

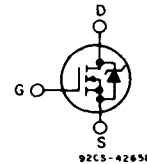
## Avalanche Energy Rated N-Channel Power MOSFETs

4.5A and 5.5A, 150V-200V  
 $r_{DS(on)} = 0.4\Omega$  and  $0.6\Omega$

### Features:

- Single pulse avalanche energy rated
- SOA is power-dissipation limited
- Nanosecond switching speeds
- Linear transfer characteristics
- High input impedance

### N-CHANNEL ENHANCEMENT MODE

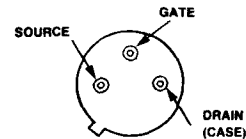


TERMINAL DIAGRAM

The IRFF230R, IRFF231R, IRFF232R and IRFF233R are advanced power MOSFETs designed, tested, and guaranteed to withstand a specified level of energy in the breakdown avalanche mode of operation. These are n-channel enhancement-mode silicon-gate power field-effect transistors designed for applications such as switching regulators, switching converters, motor drivers, relay drivers, and drivers for high-power bipolar switching transistors requiring high speed and low gate-drive power. These types can be operated directly from integrated circuits.

The IRFF-types are supplied in the JEDEC TO-205AF (LOW-PROFILE TO-39) metal package.

### TERMINAL DESIGNATION



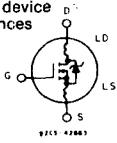
JEDEC TO-205AF

### Absolute Maximum Ratings

| Parameter                                                           | IRFF230R                                  | IRFF231R | IRFF232R | IRFF233R | Units               |
|---------------------------------------------------------------------|-------------------------------------------|----------|----------|----------|---------------------|
| $V_{DS}$ Drain - Source Voltage ①                                   | 200                                       | 150      | 200      | 150      | V                   |
| $V_{DGR}$ Drain - Gate Voltage ( $R_{GS} = 20\text{ K}\Omega$ ) ①   | 200                                       | 150      | 200      | 150      | V                   |
| $I_D @ T_C = 25^\circ\text{C}$ Continuous Drain Current             | 5.5                                       | 5.5      | 4.5      | 4.5      | A                   |
| $I_{DM}$ Pulsed Drain Current ③                                     | 22                                        | 22       | 18       | 18       | A                   |
| $V_{GS}$ Gate - Source Voltage                                      | $\pm 20$                                  |          |          |          | V                   |
| $P_D @ T_C = 25^\circ\text{C}$ Max. Power Dissipation               | 25 (See Fig. 14)                          |          |          |          | W                   |
| Linear Derating Factor                                              | 0.2 (See Fig. 14)                         |          |          |          | W/ $^\circ\text{C}$ |
| $E_{AS}$ Single Pulse Avalanche Energy Rating ④                     | 85                                        |          |          |          | mJ                  |
| $T_J$ Operating Junction and<br>$T_{stg}$ Storage Temperature Range | -55 to 150                                |          |          |          | $^\circ\text{C}$    |
| Lead Temperature                                                    | 300 (0.063 in. (1.6mm) from case for 10s) |          |          |          | $^\circ\text{C}$    |

## IRFF230R, IRFF231R, IRFF232R, IRFF233R

Electrical Characteristics @  $T_c = 25^\circ\text{C}$  (Unless Otherwise Specified)

