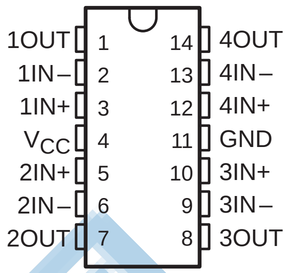
LM124, LM124A, LM224, LM224A
LM324, LM324A, LM324Y, LM2902, LM2902Q
QUADRUPLE OPERATIONAL AMPLIFIERS

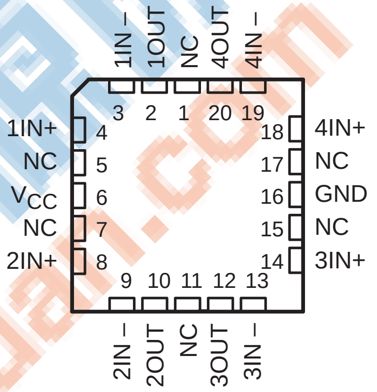
SLOS066E– SEPTEMBER 1975 – REVISED FEBRUARY1997

- **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**

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



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

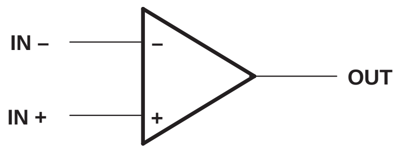


NC – No internal connection

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.

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 ±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°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 and LM2902Q are characterized for operation from –40°C to 125°C.

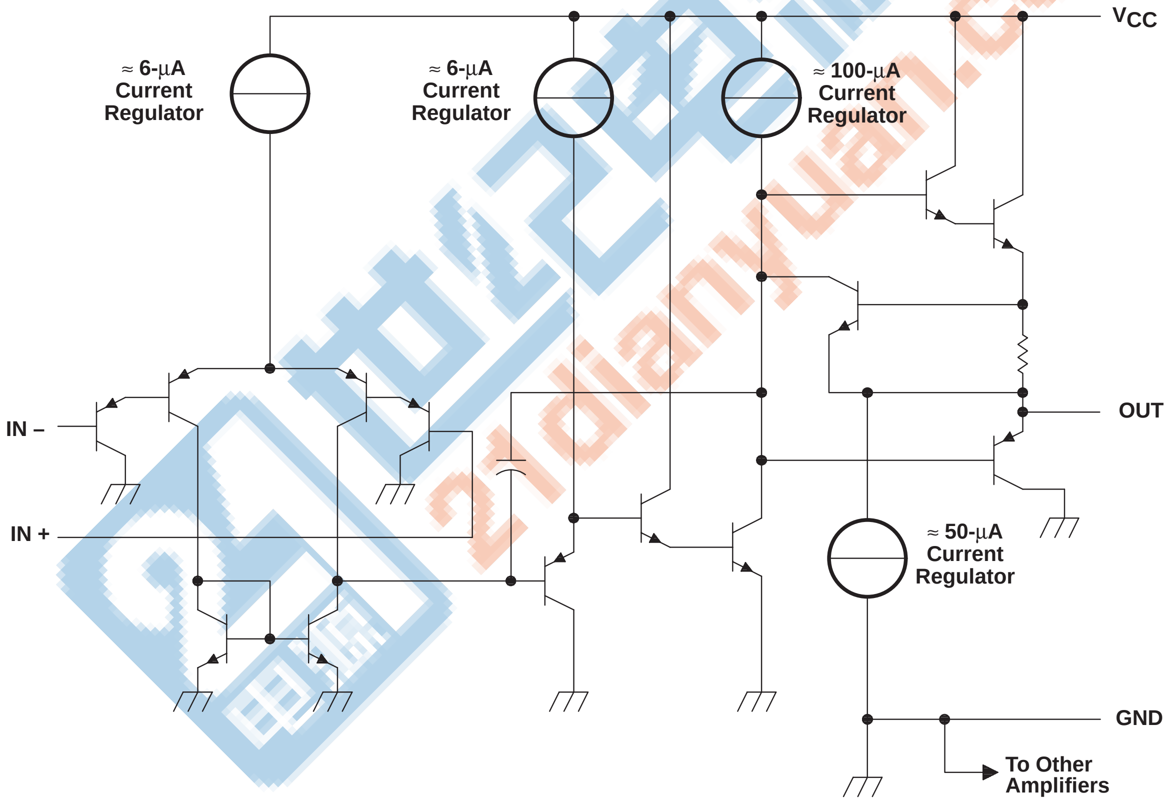
TEXAS INSTRUMENTS

AVAILABLE OPTIONS

T_A	V_{IO}max AT 25°C	PACKAGED DEVICES							CHIP FORM (Y)
		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	LM324D	LM324DBLE	—	—	LM324N	LM324PWLE	—	LM324Y
	3 mV	LM324AD	—	—	—	LM324AN	LM324APWLE	—	
–25°C to 85°C	5 mV	LM224D	—	—	—	LM224N	—	—	—
	3 mV	LM224AD	—	—	—	LM224AN	—	—	
–40°C to 125°C	7 mV	LM2902D	LM2902DBLE	—	—	LM2902N	LM2902PWLE	—	—
		LM2902QD		—	—	LM2902QN		—	
–55°C to 125°C	5 mV	—	—	LM124FK	LM124J	—	—	LM124W	—
	2 mV	—	—	LM124AFK	LM124AJ	—	—		

