

# International Rectifier

PD - 95956A

## IRLR3705ZPbF IRLU3705ZPbF

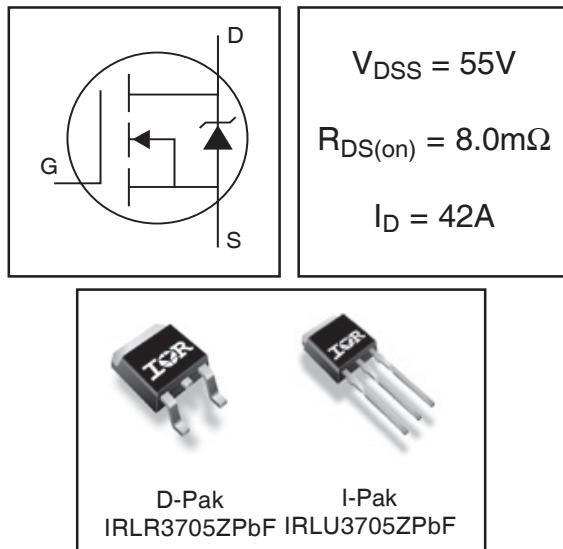
### Features

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

### Description

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 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)	89	
$I_D @ T_C = 100^\circ C$	Continuous Drain Current, $V_{GS} @ 10V$	63	A
$I_D @ T_C = 25^\circ C$	Continuous Drain Current, $V_{GS} @ 10V$ (Package Limited)	42	
$I_{DM}$	Pulsed Drain Current ①	360	
$P_D @ T_C = 25^\circ C$	Power Dissipation	130	W
	Linear Derating Factor	0.88	W/°C
$V_{GS}$	Gate-to-Source Voltage	$\pm 16$	V
$E_{AS} \text{ (Thermally limited)}$	Single Pulse Avalanche Energy ②	110	mJ
$E_{AS} \text{ (Tested )}$	Single Pulse Avalanche Energy Tested Value ③	190	
$I_{AR}$	Avalanche Current ④	See Fig.12a, 12b, 15, 16	A
$E_{AR}$	Repetitive Avalanche Energy ⑤		mJ
$T_J$	Operating Junction and	-55 to + 175	
$T_{STG}$	Storage Temperature Range		°C
	Soldering Temperature, for 10 seconds	300 (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 ⑥	---	1.14	
$R_{\theta JA}$	Junction-to-Ambient (PCB mount) ⑦ ⑧	---	40	°C/W
$R_{\theta JA}$	Junction-to-Ambient ⑨	---	110	

HEXFET® is a registered trademark of International Rectifier.

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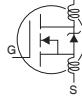
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10/01/10

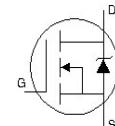
# IRLR/U3705ZPbF

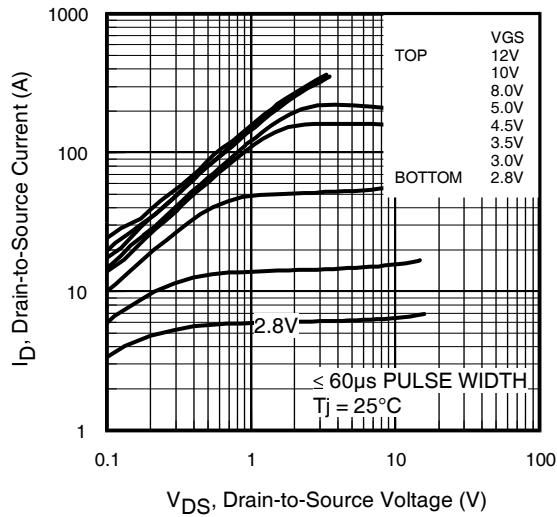
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Rectifier

