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

DESCRIPTIONS

The FOP611, FOP612, FOP614 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 FOP611, FOP612, FOP614 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.

FEATURES

- 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: SOT23-5, SOP8

APPLICATIONS

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

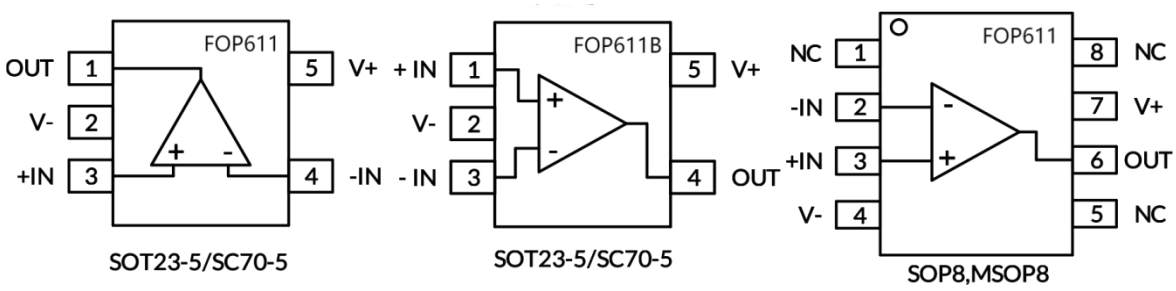
Order information

Mode	Package	Channel	Op Temp(°C)	Body Size(NOM)	Ordering Number	Packing Option
FOP611	SOT23-5	1	-40°C ~125°C	2.90mm×1.60mm	FOP611YSOT235G/TR	Tape and Reel,3000
	SOP8	1	-40°C ~125°C	4.90mm×3.90mm	FOP611YSOP8G/TR	Tape and Reel,4000
	MSOP8	1	-40°C ~125°C	3.00mm×3.00mm	FOP611YMSOP8G/TR	Tape and Reel,4000
	SC70-5 (2)	1	-40°C ~125°C	2.10mm×1.25mm	FOP611YSC705G/TR	Tape and Reel,3000
FOP611B	SOT23-5	1	-40°C ~125°C	2.90mm×1.60mm	FOP611BYSOT235G/TR	Tape and Reel,3000
	SC70-5	1	-40°C ~125°C	2.10mm×1.25mm	FOP611BYSC705G/TR	Tape and Reel,3000
FOP612	SOP8	2	-40°C ~125°C	4.90mm×3.90mm	FOP612YSOP8G/TR	Tape and Reel,4000
	MSOP8	2	-40°C ~125°C	3.00mm×3.00mm	FOP612YMSOP8G/TR	Tape and Reel,4000
	TSSOP8	2	-40°C ~125°C	3.00mm×4.40mm	FOP612YTSSOP8G/T	Tape and Reel,4000
FOP614	SOP14	4	-40°C ~125°C	8.65mm×3.90mm	FOP614YSOP14G/T	Tape and Reel,4000
	TSSOP14	4	-40°C ~125°C	5.00mm×4.40mm	FOP612YTSSOP14G/T	Tape and Reel,4000

NOTE:
(1) For all available packages, see the orderable addendum at the end of the data sheet.
(2) Equivalent to SOT353.
(3) 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.

Pin Configuration and Functions (Top View)

● FOP611/FOP611B

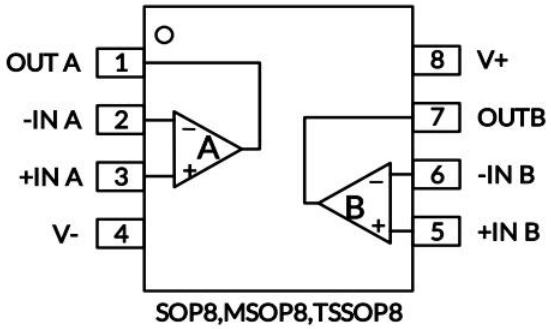


Name	Pin			I/O (1)	Description
	FOP611	FOP611B	FOP611		
	SOT23-5/SC70-5	SOT23-5/SC70-5	SOP8/MSOP8		
-IN	4	3	2	I	Negative (inverting) input
+IN	3	1	3	I	Positive (noninverting) input
NC (2)	-	-	1,5,8	-	No internal connection (can be left floating)
OUT	1	4	6	O	Output
V-	2	2	4	-	Negative (lowest) power supply
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.

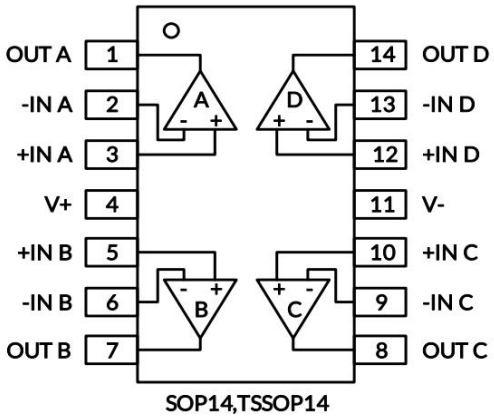
● FOP612



Name	Pin	I/O (1)	Description
	SOP8/MSOP8/TSSOP8		
-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.

● FOP614



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.

