

## SMPS MOSFET

IRFR3706PbF  
IRFU3706PbF

### Applications

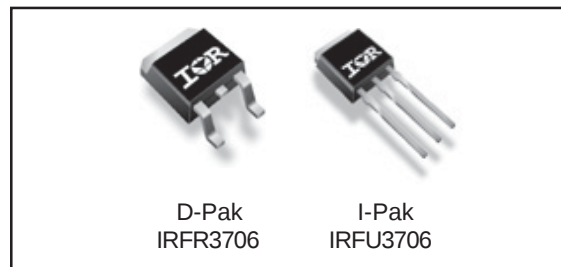
- High Frequency Isolated DC-DC Converters with Synchronous Rectification for Telecom and Industrial Use
- High Frequency Buck Converters for Computer Processor Power
- Lead-Free

### Benefits

- Ultra-Low Gate Impedance
- Very Low  $R_{DS(on)}$  at 4.5V  $V_{GS}$
- Fully Characterized Avalanche Voltage and Current

HEXFET® Power MOSFET

| $V_{DSS}$ | $R_{DS(on)}$ max | $I_D$            |
|-----------|------------------|------------------|
| 20V       | 9.0m $\Omega$    | 75A <sup>④</sup> |



### Absolute Maximum Ratings

| Symbol                            | Parameter                                | Max.            | Units                |
|-----------------------------------|------------------------------------------|-----------------|----------------------|
| $V_{DS}$                          | Drain-Source Voltage                     | 20              | V                    |
| $V_{GS}$                          | Gate-to-Source Voltage                   | $\pm 12$        | V                    |
| $I_D$ @ $T_C = 25^\circ\text{C}$  | Continuous Drain Current, $V_{GS}$ @ 10V | 75 <sup>④</sup> | A                    |
| $I_D$ @ $T_C = 100^\circ\text{C}$ | Continuous Drain Current, $V_{GS}$ @ 10V | 53 <sup>④</sup> |                      |
| $I_{DM}$                          | Pulsed Drain Current <sup>①</sup>        | 280             |                      |
| $P_D$ @ $T_C = 25^\circ\text{C}$  | Maximum Power Dissipation <sup>③</sup>   | 88              | W                    |
| $P_D$ @ $T_C = 100^\circ\text{C}$ | Maximum Power Dissipation <sup>③</sup>   | 44              | W                    |
|                                   | Linear Derating Factor                   | 0.59            | mW/ $^\circ\text{C}$ |
| $T_J, T_{STG}$                    | Junction and Storage Temperature Range   | -55 to + 175    | $^\circ\text{C}$     |

### Thermal Resistance

|                 | Parameter                                     | Typ. | Max. | Units                     |
|-----------------|-----------------------------------------------|------|------|---------------------------|
| $R_{\theta JC}$ | Junction-to-Case <sup>⑤</sup>                 | —    | 1.7  | $^\circ\text{C}/\text{W}$ |
| $R_{\theta JA}$ | Junction-to-Ambient (PCB mount)* <sup>⑤</sup> | —    | 50   |                           |
| $R_{\theta JA}$ | Junction-to-Ambient <sup>⑤</sup>              | —    | 110  |                           |

\* When mounted on 1" square PCB (FR-4 or G-10 Material) .  
For recommended footprint and soldering techniques refer to application note #AN-994

Notes ① through ⑤ are on page 10

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# IRFR/U3706PbF

International  
**IR** Rectifier

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

|                                 | Parameter                            | Min. | Typ.  | Max. | Units              | Conditions                                           |
|---------------------------------|--------------------------------------|------|-------|------|--------------------|------------------------------------------------------|
| $V_{(BR)DSS}$                   | Drain-to-Source Breakdown Voltage    | 20   | —     | —    | V                  | $V_{GS} = 0V, I_D = 250\mu A$                        |
| $\Delta V_{(BR)DSS}/\Delta T_J$ | Breakdown Voltage Temp. Coefficient  | —    | 0.021 | —    | $V/^\circ\text{C}$ | Reference to $25^\circ\text{C}, I_D = 1\text{mA}$    |
| $R_{DS(on)}$                    | Static Drain-to-Source On-Resistance | —    | 6.9   | 9.0  | $m\Omega$          | $V_{GS} = 10V, I_D = 15A$ ③                          |
|                                 |                                      | —    | 8.1   | 11   |                    | $V_{GS} = 4.5V, I_D = 12A$ ③                         |
|                                 |                                      | —    | 11.5  | 23   |                    | $V_{GS} = 2.8V, I_D = 7.5A$ ③                        |
| $V_{GS(th)}$                    | Gate Threshold Voltage               | 0.6  | —     | 2.0  | V                  | $V_{DS} = V_{GS}, I_D = 250\mu A$                    |
| $I_{DSS}$                       | Drain-to-Source Leakage Current      | —    | —     | 20   | $\mu A$            | $V_{DS} = 16V, V_{GS} = 0V$                          |
|                                 |                                      | —    | —     | 100  |                    | $V_{DS} = 16V, V_{GS} = 0V, T_J = 125^\circ\text{C}$ |
| $I_{GSS}$                       | Gate-to-Source Forward Leakage       | —    | —     | 200  | $nA$               | $V_{GS} = 12V$                                       |
|                                 | Gate-to-Source Reverse Leakage       | —    | —     | -200 |                    | $V_{GS} = -12V$                                      |

