

# 1.1MHz, Precision, Rail-to-Rail I/O CMOS Operational Amplifier

## 1 FEATURES

- **High Gain Bandwidth: 1.1MHz**
- **Rail-to-Rail Input and Output**  
 **$\pm 4.5\text{mV}$  Max  $V_{os}$**
- **Input Voltage Range:  $-0.1\text{V}$  to  $+5.6\text{V}$**   
**with  $V_s = 5.5\text{V}$**
- **Supply Range:  $+2.5\text{V}$  to  $+5.5\text{V}$**
- **Specified Up to  $+125^\circ\text{C}$**
- **Packages: SOP14, TSSOP14**

## 2 APPLICATIONS

- **Sensors**
- **Photodiode Amplification**
- **Active Filters**
- **Test Equipment**
- **Driving A/D Converters**

## 3 DESCRIPTIONS

The RS324A products offer low voltage operation and rail-to-rail input and output, as well as excellent speed/power consumption ratio, providing an excellent bandwidth (1.1MHz) and slew rate of  $0.5\text{V}/\mu\text{s}$ . The op-amps are unity gain stable and feature an ultra-low input bias current.

The RS324A has lower offset, which is guaranteed not upper than  $\pm 4.5\text{mV}$  at  $25^\circ\text{C}$  with  $V_s = 5\text{V}$ ,  $V_{CM} = V_s/2$ .

The devices are ideal for sensor interfaces, active filters and portable applications. The RS324A families of operational amplifiers are specified at the full temperature range of  $-40^\circ\text{C}$  to  $+125^\circ\text{C}$  under single or dual power supplies of  $2.5\text{V}$  to  $5.5\text{V}$ .

**Device Information<sup>(1)</sup>**

PART NUMBER	PACKAGE	BODY SIZE(NOM)
RS324A	SOP14	8.65mm×3.90mm
	TSSOP14	5.00mm×4.40mm

(1) For all available packages, see the orderable addendum at the end of the data sheet.

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## 4 REVISION HISTORY

Note: Page numbers for previous revisions may different from page numbers in the current version.

VERSION	Change Date	Change Item
A.2	2022/11/08	1. Update Package Qty on Page 4@RevA.1 2.Added TAPE AND REEL INFORMATION
A.2.1	2024/02/29	Modify packaging naming
A.3	2024/06/26	1. Add MSL on Page 4@RevA.2.1 2. Update PACKAGE note

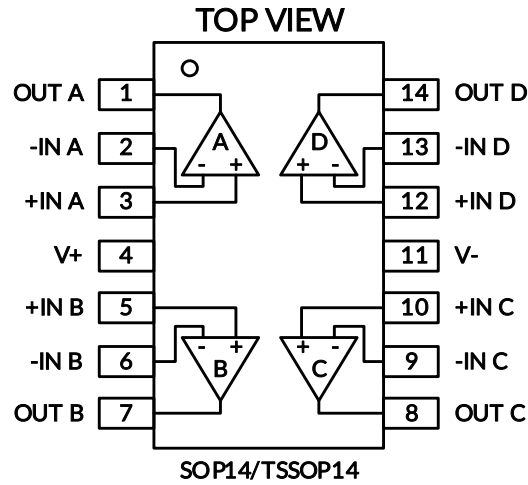
**5 PACKAGE/ORDERING INFORMATION <sup>(1)</sup>**

PRODUCT	ORDERING NUMBER	TEMPERATURE RANGE	PACKAGE LEAD	PACKAGE MARKING <sup>(2)</sup>	MSL <sup>(3)</sup>	PACKAGE OPTION
RS324A	RS324AXP	-40°C ~125°C	SOP14	RS324A	MSL3	Tape and Reel, 4000
	RS324AXQ	-40°C ~125°C	TSSOP14	RS324A	MSL3	Tape and Reel, 4000

## NOTE:

- (1) This information is the most current data available for the designated devices. This data is subject to change without notice and revision of this document. For browser-based versions of this data sheet, refer to the right-hand navigation.
- (2) There may be additional marking, which relates to the lot trace code information (data code and vendor code), the logo or the environmental category on the device.
- (3) RUNIC classify the MSL level with using the common preconditioning setting in our assembly factory conforming to the JEDEC industrial standard J-STD-20F. Please align with RUNIC if your end application is quite critical to the preconditioning setting or if you have special requirement.

