Features

- Single-supply operation: 2.7 V to 5.5 V
- High output current: ±250 mA
- Low supply current: 750 μA/amplifier
- Wide bandwidth: 3 MHz
- Slew rate: 5 V/μs
- No phase reversal
- Low input currents
- Unity gain stable
- Rail-to-rail input and output

Application

- Multimedia audio
- LCD drivers
- ASIC input or output amplifiers
- Headphone drivers

Description

The CBM8531, CBM8532, and CBM8534 are single, dual, and quad rail-to-rail input/output single-supply amplifiers featuring 250mA output drive current. This high output current makes these amplifiers excellent for driving either resistive or capacitive loads. AC performance is very good with 3 MHz bandwidth,5 V/μs slew rate, and low distortion. All are guaranteed to operate from a 2.7 V single supply as well as a 5.5 V supply.

The very low input bias currents enable the CBM8531, CBM8532, and CBM8534 to be used for integrators, diode amplification, and other applications requiring low input bias current. Supply current is only 750 μA per amplifier at 5 V, allowing low current applications to control high current loads.

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.

The CBM8531/CBM8532/CBM8534 are specified over the extended industrial temperature range (−40°C to +125°C). The CBM8531 is available in 8-lead SOIC, 5-lead SC70, and 5-lead SOT-23 packages. The CBM8532 is available in 8-lead SOIC, 8-lead MSOP, and 8-lead TSSOP surface-mount packages. The CBM8534 is available in narrow 14-lead SOIC and 14-lead TSSOP surface-mount packages.

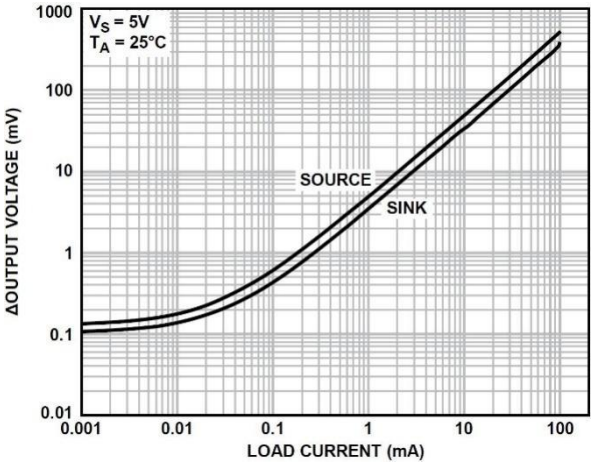
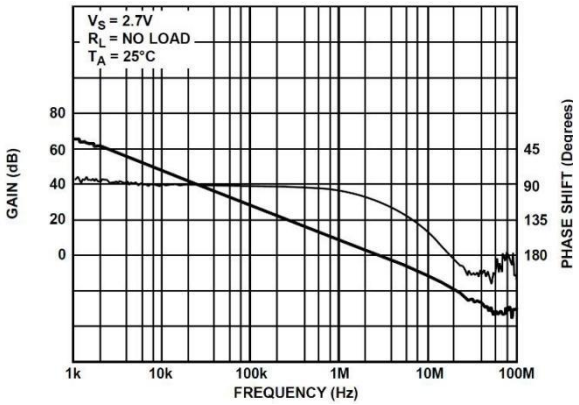
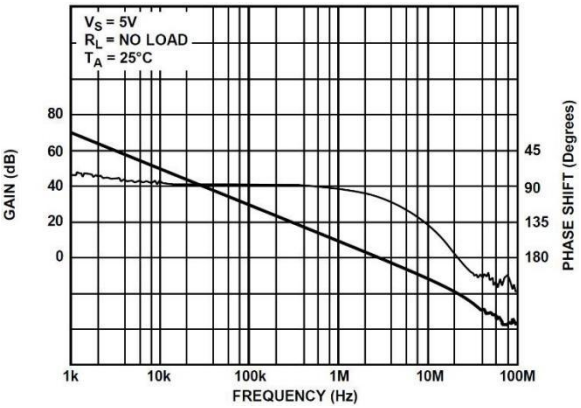


Figure 12. Output Voltage to Supply Rail vs. Load Current Figure

13. Output Voltage to Supply Rail vs. Load Current



14. Open-Loop Gain and Phase Shift vs. Figure Frequency



15. Open-Loop Gain and Phase Shift vs. Figure Frequency

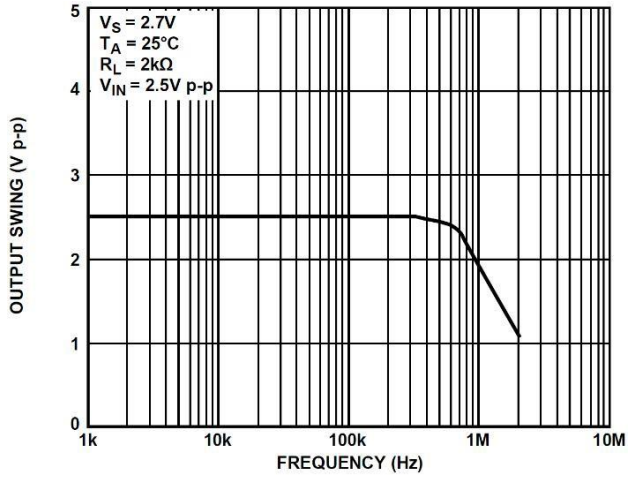
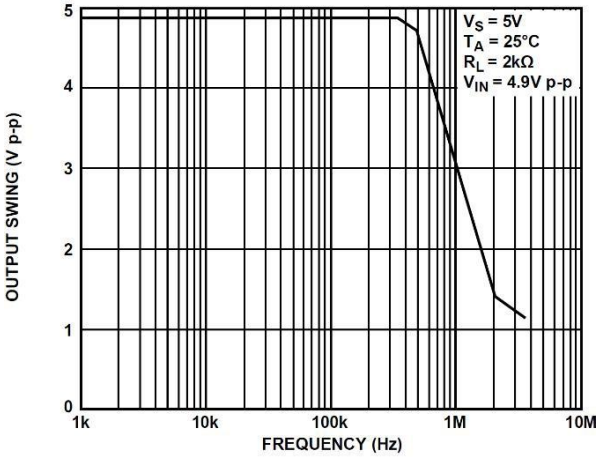


