1MHz, Precision, Rail-to-Rail I/O
CMOS Operational Amplifier

1 FEATURES

- **High Gain Bandwidth: 1MHz**
- **Rail-To-Rail Input and Output**
  ±4.5mV Max Vos
- **Input Voltage Range: -0.1V to +5.6V with Vs = 5.5V**
- **Supply Range: +2.5V to +5.5V**
- **Specified Up to +125°C**
- **Micro Size Packages: SC70-5**

2 APPLICATIONS

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

3 DESCRIPTION

The RS321BK products offer low voltage operation and rail-to-rail input and output, as well as excellent speed/power consumption ratio, providing an excellent bandwidth (1MHz) and slew rate of 0.45V/μs. The op-amps are unity gain stable and feature an ultra-low input bias current.

The RS321BK has lower offset, which is guaranteed not upper than ±4.5mV at 25°C with Vs = 5V, V_{CM} = Vs/2.

The devices are ideal for sensor interfaces, active filters and portable applications. The RS321BK families of operational amplifiers are specified at the full temperature range of −40°C to +125°C under single or dual power supplies of 2.5V to 5.5V.

Device Information (1)

PART NUMBER	PACKAGE	BODY SIZE(NOM)
RS321BK	SOT23-5	2.90mm×1.60mm
	SC70-5	2.10mm×1.25mm

(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 DESCRIPTION 1
4 REVISION HISTORY 3
5 PACKAGE/ORDERING INFORMATION (1) 4
6 PIN CONFIGURATION AND FUNCTIONS 5
7 SPECIFICATIONS 6
  7.1 Absolute Maximum Ratings 6
  7.2 ESD Ratings 6
  7.3 Recommended Operating Conditions 6
  7.4 Electrical Characteristics 7
  7.5 Typical Characteristics 8
8 APPLICATION AND IMPLEMENTATION 10
  8.1 Application Notes 10
  8.2 Layout Guidelines 10
  8.3 Instrumentation Amplifier 10
9 PACKAGE OUTLINE DIMENSIONS 11
10 TAPE AND REEL INFORMATION 13

4 REVISION HISTORY

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

Version	Change Date	Change Item
B.1	2022/05/24	Added the TAPE AND REEL INFORMATION
B.2	2024/12/19	1. Modify packaging naming 2. Add MSL on Page 5 in RevB.1 3. Add Package thermal impedance on Page 4 in RevB.1 4. Update PACKAGE note

5 PACKAGE/ORDERING INFORMATION (1)

Orderable Device	Package Type	Pin	Channel	Op Temp(°C)	Device Marking (2)	MSL (3)	Package Qty
RS321BKXF	SOT23-5	5	1	-40°C ~125°C	321BK	MSL3	Tape and Reel, 3000
RS321BKXC5	SC70-5 (4)	5	1	-40°C ~125°C	321BK	MSL3	Tape and Reel, 3000

NOTE:

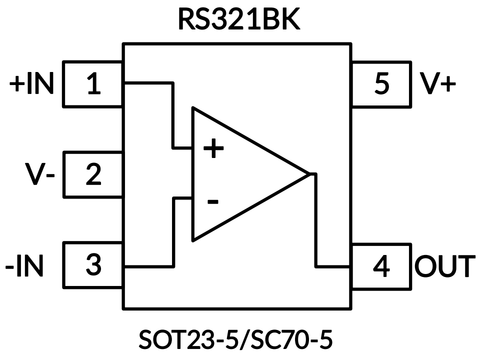
(1) This information is the most current data available for the designated devices. This data is subject to change without notice and revision of this document. For browser-based versions of this data sheet, refer to the right-hand navigation.

(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.

(4) Equivalent to SOT353.

