

## Features

- Low Quiescent Current: 80  $\mu$ A/amp
- Supply Voltage: 2.1V to 6.0V
- Input Voltage Noise Density: 27nV/ $\sqrt$ Hz at 1 kHz
- Rail-to-Rail Input and Output
- Gain Bandwidth: 1 MHz
- Slew Rate: 0.7V/ $\mu$ s
- Low Offset Voltage:  $\pm$ 3mV Maximum
- Offset Voltage Temperature Drift: 2 $\mu$ V/ $^{\circ}$ C
- Extended Temperature Range:  $-40^{\circ}$ C to  $+125^{\circ}$ C

## Application

- Sensor Interface
- Smoke/Gas/Environment Sensors
- Portable Instruments and Mobile Device
- Active Filters, ASIC Input or Output Amplifier

## Description

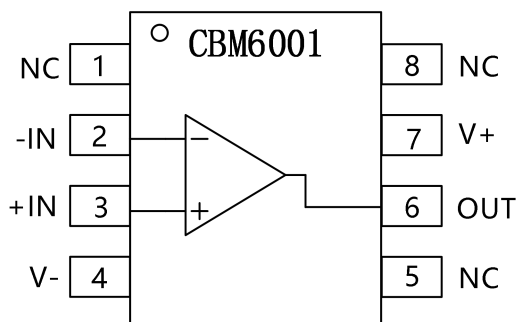
The CBM600X series are CMOS dual, and quad RRIO op-amps with low offset, low power and stable high frequency response. These devices own very good AC performance with 1MHz bandwidth, 0.6V/ $\mu$ s slew rate and low distortion while drawing only 80 $\mu$ A of quiescent current per amplifier. The input commonmode voltage range extends 300mV beyond  $V-$  and  $V+$ , and the outputs swing rail-to-rail. The CBM600X family can be used as plug-in replacements for many commercially available op-amps to reduce power and improve input/output range and performance.

The combination of features makes the CBM600X ideal choices for motor control and portable audio amplification, sound ports, and other consumer Audio. The CBM600X Op-amp is very stable, and it is capable of driving heavy capacitive loads such as those found in LCDs. The ability to swing rail-to-rail at the inputs and outputs enables designers to buffer CMOS DACs, ASICs, or other wide output swing devices in single-supply systems.

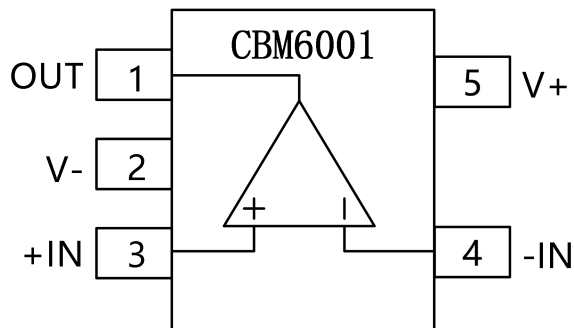
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## Pin Configurations

