## 1.Features

- Wide Supply Ranges
  Single Supply: 3V to 32V (26 V for LM2902)
  Dual Supplies: +1.5V to +16V (+13V for LM2902)
- Low Supply-Current Drain independent of Supply Voltage: 0.8mA Typical
- Common-Mode Input Voltage Range includes Ground, Allowing Direct Sensing Near Ground
- Low Input Bias and Offset Parameters
  Input Offset Voltage: 3mV Typical
  Input Offset Current: 2nA Typical
  Input Bias Current: 20 nA Typical
- Differential Input Voltage Range Equal to Maximum-Rated Supply Voltage: 32V(26V for LM2902)
- Open-Loop Differential Voltage Amplification: 100V/mV Typical
- Internal Frequency Compensation
- On Products Compliant to MIL-PRF-38535, All Parameters are Tested Unless Otherwise Noted. On All Other Products, Production Processing Does Not Necessarily Include Testingof All Parameters.

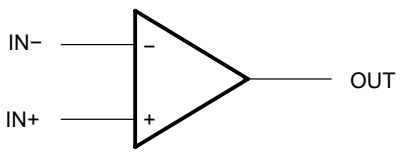
## 2.Description

These devices consist of four independent high-gain frequency-compensated operational amplifiers that are designed specifically to operate from a single supply or split supply over a wide range of voltages.

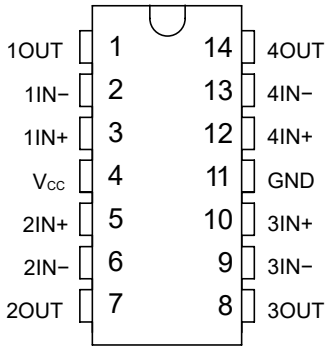
## 3.Applications

- Blu-ray Players and Home Theaters
- Chemical and Gas Sensors
- DVD Recorders and Players
- Digital Multimeter: Bench and Systems
- Digital Multimeter: Handhelds
- Field Transmitter: Temperature Sensors
- Motor Control: AC Induction, Brushed DC, Brushless DC, High-Voltage, Low-Voltage, Permanent Magnet, and Stepper Motor
- Oscilloscopes
- TV: LCD and Digital
- Temperature Sensors or Controllers Using Modbus
- Weigh Scales

## 4.Symbol (Each Amplifier)



## 5.Pinning Information




**DR,PWR**
**14-Pin SOP, DIP,TSSOP**

Pin Functions

| Pin | | | I/O | Description |
|---|---|---|---|---|
| Name | LCCC NO. | SOP, DIP | | |
| 1IN- | | 2 | I | Negative input |
| 1IN+ | | 3 | I | Positive input |
| 1OUT | | 1 | O | Output |
| 2IN- | | 6 | I | Negative input |
| 2IN+ | | 5 | I | Positive input |
| 2OUT | | 7 | O | Output |
| 3IN- | | 9 | I | Negative input |
| 3IN+ | | 10 | I | Positive input |
| 3OUT | | 8 | O | Output |
| 4IN- | | 13 | I | Negative input |
| 4IN+ | | 12 | I | Positive input |
| 4OUT | | 14 | O | Output |
| GND | | 11 | - | Ground |
| $V_{CC}$ | 6 | 4 | - | Power supply |

## 6.Absolute Maximum Ratings

over operating free-air temperature range (unless otherwise noted)(1)

| Parameter | Symbol | LM2902 | | LMX24 | | Units |
|---|---|---|---|---|---|---|
| | | Min | Max | Min | Max | |
| Supply voltage (2) | $V_{CC}$ | | 26 | | 32 | V |
| Differential input voltage (3) | $V_{ID}$ | | ±26 | | ±32 | V |
| Input voltage (either input) | $V_I$ | -0.3 | 26 | -0.3 | 32 | V |
| Duration of output short circuit (one amplifier) to ground at (or Unlimited Unlimited below) $T_A$=25°C, $V_{CC}$≤15V (4) | | Unlimited | | Unlimited | | |
| Operating virtual junction temperature | $T_J$ | | 150 | | 150 | °C |
| Storage temperature | $T_{STG}$ | -65 | 150 | -65 | 150 | °C |

(1) Stresses beyond those listed under Absolute Maximum Ratings may cause permanent damage to the device. These are stress ratings only, and 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.

