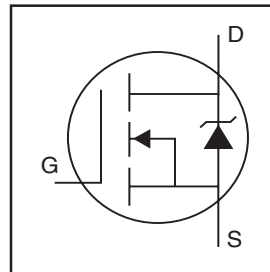


### Features

- Advanced Process Technology
- Ultra Low On-Resistance
- 175°C Operating Temperature
- Fast Switching
- Repetitive Avalanche Allowed up to  $T_{jmax}$



$$V_{DSS} = 55V$$

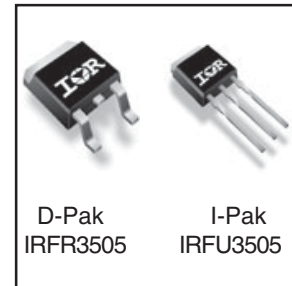
$$R_{DS(on)} = 0.013\Omega$$

$$I_D = 30A$$

### Description

Specifically designed for Automotive applications, this HEXFET® Power MOSFET utilizes the latest processing techniques to achieve extremely low on-resistance per silicon area. Additional features of this product 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 Automotive applications and a wide variety of other applications.

The D-Pak is designed for surface mounting using vapor phase, infrared, or wave soldering techniques. The straight lead version (IRFU series) is for through-hole mounting applications. Power dissipation levels up to 1.5 watts are possible in typical surface mount applications.



D-Pak  
IRFR3505

I-Pak  
IRFU3505

### Absolute Maximum Ratings

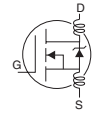
|                           | Parameter                                                  | Max.                     | Units |
|---------------------------|------------------------------------------------------------|--------------------------|-------|
| $I_D @ T_C = 25^\circ C$  | Continuous Drain Current, $V_{GS} @ 10V$ (Silicon limited) | 71                       | A     |
| $I_D @ T_C = 100^\circ C$ | Continuous Drain Current, $V_{GS} @ 10V$ (See Fig.9)       | 49                       |       |
| $I_D @ T_C = 25^\circ C$  | Continuous Drain Current, $V_{GS} @ 10V$ (Package limited) | 30                       |       |
| $I_{DM}$                  | Pulsed Drain Current ①                                     | 280                      |       |
| $P_D @ T_C = 25^\circ C$  | Power Dissipation                                          | 140                      | W     |
|                           | Linear Derating Factor                                     | 0.92                     | W/°C  |
| $V_{GS}$                  | Gate-to-Source Voltage                                     | $\pm 20$                 | V     |
| $E_{AS}$                  | Single Pulse Avalanche Energy②                             | 210                      | mJ    |
| $E_{AS} (tested)$         | Single Pulse Avalanche Energy Tested Value②                | 410                      |       |
| $I_{AR}$                  | Avalanche Current①                                         | See Fig.12a, 12b, 15, 16 | A     |
| $E_{AR}$                  | Repetitive Avalanche Energy③                               |                          | mJ    |
| $dv/dt$                   | Peak Diode Recovery $dv/dt$ ③                              | 4.0                      | 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 )   |       |

### Thermal Resistance

|                 | Parameter                        | Typ. | Max. | Units |
|-----------------|----------------------------------|------|------|-------|
| $R_{\theta JC}$ | Junction-to-Case                 | —    | 1.09 | °C/W  |
| $R_{\theta JA}$ | Junction-to-Ambient (PCB mount)④ | —    | 40   |       |
| $R_{\theta JA}$ | Junction-to-Ambient              | —    | 110  |       |

