IRHYS67234CM (JANSR2N7594T3)

PD-97193F

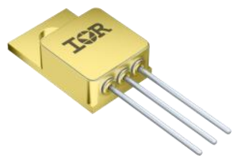
Radiation Hardened Power MOSFET
Thru-Hole (Low–Ohmic TO-257AA)
250V, 12A, N-channel, R6 Technology

Features

- Single event effect (SEE) hardened
- Low $R_{DS\ (on)}$
- Low total gate charge
- Fast switching
- Simple drive requirements
- Hermetically sealed
- Electrically isolated
- Ceramic eyelets
- Light weight
- ESD rating: Class 2 per MIL-STD-750, Method 1020

Product Summary

- **BV_{DSS}:** 250V
- **I_D:** 12A
- **$R_{DS\ (on),\ max}$:** 22mΩ
- **$Q_{G,\ max}$:** 40nC
- **REF:** MIL-PRF-19500/755



Low-Ohmic TO-257AA

Potential Applications

- Isolated DC-DC converters
- Motor drives
- Electric propulsion
- Thermal management

Product Validation

Qualified to JANS screening flow according to MIL-PRF-19500 for space applications

Description

IR HiRel R6 technology provides high performance power MOSFETs for space applications. These devices have been characterized for both Total Dose and Single Event Effect (SEE) with useful performance up to LET of 90 ($MeV\cdot cm^2/mg$). The combination of low $R_{DS(on)}$ and low gate charge reduces the power losses in 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
IRHYS67234CM	Low-Ohmic TO-257AA	COTS	100 krad(Si)
IRHYS67234CMSCS	Low-Ohmic TO-257AA	S-Level	100 krad(Si)
JANSR2N7594T3	Low-Ohmic TO-257AA	JANS	100 krad(Si)
IRHYS63234CM	Low-Ohmic TO-257AA	COTS	300 krad(Si)
IRHYS63234CMSCS	Low-Ohmic TO-257AA	S-Level	300 krad(Si)
JANSF2N7594T3	Low-Ohmic TO-257AA	JANS	300 krad(Si)
IRHYS64234CM	Low-Ohmic TO-257AA	COTS	500 krad(Si)
IRHYS64234CMSCS	Low-Ohmic TO-257AA	S-Level	500 krad(Si)
JANSG2N7594T3	Low-Ohmic TO-257AA	JANS	500 krad(Si)

Table of contents

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	12	A
I_{D2} @ V_{GS} = 12V, T_C = 100°C	Continuous Drain Current	7.6	A
I_{DM} @ T_C = 25°C	Pulsed Drain Current [1]	48	A
P_D @ T_C = 25°C	Maximum Power Dissipation	75	W
	Linear Derating Factor	0.6	W/°C
V_{GS}	Gate-to-Source Voltage	± 20	V
E_{AS}	Single Pulse Avalanche Energy [2]	80	mJ
I_{AR}	Avalanche Current [1]	12	A
E_{AR}	Repetitive Avalanche Energy [1]	7.5	mJ
dv/dt	Peak Diode Reverse Recovery [3]	5.2	V/ns
T_J T_{STG}	Operating Junction and Storage Temperature Range	-55 to +150	°C
	Lead Temperature	300 (0.063 in. /1.6 mm from case for 10s)	°C
	Weight	4.3 (Typical)	g

[1] Repetitive Rating; Pulse width limited by maximum junction temperature.
[2] V_{DD} = 50V, starting T_J = 25°C, L = 1.1mH, Peak I_L = 12A, V_{GS} = 12V
[3] $I_{SD} \leq$ 12A, di/dt $\leq$ 508A/µs, $V_{DD} \leq$ 250V, $T_J \leq$ 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	250	—	—	V	V_{GS} = 0V, I_D = 1.0mA
$\Delta BV_{DSS}/\Delta T_J$	Breakdown Voltage Temp. Coefficient	—	0.26	—	V/°C	Reference to 25°C, I_D = 1.0mA
$R_{DS(on)}$	Static Drain-to-Source On-State Resistance	—	—	22	mΩ	V_{GS} = 12V, I_{D2} = 7.6A [1]
$V_{GS(th)}$	Gate Threshold Voltage	2.0	—	4.0	V	V_{DS} = V_{GS}, I_D = 1mA
$\Delta V_{GS(th)}/\Delta T_J$	Gate Threshold Voltage Coefficient	—	-10.2	—	mV/°C	
Gfs	Forward Transconductance	8.6	—	—	S	V_{DS} = 15V, I_{D2} = 7.6A [1]
I_{DSS}	Zero Gate Voltage Drain Current	—	—	10	µA	V_{DS} = 200V, V_{GS} = 0V
		—	—	25		V_{DS} = 200V, 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	—	—	40	nC	I_{D1} = 12A V_{DS} = 125V V_{GS} = 12V
Q_{GS}	Gate-to-Source Charge	—	—	12		
Q_{GD}	Gate-to-Drain ('Miller') Charge	—	—	17		
$t_{d(on)}$	Turn-On Delay Time	—	—	19	ns	I_{D1} = 12A ** V_{DD} = 125V R_G = 7.5Ω V_{GS} = 12V
t_r	Rise Time	—	—	27		
$t_{d(off)}$	Turn-Off Delay Time	—	—	36		
t_f	Fall Time	—	—	20		
$L_s + L_D$	Total Inductance	—	6.8	—	nH	Measured from Drain lead (6mm / 0.25 in from package) to Source lead (6mm/ 0.25 in from package) with Source wire internally bonded from Source pin to Drain pad
C_{iss}	Input Capacitance	—	1420	—	pF	V_{GS} = 0V V_{DS} = 25V f = 1.0MHz
C_{oss}	Output Capacitance	—	184	—		
C_{rss}	Reverse Transfer Capacitance	—	2.2	—		
R_G	Gate Resistance	—	9.8	—	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)	—	—	12	A	
I_{SM}	Pulsed Source Current (Body Diode) [1]	—	—	48	A	
V_{SD}	Diode Forward Voltage	—	—	1.2	V	$T_J = 25°C$, $I_S = 12A$, $V_{GS} = 0V$ [2]
t_{rr}	Reverse Recovery Time	—	281	450	ns	$T_J = 25°C$, $I_F = 12A$, $V_{DD} \le 50V$ di/dt = 100A/µs
Q_{rr}	Reverse Recovery Charge	—	3.3	—	µC	
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	—	—	1.67	°C/W
$R_{\theta JA}$	Junction-to- Ambient (Typical socket mount)	—	—	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 @ $T_J = 25°C$, Post Total Dose Irradiation [3, 4]

