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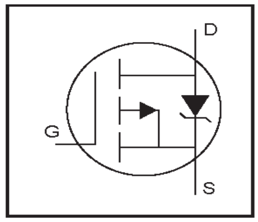
International
IOR Rectifier

# IRF9Z24NSPbF
# IRF9Z24NLPBF

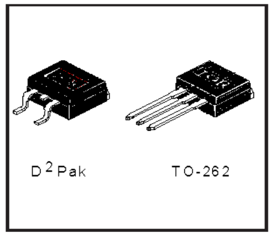
- Advanced Process Technology
- Surface Mount (IRF9Z24NS)
- Low-profile through-hole (IRF9Z24NL)
- 175°C Operating Temperature
- P-Channel
- Fast Switching
- Fully Avalanche Rated
- Lead-Free




$V_{DSS}$ = -55V

$R_{DS(on)}$ = 0.175Ω

$I_D$ = -12A




**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 D²Pak is a surface mount power package capable of accommodating die sizes up to HEX-4. It provides the highest power capability and the lowest possible on-resistance in any existing surface mount package. The D²Pak is suitable for high current applications because of its low internal connection resistance and can dissipate up to 2.0W in a typical surface mount application.
The through-hole version (IRF9Z24NL) is available for low-profile applications.

## Absolute Maximum Ratings

| | Parameter | Max. | Units |
|---|---|---|---|
| $I_D$ @ $T_C$ = 25°C | Continuous Drain Current, $V_{GS}$ @ -10V⑤ | -12 | A |
| $I_D$ @ $T_C$ = 100°C | Continuous Drain Current, $V_{GS}$ @ -10V⑤ | -8.5 | |
| $I_{DM}$ | Pulsed Drain Current ①⑤ | -48 | |
| $P_D$ @$T_A$ = 25°C | Power Dissipation | 3.8 | W |
| $P_D$ @$T_C$ = 25°C | Power Dissipation | 45 | W |
| | Linear Derating Factor | 0.30 | W/°C |
| $V_{GS}$ | Gate-to-Source Voltage | ± 20 | V |
| $E_{AS}$ | Single Pulse Avalanche Energy②⑤ | 96 | mJ |
| $I_{AR}$ | Avalanche Current① | -7.2 | A |
| $E_{AR}$ | Repetitive Avalanche Energy① | 4.5 | mJ |
| dv/dt | Peak Diode Recovery dv/dt ③⑤ | -5.0 | 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 ) | |

## Thermal Resistance

| | Parameter | Typ. | Max. | Units |
|---|---|---|---|---|
| $R_{\theta JC}$ | Junction-to-Case | ––– | 3.3 | °C/W |
| $R_{\theta JA}$ | Junction-to-Ambient ( PCB Mounted,steady-state)** | ––– | 40 | |

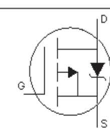


04/25/05

## 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, $I_D$ = -1mA⑤ |
| $R_{DS(on)}$ | Static Drain-to-Source On-Resistance | ––– | ––– | 0.175 | Ω | $V_{GS}$ = -10V, $I_D$ = -7.2A 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, $I_D$ = -7.2A |
| $I_{DSS}$ | 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 | nC | $I_D$ = -7.2A |
| $Q_{gs}$ | Gate-to-Source Charge | ––– | ––– | 5.1 | | $V_{DS}$ = -44V |
| $Q_{gd}$ | Gate-to-Drain ("Miller") Charge | ––– | ––– | 10 | | $V_{GS}$ = -10V, See Fig. 6 and 13 ④⑤ |
| $t_{d(on)}$ | Turn-On Delay Time | ––– | 13 | ––– | ns | $V_{DD}$ = -28V |
| $t_r$ | Rise Time | ––– | 55 | ––– | | $I_D$ = -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 ④⑤ |
| $L_S$ | Internal Source Inductance | | 7.5 | | nH | Between lead, and center of die contact |
| $C_{iss}$ | Input Capacitance | ––– | 350 | ––– | pF | $V_{GS}$ = 0V |
| $C_{oss}$ | Output Capacitance | ––– | 170 | ––– | | $V_{DS}$ = -25V |
| $C_{rss}$ | Reverse Transfer Capacitance | ––– | 92 | ––– | | ƒ = 1.0MHz, See Fig. 5⑤ |

## Source-Drain Ratings and Characteristics

| | Parameter | Min. | Typ. | Max. | Units | Conditions |
|---|---|---|---|---|---|---|
| $I_S$ | Continuous Source Current (Body Diode) | ––– | ––– | -12 | A | MOSFET symbol showing the integral reverse p-n junction diode.  |
| $I_{SM}$ | Pulsed Source Current (Body Diode) • | ––– | ––– | -48 | | |
| $V_{SD}$ | 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 RecoveryCharge | ––– | 84 | 130 | nC | di/dt = -100A/µs ④⑤ |
| $t_{on}$ | 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 = 3.7mH $R_G$ = 25Ω, $I_{AS}$ = -7.2A. (See Figure 12)

③ $I_{SD}$ ≤ -7.2A, di/dt ≤ -280A/µs, $V_{DD}$ ≤ $V_{(BR)DSS}$, $T_J$ ≤ 175°C

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

⑤ 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.

