

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

SLOS080D – SEPTEMBER 1978 – REVISED AUGUST 1996

- 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)†	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 TL072IP —	—	—
–55°C to 125°C	6 mV 6 mV 9 mV	—	TL071MFK TL072MFK TL074MFK	— — TL074MJ	TL071MJG TL072MJG —	— — TL074MN	— TL072MP —	—	— — TL074MW

† 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).



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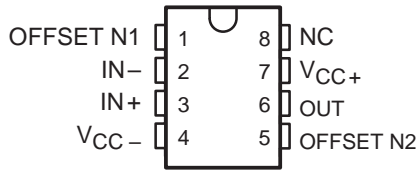
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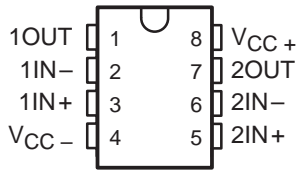
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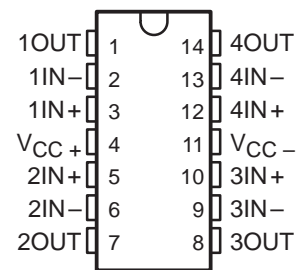
**TL071, TL071A, TL071B**  
D, JG, P, OR PW PACKAGE  
(TOP VIEW)



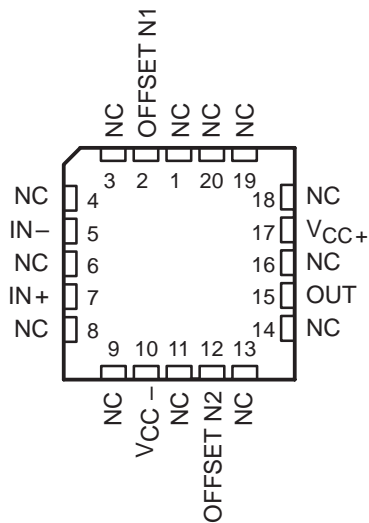
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D, JG, P, OR PW PACKAGE  
(TOP VIEW)



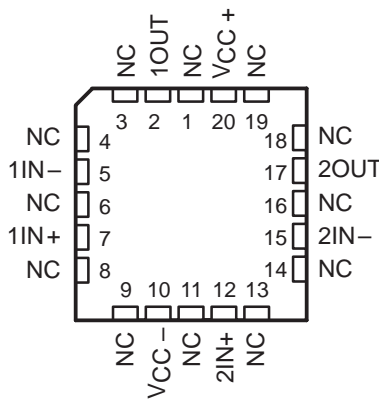
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D, J, N, OR PW PACKAGE  
TL074...W PACKAGE  
(TOP VIEW)



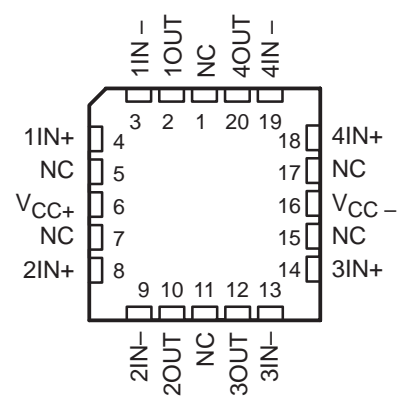
**TL071**  
FK PACKAGE  
(TOP VIEW)



**TL072**  
FK PACKAGE  
(TOP VIEW)

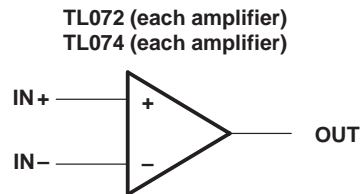
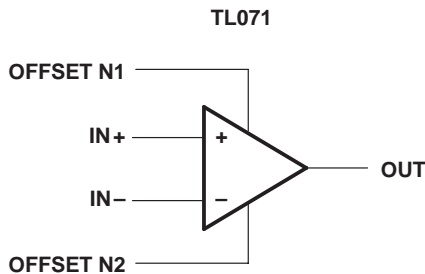