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

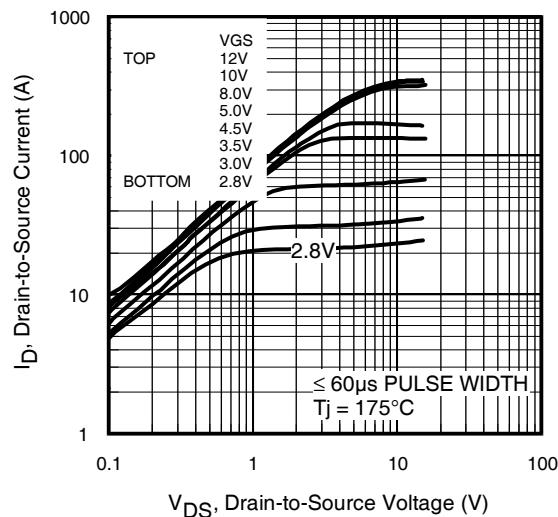
	Parameter	Min.	Typ.	Max.	Units	Conditions
$V_{(\text{BR})\text{DSS}}$	Drain-to-Source Breakdown Voltage	55	—	—	V	$V_{\text{GS}} = 0\text{V}, I_D = 250\mu\text{A}$
$\Delta V_{(\text{BR})\text{DSS}/\Delta T_J}$	Breakdown Voltage Temp. Coefficient	—	0.053	—	V/ $^\circ\text{C}$	Reference to $25^\circ\text{C}, I_D = 1\text{mA}$
$R_{\text{DS}(\text{on})}$	Static Drain-to-Source On-Resistance	—	6.5	8.0	$\text{m}\Omega$	$V_{\text{GS}} = 10\text{V}, I_D = 42\text{A}$ ③
		—	—	11		$V_{\text{GS}} = 5.0\text{V}, I_D = 34\text{A}$ ③
		—	—	12		$V_{\text{GS}} = 4.5\text{V}, I_D = 21\text{A}$ ③
$V_{\text{GS}(\text{th})}$	Gate Threshold Voltage	1.0	—	3.0	V	$V_{\text{DS}} = V_{\text{GS}}, I_D = 250\mu\text{A}$
$g_{\text{fs}}$	Forward Transconductance	89	—	—	S	$V_{\text{DS}} = 25\text{V}, I_D = 42\text{A}$
$I_{\text{DSS}}$	Drain-to-Source Leakage Current	—	—	20	$\mu\text{A}$	$V_{\text{DS}} = 55\text{V}, V_{\text{GS}} = 0\text{V}$
		—	—	250		$V_{\text{DS}} = 55\text{V}, V_{\text{GS}} = 0\text{V}, T_J = 125^\circ\text{C}$
$I_{\text{GSS}}$	Gate-to-Source Forward Leakage	—	—	200	nA	$V_{\text{GS}} = 16\text{V}$
	Gate-to-Source Reverse Leakage	—	—	-200		$V_{\text{GS}} = -16\text{V}$
$Q_g$	Total Gate Charge	—	44	66	nC	$I_D = 42\text{A}$
$Q_{\text{gs}}$	Gate-to-Source Charge	—	13	—		$V_{\text{DS}} = 44\text{V}$
$Q_{\text{gd}}$	Gate-to-Drain ("Miller") Charge	—	22	—		$V_{\text{GS}} = 5.0\text{V}$ ③
$t_{\text{d}(\text{on})}$	Turn-On Delay Time	—	17	—	ns	$V_{\text{DD}} = 28\text{V}$
$t_r$	Rise Time	—	150	—		$I_D = 42\text{A}$
$t_{\text{d}(\text{off})}$	Turn-Off Delay Time	—	33	—		$R_G = 4.2 \Omega$
$t_f$	Fall Time	—	70	—		$V_{\text{GS}} = 5.0\text{V}$ 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	—	2900	—	pF	$V_{\text{GS}} = 0\text{V}$
$C_{\text{oss}}$	Output Capacitance	—	420	—		$V_{\text{DS}} = 25\text{V}$
$C_{\text{rss}}$	Reverse Transfer Capacitance	—	230	—		$f = 1.0\text{MHz}$
$C_{\text{oss}}$	Output Capacitance	—	1550	—		$V_{\text{GS}} = 0\text{V}, V_{\text{DS}} = 1.0\text{V}, f = 1.0\text{MHz}$
$C_{\text{oss}}$	Output Capacitance	—	320	—		$V_{\text{GS}} = 0\text{V}, V_{\text{DS}} = 44\text{V}, f = 1.0\text{MHz}$
$C_{\text{oss eff.}}$	Effective Output Capacitance	—	500	—		$V_{\text{GS}} = 0\text{V}, V_{\text{DS}} = 0\text{V to } 44\text{V}$ ④

## Source-Drain Ratings and Characteristics

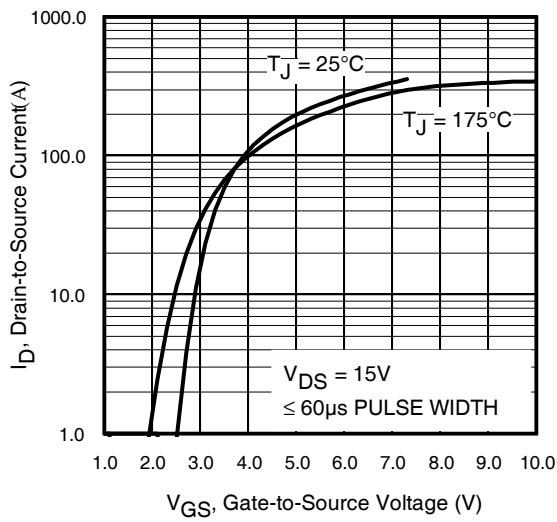
	Parameter	Min.	Typ.	Max.	Units	Conditions
$I_S$	Continuous Source Current (Body Diode)	—	—	42	A	MOSFET symbol showing the integral reverse p-n junction diode.
	Pulsed Source Current (Body Diode) ①	—	—	360		
$V_{\text{SD}}$	Diode Forward Voltage	—	—	1.3	V	$T_J = 25^\circ\text{C}, I_S = 42\text{A}, V_{\text{GS}} = 0\text{V}$ ③
$t_{\text{rr}}$	Reverse Recovery Time	—	21	42	ns	$T_J = 25^\circ\text{C}, I_F = 42\text{A}, V_{\text{DD}} = 28\text{V}$
$Q_{\text{rr}}$	Reverse Recovery Charge	—	14	28	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)				



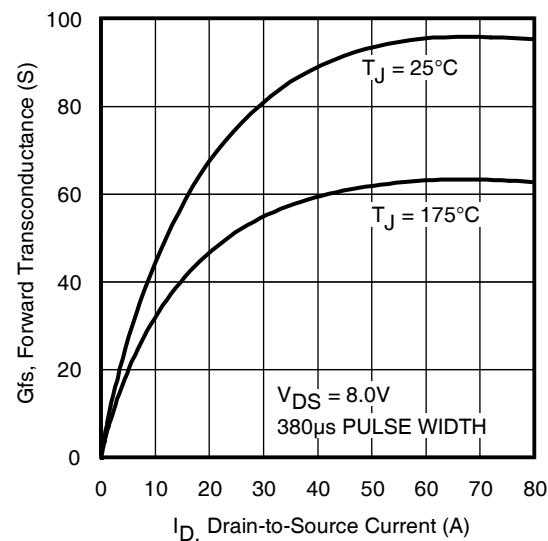
**Fig 1.** Typical Output Characteristics