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)	SOT23-5		230	°C/W
		SOP8		110.88	
		MSOP8		165.7	
		TSSOP8		240	
		SOP14		104.5	
		TSSOP14		89.21	
		SC70-5		376	
Temperature	Operating range, T_A		-40	125	°C
	Junction, T_J (6)		-40	150	
	Storage, Tstg		-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 ±150mA 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.

ESD Ratings

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

			VALUE	UNIT
$V_{(ESD)}$	Electrostatic discharge	Human-body model (HBM), per ANSI/ESDA/JEDEC JS-001(1)	±5000	V
		Charged-device model (CDM), per ANSI/ESDA/JEDEC JS-002(2)	±1000	
		Machine Model (MM)	±400	

(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.

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	

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	FOP611, FOP612, FOP614			
				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	uA
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	-0.8	±0.1	0.8	mV
V_{OS} T_C	Input Offset Voltage Average Drift	V_{CM}= V_S/2	Full		±1		uV/°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	110	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/us
GBP	Gain-Bandwidth Product		25°C		1.4		MHz
PM	Phase Margin [5]		25°C		64		°
t_S	Settling Time,0.1%	V_S =±2.5V, G=+1, C_L=100pF, Step=2V	25°C		6.5		us
t_{OR}	Overload Recovery Time	V_{IN}·Gain≥VS,G=-10	25°C		5.3		us
NOISE							
En	Input Voltage Noise	f = 0.1Hz to 10Hz, V_S=±2.5V	25°C		4.5		uVPP
en	Input Voltage Noise Density	f = 1KHz	25°C		TBD		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 overtime 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 $P_D = (T_{J(MAX)} - TA) / R_{\theta JA}$. 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.

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.

