

# IRF1405PbF

## Typical Applications

- Industrial motor drive

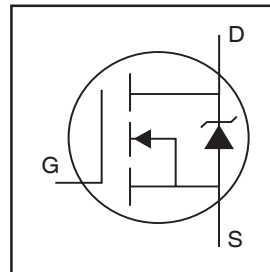
## Benefits

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

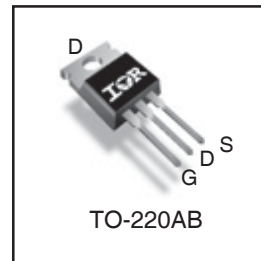
## Description

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

## HEXFET® Power MOSFET



$V_{DS} = 55V$   
 $R_{DS(on)} = 5.3m\Omega$   
 $I_D = 169A^{⑥}$



## Absolute Maximum Ratings

|                           | Parameter                                  | Max.                     | Units |
|---------------------------|--------------------------------------------|--------------------------|-------|
| $I_D @ T_C = 25^\circ C$  | Continuous Drain Current, $V_{GS} @ 10V$   | 169 <sup>⑥</sup>         | A     |
| $I_D @ T_C = 100^\circ C$ | Continuous Drain Current, $V_{GS} @ 10V$   | 118 <sup>⑥</sup>         |       |
| $I_{DM}$                  | Pulsed Drain Current <sup>①</sup>          | 680                      |       |
| $P_D @ T_C = 25^\circ C$  | Power Dissipation                          | 330                      | W     |
|                           | Linear Derating Factor                     | 2.2                      | W/°C  |
| $V_{GS}$                  | Gate-to-Source Voltage                     | $\pm 20$                 | V     |
| $E_{AS}$                  | Single Pulse Avalanche Energy <sup>②</sup> | 560                      | mJ    |
| $I_{AR}$                  | Avalanche Current <sup>①</sup>             | See Fig.12a, 12b, 15, 16 | A     |
| $E_{AR}$                  | Repetitive Avalanche Energy <sup>②</sup>   |                          | mJ    |
| dv/dt                     | Peak Diode recovery dv/dt <sup>③</sup>     | 5.0                      | 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   |       |

# IRF1405PbF

International  
IR Rectifier

## 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    | 55   | —     | —    | V     | V <sub>GS</sub> = 0V, I <sub>D</sub> = 250μA                        |
| ΔV <sub>(BR)DSS</sub> /ΔT <sub>J</sub> | Breakdown Voltage Temp. Coefficient  | —    | 0.057 | —    | V/°C  | Reference to 25°C, I <sub>D</sub> = 1mA                             |
| R <sub>DS(on)</sub>                    | Static Drain-to-Source On-Resistance | —    | 4.6   | 5.3  | mΩ    | V <sub>GS</sub> = 10V, I <sub>D</sub> = 101A 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             | 69   | —     | —    | S     | V <sub>DS</sub> = 25V, I <sub>D</sub> = 101A                        |
| I <sub>DSS</sub>                       | Drain-to-Source Leakage Current      | —    | —     | 20   | μA    | V <sub>DS</sub> = 55V, V <sub>GS</sub> = 0V                         |
|                                        |                                      | —    | —     | 250  |       | V <sub>DS</sub> = 44V, 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                    | —    | 170   | 260  |       | I <sub>D</sub> = 101A                                               |
| Q <sub>gs</sub>                        | Gate-to-Source Charge                | —    | 44    | 66   | nC    | V <sub>DS</sub> = 44V                                               |
| Q <sub>gd</sub>                        | Gate-to-Drain ("Miller") Charge      | —    | 62    | 93   |       | V <sub>GS</sub> = 10V ④                                             |
| t <sub>d(on)</sub>                     | Turn-On Delay Time                   | —    | 13    | —    |       | V <sub>DD</sub> = 38V                                               |
| t <sub>r</sub>                         | Rise Time                            | —    | 190   | —    |       | I <sub>D</sub> = 101A                                               |
| t <sub>d(off)</sub>                    | Turn-Off Delay Time                  | —    | 130   | —    | ns    | R <sub>G</sub> = 1.1 Ω                                              |
| t <sub>f</sub>                         | Fall Time                            | —    | 110   | —    |       | V <sub>GS</sub> = 10V ④                                             |
| L <sub>D</sub>                         | Internal Drain Inductance            | —    | 4.5   | —    | nH    | Between lead, 6mm (0.25in.) from package and center of die contact  |
| L <sub>S</sub>                         | Internal Source Inductance           | —    | 7.5   | —    |       |                                                                     |
| C <sub>iss</sub>                       | Input Capacitance                    | —    | 5480  | —    |       | V <sub>GS</sub> = 0V                                                |
| C <sub>oss</sub>                       | Output Capacitance                   | —    | 1210  | —    |       | V <sub>DS</sub> = 25V                                               |
| C <sub>rss</sub>                       | Reverse Transfer Capacitance         | —    | 280   | —    | pF    | f = 1.0MHz, See Fig.5                                               |
| C <sub>oss</sub>                       | Output Capacitance                   | —    | 5210  | —    |       | V <sub>GS</sub> = 0V, V <sub>DS</sub> = 1.0V, f = 1.0MHz            |
| C <sub>oss</sub>                       | Output Capacitance                   | —    | 900   | —    |       | V <sub>GS</sub> = 0V, V <sub>DS</sub> = 44V, f = 1.0MHz             |
| C <sub>oss eff.</sub>                  | Effective Output Capacitance ⑤       | —    | 1500  | —    |       | V <sub>GS</sub> = 0V, V <sub>DS</sub> = 0V to 44V                   |

