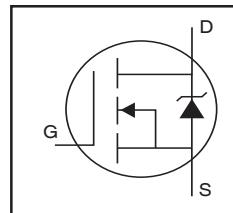


# AUIRF3504

## Features

- Advanced Planar Technology
- Low On-Resistance
- 175°C Operating Temperature
- Fast Switching
- Fully Avalanche Rated
- Repetitive Avalanche Allowed up to  $T_{jmax}$
- Lead-Free, RoHS Compliant
- Automotive Qualified\*

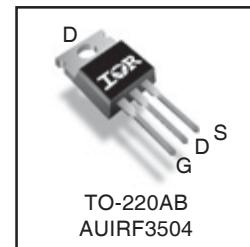


HEXFET® Power MOSFET

$V_{(BR)DSS}$	40V
$R_{DS(on)}$	typ. 7.8mΩ
	max 9.2mΩ
$I_D$	87A

## Description

Specifically designed for Automotive applications, this Stripe Planar design of HEXFET® Power MOSFETs utilizes the latest processing techniques to achieve 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 Automotive and a wide variety of other applications.



G	D	S
Gate	Drain	Source

## Absolute Maximum Ratings

Stresses beyond those listed under "Absolute Maximum Ratings" may cause permanent damage to the device. These are stress ratings only; and functional operation of the device at these or any other condition beyond those indicated in the specifications is not implied. Exposure to absolute-maximum-rated conditions for extended periods may affect device reliability. The thermal resistance and power dissipation ratings are measured under board mounted and still air conditions. Ambient temperature ( $T_A$ ) is 25°C, unless otherwise specified.

	Parameter	Max.	Units
$I_D$ @ $T_C = 25^\circ\text{C}$	Continuous Drain Current, $V_{GS} @ 10\text{V}$	87	A
$I_D$ @ $T_C = 100^\circ\text{C}$	Continuous Drain Current, $V_{GS} @ 10\text{V}$	61	
$I_{DM}$	Pulsed Drain Current ①	350	
$P_D$ @ $T_C = 25^\circ\text{C}$	Power Dissipation	143	W
	Linear Derating Factor	0.95	W/°C
$V_{GS}$	Gate-to-Source Voltage	± 20	V
$E_{AS}$	Single Pulse Avalanche Energy (Thermally Limited) ②	199	mJ
$E_{AS}$ (tested)	Single Pulse Avalanche Energy Tested Value ⑦	368	
$I_{AR}$	Avalanche Current ①	See Fig. 12a, 12b, 15, 16	A
$E_{AR}$	Repetitive Avalanche Energy ⑥		mJ
$T_J$	Operating Junction and	-55 to + 175	°C
$T_{STG}$	Storage Temperature Range		
	Soldering Temperature, for 10 seconds (1.6mm from case)		
	Mounting Torque, 6-32 or M3 screw	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	0.50	—	
$R_{\theta JA}$	Junction-to-Ambient	—	62	

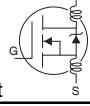
HEXFET® is a registered trademark of International Rectifier.

\*Qualification standards can be found at <http://www.irf.com/>

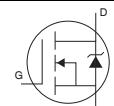
Static Electrical Characteristics @  $T_J = 25^\circ\text{C}$  (unless otherwise specified)

	Parameter	Min.	Typ.	Max.	Units	Conditions
$V_{(\text{BR})\text{DSS}}$	Drain-to-Source Breakdown Voltage	40	—	—	V	$V_{\text{GS}} = 0\text{V}$ , $I_D = 250\mu\text{A}$
$\Delta V_{(\text{BR})\text{DSS}/\Delta T_J}$	Breakdown Voltage Temp. Coefficient	—	0.04	—	V/ $^\circ\text{C}$	Reference to $25^\circ\text{C}$ , $I_D = 1\text{mA}$
$R_{\text{DS}(\text{on})}$	Static Drain-to-Source On-Resistance	—	7.8	9.2	$\text{m}\Omega$	$V_{\text{GS}} = 10\text{V}$ , $I_D = 52\text{A}$ ④
$V_{\text{GS}(\text{th})}$	Gate Threshold Voltage	2.0	—	4.0	V	$V_{\text{DS}} = V_{\text{GS}}$ , $I_D = 100\mu\text{A}$
$g_{\text{fs}}$	Forward Transconductance	46	—	—	S	$V_{\text{DS}} = 10\text{V}$ , $I_D = 52\text{A}$
$I_{\text{DSS}}$	Drain-to-Source Leakage Current	—	—	20	$\mu\text{A}$	$V_{\text{DS}} = 40\text{V}$ , $V_{\text{GS}} = 0\text{V}$
		—	—	250	$\mu\text{A}$	$V_{\text{DS}} = 40\text{V}$ , $V_{\text{GS}} = 0\text{V}$ , $T_J = 125^\circ\text{C}$
$I_{\text{GSS}}$	Gate-to-Source Forward Leakage	—	—	200	nA	$V_{\text{GS}} = 20\text{V}$
	Gate-to-Source Reverse Leakage	—	—	-200	nA	$V_{\text{GS}} = -20\text{V}$

