

# DATA SHEET

**LM124/224/324/324A/  
SA534/LM2902**  
Low power quad op amps

Product data  
Supersedes data of 2002 Jul 12

2003 Sep 19

# Low power quad op amps

## LM124/224/324/324A/ SA534/LM2902

### DESCRIPTION

The LM124/SA534/LM2902 series consists of four independent, high-gain, internally frequency-compensated operational amplifiers designed specifically to operate from a single power supply over a wide range of voltages.

### UNIQUE FEATURES

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 crossover frequency and the input bias current are temperature-compensated.

### 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: 3 V<sub>DC</sub> to 30 V<sub>DC</sub> or dual supplies: ±1.5 V<sub>DC</sub> to ±15 V<sub>DC</sub>
- Very low supply current drain: essentially independent of supply voltage (1 mW/op amp at +5 V<sub>DC</sub>)
- Low input biasing current: 45 nA<sub>DC</sub> (temperature-compensated)
- Low input offset voltage: 2 mV<sub>DC</sub> and offset current: 5 nA<sub>DC</sub>
- Differential input voltage range equal to the power supply voltage
- Large output voltage: 0V<sub>DC</sub> to V<sub>CC</sub>-1.5 V<sub>DC</sub> swing

### PIN CONFIGURATION

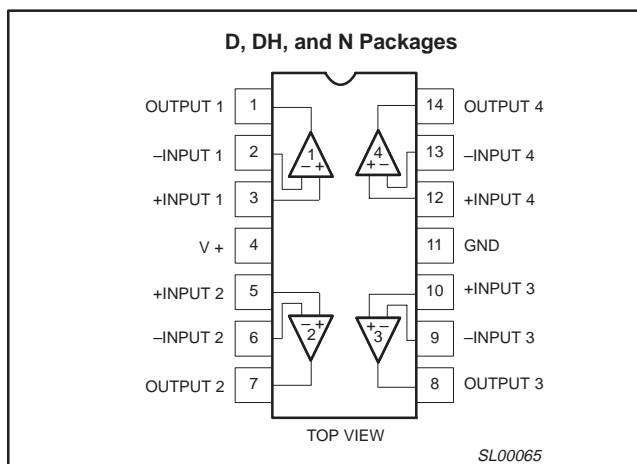


Figure 1. Pin configuration.

### ORDERING INFORMATION

DESCRIPTION	TEMPERATURE RANGE	ORDER CODE	DWG #
14-Pin Plastic Dual In-Line Package (DIP)	-55° C to +125 °C	LM124N	SOT27-1
14-Pin Plastic Small Outline (SO) Package	-25 °C to +85 °C	LM224D	SOT108-1
14-Pin Plastic Dual In-Line Package (DIP)	-25 °C to +85 °C	LM224N	SOT27-1
14-Pin Plastic Small Outline (SO) Package	0 °C to +70 °C	LM324AD	SOT108-1
14-Pin Plastic Dual In-Line Package (DIP)	0 °C to +70 °C	LM324AN	SOT27-1
14-Pin Plastic Small Outline (SO) Package	0 °C to +70 °C	LM324D	SOT108-1
14-Pin Plastic Thin Shrink Small Outline Package (TSSOP)	0 °C to +70 °C	LM324DH	SOT402-1
14-Pin Plastic Dual In-Line Package (DIP)	0 °C to +70 °C	LM324N	SOT27-1
14-Pin Plastic Small Outline (SO) Package	-40 °C to +85 °C	SA534D	SOT108-1
14-Pin Plastic Dual In-Line Package (DIP)	-40 °C to +85 °C	SA534N	SOT27-1
14-Pin Plastic Small Outline (SO) Package	-40 °C to +125 °C	LM2902D	SOT108-1
14-Pin Plastic Thin Shrink Small Outline Package (TSSOP)	-40 °C to +125 °C	LM2902DH	SOT402-1
14-Pin Plastic Dual In-Line Package (DIP)	-40 °C to +125 °C	LM2902N	SOT27-1

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## ABSOLUTE MAXIMUM RATINGS

SYMBOL	PARAMETER	RATING	UNIT
$V_{CC}$	Supply voltage	32 or $\pm 16$	$V_{DC}$
$V_{IN}$	Differential input voltage	32	$V_{DC}$
$V_{IN}$	Input voltage	-0.3 to +32	$V_{DC}$
$P_D$	Maximum power dissipation, $T_{amb} = 25\text{ }^\circ\text{C}$ (still-air) <sup>1</sup> N package D package DH package	1420 1040 762	mW mW mW
	Output short-circuit to GND one amplifier <sup>2</sup> $V_{CC} < 15 V_{DC}$ and $T_{amb} = 25\text{ }^\circ\text{C}$	Continuous	
$I_{IN}$	Input current ( $V_{IN} < -0.3\text{ V}$ ) <sup>3</sup>	50	mA
$T_{amb}$	Operating ambient temperature range LM324/324A LM224 SA534 LM2902 LM124	0 to +70 -25 to +85 -40 to +85 -40 to +125 -55 to +125	$^\circ\text{C}$ $^\circ\text{C}$ $^\circ\text{C}$ $^\circ\text{C}$ $^\circ\text{C}$
$T_{stg}$	Storage temperature range	-65 to +150	$^\circ\text{C}$
$T_{sld}$	Lead soldering temperature (10 sec max)	230	$^\circ\text{C}$

## NOTES:

- Derate above 25  $^\circ\text{C}$  at the following rates:  
N package at 11.4 mW/ $^\circ\text{C}$   
D package at 8.3 mW/ $^\circ\text{C}$   
DH package at 6.1 mW/ $^\circ\text{C}$
- Short-circuits from the output to  $V_{CC+}$  can cause excessive heating and eventual destruction. The maximum output current is approximately 40 mA, independent of the magnitude of  $V_{CC}$ . At values of supply voltage in excess of +15  $V_{DC}$  continuous short-circuits can exceed the power dissipation ratings and cause eventual destruction.
- 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 bias clamps. In addition, there is also lateral NPN parasitic transistor action on the IC chip. This action can cause the output voltages of the op amps to go to the  $V+$  rail (or to ground for a large overdrive) during the time that the input is driven negative.