(2) All voltage values (except differential voltages and $V_{CC}$ specified for the measurement of $I_{OS}$) are with respect to the network GND.

(3) Differential voltages are at IN+, with respect to IN-.

(4) Short circuits from outputs to $V_{CC}$ can cause excessive heating and eventual destruction.

## 7.ESD Ratings

| Parameter (LMX24, LM2902) | | Symbol | Value | Units |
|---|---|---|---|---|
| Electrostatic discharge | Human-body model (HBM), per ANSI/ESDA/JEDEC JS-001(1) | $V_{ESD}$ | ±500 | V |
| | Charged-device model (CDM), per JEDEC specification JESD22-C101 | | ±1000 | V |

(1) JEDEC document JEP155 states that 500-V HBM allows safe manufacturing with a standard ESD control process.

## 8.Recommended Operating Conditions

over operating free-air temperature range (unless otherwise noted)(1)

| Parameter | | Symbol | LM2902 | | LMX24 | | Units |
|---|---|---|---|---|---|---|---|
| | | | Min | Max | Min | Max | |
| Supply voltage | | $V_{CC}$ | 3 | 26 | 3 | 30 | V |
| Common-mode voltage | | $V_{CM}$ | 0 | $V_{CC}$-2 | 0 | $V_{CC}$-2 | V |
| Operating free air temperature | LM124 | $T_A$ | | | -40 | 105 | °C |
| | LM2902 | | -40 | 105 | | | °C |
| | LM224 | | | | -20 | 85 | °C |
| | LM324 | | | | 0 | 70 | °C |

## 9.Thermal Information

| Thermal Metric (1) | Symbol | LMX24,LM2902 | | Units |
|---|---|---|---|---|
| | | (SOP) | (DIP) | |
| | | 14Pins | 14Pins | |
| Junction-to-ambient thermal resistance | $R_{\theta JA}$ (2) (3) | 86 | 80 | °C/W |
| Junction-to-case (top) thermal resistance | $R_{\theta JC}$ (4) | - | - | °C/W |

(1) Short circuits from outputs to $V_{CC}$ can cause excessive heating and eventual destruction.

(2) Maximum power dissipation is a function of $T_{J(max)}$, $R_{\theta JA}$, and $T_A$. The maximum allowable power dissipation at any allowable ambient temperature is $P_D = (T_{J(max)} – T_A)/R_{\theta JA}$. Operating at the absolute maximum $T_J$ of 150°C can affect reliability.

(3) Maximum power dissipation is a function of $T_{J(max)}$, $R_{\theta JA}$, and $T_C$. The maximum allowable power dissipation at any allowable case temperature is $P_D = (T_{J(max)} – T_C)/R_{\theta JC}$. Operating at the absolute maximum $T_J$ of 150°C can affect reliability.

## 10.Electrical Characteristics (LMx24)

at specified free-air temperature, $V_{CC}$=5V (unless otherwise noted)

| Parameter | Symbol | Test Conditions(1) | | $T_A$ (2) | LMX24 | | | LM2902 | | | Units |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | Min | Typ(3) | Max | Min | Typ(3) | Max | |
| Input offset voltage | $V_{IO}$ | $V_{CC}$=5V to MAX | | 25°C | | 3 | 5 | | 3 | 7 | mV |
| | | $V_{IC}=V_{ICR}$ min,$V_O$=1.4V | | Full range | | | 7 | | | 10 | mV |
| Input offset current | $I_{IO}$ | $V_O$=1.4V | | 25°C | | 2 | 30 | | 2 | 50 | nA |
| | | | | Full range | | | 100 | | | 300 | nA |
| Input bias current | $I_{IB}$ | $V_O$=1.4V | | 25°C | | -20 | -150 | | -20 | -250 | nA |
| | | | | Full range | | | -300 | | | -500 | nA |
| Common-mode input voltage range | $V_{ICR}$ | $V_{CC}$=5V to MAX | | 25°C | | | 0 to $V_{CC}$ - 1.5 | | | 0 to $V_{CC}$ - 1.5 | V |
| | | | | Full range | | | 0 to $V_{CC}$ - 2 | | | 0 to $V_{CC}$ - 2 | V |
| High-level output voltage | $V_{OH}$ | $R_L$=2kΩ | | 25°C | $V_{CC}$ - 1.5 | | | $V_{CC}$ - 1.5 | | | V |
| | | $V_{CC}$=MAX | $R_L$=2kΩ | Full range | 26 | | | 22 | | | V |
| | | | $R_L$=10kΩ | Full range | 27 | 28 | | 23 | 24 | | V |
| Low-level output voltage | $V_{OL}$ | $R_L$≤10kΩ | | Full range | | 5 | 20 | | 5 | 20 | mV |
| Large-signal differential voltage amplification | $A_{VD}$ | $V_{CC}$=15V, $V_O$=1V to 11V, $R_L$≥2kΩ | | 25°C | 50 | 100 | | | | | V/mV |
| | | | | Full range | 25 | | | 15 | 100 | | V/mV |
| Common-mode rejection ratio | CMRR | $V_{IC}=V_{ICR}$min | | 25°C | 70 | 80 | | 50 | 80 | | dB |
| Supply-voltage rejection ratio ($\Delta V_{CC}/\Delta V_{IO}$) | $k_{SVR}$ | | | 25°C | 65 | 100 | | 50 | 100 | | dB |
| Crosstalk attenuation | $V_{O1}/V_{O2}$ | f=1kHz to 20kHz | | 25°C | | 120 | | | 120 | | dB |

