4.5ns, High-Speed Comparators

Features

- Low Propagation Delay: 4.5 ns
- Low Quiescent Current: 3.3mA
- Low Input Offset Voltage: 1 mV Typical
- Supply Operation From: 2.7V ~ 5.5V
- Rail-to-Rail Input
- Push-Pull Outputs
- Internal Hysteresis for Noise Immunity
- Input Bias Current: 2 pA Typical
- No Phase Inversion for Overdrive Inputs
- Extended Temperature Ranges
  From -40°C to +125°C
- Small Packaging：
  COS3501：SOT23-6 / SOP8
  COS3502：SOT23-8 / SOP8 / MSOP8

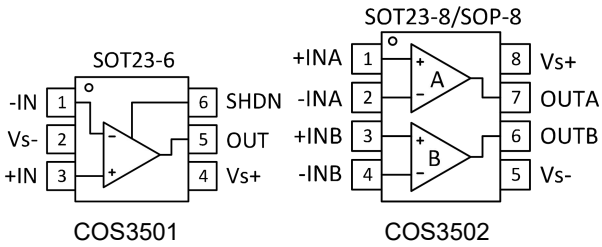
Applications

- Inspection Equipment
- Threshold Detectors/Discriminators
- Peak and Zero-crossing detectors
- Logic Level Shifting or Translation
- Portable Equipment
- Sensor Conditioning
- High-Speed Sampling Systems
- Battery Powered Electronics
- IR Receivers
- Window Comparators

General Description

The COS3501 and COS3502 are single and dual channel comparators which feature a high speed 4.5ns propagation delay and rail-to-rail push-pull output. Their operating voltage ranges from 2.7V to 5.5V, making them ideal for 3.3V and 5V systems. Input bias current is typically 2.0pA, and input offset voltage is typically 1 mV.

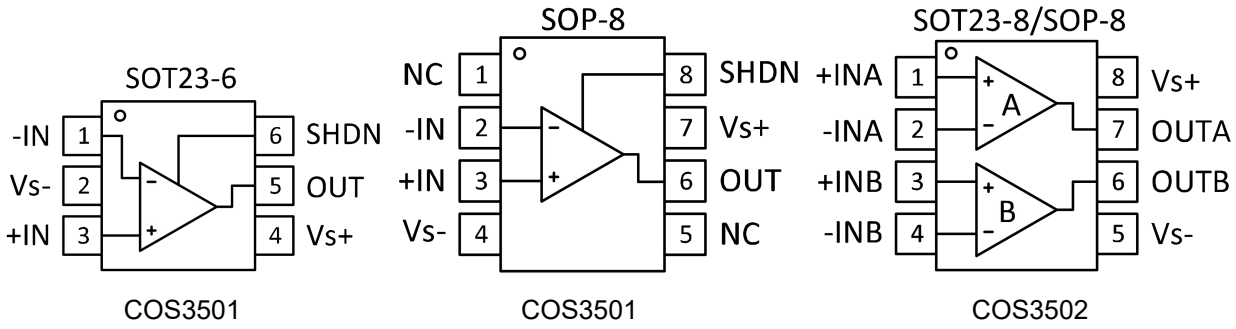
The COS350x family feature 1.6mV of internal hysteresis for improved noise immunity. The input common-mode range extends 0.2V beyond the power-supply rails. They have push-pull output stages capable of sinking and sourcing milliamps of current when controlling an LED or driving a capacitive load.



Pin Diagram

Rev1.0

1. Pin Configuration and Functions



Pin Functions

Name	3501		3502	Type	Description
	SOT23-6	SOP-8	SOP8/ SOT23-8		
-IN	1	2	2, 4	I	Negative (inverting) input
+IN	3	3	1, 3	I	Positive (non-inverting) input
OUT	5	6	7, 8	O	Output
Vs-	2	4	5	P	Negative (lowest) power supply
Vs+	4	7	8	P	Positive (highest) power supply
SHDN	6	8	-	I	Shutdown when pin is high
NC	-	1, 5	-	-	No internal connection, can be left floating

2. Package and Ordering Information

Model	Channel	Order Number	Package	Package Option	Marking Information
COS3501	1	COS3501TR	SOT23-6	Tape and Reel, 3000	COS3501
		COS3501SR	SOP-8	Tape and Reel, 4000	COS3501
COS3502	2	COS3502SR	SOP-8	Tape and Reel, 4000	COS3502
		COS3502TR	SOT23-8	Tape and Reel, 3000	COS3502
		COS3502MR	MSOP-8	Tape and Reel, 3000	COS3502

