



**HARRIS**

# IRFF9220, IRFF9221 IRFF9222, IRFF9223

**Avalanche Energy Rated  
P-Channel Power MOSFETs**

August 1991

### Features

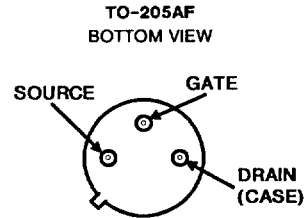
- -2A and -2.5A, -150V and -200V
- $r_{DS(ON)} = 1.50\Omega$  and  $2.40\Omega$
- Single Pulse Avalanche Energy Rated
- SOA is Power-Dissipation Limited
- Nanosecond Switching Speeds
- Linear Transfer Characteristics
- High Input Impedance

### Description

The IRFF9220, IRFF9221, IRFF9222 and IRFF9223 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.

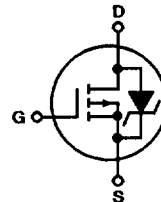
The IRFF types are supplied in the JEDEC TO-205AF (Low Profile TO-39) metal package.

### Package



### Terminal Diagram

P-CHANNEL ENHANCEMENT MODE



### Absolute Maximum Ratings ( $T_C = 25^\circ\text{C}$ ) Unless Otherwise Specified

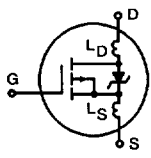
	IRFF9220	IRFF9221	IRFF9222	IRFF9223	UNITS	
Drain-Source Voltage (1) .....	$V_{DS}$	-200	-150	-200	-150	V
Drain-Gate Voltage ( $R_{GS} = 20k\Omega$ ) (1) .....	$V_{DGR}$	-200	-150	-200	-150	V
Continuous Drain Current $T_C = 25^\circ\text{C}$ .....	$I_D$	-2.5	-2.5	-2.0	-2.0	A
Pulsed Drain Current (3) .....	$I_{DM}$	-10	-10	-8	-8	A
Gate-Source Voltage .....	$V_{GS}$	$\pm 20$	$\pm 20$	$\pm 20$	$\pm 20$	V
Maximum Power Dissipation .....	$P_D$	20	20	20	20	W
(See Figure 14)						
Linear Derating Factor .....		0.16	0.16	0.16	0.16	W/ $^\circ\text{C}$
(See Figure 14)						
Single Pulse Avalanche Energy Rating (4) .....	$E_{AS}$	290	290	290	290	mJ
Operating and Storage Junction Temperature Range .....	$T_J, T_{STG}$	-55 to +150	-55 to +150	-55 to +150	-55 to +150	$^\circ\text{C}$
Maximum Lead Temperature for Soldering (0.063" (1.6mm) from case for 10s) .....	$T_L$	300	300	300	300	$^\circ\text{C}$

#### NOTES:

1.  $T_J = +25^\circ\text{C}$  to  $+150^\circ\text{C}$
2. Pulse Test: Pulse width  $\leq 300\mu\text{s}$ , Duty Cycle  $\leq 2\%$
3. Repetitive Rating: Pulse width limited by max. junction temperature. See Transient Thermal Impedance Curve (Figure 5)
4.  $V_{DD} = 50\text{V}$ , Start  $T_J = +25^\circ\text{C}$ ,  $L = 69.6\text{mH}$ ,  $R_G = 25\Omega$ , Peak  $I_L = 2.5\text{A}$   
(See Figures 15 and 16)