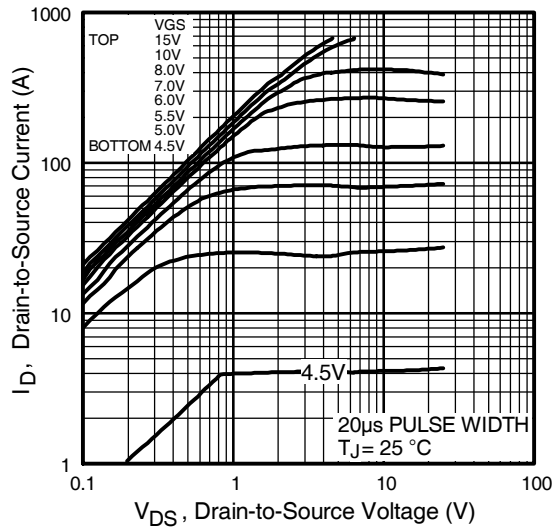
## Source-Drain Ratings and Characteristics

|                 | Parameter                              | Min.                                                                 | Typ. | Max. | Units | Conditions                                                           |
|-----------------|----------------------------------------|----------------------------------------------------------------------|------|------|-------|----------------------------------------------------------------------|
| I <sub>S</sub>  | Continuous Source Current (Body Diode) | —                                                                    | —    | 169⑥ | A     | MOSFET symbol showing the integral reverse p-n junction diode.       |
| I <sub>SM</sub> | Pulsed Source Current (Body Diode) ①   | —                                                                    | —    | 680  |       |                                                                      |
| V <sub>SD</sub> | Diode Forward Voltage                  | —                                                                    | —    | 1.3  | V     | T <sub>J</sub> = 25°C, I <sub>S</sub> = 101A, V <sub>GS</sub> = 0V ④ |
| t <sub>rr</sub> | Reverse Recovery Time                  | —                                                                    | 88   | 130  | ns    | T <sub>J</sub> = 25°C, I <sub>F</sub> = 101A                         |
| Q <sub>rr</sub> | Reverse Recovery Charge                | —                                                                    | 250  | 380  | 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 LS+LD) |      |      |       |                                                                      |

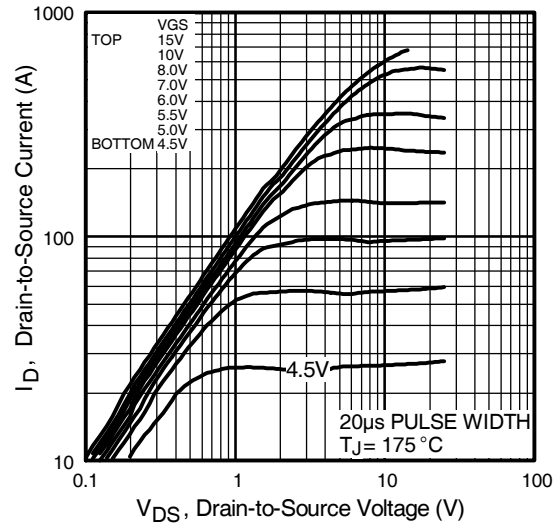
### Notes:

- ① Repetitive rating; pulse width limited by max. junction temperature. (See fig. 11).
- ② Starting T<sub>J</sub> = 25°C, L = 0.11mH  
R<sub>G</sub> = 25Ω, I<sub>AS</sub> = 101A. (See Figure 12).
- ③ I<sub>SD</sub> ≤ 101A, di/dt ≤ 210A/μs, V<sub>DD</sub> ≤ V<sub>(BR)DSS</sub>, T<sub>J</sub> ≤ 175°C
- ④ Pulse width ≤ 400μs; duty cycle ≤ 2%.

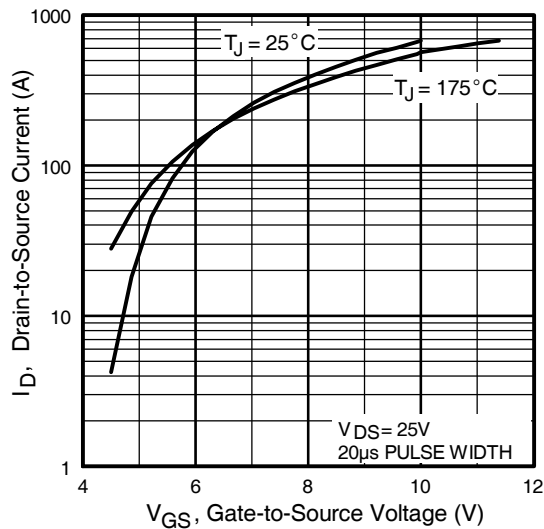
- ⑤ C<sub>oss eff.</sub> is a fixed capacitance that gives the same charging time as C<sub>oss</sub> while V<sub>DS</sub> is rising from 0 to 80% V<sub>DSS</sub>.
- ⑥ Calculated continuous current based on maximum allowable junction temperature. Package limitation current is 75A.
- ⑦ Limited by T<sub>Jmax</sub>, see Fig.12a, 12b, 15, 16 for typical repetitive avalanche performance.



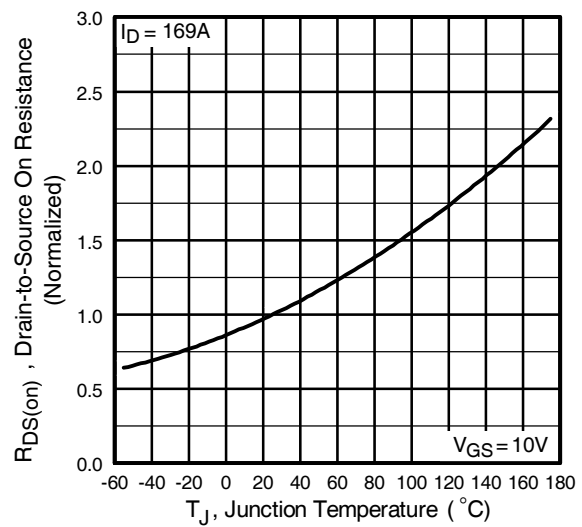
**Fig 1.** Typical Output Characteristics



**Fig 2.** Typical Output Characteristics



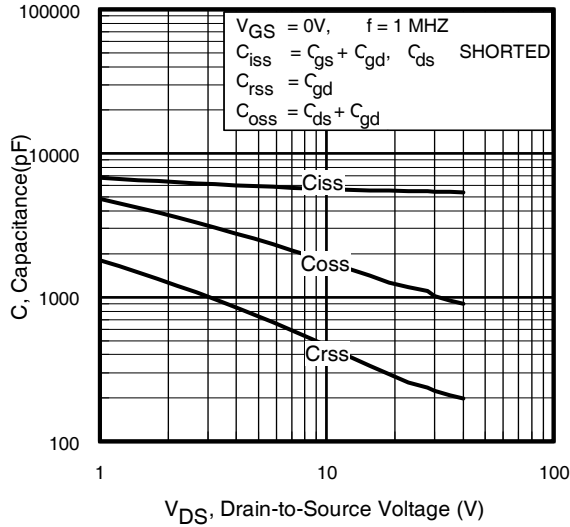
**Fig 3.** Typical Transfer Characteristics



