

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

SLOS066E—SEPTEMBER 1975—REVISED FEBRUARY 1997

- **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

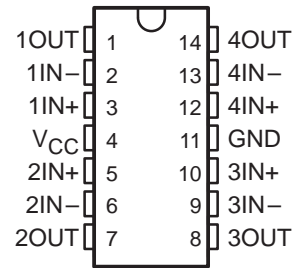
These devices consist of four independent high-gain frequency-compensated operational amplifiers that are designed specifically to operate from a single supply over a wide range of voltages. Operation from split supplies is also possible when the difference between the two supplies is 3 V to 30 V (for 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.

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.

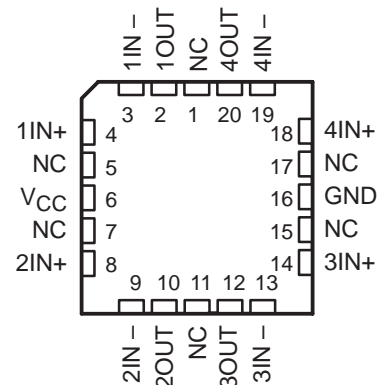
The LM2902Q is manufactured to demanding automotive requirements.

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 .

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

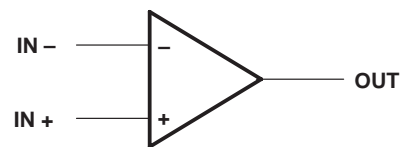


LM124, LM124A . . . FK PACKAGE
(TOP VIEW)



NC – No internal connection

symbol (each amplifier)



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

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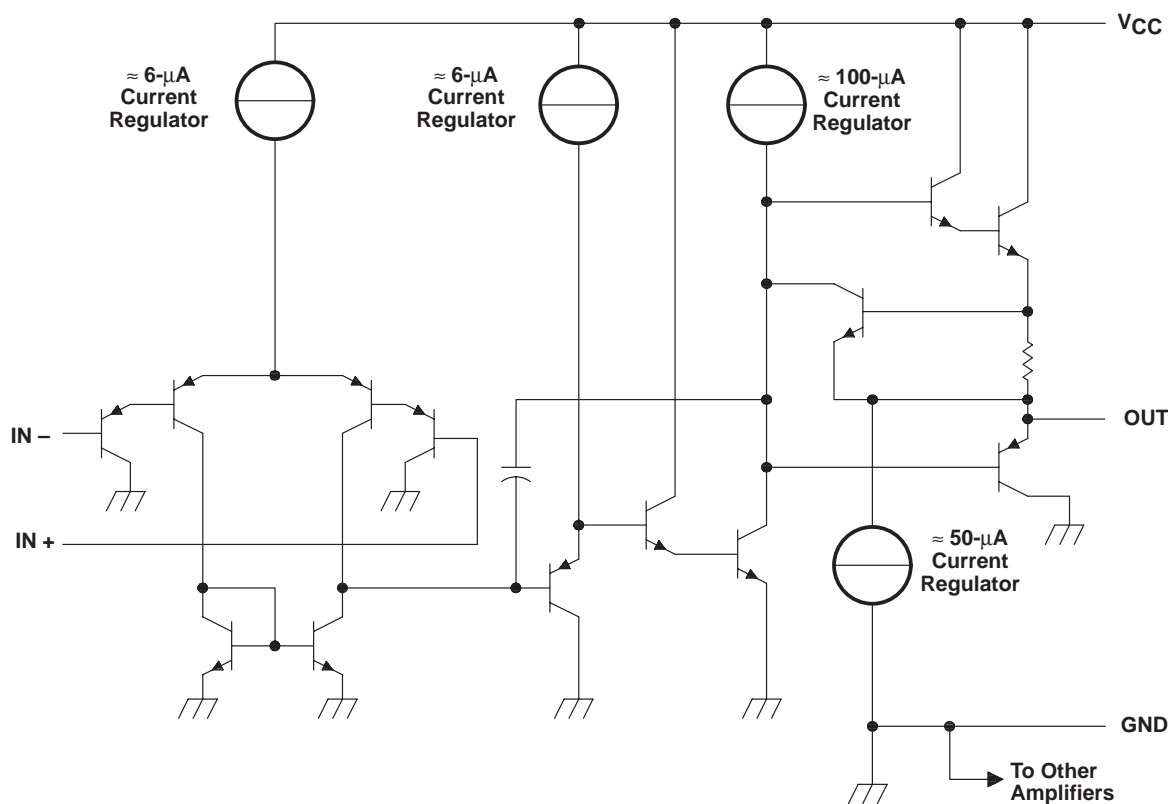
AVAILABLE OPTIONS

