

# IRFB3806PbF IRFS3806PbF IRFSL3806PbF

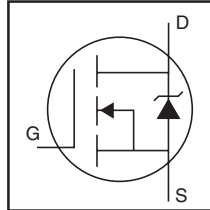
HEXFET® Power MOSFET

## Applications

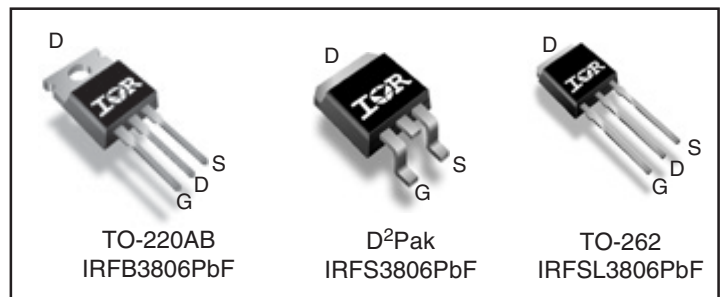
- High Efficiency Synchronous Rectification in SMPS
- Uninterruptible Power Supply
- High Speed Power Switching
- Hard Switched and High Frequency Circuits

## Benefits

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



|                          |               |
|--------------------------|---------------|
| $V_{DSS}$                | <b>60V</b>    |
| $R_{DS(on)}$ <b>typ.</b> | <b>12.6mΩ</b> |
| <b>max.</b>              | <b>15.8mΩ</b> |
| $I_D$                    | <b>43A</b>    |



|          |          |          |
|----------|----------|----------|
| <b>G</b> | <b>D</b> | <b>S</b> |
| Gate     | Drain    | Source   |

## Absolute Maximum Ratings

| Symbol                            | Parameter                                               | Max.             | Units |
|-----------------------------------|---------------------------------------------------------|------------------|-------|
| $I_D$ @ $T_C = 25^\circ\text{C}$  | Continuous Drain Current, $V_{GS}$ @ 10V                | 43               | A     |
| $I_D$ @ $T_C = 100^\circ\text{C}$ | Continuous Drain Current, $V_{GS}$ @ 10V                | 31               |       |
| $I_{DM}$                          | Pulsed Drain Current ①                                  | 170              |       |
| $P_D$ @ $T_C = 25^\circ\text{C}$  | Maximum Power Dissipation                               | 71               | W     |
|                                   | Linear Derating Factor                                  | 0.47             | W/°C  |
| $V_{GS}$                          | Gate-to-Source Voltage                                  | ± 20             | V     |
| dv/dt                             | Peak Diode Recovery ③                                   | 24               | V/ns  |
| $T_J$                             | Operating Junction and                                  | -55 to + 175     | °C    |
| $T_{STG}$                         | Storage Temperature Range                               |                  |       |
|                                   | Soldering Temperature, for 10 seconds (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 | 73  | mJ |
| $I_{AR}$                     | Avalanche Current ①             | 25  | A  |
| $E_{AR}$                     | Repetitive Avalanche Energy ④   | 7.1 | mJ |

## Thermal Resistance

| Symbol          | Parameter                                  | Typ. | Max. | Units |
|-----------------|--------------------------------------------|------|------|-------|
| $R_{\theta JC}$ | Junction-to-Case ⑤                         | —    | 2.12 | °C/W  |
| $R_{\theta CS}$ | Case-to-Sink, Flat Greased Surface, TO-220 | 0.50 | —    |       |
| $R_{\theta JA}$ | Junction-to-Ambient, TO-220 ⑦⑧             | —    | 62   |       |
| $R_{\theta JA}$ | Junction-to-Ambient (PCB Mount) , D²Pak ⑦⑧ | —    | 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    | 60   | —     | —    | V                   | $V_{GS} = 0V, I_D = 250\mu A$                        |
| $\Delta V_{(BR)DSS}/\Delta T_J$ | Breakdown Voltage Temp. Coefficient  | —    | 0.075 | —    | V/ $^\circ\text{C}$ | Reference to $25^\circ\text{C}$ , $I_D = 5mA$ ①      |
| $R_{DS(on)}$                    | Static Drain-to-Source On-Resistance | —    | 12.6  | 15.8 | m $\Omega$          | $V_{GS} = 10V, I_D = 25A$ ②                          |
| $V_{GS(th)}$                    | Gate Threshold Voltage               | 2.0  | —     | 4.0  | V                   | $V_{DS} = V_{GS}, I_D = 50\mu A$                     |
| $I_{DSS}$                       | Drain-to-Source Leakage Current      | —    | —     | 20   | $\mu A$             | $V_{DS} = 60V, V_{GS} = 0V$                          |
|                                 |                                      | —    | —     | 250  |                     | $V_{DS} = 48V, V_{GS} = 0V, T_J = 125^\circ\text{C}$ |
| $I_{GSS}$                       | Gate-to-Source Forward Leakage       | —    | —     | 100  | nA                  | $V_{GS} = 20V$                                       |
|                                 | Gate-to-Source Reverse Leakage       | —    | —     | -100 |                     | $V_{GS} = -20V$                                      |

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

| Symbol                      | Parameter                                      | Min. | Typ. | Max. | Units    | Conditions                                                                                  |
|-----------------------------|------------------------------------------------|------|------|------|----------|---------------------------------------------------------------------------------------------|
| $g_{fs}$                    | Forward Transconductance                       | 41   | —    | —    | S        | $V_{DS} = 10V, I_D = 25A$                                                                   |
| $Q_g$                       | Total Gate Charge                              | —    | 22   | 30   | nC       | $I_D = 25A$<br>$V_{DS} = 30V$<br>$V_{GS} = 10V$ ④<br>$I_D = 25A, V_{DS} = 0V, V_{GS} = 10V$ |
| $Q_{gs}$                    | Gate-to-Source Charge                          | —    | 5.0  | —    |          |                                                                                             |
| $Q_{gd}$                    | Gate-to-Drain ("Miller") Charge                | —    | 6.3  | —    |          |                                                                                             |
| $Q_{sync}$                  | Total Gate Charge Sync. ( $Q_g - Q_{gd}$ )     | —    | 28.3 | —    |          |                                                                                             |
| $R_{G(int)}$                | Internal Gate Resistance                       | —    | 0.79 | —    | $\Omega$ |                                                                                             |
| $t_{d(on)}$                 | Turn-On Delay Time                             | —    | 6.3  | —    | ns       | $V_{DD} = 39V$<br>$I_D = 25A$<br>$R_G = 20\Omega$<br>$V_{GS} = 10V$ ④                       |
| $t_r$                       | Rise Time                                      | —    | 40   | —    |          |                                                                                             |
| $t_{d(off)}$                | Turn-Off Delay Time                            | —    | 49   | —    |          |                                                                                             |
| $t_f$                       | Fall Time                                      | —    | 47   | —    |          |                                                                                             |
| $C_{iss}$                   | Input Capacitance                              | —    | 1150 | —    | pF       | $V_{GS} = 0V$                                                                               |
| $C_{oss}$                   | Output Capacitance                             | —    | 130  | —    |          | $V_{DS} = 50V$                                                                              |
| $C_{rss}$                   | Reverse Transfer Capacitance                   | —    | 67   | —    |          | $f = 1.0MHz$                                                                                |
| $C_{oss \text{ eff. (ER)}}$ | Effective Output Capacitance (Energy Related)⑥ | —    | 190  | —    |          | $V_{GS} = 0V, V_{DS} = 0V \text{ to } 60V$ ⑤                                                |
| $C_{oss \text{ eff. (TR)}}$ | Effective Output Capacitance (Time Related)⑤   | —    | 230  | —    |          | $V_{GS} = 0V, V_{DS} = 0V \text{ to } 60V$ ⑤                                                |

