

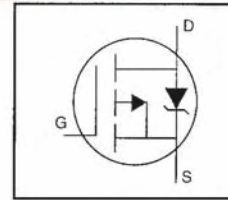
# International IOR Rectifier HEXFET® Power MOSFET

- Dynamic dv/dt Rating
- Repetitive Avalanche Rated
- Surface Mount (IRFR9024)
- Straight Lead (IRFU9024)
- Available in Tape & Reel
- P-Channel
- Fast Switching
- Lead-Free

## Description

Third Generation HEXFETs from International Rectifier provide the designer with the best combination of fast switching, ruggedized device design, low on-resistance and cost-effectiveness.

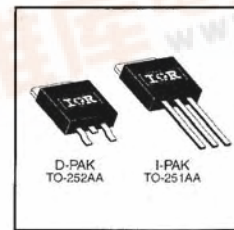
The D-Pak is designed for surface mounting using vapor phase, infrared, or wave soldering techniques. The straight lead version (IRFU series) is for through-hole mounting applications. Power dissipation levels up to 1.5 watts are possible in typical surface mount applications.



$$V_{DS} = -60V$$

$$R_{DS(on)} = 0.28\Omega$$

$$I_D = -8.8A$$



## Absolute Maximum Ratings

|                           | Parameter                                  | Max.                  | Units |
|---------------------------|--------------------------------------------|-----------------------|-------|
| $I_D @ T_C = 25^\circ C$  | Continuous Drain Current, $V_{GS} @ -10 V$ | -8.8                  | A     |
| $I_D @ T_C = 100^\circ C$ | Continuous Drain Current, $V_{GS} @ -10 V$ | -5.6                  |       |
| $I_{DM}$                  | Pulsed Drain Current ①                     | -35                   |       |
| $P_D @ T_C = 25^\circ C$  | Power Dissipation                          | 42                    | W     |
| $P_D @ T_A = 25^\circ C$  | Power Dissipation (PCB Mount)**            | 2.5                   |       |
|                           | Linear Derating Factor                     | 0.33                  | W/°C  |
|                           | Linear Derating Factor (PCB Mount)**       | 0.020                 |       |
| $V_{GS}$                  | Gate-to-Source Voltage                     | $\pm 20$              | V     |
| $E_{AS}$                  | Single Pulse Avalanche Energy ②            | 300                   | mJ    |
| $I_{AR}$                  | Avalanche Current ①                        | -8.8                  | A     |
| $E_{AR}$                  | Repetitive Avalanche Energy ①              | 5.0                   | mJ    |
| dv/dt                     | Peak Diode Recovery dv/dt ③                | -4.5                  | V/ns  |
| $T_J, T_{STG}$            | Junction and Storage Temperature Range     | -55 to +150           | °C    |
|                           | Soldering Temperature, for 10 seconds      | 260 (1.6mm from case) |       |

## Thermal Resistance

|                 | Parameter                         | Min. | Typ. | Max. | Units |
|-----------------|-----------------------------------|------|------|------|-------|
| $R_{\theta JC}$ | Junction-to-Case                  | —    | —    | 3.0  | °C/W  |
| $R_{\theta JA}$ | Junction-to-Ambient (PCB mount)** | —    | —    | 50   |       |
| $R_{\theta JA}$ | Junction-to-Ambient               | —    | —    | 110  |       |

\*\* When mounted on 1" square PCB (FR-4 or G-10 Material).

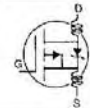
For recommended footprint and soldering techniques refer to application note #AN-994.

