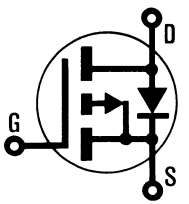
INTERNATIONAL RECTIFIER IOR

HEXFET® TRANSISTORS

P-CHANNEL POWER MOSFETs TO-39 PACKAGE



IRFF9210
IRFF9211
IRFF9212
IRFF9213

-200 Volt, 3.0 Ohm HEXFET

The HEXFET® technology is the key to International Rectifier's advanced line of power MOSFET transistors. The efficient geometry and unique processing of the HEXFET design achieve very low on-state resistance combined with high transconductance and, extreme device ruggedness.

The P-Channel HEXFETs are designed for applications which require the convenience of reverse polarity operation. They retain all of the features of the more common N-Channel HEXFETs such as voltage control, freedom from second breakdown, very fast switching, ease of paralleling, and excellent temperature stability. The P-Channel IRFF9210 device is an approximate electrical complement to the N-Channel IRFF110 HEXFET.

P-Channel HEXFETs are intended for use in power stages where complementary symmetry with N-Channel devices offers circuit simplification. They are also very useful in drive stages because of the circuit versatility offered by the reverse polarity connection. Applications include motor control, audio amplifiers, switched mode converters, control circuits and pulse amplifiers

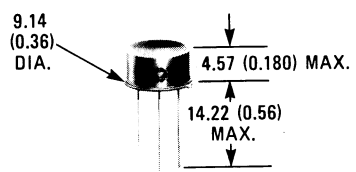
Features:

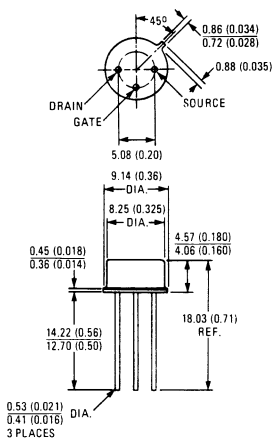
- P-Channel Versatility
- Fast Switching
- Low Drive Current
- Ease of Paralleling
- No Second Breakdown
- Excellent Temperature Stability

Product Summary

Part Number	V_{DS}	$R_{DS(on)}$	I_D
IRFF9210	-200V	3.0Ω	-1.6A
IRFF9211	-150V	3.0Ω	-1.6A
IRFF9212	-200V	4.5Ω	-1.3A
IRFF9213	-150V	4.5Ω	-1.3A

CASE STYLE AND DIMENSIONS





Conforms to JEDEC Outline TO-205AF (TO-39)
Dimensions in Millimeters and (Inches)

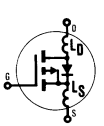
Absolute Maximum Ratings

Parameter		IRFF9210	IRFF9211	IRFF9212	IRFF9213	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	-1.6	-1.6	-1.3	-1.3	A
I_{DM}	Pulsed Drain Current ③	-6.5	-6.5	-5.5	-5.5	A
V_{GS}	Gate — Source Voltage	±20				V
P_D @ T_C = 25°C	Max. Power Dissipation	15 (See Fig. 14)				W
	Linear Derating Factor	0.12 (See Fig. 14)				W/K
I_{LM}	Inductive Current, Clamped	-6.5	(See Fig. 15 and 16) L = 100μH -6.5	-5.5	-5.5	A
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

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

Parameter		Type	Min.	Typ.	Max.	Units	Test Conditions
BV_{DSS}	Drain — Source Breakdown Voltage	IRFF9210 IRFF9212	-200	—	—	V	V_{GS} = 0V
		IRFF9211 IRFF9213	-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	IRFF9210 IRFF9211	-1.6	—	—	A	V_{DS} > $I_{D(on)}$ x $R_{DS(on)}$ max., V_{GS} = -10V
		IRFF9212 IRFF9213	-1.3	—	—	A	
$R_{DS(on)}$	Static Drain-Source On-State Resistance ②	IRFF9210 IRFF9211	—	2.3	3.0	Ω	V_{GS} = -10V, I_D = -0.8A
		IRFF9212 IRFF9213	—	3.5	4.5	Ω	
g_{fs}	Forward Transconductance ②	ALL	0.7	0.9	—	S (℧)	V_{DS} > $I_{D(on)}$ x $R_{DS(on)}$ max., I_D = -0.8A
C_{iss}	Input Capacitance	ALL	—	170	300	pF	V_{GS} = 0V, V_{DS} = -25V, f = 1.0 MHz See Fig. 10
C_{oss}	Output Capacitance	ALL	—	50	100	pF	
C_{rss}	Reverse Transfer Capacitance	ALL	—	15	35	pF	
$t_{d(on)}$	Turn-On Delay Time	ALL	—	8.0	15	ns	V_{DD} ≈ 0.5 BV_{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	—	15	25	ns	
$t_{d(off)}$	Turn-Off Delay Time	ALL	—	10	15	ns	
t_f	Fall Time	ALL	—	8.0	15	ns	
Q_g	Total Gate Charge (Gate — Source Plus Gate-Drain)	ALL	—	8.0	11	nC	V_{GS} = -15V, I_D = -3.5A, V_{DS} = 0.8V Max. Rating. See Fig. 18 for test circuit. (Gate charge is essentially independent of operating temperature.)
Q_{gs}	Gate-Source Charge	ALL	—	5.0	—	nC	
Q_{gd}	Gate-Drain ("Miller") Charge	ALL	—	3.0	—	nC	
L_D	Internal Drain Inductance	ALL	—	5.0	—	nH	Measured from the drain lead, 5mm (0.2 in.) from header to center of die.
L_S	Internal Source Inductance	ALL	—	15	—	nH	Measured from the source lead, 5mm (0.2 in.) from header to source bonding pad.

Modified MOSFET symbol showing the internal device inductances.



Thermal Resistance

R_{thJC}	Junction-to-Case	ALL	—	—	8.33	K/W	
R_{thJA}	Junction-to-Ambient	ALL	—	—	175	K/W	Free Air Operation

Source-Drain Diode Ratings and Characteristics

I_S	Continuous Source Current (Body Diode)	IRFF9210 IRFF9211	–	–	-1.6	A	Modified MOSFET symbol showing the integral reverse P-N junction rectifier.
		IRFF9212 IRFF9213	–	–	-1.3	A	
I_{SM}	Pulse Source Current (Body Diode) ③	IRFF9210 IRFF9211	–	–	-6.5	A	
		IRFF9212 IRFF9213	–	–	-5.5	A	
V_{SD}	Diode Forward Voltage ②	IRFF9210 IRFF9211	–	–	-5.8	V	T_C = 25°C, I_S = -1.6A, V_{GS} = 0V
		IRFF9212 IRFF9213	–	–	-5.5	V	T_C = 25°C, I_S = -1.3A, V_{GS} = 0V
t_{rr}	Reverse Recovery Time	ALL	–	240	–	ns	T_J = 150°C, I_F = -1.6A, dI_F/dt = 100A/μs
Q_{RR}	Reverse Recovered Charge	ALL	–	1.7	–	μC	T_J = 150°C, I_F = -1.6A, 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.				