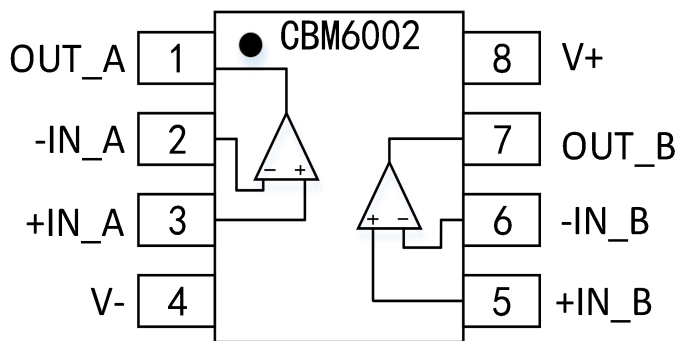


SOP-8



SOT23-5

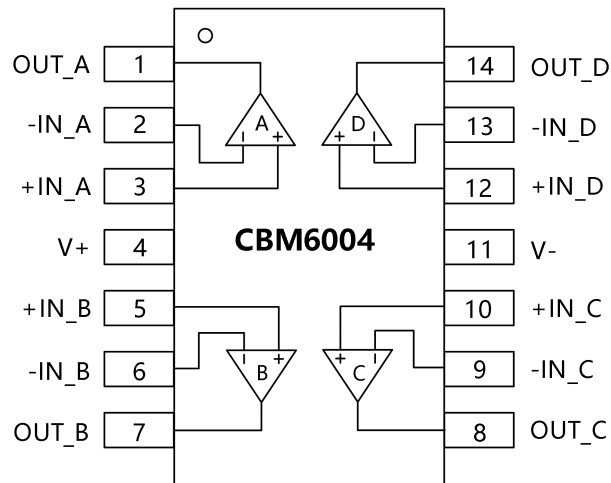
PIN_N(SOP-8)	PIN_N(SOT23-5)	SYMBOL(CBM6001)	NAME AND FUNCTION
6	1	OUT	Output
4	2	V-	Negative power supply
3	3	+IN	None inverting input
2	4	-IN	inverting input
7	5	V+	Positive power supply
1,5	--	NC	No Connect



SOIC-8(SOP8) , MSOP-8

PIN_N	SYMBOL(CBM6002)	NAME AND FUNCTION
1	OUT_A	Output A
2	-IN_A	inverting input A
3	+IN_A	None inverting input A
4	V-	Negative power supply

5	+IN_B	None inverting input B
6	-IN_B	inverting input B
7	OUT_B	Output B
8	V+	Positive power supply


**SOIC-14(SOP14),TSSOP-14**

PIN_N	SYMBOL(CBM6004)	NAME AND FUNCTION
1	OUT_A	Output A
2	-IN_A	inverting input A
3	+IN_A	None inverting input A
4	V+	Positive power supply
5	+IN_B	None inverting input B
6	-IN_B	inverting input B
7	OUT_B	Output B
8	OUT_C	Output C
9	-IN_C	inverting input C
10	+IN_C	None inverting input C
11	V-	Negative power supply
12	+IN_D	None inverting input D
13	-IN_D	inverting input D
14	OUT_D	Output D

## **Absolute Maximum Ratings <sup>(1)</sup>**

- Supply Voltage : 7V
- Input Voltage : (V<sub>-</sub>)-0.3 to (V<sub>+</sub>)+0.3
- Differential Input Voltage : ±7V
- Input Current : ±10mA
- Output Short-Circuit Duration : Infinite
- Storage Temperature Range All Packages : -65°C to +150°C
- Operating Temperature Range All Packages : -40°C to +125°C
- Junction Temperature Range All Packages : 150°C
- Lead Temperature (Soldering, 10s) : 260°C
- Thermal Information
  - SC70-5 :  $\theta_{JA}=400^{\circ}\text{C}/\text{W}$
  - SOT23-5 :  $\theta_{JA}=250^{\circ}\text{C}/\text{W},\theta_{JC}=81^{\circ}\text{C}/\text{W}$
  - SOP8 :  $\theta_{JA}=158^{\circ}\text{C}/\text{W},\theta_{JC}=43^{\circ}\text{C}/\text{W}$
  - MSOP8 :  $\theta_{JA}=210^{\circ}\text{C}/\text{W},\theta_{JC}=45^{\circ}\text{C}/\text{W}$
  - SOP14 :  $\theta_{JA}=120^{\circ}\text{C}/\text{W},\theta_{JC}=36^{\circ}\text{C}/\text{W}$
  - TSSOP14 :  $\theta_{JA}=180^{\circ}\text{C}/\text{W},\theta_{JC}=35^{\circ}\text{C}/\text{W}$

## Electrical Characteristics

(All test condition is  $V_S = 5V$ ,  $T_A = 25^\circ C$ ,  $R_L = 2k\Omega$ ,  $C_L = 100pF$ , unless otherwise noted.)

