

International  
**IR** Rectifier

**AUTOMOTIVE MOSFET**

PD - 95332A

**IRF2804PbF**  
**IRF2804SPbF**  
**IRF2804LPbF**

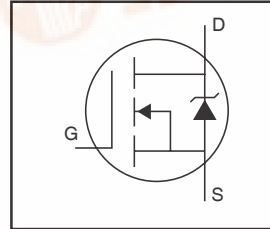
**HEXFET® Power MOSFET**

### Features

- Advanced Process Technology
- Ultra Low On-Resistance
- 175°C Operating Temperature
- Fast Switching
- Repetitive Avalanche Allowed up to  $T_{jmax}$
- Lead-Free

### Description

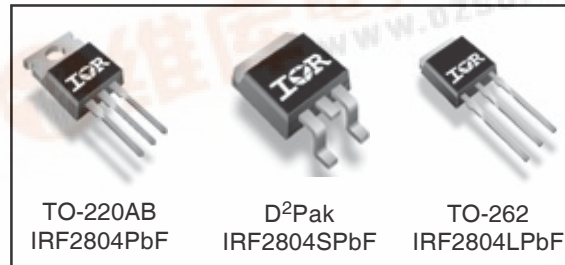
Specifically designed for Automotive applications, this HEXFET® Power MOSFET utilizes the latest processing techniques to achieve extremely low on-resistance per silicon area. Additional features of this design are a 175°C junction operating temperature, fast switching speed and improved repetitive avalanche rating. These features combine to make this design an extremely efficient and reliable device for use in Automotive applications and a wide variety of other applications.



$$V_{DSS} = 40V$$

$$R_{DS(on)} = 2.0m\Omega^{\circ}$$

$$I_D = 75A$$



### Absolute Maximum Ratings

|                            | Parameter                                                  | Max.                   | Units |
|----------------------------|------------------------------------------------------------|------------------------|-------|
| $I_D @ T_C = 25^{\circ}C$  | Continuous Drain Current, $V_{GS} @ 10V$ (Silicon Limited) | 270                    | A     |
| $I_D @ T_C = 100^{\circ}C$ | Continuous Drain Current, $V_{GS} @ 10V$ (See Fig. 9)      | 190                    |       |
| $I_D @ T_C = 25^{\circ}C$  | Continuous Drain Current, $V_{GS} @ 10V$ (Package Limited) | 75                     |       |
| $I_{DM}$                   | Pulsed Drain Current ①                                     | 1080                   |       |
| $P_D @ T_C = 25^{\circ}C$  | Maximum Power Dissipation                                  | 300                    | W     |
|                            | Linear Derating Factor                                     | 2.0                    | W/°C  |
| $V_{GS}$                   | Gate-to-Source Voltage                                     | $\pm 20$               | V     |
| $E_{AS}$                   | Single Pulse Avalanche Energy (Thermally Limited) ②        | 540                    | mJ    |
| $E_{AS} (tested)$          | Single Pulse Avalanche Energy Tested Value ③               | 1160                   |       |
| $I_{AR}$                   | Avalanche Current ①                                        | See Fig.12a,12b,15,16  | A     |
| $E_{AR}$                   | Repetitive Avalanche Energy ④                              |                        | mJ    |
| $T_J$<br>$T_{STG}$         | Operating Junction and<br>Storage Temperature Range        | -55 to + 175           | °C    |
|                            | Soldering Temperature, for 10 seconds                      | 300 (1.6mm from case ) |       |
|                            | Mounting torque, 6-32 or M3 screw                          | 10 lbf•in (1.1N•m)     |       |

### Thermal Resistance

|                 | Parameter                                      | Typ. | Max.  | Units |
|-----------------|------------------------------------------------|------|-------|-------|
| $R_{\theta JC}$ | Junction-to-Case                               | —    | 0.50⑤ | °C/W  |
| $R_{\theta CS}$ | Case-to-Sink, Flat, Greased Surface            | 0.50 | —     |       |
| $R_{\theta JA}$ | Junction-to-Ambient                            | —    | 62    |       |
| $R_{\theta JA}$ | Junction-to-Ambient (PCB Mount, steady state)⑥ | —    | 40    |       |