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

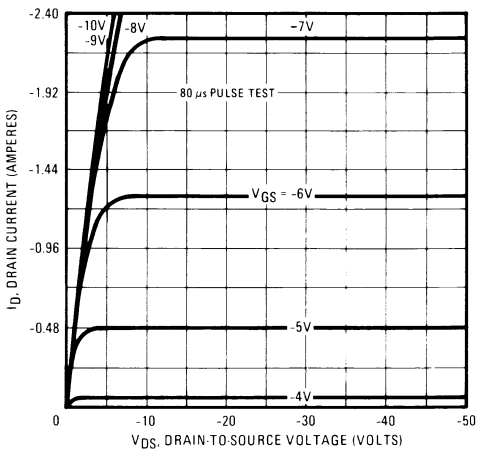


Fig. 1 – Typical Output Characteristics

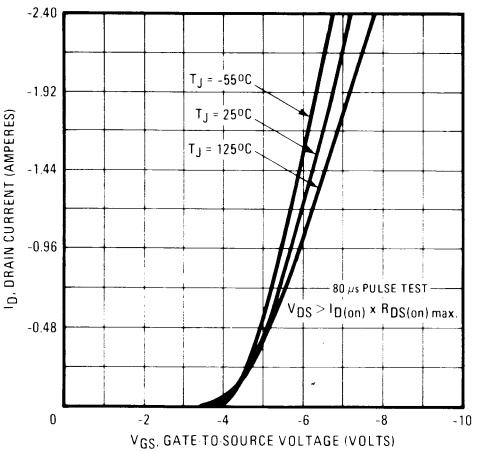


Fig. 2 – Typical Transfer Characteristics

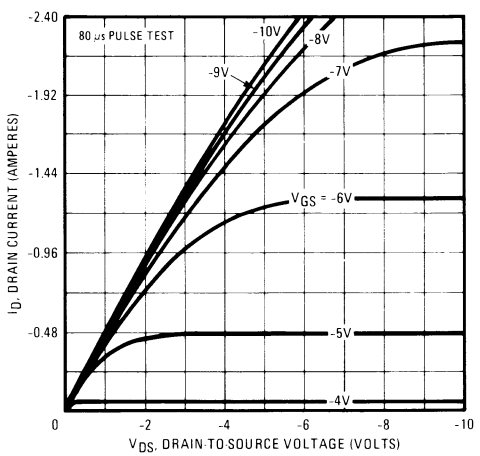


Fig. 3 – Typical Saturation Characteristics

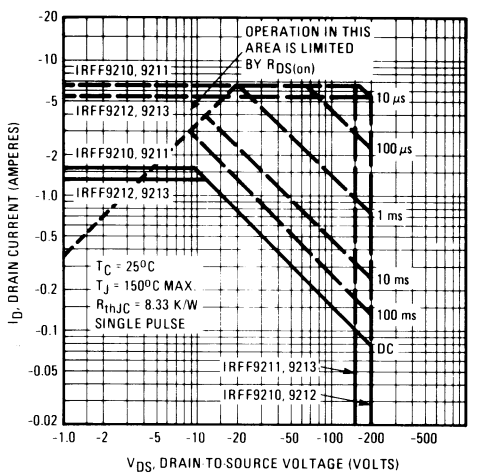


Fig. 4 – Maximum Safe Operating Area

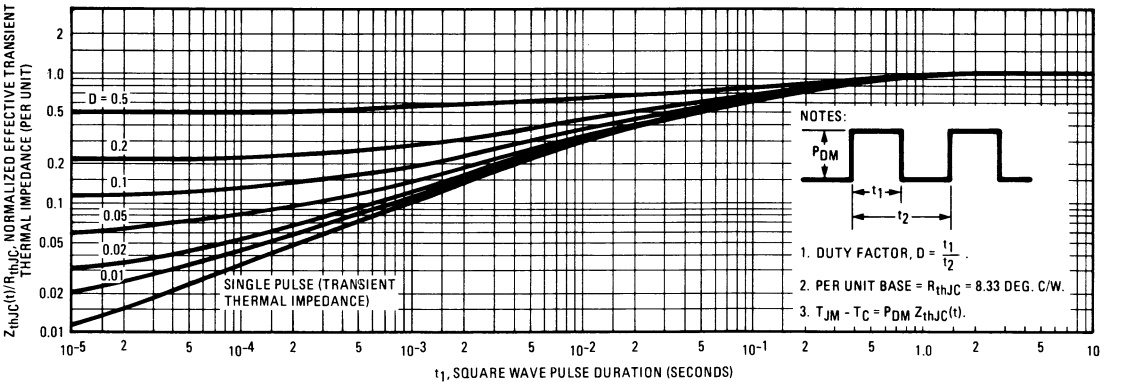


Fig. 5 – Maximum Effective Transient Thermal Impedance, Junction-to-Case Vs. Pulse Duration

