

# IRF1010EZPbF IRF1010EZSPbF IRF1010EZLPbF

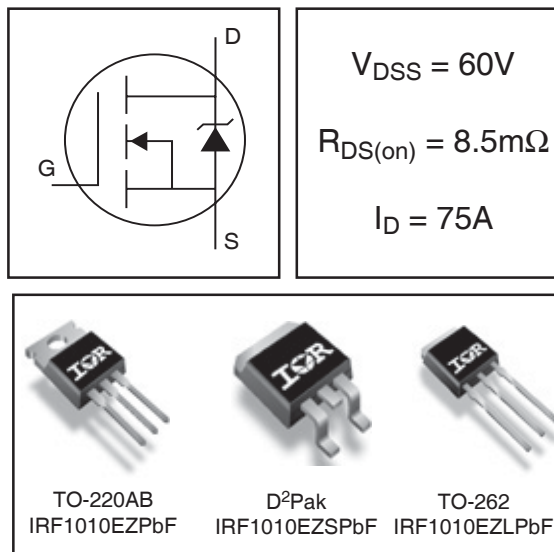
## Features

- Advanced Process Technology
- Ultra Low On-Resistance
- Dynamic dv/dt Rating
- 175°C Operating Temperature
- Fast Switching
- Repetitive Avalanche Allowed up to  $T_{jmax}$
- Lead-Free

## Description

This HEXFET® Power MOSFET utilizes the latest processing techniques to achieve extremely low on-resistance per silicon area. Additional features of this design are a 175°C junction operating temperature, fast switching speed and improved repetitive avalanche rating. These features combine to make this design an extremely efficient and reliable device for use in a wide variety of applications.

HEXFET® Power MOSFET



## Absolute Maximum Ratings

|                           | Parameter                                                  | Max.                   | Units |
|---------------------------|------------------------------------------------------------|------------------------|-------|
| $I_D @ T_C = 25^\circ C$  | Continuous Drain Current, $V_{GS} @ 10V$ (Silicon Limited) | 84                     | A     |
| $I_D @ T_C = 100^\circ C$ | Continuous Drain Current, $V_{GS} @ 10V$ (See Fig. 9)      | 60                     |       |
| $I_D @ T_C = 25^\circ C$  | Continuous Drain Current, $V_{GS} @ 10V$ (Package Limited) | 75                     |       |
| $I_{DM}$                  | Pulsed Drain Current ①                                     | 340                    |       |
| $P_D @ T_C = 25^\circ C$  | Maximum Power Dissipation                                  | 140                    | W     |
|                           | Linear Derating Factor                                     | 0.90                   | W/°C  |
| $V_{GS}$                  | Gate-to-Source Voltage                                     | $\pm 20$               | V     |
| $E_{AS}$                  | Single Pulse Avalanche Energy (Thermally Limited) ②        | 99                     | mJ    |
| $E_{AS} (tested)$         | Single Pulse Avalanche Energy Tested Value ②               | 180                    |       |
| $I_{AR}$                  | Avalanche Current ①                                        | See Fig.12a,12b,15,16  | A     |
| $E_{AR}$                  | Repetitive Avalanche Energy ③                              |                        | mJ    |
| $T_J$                     | Operating Junction and                                     | -55 to + 175           | °C    |
| $T_{STG}$                 | Storage Temperature Range                                  |                        |       |
|                           | Soldering Temperature, for 10 seconds                      | 300 (1.6mm from case ) |       |
|                           | Mounting torque, 6-32 or M3 screw                          | 10 lbf•in (1.1N•m)     |       |

## Thermal Resistance

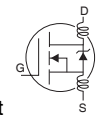
|                 | Parameter                                      | Typ. | Max. | Units |
|-----------------|------------------------------------------------|------|------|-------|
| $R_{\theta JC}$ | Junction-to-Case                               | —    | 1.11 | °C/W  |
| $R_{\theta CS}$ | Case-to-Sink, Flat, Greased Surface            | 0.50 | —    |       |
| $R_{\theta JA}$ | Junction-to-Ambient                            | —    | 62   |       |
| $R_{\theta JA}$ | Junction-to-Ambient (PCB Mount, steady state)③ | —    | 40   |       |

