

GENERAL DESCRIPTION

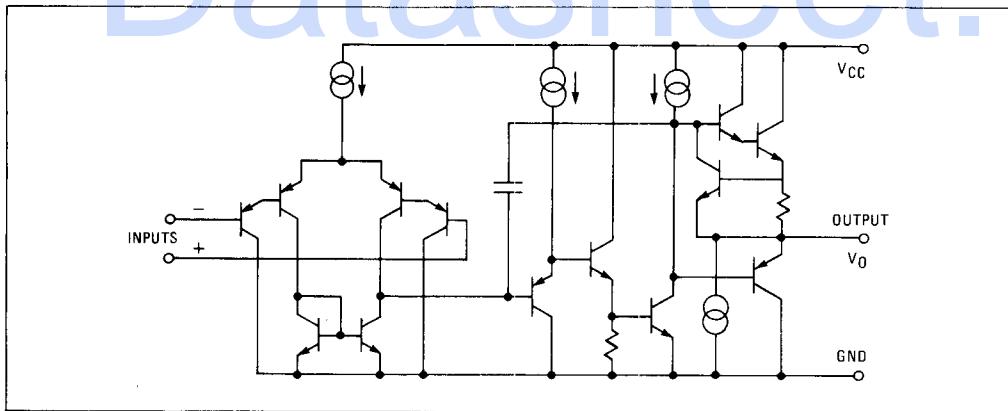
Each of the devices in this series consists of four independent, high-gain, operational amplifiers that are designed for single-supply operation. Operation from split power supplies is also possible and the low power supply drain is independent of the magnitude of the power supply voltage.

Used with a dual supply, the circuit will operate over a wide range of supply voltages. However, a large amount of crossover distortion may occur with loads to ground. An external current-sinking resistor to $-V_{CC}$ will reduce crossover distortion. There is no crossover distortion problem in single supply operation if the load is direct-coupled to ground.

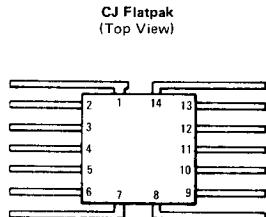
DESIGN FEATURES

- Large DC Voltage Gain 100 dB
 - Compatible with All Forms of Logic
 - Temperature Compensated
 - Wide Bandwidth at Unity Gain Frequency 1 MHz
 - Large Output Voltage Swing: 0 V_{DC} to V⁺ - 1.5 V_{DC}
 - Input Common Mode Voltage Range Includes Ground

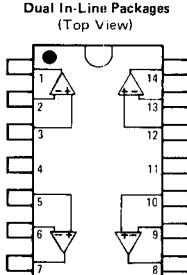
SCHEMATIC DIAGRAM (1/4 Shown)



CONNECTION INFORMATION



Order Part No.:
LM124F, LM124AF



Order Part Nos.:
LM124J, LM224J, LM324J, LM2902J,
LM224N, LM324N, LM2902N,
LM124AJ, LM224AJ, LM324AJ,
LM224AN, LM324AN

PIN	FUNCTION
1	OUTPUT 1
2	-INPUT 1
3	+INPUT 1
4	V ⁺
5	+ INPUT 2
6	- INPUT 2
7	OUTPUT 2
8	OUTPUT 3
9	- INPUT 3
10	+ INPUT 3
11	GROUND
12	+ INPUT 4
13	- INPUT 4
14	OUTPUT 4

Quad Single-Supply Operational Amplifiers

124 224 324 2902

ABSOLUTE MAXIMUM RATINGS



	LM124/LM224/LM324 LM124A/LM224A/LM324A	LM2902	LM124/LM224/LM324 LM124A/LM224A/LM324A	LM2902
Supply Voltage, V^+	32 V _{DC} or +16 V _{DC}	26 V _{DC} or +13 V _{DC}	Input Current ($V_{IN} < -0.3 V_{DL}$) (Note 3)	50 mA
Differential Input Voltage	32 V _{DC}	26 V _{DC}	Operating Temperature Range	-40°C to +85°C
Input Voltage	-0.3 V _{DC} to +32 V _{DC}	-0.3 V _{DC} to +32 V _{DC}	LM324/LM324A	0°C to +70°C
Power Dissipation (Note 1)			LM224/LM224A	-25°C to +85°C
Molded DIP	570 mW	570 mW	LM124/LM124A	-55°C to +125°C
Cavity DIP	900 mW		Storage Temperature Range	-65°C to +150°C
Flat Pack	800 mW		Lead Temperature (Soldering, 10 seconds)	300°C
Output Short-Circuit to GND (One Amplifier) (Note 2)	Continuous	Continuous		-65°C to +150°C
$V^+ \leq 15$ V _{DC} and $T_A = 25^\circ C$				300°C

