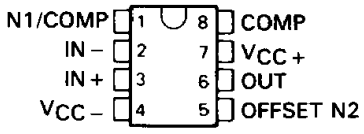
JFET-INPUT OPERATIONAL AMPLIFIERS

D2297, FEBRUARY 1977—REVISED NOVEMBER 1988

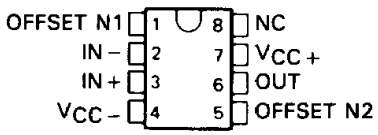
24 DEVICES COVER MILITARY, INDUSTRIAL AND COMMERCIAL TEMPERATURE RANGES

- Low-Power Consumption
- Wide Common-Mode and Differential Voltage Ranges
- Low Input Bias and Offset Currents
- Output Short-Circuit Protection
- Low Total Harmonic Distortion . . . 0.003% Typ
- High Input Impedance . . . JFET-Input Stage
- Internal Frequency Compensation (Except TL080, TL080A)
- Latch-Up-Free Operation
- High Slew Rate . . . 13 V/μs Typ
- Common-Mode Input Voltage Range Includes V_{CC+}

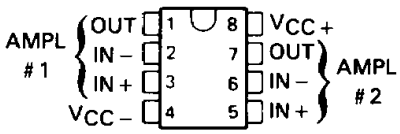
TL080, TL080A
D, JG, OR P PACKAGE
(TOP VIEW)



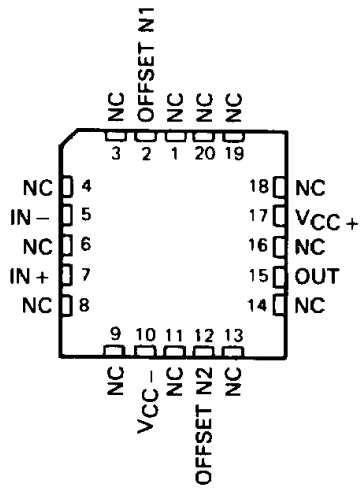
TL081, TL081A, TL081B
D, JG, OR P PACKAGE
(TOP VIEW)



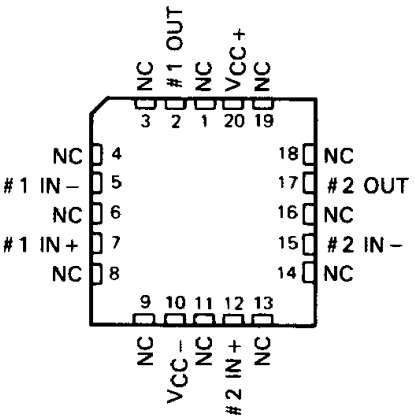
TL082, TL082A, TL082B
D, JG, OR P PACKAGE
(TOP VIEW)



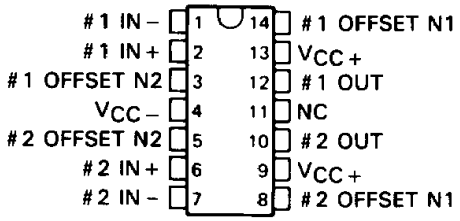
TL081M . . . FK CHIP CARRIER PACKAGE
(TOP VIEW)



TL082M . . . FK CHIP CHARRIER PACKAGE
(TOP VIEW)

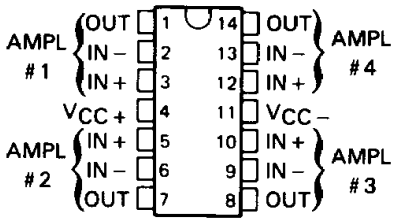


TL083, TL083A
D, J, OR N PACKAGE
(TOP VIEW)



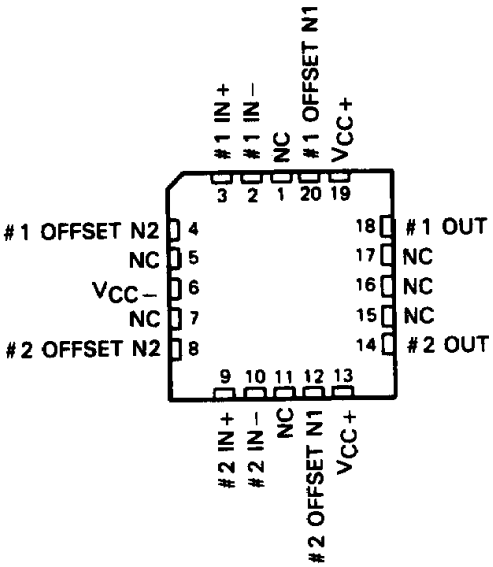
Pins 9 and 13 are internally interconnected

TL084, TL084A, TL084B
D, J, OR N PACKAGE
(TOP VIEW)

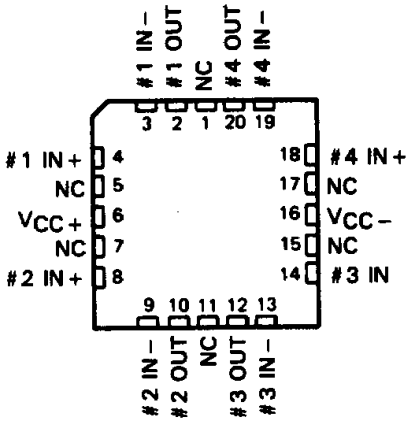


NC—No internal connection

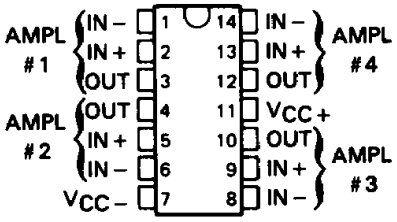
TL083M . . . FK CHIP CARRIER PACKAGE
(TOP VIEW)



TL084M . . . FK CHIP CARRIER PACKAGE
(TOP VIEW)



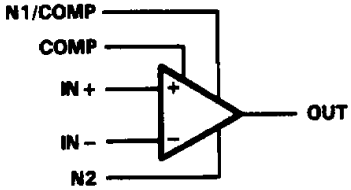
TL085
N PACKAGE
(TOP VIEW)



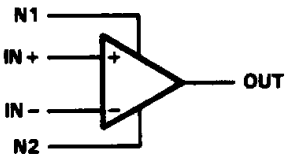
NC—No internal connection

symbols

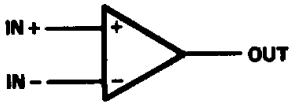
TL080



TL081
TL083 (each amplifier)



TL082 (each amplifier)
TL084 (each amplifier)
TL085 (each amplifier)



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description

The TL08_ JFET-input operational amplifier family is designed to offer a wider selection than any previously developed operational amplifier family. Each of these JFET-input operational amplifiers incorporates well-matched, high-voltage JFET and bipolar transistors in a monolithic integrated circuit. The devices feature high slew rates, low input bias and offset currents, and low offset voltage temperature coefficient. Offset adjustment and external compensation options are available within the TL08_ family.

