IRHNM9A7024

PD-97899A

Radiation Hardened Power MOSFET
Surface Mount (SMD-0.2)
60V, N-channel, R9 Technology

Features

- Single event effect (SEE) hardened
- Low $R_{DS(on)}$
- Fast switching
- Low total gate charge
- Simple drive requirements
- Hermetically sealed
- Ceramic package
- Surface mount
- Light weight
- ESD rating: class 1C per MIL-STD-750, Method 1020

Product Summary

- **BV_{DSS}**: 60V
- **I_D :** 25A*
- **$R_{DS(on),max}$:** 30mΩ
- **$Q_{G,\,max}$**: 31nC

SMD-0.2

Potential Applications

- Isolated DC-DC Converter
- Motor Drives
- Solid state relays

Product Validation

Adhered to MIL-PRF-19500 qualification requirements 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 90 MeV·cm^2/mg. Their combination of low $R_{DS(on)}$ and faster switching times reduces the power losses and increases power density in today's high speed 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
IRHNM9A7024	SMD-0.2	COTS	100krad(Si)
IRHNM9A3024	SMD-0.2	COTS	300krad(Si)
IRHNM9A7024SCS	SMD-0.2	S-Level	100krad(Si)
IRHNM9A3024SCS	SMD-0.2	S-Level	300krad(Si)

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1 Absolute Maximum Ratings

Table 2 Absolute Maximum Ratings (Pre-Irradiation)

Symbol	Parameter	Value	Unit
I_{D1} @ V_{GS} = 12V, T_C = 25°C	Continuous Drain Current	25*	A
I_{D2} @ V_{GS} = 12V, T_C = 100°C	Continuous Drain Current	20	A
I_{DM} @ T_C = 25°C	Pulsed Drain Current [1]	100	A
P_D @ T_C = 25°C	Maximum Power Dissipation	54	W
	Linear Derating Factor	0.43	W/°C
V_{GS}	Gate-to-Source Voltage	± 20	V
E_{AS}	Single Pulse Avalanche Energy [2]	520	mJ
I_{AR}	Avalanche Current [1]	25	A
E_{AR}	Repetitive Avalanche Energy [1]	5.4	mJ
dv/dt	Peak Diode Reverse Recovery [3]	8.6	V/ns
T_J T_{STG}	Operating Junction and Storage Temperature Range	-55 to +150	°C
	Package Mounting Surface Temperature	300 (for 5 s)	
	Weight	0.25 (Typical)	g

*Current is limited by package

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

[2] V_{DD} = 60V, starting T_J = 25°C, L = 2.6mH, Peak I_L = 20A, V_{GS} = 20V

[3] $I_{SD} \leq$ 25A, di/dt $\leq$ 1300A/µs, $V_{DD} \leq$ 60V, $T_J \leq$ 150°C

2 Device Characteristics

2.1 Electrical Characteristics (Pre-Irradiation)

Table 3 Static and Dynamic Electrical Characteristics @ T_j = 25°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	—	0.06	—	V/°C	Reference to 25°C, I_D = 1.0mA
$R_{DS(on)}$	Static Drain-to-Source On-State Resistance	—	—	30	mΩ	V_{GS} = 12V, I_{D2} = 20A [1]
$V_{GS(th)}$	Gate Threshold Voltage	2.0	—	4.0	V	$V_{DS} = V_{GS}$, I_D = 650µA
$\Delta V_{GS(th)}/\Delta T_J$	Gate Threshold Voltage Coefficient	—	-7.2	—	mV/°C	
Gfs	Forward Transconductance	10	—	—	S	V_{DS} = 15V, I_{D2} = 20A [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°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	—	—	31	nC	I_{D1} = 25A V_{DS} = 30V V_{GS} = 12V
Q_{GS}	Gate-to-Source Charge	—	—	10		
Q_{GD}	Gate-to-Drain ('Miller') Charge	—	—	6.4		
$t_{d(on)}$	Turn-On Delay Time	—	—	11	ns	I_{D1} = 25A ** V_{DD} = 30V R_G = 7.5Ω V_{GS} = 12V
t_r	Rise Time	—	—	20		
$t_{d(off)}$	Turn-Off Delay Time	—	—	29		
t_f	Fall Time	—	—	12		
$L_s + L_D$	Total Inductance	—	6.8	—	nH	Measured from center of Drain pad to center of Source pad
C_{iss}	Input Capacitance	—	1160	—	pF	V_{GS} = 0V V_{DS} = 25V f = 1.0MHz
C_{oss}	Output Capacitance	—	440	—		
C_{rss}	Reverse Transfer Capacitance	—	2.6	—		
R_G	Gate Resistance	—	1.5	—	Ω	f = 1.0MHz, open drain

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

[1] Pulse width ≤ 300 µs; Duty Cycle ≤ 2%

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)	—	—	25	A	
I_{SM}	Pulsed Source Current (Body Diode) [1]	—	—	100	A	
V_{SD}	Diode Forward Voltage	—	—	1.2	V	$T_J = 25°C$, $I_S = 25A$, $V_{GS} = 0V$ [2]
t_{rr}	Reverse Recovery Time	—	75	150	ns	$T_J = 25°C$, $I_F = 25A$, $V_{DD} \le 25V$ di/dt = 100A/µs [2]
Q_{rr}	Reverse Recovery Charge	—	250	—	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	—	—	2.3	°C/W

