

IRHMB7360SE (2N7391D4)

PD-97855A

Radiation Hardened Power MOSFET Thru-Hole (Low Ohmic Tabless - TO-254AA) 400V, 22A, N-channel, Rad Hard HEXFET™ Technology

Features

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

Potential Applications

- DC-DC converter
- Electric propulsion
- Motor drives

Product Validation

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

Description

IR HiRel rad hard HEXFET 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.

Product Summary

- BV_{DSS} : 400V
- I_D : 22A
- $R_{DS(on),max}$: 20m Ω
- $Q_{G,max}$: 185nC



Ordering Information

Table 1 Ordering options

Part number	Package	Screening Level	TID Level
IRHMB7360SE	Low Ohmic Tabless - TO-254AA	COTS	100 krad (Si)

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Absolute Maximum Ratings

1 Absolute Maximum Ratings

Table 2 Absolute Maximum Ratings (Pre-Irradiation)

Symbol	Parameter	Value	Unit
$I_{D1} @ V_{GS} = 12V, T_C = 25^{\circ}C$	Continuous Drain Current	22	A
$I_{D2} @ V_{GS} = 12V, T_C = 100^{\circ}C$	Continuous Drain Current	14	A
$I_{DM} @ T_C = 25^{\circ}C$	Pulsed Drain Current ¹	88	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	± 20	V
E_{AS}	Single Pulse Avalanche Energy ²	500	mJ
I_{AR}	Avalanche Current ¹	22	A
E_{AR}	Repetitive Avalanche Energy ¹	25	mJ
dv/dt	Peak Diode Reverse Recovery ³	3.0	V/ns
T_J T_{STG}	Operating Junction and Storage Temperature Range	-55 to +150	$^{\circ}C$
	Lead Temperature	300 (0.063 in. /1.6 mm from case for 10s)	
	Weight	9.3 (Typical)	

¹ Repetitive Rating; Pulse width limited by maximum junction temperature.² $V_{DD} = 50V$, starting $T_J = 25^{\circ}C$, $L = 2.0mH$, Peak $I_L = 22A$, $V_{GS} = 12V$ ³ $I_{SD} \leq 22A$, $di/dt \leq 120A/\mu s$, $V_{DD} \leq 400V$, $T_J \leq 150^{\circ}C$

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)

Symbol	Parameter	Min.	Typ.	Max.	Unit	Test Conditions
BV_{DSS}	Drain-to-Source Breakdown Voltage	400	—	—	V	$V_{GS} = 0V, I_D = 1.0mA$
$\Delta BV_{DSS}/\Delta T_J$	Breakdown Voltage Temp. Coefficient	—	0.51	—	V/ $^\circ\text{C}$	Reference to 25°C , $I_D = 1.0mA$
$R_{DS(on)}$	Static Drain-to-Source On-State Resistance	—	—	20	$m\Omega$	$V_{GS} = 12V, I_{D2} = 14A^1$
		—	—	21		$V_{GS} = 12V, I_{D1} = 22A^1$
$V_{GS(th)}$	Gate Threshold Voltage	2.5	—	4.5	V	$V_{DS} = V_{GS}, I_D = 1mA$
G_{fs}	Forward Transconductance	6.0	—	—	S	$V_{DS} = 15V, I_{D2} = 14A^1$
I_{DSS}	Zero Gate Voltage Drain Current	—	—	50	μA	$V_{DS} = 320V, V_{GS} = 0V$
		—	—	250		$V_{DS} = 320V, V_{GS} = 0V, T_J = 125^\circ\text{C}$
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	—	—	185	nC	$I_{D1} = 22A$
Q_{GS}	Gate-to-Source Charge	—	—	35		$V_{DS} = 200V$
Q_{GD}	Gate-to-Drain ('Miller') Charge	—	—	100		$V_{GS} = 12V$
$t_{d(on)}$	Turn-On Delay Time	—	—	28	ns	$I_{D1} = 22A^{**}$ $V_{DD} = 200V$ $R_G = 2.35\Omega$ $V_{GS} = 12V$
t_r	Rise Time	—	—	97		
$t_{d(off)}$	Turn-Off Delay Time	—	—	120		
t_f	Fall Time	—	—	72		
$L_s + L_D$	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	—	4000	—	pF	$V_{GS} = 0V$
C_{oss}	Output Capacitance	—	1000	—		$V_{DS} = 25V$
C_{rss}	Reverse Transfer Capacitance	—	460	—		$f = 1.0MHz$

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

¹ Pulse width $\leq 300 \mu s$; Duty Cycle $\leq 2\%$

Device Characteristics

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)	—	—	22	A	
I_{SM}	Pulsed Source Current (Body Diode) ¹	—	—	88	A	
V_{SD}	Diode Forward Voltage	—	—	1.4	V	$T_J = 25^\circ\text{C}$, $I_S = 22\text{A}$, $V_{GS} = 0\text{V}$ ²
t_{rr}	Reverse Recovery Time	—	—	720	ns	$T_J = 25^\circ\text{C}$, $I_F = 22\text{A}$, $V_{DD} \leq 50\text{V}$
Q_{rr}	Reverse Recovery Charge	—	9.4	—	μC	$di/dt = 100\text{A}/\mu\text{s}$
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

