

- Advanced Process Technology
- Ultra Low On-Resistance
- Dynamic dv/dt Rating
- 175°C Operating Temperature
- Fast Switching
- Fully Avalanche Rated

#### Description

Seventh 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.

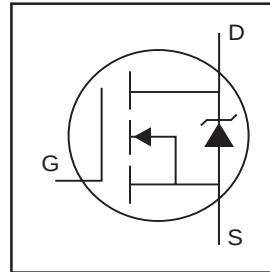
The through-hole version (IRF1404L) is available for low-profile applications.

#### Absolute Maximum Ratings

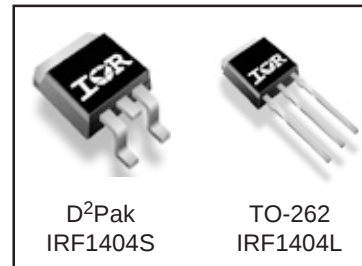
|                                   | Parameter                                 | Max.                   | Units |
|-----------------------------------|-------------------------------------------|------------------------|-------|
| $I_D$ @ $T_C = 25^\circ\text{C}$  | Continuous Drain Current, $V_{GS}$ @ 10V⑦ | 162⑥                   | A     |
| $I_D$ @ $T_C = 100^\circ\text{C}$ | Continuous Drain Current, $V_{GS}$ @ 10V⑦ | 115⑥                   |       |
| $I_{DM}$                          | Pulsed Drain Current ①⑦                   | 650                    |       |
| $P_D$ @ $T_A = 25^\circ\text{C}$  | 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                    | ± 20                   | V     |
| $E_{AS}$                          | Single Pulse Avalanche Energy⑦            | 519                    | mJ    |
| $I_{AR}$                          | Avalanche Current①                        | 95                     | A     |
| $E_{AR}$                          | Repetitive Avalanche Energy①              | 20                     | mJ    |
| dv/dt                             | Peak Diode Recovery dv/dt ③⑦              | 5.0                    | V/ns  |
| $T_J$                             | Operating Junction and                    | -55 to +175            | °C    |
| $T_{STG}$                         | Storage Temperature Range                 | -55 to +175            |       |
|                                   | 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   |       |



|                            |
|----------------------------|
| $V_{DSS} = 40\text{V}$     |
| $R_{DS(on)} = 0.004\Omega$ |
| $I_D = 162\text{A}⑥$       |



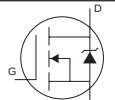
# IRF1404S/L

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  | —    | 0.036  | —     | V/ $^\circ\text{C}$ | Reference to $25^\circ\text{C}$ , $I_D = 1mA$        |
| $R_{DS(on)}$                    | Static Drain-to-Source On-Resistance | —    | 0.0035 | 0.004 | $\Omega$            | $V_{GS} = 10V, I_D = 95A$ ④                          |
| $V_{GS(th)}$                    | Gate Threshold Voltage               | 2.0  | —      | 4.0   | V                   | $V_{DS} = 10V, I_D = 250\mu A$                       |
| $g_{fs}$                        | Forward Transconductance             | 106  | —      | —     | S                   | $V_{DS} = 25V, I_D = 60A$ ⑦                          |
| $I_{DSS}$                       | Drain-to-Source Leakage Current      | —    | —      | 20    | $\mu A$             | $V_{DS} = 40V, V_{GS} = 0V$                          |
