

# International IOR Rectifier

## Applications

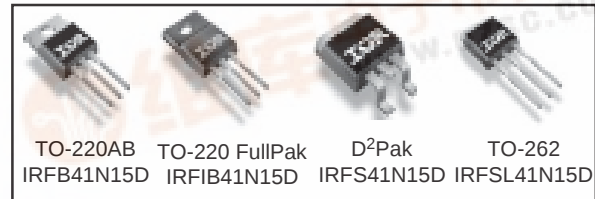
- High frequency DC-DC converters
- Lead-Free

## Benefits

- Low Gate-to-Drain Charge to Reduce Switching Losses
- Fully Characterized Capacitance Including Effective  $C_{OSS}$  to Simplify Design, (See App. Note AN1001)
- Fully Characterized Avalanche Voltage and Current

PD - 94927A  
IRFB41N15DPbF  
IRFIB41N15DPbF  
IRFS41N15DPbF  
IRFSL41N15DPbF  
HEXFET® Power MOSFET

| $V_{DSS}$ | $R_{DS(on)}$ max | $I_D$ |
|-----------|------------------|-------|
| 150V      | 0.045 $\Omega$   | 41A   |



## Absolute Maximum Ratings

|                                   | Parameter                                | Max.         | Units        |
|-----------------------------------|------------------------------------------|--------------|--------------|
| $I_D$ @ $T_C = 25^\circ\text{C}$  | Continuous Drain Current, $V_{GS}$ @ 10V | 41           | A            |
| $I_D$ @ $T_C = 100^\circ\text{C}$ | Continuous Drain Current, $V_{GS}$ @ 10V | 29           |              |
| $I_{DM}$                          | Pulsed Drain Current ①                   | 164          |              |
| $P_D$ @ $T_A = 25^\circ\text{C}$  | Power Dissipation, D²Pak                 | 3.1          | W            |
| $P_D$ @ $T_C = 25^\circ\text{C}$  | Power Dissipation, TO-220                | 200          |              |
| $P_D$ @ $T_C = 25^\circ\text{C}$  | Power Dissipation, Fullpak               | 48           |              |
|                                   | Linear Derating Factor, TO-220           | 1.3          | W/°C         |
|                                   | Linear Derating Factor, Fullpak          | 0.32         |              |
| $V_{GS}$                          | Gate-to-Source Voltage                   | $\pm 30$     | V            |
| $dv/dt$                           | Peak Diode Recovery $dv/dt$ ③            | 2.7          | V/ns         |
| $T_J$                             | Operating Junction and                   | -55 to + 175 | °C           |
| $T_{STG}$                         | Storage Temperature Range                |              |              |
|                                   | Soldering Temperature, for 10 seconds    |              |              |
|                                   | Mounting torque, 6-32 or M3 screw        | 1.1(10)      | N•m (lbf•in) |

## Thermal Resistance

|                 | Parameter                             | Typ. | Max. | Units |
|-----------------|---------------------------------------|------|------|-------|
| $R_{\theta JC}$ | Junction-to-Case                      | —    | 0.75 | °C/W  |
| $R_{\theta JC}$ | Junction-to-Case, Fullpak             | —    | 3.14 |       |
| $R_{\theta CS}$ | Case-to-Sink, Flat, Greased Surface ⑥ | 0.50 | —    |       |
| $R_{\theta JA}$ | Junction-to-Ambient, TO-220 ⑦         | —    | 62   |       |
| $R_{\theta JA}$ | Junction-to-Ambient, D²Pak ⑦          | —    | 40   |       |
| $R_{\theta JA}$ | Junction-to-Ambient, Fullpak          | —    | 65   |       |

Notes ① through ⑦ are on page 12

www.irf.com

# IRFB/IRFIB/IRFS/IRFSL41N15DPbF

International  
IR Rectifier

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

|                                 | Parameter                            | Min. | Typ. | Max.  | Units               | Conditions                                            |
|---------------------------------|--------------------------------------|------|------|-------|---------------------|-------------------------------------------------------|
| $V_{(BR)DSS}$                   | Drain-to-Source Breakdown Voltage    | 150  | —    | —     | V                   | $V_{GS} = 0V, I_D = 250\mu A$                         |
| $\Delta V_{(BR)DSS}/\Delta T_J$ | Breakdown Voltage Temp. Coefficient  | —    | 0.17 | —     | V/ $^\circ\text{C}$ | Reference to $25^\circ\text{C}$ , $I_D = 1mA$         |
| $R_{DS(on)}$                    | Static Drain-to-Source On-Resistance | —    | —    | 0.045 | $\Omega$            | $V_{GS} = 10V, I_D = 25A$ ④                           |
| $V_{GS(th)}$                    | Gate Threshold Voltage               | 3.0  | —    | 5.5   | V                   | $V_{DS} = V_{GS}, I_D = 250\mu A$                     |
| $I_{DSS}$                       | Drain-to-Source Leakage Current      | —    | —    | 25    | $\mu A$             | $V_{DS} = 150V, V_{GS} = 0V$                          |
|                                 |                                      | —    | —    | 250   |                     | $V_{DS} = 120V, V_{GS} = 0V, T_J = 150^\circ\text{C}$ |
| $I_{GSS}$                       | Gate-to-Source Forward Leakage       | —    | —    | 100   | nA                  | $V_{GS} = 30V$                                        |
|                                 | Gate-to-Source Reverse Leakage       | —    | —    | -100  |                     | $V_{GS} = -30V$                                       |

