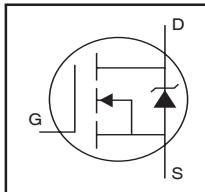


AUIRF1404Z  
AUIRF1404ZS  
AUIRF1404ZL

### Features

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

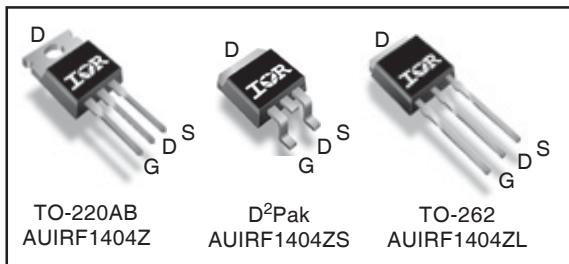


### HEXFET® Power MOSFET

$V_{(BR)DSS}$	40V
$R_{DS(on)}$ max.	3.7mΩ
$I_D$ (Silicon Limited)	180A ①
$I_D$ (Package Limited)	160A

### Description

Specifically designed for Automotive applications, this HEXFET® Power MOSFET utilizes the latest processing techniques to achieve extremely low on-resistance per silicon area. Additional features of this design are a 175°C junction operating temperature, fast switching speed and improved repetitive avalanche rating. These features combine to make this design an extremely efficient and reliable device for use in Automotive applications 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, $V_{GS}$ @ 10V (Silicon Limited)	180 ①	A
$I_D$ @ $T_C = 100^\circ\text{C}$	Continuous Drain Current, $V_{GS}$ @ 10V (Silicon Limited)	120	
$I_D$ @ $T_C = 25^\circ\text{C}$	Continuous Drain Current, $V_{GS}$ @ 10V (Package Limited)	160	
$I_{DM}$	Pulsed Drain Current ①	710	
$P_D$ @ $T_C = 25^\circ\text{C}$	Power Dissipation	200	W
	Linear Derating Factor	1.3	W/°C
$V_{GS}$	Gate-to-Source Voltage	± 20	V
$E_{AS}$	Single Pulse Avalanche Energy (Thermally Limited) ②	330	mJ
$E_{AS}$ (tested )	Single Pulse Avalanche Energy Tested Value ⑥	480	
$I_{AR}$	Avalanche Current ①	See Fig.12a, 12b, 15, 16	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 (1.6mm from case )		
	Mounting Torque, 6-32 or M3 screw ⑦	300	
		10 lbf•in (1.1N•m)	

### Thermal Resistance

	Parameter	Typ.	Max.	Units
$R_{θJC}$	Junction-to-Case ①	—	0.75 ⑨	°C/W
$R_{θCS}$	Case-to-Sink, Flat Greased Surface ⑦	0.50	—	
$R_{θJA}$	Junction-to-Ambient ⑦	—	62	
$R_{θJA}$	Junction-to-Ambient (PCB Mount) ⑧	—	40	

HEXFET® is a registered trademark of International Rectifier.

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

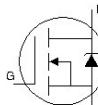
Static Electrical Characteristics @  $T_J = 25^\circ\text{C}$  (unless otherwise specified)

	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	—	0.033	—	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	—	2.7	3.7	$\text{m}\Omega$	$V_{\text{GS}} = 10\text{V}$ , $I_D = 75\text{A}$ ③
$V_{\text{GS}(\text{th})}$	Gate Threshold Voltage	2.0	—	4.0	V	$V_{\text{DS}} = V_{\text{GS}}$ , $I_D = 250\mu\text{A}$
$g_{\text{fs}}$	Forward Transconductance	170	—	—	V	$V_{\text{DS}} = 25\text{V}$ , $I_D = 75\text{A}$
$I_{\text{DSS}}$	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	$V_{\text{GS}} = 20\text{V}$
		—	—	-200	nA	$V_{\text{GS}} = -20\text{V}$

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

	Parameter	Min.	Typ.	Max.	Units	Conditions
$Q_g$	Total Gate Charge	—	100	150	nC	$I_D = 75\text{A}$
$Q_{\text{gs}}$	Gate-to-Source Charge	—	31	—		$V_{\text{DS}} = 32\text{V}$
$Q_{\text{gd}}$	Gate-to-Drain ("Miller") Charge	—	42	—		$V_{\text{GS}} = 10\text{V}$ ③
$t_{\text{d}(\text{on})}$	Turn-On Delay Time	—	18	—	ns	$V_{\text{DD}} = 20\text{V}$
$t_r$	Rise Time	—	110	—		$I_D = 75\text{A}$
$t_{\text{d}(\text{off})}$	Turn-Off Delay Time	—	36	—		$R_G = 3.0\ \Omega$
$t_f$	Fall Time	—	58	—		$V_{\text{GS}} = 10\text{V}$ 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	—		
$C_{\text{iss}}$	Input Capacitance	—	4340	—	pF	$V_{\text{GS}} = 0\text{V}$
$C_{\text{oss}}$	Output Capacitance	—	1030	—		$V_{\text{DS}} = 25\text{V}$
$C_{\text{rss}}$	Reverse Transfer Capacitance	—	550	—		$f = 1.0\text{MHz}$
$C_{\text{oss}}$	Output Capacitance	—	3300	—		$V_{\text{GS}} = 0\text{V}$ , $V_{\text{DS}} = 1.0\text{V}$ , $f = 1.0\text{MHz}$
$C_{\text{oss}}$	Output Capacitance	—	920	—	pF	$V_{\text{GS}} = 0\text{V}$ , $V_{\text{DS}} = 32\text{V}$ , $f = 1.0\text{MHz}$
$C_{\text{oss eff.}}$	Effective Output Capacitance	—	1350	—		$V_{\text{GS}} = 0\text{V}$ , $V_{\text{DS}} = 0\text{V}$ to $32\text{V}$ ④

