File Number **1568**

**IRF230, IRF231, IRF232, IRF233**

# Power MOS Field-Effect Transistors

## N-Channel Enhancement-Mode Power Field-Effect Transistors

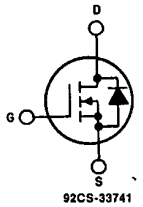
8.0A and 9.0A, 150V-200V
$r_{DS}(on)$ = 0.4 Ω and 0.6 Ω

**Features:**
- *SOA is power-dissipation limited*
- *Nanosecond switching speeds*
- *Linear transfer characteristics*
- *High input impedance*
- *Majority carrier device*

The IRF230, IRF231, IRF232 and IRF233 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 IRF-types are supplied in the JEDEC TO-204AA steel package.

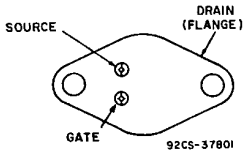
**N-CHANNEL ENHANCEMENT MODE**



92CS-33741

**TERMINAL DIAGRAM**

**TERMINAL DESIGNATION**



92CS-37801

**JEDEC TO-204AA**

### Absolute Maximum Ratings

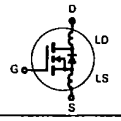
| Parameter | | IRF230 | IRF231 | IRF232 | IRF233 | Units |
|---|---|---|---|---|---|---|
| $V_{DS}$ | Drain - Source Voltage ① | 200 | 150 | 200 | 150 | V |
| $V_{DGR}$ | Drain - Gate Voltage ($R_{GS}$ = 20 KΩ) ① | 200 | 150 | 200 | 150 | V |
| $I_D$ @ $T_C$ = 25°C | Continuous Drain Current | 9.0 | 9.0 | 8.0 | 8.0 | A |
| $I_D$ @ $T_C$ = 100°C | Continuous Drain Current | 6.0 | 6.0 | 5.0 | 5.0 | A |
| $I_{DM}$ | Pulsed Drain Current ③ | 36 | 36 | 32 | 32 | A |
| $V_{GS}$ | Gate - Source Voltage | ±20 | | | | V |
| $P_D$ @ $T_C$ = 25°C | Max. Power Dissipation | 75 (See Fig. 14) | | | | W |
| | Linear Derating Factor | 0.6 (See Fig. 14) | | | | W/°C |
| $I_{LM}$ | Inductive Current, Clamped | (See Fig. 15 and 16) L = 100μH | | | | A |
| | | 36 | 36 | 32 | 32 | |
| $T_J$ $T_{stg}$ | Operating Junction and Storage Temperature Range | -55 to 150 | | | | °C |
| | Lead Temperature | 300 (0.063 in (1.6mm) from case for 10s) | | | | °C |