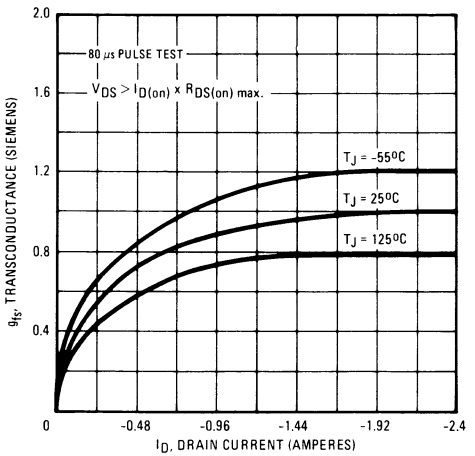


Fig. 6 – Typical Transconductance Vs. Drain Current

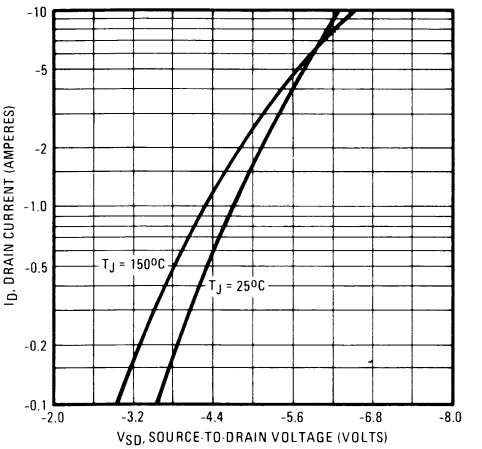


Fig. 7 – Typical Source-Drain Diode Forward Voltage

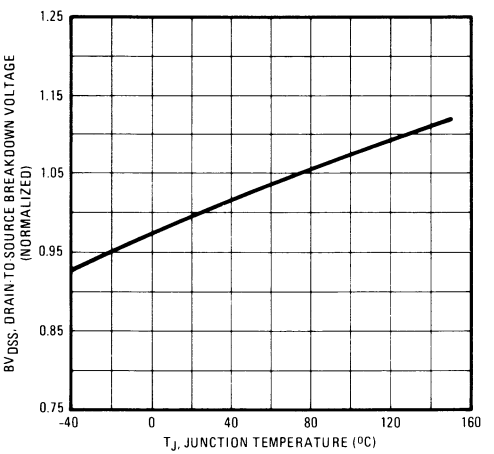


Fig. 8 – Breakdown Voltage Vs. Temperature

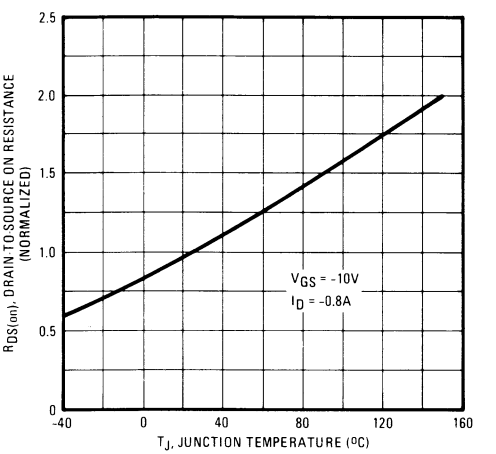


Fig. 9 – Normalized On-Resistance Vs. Temperature

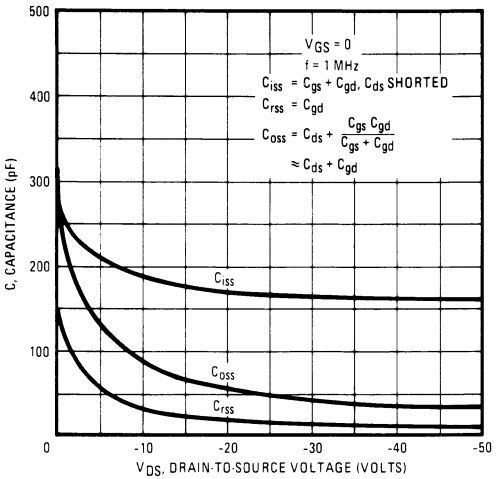


Fig. 10 — Typical Capacitance Vs. Drain-to-Source Voltage

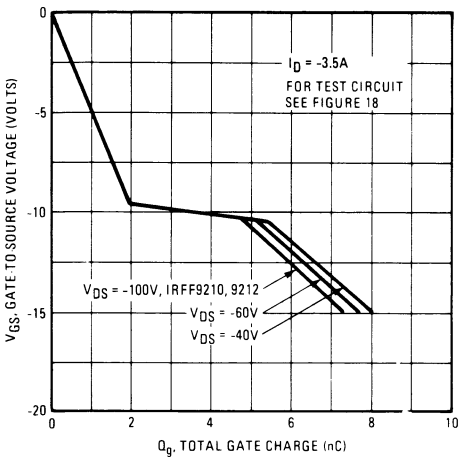


Fig. 11 — Typical Gate Charge Vs. Gate-to-Source Voltage

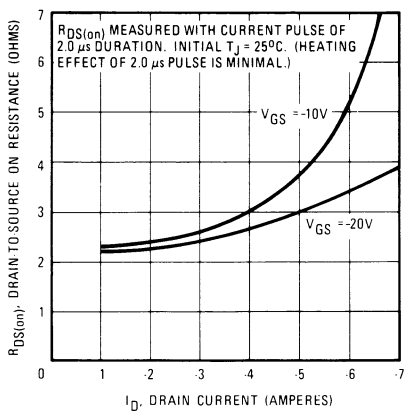


Fig. 12 — Typical On-Resistance Vs. Drain Current

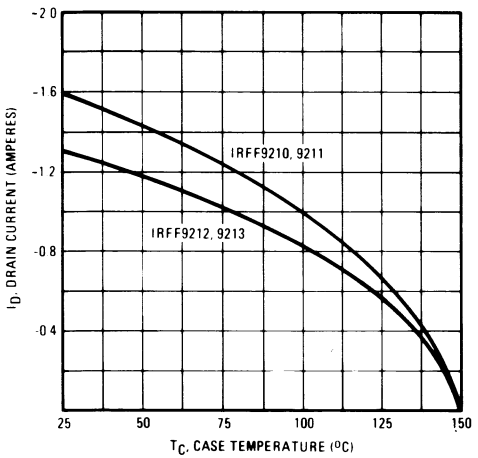


Fig. 13 — Maximum Drain Current Vs. Case Temperature

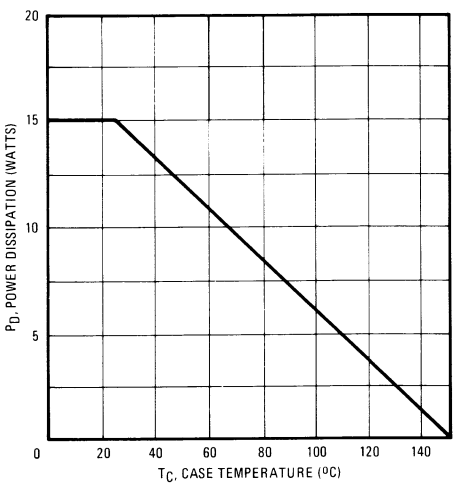


Fig. 14 — Power Vs. Temperature Derating Curve

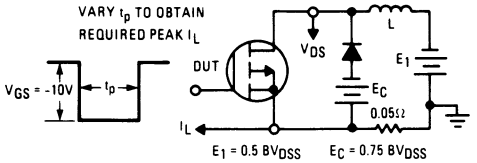


Fig. 15 – Clamped Inductive Test Circuit

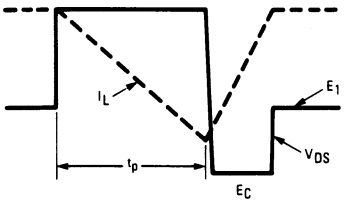


Fig. 16 – Clamped Inductive Waveforms

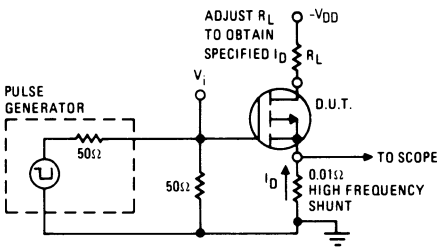


Fig. 17 – Switching Time Test Circuit

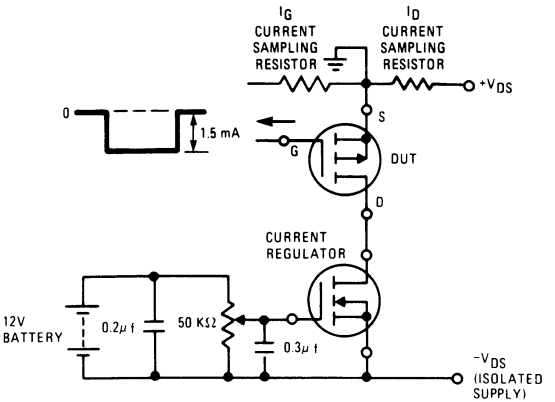


Fig. 18 – Gate Charge Test Circuit

Data Sheet No. PD-9.383C

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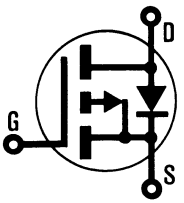
P-CHANNEL POWER MOSFETs TO-39 PACKAGE



IRFF9220
IRFF9221
IRFF9222
IRFF9223

-200 Volt, 1.5 Ohm HEXFET

The HEXFET® technology is the key to International Rectifier's advanced line of power MOSFET transistors. The efficient geometry and unique processing of the HEXFET design achieve very low on-state resistance combined with high transconductance and, extreme device ruggedness

The P-Channel HEXFETs are designed for applications which require the convenience of reverse polarity operation. They retain all of the features of the more common N-Channel HEXFETs such as voltage control, freedom from second breakdown, very fast switching, ease of paralleling, and excellent temperature stability. The P-Channel IRFF9220 device is an approximate electrical complement to the N-Channel IRFF120 HEXFET.

P-Channel HEXFETs are intended for use in power stages where complementary symmetry with N-Channel devices offers circuit simplification. They are also very useful in drive stages because of the circuit versatility offered by the reverse polarity connection. Applications include motor control, audio amplifiers, switched mode converters, control circuits and pulse amplifiers.

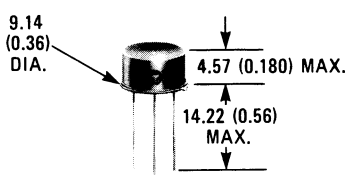
Features:

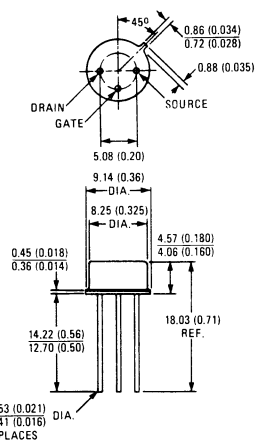
- P-Channel Versatility
- Fast Switching
- Low Drive Current
- Ease of Paralleling
- No Second Breakdown
- Excellent Temperature Stability

Product Summary

Part Number	V_{DS}	$R_{DS(on)}$	I_D
IRFF9220	-200V	1.5Ω	-2.5A
IRFF9221	-150V	1.5Ω	-2.5A
IRFF9222	-200V	2.4Ω	-2.0A
IRFF9223	-150V	2.4Ω	-2.0A

CASE STYLE AND DIMENSIONS





Conforms to JEDEC Outline TO-205AF (TO-39)
Dimensions in Millimeters and (Inches)

