

# International Rectifier

## Applications

- Motion Control Applications
- High Efficiency Synchronous Rectification in SMPS
- Uninterruptible Power Supply
- Hard Switched and High Frequency Circuits

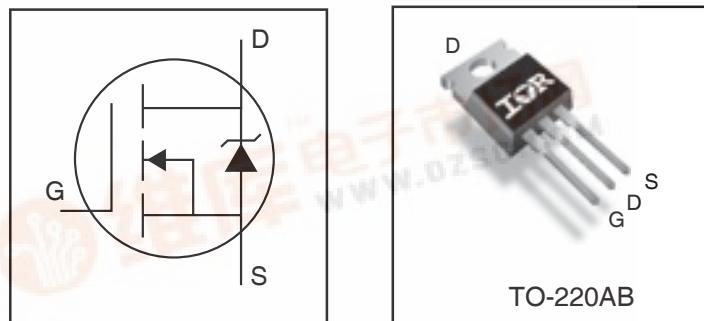
## Benefits

- Low  $R_{DS(on)}$  Reduces Losses
- Low Gate Charge Improves the Switching Performance
- Improved Diode Recovery Improves Switching & EMI Performance
- 30V Gate Voltage Rating Improves Robustness
- Fully Characterized Avalanche SOA

# IRFB4321PbF

HEXFET® Power MOSFET

$V_{DSS}$	150V
$R_{DS(on)}$	typ. 12mΩ
	max. 15mΩ
$I_D$	83A



G	D	S
Gate	Drain	Source

## Absolute Maximum Ratings

Symbol	Parameter	Max.	Units
$I_D @ T_C = 25^\circ C$	Continuous Drain Current, $V_{GS} @ 10V$	83 ①	A
$I_D @ T_C = 100^\circ C$	Continuous Drain Current, $V_{GS} @ 10V$	59	
$I_{DM}$	Pulsed Drain Current ②	330	
$P_D @ T_C = 25^\circ C$	Maximum Power Dissipation	330	W
	Linear Derating Factor	2.2	W/ $^\circ C$
$V_{GS}$	Gate-to-Source Voltage	$\pm 30$	V
$E_{AS}$ (Thermally limited)	Single Pulse Avalanche Energy ③	120	mJ
$T_J$	Operating Junction and	-55 to + 175	
$T_{STG}$	Storage Temperature Range		$^\circ C$
	Soldering Temperature, for 10 seconds (1.6mm from case)	300	
	Mounting torque, 6-32 or M3 screw	10lb-in (1.1N·m)	

## Thermal Resistance

	Parameter	Typ.	Max.	Units
$R_{\theta JC}$	Junction-to-Case ⑤	—	0.45	$^\circ C/W$
$R_{\theta CS}$	Case-to-Sink, Flat, Greased Surface	0.50	—	
$R_{\theta JA}$	Junction-to-Ambient ⑤	—	62	

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

Symbol	Parameter	Min.	Typ.	Max.	Units	Conditions
$V_{(\text{BR})\text{DSS}}$	Drain-to-Source Breakdown Voltage	150	—	—	V	$V_{GS} = 0V, I_D = 250\mu\text{A}$
$\Delta V_{(\text{BR})\text{DSS}/\Delta T_J}$	Breakdown Voltage Temp. Coefficient	—	150	—	mV/ $^\circ\text{C}$	Reference to $25^\circ\text{C}, I_D = 1\text{mA}$ ②
$R_{DS(\text{on})}$	Static Drain-to-Source On-Resistance	—	12	15	$\text{m}\Omega$	$V_{GS} = 10V, I_D = 33\text{A}$ ④
$V_{GS(\text{th})}$	Gate Threshold Voltage	3.0	—	5.0	V	$V_{DS} = V_{GS}, I_D = 250\mu\text{A}$
$I_{DSS}$	Drain-to-Source Leakage Current	—	—	20	$\mu\text{A}$	$V_{DS} = 150V, V_{GS} = 0V$
		—	—	1.0	mA	$V_{DS} = 150V, V_{GS} = 0V, T_J = 125^\circ\text{C}$
$I_{GSS}$	Gate-to-Source Forward Leakage	—	—	100	nA	$V_{GS} = 20V$
	Gate-to-Source Reverse Leakage	—	—	-100	nA	$V_{GS} = -20V$
$R_{G(\text{int})}$	Internal Gate Resistance	—	0.8	—	$\Omega$	

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

Symbol	Parameter	Min.	Typ.	Max.	Units	Conditions
$g_{fs}$	Forward Transconductance	130	—	—	S	$V_{DS} = 25V, I_D = 50\text{A}$
$Q_g$	Total Gate Charge	—	71	110	nC	$I_D = 50\text{A}$
$Q_{gs}$	Gate-to-Source Charge	—	24	—	nC	$V_{DS} = 75V$
$Q_{gd}$	Gate-to-Drain ("Miller") Charge	—	21	—	nC	$V_{GS} = 10V$ ④
$t_{d(on)}$	Turn-On Delay Time	—	18	—	ns	$V_{DD} = 75V$
$t_r$	Rise Time	—	60	—	ns	$I_D = 50\text{A}$
$t_{d(off)}$	Turn-Off Delay Time	—	25	—	ns	$R_G = 2.5\Omega$
$t_f$	Fall Time	—	35	—	ns	$V_{GS} = 10V$ ④
$C_{iss}$	Input Capacitance	—	4460	—	pF	$V_{GS} = 0V$
$C_{oss}$	Output Capacitance	—	390	—	pF	$V_{DS} = 25V$
$C_{rss}$	Reverse Transfer Capacitance	—	82	—	pF	$f = 1.0\text{MHz}$

