

## Features

- Single-Supply Operation from +1.4V ~ +5.5V
- Rail-to-Rail Input / Output
- Gain-Bandwidth Product: 15KHz (Typ.)
- Low Input Bias Current: 1pA (Typ.)
- Low Offset Voltage: 2.5mV (Max.)
- Quiescent Current: 600nA per Amplifier (Typ.)
- Operating Temperature: -40°C ~ +125°C
- Embedded RF Anti-EMI Filter
- Small Package:
  - CBM6041 Available in SOT23-5 and SC70-5 Packages
  - CBM6042 Available in SOP-8, MSOP-8 and DFN-8 Packages
  - CBM6044 Available in SOP-14 and TSSOP-14 Packages

## Application

- ASIC Input or Output Amplifier
- Sensor Interface
- Medical Communication
- Smoke Detectors
- Audio Output
- Piezoelectric Transducer Amplifier
- Medical Instrumentation
- Portable Systems

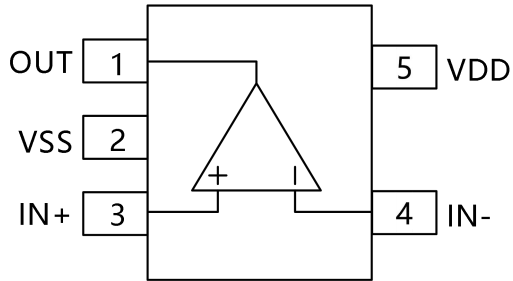
## Description

The CBM6041 family has a high gain-bandwidth product of 15KHz, a slew rate of 4.5V/ms, and a quiescent current of 600nA/amplifier at 5V. The CBM6041 family is designed to provide optimal performance in low voltage and low noise systems. They provide rail-to-rail output swing into heavy loads. The input common mode voltage range includes ground, and the maximum input offset voltage is 2.5mV for CBM6041 family. They are specified over the extended industrial temperature range (-40°C to +125°C). The operating range is from 1.4V to 5.5V. The CBM6041 single is available in Green SC70-5 and SOT23-5 packages. The CBM6042 Dual is available in Green SOP-8, MSOP-8 and DFN-8 packages. The CBM6044 Quad is available in Green SOP-14 and TSSOP-14 packages.

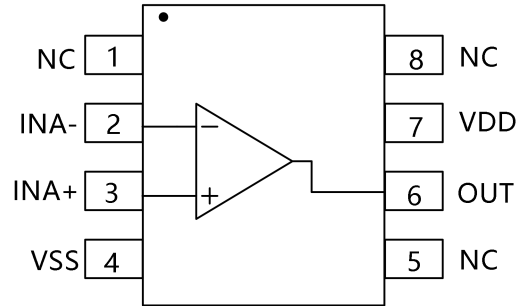
## CATALOG

Features.....	
Application.....	
Description.....	
Pin Configurations.....	1
Absolute Maximum Ratings <sup>(1)</sup> .....	2
Electrical Characteristics.....	3
Typical Characteristics.....	4
Application Notes.....	6
Package Information.....	10
MSOP-8.....	10
SOP-8.....	11
SOT23-5.....	12
TSSOP-14.....	13
SC70-5.....	14
SOP-14.....	15
DFN-8.....	16
Package/Ordering Information.....	17

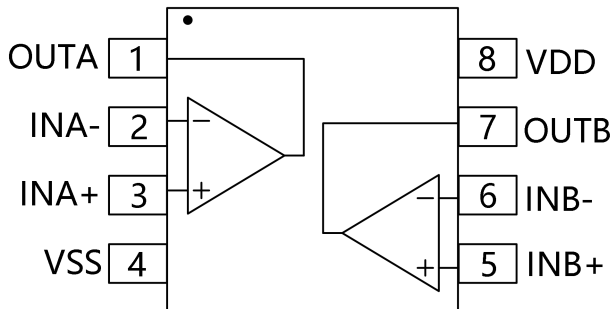
## Pin Configurations



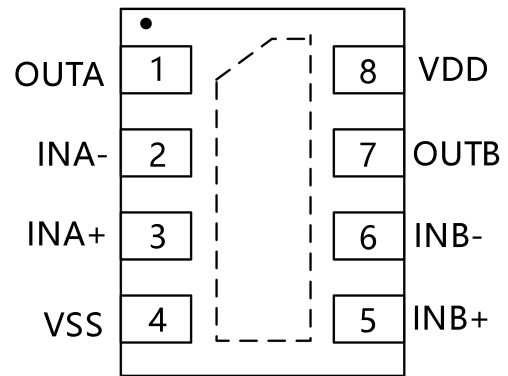
**SOT23-5/SC70-5**



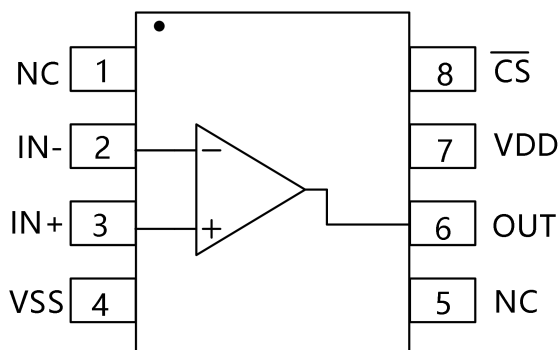
**SOT-8/MSOP-8**



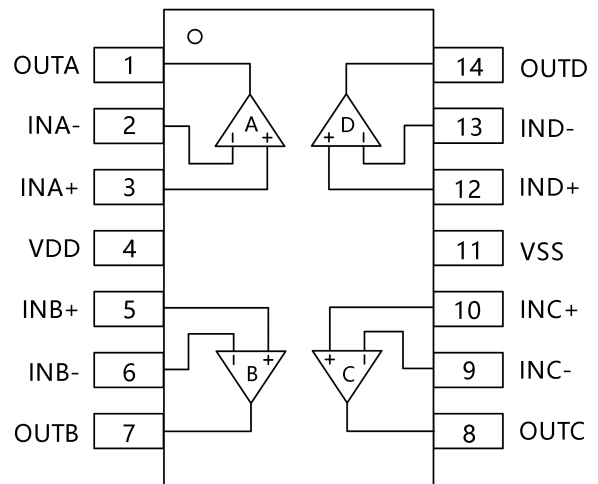
**SOP-8/MSOP-8**



**DNF-8**



**SOP8/MSOP-8**



**SOP-14/TSSOP-14**

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

Condition	Min	Max
Power Supply Voltage (VDD to VSS)	-0.5V	+7.5V
Analog Input Voltage (IN+ or IN-)	VSS-0.5V	VDD+0.5V
PDB Input Voltage	VSS-0.5V	+7V
Operating Temperature Range	-40°C	+125°C
Junction Temperature	+160°C	
Storage Temperature Range	-55°C	+150°C
Lead Temperature (soldering, 10sec)	+260°C	
<b>Package Thermal Resistance (TA=+25°C)</b>		
SOP-8, $\theta_{JA}$	125°C/W	
MSOP-8, $\theta_{JA}$	216°C/W	
SOT23-5, $\theta_{JA}$	190°C/W	
SC70-5, $\theta_{JA}$	333°C/W	
<b>ESD Susceptibility</b>		
HBM	6KV	
MM	300V	

