

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

SLOS080C - SEPTEMBER 1978 - REVISED AUGUST 1994

**15 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  
 $V_n = 18 \text{ nV}/\sqrt{\text{Hz}}$  Typ at  $f = 1 \text{ kHz}$
- High Input Impedance . . . JFET Input Stage
- Internal Frequency Compensation
- Latch-Up-Free Operation
- High Slew Rate . . .  $13 \text{ V}/\mu\text{s}$  Typ
- Common-Mode Input Voltage Range  
Includes  $V_{CC+}$

**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 for high-fidelity and audio preamplifier applications. Each amplifier features JFET inputs (for high input impedance) coupled with bipolar output stages integrated on a single monolithic chip.

The C-suffix devices are characterized for operation from 0°C to 70°C. The I-suffix devices are characterized for operation from -40°C to 85°C. The M-suffix devices are characterized for operation over the full military temperature range of -55°C to 125°C.

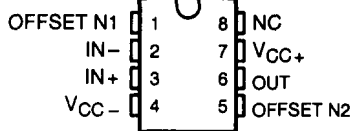
**AVAILABLE OPTIONS**

T <sub>A</sub>	V <sub>IO</sub> max AT 25°C	PACKAGE							
		SMALL OUTLINE (D) <sup>†</sup>	CHIP CARRIER (FK)	CERAMIC DIP (J)	CERAMIC DIP (JG)	PLASTIC DIP (N)	PLASTIC DIP (P)	TSSOP PACKAGE (PW)	FLAT PACKAGE (W)
0°C to 70°C	10 mV 6 mV 3 mV	TL071CD TL071ACD TL071BCD	—	—	—	—	TL071CP TL071ACP TL071BCP	TL071CPWLE — —	—
	10 mV 6 mV 3 mV	TL072CD TL072ACD TL072BCD	—	—	—	—	TL072CP TL072ACP TL072BCP	TL072CPWLE — —	—
	10 mV 6 mV 3 mV	TL074CD TL074ACD TL074BCD	—	—	—	TL074CN TL074ACN TL074BCN	—	TL074CPWLE — —	—
-40°C to 85°C	6 mV	TL071ID TL072ID TL074ID	—	—	—	— — TL074IN	TL071IP TL072P —	—	—
-55°C to 125°C	6 mV 6 mV 9 mV	—	TL071MFK TL072MFK TL074MFK	— — TL074MJ	TL071MJG TL072MJG —	—	—	—	— — TL074MW

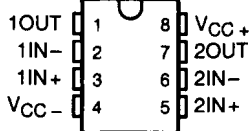
<sup>†</sup> The D package is available taped and reeled. Add the suffix R to the device type (e.g., TL071CDR). The PW package is only available left-ended taped and reeled (e.g., TL072CPWLE).

**TL071, TL071A, TL071B, TL072**  
**TL072A, TL072B, TL074, TL074A, TL074B**  
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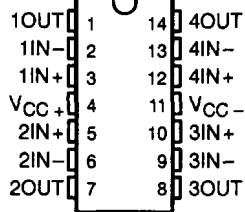
**TL071, TL071A, TL071B**  
 D, JG, P, OR PW PACKAGE  
 (TOP VIEW)



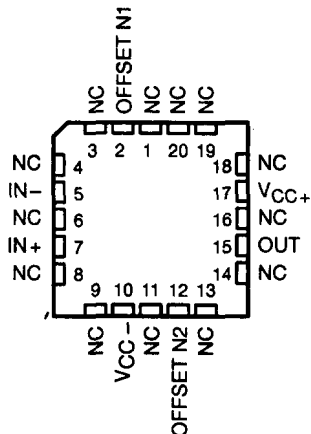
**TL072, TL072A, TL072B**  
 D, JG, P, OR PW PACKAGE  
 (TOP VIEW)



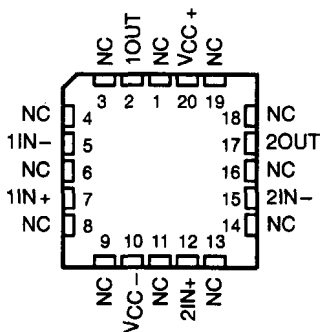
**TL074, TL074A, TL074B**  
 D, J, N, OR PW PACKAGE  
 TL074...W PACKAGE  
 (TOP VIEW)



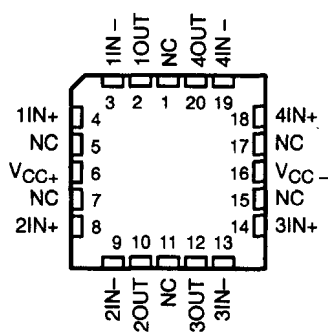
**TL071**  
 FK PACKAGE  
 (TOP VIEW)



**TL072**  
 FK PACKAGE  
 (TOP VIEW)

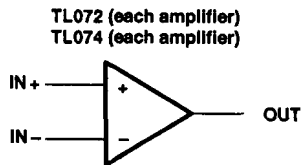
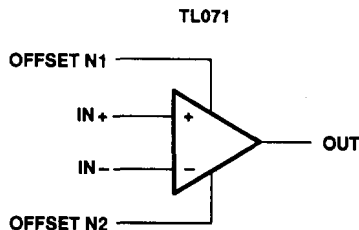


