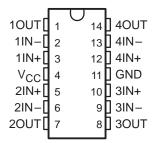
SLOS066E-SEPTEMBER 1975 - REVISED FEBRUARY1997

- Wide Range of Supply Voltages: Single Supply . . . 3 V to 30 V (LM2902 and LM2902Q 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 and LM2902Q)
- Open-Loop Differential Voltage Amplification . . . 100 V/mV Typ
- Internal Frequency Compensation

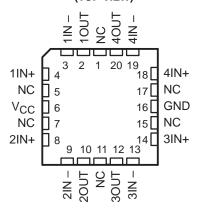
## description

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 and LM2902Q, 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.

# LM124, LM124A . . . J OR W PACKAGE ALL OTHERS . . . D, DB, N OR PW PACKAGE (TOP VIEW)

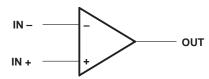


# LM124, LM124A . . . FK PACKAGE (TOP VIEW)



NC - No internal connection

#### symbol (each amplifier)



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  $\pm 15$ -V supplies.

The LM2902Q is manufactured to demanding automotive requirements.

The LM124 and LM124A are characterized for operation over the full military temperature range of  $-55^{\circ}$ C to  $125^{\circ}$ C. The LM224 and LM224A are characterized for operation from  $-25^{\circ}$ C to  $85^{\circ}$ C. The LM324 and LM324A are characterized for operation from  $0^{\circ}$ C to  $70^{\circ}$ C. The LM2902 and LM2902Q are characterized for operation from  $-40^{\circ}$ C to  $125^{\circ}$ C.

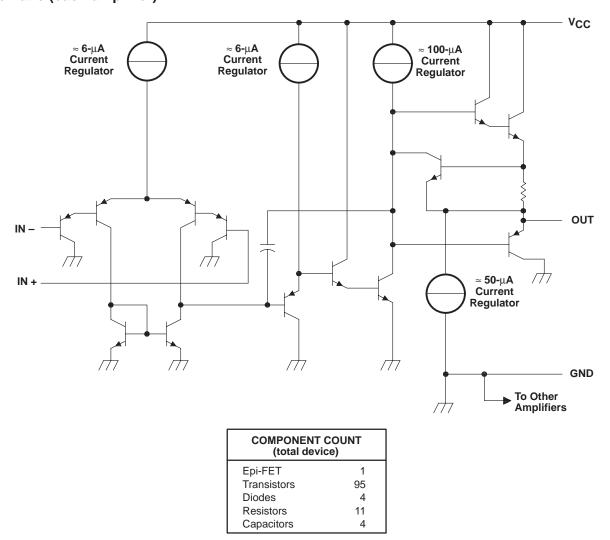
SLOS066E-SEPTEMBER 1975 - REVISED FEBRUARY1997

#### **AVAILABLE OPTIONS**

			PACKAGED DEVICES									
TA	V <sub>IO</sub> max AT 25°C	SMALL OUTLINE (D)†	VERY SMALL OUTLINE (DB) <sup>‡</sup>	CHIP CARRIER (FK)	CERAMIC DIP (J)	PLASTIC DIP (N)	TSSOP (PW)‡	FLAT PACK (W)	CHIP FORM (Y)			
0°C to	7 mV	LM324D	LM324DBLE	_	_	LM324N	LM324PWLE	_	LM324Y			
70°C	3 mV	LM324AD	_	_	_	LM324AN	LM324APWLE	_	LIVI3241			
−25°C to	5 mV	LM224D	_	_	_	LM224N	_	_				
85°C	3 mV	LM224AD	_	_	_	LM224AN	_	_	_			
−40°C to	7 \/	LM2902D	I MOOOODDI E	_	_	LM2902N	1 MACCOCODIA/I E	_				
125°C	7 mV	LM2902QD	LM2902DBLE	_	_	LM2902QN	LM2902PWLE	_	_			
−55°C to 5 mV		_	_	LM124FK	LM124J	_	_	LM124W				
125°C	2 mV	_	_	LM124AFK	LM124AJ	_			_			

<sup>&</sup>lt;sup>†</sup> The D package is available taped and reeled. Add the suffix R to the device type (e.g., LM324DR).