Note: Stress greater than those listed under Absolute Maximum Ratings may cause permanent damage to the device. This is a stress rating only and functional operation of the device at these or any other conditions outside those indicated in the operational sections of this specification are not implied. Exposure to absolute maximum rating conditions for extended periods may affect reliability.

## Electrical Characteristics

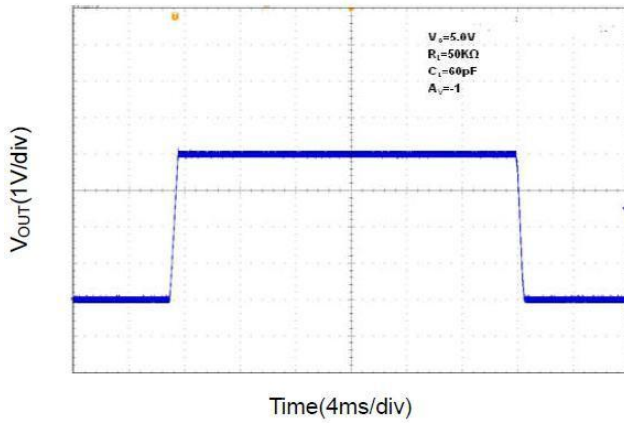
At  $V_S = +5V$ ,  $R_L = 1M\Omega$  connected to  $V_S/2$ , and  $V_{OUT} = V_S/2$ , unless otherwise noted.

Parameter	Symbol	Conditions	Typ	Min	Max	Unit
<b>INPUT CHARACTERISTICS</b>						
Input Offset Voltage	$V_{OS}$	$V_{CM} = V_S/2$	00.4	-2.5	2.5	mV
Input Bias Current	$I_B$		1			pA
Input Offset Current	$I_{OS}$		1			pA
Common-Mode Voltage Range	$V_{CM}$	$V_S = 5.5V$	-0.1 to +5.6			V
Common-Mode Rejection Ratio	$C_{MRR}$	$V_S = 5V, V_{CM} = -0.1V$ to 2.5V	84	70		dB
		$V_S = 5V, V_{CM} = -0.1V$ to 5.1V	83	67		
Open-Loop Voltage Gain	$A_{OL}$	$V_S=1.4V, R_L = 50k\Omega, V_O = V_S-0.1V$	80	75		dB
		$V_S=5V, R_L = 50k\Omega, V_O = V_S-0.1V$	93	84		
Input Offset Voltage Drift	$\Delta V_{OS}/\Delta T$		25			$\mu V/^\circ C$
<b>OUTPUT CHARACTERISTICS</b>						
Output Voltage Swing from Rail	$V_{OH}$	$V_S=1.4V, R_L = 50k\Omega$	1.395	1.39		V
	$V_{OL}$		4.5		10	mV
	$V_{OH}$	$V_S=5V, R_L = 50k\Omega$	4.997	4.990		V
	$V_{OL}$		3.5		10	mV
Output Current	$I_{SOURCE}$	$R_L = 10\Omega$ to $V_S/2$	60	45	84	mA
	$I_{SINK}$		60	45	75	
<b>POWER SUPPLY</b>						
Operating Voltage Range			1.4			V
			5.5			V
Power Supply Rejection Ratio	$P_{SRR}$	$V_S=+1.4V$ to +5.5V, $V_{CM}=+0.5V$	80	77		dB
Quiescent Current / Amplifier	$I_Q$		600			nA
<b>DYNAMIC PERFORMANCE (CL = 100pF)</b>						
Gain-Bandwidth Product	$G_{BP}$		15			KHz
Slew Rate	$S_R$	$G = +1, 2V$ Output Step	4.5			V/ms

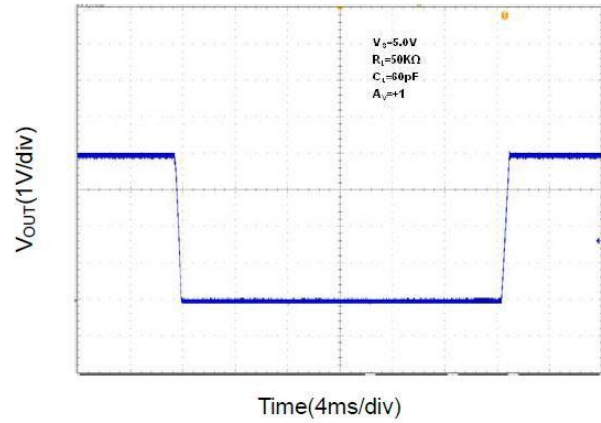
## Typical Characteristics

At  $T_A = +25^\circ\text{C}$ ,  $V_S = +5\text{V}$ , and  $R_L = 100\text{K}\Omega$  connected to  $V_S/2$ , unless otherwise noted.

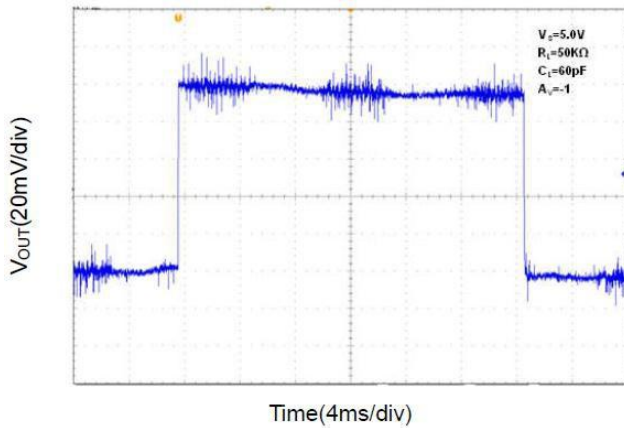
Large Signal Inverting Pulse Response



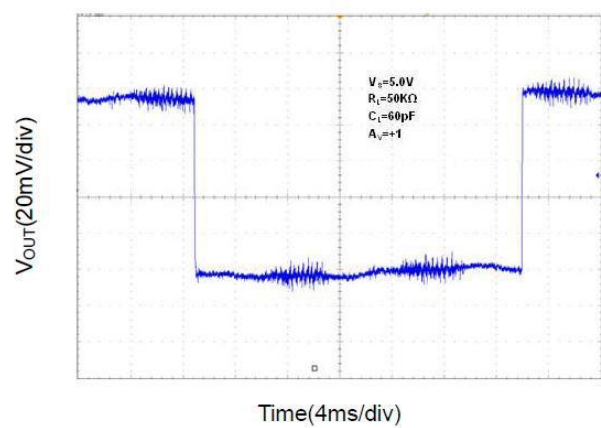
Large Signal Non-Inverting Pulse Response

