LINEAR INTEGRATED CIRCUITS

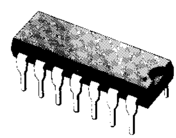
QUAD OPERATIONAL AMPLIFIERS

- SINGLE OR SPLIT POWER SUPPLY
- VERY LOW POWER CONSUMPTION
- INPUT COMMON-MODE RANGE INCLUDING GROUND
- LARGE DC VOLTAGE GAIN (100 dB)

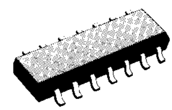
The LM124 series consist of four indipendent, high gain, internally frequency compensated opamps specifically designed to operate from a single power supply over a wide range of voltages. Both in split and in single supply the current drain is independent of the magnitude of the power supply voltage.

In the linear mode the input common-mode voltage range includes ground and the output voltage can also swing to ground, even though operating from only a single power supply voltage.

The LM124 is available in a standard 14-lead dual in-line plastic or ceramic package and in a 14-lead micropackage version.

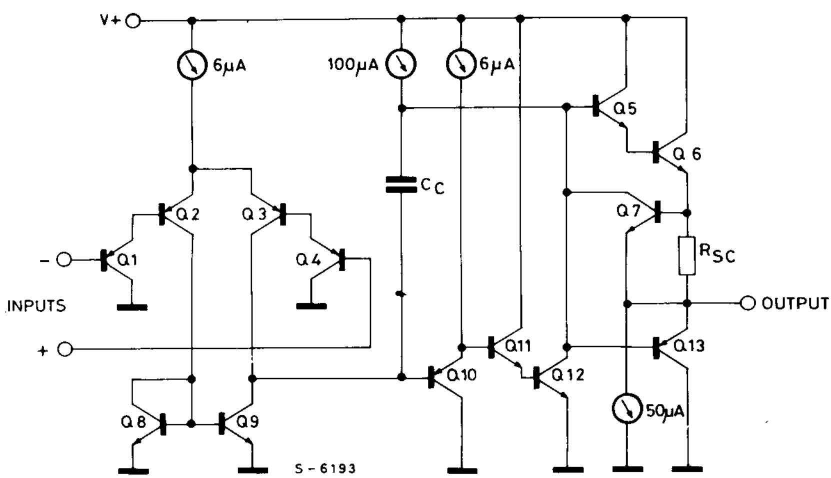


DIP-14
(Plastic and Ceramic)



SO-14

SCHEMATIC DIAGRAM
(one section)

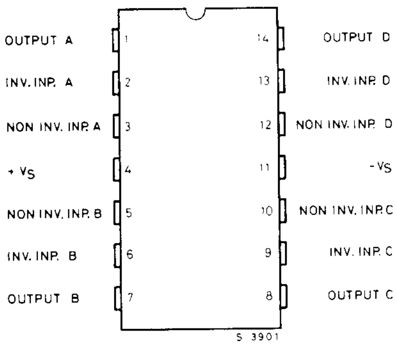


ABSOLUTE MAXIMUM RATINGS

V_s	Supply voltage	32	V
	Supply voltage (**LM2902** only)	26	V
V_i	Input voltage (single supply)	-0.3 to 26	V
V_i	Differential input voltage	32	V
T_{op}	Operating temperature for: **LM2902**	-40 to 85	°C
	LM324/324A	0 to 70	°C
	LM224/224A	-25 to 85	°C
	LM124/124A	-55 to 125	°C
T_j	Junction temperature	150	°C
T_{stg}	Storage temperature	-65 to 150	°C

CONNECTION DIAGRAM AND ORDERING NUMBERS

(top view)



Temperature range	Ceramic DIP-14	Plastic DIP-14	SO-14
Commercial 0 to 70°C	LM324J LM324AJ	LM324N LM324AN	LM324D
Industrial -25 to 85°C	LM224J LM224AJ	LM224N	LM224D
Automotive -40 to 85°C	LM2902J	LM2902N	LM2902D
Military -55 to 125°C	LM124J LM124AJ	–	–