**TL074**  
FK PACKAGE  
(TOP VIEW)



NC – No internal connection

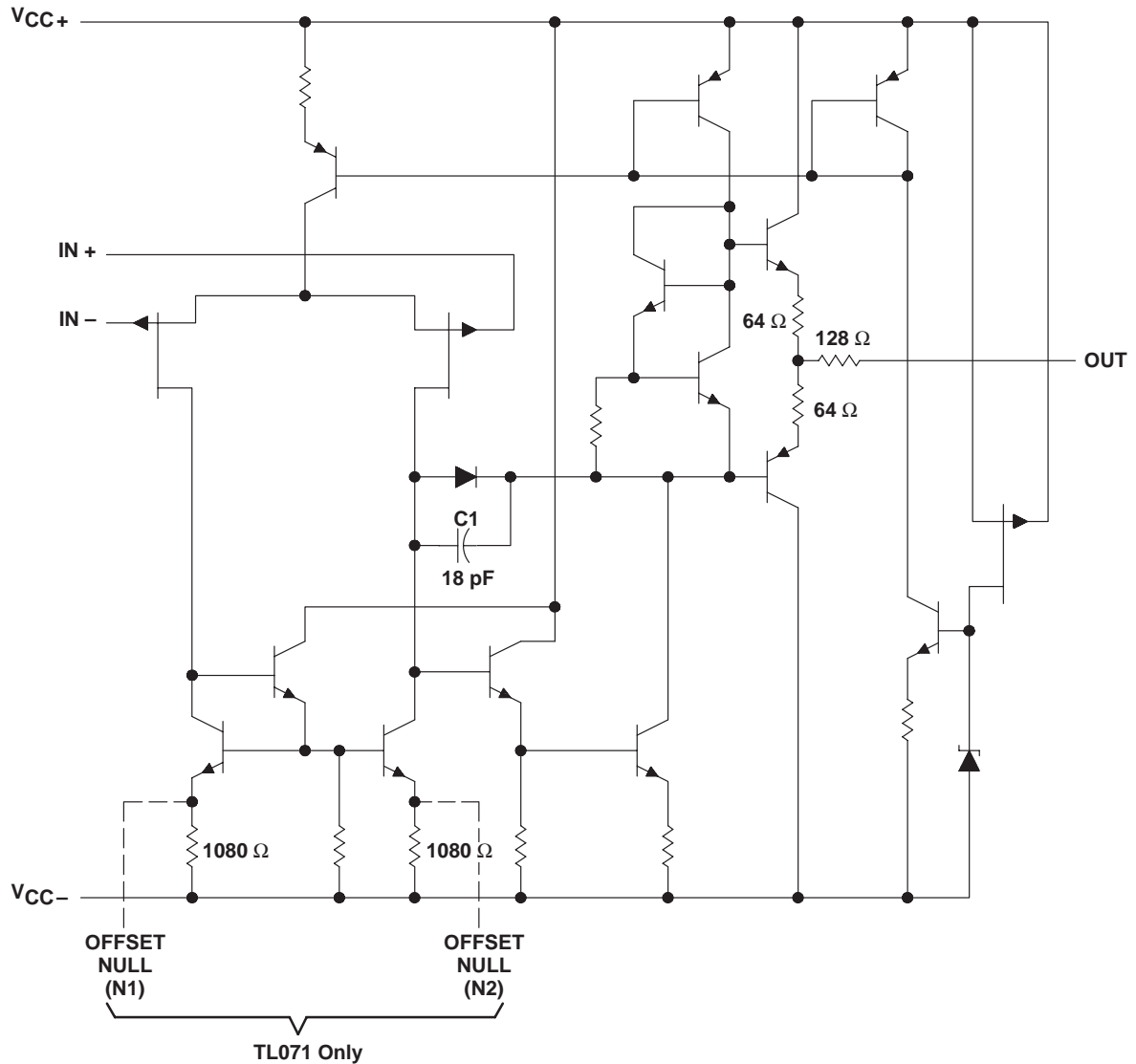
## symbols



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

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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

# TL071, TL071A, TL071B, TL072 TL072A, TL072B, TL074, TL074A, TL074B

## LOW-NOISE JFET-INPUT OPERATIONAL AMPLIFIERS

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

Supply voltage, $V_{CC+}$ (see Note 1) .....	18 V
Supply voltage, $V_{CC-}$ (see Note 1) .....	–18 V
Differential input voltage, $V_{ID}$ (see Note 2) .....	$\pm 30$ V
Input voltage, $V_I$ (see Notes 1 and 3) .....	$\pm 15$ V
Duration of output short circuit (see Note 4) .....	unlimited
Continuous total power dissipation .....	See Dissipation Rating Table
Operating free-air temperature range, $T_A$ : C suffix .....	0°C to 70°C
I suffix .....	–40°C to 85°C
M suffix .....	–55°C to 125°C
Storage temperature range .....	–65°C to 150°C
Case temperature for 60 seconds: FK package .....	260°C
Lead temperature 1,6 mm (1/16 inch) from case for 10 seconds: J, JG, or W package .....	300°C
Lead temperature 1,6 mm (1/16 inch) from case for 10 seconds: D, N, P, or PW package .....	260°C

† Stresses beyond those listed under “absolute maximum ratings” may cause permanent damage to the device. These are stress ratings only, and functional operation of the device at these or any other conditions beyond those indicated under “recommended operating conditions” is not implied. Exposure to absolute-maximum-rated conditions for extended periods may affect device reliability.

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 IN+ with respect to IN–.

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	$T_A \leq 25^\circ\text{C}$ POWER RATING	DERATING FACTOR	DERATE ABOVE $T_A$	$T_A = 70^\circ\text{C}$ POWER RATING	$T_A = 85^\circ\text{C}$ POWER RATING	$T_A = 125^\circ\text{C}$ POWER RATING
D (8 pin)	680 mW	5.8 mW/ $^\circ\text{C}$	33°C	465 mW	378 mW	N/A
D (14 pin)	680 mW	7.6 mW/ $^\circ\text{C}$	60°C	604 mW	490 mW	N/A
FK	680 mW	11.0 mW/ $^\circ\text{C}$	88°C	680 mW	680 mW	273 mW
J	680 mW	11.0 mW/ $^\circ\text{C}$	88°C	680 mW	680 mW	273 mW
JG	680 mW	8.4 mW/ $^\circ\text{C}$	69°C	672 mW	546 mW	210 mW
N	680 mW	9.2 mW/ $^\circ\text{C}$	76°C	680 mW	597 mW	N/A
P	680 mW	8.0 mW/ $^\circ\text{C}$	65°C	640 mW	520 mW	N/A
PW (8 pin)	525 mW	4.2 mW/ $^\circ\text{C}$	70°C	525 mW	N/A	N/A
PW (14 pin)	700 mW	5.6 mW/ $^\circ\text{C}$	70°C	700 mW	N/A	N/A
W	680 mW	8.0 mW/ $^\circ\text{C}$	65°C	640 mW	520 mW	200 mW

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

PARAMETER	TEST CONDITIONS†	T <sub>A</sub> ‡	TL071C TL072C TL074C			TL071AC TL072AC TL074AC			TL071BC TL072BC TL074BC			TL071I TL072I TL074I			UNIT
			MIN	TYP	MAX	MIN	TYP	MAX	MIN	TYP	MAX	MIN	TYP	MAX	
V <sub>IO</sub>	Input offset voltage	V <sub>O</sub> = 0, R <sub>S</sub> = 50 Ω	25°C		3	10	3	6	2	3	3	6	mV		
			Full range		13		7.5		5		8				
α <sub>VIO</sub>	Temperature coefficient of input offset voltage	V <sub>O</sub> = 0, R <sub>S</sub> = 50 Ω	Full range		18		18		18		18		μV/°C		
I <sub>IO</sub>	Input offset current	V <sub>O</sub> = 0	25°C		5	100	5	100	5	100	5	100	pA		
			Full range		10		2		2		2		nA		
I <sub>IB</sub>	Input bias current§	V <sub>O</sub> = 0	25°C		65	200	65	200	65	200	65	200	pA		
			Full range		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	V		
V <sub>OM</sub>	Maximum peak output voltage swing	R <sub>L</sub> = 10 kΩ	25°C		±12	±13.5	±12	±13.5	±12	±13.5	±12	±13.5	V		
		R <sub>L</sub> ≥ 10 kΩ	Full range		±12		±12		±12		±12				
		R <sub>L</sub> ≥ 2 kΩ	Full range		±10		±10		±10		±10				
A <sub>VD</sub>	Large-signal differential voltage amplification	V <sub>O</sub> = ±10 V, R <sub>L</sub> ≥ 2 kΩ	25°C		25	200	50	200	50	200	50	200	V/mV		
			Full range		15		25		25		25				
B <sub>1</sub>	Unity-gain bandwidth		25°C		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>		Ω		
CMRR	Common-mode rejection ratio	V <sub>IC</sub> = V <sub>ICRmin</sub> , V <sub>O</sub> = 0, R <sub>S</sub> = 50 Ω	25°C		70	100	75	100	75	100	75	100	dB		
k <sub>SVR</sub>	Supply-voltage rejection ratio (ΔV <sub>CC±</sub> /ΔV <sub>IO</sub> )	V <sub>CC</sub> = ±9 V to ±15 V, V <sub>O</sub> = 0, R <sub>S</sub> = 50 Ω	25°C		70	100	80	100	80	100	80	100	dB		
I <sub>CC</sub>	Supply current (each amplifier)	V <sub>O</sub> = 0, No load	25°C		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	A <sub>VD</sub> = 100	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 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 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 CONDITIONS†	$T_A$ ‡	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		$\mu V/^\circ C$	
$I_{IO}$ Input offset current	$V_O = 0$	25°C	5	100		5	100	pA	
		Full range			20		20	nA	
$I_{IB}$ Input bias current‡	$V_O = 0$	25°C	65	200		65	200	pA	
		Full range			50		50	nA	
$V_{ICR}$ 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	$T_A = 25^\circ C$		3			3		MHz	
$r_i$ Input resistance	$T_A = 25^\circ C$		$10^{12}$			$10^{12}$		$\Omega$	
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  $T_A = -55^\circ C$  to  $125^\circ C$ .



