

**LM124, LM224, LM224A,
LM324, LM324A, LM2902**
QUADRUPLE OPERATIONAL AMPLIFIERS

D1990, SEPTEMBER 1976—REVISED JANUARY 1989

- **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**

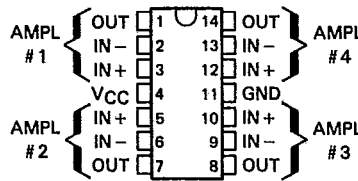
description

These devices consist of four independent, high-gain frequency-compensated operational amplifiers that were designed specifically to operate from a single supply over a wide range of voltages. Operation from split supplies is also possible so long as the difference between the two supplies is 3 V to 30 V (for the LM2902, 3 V to 26 V), and Pin 4 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.

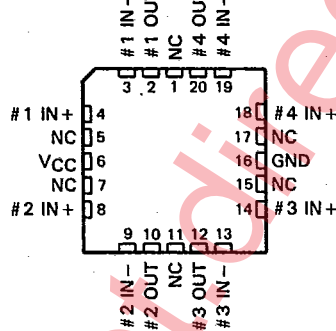
Applications include transducer amplifiers, d-c amplification blocks, and all the conventional operational amplifier circuits that now can be more easily implemented in single-supply-voltage systems. For example, the LM124 can be operated directly off of the standard 5-V supply that is used in digital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

The LM124 is characterized for operation over the full military temperature range of -55°C to 125°C . The LM2902 is characterized for operation from -40°C to 105°C , the LM224 and LM224A from -25°C to 85°C , and the LM324 and LM324A from 0°C to 70°C .

LM124 . . . J OR W PACKAGE **T-79-10**
ALL OTHERS . . . D, J, OR N PACKAGES
(TOP VIEW)

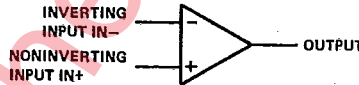


LM124
FK CHIP CARRIER PACKAGE
(TOP VIEW)



NC—No internal connection

symbol (each amplifier)



Operational Amplifiers

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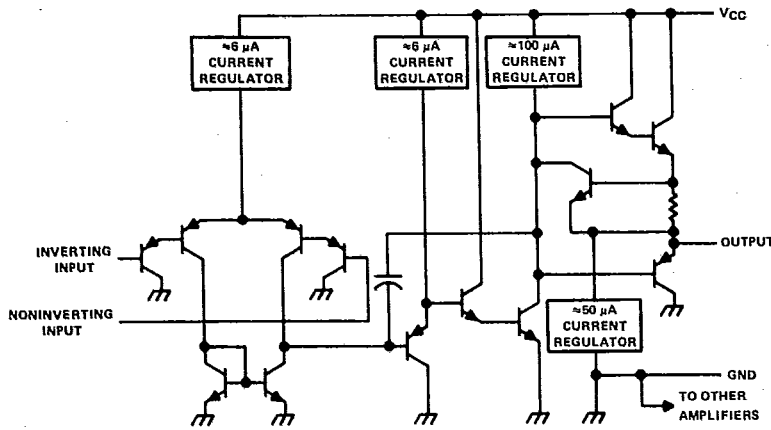
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AVAILABLE OPTIONS

T _A	V _{IO} MAX AT 25°C	PACKAGE				
		SMALL OUTLINE (D)	CHIP CARRIER (FK)	CERAMIC DIP (J)	PLASTIC DIP (N)	FLAT PACK (W)
0°C to 70°C	7 mV	LM324D	—	LM324J	LM324N	—
—25°C to 85°C	3 mV	LM324AD	—	LM324AJ	LM324AN	—
—40°C to 105°C	5 mV	LM224D	—	LM224J	LM224N	—
—55°C to 125°C	3 mV	LM224AD	—	LM224AJ	LM224AN	—
—55°C to 125°C	7 mV	LM2902D	—	LM2902J	LM2902N	—
—55°C to 125°C	5 mV	—	LM124FK	LM124J	—	LM124W

