IRHMS57160 (JANSR2N7471T1)

PD-95889G

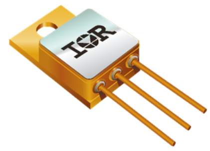
Radiation Hardened Power MOSFET
Thru-Hole (Low-Ohmic TO-254AA)
100V, 45A, N-channel, R5 Technology

Features

- Single event effect (SEE) hardened
- Low $R_{DS(on)}$
- Low total gate charge
- Simple drive requirements
- Hermetically sealed
- Electrically isolated
- Ceramic eyelets
- ESD rating: Class 3B per MIL-STD-750, Method 1020

Product Summary

- **BV_{DSS}:** 100V
- **I_D :** 45A
- **$R_{DS(on),max}$:** 14mΩ
- **$Q_{G,max}$:** 160nC
- **REF:** MIL-PRF-19500/698



Low-Ohmic TO-254AA

Potential Applications

- DC-DC converter
- Motor drives
- Thermal management

Product Validation

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

Description

IR HiRel R5 technology provides high performance power MOSFETs for space applications. This technology has over a decade of proven performance and reliability in satellite applications. These devices have been characterized for both Total Dose and Single Event Effects (SEE). The combination of low $R_{DS(on)}$ and low gate charge reduces the power losses in switching applications such as DC to DC converters and motor control. 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
IRHMS57160	Low-Ohmic TO-254AA	COTS	100 krad(Si)
JANSR2N7471T1	Low-Ohmic TO-254AA	JANS	100 krad(Si)
IRHMS53160	Low-Ohmic TO-254AA	COTS	300 krad(Si)
JANSF2N7471T1	Low-Ohmic TO-254AA	JANS	300 krad(Si)
IRHMS54160	Low-Ohmic TO-254AA	COTS	500 krad(Si)
JANSG2N7471T1	Low-Ohmic TO-254AA	JANS	500 krad(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	45*	A
I_{D2} @ V_{GS} = 12V, T_C = 100°C	Continuous Drain Current	45*	A
I_{DM} @ T_C = 25°C	Pulsed Drain Current [1]	180	A
P_D @ T_C = 25°C	Maximum Power Dissipation	208	W
	Linear Derating Factor	1.67	W/°C
V_{GS}	Gate-to-Source Voltage	± 20	V
E_{AS}	Single Pulse Avalanche Energy [2]	493	mJ
I_{AR}	Avalanche Current [1]	45	A
E_{AR}	Repetitive Avalanche Energy [1]	20.8	mJ
dv/dt	Peak Diode Reverse Recovery [3]	6.7	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	9.3 (Typical)	g

* Current is limited by package

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

[2] V_{DD} = 50V, starting T_J = 25°C, L = 0.49mH, Peak I_L = 45A, V_{GS} = 12V

[3] $I_{SD} \leq 45A$, $di/dt \leq 630A/\mu s$, $V_{DD} \leq 100V$, $T_J \leq 150°C$

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	100	—	—	V	V_{GS} = 0V, I_D = 1.0mA
$\Delta BV_{DSS}/\Delta T_J$	Breakdown Voltage Temp. Coefficient	—	0.11	—	V/°C	Reference to 25°C, I_D = 1.0mA
$R_{DS(on)}$	Static Drain-to-Source On-State Resistance	—	—	14	mΩ	V_{GS} = 12V, I_{D2} = 45A [1]
$V_{GS(th)}$	Gate Threshold Voltage	2.0	—	4.0	V	$V_{DS} = V_{GS}$, I_D = 1mA
Gfs	Forward Transconductance	42	—	—	S	V_{DS} = 15V, I_{D2} = 45A [1]
I_{DSS}	Zero Gate Voltage Drain Current	—	—	10	μA	V_{DS} = 80V, V_{GS} = 0V
		—	—	25		V_{DS} = 80V, 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	—	—	160	nC	I_{D1} = 45A V_{DS} = 50V V_{GS} = 12V
Q_{GS}	Gate-to-Source Charge	—	—	55		
Q_{GD}	Gate-to-Drain ('Miller') Charge	—	—	65		
$t_{d(on)}$	Turn-On Delay Time	—	—	35	ns	I_{D1} = 45A ** V_{DD} = 50V R_G = 2.35Ω V_{GS} = 12V
t_r	Rise Time	—	—	125		
$t_{d(off)}$	Turn-Off Delay Time	—	—	75		
t_f	Fall Time	—	—	50		
$L_s + L_D$	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	—	6270	—	pF	V_{GS} = 0V V_{DS} = 25V f = 1.0MHz
C_{oss}	Output Capacitance	—	1620	—		
C_{rss}	Reverse Transfer Capacitance	—	35	—		
R_G	Gate Resistance	—	1.0	—	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)	—	—	45	A	
I_{SM}	Pulsed Source Current (Body Diode) [1]	—	—	180	A	
V_{SD}	Diode Forward Voltage	—	—	1.2	V	$T_J = 25°C$, $I_S = 45A$, $V_{GS} = 0V$ [2]
t_{rr}	Reverse Recovery Time	—	—	270	ns	$T_J = 25°C$, $I_F = 45A$, $V_{DD} \leq 50V$ di/dt = 100A/µs [2]
Q_{rr}	Reverse Recovery Charge	—	—	2.7	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	—	—	0.60	°C/W
$R_{\theta CS}$	Junction-to-Sink	—	0.21	—	
$R_{\theta JA}$	Junction-to- Ambient (Typical socket mount)	—	—	48	