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## DC ELECTRICAL CHARACTERISTICS

 $V_{CC} = 5\text{ V}$ ;  $T_{amb} = 25\text{ }^{\circ}\text{C}$ , unless otherwise specified.

SYMBOL	PARAMETER	TEST CONDITIONS	LM124/LM224			LM324/SA534/LM2902			UNIT
			Min	Typ	Max	Min	Typ	Max	
$V_{OS}$	Offset voltage <sup>1</sup>	$R_S = 0\ \Omega$		$\pm 2$	$\pm 5$		$\pm 2$	$\pm 7$	mV
		$R_S = 0\ \Omega$ , over temp.			$\pm 7$			$\pm 9$	
$\Delta V_{OS}/\Delta T$	Temperature drift	$R_S = 0\ \Omega$ , over temp.		7			7		$\mu\text{V}/^{\circ}\text{C}$
$I_{BIAS}$	Input current <sup>2</sup>	$I_{IN}(+)$ or $I_{IN}(-)$		45	150		45	250	nA
		$I_{IN}(+)$ or $I_{IN}(-)$ , over temp.		40	300		40	500	
$\Delta I_{BIAS}/\Delta T$	Temperature drift	Over temp.		50			50		$\text{pA}/^{\circ}\text{C}$
$I_{OS}$	Offset current	$I_{IN}(+) - I_{IN}(-)$		$\pm 3$	$\pm 30$		$\pm 5$	$\pm 50$	nA
		$I_{IN}(+) - I_{IN}(-)$ , over temp.			$\pm 100$			$\pm 150$	
$\Delta I_{OS}/\Delta T$	Temperature drift	Over temp.		10			10		$\text{pA}/^{\circ}\text{C}$
$V_{CM}$	Common-mode voltage range <sup>3</sup>	$V_{CC} \leq 30\text{ V}$	0		$V_{CC} - 1.5$	0		$V_{CC} - 1.5$	V
		$V_{CC} \leq 30\text{ V}$ ; over temp.	0		$V_{CC} - 2$	0		$V_{CC} - 2$	
CMRR	Common-mode rejection ratio	$V_{CC} = 30\text{ V}$	70	85		65	70		dB
$V_{OUT}$	Output voltage swing	$R_L = 2\text{ k}\Omega$ , $V_{CC} = 30\text{ V}$ , over temp.	26			26			V
$V_{OH}$	Output voltage high	$R_L \leq 10\text{ k}\Omega$ , $V_{CC} = 30\text{ V}$ , over temp.	27	28		27	28		V
$V_{OL}$	Output voltage low	$R_L \leq 10\text{ k}\Omega$ ; over temp.		5	20		5	20	mV
$I_{CC}$	Supply current	$R_L = \infty$ , $V_{CC} = 30\text{ V}$ ; over temp.		1.5	3		1.5	3	mA
		$R_L = \infty$ ; over temp.		0.7	1.2		0.7	1.2	
$A_{VOL}$	Large-signal voltage gain	$V_{CC} = 15\text{ V}$ (for large $V_O$ swing); $R_L \geq 2\text{ k}\Omega$	50	100		25	100		V/mV
		$V_{CC} = 15\text{ V}$ (for large $V_O$ swing); $R_L \geq 2\text{ k}\Omega$ ; over temp.	25			15			
	Amplifier-to-amplifier coupling <sup>5</sup>	$f = 1\text{ kHz}$ to $20\text{ kHz}$ , input referred		-120			-120		dB
PSRR	Power supply rejection ratio	$R_S \leq 0\ \Omega$	65	100		65	100		dB
$I_{OUT}$	Output current source	$V_{IN+} = +1\text{ V}$ , $V_{IN-} = 0\text{ V}$ , $V_{CC} = 15\text{ V}$	20	40		20	40		mA
		$V_{IN+} = +1\text{ V}$ , $V_{IN-} = 0\text{ V}$ , $V_{CC} = 15\text{ V}$ , over temp.	10	20		10	20		
	Output current sink	$V_{IN-} = +1\text{ V}$ , $V_{IN+} = 0\text{ V}$ , $V_{CC} = 15\text{ V}$	10	20		10	20		
		$V_{IN-} = +1\text{ V}$ , $V_{IN+} = 0\text{ V}$ , $V_{CC} = 15\text{ V}$ , over temp.	5	8		5	8		
		$V_{IN-} = +1\text{ V}$ , $V_{IN+} = 0\text{ V}$ , $V_O = 200\text{ mV}$	12	50		12	50		
$I_{SC}$	Short-circuit current <sup>4</sup>		10	40	60	10	40	60	mA
GBW	Unity gain bandwidth			1			1		MHz
SR	Slew rate			0.3			0.3		$\text{V}/\mu\text{s}$
$V_{NOISE}$	Input noise voltage	$f = 1\text{ kHz}$		40			40		$\text{nV}/\sqrt{\text{Hz}}$
$V_{DIFF}$	Differential input voltage <sup>3</sup>				$V_{CC}$			$V_{CC}$	V

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LM124/224/324/324A/  
SA534/LM2902**DC ELECTRICAL CHARACTERISTICS** (Continued) $V_{CC} = 5\text{ V}$ ,  $T_{amb} = 25\text{ }^{\circ}\text{C}$  unless otherwise specified.