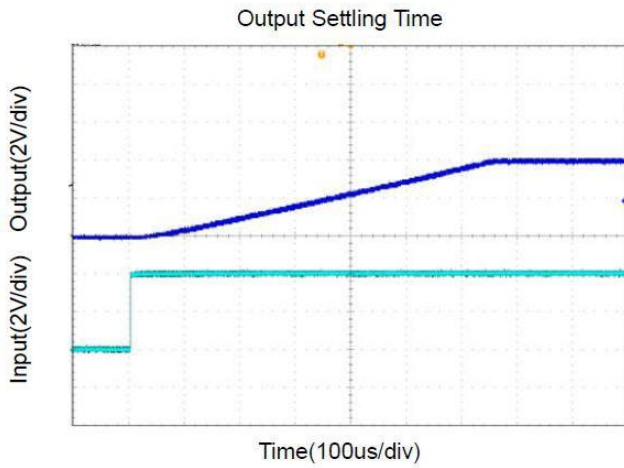
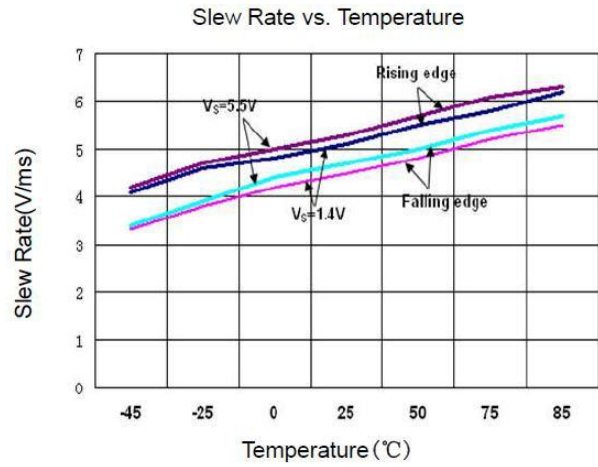
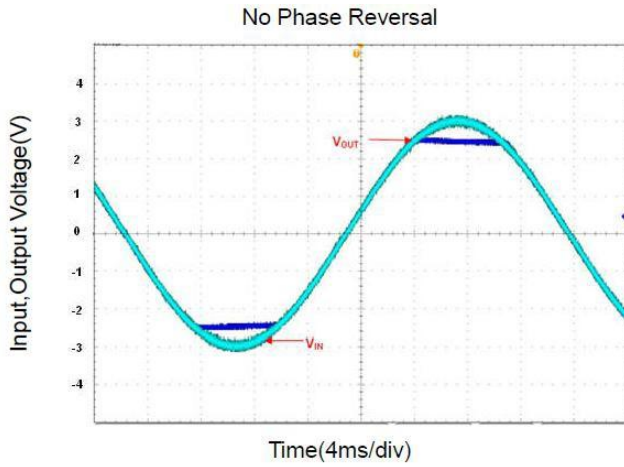


Small Signal Inverting Pulse Response



Small Signal Non-Inverting Pulse Response





## Application Notes

### Size

CBM6041 family series op amps are unity-gain stable and suitable for a wide range of general-purpose applications. The small footprints of the CBM6041 family packages save space on printed circuit boards and enable the design of smaller electronic products.

### Power Supply Bypassing and Board Layout

CBM6041 family series operates from a single 1.4V to 5.5V supply or dual  $\pm 0.7V$  to  $\pm 2.75V$  supplies. For best performance, a 0.1 $\mu F$  ceramic capacitor should be placed close to the VDD pin in single supply operation. For dual supply operation, both VDD and VSS supplies should be bypassed to ground with separate 0.1 $\mu F$  ceramic capacitors.

### Low Supply Current

The low supply current (typical 500nA per channel) of CBM6041 family will help to maximize battery life. They are ideal for battery powered systems

### Operating Voltage

CBM6041 family operates under wide input supply voltage (1.4V to 5.5V). In addition, all temperature specifications apply from  $-40^{\circ}C$  to  $+125^{\circ}C$ . Most behavior remains unchanged throughout the full operating voltage range. These guarantees ensure operation throughout the single Li-Ion battery lifetime

### Rail-to-Rail Input

CBM6041 family operates under wide input supply voltage (1.4V to 5.5V). In addition, all temperature specifications apply from  $-40^{\circ}C$  to  $+125^{\circ}C$ . Most behavior remains unchanged throughout the full operating voltage range. These guarantees ensure operation throughout the single Li-Ion battery lifetime

### Rail-to-Rail Input

The input common-mode range of CBM6041 family extends 100mV beyond the supply rails ( $VSS-0.1V$  to  $VDD+0.1V$ ). This is achieved by using complementary input stage. For normal operation, inputs should be limited to this range.

### Rail-to-Rail Output

Rail-to-Rail output swing provides maximum possible dynamic range at the output. This is particularly important when operating in low supply voltages. The output voltage of CBM6041 family can typically swing to less than 10mV from supply rail in light resistive loads ( $>50k\Omega$ ).

### Capacitive Load Tolerance

The CBM6041 family is optimized for bandwidth and speed, not for driving capacitive loads. Output capacitance will create a pole in the amplifier's feedback path, leading to excessive peaking and potential oscillation. If dealing with load capacitance is a requirement of the application, the two strategies to consider are (1) using a small resistor in series with the



amplifier's output and the load capacitance and (2) reducing the bandwidth of the amplifier's feedback loop by increasing the overall noise gain. Figure 2. shows a unity gain follower using the series resistor strategy. The resistor isolates the output from the capacitance and, more importantly, creates a zero in the feedback path that compensates for the pole created by the output capacitance.