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

|                              | Parameter                            | Min. | Typ.  | Max. | Units               | Conditions                                                                  |
|------------------------------|--------------------------------------|------|-------|------|---------------------|-----------------------------------------------------------------------------|
| $V_{(BR)DSS}$                | Drain-to-Source Breakdown Voltage    | 60   | —     | —    | V                   | $V_{GS} = 0V, I_D = 250\mu A$                                               |
| $\Delta BV_{DSS}/\Delta T_J$ | Breakdown Voltage Temp. Coefficient  | —    | 0.058 | —    | V/ $^\circ\text{C}$ | Reference to $25^\circ\text{C}$ , $I_D = 1\text{mA}$                        |
| $R_{DS(on)}$                 | Static Drain-to-Source On-Resistance | —    | 6.8   | 8.5  | m $\Omega$          | $V_{GS} = 10V, I_D = 51A$ ④                                                 |
| $V_{GS(th)}$                 | Gate Threshold Voltage               | 2.0  | —     | 4.0  | V                   | $V_{DS} = V_{GS}, I_D = 100\mu A$                                           |
| $g_{fs}$                     | Forward Transconductance             | 200  | —     | —    | S                   | $V_{DS} = 25V, I_D = 51A$                                                   |
| $I_{DSS}$                    | Drain-to-Source Leakage Current      | —    | —     | 20   | $\mu A$             | $V_{DS} = 60V, V_{GS} = 0V$                                                 |
|                              |                                      | —    | —     | 250  |                     | $V_{DS} = 60V, V_{GS} = 0V, T_J = 125^\circ\text{C}$                        |
| $I_{GSS}$                    | Gate-to-Source Forward Leakage       | —    | —     | 200  | nA                  | $V_{GS} = 20V$                                                              |
|                              | Gate-to-Source Reverse Leakage       | —    | —     | -200 |                     | $V_{GS} = -20V$                                                             |
| $Q_g$                        | Total Gate Charge                    | —    | 58    | 86   | nC                  | $I_D = 51A$                                                                 |
| $Q_{gs}$                     | Gate-to-Source Charge                | —    | 19    | 28   |                     | $V_{DS} = 48V$                                                              |
| $Q_{gd}$                     | Gate-to-Drain ("Miller") Charge      | —    | 21    | 32   |                     | $V_{GS} = 10V$ ④                                                            |
| $t_{d(on)}$                  | Turn-On Delay Time                   | —    | 19    | —    | ns                  | $V_{DD} = 30V$                                                              |
| $t_r$                        | Rise Time                            | —    | 90    | —    |                     | $I_D = 51A$                                                                 |
| $t_{d(off)}$                 | Turn-Off Delay Time                  | —    | 38    | —    |                     | $R_G = 7.95\Omega$                                                          |
| $t_f$                        | Fall Time                            | —    | 54    | —    |                     | $V_{GS} = 10V$ ④                                                            |
| $L_D$                        | Internal Drain Inductance            | —    | 4.5   | —    | nH                  | Between lead,<br>6mm (0.25in.)<br>from package<br>and center of die contact |
| $L_S$                        | Internal Source Inductance           | —    | 7.5   | —    |                     |                                                                             |
| $C_{iss}$                    | Input Capacitance                    | —    | 2810  | —    | pF                  | $V_{GS} = 0V$                                                               |
| $C_{oss}$                    | Output Capacitance                   | —    | 420   | —    |                     | $V_{DS} = 25V$                                                              |
| $C_{rss}$                    | Reverse Transfer Capacitance         | —    | 200   | —    |                     | $f = 1.0\text{MHz}$ , See Fig. 5                                            |
| $C_{oss}$                    | Output Capacitance                   | —    | 1440  | —    |                     | $V_{GS} = 0V, V_{DS} = 1.0V, f = 1.0\text{MHz}$                             |
| $C_{oss}$                    | Output Capacitance                   | —    | 320   | —    |                     | $V_{GS} = 0V, V_{DS} = 48V, f = 1.0\text{MHz}$                              |
| $C_{oss \text{ eff.}}$       | Effective Output Capacitance         | —    | 510   | —    |                     | $V_{GS} = 0V, V_{DS} = 0V \text{ to } 48V$                                  |

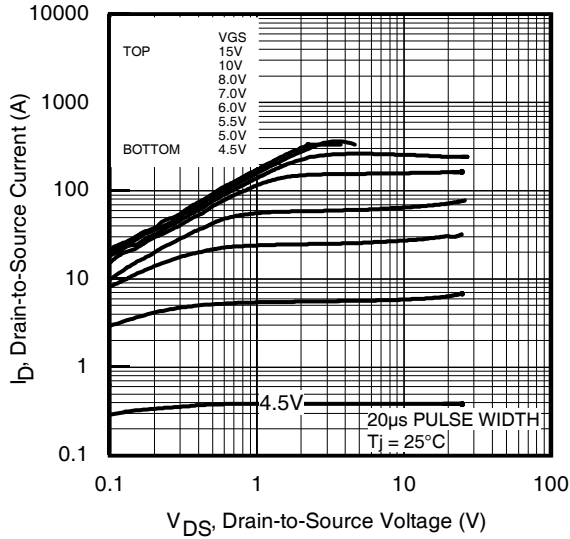


## Diode Characteristics

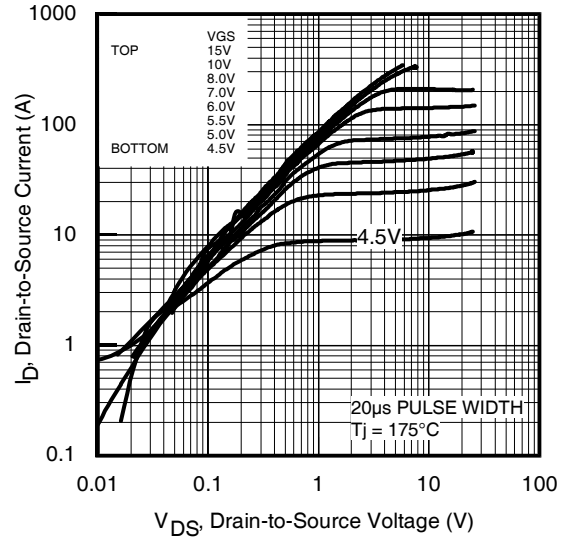
|          | Parameter                                 | Min.                                                                      | Typ. | Max. | Units | Conditions                                                              |
|----------|-------------------------------------------|---------------------------------------------------------------------------|------|------|-------|-------------------------------------------------------------------------|
| $I_S$    | Continuous Source Current<br>(Body Diode) | —                                                                         | —    | 84   | A     | MOSFET symbol<br>showing the<br>integral reverse<br>p-n junction diode. |
| $I_{SM}$ | Pulsed Source Current<br>(Body Diode) ①   | —                                                                         | —    | 340  |       |                                                                         |
| $V_{SD}$ | Diode Forward Voltage                     | —                                                                         | —    | 1.3  | V     | $T_J = 25^\circ\text{C}, I_S = 51A, V_{GS} = 0V$ ④                      |
| $t_{rr}$ | Reverse Recovery Time                     | —                                                                         | 41   | 62   | ns    | $T_J = 25^\circ\text{C}, I_F = 51A, V_{DD} = 30V$                       |
| $Q_{rr}$ | Reverse Recovery Charge                   | —                                                                         | 54   | 81   | nC    | $di/dt = 100A/\mu s$ ④                                                  |
| $t_{on}$ | Forward Turn-On Time                      | Intrinsic turn-on time is negligible (turn-on is dominated by $L_S+L_D$ ) |      |      |       |                                                                         |

