

# IRHYS9A97130CM, IRHYB9A97130CM

PD-97957A

## Radiation Hardened Power MOSFET -100V, -23A, P-channel, R9 Technology

### Features

- Single event effect (SEE) hardened (up to LET of 91.2 MeV·cm<sup>2</sup>/mg)
- Low  $R_{DS(on)}$
- Rugged SOA
- Improved avalanche energy
- Simple drive requirements
- Hermetically sealed
- Electrically isolated case
- Ceramic eyelets (Low-Ohmic TO-257AA)
- Light weight
- ESD rating: class 2 per MIL-STD-750, Method 1020

### Potential Applications

- DC-DC converter
- Motor drives
- Latching current limiter

### Product Validation

Qualified according to MIL-PRF-19500 for space applications

### Description

IR HiRel R9 technology provides superior power MOSFETs for space applications. This family of p-channel MOSFETs are the first radiation hardened devices that are based on a superjunction technology. These devices have improved immunity to Single Event Effect (SEE) and have been characterized for useful performance with Linear Energy Transfer (LET) up to 91.2 MeV·cm<sup>2</sup>/mg. Their combination of low  $R_{DS(on)}$  and improved SOA allows for better performance in applications such as Latching Current Limiters (LCL), Solid-State Power Controllers (SSPC) or DC-DC converters. These devices retain all of the well-established advantages of MOSFETs such as voltage control, fast switching and temperature stability of electrical parameters.

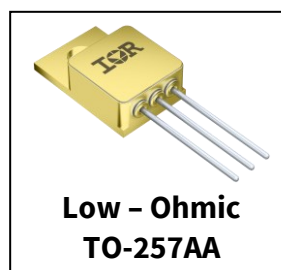
### Ordering Information

**Table 1**      **Ordering options**

Part number	Package	Screening Level	TID Level
IRHYS9A97130CM	Low-Ohmic TO-257AA	COTS	100 krad(Si)
JANSR2N7660T3	Low-Ohmic TO-257AA	JANS	100 krad(Si)
IRHYS9A93130CM	Low-Ohmic TO-257AA	COTS	300 krad(Si)
JANSF2N7660T3	Low-Ohmic TO-257AA	JANS	300 krad(Si)
IRHYB9A97130CM	Tabless TO-257AA	COTS	100 krad(Si)
JANSR2N7660D5	Tabless TO-257AA	JANS	100 krad(Si)
IRHYB9A93130CM	Tabless TO-257AA	COTS	300 krad(Si)
JANSF2N7660D5	Tabless TO-257AA	JANS	300 krad(Si)

### Product Summary

- **$BV_{DSS}$** : -100V
- **$I_D$** : -23A
- **$R_{DS(on), max}$** : 76mΩ
- **$Q_{Gmax}$** : 50nC
- **REF**: MIL-PRF-19500/780



## Table of contents

## Table of contents

<b>Features .....</b>	<b>1</b>
<b>Potential Applications.....</b>	<b>1</b>
<b>Product Validation.....</b>	<b>1</b>
<b>Ordering Information.....</b>	<b>1</b>
<b>Table of contents.....</b>	<b>2</b>
<b>1 Absolute Maximum Ratings .....</b>	<b>3</b>
<b>2 Device Characteristics .....</b>	<b>4</b>
2.1 Electrical Characteristics (Pre-Irradiation).....	4
2.2 Source-Drain Diode Ratings and Characteristics (Pre-Irradiation) .....	5
2.3 Thermal Characteristics .....	5
2.4 Radiation Characteristics.....	5
2.4.1 Electrical Characteristics - Post Total Dose Irradiation .....	5
2.4.2 Single Event Effects – Safe Operating Area .....	6
<b>3 Electrical Characteristics Curves (Pre-irradiation) .....</b>	<b>7</b>
<b>4 Test Circuits (Pre-irradiation) .....</b>	<b>11</b>
<b>5 Package Outline (Low-Ohmic TO-257AA).....</b>	<b>12</b>
<b>6 Package Outline (Tabless TO-257AA) .....</b>	<b>13</b>
<b>Revision history.....</b>	<b>14</b>

## 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	-23	A
$I_{D2} @ V_{GS} = -12V, T_C = 100^{\circ}C$	Continuous Drain Current	-15	A
$I_{DM} @ T_C = 25^{\circ}C$	Pulsed Drain Current <sup>1</sup>	-92	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>	1045	mJ
$I_{AR}$	Avalanche Current <sup>1</sup>	-15	A
$E_{AR}$	Repetitive Avalanche Energy <sup>1</sup>	7.5	mJ
$dv/dt$	Peak Diode Reverse Recovery <sup>3</sup>	-11.6	V/ns
$T_J$ $T_{STG}$	Operating Junction and Storage Temperature Range	-55 to +150	$^{\circ}C$
	Lead Temperature	300 (0.063in./1.6mm from case for 10s)	
	Weight	4.3 (Typical)	

<sup>1</sup> Repetitive Rating; Pulse width limited by maximum junction temperature.<sup>2</sup>  $V_{DD} = -100V$ , starting  $T_J = 25^{\circ}C$ ,  $L = 9.3mH$ , Peak  $I_L = -15A$ ,  $V_{GS} = -20V$ <sup>3</sup>  $I_{SD} \leq -23A$ ,  $di/dt \leq -990A/\mu s$ ,  $V_{DD} \leq -100V$ ,  $T_J \leq 150^{\circ}C$