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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			$\mu\text{s}$
		20%			20%			
$V_n$	Equivalent input noise voltage $R_S = 20\ \Omega$	$f = 1\text{ kHz}$			18			$\text{nV}/\sqrt{\text{Hz}}$
		$f = 10\text{ Hz to } 10\text{ kHz}$			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 $V_{\text{rms}} = 6\text{ V}$ , $R_L \geq 2\text{ k}\Omega$ , $f = 1\text{ kHz}$ , $A_{VD} = 1$ , $R_S \leq 1\text{ k}\Omega$ ,	0.003%			0.003%			

**PARAMETER MEASUREMENT INFORMATION**

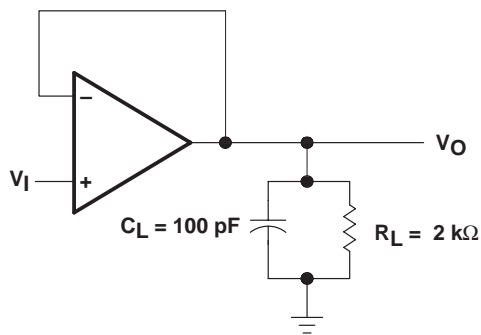


Figure 1. Unity-Gain Amplifier

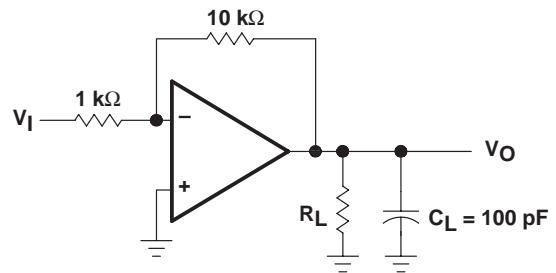


Figure 2. Gain-of-10 Inverting Amplifier

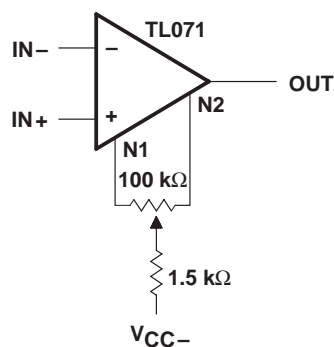


Figure 3. Input Offset Voltage Null Circuit

**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
V <sub>n</sub>	Equivalent input noise voltage	vs Frequency	19
THD	Total harmonic distortion	vs Frequency	20
		Large-signal pulse response	vs Time
V <sub>O</sub>	Output voltage	vs Elapsed time	22



