1.3MHz, Rail-to-Rail I/O CMOS Operational Amplifier

1 FEATURES

- **High Gain Bandwidth:1.3MHz**
- **Rail-to-Rail Input and Output**
  ±0.8mV Typical V_{OS}
- **Input Voltage Range: -0.1V to +5.6V with Vs = 5.5V**
- **Supply Range: +2.2V to +5.5V**
- **Shutdown: RS6331S**
- **Specified Up To +125°C**
- **Micro Size Packages: SOT23-6**

2 APPLICATIONS

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

3 DESCRIPTIONS

The RS6331S products offer low voltage operation and rail-to-rail input and output, as well as excellent speed/power consumption ratio, providing an excellent bandwidth (1.3MHz) and slew rate of 0.5V/µs. 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 RS6331S include a shutdown mode. Under logic control, the amplifiers can be switched from normal operation to a standby current that is less than 1µA.The RS6331S 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)
RS6331S	SOT23-6	2.90mm×1.60mm

(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.0	2024/12/18	Preliminary version completed
A.1	2025/03/12	Initial version completed

5 PACKAGE/ORDERING INFORMATION [1]

Orderable Device	Package Type	Pin	Channel	Op Temp(°C)	Device Marking [2]	MSL[3]	Package Qty
RS6331SXH	SOT23-6	6	1	-40°C ~125°C	6331S	MSL3	Tape and Reel,3000

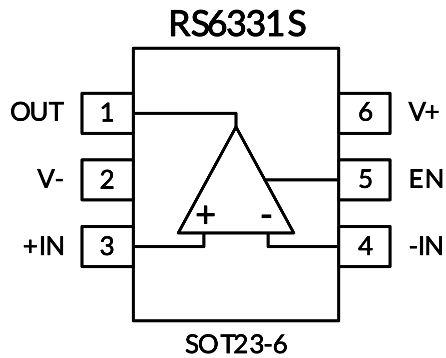
NOTE:

(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.

6 PIN CONFIGURATION AND FUNCTIONS (TOP VIEW)



Pin Description

NAME	PIN	I/O (1)	DESCRIPTION
	RS6331S		
	SOT23-6		
-IN	4	I	Inverting input
+IN	3	I	Noninverting input
OUT	1	O	Output
EN	5	I	EN=logic high (device enabled) EN=logic low (device disabled) EN=no connect (device enabled)
V-	2	-	Negative (lowest) power supply
V+	6	-	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)		-50	50	mA
	Output short-circuits (4)		Continuous		
θ_{JA}	Package thermal impedance (5)	SOT23-6		230	°C/W
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 ±50mA 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(1)	±3000	V
		Charged-device model (CDM), per ANSI/ESDA/JEDEC JS-002(2)	±1000	

(1) JEDEC document JEP155 states that 500 V HBM allows safe manufacturing with a standard ESD control process.
(2) JEDEC document JEP157 states that 250 V CDM 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	2.2		5.5	V
	Dual-supply	±1.1		±2.75	

7.4 Electrical Characteristics

(At T_A = +25°C, V_S=2.2V to 5.5V, R_L = 10kΩ connected to V_S/2, and V_{OUT} = V_S/2, V_{CM} = V_S/2, Full [9] = -40°C to 125°C, unless otherwise noted.) [1]

