10μA, 200kHz Rail-to-Rail Input/Output Operational Amplifiers

Features

- Low Quiescent Current: 10μA
- Operates on 1.8V ~ 5.5V Supplies
- Rail-to-Rail Input and Output (RRIO)
- Gain Bandwidth Product: 200kHz
- Low Input Bias Current: 1pA (typical)
- Unity Gain Stable
- No Phase Reversal
- Extended Temperature Ranges
  From -40°C to +125°C
- Small Packaging
  COS379 available in SOT23-5/SOP8
  COS2379 available in SOP8/MSOP8
  COS4379 available in SOP14/TSSOP14

Applications

- Battery or Solar Powered Systems
- Temperature Measurements
- Sensor Conditioning
- Toll Booth Tags
- Medical Instrumentation
- Battery current monitoring
- Wearable Products

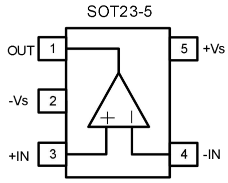
General Description

The COS379 (single), COS2379 (dual) and COS4379 (quad) are 10uA, rail-to-rail input and output amplifiers operated on 1.8V to 5.5V supplies. Despite their super low quiescent current, the COSx379 family provides excellent overall performance and versatility. They have both rail-to-rail input and output range. The output voltage swing extends to within 10mV of each rail, providing the maximum output dynamic range.

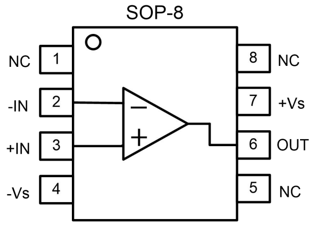
COSx379 family is unity gain stable and has a gain bandwidth product of 200kHz (typical). They provide high CMRR and PSRR performance and can operate from a single supply voltage as low as 1.8V. These features make the COSx379 family well suited for single-supply, battery-powered applications. such as battery current monitoring and sensor conditioning.

Rev1.1

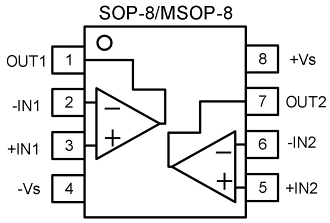
1. Pin Configuration and Functions



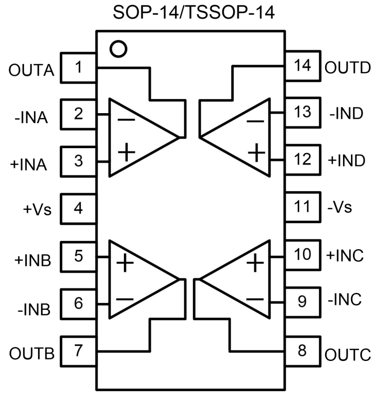
COS379



COS379



COS2379



COS4379

Pin Functions

Name	Description	Note
+Vs	Positive power supply	A bypass capacitor of 0.1μF as close to the part as possible should be placed between power supply pins or between supply pins and ground.
-Vs	Negative power supply or ground	If it is not connected to ground, bypass it with a capacitor of 0.1μF as close to the part as possible.
-IN	Negative input	Inverting input of the amplifier. Voltage range of this pin can go from -Vs -0.3V to +Vs + 0.3V.
+IN	Positive input	Non-inverting input of the amplifier. This pin has the same voltage range as –IN.
OUT	Output	The output voltage range extends to within millivolts of each supply rail.
NC	No connection	

2. Package and Ordering Information

Model	Channel	Order Number	Package	Package Option	Marking Information
COS379	1	COS379TR	SOT23-5	Tape and Reel, 3000	C379
		COS379SR	SOP-8	Tape and Reel, 3000	COS379
COS2379	2	COS2379SR	SOP-8	Tape and Reel, 3000	COS2379
		COS2379MR	MSOP-8	Tape and Reel, 3000	COS2379
COS4379	4	COS4379SR	SOP-14	Tape and Reel, 3000	COS4379
		COS4379TR	TSSOP-14	Tape and Reel, 3000	COS4379