Symbol	Parameter	Up to 500 krad (Si) [5]		Unit	Test Conditions
		Min.	Max.		
BV_{DSS}	Drain-to-Source Breakdown Voltage	250	—	V	$V_{GS} = 0V$, $I_D = 1.0mA$
$V_{GS(th)}$	Gate Threshold Voltage	2.0	4.0	V	$V_{DS} = V_{GS}$, $I_D = 1.0mA$
I_{GSS}	Gate-to-Source Leakage Forward	—	100	nA	$V_{GS} = 20V$
	Gate-to-Source Leakage Reverse	—	-100		$V_{GS} = -20V$
I_{DSS}	Zero Gate Voltage Drain Current	—	10	µA	$V_{DS} = 200V$, $V_{GS} = 0V$
$R_{DS(on)}$	Static Drain-to-Source On-State Resistance (TO-3) [2]	—	24	mΩ	$V_{GS} = 12V$, $I_{D2} = 7.6A$
$R_{DS(on)}$	Static Drain-to-Source On-State Resistance (TO-257AA) [2]	—	22	mΩ	$V_{GS} = 12V$, $I_{D2} = 7.6A$
V_{SD}	Diode Forward Voltage	—	1.2	V	$V_{GS} = 0V$, $I_F = 12A$

[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. $V_{DS} = 20V$ applied and $V_{GS} = 0$ during irradiation per MIL-STD-750, Method 1019, condition A.

[5] Part numbers IRHYS67234CM (JANSR2N7594T3), IRHYS63234CM (JANSF2N7594T3), IRHY64234CM (JANSG2N7594T3)

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 ($MeV\cdot cm^2/mg$)	Energy (MeV)	Range (µm)	V_{DS} (V)				
			V_{GS} = 0V	V_{GS} = -5V	V_{GS} = -10V	V_{GS} = -15V	V_{GS} = -20V
44 ± 5%	1350 ± 5%	125 ± 5%	250	250	250	250	40
61 ± 5%	825 ± 5%	66 ± 5%	250	250	250	50	—
90 ± 5%	1470 ± 5%	80 ± 5%	75	75	—	—	—