|                                 |                                      | —    | —      | 250   |                     | $V_{DS} = 32V, V_{GS} = 0V, T_J = 150^\circ\text{C}$ |
| $I_{GSS}$                       | Gate-to-Source Forward Leakage       | —    | —      | 200   | nA                  | $V_{GS} = 20V$                                       |
|                                 | Gate-to-Source Reverse Leakage       | —    | —      | -200  |                     | $V_{GS} = -20V$                                      |
| $Q_g$                           | Total Gate Charge                    | —    | 160    | 200   | nC                  | $I_D = 95A$                                          |
| $Q_{gs}$                        | Gate-to-Source Charge                | —    | 35     | —     |                     | $V_{DS} = 32V$                                       |
| $Q_{gd}$                        | Gate-to-Drain ("Miller") Charge      | —    | 42     | 60    |                     | $V_{GS} = 10V$ ④ ⑦                                   |
| $t_{d(on)}$                     | Turn-On Delay Time                   | —    | 17     | —     | ns                  | $V_{DD} = 20V$                                       |
| $t_r$                           | Rise Time                            | —    | 140    | —     |                     | $I_D = 95A$                                          |
| $t_{d(off)}$                    | Turn-Off Delay Time                  | —    | 72     | —     |                     | $R_G = 2.5\Omega$                                    |
| $t_f$                           | Fall Time                            | —    | 26     | —     |                     | $R_D = 0.21\Omega$ ④ ⑦                               |
| $L_S$                           | Internal Source Inductance           | —    | 7.5    | —     | nH                  | Between lead, and center of die contact              |
| $C_{iss}$                       | Input Capacitance                    | —    | 7360   | —     | pF                  | $V_{GS} = 0V$                                        |
| $C_{oss}$                       | Output Capacitance                   | —    | 1680   | —     |                     | $V_{DS} = 25V$                                       |
| $C_{rss}$                       | Reverse Transfer Capacitance         | —    | 240    | —     |                     | $f = 1.0MHz$ , See Fig. 5 ⑦                          |
| $C_{oss}$                       | Output Capacitance                   | —    | 6630   | —     |                     | $V_{GS} = 0V, V_{DS} = 1.0V, f = 1.0MHz$             |
| $C_{oss}$                       | Output Capacitance                   | —    | 1490   | —     |                     | $V_{GS} = 0V, V_{DS} = 32V, f = 1.0MHz$              |
| $C_{oss \text{ eff.}}$          | Effective Output Capacitance ⑤ ⑦     | —    | 1540   | —     |                     | $V_{GS} = 0V, V_{DS} = 0V \text{ to } 32V$           |