3. Product Specification

3.1 Absolute Maximum Ratings (1)

Parameter	Rating	Units
Power Supply: +Vs to -Vs	6.0	V
Input Voltage	-Vs -0.5V to +Vs + 0.5V	V
Input Current (2)	10	mA
Storage Temperature Range	-65 to 150	°C
Junction Temperature	150	°C
Operating Temperature Range	-40 to 125	°C
ESD Susceptibility, HBM	2000	V

(1) Stresses exceeding the absolute maximum ratings may damage the device. The device may not function or be operable above the recommended operating conditions and stressing the parts to these levels is not recommended. In addition, extended exposure to stresses above the recommended operating conditions may affect device reliability. The absolute maximum ratings are stress ratings only.
(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.

3.2 Thermal Data

Parameter	Rating	Unit
Package Thermal Resistance	190 (SOT23-5) 206 (MSOP8) 155 (SOP8) 105 (TSSOP14) 82 (SOP14)	°C/W

3.3 Recommended Operating Conditions

Parameter	Rating	Unit
DC Supply Voltage	1.8V ~ 5.5V	V
Input common-mode voltage range	-Vs ~ +Vs	V
Operating ambient temperature	-40 to +85	°C

3.4 Electrical Characteristics

(+V_S=+5V, -V_S=0, V_{CM}=V_S/2, T_A=+25°C, R_L=10kΩ to V_S/2, unless otherwise noted)

Parameter	Symbol	Conditions	Min	Typ	Max	Unit
Input Characteristics						
Input Offset Voltage	V_{OS}			1	5	mV
Input Offset Voltage Drift	$\Delta V_{OS}/\Delta T$	-40 to 125°C		2.5		μV/°C
Input Bias Current	IB			1	10	pA
Input Offset Current	I_{OS}			1	10	pA
Common-Mode Voltage Range	V_{CM}	V_S = 5.5V	-0.1		5.6	V
Common-Mode Rejection Ratio	CMRR	V_{CM} =0.1V to 4.9V		85		dB
Open-Loop Voltage Gain	AOL	V_O=0.2V to 4.8V		90		dB
Out Characteristics						
Output Voltage Swing from Rail		R_L=10kΩ		10		mV
Short-Circuit Current	I_{SC}			±20		mA
Power Supply						
Operating Voltage Range			1.8		5.5	V
Power Supply Rejection Ratio	PSRR	V_S = +1.8V to +5.5V		85		dB
Quiescent Current / Amplifier	I_Q			10		μA
Dynamic Performance						
Gain Bandwidth Product	GBWP	G=+1		200		kHz
Slew Rate	SR	G = +1 , 2V Output Step		0.1		V/μs
Noise Performance						
Voltage Noise Density	e_n	f=1kHz		120		nV/ √Hz

4.0 Application Notes

Driving Capacitive Loads

Driving large capacitive loads can cause stability problems for voltage feedback op amps. As the load capacitance increases, the feedback loop's phase margin decreases, and the closed loop bandwidth is reduced. This produces gain peaking in the frequency response, with overshoot and ringing in the step response. A unity gain buffer (G = +1) is the most sensitive to capacitive loads, but all gains show the same general behavior.

When driving large capacitive loads with these op amps (e.g., > 100 pF when G = +1), a small series resistor at the output (R_{ISO} in Figure 1) improves the feedback loop's phase margin (stability) by making the output load resistive at higher frequencies. It does not, however, improve the bandwidth.

To select R_{ISO}, check the frequency response peaking (or step response overshoot) on the bench. If the response is reasonable, you do not need R_{ISO}. Otherwise, start R_{ISO} at 1 kΩ and modify its value until the response is reasonable.

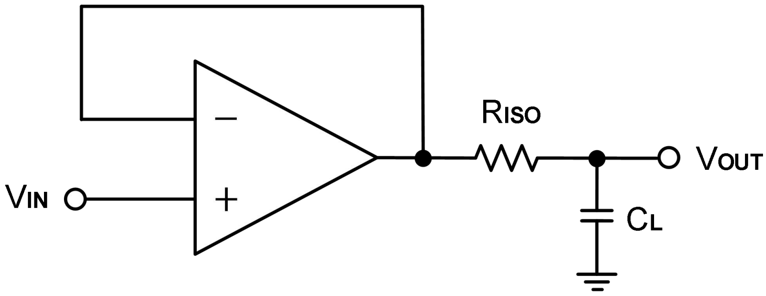


Figure 1. Indirectly Driving Heavy Capacitive Load

An improvement circuit is shown in Figure 2. It provides DC accuracy as well as AC stability. R_F provides the DC accuracy by connecting the inverting signal with the output, C_F and R_{ISO} serve to counteract the loss of phase margin by feeding the high frequency component of the output signal back to the amplifier's inverting input, thereby preserving phase margin in the overall feedback loop.