**Fig 2.** Typical Output Characteristics



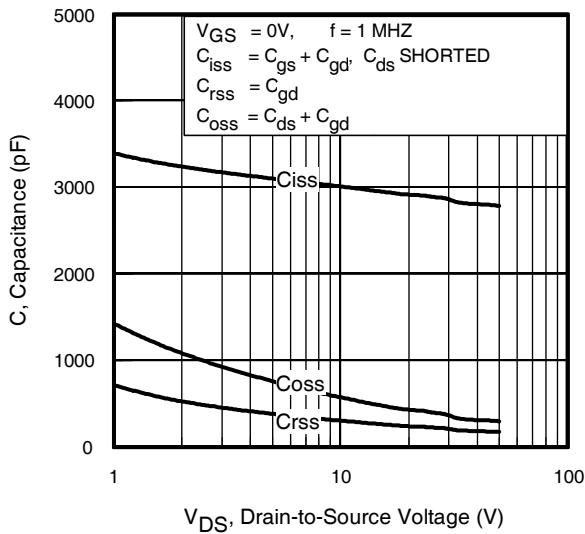
**Fig 3.** Typical Transfer Characteristics



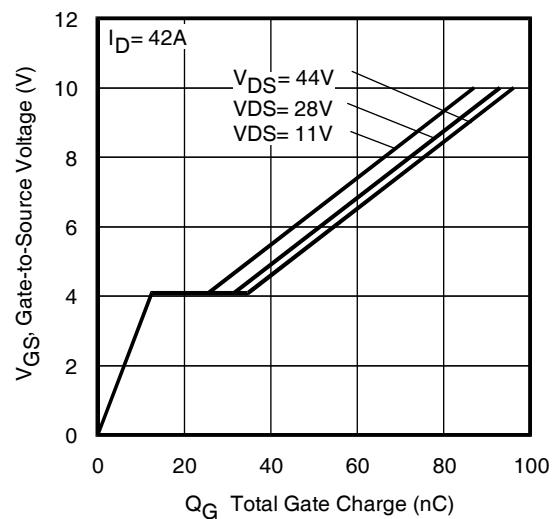
**Fig 4.** Typical Forward Transconductance  
vs. Drain Current

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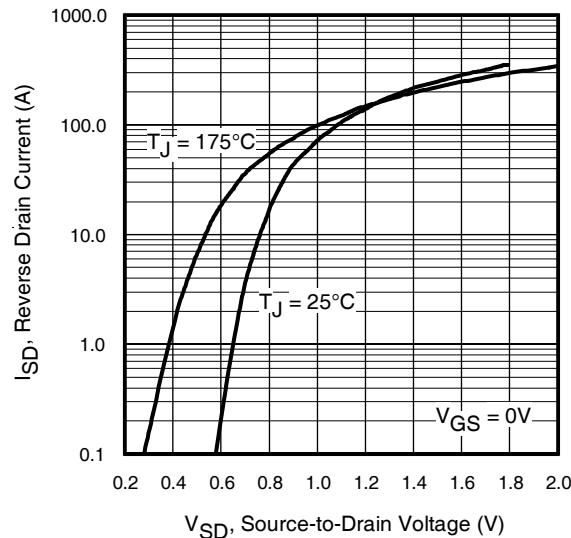
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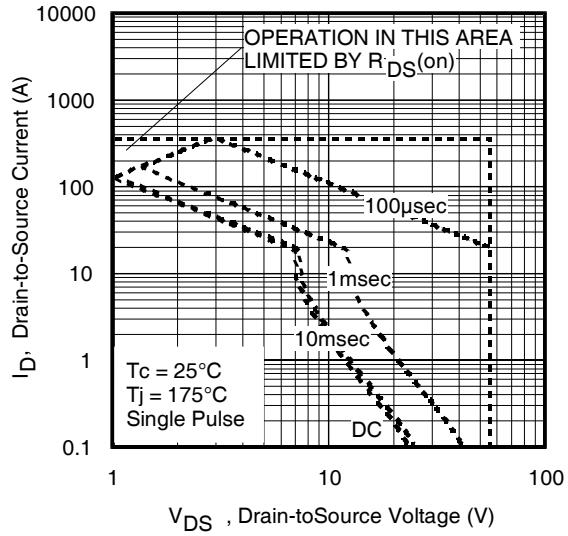
**Fig 5.** Typical Capacitance vs.  
Drain-to-Source Voltage



