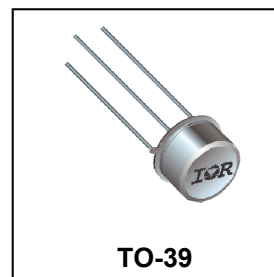


**RADIATION HARDENED
POWER MOSFET
THRU-HOLE TO-205AF (TO-39)**
200V, N-CHANNEL
REF: MIL-PRF-19500/601
RAD Hard™ HEXFET® TECHNOLOGY
Product Summary

Part Number	Radiation Level	RDS(on)	I _D	QPL Part Number
IRHF7230	100 kRads(Si)	0.35Ω	5.5A	JANSR2N7262
IRHF3230	300 kRads(Si)	0.35Ω	5.5A	JANSF2N7262
IRHF5230	500 kRads(Si)	0.35Ω	5.5A	JANSF2N7262
IRHF8230	1000 kRads(Si)	0.35Ω	5.5A	JANSH2N7262


Description

IR HiRel RADHard™ HEXFET® MOSFET technology provides high performance power MOSFETs for space applications. This technology has long history 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 RDS(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

Features

- Single Event Effect (SEE) Hardened
- Low RDS(on)
- Low Total Gate Charge
- Simple Drive Requirements
- Hermetically Sealed
- Light Weight
- ESD Rating: Class 1C per MIL-STD-750, Method 1020

Absolute Maximum Ratings
Pre-Irradiation

Symbol	Parameter	Value	Units
I _{D1} @ V _{GS} = 12V, T _C = 25°C	Continuous Drain Current	5.5	A
I _{D2} @ V _{GS} = 12V, T _C = 100°C	Continuous Drain Current	3.5	
I _{DM} @ T _C = 25°C	Pulsed Drain Current ①	22	
P _D @ T _C = 25°C	Maximum Power Dissipation	25	W
	Linear Derating Factor	0.2	W/°C
V _{GS}	Gate-to-Source Voltage	± 20	V
E _{AS}	Single Pulse Avalanche Energy ②	240	mJ
I _{AR}	Avalanche Current ①	5.5	A
E _{AR}	Repetitive Avalanche Energy ①	2.5	mJ
dv/dt	Peak Diode Recovery dv/dt ③	5.0	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)	

For Footnotes, refer to the page 2.

Electrical Characteristics @ T_j = 25°C (Unless Otherwise Specified)

Symbol	Parameter	Min.	Typ.	Max.	Units	Test Conditions
BV _{DSS}	Drain-to-Source Breakdown Voltage	200	—	—	V	V _{GS} = 0V, I _D = 1.0mA
ΔBV _{DSS} /ΔT _J	Breakdown Voltage Temp. Coefficient	—	0.25	—	V/°C	Reference to 25°C, I _D = 1.0mA
R _{DS(on)}	Static Drain-to-Source On-Resistance	—	—	0.35	Ω	V _{GS} = 12V, I _{D2} = 3.5A ④
		—	—	0.364		V _{GS} = 12V, I _{D1} = 5.5A ④
V _{GS(th)}	Gate Threshold Voltage	2.0	—	4.0	V	V _{DS} = V _{GS} , I _D = 1.0mA
G _{fs}	Forward Transconductance	2.5	—	—	S	V _{DS} = 15V, I _{D2} = 3.5A ④
I _{DSS}	Zero Gate Voltage Drain Current	—	—	25	μA	V _{DS} = 160V, V _{GS} = 0V
		—	—	250		V _{DS} = 160V, 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	—	—	50	nC	I _{D1} = 5.5A
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	—	—	25	ns	V _{DD} = 100V
t _r	Rise Time	—	—	40		I _{D1} = 5.5A
t _{d(off)}	Turn-Off Delay Time	—	—	60		R _G = 2.35Ω
t _f	Fall Time	—	—	45		V _{GS} = 12V
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	—	1100	—	pF	V _{GS} = 0V
C _{oss}	Output Capacitance	—	250	—		V _{DS} = 25V
C _{rss}	Reverse Transfer Capacitance	—	55	—		f = 1.0MHz

Source-Drain Diode Ratings and Characteristics

Symbol	Parameter	Min.	Typ.	Max.	Units	Test Conditions
I _S	Continuous Source Current (Body Diode)	—	—	5.5	A	
I _{SM}	Pulsed Source Current (Body Diode) ①	—	—	22		
V _{SD}	Diode Forward Voltage	—	—	1.4	V	T _J = 25°C, I _S = 5.5A, V _{GS} = 0V ④
t _{rr}	Reverse Recovery Time	—	—	400	ns	T _J = 25°C, I _F = 5.5A, V _{DD} ≤ 30V
Q _{rr}	Reverse Recovery Charge	—	—	3.0	μC	di/dt = 100A/μs ④
t _{on}	Forward Turn-On Time	Intrinsic turn-on time is negligible (turn-on is dominated by L _S +L _D)				

Thermal Resistance

Symbol	Parameter	Min.	Typ.	Max.	Units
R _{θJC}	Junction-to-Case	—	—	5.0	°C/W
R _{θJA}	Junction-to-Ambient (Typical Socket Mount)	—	—	175	

Footnotes:

- ① Repetitive Rating; Pulse width limited by maximum junction temperature.
- ② V_{DD} = 50V, starting T_J = 25°C, L = 15.9mH, Peak I_L = 5.5A, V_{GS} = 10V
- ③ I_{SD} ≤ 5.5A, di/dt ≤ 120A/μs, V_{DD} ≤ 200V, T_J ≤ 150°C
- ④ Pulse width ≤ 300 μs; Duty Cycle ≤ 2%
- ⑤ Total Dose Irradiation with V_{GS} Bias. 12 volt V_{GS} applied and V_{DS} = 0 during irradiation per MIL-STD-750, Method 1019, condition A.
- ⑥ Total Dose Irradiation with V_{DS} Bias. 160 volt V_{DS} applied and V_{GS} = 0 during irradiation per MIL-STD-750, Method 1019, condition A.