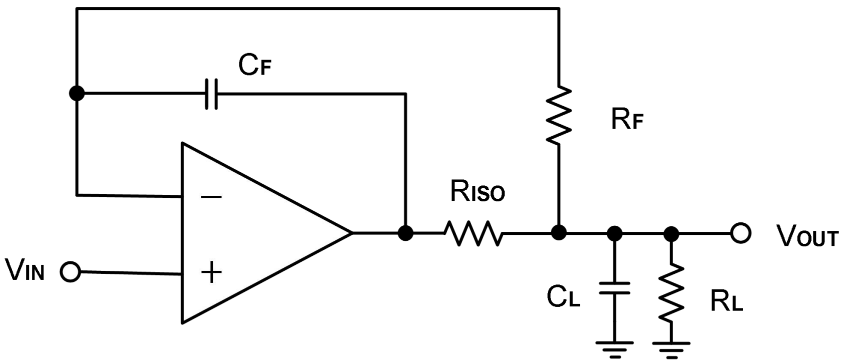


Figure 2. Indirectly Driving Heavy Capacitive Load with DC Accuracy

For non-inverting configuration, there are two others ways to increase the phase margin: (a) by increasing the amplifier's gain or (b) by placing a capacitor in parallel with the feedback resistor to counteract the parasitic capacitance associated with inverting node, as shown in Figure 3.

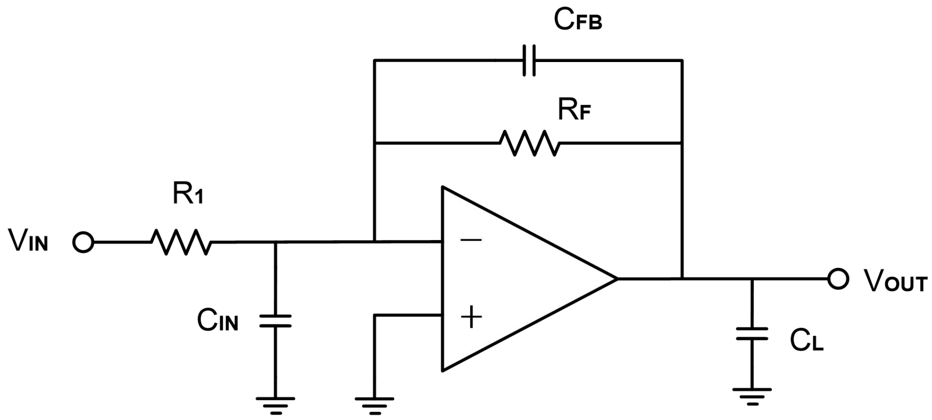


Figure 3. Adding a Feedback Capacitor in the Non-inverting Configuration

Power-Supply Bypassing and Layout

The COSx379 family operates from a single +1.8V to +5.5V supply. A 0.1μF ceramic capacitor should be placed close to the +Vs pin to bypass the power supply +Vs. 2.2μF tantalum capacitor can be added for better performance.

The length of the current path is directly proportional to the magnitude of parasitic inductances and thus the high frequency impedance of the path. High speed currents in an inductive ground return create an unwanted voltage noise. Broad ground plane areas will reduce the parasitic inductance.

Typical Application Circuits

Differential Amplifier

The circuit shown in Figure 4 performs the differential function. If the resistors ratios are equal (R_4 / R_3 = R_2 / R_1), then V_{OUT} = (V_{IP} – V_{IN}) × R_2 / R_1 + V_{REF}.