Figure 16. Closed-Loop Output Swing vs. Frequency Figure



17. Closed-Loop Output Swing vs. Frequency

Figure 24. Power Supply Rejection vs. Frequency Figure

25. Small Signal Overshoot vs. Load Capacitance

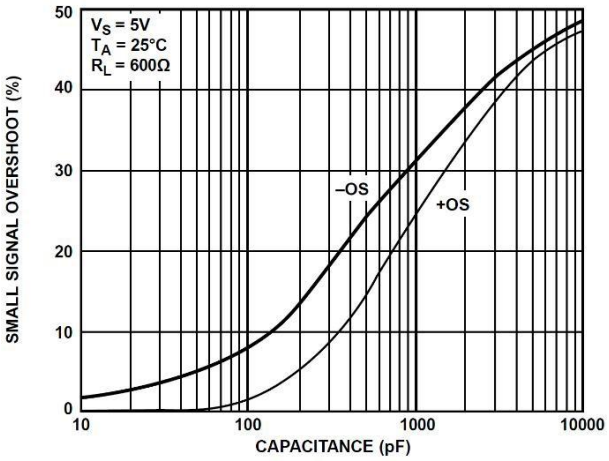


Figure 26. Small Signal Overshoot vs. Load Capacitance Figure

27. Small Signal Overshoot vs. Load Capacitance

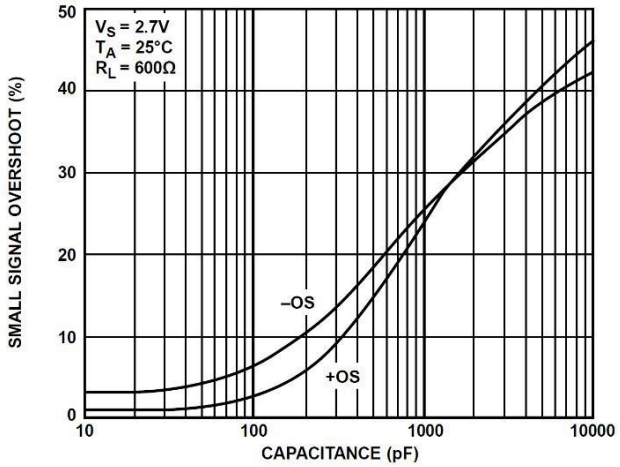
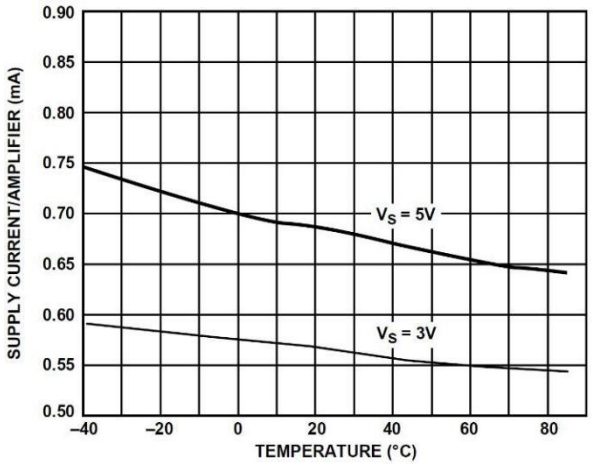


Figure 28. Small Signal Overshoot vs. Load Capacitance



29. Supply Current per Amplifier vs. Figure Temperature

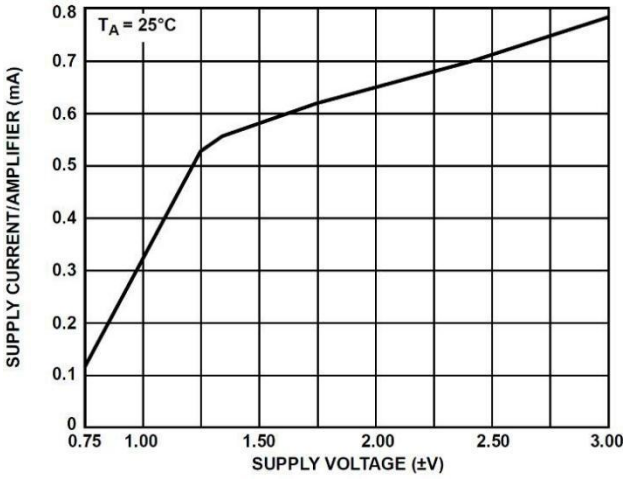
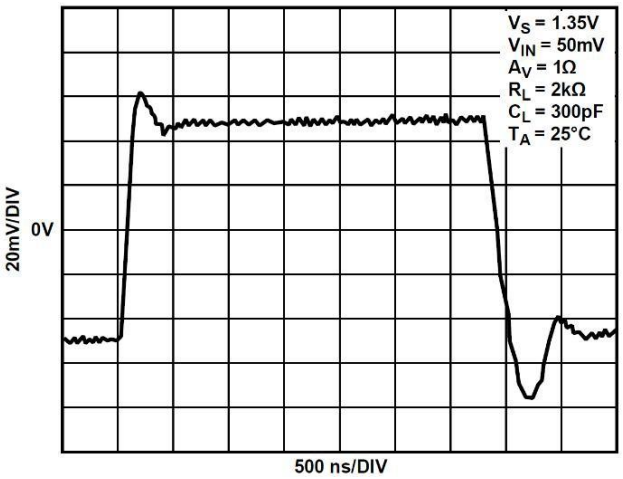


Figure 30. Supply Current per Amplifier vs. Supply Voltage Figure



31. Small Signal Transient Response

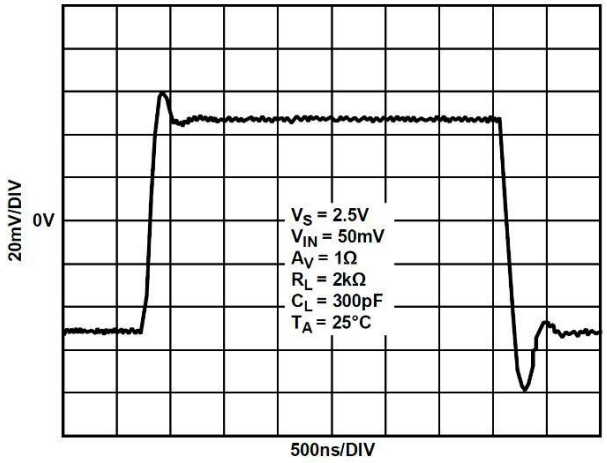


Figure 32. Small Signal Transient Response

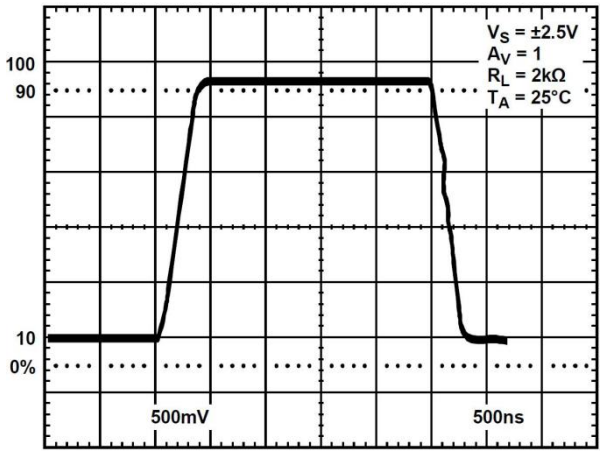


Figure 33. Large Signal Transient Response

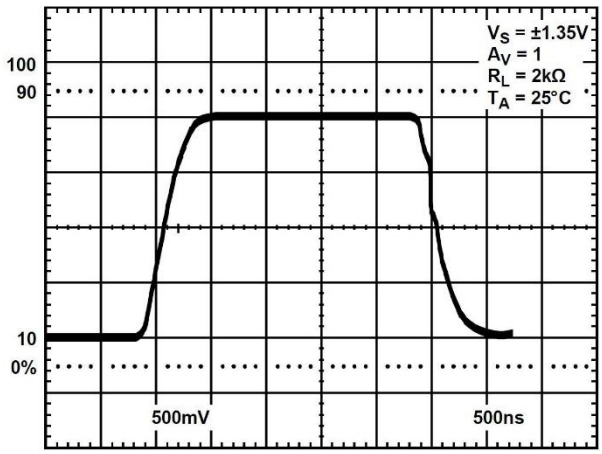
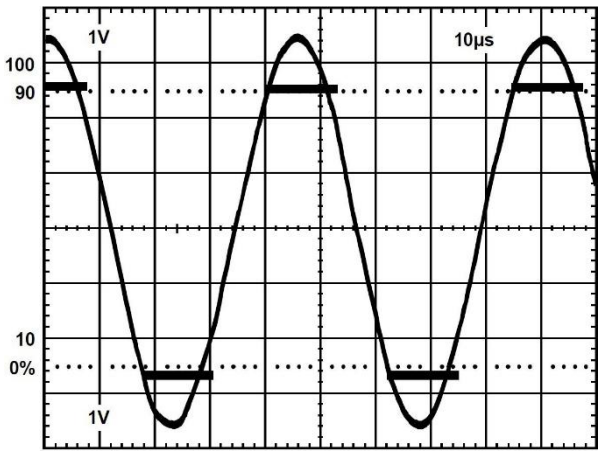


Figure 34. Large Signal Transient Response Figure



35. No Phase Reversal

Theory Of Operation

The CBM8531/CBM8532/CBM8534 are all CMOS, high output current drive, rail-to-rail input/output operational amplifiers. Their high output current drive and stability with heavy capacitive loads make the CBM8531/CBM8532/CBM8534 excellent choices as drive amplifiers for LCD panels.