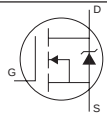
## Dynamic @ $T_J = 25^\circ\text{C}$ (unless otherwise specified)

| Symbol       | Parameter                       | Min. | Typ. | Max. | Units    | Conditions                  |
|--------------|---------------------------------|------|------|------|----------|-----------------------------|
| $g_{fs}$     | Forward Transconductance        | 53   | —    | —    | S        | $V_{DS} = 16V, I_D = 57A$   |
| $Q_g$        | Total Gate Charge               | —    | 23   | 35   | $nC$     | $I_D = 28A$                 |
| $Q_{gs}$     | Gate-to-Source Charge           | —    | 8.0  | 12   |          | $V_{DS} = 10V$              |
| $Q_{gd}$     | Gate-to-Drain ("Miller") Charge | —    | 5.5  | 8.3  |          | $V_{GS} = 4.5V$ ③           |
| $Q_{oss}$    | Output Gate Charge              | —    | 16   | 24   |          | $V_{GS} = 0V, V_{DS} = 10V$ |
| $R_g$        | Gate Resistance                 | —    | 1.8  | —    | $\Omega$ |                             |
| $t_{d(on)}$  | Turn-On Delay Time              | —    | 6.8  | —    | $ns$     | $V_{DD} = 10V$              |
| $t_r$        | Rise Time                       | —    | 87   | —    |          | $I_D = 28A$                 |
| $t_{d(off)}$ | Turn-Off Delay Time             | —    | 17   | —    |          | $R_G = 1.8\Omega$           |
| $t_f$        | Fall Time                       | —    | 4.8  | —    |          | $V_{GS} = 4.5V$ ③           |
| $C_{iss}$    | Input Capacitance               | —    | 2410 | —    | $pF$     | $V_{GS} = 0V$               |
| $C_{oss}$    | Output Capacitance              | —    | 1070 | —    |          | $V_{DS} = 10V$              |
| $C_{rss}$    | Reverse Transfer Capacitance    | —    | 140  | —    |          | $f = 1.0\text{MHz}$         |

## Avalanche Characteristics

| Symbol   | Parameter                      | Typ. | Max. | Units |
|----------|--------------------------------|------|------|-------|
| $E_{AS}$ | Single Pulse Avalanche Energy② | —    | 220  | mJ    |
| $I_{AR}$ | Avalanche Current①             | —    | 28   | A     |

## Diode Characteristics

| Symbol   | Parameter                              | Min. | Typ. | Max. | Units | Conditions                                                                                                                                           |
|----------|----------------------------------------|------|------|------|-------|------------------------------------------------------------------------------------------------------------------------------------------------------|
| $I_S$    | Continuous Source Current (Body Diode) | —    | —    | 75④  | A     | MOSFET symbol showing the integral reverse p-n junction diode.  |
| $I_{SM}$ | Pulsed Source Current (Body Diode) ①   | —    | —    | 280  |       |                                                                                                                                                      |
| $V_{SD}$ | Diode Forward Voltage                  | —    | 0.88 | 1.3  | V     | $T_J = 25^\circ\text{C}, I_S = 36A, V_{GS} = 0V$ ③                                                                                                   |
|          |                                        | —    | 0.82 | —    |       | $T_J = 125^\circ\text{C}, I_S = 36A, V_{GS} = 0V$ ③                                                                                                  |
| $t_{rr}$ | Reverse Recovery Time                  | —    | 45   | 68   | ns    | $T_J = 25^\circ\text{C}, I_F = 36A, V_R = 20V$                                                                                                       |
| $Q_{rr}$ | Reverse Recovery Charge                | —    | 65   | 98   | nC    | $di/dt = 100A/\mu s$ ③                                                                                                                               |
| $t_{rr}$ | Reverse Recovery Time                  | —    | 49   | 74   | ns    | $T_J = 125^\circ\text{C}, I_F = 36A, V_R = 20V$                                                                                                      |
| $Q_{rr}$ | Reverse Recovery Charge                | —    | 78   | 120  | nC    | $di/dt = 100A/\mu s$ ③                                                                                                                               |

