

**RADIATION HARDENED  
POWER MOSFET  
THRU-HOLE TO-205AF (TO-39)**
**IRHF9130  
JANSR2N7389**
**100V, P-CHANNEL  
REF: MIL-PRF-19500/630  
RAD Hard™HEXFET® TECHNOLOGY**
**Product Summary**

Part Number	Radiation Level	RDS(on)	I <sub>D</sub>	QPL Part Number
IRHF9130	100 kRads(Si)	0.30Ω	-6.5A	JANSR2N7389
IRHF93130	300 kRads(Si)	0.30Ω	-6.5A	JANSF2N7389


**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 parameters.

**Features**

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

**Absolute Maximum Ratings**

Pre-Irradiation			
Symbol	Parameter	Value	Units
I <sub>D1</sub> @ V <sub>GS</sub> = -12V, T <sub>C</sub> = 25°C	Continuous Drain Current	-6.5	A
I <sub>D2</sub> @ V <sub>GS</sub> = -12V, T <sub>C</sub> = 100°C	Continuous Drain Current	-4.1	
I <sub>DM</sub> @ T <sub>C</sub> = 25°C	Pulsed Drain Current ①	-26	
P <sub>D</sub> @ T <sub>C</sub> = 25°C	Maximum Power Dissipation	25	W
	Linear Derating Factor	0.2	W/°C
V <sub>GS</sub>	Gate-to-Source Voltage	± 20	V
E <sub>AS</sub>	Single Pulse Avalanche Energy ②	165	mJ
I <sub>AR</sub>	Avalanche Current ①	-6.5	A
E <sub>AR</sub>	Repetitive Avalanche Energy ①	2.5	mJ
dv/dt	Peak Diode Recovery dv/dt ③	-22	V/ns
T <sub>J</sub> T <sub>STG</sub>	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

For Footnotes, refer to the page 2.

**Electrical Characteristics @  $T_J = 25^\circ\text{C}$  (Unless Otherwise Specified)**

Symbol	Parameter	Min.	Typ.	Max.	Units	Test Conditions
$\text{BV}_{\text{DSS}}$	Drain-to-Source Breakdown Voltage	-100	—	—	V	$\text{V}_{\text{GS}} = 0\text{V}$ , $\text{I}_D = -1.0\text{mA}$
$\Delta \text{BV}_{\text{DSS}}/\Delta T_J$	Breakdown Voltage Temp. Coefficient	—	-0.112	—	V/ $^\circ\text{C}$	Reference to $25^\circ\text{C}$ , $\text{I}_D = -1.0\text{mA}$
$\text{R}_{\text{DS(on)}}$	Static Drain-to-Source On-Resistance	—	—	0.30	$\Omega$	$\text{V}_{\text{GS}} = -12\text{V}$ , $\text{I}_{D2} = -4.1\text{A}$ ④
		—	—	0.35		$\text{V}_{\text{GS}} = -12\text{V}$ , $\text{I}_{D1} = -6.5\text{A}$ ④
$\text{V}_{\text{GS(th)}}$	Gate Threshold Voltage	-2.0	—	-4.0	V	$\text{V}_{\text{DS}} = \text{V}_{\text{GS}}$ , $\text{I}_D = -1.0\text{mA}$
$\text{Gfs}$	Forward Transconductance	2.5	—	—	S	$\text{V}_{\text{DS}} = -15\text{V}$ , $\text{I}_{D2} = -4.1\text{A}$ ④
$\text{I}_{\text{DSS}}$	Zero Gate Voltage Drain Current	—	—	-25	$\mu\text{A}$	$\text{V}_{\text{DS}} = -80\text{V}$ , $\text{V}_{\text{GS}} = 0\text{V}$
		—	—	-250		$\text{V}_{\text{DS}} = -80\text{V}$ , $\text{V}_{\text{GS}} = 0\text{V}$ , $T_J = 125^\circ\text{C}$
$\text{I}_{\text{GSS}}$	Gate-to-Source Leakage Forward	—	—	-100	nA	$\text{V}_{\text{GS}} = -20\text{V}$
	Gate-to-Source Leakage Reverse	—	—	100		$\text{V}_{\text{GS}} = 20\text{V}$
$\text{Q}_G$	Total Gate Charge	—	—	45	nC	$\text{I}_{D1} = -6.5\text{A}$
$\text{Q}_{\text{GS}}$	Gate-to-Source Charge	—	—	10		$\text{V}_{\text{DS}} = -50\text{V}$
$\text{Q}_{\text{GD}}$	Gate-to-Drain ('Miller') Charge	—	—	25		$\text{V}_{\text{GS}} = -12\text{V}$
$t_{\text{d(on)}}$	Turn-On Delay Time	—	—	30	ns	$\text{V}_{\text{DD}} = -50\text{V}$
$t_{\text{r}}$	Rise Time	—	—	50		$\text{I}_{D1} = -6.5\text{A}$
$t_{\text{d(off)}}$	Turn-Off Delay Time	—	—	70		$\text{R}_G = 7.5\Omega$
$t_f$	Fall Time	—	—	70		$\text{V}_{\text{GS}} = -12\text{V}$
$\text{L}_s + \text{L}_D$	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
$\text{C}_{\text{iss}}$	Input Capacitance	—	1200	—	pF	$\text{V}_{\text{GS}} = 0\text{V}$
$\text{C}_{\text{oss}}$	Output Capacitance	—	290	—		$\text{V}_{\text{DS}} = -25\text{V}$
$\text{C}_{\text{rss}}$	Reverse Transfer Capacitance	—	76	—		$f = 1.0\text{MHz}$