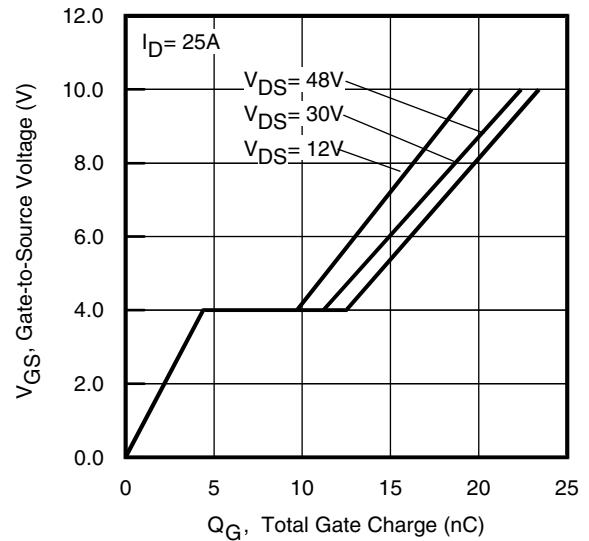
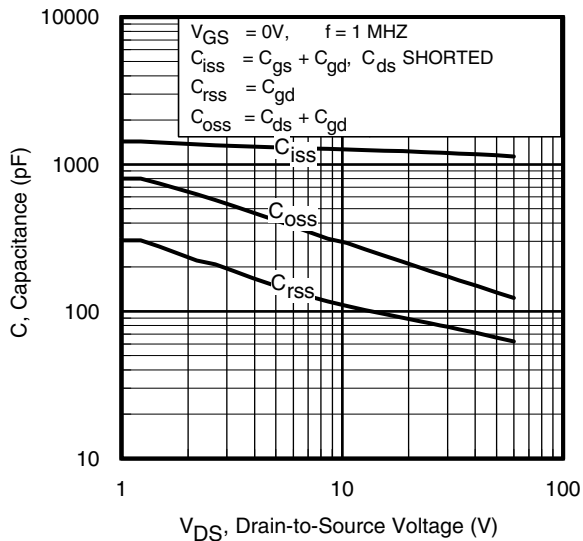
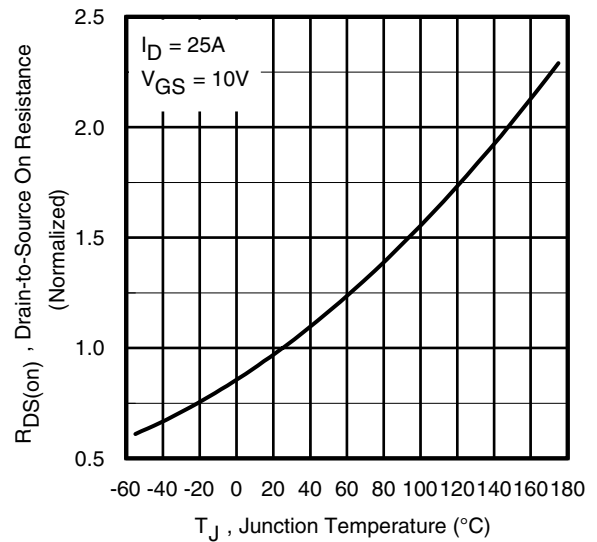
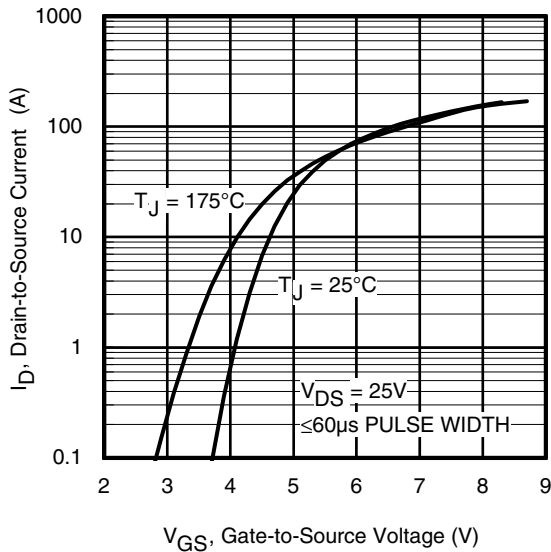
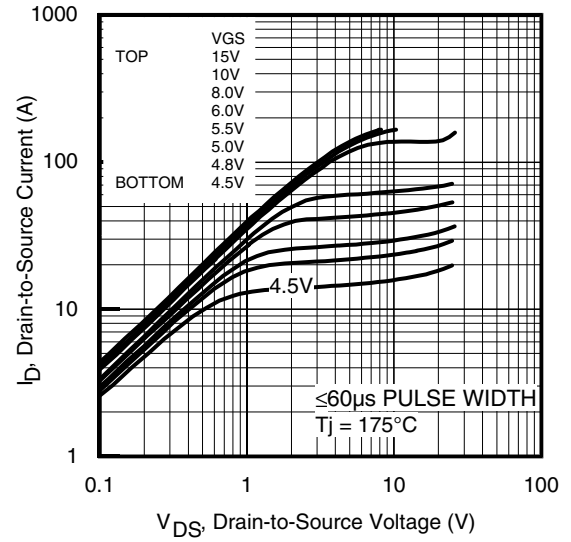
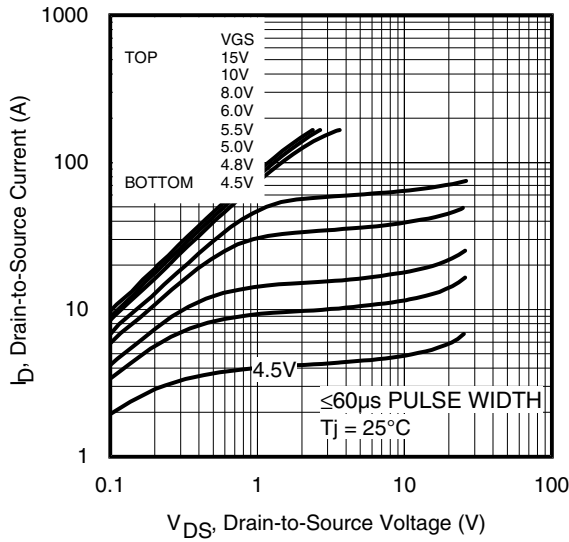
**Diode Characteristics**