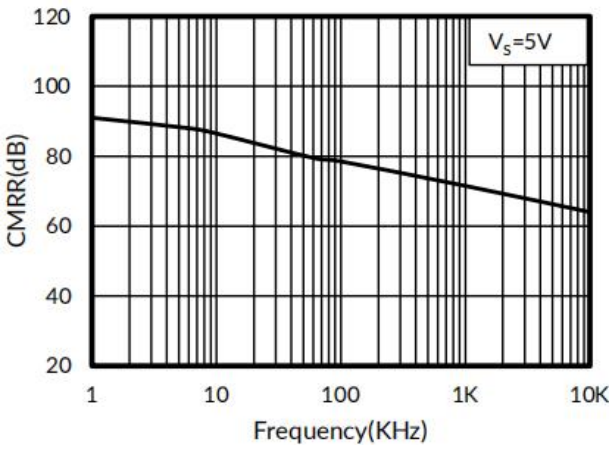


Figure 1. Common−mode Rejection Ratio vs Frequency

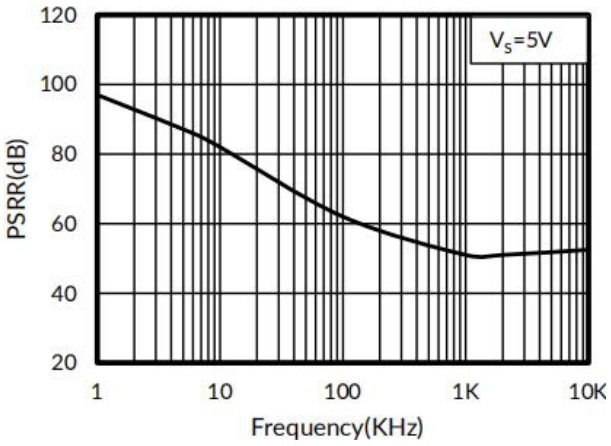


Figure 2. Power-Supply Rejection Ratio vs Frequency

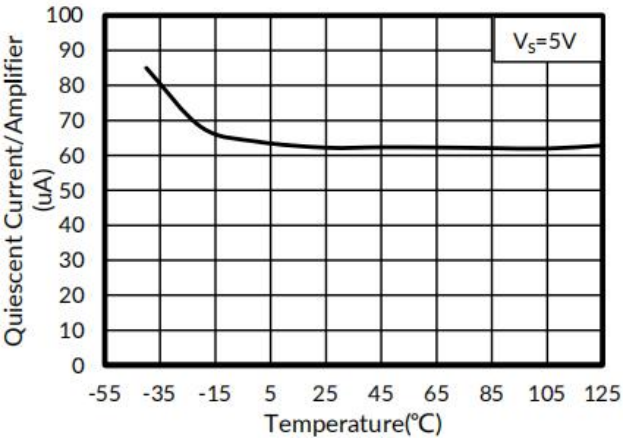


Figure 3. Quiescent Current vs Temperature

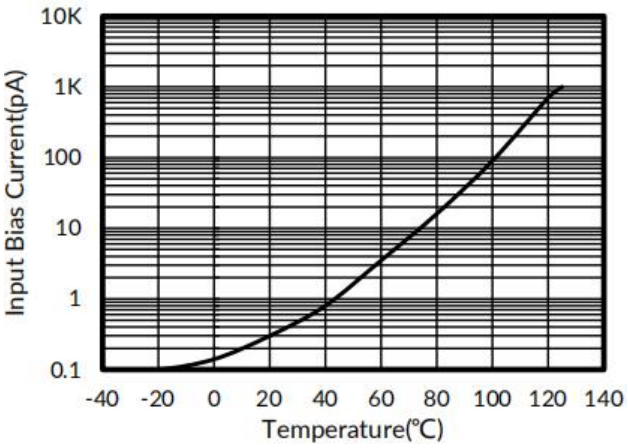


Figure 4. Input Bias Current vs Temperature

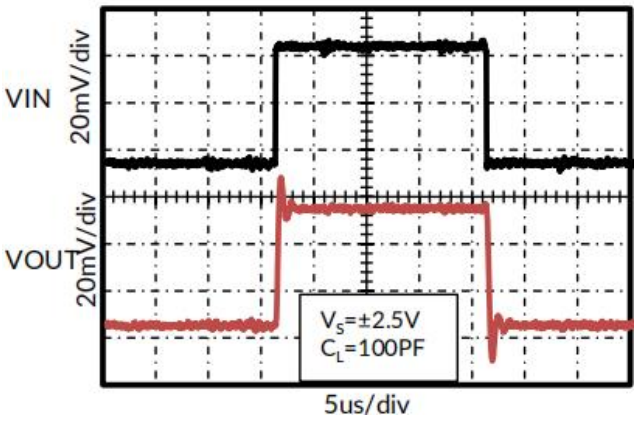


Figure 5. Small-Signal Step Response

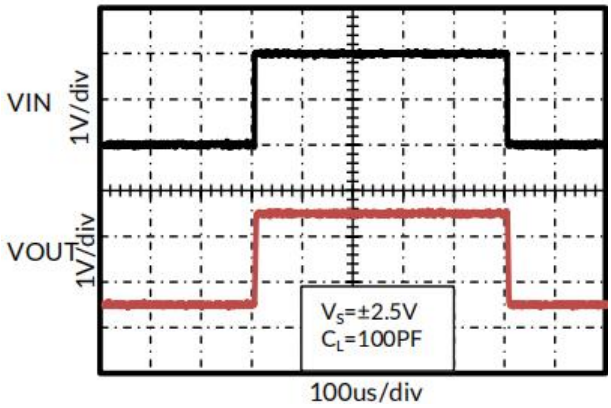


Figure 6. Large-Signal Step Response

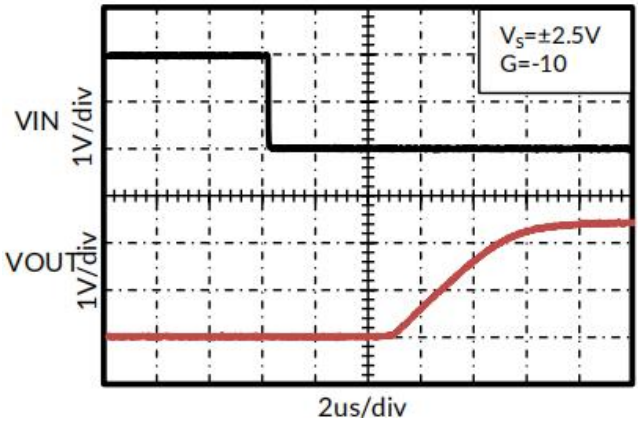


Figure 7. Negative Overvoltage Recovery

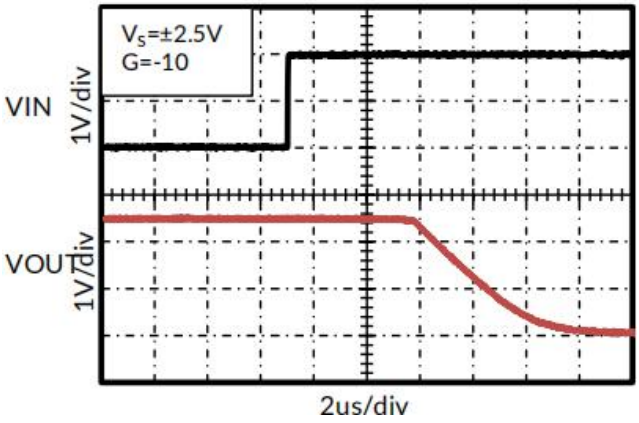


Figure 8. Positive Overvoltage Recovery

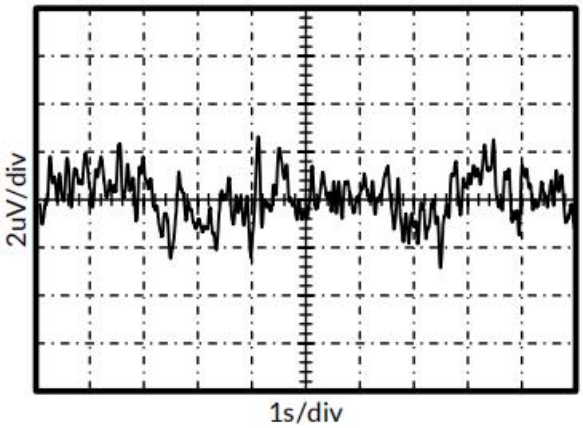


Figure 9. 0.1Hz to 10Hz Input Voltage Noise

Application and Implementation

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

Application Notes

The FOP611, FOP612, FOP614 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 0.1uF capacitor place closely across the supply pins.