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# IRF2804/S/LPbF

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

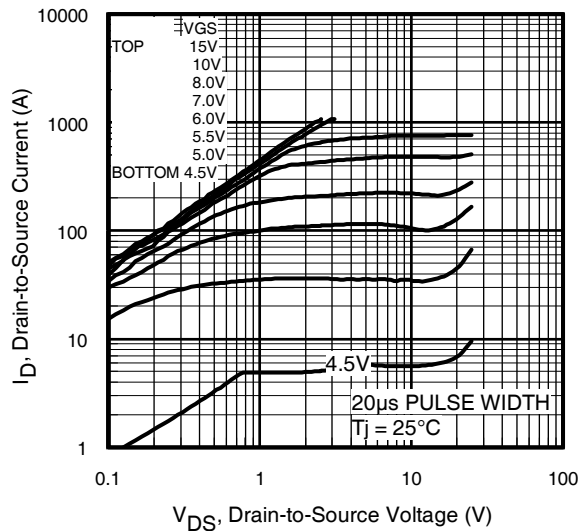
|                              | Parameter                            | Min. | Typ.  | Max. | Units | Conditions                                                                  |
|------------------------------|--------------------------------------|------|-------|------|-------|-----------------------------------------------------------------------------|
| $V_{(BR)DSS}$                | Drain-to-Source Breakdown Voltage    | 40   | —     | —    | V     | $V_{GS} = 0V, I_D = 250\mu A$                                               |
| $\Delta BV_{DSS}/\Delta T_J$ | Breakdown Voltage Temp. Coefficient  | —    | 0.031 | —    | V/°C  | Reference to $25^\circ\text{C}$ , $I_D = 1mA$                               |
| $R_{DS(on)}$ SMD             | Static Drain-to-Source On-Resistance | —    | 1.5   | 2.0  | mΩ    | $V_{GS} = 10V, I_D = 75A$ ④                                                 |
| $R_{DS(on)}$ TO-220          | Static Drain-to-Source On-Resistance | —    | 1.8   | 2.3  | mΩ    | $V_{GS} = 10V, I_D = 75A$ 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             | 130  | —     | —    | S     | $V_{DS} = 10V, I_D = 75A$                                                   |
| $I_{DSS}$                    | Drain-to-Source Leakage Current      | —    | —     | 20   | μA    | $V_{DS} = 40V, V_{GS} = 0V$                                                 |
|                              |                                      | —    | —     | 250  | μA    | $V_{DS} = 40V, V_{GS} = 0V, T_J = 125^\circ\text{C}$                        |
| $I_{GSS}$                    | Gate-to-Source Forward Leakage       | —    | —     | 200  | nA    | $V_{GS} = 20V$                                                              |
|                              | Gate-to-Source Reverse Leakage       | —    | —     | -200 | nA    | $V_{GS} = -20V$                                                             |
| $Q_g$                        | Total Gate Charge                    | —    | 160   | 240  | nC    | $I_D = 75A$                                                                 |
| $Q_{gs}$                     | Gate-to-Source Charge                | —    | 41    | 62   | nC    | $V_{DS} = 32V$                                                              |
| $Q_{gd}$                     | Gate-to-Drain ("Miller") Charge      | —    | 66    | 99   | nC    | $V_{GS} = 10V$ ④                                                            |
| $t_{d(on)}$                  | Turn-On Delay Time                   | —    | 13    | —    | ns    | $V_{DD} = 20V$                                                              |
| $t_r$                        | Rise Time                            | —    | 120   | —    | ns    | $I_D = 75A$                                                                 |
| $t_{d(off)}$                 | Turn-Off Delay Time                  | —    | 130   | —    | ns    | $R_G = 2.5\Omega$                                                           |
| $t_f$                        | Fall Time                            | —    | 130   | —    | ns    | $V_{GS} = 10V$ ④                                                            |
| $L_D$                        | Internal Drain Inductance            | —    | 4.5   | —    | nH    | Between lead,<br>6mm (0.25in.)<br>from package<br>and center of die contact |
| $L_S$                        | Internal Source Inductance           | —    | 7.5   | —    | nH    |                                                                             |
| $C_{iss}$                    | Input Capacitance                    | —    | 6450  | —    | pF    | $V_{GS} = 0V$                                                               |
| $C_{oss}$                    | Output Capacitance                   | —    | 1690  | —    | pF    | $V_{DS} = 25V$                                                              |
| $C_{rss}$                    | Reverse Transfer Capacitance         | —    | 840   | —    | pF    | $f = 1.0MHz$ , See Fig. 5                                                   |
| $C_{oss}$                    | Output Capacitance                   | —    | 5350  | —    | pF    | $V_{GS} = 0V, V_{DS} = 1.0V, f = 1.0MHz$                                    |
| $C_{oss}$                    | Output Capacitance                   | —    | 1520  | —    | pF    | $V_{GS} = 0V, V_{DS} = 32V, f = 1.0MHz$                                     |
| $C_{oss \text{ eff.}}$       | Effective Output Capacitance         | —    | 2210  | —    | pF    | $V_{GS} = 0V, V_{DS} = 0V \text{ to } 32V$                                  |

## Diode Characteristics

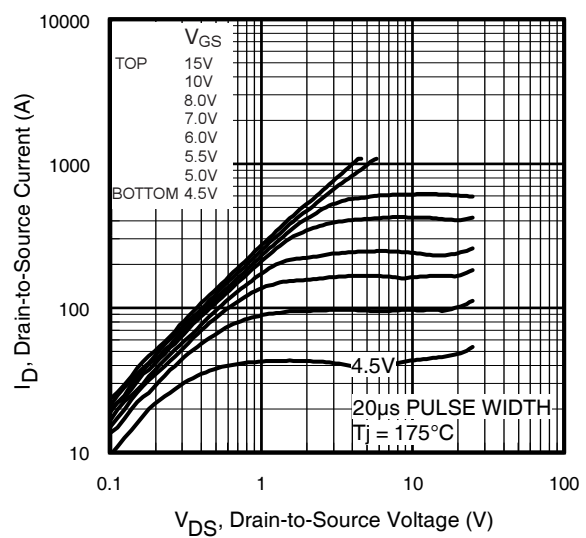
|          | Parameter                                 | Min.                                                                      | Typ. | Max. | Units | Conditions                                                              |
|----------|-------------------------------------------|---------------------------------------------------------------------------|------|------|-------|-------------------------------------------------------------------------|
| $I_S$    | Continuous Source Current<br>(Body Diode) | —                                                                         | —    | 270  | A     | MOSFET symbol<br>showing the<br>integral reverse<br>p-n junction diode. |
| $I_{SM}$ | Pulsed Source Current<br>(Body Diode) ①   | —                                                                         | —    | 1080 | A     |                                                                         |
| $V_{SD}$ | Diode Forward Voltage                     | —                                                                         | —    | 1.3  | V     | $T_J = 25^\circ\text{C}, I_S = 75A, V_{GS} = 0V$ ④                      |
| $t_{rr}$ | Reverse Recovery Time                     | —                                                                         | 56   | 84   | ns    | $T_J = 25^\circ\text{C}, I_F = 75A, V_{DD} = 20V$                       |
| $Q_{rr}$ | Reverse Recovery Charge                   | —                                                                         | 67   | 100  | nC    | $di/dt = 100A/\mu s$ ④                                                  |
| $t_{on}$ | Forward Turn-On Time                      | Intrinsic turn-on time is negligible (turn-on is dominated by $L_S+L_D$ ) |      |      |       |                                                                         |