Symbol	Parameter	Min.	Typ.	Max.	Unit
$R_{\theta JC}$	Junction-to-Case	—	—	0.50	$^\circ\text{C}/\text{W}$
$R_{\theta CS}$	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 @ $T_J = 25^\circ\text{C}$, Post Total Dose Irradiation ^{3, 4}

Symbol	Parameter	100 krad (Si) ⁵		Unit	Test Conditions
		Min.	Max.		
BV_{DSS}	Drain-to-Source Breakdown Voltage	400	—	V	$V_{GS} = 0\text{V}$, $I_D = 1.0\text{mA}$
$V_{GS(th)}$	Gate Threshold Voltage	2.0	4.5	V	$V_{DS} = V_{GS}$, $I_D = 1.0\text{mA}$
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	—	50	μA	$V_{DS} = 320\text{V}$, $V_{GS} = 0\text{V}$
$R_{DS(on)}$	Static Drain-to-Source On-State Resistance (TO-3) ²	—	20	$\text{m}\Omega$	$V_{GS} = 12\text{V}$, $I_{D2} = 14\text{A}$
$R_{DS(on)}$	Static Drain-to-Source On-State Resistance (TO-254AA) ²	—	20	$\text{m}\Omega$	$V_{GS} = 12\text{V}$, $I_{D2} = 14\text{A}$
V_{SD}	Diode Forward Voltage	—	1.4	V	$V_{GS} = 0\text{V}$, $I_F = 22\text{A}$

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

² Pulse width $\leq 300\text{ }\mu\text{s}$; Duty Cycle $\leq 2\%$

³ 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.

⁴ Total Dose Irradiation with V_{DS} Bias. $V_{DS} = 320\text{V}$ applied and $V_{GS} = 0$ during irradiation per MIL-STD-750, Method 1019, condition A.

⁵ Part numbers IRHMB7360SE

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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

Ion	LET (MeV·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	V _{GS} = -25V
Cu	28	285	43	325	325	325	325	325	325
Br	36.8	305	39	325	325	325	325	320	—

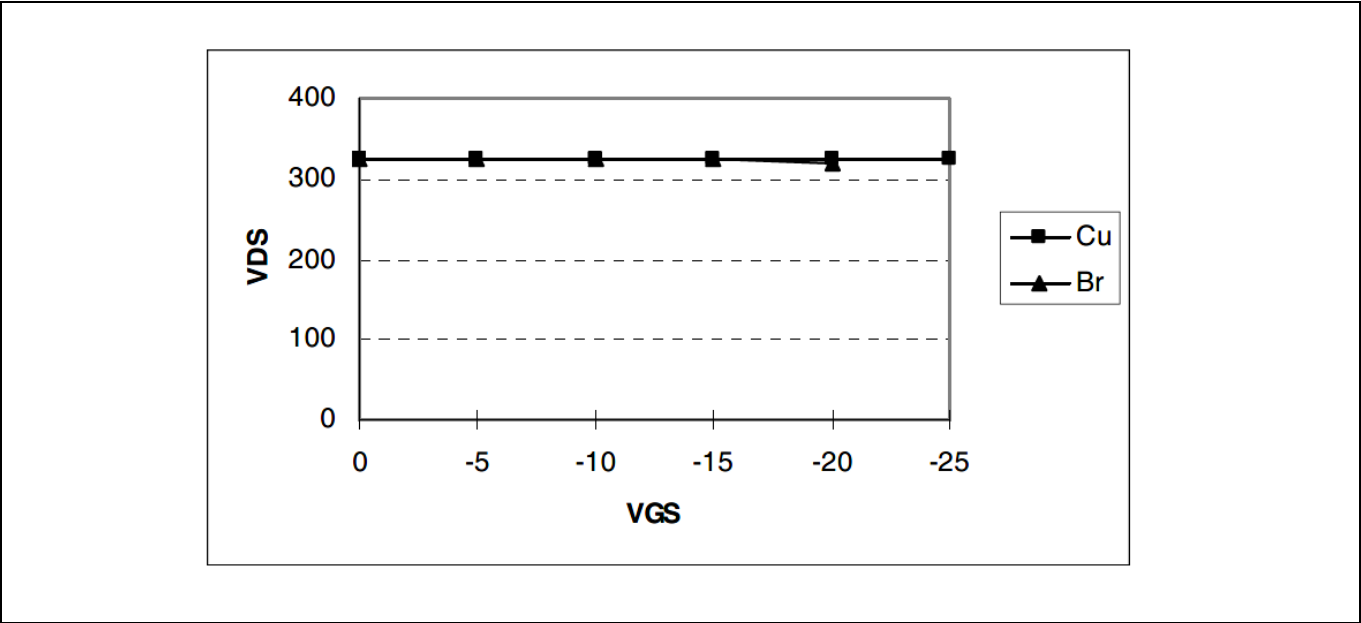


Figure 1 Typical Single Event Effect, Safe Operating Area

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Electrical Characteristics Curves (Pre-irradiation)