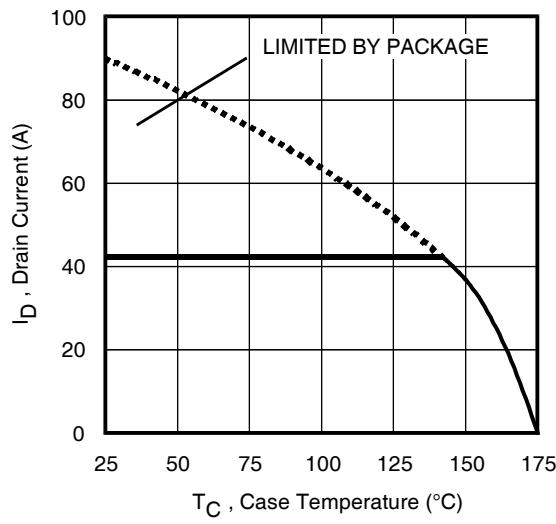
**Fig 6.** Typical Gate Charge vs.  
Gate-to-Source Voltage



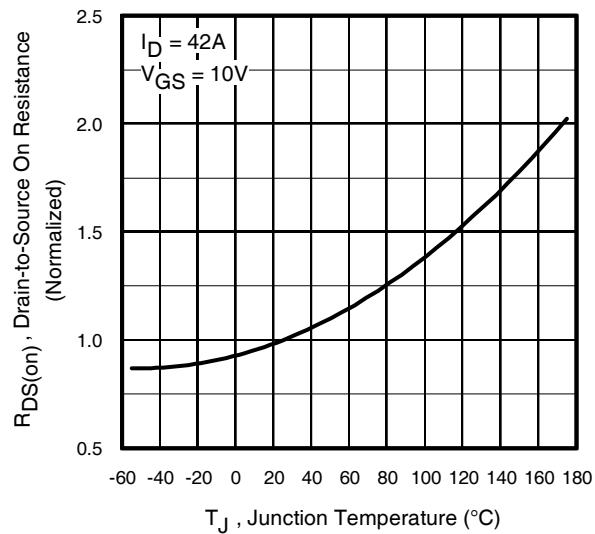
**Fig 7.** Typical Source-Drain Diode  
Forward Voltage



