

# IRF1503PbF

## Typical Applications

- Industrial Motor Drive

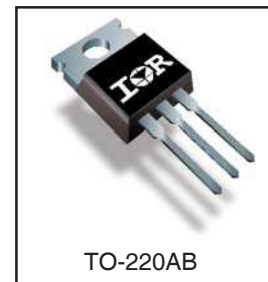
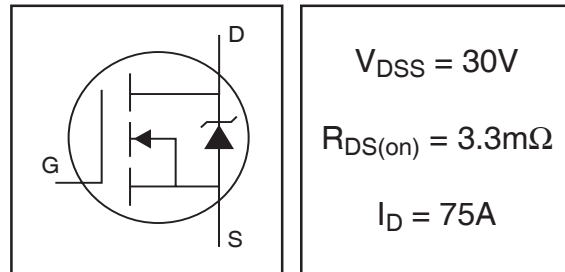
## Features

- Advanced Process Technology
- Ultra Low On-Resistance
- 175°C Operating Temperature
- Fast Switching
- Repetitive Avalanche Allowed up to Tjmax

## Description

This design of HEXFET® Power MOSFETs utilizes the latest processing techniques to achieve extremely low on-resistance per silicon area. Additional features of this HEXFET power MOSFET are a 175°C junction operating temperature, fast switching speed and improved repetitive avalanche rating. These combine to make this design an extremely efficient and reliable device for use in a wide variety of applications.

## HEXFET® Power MOSFET



## Absolute Maximum Ratings

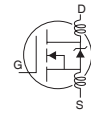
	Parameter	Max.	Units
$I_D @ T_C = 25^\circ C$	Continuous Drain Current, $V_{GS} @ 10V$ (Silicon limited)	240	A
$I_D @ T_C = 100^\circ C$	Continuous Drain Current, $V_{GS} @ 10V$ (See Fig.9)	170	
$I_D @ T_C = 25^\circ C$	Continuous Drain Current, $V_{GS} @ 10V$ (Package limited)	75	
$I_{DM}$	Pulsed Drain Current ①	960	
$P_D @ T_C = 25^\circ C$	Power Dissipation	330	W
	Linear Derating Factor	2.2	W/°C
$V_{GS}$	Gate-to-Source Voltage	$\pm 20$	V
$E_{AS}$	Single Pulse Avalanche Energy②	510	mJ
$E_{AS}$ (tested)	Single Pulse Avalanche Energy Tested Value⑥	980	
$I_{AR}$	Avalanche Current①	See Fig.12a, 12b, 15, 16	A
$E_{AR}$	Repetitive Avalanche Energy⑤		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 )	

## Thermal Resistance

	Parameter	Typ.	Max.	Units
$R_{\theta JC}$	Junction-to-Case	—	0.45	°C/W
$R_{\theta CS}$	Case-to-Sink, Flat, Greased Surface	0.50	—	
$R_{\theta JA}$	Junction-to-Ambient	—	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	30	—	—	V	$V_{GS} = 0V, I_D = 250\mu A$
$\Delta V_{(BR)DSS}/\Delta T_J$	Breakdown Voltage Temp. Coefficient	—	0.028	—	$V/^\circ\text{C}$	Reference to $25^\circ\text{C}, I_D = 1\text{mA}$
$R_{DS(on)}$	Static Drain-to-Source On-Resistance	—	2.6	3.3	$\text{m}\Omega$	$V_{GS} = 10V, I_D = 140A$ ③
$V_{GS(th)}$	Gate Threshold Voltage	2.0	—	4.0	V	$V_{DS} = 10V, I_D = 250\mu A$
$g_{fs}$	Forward Transconductance	75	—	—	S	$V_{DS} = 25V, I_D = 140A$
$I_{DSS}$	Drain-to-Source Leakage Current	—	—	20	$\mu A$	$V_{DS} = 30V, V_{GS} = 0V$
		—	—	250		$V_{DS} = 30V, V_{GS} = 0V, T_J = 125^\circ\text{C}$
$I_{GSS}$	Gate-to-Source Forward Leakage	—	—	200	nA	$V_{GS} = 20V$
	Gate-to-Source Reverse Leakage	—	—	-200		$V_{GS} = -20V$
$Q_g$	Total Gate Charge	—	130	200	nC	$I_D = 140A$
$Q_{gs}$	Gate-to-Source Charge	—	36	54		$V_{DS} = 24V$
$Q_{gd}$	Gate-to-Drain ("Miller") Charge	—	41	62		$V_{GS} = 10V$
$t_{d(on)}$	Turn-On Delay Time	—	17	—	ns	$V_{DD} = 15V$
$t_r$	Rise Time	—	130	—		$I_D = 140A$
$t_{d(off)}$	Turn-Off Delay Time	—	59	—		$R_G = 2.5\Omega$
$t_f$	Fall Time	—	48	—		$V_{GS} = 10V$ ③
$L_D$	Internal Drain Inductance	—	5.0	—	nH	Between lead, 6mm (0.25in.) from package and center of die contact
$L_S$	Internal Source Inductance	—	13	—		
$C_{iss}$	Input Capacitance	—	5730	—	pF	$V_{GS} = 0V$
$C_{oss}$	Output Capacitance	—	2250	—		$V_{DS} = 25V$
$C_{rss}$	Reverse Transfer Capacitance	—	290	—		$f = 1.0\text{MHz}$ , See Fig. 5
$C_{oss}$	Output Capacitance	—	7580	—		$V_{GS} = 0V, V_{DS} = 1.0V, f = 1.0\text{MHz}$
$C_{oss}$	Output Capacitance	—	2290	—		$V_{GS} = 0V, V_{DS} = 24V, f = 1.0\text{MHz}$
$C_{oss \text{ eff.}}$	Effective Output Capacitance ④	—	3420	—		$V_{GS} = 0V, V_{DS} = 0V \text{ to } 24V$

