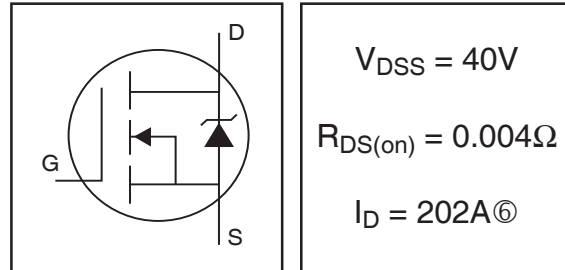


# IRF1404PbF

HEXFET® Power MOSFET

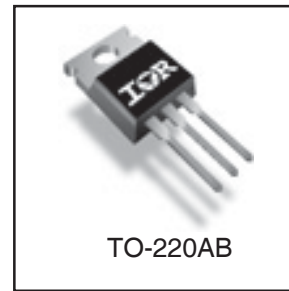
- Advanced Process Technology
- Ultra Low On-Resistance
- Dynamic dv/dt Rating
- 175°C Operating Temperature
- Fast Switching
- Fully Avalanche Rated
- Lead-Free



## Description

Seventh Generation HEXFET® Power MOSFETs from International Rectifier utilize advanced processing techniques to achieve extremely low on-resistance per silicon area. This benefit, combined with the fast switching speed and ruggedized device design that HEXFET power MOSFETs are well known for, provides the designer with an extremely efficient and reliable device for use in a wide variety of applications.

The TO-220 package is universally preferred for all commercial-industrial applications at power dissipation levels to approximately 50 watts. The low thermal resistance and low package cost of the TO-220 contribute to its wide acceptance throughout the industry.



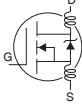
## Absolute Maximum Ratings

|                                   | Parameter                                       | Max.                     | Units |
|-----------------------------------|---|--------------------------|-------|
| $I_D$ @ $T_C = 25^\circ\text{C}$  | Continuous Drain Current, $V_{GS} @ 10\text{V}$ | 202Ⓞ                     | A     |
| $I_D$ @ $T_C = 100^\circ\text{C}$ | Continuous Drain Current, $V_{GS} @ 10\text{V}$ | 143Ⓞ                     |       |
| $I_{DM}$                          | Pulsed Drain Current ①                          | 808                      |       |
| $P_D$ @ $T_C = 25^\circ\text{C}$  | Power Dissipation                               | 333                      | W     |
|                                   | Linear Derating Factor                          | 2.2                      | W/°C  |
| $V_{GS}$                          | Gate-to-Source Voltage                          | ± 20                     | V     |
| $E_{AS}$                          | Single Pulse Avalanche Energy②                  | 620                      | mJ    |
| $I_{AR}$                          | Avalanche Current                               | See Fig.12a, 12b, 15, 16 | A     |
| $E_{AR}$                          | Repetitive Avalanche Energy②                    |                          | mJ    |
| dv/dt                             | Peak Diode Recovery dv/dt ③                     | 1.5                      | V/ns  |
| $T_J$                             | 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                    | —    | 0.45 | °C/W  |
| $R_{\theta CS}$ | Case-to-Sink, Flat, Greased Surface | 0.50 | —    |       |
| $R_{\theta JA}$ | Junction-to-Ambient                 | —    | 62   |       |