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 5 and 6) 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.

Table1. Electrical Characteristics @ Tj = 25°C, Post Total Dose Irradiation ⑤⑥

Symbol	Parameter	100 kRads (Si) ¹		Up to 300k - 1000 kRads (Si) ²		Units	Test Conditions
		Min.	Max.	Min.	Max.		
BV _{DSS}	Drain-to-Source Breakdown Voltage	200	—	200	—	V	V _{GS} = 0V, I _D = 1.0mA
V _{GS(th)}	Gate Threshold Voltage	2.0	4.0	1.25	4.5	V	V _{DS} = V _{GS} , I _D = 1.0mA
I _{GSS}	Gate-to-Source Leakage Forward	—	100	—	100	nA	V _{GS} = 20V
I _{GSS}	Gate-to-Source Leakage Reverse	—	-100	—	-100	nA	V _{GS} = -20V
I _{DSS}	Zero Gate Voltage Drain Current	—	25	—	25	μA	V _{DS} = 160V, V _{GS} = 0V
R _{DS(on)}	Static Drain-to-Source ④ On-State Resistance (TO-3)	—	0.35	—	0.48	Ω	V _{GS} = 12V, I _{D2} = 3.5A
R _{DS(on)}	Static Drain-to-Source ④ On-State Resistance (TO-39)	—	0.35	—	0.48	Ω	V _{GS} = 12V, I _{D2} = 3.5A
V _{SD}	Diode Forward Voltage ④	—	1.4	—	1.4	V	V _{GS} = 0V, I _S = 5.5A

1. Part numbers IRHF7230 (JANSR2N7262)
2. Part numbers IRHF3230 (JANSF2N7262) and IRHF4230(JANSG2N7262), IRHF8230 (JANSR2N7262)

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. a and Table 2.

Table 2. Typical Single Event Effect Safe Operating Area

Ion	LET (MeV/(mg/cm ²))	Energy (MeV)	Range (μm)	VDS (V)				
				@ VGS = 0V	@ VGS = -5V	@ VGS = -10V	@ VGS = -15V	@ VGS = -20V
Cu	28	285	43	190	180	170	125	—
Br	36.8	305	39	100	100	100	50	—

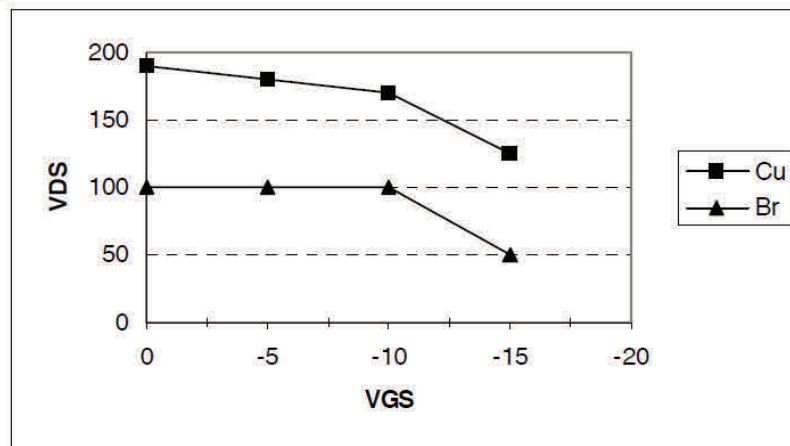


Fig a. Typical Single Event Effect, Safe Operating Area

For Footnotes, refer to the page 2.