**Source-Drain Diode Ratings and Characteristics**

Symbol	Parameter	Min.	Typ.	Max.	Units	Test Conditions
$\text{I}_s$	Continuous Source Current (Body Diode)	—	—	-6.5	A	
$\text{I}_{\text{SM}}$	Pulsed Source Current (Body Diode) ①	—	—	-26		
$\text{V}_{\text{SD}}$	Diode Forward Voltage	—	—	-3.0	V	$T_J = 25^\circ\text{C}$ , $\text{I}_s = -6.5\text{A}$ , $\text{V}_{\text{GS}} = 0\text{V}$ ④
$t_{\text{rr}}$	Reverse Recovery Time	—	—	250	ns	$T_J = 25^\circ\text{C}$ , $\text{I}_F = -6.5\text{A}$ , $\text{V}_{\text{DD}} \leq -50\text{V}$ $d\text{I}/dt = -100\text{A}/\mu\text{s}$ ④
$\text{Q}_{\text{rr}}$	Reverse Recovery Charge	—	—	0.74		
$t_{\text{on}}$	Forward Turn-On Time	Intrinsic turn-on time is negligible (turn-on is dominated by $\text{L}_s + \text{L}_D$ )				

**Thermal Resistance**

Symbol	Parameter	Min.	Typ.	Max.	Units
$\text{R}_{\theta\text{JC}}$	Junction-to-Case	—	—	5.0	°C/W
$\text{R}_{\theta\text{JA}}$	Junction-to-Ambient (Typical Socket Mount)	—	—	175	

**Footnotes:**

- ① Repetitive Rating; Pulse width limited by maximum junction temperature.
- ②  $\text{V}_{\text{DD}} = -25\text{V}$ , starting  $T_J = 25^\circ\text{C}$ ,  $L = 7.8\text{mH}$ , Peak  $\text{I}_L = -6.5\text{A}$ ,  $\text{V}_{\text{GS}} = -12\text{V}$
- ③  $\text{I}_{\text{SD}} \leq -6.5\text{A}$ ,  $d\text{I}/dt \leq -430\text{A}/\mu\text{s}$ ,  $\text{V}_{\text{DD}} \leq -100\text{V}$ ,  $T_J \leq 150^\circ\text{C}$
- ④ Pulse width  $\leq 300\ \mu\text{s}$ ; Duty Cycle  $\leq 2\%$
- ⑤ Total Dose Irradiation with  $\text{V}_{\text{GS}}$  Bias. -12 volt  $\text{V}_{\text{GS}}$  applied and  $\text{V}_{\text{DS}} = 0$  during irradiation per MIL-STD-750, Method 1019, condition A.
- ⑥ Total Dose Irradiation with  $\text{V}_{\text{DS}}$  Bias. -80 volt  $\text{V}_{\text{DS}}$  applied and  $\text{V}_{\text{GS}} = 0$  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.