## 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    | 55   | —     | —     | V                   | $V_{GS} = 0V, I_D = 250\mu A$                                               |
| $\Delta V_{(BR)DSS}/\Delta T_J$ | Breakdown Voltage Temp. Coefficient  | —    | 0.057 | —     | V/ $^\circ\text{C}$ | Reference to $25^\circ\text{C}$ , $I_D = 1\text{mA}$                        |
| $R_{DS(on)}$                    | Static Drain-to-Source On-Resistance | —    | 0.011 | 0.013 | $\Omega$            | $V_{GS} = 10V, I_D = 30A$ ④                                                 |
| $V_{GS(th)}$                    | Gate Threshold Voltage               | 2.0  | —     | 4.0   | V                   | $V_{DS} = 10V, I_D = 250\mu A$                                              |
| $g_{fs}$                        | Forward Transconductance             | 41   | —     | —     | S                   | $V_{DS} = 25V, I_D = 30A$                                                   |
| $I_{DSS}$                       | Drain-to-Source Leakage Current      | —    | —     | 20    | $\mu A$             | $V_{DS} = 55V, V_{GS} = 0V$                                                 |
|                                 |                                      | —    | —     | 250   |                     | $V_{DS} = 55V, V_{GS} = 0V, T_J = 125^\circ\text{C}$                        |
| $I_{GSS}$                       | Gate-to-Source Forward Leakage       | —    | —     | 200   | nA                  | $V_{GS} = 20V$                                                              |
|                                 | Gate-to-Source Reverse Leakage       | —    | —     | -200  |                     | $V_{GS} = -20V$                                                             |
| $Q_g$                           | Total Gate Charge                    | —    | 62    | 93    | nC                  | $I_D = 30A$                                                                 |
| $Q_{gs}$                        | Gate-to-Source Charge                | —    | 17    | 26    |                     | $V_{DS} = 44V$                                                              |
| $Q_{gd}$                        | Gate-to-Drain ("Miller") Charge      | —    | 22    | 33    |                     | $V_{GS} = 10V$ ④                                                            |
| $t_{d(on)}$                     | Turn-On Delay Time                   | —    | 13    | —     | ns                  | $V_{DD} = 28V$                                                              |
| $t_r$                           | Rise Time                            | —    | 74    | —     |                     | $I_D = 30A$                                                                 |
| $t_{d(off)}$                    | Turn-Off Delay Time                  | —    | 43    | —     |                     | $R_G = 6.8\Omega$                                                           |
| $t_f$                           | 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                    | —    | 2030  | —     | pF                  | $V_{GS} = 0V$                                                               |
| $C_{oss}$                       | Output Capacitance                   | —    | 470   | —     |                     | $V_{DS} = 25V$                                                              |
| $C_{rss}$                       | Reverse Transfer Capacitance         | —    | 91    | —     |                     | $f = 1.0\text{MHz}$ , See Fig. 5                                            |
| $C_{oss}$                       | Output Capacitance                   | —    | 2600  | —     |                     | $V_{GS} = 0V, V_{DS} = 1.0V, f = 1.0\text{MHz}$                             |
| $C_{oss}$                       | Output Capacitance                   | —    | 330   | —     |                     | $V_{GS} = 0V, V_{DS} = 44V, f = 1.0\text{MHz}$                              |
| $C_{oss \text{ eff.}}$          | Effective Output Capacitance ③       | —    | 630   | —     |                     | $V_{GS} = 0V, V_{DS} = 0V \text{ to } 44V$                                  |



## Source-Drain Ratings and Characteristics

|          | Parameter                              | Min.                                                                        | Typ. | Max. | Units | Conditions                                                     |
|----------|----------------------------------------|-----------------------------------------------------------------------------|------|------|-------|----------------------------------------------------------------|
| $I_S$    | Continuous Source Current (Body Diode) | —                                                                           | —    | 71   | A     | MOSFET symbol showing the integral reverse p-n junction diode. |
| $I_{SM}$ | Pulsed Source Current (Body Diode) ①   | —                                                                           | —    | 280  |       |                                                                |
| $V_{SD}$ | Diode Forward Voltage                  | —                                                                           | —    | 1.3  | V     | $T_J = 25^\circ\text{C}, I_S = 30A, V_{GS} = 0V$ ④             |
| $t_{rr}$ | Reverse Recovery Time                  | —                                                                           | 70   | 105  | ns    | $T_J = 25^\circ\text{C}, I_F = 30A, V_{DD} = 28V$              |
| $Q_{rr}$ | Reverse Recovery Charge                | —                                                                           | 180  | 270  | 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 through ④ are on page 11