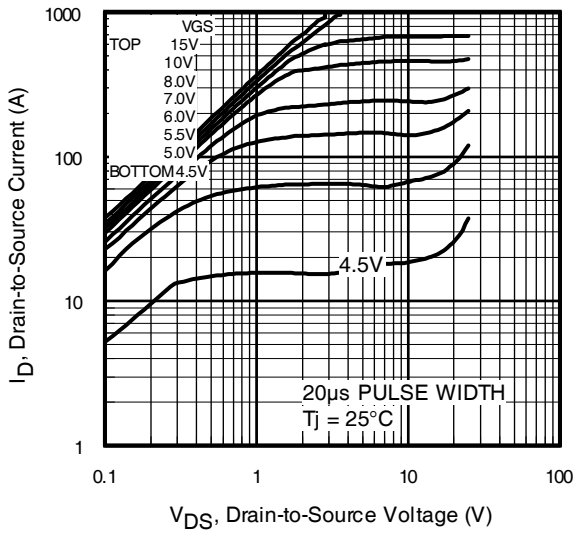


## Source-Drain Ratings and Characteristics

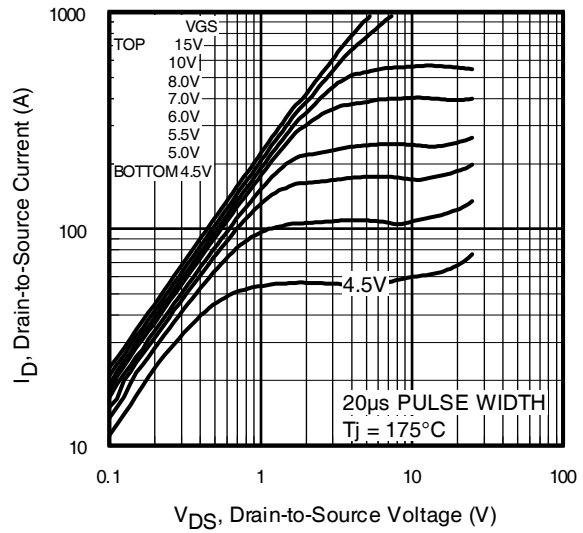
	Parameter	Min.	Typ.	Max.	Units	Conditions
$I_S$	Continuous Source Current (Body Diode)	—	—	240	A	MOSFET symbol showing the integral reverse p-n junction diode.
$I_{SM}$	Pulsed Source Current (Body Diode) ①	—	—	960		
$V_{SD}$	Diode Forward Voltage	—	—	1.3	V	$T_J = 25^\circ\text{C}, I_S = 140A, V_{GS} = 0V$ ③
$t_{rr}$	Reverse Recovery Time	—	71	110	ns	$T_J = 25^\circ\text{C}, I_F = 140A, V_{DD} = 15V$
$Q_{rr}$	Reverse Recovery Charge	—	110	170	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:

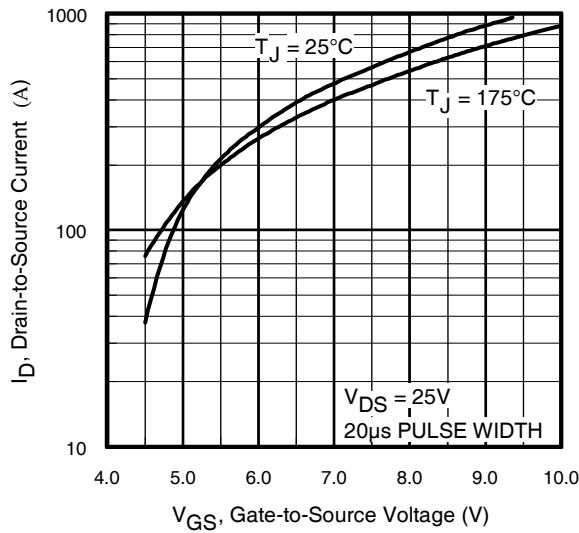
- ① Repetitive rating; pulse width limited by max. junction temperature. (See fig. 11).
- ② Starting  $T_J = 25^\circ\text{C}$ ,  $L = 0.049\text{mH}$ ,  $R_G = 25\Omega$ ,  $I_{AS} = 140A$ . (See Figure 12).
- ③ Pulse width  $\leq 400\mu s$ ; duty cycle  $\leq 2\%$ .
- ④  $C_{oss \text{ eff.}}$  is 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.12a, 12b, 15, 16 for typical repetitive avalanche performance.
- ⑥ This value determined from sample failure population. 100% tested to this value in production.



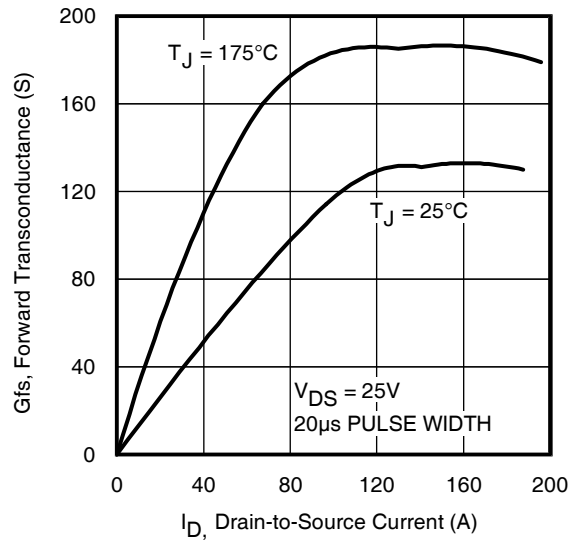
**Fig 1.** Typical Output Characteristics



