

# LM2902,LM324/LM324A,LM224/ LM224A

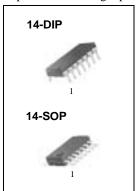
# **Quad Operational Amplifier**

#### **Features**

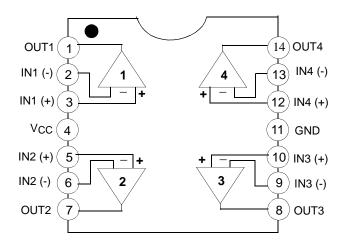
- Internally Frequency Compensated for Unity Gain
- Large DC Voltage Gain: 100dB
- Wide Power Supply Range: LM224/LM224A, LM324/LM324A : 3V~32V (or ±1.5 ~ 16V)
  - LM2902:  $3V\sim26V$  (or  $\pm1.5V\sim13V$ )
- Input Common Mode Voltage Range Includes Ground
- Large Output Voltage Swing: 0V to VCC -1.5V
- Power Drain Suitable for Battery Operation

### **Description**

The LM324/LM324A,LM2902,LM224/LM224A consist of four independent, high gain, internally frequency compensated operational amplifiers which were designed specifically to operate from a single power supply over a wide voltage range. operation from split power supplies is also possible so long as the difference between the two supplies is 3 volts to 32 volts. Application areas include transducer amplifier, DC gain blocks and all the conventional OP Amp circuits which now can be easily implemented in single power supply systems.

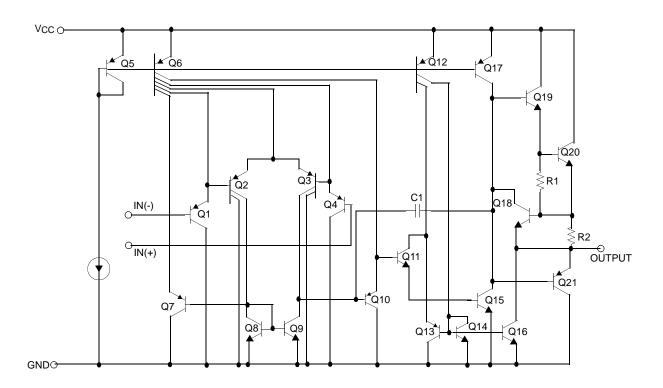


## **Internal Block Diagram**



## **Schematic Diagram**

(One Section Only)



# **Absolute Maximum Ratings**

Parameter	Symbol	LM224/LM224A	LM324/LM324A	LM2902	Unit
Power Supply Voltage	Vcc	±16 or 32	±16 or 32	±13 or 26	V
Differential Input Voltage	VI(DIFF)	32	32	26	V
Input Voltage	VI	-0.3 to +32	-0.3 to +32	-0.3 to +26	V
Output Short Circuit to GND Vcc≤15V, Ta=25°C(one Amp)	-	Continuous	Continuous	Continuous	-
Power Dissipation, T <sub>A</sub> =25°C 14-DIP 14-SOP	PD	1310 640	1310 640	1310 640	mW
Operating Temperature Range	TOPR	-25 ~ +85	0 ~ +70	-40 ~ +85	°C
Storage Temperature Range	TSTG	-65 ~ +150	-65 ~ <b>+</b> 150	-65 ~ +150	°C

## **Thermal Data**

Parameter	Symbol	Value	Unit
Thermal Resistance Junction-Ambient Max. 14-DIP 14-SOP	Rθja	95 195	°C/W

## **Electrical Characteristics**

(VCC = 5.0V, VEE = GND, TA =  $25^{\circ}$ C, unless otherwise specified)