Figure 36 illustrates a simplified equivalent circuit for the CBM8531/CBM8532/CBM8534. Like many rail-to-rail input amplifier configurations, it comprises two differential pairs, one N-channel (M1 to M2) and one P-channel (M3 to M4). These differential pairs are biased by 50 μA current sources, each with a compliance limit of approximately 0.5 V from either supply voltage rail. The differential input voltage is then converted into a pair of differential output currents. These differential output currents are then combined in a compound folded-cascade second gain stage (M5 to M9). The outputs of the second gain stage at M8 and M9 provide the gate voltage drive to the rail-to-rail output stage. Additional signal current recombination for the output stage is achieved using M11 to M14.

To achieve rail-to-rail output swings, the CBM8531/CBM8532/ CBM8534 design employs a complementary, common source output stage (M15 to M16). However, the output voltage swing is directly dependent on the load current because the difference between the output voltage and the supply is determined by the CBM8531/CBM8532/CBM8534' s output transistors on channel resistance (see Figure 12 and Figure 13). The output stage also exhibits voltage gain by virtue of the use of common source amplifiers; as a result, the voltage gain of the output stage (thus, the open-loop gain of the device) exhibits a strong dependence on the total load resistance at the output of the CBM8531/ CBM8532/CBM8534.

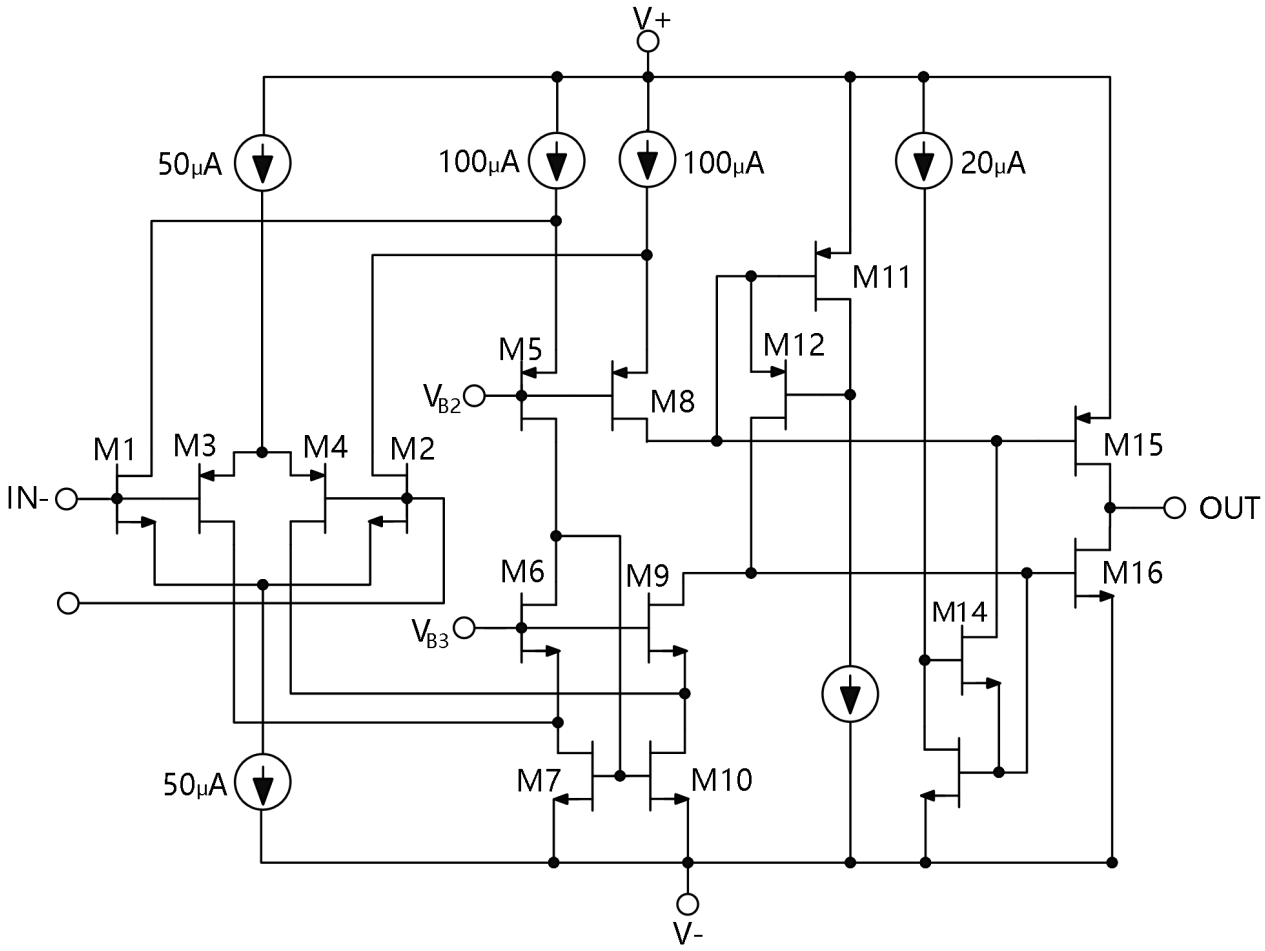


Figure 36. Simplified Equivalent Circuit

Short-Circuit Protection

As a result of the design of the output stage for the maximum load current capability, the CBM8531/CBM8532/CBM8534 do not have any internal short-circuit protection circuitry. Direct connection of the output of the CBM8531/CBM8532/CBM8534 to the positive supply in single-supply applications destroys the device. In applications where some protection is needed, but not at the expense of reduced output voltage headroom, a low value resistor in series with the output, as shown in Figure 37, can be used. The resistor, connected within the feedback loop of the amplifier, has very little effect on the performance of the amplifier other than limiting the maximum available output voltage swing. For single 5 V supply applications, resistors less than 20 Ω are not recommended.

