

# International IR Rectifier

- Logic-Level Gate Drive
- Advanced Process Technology
- Ultra Low On-Resistance
- Dynamic dv/dt Rating
- 175°C Operating Temperature
- Fast Switching
- Fully Avalanche Rated
- Lead-Free

## Description

Fifth Generation HEXFET® power MOSFETs 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<sup>2</sup>Pak 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 D<sup>2</sup>Pak 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 (IRL1004L) is available for low-profile application.

## Absolute Maximum Ratings

|                                   | Parameter                                 | Max.                  | Units |
|-----------------------------------|-------------------------------------------|-----------------------|-------|
| $I_D$ @ $T_C = 25^\circ\text{C}$  | Continuous Drain Current, $V_{GS}$ @ 10V⑥ | 130 ⑤                 | A     |
| $I_D$ @ $T_C = 100^\circ\text{C}$ | Continuous Drain Current, $V_{GS}$ @ 10V⑥ | 92 ⑤                  |       |
| $I_{DM}$                          | Pulsed Drain Current ①⑥                   | 520                   |       |
| $P_D$ @ $T_A = 25^\circ\text{C}$  | Power Dissipation                         | 3.8                   | W     |
| $P_D$ @ $T_C = 25^\circ\text{C}$  | Power Dissipation                         | 200                   | W     |
|                                   | Linear Derating Factor                    | 1.3                   | W/°C  |
| $V_{GS}$                          | Gate-to-Source Voltage                    | ± 16                  | V     |
| $E_{AS}$                          | Single Pulse Avalanche Energy⑥            | 700                   | mJ    |
| $I_{AR}$                          | Avalanche Current①                        | 78                    | A     |
| $E_{AR}$                          | Repetitive Avalanche Energy①              | 20                    | mJ    |
| dv/dt                             | Peak Diode Recovery dv/dt ③⑥              | 5.0                   | V/ns  |
| $T_J$                             | Operating Junction and                    | -55 to + 175          | °C    |
| $T_{STG}$                         | Storage Temperature Range                 |                       |       |
|                                   | Soldering Temperature, for 10 seconds     | 300 (1.6mm from case) |       |

## Thermal Resistance

|                 | Parameter                                        | Typ. | Max. | Units |
|-----------------|--------------------------------------------------|------|------|-------|
| $R_{\theta JC}$ | Junction-to-Case                                 | —    | 0.75 | °C/W  |
| $R_{\theta JA}$ | Junction-to-Ambient (PCB Mounted, steady-state)* | —    | 40   |       |

