SGS

LM 324
LM 324A
LM 2902

LINEAR INTEGRATED CIRCUITS

PRELIMINARY DATA

LOW POWER QUAD OPERATIONAL AMPLIFIERS

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

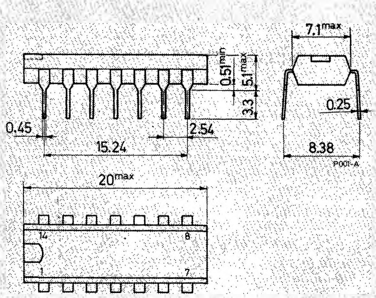
The LM 324 consists of four indipendent, high gain, internally frequency compensated opamps specifically designed to operate from a single power supply over a wide range of voltages. Botn in split and in single supply the current drain is independent of the magnitude of the power supply voltage.
In the 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 LM 324 is available in a standard 14-lead dual in-line plastic package and in a 14-lead micropackage version for thick or thin film hybrid circuits.

ABSOLUTE MAXIMUM RATINGS

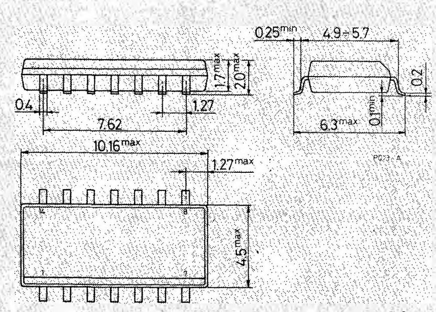
V_s	Supply voltage		32	V
V_i	Input voltage (single supply)		-0.3 to 26	V
V_i	Differential input voltage		32	V
P_{tot}	Total power dissipation		400	mW
T_{op}	Operating temperature for :	**LM 2902**	0 to 70	°C
		LM 324	-25 to 85	°C
		LM 324A	-55 to 125	°C
T_{stg}	Storage temperature		-65 to 150	°C

MECHANICAL DATA

Dimensions in mm

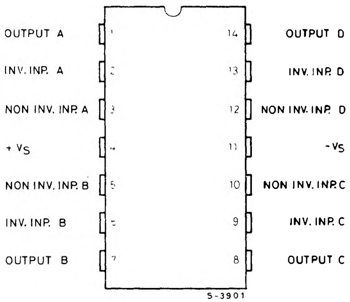


DIP-14



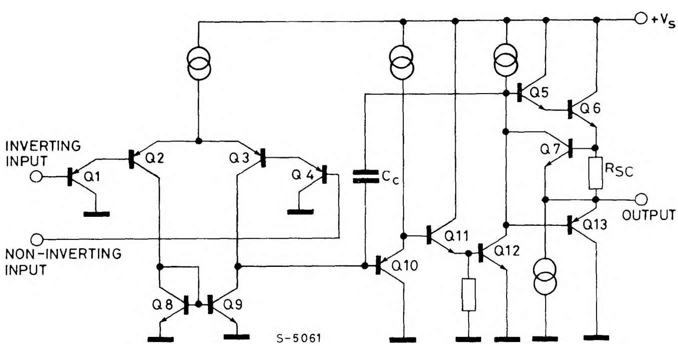
SO-14

CONNECTION DIAGRAM AND ORDERING NUMBERS
(top view)



Type	DIP-14	SO-14
LM 324	LM 324N	LM 324CM
LM 324A	LM 324AN	–
LM 2902	LM 2902N	LM 2902CM

SCHEMATIC DIAGRAM
(one section)



THERMAL DATA

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

* Measured with the device mounted on a ceramic substrate (25 x 16 x 0.6 mm).

ELECTRICAL CHARACTERISTICS (V_s = +5V, T_{amb} = -55 to 125°C for the LM 324A, T_{amb} = -25 to 85°C for the LM 324 and T_{amb} = 0 to 70°C for the LM 2902, unless otherwise specified)

	Parameter	Test conditions		LM 324			LM 324A			LM 2902			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	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	mV
						± 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		

(*) 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.