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 @ $T_j = 25°C$, Post Total Dose Irradiation [3, 4]

Symbol	Parameter	Upto 300krads (Si)[5]		Unit	Test Conditions
		Min.	Max.		
BV_{DSS}	Drain-to-Source Breakdown Voltage	60	—	V	$V_{GS} = 0V$, $I_D = 1.0mA$
$V_{GS(th)}$	Gate Threshold Voltage	2.0	4.0	V	$V_{DS} = V_{GS}$, $I_D = 650µA$
I_{GSS}	Gate-to-Source Leakage Forward	—	100	nA	$V_{GS} = 20V$
	Gate-to-Source Leakage Reverse	—	-100	nA	$V_{GS} = -20V$
I_{DSS}	Zero Gate Voltage Drain Current	—	1.0	µA	$V_{DS} = 48V$, $V_{GS} = 0V$
$R_{DS(on)}$	Static Drain-to-Source On-State Resistance (TO-3) [2]	—	30	mΩ	$V_{GS} = 12V$, $I_{D2} = 20A$
$R_{DS(on)}$	Static Drain-to-Source On-State Resistance (SMD-0.2) [2]	—	30	mΩ	$V_{GS} = 12V$, $I_{D2} = 20A$
V_{SD}	Diode Forward Voltage	—	1.2	V	$V_{GS} = 0V$, $I_F = 25A$

[1] Repetitive Rating; Pulse width limited by maximum junction temperature.
[2] Pulse width ≤ 300 µs; Duty Cycle ≤ 2%
[3] Total Dose Irradiation with V_{GS} Bias. $V_{GS} = 12V$ applied and $V_{DS} = 0$ during irradiation per MIL-STD-750, Method 1019, condition A.
[4] Total Dose Irradiation with V_{DS} Bias. $V_{DS} = 48V$ applied and $V_{GS} = 0$ during irradiation per MIL-STD-750, Method 1019, condition A.
[5] Part numbers IRHNM9A7024, IRHNM9A3024, IRHNM9A7024SCS and IRHNM9A3024SCS

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·cm²/mg)	Energy (MeV)	Range (µm)	V_{DS} (V)			
			V_{GS} = 0V	V_{GS} = -1V	V_{GS} = -5V	V_{GS} = -10V
38 ± 5%	355 ± 7.5%	43 ± 7.5%	60	60	60	60
60 ± 5%	753 ± 7.5%	60 ± 10%	60	60	60	60
90 ± 5%	1515 ± 7.5%	82 ± 7.5%	60	60	—	—

