

1.4MHz, Rail-to-Rail I/O CMOS Operational Amplifier

1 FEATURES

- **Qualified for Automotive Applications**
- **AEC-Q100 Qualified with the Grade 1**
- **HIGH GAIN BANDWIDTH: 1.4MHz**
- **RAIL-TO-RAIL INPUT AND OUTPUT**
±0.1mV Typical Vos
- **INPUT VOLTAGE RANGE: -0.1V to +5.6V**
with Vs = 5.5V
- **SUPPLY RANGE: +2.2V to +5.5V**
- **SPECIFIED UP TO +125°C**
- **Micro SIZE PACKAGES: SC70-5, SOP8, MSOP8, SOP14, TSSOP14**

2 APPLICATIONS

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

3 DESCRIPTIONS

The RS6331-Q1, RS6332-Q1, RS6334-Q1 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 (1.4MHz) 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 RS6331-Q1, RS6332-Q1, RS6334-Q1 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)
RS6331-Q1	SC70-5	2.07mm×1.30mm
RS6332-Q1	SOP8	4.90mm×3.90mm
	MSOP8	3.00mm×3.00mm
RS6334-Q1	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 differ from page numbers in the current version.

Version	Change Date	Change Item
A.0	2023/11/14	Preliminary version completed
A.1	2024/03/04	Initial version completed

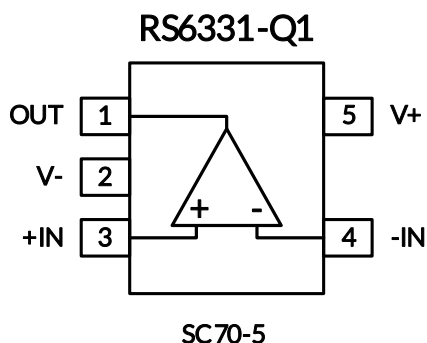
5 PACKAGE/ORDERING INFORMATION (1)

Orderable Device	Package Type	Pin	Channel	Lead finish/Ball material (2)	MSL Peak Temp (3)	Op Temp(°C)	Device Marking (4)	Package Qty
RS6331XC5-Q1	SC70-5 (5)	5	1	Plating Sn	MSL1-260°-Unlimited	-40°C ~125°C	6331	Tape and Reel,3000
RS6332PXK-Q1	SOP8	8	2	Plating Sn	MSL1-260°-Unlimited	-40°C ~125°C	RS6332P	Tape and Reel,4000
RS6332XM-Q1	MSOP8	8	2	Plating Sn	MSL1-260°-Unlimited	-40°C ~125°C	RS6332	Tape and Reel,4000
RS6334XP-Q1	SOP14	14	4	Plating Sn	MSL1-260°-Unlimited	-40°C ~125°C	RS6334	Tape and Reel,4000
RS6334XQ-Q1	TSSOP14	14	4	Plating Sn	MSL1-260°-Unlimited	-40°C ~125°C	RS6334	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) Lead finish/Ball material. Orderable Devices may have multiple material finish options. Finish options are separated by a vertical ruled line. Lead finish/Ball material values may wrap to two lines if the finish value exceeds the maximum column width.
- (3) MSL Peak Temp. The Moisture Sensitivity Level rating according to the JEDEC industry standard classifications, and peak solder temperature.
- (4) 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.
- (5) Equivalent to SOT353.

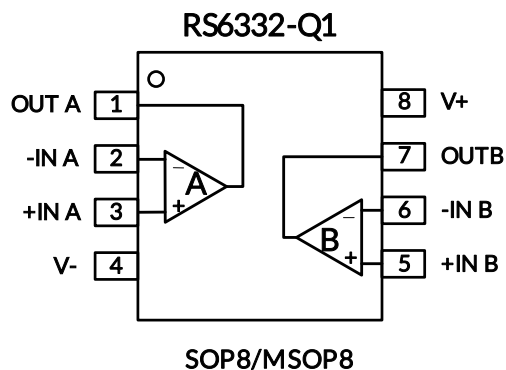
6 Pin Configuration and Functions (Top View)



Pin Description

NAME	PIN		I/O ⁽¹⁾	DESCRIPTION
	RS6331-Q1			
	SOT23-5/SC70-5			
-IN	4	I	Negative (inverting) input	
+IN	3	I	Positive (noninverting) input	
OUT	1	O	Output	
V-	2	-	Negative (lowest) power supply	
V+	5	-	Positive (highest) power supply	

(1) I = Input, O = Output.