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

	Parameter	Min.	Typ.	Max.	Units	Conditions
$Q_g$	Total Gate Charge	—	36	54	nC	$I_D = 52\text{A}$
$Q_{\text{gs}}$	Gate-to-Source Charge	—	12	18		$V_{\text{DS}} = 32\text{V}$
$Q_{\text{gd}}$	Gate-to-Drain ("Miller") Charge	—	13	20		$V_{\text{GS}} = 10\text{V}$ ④
$t_{\text{d}(\text{on})}$	Turn-On Delay Time	—	9.9	—	ns	$V_{\text{DD}} = 20\text{V}$
$t_r$	Rise Time	—	61	—		$I_D = 52\text{A}$
$t_{\text{d}(\text{off})}$	Turn-Off Delay Time	—	24	—		$R_G = 2.7\ \Omega$
$t_f$	Fall Time	—	29	—		$V_{\text{GS}} = 10\text{V}$ ④
$L_D$	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	—		
$C_{\text{iss}}$	Input Capacitance	—	2150	—	pF	$V_{\text{GS}} = 0\text{V}$
$C_{\text{oss}}$	Output Capacitance	—	600	—		$V_{\text{DS}} = 25\text{V}$
$C_{\text{rss}}$	Reverse Transfer Capacitance	—	54	—		$f = 1.0\text{MHz}$ , See Fig. 5
$C_{\text{oss}}$	Output Capacitance	—	2885	—		$V_{\text{GS}} = 0\text{V}$ , $V_{\text{DS}} = 1.0\text{V}$ , $f = 1.0\text{MHz}$
$C_{\text{oss}}$	Output Capacitance	—	526	—		$V_{\text{GS}} = 0\text{V}$ , $V_{\text{DS}} = 32\text{V}$ , $f = 1.0\text{MHz}$
$C_{\text{oss eff.}}$	Effective Output Capacitance ⑤	—	147	—		$V_{\text{GS}} = 0\text{V}$ , $V_{\text{DS}} = 0\text{V}$ to $32\text{V}$

## Diode Characteristics

	Parameter	Min.	Typ.	Max.	Units	Conditions
$I_S$	Continuous Source Current (Body Diode)	—	—	87	A	MOSFET symbol showing the integral reverse p-n junction diode.
$I_{\text{SM}}$	Pulsed Source Current (Body Diode) ①	—	—	350		
$V_{\text{SD}}$	Diode Forward Voltage	—	—	1.3	V	$T_J = 25^\circ\text{C}$ , $I_S = 52\text{A}$ , $V_{\text{GS}} = 0\text{V}$ ④
$t_{\text{rr}}$	Reverse Recovery Time	—	65	98	ns	$T_J = 25^\circ\text{C}$ , $I_F = 52\text{A}$
$Q_{\text{rr}}$	Reverse Recovery Charge	—	144	216	nC	$\text{di}/\text{dt} = 100\text{A}/\mu\text{s}$ ④
$t_{\text{on}}$	Forward Turn-On Time	Intrinsic turn-on time is negligible (turn-on is dominated by $LS+LD$ )				

## Notes:

- ① Repetitive rating; pulse width limited by max. junction temperature. (See fig. 11).
- ② Starting  $T_J = 25^\circ\text{C}$ ,  $L = 0.15\text{mH}$   
 $R_G = 50\Omega$ ,  $I_{AS} = 52\text{A}$ . (See Figure 12).
- ③  $I_{SD} \leq 52\text{A}$ ,  $\text{di}/\text{dt} \leq 6750\text{A}/\mu\text{s}$ ,  $V_{\text{DD}} \leq V_{(\text{BR})\text{DSS}}$ ,  $T_J \leq 175^\circ\text{C}$ .
- ④ Pulse width  $\leq 400\mu\text{s}$ ; duty cycle  $\leq 2\%$ .
- ⑤  $C_{\text{oss eff.}}$  is a fixed capacitance that gives the same charging time as  $C_{\text{oss}}$  while  $V_{\text{DS}}$  is rising from 0 to 80%  $V_{\text{DSS}}$ .
- ⑥ Limited by  $T_{J\text{max}}$ , see Fig.12a, 12b, 15, 16 for typical repetitive avalanche performance.
- ⑦ This value determined from sample failure population, starting  $T_J = 25^\circ\text{C}$ ,  $L = 0.15\text{mH}$ ,  $R_G = 50\Omega$ ,  $I_{AS} = 52\text{A}$ .
- ⑧  $R_\theta$  is measured at  $T_J$  of approximately  $90^\circ\text{C}$ .