TYPICAL CHARACTERISTICS†

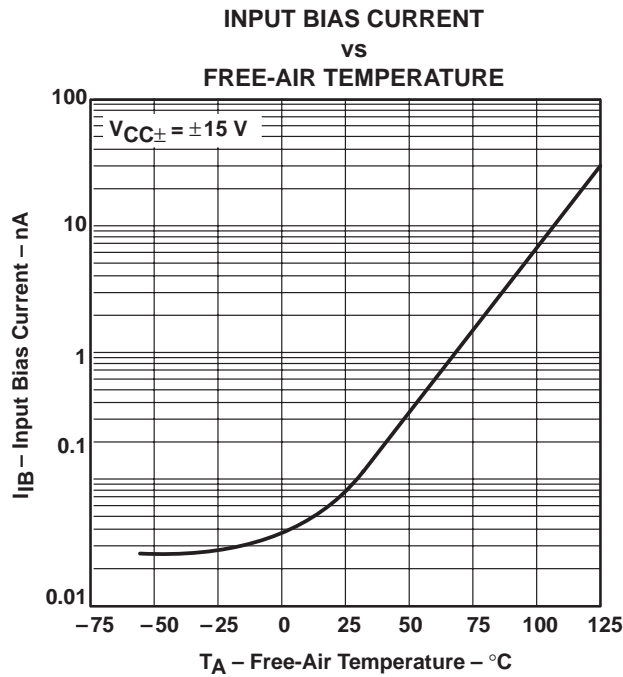


Figure 4

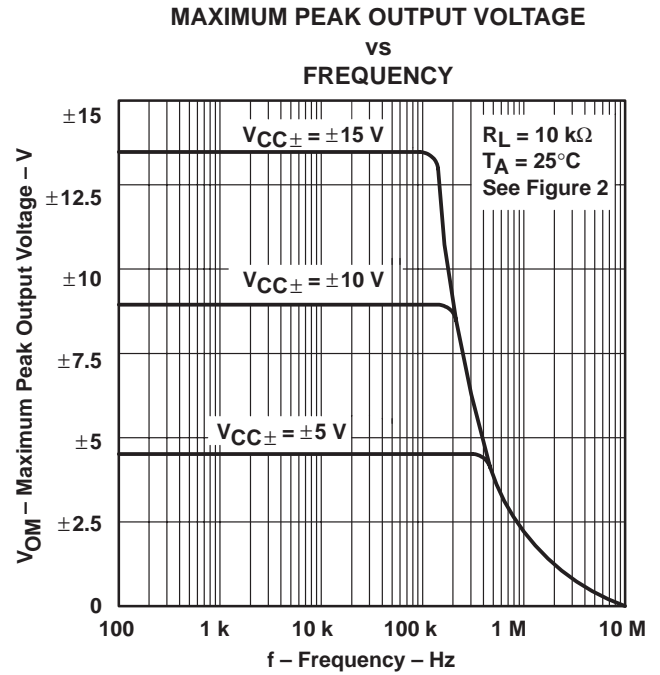


Figure 5

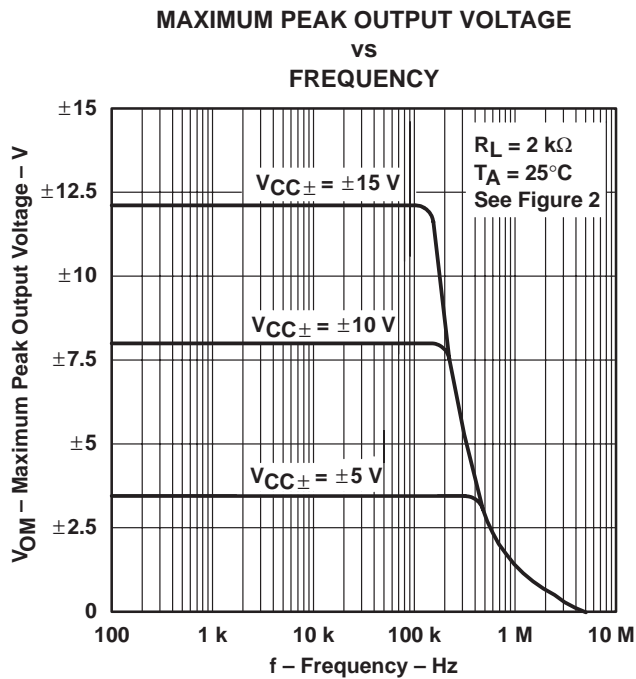


Figure 6

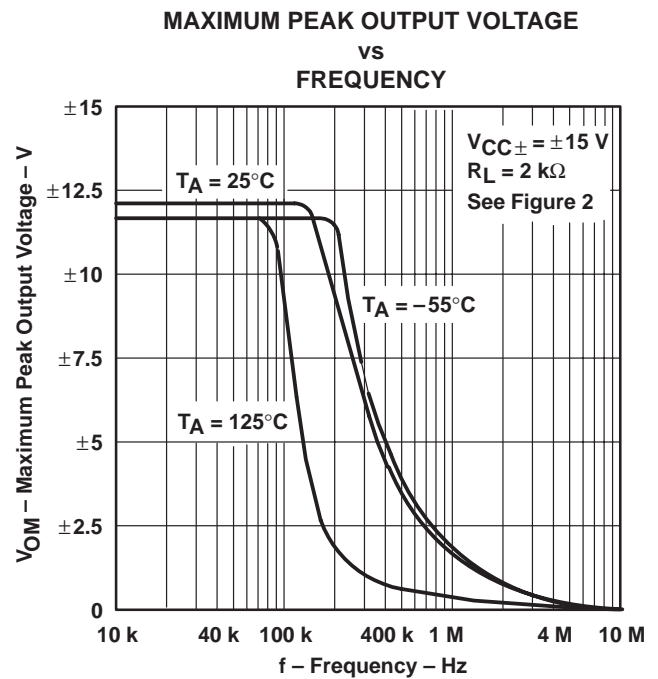


Figure 7

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

TYPICAL CHARACTERISTICS†

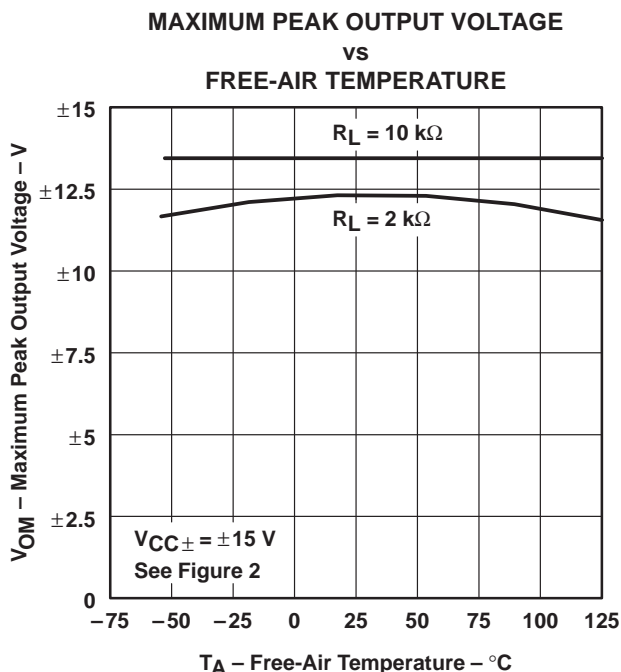


Figure 8

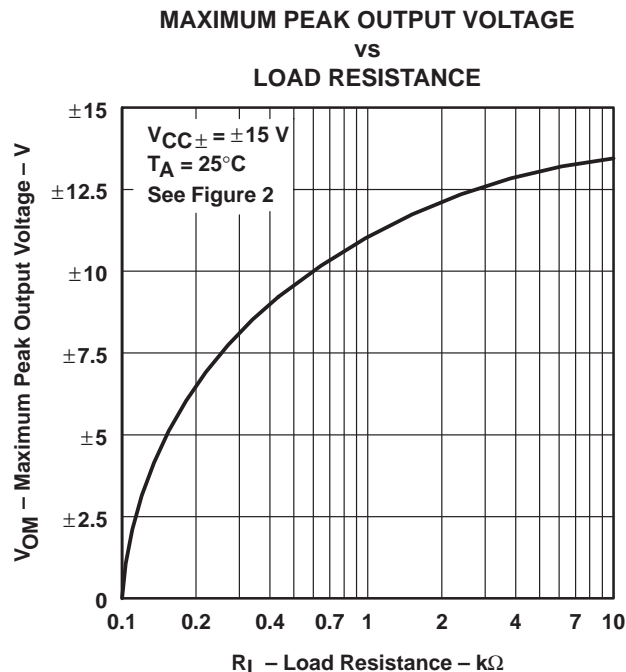