# IRFR/U9024PbF

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

|                                 | Parameter                            | Min. | Typ.   | Max. | Units              | Test Conditions                                                     |
|---------------------------------|--------------------------------------|------|--------|------|--------------------|---------------------------------------------------------------------|
| $V_{(BR)DSS}$                   | Drain-to-Source Breakdown Voltage    | -60  | —      | —    | V                  | $V_{GS}=0V$ , $I_D=-250\mu A$                                       |
| $\Delta V_{(BR)DSS}/\Delta T_J$ | Breakdown Voltage Temp. Coefficient  | —    | -0.063 | —    | $V/^\circ\text{C}$ | Reference to $25^\circ\text{C}$ , $I_D=-1mA$                        |
| $R_{DS(on)}$                    | Static Drain-to-Source On-Resistance | —    | —      | 0.28 | $\Omega$           | $V_{GS}=-10V$ , $I_D=-5.3A$ ④                                       |
| $V_{GS(th)}$                    | Gate Threshold Voltage               | -2.0 | —      | -4.0 | V                  | $V_{DS}=V_{GS}$ , $I_D=-250\mu A$                                   |
| $g_{fs}$                        | Forward Transconductance             | 2.9  | —      | —    | S                  | $V_{DS}=-25V$ , $I_D=-5.3A$ ④                                       |
| $I_{DSS}$                       | Drain-to-Source Leakage Current      | —    | —      | -100 | $\mu A$            | $V_{DS}=-60V$ , $V_{GS}=0V$                                         |
|                                 |                                      | —    | —      | -500 | $\mu A$            | $V_{DS}=-48V$ , $V_{GS}=0V$ , $T_J=125^\circ\text{C}$               |
| $I_{GSS}$                       | Gate-to-Source Forward Leakage       | —    | —      | -100 | nA                 | $V_{GS}=-20V$                                                       |
|                                 | Gate-to-Source Reverse Leakage       | —    | —      | 100  | nA                 | $V_{GS}=20V$                                                        |
| $Q_g$                           | Total Gate Charge                    | —    | —      | 19   | nC                 | $I_D=-11A$                                                          |
| $Q_{gs}$                        | Gate-to-Source Charge                | —    | —      | 5.4  | nC                 | $V_{DS}=-48V$                                                       |
| $Q_{gd}$                        | Gate-to-Drain ("Miller") Charge      | —    | —      | 11   | nC                 | $V_{GS}=-10V$ ④                                                     |
| $t_{d(on)}$                     | Turn-On Delay Time                   | —    | 13     | —    | ns                 | $V_{DD}=-30V$                                                       |
| $t_r$                           | Rise Time                            | —    | 68     | —    | ns                 | $I_D=-11A$                                                          |
| $t_{d(off)}$                    | Turn-Off Delay Time                  | —    | 15     | —    | ns                 | $R_G=18\Omega$                                                      |
| $t_f$                           | Fall Time                            | —    | 29     | —    | ns                 | $R_D=2.5\Omega$ ④                                                   |
| $L_D$                           | Internal Drain Inductance            | —    | 4.5    | —    | nH                 | Between lead, 6 mm (0.25in.) from package and center of die contact |
| $L_S$                           | Internal Source Inductance           | —    | 7.5    | —    | nH                 |                                                                     |
| $C_{iss}$                       | Input Capacitance                    | —    | 570    | —    | pF                 | $V_{GS}=0V$                                                         |
| $C_{oss}$                       | Output Capacitance                   | —    | 360    | —    | pF                 | $V_{DS}=-25V$                                                       |
| $C_{rss}$                       | Reverse Transfer Capacitance         | —    | 65     | —    | pF                 | $f=1.0MHz$                                                          |



## Source-Drain Ratings and Characteristics

|          | Parameter                              | Min.                                                                      | Typ. | Max. | Units   | Test Conditions                                                |
|----------|----------------------------------------|---------------------------------------------------------------------------|------|------|---------|----------------------------------------------------------------|
| $I_S$    | Continuous Source Current (Body Diode) | —                                                                         | —    | -8.8 | A       | MOSFET symbol showing the integral reverse p-n junction diode. |
| $I_{SM}$ | Pulsed Source Current (Body Diode) ①   | —                                                                         | —    | -35  | A       |                                                                |
| $V_{SD}$ | Diode Forward Voltage                  | —                                                                         | —    | -6.3 | V       | $T_J=25^\circ\text{C}$ , $I_S=-8.8A$ , $V_{GS}=0V$ ④           |
| $t_{rr}$ | Reverse Recovery Time                  | —                                                                         | 100  | 200  | ns      | $T_J=25^\circ\text{C}$ , $I_F=-11A$                            |
| $Q_{rr}$ | Reverse Recovery Charge                | —                                                                         | 0.32 | 0.64 | $\mu C$ | $di/dt=100A/\mu s$ ④                                           |
| $t_{on}$ | Forward Turn-On Time                   | Intrinsic turn-on time is negligible (turn-on is dominated by $L_S+L_D$ ) |      |      |         |                                                                |

