National Semiconductor

LM124/LM224/LM324/LM2902
Low Power Quad Operational Amplifiers

General Description

The LM124 series consists of four independent, high gain, internally frequency compensated operational amplifiers which were designed specifically to operate from a single power supply over a wide range of voltages. Operation from split power supplies is also possible and the low power supply current drain is independent of the magnitude of the power supply voltage.

Application areas include transducer amplifiers, DC gain blocks and all the conventional op amp circuits which now can be more easily implemented in single power supply systems. For example, the LM124 series can be directly operated off of the standard +5V power supply voltage which is used in digital systems and will easily provide the required interface electronics without requiring the additional ±15V power supplies.

Unique Characteristics

- In the linear mode the input common-mode voltage range includes ground and the output voltage can also swing to ground, even though operated from only a single power supply voltage
- The unity gain cross frequency is temperature compensated
- The input bias current is also temperature compensated

Advantages

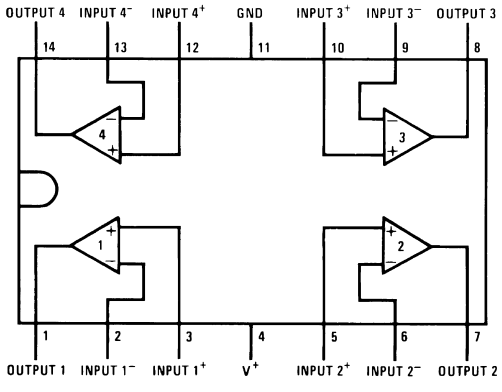
- Eliminates need for dual supplies
- Four internally compensated op amps in a single package
- Allows directly sensing near GND and V_{OUT} also goes to GND
- Compatible with all forms of logic
- Power drain suitable for battery operation

Features

- Internally frequency compensated for unity gain
- Large DC voltage gain 100 dB
- Wide bandwidth (unity gain) 1 MHz (temperature compensated)
- Wide power supply range:
  Single supply 3V to 32V
  or dual supplies ±1.5V to ±16V
- Very low supply current drain (700 µA)—essentially independent of supply voltage
- Low input biasing current 45 nA (temperature compensated)
- Low input offset voltage 2 mV and offset current: 5 nA
- Input common-mode voltage range includes ground
- Differential input voltage range equal to the power supply voltage
- Large output voltage swing 0V to V^+ – 1.5V

Connection Diagrams

Dual-In-Line Package



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Top View

Order Number LM124J, LM124AJ, LM124J/883 (Note 2)**, LM124AJ/883** (Note 1)**, LM224J, LM224AJ, LM324J, LM324M, LM324MX, LM324AM, LM324AMX, LM2902M, LM2902MX, LM324N, LM324AN, LM324MT, LM324MTX or LM2902N LM124AJRQML and LM124AJRQMLV**(Note 3)

See NS Package Number J14A, M14A or N14A

Absolute Maximum Ratings (Note 12)

If Military/Aerospace specified devices are required, please contact the National Semiconductor Sales Office/ Distributors for availability and specifications.

	LM124/LM224/LM324 LM124A/LM224A/LM324A	LM2902
Supply Voltage, V^+	32V	26V
Differential Input Voltage	32V	26V
Input Voltage	−0.3V to +32V	−0.3V to +26V
Input Current		
(V_{IN} < −0.3V) (Note 6)	50 mA	50 mA
Power Dissipation (Note 4)		
Molded DIP	1130 mW	1130 mW
Cavity DIP	1260 mW	1260 mW
Small Outline Package	800 mW	800 mW
Output Short-Circuit to GND		
(One Amplifier) (Note 5)		
$V^+ \leq 15V$ and $T_A = 25^\circ C$	Continuous	Continuous
Operating Temperature Range		−40˚C to +85˚C
LM324/LM324A	0˚C to +70˚C	
LM224/LM224A	−25˚C to +85˚C	
LM124/LM124A	−55˚C to +125˚C	
Storage Temperature Range	−65˚C to +150˚C	−65˚C to +150˚C
Lead Temperature (Soldering, 10 seconds)	260˚C	260˚C
Soldering Information		
Dual-In-Line Package		
Soldering (10 seconds)	260˚C	260˚C
Small Outline Package		
Vapor Phase (60 seconds)	215˚C	215˚C
Infrared (15 seconds)	220˚C	220˚C
See AN-450 “Surface Mounting Methods and Their Effect on Product Reliability” for other methods of soldering surface mount devices.		
ESD Tolerance (Note 13)	250V	250V