ELECTRICAL CHARACTERISTICS ($V^+ = +5.0$ V_{DC}; Note 4)

PARAMETER	CONDITIONS	LM124A			LM224A			LM324A			LM124/LM224			LM324			LM2902			UNITS
		MIN	TYP	MAX	MIN	TYP	MAX	MIN	TYP	MAX	MIN	TYP	MAX	MIN	TYP	MAX	MIN	TYP	MAX	
Input Offset Voltage	$T_A = 25^\circ C$, (Note 5)	1	2		1	3		2	3		:2	:5		:2	:7		:2	:7		mV _{DC}
Input Bias Current (Note 6)	$I_{IN(+)} + I_{IN(-)}$, $T_A = 25^\circ C$	20	50		40	80		45	100		45	150		45	250		45	250		nA _{DC}
Input Offset Current	$ I_{IN(+)} - I_{IN(-)} $, $T_A = 25^\circ C$	2	10		2	15		5	30		:3	:30		:5	:50		:5	:50		nA _{DC}
Input Common-Mode Voltage Range (Note 7)	$V^+ = 30$ V _{DC} , $T_A = 25^\circ C$	0	$V^+-1.5$	0	$V^+-1.5$	0	$V^+-1.5$	0	$V^+-1.5$	0	$V^+-1.5$	0	$V^+-1.5$	0	$V^+-1.5$	0	$V^+-1.5$	$V^+-1.5$	$V^+-1.5$	V _{DC}
Supply Current	$R_L = \infty$, $V_{CC} = 30$ V, (LM2902 $V_{CC} = 26$ V) $R_L = \infty$ On All Op Amps Over Full Temperature Range $T_A = 25^\circ C$	1.5 0.7	3 1.2		1.5 0.7	3 1.2		1.5 0.7	3 1.2		1.5 0.7	3 1.2		1.5 0.7	3 1.2		1.5 0.7	3 1.2		mA _{DC}
Large Signal Voltage Gain	$V^+ = 15$ V _{DC} (For Large V_O Swing) $R_L \geq 2$ k Ω , $T_A = 25^\circ C$	50	100		50	100		25	100		50	100		25	100			100		V/mV
Output Voltage Swing	$R_L = 2$ k Ω , $T_A = 25^\circ C$ (LM2902 $R_L \geq 10$ k Ω)									0	$V^+-1.5$	0	$V^+-1.5$	0	$V^+-1.5$	0	$V^+-1.5$	$V^+-1.5$	$V^+-1.5$	V _{DC}
Common-Mode Rejection Ratio	DC, $T_A = 25^\circ C$	70	85		70	85		65	85		70	85		65	70		50	70		dB
Power Supply Rejection Ratio	DC, $T_A = 25^\circ C$	65	100		65	100		65	100		65	100		65	100		50	100		dB
Amplifier-to-Amplifier Coupling (Note 8)	f = 1 kHz to 20 kHz, $T_A = 25^\circ C$ (Input Referred)	-120			-120			-120			-120			-120			-120			dB
Output Current Source	$V_{IN^+} = 1$ V _{DC} , $V_{IN^-} = 0$ V _{DC} , $V^+ = 15$ V _{DC} , $T_A = 25^\circ C$	20	40		20	40		20	40		20	40		20	40		20	40		mA _{DC}
Output Current Sink	$V_{IN^+} = 1$ V _{DC} , $V_{IN^-} = 0$ V _{DC} , $V^+ = 15$ V _{DC} , $T_A = 25^\circ C$	10	20		10	20		10	20		10	20		10	20		10	20		mA _{DC}
	$V_{IN^+} = 1$ V _{DC} , $V_{IN^-} = 0$ V _{DC} , $V^+ = 15$ V _{DC} , $T_A = 25^\circ C$, $V_O = 200$ mV _{DC}	12	50		12	50		12	50		12	50		12	50					μ A _{DC}
Short Circuit to Ground	$T_A = 25^\circ C$, (Note 2)	40	60		40	60		40	60		40	60		40	60		40	60		mA _{DC}

ELECTRICAL CHARACTERISTICS (CONT)

