

IRHNPC9A7014 (JANSR2N7655U9C)

PD-97968B

Radiation Hardened Power MOSFET

Surface Mount (SMD-0.1)

60V, 10A, N-channel, R9 Superjunction Technology

Features

- Single event effect (SEE) hardened (up to LET of 88.6 MeV·cm²/mg)
- Fast switching
- Low total gate charge
- Low $R_{DS(on)}$
- Simple drive requirements
- Hermetically sealed
- Ceramic package
- Light weight
- Surface mount
- ESD rating: Class 1B per MIL-STD-750, Method 1020

Product Summary

- BV_{DSS} : 60V
- I_D : 10A*
- $R_{DS(on), max}$: 70mΩ
- Q_G, max : 11nC
- REF: MIL-PRF-19500/790



Potential Applications

- Power distribution
- DC-DC converter
- Motor drives

Product Validation

Qualified according to MIL-PRF-19500 for space applications

Description

IR HiRel R9 technology provides superior power MOSFETs for space applications. These devices have improved immunity to Single Event Effect (SEE) and have been characterized for useful performance with Linear Energy Transfer (LET) up to 88.6 MeV·cm²/mg. Their combination of low $R_{DS(on)}$ and fast switching times will allow for better performance in applications such as DC-DC converters or 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
IRHNPC9A7014	SMD-0.1	COTS	100 krad(Si)
JANSR2N7655U9C	SMD-0.1	JANS	100 krad(Si)
IRHNPC9A3014	SMD-0.1	COTS	300 krad(Si)
JANSF2N7655U9C	SMD-0.1	JANS	300 krad(Si)

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Radiation Hardened Power MOSFET Surface mount (SMD-0.1)

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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	10*	A
$I_{D2} @ V_{GS} = 12V, T_C = 100^{\circ}C$	Continuous Drain Current	9.0	A
$I_{DM} @ T_C = 25^{\circ}C$	Pulsed Drain Current ¹	40	A
$P_D @ T_C = 25^{\circ}C$	Maximum Power Dissipation	25	W
	Linear Derating Factor	0.2	W/ $^{\circ}C$
V_{GS}	Gate-to-Source Voltage	± 20	V
E_{AS}	Single Pulse Avalanche Energy ²	190	mJ
I_{AR}	Avalanche Current ¹	9.0	A
E_{AR}	Repetitive Avalanche Energy ¹	2.5	mJ
dv/dt	Peak Diode Reverse Recovery ³	10	V/ns
T_J T_{STG}	Operating Junction and Storage Temperature Range	-55 to +150	$^{\circ}C$
	Lead Temperature	300 (for 5s)	
	Weight	0.1 (Typical)	

*Current is limited by package

¹ Repetitive Rating; Pulse width limited by maximum junction temperature.² $V_{DD} = 60V$, starting $T_J = 25^{\circ}C$, $L = 4.7mH$, Peak $I_L = 9A$, $V_{GS} = 20V$ ³ $I_{SD} \leq 10A$, $di/dt \leq 1520A/\mu s$, $V_{DD} \leq 60V$, $T_J \leq 150^{\circ}C$

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	$V_{GS} = 0V, I_D = 1.0mA$
$\Delta BV_{DSS}/\Delta T_J$	Breakdown Voltage Temp. Coefficient	—	0.05	—	V/ $^\circ\text{C}$	Reference to 25°C , $I_D = 1.0mA$
$R_{DS(on)}$	Static Drain-to-Source On-State Resistance	—	—	70	m Ω	$V_{GS} = 12V, I_{D2} = 9.0A^1$
$V_{GS(th)}$	Gate Threshold Voltage	2.0	—	4.0	V	$V_{DS} \geq V_{GS}, I_D = 250\mu A$
$\Delta V_{GS(th)}/\Delta T_J$	Gate Threshold Voltage Coefficient	—	-8.2	—	mV/ $^\circ\text{C}$	
G_{fs}	Forward Transconductance	7.0	—	—	S	$V_{DS} = 15V, I_{D2} = 9.0A^1$
I_{DSS}	Zero Gate Voltage Drain Current	—	—	1.0	μA	$V_{DS} = 48V, V_{GS} = 0V$
		—	—	10		$V_{DS} = 48V, V_{GS} = 0V, T_J = 125^\circ\text{C}$
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	—	8.7	11	nC	$I_{D1} = 10A$
Q_{GS}	Gate-to-Source Charge	—	3.1	4.0		$V_{DS} = 30V$
Q_{GD}	Gate-to-Drain ('Miller') Charge	—	1.6	3.0		$V_{GS} = 12V$
$t_{d(on)}$	Turn-On Delay Time	—	—	8.0	ns	$I_{D1} = 10A^{**}$ $V_{DD} = 30V$ $R_G = 7.5\Omega$ $V_{GS} = 12V$
t_r	Rise Time	—	—	11		
$t_{d(off)}$	Turn-Off Delay Time	—	—	18		
t_f	Fall Time	—	—	10		
$L_s + L_D$	Total Inductance	—	2.0	—	nH	Measured from center of Drain pad to center of Source pad
C_{iss}	Input Capacitance	—	465	—	pF	$V_{GS} = 0V$
C_{oss}	Output Capacitance	—	185	—		$V_{DS} = 25V$
C_{rss}	Reverse Transfer Capacitance	—	2.3	—		$f = 1.0MHz$
R_G	Gate Resistance	—	4.6	—	Ω	$f = 1.0MHz$, open drain