PARAMETER	CONDITIONS	$T_J$	CBM6001, CBM6002, CBM6004			UNIT
			MIN	TYP	MAX	
<b>Power Supply</b>						
$V_S$	Operating Voltage Range		2.1		6	V
$I_Q$	Quiescent Current/Amplifier			80	130	$\mu A$
$P_{SRR}$	Power-Supply Rejection Ratio		80	100		dB
<b>Input Characteristics</b>						
$V_{OS}$	Input Offset Voltage	$V_{CM} = 0V$ to $3V$	-3	0.5	3	mV
$V_{OS\ TC}$	Input Offset Voltage Average Drift			2		$\mu V/^\circ C$
$I_B$	Input Bias Current			1	10	pA
				25		pA
$I_{OS}$	Input Offset Current			1		pA
$C_{IN}$	Input Capacitance	Differential Mode		8		pF
		Common Mode		7		pF
$A_{OL}$	Open-Loop Voltage Gain	$R_L = 10k\Omega$ ,	85	110		dB
$V_{CM}$	Common-Mode Voltage Range	$V_S = 5.5V$	$(V_-) - 0.1$		$(V_+) + 0.1$	V
CMRR	Common-Mode Rejection Ratio	$V_{CM} = 0V$ to $3V$	70	100		dB
<b>Output Characteristics</b>						
$V_{OH}, V_{OL}$	Maximum Output Voltage Swing	$R_L = 10k\Omega$		3	15	mV
$I_{SC}$	Output Short-Circuit Current			100		mA
<b>Dynamic Performance</b>						
$S_R$	Slew Rate	$A_V = 1$ , $V_{OUT} = 1.5V$ to $3.5V$ , $C_{LOAD} = 60pF$ , $R_{LOAD} = 1k\Omega$		0.7		V/ $\mu s$
$G_{BP}$	Gain-Bandwidth Product			1		MHz
$P_M$	Phase Margin	$R_L = 1k\Omega$ , $C_L = 60pF$		60		$^\circ$
GM	Gain Margin	$R_L = 1k\Omega$ , $C_L = 60pF$		15		dB

Noise Performance							
$E_N$	Input Voltage Noise	$f = 0.1\text{Hz to }10\text{Hz}$			8		$\mu\text{V}_{PP}$
$e_N$	Input Voltage Noise Density	$f = 1\text{KHz}$			27		$\text{nV}/\sqrt{\text{Hz}}$
$I_N$	Input Current Noise	$f = 1\text{KHz}$			2		$\text{fA}/\sqrt{\text{Hz}}$
THD+N	Total Harmonic Distortion and Noise	$f = 1\text{kHz}, A_V = 1, R_L = 2\text{k}\Omega, V_{OUT} = 1\text{Vp-p}$			0.003		%

## Typical Characteristics

$V_S = 5V$ ,  $V_{CM} = 2.5V$ ,  $R_L = \text{Open}$ , unless otherwise specified.