Figure 9

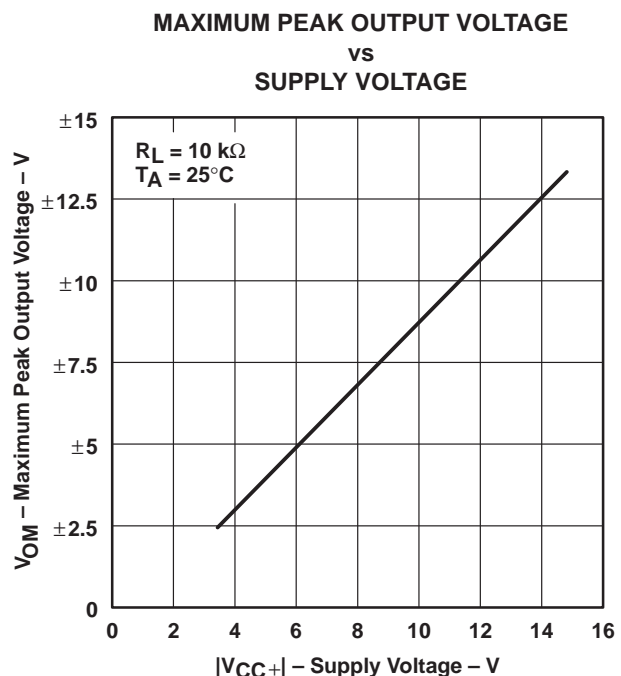


Figure 10

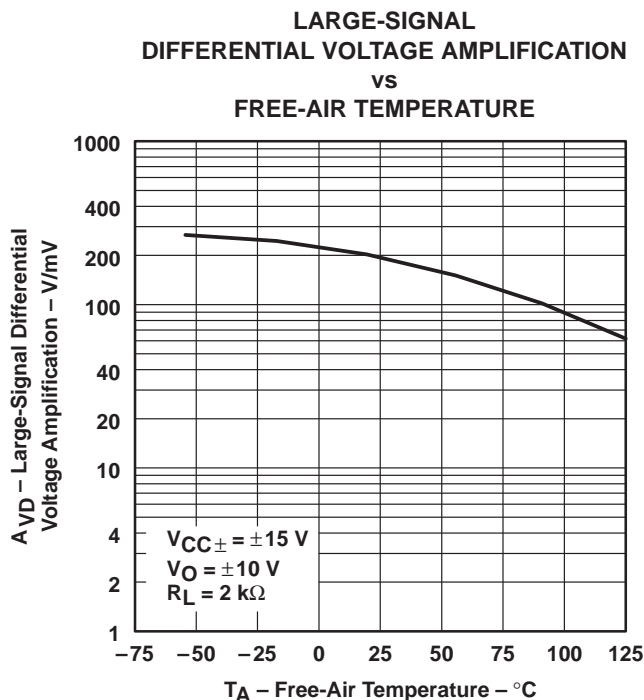


Figure 11

† 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

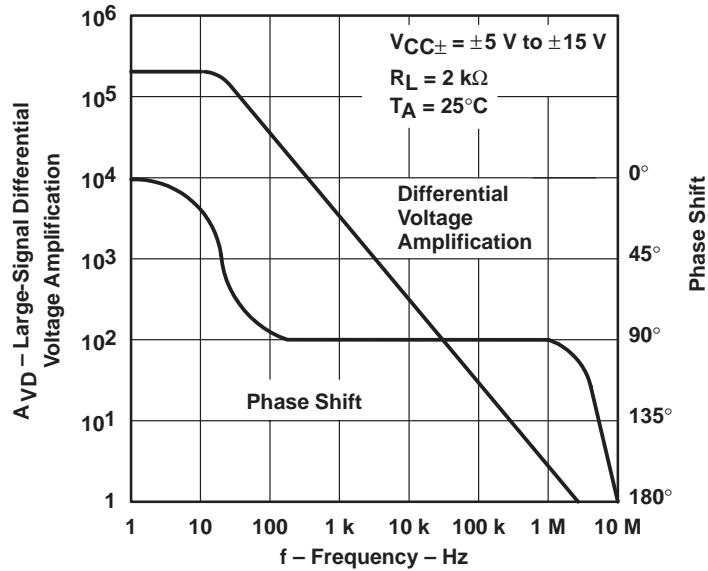


Figure 12

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

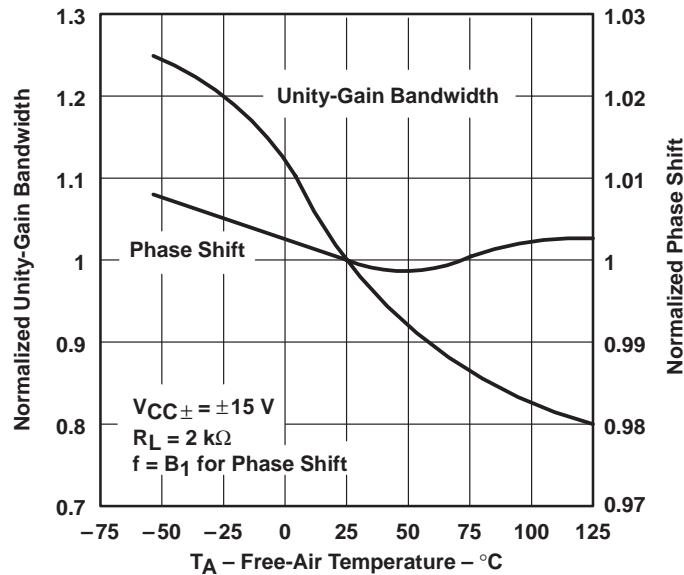


Figure 13

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

