

**IRFB4610**  
**IRFS4610**  
**IRFSL4610**

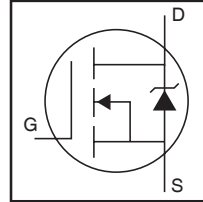
**Applications**

- High Efficiency Synchronous Rectification in SMPS
- Uninterruptible Power Supply
- High Speed Power Switching
- Hard Switched and High Frequency Circuits

**Benefits**

- Improved Gate, Avalanche and Dynamic dV/dt Ruggedness
- Fully Characterized Capacitance and Avalanche SOA
- Enhanced body diode dV/dt and dI/dt Capability

HEXFET® Power MOSFET



|                   |             |
|-------------------|-------------|
| $V_{DSS}$         | <b>100V</b> |
| $R_{DS(on)}$ typ. | <b>11mΩ</b> |
| max.              | <b>14mΩ</b> |
| $I_D$             | <b>73A</b>  |



**Absolute Maximum Ratings**

| Symbol                            | Parameter                                                  | Max.             | Units |
|-----------------------------------|------------------------------------------------------------|------------------|-------|
| $I_D$ @ $T_C = 25^\circ\text{C}$  | Continuous Drain Current, $V_{GS}$ @ 10V                   | 73               | A     |
| $I_D$ @ $T_C = 100^\circ\text{C}$ | Continuous Drain Current, $V_{GS}$ @ 10V                   | 52               |       |
| $I_{DM}$                          | Pulsed Drain Current ④                                     | 290              |       |
| $P_D$ @ $T_C = 25^\circ\text{C}$  | Maximum Power Dissipation                                  | 190              | W     |
|                                   | Linear Derating Factor                                     | 1.3              | W/°C  |
| $V_{GS}$                          | Gate-to-Source Voltage                                     | ± 20             | V     |
| dV/dt                             | Peak Diode Recovery ③                                      | 7.6              | V/ns  |
| $T_J$<br>$T_{STG}$                | Operating Junction and<br>Storage Temperature Range        | -55 to + 175     | °C    |
|                                   | Soldering Temperature, for 10 seconds<br>(1.6mm from case) | 300              |       |
|                                   | Mounting torque, 6-32 or M3 screw                          | 10lb·in (1.1N·m) |       |

**Avalanche Characteristics**

|                              |                                 |                            |    |
|------------------------------|---------------------------------|----------------------------|----|
| $E_{AS}$ (Thermally limited) | Single Pulse Avalanche Energy ② | 370                        | mJ |
| $I_{AR}$                     | Avalanche Current ①             | See Fig. 14, 15, 16a, 16b, | A  |
| $E_{AR}$                     | Repetitive Avalanche Energy ④   |                            | mJ |

**Thermal Resistance**

| Symbol          | Parameter                                   | Typ. | Max. | Units |
|-----------------|---------------------------------------------|------|------|-------|
| $R_{\theta JC}$ | Junction-to-Case ⑧                          | —    | 0.77 | °C/W  |
| $R_{\theta CS}$ | Case-to-Sink, Flat Greased Surface , TO-220 | 0.50 | —    |       |
| $R_{\theta JA}$ | Junction-to-Ambient, TO-220 ⑧               | —    | 62   |       |
| $R_{\theta JA}$ | Junction-to-Ambient (PCB Mount) , D²Pak ⑦ ⑧ | —    | 40   |       |

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

| Symbol                          | Parameter                            | Min. | Typ.  | Max. | Units               | Conditions                                             |
|---------------------------------|--------------------------------------|------|-------|------|---------------------|--------------------------------------------------------|
| $V_{(BR)DSS}$                   | Drain-to-Source Breakdown Voltage    | 100  | —     | —    | V                   | $V_{GS} = 0V, I_D = 250\mu A$                          |
| $\Delta V_{(BR)DSS}/\Delta T_J$ | Breakdown Voltage Temp. Coefficient  | —    | 0.085 | —    | V/ $^\circ\text{C}$ | Reference to $25^\circ\text{C}$ , $I_D = 1\text{mA}$ ① |
| $R_{DS(on)}$                    | Static Drain-to-Source On-Resistance | —    | 11    | 14   | m $\Omega$          | $V_{GS} = 10V, I_D = 44A$ ④                            |
| $V_{GS(th)}$                    | Gate Threshold Voltage               | 2.0  | —     | 4.0  | V                   | $V_{DS} = V_{GS}, I_D = 100\mu A$                      |
| $I_{DSS}$                       | Drain-to-Source Leakage Current      | —    | —     | 20   | $\mu A$             | $V_{DS} = 100V, V_{GS} = 0V$                           |
|                                 |                                      | —    | —     | 250  |                     | $V_{DS} = 100V, V_{GS} = 0V, T_J = 125^\circ\text{C}$  |
| $I_{GSS}$                       | Gate-to-Source Forward Leakage       | —    | —     | 200  | nA                  | $V_{GS} = 20V$                                         |
|                                 | Gate-to-Source Reverse Leakage       | —    | —     | -200 |                     | $V_{GS} = -20V$                                        |
| $R_G$                           | Gate Input Resistance                | —    | 1.5   | —    | $\Omega$            | $f = 1\text{MHz}$ , open drain                         |

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

| Symbol                      | Parameter                                     | Min. | Typ. | Max. | Units | Conditions                                                |
|-----------------------------|-----------------------------------------------|------|------|------|-------|-----------------------------------------------------------|
| $g_{fs}$                    | Forward Transconductance                      | 73   | —    | —    | S     | $V_{DS} = 50V, I_D = 44A$                                 |
| $Q_g$                       | Total Gate Charge                             | —    | 90   | 140  | nC    | $I_D = 44A$                                               |
| $Q_{gs}$                    | Gate-to-Source Charge                         | —    | 20   | —    |       | $V_{DS} = 80V$                                            |
| $Q_{gd}$                    | Gate-to-Drain ("Miller") Charge               | —    | 36   | —    |       | $V_{GS} = 10V$ ④                                          |
| $t_{d(on)}$                 | Turn-On Delay Time                            | —    | 18   | —    | ns    | $V_{DD} = 65V$                                            |
| $t_r$                       | Rise Time                                     | —    | 87   | —    |       | $I_D = 44A$                                               |
| $t_{d(off)}$                | Turn-Off Delay Time                           | —    | 53   | —    |       | $R_G = 5.6\Omega$                                         |
| $t_f$                       | Fall Time                                     | —    | 70   | —    |       | $V_{GS} = 10V$ ④                                          |
| $C_{iss}$                   | Input Capacitance                             | —    | 3550 | —    | pF    | $V_{GS} = 0V$                                             |
| $C_{oss}$                   | Output Capacitance                            | —    | 260  | —    |       | $V_{DS} = 50V$                                            |
| $C_{rss}$                   | Reverse Transfer Capacitance                  | —    | 150  | —    |       | $f = 1.0\text{MHz}$                                       |
| $C_{oss \text{ eff. (ER)}}$ | Effective Output Capacitance (Energy Related) | —    | 330  | —    |       | $V_{GS} = 0V, V_{DS} = 0V \text{ to } 80V$ ⑥, See Fig. 11 |
| $C_{oss \text{ eff. (TR)}}$ | Effective Output Capacitance (Time Related)   | —    | 380  | —    |       | $V_{GS} = 0V, V_{DS} = 0V \text{ to } 80V$ ⑤, See Fig. 5  |