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

|                        | Parameter                       | Min. | Typ. | Max. | Units | Conditions                                    |
|------------------------|---------------------------------|------|------|------|-------|-----------------------------------------------|
| gfs                    | Forward Transconductance        | 18   | —    | —    | S     | $V_{DS} = 50V, I_D = 25A$                     |
| $Q_g$                  | Total Gate Charge               | —    | 72   | 110  | nC    | $I_D = 25A$                                   |
| $Q_{gs}$               | Gate-to-Source Charge           | —    | 21   | 31   |       | $V_{DS} = 120V$                               |
| $Q_{gd}$               | Gate-to-Drain ("Miller") Charge | —    | 35   | 52   |       | $V_{GS} = 10V$ ④                              |
| $t_{d(on)}$            | Turn-On Delay Time              | —    | 16   | —    | ns    | $V_{DD} = 75V$                                |
| $t_r$                  | Rise Time                       | —    | 63   | —    |       | $I_D = 25A$                                   |
| $t_{d(off)}$           | Turn-Off Delay Time             | —    | 25   | —    |       | $R_G = 2.5\Omega$                             |
| $t_f$                  | Fall Time                       | —    | 14   | —    |       | $V_{GS} = 10V$ ④                              |
| $C_{iss}$              | Input Capacitance               | —    | 2520 | —    | pF    | $V_{GS} = 0V$                                 |
| $C_{oss}$              | Output Capacitance              | —    | 510  | —    |       | $V_{DS} = 25V$                                |
| $C_{rss}$              | Reverse Transfer Capacitance    | —    | 110  | —    |       | $f = 1.0MHz$                                  |
| $C_{oss}$              | Output Capacitance              | —    | 3090 | —    |       | $V_{GS} = 0V, V_{DS} = 1.0V, f = 1.0MHz$      |
| $C_{oss}$              | Output Capacitance              | —    | 230  | —    |       | $V_{GS} = 0V, V_{DS} = 120V, f = 1.0MHz$      |
| $C_{oss \text{ eff.}}$ | Effective Output Capacitance    | —    | 250  | —    |       | $V_{GS} = 0V, V_{DS} = 0V \text{ to } 120V$ ⑤ |

## Avalanche Characteristics

|          | Parameter                       | Typ. | Max. | Units |
|----------|---------------------------------|------|------|-------|
| $E_{AS}$ | Single Pulse Avalanche Energy ② | —    | 470  | mJ    |
| $I_{AR}$ | Avalanche Current ①             | —    | 25   | A     |
| $E_{AR}$ | Repetitive Avalanche Energy ①   | —    | 20   | mJ    |

## Diode Characteristics

|          | Parameter                                 | Min.                                                                 | Typ. | Max. | Units   | Conditions                                                              |
|----------|-------------------------------------------|----------------------------------------------------------------------|------|------|---------|-------------------------------------------------------------------------|
| $I_S$    | Continuous Source Current<br>(Body Diode) | —                                                                    | —    | 41   | A       | MOSFET symbol<br>showing the<br>integral reverse<br>p-n junction diode. |
| $I_{SM}$ | Pulsed Source Current<br>(Body Diode) ①   | —                                                                    | —    | 164  |         |                                                                         |
| $V_{SD}$ | Diode Forward Voltage                     | —                                                                    | —    | 1.3  | V       | $T_J = 25^\circ\text{C}, I_S = 25A, V_{GS} = 0V$ ④                      |
| $t_{rr}$ | Reverse Recovery Time                     | —                                                                    | 170  | 260  | ns      | $T_J = 25^\circ\text{C}, I_F = 25A$                                     |
| $Q_{rr}$ | Reverse Recovery Charge                   | —                                                                    | 1.3  | 1.9  | $\mu C$ | $di/dt = 100A/\mu s$ ④                                                  |
| $t_{on}$ | Forward Turn-On Time                      | Intrinsic turn-on time is negligible (turn-on is dominated by LS+LD) |      |      |         |                                                                         |

