

# IRHNS9A97160 (JANSR2N7665U2A)

PD-97984A

## Radiation Hardened Power MOSFET

### Surface-Mount (SupIR-SMD™)

### -100V, -91A, P-channel, R9 Superjunction Technology

#### Features

- Single event effect (SEE) hardened (up to LET of 91 MeV·cm<sup>2</sup>/mg)
- Low  $R_{DS(on)}$
- Improved SOA for linear mode operation
- Fast switching
- Low total gate charge
- Simple drive requirements
- Hermetically sealed
- Electrically isolated
- Ceramic eyelets
- Light weight
- ESD rating: Class 3B per MIL-STD-750, Method 1020

#### Potential Applications

- DC-DC converter
- Motor drives
- Inrush current protection
- Power distribution

#### 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 MeV·cm<sup>2</sup>/mg. Their combination of low  $R_{DS(on)}$  and improved SOA allows for better performance in applications such as Solid-State Power Controllers (SSPC), DC-DC converters and motor drives. These devices retain all of the well-established advantages of MOSFETs such as voltage control, fast switching and temperature stability of electrical parameters.

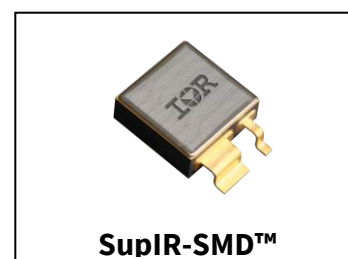
#### Ordering Information

**Table 1**      **Ordering options**

Part number	Package	Screening Level	TID Level
IRHNS9A97160	SupIR-SMD™	COTS	100 krad (Si)
JANSR2N7665U2A	SupIR-SMD™	JANS	100 krad (Si)
IRHNS9A93160	SupIR-SMD™	COTS	300 krad (Si)
JANSF2N7665U2A	SupIR-SMD™	JANS	300 krad (Si)

#### Product Summary

- $B_{VDS}$ : -100V
- $I_D$ : -91A
- $R_{DS(on)max}$ : 17mΩ
- $Q_{Gmax}$ : 230Nc
- REF: MIL-PRF-19500/791



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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	-91	A
$I_{D2} @ V_{GS} = -12V, T_C = 100^{\circ}C$	Continuous Drain Current	-57	A
$I_{DM} @ T_C = 25^{\circ}C$	Pulsed Drain Current <sup>1</sup>	-364	A
$P_D @ T_C = 25^{\circ}C$	Maximum Power Dissipation	250	W
	Linear Derating Factor	2.0	W/°C
$V_{GS}$	Gate-to-Source Voltage	± 20	V
$E_{AS}$	Single Pulse Avalanche Energy <sup>2</sup>	4224	mJ
$I_{AR}$	Avalanche Current <sup>1</sup>	-57	A
$E_{AR}$	Repetitive Avalanche Energy <sup>1</sup>	25	mJ
dv/dt	Peak Diode Reverse Recovery <sup>3</sup>	10	V/ns
$T_J$ $T_{STG}$	Operating Junction and Storage Temperature Range	-55 to +150	°C
	Lead Temperature	300 (for 5s)	
	Weight	3.3 (Typical)	g

<sup>1</sup> Repetitive Rating; Pulse width limited by maximum junction temperature.<sup>2</sup>  $V_{DD} = -100V$ , starting  $T_J = 25^{\circ}C$ ,  $L = 2.6mH$ , Peak  $I_L = -57A$ ,  $V_{GS} = -20V$ <sup>3</sup>  $I_{SD} \leq -91A$ ,  $di/dt \leq -400A/\mu s$ ,  $V_{DD} \leq -100V$ ,  $T_J \leq 150^{\circ}C$

## 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	—	-0.11	—	V/ $^\circ\text{C}$	Reference to $25^\circ\text{C}$ , $I_D = -1.0mA$
$R_{DS(on)}$	Static Drain-to-Source On-State Resistance	—	—	17	m $\Omega$	$V_{GS} = -12V, I_{D2} = -57A^1$
$V_{GS(th)}$	Gate Threshold Voltage	-2.0	—	-4.0	V	$V_{DS} \geq V_{GS}, I_D = -5mA$
$\Delta V_{GS(th)}/\Delta T_J$	Gate Threshold Voltage Coefficient	—	5.7	—	mV/ $^\circ\text{C}$	
$G_{fs}$	Forward Transconductance	50	—	—	S	$V_{DS} = -15V, I_{D2} = -57A^1$
$I_{DSS}$	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	—	—	230	nC	$I_{D1} = -91A$
$Q_{GS}$	Gate-to-Source Charge	—	—	65		$V_{DS} = -50V$
$Q_{GD}$	Gate-to-Drain ('Miller') Charge	—	—	47		$V_{GS} = -12V$
$t_{d(on)}$	Turn-On Delay Time	—	—	36	ns	$I_{D1} = -91A^{**}$ $V_{DD} = -50V$ $R_G = 2.4\Omega$ $V_{GS} = -12V$
$t_r$	Rise Time	—	—	100		
$t_{d(off)}$	Turn-Off Delay Time	—	—	176		
$t_f$	Fall Time	—	—	155		
$L_S + L_D$	Total Inductance	—	4.0	—	nH	Measured from center of Drain pad to center of Source pad
$C_{iss}$	Input Capacitance	—	12060	—	pF	$V_{GS} = 0V$
$C_{oss}$	Output Capacitance	—	2210	—		$V_{DS} = -25V$
$C_{rss}$	Reverse Transfer Capacitance	—	55	—		$f = 100KHz$
$R_G$	Gate Resistance	—	3.1	—	$\Omega$	$f = 1.0MHz$ , 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)	—	—	-91	A	
I <sub>SM</sub>	Pulsed Source Current (Body Diode) <sup>1</sup>	—	—	-364	A	
V <sub>SD</sub>	Diode Forward Voltage	—	—	-1.3	V	T <sub>J</sub> = 25°C, I <sub>S</sub> = -91A, V <sub>GS</sub> = 0V <sup>2</sup>
t <sub>rr</sub>	Reverse Recovery Time	—	134	201	ns	T <sub>J</sub> = 25°C, I <sub>F</sub> = -91A, V <sub>DD</sub> ≤ -25V di/dt = -100A/μs
Q <sub>rr</sub>	Reverse Recovery Charge	—	745	—	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	—	—	0.5	$^\circ\text{C}/\text{W}$
$R_{\theta J-PCB}$	Junction-to-PC Board (Soldered to 2" sq. inch copper clad board)	—	1.6	—	

