

# LM2902, LM324/LM324A, LM224/ LM224A

## Quad Operational Amplifier

### Features

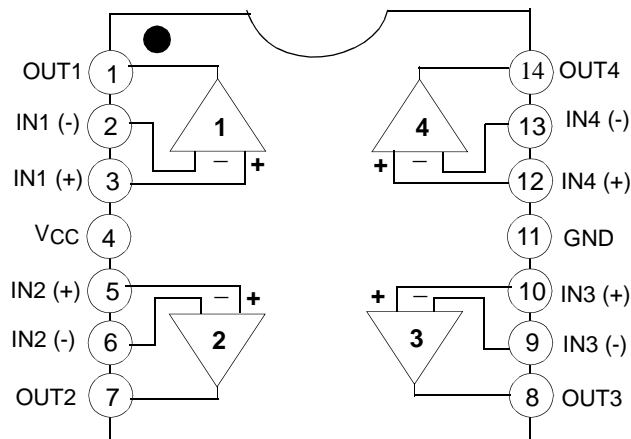
- Internally Frequency Compensated for Unity Gain
- Large DC Voltage Gain: 100dB
- Wide Power Supply Range:  
LM224/LM224A, LM324/LM324A : 3V~32V (or  $\pm 1.5 \sim 16V$ )  
LM2902: 3V~26V (or  $\pm 1.5V \sim 13V$ )
- Input Common Mode Voltage Range Includes Ground
- Large Output Voltage Swing: 0V to  $V_{CC} - 1.5V$
- Power Drain Suitable for Battery Operation

### Description

The LM324/LM324A, LM2902, LM224/LM224A consist of four independent, high gain, internally frequency compensated operational amplifiers which were designed specifically to operate from a single power supply over a wide voltage range. operation from split power supplies is also possible so long as the difference between the two supplies is 3 volts to 32 volts. Application areas include transducer amplifier, DC gain blocks and all the conventional OP Amp circuits which now can be easily implemented in single power supply systems.

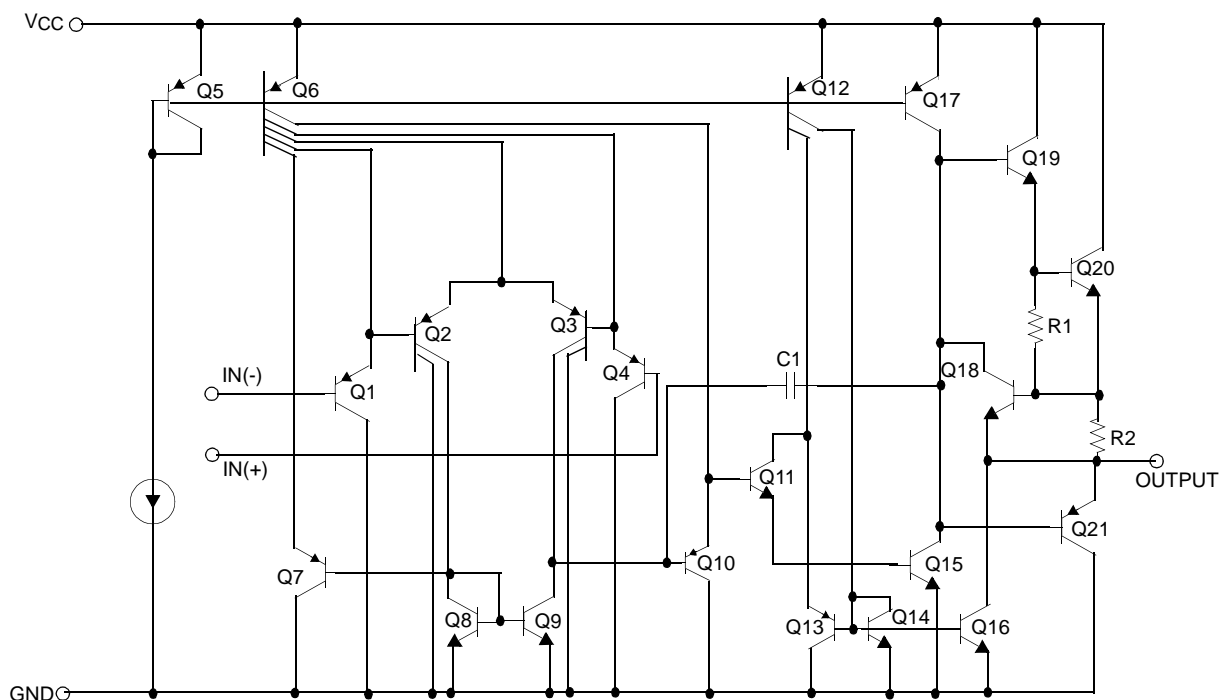


### Internal Block Diagram



## Schematic Diagram

(One Section Only)