# IRF230, IRF231, IRF232, IRF233

## Electrical Characteristics @$T_C$ = 25°C (Unless Otherwise Specified)

| Parameter | | Type | Min. | Typ. | Max. | Units | Test Conditions |
|---|---|---|---|---|---|---|---|
| $BV_{DSS}$ | Drain - Source Breakdown Voltage | IRF230 IRF232 | 200 | – | – | V | $V_{GS}$ = 0V |
| | | IRF231 IRF233 | 150 | – | – | V | $I_D$ = 250μA |
| $V_{GS(th)}$ | Gate Threshold Voltage | ALL | 2.0 | – | 4.0 | V | $V_{DS}$ = $V_{GS}$, $I_D$ = 250μA |
| $I_{GSS}$ | Gate-Source Leakage Forward | ALL | – | – | 100 | nA | $V_{GS}$ = 20V |
| $I_{GSS}$ | Gate-Source Leakage Reverse | ALL | – | – | -100 | nA | $V_{GS}$ = -20V |
| $I_{DSS}$ | Zero Gate Voltage Drain Current | ALL | – | – | 250 | μA | $V_{DS}$ = Max. Rating, $V_{GS}$ = 0V |
| | | | – | – | 1000 | μA | $V_{DS}$ = Max. Rating x 0.8, $V_{GS}$ = 0V, $T_C$ = 125°C |
| $I_{D(on)}$ | On-State Drain Current ② | IRF230 IRF231 | 9.0 | – | – | A | $V_{DS} > I_{D(on)} \times R_{DS(on)}$ max., $V_{GS}$ = 10V |
| | | IRF232 IRF233 | 8.0 | – | – | A | |
| $R_{DS(on)}$ | Static Drain-Source On-State Resistance ② | IRF230 IRF231 | – | 0.25 | 0.4 | Ω | $V_{GS}$ = 10V, $I_D$ = 5.0A |
| | | IRF232 IRF233 | – | 0.4 | 0.6 | Ω | |
| $g_{fs}$ | Forward Transconductance ② | ALL | 3.0 | 4.8 | – | S(℧) | $V_{DS} > I_{D(on)} \times R_{DS(on)}$ max., $I_D$ = 5.0A |
| $C_{iss}$ | Input Capacitance | ALL | – | 600 | 800 | pF | $V_{GS}$ = 0V, $V_{DS}$ = 25V, f = 1.0 MHz See Fig. 10 |
| $C_{oss}$ | Output Capacitance | ALL | – | 250 | 450 | pF | |
| $C_{rss}$ | Reverse Transfer Capacitance | ALL | – | 80 | 150 | pF | |
| $t_{d(on)}$ | Turn-On Delay Time | ALL | – | – | 30 | ns | $V_{DD}$ = 90V, $I_D$ = 5.0A, $Z_o$ = 15Ω See Fig. 17 (MOSFET switching times are essentially independent of operating temperature.) |
| $t_r$ | Rise Time | ALL | – | – | 50 | ns | |
| $t_{d(off)}$ | Turn-Off Delay Time | ALL | – | – | 50 | ns | |
| $t_f$ | Fall Time | ALL | – | – | 40 | ns | |
| $Q_g$ | Total Gate Charge (Gate-Source Plus Gate-Drain) | ALL | – | 19 | 30 | nC | $V_{GS}$ = 10V, $I_D$ = 12A, $V_{DS}$ = 0.8 Max. Rating. See Fig. 18 for test circuit. (Gate charge is essentially independent of operating temperature.) |
| $Q_{gs}$ | Gate-Source Charge | ALL | – | 10 | – | nC | |
| $Q_{gd}$ | Gate-Drain ("Miller") Charge | ALL | – | 9.0 | – | nC | |
| $L_D$ | Internal Drain Inductance | ALL | – | 5.0 | – | nH | Measured between the contact screw on header that is closer to source and gate pins and center of die. |
| $L_S$ | Internal Source Inductance | ALL | – | 12.5 | – | nH | Measured from the source pin, 6 mm (0.25 in.) from header and source bonding pad. |

Modified MOSFET symbol showing the internal device inductances.




## Thermal Resistance

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| $R_{thJC}$ | Junction-to-Case | ALL | – | – | 1.67 | °C/W | |
| $R_{thCS}$ | Case-to-Sink | ALL | – | 0.1 | – | °C/W | Mounting surface flat, smooth, and greased. |
| $R_{thJA}$ | Junction-to-Ambient | ALL | – | – | 30 | °C/W | Free Air Operation |

## Source-Drain Diode Ratings and Characteristics

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| $I_S$ | Continuous Source Current (Body Diode) | IRF230 IRF231 | – | – | 9.0 | A | Modified MOSFET symbol showing the integral reverse P-N junction rectifier. |
| | | IRF232 IRF233 | – | – | 8.0 | A | |
| $I_{SM}$ | Pulse Source Current (Body Diode) ③ | IRF230 IRF231 | – | – | 36 | A | |
| | | IRF232 IRF233 | – | – | 32 | A | |
| $V_{SD}$ | Diode Forward Voltage ② | IRF230 IRF231 | – | – | 2.0 | V | $T_C$ = 25°C, $I_S$ = 9.0A, $V_{GS}$ = 0V |
| | | IRF232 IRF233 | – | – | 1.8 | V | $T_C$ = 25°C, $I_S$ = 8.0A, $V_{GS}$ = 0V |
| $t_{rr}$ | Reverse Recovery Time | ALL | – | 450 | – | ns | $T_J$ = 150°C, $I_F$ = 9.0A, $dI_F/dt$ = 100A/μs |
| $Q_{RR}$ | Reverse Recovered Charge | ALL | – | 3.0 | – | μC | $T_J$ = 150°C, $I_F$ = 9.0A, $dI_F/dt$ = 100A/μs |
| $t_{on}$ | Forward Turn-on Time | ALL | Intrinsic turn on time is negligible. Turn-on speed is substantially controlled by $L_S$ + $L_D$ | | | | |


①$T_J$ = 25°C to 150°C. ②Pulse Test: Pulse width ≤ 300μs, Duty Cycle ≤ 2%. ③ Repetitive Rating: Pulse width limited by max junction temperature. See Transient Thermal Impedance Curve (Fig. 5).

