

LM124, LM124A, LM224, LM224A LM324, LM324A, LM2902 QUADRUPLE OPERATIONAL AMPLIFIERS

SLOS066F – SEPTEMBER 1975 – REVISED JANUARY 2002

- **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**

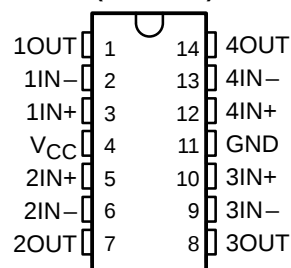
description

These devices consist of four independent high-gain frequency-compensated operational amplifiers that are designed specifically to operate from a single supply over a wide range of voltages. Operation from split supplies is also 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.

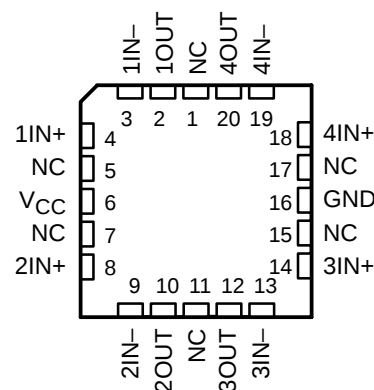
Applications include transducer amplifiers, dc amplification blocks, and all the conventional operational-amplifier circuits that now can be more easily implemented in single-supply-voltage systems. For example, the LM124 can be operated directly from the standard 5-V supply that is used in digital systems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

The LM124 and LM124A are characterized for operation over the full military temperature range of -55°C to 125°C . The LM224 and LM224A are characterized for operation from -25°C to 85°C . The LM324 and LM324A are characterized for operation from 0°C to 70°C . The LM2902 is characterized for operation from -40°C to 125°C .

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



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



NC – No internal connection

LM124, LM124A, LM224, LM224A
LM324, LM324A, LM2902
QUADRUPLE OPERATIONAL AMPLIFIERS

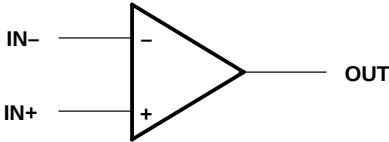
SLOS066F – SEPTEMBER 1975 – REVISED JANUARY 2002

AVAILABLE OPTIONS

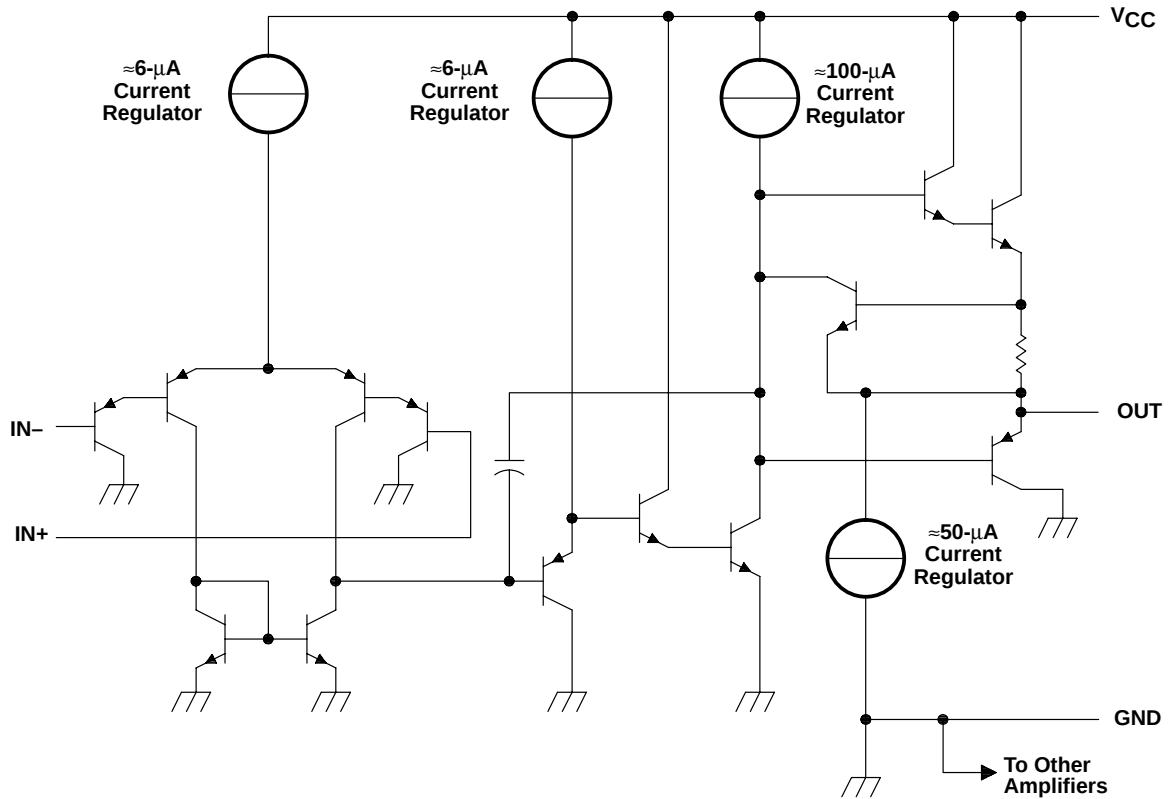
T _A	V _{IO} MAX AT 25°C	SMALL OUTLINE (D)	VERY SMALL OUTLINE (DB)	CHIP CARRIER (FK)	CERAMIC DIP (J)	PLASTIC DIP (N)	TSSOP (PW)	FLAT PACK (W)
0°C to 70°C	7 mV 3 mV	LM324D LM324AD	LM324DB —	— —	— —	LM324N LM324AN	LM324PW LM324APW	— —
–25°C to 85°C	5 mV 3 mV	LM224D LM224AD	— —	— —	— —	LM224N LM224AN	— —	— —
–40°C to 125°C	7 mV	LM2902D	LM2902DB	—	—	LM2902N	LM2902PW	—
–55°C to 125°C	5 mV 2 mV	LM124D —	— —	LM124FK LM124AFK	LM124J LM124AJ	— —	— —	LM124W —