#### schematic (each amplifier)



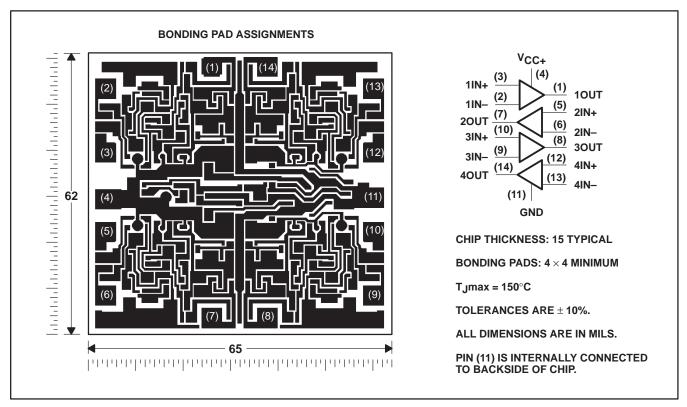


<sup>&</sup>lt;sup>‡</sup> The DB and PW packages are only available left-end taped and reeled.

SLOS066E- SEPTEMBER 1975 - REVISED FEBRUARY1997

#### LM324Y chip information

This chip, when properly assembled, displays characteristics similar to the LM324. Thermal compression or ultrasonic bonding may be used on the doped-aluminum bonding pads. Chips may be mounted with conductive epoxy or a gold-silicon preform.



## LM124, LM124A, LM224, LM224A LM324, LM324A, LM324Y, LM2902, LM2902Q QUADRUPLE OPERATIONAL AMPLIFIERS

SLOS066E-SEPTEMBER 1975 - REVISED FEBRUARY1997

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

		LM124, LM124A LM224, LM224A LM324, LM324A	LM2902, LM2902Q	UNIT		
Supply voltage, V <sub>CC</sub> (see Note 1)		32	26	V		
Differential input voltage, V <sub>ID</sub> (see Note 2)		±32	±26	V		
Input voltage, V <sub>I</sub> (either input)		-0.3 to 32	-0.3 to 26	V		
Duration of output short circuit (one amplifier) to ground at (or be $V_{CC} \le 15 \text{ V}$ (see Note 3)	unlimited	unlimited				
Continuous total dissipation		See Dissipation Rating Table				
	LM124, LM124A	-55 to 125				
Operating free six temperature range. To	LM224, LM224A	-25 to 85		°C		
Operating free-air temperature range, T <sub>A</sub>	LM324, LM324A	0 to 70				
	LM2902, LM2902Q		-40 to 125			
Storage temperature range	-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 or W package	300	300	°C		
Lead temperature 1,6 mm (1/16 inch) from case for 10 seconds	D, DB, N, or PW package	260	260	°C		

<sup>†</sup> 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 VCC specified for the measurement of IOS) are with respect to the network GND.
  - 2. Differential voltages are at IN + with respect to IN -.
  - 3. Short circuits from outputs to V<sub>CC</sub> can cause excessive heating and eventual destruction.

#### **DISSIPATION RATING TABLE**

PACKAGE	T <sub>A</sub> ≤ 25°C POWER RATING	DERATING FACTOR	DERATE ABOVE T <sub>A</sub>	T <sub>A</sub> = 70°C POWER RATING	T <sub>A</sub> = 85°C POWER RATING	T <sub>A</sub> = 125°C POWER RATING
D	900 mW	7.6 mW/°C	32°C	611 mW	497 mW	N/A
DB	775 mW	6.2 mW/°C	25°C	496 mW	403 mW	N/A
FK	900 mW	11.0 mW/°C	68°C	878 mW	713 mW	273 mW
J (LM124_)	900 mW	11.0 mW/°C	68°C	878 mW	713 mW	273 mW
J (all others)	900 mW	8.2 mW/°C	40°C	654 mW	531 mW	N/A
N	900 mW	9.2 mW/°C	52°C	734 mW	596 mW	N/A
PW	700 mW	5.6 mW/°C	25°C	448 mW	364 mW	N/A
W	900 mW	8.0 mW/°C	37°C	636 mW	516 mW	196 mW

