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

D2393, SEPTEMBER 1978—REVISED SEPTEMBER 1983

19 DEVICES COVER COMMERCIAL, INDUSTRIAL, AND MILITARY TEMPERATURE RANGES

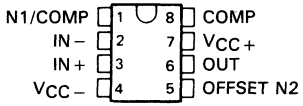
- Low Power Consumption
- Wide Common-Mode and Differential Voltage Ranges
- Low Input Bias and Offset Currents
- Output Short-Circuit Protection
- Low Total Harmonic Distortion 0.003% Typ
- Low Noise . . . Vn = 18 nV$\sqrt{\text{Hz}}$ Typ
- High Input Impedance . . . JFET-Input Stage
- Internal Frequency Compensation (Except TL070, TL070A)
- Latch-Up-Free Operation
- High Slew Rate . . . 13 V/μs Typ

description

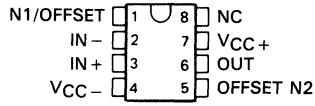
The JFET-input operational amplifiers on the TL07_ series are designed as low-noise versions of the TL08_ series amplifiers with low input bias and offset currents and fast slew rate. The low harmonic distortion and low noise make the TL07_ series ideally suited as amplifiers for high-fidelity and audio preamplifier applications. Each amplifier features JFET-inputs (for high input impedance) coupled with bipolar output stages all integrated on a single monolithic chip.

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 −25°C to 85°C, and those with a "C" suffix are characterized for operation from 0°C to 70°C.

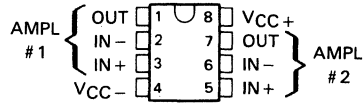
TL070, TL070A
D, JG, OR P DUAL-IN-LINE PACKAGE
(TOP VIEW)



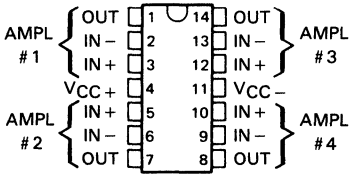
TL071, TL071A, TL071B
D, JG, OR P DUAL-IN-LINE PACKAGE
(TOP VIEW)



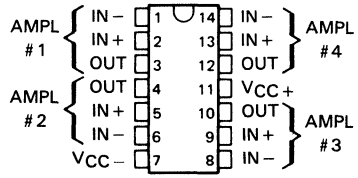
TL072, TL072A, TL072B
D, JG, OR P DUAL-IN-LINE PACKAGE
(TOP VIEW)



TL074, TL074A, TL074B
D, J, OR N DUAL-IN-LINE
OR W FLAT PACKAGE
(TOP VIEW)

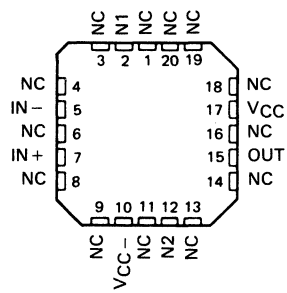


TL075
N DUAL-IN-LINE PACKAGE
(TOP VIEW)

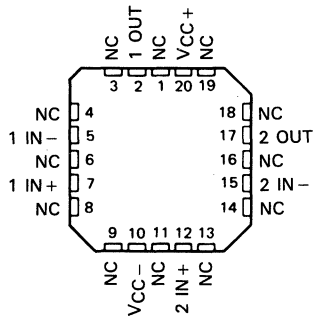


NC—No internal connection

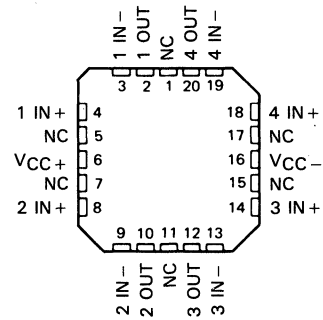
TL071
FH OR FK CHIP-CARRIER PACKAGE
(TOP VIEW)



TL072
FH OR FK CHIP-CARRIER PACKAGE
(TOP VIEW)