6 PIN CONFIGURATION AND FUNCTIONS


RS321BK
+IN
1
V-
2
-IN
3
5
V+
4
OUT
+
-
SOT23-5/SC70-5

PIN DESCRIPTION

NAME	PIN	I/O [1]	DESCRIPTION
	RS321BK		
	SOT23-5/SC70-5		
+IN	1	I	Positive (noninverting) input
V-	2	-	Negative (lowest) power supply
-IN	3	I	Negative (inverting) input
OUT	4	O	Output
V+	5	-	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, Vs=(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)		-140	140	mA
	Output short-circuit (4)		Continuous		
θ_{JA}	Package thermal impedance (5)	SOT23-5		230	°C/W
		SC70-5		380	
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 ±140mA 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)	±3000	V
		Machine Model (MM)	±200	

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, Vs= (V+) - (V-)	Single-supply	2.5		5.5	V
	Dual-supply	±1.25		±2.75	

7.4 Electrical Characteristics

(At T_A=+25°C, Vs=5V, R_L = 10kΩ connected to Vs/2, and V_{OUT} = Vs/2, Full [9] = -40°C to +125°C, unless otherwise noted.) [1]

PARAMETER		CONDITIONS	T_J	RS321BK			UNITS
				MIN [2]	TYP [3]	MAX [2]	
POWER SUPPLY							
Vs	Operating Voltage Range		25°C	2.5		5.5	V
I_Q	Quiescent Current Per Amplifier		25°C		85	140	μA
PSRR	Power-Supply Rejection Ratio	Vs=2.5V to 5.5V, V_{CM}=(V-)+0.5V	25°C	70	75		dB
			Full	64			
INPUT							
Vos	Input Offset Voltage	V_{CM}=0V to 3.5V	25°C	-4.5	±0.8	4.5	mV
Vos TC	Input Offset Voltage Average Drift		Full		2		μV/°C
IB	Input Bias Current [4] [5]		25°C		10		pA
Ios	Input Offset Current [4]		25°C		10		pA
V_{CM}	Common-Mode Voltage Range	Vs= 5.5V	25°C	-0.1		5.6	V
CMRR	Common-Mode Rejection Ratio	Vs= 5.5V, V_{CM}=-0.1V to 4V	25°C	65	85		dB
			Full	62			
		Vs= 5.5V, V_{CM}=-0.1V to 5.6V	25°C	58	80		
			Full	56			
OUTPUT							
A_{OL}	Open-Loop Voltage Gain	R_L=2KΩ, Vo=0.15V to 4.85V	25°C	85	95		dB
			Full	75			
		R_L=10KΩ, Vo= 0.05V to 4.95V	25°C	88	100		
			Full	80			
	Output Swing From Rail	R_L=2KΩ	25°C		25		mV
		R_L=10KΩ			8		
Iout	Output Current Source [6] [7]		25°C		120		mA
FREQUENCY RESPONSE							
SR	Slew Rate [8]		25°C		0.45		V/μs
GBP	Gain-Bandwidth Product		25°C		1		MHz
PM	Phase Margin [4]		25°C		64		°
t_S	Settling Time, 0.1%				1.3		μs
	Overload Recovery Time	V_{IN}·Gain≥V_S			2.3		μs
NOISE							
e_n	Input Voltage Noise Density [4]	f = 1KHz	25°C		22		$nV/\sqrt{Hz}$
		f = 10KHz	25°C		20		$nV/\sqrt{Hz}$

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) 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 $T_{J(MAX)}$, $R_{θJA}$, and T_A. The maximum allowable power dissipation at any ambient temperature is P_D = ($T_{J(MAX)}$ - T_A) / $R_{θJA}$. 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°C, Vs=5V, R_L = 10kΩ connected to Vs/2, V_{OUT} = Vs/2, unless otherwise noted.