PARAMETER		CONDITIONS	T_J	RS6331S			
				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=±2.5V, Io=0mA	25°C		62.5	100	µA
PSRR	Power-Supply Rejection Ratio	V_S=2.2V to 5.5V	25°C	75	92		dB
			Full	65			
INPUT							
V_{OS}	Input Offset Voltage	V_{CM}= V_S/2	25°C	-3	±0.8	3	mV
V_{OS} T_C	Input Offset Voltage Average Drift	V_{CM}= V_S/2	Full		±2		µV/°C
IB	Input Bias Current [4] [5]	V_{CM}=0V	25°C		±1	±10	pA
I_{OS}	Input Offset Current [5]	V_{CM}=0V	25°C		±1	±10	pA
V_{CM}	Common-Mode Voltage Range	V_S= 5.5V	25°C	-0.1		5.6	V
CMRR	Common-Mode Rejection Ratio	V_S= 5.5V V_{CM}=-0.1V to 3.5V	25°C	74	93		dB
			Full	63			
		V_S= 5.5V V_{CM}=-0.1V to 5.6V	25°C	60	77		
			Full	59			
OUTPUT							
A_{OL}	Open-Loop Voltage Gain	R_L=10kΩ, Vo=(V-)+0.1V to (V+)-0.1V	25°C	100	122		dB
			Full	87			
	Output Swing from Rail	V_S= ±2.5V, R_L=10kΩ	25°C		10	20	mV
I_{OUT}	Output Short-Circuit Current[6] [7]		25°C	±60	±96		mA
C_{LOAD}	Capacitive Load Drive				100		pF
FREQUENCY RESPONSE							
SR	Slew Rate [8]	G=+1, C_L=100pF	25°C		0.5		V/µs
GBP	Gain-Bandwidth Product		25°C		1.3		MHz
PM	Phase Margin [5]		25°C		64		°
t_S	Settling Time,0.1%	V_S=5V, G=+1, C_L=100pF, Step=2V	25°C		6.5		µs
t_{OR}	Overload Recovery Time	V_{IN}·Gain≥V_S,G=-10	25°C		5.3		µs
NOISE							
E_n	Input Voltage Noise	f = 0.1Hz to 10Hz, V_S=5V	25°C		4.5		$µV_{PP}$
e_n	Input Voltage Noise Density	f = 1kHz	25°C		47		$nV/\sqrt{Hz}$
ENABLE/SHUTDOWN (RS6331S)							
$I_{Q(OFF)}$	Supply Current in Shutdown		25°C		0.5	1	µA
t_{OFF}			25°C		3		µs
t_{ON}			25°C		20		µs
V_L	Shut Down	V_S=3.3V	25°C	0		0.5	V
		V_S=5V	25°C	0		0.7	V
V_H	Amplifier Is Active	V_S=3.3V	25°C	1.1		3.3	V
		V_S=5V	25°C	3.2		5	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) 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°C, Vs=5V, R_L = 10kΩ connected to Vs/2, V_{OUT} = Vs/2, unless otherwise noted.