TYPICAL CHARACTERISTICS†

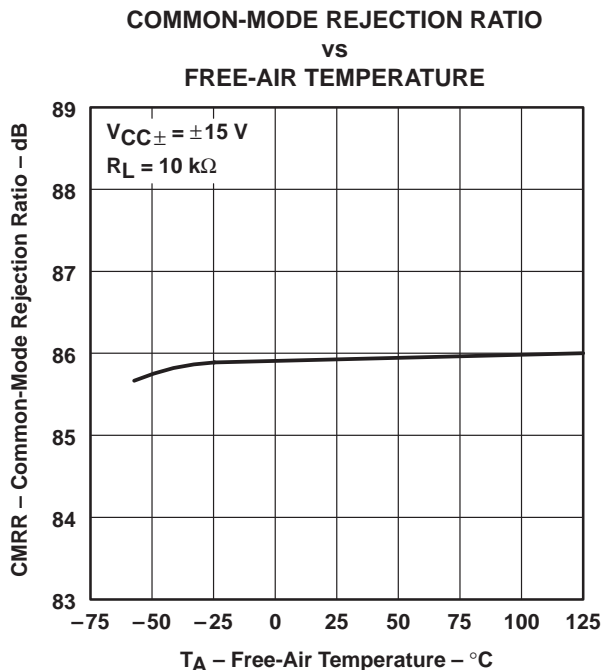


Figure 14

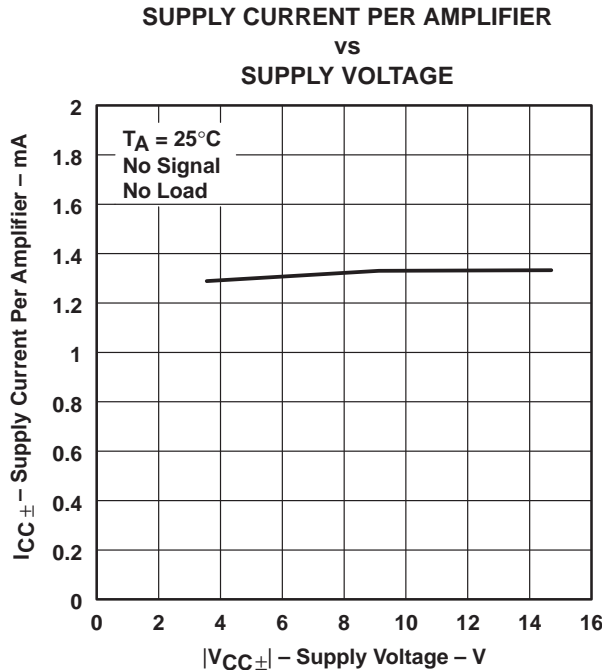


Figure 15

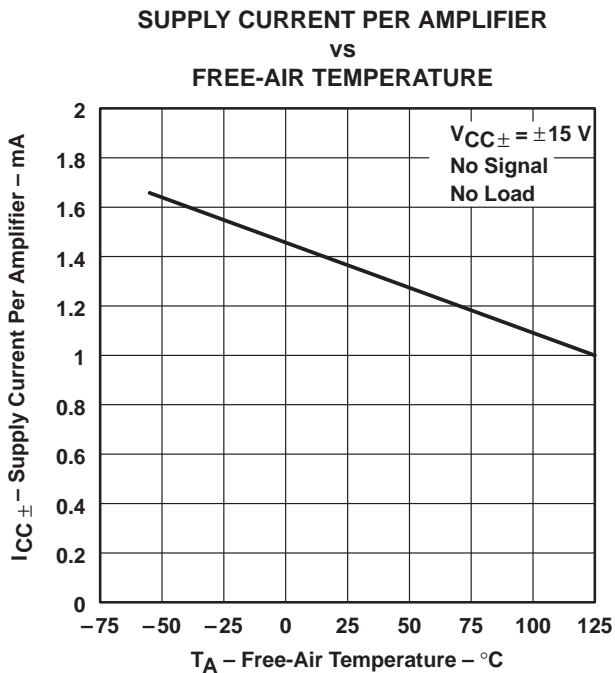


Figure 16

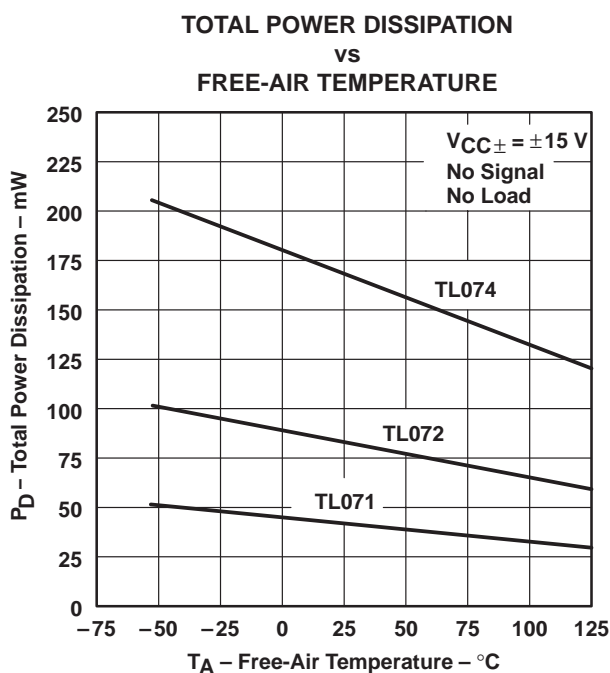


Figure 17

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

TYPICAL CHARACTERISTICS

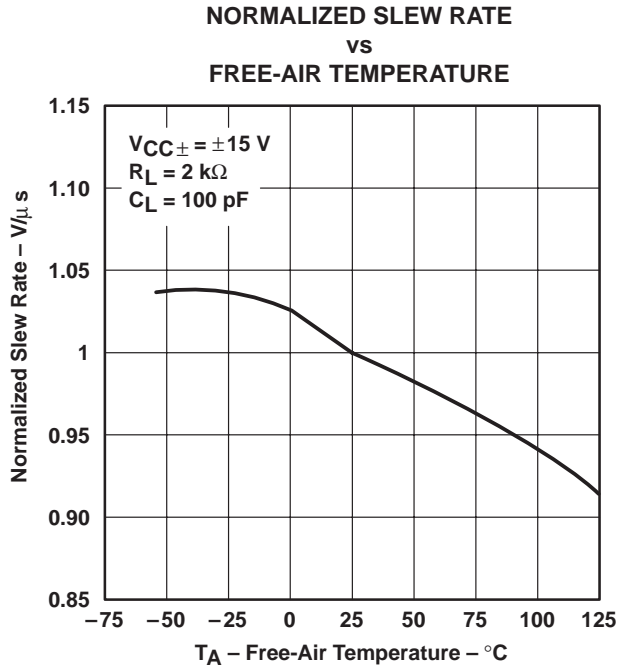


Figure 18

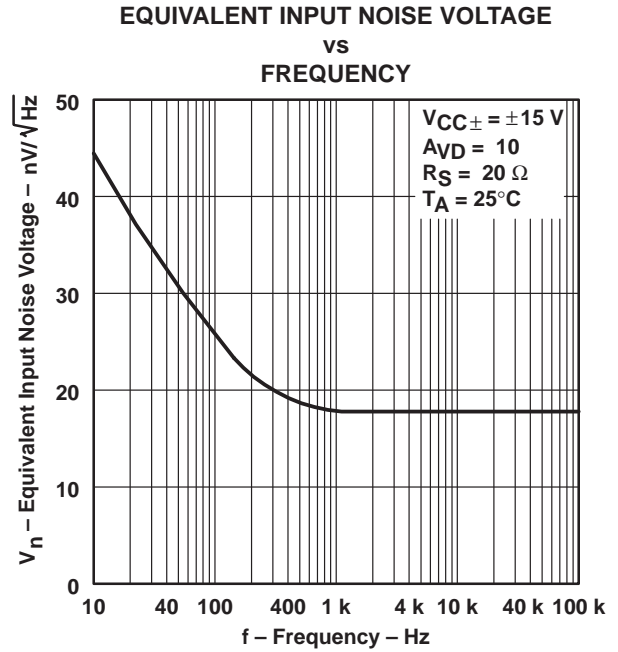