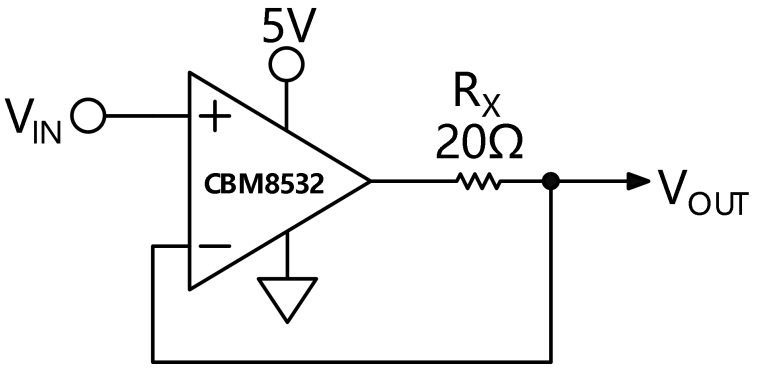


Figure 37. Output Short-Circuit Protection

Power Dissipation

Although the CBM8531/CBM8532/CBM8534 are capable of providing load currents to 250 mA, the usable output load current drive capability is limited to the maximum power dissipation allowed by the device package used. In any application, the absolute maximum junction temperature for the CBM8531/CBM8532/CBM8534 is 150°C. The maximum junction temperature should never be exceeded because the device could suffer premature failure. Accurately measuring power dissipation of an integrated circuit is not always a straightforward exercise; therefore, Figure 38 is provided as a design aid for either setting a safe output current drive level or selecting a heat sink for the package options available on the CBM8531/CBM8532/CBM8534.

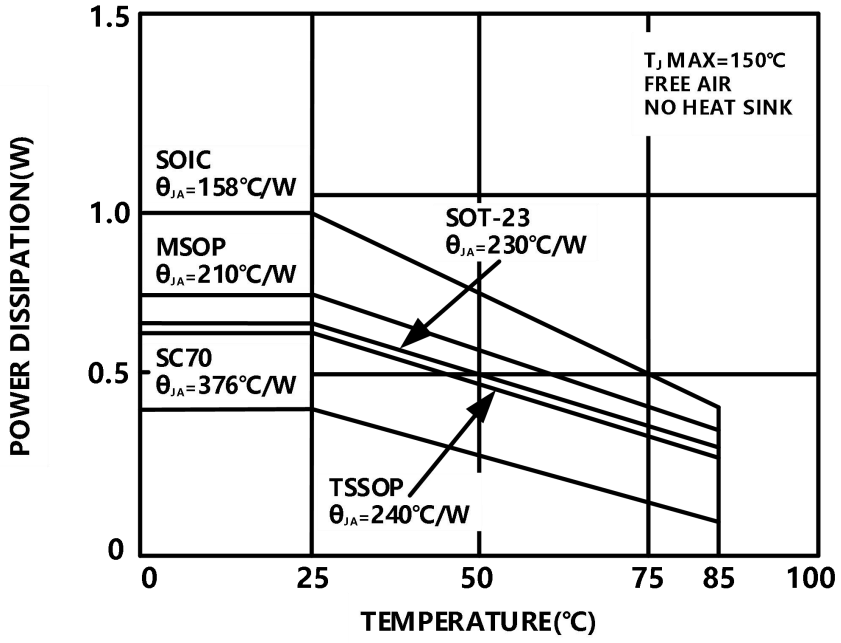


Figure 38. Maximum Power Dissipation vs. Ambient Temperature T_J

The thermal resistance curves were determined using the CBM8531/CBM8532/CBM8534 thermal resistance data for each package and a maximum junction temperature of 150℃. The following formula can be used to calculate the internal junction temperature of the CBM8531/CBM8532/CBM8534 for any application:

$T_J = P_{DISS} \times \theta_{JA} + T_A$

where:

T_J is the junction temperature. P_{DISS} is the power dissipation.

θ_{JA} is the package thermal resistance, junction-to-case.

T_A is the ambient temperature of the circuit.

To calculate the power dissipated by the CBM8531/CBM8532/ CBM8534, the following equation can be used:

$P_{DISS} = I_{LOAD} \times (V_S - V_{OUT})$

where:

I_{LOAD} is the output load current.

V_S is the supply voltage.

V_{OUT} is the output voltage.

The quantity within the parentheses is the maximum voltage developed across either output transistor. As an additional design aid in calculating available load current from the CBM8531/CBM8532/CBM8534, Figure 5 illustrates the output voltage of the CBM8531/CBM8532/CBM8534 as a function of load resistance.

POWER CALCULATIONS FOR VARYING OR UNKNOWN LOADS

Often, calculating power dissipated by an integrated circuit to determine if the device is being operated in a safe range is not as simple as it may seem. In many cases, power cannot be directly measured, which may be the result of irregular output waveforms or varying loads; indirect methods of measuring power are required.

There are two methods to calculate power dissipated by an integrated circuit. The first can be done by measuring the package temperature and the board temperature, and the other is to directly measure the supply current of the circuit.

CALCULATING POWER BY MEASURING AMBIENT AND CASE TEMPERATURE

Given the two equations for calculating junction temperature

$T_J = T_A + P_{DISS}\ \theta_{JA}$

where:

T_J is the junction temperature. T_A is the ambient temperature.

θ_{JA} is the junction to ambient thermal resistance.

$T_J = T_C + P_{DISS}\,\theta_{JA}$

where:

T_C is the case temperature.

θ_{JA} and θ_{JC} are given in the data sheet.

The two equations can be solved for P (power) $T_A + P_{DISS}\theta_{JA} = T_C + P\theta_{JC}$

$P_{DISS} = (T_A - T_C)/(\theta_{JC} - \theta_{JA})$

Once power is determined, it is necessary to go back and calculate the junction temperature to ensure that it has not been exceeded.

The temperature measurements should be directly on the package and on a spot on the board that is near the package but not touching it. Measuring the package could be difficult. A very small bimetallic junction glued to the package can be used, or measurement can be done using an infrared sensing device if the spot size is small enough.

CALCULATING POWER BY MEASURING SUPPLY CURRENT

Power can be calculated directly, knowing the supply voltage and current. However, supply current may have a dc component with a pulse into a capacitive load, which can make rms current very difficult to calculate. It can be overcome by lifting the supply pin and inserting an rms current meter into the circuit. For this to work, be sure the current is being delivered by the supply pin being measured. This is usually a good method in a single-supply system; however, if the system uses dual supplies, both supplies may need to be monitored.

INPUT OVERVOLTAGE PROTECTION

As with any semiconductor device, whenever the condition exists for the input to exceed either supply voltage, the input overvoltage characteristic of the device must be considered. When an overvoltage occurs, the amplifier can be damaged, depending on the magnitude of the applied voltage and the magnitude of the fault current. Although not shown here, when the input voltage exceeds either supply by more than 0.6V, pn junctions internal to the CBM8531/CBM8532/CBM8534 energize, allowing current to flow from the input to the supplies. As illustrated in the simplified equivalent input circuit (see Figure 36), the CBM8531/CBM8532/CBM8534 do not have any internal current limiting resistors; therefore, fault currents can quickly rise to damaging levels.

This input current is not inherently damaging to the device, as long as it is limited to 5 mA or less. For the CBM8531/CBM8532/ CBM8534, once the input voltage exceeds the supply by more than

0.6 V, the input current quickly exceeds 5 mA. If this condition continues to exist, an external series resistor should be added. The size of the resistor is calculated by dividing the maximum overvoltage by 5 mA. For example, if the input voltage could reach 10 V, the external resistor should be (10 V/5 mA) = 2 kΩ.

This resistance should be placed in series with either or both inputs if they are exposed to an overvoltage condition.

