

# IRF1404

HEXFET® Power MOSFET

- Advanced Process Technology
- Ultra Low On-Resistance
- Dynamic dv/dt Rating
- 175°C Operating Temperature
- Fast Switching
- Fully Avalanche Rated
- Automotive Qualified (Q101)

## 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 including automotive.

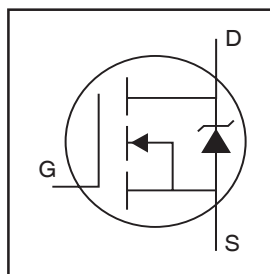
The TO-220 package is universally preferred for all automotive-commercial-industrial applications at power dissipation levels to approximately 50 watts. The low thermal resistance and low package cost of the TO-220 contribute to its wide acceptance throughout the industry.

## Absolute Maximum Ratings

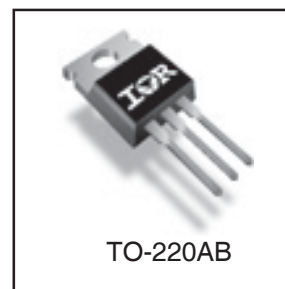
|                                   | Parameter                                  | Max.                     | Units |
|-----------------------------------|--------------------------------------------|--------------------------|-------|
| $I_D$ @ $T_C = 25^\circ\text{C}$  | Continuous Drain Current, $V_{GS}$ @ 10V   | 202 <sup>⑥</sup>         | A     |
| $I_D$ @ $T_C = 100^\circ\text{C}$ | Continuous Drain Current, $V_{GS}$ @ 10V   | 143 <sup>⑥</sup>         |       |
| $I_{DM}$                          | Pulsed Drain Current <sup>①</sup>          | 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 Energy <sup>②</sup> | 620                      | mJ    |
| $I_{AR}$                          | Avalanche Current                          | 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>     | 1.5                      | V/ns  |
| $T_J$                             | Operating Junction and                     | -55 to + 175             | °C    |
| $T_{STG}$                         | Storage Temperature Range                  | -55 to + 175             |       |
|                                   | 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   |       |

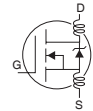


|                                |
|--------------------------------|
| $V_{DSS} = 40\text{V}$         |
| $R_{DS(on)} = 0.004\Omega$     |
| $I_D = 202\text{A}^{\text{⑥}}$ |