Parameter	Symbol			Conditions LM224			ı		LM324	ļ	L	Unit	
Farameter	Syllibol			Min.	Тур.	Max.	Min.	Тур.	Max.	Min.	Тур.	Max.	Onit
Input Offset Voltage	VIO	$VCM = 0V$ $-1.5V$ $VO(P) = 1$ $= 0\Omega \text{ (No)}$	.4V, Rs	-	1.5	5.0	-	1.5	7.0	-	1.5	7.0	mV
Input Offset Current	lio	VCM = 0\	/	-	2.0	30	-	3.0	50	-	3.0	50	nA
Input Bias Current	IBIAS	VCM = 0/	/	-	40	150	-	40	250	-	40	250	nA
Input Common- Mode Voltage Range	V <sub>I(R)</sub>	Note1		0	-	VCC -1.5	0	VCC -1.5	-	0	-	VCC -1.5	V
Supply Current	Icc		R <sub>L</sub> = ∞,V <sub>CC</sub> = 30V (LM2902,V <sub>CC</sub> =26V)		1.0	3	-	1.0	3	-	1.0	3	mA
		RL = ∞,V	CC = 5V	-	0.7	1.2	-	0.7	1.2	-	0.7	1.2	mA
Large Signal Voltage Gain	G∨		VCC = $15V$ ,RL= $2k\Omega$ VO(P) = $1V$ to $11V$		100	-	25	100	-	25	100	-	V/ mV
Outrol Valtana	VO(H)	Note1	$R_L = 2k\Omega$	26	-	-	26	-	-	22	-	-	V
Output Voltage Swing	VO(H)	Note	RL=10kΩ	27	28	-	27	28	-	23	24	-	V
- Chinig	VO(L)	VCC = 5\	/,RL=10kΩ	-	5	20	-	5	20	-	5	100	mV
Common-Mode Rejection Ratio	CMRR		-		85	-	65	75	-	50	75	-	dB
Power Supply Rejection Ratio	PSRR		-	65	100	-	65	100	-	50	100	-	dB
Channel Separation	CS	f = 1kHz (Note2)	to 20kHz	-	120	-	-	120	-	-	120	-	dB
Short Circuit to GND	Isc	Vcc = 15	SV.	-	40	60	-	40	60	-	40	60	mA
	ISOURCE	VI(+) = 1V, VI(-) = 0V VCC = 15V VO(P) = 2V		20	40	-	20	40	-	20	40	-	mA
Output Current	lowie	VI(+) = 0V, VI(-) = 1V VCC = 15V VO(P) = 2V		10	13	-	10	13	-	10	13	-	mA
	ISINK	V <sub>I</sub> (+) = 0V, V <sub>I</sub> (-) = 1V V <sub>C</sub> C = 5V,V <sub>O</sub> (R) = 200mV		12	45	-	12	45	-	-	-	-	μΑ
Differential Input Voltage	VI(DIFF)		-	-	-	Vcc	-	-	Vcc	-	-	Vcc	V

- 1. VCC=30V for LM224 and LM324 , VCC=26V for LM2902
- 2. This parameter, although guaranteed, is not 100% tested in production.

### **Electrical Characteristics** (Continued)

(VCC = 5.0V, VEE = GND, unless otherwise specified)

The following specification apply over the range of -25°C  $\leq$  TA  $\leq$  + 85°C for the LM224; and the 0°C  $\leq$  TA  $\leq$  +70°C for the LM324; and the -40°C  $\leq$  TA  $\leq$  +85°C for the LM2902

Donomoton	Complete	Symbol Conditions		LM224			LM324			L	11		
Parameter	Symbol			Min.	Тур.	Max.	Min.	Тур.	Max.	Min.	Тур.	Max.	Unit
Input Offset Voltage	VIO	-1.5V VO(P) =	0V to VCC 1.4V, 2 (Note1)	-	-	7.0	-	-	9.0	-	-	10.0	mV
Input Offset Voltage Drift	ΔV <sub>ΙΟ</sub> /ΔΤ	Rs = 00	2 (Note2)	-	7.0	-	-	7.0	-	-	7.0	-	μV/°C
Input Offset Current	ΙO	VCM = 0	VC	-	-	100	-	-	150	-	-	200	nA
Input Offset Current Drift	ΔΙΙΟ/ΔΤ	Rs = 00	2 (Note2)	-	10	-	-	10	-	-	10	-	pA/°C
Input Bias Current	IBIAS	VCM = 0	VC	-	-	300	-	-	500	-	-	500	nA
Input Common-Mode Voltage Range	VI(R)	Note1		0	-	VCC -2.0	0	-	VCC -2.0	0	-	VCC -2.0	V
Large Signal Voltage Gain	Gv	$V_{CC} = 15V$ , $R_{L} = 2.0kΩ$ $V_{O(P)} = 1V$ to 11V		25	-	-	15	-	-	15	-	-	V/mV
	VO(H)	Note1	RL=2kΩ	26	-	-	26	-	-	22	-	-	V
Output Voltage	VO(H)	NOLET	R <sub>L</sub> =10kΩ	27	28	-	27	28	-	23	24	-	V
Swing	VO(L)		$VCC = 5V$ , $R_L=10k\Omega$		5	20	-	5	20	-	5	100	mV
	ISOURCE	VI(+) = 1V, VI(-) = 0V VCC = 15V, VO(P) = 2V		10	20	-	10	20	-	10	20	-	mA
Output Current	ISINK	VI(+) = 0V, VI(-) = 1V VCC = 15V, VO(P) = 2V		10	13	-	5	8	-	5	8	-	mA
Differential Input Voltage	VI(DIFF)		-	-	-	Vcc	-	-	Vcc	-	-	Vcc	V

