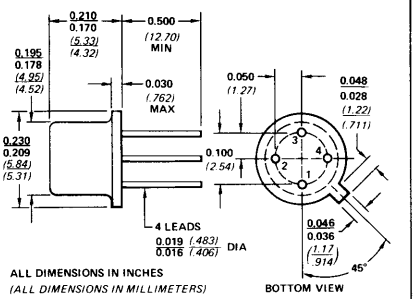
Performance Curves MB
See Page 4-3

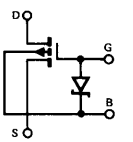
P-CHANNEL ENHANCEMENT-TYPE SILICON MOS FIELD-EFFECT TRANSISTOR

FOR AUDIO & RF AMPLIFIERS, CHOPPERS, MULTIPLEX AND COMMUTATING APPLICATIONS

- Integrated Zener Clamp Protects the Gate
- Normally OFF with Zero Gate Voltage



TO-72



PIN	OUT
1	D
2	G
3	B,C
4	S

ABSOLUTE MAXIMUM RATINGS (25°C)

Drain-to-Source Voltage	-25 V
Gate-to-Source Voltage	-25 V
Gate-to-Drain Voltage	-25 V
Drain Current	-50 mA
Gate Current (Forward Direction For Zener Clamp)	±0.1 mA
Storage Temperature	-65 to +150°C
Operating Junction Temperature Range	-55 to +125°C
Total Dissipation at 25°C Ambient Temperature (Derate 2.25 mW/°C)	225 mW

ELECTRICAL CHARACTERISTICS (25°C unless otherwise noted)

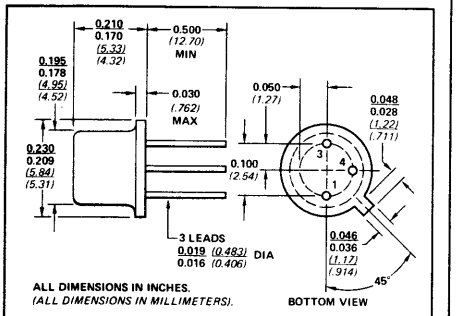
		Characteristic		Min	Typ	Max	Unit	Test Conditions	
1	STATIC	I_{GSS}	Gate Leakage Current			-1	nA	V_{GS} = -15 V, V_{DS} = V_{BS} = 0	
2	STATIC	BV_{DSS}	Drain-Source Breakdown Voltage	-25			V	I_D = -10 μA, V_{GS} = V_{BS} = 0	
3	STATIC	$V_{GS(th)}$	Gate Threshold Voltage	-3		-6		V_{GS} = V_{DS}, I_D = -10 μA, V_{BS} = 0	
4	STATIC	I_{DSS}	Drain Cutoff Current			-10	nA	V_{DS} = -20 V, V_{GS} = V_{BS} = 0	
5	STATIC	$I_{D(on)}$	Drain Current	-3			mA	V_{GS} = V_{DS} = -10 V, V_{BS} = 0	
6	STATIC	$r_{DS(on)}$	Drain-Source ON Resistance		150		Ω	V_{GS} = -15 V, I_D = -1 mA, V_{BS} = 0	
7	DYN	g_{fs}	Common-Source Forward Transconductance	1,000			μmho	V_{GS} = V_{DS} = -10 V, V_{BS} = 0	f = 1 kHz
8	DYN	g_{fs}	Common-Source Forward Transconductance	1,000			μmho	V_{GS} = V_{DS} = -10 V, V_{BS} = 0	f = 10 MHz
9	DYN	C_{gs}	Gate-Source Capacitance			4	pF	V_{GS} = V_{DS} = -10 V, V_{BS} = 0	f = 1 MHz
10	DYN	C_{gd}	Gate-Source Capacitance			4	pF	V_{GS} = V_{DS} = -10 V, V_{BS} = 0	f = 1 MHz
11	DYN	C_{ds}	Drain-Source Capacitance		0.15		pF	V_{GS} = V_{DS} = -10 V, V_{BS} = 0	f = 1 MHz

MB

PICO AMPERE DIODES

SILICON LOW LEAKAGE DIODES FOR CLIPPING AND PROTECTION APPLICATIONS

- **Ultra Low Leakage (PAD 1-5)**
- **High Reverse Impedance**
- **Low Capacitance**