**TL074**  
 FK PACKAGE  
 (TOP VIEW)



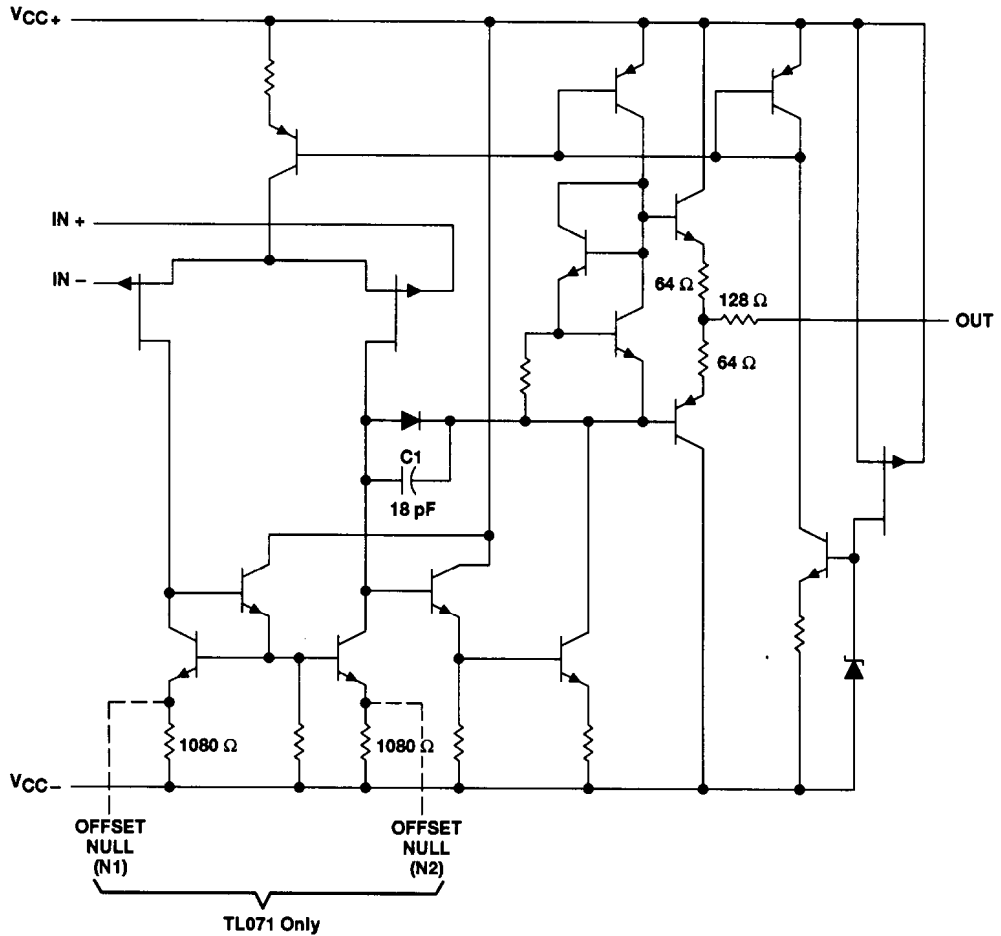
NC - No internal connection

**symbols**



**TL071, TL071A, TL071B, TL072**  
**TL072A, TL072B, TL074, TL074A, TL074B**  
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**schematic (each amplifier)**



All component values shown are nominal.

COMPONENT COUNT†			
COMPONENT TYPE	TL071	TL072	TL074
Resistors	11	22	44
Transistors	14	28	56
JFET	2	4	6
Diodes	1	2	4
Capacitors	1	2	4
epi-FET	1	2	4

† Includes bias and trim circuitry



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

PARAMETER	TEST CONDITIONS†	T <sub>A</sub> ‡	TL071C			TL071AC			TL071BC			TL071I			UNIT
			MIN	TYP	MAX	MIN	TYP	MAX	MIN	TYP	MAX	MIN	TYP	MAX	
V <sub>IO</sub>	VO = 0, R <sub>S</sub> = 50 Ω	25°C	3	10	3	6	3	6	2	3	3	6	6	mV	
		Full range		13		7.5		5		8		8			
αV <sub>IO</sub>	VO = 0, R <sub>S</sub> = 50 Ω	Full range		18		18		18		18		18		μV/°C	
I <sub>IO</sub>	VO = 0	25°C	5	100	5	100	5	100	5	100	5	100	pA		
		Full range		10		2		2		2		2	nA		
I <sub>IB</sub>	VO = 0	25°C	65	200	65	200	65	200	65	200	65	200	pA		
		Full range		7		7		7		7		20	nA		
V <sub>ICR</sub>	Common-mode input voltage range	25°C	±11	-12 to 15	±11	-12 to 15	±11	-12 to 15	±11	-12 to 15	±11	-12 to 15	V		
V <sub>OM</sub>	Maximum peak output voltage swing	25°C	±12	±13.5	±12	±13.5	±12	±13.5	±12	±13.5	±12	±13.5	V		
		Full range		±10		±10		±10		±10		±10			
AVD	Large-signal differential voltage amplification	25°C	25	200	25	200	25	200	25	200	25	200	V/mV		
		Full range		15		25		25		25		25			
B <sub>1</sub>	Unity-gain bandwidth	25°C		3		3		3		3		3	MHz		
r <sub>i</sub>	Input resistance	25°C		10 <sup>12</sup>		10 <sup>12</sup>		10 <sup>12</sup>		10 <sup>12</sup>		10 <sup>12</sup>	Ω		
CMRR	Common-mode rejection ratio	25°C	70	100	75	100	75	100	75	100	75	100	dB		
k <sub>SVR</sub>	Supply-voltage rejection ratio (ΔV <sub>CC±</sub> /ΔV <sub>IO</sub> )	25°C	70	100	80	100	80	100	80	100	80	100	dB		
I <sub>CC</sub>	Supply current (each amplifier)	25°C	1.4	2.5	1.4	2.5	1.4	2.5	1.4	2.5	1.4	2.5	mA		
V <sub>O1</sub> /V <sub>O2</sub>	Crosstalk attenuation	25°C		120		120		120		120		120	dB		

† All characteristics are measured under open-loop conditions with zero common-mode voltage unless otherwise specified.