SYMBOL	PARAMETER	TEST CONDITIONS	LM324A			UNIT
			Min	Typ	Max	
$V_{OS}$	Offset voltage <sup>1</sup>	$R_S = 0\ \Omega$		$\pm 2$	$\pm 3$	mV
		$R_S = 0\ \Omega$ , over temp.			$\pm 5$	
$\Delta V_{OS}/\Delta T$	Temperature drift	$R_S = 0\ \Omega$ , over temp.		7	30	$\mu\text{V}/^{\circ}\text{C}$
$I_{BIAS}$	Input current <sup>2</sup>	$I_{IN(+)}$ or $I_{IN(-)}$		45	100	nA
		$I_{IN(+)}$ or $I_{IN(-)}$ , over temp.		40	200	
$\Delta I_{BIAS}/\Delta T$	Temperature drift	Over temp.		50		$\text{pA}/^{\circ}\text{C}$
$I_{OS}$	Offset current	$I_{IN(+)} - I_{IN(-)}$		$\pm 5$	$\pm 30$	nA
		$I_{IN(+)} - I_{IN(-)}$ , over temp.			$\pm 75$	
$\Delta I_{OS}/\Delta T$	Temperature drift	Over temp.		10	300	$\text{pA}/^{\circ}\text{C}$
$V_{CM}$	Common-mode voltage range <sup>3</sup>	$V_{CC} \leq 30\text{ V}$	0		$V_{CC} - 1.5$	V
		$V_{CC} \leq 30\text{ V}$ , over temp.	0		$V_{CC} - 2$	V
CMRR	Common-mode rejection ratio	$V_{CC} = 30\text{ V}$	65	85		dB
$V_{OUT}$	Output voltage swing	$R_L = 2\text{ k}\Omega$ , $V_{CC} = 30\text{ V}$ ; over temp.	26			V
$V_{OH}$	Output voltage high	$R_L \leq 10\text{ k}\Omega$ , $V_{CC} = 30\text{ V}$ ; over temp.	27	28		V
$V_{OL}$	Output voltage low	$R_L \leq 10\text{ k}\Omega$ , over temp.		5	20	mV
$I_{CC}$	Supply current	$R_L = \infty$ , $V_{CC} = 30\text{ V}$ , over temp.		1.5	3	mA
		$R_L = \infty$ , over temp.		0.7	1.2	mA
$A_{VOL}$	Large-signal voltage gain	$V_{CC} = 15\text{ V}$ (for large $V_O$ swing), $R_L \geq 2\text{ k}\Omega$	25	100		V/mV
		$V_{CC} = 15\text{ V}$ (for large $V_O$ swing), $R_L \geq 2\text{ k}\Omega$ , over temp.	15			V/mV
	Amplifier-to-amplifier coupling <sup>5</sup>	$f = 1\text{ kHz}$ to $20\text{ kHz}$ , input referred		-120		dB
PSRR	Power supply rejection ratio	$R_S \leq 0\ \Omega$	65	100		dB
$I_{OUT}$	Output current source	$V_{IN+} = +1\text{ V}$ , $V_{IN-} = 0\text{ V}$ , $V_{CC} = 15\text{ V}$	20	40		mA
		$V_{IN+} = +1\text{ V}$ , $V_{IN-} = 0\text{ V}$ , $V_{CC} = 15\text{ V}$ , over temp.	10	20		mA
	Output current sink	$V_{IN-} = +1\text{ V}$ , $V_{IN+} = 0\text{ V}$ , $V_{CC} = 15\text{ V}$	10	20		mA
		$V_{IN-} = +1\text{ V}$ , $V_{IN+} = 0\text{ V}$ , $V_{CC} = 15\text{ V}$ , over temp.	5	8		mA
		$V_{IN-} = +1\text{ V}$ , $V_{IN+} = 0\text{ V}$ , $V_O = 200\text{ mV}$	12	50		$\mu\text{A}$
$I_{SC}$	Short-circuit current <sup>4</sup>		10	40	60	mA
$V_{DIFF}$	Differential input voltage <sup>3</sup>				$V_{CC}$	V
GBW	Unity gain bandwidth			1		MHz
SR	Slew rate			0.3		$\text{V}/\mu\text{s}$
$V_{NOISE}$	Input noise voltage	$f = 1\text{ kHz}$		40		$\text{nV}/\sqrt{\text{Hz}}$

**NOTES:**

- $V_O \approx 1.4 V_{DC}$ ,  $R_S = 0\ \Omega$  with  $V_{CC}$  from  $5\text{ V}$  to  $30\text{ V}$  and over full input common-mode range ( $0 V_{DC+}$  to  $V_{CC} - 1.5\text{ V}$ ).
- The direction of the input current is out of the IC due to the PNP input stage. This current is essentially constant, independent of the state of the output so no loading change exists on the input lines.
- The input common-mode voltage or either input signal voltage should not be allowed to go negative by more than  $0.3\text{ V}$ . The upper end of the common-mode voltage range is  $V_{CC} - 1.5$ , but either or both inputs can go to  $+32\text{ V}$  without damage.
- Short-circuits from the output to  $V_{CC}$  can cause excessive heating and eventual destruction. The maximum output current is approximately  $40\text{ mA}$  independent of the magnitude of  $V_{CC}$ . At values of supply voltage in excess of  $+15 V_{DC}$ , continuous short-circuits can exceed the power dissipation ratings and cause eventual destruction. Destructive dissipation can result from simultaneous shorts on all amplifiers.
- Due to proximity of external components, insure that coupling is not originating via stray capacitance between these external parts. This typically can be detected as this type of coupling increases at higher frequencies.