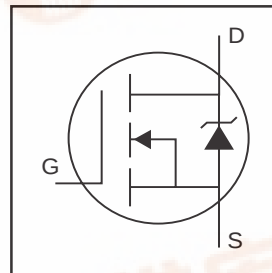
www.irf.com

PD - 95575

IRL1004SPbF

IRL1004LPbF

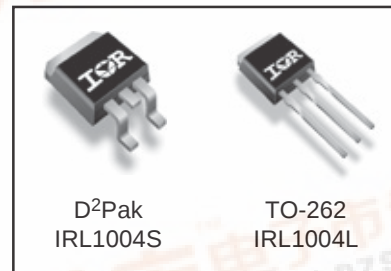
HEXFET® Power MOSFET



$$V_{DSS} = 40V$$

$$R_{DS(on)} = 0.0065\Omega$$

$$I_D = 130A \text{ ⑤}$$



D<sup>2</sup>Pak  
IRL1004S

TO-262  
IRL1004L

# IRL1004S/LPbF

International  
IR Rectifier

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

|                                 | Parameter                            | Min. | Typ. | Max.   | Units    | Conditions                                                                                   |
|---------------------------------|--------------------------------------|------|------|--------|----------|----------------------------------------------------------------------------------------------|
| $V_{(BR)DSS}$                   | Drain-to-Source Breakdown Voltage    | 40   | —    | —      | V        | $V_{GS} = 0V, I_D = 250\mu A$                                                                |
| $\Delta V_{(BR)DSS}/\Delta T_J$ | Breakdown Voltage Temp. Coefficient  | —    | 0.04 | —      | V/°C     | Reference to $25^\circ\text{C}, I_D = 1mA$                                                   |
| $R_{DS(on)}$                    | Static Drain-to-Source On-Resistance | —    | —    | 0.0065 | $\Omega$ | $V_{GS} = 10V, I_D = 78A$ ④                                                                  |
|                                 |                                      | —    | —    | 0.009  |          | $V_{GS} = 4.5V, I_D = 65A$ ④                                                                 |
| $V_{GS(th)}$                    | Gate Threshold Voltage               | 1.0  | —    | —      | V        | $V_{DS} = V_{GS}, I_D = 250\mu A$                                                            |
| $g_{fs}$                        | Forward Transconductance             | 63   | —    | —      | S        | $V_{DS} = 25V, I_D = 78A$ ⑥                                                                  |
| $I_{DSS}$                       | Drain-to-Source Leakage Current      | —    | —    | 25     | $\mu A$  | $V_{DS} = 40V, V_{GS} = 0V$                                                                  |
|                                 |                                      | —    | —    | 250    |          | $V_{DS} = 32V, V_{GS} = 0V, T_J = 150^\circ\text{C}$                                         |
| $I_{GSS}$                       | Gate-to-Source Forward Leakage       | —    | —    | 100    | nA       | $V_{GS} = 16V$                                                                               |
|                                 | Gate-to-Source Reverse Leakage       | —    | —    | -100   |          | $V_{GS} = -16V$                                                                              |
| $Q_g$                           | Total Gate Charge                    | —    | —    | 100    | nC       | $I_D = 78A$                                                                                  |
| $Q_{gs}$                        | Gate-to-Source Charge                | —    | —    | 32     |          | $V_{DS} = 32V$                                                                               |
| $Q_{gd}$                        | Gate-to-Drain ("Miller") Charge      | —    | —    | 43     |          | $V_{GS} = 4.5V$ , See Fig. 6 and 13 ④⑥                                                       |
| $t_{d(on)}$                     | Turn-On Delay Time                   | —    | 16   | —      | ns       | $V_{DD} = 20V,$<br>$I_D = 78A,$<br>$R_G = 2.5\Omega,$<br>$R_D = 0.18\Omega$ , See Fig. 10 ④⑥ |
| $t_r$                           | Rise Time                            | —    | 210  | —      |          |                                                                                              |
| $t_{d(off)}$                    | Turn-Off Delay Time                  | —    | 25   | —      |          |                                                                                              |
| $t_f$                           | Fall Time                            | —    | 14   | —      |          |                                                                                              |
| $L_S$                           | Internal Source Inductance           | —    | 7.5  | —      | nH       | Between lead,<br>and center of die contact                                                   |
| $C_{iss}$                       | Input Capacitance                    | —    | 5330 | —      | pF       | $V_{GS} = 0V$                                                                                |
| $C_{oss}$                       | Output Capacitance                   | —    | 1480 | —      |          | $V_{DS} = 25V$                                                                               |
| $C_{rss}$                       | Reverse Transfer Capacitance         | —    | 320  | —      |          | $f = 1.0MHz$ , See Fig. 5④⑥                                                                  |

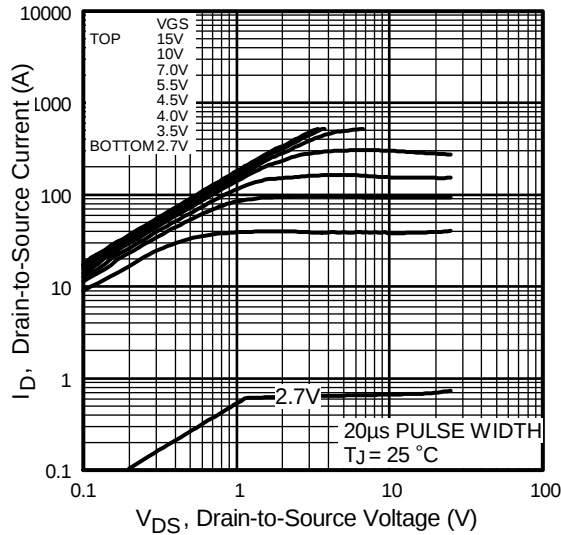
## Source-Drain Ratings and Characteristics

|          | Parameter                                   | Min.                                                                        | Typ. | Max.  | Units | Conditions                                                              |
|----------|---------------------------------------------|-----------------------------------------------------------------------------|------|-------|-------|-------------------------------------------------------------------------|
| $I_S$    | Continuous Source Current<br>(Body Diode) ⑦ | —                                                                           | —    | 130 ③ | A     | MOSFET symbol<br>showing the<br>integral reverse<br>p-n junction diode. |
| $I_{SM}$ | Pulsed Source Current<br>(Body Diode) ①②    | —                                                                           | —    | 520   |       |                                                                         |
| $V_{SD}$ | Diode Forward Voltage                       | —                                                                           | —    | 1.3   | V     | $T_J = 25^\circ\text{C}, I_S = 78A, V_{GS} = 0V$ ④                      |
| $t_{rr}$ | Reverse Recovery Time                       | —                                                                           | 78   | 120   | ns    | $T_J = 25^\circ\text{C}, I_F = 78A$                                     |
| $Q_{rr}$ | Reverse Recovery Charge                     | —                                                                           | 180  | 270   | nC    | $di/dt = 100A/\mu s$ ④⑥                                                 |
| $t_{on}$ | Forward Turn-On Time                        | Intrinsic turn-on time is negligible (turn-on is dominated by $L_S + L_D$ ) |      |       |       |                                                                         |