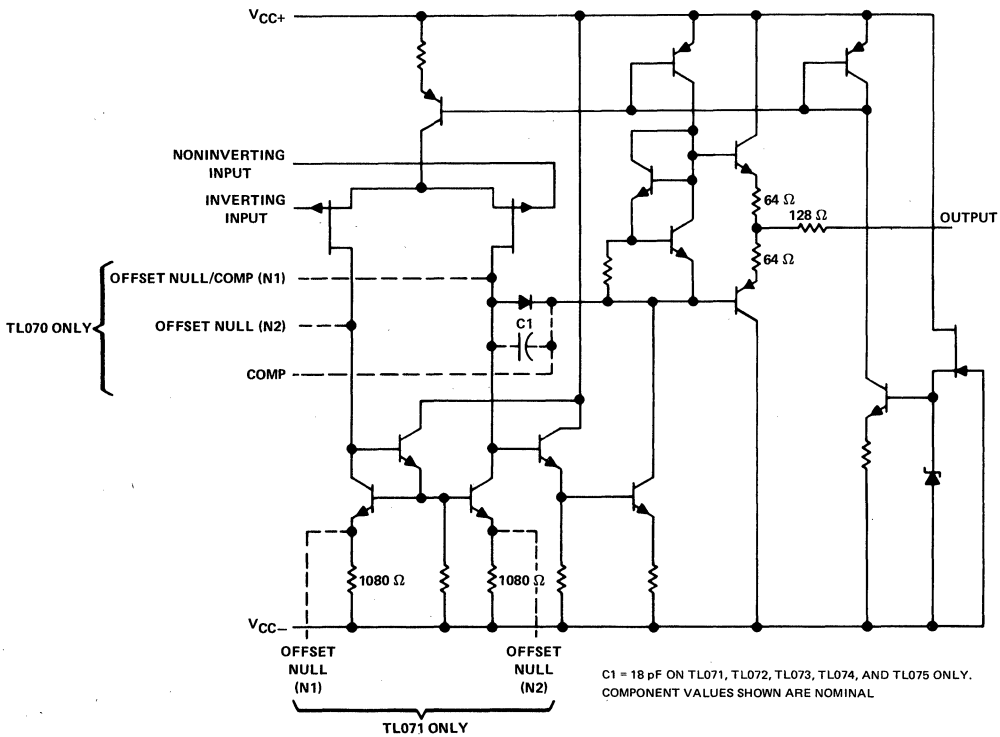


TL074
FH OR FK CHIP-CARRIER PACKAGE
(TOP VIEW)



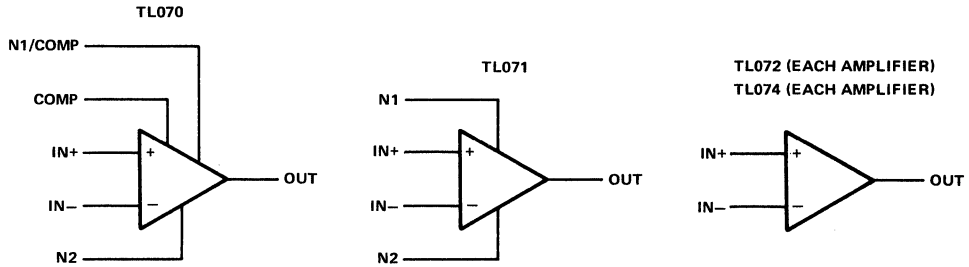
NC—No internal connection

schematic (each amplifier)



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

symbols



DEVICE TYPES, SUFFIX VERSIONS, AND PACKAGES					
	TL070	TL071	TL072	TL074	TL075
TL07_M	*	FH, FK, JG	FH, FK, JG	FH, FK, J, W	*
TL07_I	D, JG, P	D, JG, P	D, JG, P	D, J, N	*
TL07_C	D, JG, P	D, JG, P	D, JG, P	D, J, N	N
TL07_AC	D, JG, P	D, JG, P	D, JG, P	D, J, N	*
TL07_BC	*	D, JG, P	D, JG, P	D, J, N	*

*These combinations are not defined by this data sheet.

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 at (or below) 25°C free-air temperature (see Note 5)		680	680	680	mW
Operating free-air temperature range		−55 to 125	−25 to 85	0 to 70	°C
Storage temperature range		−65 to 150	−65 to 150	−65 to 150	°C
Lead temperature 1,6 mm (1/16 inch) from case for 60 seconds	J, JG, JH, FK, 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

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 volts, 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.
5. For operation above 25°C free-air temperature, refer to Dissipation Derating Curves, Section 2. In the J and JG packages, TL07_M chips are alloy-mounted; TL07_I, TL07_C, TL07_AC, and TL07_BC chips are glass mounted.