Layout Guidelins

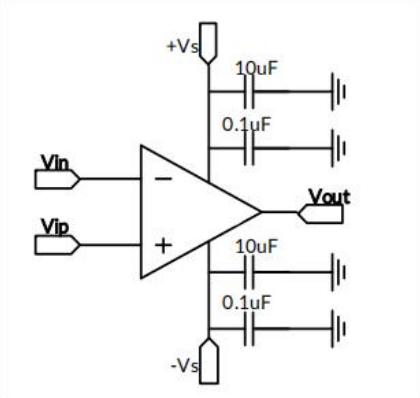


Figure 10. Amplifier with Bypass Capacitors

INSTRUMENTATION AMPLIFIER

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

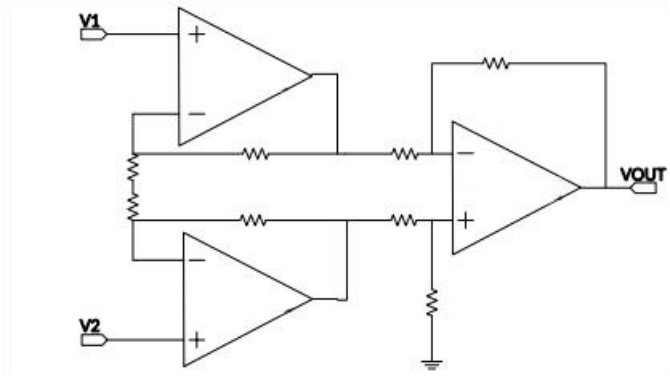
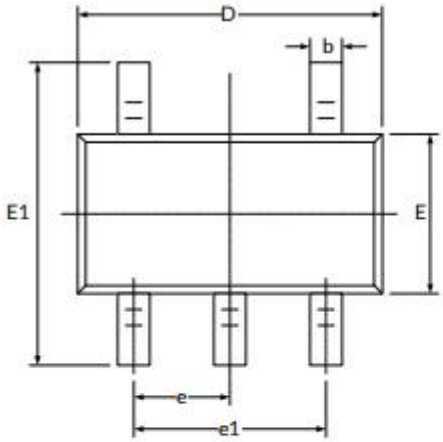
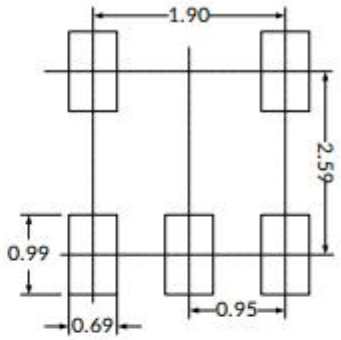


Figure 11. Amplifier instrumentation amplifier

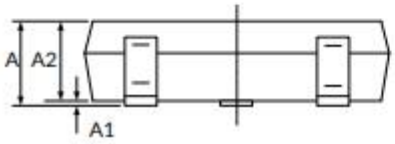
Package Outline Dimensions(All dimensions in mm.)

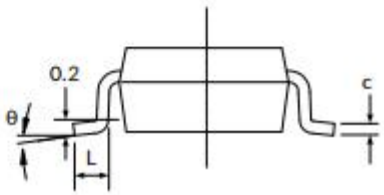
(1) Package Type: SOT23-5 (3)





RECOMMENDED LAND PATTERN (Unit: mm)



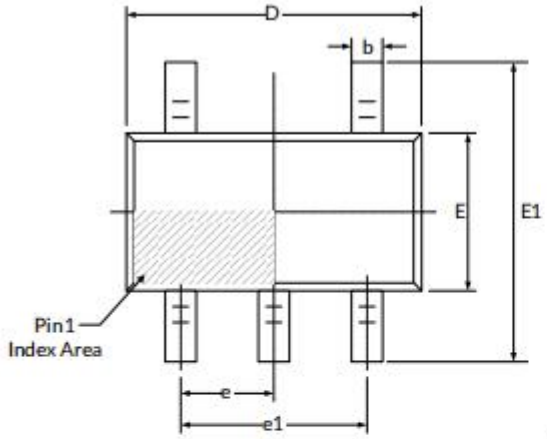


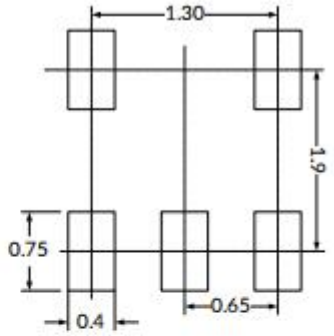
Symbol	Dimensions In Millimeters		Dimensions In Inches	
	Min	Max	Min	Max
A (1)	1.050	1.250	0.041	0.049
A1	0.000	0.100	0.000	0.004
A2	1.050	1.150	0.041	0.045
b	0.300	0.500	0.012	0.020
c	0.100	0.200	0.004	0.008
D (1)	2.820	3.020	0.111	0.119
E (1)	1.500	1.700	0.059	0.067
E1	2.650	2.950	0.104	0.116
e	0.950(BSC)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

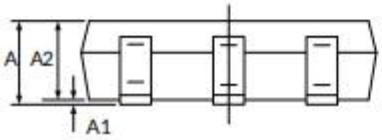
1. Plastic or metal protrusions of 0.15mm maximum per side are not included.
2. BSC (Basic Spacing between Centers), "Basic" spacing is nominal.
3. This drawing is subject to change without notice.