## 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	—	-0.10	—	V/ $^\circ\text{C}$	Reference to $25^\circ\text{C}$ , $I_D = -1.0mA$
$R_{DS(on)}$	Static Drain-to-Source On-State Resistance	—	—	76	m $\Omega$	$V_{GS} = -12V, I_{D2} = -15A^1$
$V_{GS(th)}$	Gate Threshold Voltage	-2.0	—	-4.0	V	$V_{DS} \geq V_{GS}, I_D = -1mA$
$\Delta V_{GS(th)}/\Delta T_J$	Gate Threshold Voltage Coefficient	—	5.3	—	mV/ $^\circ\text{C}$	
$G_{fs}$	Forward Transconductance	12	—	—	S	$V_{DS} = -15V, I_{D2} = -15A^1$
$I_{DSS}$	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	$I_{D1} = -23A$
$Q_{GS}$	Gate-to-Source Charge	—	—	16		$V_{DS} = -50V$
$Q_{GD}$	Gate-to-Drain ('Miller') Charge	—	—	12		$V_{GS} = -12V$
$t_{d(on)}$	Turn-On Delay Time	—	—	21	ns	$I_{D1} = -23A^{**}$ $V_{DD} = -50V$ $R_G = 7.5\Omega$ $V_{GS} = -12V$
$t_r$	Rise Time	—	—	60		
$t_{d(off)}$	Turn-Off Delay Time	—	—	68		
$t_f$	Fall Time	—	—	38		
$L_s + L_D$	Total Inductance	—	6.8	—	nH	Measured from Drain lead (6mm /0.25in. from package) to Source lead (6mm /0.25in. from package) with Source wires internally bonded from Source Pin to Drain Pad
$C_{iss}$	Input Capacitance	—	2490	—	pF	$V_{GS} = 0V$
$C_{oss}$	Output Capacitance	—	490	—		$V_{DS} = -25V$
$C_{rss}$	Reverse Transfer Capacitance	—	6.6	—		$f = 1.0MHz$
$R_G$	Gate Resistance	—	5.6	—	$\Omega$	$f = 1.0MHz$ , 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)	—	—	-23	A	
I <sub>SM</sub>	Pulsed Source Current (Body Diode) <sup>1</sup>	—	—	-92	A	
V <sub>SD</sub>	Diode Forward Voltage	—	—	-1.3	V	T <sub>J</sub> = 25°C, I <sub>S</sub> = -23A, V <sub>GS</sub> = 0V <sup>2</sup>
t <sub>rr</sub>	Reverse Recovery Time	—	75	113	ns	T <sub>J</sub> = 25°C, I <sub>F</sub> = -23A, V <sub>DD</sub> ≤ -25V di/dt = -100A/μs <sup>2</sup>
Q <sub>rr</sub>	Reverse Recovery Charge	—	255	—	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	—	—	1.67	$^\circ\text{C}/\text{W}$
$R_{\theta JA}$	Junction-to-Ambient	—	—	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 300krads (Si) <sup>5</sup>		Unit	Test Conditions
		Min.	Max.		
$BV_{DSS}$	Drain-to-Source Breakdown Voltage	-100	—	V	$V_{GS} = 0\text{V}$ , $I_D = -1\text{mA}$
$V_{GS(th)}$	Gate Threshold Voltage	-2.0	-4.0	V	$V_{DS} \geq V_{GS}$ , $I_D = -1\text{mA}$
$I_{GSS}$	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>	—	73	$\text{m}\Omega$	$V_{GS} = -12\text{V}$ , $I_{D2} = -15\text{A}$
$R_{DS(on)}$	Static Drain-to-Source On-State Resistance (Low-Ohmic TO-257AA) <sup>2</sup>	—	76	$\text{m}\Omega$	$V_{GS} = -12\text{V}$ , $I_{D2} = -15\text{A}$
$V_{SD}$	Diode Forward Voltage	—	-1.3	V	$V_{GS} = 0\text{V}$ , $I_F = -23\text{A}$

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

<sup>2</sup> Pulse width  $\leq 300\text{ }\mu\text{s}$ ; 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 IRHYS9A97130CM (JANSR2N7660T3), IRHYS9A93130CM (JANSF2N7660T3), IRHYB9A97130CM (JANSR2N7660D5), and IRHYB9A93130CM (JANSF2N7660D5)

## 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 (MeV·cm <sup>2</sup> /mg)	Energy (MeV)	Range (μm)	V <sub>DS</sub> (V)			
			V <sub>GS</sub> = 0V	V <sub>GS</sub> = 1V	V <sub>GS</sub> = 5V	V <sub>GS</sub> = 10V
38.5 ± 2%	336.5 ± 5%	41.4 ± 5%	-100	-100	-100	-100
61.3 ± 2%	623.5 ± 5%	51.5 ± 5%	-100	-100	-100	—
91.2 ± 2%	1322.5 ± 5%	72.9 ± 5%	-100	-100	—	—

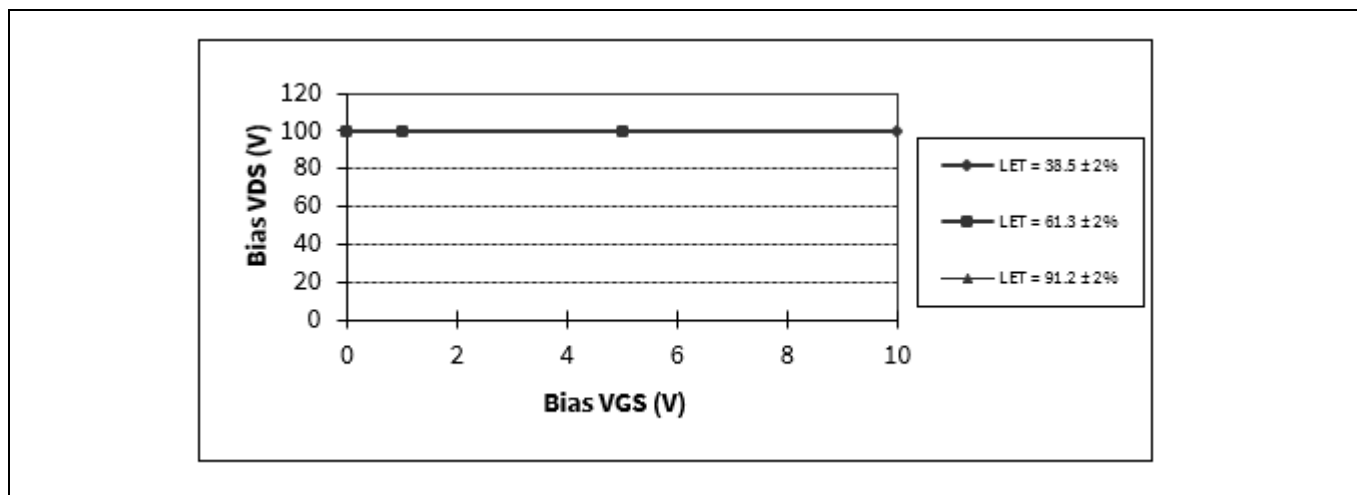


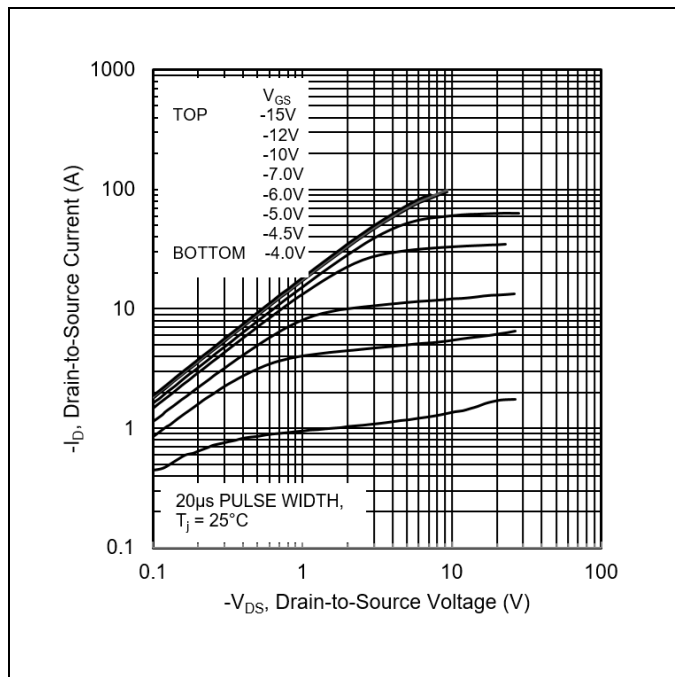
Figure 1 Typical Single Event Effect, Safe Operating Area