TO-18

Case Lead for PAD 1, 2, 5 Only

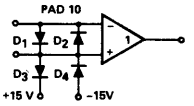
PIN	OUT
1	Cathode
3	Anode
4	Case

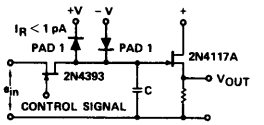
ABSOLUTE MAXIMUM RATINGS (25°C)

Forward Current ..... 50 mA
Total Device Dissipation ..... 300 mW
Storage Temperature Range ..... -55°C to +125°C

ELECTRICAL CHARACTERISTICS (25°C unless otherwise noted)

		Characteristic	Min	Typ	Max	Unit	Test Conditions	
1	STATIC	I_R Reverse Current			1	pA	V_R = -20 V	PAD 1
2					2			2
3					5			5
4					10			PAD 10
5					20			20
6					50			50
7					100			PAD 100
8		BV_R Breakdown Voltage (Reverse)	45		120	V	I_R = -1 μA	PAD 1, 2, 5
9			35					PAD 10, 20, 50, 100
10		V_F Forward Voltage Drop		0.8	1.5		I_F = 5 mA	PAD 1, 2, 5, 10, 20, 50, 100
11	DY	C Capacitance			0.8	pF	V_R = -5 V, f = 1 MHz	PAD 1, 2, 5
12					2			PAD 10, 20, 50, 100





APPLICATION

Operational Amplifier Protection. Input Differential Voltage limited to 0.8 V (typ) by PADS D_1 and D_2 Common mode input voltage limited by PADS D_3 and D_4 to ±15 V.

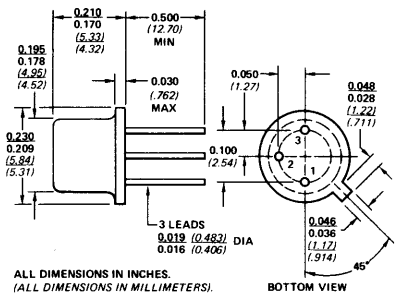
Typical sample and hold circuit with clipping. PAD diodes reduce offset voltages fed capacitively from the FET switch gate.

Performance Curves PC
See Page 4-55

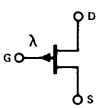
P-CHANNEL SILICON JUNCTION PHOTOSENSITIVE FIELD EFFECT TRANSISTOR

FUNCTIONALLY INTEGRATED PHOTODIODE AND LOW-NOISE AMPLIFIER

- **High Input Sensitivity**
- **Adjustable Threshold**



TO-18
WITH TOP LENSE



PIN	OUT
1	S
2	G,C
3	D

ABSOLUTE MAXIMUM RATINGS (25°C)

Gate-Drain or Gate-Source Voltage (Note 1) . . . . . 30 V
Total Device Dissipation at (or below) 25°C
Free-Air Temperature (Note 2) . . . . . 300 mW
Storage Temperature Range . . . . . -65 to +200°C

ELECTRICAL CHARACTERISTICS Equivalent to 2N2608
(25°C unless otherwise noted)

		Characteristic			Min	Typ	Max	Unit	Test Conditions	
1	PHOTO	S_{IN}	Input Sensitivity (Gate Current per Unit Radiant Power Density)		0.4	1.2		μA/mW/cm²	λ = 0.9 microns V_{GS} = 5 V, V_{DS} = 0	
2	PHOTO	D	Detectivity		0.6	2.7		$\frac{10^{10}}{(cm)\sqrt{Hz}}{W}$	V_{GS} = 0, V_{DS} = -5 V, λ = 0.9 microns BW = 1 Hz, R_G = 1 MΩ	f = 1 kHz
3	PHOTO	Response Time 10% to 90% Points	t_r		0.1		μsec	Xenon Flash Source R_G = 0, R_L = 330 Ω V_{GS} = 0, V_{DS} = -5 V		
			t_f		1.5					
4	STATIC	I_{GSS}	Gate-Source Dark Current (Note 3)				10	nA	V_{GS} = 30 V, V_{DS} = 0	T_A = 150°C
5	STATIC	I_{GSS}	Gate-Source Dark Current (Note 3)				10	μA	V_{GS} = 5 V, V_{DS} = 0	
6	STATIC	BV_{GSS}	Gate Source Breakdown Voltage		30			V	I_G = 1 μA, V_{DS} = 0	
7	STATIC	$V_{GS(off)}$	Gate-Source Cutoff Voltage (Note 3)		1	2	4		I_D = -1 μA, V_{DS} = -5 V	
8	STATIC	I_{DSS}	Saturation Drain Current		-0.90	-1.60	-4.50	mA	V_{GS} = 0, V_{DS} = -5 V	
9	DYN	g_{fs}	Common-Source Forward Transconductance		1000	1600		μmho	V_{GS} = 0, V_{DS} = -5 V	f = 1 kHz
10	DYN	C_{iss}	Common-Source Input Capacitance			12	17	pF	V_{GS} = 1 V, V_{DS} = -5 V	f = 140 kHz
11	DYN	NF	Noise Figure (Note 3)			0.5	3.0	dB	V_{GS} = 0, V_{DS} = -5 V, BW = 16%, R_{gen} = 1 MΩ	f = 1 kHz