‡ Full range is T<sub>A</sub> = 0°C to 70°C for TL07\_C, TL07\_AC, TL07\_BC and is T<sub>A</sub> = -40°C to 85°C for TL07\_I.

§ Input bias currents of a FET-input operational amplifier are normal junction reverse currents, which are temperature sensitive as shown in Figure 4. Pulse techniques must be used that will maintain the junction temperature as close to the ambient temperature as possible.



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

PARAMETER	TEST CONDITION†	$T_A$ ‡	TL071M TL072M			TL074M			UNIT
			MIN	TYP	MAX	MIN	TYP	MAX	
$V_{IO}$ Input offset voltage	$V_O = 0, R_S = 50 \Omega$	25°C		3	6		3	9	mV
		Full range			9		15		
$\alpha_{VIO}$ Temperature coefficient of input offset voltage	$V_O = 0, R_S = 50 \Omega$	Full range		18			18		$\mu\text{V}/^\circ\text{C}$
$I_{IO}$ Input offset current	$V_O = 0$	25°C		5	100		5	100	$\mu\text{A}$
		Full range			20		20		
$I_{IB}$ Input bias current‡	$V_O = 0$	25°C		65	200		65	200	$\mu\text{A}$
		Full range			50		50		
$V_{ICR}$ Common-mode input voltage range		25°C	$\pm 11$	-12 to 15		$\pm 11$	-12 to 15		V
$V_{OM}$ Maximum peak output voltage swing	$R_L = 10 \text{ k}\Omega$	25°C	$\pm 12$	$\pm 13.5$		$\pm 12$	$\pm 13.5$		V
	$R_L \geq 10 \text{ k}\Omega$	Full range	$\pm 12$			$\pm 12$			
	$R_L \geq 2 \text{ k}\Omega$		$\pm 10$			$\pm 10$			
$A_{VD}$ Large-signal differential voltage amplification	$V_O = \pm 10 \text{ V}, R_L \geq 2 \text{ k}\Omega$	25°C	35	200		35	200		V/mV
		Full range	15			15			
$B_1$ Unity-gain bandwidth	$T_A = 25^\circ\text{C}$			3		3			MHz
$r_i$ Input resistance	$T_A = 25^\circ\text{C}$			$10^{12}$		$10^{12}$			$\Omega$
CMRR Common-mode rejection ratio	$V_{IC} = V_{ICRmin}, V_O = 0, R_S = 50 \Omega$	25°C	80	86		80	86		dB
$k_{SVR}$ Supply-voltage rejection ratio ( $\Delta V_{CC\pm}/\Delta V_{IO}$ )	$V_{CC} = \pm 9 \text{ V to } \pm 15 \text{ V}, V_O = 0, R_S = 50 \Omega$	25°C	80	86		80	86		dB
$I_{CC}$ Supply current (each amplifier)	$V_O = 0, \text{ No load}$	25°C		1.4	2.5		1.4	2.5	mA
$V_{O1}/V_{O2}$ Crosstalk attenuation	$A_{VD} = 100$	25°C		120			120		dB

† Input bias currents of a FET-input operational amplifier are normal junction reverse currents, which are temperature sensitive as shown in Figure 4. Pulse techniques must be used that will maintain the junction temperature as close to the ambient temperature as possible.

‡ All characteristics are measured under open-loop conditions with zero common-mode voltage unless otherwise specified. Full range is  $T_A = -55^\circ\text{C}$  to  $125^\circ\text{C}$ .

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

PARAMETER	TEST CONDITIONS	TL07xM			ALL OTHERS			UNIT
		MIN	TYP	MAX	MIN	TYP	MAX	
SR	Slew rate at unity gain $V_I = 10\text{ V}$ , $C_L = 100\text{ pF}$ , $R_L = 2\text{ k}\Omega$ , See Figure 1	5	13		8	13		$\text{V}/\mu\text{s}$
$t_r$	Rise time overshoot factor $V_I = 20\text{ mV}$ , $C_L = 100\text{ pF}$ , $R_L = 2\text{ k}\Omega$ , See Figure 1		0.1			0.1		$\mu\text{s}$
$V_n$	Equivalent input noise voltage $R_S = 20\ \Omega$	$f = 1\text{ kHz}$		18		18		$\text{nV}/\sqrt{\text{Hz}}$
		$f = 10\text{ Hz to } 10\text{ kHz}$		4		4		$\mu\text{V}$
$I_n$	Equivalent input noise current $R_S = 20\ \Omega$ , $f = 1\text{ kHz}$		0.01			0.01		$\text{pA}/\sqrt{\text{Hz}}$
THD	Total harmonic distortion $V_O(\text{RMS}) = 10\text{ V}$ , $R_L \geq 2\text{ k}\Omega$ , $R_S \leq 1\text{ k}\Omega$ , $f = 1\text{ kHz}$		0.003%			0.003%		