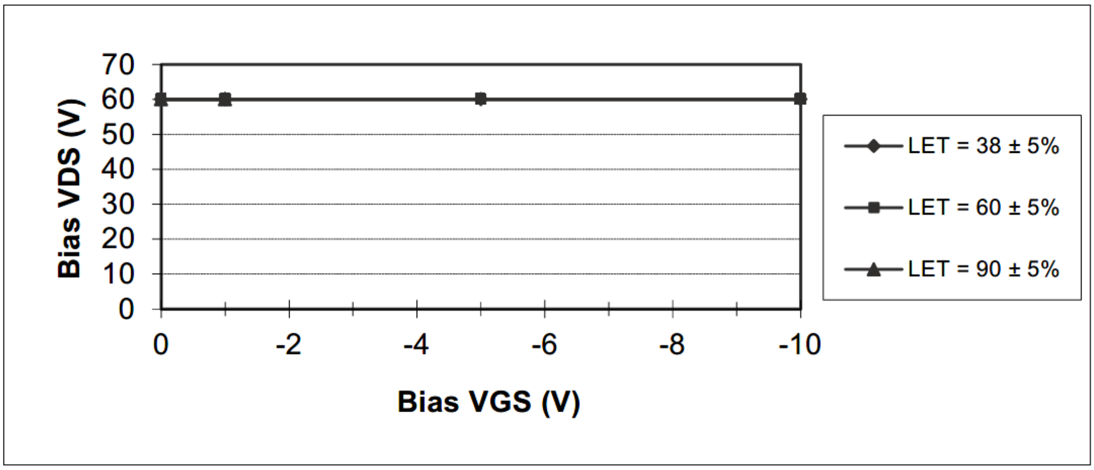


Figure 1 Typical Single Event Effect, Safe Operating Area

3 Electrical Characteristics Curves (Pre-irradiation)

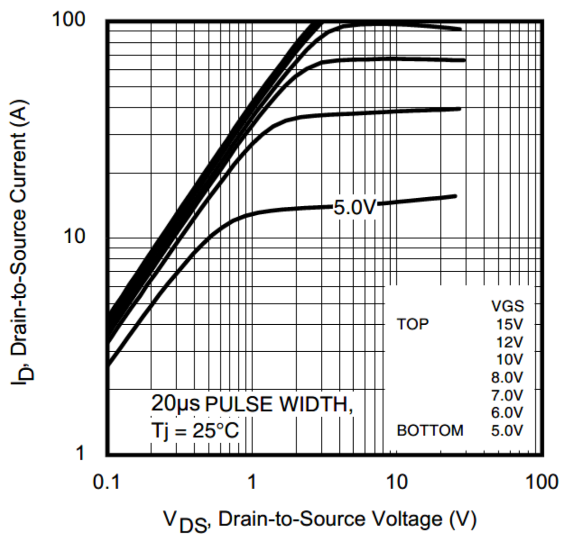


Figure 2 **Typical Output Characteristics**

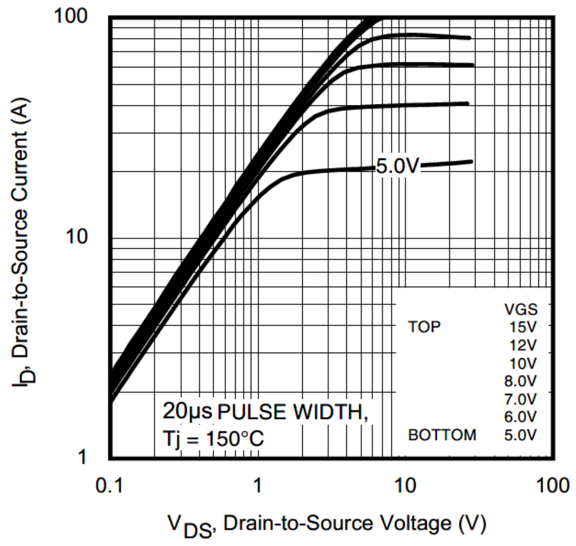


Figure 3 **Typical Output Characteristics**

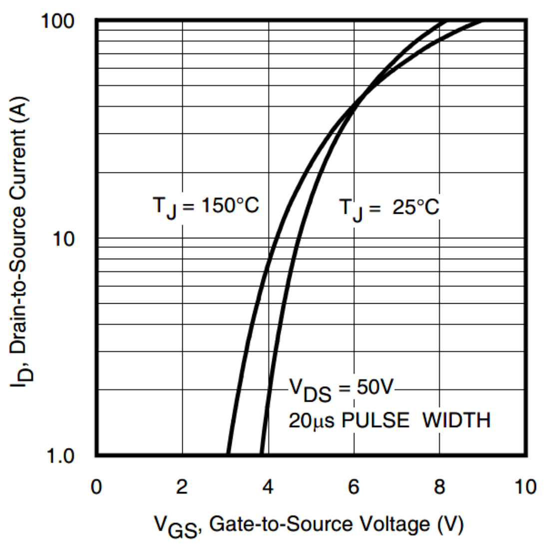


Figure 4 **Typical Transfer Characteristics**

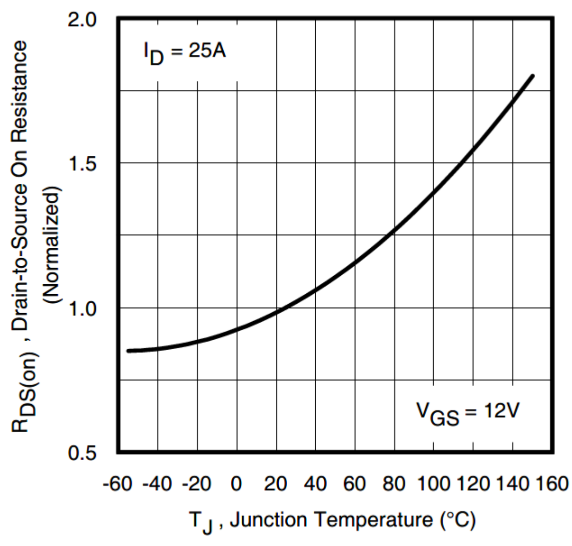


Figure 5 **Normalized On-Resistance Vs. Temperature**

Electrical Characteristics Curves (Pre-irradiation)

