International IGR Rectifier

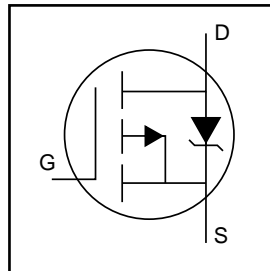**PRELIMINARY**

IRFR/U9024N

HEXFET® Power MOSFET

- Ultra Low On-Resistance
- P-Channel
- Surface Mount (IRFR9024N)
- Straight Lead (IRFU9024N)
- Advanced Process Technology
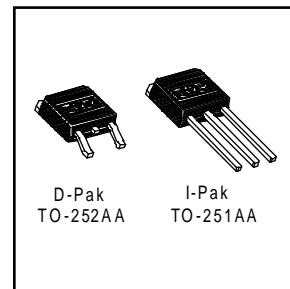- Fast Switching
- Fully Avalanche Rated

$$V_{DSS} = -55V$$

$$R_{DS(on)} = 0.175\Omega$$

$$I_D = -11A$$

Description

Fifth Generation HEXFETs from International Rectifier utilize advanced processing techniques to achieve extremely low on-resistance per silicon area. This benefit, combined with the fast switching speed and ruggedized device design that HEXFET Power MOSFETs are well known for, provides the designer with an extremely efficient and reliable device for use in a wide variety of applications.

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.
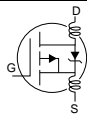

D-Pak
TO-252AA

I-Pak
TO-251AA

Absolute Maximum Ratings

	Parameter	Max.	Units
I_D @ T_C = 25°C	Continuous Drain Current, V_{GS} @ -10V	-11	
I_D @ T_C = 100°C	Continuous Drain Current, V_{GS} @ -10V	-8	A
I_{DM}	Pulsed Drain Current ①	-44	
P_D @T_C = 25°C	Power Dissipation	38	W
	Linear Derating Factor	0.30	W/°C
V_{GS}	Gate-to-Source Voltage	± 20	V
E_{AS}	Single Pulse Avalanche Energy②	62	mJ
I_{AR}	Avalanche Current①	-6.6	A
E_{AR}	Repetitive Avalanche Energy①	3.8	mJ
dv/dt	Peak Diode Recovery dv/dt ③	-10	V/ns
T_J	Operating Junction and	-55 to + 150	
T_{STG}	Storage Temperature Range		°C
	Soldering Temperature, for 10 seconds	300 (1.6mm from case)	

Thermal Resistance

	Parameter	Typ.	Max.	Units
$R_{\theta JC}$	Junction-to-Case	——	3.3	
$R_{\theta JA}$	Junction-to-Ambient (PCB mount)**	——	50	°C/W
$R_{\theta JA}$	Junction-to-Ambient	——	110	

Electrical Characteristics @ T_J = 25°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 = -250µA
$\Delta V_{(BR)DSS}/\Delta T_J$	Breakdown Voltage Temp. Coefficient	——	-0.05	——	V/°C	Reference to 25°C, I_D = -1mA
$R_{DS(on)}$	Static Drain-to-Source On-Resistance	——	——	0.175	Ω	V_{GS} = -10V, I_D = -6.6A ④
$V_{GS(th)}$	Gate Threshold Voltage	-2.0	——	-4.0	V	V_{DS} = V_{GS}, I_D = -250µA
g_{fs}	Forward Transconductance	2.5	——	——	S	V_{DS} = -25V, I_D = -7.2A⑥
I_{DSS}	Drain-to-Source Leakage Current	——	——	-25	µA	V_{DS} = -55V, V_{GS} = 0V
		——	——	-250		V_{DS} = -44V, V_{GS} = 0V, T_J = 150°C
I_{GSS}	Gate-to-Source Forward Leakage	——	——	100	nA	V_{GS} = 20V
	Gate-to-Source Reverse Leakage	——	——	-100		V_{GS} = -20V
Q_g	Total Gate Charge	——	——	19		I_D = -7.2A
Q_{gs}	Gate-to-Source Charge	——	——	5.1	nC	V_{DS} = -44V
Q_{gd}	Gate-to-Drain ("Miller") Charge	——	——	10		V_{GS} = -10V, See Fig. 6 and 13 ④⑥
$t_{d(on)}$	Turn-On Delay Time	——	13	——		V_{DD} = -28V
t_r	Rise Time	——	55	——	ns	I_D = -7.2A
$t_{d(off)}$	Turn-Off Delay Time	——	23	——		R_G = 24Ω
t_f	Fall Time	——	37	——		R_D = 3.7Ω, See Fig. 10 ④⑥
L_D	Internal Drain Inductance	——	4.5	——	nH	Between lead, 6mm (0.25in.) from package and center of die contact⑤
L_S	Internal Source Inductance	——	7.5	——		
C_{iss}	Input Capacitance	——	350	——		V_{GS} = 0V
C_{oss}	Output Capacitance	——	170	——	pF	V_{DS} = -25V
C_{rss}	Reverse Transfer Capacitance	——	92	——		f = 1.0MHz, See Fig. 5⑥