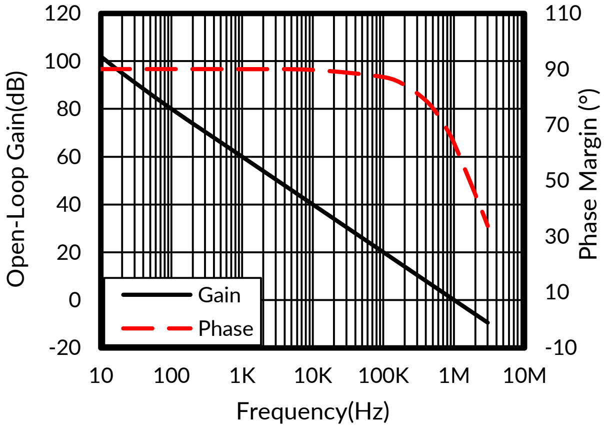


Figure 1. Open-Loop Gain and Phase vs Frequency

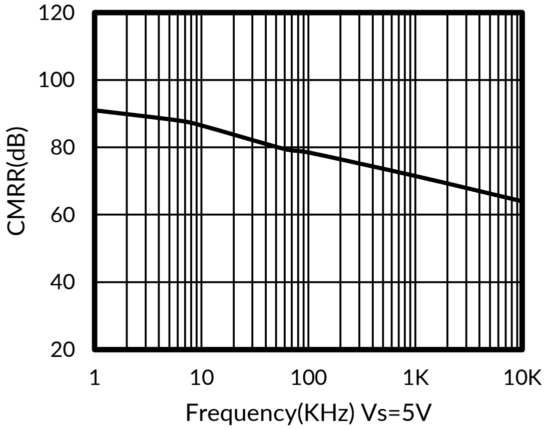


Figure 2. Common−Mode Rejection Ratio vs Frequency

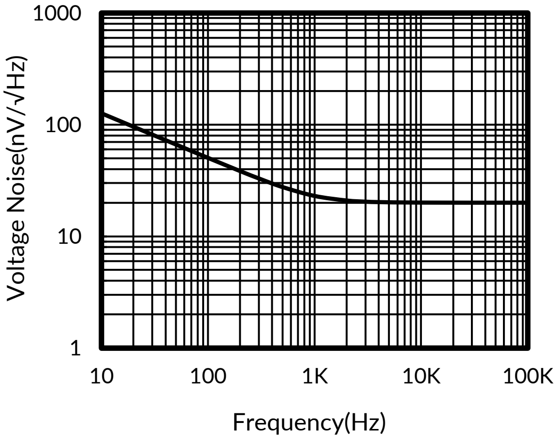


Figure 3. Input Voltage Noise Spectral Density vs Frequency

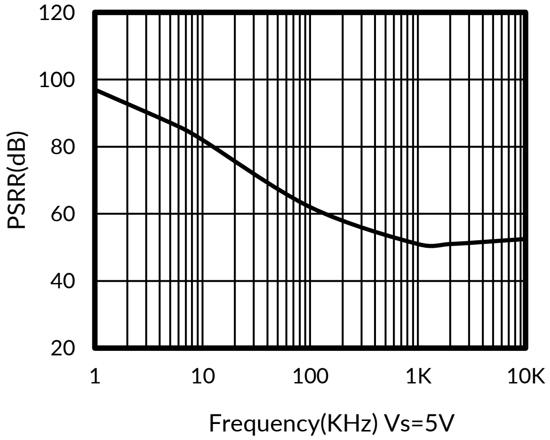


Figure 4. Power−Supply Rejection Ratio vs Frequency

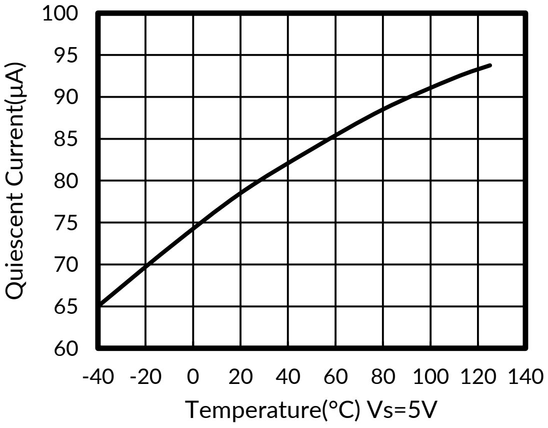


Figure 5. Quiescent Current Vs Temperature

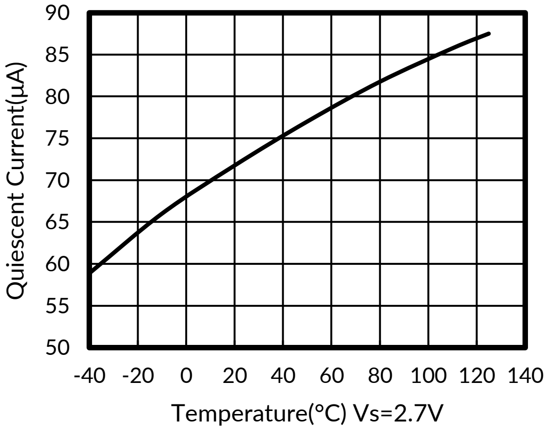


Figure 6. Quiescent Current vs Temperature

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°C, V_S=5V, R_L = 10kΩ connected to $V_S/2$, V_{OUT} = $V_S/2$, unless otherwise noted.