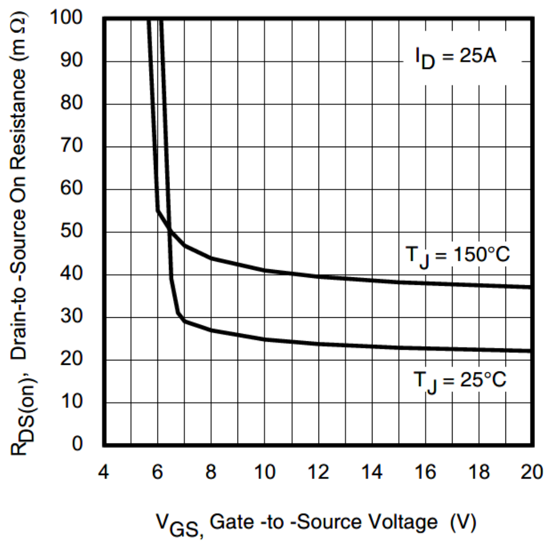


Figure 6 **Typical On-Resistance Vs. Gate Voltage**

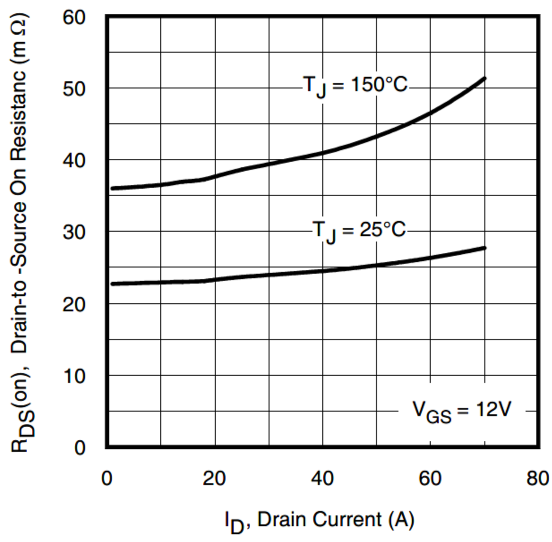


Figure 7 **Typical On-Resistance Vs. Drain Current**

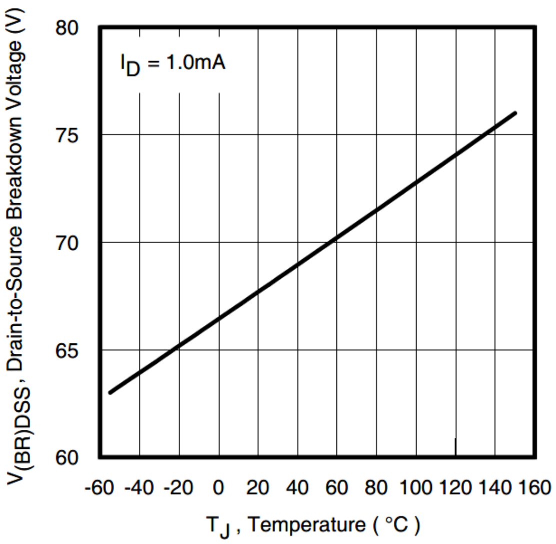


Figure 8 **Typical Drain-to-Source Breakdown Voltage Vs. Temperature**

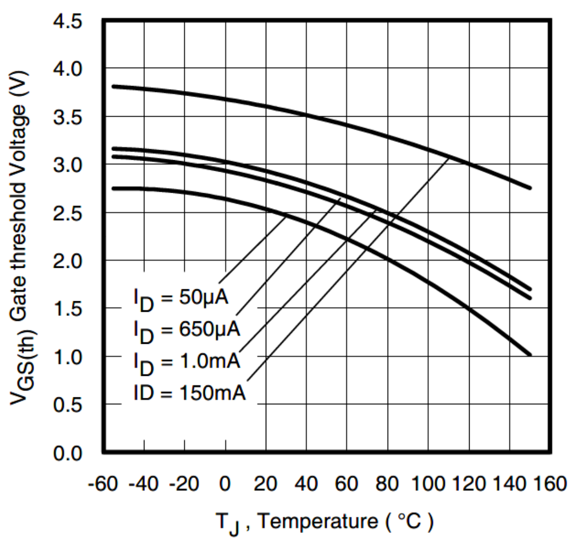


Figure 9 **Typical Threshold Voltage Vs. Temperature**

Electrical Characteristics Curves (Pre-irradiation)

