

# IRHY7230CM (JANSR2N7381)

PD-91273F

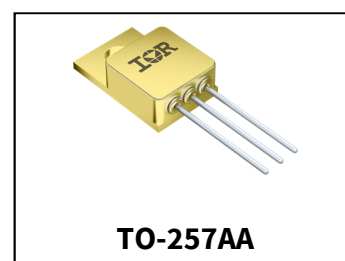
## Radiation Hardened Power MOSFET Thru-Hole (TO-257AA) 200V, 9.4A, N-channel, Rad Hard HEXFET™ Technology

### Features

- Single event effect (SEE) hardened
- Low  $R_{DS(on)}$
- Low total gate charge
- Simple drive requirements
- Hermetically sealed
- Electrically isolated
- Ceramic eyelets
- ESD rating: Class 1C per MIL-STD-750, Method 1020

### Product Summary

- $BV_{DSS}$ : 200V
- $I_D$ : 9.4A
- $R_{DS(on),max}$ : 0.40Ω
- $Q_{G,max}$ : 50nC
- REF: MIL-PRF-19500/614



### Potential Applications

- DC-DC converter
- Motor drives

### Product Validation

Qualified 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.

### Ordering Information

Table 1 Ordering options

Part number	Package	Screening Level	TID Level
IRHY7230CM	TO-257AA	COTS	100 krad(Si)
JANSR2N7381	TO-257AA	JANS	100 krad(Si)
IRHY3230CM	TO-257AA	COTS	300 krad(Si)
JANSF2N7381	TO-257AA	JANS	300 krad(Si)
IRHY4230CM	TO-257AA	COTS	500 krad(Si)
JANSG2N7381	TO-257AA	JANS	500 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	9.4	A
$I_{D2} @ V_{GS} = 12V, T_C = 100^\circ C$	Continuous Drain Current	6.0	A
$I_{DM} @ T_C = 25^\circ C$	Pulsed Drain Current <sup>1</sup>	37.6	A
$P_D @ T_C = 25^\circ C$	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 <sup>2</sup>	150	mJ
$I_{AR}$	Avalanche Current <sup>1</sup>	9.4	A
$E_{AR}$	Repetitive Avalanche Energy <sup>1</sup>	7.5	mJ
dv/dt	Peak Diode Reverse Recovery <sup>3</sup>	16	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	7.0 (Typical)	g

<sup>1</sup> Repetitive Rating; Pulse width limited by maximum junction temperature.

<sup>2</sup>  $V_{DD} = 50V$ , starting  $T_J = 25^\circ C$ ,  $L = 3.4mH$ , Peak  $I_L = 9.4A$ ,  $V_{GS} = 12V$

<sup>3</sup>  $I_{SD} \leq 9.4A$ ,  $di/dt \leq 660A/\mu s$ ,  $V_{DD} \leq 200V$ ,  $T_J \leq 150^\circ C$

## 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	200	—	—	V	$V_{GS} = 0V, I_D = 1.0mA$
$\Delta BV_{DSS}/\Delta T_J$	Breakdown Voltage Temp. Coefficient	—	0.23	—	V/ $^\circ\text{C}$	Reference to $25^\circ\text{C}$ , $I_D = 1.0mA$
$R_{DS(on)}$	Static Drain-to-Source On-State Resistance	—	—	0.40	$\Omega$	$V_{GS} = 12V, I_{D2} = 6.0A^1$
		—	—	0.49		$V_{GS} = 12V, I_{D1} = 9.4A^1$
$V_{GS(th)}$	Gate Threshold Voltage	2.0	—	4.0	V	$V_{DS} = V_{GS}, I_D = 1mA$
$G_{fs}$	Forward Transconductance	2.5	—	—	S	$V_{DS} = 15V, I_{D2} = 6.0A^1$
$I_{DSS}$	Zero Gate Voltage Drain Current	—	—	25	$\mu\text{A}$	$V_{DS} = 160V, V_{GS} = 0V$
		—	—	250		$V_{DS} = 160V, V_{GS} = 0V, T_J = 125^\circ\text{C}$
$I_{GSS}$	Gate-to-Source Leakage Forward	—	—	100	nA	$V_{GS} = 20V$
	Gate-to-Source Leakage Reverse	—	—	-100		$V_{GS} = -20V$
$Q_G$	Total Gate Charge	—	—	50	nC	$I_{D1} = 9.4A$
$Q_{GS}$	Gate-to-Source Charge	—	—	10		$V_{DS} = 100V$
$Q_{GD}$	Gate-to-Drain ('Miller') Charge	—	—	25		$V_{GS} = 12V$
$t_{d(on)}$	Turn-On Delay Time	—	—	35	ns	$I_{D1} = 9.4A^{**}$ $V_{DD} = 100V$ $R_G = 7.5\Omega$ $V_{GS} = 12V$
$t_r$	Rise Time	—	—	75		
$t_{d(off)}$	Turn-Off Delay Time	—	—	70		
$t_f$	Fall Time	—	—	60		
$L_s + L_D$	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 pad
$C_{iss}$	Input Capacitance	—	1200	—	pF	$V_{GS} = 0V$ $V_{DS} = 25V$ $f = 1.0MHz$
$C_{oss}$	Output Capacitance	—	250	—		
$C_{rss}$	Reverse Transfer Capacitance	—	63	—		