## Absolute Maximum Ratings

| Parameter  | Symbol   | LM224/LM224A | LM324/LM324A | LM2902      | Unit |
|--|----------|--------------|--------------|-------------|------|
| Power Supply Voltage                                     | VCC      | ±16 or 32    | ±16 or 32    | ±13 or 26   | V    |
| Differential Input Voltage                               | VI(DIFF) | 32           | 32           | 26          | V    |
| Input Voltage  | VI       | -0.3 to +32  | -0.3 to +32  | -0.3 to +26 | V    |
| Output Short Circuit to GND<br>Vcc≤15V, TA=25°C(one Amp) | -        | Continuous   | Continuous   | Continuous  | -    |
| Power Dissipation, TA=25°C<br>14-DIP<br>14-SOP           | PD       | 1310<br>640  | 1310<br>640  | 1310<br>640 | mW   |
| Operating Temperature Range                              | TOPR     | -25 ~ +85    | 0 ~ +70      | -40 ~ +85   | °C   |
| Storage Temperature Range                                | TSTG     | -65 ~ +150   | -65 ~ +150   | -65 ~ +150  | °C   |

## Thermal Data

| Parameter  | Symbol | Value     | Unit |
|--|--------|-----------|------|
| Thermal Resistance Junction-Ambient Max.<br>14-DIP<br>14-SOP | Rθja   | 95<br>195 | °C/W |

## Electrical Characteristics

( $V_{CC} = 5.0V$ ,  $V_{EE} = GND$ ,  $T_A = 25^\circ C$ , unless otherwise specified)

| Parameter                       | Symbol        | Conditions  | LM224             |      |                | LM324 |                |          | LM2902 |      |                | Unit     |   |
|---------------------------------|---------------|---|-------------------|------|----------------|-------|----------------|----------|--------|------|----------------|----------|---|
|                                 |               |   | Min.              | Typ. | Max.           | Min.  | Typ.           | Max.     | Min.   | Typ. | Max.           |          |   |
| Input Offset Voltage            | $V_{IO}$      | $V_{CM} = 0V$ to $V_{CC} - 1.5V$<br>$V_{O(P)} = 1.4V$ , $R_S = 0\Omega$ (Note1) | -                 | 1.5  | 5.0            | -     | 1.5            | 7.0      | -      | 1.5  | 7.0            | mV       |   |
| Input Offset Current            | $I_{IO}$      | $V_{CM} = 0V$   | -                 | 2.0  | 30             | -     | 3.0            | 50       | -      | 3.0  | 50             | nA       |   |
| Input Bias Current              | $I_{BIAS}$    | $V_{CM} = 0V$   | -                 | 40   | 150            | -     | 40             | 250      | -      | 40   | 250            | nA       |   |
| Input Common-Mode Voltage Range | $V_{I(R)}$    | Note1   | 0                 | -    | $V_{CC} - 1.5$ | 0     | $V_{CC} - 1.5$ | -        | 0      | -    | $V_{CC} - 1.5$ | V        |   |
| Supply Current                  | $I_{CC}$      | $R_L = \infty$ , $V_{CC} = 30V$<br>(LM2902, $V_{CC} = 26V$ )                    | -                 | 1.0  | 3              | -     | 1.0            | 3        | -      | 1.0  | 3              | mA       |   |
|                                 |               | $R_L = \infty$ , $V_{CC} = 5V$  | -                 | 0.7  | 1.2            | -     | 0.7            | 1.2      | -      | 0.7  | 1.2            | mA       |   |
| Large Signal Voltage Gain       | $G_V$         | $V_{CC} = 15V$ , $R_L = 2k\Omega$<br>$V_{O(P)} = 1V$ to $11V$                   | 50                | 100  | -              | 25    | 100            | -        | 25     | 100  | -              | V/<br>mV |   |
| Output Voltage Swing            | $V_{O(H)}$    | Note1   | $R_L = 2k\Omega$  | 26   | -              | -     | 26             | -        | -      | 22   | -              | -        | V |
|                                 |               |   | $R_L = 10k\Omega$ | 27   | 28             | -     | 27             | 28       | -      | 23   | 24             | -        | V |
|                                 | $V_{O(L)}$    | $V_{CC} = 5V$ , $R_L = 10k\Omega$   | -                 | 5    | 20             | -     | 5              | 20       | -      | 5    | 100            | mV       |   |
| Common-Mode Rejection Ratio     | CMRR          | -   | 70                | 85   | -              | 65    | 75             | -        | 50     | 75   | -              | dB       |   |
| Power Supply Rejection Ratio    | PSRR          | -   | 65                | 100  | -              | 65    | 100            | -        | 50     | 100  | -              | dB       |   |
| Channel Separation              | CS            | $f = 1kHz$ to $20kHz$<br>(Note2)  | -                 | 120  | -              | -     | 120            | -        | -      | 120  | -              | dB       |   |
| Short Circuit to GND            | $I_{SC}$      | $V_{CC} = 15V$  | -                 | 40   | 60             | -     | 40             | 60       | -      | 40   | 60             | mA       |   |
| Output Current                  | $I_{SOURCE}$  | $V_{I(+)} = 1V$ , $V_{I(-)} = 0V$<br>$V_{CC} = 15V$<br>$V_{O(P)} = 2V$          | 20                | 40   | -              | 20    | 40             | -        | 20     | 40   | -              | mA       |   |
|                                 | $I_{SINK}$    | $V_{I(+)} = 0V$ , $V_{I(-)} = 1V$<br>$V_{CC} = 15V$<br>$V_{O(P)} = 2V$          | 10                | 13   | -              | 10    | 13             | -        | 10     | 13   | -              | mA       |   |
|                                 |               | $V_{I(+)} = 0V$ , $V_{I(-)} = 1V$<br>$V_{CC} = 5V$ , $V_{O(R)} = 200mV$         | 12                | 45   | -              | 12    | 45             | -        | -      | -    | -              | $\mu A$  |   |
| Differential Input Voltage      | $V_{I(DIFF)}$ | -   | -                 | -    | $V_{CC}$       | -     | -              | $V_{CC}$ | -      | -    | $V_{CC}$       | V        |   |

