



# LM224A-LM324A

## Low power quad operational amplifiers

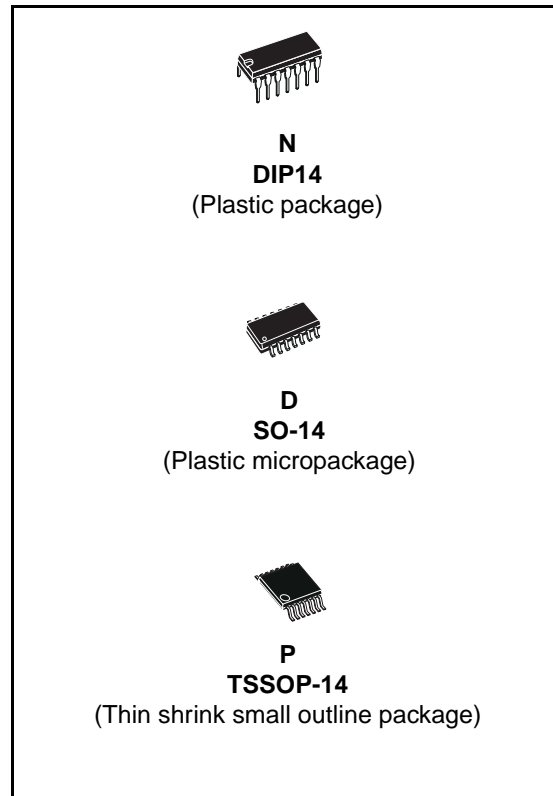
### Features

- Wide gain bandwidth: 1.3 MHz
- Input common-mode voltage range includes ground
- Large voltage gain: 100 dB
- Very low supply current/amplifier: 375  $\mu$ A
- Low input bias current: 20 nA
- Low input offset voltage: 3 mV max.
- Low input offset current: 2 nA
- Wide power supply range:  
Single supply: +3 V to +30 V  
Dual supplies:  $\pm$ 1.5 V to  $\pm$ 15 V

### Description

These circuits consist of four independent, high gain, internally frequency compensated operational amplifiers. They 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.



### Order codes

Part number	Temperature range	Package	Packaging
LM224AN	-40° C, +105° C	DIP	Tube
LM224AD/ADT		SO	Tube or tape & reel
LM224APT		TSSOP (Thin shrink outline package)	Tape & reel
LM324AN	0° C, +70° C	DIP	Tube
LM324AD/ADT		SO	Tube or tape & reel
LM324APT		TSSOP (Thin shrink outline package)	Tape & reel

## 2 Absolute maximum ratings

Table 1. Absolute maximum ratings

Symbol	Parameter	LM224A	LM324A	Unit
$V_{CC}$	Supply voltage	±16 or 32		V
$V_i$	Input voltage	-0.3 to $V_{CC} + 0.3$		V
$V_{id}$	Differential input voltage <sup>(1)</sup>	32		V
$P_{tot}$	Power dissipation:			
	N suffix D suffix	500 400	500 400	mW
	Output short-circuit duration <sup>(2)</sup>	Infinite		
$I_{in}$	Input current <sup>(3)</sup>	50		mA
$T_{oper}$	Operating free-air temperature range	-40 to +105	0 to +70	°C
$T_{stg}$	Storage temperature range	-65 to +150		°C
$T_j$	Maximum junction temperature	150		°C
$R_{thja}$	Thermal resistance junction to ambient <sup>(4)</sup> :			
	SO14	103		°C/W
	TSSOP14	100		
DIP14	83			
$R_{thjc}$	Thermal resistance junction to case:			
	SO14	31		°C/W
	TSSOP14	32		
DIP14	33			
ESD	HBM: human body model <sup>(5)</sup>	700		V
	MM: machine model <sup>(6)</sup>	150		
	CDM: charged device model	1500		

- Neither of the input voltages must exceed the magnitude of  $V_{CC}^+$  or  $V_{CC}^-$ .
- Short-circuits from the output to  $V_{CC}$  can cause excessive heating if  $V_{CC} > 15$  V. The maximum output current is approximately 40 mA independent of the magnitude of  $V_{CC}$ . Destructive dissipation can result from simultaneous short-circuits on all amplifiers.
- This input current only exists when the voltage at any of the input leads is driven negative. It is due to the collector-base junction of the input PNP transistor becoming forward biased and thereby acting as input diode clamps. In addition to this diode action, there is also NPN parasitic action on the IC chip. This transistor action can cause the output voltages of the op-amps to go to the  $V_{CC}$  voltage level (or to ground for a large overdrive) for the time during which an input is driven negative. This is not destructive and normal output will set up again for input voltage higher than -0.3 V.
- Short-circuits can cause excessive heating. Destructive dissipation can result from simultaneous short-circuits on all amplifiers. These are typical values given for a single layer board (except for TSSOP which is a two-layer board).
- Human body model, 100 pF discharged through a 1.5 kΩ resistor into pin of device.
- Machine model ESD, a 200 pF cap is charged to the specified voltage, then discharged directly into the IC with no external series resistor (internal resistor < 5Ω), into pin-to-pin of device.