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

¹ 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 _S	Continuous Source Current (Body Diode)	—	—	10	A	
I _{SM}	Pulsed Source Current (Body Diode) ¹	—	—	40	A	
V _{SD}	Diode Forward Voltage	—	—	1.2	V	T _J = 25°C, I _S = 10A, V _{GS} = 0V ²
t _{rr}	Reverse Recovery Time	—	63	95	ns	T _J = 25°C, I _F = 10A, V _{DD} ≤ 25V di/dt = 100A/μs
Q _{rr}	Reverse Recovery Charge	—	179	—	nC	
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	—	—	5.0	$^\circ\text{C}/\text{W}$
$R_{\theta J-PCB}$	Junction-to- PC Board (Soldered to 2" sq. inch copper clad board)	—	15	—	

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 ^{3, 4}

Symbol	Parameter	Up to 300krads (Si) ⁵		Unit	Test Conditions
		Min.	Max.		
BV_{DSS}	Drain-to-Source Breakdown Voltage	60	—	V	$V_{GS} = 0\text{V}$, $I_D = 1\text{mA}$
$V_{GS(th)}$	Gate Threshold Voltage	2.0	4.0	V	$V_{DS} \geq V_{GS}$, $I_D = 250\mu\text{A}$
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	—	1.0	μA	$V_{DS} = 48\text{V}$, $V_{GS} = 0\text{V}$
$R_{DS(on)}$	Static Drain-to-Source On-State Resistance (TO-3) ²	—	73	$\text{m}\Omega$	$V_{GS} = 12\text{V}$, $I_{D2} = 9.0\text{A}$
$R_{DS(on)}$	Static Drain-to-Source On-State Resistance (SMD-0.1) ²	—	70	$\text{m}\Omega$	$V_{GS} = 12\text{V}$, $I_{D2} = 9.0\text{A}$
V_{SD}	Diode Forward Voltage	—	1.2	V	$V_{GS} = 0\text{V}$, $I_F = 10\text{A}$

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

² Pulse width $\leq 300\mu\text{s}$; Duty Cycle $\leq 2\%$

³ 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.

⁴ 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.

⁵ Part numbers IRHNPC9A7014 (JANSR2N7655U9C) and IRHNPC9A3014 (JANSF2N7655U9C).

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Radiation Hardened Power MOSFET Surface mount (SMD-0.1)
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

Ion	LET (MeV·cm ² /mg)	Energy (MeV)	Range (μm)	V _{DS} (V)			
				V _{GS} = 0V	V _{GS} = - 3V	V _{GS} = -10V	V _{GS} = -15V
Kr	35.7 ± 5%	486 ± 7.5%	58.5 ± 7.5%	60	60	60	60
Xe	58.5 ± 5%	865 ± 7.5%	68.9 ± 7.5%	60	60	60	—
Au	88.6 ± 5%	1685 ± 7.5%	90.3 ± 7.5%	60	60	—	—

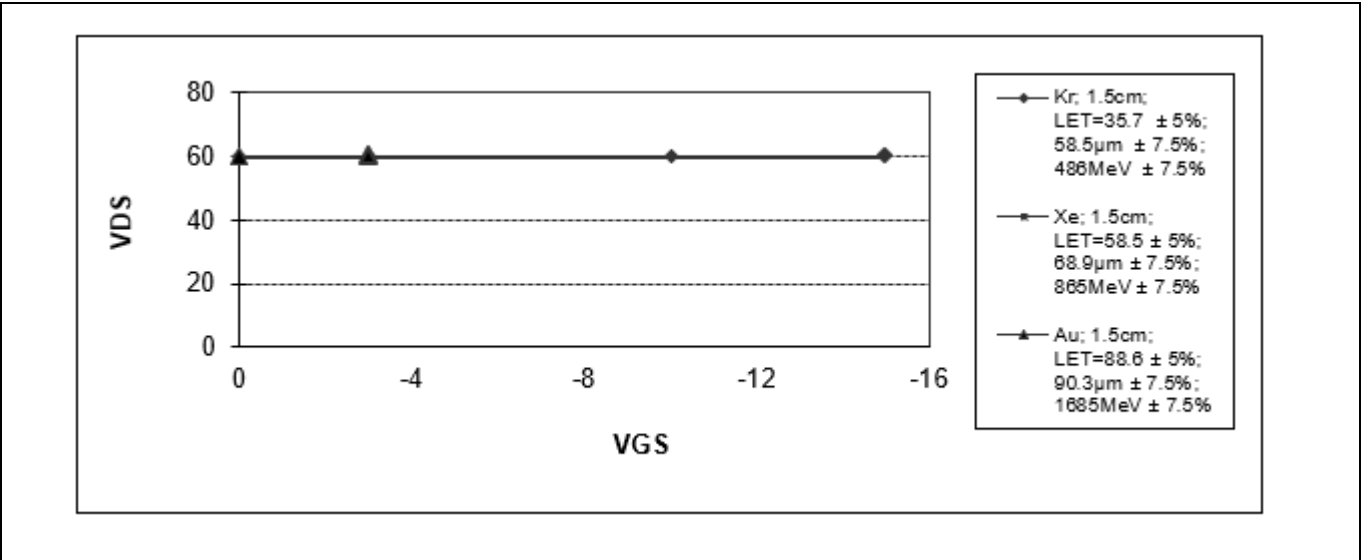


Figure 1 Typical Single Event Effect, Safe Operating Area

IRHNPC9A7014 (JANSR2N7655U9C)

Radiation Hardened Power MOSFET Surface mount (SMD-0.1)

Electrical Characteristics Curves (Pre-irradiation)