# IRHYS9A97130CM, IRHYB9A97130CM

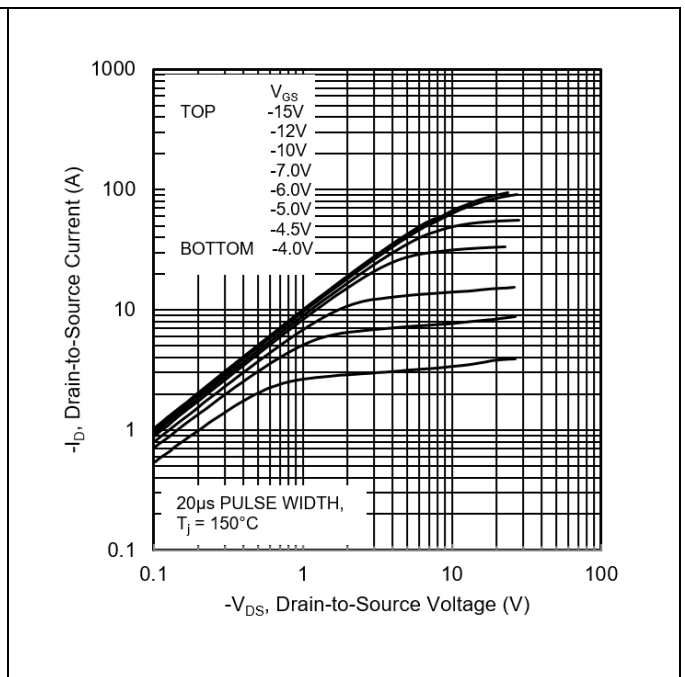
## Radiation Hardened Power MOSFET Thru-Hole (TO-257AA)

### Electrical Characteristics Curves (Pre-irradiation)

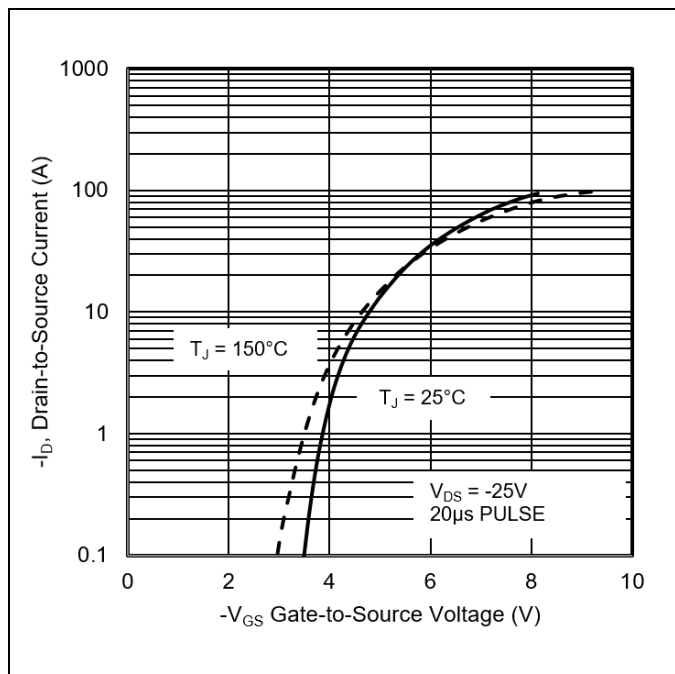
### 3 Electrical Characteristics Curves (Pre-irradiation)



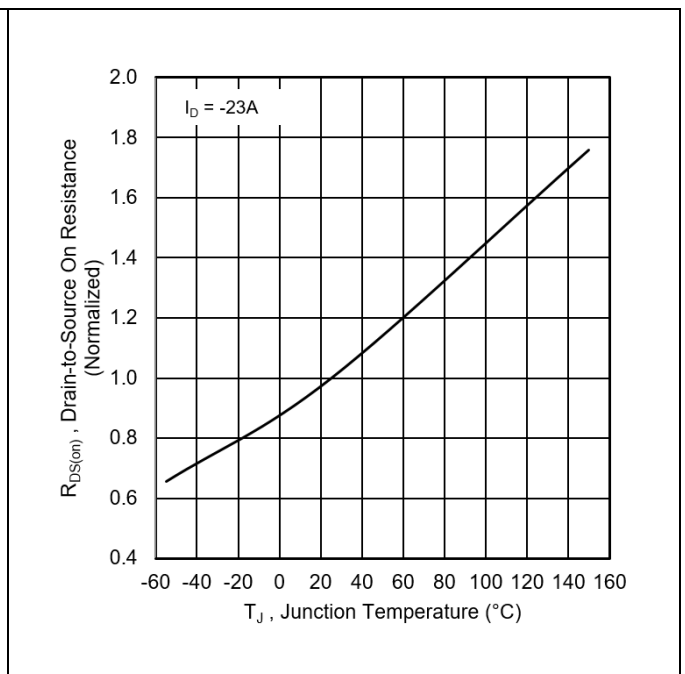
**Figure 2** Typical Output Characteristics