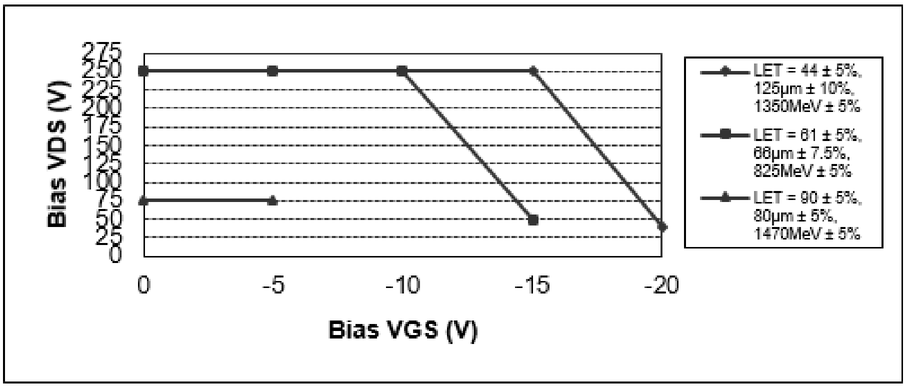


Figure 1 Typical Single Event Effect, Safe Operating Area

3 Electrical Characteristics Curves (Pre-irradiation)

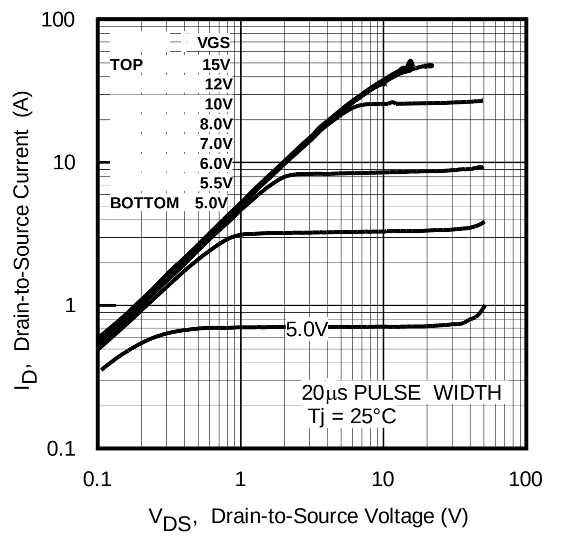


Figure 2 **Typical Output Characteristics**

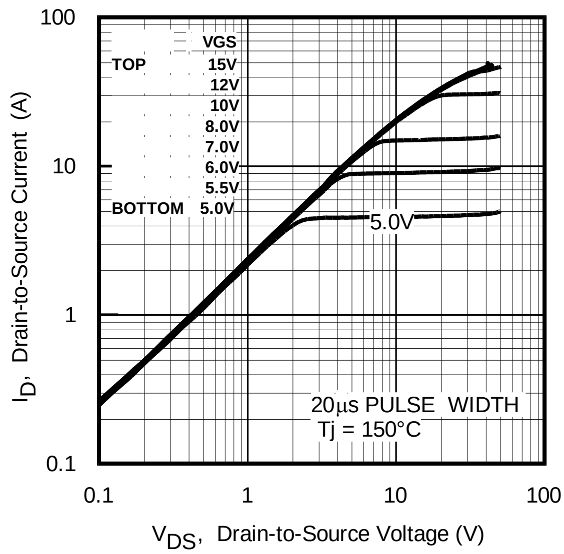


Figure 3 **Typical Output Characteristics**

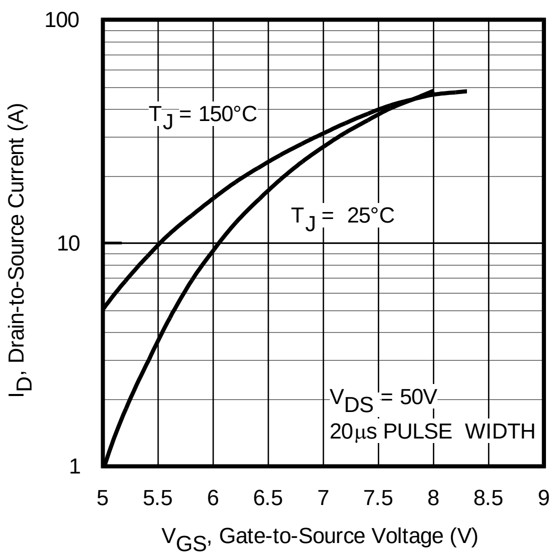


Figure 4 **Typical Transfer Characteristics**

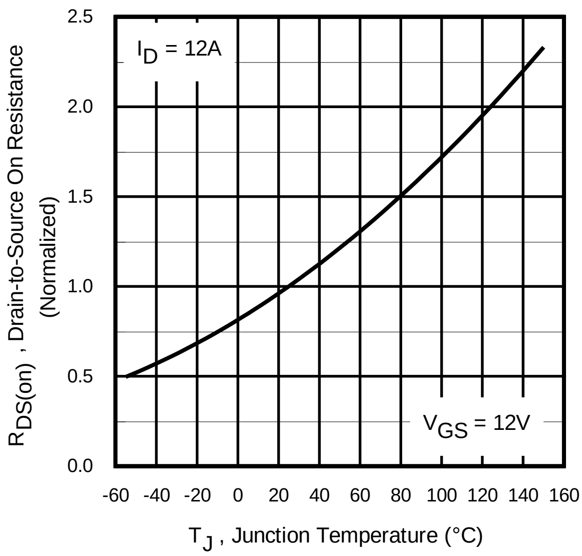


Figure 5 **Normalized On-Resistance Vs. Temperature**

Electrical Characteristics Curves (Pre-irradiation)

