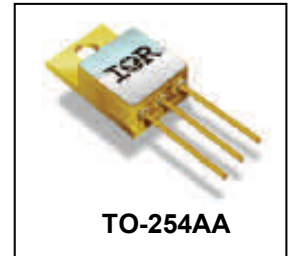


**RADIATION HARDENED  
POWER MOSFET  
THRU-HOLE (TO-254AA)**

**30V, N-CHANNEL  
R5 TECHNOLOGY**

**Product Summary**

Part Number	Radiation Level	RDS(on)	I <sub>D</sub>
IRHM57Z60	100 kRads(Si)	0.0095Ω	35A*
IRHM53Z60	300 kRads(Si)	0.0095Ω	35A*
IRHM54Z60	600 kRads(Si)	0.0095Ω	35A*
IRHM58Z60	1000 kRads(Si)	0.010Ω	35A*



**Description**

IR HiRel R5 technology provides high performance power MOSFETs for space applications. These devices have been characterized for Single Event Effects (SEE) with useful performance up to an LET of 80 (MeV/(mg/cm<sup>2</sup>)). 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
- Neutron Tolerant
- Identical Pre- and Post-Electrical Test Conditions
- Repetitive Avalanche Ratings
- Dynamic dv/dt Ratings
- 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**

	Parameter		Pre-Irradiation Units
I <sub>D</sub> @ V <sub>GS</sub> = 12V, T <sub>C</sub> = 25°C	Continuous Drain Current	35*	A
I <sub>D</sub> @ V <sub>GS</sub> = 12V, T <sub>C</sub> = 100°C	Continuous Drain Current	35*	
I <sub>DM</sub>	Pulsed Drain Current ①	140	
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	35	A
E <sub>AR</sub>	Repetitive Avalanche Energy ①	25	mJ
dv/dt	Peak Diode Recovery dv/dt ③	1.1	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)	

\*Current is limited by package

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	30	—	—	V	V <sub>GS</sub> = 0V, I <sub>D</sub> = 1.0mA
ΔBV <sub>DSS</sub> /ΔT <sub>J</sub>	Breakdown Voltage Temp. Coefficient	—	0.028	—	V/°C	Reference to 25°C, I <sub>D</sub> = 1.0mA
R <sub>DS(on)</sub>	Static Drain-to-Source On-State Resistance	—	—	0.0095	Ω	V <sub>GS</sub> = 12V, I <sub>D</sub> = 35A ④
V <sub>GS(th)</sub>	Gate Threshold Voltage	2.0	—	4.0	V	V <sub>DS</sub> = V <sub>GS</sub> , I <sub>D</sub> = 1.0mA
G <sub>fs</sub>	Forward Transconductance	45	—	—	S	V <sub>DS</sub> = 15V, I <sub>D</sub> = 35A ④
I <sub>DSS</sub>	Zero Gate Voltage Drain Current	—	—	10	μA	V <sub>DS</sub> = 24V, V <sub>GS</sub> = 0V
		—	—	25		V <sub>DS</sub> = 24V, 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	—	—	200	nC	I <sub>D</sub> = 35A
Q <sub>GS</sub>	Gate-to-Source Charge	—	—	55		V <sub>DS</sub> = 15V
Q <sub>GD</sub>	Gate-to-Drain ('Miller') Charge	—	—	40		V <sub>GS</sub> = 12V
t <sub>d(on)</sub>	Turn-On Delay Time	—	—	35	ns	V <sub>DD</sub> = 15V
t <sub>r</sub>	Rise Time	—	—	125		I <sub>D</sub> = 35A
t <sub>d(off)</sub>	Turn-Off Delay Time	—	—	80		R <sub>G</sub> = 2.35Ω
t <sub>f</sub>	Fall Time	—	—	50		V <sub>GS</sub> = 12V
L <sub>S</sub> + L <sub>D</sub>	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 <sub>iss</sub>	Input Capacitance	—	9720	—	pF	V <sub>GS</sub> = 0V
C <sub>oss</sub>	Output Capacitance	—	4230	—		V <sub>DS</sub> = 25V
C <sub>rss</sub>	Reverse Transfer Capacitance	—	56	—		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)	—	—	35*	A	
I <sub>SM</sub>	Pulsed Source Current (Body Diode) ①	—	—	140		
V <sub>SD</sub>	Diode Forward Voltage	—	—	1.2	V	T <sub>J</sub> = 25°C, I <sub>S</sub> = 35A, V <sub>GS</sub> = 0V④
t <sub>rr</sub>	Reverse Recovery Time	—	—	153	ns	T <sub>J</sub> = 25°C, I <sub>F</sub> = 35A, V <sub>DD</sub> ≤ 25V
Q <sub>rr</sub>	Reverse Recovery Charge	—	—	324	nC	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> )				