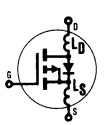
Absolute Maximum Ratings

Parameter		IRFF9220	IRFF9221	IRFF9222	IRFF9223	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	-2.5	-2.5	-2.0	-2.0	A
I_{DM}	Pulsed Drain Current ③	-10	-10	-8.0	-8.0	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/K
I_{LM}	Inductive Current, Clamped	-10	(See Fig. 15 and 16) L = 100μH -10	-8.0	-8.0	A
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

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

Parameter		Type	Min.	Typ.	Max.	Units	Test Conditions
BV_{DSS}	Drain – Source Breakdown Voltage	IRFF9220 IRFF9222	-200	–	–	V	V_{GS} = 0V
		IRFF9221 IRFF9223	-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	IRFF9220 IRFF9221	-2.5	–	–	A	V_{DS} > $I_{D(on)}$ x $R_{DS(on)}$ max., V_{GS} = -10V
		IRFF9222 IRFF9223	-2.0	–	–	A	
$R_{DS(on)}$	Static Drain-Source On-State Resistance ②	IRFF9220 IRFF9221	–	1.0	1.5	Ω	V_{GS} = -10V, I_D = -1.5A
		IRFF9222 IRFF9223	–	1.5	2.4	Ω	
g_{fs}	Forward Transconductance ②	ALL	1.0	1.8	–	S (℧)	V_{DS} > $I_{D(on)}$ x $R_{DS(on)}$ max., I_D = -1.5A
C_{iss}	Input Capacitance	ALL	–	350	400	pF	V_{GS} = 0V, V_{DS} = -25V, f = 1.0 MHz See Fig. 10
C_{oss}	Output Capacitance	ALL	–	100	125	pF	
C_{rss}	Reverse Transfer Capacitance	ALL	–	30	45	pF	
$t_{d(on)}$	Turn-On Delay Time	ALL	–	15	40	ns	V_{DD} = 0.5 BV_{DSS}, I_D = -1.5A, Z_o = 50Ω See Fig. 17 (MOSFET switching times are essentially independent of operating temperature.)
t_r	Rise Time	ALL	–	25	50	ns	
$t_{d(off)}$	Turn-Off Delay Time	ALL	–	20	50	ns	
t_f	Fall Time	ALL	–	15	40	ns	
Q_g	Total Gate Charge (Gate – Source Plus Gate-Drain)	ALL	–	16	22	nC	V_{GS} = -15V, I_D = -4.0A, V_{DS} = 0.8V Max. Rating. See Fig. 18 for test circuit. (Gate charge is essentially independent of operating temperature.)
Q_{gs}	Gate-Source Charge	ALL	–	9.0	–	nC	
Q_{gd}	Gate-Drain ("Miller") Charge	ALL	–	7.0	–	nC	
L_D	Internal Drain Inductance	ALL	–	5.0	–	nH	Measured from the drain lead, 5mm (0.2 in.) from header to center of die.
L_S	Internal Source Inductance	ALL	–	15	–	nH	Measured from the source lead, 5mm (0.2 in.) from header to source bonding pad.

Modified MOSFET symbol showing the internal device inductances.



Thermal Resistance

R_{thJC}	Junction-to-Case	ALL	–	–	6.25	K/W	
R_{thJA}	Junction-to-Ambient	ALL	–	–	175	K/W	Free Air Operation

Source-Drain Diode Ratings and Characteristics

I_S	Continuous Source Current (Body Diode)	IRFF9220 IRFF9221	–	–	-2.5	A	Modified MOSFET symbol showing the integral reverse P-N junction rectifier.
		IRFF9222 IRFF9223	–	–	-2.0	A	
I_{SM}	Pulse Source Current (Body Diode) ③	IRFF9220 IRFF9221	–	–	-10	A	
		IRFF9222 IRFF9223	–	–	-8.0	A	
V_{SD}	Diode Forward Voltage ②	IRFF9220 IRFF9221	–	–	-7.0	V	T_C = 25°C, I_S = -2.5A, V_{GS} = 0V
		IRFF9222 IRFF9223	–	–	-6.8	V	T_C = 25°C, I_S = -2.0A, V_{GS} = 0V
t_{rr}	Reverse Recovery Time	ALL	–	300	–	ns	T_J = 150°C, I_F = -2.5A, dI_F/dt = 100A/μs
Q_{RR}	Reverse Recovered Charge	ALL	–	1.9	–	μC	T_J = 150°C, I_F = -2.5A, 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 $L_S + L_D$.				

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

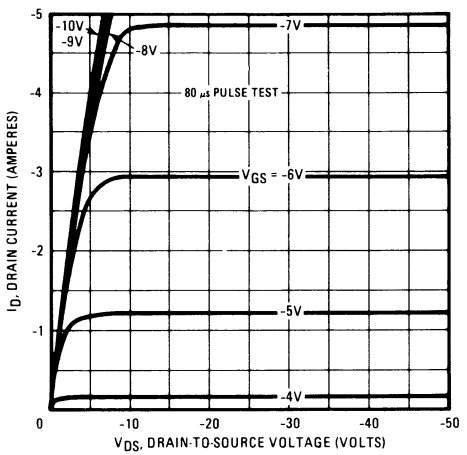


Fig. 1 – Typical Output Characteristics

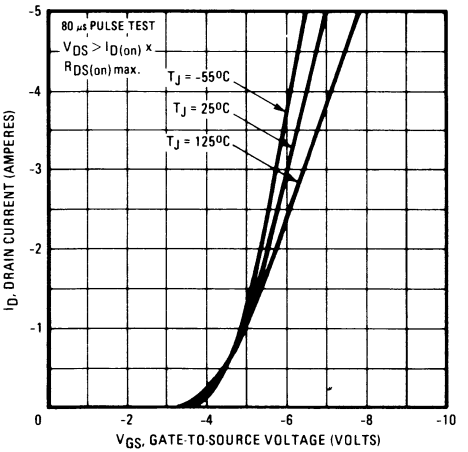


Fig. 2 – Typical Transfer Characteristics

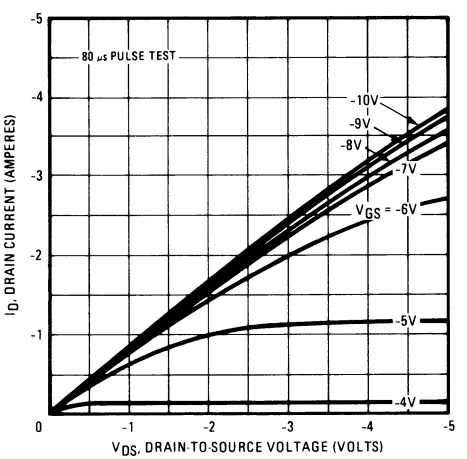


Fig. 3 – Typical Saturation Characteristics

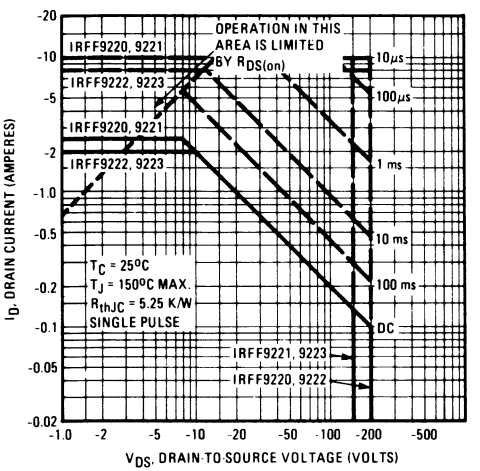


Fig. 4 – Maximum Safe Operating Area

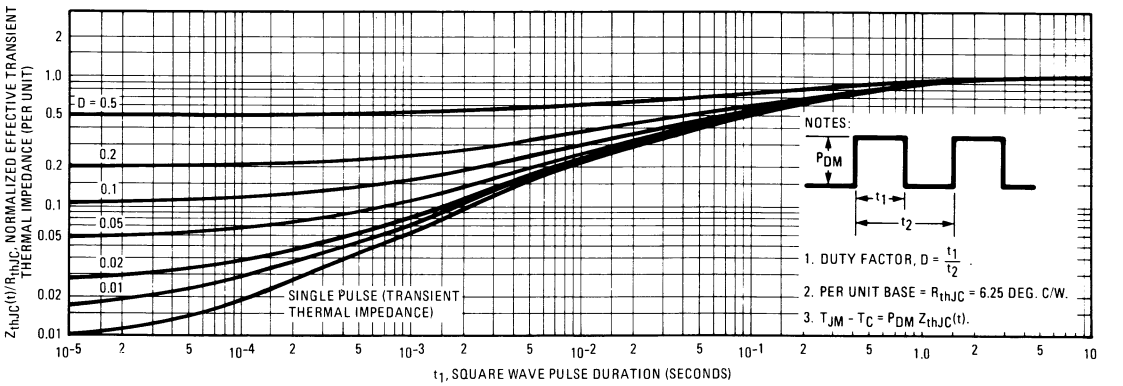


Fig. 5 — Maximum Effective Transient Thermal Impedance, Junction-to-Case Vs. Pulse Duration