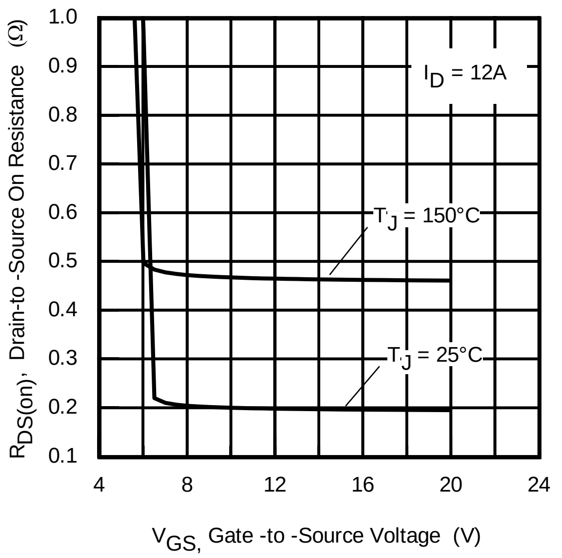


Figure 6 **Typical On-Resistance Vs. Gate Voltage**

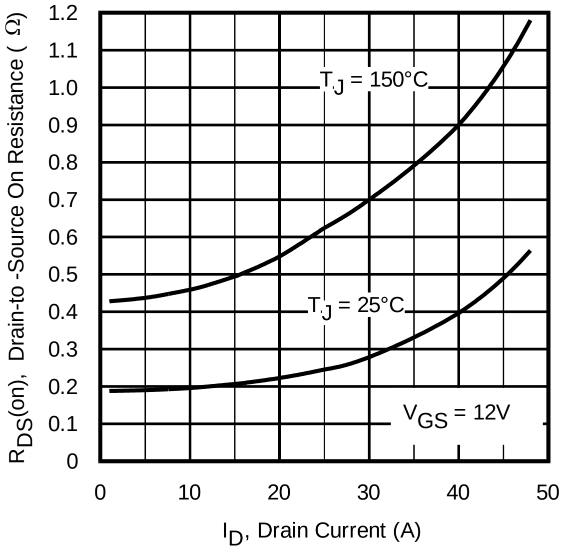


Figure 7 **Typical On-Resistance Vs. Drain Current**

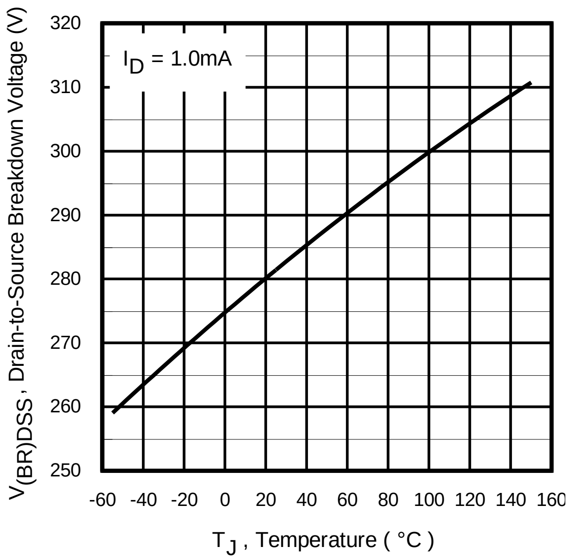


Figure 8 **Typical Drain -to-Source Breakdown Voltage Vs. Temperature**

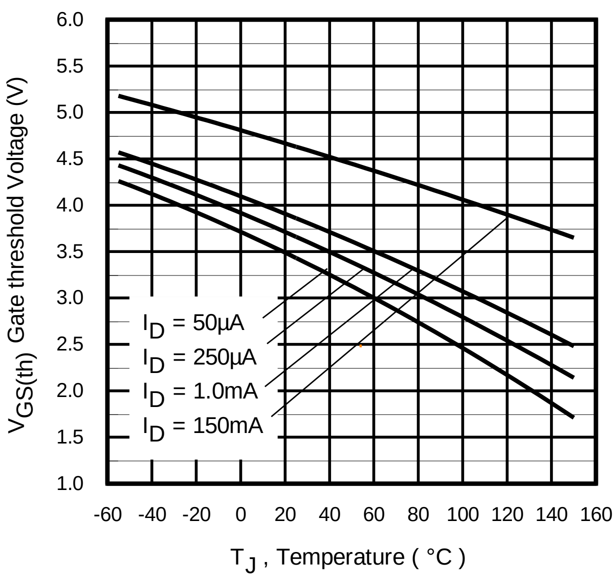


Figure 9 **Typical Threshold Voltage Vs. Temperature**

Electrical Characteristics Curves (Pre-irradiation)