## 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	$V_{DS} \geq V_{GS}$ , $I_D = -5.0\text{mA}$
$I_{GSS}$	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>	—	18	$\text{m}\Omega$	$V_{GS} = -12\text{V}$ , $I_{D2} = -57\text{A}$
$R_{DS(on)}$	Static Drain-to-Source On-State Resistance (SupIR-SMD) <sup>2</sup>	—	17	$\text{m}\Omega$	$V_{GS} = -12\text{V}$ , $I_{D2} = -57\text{A}$
$V_{SD}$	Diode Forward Voltage	—	-1.3	V	$V_{GS} = 0\text{V}$ , $I_F = -75\text{A}$

<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 IRHNS9A97160 (JANSR2N7665U2A) and IRHNS9A93160 (JANSF2N7665U2A)

**IRHNS9A97160 (JANSR2N7665U2A)**  
**Radiation Hardened Power MOSFET Surface Mount (SupIR-SMD™)**

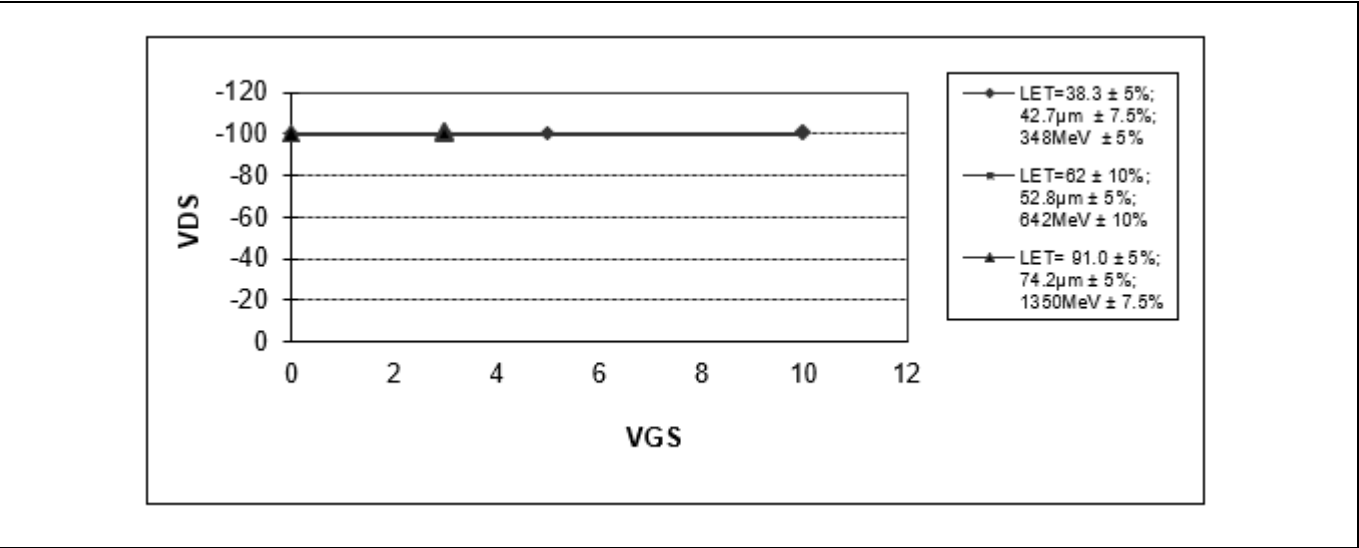
**Device Characteristics**

**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> = 3V	V <sub>GS</sub> = 5V	V <sub>GS</sub> = 10V
38.3 ± 5%	348 ± 5%	42.7 ± 7.5%	-100	-100	-100	-100
62.0 ± 10%	642 ± 10%	52.8 ± 5%	-100	-100	-100	—
91.0 ± 5%	1350 ± 7.5%	74.2 ± 5%	-100	-100	—	—



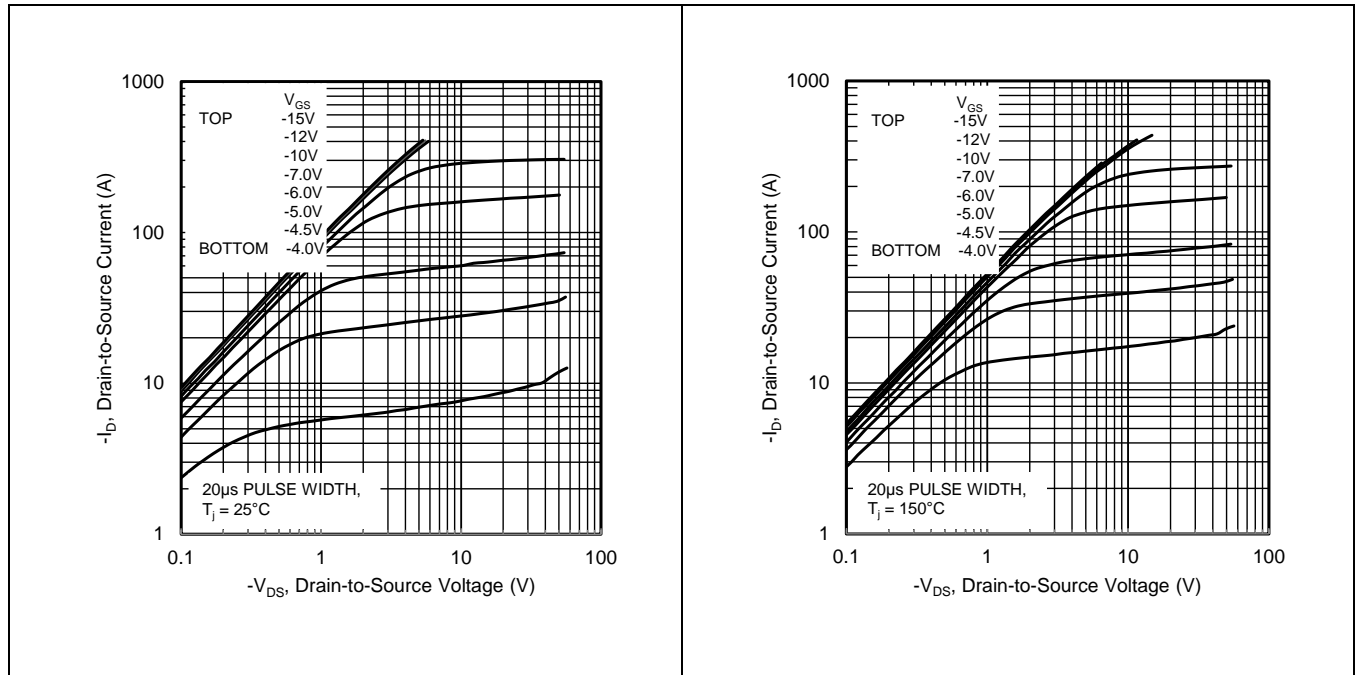
**Figure 1 Typical Single Event Effect, Safe Operating Area**

