

# IRFR48ZPbF IRFU48ZPbF

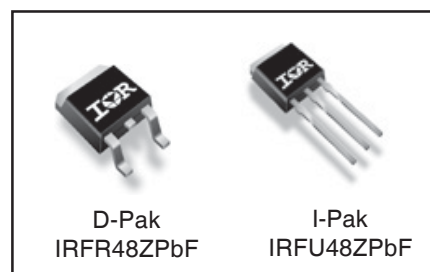
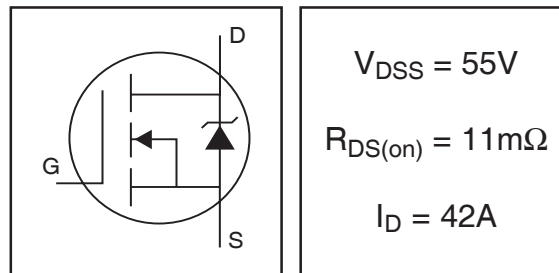
## Features

- Advanced Process Technology
- Ultra Low On-Resistance
- 175°C Operating Temperature
- Fast Switching
- Repetitive Avalanche Allowed up to  $T_{jmax}$
- 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) | 62                       | A     |
| $I_D @ T_C = 100^\circ C$    | Continuous Drain Current, $V_{GS} @ 10V$                   | 44                       |       |
| $I_D @ T_C = 25^\circ C$     | Continuous Drain Current, $V_{GS} @ 10V$ (Package Limited) | 42                       |       |
| $I_{DM}$                     | Pulsed Drain Current ①                                     | 250                      |       |
| $P_D @ T_C = 25^\circ C$     | Power Dissipation                                          | 91                       | W     |
|                              | Linear Derating Factor                                     | 0.61                     | W/°C  |
| $V_{GS}$                     | Gate-to-Source Voltage                                     | $\pm 20$                 | V     |
| $E_{AS}$ (Thermally limited) | Single Pulse Avalanche Energy ②                            | 74                       | mJ    |
| $E_{AS}$ (Tested )           | Single Pulse Avalanche Energy Tested Value ②               | 110                      |       |
| $I_{AR}$                     | Avalanche Current ③                                        | See Fig.12a, 12b, 15, 16 | A     |
| $E_{AR}$                     | Repetitive Avalanche Energy ③                              |                          | mJ    |
| $T_J$                        | Operating Junction and                                     | -55 to + 175             | °C    |
| $T_{STG}$                    | Storage Temperature Range                                  |                          |       |
|                              | Soldering Temperature, for 10 seconds                      |                          |       |
|                              | Mounting Torque, 6-32 or M3 screw                          |                          |       |

## Thermal Resistance

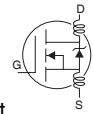
|                 | Parameter                           | Typ. | Max. | Units |
|-----------------|-------------------------------------|------|------|-------|
| $R_{\theta JC}$ | Junction-to-Case ④                  | ---  | 1.64 | °C/W  |
| $R_{\theta JA}$ | Junction-to-Ambient (PCB mount) ④ ⑤ | ---  | 40   |       |
| $R_{\theta JA}$ | Junction-to-Ambient ④               | ---  | 110  |       |

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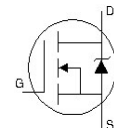
## Electrical Characteristics @ $T_J = 25^\circ\text{C}$ (unless otherwise specified)