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

<sup>1</sup> Pulse width  $\leq 300 \mu\text{s}$ ; 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)	—	—	9.4	A	
$I_{SM}$	Pulsed Source Current (Body Diode) <sup>1</sup>	—	—	37.6	A	
$V_{SD}$	Diode Forward Voltage	—	—	1.4	V	$T_J = 25^\circ\text{C}$ , $I_S = 9.4\text{A}$ , $V_{GS} = 0\text{V}$ <sup>2</sup>
$t_{rr}$	Reverse Recovery Time	—	—	460	ns	$T_J = 25^\circ\text{C}$ , $I_F = 9.4\text{A}$ , $V_{DD} \leq 50\text{V}$ $di/dt = 100\text{A}/\mu\text{s}$ <sup>2</sup>
$Q_{rr}$	Reverse Recovery Charge	—	—	2.4	$\mu\text{C}$	
$t_{on}$	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	$^\circ\text{C}/\text{W}$
$R_{\theta JA}$	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 @  $T_J = 25^\circ\text{C}$ , Post Total Dose Irradiation<sup>3, 4</sup>

Symbol	Parameter	100 krad (Si) <sup>5</sup>		Up to 500 krad (Si) <sup>6</sup>		Unit	Test Conditions
		Min.	Max.	Min.	Max.		
$BV_{DSS}$	Drain-to-Source Breakdown Voltage	200	—	200	—	V	$V_{GS} = 0\text{V}$ , $I_D = 1.0\text{mA}$
$V_{GS(th)}$	Gate Threshold Voltage	2.0	4.0	1.25	4.5	V	$V_{DS} = V_{GS}$ , $I_D = 1.0\text{mA}$
$I_{GSS}$	Gate-to-Source Leakage Forward	—	100	—	100	nA	$V_{GS} = 20\text{V}$
	Gate-to-Source Leakage Reverse	—	-100	—	-100		$V_{GS} = -20\text{V}$
$I_{DSS}$	Zero Gate Voltage Drain Current	—	25	—	25	$\mu\text{A}$	$V_{DS} = 160\text{V}$ , $V_{GS} = 0\text{V}$
$R_{DS(on)}$	Static Drain-to-Source On-State Resistance (TO-3) <sup>2</sup>	—	0.40	—	0.53	$\Omega$	$V_{GS} = 12\text{V}$ , $I_{D2} = 6.0\text{A}$
$R_{DS(on)}$	Static Drain-to-Source On-State Resistance (TO-257AA) <sup>2</sup>	—	0.40	—	0.53	$\Omega$	$V_{GS} = 12\text{V}$ , $I_{D2} = 6.0\text{A}$
$V_{SD}$	Diode Forward Voltage	—	1.4	—	1.4	V	$V_{GS} = 0\text{V}$ , $I_F = 9.4\text{A}$

<sup>1</sup> Repetitive Rating; Pulse width limited by maximum junction temperature.<sup>2</sup> Pulse width  $\leq 300 \mu\text{s}$ ; Duty Cycle  $\leq 2\%$ <sup>3</sup> 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.<sup>4</sup> Total Dose Irradiation with  $V_{DS}$  Bias.  $V_{DS} = 160\text{V}$  applied and  $V_{GS} = 0$  during irradiation per MIL-STD-750, Method 1019, condition A.<sup>5</sup> Part numbers IRHY7230CM (JANSR2N7381)<sup>6</sup> Part numbers IRHY3230CM (JANSF2N7381) and IRHY4230CM (JANS2N7381)

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 <sup>2</sup> /mg)	Energy (MeV)	Range (μm)	V <sub>DS</sub> (V)				
				V <sub>GS</sub> = 0V	V <sub>GS</sub> = -5V	V <sub>GS</sub> = -10V	V <sub>GS</sub> = -15V	V <sub>GS</sub> = -20V
Cu	28	285	43	190	180	170	125	—
Br	36.8	305	39	100	100	100	50	—

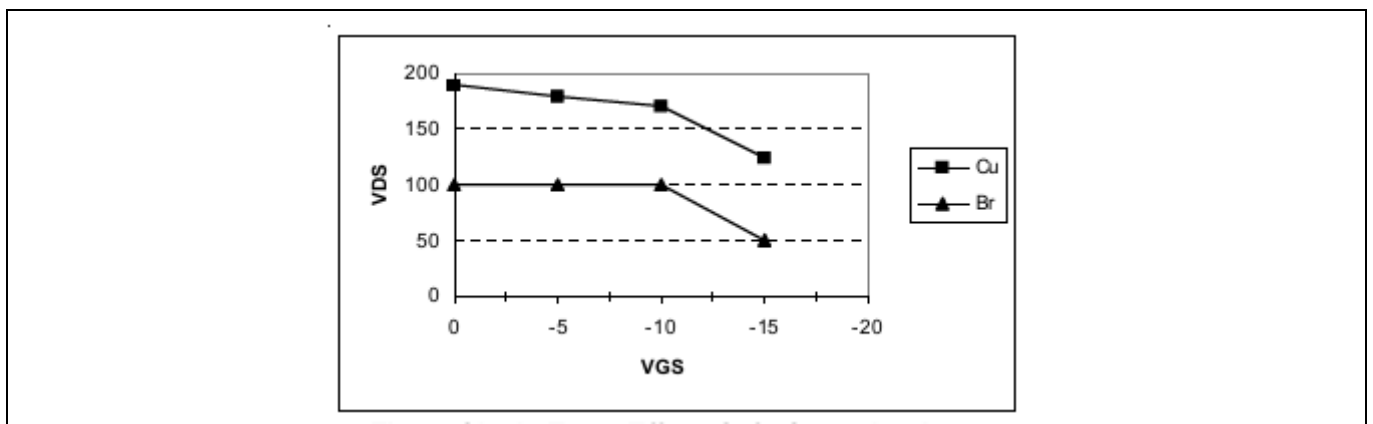


Figure 1 Typical Single Event Effect, Safe Operating Area

Electrical Characteristics Curves (Pre-irradiation)