Source-Drain Ratings and Characteristics

	Parameter	Min.	Typ.	Max.	Units	Conditions
I_S	Continuous Source Current (Body Diode)	——	——	-11	A	MOSFET symbol showing the integral reverse p-n junction diode.
I_{SM}	Pulsed Source Current (Body Diode) ①	——	——	-44		
V_{SD}	Diode Forward Voltage	——	——	-1.6	V	T_J = 25°C, I_S = -7.2A, V_{GS} = 0V ④
t_{rr}	Reverse Recovery Time	——	47	71	ns	T_J = 25°C, I_F = -7.2A
Q_{rr}	Reverse Recovery Charge	——	84	130	nC	di/dt = 100A/µs ④⑥
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. (See fig. 11)

② Starting T_J = 25°C, L = 2.8mH
  R_G = 25Ω, I_{AS} = -6.6A. (See Figure 12)

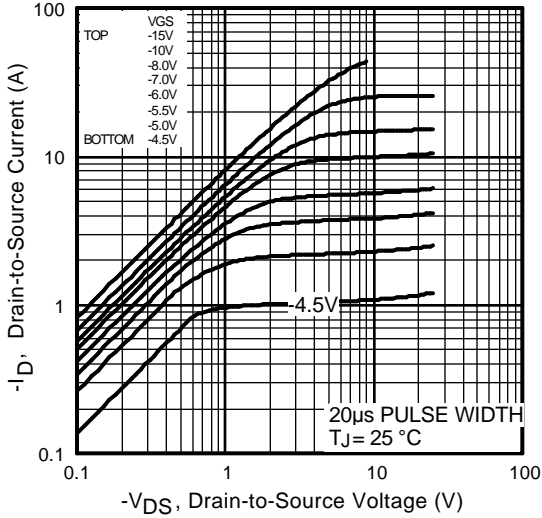③ I_{SD} ≤ -6.6A, di/dt ≤ 240A/µs, V_{DD} ≤ $V_{(BR)DSS}$,
  T_J ≤ 150°C

④ Pulse width ≤ 300µs; duty cycle ≤ 2%.

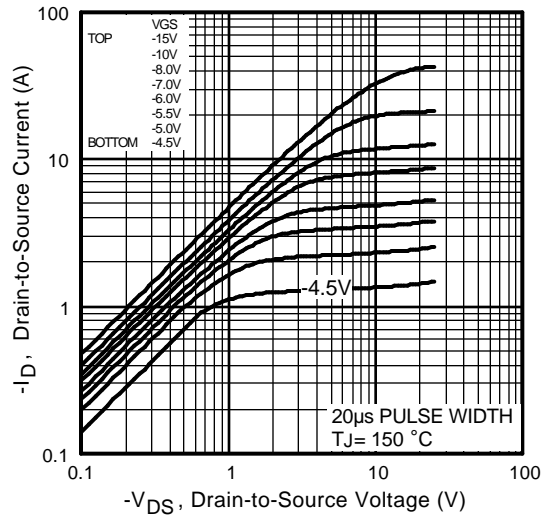⑤ This is applied for I-PAK, L_S of D-PAK is measured between lead and center of die contact

⑥ Uses IRF9Z24N data and test conditions.

