

# IRHNS9A7264 (JANSR2N7658U2A)

PD-97965C

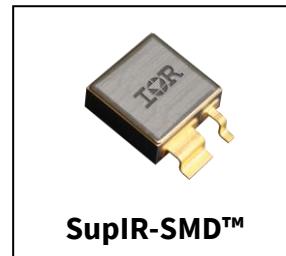
**Radiation Hardened Power MOSFET**  
**Surface Mount (SupIR-SMD™)**  
**250V, 82A, N-channel, R9 Superjunction Technology**

## Features

- Single event effect (SEE) hardened (up to LET of 88.2 MeV·cm<sup>2</sup>/mg)
- Low  $R_{DS(on)}$
- Fast switching
- Low total gate charge
- Simple drive requirements
- Hermetically sealed
- Ceramic package
- Light weight
- Surface mount
- ESD rating: Class 3B per MIL-STD-750, Method 1020

## Product Summary

- $BV_{DSS}$ : 250V
- $I_D$ : 82A
- $R_{DS(on), max}$ : 17mΩ
- $Q_{Gmax}$ : 165nC
- DLA Ref: MIL-PRF-19500/777



SupIR-SMD™

## Potential Applications

- 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 88.2 MeV·cm<sup>2</sup>/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
IRHNS9A7264	SupIR-SMD™	COTS	100 krad(Si)
JANSR2N7658U2A	SupIR-SMD™	JANS	100 krad(Si)
IRHNS9A3264	SupIR-SMD™	COTS	300 krad(Si)
JANSF2N7658U2A	SupIR-SMD™	JANS	300 krad(Si)

Please read the Important Notice and Warnings at the end of this document

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**Absolute Maximum Ratings****1 Absolute Maximum Ratings****Table 2 Absolute Maximum Ratings (Pre-Irradiation)**

<b>Symbol</b>	<b>Parameter</b>	<b>Value</b>	<b>Unit</b>
$I_{D1}$ @ $V_{GS} = 12V$ , $T_C = 25^\circ C$	Continuous Drain Current	82	A
$I_{D2}$ @ $V_{GS} = 12V$ , $T_C = 100^\circ C$	Continuous Drain Current	52	A
$I_{DM}$ @ $T_C = 25^\circ C$	Pulsed Drain Current <sup>1</sup>	328	A
$P_D$ @ $T_C = 25^\circ C$	Maximum Power Dissipation	250	W
	Linear Derating Factor	2.0	W/ $^\circ C$
$V_{GS}$	Gate-to-Source Voltage	$\pm 20$	V
$E_{AS}$	Single Pulse Avalanche Energy <sup>2</sup>	2298	mJ
$I_{AR}$	Avalanche Current <sup>1</sup>	52	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	$^\circ C$
	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>  $V_{DD} = 125V$ , starting  $T_J = 25^\circ C$ ,  $L = 1.7mH$ , Peak  $I_L = 52A$ ,  $V_{GS} = 20V$ <sup>3</sup>  $I_{SD} \leq 82A$ ,  $di/dt \leq 2830A/\mu s$ ,  $V_{DD} \leq 250V$ ,  $T_J \leq 150^\circ C$

## 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)**

<b>Symbol</b>	<b>Parameter</b>	<b>Min.</b>	<b>Typ.</b>	<b>Max.</b>	<b>Unit</b>	<b>Test Conditions</b>
$\text{BV}_{\text{DSS}}$	Drain-to-Source Breakdown Voltage	250	—	—	V	$\text{V}_{\text{GS}} = 0\text{V}, \text{I}_D = 1.0\text{mA}$
$\Delta \text{BV}_{\text{DSS}}/\Delta T_J$	Breakdown Voltage Temp. Coefficient	—	0.20	—	$\text{V}/^\circ\text{C}$	Reference to $25^\circ\text{C}, \text{I}_D = 1.0\text{mA}$
$R_{\text{DS}(\text{on})}$	Static Drain-to-Source On-State Resistance	—	—	17	$\text{m}\Omega$	$\text{V}_{\text{GS}} = 12\text{V}, \text{I}_{\text{D2}} = 52\text{A}^1$
$\text{V}_{\text{GS}(\text{th})}$	Gate Threshold Voltage	2.0	—	4.0	V	$\text{V}_{\text{DS}} \geq \text{V}_{\text{GS}}, \text{I}_D = 6\text{mA}$
$\Delta \text{V}_{\text{GS}(\text{th})}/\Delta T_J$	Gate Threshold Voltage Coefficient	—	-9.2	—	$\text{mV}/^\circ\text{C}$	
$G_{\text{fs}}$	Forward Transconductance	50	—	—	S	$\text{V}_{\text{DS}} = 15\text{V}, \text{I}_{\text{D2}} = 52\text{A}^1$
$I_{\text{DSS}}$	Zero Gate Voltage Drain Current	—	—	1.0	$\mu\text{A}$	$\text{V}_{\text{DS}} = 200\text{V}, \text{V}_{\text{GS}} = 0\text{V}$
		—	—	25		$\text{V}_{\text{DS}} = 200\text{V}, \text{V}_{\text{GS}} = 0\text{V}, T_J = 125^\circ\text{C}$
$I_{\text{GSS}}$	Gate-to-Source Leakage Forward	—	—	100	$\text{nA}$	$\text{V}_{\text{GS}} = 20\text{V}$
	Gate-to-Source Leakage Reverse	—	—	-100		$\text{V}_{\text{GS}} = -20\text{V}$
$Q_G$	Total Gate Charge	—	—	165	$\text{nC}$	$I_{\text{D1}} = 82\text{A}$
$Q_{\text{GS}}$	Gate-to-Source Charge	—	—	64		$\text{V}_{\text{DS}} = 125\text{V}$
$Q_{\text{GD}}$	Gate-to-Drain ('Miller') Charge	—	—	48		$\text{V}_{\text{GS}} = 12\text{V}$
$t_{\text{d}(\text{on})}$	Turn-On Delay Time	—	—	39	$\text{ns}$	$I_{\text{D1}} = 82\text{A}^{**}$ $\text{V}_{\text{DD}} = 125\text{V}$ $R_G = 2.4\Omega$ $\text{V}_{\text{GS}} = 12\text{V}$
$t_r$	Rise Time	—	—	39		
$t_{\text{d}(\text{off})}$	Turn-Off Delay Time	—	—	114		
$t_f$	Fall Time	—	—	27		
$L_s + L_D$	Total Inductance	—	4.0	—	$\text{nH}$	Measured from center of Drain pad to center of Source pad
$C_{\text{iss}}$	Input Capacitance	—	8364	—	$\text{pF}$	$\text{V}_{\text{GS}} = 0\text{V}$ $\text{V}_{\text{DS}} = 25\text{V}$ $f = 100\text{KHz}$
$C_{\text{oss}}$	Output Capacitance	—	1200	—		
$C_{\text{rss}}$	Reverse Transfer Capacitance	—	1.1	—		
$R_G$	Gate Resistance	—	1.4	—	$\Omega$	$f = 1.0\text{MHz}$ , open drain