### Notes:

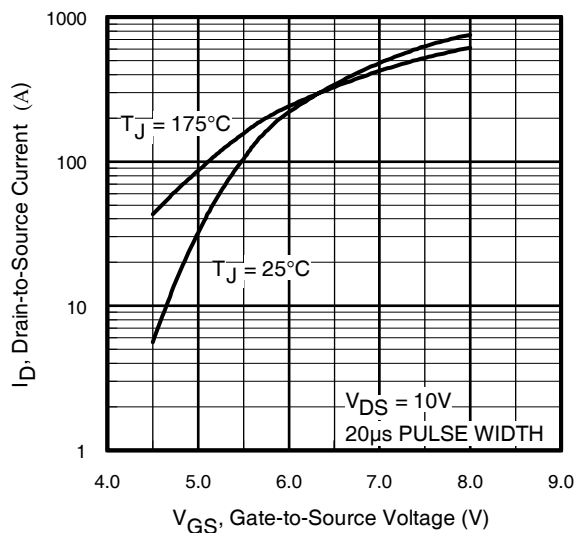
- ① Repetitive rating; pulse width limited by max. junction temperature. (See fig. 11).
- ② Limited by  $T_{Jmax}$ ; starting  $T_J = 25^\circ\text{C}$ ,  $L = 0.24mH, R_G = 25\Omega, I_{AS} = 75A, V_{GS} = 10V$ .  
Part not recommended for use above this value.
- ③  $I_{SD} \leq 75A, di/dt \leq 220A/\mu s, V_{DD} \leq V_{(BR)DSS}, T_J \leq 175^\circ\text{C}$ .
- ④ Pulse width  $\leq 1.0ms$ ; duty cycle  $\leq 2\%$ .
- ⑤  $C_{oss \text{ eff.}}$  is a fixed capacitance that gives the same charging time as  $C_{oss}$  while  $V_{DS}$  is rising from 0 to 80%  $V_{DSS}$ .
- ⑥ Limited by  $T_{Jmax}$ ; see Fig.12a, 12b, 15, 16 for typical repetitive avalanche performance.
- ⑦ This value determined from sample failure population. 100% tested to this value in production.
- ⑧ This is applied to D<sup>2</sup>Pak, when mounted on 1" square PCB (FR-4 or G-10 Material). For recommended footprint and soldering techniques refer to application note #AN-994.
- ⑨ Max  $R_{DS(on)}$  for D<sup>2</sup>Pak and TO-262 (SMD) devices.
- ⑩ TO-220 device will have an  $R_{th}$  value of  $0.45^\circ\text{C/W}$ .



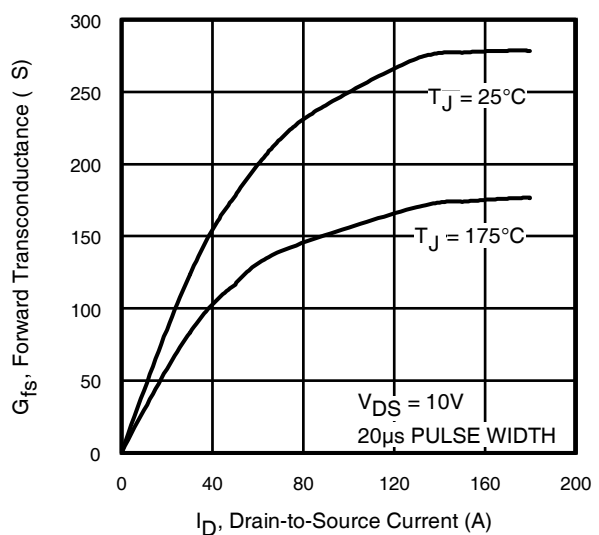
**Fig 1.** Typical Output Characteristics



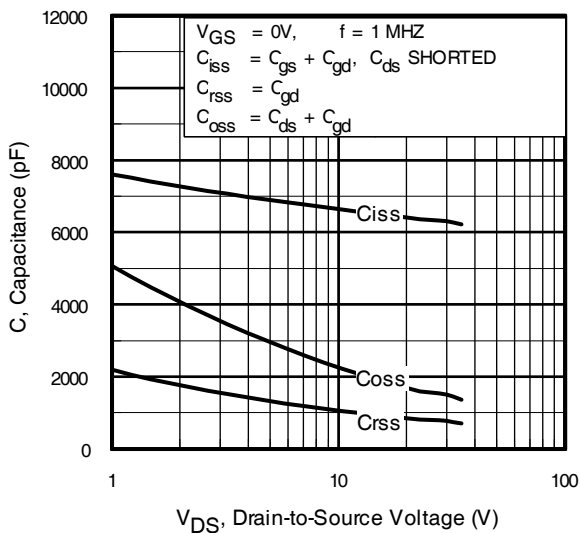
**Fig 2.** Typical Output Characteristics



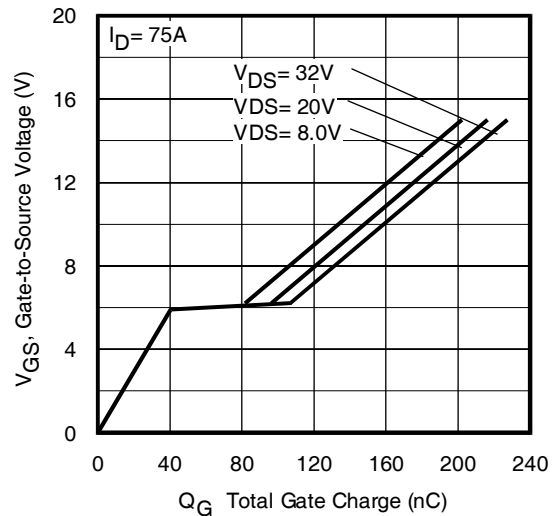
**Fig 3.** Typical Transfer Characteristics