**Fig 2.** Typical Output Characteristics

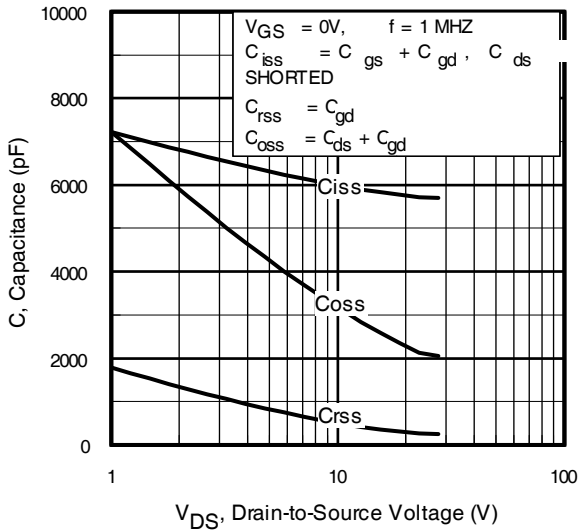


**Fig 3.** Typical Transfer Characteristics

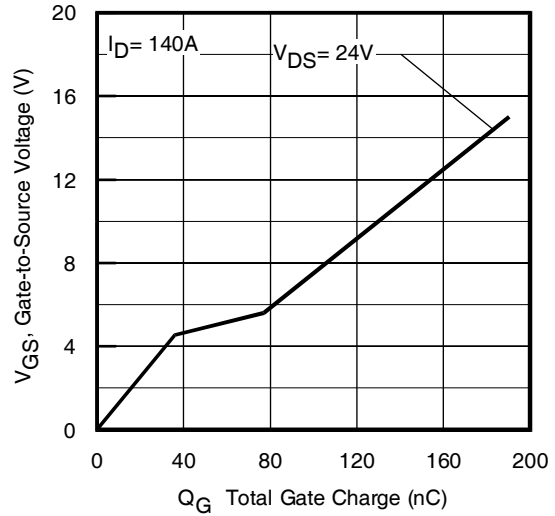


**Fig 4.** Typical Forward Transconductance Vs. Drain Current

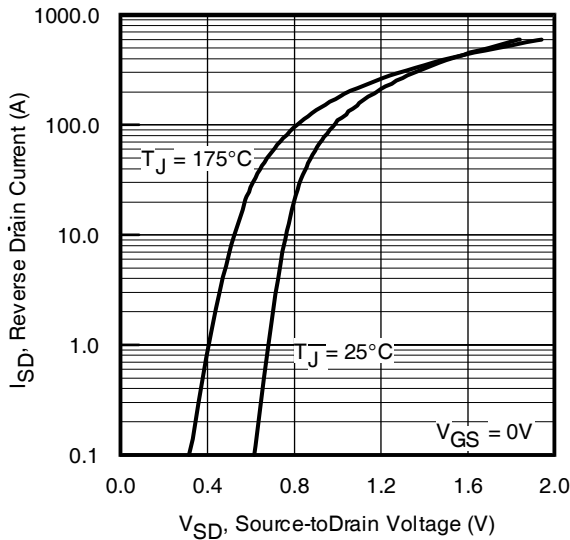
# IRF1503PbF



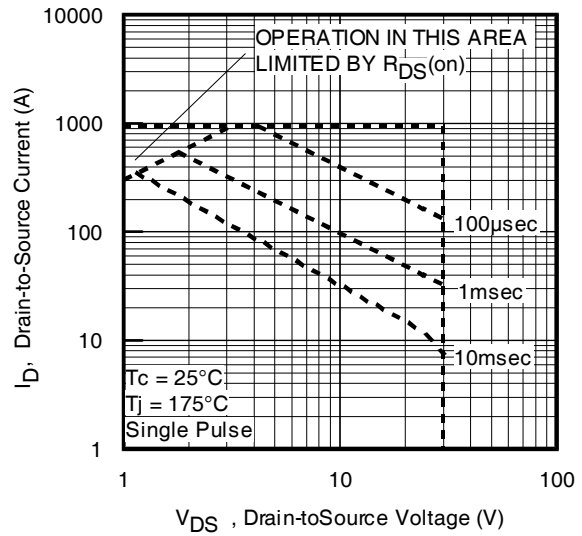
**Fig 5.** Typical Capacitance Vs. Drain-to-Source Voltage



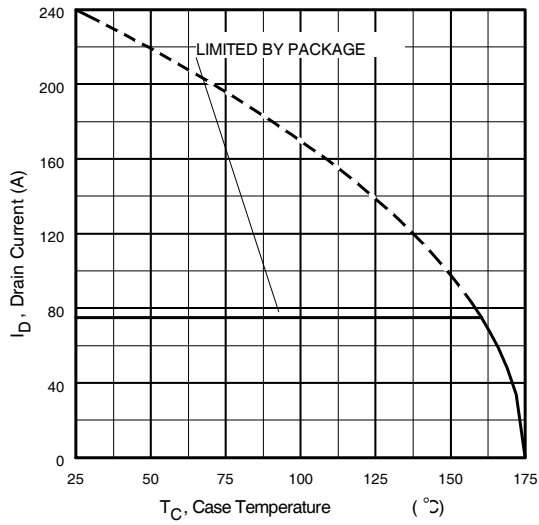
**Fig 6.** Typical Gate Charge Vs. Gate-to-Source Voltage



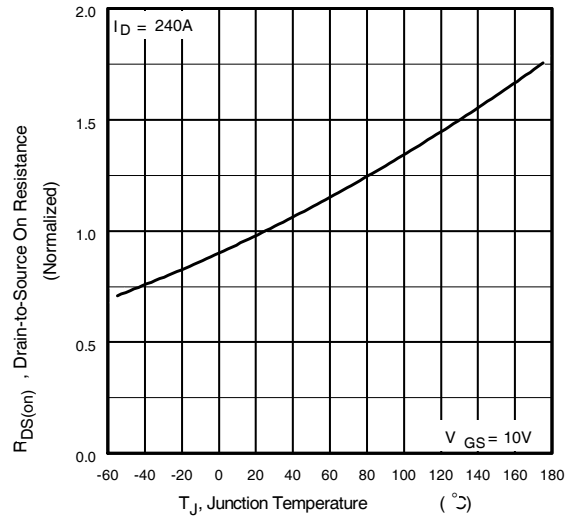
**Fig 7.** Typical Source-Drain Diode Forward Voltage



