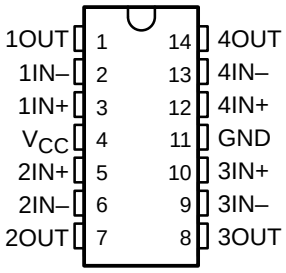
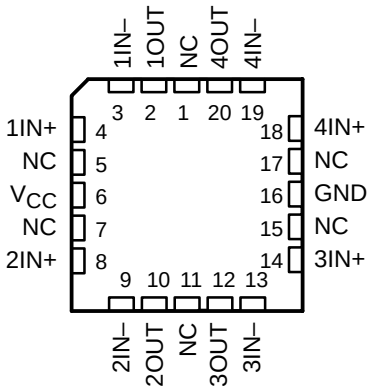
- **Wide Range of Supply Voltages:**
  Single Supply . . . 3 V to 30 V
  (LM2902, 3 V to 26 V) or Dual Supplies
- **Low Supply-Current Drain Independent of Supply Voltage . . . 0.8 mA Typ**
- **Common-Mode Input Voltage Range Includes Ground, Allowing Direct Sensing Near Ground**
- **Low Input Bias and Offset Parameters:**
  - **Input Offset Voltage . . . 3 mV Typ**
    A Versions . . . 2 mV Typ
  - **Input Offset Current . . . 2 nA Typ**
  - **Input Bias Current . . . 20 nA Typ**
    A Versions . . . 15 nA Typ
- **Differential Input Voltage Range Equal to Maximum-Rated Supply Voltage . . . 32 V (26 V for LM2902)**
- **Open-Loop Differential Voltage Amplification . . . 100 V/mV Typ**
- **Internal Frequency Compensation**

LM124 . . . D, J, OR W PACKAGE
LM124A . . . J PACKAGE
LM224, LM224A . . . D OR N PACKAGE
LM324 . . . D, N, NS, OR PW PACKAGE
LM324A . . . D, DB, N, NS, OR PW PACKAGE
LM2902 . . . D, N, NS, OR PW PACKAGE
(TOP VIEW)



LM124, LM124A . . . FK PACKAGE
(TOP VIEW)



NC – No internal connection

description/ordering information

These devices consist of four independent high-gain frequency-compensated operational amplifiers that are designed specifically to operate from a single supply over a wide range of voltages. Operation from split supplies also is possible when the difference between the two supplies is 3 V to 30 V (for the LM2902, 3 V to 26 V) and V_{CC} is at least 1.5 V more positive than the input common-mode voltage. The low supply-current drain is independent of the magnitude of the supply voltage.

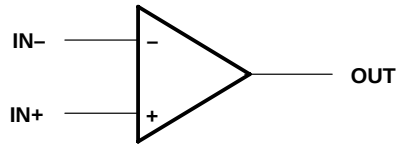
Applications include transducer amplifiers, dc amplification blocks, and all the conventional operational-amplifier circuits that now can be more easily implemented in single-supply-voltage systems. For example, the LM124 can be operated directly from the standard 5-V supply that is used in digital systems and easily provides the required interface electronics without requiring additional ±15-V supplies.

