# IRF9520, IRF9521
# IRF9522, IRF9523

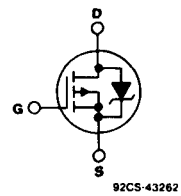
File Number **2281**

# Avalanche-Energy-Rated P-Channel Power MOSFETs

-5 A and -6 A, -60 V and -100 V
$r_{DS(on)}$ = 0.60 Ω and 0.80 Ω

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

**TERMINAL DIAGRAM**

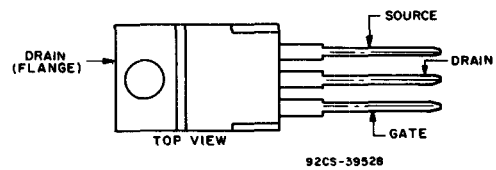



**P-CHANNEL ENHANCEMENT MODE**

The IRF9520, IRF9521, IRF9522 and IRF9523 are advanced power MOSFETs designed, tested, and guaranteed to withstand a specified level of energy in the breakdown avalanche mode of operation. These are p-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.

**TERMINAL DESIGNATION**




**JEDEC TO-220AB**

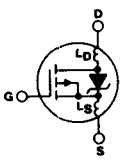
**ABSOLUTE-MAXIMUM RATINGS**

| CHARACTERISTIC | | IRF9520 | IRF9521 | IRF9522 | IRF9523 | UNITS |
|---|---|---|---|---|---|---|
| Drain-Source Voltage ① | $V_{DS}$ | -100 | -60 | -100 | -60 | V |
| Drain-Gate Voltage ($R_{GS}$ = 20 kΩ) ① | $V_{DGR}$ | -100 | -60 | -100 | -60 | V |
| Continuous Drain Current | $I_D$ @ $T_C$ = 25°C | -6 | -6 | -5 | -5 | A |
| Continuous Drain Current | $I_D$ @ $T_C$ = 100°C | -4 | -4 | -3.5 | -3.5 | A |
| Pulsed Drain Current ③ | $I_{DM}$ | -24 | -24 | -20 | -20 | A |
| Gate-Source Voltage | $V_{GS}$ | ±20 | | | | V |
| Maximum Power Dissipation | $P_D$ @ $T_C$ = 25°C | 40 (See Fig. 14) | | | | W |
| Linear Derating Factor | | 0.32 (See Fig. 14) | | | | W/°C |
| Single-Pulse Avalanche Energy Rating ④ | $E_{as}$ | 370 | | | | mJ |
| Operating Junction and Storage Temperature Range | $T_J$ $T_{stg}$ | -55 to +150 | | | | °C |
| Lead Temperature | | 300 (0.063 in. [1.6 mm] from case for 10 s) | | | | °C |