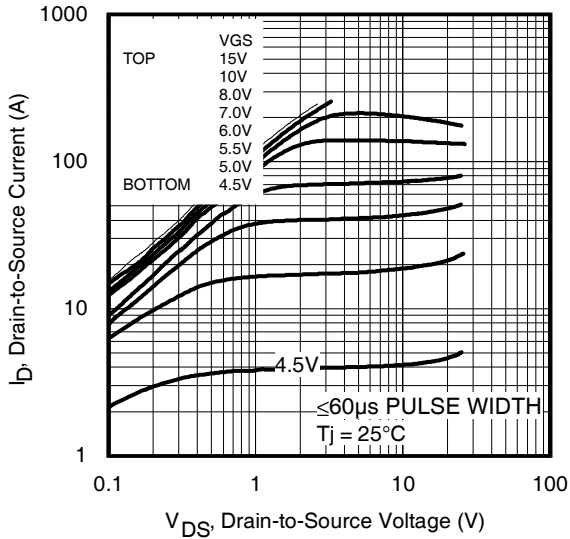
|                                 | Parameter                            | Min. | Typ.  | Max. | Units               | Conditions                                                                  |
|---------------------------------|--------------------------------------|------|-------|------|---------------------|-----------------------------------------------------------------------------|
| $V_{(BR)DSS}$                   | Drain-to-Source Breakdown Voltage    | 55   | —     | —    | V                   | $V_{GS} = 0V$ , $I_D = 250\mu A$                                            |
| $\Delta V_{(BR)DSS}/\Delta T_J$ | Breakdown Voltage Temp. Coefficient  | —    | 0.054 | —    | V/ $^\circ\text{C}$ | Reference to $25^\circ\text{C}$ , $I_D = 1mA$                               |
| $R_{DS(on)}$                    | Static Drain-to-Source On-Resistance | —    | 8.86  | 11   | m $\Omega$          | $V_{GS} = 10V$ , $I_D = 37A$ ③                                              |
| $V_{GS(th)}$                    | Gate Threshold Voltage               | 2.0  | —     | 4.0  | V                   | $V_{DS} = V_{GS}$ , $I_D = 50\mu A$                                         |
| $g_{fs}$                        | Forward Transconductance             | 120  | —     | —    | S                   | $V_{DS} = 25V$ , $I_D = 37A$                                                |
| $I_{DSS}$                       | Drain-to-Source Leakage Current      | —    | —     | 20   | $\mu A$             | $V_{DS} = 55V$ , $V_{GS} = 0V$                                              |
|                                 |                                      | —    | —     | 250  |                     | $V_{DS} = 55V$ , $V_{GS} = 0V$ , $T_J = 125^\circ\text{C}$                  |
| $I_{GSS}$                       | Gate-to-Source Forward Leakage       | —    | —     | 200  | nA                  | $V_{GS} = 20V$                                                              |
|                                 | Gate-to-Source Reverse Leakage       | —    | —     | -200 |                     | $V_{GS} = -20V$                                                             |
| $Q_g$                           | Total Gate Charge                    | —    | 40    | 60   | nC                  | $I_D = 37A$                                                                 |
| $Q_{gs}$                        | Gate-to-Source Charge                | —    | 11    | —    |                     | $V_{DS} = 44V$                                                              |
| $Q_{gd}$                        | Gate-to-Drain ("Miller") Charge      | —    | 15    | —    |                     | $V_{GS} = 10V$ ③                                                            |
| $t_{d(on)}$                     | Turn-On Delay Time                   | —    | 15    | —    | ns                  | $V_{DD} = 28V$                                                              |
| $t_r$                           | Rise Time                            | —    | 61    | —    |                     | $I_D = 37A$                                                                 |
| $t_{d(off)}$                    | Turn-Off Delay Time                  | —    | 40    | —    |                     | $R_G = 12\Omega$                                                            |
| $t_f$                           | Fall Time                            | —    | 35    | —    |                     | $V_{GS} = 10V$ ③                                                            |
| $L_D$                           | Internal Drain Inductance            | —    | 4.5   | —    | nH                  | Between lead,<br>6mm (0.25in.)<br>from package<br>and center of die contact |
| $L_S$                           | Internal Source Inductance           | —    | 7.5   | —    |                     |                                                                             |
| $C_{iss}$                       | Input Capacitance                    | —    | 1720  | —    | pF                  | $V_{GS} = 0V$                                                               |
| $C_{oss}$                       | Output Capacitance                   | —    | 290   | —    |                     | $V_{DS} = 25V$                                                              |
| $C_{rss}$                       | Reverse Transfer Capacitance         | —    | 160   | —    |                     | $f = 1.0MHz$                                                                |
| $C_{oss}$                       | Output Capacitance                   | —    | 1000  | —    |                     | $V_{GS} = 0V$ , $V_{DS} = 1.0V$ , $f = 1.0MHz$                              |
| $C_{oss}$                       | Output Capacitance                   | —    | 230   | —    |                     | $V_{GS} = 0V$ , $V_{DS} = 44V$ , $f = 1.0MHz$                               |
| $C_{oss\text{ eff.}}$           | Effective Output Capacitance         | —    | 360   | —    |                     | $V_{GS} = 0V$ , $V_{DS} = 0V$ to $44V$ ④                                    |



