

## Description

The LM2902/LM2904 series amplifiers consist of four and two independent high-gain operational amplifiers with very low input offset voltage specification. They have been designed to operate from a single power supply over a wide range of voltages; however operation from split power supplies is also possible. They offer low power supply current independent of the magnitude of the power supply voltage.

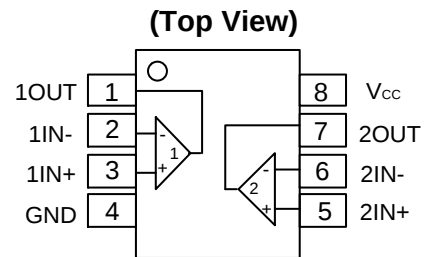
The LM2902/LM2904 series are characterized for operation from -40°C to +125°C and the dual devices are available in SO-8, MSOP-8, TSSOP-8 and the quad devices available in SO-14 and TSSOP-14 with industry standard pin-outs. Both use green mold compound as standard.

## Features

- Wide Power Supply Voltage Range:
  - Single Supply: 3V to 36V
  - Dual Supplies:  $\pm 1.5V$  to  $\pm 18V$
- Very Low Supply Current Drain
  - LM2904 500 $\mu A$  – Independent of Supply Voltage
  - LM2902 700 $\mu A$  – Independent of Supply Voltage
- Low Input Bias Current: 20nA
- Low Input Offset Voltage:
  - A Version: 1mV Typ
  - Non-A Version: 2mV Typ
- Large DC Voltage Gain: 100dB
- Wide Bandwidth (Unity Gain): 700kHz (Temperature Compensated)
- Internally Compensated with Unity Gain
- Input Common-Mode Voltage Range Includes Ground
- Differential Input Voltage Range Equal to the Power Supply Voltage
- Large Output Voltage Swing: 0V to  $V_{CC} - 1.5V$
- SO-8, MSOP-8, TSSOP-8 (DUALS) and SO-14, TSSOP-14 (QUADS) Packages Available
- **Totally Lead-Free & Fully RoHS Compliant (Notes 1 & 2)**
- **Halogen and Antimony Free. "Green" Device (Note 3)**
- **An Automotive-Compliant Part is Available Under Separate Datasheet ([LM2902Q](#) [LM2904Q](#))**

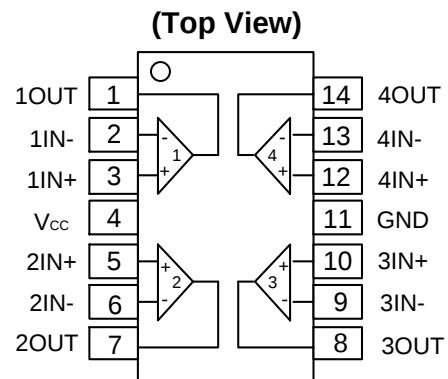
- Notes:
1. No purposely added lead. Fully EU Directive 2002/95/EC (RoHS), 2011/65/EU (RoHS 2) & 2015/863/EU (RoHS 3) compliant.
  2. See <https://www.diodes.com/quality/lead-free/> for more information about Diodes Incorporated's definitions of Halogen- and Antimony-free, "Green" and Lead-free.
  3. Halogen- and Antimony-free "Green" products are defined as those which contain <900ppm bromine, <900ppm chlorine (<1500ppm total Br + Cl) and <1000ppm antimony compounds.

## Pin Assignments



**SO-8/TSSOP-8/MSOP-8**

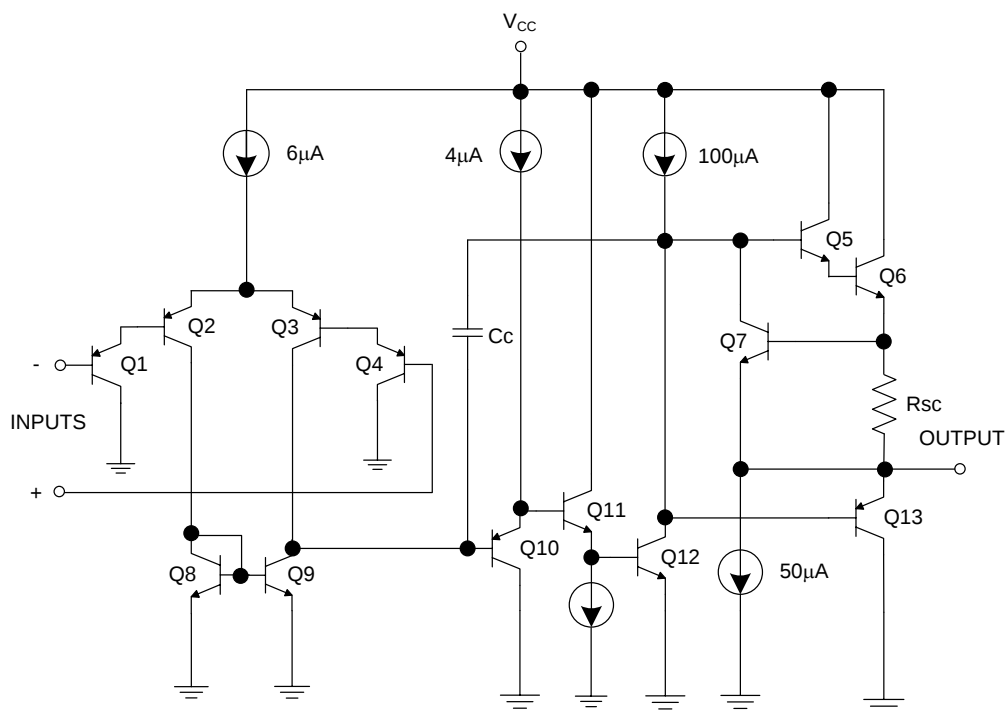
LM2904/LM2904A



**SO-14/TSSOP-14**

LM2902/LM2902A

## Functional Block Diagram



Each Amplifier

## Pin Descriptions

| LM2902, LM2902A |            |                               |
|-----------------|------------|-------------------------------|
| Pin Name        | Pin Number | Function                      |
| 1OUT            | 1          | Channel 1 Output              |
| 1IN-            | 2          | Channel 1 Inverting Input     |
| 1IN+            | 3          | Channel 1 Non-Inverting Input |
| V <sub>CC</sub> | 4          | Chip Supply Voltage           |
| 2IN+            | 5          | Channel 2 Non-Inverting Input |
| 2IN-            | 6          | Channel 2 Inverting Input     |
| 2OUT            | 7          | Channel 2 Output              |
| 3OUT            | 8          | Channel 3 Output              |
| 3IN-            | 9          | Channel 3 Inverting Input     |
| 3IN+            | 10         | Channel 3 Non-Inverting Input |
| GND             | 11         | Ground                        |
| 4IN+            | 12         | Channel 4 Non-Inverting Input |
| 4IN-            | 13         | Channel 4 Inverting Input     |
| 4OUT            | 14         | Channel 4 Output              |
| LM2904, LM2904A |            |                               |
| 1OUT            | 1          | Channel 1 Output              |
| 1IN-            | 2          | Channel 1 Inverting Input     |
| 1IN+            | 3          | Channel 1 Non-Inverting Input |
| GND             | 4          | Ground                        |
| 2IN+            | 5          | Channel 2 Non-Inverting Input |
| 2IN-            | 6          | Channel 2 Inverting Input     |
| 2OUT            | 7          | Channel 2 Output              |
| V <sub>CC</sub> | 8          | Chip Supply Voltage           |