OUTPUT PHASE REVERSAL

Some operational amplifiers designed for single-supply operation exhibit an output voltage phase reversal when their inputs are driven beyond their useful common-mode range. The CBM8531/ CBM8532/CBM8534 are free from reasonable input voltage range restrictions, provided that input voltages no greater than the supply voltage rails are applied. Although the output of the device does not change phase, large currents can flow through internal junctions to the supply rails, which was described in the Input Overvoltage Protection section. Without limit, these fault currents can easily destroy the amplifier. The technique recommended in the Input Overvoltage Protection section should therefore be applied in those applications where the possibility of input voltages exceeding the supply voltages exists.

CAPACITIVE LOAD DRIVE

The CBM8531/CBM8532/CBM8534 exhibit excellent capacitive load driving capabilities. They can drive up to 10 nF directly, as shown in Figure 25 through Figure 28. However, even though the device is stable, a capacitive load does not come without a penalty in bandwidth. As shown in Figure 39, the bandwidth is reduced to less than 1 MHz for loads greater than 10 nF. A snubber network on the output does not increase the bandwidth, but it does significantly reduce the amount of overshoot for a given capacitive load. A snubber consists of a series RC network (RS, CS), as shown in Figure 40, connected from the output of the device to ground. This network operates in parallel with the load capacitor, CL, to provide phase lag compensation. The actual value of the resistor and capacitor is best determined empirically.

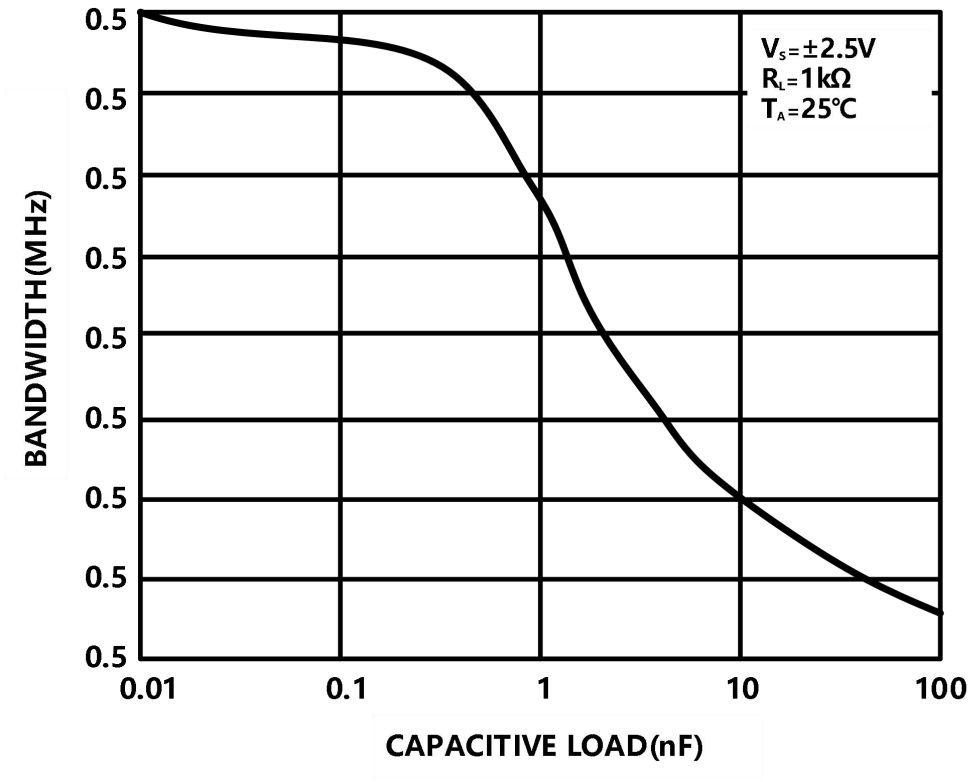


Figure 39. Unity-Gain Bandwidth vs. Capacitive Load

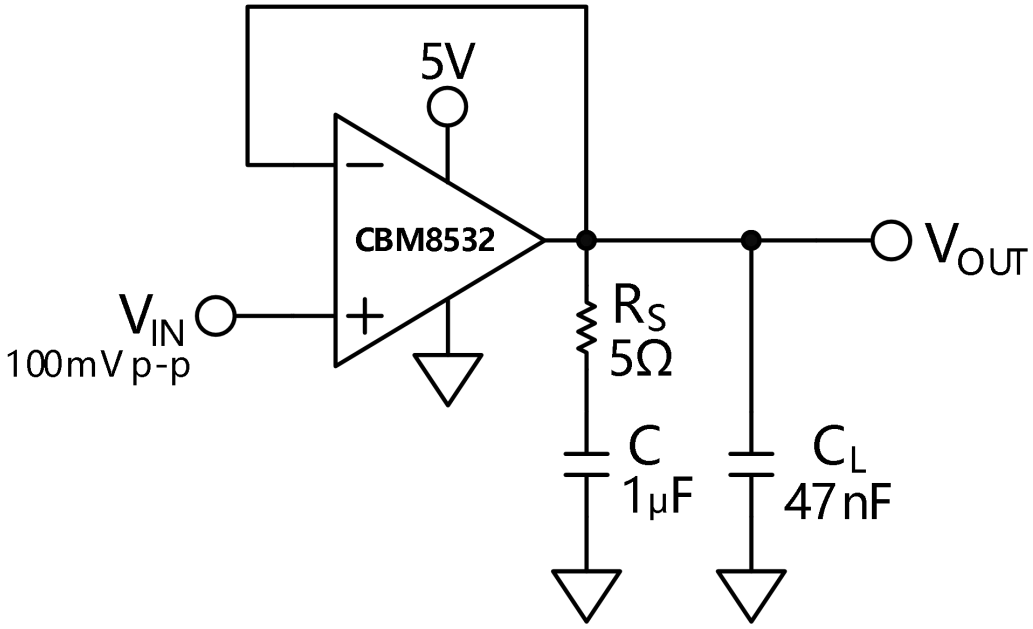


Figure 40. Snubber Network Compensates for Capacitive Loads

The first step is to determine the value of the resistor, RS. A good starting value is 100 Ω. This value is reduced until the small signal transient response is optimized. Next, CS is determined; 10 µF is a good starting point. This value is reduced to the smallest value for acceptable performance (typically, 1µF). For the case of a 47 nF load capacitor on the CBM8531/CBM8532/CBM8534, the optimal snubber network is 5Ω in series with 1µF. The benefit is immediately apparent, as seen in Figure 41. The top trace was taken with a 47nF load, and the bottom trace was taken with the 5 Ω in series with a 1µF snubber network in place. The amount of overshoot and ringing is dramatically reduced. Table 5 illustrates a few sample snubber networks for large load capacitors.