**Figure 3** Typical Output Characteristics



**Figure 4** Typical Transfer Characteristics

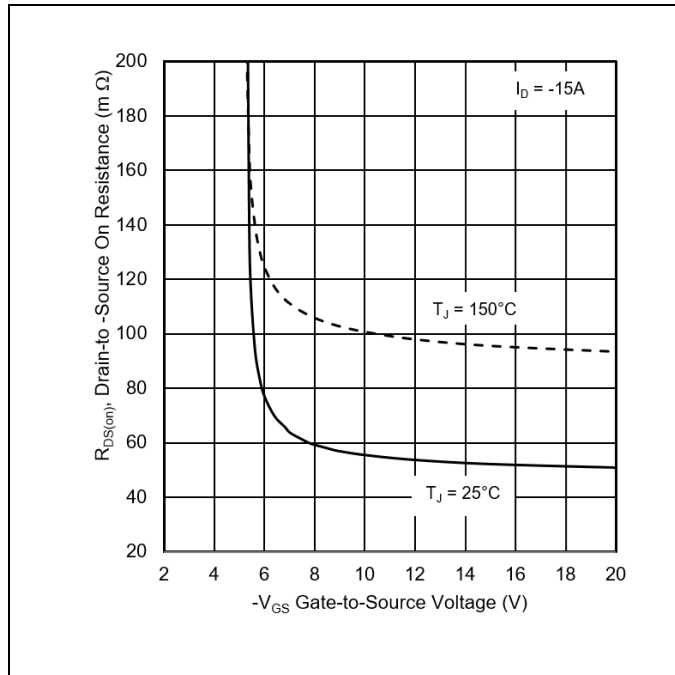


**Figure 5** Normalized On-Resistance Vs. Temperature

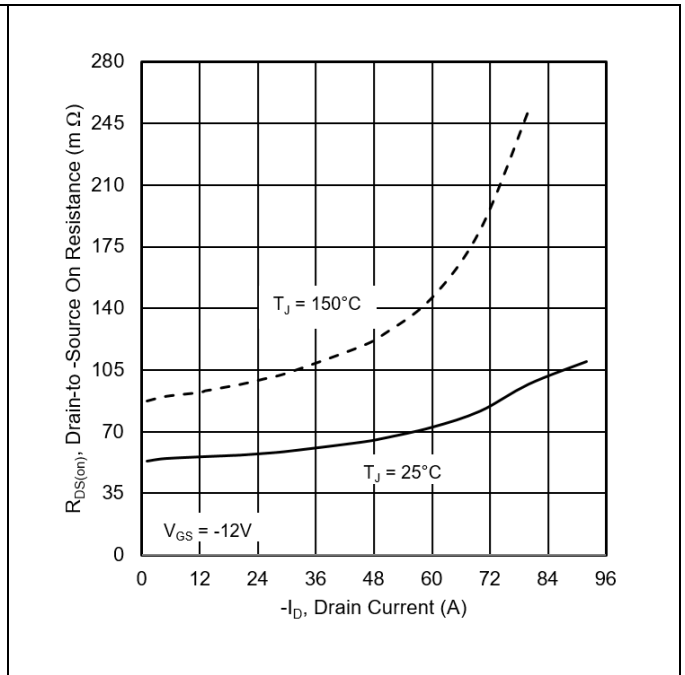
# IRHYS9A97130CM, IRHYB9A97130CM

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

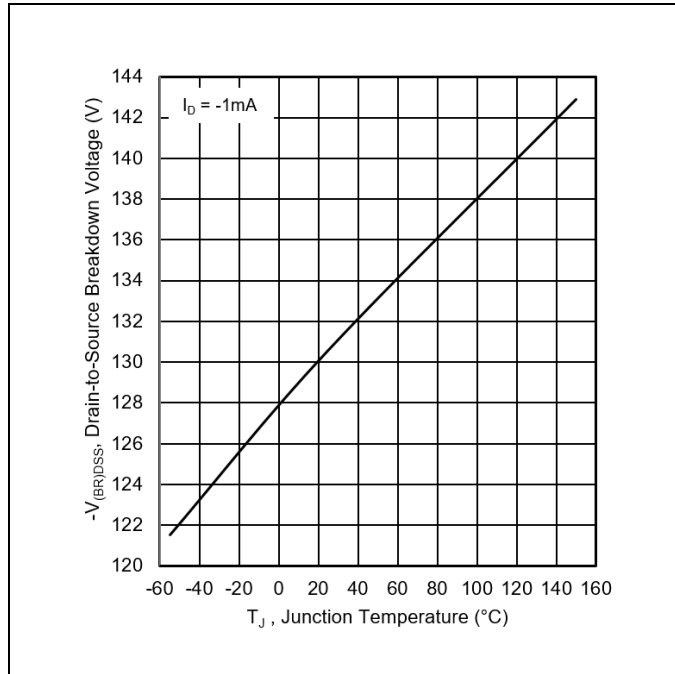
### Electrical Characteristics Curves (Pre-irradiation)



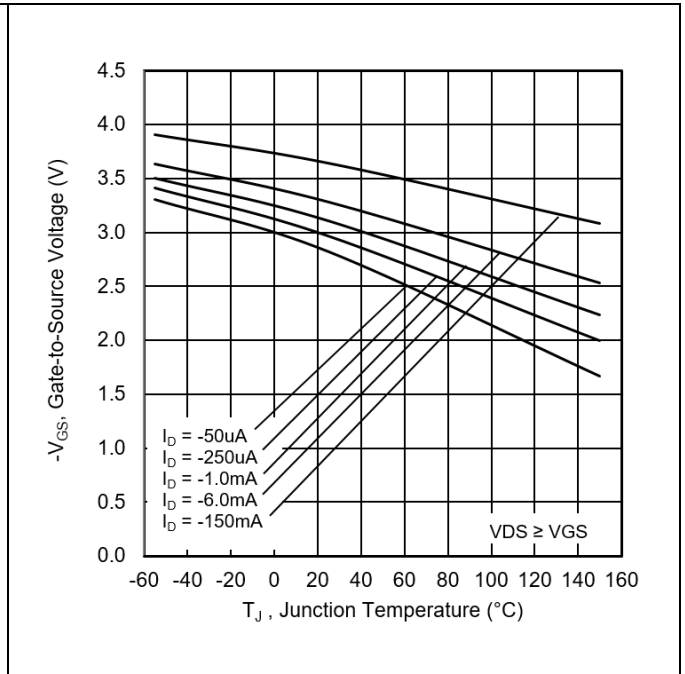
**Figure 6** Typical On-Resistance Vs. Gate Voltage



**Figure 7** Typical On-Resistance Vs. Drain Current



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



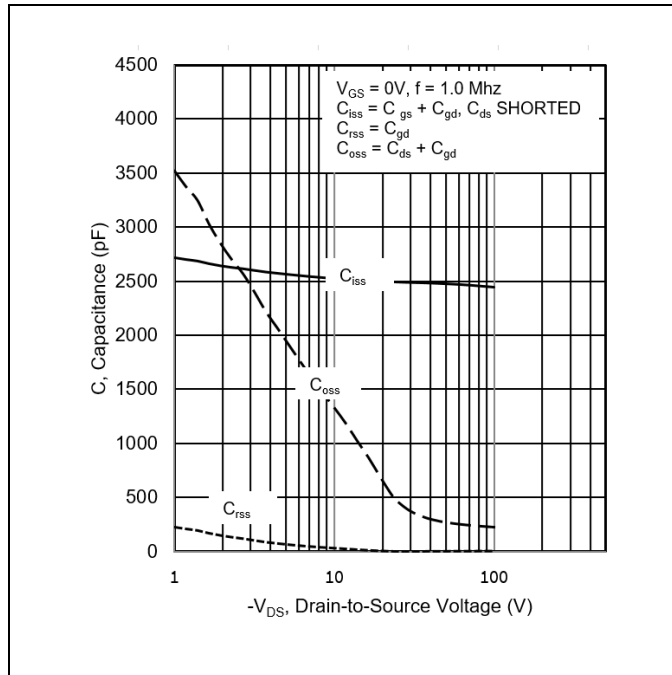
**Figure 9** Typical Threshold Voltage Vs. Temperature