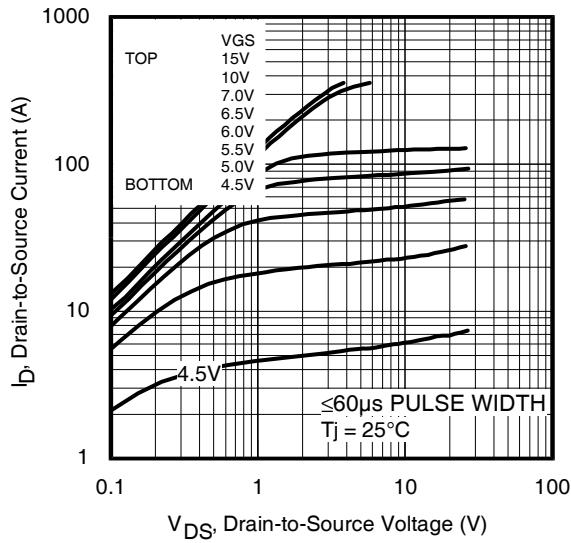
**Qualification Information<sup>†</sup>**

<b>Qualification Level</b>	Automotive (per AEC-Q101) <sup>††</sup>	
	Comments: This part number(s) passed Automotive qualification. IR's Industrial and Consumer qualification level is granted by extension of the higher Automotive level.	
<b>Moisture Sensitivity Level</b>	TO-220	N/A
<b>ESD</b>	Machine Model	Class M4 (+/- 500V) <sup>†††</sup> AEC-Q101-002
	Human Body Model	Class H1C (+/- 1500V) <sup>†††</sup> AEC-Q101-001
	Charged Device Model	Class C5 (+/- 2000V) <sup>†††</sup> AEC-Q101-005
<b>RoHS Compliant</b>	Yes	

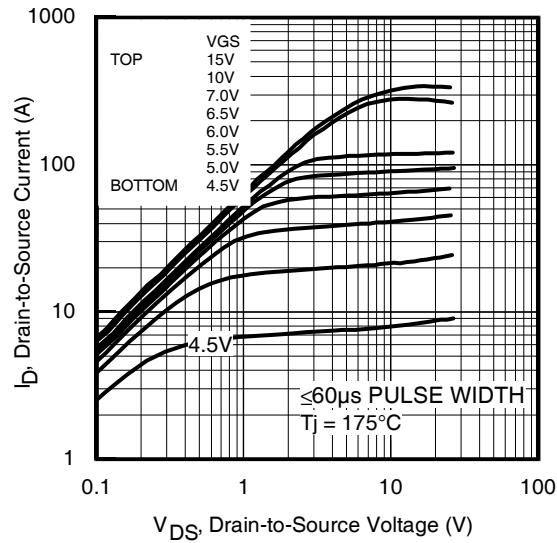
<sup>†</sup> Qualification standards can be found at International Rectifier's web site: <http://www.irf.com/>

<sup>††</sup> Exceptions (if any) to AEC-Q101 requirements are noted in the qualification report.

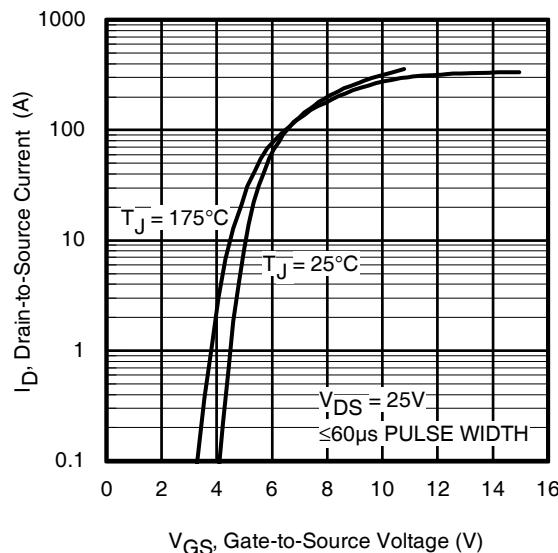
<sup>†††</sup> Highest passing voltage.



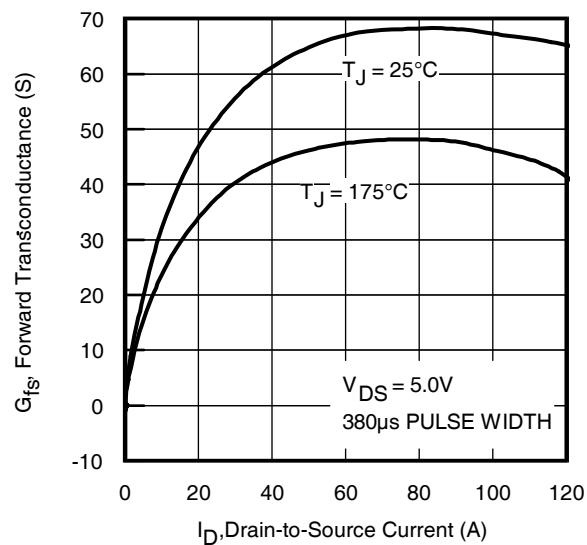
**Fig 1.** Typical Output Characteristics