### Notes:

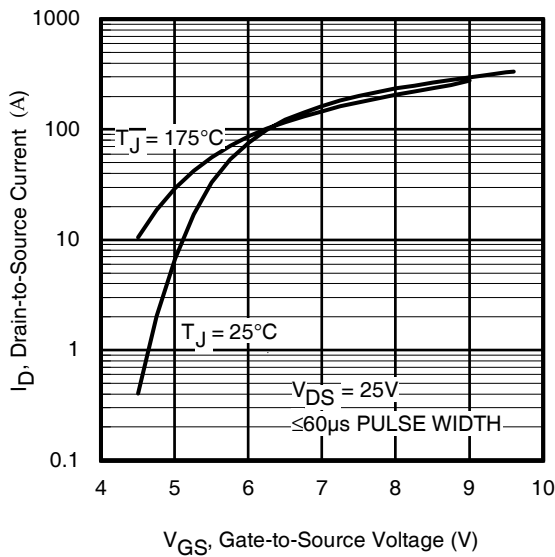
- ① Repetitive rating; pulse width limited by max. junction temperature. (See fig. 11).
- ② Limited by  $T_{Jmax}$ , starting  $T_J = 25^\circ\text{C}$ ,  $L = 0.077\text{mH}$ ,  $R_G = 25\Omega$ ,  $I_{AS} = 51A$ ,  $V_{GS} = 10V$ . Part not recommended for use above this value.
- ③  $I_{SD} \leq 51A$ ,  $di/dt \leq 260A/\mu s$ ,  $V_{DD} \leq V_{(BR)DSS}$ ,  $T_J \leq 175^\circ\text{C}$ .
- ④ Pulse width  $\leq 1.0\text{ms}$ ; 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 Limited by  $T_{Jmax}$ , see Fig.12a, 12b, 15, 16 for typical repetitive avalanche performance.
- ⑦ This value determined from sample failure population. 100% tested to this value in production.
- ⑧ 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.



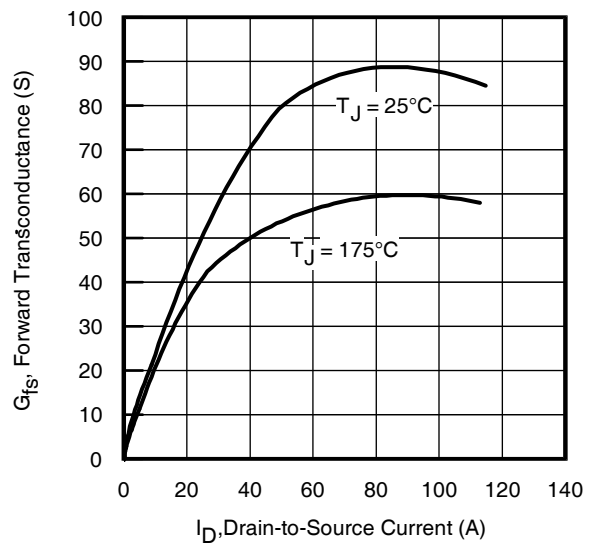
**Fig 1.** Typical Output Characteristics



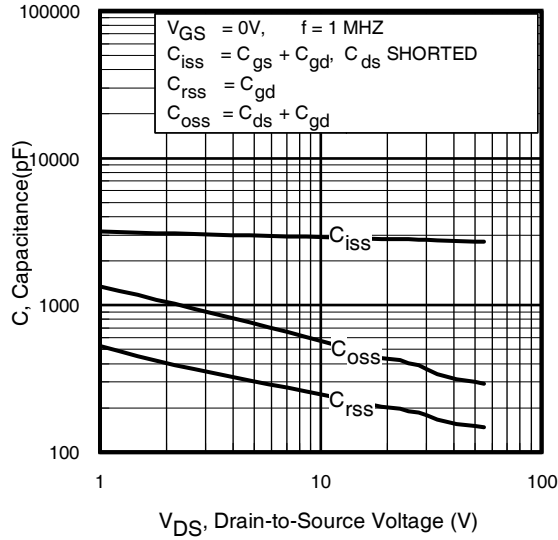
**Fig 2.** Typical Output Characteristics



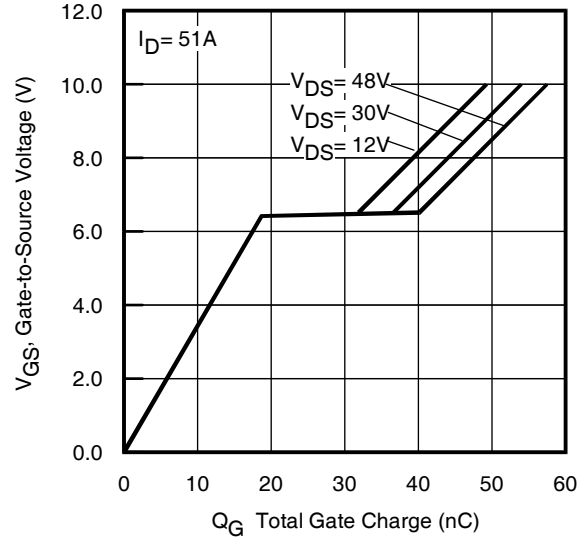
**Fig 3.** Typical Transfer Characteristics