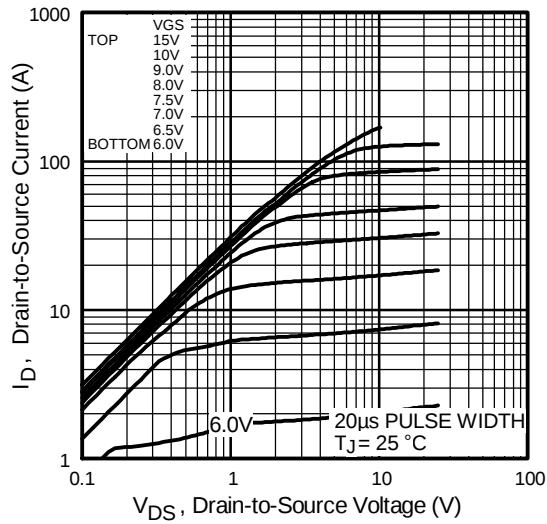


Fig 1. Typical Output Characteristics

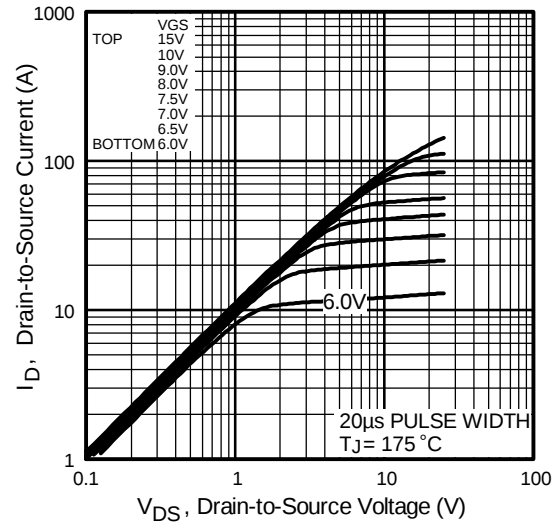


Fig 2. Typical Output Characteristics

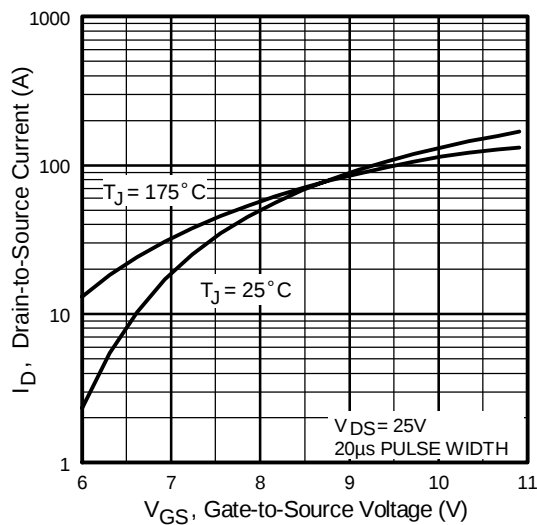


Fig 3. Typical Transfer Characteristics

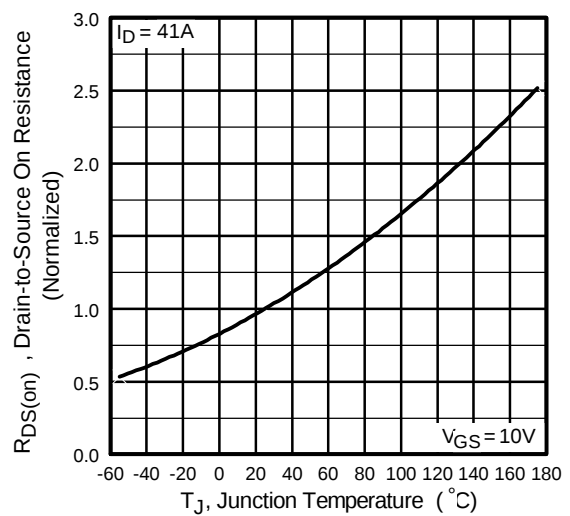
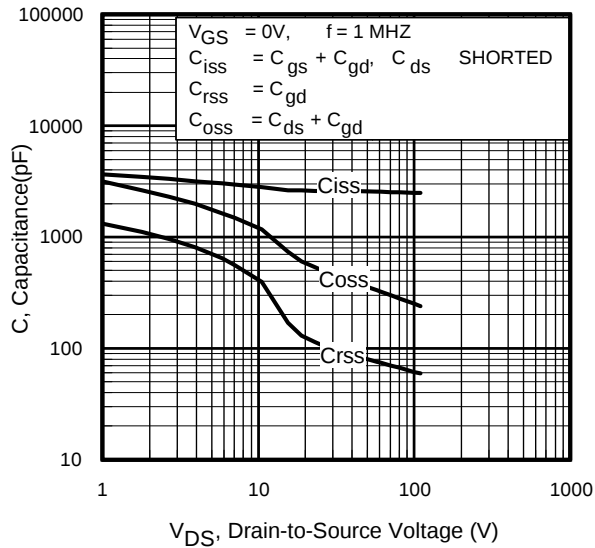
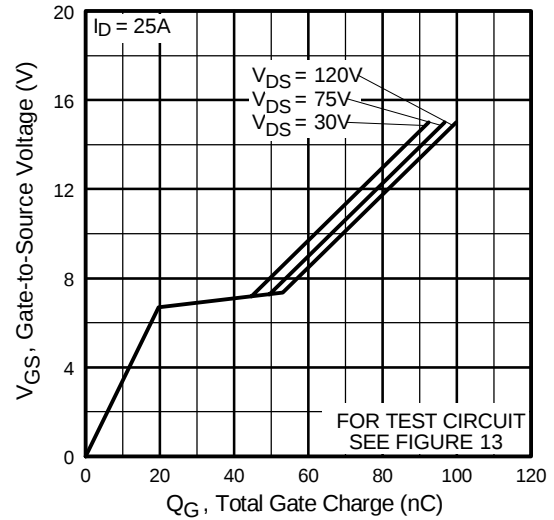


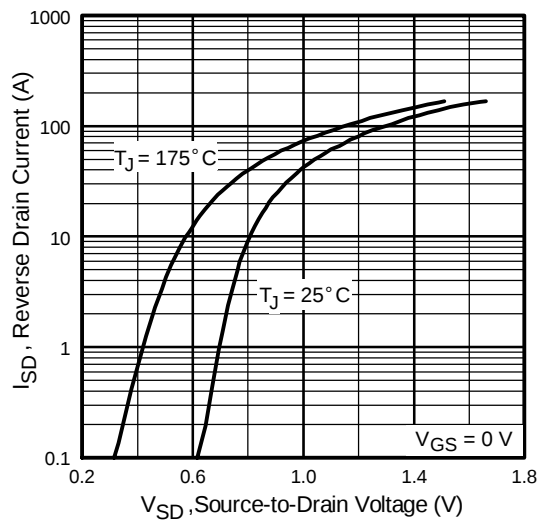
Fig 4. Normalized On-Resistance vs. Temperature



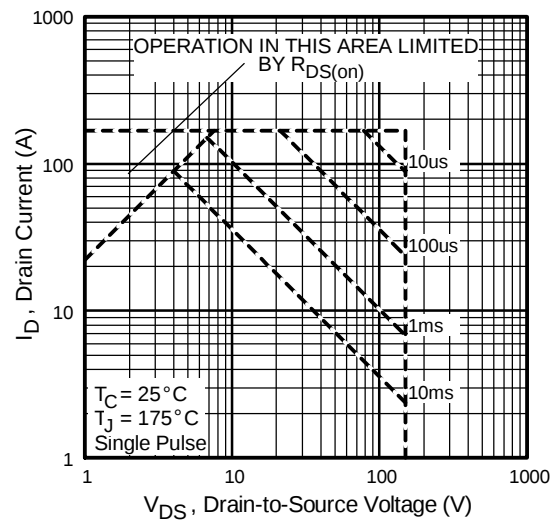
**Fig 5.** Typical Capacitance Vs. Drain-to-Source Voltage