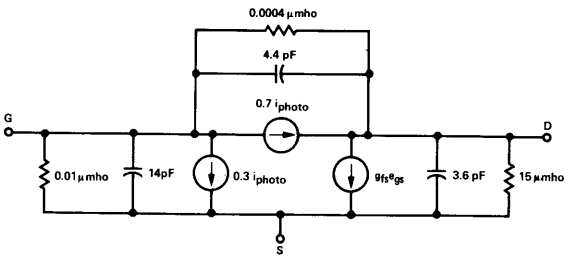
NOTES:
1. Due to symmetrical geometry, these units may be operated with source and drain leads interchanged.
2. Derate linearly to +175°C free-air temperature at the rate of 2 mW/°C.
3. Measured under dark conditions.

PC

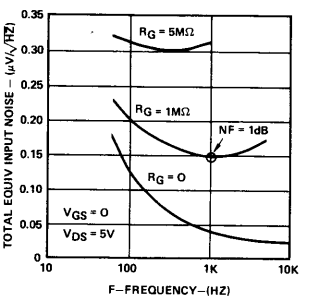
APPLICATIONS

Small Signal Equivalent Circuit

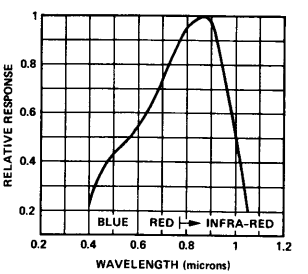
($25^{\circ}C$, f = 1 kHz, V_{DS} = -5 V, V_{GS} = 0 V)



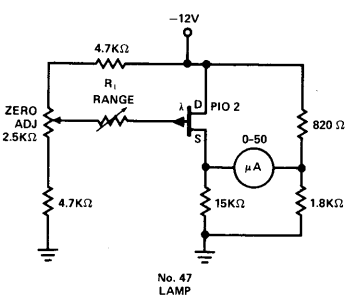
Typical Noise Data



Typical Spectral Response



Photometer Circuit



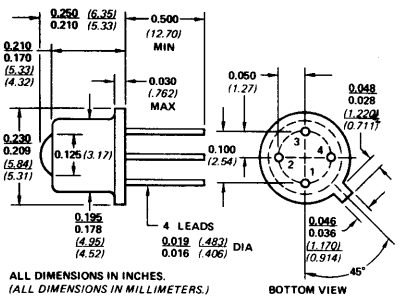
R_1 RANGE RESISTOR VALUE	FULL–SCALE OPTICAL DENSITY CALIBRATION
10 K	0.0 (100% TRANSMISSION)
100K	1.0 (10% TRANSMISSION)
1M	2.0 (1% TRANSMISSION)
10M	3.0 (0.1% TRANSMISSION)
100M	4.0 (0.01% TRANSMISSION)

Performance Curves NS
See Page 4-43

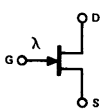
N-CHANNEL SILICON JUNCTION PHOTOSENSITIVE FIELD-EFFECT TRANSISTORS

FUNCTIONALLY INTEGRATED PHOTODIODE AND LOW NOISE AMPLIFIER

- High Input Sensitivity
- Adjustable Threshold



TO-72
WITH TOP LENS



PIN	OUT
1	S
2	D
3	G
4	C

ABSOLUTE MAXIMUM RATINGS (25°C)

Gate-Drain or Gate-Source Voltage (Note 1) . . . . . -40 V
Total Device Dissipation
(Derate 2.4 mW/°C to 150°C) . . . . . 300 mW
Storage Temperature Range . . . . . -65 to +150°C

ELECTRICAL CHARACTERISTICS (25°C unless otherwise noted)