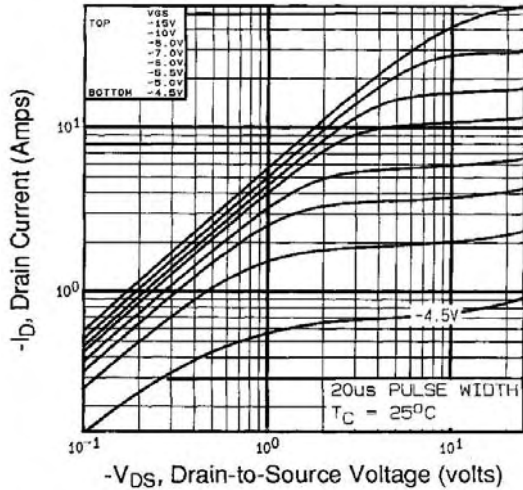
### Notes:

① Repetitive rating; pulse width limited by max. junction temperature

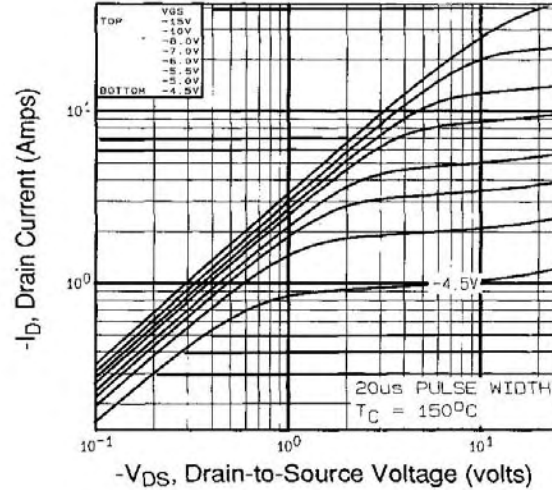
②  $V_{DD}=-25V$ , starting  $T_J=25^\circ\text{C}$ ,  $L=4.5mH$   
 $R_G=25\Omega$ ,  $I_{AS}=-8.8A$

③  $I_{SDS}\leq 11A$ ,  $di/dt\leq 140A/\mu s$ ,  $V_{DD}\leq V_{(BR)DSS}$ ,  
 $T_J\leq 150^\circ\text{C}$

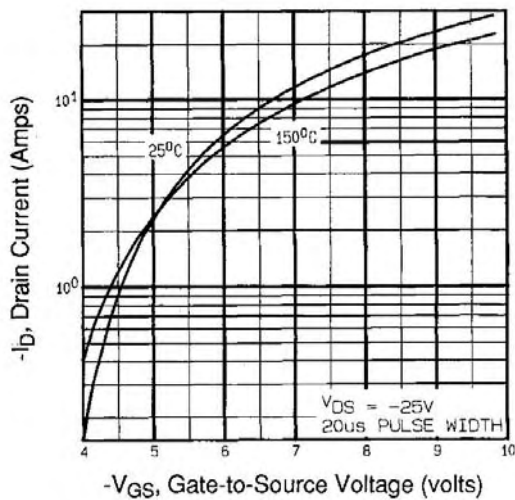
④ Pulse width  $\leq 300\mu s$ ; duty cycle  $\leq 2\%$ .



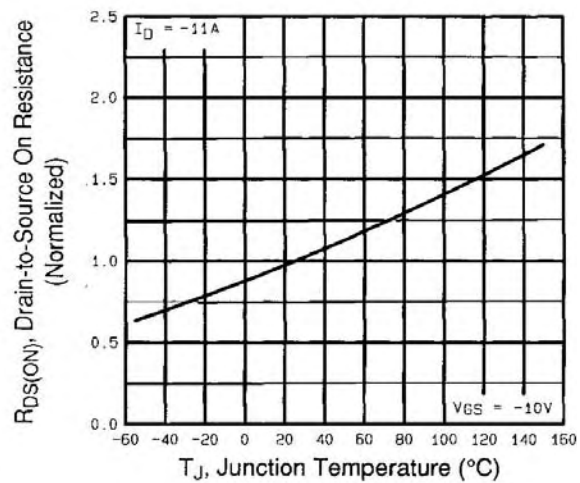
**Fig 1.** Typical Output Characteristics,  
 $T_C = 25^\circ\text{C}$