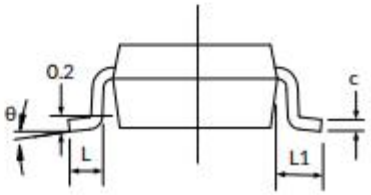
(2) Package Type: SC70-5 (3)





RECOMMENDED LAND PATTERN (Unit: mm)



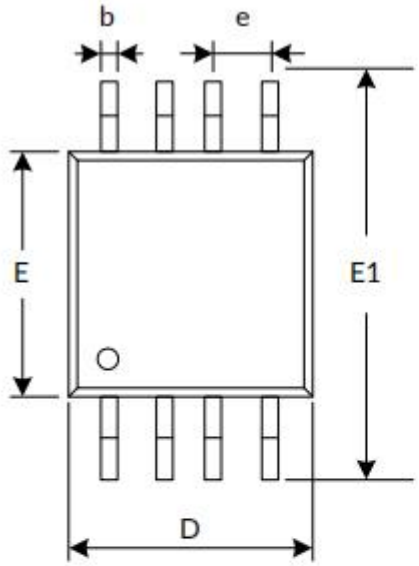


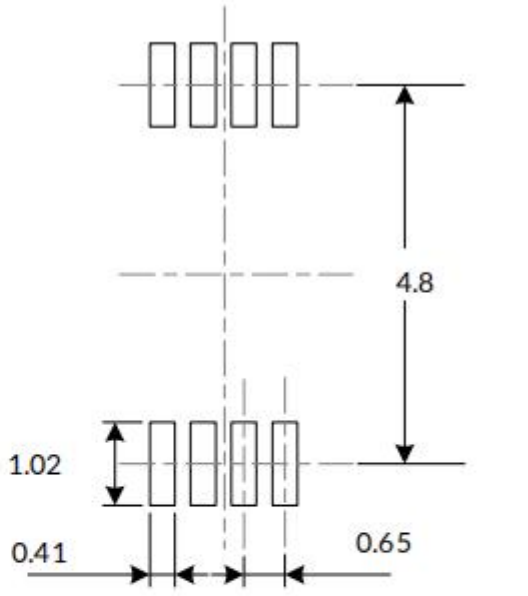
Symbol	Dimensions In Millimeters		Dimensions In Inches	
	Min	Max	Min	Max
A (1)	0.900	1.100	0.035	0.043
A1	0.000	0.100	0.000	0.004
A2	0.900	1.000	0.035	0.039
b	0.150	0.350	0.006	0.014
c	0.080	0.150	0.003	0.006
D (1)	2.000	2.200	0.079	0.087
E (1)	1.150	1.350	0.045	0.053
E1	2.150	2.450	0.085	0.096
e	0.650(BSC) (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:

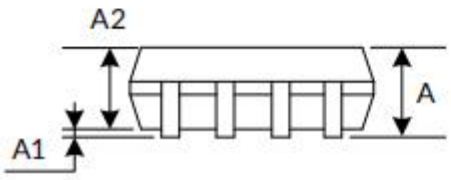
1. Plastic or metal protrusions of 0.15mm maximum per side are not included.
2. BSC (Basic Spacing between Centers), "Basic" spacing is nominal.
3. This drawing is subject to change without notice.

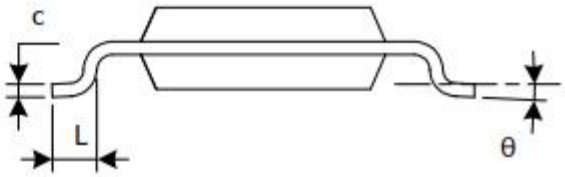
(3) Package Type: MSOP8 (3)





RECOMMENDED LAND PATTERN (Unit: mm)