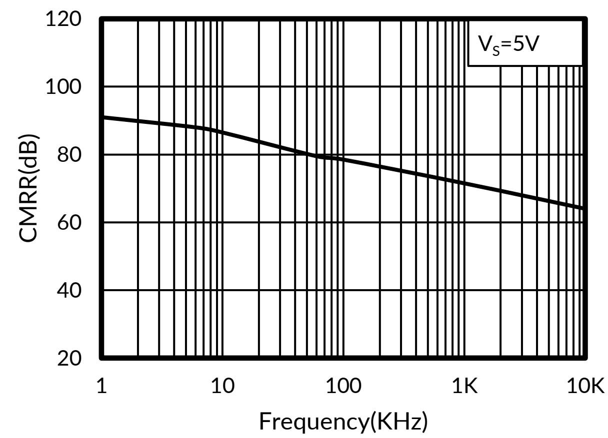


Figure 1. Common−mode Rejection Ratio vs Frequency

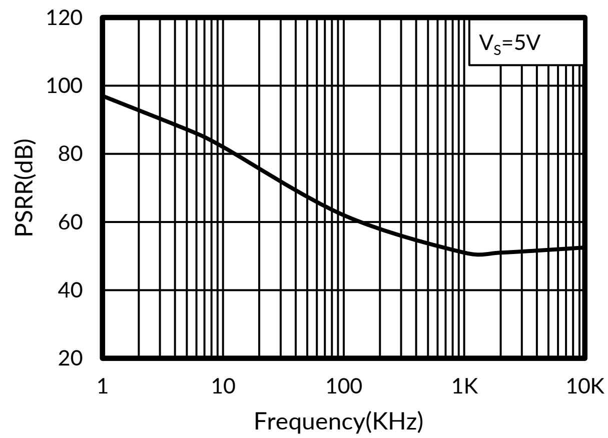


Figure 2. Power-Supply Rejection Ratio vs Frequency

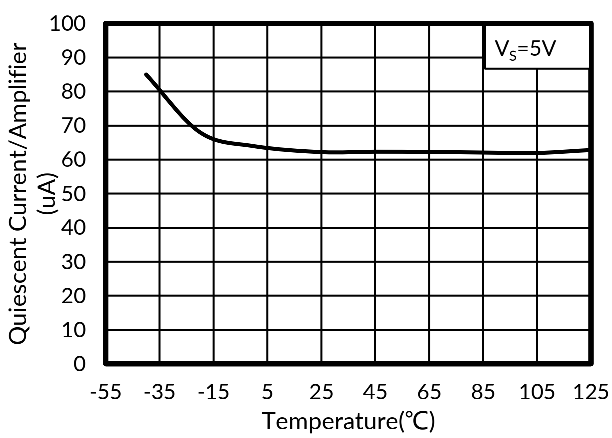


Figure 3. Quiescent Current vs Temperature

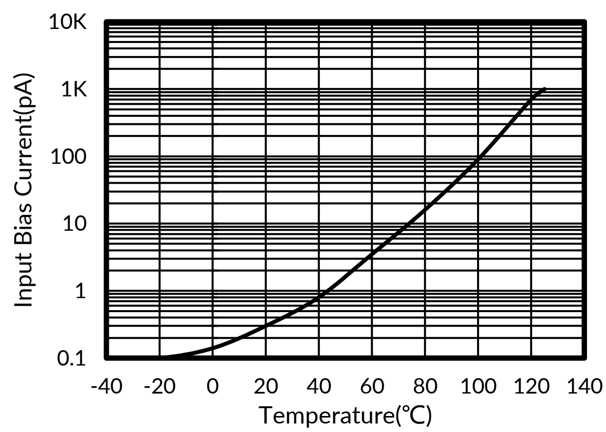


Figure 4. Input Bias Current vs Temperature

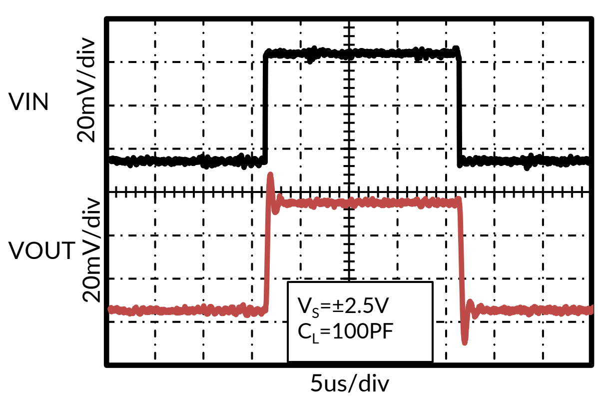


Figure 5. Small-Signal Step Response

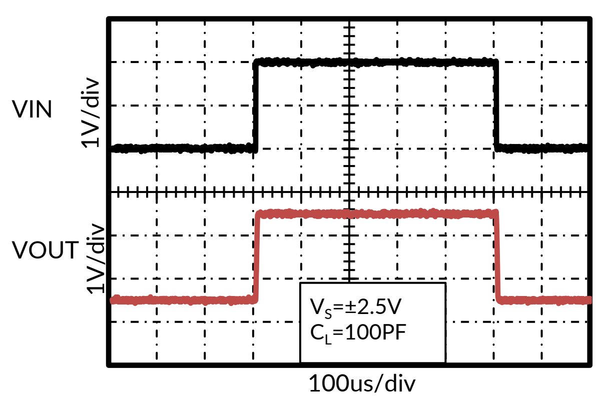


Figure 6. Large-Signal Step Response

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

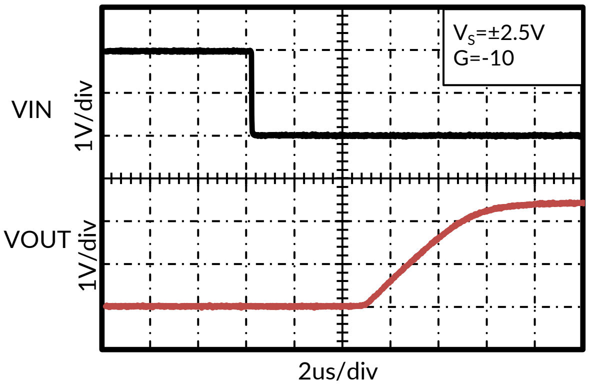


Figure 7. Negative Overvoltage Recovery

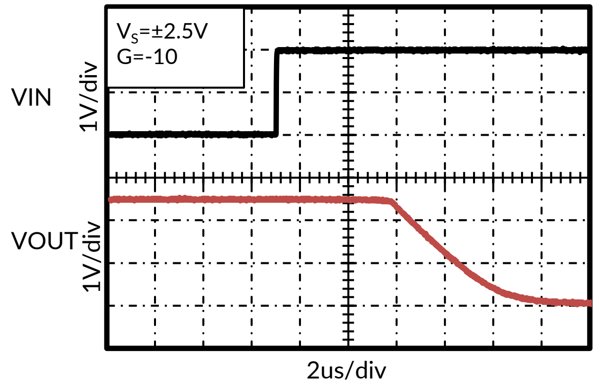


Figure 8. Positive Overvoltage Recovery

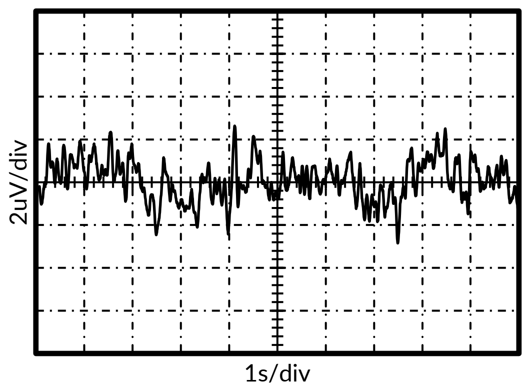


Figure 9. 0.1Hz to 10Hz Input Voltage Noise

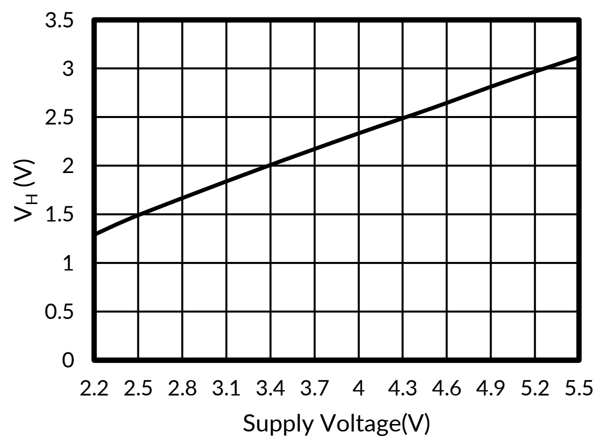


Figure 10. V_H vs Supply Voltage