## Diode Characteristics

	Parameter	Min.	Typ.	Max.	Units	Conditions
$I_S$	Continuous Source Current (Body Diode)	—	—	160	A	MOSFET symbol showing the integral reverse p-n junction diode.
$I_{\text{SM}}$	Pulsed Source Current (Body Diode) ①	—	—	750		
$V_{\text{SD}}$	Diode Forward Voltage	—	—	1.3	V	$T_J = 25^\circ\text{C}$ , $I_S = 75\text{A}$ , $V_{\text{GS}} = 0\text{V}$ ③
$t_{\text{rr}}$	Reverse Recovery Time	—	28	42	ns	$T_J = 25^\circ\text{C}$ , $I_F = 75\text{A}$ , $V_{\text{DD}} = 20\text{V}$
$Q_{\text{rr}}$	Reverse Recovery Charge	—	34	51	nC	$dI/dt = 100\text{A}/\mu\text{s}$ ③
$t_{\text{on}}$	Forward Turn-On Time	Intrinsic turn-on time is negligible (turn-on is dominated by $LS+LD$ )				

## Notes:

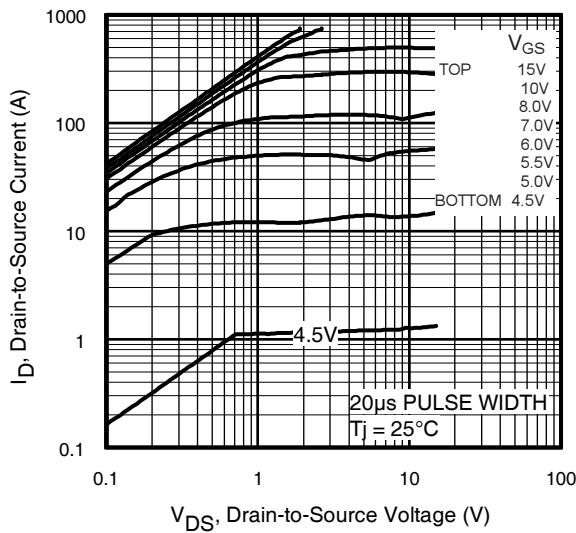
- ① Repetitive rating; pulse width limited by max. junction temperature. (See fig. 11).
- ② Limited by  $T_{\text{Jmax}}$ , starting  $T_J = 25^\circ\text{C}$ ,  $L = 0.11\text{mH}$   $R_G = 25\Omega$ ,  $I_{\text{AS}} = 75\text{A}$ ,  $V_{\text{GS}} = 10\text{V}$ . Part not recommended for use above this value.
- ③ Pulse width  $\leq 1.0\text{ms}$ ; duty cycle  $\leq 2\%$ .
- ④  $C_{\text{oss eff.}}$  is a fixed capacitance that gives the same charging time as  $C_{\text{oss}}$  while  $V_{\text{DS}}$  is rising from 0 to 80%  $V_{\text{DSS}}$ .
- ⑤ Limited by  $T_{\text{Jmax}}$ , see Fig.12a, 12b, 15, 16 for typical repetitive avalanche performance.
- ⑥ This value is determined from sample failure population, starting  $T_J = 25^\circ\text{C}$ ,  $L = 0.11\text{mH}$ ,  $R_G = 25\Omega$ ,  $I_{\text{AS}} = 75\text{A}$ ,  $V_{\text{GS}} = 10\text{V}$ .
- ⑦ This is only applied to TO-220AB package.
- ⑧ This is applied to D<sup>2</sup>Pak, when mounted on 1" square PCB (FR-4 or G-10 Material). For recommended footprint and soldering techniques refer to application note #AN-994.
- ⑨ TO-220 device will have an  $R_{\text{th}}$  value of  $0.65^\circ\text{C}/\text{W}$ .
- ⑩  $R_{\theta}$  is measured at  $T_J$  approximately  $90^\circ\text{C}$ .
- ⑪ Calculated continuous current based on maximum allowable junction temperature. Package limitation current is 160A. Note that current limitations arising from heating of the device leads may occur with some lead mounting arrangements.(Refer to AN-1140) <http://www.irf.com/technical-info/appnotes/an-1140.pdf>

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

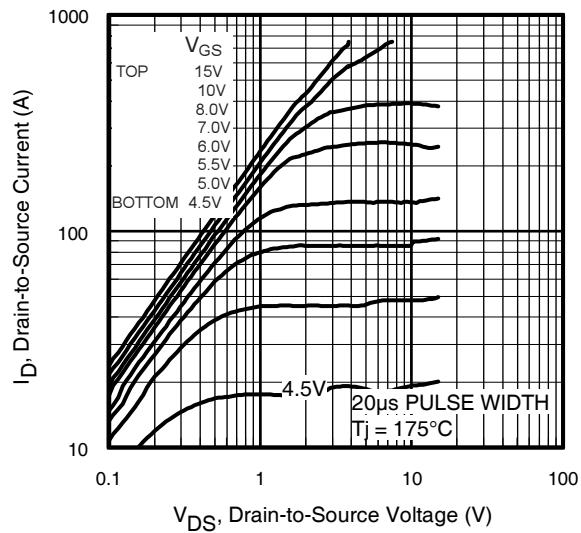
		Automotive (per AEC-Q101) <sup>††</sup>	
<b>Qualification Level</b>		Comments: This part number(s) passed Automotive qualification. IR's Industrial and Consumer qualification level is granted by extension of the higher Automotive level.	
<b>Moisture Sensitivity Level</b>	TO-220AB	N/A	
	TO-262	N/A	
	D <sup>2</sup> PAK	MSL1	
<b>ESD</b>	Machine Model	Class M4 AEC-Q101-002	
	Human Body Model	Class H1C AEC-Q101-001	
	Charged Device Model	Class C3 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/>

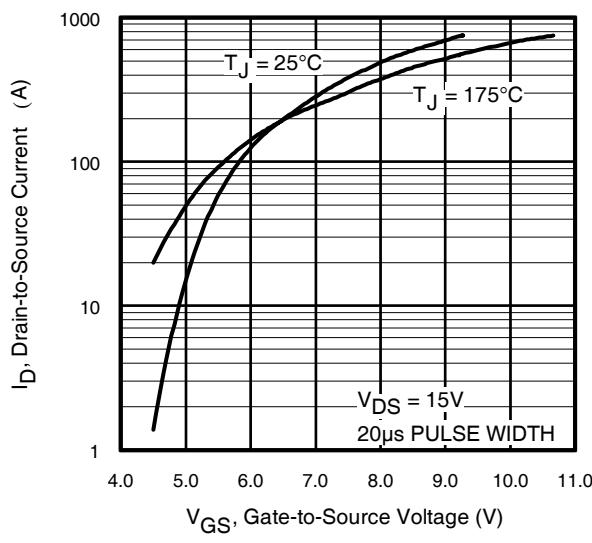
<sup>††</sup> Exceptions to AEC-Q101 requirements are noted in the qualification report.