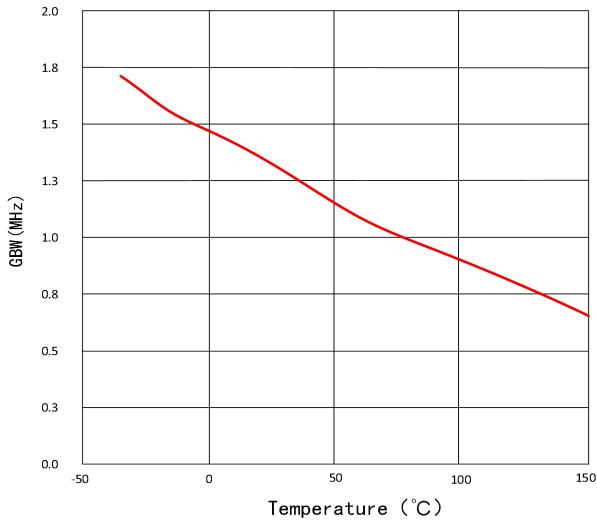


Figure 1. Unity Gain Bandwidth vs. Temperature

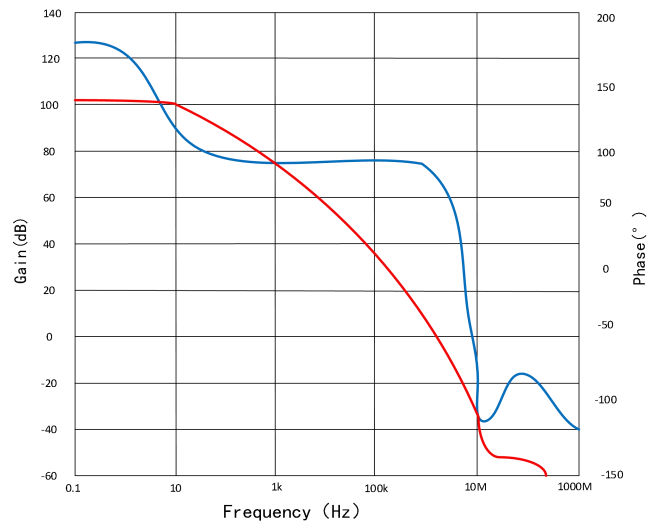


Figure 2. Open-Loop Gain and Phase

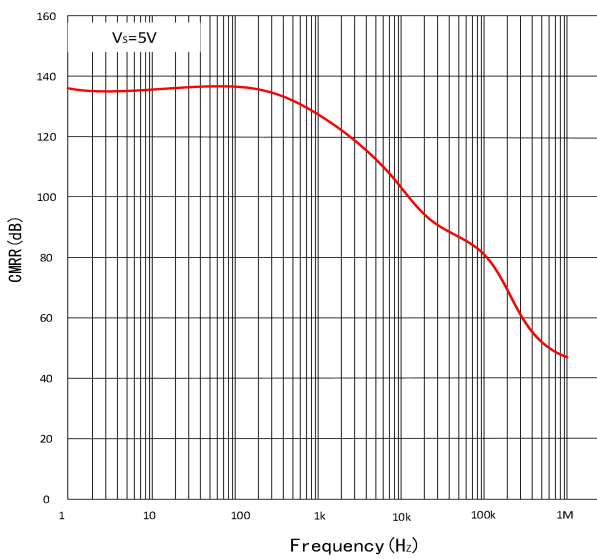


Figure 3. CMRR vs. Frequency

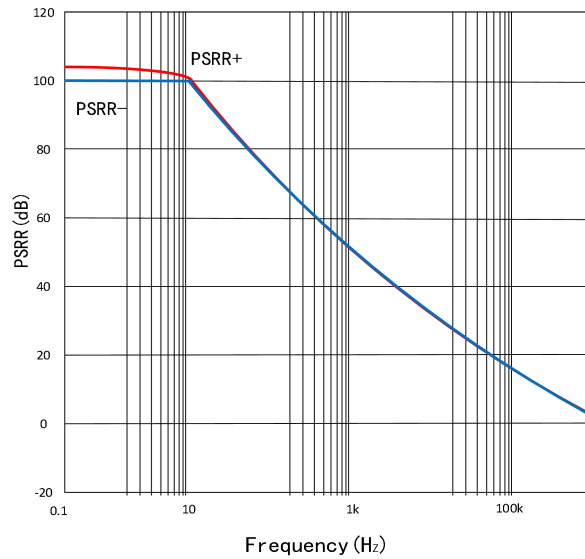


Figure 4. PSRR vs. Frequency



## **Application Information**

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### **Low Supply Voltage and Low Power Consumption**

The CBM600X family of operational amplifiers can operate with power supply voltages from 2.1 V to 6.0 V. Each amplifier draws only 80  $\mu$ A quiescent current. The low supply voltage capability and low supply current are ideal for portable applications demanding high capacitive load driving capability and stable wide bandwidth. The CBM600X family is optimized for wide bandwidth low power applications. They have an industry leading high GBWP to power ratio and are unity gain stable for any capacitive load. When the load capacitance increases, the increased capacitance at the output pushed the non-dominant pole to lower frequency in the open loop frequency response, lowering the phase and gain margin. Higher gain configurations tend to have better capacitive drive capability than lower gain configurations due to lower closed loop bandwidth and hence higher phase margin.

### **Ground Sensing and Rail to Rail Output**

The CBM600X family has excellent output drive capability, delivering over 100mA of output drive current. The output stage is a rail-to rail topology that is capable of swinging to within 10mV of either rail. Since the inputs can go 300mV beyond either rail, the op-amp can easily perform true ground sensing.