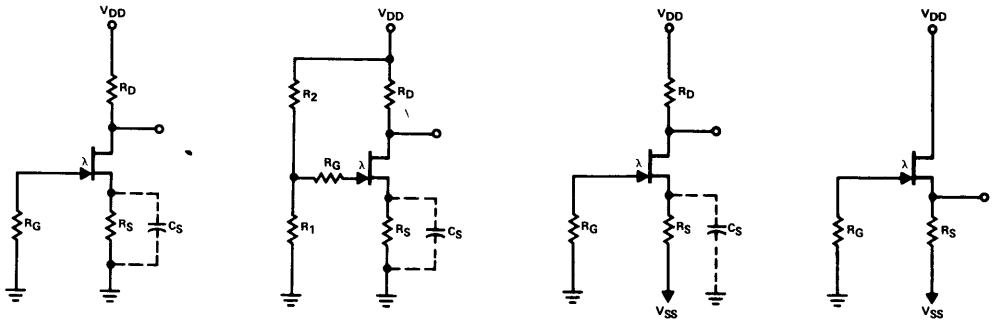
			Characteristic	Min	Typ	Unit	Test Conditions
1	PHOTO	S_{IN}	Input Sensitivity (Gate Current per Unit Radiant Power Density)	0.8	3	μA/mW/cm²	λ = 0.9 microns, I_D = 300 μA, V_{DG} = 20 V, Radiant Power Density = 0.1 mW/cm²

			Characteristic	P236		P237		P238		Unit	Test Conditions	
				Min	Max	Min	Max	Min	Max			
2	STATIC	I_{GSS}	Gate Reverse Dark Current		-0.25		-0.25		-0.25	nA	V_{GS} = -30 V, V_{DS} = 0	
					-0.25		-0.25		-0.25	μA		150°C
3		I_G	Gate Dark Current		-30		-30		-30	pA	V_{DG} = 20 V, I_D = 300 μA	
4		BV_{GSS}	Gate-Source Breakdown Voltage	-40		-40		-40		V	I_G = -1 μA, V_{DS} = 0	
5		$V_{GS(off)}$	Gate-Source Cutoff Voltage	-0.7	-2	-1	-3	-1.8	-5		V_{DS} = 20 V, I_D = 1 μA	
6		I_{DSS}	Saturation Drain Current (Note 2)	0.4	1.2	1.0	3.0	2.5	7.5	mA	V_{DS} = 20 V, V_{GS} = 0	
7	DYNAMIC	g_{fs}	Common-Source Forward Transconductance (Note 2)	700	2000	1000	3000	1300	4000	μmho	V_{DS} = 20 V, V_{GS} = 0	f = 1 kHz
8		g_{os}	Common-Source Output Conductance (Input Shorted)		1.5		4		10			
9		C_{rss}	Common-Source Reverse Transfer Capacitance		5		5		5	pF		f = 1 MHz
10		C_{iss}	Common-Source Input Capacitance		25		25		25			
11		$\overline{e}_n$	Short Circuit Equivalent Input Spot Noise Voltage		20		20		20	$\frac{nV}{\sqrt{Hz}}$	V_{DS} = 10 V, V_{GS} = 0	f = 10 Hz
					10		10		10			f = 1 kHz
12		NF	Spot Noise Figure		2		2		2	dB	V_{DS} = 10 V, V_{GS} = 0, R_{gen} = 10 meg	

NOTES:
1. Due to symmetrical geometry, these units may be operated with source and drain leads interchanged.
2. Pulse test duration = 2 ms.

NS

APPLICATIONS



Photofet Amplifier Design Chart
(C_S selected for 3 dB at 10 Hz)