### 3 Electrical Characteristics Curves (Pre-irradiation)

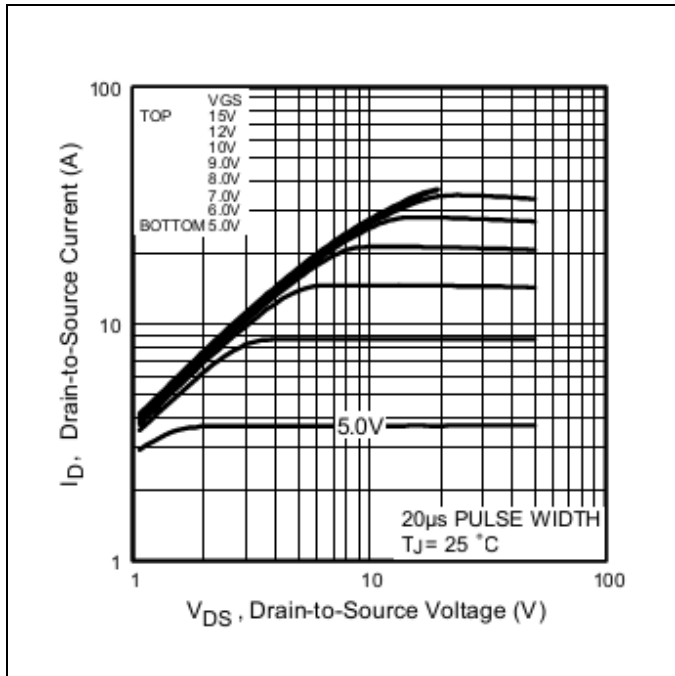


Figure 2 Typical Output Characteristics

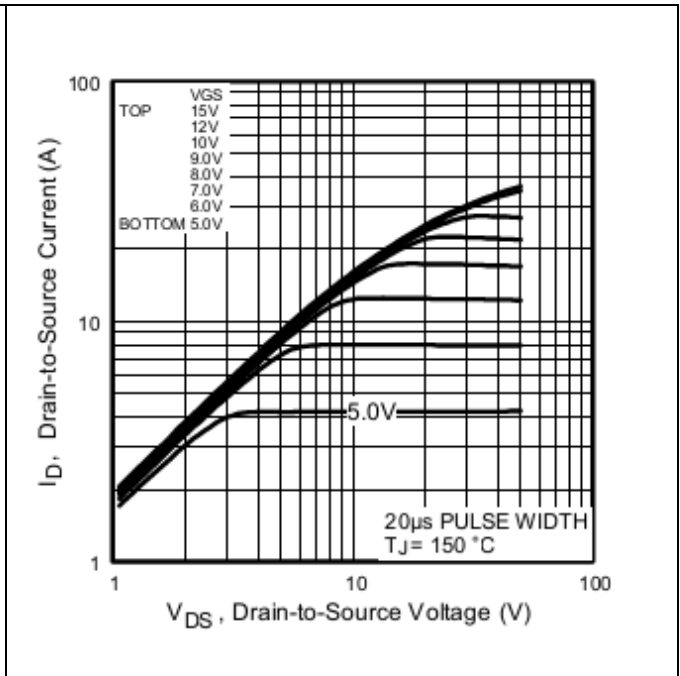