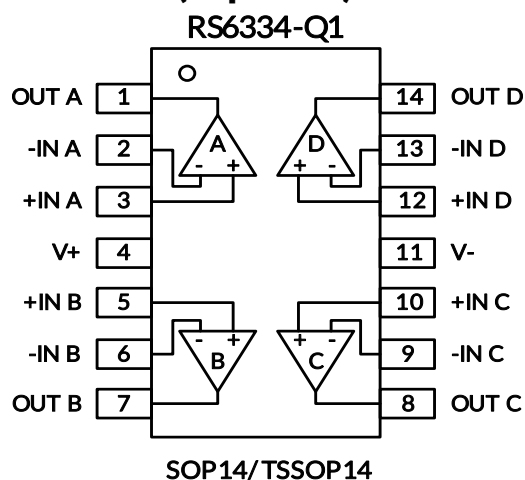


Pin Description

NAME	PIN		I/O ⁽¹⁾	DESCRIPTION
	SOP8/MSOP8			
-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	
OUTA	1	O	Output, channel A	
OUTB	7	O	Output, channel B	
V-	4	-	Negative (lowest) power supply	
V+	8	-	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⁾	-150	150	mA
	Output short-circuits ⁽⁴⁾	Continuous		
θ_{JA}	Package thermal impedance ⁽⁵⁾	SC70-5	380	°C/W
		SOP8	110	
		MSOP8	170	
		SOP14	105	
		TSSOP14	90	
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 ± 150 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 AEC Q100-002 ⁽¹⁾	± 2000	V
		Charged-Device Model (CDM), per AEC Q100-011	± 1000	
		Latch-Up (LU), per AEC Q100-004	± 100	mA

(1) AEC Q100-002 indicates that HBM stressing shall be in accordance with the ANSI/ESDA/JEDEC JS-001 specification.



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 $T_A = +25^\circ\text{C}$, $V_S = 2.2\text{V}$ to 5.5V , $R_L = 10\text{k}\Omega$ 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	RS633X-Q1				
			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	$V_S = \pm 2.5\text{V}$, $I_O = 0\text{mA}$	25°C		62	90	μA
			Full			105	
PSRR	Power-Supply Rejection Ratio	$V_S = 2.7\text{V}$ to 5.5V	25°C	74	90		dB
			Full	70			
INPUT							
V_{OS}	Input Offset Voltage	$V_{CM} = V_S/2$	25°C	-1	± 0.1	1	mV
			Full	-1.5		1.5	
$V_{OS} T_C$	Input Offset Voltage Average Drift	$V_{CM} = V_S/2$	Full		± 1		$\mu\text{V}/^\circ\text{C}$
I_B	Input Bias Current ⁽⁴⁾ ⁽⁵⁾	$V_{CM} = 0\text{V}$	25°C		± 1	± 10	μA
I_{OS}	Input Offset Current ⁽⁵⁾	$V_{CM} = 0\text{V}$	25°C		± 1	± 10	μA
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 3.5V	25°C	74	90		dB
			Full	70			
		$V_S = 5.5\text{V}$ $V_{CM} = -0.1\text{V}$ to 5.6V	25°C	60	70		
			Full	56			
OUTPUT							
A_{OL}	Open-Loop Voltage Gain	$R_L = 10\text{k}\Omega$, $V_O = (V_-) + 0.1\text{V}$ to $(V_+) - 0.1\text{V}$	25°C	110	122		dB
			Full	105			
	Output Swing From Rail	$V_S = \pm 2.5\text{V}$, $R_L = 10\text{k}\Omega$	25°C		10	20	mV
			Full			25	
I_{OUT}	Output Short-Circuit Current ⁽⁶⁾ ⁽⁷⁾		25°C	± 60	± 100		mA
			Full	± 50			
C_{LOAD}	Capacitive Load Drive				100		pF
FREQUENCY RESPONSE							
SR	Slew Rate ⁽⁸⁾	$G = +1$, $C_L = 100\text{pF}$	25°C		0.5		$\text{V}/\mu\text{s}$
GBP	Gain-Bandwidth Product		25°C		1.4		MHz
PM	Phase Margin ⁽⁵⁾		25°C		64		°
t_S	Settling Time, 0.1%	$V_S = \pm 2.5\text{V}$, $G = +1$, $C_L = 100\text{pF}$, Step = 2V	25°C		6.5		μs
t_{OR}	Overload Recovery Time	$V_{IN} \cdot \text{Gain} \geq V_S$, $G = -10$	25°C		5.3		μs
NOISE							
E_n	Input Voltage Noise	$f = 0.1\text{Hz}$ to 10Hz , $V_S = \pm 2.5\text{V}$	25°C		4.5		μV_{PP}
e_n	Input Voltage Noise Density	$f = 1\text{KHz}$	25°C		47		$\text{nV}/\sqrt{\text{Hz}}$

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) Positive current corresponds to current flowing into the device.
- (5) This parameter is ensured by design and/or characterization and is not tested in production.
- (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.