T _A	V _I Omax 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)



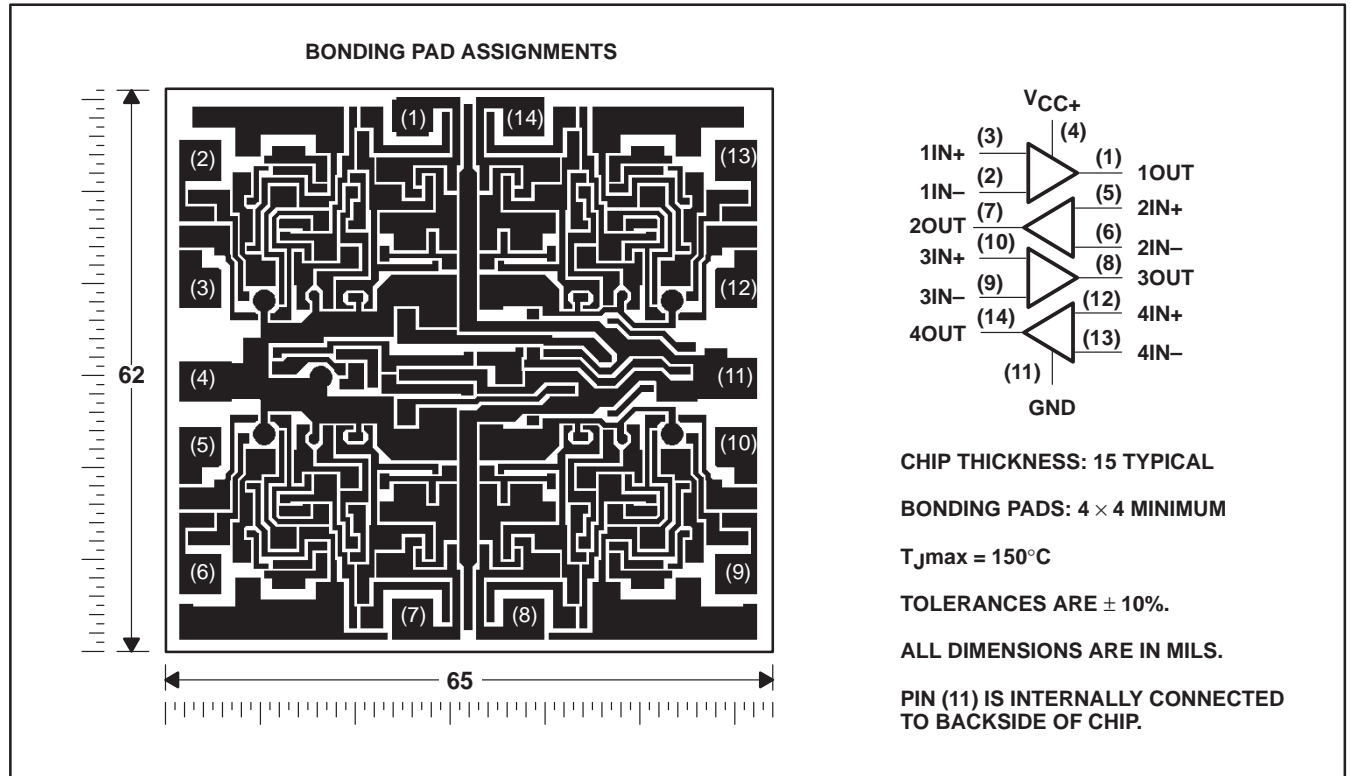
COMPONENT COUNT (total device)	
Epi-FET	1
Transistors	95
Diodes	4
Resistors	11
Capacitors	4

