IRHLF7970Z4

PD-94685H

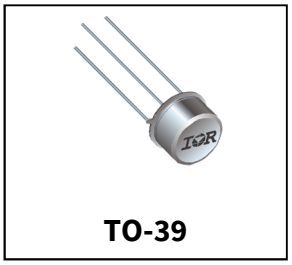
Radiation Hardened Logic Level Power MOSFET
Thru-Hole TO-205AF (TO-39)
60V, -1.5A, P-channel, R7 Technology

Features

- 5V CMOS and TTL compatible
- Fast switching
- Single event effect (SEE) hardened
- Low total gate charge
- Simple drive requirements
- Light weight
- Hermetically sealed
- ESD rating: Class 0B per MIL-STD-750, Method 1020

Product Summary

- **BV_{DSS}:** -60V
- **I_D :** -1.5A
- **$R_{DS(on),max}$:** 1.35Ω
- **$Q_{G,max}$:** 2.8nC



TO-39

Potential Applications

- DC-DC converter
- Motor drives

Product Validation

Qualified according to MIL-PRF-19500 for space applications

Description

IR HiRel R7 Logic Level Power MOSFETs provide simple solution to interfacing CMOS and TTL control circuits to power devices in space and other radiation environments. The threshold voltage remains within acceptable operating limits over the full operating temperature and post radiation. This is achieved while maintaining single event gate rupture and single event burnout immunity. The device is ideal when used to interface directly with most logic gates, linear IC's, micro-controllers, and other device types that operate from a 3.3-5V source. It may also be used to increase the output current of a PWM, voltage comparator or an operational amplifier where the logic level drive signal is available.

Ordering Information

Table 1 Ordering options

Part number	Package	Screening Level	TID Level
IRHLF7970Z4	TO-39	COTS	100 krad(Si)
IRHLF7970Z4SCS	TO-39	S-Level	100 krad(Si)
IRHLF7930Z4	TO-39	COTS	300 krad(Si)
IRHLF7930Z4SCS	TO-39	S-Level	300 krad(Si)

Table of contents

Features **1**
Potential Applications **1**
Product Validation **1**
Description **1**
Ordering Information **1**
Table of contents **2**
1 Absolute Maximum Ratings **3**
2 Device Characteristics **4**
2.1 Electrical Characteristics (Pre-Irradiation) 4
2.2 Source-Drain Diode Ratings and Characteristics (Pre-Irradiation) 5
2.3 Thermal Characteristics 5
2.4 Radiation Characteristics 5
2.4.1 Electrical Characteristics — Post Total Dose Irradiation 5
2.4.2 Single Event Effects — Safe Operating Area 6
3 Electrical Characteristics Curves (Pre-irradiation) **7**
4 Test Circuits (Pre-irradiation) **11**
5 Package Outline **12**
Revision history **13**

1 Absolute Maximum Ratings

Table 2 Absolute Maximum Ratings (Pre-Irradiation)

Symbol	Parameter	Value	Unit
I_{D1} @ V_{GS} = -4.5V, T_C = 25°C	Continuous Drain Current	-1.5	A
I_{D2} @ V_{GS} = -4.5V, T_C = 100°C	Continuous Drain Current	-1.0	A
I_{DM} @ T_C = 25°C	Pulsed Drain Current [1]	-6.0	A
P_D @ T_C = 25°C	Maximum Power Dissipation	5.0	W
	Linear Derating Factor	0.04	W/°C
V_{GS}	Gate-to-Source Voltage	± 10	V
E_{AS}	Single Pulse Avalanche Energy [2]	11	mJ
I_{AR}	Avalanche Current [1]	-1.5	A
E_{AR}	Repetitive Avalanche Energy [1]	0.5	mJ
dv/dt	Peak Diode Reverse Recovery [3]	-4.0	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)	
	Weight	0.98 (Typical)	g

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

[2] V_{DD} =- 25V, starting T_J = 25°C, L = 9.7mH, Peak I_L = -1.5A, V_{GS} = -10V

