

# IRF9204PbF

## Features

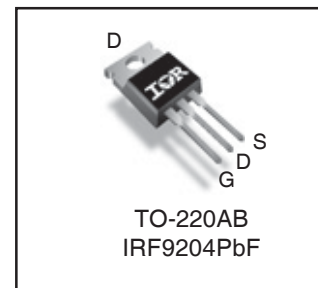
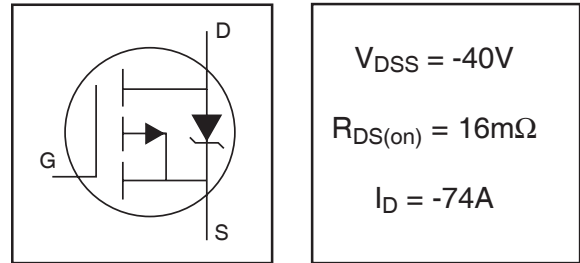
- Advanced Process Technology
- Ultra Low On-Resistance
- Dynamic dv/dt Rating
- 175°C Operating Temperature
- Fast Switching
- P-Channel
- Fully Avalanche Rated
- Lead-Free

## Description

This HEXFET® Power MOSFET utilizes advanced processing techniques to achieve extremely low on-resistance per silicon area. This benefit, combined with the fast switching speed and ruggedized device design that HEXFET Power MOSFETs are well known for, provides the designer with an extremely efficient and reliable device for use in a wide variety of applications.

The TO-220 package is universally preferred for all commercial-industrial applications at power dissipation levels to approximately 50 watts. The low thermal resistance and low package cost of the TO-220 contribute to its wide acceptance throughout the industry.

## HEXFET® Power MOSFET



<b>G</b>	<b>D</b>	<b>S</b>
Gate	Drain	Source

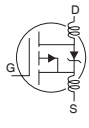
## Absolute Maximum Ratings

	Parameter	Max.	Units
$I_D @ T_C = 25^\circ C$	Continuous Drain Current, $V_{GS} @ 10V$ (Silicon Limited)	-74	A
$I_D @ T_C = 100^\circ C$	Continuous Drain Current, $V_{GS} @ 10V$ (Silicon Limited)	-53	
$I_D @ T_C = 25^\circ C$	Continuous Drain Current, $V_{GS} @ 10V$ (Wire Bond Limited)	-56	
$I_{DM}$	Pulsed Drain Current ①	-300	
$P_D @ T_C = 25^\circ C$	Power Dissipation	143	W
	Linear Derating Factor	0.95	W/°C
$V_{GS}$	Gate-to-Source Voltage	$\pm 20$	V
$E_{AS}$ (Thermally limited)	Single Pulse Avalanche Energy ②	270	mJ
$E_{AS}$ (Tested )	Single Pulse Avalanche Energy Tested Value ⑥	502	
$I_{AR}$	Avalanche Current ①	See Fig.17a, 17b, 14, 15	A
$E_{AR}$	Repetitive Avalanche Energy ⑤		mJ
$T_J$	Operating Junction and	-55 to + 175	°C
$T_{STG}$	Storage Temperature Range		
	Soldering Temperature, for 10 seconds	300 (1.6mm from case )	
	Mounting Torque, 6-32 or M3 screw ⑦	10 lbf•in (1.1N•m)	

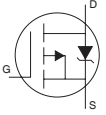
## Thermal Resistance

	Parameter	Typ.	Max.	Units
$R_{\theta JC}$	Junction-to-Case ⑧	—	1.05	°C/W
$R_{\theta CS}$	Case-to-Sink, Flat, Greased Surface ⑦	0.50	—	
$R_{\theta JA}$	Junction-to-Ambient ⑨	—	62	