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	100	—	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	$V_{DS} = 80V$, $V_{GS} = 0V$
$R_{DS(on)}$	Static Drain-to-Source On-State Resistance (TO-3) [2]	—	13	mΩ	$V_{GS} = 12V$, $I_{D2} = 45A$
$R_{DS(on)}$	Static Drain-to-Source On-State Resistance (TO-254AA) [2]	—	14	mΩ	$V_{GS} = 12V$, $I_{D2} = 45A$
V_{SD}	Diode Forward Voltage	—	1.2	V	$V_{GS} = 0V$, $I_F = 45A$

[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. $V_{DS} = 80V$ applied and $V_{GS} = 0$ during irradiation per MIL-STD-750, Method 1019, condition A.

[5] Part numbers IRHMS57160 (JANSR2N7471T1), IRHM53160 (JANSF2N7471T1) and IRHMS54160 (JANSG2N7471T1)

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} = -5V	V_{GS} = -10V	V_{GS} = -15V	V_{GS} = -20V
38 ± 5%	300 ± 7.5%	38 ± 7.5%	100	100	100	100	100
61 ± 5%	330 ± 7.5%	31 ± 10%	100	100	100	35	25
84 ± 5%	350 ± 7.5%	28 ± 7.5%	100	100	80	25	—

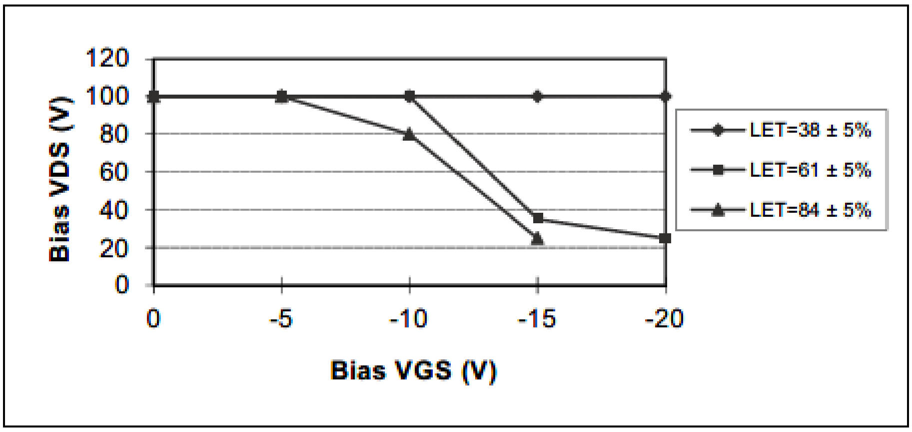


Figure 1 Typical Single Event Effect, Safe Operating Area

3 Electrical Characteristics Curves (Pre-irradiation)

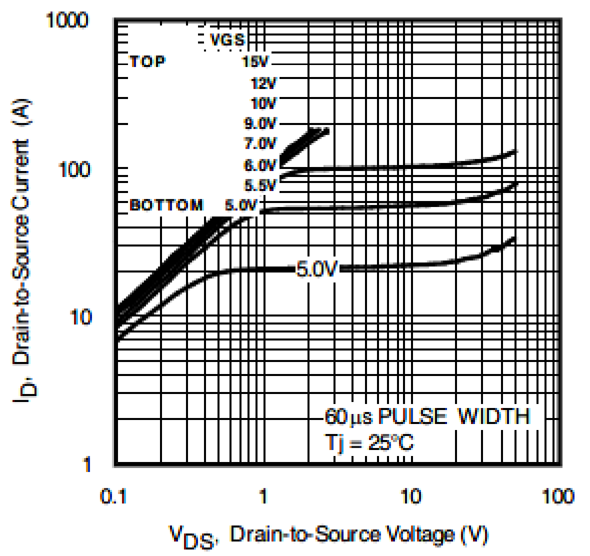


Figure 2 Typical Output Characteristics

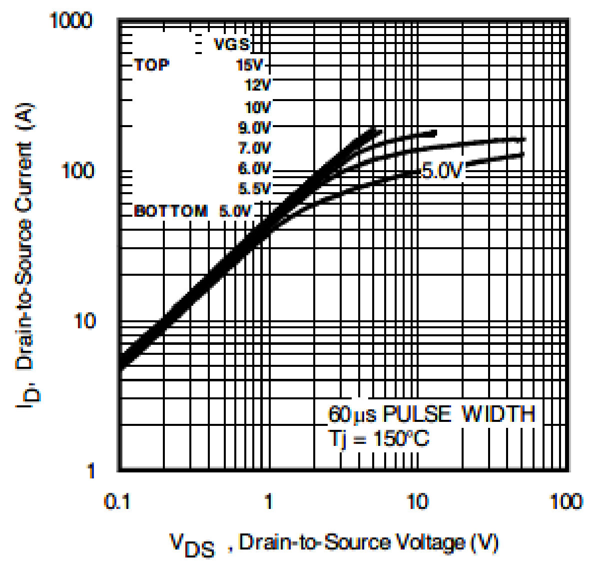


Figure 3 Typical Output Characteristics

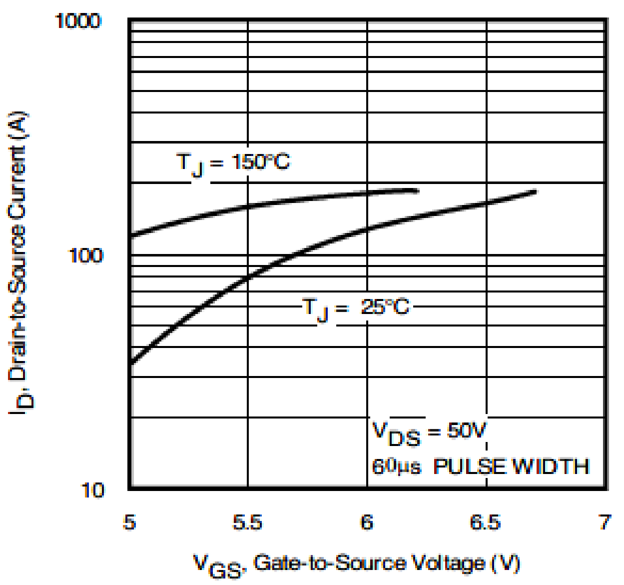


Figure 4 Typical Transfer Characteristics

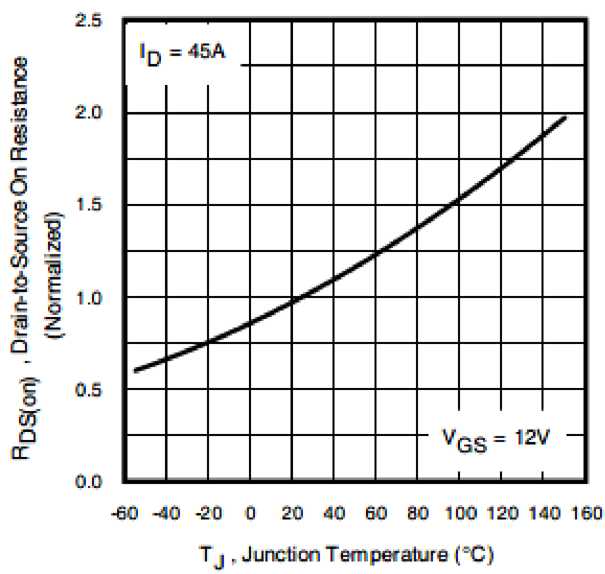


Figure 5 Normalized On-Resistance Vs. Temperature

Electrical Characteristics Curves (Pre-irradiation)

