PD- 95063A

International
IOR Rectifier

**SMPS MOSFET**

# IRFR220NPbF
# IRFU220NPbF

HEXFET® Power MOSFET

**Applications**
- High frequency DC-DC converters
- Lead-Free

| $V_{DSS}$ | $R_{DS(on)}$ max (mΩ) | $I_D$ |
|---|---|---|
| 200V | 600 | 5.0A |

**Benefits**
- Low Gate to Drain Charge to Reduce Switching Losses
- Fully Characterized Capacitance Including Effective $C_{OSS}$ to Simplify Design, (See App. Note AN1001)
- Fully Characterized Avalanche Voltage and Current

D-Pak IRFR22ON | I-Pak IRFU220N

## Absolute Maximum Ratings

| | Parameter | Max. | Units |
|---|---|---|---|
| $I_D$ @ $T_C$ = 25°C | Continuous Drain Current, $V_{GS}$ @ 10V | 5.0 | A |
| $I_D$ @ $T_C$ = 100°C | Continuous Drain Current, $V_{GS}$ @ 10V | 3.5 | |
| $I_{DM}$ | Pulsed Drain Current ① | 20 | |
| $P_D$ @$T_C$ = 25°C | Power Dissipation | 43 | W |
| | Linear Derating Factor | 0.71 | W/°C |
| $V_{GS}$ | Gate-to-Source Voltage | ± 20 | V |
| dv/dt | Peak Diode Recovery dv/dt ③ | 7.5 | V/ns |
| $T_J$<br>$T_{STG}$ | Operating Junction and<br>Storage Temperature Range | -55 to + 175 | °C |
| | Soldering Temperature, for 10 seconds | 300 (1.6mm from case ) | |

## Typical SMPS Topologies

- Telecom 48V input Forward Converters

Notes ① through ⑤ are on page 10

## Static @ $T_J$ = 25°C (unless otherwise specified)

| | Parameter | Min. | Typ. | Max. | Units | Conditions |
|---|---|---|---|---|---|---|
| $V_{(BR)DSS}$ | Drain-to-Source Breakdown Voltage | 200 | — | — | V | $V_{GS}$ = 0V, $I_D$ = 250µA |
| $\Delta V_{(BR)DSS}/\Delta T_J$ | Breakdown Voltage Temp. Coefficient | — | 0.23 | — | V/°C | Reference to 25°C, $I_D$ = 1mA ④ |
| $R_{DS(on)}$ | Static Drain-to-Source On-Resistance | — | — | 600 | mΩ | $V_{GS}$ = 10V, $I_D$ = 2.9A ④ |
| $V_{GS(th)}$ | Gate Threshold Voltage | 2.0 | — | 4.0 | V | $V_{DS}$ = $V_{GS}$, $I_D$ = 250µA |
| $I_{DSS}$ | Drain-to-Source Leakage Current | — | — | 25 | µA | $V_{DS}$ = 200V, $V_{GS}$ = 0V |
| | | — | — | 250 | | $V_{DS}$ = 160V, $V_{GS}$ = 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 |