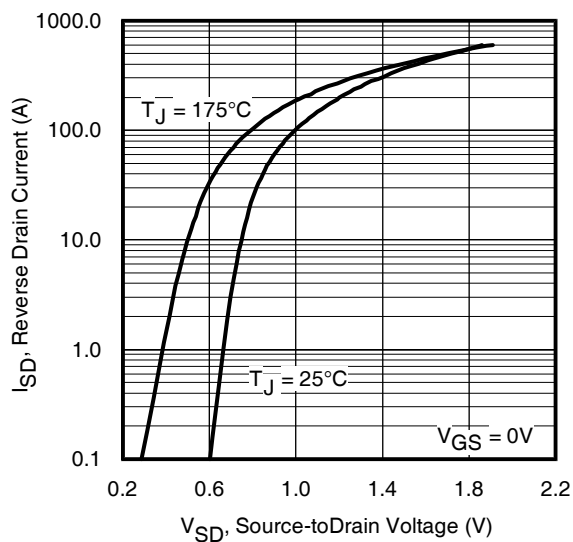
**Fig 4.** Typical Forward Transconductance vs. Drain Current



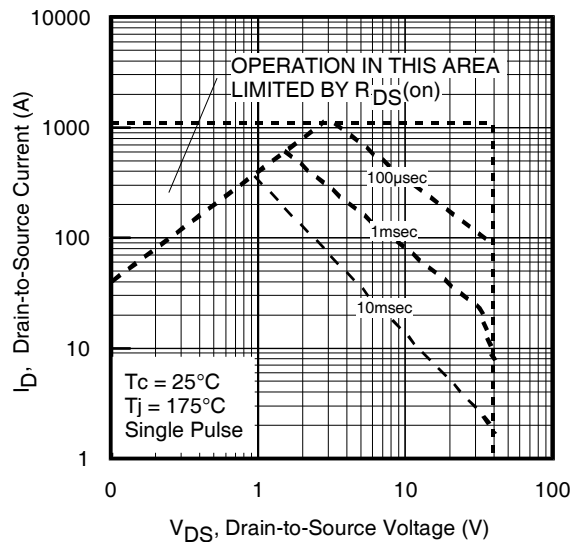
**Fig 5.** Typical Capacitance vs. Drain-to-Source Voltage



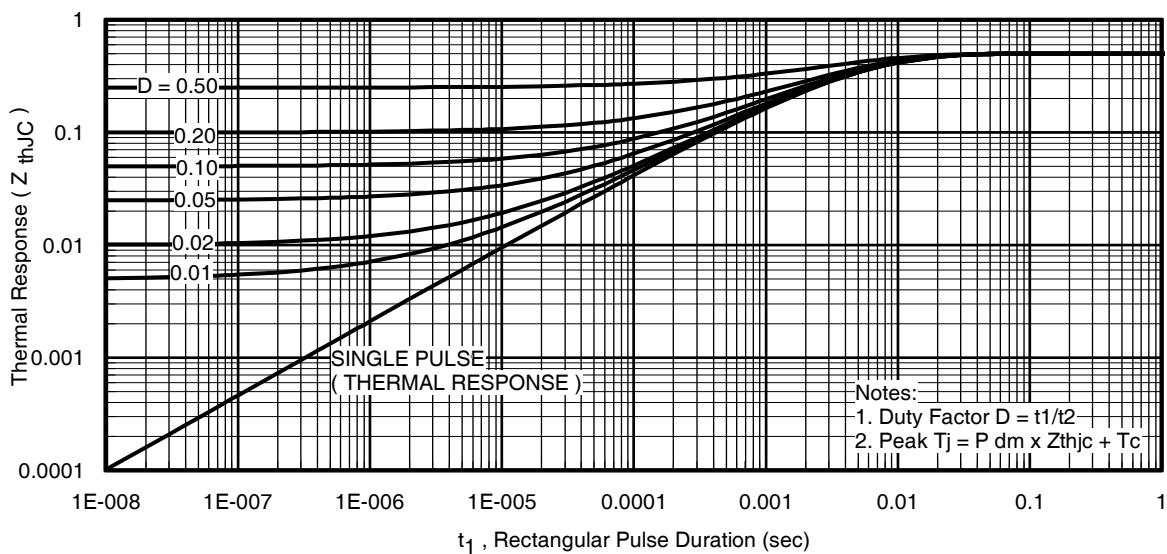
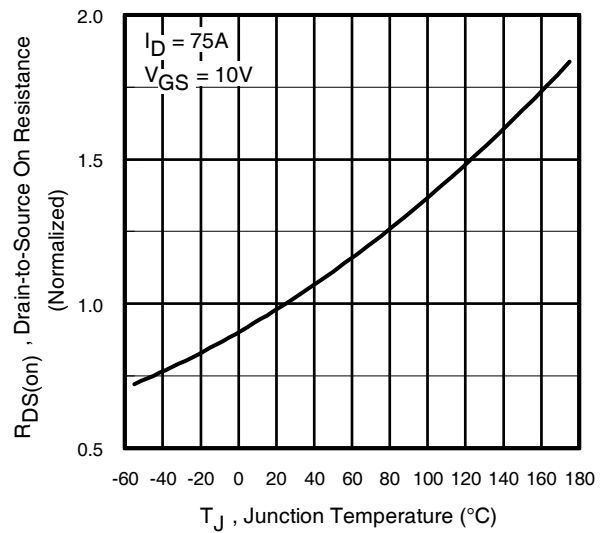
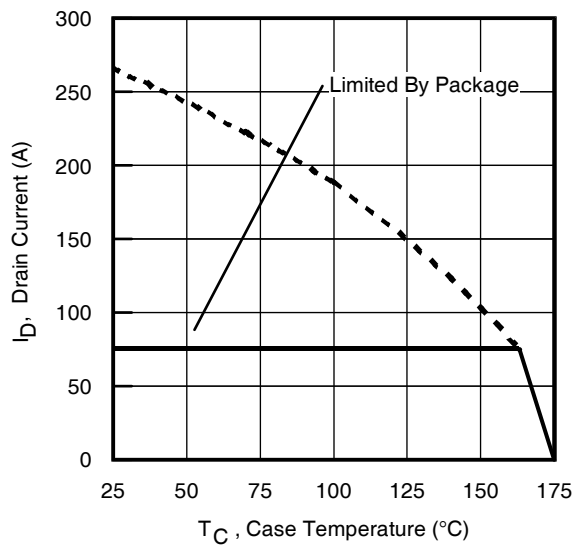
**Fig 6.** Typical Gate Charge vs. Gate-to-Source Voltage