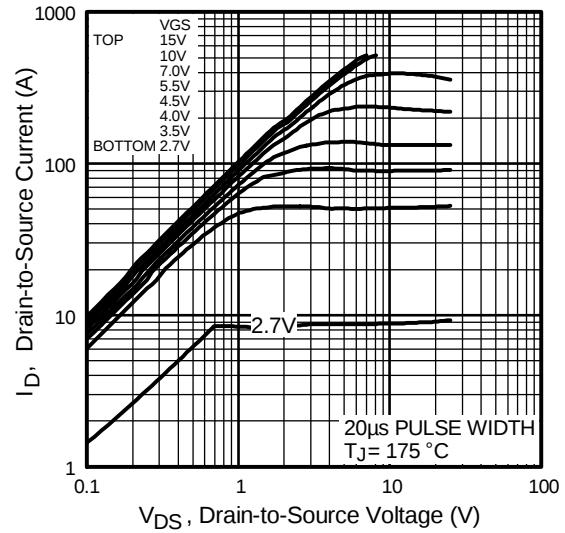
### Notes:

- ① Repetitive rating; pulse width limited by max. junction temperature. (See fig. 11)
- ② Starting  $T_J = 25^\circ\text{C}$ ,  $L = 0.23mH$   
 $R_G = 25\Omega$ ,  $I_{AS} = 78A$ . (See Figure 12)
- ③  $I_{SD} \leq 78A$ ,  $di/dt \leq 370A/\mu s$ ,  $V_{DD} \leq V_{(BR)DSS}$ ,  
 $T_J \leq 175^\circ\text{C}$
- ④ Pulse width  $\leq 300\mu s$ ; duty cycle  $\leq 2\%$ .
- ⑤ Calculated continuous current based on maximum allowable junction temperature; for recommended current-handling of the package refer to Design Tip # 93-4
- ⑥ Uses IRL1004 data and test conditions

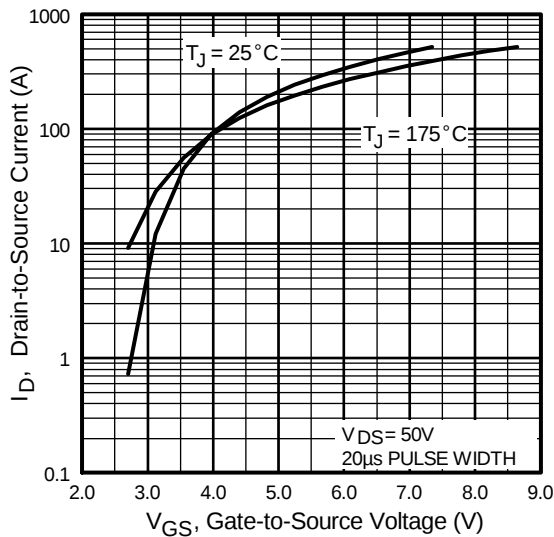
\* When mounted on 1" square PCB (FR-4 or G-10 Material).  
For recommended footprint and soldering techniques refer to application note #AN-994.



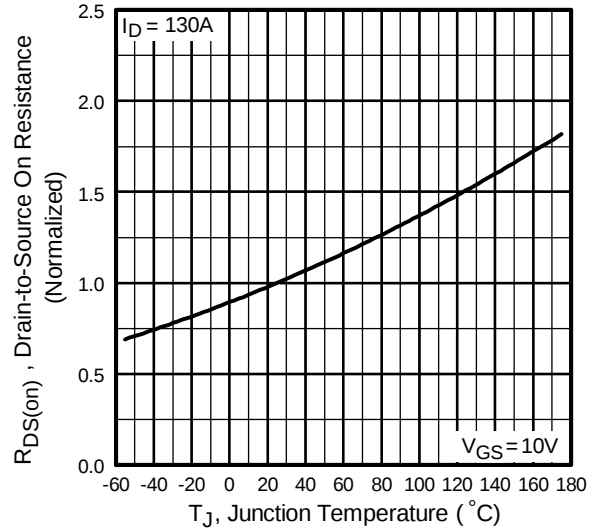
**Fig 1.** Typical Output Characteristics