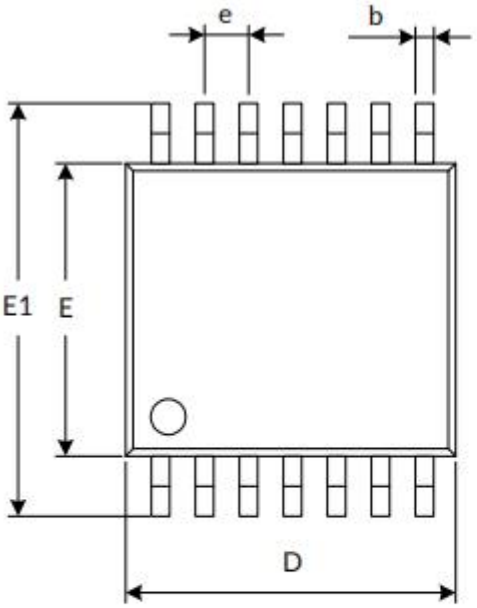


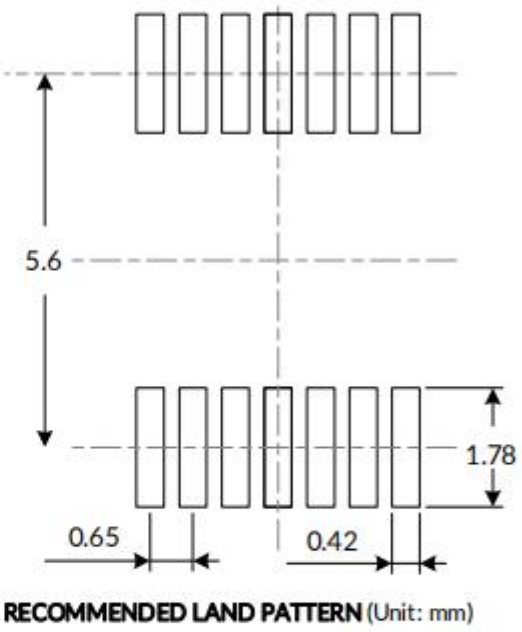
Symbol	Dimensions In Millimeters		Dimensions In Inches	
	Min	Max	Min	Max
A (1)	0.820	1.100	0.032	0.043
A1	0.020	0.150	0.001	0.006
A2	0.750	0.950	0.030	0.037
b	0.250	0.380	0.010	0.015
c	0.090	0.230	0.004	0.009
D (1)	2.900	3.100	0.114	0.122
e	0.650(BSC) (2)		0.026(BSC) (2)	
E (1)	2.900	3.100	0.114	0.122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

NOTE:

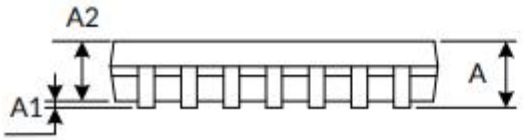
1. Plastic or metal protrusions of 0.15mm maximum per side are not included.
2. BSC (Basic Spacing between Centers), "Basic" spacing is nominal.
3. This drawing is subject to change without notice.

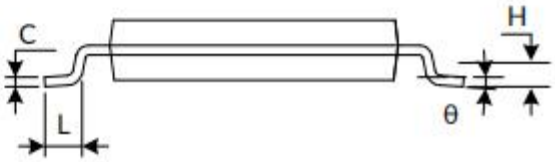
(4) Package Type: TTSSOP14 (3)





RECOMMENDED LAND PATTERN (Unit: mm)



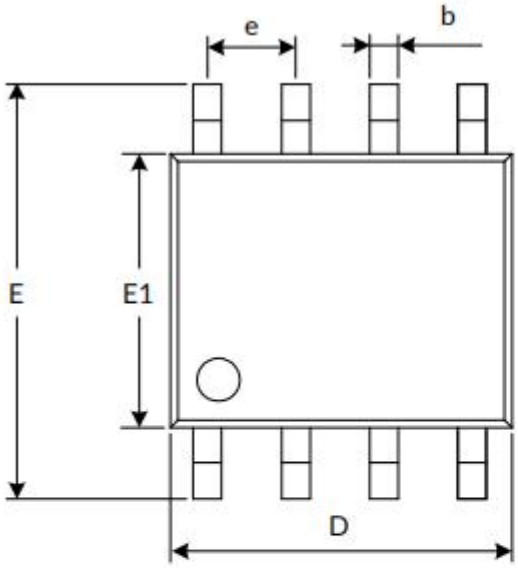


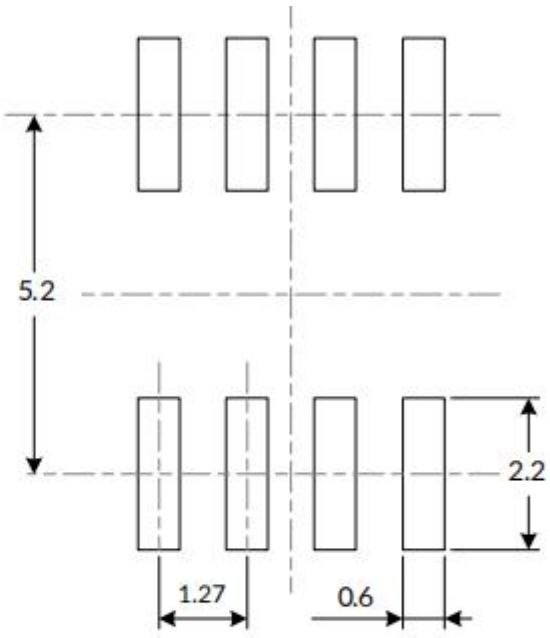
Symbol	Dimensions In Millimeters		Dimensions In Inches	
	Min	Max	Min	Max
A (1)		1.200		0.047
A1	0.050	0.150	0.002	0.006
A2	0.800	1.050	0.031	0.041
b	0.190	0.300	0.007	0.012
c	0.090	0.200	0.004	0.008
D (1)	4.860	5.100	0.191	0.201
E (1)	4.300	4.500	0.169	0.177
E1	6.250	6.550	0.246	0.258
e	0.650(BSC) (2)		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:

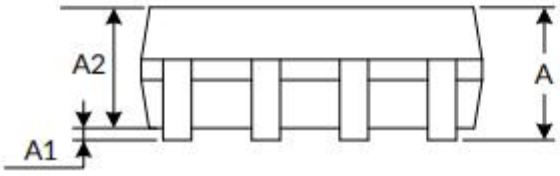
1. Plastic or metal protrusions of 0.15mm maximum per side are not included.
2. BSC (Basic Spacing between Centers), "Basic" spacing is nominal.
3. This drawing is subject to change without notice.