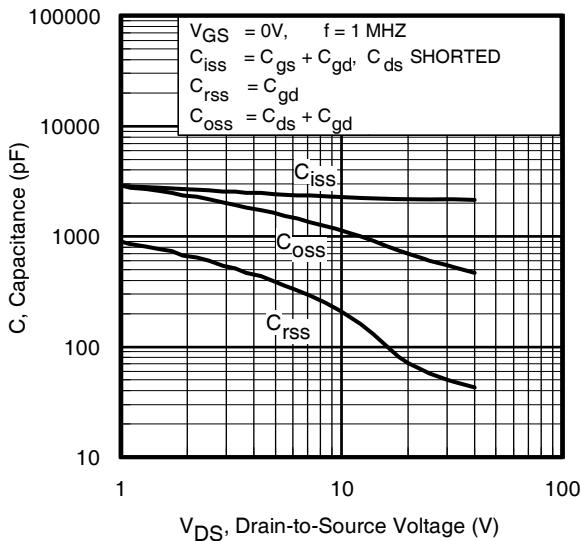
**Fig 2.** Typical Output Characteristics



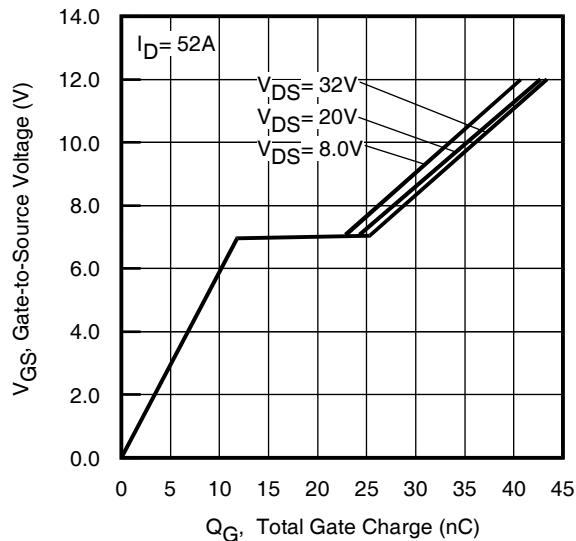
**Fig 3.** Typical Transfer Characteristics



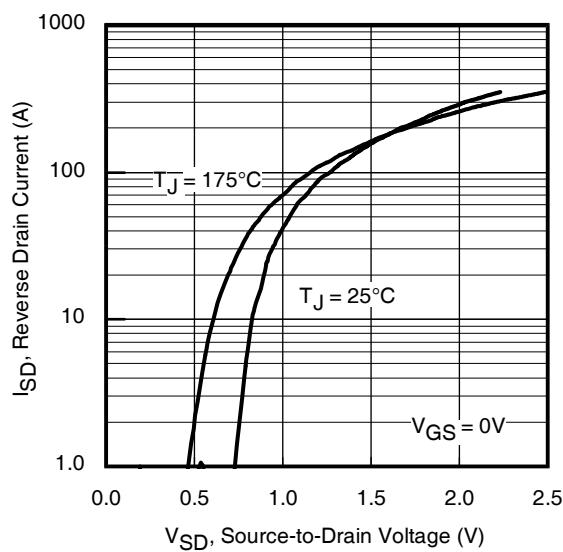
**Fig 4.** Typical Forward Transconductance vs. Drain Current



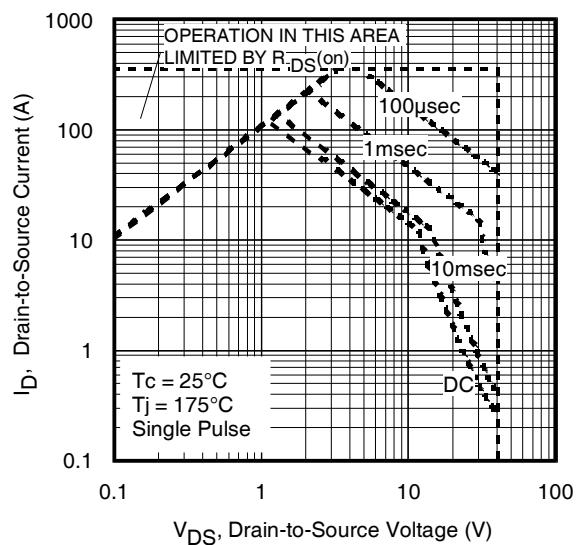
**Fig 5.** Typical Capacitance vs.  
Drain-to-Source Voltage



