TL070, TL070A, TL071, TL071A, TL071B, TL072, TL072A, TL072B, TL074, TL074A, TL074B, TL075
LOW-NOISE JFET-INPUT OPERATIONAL AMPLIFIERS

D2393, SEPTEMBER 1978—REVISED JANUARY 1989

19 DEVICES COVER COMMERCIAL, INDUSTRIAL, AND MILITARY TEMPERATURE RANGES

T-79-15

- 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
- Common-Mode Input Voltage Range Includes V_{CC+}
- Low Noise . . . V_n = 18 nV/$\sqrt{Hz}$ Typ
- High Input Impedance . . . JFET-Input Stage
- Internal Frequency Compensation (Except TL070, TL070A)
- Latch-Up-Free Operation
- High Slew Rate . . . 13 V/μs Typ

NOTICE
SEE ORDER OF DATA FOR ERRATA INFORMATION

2 Operational Amplifiers

description

The JFET-input operational amplifiers in the TL07__ series are designed as low-noise versions of the TL08__ series amplifiers with low input bias and offset currents and fast slew rate. The low harmonic distortion and low noise make the TL07__ series ideally suited as amplifiers for high-fidelity and audio preamplifier applications. Each amplifier features JFET-inputs (for high input impedance) coupled with bipolar output stages all integrated on a single monolithic chip.

The M suffix devices are characterized for operation over the full military temperature range of −55°C to 125°C. The I suffix devices are characterized for operation from −40°C to 85°C, and the C suffix devices 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)	METAL CAN (L)	PLASTIC DIP (N)	PLASTIC DIP (P)	FLAT PACK (W)
0°C to 70°C	10 mV	TL070CD			TL070CJG			TL070CP	
	6 mV	TL070ACD			TL070ACJG			TL070ACP	
	10 mV	TL071CD			TL071CJG			TL071CP	
	6 mV	TL071ACD			TL071ACJG			TL071ACP	
	3 mV	TL071BCD			TL071BCJG			TL071BCP	
	10 mV	TL072CD			TL072CJG			TL072CP	
	6 mV	TL072ACD			TL072ACJG			TL072ACP	
	3 mV	TL072BCD			TL072BCJG			TL072BCP	
	10 mV	TL074CD		TL074CJ			TL074CN		
	6 mV	TL074ACD		TL074ACJ			TL074ACN		
	3 mV	TL074BCD		TL074BCJ			TL074BCN		
	10 mV						TL075CN		
−40°C to 85°C	6 mV	TL070ID			TL070IJG			TL070IP	
	6 mV	TL071ID			TL071IJG			TL071IP	
	6 mV	TL072ID			TL072IJG			TL072IP	
	6 mV	TL074ID		TL074IJ			TL074IN		
−55°C to 125°C	6 mV		TL071MFK		TL071MJG	TL071ML			
	6 mV		TL072MFK		TL072MJG	TL072ML			
	9 mV		TL074MFK	TL074MJ					TL074MW

The D package is available taped and reeled. Add the suffix R to the device type (e.g., TL071CDR).

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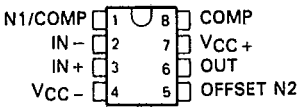
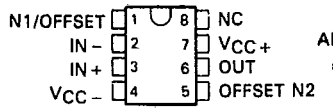
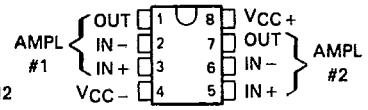
TL070, TL070A
D, JG, OR P PACKAGE
(TOP VIEW)



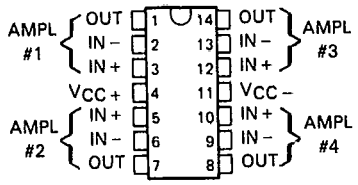
TL071, TL071A, TL071B
D, JG, OR P PACKAGE
(TOP VIEW)



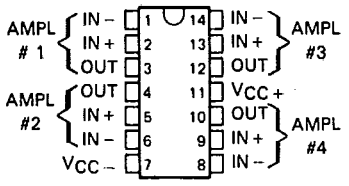
TL072, TL072A, TL072B
D, JG, OR P PACKAGE
(TOP VIEW)



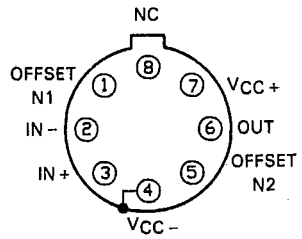
TL074, TL074A, TL074B
D, J, OR N PACKAGE
TL074 . . . W PACKAGE
(TOP VIEW)



TL075
N PACKAGE
(TOP VIEW)

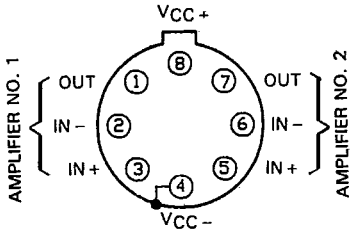


TL071 . . . L PACKAGE
(TOP VIEW)



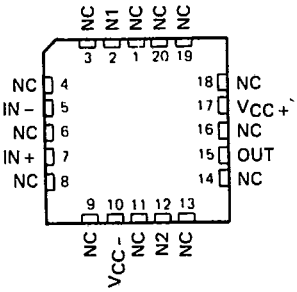
PIN 4 IS IN ELECTRICAL CONTACT WITH THE CASE

