

**1 Features**

- Wide Supply Ranges
  - Single Supply: 3 V to 32 V (26 V for LM2902)
  - Dual Supplies:  $\pm 1.5$  V to  $\pm 16$  V ( $\pm 13$  V for LM2902)
- Low Supply-Current Drain Independent of Supply Voltage: 0.8 mA Typical
- Common-Mode Input Voltage Range Includes Ground, Allowing Direct Sensing Near Ground
- Low Input Bias and Offset Parameters
  - Input Offset Voltage: 3 mV Typical
  - Input Offset Current: 2 nA Typical
  - Input Bias Current: 20 nA Typical
- Differential Input Voltage Range Equal to Maximum-Rated Supply Voltage: 32 V (26 V for LM2902)
- Open-Loop Differential Voltage Amplification: 100 V/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 Testing of All Parameters.

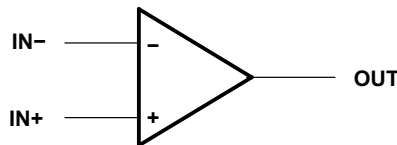
**2 Applications**

- 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

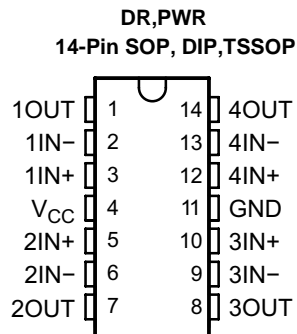
**3 Description**

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.

**Symbol (Each Amplifier)**



### 4 Pin Configuration and Functions



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 <sub>CC</sub>	6	4	—	Power supply

### 5 Specifications

#### 5.1 Absolute Maximum Ratings

over operating free-air temperature range (unless otherwise noted)<sup>(1)</sup>

	LM2902		LM124, LM224		UNIT
	MIN	MAX	MIN	MAX	
Supply voltage, $V_{CC}$ <sup>(2)</sup>	±13	26	±16	32	V
Differential input voltage, $V_{ID}$ <sup>(3)</sup>	±26		±32		V
Input voltage, $V_I$ (either input)	-0.3	26	-0.3	to 32	V
Duration of output short circuit (one amplifier) to ground at (or below) $T_A = 25^\circ\text{C}$ , $V_{CC} \leq 15\text{ V}$ <sup>(4)</sup>	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.

#### 5.2 ESD

LM124, LM224, LM2902			
$V_{(ESD)}$ Electrostatic discharge	Human-body model (HBM), per ANSI/ESDA/JEDEC JS-001 <sup>(1)</sup>	±500	V
	Charged-device model (CDM), per JEDEC specification JESD22-C101	±1000	

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

#### 5.3 Recommended Operating Conditions

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

	LM2902		LM124, LM224		UNIT
	MIN	MAX	MIN	MAX	
$V_{CC}$ Supply voltage	3	26	3	32	V
$V_{CM}$ Common-mode voltage	0	$V_{CC} - 2$	0	$V_{CC} - 2$	V
$T_A$ Operating free air temperature	LM124		-40	105	°C
	LM2902	-40	105		
	LM224		-20	85	

### 5.4 Thermal Information

THERMAL METRIC <sup>(1)</sup>	LM124, LM224, LM2902		
	(SOP)	(DIP)	UNIT
	14 PINS	14 PINS	
$R_{\theta JA}$ <sup>(2)(3)</sup> Junction-to-ambient thermal resistance	86	80	°C/W
$R_{\theta JC}$ <sup>(4)</sup> Junction-to-case (top) thermal resistance	—	—	

- (1) Short circuits from outputs to VCC 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.