THERMAL DATA

			Ceramic DIP-14	SO-14	Plastic DIP-14
$R_{th\ j\text{-}amb}$	Thermal resistance junction-ambient	max	150°C/W	165°C/W	200°C/W

ELECTRICAL CHARACTERISTICS (V_s = +5V, T_{amb} = -55 to 125°C for the LM124/LM124A and T_{amb} = -25 to 85°C for the LM224/LM224A unless otherwise specified)

Symbol	Parameter	Test conditions		LM124/LM224			LM124A			LM224A			Unit
				Min.	Typ.	Max.	Min.	Typ.	Max.	Min.	Typ.	Max.	
I_S	Supply current	$R_L = \infty$	V_s = 30V		1.5	3		1.5	3		1.5	3	mA
					0.7	1.2		0.7	1.2		0.7	1.2	
I_b	Input bias current	T_{amb} = 25°C			45	150		20	50		40	80	nA
					40	300		40	100		40	100	
V_{os}	Input offset voltage	R_g = 0, V_s = 5V to 30V	T_{amb} = 25°C		2	5		1	2		1	3	mV
						7			4			4	
$\frac{\Delta V_{os}}{\Delta T}$	Input offset voltage drift	R_g = 0			7			7	20		7	20	µV/°C
I_{os}	Input offset current	T_{amb} = 25°C			3	30		2	10		2	15	nA
						100			30			30	
$\frac{\Delta I_{os}}{\Delta T}$	Input offset current drift				10			10	200		10	200	pA/°C
I_{sc}	Output short circuit to ground current	T_{amb} = 25°C (*)			40	60		40	60		40	60	mA
G_v	Large signal open loop voltage gain	V_s = 15V, $R_L \geq$ 2 KΩ	T_{amb} = 25°C	94	100		94	100		94	100		dB
				88			88			88			
	Input common-mode voltage range	V_s = 30V	T_{amb} = 25°C	0		V_s-1.5	0		V_s-1.5	0		V_s-1.5	V
				0		V_s-2	0		V_s-2	0		V_s-2	
V_o	Output voltage swing	T_{amb} = 25°C	R_L = 2 KΩ			V_s-1.5			V_s-1.5				V
			$R_L \geq$ 10 KΩ									V_s-1.5	
		V_s = 30V	R_L = 2 KΩ	26			26			26			V
			$R_L \geq$ 10 KΩ	27	28		27	28		27	28		
$V_{o\,sat}$	Output saturation voltage to ground	$R_L \leq$ 10 KΩ			5	20		5	20		5	20	mV
CMR	Common mode rejection	T_{amb} = 25°C		70	85		70	85		70	85		dB
SVR	Supply voltage rejection	T_{amb} = 25°C		65	100		65	100		65	100		dB
CS	Channel separation	f = 1 KHz to 20 KHz, T_{amb} = 25°C (Input referred)			120			120			120		dB
I_o^+	Output source current	V_s = 15V, V_i^+ = 1V, V_i^- = 0V	T_{amb} = 25°C	20	40		20	40		20	40		mA
				10	20		10	20		10	20		
I_o^-	Output sink current	V_i^+ = 0V, V_i^- = 1V, V_o = 200 mV	T_{amb} = 25°C	12	50		12	50		12	50		µA
		V_i^- = 1V, V_i^+ = 0V, V_s = 15V	T_{amb} = 25°C	10	20		10	20		10	20		mA
				5	8		10	15		5	8		

(*) Short circuits from the output to positive supply voltage can cause excessive heating and eventual destruction. The maximum output current is 40 mA typ. independent of the magnitude of V_s. Destructive dissipation can result from simultaneous shorts on all amplifiers.

ELECTRICAL CHARACTERISTICS (V_s = + 5V, T_{amb} = 0 to 70°C for the LM324A/LM324 and T_{amb} = -40 to 85°C for the LM2902, unless otherwise specified).