3 Electrical Characteristics Curves (Pre-irradiation)

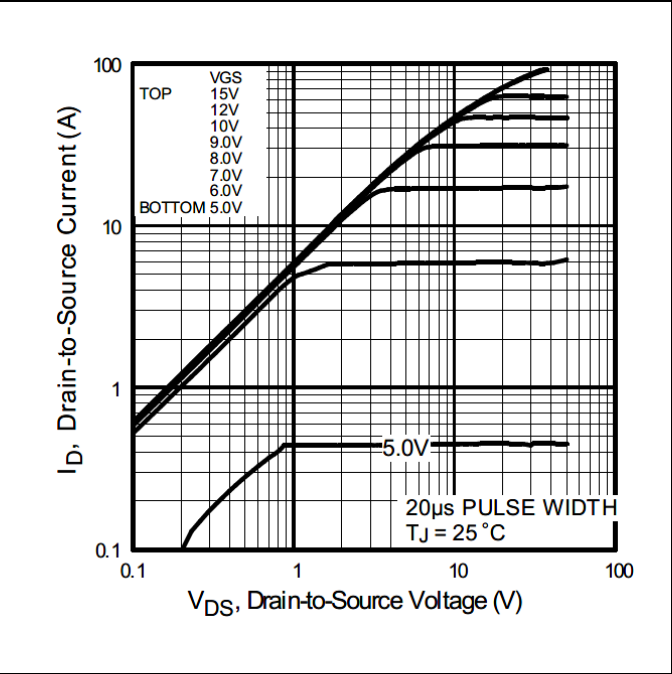


Figure 2 Typical Output Characteristics

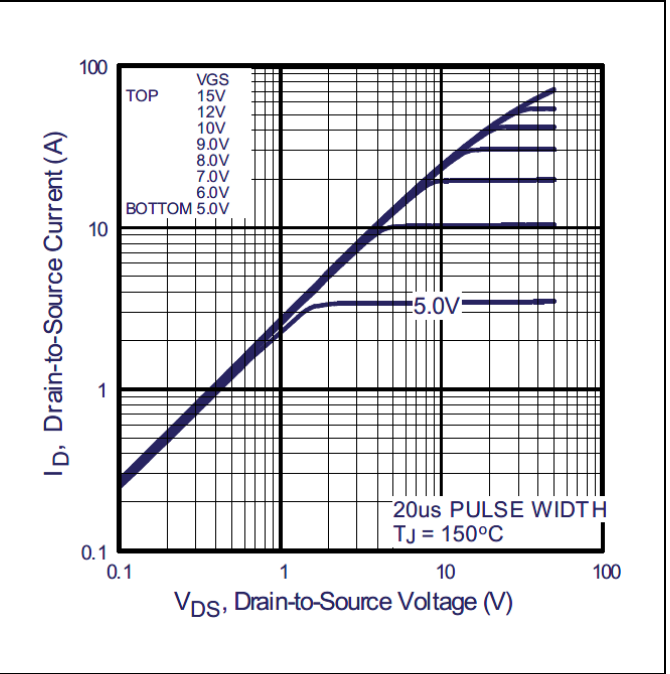


Figure 3 Typical Output Characteristics

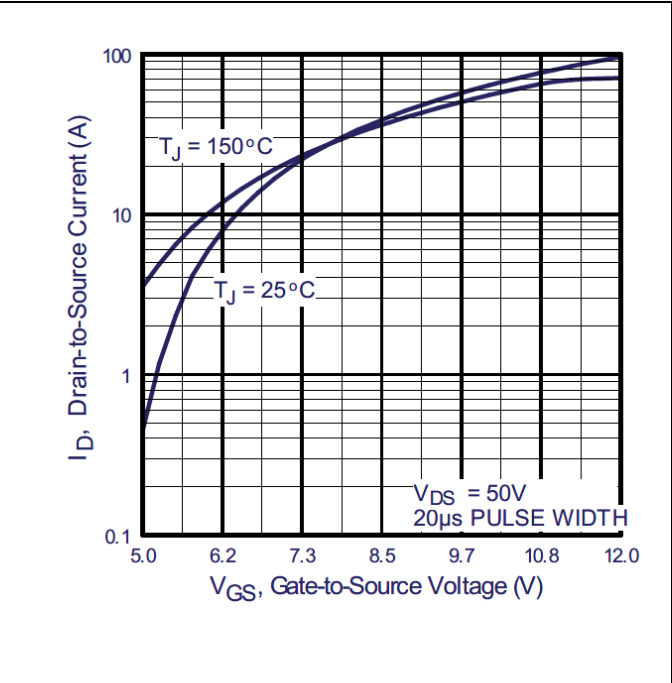


Figure 4 Typical Transfer Characteristics

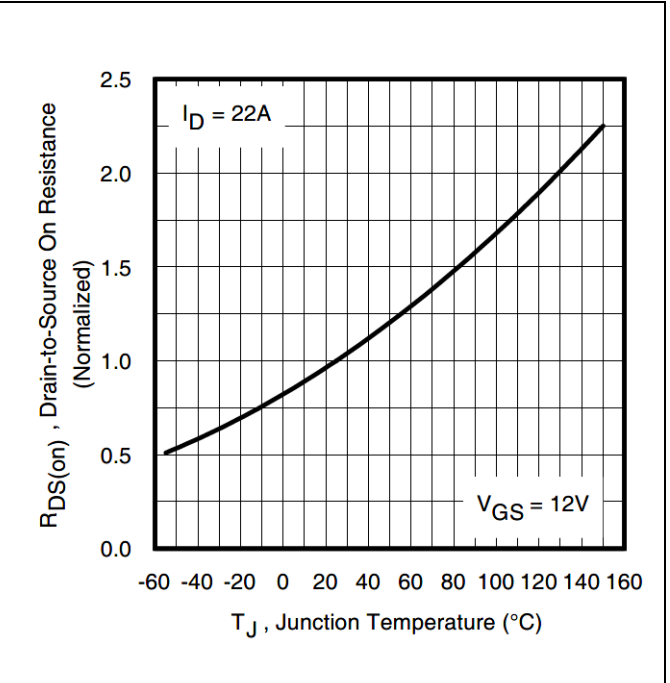


Figure 5 Normalized On-Resistance Vs. Temperature

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Electrical Characteristics Curves (Pre-irradiation)