**Fig 2.** Typical Output Characteristics



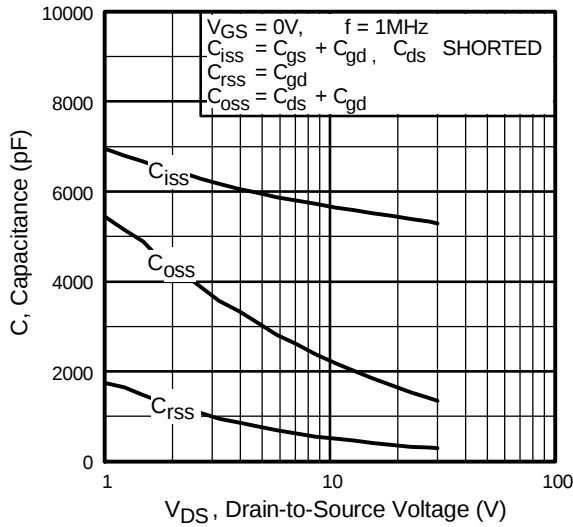
**Fig 3.** Typical Transfer Characteristics



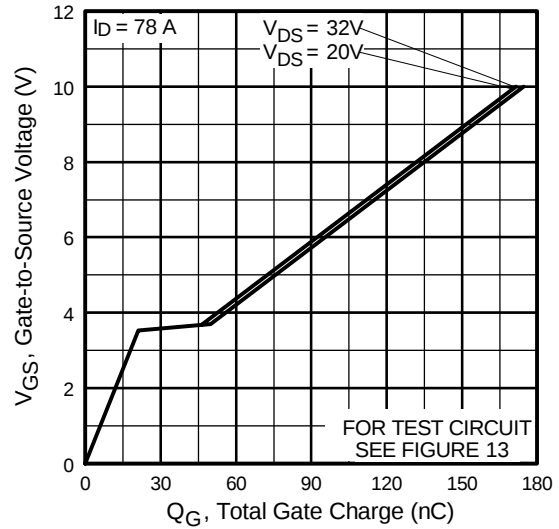
**Fig 4.** Normalized On-Resistance Vs. Temperature

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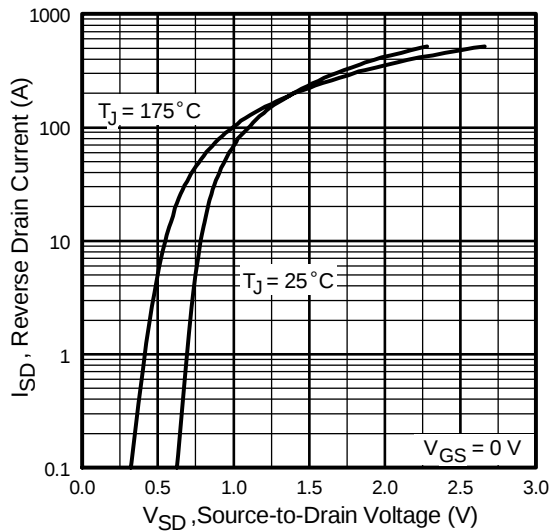
International  
**IR** Rectifier



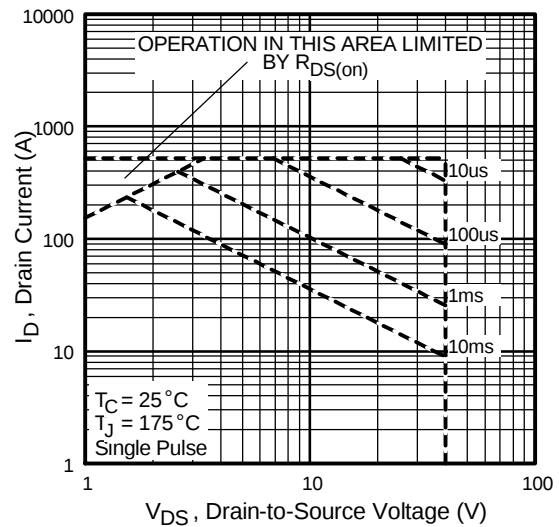
**Fig 5.** Typical Capacitance Vs. Drain-to-Source Voltage