Figure 19

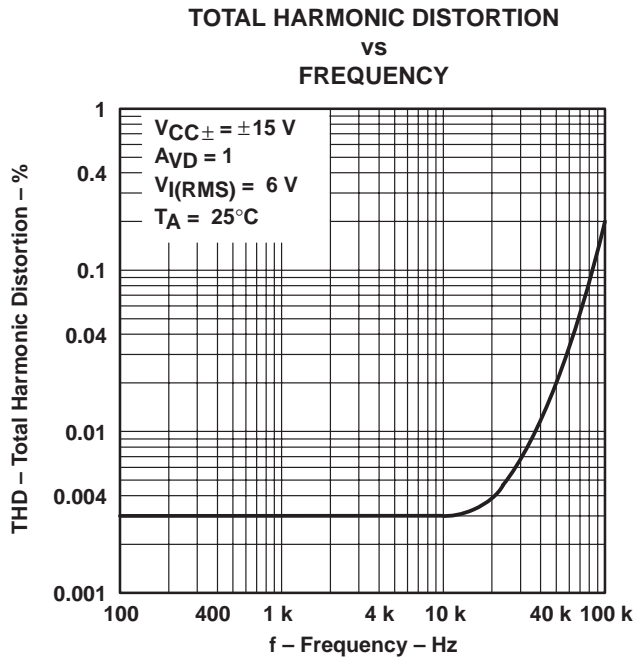


Figure 20

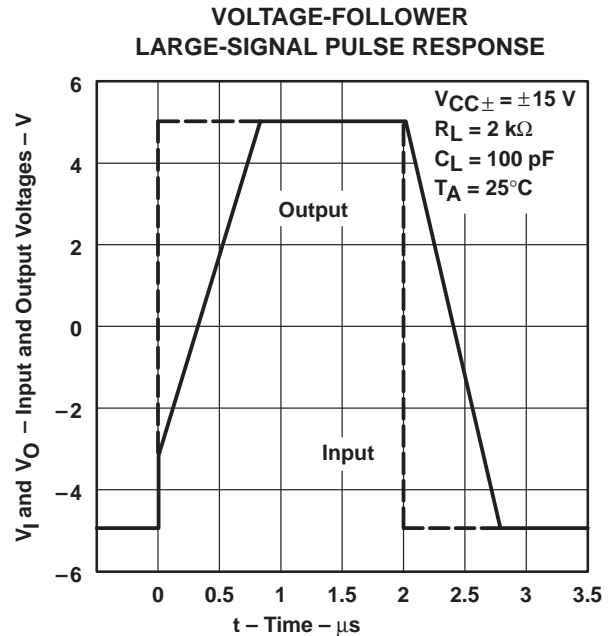


Figure 21

TYPICAL CHARACTERISTICS

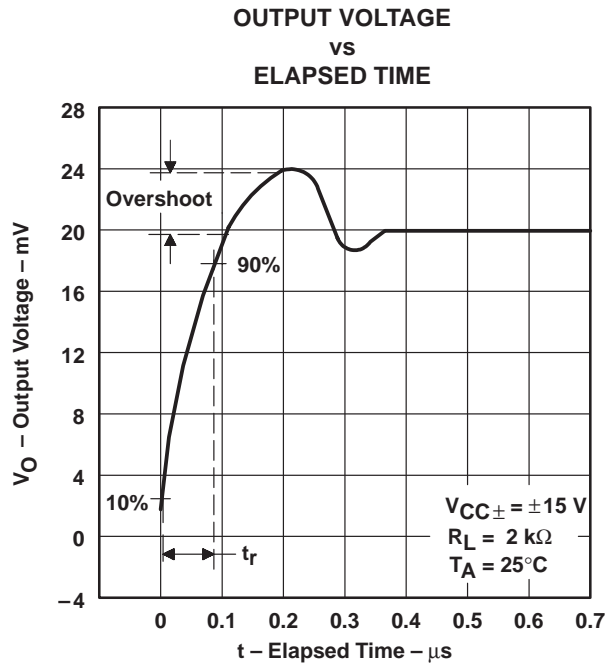


Figure 22

## 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

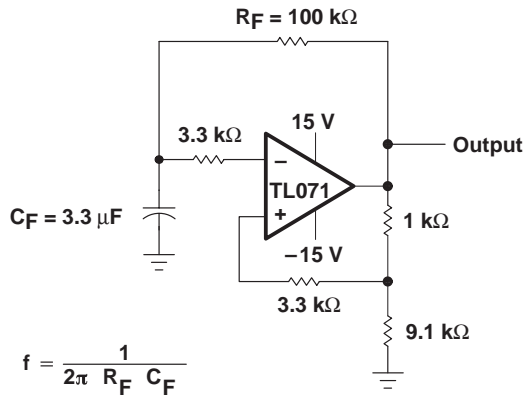


Figure 23. 0.5-Hz Square-Wave Oscillator

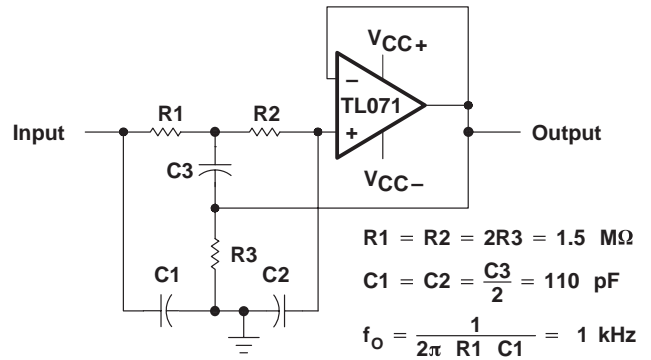