## Diode Characteristics

| Symbol    | Parameter                                 | Min.                                                                 | Typ. | Max. | Units | Conditions                                                              |
|-----------|-------------------------------------------|----------------------------------------------------------------------|------|------|-------|-------------------------------------------------------------------------|
| $I_S$     | Continuous Source Current<br>(Body Diode) | —                                                                    | —    | 73   | A     | MOSFET symbol<br>showing the<br>integral reverse<br>p-n junction diode. |
| $I_{SM}$  | Pulsed Source Current<br>(Body Diode) ①   | —                                                                    | —    | 290  |       |                                                                         |
| $V_{SD}$  | Diode Forward Voltage                     | —                                                                    | —    | 1.3  | V     | $T_J = 25^\circ\text{C}, I_S = 44A, V_{GS} = 0V$ ④                      |
| $t_{rr}$  | Reverse Recovery Time                     | —                                                                    | 35   | 53   | ns    | $T_J = 25^\circ\text{C}$                                                |
|           |                                           | —                                                                    | 42   | 63   |       | $T_J = 125^\circ\text{C}$                                               |
| $Q_{rr}$  | Reverse Recovery Charge                   | —                                                                    | 44   | 66   | nC    | $T_J = 25^\circ\text{C}$                                                |
|           |                                           | —                                                                    | 65   | 98   |       | $T_J = 125^\circ\text{C}$                                               |
| $I_{RRM}$ | Reverse Recovery Current                  | —                                                                    | 2.1  | —    | A     | $T_J = 25^\circ\text{C}$                                                |
| $t_{on}$  | Forward Turn-On Time                      | Intrinsic turn-on time is negligible (turn-on is dominated by LS+LD) |      |      |       |                                                                         |

## Notes:

- ① Repetitive rating; pulse width limited by max. junction temperature.
- ② Limited by  $T_{Jmax}$ , starting  $T_J = 25^\circ\text{C}$ ,  $L = 0.39\text{mH}$   
 $R_G = 25\Omega$ ,  $I_{AS} = 44A$ ,  $V_{GS} = 10V$ . Part not recommended for use above this value.
- ③  $I_{SD} \leq 44A$ ,  $di/dt \leq 660A/\mu s$ ,  $V_{DD} \leq V_{(BR)DSS}$ ,  $T_J \leq 175^\circ\text{C}$ .
- ④ Pulse width  $\leq 400\mu s$ ; duty cycle  $\leq 2\%$ .

- ⑤  $C_{oss \text{ eff. (TR)}}$  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  $C_{oss \text{ eff. (ER)}}$  is a fixed capacitance that gives the same energy as  $C_{oss}$  while  $V_{DS}$  is rising from 0 to 80%  $V_{DSS}$ .
- ⑦ When mounted on 1" square PCB (FR-4 or G-10 Material). For recommended footprint and soldering techniques refer to application note #AN-994.
- ⑧  $R_G$  is measured at  $T_J$  approximately  $90^\circ\text{C}$