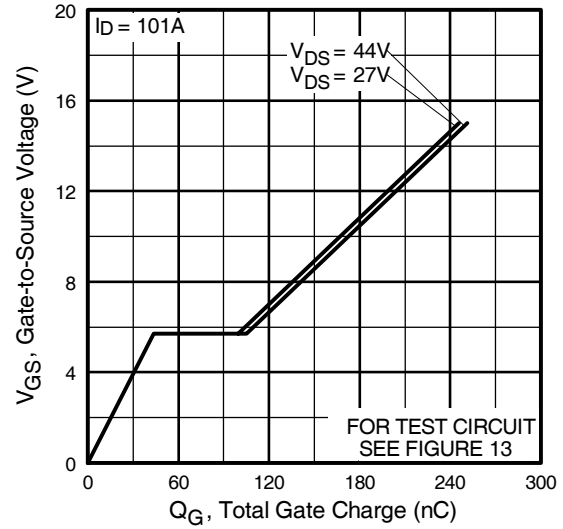
**Fig 4.** Normalized On-Resistance  
Vs. Temperature

# IRF1405PbF

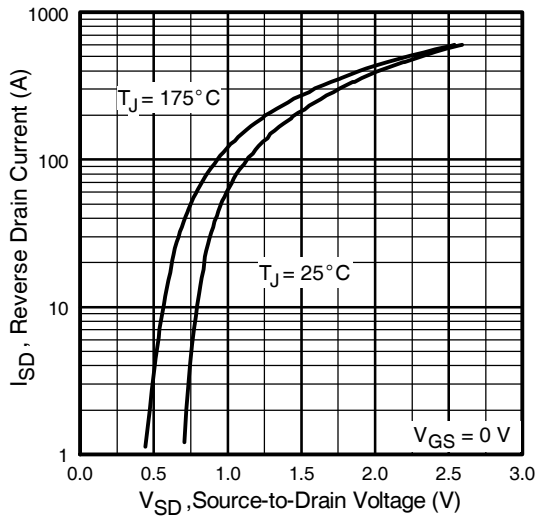
International  
**IR** Rectifier



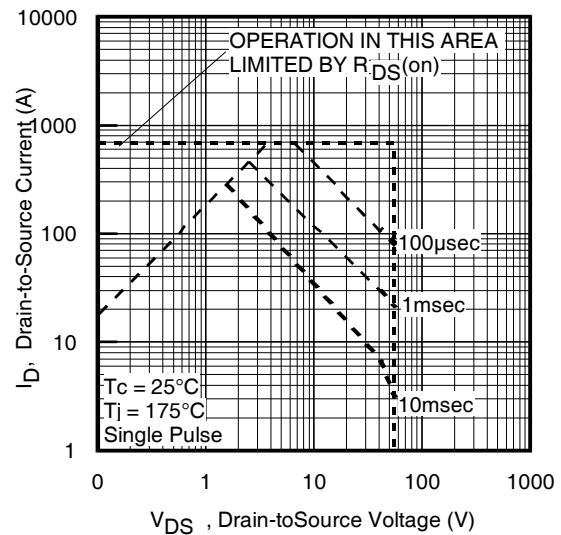
**Fig 5.** Typical Capacitance Vs. Drain-to-Source Voltage



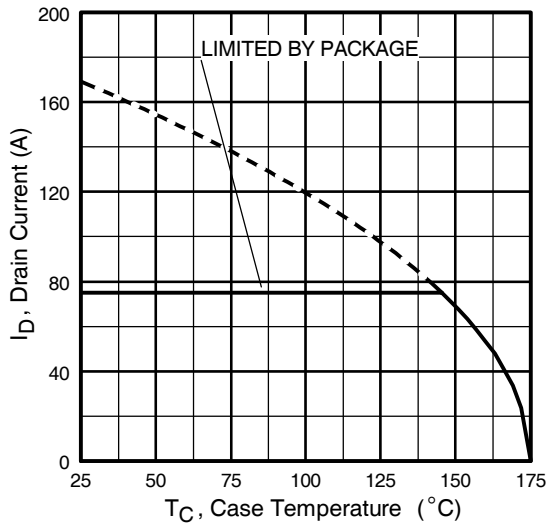
**Fig 6.** Typical Gate Charge Vs. Gate-to-Source Voltage