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	
α_{VIO}	Temperature coefficient of input offset voltage	V_O = 0, T_A = −55° to 125°C	R_S = 50 Ω,		10			10		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		30	200		30	200	pA
			T_A = −55°C to 125°C			50			20	nA
V_{ICR}	Common-mode input voltage range	T_A = 25°C		±11	±12		±11	±12		V
V_{OM}	Maximum peak output voltage swing	T_A = 25°C,	R_L = 10 kΩ	±12	±13.5		±12	±13.5		V
		T_A = −55°C to 125°C	R_L ≥ 10 kΩ	±12			±12			
			R_L ≥ 2 kΩ	±10	±12		±10	±12		
A_{VD}	Large-signal differential voltage amplification	V_O = ±10 V, T_A = 25°C	R_L ≥ 2 kΩ,	35	200		35	200		V/mV
		V_O = ±10 V, T_A = −55°C to 125°C	R_L ≥ 2 kΩ,	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 Ω,	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} = ±15 V to ±9 V, R_S = 50 Ω,	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	2.5		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 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†		TL070I TL071I TL072I TL074I			TL070C TL071C TL072C TL074C TL075C			TL070AC TL071AC TL072AC TL074AC			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			10			10			10			10		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		30	200		30	200		30	200		30	200	pA
			T_A = full range			20			7			7			7	nA
V_{ICR}	Common-mode input voltage range	T_A = 25°C		±11	±12		±11	±12		±11	±12		±11	±12		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, 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 input voltage unless otherwise specified. Full range for T_A is 25°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 18. Pulse techniques must be used that will maintain the junction temperatures as close to the ambient temperature as is possible.

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

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	10	13		8	13		V/μs
t_r	Rise time	V_I = 20 mV, C_L = 100 pF,	R_L = 2 kΩ, See Figure 1		0.1			0.1		μs
	Overshoot factor				10			10		%
V_n	Equivalent input noise voltage	R_S = 100 Ω	f = 1 kHz		18			18		$nV/\sqrt{Hz}$
			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		$pA/\sqrt{Hz}$
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