## 6 PIN CONFIGURATION AND FUNCTIONS



### PIN DESCRIPTION

NAME	PIN	I/O <sup>(1)</sup>	DESCRIPTION
	SOP14/TSSOP14		
-INA	2	I	Inverting input, channel A
+INA	3	I	Noninverting input, channel A
-INB	6	I	Inverting input, channel B
+INB	5	I	Noninverting input, channel B
-INC	9	I	Inverting input, channel C
+INC	10	I	Noninverting input, channel C
-IND	13	I	Inverting input, channel D
+IND	12	I	Noninverting input, channel D
OUTA	1	O	Output, channel A
OUTB	7	O	Output, channel B
OUTC	8	O	Output, channel C
OUTD	14	O	Output, channel D
V-	11	-	Negative (lowest) power supply
V+	4	-	Positive (highest) power supply

(1) I = Input, O = Output.

## 7 SPECIFICATIONS

### 7.1 Absolute Maximum Ratings

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

			MIN	MAX	UNIT
Voltage	Supply, $V_S = (V+) - (V-)$			7	V
	Signal input pin <sup>(2)</sup>		(V-)-0.5	(V+) +0.5	
	Signal output pin <sup>(3)</sup>		(V-)-0.5	(V+) +0.5	
Current	Signal input pin <sup>(2)</sup>		-10	10	mA
	Signal output pin <sup>(3)</sup>		-140	140	mA
	Output short-circuit <sup>(4)</sup>		Continuous		
$\theta_{JA}$	Package thermal impedance <sup>(5)</sup>	SOP14		105	°C/W
		TSSOP14		90	
Temperature	Operating range, $T_A$		-40	125	°C
	Junction, $T_J$ <sup>(6)</sup>		-40	150	
	Storage, $T_{stg}$		-65	150	

(1) Stresses above these ratings may cause permanent damage. Exposure to absolute maximum conditions for extended periods may degrade device reliability. These are stress ratings only, and functional operation of the device at these or any other conditions beyond those specified is not implied.

(2) Input terminals are diode-clamped to the power-supply rails. Input signals that can swing more than 0.5V beyond the supply rails should be current-limited to 10mA or less.

(3) Output terminals are diode-clamped to the power-supply rails. Output signals that can swing more than 0.5V beyond the supply rails should be current-limited to  $\pm 140$ mA or less.

(4) Short-circuit to ground, one amplifier per package.

(5) The package thermal impedance is calculated in accordance with JESD-51.

(6) The maximum power dissipation is a function of  $T_{J(MAX)}$ ,  $R_{\theta JA}$ , and  $T_A$ . The maximum allowable power dissipation at any ambient temperature is  $P_D = (T_{J(MAX)} - T_A) / R_{\theta JA}$ . All numbers apply for packages soldered directly onto a PCB.

### 7.2 ESD Ratings

The following ESD information is provided for handling of ESD-sensitive devices in an ESD protected area only.

			VALUE	UNIT
$V_{(ESD)}$	Electrostatic discharge	Human-Body Model (HBM), per ANSI/ESDA/JEDEC JS-001 <sup>(1)</sup>	$\pm 3000$	V
		Machine Model (MM)	$\pm 200$	

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



#### ESD SENSITIVITY CAUTION

ESD damage can range from subtle performance degradation to complete device failure. Precision integrated circuits may be more susceptible to damage because very small parametric changes could cause the device not to meet its published specifications.

### 7.3 Recommended Operating Conditions

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

		MIN	NOM	MAX	UNIT
Supply voltage, $V_S = (V+) - (V-)$	Single-supply	2.5		5.5	V
	Dual-supply	$\pm 1.25$		$\pm 2.75$	

## 7.4 Electrical Characteristics

(At  $T_A = +25^\circ\text{C}$ ,  $V_S = 5\text{V}$ ,  $R_L = 10\text{k}\Omega$  connected to  $V_S/2$ , and  $V_{OUT} = V_S/2$ , Full <sup>(9)</sup> =  $-40^\circ\text{C}$  to  $+125^\circ\text{C}$ , unless otherwise noted.) <sup>(1)</sup>