**Absolute Maximum Ratings** (Note 4) (@T<sub>A</sub> = +25°C, unless otherwise specified.)

| Symbol          | Parameter                                               |                                                  | Rating      | Unit |
|-----------------|---------------------------------------------------------|--------------------------------------------------|-------------|------|
| V <sub>CC</sub> | Supply Voltage                                          |                                                  | ±18 or 36   | V    |
| V <sub>ID</sub> | Differential Input Voltage                              |                                                  | 36          | V    |
| V <sub>IN</sub> | Input Voltage                                           |                                                  | -0.3 to +36 | V    |
| θ <sub>JA</sub> | Package Thermal Impedance<br>(Note 5)                   | SO-8                                             | TBD         | °C/W |
|                 |                                                         | MSOP-8                                           | TBD         |      |
|                 |                                                         | TSSOP-8                                          | TBD         |      |
|                 |                                                         | SO-14                                            | TBD         |      |
|                 |                                                         | TSSOP-14                                         | TBD         |      |
| θ <sub>JC</sub> | Package Thermal Impedance<br>(Note 6)                   | SO-8                                             | TBD         | °C/W |
|                 |                                                         | MSOP-8                                           | TBD         |      |
|                 |                                                         | TSSOP-8                                          | TBD         |      |
|                 |                                                         | SO-14                                            | TBD         |      |
|                 |                                                         | TSSOP-14                                         | TBD         |      |
| —               | Output Short-Circuit to GND<br>(One Amplifier) (Note 7) | V <sub>CC</sub> ≤ 15V and T <sub>A</sub> = +25°C | Continuous  | —    |
| T <sub>A</sub>  | Operating Temperature Range                             |                                                  | -40 to +125 | °C   |
| T <sub>J</sub>  | Operating Junction Temperature                          |                                                  | +150        | °C   |
| T <sub>ST</sub> | Storage Temperature Range                               |                                                  | -65 to +150 | °C   |
| ESD             | Human Body Mode ESD Protection (Note 8)                 |                                                  | 300         | V    |
|                 | Machine Mode ESD Protection                             |                                                  | 150         |      |

- Notes:
- Stresses beyond those listed under absolute maximum ratings may cause permanent damage to the device. These are stress ratings only; functional operation of the device at these or any other conditions beyond those indicated under recommended operating conditions is not implied. Exposure to absolute-maximum-rated conditions for extended periods may affect device reliability.
  - Maximum power dissipation is a function of T<sub>J(max)</sub>, θ<sub>JA</sub>, and T<sub>A</sub>. The maximum allowable power dissipation at any allowable ambient temperature is P<sub>D</sub> = (T<sub>J(max)</sub> - T<sub>A</sub>)/θ<sub>JA</sub>. Operating at the absolute maximum T<sub>J</sub> of +150°C can affect reliability.
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  - Short circuits from outputs to V<sub>CC</sub> or ground can cause excessive heating and eventual destruction.
  - Human body model, 1.5kΩ in series with 100pF.

**Electrical Characteristics** (Notes 12 & 13) (@  $V_{CC} = +5.0V$ ,  $T_A = +25^\circ C$ , unless otherwise specified.)

| LM2902, LM2902A          |                                        |                                                                                                      |                                                              |                     |                     |                |          |                  |
|--------------------------|----------------------------------------|------------------------------------------------------------------------------------------------------|--------------------------------------------------------------|---------------------|---------------------|----------------|----------|------------------|
| Parameter                |                                        | Conditions                                                                                           |                                                              | $T_A$               | Min                 | Typ            | Max      | Unit             |
| $V_{IO}$                 | Input Offset Voltage                   | $V_{IC} = V_{CMR} \text{ Min,}$<br>$V_O = 1.4V,$<br>$V_{CC} = 5V \text{ to Max,}$<br>$R_S = 0\Omega$ | Non-A Device                                                 | $T_A = +25^\circ C$ | —                   | 2              | 7        | mV               |
|                          |                                        |                                                                                                      |                                                              | Full Range          | —                   | —              | 10       |                  |
|                          |                                        | A-Suffix Device                                                                                      |                                                              | $T_A = +25^\circ C$ | —                   | 1              | 2        |                  |
|                          |                                        |                                                                                                      |                                                              | Full Range          | —                   | —              | 4        |                  |
| $\Delta V_{IO}/\Delta T$ | Input Offset Voltage Temperature Drift | $R_S = 0\Omega$                                                                                      |                                                              | Full Range          | —                   | 7              | —        | $\mu V/^\circ C$ |
| $I_B$                    | Input Bias Current                     | $I_{IN+}$ or $I_{IN-}$ with OUT in Linear Range,<br>$V_{CMR} = 0V$ (Note 9)                          |                                                              | $T_A = +25^\circ C$ | —                   | -20            | -200     | nA               |
|                          |                                        |                                                                                                      |                                                              | Full Range          | —                   | —              | -500     |                  |
| $I_{IO}$                 | Input Offset Current                   | $I_{IN+} - I_{IN-}, V_{CM} = 0V$                                                                     |                                                              | $T_A = +25^\circ C$ | —                   | 2              | 50       | nA               |
|                          |                                        |                                                                                                      |                                                              | Full Range          | —                   | —              | 150      |                  |
| $\Delta I_{IO}/\Delta T$ | Input Offset Current Temperature Drift | —                                                                                                    |                                                              | Full Range          | —                   | 10             | —        | $pA/^\circ C$    |
| $V_{CMR}$                | Input Common-Mode Voltage Range        | $V_{CC} = 30V$ (Note 10)                                                                             |                                                              | $T_A = +25^\circ C$ | 0 to $V_{CC} - 1.5$ | —              | —        | V                |
|                          |                                        |                                                                                                      |                                                              | Full Range          | 0 to $V_{CC} - 2.0$ | —              | —        |                  |
| $I_{CC}$                 | Supply Current (Four Amplifiers)       | $V_O = 0.5V_{CC}$ , No Load                                                                          | $V_{CC} = 30V$                                               | Full Range          | —                   | 1.0            | 3.0      | mA               |
|                          |                                        | $V_O = 0.5V_{CC}$ , No Load                                                                          | $V_{CC} = 5V$                                                | Full Range          | —                   | 0.7            | 1.2      |                  |
| $A_V$                    | Voltage Gain                           | $V_{CC} = 15V, V_{OUT} = 1V \text{ to } 11V,$<br>$R_L \geq 2k\Omega$                                 |                                                              | $T_A = +25^\circ C$ | 25                  | 100            | —        | V/mV             |
|                          |                                        |                                                                                                      |                                                              | Full Range          | 15                  | —              | —        |                  |
| CMRR                     | Common Mode Rejection Ratio            | DC, $V_{CMR} = 0V \text{ to } V_{CC} - 1.5V$                                                         |                                                              | $T_A = +25^\circ C$ | 60                  | 70             | —        | dB               |
| PSRR                     | Power Supply Rejection Ratio           | $V_{CC} = 5V \text{ to } 30V$                                                                        |                                                              | $T_A = +25^\circ C$ | 70                  | 100            | —        | dB               |
| —                        | Amplifier to Amplifier Coupling        | $f = 1kHz \text{ to } 20kHz$ (Input Referred)<br>(Note 11)                                           |                                                              | $T_A = +25^\circ C$ | —                   | -120           | —        | dB               |
| $I_{SINK}$               | Output Current                         | Sink                                                                                                 | $V_{IN+} = 1V, V_{IN-} = 0V, V_{CC} = 15V,$<br>$V_O = 200mV$ | $T_A = +25^\circ C$ | 12                  | 50             | —        | $\mu A$          |
|                          |                                        |                                                                                                      | $V_{IN+} = 1V, V_{IN-} = 0V, V_{CC} = 15V,$<br>$V_O = 15V$   | $T_A = +25^\circ C$ | 10                  | 20             | —        | mA               |
|                          |                                        | Source                                                                                               | $V_{IN+} = 1V, V_{IN-} = 0V, V_{CC} = 15V,$<br>$V_O = 0V$    | $T_A = +25^\circ C$ | -20                 | -40            | -60      |                  |
|                          |                                        |                                                                                                      |                                                              | Full Range          | -10                 | —              | —        |                  |
| $I_{SC}$                 | Short-Circuit to Ground                | $V_{CC} = 5V, GND = -5V, V_O = 0V$                                                                   |                                                              | $T_A = +25^\circ C$ | —                   | $\pm 40$       | $\pm 60$ | mA               |
| $V_{OH}$                 | High-Level Output Voltage Swing        | $R_L = 10k\Omega$                                                                                    |                                                              | $T_A = +25^\circ C$ | —                   | $V_{CC} - 1.5$ | —        | V                |
|                          |                                        | $V_{CC} = 30V$                                                                                       | $R_L = 2k\Omega$                                             | Full Range          | 26                  | —              | —        |                  |
|                          |                                        |                                                                                                      | $R_L \geq 10k\Omega$                                         |                     | 27                  | 28             | —        |                  |
| $V_{OL}$                 | Low-Level Output Voltage Swing         | $R_L \leq 10k\Omega$                                                                                 |                                                              | Full Range          | —                   | 5              | 20       | mV               |