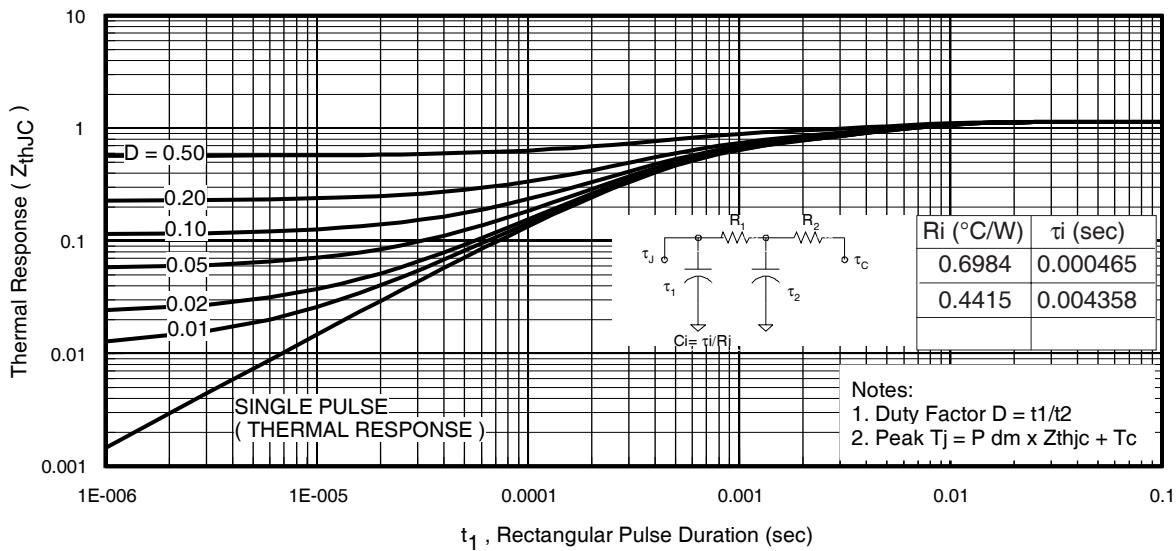
**Fig 8.** Maximum Safe Operating Area



**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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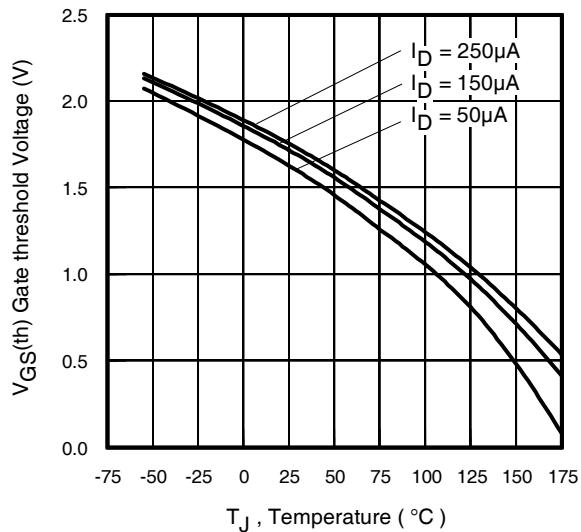
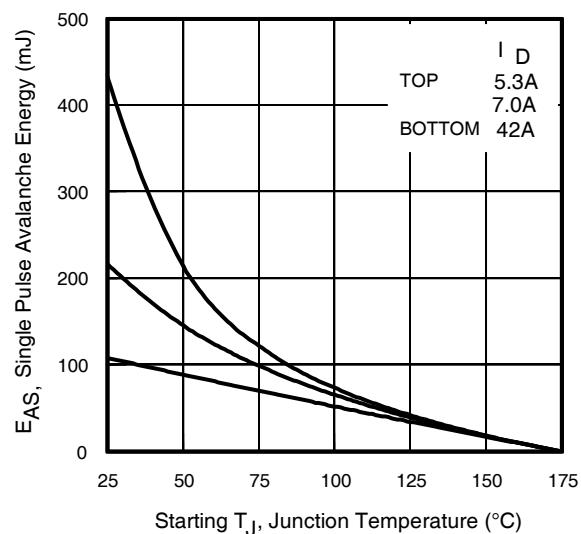
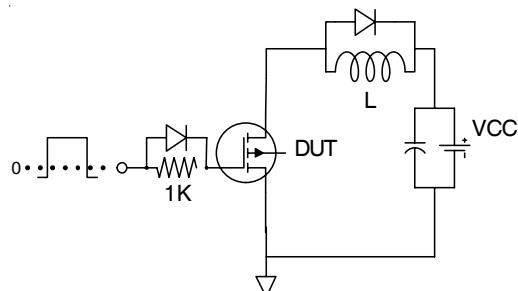
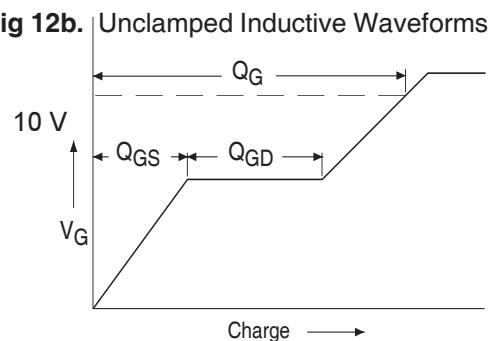
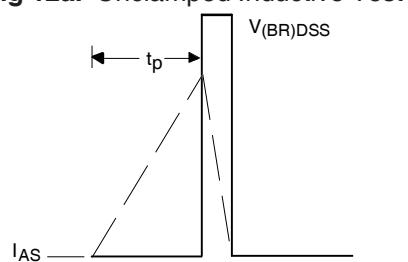
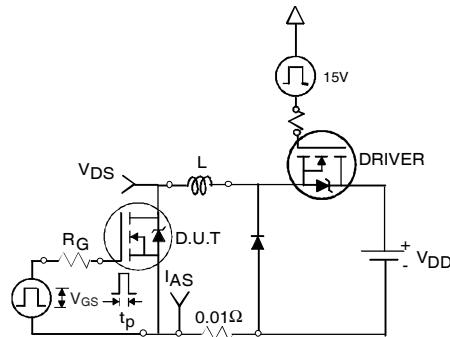
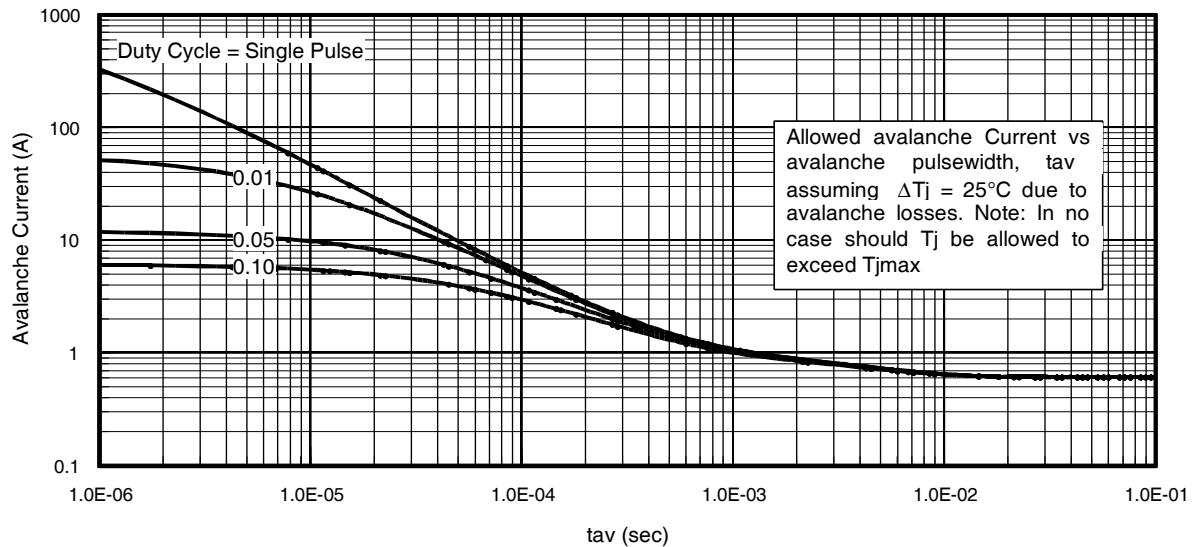
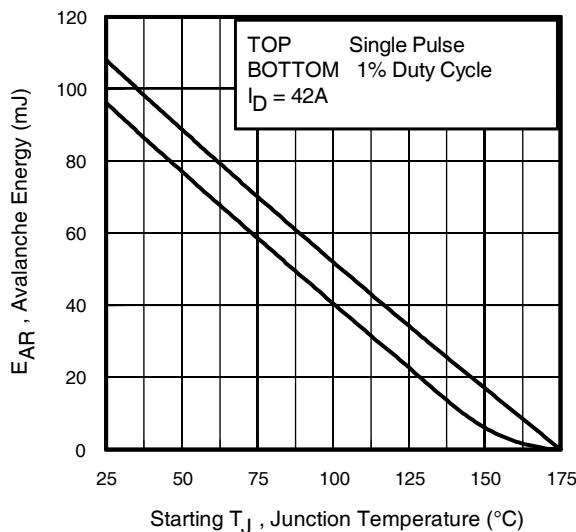