Parameter		Test conditions		LM 324 Min.	LM 324 Typ.	LM 324 Max.	LM 324A Min.	LM 324A Typ.	LM 324A Max.	LM 2902 Min.	LM 2902 Typ.	LM 2902 Max.	Unit
I_S	Supply current	$R_L = \infty$	V_s = 30V (*)		1.5	3		1.5	3		1.5	3	mA
					0.7	1.2		0.7	1.2		0.7	1.2	
I_b	Input bias current	T_{amb} = 25°C			45	250		45	100		45	250	nA
						500			200			500	
V_{os}	Input offset voltage	R_g = 0, V_s = 5V to 30V (*)	T_{amb} = 25°C		2	7		2	3		2	7	V
						9			5			10	
$\frac{\Delta V_{os}}{\Delta T}$	Input offset voltage drift	R_g = 0			7			7	30		7		μV/°C
I_{os}	Input offset current	T_{amb} = 25°C			5	50		5	30		5	50	nA
						150			75			200	
$\frac{\Delta I_{os}}{\Delta T}$	Input offset current drift				10			10	300		10		pA/°C
I_{sc}	Output short circuit to ground current	T_{amb} = 25°C (**)			40	60		40	60		40	60	mA
G_v	Large signal open loop voltage gain	V_s = 15V, $R_L \geq$ 2 KΩ	T_{amb} = 25°C	88	100		88	100			100		dB
				83			83			83			
	Input common-mode voltage range	V_s = 30V (*)	T_{amb} = 25°C	0		V_s-1.5	0		V_s-1.5	0		V_s-1.5	V
				0		V_s-2	0		V_s-2	0		V_s-2	
V_o	Output voltage swing	T_{amb} = 25°C	R_L = 2 KΩ			V_s-1.5			V_s-1.5				V
			$R_L \geq$ 10 KΩ									V_s-1.5	
		V_s = 30V (*)	R_L = 2 KΩ	26			26			22			V
			$R_L \geq$ 10 KΩ	27	28		27	28		23	24		
$V_{o\,sat}$	Output saturation voltage to ground	$R_L \leq$ 10 KΩ			5	20		5	20		5	100	mV
CMR	Common mode rejection	T_{amb} = 25°C		65	70		65	85		50	70		dB
SVR	Supply voltage rejection	T_{amb} = 25°C		65	70		65	100		50	70		dB
CS	Channel separation	f = 1 KHz to 20 KHz, T_{amb} = 25°C (Input referred)			120			120			120		dB
I_{o^+}	Output source current	V_s = 15V, V_{i^+} = 1V, V_{i^-} = 0V	T_{amb} = 25°C	20	40		20	40		20	40		mA
				10	20		10	20		10	20		
I_{o^-}	Output sink current	V_{i^+} = 0V, V_{i^-} = 1V, V_o = 200 mV	T_{amb} = 25°C	12	50		12	50					μA
		V_{i^-} = 1V, V_{i^+} = 0V, V_s = 15V	T_{amb} = 25°C	10	20		10	20		10	20		mA
				5	8		5	8		5	8		

(*) V_S = 26V for LM2902.
(**) Short circuits from the output to positive supply voltage can cause excessive heating and eventual destruction. The maximum output current it 40mA typ. independent of the magnitude of V_S. Destructive dissipation can result from simultaneous short on all amplifiers.