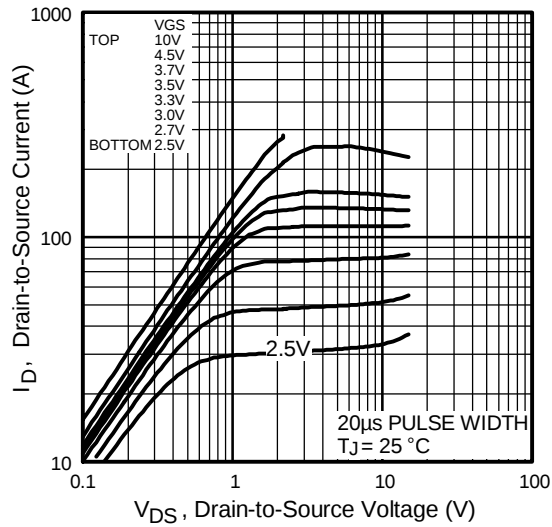


Fig 1. Typical Output Characteristics

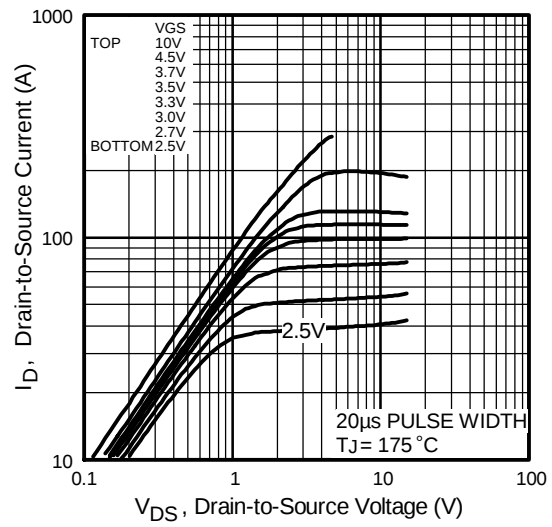


Fig 2. Typical Output Characteristics

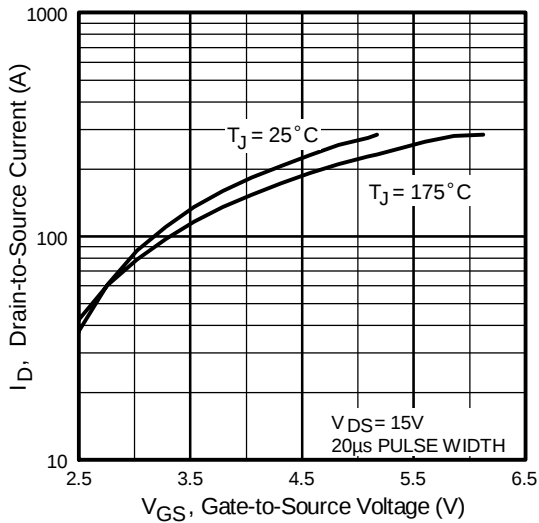


Fig 3. Typical Transfer Characteristics

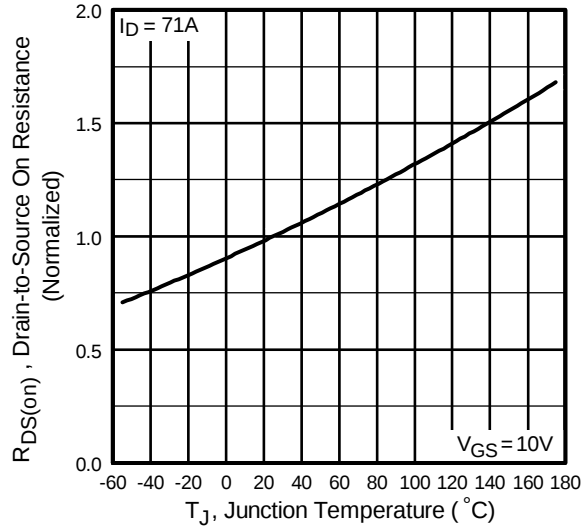
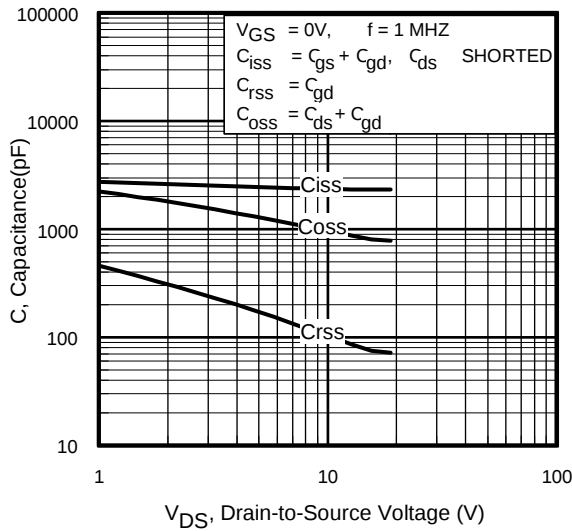
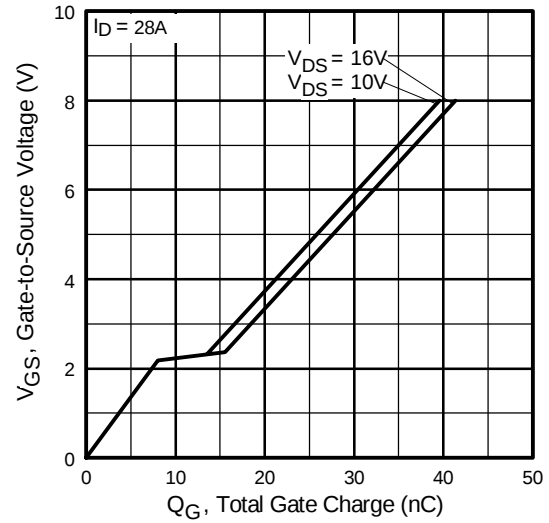