**ELECTRICAL CHARACTERISTICS** *At Case Temperature ($T_C$) = 25°C Unless Otherwise Specified*

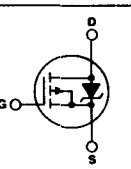
| CHARACTERISTIC | | TYPE | MIN. | TYP. | MAX. | UNITS | TEST CONDITIONS |
|---|---|---|---|---|---|---|---|
| Drain-Source Breakdown Voltage | $BV_{DSS}$ | IRF9520 IRF9522 | -100 | — | — | V | $V_{GS}$ = 0 V |
| | | IRF9521 IRF9523 | -60 | — | — | V | $I_D$ = -250 μA |
| Gate Threshold Voltage | $V_{GS(th)}$ | ALL | -2.0 | — | -4.0 | V | $V_{DS}$ = $V_{GS}$, $I_D$ = -250 μA |
| Gate-Source Leakage Forward | $I_{GSS}$ | ALL | — | — | -500 | nA | $V_{GS}$ = -20 V |
| Gate-Source Leakage Reverse | $I_{GSS}$ | ALL | — | — | 500 | nA | $V_{GS}$ = 20 V |
| Zero-Gate Voltage Drain Current | $I_{DSS}$ | ALL | — | — | -250 | μA | $V_{DS}$ = Max. Rating, $V_{GS}$ = 0 V |
| | | | — | — | -1000 | μA | $V_{DS}$ = Max. Rating x 0.8, $V_{GS}$ = 0 V, $T_C$ = 125°C |
| On-State Drain Current ② | $I_{D(on)}$ | IRF9520 IRF9521 | -6 | — | — | A | $V_{DS} > I_{D(on)} \times r_{DS(on)\ max.}$, $V_{GS}$ = -10 V |
| | | IRF9522 IRF9523 | -5 | — | — | A | |
| Static Drain-Source On-State Resistance ② | $r_{DS(on)}$ | IRF9520 IRF9521 | — | 0.5 | 0.6 | Ω | $V_{GS}$ = 10 V, $I_D$ = -3.5 A |
| | | IRF9522 IRF9523 | — | 0.6 | 0.8 | Ω | |
| Forward Transconductance ② | $g_{fs}$ | ALL | 0.9 | 2 | — | S(℧) | $V_{DS} > I_{D(on)} \times r_{DS(on)\ max.}$, $I_D$ = -3.5 A |
| Input Capacitance | $C_{iss}$ | ALL | — | 300 | — | pF | $V_{GS}$ = 0 V, $V_{DS}$ = -25 V, f = 1.0 MHz See Fig. 10 |
| Output Capacitance | $C_{oss}$ | ALL | — | 200 | — | pF | |
| Reverse Transfer Capacitance | $C_{rss}$ | ALL | — | 50 | — | pF | |
| Turn-On Delay Time | $t_{d(on)}$ | ALL | — | 25 | 50 | ns | $V_{DD}$ = 0.5 $BV_{DSS}$, $I_D$ = -3.5 A, $Z_O$ = 50 Ω See Fig. 17 (MOSFET switching times are essentially independent of operating temperature.) |
| Rise Time | $t_r$ | ALL | — | 50 | 100 | ns | |
| Turn-Off Delay Time | $t_{d(off)}$ | ALL | — | 50 | 100 | ns | |
| Fall Time | $t_f$ | ALL | — | 50 | 100 | ns | |
| Total Gate Charge (Gate-Source Plus Gate-Drain) | $Q_g$ | ALL | — | 16 | 22 | nC | $V_{GS}$ = -15 V, $I_D$ = -8.0 A, $V_{DS}$ = 0.8 Max. Rating. See Fig. 18 for test circuit. (Gate charge is essentially independent of operating temperature.) |
| Gate-Source Charge | $Q_{gs}$ | ALL | — | 9 | 13.5 | nC | |
| Gate-Drain ("Miller") Charge | $Q_{gd}$ | ALL | — | 7 | 10.5 | nC | |
| Internal Drain Inductance | $L_D$ | 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. |
| Internal Source Inductance | $L_S$ | ALL | — | 7.5 | — | nH | Measured from the source lead, 6 mm (0.25 in.) from package to source bonding pad. |
| Junction-to-Case | $R_{\theta JC}$ | ALL | — | — | 3.12 | °C/W | |
| Case-to-Sink | $R_{\theta CS}$ | ALL | — | 0.1 | — | °C/W | Mounting surface flat, smooth, and greased. |
| Junction-to-Ambient | $R_{\theta JA}$ | ALL | — | — | 80 | °C/W | Typical socket mount. |

Modified MOSFET symbol showing the internal device inductances.




**SOURCE-DRAIN DIODE RATINGS AND CHARACTERISTICS**

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| Continuous Source Current (Body Diode) | $I_S$ | IRF9520 IRF9521 | — | — | -6 | A | Modified MOSFET symbol showing the integral reverse P-N junction rectifier. |
| | | IRF9522 IRF9523 | — | — | -5 | A | |
| Pulse Source Current (Body Diode) ③ | $I_{SM}$ | IRF9520 IRF9521 | — | — | -24 | A | |
| | | IRF9522 IRF9523 | — | — | -20 | A | |
| Diode Forward Voltage ② | $V_{SD}$ | IRF9520 IRF9521 | — | — | -1.5 | V | $T_C$ = 25°C, $I_S$ = -6 A, $V_{GS}$ = 0 V |
| | | IRF9522 IRF9523 | — | — | -1.5 | V | $T_C$ = 25°C, $I_S$ = -5 A, $V_{GS}$ = 0 V |
| Reverse Recovery Time | $t_{rr}$ | ALL | — | 230 | — | ns | $T_J$ = 150°C, $I_F$ = -6 A, $dI_F/dt$ = 100 A/μs |
| Reverse Recovered Charge | $Q_{RR}$ | ALL | — | 1.3 | — | μC | $T_J$ = 150°C, $I_F$ = -6 A, $dI_F/dt$ = 100 A/μs |
| Forward Turn-on Time | $t_{on}$ | 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 ≤ 300 μs, Duty Cycle ≤ 2%.*
③ Repetitive Rating: Pulse width limited by max. junction temperature. See Transient Thermal Impedance Curve (Fig. 5).
④ $V_{DD}$ = 25 V, Starting $T_j$ = 25°C, L = 15.4 mH, $R_G$ = 25 Ω, Peak $I_L$ = 6 A (See Figs. 15 & 16).