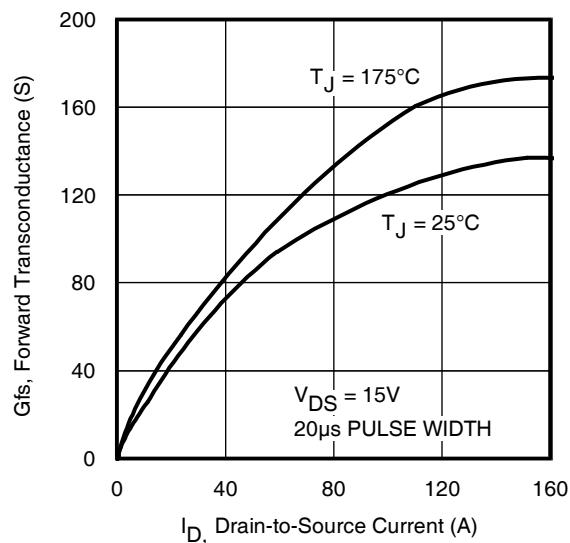
**Fig 1.** Typical Output Characteristics



**Fig 2.** Typical Output Characteristics



**Fig 3.** Typical Transfer Characteristics



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

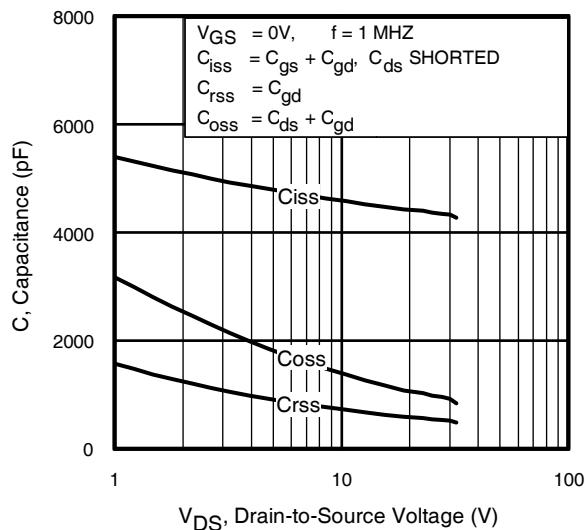


Fig 5. Typical Capacitance Vs.  
Drain-to-Source Voltage

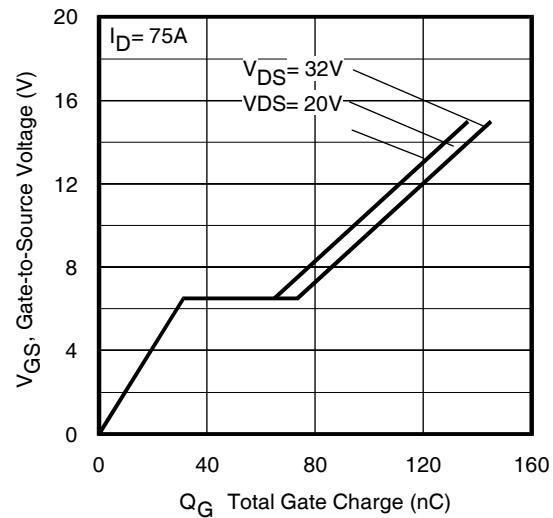


Fig 6. Typical Gate Charge Vs.  
Gate-to-Source Voltage

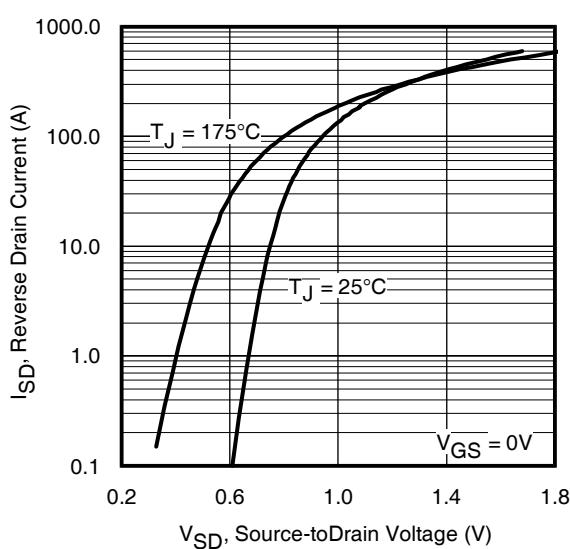


Fig 7. Typical Source-Drain Diode  
Forward Voltage

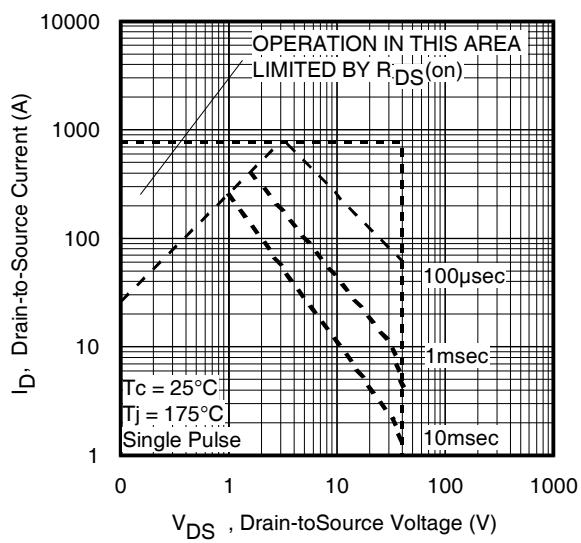