## Source-Drain Ratings and Characteristics

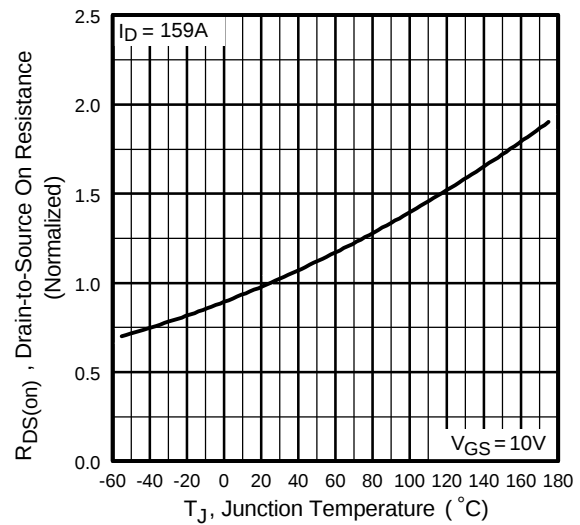
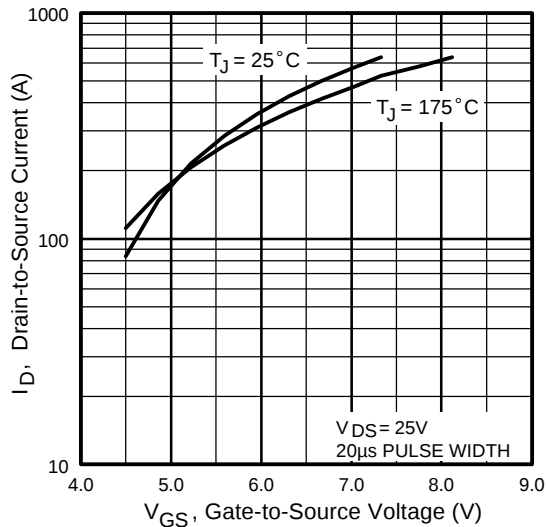
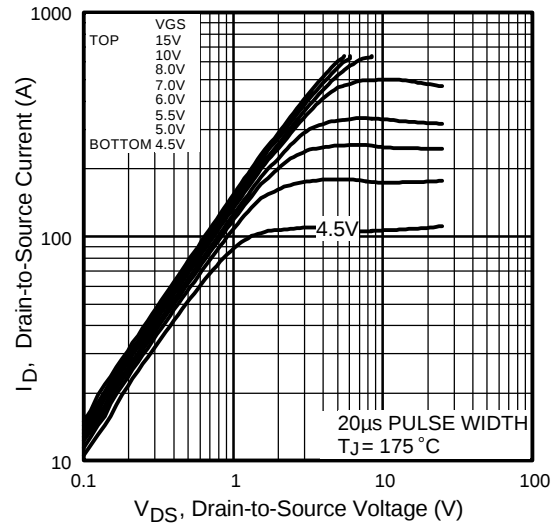
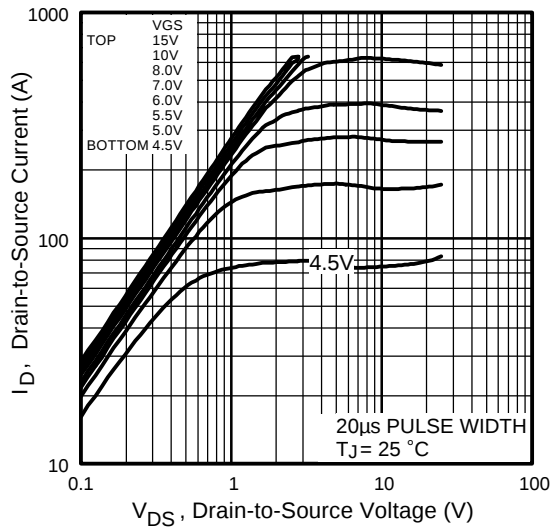
|          | Parameter                              | Min.                                                                        | Typ. | Max. | Units | Conditions                                                                                                                                           |
|----------|----------------------------------------|-----------------------------------------------------------------------------|------|------|-------|------------------------------------------------------------------------------------------------------------------------------------------------------|
| $I_S$    | Continuous Source Current (Body Diode) | —                                                                           | —    | 162  | A     | MOSFET symbol showing the integral reverse p-n junction diode.  |
| $I_{SM}$ | Pulsed Source Current (Body Diode) ①   | —                                                                           | —    | 650  |       |                                                                                                                                                      |
| $V_{SD}$ | Diode Forward Voltage                  | —                                                                           | —    | 1.3  | V     | $T_J = 25^\circ\text{C}, I_S = 95A, V_{GS} = 0V$ ④                                                                                                   |
| $t_{rr}$ | Reverse Recovery Time                  | —                                                                           | 71   | 110  | ns    | $T_J = 25^\circ\text{C}, I_F = 95A$                                                                                                                  |
| $Q_{rr}$ | Reverse Recovery Charge                | —                                                                           | 180  | 270  | nC    | $di/dt = 100A/\mu s$ ④ ⑦                                                                                                                             |
| $t_{on}$ | 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  $T_J = 25^\circ\text{C}$ ,  $L = 0.12mH$ ,  $R_G = 25\Omega$ ,  $I_{AS} = 95A$ . (See Figure 12)
- ③  $I_{SD} \leq 95A$ ,  $di/dt \leq 150A/\mu s$ ,  $V_{DD} \leq V_{(BR)DSS}$ ,  $T_J \leq 175^\circ\text{C}$
- ④ Pulse width  $\leq 300\mu s$ ; duty cycle  $\leq 2\%$ .
- ⑤  $C_{oss \text{ eff.}}$  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 Calculated continuous current based on maximum allowable junction temperature. Package limitation current is 75A
- ⑦ Use IRF1404 data and test conditions.