| Parameter | Symbol | Test Conditions(1) | $T_A$ (2) | LMX24 | | | LM2902 | | | Units |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | Min | Typ(3) | Max | Min | Typ(3) | Max | |
| Output current | $I_O$ | $V_{CC}$=15V, $V_{ID}$=1V | 25°C | -20 | -30 | -60 | -20 | -30 | -60 | mA |
| | | $V_O$=0 (Source) | Full range | -10 | | | -10 | | | mA |
| | | $V_{CC}$=15V, $V_{ID}$=-1V | 25°C | 10 | 20 | | 10 | 20 | | mA |
| | | $V_O$=15V (Sink) | Full range | 5 | | | 5 | | | mA |
| | | $V_{ID}$=-1V, $V_O$=200mV | 25°C | 12 | 30 | | | 30 | | μA |
| Short-circuit output current | $I_{OS}$ | $V_{CC}$ at 5V, $V_O$=0 GND at -5V | 25°C | | ±40 | ±60 | | ±40 | ±60 | mA |
| Supply current (four amplifiers) | $I_{CC}$ | $V_O$=2.5V, no load | Full range | | 0.7 | 1.2 | | 0.7 | 1.2 | mA |
| | | $V_{CC}$=MAX, $V_O$=0.5$V_{CC}$ no load | Full range | | 1.4 | 3 | | 1.4 | 3 | mA |

(1) All characteristics are measured under open-loop conditions, with zero common-mode input voltage, unless otherwise specified. MAX $V_{CC}$ for testing purposes is 26 V for LM2902 and 30 V for the others.

(2) Full range is -40°C to 125°C for LM124, –20°C to 85°C for LM224

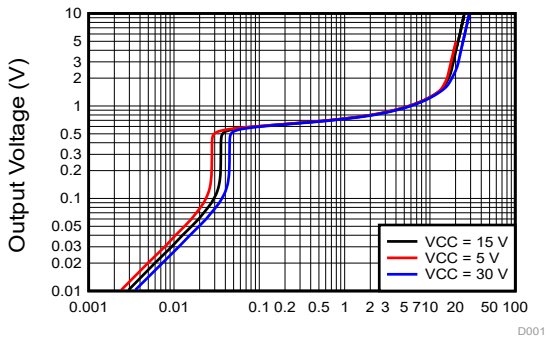
(3) All typical values are at $T_A$=25°C