## Diode Characteristics

Symbol	Parameter	Min.	Typ.	Max.	Units	Conditions
$I_s$	Continuous Source Current (Body Diode)	—	—	83①	A	MOSFET symbol showing the integral reverse p-n junction diode.
$I_{SM}$	Pulsed Source Current (Body Diode) ②	—	—	330	A	
$V_{SD}$	Diode Forward Voltage	—	—	1.3	V	$T_J = 25^\circ\text{C}, I_s = 50\text{A}, V_{GS} = 0V$ ④
$t_{rr}$	Reverse Recovery Time	—	89	130	ns	$I_D = 50\text{A}$
$Q_{rr}$	Reverse Recovery Charge	—	300	450	nC	$V_R = 128V,$ $dI/dt = 100\text{A}/\mu\text{s}$ ④
$I_{RRM}$	Reverse Recovery Current	—	6.5	—	A	
$t_{on}$	Forward Turn-On Time	Intrinsic turn-on time is negligible (turn-on is dominated by LS+LD)				

## Notes:

① Calculated continuous current based on maximum allowable junction temperature. Package limitation current is 75A

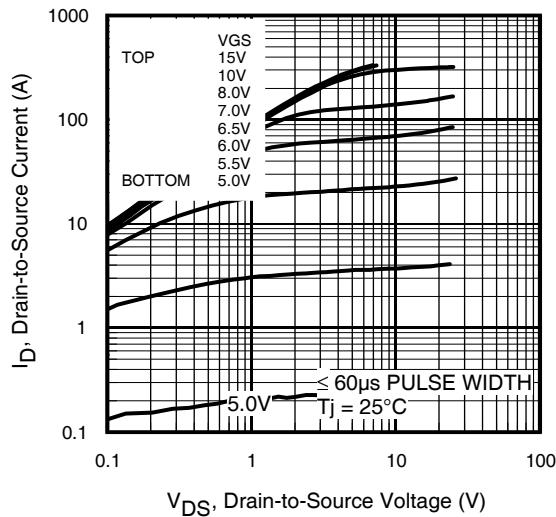
② Repetitive rating; pulse width limited by max. junction temperature.

③ Limited by  $T_{J\text{max}}$ , starting  $T_J = 25^\circ\text{C}$ ,  $L = 0.095\text{mH}$

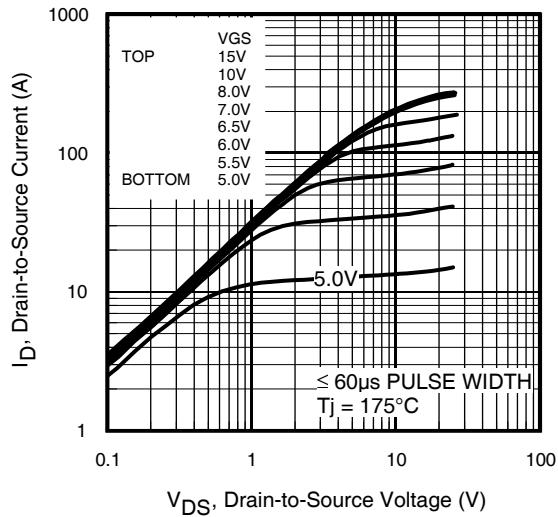
$R_G = 25\Omega$ ,  $I_{AS} = 50\text{A}$ ,  $V_{GS} = 10V$ . Part not recommended for use above this value.

④ Pulse width  $\leq 400\mu\text{s}$ ; duty cycle  $\leq 2\%$ .

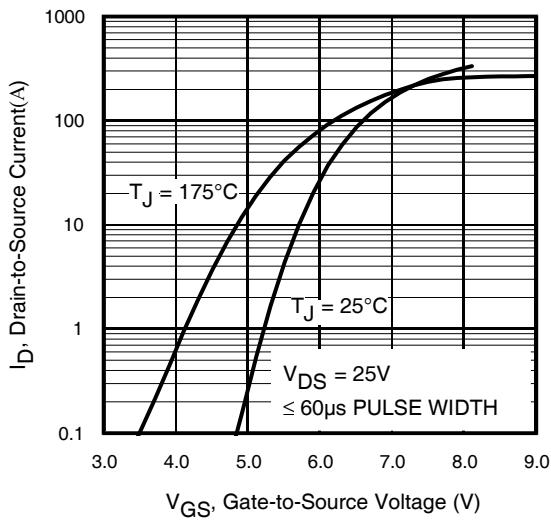
⑤  $R_\theta$  is measured at  $T_J$  approximately  $90^\circ\text{C}$