Fig 14. Threshold Voltage vs. Temperature

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**Fig 15.** Typical Avalanche Current vs.Pulsewidth



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

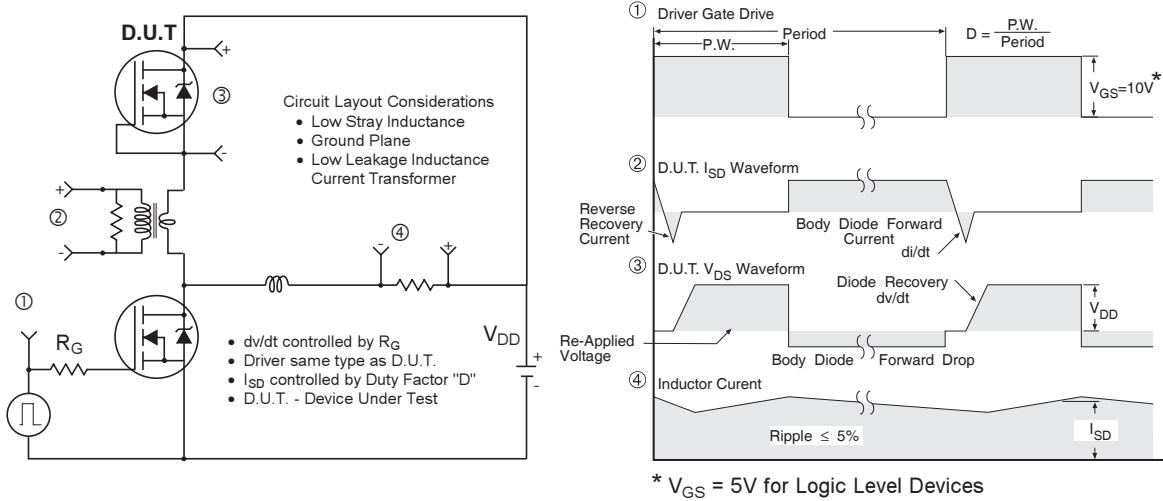
**Notes on Repetitive Avalanche Curves , Figures 15, 16:  
 (For further info, see AN-1005 at [www.irf.com](http://www.irf.com))**

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.  $P_{D(ave)}$  = 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 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)

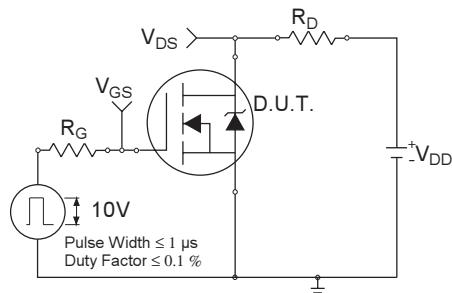
$$P_{D(ave)} = 1/2 (1.3 \cdot BV \cdot I_{av}) = \Delta T / Z_{thJC}$$

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

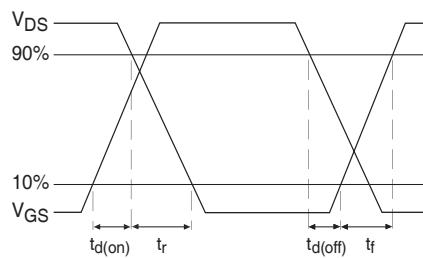
$$E_{AS(AR)} = P_{D(ave)} \cdot t_{av}$$



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



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



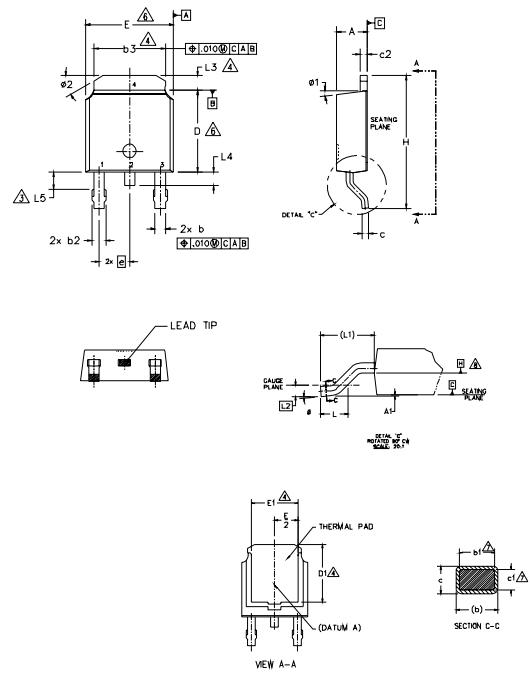
**Fig 18b.** Switching Time Waveforms

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**IRLR/U3705ZPbF**

## D-Pak (TO-252AA) Package Outline

Dimensions are shown in millimeters (inches)



NOTES:

- DIMENSIONING AND TOLERANCING PER ASME Y14.5M-1994
- DIMENSIONS ARE SHOWN IN INCHES [MILLIMETERS]
- △ LEAD DIMENSION UNCONTROLLED IN L5.
- △ DIMENSION D1, E1, L3 & b3 ESTABLISH A MINIMUM MOUNTING SURFACE FOR THERMAL PAD.
- SECTION C-C DIMENSIONS APPLY TO THE FLAT SECTION OF THE LEAD BETWEEN .005 [0.13] PER SIDE. THESE DIMENSIONS ARE MEASURED AT THE OUTMOST EXTREMES OF THE PLASTIC BODY.
- △ DIMENSION D & E DO NOT INCLUDE MOLD FLASH. MOLD FLASH SHALL NOT EXCEED .005 [0.13] PER SIDE. THESE DIMENSIONS ARE MEASURED AT THE OUTMOST EXTREMES OF THE PLASTIC BODY.
- △ DIMENSION b1 & c1 APPLIED TO BASE METAL ONLY.
- △ DATUM A & B TO BE DETERMINED AT DATUM PLANE H.
- OUTLINE CONFORMS TO JEDEC OUTLINE TO-252AA.

S Y M B O L	DIMENSIONS		N O T E S
	MILLIMETERS	INCHES	
	MIN.	MAX.	
A	2.18	2.39	.086 .094
A1	—	0.13	— .005
b	0.64	0.89	.025 .035
b1	0.65	0.79	.025 .031
b2	0.76	1.14	.030 .045
b3	4.95	5.46	.195 .215
c	0.46	0.61	.018 .024
c1	0.41	0.56	.016 .022
c2	0.46	0.89	.018 .035
D	5.97	6.22	.235 .245
D1	5.21	—	.205 —
E	6.35	6.73	.250 .265
E1	4.32	—	.170 —
e	2.29 BSC	.090 BSC	
H	9.40	10.41	.370 .410
L	1.40	1.78	.055 .070
L1	2.74 BSC	.108 REF.	
L2	0.51 BSC	.020 BSC	
L3	0.89	1.27	.035 .050
L4	—	1.02	— .040
L5	1.14	1.52	.045 .060
φ	0°	10°	0° 10°
ø1	0°	15°	0° 15°
ø2	25°	35°	25° 35°

### LEAD ASSIGNMENTS

#### HEXFET

- GATE
- DRAIN
- SOURCE
- DRAIN

#### IGBT & CoPAK

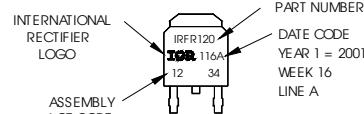
- GATE
- COLLECTOR
- Emitter
- COLLECTOR

## D-Pak (TO-252AA) Part Marking Information

EXAMPLE: THIS IS AN IRFR120  
WITH ASSEMBLY  
LOT CODE 1234  
ASSEMBLED ON WW 16, 2001  
IN THE ASSEMBLY LINE "A"

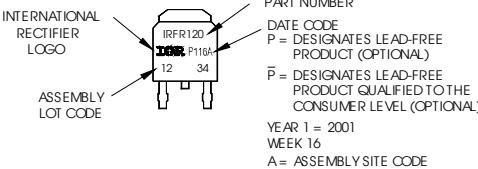
Note: "P" in assembly line position  
indicates "Lead-Free"

"P" in assembly line position  
indicates "Lead-Free" qualification to the consumer-level



PART NUMBER  
DATE CODE  
YEAR 1 = 2001  
WEEK 16  
LINE A

OR



PART NUMBER  
DATE CODE  
P = DESIGNATES LEAD-FREE PRODUCT (OPTIONAL)  
P = DESIGNATES LEAD-FREE PRODUCT QUALIFIED TO THE CONSUMER LEVEL (OPTIONAL)  
YEAR 1 = 2001  
WEEK 16  
A = ASSEMBLY SITE CODE

### Notes:

- For an Automotive Qualified version of this part please see <http://www.irf.com/product-info/auto/>
- For the most current drawing please refer to IR website at <http://www.irf.com/package/>

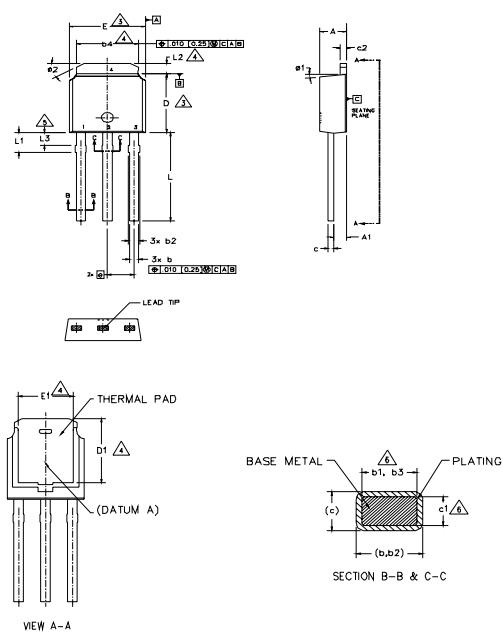
[www.irf.com](http://www.irf.com)

# IRLR/U3705ZPbF

International  
**IR** Rectifier

## I-Pak (TO-251AA) Package Outline

Dimensions are shown in millimeters (inches)



### NOTES:

- 1.- DIMENSIONING AND TOLERANCING PER ASME Y14.5M-1994
- 2.- DIMENSIONS ARE SHOWN IN INCHES [MILLIMETERS]
- 3.- DIMENSION D & E DO NOT INCLUDE MOLD FLASH. MOLD FLASH SHALL NOT EXCEED .005 [0.13] PER SIDE. THESE DIMENSIONS ARE MEASURED AT THE OUTMOST EXTREMES OF THE PLASTIC BODY.
- 4.- THERMAL PAD CONTOUR OPTION WITHIN DIMENSION E4, L2, E1 & D1.
- 5.- LEAD DIMENSION UNCONTROLLED IN L3.
- 6.- DIMENSION b1, b3 & c1 APPLY TO BASE METAL ONLY.
- 7.- OUTLINE CONFORMS TO JEDEC OUTLINE TO-251AA (Date 06/02).
- 8.- CONTROLLING DIMENSION : INCHES.