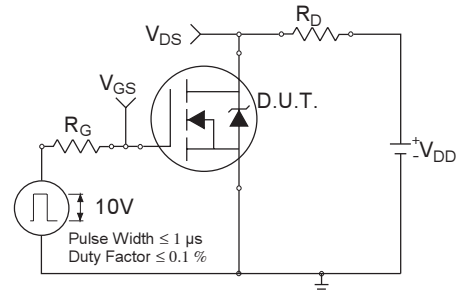
**Fig 7.** Typical Source-Drain Diode Forward Voltage



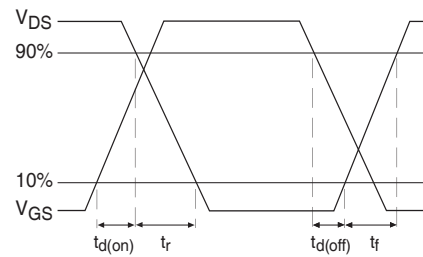
**Fig 8.** Maximum Safe Operating Area



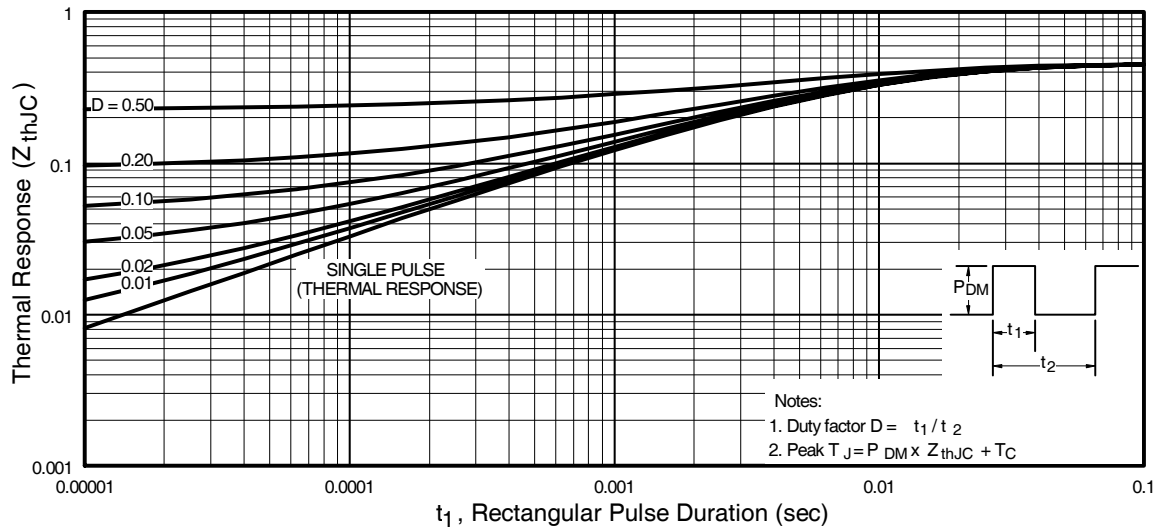
**Fig 9.** Maximum Drain Current Vs. Case Temperature



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



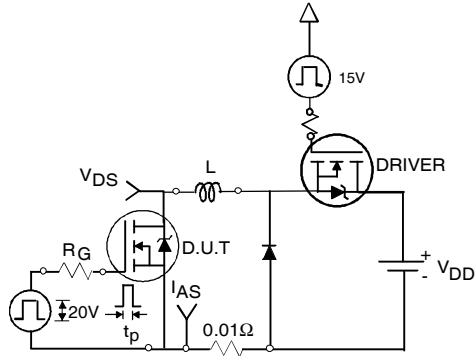
**Fig 10b.** Switching Time Waveforms



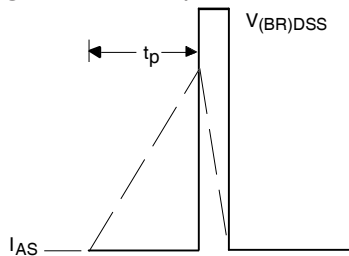
**Fig 11.** Maximum Effective Transient Thermal Impedance, Junction-to-Case