## Dynamic @ $T_J$ = 25°C (unless otherwise specified)

| | Parameter | Min. | Typ. | Max. | Units | Conditions |
|---|---|---|---|---|---|---|
| $g_{fs}$ | Forward Transconductance | 2.6 | — | — | S | $V_{DS}$ = 50V, $I_D$ = 2.9A |
| $Q_g$ | Total Gate Charge | — | 15 | 23 | nC | $I_D$ = 2.9A |
| $Q_{gs}$ | Gate-to-Source Charge | — | 2.4 | 3.6 | | $V_{DS}$ = 160V |
| $Q_{gd}$ | Gate-to-Drain ("Miller") Charge | — | 6.1 | 9.2 | | $V_{GS}$ = 10V, |
| $t_{d(on)}$ | Turn-On Delay Time | — | 6.4 | — | ns | $V_{DD}$ = 100V |
| $t_r$ | Rise Time | — | 11 | — | | $I_D$ = 2.9A |
| $t_{d(off)}$ | Turn-Off Delay Time | — | 20 | — | | $R_G$ = 24Ω |
| $t_f$ | Fall Time | — | 12 | — | | $V_{GS}$ = 10V ④ |
| $C_{iss}$ | Input Capacitance | — | 300 | — | pF | $V_{GS}$ = 0V |
| $C_{oss}$ | Output Capacitance | — | 53 | — | | $V_{DS}$ = 25V |
| $C_{rss}$ | Reverse Transfer Capacitance | — | 15 | — | | $f$ = 1.0MHz |
| $C_{oss}$ | Output Capacitance | — | 300 | — | | $V_{GS}$ = 0V, $V_{DS}$ = 1.0V, $f$ = 1.0MHz |
| $C_{oss}$ | Output Capacitance | — | 23 | — | | $V_{GS}$ = 0V, $V_{DS}$ = 160V, $f$ = 1.0MHz |
| $C_{oss}$ eff. | Effective Output Capacitance | — | 46 | — | | $V_{GS}$ = 0V, $V_{DS}$ = 0V to 160V ⑤ |

## Avalanche Characteristics

| | Parameter | Typ. | Max. | Units |
|---|---|---|---|---|
| $E_{AS}$ | Single Pulse Avalanche Energy② | — | 46 | mJ |
| $I_{AR}$ | Avalanche Current① | — | 2.9 | A |
| $E_{AR}$ | Repetitive Avalanche Energy① | — | 4.3 | mJ |

## Thermal Resistance

| | Parameter | Typ. | Max. | Units |
|---|---|---|---|---|
| $R_{\theta JC}$ | Junction-to-Case | — | 3.5 | °C/W |
| $R_{\theta JA}$ | Junction-to-Ambient (PCB mount)* | — | 50 | |
| $R_{\theta JA}$ | Junction-to-Ambient | — | 110 | |

## Diode Characteristics

| | Parameter | Min. | Typ. | Max. | Units | Conditions |
|---|---|---|---|---|---|---|
| $I_S$ | Continuous Source Current (Body Diode) | — | — | 5.0 | A | MOSFET symbol showing the integral reverse p-n junction diode. |
| $I_{SM}$ | Pulsed Source Current (Body Diode) ① | — | — | 20 | | |
| $V_{SD}$ | Diode Forward Voltage | — | — | 1.3 | V | $T_J$ = 25°C, $I_S$ = 2.9A, $V_{GS}$ = 0V ④ |
| $t_{rr}$ | Reverse Recovery Time | — | 90 | 140 | ns | $T_J$ = 25°C, $I_F$ = 2.9A |
| $Q_{rr}$ | Reverse RecoveryCharge | — | 320 | 480 | nC | di/dt = 100A/µs ④ |
| $t_{on}$ | Forward Turn-On Time | Intrinsic turn-on time is negligible (turn-on is dominated by $L_S$+$L_D$) | | | | |