## Electrical Characteristics @ T<sub>J</sub> = 25°C (unless otherwise specified)

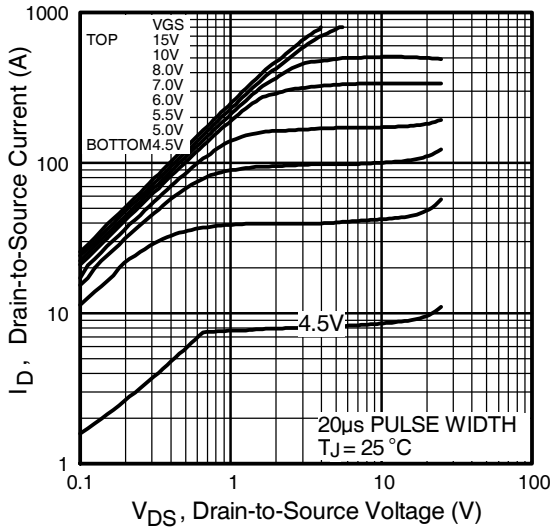
|                                      | Parameter                            | Min. | Typ.   | Max.  | Units | Conditions   |
|--------------------------------------|--------------------------------------|------|--------|-------|-------|--|
| V <sub>(BR)DSS</sub>                 | Drain-to-Source Breakdown Voltage    | 40   | —      | —     | V     | V <sub>GS</sub> = 0V, I <sub>D</sub> = 250μA   |
| ΔV <sub>(BR)DSS/ΔT<sub>J</sub></sub> | Breakdown Voltage Temp. Coefficient  | —    | 0.039  | —     | V/°C  | Reference to 25°C, I <sub>D</sub> = 1mA  |
| R <sub>DS(on)</sub>                  | Static Drain-to-Source On-Resistance | —    | 0.0035 | 0.004 | Ω     | V <sub>GS</sub> = 10V, I <sub>D</sub> = 121A ④                                       |
| V <sub>GS(th)</sub>                  | Gate Threshold Voltage               | 2.0  | —      | 4.0   | V     | V <sub>DS</sub> = V <sub>GS</sub> , I <sub>D</sub> = 250μA                           |
| g <sub>fs</sub>                      | Forward Transconductance             | 76   | —      | —     | S     | V <sub>DS</sub> = 25V, I <sub>D</sub> = 121A   |
| I <sub>DSS</sub>                     | Drain-to-Source Leakage Current      | —    | —      | 20    | μA    | V <sub>DS</sub> = 40V, V <sub>GS</sub> = 0V  |
|                                      |                                      | —    | —      | 250   |       | V <sub>DS</sub> = 32V, V <sub>GS</sub> = 0V, T <sub>J</sub> = 150°C                  |
| I <sub>GSS</sub>                     | Gate-to-Source Forward Leakage       | —    | —      | 200   | nA    | V <sub>GS</sub> = 20V  |
|                                      | Gate-to-Source Reverse Leakage       | —    | —      | -200  |       | V <sub>GS</sub> = -20V   |
| Q <sub>g</sub>                       | Total Gate Charge                    | —    | 131    | 196   | nC    | I <sub>D</sub> = 121A  |
| Q <sub>gs</sub>                      | Gate-to-Source Charge                | —    | 36     | —     |       | V <sub>DS</sub> = 32V  |
| Q <sub>gd</sub>                      | Gate-to-Drain ("Miller") Charge      | —    | 37     | 56    |       | V <sub>GS</sub> = 10V ④  |
| t <sub>d(on)</sub>                   | Turn-On Delay Time                   | —    | 17     | —     | ns    | V <sub>DD</sub> = 20V  |
| t <sub>r</sub>                       | Rise Time                            | —    | 190    | —     |       | I <sub>D</sub> = 121A  |
| t <sub>d(off)</sub>                  | Turn-Off Delay Time                  | —    | 46     | —     |       | R <sub>G</sub> = 2.5Ω  |
| t <sub>f</sub>                       | Fall Time                            | —    | 33     | —     |       | R <sub>D</sub> = 0.2Ω ④  |
| L <sub>D</sub>                       | Internal Drain Inductance            | —    | 4.5    | —     | nH    | Between lead,<br>6mm (0.25in.)<br>from package<br>and center of die contact          |
| L <sub>S</sub>                       | Internal Source Inductance           | —    | 7.5    | —     |       |  |
| C <sub>iss</sub>                     | Input Capacitance                    | —    | 5669   | —     | pF    | V <sub>GS</sub> = 0V   |
| C <sub>oss</sub>                     | Output Capacitance                   | —    | 1659   | —     |       | V <sub>DS</sub> = 25V  |
| C <sub>rss</sub>                     | Reverse Transfer Capacitance         | —    | 223    | —     |       | f = 1.0MHz, See Fig. 5   |
| C <sub>oss</sub>                     | Output Capacitance                   | —    | 6205   | —     |       | V <sub>GS</sub> = 0V, V <sub>DS</sub> = 1.0V, f = 1.0MHz                             |
| C <sub>oss</sub>                     | Output Capacitance                   | —    | 1467   | —     |       | V <sub>GS</sub> = 0V, V <sub>DS</sub> = 32V, f = 1.0MHz                              |
| C <sub>oss eff.</sub>                | Effective Output Capacitance ⑤       | —    | 2249   | —     |       | V <sub>GS</sub> = 0V, V <sub>DS</sub> = 0V to 32V                                    |