[3] $I_{SD} \leq$ -1.5A, di/dt ≤ -170A/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 = -250µA
$\Delta BV_{DSS}/\Delta T_J$	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	—	—	1.35	Ω	V_{GS} = -4.5V, I_{D2} = -1.0A [1]
$V_{GS(th)}$	Gate Threshold Voltage	-1.0	—	-2.0	V	V_{DS} = V_{GS}, I_D = -250µA
$\Delta V_{GS(th)}/\Delta T_J$	Gate Threshold Voltage Coefficient	—	3.12	—		
Gfs	Forward Transconductance	1.0	—	—	S	V_{DS} = -10V, I_{D2} = -1.0A [1]
I_{DSS}	Zero Gate Voltage Drain Current	—	—	-1.0	µA	V_{DS} = -48V, V_{GS} = 0V
		—	—	-20		V_{DS} =- 48V, V_{GS} = 0V, T_J = 125°C
I_{GSS}	Gate-to-Source Leakage Forward	—	—	-100	nA	V_{GS} = -10V
	Gate-to-Source Leakage Reverse	—	—	100		V_{GS} = 10V
Q_G	Total Gate Charge	—	—	2.8	nC	I_{D1} = -1.5A V_{DS} = -30V V_{GS} = -4.5V
Q_{GS}	Gate-to-Source Charge	—	—	1.8		
Q_{GD}	Gate-to-Drain ('Miller') Charge	—	—	0.8		
$t_{d(on)}$	Turn-On Delay Time	—	—	24	ns	I_{D1} = -1.5A ** V_{DD} = -30V R_G = 24Ω V_{GS} = -4.5V
t_r	Rise Time	—	—	45		
$t_{d(off)}$	Turn-Off Delay Time	—	—	12		
t_f	Fall Time	—	—	27		
L_s +L_D	Total Inductance	—	7.0	—	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 pin
C_{iss}	Input Capacitance	—	177	—	pF	V_{GS} = 0V V_{DS} = -25V f = 1.0MHz
C_{oss}	Output Capacitance	—	40	—		
C_{rss}	Reverse Transfer Capacitance	—	8.0	—		
R_G	Gate Resistance	—	—	72	Ω	f = 5.0MHz, 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)	—	—	-1.5	A	
I_{SM}	Pulsed Source Current (Body Diode) [1]	—	—	-6.0	A	
V_{SD}	Diode Forward Voltage	—	—	-5.0	V	T_J = 25°C, I_S = -1.5A, V_{GS} = 0V [2]
t_{rr}	Reverse Recovery Time	—	—	40	ns	T_J = 25°C, I_F =-1.5A, V_{DD} ≤ -25V di/dt = -100A/µs [2]
Q_{rr}	Reverse Recovery Charge	—	—	50	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	—	—	25	°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	Up to 300 krad (Si)[5]		Unit	Test Conditions
		Min.	Max.		
BV_{DSS}	Drain-to-Source Breakdown Voltage	-60	—	V	V_{GS} = 0V, I_D = -250µA
$V_{GS(th)}$	Gate Threshold Voltage	-1.0	-2.0	V	V_{DS} = V_{GS}, I_D = -250µA
I_{GSS}	Gate-to-Source Leakage Forward	—	-100	nA	V_{GS} = -10V
	Gate-to-Source Leakage Reverse	—	100		V_{GS} = 10V
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]	—	1.35	Ω	V_{GS} = -4.5V, I_{D2} = -1.0A
$R_{DS(on)}$	Static Drain-to-Source On-State Resistance (TO-39) [2]	—	1.35	Ω	V_{GS} = -4.5V, I_{D2} = -1.0A
V_{SD}	Diode Forward Voltage	—	-5.0	V	V_{GS} = 0V, I_F = -1.5A

[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} = -10V 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 IRHLF7970Z4 and IRHLF7930Z4

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} = 2V	V_{GS} = 4V	V_{GS} = 5V	V_{GS} = 6V	V_{GS} = 7V
38 ± 5%	300 ± 7.5%	38 ± 7.5%	-60	-60	-60	-60	-60	-50
62 ± 5%	355 ± 7.5%	33 ± 7.5%	-60	-60	-60	-60	-60	—
85 ± 5%	380 ± 7.5%	29 ± 7.5%	-60	-60	-60	-60	—	—