## Electrical Characteristics @ $T_J = 25^\circ\text{C}$ (unless otherwise specified)

	Parameter	Min.	Typ.	Max.	Units	Conditions
$V_{(BR)DSS}$	Drain-to-Source Breakdown Voltage	-40	—	—	V	$V_{GS} = 0V, I_D = -250\mu A$
$\Delta V_{(BR)DSS}/\Delta T_J$	Breakdown Voltage Temp. Coefficient	—	0.03	—	V/ $^\circ\text{C}$	Reference to $25^\circ\text{C}, I_D = -1mA$
$R_{DS(on)}$	Static Drain-to-Source On-Resistance	—	—	16	m $\Omega$	$V_{GS} = -10V, I_D = -37A$ ③
		—	—	23		$V_{GS} = -4.5V, I_D = -30A$ ③
$V_{GS(th)}$	Gate Threshold Voltage	-1.0	-2.0	-3.0	V	$V_{DS} = V_{GS}, I_D = -100\mu A$
$g_{fs}$	Forward Transconductance	29	—	—	S	$V_{DS} = -10V, I_D = -37A$
$I_{DSS}$	Drain-to-Source Leakage Current	—	—	-25	$\mu A$	$V_{DS} = -40V, V_{GS} = 0V$
		—	—	-250		$V_{DS} = -40V, V_{GS} = 0V, T_J = 125^\circ\text{C}$
$I_{GSS}$	Gate-to-Source Forward Leakage	—	—	-100	nA	$V_{GS} = -20V$
	Gate-to-Source Reverse Leakage	—	—	100		$V_{GS} = 20V$
$Q_g$	Total Gate Charge	—	149	224	nC	$I_D = -37A$
$Q_{gs}$	Gate-to-Source Charge	—	27	—		$V_{DS} = -32V$
$Q_{gd}$	Gate-to-Drain ("Miller") Charge	—	31	—		$V_{GS} = -10V$ ③
$t_{d(on)}$	Turn-On Delay Time	—	27	—	ns	$V_{DD} = -20V$
$t_r$	Rise Time	—	383	—		$I_D = -37A$
$t_{d(off)}$	Turn-Off Delay Time	—	139	—		$R_G = 7.5 \Omega$
$t_f$	Fall Time	—	153	—		$V_{GS} = -10V$ ③
$L_D$	Internal Drain Inductance	—	4.5	—	nH	Between lead, 6mm (0.25in.) from package and center of die contact
$L_S$	Internal Source Inductance	—	7.5	—		
$C_{iss}$	Input Capacitance	—	7676	—	pF	$V_{GS} = 0V$
$C_{oss}$	Output Capacitance	—	654	—		$V_{DS} = -25V$
$C_{rss}$	Reverse Transfer Capacitance	—	539	—		$f = 1.0KHz$
$C_{oss}$	Output Capacitance	—	1747	—		$V_{GS} = 0V, V_{DS} = 1.0V, f = 1.0KHz$
$C_{oss}$	Output Capacitance	—	598	—		$V_{GS} = 0V, V_{DS} = -32V, f = 1.0KHz$
$C_{oss \text{ eff.}}$	Effective Output Capacitance	—	797	—		$V_{GS} = 0V, V_{DS} = 0V \text{ to } -32V$ ④

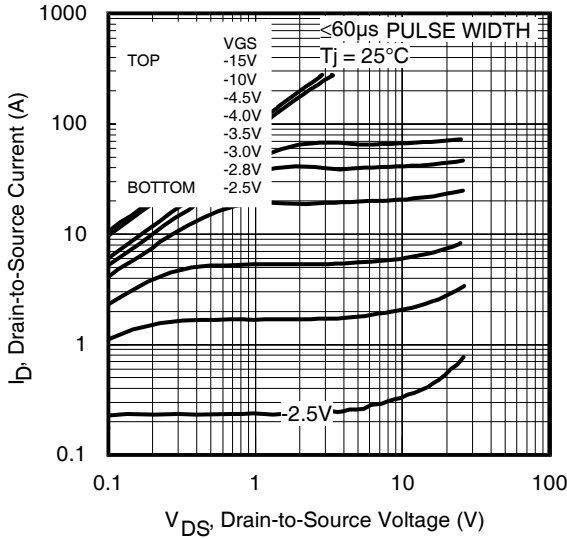
## Source-Drain Ratings and Characteristics

	Parameter	Min.	Typ.	Max.	Units	Conditions
$I_S$	Continuous Source Current (Body Diode)	—	—	-74	A	MOSFET symbol showing the integral reverse p-n junction diode.
$I_{SM}$	Pulsed Source Current (Body Diode) ①	—	—	-300		
$V_{SD}$	Diode Forward Voltage	—	—	-1.3	V	$T_J = 25^\circ\text{C}, I_S = -37A, V_{GS} = 0V$ ③
$t_{rr}$	Reverse Recovery Time	—	51	77	ns	$T_J = 25^\circ\text{C}, I_F = -37A, V_{DD} = -20V$
$Q_{rr}$	Reverse Recovery Charge	—	377	566	nC	$di/dt = 100A/\mu s$ ③
$t_{on}$	Forward Turn-On Time	Intrinsic turn-on time is negligible (turn-on is dominated by $L_S+L_D$ )				

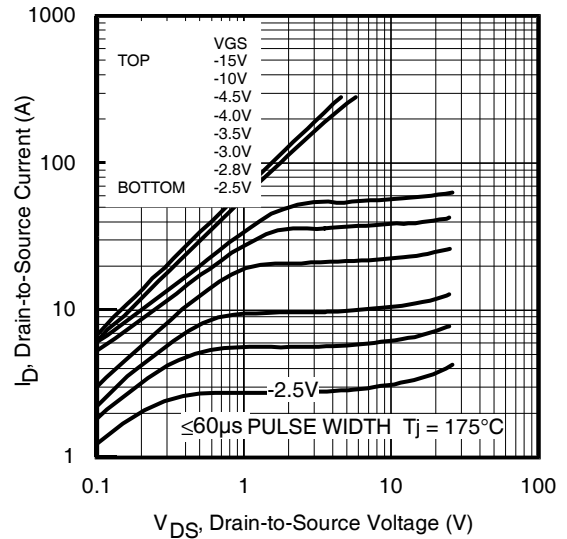
### Notes:

- ① Repetitive rating; pulse width limited by max. junction temperature. (See fig. 11).
- ② Limited by  $T_{Jmax}$ ; starting  $T_J = 25^\circ\text{C}, L = 0.399mH$   
 $R_G = 25\Omega, I_{AS} = -37A, V_{GS} = -10V$ . Part not recommended for use above this value.
- ③ Pulse width  $\leq 1.0ms$ ; duty cycle  $\leq 2\%$ .
- ④  $C_{oss \text{ eff.}}$  is a fixed capacitance that gives the same charging time as  $C_{oss}$  while  $V_{DS}$  is rising from 0 to 80%  $V_{DSS}$ .