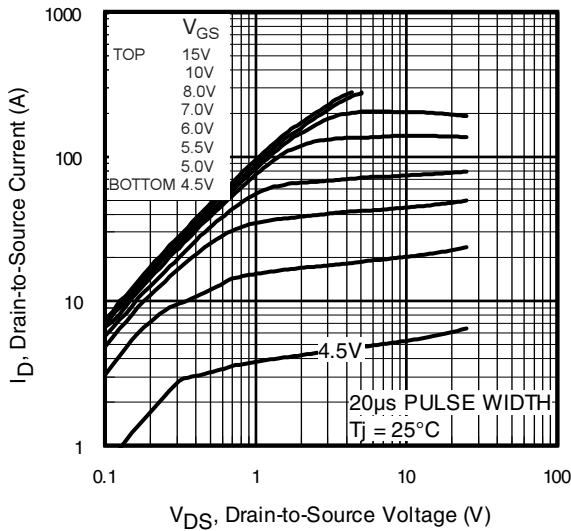


Fig 1. Typical Output Characteristics

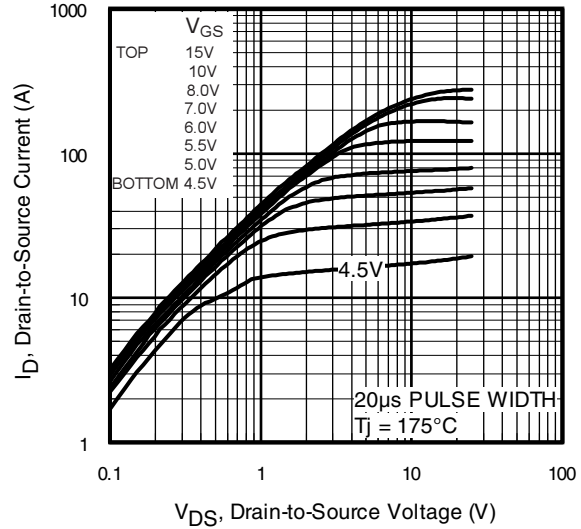


Fig 2. Typical Output Characteristics

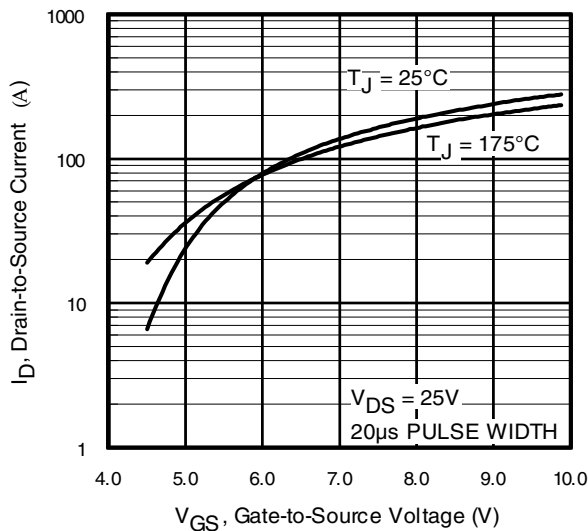


Fig 3. Typical Transfer Characteristics

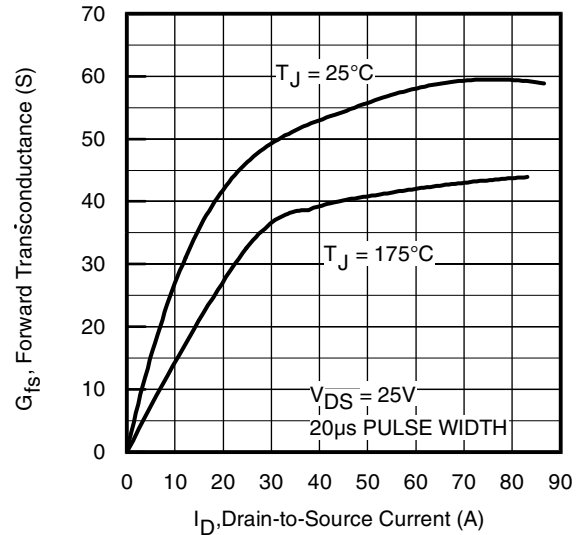
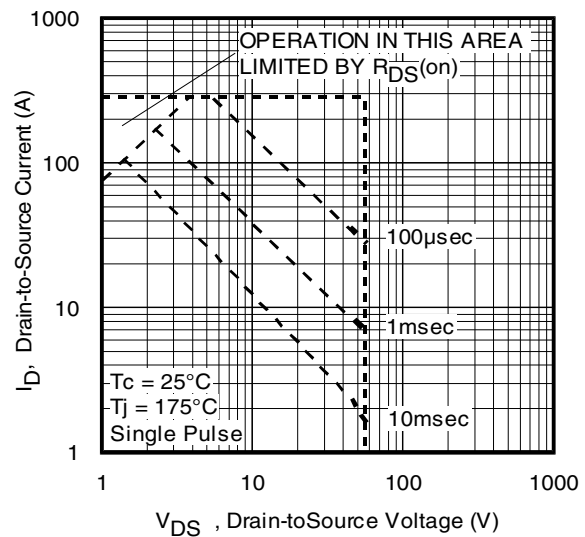
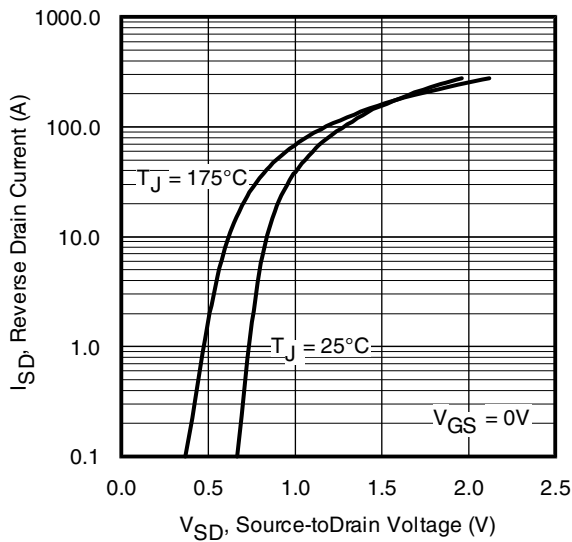
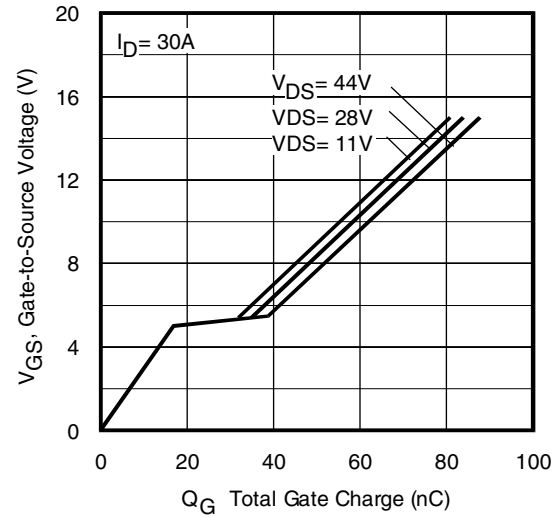
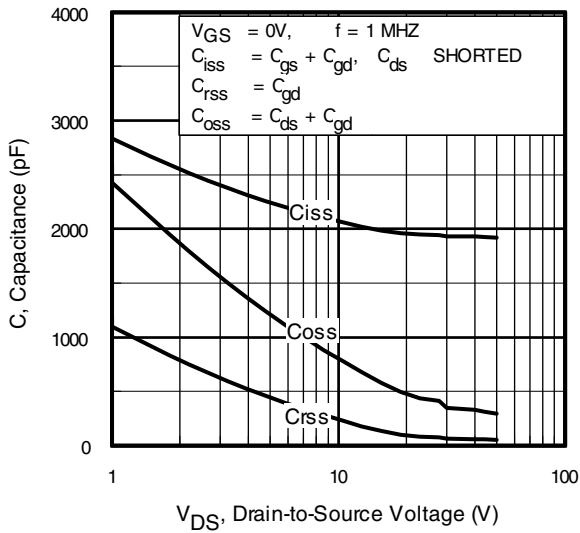
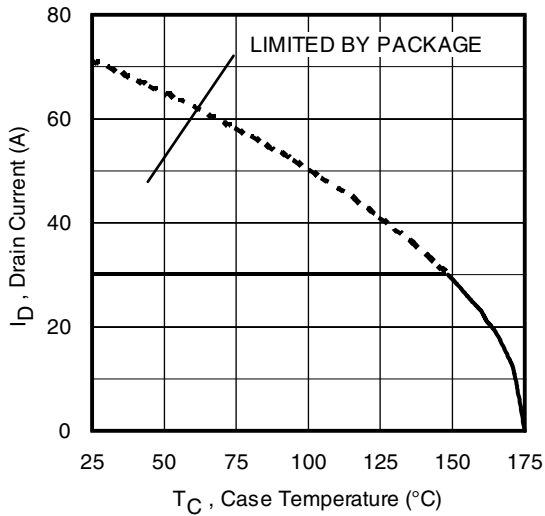
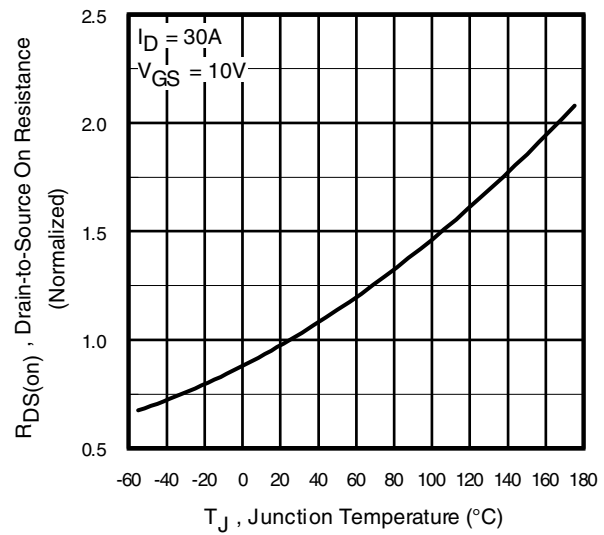