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

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

**Device Characteristics****2.2 Source-Drain Diode Ratings and Characteristics (Pre-Irradiation)****Table 4 Source-Drain Diode Characteristics**

<b>Symbol</b>	<b>Parameter</b>	<b>Min.</b>	<b>Typ.</b>	<b>Max.</b>	<b>Unit</b>	<b>Test Conditions</b>
$I_S$	Continuous Source Current (Body Diode)	—	—	82	A	
$I_{SM}$	Pulsed Source Current (Body Diode) <sup>1</sup>	—	—	328	A	
$V_{SD}$	Diode Forward Voltage	—	—	1.2	V	$T_J = 25^\circ\text{C}$ , $I_S = 82\text{A}$ , $V_{GS} = 0\text{V}$ <sup>2</sup>
$t_{rr}$	Reverse Recovery Time	—	356	415	ns	$T_J = 25^\circ\text{C}$ , $I_F = 82\text{A}$ , $V_{DD} \leq 25\text{V}$
$Q_{rr}$	Reverse Recovery Charge	—	6.3	—	$\mu\text{C}$	$dI/dt = 100\text{A}/\mu\text{s}$
$t_{on}$	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**

<b>Symbol</b>	<b>Parameter</b>	<b>Min.</b>	<b>Typ.</b>	<b>Max.</b>	<b>Unit</b>
$R_{\theta JC}$	Junction-to-Case	—	—	0.5	$^\circ\text{C}/\text{W}$
$R_{\theta J - \text{PCB}}$	Junction-to-PC Board (Soldered to 2" sq 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>**

<b>Symbol</b>	<b>Parameter</b>	<b>Up to 300 krad (Si)<sup>5</sup></b>		<b>Unit</b>	<b>Test Conditions</b>
		<b>Min.</b>	<b>Max.</b>		
$BV_{DSS}$	Drain-to-Source Breakdown Voltage	250	—	V	$V_{GS} = 0\text{V}$ , $I_D = 1.0\text{mA}$
$V_{GS(\text{th})}$	Gate Threshold Voltage	2.0	4.0	V	$V_{DS} \geq V_{GS}$ , $I_D = 6.0\text{mA}$
$I_{GSS}$	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	—	1.0	$\mu\text{A}$	$V_{DS} = 200\text{V}$ , $V_{GS} = 0\text{V}$
$R_{DS(\text{on})}$	Static Drain-to-Source On-State Resistance (TO-3) <sup>2</sup>	—	18.5	$\text{m}\Omega$	$V_{GS} = 12\text{V}$ , $I_{D2} = 52\text{A}$
$R_{DS(\text{on})}$	Static Drain-to-Source On-State Resistance (SupIR-SMD) <sup>2</sup>	—	17	$\text{m}\Omega$	$V_{GS} = 12\text{V}$ , $I_{D2} = 52\text{A}$
$V_{SD}$	Diode Forward Voltage	—	1.2	V	$V_{GS} = 0\text{V}$ , $I_F = 75\text{A}$

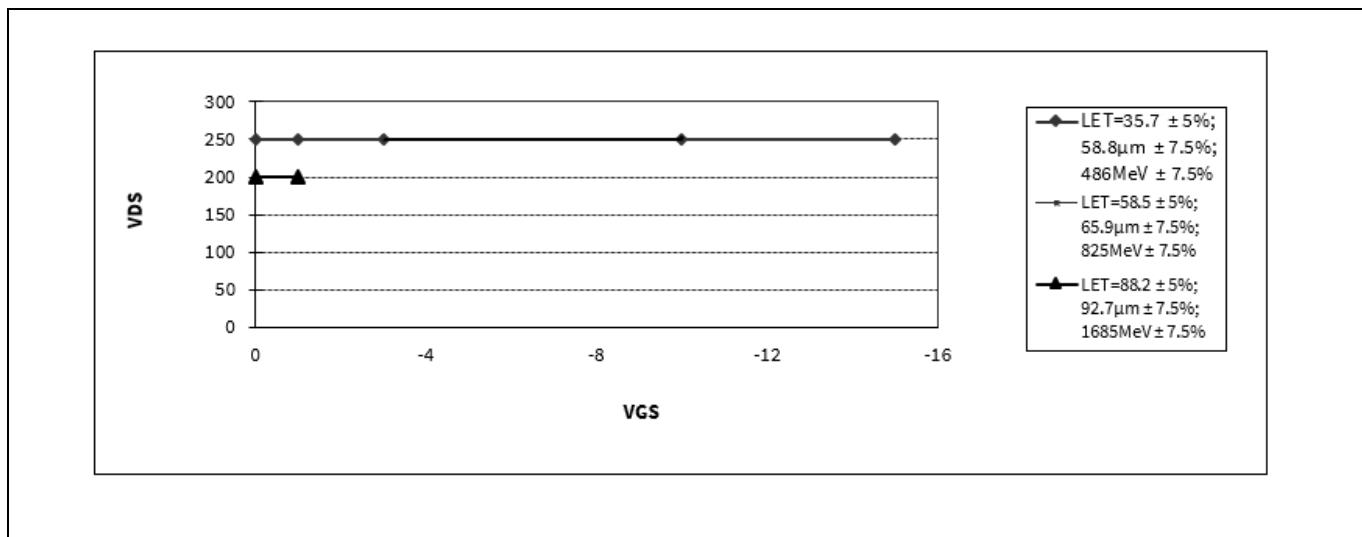
<sup>1</sup> Repetitive Rating; Pulse width limited by maximum junction temperature.<sup>2</sup> Pulse width  $\leq 300\ \mu\text{s}$ ; Duty Cycle  $\leq 2\%$ <sup>3</sup> Total Dose Irradiation with  $V_{GS}$  Bias.  $V_{GS} = 12\text{V}$  applied and  $V_{DS} = 0$  during irradiation per MIL-STD-750, Method 1019, condition A.<sup>4</sup> Total Dose Irradiation with  $V_{DS}$  Bias.  $V_{DS} = 200\text{V}$  applied and  $V_{GS} = 0$  during irradiation per MIL-STD-750, Method 1019, condition A.<sup>5</sup> Part numbers IRHNS9A7264 (JANSR2N7658U2A) and IRHNS9A3264 (JANSF2N7658U2A)

