

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

1 FEATURES

- **HIGH GAIN BANDWIDTH:1.1MHz**
- **RAIL-TO-RAIL INPUT AND OUTPUT**
±0.8mV Typical Vos
- **INPUT VOLTAGE RANGE: -0.1V to +5.6V**
with Vs = 5.5V
- **SUPPLY RANGE: +2.2V to +5.5V**
- **SHUTDOWN: RS321S/RS358S**
- **SPECIFIED UP TO +125°C**
- **Micro SIZE PACKAGES: SOT23-5, SOT23-6**

2 APPLICATIONS

- **SENSORS**
- **PHOTODIODE AMPLIFICATION**
- **ACTIVE FILTERS**
- **TEST EQUIPMENT**
- **DRIVING A/D CONVERTERS**

3 DESCRIPTIONS

The RS321, RS358, RS324, RS321S, RS358S families of 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 0.5V/us. The op-amps are unity gain stable and feature an ultra-low input bias current.

The devices are ideal for sensor interfaces, active filters and portable applications. The RS321S, RS358S include a shutdown mode. Under logic control, the amplifiers can be switched from normal operation to a standby current that is less than 1uA. The RS321, RS358, RS324, RS321S, RS358S families of operational amplifiers are specified at the full temperature range of -40°C to +125°C under single or dual power supplies of 2.2V to 5.5V.

Device Information (1)

| PART NUMBER | PACKAGE | BODY SIZE(NOM) |
|-------------|----------|----------------|
| RS321 | SOT23-5 | 2.90mm×1.60mm |
| | SOP8 | 4.90mm×3.90mm |
| | MSOP8 | 3.00mm×3.00mm |
| RS321S | SOT23-6 | 2.90mm×1.60mm |
| | SOP8 | 4.90mm×3.90mm |
| RS358 | SOP8 | 4.90mm×3.90mm |
| | MSOP8 | 3.00mm×3.00mm |
| | DFN2X2-8 | 2.00mm×2.00mm |
| RS358S | MSOP10 | 3.00mm×3.00mm |
| RS324 | 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.

Table of Contents

| | |
|--|----|
| 1 FEATURES | 1 |
| 2 APPLICATIONS | 1 |
| 3 DESCRIPTIONS | 1 |
| 4 Revision History | 3 |
| 5 PACKAGE/ORDERING INFORMATION ⁽¹⁾ | 4 |
| 6 Pin Configuration and Functions (Top View) | 5 |
| 7 SPECIFICATIONS | 8 |
| 7.1 Absolute Maximum Ratings | 8 |
| 7.2 ESD Ratings | 8 |
| 7.3 Recommended Operating Conditions | 9 |
| 7.4 ELECTRICAL CHARACTERISTICS | 10 |
| 7.5 TYPICAL CHARACTERISTICS | 12 |
| 8 Application and Implementation | 15 |
| 8.1 APPLICATION NOTES | 15 |
| 8.2 RS321S/RS358S ENABLE FUNCTION | 15 |
| 8.3 LAYOUT GUIDELINS | 15 |
| 8.4 INSTRUMENTATION AMPLIFIER | 15 |
| 9 PACKAGE OUTLINE DIMENSIONS | 16 |
| 10 TAPE AND REEL INFORMATION | 24 |

4 Revision History

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

| Version | Change Date | Change Item |
|---------|-------------|--|
| C.2 | 2021/11/11 | (1) Added the DFN2X2-8 package (2) Added the information of package size (3) Update Package Qty on Page 2@RevC.1 |
| C.3 | 2023/09/22 | (1) Added Pin Description (2) Update ELECTRICAL CHARACTERISTICS on Page 9@RevC.2 |
| C.3.1 | 2024/03/04 | Modify packaging naming |

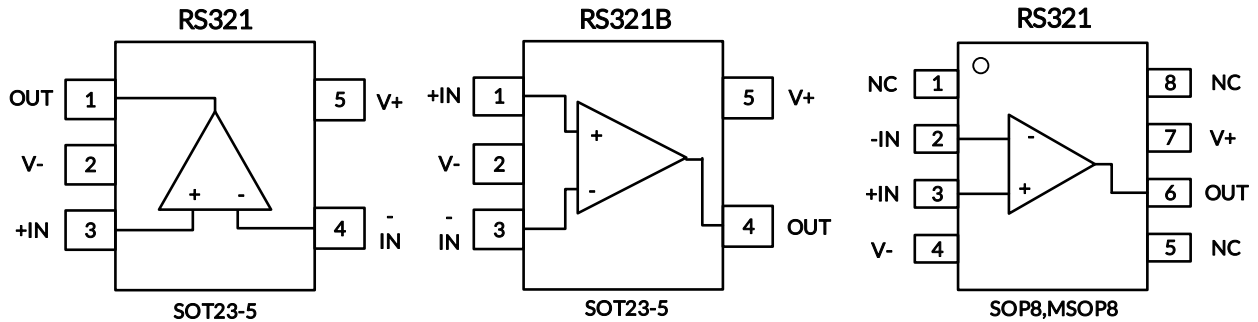
5 PACKAGE/ORDERING INFORMATION ⁽¹⁾

| Orderable Device | Package Type | Pin | Channel | Op Temp(°C) | Device Marking ⁽²⁾ | Package Qty |
|------------------|--------------|-----|---------|--------------|-------------------------------|--------------------|
| RS321XF | SOT23-5 | 5 | 1 | -40°C ~125°C | 321 | Tape and Reel,3000 |
| RS321BXF | SOT23-5 | 5 | 1 | -40°C ~125°C | 321B | Tape and Reel,3000 |
| RS321XK | SOP8 | 8 | 1 | -40°C ~125°C | RS321 | Tape and Reel,4000 |
| RS321XM | MSOP8 | 8 | 1 | -40°C ~125°C | RS321 | Tape and Reel,4000 |
| RS321SXK | SOP8 | 8 | 1 | -40°C ~125°C | RS321S | Tape and Reel,4000 |
| RS321SXH | SOT23-6 | 6 | 1 | -40°C ~125°C | 321S | Tape and Reel,3000 |
| RS358XK | SOP8 | 8 | 2 | -40°C ~125°C | RS358 | Tape and Reel,4000 |
| RS358XM | MSOP8 | 8 | 2 | -40°C ~125°C | RS358 | Tape and Reel,4000 |
| RS358XTDE8 | DFN2X2-8 | 8 | 2 | -40°C ~125°C | 358 | Tape and Reel,3000 |
| RS358SXN | MSOP10 | 10 | 2 | -40°C ~125°C | RS358S | Tape and Reel,4000 |
| RS324XP | SOP14 | 14 | 4 | -40°C ~125°C | RS324 | Tape and Reel,4000 |
| RS324XQ | TSSOP14 | 14 | 4 | -40°C ~125°C | RS324 | 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.