TL072 . . . L PACKAGE
(TOP VIEW)

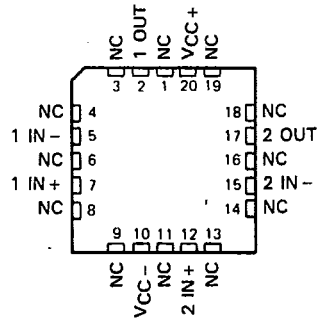


PIN 4 IS IN ELECTRICAL CONTACT WITH THE CASE

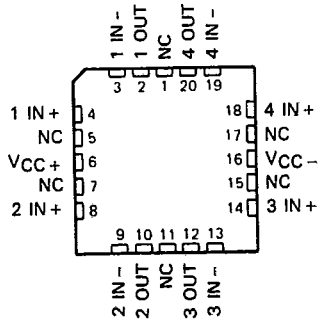
TL071
FK PACKAGE
(TOP VIEW)



TL072
FK PACKAGE
(TOP VIEW)



TL074
FK PACKAGE
(TOP VIEW)



NC—No internal connection.

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schematic (each amplifier)

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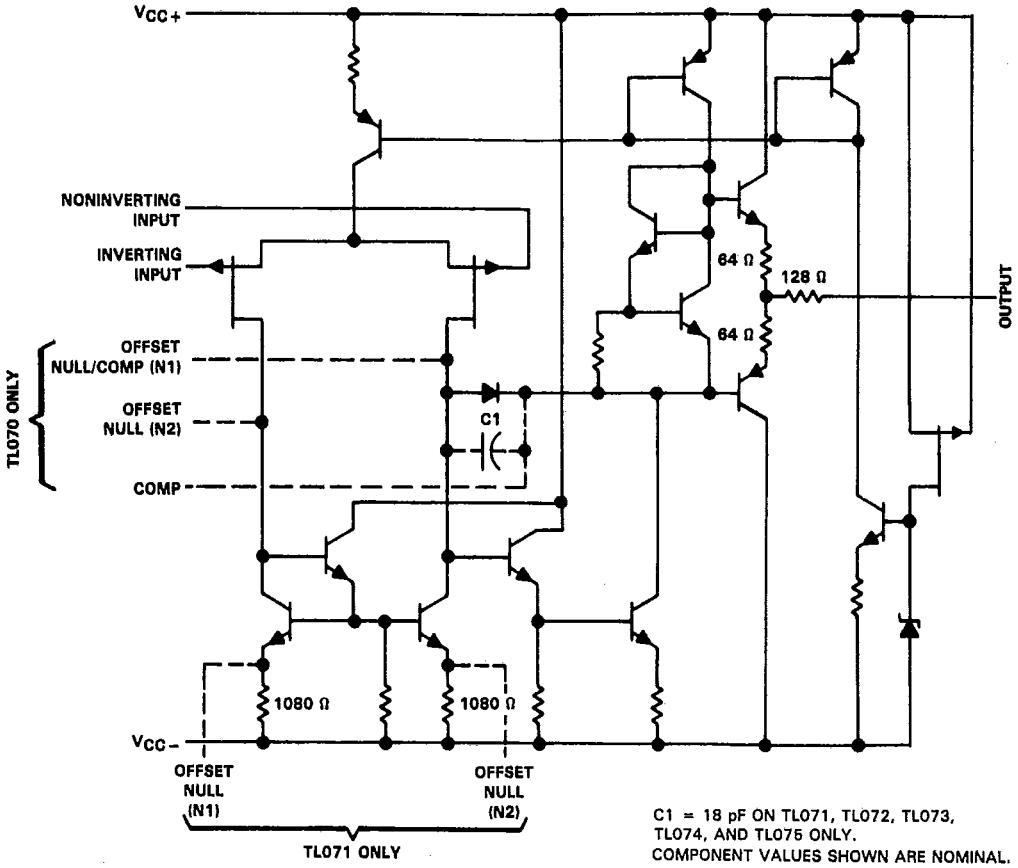
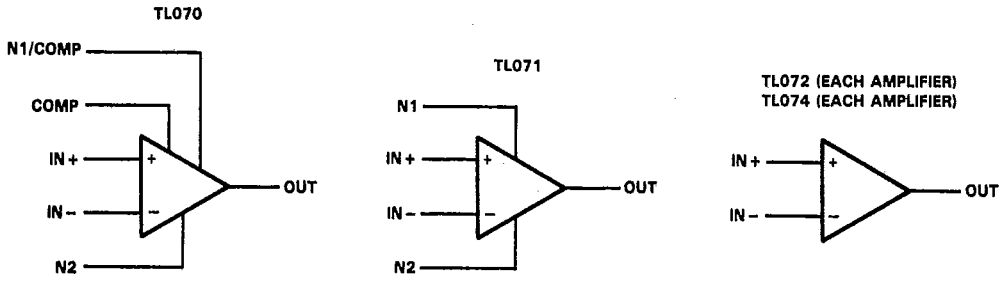


C1 = 18 pF ON TL071, TL072, TL073, TL074, AND TL075 ONLY.
COMPONENT VALUES SHOWN ARE NOMINAL.

symbols



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

		TL07__M	TL07__I	TL07__C TL07__AC TL07__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, JG, or W 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
Lead temperature 1,6 mm (1/16 inch) from case for 10 seconds	L package	300			°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.