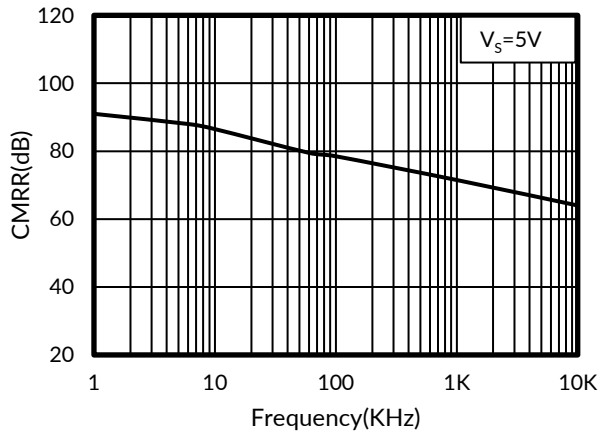


Figure 1. Common-mode Rejection Ratio vs Frequency

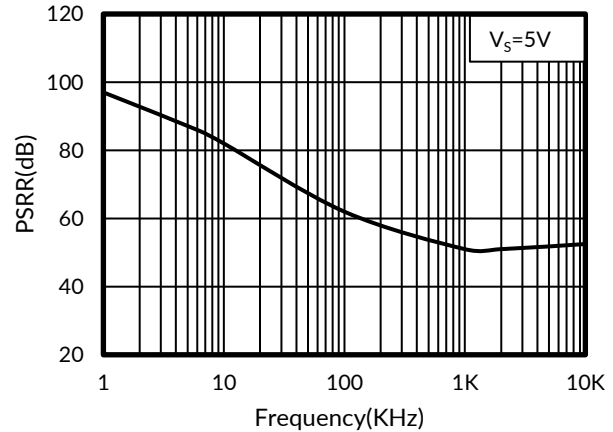


Figure 2. Power-Supply Rejection Ratio vs Frequency

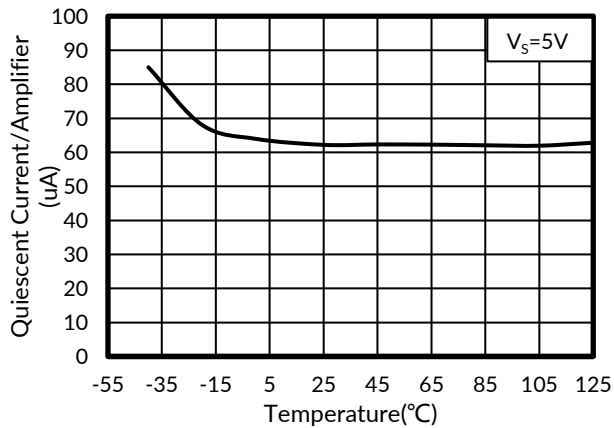


Figure 3. Quiescent Current vs Temperature

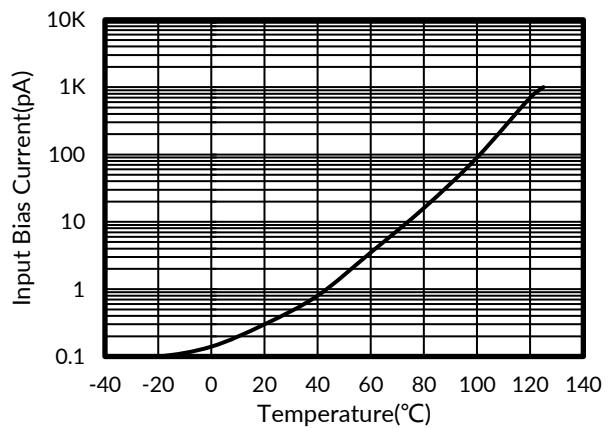


Figure 4. Input Bias Current vs Temperature

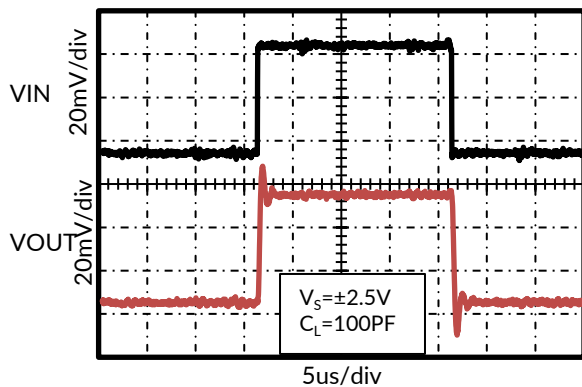


Figure 5. Small-Signal Step Response

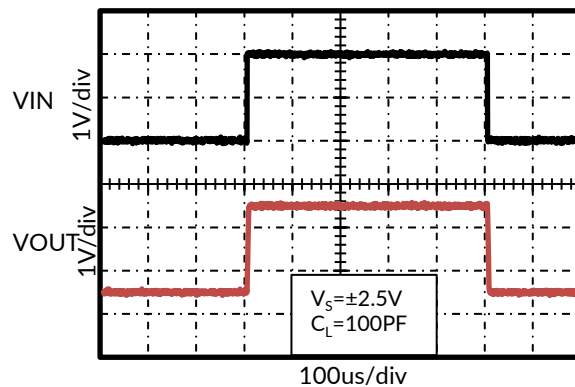


Figure 6. Large-Signal Step Response

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.