| Parameter                                                      | Type                 | Min. | Typ. | Max. | Units | Test Conditions                                                                                                                                                                      |                                                                                     |
|----------------------------------------------------------------|----------------------|------|------|------|-------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------|
| BV <sub>DSS</sub> Drain - Source Breakdown Voltage             | IRFF230R<br>IRFF232R | 200  | —    | —    | V     | V <sub>GS</sub> = 0V<br>I <sub>D</sub> = 250μA                                                                                                                                       |                                                                                     |
|                                                                | IRFF231R<br>IRFF233R | 150  | —    | —    | V     |                                                                                                                                                                                      |                                                                                     |
| V <sub>GS(th)</sub> Gate Threshold Voltage                     | ALL                  | 2.0  | —    | 4.0  | V     | V <sub>DS</sub> = V <sub>GS</sub> , I <sub>D</sub> = 250μA                                                                                                                           |                                                                                     |
| I <sub>GSS</sub> Gate-Source Leakage Forward                   | ALL                  | —    | —    | 100  | nA    | V <sub>GS</sub> = 20V                                                                                                                                                                |                                                                                     |
| I <sub>GSS</sub> Gate-Source Leakage Reverse                   | ALL                  | —    | —    | -100 | nA    | V <sub>GS</sub> = -20V                                                                                                                                                               |                                                                                     |
| I <sub>OSS</sub> Zero Gate Voltage Drain Current               | ALL                  | —    | —    | 250  | μA    | V <sub>DS</sub> = Max. Rating, V <sub>GS</sub> = 0V                                                                                                                                  | V <sub>DS</sub> = Max. Rating x 0.8, V <sub>GS</sub> = 0V, T <sub>C</sub> = 125°C   |
|                                                                |                      | —    | —    | 1000 | μA    |                                                                                                                                                                                      |                                                                                     |
| I <sub>D(on)</sub> On-State Drain Current ②                    | IRFF230R<br>IRFF231R | 5.5  | —    | —    | A     | V <sub>DS</sub> > I <sub>D(on)</sub> x R <sub>DS(on)</sub> max., V <sub>GS</sub> = 10V                                                                                               |                                                                                     |
|                                                                | IRFF232R<br>IRFF233R | 4.5  | —    | —    | A     |                                                                                                                                                                                      |                                                                                     |
| R <sub>DS(on)</sub> Static Drain-Source On-State Resistance ②  | IRFF230R<br>IRFF231R | —    | 0.25 | 0.4  | Ω     | V <sub>GS</sub> = 10V, I <sub>D</sub> = 3.0A                                                                                                                                         |                                                                                     |
|                                                                | IRFF232R<br>IRFF233R | —    | 0.4  | 0.6  | Ω     |                                                                                                                                                                                      |                                                                                     |
|                                                                |                      |      |      |      |       |                                                                                                                                                                                      |                                                                                     |
| g <sub>fs</sub> Forward Transconductance ②                     | ALL                  | 2.5  | 4.5  | —    | S(V)  | V <sub>DS</sub> > I <sub>D(on)</sub> x R <sub>DS(on)</sub> max., I <sub>D</sub> = 3.0A                                                                                               |                                                                                     |
| C <sub>iss</sub> Input Capacitance                             | ALL                  | —    | 600  | —    | pF    | V <sub>GS</sub> = 0V, V <sub>DS</sub> = 25V, f = 1.0 MHz<br>See Fig. 10                                                                                                              |                                                                                     |
| C <sub>oss</sub> Output Capacitance                            | ALL                  | —    | 250  | —    | pF    |                                                                                                                                                                                      |                                                                                     |
| C <sub>rss</sub> Reverse Transfer Capacitance                  | ALL                  | —    | 80   | —    | pF    |                                                                                                                                                                                      |                                                                                     |
| t <sub>d(on)</sub> Turn-On Delay Time                          | ALL                  | —    | —    | 30   | ns    | V <sub>DD</sub> = 90V, I <sub>D</sub> = 3.0A, Z <sub>0</sub> = 15Ω<br>See Fig. 17<br>(MOSFET switching times are essentially independent of operating temperature.)                  |                                                                                     |
| t <sub>r</sub> Rise Time                                       | ALL                  | —    | —    | 50   | ns    |                                                                                                                                                                                      |                                                                                     |
| t <sub>d(off)</sub> Turn-Off Delay Time                        | ALL                  | —    | —    | 50   | ns    |                                                                                                                                                                                      |                                                                                     |
| t <sub>f</sub> Fall Time                                       | ALL                  | —    | —    | 40   | ns    |                                                                                                                                                                                      |                                                                                     |
| Q <sub>g</sub> Total Gate Charge (Gate-Source Plus Gate-Drain) | ALL                  | —    | 19   | 30   | nC    | V <sub>GS</sub> = 10V, I <sub>D</sub> = 11A, V <sub>DS</sub> = 0.8V Max. Rating.<br>See Fig. 18 for test circuit. (Gate charge is essentially independent of operating temperature.) |                                                                                     |
| Q <sub>gs</sub> Gate-Source Charge                             | ALL                  | —    | 10   | —    | nC    |                                                                                                                                                                                      |                                                                                     |
| Q <sub>gd</sub> Gate-Drain ("Miller") Charge                   | ALL                  | —    | 9.0  | —    | nC    |                                                                                                                                                                                      |                                                                                     |
| L <sub>D</sub> Internal Drain Inductance                       | ALL                  | —    | 5.0  | —    | nH    | Measured from the drain lead, 5 mm (0.2 in.) from header to center of die.                                                                                                           |  |
| L <sub>S</sub> Internal Source Inductance                      | ALL                  | —    | 15   | —    | nH    | Measured from the source lead, 5 mm (0.2 in.) from header to source bonding pad.                                                                                                     |                                                                                     |