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

|                                 | Parameter                            | Min. | Typ.   | Max.  | Units               | Conditions                                                                  |
|---------------------------------|--------------------------------------|------|--------|-------|---------------------|-----------------------------------------------------------------------------|
| $V_{(BR)DSS}$                   | Drain-to-Source Breakdown Voltage    | 40   | —      | —     | V                   | $V_{GS} = 0V$ , $I_D = 250\mu A$                                            |
| $\Delta V_{(BR)DSS}/\Delta T_J$ | Breakdown Voltage Temp. Coefficient  | —    | 0.039  | —     | V/ $^\circ\text{C}$ | Reference to $25^\circ\text{C}$ , $I_D = 1mA$                               |
| $R_{DS(on)}$                    | Static Drain-to-Source On-Resistance | —    | 0.0035 | 0.004 | $\Omega$            | $V_{GS} = 10V$ , $I_D = 121A$ ④                                             |
| $V_{GS(th)}$                    | Gate Threshold Voltage               | 2.0  | —      | 4.0   | V                   | $V_{DS} = 10V$ , $I_D = 250\mu A$                                           |
| $g_{fs}$                        | Forward Transconductance             | 76   | —      | —     | S                   | $V_{DS} = 25V$ , $I_D = 121A$                                               |
| $I_{DSS}$                       | Drain-to-Source Leakage Current      | —    | —      | 20    | $\mu A$             | $V_{DS} = 40V$ , $V_{GS} = 0V$                                              |
|                                 |                                      | —    | —      | 250   |                     | $V_{DS} = 32V$ , $V_{GS} = 0V$ , $T_J = 150^\circ\text{C}$                  |
| $I_{GSS}$                       | Gate-to-Source Forward Leakage       | —    | —      | 200   | nA                  | $V_{GS} = 20V$                                                              |
|                                 | Gate-to-Source Reverse Leakage       | —    | —      | -200  |                     | $V_{GS} = -20V$                                                             |
| $Q_g$                           | Total Gate Charge                    | —    | 131    | 196   | nC                  | $I_D = 121A$                                                                |
| $Q_{gs}$                        | Gate-to-Source Charge                | —    | 36     | —     |                     | $V_{DS} = 32V$                                                              |
| $Q_{gd}$                        | Gate-to-Drain ("Miller") Charge      | —    | 37     | 56    |                     | $V_{GS} = 10V$ ④                                                            |
| $t_{d(on)}$                     | Turn-On Delay Time                   | —    | 17     | —     | ns                  | $V_{DD} = 20V$                                                              |
| $t_r$                           | Rise Time                            | —    | 190    | —     |                     | $I_D = 121A$                                                                |
| $t_{d(off)}$                    | Turn-Off Delay Time                  | —    | 46     | —     |                     | $R_G = 2.5\Omega$                                                           |
| $t_f$                           | Fall Time                            | —    | 33     | —     |                     | $R_D = 0.2\Omega$ 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                    | —    | 5669   | —     | pF                  | $V_{GS} = 0V$                                                               |
| $C_{oss}$                       | Output Capacitance                   | —    | 1659   | —     |                     | $V_{DS} = 25V$                                                              |
| $C_{rss}$                       | Reverse Transfer Capacitance         | —    | 223    | —     |                     | $f = 1.0MHz$ , See Fig. 5                                                   |
| $C_{oss}$                       | Output Capacitance                   | —    | 6205   | —     |                     | $V_{GS} = 0V$ , $V_{DS} = 1.0V$ , $f = 1.0MHz$                              |
| $C_{oss}$                       | Output Capacitance                   | —    | 1467   | —     |                     | $V_{GS} = 0V$ , $V_{DS} = 32V$ , $f = 1.0MHz$                               |
| $C_{oss \text{ eff.}}$          | Effective Output Capacitance ⑤       | —    | 2249   | —     |                     | $V_{GS} = 0V$ , $V_{DS} = 0V$ to $32V$                                      |



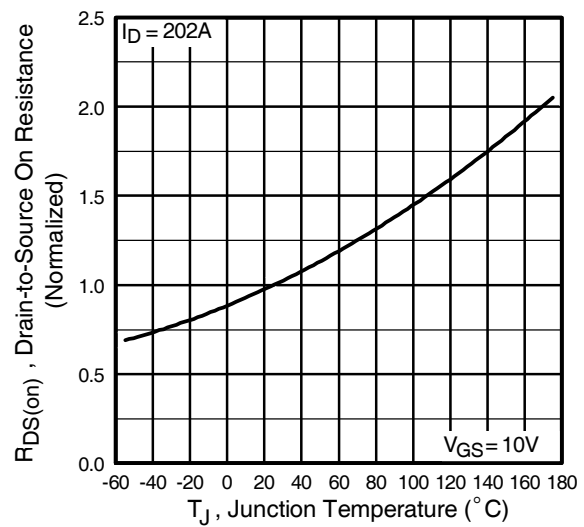
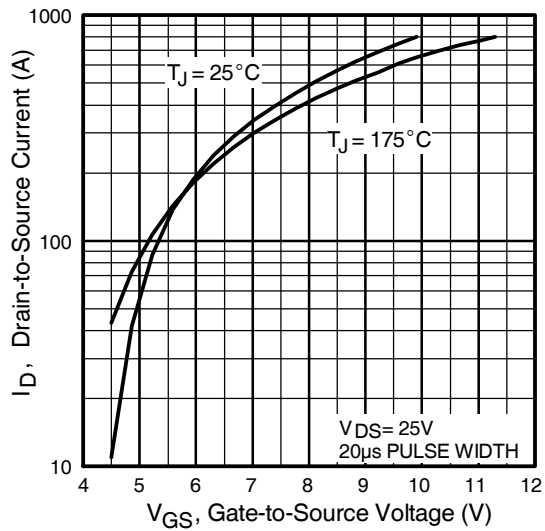
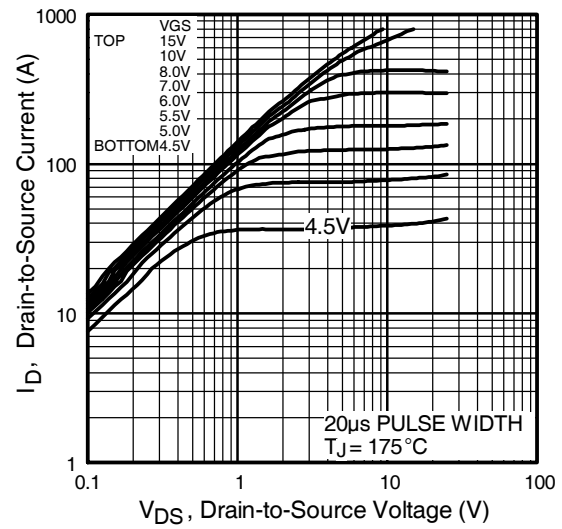
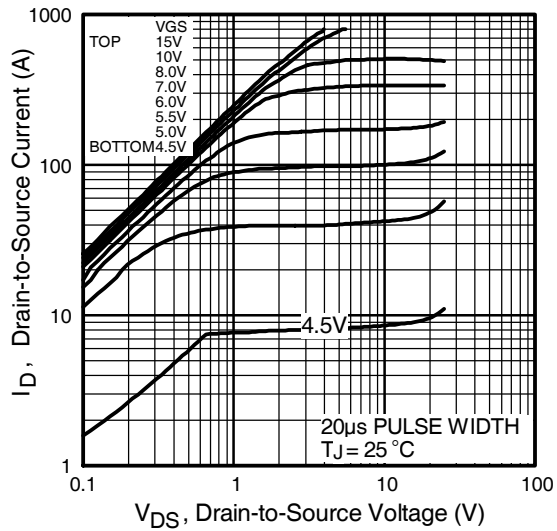
## Source-Drain Ratings and Characteristics