## 11.Operating Conditions

$V_{CC}$=±15 V, $T_A$=25°C

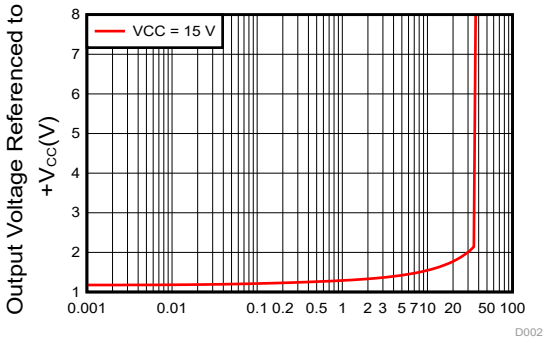
| Parameter | Symbol | Test Conditions | Typ | Units |
|---|---|---|---|---|
| Slew rate at unity gain | SR | $R_L$=1MΩ, $C_L$=30pF, $V_I$=±10V (see Figure 7) | 0.5 | V/μs |
| Unity-gain bandwidth | $B_1$ | $R_L$=1MΩ, $C_L$=20pF (see Figure 7) | 1.2 | MHz |
| Equivalent input noise voltage | $V_n$ | $R_S$=100Ω, $V_I$=0V, f=1kHz (see Figure 8) | 35 | nV/√Hz |

## 12.Typical Characterisitics



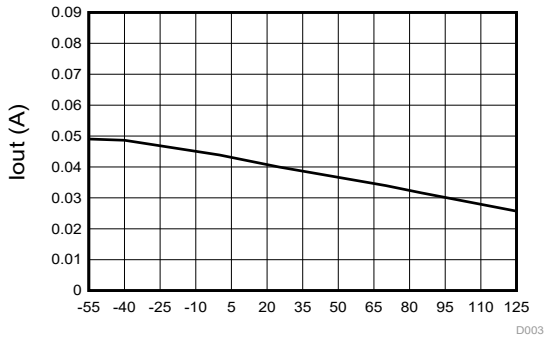

Output Sink Current (mA)

Figure 1: Output Sinking Characteristics



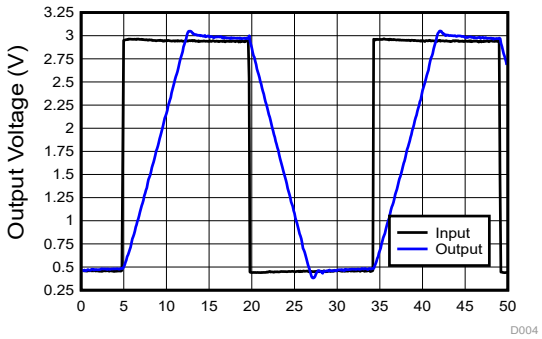

Output Source Current (mA)

Figure 2: Output Sourcing Characteristics



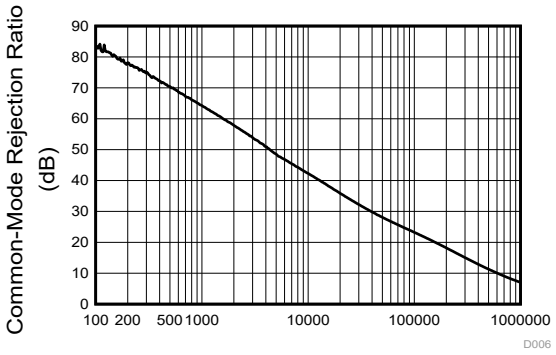

Temperature (°C)

Figure 3: Source Current Limiting



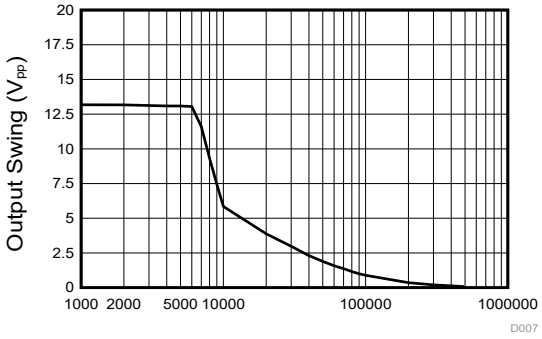

Time (µS)

Figure 4: Voltage Follower Large Signal Response (50 pF)




Frequency (Hz)

Figure 5: Common-Mode Rejection Ratio




Frequency (Hz)

Figure 6: Maximum Output Swing vs. Frequency ($V_{CC}$ = 15 V)