**Table 1. Electrical Characteristics @  $T_j = 25^\circ\text{C}$ , Post Total Dose Irradiation ⑤⑥**

<b>Symbol</b>	<b>Parameter</b>	<b>100 kRads (Si)<sup>1</sup></b>		<b>300 kRads (Si)<sup>2</sup></b>		<b>Units</b>	<b>Test Conditions</b>
		<b>Min.</b>	<b>Max.</b>	<b>Min.</b>	<b>Max.</b>		
$\text{BV}_{\text{DSS}}$	Drain-to-Source Breakdown Voltage	-100	—	-100	—	V	$\text{V}_{\text{GS}} = 0\text{V}$ , $\text{I}_{\text{D}} = -1.0\text{mA}$
$\text{V}_{\text{GS(th)}}$	Gate Threshold Voltage	-2.0	-4.0	-2.0	-5.0	V	$\text{V}_{\text{DS}} = \text{V}_{\text{GS}}$ , $\text{I}_{\text{D}} = -1.0\text{mA}$
$\text{I}_{\text{GSS}}$	Gate-to-Source Leakage Forward	—	-100	—	-100	nA	$\text{V}_{\text{GS}} = -20\text{V}$
$\text{I}_{\text{GSS}}$	Gate-to-Source Leakage Reverse	—	100	—	100	nA	$\text{V}_{\text{GS}} = 20\text{V}$
$\text{I}_{\text{DSS}}$	Zero Gate Voltage Drain Current	—	-25	—	-25	$\mu\text{A}$	$\text{V}_{\text{DS}} = -80\text{V}$ , $\text{V}_{\text{GS}} = 0\text{V}$
$\text{R}_{\text{DS(on)}}$	Static Drain-to-Source ④ On-State Resistance (TO-3)	—	0.30	—	0.30	$\Omega$	$\text{V}_{\text{GS}} = -12\text{V}$ , $\text{I}_{\text{D2}} = -4.1\text{A}$
$\text{R}_{\text{DS(on)}}$	Static Drain-to-Source ④ On-State Resistance (TO-39)	—	0.30	—	0.30	$\Omega$	$\text{V}_{\text{GS}} = -12\text{V}$ , $\text{I}_{\text{D2}} = -4.1\text{A}$
$\text{V}_{\text{SD}}$	Diode Forward Voltage ④	—	-3.0	—	-3.0	V	$\text{V}_{\text{GS}} = 0\text{V}$ , $\text{I}_{\text{S}} = -6.5\text{A}$

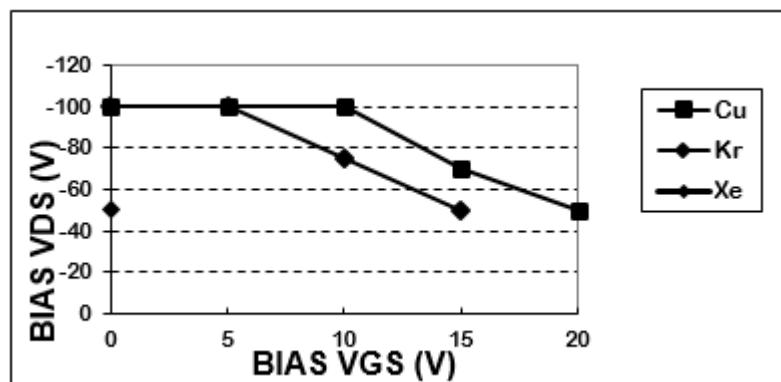
1. Part numbers IRHF9130 (JANSR2N7389)

2. Part numbers IRHF91230 (JANSF2N7389)

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.

