

**RADIATION HARDENED  
POWER MOSFET  
THRU-HOLE (TABLESS - TO-254AA)**
**400V, N-CHANNEL  
RAD-Hard HEXFET TECHNOLOGY**
**Product Summary**

Part Number	Radiation Level	RDS(on)	I <sub>D</sub>
IRHMB7360SE	100 kRads(Si)	0.20Ω	22A


**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<sub>ds(on)</sub> 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, ease of paralleling and temperature stability of electrical parameters.

**Features**

- Single Event Effect (SEE) Hardened
- Low RDS(on)
- Low Total Gate Charge
- Simple Drive Requirements
- Ease of Paralleling
- Hermetically Sealed
- Electrically Isolated
- Ceramic Eyelets
- Light Weight
- ESD Rating: Class 3B per MIL-STD-750, Method 1020

**Absolute Maximum Ratings**
**Pre-Irradiation**

	Parameter		Units
I <sub>D</sub> @ V <sub>GS</sub> = 12V, T <sub>C</sub> = 25°C	Continuous Drain Current	22	A
I <sub>D</sub> @ V <sub>GS</sub> = 12V, T <sub>C</sub> = 100°C	Continuous Drain Current	14	
I <sub>DM</sub>	Pulsed Drain Current ①	88	
P <sub>D</sub> @ T <sub>C</sub> = 25°C	Maximum Power Dissipation	250	W
	Linear Derating Factor	2.0	W/°C
V <sub>GS</sub>	Gate-to-Source Voltage	± 20	V
E <sub>AS</sub>	Single Pulse Avalanche Energy ②	500	mJ
I <sub>AR</sub>	Avalanche Current ①	22	A
E <sub>AR</sub>	Repetitive Avalanche Energy ①	25	mJ
dv/dt	Peak Diode Recovery dv/dt ③	3.0	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	9.3 (Typical)	

For Footnotes, refer to the page 2.

**Electrical Characteristics @ T<sub>J</sub> = 25°C (Unless Otherwise Specified)**

	Parameter	Min.	Typ.	Max.	Units	Test Conditions
BV <sub>DSS</sub>	Drain-to-Source Breakdown Voltage	400	—	—	V	V <sub>GS</sub> = 0V, I <sub>D</sub> = 1.0mA
ΔBV <sub>DSS</sub> /ΔT <sub>J</sub>	Breakdown Voltage Temp. Coefficient	—	0.51	—	V/°C	Reference to 25°C, I <sub>D</sub> = 1.0mA
R <sub>DS(on)</sub>	Static Drain-to-Source On-State Resistance	—	—	0.20	Ω	V <sub>GS</sub> = 12V, I <sub>D</sub> = 14A ④
		—	—	0.21		V <sub>GS</sub> = 12V, I <sub>D</sub> = 22A ④
V <sub>GS(th)</sub>	Gate Threshold Voltage	2.5	—	4.5	V	V <sub>DS</sub> = V <sub>GS</sub> , I <sub>D</sub> = 1.0mA
G <sub>fs</sub>	Forward Transconductance	6.0	—	—	S	V <sub>DS</sub> = 15V, I <sub>D</sub> = 14A ④
I <sub>DSS</sub>	Zero Gate Voltage Drain Current	—	—	50	μA	V <sub>DS</sub> = 320V, V <sub>GS</sub> = 0V
		—	—	250		V <sub>DS</sub> = 320V, V <sub>GS</sub> = 0V, T <sub>J</sub> = 125°C
I <sub>GSS</sub>	Gate-to-Source Leakage Forward	—	—	100	nA	V <sub>GS</sub> = 20V
	Gate-to-Source Leakage Reverse	—	—	-100		V <sub>GS</sub> = -20V
Q <sub>G</sub>	Total Gate Charge	—	—	185	nC	I <sub>D</sub> = 22A
Q <sub>GS</sub>	Gate-to-Source Charge	—	—	35		V <sub>DS</sub> = 200V
Q <sub>GD</sub>	Gate-to-Drain ('Miller') Charge	—	—	100		V <sub>GS</sub> = 12V
t <sub>d(on)</sub>	Turn-On Delay Time	—	—	28	ns	V <sub>DD</sub> = 200V
t <sub>r</sub>	Rise Time	—	—	97		I <sub>D</sub> = 22A
t <sub>d(off)</sub>	Turn-Off Delay Time	—	—	120		R <sub>G</sub> = 2.35Ω
t <sub>f</sub>	Fall Time	—	—	72		V <sub>GS</sub> = 12V
L <sub>S</sub> + L <sub>D</sub>	Total Inductance	—	6.8	—	nH	Measured from Drain lead (6mm / 0.25in from package) to Source lead (6mm / 0.25 in from package) with Source wire internally bonded from Source pin to Drain pad
C <sub>iss</sub>	Input Capacitance	—	4000	—	pF	V <sub>GS</sub> = 0V
C <sub>oss</sub>	Output Capacitance	—	1000	—		V <sub>DS</sub> = 25V
C <sub>rss</sub>	Reverse Transfer Capacitance	—	460	—		f = 1.0MHz