## 13.Parameter Measurement Information

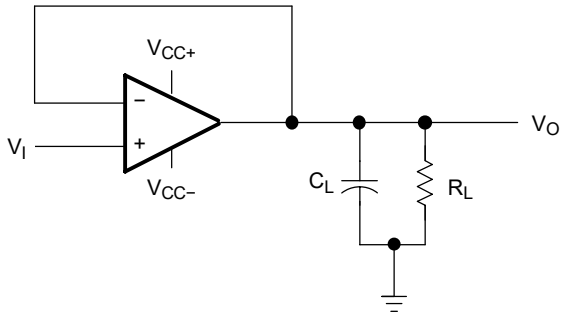



Figure 7: Unity-Gain Amplifier

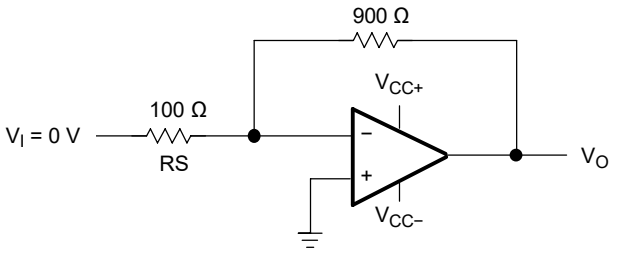



Figure 8: Noise-Test Circuit

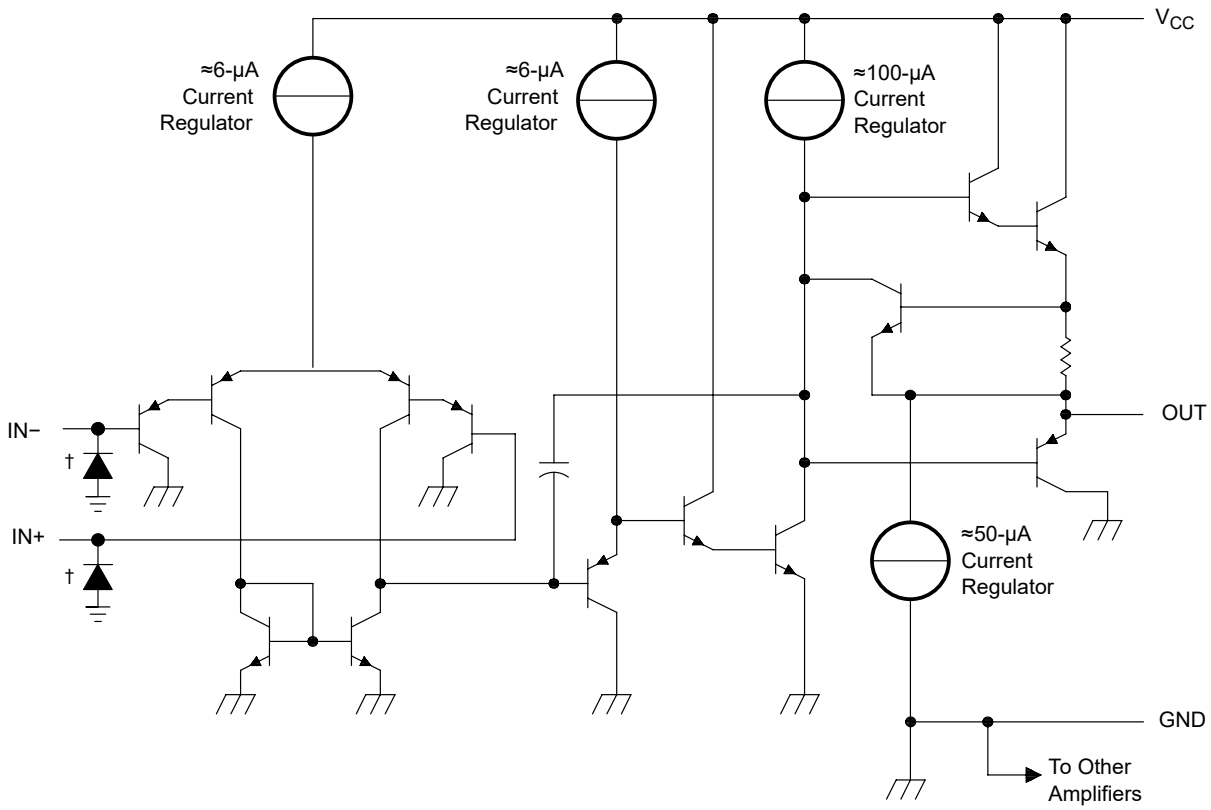
## 14.Detailed Description

### 14.1 Overview

These devices consist of four independent high-gain frequency-compensated operational amplifiers that are designed specifically to operate from a single supply over a wide range of voltages. Operation from split supplies also is possible if the difference between the two supplies is 3 V to 32 V (3 V to 26 V for the LM2902 device), and $V_{CC}$ is at least 1.5 V more positive than the input common-mode voltage. The low supply-current drain is independent of the magnitude of the supply voltage.