# IRF1405PbF

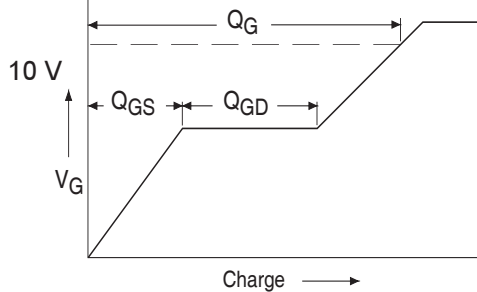
International  
**IR** Rectifier



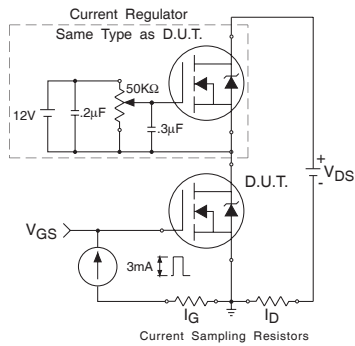
**Fig 12a.** Unclamped Inductive Test Circuit



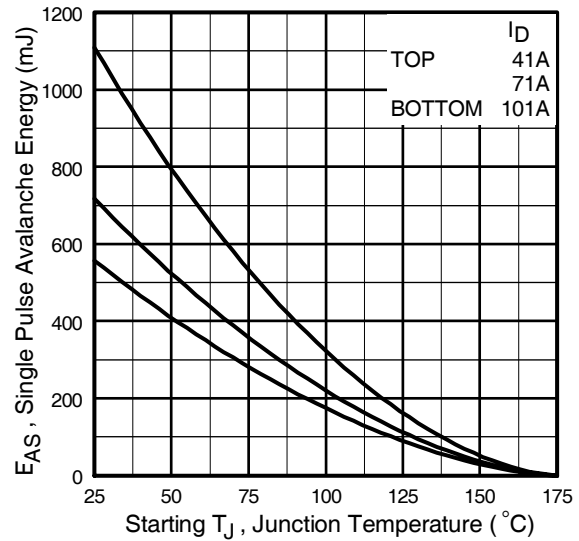
**Fig 12b.** Unclamped Inductive Waveforms