**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> = -3V	V <sub>GS</sub> = -10V	V <sub>GS</sub> = -15V
35.7 ± 5%	486 ± 7.5%	58.8 ± 7.5%	250	250	250	250	250
58.5 ± 5%	825 ± 7.5%	65.9 ± 7.5%	250	250	250	250	—
88.2 ± 5%	1685 ± 7.5%	92.7 ± 7.5%	200	200	—	—	—

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

## Electrical Characteristics Curves (Pre-irradiation)

## 3 Electrical Characteristics Curves (Pre-irradiation)

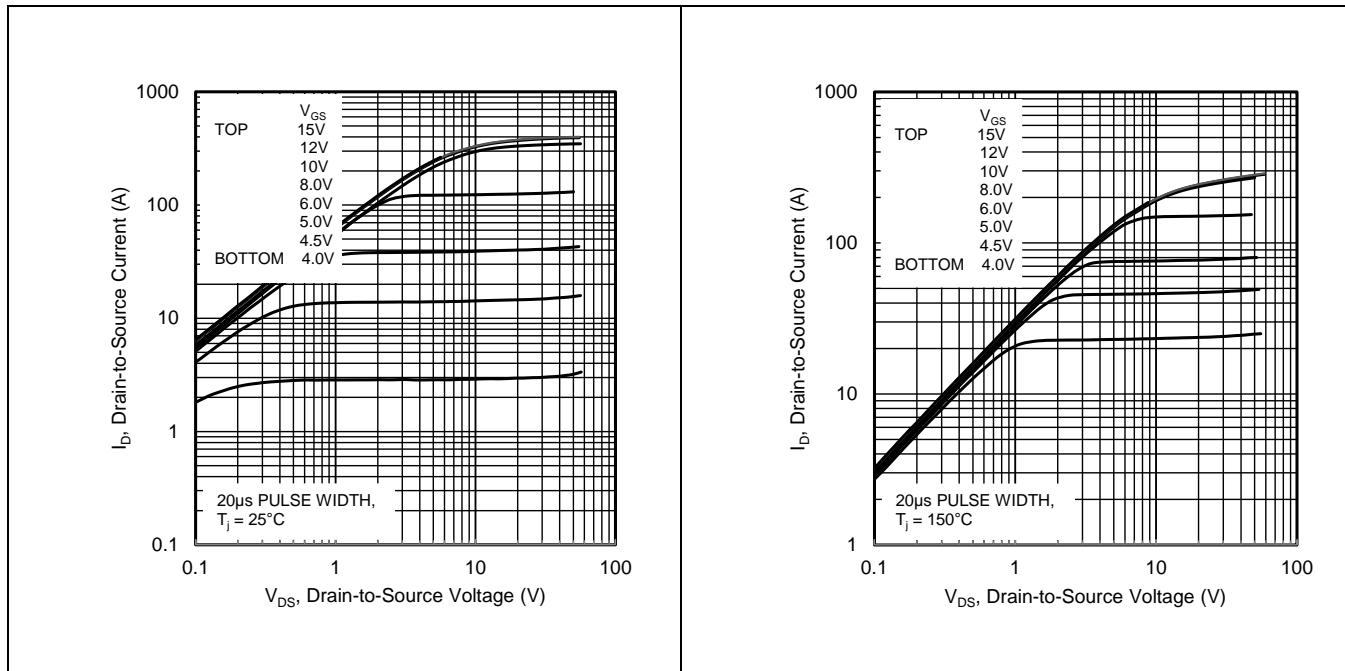


Figure 2 Typical Output Characteristics

Figure 3 Typical Output Characteristics

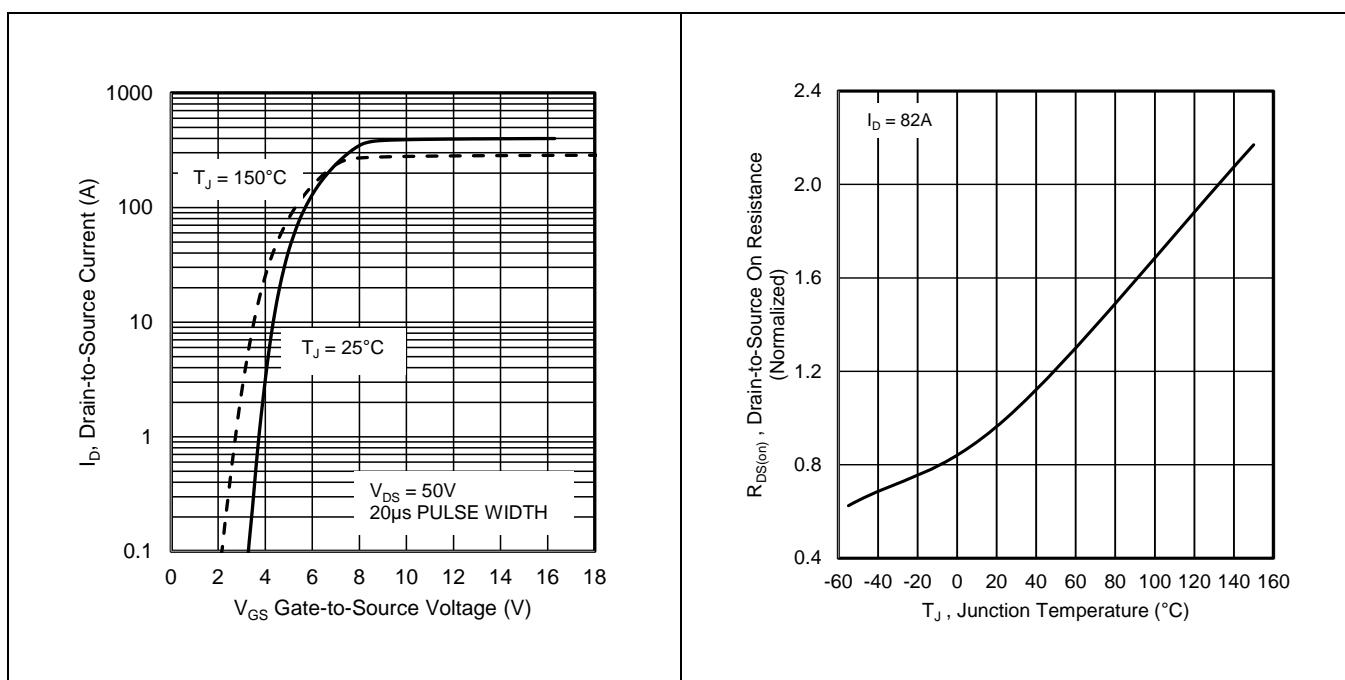


Figure 4 Typical Transfer Characteristics

Figure 5 Normalized On-Resistance Vs. Temperature

## Electrical Characteristics Curves (Pre-irradiation)

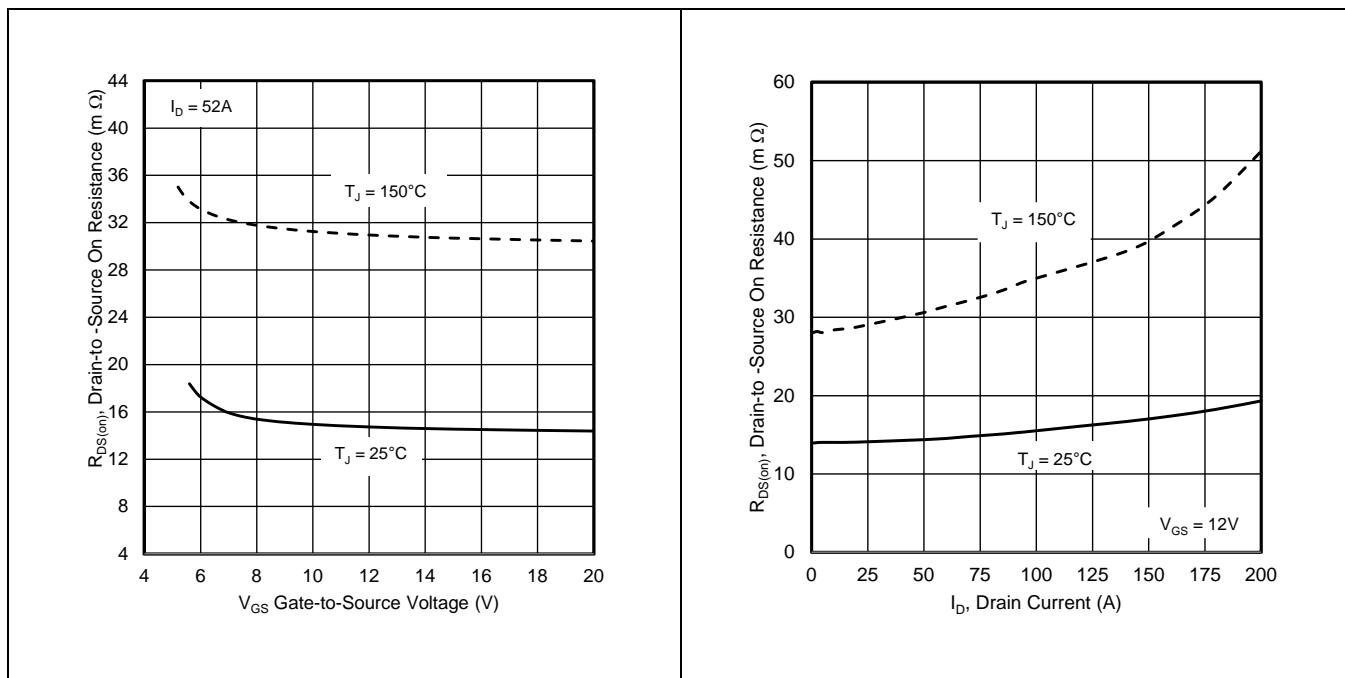