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## Radiation Hardened Power MOSFET Surface Mount (SupIR-SMD™)

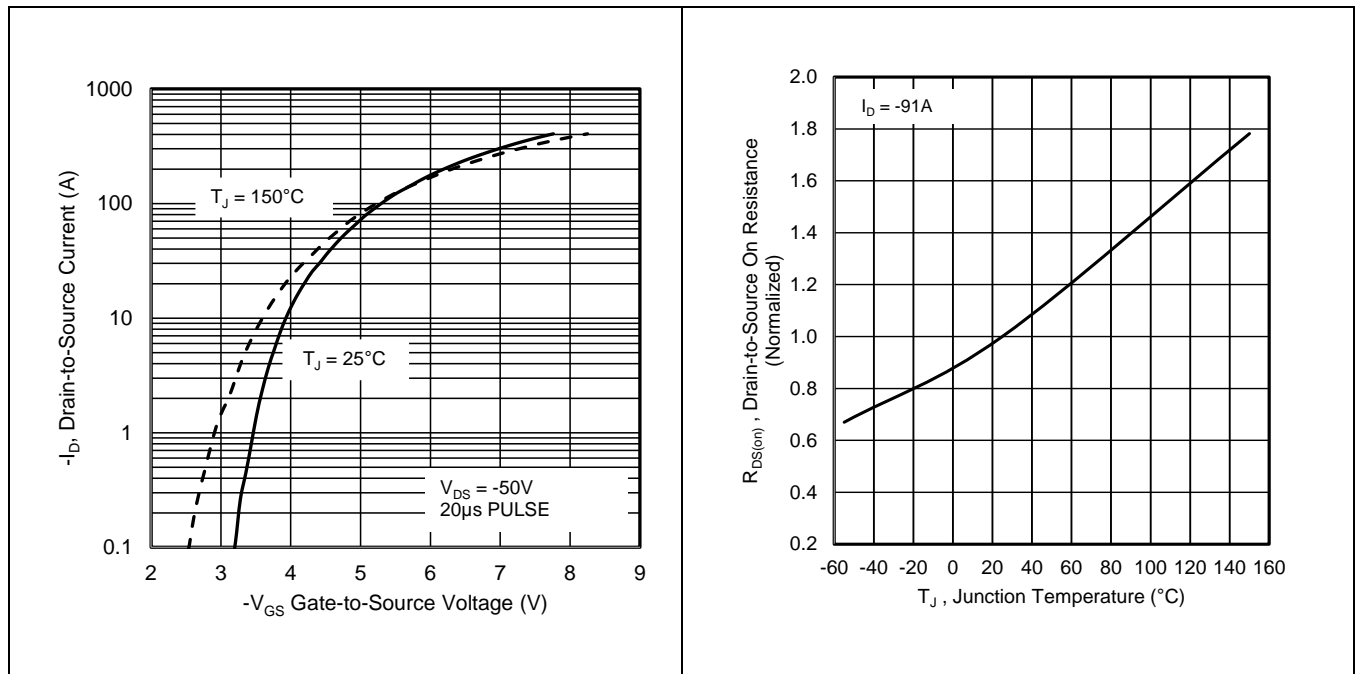
### Electrical Characteristics Curves (Pre-irradiation)