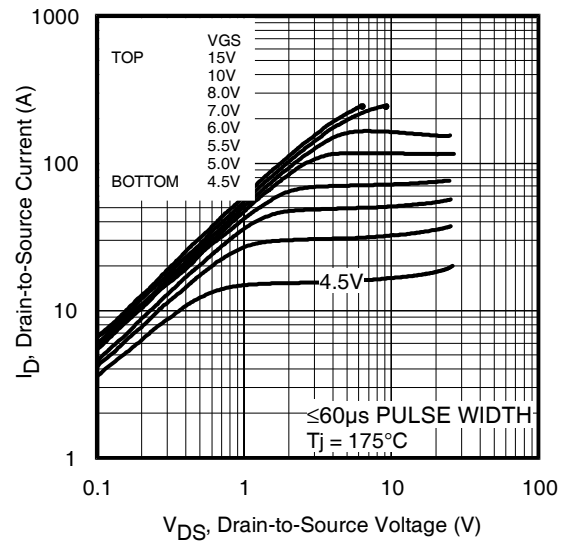
## Source-Drain Ratings and Characteristics

|          | Parameter                                 | Min.                                                                      | Typ. | Max. | Units | Conditions                                                              |
|----------|-------------------------------------------|---------------------------------------------------------------------------|------|------|-------|-------------------------------------------------------------------------|
| $I_S$    | Continuous Source Current<br>(Body Diode) | —                                                                         | —    | 37   | A     | MOSFET symbol<br>showing the<br>integral reverse<br>p-n junction diode. |
| $I_{SM}$ | Pulsed Source Current<br>(Body Diode) ①   | —                                                                         | —    | 250  |       |                                                                         |
| $V_{SD}$ | Diode Forward Voltage                     | —                                                                         | —    | 1.3  | V     | $T_J = 25^\circ\text{C}$ , $I_S = 37A$ , $V_{GS} = 0V$ ③                |
| $t_{rr}$ | Reverse Recovery Time                     | —                                                                         | 20   | 40   | ns    | $T_J = 25^\circ\text{C}$ , $I_F = 37A$ , $V_{DD} = 28V$                 |
| $Q_{rr}$ | Reverse Recovery Charge                   | —                                                                         | 14   | 28   | nC    | $di/dt = 100A/\mu s$ ③                                                  |
| $t_{on}$ | Forward Turn-On Time                      | Intrinsic turn-on time is negligible (turn-on is dominated by $L_S+L_D$ ) |      |      |       |                                                                         |

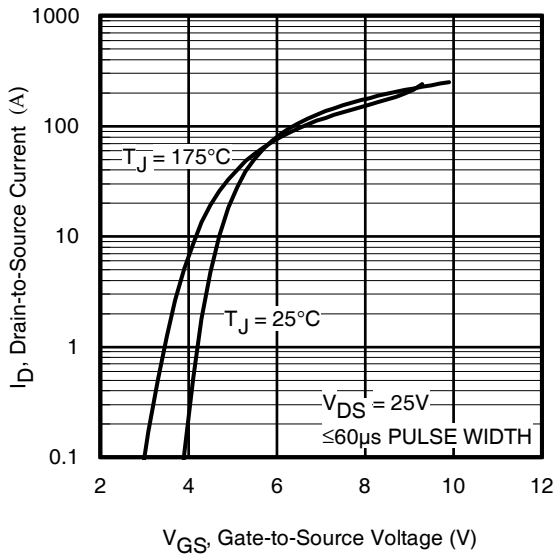




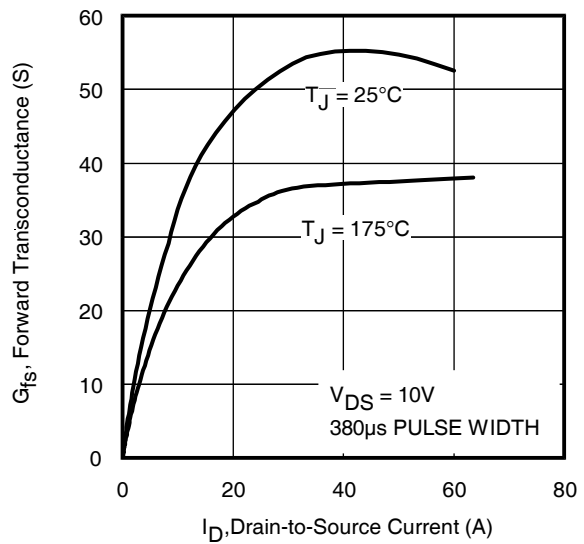
**Fig 1.** Typical Output Characteristics



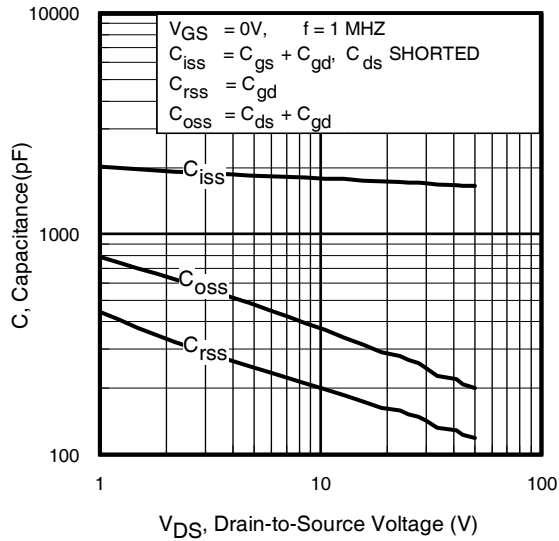
**Fig 2.** Typical Output Characteristics