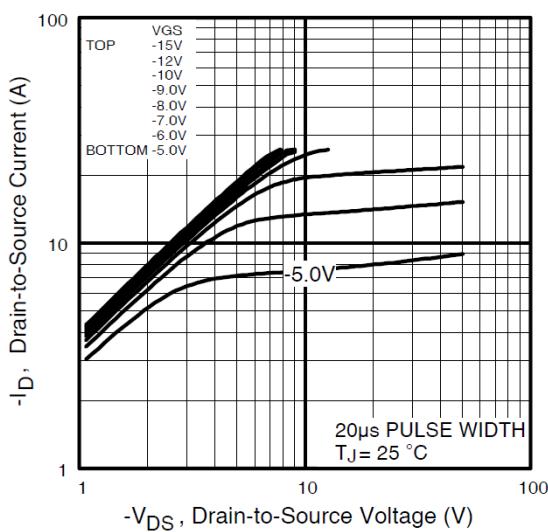
**Table 2. Typical Single Event Effect Safe Operating Area**

<b>Ion</b>	<b>LET (MeV/(mg/cm<sup>2</sup>))</b>	<b>Energy (MeV)</b>	<b>Range (<math>\mu\text{m}</math>)</b>	<b>VDS (V)</b>				
				<b>@ <math>\text{VGS} = 0\text{V}</math></b>	<b>@ <math>\text{VGS} = 5\text{V}</math></b>	<b>@ <math>\text{VGS} = 10\text{V}</math></b>	<b>@ <math>\text{VGS} = 15\text{V}</math></b>	<b>@ <math>\text{VGS} = 20\text{V}</math></b>
Cu	28	285	43	-100	-100	-100	-70	-50
Kr	38.8	320	39.6	-100	-100	-75	-50	—
Xe	63.4	348	32.5	-50	—	—	—	—

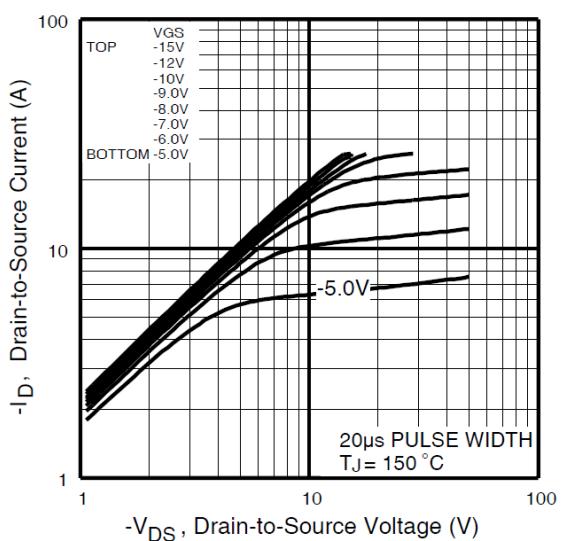


**Fig a.** Typical Single Event Effect, Safe Operating Area

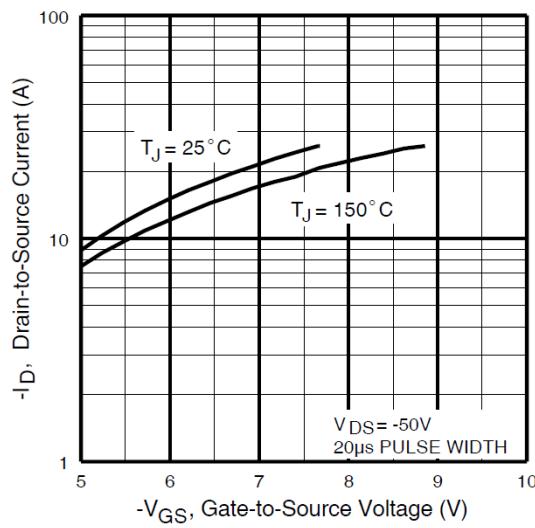
For Footnotes, refer to the page 2.



