National Semiconductor

LM741 Operational Amplifier

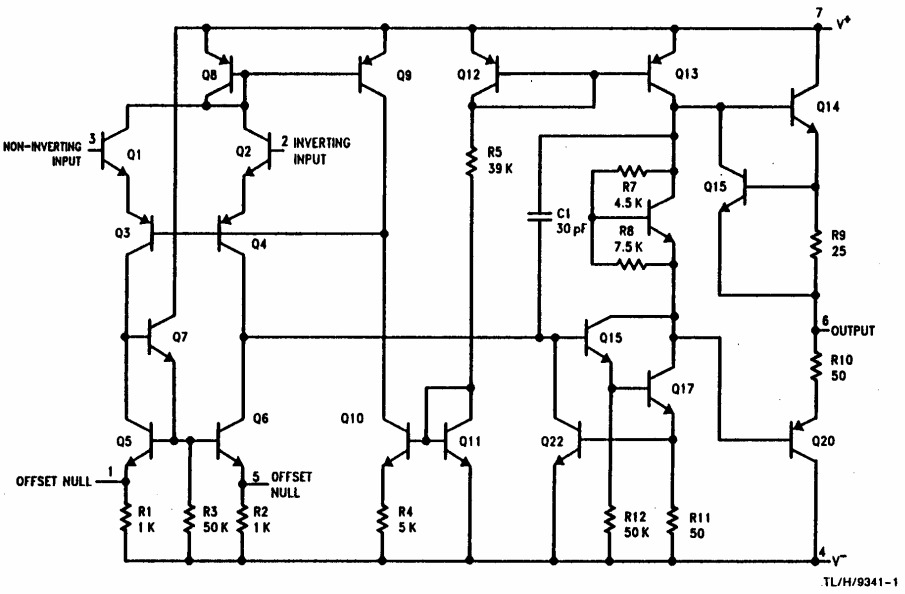
General Description

The LM741 series are general purpose operational amplifiers which feature improved performance over industry standards like the LM709. They are direct, plug-in replacements for the 709C, LM201, MC1439 and 748 in most applications.

The amplifiers offer many features which make their application nearly foolproof: overload protection on the input and output, no latch-up when the common mode range is exceeded, as well as freedom from oscillations.

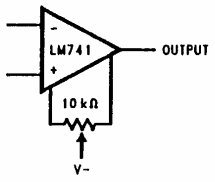
The LM741C/LM741E are identical to the LM741/LM741A except that the LM741C/LM741E have their performance guaranteed over a 0°C to +70°C temperature range, instead of −55°C to +125°C.

Schematic Diagram



TL/H/9341-1

Offset Nulling Circuit



TL/H/9341-7

1-445

LM741

Absolute Maximum Ratings

If Military/Aerospace specified devices are required, please contact the National Semiconductor Sales Office/ Distributors for availability and specifications.
(Note 5)

	LM741A	LM741E	LM741	LM741C
Supply Voltage	±22V	±22V	±22V	±18V
Power Dissipation (Note 1)	500 mW	500 mW	500 mW	500 mW
Differential Input Voltage	±30V	±30V	±30V	±30V
Input Voltage (Note 2)	±15V	±15V	±15V	±15V
Output Short Circuit Duration	Continuous	Continuous	Continuous	Continuous
Operating Temperature Range	−55°C to +125°C	0°C to +70°C	−55°C to +125°C	0°C to +70°C
Storage Temperature Range	−65°C to +150°C	−65°C to +150°C	−65°C to +150°C	−65°C to +150°C
Junction Temperature	150°C	100°C	150°C	100°C
Soldering Information				
N-Package (10 seconds)	260°C	260°C	260°C	260°C
J- or H-Package (10 seconds)	300°C	300°C	300°C	300°C
M-Package				
Vapor Phase (60 seconds)	215°C	215°C	215°C	215°C
Infrared (15 seconds)	215°C	215°C	215°C	215°C
See AN-450 "Surface Mounting Methods and Their Effect on Product Reliability" for other methods of soldering surface mount devices.				
ESD Tolerance (Note 6)	400V	400V	400V	400V

Electrical Characteristics (Note 3)

Parameter	Conditions	LM741A/LM741E			LM741			LM741C			Units
		Min	Typ	Max	Min	Typ	Max	Min	Typ	Max	
Input Offset Voltage	$T_A = 25°C$ $R_S \le 10\,k\Omega$ $R_S \le 50\Omega$		 0.8	 3.0		1.0	5.0		2.0	6.0	 mV mV
	$T_{AMIN} \le T_A \le T_{AMAX}$ $R_S \le 50\Omega$ $R_S \le 10\,k\Omega$			4.0			 6.0			 7.5	mV mV
Average Input Offset Voltage Drift				15							µV/°C
Input Offset Voltage Adjustment Range	$T_A = 25°C$, $V_S = \pm 20V$	±10				±15			±15		mV
Input Offset Current	$T_A = 25°C$		3.0	30		20	200		20	200	nA
	$T_{AMIN} \le T_A \le T_{AMAX}$			70		85	500			300	nA
Average Input Offset Current Drift				0.5							nA/°C
Input Bias Current	$T_A = 25°C$		30	80		80	500		80	500	nA
	$T_{AMIN} \le T_A \le T_{AMAX}$			0.210			1.5			0.8	µA
Input Resistance	$T_A = 25°C$, $V_S = \pm 20V$	1.0	6.0		0.3	2.0		0.3	2.0		MΩ
	$T_{AMIN} \le T_A \le T_{AMAX}$, $V_S = \pm 20V$	0.5									MΩ
Input Voltage Range	$T_A = 25°C$							±12	±13		V
	$T_{AMIN} \le T_A \le T_{AMAX}$				±12	±13					V
Large Signal Voltage Gain	$T_A = 25°C$, $R_L \ge 2\,k\Omega$ $V_S = \pm 20V$, $V_O = \pm 15V$ $V_S = \pm 15V$, $V_O = \pm 10V$	50			 50	 200		 20	 200		 V/mV V/mV
	$T_{AMIN} \le T_A \le T_{AMAX}$, $R_L \ge 2\,k\Omega$, $V_S = \pm 20V$, $V_O = \pm 15V$ $V_S = \pm 15V$, $V_O = \pm 10V$ $V_S = \pm 5V$, $V_O = \pm 2V$	 32 10			 25			 15			 V/mV V/mV V/mV

Electrical Characteristics (Note 3) (Continued)