### Note :

- $V_{CC} = 30V$  for LM224 and LM324,  $V_{CC} = 26V$  for LM2902
- This parameter, although guaranteed, is not 100% tested in production.

**Electrical Characteristics** (Continued)

(VCC = 5.0V, VEE = GND, unless otherwise specified)

The following specifications apply over the range of  $-25^{\circ}\text{C} \leq T_A \leq +85^{\circ}\text{C}$  for the LM224; and the  $0^{\circ}\text{C} \leq T_A \leq +70^{\circ}\text{C}$  for the LM324; and the  $-40^{\circ}\text{C} \leq T_A \leq +85^{\circ}\text{C}$  for the LM2902

| Parameter                       | Symbol               | Conditions   | LM224                 |      |                      | LM324 |      |                      | LM2902 |      |                      | Unit  |   |
|---------------------------------|----------------------|--|-----------------------|------|----------------------|-------|------|----------------------|--------|------|----------------------|-------|---|
|                                 |                      |  | Min.                  | Typ. | Max.                 | Min.  | Typ. | Max.                 | Min.   | Typ. | Max.                 |       |   |
| Input Offset Voltage            | V <sub>IO</sub>      | V <sub>ICM</sub> = 0V to V <sub>CC</sub> -1.5V<br>V <sub>O(P)</sub> = 1.4V,<br>R <sub>S</sub> = 0Ω (Note1) | -                     | -    | 7.0                  | -     | -    | 9.0                  | -      | -    | 10.0                 | mV    |   |
| Input Offset Voltage Drift      | ΔV <sub>IO</sub> /ΔT | R <sub>S</sub> = 0Ω (Note2)  | -                     | 7.0  | -                    | -     | 7.0  | -                    | -      | 7.0  | -                    | μV/°C |   |
| Input Offset Current            | I <sub>IO</sub>      | V <sub>CM</sub> = 0V   | -                     | -    | 100                  | -     | -    | 150                  | -      | -    | 200                  | nA    |   |
| Input Offset Current Drift      | ΔI <sub>IO</sub> /ΔT | R <sub>S</sub> = 0Ω (Note2)  | -                     | 10   | -                    | -     | 10   | -                    | -      | 10   | -                    | pA/°C |   |
| Input Bias Current              | I <sub>BIAS</sub>    | V <sub>CM</sub> = 0V   | -                     | -    | 300                  | -     | -    | 500                  | -      | -    | 500                  | nA    |   |
| Input Common-Mode Voltage Range | V <sub>I(R)</sub>    | Note1  | 0                     | -    | V <sub>CC</sub> -2.0 | 0     | -    | V <sub>CC</sub> -2.0 | 0      | -    | V <sub>CC</sub> -2.0 | V     |   |
| Large Signal Voltage Gain       | G <sub>V</sub>       | V <sub>CC</sub> = 15V,<br>R <sub>L</sub> = 2.0kΩ<br>V <sub>O(P)</sub> = 1V to 11V                          | 25                    | -    | -                    | 15    | -    | -                    | 15     | -    | -                    | V/mV  |   |
| Output Voltage Swing            | V <sub>O(H)</sub>    | Note1  | R <sub>L</sub> = 2kΩ  | 26   | -                    | -     | 26   | -                    | -      | 22   | -                    | -     | V |
|                                 |                      |  | R <sub>L</sub> = 10kΩ | 27   | 28                   | -     | 27   | 28                   | -      | 23   | 24                   | -     | V |
|                                 | V <sub>O(L)</sub>    | V <sub>CC</sub> = 5V,<br>R <sub>L</sub> = 10kΩ   | -                     | 5    | 20                   | -     | 5    | 20                   | -      | 5    | 100                  | mV    |   |
| Output Current                  | I <sub>SOURCE</sub>  | V <sub>I(+)</sub> = 1V, V <sub>I(-)</sub> = 0V<br>V <sub>CC</sub> = 15V,<br>V <sub>O(P)</sub> = 2V         | 10                    | 20   | -                    | 10    | 20   | -                    | 10     | 20   | -                    | mA    |   |
|                                 | I <sub>SINK</sub>    | V <sub>I(+)</sub> = 0V,<br>V <sub>I(-)</sub> = 1V<br>V <sub>CC</sub> = 15V,<br>V <sub>O(P)</sub> = 2V      | 10                    | 13   | -                    | 5     | 8    | -                    | 5      | 8    | -                    | mA    |   |
| Differential Input Voltage      | V <sub>I(DIFF)</sub> | -  | -                     | -    | V <sub>CC</sub>      | -     | -    | V <sub>CC</sub>      | -      | -    | V <sub>CC</sub>      | V     |   |