### 5.5 Electrical Characteristics for LMx24

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

PARAMETER	TEST CONDITIONS <sup>(1)</sup>	$T_A$ <sup>(2)</sup>	LM124, LM224			LM2902			UNIT	
			MIN	TYP <sup>(3)</sup>	MAX	MIN	TYP <sup>(3)</sup>	MAX		
$V_{IO}$ Input offset voltage	$V_{CC} = 5\text{ V to MAX}$ , $V_{IC} = V_{ICRmin}$ , $V_O = 1.4\text{ V}$	25°C	3		5	3		7	mV	
		Full range			7			10		
$I_{IO}$ Input offset current	$V_O = 1.4\text{ V}$	25°C	2		30	2		50	nA	
		Full range			100			300		
$I_{IB}$ Input bias current	$V_O = 1.4\text{ V}$	25°C	20		150	20		250	nA	
		Full range			300			500		
$V_{ICR}$ Common-mode input voltage range	$V_{CC} = 5\text{ V to MAX}$	25°C	0 to $V_{CC} - 1.5$			0 to $V_{CC} - 1.5$			V	
		Full range	0 to $V_{CC} - 2$			0 to $V_{CC} - 2$				
$V_{OH}$ High-level output voltage	$R_L = 2\text{ k}\Omega$	25°C	$V_{CC} - 1.5$			$V_{CC} - 1.5$			V	
	$R_L = 10\text{ k}\Omega$	25°C								
	$V_{CC} = \text{MAX}$	Full range	26			22				
	$R_L \geq 10\text{ k}\Omega$	Full range	27	28		23	24			
$V_{OL}$ Low-level output voltage	$R_L \leq 10\text{ k}\Omega$	Full range	5		20	5		20	mV	
$A_{VD}$ Large-signal differential voltage amplification	$V_{CC} = 15\text{ V}$ , $V_O = 1\text{ V to }11\text{ V}$ , $R_L \geq 2\text{ k}\Omega$	25°C	50	100		100			V/mV	
		Full range	25			15				
CMRR Common-mode rejection ratio	$V_{IC} = V_{ICRmin}$	25°C	70	80		50	80		dB	
$k_{SVR}$ Supply-voltage rejection ratio ( $\Delta V_{CC}/\Delta V_{IO}$ )		25°C	65	100		50	100		dB	
$V_{O1}/V_{O2}$ Crosstalk attenuation	$f = 1\text{ kHz to }20\text{ kHz}$	25°C	120			120			dB	
$I_O$ Output current	$V_{CC} = 15\text{ V}$ , $V_{ID} = 1\text{ V}$ , $V_O = 0$	Source	25°C	-20	-30	-60	-20	-30	-60	mA
			Full range	-10			-10			
	$V_{CC} = 15\text{ V}$ , $V_{ID} = -1\text{ V}$ , $V_O = 15\text{ V}$	Sink	25°C	10	20		10	20		
			Full range	5			5			
	$V_{ID} = -1\text{ V}$ , $V_O = 200\text{ mV}$	25°C	12	30		30			$\mu\text{A}$	
$I_{OS}$ Short-circuit output current	$V_{CC}$ at 5 V, $V_O = 0$ , GND at -5 V	25°C	$\pm 40$			$\pm 60$			mA	
$I_{CC}$ Supply current (four amplifiers)	$V_O = 2.5\text{ V}$ , no load	Full range	0.7		1.2	0.7		1.2	mA	
	$V_{CC} = \text{MAX}$ , $V_O = 0.5 V_{CC}$ , no load	Full range	1.4		3	1.4		3		

- (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 -55°C to 125°C for LM124, -20°C to 85°C for LM224
- (3) All typical values are at  $T_A = 25^\circ\text{C}$

### 5.6 Operating Conditions

$V_{CC} = \pm 15\text{ V}$ ,  $T_A = 25^\circ\text{C}$

PARAMETER		TEST CONDITIONS	TYP	UNIT
SR	Slew rate at unity gain	$R_L = 1\text{ M}\Omega$ , $C_L = 30\text{ pF}$ , $V_I = \pm 10\text{ V}$ (see Figure 7)	0.5	V/ $\mu$ s
$B_1$	Unity-gain bandwidth	$R_L = 1\text{ M}\Omega$ , $C_L = 20\text{ pF}$ (see Figure 7)	1.2	MHz
$V_n$	Equivalent input noise voltage	$R_S = 100\ \Omega$ , $V_I = 0\text{ V}$ , $f = 1\text{ kHz}$ (see Figure 8)	35	nV/ $\sqrt{\text{Hz}}$