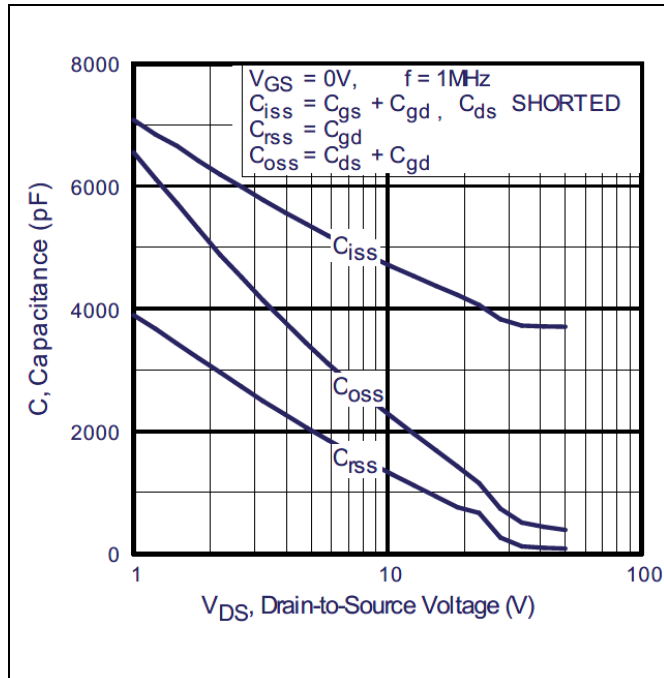


Figure 6 Typical Capacitance Vs. Drain-to-Source Voltage

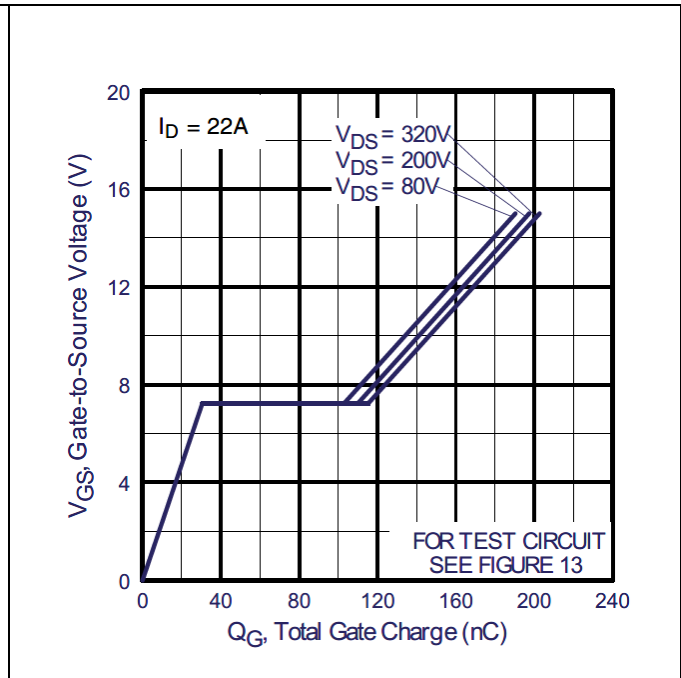


Figure 7 Typical Gate-to-Source Voltage Vs. Gate Charge

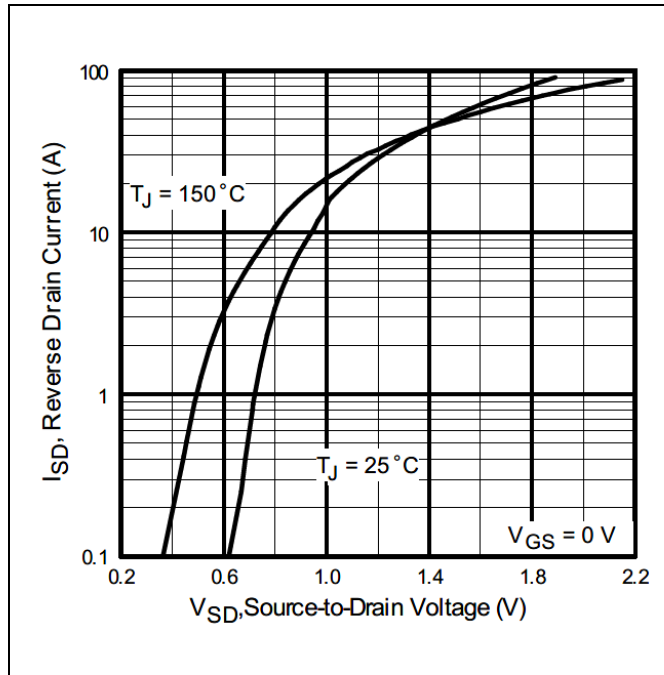


Figure 8 Typical Source-Drain Current Vs. Diode Forward Voltage

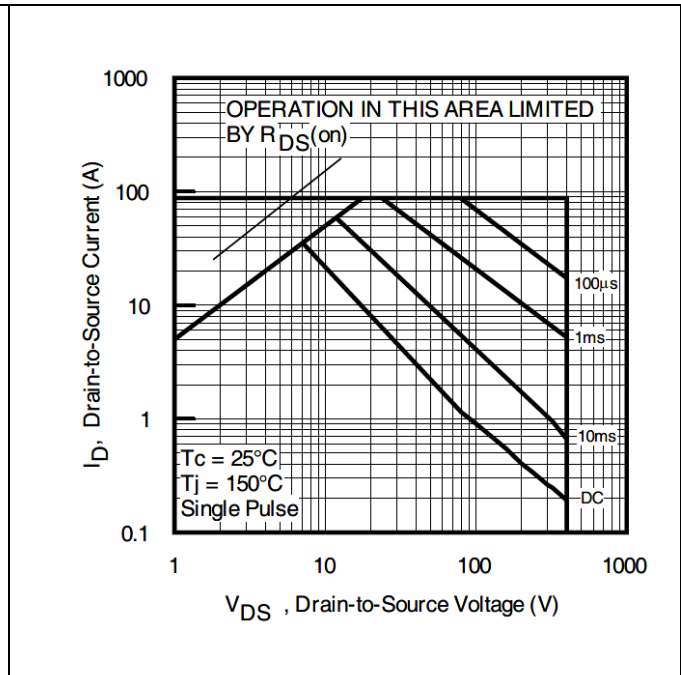


Figure 9 Maximum Safe Operating Area

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Electrical Characteristics Curves (Pre-irradiation)