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

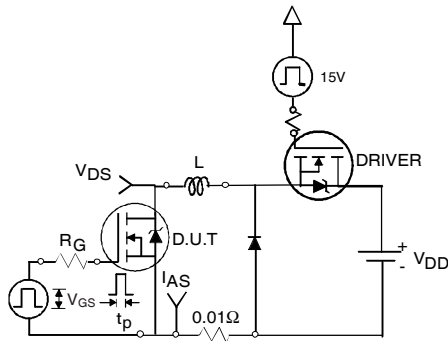


**Fig 8.** Maximum Safe Operating Area

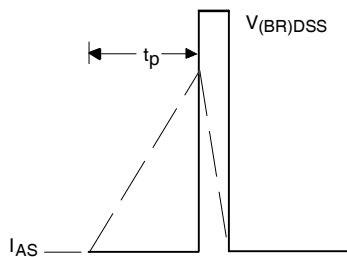


# IRF2804/S/LPbF

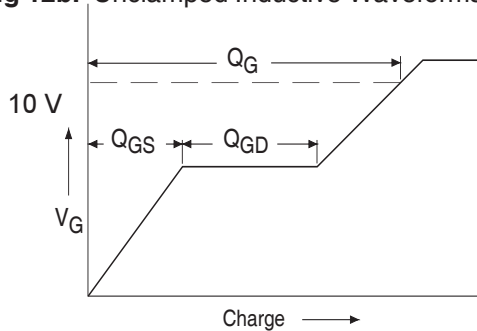
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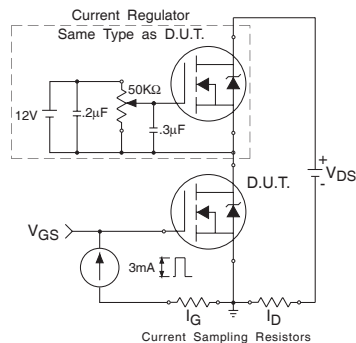
**Fig 12a.** Unclamped Inductive Test Circuit



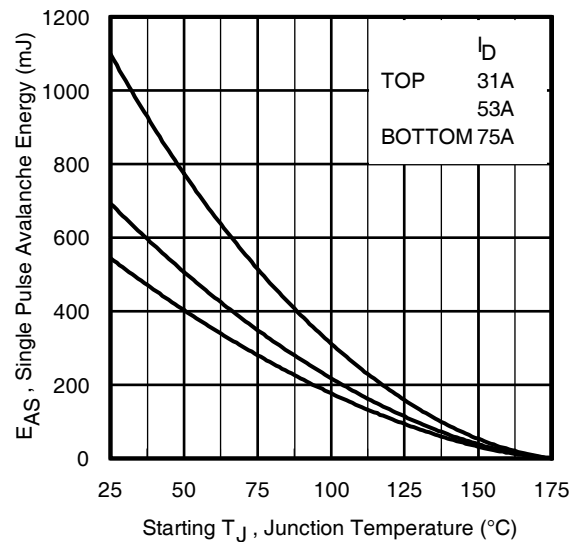
**Fig 12b.** Unclamped Inductive Waveforms