**Source-Drain Diode Ratings and Characteristics**

	Parameter	Min.	Typ.	Max.	Units	Test Conditions
I <sub>S</sub>	Continuous Source Current (Body Diode)	—	—	22	A	
I <sub>SM</sub>	Pulsed Source Current (Body Diode) ①	—	—	88		
V <sub>SD</sub>	Diode Forward Voltage	—	—	1.4	V	T <sub>J</sub> = 25°C, I <sub>S</sub> = 22A, V <sub>GS</sub> = 0V④
t <sub>rr</sub>	Reverse Recovery Time	—	—	720	ns	T <sub>J</sub> = 25°C, I <sub>F</sub> = 22A, V <sub>DD</sub> ≤ 50V
Q <sub>rr</sub>	Reverse Recovery Charge	—	—	14	μC	di/dt = 100A/μs ④
t <sub>on</sub>	Forward Turn-On Time	Intrinsic turn-on time is negligible (turn-on is dominated by L <sub>S</sub> +L <sub>D</sub> )				

**Thermal Resistance**

	Parameter	Min.	Typ.	Max.	Units
R <sub>θJC</sub>	Junction-to-Case	—	—	0.5	°C/W
R <sub>θCS</sub>	Case -to-Sink	—	0.21	—	
R <sub>θJA</sub>	Junction-to-Ambient (Typical socket mount)	—	—	48	

**Footnotes:**

- ① Repetitive Rating; Pulse width limited by maximum junction temperature.
- ② V<sub>DD</sub> = 50V, starting T<sub>J</sub> = 25°C, L = 2.0mH, Peak I<sub>L</sub> = 22A, V<sub>GS</sub> = 12V
- ③ I<sub>SD</sub> ≤ 22A, di/dt ≤ 120A/μs, V<sub>DD</sub> ≤ 400V, T<sub>J</sub> ≤ 150°C
- ④ Pulse width ≤ 300 μs; Duty Cycle ≤ 2%
- ⑤ **Total Dose Irradiation with V<sub>GS</sub> Bias.** 12 volt V<sub>GS</sub> applied and V<sub>DS</sub> = 0 during irradiation per MIL-STD-750, Method 1019, condition A.
- ⑥ **Total Dose Irradiation with V<sub>DS</sub> Bias.** 320 volt V<sub>DS</sub> applied and V<sub>GS</sub> = 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.

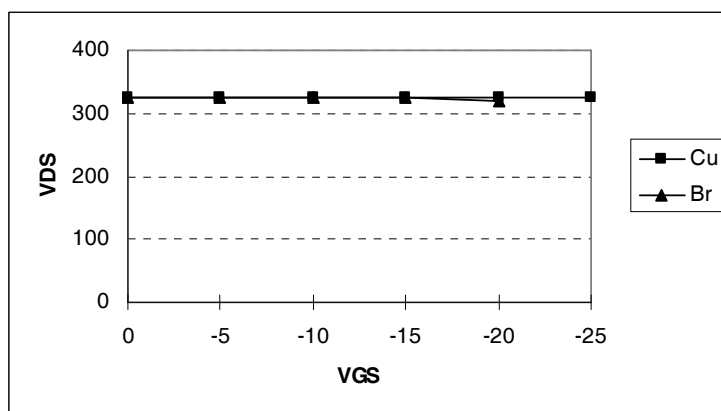
**Table 1. Electrical Characteristics @ Tj = 25°C, Post Total Dose Irradiation ⑤⑥**