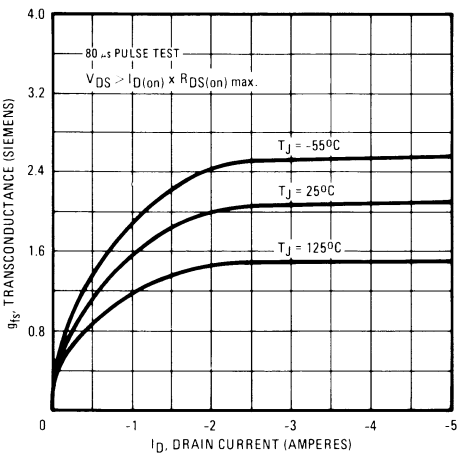


Fig. 6 — Typical Transconductance Vs. Drain Current

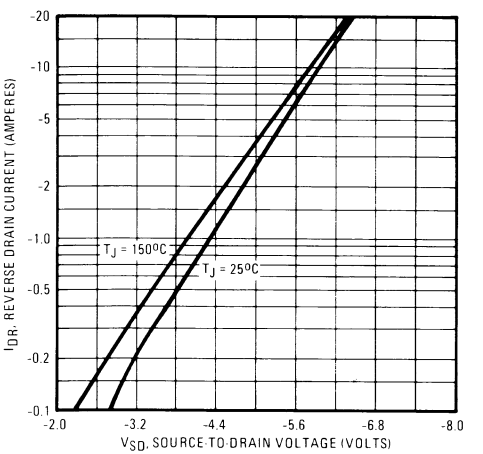


Fig. 7 — Typical Source-Drain Diode Forward Voltage

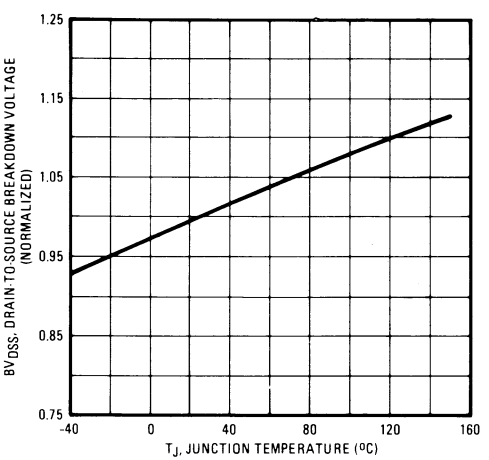


Fig. 8 — Breakdown Voltage Vs. Temperature

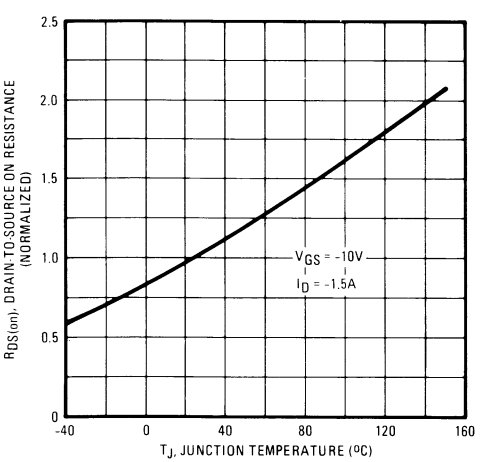


Fig. 9 — Normalized On-Resistance Vs. Temperature

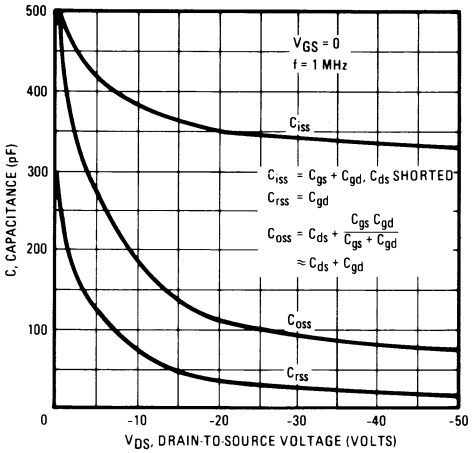


Fig. 10 — Typical Capacitance Vs. Drain-to-Source Voltage

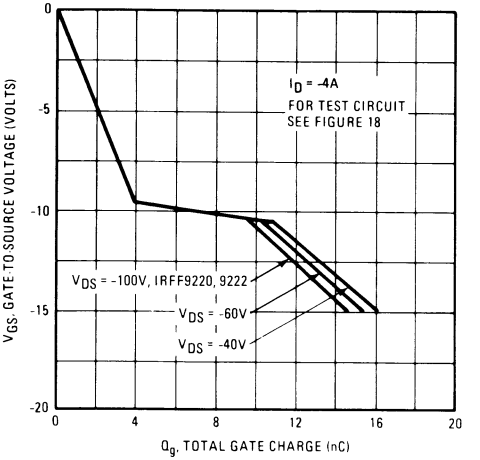


Fig. 11 — Typical Gate Charge Vs. Gate-to-Source Voltage

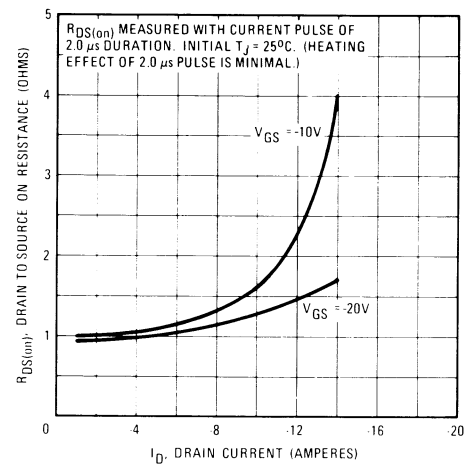


Fig. 12 — Typical On-Resistance Vs. Drain Current

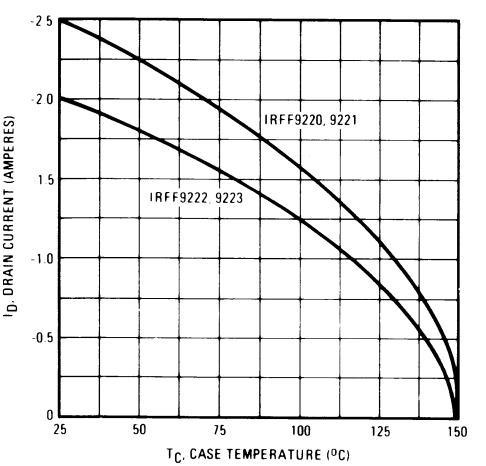


Fig. 13 — Maximum Drain Current Vs. Case Temperature

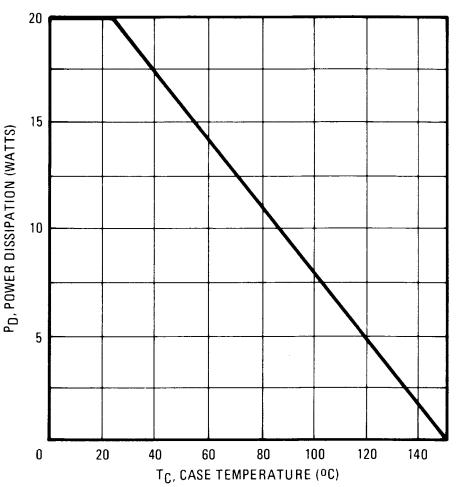


Fig. 14 — Power Vs. Temperature Derating Curve

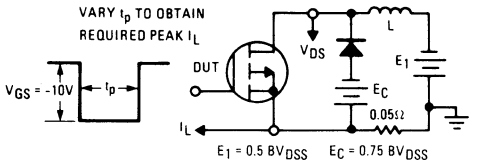


Fig. 15 – Clamped Inductive Test Circuit

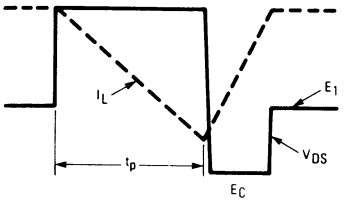


Fig. 16 – Clamped Inductive Waveforms

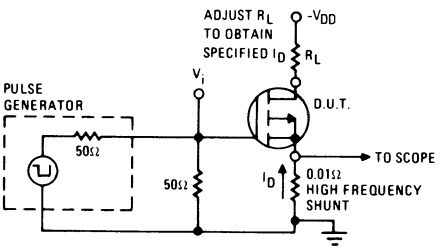


Fig. 17 – Switching Time Test Circuit

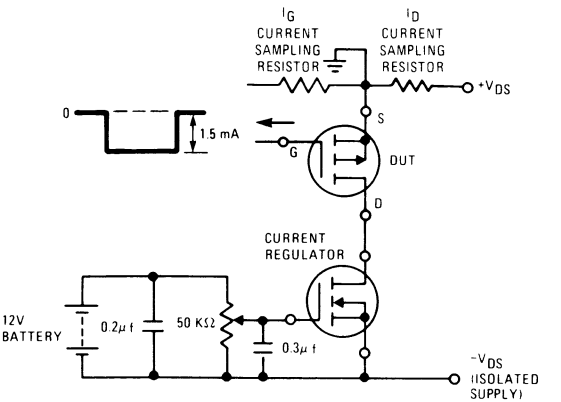
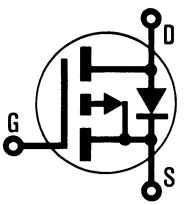


Fig. 18 – Gate Charge Test Circuit

INTERNATIONAL RECTIFIER IOR

HEXFET® TRANSISTORS IRFF9230

P-CHANNEL POWER MOSFETs TO-39 PACKAGE



IRFF9231

IRFF9232

IRFF9233

-200 Volt, 0.8 Ohm HEXFET

The HEXFET® technology is the key to International Rectifier's advanced line of power MOSFET transistors. The efficient geometry and unique processing of the HEXFET design achieve very low on-state resistance combined with high transconductance and, extreme device ruggedness.

The P-Channel HEXFETs are designed for applications which require the convenience of reverse polarity operation. They retain all of the features of the more comon N-Channel HEXFETs such as voltage control, freedom from second breakdown, very fast switching, ease of paralleling, and excellent temperature stability. The P-Channel IRFF9230 device is an approximate electrical complement to the N-Channel IRFF130 HEXFET.

P-Channel HEXFETs are intended for use in power stages where complementary symmetry with N-Channel devices offers circuit simplification. They are also very useful in drive stages because of the circuit versatility offered by the reverse polarity connection. applications include motor control, audio amplifiers, switched mode converters, control circuits and pulse amplifiers.

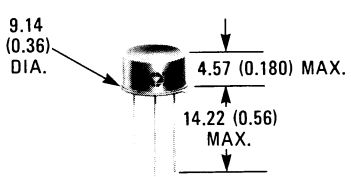
Features:

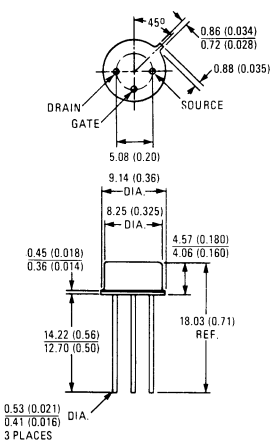
- P-Channel Versatility