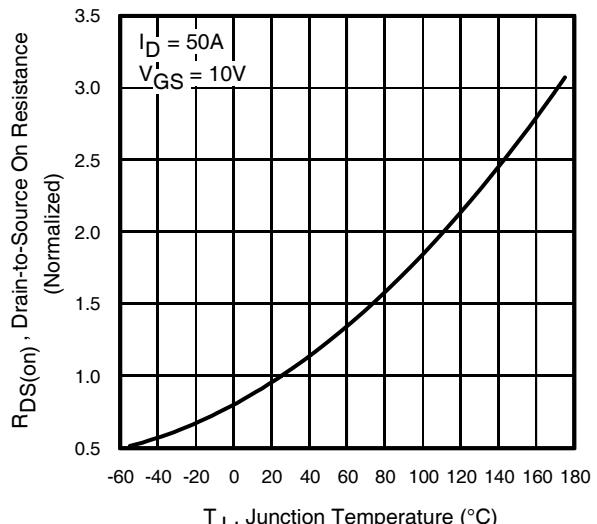
**Fig 1.** Typical Output Characteristics



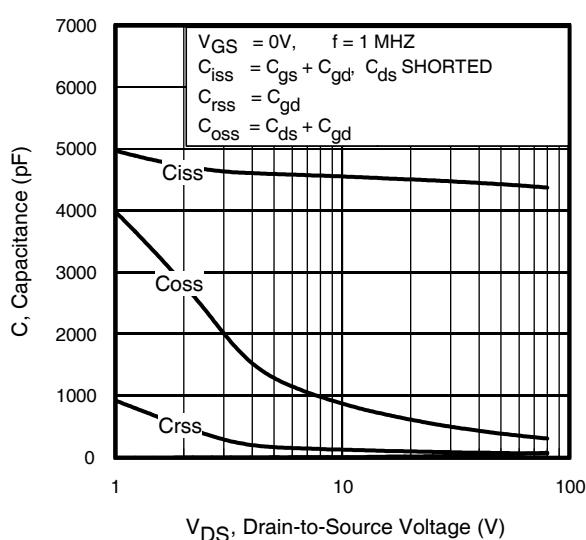
**Fig 2.** Typical Output Characteristics



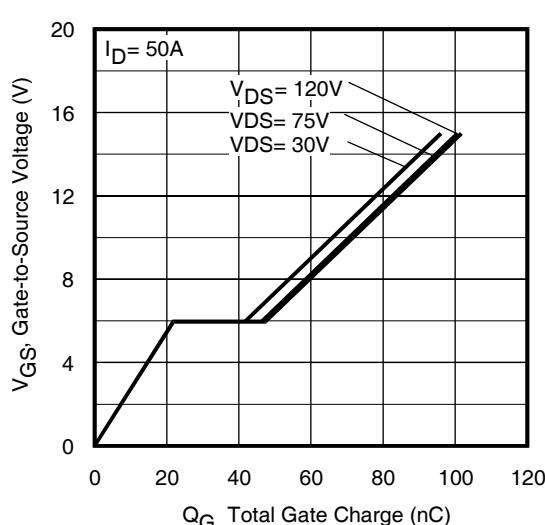
**Fig 3.** Typical Transfer Characteristics



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



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



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

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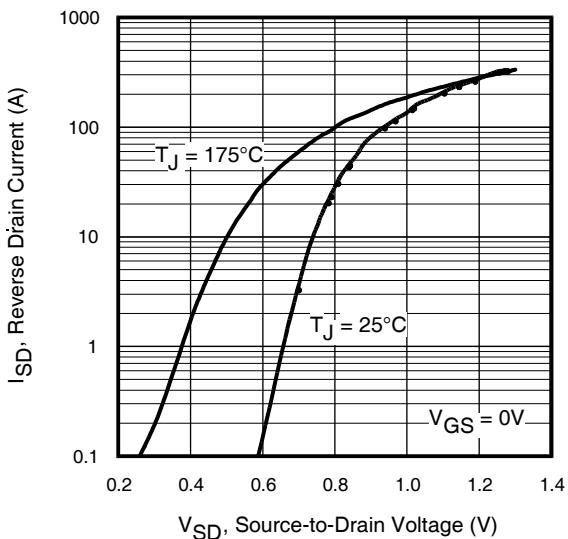