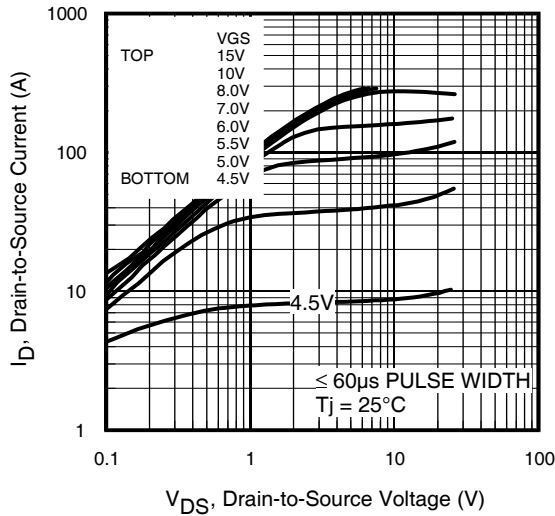


Fig 1. Typical Output Characteristics

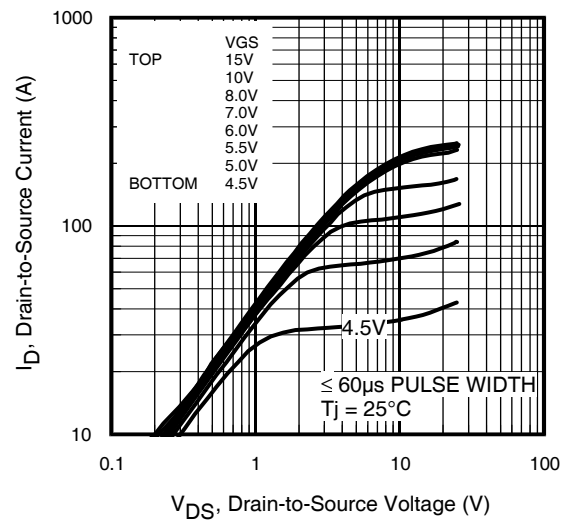


Fig 2. Typical Output Characteristics

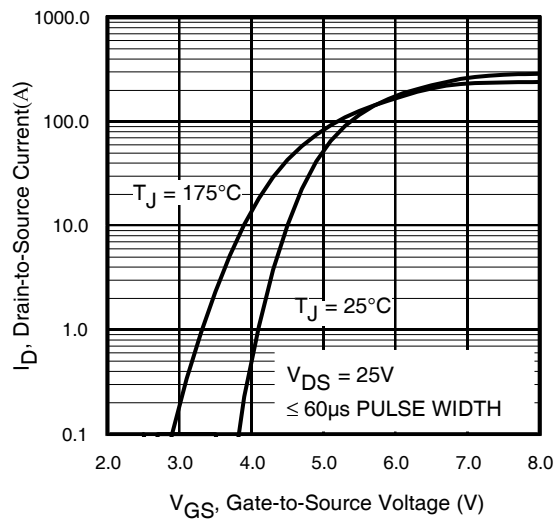


Fig 3. Typical Transfer Characteristics

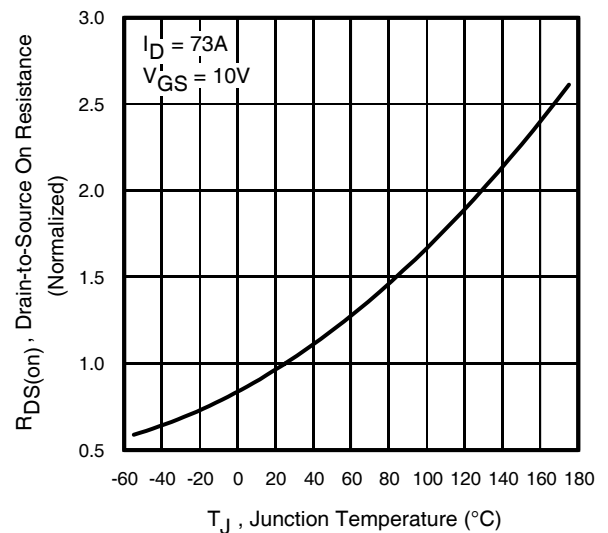


Fig 4. Normalized On-Resistance vs. Temperature

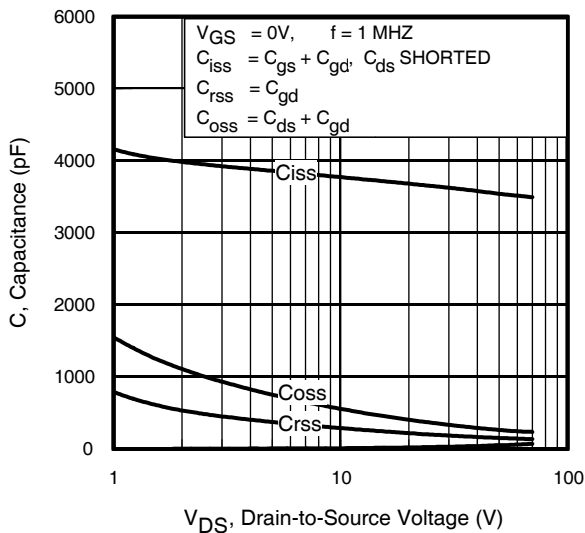


Fig 5. Typical Capacitance vs. Drain-to-Source Voltage

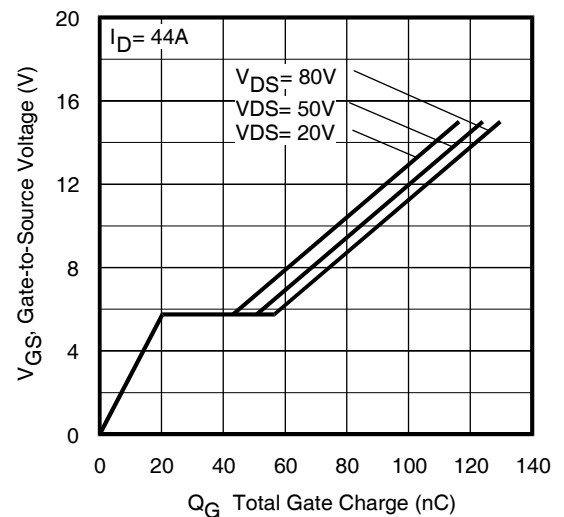
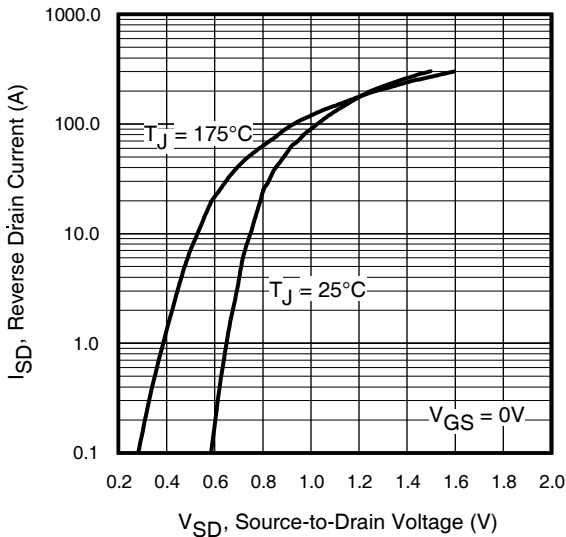
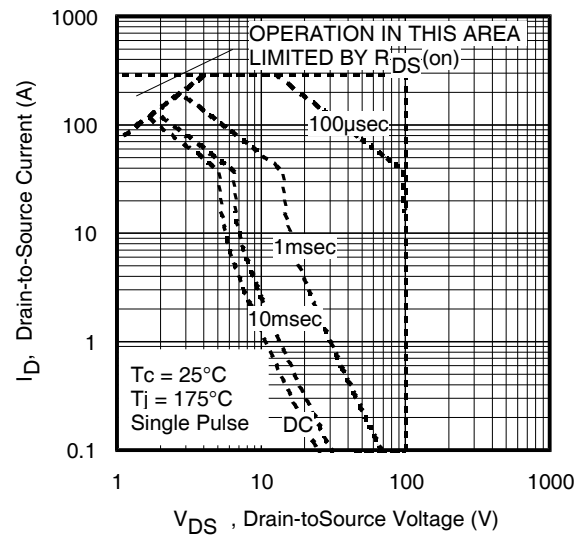


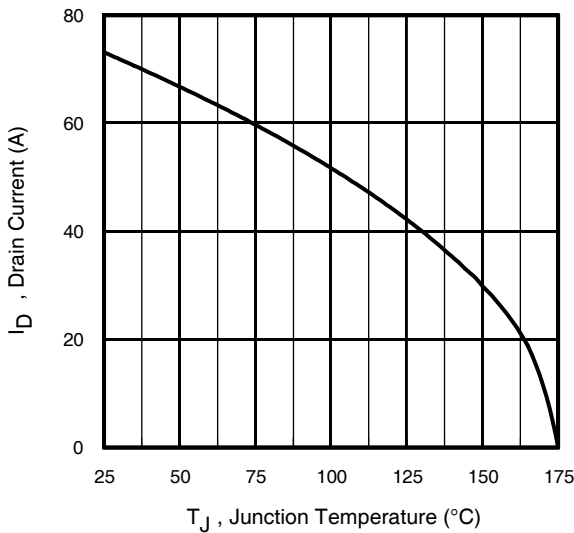
Fig 6. Typical Gate Charge vs. Gate-to-Source Voltage