Electrical Characteristics

$V^+ = +5.0V$, (Note 7), unless otherwise stated

Parameter	Conditions	LM124A			LM224A			LM324A			Units
		Min	Typ	Max	Min	Typ	Max	Min	Typ	Max	
Input Offset Voltage	(Note 8) $T_A = 25^\circ C$		1	2		1	3		2	3	mV
Input Bias Current (Note 9)	$I_{IN(+)}$ or $I_{IN(-)}$, $V_{CM} = 0V$, $T_A = 25^\circ C$		20	50		40	80		45	100	nA
Input Offset Current	$I_{IN(+)}$ or $I_{IN(-)}$, $V_{CM} = 0V$, $T_A = 25^\circ C$		2	10		2	15		5	30	nA
Input Common-Mode Voltage Range (Note 10)	$V^+ = 30V$, (LM2902, $V^+ = 26V$), $T_A = 25^\circ C$	0		$V^+ - 1.5$	0		$V^+ - 1.5$	0		$V^+ - 1.5$	V
Supply Current	Over Full Temperature Range $R_L = \infty$ On All Op Amps										mA
	$V^+ = 30V$ (LM2902 $V^+ = 26V$)		1.5	3		1.5	3		1.5	3	
	$V^+ = 5V$		0.7	1.2		0.7	1.2		0.7	1.2	
Large Signal Voltage Gain	$V^+ = 15V$, $R_L \geq 2k\Omega$, ($V_O = 1V$ to $11V$), $T_A = 25^\circ C$	50	100		50	100		25	100		V/mV
Common-Mode	DC, $V_{CM} = 0V$ to $V^+ - 1.5V$,	70	85		70	85		65	85		dB

Electrical Characteristics (Continued)

V^+ = +5.0V, (Note 7), unless otherwise stated

Parameter		Conditions		LM124A			LM224A			LM324A			Units
				Min	Typ	Max	Min	Typ	Max	Min	Typ	Max	
Rejection Ratio		T_A = 25˚C											
Power Supply Rejection Ratio		V^+ = 5V to 30V (LM2902, V^+ = 5V to 26V), T_A = 25˚C		65	100		65	100		65	100		dB
Amplifier-to-Amplifier Coupling (Note 11)		f = 1 kHz to 20 kHz, T_A = 25˚C (Input Referred)			−120			−120			−120		dB
Output Current	Source	V_{IN}^+ = 1V, V_{IN}^- = 0V, V^+ = 15V, V_O = 2V, T_A = 25˚C		20	40		20	40		20	40		mA
	Sink	V_{IN}^- = 1V, V_{IN}^+ = 0V, V^+ = 15V, V_O = 2V, T_A = 25˚C		10	20		10	20		10	20		mA
		V_{IN}^- = 1V, V_{IN}^+ = 0V, V^+ = 15V, V_O = 200 mV, T_A = 25˚C		12	50		12	50		12	50		µA
Short Circuit to Ground		(Note 5) V^+ = 15V, T_A = 25˚C			40	60		40	60		40	60	mA
Input Offset Voltage		(Note 8)				4			4			5	mV
V_{OS} Drift		R_S = 0Ω			7	20		7	20		7	30	µV/˚C
Input Offset Current		$I_{IN(+)} - I_{IN(-)}$, V_{CM} = 0V				30			30			75	nA
I_{OS} Drift		R_S = 0Ω			10	200		10	200		10	300	pA/˚C
Input Bias Current		$I_{IN(+)}$ or $I_{IN(-)}$			40	100		40	100		40	200	nA
Input Common-Mode Voltage Range (Note 10)		V^+ = +30V (LM2902, V^+ = 26V)		0		V^+–2	0		V^+–2	0		V^+–2	V
Large Signal Voltage Gain		V^+ = +15V (V_OSwing = 1V to 11V) $R_L \geq 2$ kΩ		25			25			15			V/mV
Output Voltage Swing	V_{OH}	V^+ = 30V	R_L = 2 kΩ	26			26			26			V
		(LM2902, V^+ = 26V)	R_L = 10 kΩ	27	28		27	28		27	28		
	V_{OL}	V^+ = 5V, R_L = 10 kΩ			5	20		5	20		5	20	mV
Output Current	Source	V_O = 2V	V_{IN}^+ = +1V, V_{IN}^- = 0V, V^+ = 15V	10	20		10	20		10	20		mA
	Sink		V_{IN}^- = +1V, V_{IN}^+ = 0V, V^+ = 15V	10	15		5	8		5	8		

