

# LM324, LM324A, LM224, LM2902, LM2902V, NCV2902

## Single Supply Quad Operational Amplifiers

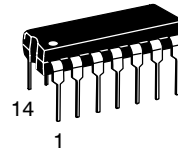
The LM324 series are low-cost, quad operational amplifiers with true differential inputs. They have several distinct advantages over standard operational amplifier types in single supply applications. The quad amplifier can operate at supply voltages as low as 3.0 V or as high as 32 V with quiescent currents about one-fifth of those associated with the MC1741 (on a per amplifier basis). The common mode input range includes the negative supply, thereby eliminating the necessity for external biasing components in many applications. The output voltage range also includes the negative power supply voltage.

### Features

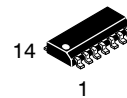
- Short Circuited Protected Outputs
- True Differential Input Stage
- Single Supply Operation: 3.0 V to 32 V
- Low Input Bias Currents: 100 nA Maximum (LM324A)
- Four Amplifiers Per Package
- Internally Compensated
- Common Mode Range Extends to Negative Supply
- Industry Standard Pinouts
- ESD Clamps on the Inputs Increase Ruggedness without Affecting Device Operation
- NCV Prefix for Automotive and Other Applications Requiring Site and Control Changes
- Pb-Free Packages are Available



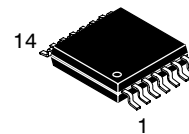
**ON Semiconductor®**



**PDIP-14  
N SUFFIX  
CASE 646**

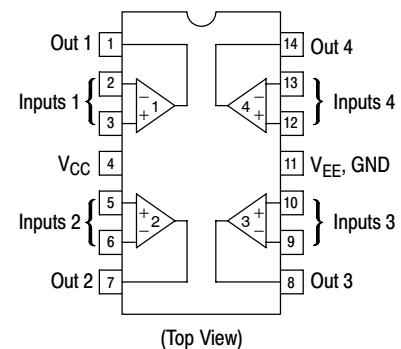


**SOIC-14  
D SUFFIX  
CASE 751A**



**TSSOP-14  
DTB SUFFIX  
CASE 948G**

### PIN CONNECTIONS



### ORDERING INFORMATION

See detailed ordering and shipping information in the package dimensions section on page 10 of this data sheet.

### DEVICE MARKING INFORMATION

See general marking information in the device marking section on page 12 of this data sheet.

## LM324, LM324A, LM224, LM2902, LM2902V, NCV2902

### MAXIMUM RATINGS ( $T_A = +25^\circ\text{C}$ , unless otherwise noted.)

Rating	Symbol	Value	Unit
Power Supply Voltages Single Supply Split Supplies	$V_{CC}$ $V_{CC}, V_{EE}$	32 $\pm 16$	Vdc
Input Differential Voltage Range (Note 1)	$V_{IDR}$	$\pm 32$	Vdc
Input Common Mode Voltage Range	$V_{ICR}$	-0.3 to 32	Vdc
Output Short Circuit Duration	$t_{SC}$	Continuous	
Junction Temperature (Note 2)	$T_J$	150	$^\circ\text{C}$
Thermal Resistance, Junction-to-Air (Note 3)	$R_{\theta JA}$	Case 646 118 Case 751A 156 Case 948G 190	$^\circ\text{C}/\text{W}$
Storage Temperature Range	$T_{stg}$	-65 to +150	$^\circ\text{C}$
ESD Protection at any Pin Human Body Model Machine Model	$V_{esd}$	2000 200	V
Operating Ambient Temperature Range	$T_A$	LM224 -25 to +85 LM324, 324A 0 to +70 LM2902 -40 to +105 LM2902V, NCV2902 (Note 4) -40 to +125	$^\circ\text{C}$

Stresses exceeding Maximum Ratings may damage the device. Maximum Ratings are stress ratings only. Functional operation above the Recommended Operating Conditions is not implied. Extended exposure to stresses above the Recommended Operating Conditions may affect device reliability.