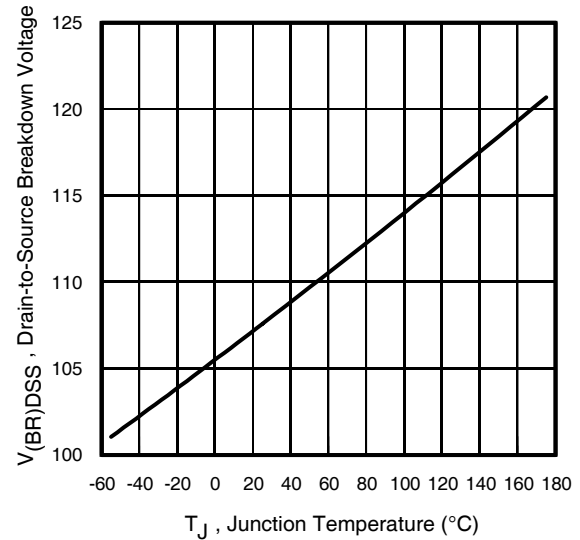
**Fig 7.** Typical Source-Drain Diode Forward Voltage



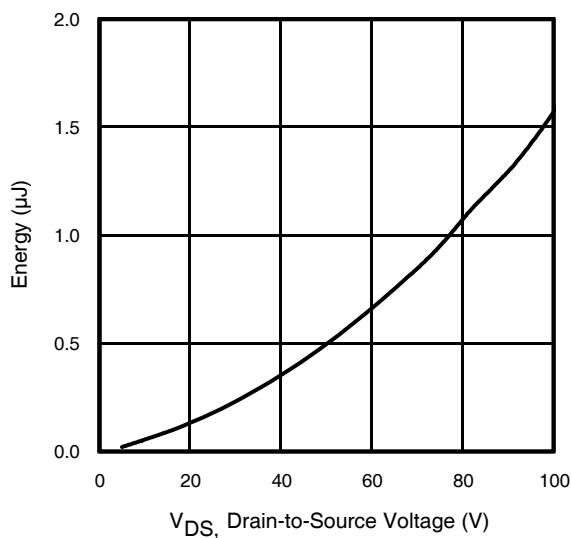
**Fig 8.** Maximum Safe Operating Area



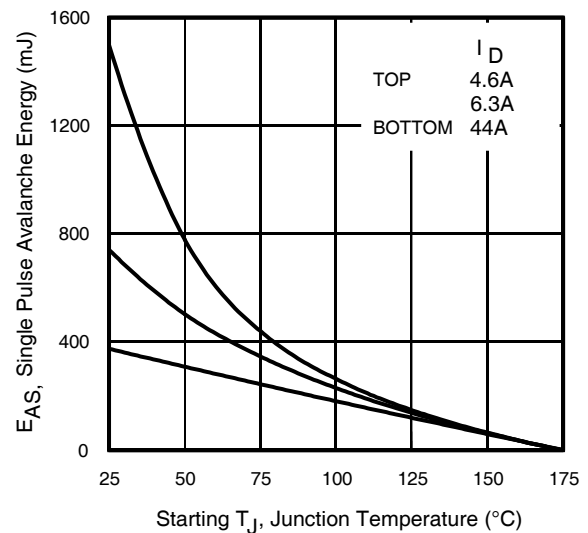
**Fig 9.** Maximum Drain Current vs. Case Temperature