**AC Electrical Characteristics** (Notes 12 & 13) (@  $V_{CC} = \pm 15.0V$ ,  $T_A = +25^\circ C$ , unless otherwise specified.)

| LM2902, LM2902A |                                |                                             |     |                 |
|-----------------|--------------------------------|---------------------------------------------|-----|-----------------|
| Parameter       |                                | Conditions                                  | Typ | Unit            |
| SR              | Slew Rate at Unity Gain        | $R_L = 1M\Omega, C_L = 30pF, V_I = \pm 10V$ | 0.3 | V/ $\mu s$      |
| B1              | Unity Gain Bandwidth           | $R_L = 1M\Omega, C_L = 20pF$                | 0.7 | MHz             |
| Vn              | Equivalent Input Noise Voltage | $R_S = 100\Omega, V_I = 0V, f = 1kHz$       | 40  | nV/ $\sqrt{Hz}$ |

- Notes:
- 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 of either input signal voltage should not be allowed to go negative by more than 0.3V (@  $+25^\circ C$ ). The upper end of the common-mode voltage range is  $V_{CC} - 1.5V$  (@  $+25^\circ C$ ), but either or both inputs can go to +36V without damage, independent of the magnitude of  $V_{CC}$ .
  - 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 capacitance increases at higher frequencies.
  - Typical values are all at  $T_A = +25^\circ C$  conditions and represent the most likely parametric norm as determined at the time of characterization. Actual typical values may vary over time and will also depend on the application and configuration. The typical values are not tested and are not guaranteed on shipped production material.
  - All limits are guaranteed by testing or statistical analysis. Limits over the full temperature are guaranteed by design, but not tested in production.

**Electrical Characteristics** (Cont.) (Notes 12 & 13) (@  $V_{CC} = +5.0V$ ,  $T_A = +25^\circ C$ , unless otherwise specified.)

| LM2904, LM2904A          |                                        |                                                                                      |                                                                     |                     |                     |          |          |                  |
|--------------------------|----------------------------------------|--------------------------------------------------------------------------------------|---------------------------------------------------------------------|---------------------|---------------------|----------|----------|------------------|
| Parameter                |                                        | Conditions                                                                           |                                                                     | $T_A$               | Min                 | Typ      | Max      | Unit             |
| $V_{IO}$                 | Input Offset Voltage                   | $V_{IC} = V_{CMR}$ Min,<br>$V_O = 1.4V$ ,<br>$V_{CC} = 5V$ to Max<br>$R_S = 0\Omega$ | Non-A Device                                                        | $T_A = +25^\circ C$ | —                   | 2        | 7        | mV               |
|                          |                                        |                                                                                      |                                                                     | Full Range          | —                   | —        | 10       |                  |
|                          |                                        | A-Suffix Device                                                                      |                                                                     | $T_A = +25^\circ C$ | —                   | 1        | 2        |                  |
|                          |                                        |                                                                                      |                                                                     | Full Range          | —                   | —        | 4        |                  |
| $\Delta V_{IO}/\Delta T$ | Input Offset Voltage Temperature Drift | $R_S = 0\Omega$                                                                      |                                                                     | Full Range          | —                   | 7        | —        | $\mu V/^\circ C$ |
| $I_B$                    | Input Bias Current                     | $I_{IN+}$ or $I_{IN-}$ with OUT in Linear Range,<br>$V_{CMR} = 0V$ (Note 9)          |                                                                     | $T_A = +25^\circ C$ | —                   | -20      | -250     | nA               |
|                          |                                        |                                                                                      |                                                                     | Full Range          | —                   | —        | -500     |                  |
| $I_{IO}$                 | Input Offset Current                   | $I_{IN+} - I_{IN-}$ , $V_{CM} = 0V$                                                  |                                                                     | $T_A = +25^\circ C$ | —                   | 2        | 50       | nA               |
|                          |                                        |                                                                                      |                                                                     | Full Range          | —                   | —        | 150      |                  |
| $\Delta I_{IO}/\Delta T$ | Input Offset Current Temperature Drift | —                                                                                    |                                                                     | Full Range          | —                   | 10       | —        | $pA/^\circ C$    |
| $V_{CMR}$                | Input Common-Mode Voltage Range        | $V_{CC} = 30V$ (Note 10)                                                             |                                                                     | $T_A = +25^\circ C$ | 0 to $V_{CC} - 1.5$ | —        | —        | V                |
|                          |                                        |                                                                                      |                                                                     | Full Range          | 0 to $V_{CC} - 2.0$ | —        | —        |                  |
| $I_{CC}$                 | Supply Current (Two Amplifiers)        | $V_O = 0.5V_{CC}$ , No Load                                                          | $V_{CC} = 30V$                                                      | Full Range          | —                   | 0.7      | 2.0      | mA               |
|                          |                                        | $V_O = 0.5V_{CC}$ , No Load                                                          | $V_{CC} = 5V$                                                       | Full Range          | —                   | 0.5      | 1.2      |                  |
| $A_V$                    | Voltage Gain                           | $V_{CC} = 15V$ , $V_{OUT} = 1V$ to $11V$ ,<br>$R_L \geq 2k\Omega$                    |                                                                     | $T_A = +25^\circ C$ | 25                  | 100      | —        | V/mV             |
|                          |                                        |                                                                                      |                                                                     | Full Range          | 15                  | —        | —        |                  |
| CMRR                     | Common Mode Rejection Ratio            | DC, $V_{CMR} = 0V$ to $V_{CC} - 1.5V$                                                |                                                                     | $T_A = +25^\circ C$ | 60                  | 70       | —        | dB               |
| PSRR                     | Power Supply Rejection Ratio           | $V_{CC} = 5V$ to $30V$                                                               |                                                                     | $T_A = +25^\circ C$ | 70                  | 100      | —        | dB               |
| —                        | Amplifier to Amplifier Coupling        | $f = 1kHz$ to $20kHz$ (Note 11)                                                      |                                                                     | $T_A = +25^\circ C$ | —                   | 120      | —        | dB               |
| $I_{SINK}$               | Output Current                         | Sink                                                                                 | $V_{IN-} = 1V$ , $V_{IN+} = 0V$ , $V_{CC} = 15V$ ,<br>$V_O = 200mV$ | $T_A = +25^\circ C$ | 12                  | 50       | —        | $\mu A$          |
|                          |                                        |                                                                                      | $V_{IN-} = 1V$ , $V_{IN+} = 0V$ , $V_{CC} = 15V$ , $V_O = 15V$      | $T_A = +25^\circ C$ | 10                  | 20       | —        | mA               |
|                          |                                        | Source                                                                               | $V_{IN+} = 1V$ , $V_{IN-} = 0V$ , $V_{CC} = 15V$ , $V_O = 0V$       | $T_A = +25^\circ C$ | -20                 | -40      | -60      |                  |
|                          |                                        |                                                                                      |                                                                     | Full Range          | -10                 | —        | —        |                  |
| $I_{SC}$                 | Short-Circuit to Ground                | $V_{CC} = 5V$ , GND = $-5V$ , $V_O = 0V$                                             |                                                                     | $T_A = +25^\circ C$ | —                   | $\pm 40$ | $\pm 60$ | mA               |
| $V_{OH}$                 | High-Level Output Voltage Swing        | $R_L = 10k\Omega$                                                                    |                                                                     | $T_A = +25^\circ C$ | $V_{CC} - 1.5$      | —        | —        | V                |
|                          |                                        | $V_{CC} = 30V$                                                                       | $R_L = 2k\Omega$                                                    | Full Range          | 26                  | —        | —        |                  |
|                          |                                        |                                                                                      | $R_L \geq 10k\Omega$                                                |                     | 27                  | 28       | —        |                  |
| $V_{OL}$                 | Low-Level Output Voltage Swing         | $R_L \leq 10k\Omega$                                                                 |                                                                     | Full Range          | —                   | 5        | 20       | mV               |