| Symbol    | Parameter                                 | Min.                                                                 | Typ. | Max. | Units | Conditions                                                              |
|-----------|-------------------------------------------|----------------------------------------------------------------------|------|------|-------|-------------------------------------------------------------------------|
| $I_S$     | Continuous Source Current<br>(Body Diode) | —                                                                    | —    | 43   | A     | MOSFET symbol<br>showing the<br>integral reverse<br>p-n junction diode. |
| $I_{SM}$  | Pulsed Source Current<br>(Body Diode) ①   | —                                                                    | —    | 170  |       |                                                                         |
| $V_{SD}$  | Diode Forward Voltage                     | —                                                                    | —    | 1.3  | V     | $T_J = 25^\circ\text{C}, I_S = 25A, V_{GS} = 0V$ ④                      |
| $t_{rr}$  | Reverse Recovery Time                     | —                                                                    | 22   | 33   | ns    | $T_J = 25^\circ\text{C}$ $V_R = 51V,$                                   |
|           |                                           | —                                                                    | 26   | 39   |       | $T_J = 125^\circ\text{C}$ $I_F = 25A$                                   |
| $Q_{rr}$  | Reverse Recovery Charge                   | —                                                                    | 17   | 26   | nC    | $T_J = 25^\circ\text{C}$ $di/dt = 100A/\mu s$ ④                         |
|           |                                           | —                                                                    | 24   | 36   |       | $T_J = 125^\circ\text{C}$                                               |
| $I_{RRM}$ | Reverse Recovery Current                  | —                                                                    | 1.4  | —    | 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  $T_J = 25^\circ\text{C}$ ,  $L = 0.23mH$   
 $R_G = 25\Omega$ ,  $I_{AS} = 25A$ ,  $V_{GS} = 10V$ . Part not recommended for use above this value.  
 ③  $I_{SD} \leq 25A$ ,  $di/dt \leq 1580A/\mu s$ ,  $V_{DD} \leq V_{(BR)DSS}$ ,  $T_J \leq 175^\circ\text{C}$ .  
 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  $R_\theta$  is measured at  $T_J$  approximately  $90^\circ\text{C}$ .