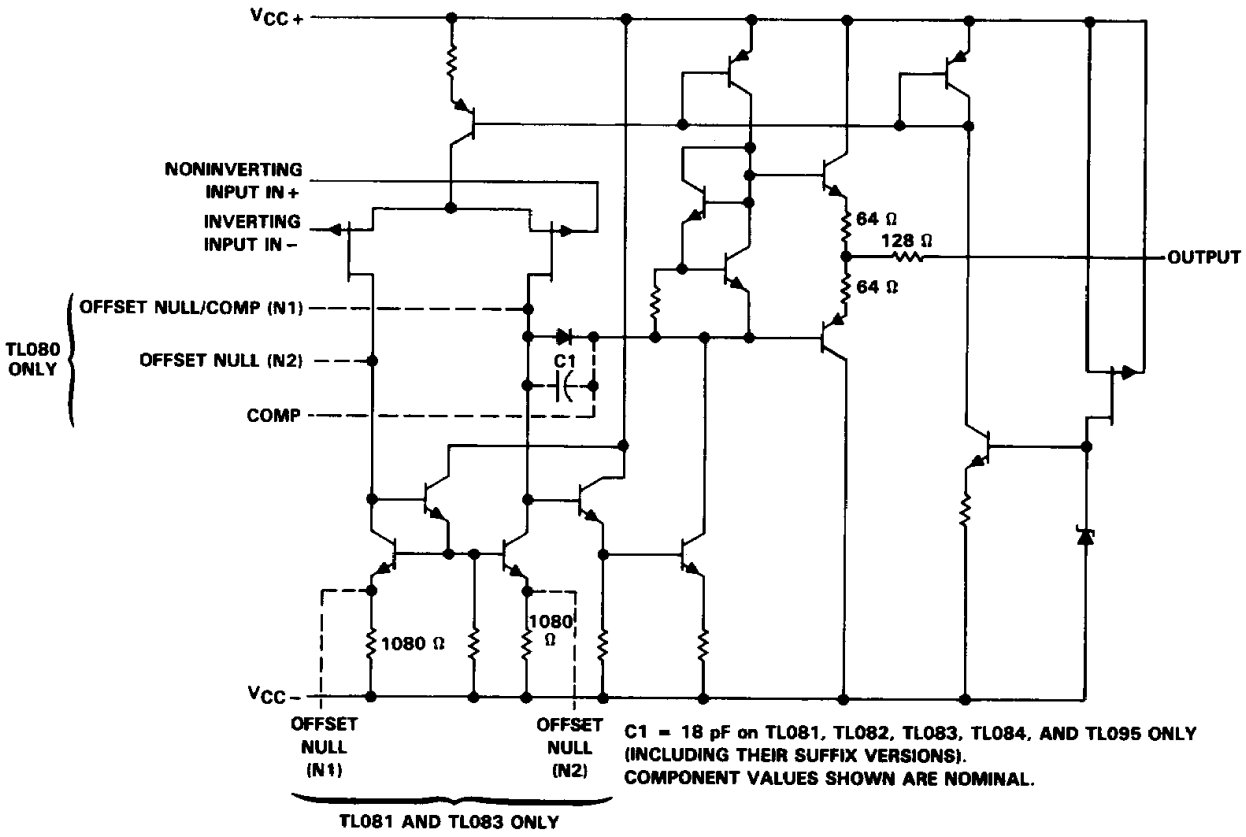
Device types with an "M" suffix are characterized for operation over the full military temperature range of −55°C to 125°C, those with an "I" suffix are characterized for operation from −40°C to 85°C, and those with a "C" suffix are characterized for operation from 0°C to 70°C.

AVAILABLE OPTIONS

T_A	V_{IO} MAX AT 25°C	PACKAGE					
		SMALL OUTLINE (D)	CHIP CARRIER (FK)	CERAMIC DIP (J)	CERAMIC DIP (JG)	PLASTIC DIP (N)	PLASTIC DIP (P)
0°C TO 70°C	15 mV	TL080CD			TL080CJG		TL080CP
	6 mV	TL080ACD			TL080ACJG		TL080ACP
	15 mV	TL081CD			TL081CJG		TL081CP
	6 mV	TL081ACD			TL081ACJG		TL081ACP
	3 mV	TL081BCD			TL081BCJG		TL081BCP
	15 mV	TL082CD			TL082CJG		TL082CP
	6 mV	TL082ACD			TL082ACJG		TL082ACP
	3 mV	TL082BCD			TL082BCJG		TL082BCP
	15 mV	TL083CD		TL083CJ		TL083CN	
	6 mV	TL083ACD		TL083ACJ		TL083ACN	
	15 mV	TL084CD		TL084CJ		TL084CN	
	6 mV	TL084ACD		TL084ACJ		TL084ACN	
	3 mV	TL084BCD		TL084BCJ		TL084BCN	
	15 mV					TL085CN	
−40°C TO 85°C	6 mV	TL080ID			TL080IJG		TL080IP
	6 mV	TL081ID			TL081IJG		TL081IP
	6 mV	TL082ID			TL082IJG		TL082IP
	6 mV	TL083ID		TL083IJ		TL083IN	
	6 mV	TL084ID		TL084IJ		TL084IN	
−55°C TO 125°C	6 mV				TL080MJG		
	6 mV		TL081MFK		TL081MJG		
	6 mV		TL082MFK		TL082MJG		
	6 mV		TL083MFK	TL083MJ			
	9 mV		TL084MFK	TL084MJ			

The D package is available taped and reeled. Add "R" suffix to device type (e.g., TL080CDR).

schematic (each amplifier)



C1 = 18 pF on TL081, TL082, TL083, TL084, AND TL095 ONLY (INCLUDING THEIR SUFFIX VERSIONS).
COMPONENT VALUES SHOWN ARE NOMINAL.

absolute maximum ratings over operating free-air temperature range (unless otherwise noted)

		TL08_M	TL08_I	TL08_C TL08_AC TL08_BC	UNIT
Supply voltage, V_{CC+} (see Note 1)		18	18	18	V
Supply voltage, V_{CC-} (see Note 1)		−18	−18	−18	V
Differential input voltage (see Note 2)		±30	±30	±30	V
Input voltage (see Notes 1 and 3)		±15	±15	±15	V
Duration of output short circuit (see Note 4)		unlimited	unlimited	unlimited	
Continuous total dissipation		See Dissipation Rating Table			
Operating free-air temperature range		−55 to 125	−40 to 85	0 to 70	°C
Storage temperature range		−65 to 150	−65 to 150	−65 to 150	°C
Case temperature for 60 seconds	FK package	260			°C
Lead temperature 1,6 mm (1/16 inch) from case for 60 seconds	J or JG package	300	300	300	°C
Lead temperature 1,6 mm (1/16 inch) from case for 10 seconds	D, N, or P package		260	260	°C

NOTES: 1. All voltage values, except differential voltages, are with respect to the midpoint between V_{CC+} and V_{CC-}.
2. Differential voltages are at the noninverting input terminal with respect to the inverting input terminal.
3. The magnitude of the input voltage must never exceed the magnitude of the supply voltage or 15 V, whichever is less.
4. The output may be shorted to ground or to either supply. Temperature and/or supply voltages must be limited to ensure that the dissipation rating is not exceeded.