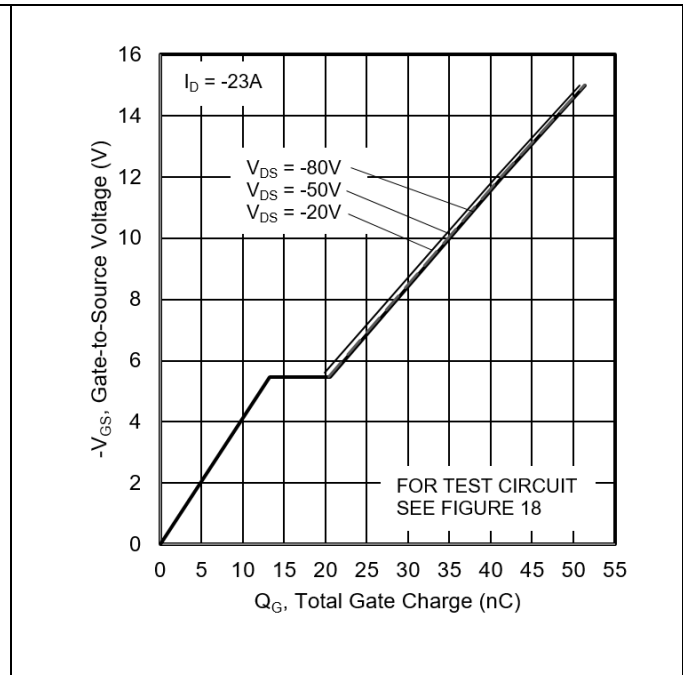
# IRHYS9A97130CM, IRHYB9A97130CM

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

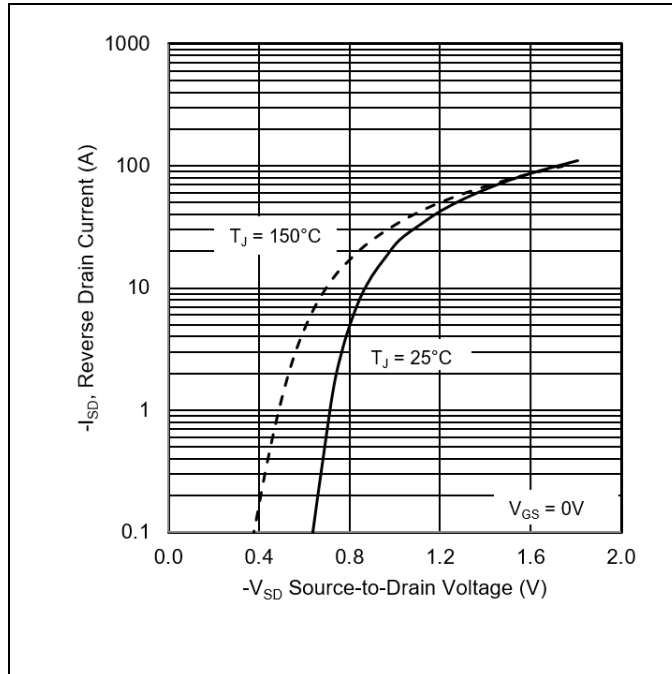
### Electrical Characteristics Curves (Pre-irradiation)



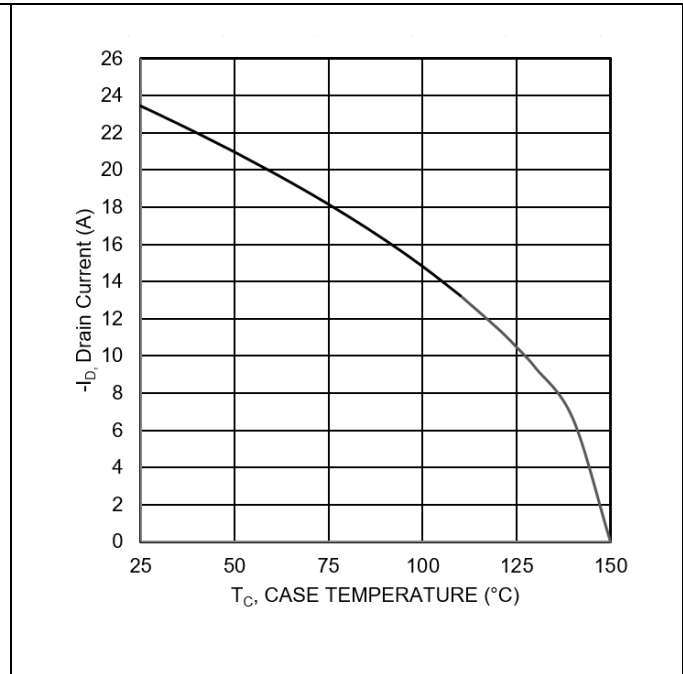
**Figure 10** Typical Capacitance Vs. Drain-to-Source Voltage