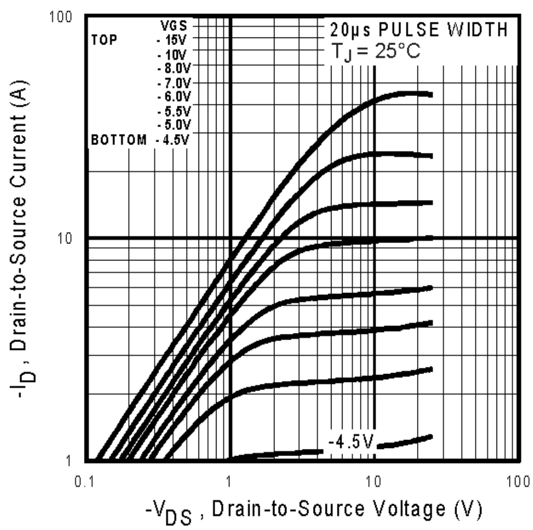



**Fig 1.** Typical Output Characteristics

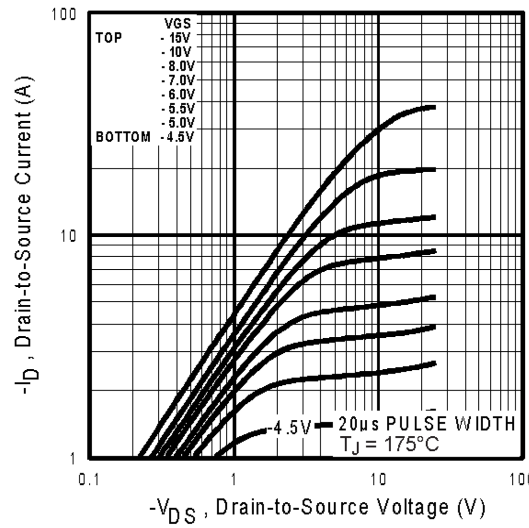



**Fig 2.** Typical Output Characteristics

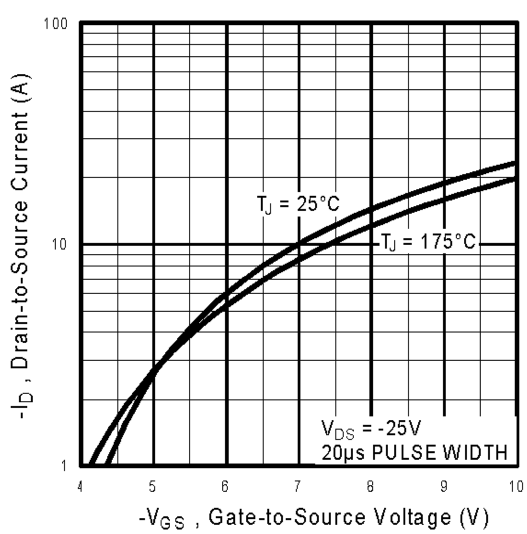



**Fig 3.** Typical Transfer Characteristics

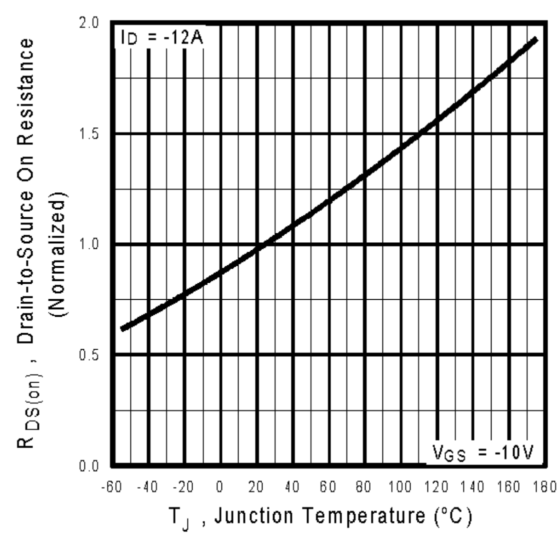



**Fig 4.** Normalized On-Resistance Vs. Temperature

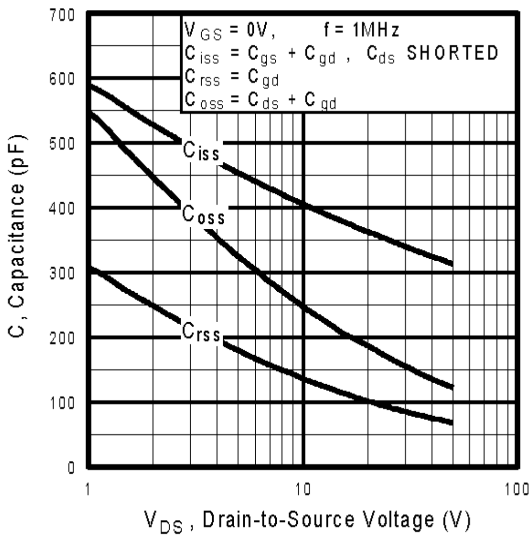



**Fig 5.** Typical Capacitance Vs. Drain-to-Source Voltage

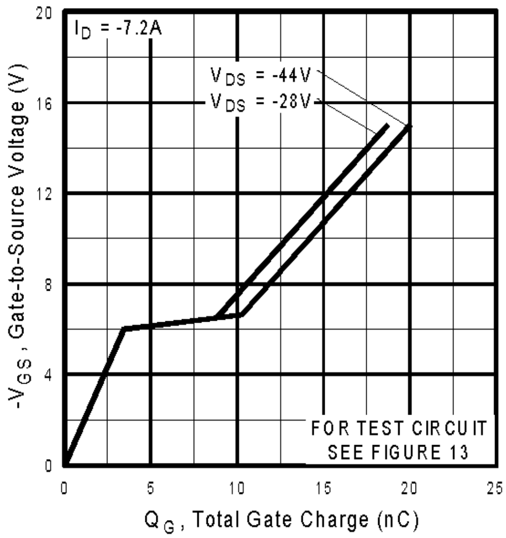



**Fig 6.** Typical Gate Charge Vs. Gate-to-Source Voltage

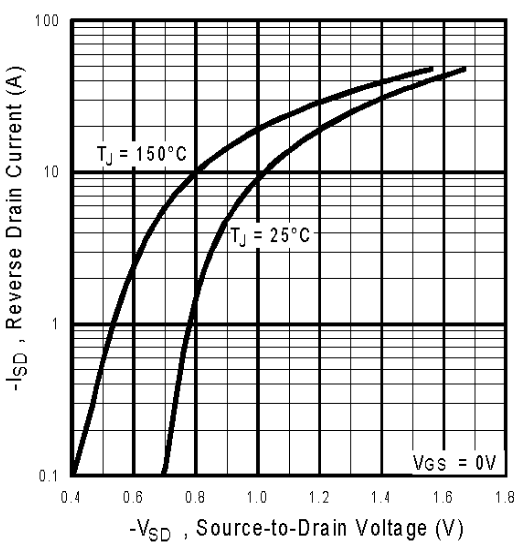



