

TL061, TL061A, TL061B, TL062, TL062A TL062B, TL064, TL064A, TL064B LOW-POWER JFET-INPUT OPERATIONAL AMPLIFIERS

SLOS078G – NOVEMBER 1978 – REVISED MAY 2002

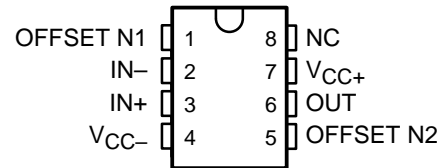
- Very Low Power Consumption
- Typical Supply Current . . . 200 μ A (Per Amplifier)
- Wide Common-Mode and Differential Voltage Ranges
- Low Input Bias and Offset Currents
- Common-Mode Input Voltage Range Includes V_{CC+}
- Output Short-Circuit Protection
- High Input Impedance . . . JFET-Input Stage
- Internal Frequency Compensation
- Latch-Up-Free Operation
- High Slew Rate . . . 3.5 V/ μ s Typ

description

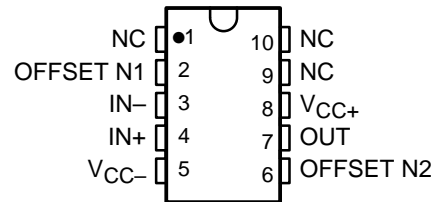
The JFET-input operational amplifiers of the TL06_ series are designed as low-power versions of the TL08_ series amplifiers. They feature high input impedance, wide bandwidth, high slew rate, and low input offset and input bias currents. The TL06_ series feature the same terminal assignments as the TL07_ and TL08_ series. Each of these JFET-input operational amplifiers incorporates well-matched, high-voltage JFET and bipolar transistors in a monolithic integrated circuit.

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, and the M-suffix devices are characterized for operation over the full military temperature range of -55°C to 125°C.

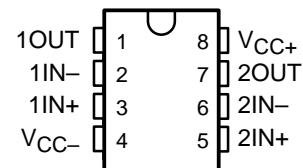
TL061, TL061A, TL061B
D, JG, P, OR PW PACKAGE
(TOP VIEW)



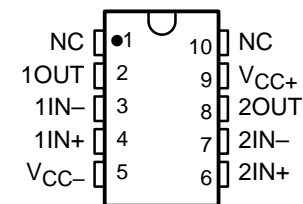
TL061 . . . U PACKAGE
(TOP VIEW)



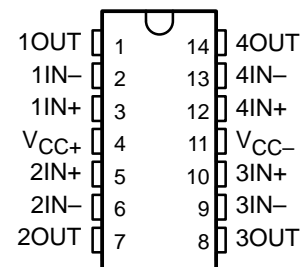
TL062, TL062A, TL062B
D, JG, P, OR PW PACKAGE
(TOP VIEW)



TL062 . . . U PACKAGE
(TOP VIEW)



TL064 . . . D, J, N, PW, OR W PACKAGE
TL064A, TL064B . . . D OR N PACKAGE
(TOP VIEW)



NC – No internal connection



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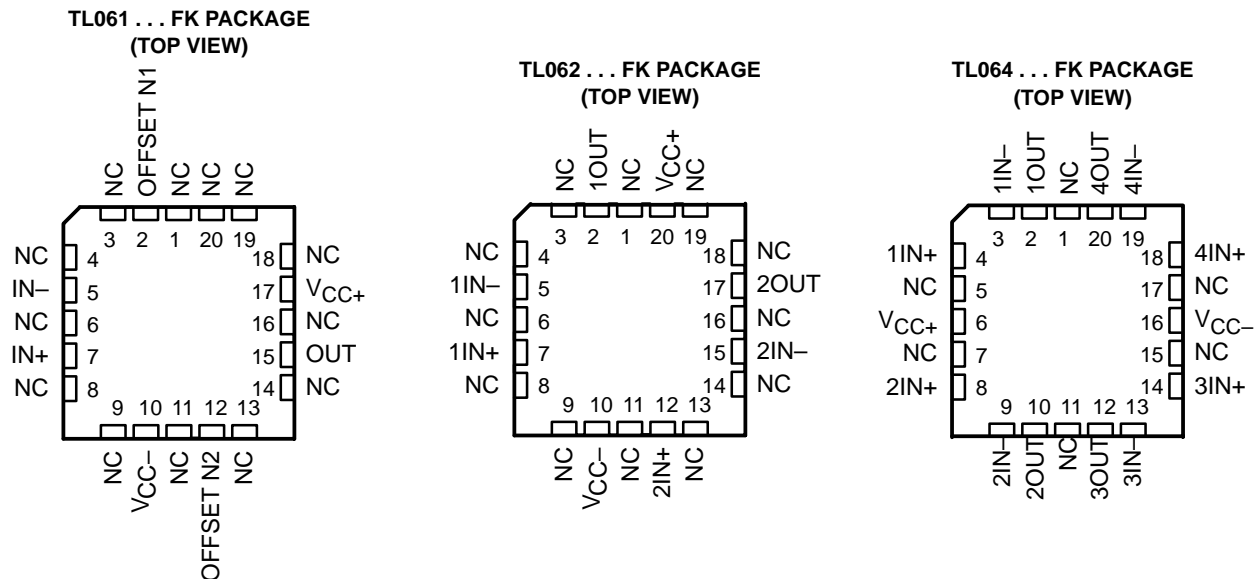
 **TEXAS
INSTRUMENTS**

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AVAILABLE OPTIONS

T _A	V _{IO} MAX AT 25°C	PACKAGE				
		SMALL OUTLINE (D008)†	SMALL OUTLINE (D014)†	PLASTIC DIP (N)	PLASTIC DIP (P)	TSSOP (PW)
0°C to 70°C	15 mV 6 mV 3 mV	TL061CD TL061ACD TL061BCD			TL061CP TL061ACP TL061BCP	TL061CPW
	15 mV 6 mV 3 mV	TL062CD TL062ACD TL062BCD			TL062CP TL062ACP TL062BCP	TL062CPW
	15 mV 6 mV 3 mV		TL064CD TL064ACD TL064BCD	TL064CN TL064ACN TL064BCN		TL064CPW

T _A	V _{IO} MAX AT 25°C	PACKAGE								
		SMALL OUTLINE (D008)†	SMALL OUTLINE (D014)†	CHIP CARRIER (FK)	CERAMIC DIP (J)	CERAMIC DIP (JG)	PLASTIC DIP (N)	PLASTIC DIP (P)	FLAT PACK (U)	FLAT PACK (W)
-40°C to 85°C	6 mV	TL061ID TL062ID	TL064ID				TL064IN	TL061IP TL062IP		
-55°C to 125°C	6 mV 9 mV			TL062MFK TL064MFK	TL064MJ	TL062MJG			TL062MU	TL064MW

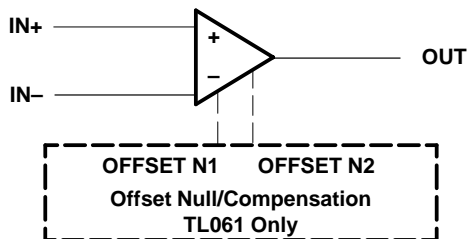
† The D package is available taped and reeled. Add the suffix R to the device type (e.g., TL061CDR).