DISSIPATION RATING TABLE

PACKAGE	$T_A \leq 25°C$ 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	33°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 (TL07__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 (TL07__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
L	680 mW	6.6 mW/°C	25°C	528 mW	429 mW	165 mW
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
W	680 mW	8.0 mW/°C	65°C	640 mW	520 mW	200 mW

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

PARAMETER		TEST CONDITIONS†		TL071M TL072M			TL074M			UNIT
				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	9	mV
			T_A = −55°C to 125°C			9			15	
αV_{IO}	Temperature coefficient of input offset voltage	V_O = 0, R_S = 50 Ω, T_A = −55°C to 125°C			18			18		μV/°C
I_{IO}	Input offset current‡	V_O = 0	T_A = 25°C		5	100		5	100	pA
			T_A = −55°C to 125°C			20			20	nA
I_{IB}	Input bias current	V_O = 0	T_A = 25°C		65	200		65	200	pA
			T_A = −55°C to 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	R_L = 10 kΩ	T_A = 25°C	±12	±13.5		±12	±13.5		V
		R_L ≥ 10 kΩ	T_A = −55°C to 125°C	±12			±12			
		R_L ≥ 2 kΩ		±10			±10			
A_{VD}	Large-signal differential voltage amplification	V_O = ±10 V,	T_A = 25°C	35	200		35	200		V/mV
		R_L ≥ 2 kΩ	T_A = −55°C to 125°C	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, V_O = 0, R_S = 50 Ω, T_A = 25°C		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		80	86		dB
I_{CC}	Supply current (each amplifier)	No load, V_O = 0, T_A = 25°C			1.4	2.5		1.4	2.5	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 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 6. Pulse techniques must be used that will maintain the junction temperature as close to the ambient temperature as possible.

2 Operational Amplifiers

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

PARAMETER		TEST CONDITIONS†		TL070I, TL071I, TL072I, TL074I			TL070C, TL071C, TL072C, TL074C			TL070AC, TL071AC, TL072AC, TL074AC			TL070BC, TL071BC, TL072BC, TL074BC			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	10		3	6		2	3	mV
			T_A = full range			8			13			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	100		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		65	200		65	200		65	200		65	200	pA
			T_A = full range			20			7			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	R_L = 10 kΩ	T_A = 25°C	±12	±13.5		±12	±13.5		±12	±13.5		±12	±13.5		V
		R_L ≥ 10 kΩ	T_A = full range	±12			±12			±12			±12			
		R_L ≥ 2 kΩ		±10			±10			±10			±10			
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
			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	100		70	100		80	100		80	100		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	100		70	100		80	100		80	100		dB
I_{CC}	Supply current (each amplifier)	No load,	V_O = 0, T_A = 25°C		1.4	2.5		1.4	2.5		1.4	2.5		1.4	2.5	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 voltage unless otherwise specified. Full range for T_A is −40°C to 85°C for TL07_I and 0°C to 70°C for TL07_C, TL07_AC, and TL07_BC.

‡Input bias currents of a FET-input operational amplifier are normal junction reverse currents, which are temperature sensitive as shown in Figure 6. Pulse techniques must be used that will maintain the junction temperature as close to the ambient temperature as possible.

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

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PARAMETER		TEST CONDITIONS		TL07_M MIN	TL07_M TYP	TL07_M MAX	ALL OTHERS MIN	ALL OTHERS TYP	ALL OTHERS 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		8	13		V/μs
t_r	Rise time	V_I = 20 mV,	R_L = 2 kΩ,		0.1			0.1		μs
	overshoot factor	C_L = 100 pF,	See Figure 1		20			20		%
V_n	Equivalent input noise voltage	R_S = 100 Ω	f = 1 kHz		18			18		nV/√Hz
			f = 10 Hz to 10 kHz		4			4		μV
I_n	Equivalent input noise current	R_S = 100 Ω,	f = 1 kHz		0.01			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			0.003		%