Figure 3 Typical Output Characteristics

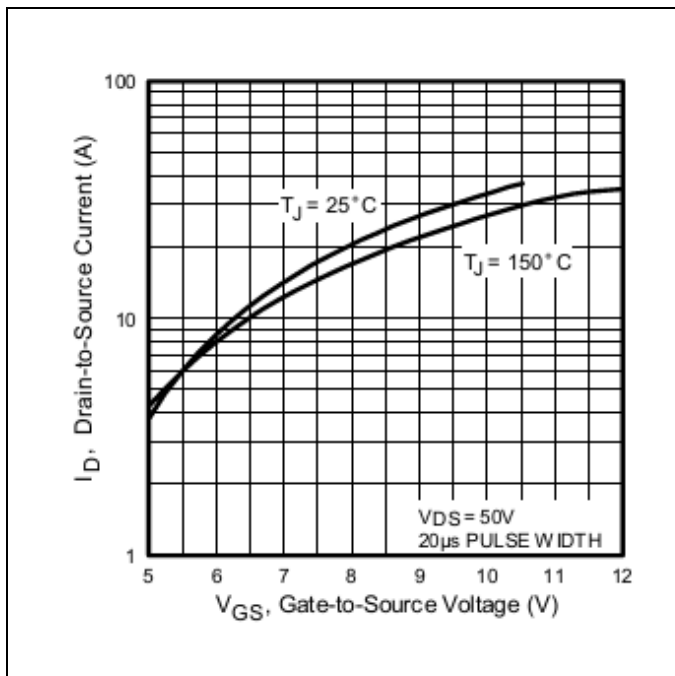


Figure 4 Typical Transfer Characteristics

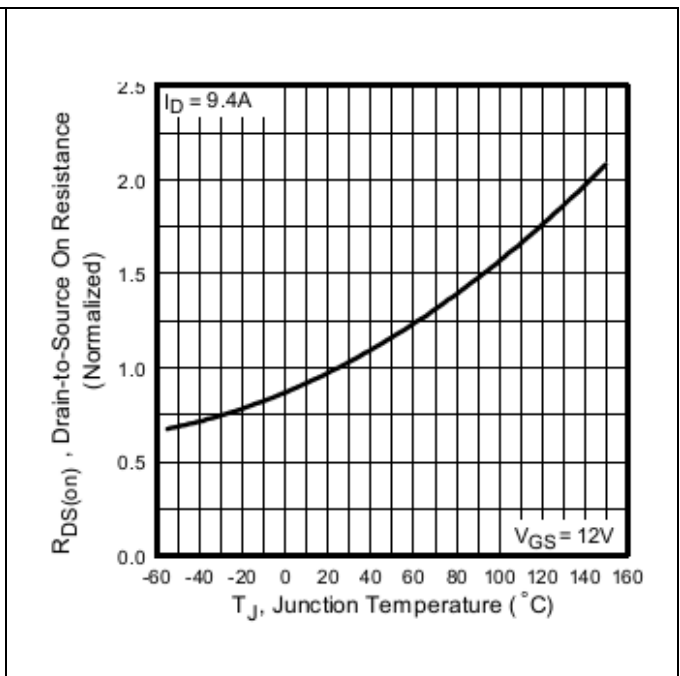
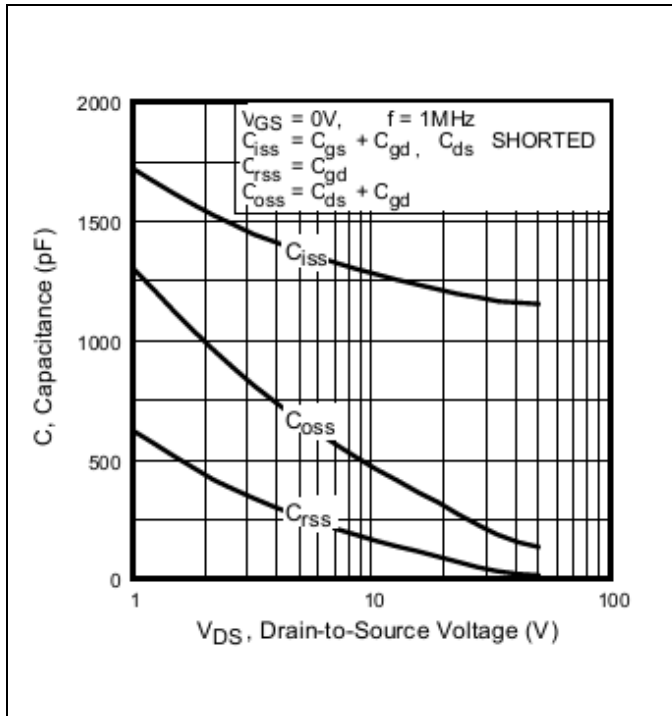