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DISSIPATION RATING TABLE

PACKAGE	$T_A \le 25°C$ POWER RATING	DERATING FACTOR	DERATE ABOVE T_A	$T_A = 70°C$ POWER RATING	$T_A = 85°C$ POWER RATING	$T_A = 125°C$ POWER RATING
D (8 Pin)	680 mW	5.8 mW/°C	32°C	464 mW	377 mW	N/A
D (14 Pin)	680 mW	7.6 mW/°C	60°C	608 mW	494 mW	N/A
FK	680 mW	11.0 mW/°C	88°C	680 mW	680 mW	275 mW
J (TL08_M)	680 mW	11.0 mW/°C	88°C	680 mW	680 mW	275 mW
J (all others)	680 mW	8.2 mW/°C	67°C	656 mW	533 mW	N/A
JG (TL08_M)	680 mW	8.4 mW/°C	69°C	672 mW	546 mW	210 mW
JG (all others)	680 mW	6.6 mW/°C	47°C	528 mW	429 mW	N/A
N	680 mW	9.2 mW/°C	76°C	680 mW	598 mW	N/A
P	680 mW	8.0 mW/°C	65°C	640 mW	520 mW	N/A

electrical characteristics, $V_{CC\pm} = \pm 15$ V (unless otherwise noted)

PARAMETER		TEST CONDITIONS†		TL080M, TL081M TL082M, TL083M			TL084M			UNIT
				MIN	TYP	MAX	MIN	TYP	MAX	
V_{IO}	Input offset voltage	$V_O = 0$, $R_S = 50\ \Omega$	$T_A = 25°C$		3	6		3	9	mV
			$T_A = -55°C$ to $125°C$			9			15	
α_{VIO}	Temperature coefficient of input offset voltage	$V_O = 0$, $T_A = -55°C$ to $125°C$	$R_S = 50\ \Omega$,		18			18		μV/°C
I_{IO}	Input offset current‡	$V_O = 0$	$T_A = 25°C$		5	100		5	100	pA
			$T_A = 125°C$			20			20	nA
I_{IB}	Input bias current‡	$V_O = 0$	$T_A = 25°C$		30	200		30	200	pA
			$T_A = 125°C$			50			50	nA
V_{ICR}	Common-mode input voltage range	$T_A = 25°C$		±11	−12 to 15		±11	−12 to 15		V
V_{OM}	Maximum peak output voltage swing	$T_A = 25°C$,	$R_L = 10\ k\Omega$	±12	±13.5		±12	±13.5		V
		$T_A = -55°C$ to $125°C$	$R_L \ge 10\ k\Omega$	±12			±12			
			$R_L \ge 2\ k\Omega$	±10	±12		±10	±12		
A_{VD}	Large-signal differential voltage amplification	$V_O = \pm 10$ V, $T_A = 25°C$	$R_L \ge 2\ k\Omega$,	25	200		25	200		V/mV
		$V_O = \pm 10$ V, $T_A = -55°C$ to $125°C$	$R_L \ge 2\ k\Omega$,	15			15			
B_1	Unity-gain bandwidth	$T_A = 25°C$			3			3		MHz
r_i	Input resistance	$T_A = 25°C$			10^{12}			10^{12}		Ω
CMRR	Common-mode rejection ratio	$V_{IC} = V_{ICR}$ min, $R_S = 50\ \Omega$,	$V_O = 0$, $T_A = 25°C$	80	86		80	86		dB
k_{SVR}	Supply voltage rejection ratio ($\Delta V_{CC\pm}/\Delta V_{IO}$)	$V_{CC} = \pm 15$ V to ± 9 V, $R_S = 50\ \Omega$,	$V_O = 0$, $T_A = 25°C$	80	86		80	86		dB
I_{CC}	Supply current (per amplifier)	No load, $T_A = 25°C$	$V_O = 0$,		1.4	2.8		1.4	2.8	mA
V_{o1}/V_{o2}	Crosstalk attenuation	$A_{VD} = 100$,	$T_A = 25°C$		120			120		dB

† All characteristics are measured under open-loop conditions with zero common-mode input voltage unless otherwise specified.
‡ Input bias currents of a FET-input operational amplifier are normal junction reverse currents, which are temperature sensitive as shown in Figure 18. Pulse techniques must be used that will maintain the junction temperatures as close to the ambient temperature as is possible.

electrical characteristics, $V_{CC\pm}$ = ±15 V (unless otherwise noted)

PARAMETER		TEST CONDITIONS†		TL080I TL081I TL082I TL083I TL084I			TL080C TL081C TL082C TL083C TL084C TL085C			TL080AC TL081AC TL082AC TL083AC TL084AC			TL081BC TL082BC TL084BC			UNIT
				MIN	TYP	MAX	MIN	TYP	MAX	MIN	TYP	MAX	MIN	TYP	MAX	
V_{IO}	Input offset voltage	V_O = 0, R_S = 50 Ω	T_A = 25°C		3	6		3	15		3	6		2	3	mV
			T_A = full range			9			20			7.5			5	
α_{VIO}	Temperature coefficient of input offset voltage	V_O = 0, R_S = 50 Ω, T_A = full range			18			18			18			18		μV/°C
I_{IO}	Input offset current‡	V_O = 0	T_A = 25°C		5	100		5	200		5	100		5	100	pA
			T_A = full range			10			2			2			2	nA
I_{IB}	Input bias current‡	V_O = 0	T_A = 25°C		30	200		30	400		30	200		30	200	pA
			T_A = full range			20			10			7			7	nA
V_{ICR}	Common-mode input voltage range	T_A = 25°C		±11	−12 to 15		±11	−12 to 15		±11	−12 to 15		±11	−12 to 15		V
V_{OM}	Maximum peak output voltage swing	T_A = 25°C,	R_L = 10 kΩ	±12	±13.5		±12	±13.5		±12	±13.5		±12	±13.5		V
		T_A = full range	R_L = ≥ 10 kΩ	±12			±12			±12			±12			
			R_L ≥ 2 kΩ	±10	±12		±10	±12		±10	±12		±10	±12		
A_{VD}	Large-signal differential voltage amplification	V_O = ±10 V, R_L ≥ 2 kΩ, T_A = 25°C		50	200		25	200		50	200		50	200		V/mV
		V_O = ±10 V, R_L ≥ 2 kΩ, T_A = full range		25			15			25			25			
B_1	Unity-gain bandwidth	T_A = 25°C			3			3			3			3		MHz
r_i	Input resistance	T_A = 25°C			10^{12}			10^{12}			10^{12}			10^{12}		Ω
CMRR	Common-mode rejection ratio	V_{IC} = V_{ICR} min, V_O = 0, R_S = 50 Ω, T_A = 25°C		80	86		70	86		80	86		80	86		dB
k_{SVR}	Supply voltage rejection ratio ($\Delta V_{CC\pm}/\Delta V_{IO}$)	V_{CC} = ±15 V to ±9 V, V_O = 0, R_S = 50 Ω, T_A = 25°C		80	86		70	86		80	86		80	86		dB
I_{CC}	Supply current (per amplifier)	No load, T_A = 25°C, V_O = 0,			1.4	2.8		1.4	2.8		1.4	2.8		1.4	2.8	mA
V_{o1}/V_{o2}	Crosstalk attenuation	A_{VD} = 100, T_A = 25°C			120			120			120			120		dB

† All characteristics are measured under open-loop conditions with zero common-mode input voltage unless otherwise specified. Full range for T_A is −40°C to 85°C for TL08_I and 0°C to 70°C for TL08_C, TL08_AC, and TL08_BC.

‡ Input bias currents of a FET-input operational amplifier are normal junction reverse currents, which are temperature sensitive as shown in Figure 18. Pulse techniques must be used that will maintain the junction temperatures as close to the ambient temperature as is possible.