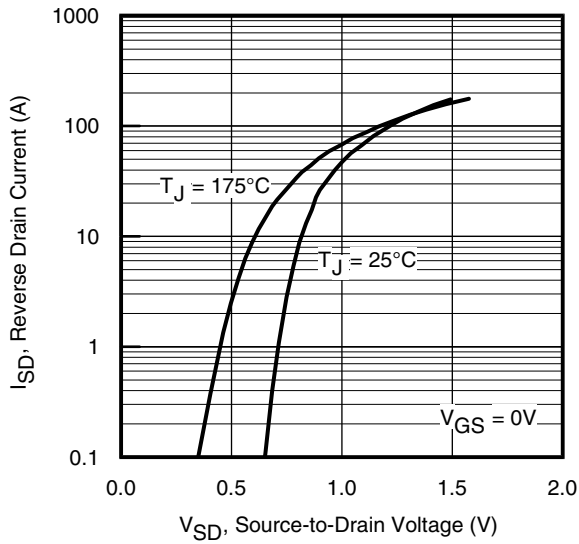


Fig 7. Typical Source-Drain Diode Forward Voltage

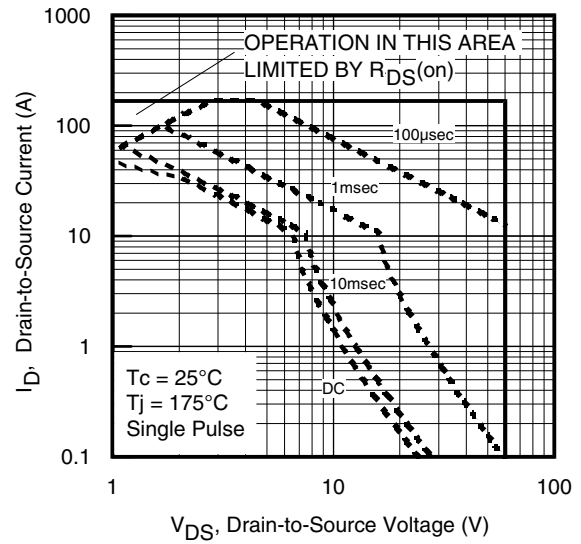


Fig 8. Maximum Safe Operating Area

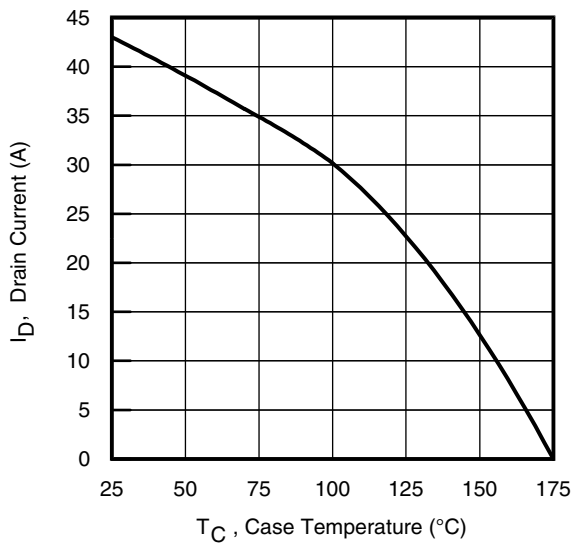


Fig 9. Maximum Drain Current vs. Case Temperature

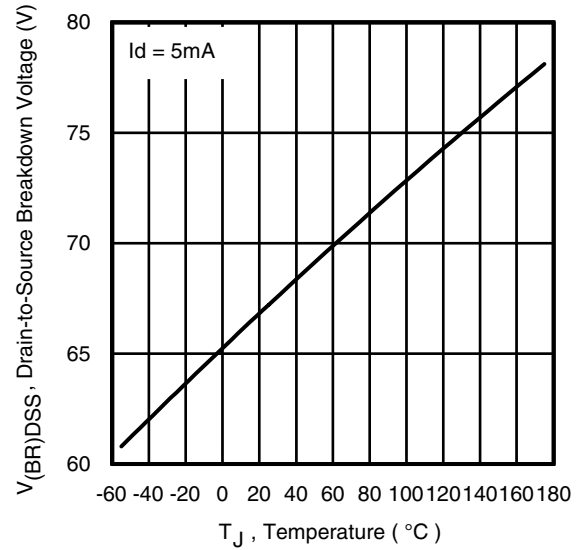


Fig 10. Drain-to-Source Breakdown Voltage

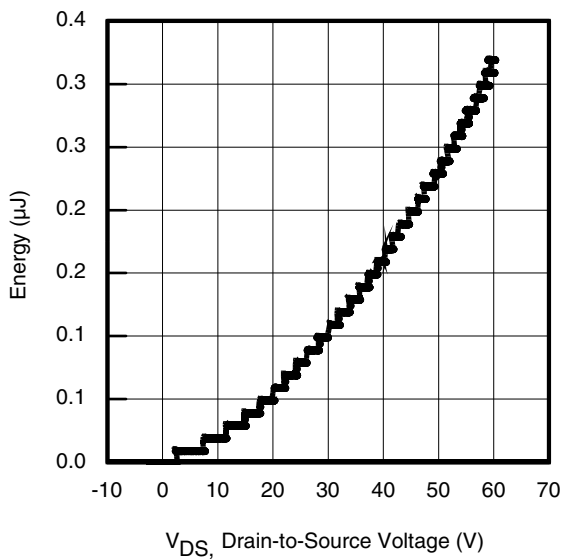


Fig 11. Typical  $C_{OSS}$  Stored Energy

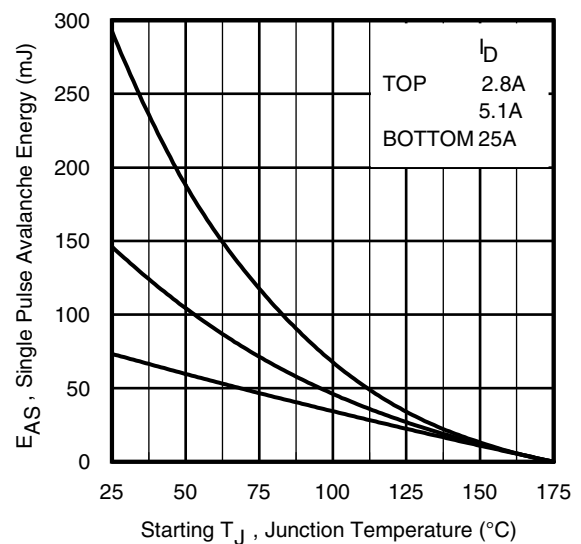


Fig 12. Maximum Avalanche Energy vs. Drain Current

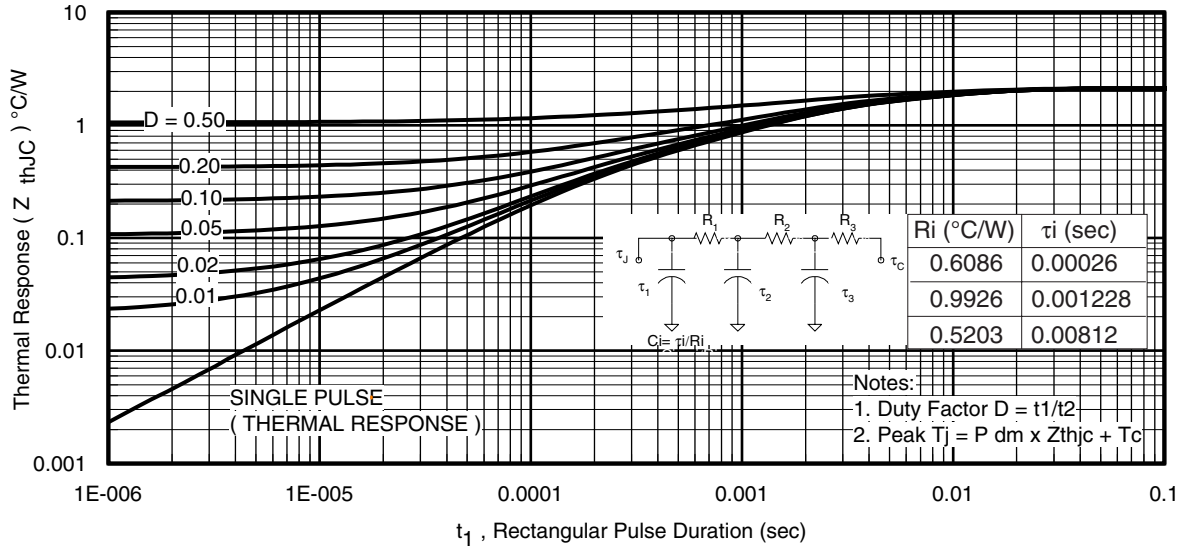


Fig 13. Maximum Effective Transient Thermal Impedance, Junction-to-Case

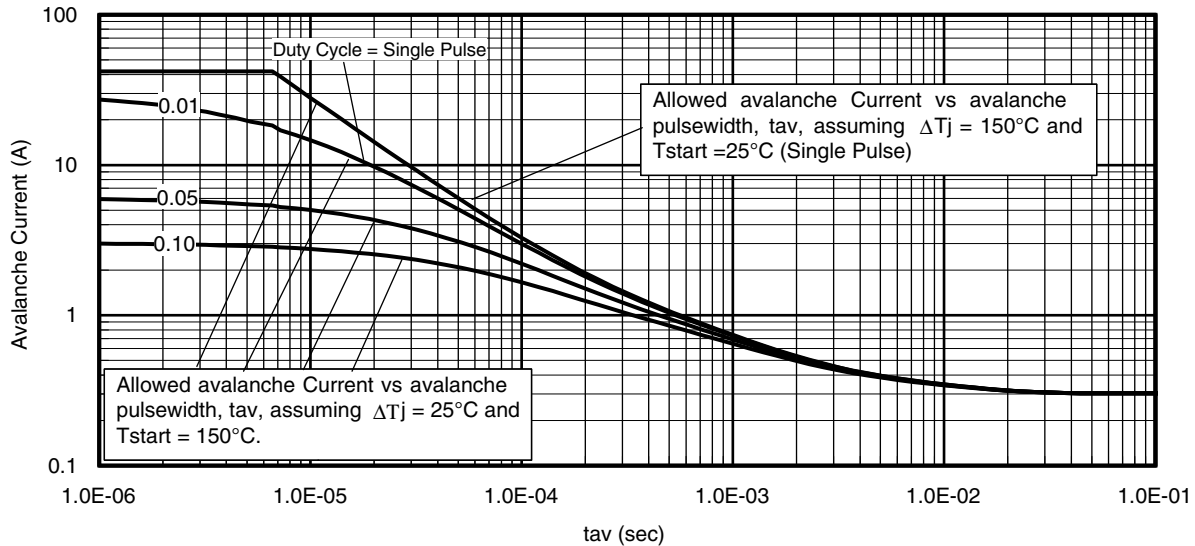


Fig 14. Typical Avalanche Current vs. Pulsewidth