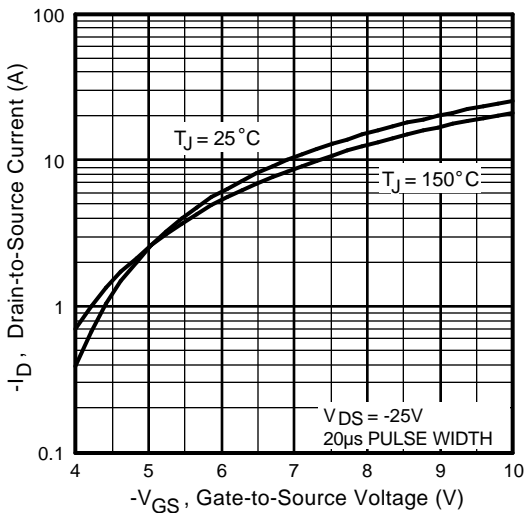** When mounted on 1" square PCB (FR-4 or G-10 Material) .
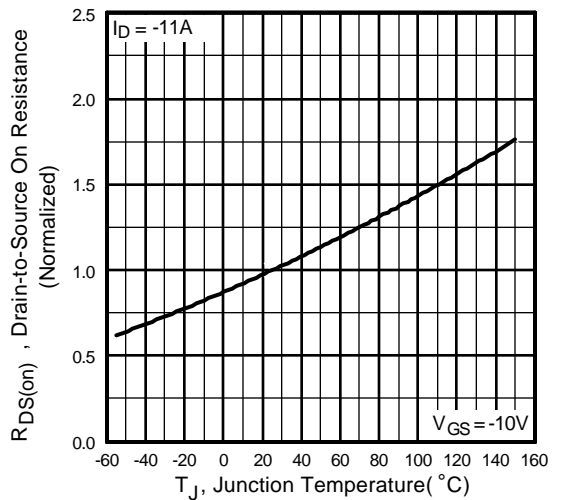 For recommended footprint and soldering techniques refer to application note #AN-994

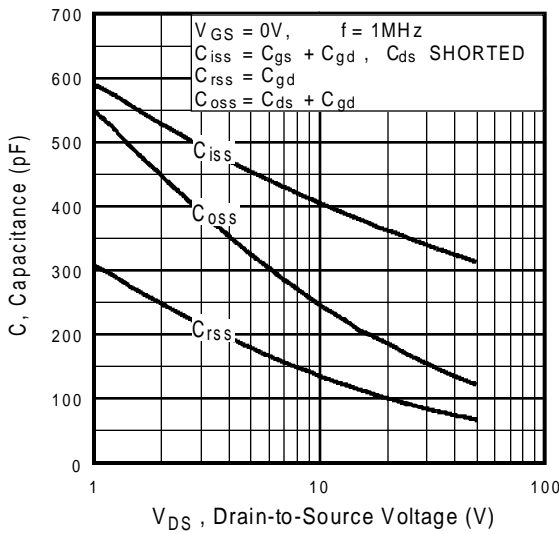**Fig 1.** Typical Output Characteristics
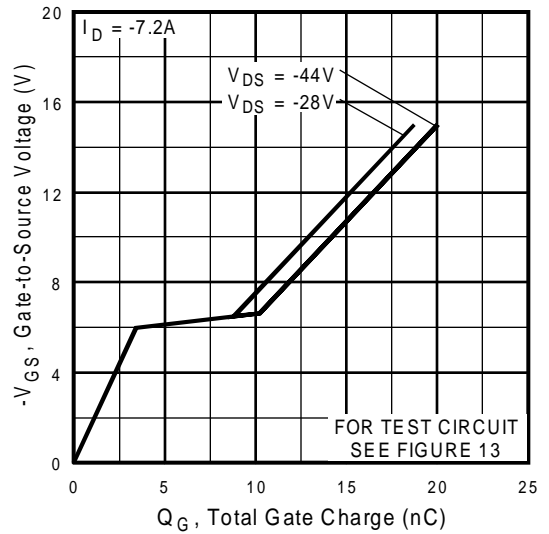

Fig 2. Typical Output Characteristics

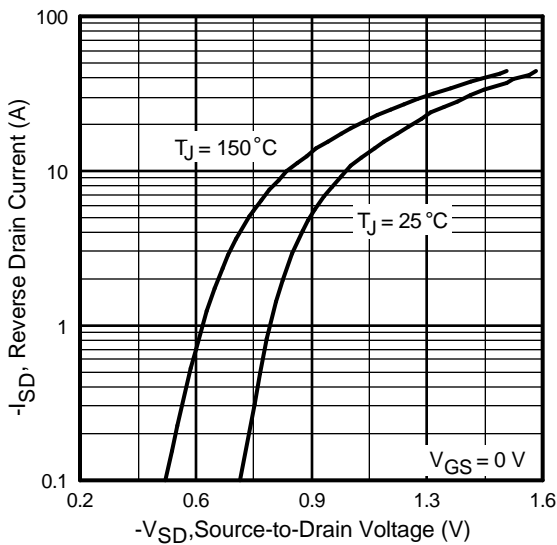**Fig 3.** Typical Transfer Characteristics