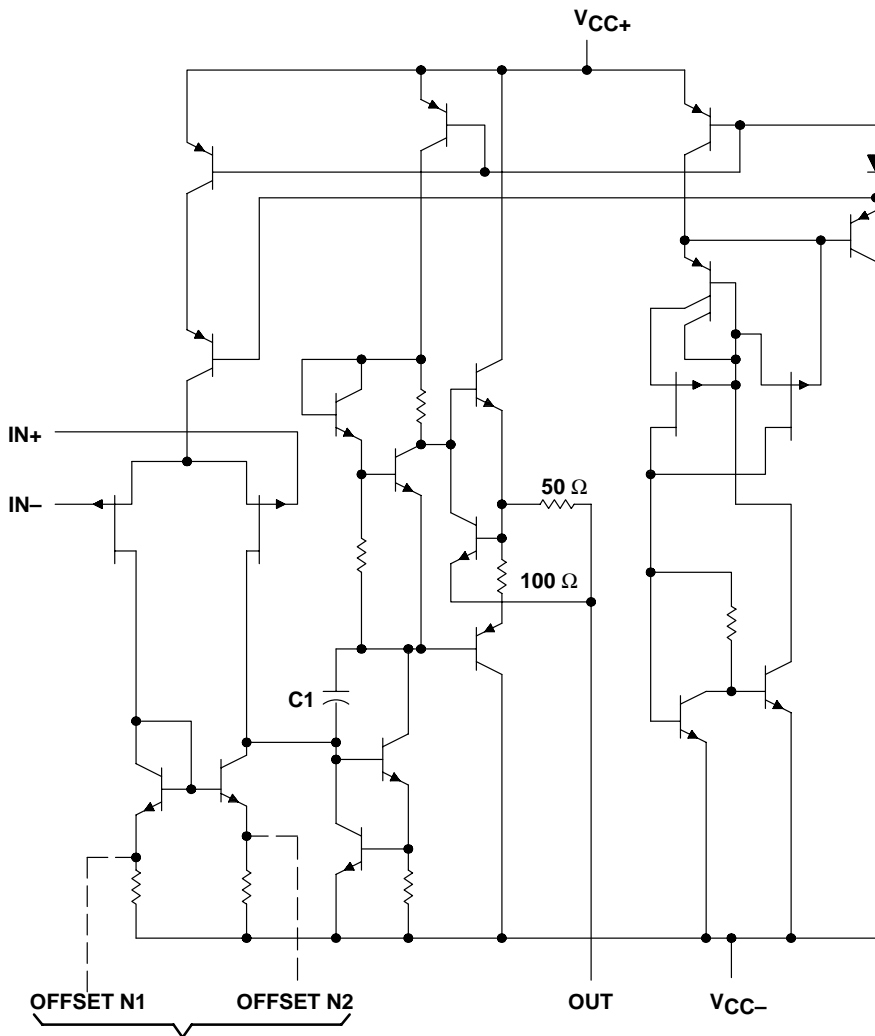
TL061, TL061A, TL061B, TL062, TL062A
 TL062B, TL064, TL064A, TL064B
LOW-POWER JFET-INPUT OPERATIONAL AMPLIFIERS

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symbol (each amplifier)



schematic (each amplifier)



TL061 Only
 C1 = 10 pF on TL061, TL062, and TL064
 Component values shown are nominal.

**TL061, TL061A, TL061B, TL062, TL062A
TL062B, TL064, TL064A, TL064B
LOW-POWER JFET-INPUT OPERATIONAL AMPLIFIERS**

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

	TL06_C TL06_AC TL06_BC	TL06_I	TL06_M	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, V_{ID} (see Note 2)	± 30	± 30	± 30	V
Input voltage, V_I (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			
Storage temperature range, T_{stg}	-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, U, 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	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/°C	33°C	465 mW	378 mW	N/A
D (14 pin)	680 mW	7.6 mW/°C	60°C	604 mW	490 mW	N/A
FK	680 mW	11.0 mW/°C	88°C	680 mW	680 mW	273 mW
J	680 mW	11.0 mW/°C	88°C	680 mW	680 mW	273 mW
JG	680 mW	8.4 mW/°C	69°C	672 mW	546 mW	210 mW
N	680 mW	9.2 mW/°C	76°C	680 mW	597 mW	N/A
P	680 mW	8.0 mW/°C	65°C	640 mW	520 mW	N/A
PW (8 pin)	525 mW	4.2 mW/°C	25°C	336 mW	N/A	N/A
PW (14 pin)	700 mW	5.6 mW/°C	25°C	448 mW	N/A	N/A
U	675 mW	5.4 mW/°C	25°C	432 mW	351 mW	135 mW
W	680 mW	8.0 mW/°C	65°C	640 mW	520 mW	200 mW



**TL061, TL061A, TL061B, TL062, TL062A
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electrical characteristics, $V_{CC\pm} = \pm 15$ V (unless otherwise noted)

PARAMETER	TEST CONDITIONS†		TL061C TL062C TL064C			TL061AC TL062AC TL064AC			UNIT
			MIN	TYP	MAX	MIN	TYP	MAX	
V_{IO} Input offset voltage	$V_O = 0,$ $R_S = 50 \Omega$	$T_A = 25^\circ\text{C}$	3 15		3 6		mV		
		$T_A = \text{Full range}$	20		7.5				
$\alpha_{V_{IO}}$ Temperature coefficient of input offset voltage	$V_O = 0, R_S = 50 \Omega,$ $T_A = \text{Full range}$		10			10		$\mu\text{V}/^\circ\text{C}$	
I_{IO} Input offset current	$V_O = 0$	$T_A = 25^\circ\text{C}$	5 200		5 100		pA		
		$T_A = \text{Full range}$	5		3		nA		
I_{IB} Input bias current‡	$V_O = 0$	$T_A = 25^\circ\text{C}$	30 400		30 200		pA		
		$T_A = \text{Full range}$	10		7		nA		
V_{ICR} Common-mode input voltage range	$T_A = 25^\circ\text{C}$		± 11	-12 to 15	± 11	-12 to 15	V		
V_{OM} Maximum peak output voltage swing	$R_L = 10 \text{ k}\Omega, T_A = 25^\circ\text{C}$		± 10	± 13.5	± 10	± 13.5	V		
	$R_L \geq 10 \text{ k}\Omega, T_A = \text{Full range}$		± 10		± 10				
A_{VD} Large-signal differential voltage amplification	$V_O = \pm 10 \text{ V},$ $R_L \geq 10 \text{ k}\Omega$	$T_A = 25^\circ\text{C}$	3 6		4 6		V/mV		
		$T_A = \text{Full range}$	3		4				
B_1 Unity-gain bandwidth	$R_L = 10 \text{ k}\Omega, T_A = 25^\circ\text{C}$		1		1		MHz		
r_i Input resistance	$T_A = 25^\circ\text{C}$		10^{12}			10^{12}	Ω		
CMRR Common-mode rejection ratio	$V_{IC} = V_{ICRmin}, V_O = 0,$ $R_S = 50 \Omega, T_A = 25^\circ\text{C}$		70 86		80 86		dB		
k_{SVR} Supply-voltage rejection ratio ($\Delta V_{CC\pm}/\Delta V_{IO}$)	$V_{CC} = \pm 9 \text{ V to } \pm 15 \text{ V},$ $V_O = 0, R_S = 50 \Omega,$ $T_A = 25^\circ\text{C}$		70 95		80 95		dB		
P_D Total power dissipation (each amplifier)	$V_O = 0,$ No load	$T_A = 25^\circ\text{C},$	6 7.5		6 7.5		mW		
I_{CC} Supply current (each amplifier)	$V_O = 0,$ No load	$T_A = 25^\circ\text{C},$	200 250		200 250		μA		
V_{O1}/V_{O2} Crosstalk attenuation	$A_{VD} = 100, T_A = 25^\circ\text{C}$		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 0°C to 70°C for TL06_C, TL06_AC, and TL06_BC and -40°C to 85°C for TL06_I.

‡ Input bias currents of an FET-input operational amplifier are normal junction reverse currents, which are temperature sensitive, as shown in Figure 15. Pulse techniques are used to maintain the junction temperature as close to the ambient temperature as possible.