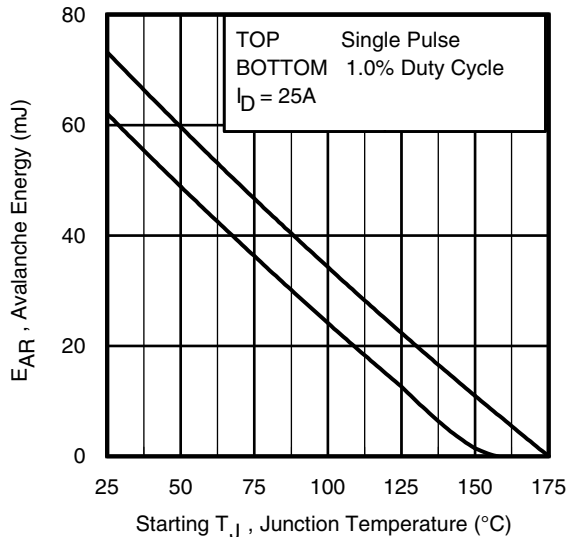


Fig 15. Maximum Avalanche Energy vs. Temperature

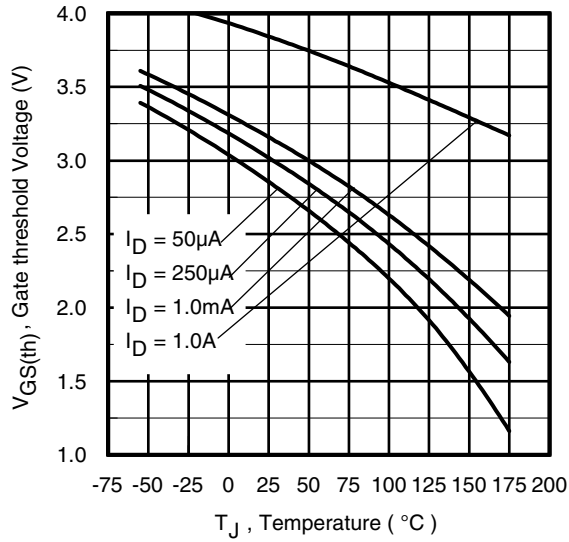
**Notes on Repetitive Avalanche Curves , Figures 14, 15:**  
(For further info, see AN-1005 at [www.irf.com](http://www.irf.com))

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)

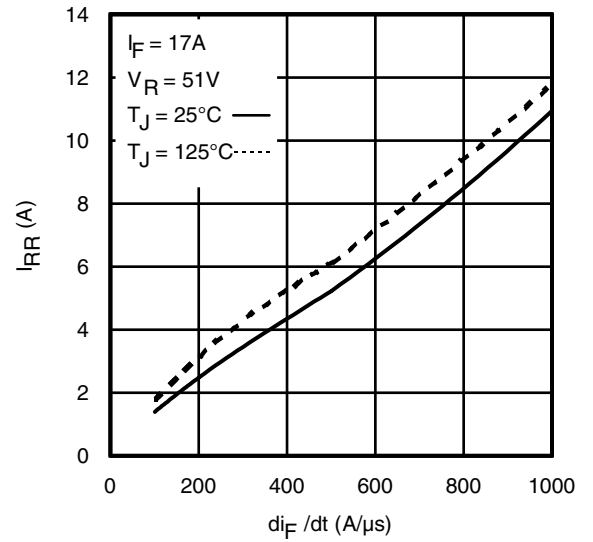
$$P_{D(ave)} = 1/2 (1.3 \cdot BV \cdot I_{av}) = \Delta T / Z_{thJC}$$

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

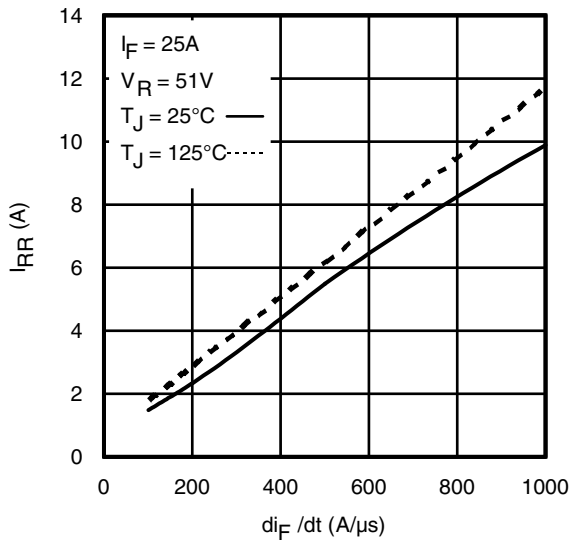
$$E_{AS(AR)} = P_{D(ave)} \cdot t_{av}$$



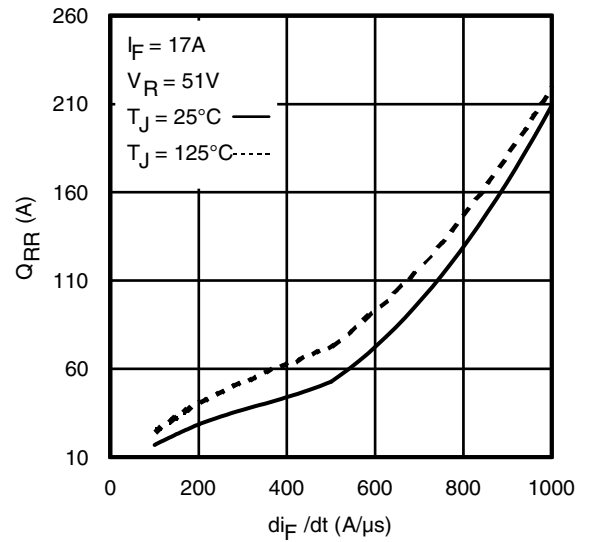
**Fig 16.** Threshold Voltage vs. Temperature



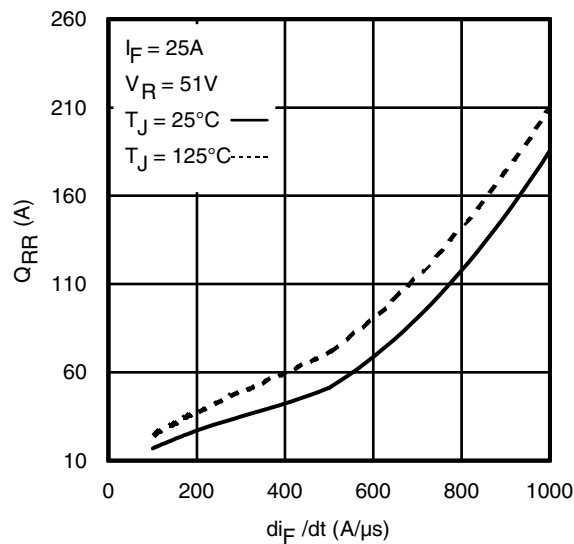
**Fig. 17** - Typical Recovery Current vs.  $di_F/dt$