## Thermal Resistance

|                                       |     |   |   |     |      |                    |
|---------------------------------------|-----|---|---|-----|------|--------------------|
| R <sub>thJC</sub> Junction-to-Case    | ALL | — | — | 5.0 | °C/W |                    |
| R <sub>thJA</sub> Junction-to-Ambient | ALL | — | — | 175 | °C/W | Free Air Operation |

## Source-Drain Diode Ratings and Characteristics

|                                                       |                      |                                                                                                                         |     |     |    |                                                                              |                                                                                       |
|-------------------------------------------------------|----------------------|-------------------------------------------------------------------------------------------------------------------------|-----|-----|----|------------------------------------------------------------------------------|---------------------------------------------------------------------------------------|
| I <sub>S</sub> Continuous Source Current (Body Diode) | IRFF230R<br>IRFF231R | —                                                                                                                       | —   | 5.5 | A  | Modified MOSFET symbol showing the integral reverse P-N junction rectifier.  |  |
|                                                       | IRFF232R<br>IRFF233R | —                                                                                                                       | —   | 4.5 | A  |                                                                              |                                                                                       |
| I <sub>SM</sub> Pulse Source Current (Body Diode) ③   | IRFF230R<br>IRFF231R | —                                                                                                                       | —   | 22  | A  |                                                                              |                                                                                       |
|                                                       | IRFF232R<br>IRFF233R | —                                                                                                                       | —   | 18  | A  |                                                                              |                                                                                       |
| V <sub>SD</sub> Diode Forward Voltage ②               | IRFF230R<br>IRFF231R | —                                                                                                                       | —   | 2.0 | V  | T <sub>C</sub> = 25°C, I <sub>S</sub> = 5.5A, V <sub>GS</sub> = 0V           |                                                                                       |
|                                                       | IRFF232R<br>IRFF233R | —                                                                                                                       | —   | 1.8 | V  |                                                                              |                                                                                       |
| t <sub>rr</sub> Reverse Recovery Time                 | ALL                  | —                                                                                                                       | 450 | —   | ns | T <sub>J</sub> = 150°C, I <sub>F</sub> = 5.5A, dI <sub>F</sub> /dt = 100A/μs |                                                                                       |
| Q <sub>RR</sub> Reverse Recovered Charge              | ALL                  | —                                                                                                                       | 3.0 | —   | μC | T <sub>J</sub> = 150°C, I <sub>F</sub> = 5.5A, dI <sub>F</sub> /dt = 100A/μs |                                                                                       |
| t <sub>on</sub> Forward Turn-on Time                  | ALL                  | Intrinsic turn-on time is negligible.<br>Turn-on speed is substantially controlled by L <sub>S</sub> + L <sub>D</sub> . |     |     |    |                                                                              |                                                                                       |

① T<sub>J</sub> = 25°C to 150°C. ② Pulse Test: Pulse width ≤ 300μs, Duty Cycle ≤ 2%.

③ Repetitive Rating: Pulse width limited by max. junction temperature. See Transient Thermal Impedance Curve (Fig. 5).

④ V<sub>DD</sub> = 20V, starting T<sub>J</sub> = 25°C, L = 8.9mH, R<sub>GS</sub> = 50Ω, I<sub>peak</sub> = 5.5A.

IRFF230R, IRFF231R, IRFF232R, IRFF233R

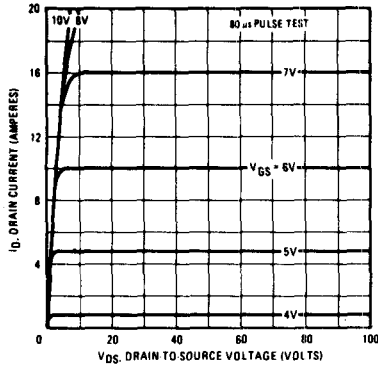


Fig. 1 - Typical output characteristics.

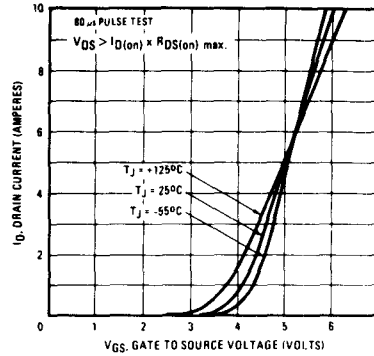


Fig. 2 - Typical transfer characteristics.

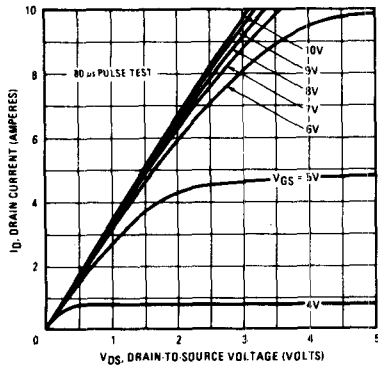


Fig. 3 - Typical saturation characteristics.