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

PARAMETER		TEST CONDITIONS†		- t	LM124, LM224		LM324			LM2902, LM2902Q			LIAUT		
	PARAMETER	TEST CONDITIONS!		T <sub>A</sub> ‡	MIN	TYP§	MAX	MIN	TYP§	MAX	MIN	TYP§	MAX	UNIT	
V/- a	Input offset voltage	V <sub>CC</sub> = 5 V to MA		25°C		3	5		3	7		3	7	mV	
VIO	Input offset voltage	$V_{IC} = V_{ICR}$ min, $V_{O} = 1.4 \text{ V}$		Full range			7			9			10	IIIV	
lio	Input offset current	V <sub>O</sub> = 1.4 V		25°C		2	30		2	50		2	50	nA	
10	input onset current	V() = 1.4 V	V() = 1.4 V			-	100			150			300	ПА	
I <sub>IB</sub>	Input bias current	V <sub>O</sub> = 1.4 V		25°C		-20	-150		-20	-250		-20	-250	nA	
ıВ	input bias current	V() = 1.4 V		Full range			-300			-500			-500	11/5	
	Common-mode input	V <sub>CC</sub> = 5 V to MAX		25°C	0 to V <sub>CC</sub> - 1.5			0 to V <sub>CC</sub> – 1.5			0 to V <sub>CC</sub> -1 .5				
VICR	voltage range			Full range	0 to V <sub>CC</sub> - 2			0 to V <sub>CC</sub> - 2			0 to V <sub>CC</sub> -2			V	
		R <sub>L</sub> = 2 kΩ		25°C	V <sub>CC</sub> - 1.5			V <sub>CC</sub> - 1.5							
Vон	High-level output voltage	R <sub>L</sub> = 10 kΩ		25°C							V <sub>CC</sub> -1 .5			V	
		V <sub>CC</sub> = MAX,	$R_L = 2 k\Omega$	Full range	26			26			22				
		V <sub>CC</sub> = MAX,	$R_L \ge 10 \ k\Omega$	Full range	27	28		27	28		23	24			
$V_{OL}$	Low-level output voltage	$R_L \le 10 \text{ k}\Omega$		Full range		5	20		5	20		5	20	mV	
A <sub>VD</sub>	Large-signal differential voltage amplification	$V_{CC} = 15 \text{ V, } V_{O}$ $R_{L} = \ge 2 \text{ k}\Omega$	= 1 V to 11 V,	25°C Full range	50 25	100		25 15	100		15	100		V/mV	
CMRR	Common-mode rejection ratio	V <sub>IC</sub> = V <sub>ICR</sub> min		25°C	70	80		65	80		50	80		dB	
ksvR	Supply-voltage rejection ratio (ΔV <sub>CC</sub> /ΔV <sub>IO</sub> )			25°C	65	100		65	100		50	100		dB	
V <sub>O1</sub> /V <sub>O2</sub>	Crosstalk attenuation	f = 1 kHz to 20 kl	Hz	25°C		120			120			120		dB	
		V <sub>CC</sub> = 15 V,	V <sub>ID</sub> = 1 V,	25°C	-20	-30	-60	-20	-30	-60	-20	-30	-60		
		V <sub>O</sub> = 0	15	Full range	-10			-10			-10			^	
IO	Output current	V <sub>CC</sub> = 15 V,	V <sub>ID</sub> = -1 V,	25°C	10	20		10	20		10	20		mA	
		V <sub>O</sub> = 15 V		Full range	5			5			5				
		$V_{ID} = -1 V$ ,	$V_O = 200 \text{ mV}$	25°C	12	30		12	30			30		μΑ	
los	Short-circuit output current	V <sub>CC</sub> at 5 V, GND at -5 V	V <sub>O</sub> = 0	25°C		±40	±60		±40	±60		±40	±60	mA	
		$V_0 = 2.5 V$ ,	No load	Full range		0.7	1.2		0.7	1.2		0.7	1.2		
lcc	Supply current (four amplifiers)	$V_{CC} = MAX,$ $V_{O} = 0.5 V_{CC},$	No load	Full range		1.4	3		1.4	3		1.4	3	mA	

<sup>†</sup> All characteristics are measured under open-loop conditions with zero common-mode input voltage unless otherwise specified. MAX V<sub>CC</sub> for testing purposes is 26 V for LM2902 and LM2902Q, 30 V for the others.