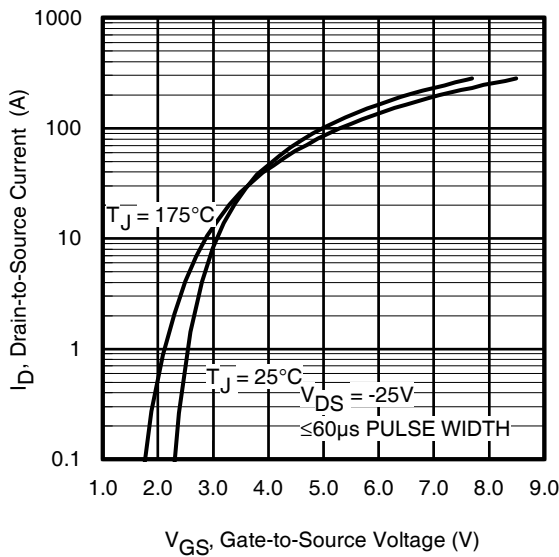
- ⑤ Limited by  $T_{Jmax}$ , see Fig.17a, 17b, 14, 15 for typical repetitive avalanche performance.
- ⑥ This value determined from sample failure population. 100% tested to this value in production.
- ⑦ This is only applied to TO-220AB package.
- ⑧  $R_\theta$  is measured at  $T_J$  approximately  $90^\circ\text{C}$



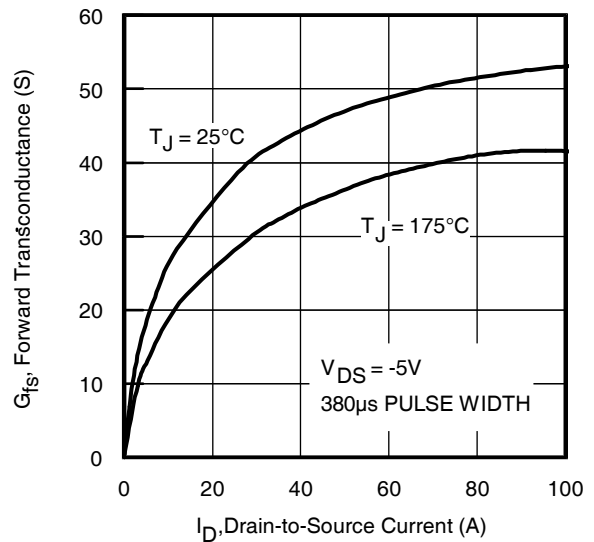
**Fig 1.** Typical Output Characteristics



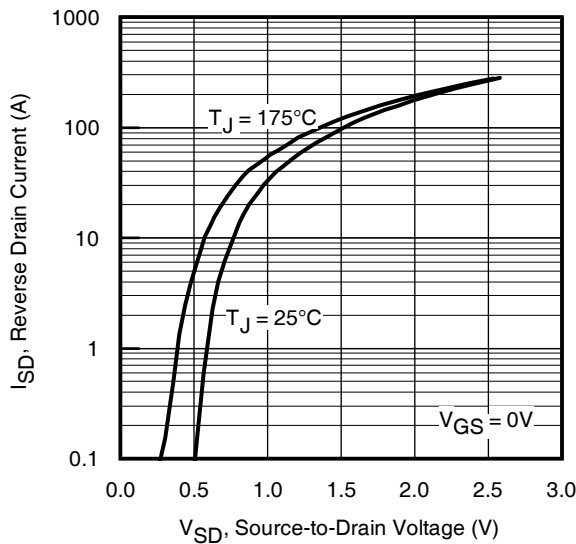
**Fig 2.** Typical Output Characteristics



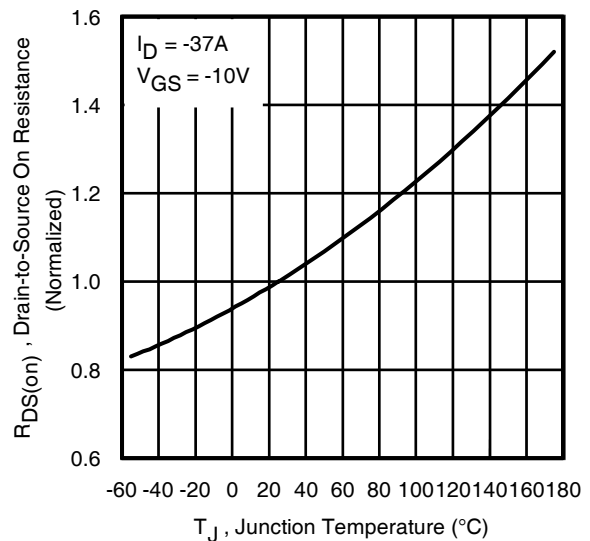
**Fig 3.** Typical Transfer Characteristics