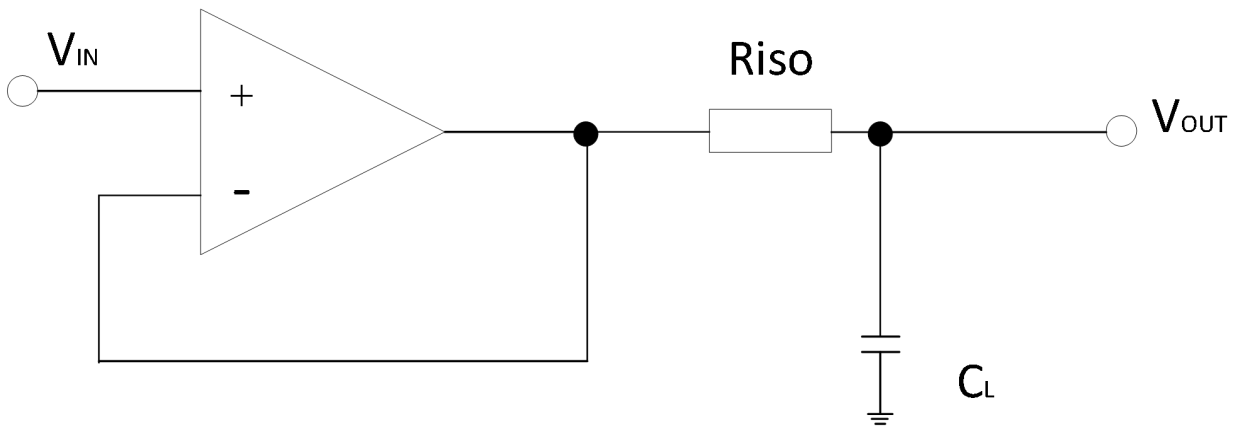
The maximum output current is a function of total supply voltage. As the supply voltage to the amplifier increases, the output current capability also increases. Attention must be paid to keep the junction temperature of the IC below 150°C when the output is in continuous short-circuit. The output of the amplifier has reverse-biased ESD diodes connected to each supply. The output should not be forced more than 0.5V beyond either supply, otherwise current will flow through these diodes.

### **Driving Large Capacitive Load**

The CBM600X family of OPA is designed to drive large capacitive loads. Refer to Typical Performance Characteristics for “Phase Margin vs. Load Capacitance”. As always, larger load capacitance decreases overall phase margin in a feedback system where internal frequency compensation is utilized. 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

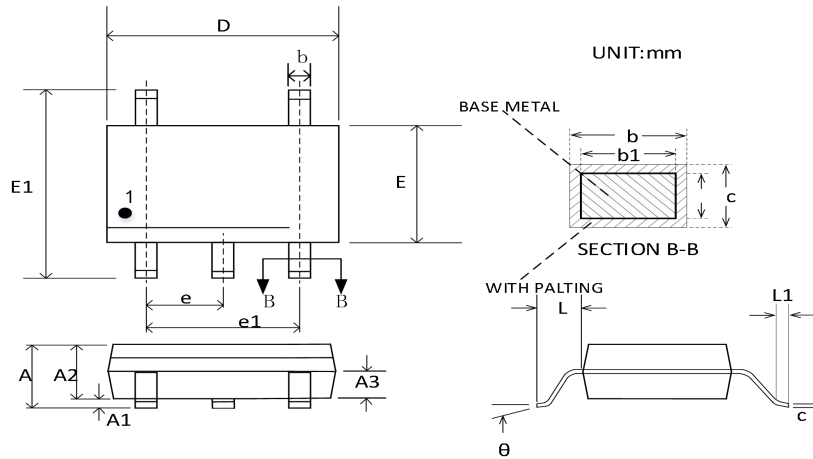
frequency response, with overshoot and ringing in output step response. The unity-gain buffer ( $G = +1V/V$ ) is the most sensitive to large capacitive loads.

When driving large capacitive loads with the CBM600X OPA family (e.g.,  $> 200pF$  when  $G = +1V/V$ ), a small series resistor at the output improves the feedback loops phase margin and stability by making the output load resistive at higher frequencies.