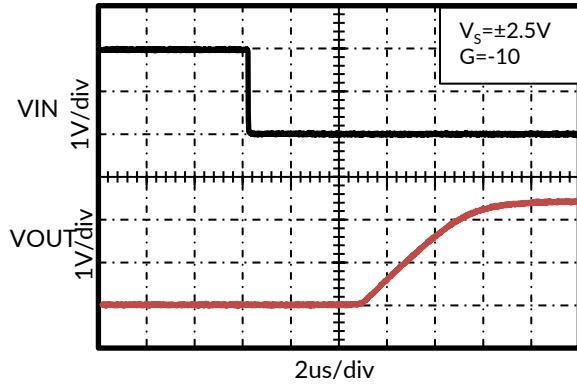


Figure 7. Negative Overvoltage Recovery

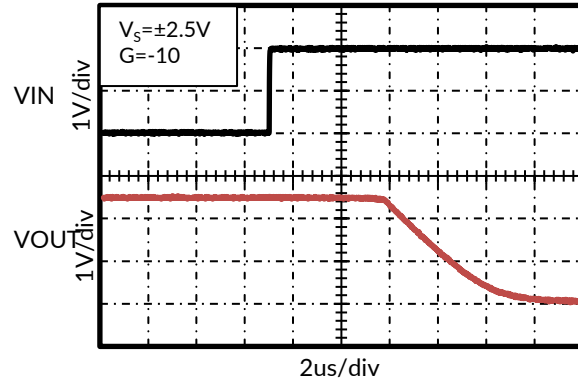


Figure 8. Positive Overvoltage Recovery

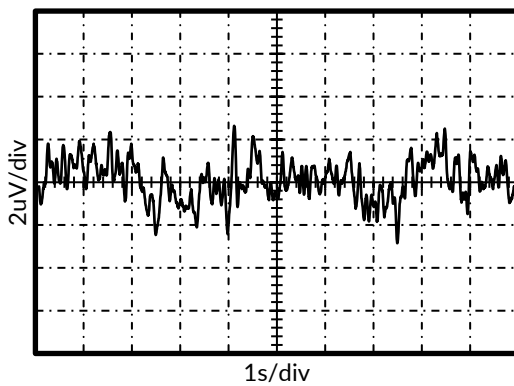


Figure 9. 0.1Hz to 10Hz Input Voltage Noise

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 RS6331-Q1, RS6332-Q1, RS6334-Q1 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 0.1uF capacitor place closely across the supply pins.

8.2 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 0.1uF 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.

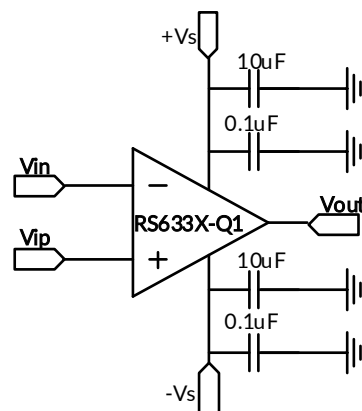


Figure 10. Amplifier with Bypass Capacitors

8.3 INSTRUMENTATION AMPLIFIER

In the three-op amp, instrumentation amplifier configuration shown in Figure 11.