ORDERING INFORMATION

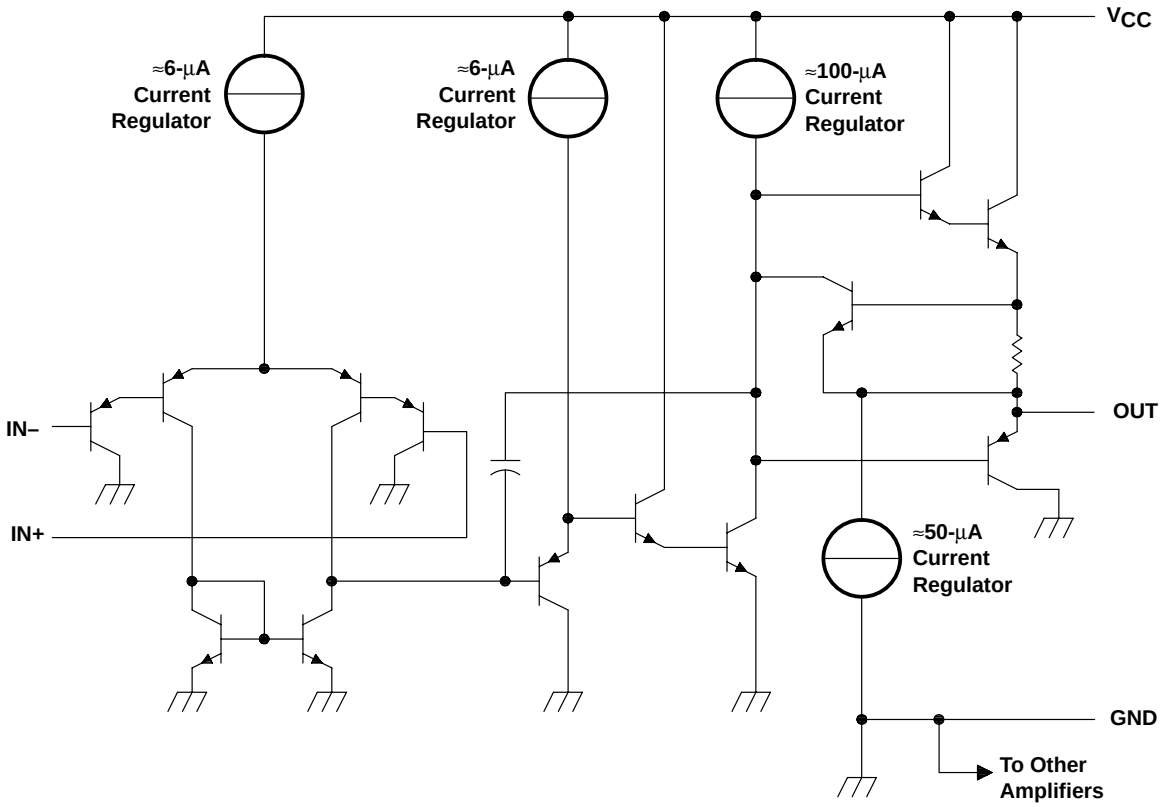
T_A	V_{IO}max AT 25°C	PACKAGE†		ORDERABLE PART NUMBER	TOP-SIDE MARKING
0°C to 70°C	7 mV	PDIP (N)	Tube	LM324N	LM324N
		SOIC (D)	Tube	LM324D	LM324
			Tape and reel	LM324DR	
		SOP (NS)	Tape and reel	LM324NSR	LM324
		TSSOP (PW)	Tape and reel	LM324PWR	L324
	3 mV	PDIP (N)	Tube	LM324AN	LM324AN
		SOIC (D)	Tube	LM324AD	LM324A
			Tape and reel	LM324ADR	
		SOP (NS)	Tape and reel	LM324ANSR	LM324A
		SSOP (DB)	Tape and reel	LM324ADBR	LM324A
		TSSOP (PW)	Tape and reel	LM324APWR	L324A
–25°C to 85°C	5 mV	PDIP (N)	Tube	LM224N	LM224N
		SOIC (D)	Tube	LM224D	LM224
			Tape and reel	LM224DR	
	3 mV	PDIP (N)	Tube	LM224AN	LM224AN
		SOIC (D)	Tube	LM224AD	LM224A
			Tape and reel	LM224ADR	
–40°C to 125°C	7 mV	PDIP (N)	Tube	LM2902N	LM2902N
		SOIC (D)	Tube	LM2902D	LM2902
			Tape and reel	LM2902DR	
		SOP (NS)	Tape and reel	LM2902NSR	LM2902
		TSSOP (PW)	Tape and reel	LM2902PWR	L2902
–55°C to 125°C	5 mV	CDIP (J)	Tube	LM124J	LM124J
			Tube	LM124JB	LM124JB
		CFP (W)	Tube	LM124W	LM124W
		LCCC (FK)	Tube	LM124FKB	LM124FKB
		SOIC (D)	Tube	LM124D	LM124
			Tape and reel	LM124DR	
	2 mV	CDIP (J)	Tube	LM124AJ	LM124AJ
			Tube	LM124AJB	LM124AJB
		LCCC (FK)	Tube	LM124AFKB	LM124AFKB