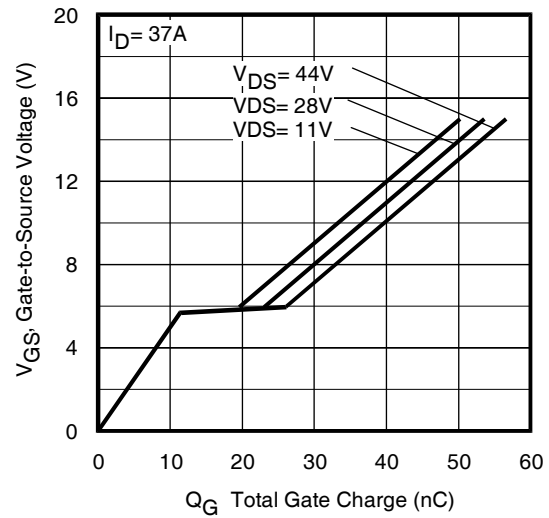
**Fig 3.** Typical Transfer Characteristics



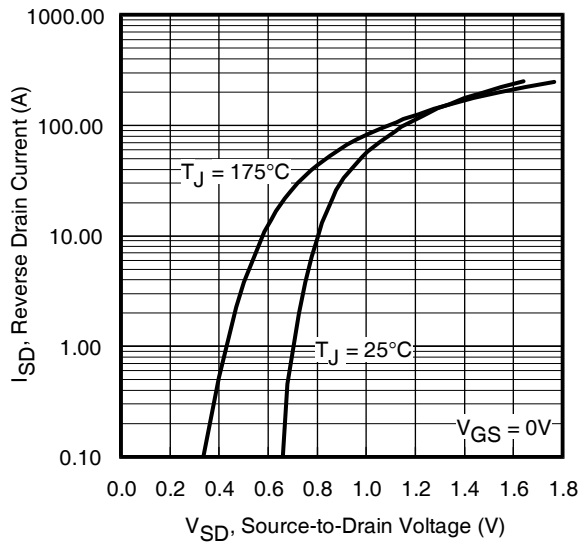
**Fig 4.** Typical Forward Transconductance vs. Drain Current



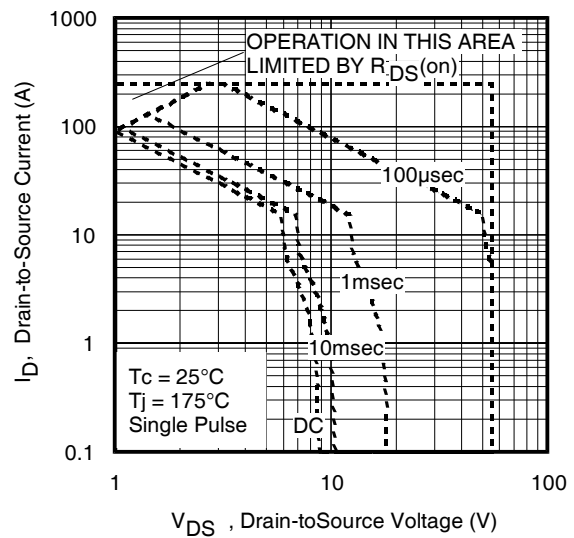
**Fig 5.** Typical Capacitance vs. Drain-to-Source Voltage