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operating characteristics, $V_{CC\pm}$ = ±15 V, T_A = 25°C

PARAMETER		TEST CONDITIONS		MIN	TYP	MAX	UNIT
SR	Slew rate at unity gain	V_I = 10 V, C_L = 100 pF,	R_L = 2 kΩ, See Figure 1	8	13		V/μs
t_r	Rise time	V_I = 20 mV, C_L = 100 pF,	R_L = 2 kΩ, See Figure 1		0.05		μs
	Overshoot factor				20%		
V_n	Equivalent input noise voltage	R_S = 100 Ω	f = 1 kHz		18		nV/√Hz
			f = 10 Hz to 10 kHz		4		μV
I_n	Equivalent input noise current	R_S = 100 Ω,	f = 1 kHz		0.01		pA/√Hz
THD	Total harmonic distortion	$V_{O(rms)}$ = 10 V, $R_L \geq$ 2 kΩ,	$R_S \leq$ 1 kΩ, f = 1 kHz		0.003%		

PARAMETER MEASUREMENT INFORMATION

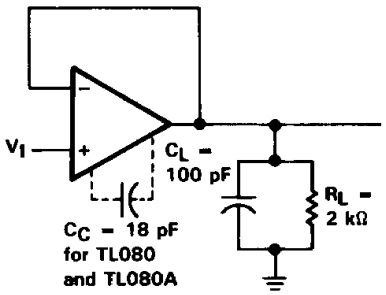

FIGURE 1. UNITY-GAIN AMPLIFIER

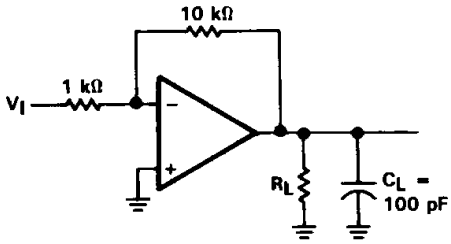

FIGURE 2. GAIN-OF-10 INVERTING AMPLIFIER

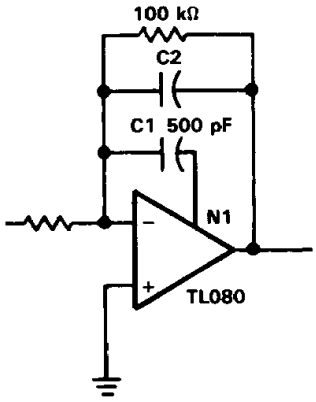

FIGURE 3. FEED-FORWARD COMPENSATION

INPUT OFFSET VOLTAGE NULL CIRCUITS

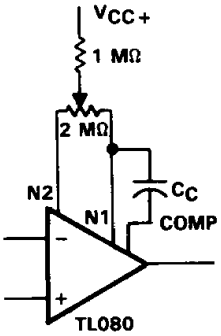

FIGURE 4

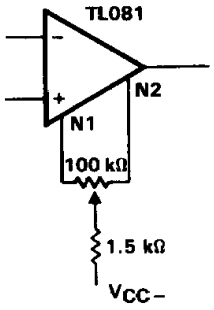

FIGURE 5

TYPICAL CHARACTERISTICS†

MAXIMUM PEAK OUTPUT VOLTAGE
vs
FREQUENCY

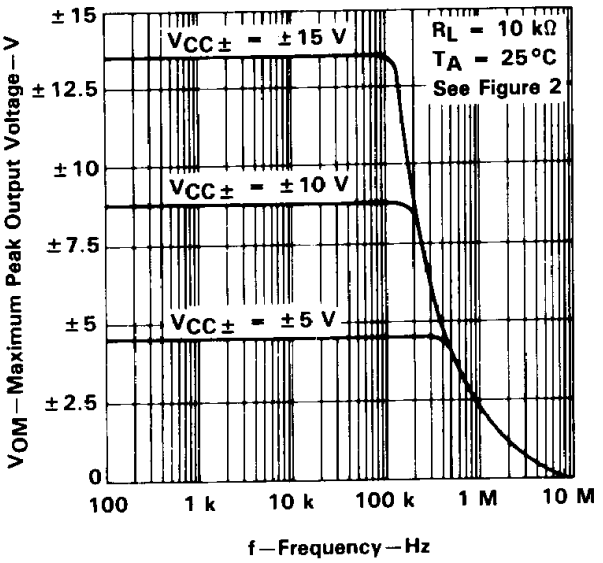

FIGURE 6

MAXIMUM PEAK OUTPUT VOLTAGE
vs
FREQUENCY

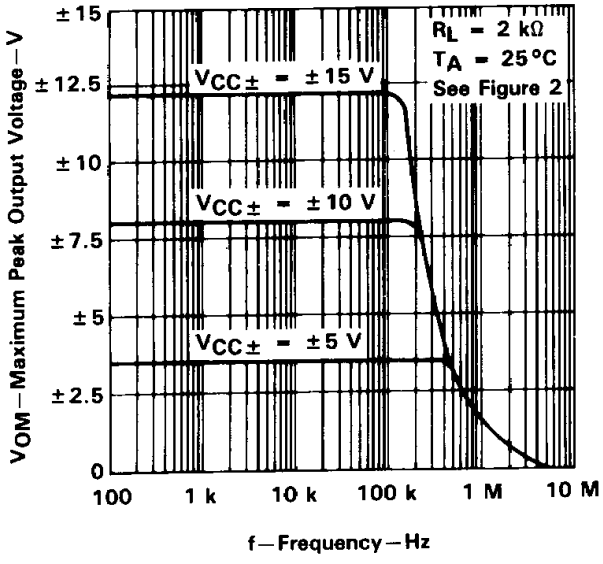

FIGURE 7

MAXIMUM PEAK OUTPUT VOLTAGE
vs
FREQUENCY

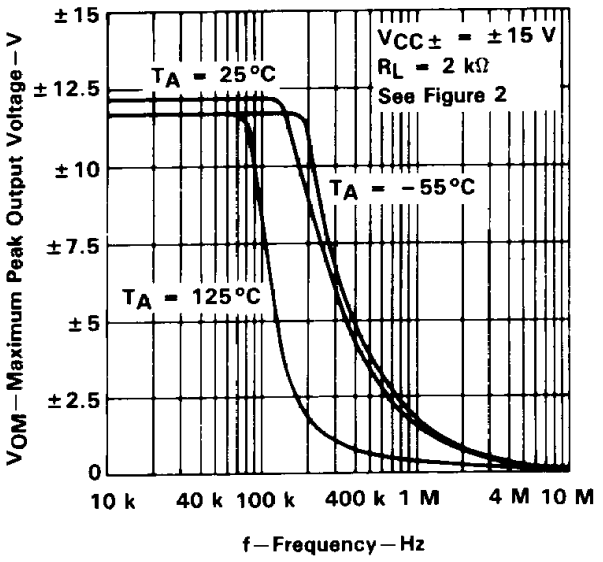

FIGURE 8

MAXIMUM PEAK OUTPUT VOLTAGE
vs
FREE-AIR TEMPERATURE

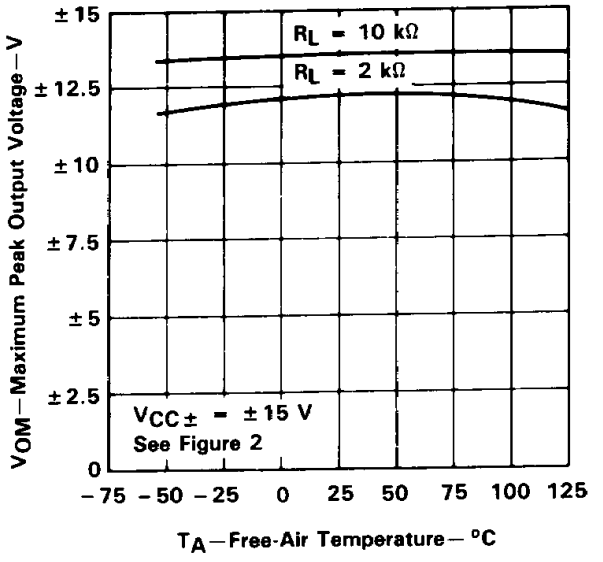

FIGURE 9

† Data at high and low temperatures are applicable only within the rated operating free-air temperature ranges of the various devices. A 12-pF compensation capacitor is used with TL080 and TL080A.