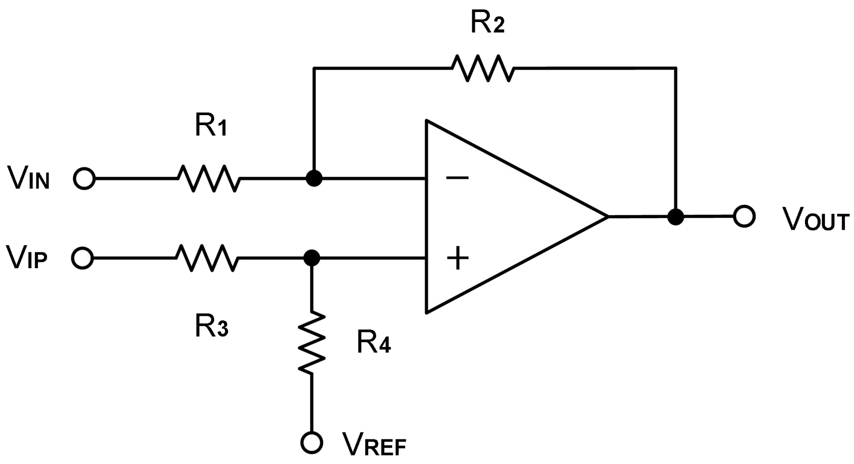
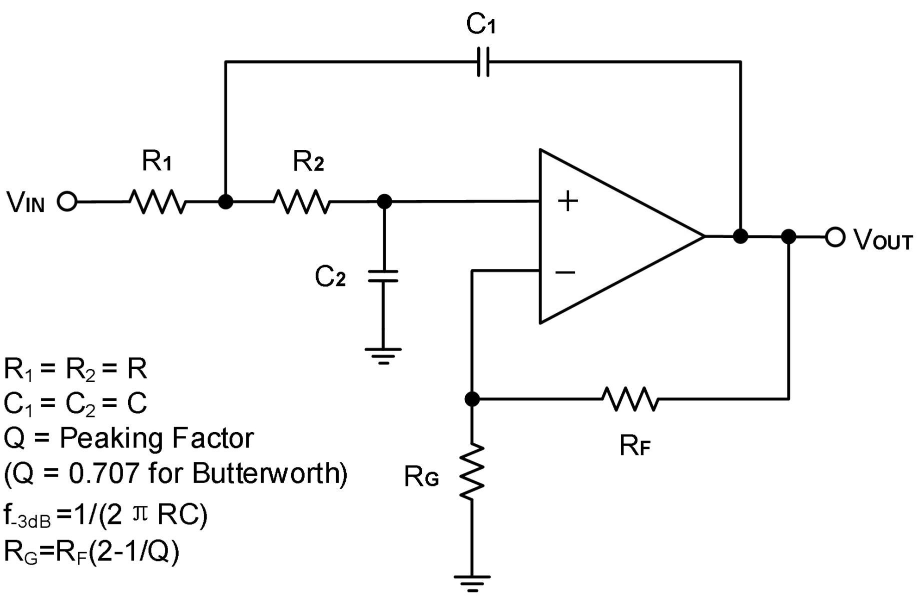


Figure 4. Differential Amplifier

Low Pass Active Filter

When receiving low-level signals, limiting the bandwidth of the incoming signals into the system is often required. The simplest way to establish this limited bandwidth is to place an RC filter at the noninverting terminal of the amplifier. If even more attenuation is needed, a multiple pole filter is required. The Sallen-Key filter can be used for this task, as Figure 5. For best results, the amplifier should have a bandwidth that is 8 to 10 times the filter frequency bandwidth. Failure to follow this guideline can result in reduction of phase margin. The large values of feedback resistors can couple with parasitic capacitance and cause undesired effects such as ringing or oscillation in high-speed amplifiers. Keep resistors value as low as possible and consistent with output loading consideration.