Snubber Networks for Large Capacitive Loads

Load Capacitance(C_L)	Snubber Network(R_S, C_S)
0.47 nF	300 Ω, 0.1µF
4.7 nF	30 Ω, 1µF
47 nF	5 Ω, 1µF

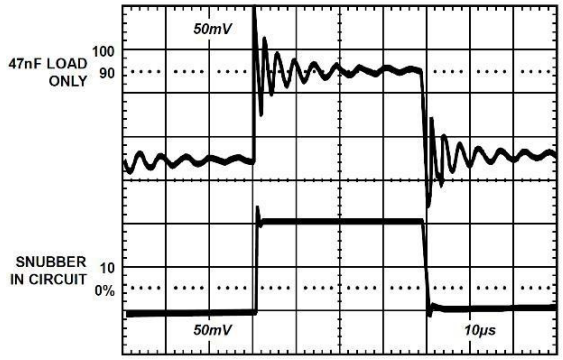


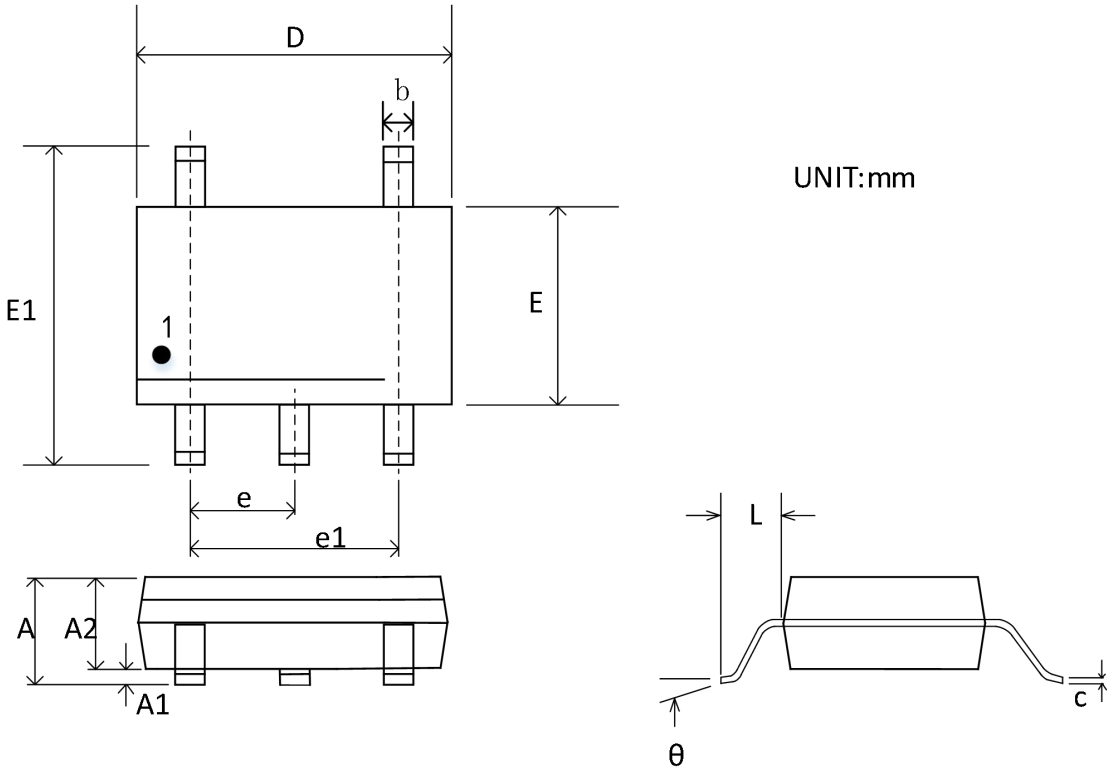
Figure 41. Overshoot and Ringing Are Reduced by Adding a Snubber Network in Parallel with the 47 nF Load

Package Outline Dimensions

SC70-5

Symbol	Dimensions In Millimeters		Dimensions Inches	
	Min	Max	Min	Max
A	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	2.000	2.200	0.079	0.087
E	1.150	1.350	0.045	0.053
E1	2.150	2.450	0.085	0.096
e	0.650 TYP		0.026TYP	
e1	1.200	1.400	0.047	0.055
L	0.525 REF		0.021 REF	
L1	0.260	0.460	0.010	0.018
θ	0°	8°	0°	8°

