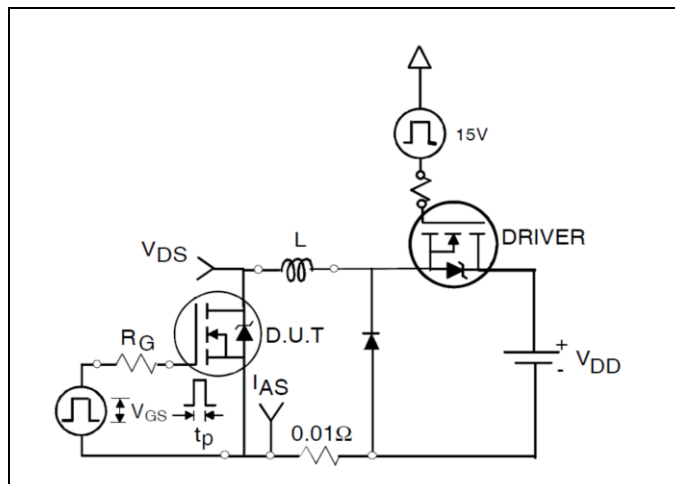
## 4 Test Circuits (Pre-irradiation)



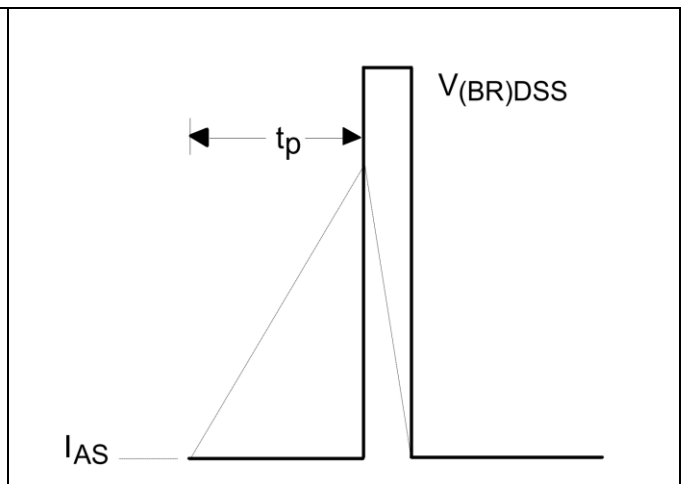
**Figure 17 Gate Charge Test Circuit**



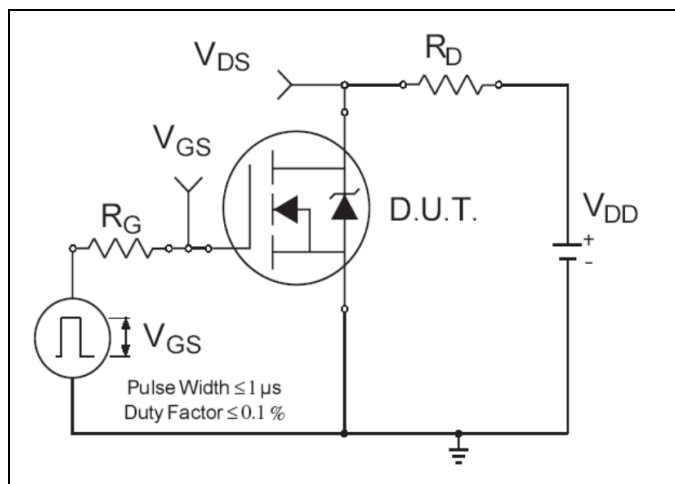
**Figure 18 Gate Charge Waveform**



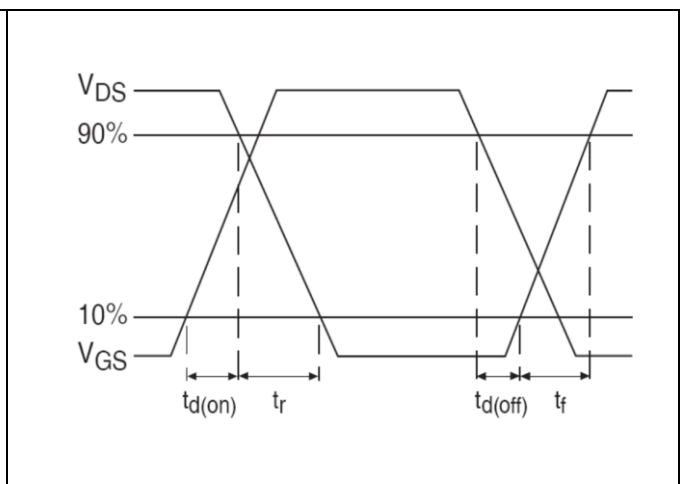
**Figure 19 Unclamped Inductive Test Circuit**