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



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

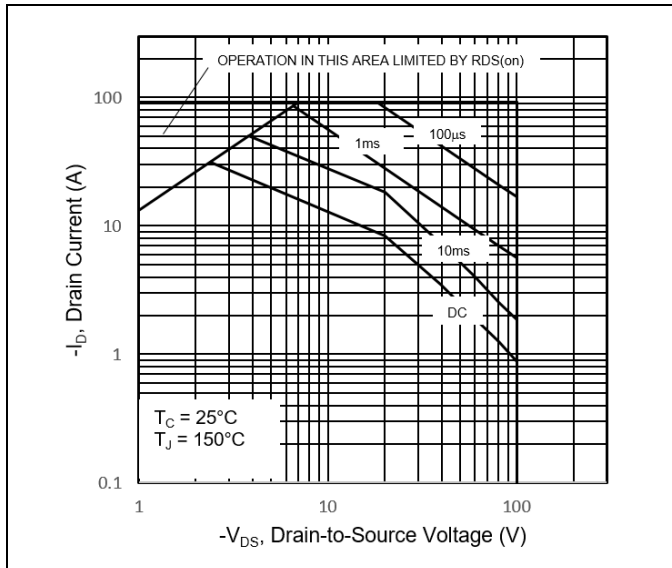


**Figure 13** Maximum Drain Current Vs. Case Temperature

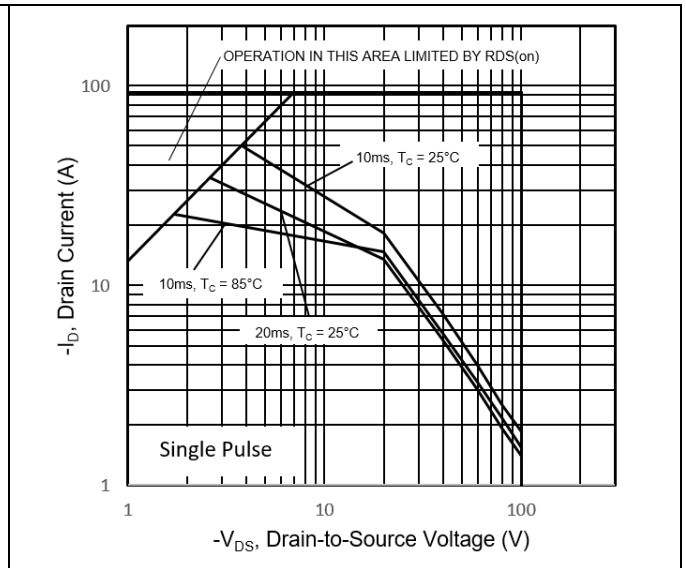
# IRHYS9A97130CM, IRHYB9A97130CM

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

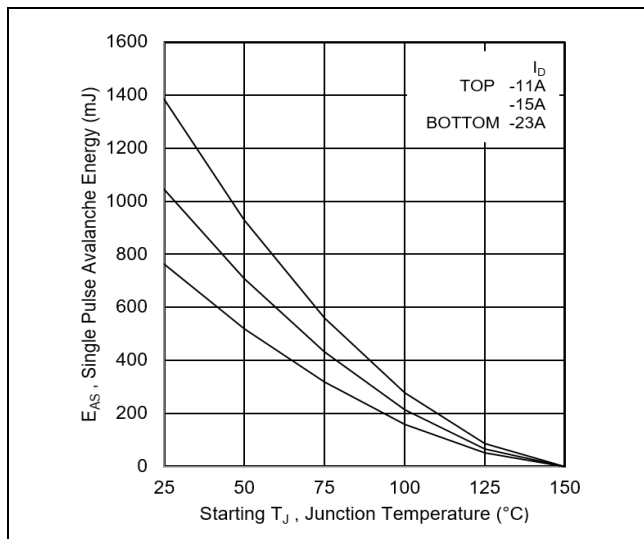
### Electrical Characteristics Curves (Pre-irradiation)



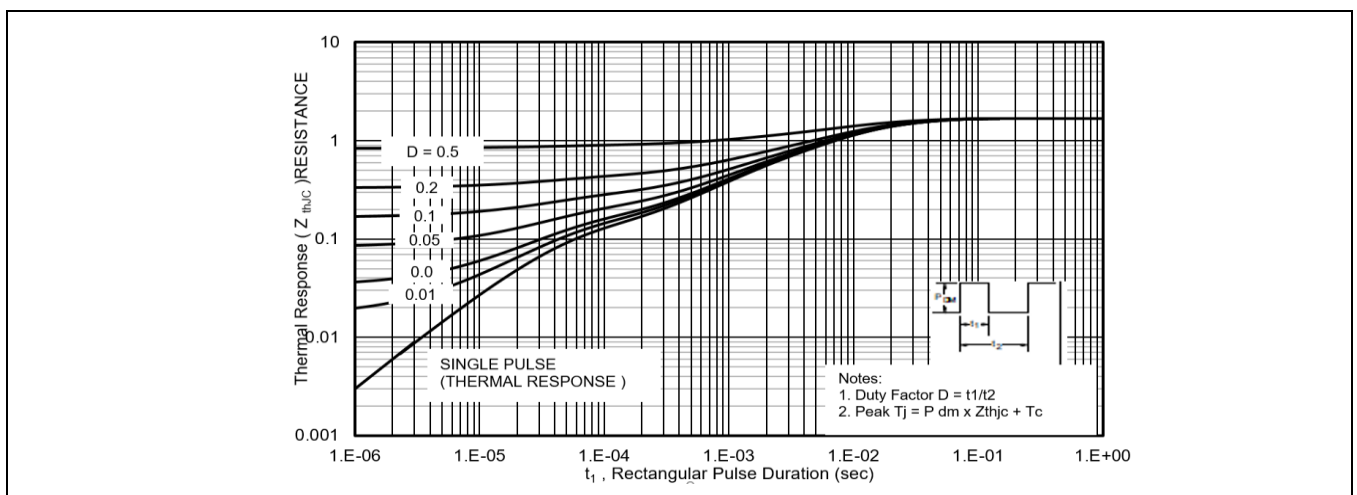
**Figure 14 Maximum Safe Operating Area**



**Figure 15 Maximum Safe Operating Area**



**Figure 16 Maximum Avalanche Energy Vs. Junction Temperature**



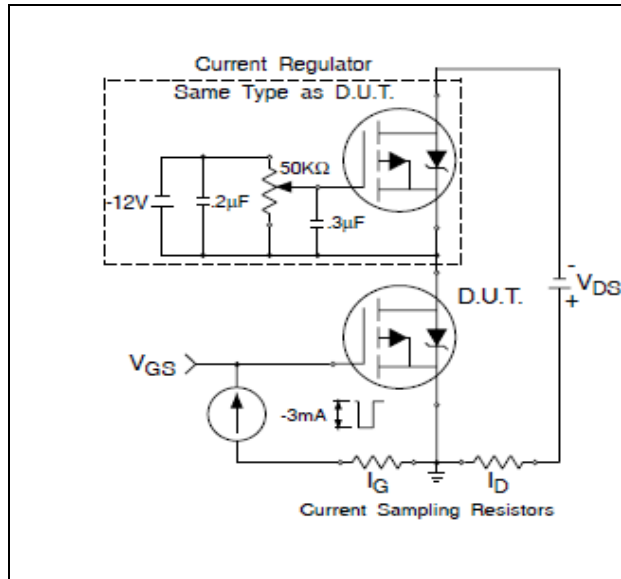
**Figure 17 Maximum Effective Transient Thermal Impedance, Junction-to-Case**

# IRHYS9A97130CM, IRHYB9A97130CM

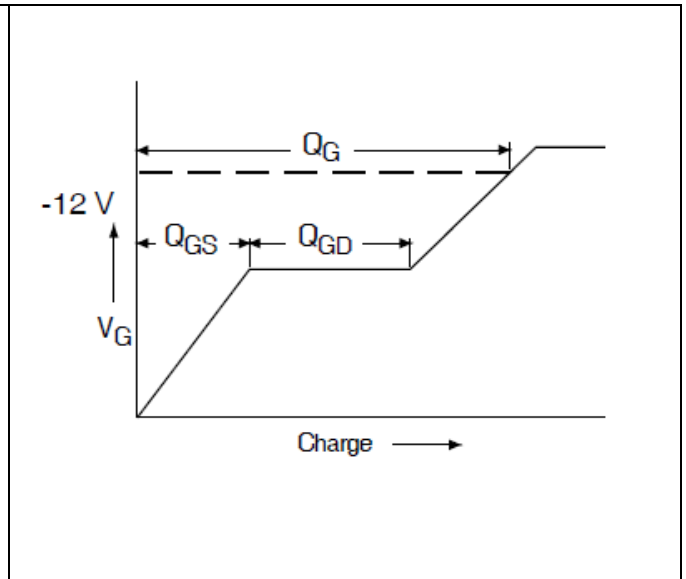
## Radiation Hardened Power MOSFET Thru-Hole (TO-257AA)