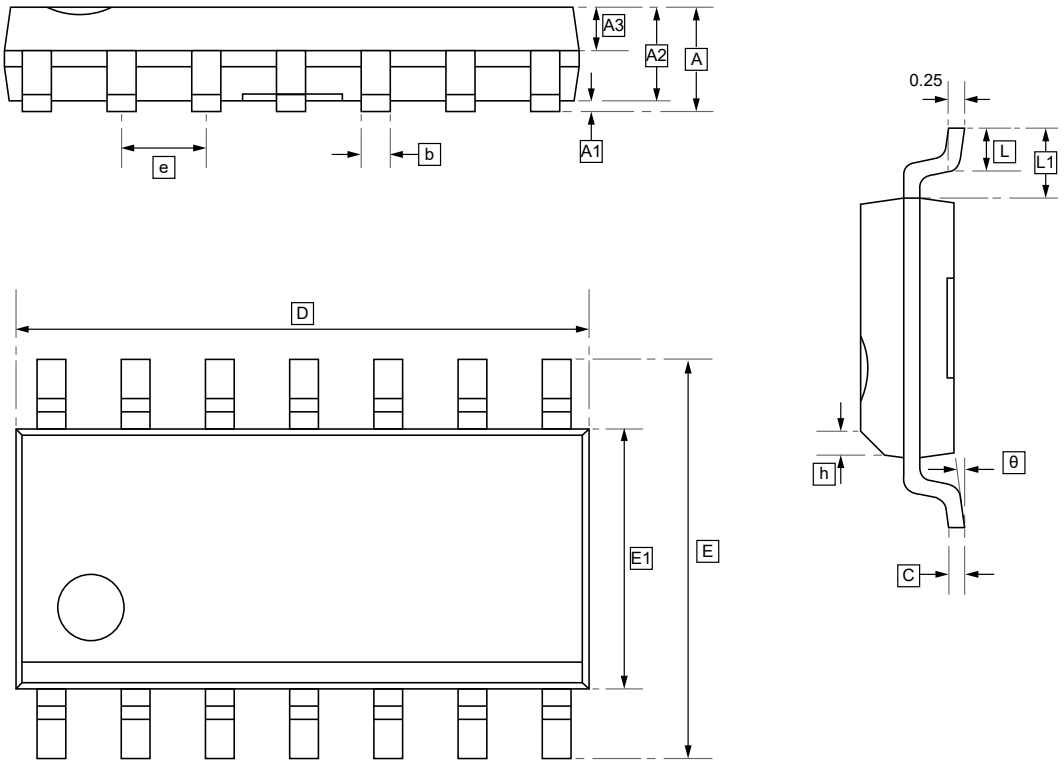
Applications include transducer amplifiers, DC amplification blocks, and all the conventional operational-amplifier circuits that now can be more easily implemented in single-supply-voltage systems. For example, the LM124 device can be operated directly from the standard 5-V supply that is used in digital systems and provides the required interface electronics, without requiring additional ±15-V supplies.

## 14.2 Functional Block Diagram




| COMPONENT COUNT (total device) | |
|---|---|
| Epi-FET | 1 |
| Transistors | 95 |
| Diodes | 4 |
| Resistors | 11 |
| Capacitors | 4 |