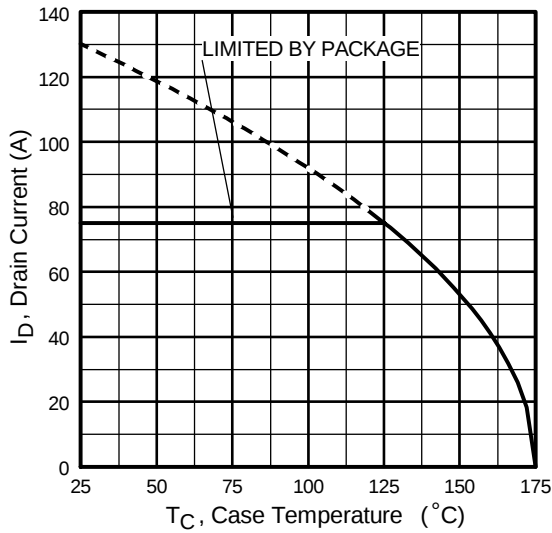
**Fig 6.** Typical Gate Charge Vs. Gate-to-Source Voltage



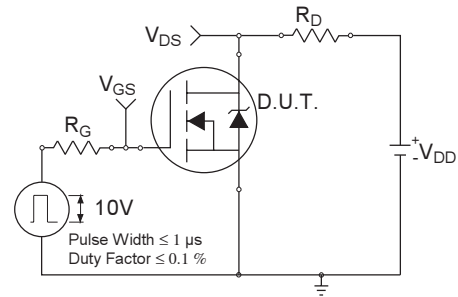
**Fig 7.** Typical Source-Drain Diode Forward Voltage



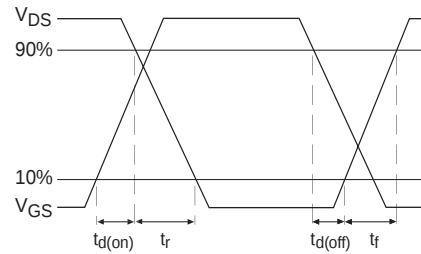
**Fig 8.** Maximum Safe Operating Area



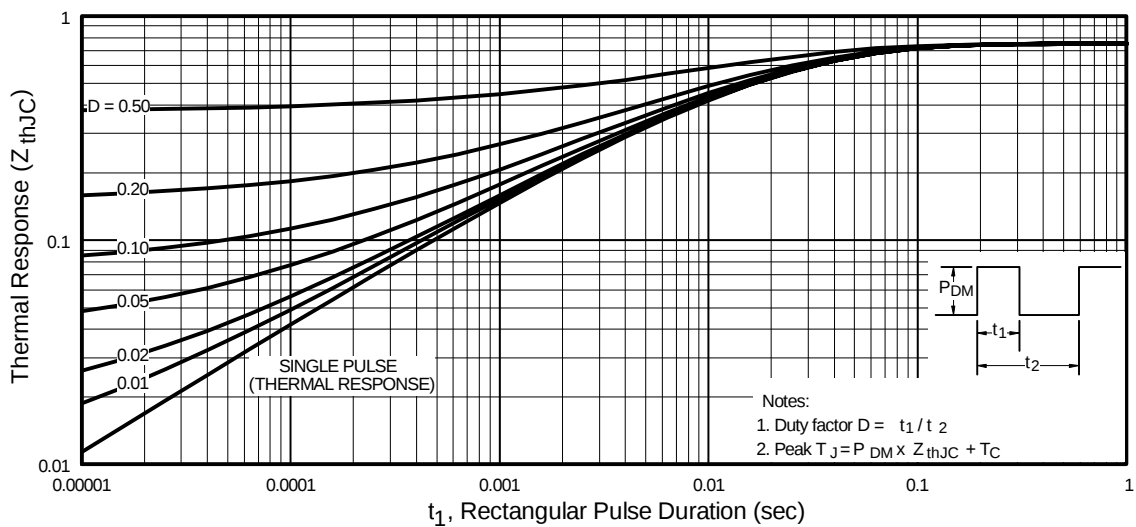
**Fig 9.** Maximum Drain Current Vs. Case Temperature



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



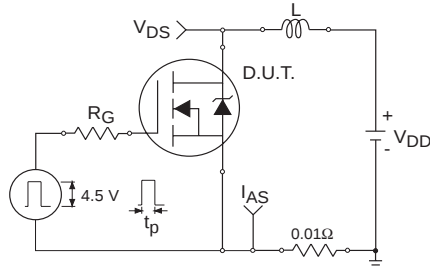
**Fig 10b.** Switching Time Waveforms



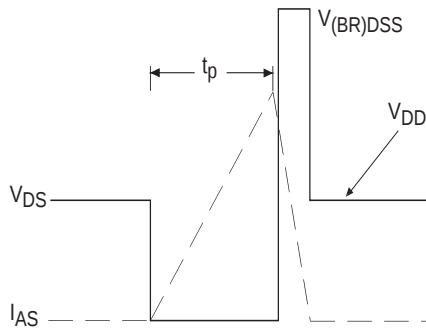
**Fig 11.** Maximum Effective Transient Thermal Impedance, Junction-to-Case