**TL061, TL061A, TL061B, TL062, TL062A
TL062B, TL064, TL064A, TL064B
LOW-POWER JFET-INPUT OPERATIONAL AMPLIFIERS**

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

PARAMETER	TEST CONDITIONS†	TL061BC TL062BC TL064BC			TL061 TL062I TL064I			UNIT		
		MIN	TYP	MAX	MIN	TYP	MAX			
V_{IO}	Input offset voltage	$V_O = 0,$ $R_S = 50\ \Omega$		$T_A = 25^\circ\text{C}$	2	3		3	6	mV
				$T_A = \text{Full range}$					9	
$\alpha_{V_{IO}}$	Temperature coefficient of input offset voltage	$V_O = 0, R_S = 50\ \Omega,$ $T_A = \text{Full range}$			10			10		$\mu\text{V}/^\circ\text{C}$
I_{IO}	Input offset current	$V_O = 0$		$T_A = 25^\circ\text{C}$	5	100		5	100	pA
				$T_A = \text{Full range}$					10	nA
I_{IB}	Input bias current‡	$V_O = 0$		$T_A = 25^\circ\text{C}$	30	200		30	200	pA
				$T_A = \text{Full range}$					20	nA
V_{ICR}	Common-mode input voltage range	$T_A = 25^\circ\text{C}$			± 11	-12 to 15		± 11	-12 to 15	V
V_{OM}	Maximum peak output voltage swing	$R_L = 10\ \text{k}\Omega,$ $T_A = 25^\circ\text{C}$			± 10	± 13.5		± 10	± 13.5	V
		$R_L \geq 10\ \text{k}\Omega,$ $T_A = \text{Full range}$			± 10			± 10		
A_{VD}	Large-signal differential voltage amplification	$V_O = \pm 10\ \text{V},$ $R_L \geq 10\ \text{k}\Omega$		$T_A = 25^\circ\text{C}$	4	6		4	6	V/mV
				$T_A = \text{Full range}$	4			4		
B_1	Unity-gain bandwidth	$R_L = 10\ \text{k}\Omega,$ $T_A = 25^\circ\text{C}$			1			1		MHz
r_i	Input resistance	$T_A = 25^\circ\text{C}$			1012			1012		Ω
CMRR	Common-mode rejection ratio	$V_{IC} = V_{ICRmin}, V_O = 0,$ $R_S = 50\ \Omega, T_A = 25^\circ\text{C}$			80	86		80	86	dB
k_{SVR}	Supply-voltage rejection ratio ($\Delta V_{CC\pm}/\Delta V_{IO}$)	$V_{CC} = \pm 9\ \text{V to } \pm 15\ \text{V},$ $V_O = 0, R_S = 50\ \Omega,$ $T_A = 25^\circ\text{C}$			80	95		80	95	dB
P_D	Total power dissipation (each amplifier)	$V_O = 0,$ No load		$T_A = 25^\circ\text{C},$	6	7.5		6	7.5	mW
I_{CC}	Supply current (each amplifier)	$V_O = 0,$ No load		$T_A = 25^\circ\text{C},$	200	250		200	250	μA
V_{O1}/V_{O2}	Crosstalk attenuation	$A_{VD} = 100,$ $T_A = 25^\circ\text{C}$			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 0°C to 70°C for TL06_C, TL06_AC, and TL06_BC and -40°C to 85°C for TL06_I.

‡ Input bias currents of an FET-input operational amplifier are normal junction reverse currents, which are temperature sensitive, as shown in Figure 15. Pulse techniques are used to maintain the junction temperature as close to the ambient temperature as possible.



**TL061, TL061A, TL061B, TL062, TL062A
TL062B, TL064, TL064A, TL064B
LOW-POWER JFET-INPUT OPERATIONAL AMPLIFIERS**

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

PARAMETER	TEST CONDITIONS†	TL061M TL062M			TL064M			UNIT
		MIN	TYP	MAX	MIN	TYP	MAX	
V_{IO} Input offset voltage	$V_O = 0$, $R_S = 50 \Omega$	$T_A = 25^\circ\text{C}$		3	6	$T_A = 25^\circ\text{C}$		mV
		$T_A = -55^\circ\text{C to } 125^\circ\text{C}$		9		15		
$\alpha_{V_{IO}}$ Temperature coefficient of input offset voltage	$V_O = 0$, $R_S = 50 \Omega$, $T_A = -55^\circ\text{C to } 125^\circ\text{C}$	10			10			$\mu\text{V}/^\circ\text{C}$
I_{IO} Input offset current	$V_O = 0$	$T_A = 25^\circ\text{C}$		5	100	$T_A = 25^\circ\text{C}$		pA
		$T_A = -55^\circ\text{C}$		20*		20*		nA
		$T_A = 125^\circ\text{C}$		20		20		
I_{IB} Input bias current‡	$V_O = 0$	$T_A = 25^\circ\text{C}$		30	200	$T_A = 25^\circ\text{C}$		pA
		$T_A = -55^\circ\text{C}$		50*		50*		nA
		$T_A = 125^\circ\text{C}$		50		50		
V_{ICR} Common-mode input voltage range	$T_A = 25^\circ\text{C}$	± 11.5	-12 to 15	± 11.5	-12 to 15			V
V_{OM} Maximum peak output voltage swing	$R_L = 10 \text{ k}\Omega$, $T_A = 25^\circ\text{C}$	± 10	± 13.5	± 10	± 13.5			V
	$R_L \geq 10 \text{ k}\Omega$, $T_A = -55^\circ\text{C to } 125^\circ\text{C}$	± 10		± 10				
A_{VD} Large-signal differential voltage amplification	$V_O = \pm 10 \text{ V}$, $R_L \geq 10 \text{ k}\Omega$	$T_A = 25^\circ\text{C}$		4	6	$T_A = 25^\circ\text{C}$		V/mV
		$T_A = -55^\circ\text{C to } 125^\circ\text{C}$		4		4		
B_1 Unity-gain bandwidth	$R_L = 10 \text{ k}\Omega$, $T_A = 25^\circ\text{C}$							MHz
r_i Input resistance	$T_A = 25^\circ\text{C}$	10^{12}			10^{12}			Ω
CMRR Common-mode rejection ratio	$V_{IC} = V_{ICRmin}$, $V_O = 0$, $R_S = 50 \Omega$, $T_A = 25^\circ\text{C}$	80	86	80	86			dB
k_{SVR} Supply-voltage rejection ratio ($\Delta V_{CC\pm}/\Delta V_{IO}$)	$V_{CC} = \pm 9 \text{ V to } \pm 15 \text{ V}$, $V_O = 0$, $R_S = 50 \Omega$, $T_A = 25^\circ\text{C}$	80	95	80	95			dB
P_D Total power dissipation (each amplifier)	$V_O = 0$, No load	$T_A = 25^\circ\text{C}$		6	7.5	6	7.5	mW
I_{CC} Supply current (each amplifier)	$V_O = 0$, No load	$T_A = 25^\circ\text{C}$		200	250	200	250	μA
V_{O1}/V_{O2} Crosstalk attenuation	$A_{VD} = 100$, $T_A = 25^\circ\text{C}$	120			120			dB

* This parameter is not production tested.

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

‡ Input bias currents of an FET-input operational amplifier are normal junction reverse currents, which are temperature sensitive, as shown in Figure 15. Pulse techniques are used to maintain the junction temperature as close to the ambient temperature as possible.