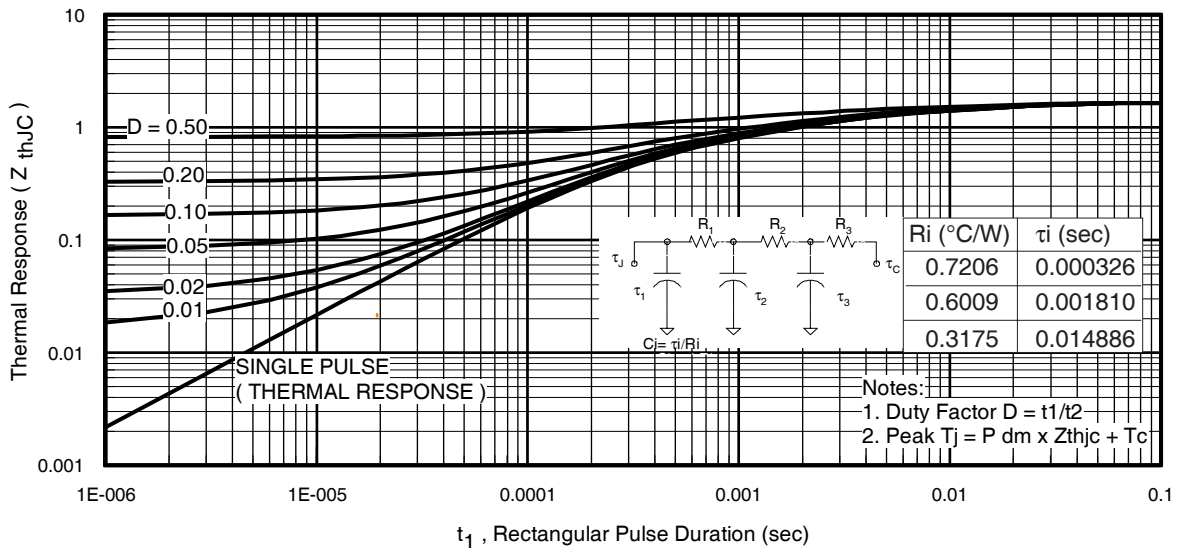
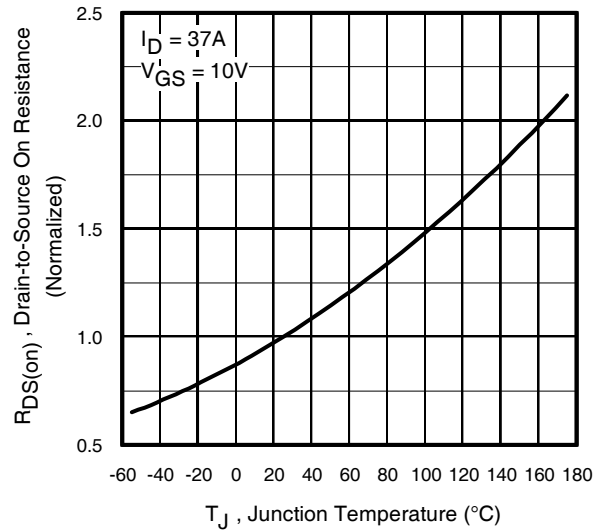
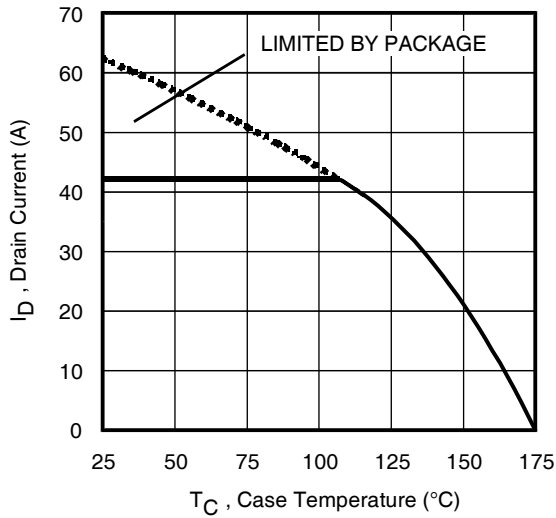
**Fig 6.** Typical Gate Charge vs. Gate-to-Source Voltage



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



**Fig 8.** Maximum Safe Operating Area



# IRFR/U48ZPbF

International  
**IR** Rectifier



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



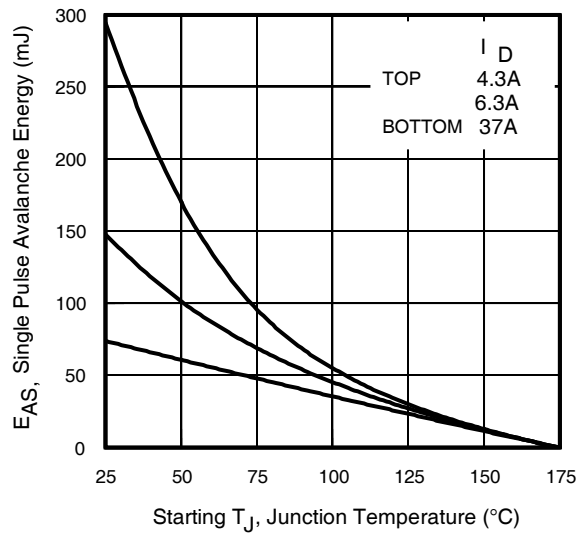
**Fig 12b.** Unclamped Inductive Waveforms