PARAMETER MEASUREMENT INFORMATION

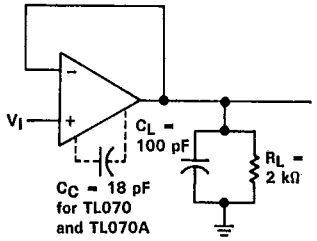

FIGURE 1. UNITY-GAIN AMPLIFIER

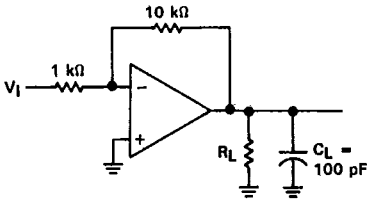

FIGURE 2. GAIN-OF-10 INVERTING AMPLIFIER

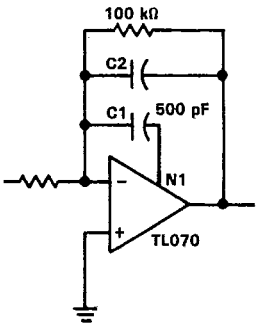

FIGURE 3. FEED-FORWARD COMPENSATION

INPUT OFFSET VOLTAGE NULL CIRCUITS

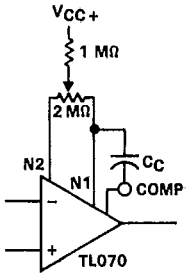

FIGURE 4

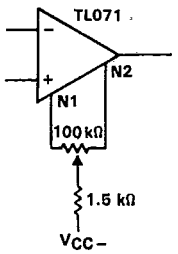

FIGURE 5

TYPICAL CHARACTERISTICS†

INPUT BIAS CURRENT
vs
FREE-AIR TEMPERATURE

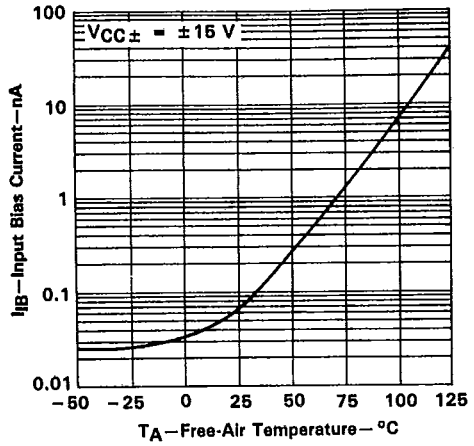

FIGURE 6

MAXIMUM PEAK OUTPUT VOLTAGE
vs
FREQUENCY

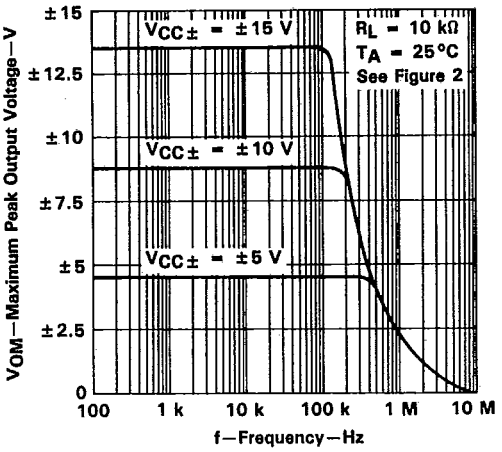

FIGURE 7

MAXIMUM PEAK OUTPUT VOLTAGE
vs
FREQUENCY

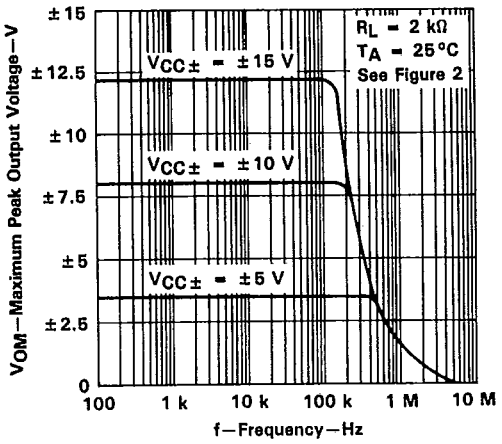

FIGURE 8

MAXIMUM PEAK OUTPUT VOLTAGE
vs
FREQUENCY

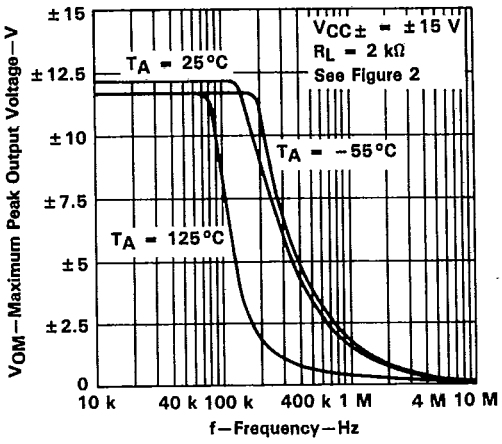

FIGURE 9

†Data at high and low temperatures are applicable only within the rated operating free-air temperature ranges of the various devices. An 18-pF compensation capacitor is used with TL070 and TL070A.

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TYPICAL CHARACTERISTICS†

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MAXIMUM PEAK OUTPUT VOLTAGE
vs
FREE-AIR TEMPERATURE