The D package is available taped and reeled. Add the suffix R to the device type when ordering. (e.g., LM324DR)

schematic (each amplifier)



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Operational Amplifiers

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**LM124, LM224, LM224A,
LM324, LM324A, LM2902
QUADRUPLE OPERATIONAL AMPLIFIERS**

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

	LM124 LM224, LM224A, LM324, LM324A	LM2902	UNIT
Supply voltage, V_{CC} (see Note 1)	32	26	V
Differential voltage (see Note 2)	± 32	± 26	V
Input voltage range (either input)	-0.3 to 32	-0.3 to 26	V
Duration of output short-circuit (one amplifier) to ground at (or below) 25°C free-air temperature ($V_{CC} \leq 15$ V) (see Note 3)	unlimited	unlimited	
Continuous total dissipation	See Dissipation Rating Table		
Operating free-air temperature range	LM124	-55 to 125	°C
	LM224, LM224A	-25 to 85	
	LM324, LM324A	0 to 70	
	LM2902	-40 to 105	
Storage temperature range	-65 to 160	-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 or W package	300	°C
Lead temperature 1.6 mm (1/16 inch) from case for 10 seconds	D or N package	260	°C

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Operational Amplifiers

- NOTES: 1. All voltage values, except differential voltages and V_{CC} specified for the measurement of I_{OS} , are with respect to the network ground terminal.
 2. Differential voltages are at the noninverting input terminal with respect to the inverting input terminal.
 3. Short circuits from outputs to V_{CC} can cause excessive heating and eventual destruction.

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	900 mW	7.6 mW/°C	32°C	608 mW	494 mW	N/A
FK	900 mW	11.0 mW/°C	68°C	880 mW	715 mW	275 mW
J (LM124)	900 mW	11.0 mW/°C	68°C	880 mW	715 mW	275 mW
J (all others)	900 mW	8.2 mW/°C	40°C	656 mW	533 mW	N/A
N	900 mW	9.2 mW/°C	52°C	736 mW	598 mW	N/A
W	900 mW	8.0 mW/°C	37°C	640 mW	520 mW	200 mW

LM124, LM224, LM324, LM2902
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electrical characteristics at specified free-air temperature, $V_{CC} = 5\text{ V}$ (unless otherwise noted)

PARAMETER	TEST CONDITIONS†	LM124, LM224			LM324			LM2902			UNIT
		MIN	TYP	MAX	MIN	TYP	MAX	MIN	TYP	MAX	
V_{IO} Input offset voltage	$V_{CC} = 5\text{ V to MAX,}$ $V_{IC} = V_{ICR\text{ min,}}$ $V_O = 1.4\text{ V}$	3	5	7	3	7	7	3	7	7	mV
	Full range			7			8			10	
I_{IO} Input offset current	$V_O = 1.4\text{ V}$	2	30	50	2	50	50	2	50	50	nA
	Full range			100			150			200	
I_{IB} Input bias current	$V_O = 1.4\text{ V}$	-20	-150	-250	-20	-250	-250	-20	-250	-250	nA
	Full range			-300			-500			-500	
Common-mode input voltage range	$V_{CC} = 5\text{ V to MAX}$	0 to $V_{CC}-1.5$			0 to $V_{CC}-1.5$			0 to $V_{CC}-1.5$			V
	Full range										
V_{OH} High-level output voltage	$R_L = 2\text{ k}\Omega$										V
	$R_L = 10\text{ k}\Omega$										
V_{OL} Low-level output voltage	$V_{CC} = \text{MAX, } R_L = 2\text{ k}\Omega$	26			26			23			mV
	$V_{CC} = \text{MAX, } R_L = 10\text{ k}\Omega$	27	28	28	27	28	28	23	24	24	
AVD Large-signal differential voltage amplification	$R_L \leq 10\text{ k}\Omega$	5	20	20	5	20	20	5	100	100	V/mV
	$V_{CC} = 15\text{ V,}$ $V_O = 1\text{ V to }11\text{ V,}$ $R_L \geq 2\text{ k}\Omega$										
CMRR Common-mode rejection ratio	$V_{IC} = V_{ICR\text{ min}}$	70	80	80	65	80	80	50	80	80	dB
	Supply voltage rejection										
kSVR Supply voltage rejection ratio ($\Delta V_{CC}/\Delta V_{IO}$)	$f = 1\text{ kHz to }20\text{ kHz}$	65	100	100	65	100	100	50	100	100	dB
	$V_{CC} = 15\text{ V,}$ $V_{ID} = 1\text{ V,}$ $V_O = 0$										
I_O Output current	$V_{CC} = 15\text{ V,}$ $V_{ID} = -1\text{ V,}$ $V_O = 15\text{ V}$	10	20	20	10	20	20	10	20	20	mA
	$V_{ID} = -1\text{ V,}$ $V_O = 200\text{ mV}$										
IOS Short-circuit output current	$V_{CC} \text{ at } 5\text{ V,}$ $\text{GND at } -5\text{ V, } V_{VO} = 0$	±40	±60	±60	±40	±60	±60	±40	±60	±60	mA
	$V_O = 2.5\text{ V,}$ No load										
ICC Supply current (four amplifiers)	$V_{CC} = \text{MAX,}$ $V_O = 0.5\text{ }V_{CC}$	0.7	1.2	1.2	0.7	1.2	1.2	0.7	1.2	1.2	mA
	No load										