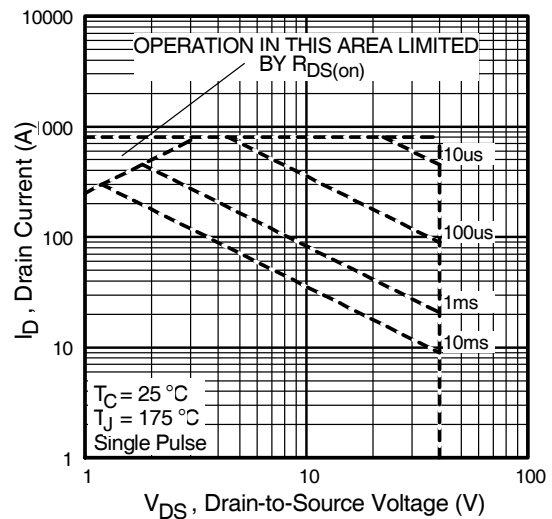
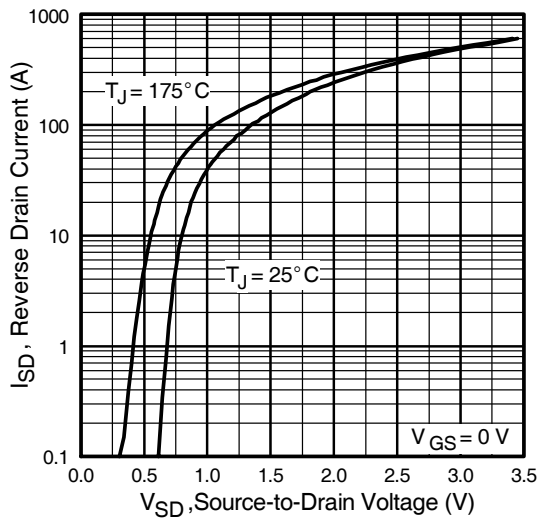
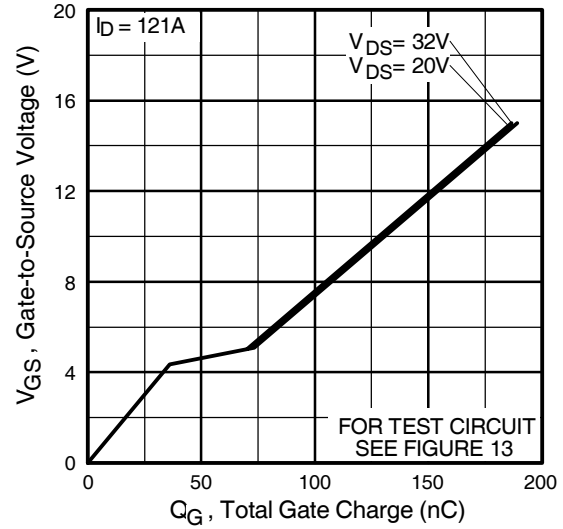
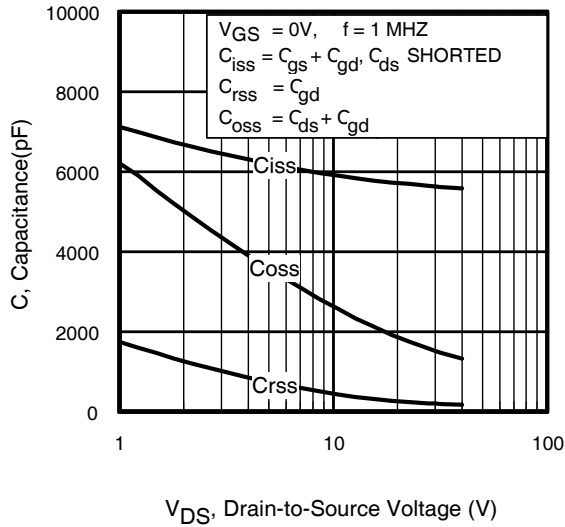
|          | Parameter                                 | Min.                                                                        | Typ. | Max.  | Units | Conditions                                                              |
|----------|-------------------------------------------|-----------------------------------------------------------------------------|------|-------|-------|-------------------------------------------------------------------------|
| $I_S$    | Continuous Source Current<br>(Body Diode) | —                                                                           | —    | 202 ⑥ | A     | MOSFET symbol<br>showing the<br>integral reverse<br>p-n junction diode. |
| $I_{SM}$ | Pulsed Source Current<br>(Body Diode) ①   | —                                                                           | —    | 808   |       |                                                                         |
| $V_{SD}$ | Diode Forward Voltage                     | —                                                                           | —    | 1.5   | V     | $T_J = 25^\circ\text{C}$ , $I_S = 121A$ , $V_{GS} = 0V$ ④               |
| $t_{rr}$ | Reverse Recovery Time                     | —                                                                           | 78   | 117   | ns    | $T_J = 25^\circ\text{C}$ , $I_F = 121A$                                 |
| $Q_{rr}$ | Reverse Recovery Charge                   | —                                                                           | 163  | 245   | nC    | $di/dt = 100A/\mu s$ ④                                                  |
| $t_{on}$ | Forward Turn-On Time                      | Intrinsic turn-on time is negligible (turn-on is dominated by $L_S + L_D$ ) |      |       |       |                                                                         |