Fig 4. Typical Forward Transconductance Vs. Drain Current

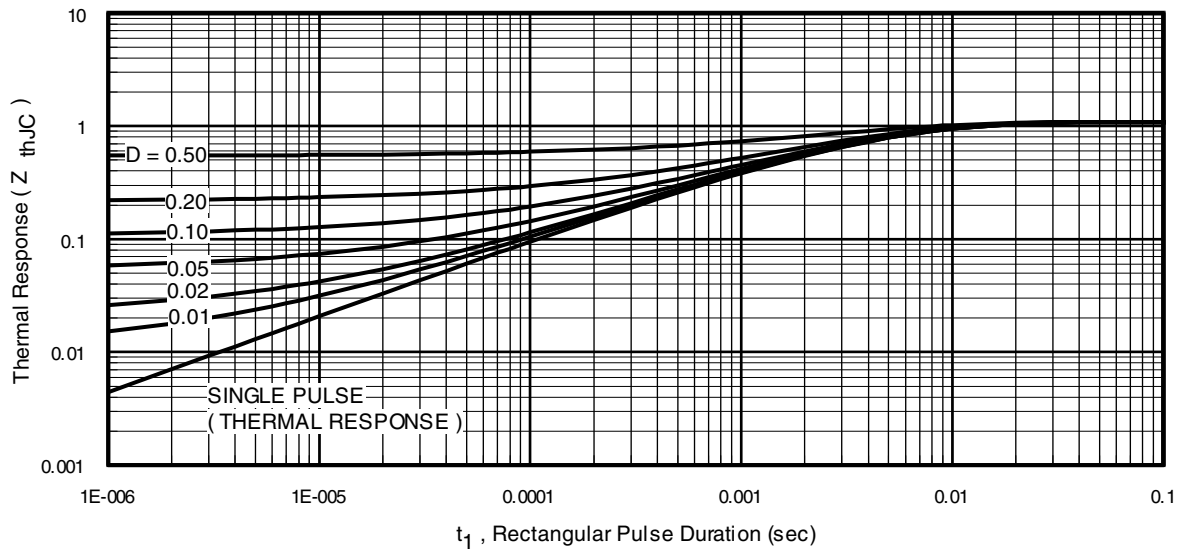




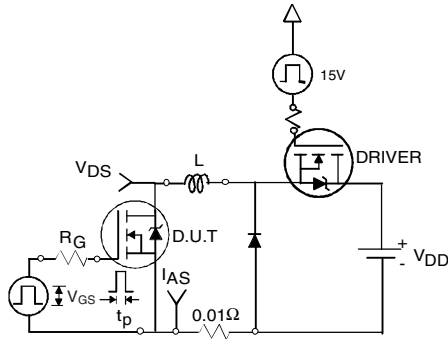
**Fig 9.** Maximum Drain Current Vs. Case Temperature