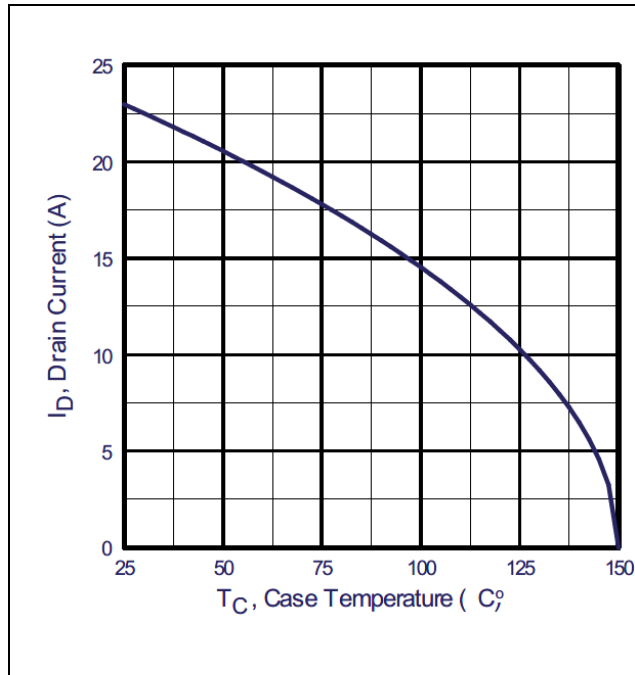


Figure 10 Maximum Drain Current Vs. Case Temperature

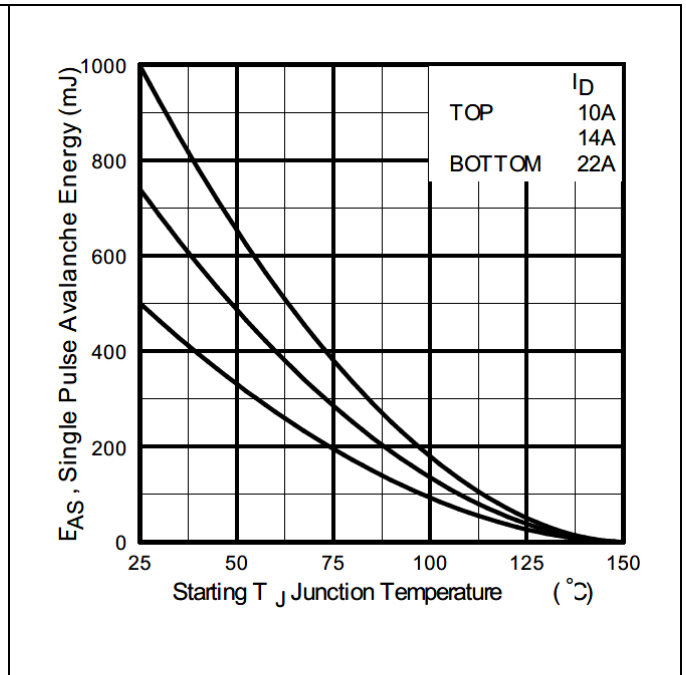


Figure 11 Maximum Avalanche Energy Vs. Junction Temperature

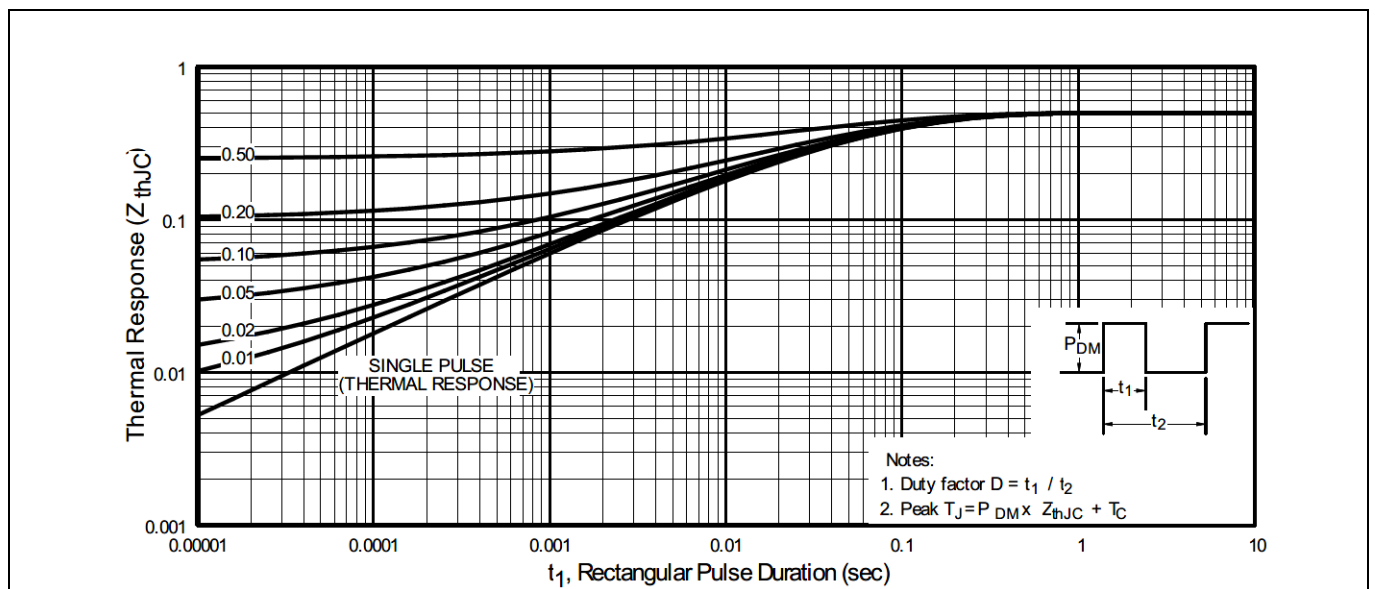


Figure 12 Maximum Effective Transient Thermal Impedance, Junction-to-Case

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Test Circuits (Pre-irradiation)