**PARAMETER MEASUREMENT INFORMATION**

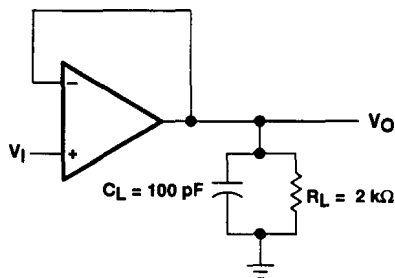


Figure 1. Unity-Gain Amplifier

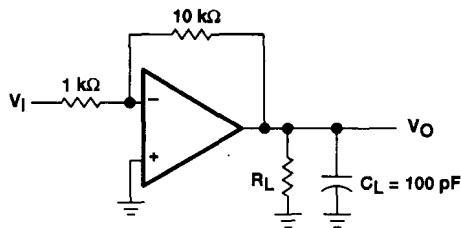


Figure 2. Gain-of-10 Inverting Amplifier

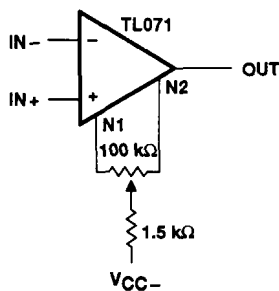


Figure 3. Input Offset Voltage Null Circuit

**TL071, TL071A, TL071B, TL072  
 TL072A, TL072B, TL074, TL074A, TL074B  
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**TYPICAL CHARACTERISTICS**

**Table of Graphs**

			FIGURE
I <sub>B</sub>	Input bias current	vs Free-air temperature	4
V <sub>OM</sub>	Maximum output voltage	vs Frequency	5, 6, 7
		vs Free-air temperature	8
		vs Load resistance	9
		vs Supply voltage	10
A <sub>VD</sub>	Large-signal differential voltage amplification	vs Free-air temperature	11
		vs Frequency	12
	Phase shift	vs Frequency	12
	Normalized unity-gain bandwidth	vs Free-air temperature	13
	Normalized phase shift	vs Free-air temperature	13
CMRR	Common-mode rejection ratio	vs Free-air temperature	14
I <sub>CC</sub>	Supply current	vs Supply voltage	15
		vs Free-air temperature	16
P <sub>D</sub>	Total power dissipation	vs Free-air temperature	17
	Normalized slew rate	vs Free-air temperature	18
V <sub>n</sub>	Equivalent input noise voltage	vs Frequency	19
THD	Total harmonic distortion	vs Frequency	20
	Large-signal pulse response	vs Time	21
V <sub>O</sub>	Output voltage	vs Time	22