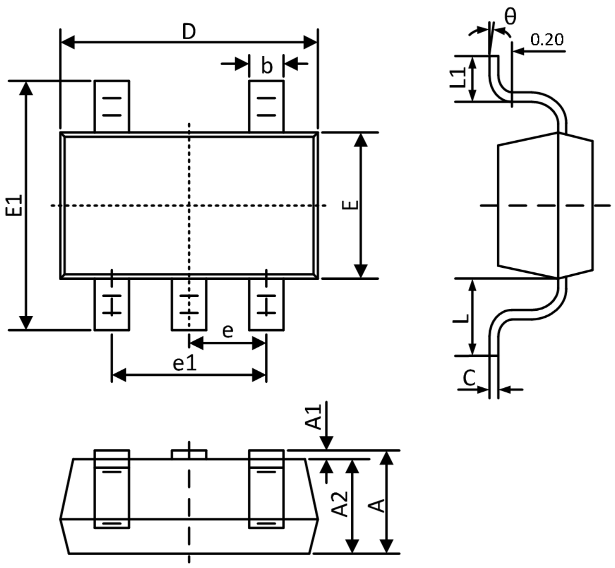


$R_1 = R_2 = R$
$C_1 = C_2 = C$
Q = Peaking Factor
(Q = 0.707 for Butterworth)
$f_{-3dB} = 1/(2\pi RC)$
$R_G = R_F(2-1/Q)$

Figure 5. Two-Pole Low-Pass Sallen-Key Active Filter

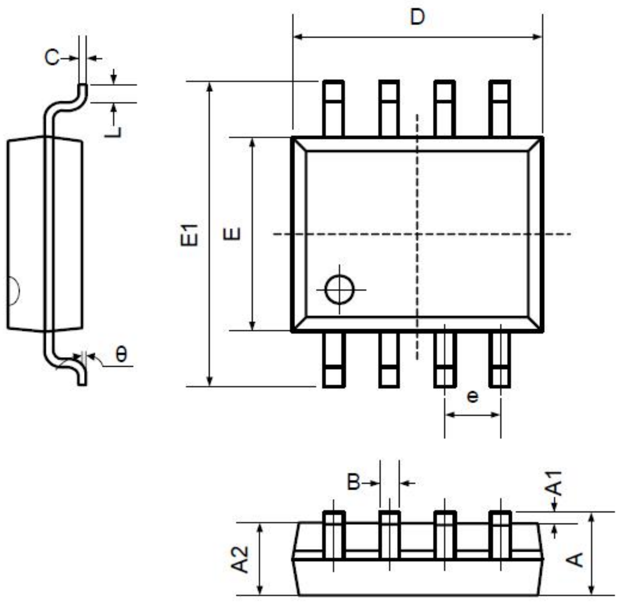
5. Package Information

5.1 SOT23-5 (Package Outline Dimensions)



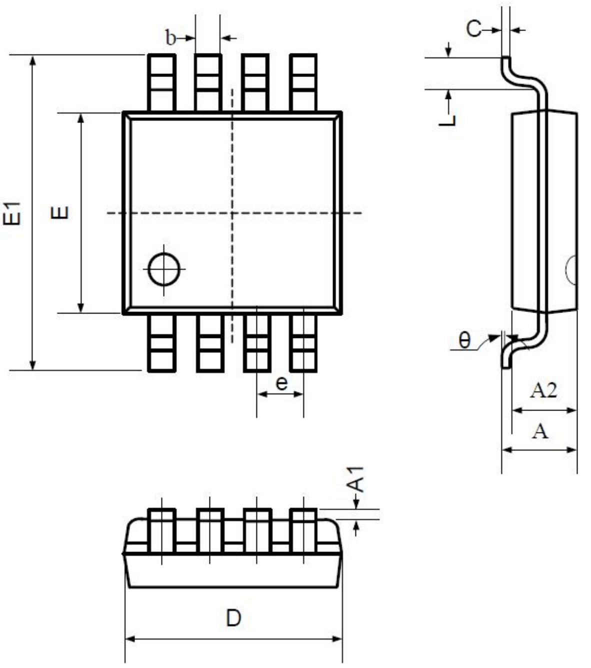
Symbol	Dimensions In Millimeters		Dimensions In Inches	
	MIN	MAX	MIN	MAX
A	1.050	1.250	0.041	0.049
A1	0.000	0.100	0.000	0.004
A2	1.050	1.150	0.041	0.045
b	0.300	0.400	0.012	0.016
c	0.100	0.200	0.004	0.008
D	2.820	3.020	0.111	0.119
E	1.500	1.700	0.059	0.067
E1	2.650	2.950	0.104	0.116
e	0.950TYP		0.037TYP	
e1	1.800	2.000	0.071	0.079
L	0.700REF		0.028REF	
L1	0.300	0.600	0.012	0.024
θ	0°	8°	0°	8°