1. Split Power Supplies.
2. For supply voltages less than 32 V, the absolute maximum input voltage is equal to the supply voltage.
3. All  $R_{\theta JA}$  measurements made on evaluation board with 1 oz. copper traces of minimum pad size. All device outputs were active.
4. *NCV2902 is qualified for automotive use.*

# LM324, LM324A, LM224, LM2902, LM2902V, NCV2902

## ELECTRICAL CHARACTERISTICS ( $V_{CC} = 5.0\text{ V}$ , $V_{EE} = \text{GND}$ , $T_A = 25^\circ\text{C}$ , unless otherwise noted.)

Characteristics	Symbol	LM224			LM324A			LM324			LM2902			LM2902V/NCV2902			Unit
		Min	Typ	Max	Min	Typ	Max	Min	Typ	Max	Min	Typ	Max	Min	Typ	Max	
Input Offset Voltage $V_{CC} = 5.0\text{ V}$ to $30\text{ V}$ $V_{ICR} = 0\text{ V}$ to $V_{CC} - 1.7\text{ V}$ , $V_O = 1.4\text{ V}$ , $R_S = 0\ \Omega$ $T_A = 25^\circ\text{C}$ $T_A = T_{\text{high}}$ (Note 5) $T_A = T_{\text{low}}$ (Note 5)	$V_{IO}$	-	2.0	5.0	-	2.0	3.0	-	2.0	7.0	-	2.0	7.0	-	2.0	7.0	mV
Average Temperature Coefficient of Input Offset Voltage $T_A = T_{\text{high}}$ to $T_{\text{low}}$ (Notes 5 and 7)	$\Delta V_{IO}/\Delta T$	-	7.0	-	-	7.0	30	-	7.0	-	-	7.0	-	-	7.0	-	$\mu\text{V}/^\circ\text{C}$
Input Offset Current $T_A = T_{\text{high}}$ to $T_{\text{low}}$ (Note 5)	$I_{IO}$	-	3.0	30	-	5.0	30	-	5.0	50	-	5.0	50	-	5.0	50	nA
Average Temperature Coefficient of Input Offset Current $T_A = T_{\text{high}}$ to $T_{\text{low}}$ (Notes 5 and 7)	$\Delta I_{IO}/\Delta T$	-	10	-	-	10	300	-	10	-	-	10	-	-	10	-	$\text{pA}/^\circ\text{C}$
Input Bias Current $T_A = T_{\text{high}}$ to $T_{\text{low}}$ (Note 5)	$I_{IB}$	-	-90	-150	-	-45	-100	-	-90	-250	-	-90	-250	-	-90	-250	nA
Input Common Mode Voltage Range (Note 6) $V_{CC} = 30\text{ V}$ $T_A = +25^\circ\text{C}$ $T_A = T_{\text{high}}$ to $T_{\text{low}}$ (Note 5)	$V_{ICR}$	0	-	28.3	0	-	28.3	0	-	28.3	0	-	24.3	0	-	24.3	V
Differential Input Voltage Range	$V_{IDR}$	-	-	$V_{CC}$	-	-	$V_{CC}$	-	-	$V_{CC}$	-	-	$V_{CC}$	-	-	$V_{CC}$	V
Large Signal Open Loop Voltage Gain $R_L = 2.0\text{ k}\Omega$ , $V_{CC} = 15\text{ V}$ , for Large $V_O$ Swing $T_A = T_{\text{high}}$ to $T_{\text{low}}$ (Note 5)	$A_{VOL}$	50	100	-	25	100	-	25	100	-	25	100	-	25	100	-	V/mV
Channel Separation $10\text{ kHz} \leq f \leq 20\text{ kHz}$ , Input Referenced	CS	-	-120	-	-	-120	-	-	-120	-	-	-120	-	-	-120	-	dB
Common Mode Rejection, $R_S \leq 10\text{ k}\Omega$	CMR	70	85	-	65	70	-	65	70	-	50	70	-	50	70	-	dB
Power Supply Rejection	PSR	65	100	-	65	100	-	65	100	-	50	100	-	50	100	-	dB