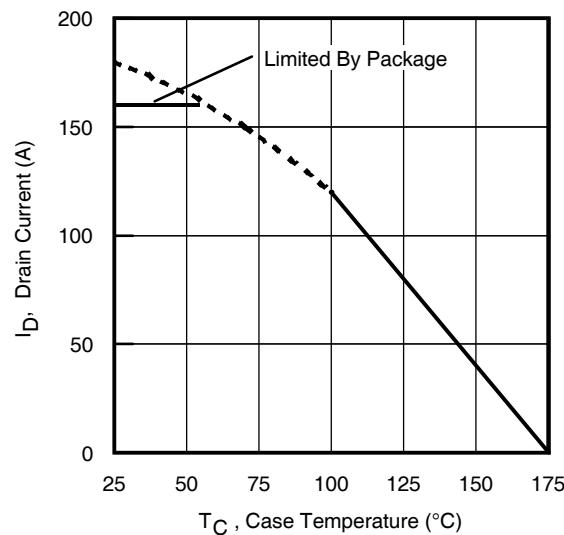
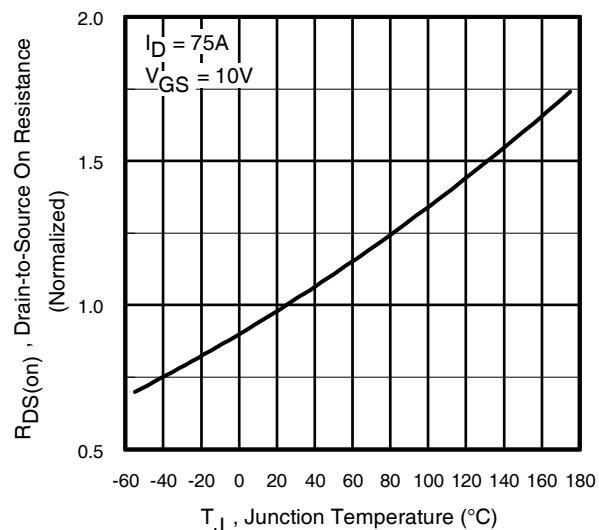


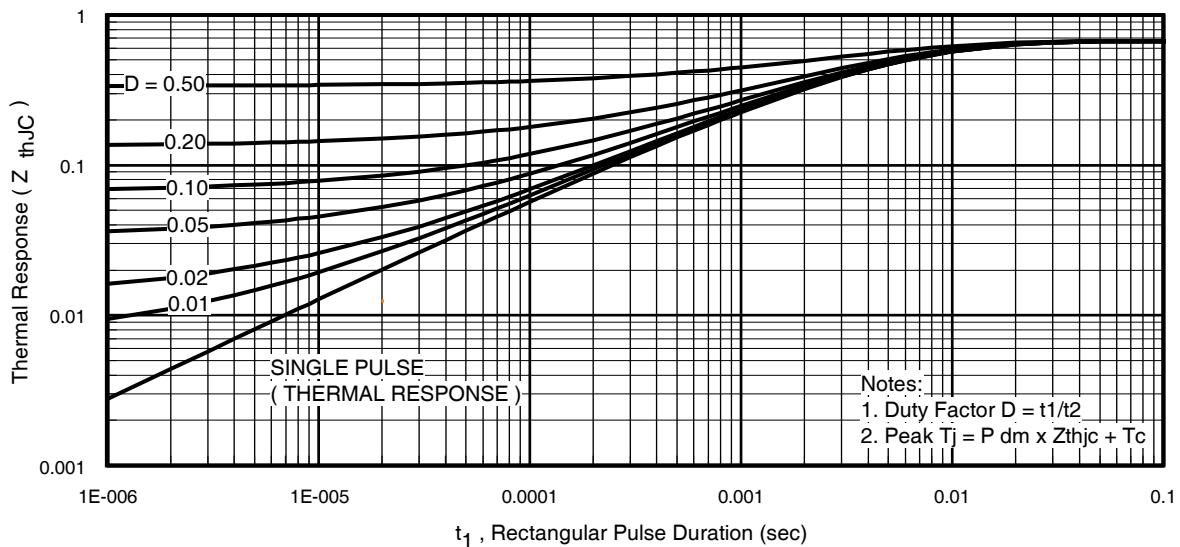
Fig 8. Maximum Safe Operating Area



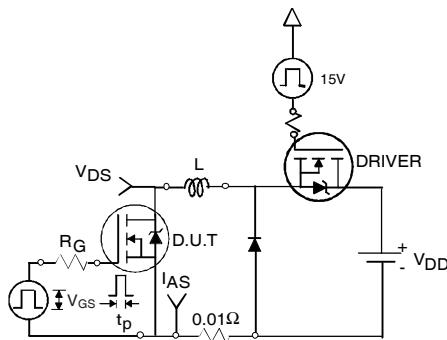
**Fig 9.** Maximum Drain Current Vs.  
Case Temperature



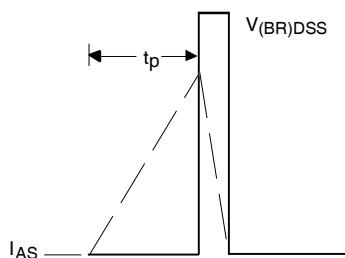
**Fig 10.** Normalized On-Resistance  
Vs. Temperature



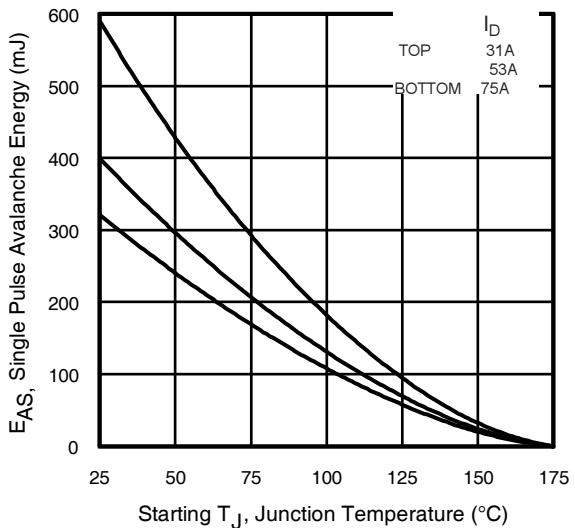
**Fig 11.** Maximum Effective Transient Thermal Impedance, Junction-to-Case



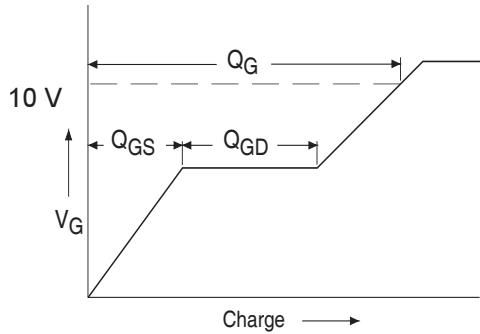
**Fig 12a.** Unclamped Inductive Test Circuit