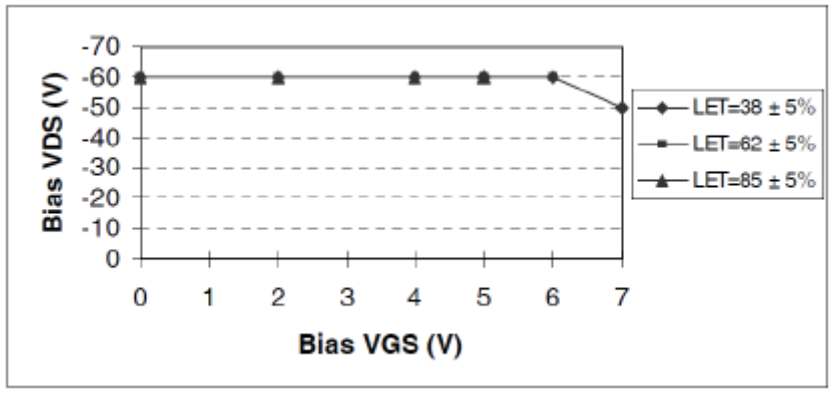


Figure 1 Typical Single Event Effect, Safe Operating Area

3 Electrical Characteristics Curves (Pre-irradiation)

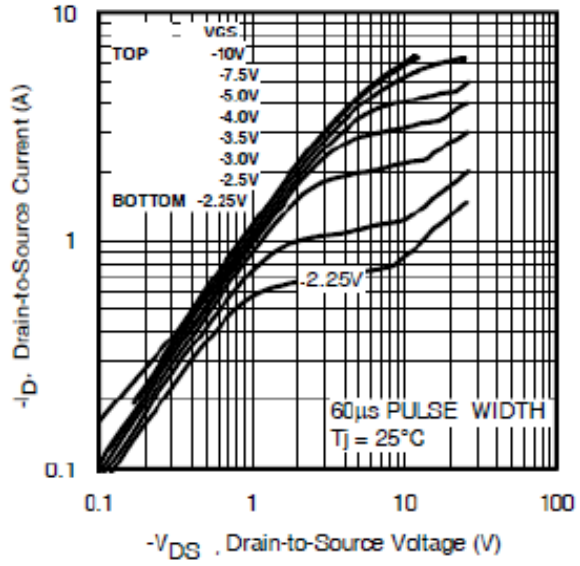


Figure 2 Typical Output Characteristics

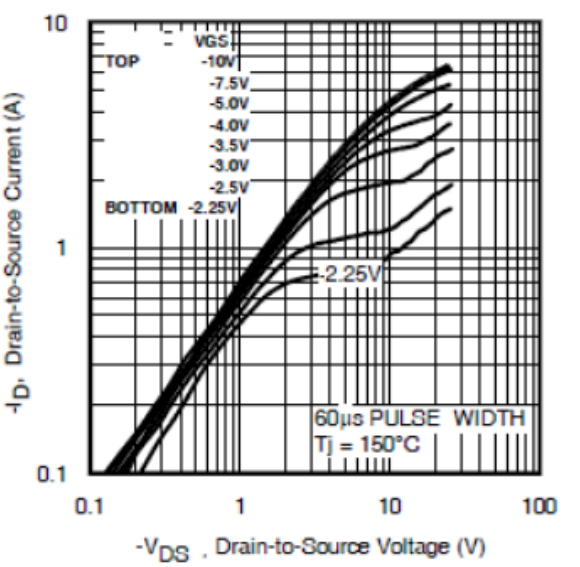


Figure 3 Typical Output Characteristics

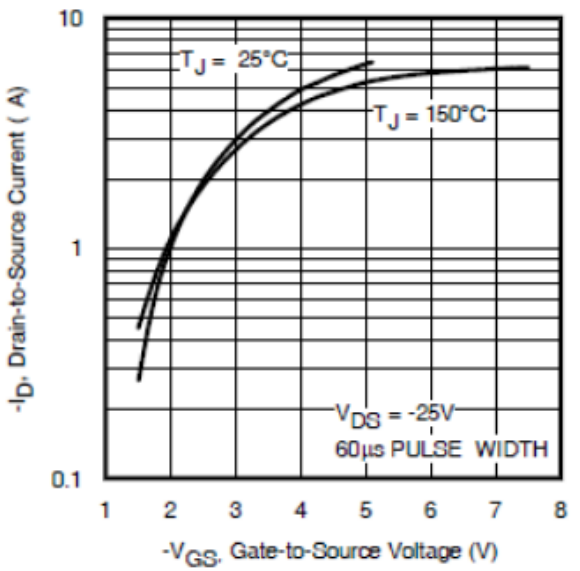


Figure 4 Typical Transfer Characteristics

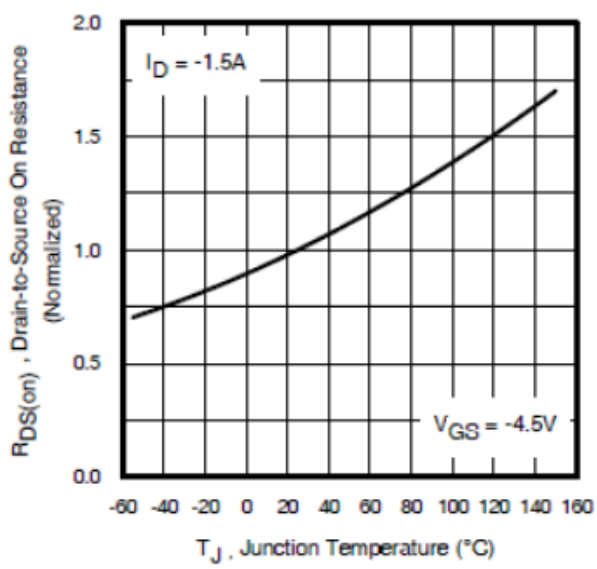


Figure 5 Normalized On-Resistance Vs. Temperature

Electrical Characteristics Curves (Pre-irradiation)