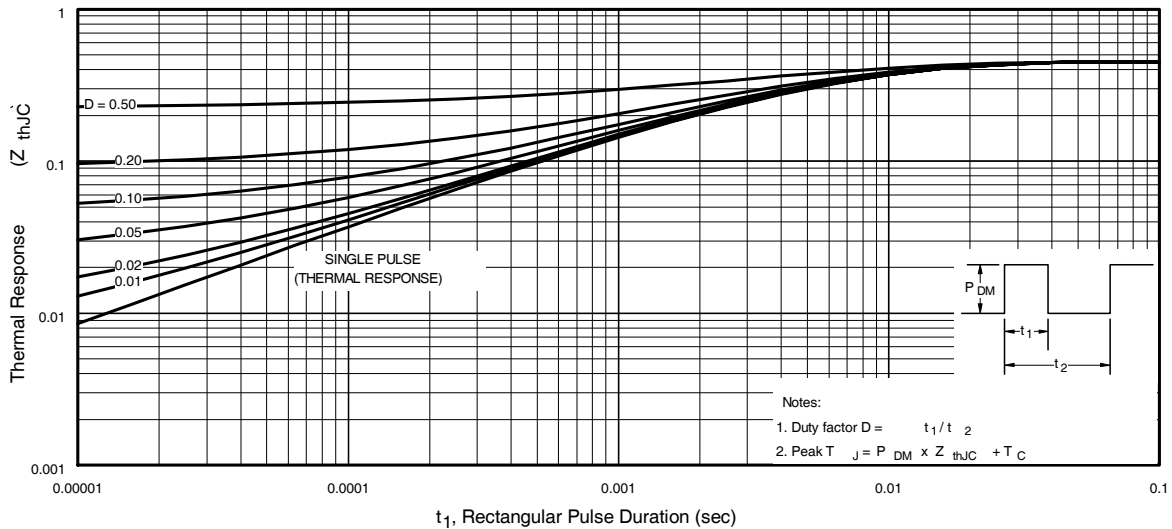
**Fig 8.** Maximum Safe Operating Area



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

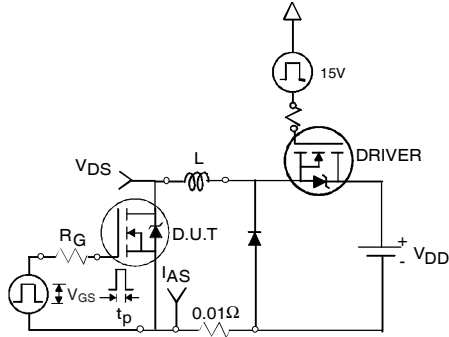


**Fig 10.** Normalized On-Resistance Vs. Temperature

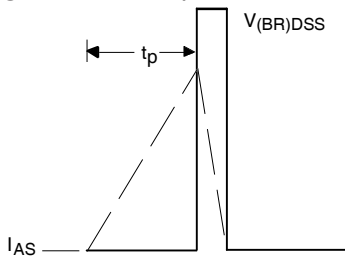


**Fig 11.** Maximum Effective Transient Thermal Impedance, Junction-to-Case

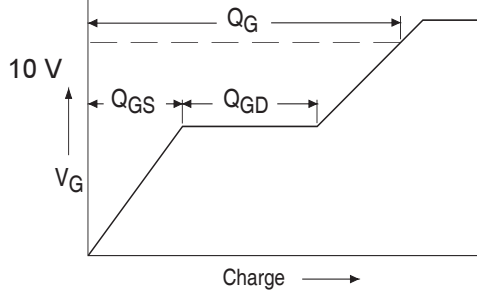
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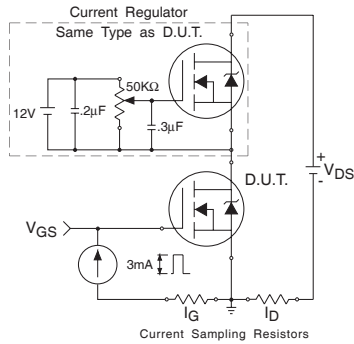
**Fig 12a.** Unclamped Inductive Test Circuit