5.2 SOP8 (Package Outline Dimensions)



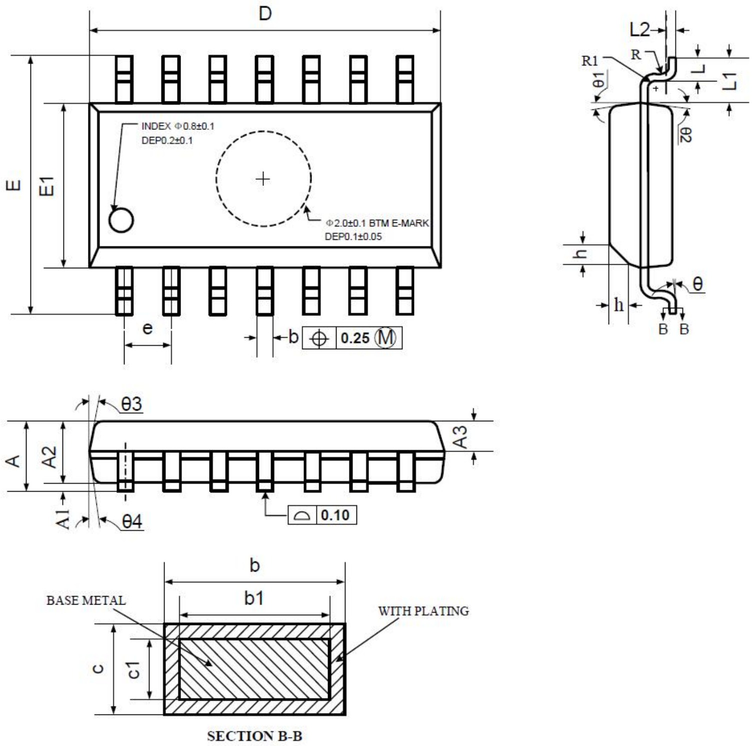
Symbol	Dimensions In Millimeters		Dimensions In Inches	
	Min	Max	Min	Max
A	1.350	1.750	0.053	0.069
A1	0.100	0.250	0.004	0.010
A2	1.350	1.550	0.053	0.061
B	0.330	0.510	0.013	0.020
C	0.190	0.250	0.007	0.010
D	4.780	5.000	0.188	0.197
E	3.800	4.000	0.150	0.157
E1	5.800	6.300	0.228	0.248
e	1.270TYP		0.050TYP	
L	0.400	1.270	0.016	0.050
θ	0°	8°	0°	8°

5.3 MSOP8 (Package Outline Dimensions)



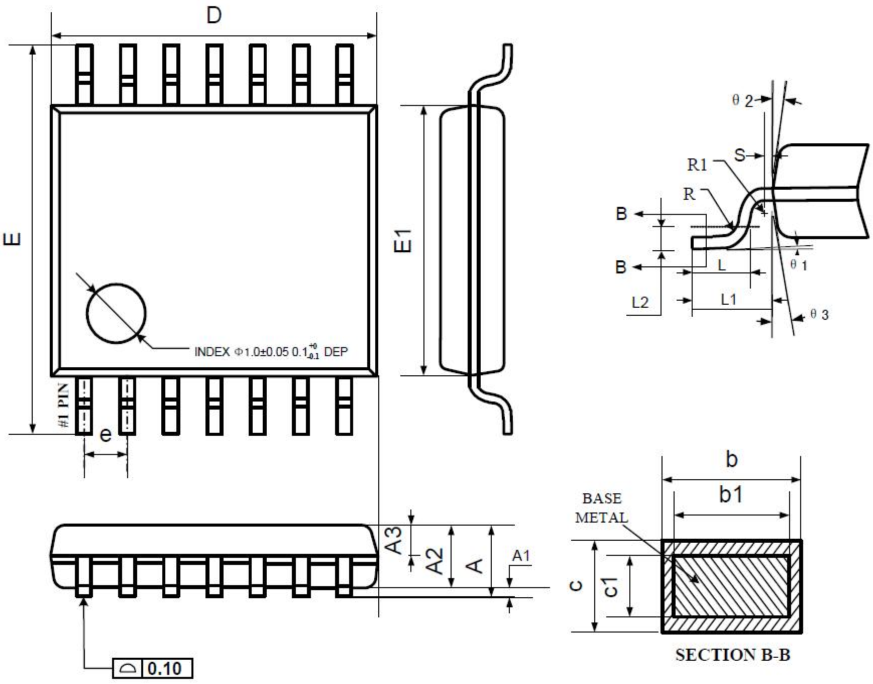
Symbol	Dimensions In Millimeters		Dimensions In Inches	
	Min	Max	Min	Max
A	0.800	1.200	0.031	0.047
A1	0.000	0.200	0.000	0.008
A2	0.760	0.970	0.030	0.038
b	0.30 TYP		0.012 TYP	
c	0.15 TYP		0.006 TYP	
D	2.900	3.100	0.114	0.122
e	0.65 TYP		0.026 TYP	
E	2.900	3.100	0.114	0.122
E1	4.700	5.100	0.185	0.201
L	0.410	0.650	0.016	0.026
θ	0°	6°	0°	6°