Figure 6 Typical On-Resistance Vs Gate Voltage

Figure 7 Typical On-Resistance Vs Drain Current

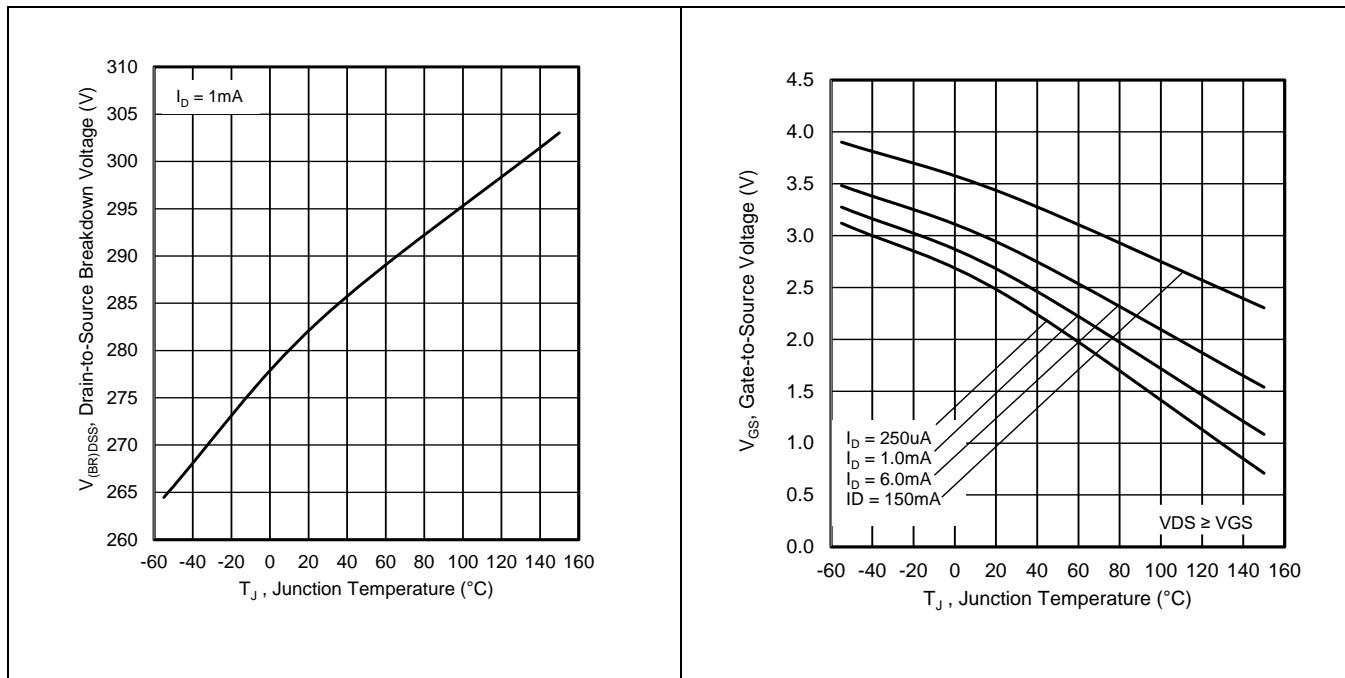
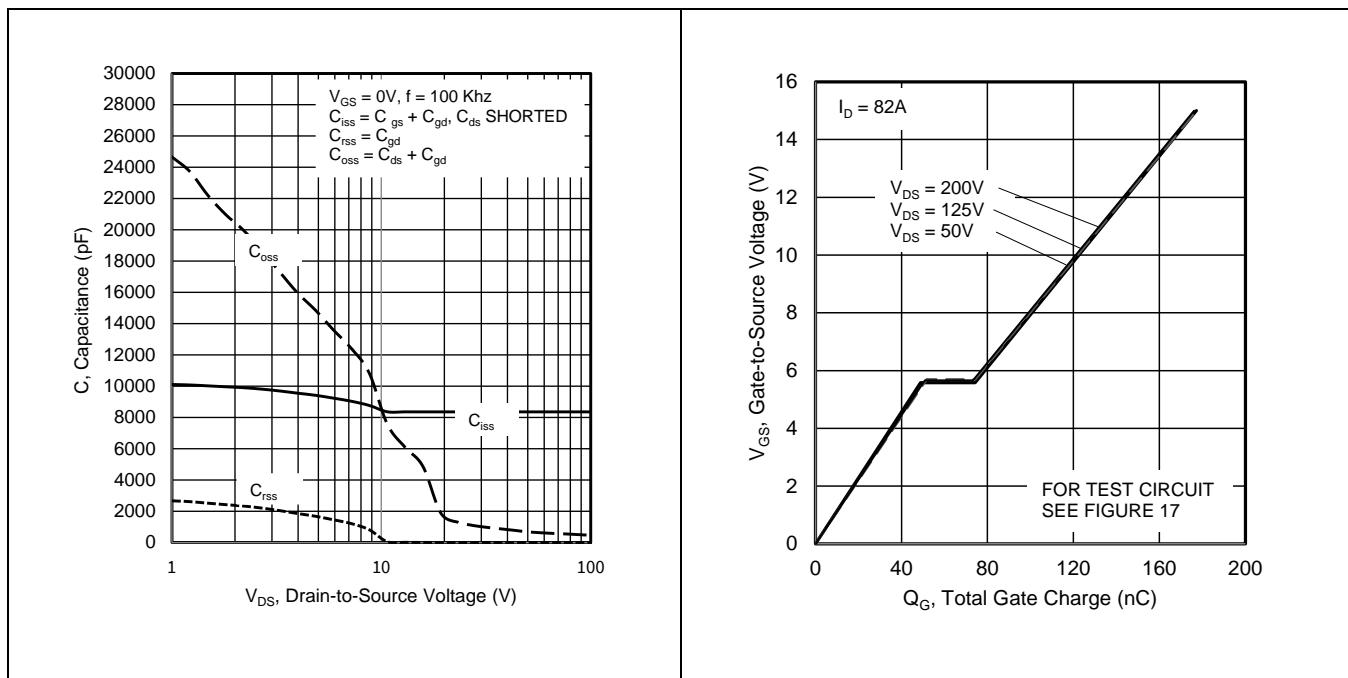


Figure 8 Typical Drain-to-Source Breakdown Voltage Vs. Temperature

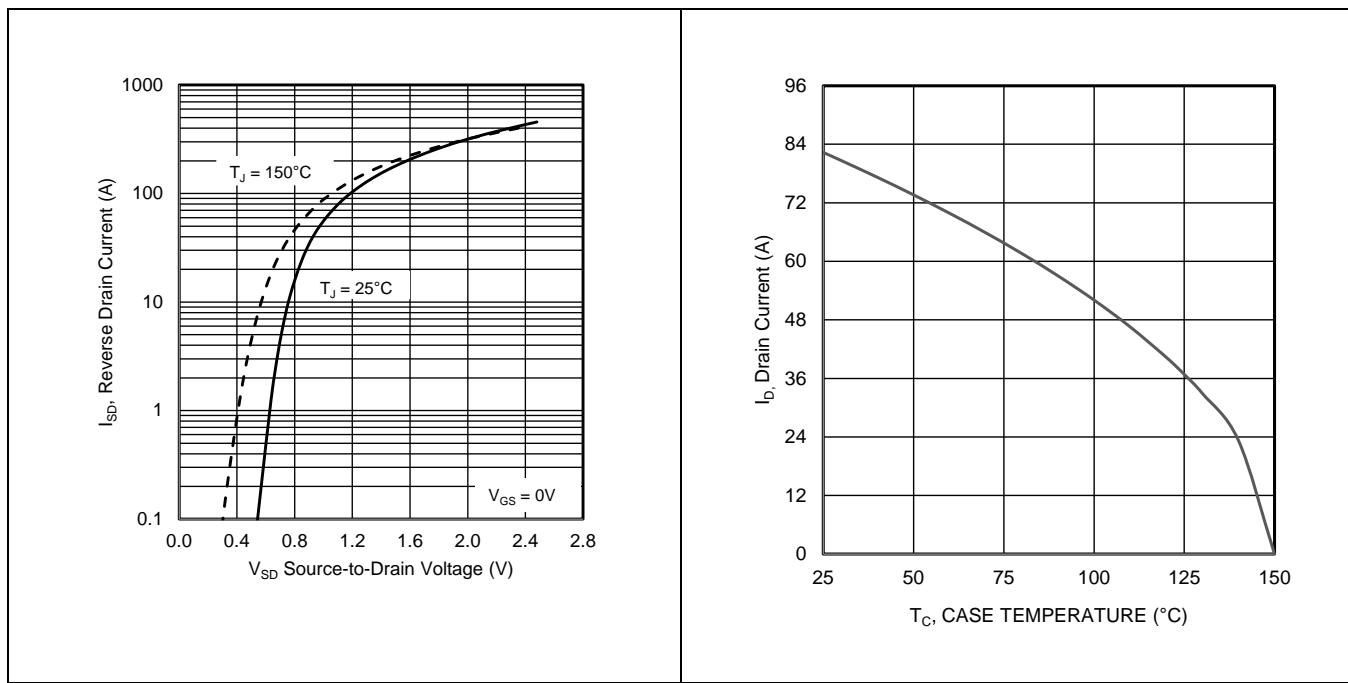
Figure 9 Typical Threshold Voltage Vs. Temperature