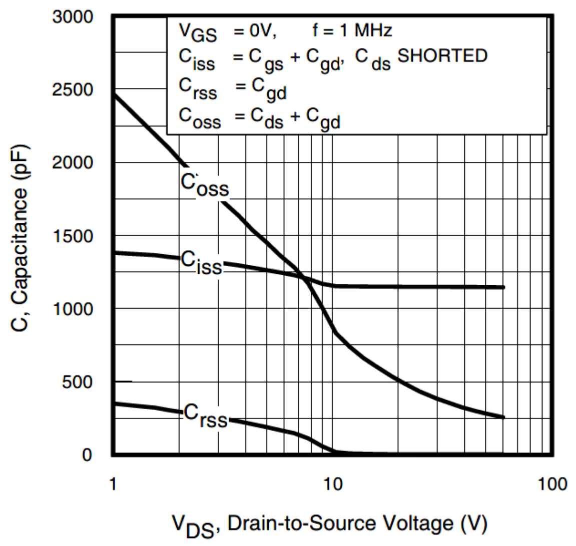


Figure 10 **Typical Capacitance Vs. Drain-to-Source Voltage**

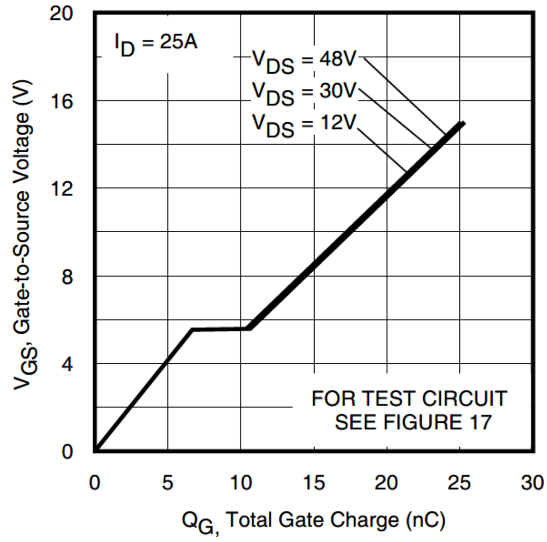


Figure 11 **Typical Gate Charge Vs. Gate-to-Source Voltage**

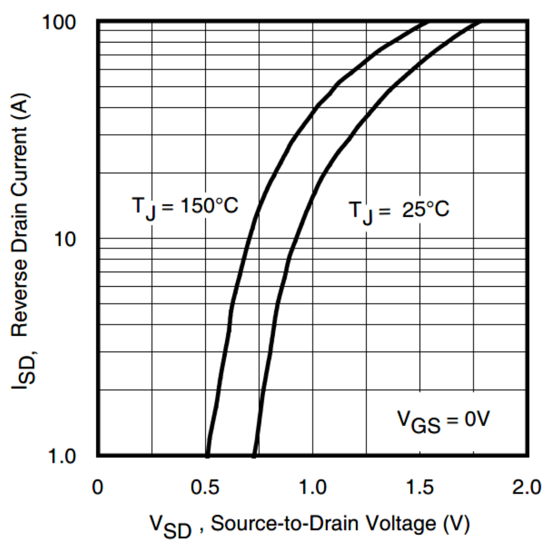


Figure 12 **Typical Source-Drain Vs. Diode Forward Voltage**

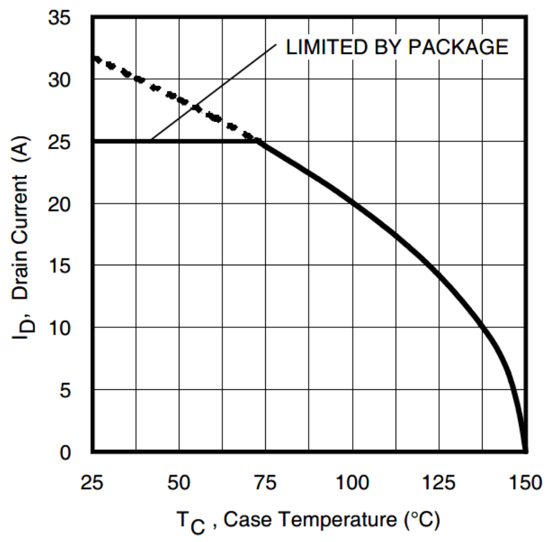


Figure 13 **Maximum Drain Current Vs. Case Temperature**

Electrical Characteristics Curves (Pre-irradiation)