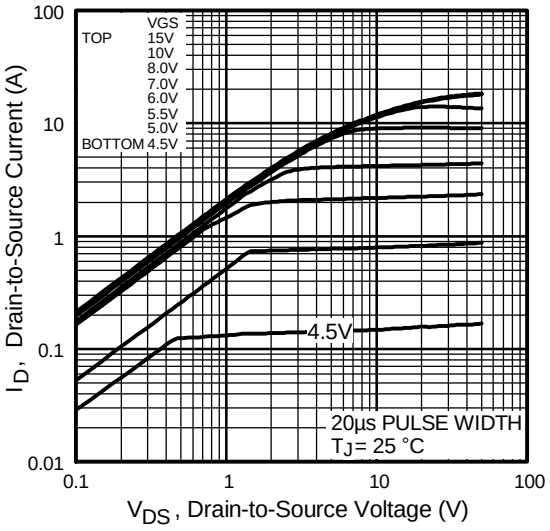



**Fig 1.** Typical Output Characteristics

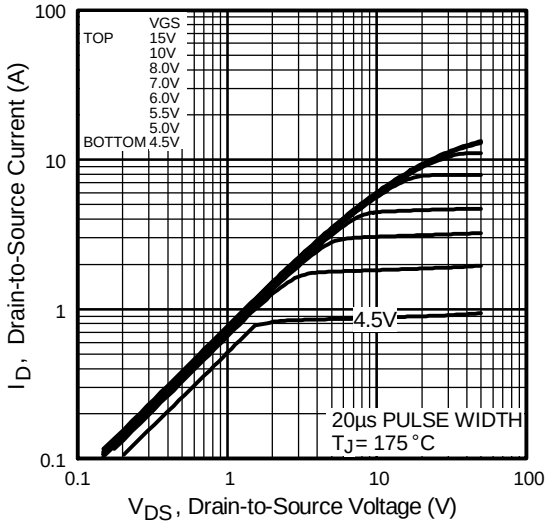



**Fig 2.** Typical Output Characteristics

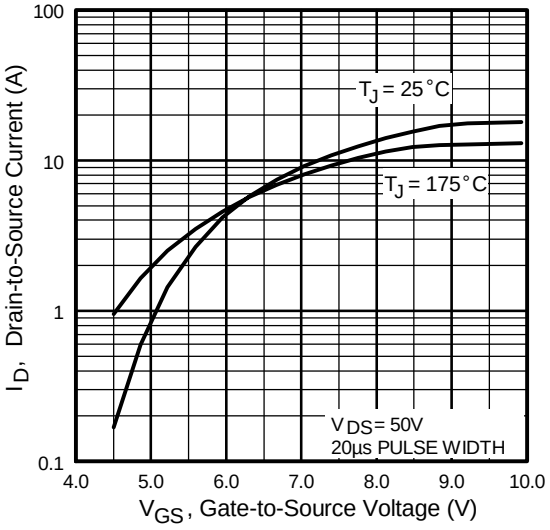



**Fig 3.** Typical Transfer Characteristics

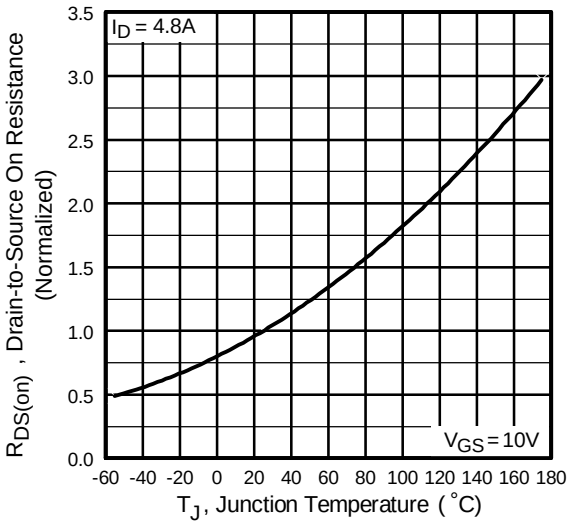



**Fig 4.** Normalized On-Resistance Vs. Temperature

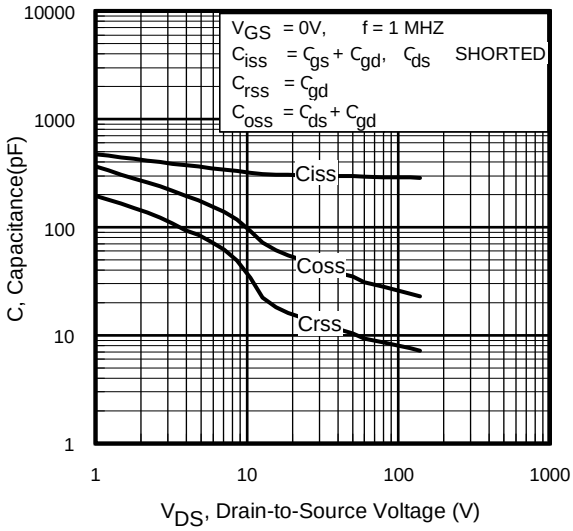