**Fig 10.** Drain-to-Source Breakdown Voltage



**Fig 11.** Typical  $C_{OSS}$  Stored Energy



**Fig 12.** Maximum Avalanche Energy Vs. Drain Current  
www.irf.com

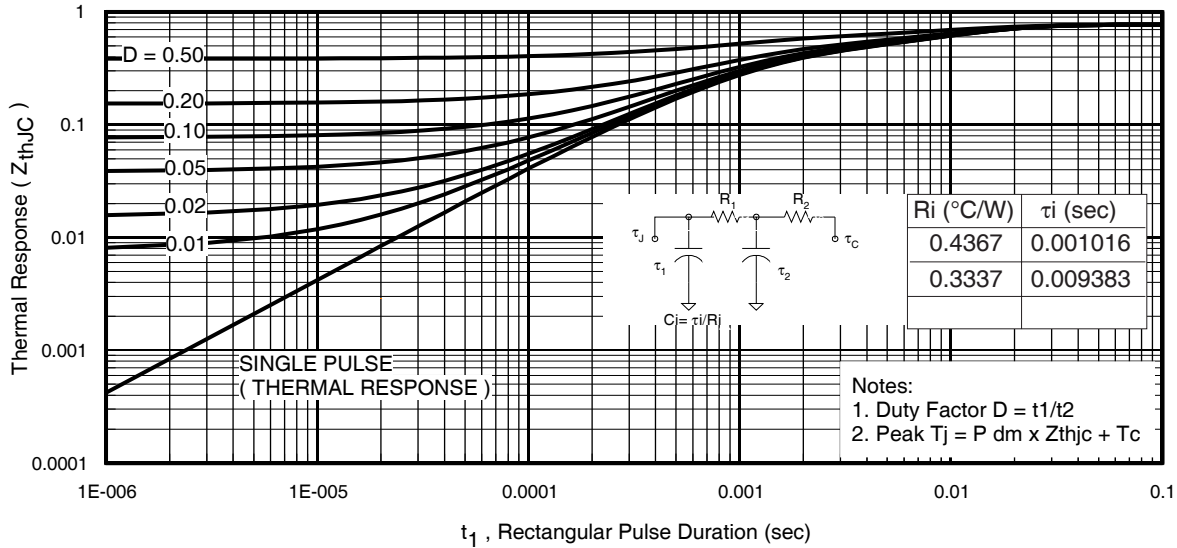


Fig 13. Maximum Effective Transient Thermal Impedance, Junction-to-Case

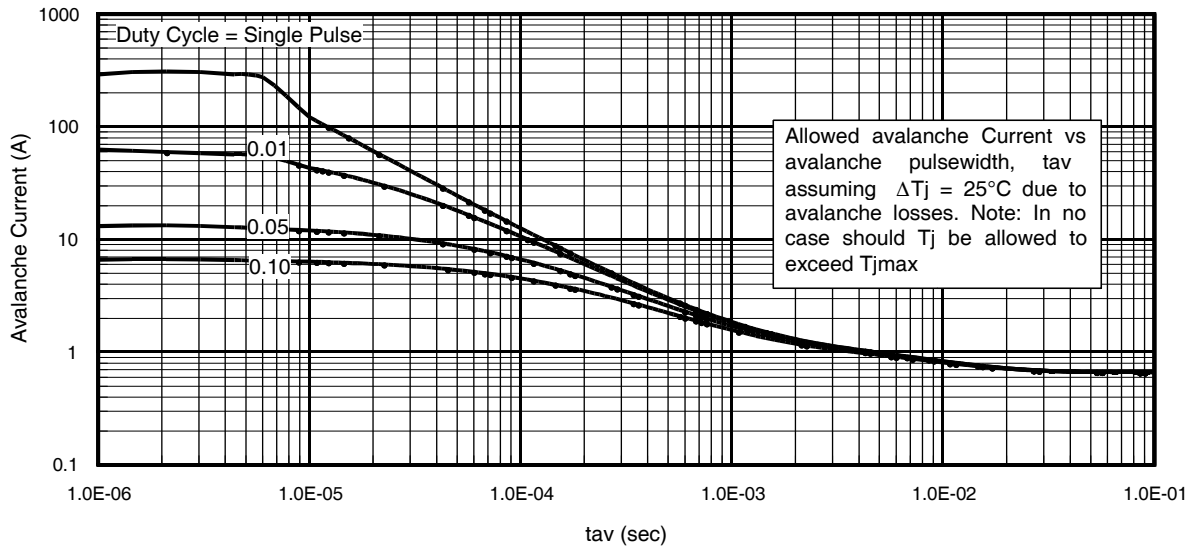


Fig 14. Typical Avalanche Current vs. Pulsewidth

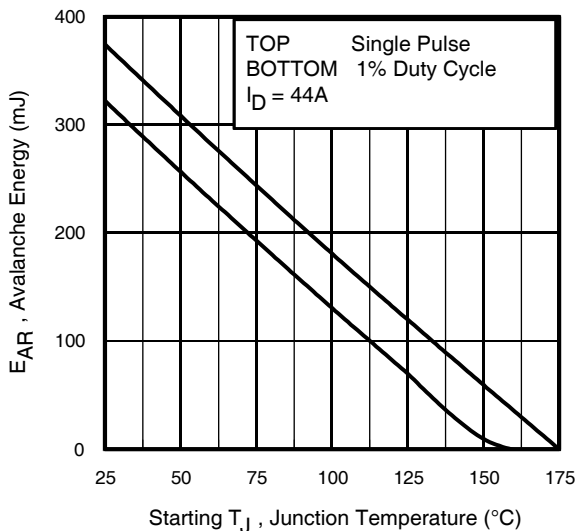


Fig 15. Maximum Avalanche Energy vs. Temperature

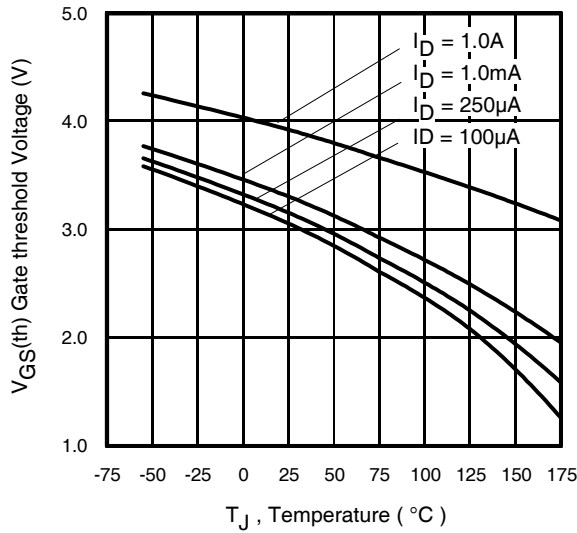
**Notes on Repetitive Avalanche Curves , Figures 14, 15:**  
(For further info, see AN-1005 at [www.irf.com](http://www.irf.com))

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 16a, 16b.
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 14, 15).  
 $t_{av}$  = Average time in avalanche.  
 $D$  = Duty cycle in avalanche =  $t_{av} \cdot f$   
 $Z_{thJC}(D, t_{av})$  = Transient thermal resistance, see Figures 13)

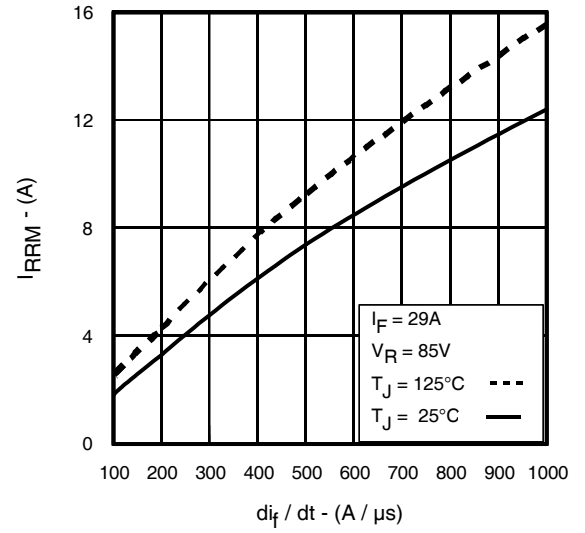
$$P_{D(ave)} = 1/2 (1.3 \cdot BV \cdot I_{av}) = \Delta T / Z_{thJC}$$

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

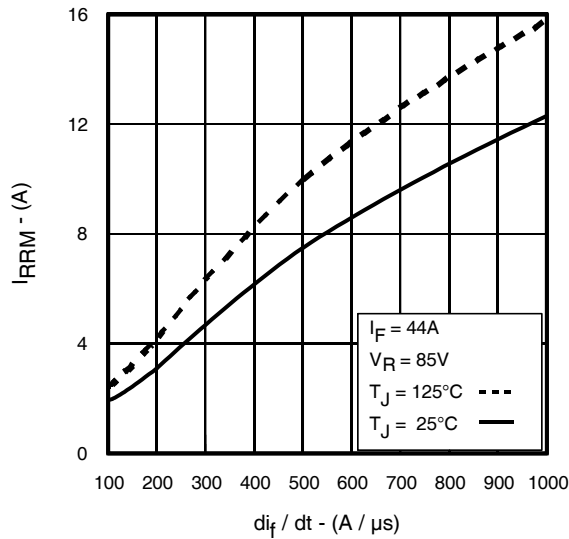
$$E_{AS(AR)} = P_{D(ave)} \cdot t_{av}$$



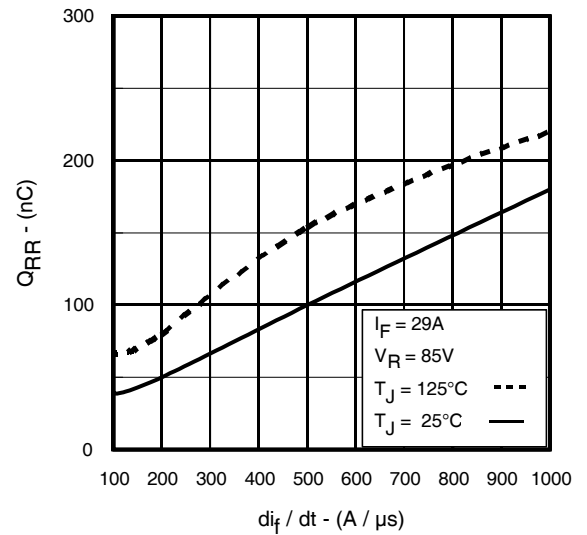
**Fig. 16.** Threshold Voltage Vs. Temperature