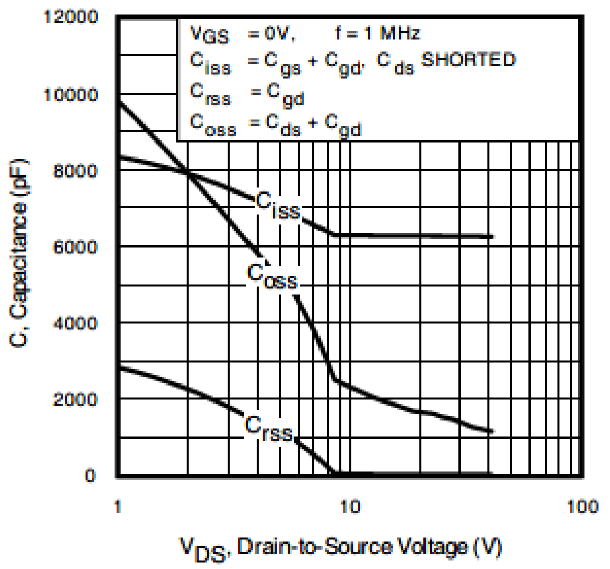


Figure 6 Typical Capacitance Vs. Drain-to-Source Voltage

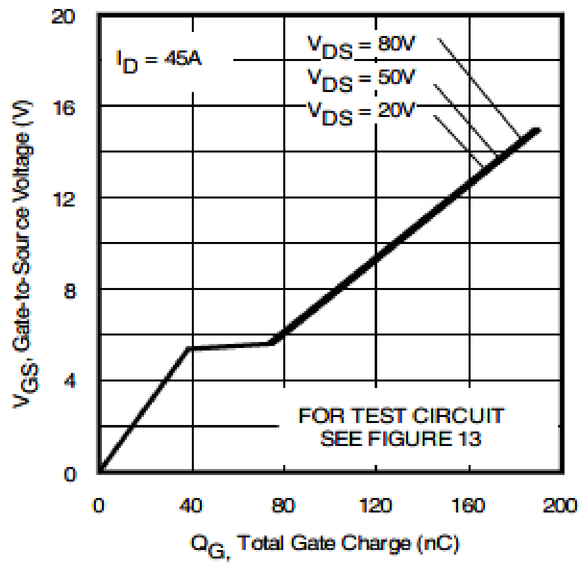


Figure 7 Typical Gate-to-Source Voltage Vs. Typical Gate Charge

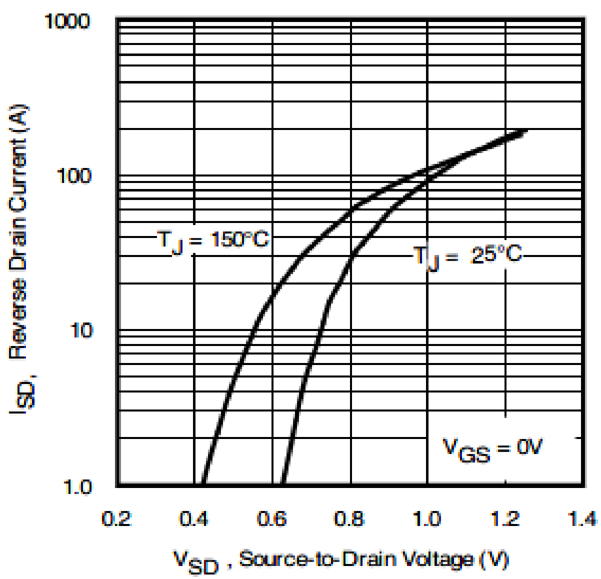


Figure 8 Typical Source-Drain Current Vs. Diode Forward Voltage

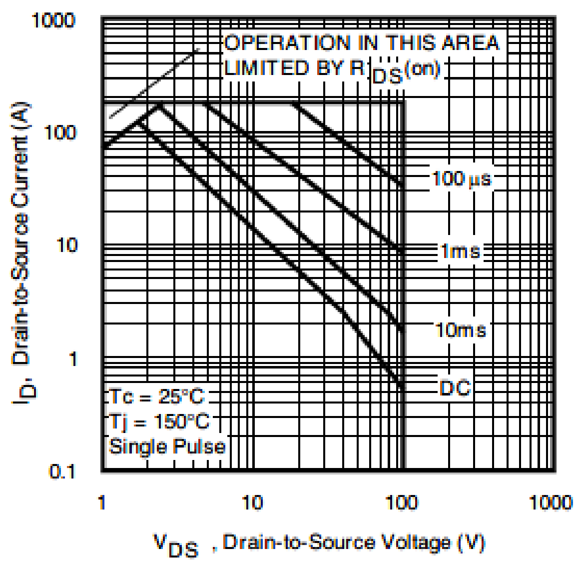


Figure 9 Maximum Safe Operating Area

Electrical Characteristics Curves (Pre-irradiation)