6 Pin Configuration and Functions (Top View)

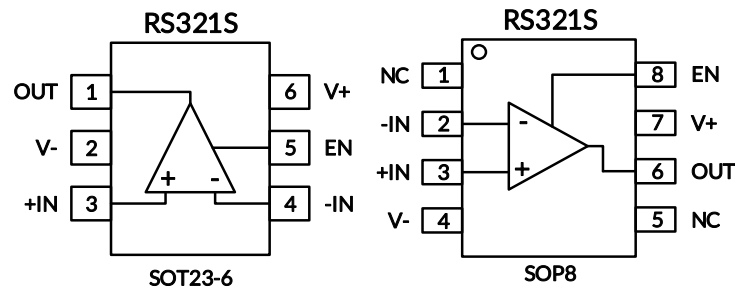


Pin Description

| NAME | PIN | | | I/O ⁽¹⁾ | DESCRIPTION |
|-------------------|---------|---------|------------|--------------------|---|
| | RS321 | RS321B | RS321 | | |
| | SOT23-5 | SOT23-5 | SOP8/MSOP8 | | |
| -IN | 4 | 3 | 2 | I | Negative (inverting) input |
| +IN | 3 | 1 | 3 | I | Positive (noninverting) input |
| NC ⁽²⁾ | - | - | 1,5,8 | - | No internal connection (can be left floating) |
| OUT | 1 | 4 | 6 | O | Output |
| V- | 2 | 2 | 4 | - | Negative (lowest) power supply |
| V+ | 5 | 5 | 7 | - | Positive (highest) power supply |

(1) I = Input, O = Output.

(2) There is no internal connection. Typically, GND is the recommended connection to a heat spreading plane.



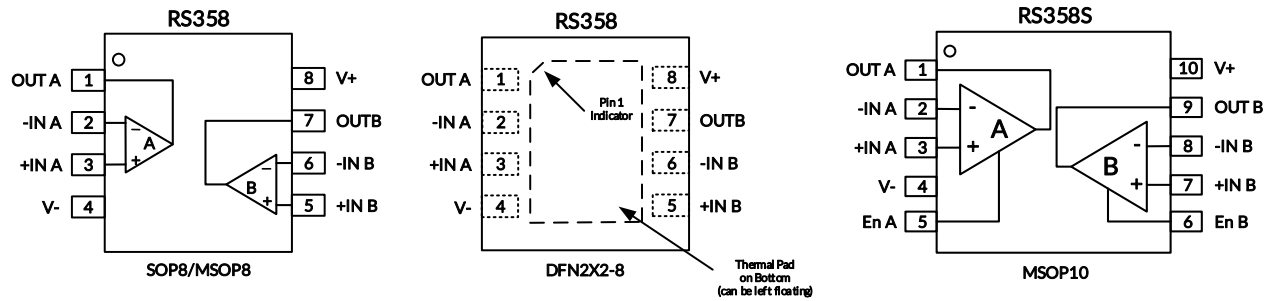
Pin Description

| NAME | PIN | | I/O ⁽¹⁾ | DESCRIPTION |
|-------------------|---------|------|--------------------|--|
| | RS321S | | | |
| | SOT23-6 | SOP8 | | |
| -IN | 4 | 2 | I | Inverting input |
| +IN | 3 | 3 | I | Noninverting input |
| OUT | 1 | 6 | O | Output |
| EN | 5 | 8 | I | Enable pin. This pin turns the regulator on or off. Low = disabled, high = normal operation (pin must be driven) |
| NC ⁽²⁾ | - | 1,5 | - | No internal connection (can be left floating) |
| V- | 2 | 4 | - | Negative (lowest) power supply |
| V+ | 6 | 7 | - | Positive (highest) power supply |

(1) I = Input, O = Output.

(2) There is no internal connection. Typically, GND is the recommended connection to a heat spreading plane.

Pin Configuration and Functions (Top View)

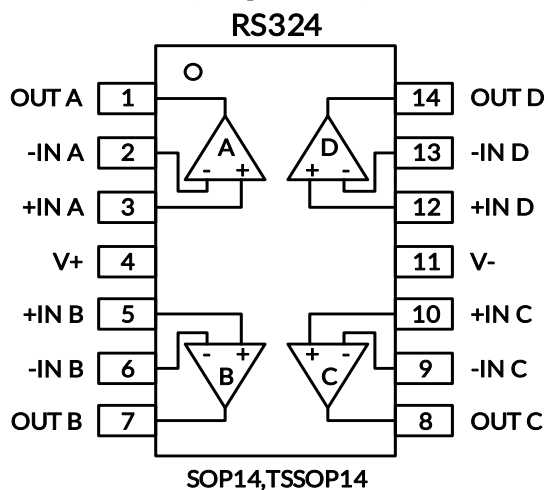


Pin Description

| NAME | PIN | | I/O ⁽¹⁾ | DESCRIPTION |
|------|-------------------------|--------|--------------------|---|
| | RS358 | RS358S | | |
| | SOP8/MSOP8/ DFN2X2-8 | MSOP10 | | |
| -INA | 2 | 2 | I | Inverting input, channel A |
| +INA | 3 | 3 | I | Noninverting input, channel A |
| -INB | 6 | 8 | I | Inverting input, channel B |
| +INB | 5 | 7 | I | Noninverting input, channel B |
| OUTA | 1 | 1 | O | Output, channel A |
| OUTB | 7 | 9 | O | Output, channel B |
| EnA | - | 5 | I | Enable pin, channel A. This pin turns the regulator on or off. Low = disabled, high = normal operation (pin must be driven) |
| EnB | - | 6 | I | Enable pin, channel B. This pin turns the regulator on or off. Low = disabled, high = normal operation (pin must be driven) |
| V- | 4 | 4 | - | Negative (lowest) power supply |
| V+ | 8 | 10 | - | Positive (highest) power supply |
| - | Thermal Pad | - | - | Connect thermal pad to V- |

(1) I = Input, O = Output.

Pin Configuration and Functions (Top View)



Pin Description

| NAME | PIN | I/O ⁽¹⁾ | 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) ⁽¹⁾

| | | MIN | MAX | UNIT |
|---------------|--|------------|-----------|------|
| Voltage | Supply, $V_s=(V+) - (V-)$ | | 7 | V |
| | Signal input pin ⁽²⁾ | (V-)-0.5 | (V+) +0.5 | |
| | Signal output pin ⁽³⁾ | (V-)-0.5 | (V+) +0.5 | |
| Current | Signal input pin ⁽²⁾ | -10 | 10 | mA |
| | Signal output pin ⁽³⁾ | -100 | 100 | mA |
| | Output short-circuit ⁽⁴⁾ | Continuous | | |
| θ_{JA} | Package thermal impedance ⁽⁵⁾ | SOT23-5 | 230 | °C/W |
| | | SOP8 | 110 | |
| | | MSOP8 | 170 | |
| | | SOP14 | 105 | |
| | | TSSOP14 | 90 | |
| | | SOT23-6 | 230 | |
| | | DFN2X2-8 | 80 | |
| MSOP10 | 200 | | | |
| Temperature | Operating range, T_A | -40 | 125 | °C |
| | Junction, T_J ⁽⁶⁾ | -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 ± 100 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) | ± 5000 |
| | | Machine Model (MM) | ± 400 |