# Low power quad op amps

## LM124/224/324/324A/ SA534/LM2902

### EQUIVALENT CIRCUIT

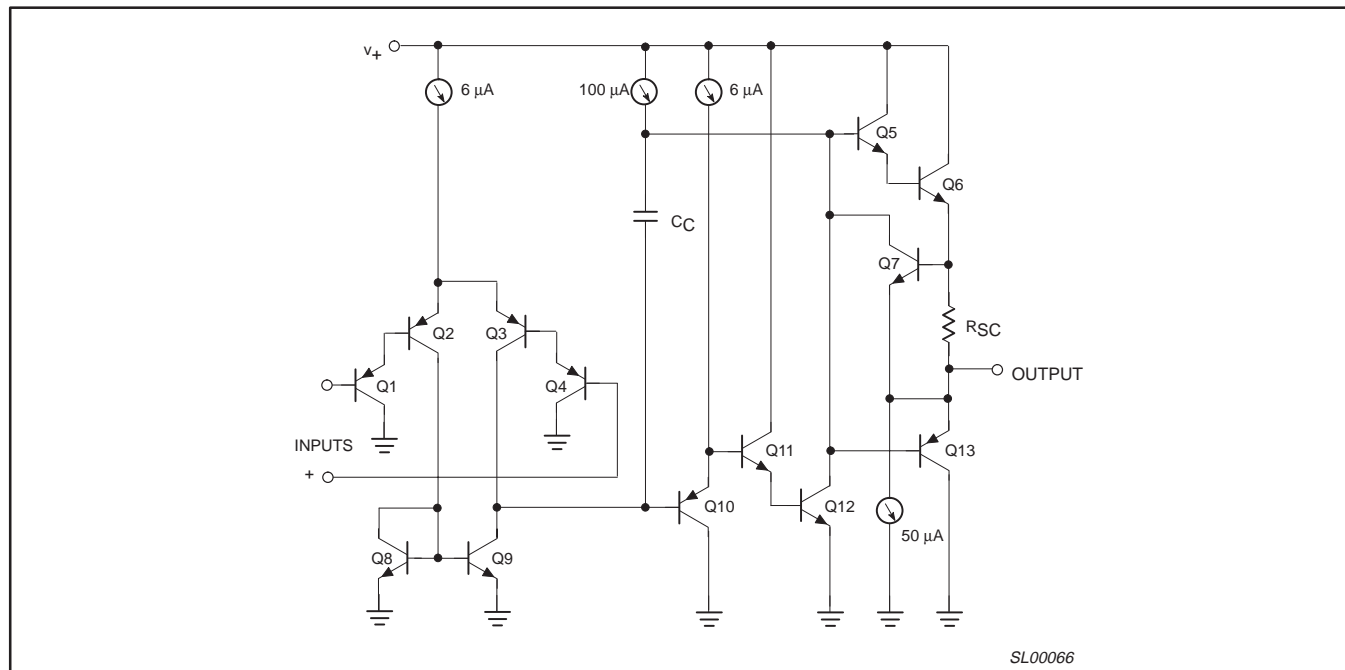


Figure 2. Equivalent circuit.

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TYPICAL PERFORMANCE CHARACTERISTICS