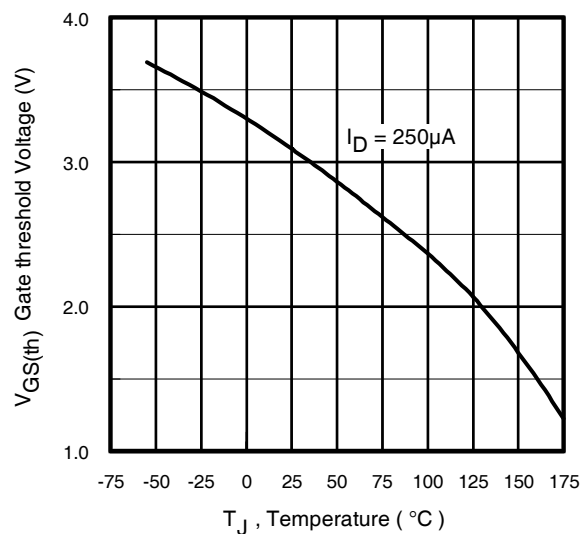
**Fig 13a.** Basic Gate Charge Waveform



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



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



**Fig 14.** Threshold Voltage vs. Temperature

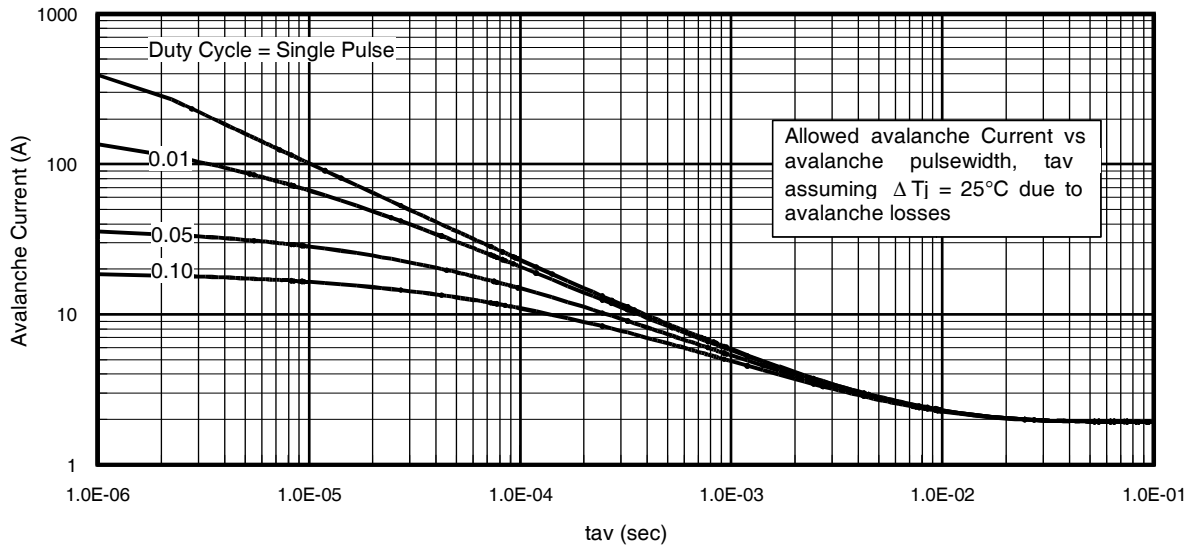


Fig 15. Typical Avalanche Current Vs. Pulsewidth

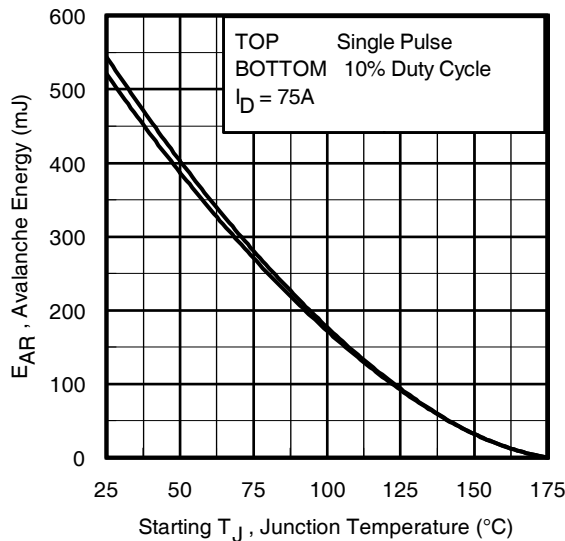


Fig 16. Maximum Avalanche Energy vs. Temperature

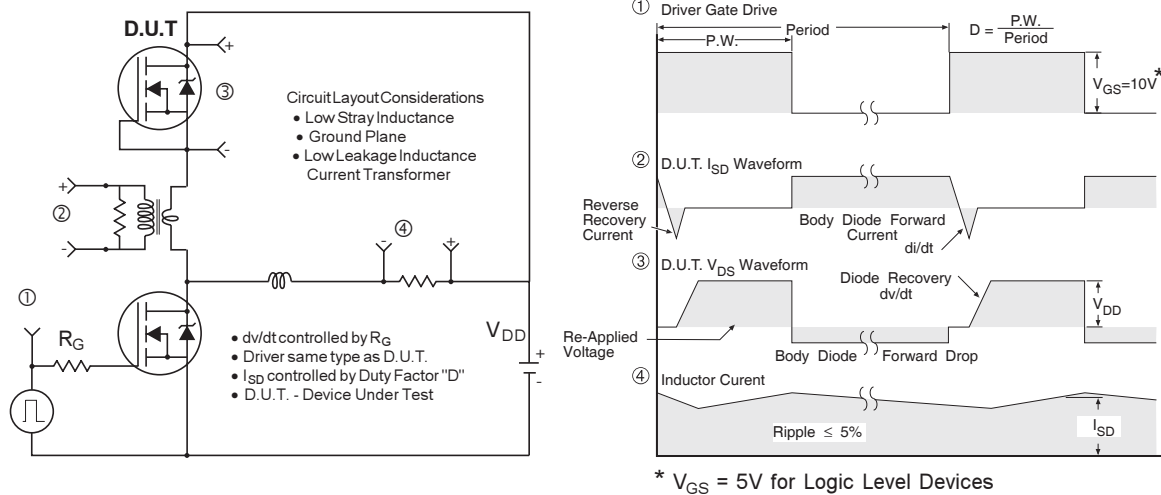
**Notes on Repetitive Avalanche Curves , Figures 15, 16:**  
(For further info, see AN-1005 at [www.irf.com](http://www.irf.com))

1. Avalanche failures assumption:  
Purely a thermal phenomenon and failure occurs at a temperature far in excess of  $T_{jmax}$ . This is validated for every part type.
2. Safe operation in Avalanche is allowed as long as  $T_{jmax}$  is not exceeded.
3. Equation below based on circuit and waveforms shown in Figures 12a, 12b.
4.  $P_{D(ave)}$  = Average power dissipation per single avalanche pulse.
5. BV = Rated breakdown voltage (1.3 factor accounts for voltage increase during avalanche).
6.  $I_{av}$  = Allowable avalanche current.
7.  $\Delta T$  = Allowable rise in junction temperature, not to exceed  $T_{jmax}$  (assumed as 25°C in Figure 15, 16).  
 $t_{av}$  = Average time in avalanche.  
 $D$  = Duty cycle in avalanche =  $t_{av} \cdot f$   
 $Z_{thJC}(D, t_{av})$  = Transient thermal resistance, see figure 11)