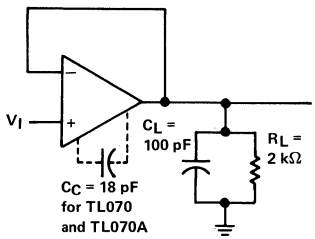


FIGURE 1–UNITY-GAIN AMPLIFIER

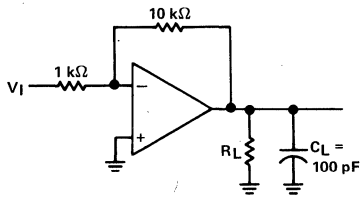


FIGURE 2–GAIN-OF-10 INVERTING AMPLIFIER

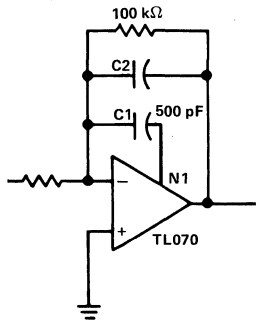


FIGURE 3–FEED-FORWARD COMPENSATION

INPUT OFFSET VOLTAGE NULL CIRCUITS

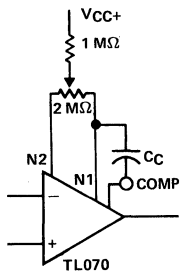


FIGURE 4

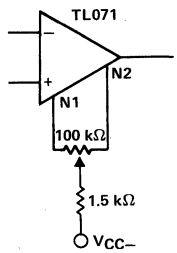


FIGURE 5

TYPICAL CHARACTERISTICS†

MAXIMUM PEAK OUTPUT VOLTAGE vs FREQUENCY

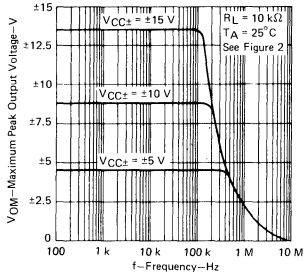


FIGURE 6

MAXIMUM PEAK OUTPUT VOLTAGE vs FREQUENCY

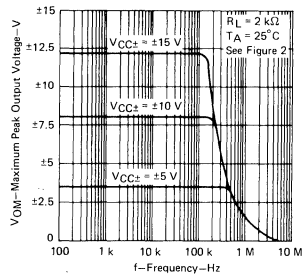


FIGURE 7

MAXIMUM PEAK OUTPUT VOLTAGE vs FREQUENCY

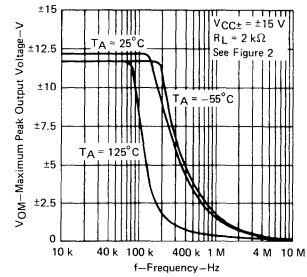


FIGURE 8

MAXIMUM PEAK OUTPUT VOLTAGE vs FREE-AIR TEMPERATURE

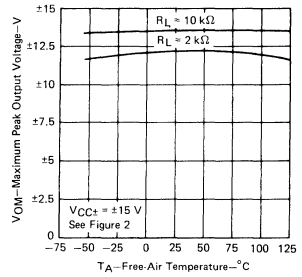


FIGURE 9

MAXIMUM PEAK OUTPUT VOLTAGE vs LOAD RESISTANCE

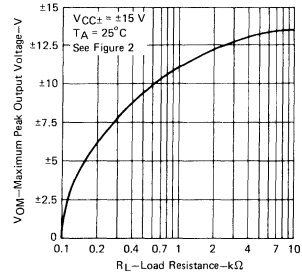


FIGURE 10

MAXIMUM PEAK OUTPUT VOLTAGE vs SUPPLY VOLTAGE

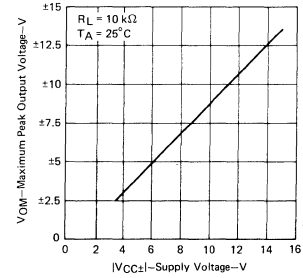


FIGURE 11

TOTAL POWER DISSIPATED vs FREE-AIR TEMPERATURE

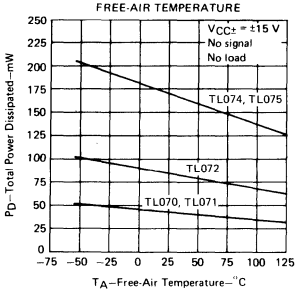


FIGURE 12