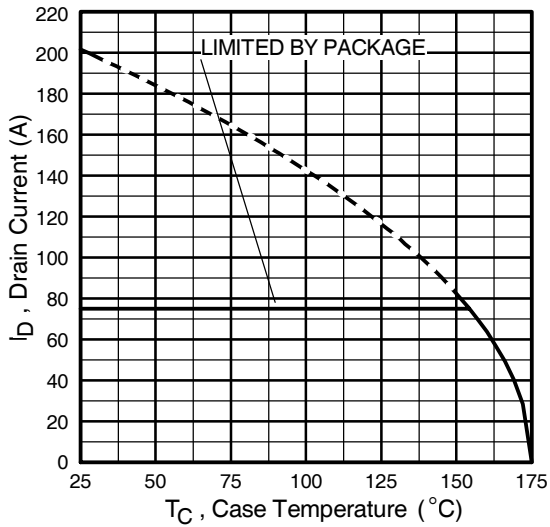
### Notes:

- ① Repetitive rating; pulse width limited by max. junction temperature. (See fig. 11)
- ② Starting  $T_J = 25^\circ\text{C}$ ,  $L = 85\mu H$   
 $R_G = 25\Omega$ ,  $I_{AS} = 121A$ . (See Figure 12)
- ③  $I_{SD} \leq 121A$ ,  $di/dt \leq 130A/\mu s$ ,  $V_{DD} \leq V_{(BR)DSS}$ ,  
 $T_J \leq 175^\circ\text{C}$