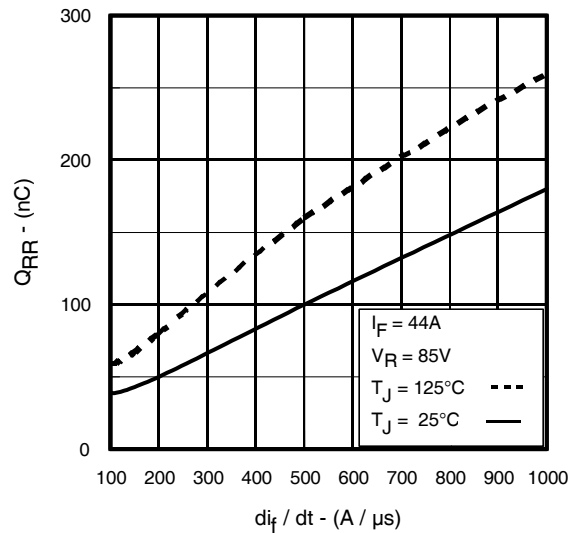
**Fig. 17 -** Typical Recovery Current vs.  $di_T/dt$



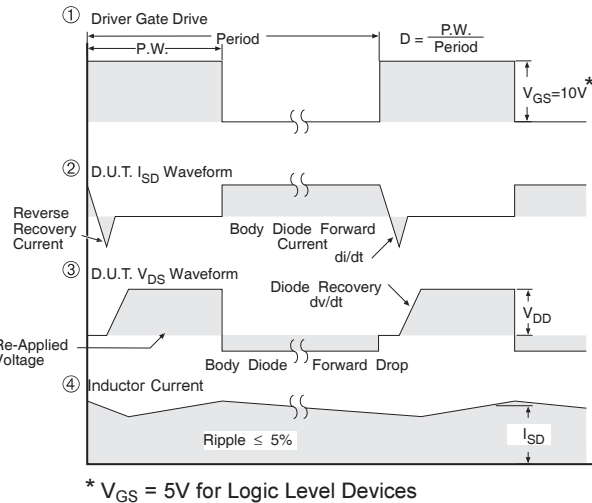
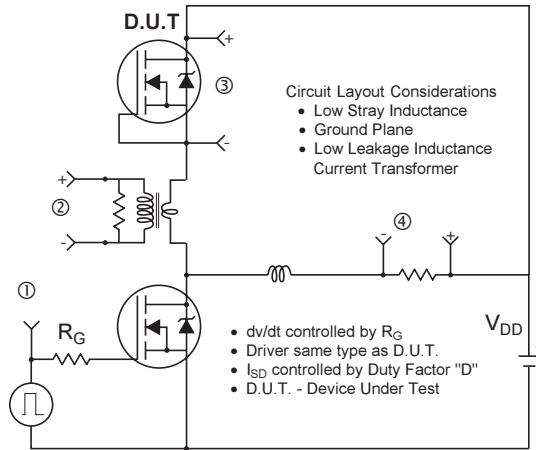
**Fig. 18 -** Typical Recovery Current vs.  $di_T/dt$



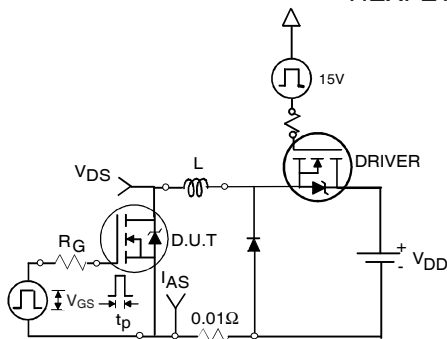
**Fig. 19 -** Typical Stored Charge vs.  $di_T/dt$



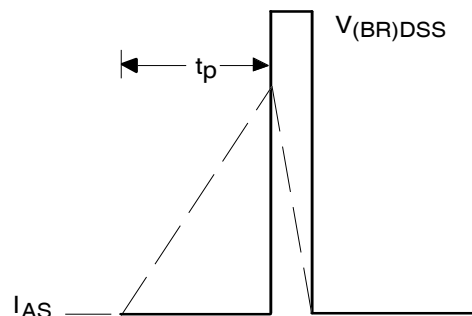
**Fig. 20 -** Typical Stored Charge vs.  $di_T/dt$



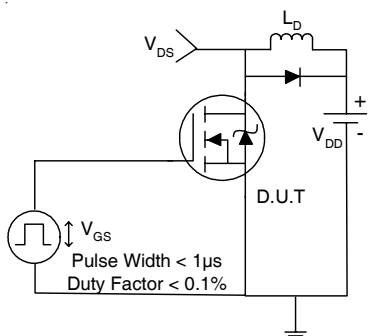
**Fig 21. Peak Diode Recovery  $dv/dt$  Test Circuit for N-Channel HEXFET® Power MOSFETs**



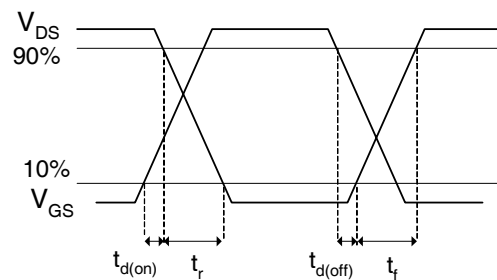
**Fig 22a. Unclamped Inductive Test Circuit**



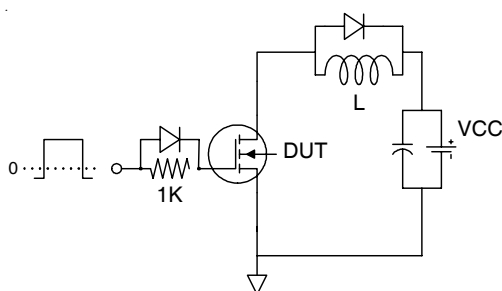
**Fig 22b. Unclamped Inductive Waveforms**