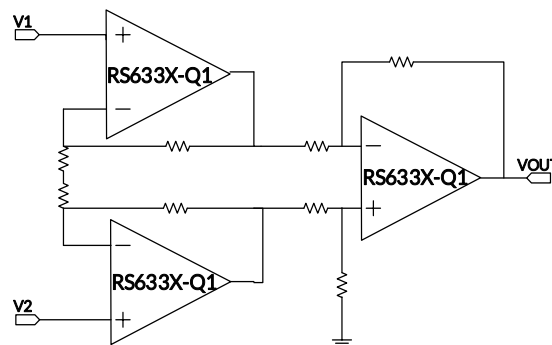
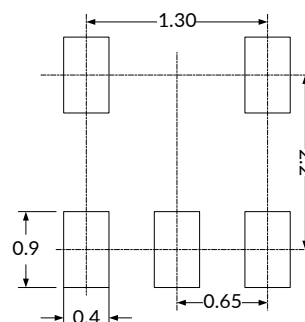
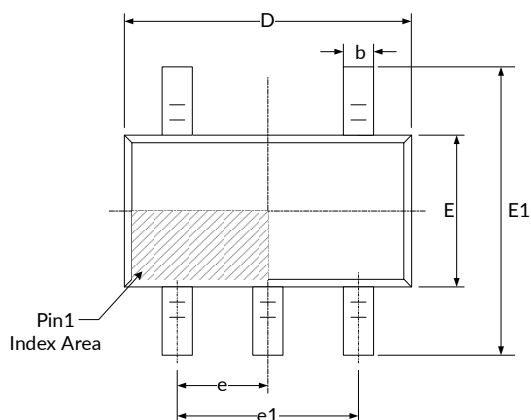
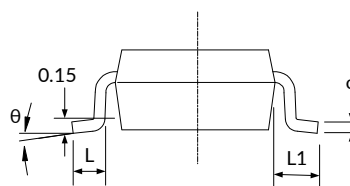
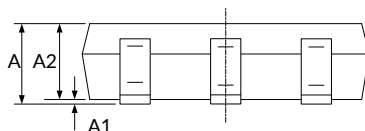


Figure 11. Amplifier instrumentation amplifier

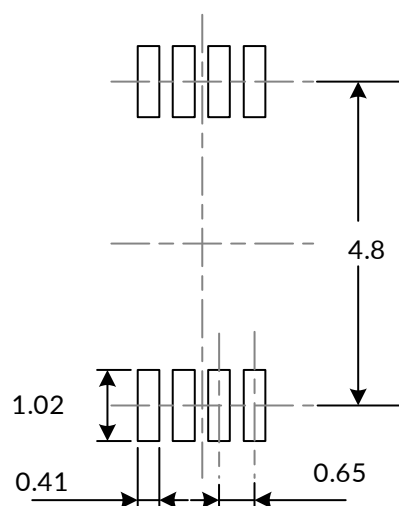
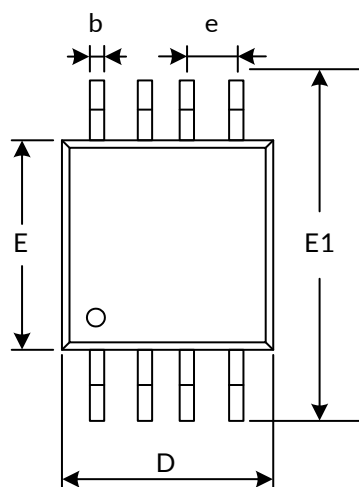
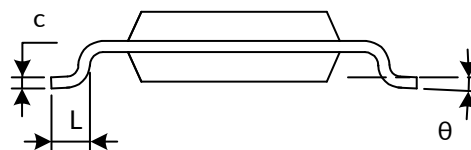
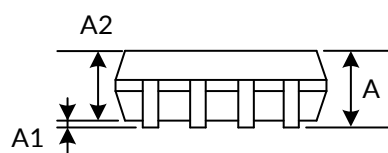
9 PACKAGE OUTLINE DIMENSIONS

SC70-5 (4)

RECOMMENDED LAND PATTERN (Unit: mm)


Symbol	Dimensions In Millimeters		Dimensions In Inches	
	Min	Max	Min	Max
A ⁽¹⁾	0.850	1.050	0.033	0.041
A1	0.000	0.100	0.000	0.004
A2	0.800	1.000	0.031	0.039
b	0.150	0.350	0.006	0.014
c	0.080	0.150	0.003	0.006
D ⁽¹⁾	2.020	2.120	0.079	0.084
E ⁽¹⁾	1.250	1.350	0.049	0.053
E1	2.200	2.400	0.087	0.094
e	0.650(BSC) ⁽²⁾		0.026(BSC) ⁽²⁾	
e1	1.300(BSC) ⁽²⁾		0.051(BSC) ⁽²⁾	
L	0.280	0.380	0.011	0.015
L1	0.500(REF) ⁽³⁾		0.020(REF) ⁽³⁾	
θ	0°	8°	0°	8°

NOTE:

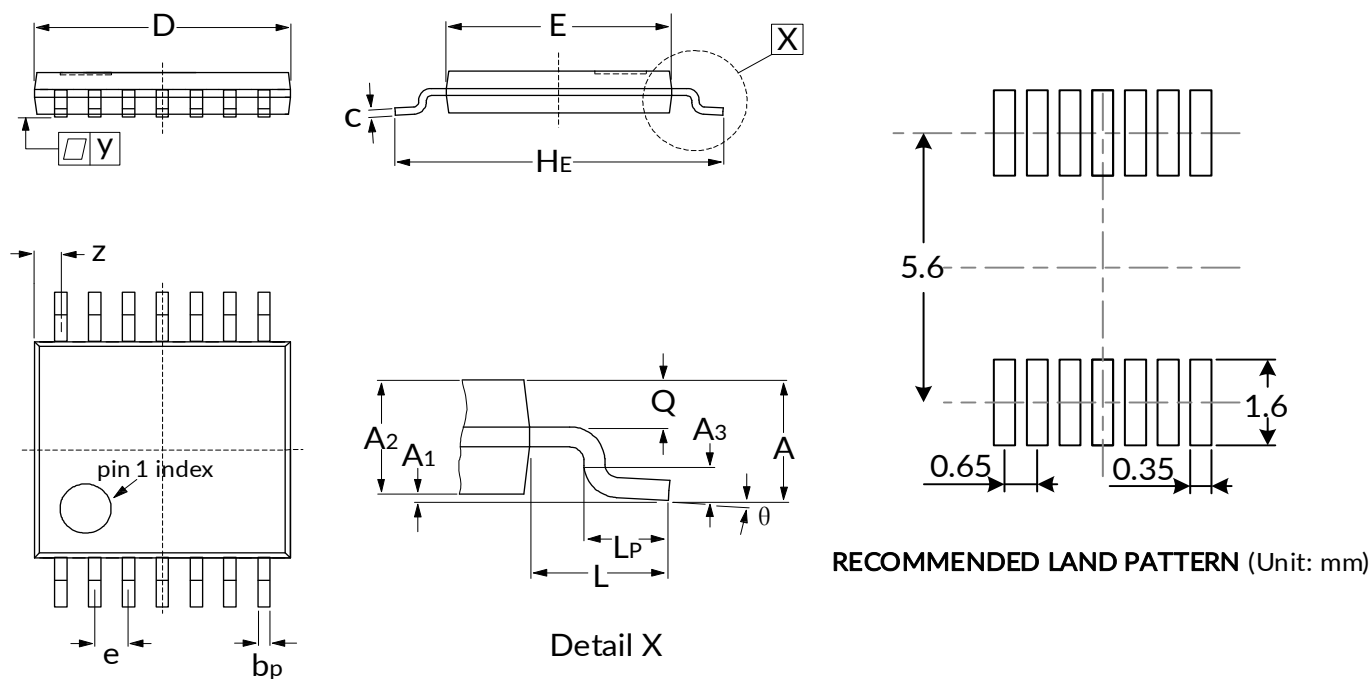
1. Plastic or metal protrusions of 0.15mm maximum per side are not included.
2. BSC (Basic Spacing between Centers), "Basic" spacing is nominal.
3. REF is the abbreviation for Reference.
4. This drawing is subject to change without notice.

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:

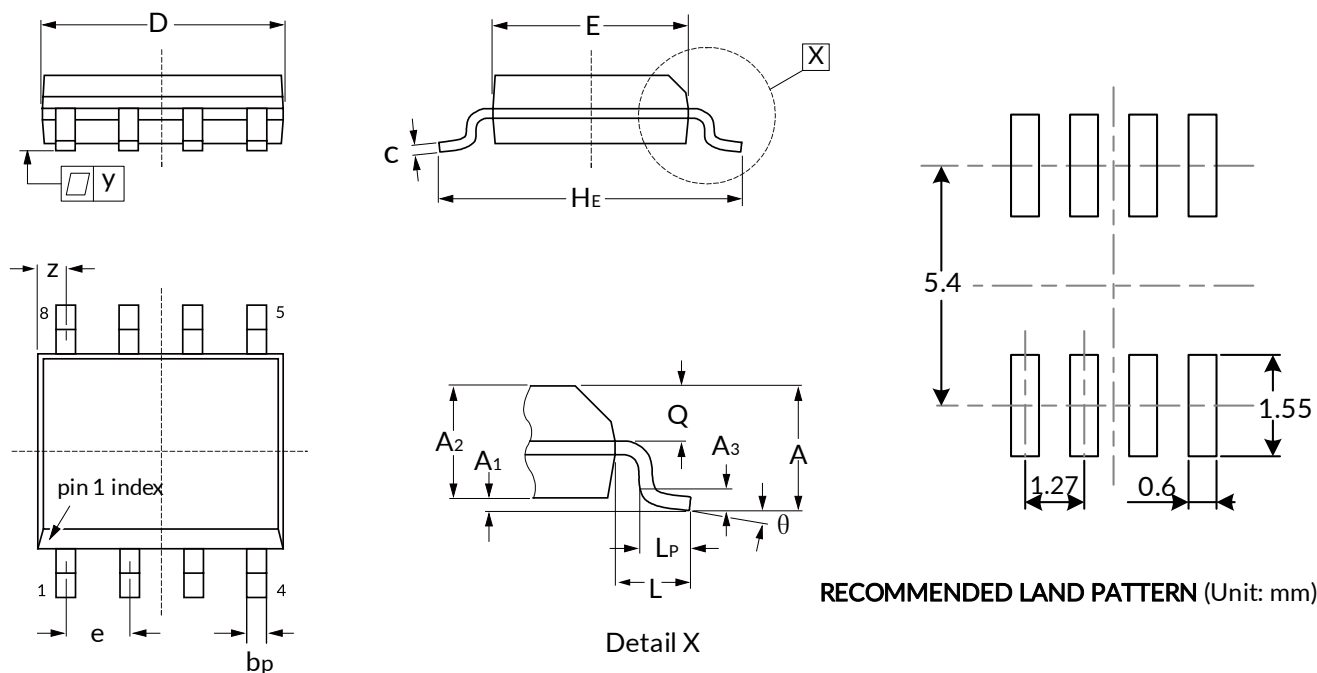
1. Plastic or metal protrusions of 0.15mm maximum per side are not included.
2. BSC (Basic Spacing between Centers), "Basic" spacing is nominal.
3. This drawing is subject to change without notice.