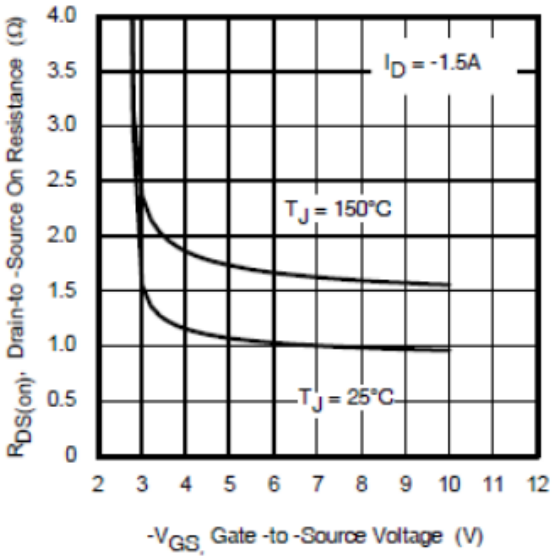


Figure 6 **Typical On-Resistance Vs Gate Voltage**

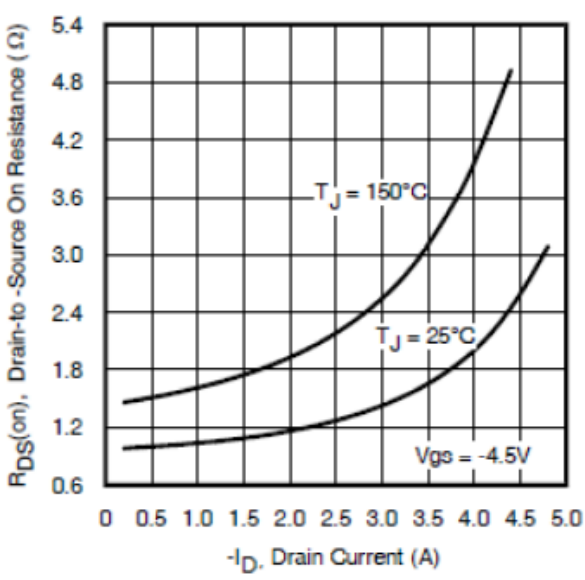


Figure 7 **Typical On-Resistance Vs Drain Current**

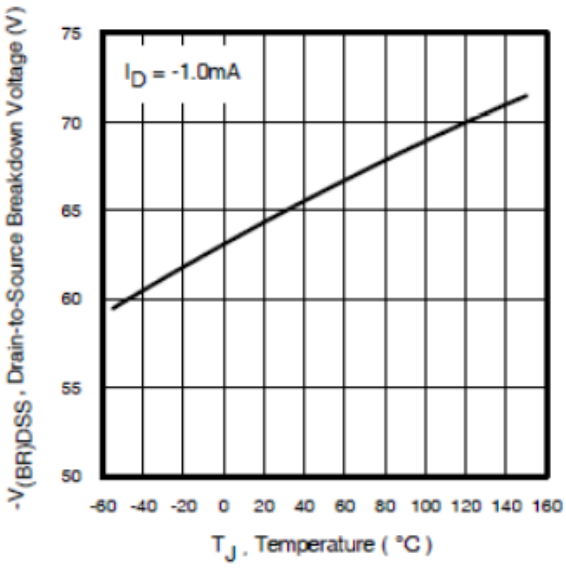


Figure 8 **Typical Drain-to Source Breakdown Voltage Vs. Temperature**

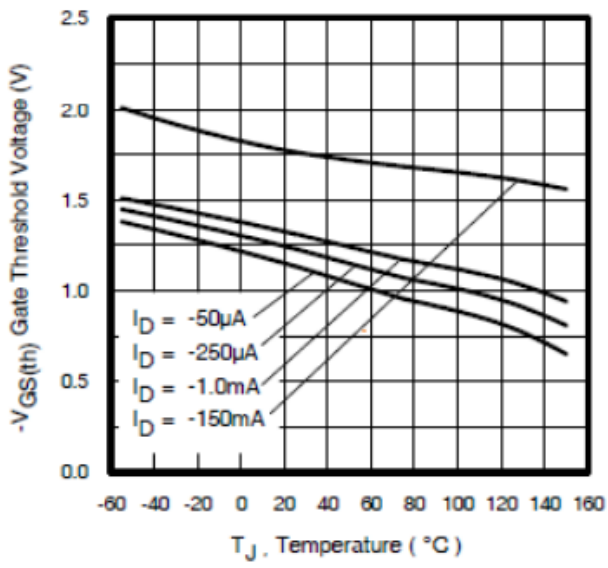


Figure 9 **Typical Threshold Voltage Vs Temperature**

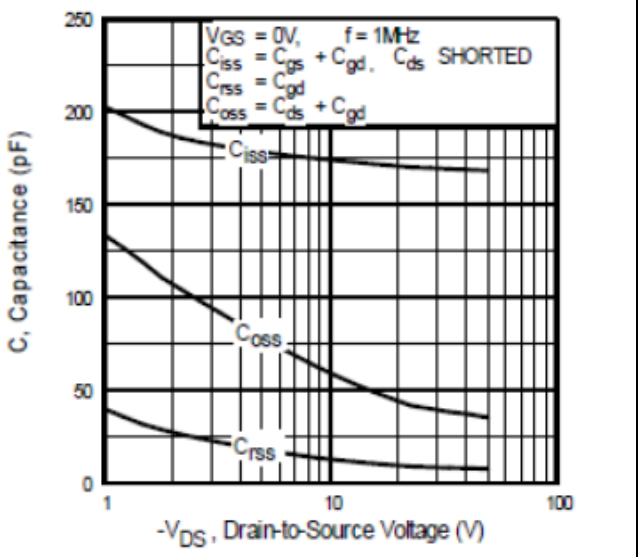