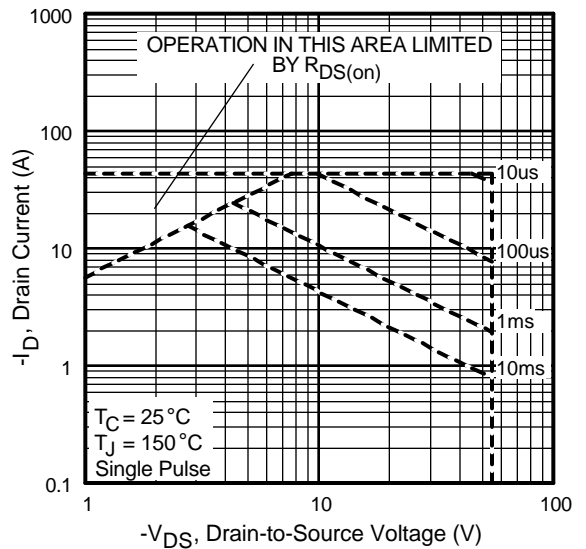**Fig 4.** Normalized On-Resistance
Vs. Temperature

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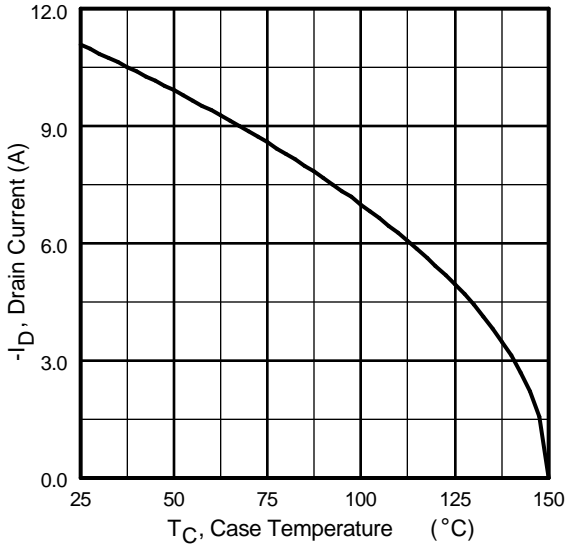Drain-to-Source Voltage

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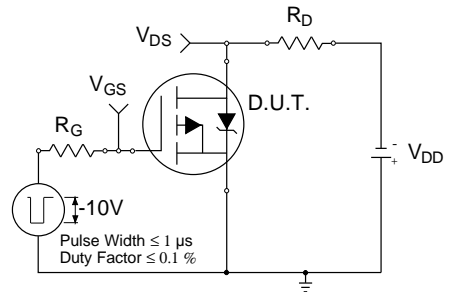Gate-to-Source Voltage

Fig 7. Typical Source-Drain Diode
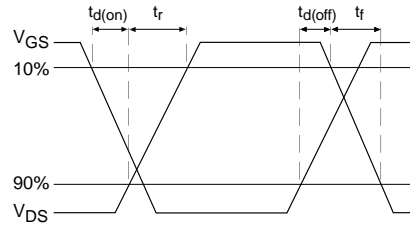Forward Voltage