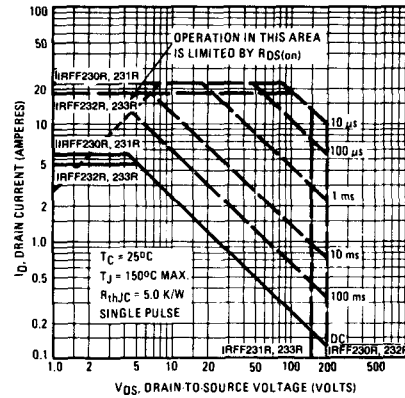


Fig. 4 - Maximum safe operating area.

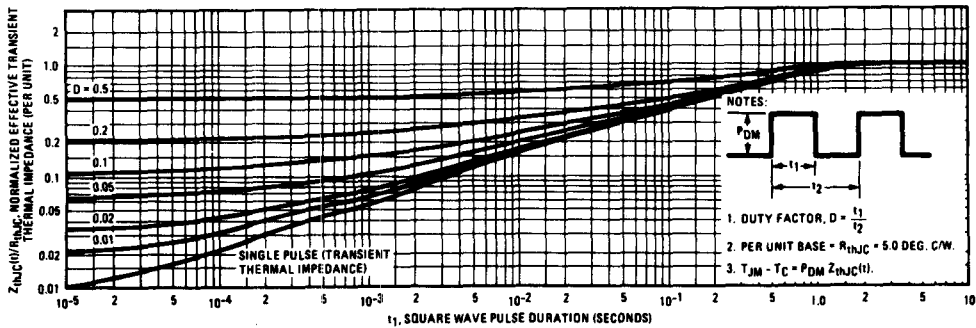


Fig. 5 - Maximum effective transient thermal impedance, junction-to-case vs. pulse duration.

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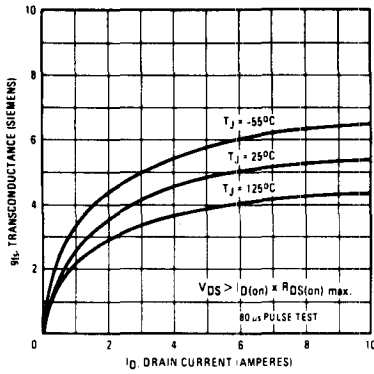


Fig. 6 - Typical transconductance vs. drain current.

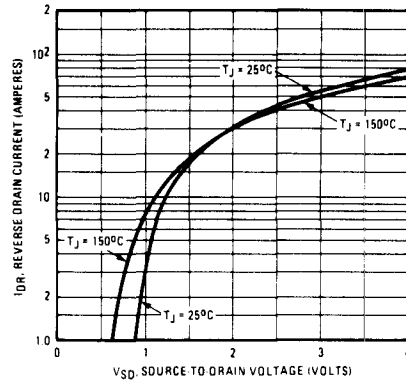


Fig. 7 - Typical source-drain diode forward voltage.

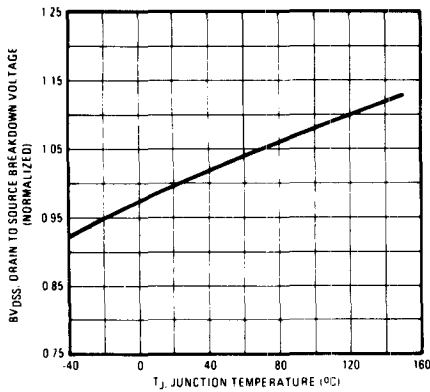


Fig. 8 - Breakdown voltage vs. temperature.

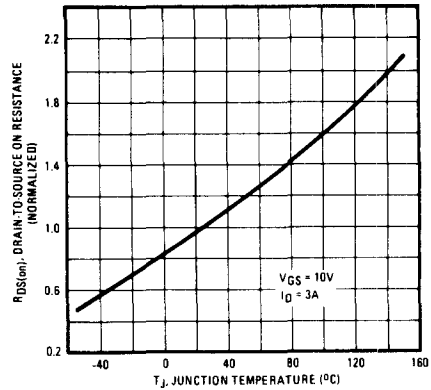


Fig. 9 - Normalized on-resistance vs. temperature.