Parameter	Conditions	LM741A/LM741E			LM741			LM741C			Units
		Min	Typ	Max	Min	Typ	Max	Min	Typ	Max	
Output Voltage Swing	$V_S = \pm 20V$										
	$R_L \geq 10\ k\Omega$	±16									V
	$R_L \geq 2\ k\Omega$	±15									V
	$V_S = \pm 15V$										
	$R_L \geq 10\ k\Omega$				±12	±14		±12	±14		V
	$R_L \geq 2\ k\Omega$				±10	±13		±10	±13		V
Output Short Circuit Current	$T_A = 25°C$	10	25	35		25			25		mA
	$T_{AMIN} \leq T_A \leq T_{AMAX}$	10		40							mA
Common-Mode Rejection Ratio	$T_{AMIN} \leq T_A \leq T_{AMAX}$										
	$R_S \leq 10\ k\Omega$, $V_{CM} = \pm 12V$				70	90		70	90		dB
	$R_S \leq 50\Omega$, $V_{CM} = \pm 12V$	80	95								dB
Supply Voltage Rejection Ratio	$T_{AMIN} \leq T_A \leq T_{AMAX}$, $V_S = \pm 20V$ to $V_S = \pm 5V$										
	$R_S \leq 50\Omega$	86	96								dB
	$R_S \leq 10\ k\Omega$				77	96		77	96		dB
Transient Response	$T_A = 25°C$, Unity Gain										
Rise Time			0.25	0.8		0.3			0.3		µs
Overshoot			6.0	20		5			5		%
Bandwidth (Note 4)	$T_A = 25°C$	0.437	1.5								MHz
Slew Rate	$T_A = 25°C$, Unity Gain	0.3	0.7			0.5			0.5		V/µs
Supply Current	$T_A = 25°C$					1.7	2.8		1.7	2.8	mA
Power Consumption	$T_A = 25°C$										
	$V_S = \pm 20V$		80	150							mW
	$V_S = \pm 15V$					50	85		50	85	mW
LM741A	$V_S = \pm 20V$										
	$T_A = T_{AMIN}$			165							mW
	$T_A = T_{AMAX}$			135							mW
LM741E	$V_S = \pm 20V$										
	$T_A = T_{AMIN}$			150							mW
	$T_A = T_{AMAX}$			150							mW
LM741	$V_S = \pm 15V$										
	$T_A = T_{AMIN}$					60	100				mW
	$T_A = T_{AMAX}$					45	75				mW

Note 1: For operation at elevated temperatures, these devices must be derated based on thermal resistance, and T_j max. (listed under "Absolute Maximum Ratings"). $T_j = T_A + (\theta_{jA} P_D)$.

Thermal Resistance	Cerdip (J)	DIP (N)	HO8 (H)	SO-8 (M)
θ_{jA} (Junction to Ambient)	100°C/W	100°C/W	170°C/W	195°C/W
θ_{jC} (Junction to Case)	N/A	N/A	25°C/W	N/A

Note 2: For supply voltages less than ±15V, the absolute maximum input voltage is equal to the supply voltage.

Note 3: Unless otherwise specified, these specifications apply for $V_S = \pm 15V$, $-55°C \leq T_A \leq +125°C$ (LM741/LM741A). For the LM741C/LM741E, these specifications are limited to $0°C \leq T_A \leq +70°C$.

Note 4: Calculated value from: BW (MHz) = 0.35/Rise Time(µs).

Note 5: For military specifications see RETS741X for LM741 and RETS741AX for LM741A.

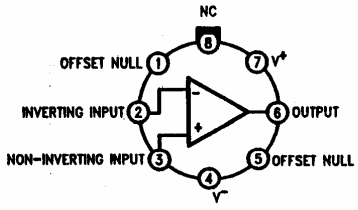
Note 6: Human body model, 1.5 kΩ in series with 100 pF.

1-447

LM741

Connection Diagrams

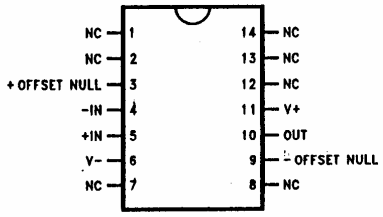
Metal Can Package



TL/H/9341-2

Order Number LM741H, LM741H/883*, LM741AH/883
LM741CH or LM741EH
See NS Package Number H08C

Ceramic Dual-In-Line Package

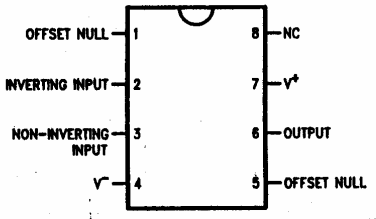


TL/H/9341-5

Order Number LM741J-14/883*, LM741AJ-14/883**
See NS Package Number J14A

*also available per JM38510/10101
**also available per JM38510/10102

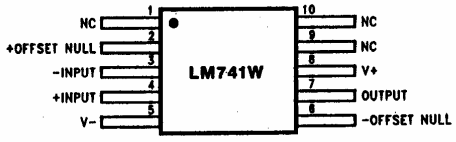
Dual-In-Line or S.O. Package



TL/H/9341-3

Order Number LM741J, LM741J/883, LM741CJ,
LM741CM, LM741CN or LM741EN
See NS Package Number J08A, M08A or N08E

Ceramic Flatpak



TL/H/9341-6

Order Number LM741W/883
See NS Package Number W10A

*LM741H is available per JM38510/10101

1-448

MAXIMUM RATINGS

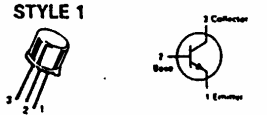
Rating	Symbol	2N2219 2N2222	2N2219A 2N2222A	Unit
Collector-Emitter Voltage	V_{CEO}	30	40	Vdc
Collector-Base Voltage	V_{CBO}	60	75	Vdc
Emitter-Base Voltage	V_{EBO}	5.0	6.0	Vdc
Collector Current — Continuous	I_C	800	800	mAdc
		2N2218A 2N2219,A	2N2222,A	
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	0.8 4.57	0.4 2.28	Watt mW/°C
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	3.0 17.1	1.2 6.85	Watts mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−65 to +200		°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	2N2218A 2N2219,A	2N2222,A	Unit
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$	219	145.8	°C/W
Thermal Resistance, Junction to Case	$R_{\theta JC}$	58	437.5	°C/W

2N2218A,2N2219,A★
2N2222,A★

2N2218, A/2N2219,A
CASE 79-04
TO-39 (TO-205AD)
STYLE 1



A/2N2222,A
CASE 22-03
TO-18 (TO-206AA)
STYLE 1

GENERAL PURPOSE TRANSISTORS
NPN SILICON

★2N2219A and 2N2222A are Motorola designated preferred devices.