3. Product Specification

3.1 Absolute Maximum Ratings (1)

Parameter	Rating	Units
Power Supply: +Vs to -Vs	6	V
Input Voltage	-Vs -0.3V to +Vs + 0.3V	V
Input Current (2)	±10	mA
Output Short Circuit Current	±70	mA
Storage Temperature Range	-65 to 150	°C
Junction Temperature	150	°C
Operating Temperature Range	-40 to 125	°C
ESD Susceptibility, HBM	3000	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, $R_{\theta JA}$ (Juntion-to-ambient)	192 (SOT23-6) 190 (SOT23-8) 206 (MSOP8) 155 (SOP8)	°C/W

3.3 Recommended Operating Conditions

Parameter	Rating	Unit
DC Supply Voltage	2.7 ~ 5.5	V
Input Common-mode Voltage Range	-Vs ~ +Vs	V
Operating Ambient Temperature	-40 ~ +125	°C

3.4 Electrical Characteristics

(V_S= 2.7V to 5.5V, C_L=15pF, T_A=+25°C, unless otherwise noted)

Parameter	Symbol	Conditions	Min	Typ	Max	Unit
Input Characteristics						
Input Offset Voltage	V_{OS}			1.0	5.0	mV
Input Offset Voltage Drift	$\Delta V_{OS}/\Delta T$	-40 to 125°C		5		µV/°C
Input Hysteresis	V_{HYS}			1.6		mV
Input Bias Current	I_B			2	10	pA
Input Offset Current	I_{OS}			2	10	pA
Common-Mode Voltage Range	V_{CM}		-0.2		Vs+0.2	V
Common-Mode Rejection Ratio	CMRR	V_{CM} =-0.2V to Vs+0.2V	55			dB
Output Characteristics						
Voltage Output Swing from Lower Rail	V_{OL}	I_{SINK}=1mA		38	50	mV
Voltage Output Swing from Upper Rail	V_{OH}	I_{SOURCE}=1mA		35	50	mV
Short-Circuit Current	I_{SR}	Sourcing		58		mA
	I_{SK}	Sinking		59		mA
Power Supply						
Operating Voltage Range	V_S		2.7		5.5	V
Power Supply Rejection Ratio	PSRR	V_S = +2.7V to +5.5V		80		dB
Quiescent Current / per Channel	I_Q	Vs = 5V, V_O = High		3.3		mA
Quiescent Current in Shutdown	I_{QSD}				1	µA
Shutdown						
Shutdown Turnoff Time	t_{OFF}			10		ns
Shutdown Turnon Time	t_{ON}			100		ns
SHDN Low Threshold	V_L	Comparator is enabled			+Vs-1.7	V
SHDN High Threshold	V_H	Comparator is enabled	+Vs-0.9			V
Input Bias Current of SHDN Pin				2		pA

Switching Characteristics						
Propagation Delay Time	t_{PD}	ΔV_{IN}=40mV, Overdrive=20mV		4.5	7	ns
		ΔV_{IN}=100mV, Overdrive=50mV		3	5.5	ns
Propagation Delay Skew	$\Delta t_{(SKEW)}$	ΔV_{IN}=100mV, overdrive=20mV		0.5		ns
Rise Time	t_R	10% to 90%		1.5		ns
Fall Time	t_F	10% to 90%		1.5		ns
Maximum Toggle Frequency	f_{MAX}	Overdrive=50mV, Vs=5V		90		MHz

4.0 Application Notes

Shutdown Mode

A shutdown pin is available for COS3501 which allows the device to go into idle when it is not in use. The COS3502 does not have the shutdown feature. When the shutdown pin is high for COS3501, the device does not draw current, and the output goes to high impedance. When the shutdown pin is low, the COS3501 is active. When the COS3501 shutdown feature is not used, connect the shutdown pin to the most negative supply, as shown in Figure 1. Exiting shutdown mode requires approximately 100 ns.