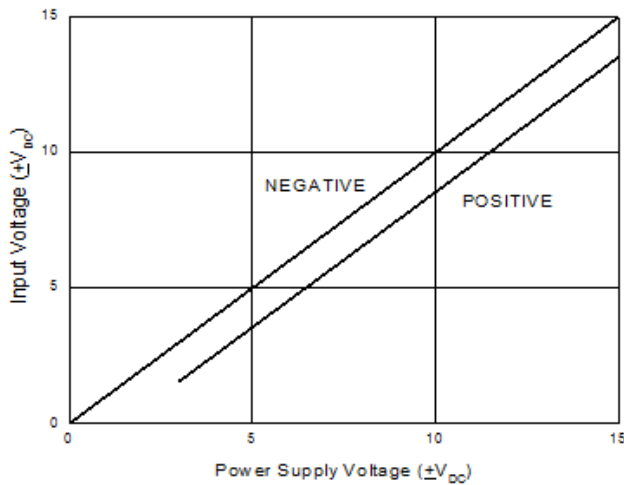
**AC Electrical Characteristics** (Notes 12 & 13) (@  $V_{CC} = \pm 15.0V$ ,  $T_A = +25^\circ C$ , unless otherwise specified.)

| LM2904, LM2904A |                                |                                                   |     |                 |
|-----------------|--------------------------------|---------------------------------------------------|-----|-----------------|
| Parameter       |                                | Conditions                                        | Typ | Unit            |
| SR              | Slew Rate at Unity Gain        | $R_L = 1M\Omega$ , $C_L = 30pF$ , $V_I = \pm 10V$ | 0.3 | V/ $\mu s$      |
| B1              | Unity Gain Bandwidth           | $R_L = 1M\Omega$ , $C_L = 20pF$                   | 0.7 | MHz             |
| Vn              | Equivalent Input Noise Voltage | $R_S = 100\Omega$ , $V_I = 0V$ , $f = 1kHz$       | 40  | nV/ $\sqrt{Hz}$ |

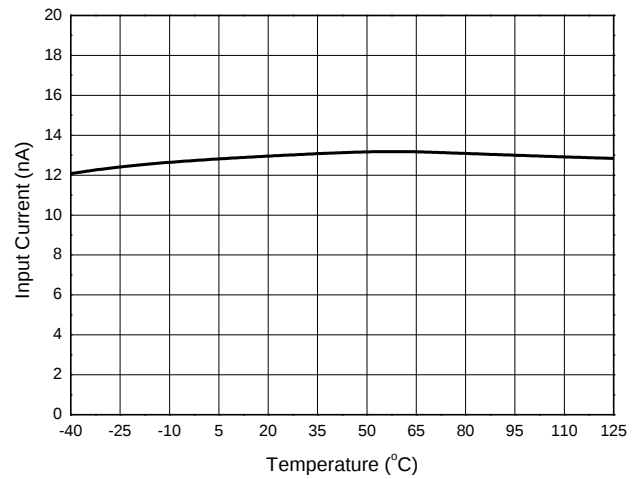
- Notes:
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  - The input common-mode voltage of either input signal voltage should not be allowed to go negative by more than 0.3V (@  $+25^\circ C$ ). The upper end of the common-mode voltage range is  $V_{CC} - 1.5V$  (@  $+25^\circ C$ ), but either or both inputs can go to +36V without damage, independent of the magnitude of  $V_{CC}$ .
  - 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 capacitance increases at higher frequencies.
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  - All limits are guaranteed by testing or statistical analysis. Limits over the full temperature are guaranteed by design, but not tested in production.

## Performance Characteristics

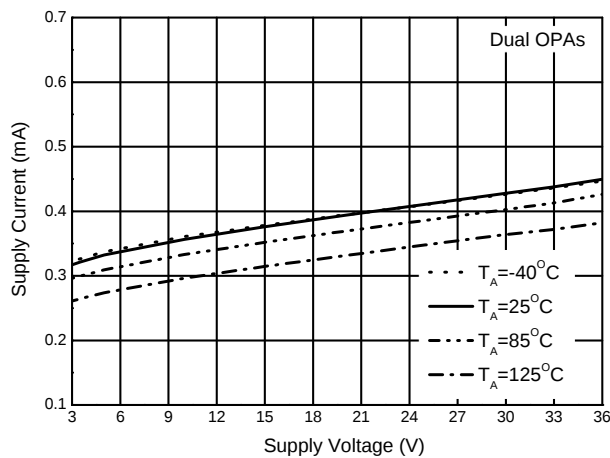
Input Voltage Range



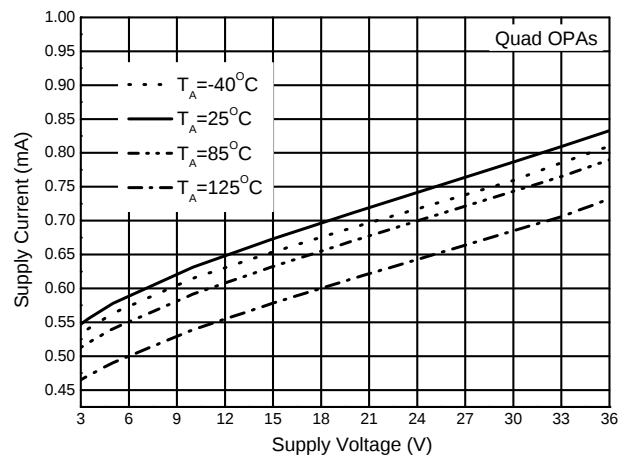
Input Current



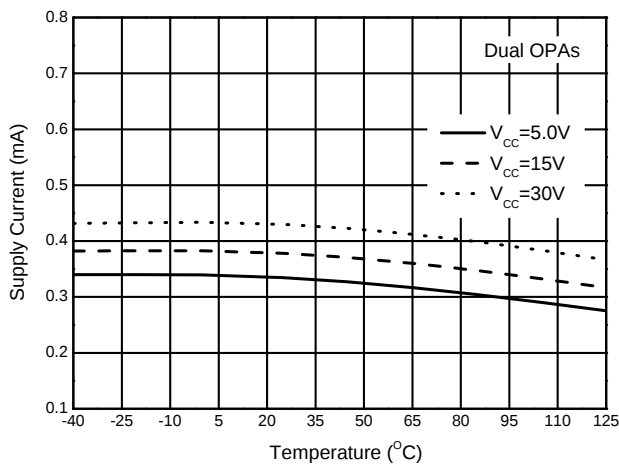
Supply Current vs. Supply Voltage (LM2904/LM2904A)



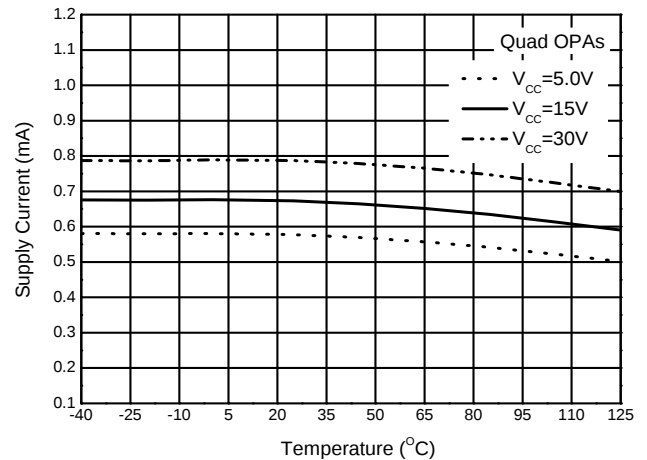
Supply Current vs. Supply Voltage (LM2902/LM2902A)