5.4 SOP14 (Package Outline Dimensions)



Symbol	Dimensions In Millimeters		
	MIN	NOM	MAX
A	1.35	1.60	1.75
A1	0.10	0.15	0.25
A2	1.25	1.45	1.65
A3	0.55	0.65	0.75
b	0.36		0.49
b1	0.35	0.40	0.45
c	0.16		0.25
c1	0.15	0.20	0.25
D	8.53	8.63	8.73
E	5.80	6.00	6.20
E1	3.80	3.90	4.00
e	1.27 BSC		
L	0.45	0.60	0.80
L1	1.04 REF		
L2	0.25 BSC		
R	0.07		
R1	0.07		
h	0.30	0.40	0.50
θ	0°		8°
θ1	6°	8°	10°
θ2	6°	8°	10°
θ3	5°	7°	9°
θ4	5°	7°	9°

5.5 TSSOP14 (Package Outline Dimensions)



Symbol	Dimensions In Millimeters		
	MIN	NOM	MAX
A	—	—	1.20
A1	0.05	—	0.15
A2	0.90	1.00	1.05
A3	0.34	0.44	0.54
b	0.20	—	0.28
b1	0.20	0.22	0.24
c	0.10	—	0.19
c1	0.10	0.13	0.15
D	4.86	4.96	5.06
E	6.20	6.40	6.60
E1	4.30	4.40	4.50
e	0.65 BSC		
L	0.45	0.60	0.75
L1	1.00 REF		
L2	0.25 BSC		
R	0.09	—	—
R1	0.09	—	—
S	0.20	—	—
θ1	0°	—	8°
θ2	10°	12°	14°
θ3	10°	12°	14°

6. Related Parts

Part Number	Description
COS6042	24kHz, 0.5μA, Nano-Power Op Amps, 1.4V to 5.5V Supply
COS8042	160MHz, 5.5mA, High Speed Op Amps, 3V to 12V Supply
COS2172	10MHz, 1.2mA, RRIO Op Amps, 4.5 to 40V Supply
COS2333	350kHz, 18μA, Precision Op Amps, 1.8 to 5.5V Supply, Zero Drift, Vos<10μV
COS8552	1.5MHz, 55μA, Precision Op Amps, 1.8 to 5.5V Supply, Zero Drift, Vos<10μV
COS2388	9MHz, 570μA, Precision Op Amps, 1.8 to 5.5V Supply, Zero Drift, Vos<10μV
COS2227	10MHz, 1.3mA, Precision Op Amps, 4.5 to 36V Supply, Vos<50μV
COS2182	5MHz, 580μA, RRIO Precision Op Amps, 4.5 to 40V Supply, Vos<50μV
COS620	1.5MHz, 1.3mA, Instrumentation Amps, 4.5 to 36V Supply, Vos<50μV
COSINA333	150kHz, 65μA, Instrumentation Amps, 1.8 to 5.5V Supply, Vos<25μV