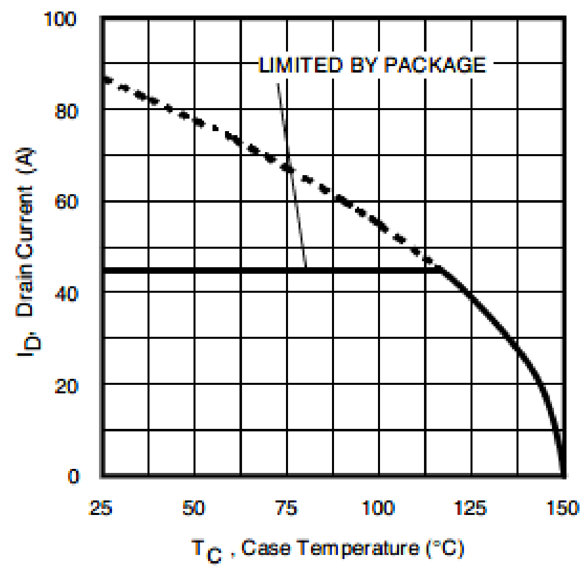


Figure 10 Maximum Drain Current Vs. Case Temperature

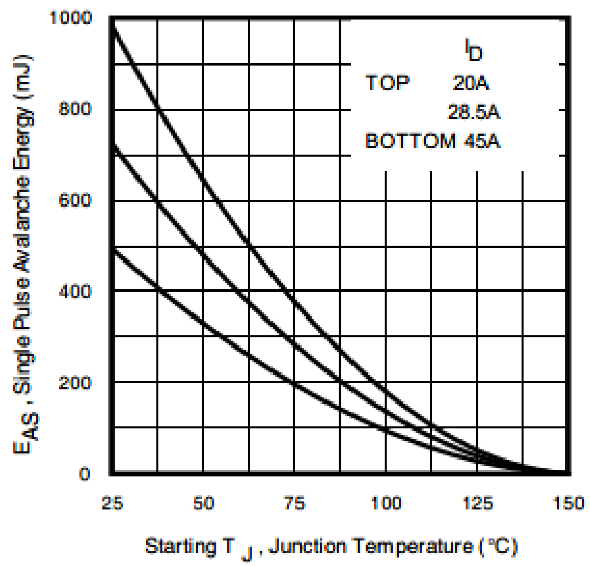


Figure 11 Maximum Avalanche Energy Vs. Junction Temperature

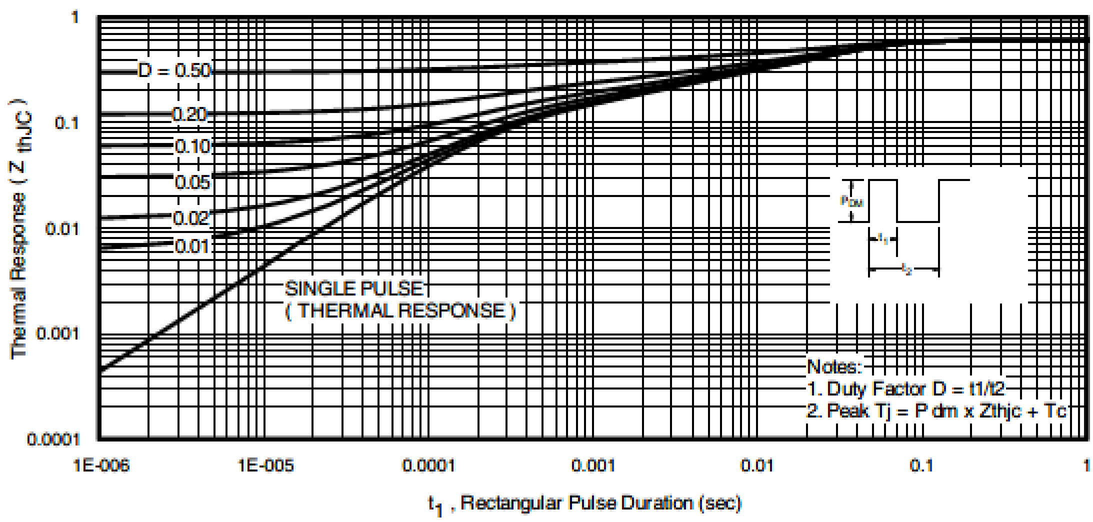


Figure 12 Maximum Effective Transient Thermal Impedance, Junction-to-Case

4 Test Circuits (Pre-irradiation)

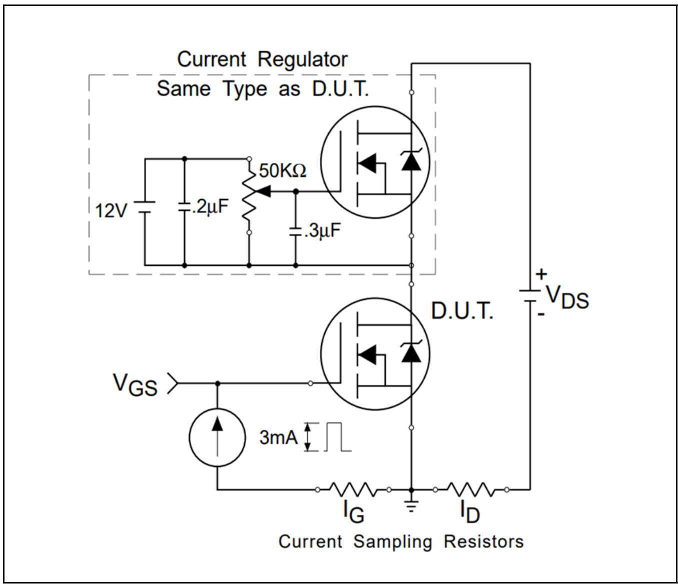