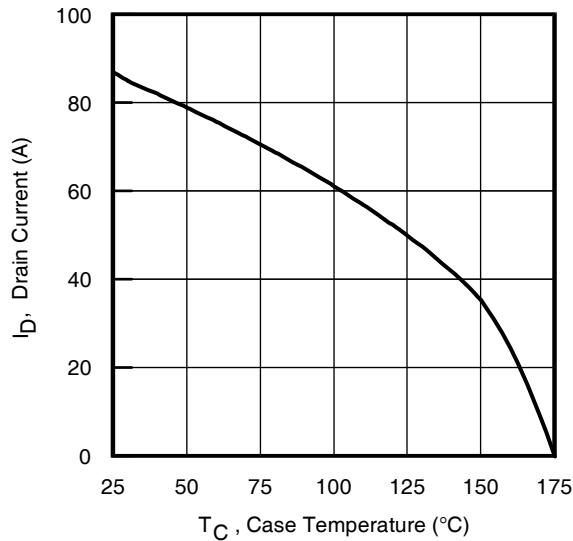
**Fig 6.** Typical Gate Charge vs.  
Gate-to-Source Voltage



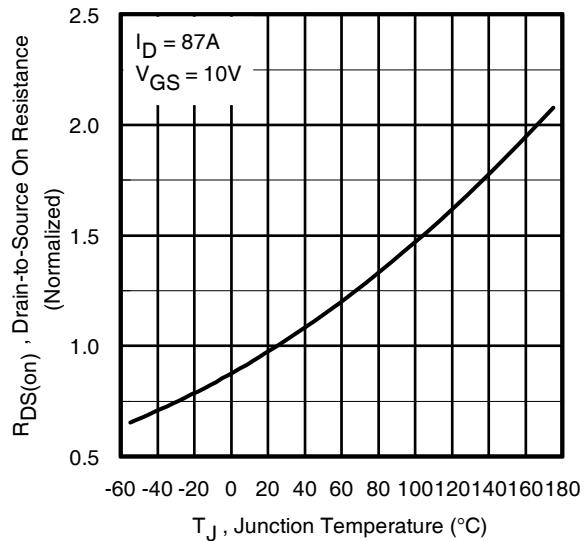
**Fig 7.** Typical Source-Drain Diode  
Forward Voltage