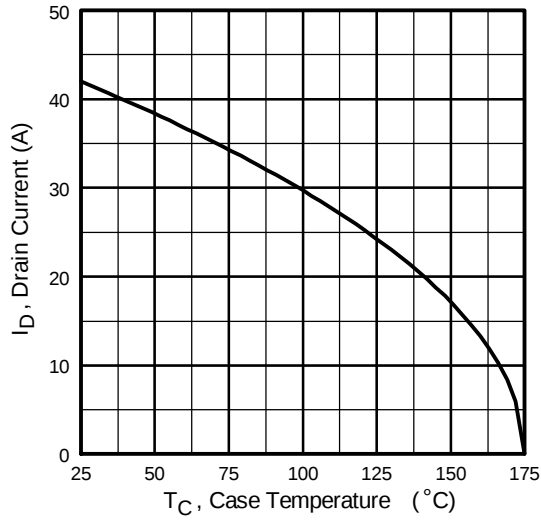
**Fig 6.** Typical Gate Charge Vs. Gate-to-Source Voltage



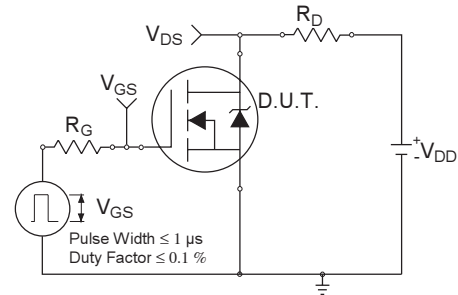
**Fig 7.** Typical Source-Drain Diode Forward Voltage



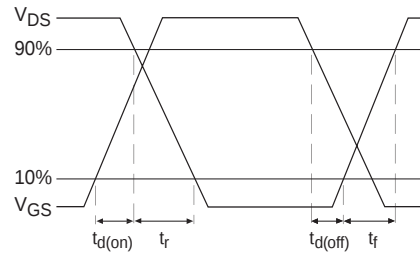
**Fig 8.** Maximum Safe Operating Area



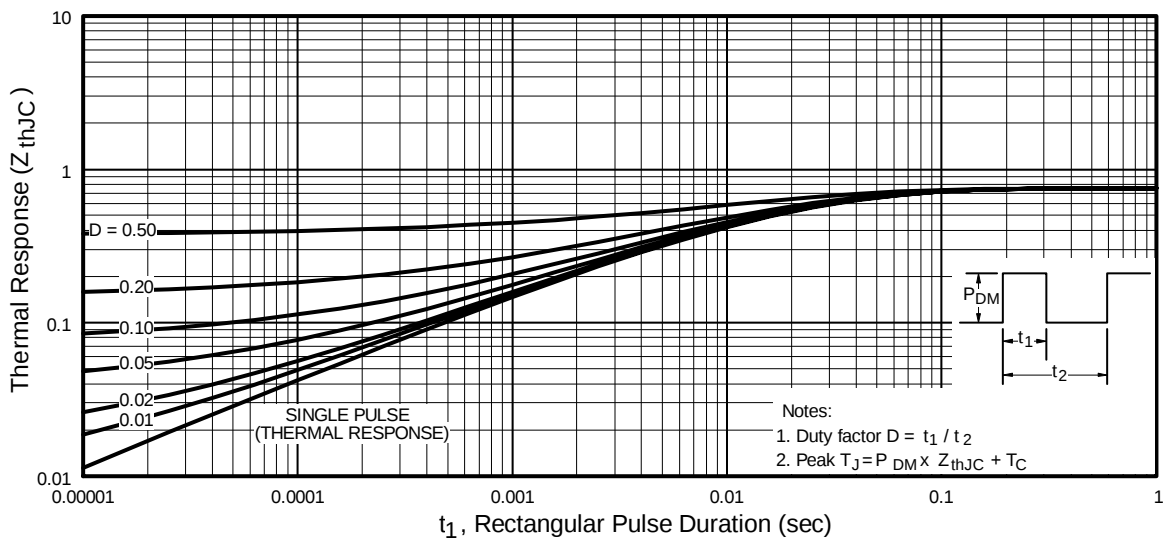
**Fig 9.** Maximum Drain Current Vs. Case Temperature



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



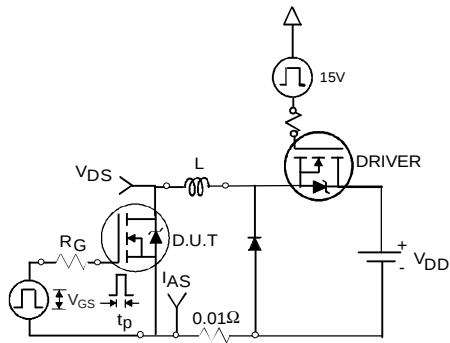
**Fig 10b.** Switching Time Waveforms



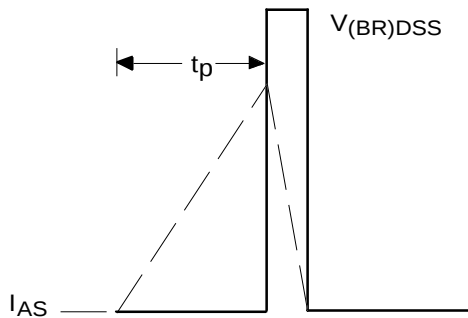
**Fig 11.** Maximum Effective Transient Thermal Impedance, Junction-to-Case