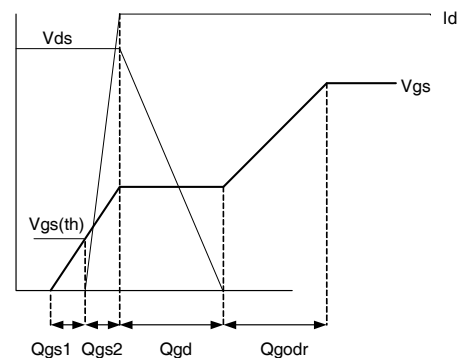
**Fig 23a. Switching Time Test Circuit**



**Fig 23b. Switching Time Waveforms**



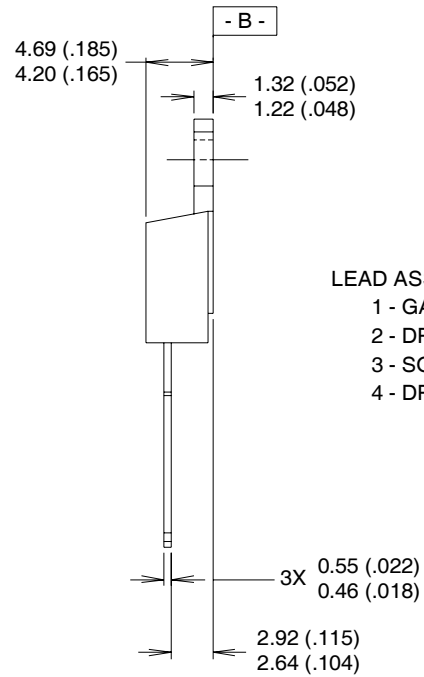
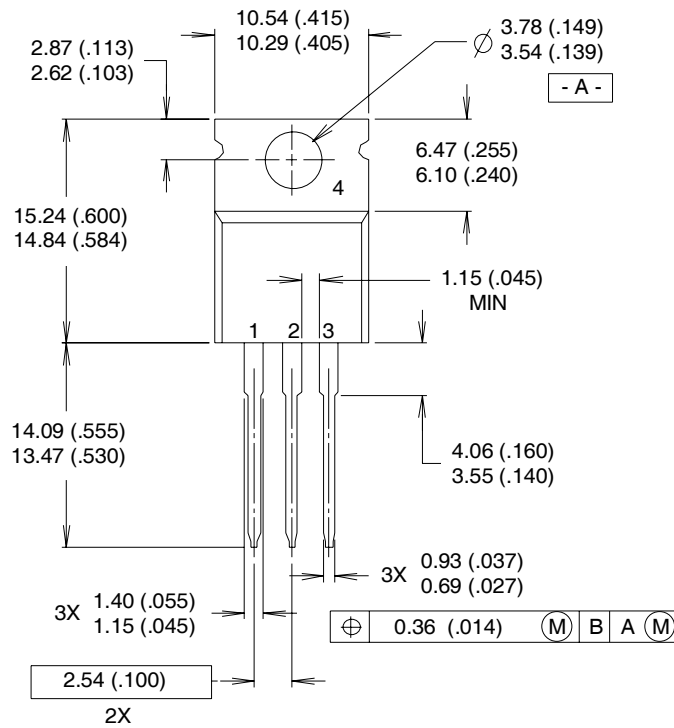
**Fig 24a. Gate Charge Test Circuit**



**Fig 24b. Gate Charge Waveform**

## TO-220AB Package Outline

Dimensions are shown in millimeters (inches)



### LEAD ASSIGNMENTS

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

### NOTES:

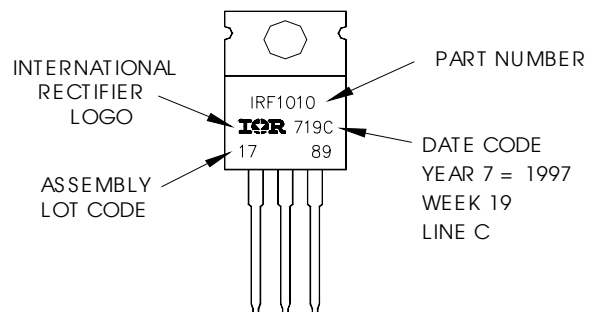
- 1 DIMENSIONING & TOLERANCING PER ANSI Y14.5M, 1982.
- 2 CONTROLLING DIMENSION : INCH

- 3 OUTLINE CONFORMS TO JEDEC OUTLINE TO-220AB.
- 4 HEATSINK & LEAD MEASUREMENTS DO NOT INCLUDE BURRS.

## TO-220AB Part Marking Information

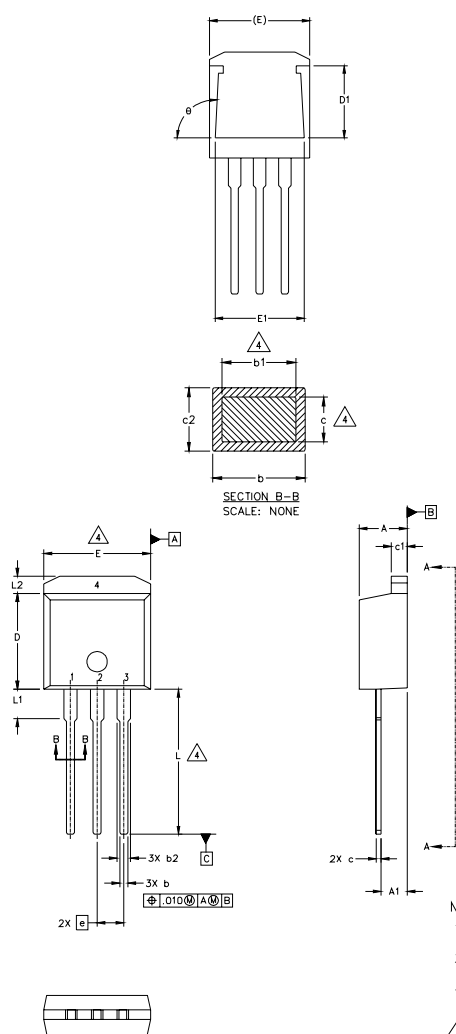
EXAMPLE: THIS IS AN IRF1010  
LOT CODE 1789  
ASSEMBLED ON WW 19, 1997  
IN THE ASSEMBLY LINE "C"

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



TO-220AB packages are not recommended for Surface Mount Application.

## 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 |       |
| E1     | 6.22        |       | .245     |      |       |
| e      | 2.54 BSC    |       | .100 BSC |      | 3     |
| 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
- 4- COLLECTOR

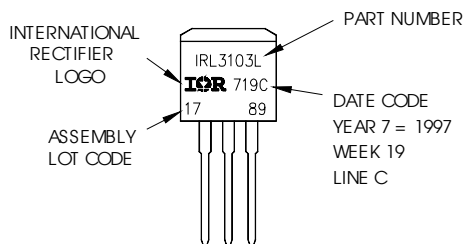
#### NOTES:

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.