TYPICAL CHARACTERISTICS†

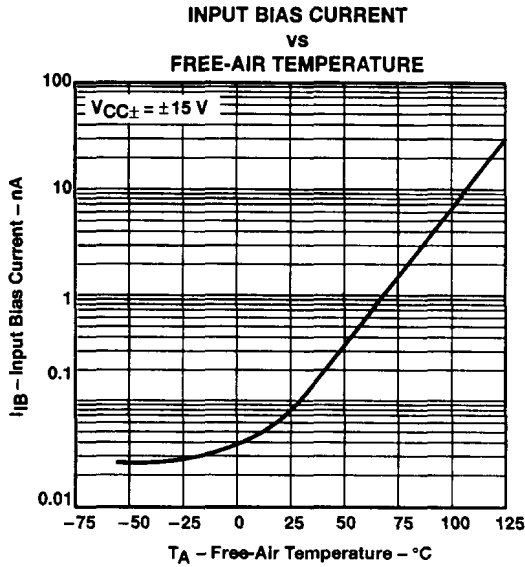


Figure 4

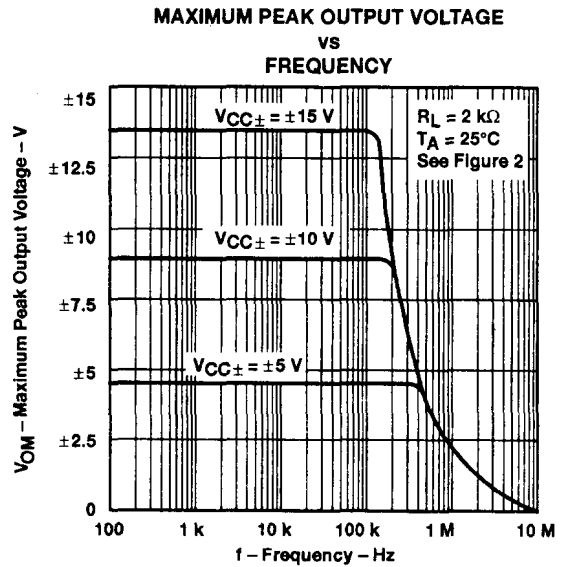


Figure 5

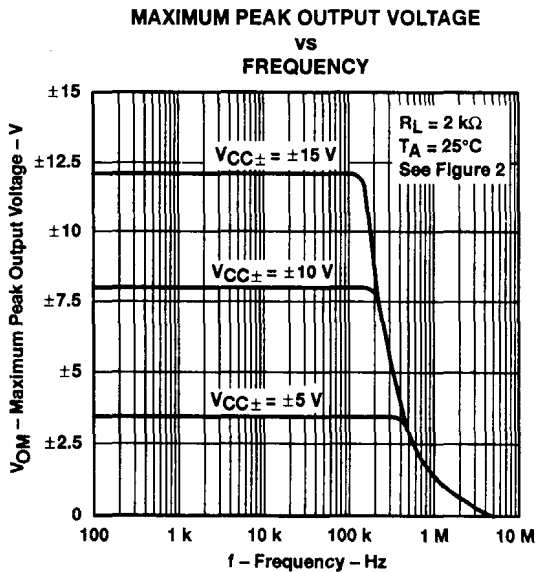


Figure 6

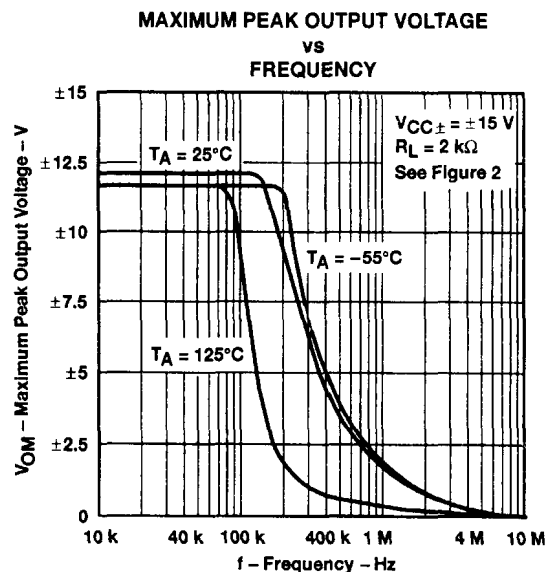


Figure 7

† Data at high and low temperatures are applicable only within the rated operating free-air temperature ranges of the various devices.

**TL071, TL071A, TL071B, TL072  
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**TYPICAL CHARACTERISTICS†**

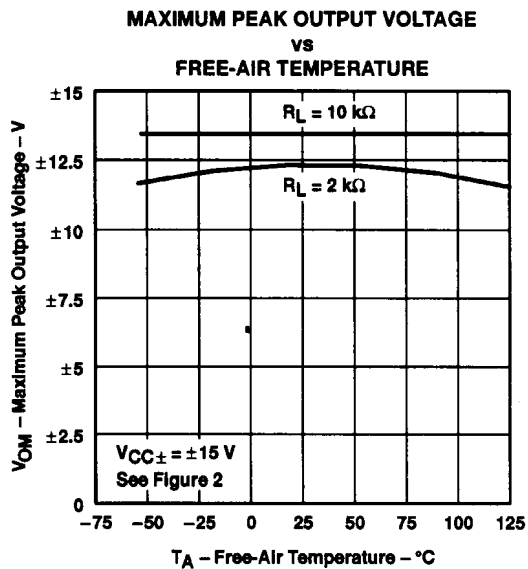


Figure 8

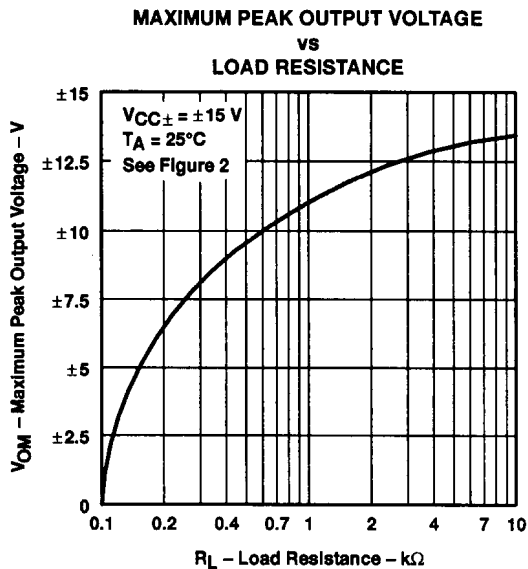


Figure 9

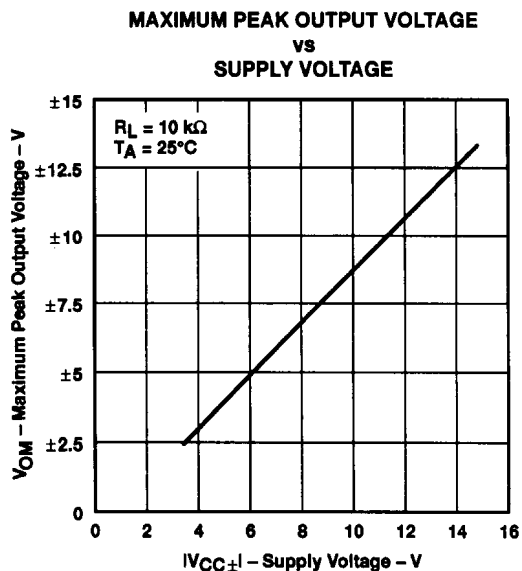


Figure 10

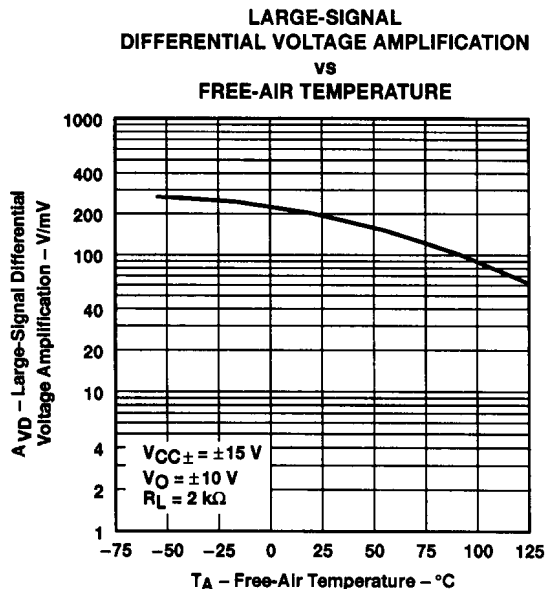


Figure 11

† Data at high and low temperatures are applicable only within the rated operating free-air temperature ranges of the various devices.