**Fig 7.** Typical Source-Drain Diode Forward Voltage

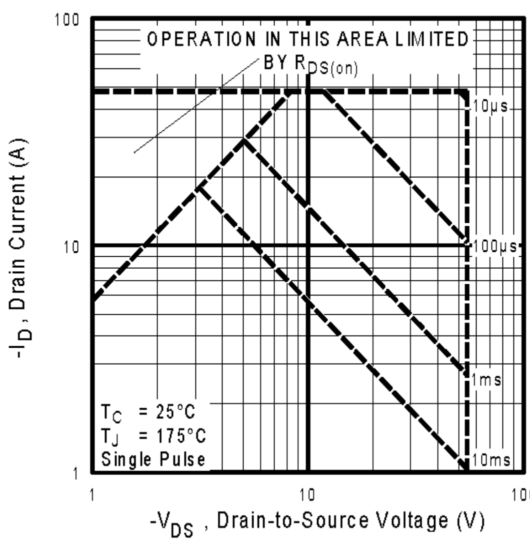



**Fig 8.** Maximum Safe Operating Area

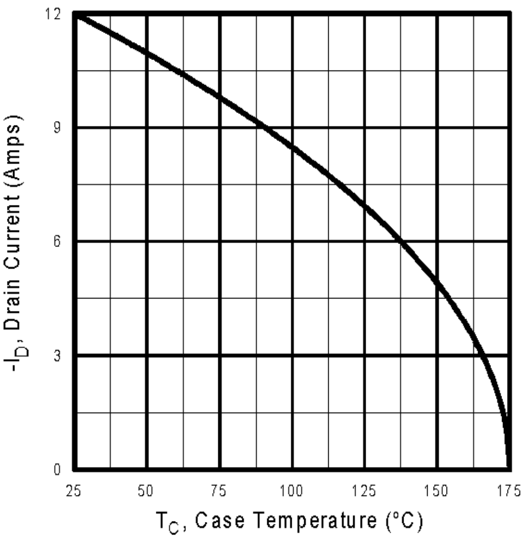



**Fig 9.** Maximum Drain Current Vs. Case Temperature

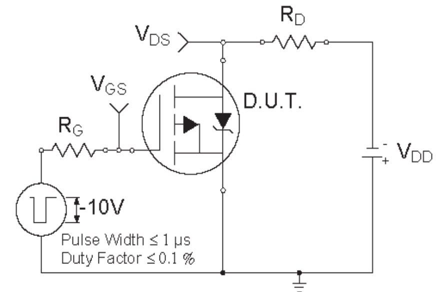



**Fig 10a.** Switching Time Test Circuit

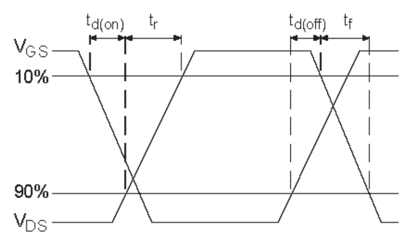



**Fig 10b.** Switching Time Waveforms

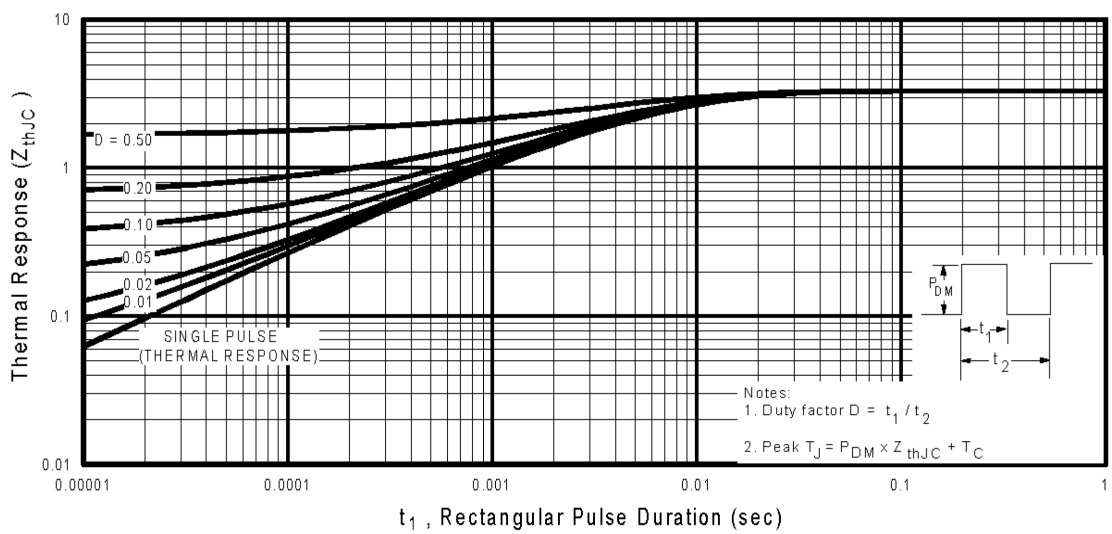



**Fig 11.** Maximum Effective Transient Thermal Impedance, Junction-to-Case

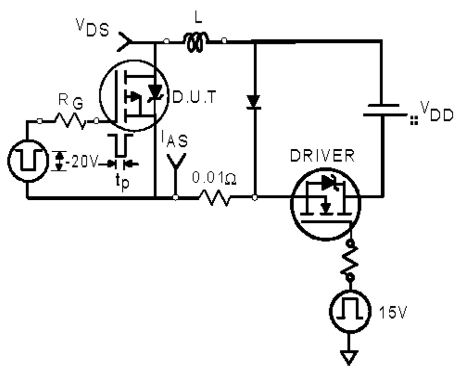



**Fig 12a.** Unclamped Inductive Test Circuit

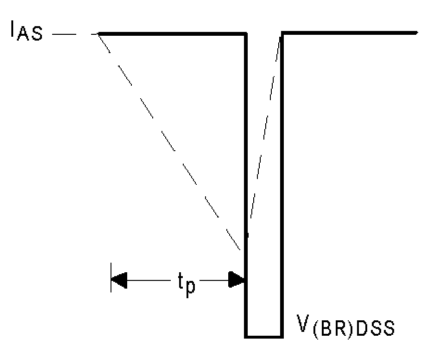