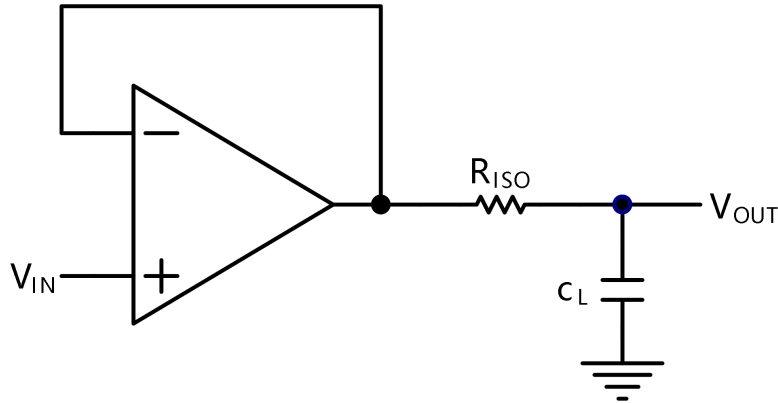


Figure 2. Indirectly Driving a Capacitive Load Using Isolation Resistor

The bigger the  $R_{ISO}$  resistor value, the more stable  $V_{OUT}$  will be. However, if there is a resistive load  $R_L$  in parallel with the capacitive load, a voltage divider (proportional to  $R_{ISO}/R_L$ ) is formed, this will result in a gain error.

The circuit in Figure 3 is an improvement to the one in Figure 2.  $R_F$  provides the DC accuracy by feed-forward the  $V_{IN}$  to  $R_L$ .  $C_F$  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 the phase margin in the overall feedback loop. Capacitive drive can be increased by increasing the value of  $C_F$ . This in turn will slow down the pulse response.

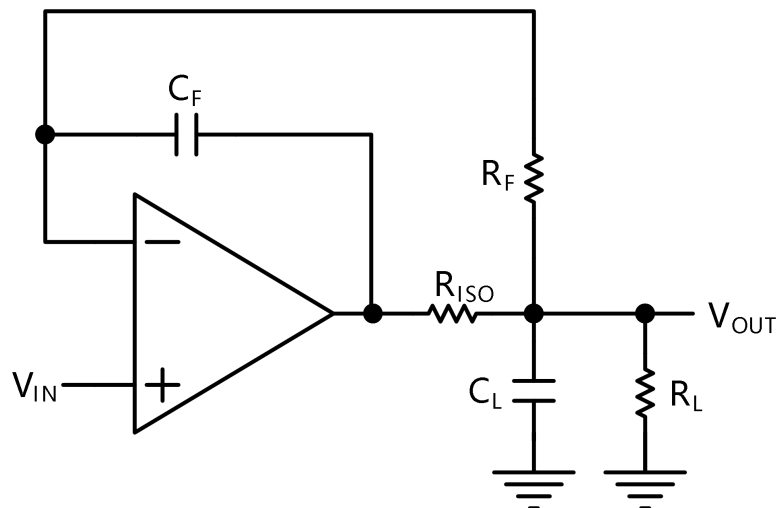


Figure 3. Indirectly Driving a Capacitive Load with DC Accuracy

## Typical Application Circuits

### Differential amplifier

The differential amplifier allows the subtraction of two input voltages or cancellation of a signal common to the two inputs. It is useful as a computational amplifier in making a differential to single-end conversion or in rejecting a common mode signal. Figure 4. shown the differential amplifier using CBM6041 family.

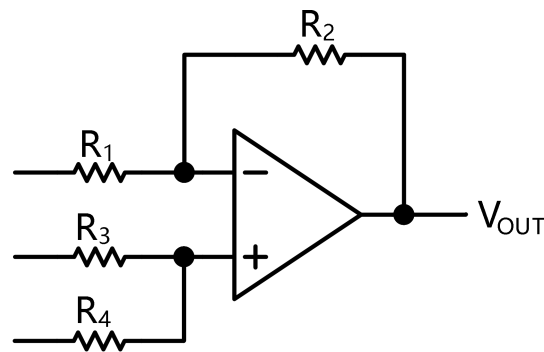


Figure 4. Differential Amplifier

$$V_{OUT} = \left( \frac{R_1 + R_2}{R_3 + R_4} \right) \frac{R_4}{R_1} V_{IN} - \frac{R_2}{R_1} V_{IP} + \left( \frac{R_1 + R_2}{R_3 + R_4} \right) \frac{R_3}{R_1} V_{REF}$$

If the resistor ratios are equal (i.e.  $R_1=R_3$  and  $R_2=R_4$ ), then

$$V_{OUT} = \frac{R_2}{R_1} (V_{IP} - V_{IN}) + V_{REF}$$

### Low Pass Active Filter

The low pass active filter is shown in Figure 5. The DC gain is defined by  $-R_2/R_1$ . The filter has a -20dB/decade roll-off after its corner frequency  $f_C=1/(2\pi R_3 C_1)$ .

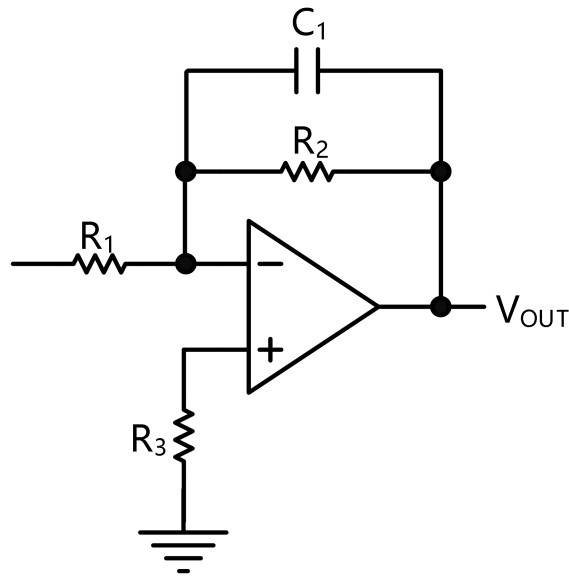


Figure 5. Low Pass Active Filter

### Instrumentation Amplifier

The triple CBM6041 family can be used to build a three-op-amp instrumentation amplifier as shown in Figure 6. The amplifier in Figure 6 is a high input impedance differential amplifier with gain of  $R_2/R_1$ . The two differential voltage followers assure the high input impedance of the amplifier.