TYPICAL CHARACTERISTICS†

LARGE-SIGNAL  
 DIFFERENTIAL VOLTAGE AMPLIFICATION  
 AND PHASE SHIFT  
 vs  
 FREQUENCY

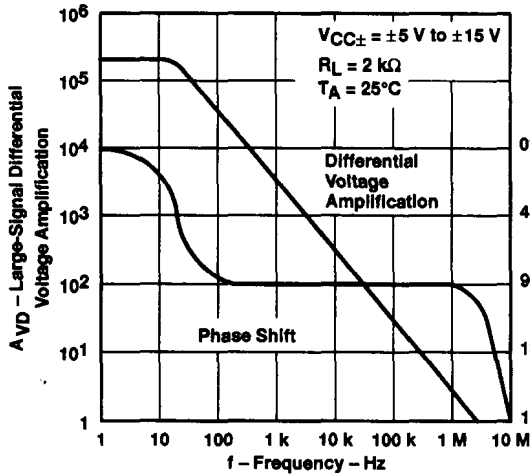


Figure 12

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

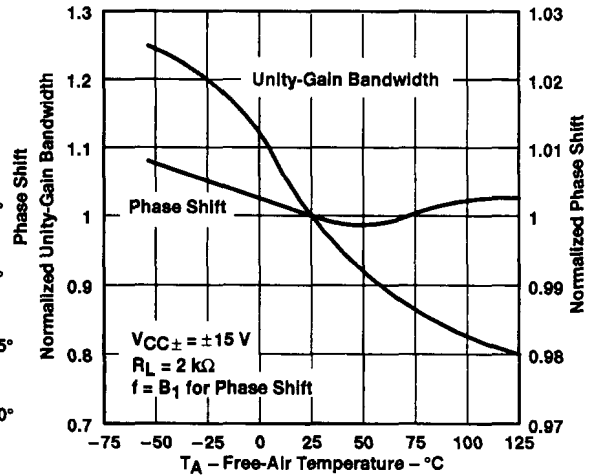


Figure 13

COMMON-MODE REJECTION RATIO  
 vs  
 FREE-AIR TEMPERATURE

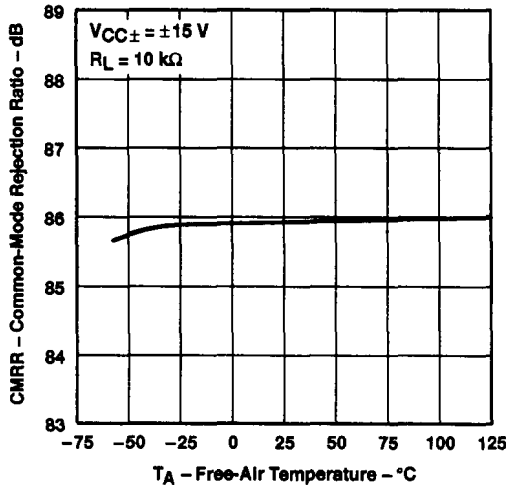


Figure 14

SUPPLY CURRENT PER AMPLIFIER  
 vs  
 SUPPLY VOLTAGE

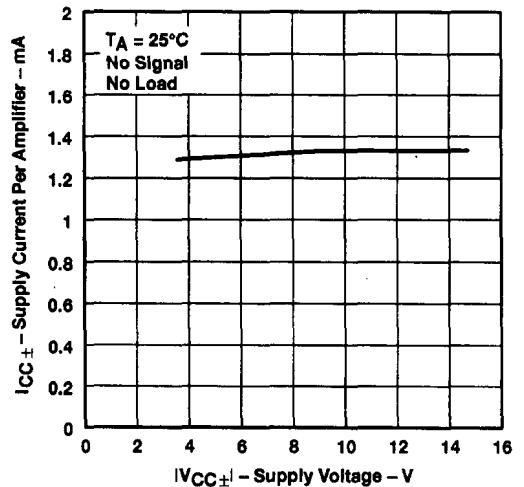
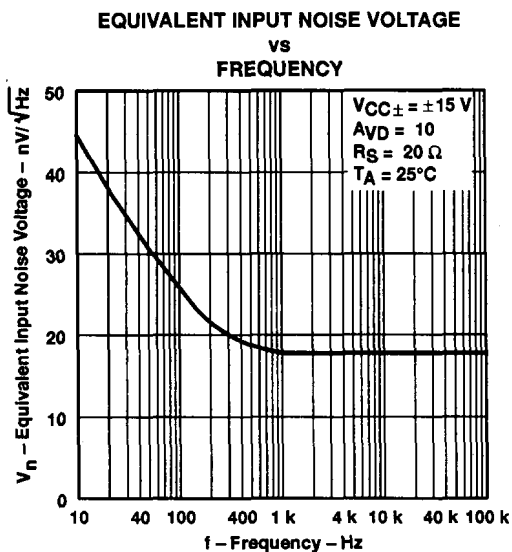
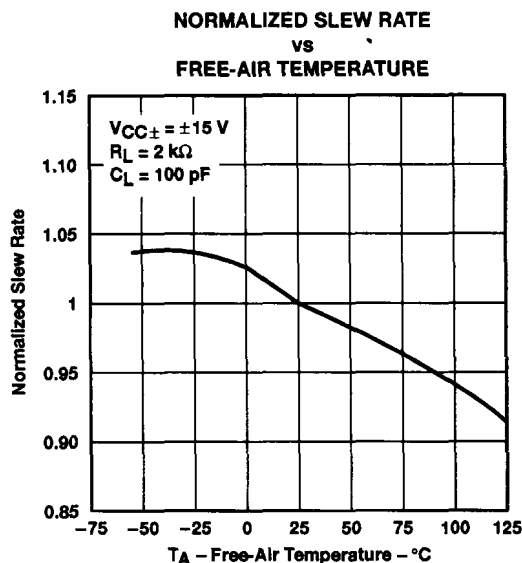
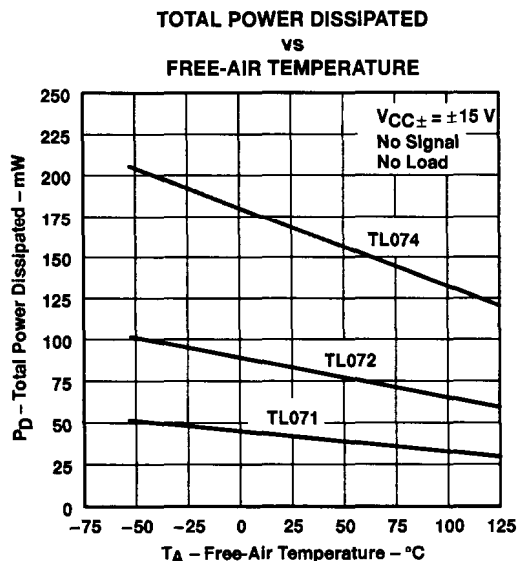
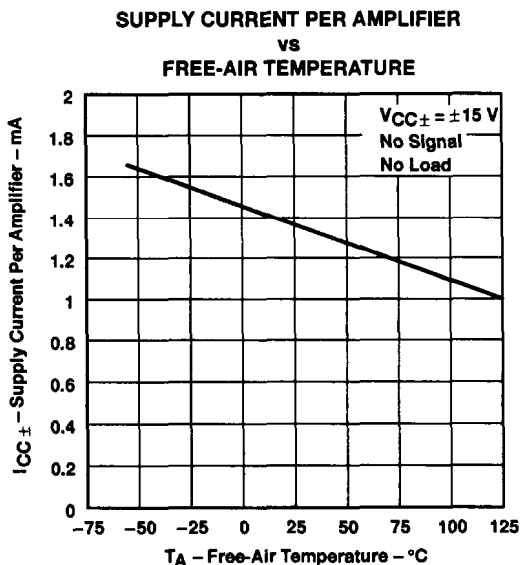