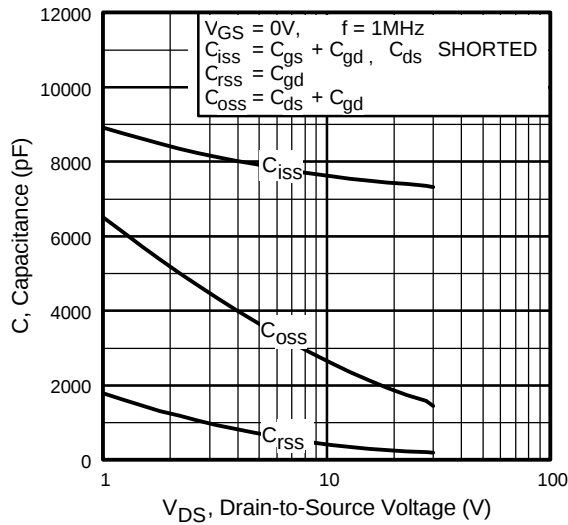
\* When mounted on 1" square PCB (FR-4 or G-10 Material).

For recommended footprint and soldering techniques refer to application note #AN-994.

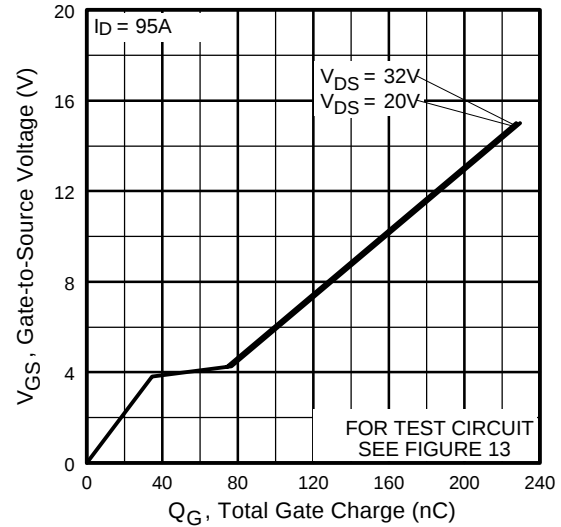


# IRF1404S/L

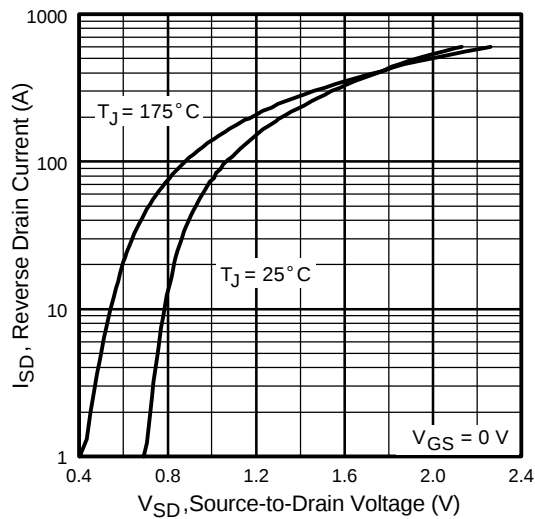
International  
**IR** Rectifier



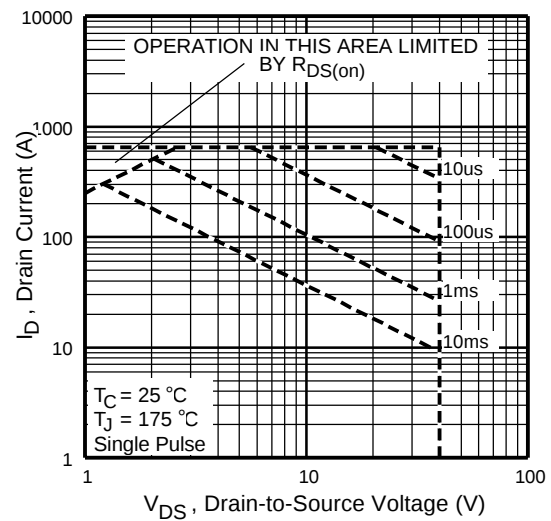
**Fig 5.** Typical Capacitance Vs. Drain-to-Source Voltage



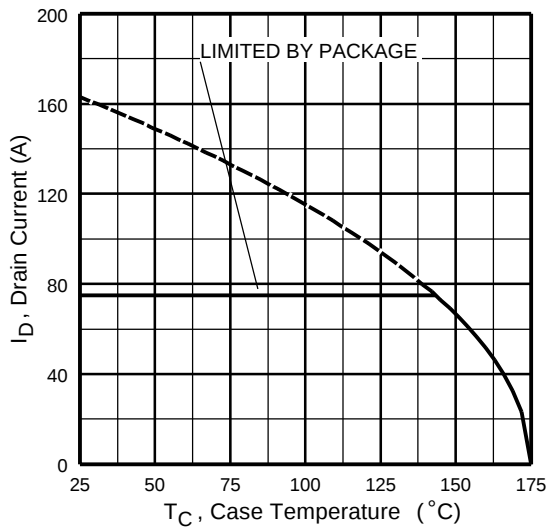
**Fig 6.** Typical Gate Charge Vs. Gate-to-Source Voltage



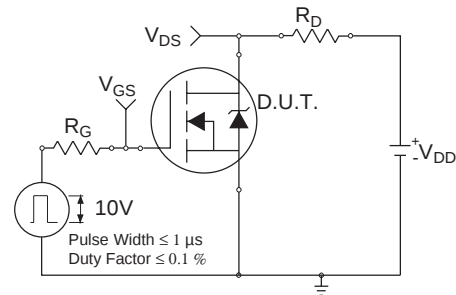
**Fig 7.** Typical Source-Drain Diode Forward Voltage