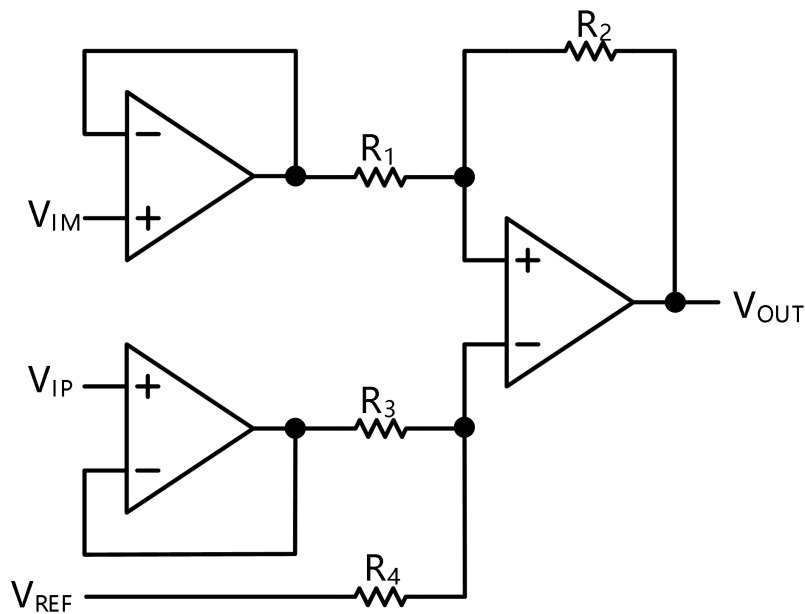
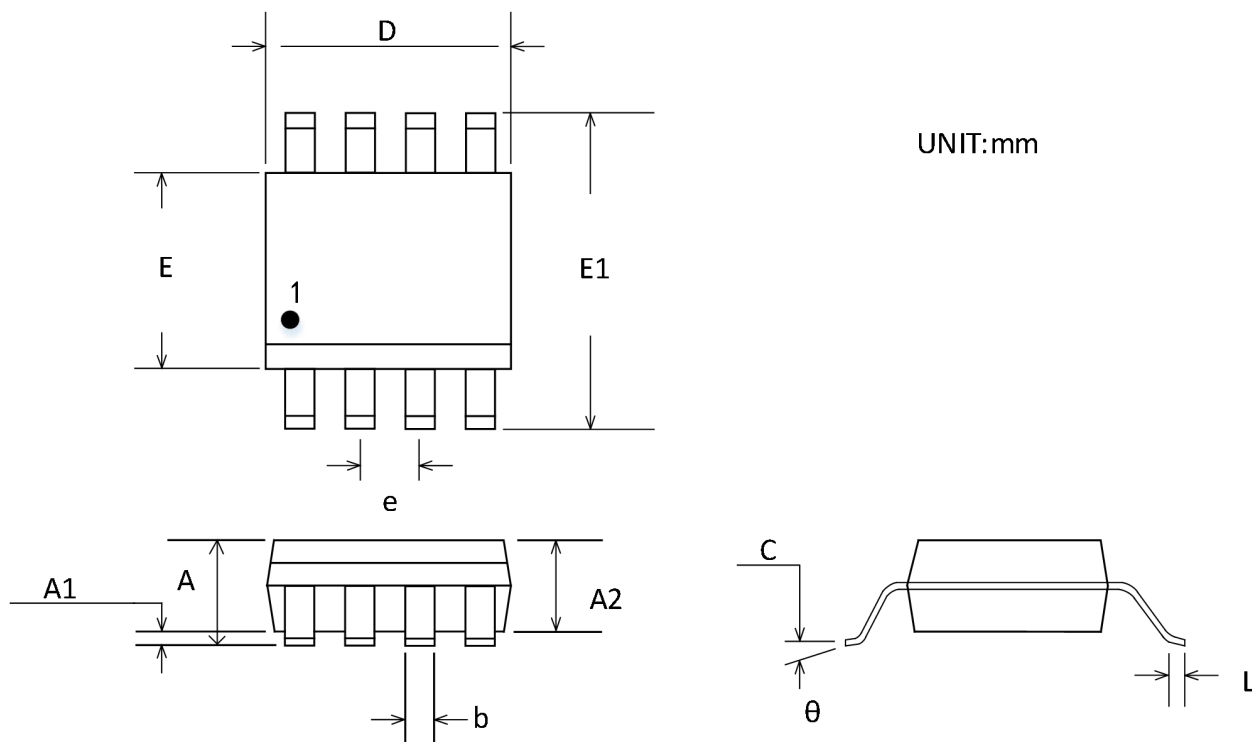


