## IRF710R, IRF711R, IRF712R, IRF713R

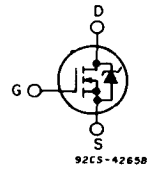
File Number **2000**

# Avalanche Energy Rated N-Channel Power MOSFETs

1.5A and 1.3A, 400V-350V
$r_{DS}(on) = 3.6\Omega$ and $5.0\Omega$

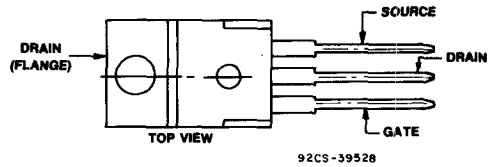
**Features:**
- *Single pulse avalanche energy rated*
- *SOA is power-dissipation limited*
- *Nanosecond switching speeds*
- *Linear transfer characteristics*
- *High input impedance*

**N-CHANNEL ENHANCEMENT MODE**




**TERMINAL DIAGRAM**

**TERMINAL DESIGNATION**




**JEDEC TO-220AB**

The IRF710R, IRF711R, IRF712R and IRF713R 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 IRF-types are supplied in the JEDEC TO-220AB plastic package.

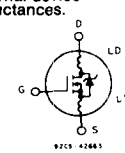
**Absolute Maximum Ratings**

| Parameter | | IRF710R | IRF711R | IRF712R | IRF713R | Units |
|---|---|---|---|---|---|---|
| $V_{DS}$ | Drain - Source Voltage ① | 400 | 350 | 400 | 350 | V |
| $V_{DGR}$ | Drain - Gate Voltage ($R_{GS} = 20\ K\Omega$) ① | 400 | 350 | 400 | 350 | V |
| $I_D$ @ $T_C = 25°C$ | Continuous Drain Current | 1.5 | 1.5 | 1.3 | 1.3 | A |
| $I_D$ @ $T_C = 100°C$ | Continuous Drain Current | 1.0 | 1.0 | 0.8 | 0.8 | A |
| $I_{DM}$ | Pulsed Drain Current ③ | 6.0 | 6.0 | 5.0 | 5.0 | A |
| $V_{GS}$ | Gate - Source Voltage | ±20 | | | | V |
| $P_D$ @ $T_C = 25°C$ | Max. Power Dissipation | 20 (See Fig. 14) | | | | W |
| | Linear Derating Factor | 0.16 (See Fig. 14) | | | | W/°C |
| $E_{as}$ | Single Pulse Avalanche Energy Rating ④ | 120 | | | | mj |
| $T_J$<br>$T_{stg}$ | Operating Junction and<br>Storage Temperature Range | -55 to 150 | | | | °C |
| | Lead Temperature | 300 (0.063 in. (1.6mm) from case for 10s) | | | | °C |

