Single Supply Quad Operational Amplifiers

The LM324S and LM2902S 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 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
- Four Amplifiers Per Package
- Internally Compensated
- Common Mode Range Extends to Negative Supply
- Industry Standard Pinouts
- These Devices are Pb–Free, Halogen Free/BFR Free and are RoHS Compliant



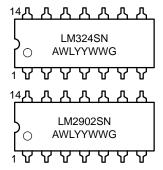
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MARKING DIAGRAMS





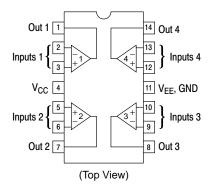


LMxxxx = Specific Device Code

A = Assembly Location

WL = Wafer Lot
 Y, YY = Year
 WW = Work Week
 G = Pb-Free Package

PIN CONNECTIONS



ORDERING INFORMATION

See detailed ordering and shipping information on page 7 of this data sheet.

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

Rating		Symbol	Value	Unit
Power Supply Voltages				Vdc
	Single Supply	V_{CC}	32	
	Split Supplies	V_{CC}, V_{EE}	±16	
Input Differential Voltage Range (Note 1)		V _{IDR}	±32	Vdc
Input Common Mode Voltage Range (Note 2)		V _{ICR}	-0.3 to 32	Vdc
Output Short Circuit Duration		t _{SC}	Continuous	
Junction Temperature		T_J	150	°C
Thermal Resistance, Junction-to-Air (Note 3)	Case 646	$R_{ heta JA}$	118	°C/W
Storage Temperature Range		T _{stg}	-65 to +150	°C
Operating Ambient Temperature Range		T _A		°C
	LM324S		0 to +70	
	LM2902S		-40 to +105	

Stresses exceeding those listed in the Maximum Ratings table may damage the device. If any of these limits are exceeded, device functionality should not be assumed, damage may occur and reliability may be affected.

Split Power Supplies.
 For supply voltages less than 32 V, the absolute maximum input voltage is equal to the supply voltage.

^{3.} All R_{0JA} measurements made on evaluation board with 1 oz. copper traces of minimum pad size. All device outputs were active.

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

		LM324S		LM2902S				
Characteristics	Symbol	Min	Тур	Max	Min	Тур	Max	Unit
Input Offset Voltage	V _{IO}							mV
V_{CC} = 5.0 V to 30 V, V_{ICR} = 0 V to V_{CC} –1.7 V, V_{O} = 1.4 V, R_{S} = 0 Ω								
T _A = 25°C		_	2.0	7.0	_	2.0	7.0	
$T_A = T_{high}$ (Note 4)		_	_	9.0	_	_	10	
$T_A = T_{low}$ (Note 4)		_	_	9.0	_	_	10	
Average Temperature Coefficient of Input Offset Voltage	$\Delta V_{IO}/\Delta T$	-	7.0	-	-	7.0	-	μV/°C
$T_A = T_{high}$ to T_{low} (Notes 4 and 6)								
Input Offset Current	I _{IO}	_	5.0	50	-	5.0	50	nA
$T_A = T_{high}$ to T_{low} (Note 4)		_	_	150	-	_	200	
Average Temperature Coefficient of Input Offset Current $T_A = T_{high}$ to T_{low} (Notes 4 and 6)	$\Delta I_{IO}/\Delta T$	_	10	-	_	10	-	pA/°C
Input Bias Current	I _{IB}	-	-90	-250	_	-90	-250	nA
$T_A = T_{high}$ to T_{low} (Note 4)		-	_	-500	-	_	-500	
Input Common Mode Voltage Range (Note 5)	V _{ICR}							V
V _{CC} = 30 V								
$T_A = +25^{\circ}C$		0	_	28.3	0	_	28.3	
$T_A = T_{high}$ to T_{low} (Note 4)		0	_	28	0	_	28	
Differential Input Voltage Range	V_{IDR}	-	-	V _{CC}	_	-	V _{CC}	V
Large Signal Open Loop Voltage Gain	A _{VOL}							V/mV
R_L = 2.0 k Ω , V_{CC} = 15 V, for Large V_O Swing		25	100	_	25	100	-	
$T_A = T_{high}$ to T_{low} (Note 4)		15	_	_	15	_	-	
Channel Separation 10 kHz \leq f \leq 20 kHz, Input Referenced	CS	-	-120	-	_	-120	-	dB
Common Mode Rejection, $R_S \leq 10 \; k\Omega$	CMR	65	70	-	50	70	-	dB
Power Supply Rejection	PSR	65	100	_	50	100	-	dB

Product parametric performance is indicated in the Electrical Characteristics for the listed test conditions, unless otherwise noted. Product

performance may not be indicated by the Electrical Characteristics for the listed test conditions, unless otherwise noted. Product performance may not be indicated by the Electrical Characteristics if operated under different conditions.

4. LM324S: T_{low} = 0°C, T_{high} = +70°C
LM2902S: T_{low} = -40°C, T_{high} = +105°C

5. 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 V, but either or both inputs can go to +32 V without damage, independent of the magnitude of V_{CC}.
6. Guaranteed by design.