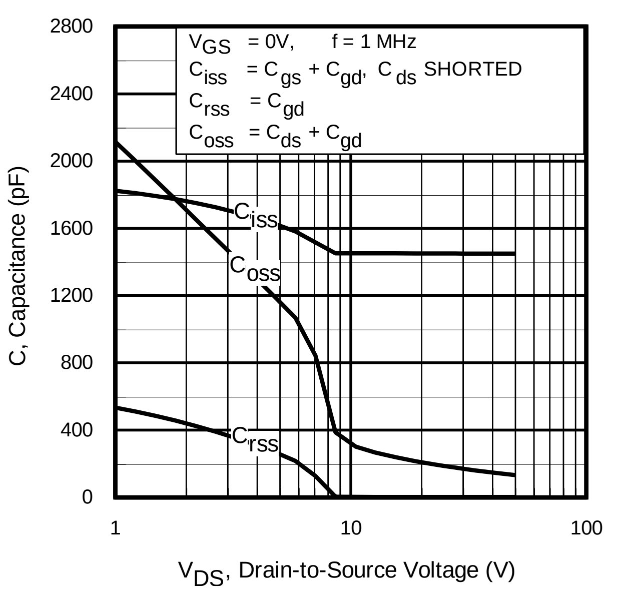


Figure 10 **Typical Capacitance Vs. Drain-to-Source Voltage**

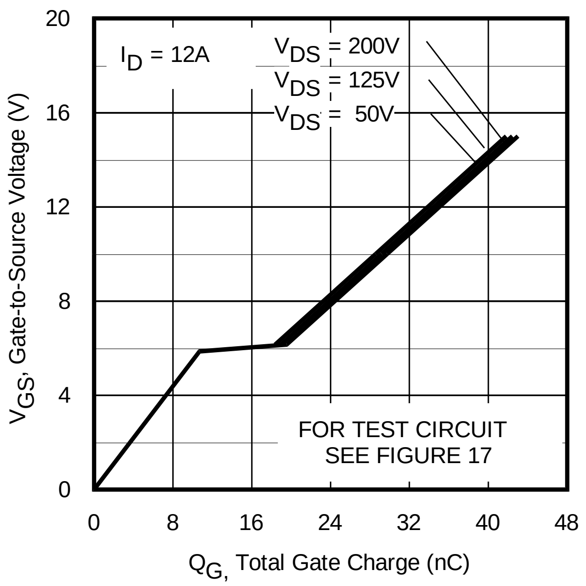


Figure 11 **Typical Gate Charge Vs. Typical Gate-to-Source Voltage**

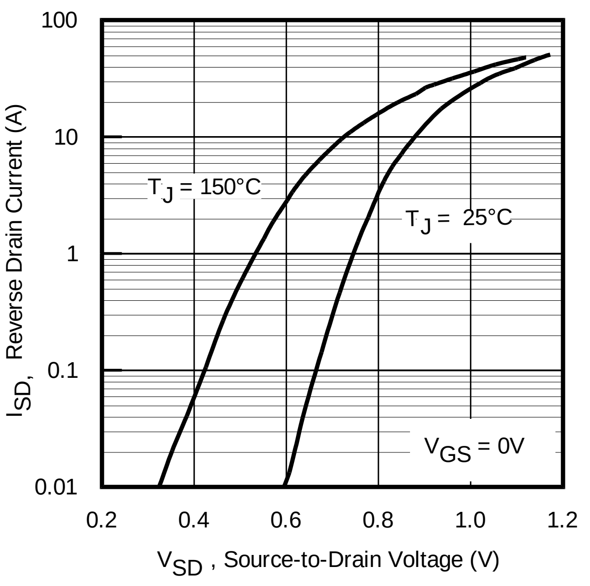


Figure 12 **Typical Source-Drain Current Vs. Diode Forward Voltage**

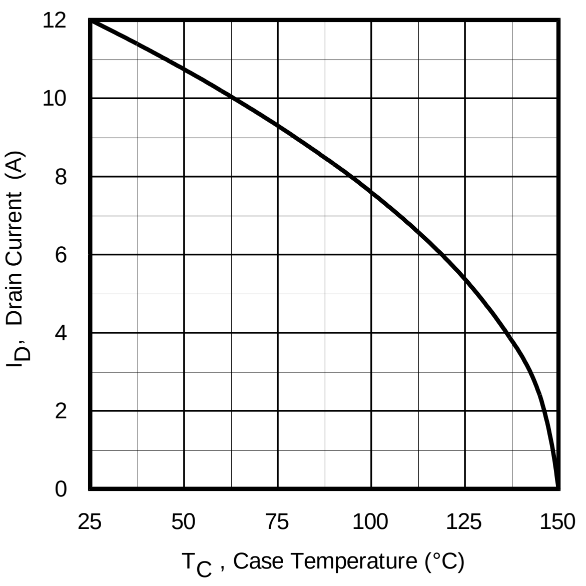


Figure 13 **Maximum Drain Current Vs. Case Temperature**

Electrical Characteristics Curves (Pre-irradiation)