## 3 Electrical Characteristics Curves (Pre-irradiation)



**Figure 2** Typical Output Characteristics

**Figure 3** Typical Output Characteristics



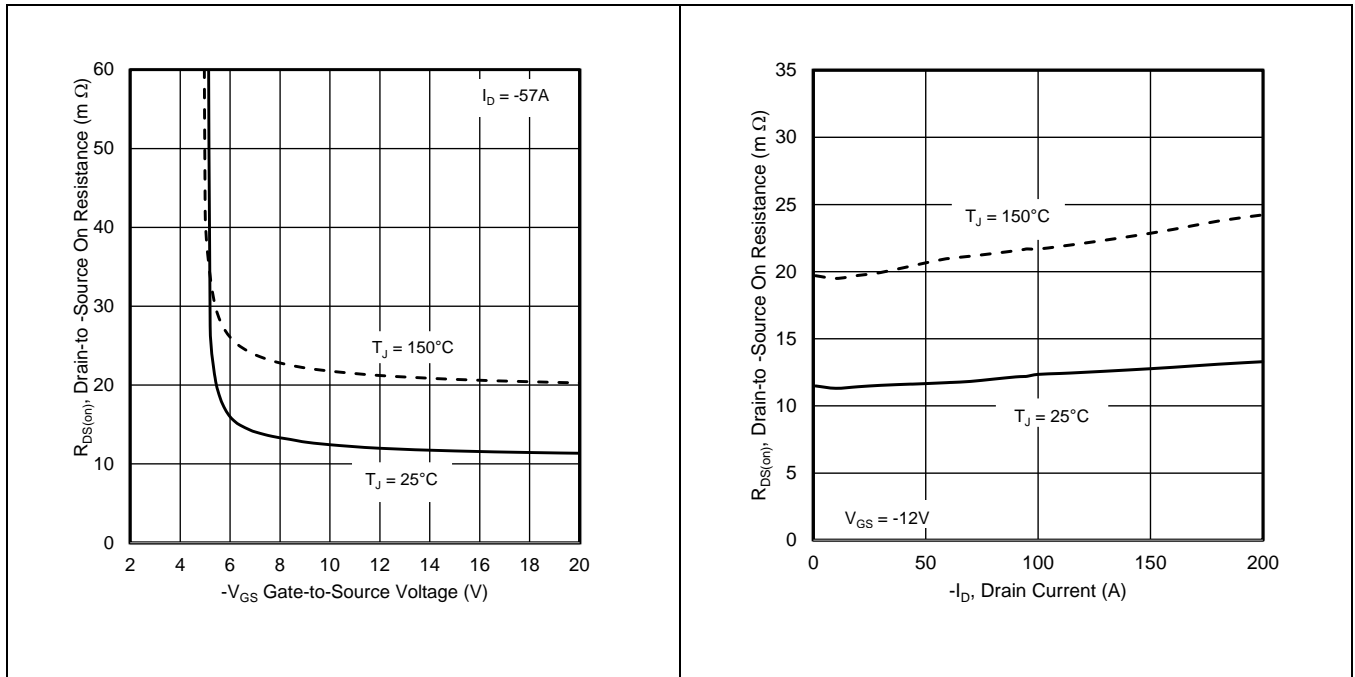
**Figure 4** Typical Transfer Characteristics

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

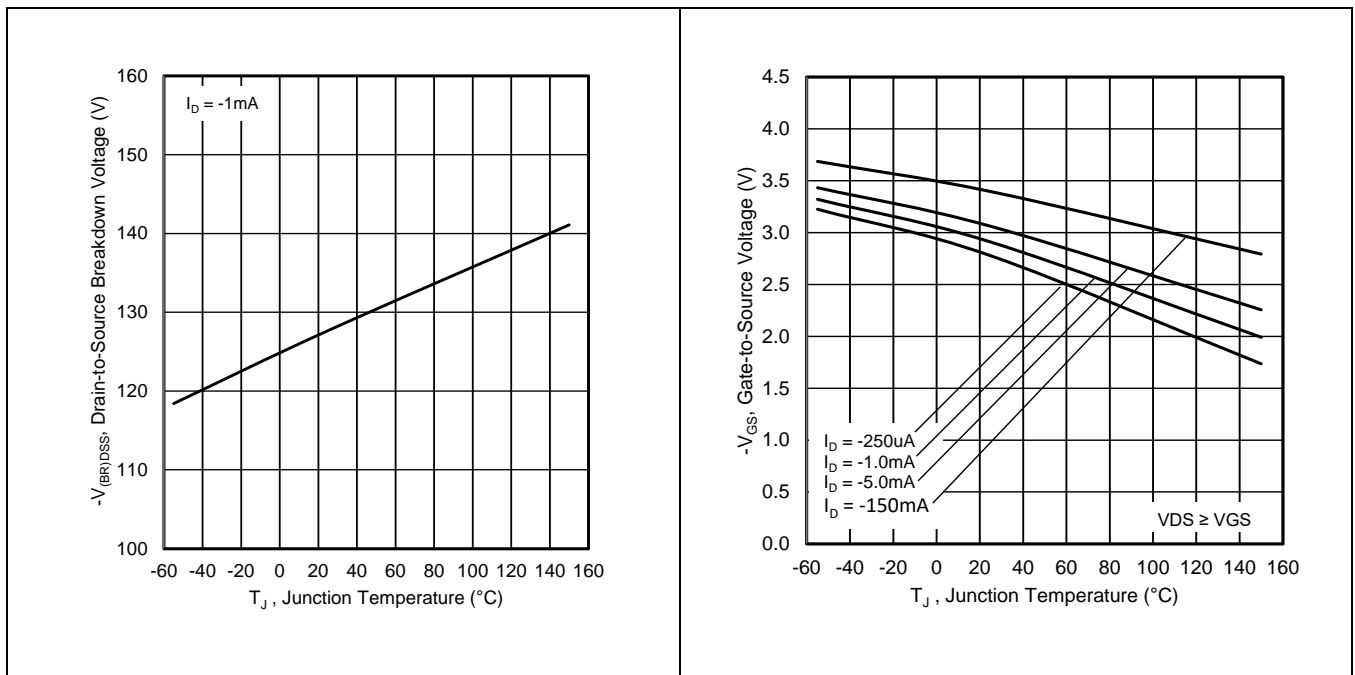
# IRHNS9A97160 (JANSR2N7665U2A)