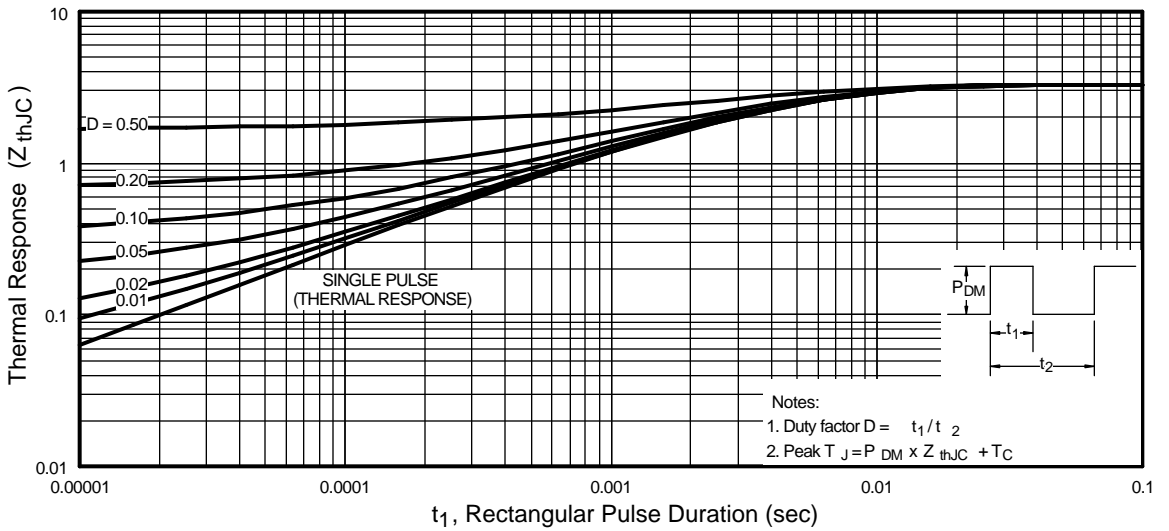**Fig 8.** Maximum Safe Operating Area

Fig 9. Maximum Drain Current Vs.
Case Temperature

Fig 10a. Switching Time Test Circuit

Fig 10b. Switching Time Waveforms

Notes:
1. Duty factor $D = t_1/t_2$
2. Peak $T_J = P_{DM} \times Z_{thJC} + T_C$

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

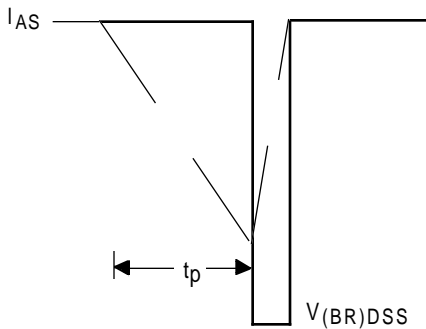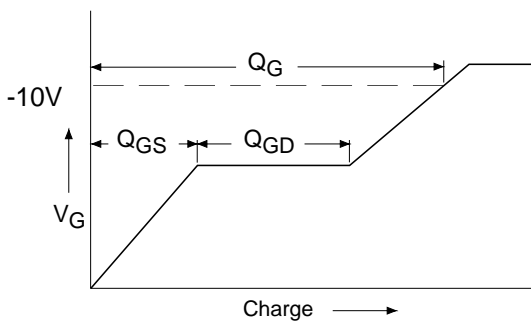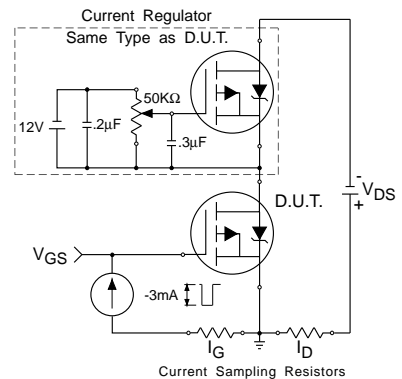## Peak Diode Recovery dv/dt Test Circuit

D.U.T*.

③

Circuit Layout Considerations
- Low Stray Inductance
- Ground Plane
- Low Leakage Inductance
  Current Transformer

②

④

R_G

- dv/dt controlled by R_G
- I_{SD} controlled by Duty Factor "D"
- D.U.T. - Device Under Test

V_{DD}

V_{GS}

* Reverse Polarity of D.U.T for P-Channel

① Driver Gate Drive

P.W.