3 Electrical Characteristics Curves (Pre-irradiation)

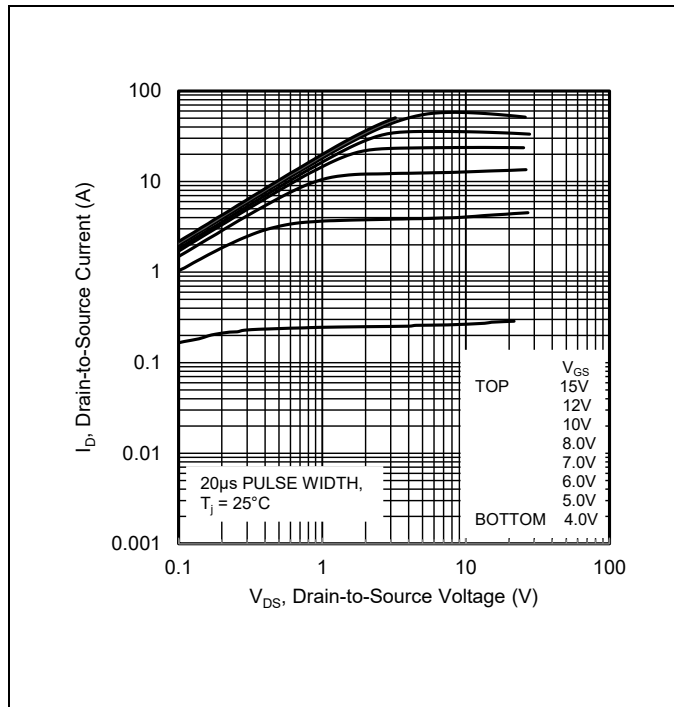


Figure 2 Typical Output Characteristics

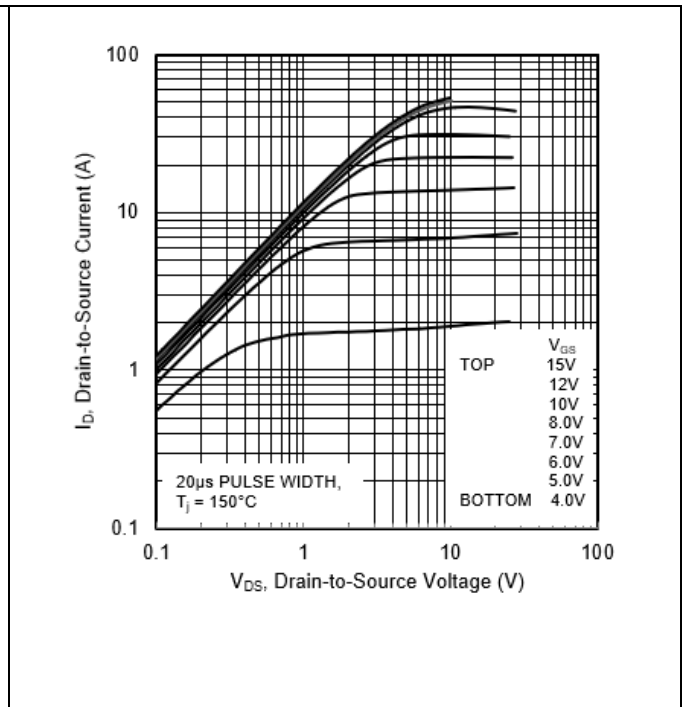


Figure 3 Typical Output Characteristics

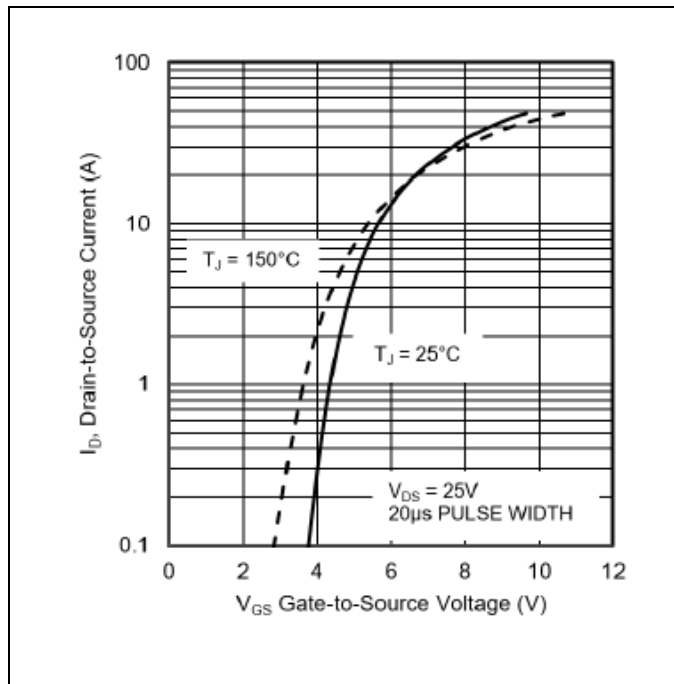


Figure 4 Typical Transfer Characteristics

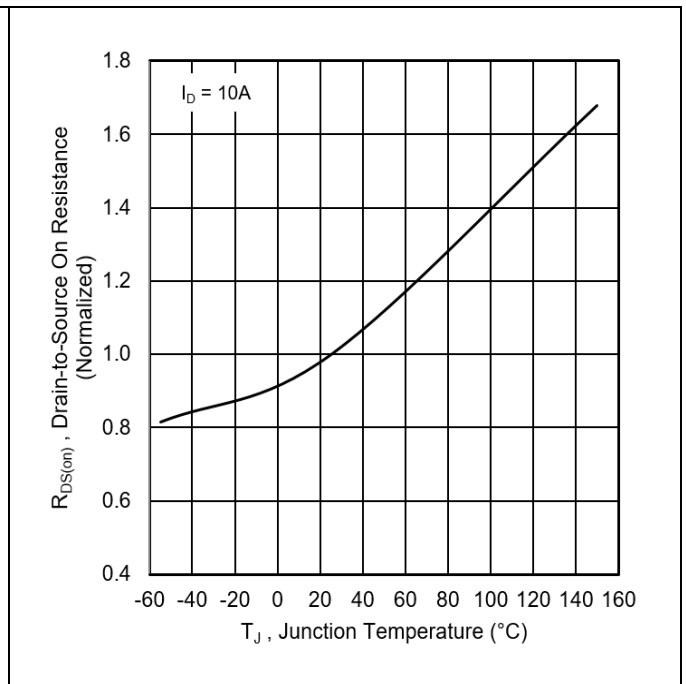


Figure 5 Normalized On-Resistance Vs. Temperature

IRHNPC9A7014 (JANSR2N7655U9C)