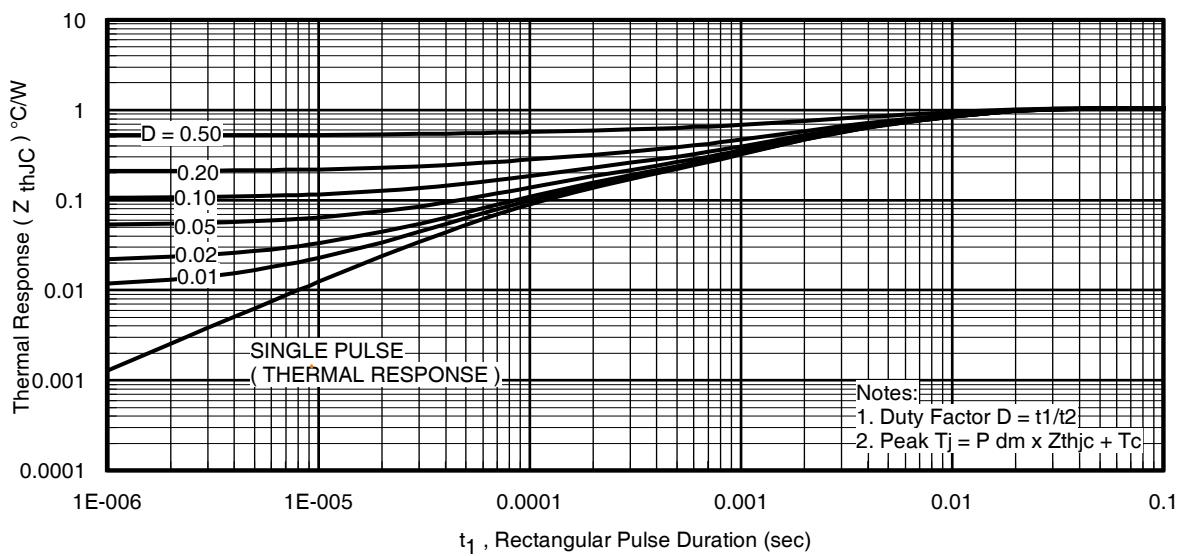
**Fig 8.** Maximum Safe Operating Area



**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

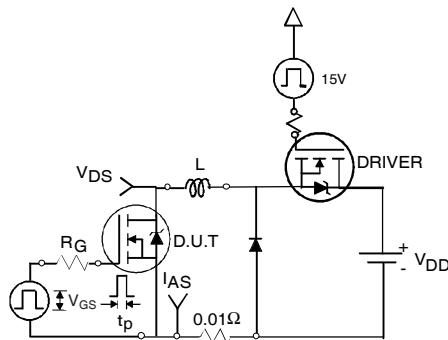


Fig 12a. Unclamped Inductive Test Circuit

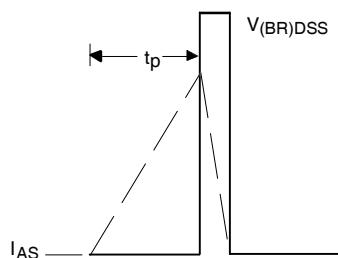


Fig 12b. Unclamped Inductive Waveforms

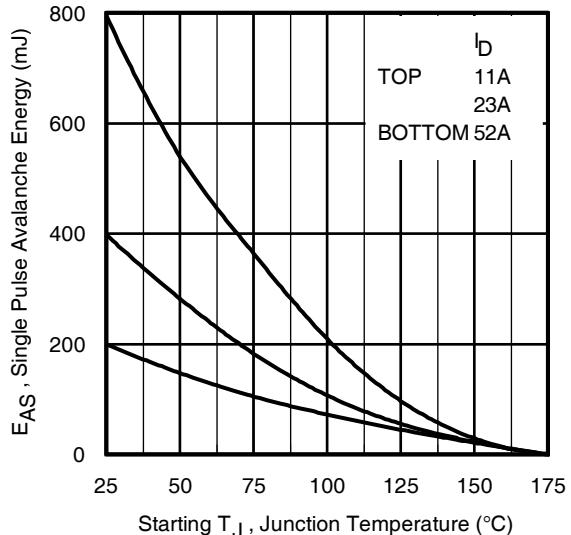


Fig 12c. Maximum Avalanche Energy vs. Drain Current

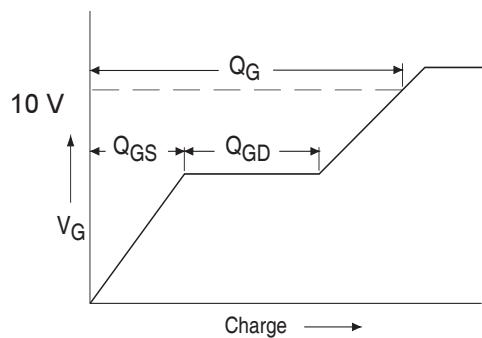


Fig 13a. Basic Gate Charge Waveform

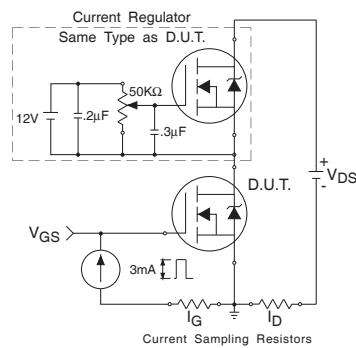


Fig 13b. Gate Charge Test Circuit

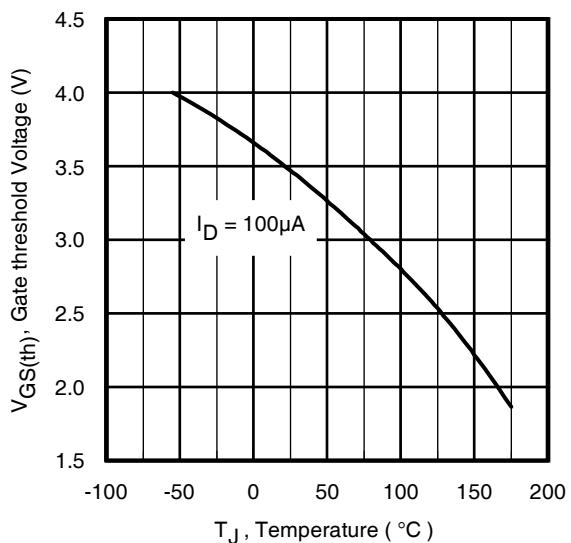


Fig 14. Threshold Voltage vs. Temperature