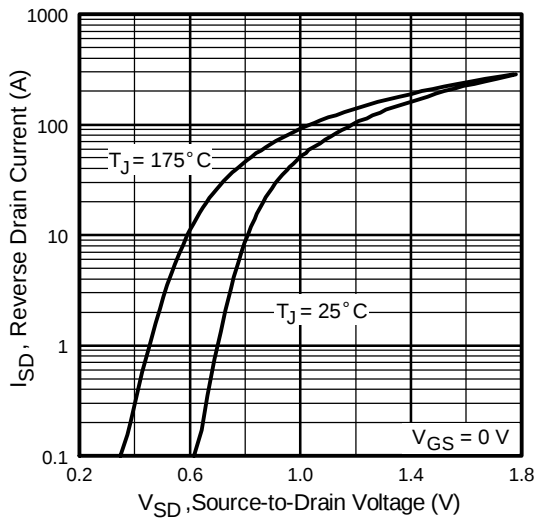
Fig 4. Normalized On-Resistance Vs. Temperature



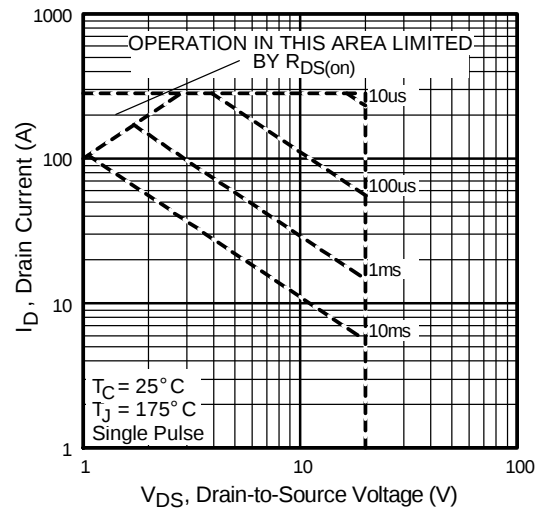
**Fig 5.** Typical Capacitance Vs. Drain-to-Source Voltage



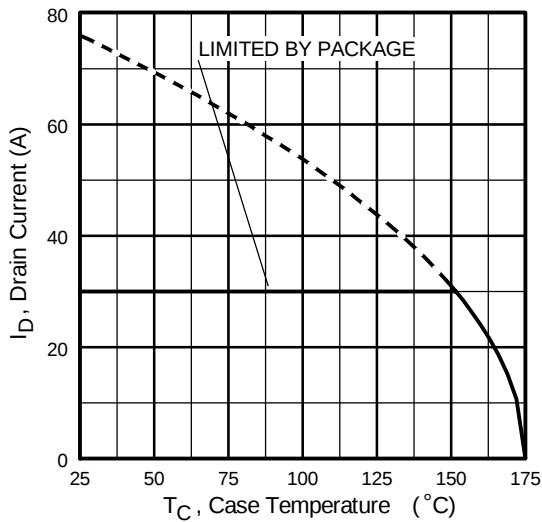
**Fig 6.** Typical Gate Charge Vs. Gate-to-Source Voltage



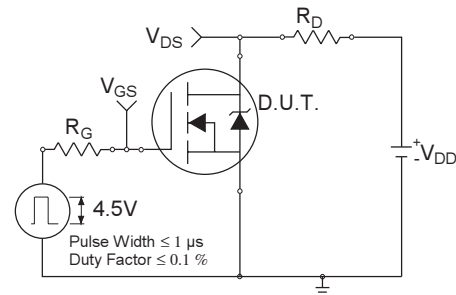
**Fig 7.** Typical Source-Drain Diode Forward Voltage