LM124, LM124A, LM224, LM224A
 LM324, LM324A, LM324Y, LM2902, LM2902Q
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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**

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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) $T_A = 25^\circ\text{C}$, $V_{CC} \leq 15\text{ V}$ (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	$T_A \leq 25^\circ\text{C}$ 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	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_A ‡	LM124, LM224			LM324			LM2902, LM2902Q			UNIT	
			MIN	TYP§	MAX	MIN	TYP§	MAX	MIN	TYP§	MAX		
V_{IO}	Input offset voltage	$V_{CC} = 5\text{ V to MAX}$, $V_{IC} = V_{ICRmin}$, $V_O = 1.4\text{ V}$	25°C	3	5		3	7		3	7	mV	
			Full range		7			9			10		
I_{IO}	Input offset current	$V_O = 1.4\text{ V}$	25°C	2	30		2	50		2	50	nA	
			Full range		100			150			300		
I_{IB}	Input bias current	$V_O = 1.4\text{ V}$	25°C	-20	-150		-20	-250		-20	-250	nA	
			Full range		-300			-500			-500		
V_{ICR}	Common-mode input voltage range	$V_{CC} = 5\text{ V to MAX}$	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	$R_L = 2\text{ k}\Omega$	25°C	$V_{CC} - 1.5$			$V_{CC} - 1.5$					V	
			25°C						$V_{CC} - 1.5$				
			Full range	26			26		22				
			Full range	27	28		27	28	23	24			
V_{OL}	Low-level output voltage	$R_L \leq 10\text{ k}\Omega$	Full range		5	20		5	20		5	20	mV
A_{VD}	Large-signal differential voltage amplification	$V_{CC} = 15\text{ V}$, $V_O = 1\text{ V to }11\text{ V}$, $R_L \geq 2\text{ k}\Omega$	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 ($\Delta V_{CC}/\Delta V_{IO}$)		25°C	65	100		65	100		50	100	dB	
V_{O1}/V_{O2}	Crosstalk attenuation	$f = 1\text{ kHz to }20\text{ kHz}$	25°C		120			120			120	dB	
I_O	Output current	$V_{CC} = 15\text{ V}$, $V_O = 0$	25°C	-20	-30	-60	-20	-30	-60	-20	-30	-60	mA
			Full range	-10			-10			-10			
			25°C	10	20		10	20		10	20		
			Full range	5			5			5			
I_{OS}	Short-circuit output current	V_{CC} at 5 V, GND at -5 V	25°C		± 40	± 60		± 40	± 60		± 40	± 60	mA
I_{CC}	Supply current (four amplifiers)	$V_O = 2.5\text{ V}$, $V_{CC} = \text{MAX}$, $V_O = 0.5 V_{CC}$, No load	Full range		0.7	1.2		0.7	1.2		0.7	1.2	mA
			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 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 $T_A = 25^\circ\text{C}$.