Radiation Hardened Power MOSFET Surface mount (SMD-0.1)

Electrical Characteristics Curves (Pre-irradiation)

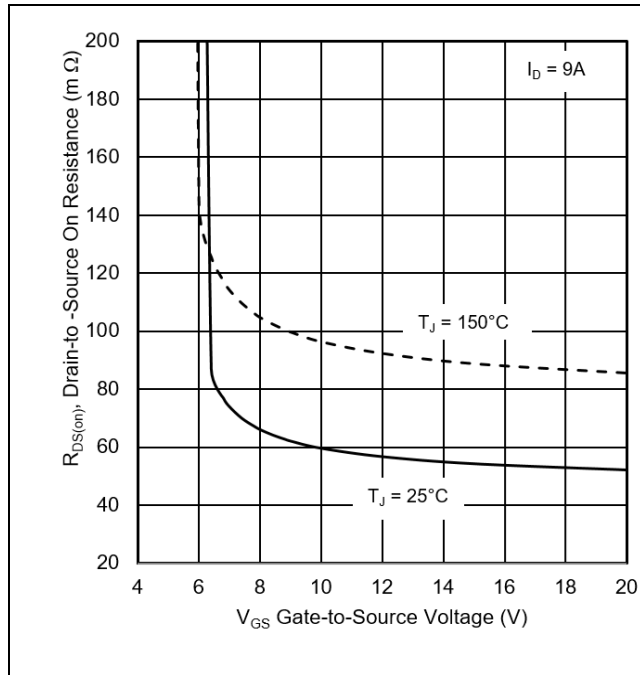


Figure 6 Typical On-Resistance Vs. Gate Voltage

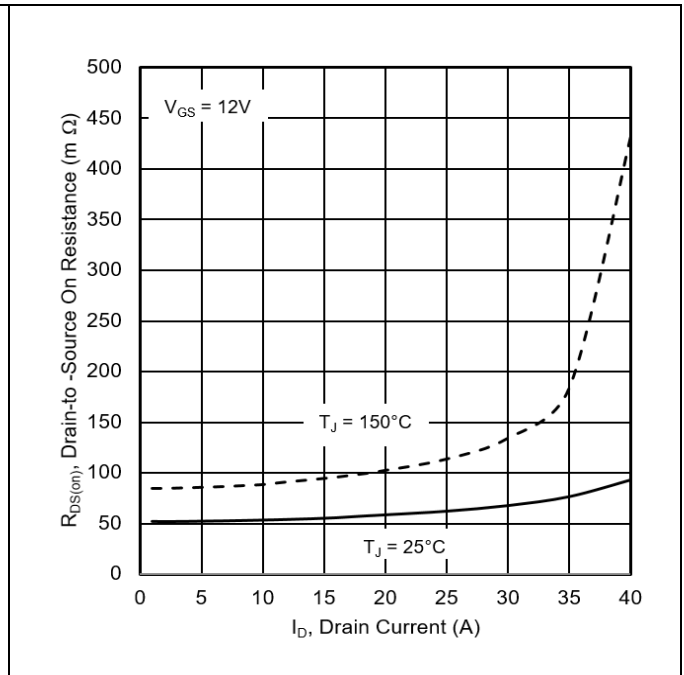


Figure 7 Typical On-Resistance Vs. Drain Current

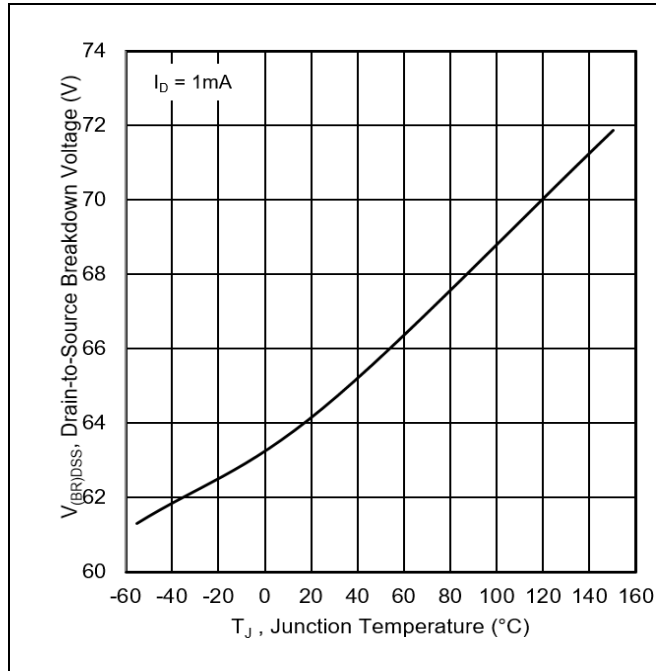


Figure 8 Typical Drain-to-Source Breakdown Voltage Vs. Temperature

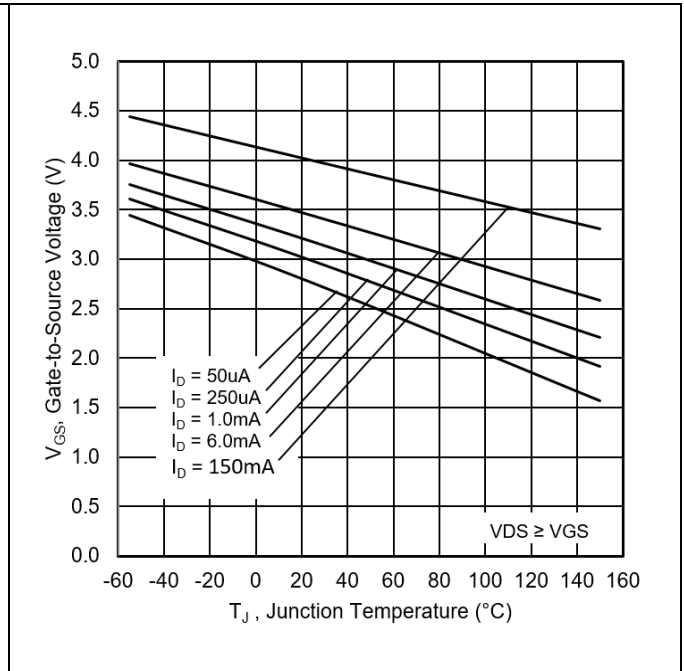


Figure 9 Typical Threshold Voltage Vs. Temperature

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Radiation Hardened Power MOSFET Surface mount (SMD-0.1)

Electrical Characteristics Curves (Pre-irradiation)