# IRFB/IRFIB/IRFS/IRFSL41N15DPbF

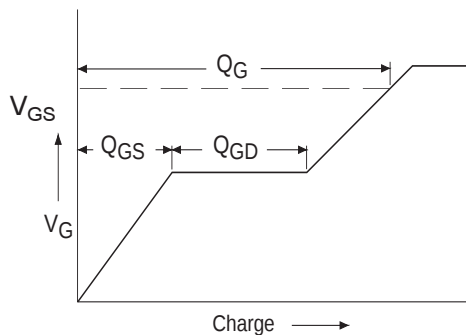
International  
**IR** Rectifier



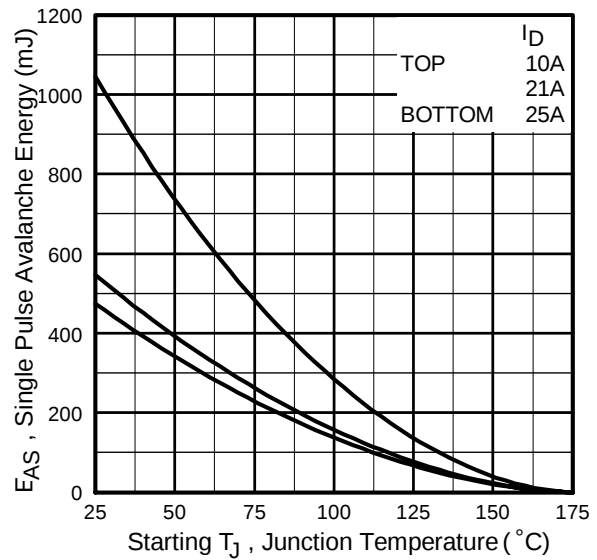
**Fig 12a.** Unclamped Inductive Test Circuit



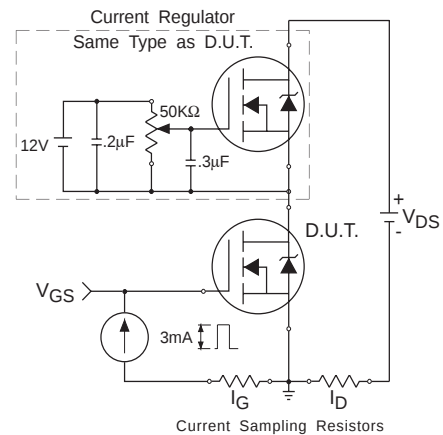
**Fig 12b.** Unclamped Inductive Waveforms



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

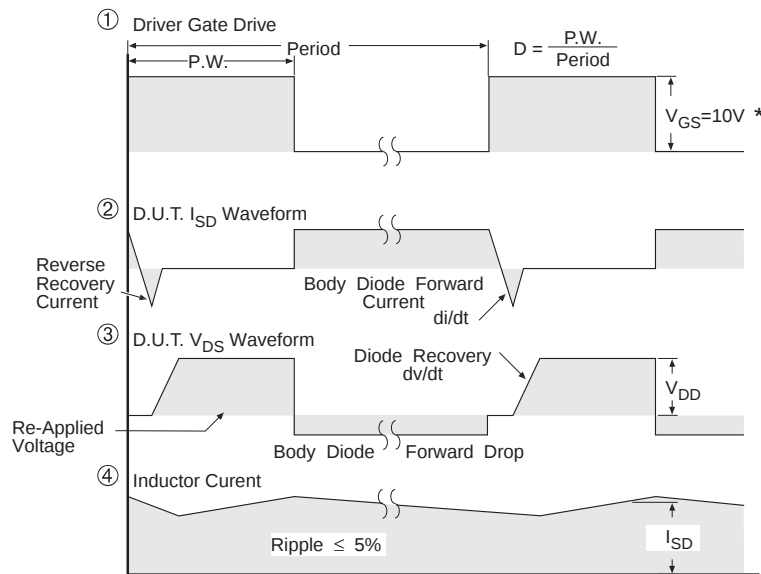
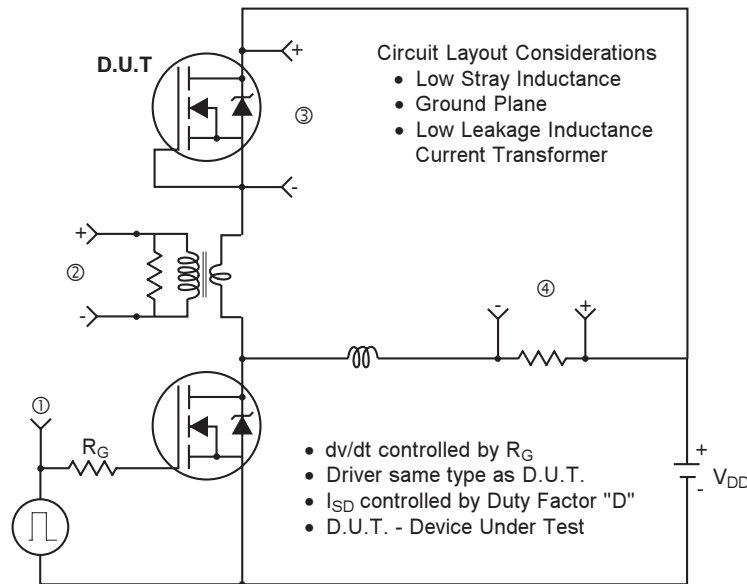