\* Current is limited by package

**Thermal Resistance**

	Parameter	Min.	Typ.	Max.	Units
R <sub>θJC</sub>	Junction-to-Case	—	—	0.50	°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> = 25V, starting T<sub>J</sub> = 25°C, L = 0.8mH, Peak I<sub>L</sub> = 35A, V<sub>GS</sub> = 12V
- ③ I<sub>SD</sub> ≤ 35A, di/dt ≤ 132A/μs, V<sub>DD</sub> ≤ 30V, 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.** 24volt 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.

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

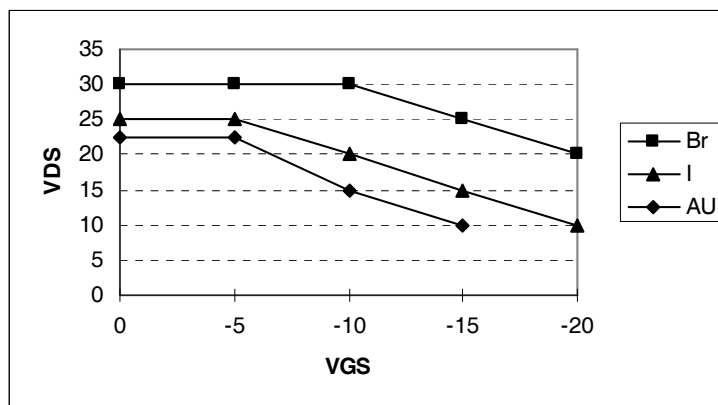
	Parameter	Up to 600 kRads (Si) <sup>1</sup>		1000 kRads (Si) <sup>2</sup>		Units	Test Conditions
		Min.	Max.	Min.	Max.		
BV <sub>DSS</sub>	Drain-to-Source Breakdown Voltage	30	—	30	—	V	V <sub>GS</sub> = 0V, I <sub>D</sub> = 1.0mA
V <sub>GS(th)</sub>	Gate Threshold Voltage	2.0	4.0	1.5	4.0	V	V <sub>DS</sub> = V <sub>GS</sub> , I <sub>D</sub> = 1.0mA
I <sub>GSS</sub>	Gate-to-Source Leakage Forward	—	100	—	100	nA	V <sub>GS</sub> = 20V
I <sub>GSS</sub>	Gate-to-Source Leakage Reverse	—	-100	—	-100	nA	V <sub>GS</sub> = -20V
I <sub>DSS</sub>	Zero Gate Voltage Drain Current	—	10	—	25	μA	V <sub>DS</sub> = 24V, V <sub>GS</sub> = 0V
R <sub>DS(on)</sub>	Static Drain-to-Source ④ On-State Resistance (TO-3)	—	0.004	—	0.005	Ω	V <sub>GS</sub> = 12V, I <sub>D</sub> = 35A
R <sub>DS(on)</sub>	Static Drain-to-Source ④ On-State Resistance (TO-254AA)	—	0.0095	—	0.01	Ω	V <sub>GS</sub> = 12V, I <sub>D</sub> = 35A
V <sub>SD</sub>	Diode Forward Voltage ④	—	1.2	—	1.2	V	V <sub>GS</sub> = 0V, I <sub>D</sub> = 35A

1. Part numbers IRHM57Z60, IRHM53Z60 and IRHM54Z60
2. Part number IRHM58Z60

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.