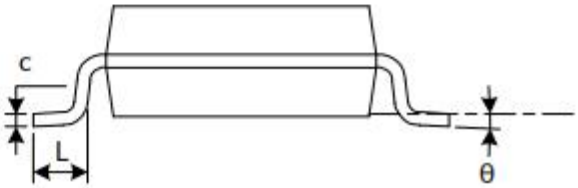
(5) Package Type: SOP8 (3)





RECOMMENDED LAND PATTERN (Unit: mm)



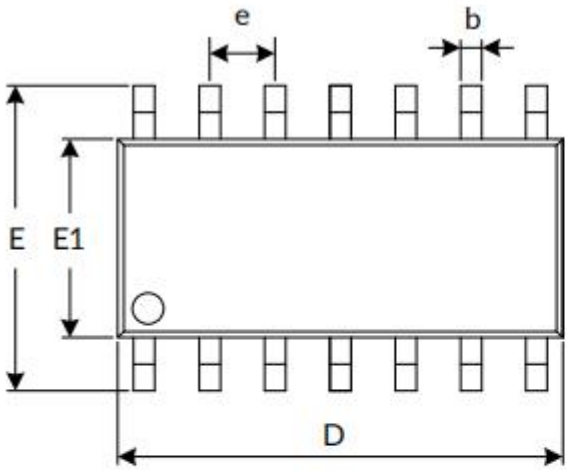


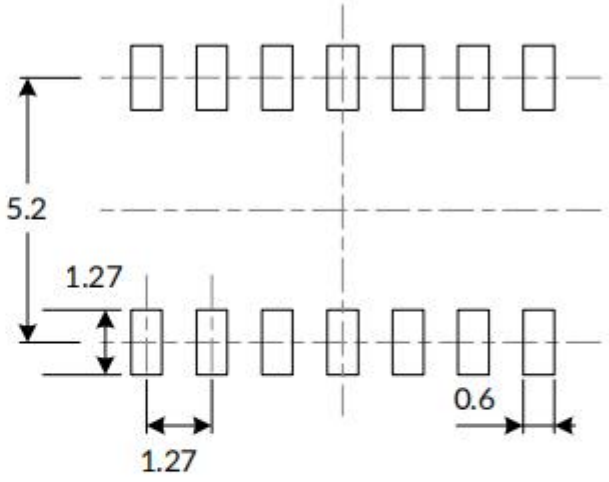
Symbol	Dimensions In Millimeters		Dimensions In Inches	
	Min	Max	Min	Max
A (1)	1.350	1.750	0.053	0.069
A1	0.100	0.250	0.004	0.010
A2	1.350	1.550	0.053	0.061
b	0.330	0.510	0.013	0.020
c	0.170	0.250	0.007	0.010
D (1)	4.800	5.000	0.189	0.197
e	1.270(BSC) (2)		0.050(BSC) (2)	
E	5.800	6.200	0.228	0.244
E1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

NOTE:

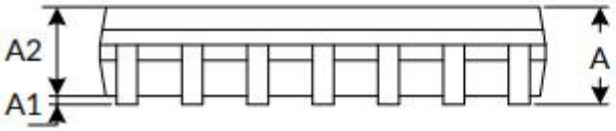
1. Plastic or metal protrusions of 0.15mm maximum per side are not included.
2. BSC (Basic Spacing between Centers), "Basic" spacing is nominal.
3. This drawing is subject to change without notice.

(6) Package Type: SOP14 (3)





RECOMMENDED LAND PATTERN (Unit: mm)

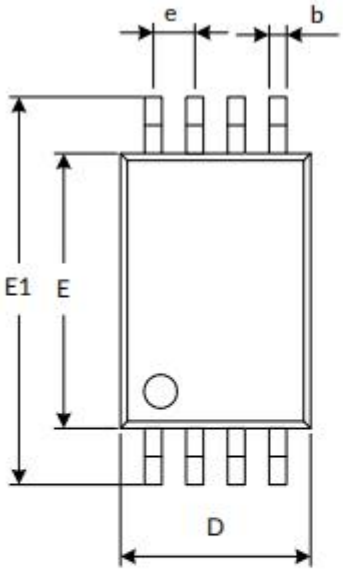


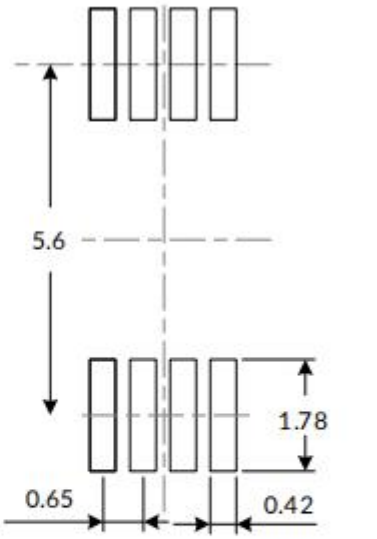
Symbol	Dimensions In Millimeters		Dimensions In Inches	
	Min	Max	Min	Max
A (1)	1.350	1.750	0.053	0.069
A1	0.100	0.250	0.004	0.010
A2	1.350	1.550	0.053	0.061
b	0.310	0.510	0.012	0.020
c	0.100	0.250	0.004	0.010
D (1)	8.450	8.850	0.333	0.348
e	1.270(BSC) (2)		0.050(BSC) (2)	
E	5.800	6.200	0.228	0.244
E1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