## IRF230, IRF231, IRF232, IRF233

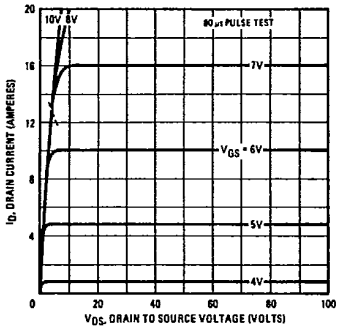



Fig. 1 – Typical Output Characteristics

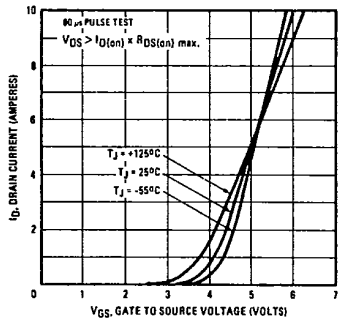



Fig. 2 – Typical Transfer Characteristics

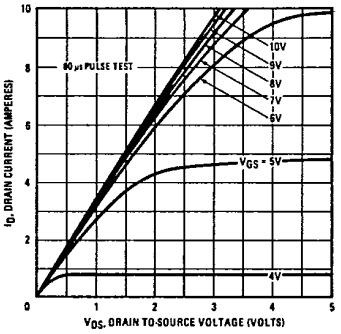



Fig. 3 – Typical Saturation Characteristics

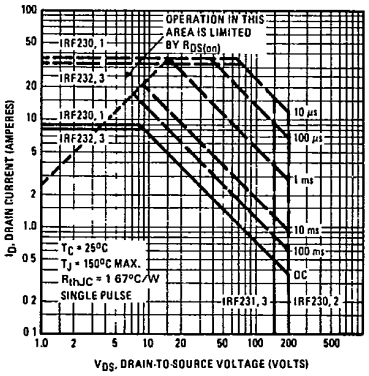



Fig. 4 – Maximum Safe Operating Area

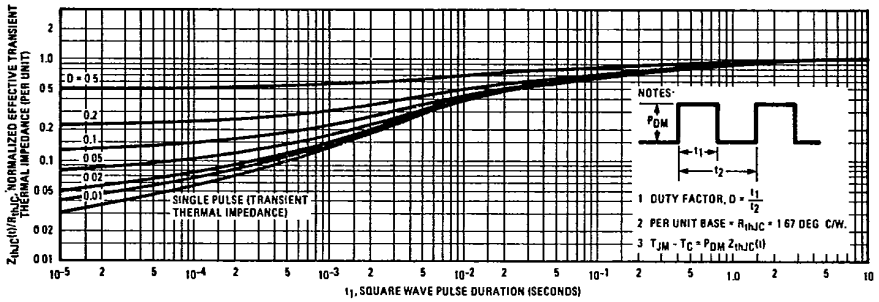



Fig. 5 – Maximum Effective Transient Thermal Impedance, Junction-to-Case Vs. Pulse Duration