## Source-Drain Ratings and Characteristics

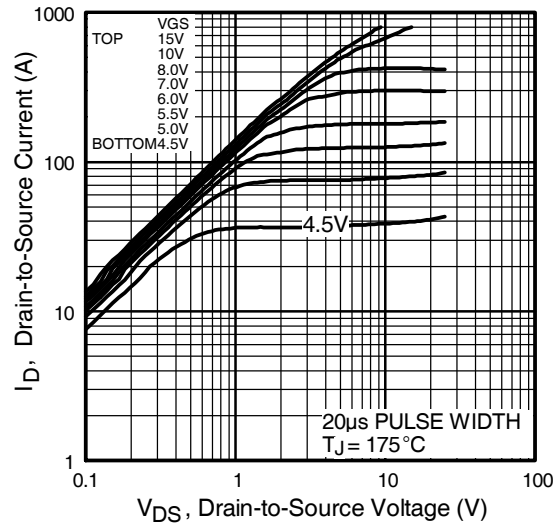
|                 | Parameter                                 | Min.   | Typ. | Max.  | Units | Conditions  |
|-----------------|---|--|------|-------|-------|---|
| I <sub>S</sub>  | Continuous Source Current<br>(Body Diode) | —  | —    | 202 ⑥ | A     | MOSFET symbol<br>showing the<br>integral reverse<br>p-n junction diode. |
| I <sub>SM</sub> | Pulsed Source Current<br>(Body Diode) ①   | —  | —    | 808   |       |   |
| V <sub>SD</sub> | Diode Forward Voltage                     | —  | —    | 1.5   | V     | T <sub>J</sub> = 25°C, I <sub>S</sub> = 121A, V <sub>GS</sub> = 0V ④    |
| t <sub>rr</sub> | Reverse Recovery Time                     | —  | 78   | 117   | ns    | T <sub>J</sub> = 25°C, I <sub>F</sub> = 121A                            |
| Q <sub>rr</sub> | Reverse Recovery Charge                   | —  | 163  | 245   | nC    | di/dt = 100A/μs ④   |
| t <sub>on</sub> | Forward Turn-On Time                      | Intrinsic turn-on time is negligible (turn-on is dominated by L <sub>S</sub> +L <sub>D</sub> ) |      |       |       |   |

### Notes:

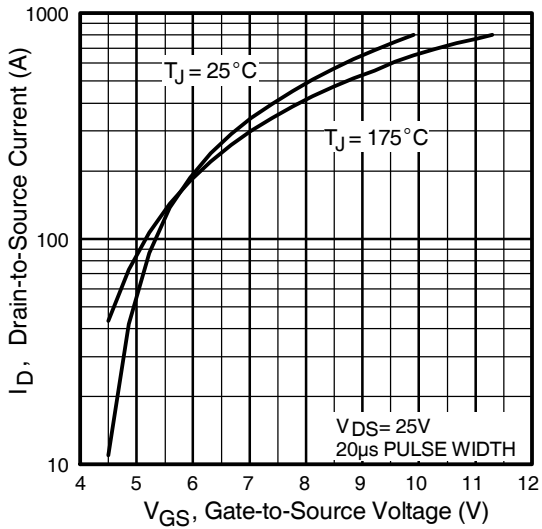
- ① Repetitive rating; pulse width limited by max. junction temperature. (See fig. 11)
- ② Starting T<sub>J</sub> = 25°C, L = 85μH  
R<sub>G</sub> = 25Ω, I<sub>AS</sub> = 121A. (See Figure 12)
- ③ I<sub>SD</sub> ≤ 121A, di/dt ≤ 130A/μs, V<sub>DD</sub> ≤ V<sub>(BR)DSS</sub>,  
T<sub>J</sub> ≤ 175°C
- ④ Pulse width ≤ 400μs; duty cycle ≤ 2%.
- ⑤ C<sub>oss eff.</sub> is a fixed capacitance that gives the same charging time as C<sub>oss</sub> while V<sub>DS</sub> is rising from 0 to 80% V<sub>DSS</sub>
- ⑥ Calculated continuous current based on maximum allowable junction temperature. Package limitation current is 75A.