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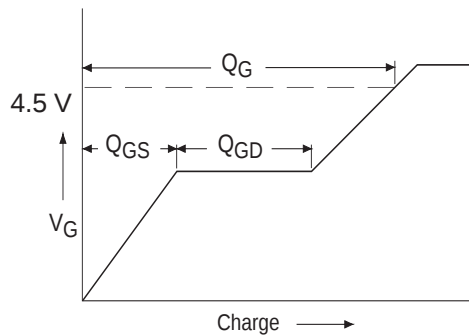
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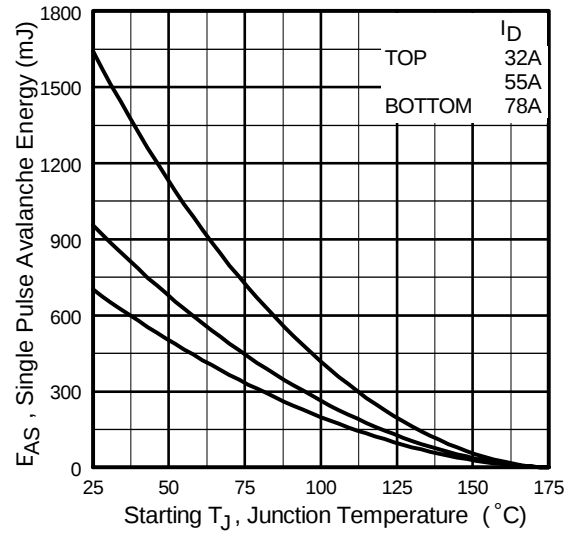
**Fig 12a.** Unclamped Inductive Test Circuit



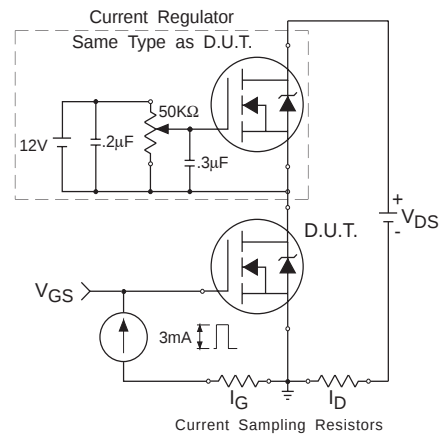
**Fig 12b.** Unclamped Inductive Waveforms



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

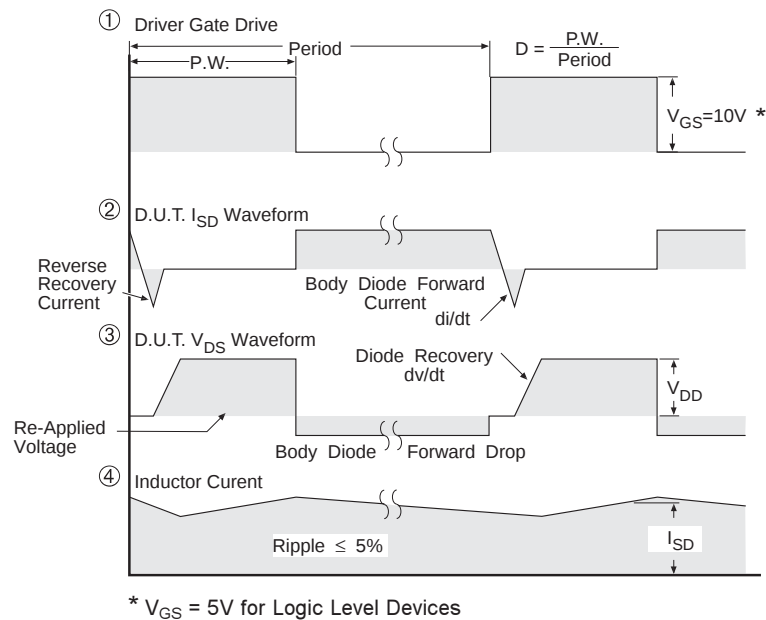
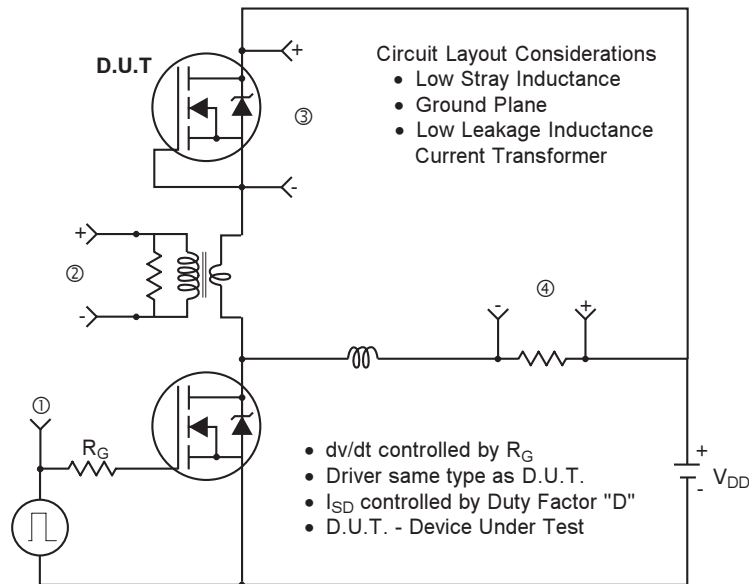