### Test Circuits (Pre-irradiation)

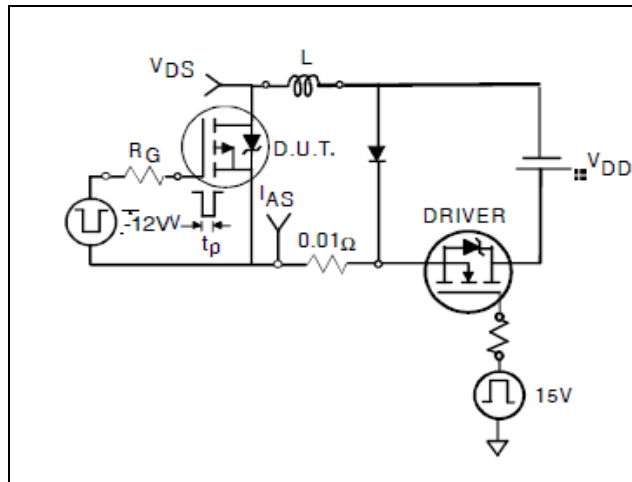
## 4 Test Circuits (Pre-irradiation)



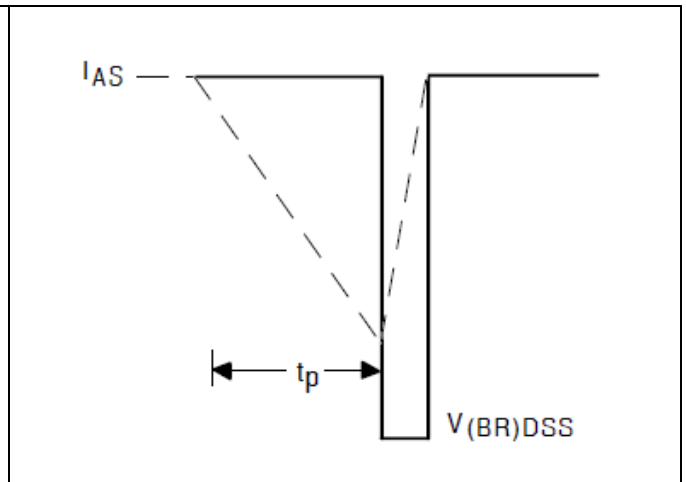
**Figure 18 Gate Charge Test Circuit**



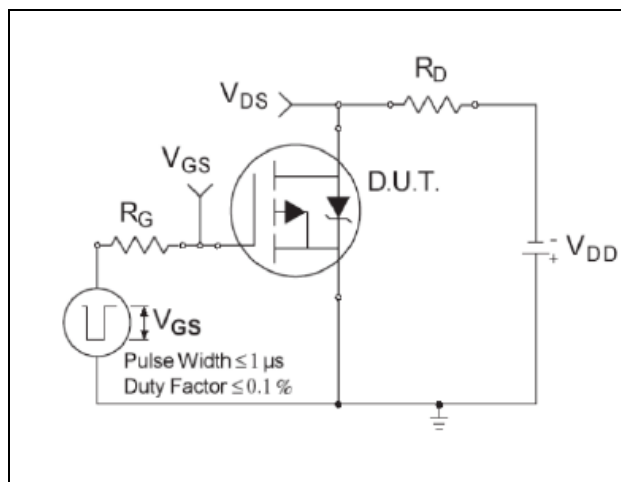
**Figure 19 Gate Charge Waveform**



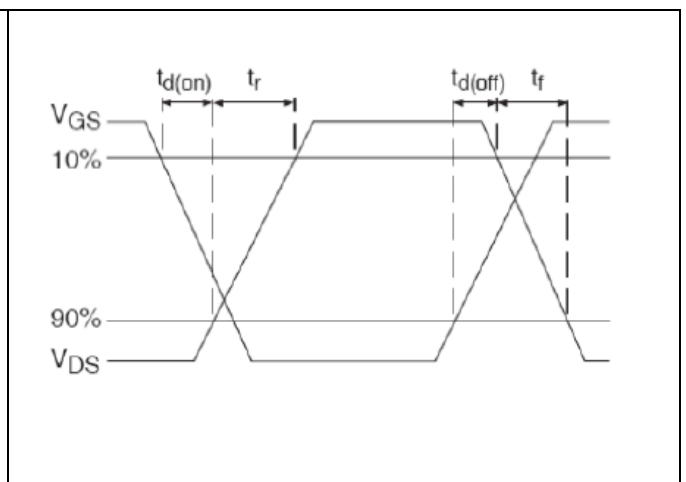
**Figure 20 Unclamped Inductive Test Circuit**