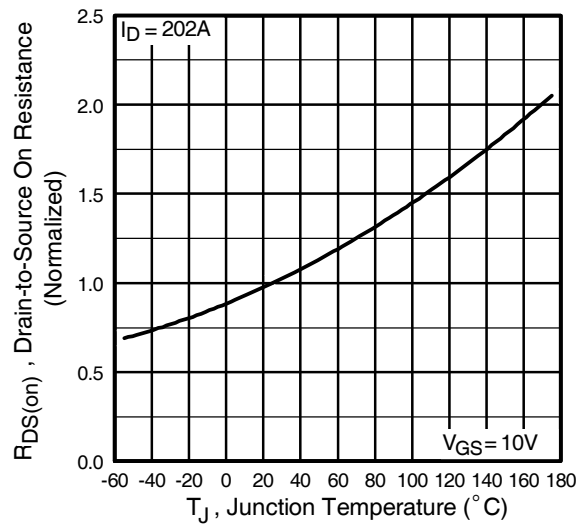
**Fig 1.** Typical Output Characteristics



**Fig 2.** Typical Output Characteristics

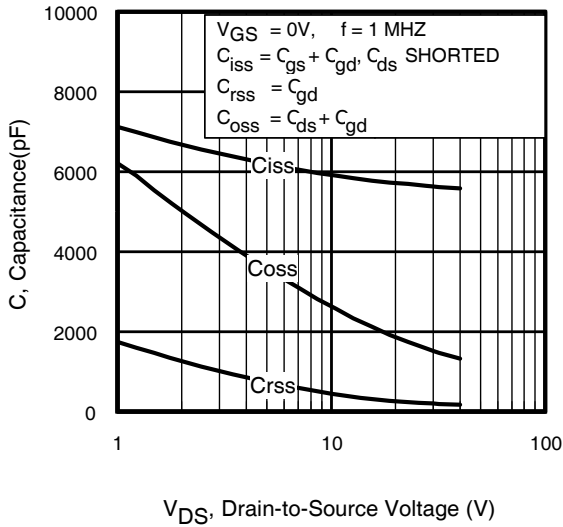


**Fig 3.** Typical Transfer Characteristics

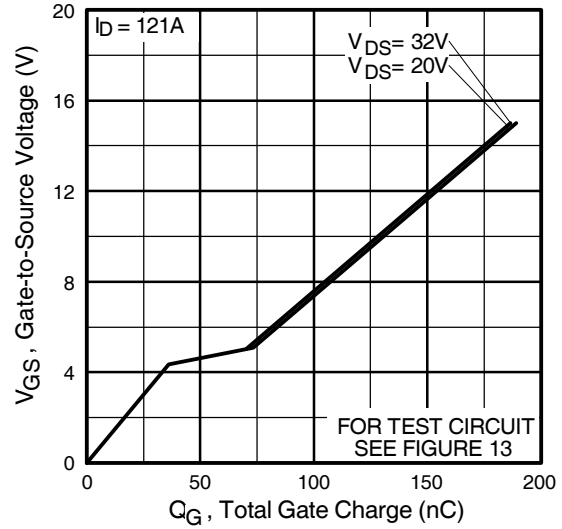


**Fig 4.** Normalized On-Resistance Vs. Temperature

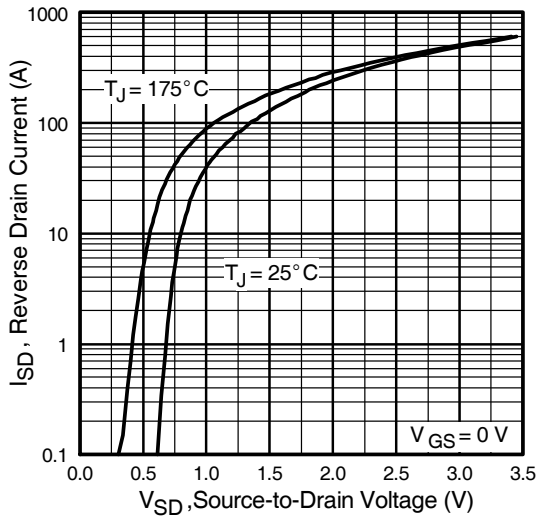
# IRF1404PbF



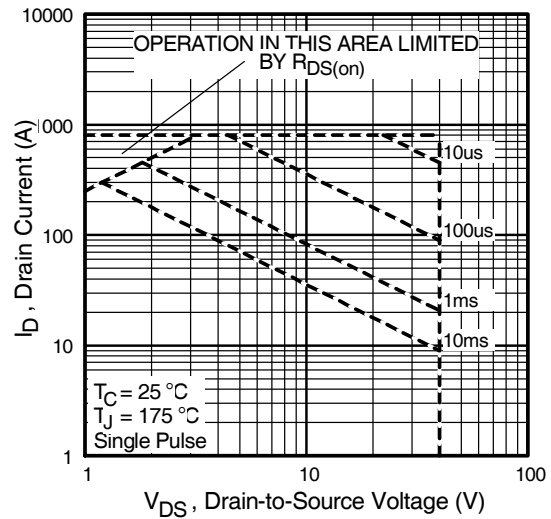
**Fig 5.** Typical Capacitance Vs. Drain-to-Source Voltage