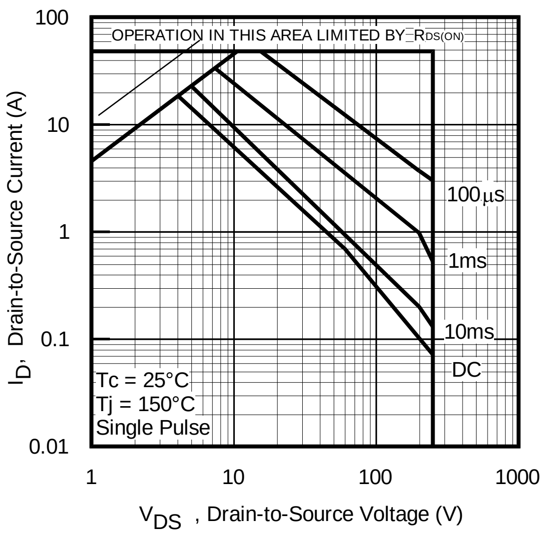


Figure 14 Maximum Safe Operating Area

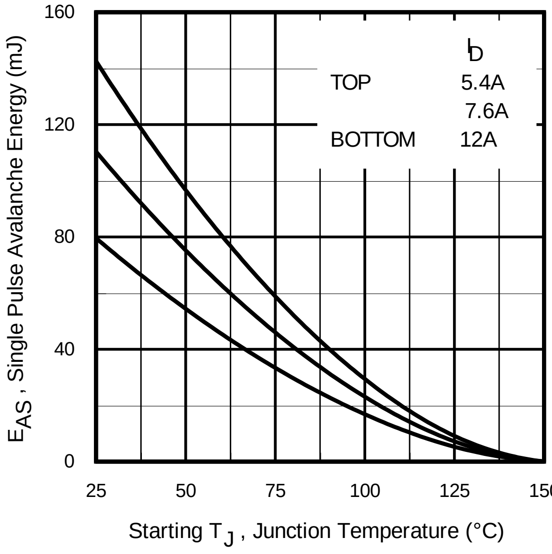


Figure 15 Maximum Avalanche Energy Vs. Junction Temperature

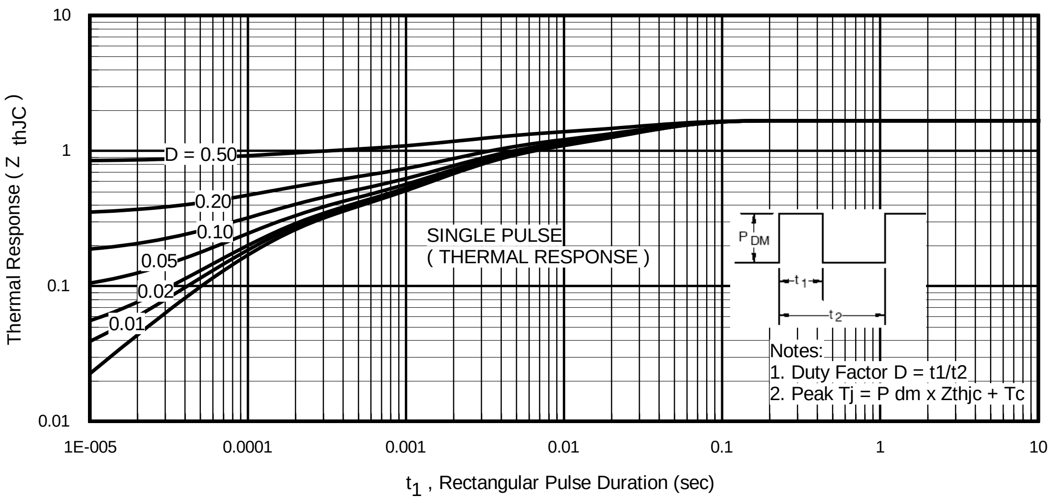


Figure 16 Maximum Effective Transient Thermal Impedance, Junction-to-Case

4 Test Circuits (Pre-irradiation)

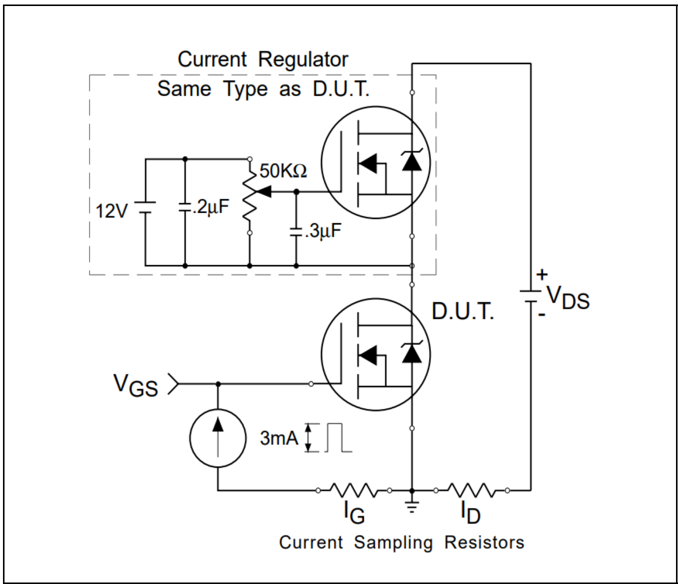


Figure 17 Gate Charge Test Circuit

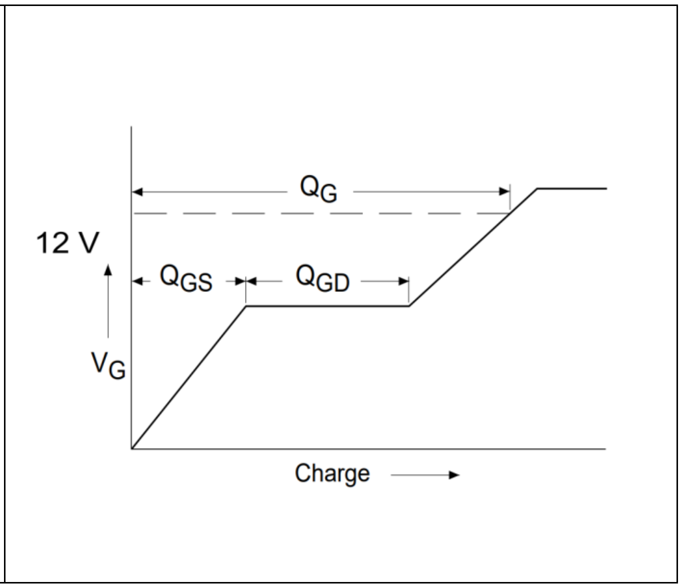


Figure 18 Gate Charge Waveform