Period

$D = \dfrac{P.W.}{Period}$

$[V_{GS}=10V]$ ***

② D.U.T. I_{SD} Waveform

Reverse
Recovery
Current

Body Diode Forward
Current

di/dt

③ D.U.T. V_{DS} Waveform

Diode Recovery
dv/dt

$[V_{DD}]$

Re-Applied
Voltage

Body Diode Forward Drop

④ Inductor Curent

Ripple ≤ 5%

$[I_{SD}]$

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

Fig 14. For P-Channel HEXFETS

Package Outline

TO-252AA Outline
Dimensions are shown in millimeters (inches)

6.73 (.265)
6.35 (.250)
- A -

5.46 (.215)
5.21 (.205)

1.27 (.050)
0.88 (.035)

4

6.22 (.245)
5.97 (.235)

1.02 (.040)
1.64 (.025)

1   2   3

- B -

1.52 (.060)
1.15 (.045)

3X 0.89 (.035)
0.64 (.025)

2X 1.14 (.045)
0.76 (.030)

2.28 (.090)

⊕ 0.25 (.010) Ⓜ A Ⓜ B

4.57 (.180)
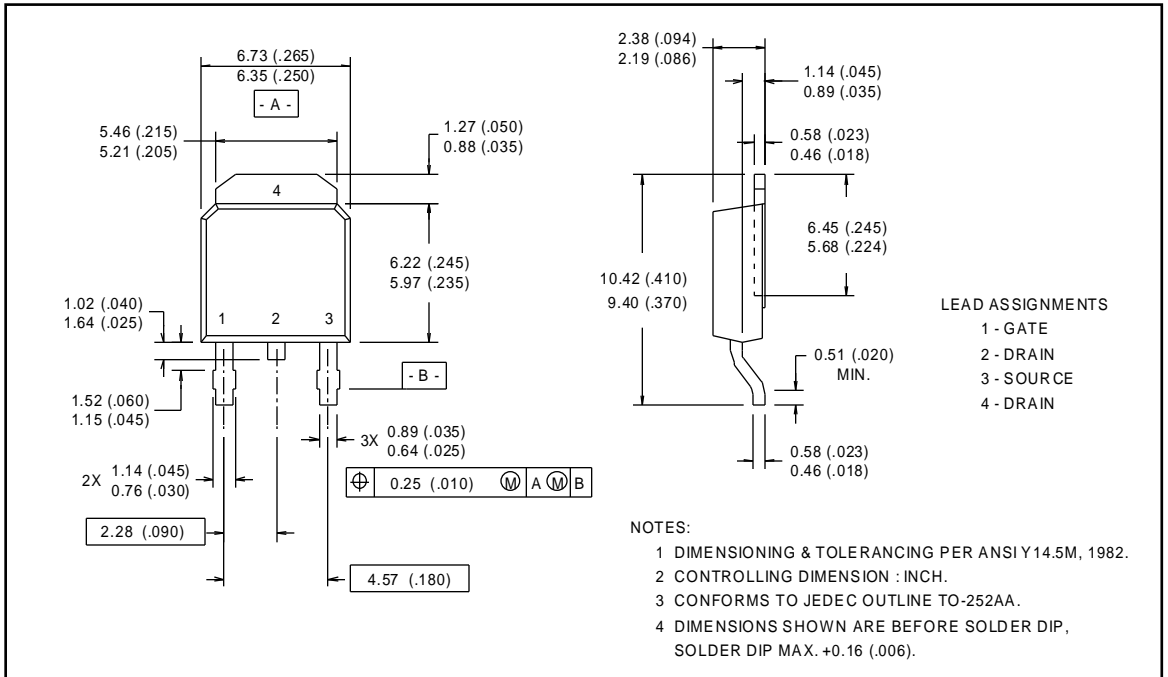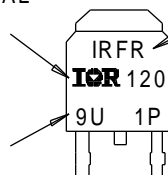
2.38 (.094)
2.19 (.086)

1.14 (.045)
0.89 (.035)

0.58 (.023)
0.46 (.018)

6.45 (.245)
5.68 (.224)

10.42 (.410)
9.40 (.370)

0.51 (.020)
MIN.

0.58 (.023)
0.46 (.018)

LEAD ASSIGNMENTS
1 - GATE
2 - DRAIN
3 - SOURCE
4 - DRAIN

NOTES:
1 DIMENSIONING & TOLERANCING PER ANSI Y14.5M, 1982.
2 CONTROLLING DIMENSION : INCH.
3 CONFORMS TO JEDEC OUTLINE TO-252AA.
4 DIMENSIONS SHOWN ARE BEFORE SOLDER DIP,
   SOLDER DIP MAX. +0.16 (.006).