# Specifications IRFF9220, IRFF9221, IRFF9222, IRFF9223

**Electrical Characteristics**  $T_C = +25^\circ\text{C}$ , Unless Otherwise Specified

CHARACTERISTIC	SYMBOL	TEST CONDITIONS	LIMITS			UNITS
			MIN	TYP	MAX	
Drain-Source Breakdown Voltage IRFF9220, IRFF9222 IRFF9221, IRFF9223	$BV_{DSS}$	$V_{GS} = 0V, I_D = -250\mu A$	-200	-	-	V
			-150	-	-	V
Gate Threshold Voltage	$V_{GS(TH)}$	$V_{DS} = V_{GS}, I_D = -250\mu A$	-2.0	-	-4.0	V
Gate-Source Leakage Forward	$I_{GSS}$	$V_{GS} = -20V$	-	-	-100	nA
Gate-Source Leakage Reverse	$I_{GSS}$	$V_{GS} = 20V$	-	-	100	nA
Zero Gate Voltage Drain Current	$I_{DSS}$	$V_{DS} = \text{Max Rating}, V_{GS} = 0V$	-	-	-250	$\mu A$
		$V_{DS} = \text{Max Rating} \times 0.8, V_{GS} = 0V, T_C = +125^\circ\text{C}$	-	-	-1000	$\mu A$
On-State Drain Current (Note 2) IRFF9220, IRFF9221 IRFF9222, IRFF9223	$I_{D(ON)}$	$V_{DS} > I_{D(ON)} \times r_{DS(ON)} \text{ Max}, V_{GS} = -10V$	-2.5	-	-	A
			-2.0	-	-	A
Static Drain-Source On-State Resistance (Note 2) IRFF9220, IRFF9221 IRFF9222, IRFF9223	$r_{DS(ON)}$	$V_{GS} = -10V, I_D = 1.5A$	-	1.0	1.5	$\Omega$
			-	1.5	2.4	$\Omega$
			1	1.8	-	S( $\bar{I}$ )
Forward Transconductance (Note 2)	$g_{ts}$	$V_{DS} > I_{D(ON)} \times r_{DS(ON)} \text{ Max}, I_D = 1.5A$	-	350	-	pF
Input Capacitance	$C_{ISS}$	$V_{GS} = 0V, V_{DS} = -25V, f = 1.0\text{MHz}$	-	100	-	pF
Output Capacitance	$C_{OSS}$	See Figure 10	-	30	-	pF
Reverse Transfer Capacitance	$C_{RSS}$		-	15	40	ns
Turn-On Delay Time	$t_{d(ON)}$	$V_{DD} = 0.5 BV_{DSS}, I_D = -2.5A, R_G = 9.1\Omega$	-	25	50	ns
Rise Time	$t_r$	See Figure 17. (MOSFET switching times are essentially independent of operating temperature.)	-	80	120	ns
Turn-Off Delay Time	$t_{d(OFF)}$		-	50	75	ns
Fall Time	$t_f$		-	16	22	nC
Total Gate Charge (Gate-Source + Gate-Drain)	$Q_g$	$V_{GS} = -10V, I_D = -2.5V_{DS} = 0.8 \text{ Max Rating}$ . See Figure 18 for test circuit. (Gate charge is essentially independent of operating temperature.)	-	9	-	nC
Gate-Source Charge	$Q_{gs}$		-	7	-	nC
Gate-Drain ("Miller") Charge	$Q_{gd}$		-	5.0	-	nH
Internal Drain Inductance	$L_D$	Measured from the drain lead, 5mm (0.2") from header to center of die.	-	15	-	nH
Internal Source Inductance	$L_S$	Measured from the source lead, 5mm (0.2") from header to source bonding pad.				
Junction-to-Case	$R_{\theta JC}$					
Junction-to-Ambient	$R_{\theta JA}$	Typical socket mount	-	-	175	$^\circ\text{C/W}$

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**P-CHANNEL POWER MOSFETS**

## Source Drain Diode Ratings and Characteristics

Continuous Source Current (Body Diode)	$I_S$	Modified MOSFET symbol showing the integral reverse P-N junction rectifier.	-	-	-2.5	A
Pulse Source Current (Body Diode) (Note 3)	$I_{SM}$		-	-	-10	A
Diode Forward Voltage (Note 2)	$V_{SD}$	$T_C = +25^\circ\text{C}, I_S = -2.5A, V_{GS} = 0V$	-	-	-1.5	V
Reverse Recovery Time	$t_{rr}$	$T_J = +150^\circ\text{C}, I_F = -2.5A, dI_F/dt = 100A/\mu s$	-	300	-	ns
Reverse Recovered Charge	$Q_{RR}$	$T_J = +150^\circ\text{C}, I_F = -2.5A, dI_F/dt = 100A/\mu s$	-	1.9	-	$\mu C$
Forward Turn-on Time	$t_{ON}$	Intrinsic turn-on time is negligible. Turn-on speed is substantially controlled by $L_S + L_D$ .	-	-	-	-