## Electrical Characteristics Curves (Pre-irradiation)



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

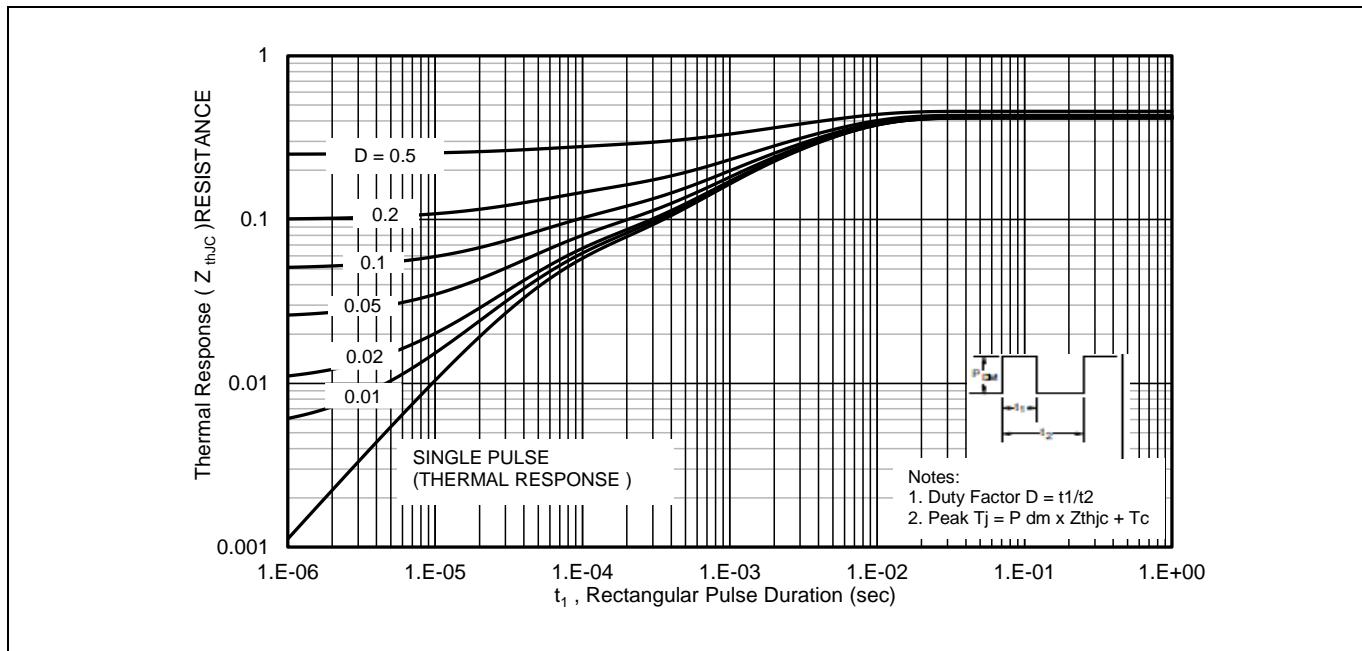
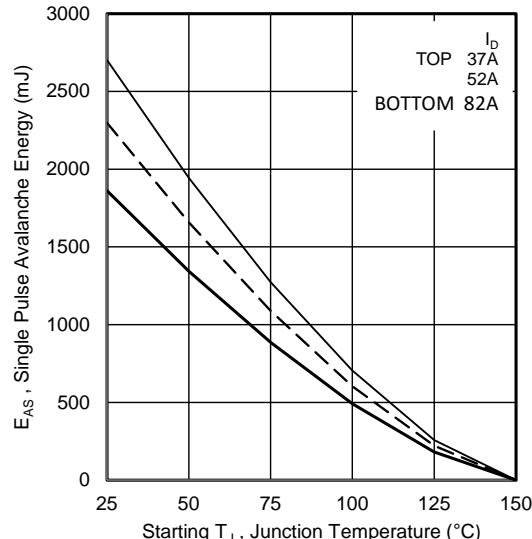
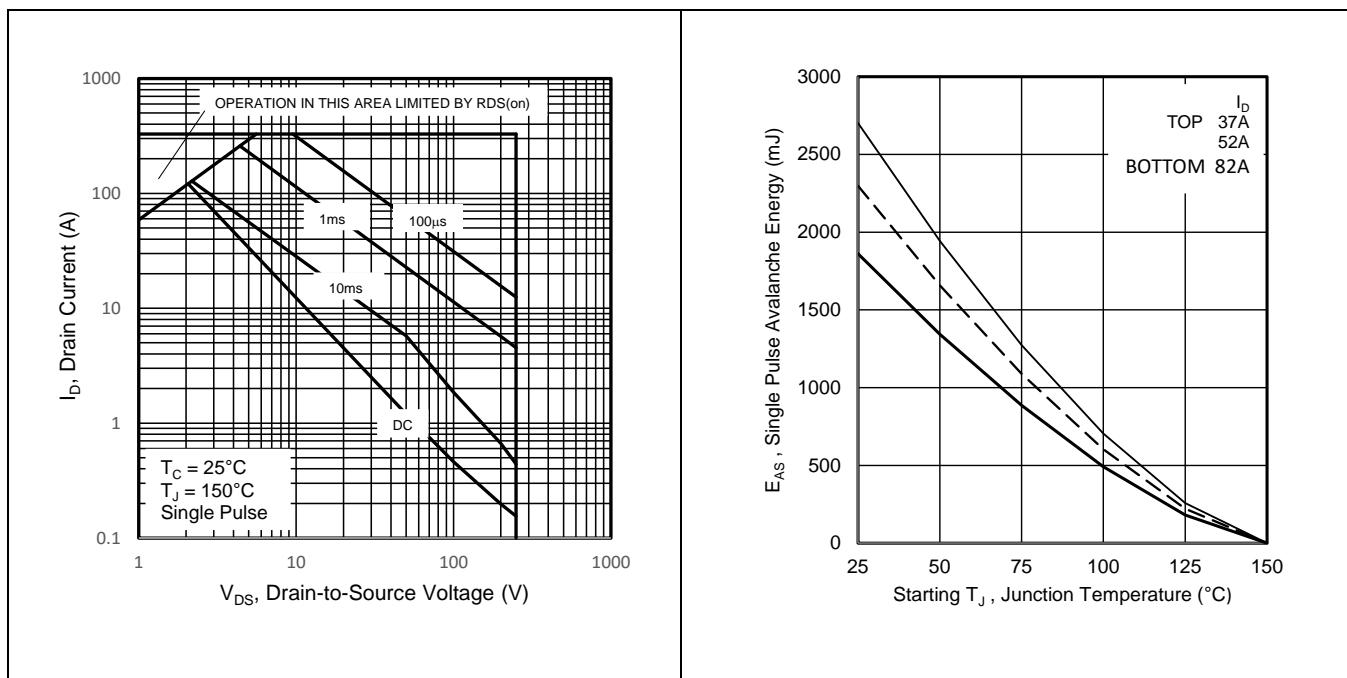
**Figure 11** Gate-to-Source Voltage Vs.  
Typical Gate Charge