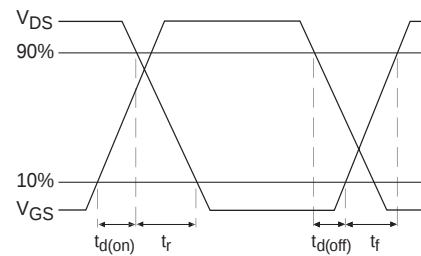
**Fig 8.** Maximum Safe Operating Area



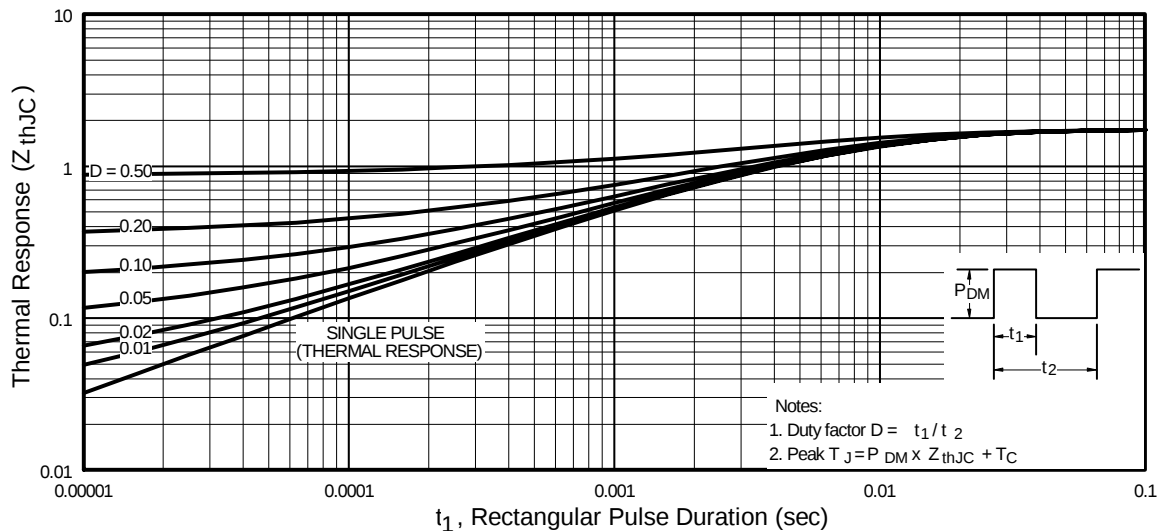
**Fig 9.** Maximum Drain Current Vs. Case Temperature



**Fig 10a.** Switching Time Test Circuit



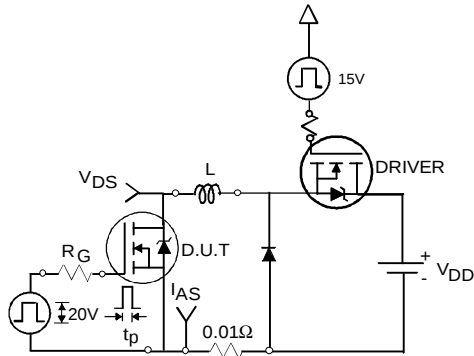
**Fig 10b.** Switching Time Waveforms



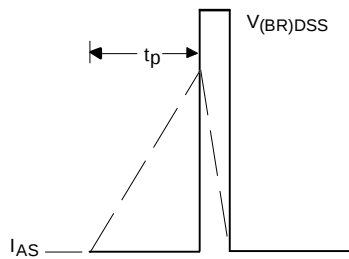
**Fig 11.** Maximum Effective Transient Thermal Impedance, Junction-to-Case

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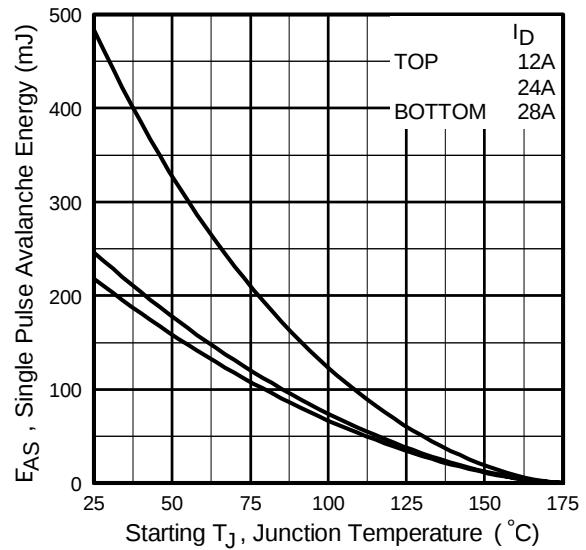
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**IR** Rectifier



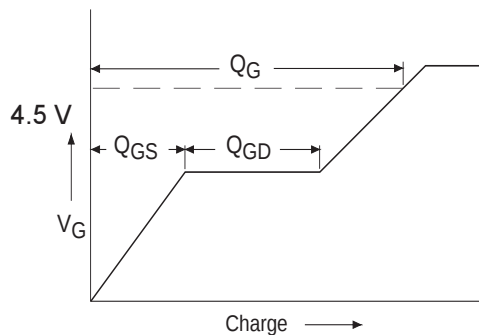
**Fig 12a.** Unclamped Inductive Test Circuit



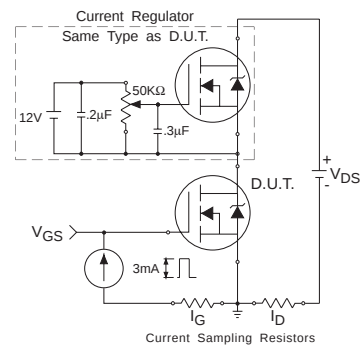
**Fig 12b.** Unclamped Inductive Waveforms