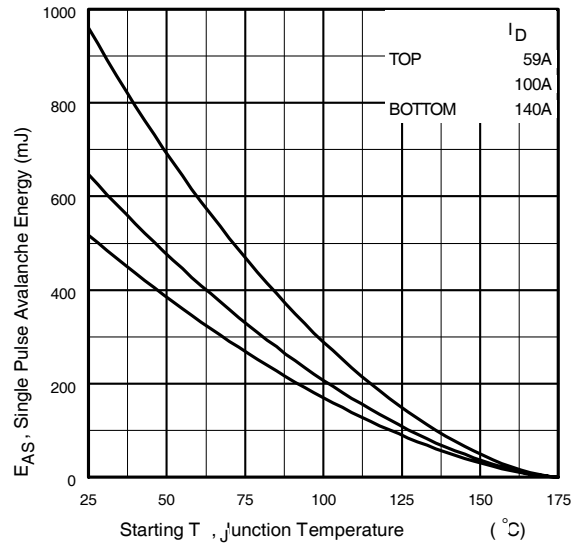
**Fig 12b.** Unclamped Inductive Waveforms



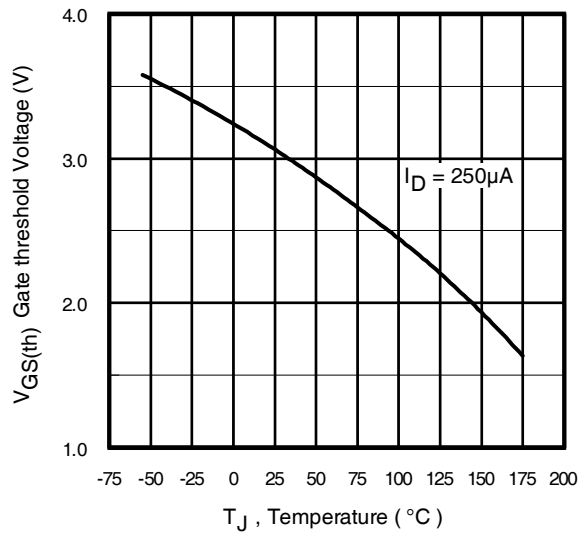
**Fig 13a.** Basic Gate Charge Waveform



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



**Fig 12c.** Maximum Avalanche Energy Vs. Drain Current



**Fig 14.** Threshold Voltage Vs. Temperature

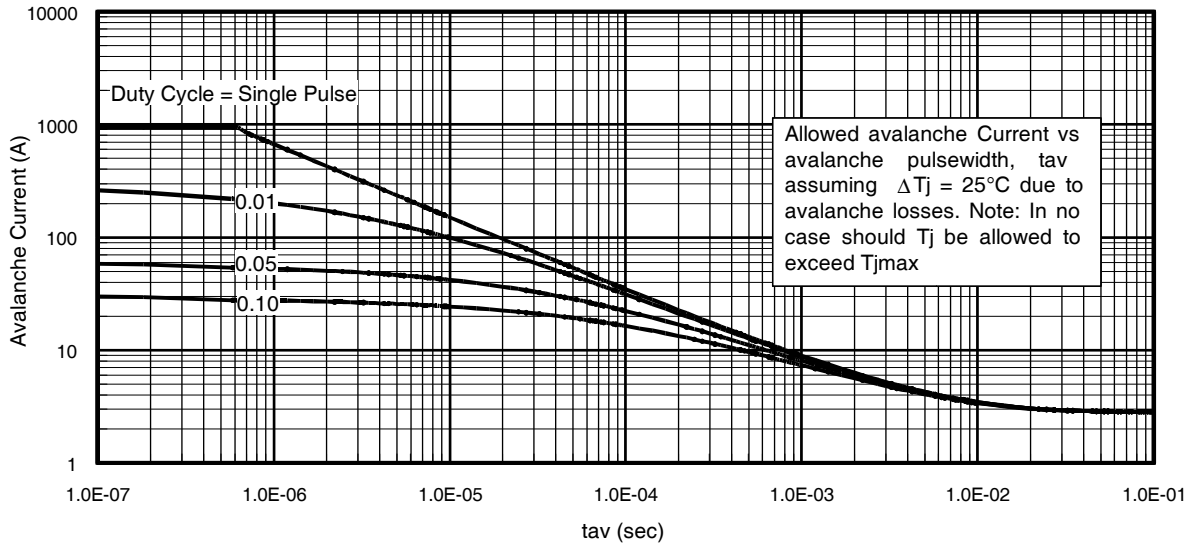


Fig 15. Typical Avalanche Current Vs.Pulsewidth

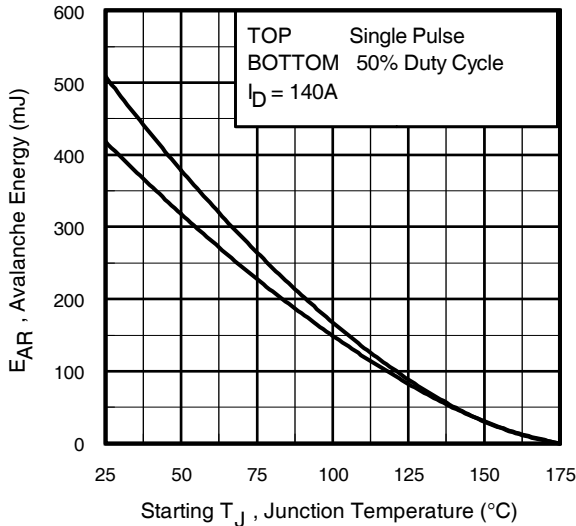


Fig 16. Maximum Avalanche Energy Vs. Temperature