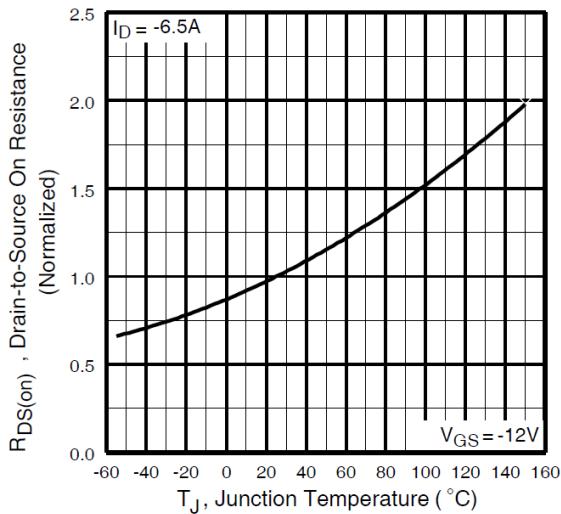
**Fig 1. Typical Output Characteristics**



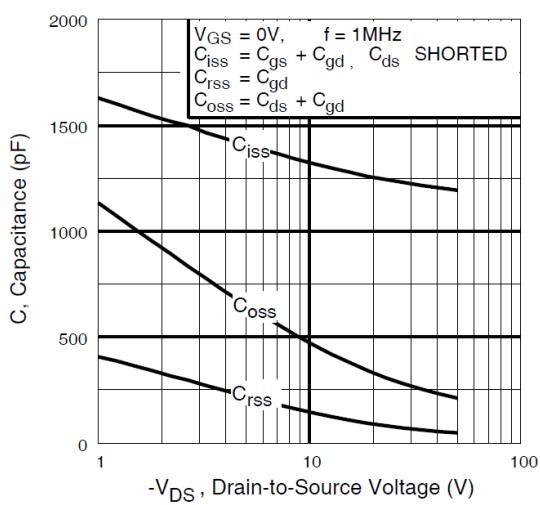
**Fig 2. Typical Output Characteristics**



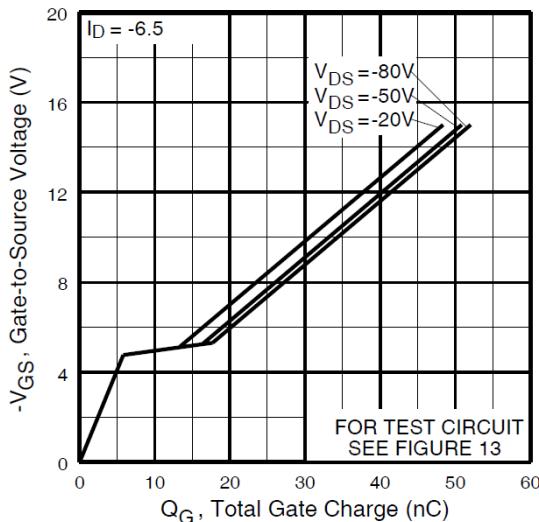
**Fig 3. Typical Transfer Characteristics**