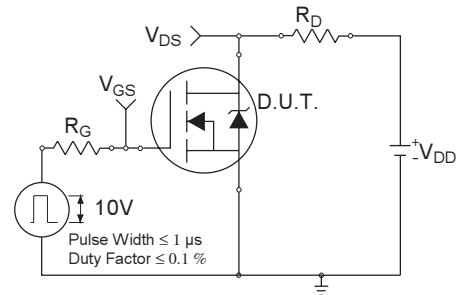
- ④ Pulse width  $\leq 400\mu s$ ; duty cycle  $\leq 2\%$ .
- ⑤  $C_{oss \text{ eff.}}$  is a fixed capacitance that gives the same charging time as  $C_{oss}$  while  $V_{DS}$  is rising from 0 to 80%  $V_{DSS}$
- ⑥ Calculated continuous current based on maximum allowable junction temperature. Package limitation current is 75A.



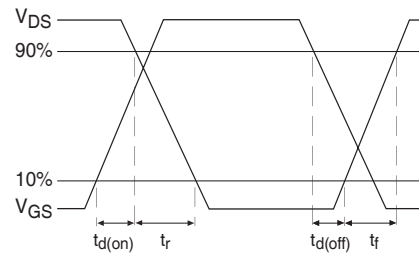




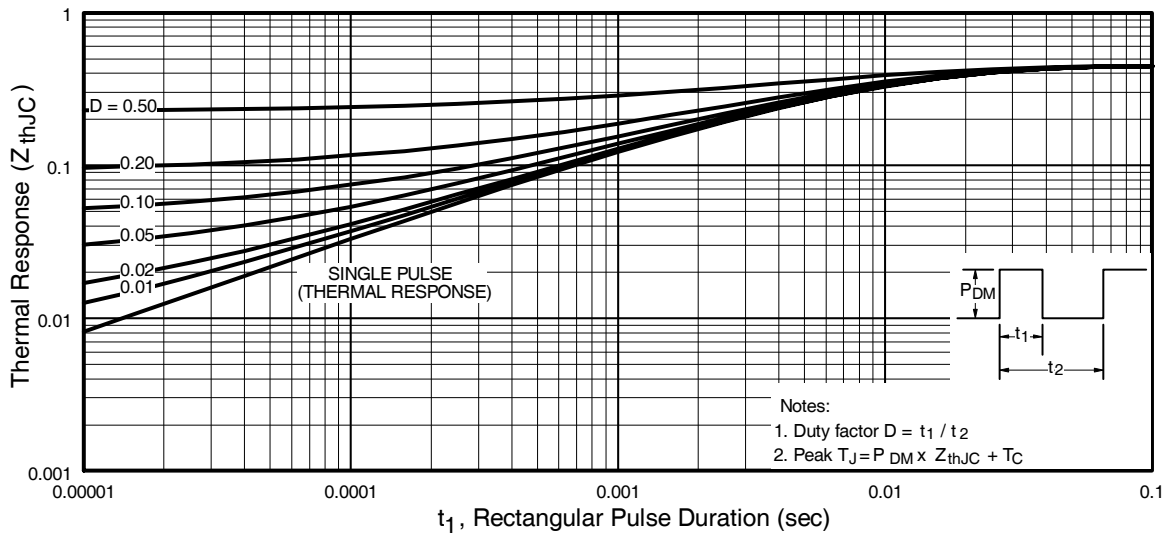
**Fig 9.** Maximum Drain Current Vs. Case Temperature



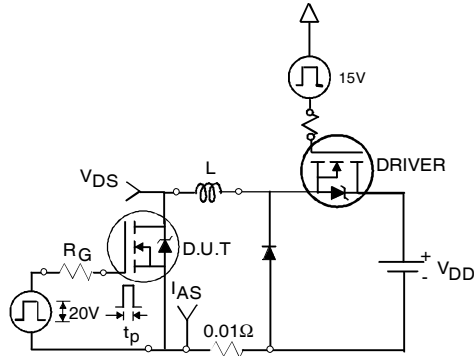
**Fig 10a.** Switching Time Test Circuit