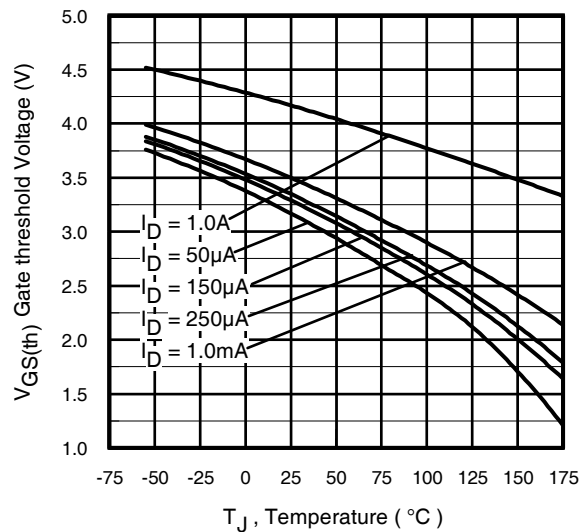
**Fig 13a.** Basic Gate Charge Waveform



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



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



**Fig 14.** Threshold Voltage vs. Temperature

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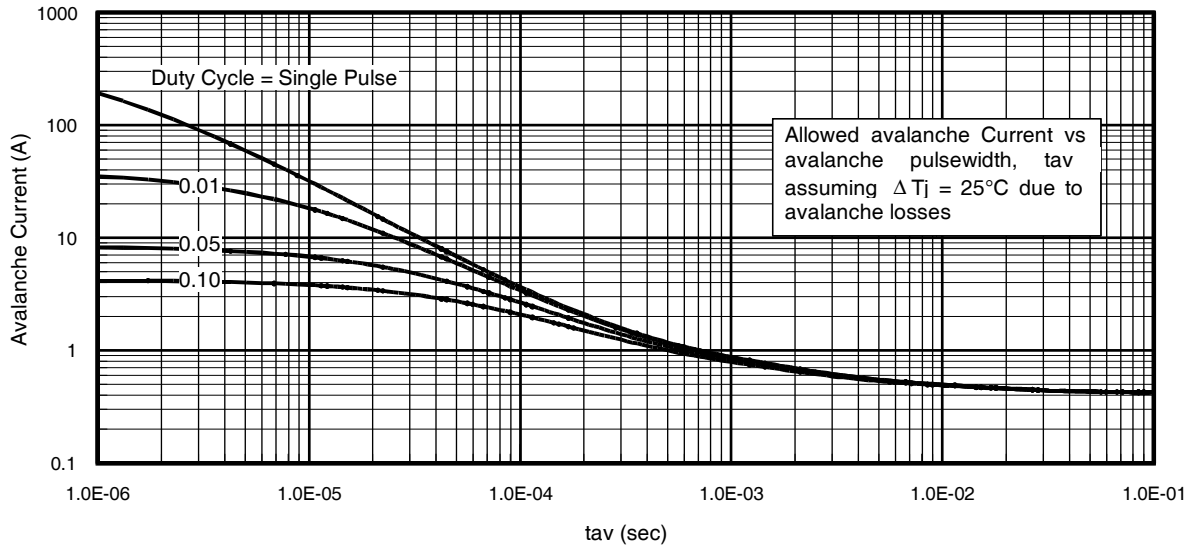