Fig. 1 - Supply current vs. supply voltage

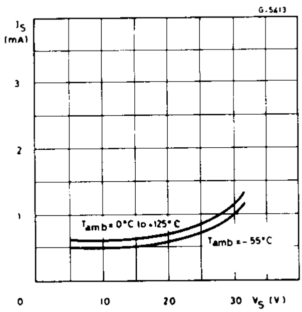


Fig. 2 - Input voltage range vs. supply voltage

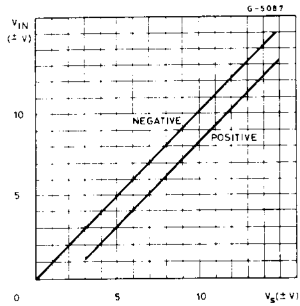


Fig. 3 - Output short circuit current vs. ambient temperature

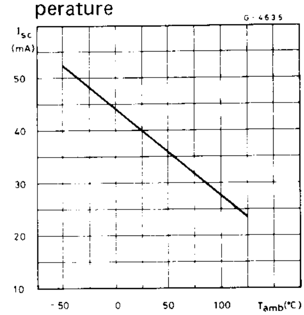


Fig. 4 - Open loop frequency reponse

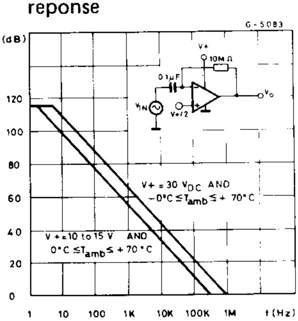


Fig. 5 - Large signal frequency response

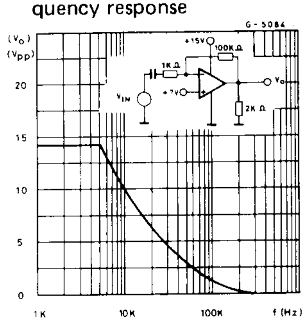


Fig. 6 - Voltage follower pulse response (small signal)

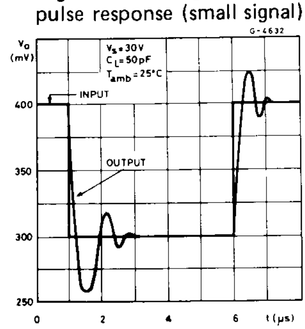


Fig. 7 - Input current

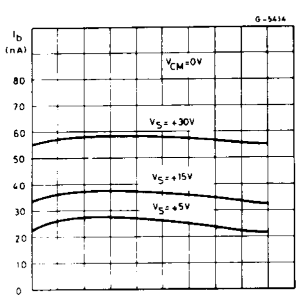


Fig. 8 - Output characteristics vs. current sourcing

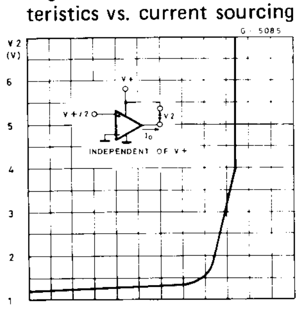
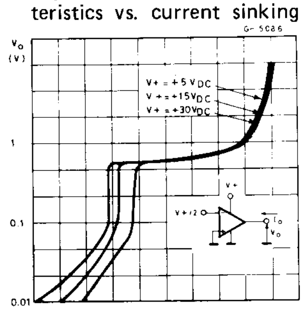


Fig. 9 - Output characteristics vs. current sinking



APPLICATION INFORMATION

The LM124 can operate with a single power supply voltage, has true-differential inputs and remains in the linear mode with an input common-mode voltage of 0V. The four included op amps work over a wide range of power supply voltage with little change in performance characteristics. At 25°C operation is possible down to a minimum supply voltage of 2.3V.

The input common-mode voltage or either input signal voltage should not be allowed to go negative by more than 0.3V. The upper end of the common-mode voltage range is V_s - 1.5V, but either or both inputs can go to + 32V without damage.

If the voltage at any of the input leads is driven negative ($V_{in} < -0.3V$), the collector-base junction of the input PNP transistor becomes forward biased and thereby acts as an input diode clamps (max current: 50 mA). In addition to this diode action, there is also lateral NPN parasitic transistor action on the IC chip. This can cause the output voltage to go to the positive supply voltage level (or to ground for a large overdrive) for the time duration that an input is driven negative. This is not destructive and normal output states will re-establish when the input voltage gain returns positive ($V_{in} > -0.3V$). The output stage design allows the amplifiers to both source and sink large output currents.

Therefore both NPN and PNP external current boost transistors can be used to extend the power capability of the basic amplifiers. The output voltage needs to raise approximately 1 diode drop above ground to bias the on-chip vertical PNP transistor for output current sinking applications.