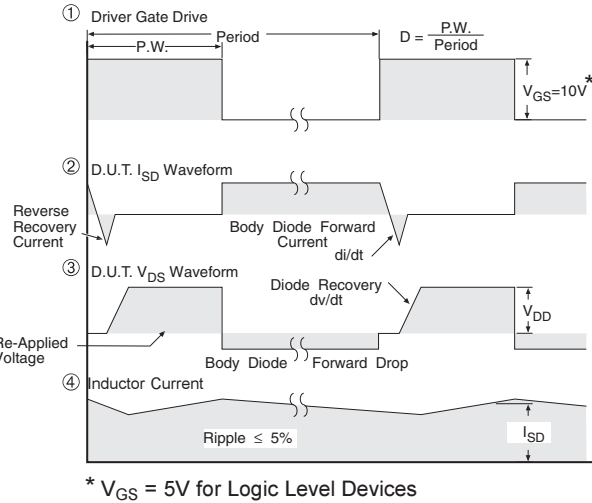
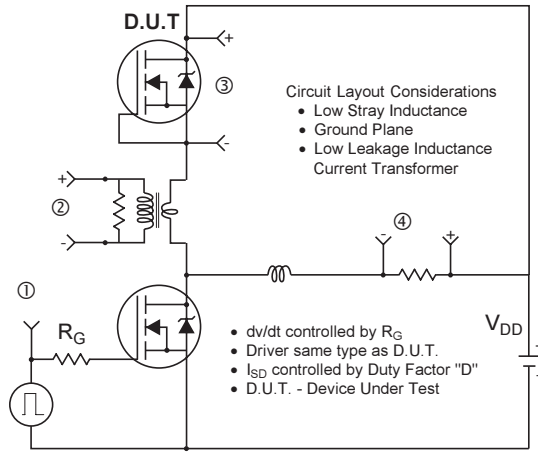
**Fig. 18** - Typical Recovery Current vs.  $di_F/dt$



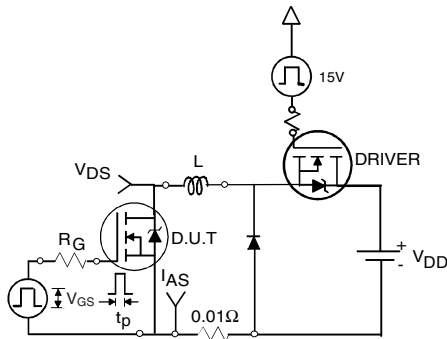
**Fig. 19** - Typical Stored Charge vs.  $di_F/dt$



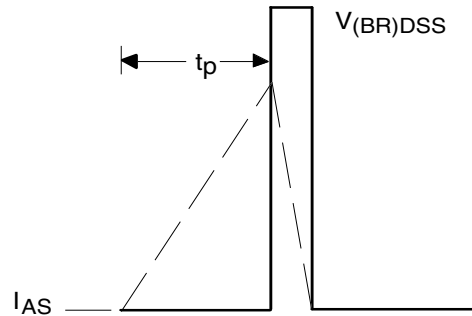
**Fig. 20** - Typical Stored Charge vs.  $di_F/dt$



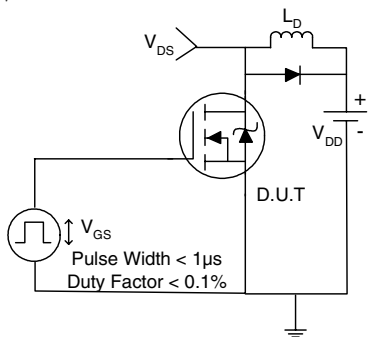
**Fig 20. Peak Diode Recovery  $dv/dt$  Test Circuit for N-Channel HEXFET® Power MOSFETs**



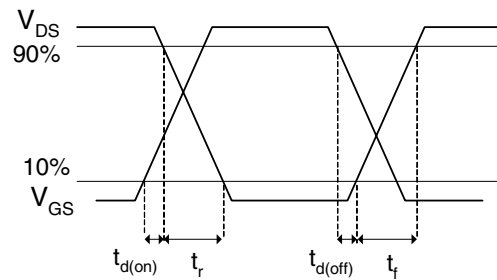
**Fig 21a. Unclamped Inductive Test Circuit**



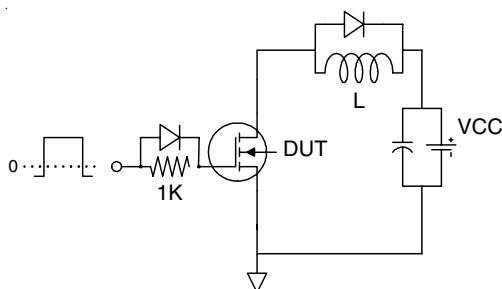
**Fig 21b. Unclamped Inductive Waveforms**



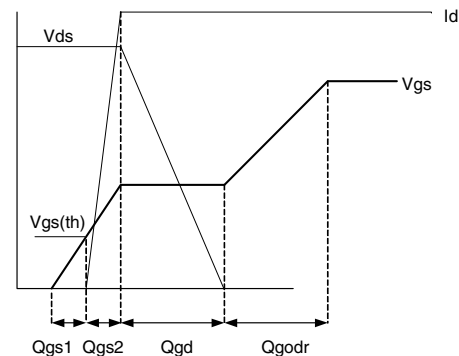
**Fig 22a. Switching Time Test Circuit**