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

| Parameter | | Type | Min. | Typ. | Max. | Units | Test Conditions |
|---|---|---|---|---|---|---|---|
| $BV_{DSS}$ | Drain - Source Breakdown Voltage | IRF710R IRF712R | 400 | — | — | V | $V_{GS}$ = 0V |
| | | IRF711R IRF713R | 350 | — | — | V | $I_D$ = 250μA |
| $V_{GS(th)}$ | Gate Threshold Voltage | ALL | 2.0 | — | 4.0 | V | $V_{DS} = V_{GS}$, $I_D$ = 250μ A |
| $I_{GSS}$ | Gate-Source Leakage Forward | ALL | — | — | 500 | nA | $V_{GS}$ = 20V |
| $I_{GSS}$ | Gate-Source Leakage Reverse | ALL | — | — | -500 | 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 | IRF710R IRF711R | 1.5 | — | — | A | $V_{DS} > I_{D(on)} \times R_{DS(on)\ max.}$, $V_{GS}$ = 10V |
| | | IRF712R IRF713R | 1.3 | — | — | A | |
| $R_{DS(on)}$ | Static Drain-Source On-State Resistance ② | IRF710R IRF711R | — | 3.3 | 3.6 | Ω | $V_{GS}$ = 10V, $I_D$ = 0.8A |
| | | IRF712R IRF713R | — | 3.6 | 5.0 | Ω | |
| $g_{fs}$ | Forward Transconductance ② | ALL | 0.5 | 1.2 | — | S (℧) | $V_{DS} > I_{D(on)} \times R_{DS(on)max.}$, $I_D$ = 0.8A |
| $C_{iss}$ | Input Capacitance | ALL | — | 135 | — | pF | $V_{GS}$ = 0V, $V_{DS}$ = 25V, f = 1.0 MHz See Fig. 10 |
| $C_{oss}$ | Output Capacitance | ALL | — | 35 | — | pF | |
| $C_{rss}$ | Reverse Transfer Capacitance | ALL | — | 8.0 | — | pF | |
| $t_{d(on)}$ | Turn-On Delay Time | ALL | — | 3.0 | 10 | ns | $V_{DD} \simeq 0.5BV_{DSS}$, $I_D$ = 0.8A, $Z_o$ = 50Ω See Fig. 17 (MOSFET switching times are essentially independent of operating temperature.) |
| $t_r$ | Rise Time | ALL | — | 10 | 20 | ns | |
| $t_{d(off)}$ | Turn-Off Delay Time | ALL | — | 5.0 | 10 | ns | |
| $t_f$ | Fall Time | ALL | — | 8.0 | 15 | ns | |
| $Q_g$ | Total Gate Charge (Gate-Source Plus Gate-Drain) | ALL | — | 6.0 | 7.5 | nC | $V_{GS}$ = 10V, $I_D$ = 2.0A, $V_{DS}$ = 0.8 Max. Rating. See Fig. 18 for test circuit. (Gate charge is essentially independent of operating temperature.) |
| $Q_{gs}$ | Gate-Source Charge | ALL | — | 3.0 | — | nC | |
| $Q_{gd}$ | Gate-Drain ("Miller") Charge | ALL | — | 3.0 | — | nC | |
| $L_D$ | Internal Drain Inductance | ALL | — | 3.5 | — | nH | Measured from the contact screw on tab to center of die. |
| | | | — | 4.5 | — | nH | Measured from the drain lead, 6mm (0.25 in.) from package to center of die. |
| $L_S$ | Internal Source Inductance | ALL | — | 7.5 | — | nH | Measured from the source lead, 6mm (0.25 in.) from package to source bonding pad. |

Modified MOSFET symbol showing the internal device inductances.




### Thermal Resistance

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| $R_{thJC}$ | Junction-to-Case | ALL | — | — | 6.4 | °C/W | |
| $R_{thCS}$ | Case-to-Sink | ALL | — | 1.0 | — | °C/W | Mounting surface flat, smooth, and greased. |
| $R_{thJA}$ | Junction-to-Ambient | ALL | — | — | 80 | °C/W | Free Air Operation |

### Source-Drain Diode Ratings and Characteristics

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| $I_S$ | Continuous Source Current (Body Diode) | IRF710R IRF711R | — | — | 1.5 | A | Modified MOSFET symbol showing the integral reverse P-N junction rectifier. |
| | | IRF712R IRF713R | — | — | 1.3 | A | |
| $I_{SM}$ | Pulse Source Current (Body Diode) ③ | IRF710R IRF711R | — | — | 6.0 | A | |
| | | IRF712R IRF713R | — | — | 5.0 | A | |
| $V_{SD}$ | Diode Forward Voltage ② | IRF710R IRF711R | — | — | 1.6 | V | $T_C$ = 25°C, $I_S$ = 1.5A, $V_{GS}$ = 0V |
| | | IRF712R IRF713R | — | — | 1.5 | V | $T_C$ = 25°C, $I_S$ = 1.3A, $V_{GS}$ = 0V |
| $t_{rr}$ | Reverse Recovery Time | ALL | — | 380 | — | ns | $T_J$ = 150°C, $I_F$ = 1.5A, $dI_F/dt$ = 100A/μs |
| $Q_{RR}$ | Reverse Recovered Charge | ALL | — | 2.7 | — | μC | $T_J$ = 150°C, $I_F$ = 1.5A, $dI_F/dt$ = 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. 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 $V_{DD}$ = 50V, starting $T_J$ = 25°C, L = 53 mH, $R_{gs}$ = 50Ω, $I_{peak}$ = 2A. See figures 15, 16.