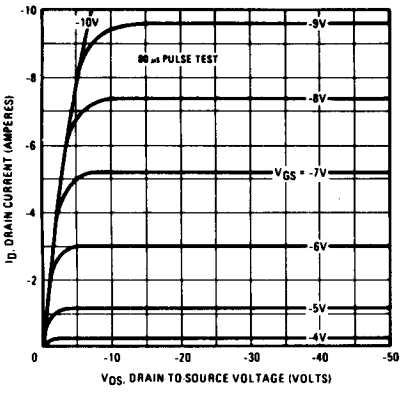



*Fig. 1 - Typical output characteristics.*

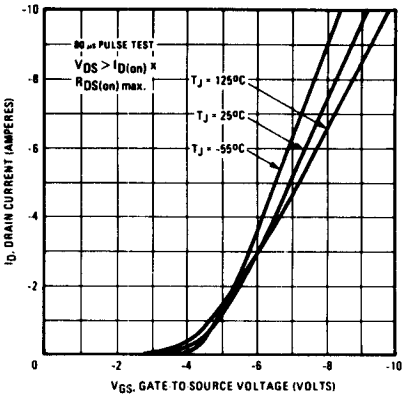



*Fig. 2 - Typical transfer characteristics.*

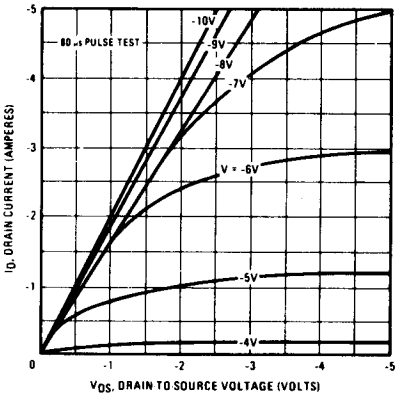



*Fig. 3 - Typical saturation characteristics.*

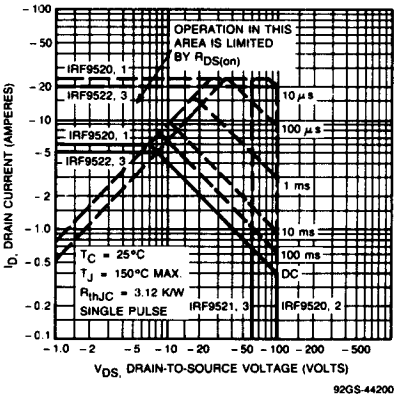



*Fig. 4 - Maximum safe operating area.*

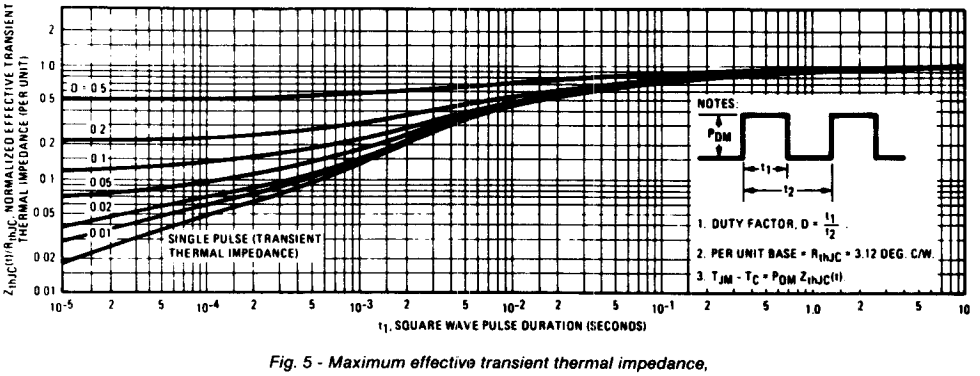



*Fig. 5 - Maximum effective transient thermal impedance, junction-to-case vs. pulse duration.*