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

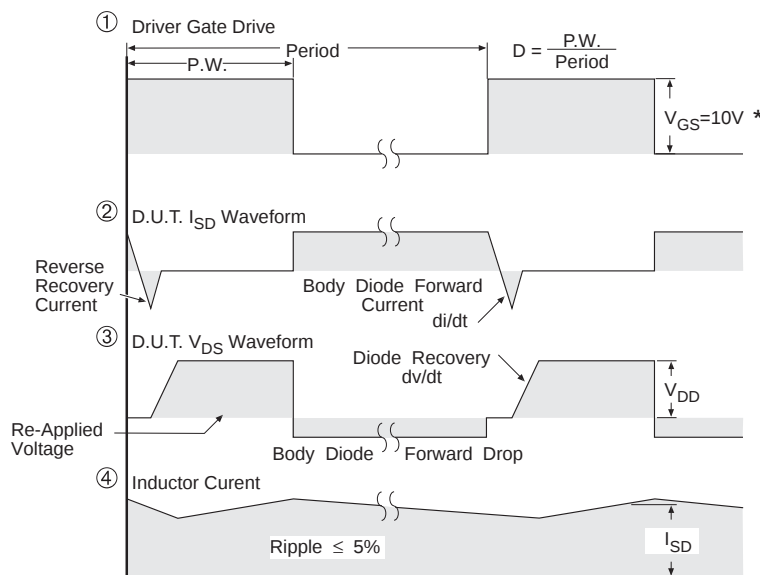
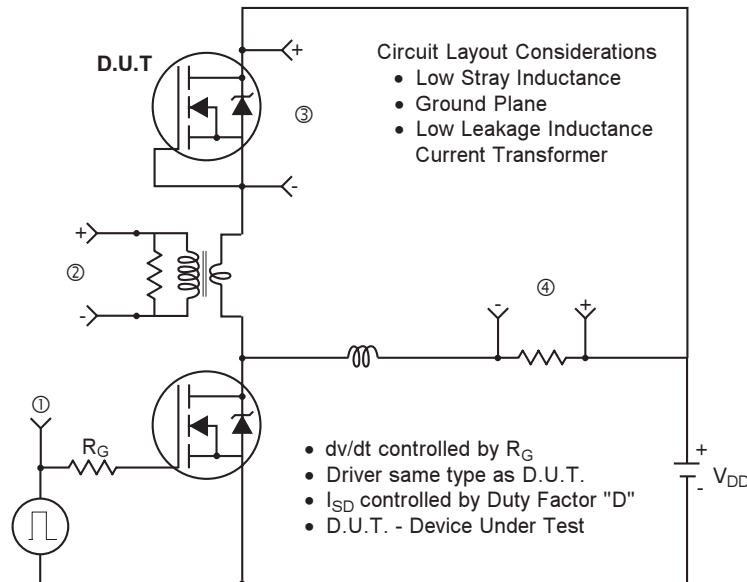


**Fig 13a.** Basic Gate Charge Waveform



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

### Peak Diode Recovery dv/dt Test Circuit



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

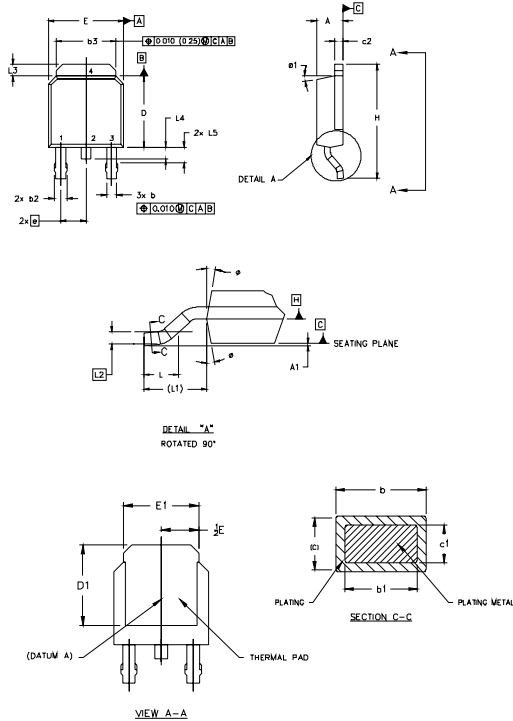
**Fig 14.** For N-Channel HEXFET® Power MOSFETs

# IRFR/U3706PbF

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

Dimensions are shown in millimeters (inches)