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

		LM324S		LM2902S				
Characteristics		Min	Тур	Max	Min	Тур	Max	Unit
Output Voltage - High Limit	V _{OH}							V
$V_{CC} = 5.0 \text{ V}, R_L = 2.0 \text{ k}\Omega, T_A = 25^{\circ}\text{C}$		3.3	3.5	-	3.3	3.5	_	
V_{CC} = 30 V, R_L = 2.0 k Ω , $(T_A = T_{high to} T_{low})$ (Note 7)		26	-	-	26	_	_	
V_{CC} = 30 V, R_L = 10 k Ω , (T_A = $T_{high\ to}$ T_{low}) (Note 7)		27	28	-	27	28	_	
Output Voltage – Low Limit, $V_{CC} = 5.0 \text{ V}, R_L = 10 \text{ k}\Omega, T_A = T_{high} \text{ to } T_{low} \text{ (Note 7)}$		_	5.0	20	-	5.0	100	mV
Output Source Current (V _{ID} = +1.0 V, V _{CC} = 15 V)	I _O +							mA
T _A = 25°C		20	40	-	20	40	_	
$T_A = T_{high}$ to T_{low} (Note 7)		10	20	-	10	20	_	
Output Sink Current	I _O –							mA
$V_{ID} = -1.0 \text{ V}, V_{CC} = 15 \text{ V}, T_A = 25^{\circ}\text{C}$		10	20	-	10	20	_	
$T_A = T_{high}$ to T_{low} (Note 7)		5.0	8.0	-	5.0	8.0	_	
$V_{ID} = -1.0 \text{ V}, V_O = 200 \text{ mV}, T_A = 25^{\circ}\text{C}$		12	50	-	_	_	_	μΑ
Output Short Circuit to Ground (Note 8)		_	40	60	_	40	60	mA
Power Supply Current (T _A = T _{high} to T _{low}) (Note 7)								mA
$V_{CC} = 30 \text{ V } V_{O} = 0 \text{ V}, R_{L} = \infty$		_	_	3.0	_	_	3.0	
$V_{CC} = 5.0 \text{ V}, V_{O} = 0 \text{ V}, R_{L} = \infty$		_	_	1.2	_	_	1.2	

Product parametric performance is indicated in the Electrical Characteristics for the listed test conditions, unless otherwise noted. Product performance may not be indicated by the Electrical Characteristics if operated under different conditions.

- 7. LM324S: T_{low} = 0°C, T_{high} = +70°C
 LM2902S: T_{low} = -40°C, T_{high} = +105°C

 8. 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 V, but either or both inputs can go to +32 V without damage, independent of the magnitude of V_{CC}.

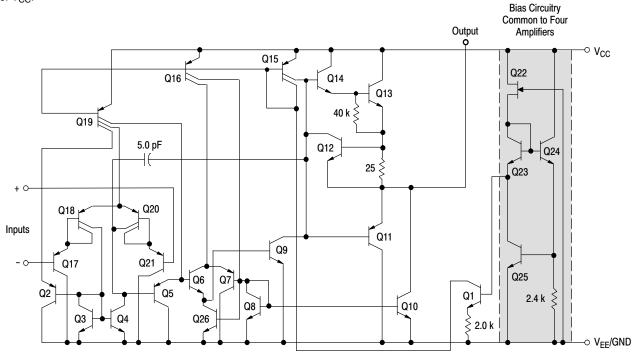


Figure 1. Representative Circuit Diagram

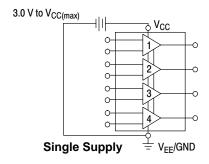
(One-Fourth of Circuit Shown)

CIRCUIT DESCRIPTION

The LM324S and LM2902S are made using four internally compensated, two-stage operational amplifiers. The first stage of each consists of differential input devices Q20 and Q18 with input buffer transistors Q21 and Q17 and the differential to single ended converter Q3 and Q4. The first stage performs not only the first stage gain function but also performs the level shifting and transconductance reduction functions. By reducing the transconductance, a smaller compensation capacitor (only 5.0 pF) can be employed, thus saving chip area. The transconductance reduction is accomplished by splitting the collectors of Q20

and Q18. Another feature of this input stage is that the input common mode range can include the negative supply or ground, in single supply operation, without saturating either the input devices or the differential to single–ended converter. The second stage consists of a standard current source load amplifier stage.

Each amplifier is biased from an internal-voltage regulator which has a low temperature coefficient thus giving each amplifier good temperature characteristics as well as excellent power supply rejection.



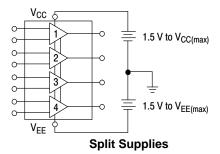


Figure 2.