**Fig 12b.** Unclamped Inductive Waveforms

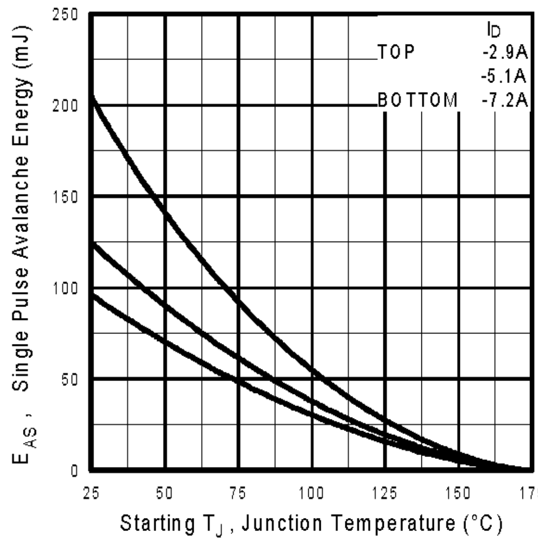



**Fig 12c.** Maximum Avalanche Energy Vs. Drain Current

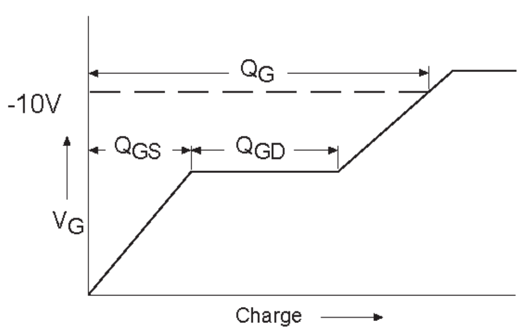



**Fig 13a.** Basic Gate Charge Waveform

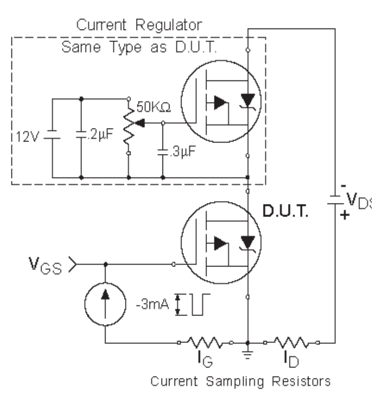



**Fig 13b.** Gate Charge Test Circuit

## Peak Diode Recovery dv/dt Test Circuit

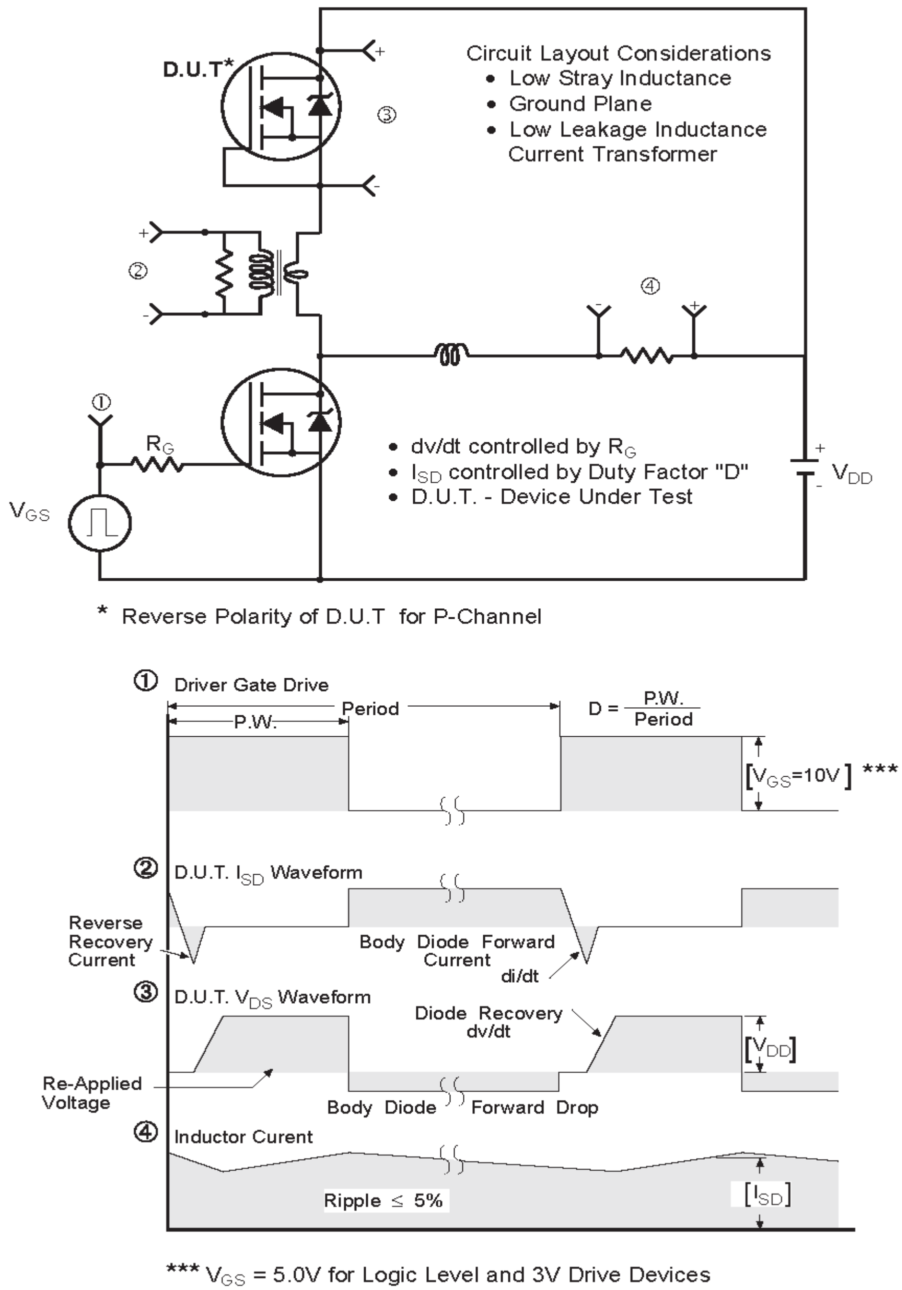
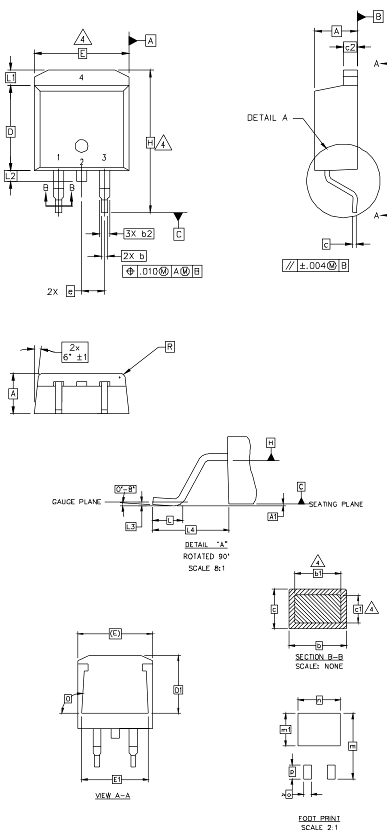



**Fig 14.** For P-Channel HEXFETS

## D²Pak Package Outline (Dimensions are shown in millimeters (inches)




NOTES:
1. DIMENSIONING AND TOLERANCING PER ASME Y14.5M-1994
2. DIMENSIONS ARE SHOWN IN MILLIMETERS [INCHES].