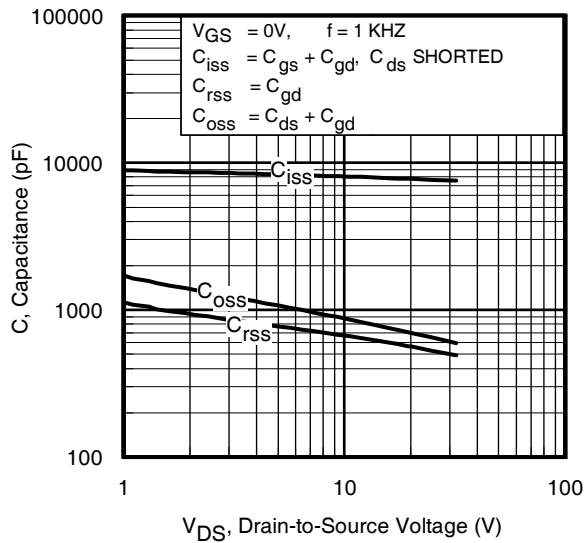
**Fig 4.** Typical Forward Transconductance Vs. Drain Current



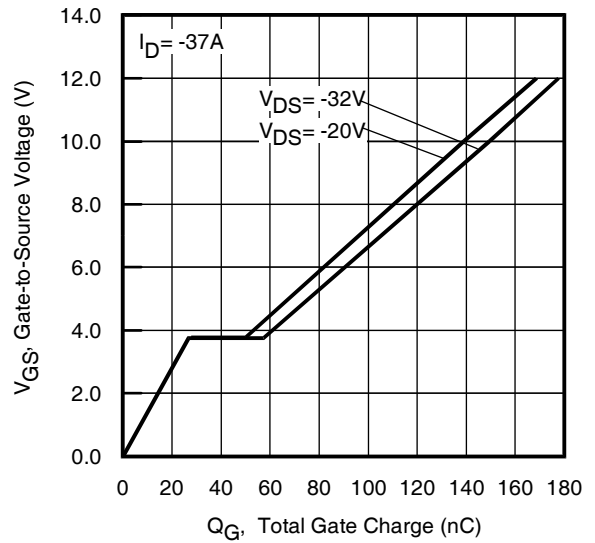
**Fig 5.** Typical Source-Drain Diode Forward Voltage  
[www.irf.com](http://www.irf.com)



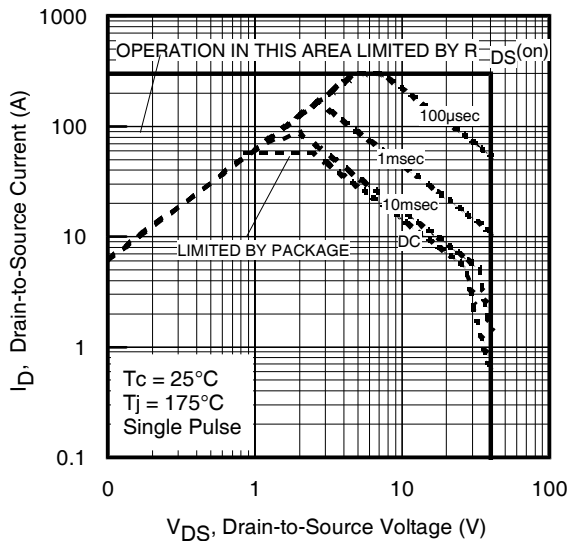
**Fig 6.** Normalized On-Resistance Vs. Temperature



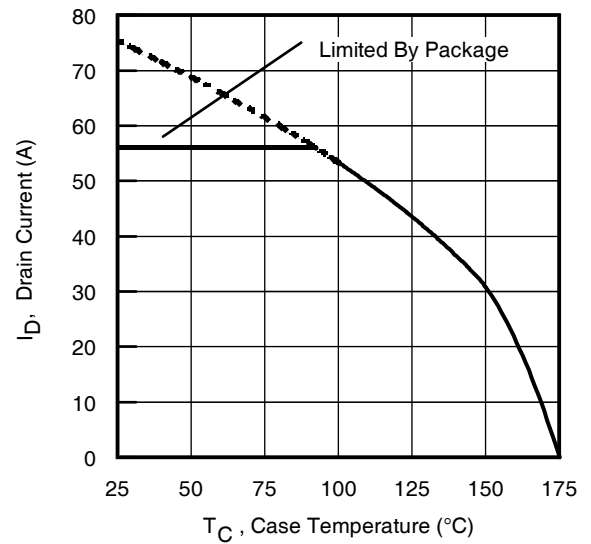
**Fig 7.** Typical Capacitance Vs. Drain-to-Source Voltage