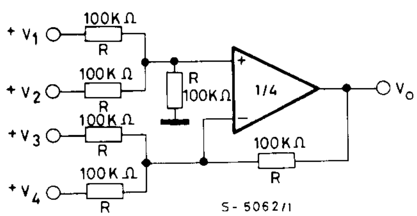
Output short circuits either to ground or to the positive power supply should be of short time duration. Units can be destroyed, not as a result of the short circuit current causing metal fusing, but rather due to the large increase in IC chip dissipation which will cause eventual failure due to excessive junction temperature. **Putting direct short-circuits on more than one amplifier at a time, the total IC power dissipation will increase to destructive levels, if not properly protected with external dissipation limiting resistors in series with the output leads of the amplifiers.**

The larger value of output source current which is available at 25°C provides a larger output current capability at elevated temperatures (see typical performance characteristics) than a standard IC op amp.

The circuits presented in the following section emphasize operation on a single power supply voltage. If split supplies are used, all the standard op amps configuration can be realized.

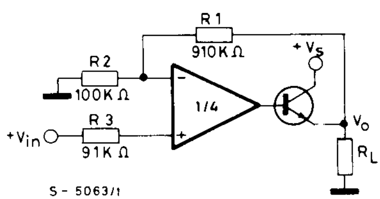
Typical single supply application circuits (V_s = 5V)

Fig. 10 - DC summing amplifier



where: $V_o = V_1 + V_2 - V_3 - V_4$
$(V_1 + V_2)' \geq (V_3 + V_4)$ to keep $V_o > 0V$

Fig. 11 - Power amplifier



V_o = 0V for V_{IN} = 0V
G_V = 20 dB

APPLICATION INFORMATION (continued)

Fig. 12 - LED driver

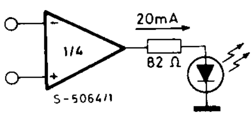


Fig. 13 - Lamp driver

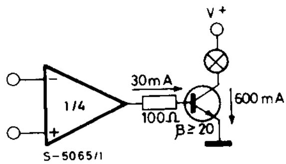
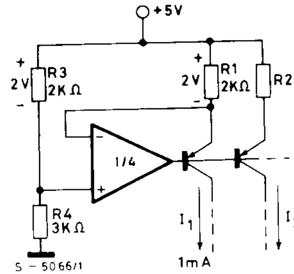
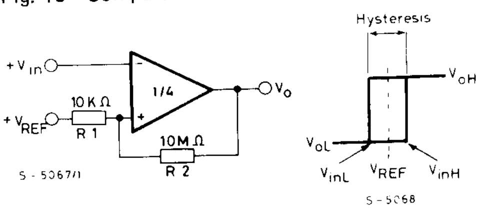


Fig. 14 - Fixed current sources



$$I_2 = \left(\frac{R1}{R2}\right) I_1$$

Fig. 15 - Comparator with Hysteresis

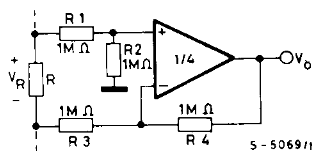


$$V_{in\ L} = \frac{R1}{R1 + R2} (V_{OL} - V_{REF}) + V_{REF}$$

$$V_{in\ H} = \frac{R1}{R1 + R2} (V_{OH} - V_{REF}) + V_{REF}$$

$$\text{Hysteresis} = \frac{R1}{R1 + R2} (V_{OH} - V_{OL})$$

Fig. 16 - Ground referencing a differential input signal



$$V_O = V_R$$

Fig. 17 - Driving TTL

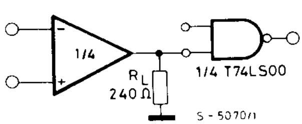
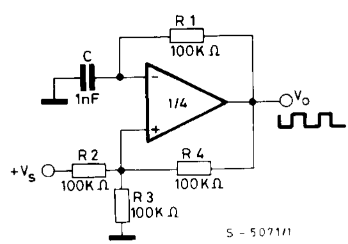
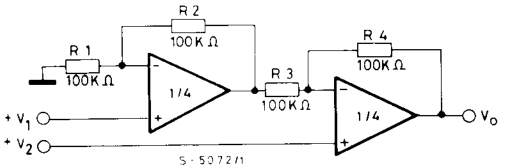