**Fig 5.** Typical Capacitance Vs. Drain-to-Source Voltage

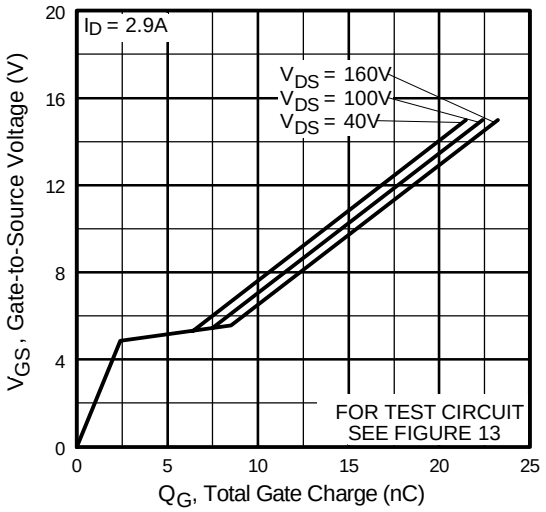



**Fig 6.** Typical Gate Charge Vs. Gate-to-Source Voltage

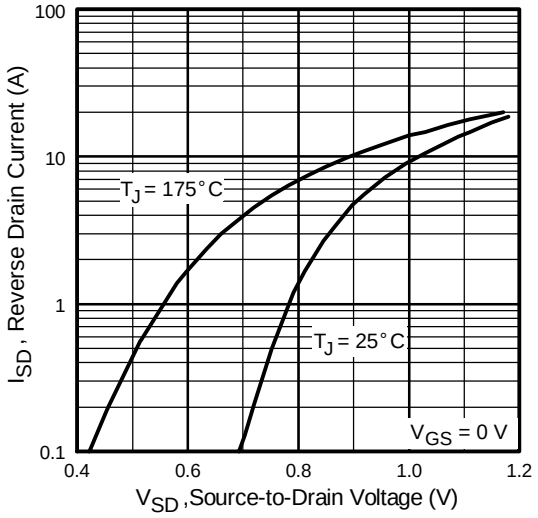



**Fig 7.** Typical Source-Drain Diode Forward Voltage

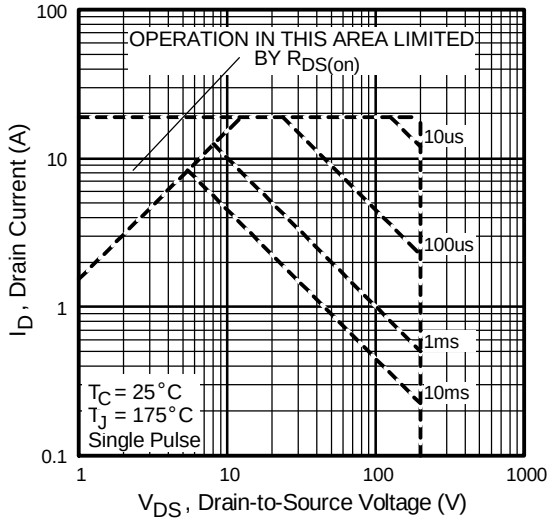



**Fig 8.** Maximum Safe Operating Area

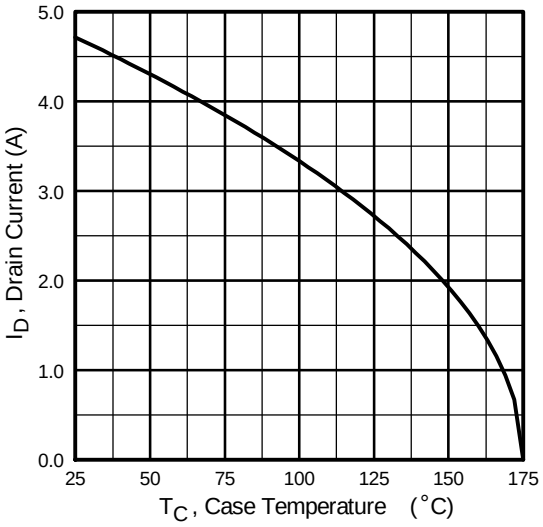