3. DIMENSION D & E DO NOT INCLUDE MOLD FLASH. MOLD FLASH SHALL NOT EXCEED 0.127 [.005"] PER SIDE. THESE DIMENSIONS ARE MEASURED AT THE OUTMOST EXTREMES OF THE PLASTIC BODY.
4. DIMENSION b1 AND c1 APPLY TO BASE METAL ONLY.
5. CONTROLLING DIMENSION: INCH.

| SYMBOL | DIMENSIONS | | | | NOTES |
|---|---|---|---|---|---|
| | MILLIMETERS | | INCHES | | |
| | MIN. | MAX. | MIN. | MAX. | |
| A | 4.06 | 4.83 | .160 | .190 | |
| A1 | 0.00 | 0.254 | .000 | .010 | |
| b | 0.51 | 0.99 | .020 | .039 | |
| b1 | 0.51 | 0.89 | .020 | .035 | 4 |
| b2 | 1.14 | 1.78 | .045 | .070 | |
| c | 0.38 | 0.74 | .015 | .029 | |
| c1 | 0.38 | 0.58 | .015 | .023 | 4 |
| c2 | 1.14 | 1.65 | .045 | .065 | |
| D | 8.51 | 9.65 | .335 | .380 | 3 |
| D1 | 6.86 | | .270 | | |
| E | 9.65 | 10.67 | .380 | .420 | 3 |
| E1 | 6.22 | | .245 | | |
| e | 2.54 BSC | | .100 BSC | | |
| H | 14.61 | 15.88 | .575 | .625 | |
| L | 1.78 | 2.79 | .070 | .110 | |
| L1 | | 1.65 | | .065 | |
| L2 | 1.27 | 1.78 | .050 | .070 | |
| L3 | 0.25 BSC | | .010 BSC | | |
| L4 | 4.78 | 5.28 | .188 | .208 | |
| m | 17.78 | | .700 | | |
| m1 | 8.89 | | .350 | | |
| n | 11.43 | | .450 | | |
| o | 2.08 | | .082 | | |
| p | 3.81 | | .150 | | |
| R | 0.51 | 0.71 | .020 | .028 | |
| θ | 90° | 93° | 90° | 93° | |