Electrical Characteristics

V^+ = +5.0V, (Note 7), unless otherwise stated

Parameter	Conditions	LM124/LM224			LM324			LM2902			Units
		Min	Typ	Max	Min	Typ	Max	Min	Typ	Max	
Input Offset Voltage	(Note 8) T_A = 25˚C		2	5		2	7		2	7	mV
Input Bias Current (Note 9)	$I_{IN(+)}$ or $I_{IN(-)}$, V_{CM} = 0V, T_A = 25˚C		45	150		45	250		45	250	nA
Input Offset Current	$I_{IN(+)}$ or $I_{IN(-)}$, V_{CM} = 0V, T_A = 25˚C		3	30		5	50		5	50	nA
Input Common-Mode Voltage Range (Note 10)	V^+ = 30V, (LM2902, V^+ = 26V), T_A = 25˚C	0		V^+–1.5	0		V^+–1.5	0		V^+–1.5	V

Electrical Characteristics (Continued)

V^+ = +5.0V, (Note 7), unless otherwise stated

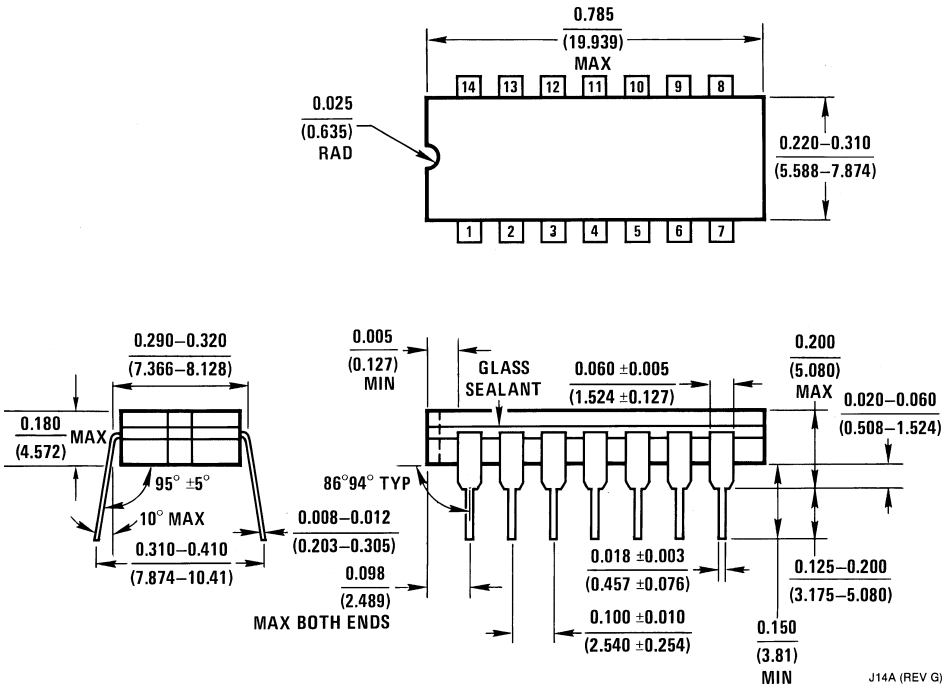
Parameter		Conditions		LM124/LM224			LM324			LM2902			Units
				Min	Typ	Max	Min	Typ	Max	Min	Typ	Max	
Supply Current		Over Full Temperature Range $R_L = \infty$ On All Op Amps											mA
		V^+ = 30V (LM2902 V^+ = 26V)			1.5	3		1.5	3		1.5	3	
		V^+ = 5V			0.7	1.2		0.7	1.2		0.7	1.2	
Large Signal Voltage Gain		V^+ = 15V, $R_L \geq 2k\Omega$, (V_O = 1V to 11V), T_A = 25˚C		50	100		25	100		25	100		V/mV
Common-Mode Rejection Ratio		DC, V_{CM} = 0V to V^+ − 1.5V, T_A = 25˚C		70	85		65	85		50	70		dB
Power Supply Rejection Ratio		V^+ = 5V to 30V (LM2902, V^+ = 5V to 26V), T_A = 25˚C		65	100		65	100		50	100		dB
Amplifier-to-Amplifier Coupling (Note 11)		f = 1 kHz to 20 kHz, T_A = 25˚C (Input Referred)			−120			−120			−120		dB
Output Current	Source	V_{IN}^+ = 1V, V_{IN}^- = 0V, V^+ = 15V, V_O = 2V, T_A = 25˚C		20	40		20	40		20	40		mA
	Sink	V_{IN}^- = 1V, V_{IN}^+ = 0V, V^+ = 15V, V_O = 2V, T_A = 25˚C		10	20		10	20		10	20		mA