Figure 13 Gate Charge Test Circuit

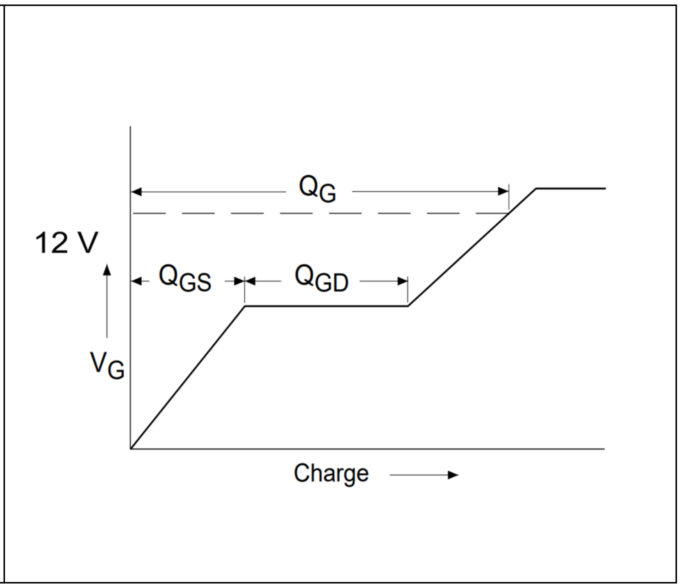


Figure 14 Gate Charge Waveform

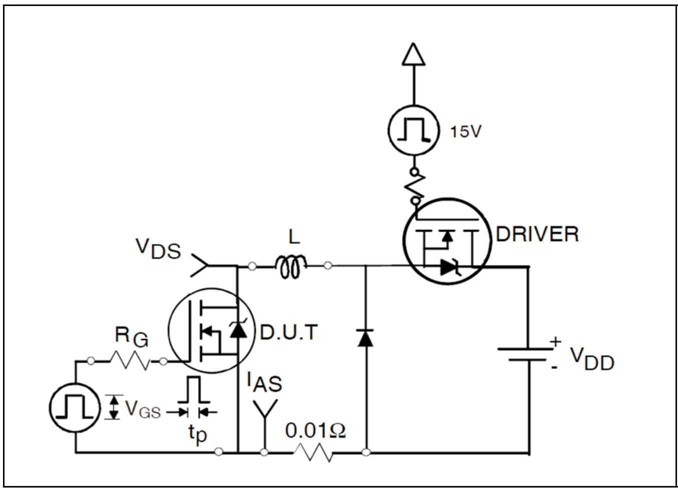


Figure 15 Unclamped Inductive Test Circuit

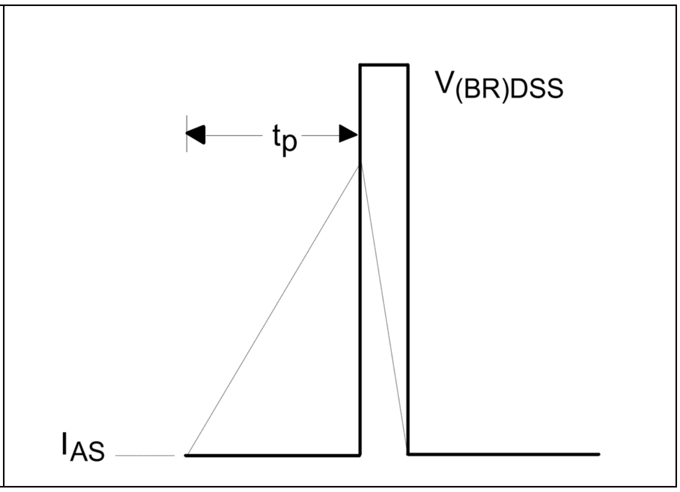


Figure 16 Unclamped Inductive Waveform

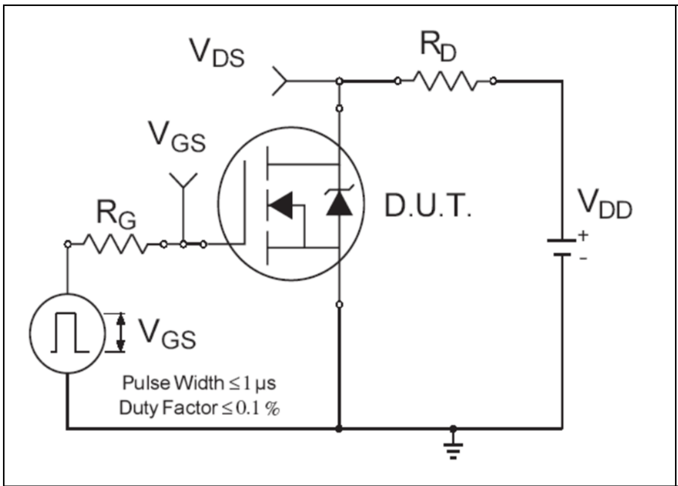


Figure 17 Switching Time Test Circuit

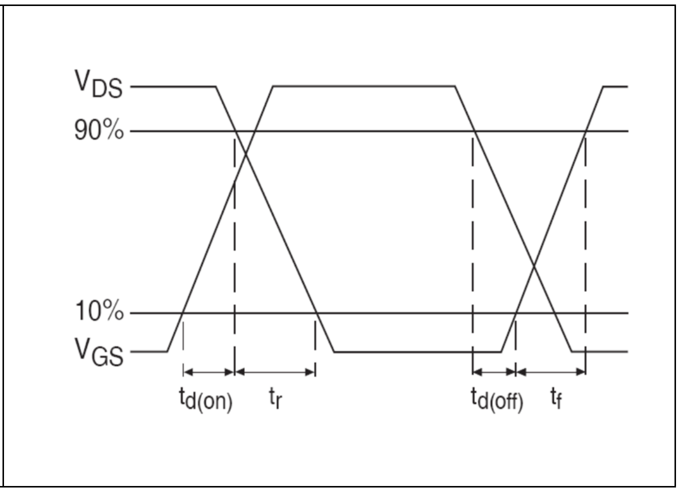