**Fig 2.** Typical Output Characteristics,  
 $T_C = 150^\circ\text{C}$



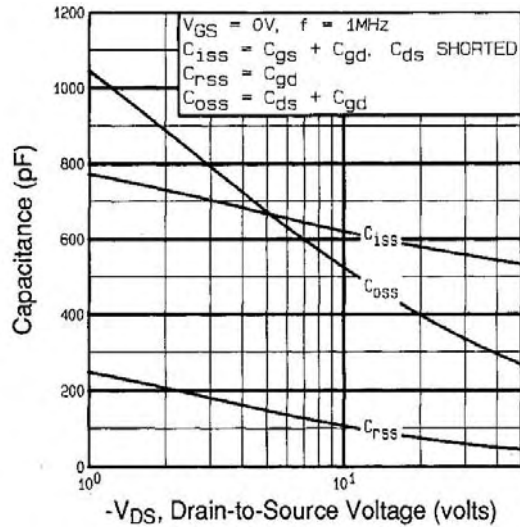
**Fig 3.** Typical Transfer Characteristics



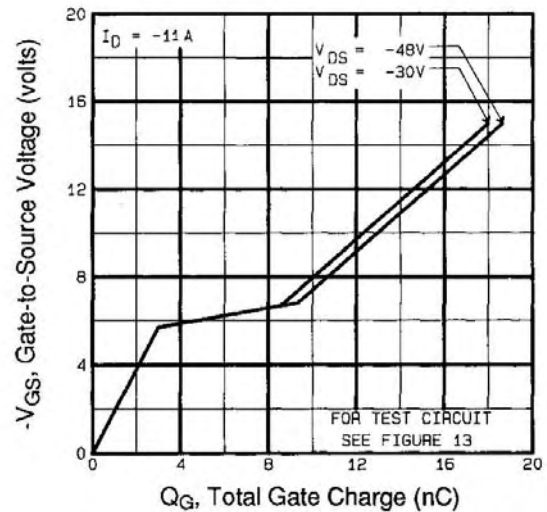
**Fig 4.** Normalized On-Resistance  
Vs. Temperature

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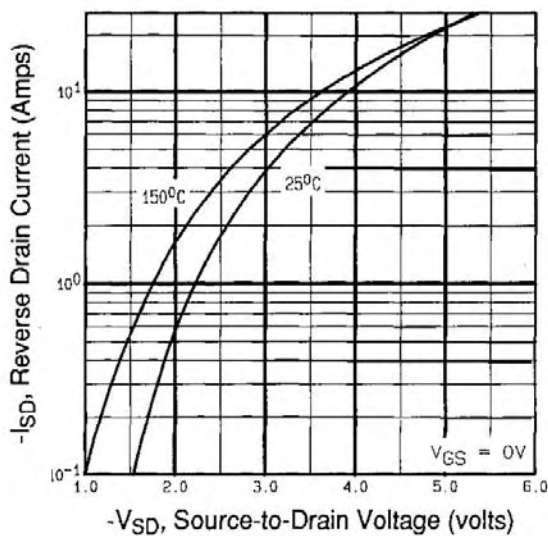
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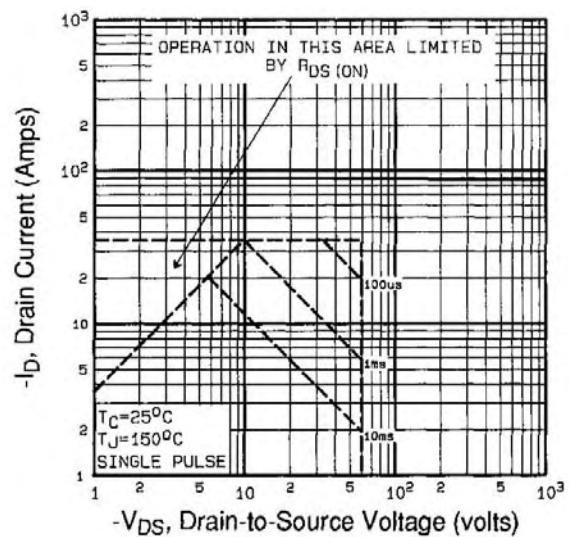
**Fig 5.** Typical Capacitance Vs. Drain-to-Source Voltage



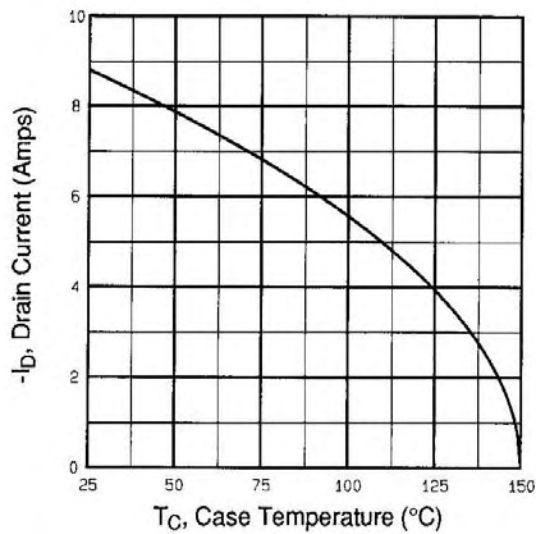
**Fig 6.** Typical Gate Charge Vs. Gate-to-Source Voltage