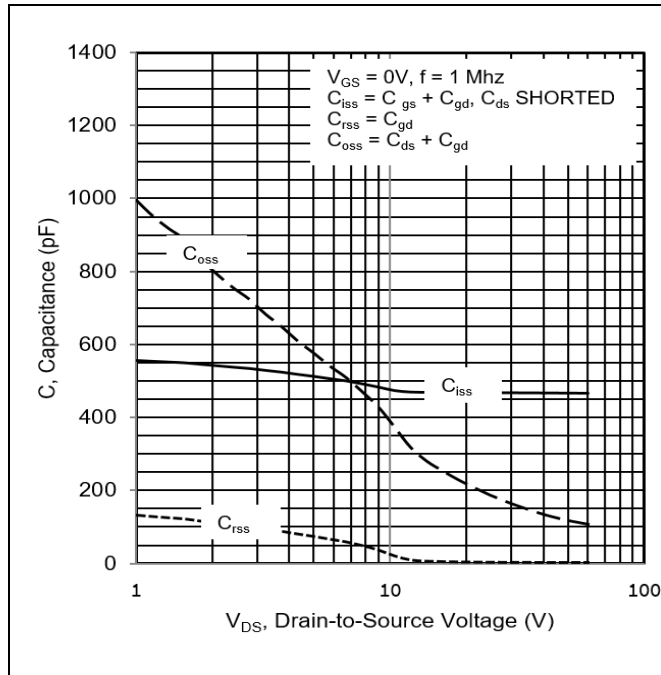


Figure 10 Typical Capacitance Vs. Drain-to-Source Voltage

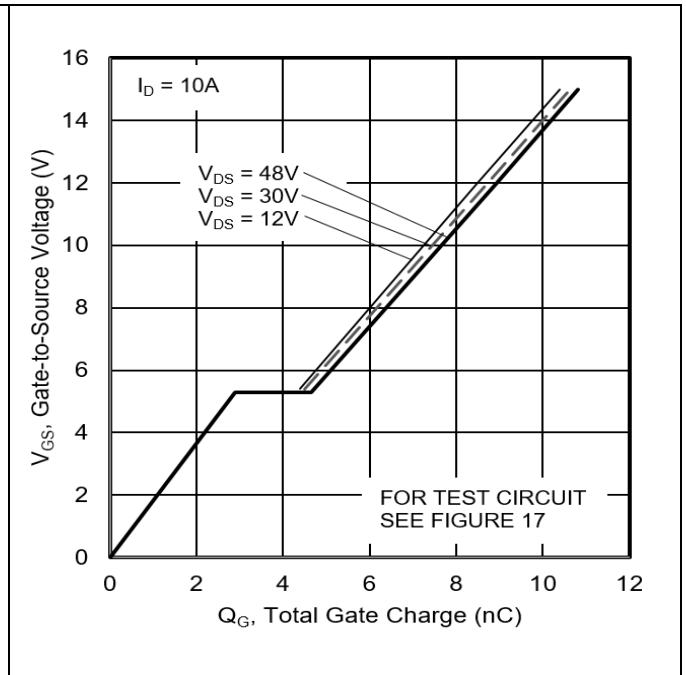


Figure 11 Typical Gate Charge Vs. Gate-to-Source Voltage

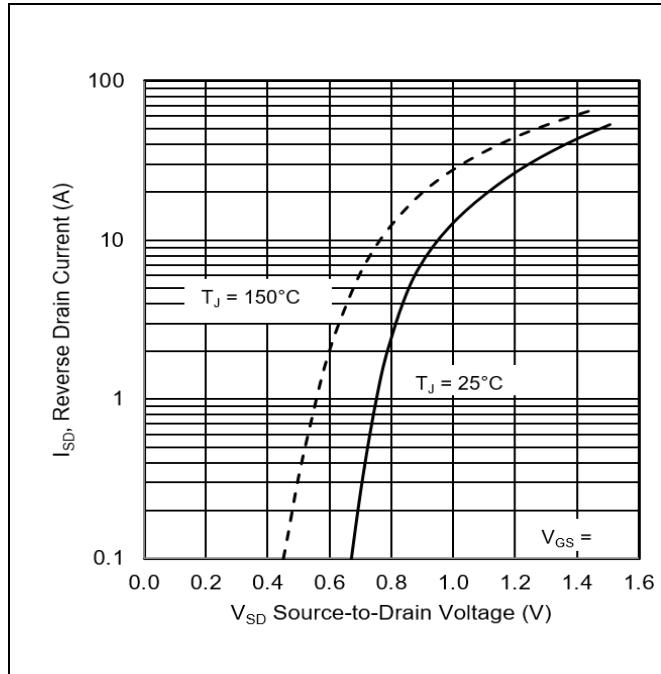


Figure 12 Typical Source-Drain Vs. Diode Forward Voltage

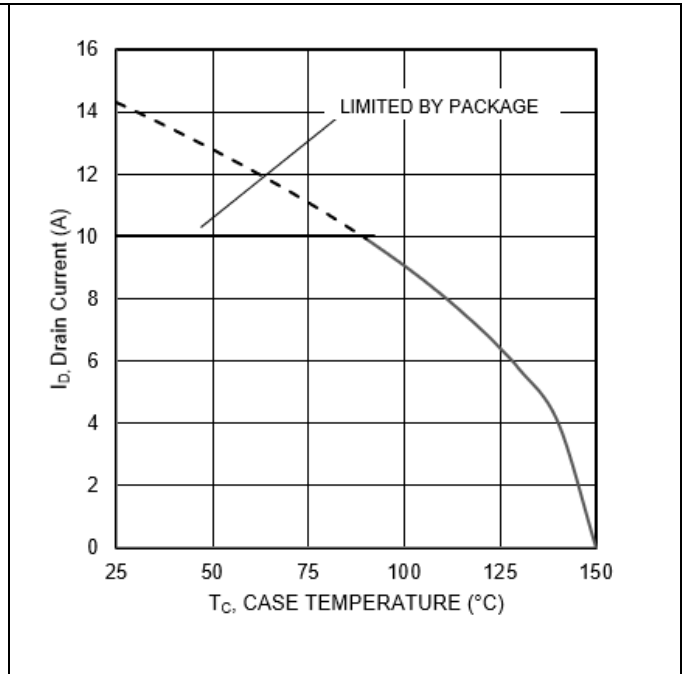


Figure 13 Maximum Drain Current Vs. Case Temperature

IRHNPC9A7014 (JANSR2N7655U9C)

Radiation Hardened Power MOSFET Surface mount (SMD-0.1)

Electrical Characteristics Curves (Pre-irradiation)