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

PARAMETER	TEST CONDITIONS	MIN	TYP	MAX	UNIT	
SR Slew rate at unity gain (see Note 5)	$V_I = 10 \text{ V}$, $C_L = 100 \text{ pF}$, $R_L = 10 \text{ k}\Omega$, See Figure 1	C and I suffix		1.5	3.5	$\text{V}/\mu\text{s}$
		M suffix		2	3.5	
t_r Rise time	$V_I = 20 \text{ V}$, $C_L = 100 \text{ pF}$, See Figure 1	$R_L = 10 \text{ k}\Omega$		0.2		μs
Overshoot factor		See Figure 1		10%		
V_n Equivalent input noise voltage	$R_S = 20 \Omega$, $f = 1 \text{ kHz}$	42			$\text{nV}/\sqrt{\text{Hz}}$	

NOTE 5: Slew rate at $-55^\circ\text{C to } 125^\circ\text{C}$ is $0.7 \text{ V}/\mu\text{s min}$.



PARAMETER MEASUREMENT INFORMATION

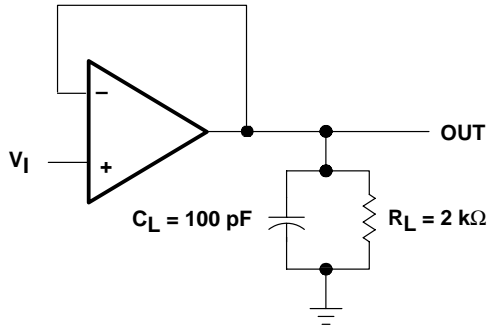


Figure 1. Unity-Gain Amplifier

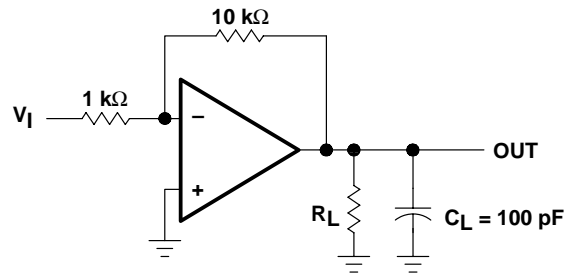


Figure 2. Gain-of-10 Inverting Amplifier

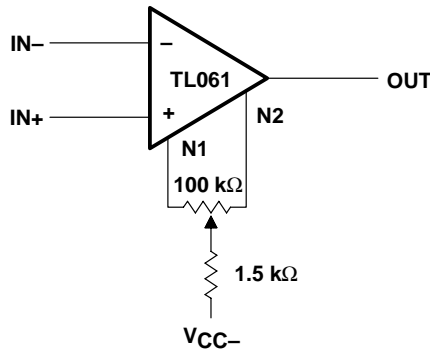


Figure 3. Input Offset-Voltage Null Circuit

TYPICAL CHARACTERISTICS

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TYPICAL CHARACTERISTICS†

**MAXIMUM PEAK OUTPUT VOLTAGE
 vs
 SUPPLY VOLTAGE**