5.7 Typical Characteristics

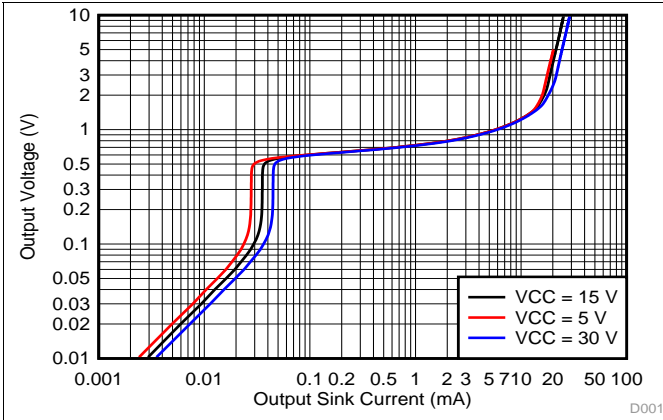


Figure 1. Output Sinking Characteristics

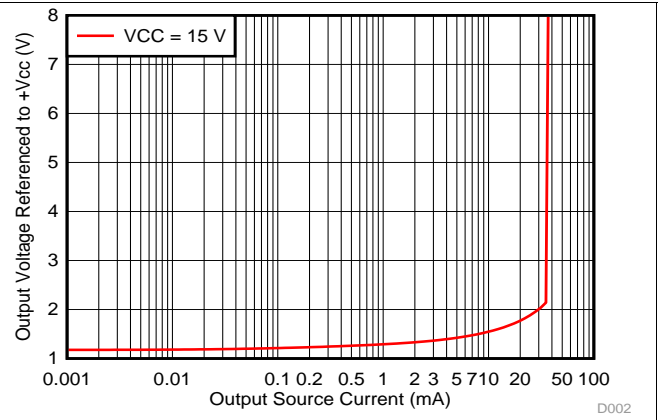


Figure 2. Output Sourcing Characteristics

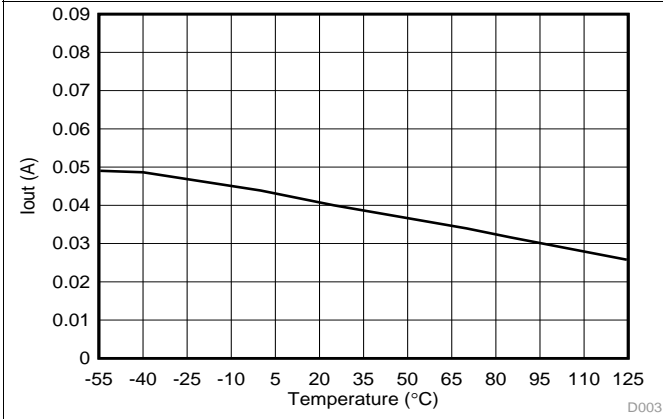


Figure 3. Source Current Limiting

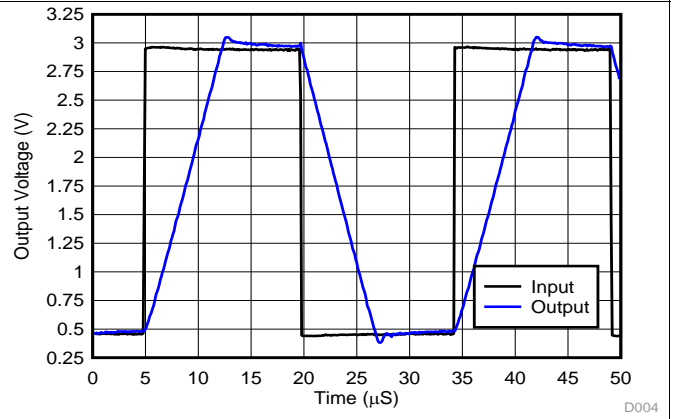


Figure 4. Voltage Follower Large Signal Response (50 pF)