Figure 5 Normalized On-Resistance Vs. Temperature

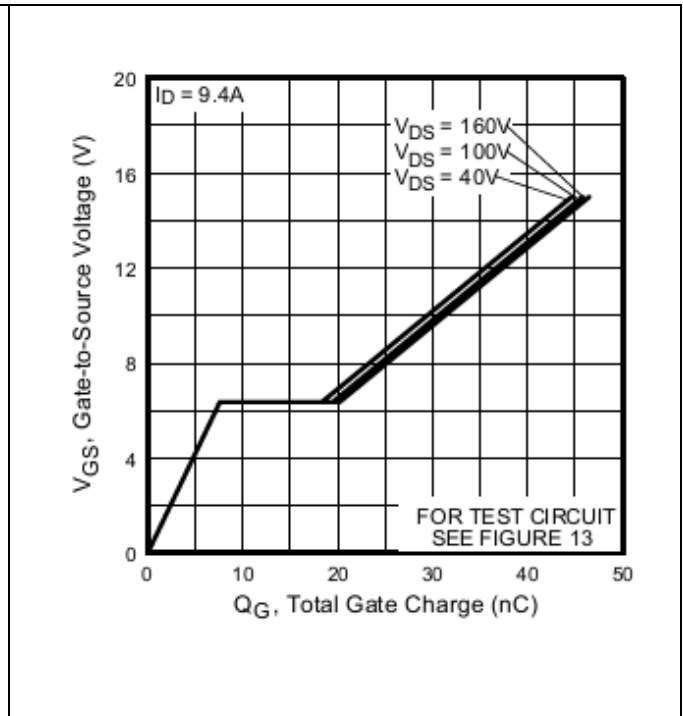
**IRHY7230CM (JANSR2N7381)**

**Radiation Hardened Power MOSFET Thru-Hole (TO-257AA)**

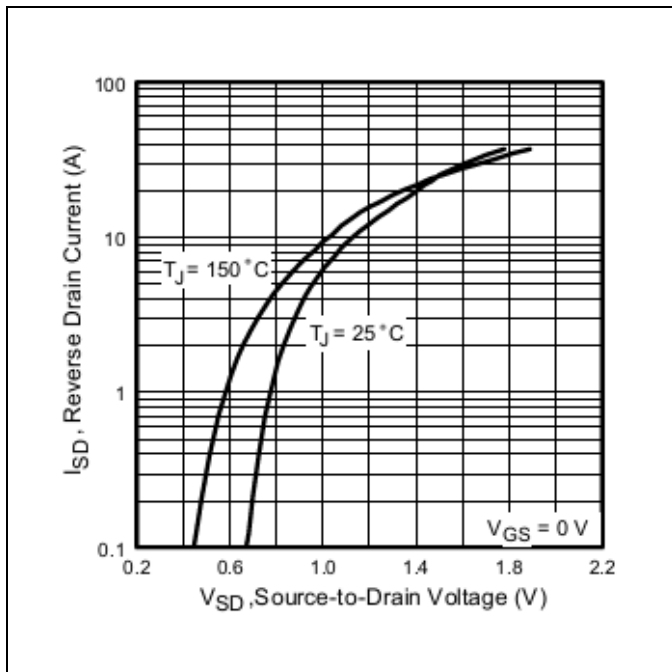
**Electrical Characteristics Curves (Pre-irradiation)**



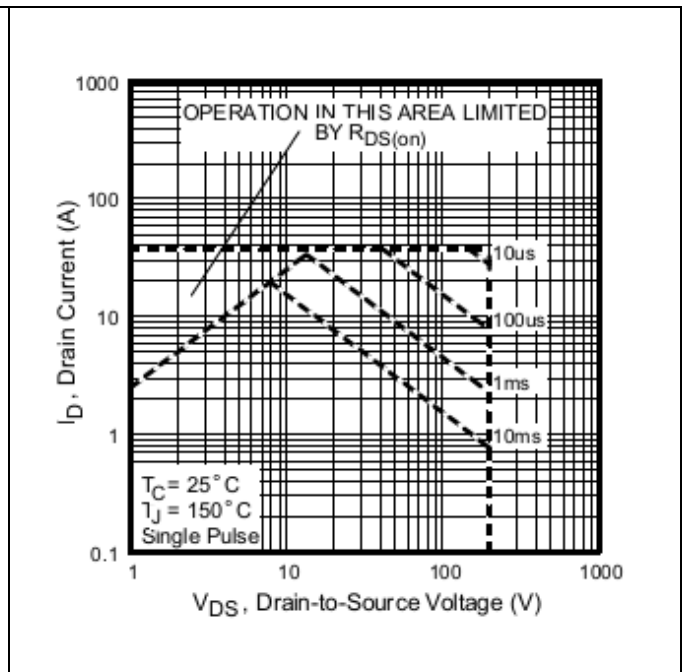
**Figure 6 Typical Capacitance Vs. Drain-to-Source Voltage**



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



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



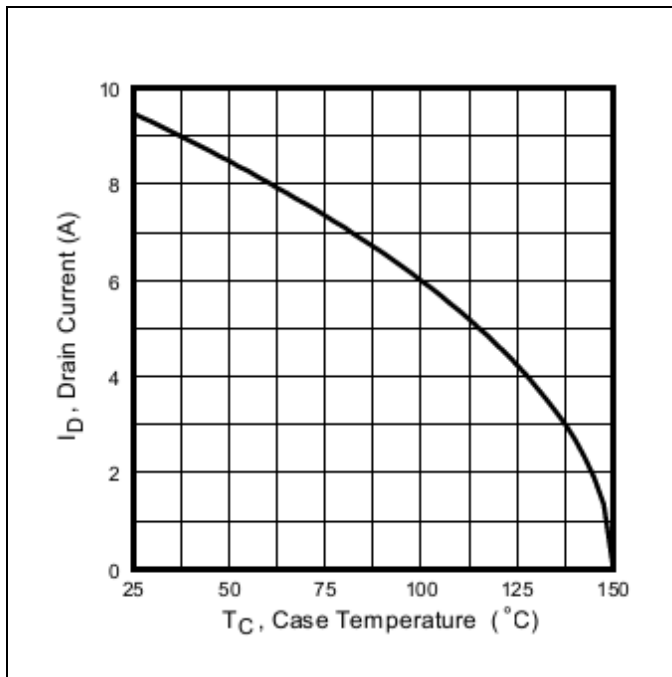
**Figure 9 Maximum Safe Operating Area**