Figure 10 Typical Capacitance Vs. Drain-to-Source Voltage

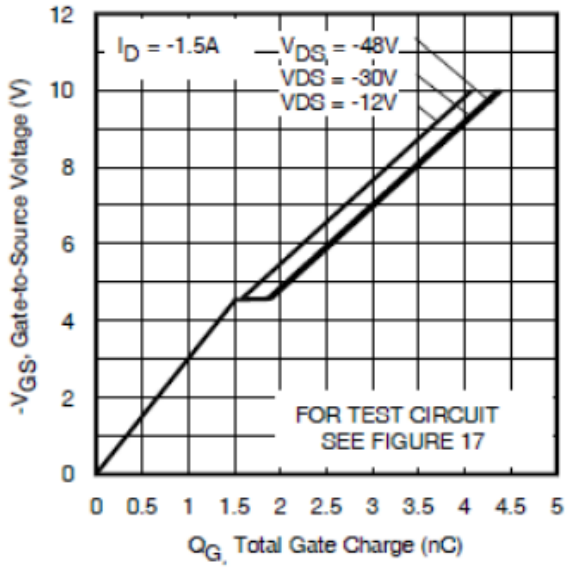


Figure 11 Typical Gate Charge Vs. Gate-to-Source Voltage

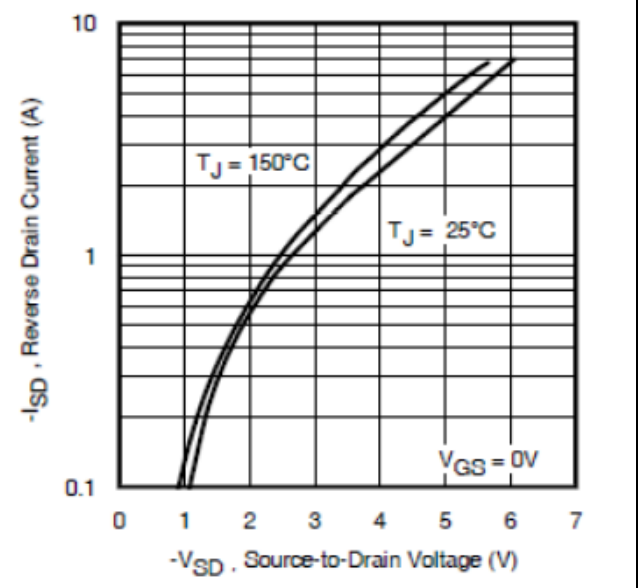


Figure 12 Typical Source-Drain Diode Forward Voltage

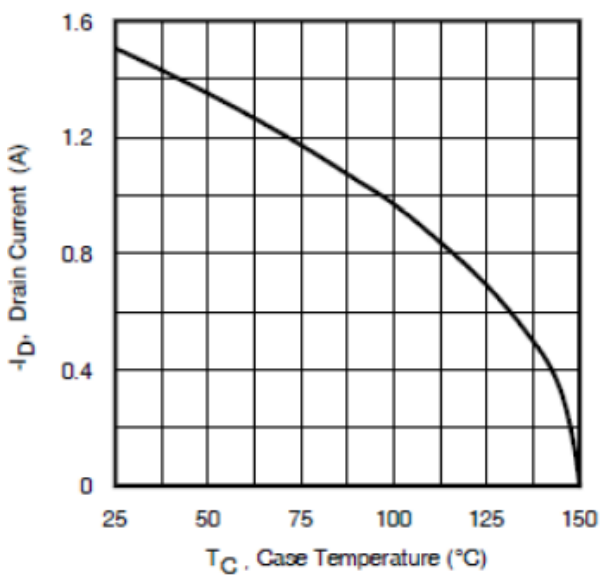


Figure 13 Maximum Drain Current Vs. Case Temperature

Electrical Characteristics Curves (Pre-irradiation)