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- NOTES:
- 1.0 DIMENSIONING AND TOLERANCING PER ASME Y14.5 M- 1994.
  - 2.0 DIMENSIONS ARE SHOWN IN INCHES [MILLIMETERS].
  - 3.0 LEAD DIMENSION UNCONTROLLED IN L5
  - 4.0 DIMENSION D1 AND E1 ESTABLISH A MINIMUM MOUNTING SURFACE FOR THERMAL PAD.
  - 5.0 SECTION C-C DIMENSIONS APPLY TO THE FLAT SECTION OF THE LEAD BETWEEN .005 [0.127] AND .010 [0.2540] FROM THE LEAD TIP.
  - 6.0 DIMENSION D & E DO NOT INCLUDE MOLD FLASH. MOLD FLASH SHALL NOT EXCEED .005" (0.127) PER SIDE. THESE DIMENSIONS ARE MEASURED AT THE OUTERMOST EXTREMES OF THE PLASTIC BODY.
  - 7.0 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  | 5     |
| b1     | 0.64        | 0.79  | .025      | 0.031 | 5     |
| b2     | 0.76        | 1.14  | .030      | .045  |       |
| b3     | 4.95        | 5.46  | .195      | .215  |       |
| c      | 0.46        | 0.61  | .018      | .024  | 5     |
| c1     | 0.41        | 0.56  | .016      | .022  | 5     |
| c2     | .046        | 0.89  | .018      | .035  | 5     |
| D      | 5.97        | 6.22  | .235      | .245  | 6     |
| D1     | 5.21        | —     | .205      | —     | 4     |
| E      | 6.35        | 6.73  | .250      | .266  | 6     |
| E1     | 4.32        | —     | .170      | —     | 4     |
| e      | 2.29        |       | .090 BSC  |       |       |
| H      | 9.40        | 10.41 | .370      | .410  |       |
| L      | 1.40        | 1.78  | .056      | .070  |       |
| L1     | 2.74 REF.   |       | .108 REF. |       |       |
| L2     | 0.051 BSC   |       | .020 BSC  |       |       |
| L3     | 0.89        | 1.27  | .036      | .050  |       |
| L4     |             | 1.02  |           | .040  |       |
| L5     | 1.14        | 1.52  | .045      | .060  | 3     |
| ø      | 0"          | 10"   | 0"        | 10"   |       |
| ø1     | 0"          | 15"   | 0"        | 15"   |       |

### LEAD ASSIGNMENTS

#### HEXFET

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

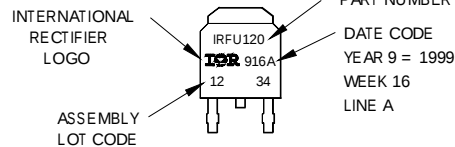
#### IGBTs, CoPACK

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

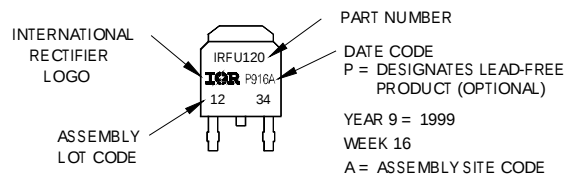
## D-Pak (TO-252AA) Part Marking Information

EXAMPLE: THIS IS AN IRFR120  
WITH ASSEMBLY  
LOT CODE 1234  
ASSEMBLED ON WW 16, 1999  
IN THE ASSEMBLY LINE "A"

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

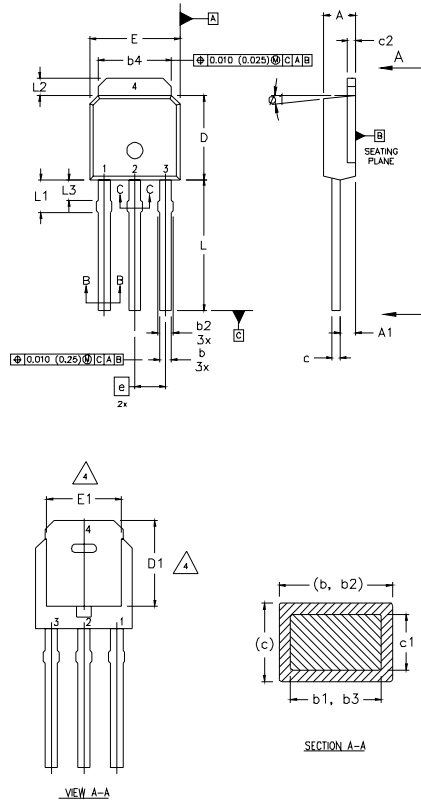


OR



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

Dimensions are shown in millimeters (inches)



### NOTES:

- 1 DIMENSIONING AND TOLERANCING PER ASME Y14.5 M- 1994.
- 2 DIMENSIONS ARE SHOWN IN MILLIMETERS [INCHES].
- 3 DIMENSION D & E DO NOT INCLUDE MOLD FLASH. MOLD FLASH SHALL NOT EXCEED 0.005" (0.127) PER SIDE. THESE DIMENSIONS ARE MEASURED AT THE OUTERMOST EXTREMES OF THE PLASTIC BODY.
- 4 THERMAL PAD CONTOUR OPTION WITHIN DIMENSION b4, L2, E1 & D1.
- 5 LEAD DIMENSION UNCONTROLLED IN L3.
- 6 DIMENSION b1, b3 APPLY TO BASE METAL ONLY.
- 7 OUTLINE CONFORMS TO JEDEC OUTLINE TO-251AA.
- 8 CONTROLLING DIMENSION : INCHES.