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 | 2.2 | | 5.5 | V |
| | Dual-supply | ± 1.1 | | ± 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 $V_{OUT} = V_S/2$, $V_{CM} = V_S/2$, Full ⁽⁹⁾ = -40°C to $+125^\circ\text{C}$, unless otherwise noted.) ⁽¹⁾

| PARAMETER | CONDITIONS | T_J | RS321S, RS358S, RS321, RS358, RS324 | | | | |
|---|--|--|--|--------------------|--------------------|---------------|------------------------------|
| | | | MIN ⁽²⁾ | TYP ⁽³⁾ | MAX ⁽²⁾ | UNIT | |
| POWER SUPPLY | | | | | | | |
| V_S | Operating Voltage Range | 25°C | 2.2 | | 5.5 | V | |
| I_Q | Quiescent Current Per Amplifier | 25°C | | 60 | 80 | μA | |
| PSRR | Power-Supply Rejection Ratio | $V_S = 2.2\text{V}$ to 5.5V , $V_{CM} = (V_-) + 0.5\text{V}$ | 25°C | 62 | 85 | dB | |
| | | Full | 58 | | | | |
| INPUT | | | | | | | |
| V_{OS} | Input Offset Voltage | $V_{CM} = V_S/2$ | 25°C | -4.5 | ± 0.8 | 4.5 | mV |
| $V_{OS} T_C$ | Input Offset Voltage Average Drift | $V_{CM} = V_S/2$ | Full | | ± 2.9 | | $\mu\text{V}/^\circ\text{C}$ |
| I_B | Input Bias Current ⁽⁴⁾⁽⁵⁾ | | 25°C | ± 1 | ± 10 | | pA |
| I_{OS} | Input Offset Current ⁽⁴⁾ | | 25°C | ± 1 | ± 10 | | pA |
| V_{CM} | Common-Mode Voltage Range | $V_S = 5.5\text{V}$ | 25°C | -0.1 | | 5.6 | V |
| CMRR | Common-Mode Rejection Ratio | $V_S = 5.5\text{V}$, $V_{CM} = -0.1\text{V}$ to 4V | 25°C | 65 | 80 | dB | |
| | | | Full | 62 | | | |
| | | $V_S = 5.5\text{V}$, $V_{CM} = -0.1\text{V}$ to 5.6V | 25°C | 57 | 75 | | |
| | | | Full | 55 | | | |
| OUTPUT | | | | | | | |
| A_{OL} | Open-Loop Voltage Gain | $R_L = 2\text{k}\Omega$, $V_O = 0.15\text{V}$ to 4.85V | 25°C | 75 | 95 | dB | |
| | | | Full | 72 | | | |
| | | $R_L = 10\text{k}\Omega$, $V_O = 0.05\text{V}$ to 4.95V | 25°C | 85 | 100 | | |
| | | | Full | 82 | | | |
| | Output Swing from Rail | $R_L = 2\text{k}\Omega$ | 25°C | | 26 | mV | |
| | | $R_L = 10\text{k}\Omega$ | | | 8 | | |
| I_{OUT} | Output Short-Circuit Current ⁽⁶⁾⁽⁷⁾ | | 25°C | | ± 54 | | mA |
| FREQUENCY RESPONSE | | | | | | | |
| SR | Slew Rate ⁽⁸⁾ | | 25°C | | 0.5 | | V/ μs |
| GBP | Gain-Bandwidth Product | | 25°C | | 1.1 | | MHz |
| PM | Phase Margin | | 25°C | | 64 | | $^\circ$ |
| t_S | Settling Time, 0.1% | | | | 1.3 | | μs |
| | Overload Recovery Time | $V_{IN} \cdot \text{Gain} \geq V_S$ | | | 2.3 | | μs |
| NOISE | | | | | | | |
| e_n | Input Voltage Noise Density | $f = 1\text{KHz}$ | 25°C | | 23 | | $\text{nV}/\sqrt{\text{Hz}}$ |
| | | $f = 10\text{KHz}$ | 25°C | | 20 | | $\text{nV}/\sqrt{\text{Hz}}$ |
| ENABLE/SHUTDOWN (RS321S, RS358S) | | | | | | | |
| $I_{Q(OFF)}$ | Supply Current in Shutdown | | 25°C | | <1 | | μA |
| t_{OFF} | | | 25°C | | 3 | | μs |
| t_{ON} | | | 25°C | | 20 | | μs |
| V_L | Shut Down | | 25°C | V_- | | $(V_-) + 0.8$ | V |
| V_H | Amplifier is Active | | 25°C | $(V_-) + 2$ | | V_+ | V |

NOTE:

- (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°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 $T_{J(MAX)}$, $R_{\theta JA}$, and T_A . The maximum allowable power dissipation at any ambient temperature is $PD = (T_{J(MAX)} - T_A) / R_{\theta JA}$. 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.