Fig. 18 - Squarewave oscillator



APPLICATION INFORMATION (continued

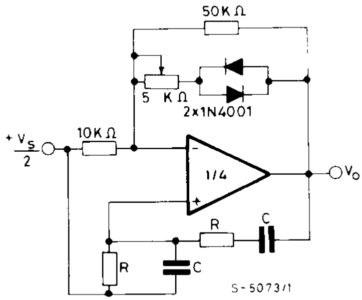
Fig. 19 - High input Z, DC differential amplifier



For $\frac{R1}{R2} = \frac{R4}{R3}$ (CMRR depends on this resistor ratio match)

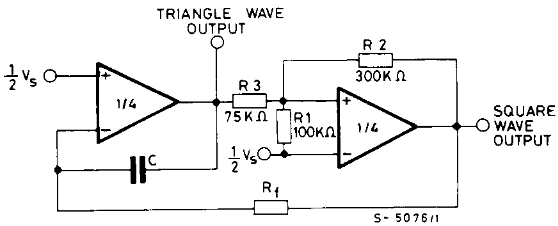
$$V_O = 1 + \frac{R4}{R3} \; (V2 - V1)$$

Fig. 20 - Wien bridge oscillator



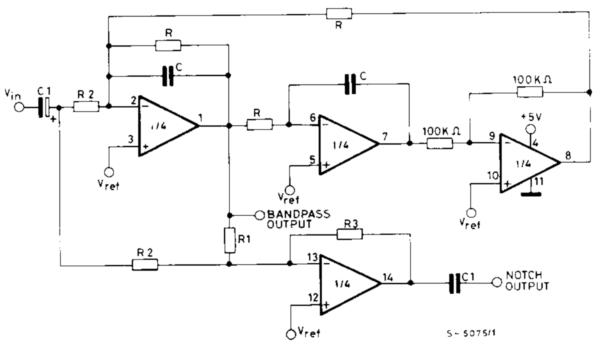
$$f_o = \frac{1}{2\pi RC}$$

Fig. 21 - Function generator



$$f = \frac{R1 + R_C}{4\,CR_f\,R1} \qquad R3 = \frac{R2\ R1}{R2 + R1}$$

Fig. 22 - Bi-Quad filter



$f_o = \frac{1}{2\pi\ RC}$; R1= QR; R2= $\frac{R1}{G_{BP}}$;

$V_{ref} = \frac{1}{2}\ V_s$; R3= G_N R2; C1= 10C

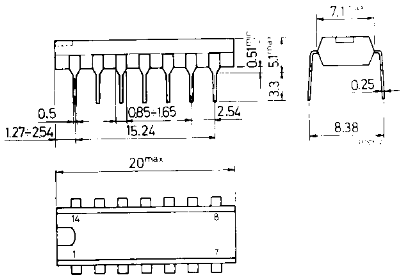
Example:

f_o = 1 KHz	R = 160 KΩ
Q = 10	C = 1 nF
G_{BP}= 1	R1= 1.6 MΩ
G_N= 1	R2= 1.6 MΩ
	R3= 1.6 MΩ

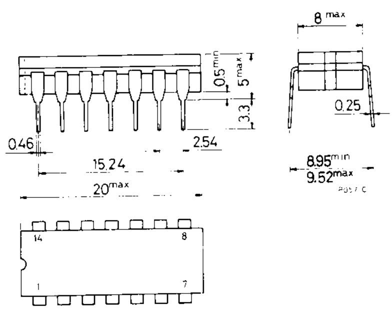
Where: G_{BP}= Center Frequency Gain
G_N = Passband Notch Gain

MECHANICAL DATA (Dimensions in mm)

DIP-14 (Plastic)



DIP-14 (Ceramic)



SO-14