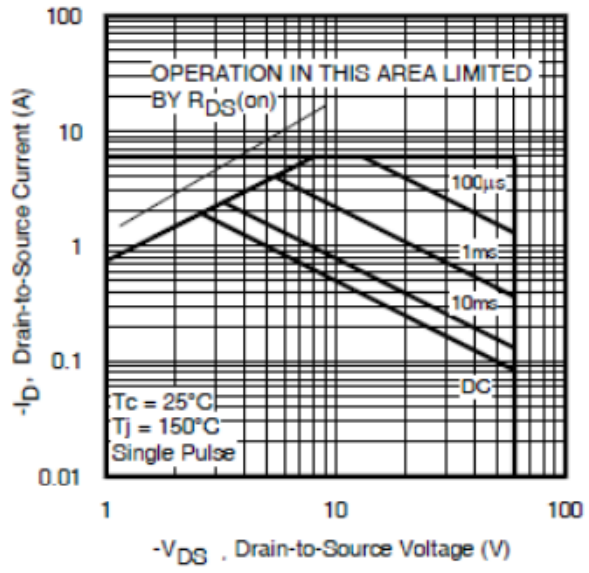


Figure 14 Maximum Safe Operating Area

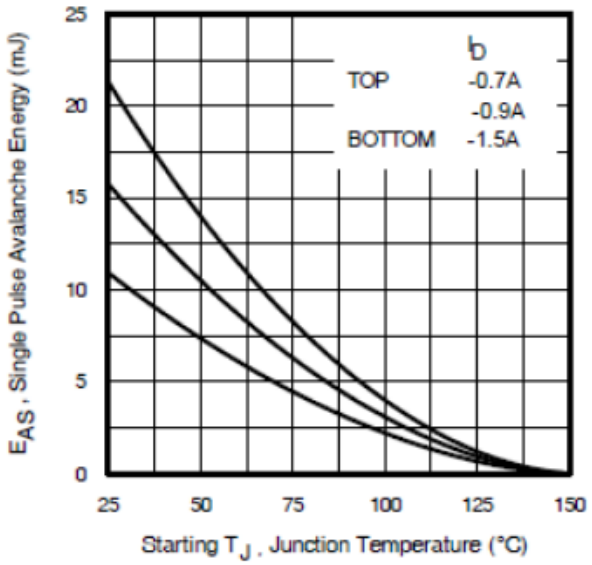


Figure 15 Maximum Avalanche Energy Vs. Junction Temperature

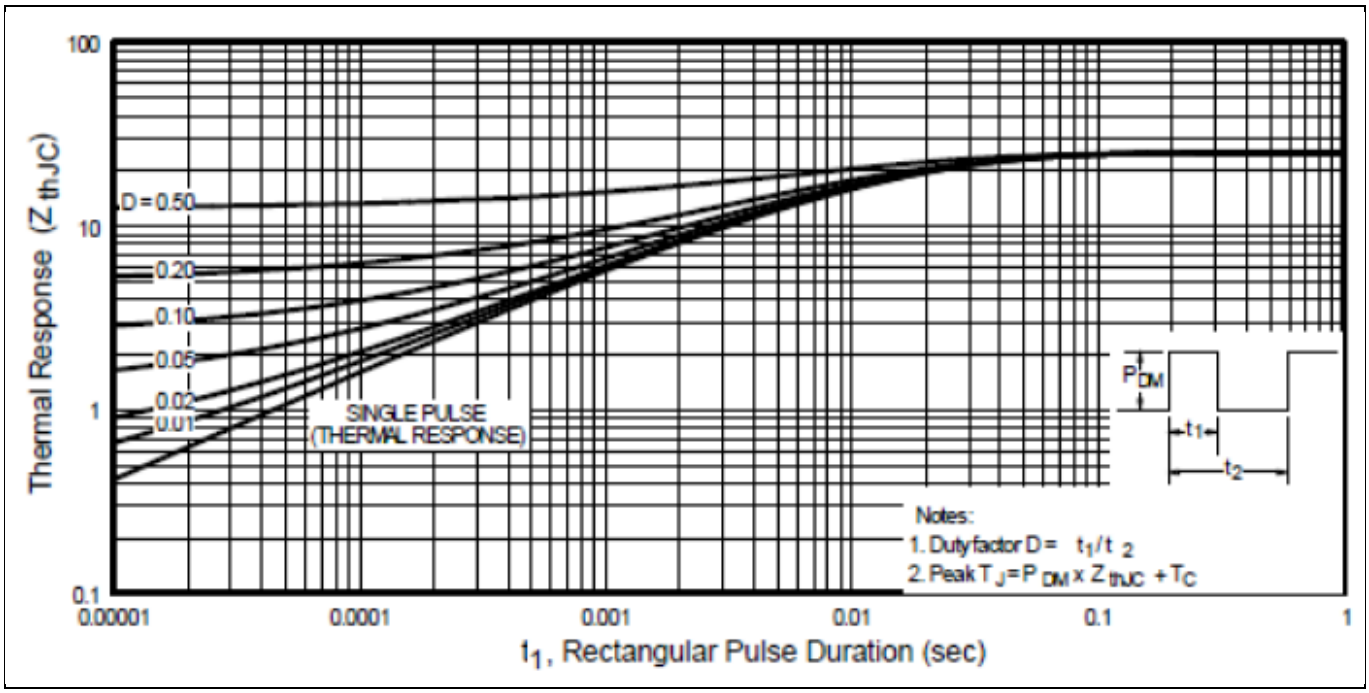


Figure 16 Maximum Effective Transient Thermal Impedance, Junction-to-Case

4 Test Circuits (Pre-irradiation)

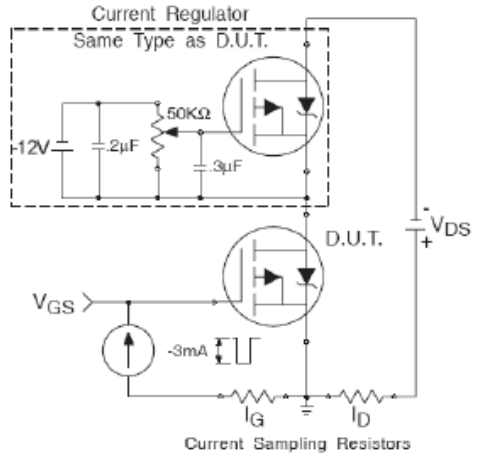


Figure 17 Gate Charge Test Circuit

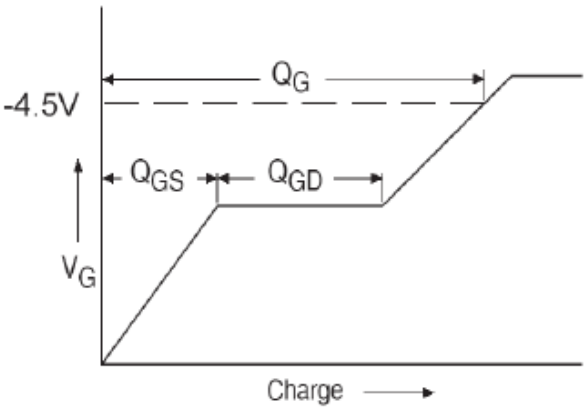


Figure 18 Gate Charge Waveform