## Radiation Hardened Power MOSFET Surface Mount (SupIR-SMD™)

### Electrical Characteristics Curves (Pre-irradiation)



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



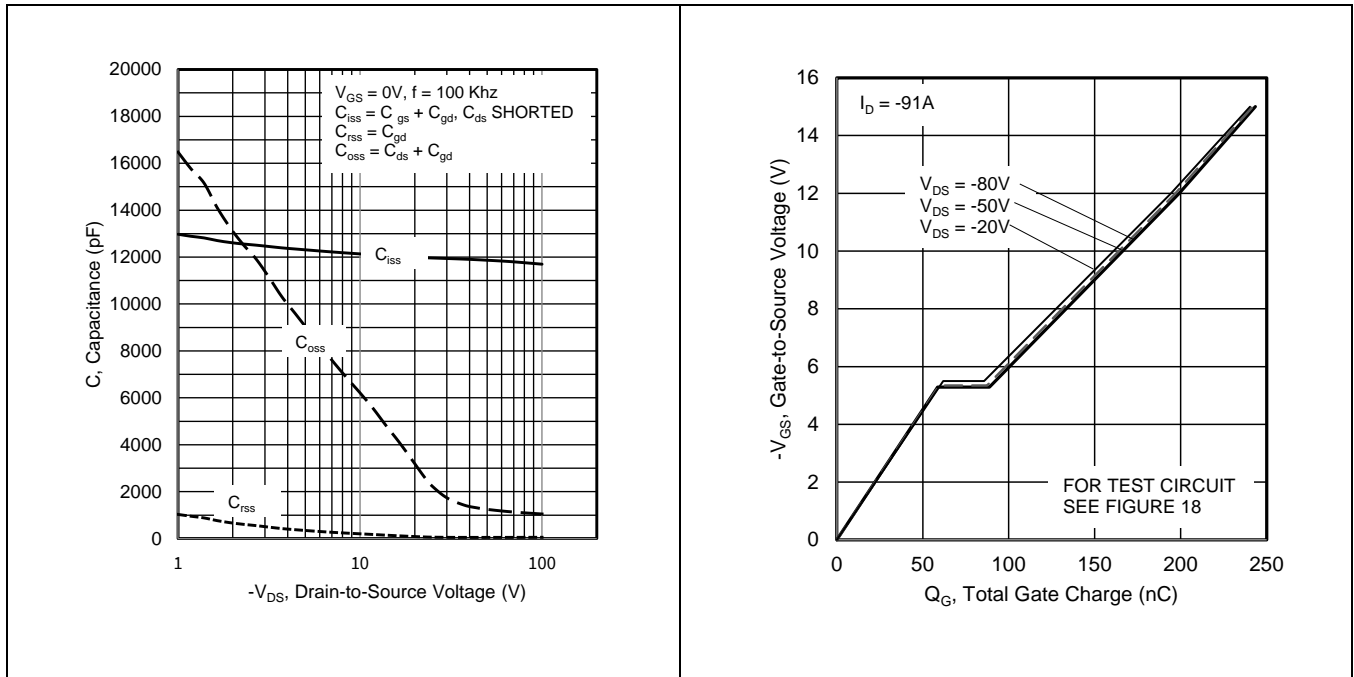
**Figure 8 Typical Drain-to-Source Breakdown Voltage Vs. Temperature** **Figure 9 Typical Gate-to-Source Voltage Vs. Temperature**



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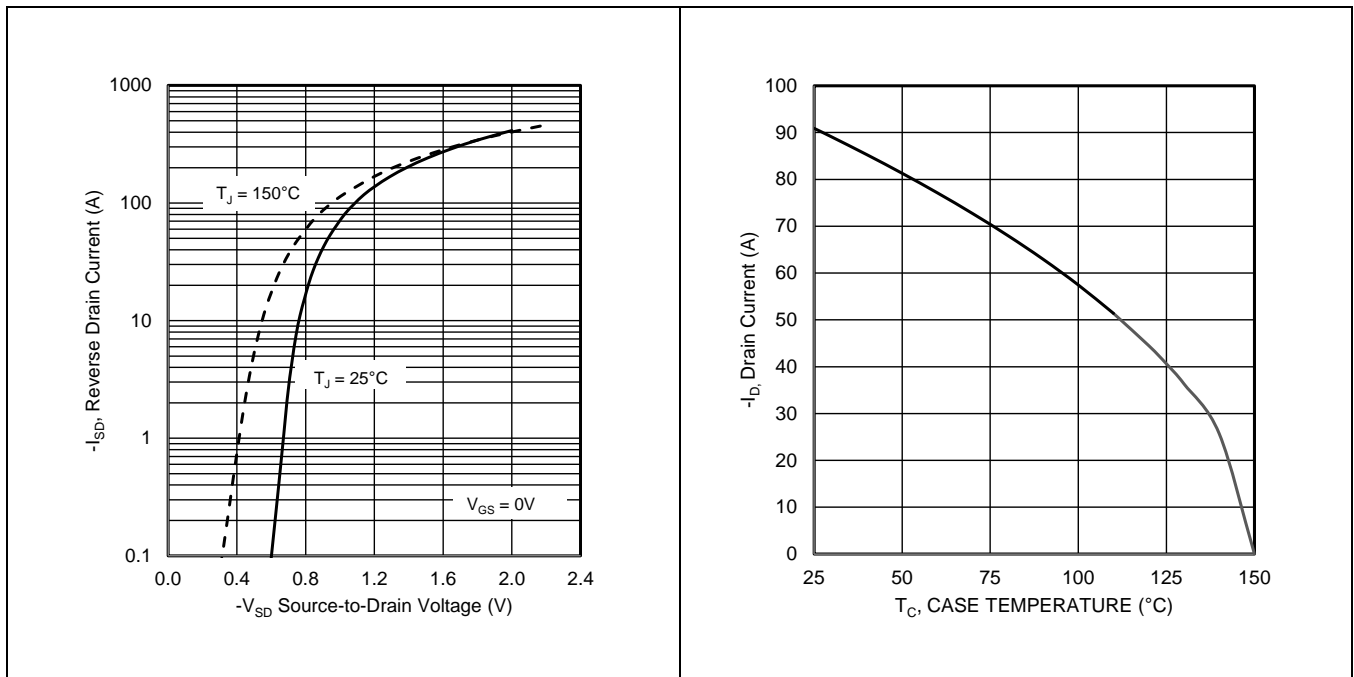
## Radiation Hardened Power MOSFET Surface Mount (SupIR-SMD™)