**Fig 9.** Maximum Drain Current Vs. Case Temperature

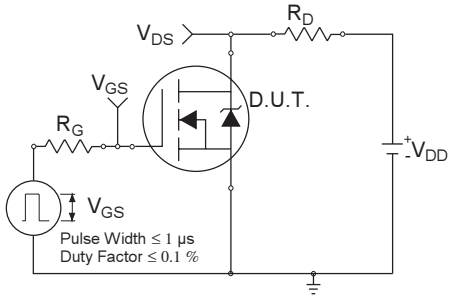



**Fig 10a.** Switching Time Test Circuit

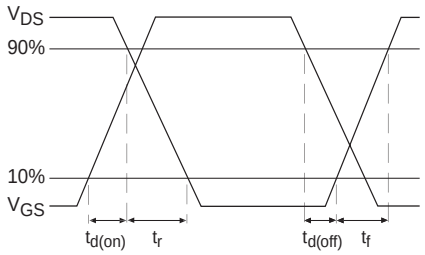



**Fig 10b.** Switching Time Waveforms

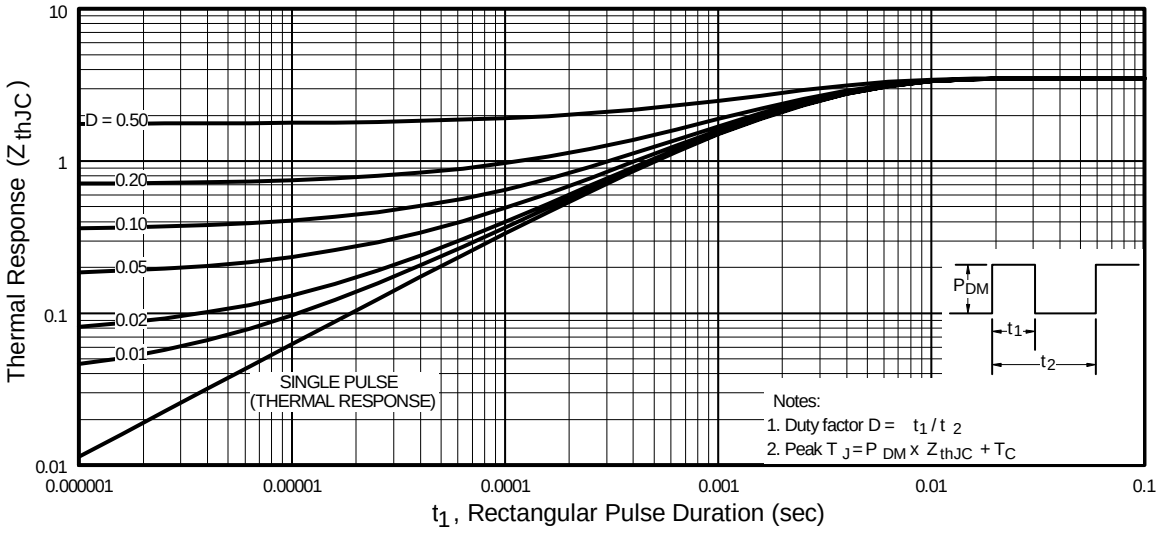



**Fig 11.** Maximum Effective Transient Thermal Impedance, Junction-to-Case

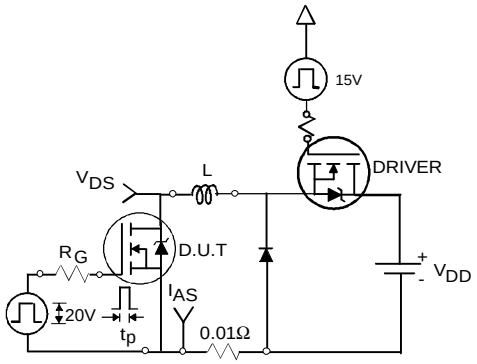



**Fig 12a.** Unclamped Inductive Test Circuit

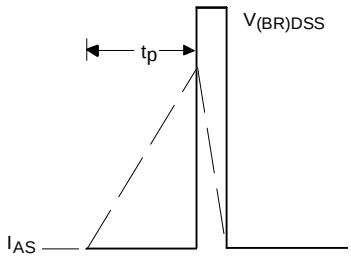