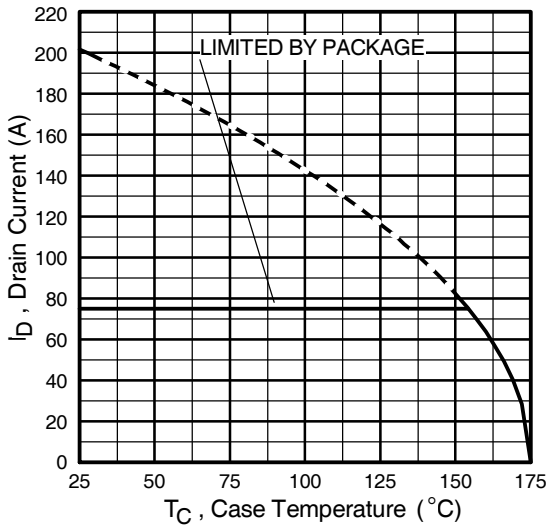
**Fig 6.** Typical Gate Charge Vs. Gate-to-Source Voltage



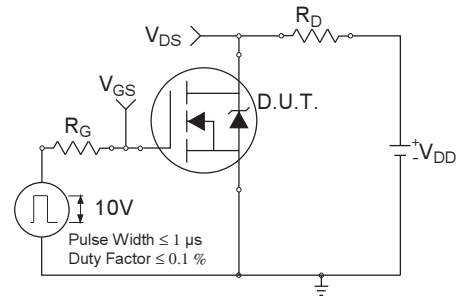
**Fig 7.** Typical Source-Drain Diode Forward Voltage



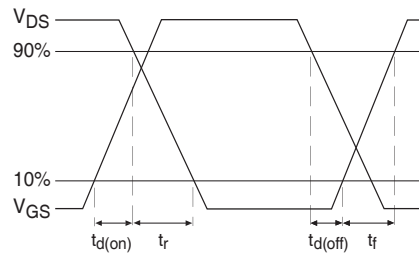
**Fig 8.** Maximum Safe Operating Area



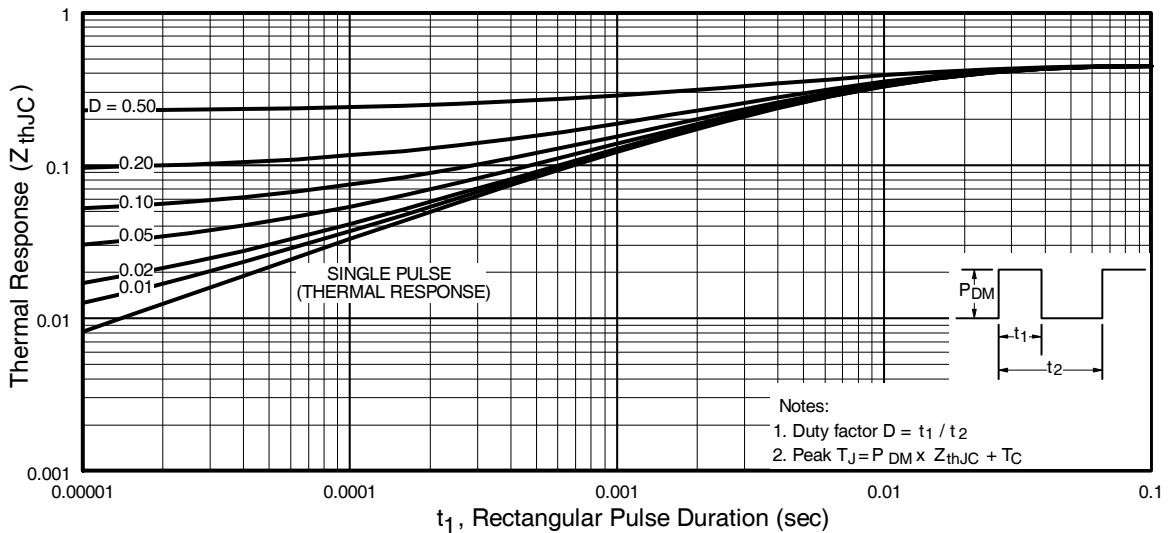
**Fig 9.** Maximum Drain Current Vs. Case Temperature