Figure 6. Instrument Amplifier

## Package Information

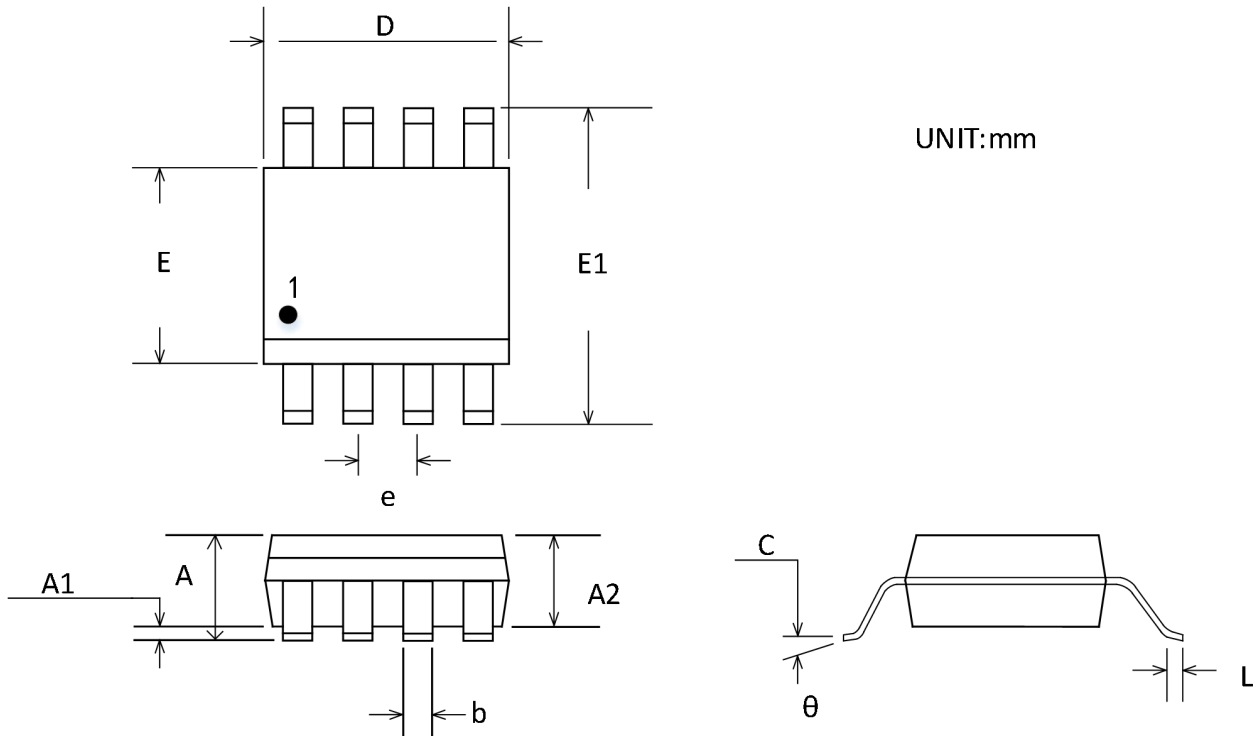
### MSOP-8



UNIT:mm

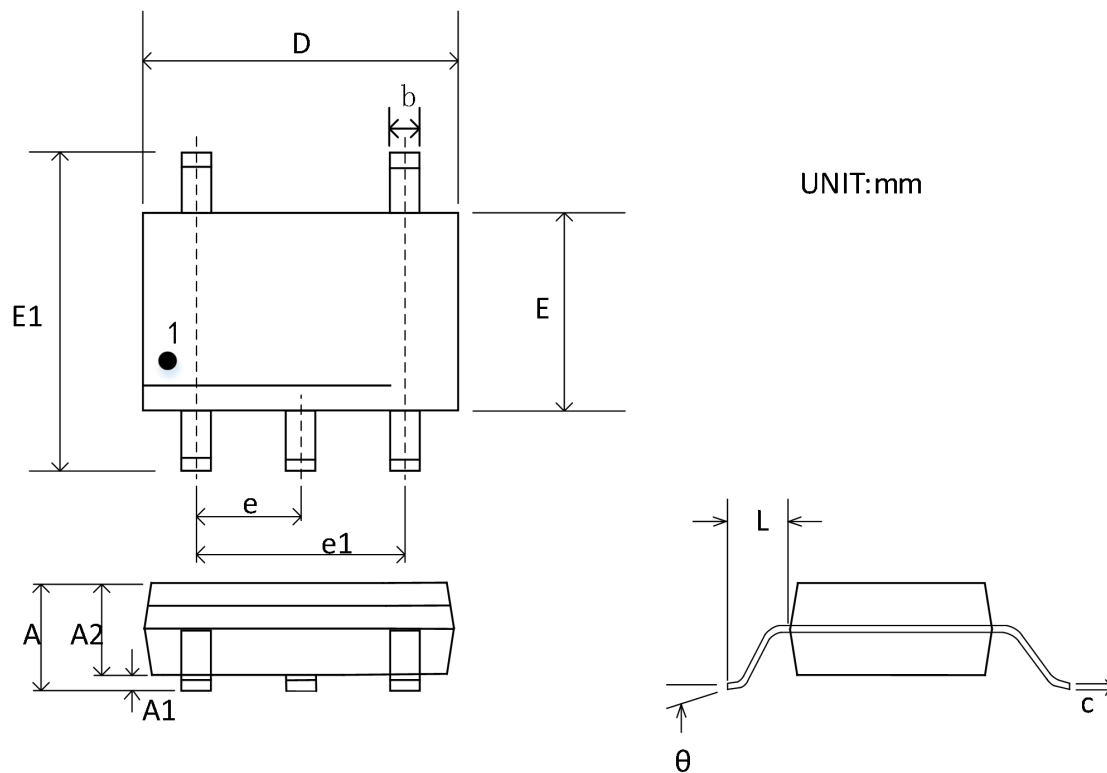
Symbol	Dimensions In Millimeters		Dimensions Inches	
	Min	Max	Min	Max
A	0.820	1.100	0.032	0.043
A1	0.020	0.150	0.001	0.006
A2	0.750	0.950	0.030	0.037
b	0.250	0.380	0.010	0.015
c	0.090	0.230	0.004	0.009
D	2.900	3.100	0.114	0.122
E	2.900	3.100	0.114	0.122
E1	4.750	5.050	0.187	0.199
e	0.650 BSC		0.026 BSC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

## SOP-8



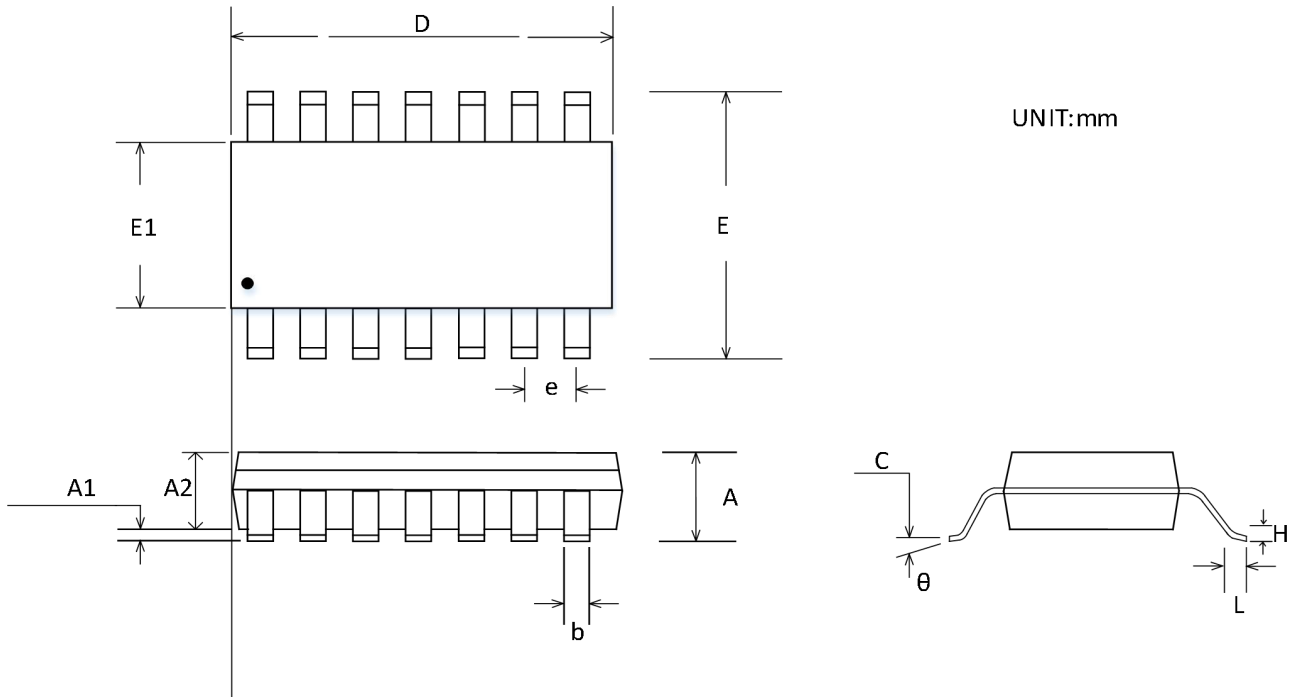
Symbol	Dimensions In Millimeters		Dimensions Inches	
	Min	Max	Min	Max
<b>A</b>	1.350	1.750	0.053	0.069
<b>A1</b>	0.100	0.250	0.004	0.010
<b>A2</b>	1.350	1.550	0.053	0.061
<b>b</b>	0.330	0.510	0.013	0.020
<b>c</b>	0.170	0.250	0.007	0.010
<b>D</b>	4.800	5.000	0.189	0.197
<b>E</b>	5.800	6.200	0.228	0.244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