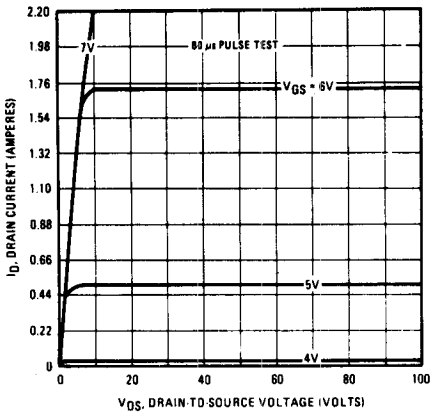



Fig. 1 – Typical Output Characteristics

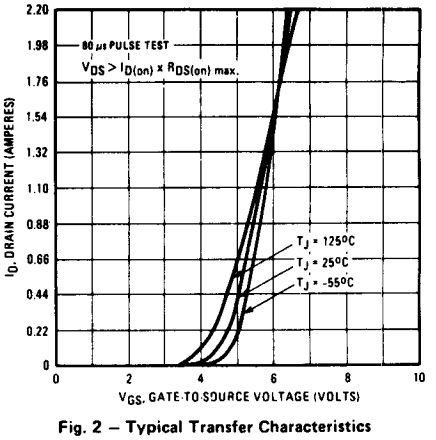



Fig. 2 – Typical Transfer Characteristics

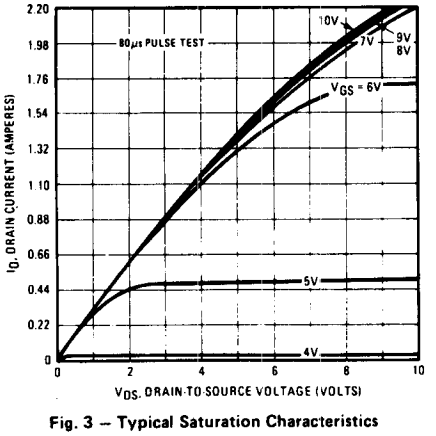



Fig. 3 – Typical Saturation Characteristics

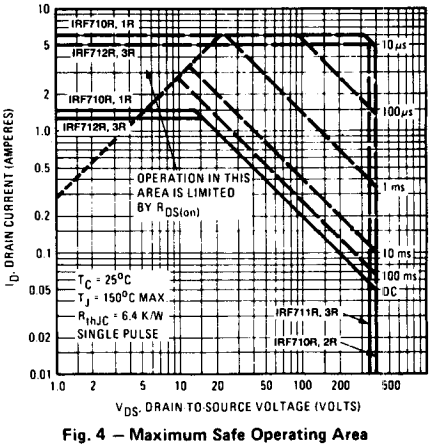



Fig. 4 – Maximum Safe Operating Area

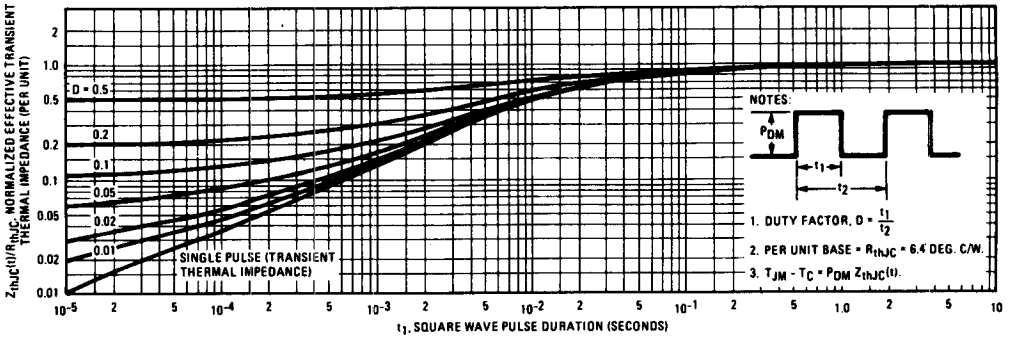



Fig. 5 – Maximum Effective Transient Thermal Impedance, Junction-to-Case Vs. Pulse Duration