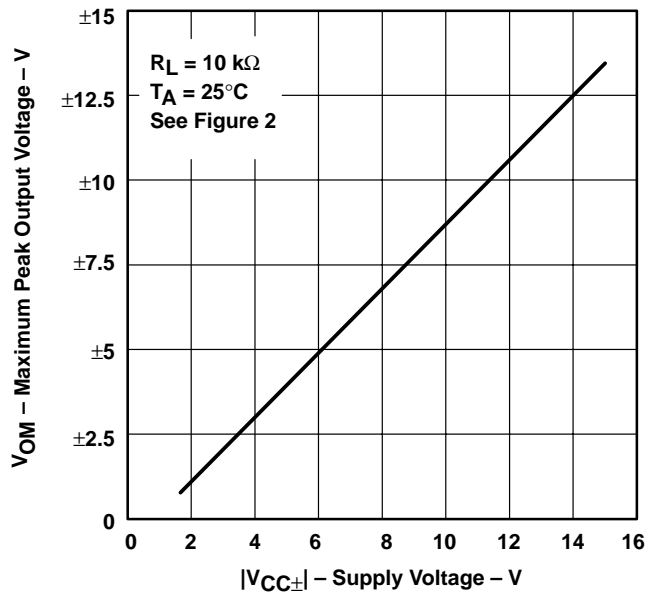


Figure 4

**MAXIMUM PEAK OUTPUT VOLTAGE
 vs
 FREE-AIR TEMPERATURE**

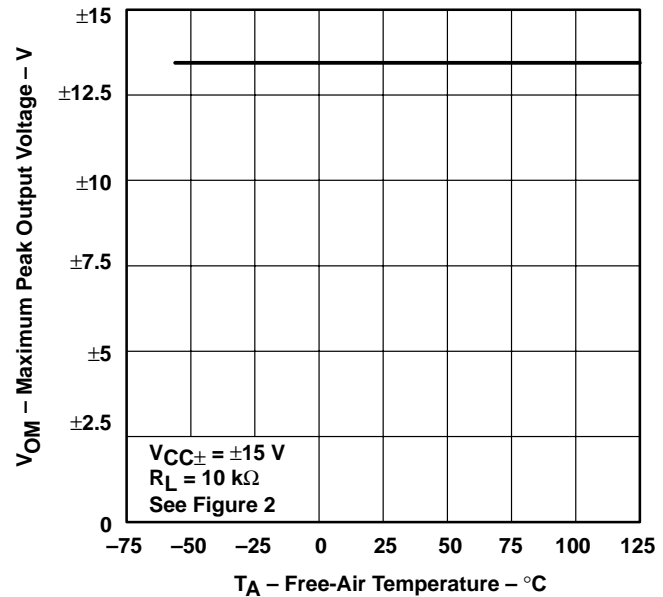


Figure 5

**MAXIMUM PEAK OUTPUT VOLTAGE
 vs
 LOAD RESISTANCE**

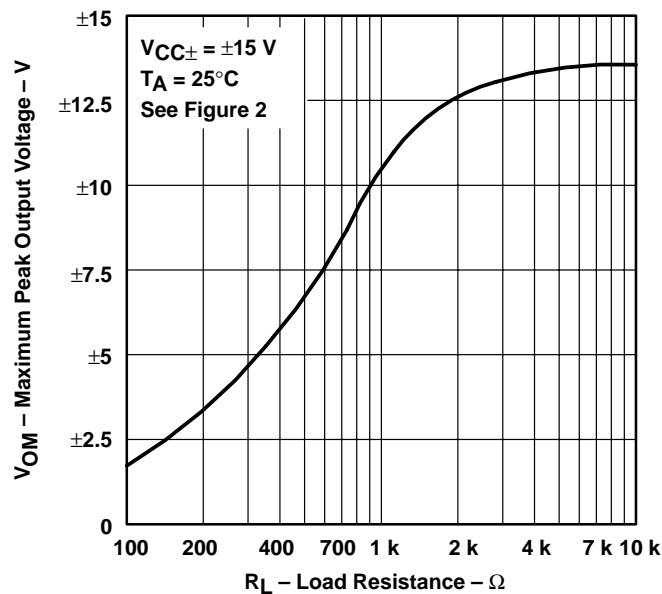


Figure 6

**MAXIMUM PEAK OUTPUT VOLTAGE
 vs
 FREQUENCY**

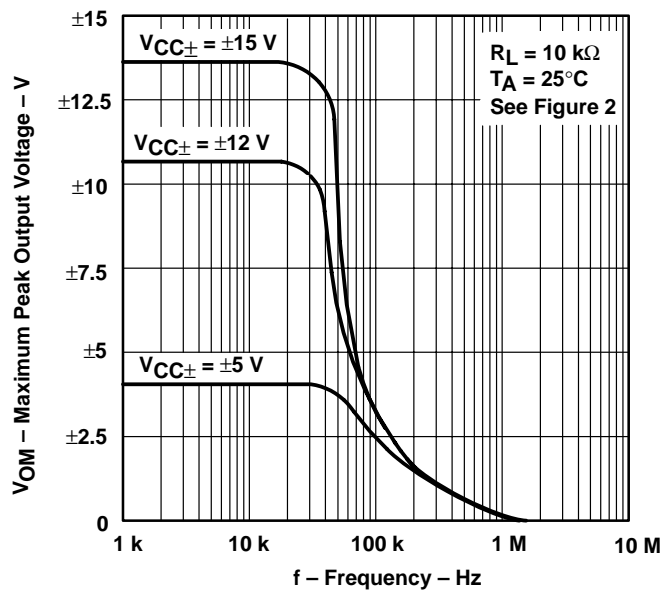


Figure 7

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



TYPICAL CHARACTERISTICS†

DIFFERENTIAL VOLTAGE AMPLIFICATION
 VS
 FREE-AIR TEMPERATURE

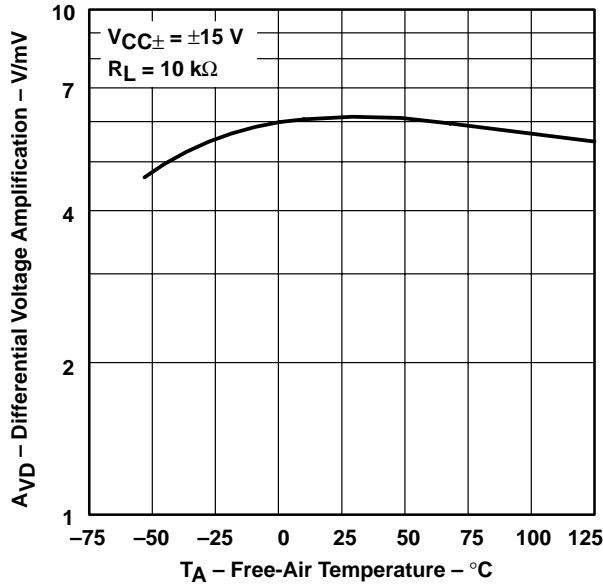


Figure 8

LARGE-SIGNAL
 DIFFERENTIAL VOLTAGE
 AMPLIFICATION AND PHASE SHIFT
 VS
 FREQUENCY

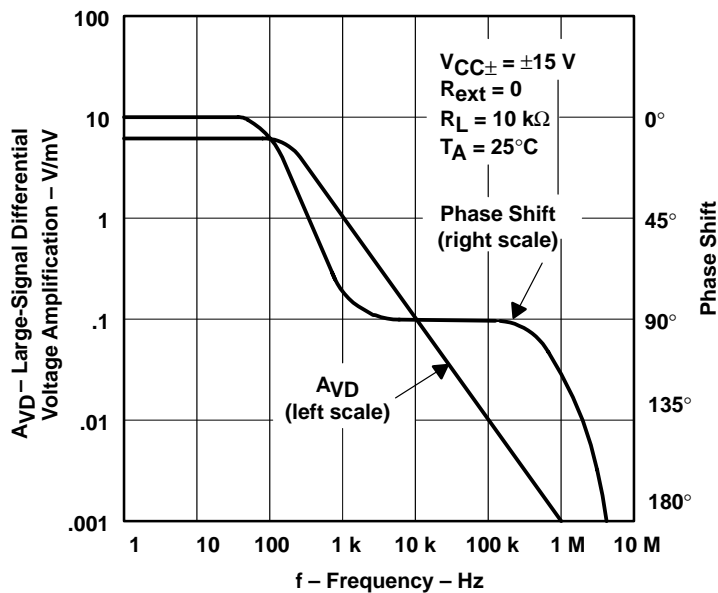


Figure 9

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

TYPICAL CHARACTERISTICS†

SUPPLY CURRENT
 vs
 SUPPLY VOLTAGE

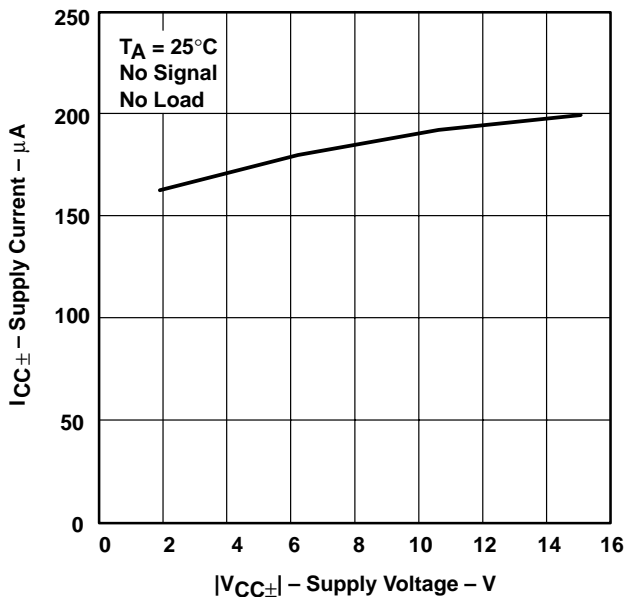


Figure 10

SUPPLY CURRENT
 vs
 FREE-AIR TEMPERATURE

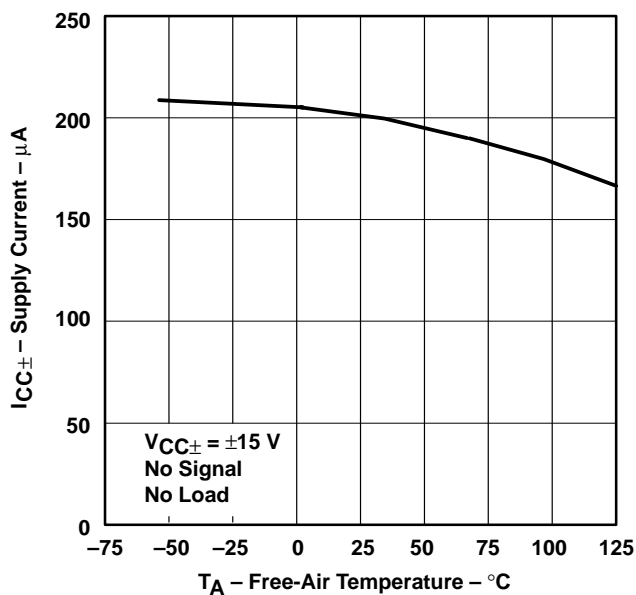


Figure 11

TOTAL POWER DISSIPATION
 vs
 FREE-AIR TEMPERATURE

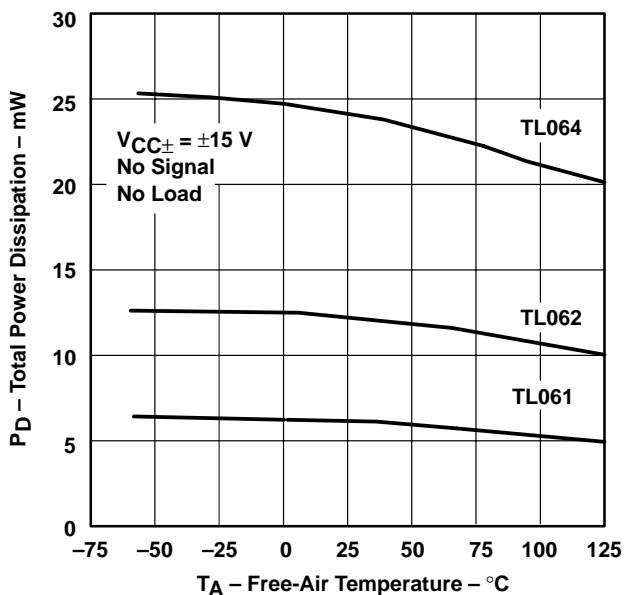


Figure 12

ALL EXCEPT TL06_C
 COMMON-MODE REJECTION RATIO
 vs