**Figure 20 Unclamped Inductive Waveform**



**Figure 21 Switching Time Test Circuit**



**Figure 22 Switching Time Waveforms**

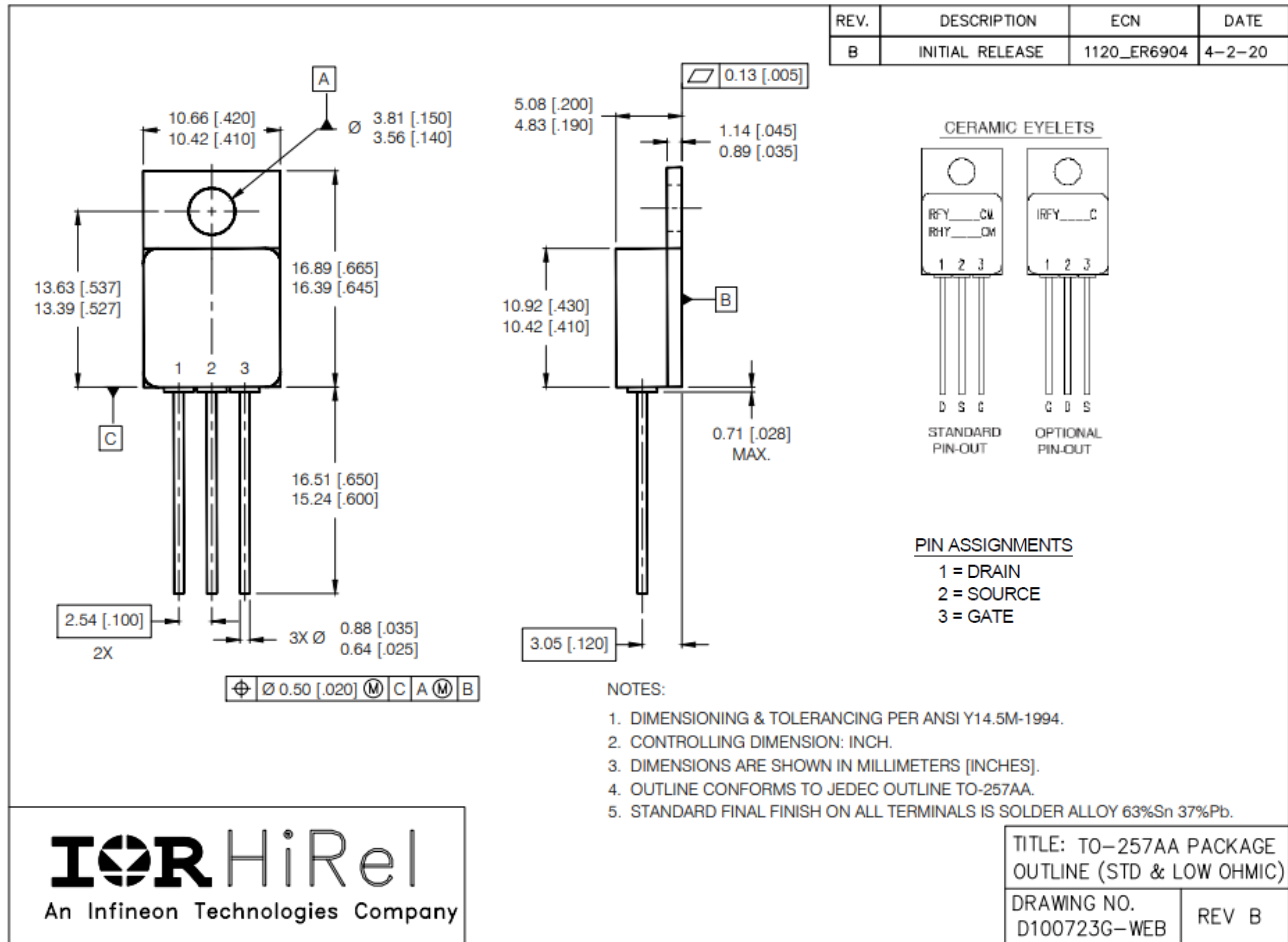
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## Radiation Hardened Power MOSFET Thru-Hole (Low-Ohmic TO-257AA)

### Package Outline

## 5 Package Outline

Note: For the most updated package outline, please see the website: [Low-Ohmic TO-257AA](#)



### 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.

# IRHYS6S7130CM

## Radiation Hardened Power MOSFET Thru-Hole (Low-Ohmic TO-257AA)

### Revision history

### Revision history

| Document version | Date of release | Description of changes          |
|------------------|-----------------|---------------------------------|
|                  | 03/01/2017      | Datasheet (PD-97863)            |
| Rev A            | 07/12/2024      | Updated based on ECN-1120_09980 |

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