Pre-Irradiation

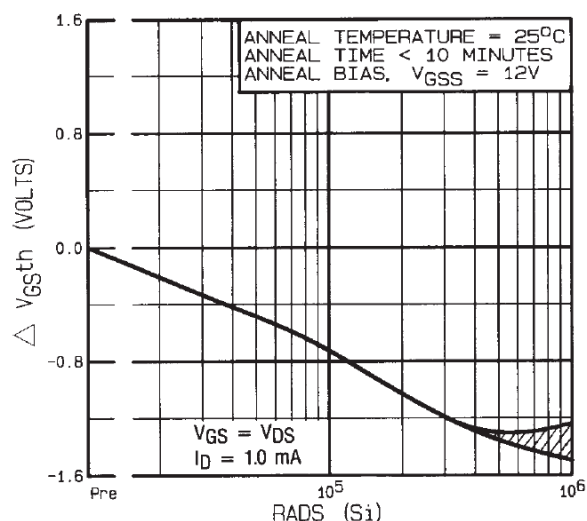


Fig 1. Typical Response of Gate Threshold

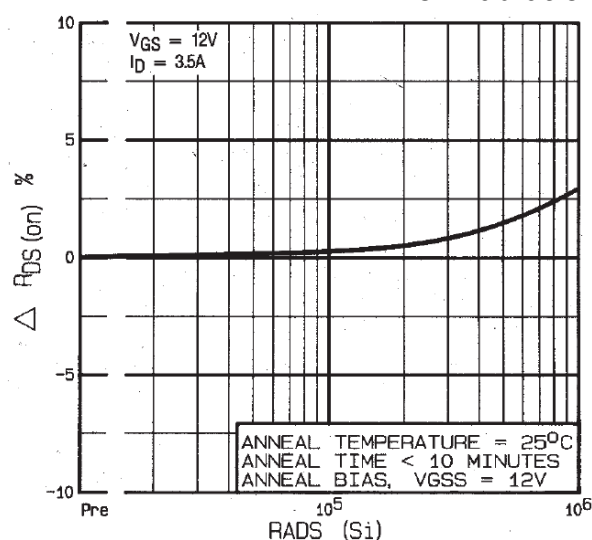


Fig 2. Typical Response of On-State Resistance Vs. Total Dose Exposure

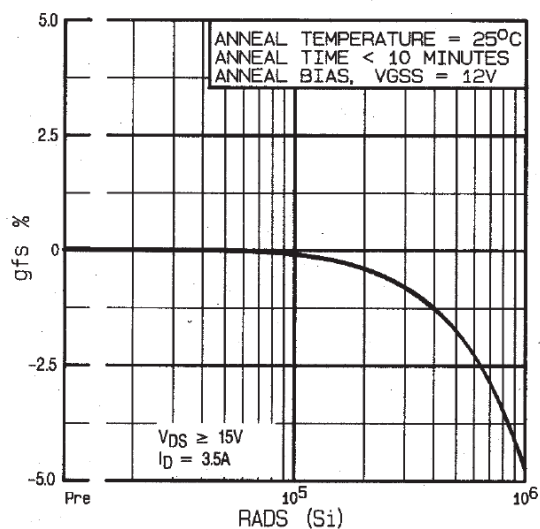


Fig 3. Typical Response of Transconductance Vs. Total Dose Exposure

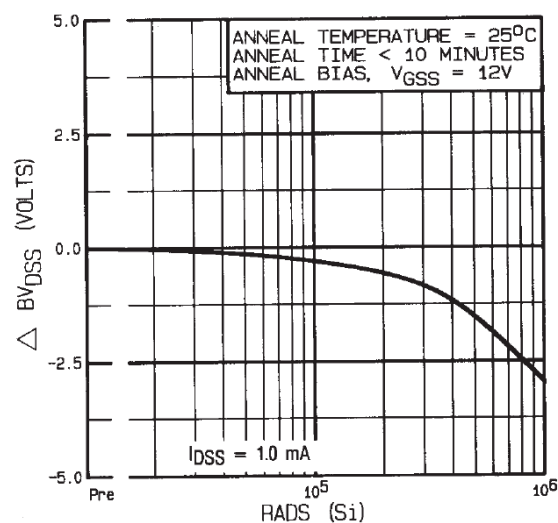


Fig 4. Typical Response of Drain to Source Breakdown Vs. Total Dose Exposure

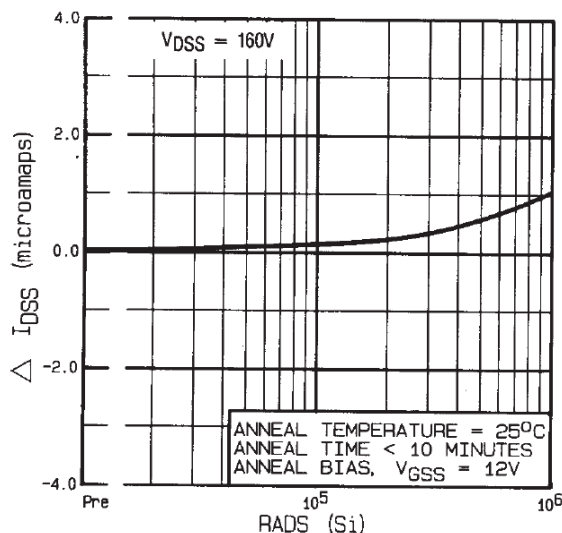


Fig 5. Typical Zero Gate Voltage Drain Current Vs. Total Dose Exposure

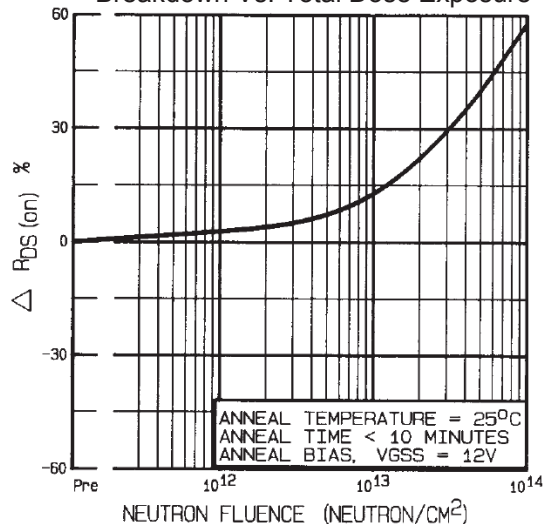


Fig 6. Typical On-State Resistance Vs. Neutron Fluence Level

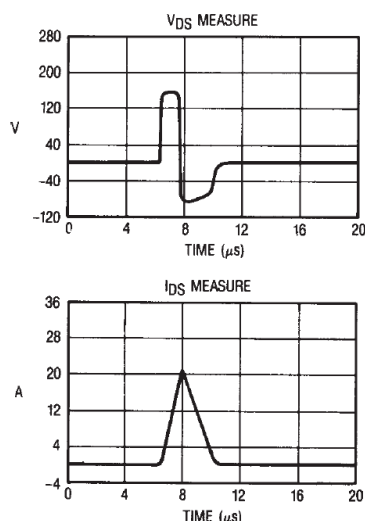


Fig 7. Typical Transient Response of Rad Hard HEX-FET During 1×10^{12} Rad (Si)/Sec Exposure