5. LM224:  $T_{\text{low}} = -25^\circ\text{C}$ ,  $T_{\text{high}} = +85^\circ\text{C}$   
 LM324/LM324A:  $T_{\text{low}} = 0^\circ\text{C}$ ,  $T_{\text{high}} = +70^\circ\text{C}$   
 LM2902:  $T_{\text{low}} = -40^\circ\text{C}$ ,  $T_{\text{high}} = +105^\circ\text{C}$   
 LM2902V & NCV2902:  $T_{\text{low}} = -40^\circ\text{C}$ ,  $T_{\text{high}} = +125^\circ\text{C}$   
*NCV2902 is qualified for automotive use.*

6. The input common mode voltage or 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  $V_{CC} - 1.7\text{ V}$ , but either or both inputs can go to +32 V without damage, independent of the magnitude of  $V_{CC}$ .
7. Guaranteed by design.

# LM324, LM324A, LM224, LM2902, LM2902V, NCV2902

## ELECTRICAL CHARACTERISTICS ( $V_{CC} = 5.0\text{ V}$ , $V_{EE} = \text{GND}$ , $T_A = 25^\circ\text{C}$ , unless otherwise noted.)

Characteristics	Symbol	LM224			LM324A			LM324			LM2902			LM2902V/NCV2902			Unit
		Min	Typ	Max	Min	Typ	Max	Min	Typ	Max	Min	Typ	Max	Min	Typ	Max	
Output Voltage – High Limit ( $T_A = T_{\text{high}}$ to $T_{\text{low}}$ ) (Note 8) $V_{CC} = 5.0\text{ V}$ , $R_L = 2.0\text{ k}\Omega$ , $T_A = 25^\circ\text{C}$ $V_{CC} = 30\text{ V}$ , $R_L = 2.0\text{ k}\Omega$ $V_{CC} = 30\text{ V}$ , $R_L = 10\text{ k}\Omega$	$V_{OH}$	3.3	3.5	–	3.3	3.5	–	3.3	3.5	–	3.3	3.5	–	3.3	3.5	–	V
Output Voltage – Low Limit, $V_{CC} = 5.0\text{ V}$ , $R_L = 10\text{ k}\Omega$ , $T_A = T_{\text{high}}$ to $T_{\text{low}}$ (Note 8)	$V_{OL}$	–	5.0	20	–	5.0	20	–	5.0	20	–	5.0	100	–	5.0	100	mV
Output Source Current ( $V_{ID} = +1.0\text{ V}$ , $V_{CC} = 15\text{ V}$ ) $T_A = 25^\circ\text{C}$ $T_A = T_{\text{high}}$ to $T_{\text{low}}$ (Note 8)	$I_{O+}$	20	40	–	20	40	–	20	40	–	20	40	–	20	40	–	mA
Output Sink Current ( $V_{ID} = -1.0\text{ V}$ , $V_{CC} = 15\text{ V}$ ) $T_A = 25^\circ\text{C}$ $T_A = T_{\text{high}}$ to $T_{\text{low}}$ (Note 8)	$I_{O-}$	10	20	–	10	20	–	10	20	–	10	20	–	10	20	–	mA
$(V_{ID} = -1.0\text{ V}$ , $V_O = 200\text{ mV}$ , $T_A = 25^\circ\text{C})$		12	50	–	12	50	–	12	50	–	–	–	–	–	–	–	$\mu\text{A}$
Output Short Circuit to Ground (Note 9)	$I_{SC}$	–	40	60	–	40	60	–	40	60	–	40	60	–	40	60	mA
Power Supply Current ( $T_A = T_{\text{high}}$ to $T_{\text{low}}$ ) (Note 8) $V_{CC} = 30\text{ V}$ , $V_O = 0\text{ V}$ , $R_L = \infty$ $V_{CC} = 5.0\text{ V}$ , $V_O = 0\text{ V}$ , $R_L = \infty$	$I_{CC}$	–	–	3.0	–	1.4	3.0	–	–	3.0	–	–	3.0	–	–	3.0	mA
		–	–	1.2	–	0.7	1.2	–	–	1.2	–	–	1.2	–	–	1.2	