- 1. VCC=30V for LM224 and LM324 , VCC=26V for LM2902
- 2. These parameters, although guaranteed, are not 100% tested in production.

# **Electrical Characteristics** (Continued)

(VCC = 5.0V, VEE = GND,  $TA = 25^{\circ}C$ , unless otherwise specified)

Donomoton	Complete	Conditions		L	M224	A	L	11!4		
Parameter	Symbol			Min.	Тур.	Max.	Min.	Тур.	Max.	Unit
Input Offset Voltage	VIO	$V_{CM} = 0V \text{ to } V_{CC}$ -1.5V $V_{O(P)} = 1.4V, R_{S} = 0\Omega$ (Note1)		-	1.0	3.0	-	1.5	3.0	mV
Input Offset Current	lio	<b>ACW</b> = 0/	/	-	2	15	-	3.0	30	nA
Input Bias Current	IBIAS	$\Lambda CW = 0$	/	-	40	80	-	40	100	nA
Input Common-Mode Voltage Range	V <sub>I(R)</sub>	Vcc = 30	V	0	-	VCC -1.5	0	-	VCC -1.5	٧
Cupply Current	loo	Vcc = 30	)V, R <sub>L</sub> = ∞	-	1.5	3	-	1.5	3	mA
Supply Current	ICC	Vcc = 5\	/, R <sub>L</sub> = ∞	-	0.7	1.2	-	0.7	1.2	mA
Large Signal Voltage Gain	G∨	$V_{CC} = 15V, R_L = 2k\Omega$ $V_{O(P)} = 1V \text{ to } 11V$		50	100	-	25	100	-	V/mV
	Vous	Note1	$R_L = 2k\Omega$	26	-	-	26	-	-	V
Output Voltage Swing	VO(H)	Note	$R_L = 10k\Omega$	27	28	-	27	28	-	V
	VO(L)	Vcc = 5\	/, RL=10kΩ	-	5	20	-	5	20	mV
Common-Mode Rejection Ratio	CMRR		1	70	85	-	65	85	-	dB
Power Supply Rejection Ratio	PSRR		-	65	100	-	65	100	-	dB
Channel Separation	cs	f = 1kHz (Note2)	to 20kHz	-	120	-	-	120	-	dB
Short Circuit to GND	Isc	Vcc = 15	5V	-	40	60	-	40	60	mA
	ISOURCE	V <sub>I</sub> (+) = 1V, V <sub>I</sub> (-) = 0V VCC =15V, VO(P) = 2V		20	40	-	20	40	-	mA
Output Current		\ /	$V, V_{I(-)} = 1V$ $V, V_{O(P)} = 2V$	10	20	-	10	20	-	mA
	ISINK	V <sub>I(+)</sub> = 0v, V <sub>I(-)</sub> = 1V VCC = 5V V <sub>O(P)</sub> = 200mV		12	50	-	12	50	-	μΑ
Differential Input Voltage	VI(DIFF)		-	-	-	Vcc	-	-	Vcc	V

<sup>1.</sup> V<sub>CC</sub>=30V for LM224A, LM324A

<sup>2.</sup> This parameter, although guaranteed, is not 100% tested in production.