Fig 7. Typical Source-Drain Diode Forward Voltage

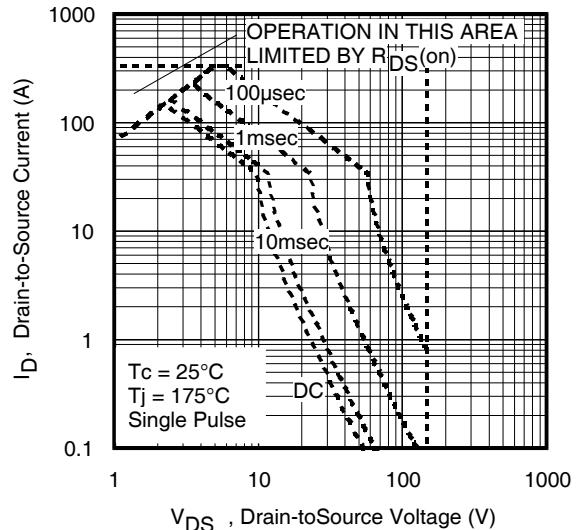


Fig 8. Maximum Safe Operating Area

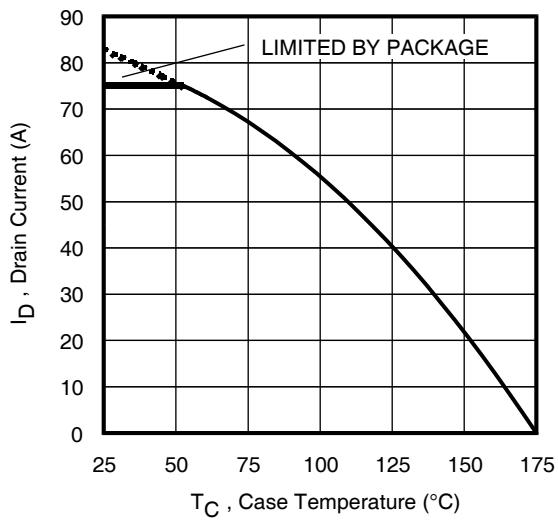


Fig 9. Maximum Drain Current vs. Case Temperature

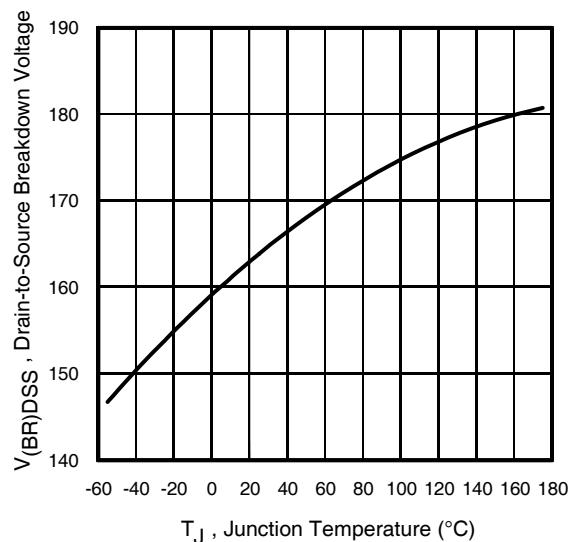


Fig 10. Drain-to-Source Breakdown Voltage

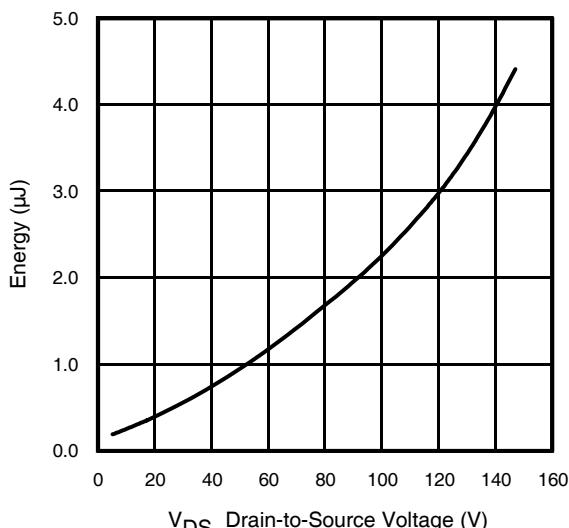