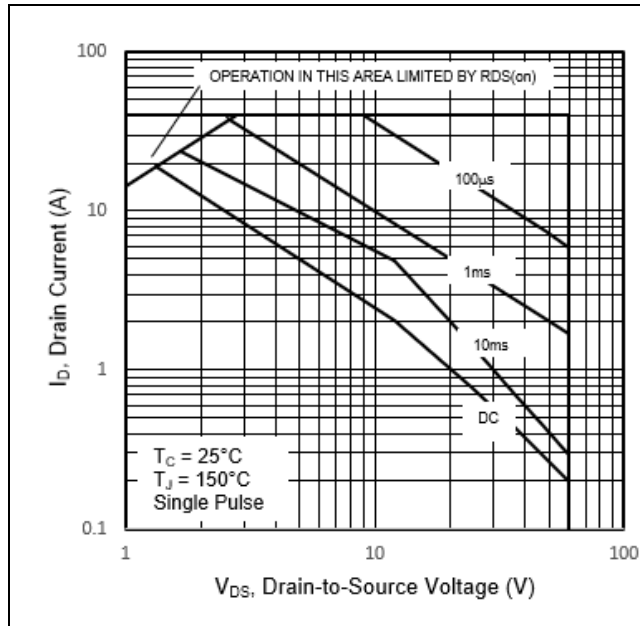


Figure 14 Maximum Safe Operating Area

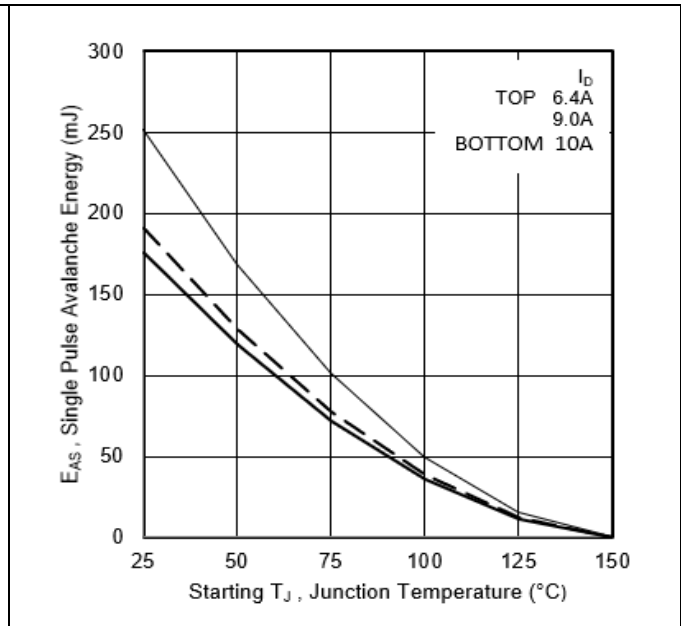


Figure 15 Maximum Avalanche Energy Vs. Drain Current

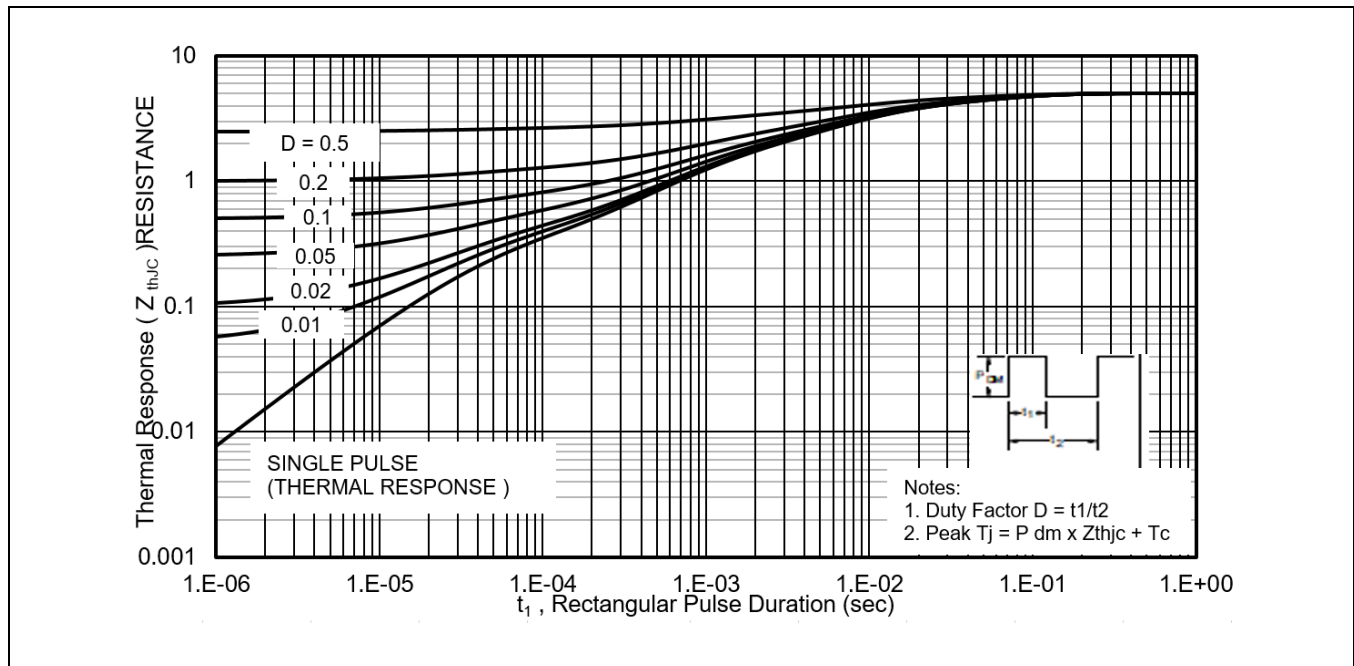


Figure 16 Maximum Effective Transient Thermal Impedance, Junction-to-Case

IRHNPC9A7014 (JANSR2N7655U9C)

Radiation Hardened Power MOSFET Surface mount (SMD-0.1)

Test Circuits (Pre-irradiation)