**Fig 22b. Switching Time Waveforms**

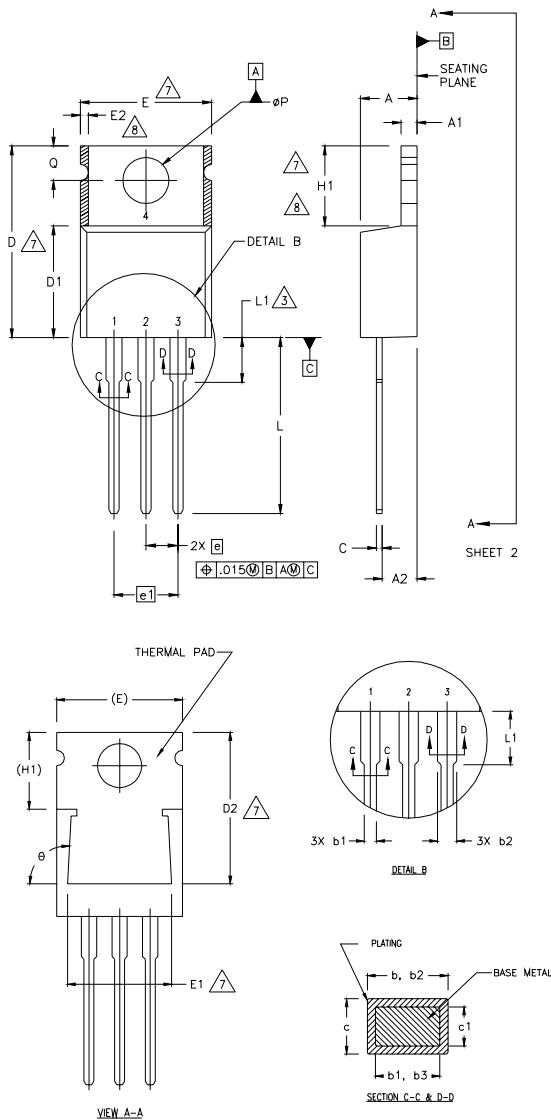


**Fig 23a. Gate Charge Test Circuit**



**Fig 23b. Gate Charge Waveform**

# TO-220AB Package Outline (Dimensions are shown in millimeters (inches))



## NOTES:

- 1 DIMENSIONING AND TOLERANCING PER ASME Y14.5 M- 1994.
- 2 DIMENSIONS ARE SHOWN IN INCHES [MILLIMETERS].
- 3 LEAD DIMENSION AND FINISH UNCONTROLLED IN L1.
- 4 DIMENSION D & E DO NOT INCLUDE MOLD FLASH. MOLD FLASH SHALL NOT EXCEED .005" (0.127) PER SIDE. THESE DIMENSIONS ARE MEASURED AT THE OUTERMOST EXTREMES OF THE PLASTIC BODY.
- 5 DIMENSION b1 & c1 APPLY TO BASE METAL ONLY.
- 6 CONTROLLING DIMENSION : INCHES.
- 7 THERMAL PAD CONTOUR OPTIONAL WITHIN DIMENSIONS E,H1,D2 & E1
- 8 DIMENSION E2 X H1 DEFINE A ZONE WHERE STAMPING AND SINGULATION IRREGULARITIES ARE ALLOWED.

## LEAD ASSIGNMENTS

### HEXFET

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

### IGBTs, CoPACK

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

### DIODES

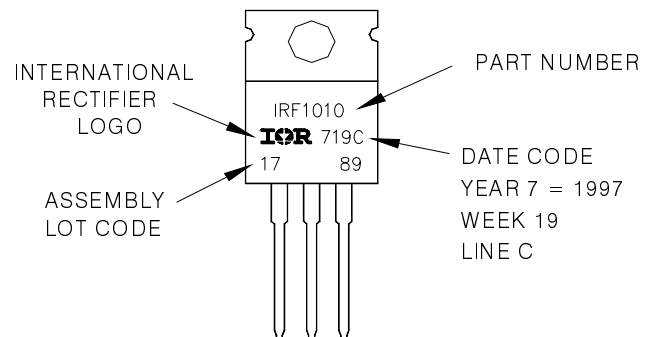
- 1.- ANODE/OPEN
- 2.- CATHODE
- 3.- ANODE

| 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 | 5     |
| D      | 14.22       | 16.51 | .560     | .650 |       |
| D1     | 8.38        | 9.02  | .330     | .355 | 4     |
| D2     | 12.19       | 12.88 | .480     | .507 |       |
| E      | 9.66        | 10.66 | .380     | .420 | 4,7   |
| E1     | 8.38        | 8.89  | .330     | .350 |       |
| 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 | 3     |
| ø      | 90°–93°     |       | 90°–93°  |      |       |

## 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"

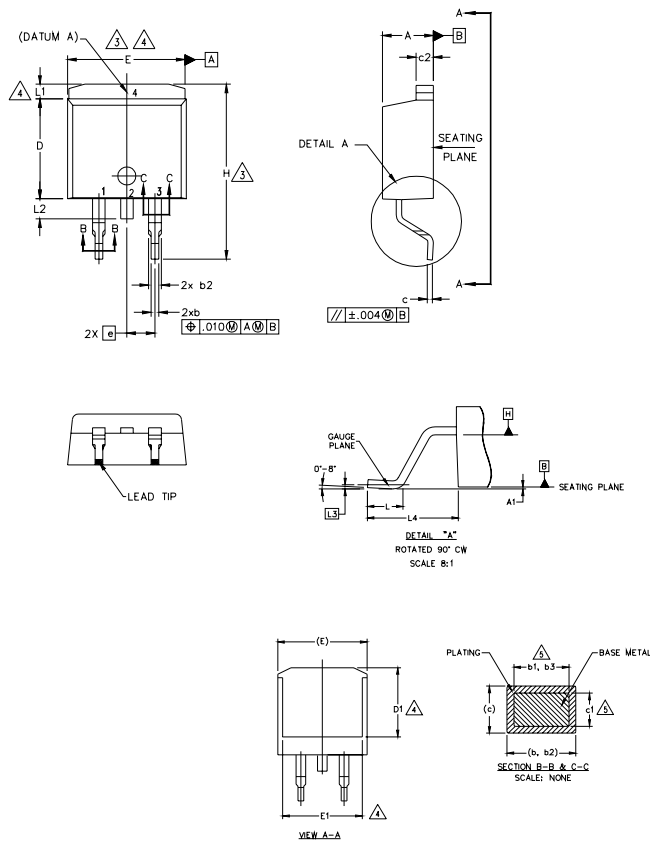


TO-220AB packages are not recommended for Surface Mount Application.

**Note:** For the most current drawing please refer to IR website at <http://www.irf.com/package/>

## D<sup>2</sup>Pak (TO-263AB) Package Outline

Dimensions are shown in millimeters (inches)



### NOTES:

1. DIMENSIONING AND TOLERANCING PER ASME Y14.5M-1994
2. DIMENSIONS ARE SHOWN IN MILLIMETERS [INCHES].
3. DIMENSION D & E DO NOT INCLUDE MOLD FLASH. MOLD FLASH SHALL NOT EXCEED 0.127 [0.005] PER SIDE. THESE DIMENSIONS ARE MEASURED AT THE OUTMOST EXTREMES OF THE PLASTIC BODY AT DATUM H.
4. THERMAL PAD CONTOUR OPTIONAL WITHIN DIMENSION E, L1, D1 & E1.
5. DIMENSION b1 AND c1 APPLY TO BASE METAL ONLY.
6. DATUM A & B TO BE DETERMINED AT DATUM PLANE H.
7. CONTROLLING DIMENSION: INCH.
8. OUTLINE CONFORMS TO JEDEC OUTLINE TO-263AB.