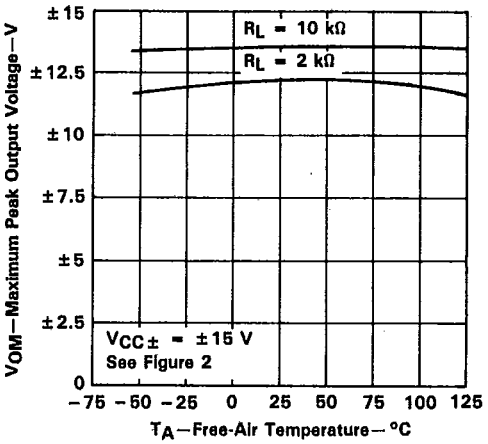

FIGURE 10

MAXIMUM PEAK OUTPUT VOLTAGE
vs
LOAD RESISTANCE

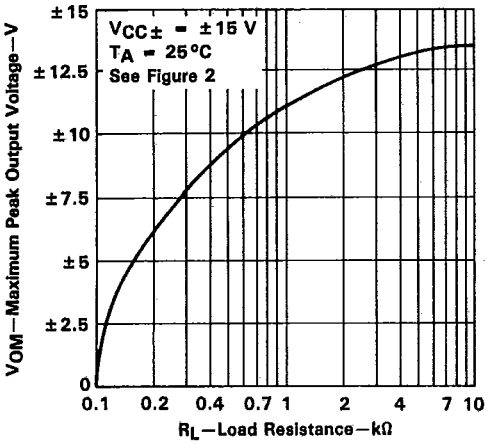

FIGURE 11

MAXIMUM PEAK OUTPUT VOLTAGE
vs
SUPPLY VOLTAGE

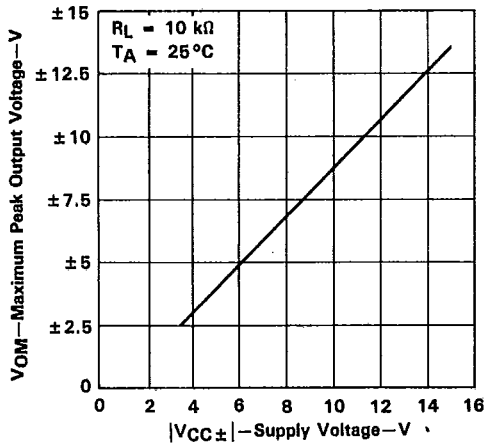

FIGURE 12

LARGE-SIGNAL
DIFFERENTIAL VOLTAGE AMPLIFICATION
vs
FREE-AIR TEMPERATURE

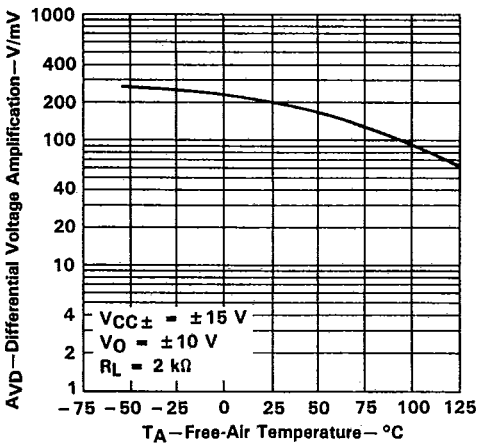

FIGURE 13

†Data at high and low temperatures are applicable only within the rated operating free-air temperature ranges of the various devices. An 18-pF compensation capacitor is used with TL070 and TL070A.