V_{DD} (V)	R_S (Ω)	Circuit	R_1 (Ω)	R_2 (Ω)	R_D (Ω)	C_S (μF)	I_{DD} (mA) Max	t_r (μs)	t_f (μs)	f_{3dB} (kHz)	e_o (V) Max	A_V
P236												
10	6800	A	1M	∞	30K	0	0.13	70	70	3	4	2.9 - 3.4
						20		180	180	1.7	4.5	9 - 14.5
15	6800	A	1M	∞	51K	0	0.13	90	90	3	6	5.0 - 5.2
						20		260	300	1.5	8	15 - 23
	30K	B	1M	4M	36K	20	0.13	300	340	1.6	6	14.3 - 16.2
20	6800	A	1M	∞	75K	0	0.13	110	120	2	8	7 - 8
						20		310	360	1.5	9	20 - 30
	47 K	B	1M	4M	47K	20	0.13	300	400	1.5	8	17 - 20
30	6800	A	1M	∞	100K	0	0.13	150	150	2	14	9 - 10
						20		500	700	1.5	16	21 - 30
	100K	B	1M	1M	40K	20	0.15	290	350	1.7	5	16 - 19
V_{DD} = +15 V_{SS} = -15	100K	C	1M	∞	40K	20	0.15	290	350	1.7	5	16 - 19
		D			0	0		17	17	16	14	0.98
P237												
20	2700	A	1M	∞	15K	0	0.55	75	75	4.5	7	3.5 - 3.7
						40		180	190	2.5	8	9.7 - 15
	8200	B	1M	3M	6.8K	50	0.75	110	115	2	6	7 - 8.5
30	2700	A	1M	∞	27K	0	0.55	105	105	4.5	12	6 - 7
						40		260	260	2	12	16 - 25
	12K	B	1M	3M	12K	50	0.75	170	160	2.3	10	12 - 15
40	2700	A	1M	∞	39K	0	0.55	125	125	3.3	14	8.4 - 10
						40		350	350	1.7	16	20 - 30
	15K	B	1M	3M	18K	50	0.75	320	350	1.7	16	16 - 20
V_{DD} = +15 V_{SS} = -15	12K	C	1M	∞	12K	50	0.75	170	160	2.3	10	12 - 15
	22K	D	1M	∞	0	0	0.75	20	20	14	14	0.98
P238												
20	910	A	1M	∞	3900	0	2.3	60	60	4	10	2.4 - 2.8
						75		100	120	3	10	5.4 - 7.0
30	4300	B	1M	3.4M	4300	75	2.1	160	160	3.3	9	7.2
	910	A	1M	∞	6800	0	2.3	80	80	10	12	4.2 - 4.7
						75		140	140	1.7	12	9.9 - 11.8
40	4300	B	1M	5M	6800	75	2.1	185	185	2	11	10.5
V_{DD} = +15 V_{SS} = -15	9100	D	∞	∞	0	0	1.9	23	23	12	16	0.95

APPLICATIONS (Cont'd)

The silicon photoFET combines, in a single structure, a sensitive silicon photodiode and a low-noise field effect transistor. Several practical circuits are shown on page 3. The design chart suggests component values for each of these circuits with a range of supply voltage.

The result of illumination is a photo current flowing in the gate circuit causing a positive voltage rise at the gate. This photo signal voltage is directly proportional to the value of R_G, and results in increased drain current as illumination is increased.

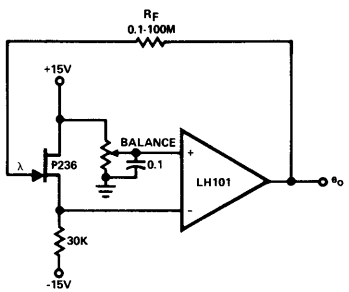
The photoFET is useful in both light level threshold sensing and in modulated light detection. Accordingly, the design chart gives component values for both applications. Whenever a C_S is specified, the ac circuit gain is increased while the response to changes in absolute illumination intensity is differentiated to some extent.

For threshold-sensing applications, the P236 is recommended. The design chart provides for operation at or very near zero temperature coefficient for all circuits with the P236. The P237 and 238 exhibit increased temperature effects, but are useful for stable light threshold sensing at constant temperature. High temperature operation is not recommended with any of the devices due to increasing gate current. Refer to circuit configurations.

For high-frequency modulated light detection or for good transient response, the source-follower circuit D is recommended. As the gate-circuit time constant directly affects the response, this circuit should provide the highest frequency response.

Circuit A is a typical dc/ac amplifier. Capacitor C_S is employed only for good ac gain. Circuit B is similar to A except that the dc operating point is stabilized for a wide range of temperature and device parameters. Circuit C is equivalent to B except that a balanced supply is used and stabilization is further improved. Circuits B and C exhibit near unity dc gain and are primarily intended for modulated light detection. Circuit D is a simple source follower providing reduced input capacity and near unity gain.

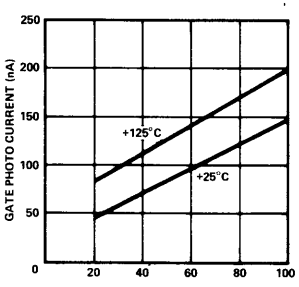
Circuit for High Speed Photo Switching and Communications



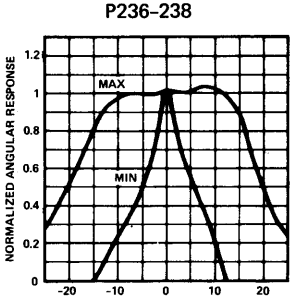
This circuit exhibits good pulse response and low noise performance due to the closed loop operation. Gain is a function of the value of R_F.