**Note:**

- V<sub>CC</sub> = 30V for LM224 and LM324, V<sub>CC</sub> = 26V for LM2902
- These parameters, although guaranteed, are not 100% tested in production.

**Electrical Characteristics** (Continued)

(VCC = 5.0V, VEE = GND, TA = 25°C, unless otherwise specified)

| Parameter                       | Symbol               | Conditions  | LM224A                |      |                      | LM324A |      |                      | Unit |   |
|---------------------------------|----------------------|---|-----------------------|------|----------------------|--------|------|----------------------|------|---|
|                                 |                      |   | Min.                  | Typ. | Max.                 | Min.   | Typ. | Max.                 |      |   |
| Input Offset Voltage            | V <sub>IO</sub>      | V <sub>CM</sub> = 0V to V <sub>CC</sub> -1.5V<br>V <sub>O(P)</sub> = 1.4V, R <sub>S</sub> = 0Ω<br>(Note1) | -                     | 1.0  | 3.0                  | -      | 1.5  | 3.0                  | mV   |   |
| Input Offset Current            | I <sub>IO</sub>      | V <sub>CM</sub> = 0V  | -                     | 2    | 15                   | -      | 3.0  | 30                   | nA   |   |
| Input Bias Current              | I <sub>BIAS</sub>    | V <sub>CM</sub> = 0V  | -                     | 40   | 80                   | -      | 40   | 100                  | nA   |   |
| Input Common-Mode Voltage Range | V <sub>I(R)</sub>    | V <sub>CC</sub> = 30V   | 0                     | -    | V <sub>CC</sub> -1.5 | 0      | -    | V <sub>CC</sub> -1.5 | V    |   |
| Supply Current                  | I <sub>CC</sub>      | V <sub>CC</sub> = 30V, R <sub>L</sub> = ∞   | -                     | 1.5  | 3                    | -      | 1.5  | 3                    | mA   |   |
|                                 |                      | V <sub>CC</sub> = 5V, R <sub>L</sub> = ∞  | -                     | 0.7  | 1.2                  | -      | 0.7  | 1.2                  | mA   |   |
| Large Signal Voltage Gain       | G <sub>V</sub>       | V <sub>CC</sub> = 15V, R <sub>L</sub> = 2kΩ<br>V <sub>O(P)</sub> = 1V to 11V                              | 50                    | 100  | -                    | 25     | 100  | -                    | V/mV |   |
| Output Voltage Swing            | V <sub>O(H)</sub>    | Note1   | R <sub>L</sub> = 2kΩ  | 26   | -                    | -      | 26   | -                    | -    | V |
|                                 |                      |   | R <sub>L</sub> = 10kΩ | 27   | 28                   | -      | 27   | 28                   | -    | V |
|                                 | V <sub>O(L)</sub>    | V <sub>CC</sub> = 5V, R <sub>L</sub> = 10kΩ   | -                     | 5    | 20                   | -      | 5    | 20                   | mV   |   |
| Common-Mode Rejection Ratio     | CMRR                 | -   | 70                    | 85   | -                    | 65     | 85   | -                    | dB   |   |
| Power Supply Rejection Ratio    | PSRR                 | -   | 65                    | 100  | -                    | 65     | 100  | -                    | dB   |   |
| Channel Separation              | CS                   | f = 1kHz to 20kHz<br>(Note2)  | -                     | 120  | -                    | -      | 120  | -                    | dB   |   |
| Short Circuit to GND            | I <sub>SC</sub>      | V <sub>CC</sub> = 15V   | -                     | 40   | 60                   | -      | 40   | 60                   | mA   |   |
| Output Current                  | I <sub>SOURCE</sub>  | V <sub>I(+)</sub> = 1V, V <sub>I(-)</sub> = 0V<br>V <sub>CC</sub> = 15V, V <sub>O(P)</sub> = 2V           | 20                    | 40   | -                    | 20     | 40   | -                    | mA   |   |
|                                 |                      | V <sub>I(+)</sub> = 0V, V <sub>I(-)</sub> = 1V<br>V <sub>CC</sub> = 15V, V <sub>O(P)</sub> = 2V           | 10                    | 20   | -                    | 10     | 20   | -                    | mA   |   |
|                                 | I <sub>SINK</sub>    | V <sub>I(+)</sub> = 0V, V <sub>I(-)</sub> = 1V<br>V <sub>CC</sub> = 5V<br>V <sub>O(P)</sub> = 200mV       | 12                    | 50   | -                    | 12     | 50   | -                    | μA   |   |
| Differential Input Voltage      | V <sub>I(DIFF)</sub> | -   | -                     | -    | V <sub>CC</sub>      | -      | -    | V <sub>CC</sub>      | V    |   |

**Note:**

- V<sub>CC</sub> = 30V for LM224A, LM324A
- This parameter, although guaranteed, is not 100% tested in production.