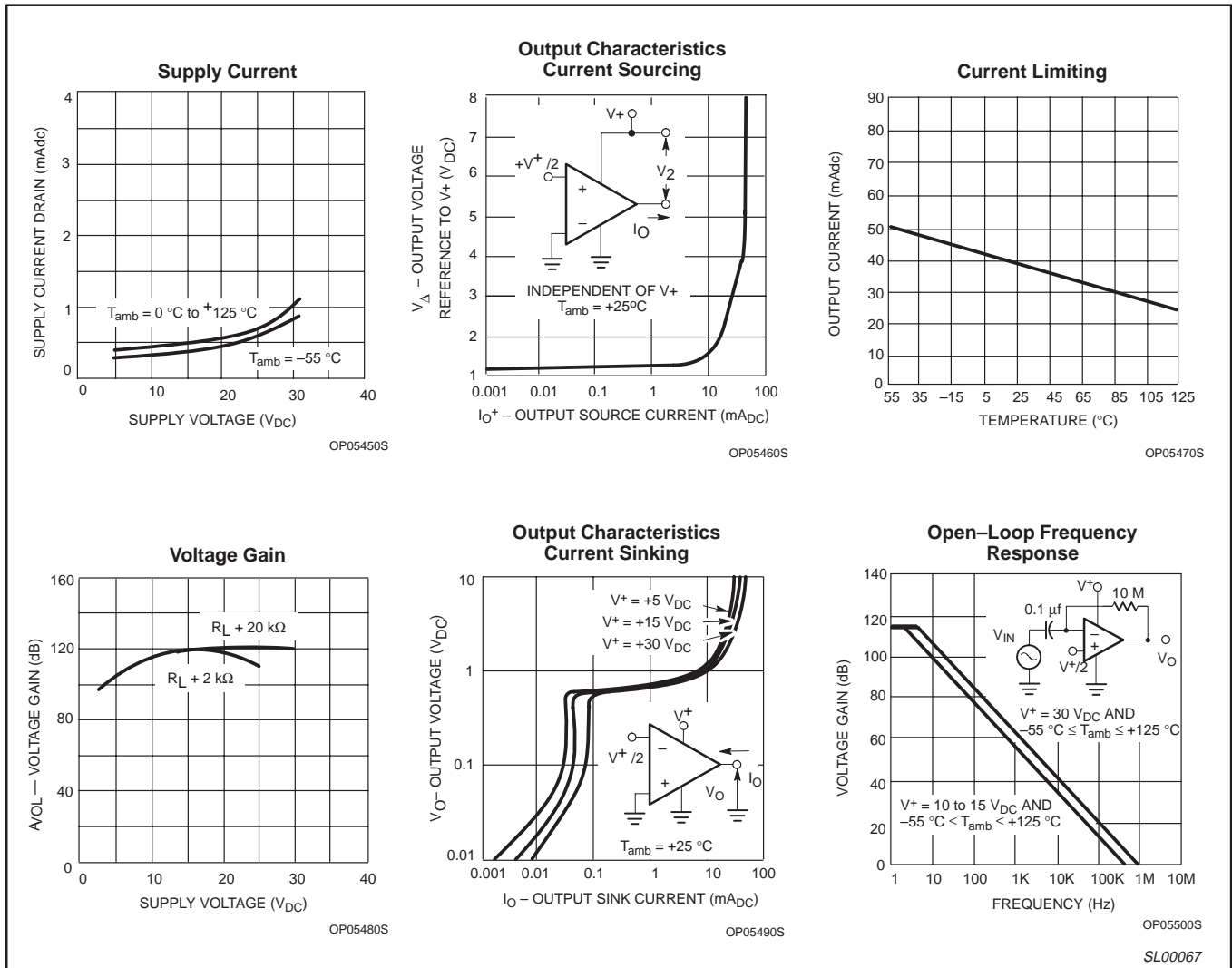


Figure 3. Typical Performance Characteristics

# Low power quad op amps

## LM124/224/324/324A/ SA534/LM2902

### TYPICAL PERFORMANCE CHARACTERISTICS (Continued)

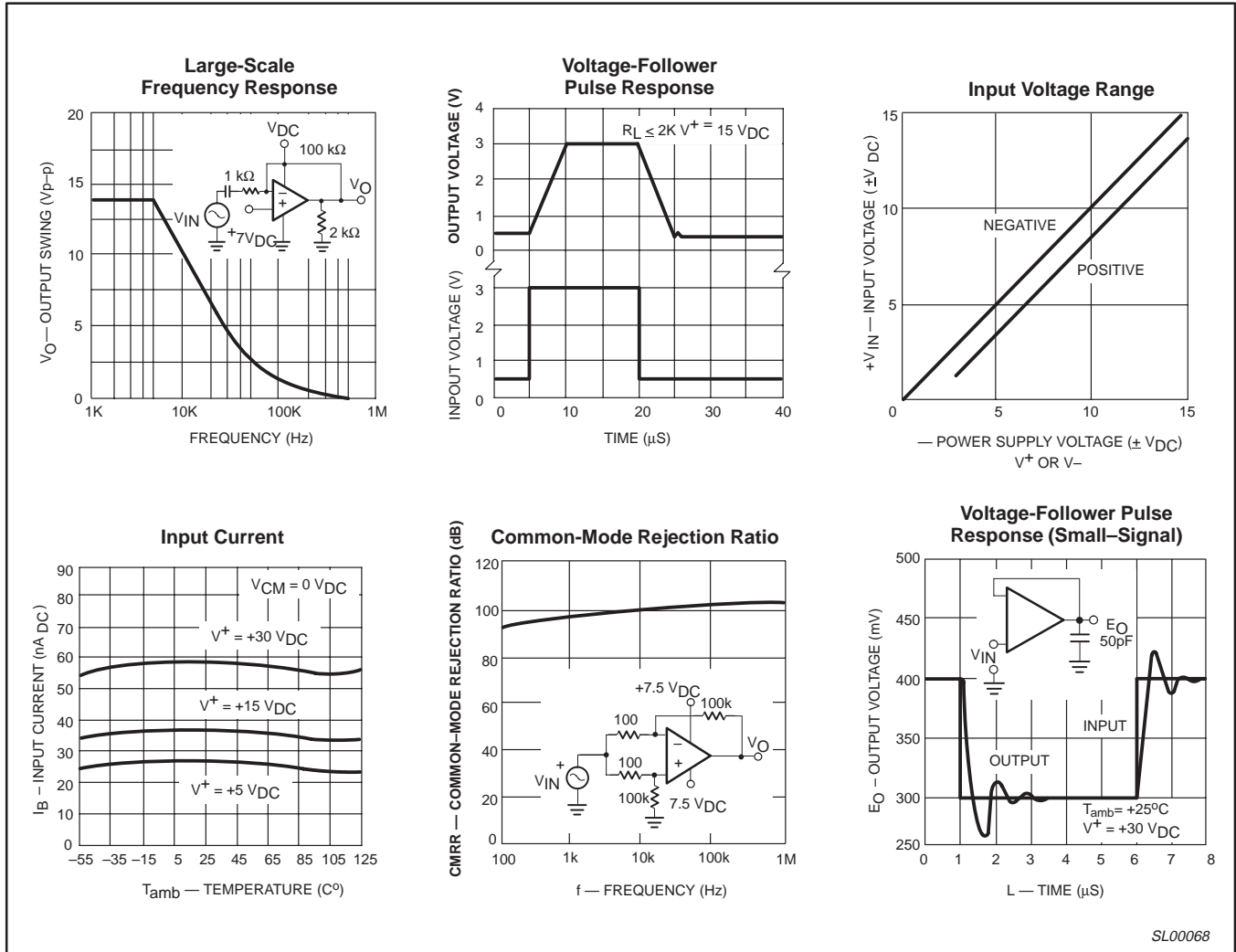


Figure 4. Typical Performance Characteristics (cont.)