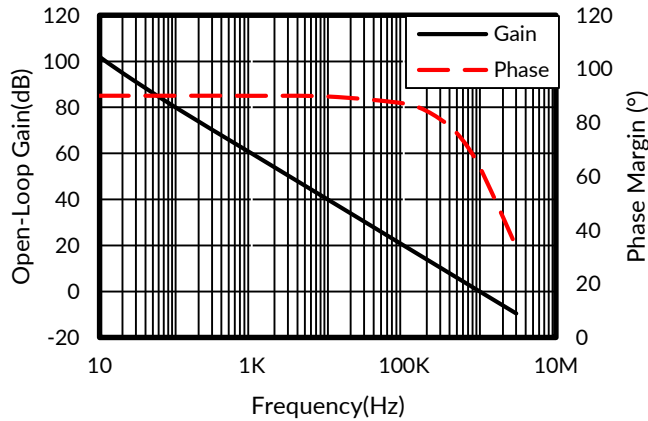


Figure 1. Open-Loop Gain and Phase vs Frequency

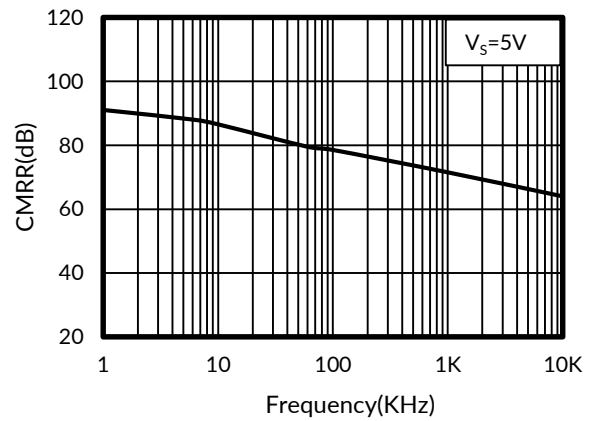


Figure 2. Common-Mode Rejection Ratio vs Frequency

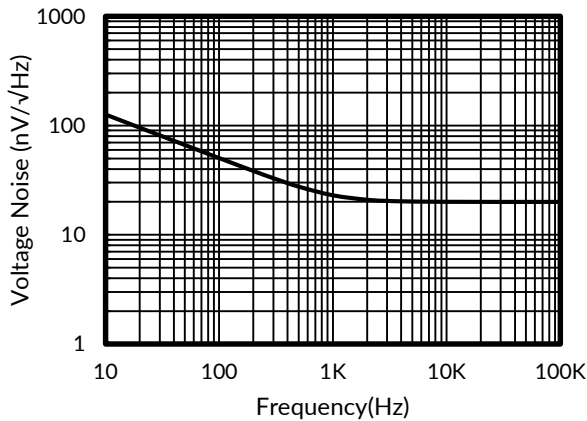


Figure 3. Input Voltage Noise Spectral Density vs Frequency

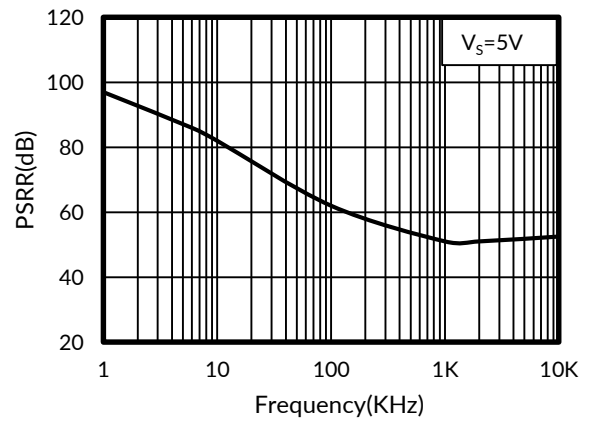


Figure 4. Power-Supply Rejection Ratio vs Frequency

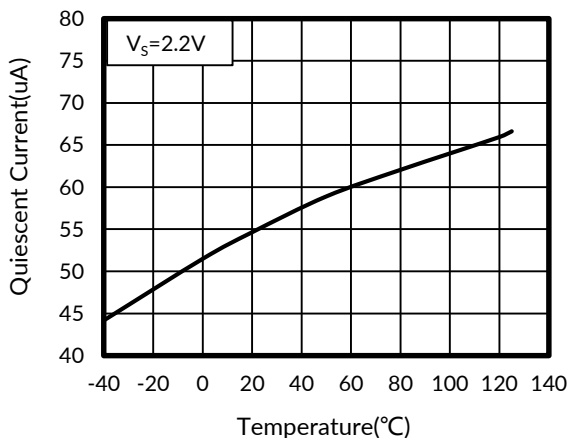


Figure 5. Quiescent Current vs Temperature

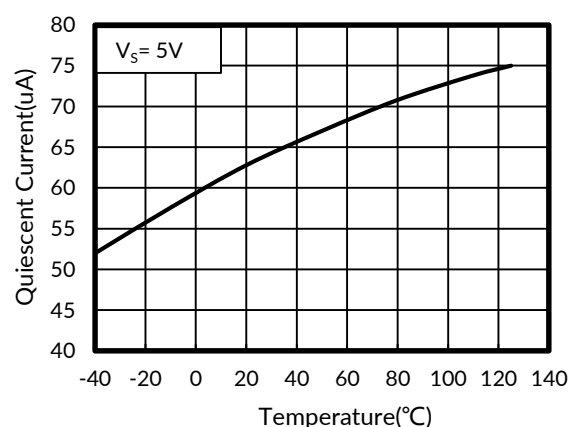


Figure 6. Quiescent Current vs Temperature

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.

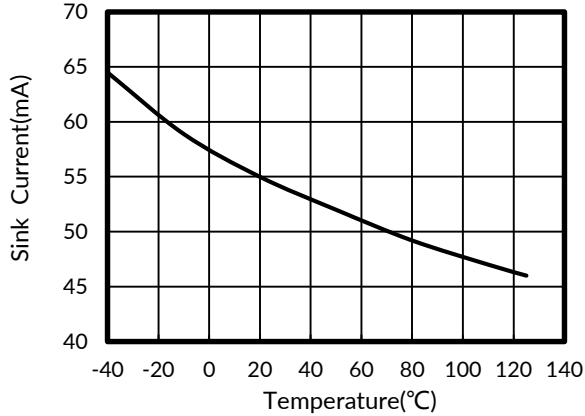


Figure 7. Sink Current vs Temperature

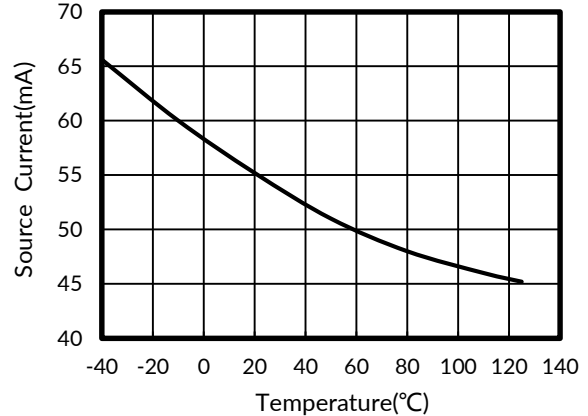


Figure 8. Source Current vs Temperature

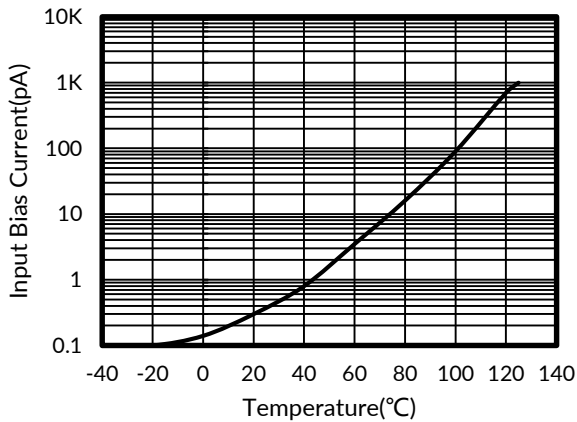


Figure 9. Input Bias Current vs Temperature

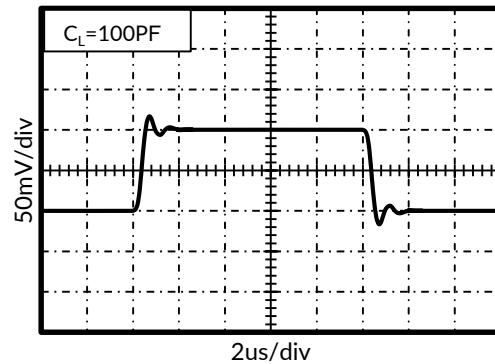


Figure 10. Small-Signal Step Response

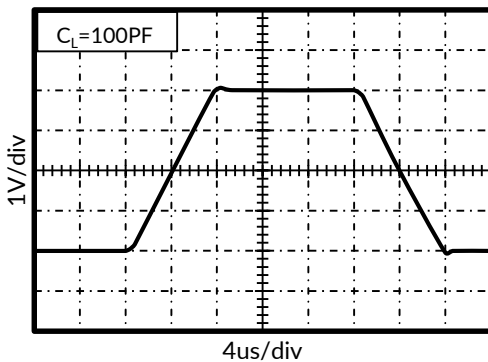


Figure 11. Large-Signal Step Response

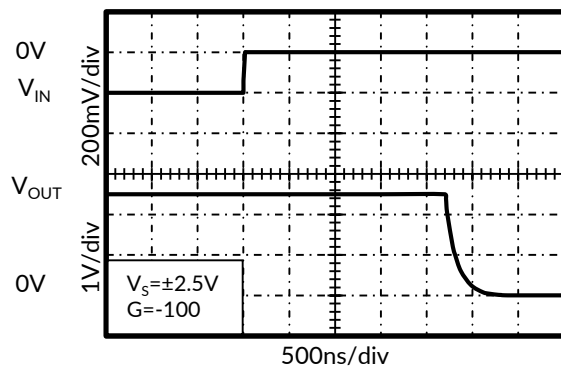


Figure 12. Positive Overvoltage Recovery

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.