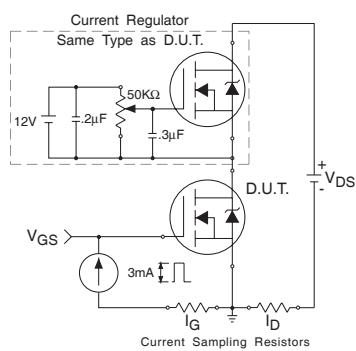
**Fig 12b.** Unclamped Inductive Waveforms



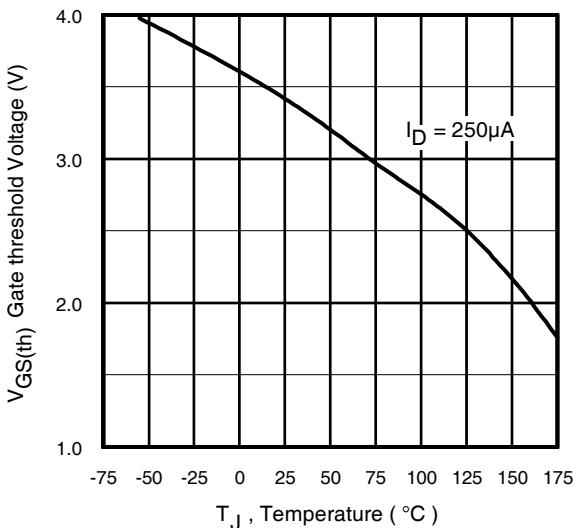
**Fig 12c.** Maximum Avalanche Energy Vs. Drain Current



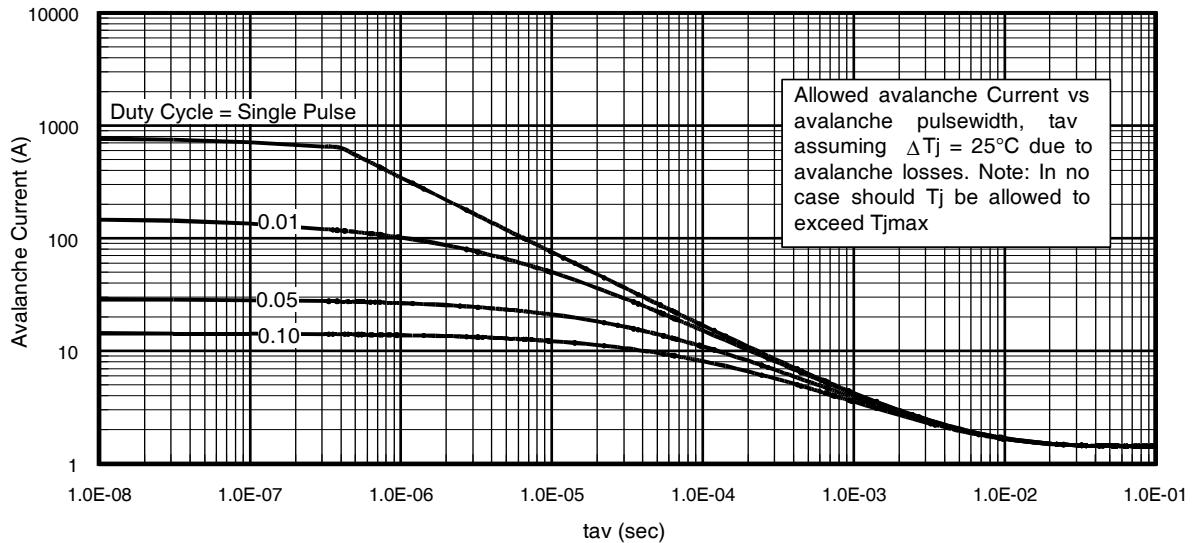
**Fig 13a.** Basic Gate Charge Waveform



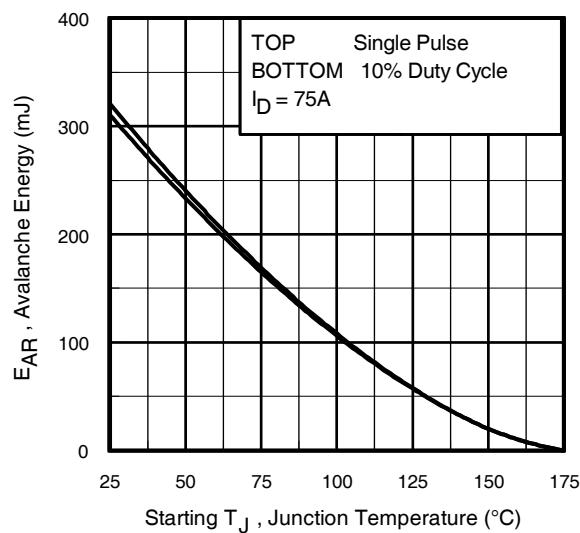
**Fig 13b.** Gate Charge Test Circuit  
[www.irf.com](http://www.irf.com)