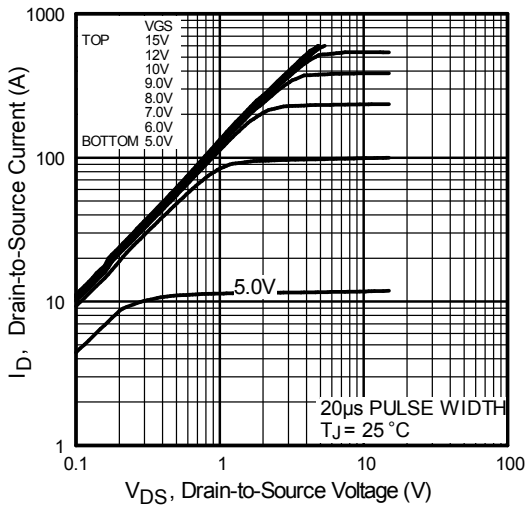
**Table 2. Typical Single Event Effect Safe Operating Area**

Ion	LET (MeV/(mg/cm <sup>2</sup> ))	Energy (MeV)	Range (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
Br	37.9	255	33.4	30	30	30	25	20
I	59.4	290	28.8	25	25	20	15	10
Au	80.3	313	26.5	22.5	22.5	15	10	—

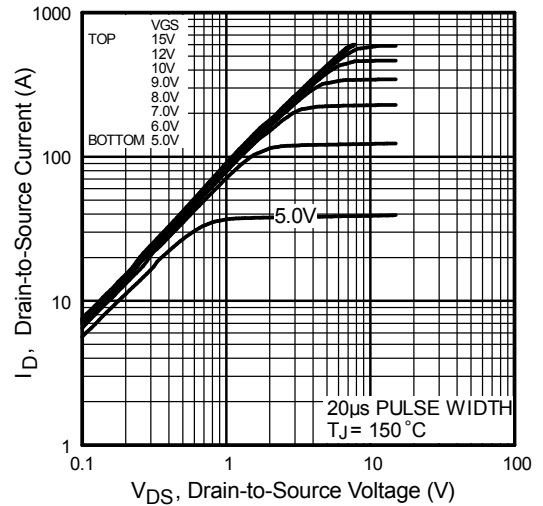


**Fig a.** Typical Single Event Effect, Safe Operating Area

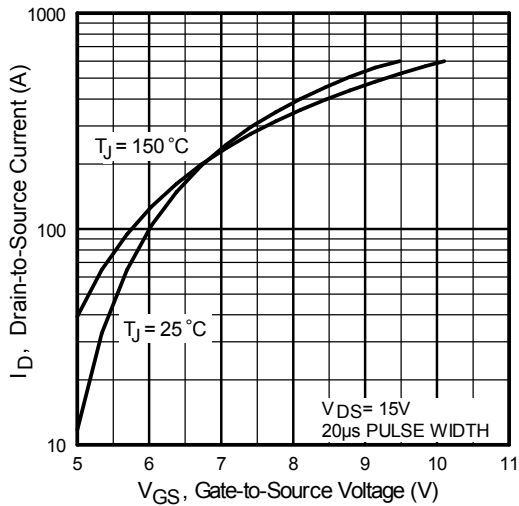
For Footnotes, refer to the page 2.



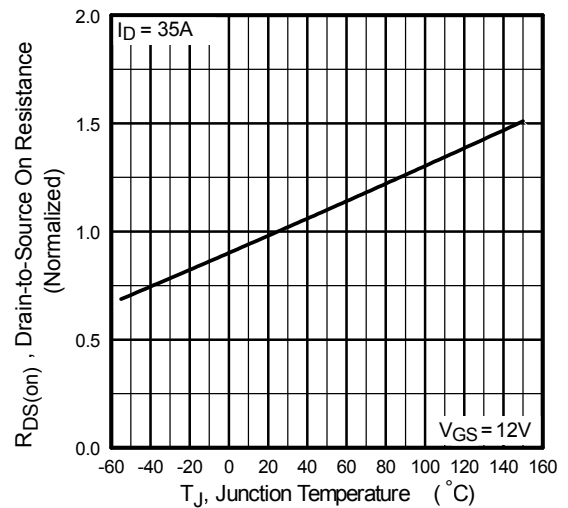
**Fig 1.** Typical Output Characteristics