- Fast Switching
- Low Drive Current
- Ease of Paralleling
- No Second Breakdown
- Excellent Temperature Stability

Product Summary

Part Number	V_{DS}	$R_{DS(on)}$	I_D
IRFF9230	-200V	0.8Ω	-4.0A
IRFF9231	-150V	0.8Ω	-4.0A
IRFF9232	-200V	1.2Ω	-3.5A
IRFF9233	-150V	1.2Ω	-3.5A

CASE STYLE AND DIMENSIONS





Conforms to JEDEC Outline TO-205AF (TO-39)
Dimensions in Millimeters and (Inches)

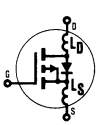
Absolute Maximum Ratings

Parameter		IRFF9230	IRFF9231	IRFF9232	IRFF9233	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	-4.0	-4.0	-3.5	-3.5	A
I_{DM}	Pulsed Drain Current ③	-16	-16	-14	-14	A
V_{GS}	Gate – Source Voltage	±20				V
P_D @ T_C = 25°C	Max. Power Dissipation	25 (See Fig. 14)				W
	Linear Derating Factor	0.2 (See Fig. 14)				W/K
I_{LM}	Inductive Current, Clamped	(See Fig. 15 and 16) L = 100μH -16	-16	-14	-14	A
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

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

Parameter		Type	Min.	Typ.	Max.	Units	Test Conditions
BV_{DSS}	Drain – Source Breakdown Voltage	IRFF9230 IRFF9232	-200	–	–	V	V_{GS} = 0V
		IRFF9231 IRFF9233	-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	IRFF9230 IRFF9231	-4.0	–	–	A	V_{DS} > $I_{D(on)}$ x $R_{DS(on)}$ max., V_{GS} = -10V
		IRFF9232 IRFF9233	-3.5	–	–	A	
$R_{DS(on)}$	Static Drain-Source On-State Resistance ②	IRFF9230 IRFF9231	–	0.5	0.8	Ω	V_{GS} = -10V, I_D = -2.0A
		IRFF9232 IRFF9233	–	0.8	1.2	Ω	
g_{fs}	Forward Transconductance ②	ALL	2.2	3.5	–	S(℧)	V_{DS} > $I_{D(on)}$ x $R_{DS(on)}$ max., I_D = 2.0A
C_{iss}	Input Capacitance	ALL	–	550	650	pF	V_{GS} = 0V, V_{DS} = -25V, f = 1.0 MHz See Fig. 10
C_{oss}	Output Capacitance	ALL	–	170	300	pF	
C_{rss}	Reverse Transfer Capacitance	ALL	–	50	90	pF	
$t_{d(on)}$	Turn-On Delay Time	ALL	–	30	50	ns	V_{DD} ≈ 0.5 BV_{DSS}, I_D = 2.0A, Z_o = 50Ω See Fig. 17 (MOSFET switching times are essentially independent of operating temperature.)
t_r	Rise Time	ALL	–	50	100	ns	
$t_{d(off)}$	Turn-Off Delay Time	ALL	–	50	100	ns	
t_f	Fall Time	ALL	–	40	80	ns	
Q_g	Total Gate Charge (Gate – Source Plus Gate-Drain)	ALL	–	31	45	nC	V_{GS} = -15V, I_D = -8.0A, V_{DS} = 0.8V Max. Rating. See Fig. 18 for test circuit. (Gate charge is essentially independent of operating temperature.)
Q_{gs}	Gate-Source Charge	ALL	–	18	–	nC	
Q_{gd}	Gate-Drain (''Miller'') Charge	ALL	–	13	–	nC	
L_D	Internal Drain Inductance	ALL	–	5.0	–	nH	Measured from the drain lead, 5mm (0.2 in.) from header to center of die.
L_S	Internal Source Inductance	ALL	–	15	–	nH	Measured from the source lead, 5mm (0.2 in.) from header to source bonding pad.