 $<sup>\</sup>ddagger$  Full range is  $-55^{\circ}$ C to  $125^{\circ}$ C for LM124,  $-25^{\circ}$ C to  $85^{\circ}$ C for LM224,  $0^{\circ}$ C to  $70^{\circ}$ C for LM324, and  $-40^{\circ}$ C to  $125^{\circ}$ C for LM2902 and LM2902Q.

<sup>§</sup> All typical values are at  $T_A = 25$ °C.

## electrical characteristics at specified free-air temperature, V<sub>CC</sub> = 5 V (unless otherwise noted)

				T <sub>A</sub> ‡	LM124A		LM224A			LM324A				
	PARAMETER		TEST CONDITIONST		MIN	TYP§	MAX	MIN	TYP§	MAX	MIN	TYP§	MAX	UNIT
		V <sub>CC</sub> = 5 V to 30	0 V,	25°C			2		2	3		2	3	.,
VIO	V <sub>IO</sub> Input offset voltage		$V_0 = 1.4 \text{ V}$	Full range			4			4			5	mV
	lt#t	V 44V		25°C			10			2	15	2	30	0
110	Input offset current	V <sub>O</sub> = 1.4 V		Full range			30			30			75	nA
	Innuit bigg gurrant	V- 4.4.V		25°C			-50		-15	-80		-15	-100	nA
IB	Input bias current	V <sub>O</sub> = 1.4 V		Full range			-100			-100			-200	nA
V	Common-mode input	V 20 V		25°C	0 to V <sub>CC</sub> -1.5			0 to V <sub>CC</sub> -1.5			0 to V <sub>CC</sub> -1.5			V
VICR	voltage range	VCC = 30 V		Full range	0 to V <sub>CC</sub> -2			0 to V <sub>CC</sub> -2			0 to V <sub>CC</sub> -2			\ 
		$R_L = 2 k\Omega$		25°C	V <sub>CC</sub> -1.5			V <sub>CC</sub> -1.5			V <sub>CC</sub> -1.5			V
VOH	High-level output voltage	$V_{CC} = 30 \text{ V},$	$R_L = 2 k\Omega$	Full range	26			26			26			
		$V_{CC} = 30 \text{ V},$	$R_L \ge 10 \text{ k}\Omega$	Full range	27			27	28		27	28		
$V_{OL}$	Low-level output voltage	$R_L \le 10 \text{ k}\Omega$		Full range			20		5	20		5	20	mV
A <sub>VD</sub>	Large-signal differential voltage amplification	$V_{CC} = 15 \text{ V}, V_{C}$ $R_{L} = 2 \text{ k}\Omega$	) = 1 V to 11 V,	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
ksvr	Supply-voltage rejection ratio $(\Delta V_{CC}/\Delta V_{IO})$			25°C	65			65	100		65	100		dB
V <sub>O1</sub> /V <sub>O2</sub>	Crosstalk attenuation	f = 1 kHz to 20	kHz	25°C		120			120			120		dB
		V <sub>CC</sub> = 15 V,	V <sub>ID</sub> = 1 V,	25°C	-20			-20	-30	-60	-20	-30	-60	
		V <sub>O</sub> = 0		Full range	-10			-10			-10			4
IO	Output current	V <sub>CC</sub> = 15 V,	V <sub>ID</sub> = −1 V,	25°C	10			10	20		10	20		mA
		V <sub>O</sub> = 15 V		Full range	5			5			5			
		$V_{ID} = -1 V$ ,	$V_0 = 200 \text{ mV}$	25°C	12			12	30		12	30		μΑ
los	Short-circuit output current	V <sub>CC</sub> at 5 V, V <sub>O</sub> = 0	GND at -5 V,	25°C		±40	±60		±40	±60		±40	±60	mA
	<u> </u>	$V_0 = 2.5 V$ ,	No load	Full range		0.7	1.2		0.7	1.2		0.7	1.2	
ICC	Supply current (four amplifiers)	V <sub>CC</sub> = 30 V, No load	V <sub>O</sub> = 15 V,	Full range		1.4	3		1.4	3		1.4	3	mA

<sup>†</sup> 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<sub>A</sub> = 25°C.