PARAMETER		CONDITIONS	T <sub>J</sub>	RS324A			
				MIN <sup>(2)</sup>	TYP <sup>(3)</sup>	MAX <sup>(2)</sup>	UNIT
POWER SUPPLY							
V <sub>S</sub>	Operating Voltage Range		25°C	2.5		5.5	V
I <sub>Q</sub>	Quiescent Current Per Amplifier		25°C		60	110	μA
PSRR	Power-Supply Rejection Ratio	V <sub>S</sub> =2.5V to 5.5V, V <sub>CM</sub> =(V-)+0.5V	25°C	74	90		dB
			Full	65			
INPUT							
V <sub>OS</sub>	Input Offset Voltage	V <sub>CM</sub> =0V to 3.5V	25°C	-4.5	±0.8	4.5	mV
V <sub>OS</sub> T <sub>C</sub>	Input Offset Voltage Average Drift		Full		±2		μV/°C
I <sub>B</sub>	Input Bias Current <sup>(4) (5)</sup>		25°C		±10	±100	pA
I <sub>OS</sub>	Input Offset Current <sup>(4)</sup>		25°C		±1	±10	pA
V <sub>CM</sub>	Common-Mode Voltage Range	V <sub>S</sub> = 5.5V	25°C	-0.1		5.6	V
CMRR	Common-Mode Rejection Ratio	V <sub>S</sub> = 5.5V, V <sub>CM</sub> =-0.1V to 4V	25°C	74	90		dB
			Full	68			
		V <sub>S</sub> = 5.5V, V <sub>CM</sub> =-0.1V to 5.6V	25°C	63	80		
			Full	57			
OUTPUT							
A <sub>OL</sub>	Open-Loop Voltage Gain	R <sub>L</sub> =2KΩ, V <sub>O</sub> =0.15V to 4.85V	25°C	85	105		dB
			Full	80			
		R <sub>L</sub> =10KΩ, V <sub>O</sub> = 0.05V to 4.95V	25°C	88	110		
			Full	83			
	Output Swing From Rail	R <sub>L</sub> =2KΩ	25°C		25		mV
		R <sub>L</sub> =10KΩ			8		
I <sub>OUT</sub>	Output Short-Circuit Current <sup>(6) (7)</sup>		25°C		130		mA
FREQUENCY RESPONSE							
SR	Slew Rate <sup>(8)</sup>		25°C		0.5		V/μs
GBP	Gain-Bandwidth Product		25°C		1.1		MHz
PM	Phase Margin		25°C		64		°
t <sub>s</sub>	Settling Time, 0.1%				1.3		μs
	Overload Recovery Time	V <sub>IN</sub> ·Gain≥V <sub>S</sub>			2.3		μs
NOISE							
e <sub>n</sub>	Input Voltage Noise Density	f = 1KHz	25°C		22		nV/√Hz
		f = 10KHz	25°C		20		nV/√Hz

(1) Electrical table values apply only for factory testing conditions at the temperature indicated. Factory testing conditions result in very limited self-heating of the device.

(2) Limits are 100% production tested at  $25^\circ\text{C}$ . Limits over the operating temperature range are ensured through correlations using statistical quality control (SQC) method.

(3) Typical values 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.

(4) This parameter is ensured by design and/or characterization and is not tested in production.

(5) Positive current corresponds to current flowing into the device.

(6) The maximum power dissipation is a function of  $T_{J(\text{MAX})}$ ,  $R_{\theta JA}$ , and  $T_A$ . The maximum allowable power dissipation at any ambient temperature is  $P_D = (T_{J(\text{MAX})} - T_A) / R_{\theta JA}$ . All numbers apply for packages soldered directly onto a PCB.

(7) Short circuit test is a momentary test.

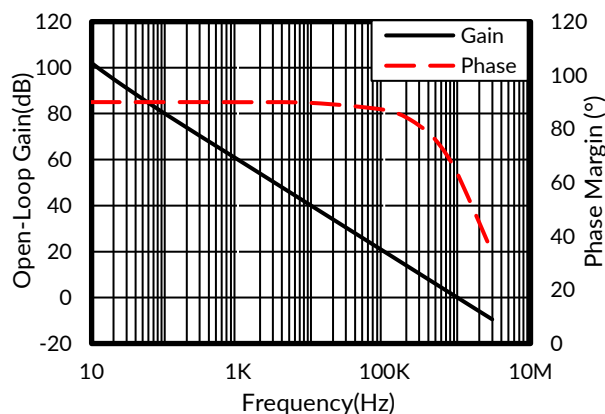
(8) Number specified is the slower of positive and negative slew rates.

(9) Specified by characterization only.