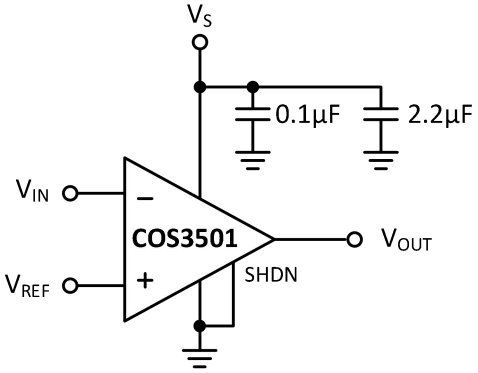


Figure 1 Basic Connections for the COS3501

Power-Supply Bypassing and Layout

For single-supply operation, bypass the power supply V_S with a 0.1µF ceramic capacitor which should be placed close to the V_S pin. For dual-supply operation, both the positive and negative supplies should be bypassed to ground with separate 0.1µF ceramic capacitors. 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. Thus a ground plane layer is important for high speed circuit design.

Inverting Comparator with Hysteresis

When higher levels of hysteresis are required, positive feedback can be externally added. The inverting comparator with hysteresis requires a three-resistor network that is referenced to the comparator supply voltage (Vcc), as shown in Figure 2. When V_{IN} at the inverting input is less than V_T, the output voltage is high. The three network resistors can be represented as R1//R3 in series with R2. Equation 1 defines the high to low trip voltage (V_{T1}) .

$$V_{T1} = \frac{R2 \cdot Vcc}{(R1//R3)+R2} \quad (1)$$

When V_{IN} is greater than V_A, the output voltage is low, very close to ground. In this case, the three network resistors can be presented as R2//R3 in series with R1. Equation 2 define the low to high trip voltage (V_{T2}).

$$V_{T2} = \frac{(R2//R3) \cdot Vcc}{(R2//R3)+R1} \quad (2)$$

The total hysteresis provided by the network is

$$\Delta V_T = V_{T1} - V_{T2} \quad (3)$$

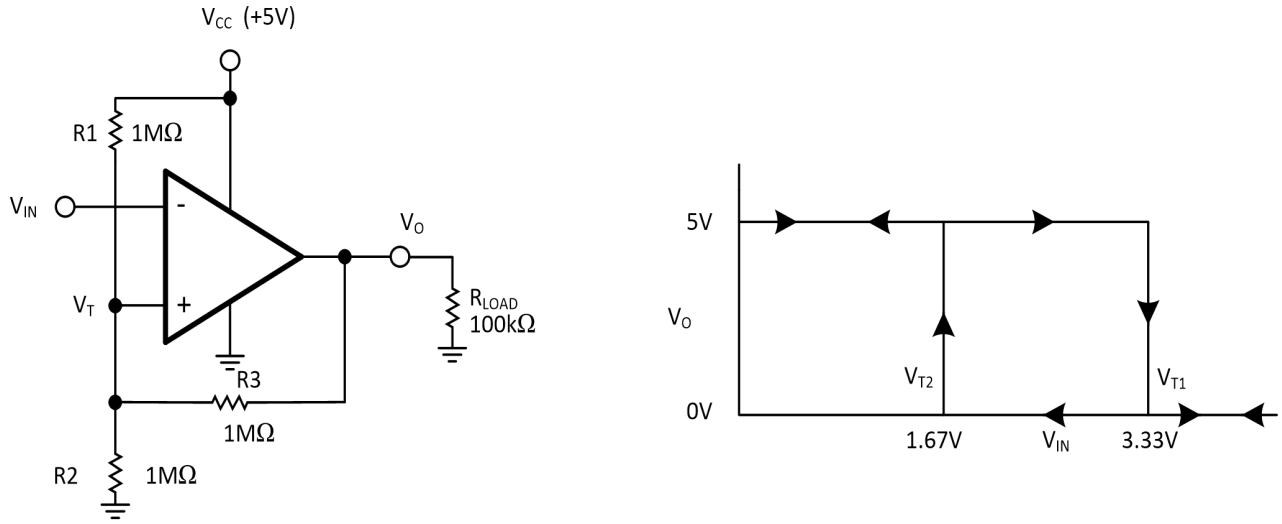


Figure 2. Inverting Configuration with Hysteresis

Non-inverting Comparator with Hysteresis

A non-inverting comparator with hysteresis requires a two-resistor network, as shown in Figure 3, and a voltage reference (V_{REF}) at the inverting input. When V_{IN} is low, the output is also low. For the output to switch from low to high, V_{IN} must rise to V_{IN1}. Equation 4 defines the low to high trip voltage (V_{IN1}) :