**Figure 21 Unclamped Inductive Waveform**



**Figure 22 Switching Time Test Circuit**



**Figure 23 Switching Time Waveforms**

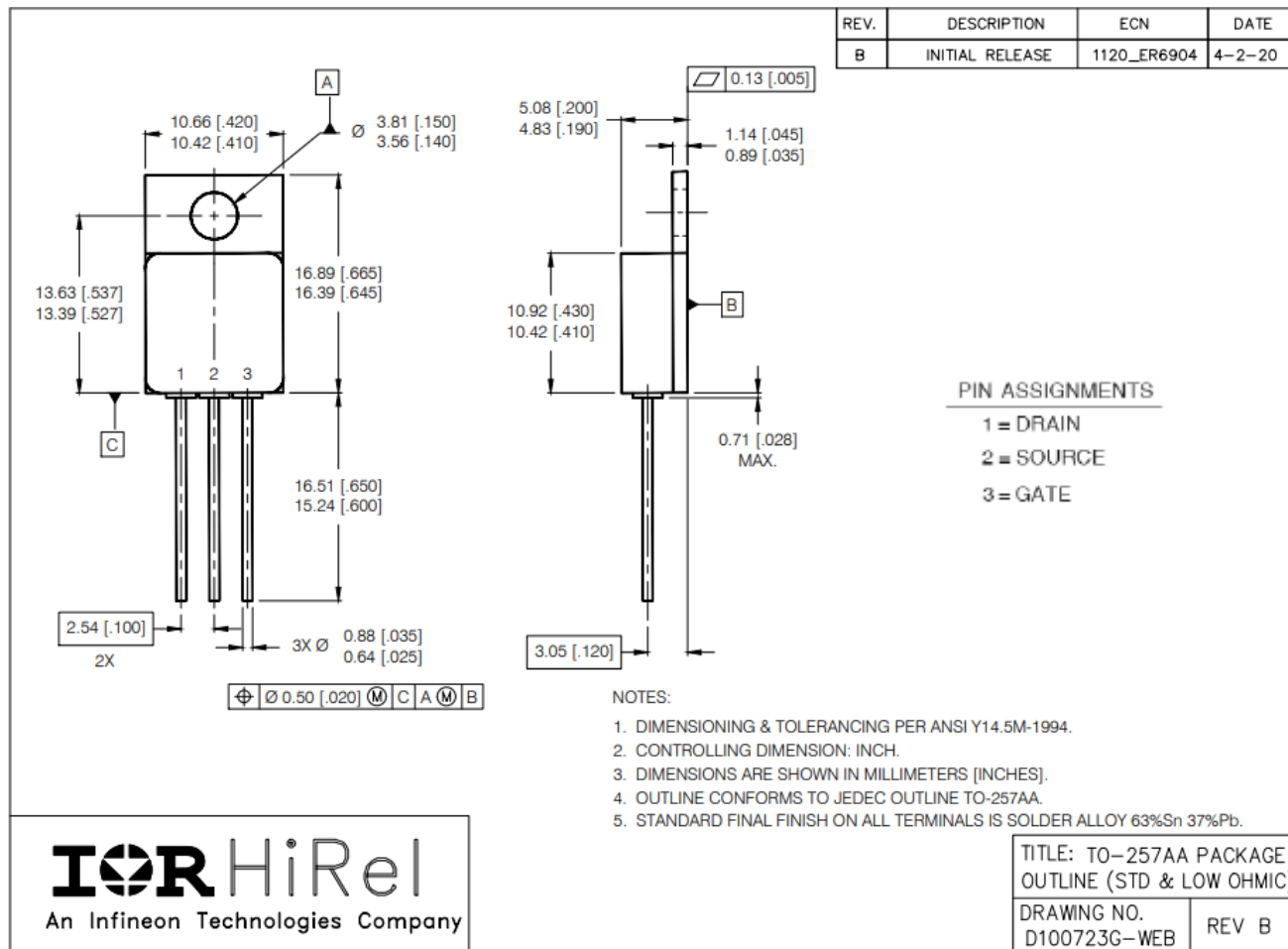
# IRHYS9A97130CM, IRHYB9A97130CM

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

### Package Outline (Low-Ohmic TO-257AA)

## 5 Package Outline (Low-Ohmic TO-257AA)

**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.

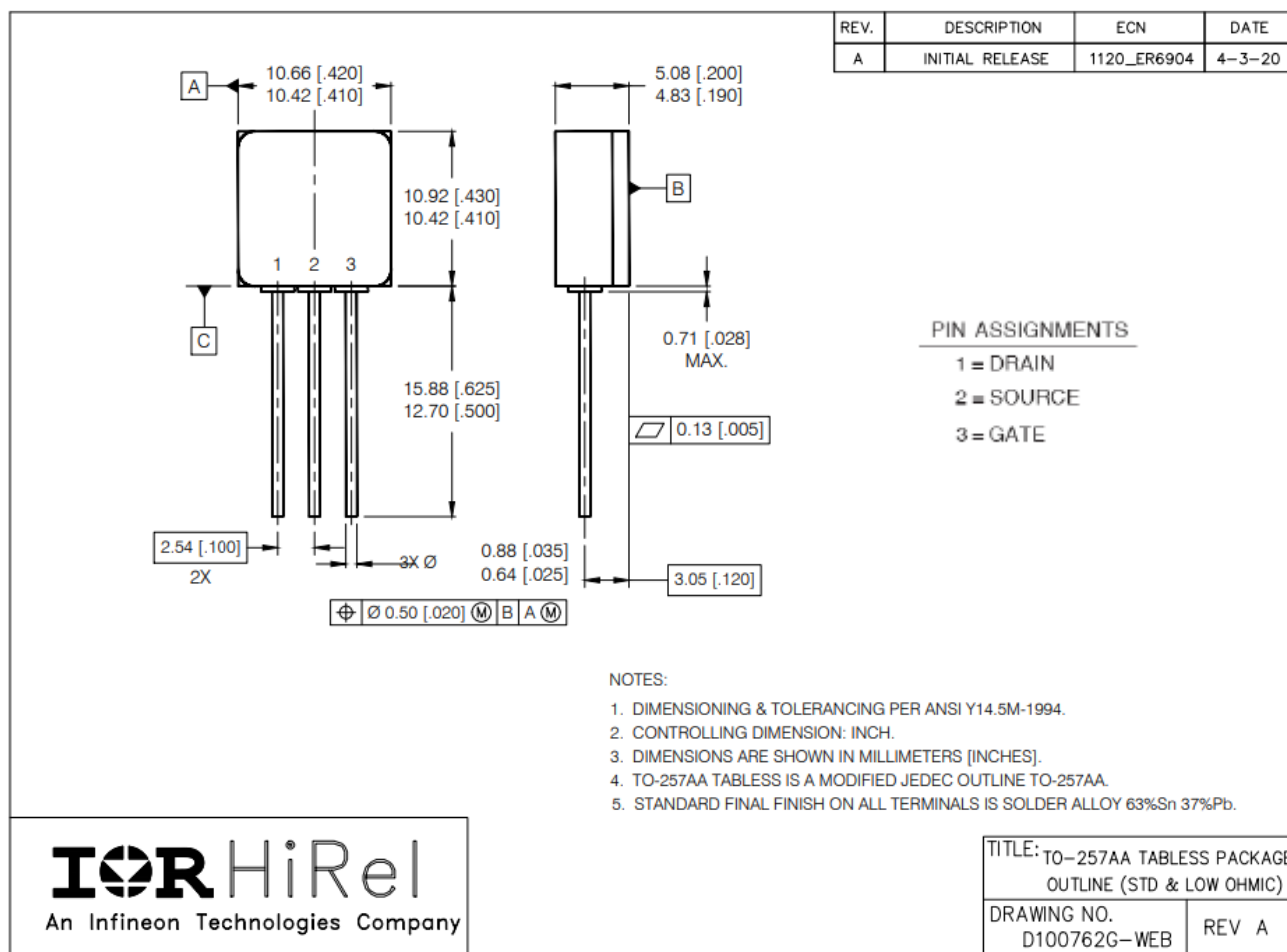
# IRHYS9A97130CM, IRHYB9A97130CM

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

### Package Outline (Tabless TO-257AA)

## 6 Package Outline (Tabless TO-257AA)

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



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**Revision history****Revision history**

Document version	Date of release	Description of changes
	04/06/2022	Preliminary datasheet with PPD number (PPD-97957)
Rev A	08/23/2022	Final datasheet with PD number

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