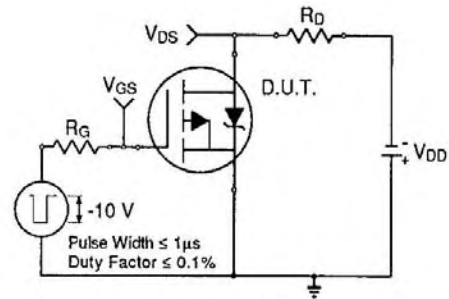
**Fig 7.** Typical Source-Drain Diode Forward Voltage



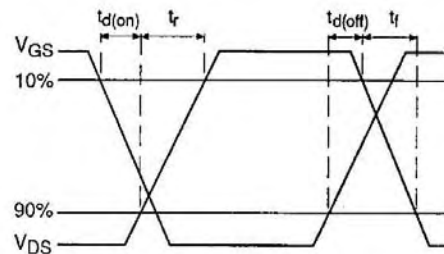
**Fig 8.** Maximum Safe Operating Area



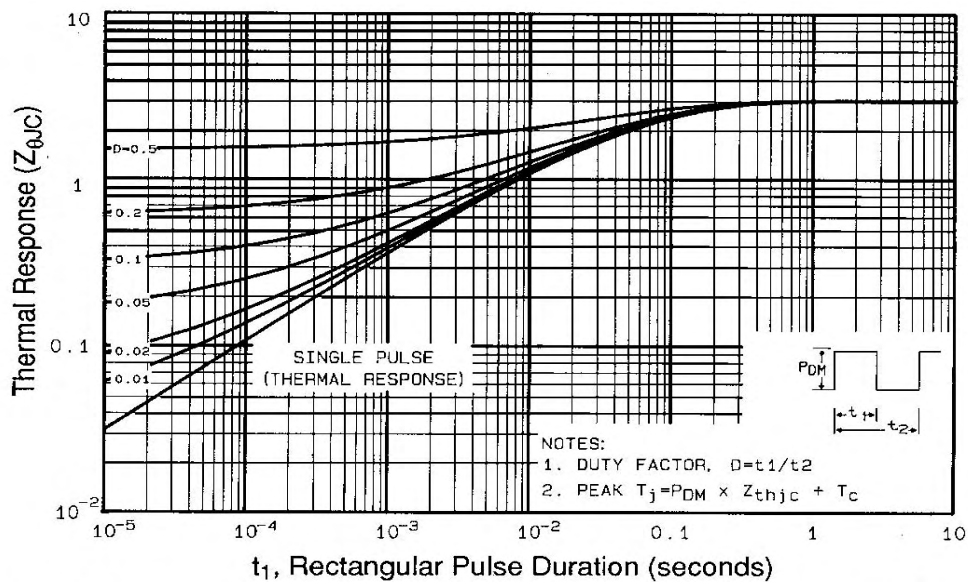
**Fig 9.** Maximum Drain Current Vs. Case Temperature