**Electrical Characteristics** (Continued)

(VCC = 5.0V, VEE = GND, unless otherwise specified)

The following specification apply over the range of  $-25^{\circ}\text{C} \leq T_A \leq +85^{\circ}\text{C}$  for the LM224A; and the  $0^{\circ}\text{C} \leq T_A \leq +70^{\circ}\text{C}$  for the LM324A

| Parameter                       | Symbol               | Conditions  | LM224A                |      |                         | LM324A |      |                         | Unit  |   |
|---------------------------------|----------------------|---|-----------------------|------|-------------------------|--------|------|-------------------------|-------|---|
|                                 |                      |   | Min.                  | Typ. | Max.                    | Min.   | Typ. | Max.                    |       |   |
| Input Offset Voltage            | V <sub>IO</sub>      | V <sub>CM</sub> = 0V to V <sub>CC</sub> -1.5V<br>V <sub>O(P)</sub> = 1.4V, R <sub>S</sub> = 0Ω<br>(Note1) | -                     | -    | 4.0                     | -      | -    | 5.0                     | mV    |   |
| Input Offset Voltage Drift      | ΔV <sub>IO</sub> /ΔT | R <sub>S</sub> = 0Ω (Note2)   | -                     | 7.0  | 20                      | -      | 7.0  | 30                      | μV/°C |   |
| Input Offset Current            | I <sub>IO</sub>      | V <sub>CM</sub> = 0V  | -                     | -    | 30                      | -      | -    | 75                      | nA    |   |
| Input Offset Current Drift      | ΔI <sub>IO</sub> /ΔT | R <sub>S</sub> = 0Ω (Note2)   | -                     | 10   | 200                     | -      | 10   | 300                     | pA/°C |   |
| Input Bias Current              | I <sub>BIAS</sub>    | -   | -                     | 40   | 100                     | -      | 40   | 200                     | nA    |   |
| Input Common-Mode Voltage Range | V <sub>I(R)</sub>    | Note1   | 0                     | -    | V <sub>CC</sub><br>-2.0 | 0      | -    | V <sub>CC</sub><br>-2.0 | V     |   |
| Large Signal Voltage Gain       | G <sub>V</sub>       | V <sub>CC</sub> = 15V, R <sub>L</sub> = 2.0kΩ   | 25                    | -    | -                       | 15     | -    | -                       | V/mV  |   |
| Output Voltage Swing            | V <sub>O(H)</sub>    | Note1   | R <sub>L</sub> = 2kΩ  | 26   | -                       | -      | 26   | -                       | -     | V |
|                                 |                      |   | R <sub>L</sub> = 10kΩ | 27   | 28                      | -      | 27   | 28                      | -     | V |
|                                 | V <sub>O(L)</sub>    | V <sub>CC</sub> = 5V, R <sub>L</sub> = 10kΩ   | -                     | 5    | 20                      | -      | 5    | 20                      | mV    |   |
| Output Current                  | I <sub>SOURCE</sub>  | V <sub>I(+)</sub> = 1V, V <sub>I(-)</sub> = 0V<br>V <sub>CC</sub> = 15V, V <sub>O(P)</sub> = 2V           | 10                    | 20   | -                       | 10     | 20   | -                       | mA    |   |
|                                 | I <sub>SINK</sub>    | V <sub>I(+)</sub> = 0V, V <sub>I(-)</sub> = 1V<br>V <sub>CC</sub> = 15V, V <sub>O(P)</sub> = 2V           | 5                     | 8    | -                       | 5      | 8    | -                       | mA    |   |
| Differential Input Voltage      | V <sub>I(DIFF)</sub> | -   | -                     | -    | V <sub>CC</sub>         | -      | -    | V <sub>CC</sub>         | V     |   |

**Note:**

1. V<sub>CC</sub> = 30V for LM224A and LM324A.
2. These parameters, although guaranteed, are not 100% tested in production.