**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))**

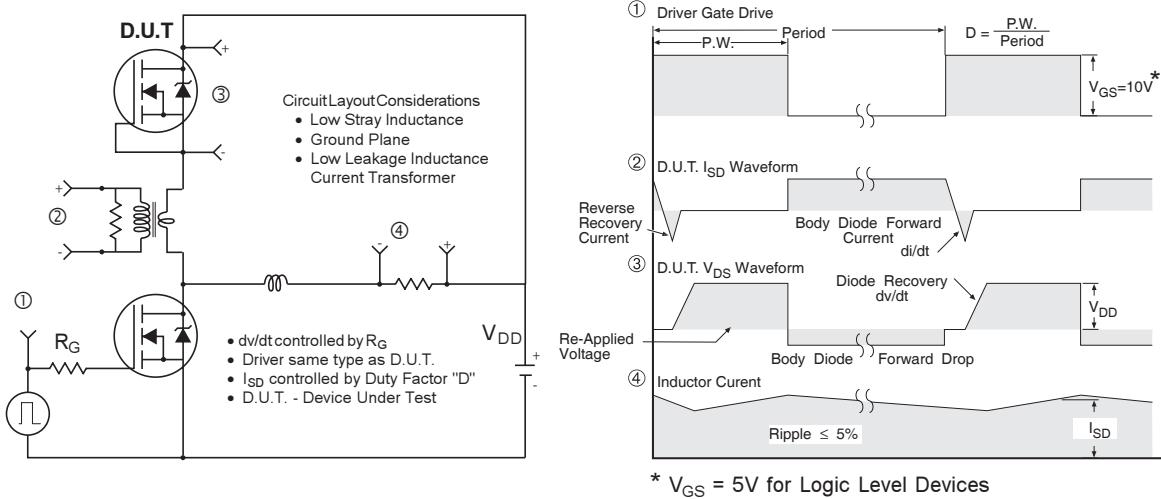
1. Avalanche failures assumption:  
Purely a thermal phenomenon and failure occurs at a temperature far in excess of T<sub>jmax</sub>. This is validated for every part type.
2. Safe operation in Avalanche is allowed as long as T<sub>jmax</sub> is not exceeded.
3. Equation below based on circuit and waveforms shown in Figures 12a, 12b.
4. P<sub>D (ave)</sub> = Average power dissipation per single avalanche pulse.
5. BV = Rated breakdown voltage (1.3 factor accounts for voltage increase during avalanche).
6. I<sub>av</sub> = Allowable avalanche current.
7. ΔT = Allowable rise in junction temperature, not to exceed T<sub>jmax</sub> (assumed as 25°C in Figure 15, 16).
- t<sub>av</sub> = Average time in avalanche.
- D = Duty cycle in avalanche = t<sub>av</sub> · f
- Z<sub>thJC</sub>(D, t<sub>av</sub>) = Transient thermal resistance, see figure 11)

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

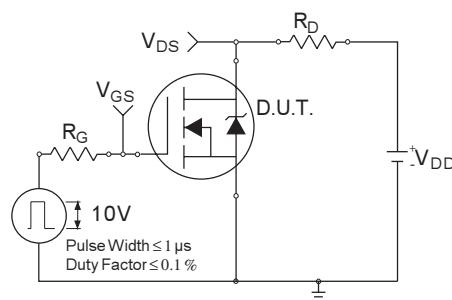
$$I_{av} = 2 \Delta T / [1.3 \cdot BV \cdot Z_{th}]$$

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

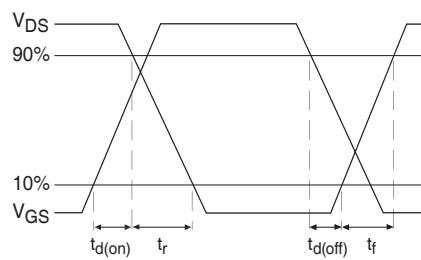
**Fig 16.** Maximum Avalanche Energy  
Vs. Temperature



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



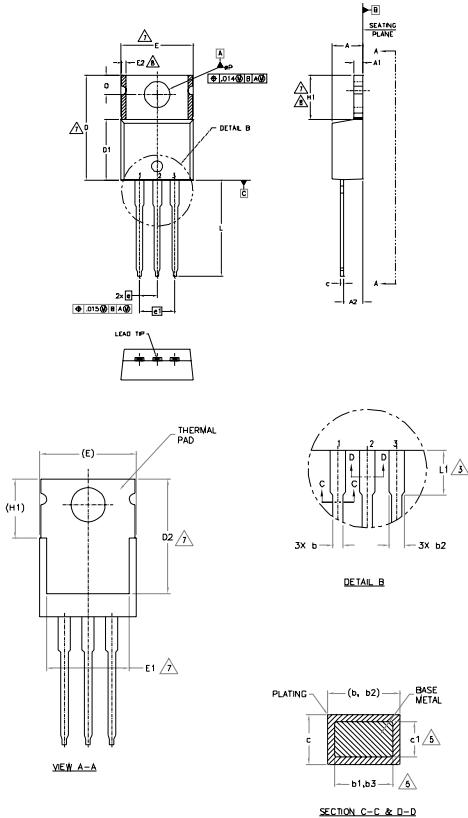
**Fig 18a.** Switching Time Test Circuit



**Fig 18b.** Switching Time Waveforms

## TO-220AB Package Outline

Dimensions are shown in millimeters (inches)



NOTES:

- 1. - DIMENSIONING AND TOLERANCING AS PER ASME Y14.5M - 1994.
- 2. - DIMENSIONS ARE SHOWN IN INCHES [MILLIMETERS].
- 3. - LEAD DIMENSION AND FINISH UNCONDITIONED IN LI.
- 4. - DIMENSION D, D1 & D2 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, B3 & C1 APPLY TO BASE METAL ONLY.
- 6. - CONTROLLING DIMENSION : INCHES.
- 7. - THERMAL PAD CONTOUR OPTIONAL. WITHIN DIMENSIONS E1,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	6.66	8.89	.270	.350	7	
E2	—	0.76	—	.030	8	
e	2.54	BS <sup>C</sup>	100 BS <sup>C</sup>			
e1	5.08	BS <sup>C</sup>	200 BS <sup>C</sup>			
H1	5.84	6.86	.230	.270	7,8	
L	12.70	14.73	.500	.580		
L1	3.56	4.06	.140	.160	3	
RP	3.54	4.08	.139	.161		
O	2.54	3.42	.100	.135		