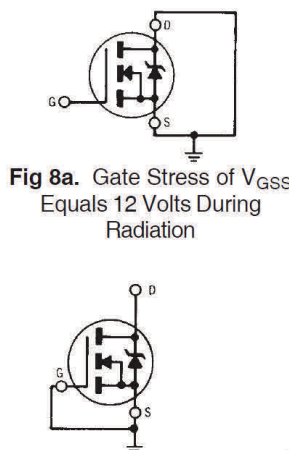


Fig 8a. V_{DSS} Stress Equals 80% of $B_{V_{DSS}}$ During Radiation

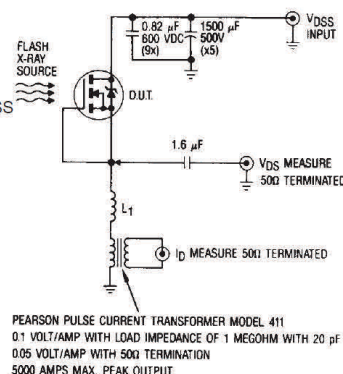


Fig 9. High Dose Rate (Gamma Dot) Test Circuit

Note: Bias Conditions during radiation: $V_{GS} = 12$ Vdc, $V_{DS} = 0$ Vdc, Fig-10,11,12,13

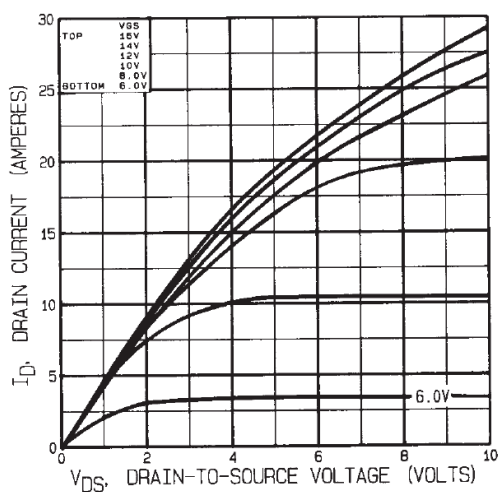


Fig 10. Typical Output Characteristics Pre-Irradiation

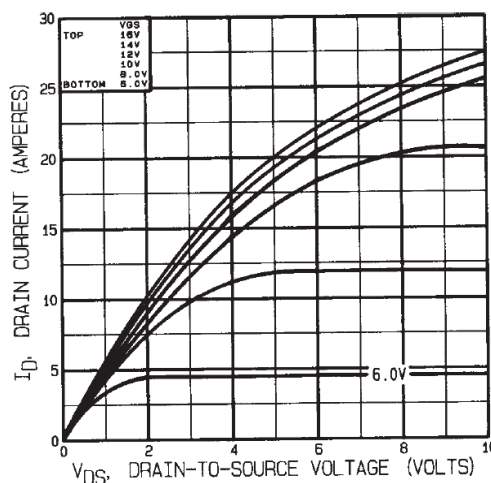


Fig 11. Typical Output Characteristics Post-Irradiation 100K Rads (Si)

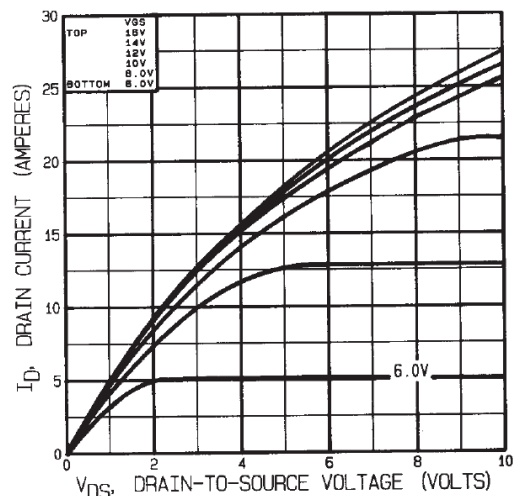


Fig 12. Typical Output Characteristics Post-Irradiation 300K Rads (Si)

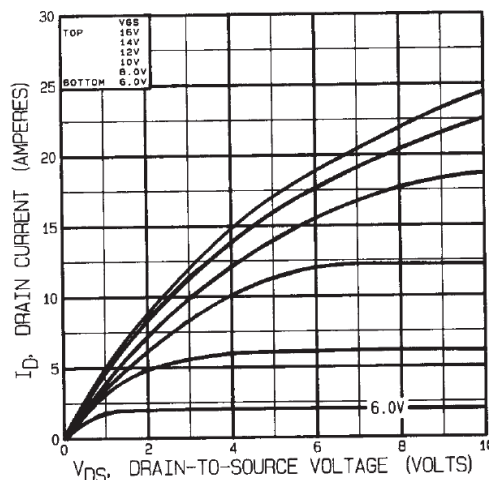


Fig 13. Typical Output Characteristics Post-Irradiation 1 Mega Rads (Si)

Note: Bias Conditions during radiation: $V_{GS} = 0$ Vdc, $V_{DS} = 160$ Vdc Fig 14,15, 16,17