**Fig 4. Normalized On-Resistance Vs. Temperature**

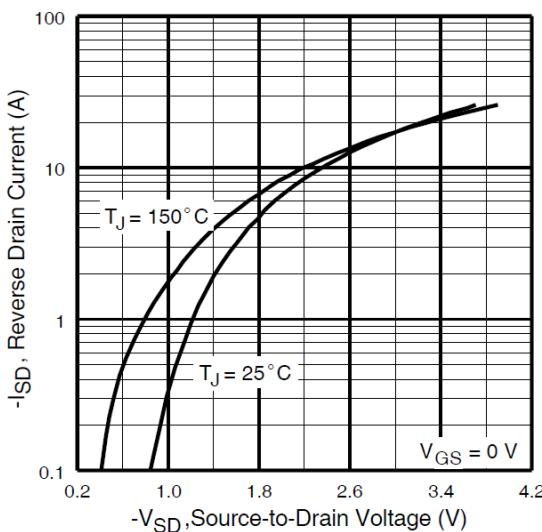


**Fig 5. Typical Capacitance Vs. Drain-to-Source Voltage**

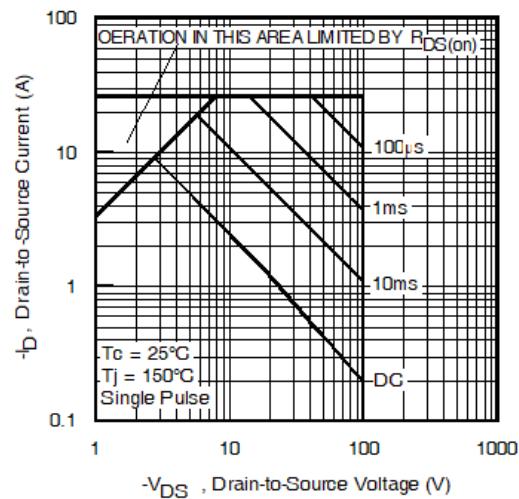


**Fig 6. Typical Gate Charge Vs. Gate-to-Source Voltage**

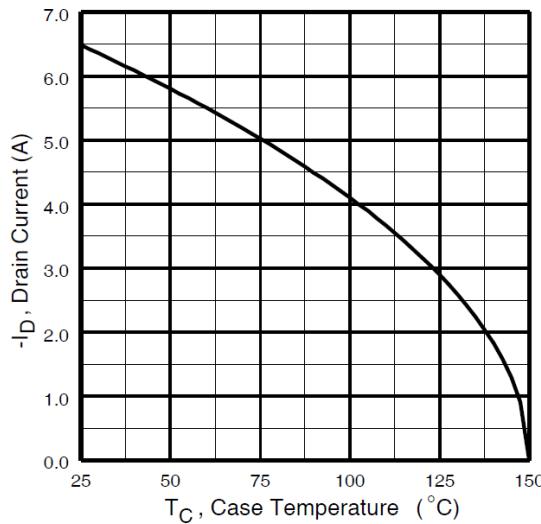
Pre-Irradiation



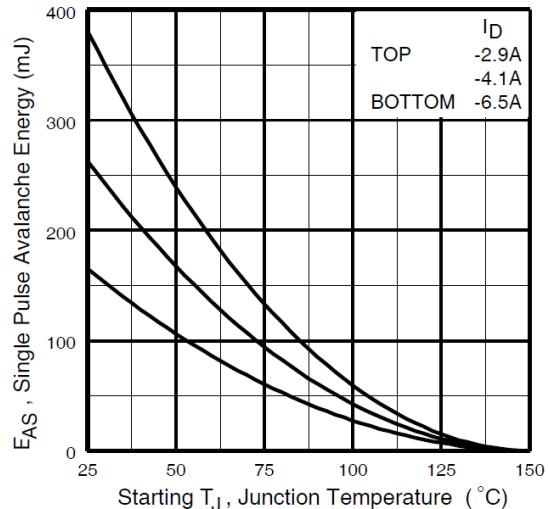
**Fig 7.** Typical Source-Drain Diode Forward Voltage



