

**GENERAL DESCRIPTION**

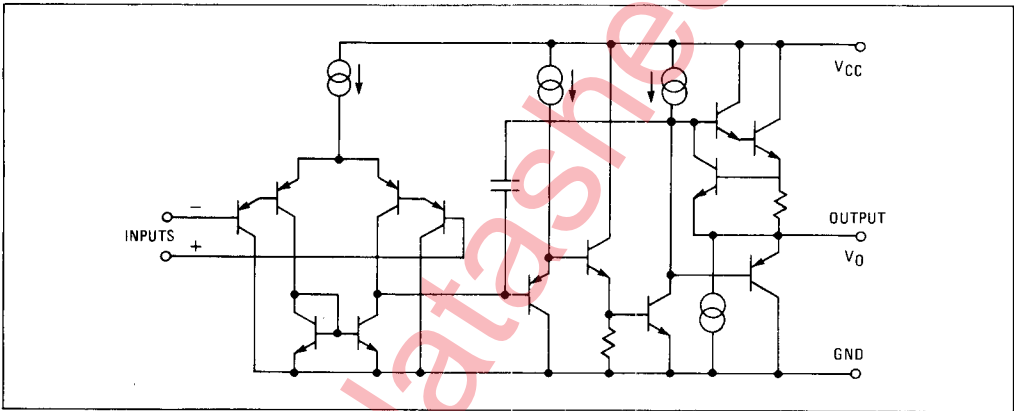
Each of the devices in this series consists of four independent, high-gain, operational amplifiers that are designed for single-supply operation. Operation from split power supplies is also possible and the low power supply drain is independent of the magnitude of the power supply voltage.

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<sub>DC</sub> to V<sup>+</sup> - 1.5 V<sub>DC</sub>
- Input Common Mode Voltage Range Includes Ground

**SCHEMATIC DIAGRAM (1/4 Shown)**



**CONNECTION INFORMATION**

**CJ Flatpak  
(Top View)**

Order Part No.:  
LM124F, LM124AF

**DB and DC  
Dual In-Line Packages  
(Top View)**

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 <sup>+</sup> |
| 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       |