## **Electrical Characteristics** (Continued)

(VCC = 5.0V, VEE = GND, unless otherwise specified)

The following specification apply over the range of -25°C  $\leq$  TA  $\leq$  +85°C for the LM224A; and the 0°C  $\leq$  TA  $\leq$  +70°C for the LM324A

Parameter	Symbol	Co	nditiono	L	M224	Α	L	Unit		
Farameter	Symbol	Col	Conditions		Тур.	Max.	Min.	Тур.	Max.	Unit
Input Offset Voltage	Vio	$V_{CM} = 0V \text{ to } V_{CC} -1.5V$ $V_{O(P)} = 1.4V, R_{S} = 0\Omega$ (Note1)		-	-	4.0	-	-	5.0	mV
Input Offset Voltage Drift	ΔV10/ΔΤ	$Rs = 0\Omega$ (	(Note2)	-	7.0	20	-	7.0	30	μV/°C
Input Offset Current	lio	VCM = 0V	'	-	_	30	-	-	75	nA
Input Offset Current Drift	ΔΙΙΟ/ΔΤ	$Rs = 0\Omega$ (	Note2)	-	10	200	-	10	300	pA/°C
Input Bias Current	IBIAS		-	-	40	100	-	40	200	nA
Input Common-Mode Voltage Range	VI(R)	Note1		0	-	VCC -2.0	0	-	VCC -2.0	V
Large Signal Voltage Gain	G∨	VCC = 15	V, RL= 2.0kΩ	25	_	-	15	-	-	V/mV
	Vous	Note1	$R_L = 2k\Omega$	26	-	-	26	-	-	V
Output Voltage Swing	VO(H)	Note	$R_L = 10k\Omega$	27	28	-	27	28	-	V
	V <sub>O(L)</sub>	$VCC = 5V$ , $R_L = 10k\Omega$		-	5	20	-	5	20	mV
Output Current	ISOURCE	VI(+) = 1V, VI(-) = 0V VCC = 15V, VO(P) = 2V VI(+) = 0V, VI(-) = 1V VCC = 15V, VO(P) = 2V		10	20	-	10	20	-	mA
Output Guilent	ISINK			5	8	-	5	8	-	mA
Differential Input Voltage	VI(DIFF)		-	-	-	Vcc	-	-	Vcc	V

- 1. VCC=30V for LM224A and LM324A.
- 2. These parameters, although guaranteed, are not 100% tested in production.

# **Typical Performance Characteristics**

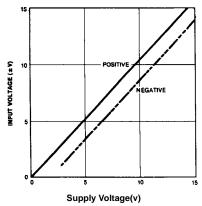


Figure 1. Input Voltage Range vs Supply Voltage

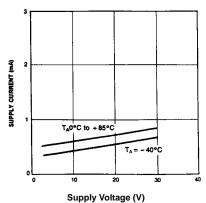


Figure 3. Supply Current vs Supply Voltage

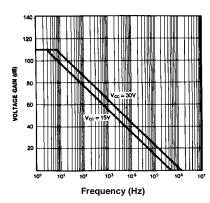


Figure 5. Open Loop Frequency Response

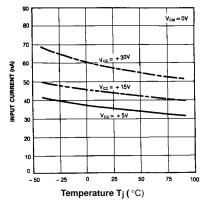


Figure 2. Input Current vs Temperature

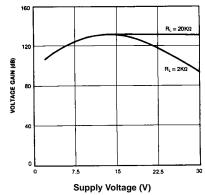


Figure 4. Voltage Gain vs Supply Voltage

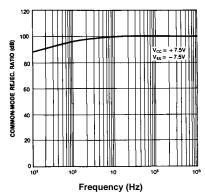


Figure 6. Common mode Rejection Ratio

## **Typical Performance Characteristics** (Continued)

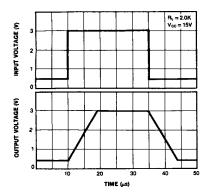


Figure 7. Voltage Follower Pulse Response

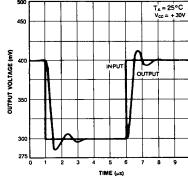


Figure 8. Voltage Follower Pulse Response (Small Signal)