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TYPICAL CHARACTERISTICS†

TL070
DIFFERENTIAL VOLTAGE AMPLIFICATION
vs
FREQUENCY WITH FEED-FORWARD COMPENSATION

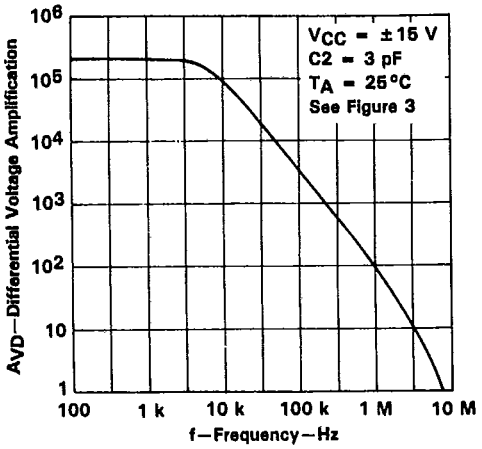

FIGURE 14

LARGE-SIGNAL
DIFFERENTIAL VOLTAGE AMPLIFICATION
and PHASE SHIFT
vs
FREQUENCY

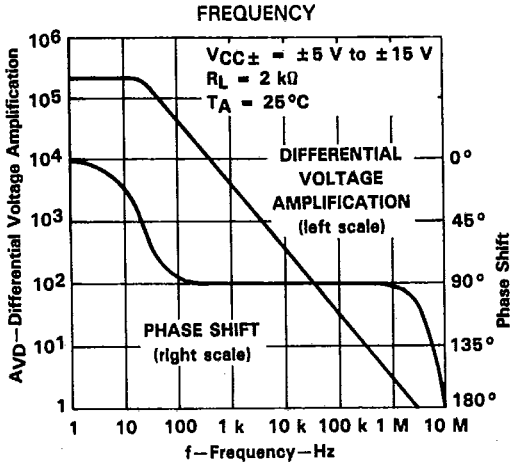

FIGURE 15

NORMALIZED UNITY-GAIN BANDWIDTH
and PHASE SHIFT
vs
FREE-AIR TEMPERATURE

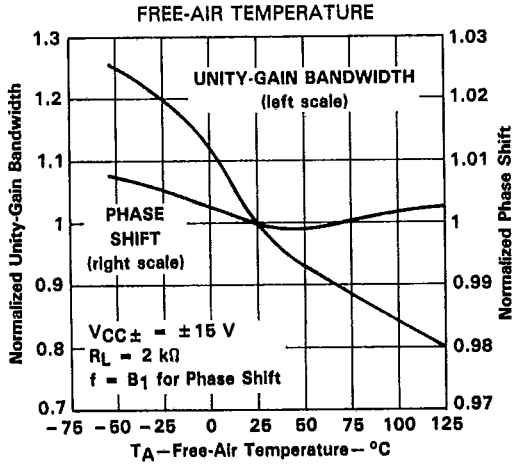

FIGURE 16

COMMON-MODE REJECTION RATIO
vs
FREE-AIR TEMPERATURE

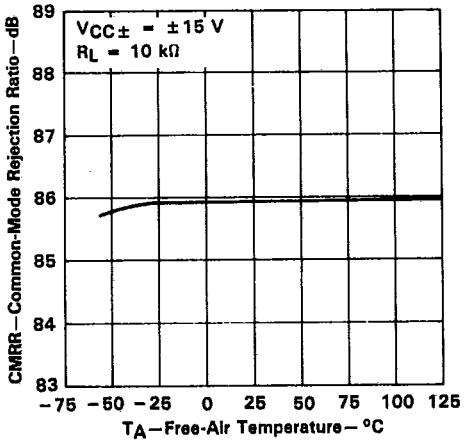

FIGURE 17

†Data at high and low temperatures are applicable only within the rated operating free-air temperature ranges of the various devices. An 18-pF compensation capacitor is used with TL070 and TL070A.

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TYPICAL CHARACTERISTICS†

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SUPPLY CURRENT PER AMPLIFIER
vs
SUPPLY VOLTAGE

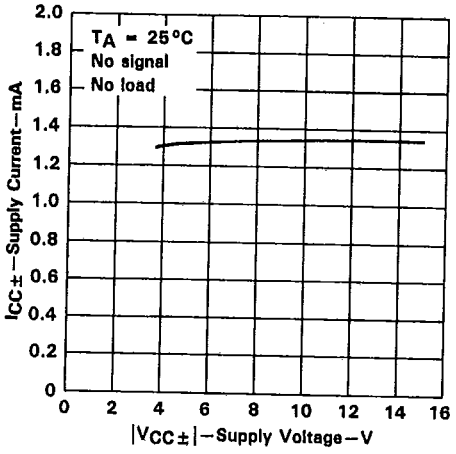

FIGURE 18

SUPPLY CURRENT PER AMPLIFIER
vs
FREE-AIR TEMPERATURE

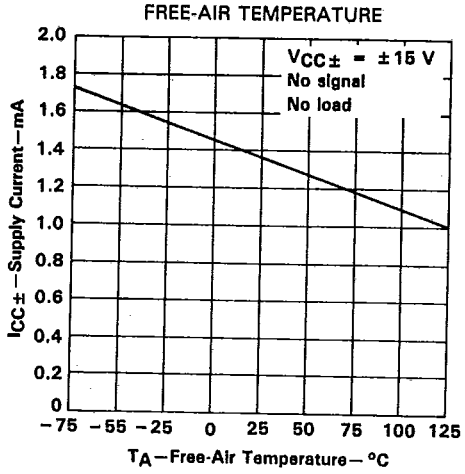

FIGURE 19

TOTAL POWER DISSIPATED
vs
FREE-AIR TEMPERATURE

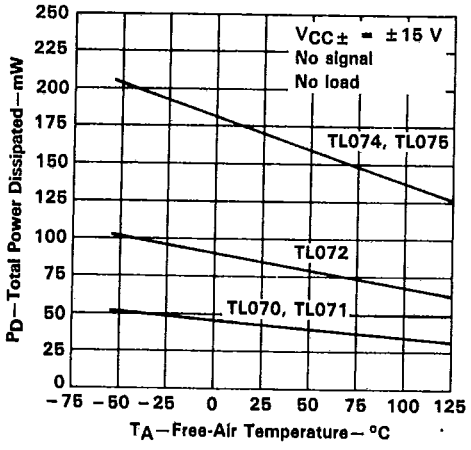

FIGURE 20

NORMALIZED SLEW RATE
vs
FREE-AIR TEMPERATURE

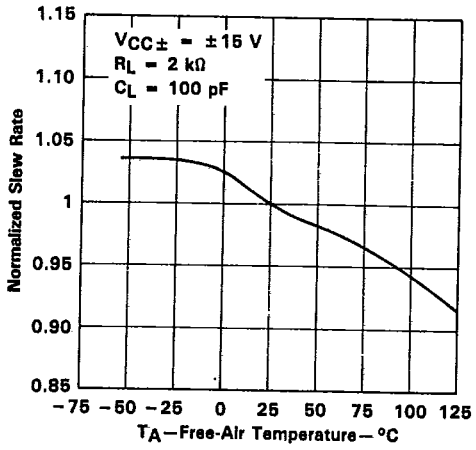

FIGURE 21

†Data at high and low temperatures are applicable only within the rated operating free-air temperature ranges of the various devices. An 18-pF compensation capacitor is used with TL070 and TL070A.