LEAD ASSIGNMENTS

HEXFET

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

IGBTs, CoPACK

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

DIODES

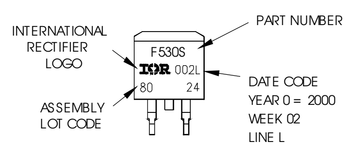
1.- ANODE *
2, 4.- CATHODE
3.- ANODE

* PART DEPENDENT.

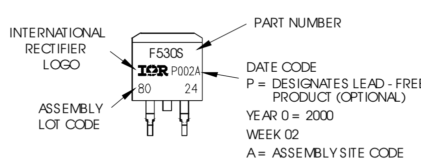
## D²Pak Part Marking Information

EXAMPLE: THIS IS AN IRF530S WITH LOT CODE 8024
ASSEMBLED ON WW 02, 2000
IN THE ASSEMBLY LINE "L"

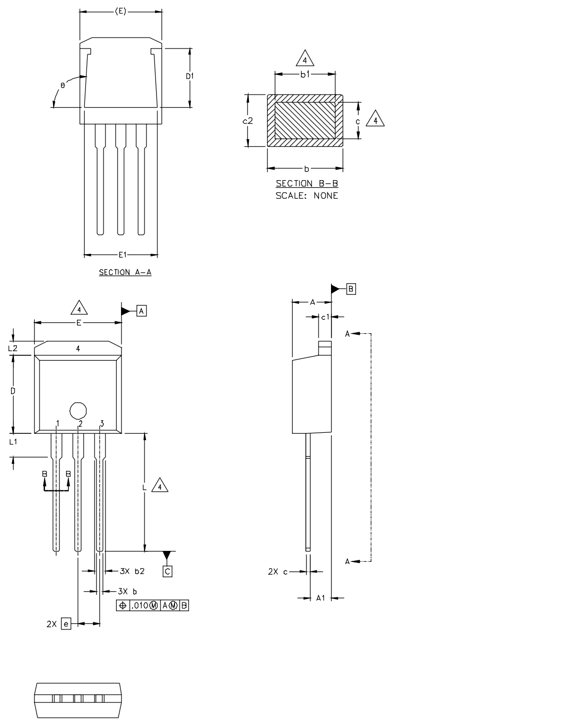
Note: "P" in assembly line position indicates "Lead - Free"




OR



## TO-262 Package Outline (Dimensions are shown in millimeters (inches)




| SYMBOL | DIMENSIONS | | | | NOTES |
|---|---|---|---|---|---|
| | MILLIMETERS | | INCHES | | |
| | MIN. | MAX. | MIN. | MAX. | |
| A | 4.06 | 4.83 | .160 | .190 | |
| A1 | 2.03 | 2.92 | .080 | .115 | |
| b | 0.51 | 0.99 | .020 | .039 | |
| b1 | 0.51 | 0.89 | .020 | .035 | 4 |
| b2 | 1.14 | 1.40 | .045 | .055 | |
| c | 0.38 | 0.63 | .015 | .025 | 4 |
| c1 | 1.14 | 1.40 | .045 | .055 | |
| c2 | 0.43 | .063 | .017 | .029 | |
| D | 8.51 | 9.65 | .335 | .380 | 3 |
| D1 | 5.33 | | .210 | | |
| E | 9.65 | 10.67 | .380 | .420 | 3 |
| E1 | 6.22 | | .245 | | |
| e | 2.54 BSC | | .100 BSC | | |
| L | 13.46 | 14.09 | .530 | .555 | |
| L1 | 3.56 | 3.71 | .140 | .146 | |
| L2 | | 1.65 | | .065 | |

NOTES:
1. DIMENSIONING AND TOLERANCING PER ASME Y14.5M-1994
2. DIMENSIONS ARE SHOWN IN MILLIMETERS [INCHES].
3. DIMENSION D & E DO NOT INCLUDE MOLD FLASH. MOLD FLASH SHALL NOT EXCEED 0.127 [.005"] PER SIDE. THESE DIMENSIONS ARE MEASURED AT THE OUTMOST EXTREMES OF THE PLASTIC BODY.
4. DIMENSION b1 AND c1 APPLY TO BASE METAL ONLY.
5. CONTROLLING DIMENSION: INCH.