SUPPLY CURRENT PER AMPLIFIER vs FREE-AIR TEMPERATURE

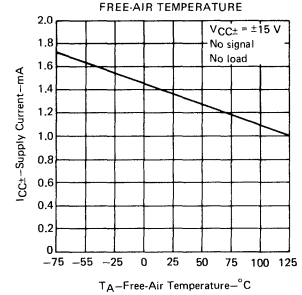


FIGURE 13

SUPPLY CURRENT vs SUPPLY VOLTAGE

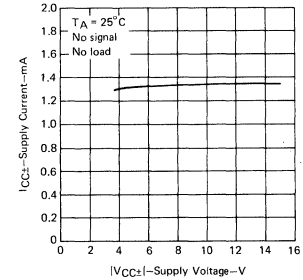


FIGURE 14

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

TYPICAL CHARACTERISTICS†

LARGE-SIGNAL
DIFFERENTIAL VOLTAGE AMPLIFICATION
vs
FREE-AIR TEMPERATURE

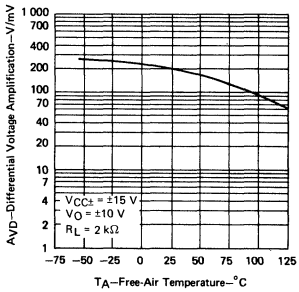


FIGURE 15

LARGE-SIGNAL
DIFFERENTIAL VOLTAGE AMPLIFICATION
and PHASE SHIFT
vs
FREQUENCY

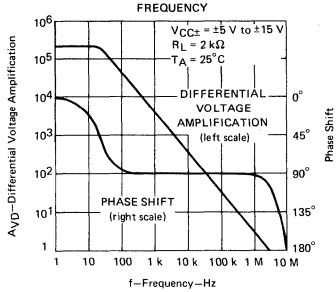


FIGURE 16

TL070
DIFFERENTIAL VOLTAGE AMPLIFICATION
vs
FREQUENCY WITH FEED-FORWARD COMPENSATION

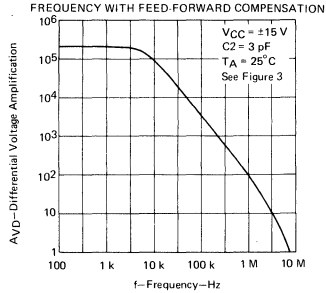


FIGURE 17

INPUT BIAS CURRENT
vs
FREE-AIR TEMPERATURE

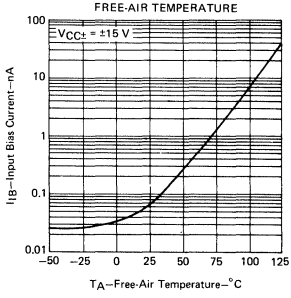


FIGURE 18

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

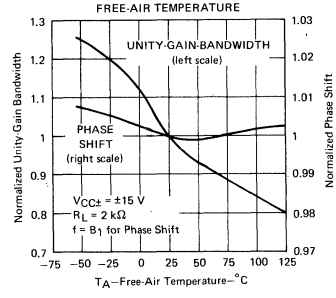


FIGURE 19

NORMALIZED SLEW RATE
vs
FREE-AIR TEMPERATURE

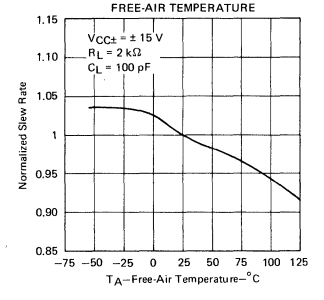


FIGURE 20

COMMON-MODE REJECTION RATIO
vs
FREE-AIR TEMPERATURE

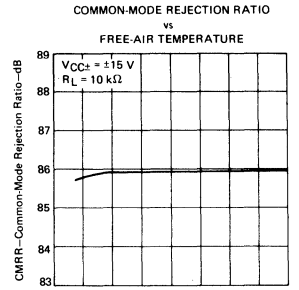


FIGURE 21

EQUIVALENT INPUT NOISE VOLTAGE