	Parameter	100 kRads (Si)		Units	Test Conditions
		Min.	Max.		
$BV_{DSS}$	Drain-to-Source Breakdown Voltage	400	—	V	$V_{GS} = 0V, I_D = 1.0mA$
$V_{GS(th)}$	Gate Threshold Voltage	2.5	4.5	V	$V_{DS} = V_{GS}, I_D = 1.0mA$
$I_{GSS}$	Gate-to-Source Leakage Forward	—	100	nA	$V_{GS} = 20V$
$I_{GSS}$	Gate-to-Source Leakage Reverse	—	-100	nA	$V_{GS} = -20V$
$I_{DSS}$	Zero Gate Voltage Drain Current	—	50	$\mu A$	$V_{DS} = 320V, V_{GS} = 0V$
$R_{DS(on)}$	Static Drain-to-Source ④ On-State Resistance (TO-3)	—	0.20	$\Omega$	$V_{GS} = 12V, I_D = 14A$
$R_{DS(on)}$	Static Drain-to-Source ④ On-State Resistance (TO-254AA)	—	0.20	$\Omega$	$V_{GS} = 12V, I_D = 14A$
$V_{SD}$	Diode Forward Voltage	—	1.4	V	$V_{GS} = 0V, I_D = 22A$

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**

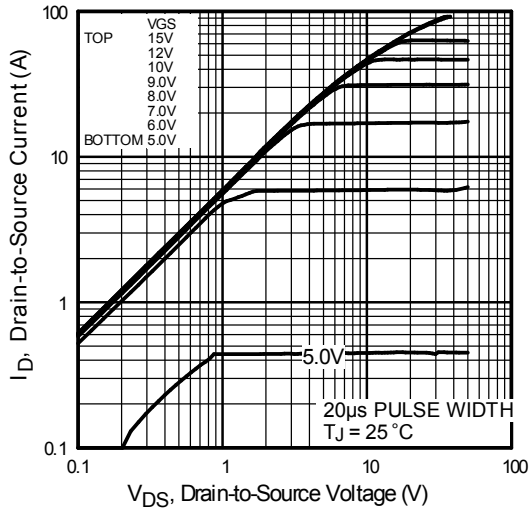
Ion	LET (MeV/(mg/cm <sup>2</sup> ))	Energy (MeV)	Range ( $\mu m$ )	VDS (V)					
				@VGS= 0V	@VGS= -5V	@VGS= -10V	@VGS= -15V	@VGS= -20V	@VGS= -25V
Cu	28	285	43	325	325	325	325	325	325
Br	36.8	305	39	325	325	325	325	320	—



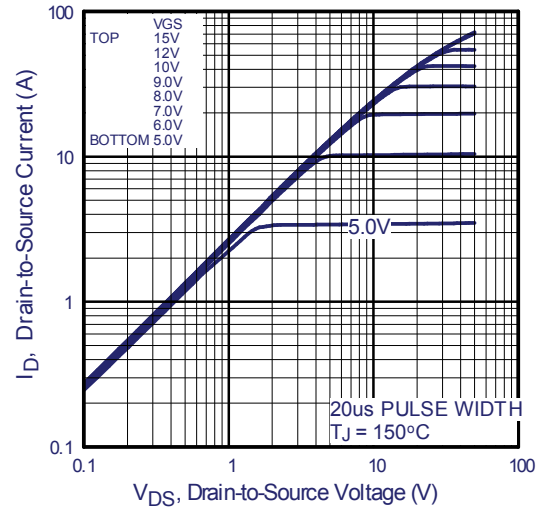
**Fig a.** Typical Single Event Effect, Safe Operating Area

For Footnotes, refer to the page 2.