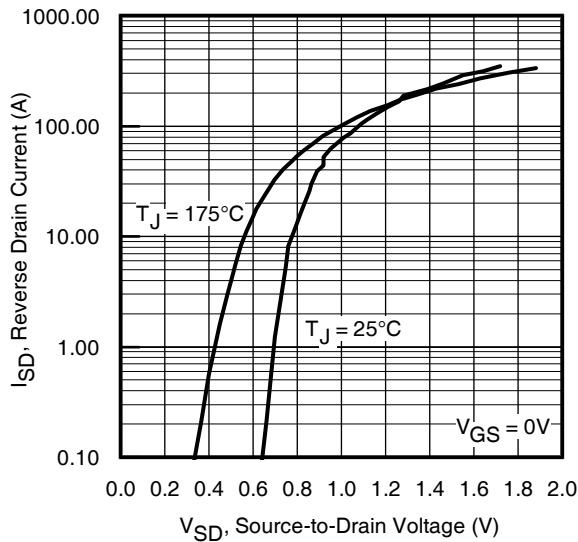
**Fig 4.** Typical Forward Transconductance vs. Drain Current



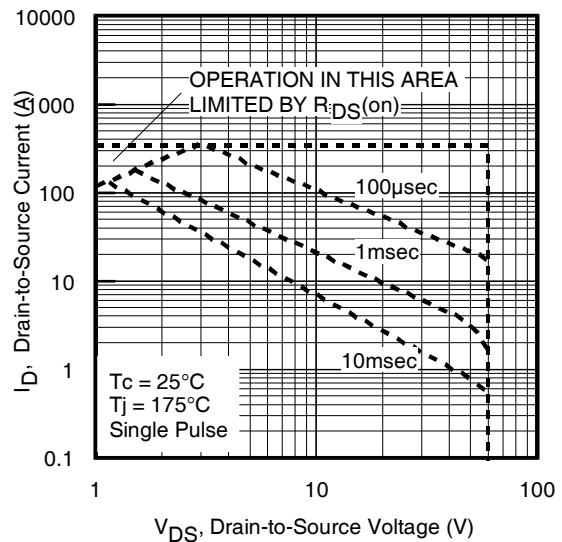
**Fig 5.** Typical Capacitance vs. Drain-to-Source Voltage



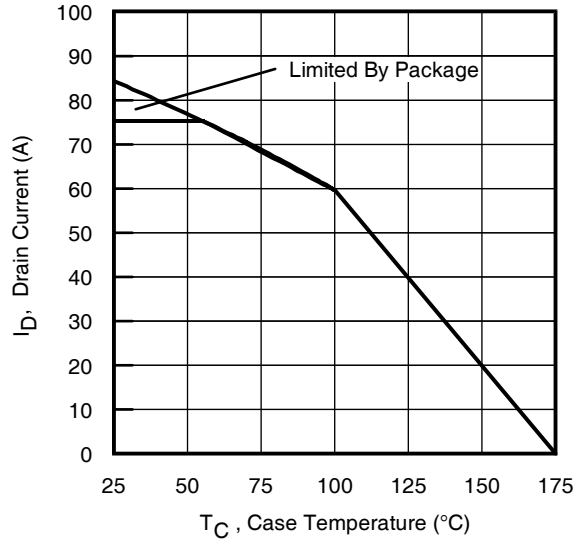
**Fig 6.** Typical Gate Charge vs. Gate-to-Source Voltage



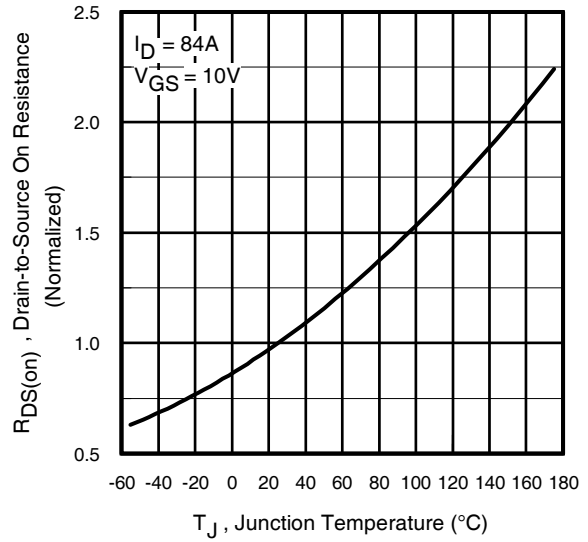
**Fig 7.** Typical Source-Drain Diode Forward Voltage