### TYPICAL APPLICATIONS

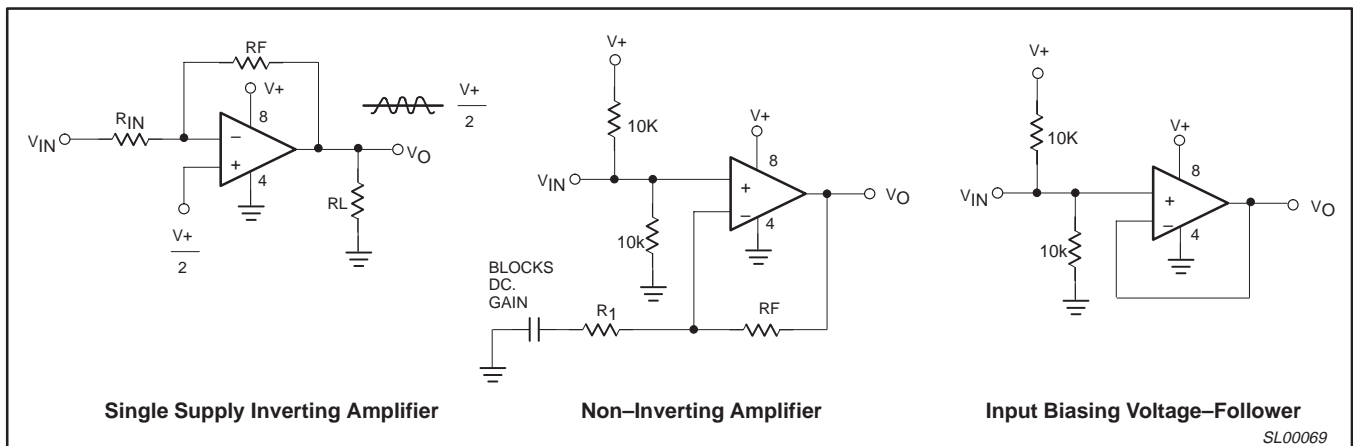


Figure 5. Typical Applications

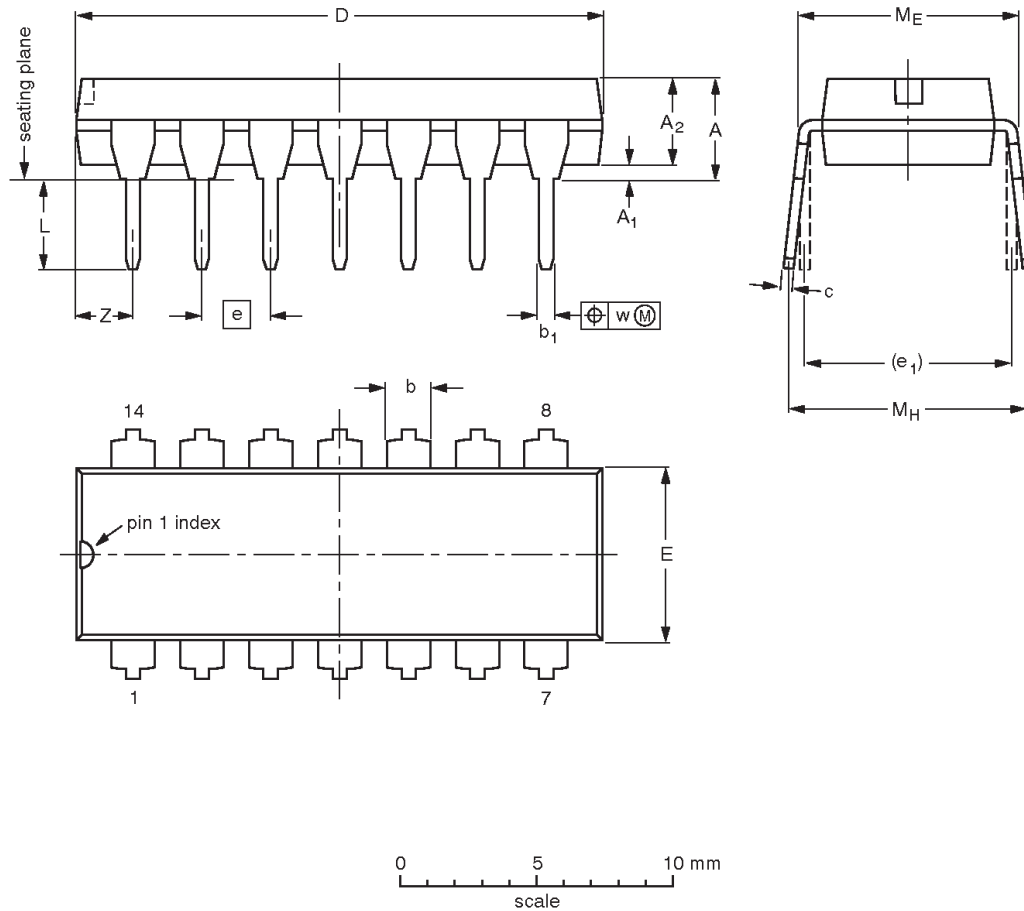


Low power quad op amps

LM124/224/324/324A/  
SA534/LM2902

DIP14: plastic dual in-line package; 14 leads (300 mil)