Figure 24. High-Q Notch Filter

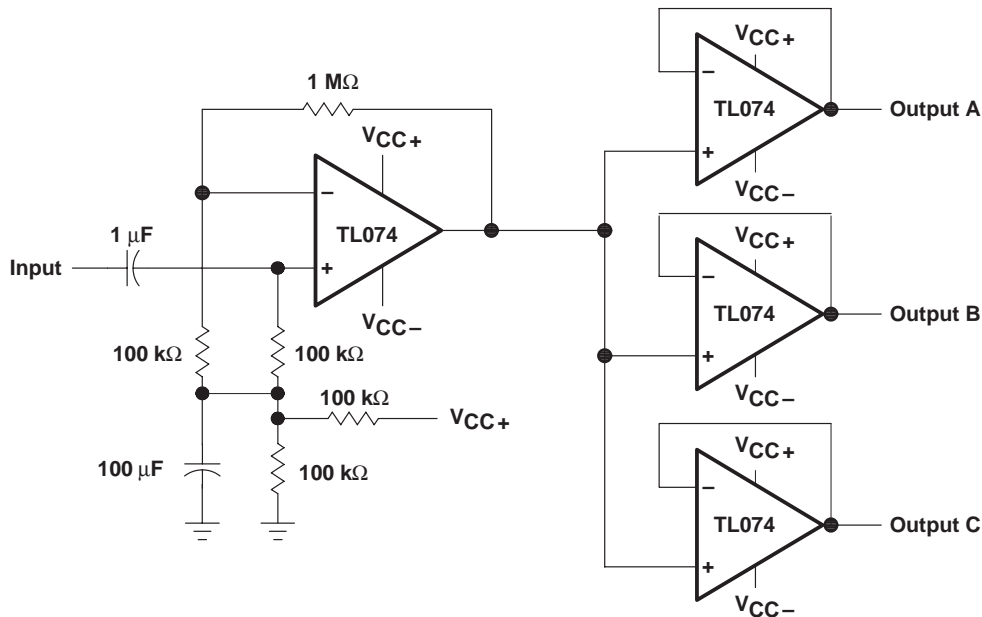
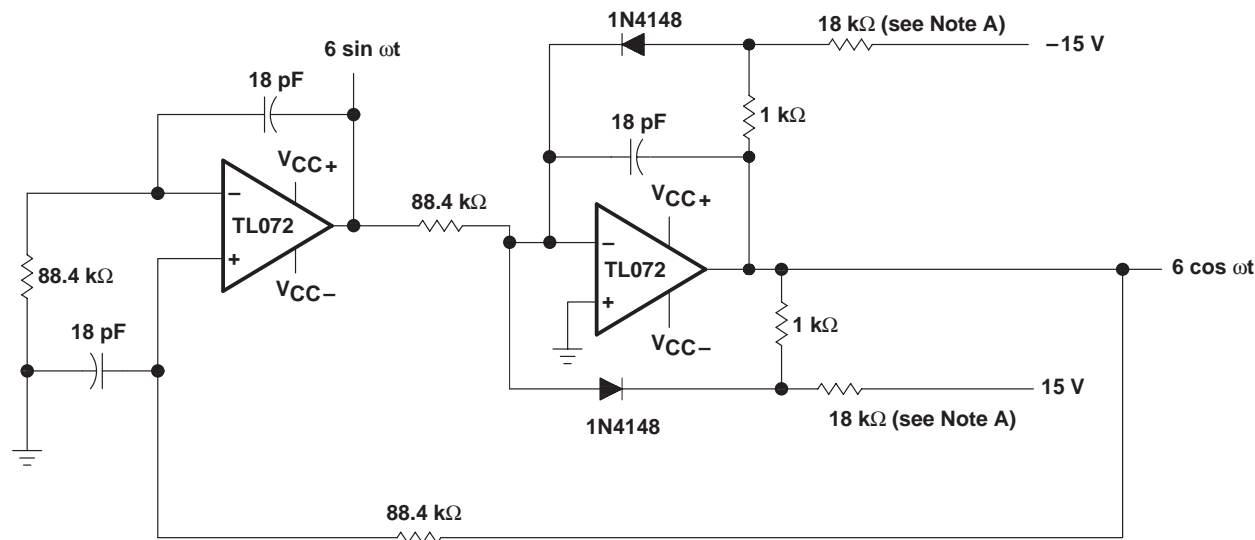


Figure 25. Audio-Distribution Amplifier

APPLICATION INFORMATION



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

Figure 26. 100-kHz Quadrature Oscillator

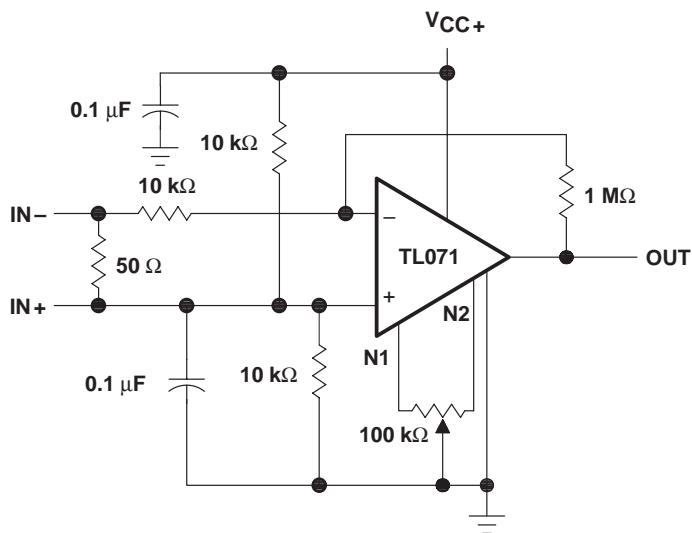


Figure 27. AC Amplifier



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