**Fig 12c.** Maximum Avalanche Energy Vs. Drain Current



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

### Peak Diode Recovery dv/dt Test Circuit



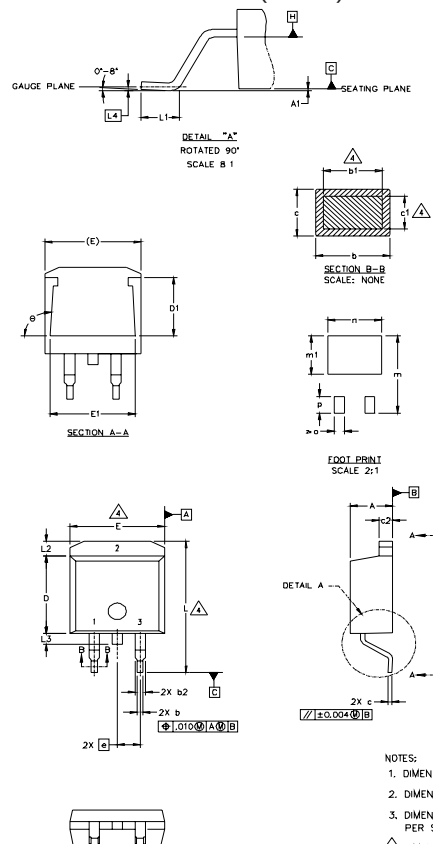
**Fig 14.** For N-channel HEXFET® Power MOSFETs

# IRL1004S/LPbF

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## D<sup>2</sup>Pak 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     |             | 0.127 |          | .005 |       |
| b      | 0.51        | 0.99  | .020     | .039 |       |
| b1     | 0.51        | 0.89  | .020     | .035 |       |
| b2     | 1.14        | 1.40  | .045     | .055 | 4     |
| c      | 0.43        | 0.63  | .017     | .025 |       |
| c1     | 0.38        | 0.74  | .015     | .029 |       |
| c2     | 1.14        | 1.40  | .045     | .055 |       |
| 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      | 14.61       | 15.88 | .575     | .625 |       |
| L1     | 1.78        | 2.79  | .070     | .110 |       |
| L2     |             | 1.65  |          | .065 |       |
| L3     | 1.27        | 1.78  | .050     | .070 |       |
| L4     | 0.25 BSC    |       | .010 BSC |      |       |
| m      | 17.78       |       | .700     |      |       |
| m1     | 8.89        |       | .350     |      |       |
| n      | 11.43       |       | .450     |      |       |
| o      | 2.08        |       | .082     |      |       |
| p      | 3.81        |       | .150     |      |       |
| θ      | 90°         | 93°   | 90°      | 93°  |       |

### LEAD ASSIGNMENTS

#### HEXFET

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

#### IGBTs, CoPACK

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

#### DIODES

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

\* PART DEPENDENT.

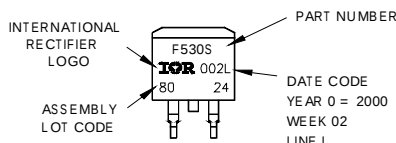
### NOTES:

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.