†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 105°C for LM2902.



LM224A, LM324A
QUADRUPLE OPERATIONAL AMPLIFIERS

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electrical characteristics at specified free-air temperature, VCC = 5 V (unless otherwise noted)

PARAMETER	TEST CONDITIONS†	LM224A			LM324A			UNIT
		MIN	TYP	MAX	MIN	TYP	MAX	
V _{IO}	VCC = 5 V to 30 V, V _{IC} = V _{ICR} min, V _O = 1.4 V	2	3	2	3	2	3	mV
I _O	V _O = 1.4 V	2	15	4	15	2	30	nA
I _{IB}	V _O = 1.4 V	-15	-80	-15	-100	-15	-100	nA
V _{ICR}	VCC = 30 V	0 to VCC-1.5		0 to VCC-1.5		0 to VCC-1.5		V
V _{OH}	R _L = 2 kΩ, VCC = 30 V, R _L = 2 kΩ	26	28	26	28	26	28	V
V _{OL}	VCC = 30 V, R _L = 10 kΩ	27	28	27	28	27	28	V
A _{VD}	R _L ≤ 10 kΩ	5	20	5	20	5	20	mV
CMRR	VCC = 15 V, V _O = 1 V to 11 V, R _L ≥ 2 kΩ	50	100	25	100	25	100	V/mV
k _{SVR}	V _{IC} = V _{ICR} min	70	80	65	80	65	80	dB
V _{1/f}	Supply voltage rejection ratio (ΔV _{CC} /ΔV _{IO})	65	100	65	100	65	100	dB
V _{1/f} /G ₂	Crosstalk attenuation	120		120		120		dB
I _O	f = 1 kHz to 20 kHz, VCC = 15 V, V _{ID} = 1 V, V _O = 0	-20	-30	-60	-20	-30	-60	mA
I _{OS}	VCC = 15 V, V _{ID} = -1 V, V _O = 15 V	-10		-10		-10		mA
I _{OS}	VCC = 15 V, V _{ID} = -1 V, V _O = 15 V	5		5		5		mA
I _{OS}	VCC = 15 V, V _{ID} = -1 V, V _O = 200 mV	12	30	12	30	12	30	μA
I _{CC}	VCC at 5 V, GND at -5 V, V _O = 0	±40	±60	±40	±60	±40	±60	mA
I _{CC}	V _O = 2.5 V, No load	1.5	2.4	1.5	2.4	1.5	2.4	mA
I _{CC}	VCC = 30 V, V _O = 15 V, No load	1.1	3	1.1	3	1.1	3	mA

† All characteristics are measured under open-loop conditions with zero common-mode input voltage unless otherwise specified. Full range is -25°C to 85°C for LM224A and 0°C to 70°C for LM324A.

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