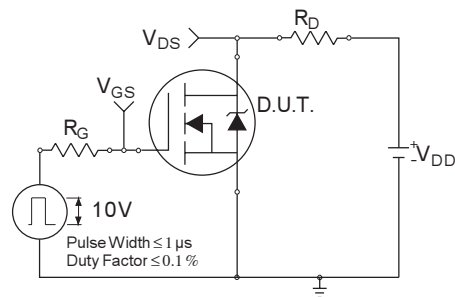
$$P_{D(ave)} = 1/2 (1.3 \cdot BV \cdot I_{av}) = \Delta T / Z_{thJC}$$

$$I_{av} = 2\Delta T / [1.3 \cdot BV \cdot Z_{th}]$$

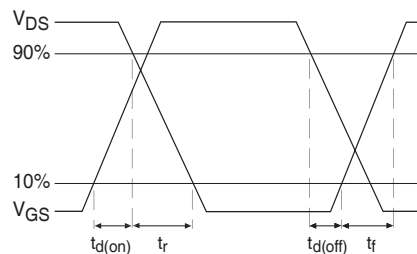
$$E_{AS(AR)} = P_{D(ave)} \cdot t_{av}$$



**Fig 17. Peak Diode Recovery  $dv/dt$  Test Circuit for N-Channel HEXFET® Power MOSFETs**

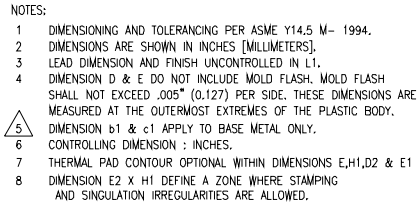


**Fig 18a. Switching Time Test Circuit**



**Fig 18b. Switching Time Waveforms**

Dimensions are shown in millimeters (inches)



| SYMBOL | DIMENSIONS  |       |          |      | NOTES |
|--------|-------------|-------|----------|------|-------|
|        | MILLIMETERS |       | INCHES   |      |       |
|        | MIN.        | MAX.  | MIN.     | MAX. |       |
| A      | 3.56        | 4.82  | .140     | .190 | 5     |
| A1     | 0.51        | 1.40  | .020     | .055 |       |
| A2     | 2.04        | 2.92  | .080     | .115 |       |
| b      | 0.38        | 1.01  | .015     | .040 |       |
| b1     | 0.38        | 0.96  | .015     | .038 |       |
| b2     | 1.15        | 1.77  | .045     | .070 | 5     |
| b3     | 1.15        | 1.73  | .045     | .068 |       |
| c      | 0.36        | 0.61  | .014     | .024 |       |
| c1     | 0.36        | 0.56  | .014     | .022 |       |
| D      | 14.22       | 16.51 | .560     | .650 |       |
| D1     | 8.38        | 9.02  | .330     | .355 | 7     |
| D2     | 12.19       | 12.88 | .480     | .507 |       |
| E      | 9.66        | 10.66 | .380     | .420 |       |
| E1     | 8.38        | 8.89  | .330     | .350 | 4,7   |
| e      | 2.54 BSC    |       | .100 BSC |      | 7     |
| e1     | 5.08        |       | .200 BSC |      |       |
| H1     | 5.85        | 6.55  | .230     | .270 | 7,8   |
| L      | 12.70       | 14.73 | .500     | .580 |       |
| L1     | —           | 6.35  | —        | .250 | 3     |
| ØP     | 3.54        | 4.08  | .139     | .161 |       |
| Q      | 2.54        | 3.42  | .100     | .135 |       |
| ø      | 90°-93°     |       | 90°-93°  |      |       |

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

- 1.- ANODE/OPEN
- 2.- CATHODE
- 3.- ANODE

Diagram illustrating the marking on the IRF1010 MOSFET package:

- INTERNATIONAL RECTIFIER LOGO**: Points to the IR logo on the package.
- PART NUMBER**: Points to the text "IRF1010" on the package.
- DATE CODE**: Points to the text "019C" on the package.
- ASSEMBLY LOT CODE**: Points to the text "17 89" on the package.

Additional information provided in the diagram:

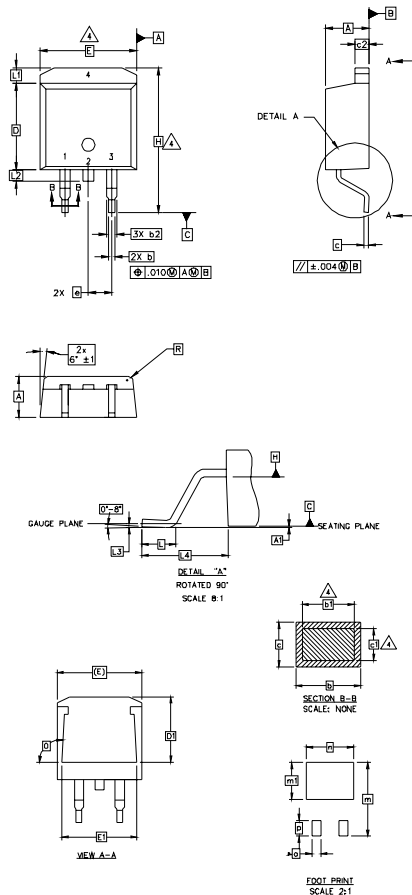
- YEAR 0 = 2000
- WEEK 19
- LINE C

# IRF2804/S/LPbF

## D<sup>2</sup>Pak Package Outline

Dimensions are shown in millimeters (inches)

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- 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 [0.005"] 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

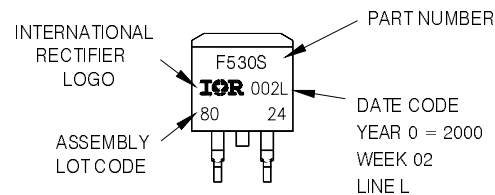
- 1.- ANODE \*
- 2, 4.- CATHODE
- 3.- ANODE

\* PART DEPENDENT.