Fig. 1 - Supply current vs. supply voltage

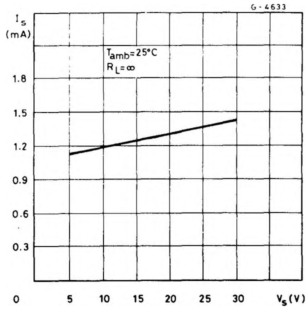


Fig. 2 - Input voltage range vs. supply voltage

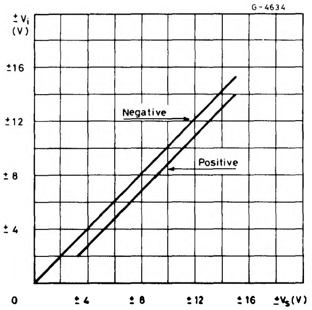


Fig. 3 - Output short circuit current vs. ambient temperature

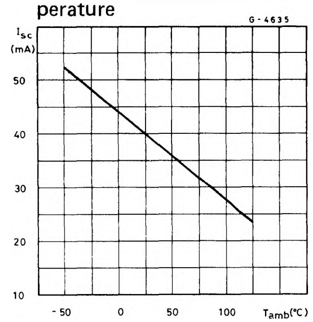


Fig. 4-Open loop frequency response

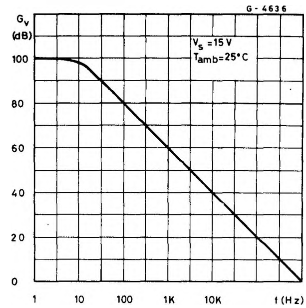


Fig. 5 - Large signal frequency response

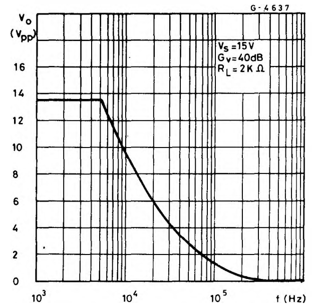
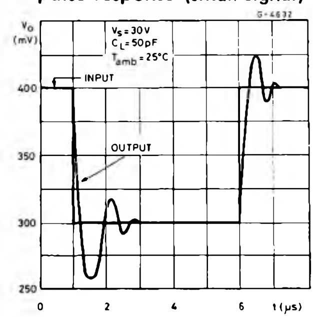


Fig. 6 - Voltage follower pulse response (small signal)



APPLICATION INFORMATION

The LM 324 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 transitor 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 again returns positive (V_{in} >-0.3V). The output stage design allows the amplifiers to both source and sink large output currents.

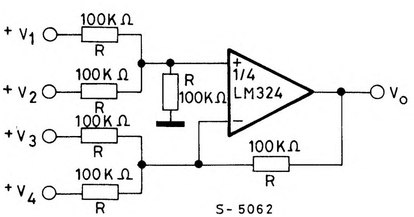
Therefore both NPN and PNP external current boost transistors can be used to extend the power capa-

APPLICATION INFORMATION (continued)

bility 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 realised.

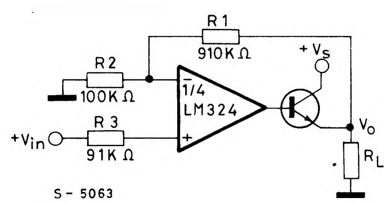
TYPICAL SINGLE SUPPLY APPLICATION CIRCUITS (V_s = 5V)

Fig. 7 - 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. 8 - Power amplifier