The D package is available taped and reeled. Add the suffix R to the device type (e.g., LM324DR). The DB and PW packages are only available taped and reeled.

symbol (each amplifier)



schematic (each amplifier)



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

**LM124, LM124A, LM224, LM224A
LM324, LM324A, LM2902
QUADRUPLE OPERATIONAL AMPLIFIERS**

SLOS066F – SEPTEMBER 1975 – REVISED JANUARY 2002

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) $T_A = 25^\circ\text{C}$, $V_{CC} \leq 15\text{ V}$ (see Note 3)		Unlimited	Unlimited	
Continuous total dissipation		See Dissipation Rating Table		
Package thermal impedance, θ_{JA} (see Note 4)	D package	86		$^\circ\text{C/W}$
	DB package	96		
	N package	80		
	PW package	113		
Case temperature for 60 seconds	FK package	260		$^\circ\text{C}$
Lead temperature 1,6 mm (1/16 inch) from case for 60 seconds	J or W package	300	300	$^\circ\text{C}$
Lead temperature 1,6 mm (1/16 inch) from case for 10 seconds	D, DB, N, or PW package	260	260	$^\circ\text{C}$
Storage temperature range, T_{stg}		-65 to 150	-65 to 150	$^\circ\text{C}$

[†] 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. The package thermal impedance is calculated in accordance with JESD 51-7.

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/ $^\circ\text{C}$	32 $^\circ\text{C}$	611 mW	497 mW	N/A
FK	900 mW	11.0 mW/ $^\circ\text{C}$	68 $^\circ\text{C}$	878 mW	713 mW	273 mW
J (LM124_)	900 mW	11.0 mW/ $^\circ\text{C}$	68 $^\circ\text{C}$	878 mW	713 mW	273 mW
J (all others)	900 mW	8.2 mW/ $^\circ\text{C}$	40 $^\circ\text{C}$	654 mW	531 mW	N/A
W	900 mW	8.0 mW/ $^\circ\text{C}$	37 $^\circ\text{C}$	636 mW	516 mW	196 mW



POST OFFICE BOX 655303 • DALLAS, TEXAS 75265

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

PARAMETER		TEST CONDITIONS†	T _A ‡	LM124, LM224			LM324			LM2902			UNIT
				MIN	TYP§	MAX	MIN	TYP§	MAX	MIN	TYP§	MAX	
V _{IO}	Input offset voltage	V _{CC} = 5 V to MAX, V _{IC} = V _{ICRmin} , 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 _{ICRmin}	25°C	70		80	65		80	50		80	dB
k _{SVR}	Supply-voltage rejection ratio (ΔV _{CC} /ΔV _{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						
		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, 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} = 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 $T_A = 25^\circ\text{C}$.

LM124, LM124A, LM224, LM224A

LM324, LM324A, LM2902

QUADRUPLER OPERATIONAL AMPLIFIERS

SLOS066 – SEPTEMBER 1975 – REVISED JANUARY 2002

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

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 _{ICRmin} , 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 ≥ 10 kΩ	Full range	27			27	28		27	28		
V _{OL}	Low-level output voltage	R _L ≤ 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 = ≥ 2 kΩ	Full range	25			25			15			V/mV
CMRR	Common-mode rejection ratio	V _{IC} = V _{ICRmin}	25°C	70			70	80		65	80		dB
k _{SVR}	Supply-voltage rejection ratio (ΔV _{CC} /ΔV _{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, 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} = 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 $T_A = 25^\circ\text{C}$.

IMPORTANT NOTICE

Texas Instruments Incorporated and its subsidiaries (TI) reserve the right to make corrections, modifications, enhancements, improvements, and other changes to its products and services at any time and to discontinue any product or service without notice. Customers should obtain the latest relevant information before placing orders and should verify that such information is current and complete. All products are sold subject to TI's terms and conditions of sale supplied at the time of order acknowledgment.

TI warrants performance of its hardware products to the specifications applicable at the time of sale in accordance with TI's standard warranty. Testing and other quality control techniques are used to the extent TI deems necessary to support this warranty. Except where mandated by government requirements, testing of all parameters of each product is not necessarily performed.

TI assumes no liability for applications assistance or customer product design. Customers are responsible for their products and applications using TI components. To minimize the risks associated with customer products and applications, customers should provide adequate design and operating safeguards.

TI does not warrant or represent that any license, either express or implied, is granted under any TI patent right, copyright, mask work right, or other TI intellectual property right relating to any combination, machine, or process in which TI products or services are used. Information published by TI regarding third-party products or services does not constitute a license from TI to use such products or services or a warranty or endorsement thereof. Use of such information may require a license from a third party under the patents or other intellectual property of the third party, or a license from TI under the patents or other intellectual property of TI.

Reproduction of information in TI data books or data sheets is permissible only if reproduction is without alteration and is accompanied by all associated warranties, conditions, limitations, and notices. Reproduction of this information with alteration is an unfair and deceptive business practice. TI is not responsible or liable for such altered documentation.

Resale of TI products or services with statements different from or beyond the parameters stated by TI for that product or service voids all express and any implied warranties for the associated TI product or service and is an unfair and deceptive business practice. TI is not responsible or liable for any such statements.

Mailing Address:

Texas Instruments
Post Office Box 655303
Dallas, Texas 75265