TYPICAL CHARACTERISTICS

EQUIVALENT INPUT NOISE VOLTAGE
vs
FREQUENCY

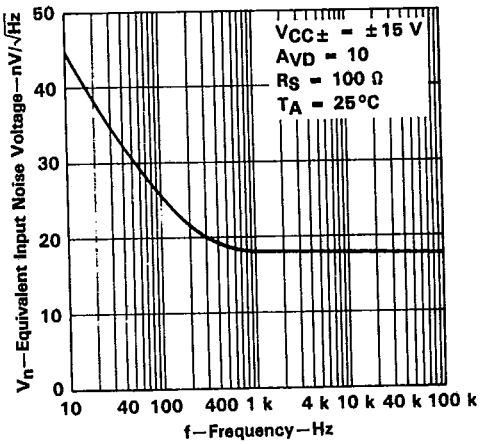

FIGURE 22

TOTAL HARMONIC DISTORTION
vs
FREQUENCY

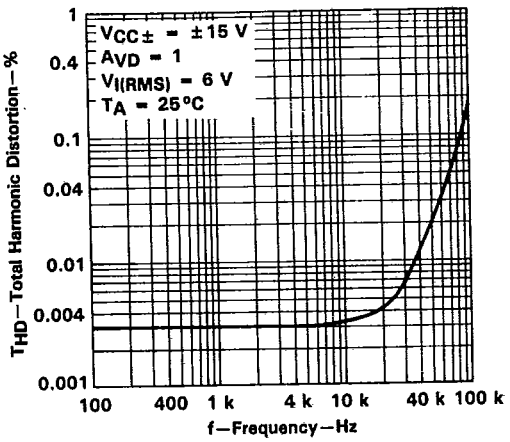

FIGURE 23

VOLTAGE-FOLLOWER
LARGE-SIGNAL PULSE RESPONSE

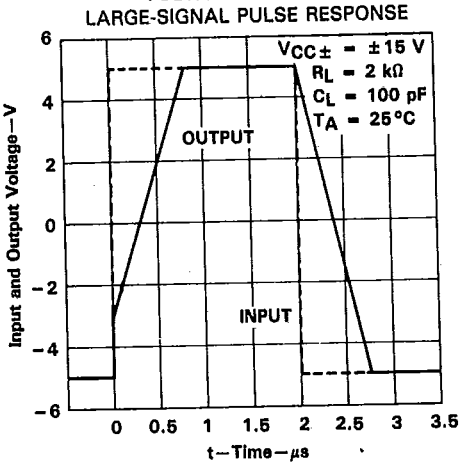

FIGURE 24

OUTPUT VOLTAGE
vs
ELAPSED TIME

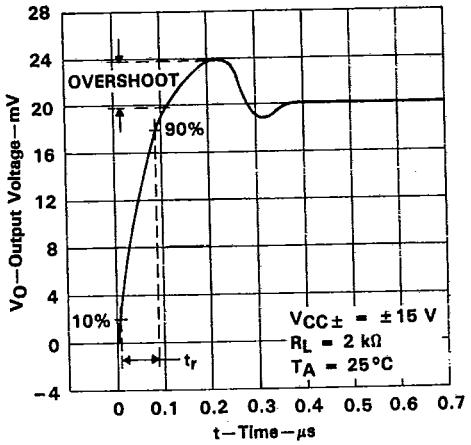

FIGURE 25

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TYPICAL APPLICATION DATA

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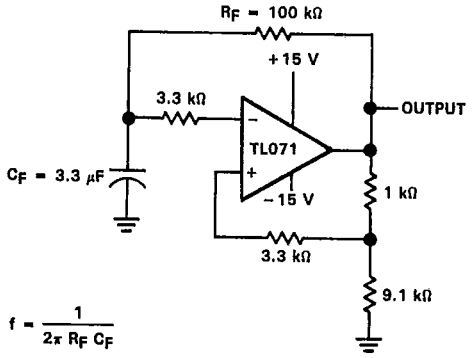