SOT27-1



**DIMENSIONS (inch dimensions are derived from the original mm dimensions)**

UNIT	A max.	A <sub>1</sub> min.	A <sub>2</sub> max.	b	b <sub>1</sub>	c	D <sup>(1)</sup>	E <sup>(1)</sup>	e	e <sub>1</sub>	L	M <sub>E</sub>	M <sub>H</sub>	w	Z <sup>(1)</sup> max.
mm	4.2	0.51	3.2	1.73 1.13	0.53 0.38	0.36 0.23	19.50 18.55	6.48 6.20	2.54	7.62	3.60 3.05	8.25 7.80	10.0 8.3	0.254	2.2
inches	0.17	0.02	0.13	0.068 0.044	0.021 0.015	0.014 0.009	0.77 0.73	0.26 0.24	0.1	0.3	0.14 0.12	0.32 0.31	0.39 0.33	0.01	0.087

**Note**

1. Plastic or metal protrusions of 0.25 mm (0.01 inch) maximum per side are not included.

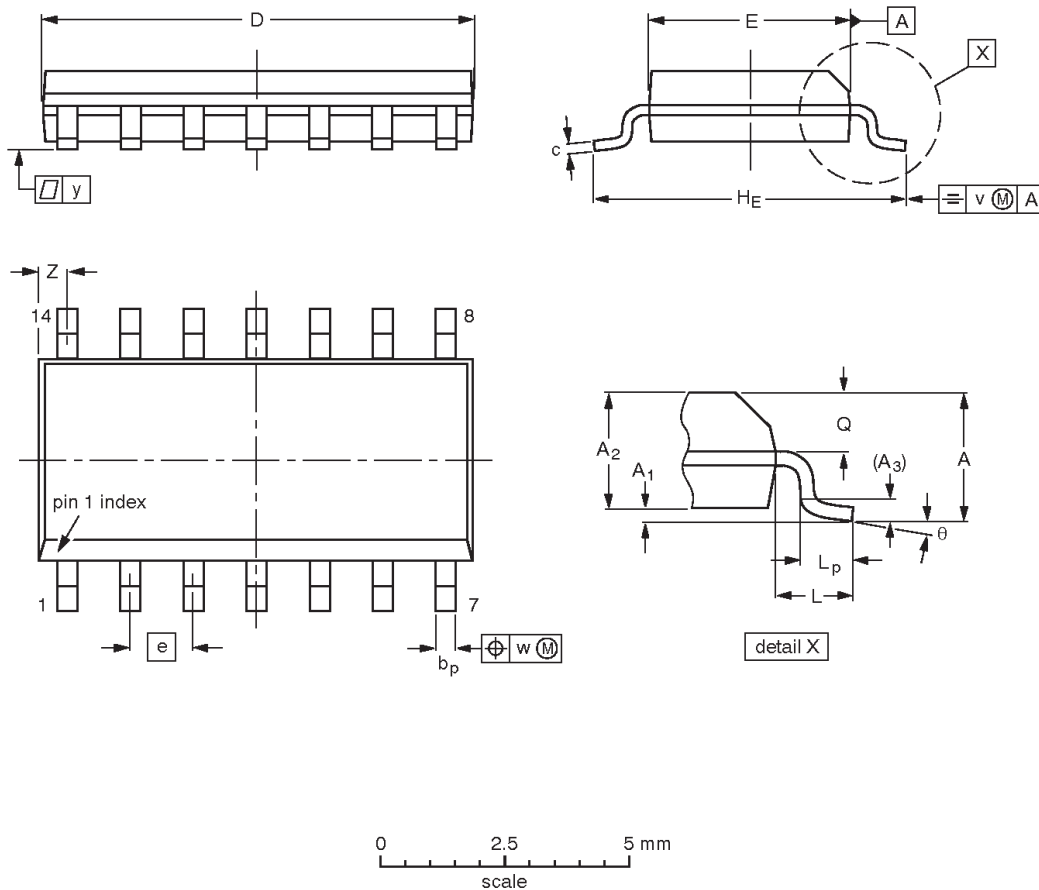
OUTLINE VERSION	REFERENCES				EUROPEAN PROJECTION	ISSUE DATE
	IEC	JEDEC	JEITA			
SOT27-1	050G04	MO-001	SC-501-14			99-12-27 03-02-13

Low power quad op amps

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SO14: plastic small outline package; 14 leads; body width 3.9 mm