 FREE-AIR TEMPERATURE

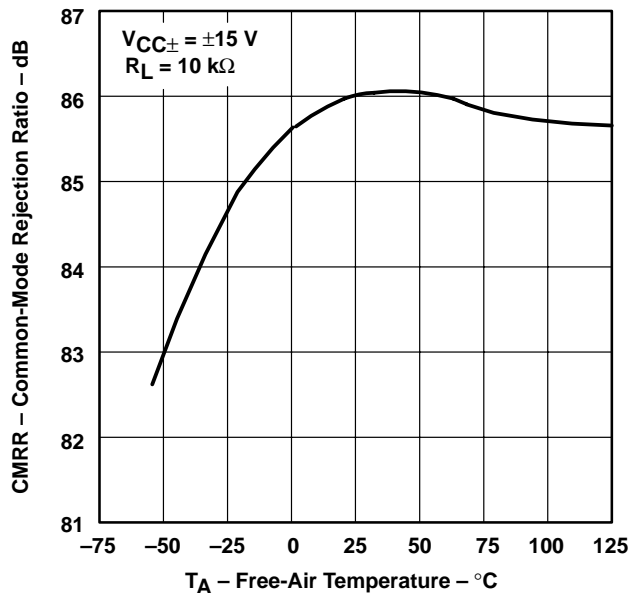


Figure 13

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

TYPICAL CHARACTERISTICS

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

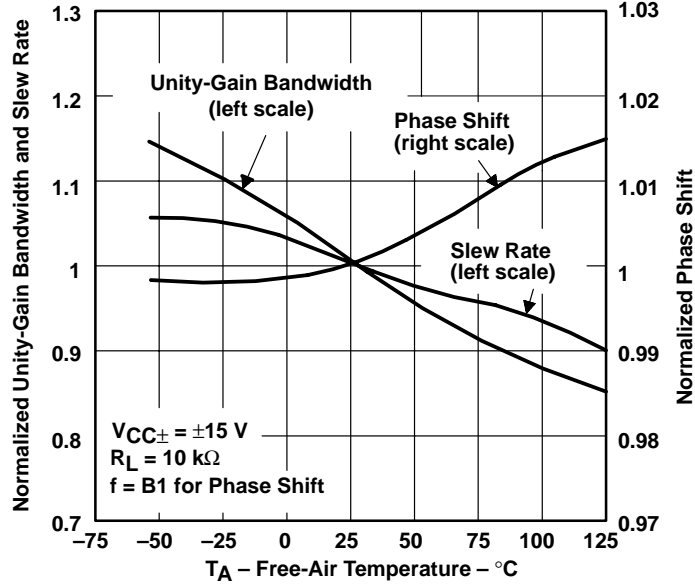


Figure 14

INPUT BIAS CURRENT
 vs
 FREE-AIR TEMPERATURE

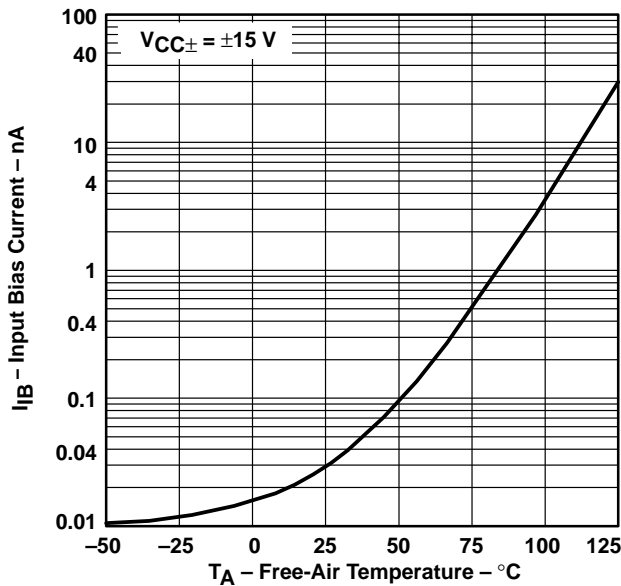


Figure 15

VOLTAGE-FOLLOWER
 LARGE-SIGNAL PULSE RESPONSE
 vs
 TIME

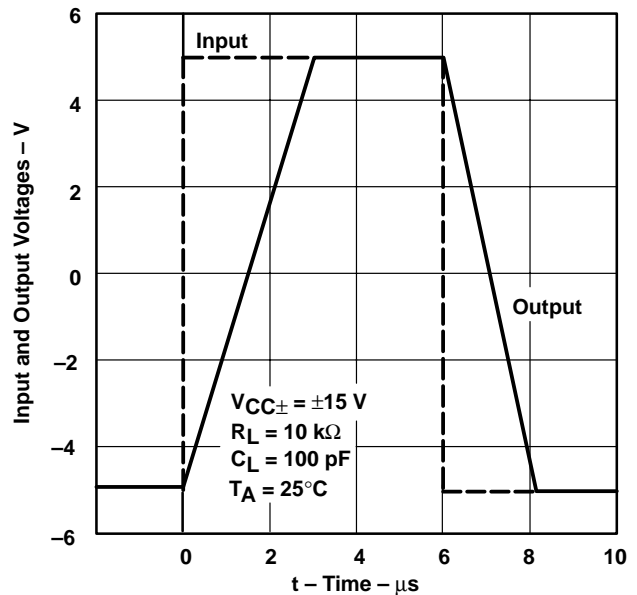


Figure 16

TYPICAL CHARACTERISTICS

OUTPUT VOLTAGE
 VS
 ELAPSED TIME

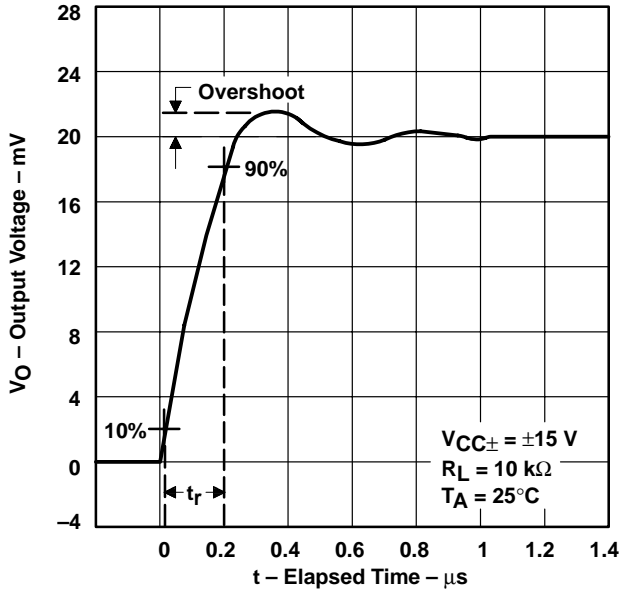


Figure 17

EQUIVALENT INPUT NOISE VOLTAGE
 VS
 FREQUENCY

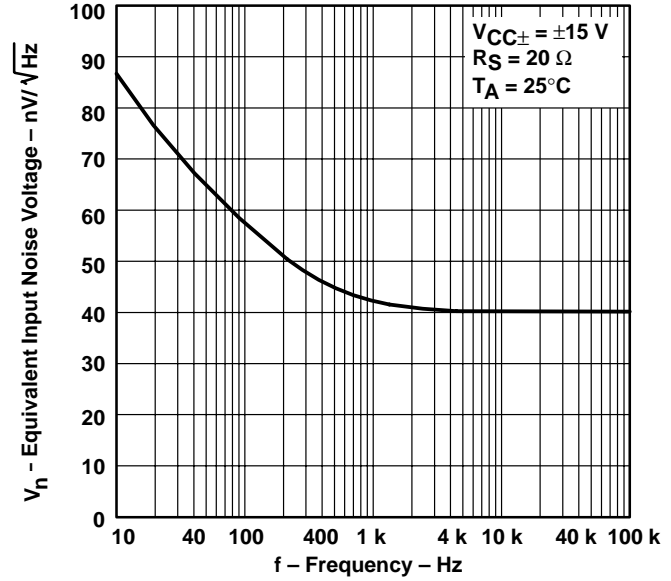


Figure 18

APPLICATION INFORMATION

Table of Application Diagrams

APPLICATION DIAGRAM	PART NUMBER	FIGURE
Instrumentation amplifier	TL064	19
0.5-Hz square-wave oscillator	TL061	20
High-Q notch filter	TL061	21
Audio-distribution amplifier	TL064	22
Low-level light detector preamplifier	TL061	23
AC amplifier	TL061	24
Microphone preamplifier with tone control	TL061	25
Instrumentation amplifier	TL062	26
IC preamplifier	TL062	27