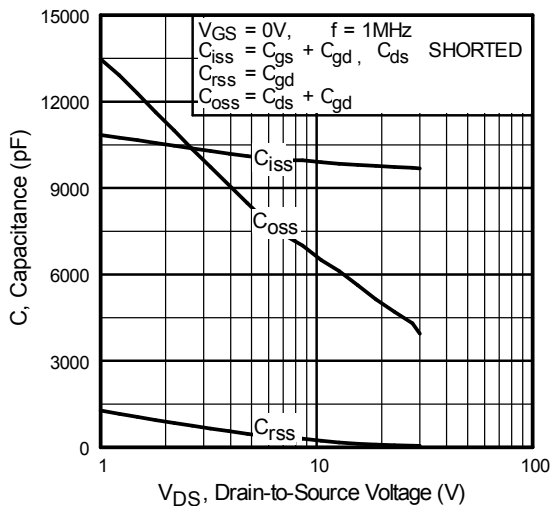
**Fig 2.** Typical Output Characteristics



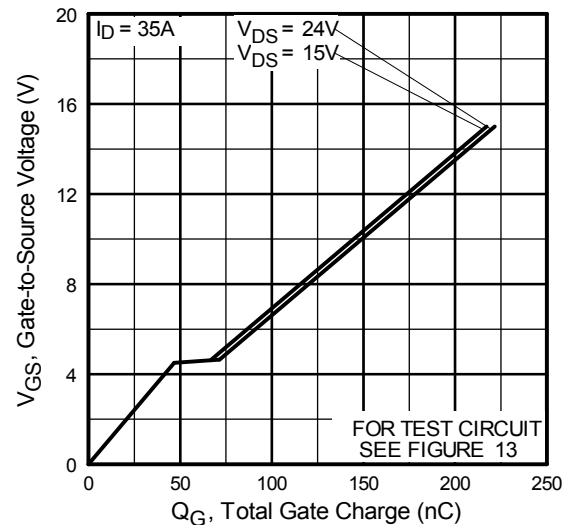
**Fig 3.** Typical Transfer Characteristics



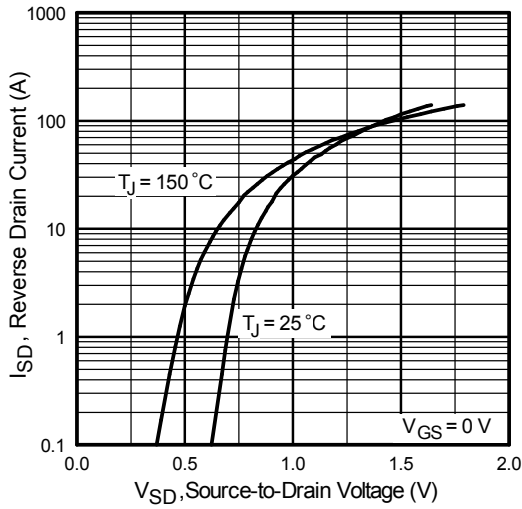
**Fig 4.** Normalized On-Resistance Vs. Temperature



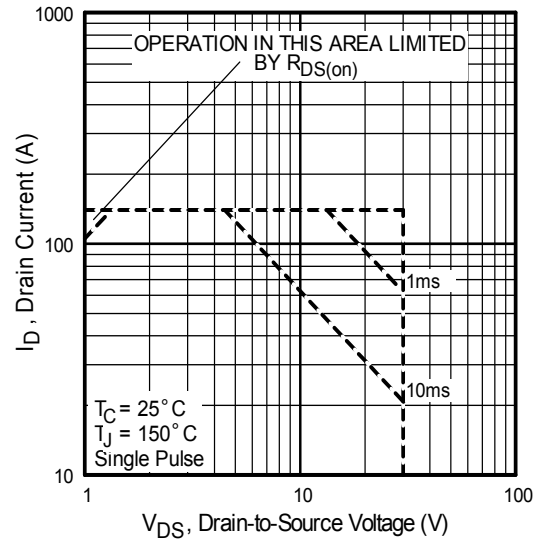
**Fig 5.** Typical Capacitance Vs. Drain-to-Source Voltage