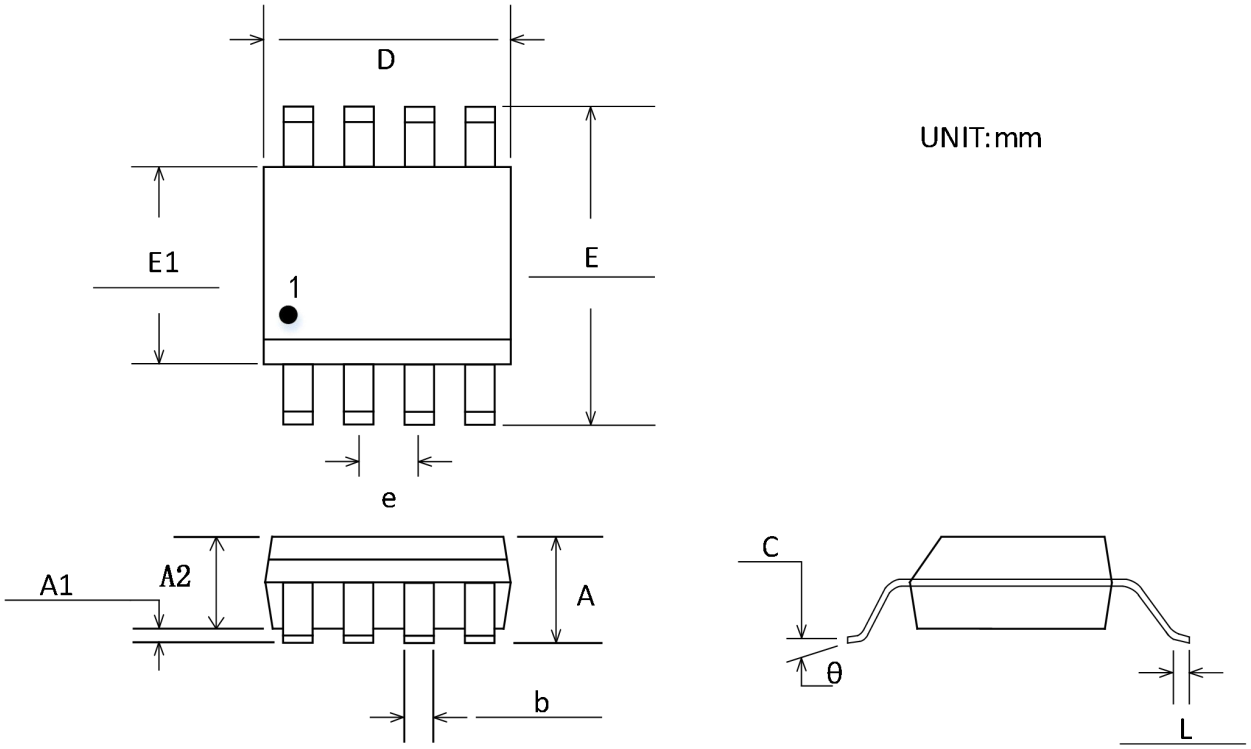
SOT23-5



UNIT:mm

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
θ	0°	8°	0°	8°

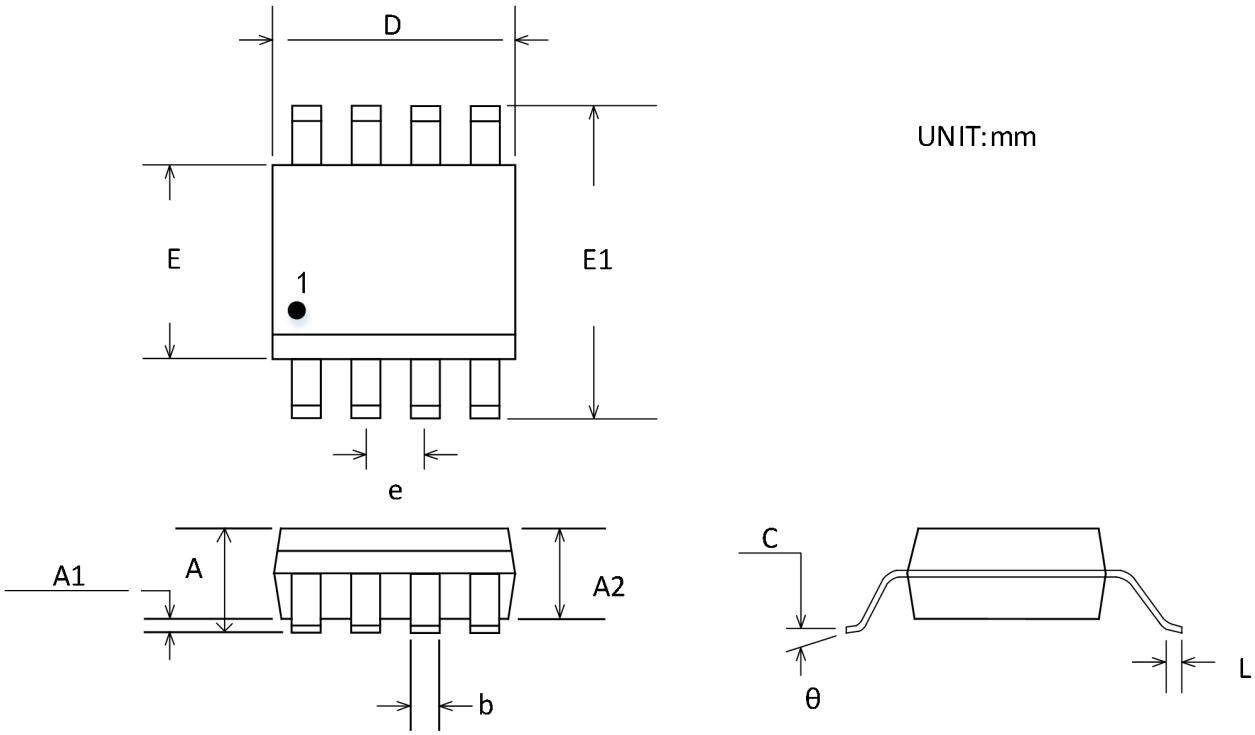
SOP-8



UNIT:mm

Symbol	Dimensions In Millimeters		Dimensions 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	0.170	0.250	0.007	0.010
D	4.800	5.000	0.189	0.197
E	5.800	6.200	0.228	0.244
E1	3.800	4.000	0.150	0.157
e	1.270 BSC		0.050 BSC	
L	0.400	1.270	0.016	0.050
θ	0°	8°	0°	8°