PARAMETER	CONDITIONS	LM124A			LM224A			LM324A			LM124/LM224			LM324			LM2902			UNITS
		MIN	TYP	MAX	MIN	TYP	MAX	MIN	TYP	MAX	MIN	TYP	MAX	MIN	TYP	MAX	MIN	TYP	MAX	
Input Offset Voltage	(Note 5)			4			4			5			±7			±9			±10	mV DC
Input Offset Voltage Drift	$R_S = 0\Omega$		7	20		7	20		7	30		7			7			7	μV/°C	
Input Offset Current	$ I_{IN(+)} - I_{IN(-)}$			30			30			75			±100			±150		45	±200	nADC
Input Offset Current Drift			10	200		10	200		10	300		10			10			10		pADC/°C
Input Bias Current	$ I_{IN(+)} \text{ or } I_{IN(-)}$		40	100		40	100		40	200		40	300		40	500		40	500	nADC
Input Common-Mode Voltage Range (Note 7)	$V^+ = 30 \text{ V}_\text{DC}$	0		$V^+ - 2$	0		$V^+ - 2$	0		$V^+ - 2$	0		$V^+ - 2$	0		$V^+ - 2$	0	$V^+ - 2$	V_DC	
Large Signal Voltage Gain	$V^+ = +15 \text{ V}_\text{DC}$ (For Large V_O Swing) $R_L \geq 2 \text{ k}\Omega$	25			25			15			25			15			15			V/mV
Output Voltage Swing V_{OH}	$V^+ = +30 \text{ V}_\text{DC}, R_L = 2 \text{ k}\Omega$ $R_L > 10 \text{ k}\Omega$ $V^+ = 5 \text{ V}_\text{DC}, R_L \leq 10 \text{ k}\Omega$	26	28		26	27	28	26	27	28	26	27	28	26	27	28	22	23	24	V_DC V_DC mV_DC
V_{OL}		5	20		5	20		5	20		5	20		5	20		5	20	100	
Output Current Source/Sink	$V_{IN^+} = +1 \text{ V}_\text{DC}, V_{IN^-} = 0 \text{ V}_\text{DC}, V^+ = 15 \text{ V}_\text{DC}$ $V_{IN^+} = +1 \text{ V}_\text{DC}, V_{IN^-} = 0 \text{ V}_\text{DC}, V^+ = 15 \text{ V}_\text{DC}$	10	20		10	20		10	20		10	20		10	20		10	20		mA mA
Differential Input Voltage	(Note 7)			V^+			V^+			V^+			V^+			V^+			V^+	V_DC

NOTES:

- For operating at high temperatures, the LM324/LM324A, LM2902 must be derated based on a +125°C maximum junction temperature and a thermal resistance of 175°C/W which applies for the device soldered in a printed circuit board, operating in a still air ambient. The LM224/LM224A and LM124/LM124A can be derated based on a +150°C maximum junction temperature. The dissipation is the total of all four amplifiers — use external resistors, where possible, to allow the amplifier to saturate or to reduce the power which is dissipated in the integrated circuit.
- Short circuits from the output to V^+ can cause excessive heating and eventual destruction. The maximum output current is approximately 40 mA independent of the magnitude of V^+ . 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.
- 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 diode clamps. In addition to this diode action, there is also lateral NPN parasitic transistor action on the IC chip. This transistor action can cause the output voltages of the op amps to go to the V^+ 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, which was negative, again returns to a value greater than -0.3 V_{DC}.
- These specifications apply for $V^+ = 15 \text{ V}_\text{DC}$ and $-55^\circ\text{C} \leq T_A \leq +125^\circ\text{C}$, unless otherwise stated. With the LM224/LM224A, all temperature specifications are limited to $-25^\circ\text{C} \leq T_A \leq +85^\circ\text{C}$, the LM324/LM324A temperature specifications are limited to $0^\circ\text{C} \leq T_A \leq +70^\circ\text{C}$, and the LM2902 specifications are limited to $-40^\circ\text{C} \leq T_A \leq +85^\circ\text{C}$.
- $V_O = 1.4 \text{ V}_\text{DC}$, $R_S = 0\Omega$ with $V^+ = 5 \text{ V}_\text{DC}$ to 30 V_DC , and over the full common-mode range (0 V_DC to $V^+ - 1.5 \text{ V}_\text{DC}$).
- 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 0.3V. The upper end of the common-mode voltage range is $V^+ - 1.5 \text{ V}_\text{DC}$, but either or both inputs can go to +32 V_{DC} without damage (+26 V_{DC} for LM2902).
- 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 capacitive increases at higher frequencies.



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TYPICAL PERFORMANCE CHARACTERISTICS