Supply Current vs. Temperature (LM2904/LM2904A)

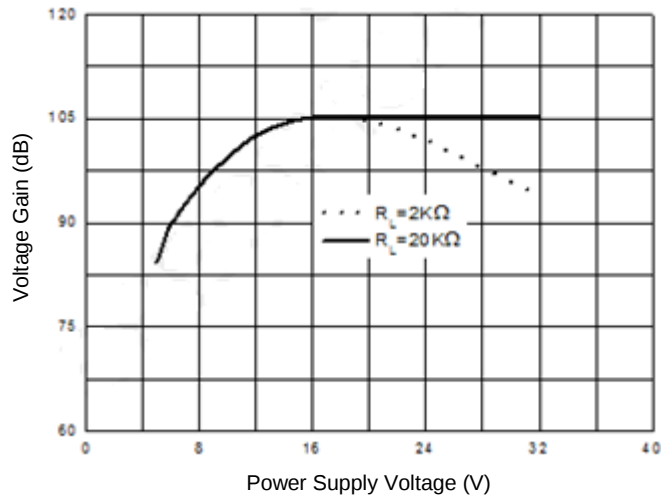


Supply Current vs. Temperature (LM2902/LM2902A)

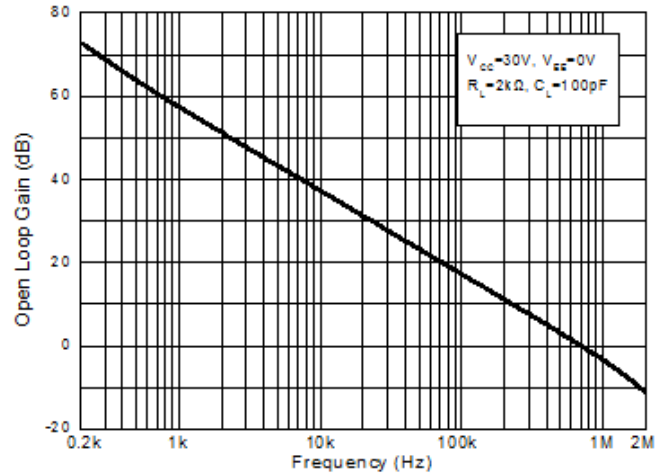


**Performance Characteristics (Cont.)**

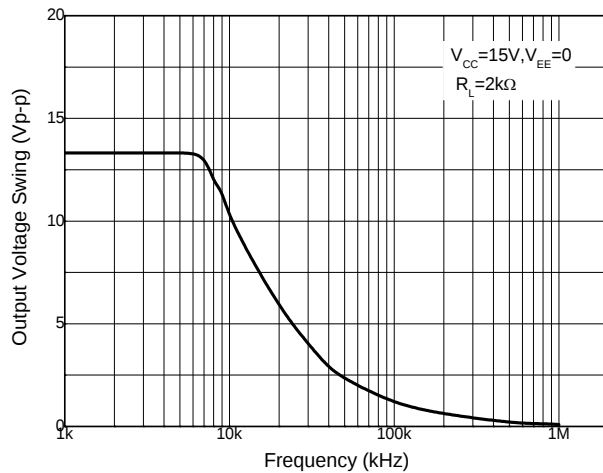
**Voltage Gain**



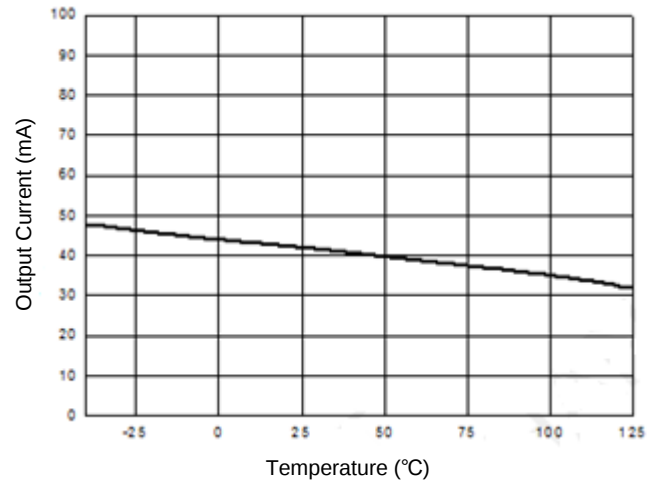
**Open Loop Frequency Response**



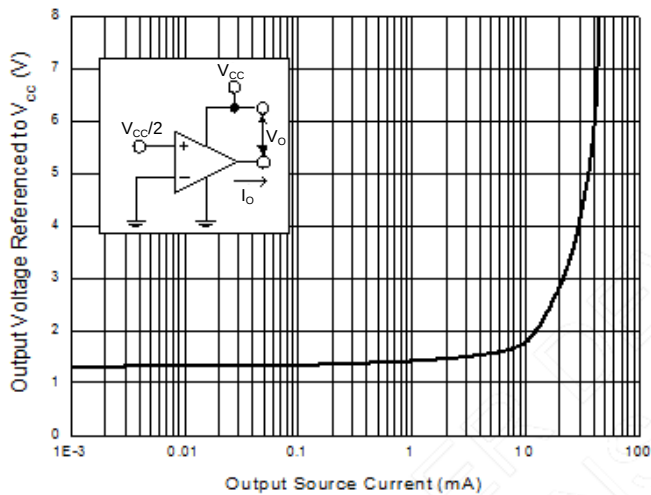
**Large Signal Frequency Response**



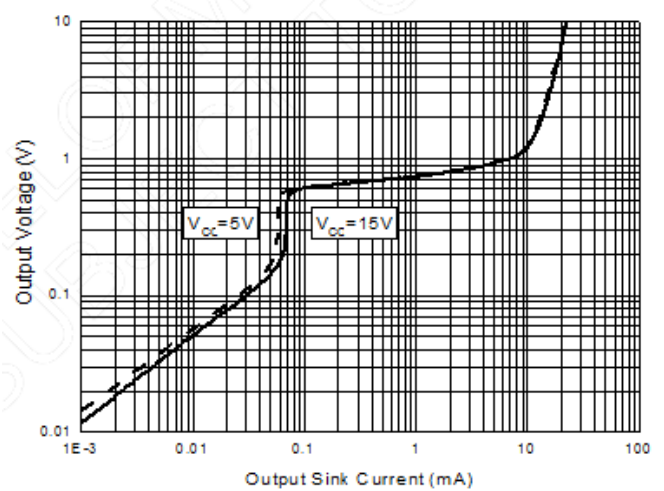
**Current Limit**



**Output Characteristics: Current Sourcing**

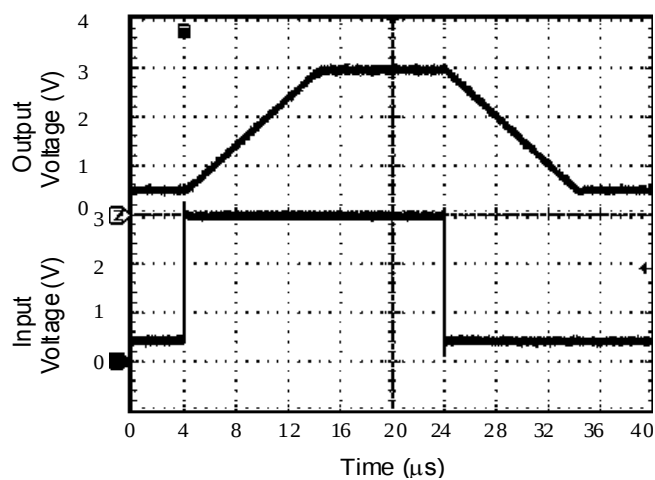


**Output Characteristics: Current Sinking**

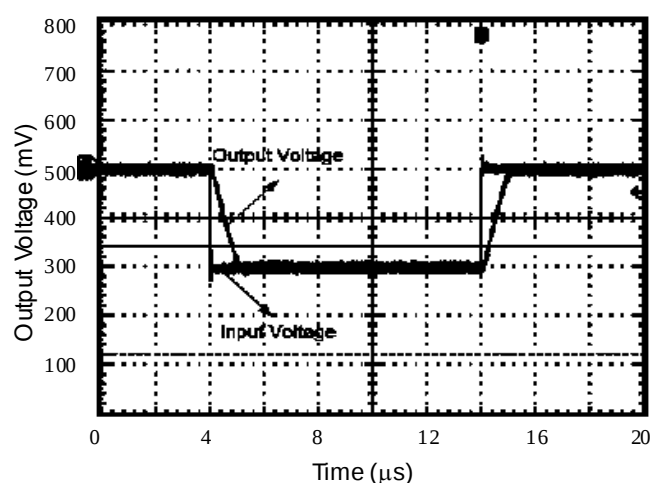


## Performance Characteristics (Cont.)

Voltage Follower Pulse Response



Voltage Follower Pulse Response (Small Signal)