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



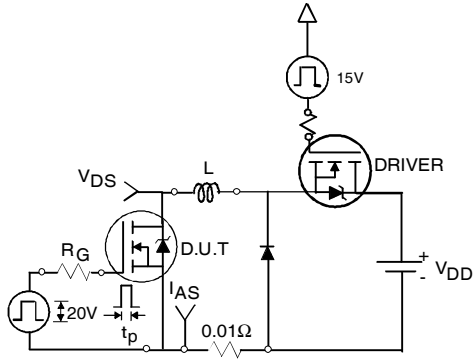
**Fig 10b.** Switching Time Waveforms



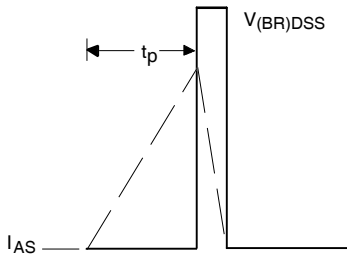
**Fig 11.** Maximum Effective Transient Thermal Impedance, Junction-to-Case

# IRF1404PbF

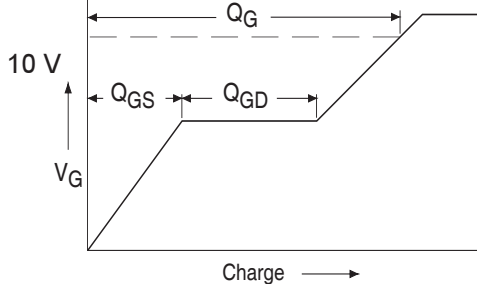
International  
**IR** Rectifier



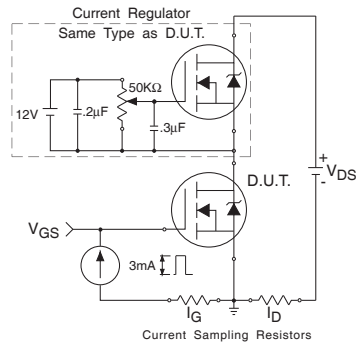
**Fig 12a.** Unclamped Inductive Test Circuit



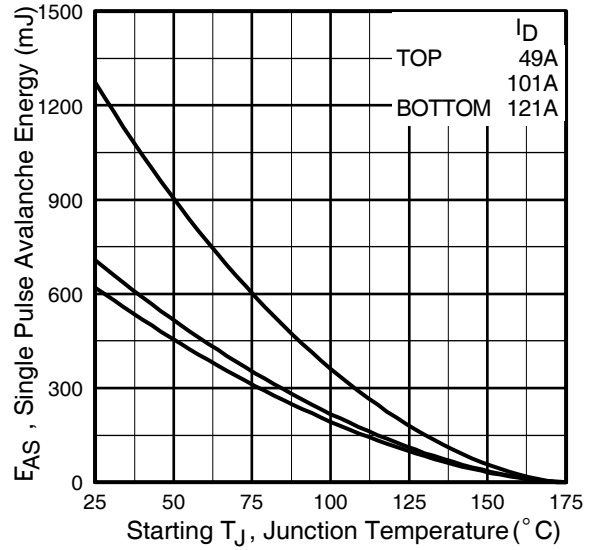
**Fig 12b.** Unclamped Inductive Waveforms