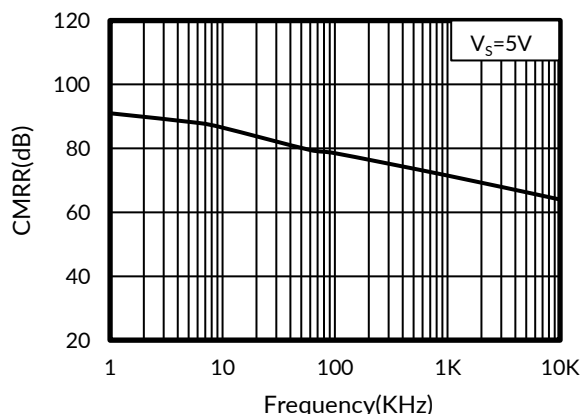
## 7.5 Typical Characteristics

NOTE: The graphs and tables provided following this note are a statistical summary based on a limited number of samples and are provided for informational purposes only.

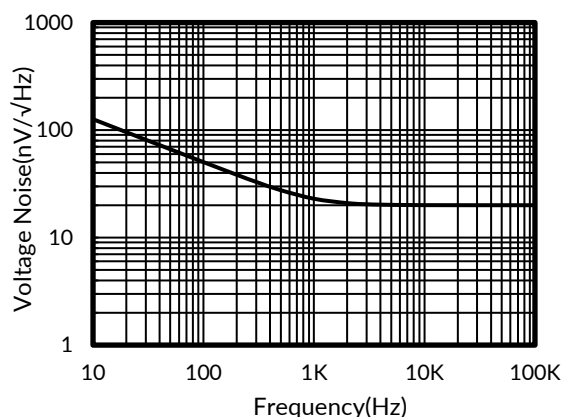
At  $T_A = +25^\circ\text{C}$ ,  $V_S = 5\text{V}$ ,  $R_L = 10\text{k}\Omega$  connected to  $V_S/2$ ,  $V_{OUT} = V_S/2$ , unless otherwise noted.



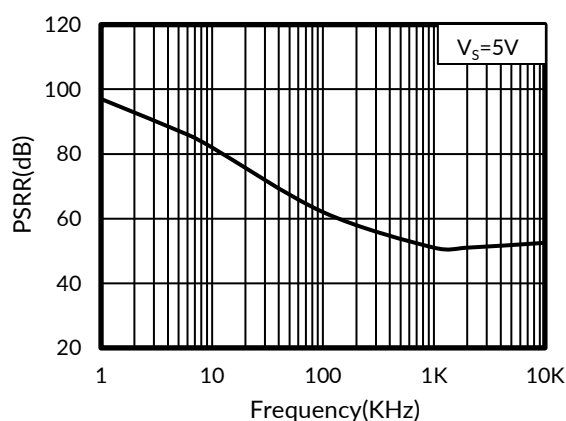
**Figure 1. Open-Loop Gain and Phase vs Frequency**



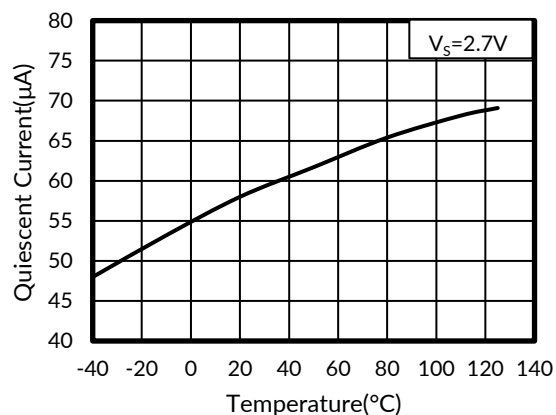
**Figure 2. Common-Mode Rejection Ratio vs Frequency**



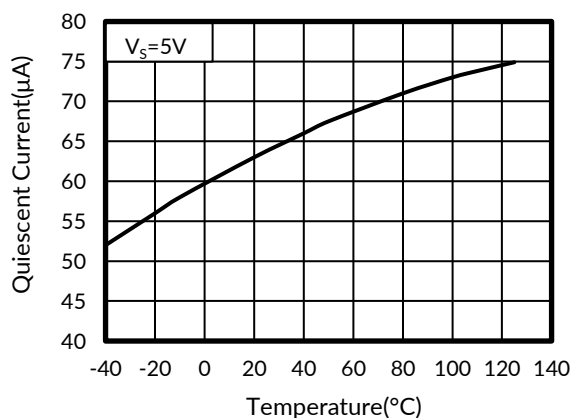
**Figure 3. Input Voltage Noise Spectral Density vs Frequency**