## Application Information

### General Information

The LM2902/LM2904 series are op amps which operate with only a single power supply voltage, have true-differential inputs, and remain in the linear mode with an input common-mode voltage of  $0V_{DC}$ . These amplifiers operate over a wide range of power supply voltage with little change in performance characteristics. At  $+25^{\circ}\text{C}$  amplifier operation is possible down to a minimum supply voltage of  $2.3V_{DC}$ .

Precautions should be taken to insure that the power supply for the integrated circuit never becomes reversed in polarity or that the unit is not inadvertently installed backwards in a test socket as an unlimited current surge through the resulting forward diode within the IC could cause fusing of the internal conductors and result in a destroyed unit.

Large differential input voltages can be easily accommodated and, as input differential voltage protection diodes are not needed, no large input currents result from large differential input voltages. The differential input voltage may be larger than  $V^+$  without damaging the device. Protection should be provided to prevent the input voltages from going negative more than  $-0.3V_{DC}$  (@  $+25^{\circ}\text{C}$ ). An input clamp diode with a resistor to the IC input terminal can be used.

To reduce the power supply current drain, the amplifiers have a Class A output stage for small signal levels which converts to Class B in a large signal mode. These allow 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.

For AC applications, where the load is capacitive coupled to the output of the amplifier, a resistor should be used, from the output of the amplifier to ground to increase the Class A bias current and prevent crossover distortion. Where the load is directly coupled, as in DC applications, there is no crossover distortion.

Capacitive loads which are applied directly to the output of the amplifier reduce the loop stability margin. Values of 50pF can be accommodated using the worst-case non-inverting unity gain connection. Large closed loop gains or resistive isolation should be used if larger load capacitance must be driven by the amplifier.

The bias network of the LM2902/LM2904 series establishes a quiescent current which is independent of the magnitude of the power supply voltage over the range of  $3V_{DC}$  to  $30V_{DC}$ .

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 function temperatures. Putting direct short-circuits on more than one amplifier at a time will increase the total IC power dissipation 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  $+25^{\circ}\text{C}$  provides a larger output current capability at elevated temperatures (see Performance Characteristics) than a standard IC op amp.

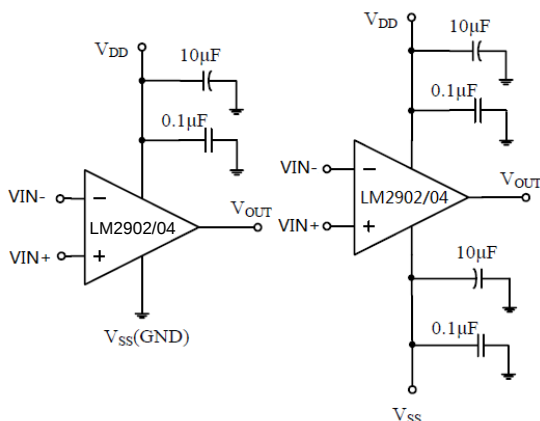
The circuits presented in the section on typical applications emphasize operation on only a single power supply voltage. If complementary power supplies are available, all of the standard op amp circuits can be used. In general, introducing a pseudo-ground (a bias voltage reference of  $V_{CC}/2$ ) will allow operation above and below this value in single power supply systems. Many application circuits are shown which take advantage of the wide input common-mode voltage range which includes ground. In most cases, input biasing is not required and input voltages which range to ground can easily be accommodated.

## Application Information (Cont.)

### Power Supply Bypassing and Layout

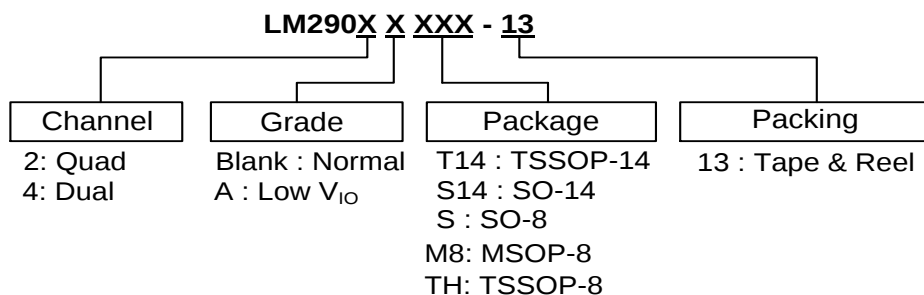
The LM2902/LM2904 operate both single supply voltage range 3V to 36V or dual supply voltage  $\pm 1.5V$  to  $\pm 18V$ .

As with any operation amplifier, proper supply bypassing is critical for low noise performance and high power supply rejection. For single supply operation system, a minimum  $0.1\mu F$  bypass capacitor should be recommended to place as close as possible between the  $V_{CC}$  Pin and GND. For dual supply operation, both the positive supply pin and negative supply pin should be bypassed to ground with a separate  $0.1\mu F$  ceramic capacitor.  $2.2\mu F$  tantalum capacitor can be added for better performance. Keep the length of leads and traces that connect capacitors between the LM2902/LM2904 power supply pin and ground as short as possible.



Amplifier with Bypass Capacitors

## Ordering Information (Note 14)

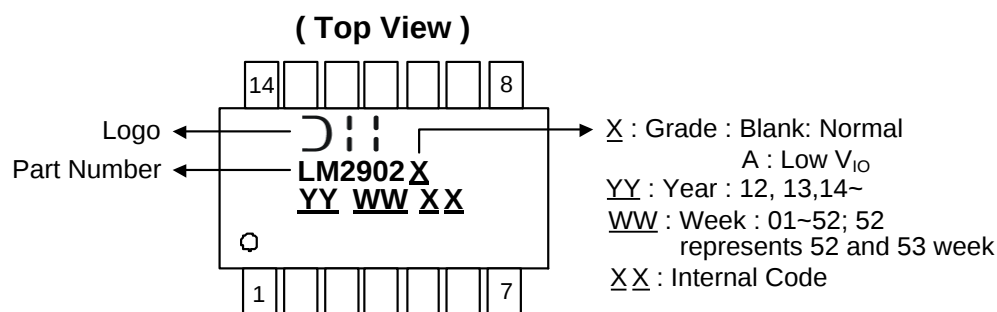


| Part Number   | Package Code | Packaging | 13" Tape and Reel |                    |
|---------------|--------------|-----------|-------------------|--------------------|
|               |              |           | Quantity          | Part Number Suffix |
| LM2902T14-13  | T14          | TSSOP-14  | 2,500/Tape & Reel | -13                |
| LM2902AT14-13 | T14          | TSSOP-14  | 2,500/Tape & Reel | -13                |
| LM2902S14-13  | S14          | SO-14     | 2,500/Tape & Reel | -13                |
| LM2902AS14-13 | S14          | SO-14     | 2,500/Tape & Reel | -13                |
| LM2904S-13    | S            | SO-8      | 2,500/Tape & Reel | -13                |
| LM2904AS-13   | S            | SO-8      | 2,500/Tape & Reel | -13                |
| LM2904AM8-13  | M8           | MSOP-8    | 2,500/Tape & Reel | -13                |
| LM2904M8-13   | M8           | MSOP-8    | 2,500/Tape & Reel | -13                |
| LM2904ATH-13  | TH           | TSSOP-8   | 2,500/Tape & Reel | -13                |
| LM2904TH-13   | TH           | TSSOP-8   | 2,500/Tape & Reel | -13                |