## Typical Performance Characteristics

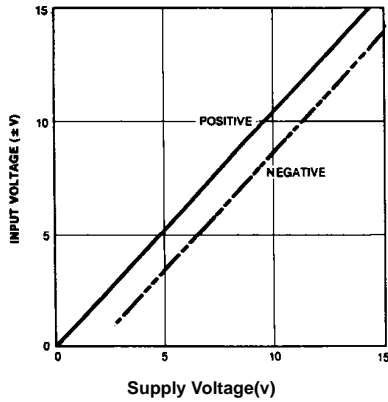


Figure 1. Input Voltage Range vs Supply Voltage

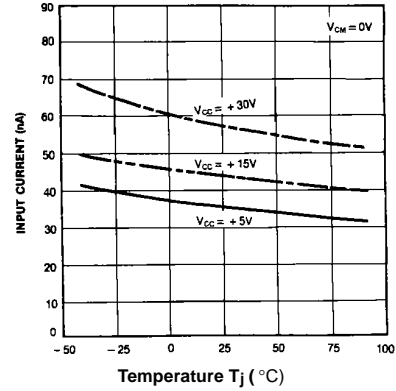


Figure 2. Input Current vs Temperature

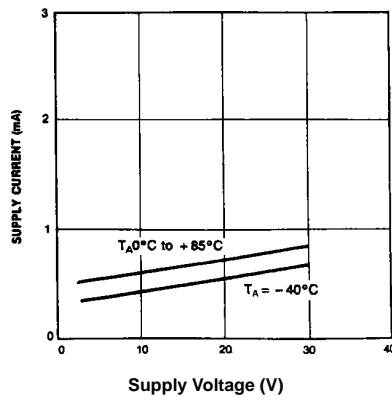


Figure 3. Supply Current vs Supply Voltage

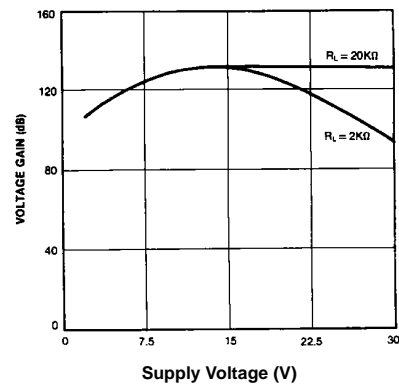


Figure 4. Voltage Gain vs Supply Voltage

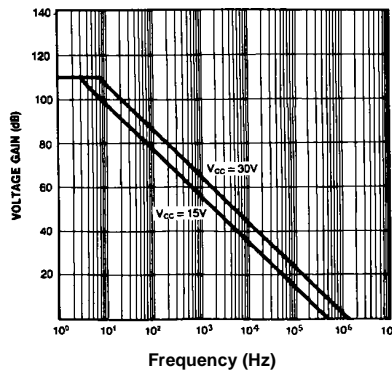


Figure 5. Open Loop Frequency Response

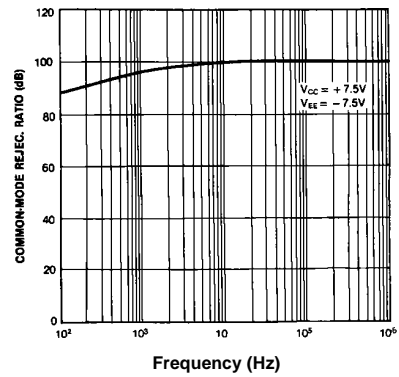


Figure 6. Common mode Rejection Ratio

## Typical Performance Characteristics (Continued)

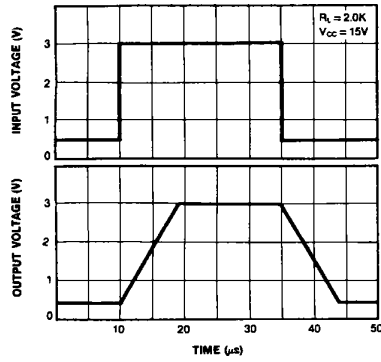


Figure 7. Voltage Follower Pulse Response

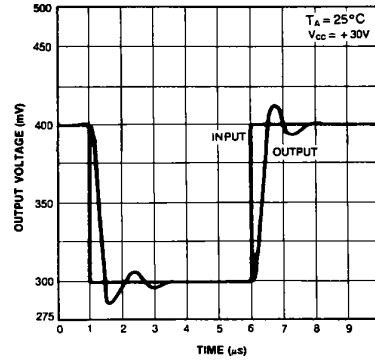


Figure 8. Voltage Follower Pulse Response (Small Signal)