4 Test Circuits (Pre-irradiation)

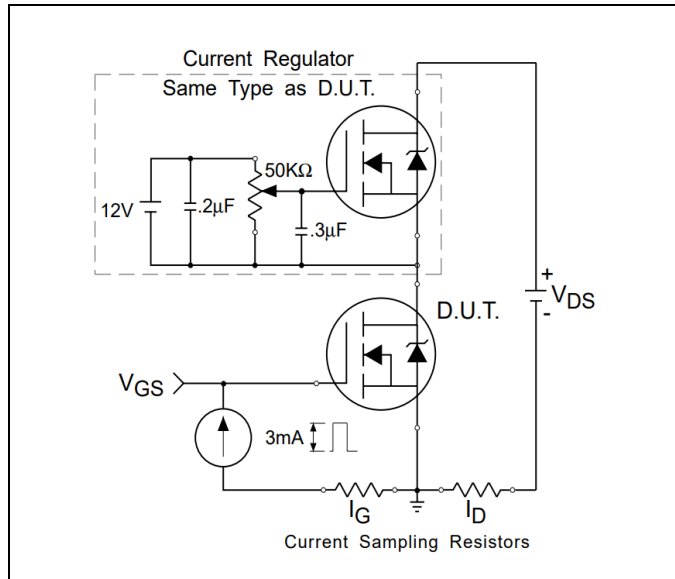


Figure 13 Gate Charge Test Circuit

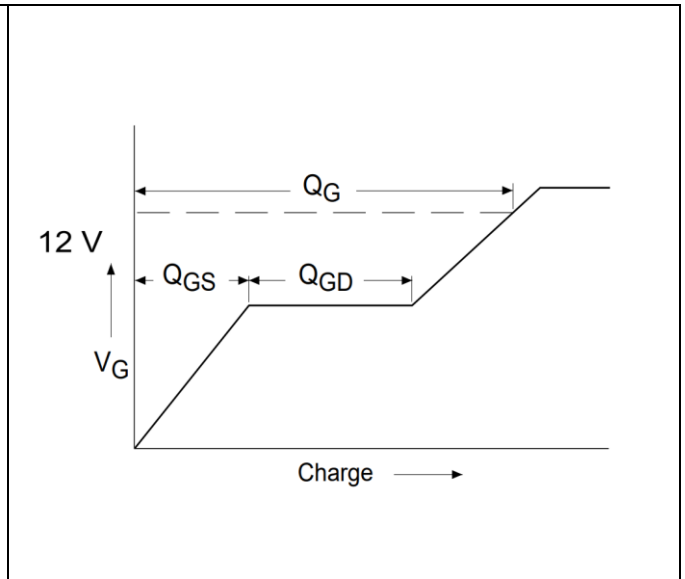


Figure 14 Gate Charge Waveform

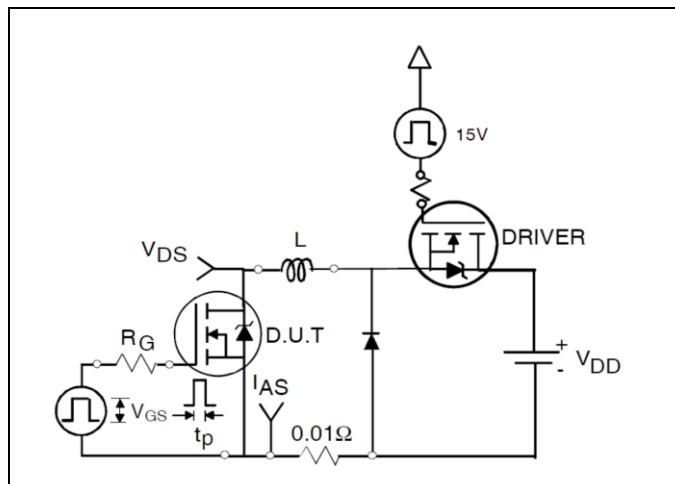


Figure 15 Unclamped Inductive Test Circuit

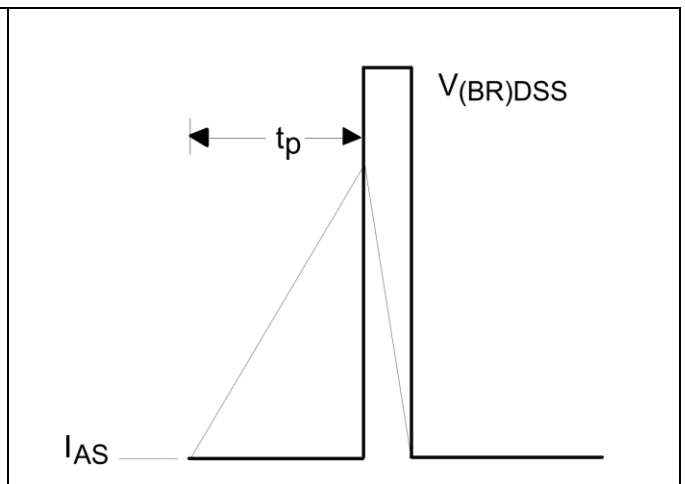


Figure 16 Unclamped Inductive Waveform