FIGURE 26. 0.5-Hz SQUARE-WAVE OSCILLATOR

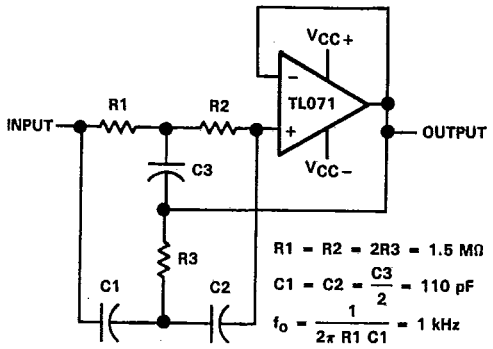

FIGURE 27. HIGH-Q NOTCH FILTER

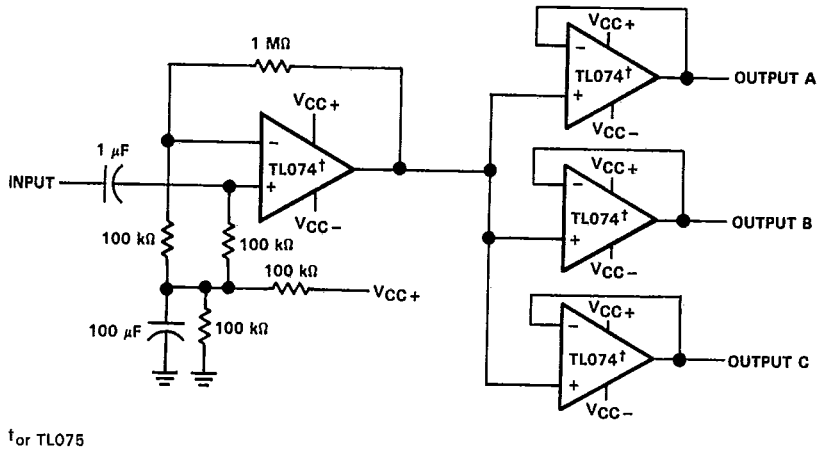

FIGURE 28. AUDIO DISTRIBUTION AMPLIFIER

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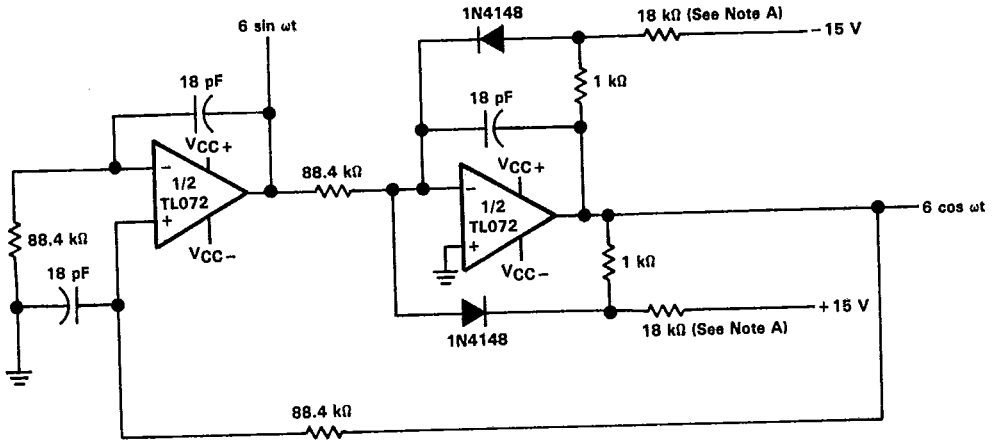
Operational Amplifiers

TYPICAL APPLICATION DATA



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

FIGURE 29. 100-kHz QUADRATURE OSCILLATOR

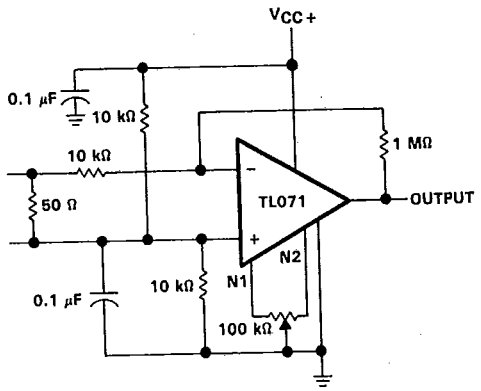


FIGURE 30. AC AMPLIFIER

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TYPICAL APPLICATION DATA

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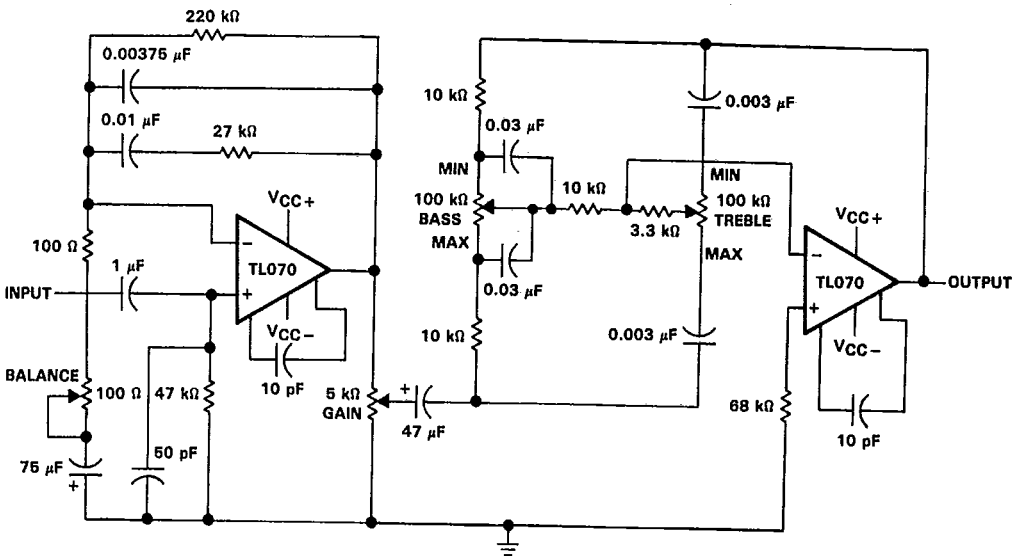

FIGURE 31. IC PREAMPLIFIER

IC PREAMPLIFIER
RESPONSE CHARACTERISTICS

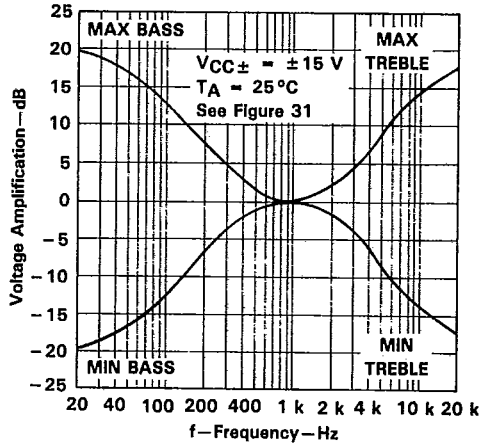

FIGURE 32