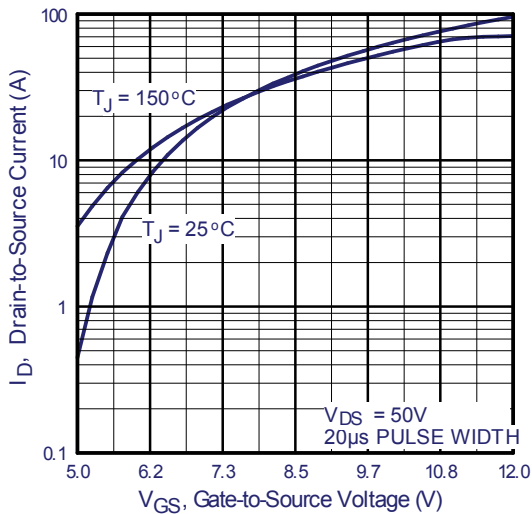
**Pre-Irradiation**



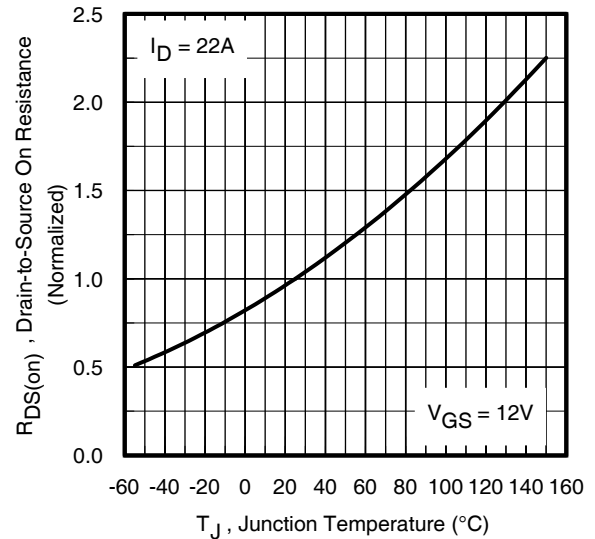
**Fig 1. Typical Output Characteristics**



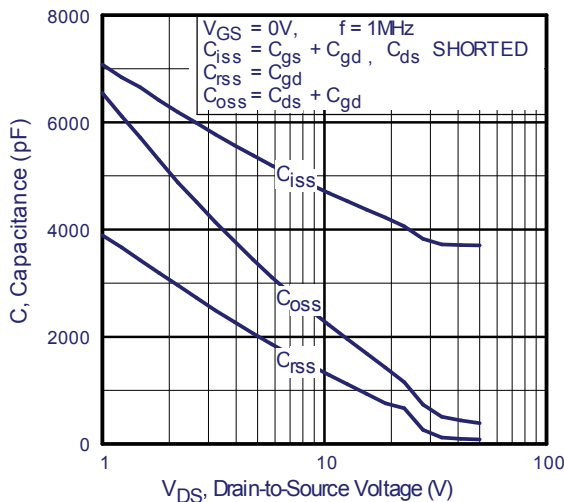
**Fig 2. Typical Output Characteristics**



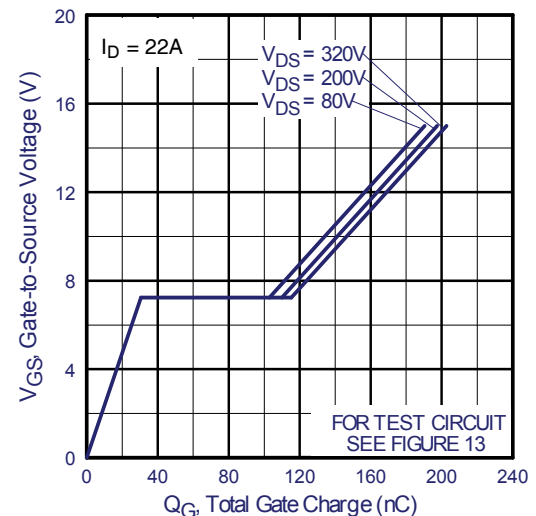
**Fig 3. Typical Transfer Characteristics**