SLOS066E - SEPTEMBER 1975 - REVISED FEBRUARY 1997

# electrical characteristics, $V_{CC}$ = 5 V, $T_A$ = 25°C (unless otherwise noted)

	DADAMETED	TEC	LN	UNIT				
	PARAMETER	IES	r conditions†		MIN	TYP	MAX	UNII
VIO	Input offset voltage					3	7	mV
Iю	Input offset current	$V_{CC} = 5 V \text{ to } MAX,$	$V_{IC} = V_{ICR}min$	$V_0 = 1.4 \text{ V}$		2	50	nA
I <sub>IB</sub>	Input bias current					-20	-250	nA
VICR	Common-mode input voltage range	V <sub>CC</sub> = 5 V to MAX			0 to V <sub>CC</sub> -1.5			V
Vон	High-level output voltage	R <sub>L</sub> = 10 kΩ			V <sub>CC</sub> -1.5			V
VOL	Low-level output voltage	$R_L \le 10 \text{ k}\Omega$				5	20	mV
AVD	Large-signal differential voltage amplification	V <sub>CC</sub> = 15 V,	V <sub>O</sub> = 1 V to 11 V,	R <sub>L</sub> ≥ 2 kΩ	15	100		V/mV
CMRR	Common-mode rejection ratio	V <sub>IC</sub> = V <sub>ICR</sub> min			65	80		dB
ksvr	Supply-voltage rejection ratio $(\Delta V_{CC\pm}/\Delta V_{IO})$				65	100		dB
		V <sub>CC</sub> = 15 V,	V <sub>ID</sub> = 1 V,	VO = 0	-20	-30	-60	
IO	Output current	V <sub>CC</sub> = 15 V,	$V_{ID} = -1 V$ ,	V <sub>O</sub> = 15 V	10	20		mA
		V <sub>ID</sub> = 1 V,	V <sub>O</sub> = 200 mV		12	30		
los	Short-circuit output current	V <sub>CC</sub> at 5 V,	GND at −5 V,	VO = 0		±40	±60	mA
la a	Cumply comment (form complificate)	$V_{O} = 2.5 V_{CC}$	No load			0.7	1.2	A
ICC	Supply current (four amplifiers)	$V_{CC} = MAX$ ,	$V_{O} = 0.5 V_{CC}$	No load		1.1	3	mA

<sup>†</sup> All characteristics are measured under open-loop conditions with zero common-mode input voltage unless otherwise specified. MAX V<sub>CC</sub> for testing purposes is 30 V.



#### **IMPORTANT NOTICE**

Texas Instruments and its subsidiaries (TI) reserve the right to make changes to their products or to discontinue any product or service without notice, and advise customers to obtain the latest version of relevant information to verify, before placing orders, that information being relied on is current and complete. All products are sold subject to the terms and conditions of sale supplied at the time of order acknowledgement, including those pertaining to warranty, patent infringement, and limitation of liability.

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

CERTAIN APPLICATIONS USING SEMICONDUCTOR PRODUCTS MAY INVOLVE POTENTIAL RISKS OF DEATH, PERSONAL INJURY, OR SEVERE PROPERTY OR ENVIRONMENTAL DAMAGE ("CRITICAL APPLICATIONS"). TI SEMICONDUCTOR PRODUCTS ARE NOT DESIGNED, AUTHORIZED, OR WARRANTED TO BE SUITABLE FOR USE IN LIFE-SUPPORT DEVICES OR SYSTEMS OR OTHER CRITICAL APPLICATIONS. INCLUSION OF TI PRODUCTS IN SUCH APPLICATIONS IS UNDERSTOOD TO BE FULLY AT THE CUSTOMER'S RISK.

In order to minimize risks associated with the customer's applications, adequate design and operating safeguards must be provided by the customer to minimize inherent or procedural hazards.

TI assumes no liability for applications assistance or customer product design. TI does not warrant or represent that any license, either express or implied, is granted under any patent right, copyright, mask work right, or other intellectual property right of TI covering or relating to any combination, machine, or process in which such semiconductor products or services might be or are used. TI's publication of information regarding any third party's products or services does not constitute TI's approval, warranty or endorsement thereof.

Copyright © 1999, Texas Instruments Incorporated