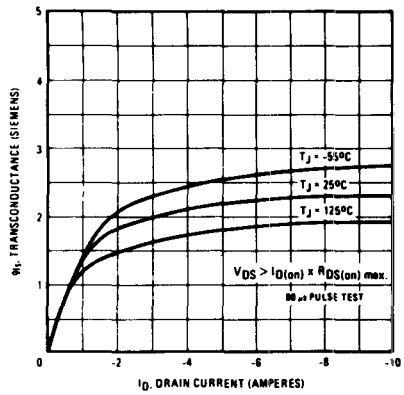



*Fig. 6 - Typical transconductance vs. drain current.*

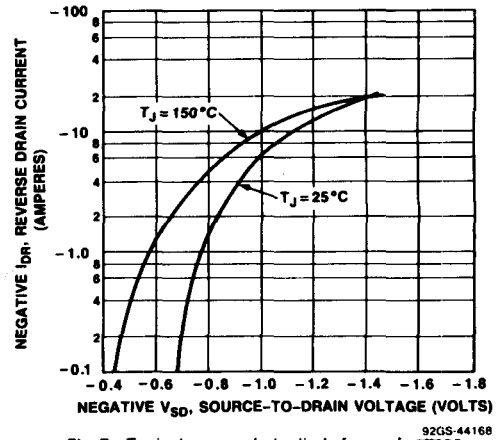



*Fig. 7 - Typical source-drain diode forward voltage.*

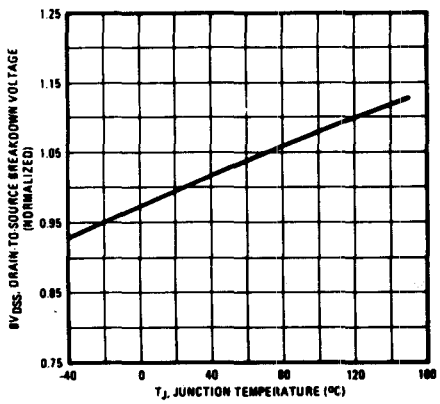



*Fig. 8 - Breakdown voltage vs. temperature.*

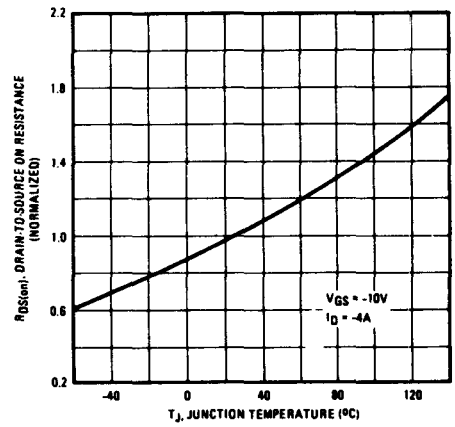



*Fig. 9 - Normalized on-resistance vs. temperature.*

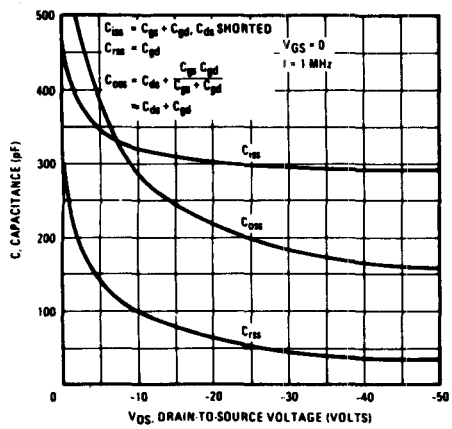



*Fig. 10 - Typical capacitance vs. drain-to-source voltage.*

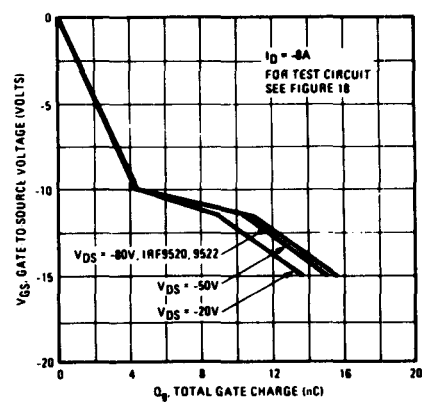



*Fig. 11 - Typical gate charge vs. gate-to-source voltage.*