SOT108-1



**DIMENSIONS (inch dimensions are derived from the original mm dimensions)**

UNIT	A max.	A <sub>1</sub>	A <sub>2</sub>	A <sub>3</sub>	b <sub>p</sub>	c	D <sup>(1)</sup>	E <sup>(1)</sup>	e	H <sub>E</sub>	L	L <sub>p</sub>	Q	v	w	y	Z <sup>(1)</sup>	θ
mm	1.75	0.25 0.10	1.45 1.25	0.25	0.49 0.36	0.25 0.19	8.75 8.55	4.0 3.8	1.27	6.2 5.8	1.05	1.0 0.4	0.7 0.6	0.25	0.25	0.1	0.7 0.3	8° 0°
inches	0.069	0.010 0.004	0.057 0.049	0.01	0.019 0.014	0.0100 0.0075	0.35 0.34	0.16 0.15	0.05	0.244 0.228	0.041	0.039 0.016	0.028 0.024	0.01	0.01	0.004	0.028 0.012	

**Note**

1. Plastic or metal protrusions of 0.15 mm (0.006 inch) maximum per side are not included.

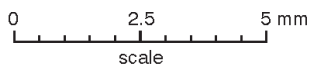
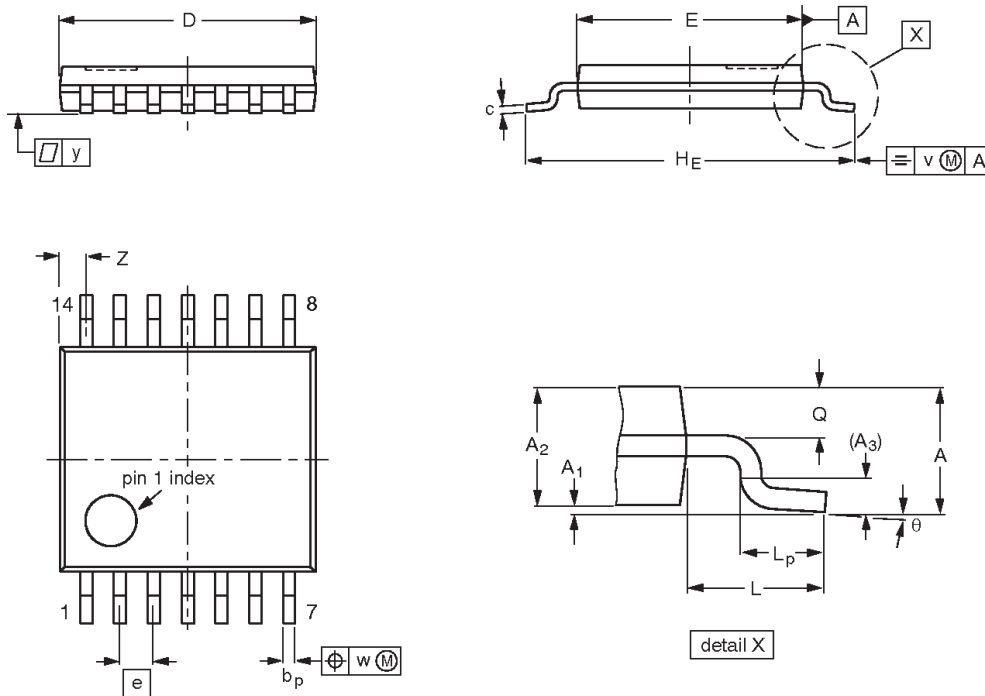
OUTLINE VERSION	REFERENCES				EUROPEAN PROJECTION	ISSUE DATE
	IEC	JEDEC	JEITA			
SOT108-1	076E06	MS-012				99-12-27 03-02-19

Low power quad op amps

LM124/224/324/324A/  
SA534/LM2902

TSSOP14: plastic thin shrink small outline package; 14 leads; body width 4.4 mm

SOT402-1



DIMENSIONS (mm are the original dimensions)

UNIT	A max.	A <sub>1</sub>	A <sub>2</sub>	A <sub>3</sub>	b <sub>p</sub>	c	D <sup>(1)</sup>	E <sup>(2)</sup>	e	H <sub>E</sub>	L	L <sub>p</sub>	Q	v	w	y	Z <sup>(1)</sup>	θ
mm	1.1	0.15 0.05	0.95 0.80	0.25	0.30 0.19	0.2 0.1	5.1 4.9	4.5 4.3	0.65	6.6 6.2	1	0.75 0.50	0.4 0.3	0.2	0.13	0.1	0.72 0.38	8° 0°

Notes

1. Plastic or metal protrusions of 0.15 mm maximum per side are not included.
2. Plastic interlead protrusions of 0.25 mm maximum per side are not included.

OUTLINE VERSION	REFERENCES				EUROPEAN PROJECTION	ISSUE DATE
	IEC	JEDEC	JEITA			
SOT402-1		MO-153				-99-12-27 03-02-18

## Low power quad op amps

LM124/224/324/324A/  
SA534/LM2902

## REVISION HISTORY

Rev	Date	Description
_5	20030919	<b>Product data (9397 750 12078). ECN 853-0929 30369 of 19 September 2003.</b> Modifications: <ul style="list-style-type: none"> <li>Modified Figure 2; Q10 and Q13 changed from NPN to PNP.</li> </ul>
_4	20020712	<b>Product data (9397 750 10172). ECN 853-0929 28616 of 12 July 2002.</b>

## Data sheet status

Level	Data sheet status <sup>[1]</sup>	Product status <sup>[2] [3]</sup>	Definitions
I	Objective data	Development	This data sheet contains data from the objective specification for product development. Philips Semiconductors reserves the right to change the specification in any manner without notice.
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