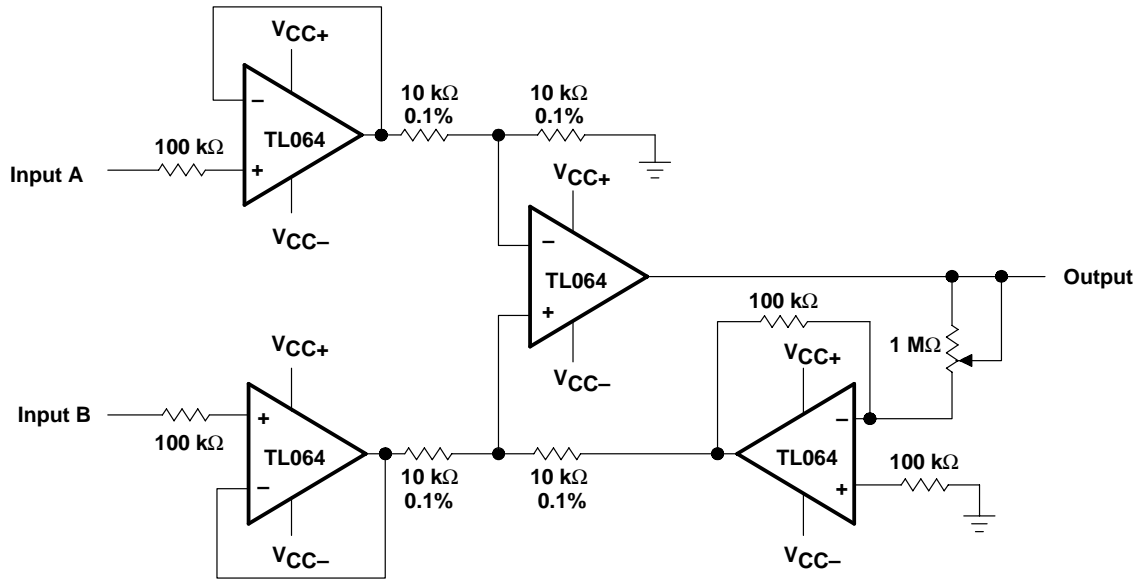


Figure 19. Instrumentation Amplifier

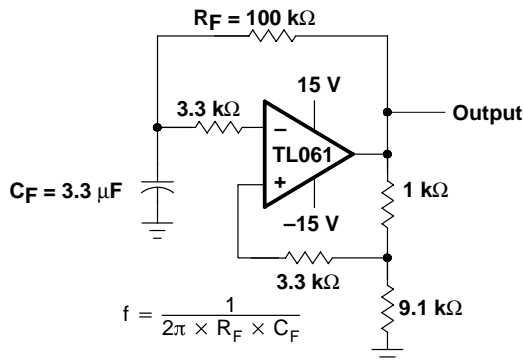


Figure 20. 0.5-Hz Square-Wave Oscillator

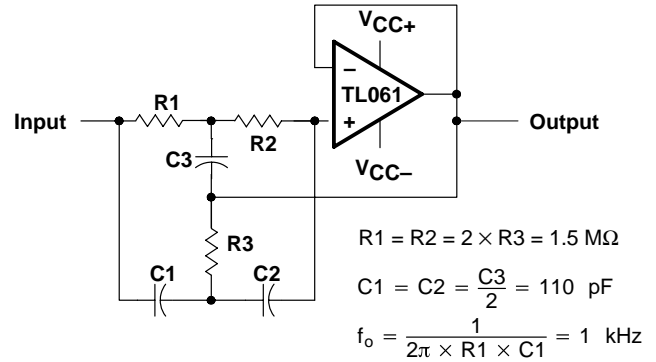


Figure 21. High-Q Notch Filter

APPLICATION INFORMATION

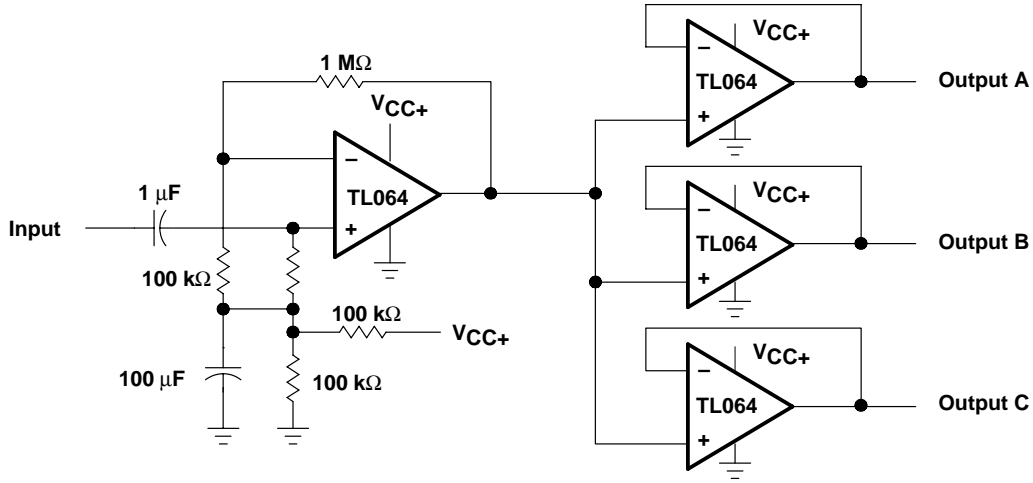


Figure 22. Audio-Distribution Amplifier

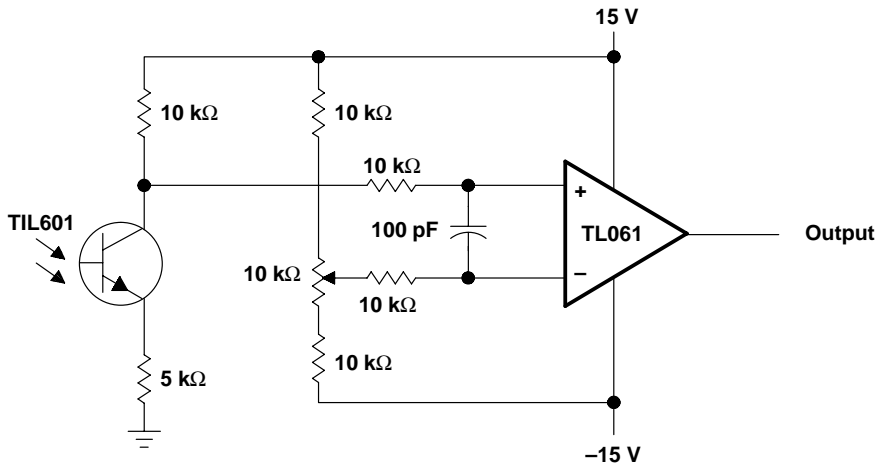


Figure 23. Low-Level Light Detector Preamplifier

APPLICATION INFORMATION