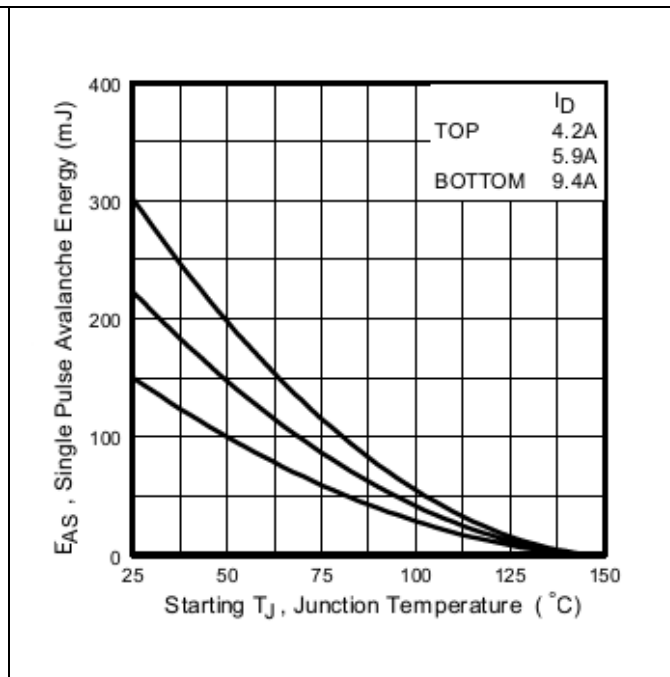
**IRHY7230CM (JANSR2N7381)**

**Radiation Hardened Power MOSFET Thru-Hole (TO-257AA)**

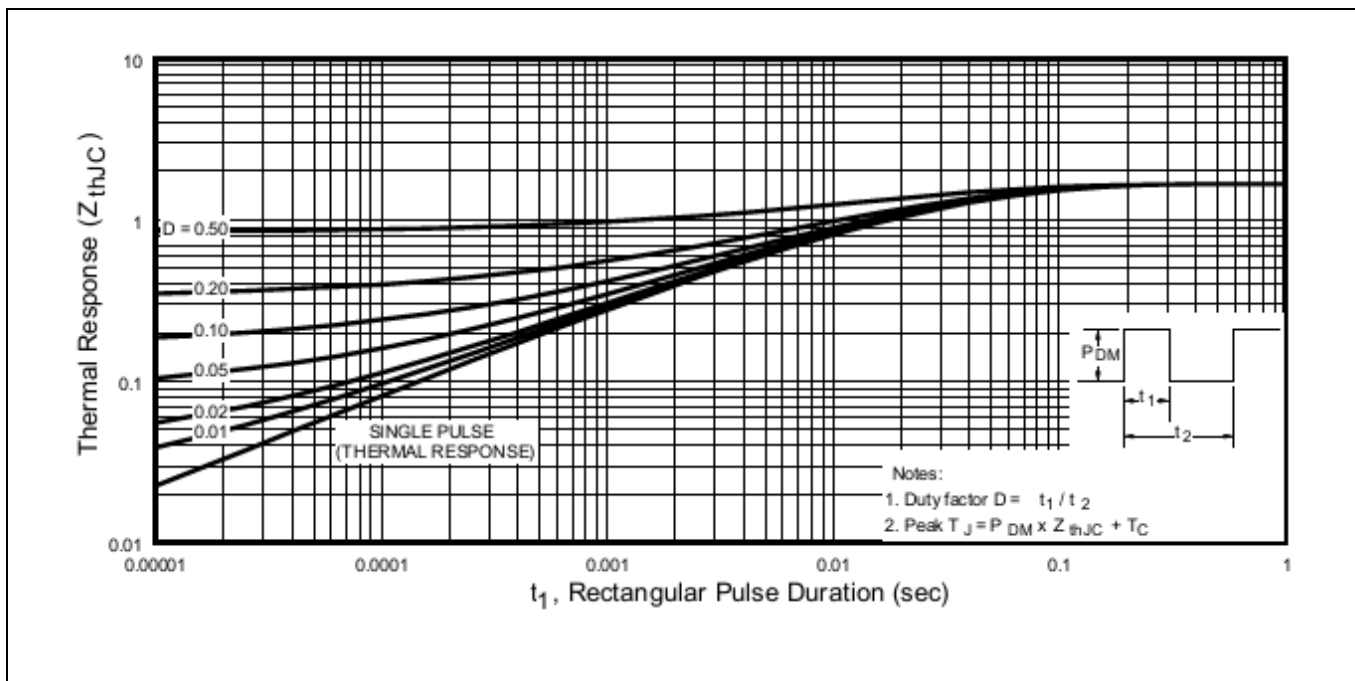
**Electrical Characteristics Curves (Pre-irradiation)**