### Electrical Characteristics Curves (Pre-irradiation)



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

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



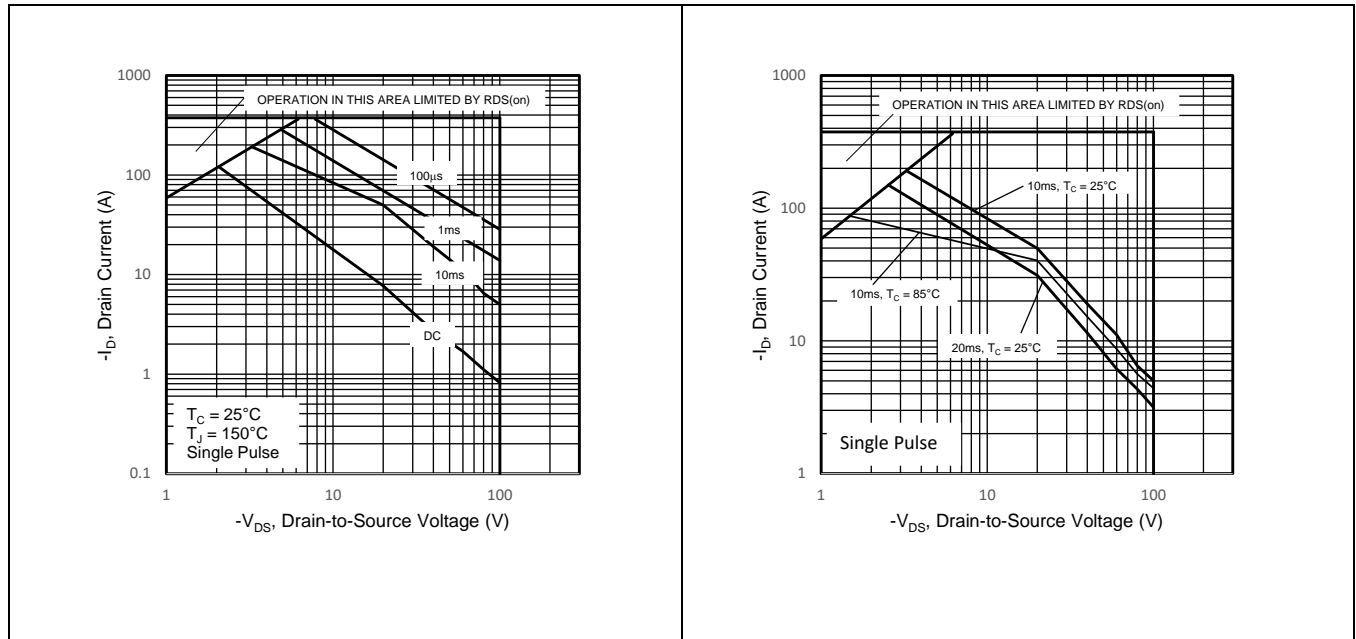
**Figure 12 Typical Source-Drain Current Vs. Diode Forward Voltage**

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

# IRHNS9A97160 (JANSR2N7665U2A)

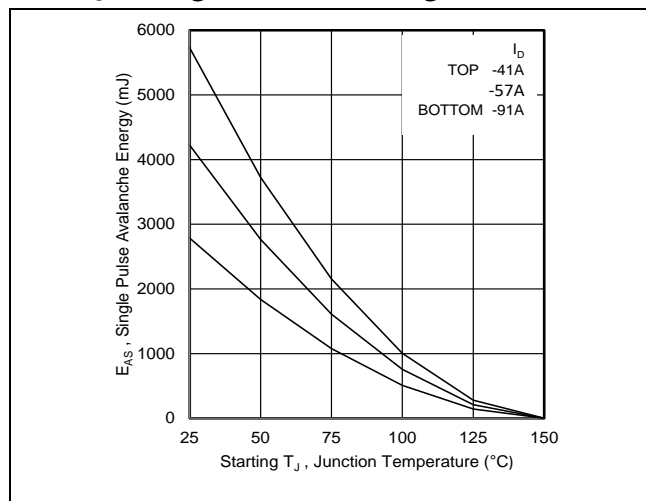
## Radiation Hardened Power MOSFET Surface Mount (SupIR-SMD™)