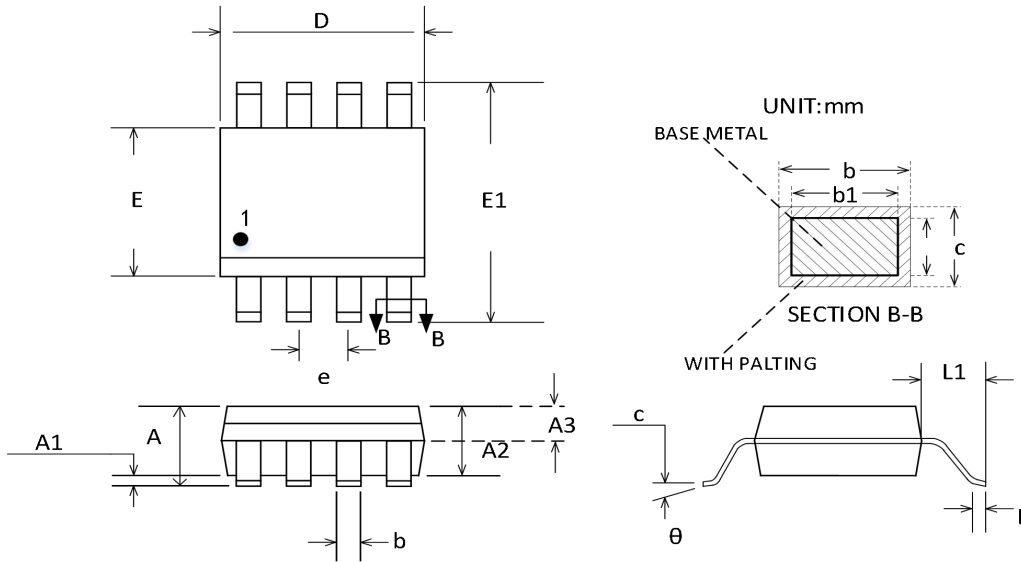
## Package Outline Dimensions

### SOT23-5



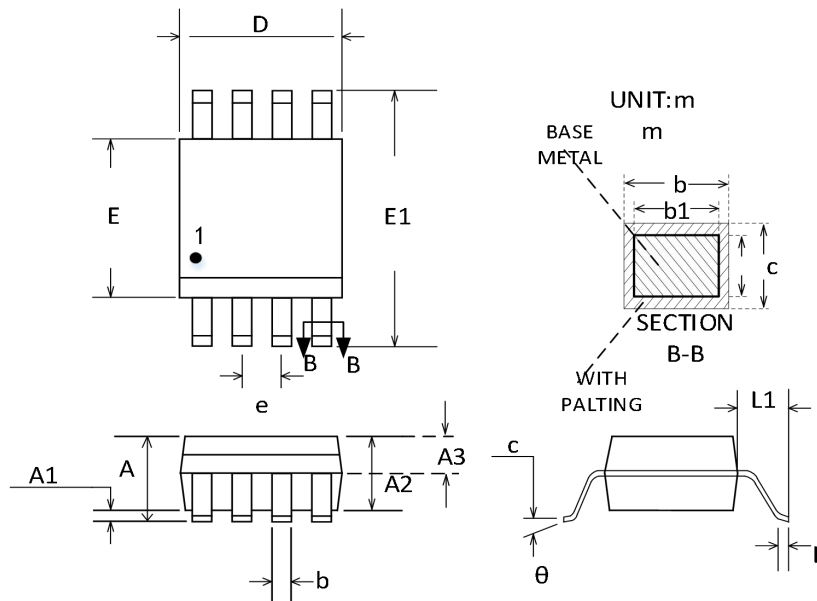
Symbol	Dimensions In Millimeters		
	Min	Typ	Max
A	--	--	1.25
A1	0.04	--	0.10
A2	1.00	1.10	1.20
A3	0.60	0.65	0.70
b	0.33	--	0.41
b1	0.32	0.35	0.38
c	0.15	--	0.19
c1	0.14	0.15	0.16
D	2.82	2.92	3.02
E	1.50	1.60	1.70
E1	2.60	2.80	3.00
e	0.95 BSC		
e1	1.90 BSC		
L	0.60 REF		
L1	0.30	--	0.60
$\theta$	0°	--	8°