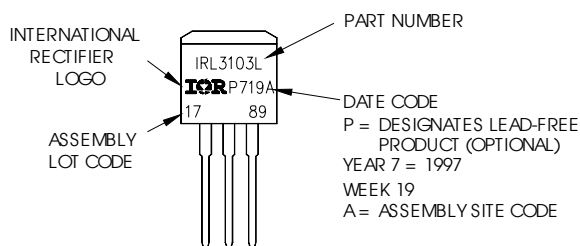
## TO-262 Part Marking Information

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

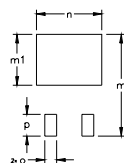
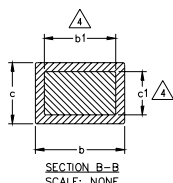
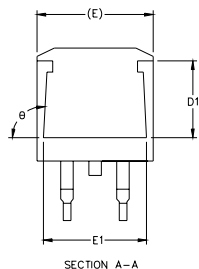
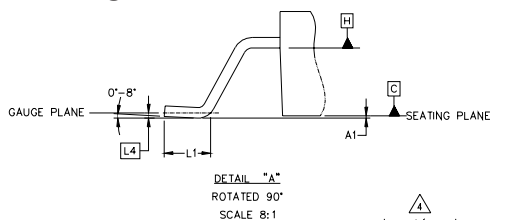
Note: "P" in assembly line position indicates "Lead-Free"



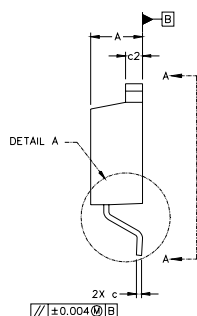
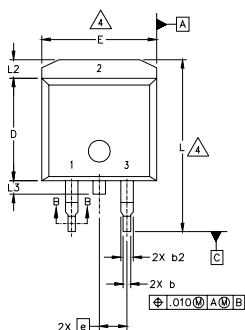
**OR**



## D<sup>2</sup>Pak Package Outline (Dimensions are shown in millimeters (inches))



FOOT PRINT  
SCALE: 2:1



| 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     |      | 3     |
| E      | 9.65        | 10.67 | .380     | .420 |       |
| 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.

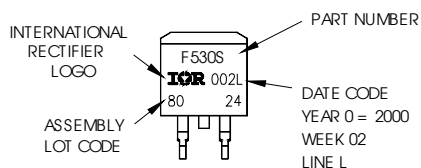
### NOTES:

- DIMENSIONING AND TOLERANCING PER ASME Y14.5M-1994
- DIMENSIONS ARE SHOWN IN MILLIMETERS [INCHES].
- 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.
- DIMENSION b1 AND c1 APPLY TO BASE METAL ONLY.
- CONTROLLING DIMENSION: INCH.

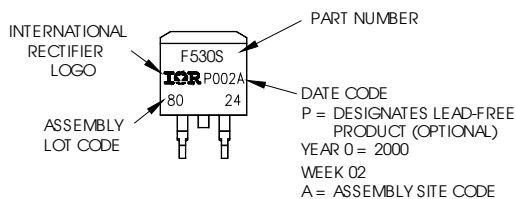
## D<sup>2</sup>Pak Part Marking Information

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

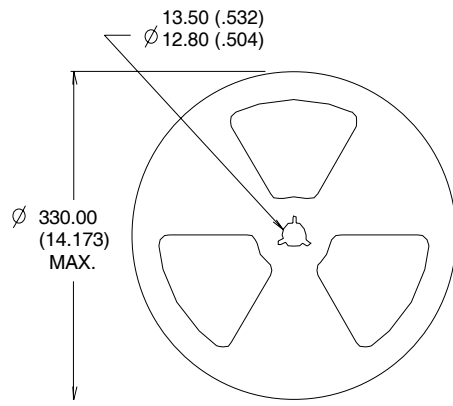
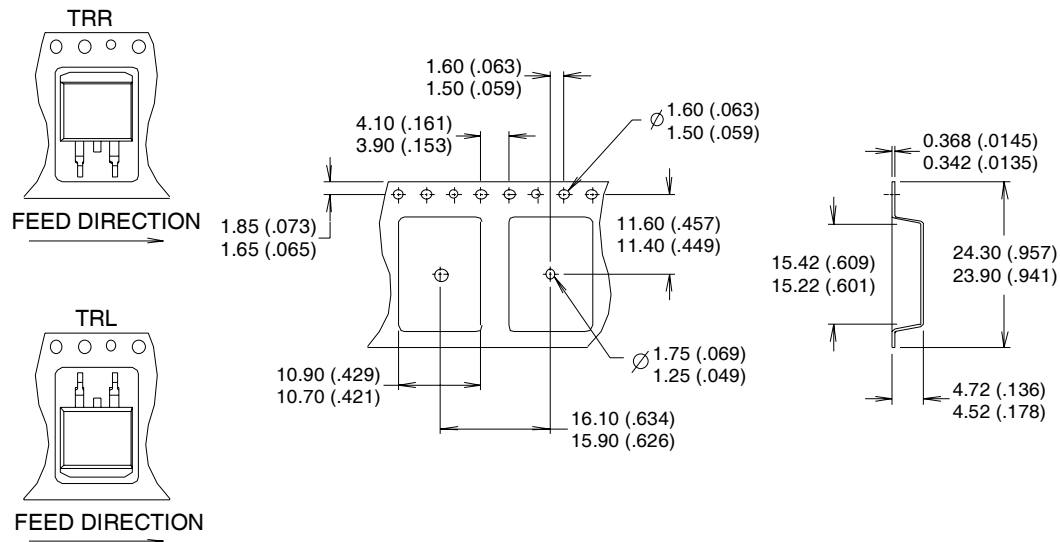
Note: "P" in assembly line  
position indicates "Lead-Free"



OR

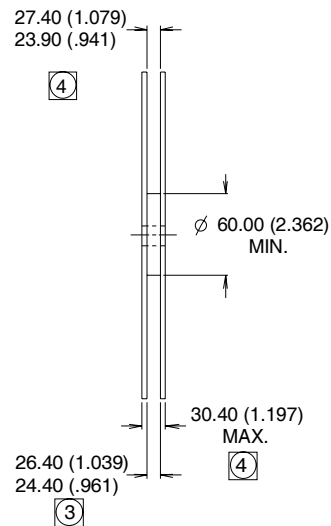


## D<sup>2</sup>Pak Tape & Reel Information



### 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.  
This product has been designed and qualified for the Automotive [Q101] market.  
Qualification Standards can be found on IR's Web site.

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](http://www.irf.com) for sales contact information. 11/04