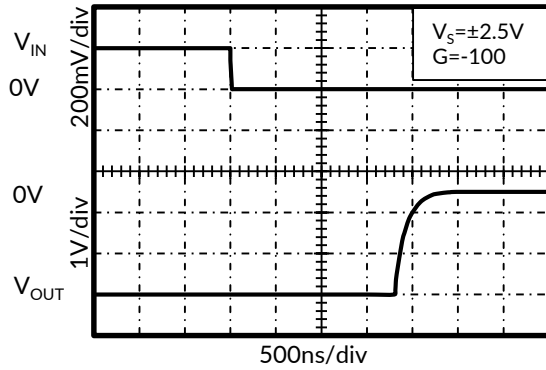


Figure 13. Negative Overvoltage Recovery

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 RS321, RS358, RS324, RS321S, RS358S are high precision, rail-to-rail operational amplifiers that can be run from a single-supply voltage 2.2V to 5.5V ($\pm 1.1V$ to $\pm 2.75V$). 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 μF capacitor placed closely across the supply pins.

8.2 RS321S/RS358S ENABLE FUNCTION

The RS321S/RS358S includes a shutdown mode. Under logic control, the amplifiers can be switched from normal mode to a standby current of 1 μA . When the Enable pin is connected to high, the amplifier is active. Connecting Enable low disables the amplifier, and places the amplifier, and place the output in a high-impedance state.

8.3 LAYOUT GUIDELINS

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 μF 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.

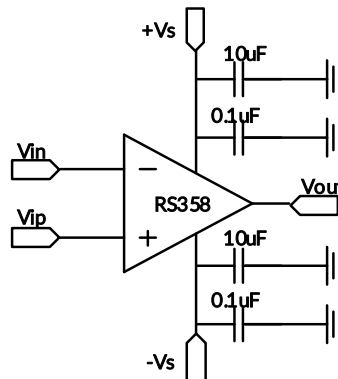


Figure 14. Amplifier with Bypass Capacitors

8.4 INSTRUMENTATION AMPLIFIER

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

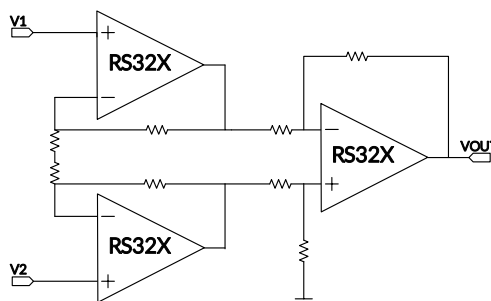
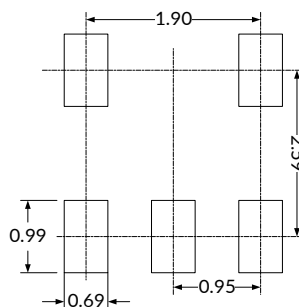
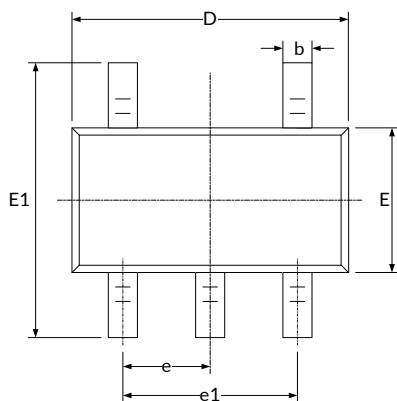


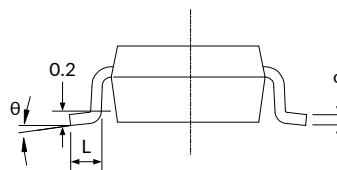
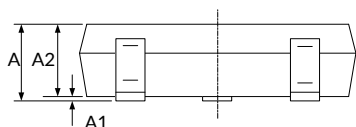
Figure 15. Amplifier instrumentation amplifier

9 PACKAGE OUTLINE DIMENSIONS

SOT23-5⁽³⁾



RECOMMENDED LAND PATTERN (Unit: mm)

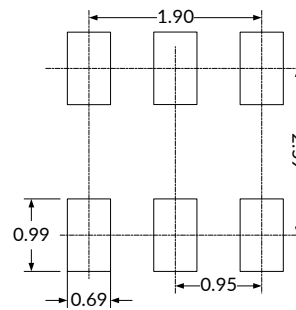
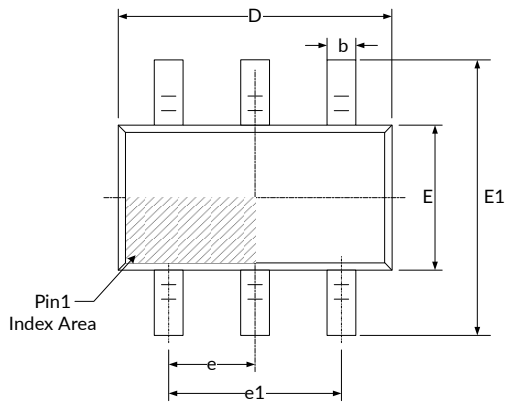


| Symbol | Dimensions In Millimeters | | Dimensions In Inches | |
|------------------|---------------------------|-------|---------------------------|-------|
| | Min | Max | Min | Max |
| A ⁽¹⁾ | 1.050 | 1.250 | 0.041 | 0.049 |
| A1 | 0.000 | 0.100 | 0.000 | 0.004 |
| A2 | 1.050 | 1.150 | 0.041 | 0.045 |
| b | 0.300 | 0.500 | 0.012 | 0.020 |
| c | 0.100 | 0.200 | 0.004 | 0.008 |
| D ⁽¹⁾ | 2.820 | 3.020 | 0.111 | 0.119 |
| E ⁽¹⁾ | 1.500 | 1.700 | 0.059 | 0.067 |
| E1 | 2.650 | 2.950 | 0.104 | 0.116 |
| e | 0.950(BSC) ⁽²⁾ | | 0.037(BSC) ⁽²⁾ | |
| e1 | 1.800 | 2.000 | 0.071 | 0.079 |
| L | 0.300 | 0.600 | 0.012 | 0.024 |
| θ | 0° | 8° | 0° | 8° |

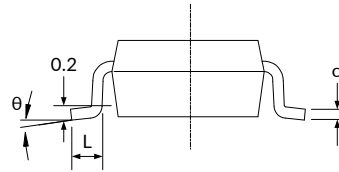
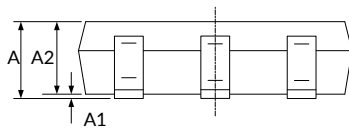
NOTE:

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.