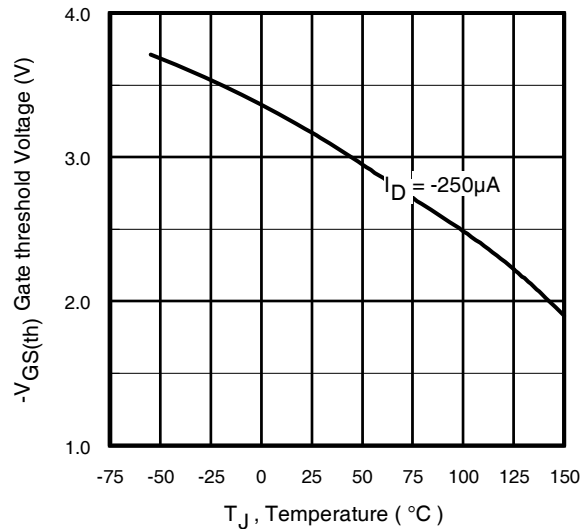
**Fig 13a.** Basic Gate Charge Waveform



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



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



**Fig 14.** Threshold Voltage Vs. Temperature

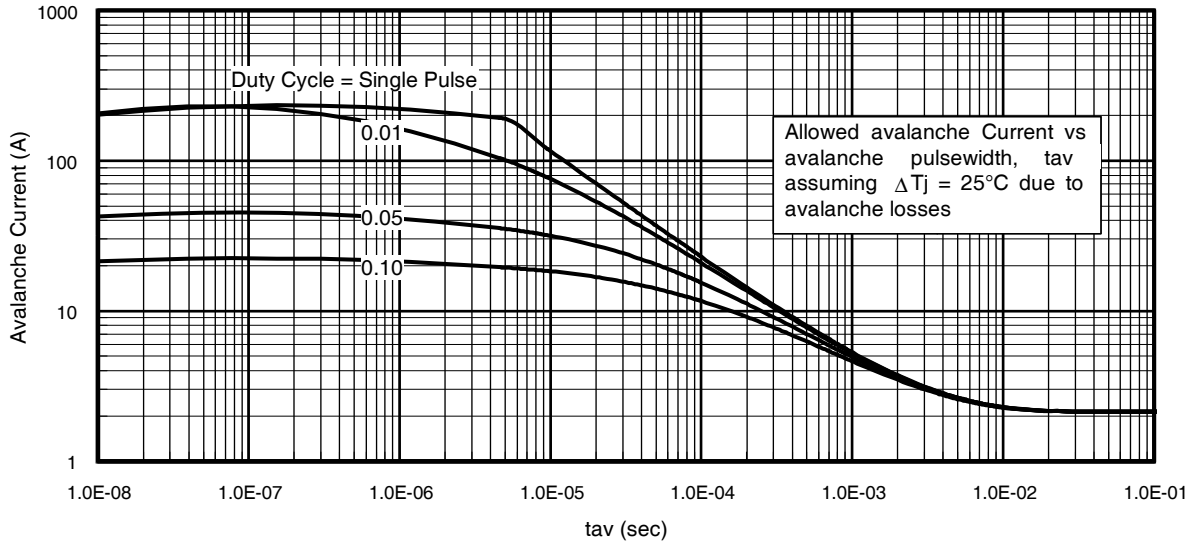


Fig 15. Typical Avalanche Current Vs.Pulsewidth

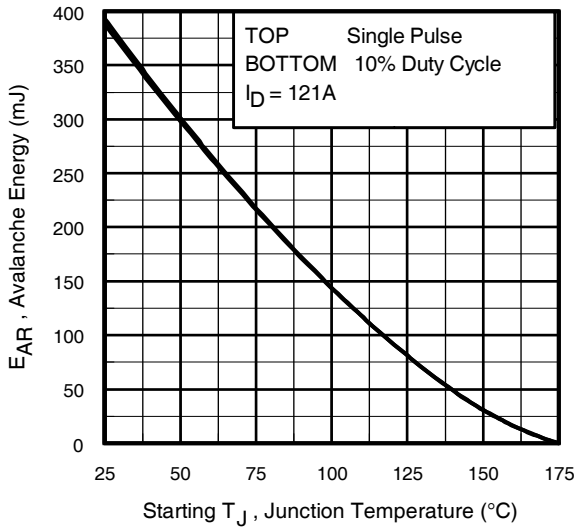


Fig 16. Maximum Avalanche Energy Vs. Temperature

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

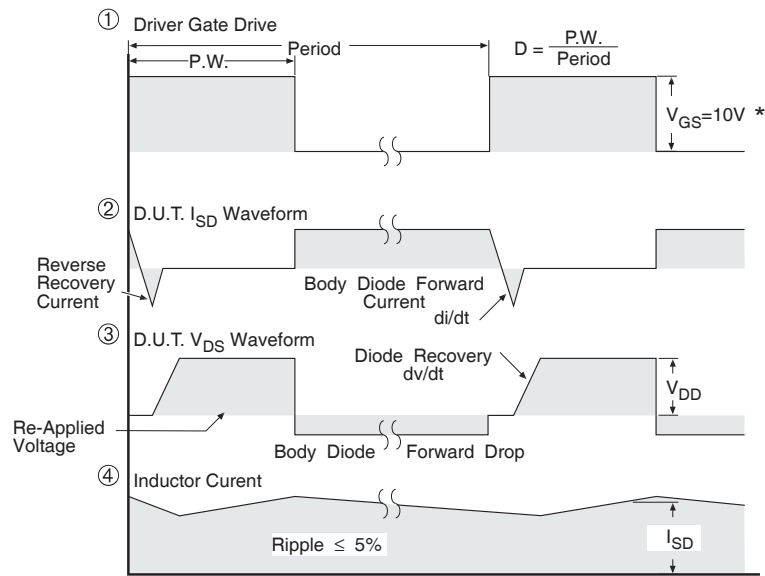
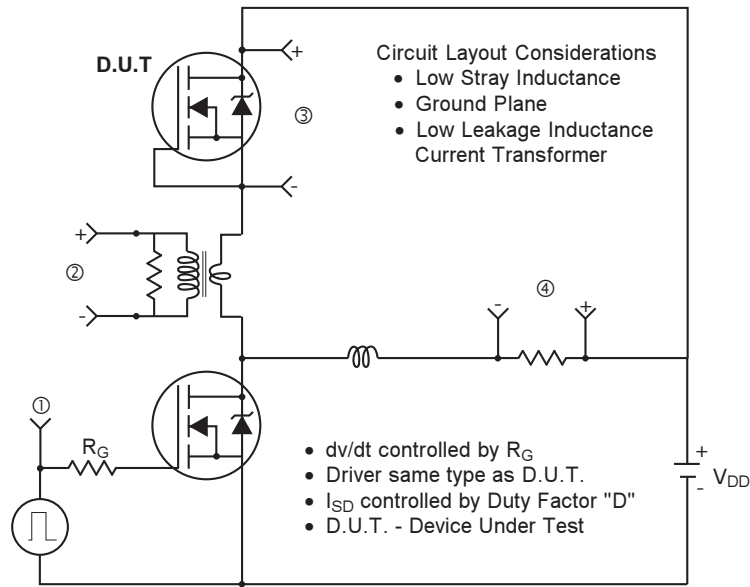
1. Avalanche failures assumption:  
Purely a thermal phenomenon and failure occurs at a temperature far in excess of  $T_{jmax}$ . This is validated for every part type.
2. Safe operation in Avalanche is allowed as long as  $T_{jmax}$  is not exceeded.
3. Equation below based on circuit and waveforms 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)

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

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

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

## Peak Diode Recovery dv/dt Test Circuit



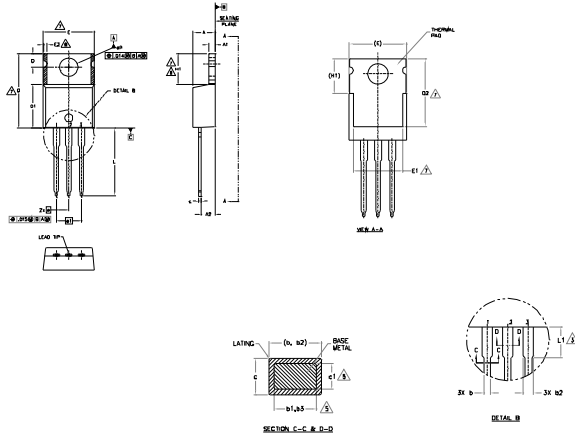
\*  $V_{GS} = 5V$  for Logic Level Devices

**Fig 17.** For N-channel HEXFET® Power MOSFETs



## 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, b2 & e1 APPLY TO BASE METAL ONLY.
  - 6.- CONTROLLING DIMENSION : INCHES.