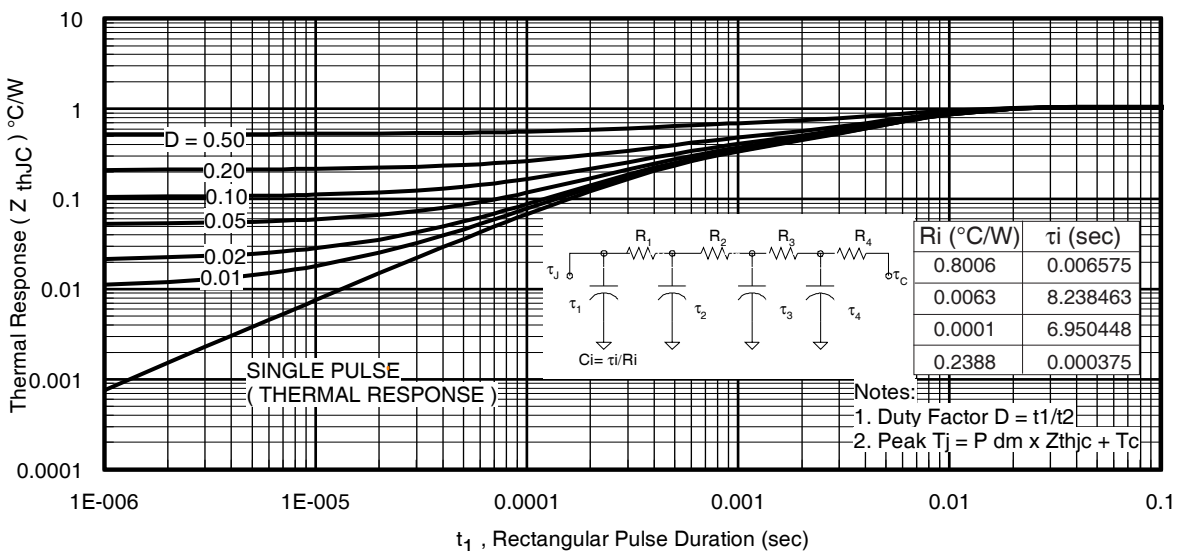
**Fig 8.** Typical Gate Charge Vs. Gate-to-Source Voltage