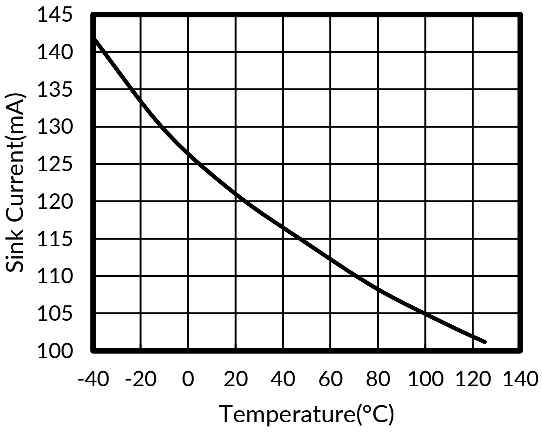


Figure 7. Sink Current vs Temperature

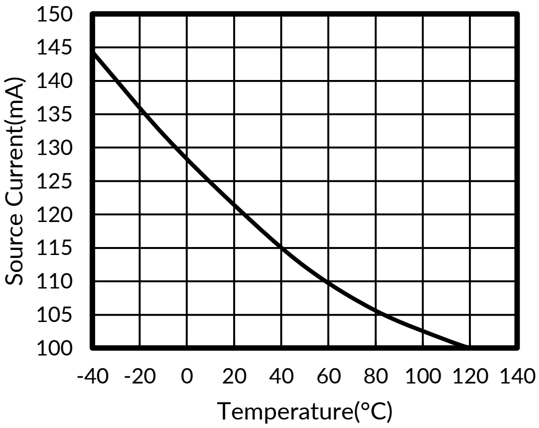


Figure 8. Source Current vs Temperature

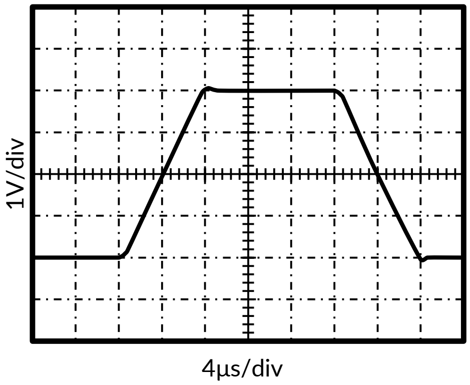


Figure 9. Large−Signal Step Response

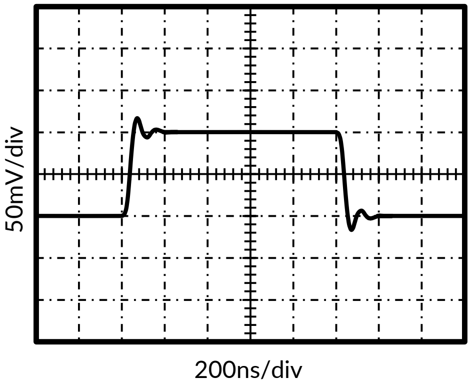


Figure 10. Small-Signal Step Response

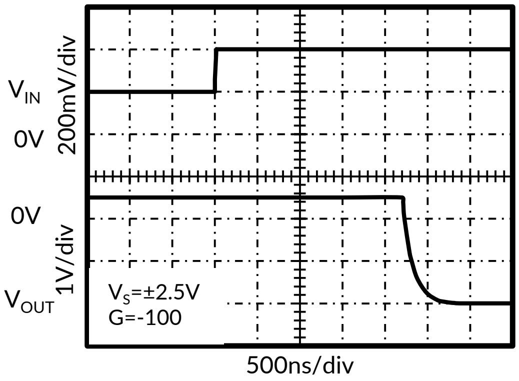


Figure 11. Positive Overvoltage Recovery

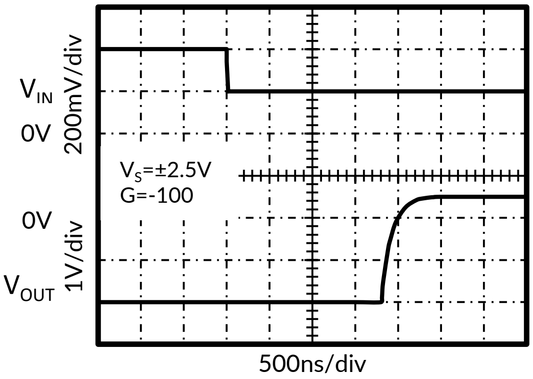


Figure 12. Negative Overvoltage Recovery

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 RS321BK is high precision, rail-to-rail operational amplifiers that can be run from a single-supply voltage 2.5V to 5.5V (±1.25V to ±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 0.1μF capacitor place 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 0.1μF 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.