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

Fig. 9 - LED driver

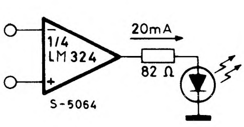


Fig. 10 - Lamp driver

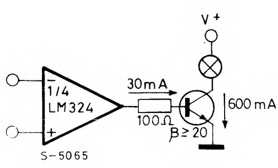
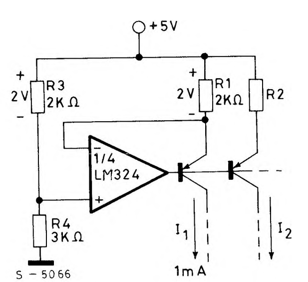


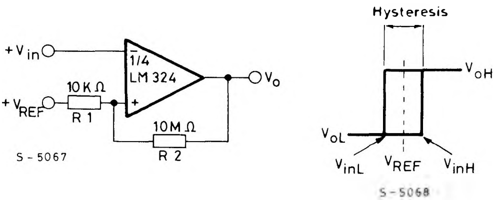
Fig. 11 - Fixed current sources



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

TYPICAL SINGLE SUPPLY APPLICATION CIRCUITS (continued)

Fig. 12 - Comparator with Hysteresis

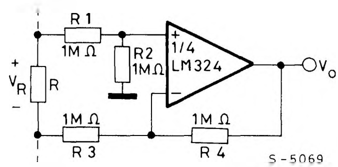


$$V_{in\,L} = \frac{R1}{R1 + R2}\,(V_{OL} - V_{REF}) + V_{REF}$$

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

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

Fig. 13 - Ground referencing a differential input signal



$$V_O = V_R$$

Fig. 14 - Driving TTL

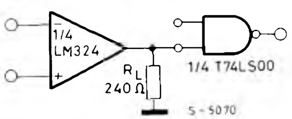


Fig. 15 - Squarewave oscillator

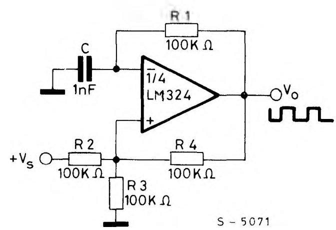
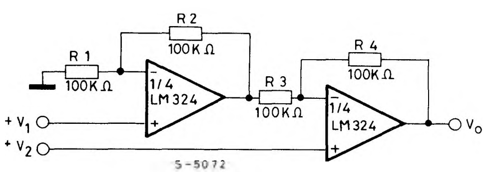


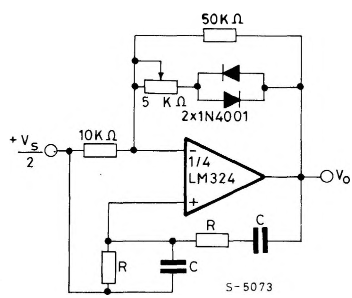
Fig. 16 - High input Z, DC differential amplifier



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

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

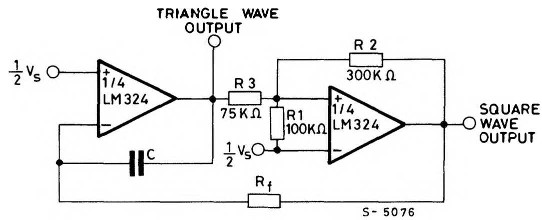
Fig. 17 - Wien bridge oscillator



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

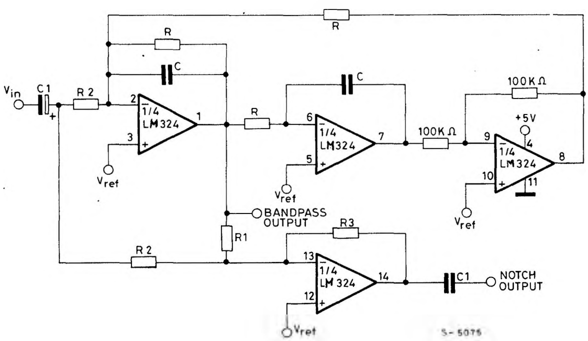
TYPICAL SINGLE SUPPLY APPLICATION CIRCUITS (continued)

Fig. 18 - Function generator



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

Fig. 19 - 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