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TYPICAL CHARACTERISTICS†

MAXIMUM PEAK OUTPUT VOLTAGE
vs
LOAD RESISTANCE

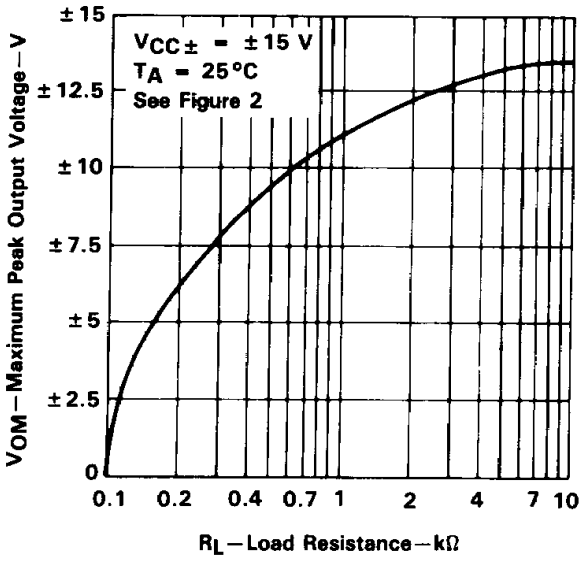

FIGURE 10

MAXIMUM PEAK OUTPUT VOLTAGE
vs
SUPPLY VOLTAGE

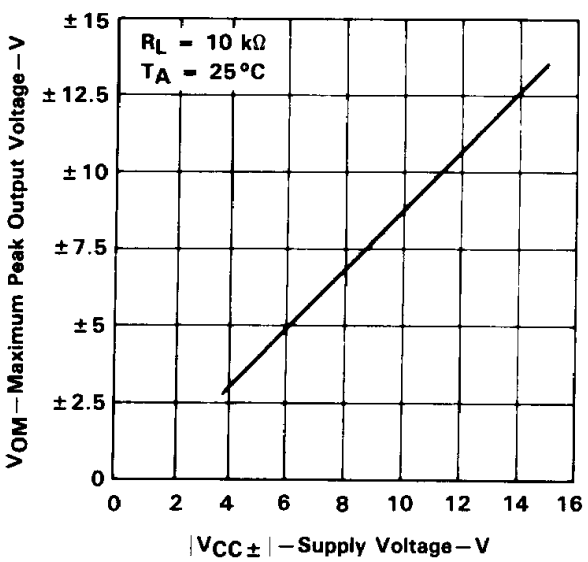

FIGURE 11

LARGE-SIGNAL
DIFFERENTIAL VOLTAGE AMPLIFICATION
vs
FREE-AIR TEMPERATURE

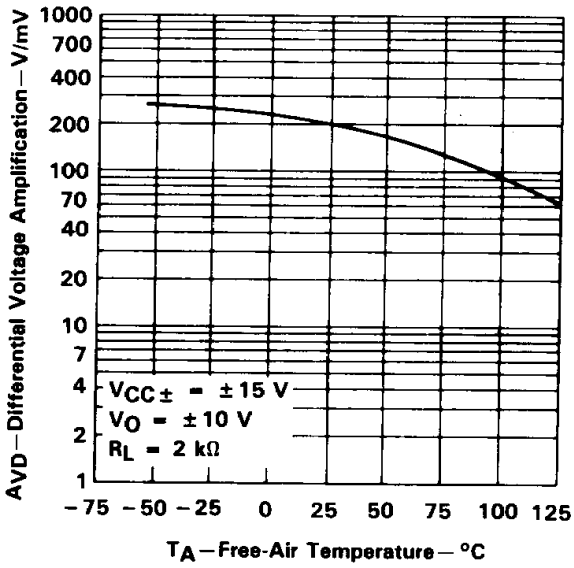

FIGURE 12

LARGE-SIGNAL
DIFFERENTIAL VOLTAGE AMPLIFICATION
and PHASE SHIFT
vs
FREQUENCY

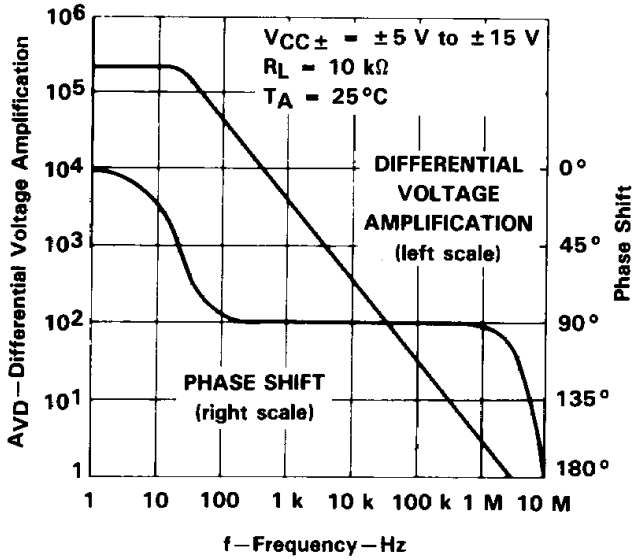

FIGURE 13

† Data at high and low temperatures are applicable only within the rated operating free-air temperature ranges of the various devices. A 12-pF compensation capacitor is used with TL080 and TL080A.