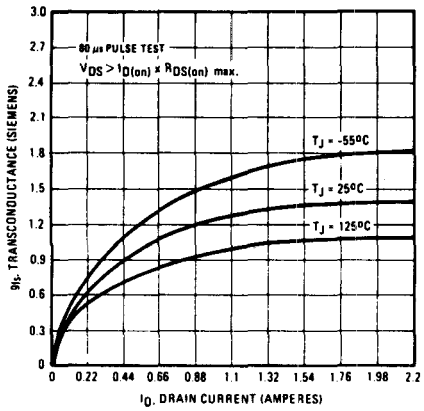



Fig. 6 – Typical Transconductance Vs. Drain Current

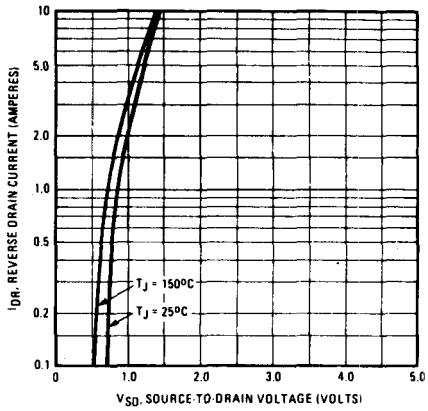



Fig. 7 – Typical Source-Drain Diode Forward Voltage

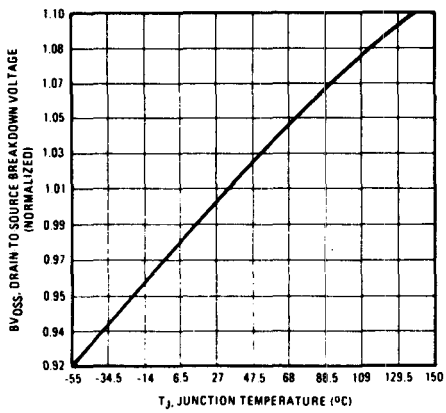



Fig. 8 – Breakdown Voltage Vs. Temperature

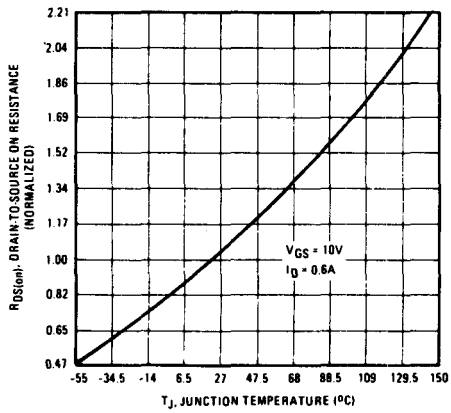



Fig. 9 – Normalized On-Resistance Vs. Temperature

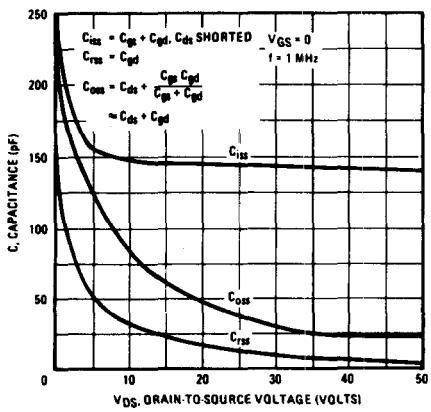



Fig. 10 – Typical Capacitance Vs. Drain-to-Source Voltage

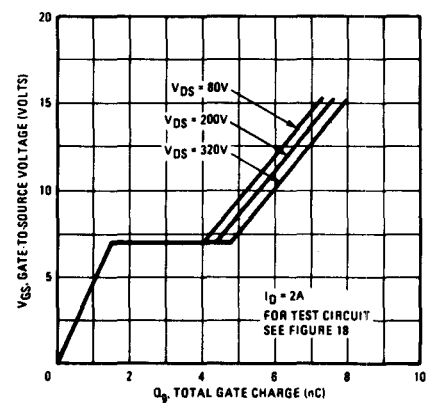



Fig. 11 – Typical Gate Charge Vs. Gate-to-Source Voltage