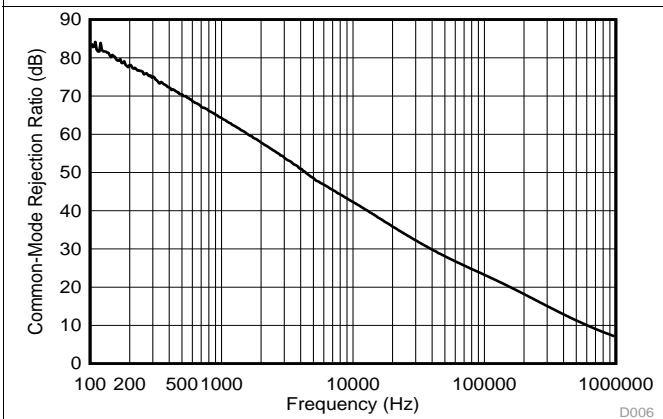


Figure 5. Common-Mode Rejection Ratio

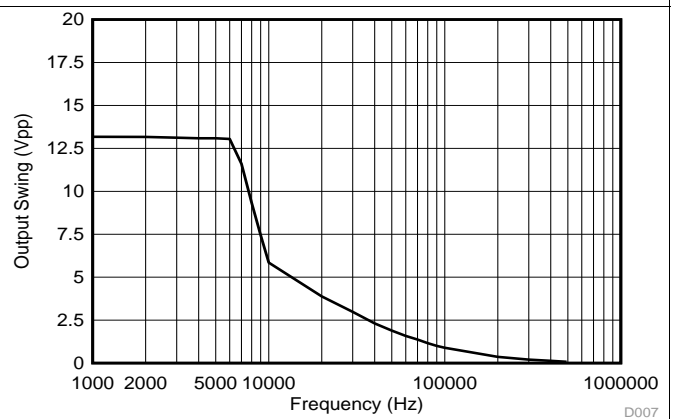


Figure 6. Maximum Output Swing vs. Frequency (VCC = 15 V)