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	$V_{CC} = 5\text{ V to }30\text{ V}$, $V_{IC} = V_{ICRmin}$, $V_O = 1.4\text{ V}$	25°C			2		2	3		2	3	mV
		Full range			4		4			5		
I_{IO} Input offset current	$V_O = 1.4\text{ V}$	25°C			10		2		15	2	30	nA
		Full range			30		30			75		
I_{IB} Input bias current	$V_O = 1.4\text{ V}$	25°C			-50		-15	-80		-15	-100	nA
		Full range			-100		-100			-200		
V_{ICR} Common-mode input voltage range	$V_{CC} = 30\text{ V}$	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	$R_L = 2\text{ k}\Omega$	25°C	$V_{CC}-1.5$			$V_{CC}-1.5$			$V_{CC}-1.5$			V
	$V_{CC} = 30\text{ V}$, $R_L = 2\text{ k}\Omega$	Full range	26			26			26			
	$V_{CC} = 30\text{ V}$, $R_L \geq 10\text{ k}\Omega$	Full range	27			27	28		27	28		
V_{OL} Low-level output voltage	$R_L \leq 10\text{ k}\Omega$	Full range			20		5	20		5	20	mV
A_{VD} Large-signal differential voltage amplification	$V_{CC} = 15\text{ V}$, $V_O = 1\text{ V to }11\text{ V}$, $R_L \geq 2\text{ k}\Omega$	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 ($\Delta V_{CC}/\Delta V_{IO}$)		25°C	65			65	100		65	100		dB
V_{O1}/V_{O2} Crosstalk attenuation	$f = 1\text{ kHz to }20\text{ kHz}$	25°C		120			120			120		dB
I_O Output current	$V_{CC} = 15\text{ V}$, $V_{ID} = 1\text{ V}$, $V_O = 0$	25°C	-20			-20	-30	-60	-20	-30	-60	mA
		Full range	-10			-10			-10			
	$V_{CC} = 15\text{ V}$, $V_{ID} = -1\text{ V}$, $V_O = 15\text{ V}$	25°C	10			10	20		10	20		
		Full range	5			5			5			
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
		Full range		0.7	1.2		0.7	1.2		0.7	1.2	
I_{CC} Supply current (four amplifiers)	$V_O = 2.5\text{ V}$, No load $V_{CC} = 30\text{ V}$, $V_O = 15\text{ V}$, No load	Full range		0.7	1.2		0.7	1.2		0.7	1.2	mA
		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 $T_A = 25^\circ\text{C}$.

LM124, LM124A, LM224, LM224A
LM324, LM324A, LM324Y, LM2902, LM2902Q
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electrical characteristics, $V_{CC} = 5\text{ V}$, $T_A = 25^\circ\text{C}$ (unless otherwise noted)

PARAMETER	TEST CONDITIONST	LM324Y			UNIT
		MIN	TYP	MAX	
V_{IO} Input offset voltage	$V_{CC} = 5\text{ V to MAX}, V_{IC} = V_{ICRmin}, V_O = 1.4\text{ V}$		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	$V_{CC} = 5\text{ V to MAX}$	0 to $V_{CC}-1.5$			V
V_{OH} High-level output voltage	$R_L = 10\text{ k}\Omega$	$V_{CC}-1.5$			V
V_{OL} Low-level output voltage	$R_L \leq 10\text{ k}\Omega$		5	20	mV
A_{VD} Large-signal differential voltage amplification	$V_{CC} = 15\text{ V}, V_O = 1\text{ V to }11\text{ V}, R_L \geq 2\text{ k}\Omega$	15	100		V/mV
CMRR Common-mode rejection ratio	$V_{IC} = V_{ICRmin}$	65	80		dB
k_{SVR} Supply-voltage rejection ratio ($\Delta V_{CC} \pm / \Delta V_{IO}$)		65	100		dB
I_O Output current	$V_{CC} = 15\text{ V}, V_{ID} = 1\text{ V}, V_O = 0$	-20	-30	-60	mA
	$V_{CC} = 15\text{ V}, V_{ID} = -1\text{ V}, V_O = 15\text{ V}$	10	20		
	$V_{ID} = 1\text{ V}, V_O = 200\text{ mV}$	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
	$V_{CC} = \text{MAX}, V_O = 0.5 V_{CC},$ 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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LM324A, Quadruple Operational Amplifier

Device Status: Active

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- > [Features](#)
- > [Datasheets](#)
- > [Pricing/Samples/Availability](#)
- > [Application Notes](#)
- > [User Manuals](#)
- > [Development Tools](#)
- > [Applications](#)

Parameter Name	LM324A
delta VCC (max) (V)	32
delta VCC (min) (V)	3
IDD / ICC per channel (max) (mA)	0.3
IDD / ICC per channel (typ) (mA)	0.175
GBW (typ) (MHz)	0.4
Slew Rate (typ) (V/us)	0.25
VIO (Full Range) (max) (mV)	5
VIO (25 deg C) (max) (mV)	3
IIB (typ) (pA)	-15000
CMRR (typ) (dB)	80
Vn (typ) (nV/rtHz)	23
Number of Channels	4
Spec'd at VCC (V)	5

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.