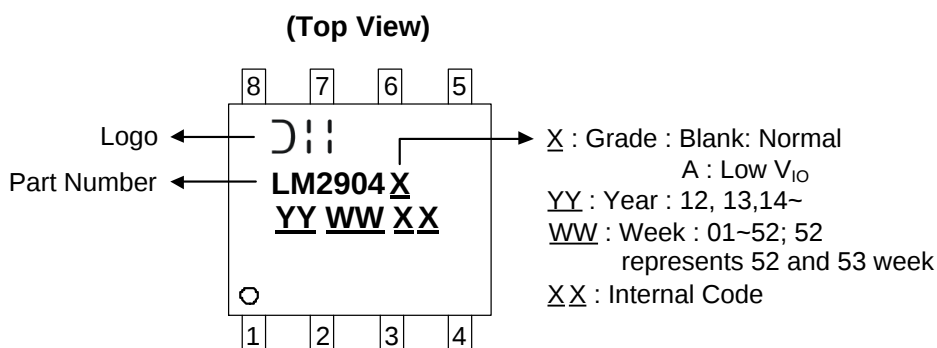
Note: 14. For packaging details, go to our website at <https://www.diodes.com/design/support/packaging/diodes-packaging/>.

## Marking Information

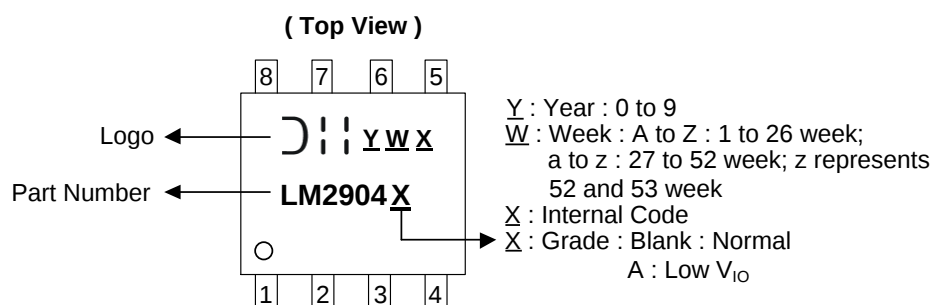
### (1) TSSOP-14 and SO-14



### (2) SO-8



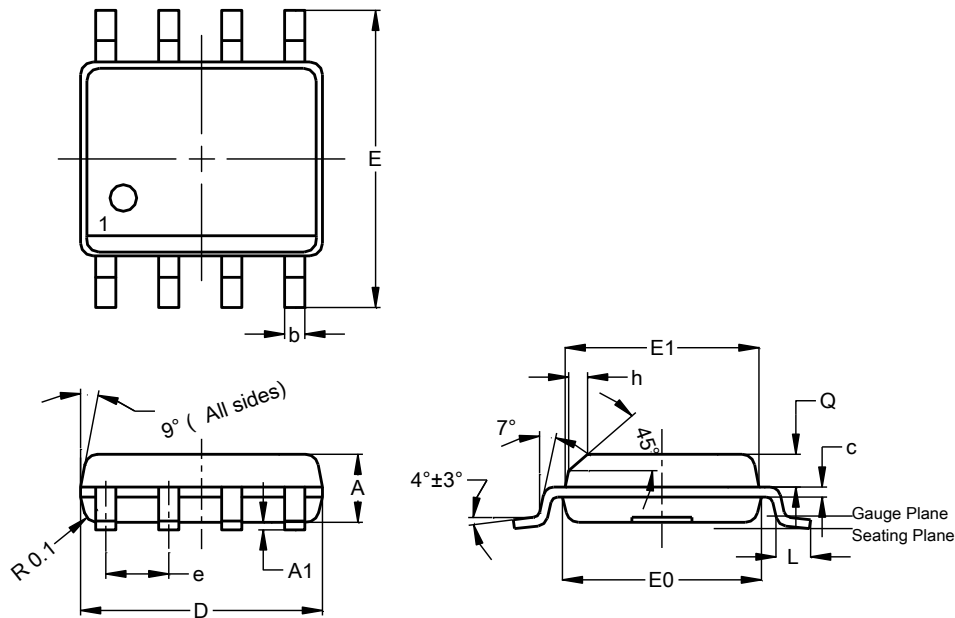
### (3) MSOP-8 and TSSOP-8



## Package Outline Dimensions

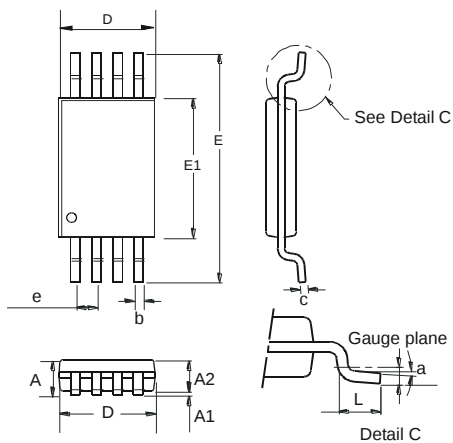
Please see <http://www.diodes.com/package-outlines.html> for the latest version.

### (1) Package Type: SO-8



| SO-8                 |      |      |      |
|----------------------|------|------|------|
| Dim                  | Min  | Max  | Typ  |
| A                    | 1.40 | 1.50 | 1.45 |
| A1                   | 0.10 | 0.20 | 0.15 |
| b                    | 0.30 | 0.50 | 0.40 |
| c                    | 0.15 | 0.25 | 0.20 |
| D                    | 4.85 | 4.95 | 4.90 |
| E                    | 5.90 | 6.10 | 6.00 |
| E1                   | 3.80 | 3.90 | 3.85 |
| E0                   | 3.85 | 3.95 | 3.90 |
| e                    | --   | --   | 1.27 |
| h                    | -    | --   | 0.35 |
| L                    | 0.62 | 0.82 | 0.72 |
| Q                    | 0.60 | 0.70 | 0.65 |
| All Dimensions in mm |      |      |      |

### (2) Package Type: TSSOP-8

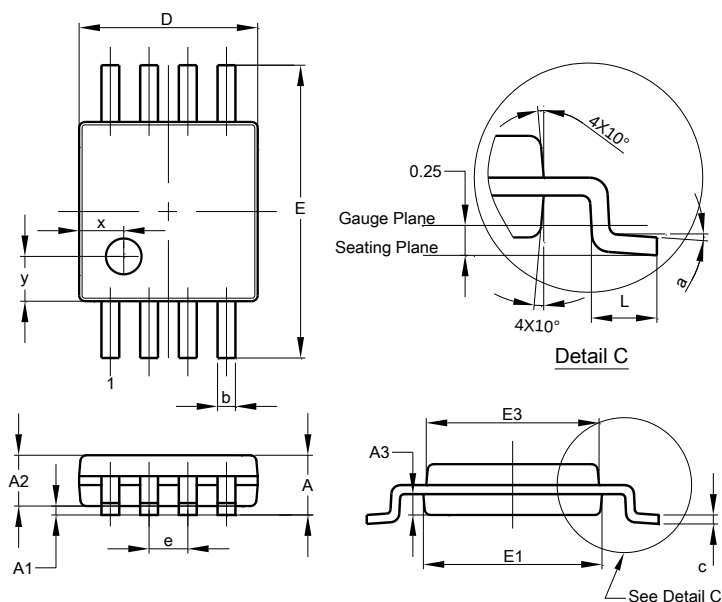


| TSSOP-8              |       |       |       |
|----------------------|-------|-------|-------|
| Dim                  | Min   | Max   | Typ   |
| a                    | 0.09  | —     | —     |
| A                    | —     | 1.20  | —     |
| A1                   | 0.05  | 0.15  | —     |
| A2                   | 0.825 | 1.025 | 0.925 |
| b                    | 0.19  | 0.30  | —     |
| c                    | 0.09  | 0.20  | —     |
| D                    | 2.90  | 3.10  | 3.025 |
| e                    | —     | —     | 0.65  |
| E                    | —     | —     | 6.40  |
| E1                   | 4.30  | 4.50  | 4.425 |
| L                    | 0.45  | 0.75  | 0.60  |
| All Dimensions in mm |       |       |       |