Modified MOSFET symbol showing the internal device inductances.



Thermal Resistance

R_{thJC}	Junction-to-Case	ALL	–	–	5.0	K/W	
R_{thJA}	Junction-to-Ambient	ALL	–	–	175	K/W	Free Air Operation

Source-Drain Diode Ratings and Characteristics

I_S	Continuous Source Current (Body Diode)	IRFF9230 IRFF9231	—	—	-4.0	A	Modified MOSFET symbol showing the integral reverse P-N junction rectifier. 
		IRFF9232 IRFF9233	—	—	-3.5	A	
I_{SM}	Pulse Source Current (Body Diode) ③	IRFF9230 IRFF9231	—	—	-16	A	
		IRFF9232 IRFF9233	—	—	-14	A	
V_{SD}	Diode Forward Voltage ②	IRFF9230 IRFF9231	—	—	-6.5	V	T_C = 25°C, I_S = -4.0A, V_{GS} = 0V
		IRFF9232 IRFF9233	—	—	-6.3	V	T_C = 25°C, I_S = -3.5A, V_{GS} = 0V
t_{rr}	Reverse Recovery Time	ALL	—	400	—	ns	T_J = 150°C, I_F = -4.0A, dI_F/dt = 100A/μs
Q_{RR}	Reverse Recovered Charge	ALL	—	2.6	—	μC	T_J = 150°C, I_F = -4.0A, 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.				

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

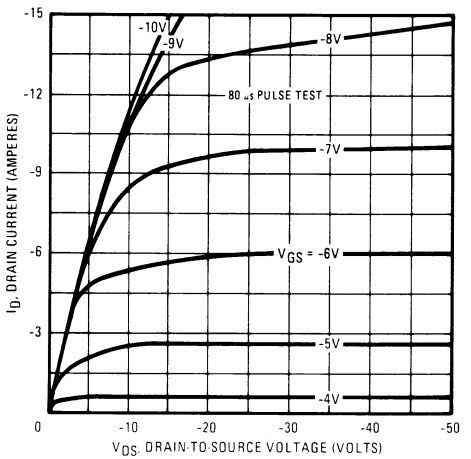


Fig. 1 — Typical Output Characteristics

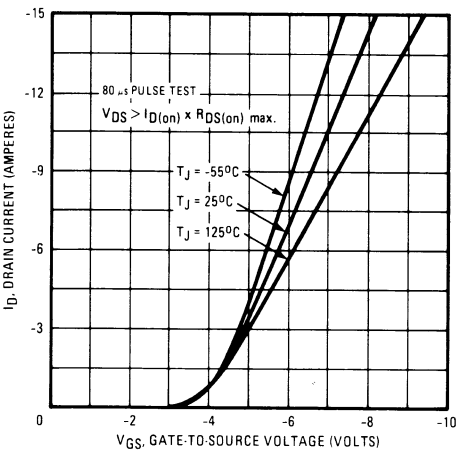


Fig. 2 — Typical Transfer Characteristics

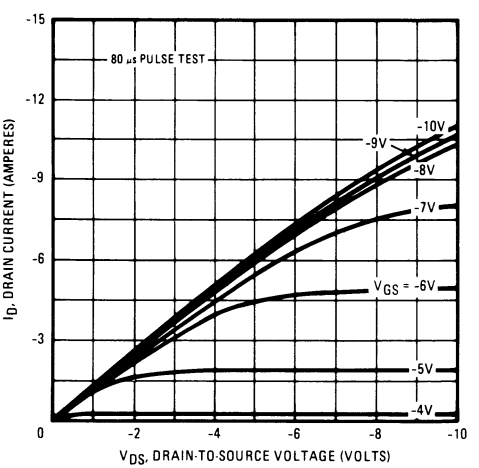


Fig. 3 — Typical Saturation Characteristics

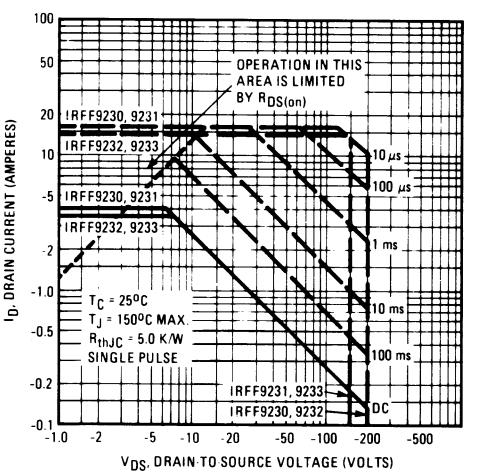


Fig. 4 — Maximum Safe Operating Area

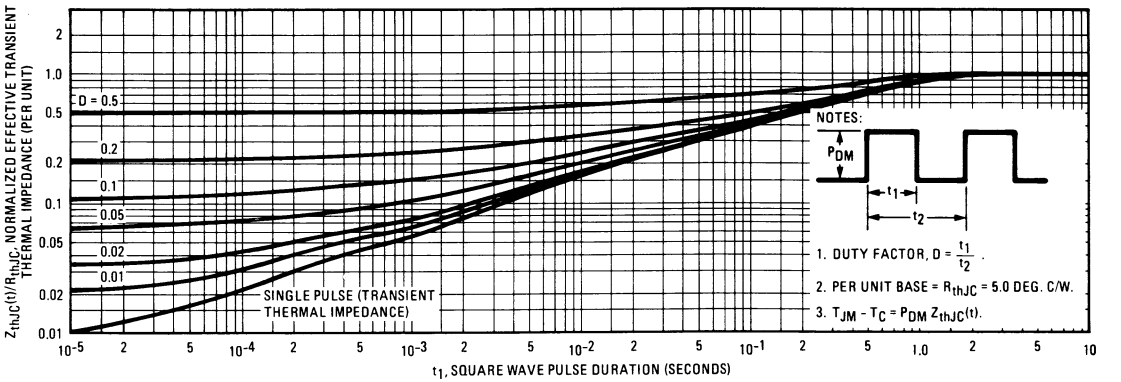


Fig. 5 – Maximum Effective Transient Thermal Impedance, Junction-to-Case Vs. Pulse Duration