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage (I_C = 10 mAdc, I_B = 0)	Non-A Suffix A-Suffix	$V_{(BR)CEO}$	30 40	— —	Vdc
Collector-Base Breakdown Voltage (I_C = 10 μAdc, I_E = 0)	Non-A Suffix A-Suffix	$V_{(BR)CBO}$	60 75	— —	Vdc
Emitter-Base Breakdown Voltage (I_E = 10 μAdc, I_C = 0)	Non-A Suffix A-Suffix	$V_{(BR)EBO}$	5.0 6.0	— —	Vdc
Collector Cutoff Current (V_{CE} = 60 Vdc, $V_{EB(off)}$ = 3.0 Vdc)	A-Suffix	I_{CEX}	—	10	nAdc
Collector Cutoff Current (V_{CB} = 50 Vdc, I_E = 0) (V_{CB} = 60 Vdc, I_E = 0) (V_{CB} = 50 Vdc, I_E = 0, T_A = 150°C) (V_{CB} = 60 Vdc, I_E = 0, T_A = 150°C)	 Non-A Suffix A-Suffix Non-A Suffix A-Suffix	I_{CBO}	 — — — —	 0.01 0.01 10 10	μAdc
Emitter Cutoff Current (V_{EB} = 3.0 Vdc, I_C = 0)	A-Suffix	I_{EBO}	—	10	nAdc
Base Cutoff Current (V_{CE} = 60 Vdc, $V_{EB(off)}$ = 3.0 Vdc)	A-Suffix	I_{BL}	—	20	nAdc
ON CHARACTERISTICS					
DC Current Gain (I_C = 0.1 mAdc, V_{CE} = 10 Vdc) (I_C = 1.0 mAdc, V_{CE} = 10 Vdc) (I_C = 10 mAdc, V_{CE} = 10 Vdc)(1) (I_C = 10 mAdc, V_{CE} = 10 Vdc, T_A = −55°C)(1) (I_C = 150 mAdc, V_{CE} = 10 Vdc)(1)	 2N2218A 2N2219,A, 2N2222,A 2N2218A 2N2219,A, 2N2222,A 2N2218A 2N2219,A, 2N2222,A 2N2218A 2N2219,A, 2N2222,A 2N2218A 2N2219,A, 2N2222,A	h_{FE}	 20 35 25 50 35 75 15 35 40 100	 — — — — — — — — 120 300	—

Revised: Spring 1993

2N2218A/19/19A/22/22A

ELECTRICAL CHARACTERISTICS (continued) (T_A = 25°C unless otherwise noted.)

Characteristic		Symbol	Min	Max	Unit
(I_C = 150 mAdc, V_{CE} = 1.0 Vdc)(1)	2N2218A		20	—	
	2N2219,A, 2N2222,A		50	—	
(I_C = 500 mAdc, V_{CE} = 10 Vdc)(1)	2N2219, 2N2222		30	—	
	2N2218A		25	—	
	2N2219A, 2N2222A		40	—	
Collector-Emitter Saturation Voltage(1)		$V_{CE(sat)}$			Vdc
(I_C = 150 mAdc, I_B = 15 mAdc)	Non-A Suffix		—	0.4	
	A-Suffix		—	0.3	
(I_C = 500 mAdc, I_B = 50 mAdc)	Non-A Suffix		—	1.6	
	A-Suffix		—	1.0	
Base-Emitter Saturation Voltage(1)		$V_{BE(sat)}$			Vdc
(I_C = 150 mAdc, I_B = 15 mAdc)	Non-A Suffix		0.6	1.3	
	A-Suffix		0.6	1.2	
(I_C = 500 mAdc, I_B = 50 mAdc)	Non-A Suffix		—	2.6	
	A-Suffix		—	2.0	
SMALL-SIGNAL CHARACTERISTICS					
Current Gain — Bandwidth Product(2)		f_T			MHz
(I_C = 20 mAdc, V_{CE} = 20 Vdc, f = 100 MHz)	All Types, Except		250	—	
	2N2219A, 2N2222A		300	—	
Output Capacitance(3)		C_{obo}	—	8.0	pF
(V_{CB} = 10 Vdc, I_E = 0, f = 1.0 MHz)					
Input Capacitance(3)		C_{ibo}			pF
(V_{EB} = 0.5 Vdc, I_C = 0, f = 1.0 MHz)	Non-A Suffix		—	30	
	A-Suffix		—	25	
Input Impedance		h_{ie}			kohms
(I_C = 1.0 mAdc, V_{CE} = 10 Vdc, f = 1.0 kHz)	2N2218A		1.0	3.5	
	2N2219A, 2N2222A		2.0	8.0	
(I_C = 10 mAdc, V_{CE} = 10 Vdc, f = 1.0 kHz)	2N2218A		0.2	1.0	
	2N2219A, 2N2222A		0.25	1.25	
Voltage Feedback Ratio		h_{re}			X 10^{-4}
(I_C = 1.0 mAdc, V_{CE} = 10 Vdc, f = 1.0 kHz)	2N2218A		—	5.0	
	2N2219A, 2N2222A		—	8.0	
(I_C = 10 mAdc, V_{CE} = 10 Vdc, f = 1.0 kHz)	2N2218A		—	2.5	
	2N2219A, 2N2222A		—	4.0	
Small-Signal Current Gain		h_{fe}			—
(I_C = 1.0 mAdc, V_{CE} = 10 Vdc, f = 1.0 kHz)	2N2218A		30	150	
	2N2219A, 2N2222A		50	300	
(I_C = 10 mAdc, V_{CE} = 10 Vdc, f = 1.0 kHz)	2N2218A		50	300	
	2N2219A, 2N2222A		75	375	
Output Admittance		h_{oe}			μmhos
(I_C = 1.0 mAdc, V_{CE} = 10 Vdc, f = 1.0 kHz)	2N2218A		3.0	15	
	2N2219A, 2N2222A		5.0	35	
(I_C = 10 mAdc, V_{CE} = 10 Vdc, f = 1.0 kHz)	2N2218A		10	100	
	2N2219A, 2N2222A		15	200	
Collector Base Time Constant		$r_b'C_c$	—	150	ps
(I_E = 20 mAdc, V_{CB} = 20Vdc, f = 31.8 MHz)	A-Suffix				
Noise Figure		NF	—	4.0	dB
(I_C = 100 μAdc, V_{CE} = 10 Vdc, R_S = 1.0 kohm, f = 1.0 kHz)	2N2222A				
Real Part of Common-Emitter High Frequency Input Impedance		$Re(h_{ie})$	—	60	Ohms
(I_C = 20 mAdc, V_{CE} = 20 Vdc, f = 300 MHz)	2N2218A, 2N2219A 2N2222A				

(1) Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%.
(2) f_T is defined as the frequency at which $|h_{fe}|$ extrapolates to unity.
(3) 2N5581 and 2N5582 are Listed C_{cb} and C_{eb} for these conditions and values.

2N2218A/19/19A/22/22A

ELECTRICAL CHARACTERISTICS (continued) (T_A = 25°C unless otherwise noted.)