SOT23-6⁽³⁾



RECOMMENDED LAND PATTERN (Unit: mm)

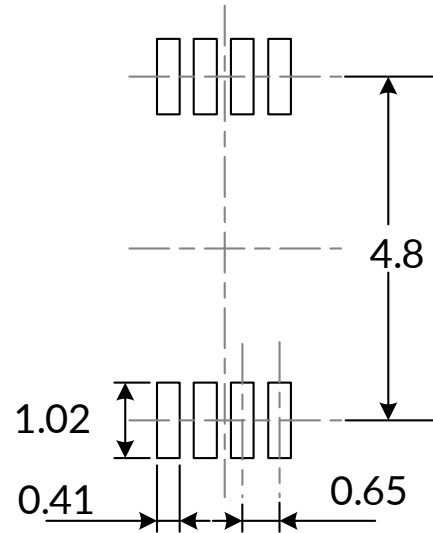
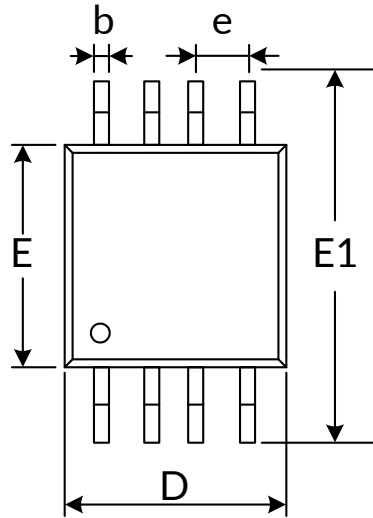


| Symbol | Dimensions In Millimeters | | Dimensions In Inches | |
|------------------|---------------------------|-------|---------------------------|-------|
| | Min | Max | Min | Max |
| A ⁽¹⁾ | 1.050 | 1.250 | 0.041 | 0.049 |
| A1 | 0.000 | 0.100 | 0.000 | 0.004 |
| A2 | 1.050 | 1.150 | 0.041 | 0.045 |
| b | 0.300 | 0.500 | 0.012 | 0.020 |
| c | 0.100 | 0.200 | 0.004 | 0.008 |
| D ⁽¹⁾ | 2.820 | 3.020 | 0.111 | 0.119 |
| E ⁽¹⁾ | 1.500 | 1.700 | 0.059 | 0.067 |
| E1 | 2.650 | 2.950 | 0.104 | 0.116 |
| e | 0.950(BSC) ⁽²⁾ | | 0.037(BSC) ⁽²⁾ | |
| e1 | 1.800 | 2.000 | 0.071 | 0.079 |
| L | 0.300 | 0.600 | 0.012 | 0.024 |
| θ | 0° | 8° | 0° | 8° |

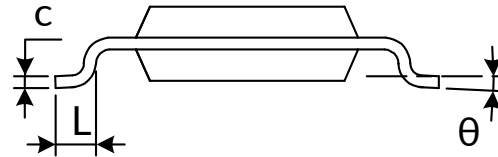
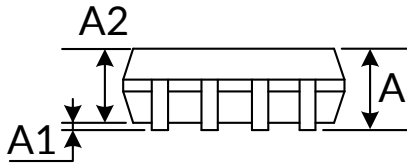
NOTE:

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.

MSOP8⁽³⁾



RECOMMENDED LAND PATTERN (Unit: mm)

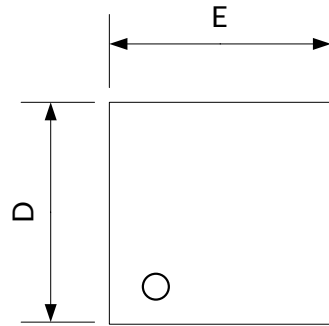


| Symbol | Dimensions In Millimeters | | Dimensions In Inches | |
|------------------|---------------------------|-------|---------------------------|-------|
| | Min | Max | Min | Max |
| A ⁽¹⁾ | 0.820 | 1.100 | 0.032 | 0.043 |
| A1 | 0.020 | 0.150 | 0.001 | 0.006 |
| A2 | 0.750 | 0.950 | 0.030 | 0.037 |
| b | 0.250 | 0.380 | 0.010 | 0.015 |
| c | 0.090 | 0.230 | 0.004 | 0.009 |
| D ⁽¹⁾ | 2.900 | 3.100 | 0.114 | 0.122 |
| e | 0.650(BSC) ⁽²⁾ | | 0.026(BSC) ⁽²⁾ | |
| E ⁽¹⁾ | 2.900 | 3.100 | 0.114 | 0.122 |
| E1 | 4.750 | 5.050 | 0.187 | 0.199 |
| L | 0.400 | 0.800 | 0.016 | 0.031 |
| θ | 0° | 6° | 0° | 6° |

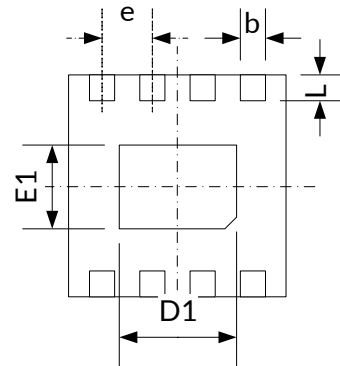
NOTE:

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.

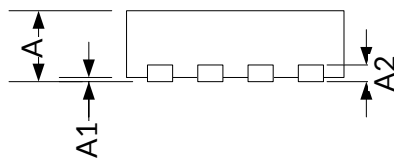
DFN2X2-8 (2)



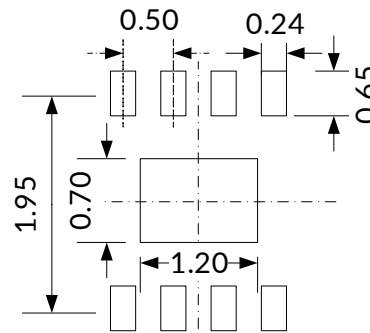
TOP VIEW



BOTTOM VIEW



SIDE VIEW



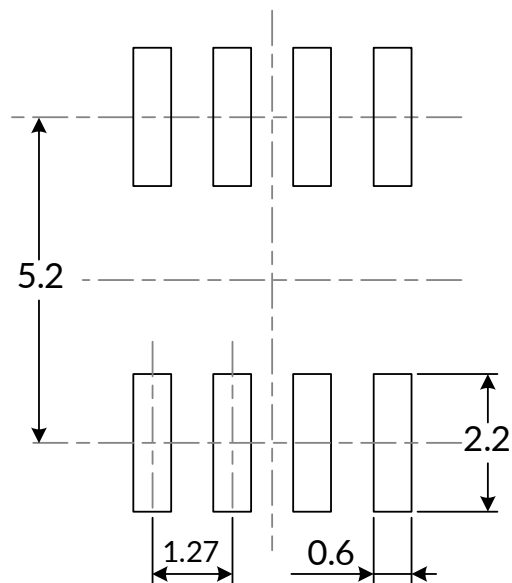
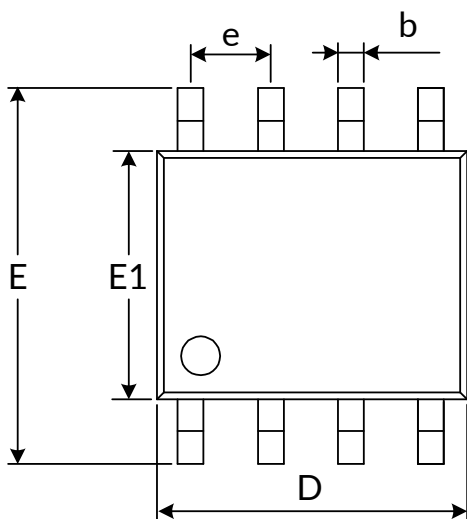
RECOMMENDED LAND
PATTERN (Unit: mm)

| Symbol | Dimensions In Millimeters | | Dimensions In Inches | |
|------------------|---------------------------|-------|----------------------|-------|
| | Min | Max | Min | Max |
| A ⁽¹⁾ | 0.700 | 0.800 | 0.028 | 0.031 |
| A1 | 0.000 | 0.050 | 0.000 | 0.002 |
| A2 | 0.203(TYP) | | 0.008(TYP) | |
| b | 0.180 | 0.300 | 0.007 | 0.012 |
| D ⁽¹⁾ | 1.900 | 2.100 | 0.075 | 0.083 |
| D1 | 1.100 | 1.300 | 0.043 | 0.051 |
| E ⁽¹⁾ | 1.900 | 2.100 | 0.075 | 0.083 |
| E1 | 0.600 | 0.800 | 0.024 | 0.031 |
| e | 0.500(TYP) | | 0.020(TYP) | |
| L | 0.250 | 0.450 | 0.010 | 0.018 |