### Electrical Characteristics Curves (Pre-irradiation)

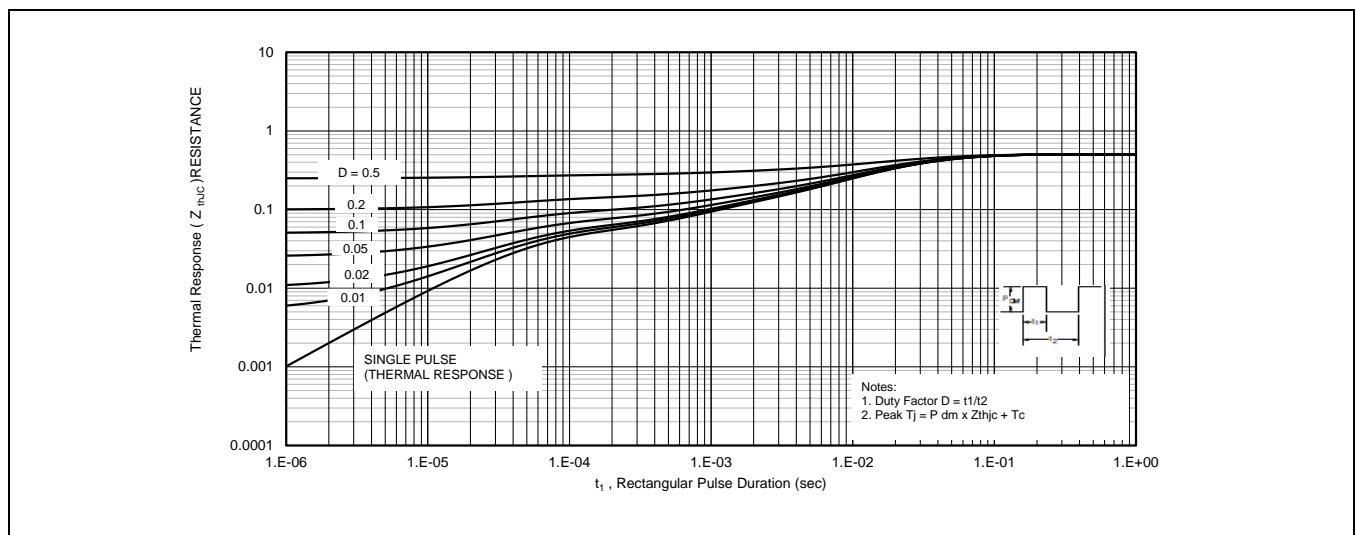


**Figure 14 Maximum Safe Operating Area**

**Figure 15 Maximum Safe Operating Area**



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



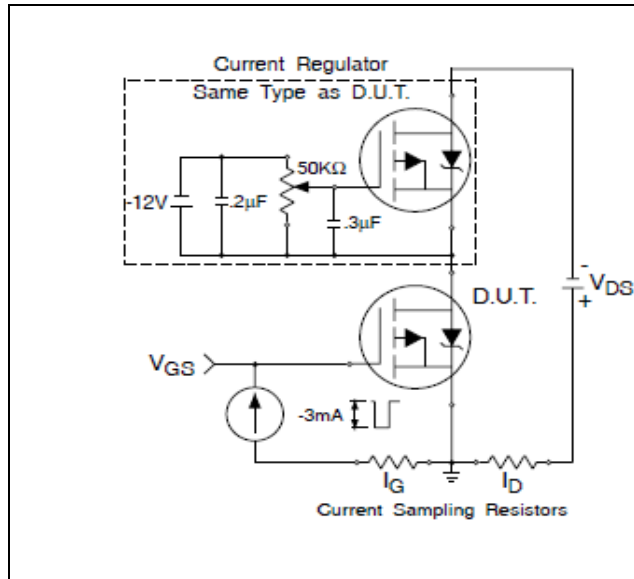
**Figure 17 Maximum Effective Transient Thermal Impedance, Junction-to-Case**

# IRHNS9A97160 (JANSR2N7665U2A)

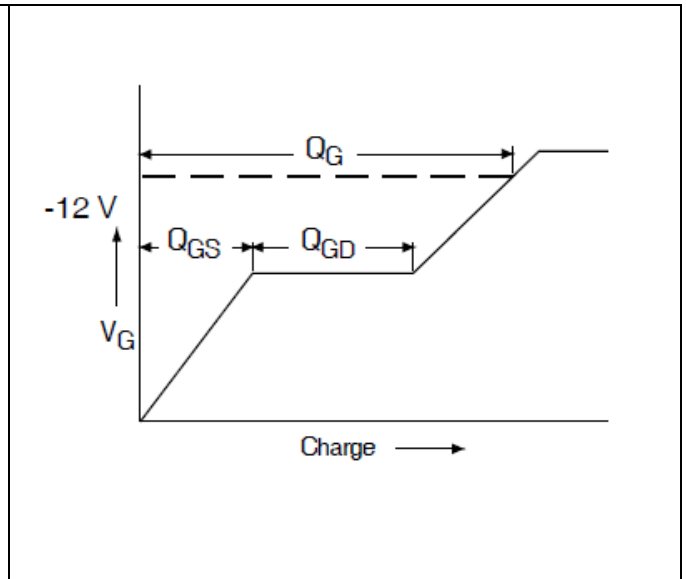
## Radiation Hardened Power MOSFET Surface Mount (SupIR-SMD™)

### Test Circuits (Pre-irradiation)

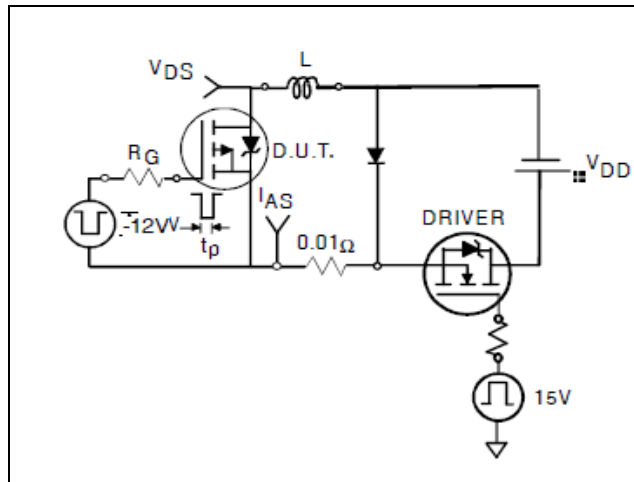
## 4 Test Circuits (Pre-irradiation)