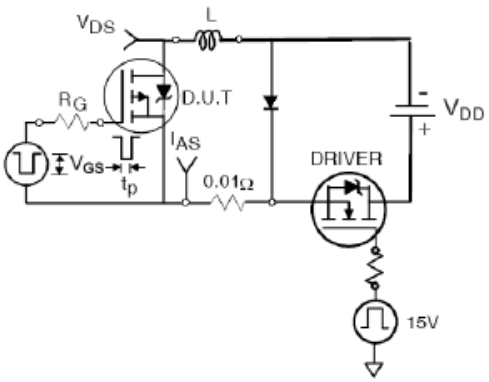


Figure 19 Unclamped Inductive Test Circuit

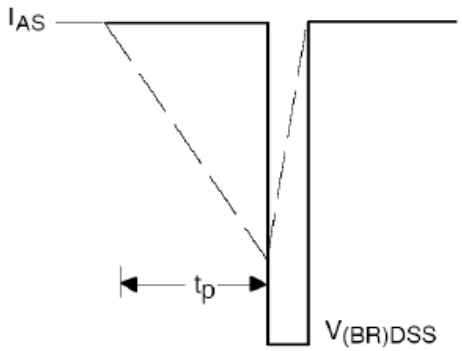


Figure 20 Unclamped Inductive Waveform

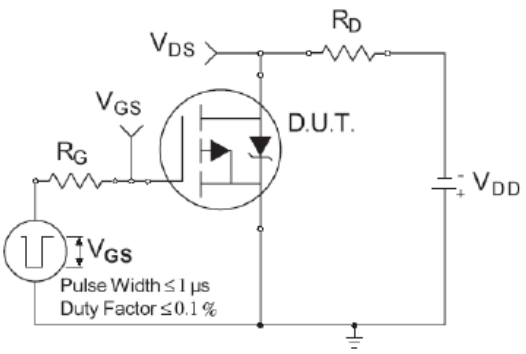


Figure 21 Switching Time Test Circuit

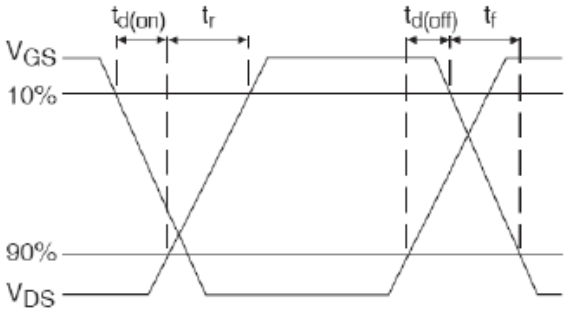
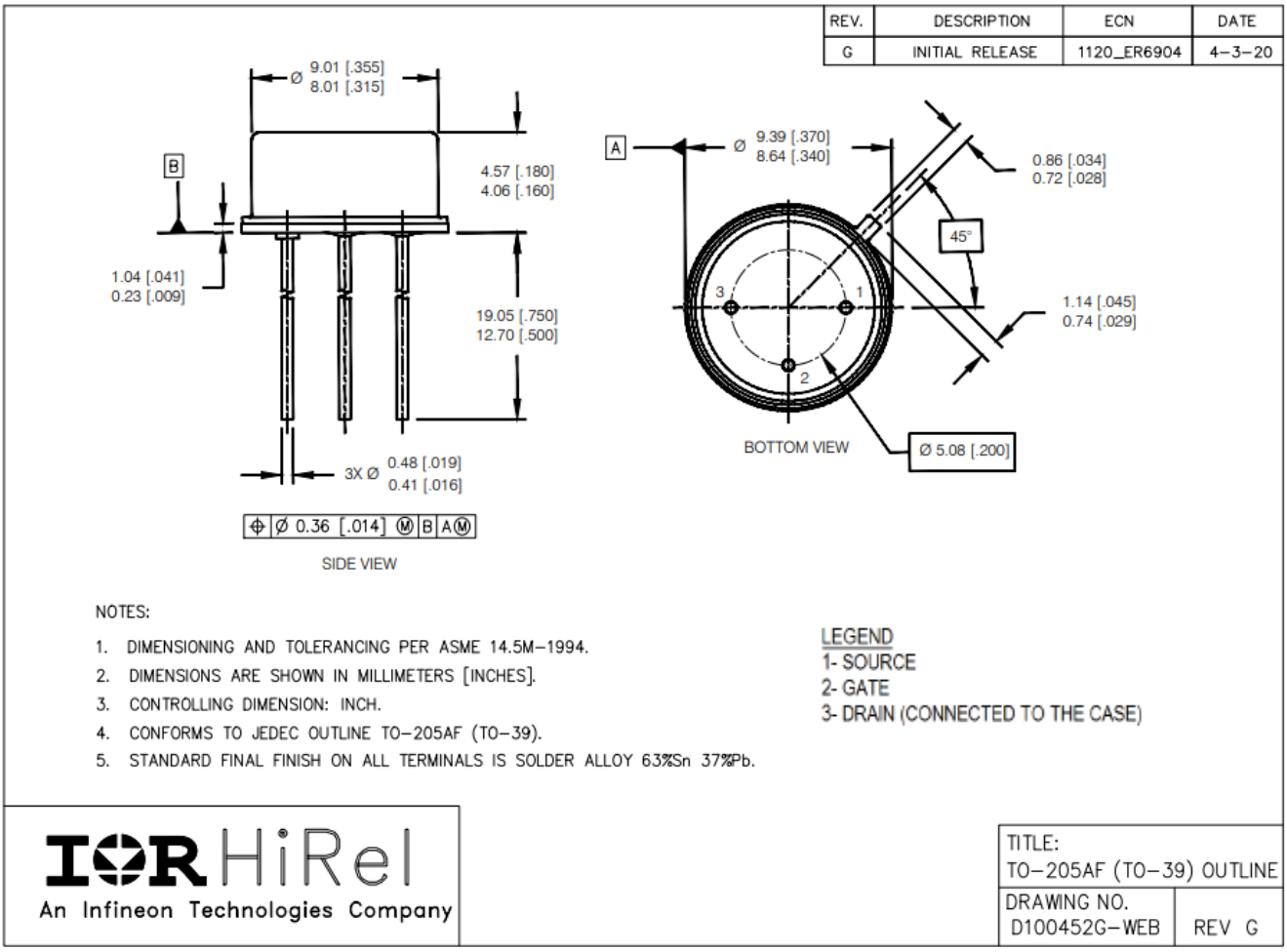


Figure 22 Switching Time Waveforms

5 Package Outline

Note: For the most updated package outline, please see the website: TO-39



Revision history

Document version	Date of release	Description of changes
	07/08/2003	Datasheet (PD-94685)
Rev A	10/23/2003	Updated from R6 to R7
Rev B	04/08/2004	Updated switchiing test condition-page2
Rev C	10/15/2007	Updated based on ECN-12213 & ECN-15269
Rev D	03/20/2008	Updated SEE table
Rev E	11/02/2010	Updated based on ECN-17337
Rev F	07/23/2018	Updated based on ECN-1120_05934
Rev G	08/14/2020	Updated based on ECN-1120_08110
Rev H	08/12/2022	Updated based on ECN-1120_09174

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