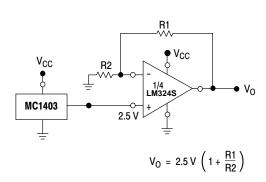


Figure 3. Voltage Reference

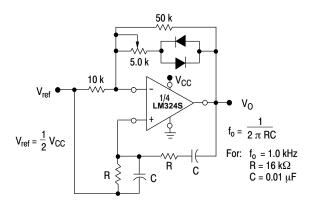


Figure 4. Wien Bridge Oscillator

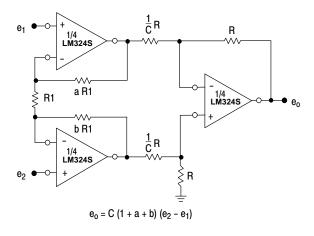


Figure 5. High Impedance Differential Amplifier

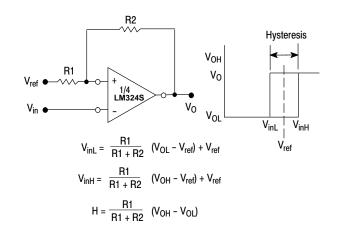


Figure 6. Comparator with Hysteresis

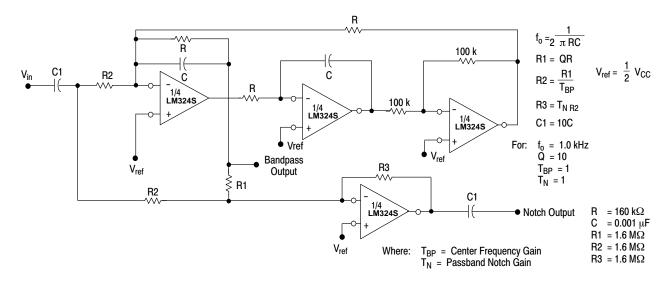


Figure 7. Bi-Quad Filter

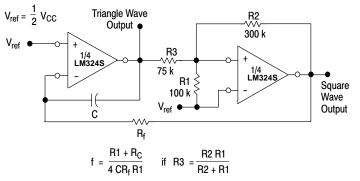


Figure 8. Function Generator

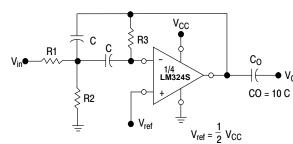


Figure 9. Multiple Feedback Bandpass Filter

Given: f₀ = center frequency

A(f₀) = gain at center frequency

Choose value fo, C

Then: R3 =
$$\frac{Q}{\pi f_0 C}$$

$$R1 = \frac{R3}{2 \text{ A(f_a)}}$$

$$R2 = \frac{R1 R3}{40^2 R1 - R3}$$

For less than 10% error from operational amplifier, $\frac{Q_0 f_0}{BW}$ < 0.1

where fo and BW are expressed in Hz.

If source impedance varies, filter may be preceded with voltage follower buffer to stabilize filter parameters.

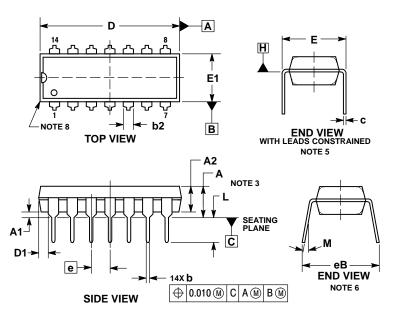
ORDERING INFORMATION

Device	Operating Temperature Range	Package	Shipping [†]
LM324SNG	0°C to +70°C	PDIP-14 (Pb-Free)	25 Units / Rail
LM2902SNG	−40°C to +105°C	PDIP-14 (Pb-Free)	25 Units / Rail

[†]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.

PACKAGE DIMENSIONS

PDIP-14 CASE 646-06 ISSUE R



- DIMENSIONING AND TOLERANCING PER ASME Y14.5M, 1994.
- CONTROLLING DIMENSION: INCHES
- DIMENSIONS A, A1 AND L ARE MEASURED WITH THE PACK-AGE SEATED IN JEDEC SEATING PLANE GAUGE GS-3. DIMENSIONS D, D1 AND E1 DO NOT INCLUDE MOLD FLASH OR PROTRUSIONS. MOLD FLASH OR PROTRUSIONS ARE
- NOT TO EXCEED 0.10 INCH.
 DIMENSION E IS MEASURED AT A POINT 0.015 BELOW DATUM PLANE H WITH THE LEADS CONSTRAINED PERPENDICULAR TO DATUM C.
- DIMENSION E3 IS MEASURED AT THE LEAD TIPS WITH THE LEADS UNCONSTRAINED.
- DATUM PLANE H IS COINCIDENT WITH THE BOTTOM OF THE LEADS, WHERE THE LEADS EXIT THE BODY.

 PACKAGE CONTOUR IS OPTIONAL (ROUNDED OR SQUARE
- CORNERS).

	INC	HES	MILLIM	IETERS		
DIM	MIN	MAX	MIN	MAX		
Α		0.210		5.33		
A1	0.015		0.38			
A2	0.115	0.195	2.92	4.95		
b	0.014	0.022	0.35	0.56		
b2	0.060	TYP	1.52 TYP			
С	0.008	0.014	0.20	0.36		
D	0.735	0.775	18.67	19.69		
D1	0.005		0.13	-		
E	0.300	0.325	7.62	8.26		
E1	0.240	0.280	6.10	7.11		
е	0.100	BSC	2.54 BSC			
eВ		0.430		10.92		
L	0.115	0.150	2.92	3.81		
М		10°		10°		

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