**Fig 12b.** Unclamped Inductive Waveforms

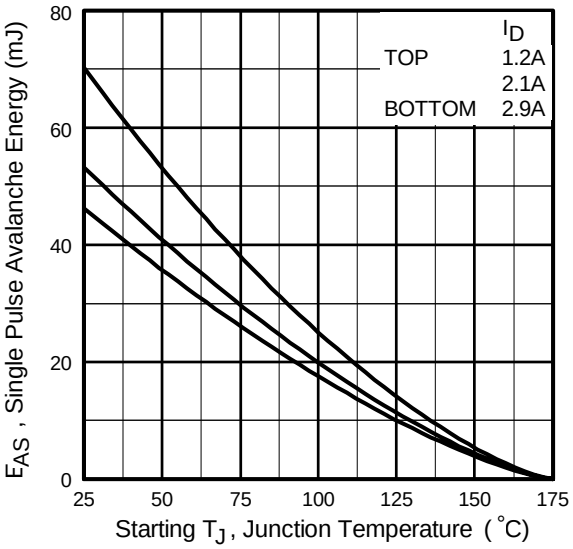



**Fig 12c.** Maximum Avalanche Energy Vs. Drain Current

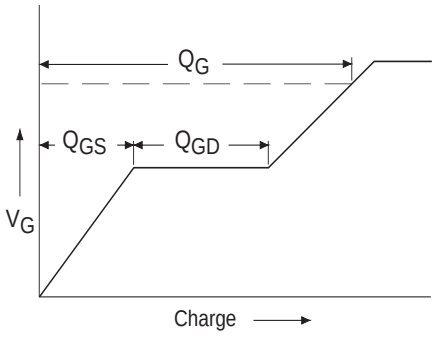



**Fig 13a.** Basic Gate Charge Waveform

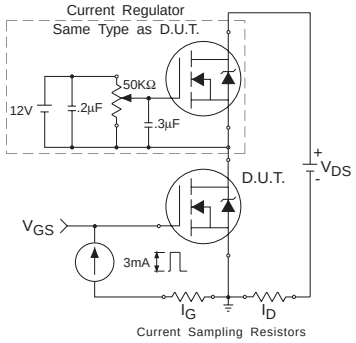



**Fig 13b.** Gate Charge Test Circuit

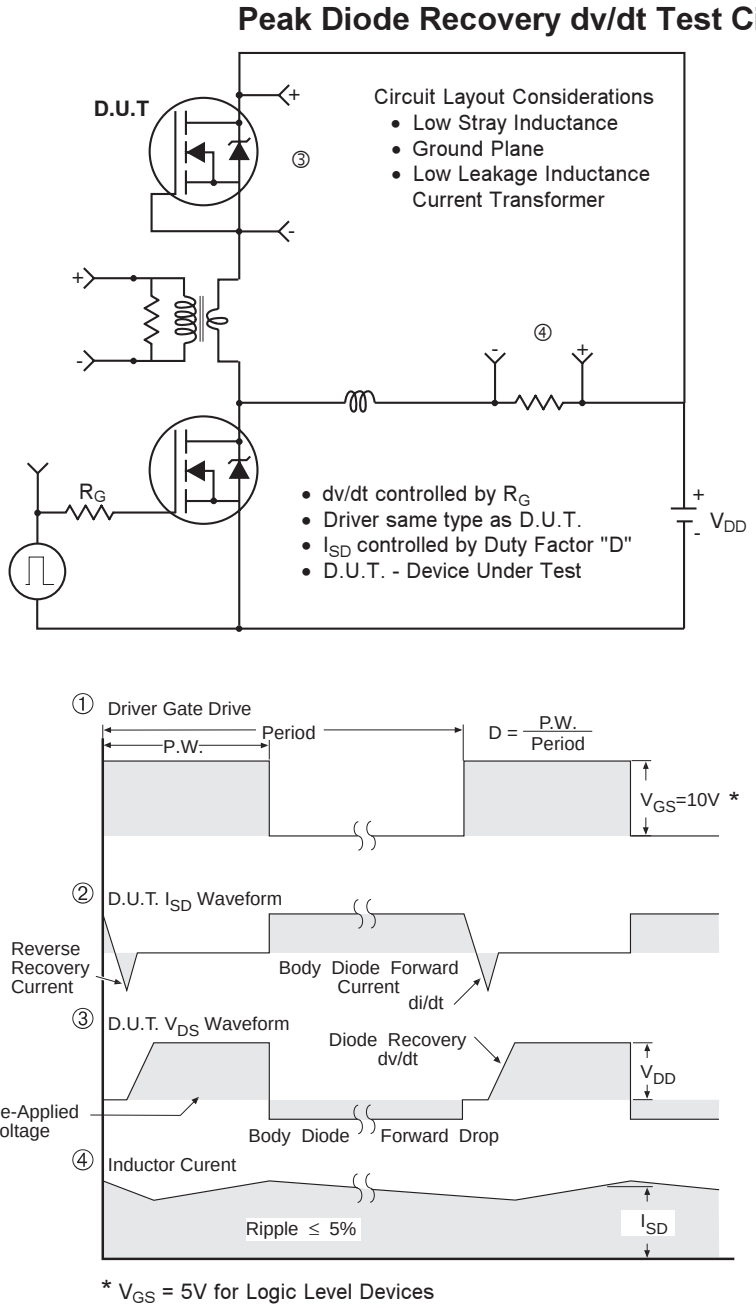
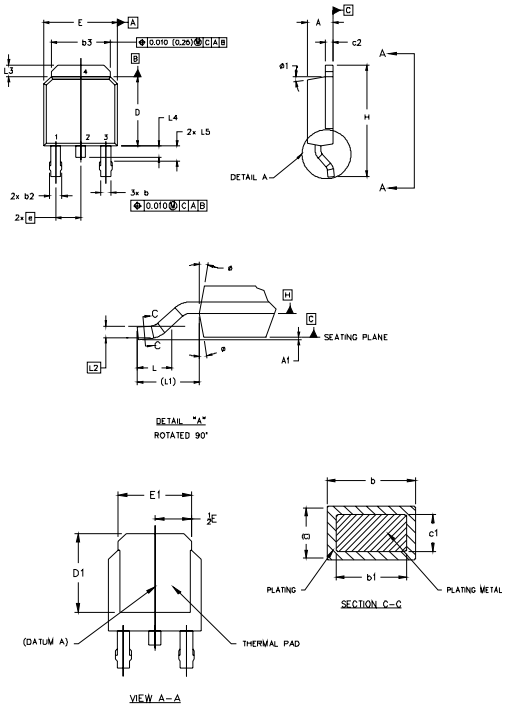



**Fig 14.** For N-Channel HEXFET® Power MOSFETs

## 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 | | 0.13 | | .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 | .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

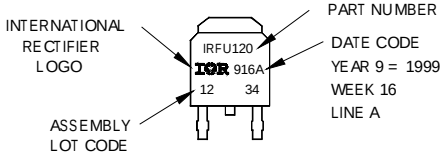
IGBTs, CoPACK

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

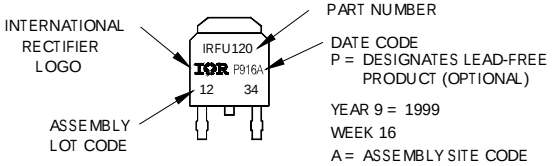
## D-Pak (TO-252AA) Part Marking Information