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

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

## Electrical Characteristics Curves (Pre-irradiation)



## Test Circuits (Pre-irradiation)

## 4 Test Circuits (Pre-irradiation)

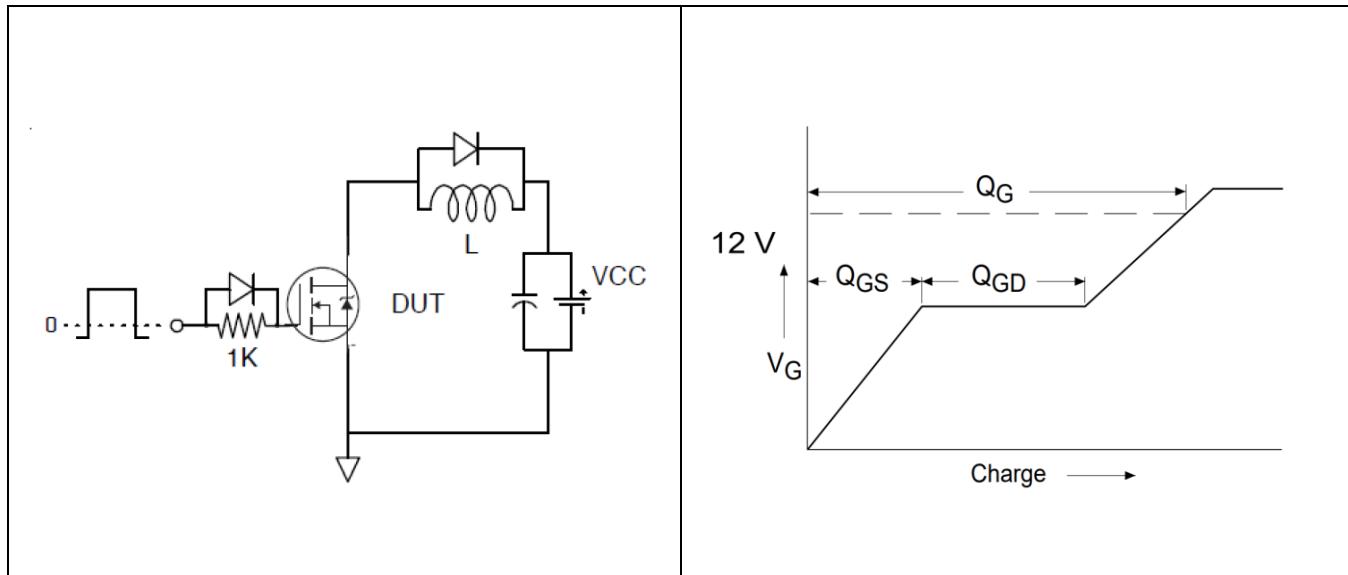


Figure 17 Gate Charge Test Circuit

Figure 18 Gate Charge Waveform

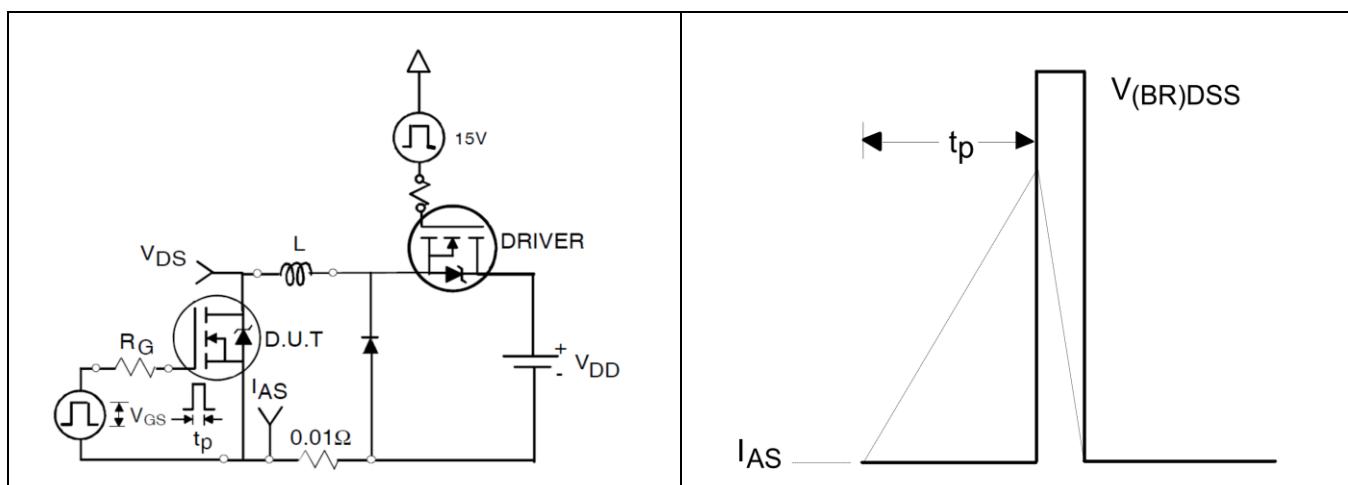


Figure 19 Unclamped Inductive Test Circuit

Figure 20 Unclamped Inductive Waveform

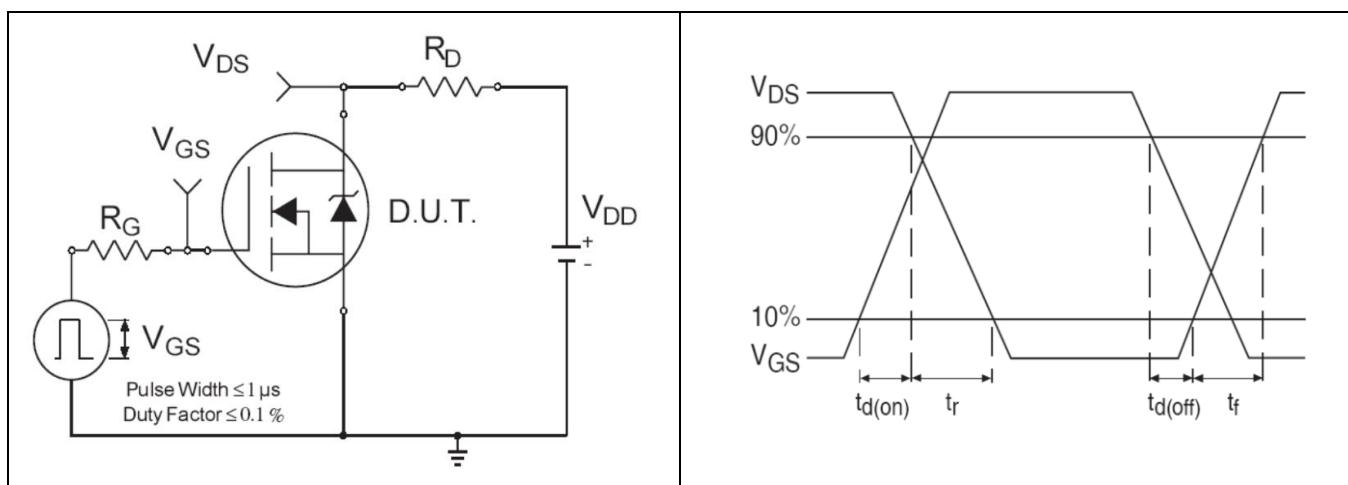