**Fig 9.** Maximum Safe Operating Area



**Fig 10.** Maximum Drain Current Vs. Case Temperature



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

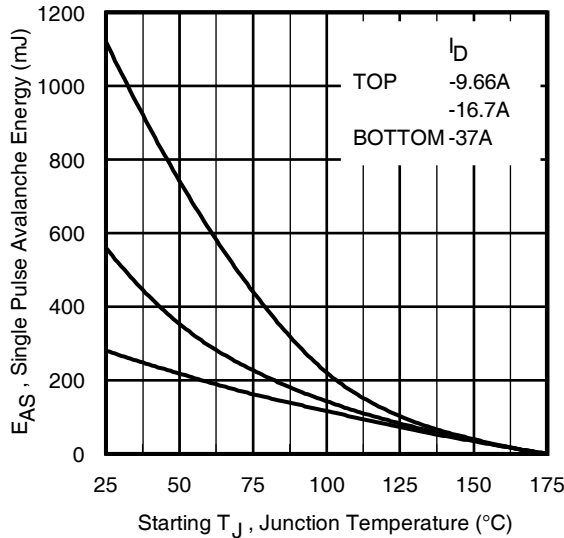


Fig 12. Maximum Avalanche Energy Vs. Drain Current

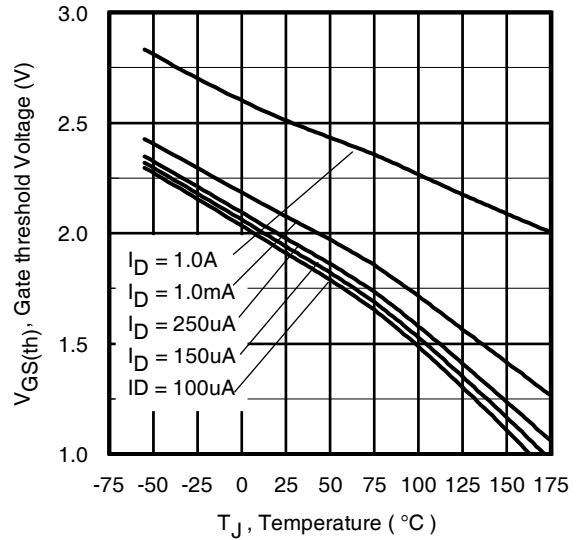


Fig 13. Threshold Voltage Vs. Temperature

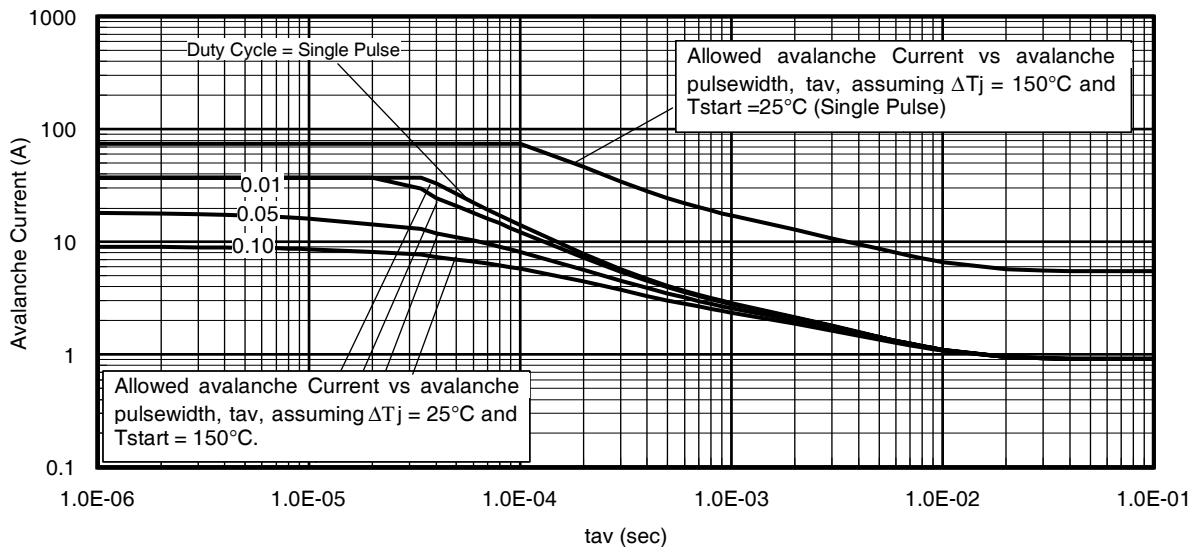


Fig 14. Typical Avalanche Current Vs. Pulsewidth

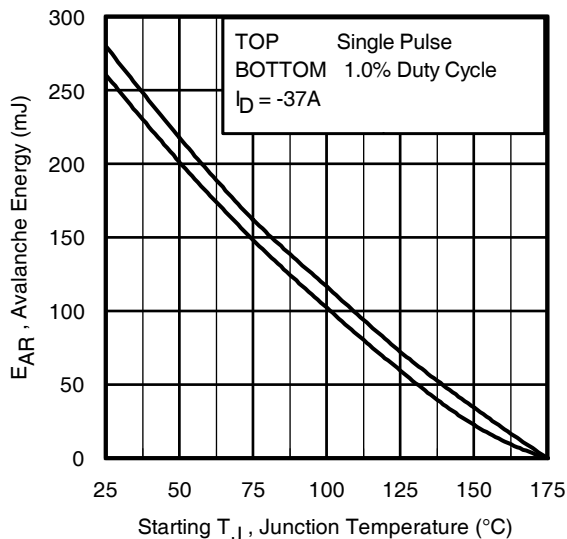


Fig 15. Maximum Avalanche Energy Vs. Temperature

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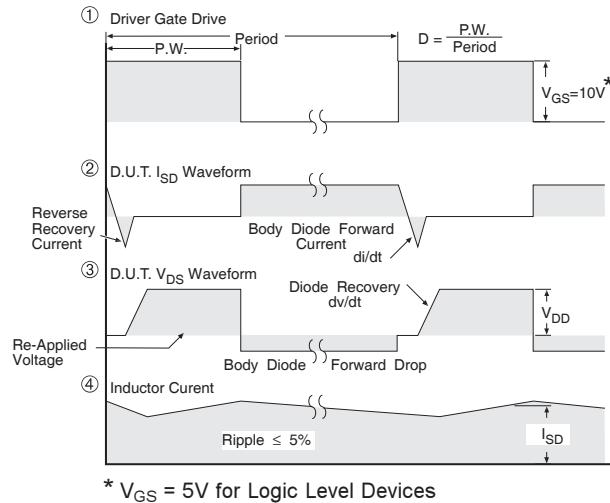
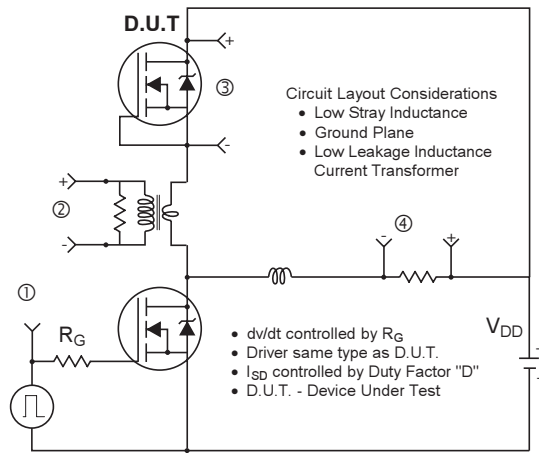
**Notes on Repetitive Avalanche Curves , Figures 14, 15:**  
(For further info, see AN-1005 at www.irf.com)