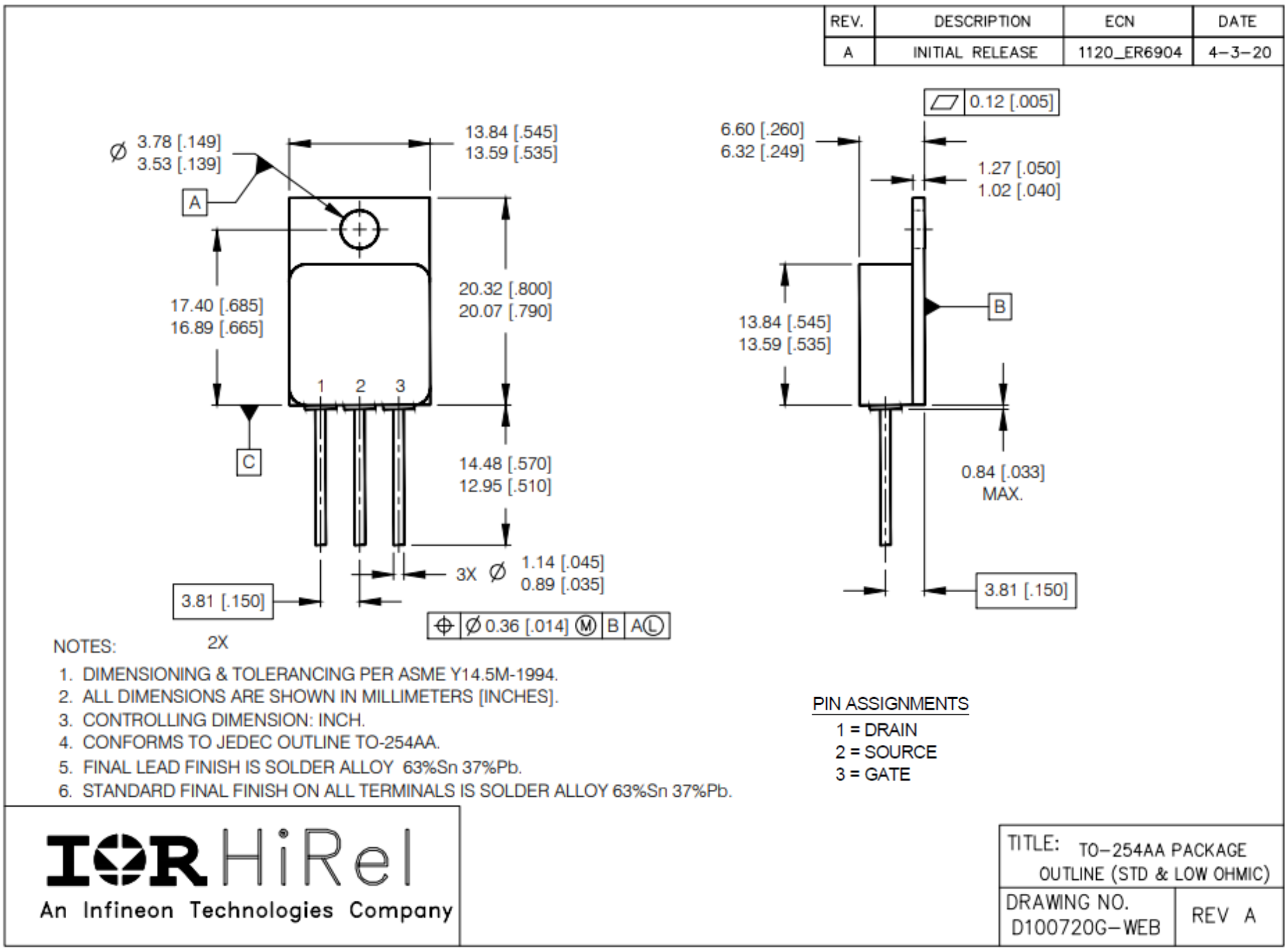


Figure 18 Switching Time Waveforms

5 Package Outline

Note: For the most updated package outline, please see the website: Low-Ohmic TO-254AA



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.

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Revision history

Document version	Date of release	Description of changes
	11/01/2004	Datasheet (PD-95889)
Rev A	04/26/2006	Updated 600kRad(si) to 500kRad(si)
Rev B	07/24/2006	Updated based on ECN-13936
Rev C	10/27/2011	Updated SEE table
Rev D	12/01/2014	Updated based on ECN-1120_03066
Rev E	11/05/2015	Updated based on ECN-1120_03980
Rev F	11/14/2017	Updated based on ECN-1120_05466
Rev G	05/26/2022	Updated based on ECN-1120_09018

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