  - 7.- THERMAL PAD CONTOUR OPTIONAL WITHIN DIMENSIONS E1, D2 & E1
  - 8.- DIMENSION E2 X H1 DEFINE A ZONE WHERE STAMPING AND SQUILLATION 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.

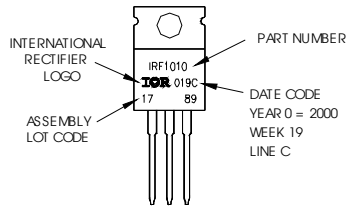
| SYMBOL | DIMENSIONS  |       |          |      | NOTES |
|--------|-------------|-------|----------|------|-------|
|        | MILLIMETERS |       | INCHES   |      |       |
|        | MIN.        | MAX.  | MIN.     | MAX. |       |
| A      | 3.56        | 4.83  | .140     | .190 |       |
| A1     | 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 |       |
| e1     | 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     |
| pP     | 3.54        | 4.08  | .139     | .161 |       |
| Q      | 2.54        | 3.42  | .100     | .135 |       |

- LEAD ASSIGNMENTS
- HEFET
- 1- GATE
  - 2- DRAIN
  - 3- SOURCE
- CRS. CAPAC
- 1- GATE
  - 2- COLLECTOR
  - 3- DIATER
- 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"



**TO-220 package is not recommended for Surface Mount Application.**

### Notes:

1. For an Automotive Qualified version of this part please see <http://www.irf.com/product-info/auto/>
2. 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.

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