1. Avalanche failures assumption:  
Purely a thermal phenomenon and failure occurs at a temperature far in excess of  $T_{jmax}$ . This is validated for every part type.
2. Safe operation in Avalanche is allowed as long as  $T_{jmax}$  is not exceeded.
3. Equation below based on circuit and waveforms shown in Figures 17a, 17b.
4.  $P_{D(ave)}$  = Average power dissipation per single avalanche pulse.
5. BV = Rated breakdown voltage (1.3 factor accounts for voltage increase during avalanche).
6.  $I_{av}$  = Allowable avalanche current.
7.  $\Delta T$  = Allowable rise in junction temperature, not to exceed  $T_{jmax}$  (assumed as 25°C in Figure 14, 15).  
 $t_{av}$  = Average time in avalanche.  
 $D$  = Duty cycle in avalanche =  $t_{av} \cdot f$   
 $Z_{thJC}(D, t_{av})$  = Transient thermal resistance, see figure 11)

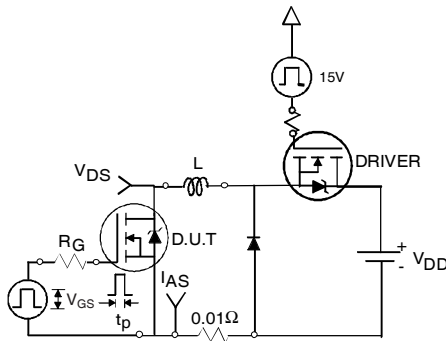
$$P_{D(ave)} = 1/2 ( 1.3 \cdot BV \cdot I_{av} ) = \Delta T / Z_{thJC}$$

$$I_{av} = 2\Delta T / [1.3 \cdot BV \cdot Z_{th}]$$

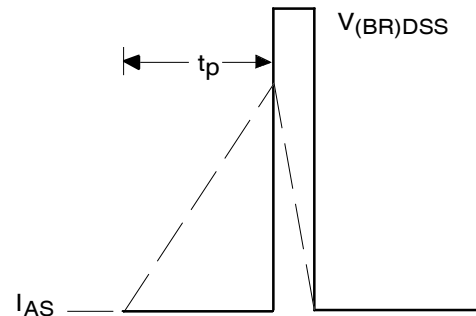
$$E_{AS(AR)} = P_{D(ave)} \cdot t_{av}$$



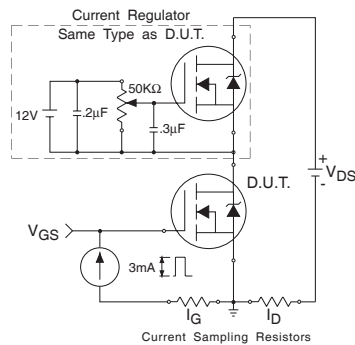
**Fig 16.** Peak Diode Recovery  $dv/dt$  Test Circuit for N-Channel HEXFET® Power MOSFETs



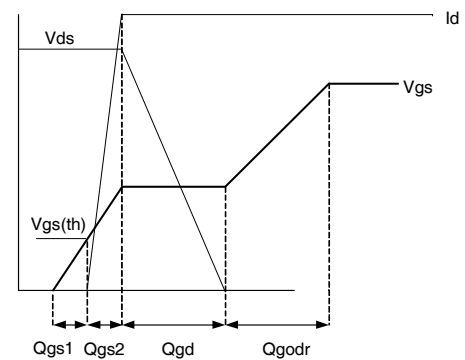
**Fig 17a.** Unclamped Inductive Test Circuit



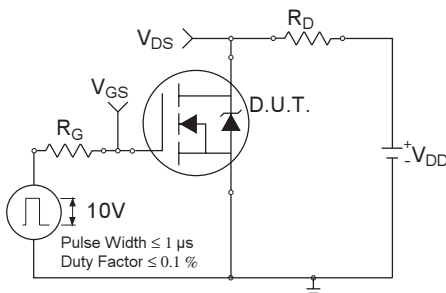
**Fig 17b.** Unclamped Inductive Waveforms



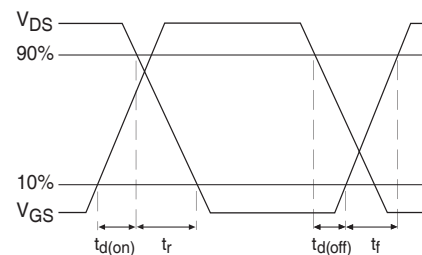
**Fig 18a.** Gate Charge Test Circuit



**Fig 18b.** Gate Charge Waveform



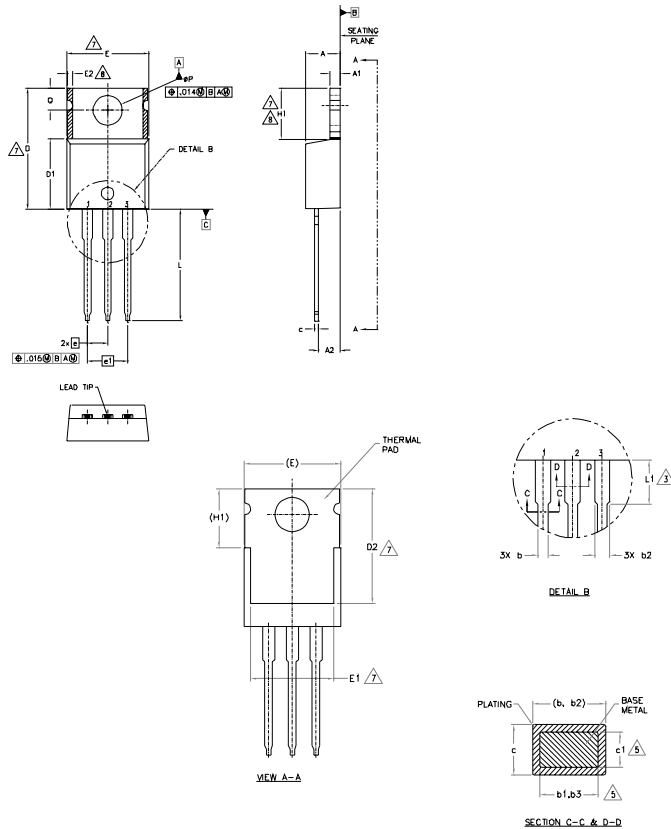
**Fig 19a.** Switching Time Test Circuit