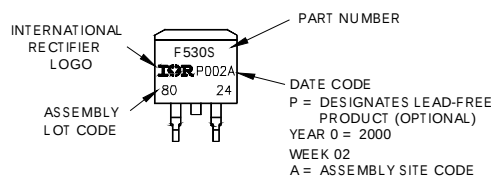
## D<sup>2</sup>Pak Part Marking Information

EXAMPLE: THIS IS AN IRL1004S WITH  
LOT CODE 8024  
ASSEMBLED ON WW 02, 2000  
IN THE ASSEMBLY LINE "L"

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

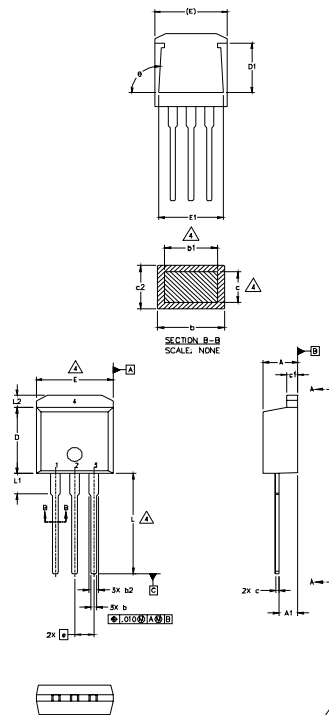


**OR**



## 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

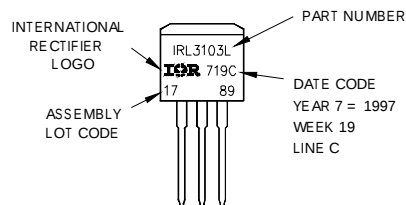
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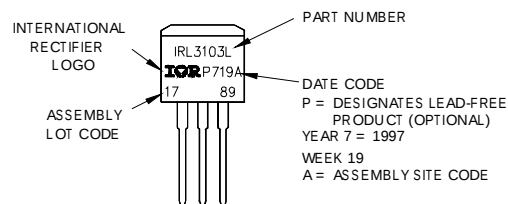
## TO-262 Part Marking Information

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

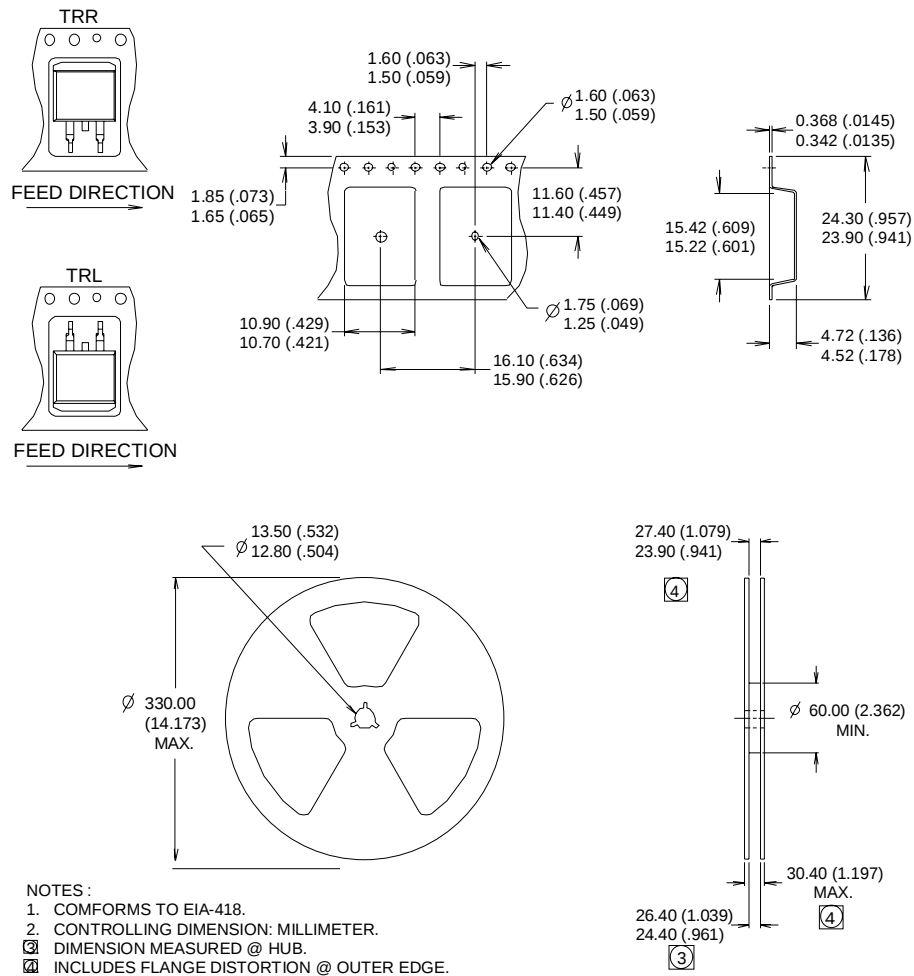


# IRL1004S/LPbF

International  
**IR** Rectifier

## D<sup>2</sup>Pak Tape & Reel Information

Dimensions are shown in millimeters (inches)



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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