Part Marking Information

TO-252AA (D-Pak)

EXAMPLE : THIS IS AN IRFR120
            WITH ASSEMBLY
            LOT CODE 9U1P

INTERNATIONAL
RECTIFIER
LOGO

IRFR
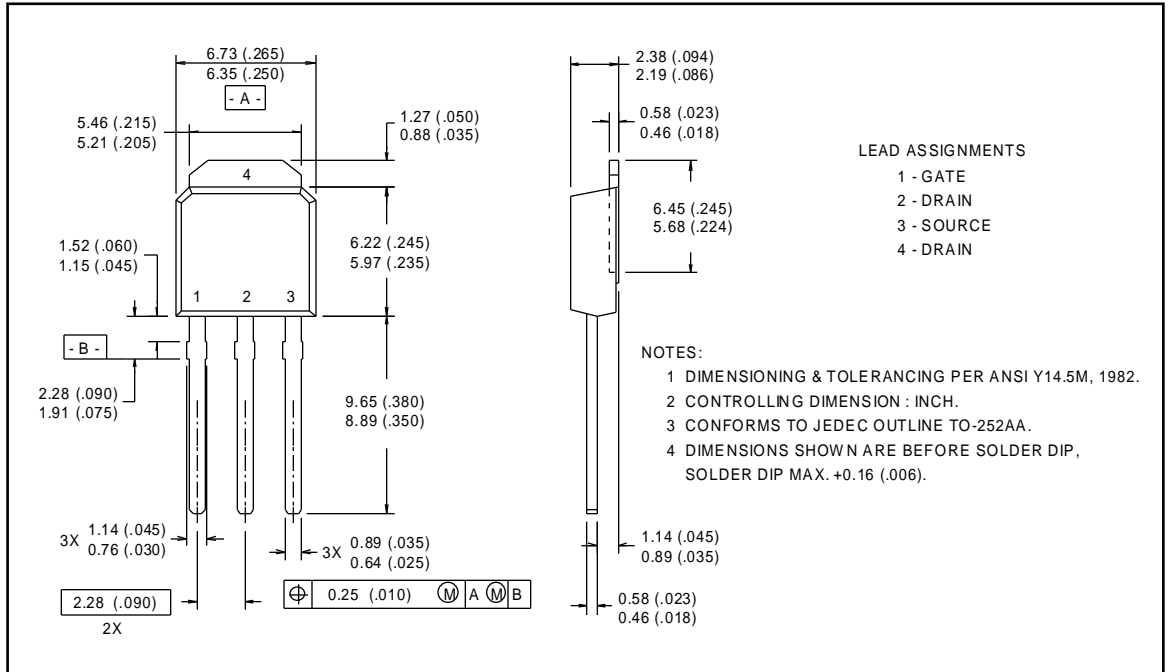**IQR** 120
9U 1P

FIRST PORTION
OF PART NUMBER

ASSEMBLY
LOT CODE

SECOND PORTION
OF PART NUMBER

Package Outline

TO-251AA Outline
Dimensions are shown in millimeters (inches)

6.73 (.265)
6.35 (.250)
- A -

5.46 (.215)
5.21 (.205)

1.27 (.050)
0.88 (.035)

4

1.52 (.060)
1.15 (.045)

6.22 (.245)
5.97 (.235)

1 2 3

- B -

2.28 (.090)
1.91 (.075)

9.65 (.380)
8.89 (.350)

3X 1.14 (.045)
0.76 (.030)

3X 0.89 (.035)
0.64 (.025)

2.28 (.090)
2X

⊕ 0.25 (.010) Ⓜ A Ⓜ B

2.38 (.094)
2.19 (.086)

0.58 (.023)
0.46 (.018)

6.45 (.245)
5.68 (.224)

1.14 (.045)
0.89 (.035)

0.58 (.023)
0.46 (.018)

LEAD ASSIGNMENTS
1 - GATE
2 - DRAIN
3 - SOURCE
4 - DRAIN

NOTES:
1 DIMENSIONING & TOLERANCING PER ANSI Y14.5M, 1982.
2 CONTROLLING DIMENSION : INCH.
3 CONFORMS TO JEDEC OUTLINE TO-252AA.
4 DIMENSIONS SHOWN ARE BEFORE SOLDER DIP,
   SOLDER DIP MAX. +0.16 (.006).
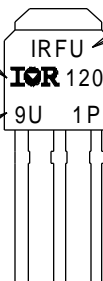
Part Marking Information

TO-251AA (I-Pak)