TSSOP14 (2)


Symbol	Dimensions In Millimeters		Dimensions In Inches	
	Min	Max	Min	Max
A ⁽¹⁾		1.100		0.043
A ₁	0.050	0.150	0.002	0.006
A ₂	0.800	0.950	0.031	0.037
A ₃	0.25		0.010	
b _p	0.190	0.300	0.007	0.012
c	0.100	0.200	0.004	0.008
D ⁽¹⁾	4.900	5.100	0.193	0.201
E ⁽¹⁾	4.300	4.500	0.169	0.177
H _E	6.200	6.600	0.244	0.260
e	0.650		0.026	
L	1		0.039	
L _P	0.500	0.750	0.020	0.030
Q	0.300	0.400	0.012	0.016
Z	0.380	0.720	0.015	0.028
y	0.1		0.004	
θ	0°	8°	0°	8°

NOTE:

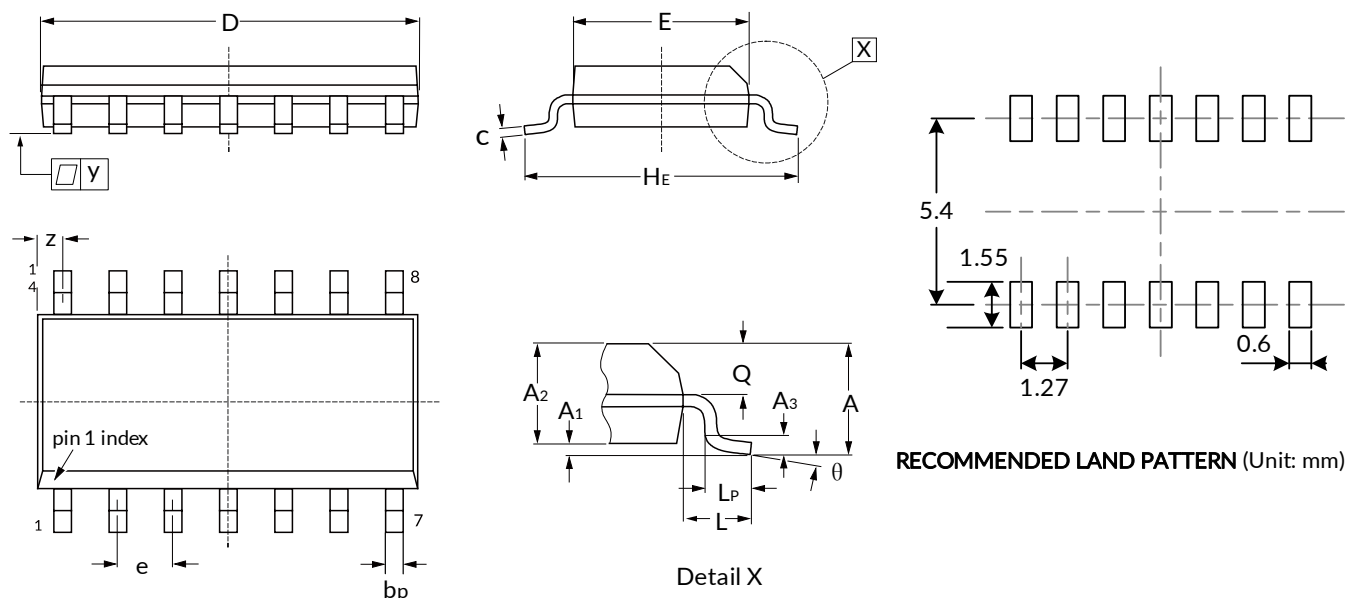
1. Plastic or metal protrusions of 0.15mm maximum per side are not included.
2. This drawing is subject to change without notice.