4 Test Circuits (Pre-irradiation)

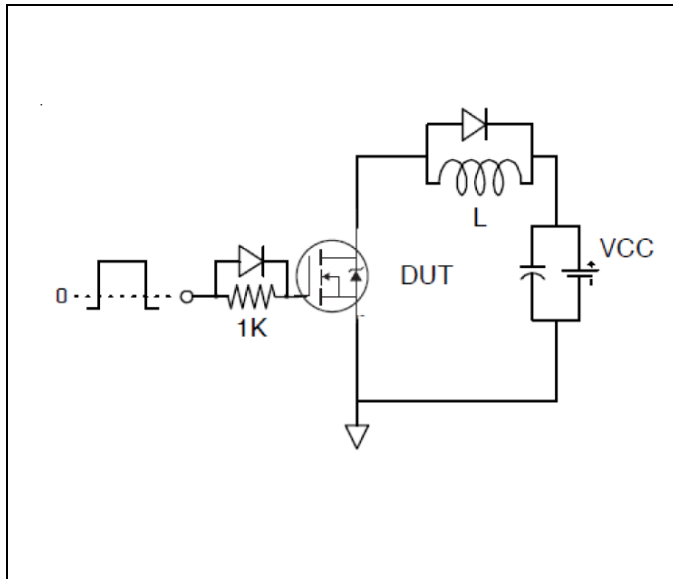


Figure 17 Gate Charge Test Circuit

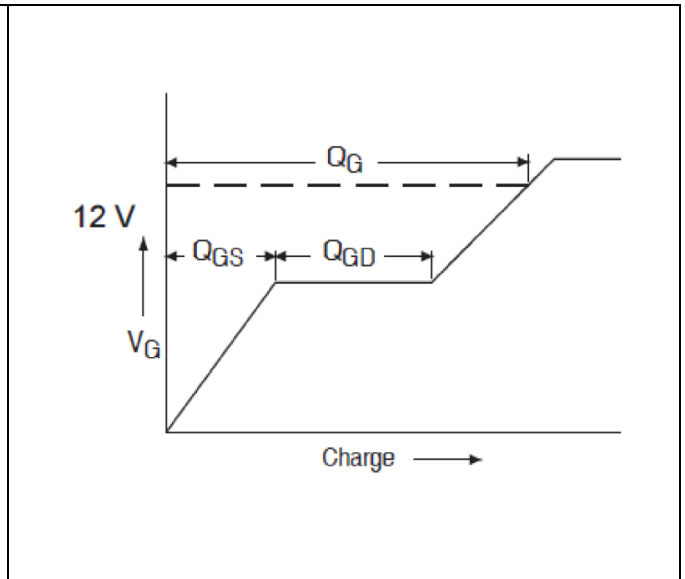


Figure 18 Gate Charge Waveform

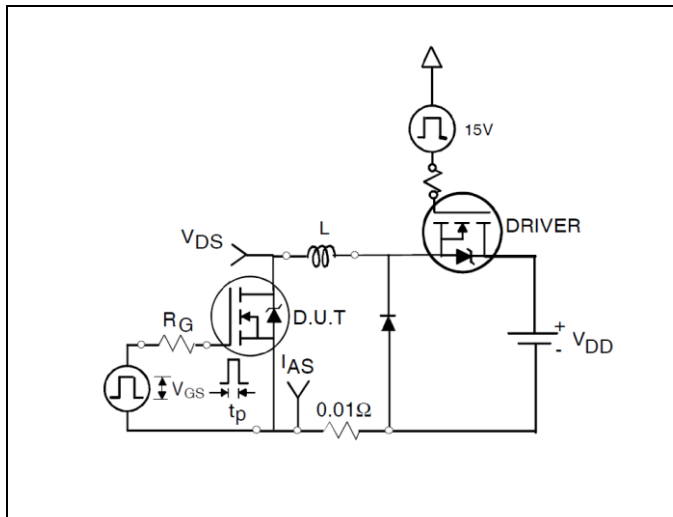


Figure 19 Unclamped Inductive Test Circuit

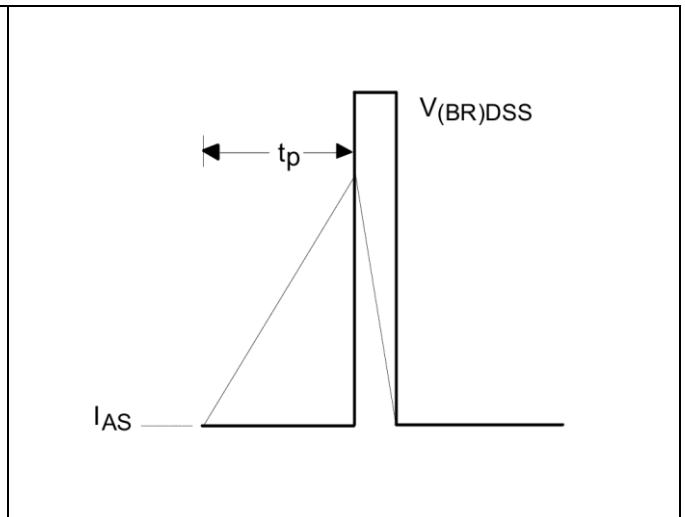


Figure 20 Unclamped Inductive Waveform

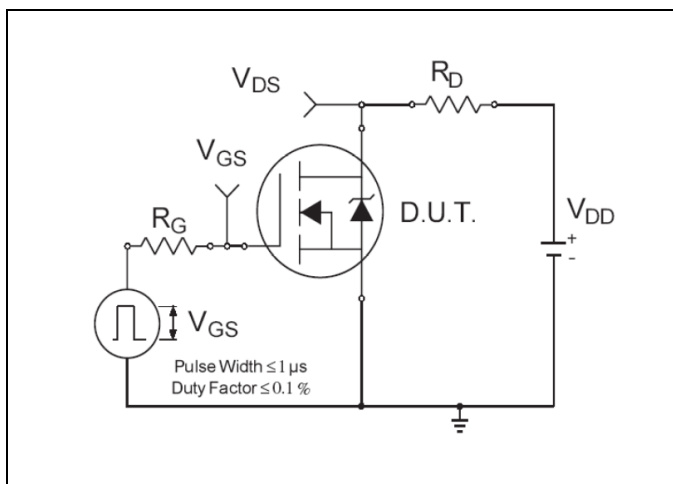


Figure 21 Switching Time Test Circuit

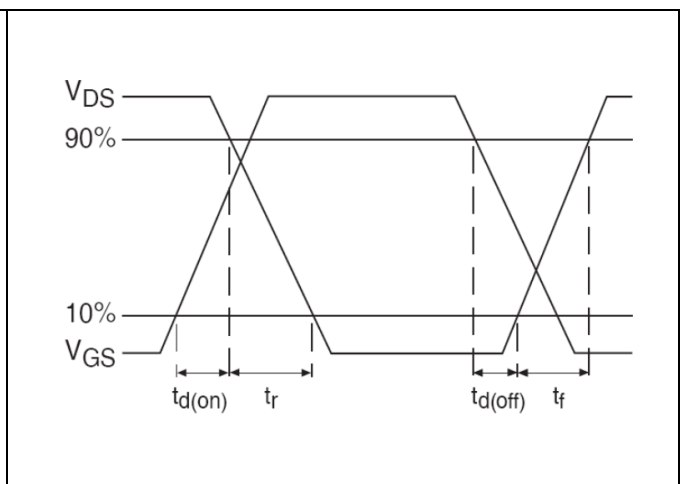


Figure 22 Switching Time Waveforms

IRHNPC9A7014 (JANSR2N7655U9C)
Radiation Hardened Power MOSFET Surface mount (SMD-0.1)

Revision history

Revision history

Document version	Date of release	Description of changes
	10/12/2022	Preliminary datasheet with PPD number (PPD-97968)
Rev A	01/27/2023	Final datasheet with PD number
Rev B	07/01/2024	Updated based on ECN-1120_09986

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Edition 2024-07-01

Published by

**International Rectifier HiRel Products,
Inc.**

**An Infineon Technologies company
El Segundo, California 90245 USA**

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