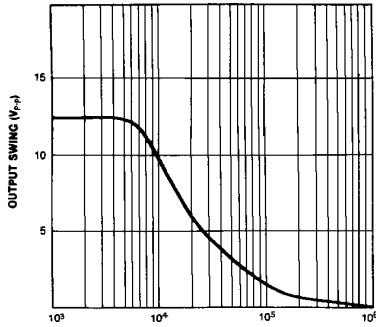


Figure 8. Large Signal Frequency Response

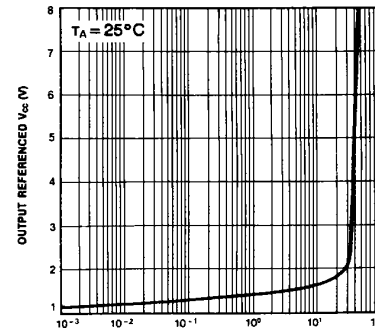


Figure 9. Output Characteristics vs Current Sourcing

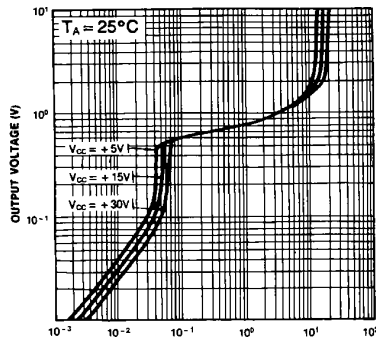


Figure 10. Output Characteristics vs Current Sinking

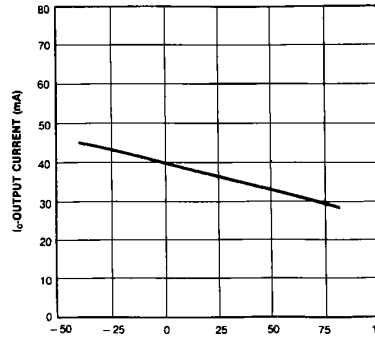


Figure 11. Current Limiting vs Temperature

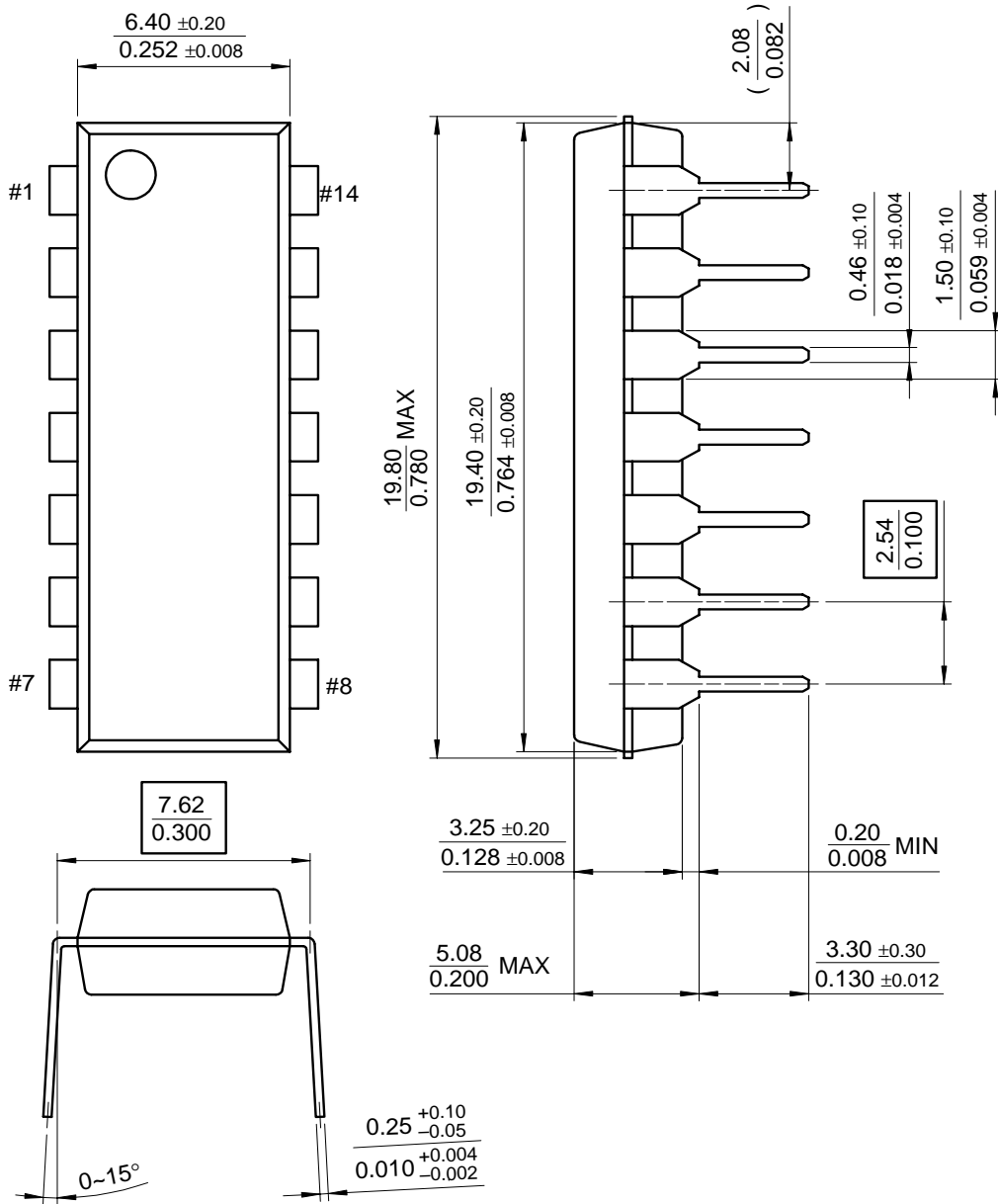


# Mechanical Dimensions

## Package

Dimensions in millimeters

### 14-DIP

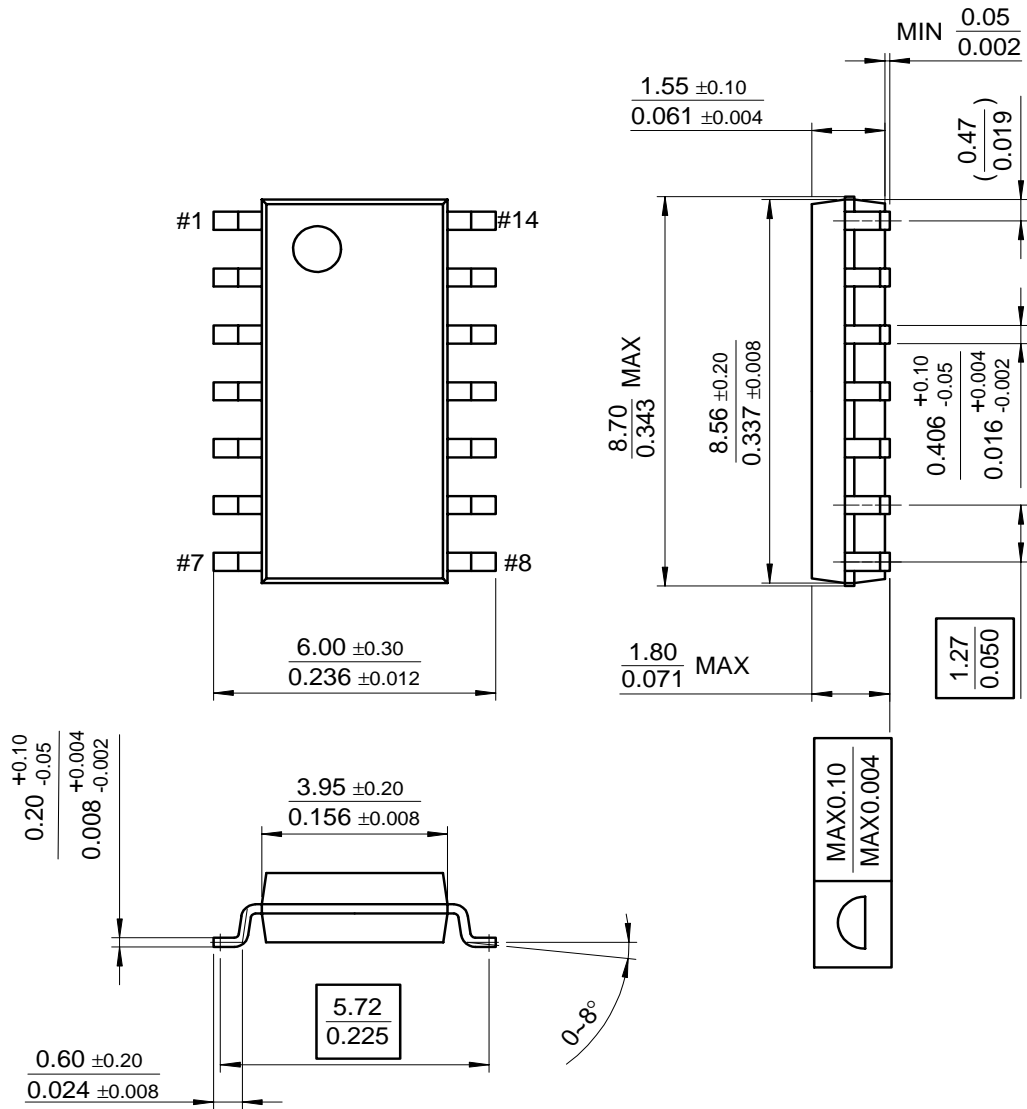


# Mechanical Dimensions (Continued)

## Package

Dimensions in millimeters

### 14-SOP



## Ordering Information

| Product Number | Package | Operating Temperature |
|----------------|---------|-----------------------|
| LM324N         | 14-DIP  | 0 ~ +70°C             |
| LM324AN        |         |                       |
| LM324M         | 14-SOP  |                       |
| LM324AM        |         |                       |
| LM2902N        | 14-DIP  | -40 ~ +85°C           |
| LM2902M        | 14-SOP  |                       |
| LM224N         | 14-DIP  | -25 ~ +85°C           |
| LM224AN        |         |                       |
| LM224M         | 14-SOP  |                       |
| LM224AM        |         |                       |

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FAIRCHILD'S PRODUCTS ARE NOT AUTHORIZED FOR USE AS CRITICAL COMPONENTS IN LIFE SUPPORT DEVICES OR SYSTEMS WITHOUT THE EXPRESS WRITTEN APPROVAL OF THE PRESIDENT OF FAIRCHILD SEMICONDUCTOR CORPORATION. As used herein:

1. Life support devices or systems are devices or systems which, (a) are intended for surgical implant into the body, or (b) support or sustain life, and (c) whose failure to perform when properly used in accordance with instructions for use provided in the labeling, can be reasonably expected to result in a significant injury of the user.
2. A critical component in any component of a life support device or system whose failure to perform can be reasonably expected to cause the failure of the life support device or system, or to affect its safety or effectiveness.