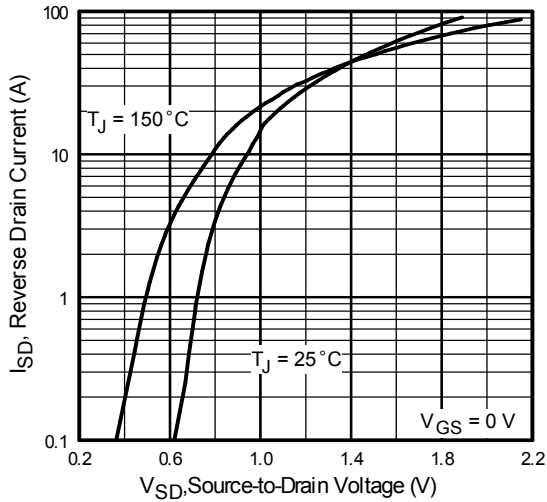
**Fig 4. Normalized On-Resistance Vs. Temperature**



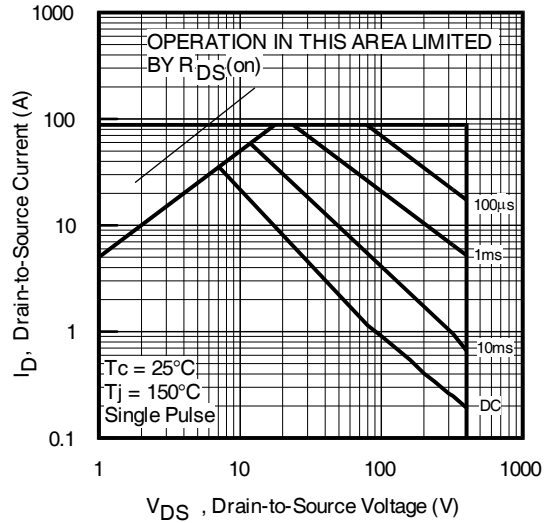
**Fig 5. Typical Capacitance Vs. Drain-to-Source Voltage**



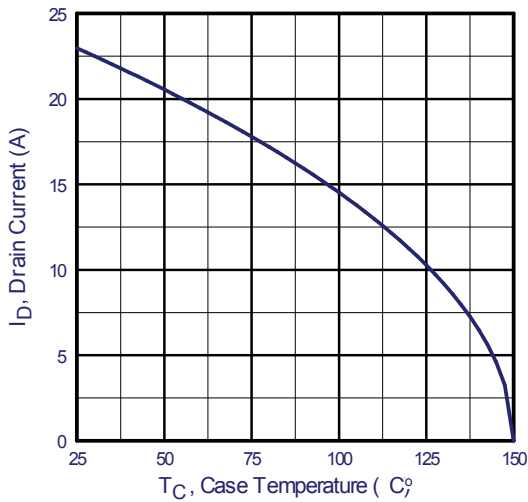
**Fig 6. Typical Gate Charge Vs. Gate-to-Source Voltage**



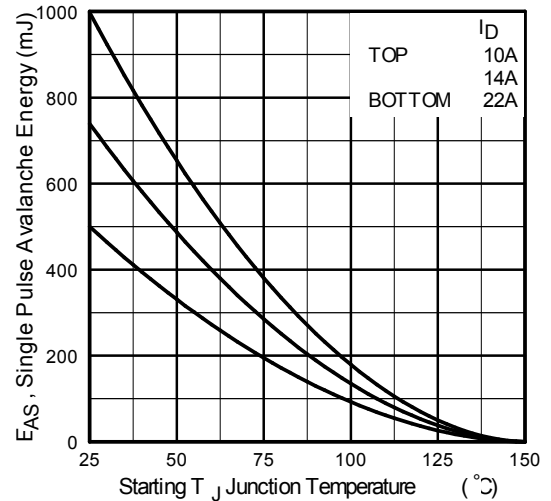
**Fig 7.** Typical Source-Drain Diode Forward Voltage