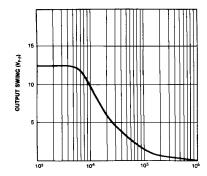


Figure 8. Large Signal Frequency Response

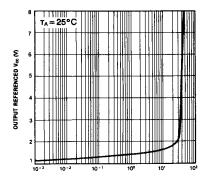


Figure 9. Output Characteristics vs Current Sourcing

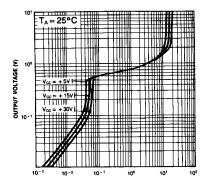


Figure 10. Output Characteristics vs Current Sinking

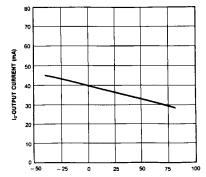
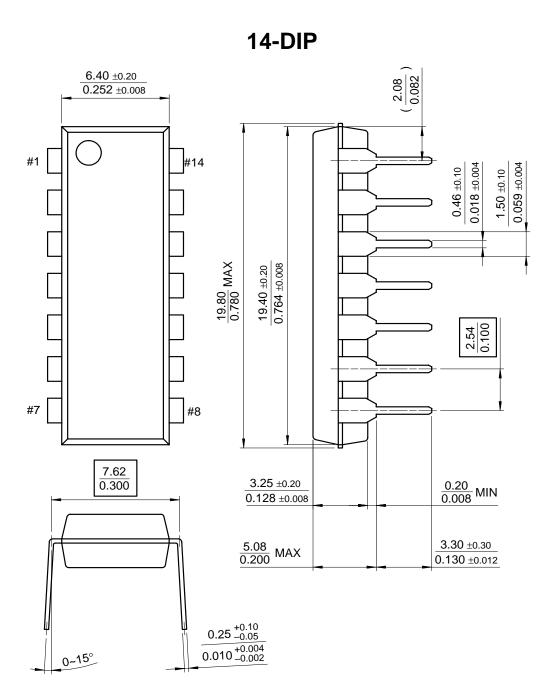


Figure 11. Current Limiting vs Temperature

### **Mechanical Dimensions**

## **Package**

#### **Dimensions in millimeters**

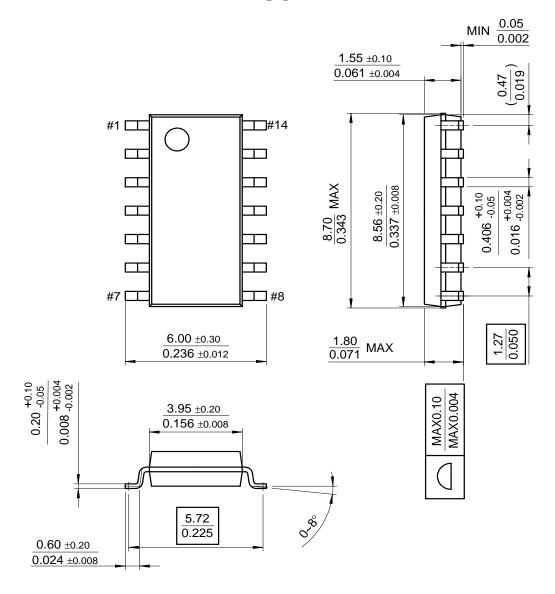


## **Mechanical Dimensions** (Continued)

## **Package**

#### **Dimensions in millimeters**

# 14-SOP



# **Ordering Information**

Product Number	Package	Operating Temperature
LM324N	- 14-DIP	
LM324AN	14-015	0 ~ +70°C
LM324M	14-SOP	0~+70 C
LM324AM	14-30F	
LM2902N	14-DIP	-40 ∼ +85°C
LM2902M	14-SOP	-40 ~ 703 C
LM224N	14-DIP	
LM224AN	14-015	-25 ~ +85°C
LM224M	14-SOP	-23 ~ <del>1</del> 03 C
LM224AM	14-301	

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- A critical component in any component of a life support device or system whose failure to perform can be reasonably expected to cause the failure of the life support device or system, or to affect its safety or effectiveness.

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