**Fig 12c.** Maximum Avalanche Energy Vs. Drain Current



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

## Peak Diode Recovery dv/dt Test Circuit



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

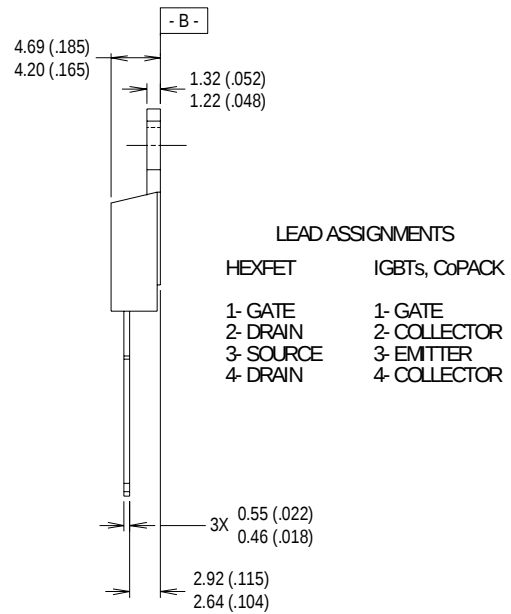
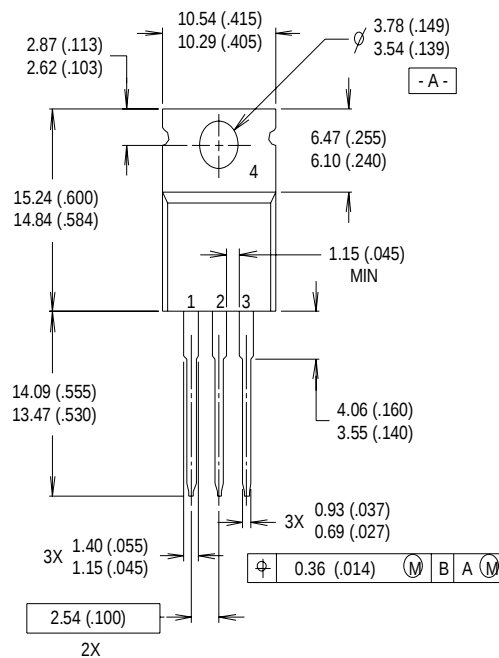
**Fig 14.** For N-Channel HEXFET® Power MOSFETs

# IRFB/IRFIB/IRFS/IRFSL41N15DPbF

International  
**IR** Rectifier

## TO-220AB Package Outline

Dimensions are shown in millimeters (inches)

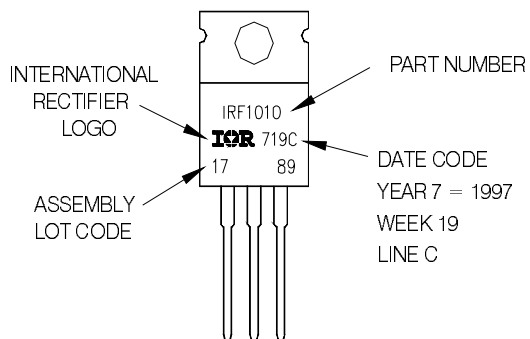


### NOTES:

- 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.

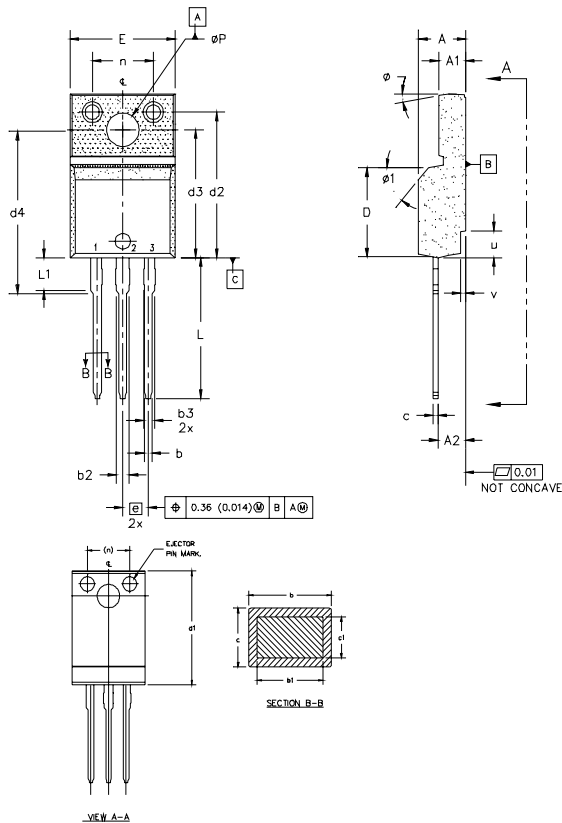
## TO-220AB Part Marking Information

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-220 Full-Pak Package Outline

Dimensions are shown in millimeters (inches)



- NOTES:
- 1.0 DIMENSIONING AND TOLERANCING PER ASME Y14.5 M- 1994.
  - 2.0 DIMENSIONS ARE SHOWN IN MILLIMETERS (INCHES).
  - 3.0 LEAD DIMENSION AND FINISH UNCONTROLLED IN L1.
  - 4.0 DIMENSION D & E DO NOT INCLUDE MOLD FLASH. MOLD FLASH SHALL NOT EXCEED 0.005" (0.127) PER SIDE. THESE DIMENSIONS ARE MEASURED AT THE OUTERMOST EXTREMES OF THE PLASTIC BODY.
  - 5.0 DIMENSION b1 APPLY TO BASE METAL ONLY.
  - 6.0 STEP OPTIONAL ON PLASTIC BODY DEFINED BY DIMENSIONS u & v.
  - 7.0 CONTROLLING DIMENSION : INCHES.