**Figure 4. Power-Supply Rejection Ratio vs Frequency**



**Figure 5. Quiescent Current vs Temperature**



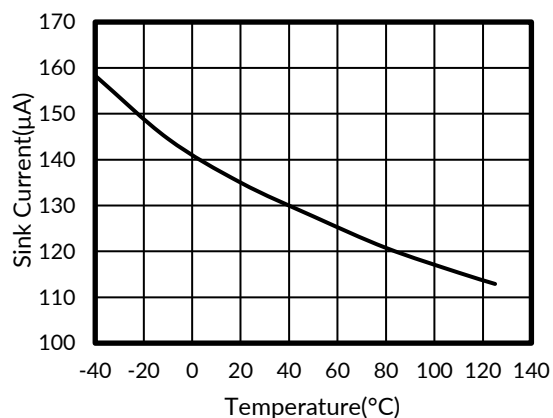
**Figure 6. Quiescent Current vs Temperature**



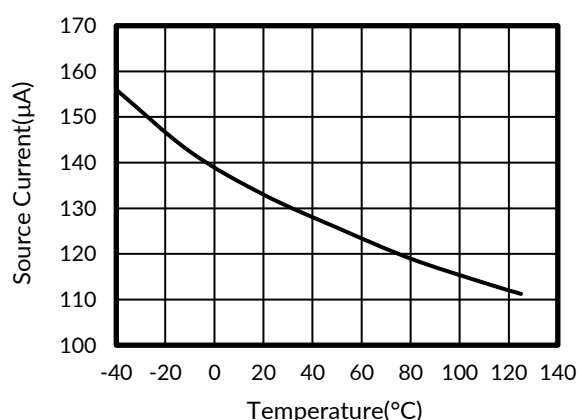
## Typical Characteristics

NOTE: The graphs and tables provided following this note are a statistical summary based on a limited number of samples and are provided for informational purposes only.

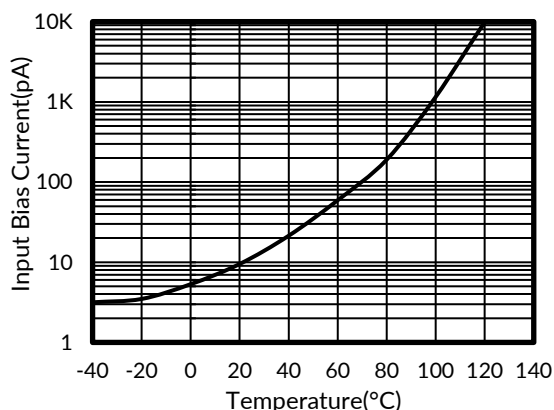
At  $T_A = +25^\circ\text{C}$ ,  $V_S = 5\text{V}$ ,  $R_L = 10\text{k}\Omega$  connected to  $V_S/2$ ,  $V_{OUT} = V_S/2$ , unless otherwise noted.



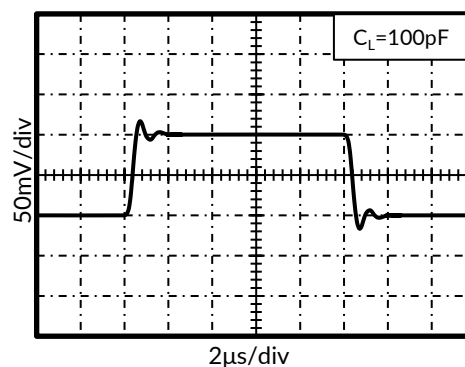
**Figure 7. Sink Current vs Temperature**



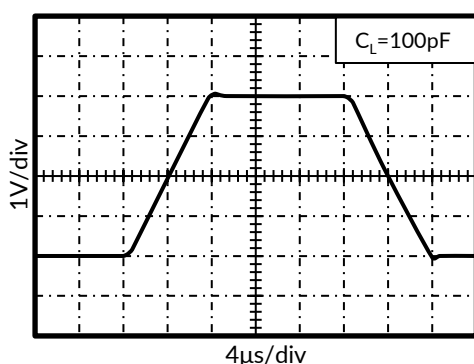
**Figure 8. Source Current vs Temperature**