Fig 15. Typical Avalanche Current vs. Pulsewidth

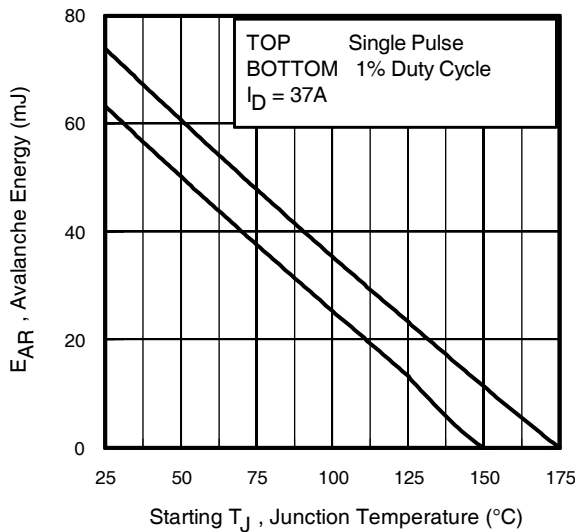


Fig 16. Maximum Avalanche Energy vs. Temperature

**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°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**



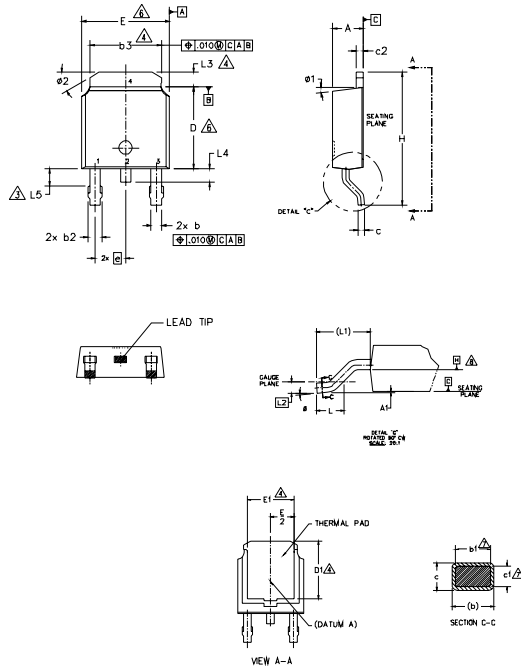
**Fig 18a. Switching Time Test Circuit**



**Fig 18b. Switching Time Waveforms**

## D-Pak (TO-252AA) 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.- LEAD DIMENSION UNCONTROLLED IN L5.
- 4.- DIMENSION D1, E1, L3 & b3 ESTABLISH A MINIMUM MOUNTING SURFACE FOR THERMAL PAD.
- 5.- SECTION C-C DIMENSIONS APPLY TO THE FLAT SECTION OF THE LEAD BETWEEN .005 AND 0.10 [0.13 AND 0.25] FROM THE LEAD TIP.
- 6.- 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.
- 7.- DIMENSION b1 & c1 APPLIED TO BASE METAL ONLY.
- 8.- DATUM A & B TO BE DETERMINED AT DATUM PLANE H.
- 9.- OUTLINE CONFORMS TO JEDEC OUTLINE TO-252AA.

| SYMBOL | DIMENSIONS  |       |           |      | NOTES |
|--------|-------------|-------|-----------|------|-------|
|        | MILLIMETERS |       | INCHES    |      |       |
|        | MIN.        | MAX.  | 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 | 7     |
| b2     | 0.76        | 1.14  | .030      | .045 |       |
| b3     | 4.95        | 5.46  | .195      | .215 | 4     |
| c      | 0.46        | 0.61  | .018      | .024 |       |
| c1     | 0.41        | 0.56  | .016      | .022 | 7     |
| c2     | 0.46        | 0.89  | .018      | .035 |       |
| D      | 5.97        | 6.22  | .235      | .245 | 6     |
| D1     | 5.21        | —     | .205      | —    | 4     |
| E      | 6.35        | 6.73  | .250      | .265 | 6     |
| E1     | 4.32        | —     | .170      | —    | 4     |
| 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 | 4     |
| L4     | —           | 1.02  | —         | .040 |       |
| L5     | 1.14        | 1.52  | .045      | .060 | 3     |
| ø      | 0"          | 10"   | 0"        | 10"  |       |
| ø1     | 0"          | 15"   | 0"        | 15"  |       |
| ø2     | 25"         | 35"   | 25"       | 35"  |       |

### LEAD ASSIGNMENTS

### HEXFET

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

### IGBT & CoPAK

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

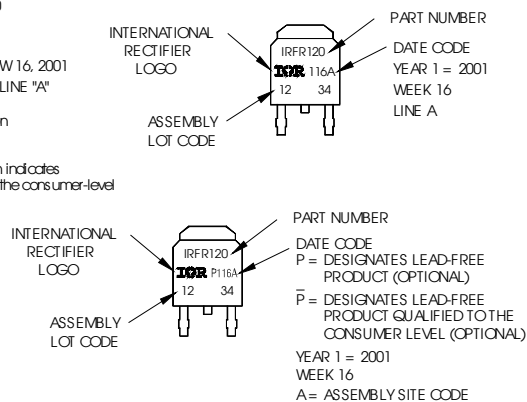
## D-Pak (TO-252AA) Part Marking Information