### LEAD ASSIGNMENTS

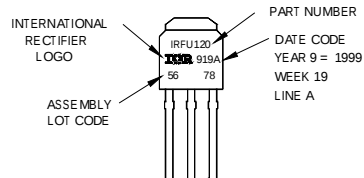
#### HEXFET

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

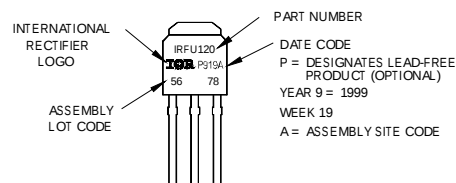
| SYMBOL | DIMENSIONS  |      |           |       | NOTES |
|--------|-------------|------|-----------|-------|-------|
|        | MILLIMETERS |      | INCHES    |       |       |
|        | MIN.        | MAX. | MIN.      | MAX.  |       |
| A      | 2.18        | 2.39 | 0.086     | .094  | 4     |
| A1     | 0.89        | 1.14 | 0.035     | 0.045 |       |
| b      | 0.64        | 0.89 | 0.025     | 0.035 |       |
| b1     | 0.64        | 0.79 | 0.025     | 0.031 |       |
| b2     | 0.76        | 1.14 | 0.030     | 0.045 | 4     |
| b3     | 0.76        | 1.04 | 0.030     | 0.041 |       |
| b4     | 5.00        | 5.46 | 0.195     | 0.215 |       |
| c      | 0.46        | 0.61 | 0.018     | 0.024 |       |
| c1     | 0.41        | 0.56 | 0.016     | 0.022 | 3, 4  |
| c2     | .046        | 0.86 | 0.018     | 0.035 |       |
| D      | 5.97        | 6.22 | 0.235     | 0.245 |       |
| D1     | 5.21        | -    | 0.205     | -     |       |
| E      | 6.35        | 6.73 | 0.250     | 0.265 | 3, 4  |
| E1     | 4.32        | -    | 0.170     | -     | 4     |
| e      | 2.29        |      | 0.090 BSC |       |       |
| L      | 8.89        | 9.60 | 0.350     | 0.380 |       |
| L1     | 1.91        | 2.29 | 0.075     | 0.090 |       |
| L2     | 0.89        | 1.27 | 0.035     | 0.050 | 4     |
| L3     | 1.14        | 1.52 | 0.045     | 0.060 | 5     |
| ø1     | 0"          | 15"  | 0"        | 15"   |       |

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

EXAMPLE: THIS IS AN IRFU120  
WITH ASSEMBLY  
LOT CODE 5678  
ASSEMBLED ON WW 19, 1999  
IN THE ASSEMBLY LINE "A"  
**Note:** "P" in assembly line  
position indicates "Lead-Free"



OR

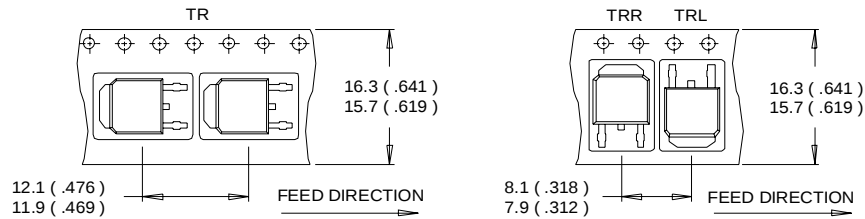


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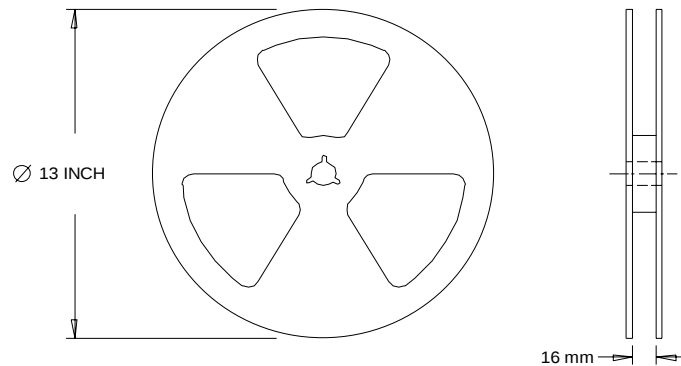
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**IR** Rectifier

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

Dimensions are shown in millimeters (inches)



- 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.
- ② Starting  $T_J = 25^\circ\text{C}$ ,  $L = 0.54\text{mH}$   
 $R_G = 25\Omega$ ,  $I_{AS} = 28\text{A}$ .
- ③ Pulse width  $\leq 400\mu\text{s}$ ; duty cycle  $\leq 2\%$ .
- ④ Calculated continuous current based on maximum allowable junction temperature. Package limitation current is 30A.
- ⑤  $R_\theta$  is measured at  $T_J$  approximately  $90^\circ\text{C}$

Data and specifications subject to change without notice.  
This product has been designed and qualified 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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Note: For the most current drawings please refer to the IR website at:  
<http://www.irf.com/package/>