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

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

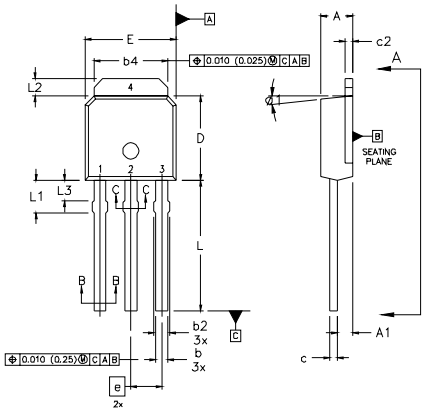


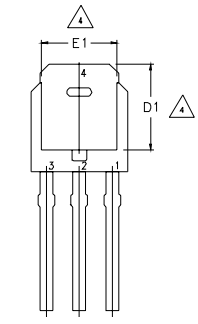

OR

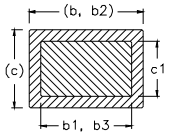


# I-Pak (TO-251AA) Package Outline

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.

| 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 | .046 | 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° | |

LEAD ASSIGNMENTS

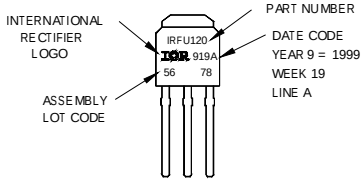
HEXFET

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

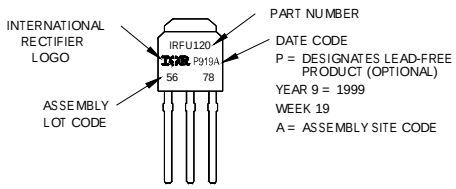
# I-Pak (TO-251AA) Part Marking Information

EXAMPLE: THIS IS AN IRFU120
WITH ASSEMBLY
LOT CODE 5678
ASSEMBLED ON WW 19, 1999
IN THE ASSEMBLY LINE "A"

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



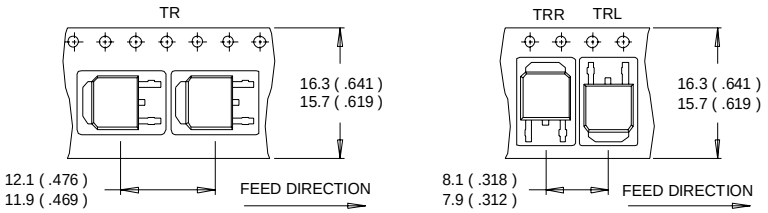

OR



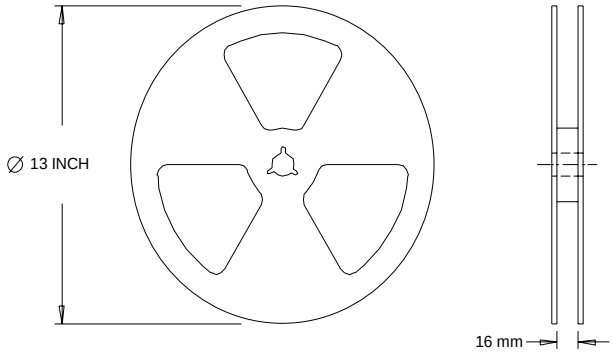
International
IOR Rectifier

## 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°C, L = 11mH $R_G$ = 25Ω, $I_{AS}$ = 2.9A.

③ $I_{SD} \leq$ 2.9A, di/dt ≤ 320A/µs, $V_{DD} \leq V_{(BR)DSS}$, $T_J \leq$ 175°C

④ Pulse width ≤ 400µs; duty cycle ≤ 2%.

⑤ $C_{oss}$ eff. is a fixed capacitance that gives the same charging time as $C_{oss}$ while $V_{DS}$ is rising from 0 to 80% $V_{DSS}$

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

International
IOR Rectifier

**IR WORLD HEADQUARTERS:** 233 Kansas St., El Segundo, California 90245, USA Tel: (310) 252-7105
TAC Fax: (310) 252-7903
Visit us at www.irf.com for sales contact information.
*Data and specifications subject to change without notice. 12/04*

Note:  For the most current drawings please refer to the IR website at:
http://www.irf.com/package/