Figure 15

† Data at high and low temperatures are applicable only within the rated operating free-air temperature ranges of the various devices.

TYPICAL CHARACTERISTICS†



† Data at high and low temperatures are applicable only within the rated operating free-air temperature ranges of the various devices.

TYPICAL CHARACTERISTICS

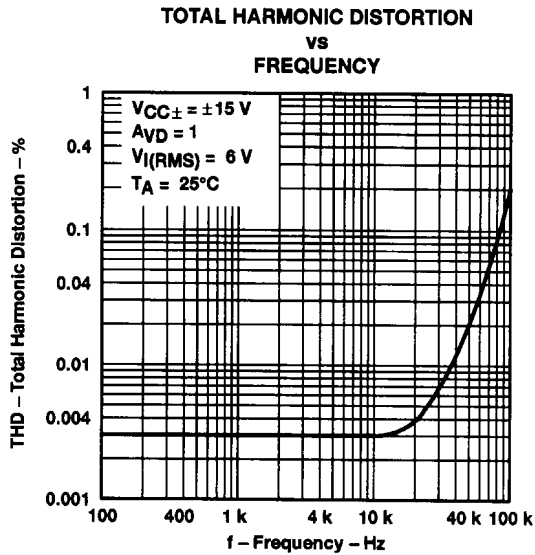


Figure 20

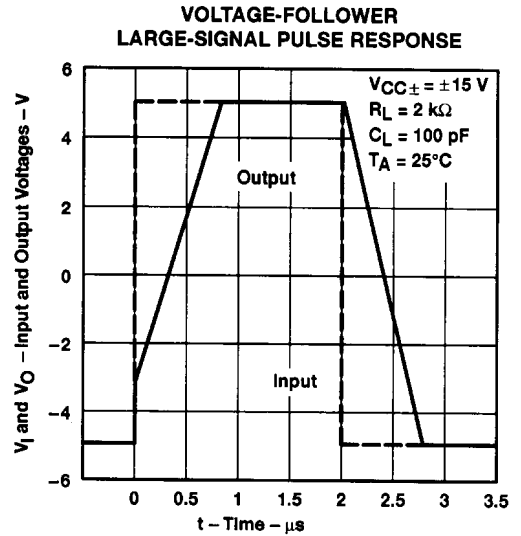


Figure 21

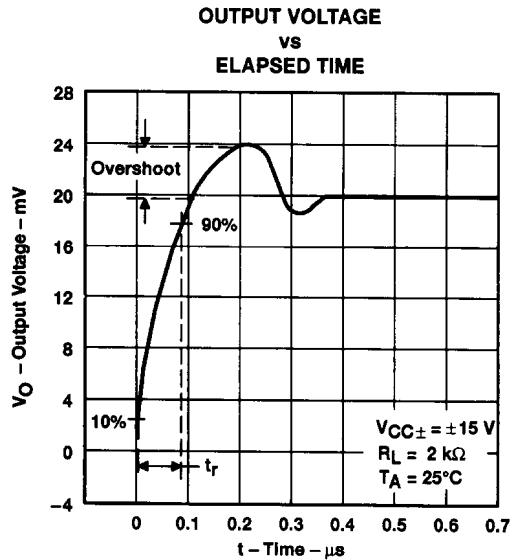
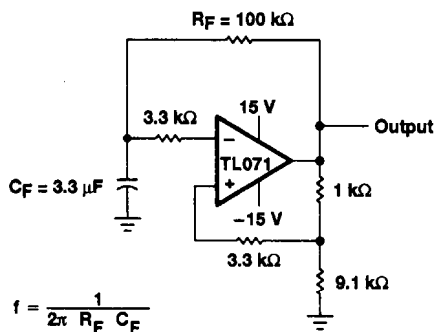