$$V_{IN1} = \frac{(R1+R2)\cdot V_{REF}}{R2} \quad (4)$$

When V_{IN} is high, the output is also high. For the comparator to switch back to a low state, V_{IN} must drop to V_{IN2},

$$V_{IN2} = \frac{(R1+R2)\cdot V_{REF} - R1\cdot V_{CC}}{R2} \quad (5)$$

The hysteresis of this circuit is the difference between V_{IN1} and V_{IN2}, as shown in following,

$$\Delta V_{IN} = V_{CC} \times \frac{R1}{R2} \quad (6)$$

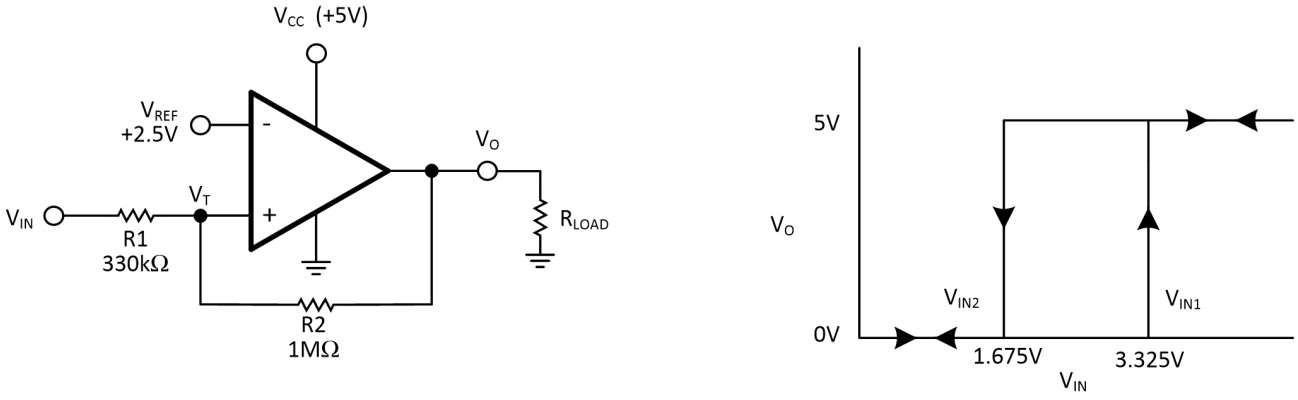


Figure 3. Non-inverting Configuration with Hysteresis

Square-Wave Oscillator

The COS3501 can be used to build a low cost square-wave oscillator as shown in Figure 4. The square-wave period is determined by the RC time constant of the capacitor (C1) and resistor (R4). The maximum frequency is limited by propagation delay of the device and the capacitance load at the output.

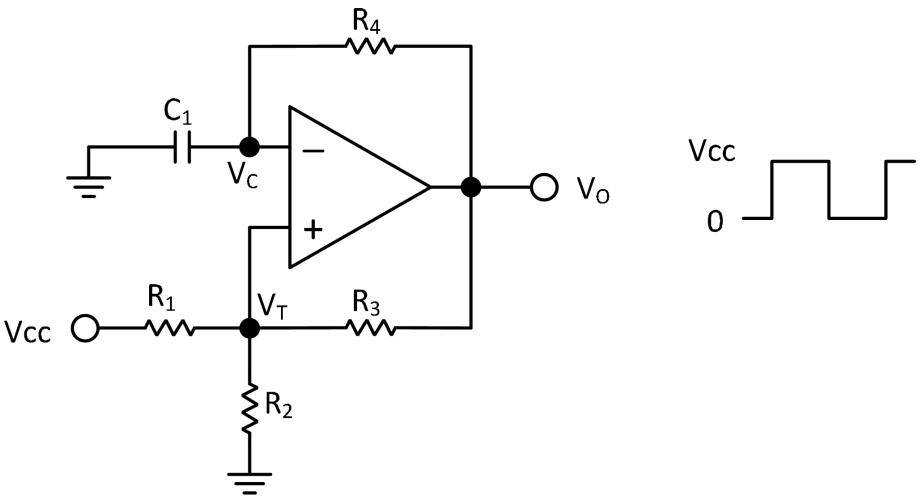


Figure 4. Square-Wave Oscillator

IR Receiver

A single COS3501 can be used to build a IR receiver analog front end as shown in Figure 5. R1 converts the IR light energy induced current into voltage and applies to the inverting input of the comparator. The RC network of R2 and C1 establishes a reference voltage Vref which tracks the mean amplitude of the IR signal. The RC constant of R2 and C1 is chosen for Vref to track the received IR current fluctuation but not the actual data bit stream. The non-inverting input is connected to Vref and the output over the R3 and R4 resistor network which provides hysteresis for improved guard against spurious toggles.