† Package drawings, standard packing quantities, thermal data, symbolization, and PCB design guidelines are available at www.ti.com/sc/package.

symbol (each amplifier)



schematic (each amplifier)



COMPONENT COUNT (total device)	
Epi-FET	1
Transistors	95
Diodes	4
Resistors	11
Capacitors	4

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

		LM124, LM124A LM224, LM224A LM324, LM324A	LM2902	UNIT
Supply voltage, V_{CC} (see Note 1)		32	26	V
Differential input voltage, V_{ID} (see Note 2)		±32	±26	V
Input voltage, V_I (either input)		–0.3 to 32	–0.3 to 26	V
Duration of output short circuit (one amplifier) to ground at (or below) T_A = 25°C, $V_{CC} \le$ 15 V (see Note 3)		Unlimited	Unlimited	
Operating virtual junction temperature, T_J		150	150	°C
Package thermal impedance, θ_{JA} (see Notes 4 and 5)	D package	86	86	°C/W
	DB package	96		
	N package	80	80	
	NS package	76	76	
	PW package	113	113	
Package thermal impedance, θ_{JC} (see Notes 6 and 7)	FK package	5.61		°C/W
	J package	15.05		
	W package	14.65		
Case temperature for 60 seconds	FK package	260		°C
Lead temperature 1,6 mm (1/16 inch) from case for 60 seconds	J or W package	300	300	°C
Lead temperature 1,6 mm (1/16 inch) from case for 10 seconds	N package	260	260	°C
Storage temperature range, T_{stg}		–65 to 150	–65 to 150	°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 and V_{CC} specified for the measurement of I_{OS}) are with respect to the network GND.
2. Differential voltages are at IN+ with respect to IN–.
3. Short circuits from outputs to V_{CC} can cause excessive heating and eventual destruction.
4. Maximum power dissipation is a function of $T_J(max)$, θ_{JA}, and T_A. The maximum allowable power dissipation at any allowable ambient temperature is $P_D = (T_J(max) – T_A)/\theta_{JA}$. Operating at the absolute maximum T_J of 150°C can affect reliability.
5. The package thermal impedance is calculated in accordance with JESD 51-7.
6. Maximum power dissipation is a function of $T_J(max)$, θ_{JC}, and T_C. The maximum allowable power dissipation at any allowable case temperature is $P_D = (T_J(max) – T_C)/\theta_{JC}$. Operating at the absolute maximum T_J of 150°C can affect reliability.
7. The package thermal impedance is calculated in accordance with MIL-STD-883.

electrical characteristics at specified free-air temperature, V_{CC} = 5 V (unless otherwise noted)