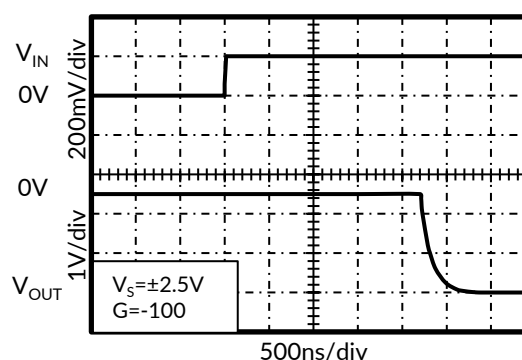
**Figure 9. Input Bias Current vs Temperature**



**Figure 10. Small-Signal Step Response**



**Figure 11. Large-Signal Step Response**

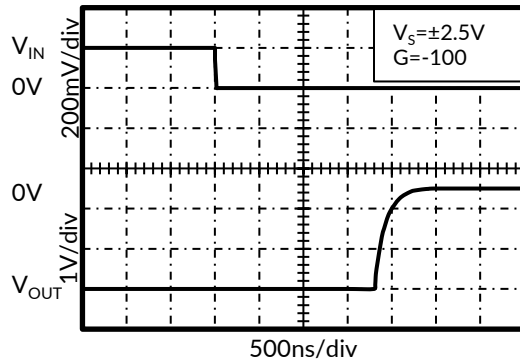


**Figure 12. Positive Overvoltage Recovery**

## Typical Characteristics

NOTE: The graphs and tables provided following this note are a statistical summary based on a limited number of samples and are provided for informational purposes only.

At  $T_A = +25^\circ\text{C}$ ,  $V_S = 5\text{V}$ ,  $R_L = 10\text{k}\Omega$  connected to  $V_S/2$ ,  $V_{OUT} = V_S/2$ , unless otherwise noted.



**Figure 13. Negative Overvoltage Recovery**

## 8 APPLICATION AND IMPLEMENTATION

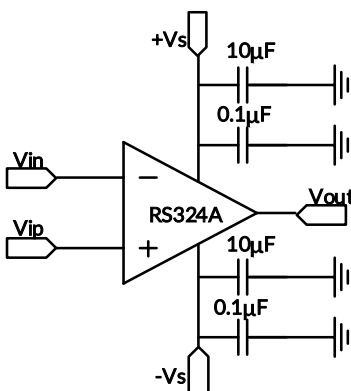
Information in the following applications sections is not part of the RUNIC component specification, and RUNIC does not warrant its accuracy or completeness. RUNIC's customers are responsible for determining suitability of components for their purposes. Customers should validate and test their design implementation to confirm system functionality.

### 8.1 Application Notes

The RS324A are high precision, rail-to-rail operational amplifiers that can be run from a single-supply voltage 2.5V to 5.5V ( $\pm 1.25\text{V}$  to  $\pm 2.75\text{V}$ ). Supply voltages higher than 7V (absolute maximum) can permanently damage the amplifier. Rail-to-rail input and output swing significantly increases dynamic range, especially in low-supply applications. Good layout practice mandates use of a  $0.1\mu\text{F}$  capacitor placed closely across the supply pins.

### 8.2 Layout Guidelines

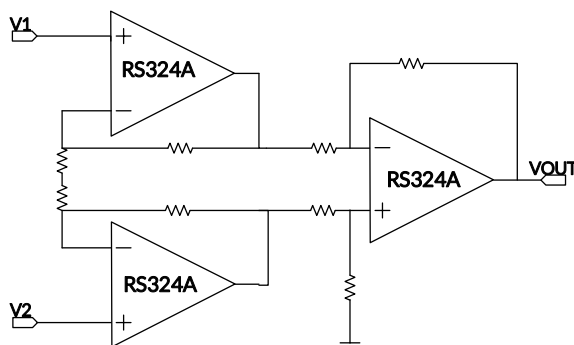
Attention to good layout practices is always recommended. Keep traces short. When possible, use a PCB ground plane with surface-mount components placed as close to the device pins as possible. Place a  $0.1\mu\text{F}$  capacitor closely across the supply pins. These guidelines should be applied throughout the analog circuit to improve performance and provide benefits such as reducing the EMI susceptibility.