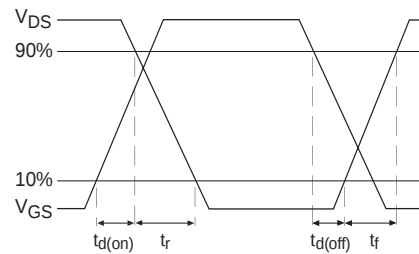
**Fig 8.** Maximum Safe Operating Area



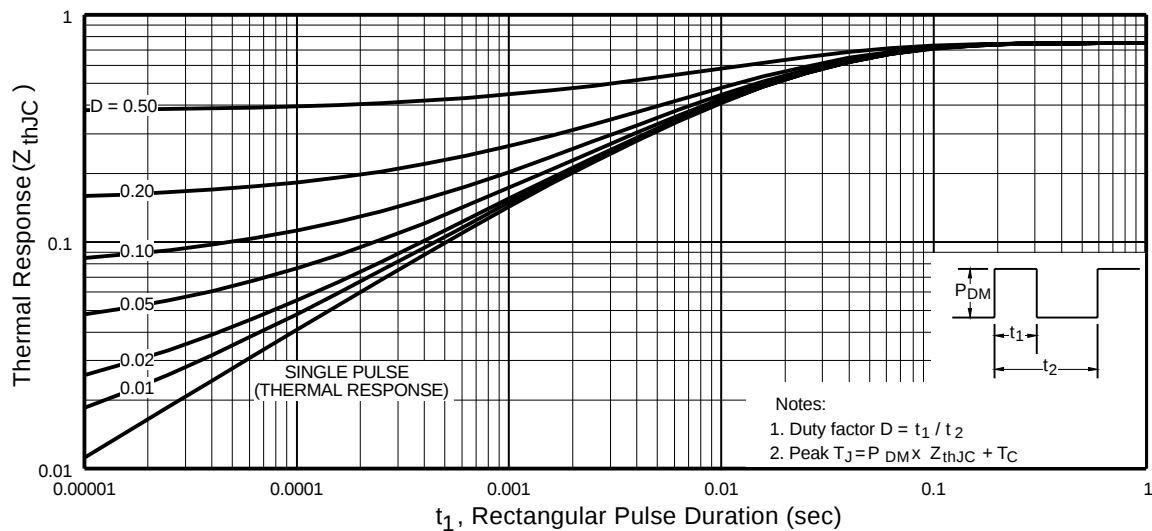
**Fig 9.** Maximum Drain Current Vs. Case Temperature



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



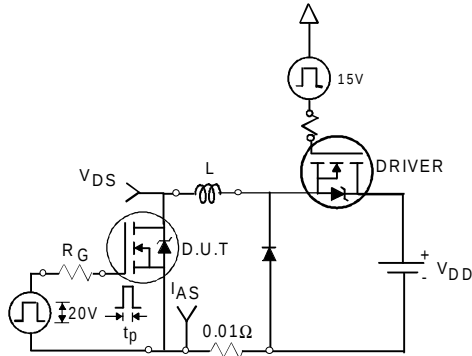
**Fig 10b.** Switching Time Waveforms



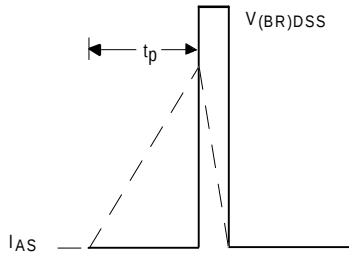
**Fig 11.** Maximum Effective Transient Thermal Impedance, Junction-to-Case

# IRF1404S/L

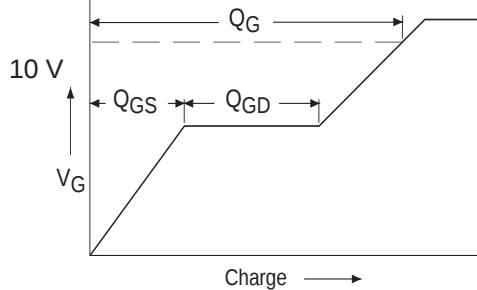
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**IR** Rectifier



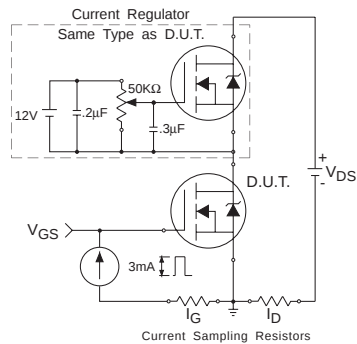
**Fig 12a.** Unclamped Inductive Test Circuit