PARAMETER		TEST CONDITIONS†	T_A‡	LM124, LM224 MIN	LM124, LM224 TYP§	LM124, LM224 MAX	LM324 MIN	LM324 TYP§	LM324 MAX	LM2902 MIN	LM2902 TYP§	LM2902 MAX	UNIT
V_{IO}	Input offset voltage	V_{CC} = 5 V to MAX, V_{IC} = V_{ICR}min, V_O = 1.4 V	25°C		3	5		3	7		3	7	mV
			Full range			7			9			10	
I_{IO}	Input offset current	V_O = 1.4 V	25°C		2	30		2	50		2	50	nA
			Full range			100			150			300	
I_{IB}	Input bias current	V_O = 1.4 V	25°C		–20	–150		–20	–250		–20	–250	nA
			Full range			–300			–500			–500	
V_{ICR}	Common-mode input voltage range	V_{CC} = 5 V to MAX	25°C	0 to V_{CC}–1.5			0 to V_{CC}–1.5			0 to V_{CC}–1.5			V
			Full range	0 to V_{CC}–2			0 to V_{CC}–2			0 to V_{CC}–2			
V_{OH}	High-level output voltage	R_L = 2 kΩ	25°C	V_{CC}–1.5			V_{CC}–1.5						V
		R_L = 10 kΩ	25°C							V_{CC}–1.5			
		V_{CC} = MAX, R_L = 2 kΩ	Full range	26			26			22			
		V_{CC} = MAX, R_L ≥ 10 kΩ	Full range	27	28		27	28		23	24		
V_{OL}	Low-level output voltage	R_L ≤ 10 kΩ	Full range		5	20		5	20		5	20	mV
A_{VD}	Large-signal differential voltage amplification	V_{CC} = 15 V, V_O = 1 V to 11 V, R_L = ≥ 2 kΩ	25°C	50	100		25	100			100		V/mV
			Full range	25			15			15			
CMRR	Common-mode rejection ratio	V_{IC} = V_{ICR}min	25°C	70	80		65	80		50	80		dB
k_{SVR}	Supply-voltage rejection ratio ($\Delta V_{CC}/\Delta V_{IO}$)		25°C	65	100		65	100		50	100		dB
V_{O1}/V_{O2}	Crosstalk attenuation	f = 1 kHz to 20 kHz	25°C		120			120			120		dB
I_O	Output current	V_{CC} = 15 V, V_{ID} = 1 V, V_O = 0	25°C	–20	–30	–60	–20	–30	–60	–20	–30	–60	mA
			Full range	–10			–10			–10			
		V_{CC} = 15 V, V_{ID} = –1 V, V_O = 15 V	25°C	10	20		10	20		10	20		
			Full range	5			5			5			
		V_{ID} = –1 V, V_O = 200 mV	25°C	12	30		12	30			30		μA
I_{OS}	Short-circuit output current	V_{CC} at 5 V, V_O = 0, GND at –5 V	25°C		±40	±60		±40	±60		±40	±60	mA
I_{CC}	Supply current (four amplifiers)	V_O = 2.5 V, No load	Full range		0.7	1.2		0.7	1.2		0.7	1.2	mA
		V_{CC} = MAX, V_O = 0.5 V_{CC}, No load	Full range		1.4	3		1.4	3		1.4	3	

† All characteristics are measured under open-loop conditions with zero common-mode input voltage unless otherwise specified. MAX V_{CC} for testing purposes is 26 V for LM2902, 30 V for the others.
‡ Full range is –55°C to 125°C for LM124, –25°C to 85°C for LM224, 0°C to 70°C for LM324, and –40°C to 125°C for LM2902.
§ All typical values are at T_A = 25°C.

electrical characteristics at specified free-air temperature, V_{CC} = 5 V (unless otherwise noted) (continued)