Fig 11. Typical  $C_{oss}$  Stored Energy

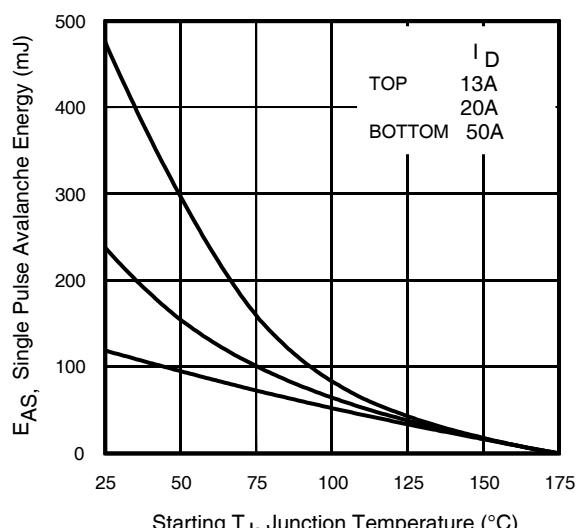


Fig 12. Maximum Avalanche Energy Vs. Drain Current

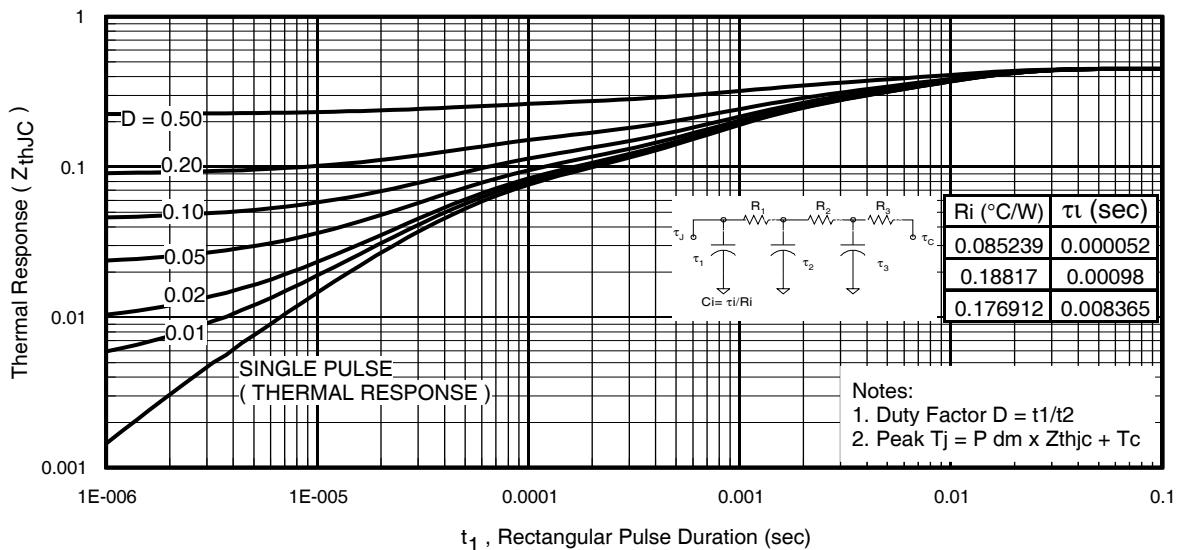


Fig 13. Maximum Effective Transient Thermal Impedance, Junction-to-Case

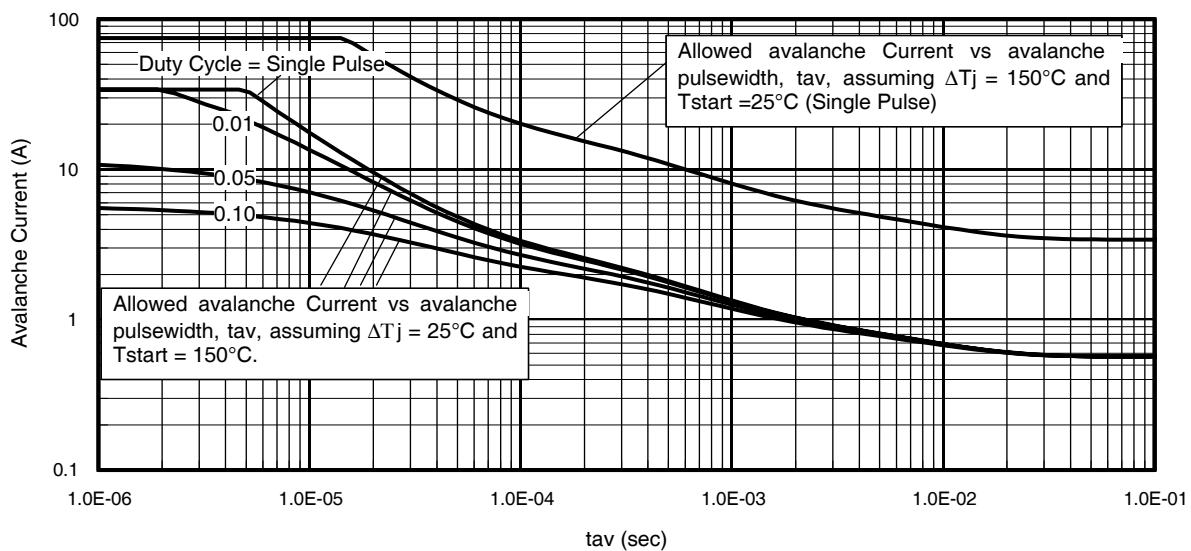
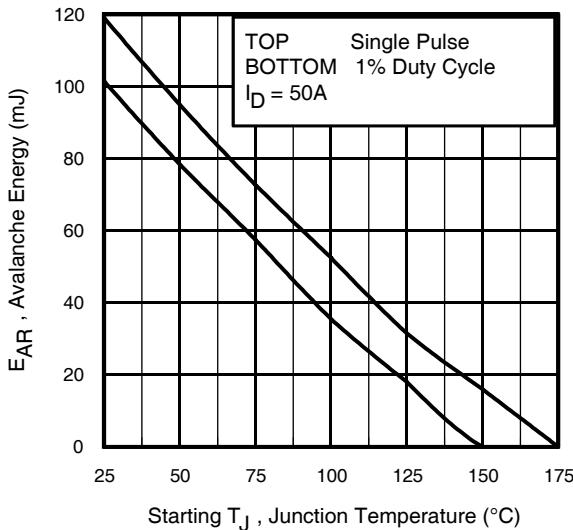