		V_{IN}^- = 1V, V_{IN}^+ = 0V, V^+ = 15V, V_O = 200 mV, T_A = 25˚C		12	50		12	50		12	50		µA
Short Circuit to Ground		(Note 5) V^+ = 15V, T_A = 25˚C			40	60		40	60		40	60	mA
Input Offset Voltage		(Note 8)				7			9			10	mV
V_{OS} Drift		R_S = 0Ω			7			7			7		µV/˚C
Input Offset Current		$I_{IN(+)} - I_{IN(-)}$, V_{CM} = 0V				100			150		45	200	nA
I_{OS} Drift		R_S = 0Ω			10			10			10		pA/˚C
Input Bias Current		$I_{IN(+)}$ or $I_{IN(-)}$			40	300		40	500		40	500	nA
Input Common-Mode Voltage Range (Note 10)		V^+ = +30V (LM2902, V^+ = 26V)		0		V^+–2	0		V^+–2	0		V^+–2	V
Large Signal Voltage Gain		V^+ = +15V (V_OSwing = 1V to 11V) $R_L \geq 2$ kΩ		25			15			15			V/mV
Output Voltage Swing	V_{OH}	V^+ = 30V	R_L = 2 kΩ	26			26			22			V
		(LM2902, V^+ = 26V)	R_L = 10 kΩ	27	28		27	28		23	24		
	V_{OL}	V^+ = 5V, R_L = 10 kΩ			5	20		5	20		5	100	mV
Output Current	Source	V_O = 2V	V_{IN}^+ = +1V, V_{IN}^- = 0V, V^+ = 15V	10	20		10	20		10	20		mA
	Sink		V_{IN}^- = +1V, V_{IN}^+ = 0V, V^+ = 15V	5	8		5	8		5	8		

Note 4: For operating at high temperatures, the LM324/LM324A/LM2902 must be derated based on a +125˚C maximum junction temperature and a thermal resistance of 88˚C/W which applies for the device soldered in a printed circuit board, operating in a still air ambient. The LM224/LM224A and LM124/LM124A can be derated based on a +150˚C maximum junction temperature. The dissipation is the total of all four amplifiers — use external resistors, where possible, to allow the amplifier to saturate of to reduce the power which is dissipated in the integrated circuit.