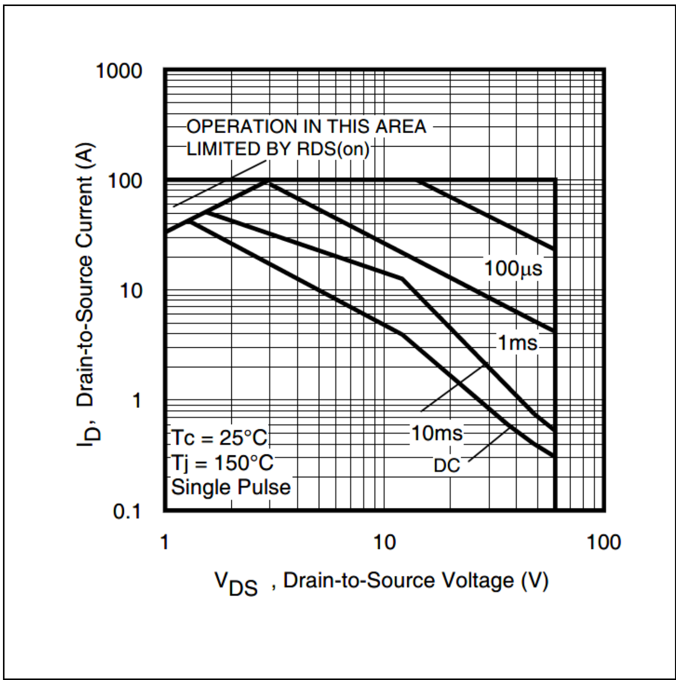


Figure 14 **Maximum Safe Operating Area**

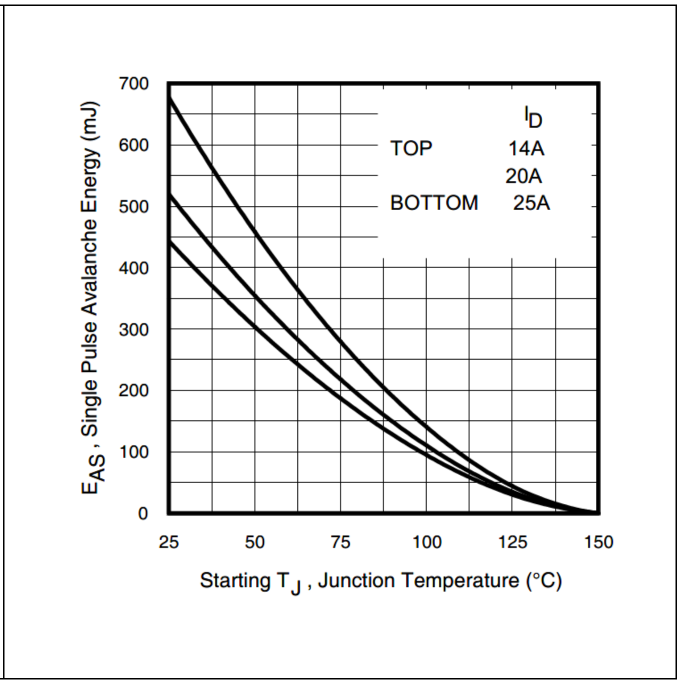


Figure 15 **Maximum Avalanche Energy Vs. Drain Current**

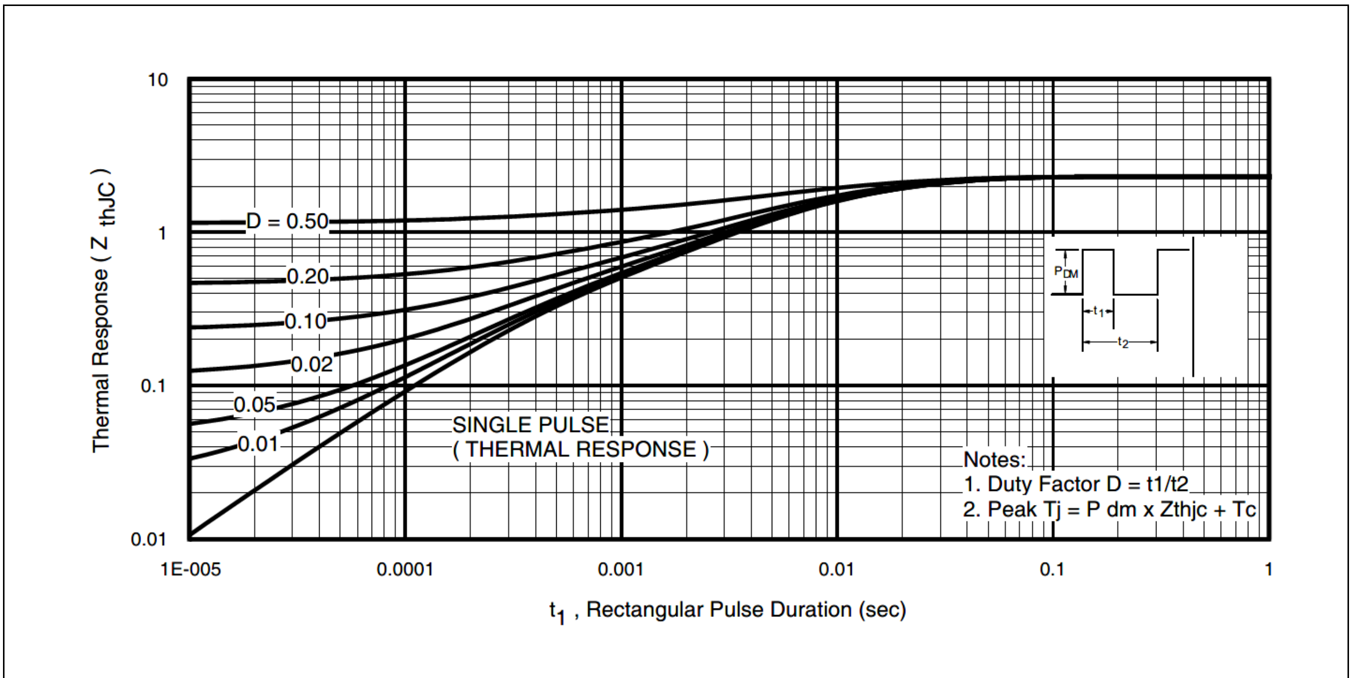


Figure 16 **Maximum Effective Transient Thermal Impedance, Junction-to-Case**

4 Test Circuits (Pre-irradiation)

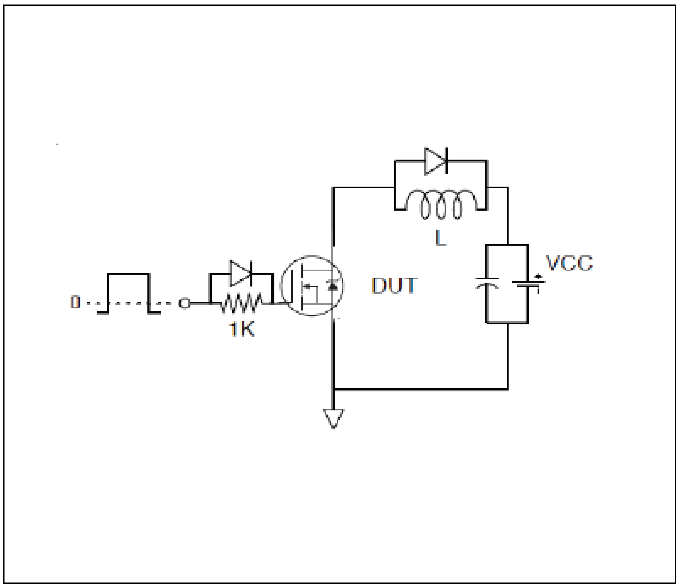


Figure 17 Gate Charge Test Circuit