**Fig 19b.** Switching Time Waveforms

## TO-220AB Package Outline

Dimensions are shown in millimeters (inches)



**NOTES:**

- 1.- DIMENSIONING AND TOLERANCING AS PER ASME Y14.5 M- 1994.
- 2.- DIMENSIONS ARE SHOWN IN INCHES [MILLIMETERS].
- 3.- LEAD DIMENSION AND FINISH UNCONTROLLED IN L1.
- 4.- DIMENSION D, D1 & E DO NOT INCLUDE MOLD FLASH. MOLD FLASH SHALL NOT EXCEED .005" (0.127) PER SIDE. THESE DIMENSIONS ARE MEASURED AT THE OUTERMOST EXTREMES OF THE PLASTIC BODY.
- 5.- DIMENSION b1, b3 & c1 APPLY TO BASE METAL ONLY.
- 6.- CONTROLLING DIMENSION : INCHES.
- 7.- THERMAL PAD CONTOUR OPTIONAL WITHIN DIMENSIONS E,H1,D2 & E1
- 8.- DIMENSION E2 X H1 DEFINE A ZONE WHERE STAMPING AND SINGULATION IRREGULARITIES ARE ALLOWED.
- 9.- OUTLINE CONFORMS TO JEDEC TO-220, EXCEPT A2 (max.) AND D2 (min.) WHERE DIMENSIONS ARE DERIVED FROM THE ACTUAL PACKAGE OUTLINE.

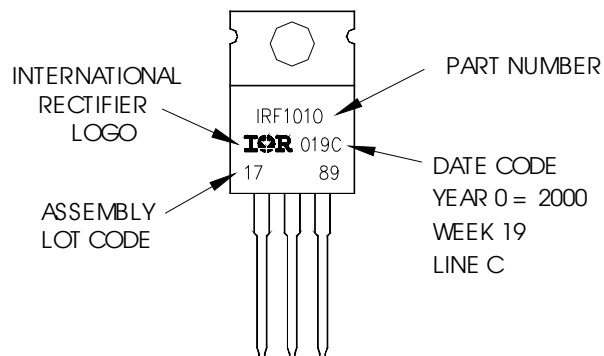
SYMBOL	DIMENSIONS				NOTES
	MILLIMETERS		INCHES		
	MIN.	MAX.	MIN.	MAX.	
A	3.56	4.83	.140	.190	
A1	0.51	1.40	.020	.055	
A2	2.03	2.92	.080	.115	
b	0.38	1.01	.015	.040	
b1	0.38	0.97	.015	.038	5
b2	1.14	1.78	.045	.070	
b3	1.14	1.73	.045	.068	5
c	0.36	0.61	.014	.024	
c1	0.36	0.56	.014	.022	5
D	14.22	16.51	.560	.650	4
D1	8.38	9.02	.330	.355	
D2	11.68	12.88	.460	.507	7
E	9.65	10.67	.380	.420	4,7
E1	6.86	8.89	.270	.350	7
E2	-	0.76	-	.030	8
e	2.54 BSC		.100 BSC		
e1	5.08 BSC		.200 BSC		
H1	5.84	6.86	.230	.270	7,8
L	12.70	14.73	.500	.580	
L1	3.56	4.06	.140	.160	3
øP	3.54	4.08	.139	.161	
Q	2.54	3.42	.100	.135	

- LEAD ASSIGNMENTS**
- HEXFET**
- 1.- GATE
  - 2.- DRAIN
  - 3.- SOURCE
- IRFzL CoPAK**
- 1.- GATE
  - 2.- COLLECTOR
  - 3.- EMITTER
- DIODES**
- 1.- ANODE
  - 2.- CATHODE
  - 3.- ANODE

## TO-220AB Part Marking Information

EXAMPLE: THIS IS AN IRF1010  
 LOT CODE 1789  
 ASSEMBLED ON WW 19, 2000  
 IN THE ASSEMBLY LINE "C"

Note: "P" in assembly line position indicates "Lead-Free"



TO-220AB packages are not recommended for Surface Mount Application.

Note: For the most current drawing please refer to IR website at <http://www.irf.com/package/>

Data and specifications subject to change without notice.  
 This product has been designed for the Industrial market.  
 Qualification Standards can be found on IR's Web site.