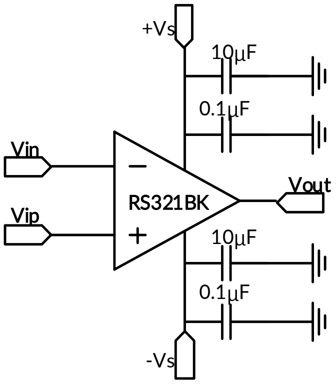


Figure 13. Amplifier with Bypass Capacitors

8.3 Instrumentation Amplifier

In the three-op amp, instrumentation amplifier configuration shown in Figure 14,

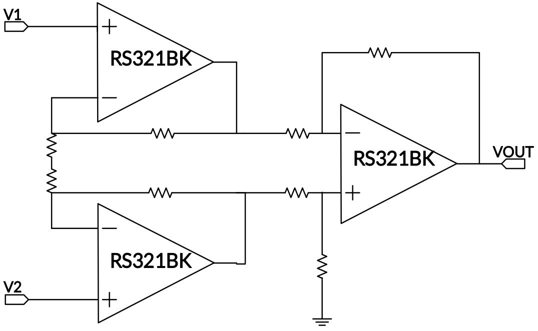
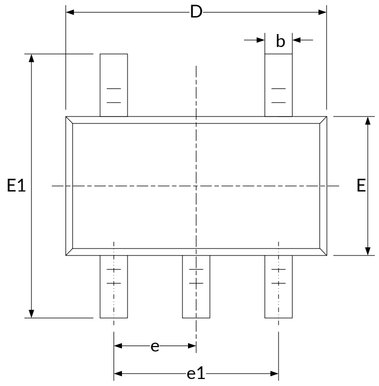
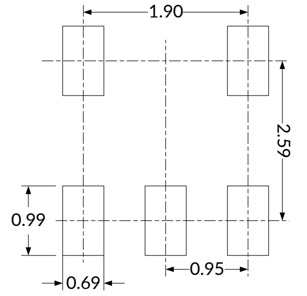


Figure 14. Amplifier Instrumentation Amplifier

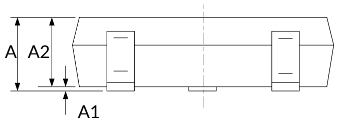
9 PACKAGE OUTLINE DIMENSIONS

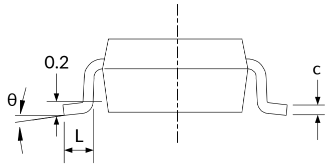
SOT23-5 (3)





RECOMMENDED LAND PATTERN (Unit: mm)



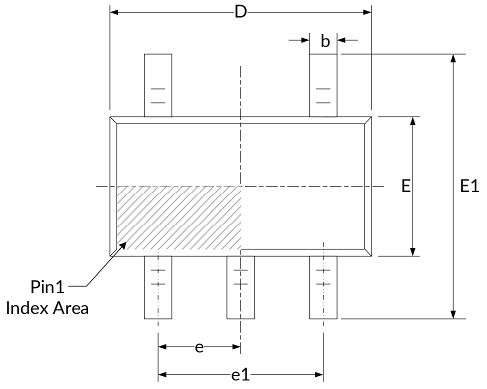


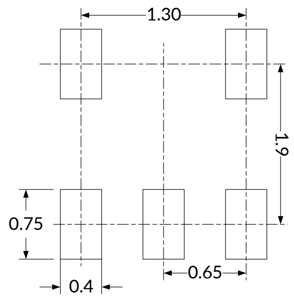
Symbol	Dimensions In Millimeters		Dimensions In Inches	
	Min	Max	Min	Max
A (1)	1.050	1.250	0.041	0.049
A1	0.000	0.100	0.000	0.004
A2	1.050	1.150	0.041	0.045
b	0.300	0.500	0.012	0.020
c	0.100	0.200	0.004	0.008
D (1)	2.820	3.020	0.111	0.119
E (1)	1.500	1.700	0.059	0.067
E1	2.650	2.950	0.104	0.116
e	0.950(BSC) (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:

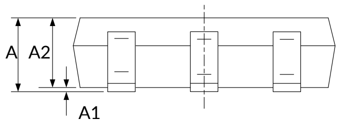
1. Plastic or metal protrusions of 0.15mm maximum per side are not included.
2. BSC (Basic Spacing between Centers), "Basic" spacing is nominal.
3. This drawing is subject to change without notice.

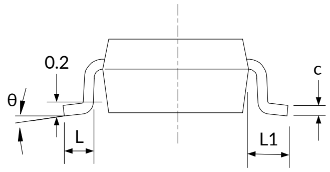
SC70-5 (3)





RECOMMENDED LAND PATTERN (Unit: mm)





Symbol	**Dimensions In Millimeters**		**Dimensions In Inches**	
	Min	**Max**	**Min**	**Max**
A (1)	0.900	1.100	0.035	0.043
A1	0.000	0.100	0.000	0.004
A2	0.900	1.000	0.035	0.039
b	0.150	0.350	0.006	0.014
c	0.080	0.150	0.003	0.006
D (1)	2.000	2.200	0.079	0.087
E (1)	1.150	1.350	0.045	0.053
E1	2.150	2.450	0.085	0.096
e	0.650(BSC) (2)		0.026(BSC) (2)	
e1	1.300(BSC) (2)		0.051(BSC) (2)	
L	0.260	0.460	0.010	0.018
L1	0.525		0.021	
θ	0°	8°	0°	8°

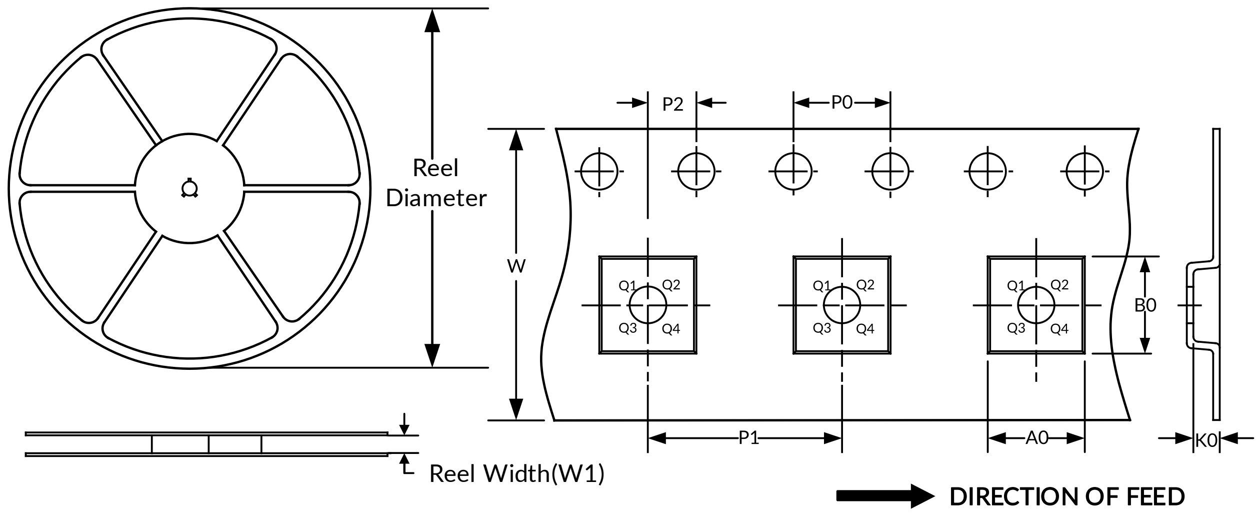
NOTE:

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


Reel
Diameter
Reel Width(W1)
P2
P0
W
Q1
Q2
Q3
Q4
B0
P1
A0
K0
DIRECTION OF FEED

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
SC70-5	7”	9.5	2.25	2.55	1.20	4.0	4.0	2.0	8.0	Q3

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

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