**Figure 14. Amplifier with Bypass Capacitors**

### 8.3 Instrumentation Amplifier

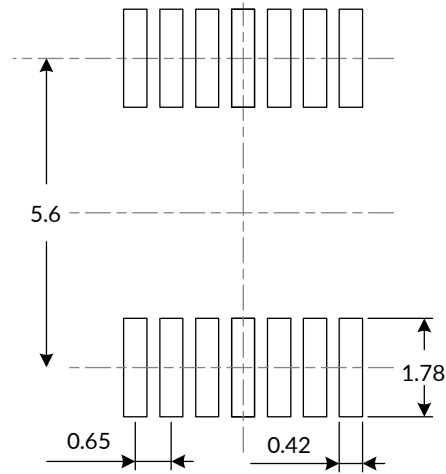
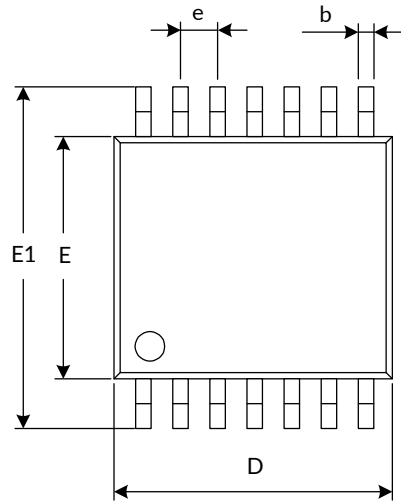
In the three-op amp, instrumentation amplifier configuration shown in Figure 15.



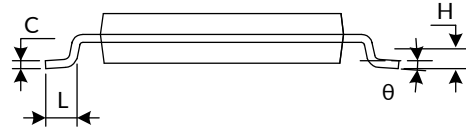
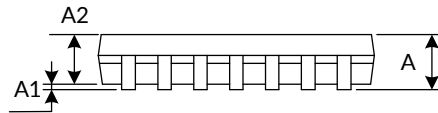
**Figure 15. Amplifier Instrumentation Amplifier**

## 9 PACKAGE OUTLINE DIMENSIONS

### TSSOP14<sup>(3)</sup>



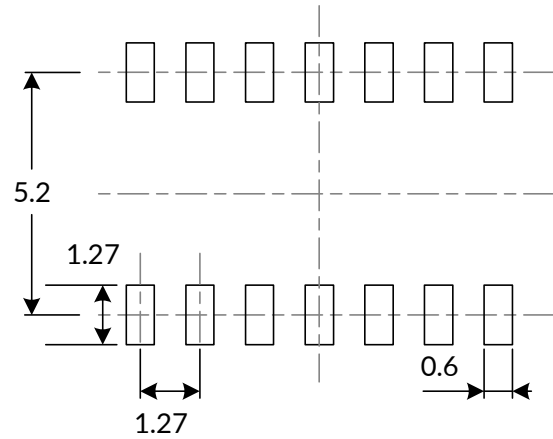
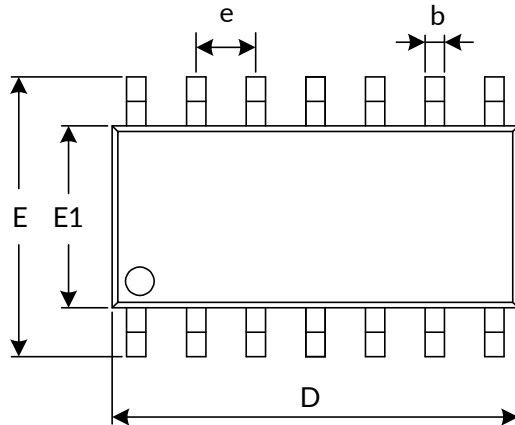
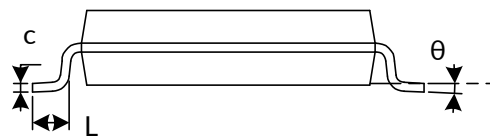
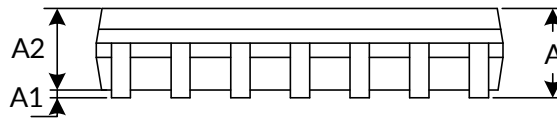
RECOMMENDED LAND PATTERN (Unit: mm)



Symbol	Dimensions In Millimeters		Dimensions In Inches	
	Min	Max	Min	Max
A <sup>(1)</sup>		1.200		0.047
A1	0.050	0.150	0.002	0.006
A2	0.800	1.050	0.031	0.041
b	0.190	0.300	0.007	0.012
c	0.090	0.200	0.004	0.008
D <sup>(1)</sup>	4.860	5.100	0.191	0.201
E <sup>(1)</sup>	4.300	4.500	0.169	0.177
E1	6.250	6.550	0.246	0.258
e	0.650(BSC) <sup>(2)</sup>		0.026(BSC) <sup>(2)</sup>	
L	0.500	0.700	0.020	0.028
H	0.250(TYP)		0.010(TYP)	
$\theta$	1°	7°	1°	7°

**NOTE:**

1. Plastic or metal protrusions of 0.15mm maximum per side are not included.
2. BSC (Basic Spacing between Centers), "Basic" spacing is nominal.
3. This drawing is subject to change without notice.