TYPICAL CHARACTERISTICS†

TL080, TL080A
DIFFERENTIAL VOLTAGE AMPLIFICATION
vs
FREQUENCY WITH FEED-FORWARD COMPENSATION

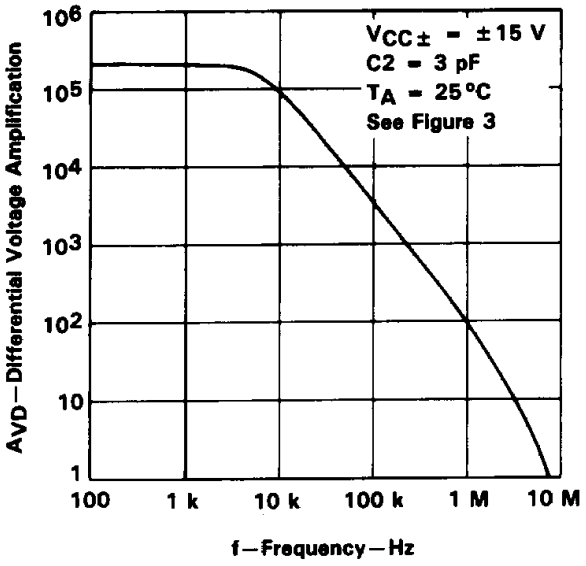

FIGURE 14

TOTAL POWER DISSIPATED
vs
FREE-AIR TEMPERATURE

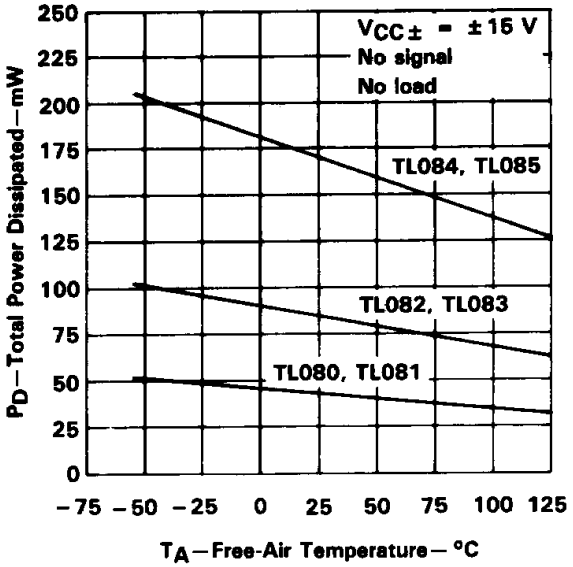

FIGURE 15

SUPPLY CURRENT PER AMPLIFIER
vs
FREE-AIR TEMPERATURE

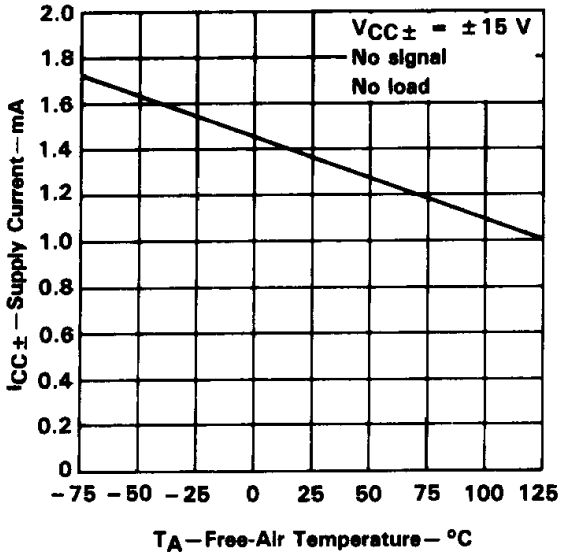

FIGURE 16

SUPPLY CURRENT
vs
SUPPLY VOLTAGE

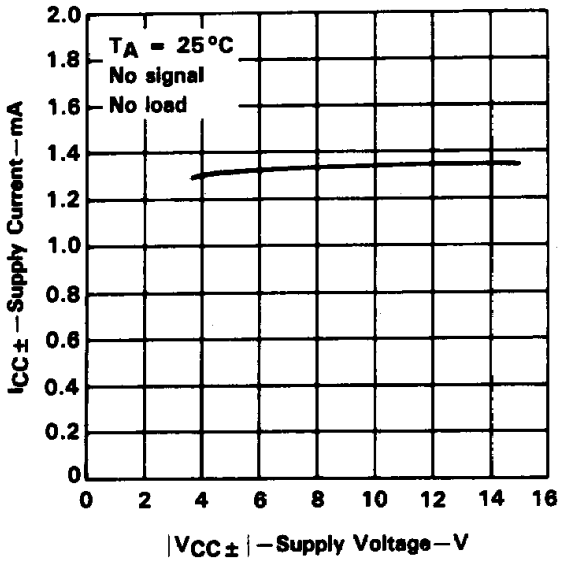

FIGURE 17

† Data at high and low temperatures are applicable only within the rated operating free-air temperature ranges of the various devices. A 12-pF compensation capacitor is used with TL080 and TL080A.

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TYPICAL CHARACTERISTICS†

INPUT BIAS CURRENT
vs
FREE-AIR TEMPERATURE

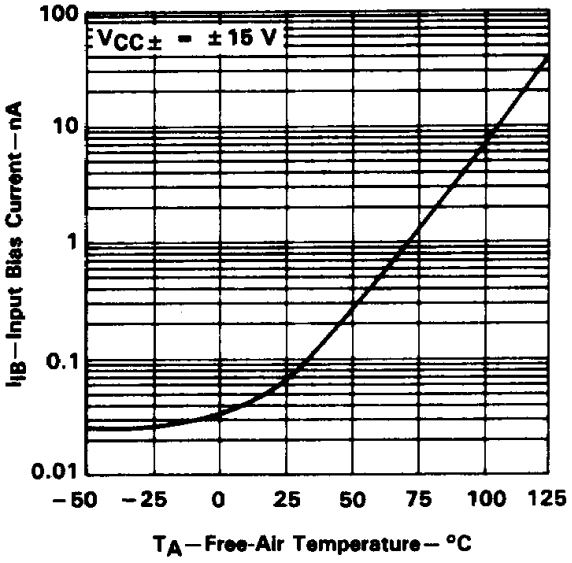

FIGURE 18

VOLTAGE-FOLLOWER
LARGE-SIGNAL PULSE RESPONSE

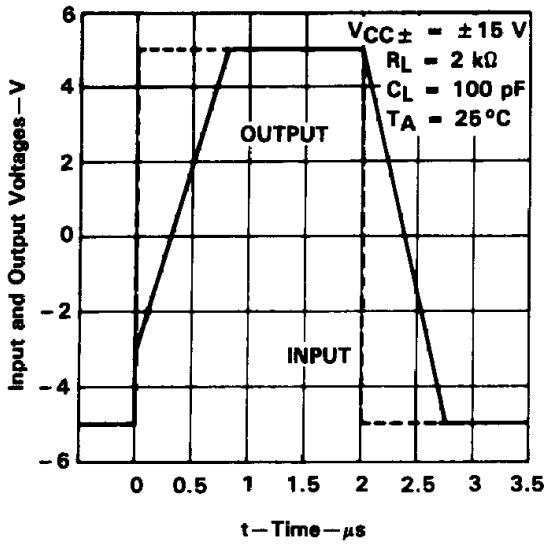

FIGURE 19

OUTPUT VOLTAGE
vs
ELAPSED TIME

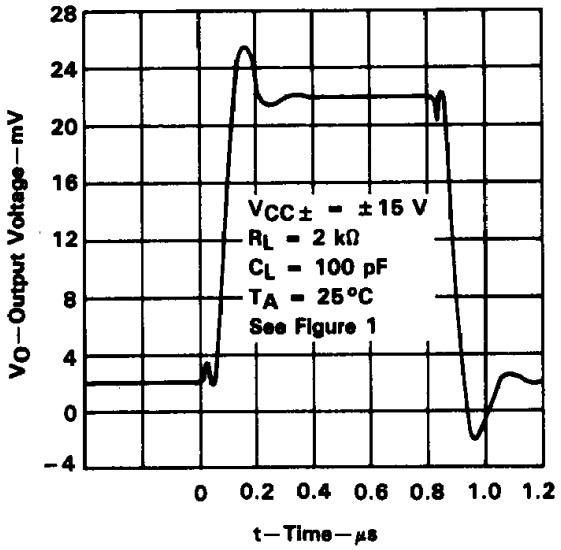

FIGURE 20

† Data at high and low temperatures are applicable only within the rated operating free-air temperature ranges of the various devices. A 12-pF compensation capacitor is used with TL080 and TL080A.