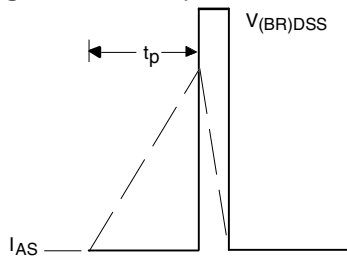
**Fig 10.** Normalized On-Resistance Vs. Temperature



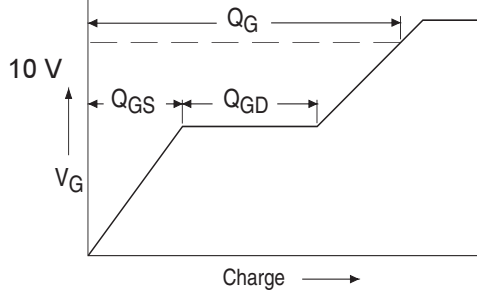
**Fig 11.** Maximum Effective Transient Thermal Impedance, Junction-to-Case



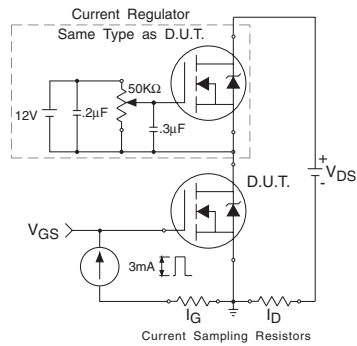
**Fig 12a.** Unclamped Inductive Test Circuit



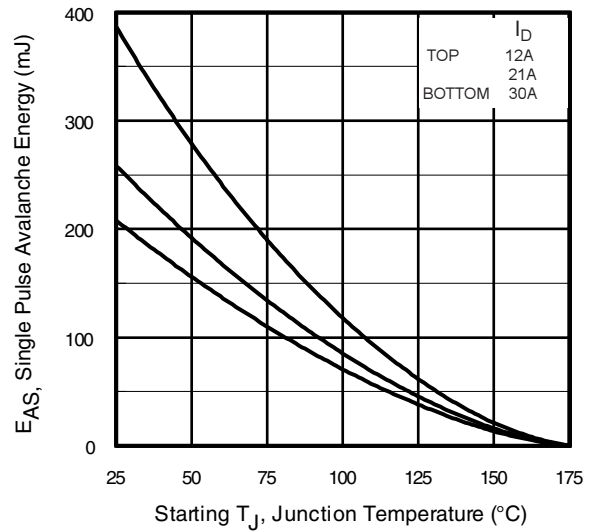
**Fig 12b.** Unclamped Inductive Waveforms