# ABSOLUTE MAXIMUM RATINGS

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

## 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           |             | $\pm 2$ | $\pm 5$     |       | $\pm 2$ | $\pm 7$     |        | $\pm 2$ | $\pm 7$     | $mV_{DC}$    |
| Input Bias Current (Note 6)              | $I_{IN(+)} \text{ or } I_{IN(-)}$ , $T_A = 25^\circ C$                                 |        | 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          |             | $\pm 3$ | $\pm 30$    |       | $\pm 5$ | $\pm 50$    |        | $\pm 5$ | $\pm 50$    | $nA_{DC}$    |
| 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      |         | $V^+ - 1.5$ | $V_{DC}$     |
| Supply Current                           | $R_L = \infty$ , $V_{CC} = 30V$ , (LM2902 $V_{CC} = 26V$ )                             |        | 1.5  | 3           |        | 1.5 | 3           |        | 1.5  | 3           |             | 1.5     | 3           |       | 1.5     | 3           |        | 1.5     | 3           | $mA_{DC}$    |
|  | $R_L = \infty$ On All Op Amps Over Full Temperature Range $T_A = 25^\circ C$           |        | 0.7  | 1.2         |        | 0.7 | 1.2         |        | 0.7  | 1.2         |             | 0.7     | 1.2         |       | 0.7     | 1.2         |        | 0.7     | 1.2         | $mA_{DC}$    |
| Large Signal Voltage Gain                | $V^+ = 15 V_{DC}$ (For Large $V_O$ Swing)  | 50     | 100  |             | 50     | 100 |             | 25     | 100  |             | 50          | 100     |             | 25    | 100     |             | 100    |         |             | $V/mV$       |
|  | $R_L \geq 2 k\Omega$ , $T_A = 25^\circ C$  |        |      |             |        |     |             |        |      |             |             |         |             |       |         |             |        |         |             |              |
| Output Voltage Swing                     | $R_L = 2 k\Omega$ , $T_A = 25^\circ C$ (LM2902 $R_L > 10 k\Omega$ )                    |        |      |             |        |     |             |        |      |             | 0           |         | $V^+ - 1.5$ | 0     |         | $V^+ - 1.5$ | 0      |         | $V^+ - 1.5$ | $V_{DC}$     |
| 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) | $f = 1 \text{ kHz}$ to $20 \text{ kHz}$ , $T_A = 25^\circ C$ (Input Referred)          |        | -120 |             | -120   |     | -120        |        | -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      |             | $mA_{DC}$    |
|  | $V_{IN-} = 1 V_{DC}$ , $V_{IN+} = 0 V_{DC}$ , $T_A = 25^\circ C$ , $V_O = 200 mV_{DC}$ | 12     | 50   |             | 12     | 50  |             | 12     | 50   |             | 12          | 50      |             | 12    | 50      |             |        |         |             | $\mu A_{DC}$ |
| 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 <sub>DC</sub> |
| Input Offset Voltage Drift               | R <sub>S</sub> = 0Ω  |        | 7   | 20                |        | 7   | 20                |        | 7   | 30                |             | 7   |                   | 7     |     | 7                 |        | 7   | μV/°C                |                  |
| Input Offset Current                     | I <sub>IN(+)</sub> - I <sub>IN(-)</sub>  |        |     | 30                |        |     | 30                |        |     | 75                |             |     | ±100              |       |     | ±150              |        | 45  | ±200                 | nA <sub>DC</sub> |
| Input Offset Current Drift               |  |        | 10  | 200               |        | 10  | 200               |        | 10  | 300               |             | 10  |                   | 10    |     | 10                |        | 10  | pA <sub>DC</sub> /°C |                  |
| Input Bias Current                       | I <sub>IN(+)</sub> or I <sub>IN(-)</sub>   |        | 40  | 100               |        | 40  | 100               |        | 40  | 200               |             | 40  | 300               |       | 40  | 500               |        | 40  | 500                  | nA <sub>DC</sub> |
| Input Common-Mode Voltage Range (Note 7) | V <sup>+</sup> = 30 V <sub>DC</sub>  | 0      |     | V <sup>+</sup> -2 | 0      |     | V <sup>+</sup> -2 | 0      |     | V <sup>+</sup> -2 | 0           |     | V <sup>+</sup> -2 | 0     |     | V <sup>+</sup> -2 | 0      |     | V <sup>+</sup> -2    | V <sub>DC</sub>  |
| Large Signal Voltage Gain                | V <sup>+</sup> = +15 V <sub>DC</sub> (For Large V <sub>O</sub> Swing)<br>R <sub>L</sub> ≥ 2 kΩ                     | 25     |     |                   | 25     |     |                   | 15     |     |                   | 25          |     |                   | 15    |     |                   | 15     |     |                      | V/mV             |
| Output Voltage Swing                     | V <sup>+</sup> = +30 V <sub>DC</sub> , R <sub>L</sub> = 2 kΩ   | 26     |     |                   | 26     |     |                   | 26     |     |                   | 26          |     |                   | 26    |     |                   | 22     |     |                      | V <sub>DC</sub>  |
|  | R <sub>L</sub> ≥ 10 kΩ   | 27     | 28  |                   | 27     | 28  |                   | 27     | 28  |                   | 27          | 28  |                   | 27    | 28  |                   | 23     | 24  |                      | V <sub>DC</sub>  |
| V <sub>OL</sub>                          | V <sup>+</sup> = 5 V <sub>DC</sub> , R <sub>L</sub> ≤ 10 kΩ  | 5      | 20  |                   | 5      | 20  |                   | 5      | 20  |                   | 5           | 20  |                   | 5     | 20  |                   | 5      | 100 |                      | mV <sub>DC</sub> |
| Output Current Source                    | V <sub>IN+</sub> = +1 V <sub>DC</sub> , V <sub>IN-</sub> = 0 V <sub>DC</sub> , V <sup>+</sup> = 15 V <sub>DC</sub> | 10     | 20  |                   | 10     | 20  |                   | 10     | 20  |                   | 10          | 20  |                   | 10    | 20  |                   | 10     | 20  |                      | mA               |
| Sink                                     | V <sub>IN+</sub> = +1 V <sub>DC</sub> , V <sub>IN-</sub> = 0 V <sub>DC</sub> , V <sup>+</sup> = 15 V <sub>DC</sub> | 10     | 15  |                   | 5      | 8   |                   | 5      | 8   |                   | 5           | 8   |                   | 5     | 8   |                   | 5      | 8   |                      | mA               |
| Differential Input Voltage               | (Note 7)   |        |     | V <sup>+</sup>    |        |     | V <sup>+</sup>    |        |     | V <sup>+</sup>    |             |     | V <sup>+</sup>    |       |     | V <sup>+</sup>    |        |     | V <sup>+</sup>       | V <sub>DC</sub>  |

## 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<sup>+</sup> can cause excessive heating and eventual destruction. The maximum output current is approximately 40 mA independent of the magnitude of V<sup>+</sup>. At values of supply voltage in excess of +15 V<sub>DC</sub>, 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<sup>+</sup> 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 reestablish when the input voltage, which was negative, again returns to a value greater than -0.3 V<sub>DC</sub>.
- These specifications apply for V<sup>+</sup> = +15 V<sub>DC</sub> and -55°C ≤ T<sub>A</sub> ≤ +125°C, unless otherwise stated. With the LM224/LM224A, all temperature specifications are limited to -25°C ≤ T<sub>A</sub> ≤ +85°C, the LM324/LM324A temperature specifications are limited to 0°C ≤ T<sub>A</sub> ≤ +170°C, and the LM2902 specifications are limited to -40°C ≤ T<sub>A</sub> ≤ +85°C.
- V<sub>O</sub> = 1.4 V<sub>DC</sub>, R<sub>S</sub> = 0Ω with V<sup>+</sup> from 5 V<sub>DC</sub> to 30 V<sub>DC</sub>, and over the full common-mode range (0 V<sub>DC</sub> to V<sup>+</sup> - 1.5 V<sub>DC</sub>).
- 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<sup>+</sup> - 1.5V, but either or both inputs can go to +32 V<sub>DC</sub> without damage (±26 V<sub>DC</sub> 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.

## TYPICAL PERFORMANCE CHARACTERISTICS