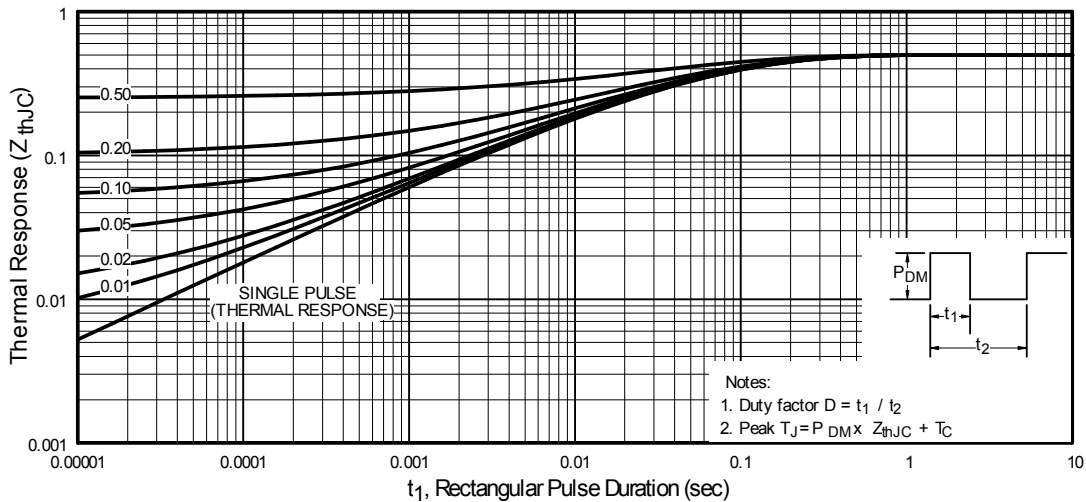
**Fig 8.** Maximum Safe Operating Area



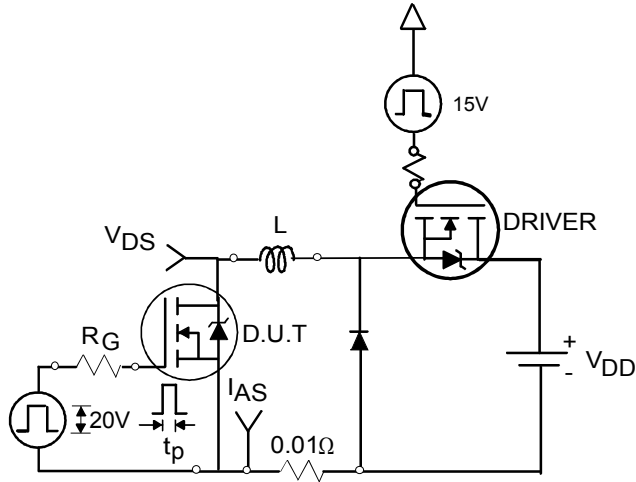
**Fig 9.** Maximum Drain Current Vs. Case Temperature



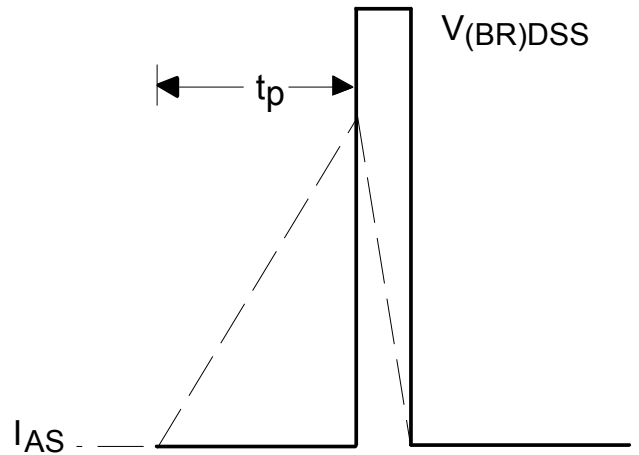
**Fig 10.** Maximum Avalanche Energy Vs. Drain Current