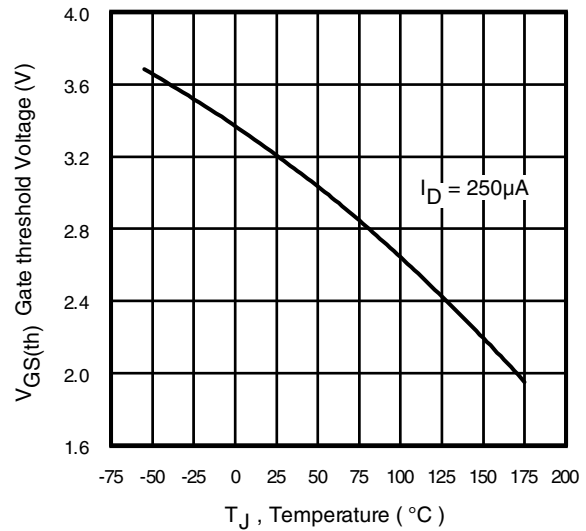
**Fig 13a.** Basic Gate Charge Waveform



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



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



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

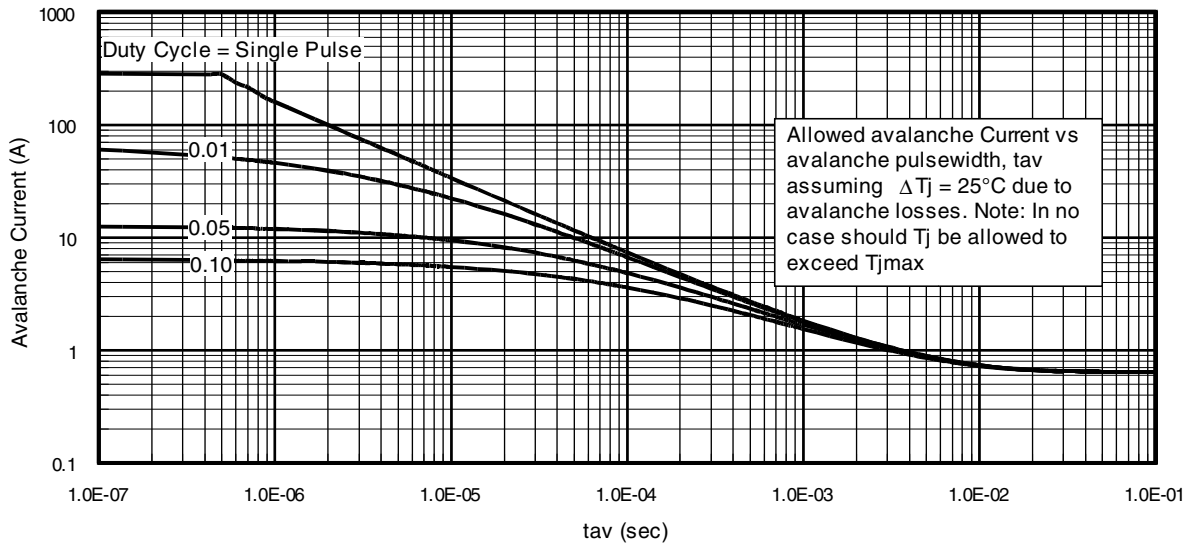


Fig 15. Typical Avalanche Current Vs. Pulsewidth

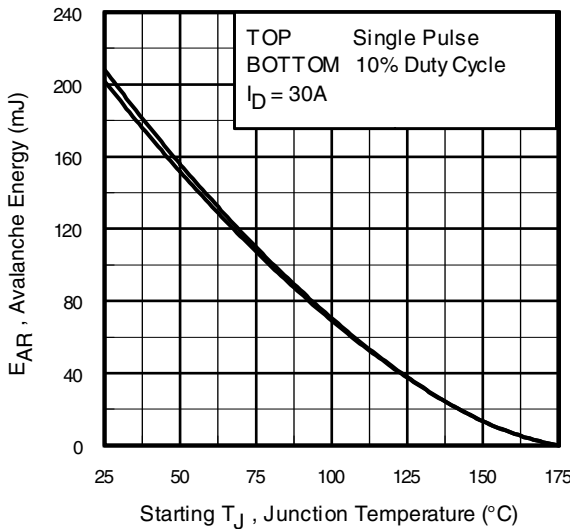


Fig 16. Maximum Avalanche Energy Vs. Temperature

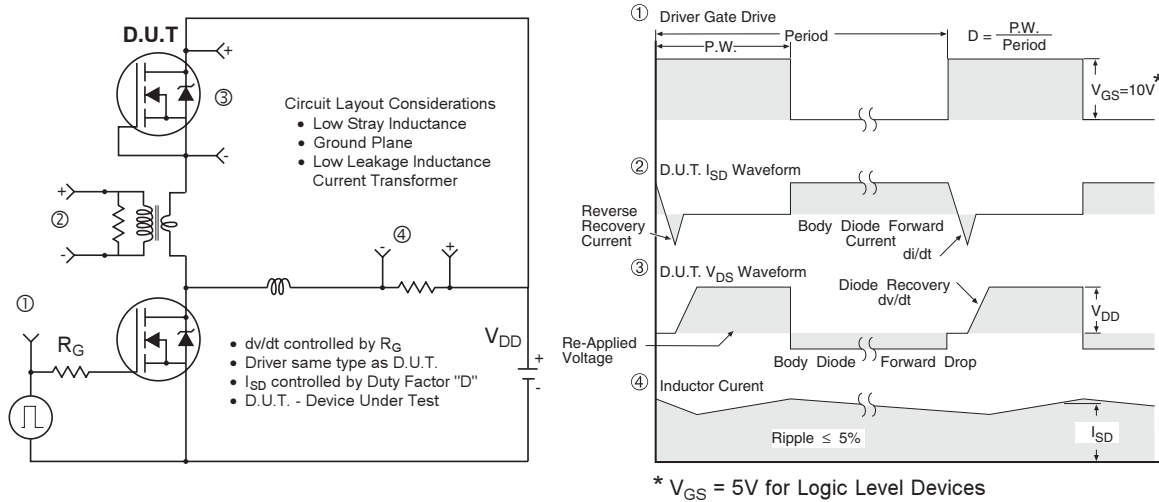
**Notes on Repetitive Avalanche Curves , Figures 15, 16:**  
(For further info, see AN-1005 at [www.irf.com](http://www.irf.com))

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)

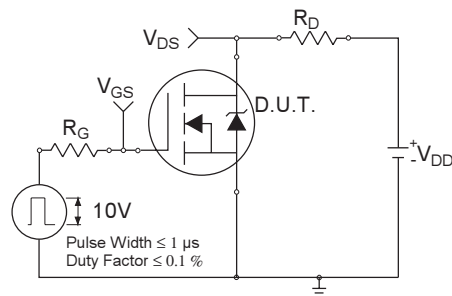
$$P_{D(ave)} = 1/2 (1.3 \cdot BV \cdot I_{av}) = \Delta T / Z_{thJC}$$