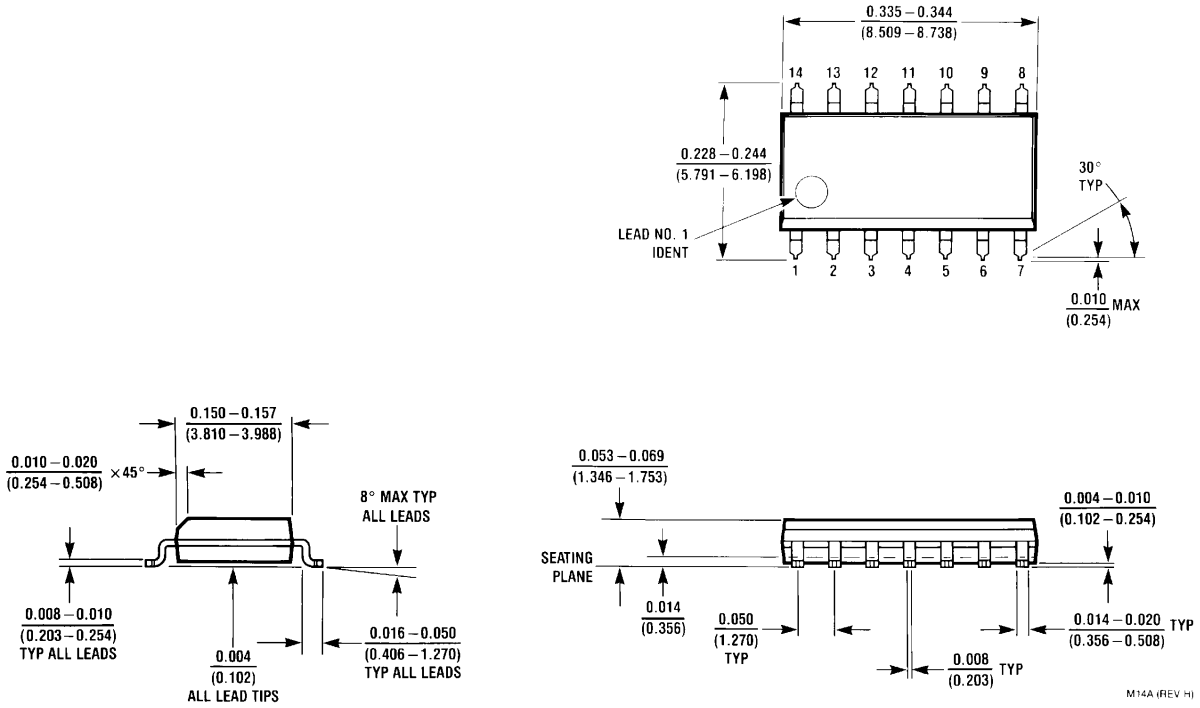
Note 5: Short circuits from the output to V^+ can cause excessive heating and eventual destruction. When considering short circuits to ground, the maximum output current is approximately 40 mA independent of the magnitude of V^+. At values of supply voltage in excess of +15V, continuous short-circuits can exceed the power dissipation ratings and cause eventual destruction. Destructive dissipation can result from simultaneous shorts on all amplifiers.

Note 6: This input current will only exist when the voltage at any of the input leads is driven negative. It is due to the collector-base junction of the input PNP transistors becoming forward biased and thereby acting as input diode clamps. In addition to this diode action, there is also lateral NPN parasitic transistor action