Fig 14. Typical Avalanche Current vs.Pulsewidth



Notes on Repetitive Avalanche Curves , Figures 14, 15:  
(For further info, see AN-1005 at [www.irf.com](http://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 16a, 16b.
  4.  $P_D(\text{ave})$  = 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  $25^{\circ}\text{C}$  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 Figures 13)

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

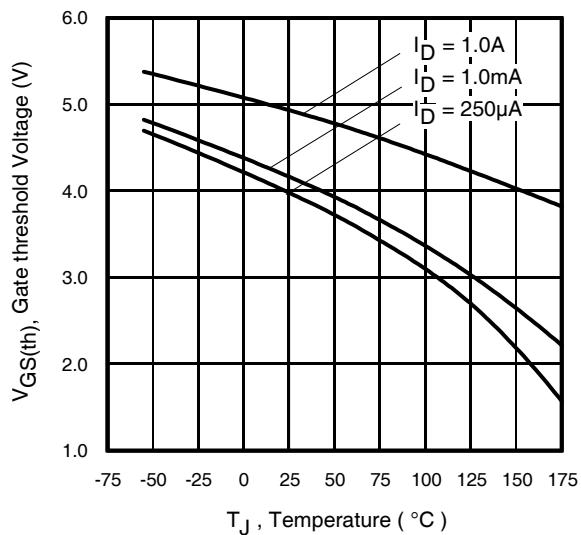
$$I_{av} = 2\Delta T / [1.3 \cdot BV \cdot Z_{th}]$$

$$E_{AS(AR)} = P_D(\text{ave}) \cdot t_{av}$$

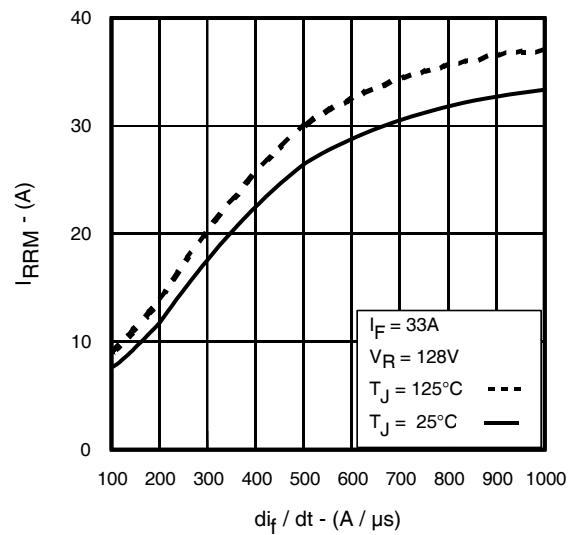
Fig 15. Maximum Avalanche Energy vs. Temperature

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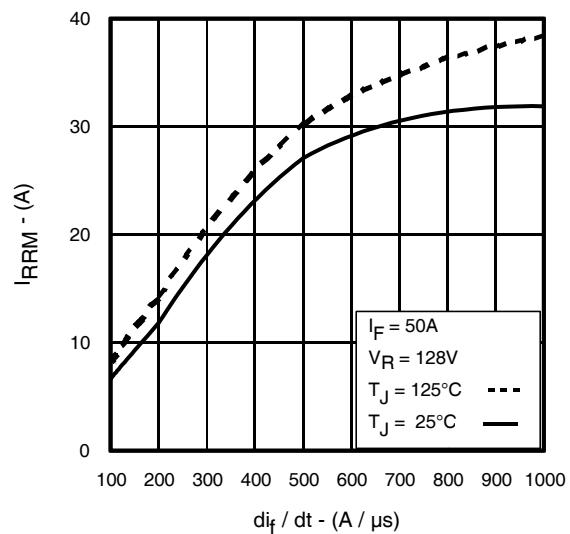
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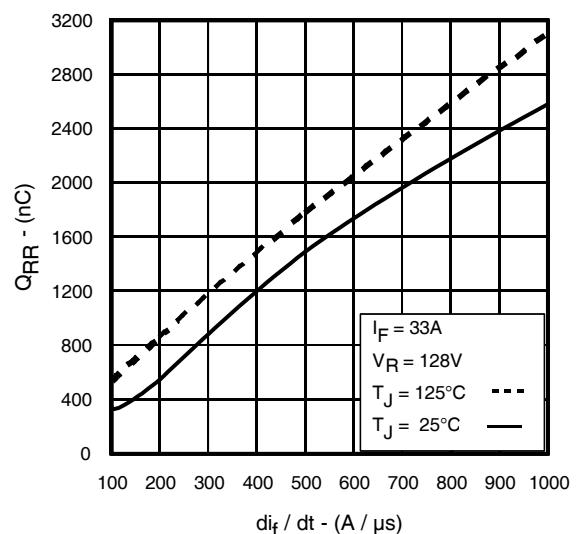
**Fig. 16.** Threshold Voltage Vs. Temperature