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



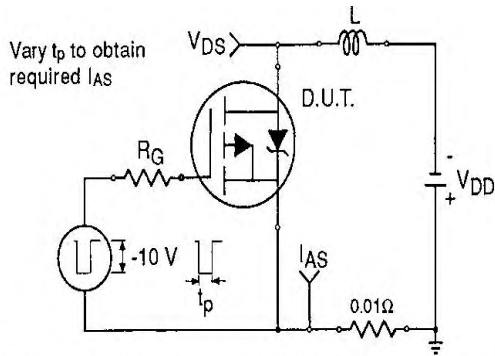
**Fig 10b.** Switching Time Waveforms



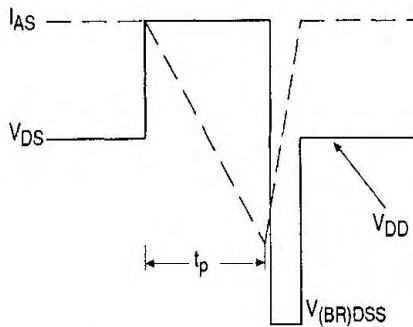
**Fig 11.** Maximum Effective Transient Thermal Impedance, Junction-to-Case  
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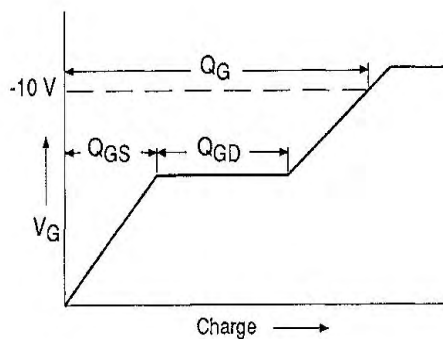
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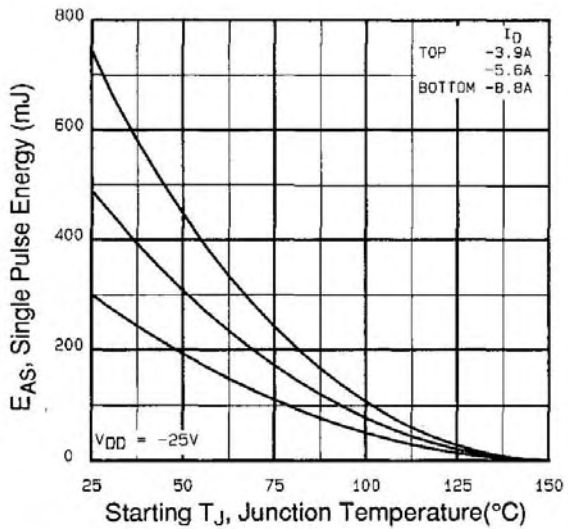
**Fig 12a.** Unclamped Inductive Test Circuit



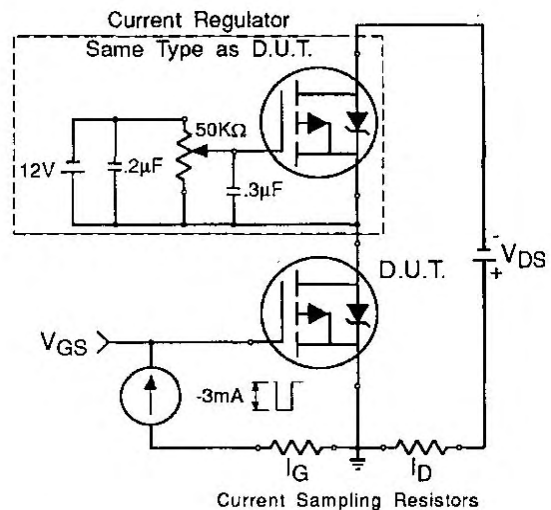
**Fig 12b.** Unclamped Inductive Waveforms