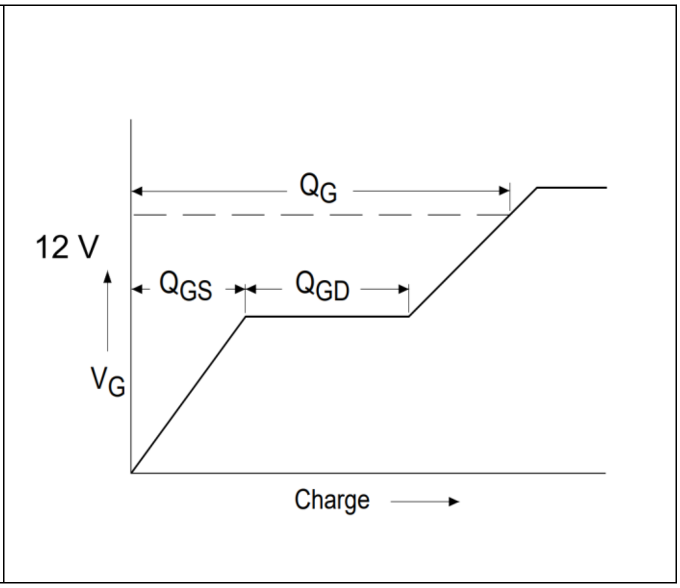


Figure 18 Gate Charge Waveform

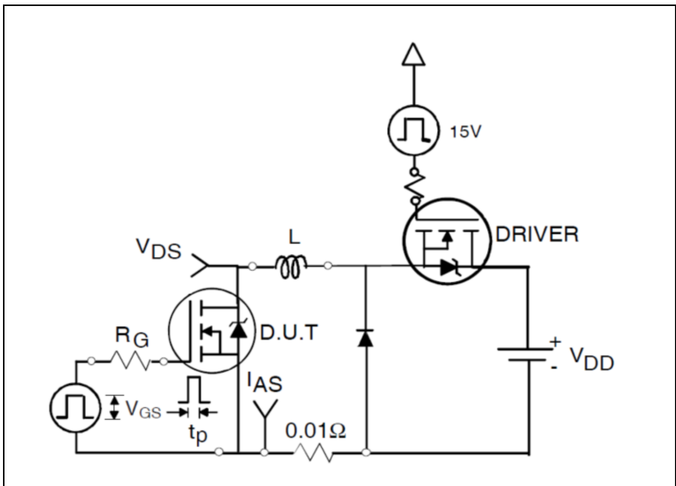


Figure 19 Unclamped Inductive Test Circuit

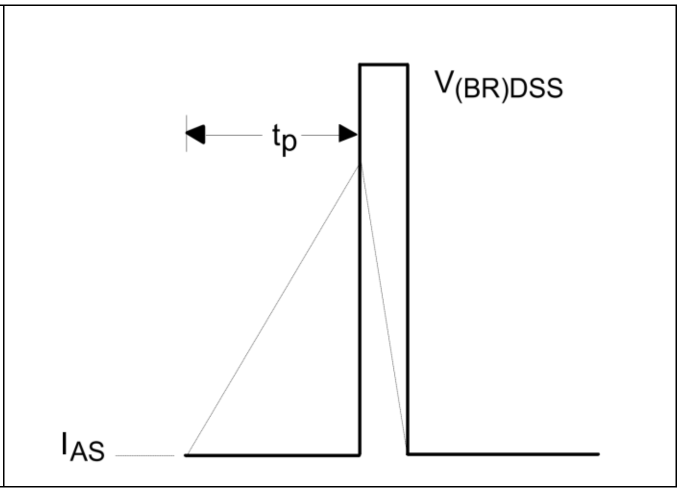


Figure 20 Unclamped Inductive Waveform

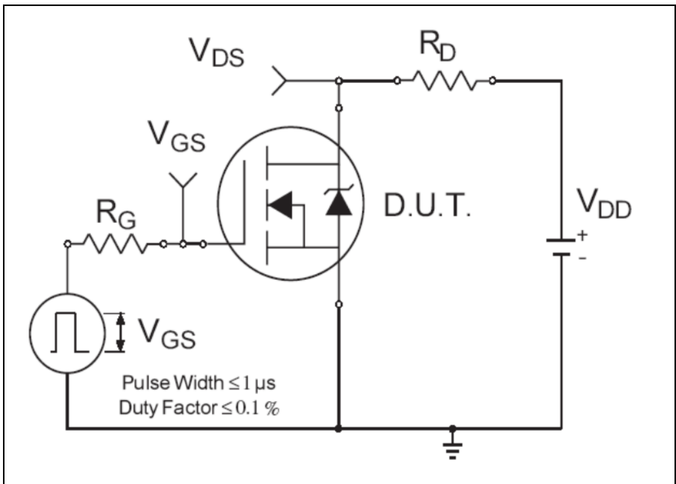


Figure 21 Switching Time Test Circuit

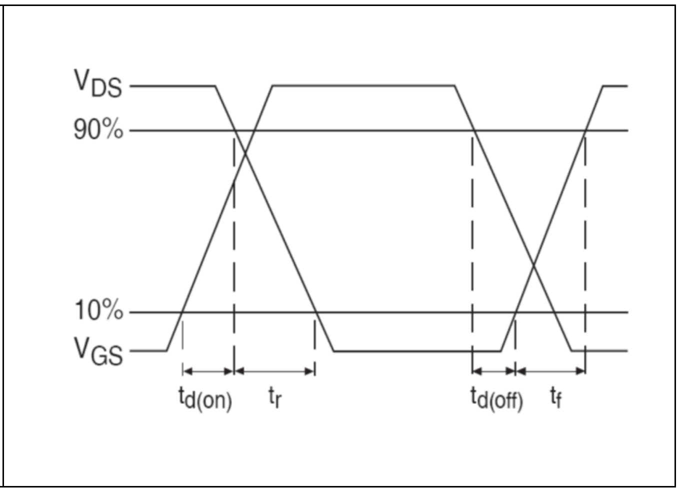