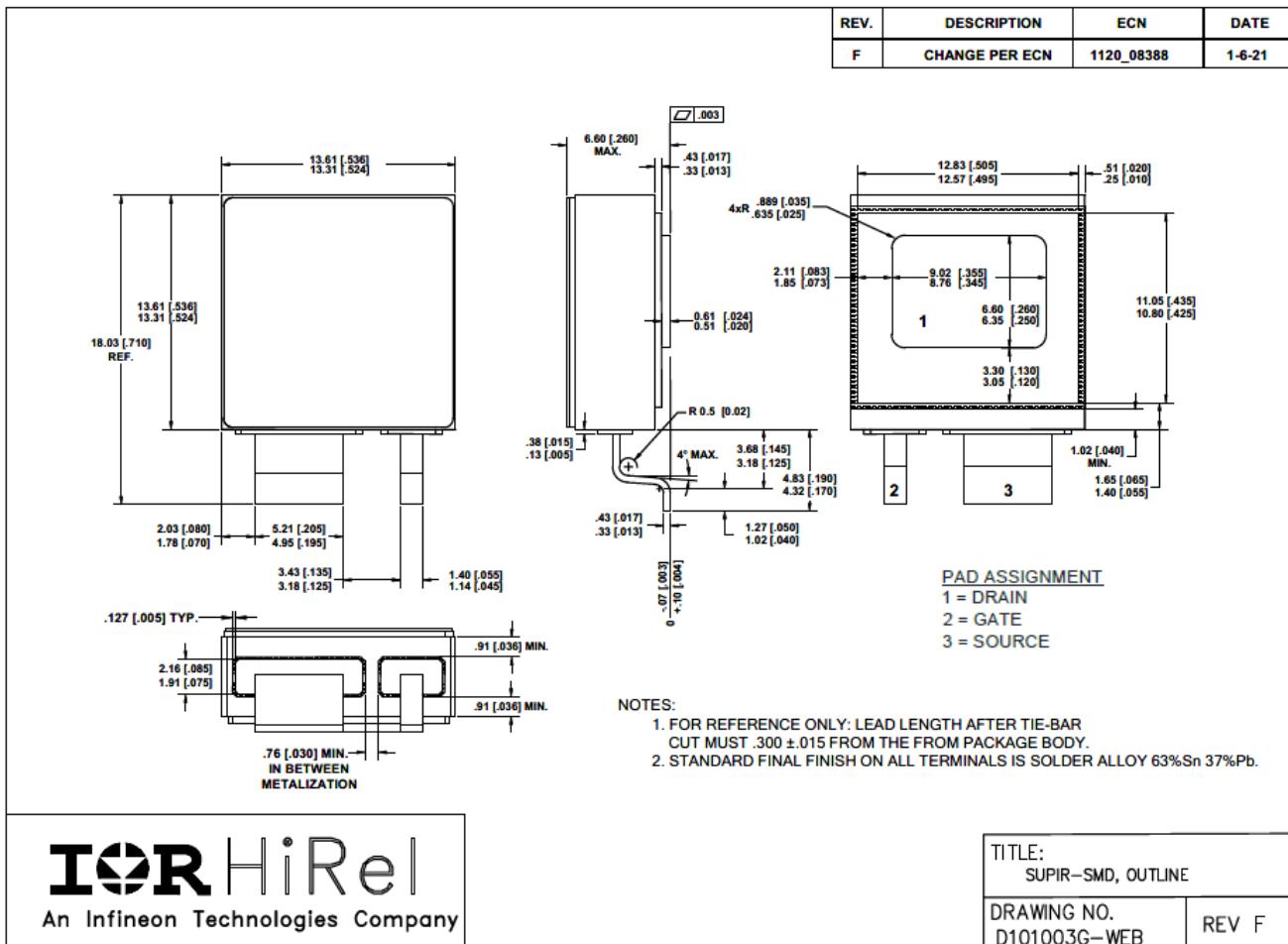
Figure 21 Switching Time Test Circuit

Figure 22 Switching Time Waveforms

## Package Outline

**5 Package Outline**

**Note: For the most updated package outline, please see the website: [SupIR-SMD™](#)**



## Revision history

Document version	Date of release	Description of changes
	08/25/2022	Preliminary datasheet with PPD number (PPD-97965A)
Rev B	10/31/2022	Final datasheet with PD number (PD-97965B)
Rev C	07/17/2023	Updated based on ECN-1120_09623

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