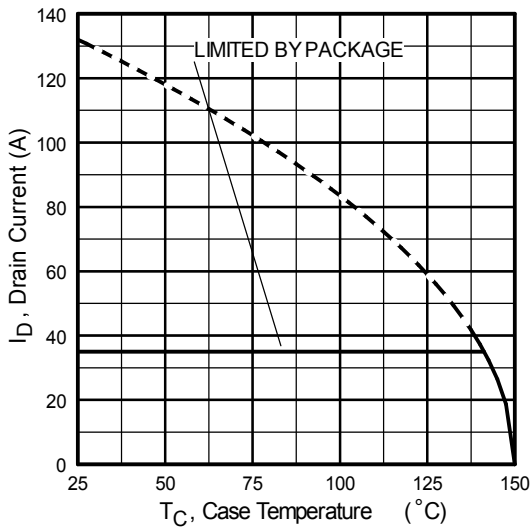
**Fig 6.** Typical Gate Charge Vs. Gate-to-Source Voltage



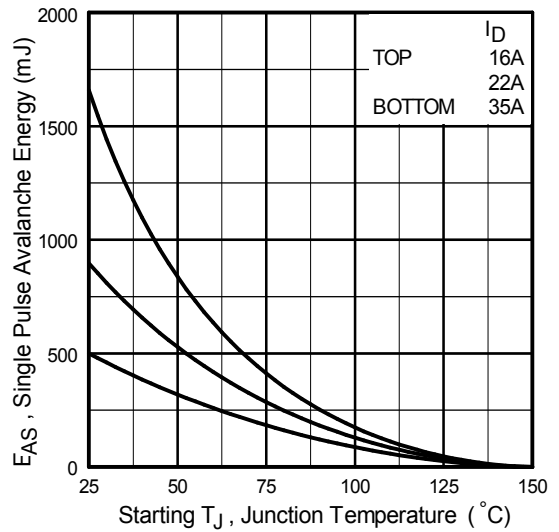
**Fig 7.** Typical Source-Drain Diode Forward Voltage



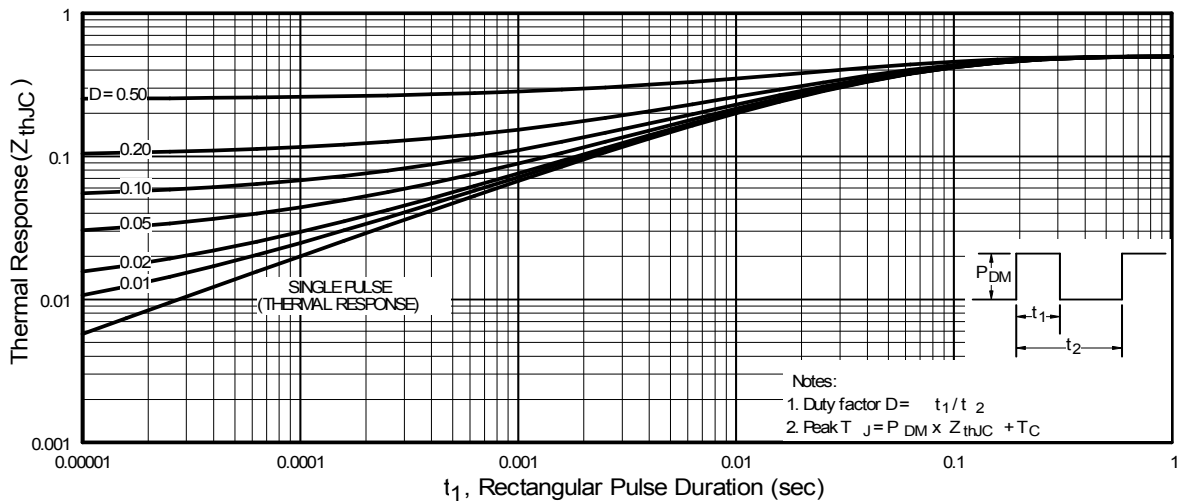
**Fig 8.** Maximum Safe Operating Area



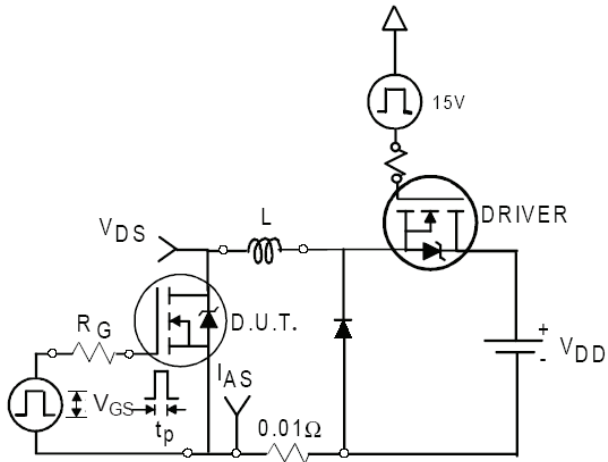
**Fig 9.** Maximum Drain Current Vs. Case Temperature