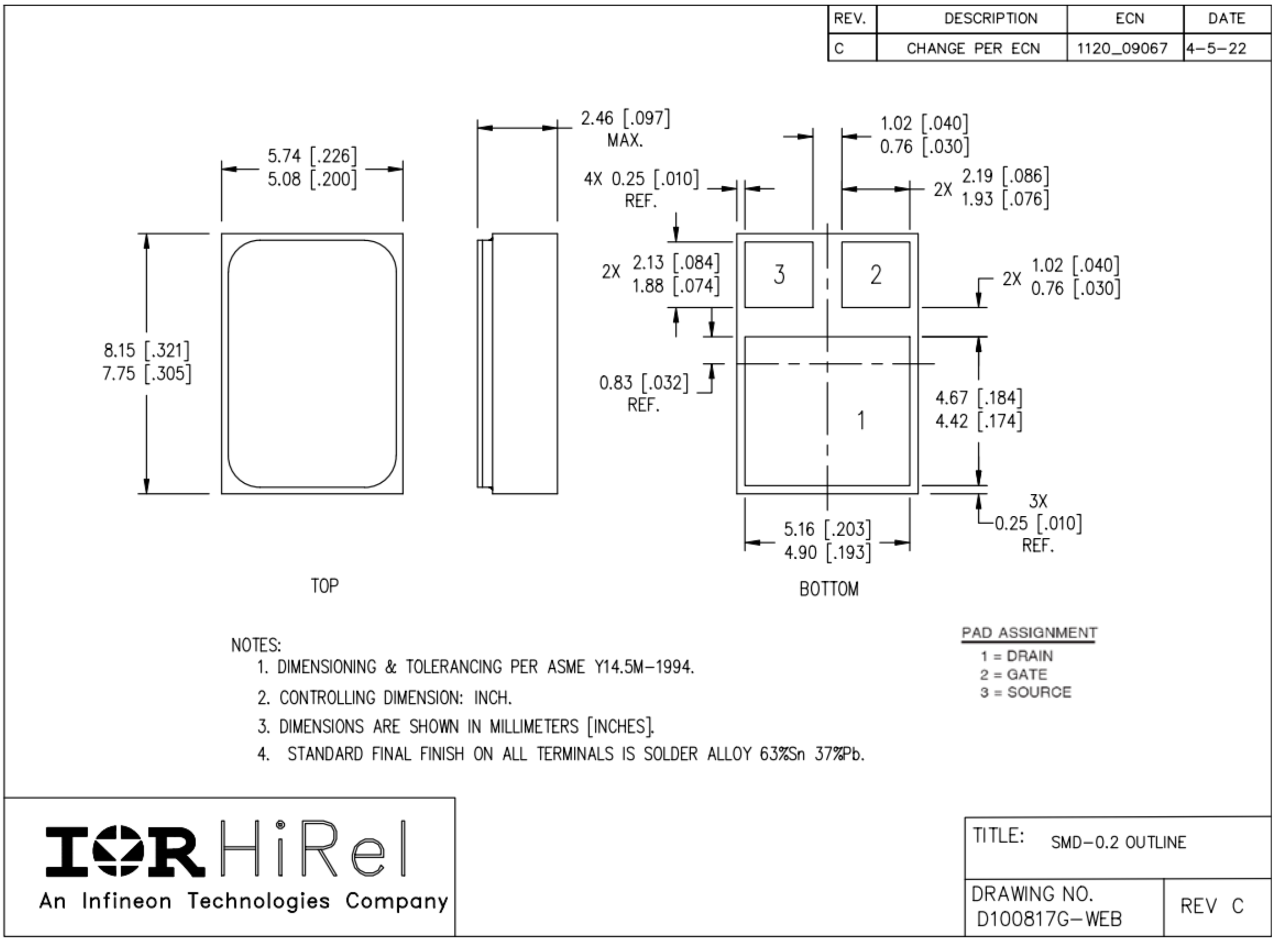


Figure 22 Switching Time Waveforms

5 Package Outline

Note: For the most updated package outline, please see the website: SMD-0.2 (Metal Lid)



Revision history

Document version	Date of release	Description of changes
	10/23/2019	Preliminary datasheet with PPD number (PPD-97899)
Rev A	05/14/2025	Final datasheet with PD number

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