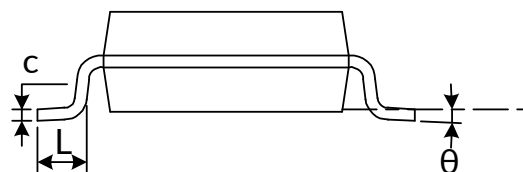
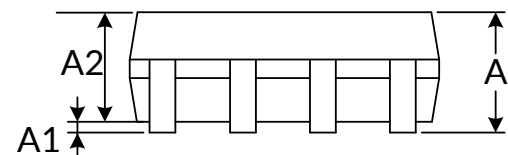
NOTE:

1. Plastic or metal protrusions of 0.075mm maximum per side are not included.
2. This drawing is subject to change without notice.

SOP8⁽³⁾



RECOMMENDED LAND PATTERN (Unit: mm)

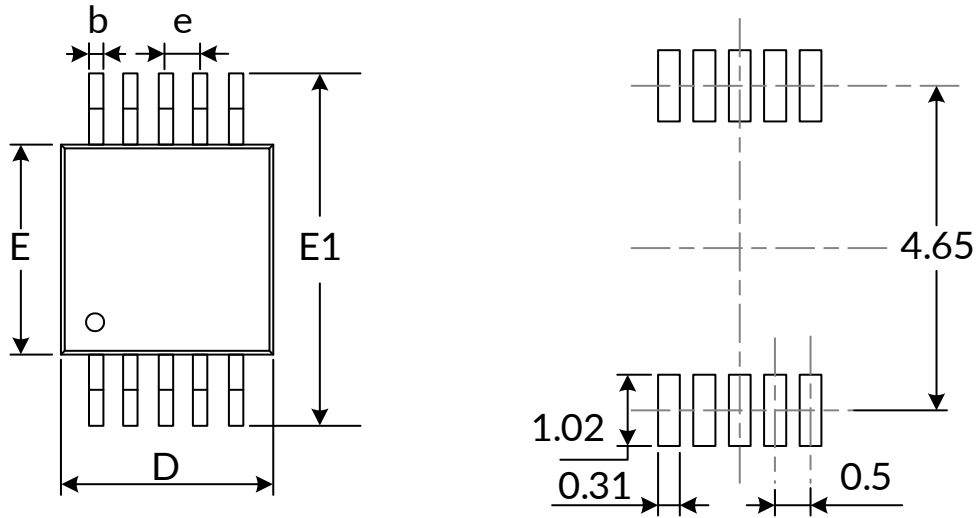


| Symbol | Dimensions In Millimeters | | Dimensions In Inches | |
|-------------------|---------------------------|-------|---------------------------|-------|
| | Min | Max | Min | Max |
| A ⁽¹⁾ | 1.350 | 1.750 | 0.053 | 0.069 |
| A1 | 0.100 | 0.250 | 0.004 | 0.010 |
| A2 | 1.350 | 1.550 | 0.053 | 0.061 |
| b | 0.330 | 0.510 | 0.013 | 0.020 |
| c | 0.170 | 0.250 | 0.007 | 0.010 |
| D ⁽¹⁾ | 4.800 | 5.000 | 0.189 | 0.197 |
| e | 1.270(BSC) ⁽²⁾ | | 0.050(BSC) ⁽²⁾ | |
| E | 5.800 | 6.200 | 0.228 | 0.244 |
| E1 ⁽¹⁾ | 3.800 | 4.000 | 0.150 | 0.157 |
| L | 0.400 | 1.270 | 0.016 | 0.050 |
| θ | 0° | 8° | 0° | 8° |

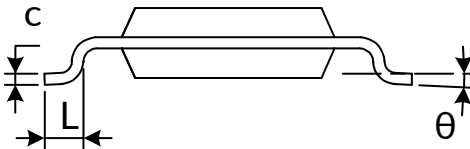
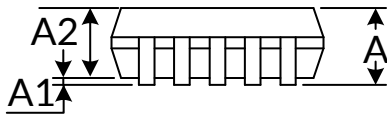
NOTE:

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.

MSOP10⁽³⁾



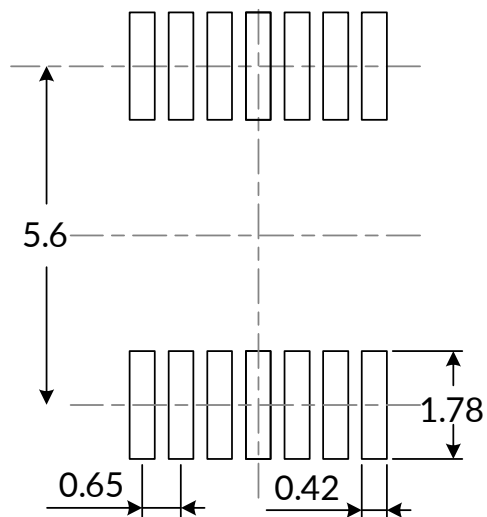
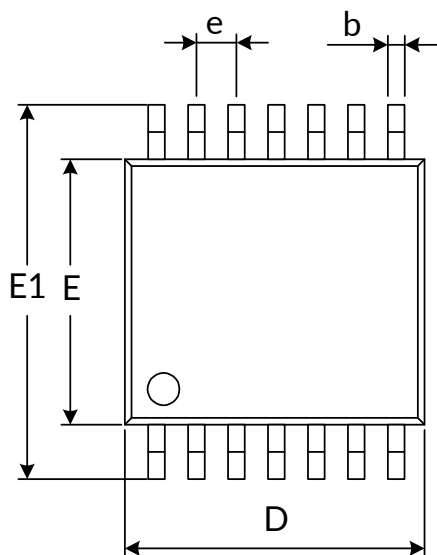
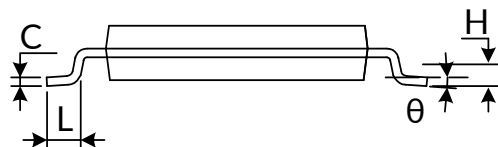
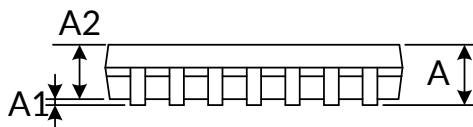
RECOMMENDED LAND PATTERN (Unit: mm)



| Symbol | Dimensions In Millimeters | | Dimensions In Inches | |
|------------------|---------------------------|-------|---------------------------|-------|
| | Min | Max | Min | Max |
| A ⁽¹⁾ | 0.820 | 1.100 | 0.032 | 0.043 |
| A1 | 0.020 | 0.150 | 0.001 | 0.006 |
| A2 | 0.750 | 0.950 | 0.030 | 0.037 |
| b | 0.180 | 0.280 | 0.007 | 0.011 |
| c | 0.090 | 0.230 | 0.004 | 0.009 |
| D ⁽¹⁾ | 2.900 | 3.100 | 0.114 | 0.122 |
| e | 0.50(BSC) ⁽²⁾ | | 0.020(BSC) ⁽²⁾ | |
| E ⁽¹⁾ | 2.900 | 3.100 | 0.114 | 0.122 |
| E1 | 4.750 | 5.050 | 0.187 | 0.199 |
| L | 0.400 | 0.800 | 0.016 | 0.031 |
| θ | 0° | 6° | 0° | 6° |

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.