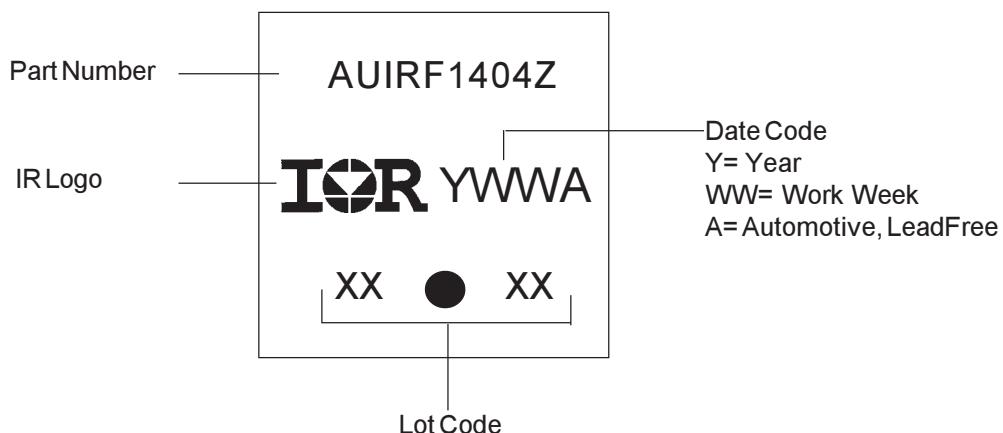
## LEAD ASSIGNMENTS

XFEI  
GATE  
DRAIN  
SOURCE

COPACK  
GATE  
COLLECTOR  
EMITTER

ODES  
ANODE  
CATHODE

## TO-220AB Part Marking Information

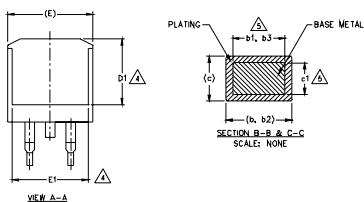
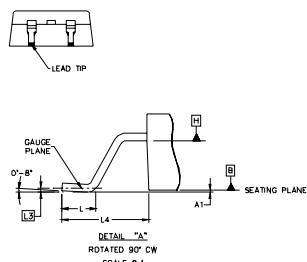
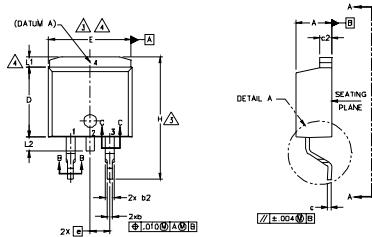


TO-220AB packages are not recommended for Surface Mount Application.

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

## D<sup>2</sup>Pak (TO-263AB) Package Outline

Dimensions are shown in millimeters (inches)



S Y M B O L	DIMENSIONS				N O T E S	
	MILLIMETERS		INCHES			
	MIN.	MAX.	MIN.	MAX.		
A	4.06	4.83	.160	.190		
A1	0.00	0.254	.000	.010	5	
b	0.51	0.99	.020	.039		
b1	0.51	0.89	.020	.035		
b2	1.14	1.78	.045	.070		
b3	1.14	1.73	.045	.068	5	
c	0.38	0.74	.015	.029		
c1	0.38	0.58	.015	.023	5	
c2	1.14	1.65	.045	.065		
D	8.38	9.65	.330	.380	3	
D1	6.86	—	.270	—	4	
E	9.65	10.67	.380	.420	3,4	
E1	6.22	—	.245	—	4	
e	2.54	BSC	.100	BSC		
H	14.61	15.88	.575	.625		
L	1.78	2.79	.070	.110		
L1	—	1.65	—	.066		
L2	—	1.78	—	.070		
L3	0.25	BSC	.010	BSC		
L4	4.78	5.28	.188	.208		

### LEAD ASSIGNMENTS

DIODES	
1.- ANODE (TWO DIE) / OPEN (ONE DIE)	
2, 4.- CATHODE	
3.- ANODE	
HEXFET	
1.- GATE	IGBTs, CoPACK
2, 4.- DRAIN	1.- GATE
3.- SOURCE	2, 4.- COLLECTOR
	3.- Emitter

NOTES:  
1. DIMENSIONING AND TOLERANCING PER ASME Y14.5M-1994  
2. DIMENSIONS ARE SHOWN IN MILLIMETERS (INCHES)  
3. DIMENSION D & E DO NOT INCLUDE MOLD FLASH. MOLD FLASH SHALL NOT EXCEED 0.127 (.005") PER SIDE. THESE DIMENSIONS ARE MEASURED AT THE OUTMOST EXTREMES OF THE PLASTIC BODY AT DATUM H.  
4. THERMAL PAD CONTOUR OPTIONAL WITHIN DIMENSION E, L1, D1 & E1.  
5. DIMENSION b1 AND c1 APPLY TO BASE METAL ONLY.  
6. DATUM A & B TO BE DETERMINED AT DATUM PLANE H.  
7. CONTROLLING DIMENSION: INCH.  
8. OUTLINE CONFORMS TO JEDEC OUTLINE TO-263AB.

## D<sup>2</sup>Pak (TO-263AB) Part Marking Information

Part Number

AUIRF1404ZS

Date Code

Y= Year

WW= Work Week

A=Automotive, LeadFree

IR Logo

**IR** YWWA

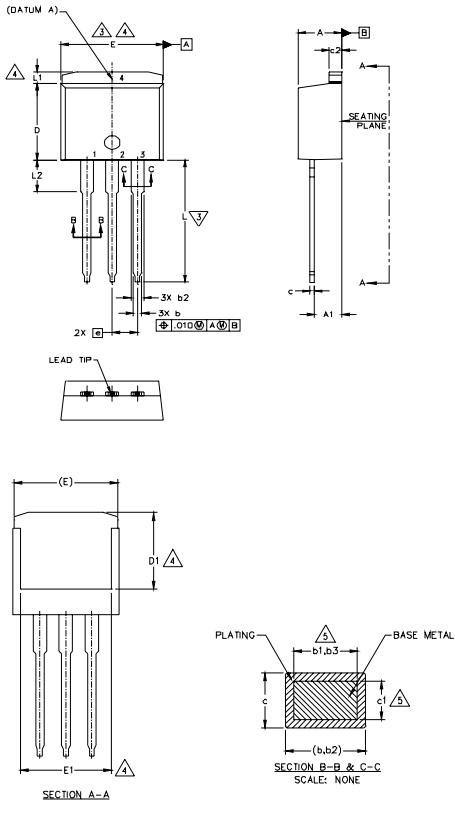
XX ● XX

Lot Code

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

## TO-262 Package Outline

Dimensions are shown in millimeters (inches)