† 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 left-end taped and reeled.

schematic (each amplifier)

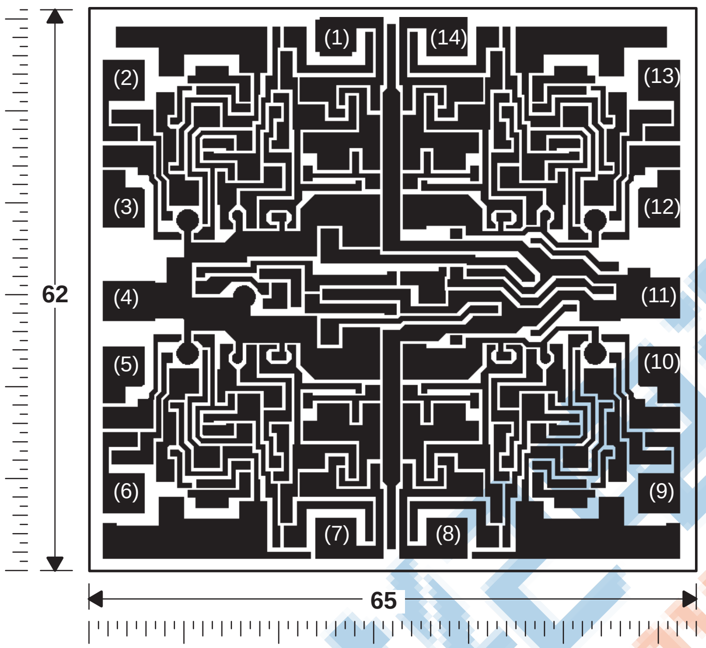


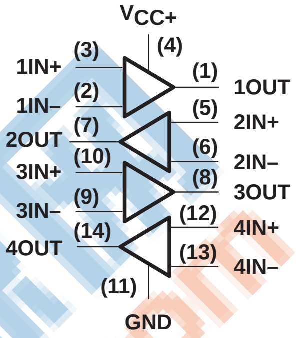
COMPONENT COUNT (total device)	
Epi-FET	1
Transistors	95
Diodes	4
Resistors	11
Capacitors	4

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.

BONDING PAD ASSIGNMENTS





CHIP THICKNESS: 15 TYPICAL

BONDING PADS: 4 × 4 MINIMUM

$T_J$max = 150°C

TOLERANCES ARE ± 10%.

ALL DIMENSIONS ARE IN MILS.

PIN (11) IS INTERNALLY CONNECTED
TO BACKSIDE OF CHIP.

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

		LM124, LM124A LM224, LM224A LM324, LM324A	LM2902, LM2902Q	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) $T_A = 25°C$, $V_{CC} \leq 15$ V (see Note 3)		unlimited	unlimited	
Continuous total dissipation		See Dissipation Rating Table		
Operating free-air temperature range, T_A	LM124, LM124A	–55 to 125		°C
	LM224, LM224A	–25 to 85		
	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

† 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.

DISSIPATION RATING TABLE

PACKAGE	$T_A \leq 25°C$ POWER RATING	DERATING FACTOR	DERATE ABOVE T_A	$T_A = 70°C$ POWER RATING	$T_A = 85°C$ POWER RATING	$T_A = 125°C$ 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 V (unless otherwise noted)

PARAMETER		TEST CONDITIONS†	T_A‡	LM124, LM224			LM324			LM2902, LM2902Q			UNIT
				MIN	TYP§	MAX	MIN	TYP§	MAX	MIN	TYP§	MAX	
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	

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† 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 and LM2902Q, 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 and LM2902Q.

§ All typical values are at T_A = 25°C.

electrical characteristics at specified free-air temperature, V_{CC} = 5 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_{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 ≥ 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_{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.

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

PARAMETER		TEST CONDITIONS†			LM324Y			UNIT
					MIN	TYP	MAX	
V_{IO}	Input offset voltage	V_{CC} = 5 V to MAX,	V_{IC} = V_{ICR}min,	V_O = 1.4 V		3	7	mV
I_{IO}	Input offset current					2	50	nA
I_{IB}	Input bias current					–20	–250	nA
V_{ICR}	Common-mode input voltage range	V_{CC} = 5 V to MAX			0 to V_{CC} – 1.5			V
V_{OH}	High-level output voltage	R_L = 10 kΩ			V_{CC} – 1.5			V
V_{OL}	Low-level output voltage	$R_L \leq$ 10 kΩ				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	15	100		V/mV
CMRR	Common-mode rejection ratio	V_{IC} = V_{ICR}min			65	80		dB
k_{SVR}	Supply-voltage rejection ratio ($\Delta V_{CC\pm}/\Delta V_{IO}$)				65	100		dB
I_O	Output current	V_{CC} = 15 V,	V_{ID} = 1 V,	V_O = 0	–20	–30	–60	mA
		V_{CC} = 15 V,	V_{ID} = –1 V,	V_O = 15 V	10	20		
		V_{ID} = 1 V,	V_O = 200 mV		12	30		
I_{OS}	Short-circuit output current	V_{CC} at 5 V,	GND at –5 V,	V_O = 0		±40	±60	mA
I_{CC}	Supply current (four amplifiers)	V_O = 2.5 V_{CC},	No load			0.7	1.2	mA
		V_{CC} = MAX,	V_O = 0.5 V_{CC},	No load		1.1	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 30 V.

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