Pre-Irradiation

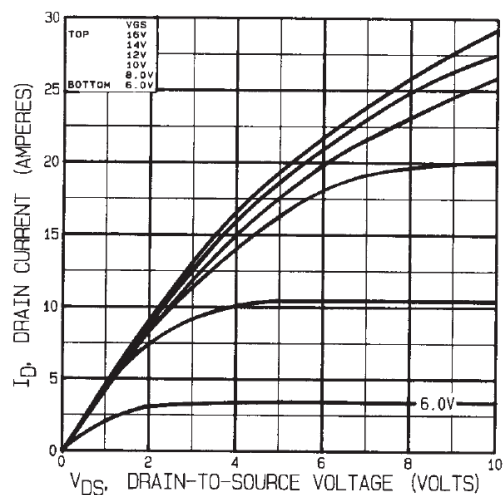


Fig 14. Typical Output Characteristics
Pre-Irradiation

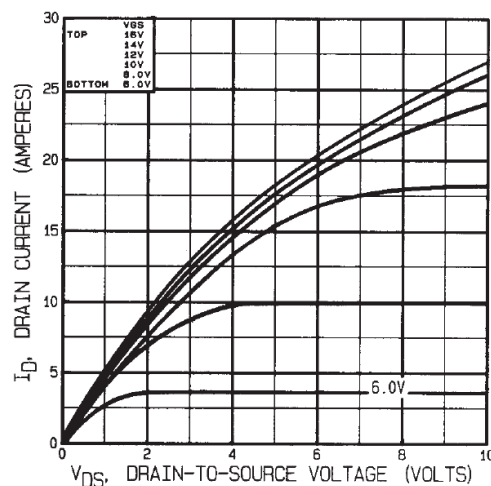


Fig 15. Typical Output Characteristics
Post-Irradiation 100K Rads (Si)

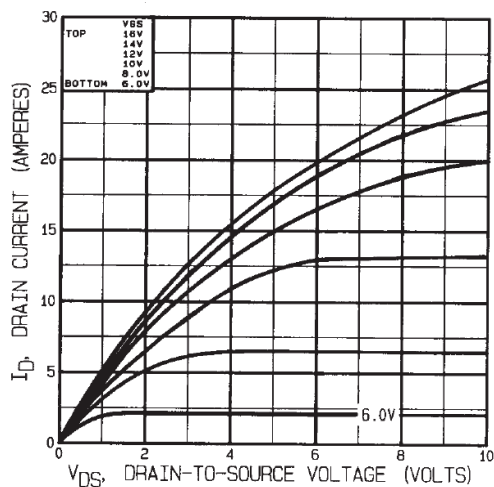


Fig 16. Typical Output Characteristics

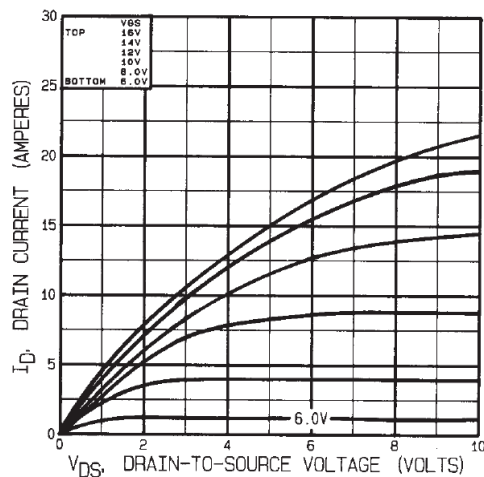


Fig 17. Typical Output Characteristics
Post-Irradiation 1 Mega Rads (Si)