Figure 22

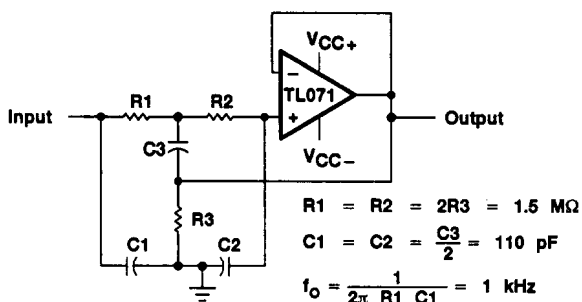
**APPLICATION INFORMATION**

**Table of Application Diagrams**

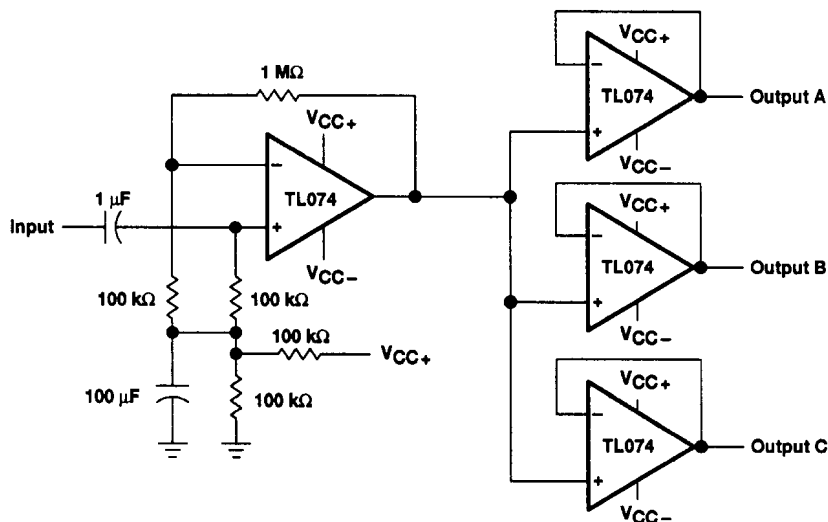
APPLICATION DIAGRAM	PART NUMBER	FIGURE
0.5-Hz square-wave oscillator	TL071	23
High-Q notch filter	TL071	24
Audio-distribution amplifier	TL074	25
100-kHz quadrature oscillator	TL072	26
AC amplifier	TL071	27



**Figure 23. 0.5-Hz Square-Wave Oscillator**

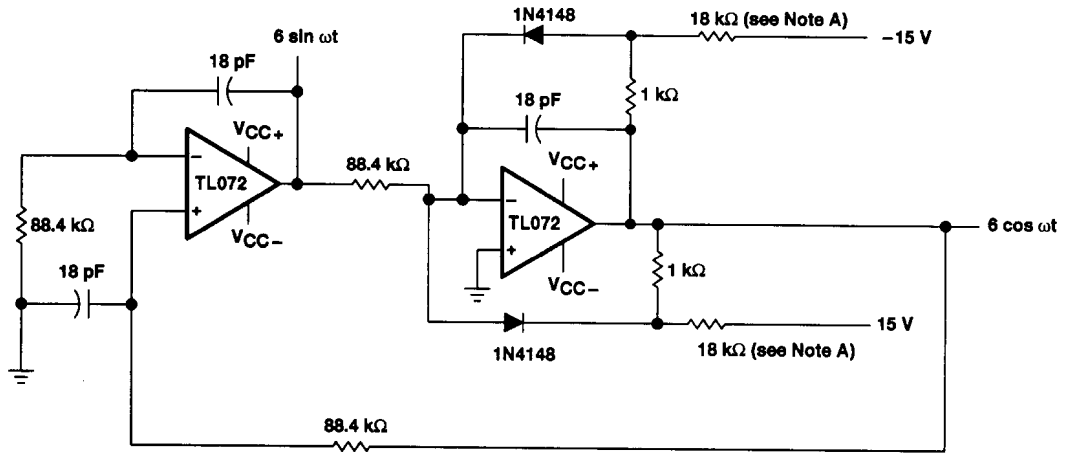


**Figure 24. High-Q Notch Filter**



**Figure 25. Audio-Distribution Amplifier**

APPLICATION INFORMATION



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

Figure 26. 100-kHz Quadrature Oscillator

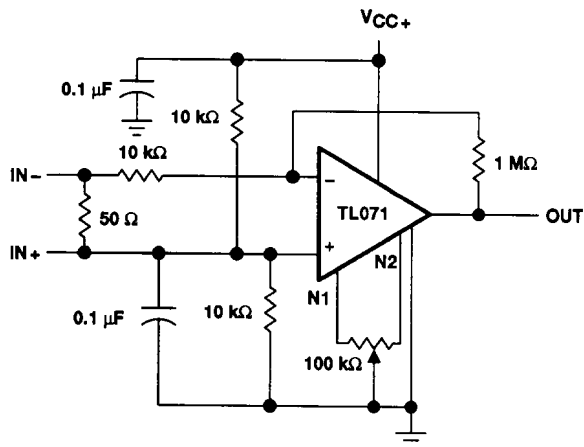


Figure 27. AC Amplifier