## 15.1 SOP-14 Package Outline Dimensions

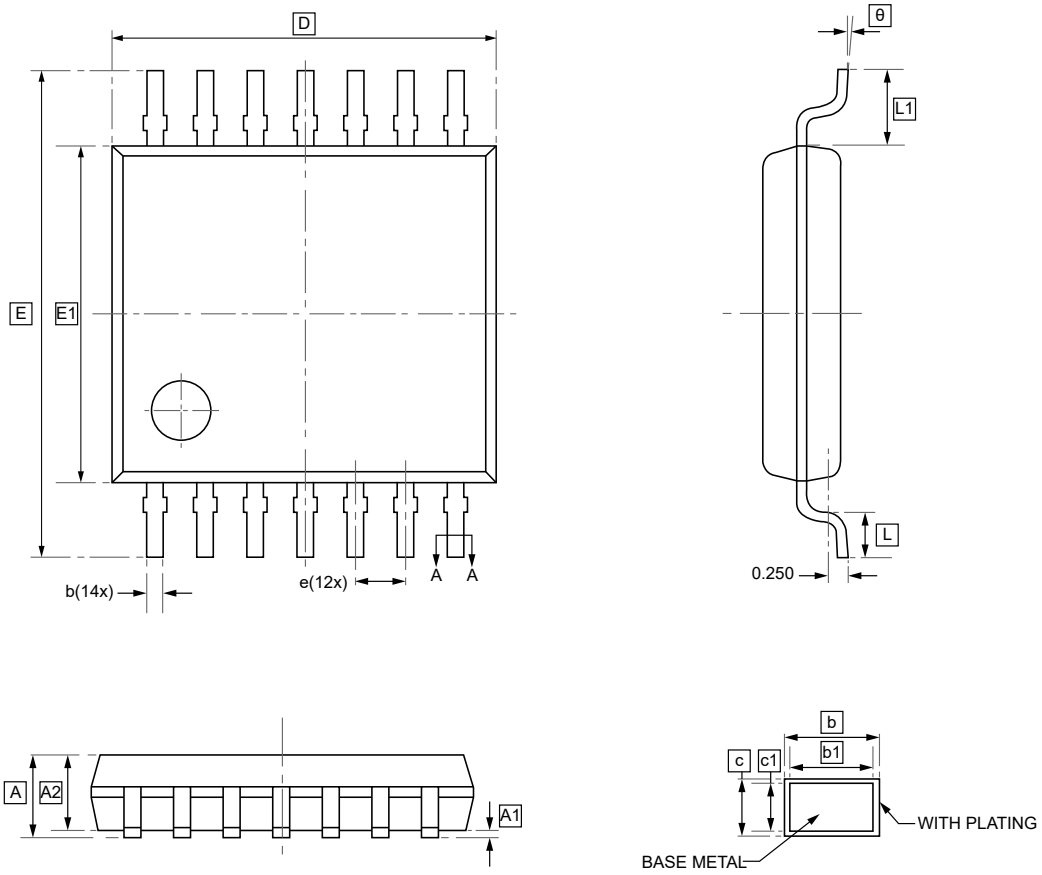



**DIMENSIONS (mm are the original dimensions)**

| Symbol | A | A1 | A2 | A3 | b | C | D | E | E1 | e | h | L |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Min | - | 0.05 | 1.35 | 0.65 | 0.203 | 0.17 | 8.45 | 5.80 | 3.80 | 1.24 | 0.25 | 0.40 |
| Max | 1.75 | 0.25 | 1.55 | 0.75 | 0.305 | 0.25 | 8.85 | 6.20 | 4.00 | 1.30 | 0.50 | 0.80 |

| Symbol | L1 | θ |
|---|---|---|
| Min | 1.00 | 0° |
| Max | 1.10 | 8° |

## 15.2 TSSOP-14 Package Outline Dimensions




**DIMENSIONS (mm are the original dimensions)**

| Symbol | A | A1 | A2 | b | b1 | c | c1 | D | E | E1 | e | L1 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Min | - | 0.05 | 0.90 | 0.20 | 0.19 | 0.13 | 0.120 | 4.90 | 6.20 | 4.30 | 0.65 | 0.85 |
| Max | 1.20 | 0.15 | 1.05 | 0.28 | 0.25 | 0.17 | 0.14 | 5.10 | 6.60 | 4.50 | BSC | 1.15 |

| Symbol | L | θ |
|---|---|---|
| Min | 0.45 | 0° |
| Max | 0.75 | 8° |

## 16.Ordering Information

SOP-14


TSSOP-14


yww: Batch Code

| Order Code | Marking | Package | Base QTY | Delivery Mode |
|---|---|---|---|---|
| UMW LM124DR | LM124 | SOP-14 | 2500 | Tape and reel |
| UMW LM224DR | LM224 | SOP-14 | 2500 | Tape and reel |
| UMW LM2902DR | LM2902 | SOP-14 | 2500 | Tape and reel |
| UMW LM2902PWR | LM2902 | TSSOP-14 | 4000 | Tape and reel |

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