SYMBOL	DIMENSIONS		NOTES
	MILLIMETERS	INCHES	
	MIN.	MAX.	
A	2.18	2.39	.086 .094
A1	0.89	1.14	.035 .045
b	0.64	0.89	.025 .035
b1	0.65	0.79	.025 .031
b2	0.76	1.14	.030 .045
b3	0.76	1.04	.030 .041
b4	4.95	5.46	.195 .215
c	0.46	0.61	.018 .024
c1	0.41	0.56	.016 .022
c2	0.46	0.89	.018 .035
D	5.97	6.22	.235 .245
D1	5.21	—	.205 —
E	6.35	6.73	.250 .265
E1	4.32	—	.170 —
e	2.29 BSC	—	.090 BSC
L	8.89	9.65	.350 .380
L1	1.91	2.29	.045 .090
L2	0.89	1.27	.035 .050
L3	1.14	1.52	.045 .060
b1	0°	15°	0° 15°
b2	25°	35°	25° 35°

### LEAD ASSIGNMENTS

#### HEXFET

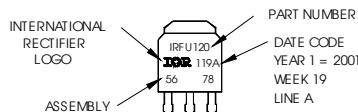
- 1.- GATE
- 2.- DRAIN
- 3.- SOURCE
- 4.- DRAIN

## I-Pak (TO-251AA) Part Marking Information

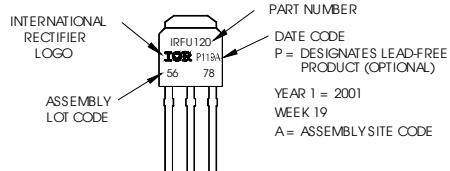
EXAMPLE: THIS IS AN IRFU120  
WITH ASSEMBLY  
LOT CODE 5678  
ASSEMBLED ON WW19, 2001  
IN THE ASSEMBLY LINE "A"

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

OR



PART NUMBER  
DATE CODE  
YEAR 1 = 2001  
WEEK 19  
LINE A



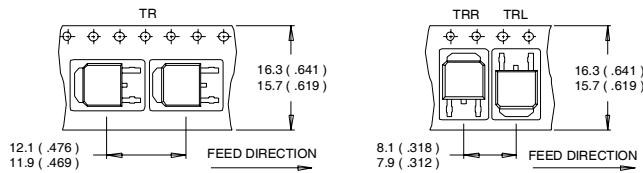
PART NUMBER  
DATE CODE  
P = DESIGNATES LEAD-FREE  
PRODUCT (OPTIONAL)  
YEAR 1 = 2001  
WEEK 19  
A = ASSEMBLY SITE CODE

### 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/>

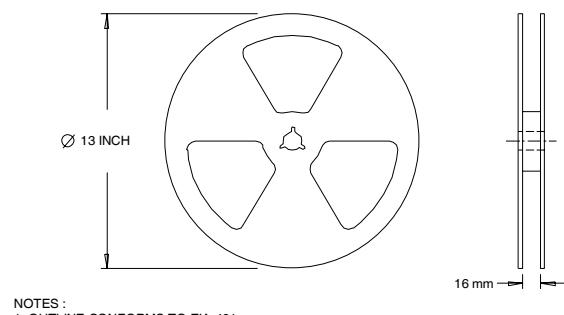
## D-Pak (TO-252AA) Tape & Reel Information

Dimensions are shown in millimeters



NOTES :

1. CONTROLLING DIMENSION : MILLIMETER.
2. ALL DIMENSIONS ARE SHOWN IN MILLIMETERS ( INCHES ).
3. OUTLINE CONFORMS TO EIA-481 & EIA-541.



NOTES :

1. OUTLINE CONFORMS TO EIA-481.

**Notes:**

- ① Repetitive rating; pulse width limited by max. junction temperature. (See fig. 11).
- ② Limited by  $T_{Jmax}$ , starting  $T_J = 25^\circ\text{C}$ ,  $L = 0.12\text{mH}$   $R_G = 25\Omega$ ,  $I_{AS} = 42\text{A}$ ,  $V_{GS} = 10\text{V}$ . Part not recommended for use above this value.
- ③ Pulse width  $\leq 1.0\text{ms}$ ; duty cycle  $\leq 2\%$ .
- ④  $C_{oss\ eff.}$  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.
- ⑦ When mounted on 1" square PCB (FR-4 or G-10 Material). For recommended footprint and soldering techniques refer to application note #AN-994
- ⑧  $R_\theta$  is measured at  $T_J$  approximately  $90^\circ\text{C}$

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.

International  
**IR** Rectifier

**IR WORLD HEADQUARTERS:** 233 Kansas St., El Segundo, California 90245, USA Tel: (310) 252-7105  
 TAC Fax: (310) 252-7903

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