## IRF230, IRF231, IRF232, IRF233

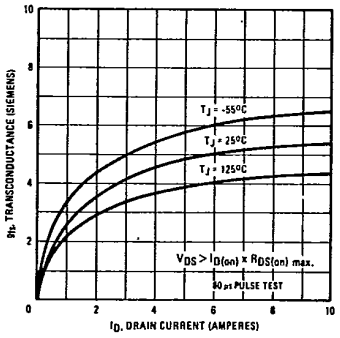



Fig. 6 – Typical Transconductance Vs. Drain Current

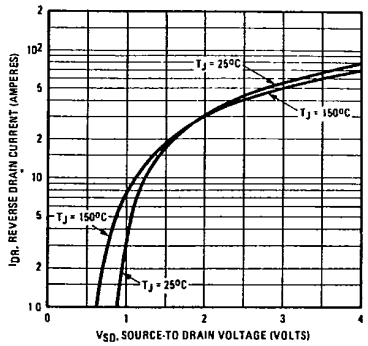



Fig. 7 – Typical Source-Drain Diode Forward Voltage

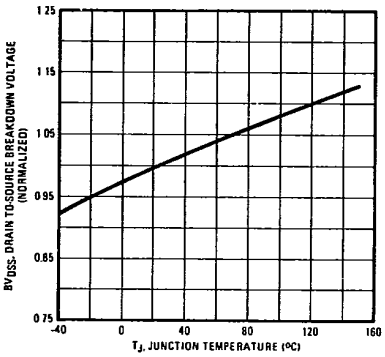



Fig. 8 – Breakdown Voltage Vs. Temperature

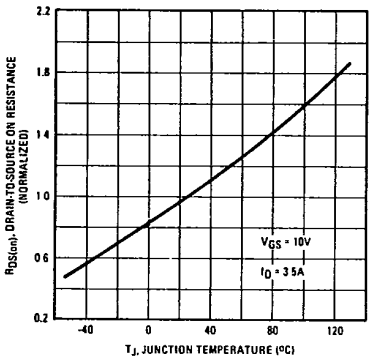



Fig. 9 – Normalized On-Resistance Vs. Temperature

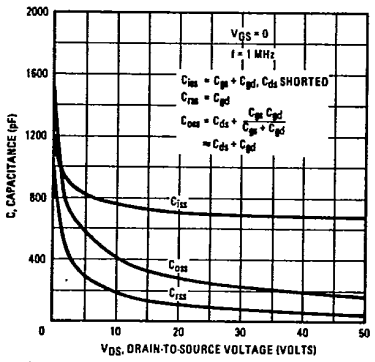



Fig. 10 – Typical Capacitance Vs. Drain-to-Source Voltage

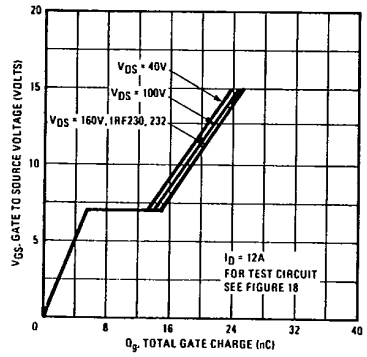



Fig. 11 – Typical Gate Charge Vs. Gate-to-Source Voltage

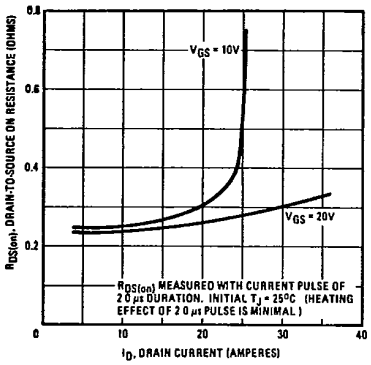



Fig. 12 – Typical On-Resistance Vs. Drain Current

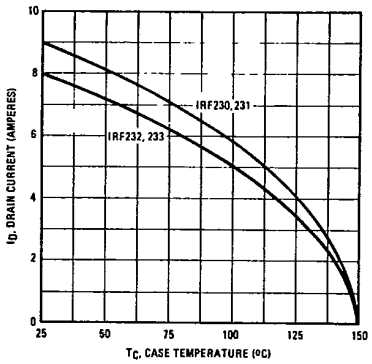



Fig. 13 – Maximum Drain Current Vs. Case Temperature

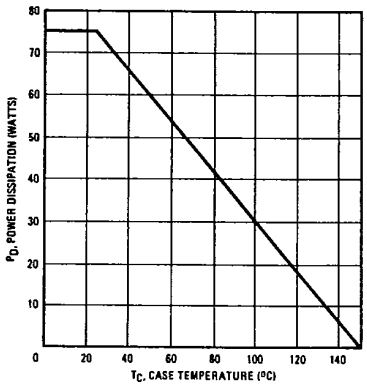



Fig. 14 – Power Vs. Temperature Derating Curve

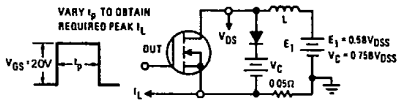



Fig. 15 – Clamped Inductive Test Circuit


Fig. 16 – Clamped Inductive Waveforms

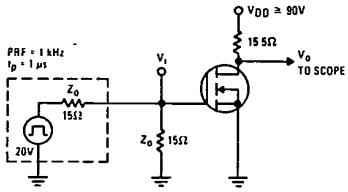



Fig. 17 – Switching Time Test Circuit

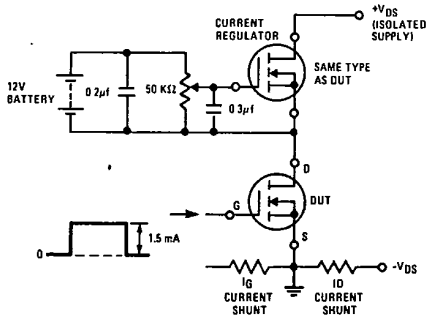



Fig. 18 – Gate Charge Test Circuit