Physical Dimensions inches (millimeters) unless otherwise noted

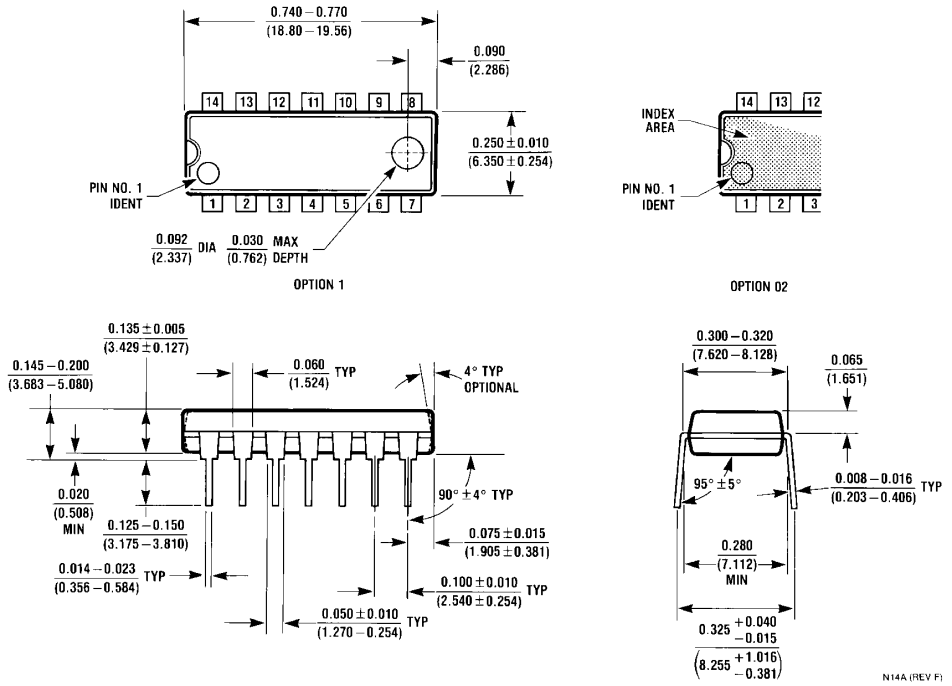


Ceramic Dual-In-Line Package (J)
Order Number JL124ABCA, JL124BCA, JL124ASCA, JL124SCA, LM124J, LM124AJ, LM124AJ/883, LM124J/883, LM224J, LM224AJ or LM324J
NS Package Number J14A

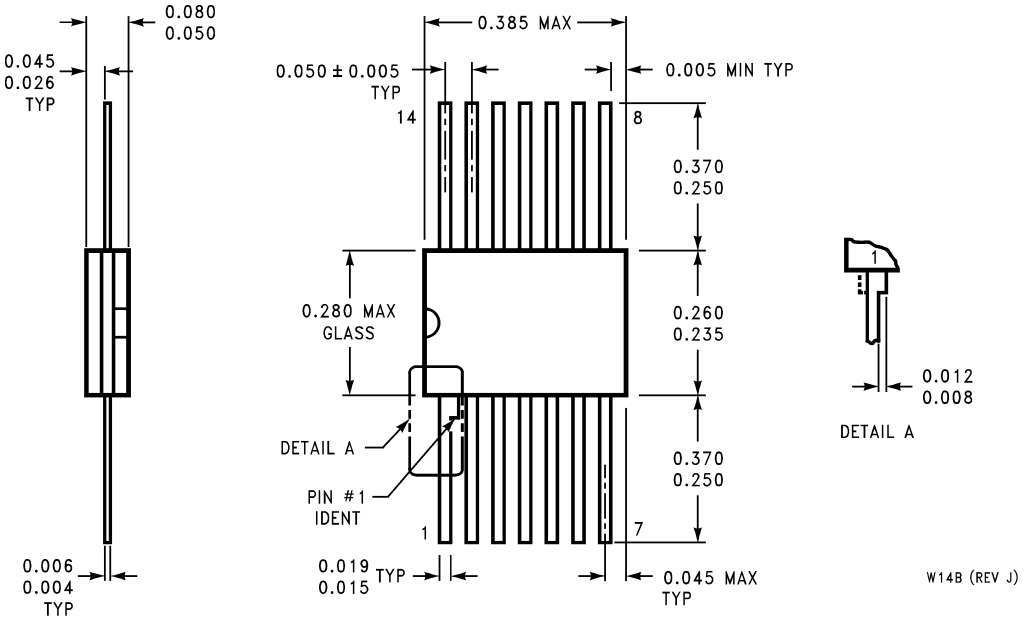


MX S.O. Package (M)
Order Number LM324M, LM324MX, LM324AM, LM324AMX, LM2902M or LM2902MX
NS Package Number M14A

Physical Dimensions inches (millimeters) unless otherwise noted (Continued)



Molded Dual-In-Line Package (N)
Order Number LM324N, LM324AN or LM2902N
NS Package Number N14A



Ceramic Flatpak Package
Order Number JL124ABDA, JL124ABZA, JL124ASDA, JL124BDA, JL124BZA, JL124SDA, LM124AW/883, LM124AWG/883, LM124W/883 or LM124WG/883
NS Package Number W14B