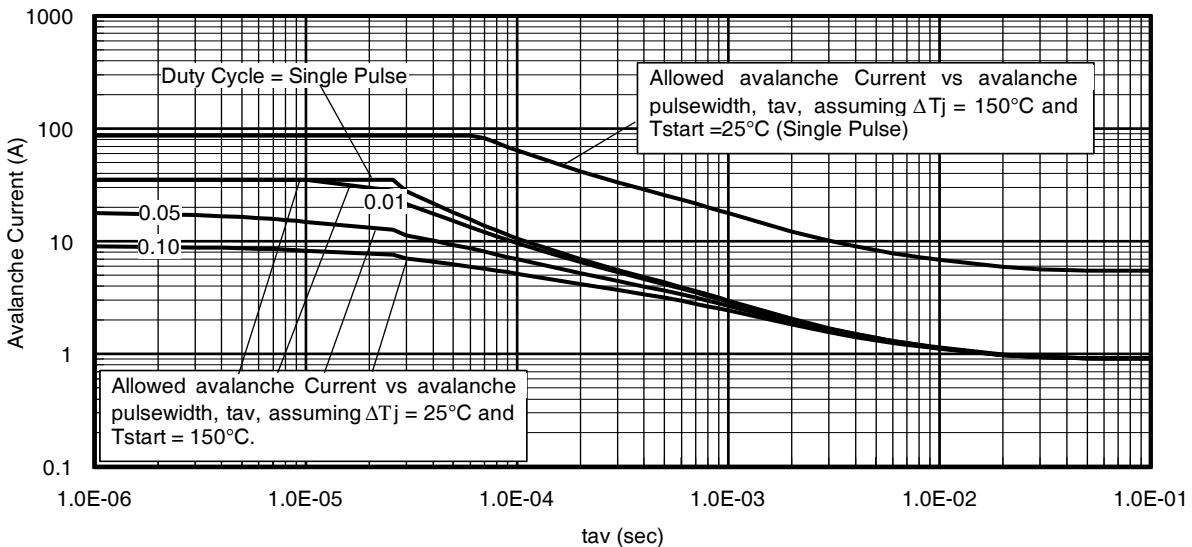
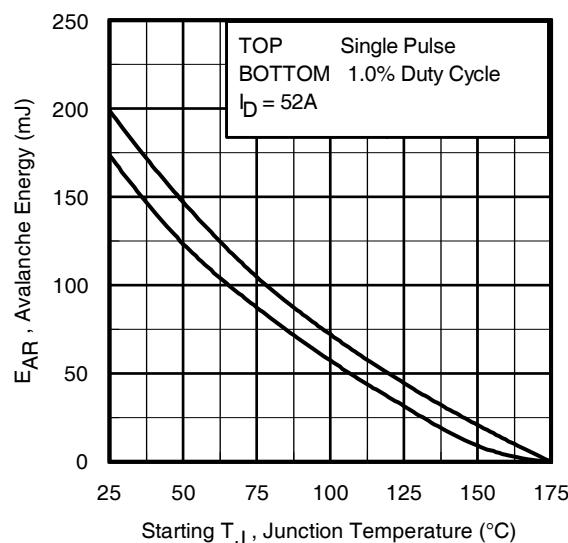


Fig 15. Typical Avalanche Current vs.Pulsewidth



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

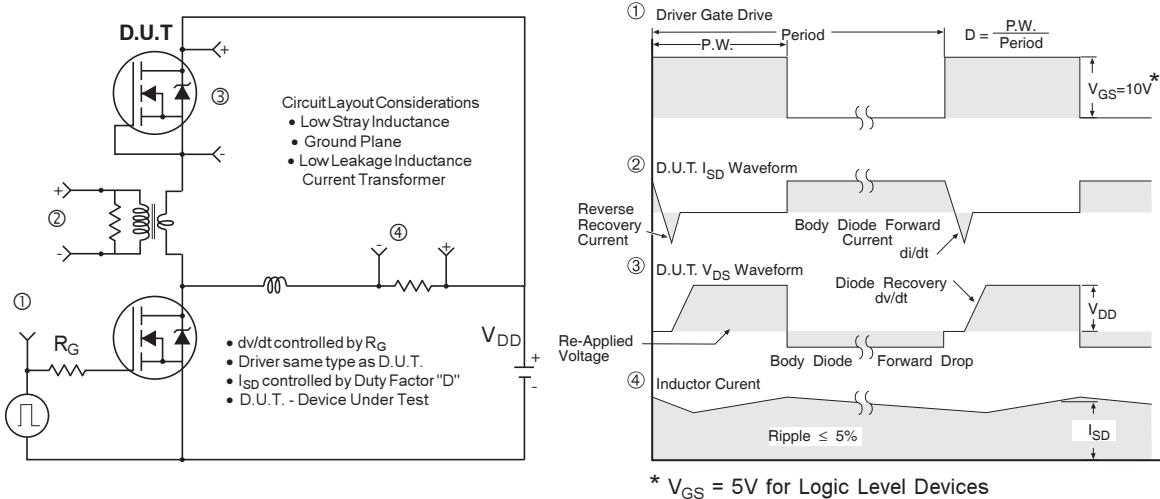
1. Avalanche failures assumption:  
Purely a thermal phenomenon and failure occurs at a temperature far in excess of  $T_{jmax}$ . This is validated for every part type.
2. Safe operation in Avalanche is allowed as long as  $T_{jmax}$  is not exceeded.
3. Equation below based on circuit and waveforms shown in Figures 12a, 12b.
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°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)