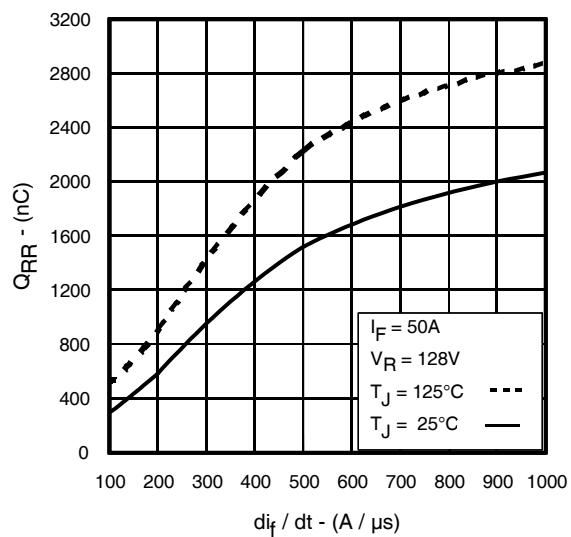
**Fig. 17 -** Typical Recovery Current vs.  $di_f/dt$



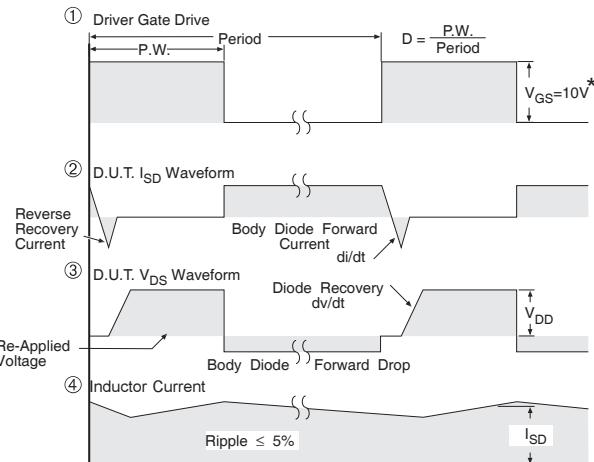
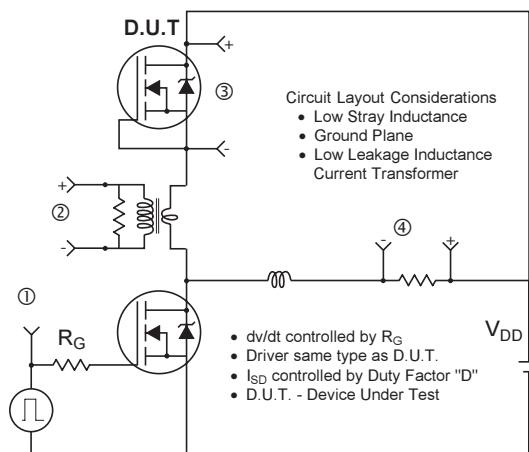
**Fig. 18 -** Typical Recovery Current vs.  $di_f/dt$



**Fig. 19 -** Typical Stored Charge vs.  $di_f/dt$

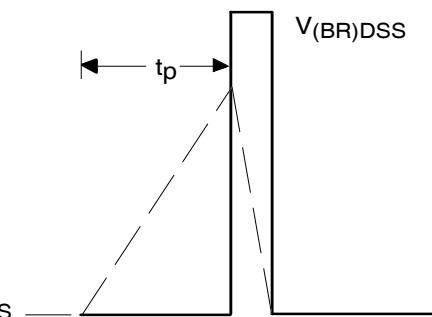
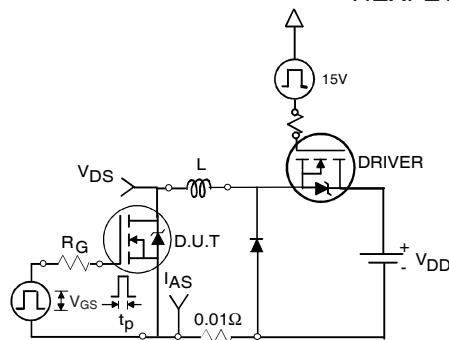


**Fig. 20 -** Typical Stored Charge vs.  $di_f/dt$



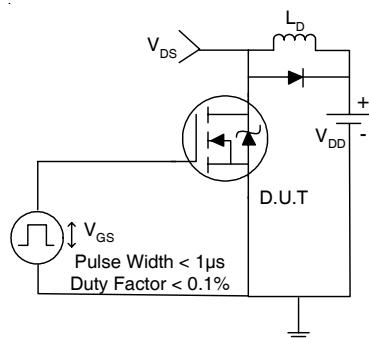
\*  $V_{GS} = 5V$  for Logic Level Devices