## Package Outline Dimensions (Cont.)

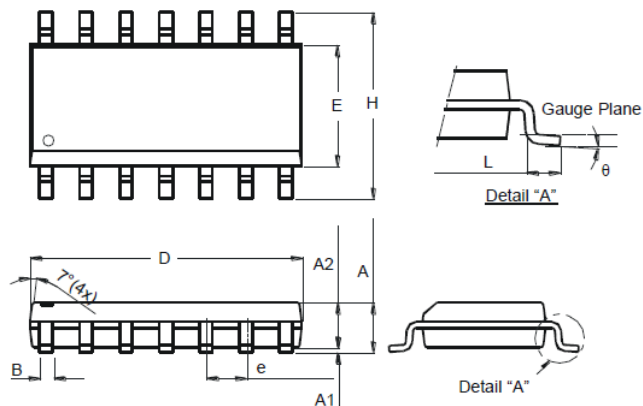
Please see <http://www.diodes.com/package-outlines.html> for the latest version.

### (3) Package Type: MSOP-8



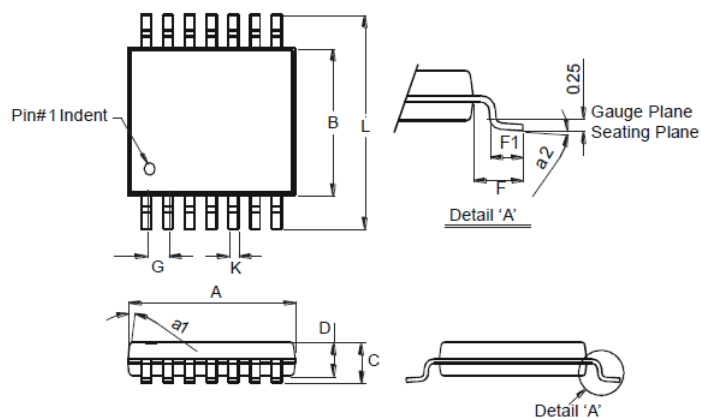
| MSOP-8               |      |      |       |
|----------------------|------|------|-------|
| Dim                  | Min  | Max  | Typ   |
| A                    | -    | 1.10 | -     |
| A1                   | 0.05 | 0.15 | 0.10  |
| A2                   | 0.75 | 0.95 | 0.86  |
| A3                   | 0.29 | 0.49 | 0.39  |
| b                    | 0.22 | 0.38 | 0.30  |
| c                    | 0.08 | 0.23 | 0.15  |
| D                    | 2.90 | 3.10 | 3.00  |
| E                    | 4.70 | 5.10 | 4.90  |
| E1                   | 2.90 | 3.10 | 3.00  |
| E3                   | 2.85 | 3.05 | 2.95  |
| e                    | -    | -    | 0.65  |
| L                    | 0.40 | 0.80 | 0.60  |
| a                    | 0°   | 8°   | 4°    |
| x                    | -    | -    | 0.750 |
| y                    | -    | -    | 0.750 |
| All Dimensions in mm |      |      |       |

### (4) Package Type: SO-14



| SO-14                |          |      |
|----------------------|----------|------|
| Dim                  | Min      | Max  |
| A                    | 1.47     | 1.73 |
| A1                   | 0.10     | 0.25 |
| A2                   | 1.45 Typ |      |
| B                    | 0.33     | 0.51 |
| D                    | 8.53     | 8.74 |
| E                    | 3.80     | 3.99 |
| e                    | 1.27 Typ |      |
| H                    | 5.80     | 6.20 |
| L                    | 0.38     | 1.27 |
| θ                    | 0°       | 8°   |
| All Dimensions in mm |          |      |

### (5) Package Type: TSSOP-14

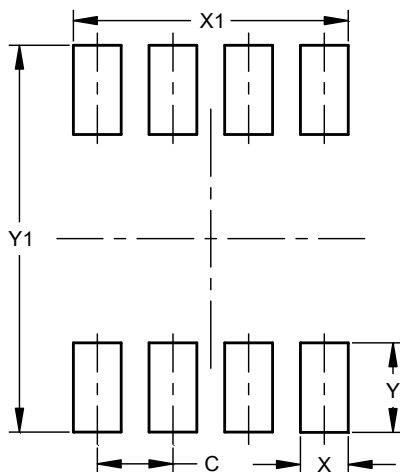


| TSSOP-14             |          |      |
|----------------------|----------|------|
| Dim                  | Min      | Max  |
| a1                   | 7° (4X)  |      |
| a2                   | 0°       | 8°   |
| A                    | 4.9      | 5.10 |
| B                    | 4.30     | 4.50 |
| C                    | -        | 1.2  |
| D                    | 0.8      | 1.05 |
| F                    | 1.00 Typ |      |
| F1                   | 0.45     | 0.75 |
| G                    | 0.65 Typ |      |
| K                    | 0.19     | 0.30 |
| L                    | 6.40 Typ |      |
| All Dimensions in mm |          |      |

## Suggested Pad Layout

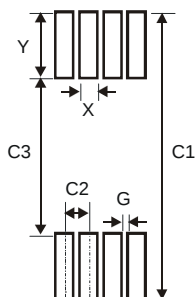
Please see <http://www.diodes.com/package-outlines.html> for the latest version.

### (1) Package Type: SO-8



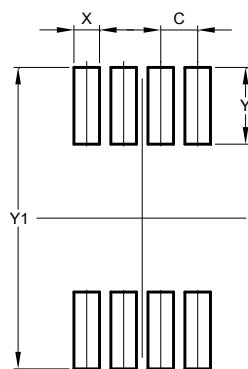
| Dimensions | Value (in mm) |
|------------|---------------|
| C          | 1.27          |
| X          | 0.802         |
| X1         | 4.612         |
| Y          | 1.505         |
| Y1         | 6.50          |

### (2) Package Type: TSSOP-8



| Dimensions | Value (in mm) |
|------------|---------------|
| X          | 0.45          |
| Y          | 1.78          |
| C1         | 7.72          |
| C2         | 0.65          |
| C3         | 4.16          |
| G          | 0.20          |

### (3) Package Type: MSOP-8

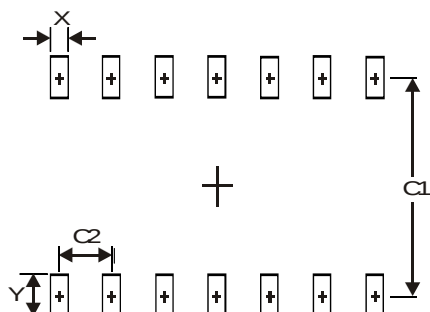


| Dimensions | Value (in mm) |
|------------|---------------|
| C          | 0.650         |
| X          | 0.450         |
| Y          | 1.350         |
| Y1         | 5.300         |

## Suggested Pad Layout (Cont.)

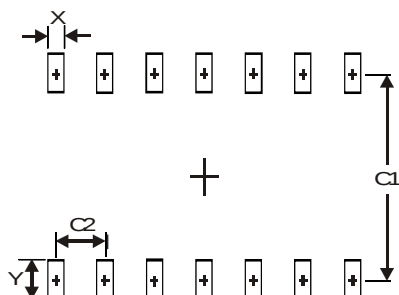
Please see <http://www.diodes.com/package-outlines.html> for the latest version.

### (4) Package Type: SO-14



| Dimensions | Value (in mm) |
|------------|---------------|
| X          | 0.60          |
| Y          | 1.50          |
| C1         | 5.4           |
| C2         | 1.27          |

### (5) Package Type: TSSOP-14



| Dimensions | Value (in mm) |
|------------|---------------|
| X          | 0.45          |
| Y          | 1.45          |
| C1         | 5.9           |
| C2         | 0.65          |

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