LEAD ASSIGNMENTS

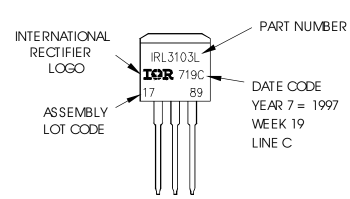
HEXFET
1.- GATE
2.- DRAIN
3.- SOURCE
4.- DRAIN

IGBT
1 - GATE
2 - COLLECTOR
3 - EMITTER

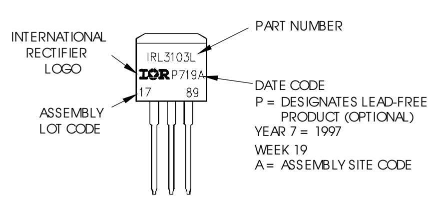
## TO-262 Part Marking Information

EXAMPLE: THIS IS AN IRL3103L
LOT CODE 1789
ASSEMBLED ON WW 19, 1997
IN THE ASSEMBLY LINE "C"

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

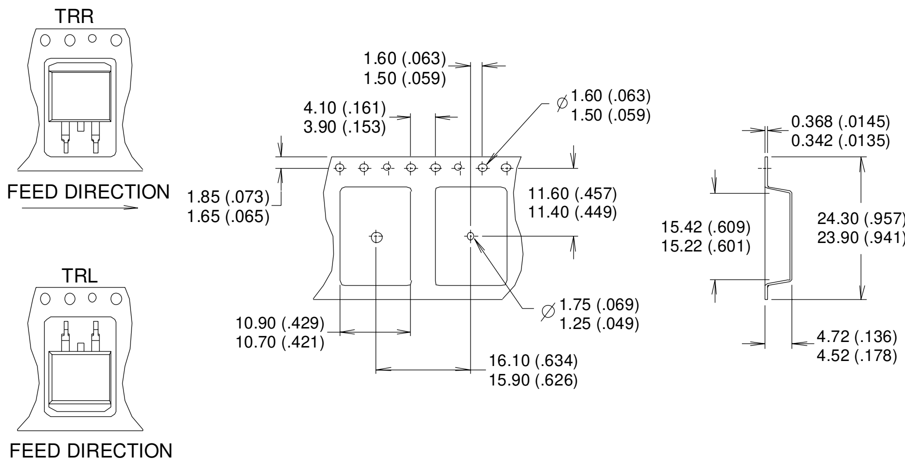


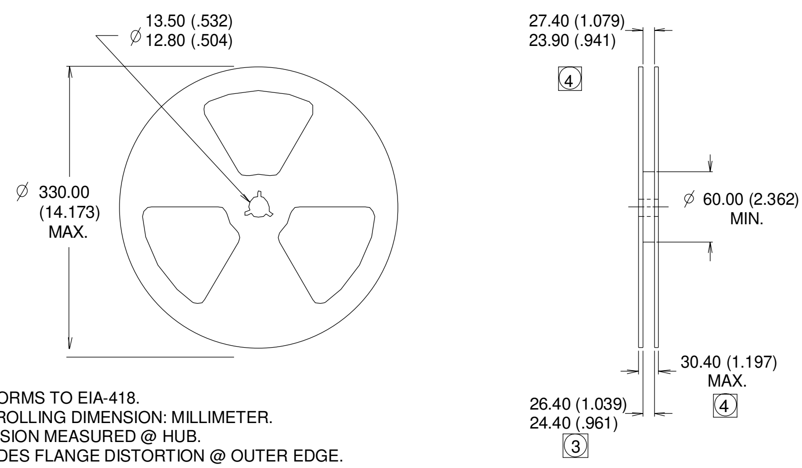

OR



## D$^2$Pak Tape & Reel Information

Dimensions are shown in millimeters (inches)




NOTES :
1. COMFORMS TO EIA-418.
2. CONTROLLING DIMENSION: MILLIMETER.
3. DIMENSION MEASURED @ HUB.
4. INCLUDES FLANGE DISTORTION @ OUTER EDGE.

Data and specifications subject to change without notice.

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Visit us at www.irf.com for sales contact information. 04/05

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