| SYMBOL | DIMENSIONS  |       |           |       | NOTES | LEAD ASSIGNMENTS                                              |
|--------|-------------|-------|-----------|-------|-------|---------------------------------------------------------------|
|        | MILLIMETERS |       | INCHES    |       |       |                                                               |
|        | MIN.        | MAX.  | MIN.      | MAX.  |       |                                                               |
| A      | 4.57        | 4.83  | 0.180     | 0.190 | 5     | HXFET<br><br>1.- GATE<br>2.- DRAIN<br>3.- SOURCE              |
| A1     | 2.57        | 2.83  | 0.101     | 0.114 |       |                                                               |
| A2     | 2.51        | 2.85  | 0.099     | 0.112 |       |                                                               |
| b      | 0.622       | 0.89  | 0.024     | 0.035 |       |                                                               |
| b1     | 0.622       | 0.838 | 0.024     | 0.033 |       |                                                               |
| b2     | 1.229       | 1.400 | 0.048     | 0.055 | 4     | IGBTs, CoPACK<br><br>1.- GATE<br>2.- COLLECTOR<br>3.- EMITTER |
| b3     | 1.229       | 1.400 | 0.048     | 0.055 |       |                                                               |
| c      | 0.440       | 0.629 | 0.017     | 0.025 |       |                                                               |
| c1     | 0.440       | 0.584 | 0.017     | 0.023 |       |                                                               |
| D      | 8.65        | 9.80  | 0.341     | 0.386 |       |                                                               |
| d1     | 15.80       | 16.12 | 0.622     | 0.635 | 4     |                                                               |
| d2     | 13.97       | 14.22 | 0.550     | 0.560 |       |                                                               |
| d3     | 12.30       | 12.92 | 0.484     | 0.509 |       |                                                               |
| d4     | 8.64        | 9.91  | 0.340     | 0.390 |       |                                                               |
| E      | 10.36       | 10.63 | 0.408     | 0.419 |       |                                                               |
| e      | 2.54 BSC    |       | 0.100 BSC |       | 3     |                                                               |
| L      | 13.20       | 13.73 | 0.520     | 0.541 |       |                                                               |
| L1     | 3.10        | 3.50  | 0.122     | 0.138 |       |                                                               |
| n      | 6.05        | 6.15  | 0.238     | 0.242 |       |                                                               |
| ϕP     | 3.05        | 3.45  | 0.120     | 0.136 |       |                                                               |
| u      | 2.40        | 2.50  | 0.094     | 0.098 | 6     |                                                               |
| v      | 0.40        | 0.50  | 0.016     | 0.020 |       |                                                               |
| ϕ      | 3"          | 7"    | 3"        | 7"    |       |                                                               |
| ϕ1     |             | 45"   |           | 45"   |       |                                                               |

LEAD ASSIGNMENTS

HEXFET

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

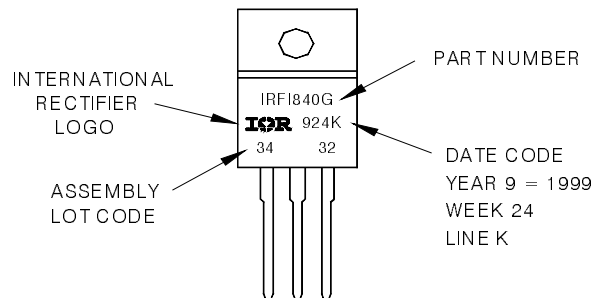
IGBTs, CoPACK

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

## TO-220 Full-Pak Part Marking Information

EXAMPLE: THIS IS AN IRF1840G  
 WITH ASSEMBLY  
 LOT CODE 3432  
 ASSEMBLED ON WW 24 1999  
 IN THE ASSEMBLY LINE "K"

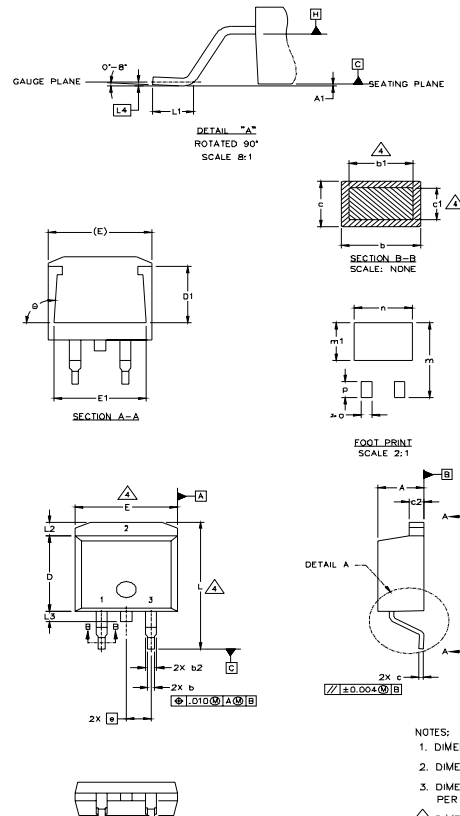
**Note:** "P" in assembly line  
 position indicates "Lead-Free"



# IRFB/IRFIB/IRFS/IRFSL41N15DPbF

International  
**IR** Rectifier

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



| 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     | IGBTs, CoPACK | DIODES      |
|------------|---------------|-------------|
| 1.- GATE   | 1.- GATE      | 1.- ANODE * |
| 2.- DRAIN  | 2.- COLLECTOR | 2.- CATHODE |
| 3.- SOURCE | 3.- EMITTER   | 3.- ANODE   |

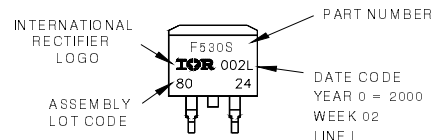
\* PART DEPENDENT.

- 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.

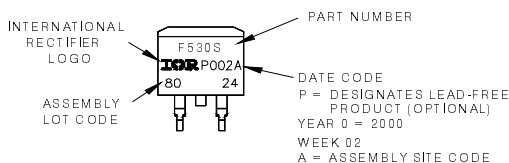
## D<sup>2</sup>Pak Part Marking Information (Lead-Free)