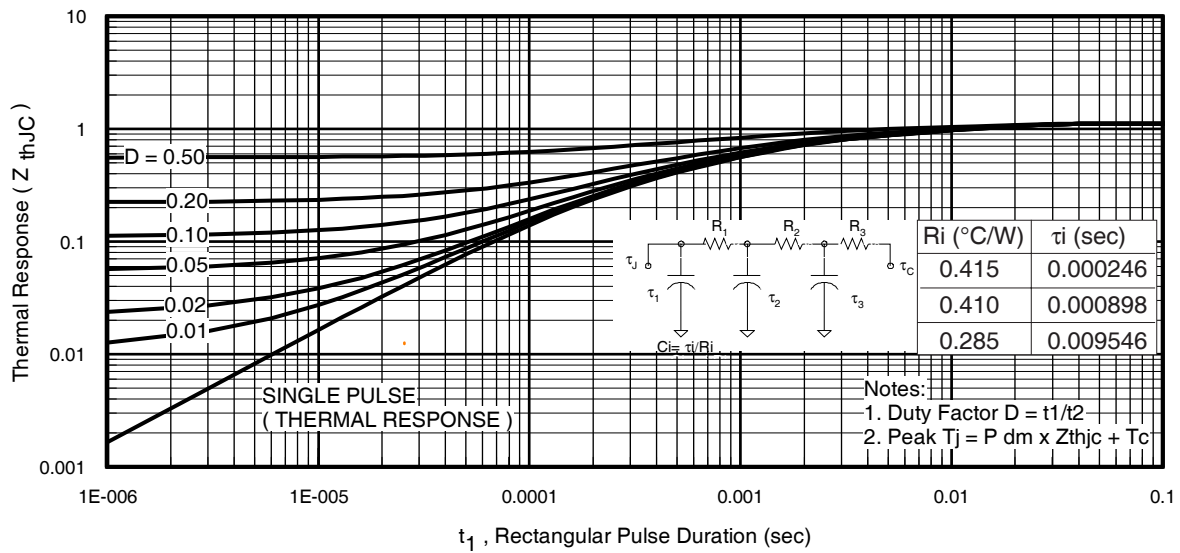
**Fig 8.** Maximum Safe Operating Area



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



**Fig 10.** Normalized On-Resistance vs. Temperature



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

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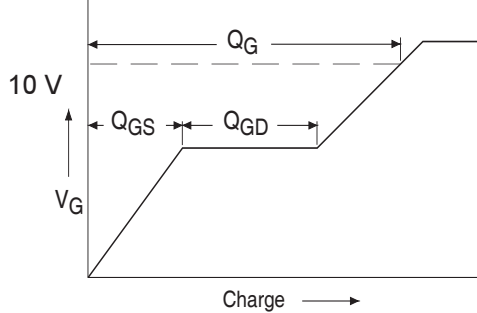
International  
**IR** Rectifier



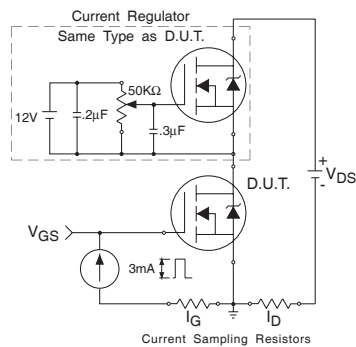
**Fig 12a.** Unclamped Inductive Test Circuit



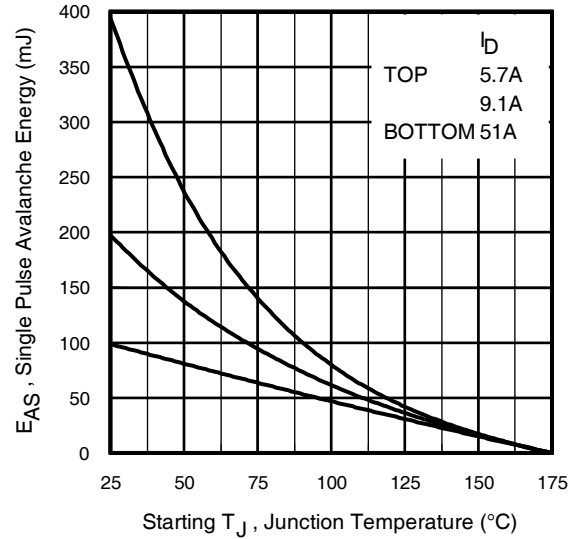
**Fig 12b.** Unclamped Inductive Waveforms