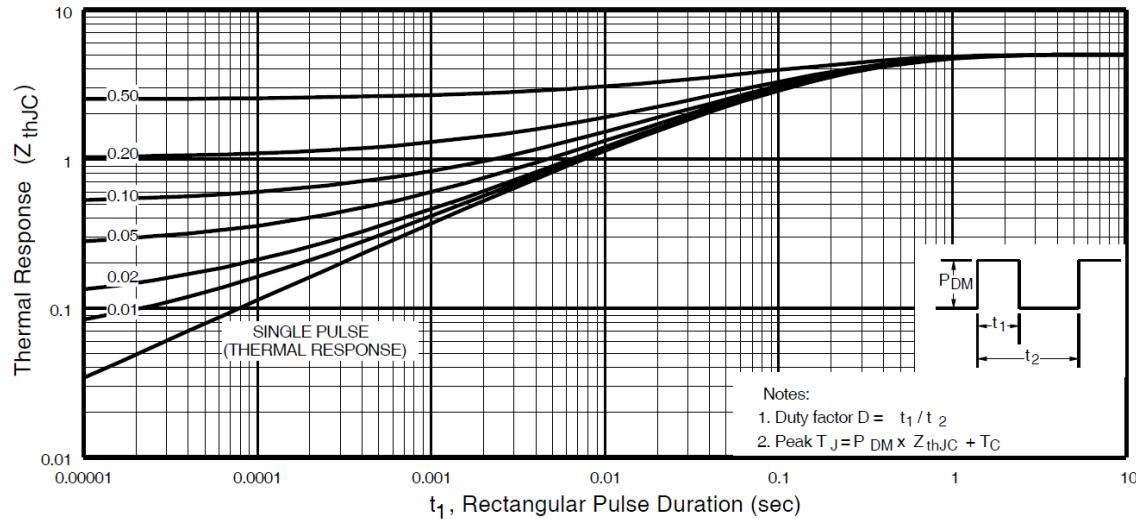
**Fig 8.** Maximum Safe Operating Area



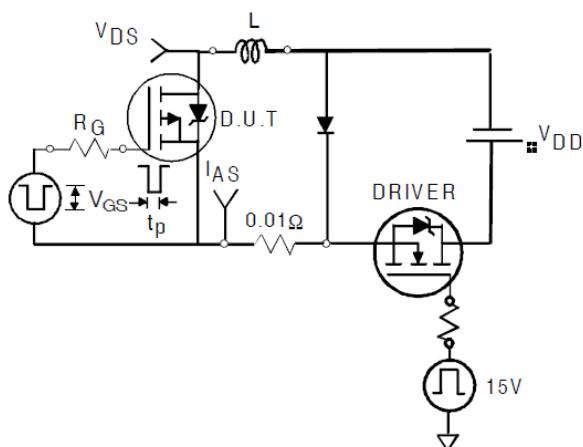
**Fig 9.** Maximum Drain Current Vs. Case Temperature



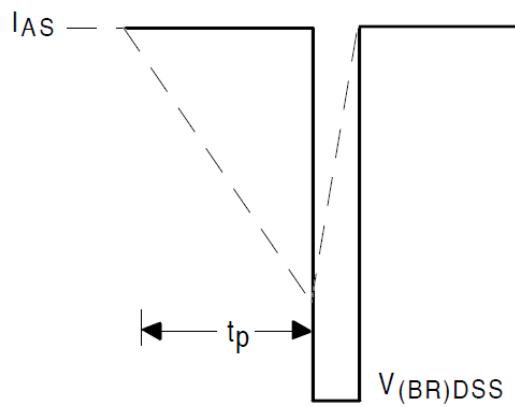
**Fig 10.** Maximum Avalanche Energy Vs. Drain Current



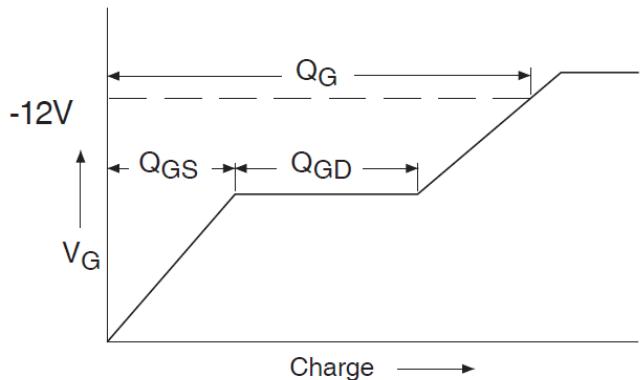
**Fig 11.** Maximum Effective Transient Thermal Impedance, Junction-to-Case



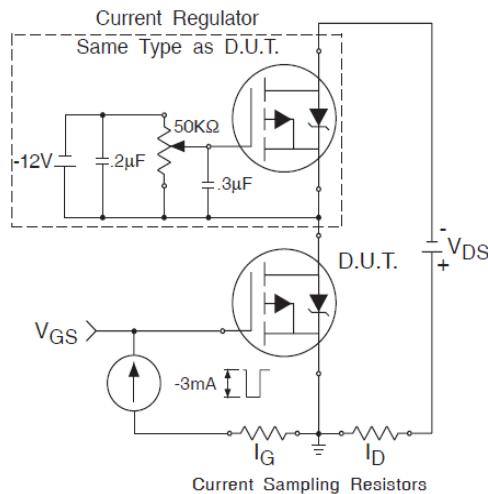
**Fig 12a.** Unclamped Inductive Test Circuit