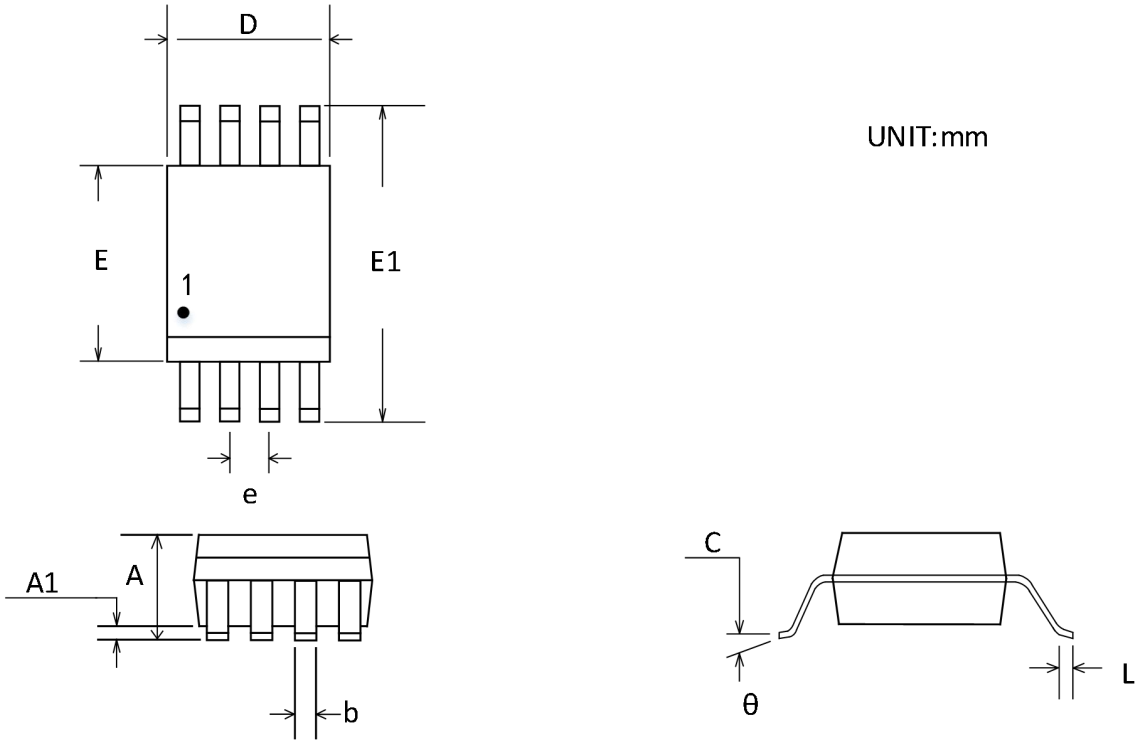
MSOP-8



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°

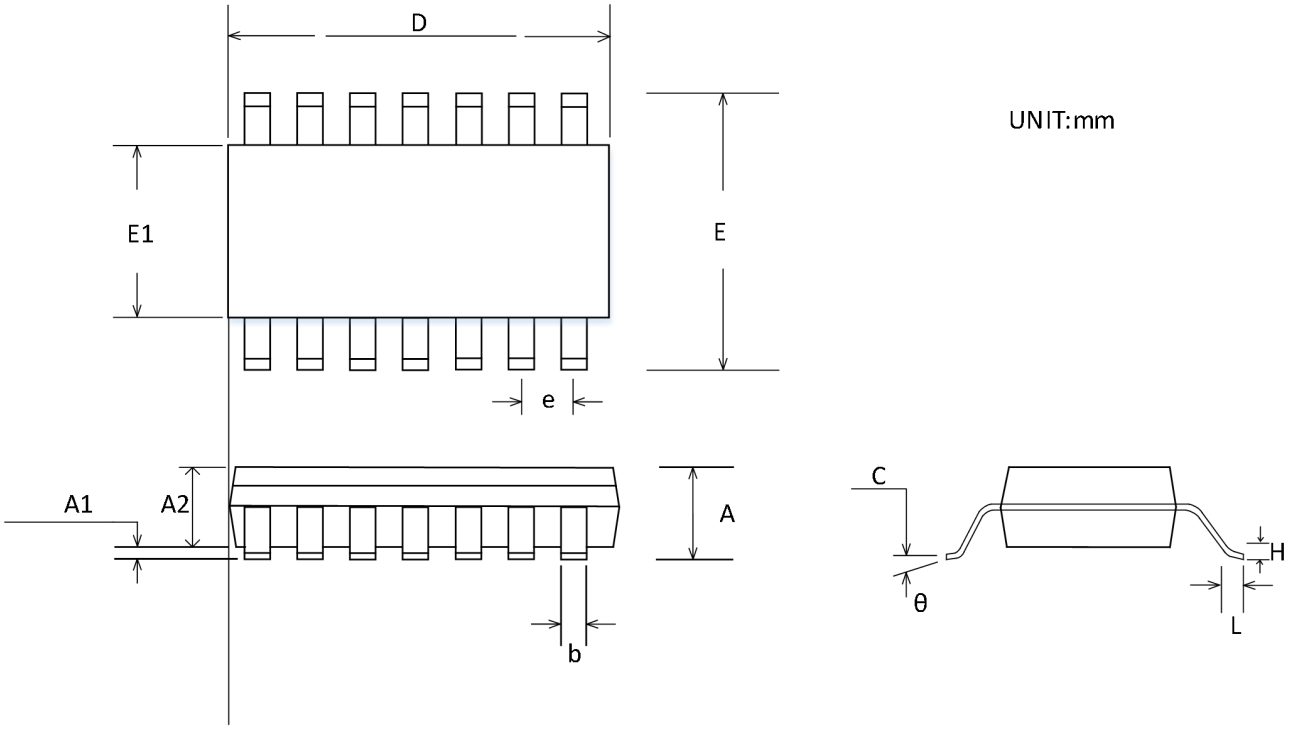
TSSOP-8



UNIT:mm

Symbol	Dimensions In Millimeters		Dimensions Inches	
	Min	Max	Min	Max
A	--	1.20	--	0.0039
A1	0.05	0.15	0.0002	0.0005
b	0.19	0.30	0.0006	0.0010
c	0.09	0.20	0.0003	0.0007
D	2.90	3.10	0.0095	0.0101
E	4.30	4.50	0.0141	0.0148
E1	6.40BSC		0.0210BSC	
e	0.65 BSC		0.0021 BSC	
L	0.45	0.75	0.0015	0.0025
θ	0°	8°	0°	6°

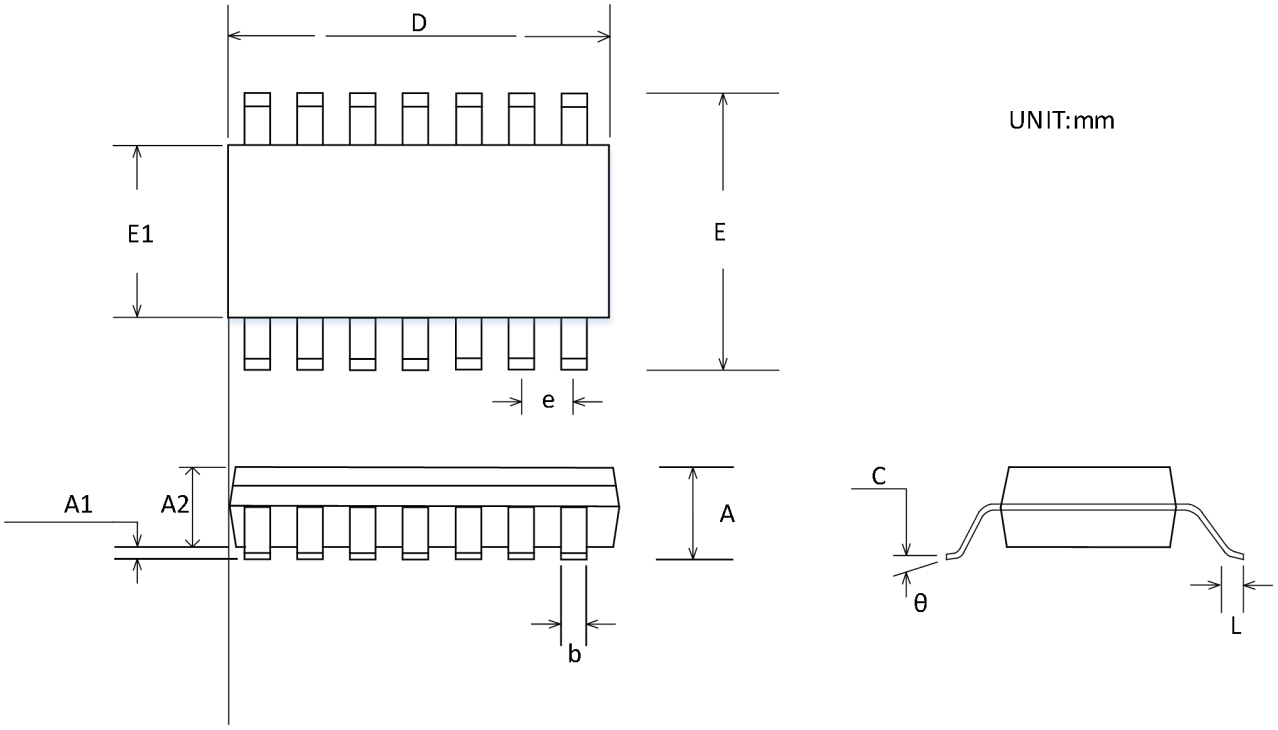
TSSOP-14



UNIT:mm

Symbol	Dimensions In Millimeters		Dimensions Inches	
	Min	Max	Min	Max
A		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	4.860	5.100	0.191	0.201
E	4.300	4.500	0.169	0.177
E1	6.250	6.550	0.246	0.258
e	0.650 BSC		0.026 BSC	
L	0.500	0.700	0.020	0.028
H	0.25 TYP		0.01 TYP	
θ	1°	7°	1°	7°

SOP-14



UNIT:mm

Symbol	Dimensions In Millimeters		Dimensions 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	0.310	0.510	0.012	0.020
c	0.100	0.250	0.004	0.010
D	8.450	8.850	0.333	0.348
E	5.800	6.200	0.228	0.244
E1	3.800	4.000	0.150	0.157
e	1.270 BSC		0.050 BSC	
L	0.400	1.270	0.016	0.050
θ	0°	8°	0°	8°

Package/Ordering Information

ORDERING NUMBER	TEMPRANGE	PACKAGE	PACKAGE MARKING	TRANSPOT MEDIA,QUANTILY
CBM8531ASC7	-40℃~85℃	SC70-5	C31	Tape and Reel,3000
CBM8531AST5	-40℃~85℃	SOT23-5	T31	Tape and Reel,3000
CBM8531AS8	-40℃~85℃	SOP-8	CBM8531A	Tape and Reel,2500
CBM8531AS8-RL	-40℃~85℃	SOP-8	CBM8531A	Tape and Reel,3000
CBM8531AS8-REEL	-40℃~85℃	SOP-8	CBM8531A	Tape and Reel,4000
CBM8532AS8	-40℃~85℃	SOP-8	CBM8532A	Tape and Reel,2500
CBM8532AS8-RL	-40℃~85℃	SOP-8	CBM8532A	Tape and Reel,3000
CBM8532AS8-REEL	-40℃~85℃	SOP-8	CBM8532A	Tape and Reel,4000
CBM8532AMS8	-40℃~85℃	MSOP-8	A32	Tape and Reel,3000
CBM8532ATS8	-40℃~85℃	TSSOP-8	T32	Tape and Reel,2500
CBM8534AS14	-40℃~85℃	SOP-14	CBM8534AS	Tape and Reel,2500
CBM8534AS14-RL	-40℃~85℃	SOP-14	CBM8534AS	Tape and Reel,3000
CBM8534AS14-REEL	-40℃~85℃	SOP-14	CBM8534AS	Tape and Reel,4000
CBM8534ATS14	-40℃~85℃	TSSOP-14	CBM8534AT	Tape and Reel,2500
CBM8534ATS14-RL	-40℃~85℃	TSSOP-14	CBM8534AT	Tape and Reel,3000
CBM8534ATS14-REEL	-40℃~85℃	TSSOP-14	CBM8534AT	Tape and Reel,4000