## 6 Parameter Measurement Information

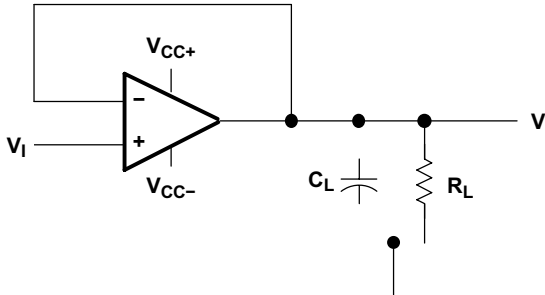


Figure 7. Unity-Gain Amplifier

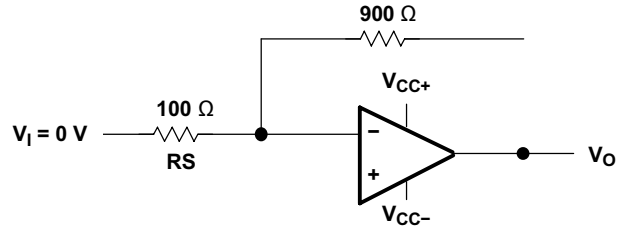


Figure 8. Noise-Test Circuit

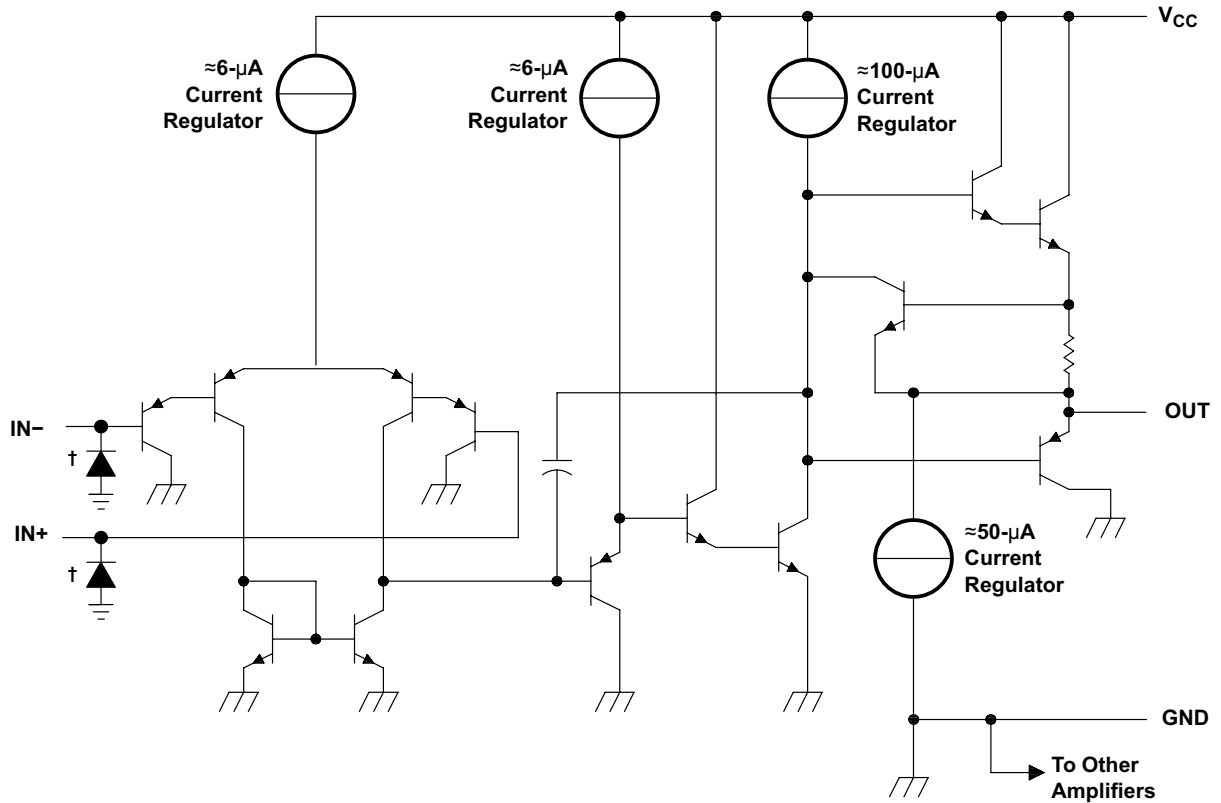
## 7 Detailed Description

### 7.1 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  $\pm 15$ -V supplies.

7.2 Functional Block Diagram

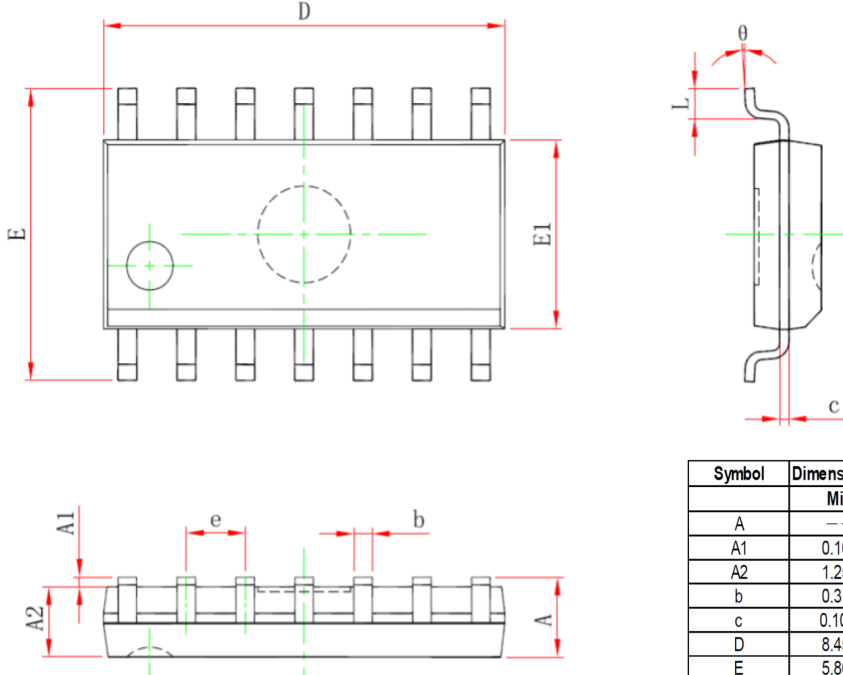


COMPONENT COUNT (total device)	
Epi-FET	1
Transistors	95
Diodes	4
Resistors	11
Capacitors	4