SOP8 (2)


Symbol	Dimensions In Millimeters		Dimensions In Inches	
	Min	Max	Min	Max
A ⁽¹⁾		1.750		0.069
A ₁	0.100	0.250	0.004	0.010
A ₂	1.250	1.450	0.049	0.057
A ₃	0.25		0.010	
b _p	0.360	0.490	0.014	0.019
c	0.190	0.250	0.007	0.010
D ⁽¹⁾	4.800	5.000	0.190	0.200
E ⁽¹⁾	3.800	4.000	0.150	0.160
H _E	5.800	6.200	0.228	0.244
e	1.270		0.050	
L	1.05		0.041	
L _P	0.400	1.000	0.016	0.039
Q	0.600	0.700	0.024	0.028
Z	0.300	0.700	0.012	0.028
y	0.1		0.004	
θ	0°	8°	0°	8°

NOTE:

1. Plastic or metal protrusions of 0.15mm maximum per side are not included.
2. This drawing is subject to change without notice.

SOP14 (2)

RECOMMENDED LAND PATTERN (Unit: mm)

Symbol	Dimensions In Millimeters		Dimensions In Inches	
	Min	Max	Min	Max
A ⁽¹⁾		1.750		0.069
A ₁	0.100	0.250	0.004	0.010
A ₂	1.250	1.450	0.049	0.057
A ₃	0.25		0.010	
b _p	0.360	0.490	0.014	0.019
c	0.190	0.250	0.007	0.010
D ⁽¹⁾	8.550	8.750	0.340	0.350
E ⁽¹⁾	3.800	4.000	0.150	0.160
H _E	5.800	6.200	0.228	0.244
e	1.270		0.050	
L	1.05		0.041	
L _P	0.400	1.000	0.016	0.039
Q	0.600	0.700	0.024	0.028
Z	0.300	0.700	0.012	0.028
y	0.1		0.004	
θ	0°	8°	0°	8°

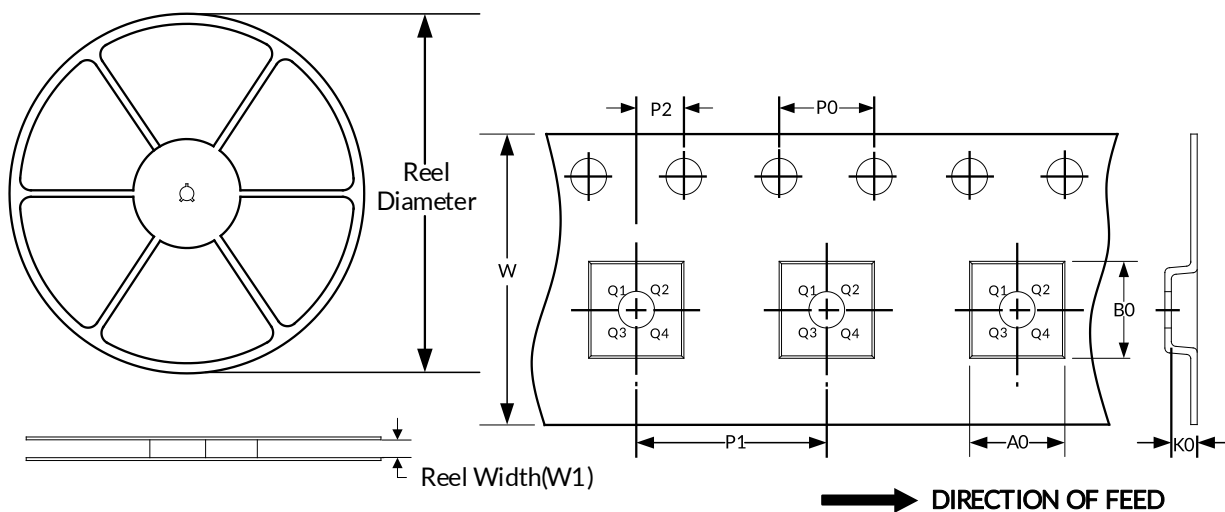
NOTE:

1. Plastic or metal protrusions of 0.15mm maximum per side are not included.
2. 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
SC70-5	7"	9.5	2.25	2.55	1.20	4.0	4.0	2.0	8.0	Q3
MSOP8	13"	12.4	5.20	3.30	1.50	4.0	8.0	2.0	12.0	Q1
SOP8	13"	12.4	6.40	5.40	2.10	4.0	8.0	2.0	12.0	Q1
TSSOP14	13"	12.4	6.95	5.60	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

NOTE:

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

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