## SOP-8



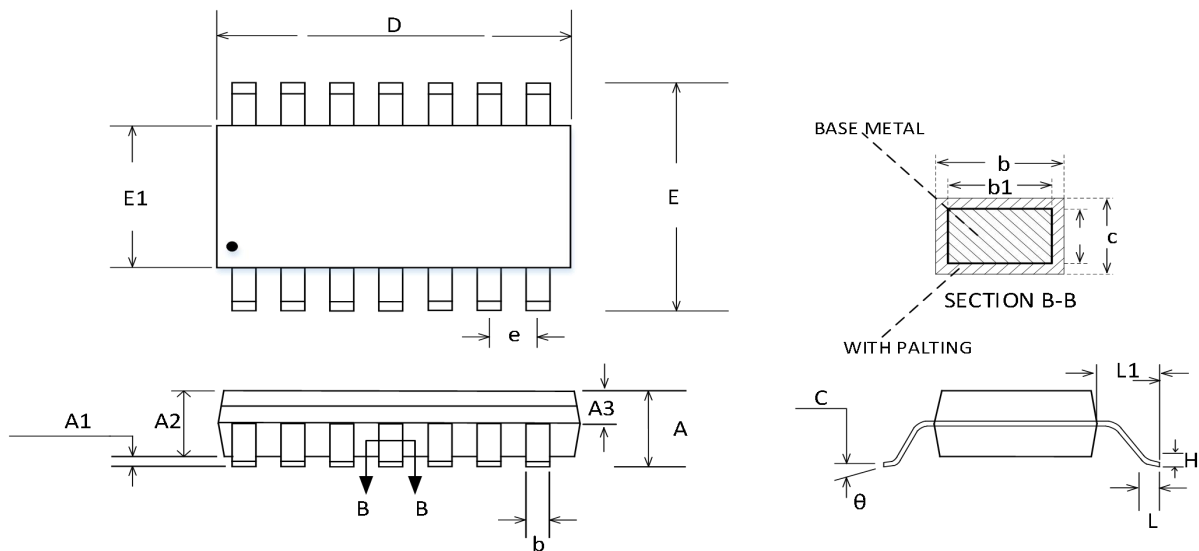
Symbol	Dimensions In Millimeters		
	Min	Typ	Max
<b>A</b>	--	--	1.75
<b>A1</b>	0.10	--	0.225
<b>A2</b>	1.30	1.40	1.50
<b>A3</b>	0.60	0.65	0.70
<b>b</b>	0.39	--	0.47
<b>b1</b>	0.38	0.41	0.44
<b>c</b>	0.20	--	0.24
<b>c1</b>	0.19	0.20	0.21
<b>D</b>	4.80	4.90	5.00
<b>E</b>	3.80	3.90	4.00
<b>E1</b>	5.80	6.00	6.20
<b>e</b>	1.27 BSC		
<b>L</b>	1.05 REF		
<b>L1</b>	0.50	--	0.80
<b><math>\theta</math></b>	0°	--	8°

## MSOP-8



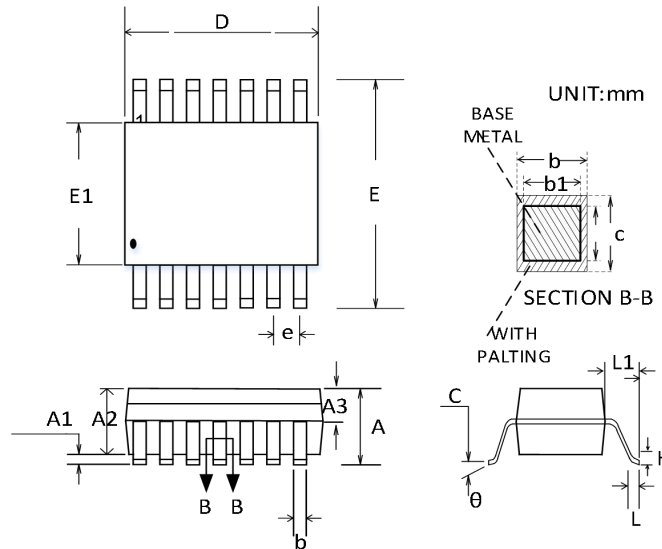
Symbol	Dimensions In Millimeters		
	Min	Typ	Max
<b>A</b>	--	--	1.10
<b>A1</b>	0.05	--	0.15
<b>A2</b>	0.75	0.85	0.95
<b>A3</b>	0.30	0.35	0.40
<b>b</b>	0.28	--	0.36
<b>b1</b>	0.27	0.30	0.33
<b>c</b>	0.15	--	0.19
<b>c1</b>	0.14	0.15	0.16
<b>D</b>	2.90	3.00	3.10
<b>E</b>	2.90	3.00	3.10
<b>E1</b>	4.70	4.90	5.10
<b>e</b>	0.65 BSC		
<b>L</b>	0.95 REF		
<b>L1</b>	0.40	--	0.70
<b><math>\theta</math></b>	0°	--	8°