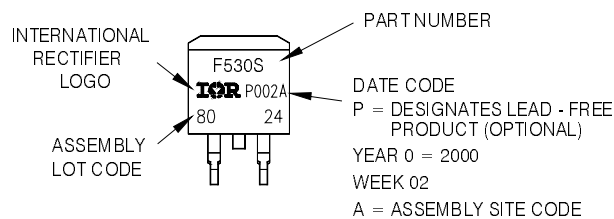
## D<sup>2</sup>Pak Part Marking Information

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"

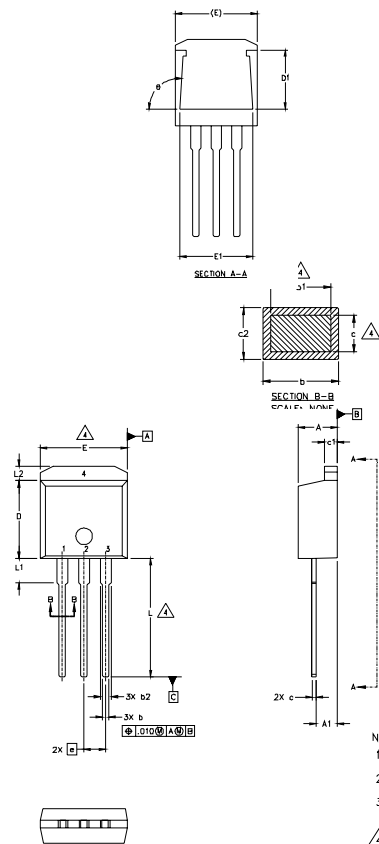


OR



## 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 | 4     |
| A1     | 2.03        | 2.92  | .080     | .115 |       |
| b      | 0.51        | 0.99  | .020     | .039 |       |
| b1     | 0.51        | 0.89  | .020     | .035 |       |
| b2     | 1.14        | 1.40  | .045     | .055 | 4     |
| c      | 0.38        | 0.63  | .015     | .025 |       |
| 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 |       |

### LEAD ASSIGNMENTS

#### HEXFET

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

#### IGBT

- 1 - GATE
- 2 - COLLECTOR
- 3 - EMITTER

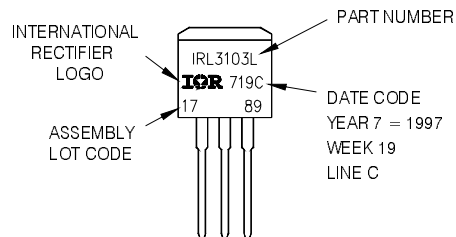
#### NOTES:

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 [0.005"] 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.

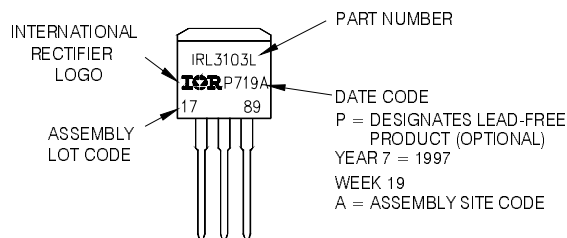
## TO-262 Part Marking Information

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**

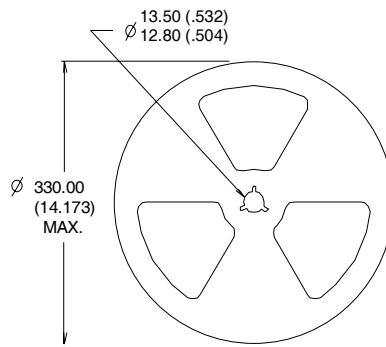
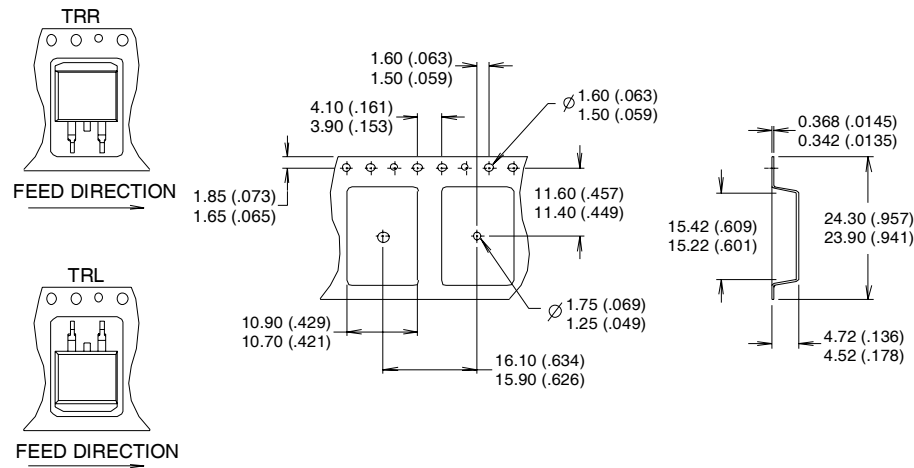


# IRF2804/S/LPbF

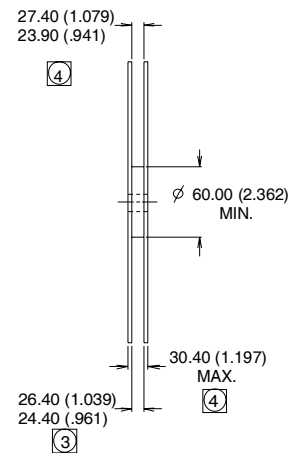
International  
**IR** Rectifier

## D<sup>2</sup>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.



**TO-220AB package is not recommended for Surface Mount Application.**

Data and specifications subject to change without notice.  
This product has been designed and qualified for the Automotive [Q101] 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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