TYPICAL CHARACTERISTICS†

COMMON-MODE REJECTION RATIO
vs
FREE-AIR TEMPERATURE

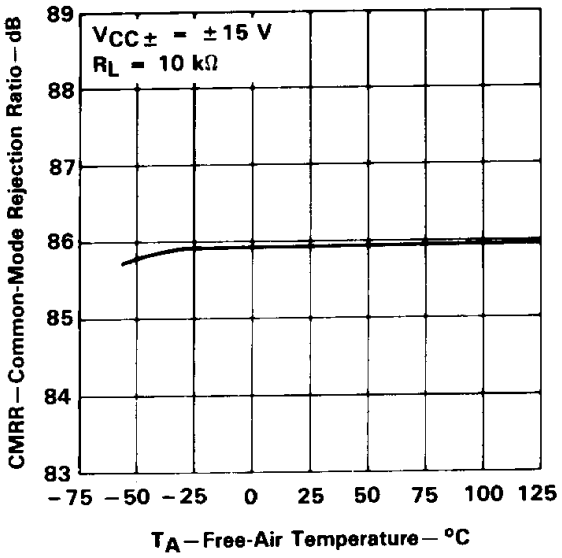

FIGURE 21

EQUIVALENT INPUT NOISE VOLTAGE
vs
FREQUENCY

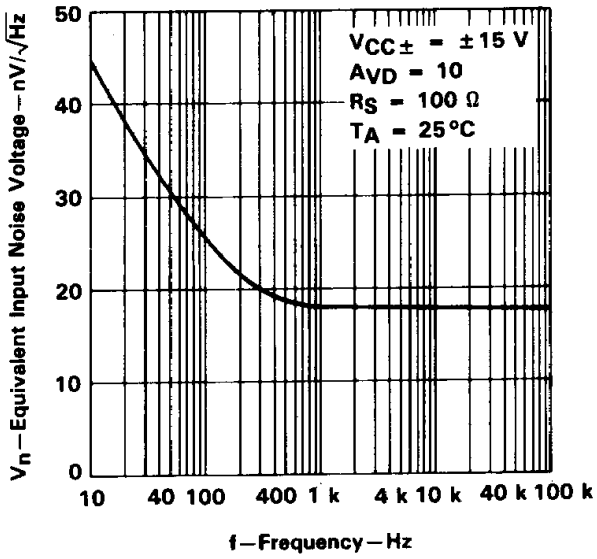

FIGURE 22

TOTAL HARMONIC DISTORTION
vs
FREQUENCY

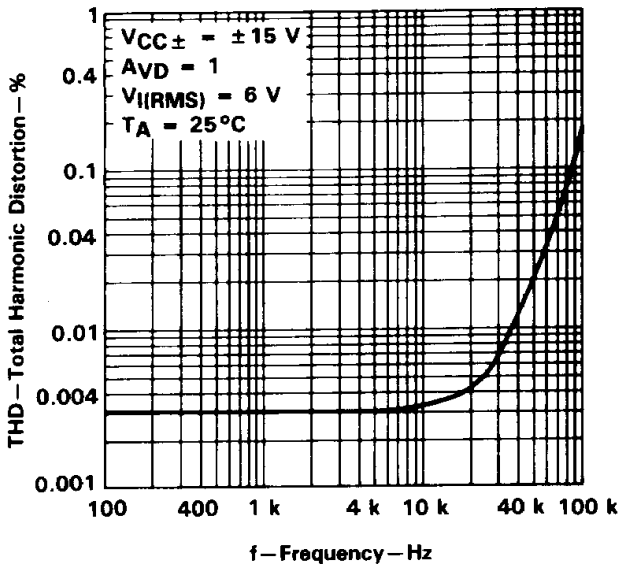

FIGURE 23

† Data at high and low temperatures are applicable only within the rated operating free-air temperature ranges of the various devices. A 12-pF compensation capacitor is used with TL080 and TL080A.

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TYPICAL APPLICATION DATA

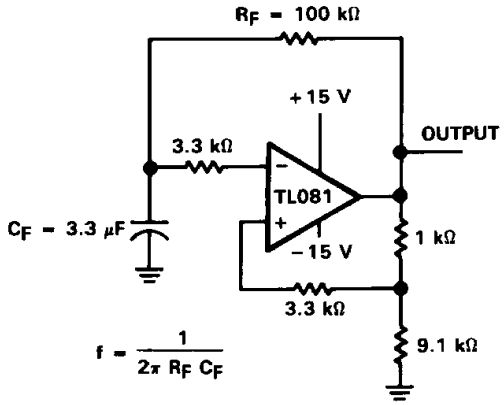


FIGURE 24. 0.5-Hz SQUARE-WAVE OSCILLATOR

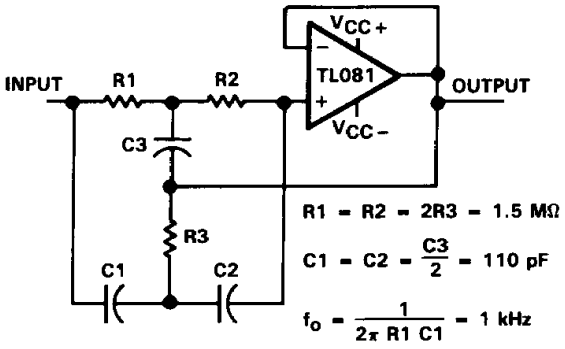


FIGURE 25. HIGH-Q NOTCH FILTER

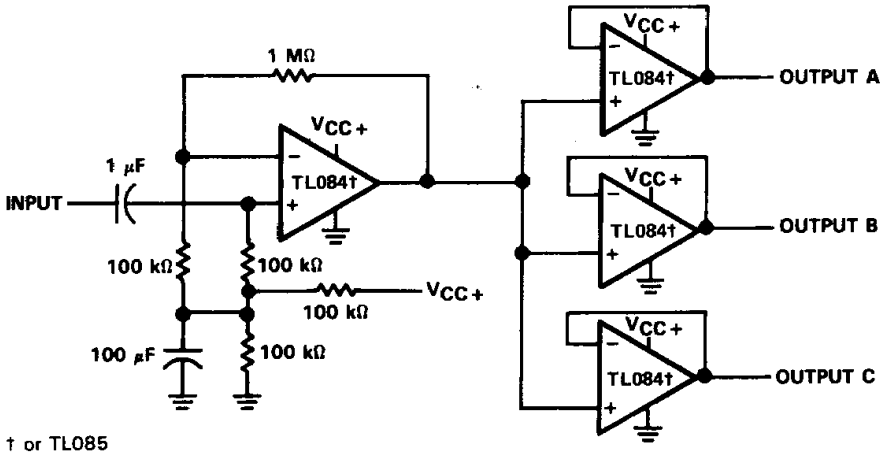
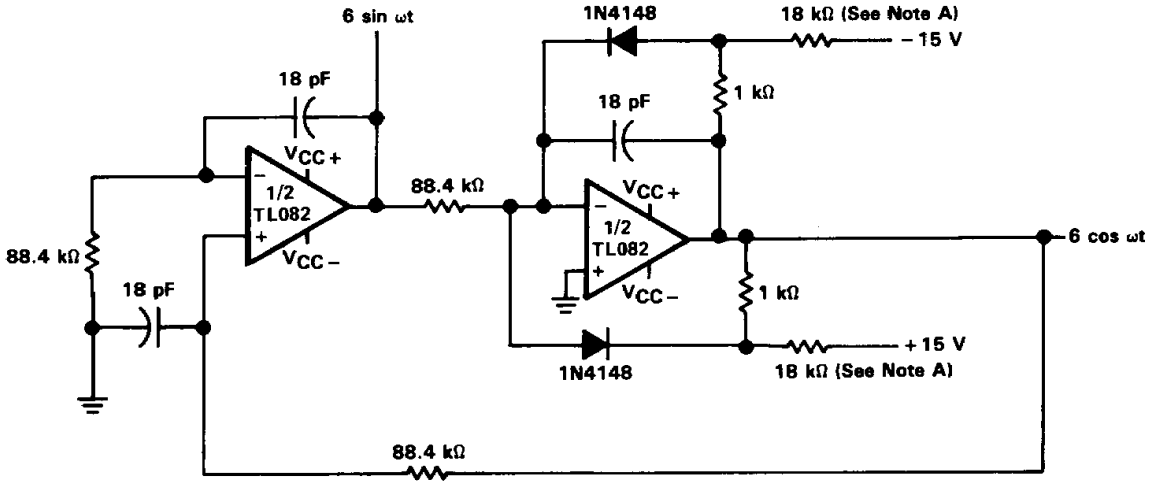