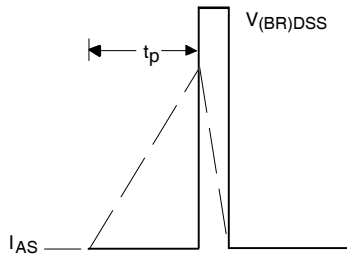
**Fig 10b.** Switching Time Waveforms



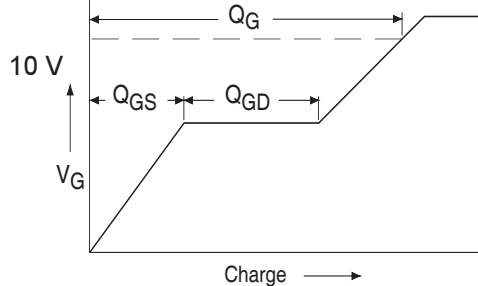
**Fig 11.** Maximum Effective Transient Thermal Impedance, Junction-to-Case



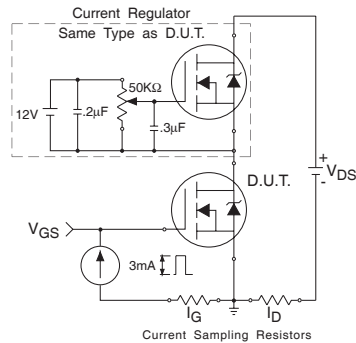
**Fig 12a.** Unclamped Inductive Test Circuit



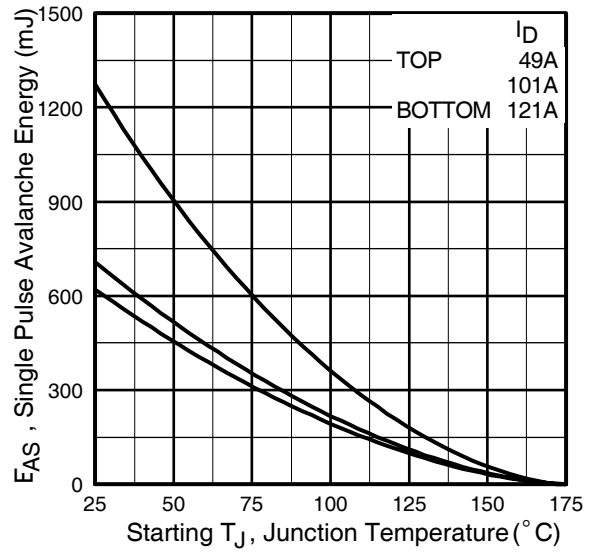
**Fig 12b.** Unclamped Inductive Waveforms