EXAMPLE : THIS IS AN IRFU120
            WITH ASSEMBLY
            LOT CODE 9U1P

INTERNATIONAL
RECTIFIER
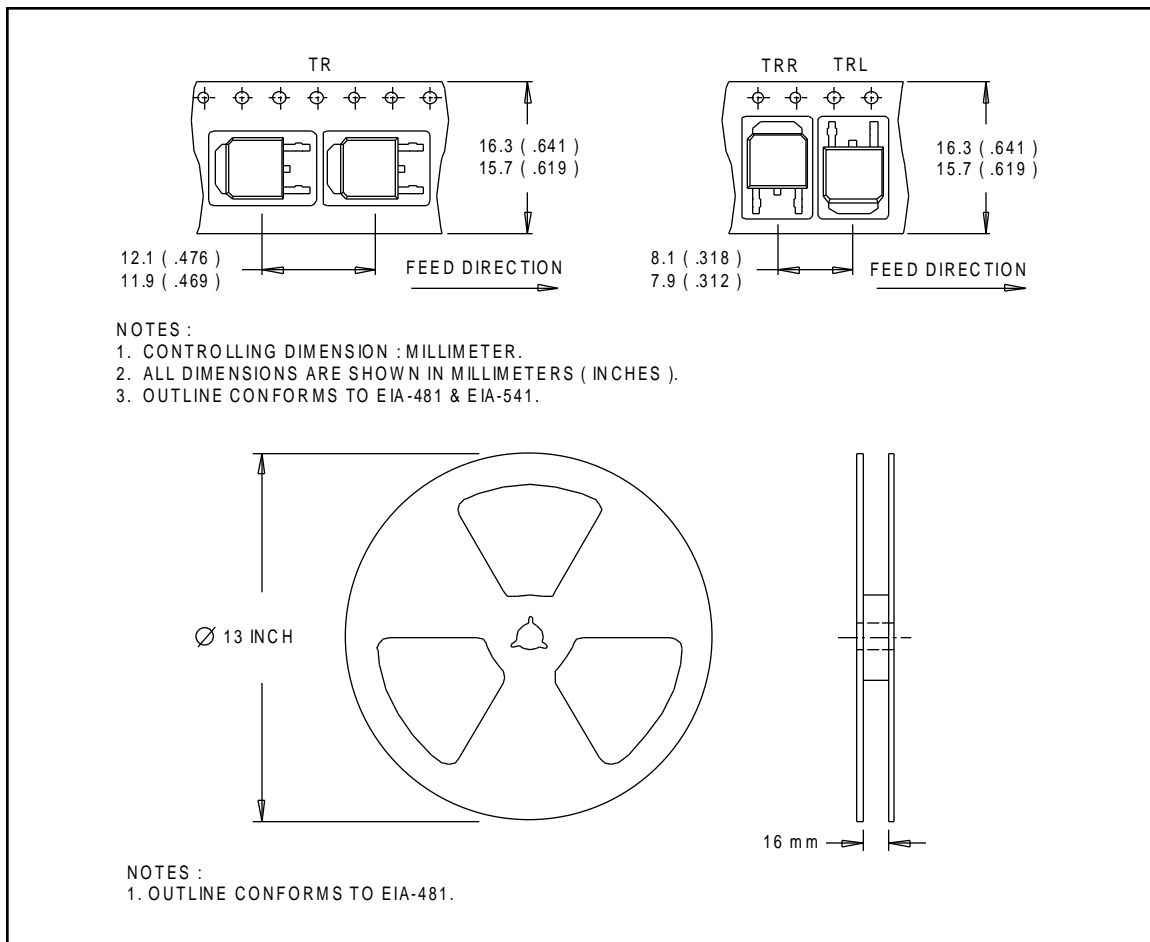LOGO

IRFU
IƆR 120
9U 1P

FIRST PORTION
OF PART NUMBER

ASSEMBLY
LOT CODE

SECOND PORTION
OF PART NUMBER

Tape & Reel Information

TO-252AA

TR

16.3 (.641)
15.7 (.619)

12.1 (.476)
11.9 (.469)

FEED DIRECTION

TRR   TRL

16.3 (.641)
15.7 (.619)

8.1 (.318)
7.9 (.312)

FEED DIRECTION

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

$\varnothing$ 13 INCH

16 mm

NOTES :
1. OUTLINE CONFORMS TO EIA-481.

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IOR Rectifier

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