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 .

Features

- 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

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Datasheets

Full datasheet in Acrobat PDF: [slos066e.pdf](#) (128 KB)

Full datasheet in Zipped PostScript: [slos066e.psz](#) (144 KB)

Pricing/Samples/Availability

Orderable Device	Package	Pins	Temp (°C)	Status	Price/unit USD (100-999)	Pack Qty	Availability / Samples
LM324AD	D	14		ACTIVE	1.00	50	Check stock or order
LM324ADBLE	DB	14		OBSOLETE			
LM324ADBR	DB	14		ACTIVE	0.84	2000	Check stock or order
LM324ADR	D	14		ACTIVE	0.87	2500	Check stock or order
LM324AN	N	14		ACTIVE	1.10	25	Check stock or order
LM324ANS	NS	14		OBSOLETE			
LM324ANSR	NS	14		ACTIVE	0.92	2000	Check stock or order
LM324APWLE	PW	14		OBSOLETE			
LM324APWR	PW	14		ACTIVE	0.84	2000	Check stock or order

Development Tools

Tool Part Number	Tool Title	Tool Type
UNIV-OPAMP-1B	Universal EVM for Single/Dual OpAmps without Shutdown in MSOP/SOIC/SOT-23 packages	Evaluation Modules (EVM)
UNIV-OPAMP-2B	Universal EVM for Single/Dual OpAmps with Shutdown in MSOP/SOIC/SOT-23 packages	Evaluation Modules (EVM)
UNIV-OPAMP-3B	Universal EVM for Single/Dual/Quad OpAmps with/without Shutdown in MSOP/TSSOP packages	Evaluation Modules (EVM)
UNIV-OPAMP-4B	Universal EVM for Single/Dual/Quad OpAmps with/without Shutdown in SOIC packages	Evaluation Modules (EVM)
UNIV-OPAMP-5B	Universal EVM for Single/Dual/Quad OpAmps with/without Shutdown in PDIP packages	Evaluation Modules (EVM)

Application Reports

View Application Reports for [Operational Amplifiers](#)

- [Analog Applications Journal May 2000](#) (SLYT015 - Updated: 04/20/2000)
- [Analog Applications Journal, September 1999 edition](#) (SLYT005 - Updated: 07/15/1999)
- [Analysis Of The Sallen-Key Architecture](#) (SLOA024A - Updated: 07/27/1999)
- [Signal Conditioning Piezoelectric Sensors](#) (SLOA033 - Updated: 09/27/1999)

- [Signal Conditioning Wheatstone Resistive Bridge Sensors \(SLOA034 - Updated: 09/27/1999\)](#)

User Manuals

- [Universal Op Amp Evaluation Module Selection Guide \(SLOU060, 10 KB - Updated: 10/22/1999\)](#)
- [Universal Op Amp Single, Dual, Quad \(SOIC\) Evaluation Module With Shutdown \(SLOU061, 1160 KB - Updated: 10/22/1999\)](#)
- [Universal Operational Amplifier EVM \(SLVU006A, 387 KB - Updated: 03/22/1999\)](#)
- [Universal Operational Amplifier Single, Dual, Quad \(MSOP/TSSOP\) \(SLOU055, 1196 KB - Updated: 10/22/1999\)](#)
- [Universal Operational Amplifier Single, Dual, Quad \(PDIP\) \(SLOU062, 1211 KB - Updated: 10/22/1999\)](#)

Table Data Updated on: 9/14/2000