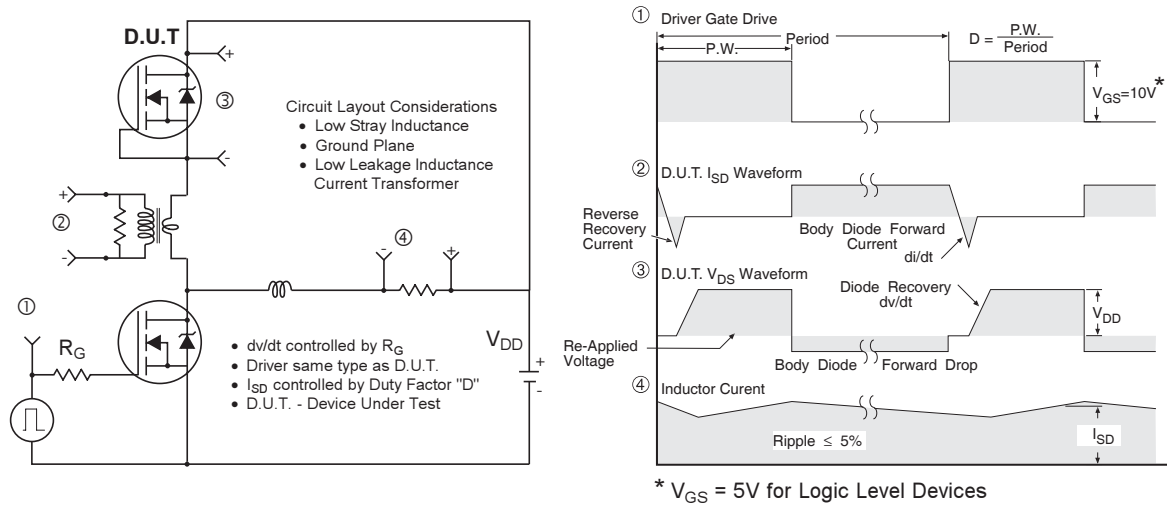
**Notes on Repetitive Avalanche Curves , Figures 15, 16:  
(For further info, see AN-1005 at www.irf.com)**

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 12a, 12b.
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 15, 16).  
 $t_{av}$  = Average time in avalanche.  
D = Duty cycle in avalanche =  $t_{av} \cdot f$   
 $Z_{thJC}(D, t_{av})$  = Transient thermal resistance, see figure 11)

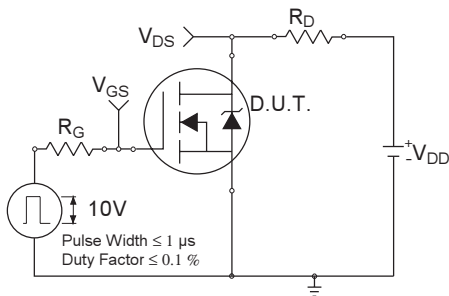
$$P_{D(ave)} = 1/2 ( 1.3 \cdot BV \cdot I_{av} ) = \Delta T / Z_{thJC}$$