8. LM224:  $T_{\text{low}} = -25^\circ\text{C}$ ,  $T_{\text{high}} = +85^\circ\text{C}$   
 LM324/LM324A:  $T_{\text{low}} = 0^\circ\text{C}$ ,  $T_{\text{high}} = +70^\circ\text{C}$   
 LM2902:  $T_{\text{low}} = -40^\circ\text{C}$ ,  $T_{\text{high}} = +105^\circ\text{C}$   
 LM2902V & NCV2902:  $T_{\text{low}} = -40^\circ\text{C}$ ,  $T_{\text{high}} = +125^\circ\text{C}$   
*NCV2902 is qualified for automotive use.*

9. The input common mode voltage or 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  $V_{CC} - 1.7\text{ V}$ , but either or both inputs can go to +32 V without damage, independent of the magnitude of  $V_{CC}$ .

# LM324, LM324A, LM224, LM2902, LM2902V, NCV2902

## ORDERING INFORMATION

Device	Operating Temperature Range	Package	Shipping <sup>†</sup>
LM224D	-25°C $T_{\text{po}}$ +85°C	SOIC-14	55 Units/Rail
LM224DG		SOIC-14 (Pb-Free)	
LM224DR2		SOIC-14	2500/Tape & Reel
LM224DR2G		SOIC-14 (Pb-Free)	
LM224DTB		TSSOP-14*	96 Units/Tube
LM224DTBG		TSSOP-14*	
LM224DTBR2		TSSOP-14*	2500/Tape & Reel
LM224DTBR2G		TSSOP-14*	
LM224N		PDIP-14	25 Units/Rail
LM224NG		PDIP-14 (Pb-Free)	
LM324D		0°C $T_{\text{po}}$ +70°C	SOIC-14
LM324DG	SOIC-14 (Pb-Free)		
LM324DR2	SOIC-14		2500/Tape & Reel
LM324DR2G	SOIC-14 (Pb-Free)		
LM324DTB	TSSOP-14*		96 Units/Tube
LM324DTBG	TSSOP-14*		
LM324DTBR2	TSSOP-14*		2500/Tape & Reel
LM324DTBR2G	TSSOP-14*		
LM324N	PDIP-14		25 Units/Rail
LM324NG	PDIP-14 (Pb-Free)		
LM324AD	SOIC-14		55 Units/Rail
LM324ADG	SOIC-14 (Pb-Free)		
LM324ADR2	SOIC-14		2500/Tape & Reel
LM324ADR2G	SOIC-14 (Pb-Free)		
LM324ADTB	TSSOP-14*		96 Units/Tube
LM324ADTBG	TSSOP-14*		
LM324ADTBR2	TSSOP-14*		2500/Tape & Reel
LM324ADTBR2G	TSSOP-14*		
LM324AN	PDIP-14		25 Units/Rail
LM324ANG	PDIP-14 (Pb-Free)		

<sup>†</sup>For information on tape and reel specifications, including part orientation and tape sizes, please refer to our Tape and Reel Packaging Specifications Brochure, BRD8011/D.

\*This package is inherently Pb-Free.