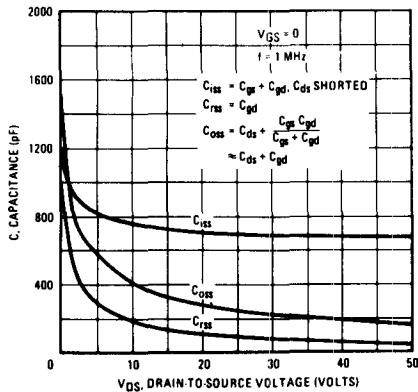


Fig. 10 - Typical capacitance vs. drain-to-source voltage.

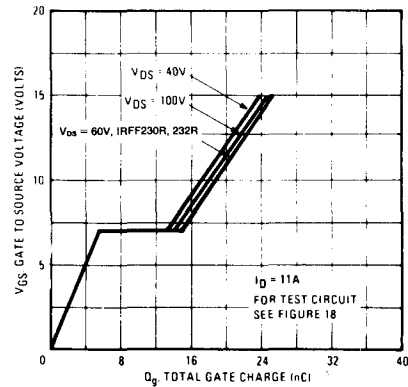


Fig. 11 - Typical gate charge vs. gate-to-source voltage.

IRFF230R, IRFF231R, IRFF232R, IRFF233R

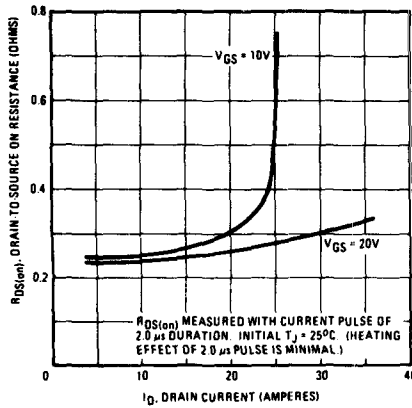


Fig. 12 - Typical on-resistance vs. drain current.

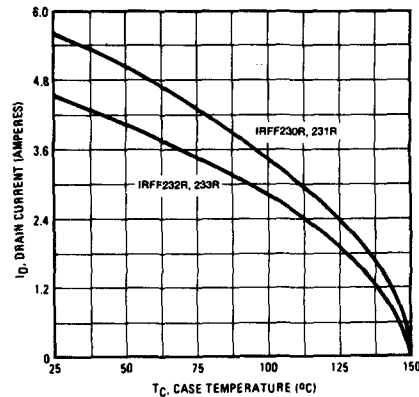


Fig. 13 - Maximum drain current vs. case temperature.

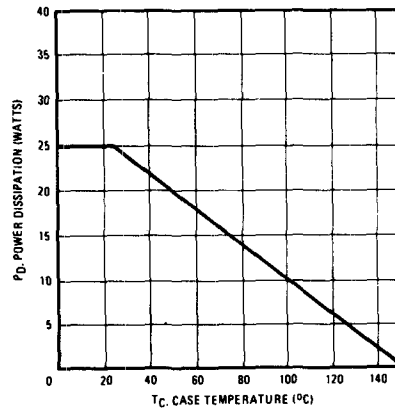


Fig. 14 - Power vs. temperature derating curve.

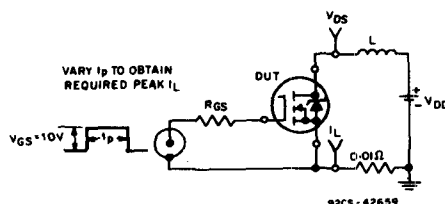


Fig. 15 - Unclamped Energy Test Circuit

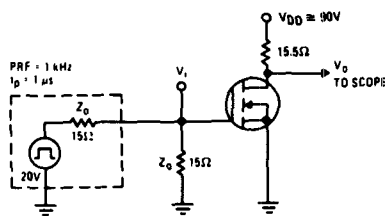


Fig. 17 - Switching time test circuit.

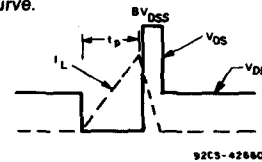


Fig. 16 - Unclamped Energy Waveforms

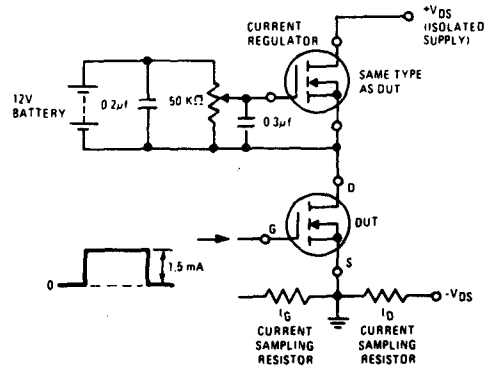


Fig. 18 - Gate charge test circuit.