**SOP14<sup>(3)</sup>**

**RECOMMENDED LAND PATTERN (Unit: mm)**


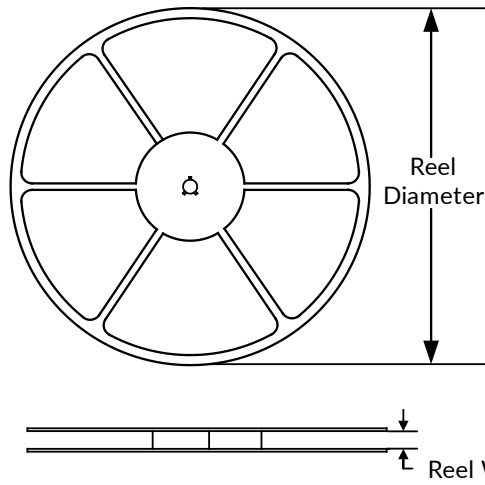
Symbol	Dimensions In Millimeters		Dimensions In Inches	
	Min	Max	Min	Max
A <sup>(1)</sup>	1.350	1.750	0.053	0.069
A1	0.100	0.250	0.004	0.010
A2	1.350	1.550	0.053	0.061
b	0.310	0.510	0.012	0.020
c	0.100	0.250	0.004	0.010
D <sup>(1)</sup>	8.450	8.850	0.333	0.348
e	1.270(BSC) <sup>(2)</sup>		0.050(BSC) <sup>(2)</sup>	
E	5.800	6.200	0.228	0.244
E1 <sup>(1)</sup>	3.800	4.000	0.150	0.157
L	0.400	1.270	0.016	0.050
θ	0°	8°	0°	8°

**NOTE:**

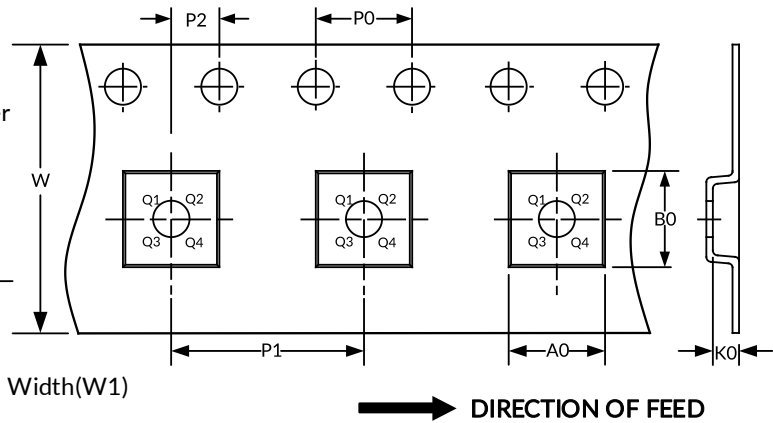
1. Plastic or metal protrusions of 0.15mm maximum per side are not included.
2. BSC (Basic Spacing between Centers), "Basic" spacing is nominal.
3. This drawing is subject to change without notice.

## 10 TAPE AND REEL INFORMATION

### REEL DIMENSIONS



### TAPE DIMENSION



NOTE: The picture is only for reference. Please make the object as the standard.

### KEY PARAMETER LIST OF TAPE AND REEL

Package Type	Reel Diameter	Reel Width(mm)	A0 (mm)	B0 (mm)	K0 (mm)	P0 (mm)	P1 (mm)	P2 (mm)	W (mm)	Pin1 Quadrant
SOP14	13"	16.4	6.60	9.30	2.10	4.0	8.0	2.0	16.0	Q1
TSSOP14	13"	12.4	6.95	5.60	1.20	4.0	8.0	2.0	12.0	Q1

NOTE:

1. All dimensions are nominal.
2. Plastic or metal protrusions of 0.15mm maximum per side are not included.

## **IMPORTANT NOTICE AND DISCLAIMER**

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