SYMBOL	DIMENSIONS				NOTES	
	MILLIMETERS		INCHES			
	MIN.	MAX.	MIN.	MAX.		
A	4.06	4.83	.160	.190		
A1	2.03	3.02	.080	.119		
b	0.51	0.99	.020	.039		
b1	0.51	0.89	.020	.035	5	
b2	1.14	1.78	.045	.070		
b3	1.14	1.73	.045	.068	5	
c	0.38	0.74	.015	.029		
c1	0.38	0.58	.015	.023	5	
c2	1.14	1.65	.045	.065		
D	8.38	9.65	.330	.380	3	
D1	6.86	—	.270	—	4	
E	9.65	10.67	.380	.420	3,4	
E1	6.22	—	.245	—	4	
e	2.54	BSC	.100	BSC		
L	13.46	14.10	.530	.555		
L1	—	1.65	—	.065	4	
L2	3.56	3.71	.140	.146		

NOTES:  
1. DIMENSIONING AND TOLERANCING PER ASME Y14.5M-1994  
2. DIMENSIONS ARE SHOWN IN MILLIMETERS (INCHES)  
3. DIMENSION D & E DO NOT INCLUDE MOLD FLASH. MOLD FLASH SHALL NOT EXCEED 0.127 (.005") PER SIDE. THESE DIMENSIONS ARE MEASURED AT THE OUTMOST EXTREMES OF THE PLASTIC BODY.  
4. THERMAL PAD CONTOUR OPTIONAL WITHIN DIMENSION E, L1, D1 & E1.  
5. DIMENSION b1 and c1 APPLY TO BASE METAL ONLY.  
6. CONTROLLING DIMENSION INCH.  
7. OUTLINE CONFORM TO JEDEC TO-262 EXCEPT A1(mm), b1(mm) AND D1(mm) WHERE DIMENSIONS DERIVED THE ACTUAL PACKAGE OUTLINE.

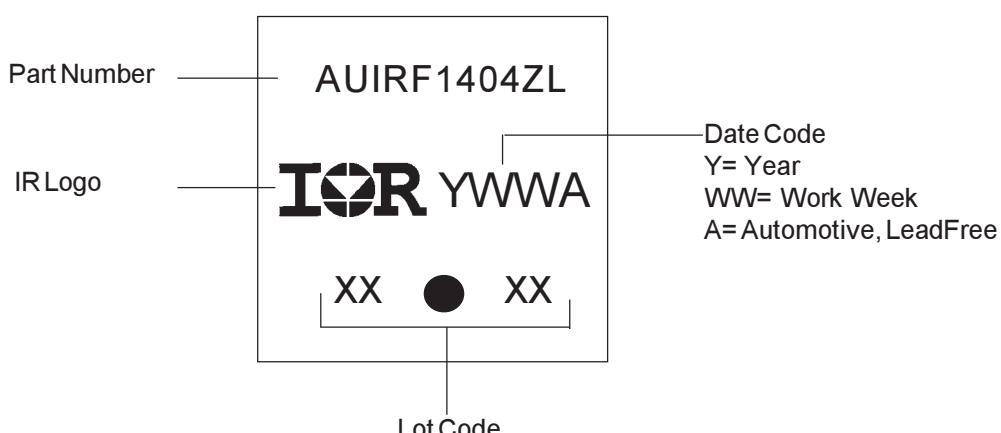
## LEAD ASSIGNMENTS

IGBT, CAPACITOR  
1.- GATE  
2.- COLLECTOR  
3.- Emitter  
4.- Collector

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

Diodes  
1.- ANODE (IN IN) / OPEN (ONE DE)  
2.- CATHODE

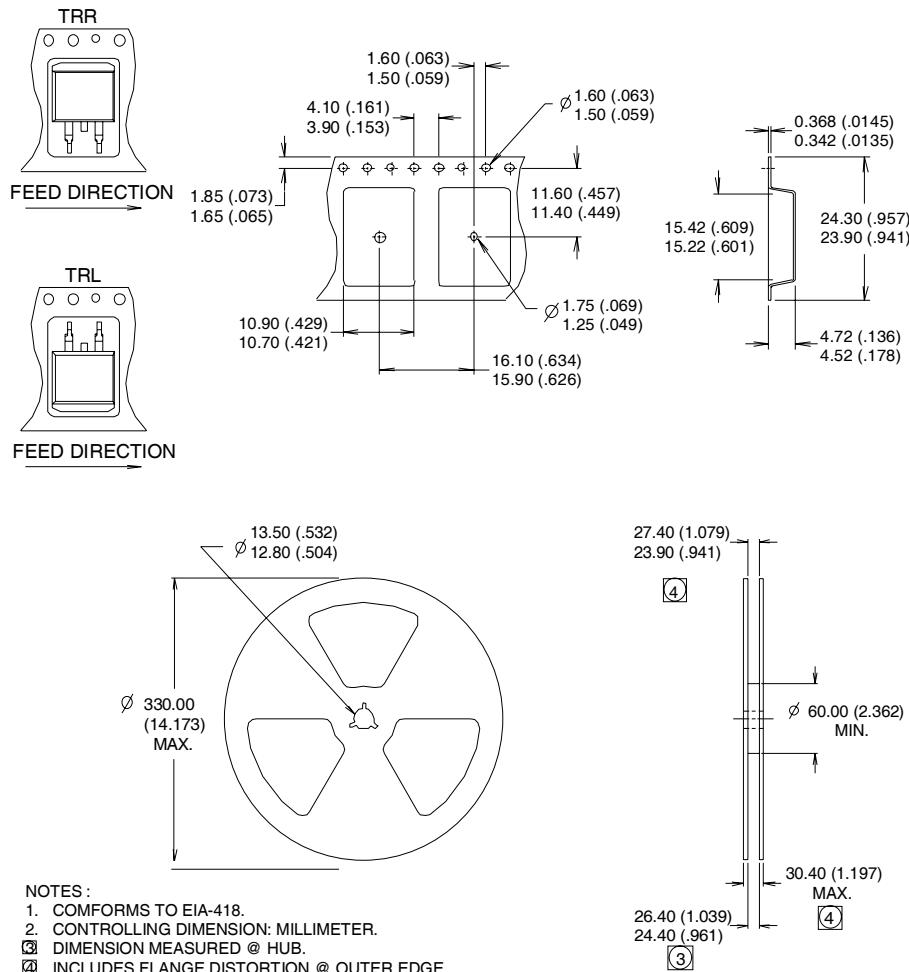
## TO-262 Part Marking Information



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

## D<sup>2</sup>Pak Tape & Reel Information

Dimensions are shown in millimeters (inches)



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



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