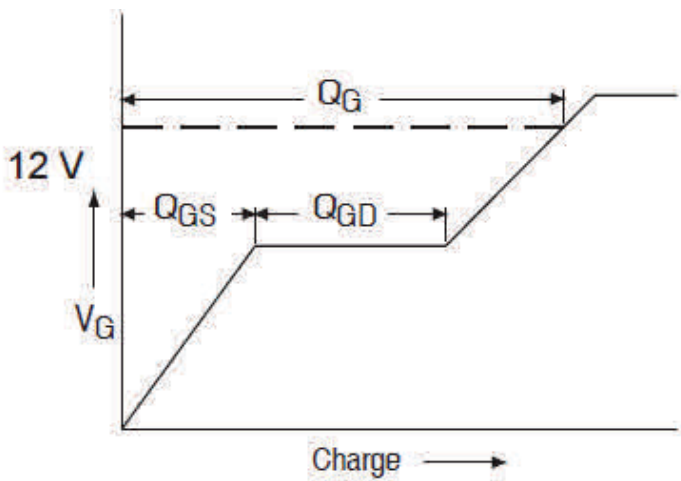
**Fig 11.** Maximum Effective Transient Thermal Impedance, Junction-to-Case



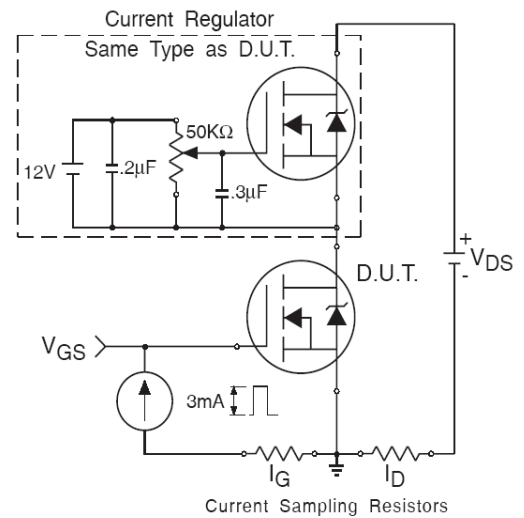
**Fig 12a.** Unclamped Inductive Test Circuit



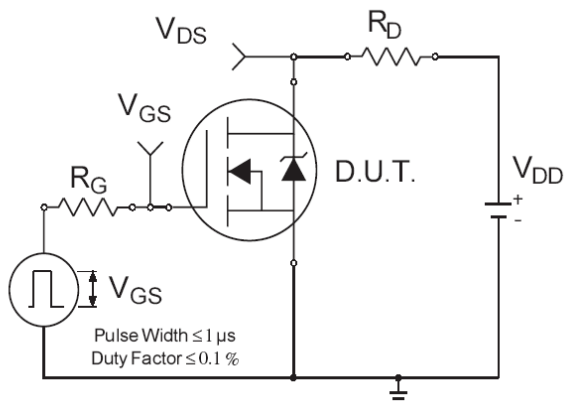
**Fig 12b.** Unclamped Inductive Waveforms