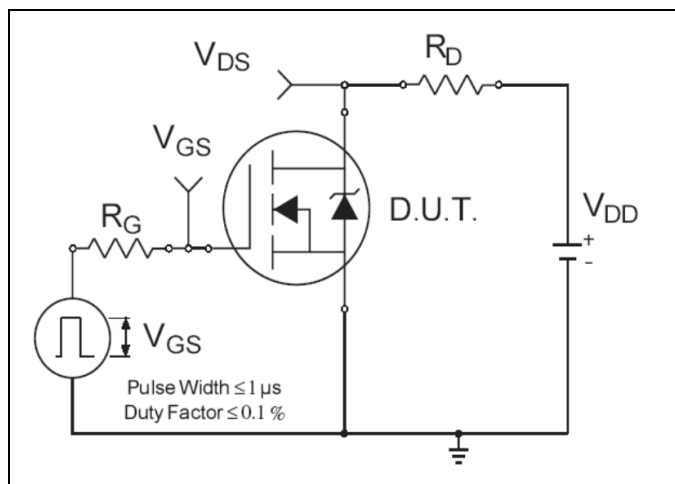


Figure 17 Switching Time Test Circuit

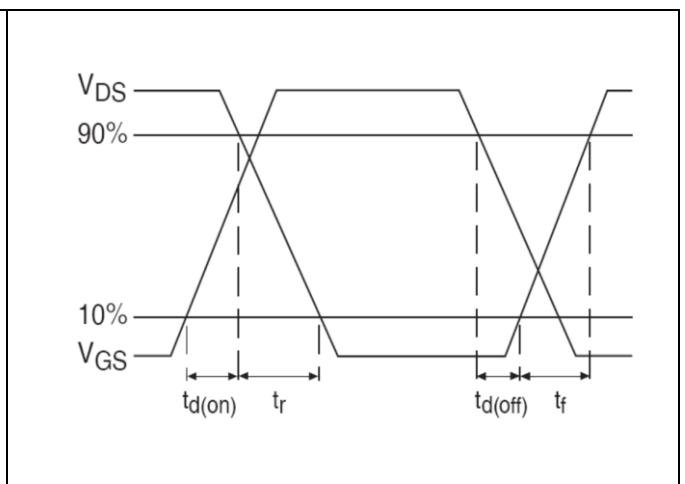


Figure 18 Switching Time Waveforms

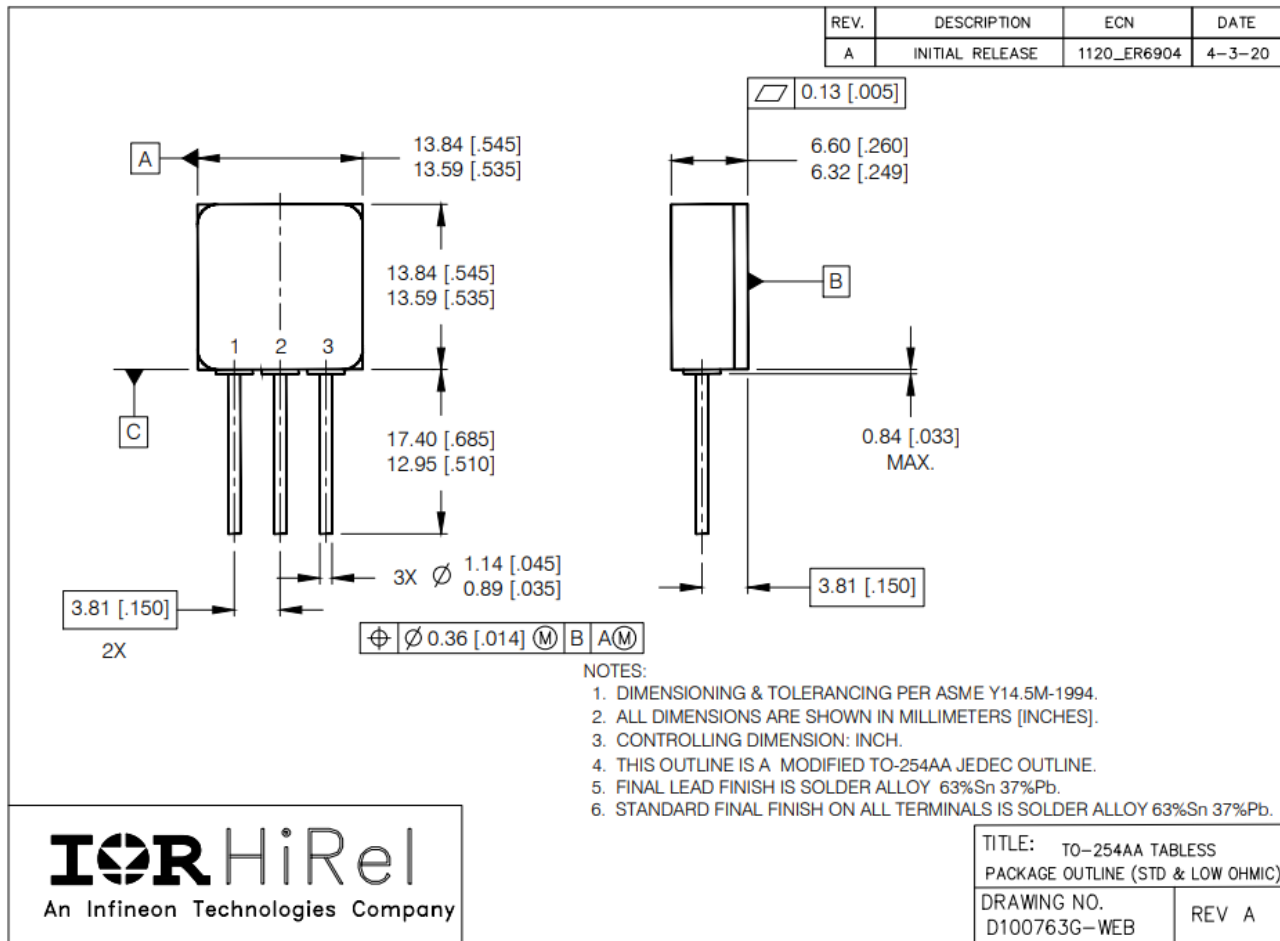
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Package Outline

5 Package Outline

Note: For the most updated package outline, please see the website : [Low Ohmic Tabless - 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.

IRHMB7360SE (2N7391D4)

Radiation Hardened Power MOSFET Thru-Hole (Low Ohmic Tabless - TO-254AA)

Revision history

Revision history

Document version	Date of release	Description of changes
	01/10/2017	Datasheet (PD-97855)
Rev A	07/01/2024	Updated based on ECN-1120_09973

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