NOTE:

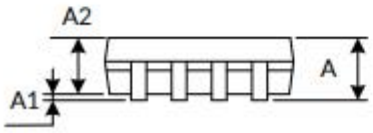
1. Plastic or metal protrusions of 0.15mm maximum per side are not included.
2. BSC (Basic Spacing between Centers), "Basic" spacing is nominal.
3. This drawing is subject to change without notice.

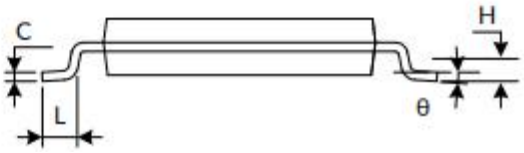
(7) Package Type: TSSOP8 (3)





RECOMMENDED LAND PATTERN (Unit: mm)

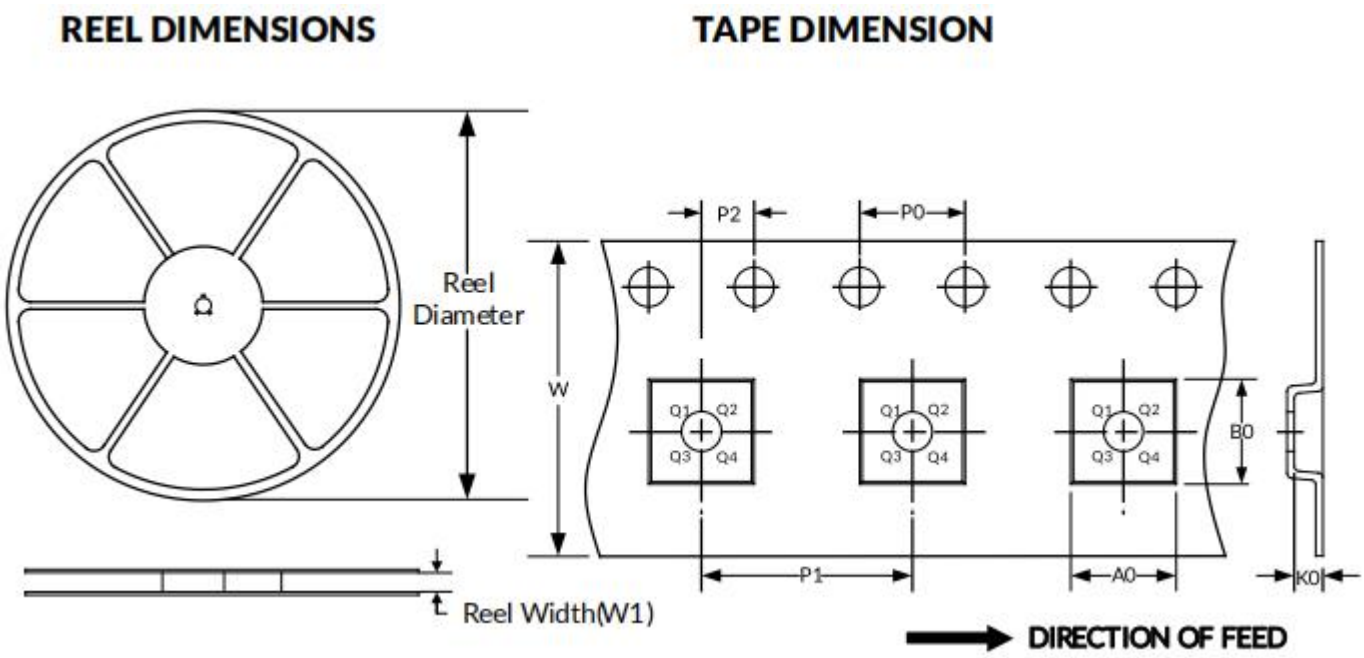




Symbol	Dimensions In Millimeters		Dimensions In Inches	
	Min	Max	Min	Max
A (1)		1.200		0.047
A1	0.050	0.150	0.002	0.006
A2	0.800	1.050	0.031	0.041
b	0.190	0.300	0.007	0.012
c	0.090	0.200	0.004	0.008
D (1)	2.900	3.100	0.114	0.122
E (1)	4.300	4.500	0.169	0.177
E1	6.250	6.550	0.246	0.258
e	0.650(BSC) (2)		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.

Tape And Reel Information



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
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
TSSOP8	13”	12.4	6.90	3.45	1.65	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.

Important Notice And Disclaimer

- We reserves the right to change the instruction manual without prior notice.
- Any semiconductor product has a certain possibility of failure or malfunction under specific conditions. The buyer is responsible for complying with safety standards and taking safety measures when using our products for system design and overall manufacturing to avoid potential failure risks that may cause personal injury or property damage.
- The improvement of product quality is endless, our company will be dedicated to provide customers with better products.