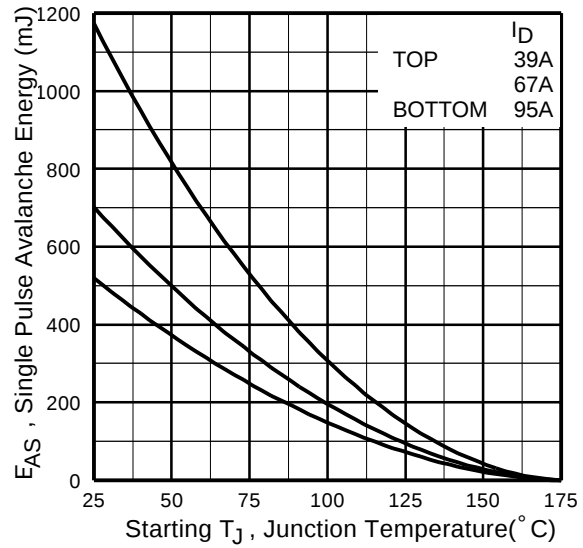
**Fig 12b.** Unclamped Inductive Waveforms



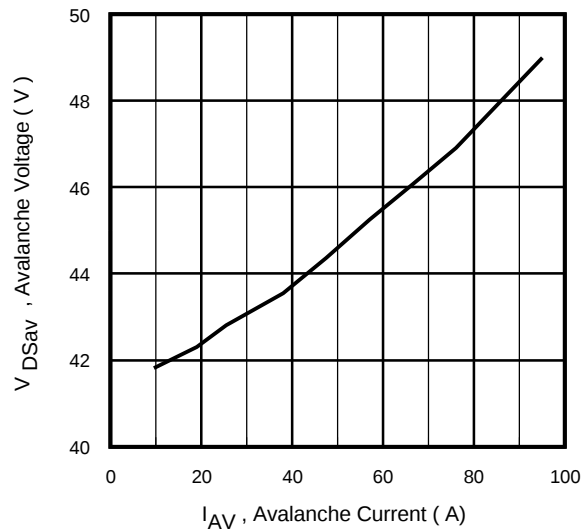
**Fig 13a.** Basic Gate Charge Waveform



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



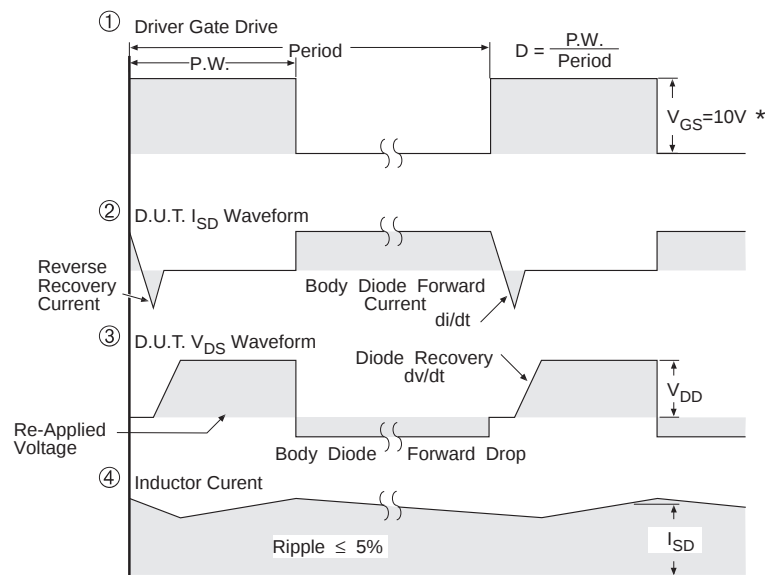
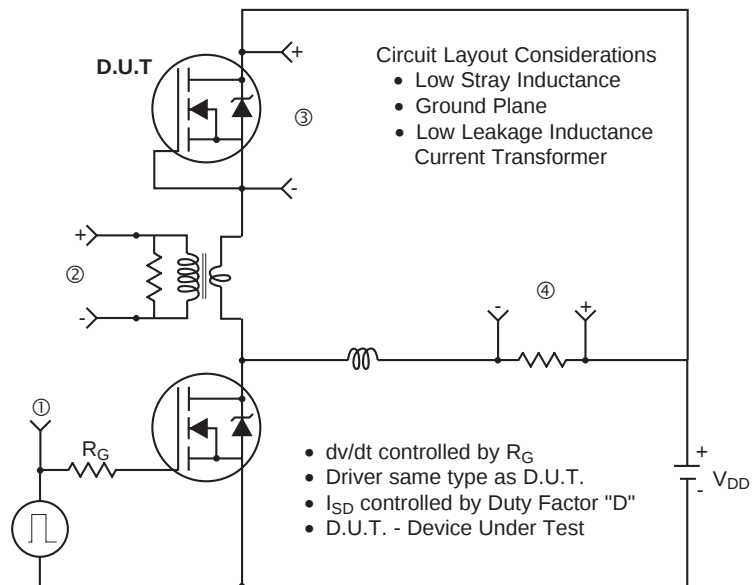
**Fig 12c.** Maximum Avalanche Energy  
Vs. Drain Current