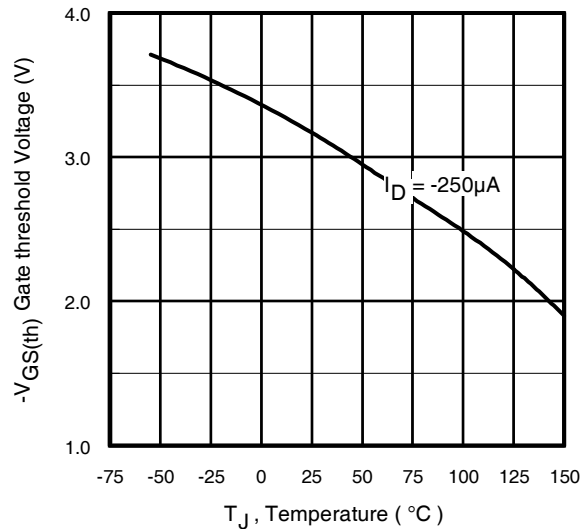
**Fig 13a.** Basic Gate Charge Waveform



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



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



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

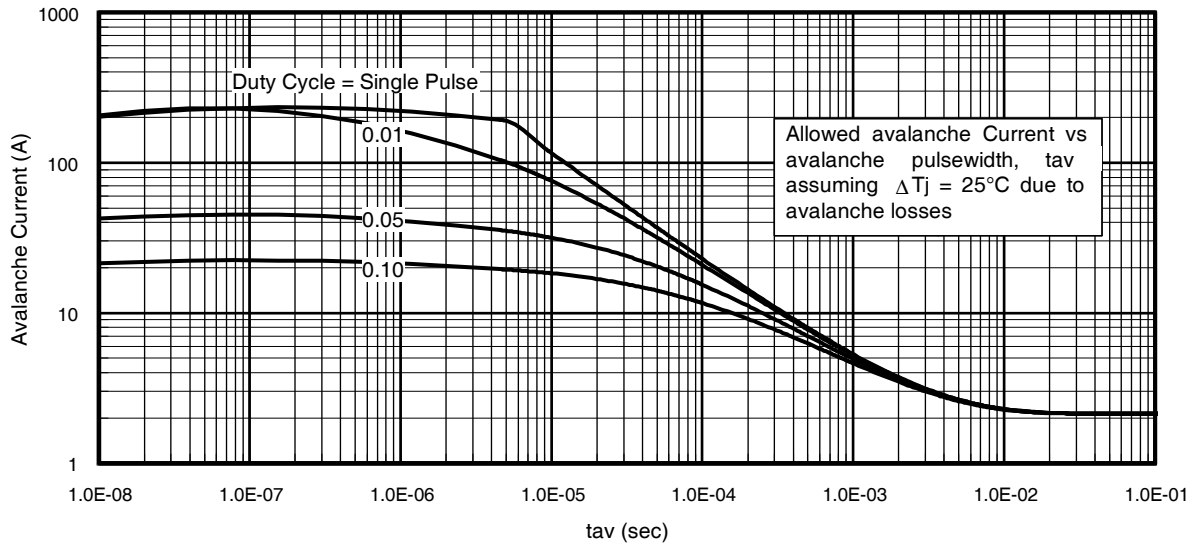


Fig 15. Typical Avalanche Current Vs. Pulsewidth

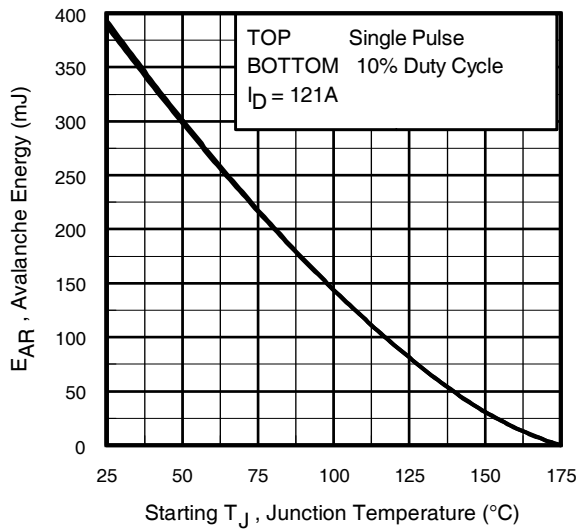


Fig 16. Maximum Avalanche Energy Vs. Temperature

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

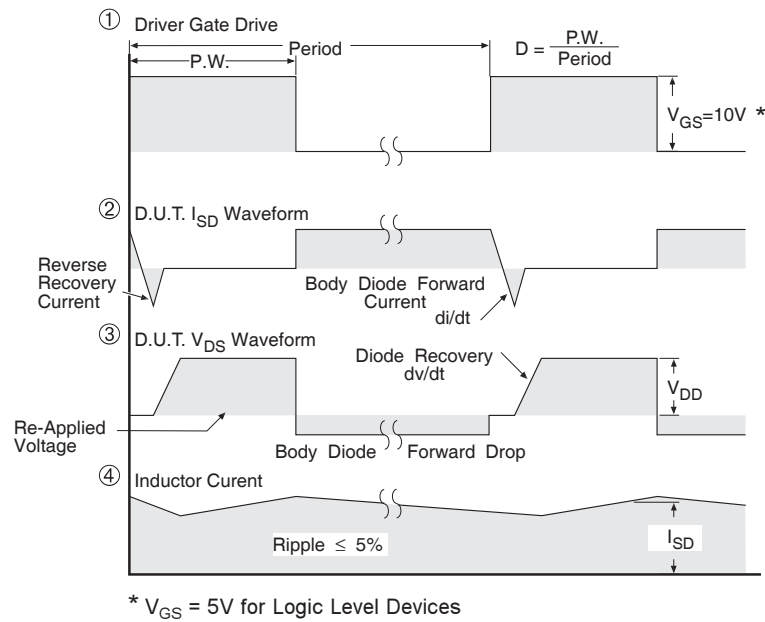
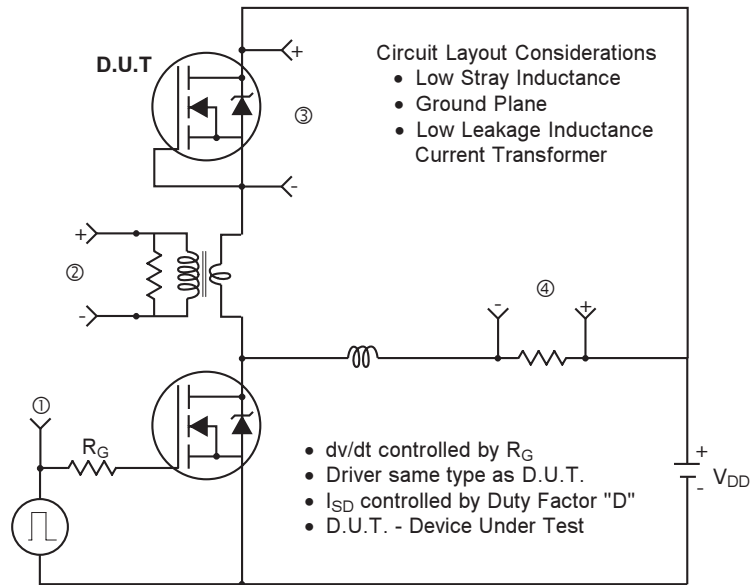
1. Avalanche failures assumption:  
Purely a thermal phenomenon and failure occurs at a temperature far in excess of  $T_{jmax}$ . This is validated for every part type.
2. Safe operation in Avalanche is allowed as long as  $T_{jmax}$  is not exceeded.
3. Equation below based on circuit and waveforms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