Characteristic		Symbol	Min	Max	Unit
SWITCHING CHARACTERISTICS					
Delay Time	(V_{CC} = 30 Vdc, $V_{BE(off)}$ = −0.5 Vdc,	t_d	—	10	ns
Rise Time	I_C = 150 mAdc, I_{B1} = 15 mAdc) (Figure 12)	t_r	—	25	ns
Storage Time	(V_{CC} = 30 Vdc, I_C = 150 mAdc,	t_s	—	225	ns
Fall Time	I_{B1} = I_{B2} = 15 mAdc) (Figure 13)	t_f	—	60	ns
Active Region Time Constant (I_C = 150 mAdc, V_{CE} = 30 Vdc) (See Figure 11 for 2N2218A, 2N2219A, 2N2221A, 2N2222A)		T_A	—	2.5	ns

FIGURE 1 – NORMALIZED DC CURRENT GAIN

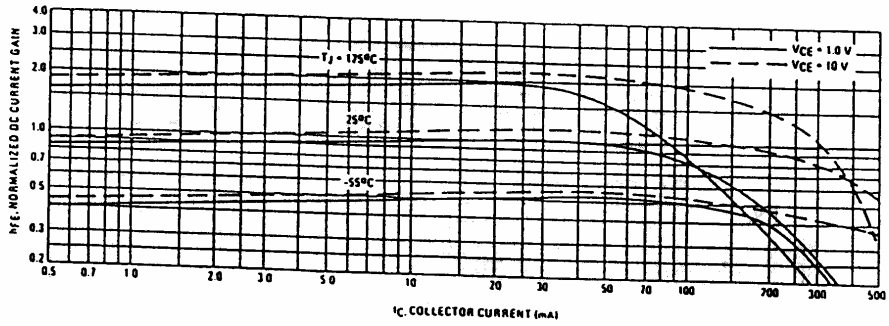
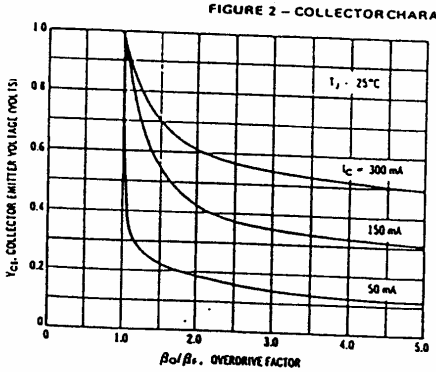


FIGURE 2 – COLLECTOR CHARACTERISTICS IN SATURATION REGION



This graph shows the effect of base current on collector current (β_o (current gain at the edge of saturation) is the current gain of the transistor at 1 volt, and β_s (forced gain) is the ratio of I_c/I_{B_s} in a circuit

EXAMPLE: For type 2N2219, estimate a base current (I_{B_s}) to insure saturation at a temperature of 25°C and a collector current of 150 mA.

Observe that at I_c = 150 mA an overdrive factor of at least 2.5 is required to drive the transistor well into the saturation region. From Figure 1, it is seen that h_{FE} @ 1 volt is approximately 0.62 of h_{FE} @ 10 volts. Using the guaranteed minimum gain of 100 @ 150 mA and 10 V, β_o = 62 and substituting values in the overdrive equation, we find:

$$\frac{\beta_o}{\beta_s} = \frac{h_{FE} @ 1.0\,V}{I_c/I_{B_s}} \qquad 2.5 \simeq \frac{62}{150/I_{B_s}} \qquad I_{B_s} \simeq 6.0 \text{ mA}$$

EE 3274 LAB **Specification Sheet: 2N2222 BJT** - 46 -

2N2218A/19/19A/22/22A

FIGURE 3 – "ON" VOLTAGES

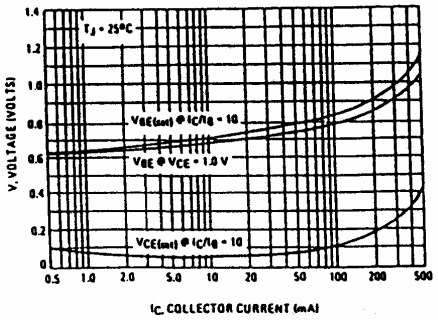
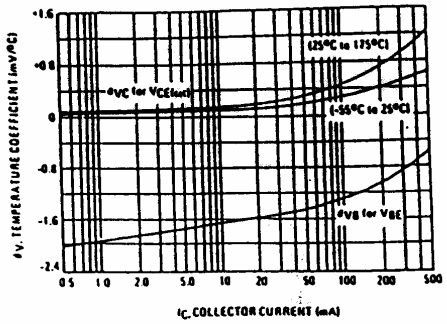


FIGURE 4 – TEMPERATURE COEFFICIENTS



h PARAMETERS

V_{CE} = 10 Vdc, f = 1.0 kHz, T_A = 25°C

This group of graphs illustrates the relationship between h_{fe} and other "h" parameters for this series of transistors. To obtain these curves, a high-gain and a low-gain unit were selected and the same units were used to develop the correspondingly numbered curves on each graph.

FIGURE 5 — INPUT IMPEDANCE

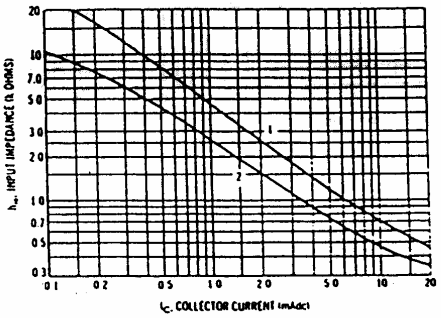


FIGURE 6 — VOLTAGE FEEDBACK RATIO

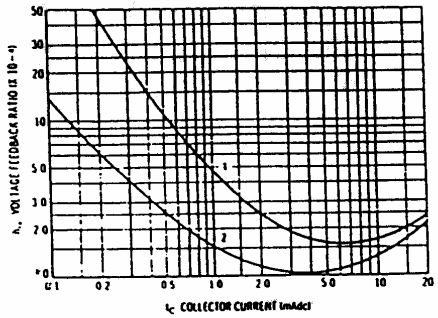


FIGURE 7 — CURRENT GAIN

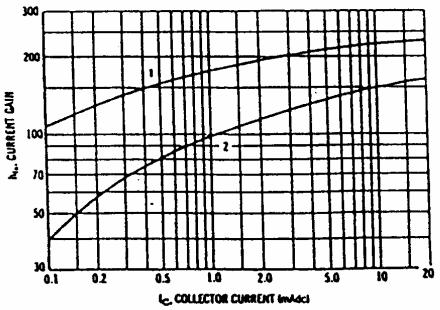
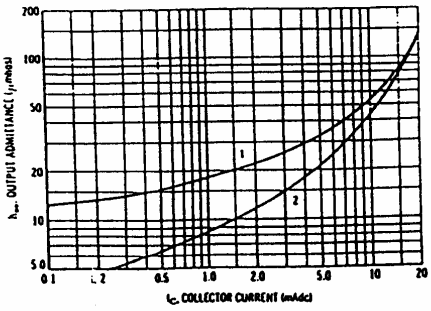