NOTES: 1.  $T_J = +25^\circ\text{C}$  to  $+150^\circ\text{C}$   
2. Pulse Test: Pulse width  $\leq 300\mu s$ , Duty Cycle  $\leq 2\%$

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

4.  $V_{DD} = 50V$ , Start  $T_J = +25^\circ\text{C}$ ,  $L = 69.6\text{mH}$ ,  $R_G = 25\Omega$ , Peak  $I_L = 2.5A$  (See Figures 15 and 16)

# IRFF9220, IRFF9221, IRFF9222, IRFF9223

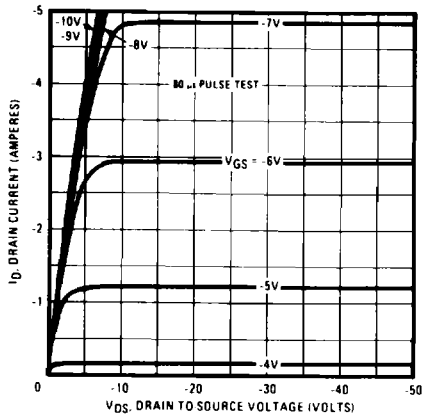


Fig. 1 - Typical output characteristics.

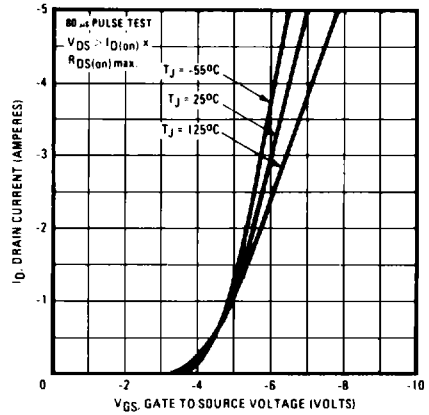


Fig. 2 - Typical transfer characteristics.

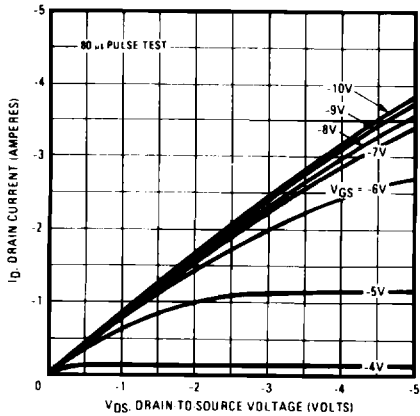
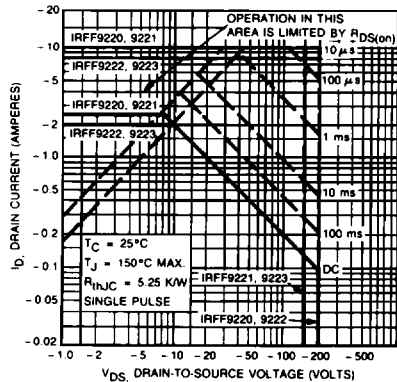


Fig. 3 - Typical saturation characteristics.



92GS-44207

Fig. 4 - Maximum safe operating area.

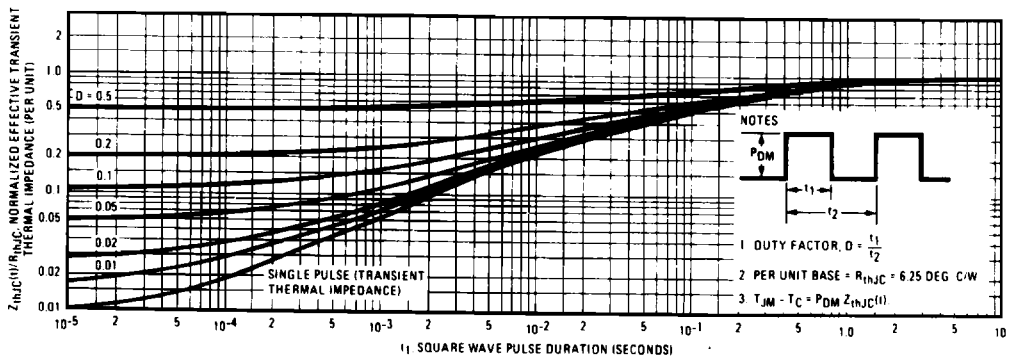


Fig. 5 - Maximum effective transient thermal impedance, junction-to-case vs. pulse duration.