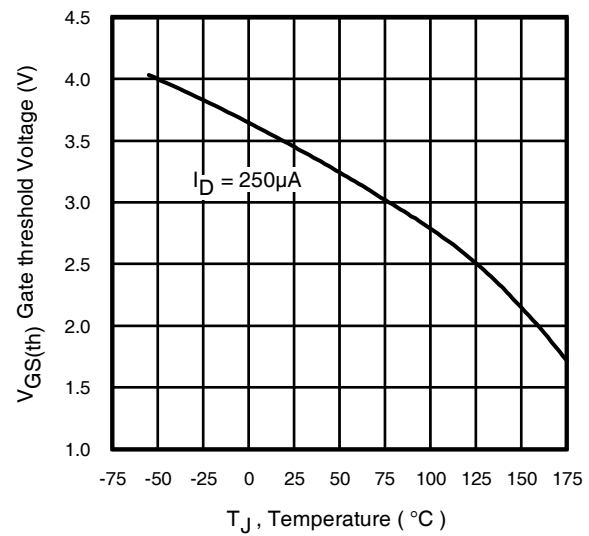
**Fig 13a.** Basic Gate Charge Waveform



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



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



**Fig 14.** Threshold Voltage vs. Temperature

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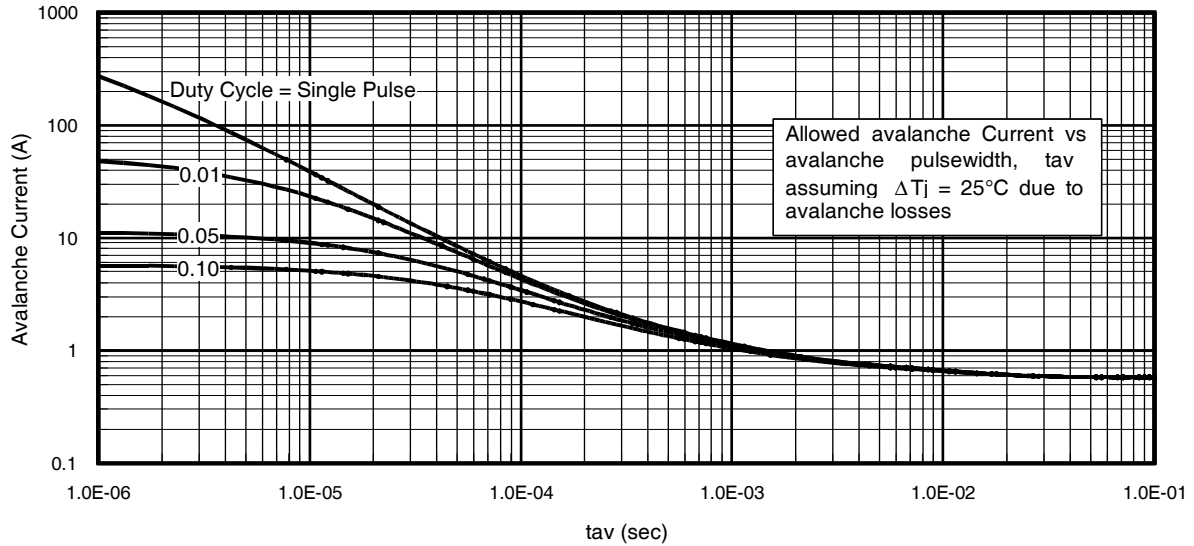


Fig 15. Typical Avalanche Current vs. Pulsewidth

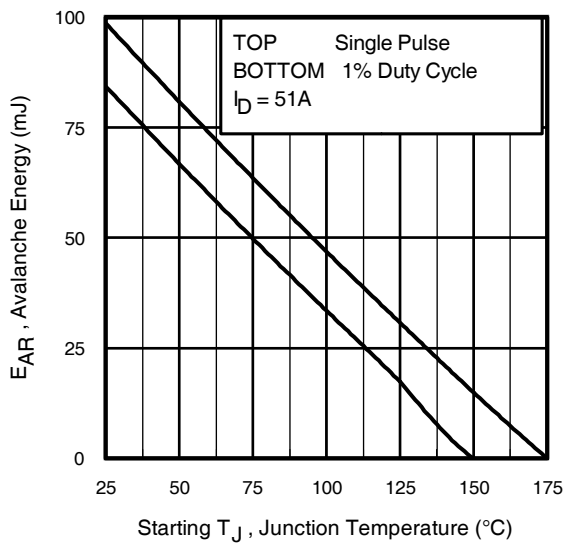


Fig 16. Maximum Avalanche Energy vs. Temperature

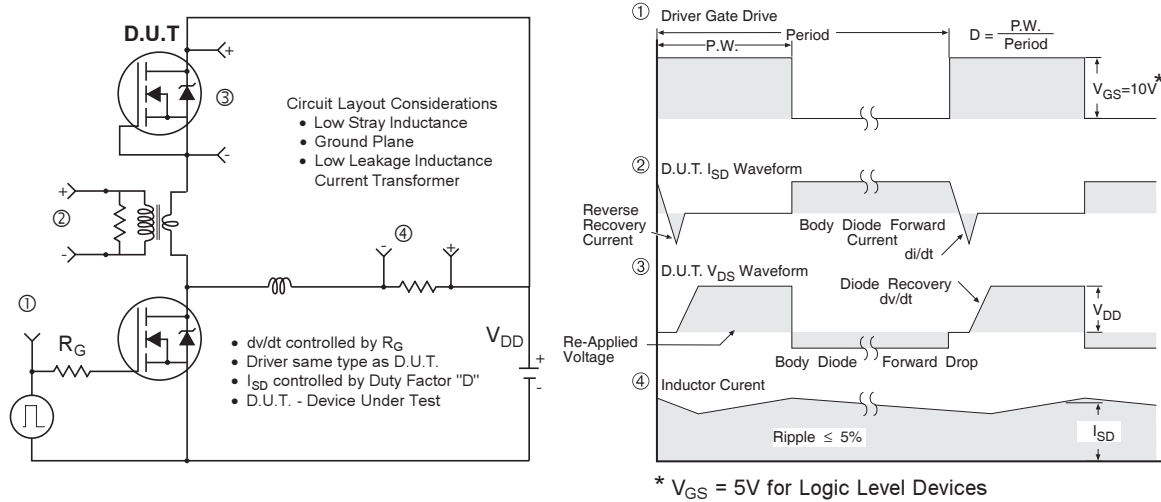
**Notes on Repetitive Avalanche Curves , Figures 15, 16:**  
(For further info, see AN-1005 at [www.irf.com](http://www.irf.com))

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 12a, 12b.
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 15, 16).  
 $t_{av}$  = Average time in avalanche.  
 $D$  = Duty cycle in avalanche =  $t_{av} \cdot f$   
 $Z_{thJC}(D, t_{av})$  = Transient thermal resistance, see figure 11)