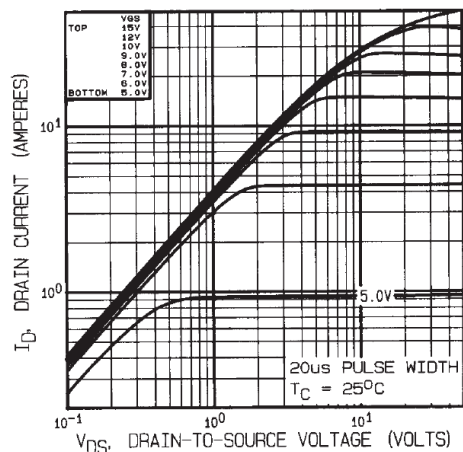


Fig 18. Typical Output Characteristics

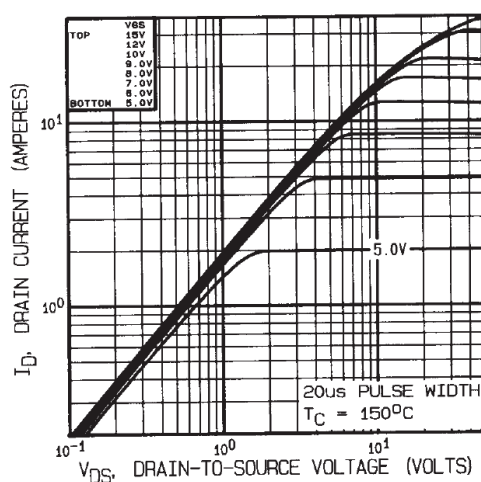


Fig 19. Typical Output Characteristics

Pre-Irradiation

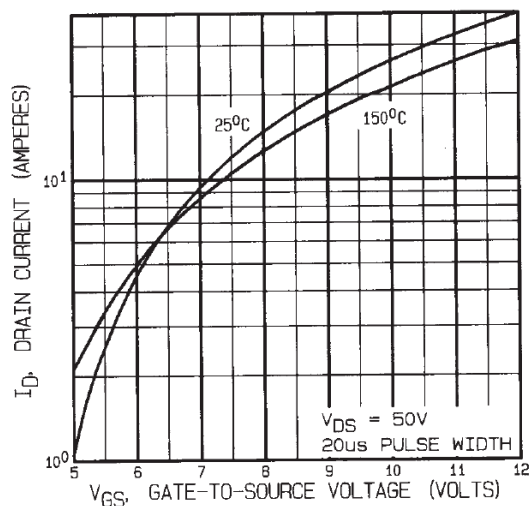


Fig 20. Typical Transfer Characteristics

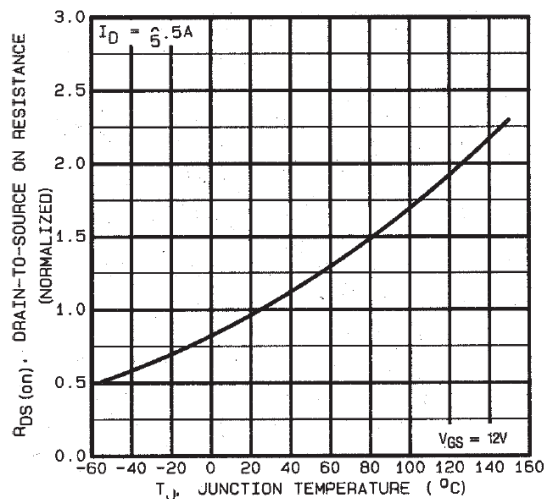


Fig 21. Normalized On-Resistance Vs. Temperature

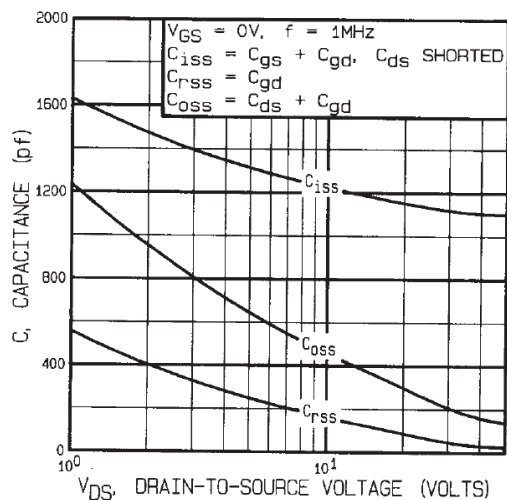


Fig 22. Typical Capacitance Vs. Drain-to-Source Voltage

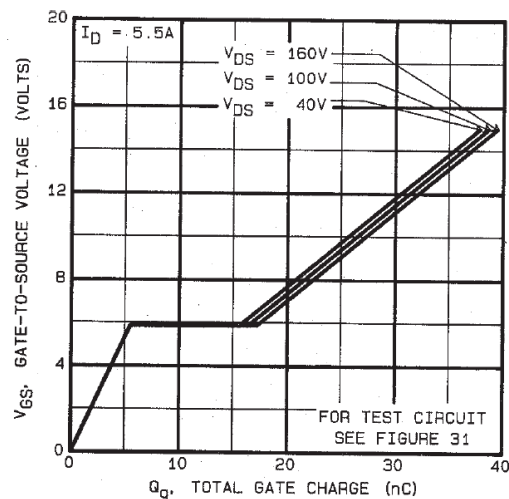


Fig 23. Typical Gate Charge Vs. Gate-to-Source Voltage

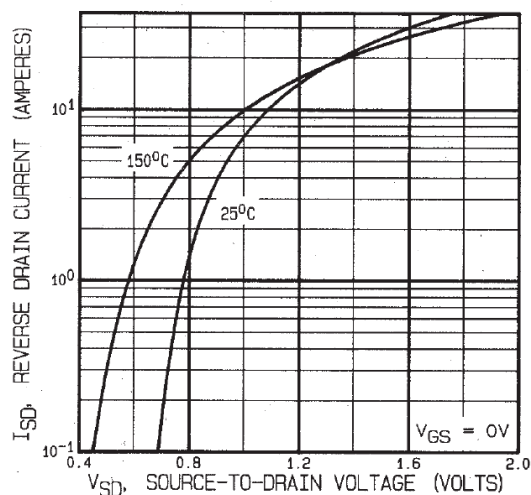


Fig 24. Typical Source-Drain Diode Forward Voltage

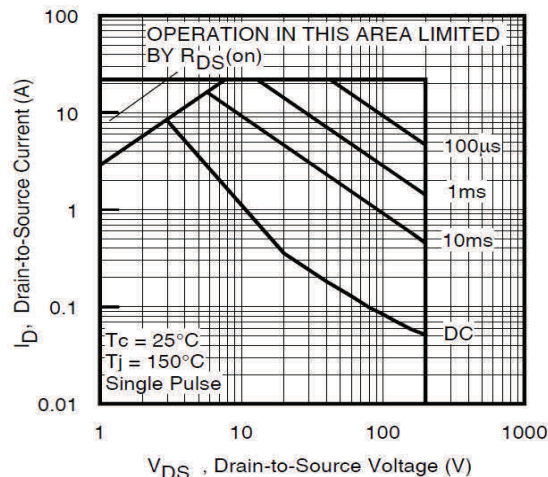


Fig 25. Maximum Safe Operating Area

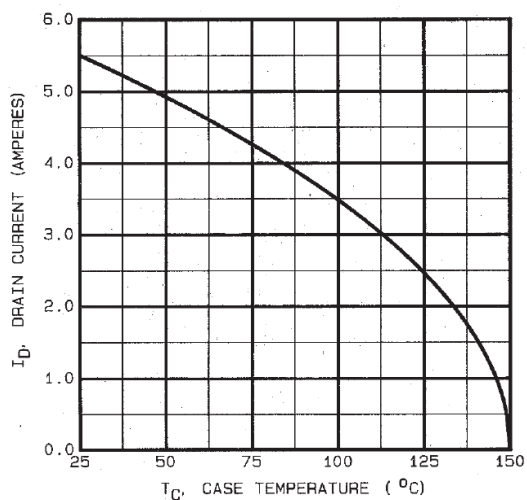


Fig 26. Maximum Drain Current Vs. Case Temperature