PERFORMANCE CURVES

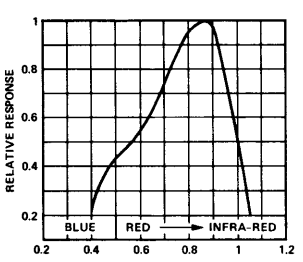
P236-238

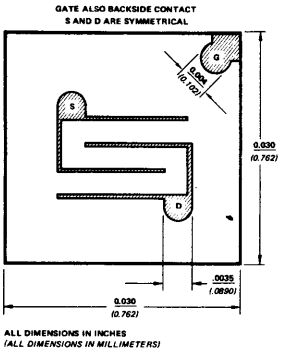


P236-238



P236-238





P-CHANNEL DEPLETION MODE SILICON JUNCTION FIELD-EFFECT TRANSISTOR

APPLICATIONS

- **General Purpose Amplifiers**

PRINCIPAL DEVICES

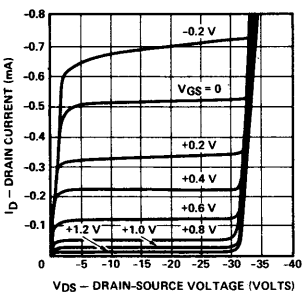
2N2386 2N2497-9 2N2608
2N2843 2N3329-31 U112
U148

PACKAGE TYPES

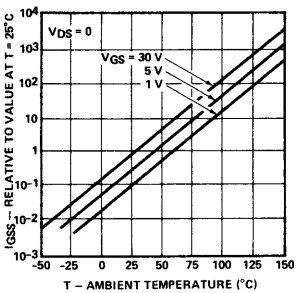
TO-5 TO-18 TO-72

PERFORMANCE CURVES (25°C unless otherwise noted)

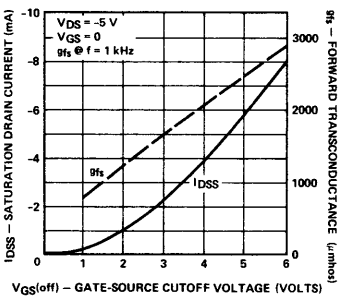
Output Characteristic



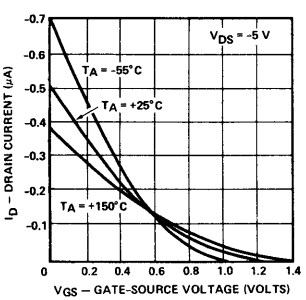
Gate Reverse Current vs Ambient Temperature



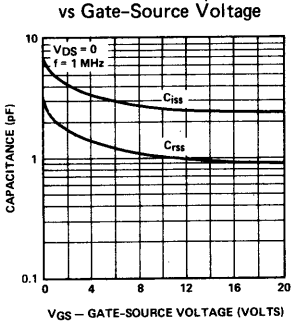
Drain Current & Transconductance vs Gate-Source Voltage



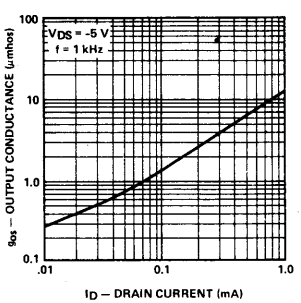
Transfer Characteristic



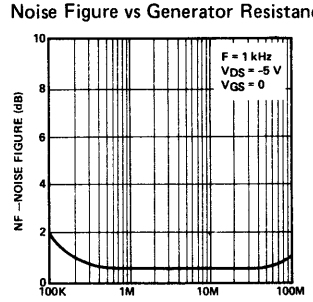
Common-Source Capacitances vs Gate-Source Voltage



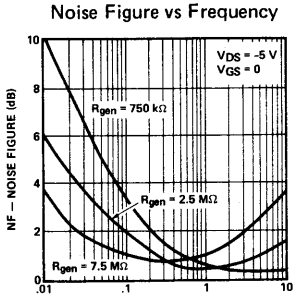
Common-Source Output Admittance vs Drain Current



Noise Figure vs Generator Resistance



Noise Figure vs Frequency



Equivalent Input Noise Voltage vs Frequency