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

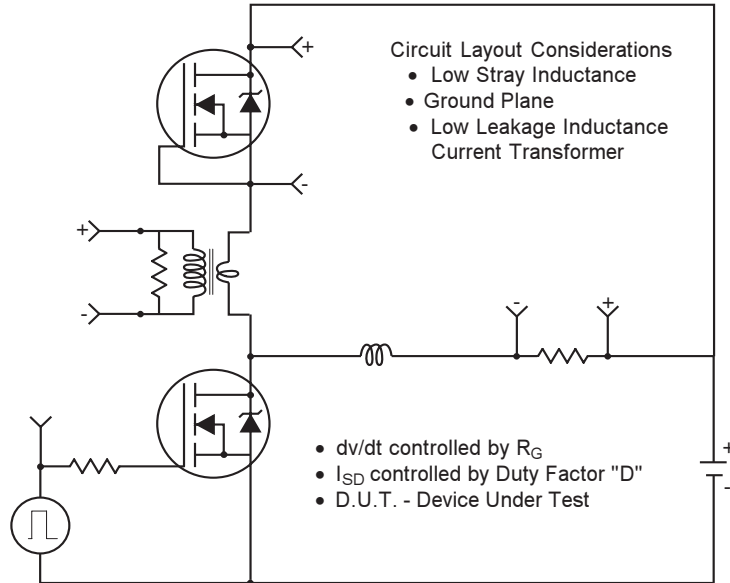


**Fig 12c.** Maximum Avalanche Energy Vs. Drain Current



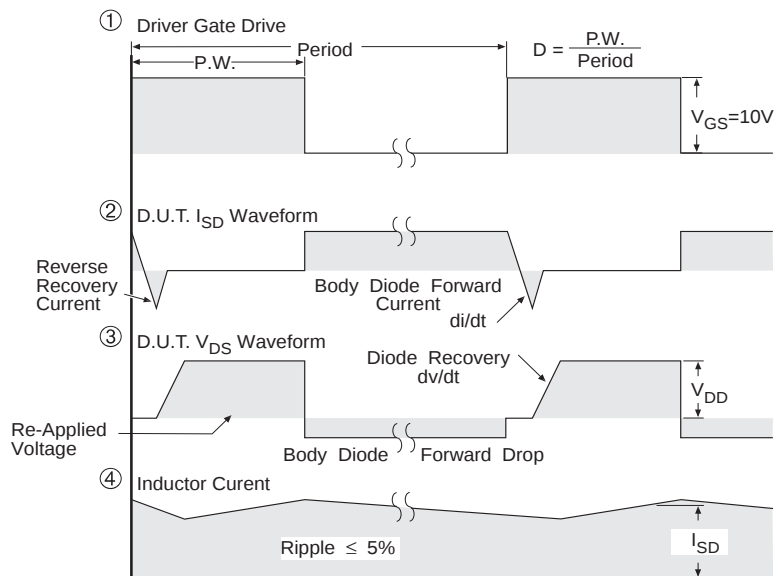
**Fig 13b.** Gate Charge Test Circuit

### Peak Diode Recovery dv/dt Test Circuit



\* Reverse Polarity for P-Channel

\*\* Use P-Channel Driver for P-Channel Measurements



\*\*\*  $V_{GS} = 5.0V$  for Logic Level and 3V Drive Devices

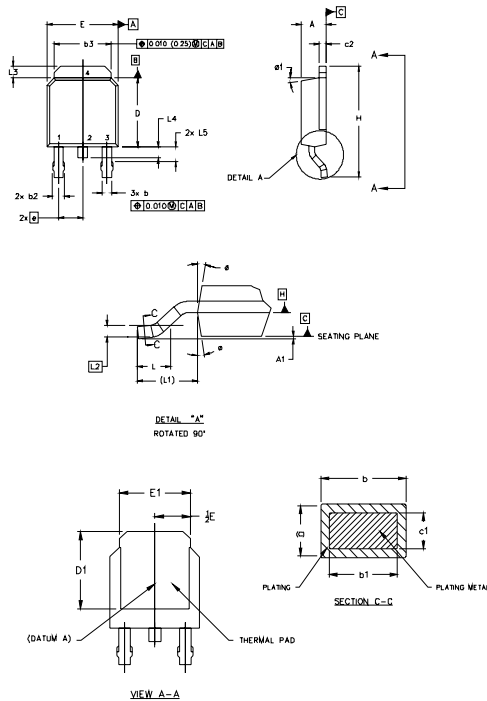
**Fig -14** For P Channel HEXFETS

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

Dimensions are shown in millimeters (inches)



- 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     |                     | 0.15  |          | .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  | 1     |
| 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      | 6.22                | 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                |       | .090 BSC |       |       |
| H      | 9.40                | 10.41 | .370     | .410  |       |
| L      | 1.40                | 1.78  | .055     | .070  |       |
| L1     | 2.74 REF. .108 REF. |       |          |       |       |
| L2     | 0.051 BSC .020 BSC  |       |          |       |       |
| L3     | 0.89                | 1.27  | .035     | .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

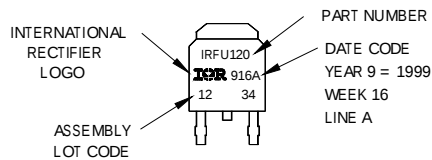
#### IGBTs, CoPACK

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

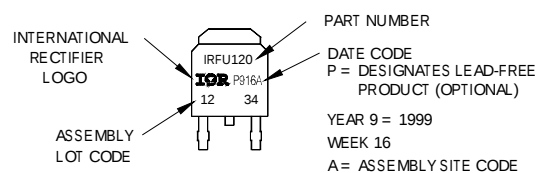
## D-Pak (TO-252AA) Part Marking Information

EXAMPLE: THIS IS AN IRFR120  
WITH ASSEMBLY  
LOT CODE 1234  
ASSEMBLED ON WW16, 1999  
IN THE ASSEMBLY LINE "A"