## SOP-14



Symbol	Dimensions In Millimeters		
	Min	Typ	Max
<b>A</b>	--	--	1.75
<b>A1</b>	0.05	--	0.225
<b>A2</b>	1.30	1.40	1.50
<b>A3</b>	0.60	0.65	0.70
<b>b</b>	0.39	--	0.47
<b>b1</b>	0.38	0.41	0.44
<b>c</b>	0.20	--	0.24
<b>c1</b>	0.19	0.20	0.21
<b>D</b>	8.55	8.65	8.75
<b>E</b>	5.80	6.00	6.20
<b>E1</b>	3.80	3.90	4.00
<b>e</b>	1.27 BSC		
<b>L</b>	0.50	--	0.80
<b>L1</b>	1.05 REF		
<b>θ</b>	0°	--	8°

## TSSOP-14



Symbol	Dimensions In Millimeters		
	Min	Typ	Max
<b>A</b>	--	--	1.20
<b>A1</b>	0.05	--	0.15
<b>A2</b>	0.90	1.00	1.05
<b>A3</b>	0.39	0.44	0.49
<b>b</b>	0.20	--	0.28
<b>b1</b>	0.19	0.22	0.25
<b>c</b>	0.13	--	0.17
<b>c1</b>	0.12	0.13	0.14
<b>D</b>	4.90	5.00	5.10
<b>E</b>	6.20	6.40	6.60
<b>E1</b>	4.30	4.40	4.50
<b>e</b>	0.65 BSC		
<b>L</b>	0.45	0.60	0.75
<b>L1</b>	1.00 BSC		
<b><math>\theta</math></b>	0°	--	8°

## Package/Ordering Information

PRODUCT TYPE	OPERATING TEMPERATURE	PACKAGE	PACKAGE MARKING	NUMBER OF PACKAGES
CBM6001AS8	-40°C~125°C	SOP-8	CBM6001A	Tape and Reel, 2500
CBM6001AS8-RL	-40°C~125°C	SOP-8	CBM6001A	Tape and Reel, 3000
CBM6001AS8-REEL	-40°C~125°C	SOP-8	CBM6001A	Tape and Reel, 4000
CBM6001AST5	-40°C~125°C	SOT23-5	AAJH	Tape and Reel, 3000
CBM6002AS8	-40°C~125°C	SOP-8	CBM6002A	Tape and Reel, 2500
CBM6002AS8-RL	-40°C~125°C	SOP-8	CBM6002A	Tape and Reel, 3000
CBM6002AS8-REEL	-40°C~125°C	SOP-8	CBM6002A	Tape and Reel, 4000
CBM6002AMS8	-40°C~125°C	MSOP-8	A02	Tape and Reel, 3000
CBM6004AS14	-40°C~125°C	SOP-14	CBM6004AS	Tape and Reel, 2500
CBM6004AS14-RL	-40°C~125°C	SOP-14	CBM6004AS	Tape and Reel, 3000
CBM6004AS14-REEL	-40°C~125°C	SOP-14	CBM6004AS	Tape and Reel, 4000
CBM6004ATS14	-40°C~125°C	TSSOP-14	CBM6004AT	Tape and Reel, 2500
CBM6004ATS14-RL	-40°C~125°C	TSSOP-14	CBM6004AT	Tape and Reel, 3000
CBM6004ATS14-REEL	-40°C~125°C	TSSOP-14	CBM6004AT	Tape and Reel, 4000