**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**

# IRHY7230CM (JANSR2N7381)

## Radiation Hardened Power MOSFET Thru-Hole (TO-257AA)

### Test Circuits (Pre-irradiation)

#### 4 Test Circuits (Pre-irradiation)

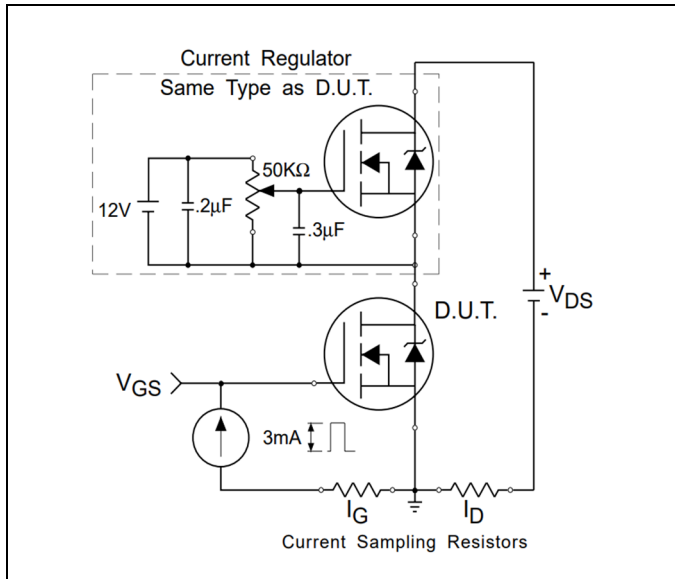


Figure 13 Gate Charge Test Circuit

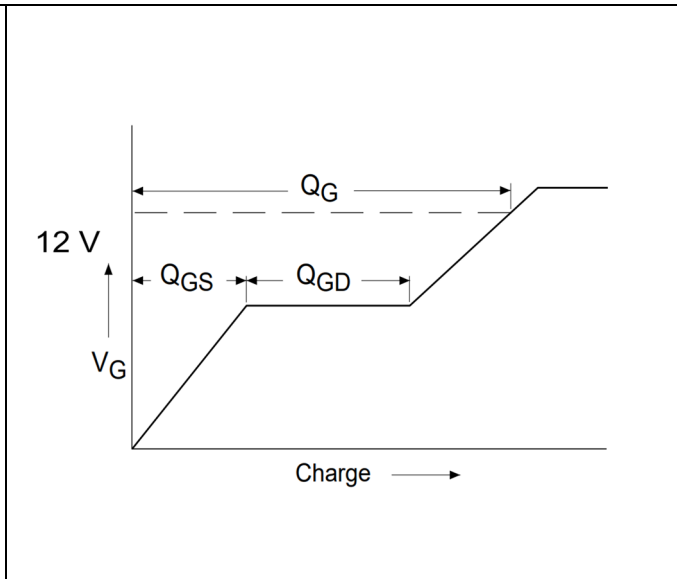


Figure 14 Gate Charge Waveform

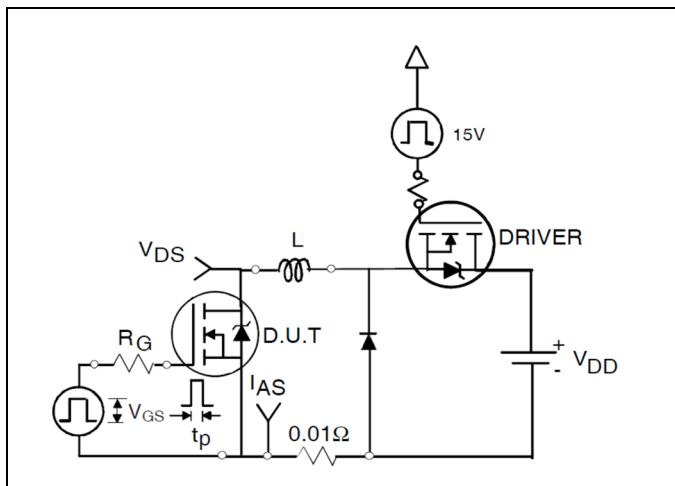


Figure 15 Unclamped Inductive Test Circuit

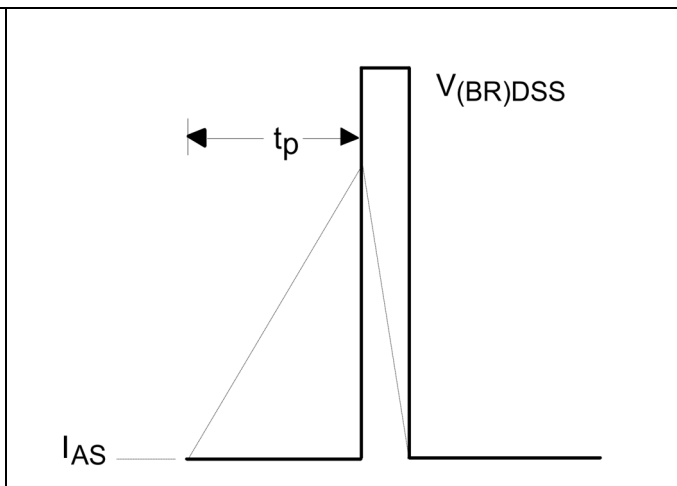


Figure 16 Unclamped Inductive Waveform

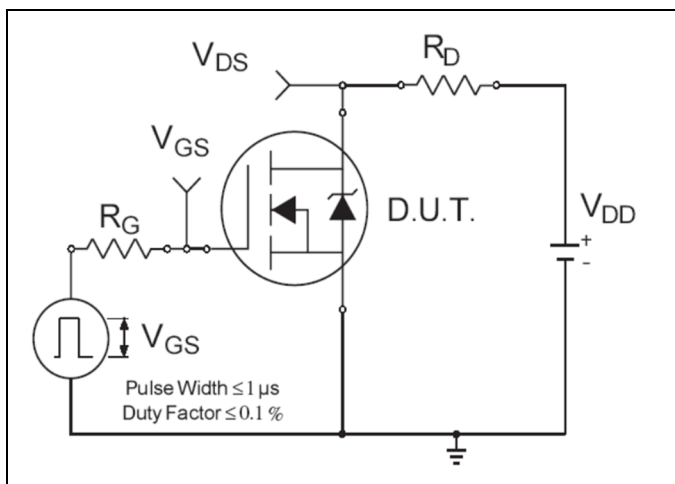


Figure 17 Switching Time Test Circuit

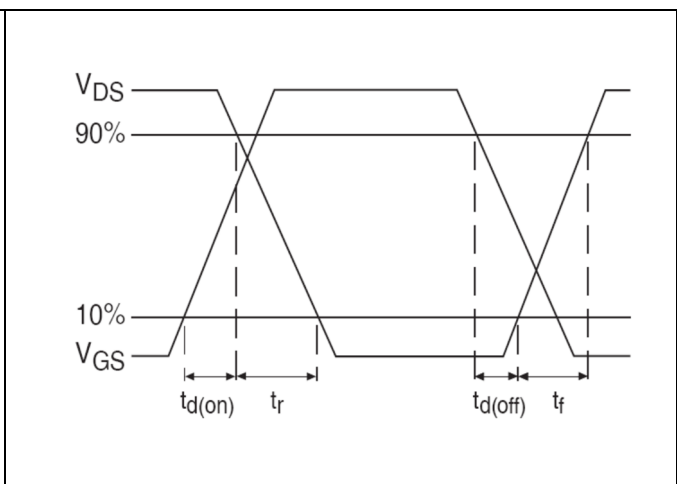


Figure 18 Switching Time Waveforms