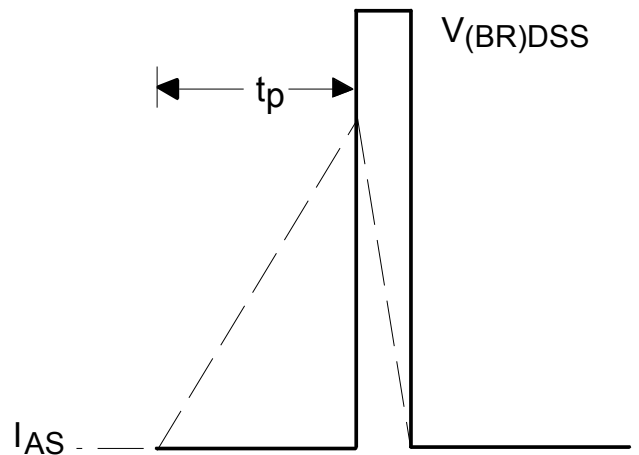
**Fig 10.** Maximum Avalanche Energy Vs. Drain Current



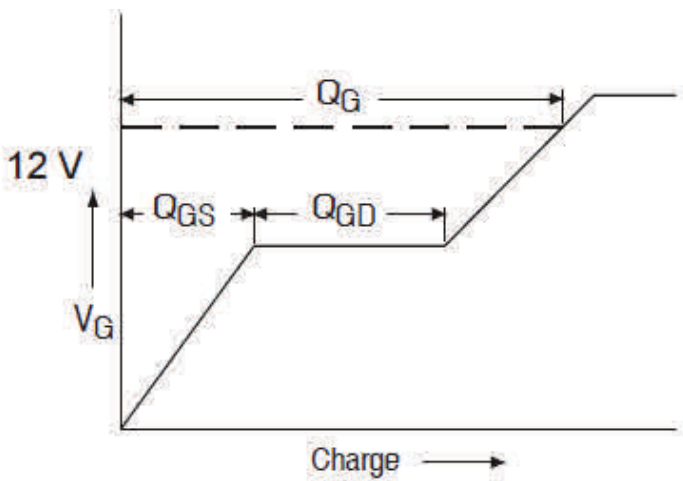
**Fig 11.** Maximum Effective Transient Thermal Impedance, Junction-to-Case



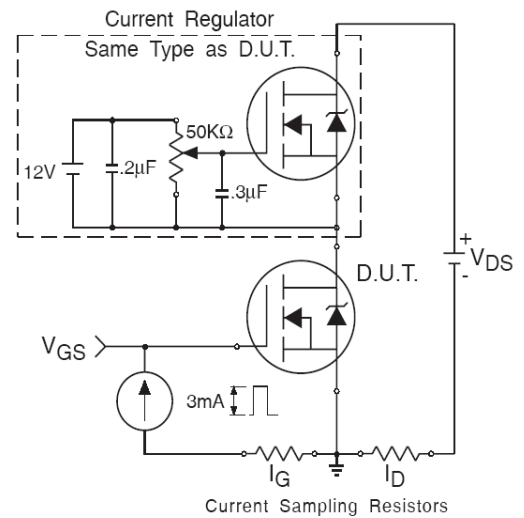
**Fig 12a.** Unclamped Inductive Test Circuit