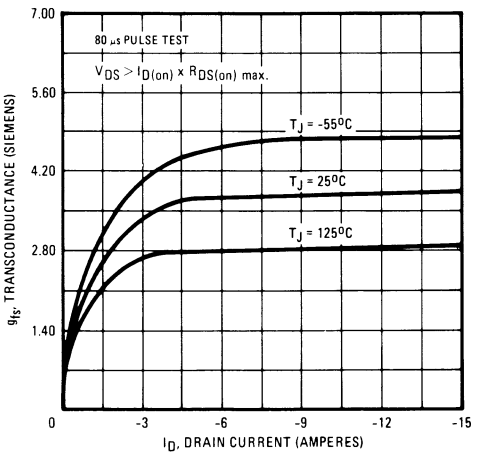


Fig. 6 – Typical Transconductance Vs. Drain Current

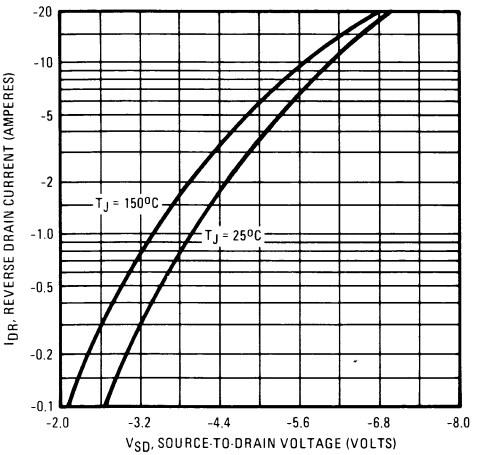


Fig. 7 – Typical Source-Drain Diode Forward Voltage

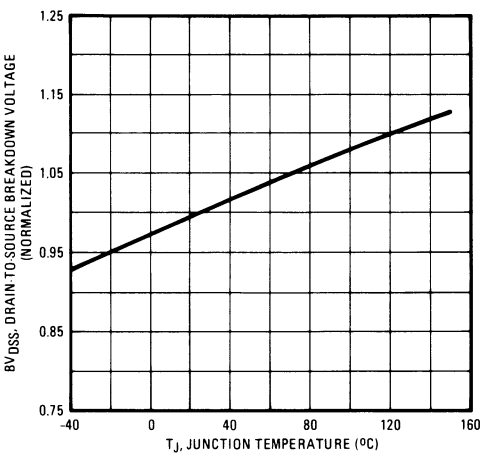


Fig. 8 – Breakdown Voltage Vs. Temperature

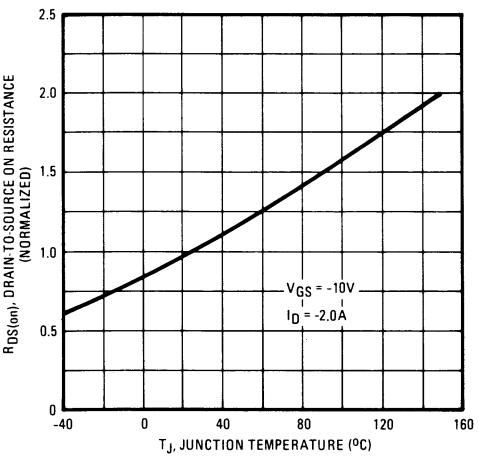
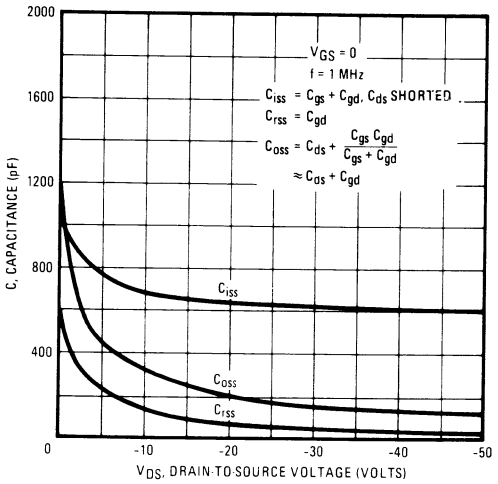


Fig. 9 – Normalized On-Resistance Vs. Temperature



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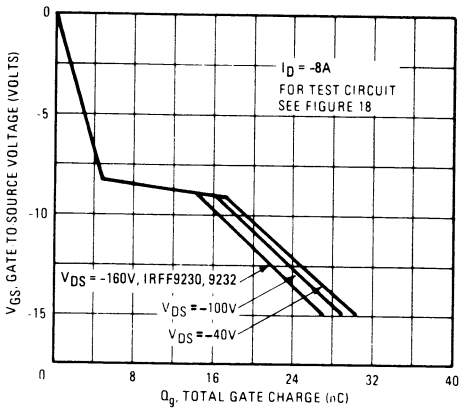

Fig. 11 – Typical Gate Charge Vs. Gate-to-Source Voltage

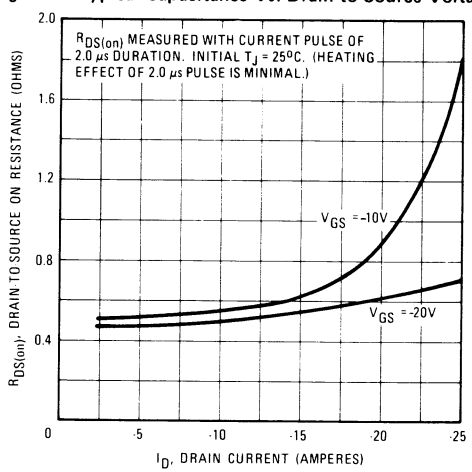

Fig. 12 – Typical On-Resistance Vs. Drain Current

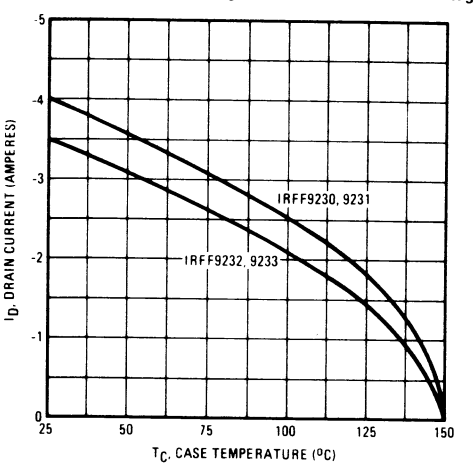

Fig. 13 – Maximum Drain Current Vs. Case Temperature

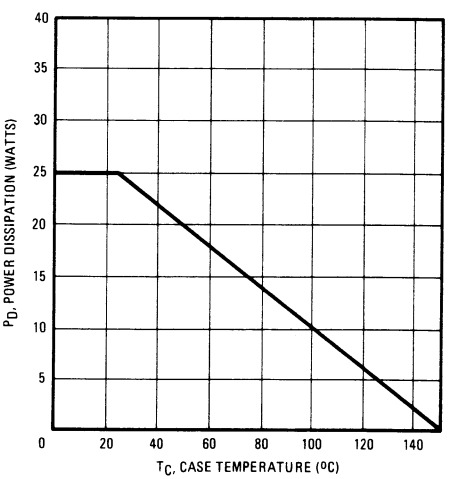

Fig. 14 – Power Vs. Temperature Derating Curve

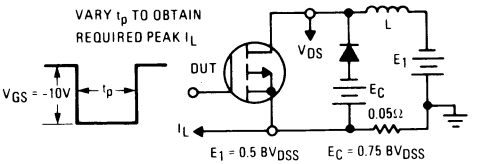

Fig. 15 – Clamped Inductive Test Circuit

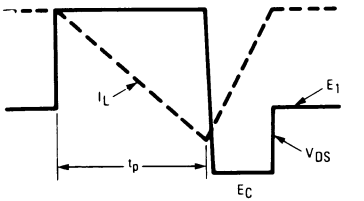

Fig. 16 – Clamped Inductive Waveforms

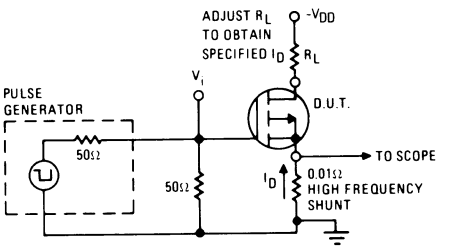

Fig. 17 – Switching Time Test Circuit

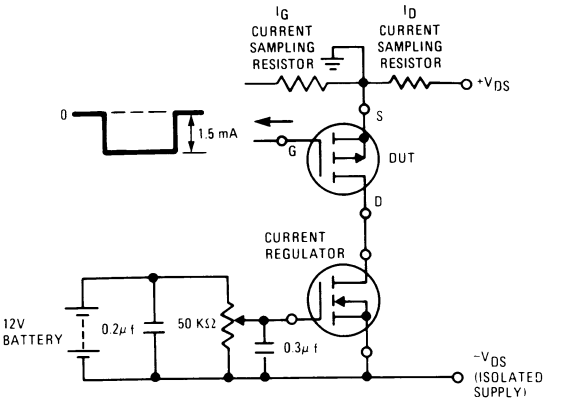

Fig. 18 – Gate Charge Test Circuit