### 3 Electrical characteristics

Table 2.  $V_{CC}^+ = +5V$ ,  $V_{CC}^- = \text{Ground}$ ,  $V_o = 1.4V$ ,  $T_{\text{amb}} = +25^\circ\text{C}$  (unless otherwise specified)

Symbol	Parameter	Min.	Typ.	Max.	Unit
$V_{io}$	Input offset voltage <sup>(1)</sup> : $T_{\text{amb}} = +25^\circ\text{C}$ $T_{\text{min}} \leq T_{\text{amb}} \leq T_{\text{max}}$		2	3 5	mV
$I_{io}$	Input offset current: $T_{\text{amb}} = +25^\circ\text{C}$ $T_{\text{min}} \leq T_{\text{amb}} \leq T_{\text{max}}$		2	20 40	nA
$I_{ib}$	Input bias current <sup>(2)</sup> : $T_{\text{amb}} = +25^\circ\text{C}$ $T_{\text{min}} \leq T_{\text{amb}} \leq T_{\text{max}}$		20	100 200	nA
$A_{vd}$	Large signal voltage gain: $V_{CC}^+ = +15\text{ V}$ , $R_L = 2\text{ k}\Omega$ , $V_o = 1.4\text{ V}$ to $11.4\text{ V}$ $T_{\text{amb}} = +25^\circ\text{C}$ $T_{\text{min}} \leq T_{\text{amb}} \leq T_{\text{max}}$	50 25	100		V/mV
SVR	Supply voltage rejection ratio ( $R_s \leq 10\text{ k}\Omega$ ): $V_{CC}^+ = 5\text{ V}$ to $30\text{ V}$ $T_{\text{amb}} = +25^\circ\text{C}$ $T_{\text{min}} \leq T_{\text{amb}} \leq T_{\text{max}}$	65 65	110		dB
$I_{CC}$	Supply current, all Amp, no load: – $T_{\text{amb}} = +25^\circ\text{C}$ $V_{CC} = +5\text{ V}$ $V_{CC} = +30\text{ V}$ – $T_{\text{min}} \leq T_{\text{amb}} \leq T_{\text{max}}$ $V_{CC} = +5\text{ V}$ $V_{CC} = +30\text{ V}$		0.7 1.5	1.2 3	mA
$V_{icm}$	Input common mode voltage range: $V_{CC} = +30\text{ V}$ <sup>(3)</sup> $T_{\text{amb}} = +25^\circ\text{C}$ $T_{\text{min}} \leq T_{\text{amb}} \leq T_{\text{max}}$	0 0		$V_{CC} - 1.5$ $V_{CC} - 2$	V
CMR	Common mode rejection ratio ( $R_s \leq 10\text{ k}\Omega$ ): $T_{\text{amb}} = +25^\circ\text{C}$ $T_{\text{min}} \leq T_{\text{amb}} \leq T_{\text{max}}$	70 60	80		dB
$I_{\text{source}}$	Output current source ( $V_{id} = +1\text{ V}$ ): $V_{CC} = +15\text{ V}$ , $V_o = +2\text{ V}$	20	40	70	mA
$I_{\text{sink}}$	Output sink current ( $V_{id} = -1\text{ V}$ ): $V_{CC} = +15\text{ V}$ , $V_o = +2\text{ V}$ $V_{CC} = +15\text{ V}$ , $V_o = +0.2\text{ V}$	10 12	20 50		mA $\mu\text{A}$