vs
FREQUENCY

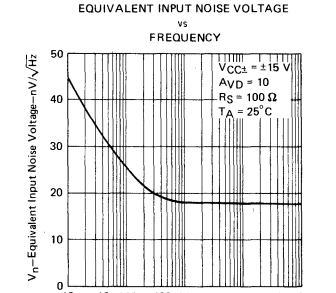


FIGURE 22

TOTAL HARMONIC DISTORTION
vs
FREQUENCY

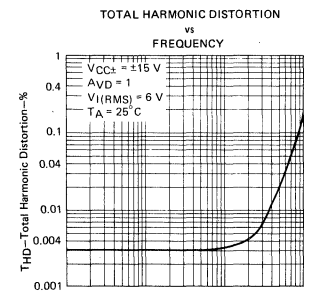


FIGURE 23

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

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TYPICAL CHARACTERISTICS

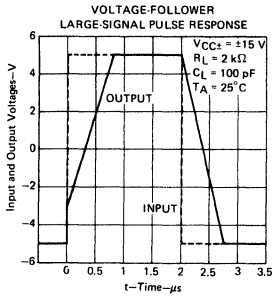


FIGURE 24

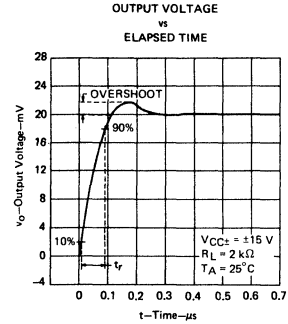


FIGURE 25

TYPICAL APPLICATION DATA

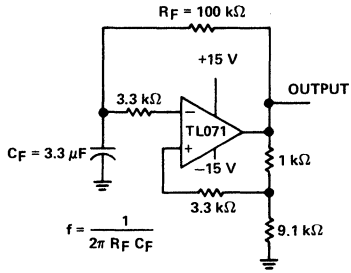


FIGURE 26–0.5-Hz SQUARE-WAVE OSCILLATOR

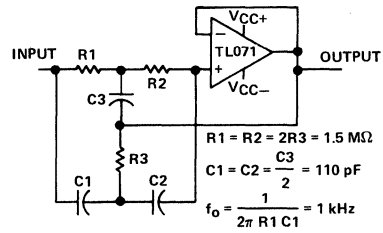
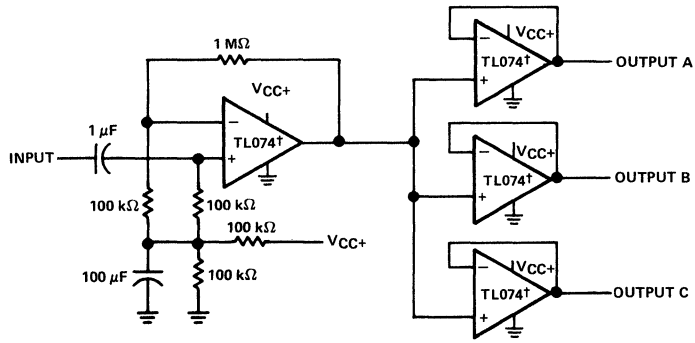


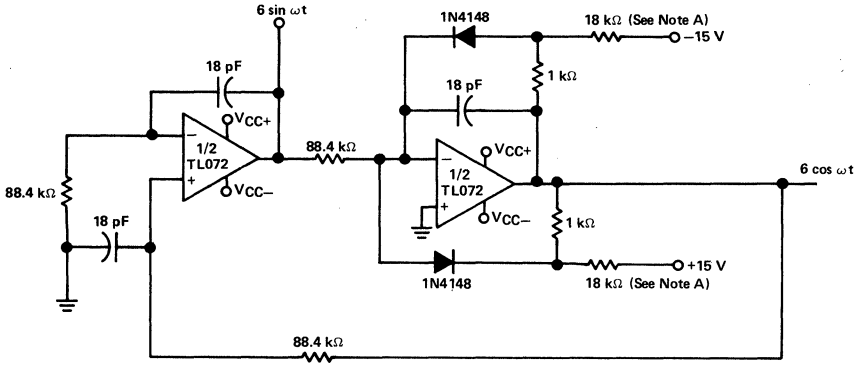
FIGURE 27–HIGH-Q NOTCH FILTER



† or TL075

FIGURE 28–AUDIO DISTRIBUTION AMPLIFIER

TYPICAL APPLICATION DATA



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

FIGURE 29–100-KHz QUADRATURE OSCILLATOR

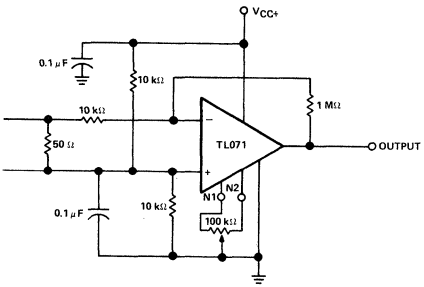


FIGURE 30–AC AMPLIFIER

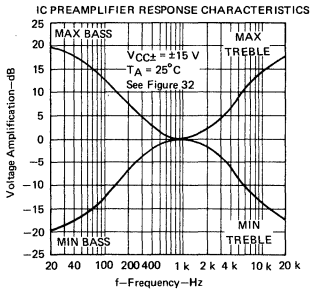


FIGURE 31

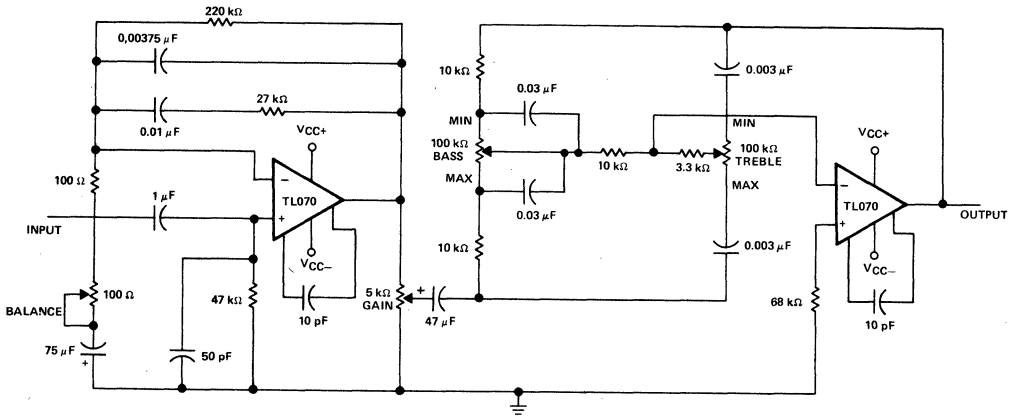


FIGURE 32–IC PREAMPLIFIER

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