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

OR



### Notes:

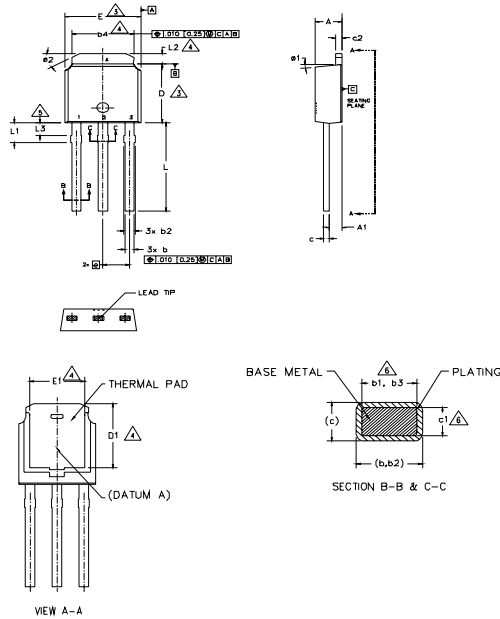
1. For an Automotive Qualified version of this part please see <http://www.irf.com/product-info/automotive/>
2. For the most current drawing please refer to IR website at <http://www.irf.com/package/>

# IRFR/U48ZPbF

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.- DIMENSION ARE SHOWN IN INCHES [MILLIMETERS]

△ 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.

△ THERMAL PAD CONTOUR OPTION WITHIN DIMENSION b4, L2, E1 & D1.

△ LEAD DIMENSION UNCONTROLLED IN L3.

△ 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. | 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 | 6     |
| b2     | 0.76        | 1.14 | .030     | .045 |       |
| b3     | 0.76        | 1.04 | .030     | .041 | 6     |
| b4     | 4.95        | 5.46 | .195     | .215 | 4     |
| c      | 0.46        | 0.61 | .018     | .024 |       |
| c1     | 0.41        | 0.56 | .016     | .022 | 6     |
| c2     | 0.46        | 0.89 | .018     | .035 |       |
| D      | 5.97        | 6.22 | .235     | .245 | 3     |
| D1     | 5.21        | -    | .205     | -    | 4     |
| E      | 6.35        | 6.73 | .250     | .265 | 3     |
| E1     | 4.32        | -    | .170     | -    | 4     |
| 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 | 4     |
| L3     | 1.14        | 1.52 | .045     | .060 | 5     |
| Ø1     | 0"          | 15"  | 0"       | 15"  |       |
| Ø2     | 25"         | 35"  | 25"      | 35"  |       |

### LEAD ASSIGNMENTS

### HEXFET

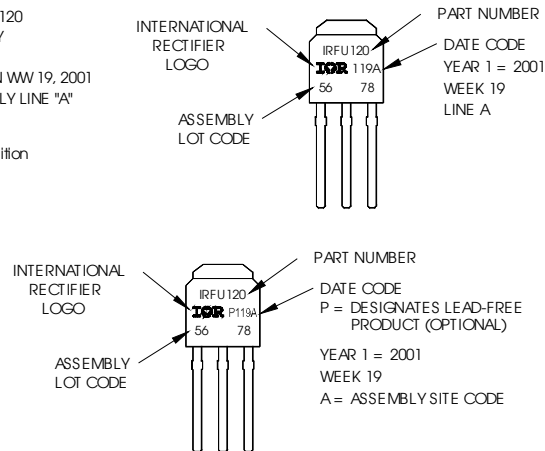
- 1.- GATE
- 2.- DRAIN
- 3.- SOURCE
- 4.- DRAIN

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

EXAMPLE: THIS IS AN IRFU120  
WITH ASSEMBLY  
LOT CODE 5678  
ASSEMBLED ON WW 19, 2001  
IN THE ASSEMBLY LINE "A"

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

OR

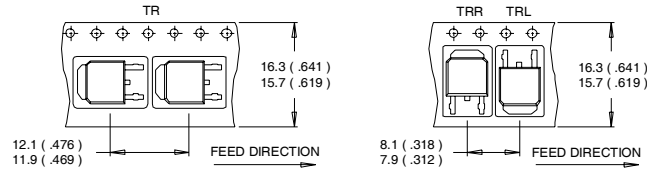


### Notes:

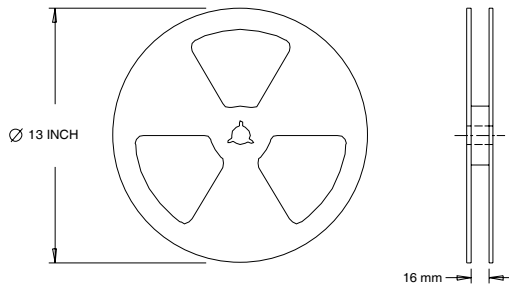
1. For an Automotive Qualified version of this part please see <http://www.irf.com/product-info/auto/>
2. For the most current drawing please refer to IR website at <http://www.irf.com/package/>

## 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  $T_J = 25^\circ\text{C}$ ,  $L = 0.11\text{mH}$ ,  $R_G = 25\Omega$ ,  $I_{AS} = 37\text{A}$ ,  $V_{GS} = 10\text{V}$ . 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  
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