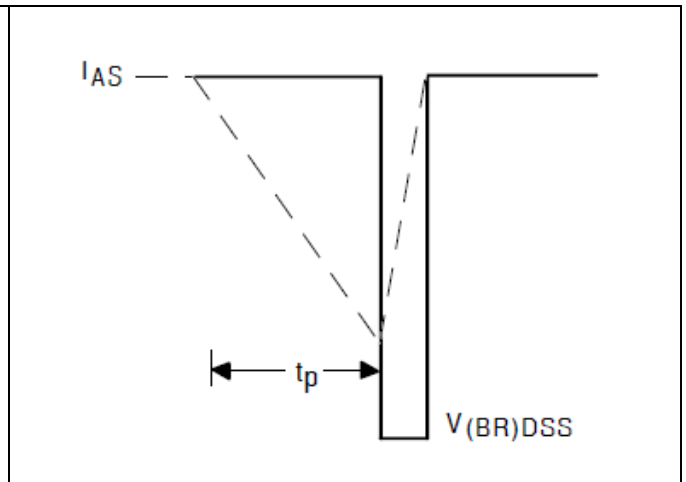
**Figure 18 Gate Charge Test Circuit**



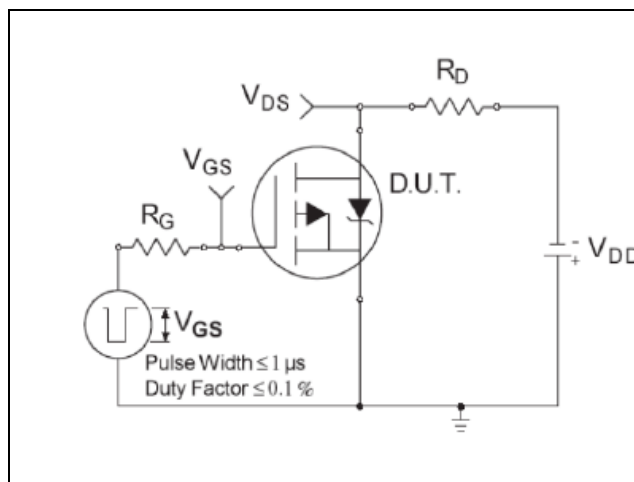
**Figure 19 Gate Charge Waveform**



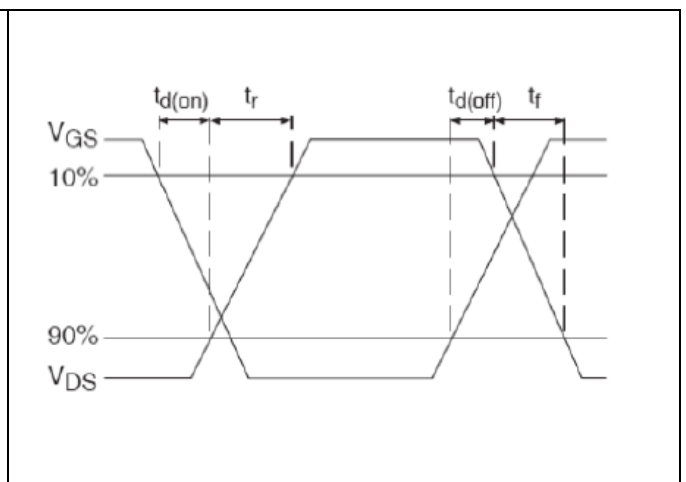
**Figure 20 Unclamped Inductive Test Circuit**



**Figure 21 Unclamped Inductive Waveform**



**Figure 22 Switching Time Test Circuit**



**Figure 23 Switching Time Waveforms**

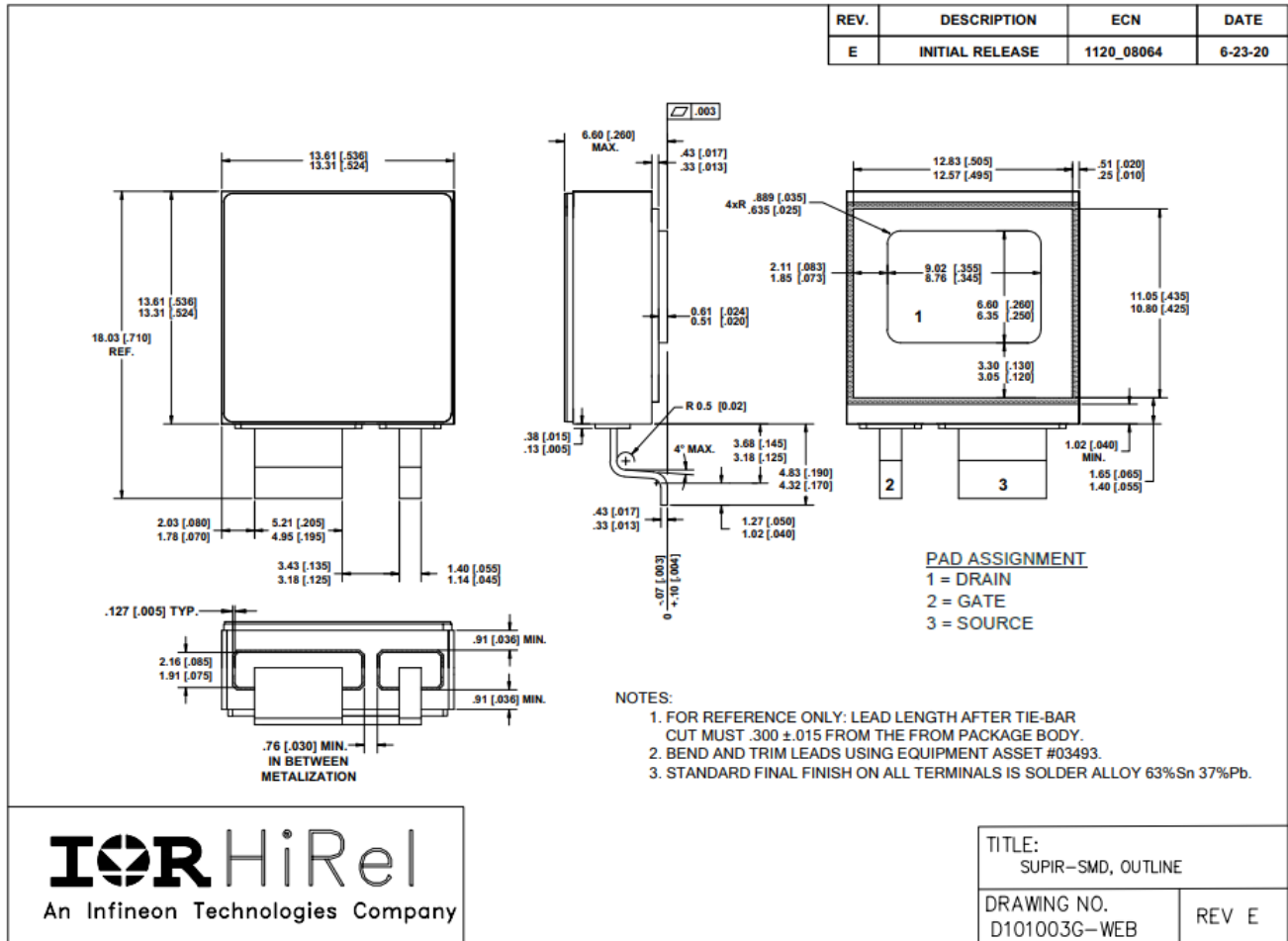
# IRHNS9A97160 (JANSR2N7665U2A)

## Radiation Hardened Power MOSFET Surface Mount (SupIR-SMD™)

### Package Outline

## 5 Package Outline

Note: For the most updated package outline, please see the website: [SupIR-SMD™](http://www.infineon.com/supir-smd)



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

Document version	Date of release	Description of changes
	03/21/2023	Preliminary datasheet with PPD number (PPD-97984)
Rev A	06/13/2023	Final datasheet with PD number (PD-97984A)

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