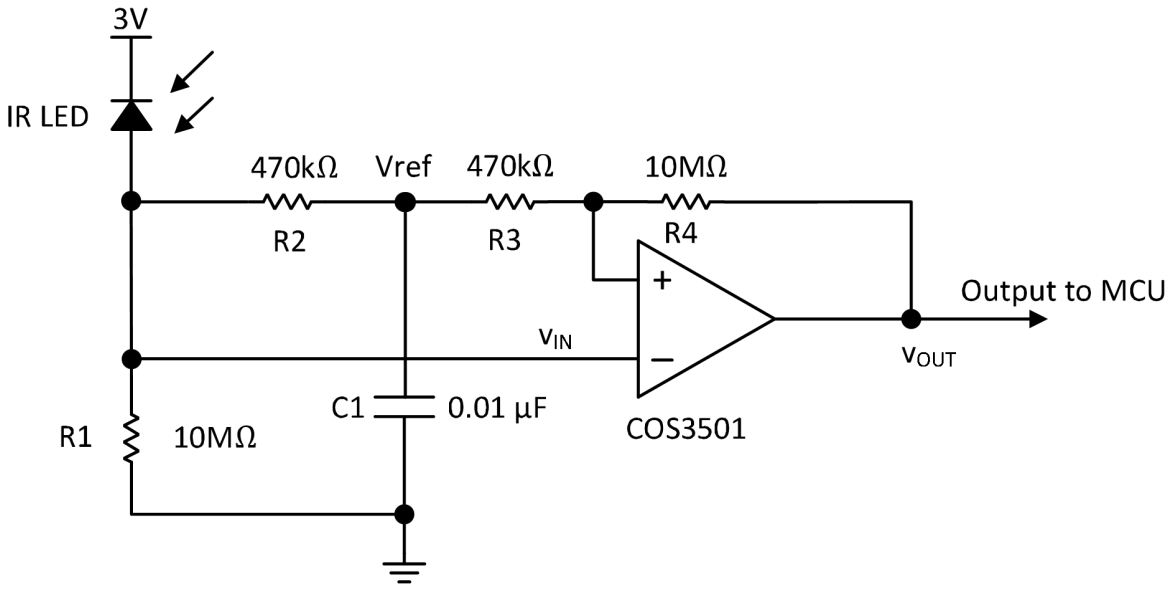
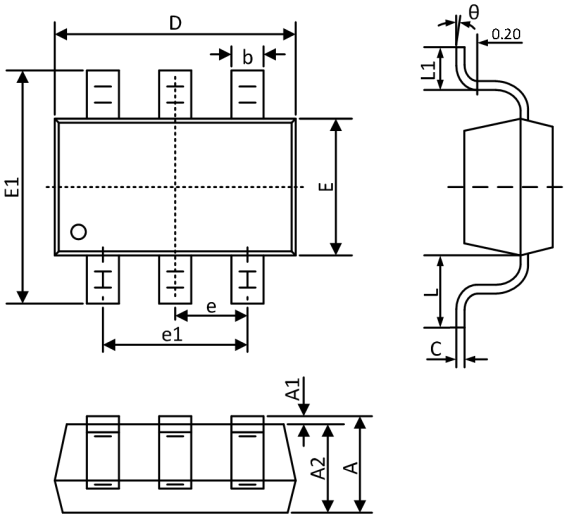