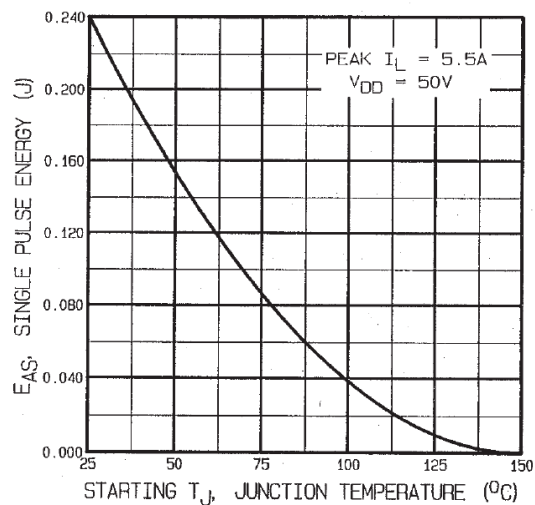


Fig 27. Maximum Avalanche Energy Vs. Drain Current

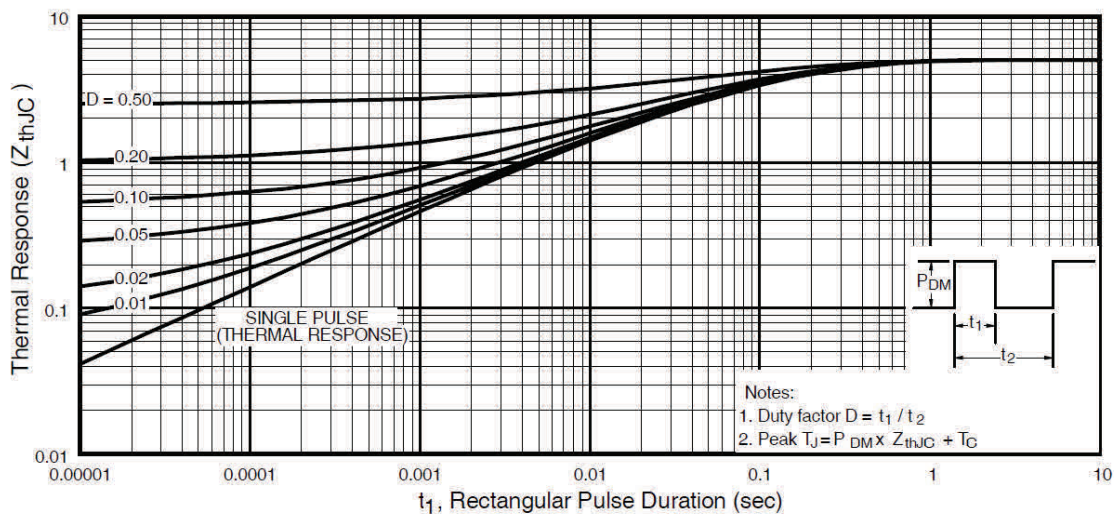


Fig 28. Maximum Effective Transient Thermal Impedance, Junction-to-Case

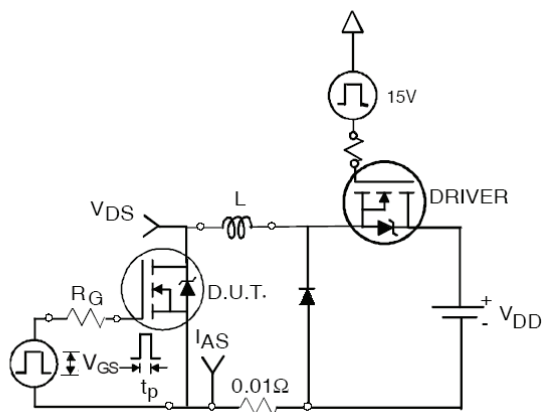


Fig 29a. Unclamped Inductive Test Circuit

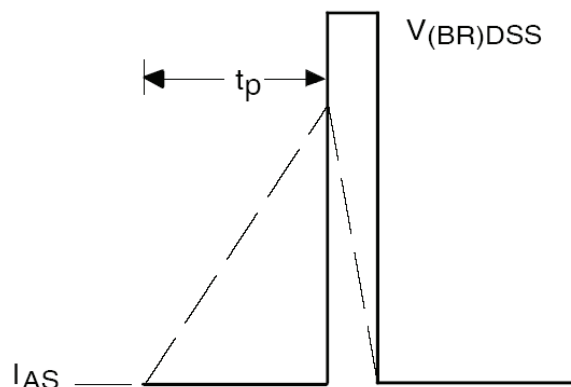


Fig 29b. Unclamped Inductive Waveforms

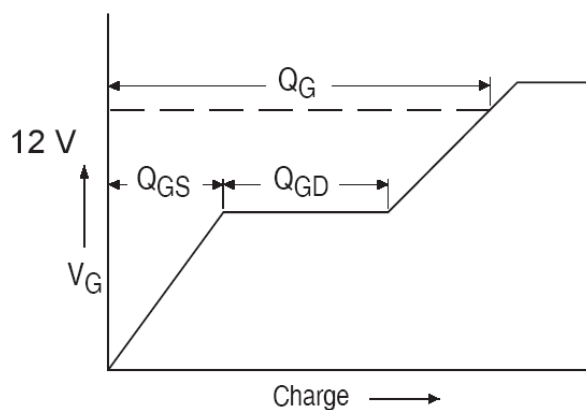


Fig 30a. Gate Charge Waveform

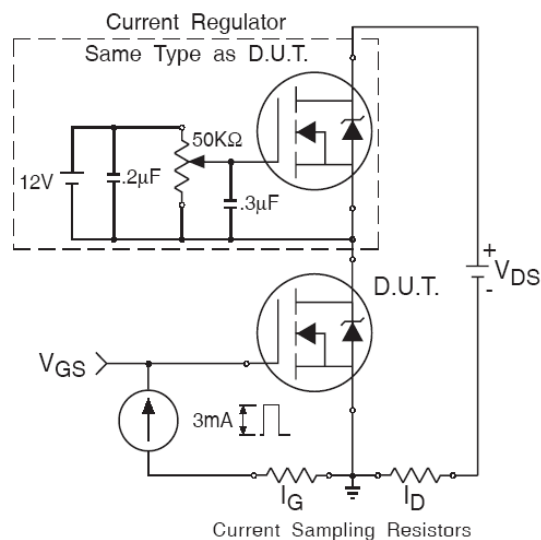


Fig 30b. Gate Charge Test Circuit

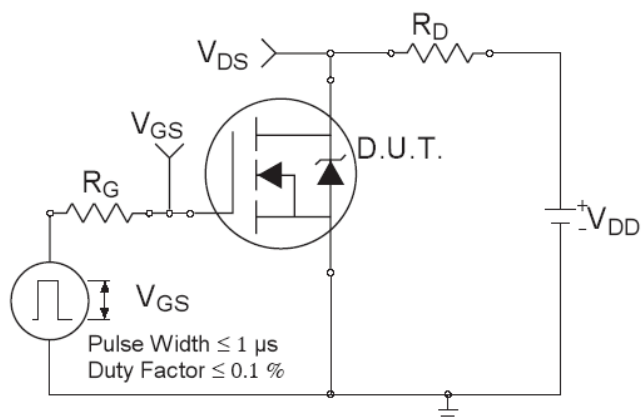


Fig 31a. Switching Time Test Circuit

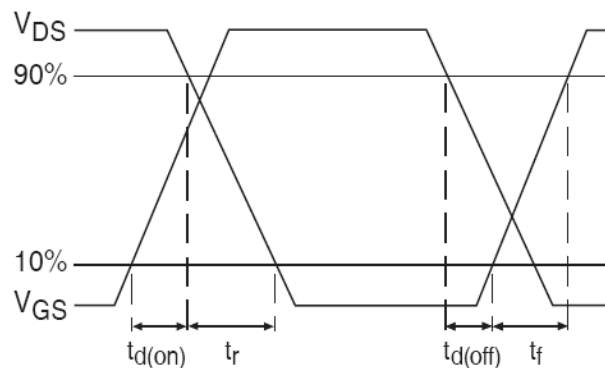
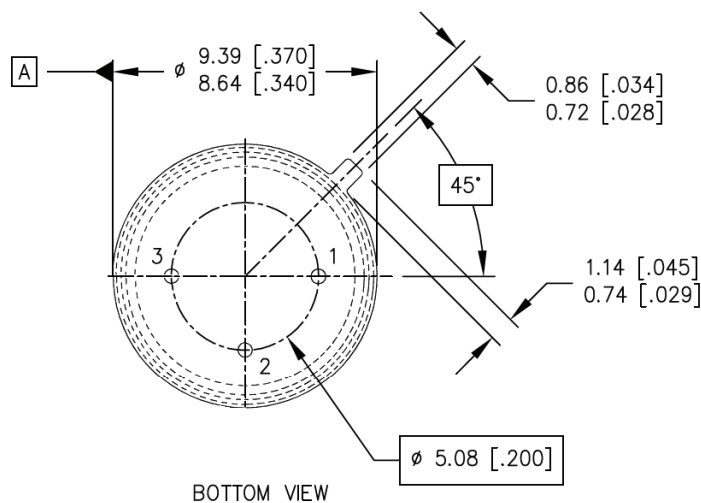
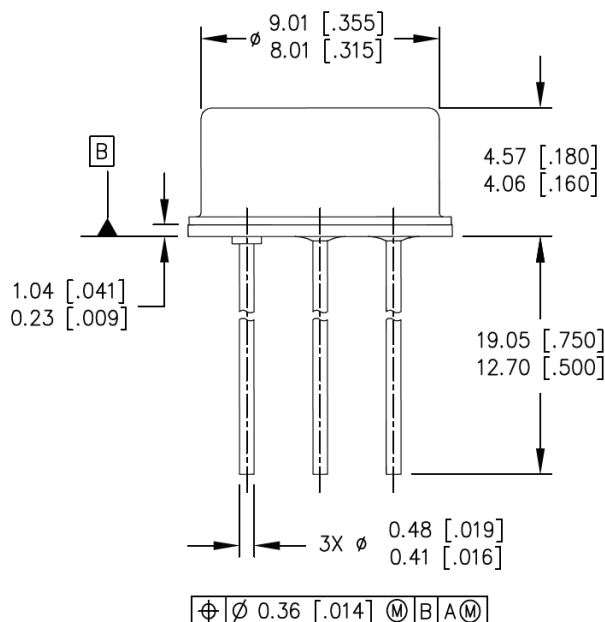


Fig 31b. Switching Time Waveforms

Case Outline and Dimensions - TO-205AF (TO-39)



NOTES:

SIDE VIEW

1. DIMENSIONING AND TOLERANCING PER ASME 14.5M-1994.
2. DIMENSIONS ARE SHOWN IN MILLIMETERS [INCHES].
3. CONTROLLING DIMENSION: INCH.
4. CONFORMS TO JEDEC OUTLINE TO-205AF (TO-39).

LEGEND

- 1- SOURCE
- 2- GATE
- 3- DRAIN (CONNECTED TO THE CASE)

IMPORTANT NOTICE

The information given in this document shall be in no event regarded as guarantee of conditions or characteristic. The data contained herein is a characterization of the component based on internal standards and is intended to demonstrate and provide guidance for typical part performance. It will require further evaluation, qualification and analysis to determine suitability in the application environment to confirm compliance to your system requirements.

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