| 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 | 5     |
| b2     | 1.14        | 1.78  | .045     | .070 |       |
| b3     | 1.14        | 1.73  | .045     | .068 | 5     |
| c      | 0.38        | 0.74  | .015     | .029 |       |
| c1     | 0.38        | 0.58  | .015     | .023 | 5     |
| c2     | 1.14        | 1.65  | .045     | .065 |       |
| D      | 8.38        | 9.65  | .330     | .380 | 3     |
| D1     | 6.86        | —     | .270     | —    | 4     |
| E      | 9.65        | 10.67 | .380     | .420 | 3,4   |
| E1     | 6.22        | —     | .245     | —    | 4     |
| e      | 2.54 BSC    |       | .100 BSC |      |       |
| H      | 14.61       | 15.88 | .575     | .625 |       |
| L      | 1.78        | 2.79  | .070     | .110 |       |
| L1     | —           | 1.65  | —        | .066 | 4     |
| L2     | 1.27        | 1.78  | —        | .070 |       |
| L3     | 0.25 BSC    |       | .010 BSC |      |       |
| L4     | 4.78        | 5.28  | .188     | .208 |       |

### LEAD ASSIGNMENTS

#### HEXFET

1. — GATE
- 2, 4. — DRAIN
3. — SOURCE

#### IGBTs, CoPACK

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

#### DIODES

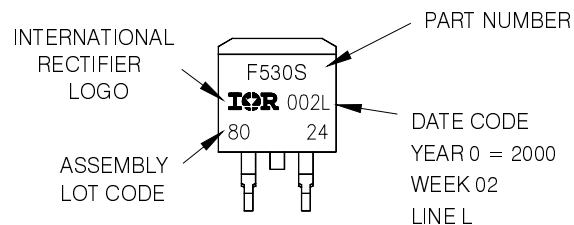
1. — ANODE \*
- 2, 4. — CATHODE
3. — ANODE

\* PART DEPENDENT.

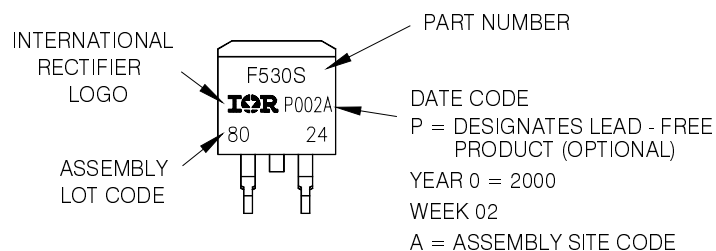
## D<sup>2</sup>Pak (TO-263AB) Part Marking Information

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



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

Dimensions are shown in millimeters (inches)



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. THERMAL PAD CONTOUR OPTIONAL WITHIN DIMENSION E, L1, D1 & E1.
5. DIMENSION b1 AND c1 APPLY TO BASE METAL ONLY.
6. CONTROLLING DIMENSION: INCH.
- 7.- OUTLINE CONFORM TO JEDEC TO-262 EXCEPT A1(max.), b(min.) AND D1(min.) WHERE DIMENSIONS DERIVED THE ACTUAL PACKAGE OUTLINE.

### LEAD ASSIGNMENTS

## HEXFET

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

## IGBTs, CoPACK

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

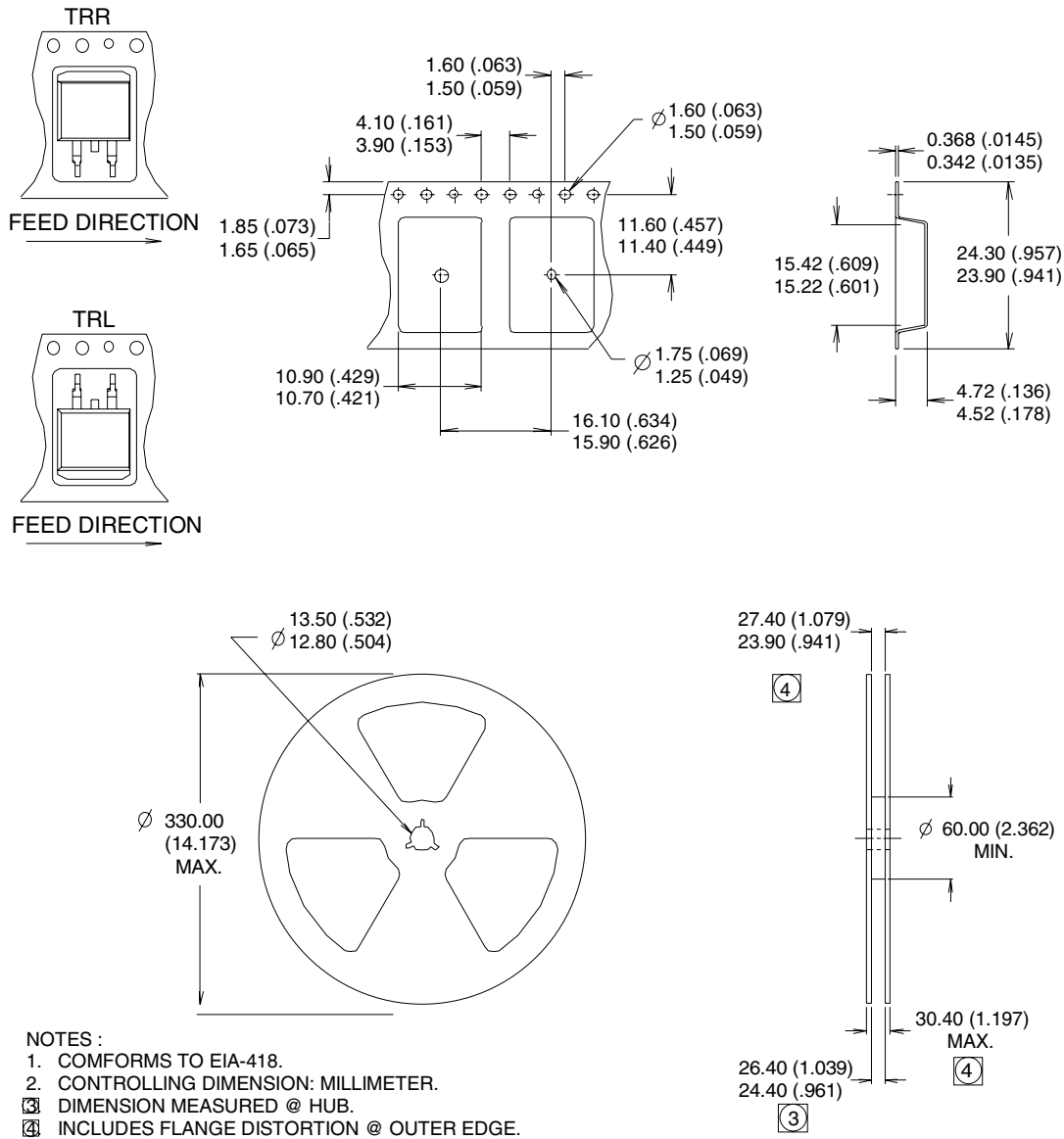
EXAMPLE: THIS IS AN IRL3103L  
LOT CODE 1789  
ASSEMBLED ON WW 19, 1997  
IN THE ASSEMBLY LINE "C"

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



## D<sup>2</sup>Pak (TO-263AB) Tape & Reel Information

Dimensions are shown in millimeters (inches)



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

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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