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

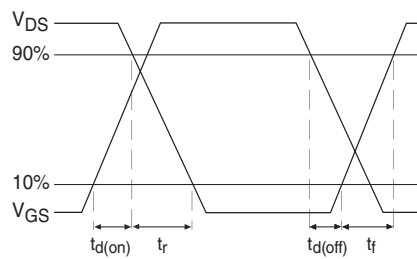
$$E_{AS(AR)} = P_{D(ave)} \cdot t_{av}$$



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



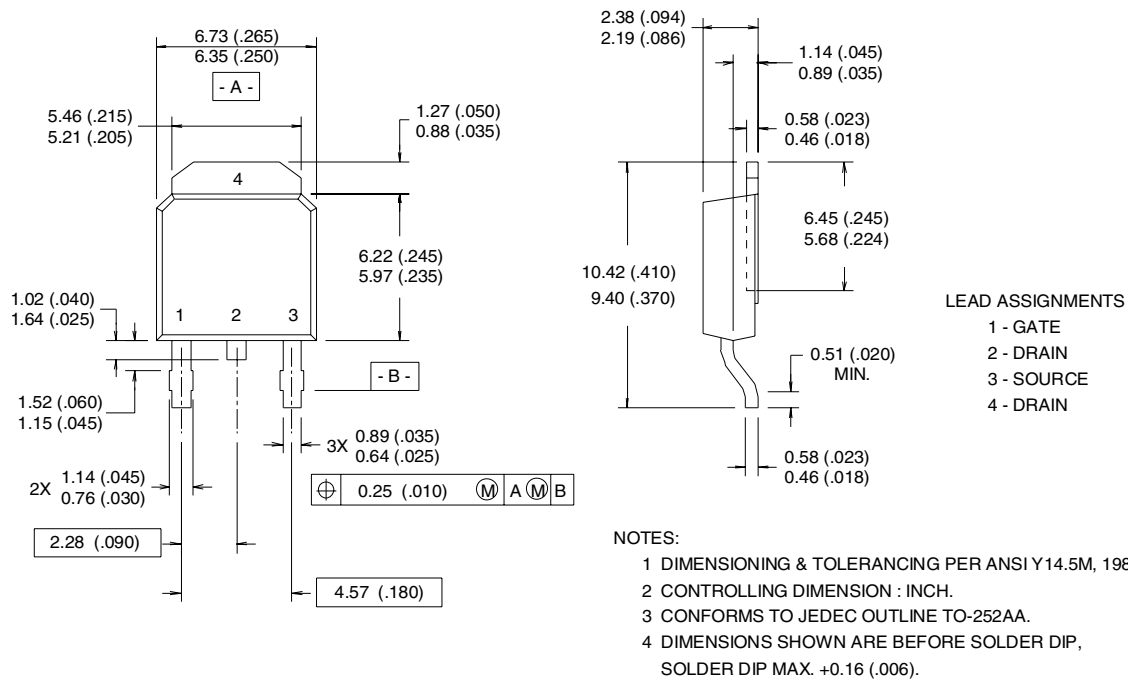
**Fig 18a. Switching Time Test Circuit**



**Fig 18b. Switching Time Waveforms**

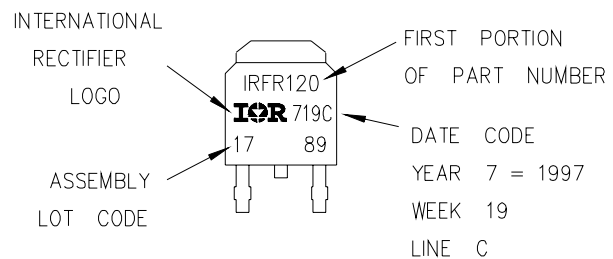
## D-Pak (TO-252AA) Package Outline

Dimensions are shown in millimeters (inches)



## D-Pak (TO-252AA) Part Marking Information

EXAMPLE: THIS IS AN IRFR120  
LOT CODE 1789  
ASSEMBLED ON WW 19, 1997  
IN THE ASSEMBLY LINE "C"