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

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

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

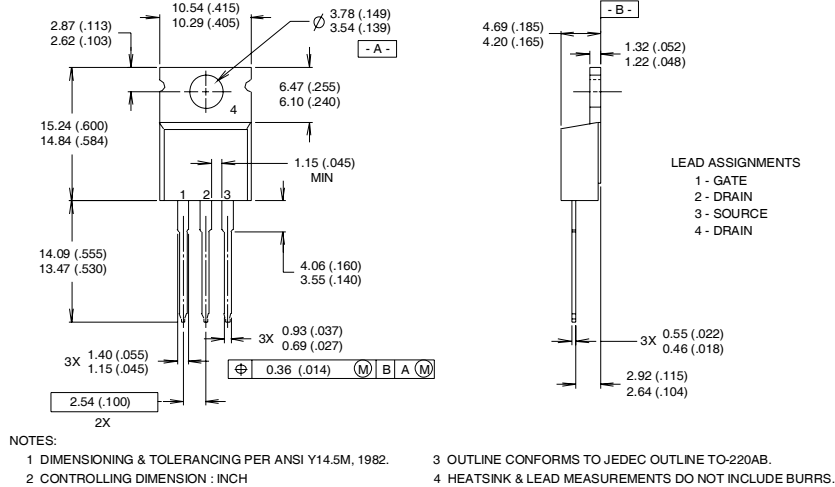
## Peak Diode Recovery dv/dt Test Circuit



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

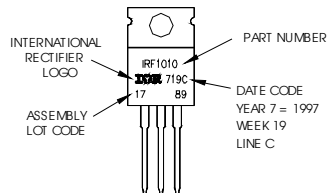
## TO-220AB Package Outline

Dimensions are shown in millimeters



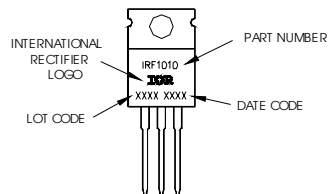
## TO-220AB Part Marking Information

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"



For GB Production

EXAMPLE: THIS IS AN IRF1010  
LOT CODE 1789  
ASSEMBLED ON WW/19, 1997  
IN THE ASSEMBLY LINE "C"



**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 automotive [Q101] market.  
Qualification Standards can be found on IR's Web site.

International  
IR Rectifier

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