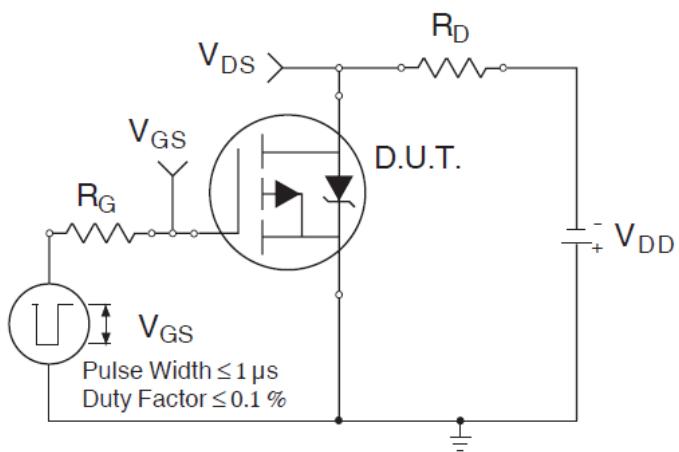
**Fig 12b.** Unclamped Inductive Wave-



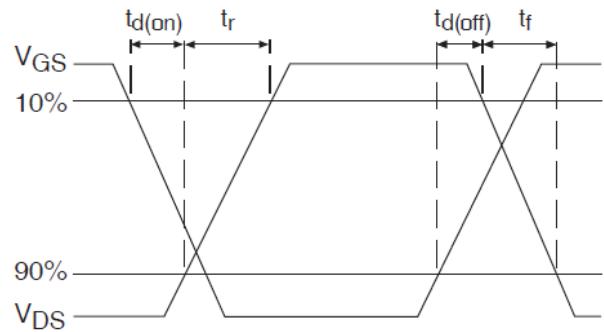
**Fig 13a.** Gate Charge Waveform



**Fig 13b.** Gate Charge Test Circuit

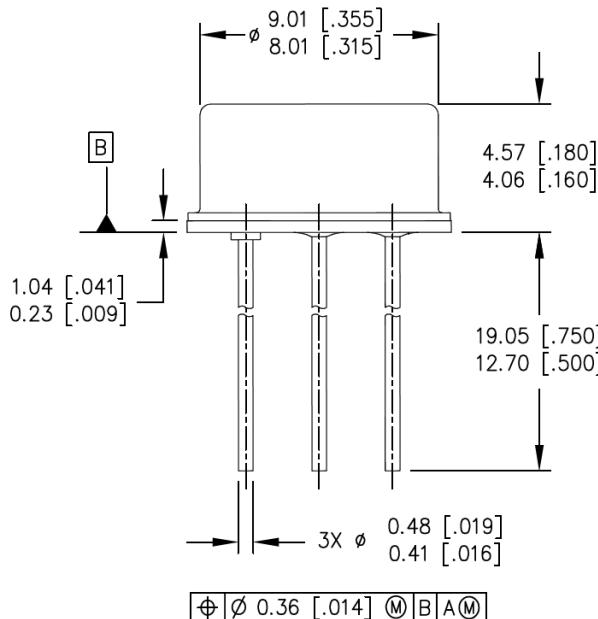


**Fig 14a.** Switching Time Test Circuit



**Fig 14b.** Switching Time Waveforms

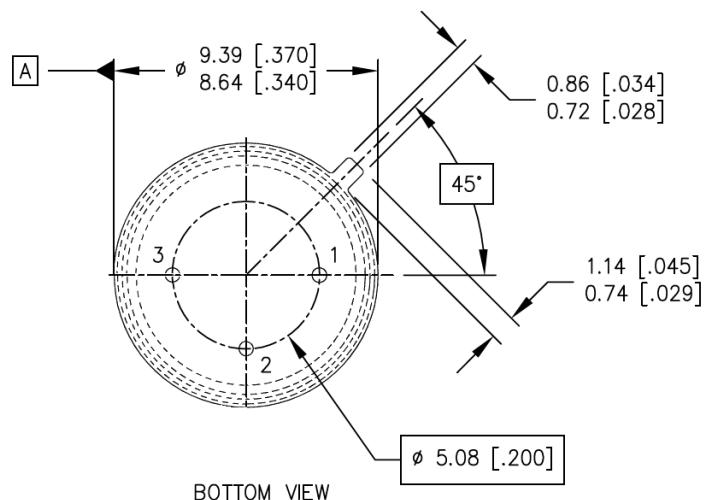
## Case Outline and Dimensions - TO-205AF (TO-39)



SIDE VIEW

NOTES:

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)

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