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

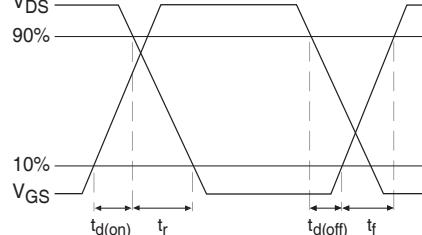
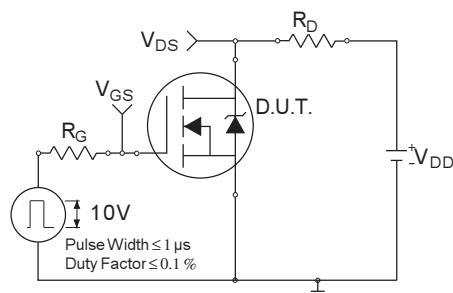
$$I_{av} = 2\Delta T / [1.3 \cdot BV \cdot Z_{th}]$$

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

Fig 16. Maximum Avalanche Energy  
vs. Temperature



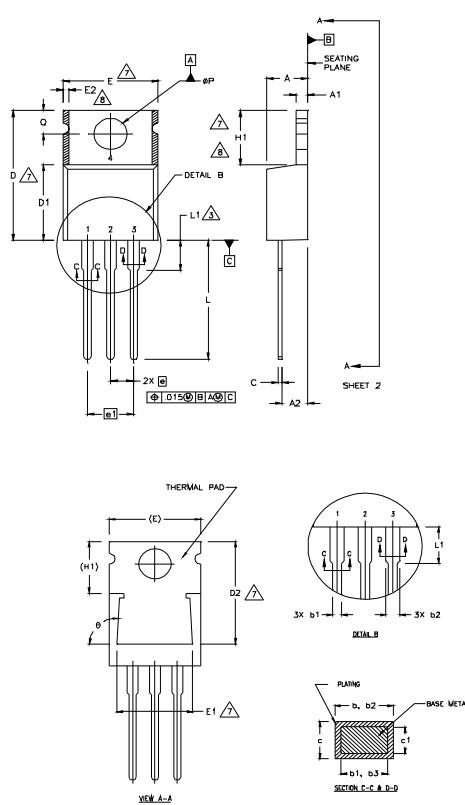
**Fig 17. Peak Diode Recovery  $dv/dt$  Test Circuit for N-Channel HEXFET® Power MOSFETs**



**Fig 18b. Switching Time Waveforms**

## 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 .006" (0.127) 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 AND SINGULATION IRRREGULARITIES ARE ALLOWED.

## LEAD ASSIGNMENTS

HEXFET  
1.- GATE  
2.- DRAIN  
3.- SOURCE

## IGBTs...CoPACK

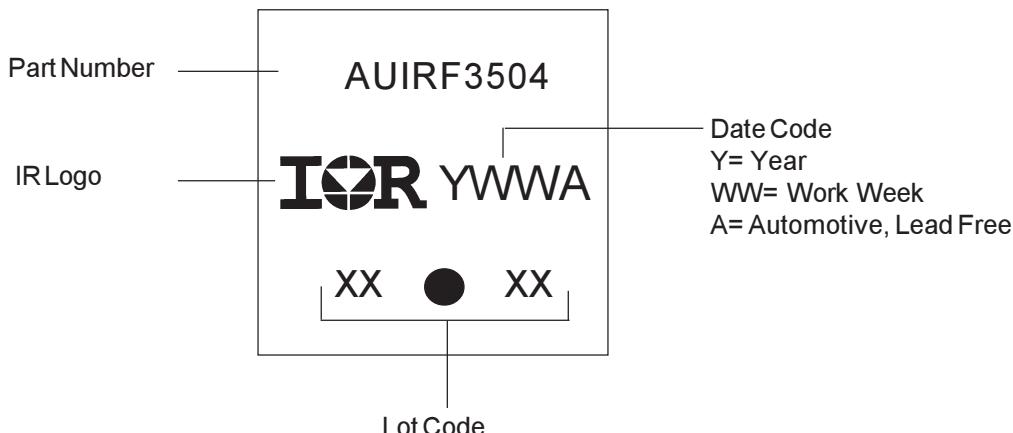
1.- GATE  
2.- COLLECTOR  
3.- EMITTER

## 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	5	
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 5.08	1.00 BSC .200 BSC				
e1						
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

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

**Ordering Information**

Base part number	Package Type	Standard Pack		Complete Part Number
		Form	Quantity	
AUIRF3504	TO-220	Tube	50	AUIRF3504

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IR warrants performance of its hardware products to the specifications applicable at the time of sale in accordance with IR's standard warranty. Testing and other quality control techniques are used to the extent IR deems necessary to support this warranty. Except where mandated by government requirements, testing of all parameters of each product is not necessarily performed.

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For technical support, please contact IR's Technical Assistance Center  
<http://www.irf.com/technical-info/>

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Tel: (310) 252-7105