**Fig 21.** Peak Diode Recovery  $dv/dt$  Test Circuit for N-Channel HEXFET® Power MOSFETs

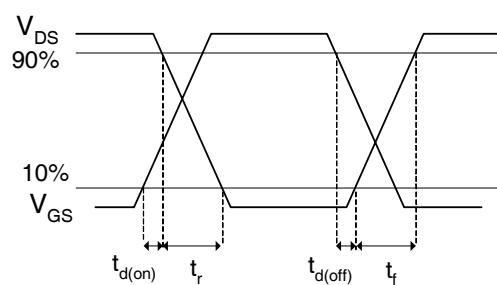


**Fig 22a.** Unclamped Inductive Test Circuit

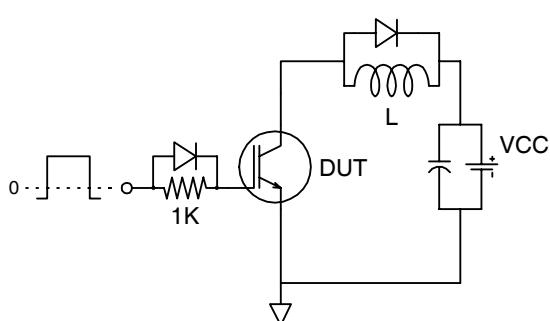
**Fig 22b.** Unclamped Inductive Waveforms



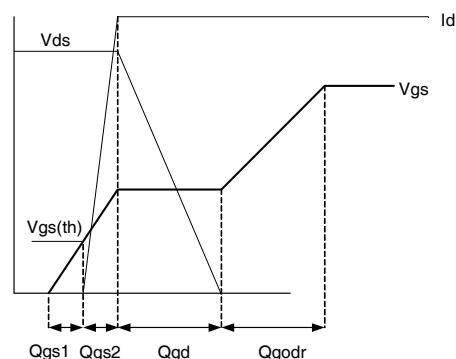
**Fig 23a.** Switching Time Test Circuit



**Fig 23b.** Switching Time Waveforms

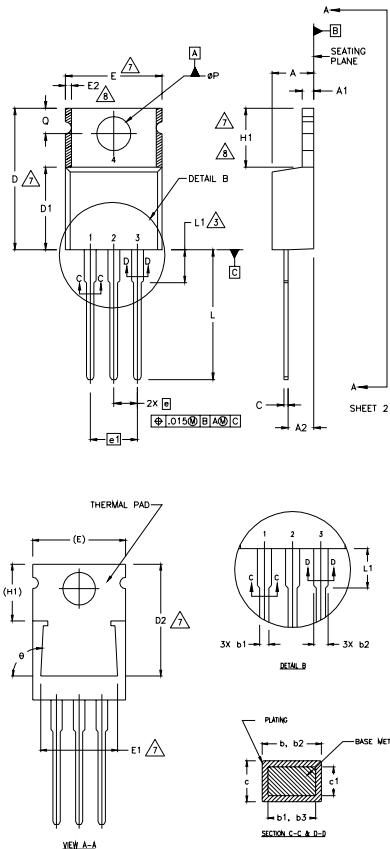


**Fig 24a.** Gate Charge Test Circuit



**Fig 24b.** Gate Charge Waveform

## TO-220AB Package Outline (Dimensions are shown in millimeters (inches))



## NOTES:

- 1 DIMENSIONING AND TOLERANCING PER ASME Y14.5 M- 1994.
- 2 DIMENSIONS ARE SHOWN IN INCHES [MILLIMETERS].
- 3 LEAD DIMENSION AND FINISH UNCONTROLLED IN L1.
- 4 DIMENSION D & E DO NOT INCLUDE MOLD FLASH. MOLD FLASH SHALL NOT EXCEED .005" (.127) PER SIDE. THESE DIMENSIONS ARE MEASURED AT THE OUTERMOST EXTREMES OF THE PLASTIC BODY.
- 5 DIMENSION b1 & 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.

## LEAD ASSIGNMENTS

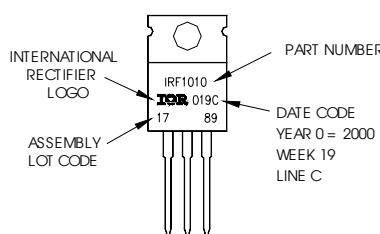
**HEXFET**  
 1. GATE  
 2. DRAIN  
 3. SOURCE
**IGBTs, CoPACK**
 1. GATE  
 2. COLLECTOR  
 3. Emitter
**DIODES**
 1. ANODE/OPEN  
 2. CATHODE  
 3. ANODE

SYMBOL	DIMENSIONS				NOTES
	MILLIMETERS		INCHES		
	MIN.	MAX.	MIN.	MAX.	
A	3.56	4.82	.140	.190	
A1	0.51	1.40	.020	.055	
A2	2.04	2.92	.080	.115	
b	0.38	1.01	.015	.040	
b1	0.38	0.96	.015	.038	
b2	1.15	1.77	.045	.070	
b3	1.15	1.73	.045	.068	
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	12.19	12.88	.480	.507	7
E	9.66	10.66	.380	.420	4,7
E1	8.38	8.89	.330	.350	7
e	2.54	BSC	.100	BSC	
e1	5.08		.200	BSC	
H1	5.85	6.55	.230	.270	7,8
L	12.70	14.73	.500	.580	
L1	-	6.35	-	.250	3
øP	3.54	4.08	.139	.161	
Q	2.54	3.42	.100	.135	
Ø	90°-93°		90°-93°		

## 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.

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

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 TAC Fax: (310) 252-7903

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