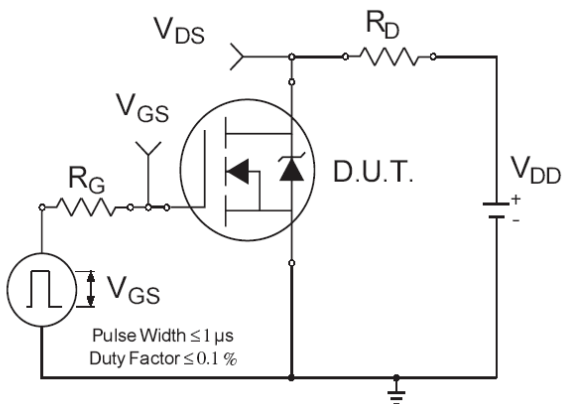
**Fig 12b.** Unclamped Inductive Waveforms



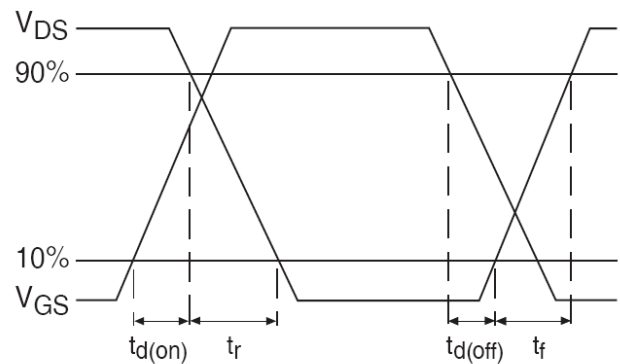
**Fig 13a.** Gate Charge Waveform



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

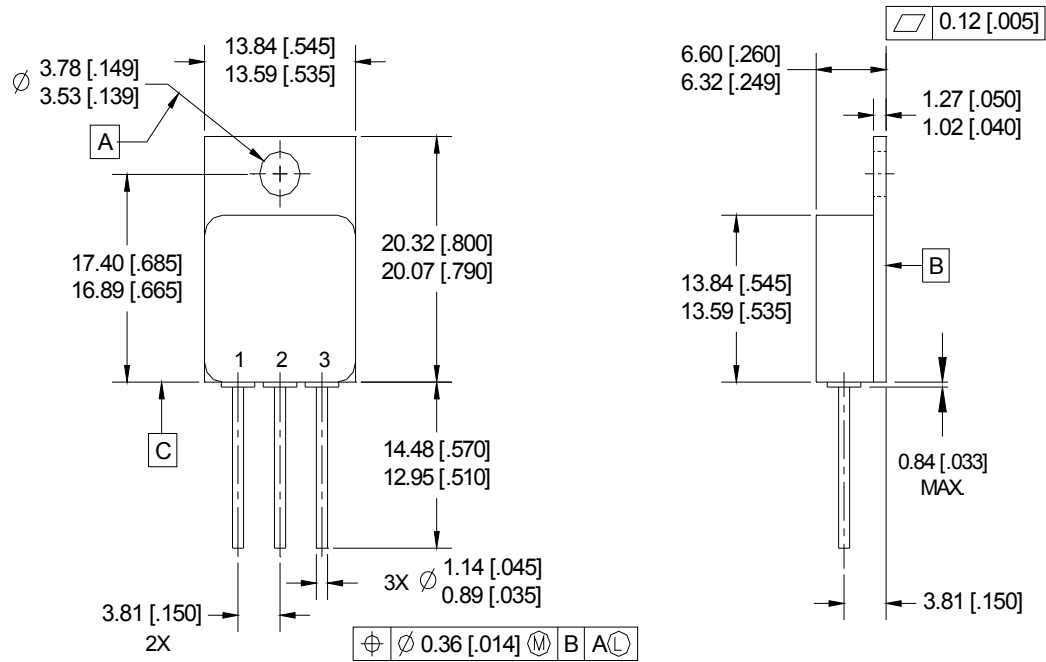


**Fig 14a.** Switching Time Test Circuit



**Fig 14b.** Switching Time Waveforms

**Case Outline and Dimensions — TO-254AA**



**NOTES:**

1. DIMENSIONING & TOLERANCING PER ASME Y14.5M-1994.
2. ALL DIMENSIONS ARE SHOWN IN MILLIMETERS [INCHES].
3. CONTROLLING DIMENSION: INCH.
4. CONFORMS TO JEDEC OUTLINE TO-254AA.

**PIN ASSIGNMENTS**

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

**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.

### **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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