## SOT23-5



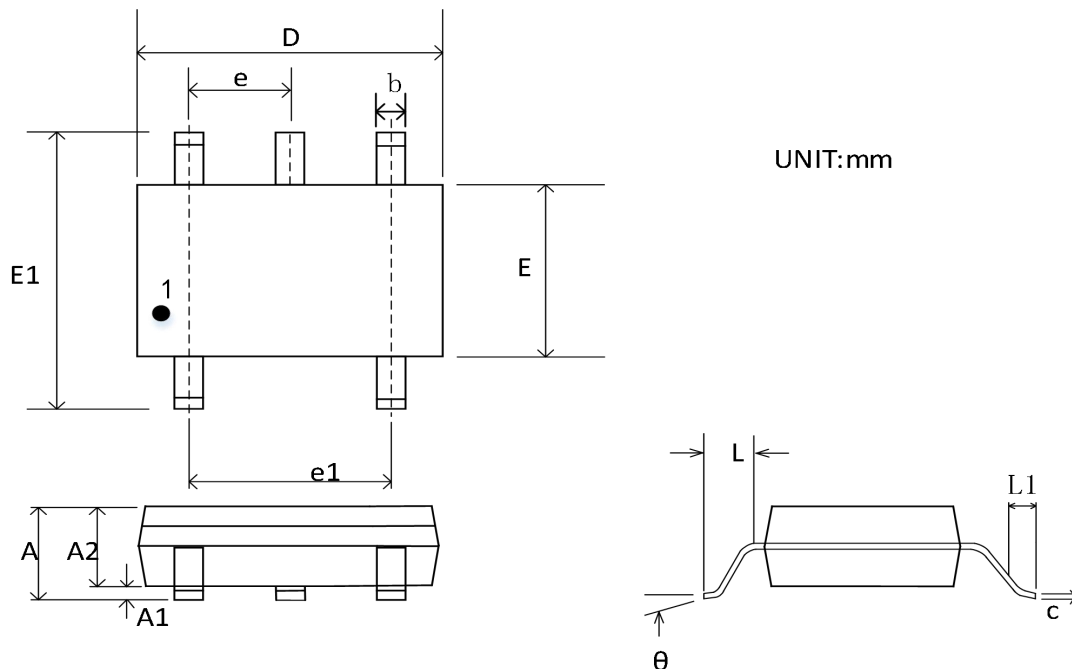
Symbol	Dimensions In Millimeters		Dimensions Inches	
	Min	Max	Min	Max
A	1.050	1.250	0.041	0.049
A1	0.000	0.100	0.000	0.004
A2	1.050	1.150	0.041	0.045
b	0.300	0.500	0.012	0.020
c	0.100	0.200	0.004	0.008
D	2.820	3.020	0.111	0.119
E	1.500	1.700	0.059	0.067
E1	2.650	2.950	0.104	0.116
e	0.950 BSC		0.037 BSC	
e1	1.800	2.000	0.071	0.079
L	0.300	0.600	0.012	0.024
$\theta$	0°	8°	0°	8°

## TSSOP-14



Symbol	Dimensions In Millimeters		Dimensions Inches	
	Min	Max	Min	Max
<b>A</b>		1.200		0.047
<b>A1</b>	0.050	0.150	0.002	0.006
<b>A2</b>	0.800	1.050	0.031	0.041
<b>b</b>	0.190	0.300	0.007	0.012
<b>c</b>	0.090	0.200	0.004	0.008
<b>D</b>	4.860	5.100	0.191	0.201
<b>E</b>	4.300	4.500	0.169	0.177
<b>E1</b>	6.250	6.550	0.246	0.258
<b>e</b>	0.650 BSC		0.026 BSC	
<b>L</b>	0.500	0.700	0.020	0.028
<b>H</b>	0.25 TYP		0.01 TYP	
<b>θ</b>	1°	7°	1°	7°