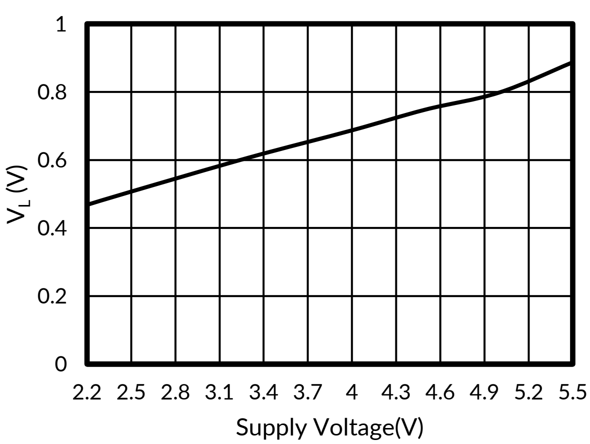


Figure 11. V_L vs Supply Voltage

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 RS6331S are high precision, rail-to-rail operational amplifiers that can be run from a single-supply voltage 2.2V to 5.5V (±1.1V 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 RS6331S Enable Function

The RS6331S includes a shutdown mode. Under logic control, the amplifiers can be switched from normal mode to a standby current of 1μA. 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 0.1uF 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.

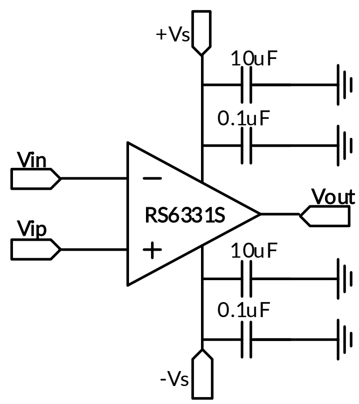


Figure 12. Amplifier with Bypass Capacitors

8.4 Instrumentation Amplifier

In the three-op amp, instrumentation amplifier configuration shown in Figure 13.

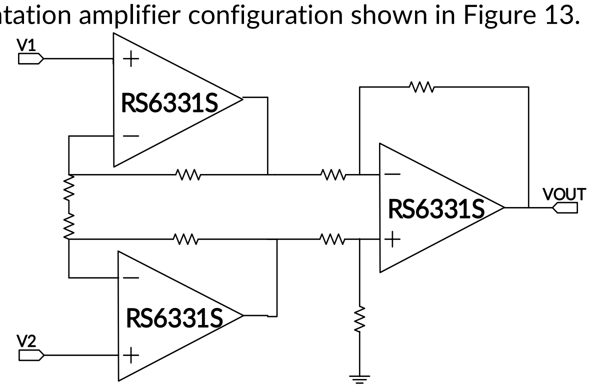
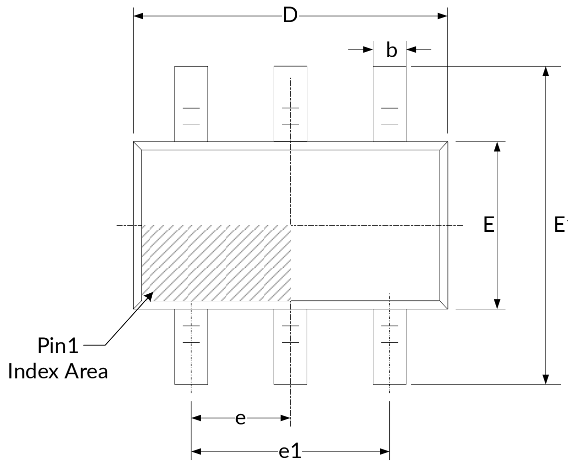
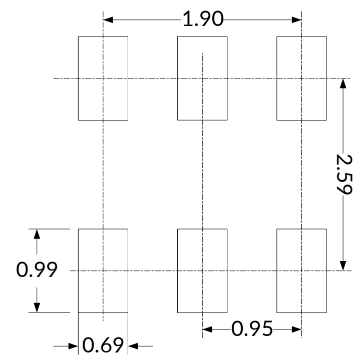