## LM324, LM324A, LM224, LM2902, LM2902V, NCV2902

### ORDERING INFORMATION (continued)

Device	Operating Temperature Range	Package	Shipping <sup>†</sup>
LM2902D	-40°C $T_{\text{to}}$ +105°C	SOIC-14	55 Units/Rail
LM2902DG		SOIC-14 (Pb-Free)	
LM2902DR2		SOIC-14	2500/Tape & Reel
LM2902DR2G		SOIC-14 (Pb-Free)	
LM2902DTB		TSSOP-14*	96 Units/Tube
LM2902DTBG		TSSOP-14*	
LM2902DTBR2		TSSOP-14*	2500/Tape & Reel
LM2902DTBR2G		TSSOP-14*	
LM2902N		PDIP-14	25 Units/Rail
LM2902NG		PDIP-14 (Pb-Free)	
LM2902VD		-40°C $T_{\text{to}}$ +125°C	SOIC-14
LM2902VDG	SOIC-14 (Pb-Free)		
LM2902VDR2	SOIC-14		2500/Tape & Reel
LM2902VDR2G	SOIC-14 (Pb-Free)		
LM2902VDTB	TSSOP-14*		96 Units/Tube
LM2902VDTBG	TSSOP-14*		
LM2902VDTBR2	TSSOP-14*		2500/Tape & Reel
LM2902VDTBR2G	TSSOP-14*		
LM2902VN	PDIP-14		25 Units/Rail
LM2902VNG	PDIP-14 (Pb-Free)		
NCV2902DR2	SOIC-14		2500/Tape & Reel
NCV2902DR2G	SOIC-14 (Pb-Free)		
NCV2902DTBR2G	TSSOP-14*		

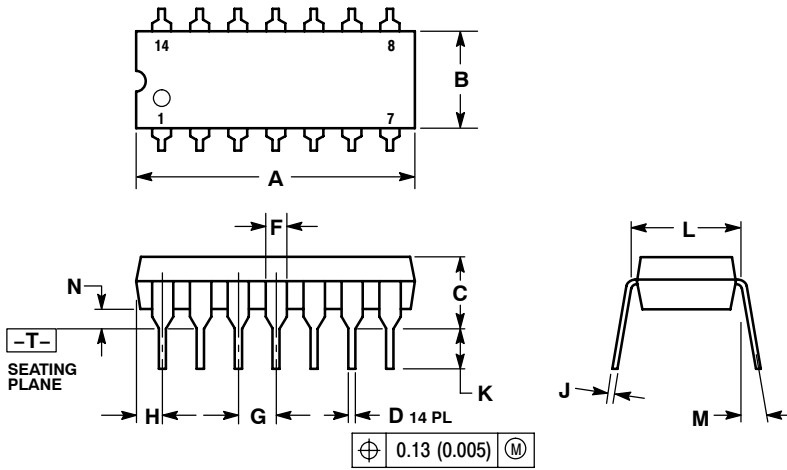
<sup>†</sup>For information on tape and reel specifications, including part orientation and tape sizes, please refer to our Tape and Reel Packaging Specifications Brochure, BRD8011/D.

\*This package is inherently Pb-Free.

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PACKAGE DIMENSIONS

**PDIP-14**  
CASE 646-06  
ISSUE P



NOTES:

1. DIMENSIONING AND TOLERANCING PER ANSI Y14.5M, 1982.
2. CONTROLLING DIMENSION: INCH.
3. DIMENSION L TO CENTER OF LEADS WHEN FORMED PARALLEL.
4. DIMENSION B DOES NOT INCLUDE MOLD FLASH.
5. ROUNDED CORNERS OPTIONAL.

DIM	INCHES		MILLIMETERS	
	MIN	MAX	MIN	MAX
A	0.715	0.770	18.16	19.56
B	0.240	0.260	6.10	6.60
C	0.145	0.185	3.69	4.69
D	0.015	0.021	0.38	0.53
F	0.040	0.070	1.02	1.78
G	0.100 BSC		2.54 BSC	
H	0.052	0.095	1.32	2.41
J	0.008	0.015	0.20	0.38
K	0.115	0.135	2.92	3.43
L	0.290	0.310	7.37	7.87
M	---	10°	---	10°
N	0.015	0.039	0.38	1.01