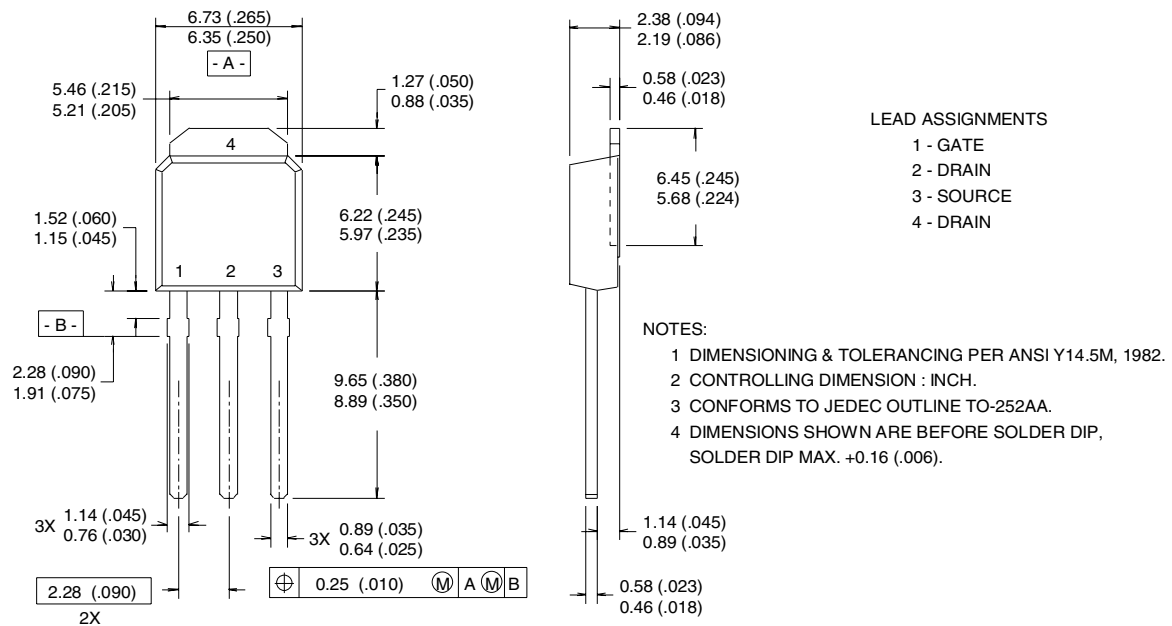


# IRFR/U3505

International  
**IR** Rectifier

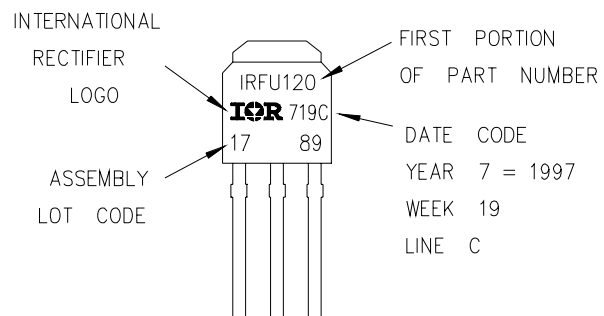
## I-Pak (TO-251AA) Package Outline

Dimensions are shown in millimeters (inches)



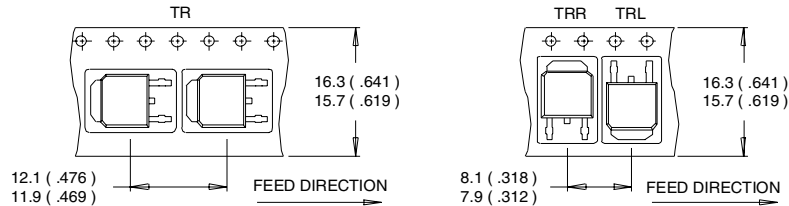
## I-Pak (TO-251AA) Part Marking Information

EXAMPLE: THIS IS AN IRFU120  
LOT CODE 1789  
ASSEMBLED ON WW 19, 1997  
IN THE ASSEMBLY LINE "C"



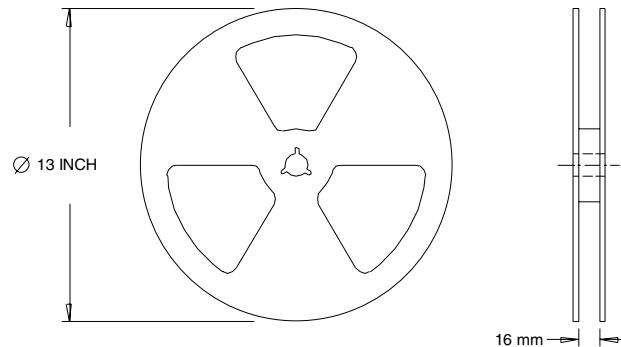
## D-Pak (TO-252AA) Tape & Reel Information

Dimensions are shown in millimeters (inches)



**NOTES :**

1. CONTROLLING DIMENSION : MILLIMETER.
2. ALL DIMENSIONS ARE SHOWN IN MILLIMETERS ( INCHES ).
3. OUTLINE CONFORMS TO EIA-481 & EIA-541.



**NOTES :**

1. OUTLINE CONFORMS TO EIA-481.

**Notes:**

- ① Repetitive rating; pulse width limited by max. junction temperature. (See fig. 11).
- ② Limited by  $T_{Jmax}$ , starting  $T_J = 25^\circ\text{C}$ ,  $L = 0.47\text{mH}$ ,  $R_G = 25\Omega$ ,  $I_{AS} = 30\text{A}$ ,  $V_{GS} = 10\text{V}$ . Part not recommended for use above this value.
- ③  $I_{SD} \leq 30\text{A}$ ,  $di/dt \leq 300\text{A}/\mu\text{s}$ ,  $V_{DD} \leq V_{(BR)DSS}$ ,  $T_J \leq 175^\circ\text{C}$
- ④ Pulse width  $\leq 1.0\text{ms}$ ; duty cycle  $\leq 2\%$ .
- ⑤  $C_{OSS}$  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 When mounted on 1" square PCB (FR-4 or G-10 Material). For recommended footprint and soldering techniques refer to application note #AN-994

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.