IRFF9220, IRFF9221, IRFF9222, IRFF9223

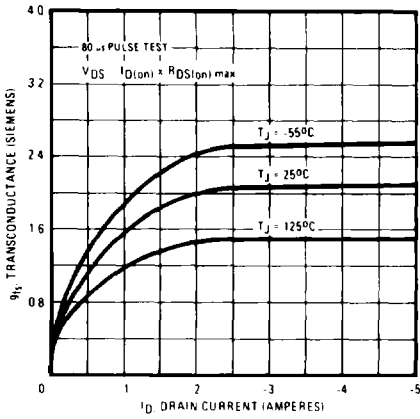


Fig. 6 - Typical transconductance vs. drain current.

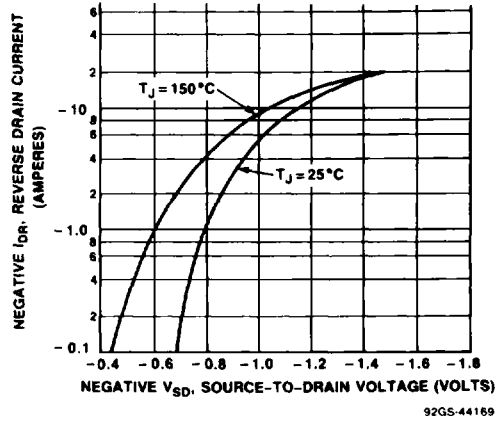


Fig. 7 - Typical source-drain diode forward voltage.

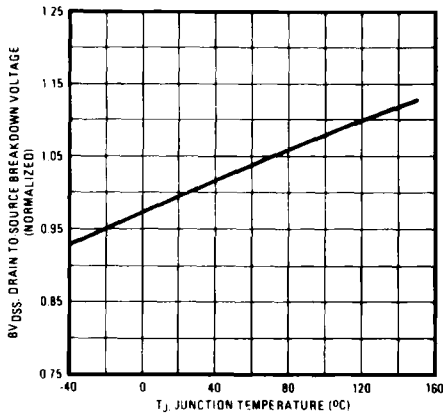


Fig. 8 - Breakdown voltage vs. temperature.

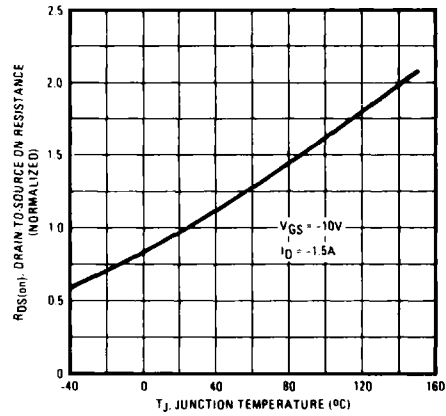


Fig. 9 - Normalized on-resistance vs. temperature.

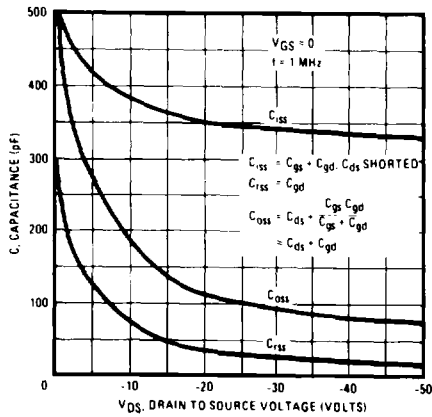


Fig. 10 - Typical capacitance vs. drain-to-source voltage.