FIGURE 8 — OUTPUT ADMITTANCE



MOTOROLA SMALL-SIGNAL TRANSISTORS, FETs AND DIODES

Revised: Spring 1993

2N2218A/19/19A/22/22A

SWITCHING TIME CHARACTERISTICS

FIGURE 9 — TURN-ON TIME

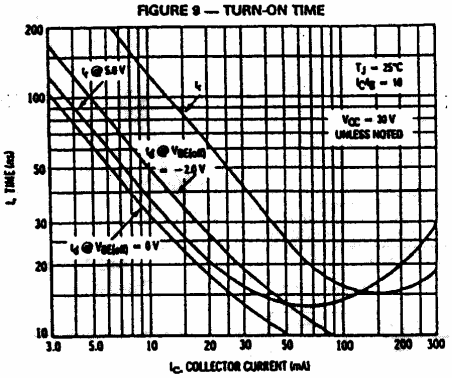


FIGURE 10 — CHARGE DATA

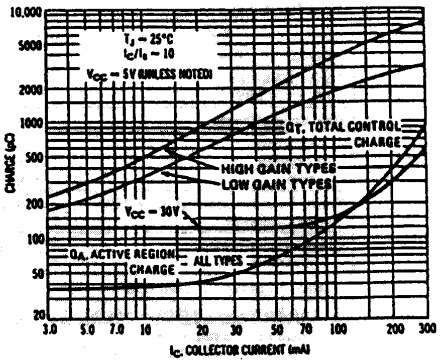


FIGURE 11 — TURN-OFF BEHAVIOR

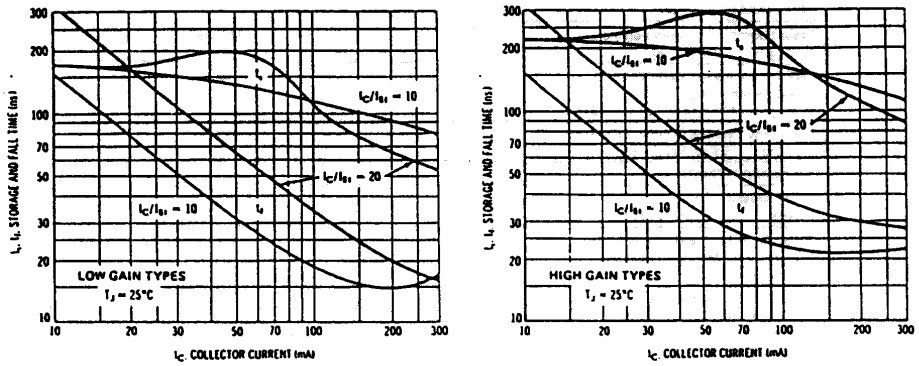


FIGURE 12 — DELAY AND RISE TIME EQUIVALENT TEST CIRCUIT

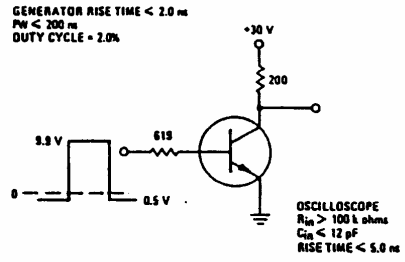
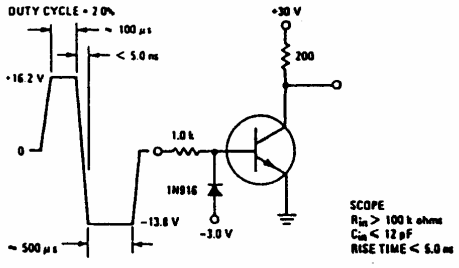
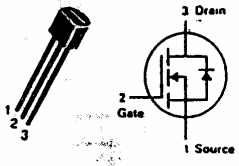


FIGURE 13 — STORAGE TIME AND FALL TIME EQUIVALENT TEST CIRCUIT



2N7000★

CASE 29-04, STYLE 22
TO-92 (TO-226AA)



TMOS FET TRANSISTOR

N-CHANNEL — ENHANCEMENT

★This is a Motorola designated preferred device.

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Drain-Source Voltage	V_{DSS}	60	Vdc
Drain-Gate Voltage (R_{GS} = 1 MΩ)	V_{DGR}	60	Vdc
Gate-Source Voltage	V_{GS}	±40	Vdc
Drain Current Continuous Pulsed	I_D I_{DM}	200 500	mAdc
Total Power Dissipation @ T_C = 25°C Derate above 25°C	P_D	350 2.8	mW mW/°C
Operating and Storage Temperature Range	T_J, T_{stg}	−55 to +150	°C

THERMAL CHARACTERISTICS

Thermal Resistance Junction to Ambient	$R_{\theta JA}$	312.5	°C/W
Maximum Lead Temperature for Soldering Purposes, 1/16" from case for 10 seconds	T_L	300	°C

ELECTRICAL CHARACTERISTICS (T_C = 25°C unless otherwise noted.)

Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Drain-Source Breakdown Voltage (V_{GS} = 0, I_D = 10 μA)		$V_{(BR)DSS}$	60	—	Vdc
Zero Gate Voltage Drain Current (V_{DS} = 48 V, V_{GS} = 0) (V_{DS} = 48 V, V_{GS} = 0, T_J = 125°C)		I_{DSS}	— —	1.0 1.0	μAdc mA
Gate-Body Leakage Current, Forward (V_{GSF} = 15 Vdc, V_{DS} = 0)		I_{GSSF}	—	- 10	nAdc
ON CHARACTERISTICS*					
Gate Threshold Voltage (V_{DS} = V_{GS}, I_D = 1.0 mA)		$V_{GS(th)}$	0.8	3.0	Vdc
Static Drain-Source On-Resistance (V_{GS} = 10 Vdc, I_D = 0.5 Adc) (V_{GS} = 4.5 V, I_D = 75 mA)		$r_{DS(on)}$	— —	5.0 6.0	Ohm
Drain-Source On-Voltage (V_{GS} = 10 V, I_D = 0.5 Adc) (V_{GS} = 4.5 V, I_D = 75 mA)		$V_{DS(on)}$	— —	2.5 0.45	Vdc
On-State Drain Current (V_{GS} = 4.5 V, V_{DS} = 10 V)		$I_{d(on)}$	75	—	mA
Forward Transconductance (V_{DS} = 10 V, I_D = 200 mA)		g_{fs}	100	—	μmhos
DYNAMIC CHARACTERISTICS					
Input Capacitance	(V_{DS} = 25 V, V_{GS} = 0 f = 1.0 MHz)	C_{iss}	—	60	pF
Output Capacitance		C_{oss}	—	25	
Reverse Transfer Capacitance		C_{rss}	—	5.0	
SWITCHING CHARACTERISTICS*					
Turn-On Delay Time	(V_{DD} = 15 V, I_D = 500 mA R_{gen} = 25 ohms, R_L = 25 ohms)	t_{on}	—	10	ns
Turn-Off Delay Time		t_{off}	—	10	

(1) Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%.