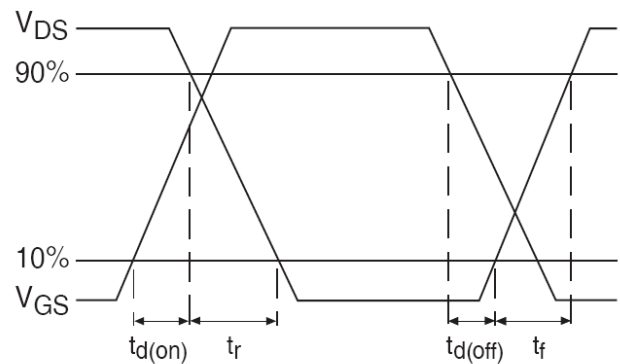
**Fig 13a.** Gate Charge Waveform



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

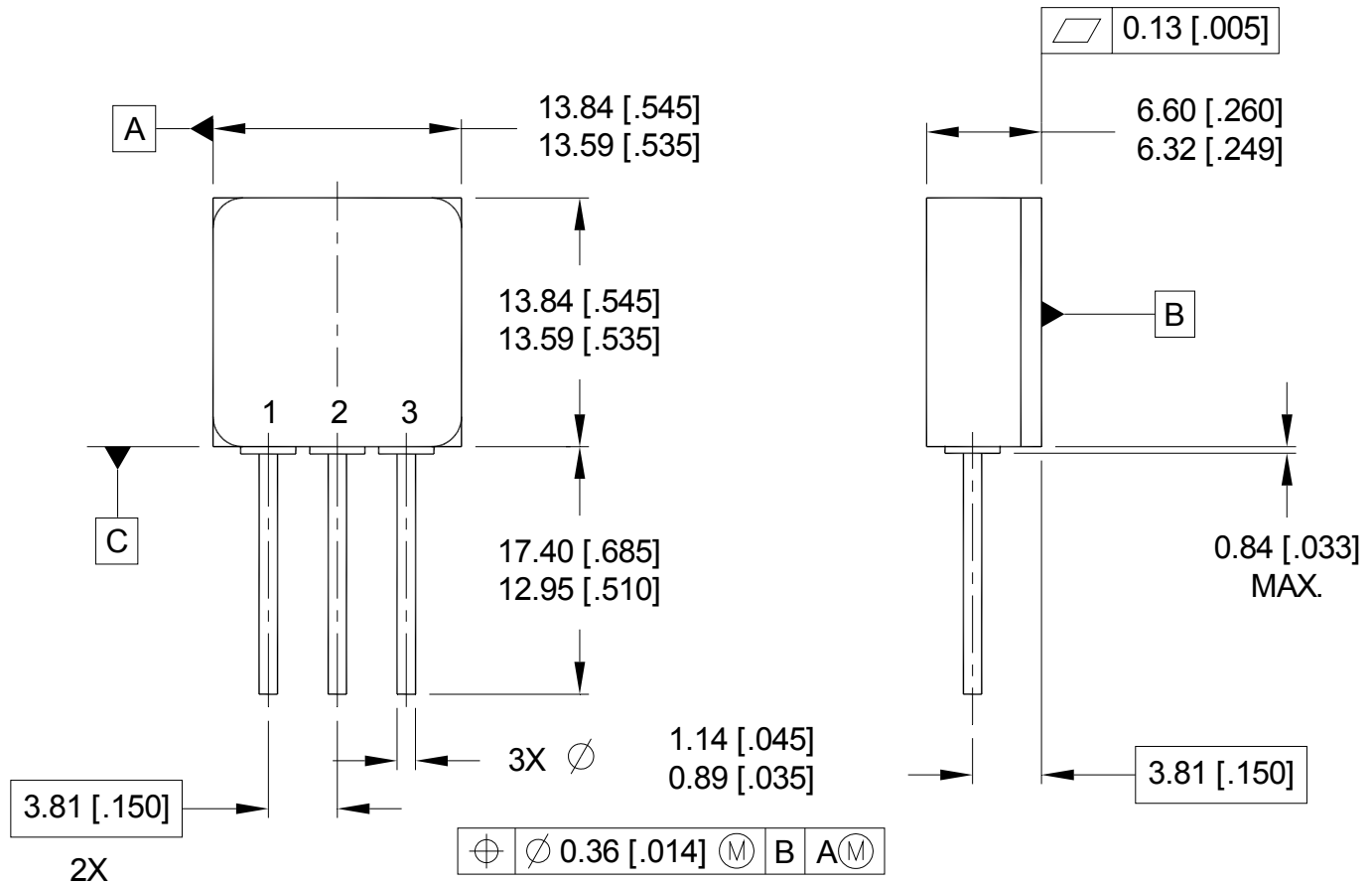


**Fig 14a.** Switching Time Test Circuit



**Fig 14b.** Switching Time Waveforms

Case Outline and Dimensions — TABLESS -TO-254AA



NOTES:

1. DIMENSIONING & TOLERANCING PER ASME Y14.5M-1994.
2. ALL DIMENSIONS ARE SHOWN IN MILLIMETERS [INCHES].
3. CONTROLLING DIMENSION: INCH.
4. THIS OUTLINE IS A MODIFIED TO-254AA JEDEC OUTLINE.
5. AVAILABLE WITH EITHER GLASS OR CERAMIC SEALS.

PIN ASSIGNMENTS

- 1 = DRAIN
- 2 = SOURCE
- 3 = GATE

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