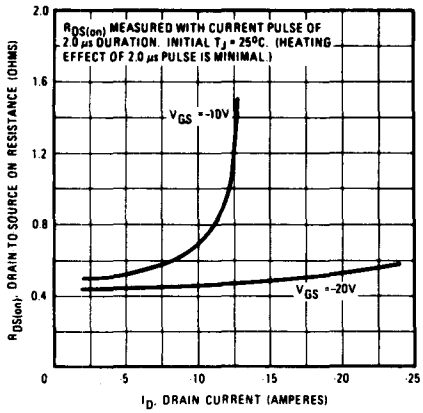



*Fig. 12 - Typical on-resistance vs. drain current.*

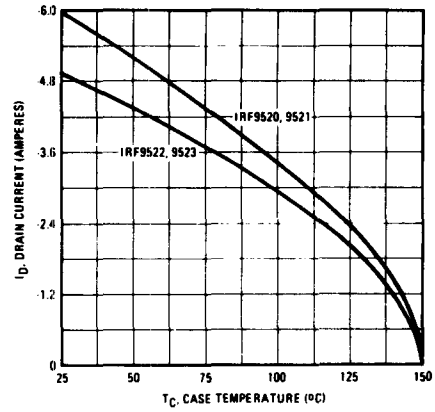



*Fig. 13 - Maximum drain current vs. case temperature.*

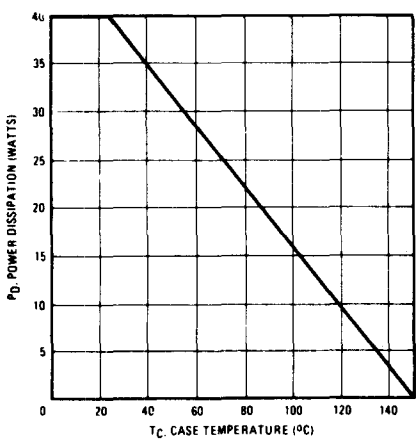



*Fig. 14 - Power vs. temperature derating curve.*

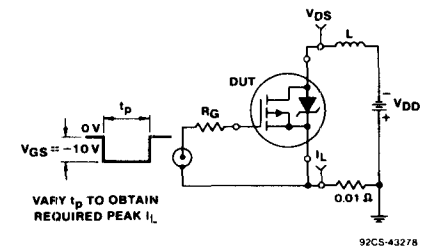



*Fig. 15 - Unclamped inductive test circuit.*

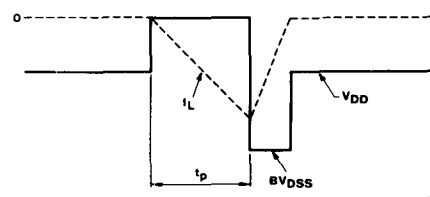



*Fig. 16 - Unclamped inductive waveforms.*

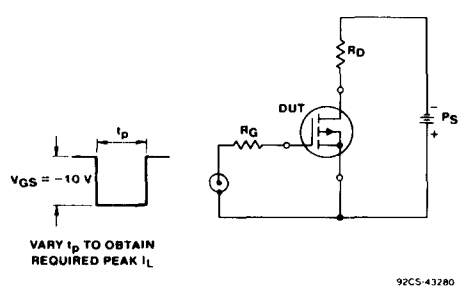



*Fig. 17 - Switching time test circuit.*

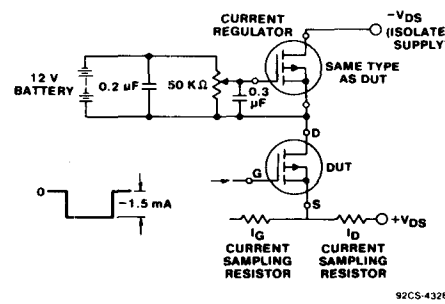



*Fig. 18 - Gate charge test circuit.*