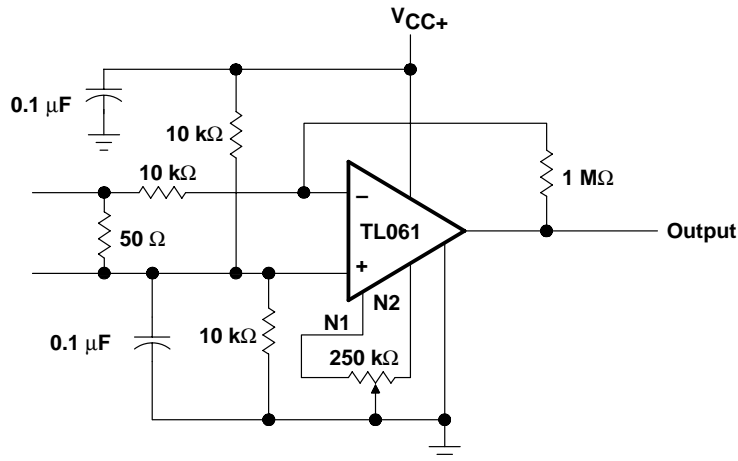


Figure 24. AC Amplifier

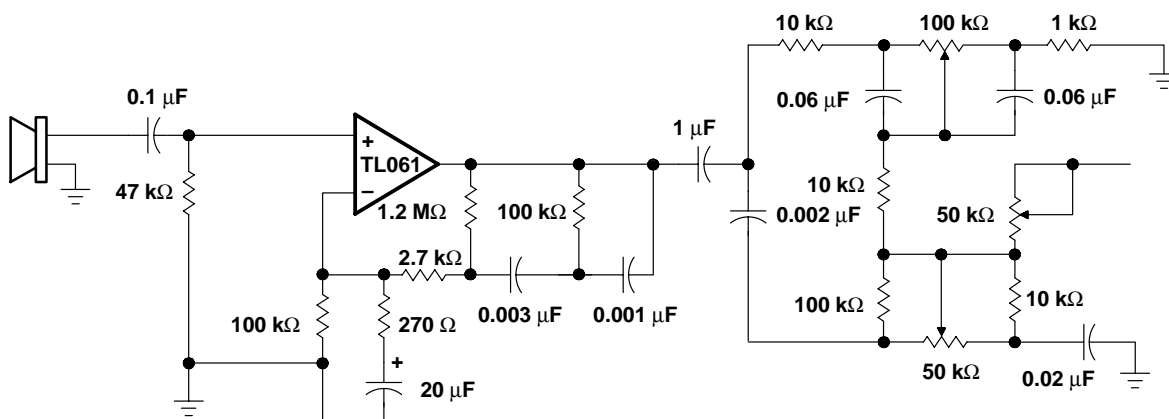


Figure 25. Microphone Preamp With Tone Control

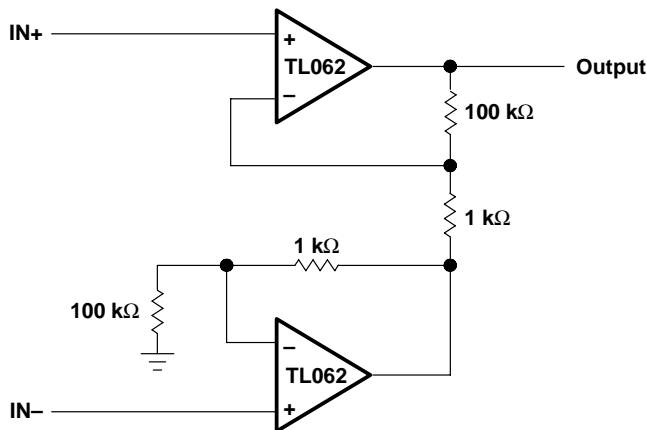


Figure 26. Instrumentation Amplifier

APPLICATION INFORMATION

IC PREAMPLIFIER RESPONSE CHARACTERISTICS

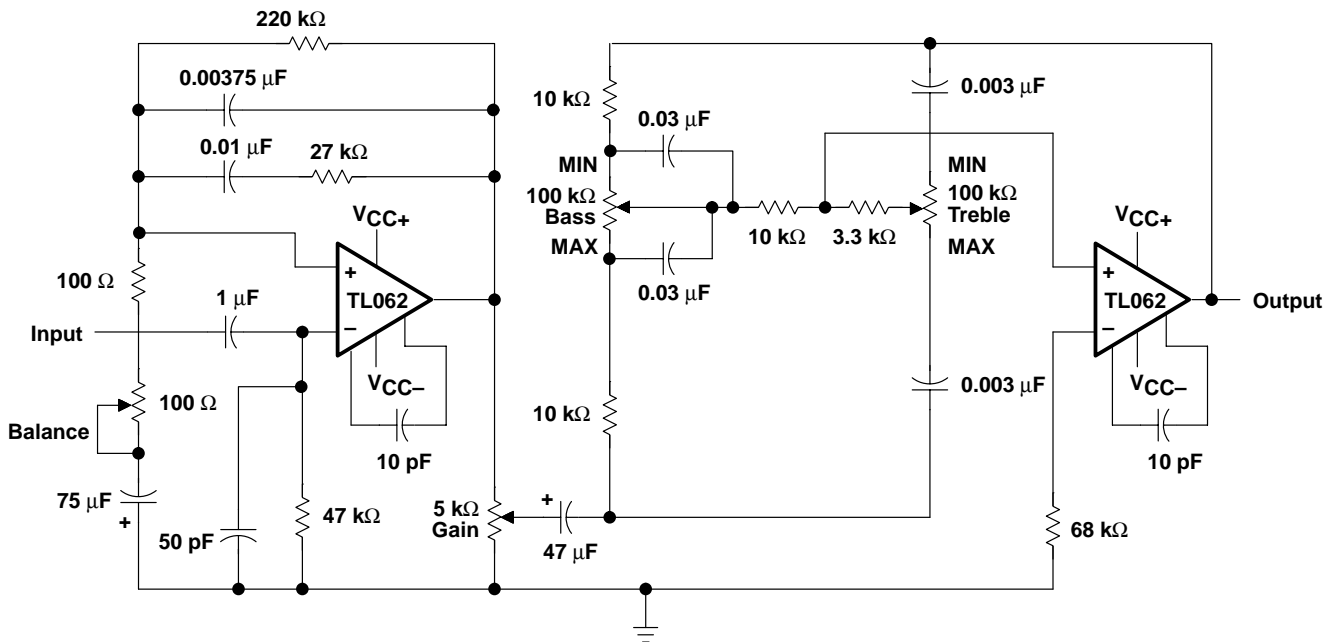
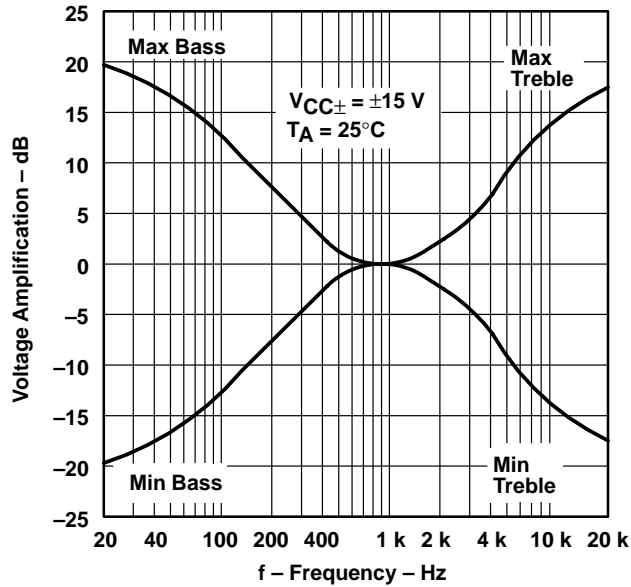


Figure 27. IC Preamplifier

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