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

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

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



**Fig 17. Peak Diode Recovery  $dv/dt$  Test Circuit for N-Channel HEXFET® Power MOSFETs**



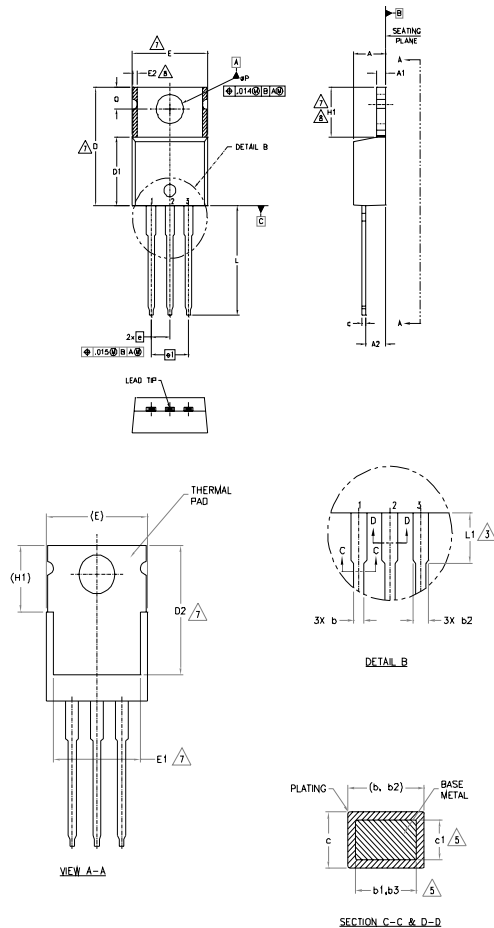
**Fig 18a. Switching Time Test Circuit**



**Fig 18b. Switching Time Waveforms**

## TO-220AB Package Outline

Dimensions are shown in millimeters (inches)



### NOTES

- 1.- DIMENSIONING AND TOLERANCING AS PER ASME Y14.5 M- 1994.
- 2.- DIMENSIONS ARE SHOWN IN INCHES [MILLIMETERS].
- 3.- LEAD DIMENSION AND FINISH UNCONTROLLED IN L1.
- 4.- DIMENSION D, D1 & 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, b3 & 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.
- 9.- OUTLINE CONFORMS TO JEDEC TO-220, EXCEPT A2 (max.) AND D2 (min.) WHERE DIMENSIONS ARE DERIVED FROM THE ACTUAL PACKAGE OUTLINE.

| SYMBOL | DIMENSIONS  |       |          |      | NOTES |
|--------|-------------|-------|----------|------|-------|
|        | MILLIMETERS |       | INCHES   |      |       |
|        | MIN.        | MAX.  | MIN.     | MAX. |       |
| A      | 3.56        | 4.83  | .140     | .190 |       |
| A1     | 0.51        | 1.40  | .020     | .055 |       |
| A2     | 2.03        | 2.92  | .080     | .115 |       |
| b      | 0.38        | 1.01  | .015     | .040 |       |
| b1     | 0.38        | 0.97  | .015     | .038 | 5     |
| b2     | 1.14        | 1.78  | .045     | .070 |       |
| b3     | 1.14        | 1.73  | .045     | .068 | 5     |
| c      | 0.36        | 0.61  | .014     | .024 |       |
| c1     | 0.36        | 0.56  | .014     | .022 | 5     |
| D      | 14.22       | 16.51 | .560     | .650 | 4     |
| D1     | 8.38        | 9.02  | .330     | .355 |       |
| D2     | 11.68       | 12.88 | .460     | .507 | 7     |
| E      | 9.65        | 10.67 | .380     | .420 | 4,7   |
| E1     | 6.86        | 8.89  | .270     | .350 | 7     |
| E2     | -           | 0.76  | -        | .030 | 8     |
| e      | 2.54 BSC    |       | .100 BSC |      |       |
| e1     | 5.08 BSC    |       | .200 BSC |      |       |
| H1     | 5.84        | 6.86  | .230     | .270 | 7,8   |
| L      | 12.70       | 14.73 | .500     | .580 |       |
| L1     | 3.56        | 4.06  | .140     | .160 | 3     |
| øP     | 3.54        | 4.08  | .139     | .161 |       |
| Q      | 2.54        | 3.42  | .100     | .135 |       |

### LEAD ASSIGNMENTS

- HEFEET
- 1- GATE
  - 2- DRAIN
  - 3- SOURCE

### IRF1010 GATE

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

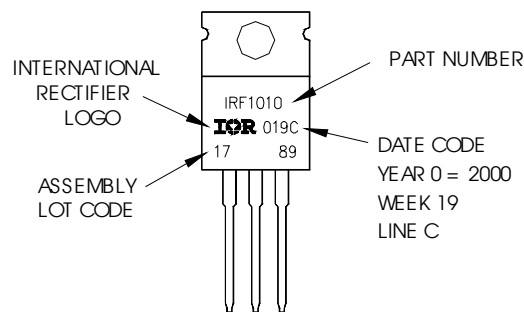
### DIODES

- 1- ANODE
- 2- CATHODE
- 3- ANODE

## TO-220AB Part Marking Information

EXAMPLE: THIS IS AN IRF1010  
LOT CODE 1789  
ASSEMBLED ON WW 19, 2000  
IN THE ASSEMBLY LINE "C"

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



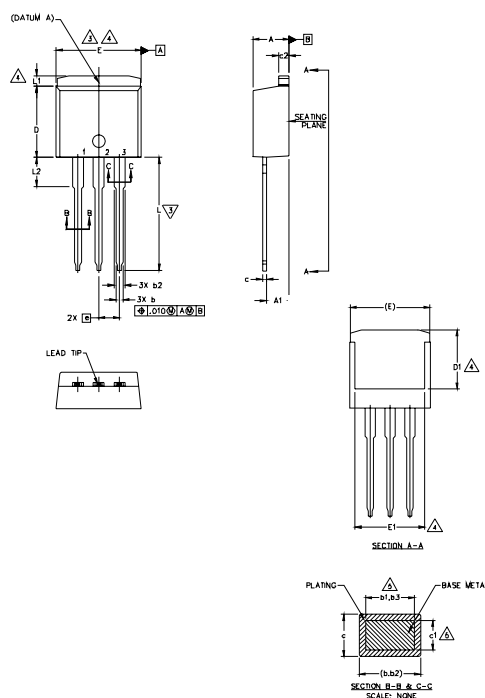
### Notes:

1. For an Automotive Qualified version of this part please see <http://www.irf.com/product-info/datasheets/data/auirf1010ez.pdf>
2. For the most current drawing please refer to IR website at <http://www.irf.com/package/>



## TO-262 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.
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.), D1(min.) WHERE DIMENSIONS DERIVED THE ACTUAL PACKAGE OUTLINE.

| SYMBOL | DIMENSIONS  |       |          |      | NOTES |
|--------|-------------|-------|----------|------|-------|
|        | MILLIMETERS |       | INCHES   |      |       |
|        | MIN.        | MAX.  | MIN.     | MAX. |       |
| A      | 4.06        | 4.83  | .160     | .190 |       |
| A1     | 2.03        | 3.02  | .080     | .119 |       |
| 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 |      |       |
| L      | 13.46       | 14.10 | .530     | .555 |       |
| L1     | —           | 1.65  | —        | .065 | 4     |
| L2     | 3.56        | 3.71  | .140     | .146 |       |

### LEAD ASSIGNMENTS

#### HEXFET

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

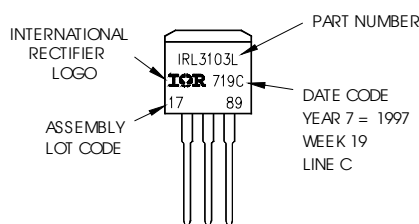
#### IGBTs, CoPACK

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

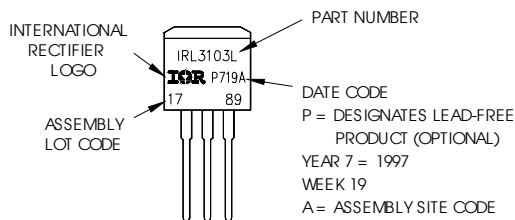
## TO-262 Part Marking Information

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



### Notes:

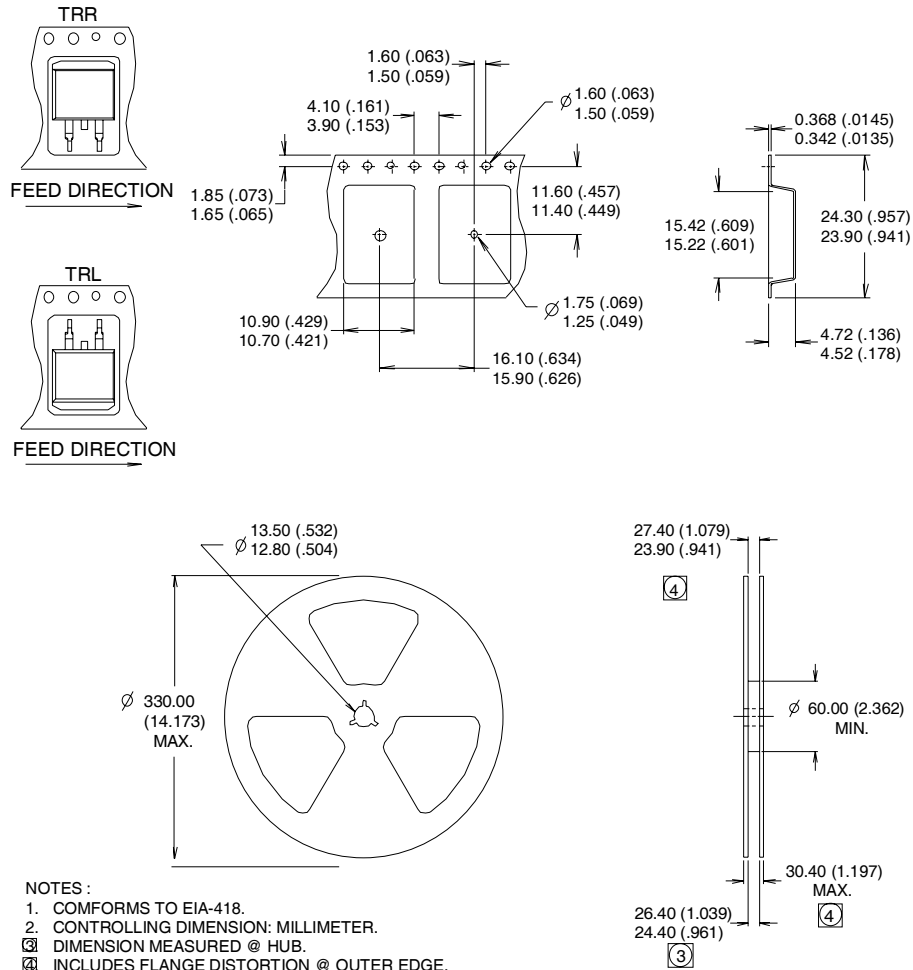
1. For an Automotive Qualified version of this part please see <http://www.irf.com/product-info/datasheets/data/auirf1010ez.pdf>
2. For the most current drawing please refer to IR website at <http://www.irf.com/package/>

# IRF1010EZ/S/LPbF

International  
**IR** Rectifier

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

Dimensions are shown in millimeters (inches)



**TO-220AB package is 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

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