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

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

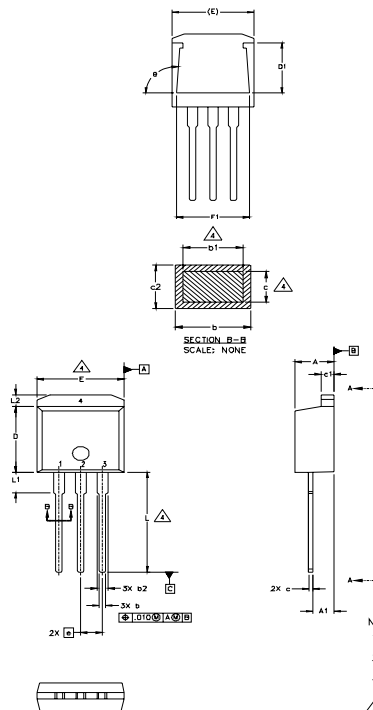


OR



## TO-262 Package Outline

Dimensions are shown in millimeters (inches)



| SYMBOL | DIMENSIONS  |       |          |      | NOTES |
|--------|-------------|-------|----------|------|-------|
|        | MILLIMETERS |       | INCHES   |      |       |
|        | MIN.        | MAX.  | MIN.     | MAX. |       |
| A      | 4.06        | 4.83  | .160     | .190 |       |
| A1     | 2.03        | 2.92  | .080     | .115 |       |
| b      | 0.51        | 0.99  | .020     | .039 |       |
| b1     | 0.51        | 0.89  | .020     | .035 | 4     |
| b2     | 1.14        | 1.40  | .045     | .055 |       |
| c      | 0.38        | 0.63  | .015     | .025 | 4     |
| 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     | IGBT          |
|------------|---------------|
| 1.- GATE   | 1 - GATE      |
| 2.- DRAIN  | 2 - COLLECTOR |
| 3.- SOURCE | 3 - EMITTER   |
| 4.- DRAIN  |               |

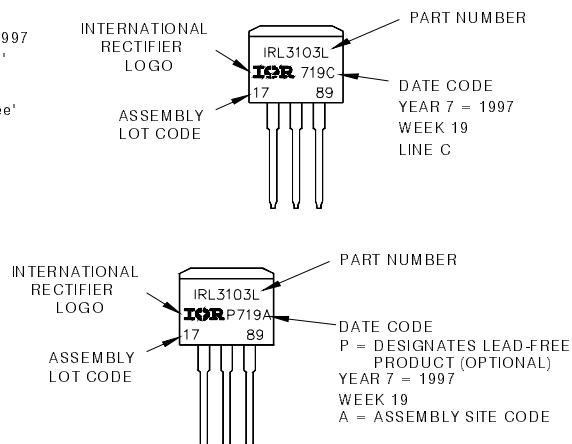
- NOTES:
1. DIMENSIONING AND TOLERANCING PER ASME Y14.5M-1994
  2. DIMENSIONS ARE SHOWN IN MILLIMETERS [INCHES].
  3. DIMENSION D & E DO NOT INCLUDE MOLD FLASH. MOLD FLASH SHALL NOT EXCEED 0.127 [0.005"] PER SIDE. THESE DIMENSIONS ARE MEASURED AT THE OUTMOST EXTREMES OF THE PLASTIC BODY.
  4. DIMENSION b1 AND c1 APPLY TO BASE METAL ONLY.
  5. CONTROLLING DIMENSION: INCH.

## TO-262 Part Marking Information

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

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

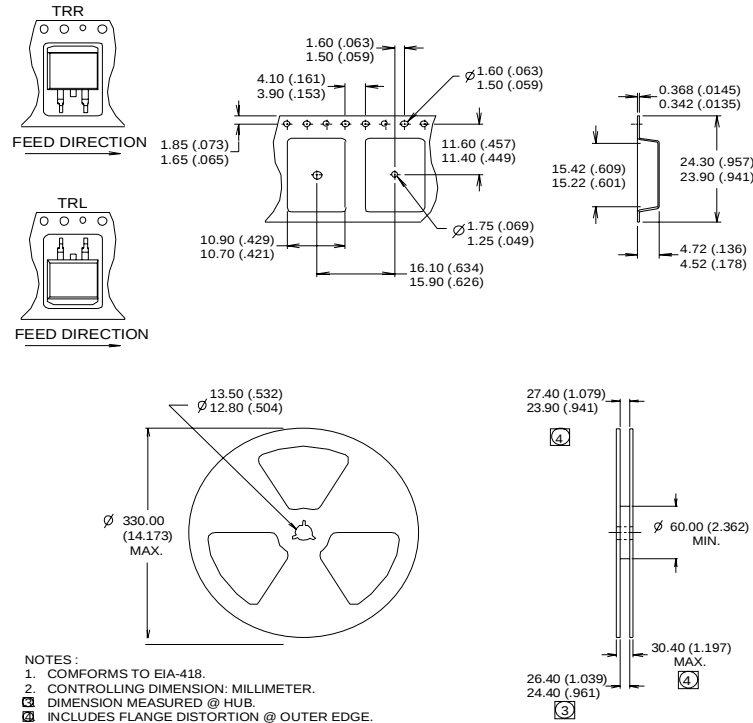
OR



# IRFB/IRFIB/IRFS/IRFSL41N15DPbF

International  
**IR** Rectifier

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



### Notes:

- ① Repetitive rating; pulse width limited by max. junction temperature.
- ② Starting  $T_J = 25^\circ\text{C}$ ,  $L = 1.5\text{mH}$ ,  $R_G = 25\Omega$ ,  $I_{AS} = 25\text{A}$ .
- ③  $I_{SD} \leq 25\text{A}$ ,  $di/dt \leq 340\text{A}/\mu\text{s}$ ,  $V_{DD} \leq V_{(BR)DSS}$ ,  $T_J \leq 175^\circ\text{C}$ .
- ④ Pulse width  $\leq 300\mu\text{s}$ ; duty cycle  $\leq 2\%$ .
- ⑤  $C_{OSS}$  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 This is only applied to TO-220AB package.
- ⑦ This is applied to D<sup>2</sup>Pak, when mounted on 1" square PCB (FR-4 or G-10 Material). For recommended footprint and soldering techniques refer to application note #AN-994.

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

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

**IR WORLD HEADQUARTERS:** 233 Kansas St., El Segundo, California 90245, USA Tel: (310) 252-7105  
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Visit us at [www.irf.com](http://www.irf.com) for sales contact information. **08/2006**

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