Figure 5. IR Receiver

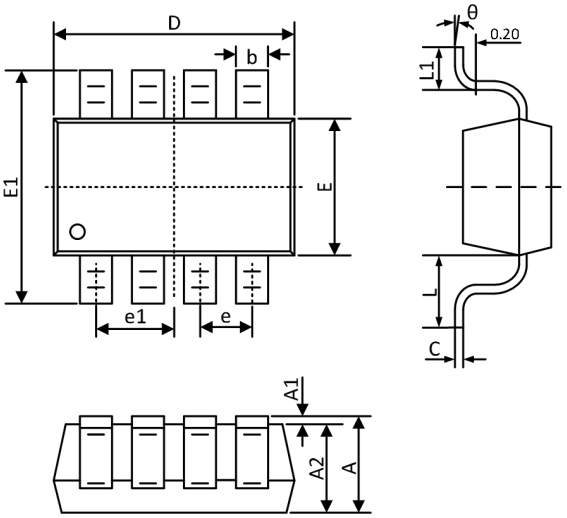
5. Package Information

5.1 SOT23-6 (Package Outline Dimensions)



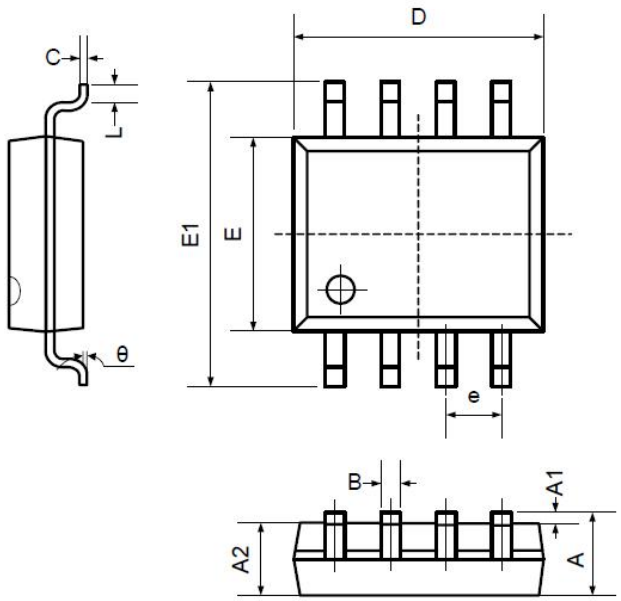
Symbol	Dimensions In Millimeters		Dimensions In Inches	
	MIN	MAX	MIN	MAX
A	1.050	1.250	0.041	0.049
A1	0.000	0.100	0.000	0.004
A2	1.050	1.150	0.041	0.045
b	0.300	0.400	0.012	0.016
c	0.100	0.200	0.004	0.008
D	2.820	3.020	0.111	0.119
E	1.500	1.700	0.059	0.067
E1	2.650	2.950	0.104	0.116
e	0.950TYP		0.037TYP	
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 SOT23-8 (Package Outline Dimensions)



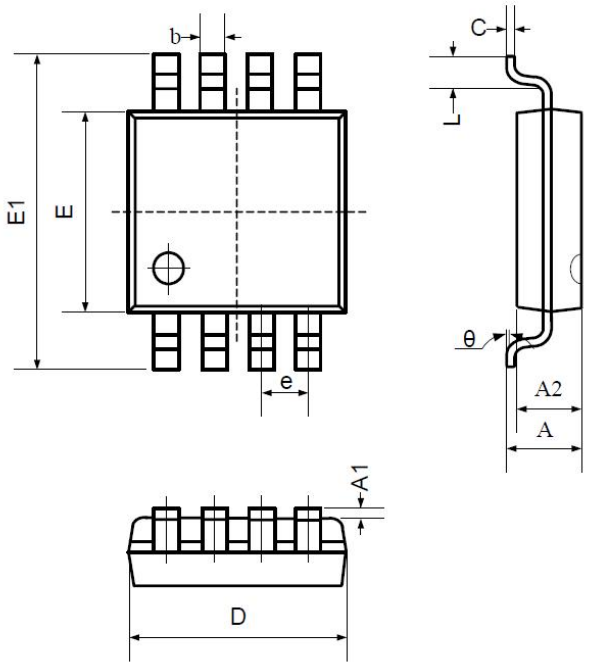
Symbol	Dimensions In Millimeters		Dimensions In Inches	
	MIN	MAX	MIN	MAX
A	1.050	1.250	0.041	0.049
A1	0.000	0.100	0.000	0.004
A2	1.050	1.150	0.041	0.045
b	0.300	0.500	0.012	0.020
c	0.100	0.200	0.004	0.008
D	2.820	3.020	0.111	0.119
E	1.500	1.700	0.059	0.067
E1	2.650	2.950	0.104	0.116
e	0.650BSC		0.026BSC	
e1	0.975BSC		0.038BSC	
L	0.700REF		0.028REF	
L1	0.300	0.600	0.012	0.024
θ	0°	8°	0°	8°

5.3 SOP-8 (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°

5.4 MSOP-8 (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°