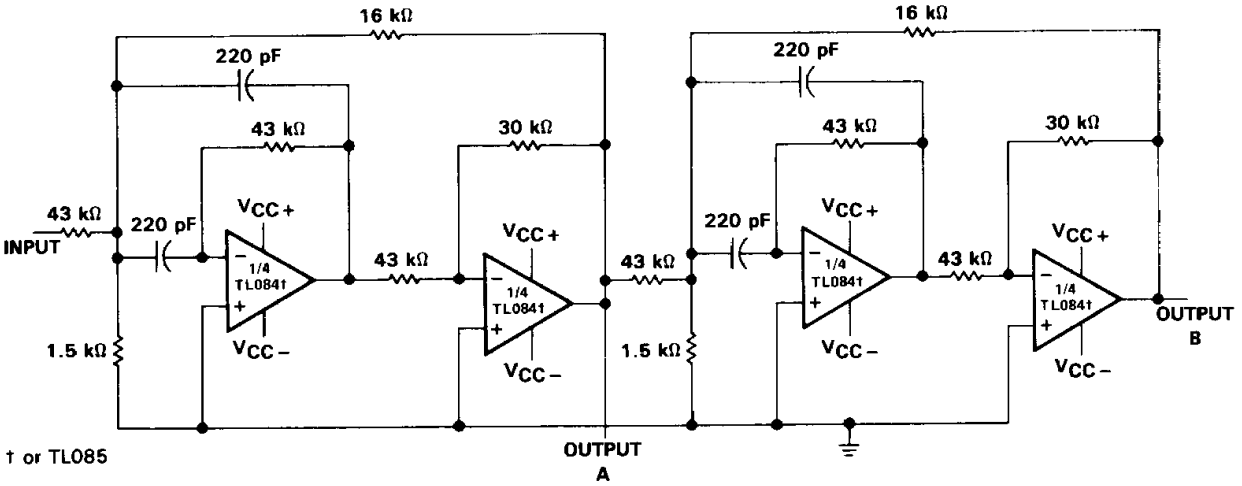
FIGURE 26. AUDIO DISTRIBUTION AMPLIFIER

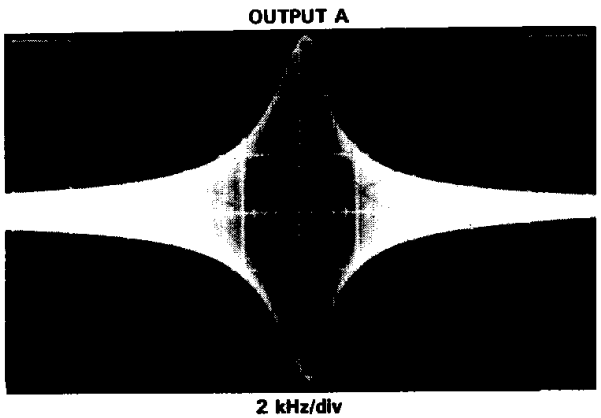


NOTE A: These resistor values may be adjusted for a symmetrical output.

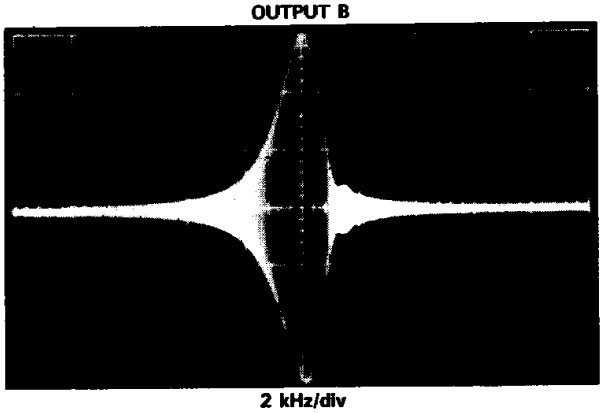
FIGURE 27. 100-kHZ QUADRATURE OSCILLATOR

TYPICAL APPLICATION DATA





2 kHz/div
SECOND-ORDER BANDPASS FILTER
f_o = 100 kHz, Q = 30, GAIN = 4



2 kHz/div
CASCADED BANDPASS FILTER
f_o = 100 kHz, Q = 69, GAIN = 16

FIGURE 28. POSITIVE-FEEDBACK BANDPASS FILTER

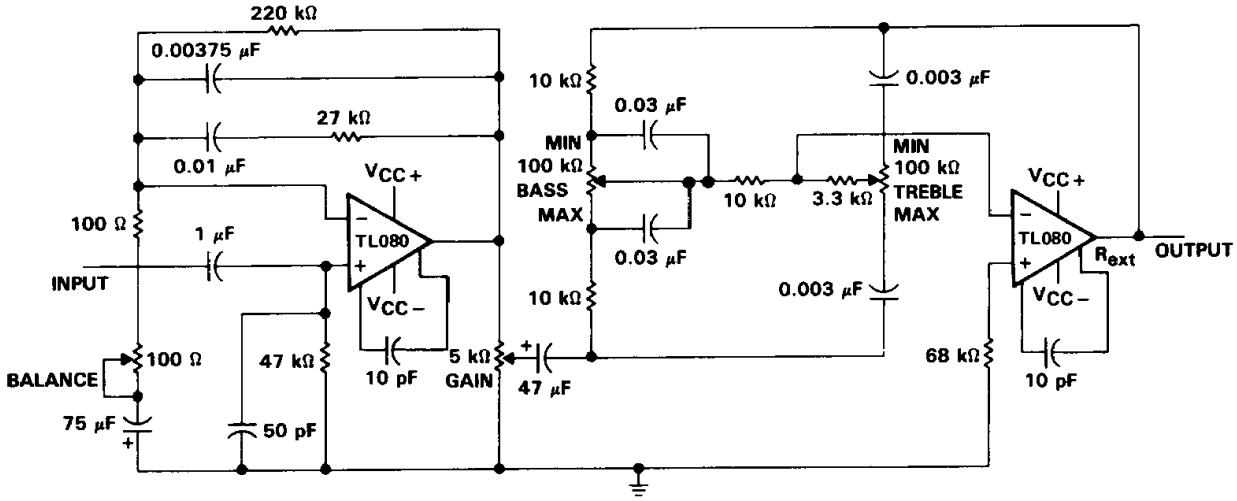


FIGURE 29. IC PREAMPLIFIER

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