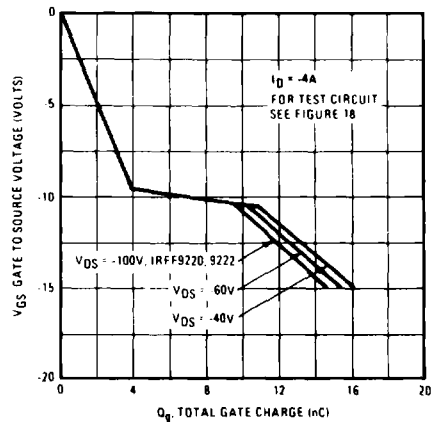


Fig. 11 - Typical gate charge vs. gate-to-source voltage.

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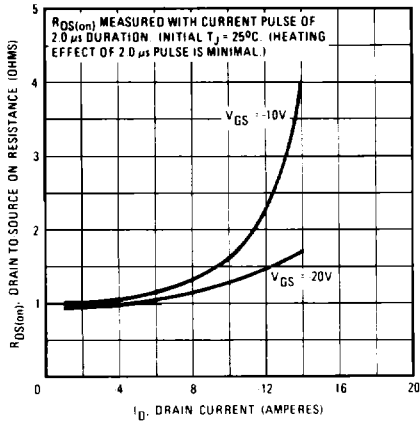


Fig. 12 - Typical on-resistance vs. drain current.

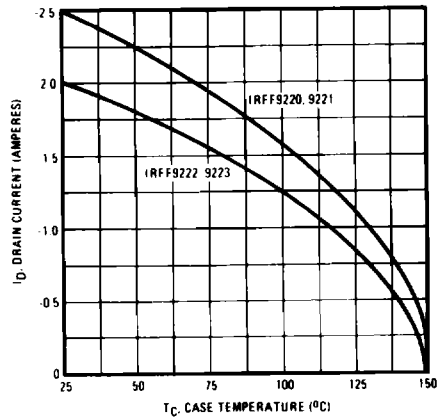


Fig. 13 - Maximum drain current vs. case temperature.

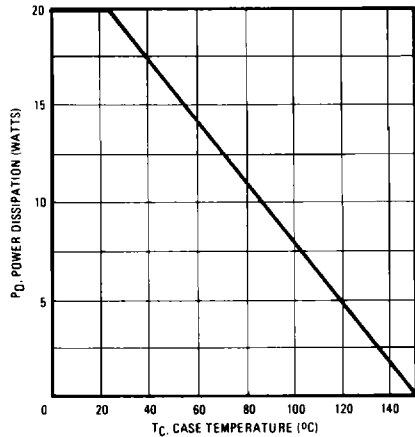


Fig. 14 - Power vs. temperature derating curve.

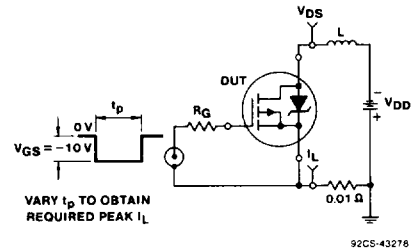


Fig. 15 - Unclamped inductive test circuit.

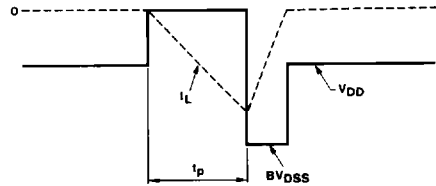


Fig. 16 - Unclamped inductive waveforms.

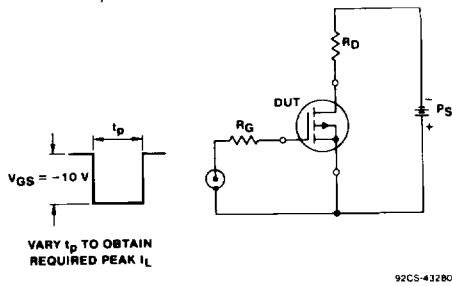


Fig. 17 - Switching time test circuit.

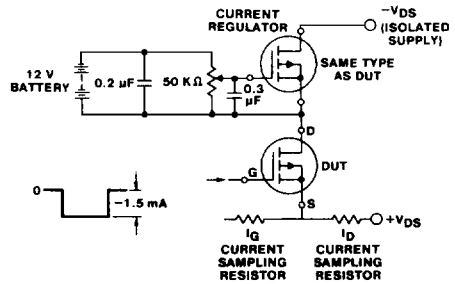


Fig. 18 - Gate charge test circuit.