Figure 13. Amplifier instrumentation amplifier

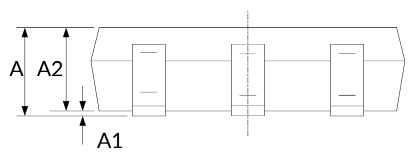
9 PACKAGE OUTLINE DIMENSIONS

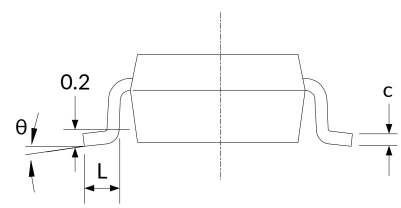
SOT23-6 (3)





RECOMMENDED LAND PATTERN (Unit: mm)





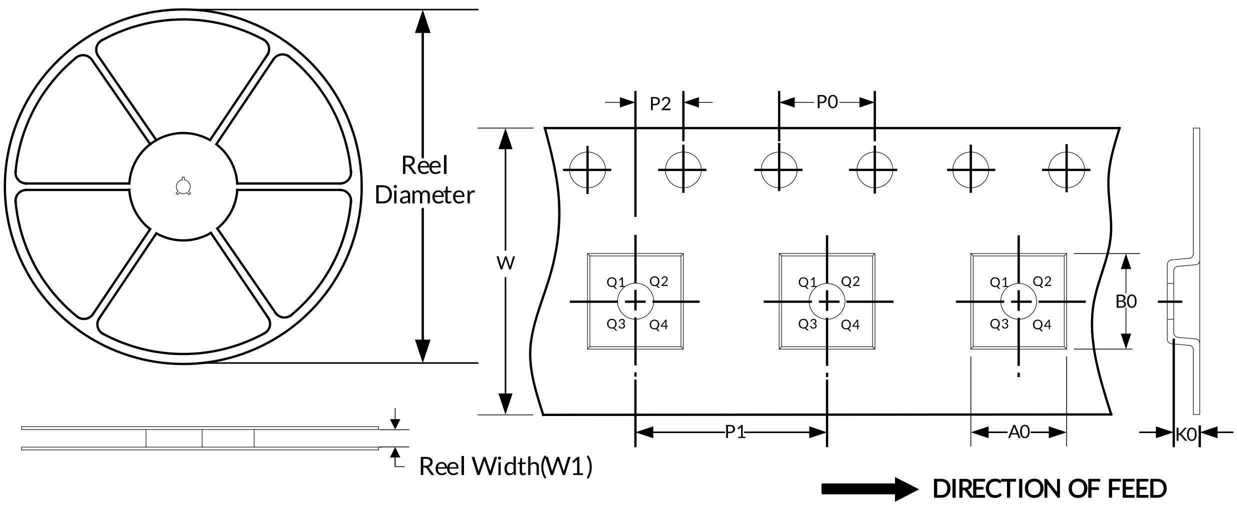
Symbol	Dimensions In Millimeters		Dimensions In Inches	
	Min	Max	Min	Max
A (1)	1.050	1.250	0.041	0.049
A1	0.000	0.100	0.000	0.004
A2	1.050	1.150	0.041	0.045
b	0.300	0.500	0.012	0.020
c	0.100	0.200	0.004	0.008
D (1)	2.820	3.020	0.111	0.119
E (1)	1.500	1.700	0.059	0.067
E1	2.650	2.950	0.104	0.116
e	0.950(BSC)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

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
SOT23-6	7"	9.5	3.17	3.23	1.37	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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