2N7000

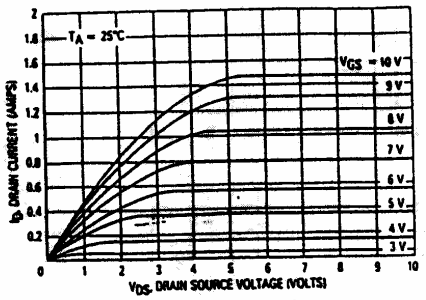


Figure 1. Ohmic Region

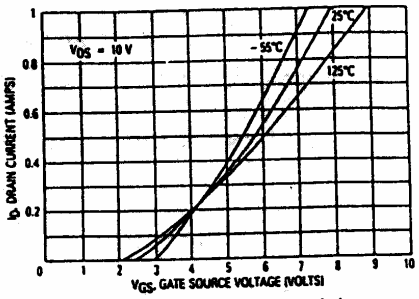


Figure 2. Transfer Characteristics

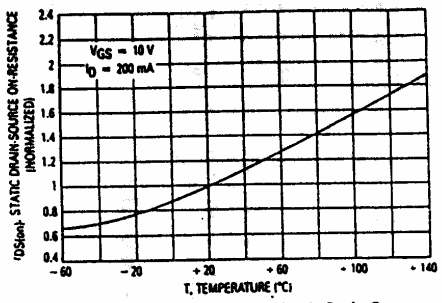


Figure 3. Temperature versus Static Drain-Source On-Resistance

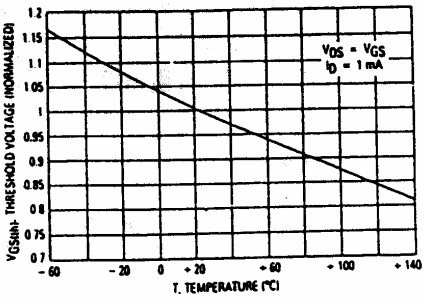


Figure 4. Temperature versus Gate Threshold Voltage

National Semiconductor

N-Channel JFETs

RF, VHF, UHF Amplifiers

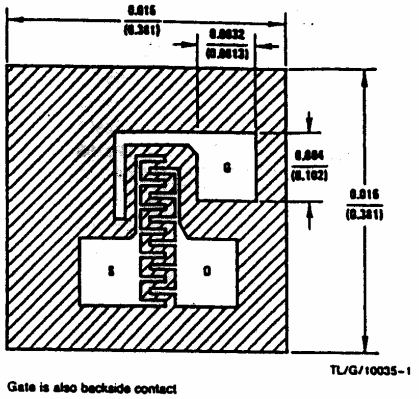
Type No.	Case Style	BVGSS (V) Min	@ IG (µA)	IGSS (nA) Max	@ VDG (V)	VP (V) Min	VP Max	@ VDS (V)	ID (nA)	IDSS (mA) Min	IDSS Max	@ VDS (V)	Re|Yfs| (mmho) Min	@ Freq. (MHz)	Re(Yos) (µmho) Max	@ f (MHz)	Ciss (pF) Max	@ VDS (V)	VGS (V)	Crss (pF) Max	@ VDS (V)	VGS (V)	NF (dB) @ RG = 1k Max	Freq. (MHz)	Process No.	Pkg. No.
2N3819	TO-92	25	1	2	15		8	15	2	2	20	15	1.6	100			8	15	0	4	15	0			50	94
2N3823	TO-72	30	1	0.5	20		8	15	0.5	4	20	15	3.2	200	200	200	6	15	0	2	15	0	2.5	100	50	25
2N4223	TO-72	30	10	0.25	20	0.1	8	15	0.25	3	18	15	2.7	200	200	200	6	15	0	2	15	0	5	200	50	25
2N4224	TO-72	30	10	0.5	20	0.1	8	15	0.5	2	20	15	1.7	200	200	200	6	15	0	2	15	0			50	25
2N4416	TO-72	30	1	0.1	20		6	15	1	5	15	15	4	400	100	400	4	15	0	0.8	15	0	4	400	50	25
2N4416A	TO-72	35	1	0.1	20	2.5	6	15	1	5	15	15	4	400	100	400	4	15	0	0.8	15	0	4	400	50	25
2N5078	TO-72	30	1	0.25	20	0.5	8	15		4	25	15	4	200	150	200	6	15	0	2	15	0	3	200	50	25
2N5245	TO-92	30	1	1	20	1	6	15	10	5	15	15	4	400	100	400	4.5	15	0	1	15	0	4	400	90	97
2N5246	TO-92	30	1	1	20	0.5	4	15	10	1.5	7	15	2.5	400	100	400	4.5	15	0	1	15	0			90	97
2N5247	TO-92	30	1	1	20	1.5	8	15	10	8	24	15	4	400	150	400	4.5	15	0	1	15	0			90	97
2N5248	TO-92	30	1	5	20	1	8	15	10	4	20	15	3	200	200	200	6	15	0	2	15	0			50	94
2N5397	TO-72	25	1	0.1	15	1	6	10	1	10	30	10	5.5	450	200	450	5	10	10 mA	1.2	10	10 mA	3.5	450	90	29
2N5398	TO-72	25	1	0.1	15	1	6	10	1	5	40	10	5.0	450	400	450	5.5	10	0	1.3	10	0	3.2	450	90	29
2N5484	TO-92	25	1	1	20	0.3	3	15	10	1	5	15	2.5	100	75	100	5	15	0	1	15	0	3	100	50	92
2N5485	TO-92	25	1	1	20	1	4	15	10	4	10	15	3	400	100	400	5	15	0	1	15	0	4	400	50	92
2N5486	TO-92	25	1	1	20	2	6	15	10	8	20	15	3.5	400	100	400	5	15	0	1	15	0	4	400	50	92
2N5468	TO-92	25	10	2	15	0.2	4	14	10	1	5	15	1	100	50	100	7	15	0	3	15	0	2.5	100	50	92
2N5469	TO-92	25	10	2	15	1	6	15	10	4	10	15	1.6	100	100	100	7	15	0	3	15	0	2.5	100	50	92
2N5470	TO-92	25	10	2	15	2	8	15	10	8	20	15	2.5	100	150	100	7	15	0	3	15	0	2.5	100	50	92
2N5949	TO-92	30	1	1	15	3	7	15	100	12	18	15	3.0	100	75	100	6	15	0	2	15	0	5	100	50	97
2N5950	TO-92	30	1	1	15	2.5	6	15	100	10	15	15	3.0	100	75	100	6	15	0	2	15	0	5	100	50	97
2N5951	TO-92	30	1	1	15	2	5	15	100	7	13	15	3.0	100	75	100	6	15	0	2	15	0	5	100	50	97
2N5952	TO-92	30	1	1	15	1.3	3.5	15	100	4	8	15	1.0	100	75	100	6	15	0	2	15	0	5	100	50	97
2N5953	TO-92	30	1	1	15	0.8	3	15	100	2.5	5	15	1.0	100	50	100	6	15	0	2	15	0	5	100	50	97
J300	TO-92	25	1	0.5	15	1	6	10	1	6	30	10	4.5	0.001	200	0.001	5.5	10	5 mA	1.7	10	5 mA			90	92
J304	TO-92	30	1	0.1	20	2	6	15	1	5	15	15	†14.2	400	†180	100									50	92
J305	TO-92	30	1	0.1	20	0.5	3	15	1	1	8	15	†13.0	400	†180	100									50	92
J308	TO-92	25	1	1	15	1	6.5	10	1	12	60	10	8	0.001	200	0.001	7.5	0	−10	2.5	0	−10			92	92
J309	TO-92	25	1	1	15	1	4.0	10	1	12	30	10	10	0.001	200	0.001	7.5	0	−10	2.5	0	−10			92	92
J310	TO-92	25	1	1	15	2	6.5	10	1	24	60	10	8	0.001	200	0.001	7.5	0	−10	2.5	0	−10			92	92