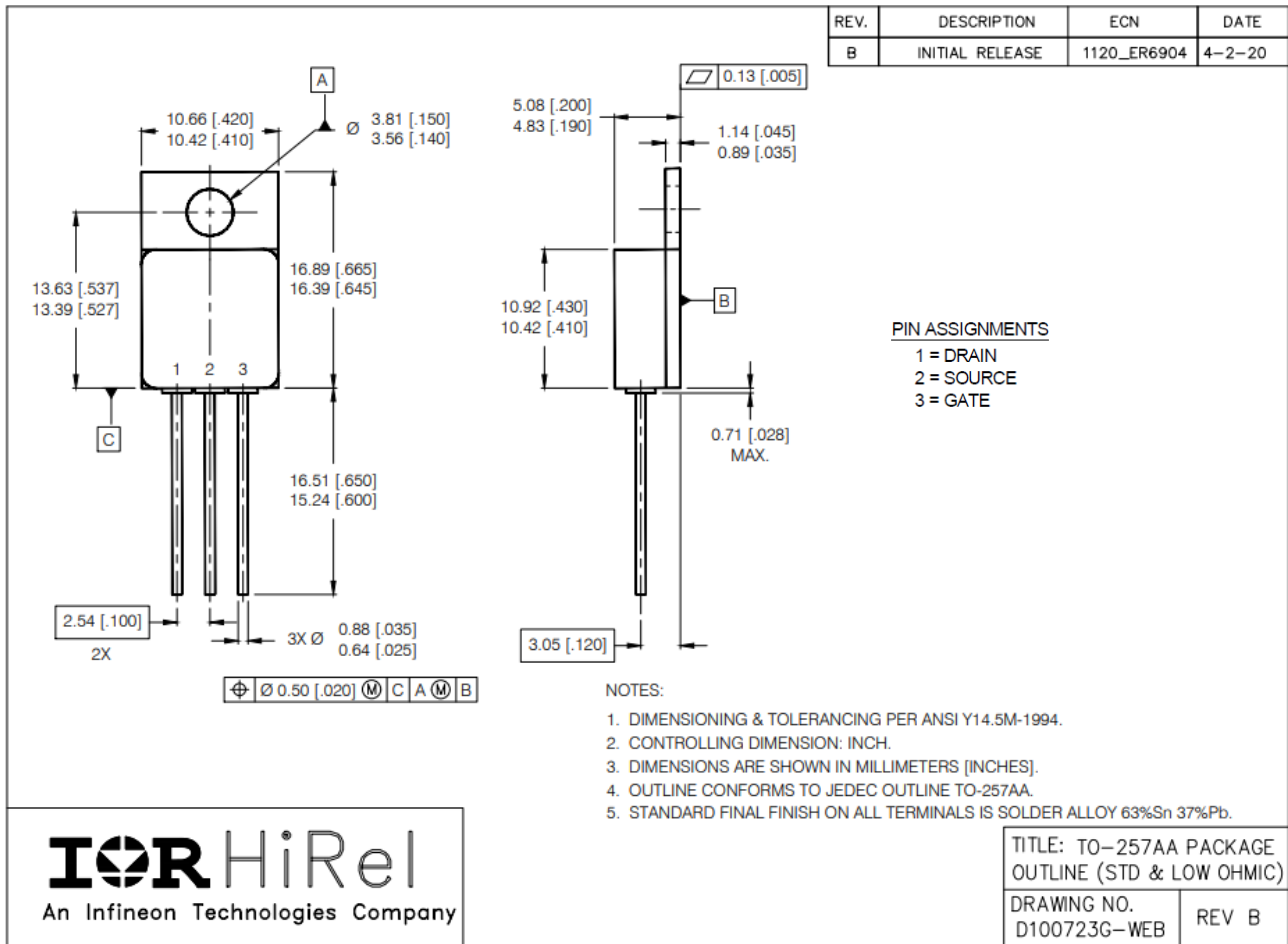
# IRHY7230CM (JANSR2N7381)

## Radiation Hardened Power MOSFET Thru-Hole (TO-257AA)

### Package Outline

# 5 Package Outline

Note: For the most updated package outline, please see the website: [TO-257AA](http://www.infineon.com/toc-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.

# IRHY7230CM (JANSR2N7381)

## Radiation Hardened Power MOSFET Thru-Hole (TO-257AA)

### Revision history

### Revision history

Document version	Date of release	Description of changes
	12/12/2001	Datasheet (PD-91273C)
Rev D	04/05/2006	Updated QPL part number
Rev E	05/16/2006	Updated 600kRad(si) to 500kRad(si)
Rev F	05/25/2022	Updated based on ECN-1120_09018

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