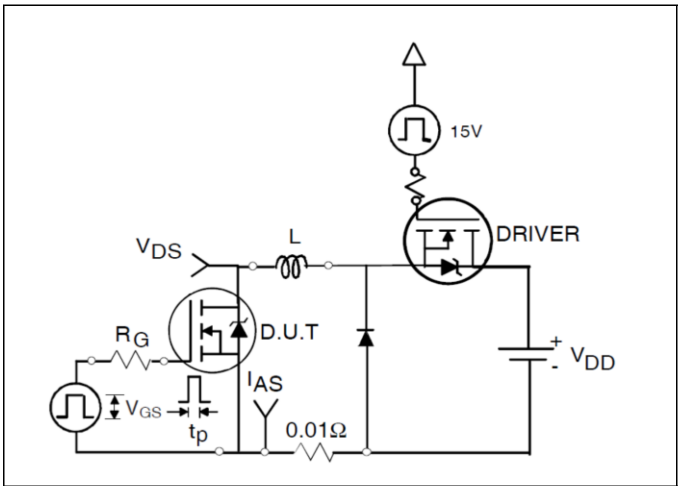


Figure 19 Unclamped Inductive Test Circuit

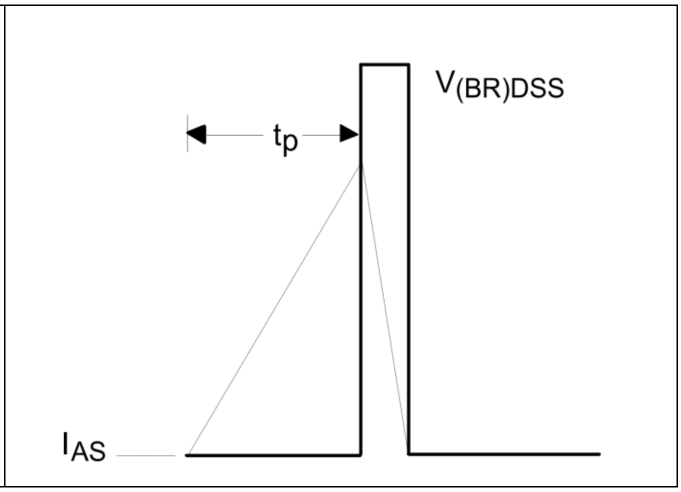


Figure 20 Unclamped Inductive Waveform

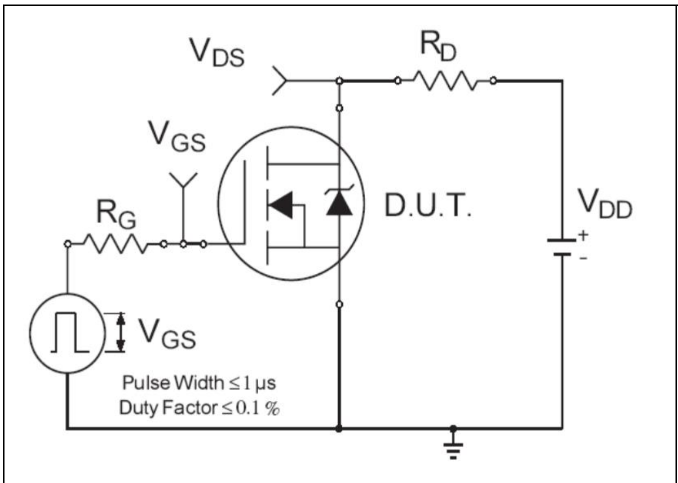


Figure 21 Switching Time Test Circuit

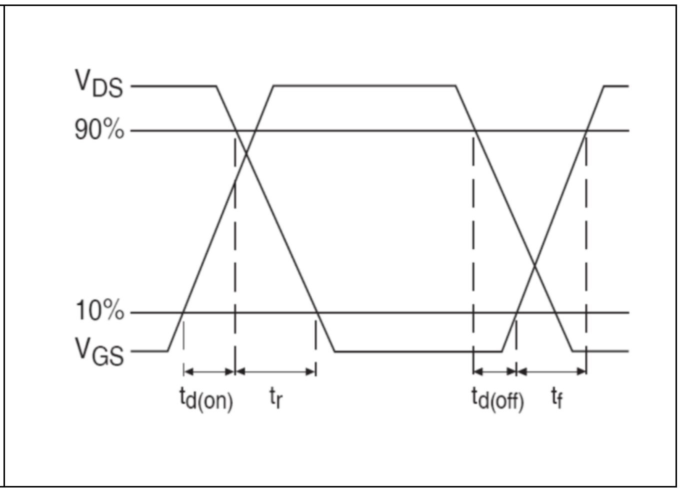
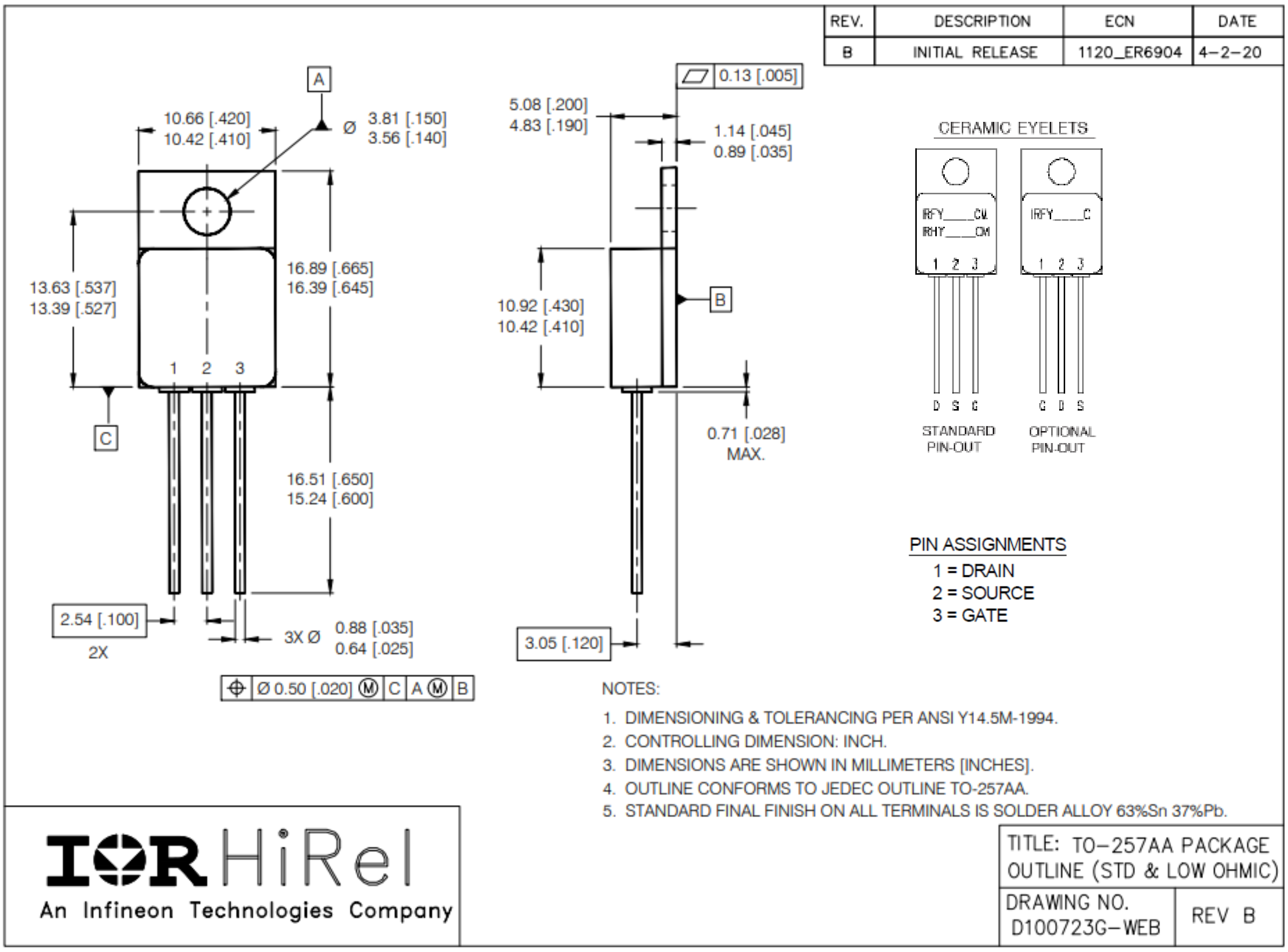


Figure 22 Switching Time Waveforms

5 Package Outline

Note: For the most updated package outline, please see the website: [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.

Revision history

Document version	Date of release	Description of changes
	05/08/2006	Datasheet (PD-97193)
Rev A	06/15/2010	Added QPL part number
Rev B	12/14/2018	Updated based on ECN-1120_06161
Rev C	06/22/2020	Updated based on ECN-1120_07983
Rev D	11/09/2020	Updated based on ECN-1120_08235
Rev E	01/29/2021	Updated based on ECN-1120_08396
Rev F	08/03/2023	Updated based on ECN-1120_09603

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