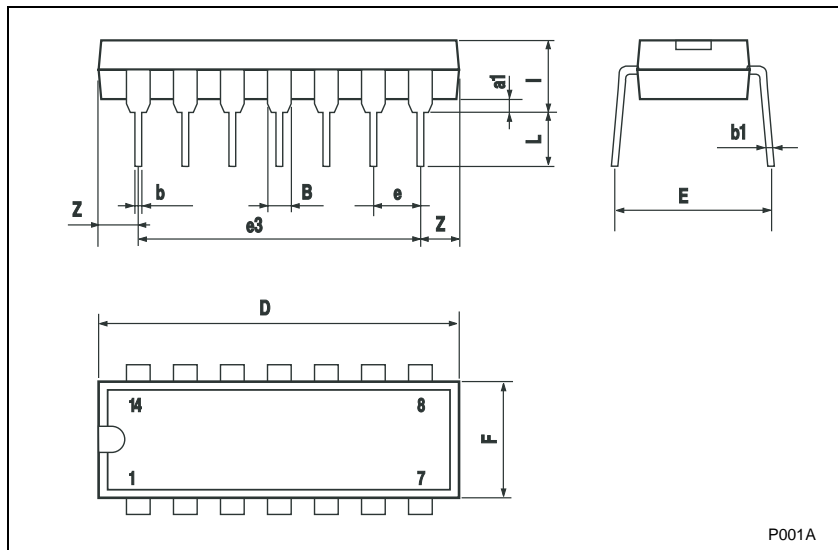
**Table 2.**  $V_{CC}^+ = +5V$ ,  $V_{CC}^- = \text{Ground}$ ,  $V_o = 1.4V$ ,  $T_{amb} = +25^\circ C$  (unless otherwise specified)

Symbol	Parameter	Min.	Typ.	Max.	Unit
$V_{OH}$	High level output voltage $V_{CC} = +30 V$ , $R_L = 2 k\Omega$ $T_{amb} = +25^\circ C$ $T_{min} \leq T_{amb} \leq T_{max}$	26 26	27		V
	$V_{CC} = +30 V$ , $R_L = 10 k\Omega$ $T_{amb} = +25^\circ C$ $T_{min} \leq T_{amb} \leq T_{max}$	27 27	28		V
	$V_{CC} = +5 V$ , $R_L = 2 k\Omega$ $T_{amb} = +25^\circ C$ $T_{min} \leq T_{amb} \leq T_{max}$	3.5 3			V
$V_{OL}$	Low level output voltage ( $R_L = 10k\Omega$ ): $T_{amb} = +25^\circ C$ $T_{min} \leq T_{amb} \leq T_{max}$		5	20 20	mV
SR	Slew rate: $V_{CC} = 15 V$ , $V_i = 0.5$ to $3 V$ , $R_L = 2 k\Omega$ , $C_L = 100 pF$ , unity gain		0.4		V/ $\mu s$
GBP	Gain bandwidth product: $V_{CC} = 30 V$ , $f = 100 kHz$ , $V_{in} = 10 mV$ , $R_L = 2 k\Omega$ , $C_L = 100pF$		1.3		MHz
THD	Total harmonic distortion: $f = 1kHz$ , $A_v = 20dB$ , $R_L = 2k\Omega$ , $V_o = 2V_{pp}$ , $C_L =$ $100pF$ , $V_{CC} = 30V$		0.015		%
$e_n$	Equivalent input noise voltage: $f = 1 kHz$ , $R_s = 100 \Omega$ , $V_{CC} = 30 V$		40		$\frac{nV}{\sqrt{Hz}}$
$DV_{io}$	Input offset voltage drift		7	30	$\mu V/^\circ C$
$DI_{io}$	Input offset current drift		10	200	$pA/^\circ C$
$V_{o1}/V_{o2}$	Channel separation <sup>(4)</sup> - $1kHz \leq f \leq 20 kHz$		120		dB

- $V_o = 1.4 V$ ,  $R_s = 0 \Omega$ ,  $5 V < V_{CC}^+ < 30 V$ ,  $0 < V_{ic} < V_{CC}^+ - 1.5 V$
- The direction of the input current is out of the IC. This current is essentially constant, independent of the state of the output so there is no load change on the input lines.
- The input common-mode voltage of either input signal voltage should not be allowed to go negative by more than 0.3 V. The upper end of the common-mode voltage range is  $V_{CC}^+ - 1.5 V$ , but either or both inputs can go to +32 V without damage.
- Due to the proximity of external components, ensure that there is no coupling originating from stray capacitance between these external parts. Typically, this can be detected at higher frequencies because this type of capacitance increases.

### 6.1 DIP14 package

Plastic DIP-14 MECHANICAL DATA						
DIM.	mm.			inch		
	MIN.	TYP.	MAX.	MIN.	TYP.	MAX.
a1	0.51			0.020		
B	1.39		1.65	0.055		0.065
b		0.5			0.020	
b1		0.25			0.010	
D			20			0.787
E		8.5			0.335	
e		2.54			0.100	
e3		15.24			0.600	
F			7.1			0.280
I			5.1			0.201
L		3.3			0.130	
Z	1.27		2.54	0.050		0.100



P001A