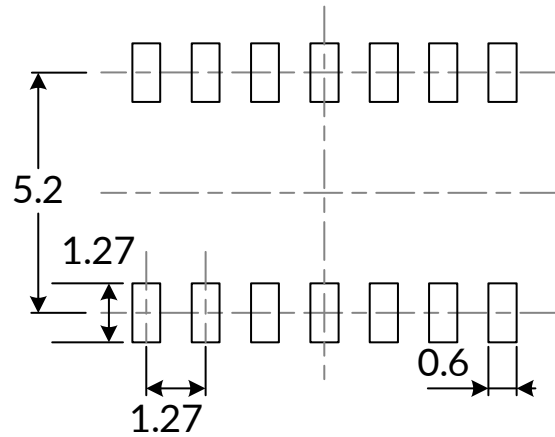
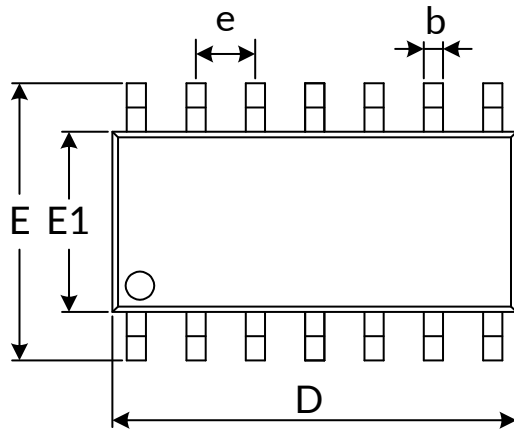
TSSOP14 (3)

RECOMMENDED LAND PATTERN (Unit: mm)


| Symbol | Dimensions In Millimeters | | Dimensions In Inches | |
|------------------|---------------------------|-------|---------------------------|-------|
| | Min | Max | Min | Max |
| A ⁽¹⁾ | | 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 ⁽¹⁾ | 4.860 | 5.100 | 0.191 | 0.201 |
| E ⁽¹⁾ | 4.300 | 4.500 | 0.169 | 0.177 |
| E1 | 6.250 | 6.550 | 0.246 | 0.258 |
| e | 0.650(BSC) ⁽²⁾ | | 0.026(BSC) ⁽²⁾ | |
| L | 0.500 | 0.700 | 0.020 | 0.028 |
| H | 0.25(TYP) | | 0.01(TYP) | |
| θ | 1° | 7° | 1° | 7° |

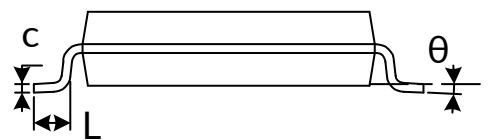
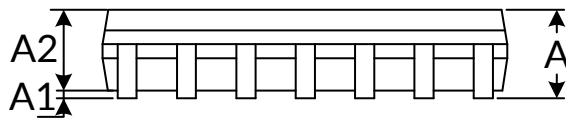
NOTE:

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 (3)



RECOMMENDED LAND PATTERN (Unit: mm)



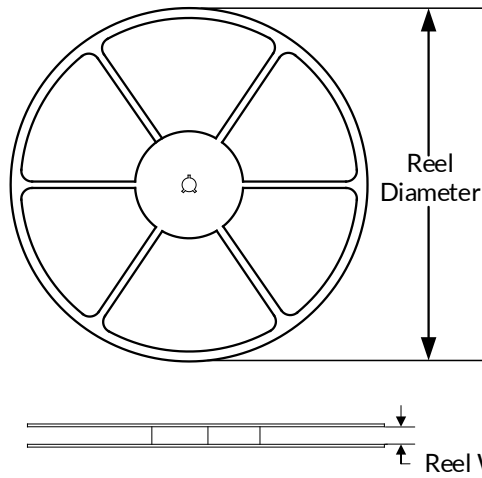
| Symbol | Dimensions In Millimeters | | Dimensions In Inches | |
|-------------------|---------------------------|-------|---------------------------|-------|
| | Min | Max | Min | Max |
| A ⁽¹⁾ | 1.350 | 1.750 | 0.053 | 0.069 |
| A1 | 0.100 | 0.250 | 0.004 | 0.010 |
| A2 | 1.350 | 1.550 | 0.053 | 0.061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

NOTE:

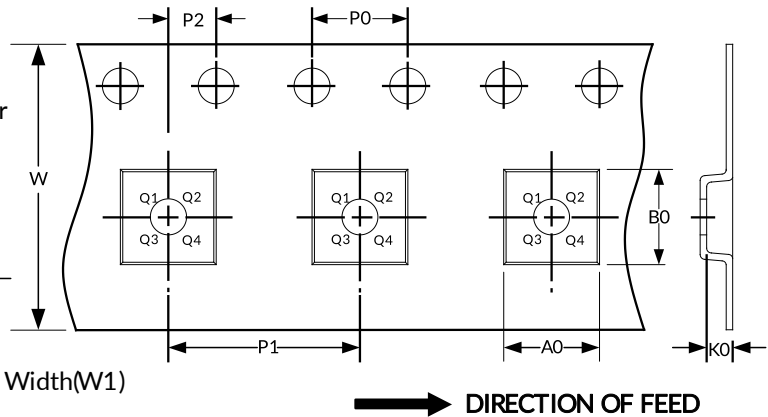
1. Plastic or metal protrusions of 0.15mm maximum per side are not included.
2. BSC (Basic Spacing between Centers), "Basic" spacing is nominal.
3. This drawing is subject to change without notice.

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 |
|--------------|---------------|----------------|---------|---------|---------|---------|---------|---------|--------|---------------|
| SOT23-5 | 7" | 9.5 | 3.20 | 3.20 | 1.40 | 4.0 | 4.0 | 2.0 | 8.0 | Q3 |
| SOT23-6 | 7" | 9.5 | 3.17 | 3.23 | 1.37 | 4.0 | 4.0 | 2.0 | 8.0 | Q3 |
| SOP8 | 13" | 12.4 | 6.40 | 5.40 | 2.10 | 4.0 | 8.0 | 2.0 | 12.0 | Q1 |
| MSOP8 | 13" | 12.4 | 5.20 | 3.30 | 1.50 | 4.0 | 8.0 | 2.0 | 12.0 | Q1 |
| DFN2X2-8 | 7" | 9.5 | 2.30 | 2.30 | 1.10 | 4.0 | 4.0 | 2.0 | 8.0 | Q2 |
| MSOP10 | 13" | 12.4 | 5.20 | 3.30 | 1.20 | 4.0 | 8.0 | 2.0 | 12.0 | Q1 |
| 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.

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