PARAMETER		TEST CONDITIONS†	T_A‡	LM124A			LM224A			LM324A			UNIT
				MIN	TYP§	MAX	MIN	TYP§	MAX	MIN	TYP§	MAX	
V_{IO}	Input offset voltage	V_{CC} = 5 V to 30 V, $V_{IC} = V_{ICR}$min, V_O = 1.4 V	25°C			2		2	3		2	3	mV
			Full range			4			4			5	
I_{IO}	Input offset current	V_O = 1.4 V	25°C			10		2	15		2	30	nA
			Full range			30			30			75	
I_{IB}	Input bias current	V_O = 1.4 V	25°C			–50		–15	–80		–15	–100	nA
			Full range			–100			–100			–200	
V_{ICR}	Common-mode input voltage range	V_{CC} = 30 V	25°C	0 to $V_{CC}-1.5$			0 to $V_{CC}-1.5$			0 to $V_{CC}-1.5$			V
			Full range	0 to $V_{CC}-2$			0 to $V_{CC}-2$			0 to $V_{CC}-2$			
V_{OH}	High-level output voltage	R_L = 2 kΩ	25°C	$V_{CC}-1.5$			$V_{CC}-1.5$			$V_{CC}-1.5$			V
		V_{CC} = 30 V, R_L = 2 kΩ	Full range	26			26			26			
		V_{CC} = 30 V, $R_L \geq$ 10 kΩ	Full range	27			27	28		27	28		
V_{OL}	Low-level output voltage	$R_L \leq$ 10 kΩ	Full range			20		5	20		5	20	mV
A_{VD}	Large-signal differential voltage amplification	V_{CC} = 15 V, V_O = 1 V to 11 V, $R_L \geq$ 2 kΩ	Full range	25			25			15			V/mV
CMRR	Common-mode rejection ratio	$V_{IC} = V_{ICR}$min	25°C	70			70	80		65	80		dB
k_{SVR}	Supply-voltage rejection ratio ($\Delta V_{CC}/\Delta V_{IO}$)		25°C	65			65	100		65	100		dB
V_{O1}/V_{O2}	Crosstalk attenuation	f = 1 kHz to 20 kHz	25°C		120			120			120		dB
I_O	Output current	V_{CC} = 15 V, V_{ID} = 1 V, V_O = 0	25°C	–20			–20	–30	–60	–20	–30	–60	mA
			Full range	–10			–10			–10			
		V_{CC} = 15 V, V_{ID} = –1 V, V_O = 15 V	25°C	10			10	20		10	20		
			Full range	5			5			5			
		V_{ID} = –1 V, V_O = 200 mV	25°C	12			12	30		12	30		µA
I_{OS}	Short-circuit output current	V_{CC} at 5 V, GND at –5 V, V_O = 0	25°C		±40	±60		±40	±60		±40	±60	mA
I_{CC}	Supply current (four amplifiers)	V_O = 2.5 V, No load	Full range		0.7	1.2		0.7	1.2		0.7	1.2	mA
		V_{CC} = 30 V, V_O = 15 V, No load	Full range		1.4	3		1.4	3		1.4	3	

† All characteristics are measured under open-loop conditions with zero common-mode input voltage unless otherwise specified.
‡ Full range is –55°C to 125°C for LM124A, –25°C to 85°C for LM224A, and 0°C to 70°C for LM324A.
§ All typical values are at T_A = 25°C.

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operating conditions, V_{CC} = ±15 V, T_A = 25°C

PARAMETER		TEST CONDITIONS	TYP	UNIT
SR	Slew rate at unity gain	R_L = 1 MΩ, C_L = 30 pF, V_I = ±10 V (see Figure 1)	0.5	V/μs
B_1	Unity-gain bandwidth	R_L = 1 MΩ, C_L = 20 pF (see Figure 1)	1.2	MHz
V_n	Equivalent input noise voltage	R_S = 100 Ω, V_I = 0 V, f = 1 kHz (see Figure 2)	35	nV/√Hz

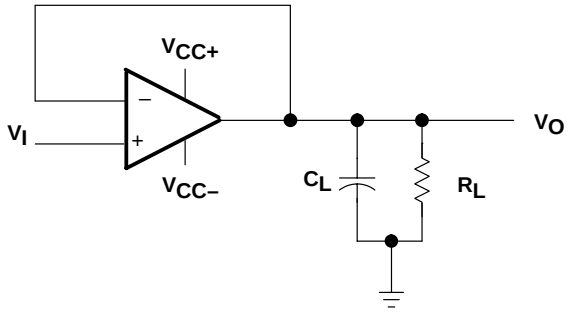

Figure 1. Unity-Gain Amplifier

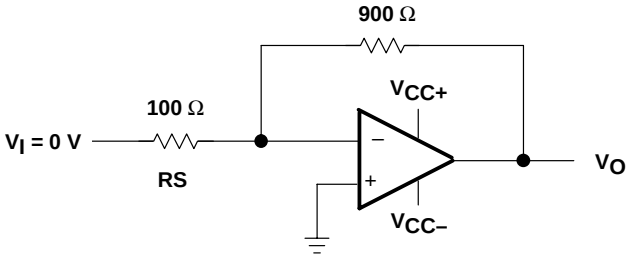

Figure 2. Noise-Test Circuit

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