**Fig 12d.** Typical Drain-to-Source Voltage  
Vs. Avalanche Current

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### Peak Diode Recovery dv/dt Test Circuit



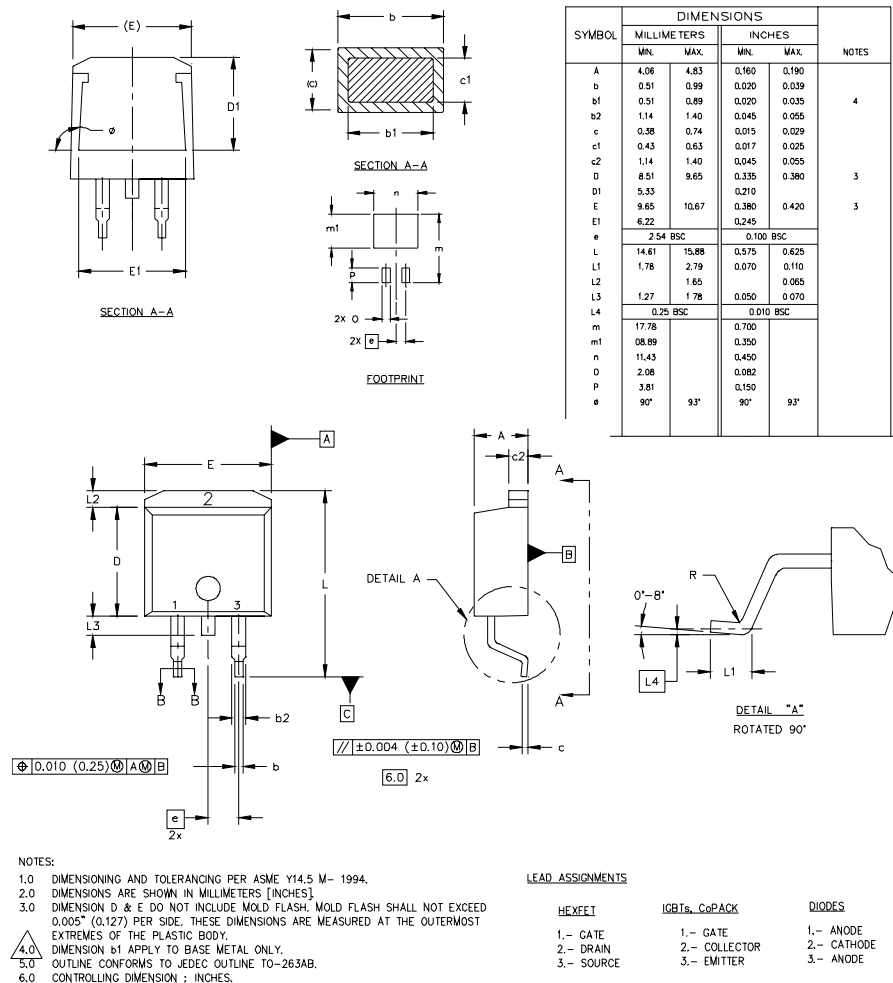
\*  $V_{GS} = 5V$  for Logic Level Devices

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

# IRF1404S/L

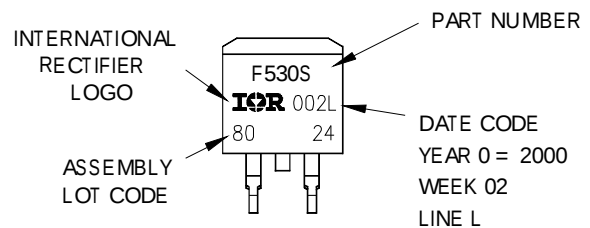
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**IR** Rectifier