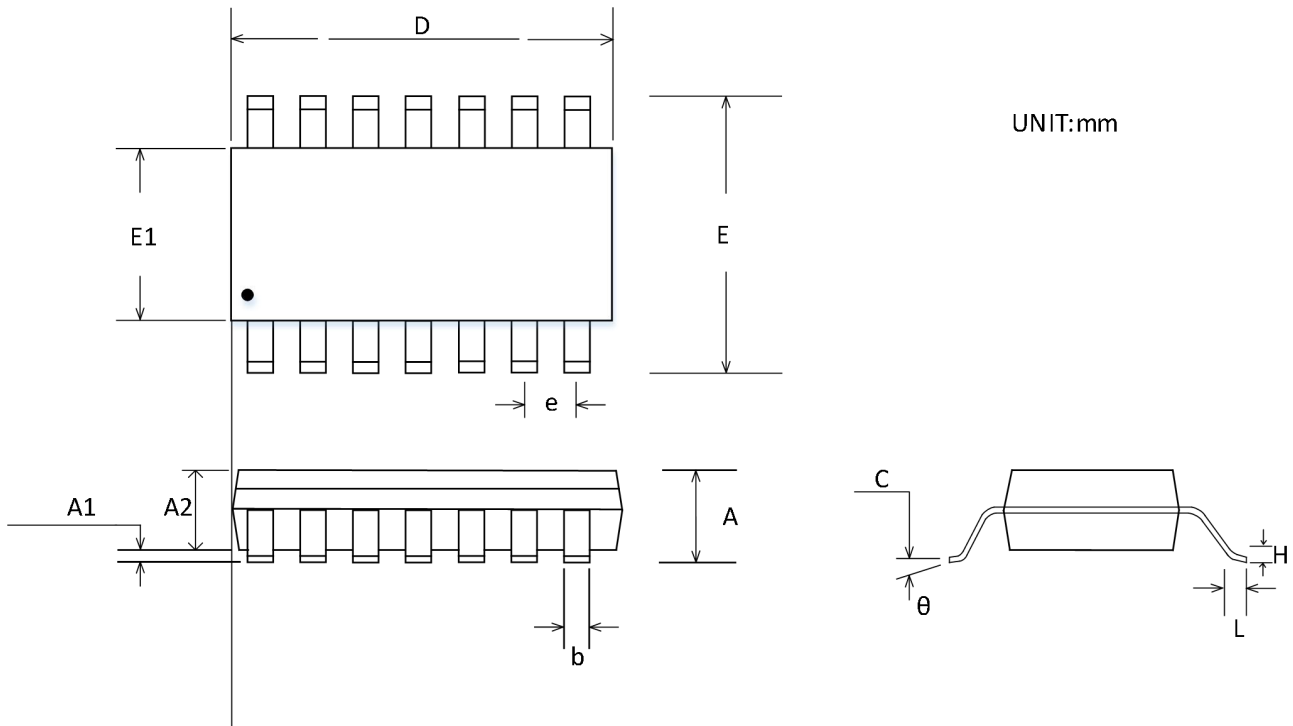
## SC70-5



Symbol	Dimensions In Millimeters		Dimensions Inches	
	Min	Max	Min	Max
<b>A</b>	0.900	1.100	0.035	0.043
<b>A1</b>	0.000	0.100	0.000	0.004
<b>A2</b>	0.900	1.000	0.035	0.039
<b>b</b>	0.150	0.350	0.006	0.014
<b>C</b>	0.080	0.150	0.003	0.006
<b>D</b>	2.000	2.200	0.079	0.087
<b>E</b>	1.150	1.350	0.045	0.053
<b>E1</b>	2.150	2.450	0.085	0.096
<b>e</b>	0.650 TYP		0.026TYP	
<b>e1</b>	1.200	1.400	0.047	0.055
<b>L</b>	0.525 REF		0.021 REF	
<b>L1</b>	0.260	0.460	0.010	0.018
<b><math>\theta</math></b>	0°	8°	0°	8°

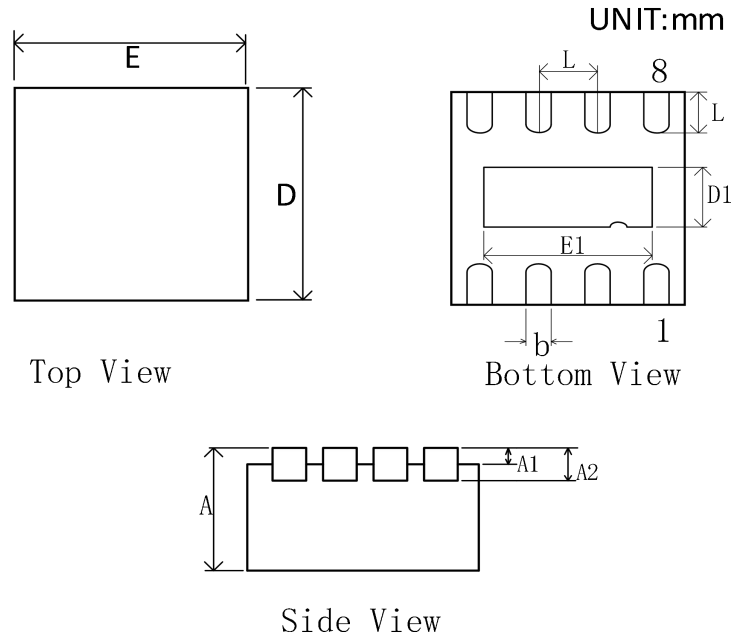


## SOP14



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

## DFN-8



Symbol	Dimensions In Millimeters			Dimensions Inches		
	Min	Nom	Max	Min	Nom	Max
<b>A</b>	0.80	0.85	0.9	0.031	0.033	0.035
<b>A1</b>	0.00	0.02	0.05	0.000	0.001	0.002
<b>A2</b>	0.153	0.203	0.253	0.006	0.008	0.010
<b>b</b>	0.18	0.24	0.30	0.007	0.009	0.012
<b>D</b>	1.9	2.0	2.1	0.075	0.079	0.083
<b>E</b>	1.9	2.0	2.1	0.075	0.079	0.083
<b>D1</b>	0.5	0.6	0.7	0.020	0.024	0.028
<b>E1</b>	1.1	1.2	1.3	0.043	0.047	0.051
<b>e</b>		0.50			0.20	
<b>k</b>	0.2			0.008		
<b>L</b>	0.25	0.35	0.45	0.010	0.014	0.018
<b>A</b>	0.80	0.85	0.9	0.031	0.033	0.035

## Package/Ordering Information

PRODUCT TYPE	OPERATING TEMPERATURE	PACKAGE	PACKAGE MARKING	NUMBER OF PACKAGES
CBM6041AST5	-40°C~125°C	SOT23-5	6041	Tape and Reel, 3000
CBM6041AS8	-40°C~125°C	SOP-8	CBM6041A	Tape and Reel, 2500
CBM6041AS8-RL	-40°C~125°C	SOP-8	CBM6041A	Tape and Reel, 3000
CBM6041AS8-REEL	-40°C~125°C	SOP-8	CBM6041A	Tape and Reel, 4000
CBM6042AS8	-40°C~125°C	SOP-8	CBM6042AS	Tape and Reel, 2500
CBM6042AS8-RL	-40°C~125°C	SOP-8	CBM6042AS	Tape and Reel, 3000
CBM6042AS8-REEL	-40°C~125°C	SOP-8	CBM6042AS	Tape and Reel, 4000
CBM6042AMS8	-40°C~125°C	MSOP-8	AFT	Tape and Reel, 3000
CBM6044AS14	-40°C~125°C	SOP-14	CBM6044AS	Tape and Reel, 2500
CBM6044AS14-RL	-40°C~125°C	SOP-14	CBM6044AS	Tape and Reel, 3000
CBM6044AS14-REEL	-40°C~125°C	SOP-14	CBM6044AS	Tape and Reel, 4000
CBM6044ATS14	-40°C~125°C	TSSOP-14	CBM6044AT	Tape and Reel, 2500
CBM6044ATS14-RL	-40°C~125°C	TSSOP-14	CBM6044AT	Tape and Reel, 3000
CBM6044ATS14-REEL	-40°C~125°C	TSSOP-14	CBM6044AT	Tape and Reel, 4000