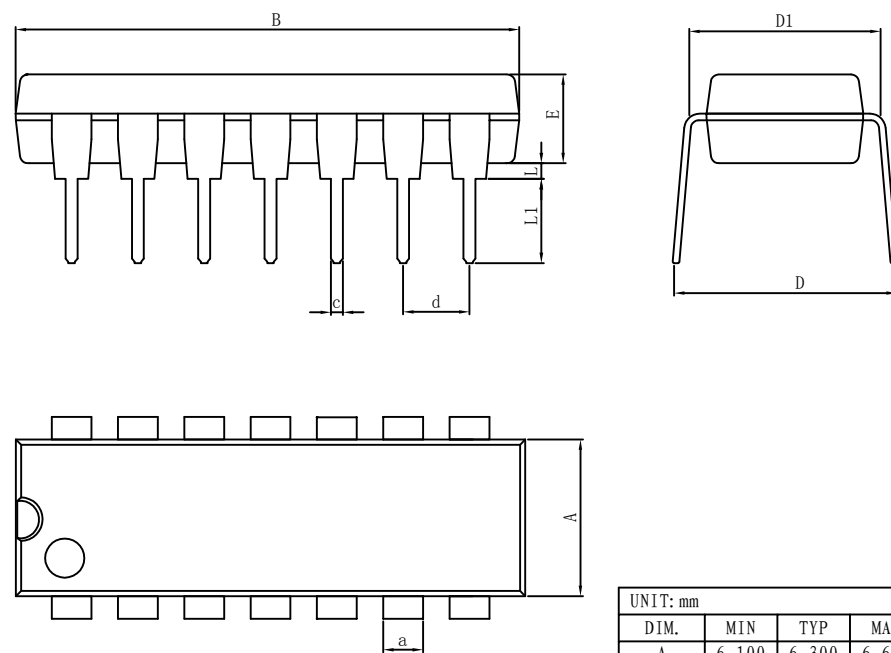
8.PACKAGE

SOP14



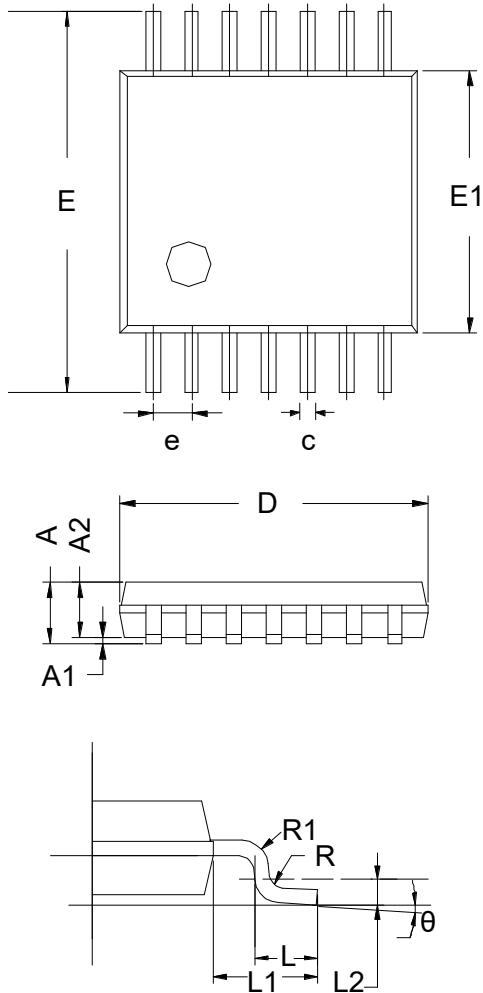
Symbol	Dimensions In Millimeters		Dimensions In Inches	
	Min	Max	Min	Max
A	--	1.750	--	0.069
A1	0.100	0.250	0.004	0.010
A2	1.250	--	0.049	--
b	0.310	0.510	0.012	0.020
c	0.100	0.250	0.004	0.010
D	8.450	8.850	0.333	0.348
E	5.800	6.200	0.228	0.244
E1	3.800	4.000	0.150	0.157
e	1.270(BSC)		0.050(BSC)	
L	0.400	1.270	0.016	0.050
θ	0°		8°	

DIP14



UNIT: mm							
DIM.	MIN	TYP	MAX	DIM.	MIN	TYP	MAX
A	6.100	6.300	6.680	a	1.504	1.524	1.544
B	18.940	19.200	19.560	c	0.437	0.457	0.477
D	8.200	8.700	9.200	d	2.530	2.540	2.550
D1	7.42	7.62	7.82	L	0.500	-	0.800
E	3.100	3.300	3.550	L1	3.000	3.200	3.600

TSSOP-14



Symbol	Dimensions In Millimeters		
	MIN	TYP	MAX
A	-	-	1.20
A1	0.05	-	0.15
A2	0.90	1.00	1.05
b	0.20	-	0.28
c	0.10	-	0.19
D	4.86	4.96	5.06
E	6.20	6.40	6.60
E1	4.30	4.40	4.50
e	0.65 BSC		
L	0.45	0.60	0.75
L1	1.00 REF		
L2	0.25 BSC		
R	0.09	-	-
θ	0°	-	8°

**9. ORDERING INFORMATION**

Order Code	Package	Baseqty	Deliverymode
UMW LM124DR	SOP-14	2500	Tape and reel
UMW LM224DR	SOP-14	2500	Tape and reel
UMW LM2902DR	SOP-14	2500	Tape and reel
UMW LM2902PWR	TSSOP-14	2500	Tape and reel