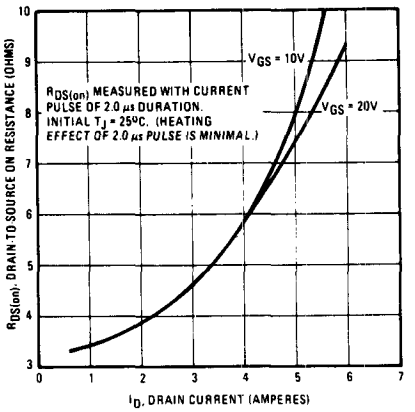



Fig. 12 – Typical On-Resistance Vs. Drain Current

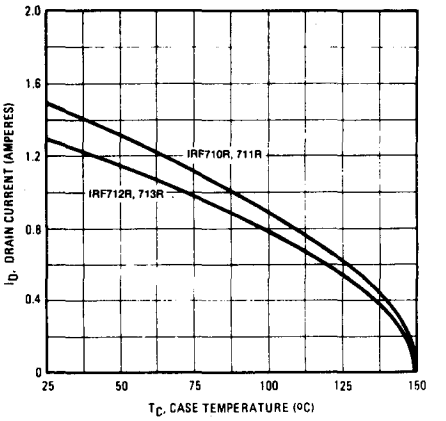



Fig. 13 – Maximum Drain Current Vs. Case Temperature

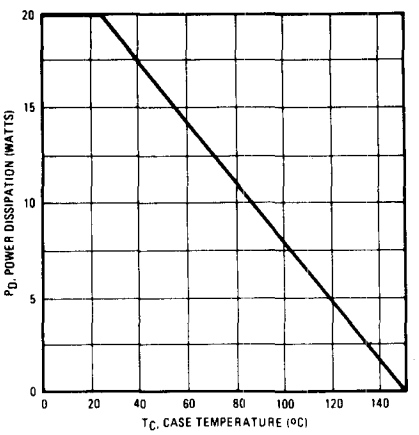



Fig. 14 – Power Vs. Temperature Derating Curve

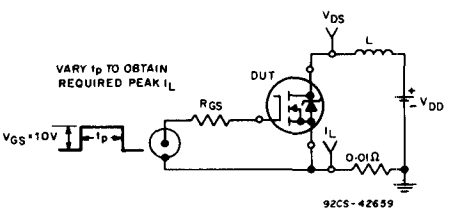



Fig. 15 — Unclamped Energy Test Circuit

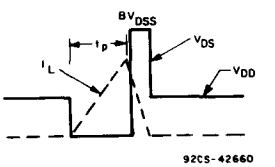



Fig. 16 — Unclamped Energy Waveforms

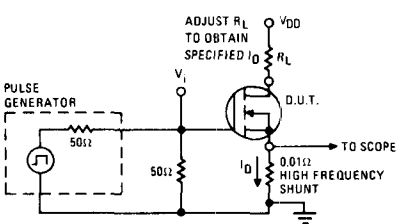



Fig. 17 – Switching Time Test Circuit

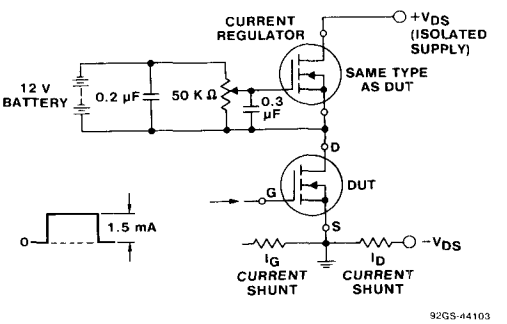



Fig. 18 – Gate Charge Test Circuit