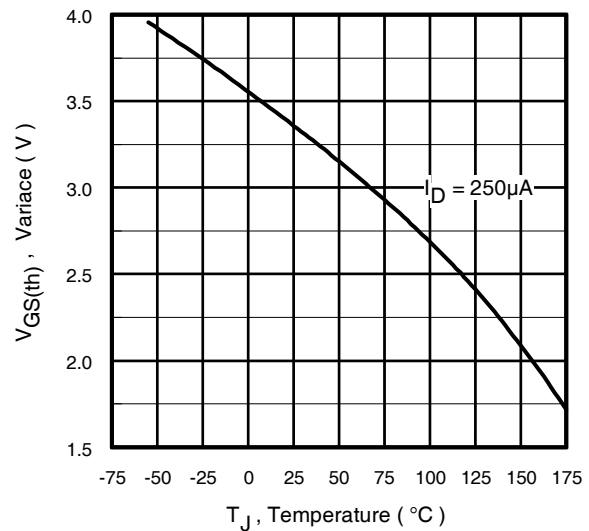
**Fig 13a.** Basic Gate Charge Waveform



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

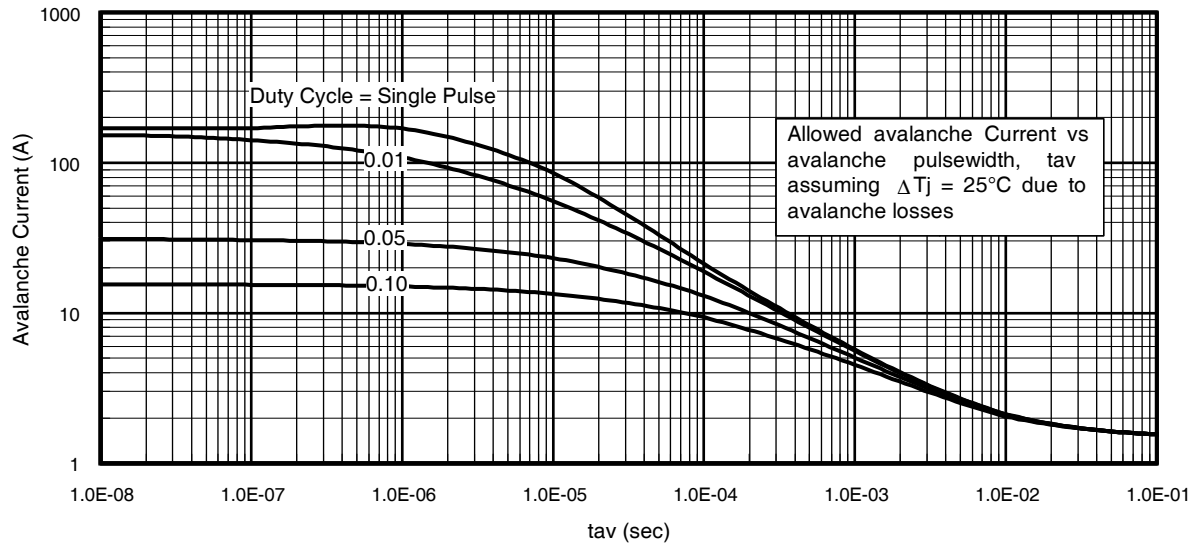


**Fig 12c.** Maximum Avalanche Energy Vs. Drain Current

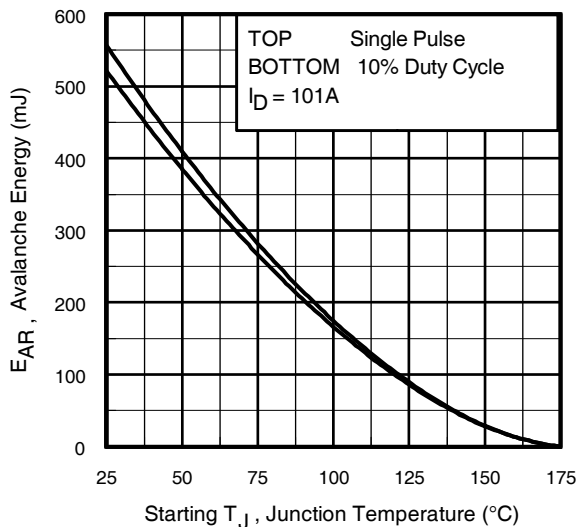


**Fig 14.** Threshold Voltage Vs. Temperature

[www.irf.com](http://www.irf.com)



**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)

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

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

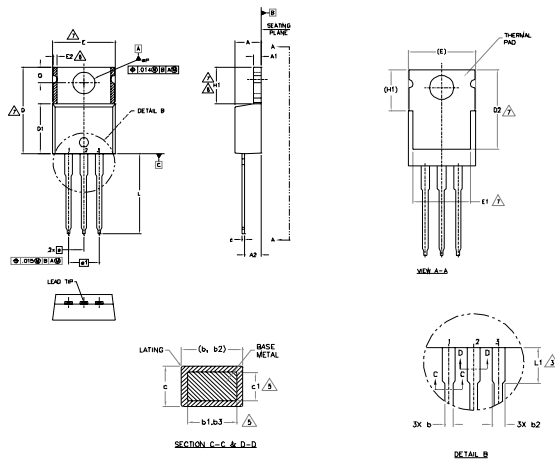
$$E_{AS(AR)} = P_{D(ave)} \cdot t_{av}$$





## 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

HEWITT  
1 - GATE  
2 - DRAIN  
3 - SOURCE

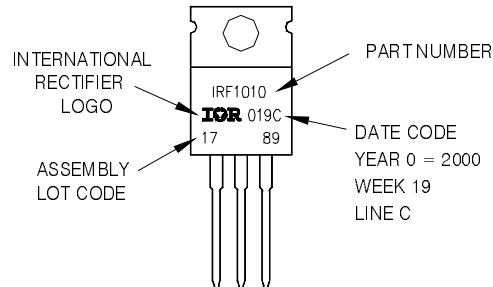
WELLS GATEPACK  
1 - GATE  
2 - COLLECTOR  
3 - EMITTER

DOCKES  
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-220AB packages are 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.

# Mouser Electronics

Authorized Distributor

Click to View Pricing, Inventory, Delivery & Lifecycle Information:

[International Rectifier:](#)

[IRF1405PBF](#)