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

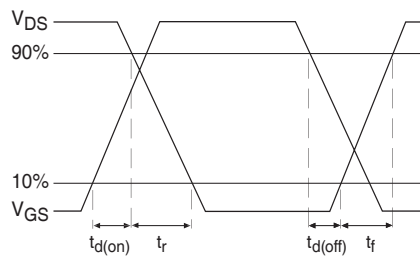
$$E_{AS(AR)} = P_{D(ave)} \cdot t_{av}$$



**Fig 17. Peak Diode Recovery  $dv/dt$  Test Circuit for N-Channel HEXFET® Power MOSFETs**



**Fig 18a. Switching Time Test Circuit**

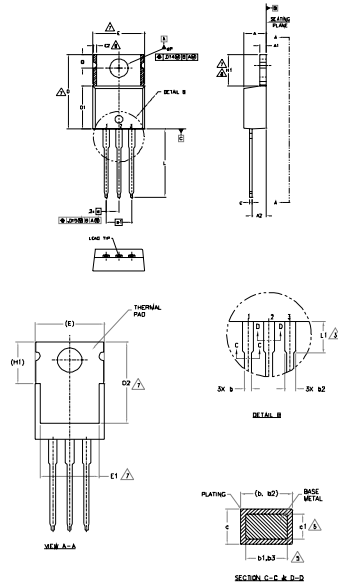


**Fig 18b. Switching Time Waveforms**



## TO-220AB Package Outline

Dimensions are shown in millimeters (inches)



- NOTES
1. DIMENSIONS AND TOLERANCES AS PER ASSE 1745 M- 1994
  2. DIMENSIONS ARE SHOWN IN INCHES (MILLIMETERS)
  3. LEAD DIMENSION AND FINISH UNCONTROLLED IN LT
  4. DIMENSION D1, D2 & D3 DO NOT INCLUDE MOLD FLASH. MOLD FLASH SHALL NOT EXCEED .007" (0.177) PER SIDE. THESE DIMENSIONS ARE MEASURED AT THE OUTERMOST EDGES OF THE PLASTIC BODY.
  5. DIMENSION D1, D2 & c1 APPLY TO BASE METAL ONLY
  6. CONTROLLING DIMENSION - INCHES
  7. THERMAL PAD CONTOUR OPTIONAL. WITHIN DIMENSIONS E1/D2 & E1
  8. DIMENSION E2 ≥ H1 DEFINE A ZONE WHERE STAMPING AND SOLDERATION DISCREPANCIES ARE ALLOWED
  9. OUTLINE DIMENSIONS TO EXEC 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	5.56	4.83	.140	.191	
A1	0.51	1.40	.020	.055	
A2	2.03	2.92	.080	.115	
B	0.38	1.01	.015	.040	5
b1	0.30	0.97	.015	0.08	5
b2	1.14	1.78	.045	0.070	5
b3	1.14	1.73	.045	.066	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	8.39	9.02	.330	.355	
D2	11.68	12.88	.460	.507	7
E	9.85	10.67	.380	.420	4,7
E1	6.86	6.89	.270	.269	7
E2	-	0.76	-	.030	8
H1	5.84	6.86	.230	.270	7,8
L	12.70	14.73	.500	.580	
L1	1.56	4.08	.140	.160	3
ØP	3.54	4.08	.139	.161	
Ø	2.54	3.42	.100	.135	

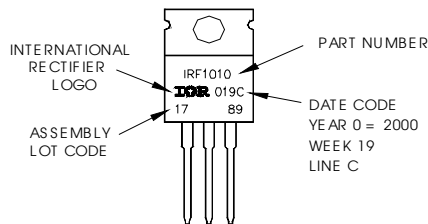
**LEAD DIMENSIONS**

- UNIT: 1- GAGE  
2- DIMEN  
3- SOURCE
- UNIT: 1- GAGE  
2- DIMEN  
3- SOURCE

## 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 package is not recommended for Surface Mount Application.**

**Notes:**

1. For an Automotive Qualified version of this part please see <http://www.irf.com/product-info/auto/>
2. 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 and qualified for Industrial market.  
Qualification Standards can be found on IR's Web site.