† = typical value

Process 50

National Semiconductor

Process 50
N-Channel JFET



TL/G/10035–1

Gate is also backside contact

DESCRIPTION

Process 50 is designed primarily for RF amplifier and mixer applications. It will operate up to 450 MHz with low noise figure and good power gain. These devices offer outstanding performance at VHF aircraft and communications frequencies. Their major advantage is low crossmodulation and intermodulation, low noise figure and good power gain. The device is also a good choice for analog switching where low capacitance is very important.

Electrical Characteristics (T_A = 25°C)

Symbol	Parameter	Conditions	Min	Typ	Max	Units
BV_{GSS}	Gate-Source Breakdown Voltage	V_{DS} = 0V, I_G = −1 μA	−25	−40		V
I_{DSS}	Zero Gate Voltage Drain Current	V_{DS} = 15V, V_{GS} = 0V	1.0	10	20	mA
g_{fs}	Forward Transconductance	V_{DS} = 15V, V_{GS} = 0V	3.0	5.5	7.0	mmhos
g_{fs}	Forward Transconductance	V_{DG} = 15V, I_D = 200 μA		1.1		mmhos
I_{GSS}	Reverse Gate Leakage	V_{GS} = −20V, V_{DS} = 0V		−5.0	−100	pA
$r_{DS(ON)}$	ON Resistance	V_{DS} = 100 mV, V_{GS} = 0V	100	175	500	Ω
$V_{GS(OFF)}$	Pinch Off Voltage	V_{DS} = 15V, I_D = 1 nA	−0.7	−3.5	−6.0	V
g_{os}	Output Conductance	V_{DG} = 15V, I_D = 1 mA, f = 1 kHz		10		μmhos
C_{rss}	Feedback Capacitance	V_{DG} = 15V, V_{GS} = 0V		0.7	0.9	pF
C_{iss}	Input Capacitance	V_{DS} = 15V, V_{GS} = 0V		3.5	4.0	pF
e_n	Noise Voltage	V_{DG} = 15V, I_D = 1 mA, f = 100 Hz		8.0		$nV/\sqrt{Hz}$
NF	Noise Figure	V_{DG} = 15V, I_D = 5 mA, R_G = 1 kΩ, f = 400 MHz		2.2	4.0	dB
G_{PS}	Power Gain	V_{DG} = 15V, I_D = 5 mA, f = 400 MHz		12		dB

Revised: Spring 1993

EE 3274 LAB **Specification Sheet: 2N5951 JFET** - 52 -

Process 50

Process 50

This process is available in the following device types. *Denotes preferred parts.

TO-72 (NS Package 29)	TO-92 (NS Package 92)	TO-92 (NS Package 94)	TO-92 (NS Package 97)
2N3823	*2N5484	→ 2N3819	2N5949
2N3966	*2N5485	2N5248	2N5950
2N4223	*2N5486	BF244A	→ 2N5951
2N4224	2N5555	BF244B	2N5952
*2N4416	2N5668	BF244C	2N5953
*2N4416A	2N5669	TIS58	BF245A
2N5078	2N5670	TIS59	BF245B
2N5103	*J304		BF245C
2N5104	*J305		BF256A
2N5105	PN4223		BF256B
2N5556	PN4224		BF256C
2N5557	*PN4416		
2N5558	PN5163		
	MPF102		
	MPF106		
	MPF107		
	MPF110		
	MPF111		

TO-236/SOT23 (NS Package 48/49)

MMBFJ304
MMBFJ305
MMBF4416
MMBF5484
MMBF5485
MMBF5486

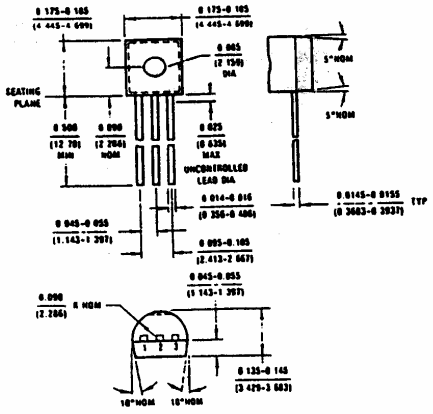
TO-92 (92, 94, 96, 97, 98)

Pin	(92) STD	
	T	FET
1	C	G
2	B	S
3	E	D

Pin	(94)	
	T	FET
1	B	S
2	C	G
3	E	D

Pin	(96)	
	T	FET
1	C	G
2	E	D
3	B	S

Pin	(97)*		(98)*
	T	FET	T
1	E	D	B
2	B	S	E
3	C	G	C



TL/G/10236–14

*Leadformed to TO-18 configuration prior to bulk shipment. For in-line leads, order option L342.
Drain-Source interchangeable on most JFET Devices.