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



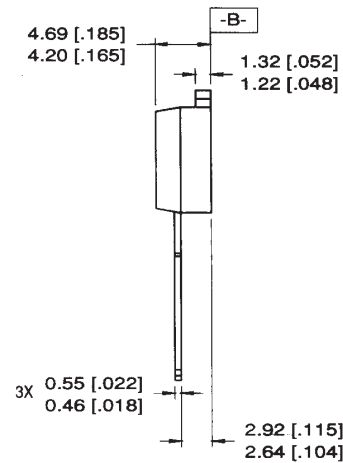
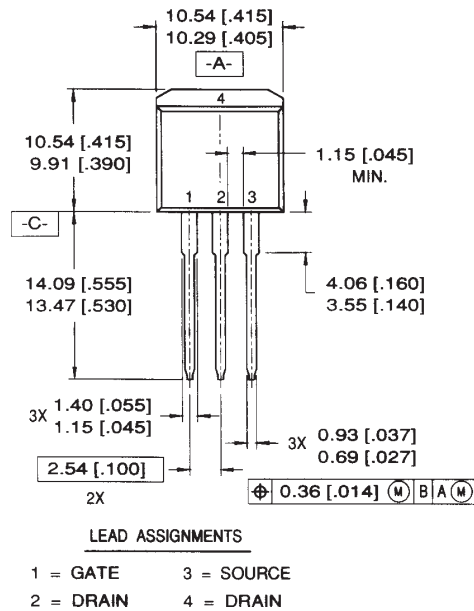
## D<sup>2</sup>Pak Part Marking Information

EXAMPLE: THIS IS AN IRF530S WITH  
LOT CODE 8024  
ASSEMBLED ON WW02, 2000  
IN THE ASSEMBLY LINE "L"



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## TO-262 Package Outline

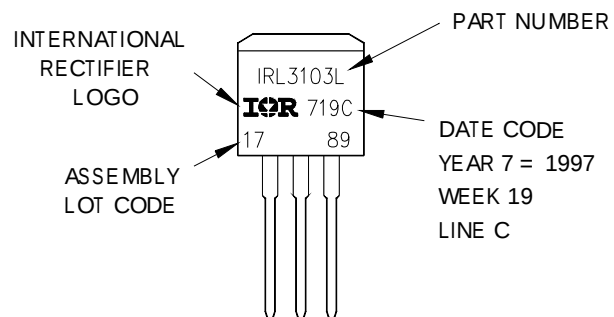


### NOTES:

1. DIMENSIONING & TOLERANCING PER ANSI Y14.5M-1982
2. CONTROLLING DIMENSION: INCH.
3. DIMENSIONS ARE SHOWN IN MILLIMETERS [INCHES].
4. HEATSINK & LEAD DIMENSIONS DO NOT INCLUDE BURRS.

## TO-262 Part Marking Information

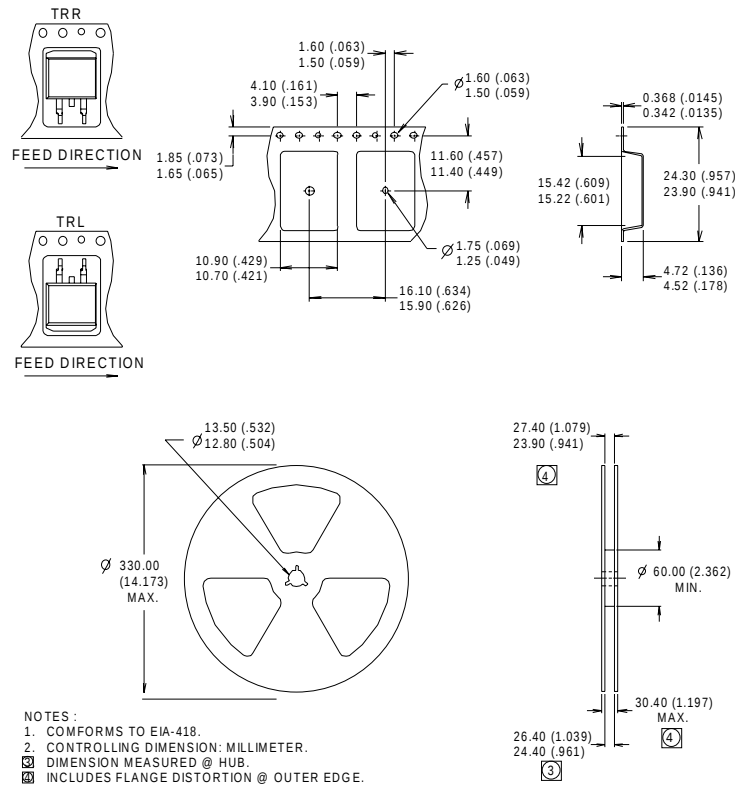
EXAMPLE: THIS IS AN IRL3103L  
LOT CODE 1789  
ASSEMBLED ON WW 19, 1997  
IN THE ASSEMBLY LINE "C"



# IRF1404S/L

International  
**IR** Rectifier

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



Data and specifications subject to change without notice.  
This product has been designed and qualified for the Industrial market.  
Qualification Standards can be found on IR's Web site.

International  
**IR** Rectifier

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