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

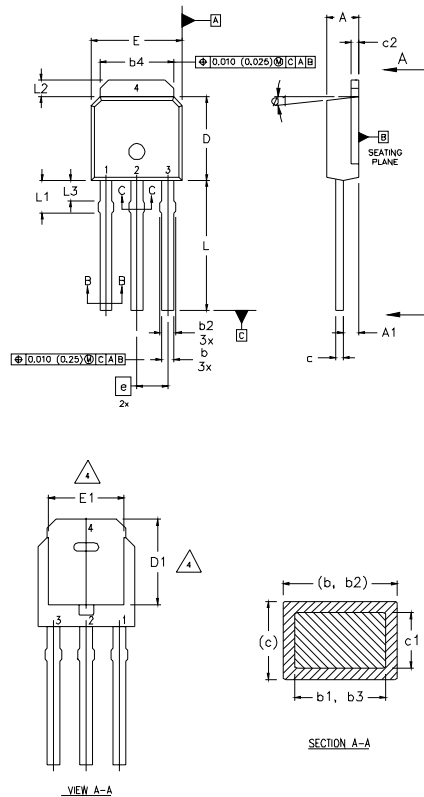


OR



## 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

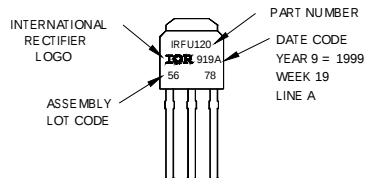
#### HEXFET

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

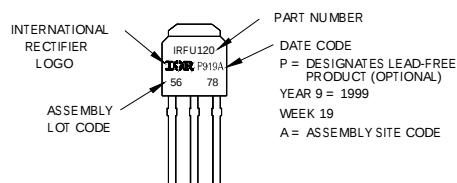
| SYMBOL | DIMENSIONS  |      |           |       | NOTES |
|--------|-------------|------|-----------|-------|-------|
|        | MILLIMETERS |      | INCHES    |       |       |
|        | MIN.        | MAX. | MIN.      | MAX.  |       |
| A      | 2.18        | 2.39 | 0.086     | .094  |       |
| 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 | 4     |
| b2     | 0.76        | 1.14 | 0.030     | 0.045 |       |
| b3     | 0.76        | 1.04 | 0.030     | 0.041 |       |
| b4     | 5.00        | 5.46 | 0.195     | 0.215 | 4     |
| c      | 0.46        | 0.61 | 0.018     | 0.024 |       |
| c1     | 0.41        | 0.56 | 0.016     | 0.022 |       |
| c2     | 0.46        | 0.86 | 0.018     | 0.035 |       |
| D      | 5.97        | 6.22 | 0.235     | 0.245 | 3, 4  |
| D1     | 5.21        | —    | 0.205     | —     | 4     |
| 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 WW19, 1999  
IN THE ASSEMBLY LINE "A"  
**Note:** "P" in assembly line  
position indicates "Lead-Free"



OR

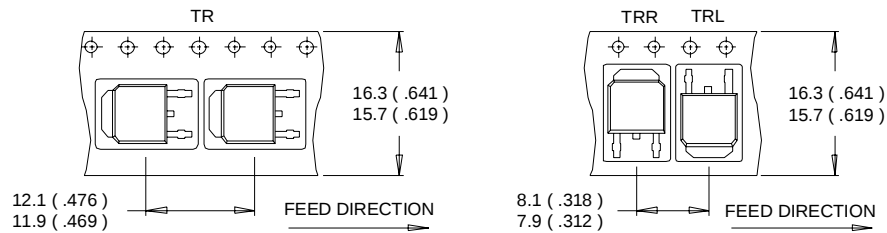


# IRFR/U9024PbF

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**IR** Rectifier

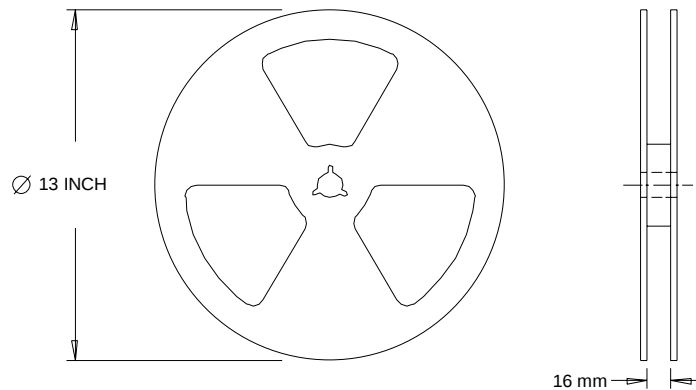
## D-Pak (TO-252AA) Tape & Reel Information

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.

Data and specifications subject to change without notice.

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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