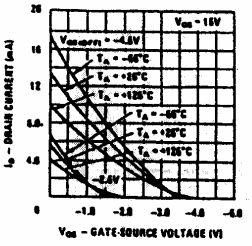
11-152

Revised: Spring 1993

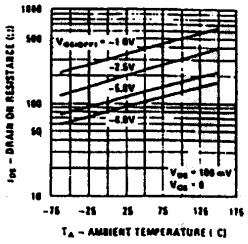
Process 50

Process 50

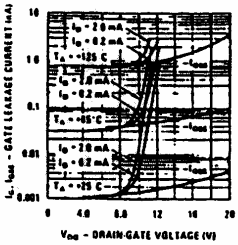
Transfer Characteristics



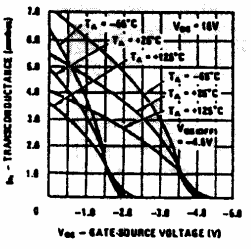
Channel Resistance vs Temperature



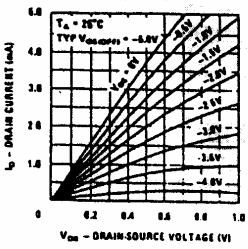
Leakage Current vs Voltage



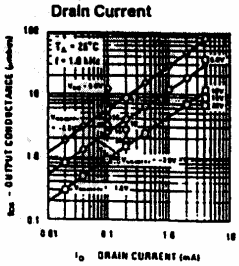
Transconductance Characteristics



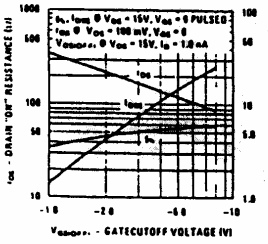
Common Drain-Source Characteristics



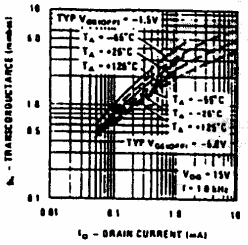
Output Conductance vs Drain Current



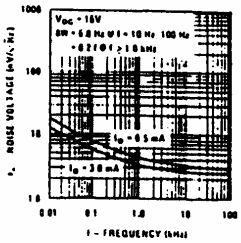
Parameter Interactions



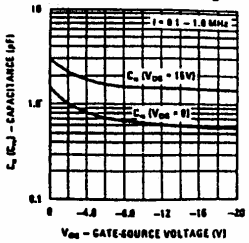
Transconductance vs Drain Current



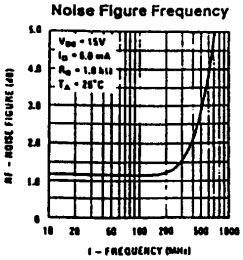
Noise Voltage vs Frequency



Capacitance vs Voltage



Noise Figure Frequency



TL/G/10035-2

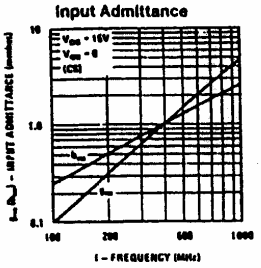
Revised: Spring 1993

Process 50

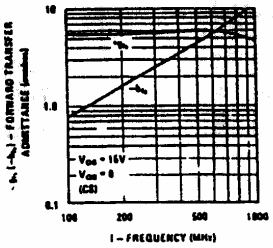
Process 50

COMMON SOURCE

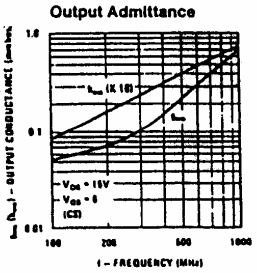
Input Admittance



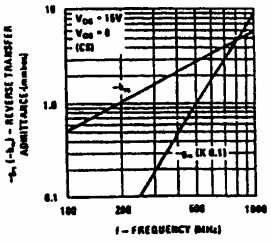
Forward Transadmittance



Output Admittance

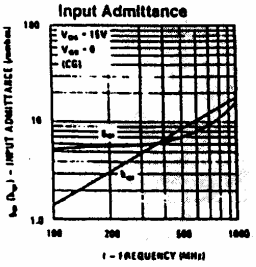


Reverse Transadmittance

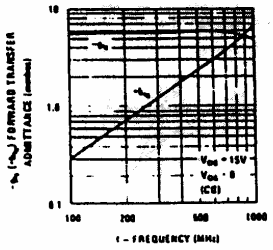


COMMON GATE

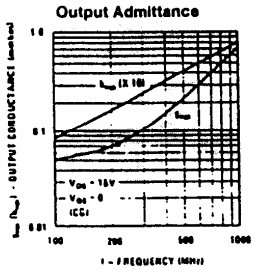
Input Admittance



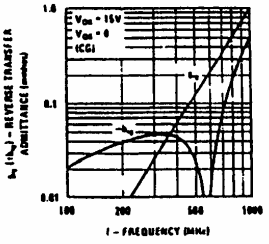
Forward Transadmittance



Output Admittance



Reverse Transadmittance



TL/G/10035-3

Revised: Spring 1993

EE 3274 LAB — Standard Lab Passive Components — - 55 -

CARBON FILM ¼ WATT RESISTORS

10 OHMS	1K OHMS	100K OHMS
12 OHMS	1.2K OHMS	120K OHMS
15 OHMS	1.5K OHMS	150K OHMS
18 OHMS	1.8K OHMS	180K OHMS
22 OHMS	2.2K OHMS	220K OHMS
27 OHMS	2.7K OHMS	270K OHMS
33 OHMS	3.3K OHMS	330K OHMS
39 OHMS	3.9K OHMS	390K OHMS
47 OHMS	4.7K OHMS	470K OHMS
56 OHMS	5.6K OHMS	560K OHMS
68 OHMS	6.8K OHMS	680K OHMS
82 OHMS	8.2K OHMS	820K OHMS
100 OHMS	10K OHMS	
120 OHMS	12K OHMS	1 MEG. OHMS
150 OHMS	15K OHMS	
180 OHMS	18K OHMS	
220 OHMS	22K OHMS	
270 OHMS	27K OHMS	
330 OHMS	33K OHMS	
390 OHMS	39K OHMS	
470 OHMS	47K OHMS	
560 OHMS	56K OHMS	
680 OHMS	68K OHMS	
820 OHMS	82K OHMS	

Revised: Spring 1993

CERAMIC DISC CAPACITORAS

10 PF	.001 uF
22 PF	.0047 uF
39 PF	.01 uF
47 PF	.022 uF
68 PF	.047 uF
100 PF	.1 uF
220 PF	
330 PF	
470 PF	

ELECTROLYTIC CAPACITORS

1 uF

4.7 uF

10 uF

.47 uF

100 uF

220 uF

Revised: Spring 1993