## Features

- Low Offset Voltage: 1uV
- Input Offset Drift: 0.005μV/°C
- High Gain Bandwidth Product: 1.6MHz
- Rail-to-Rail Input and Output
- High Gain, CMRR, PSRR:130dB
- High Slew Rate: 0.7V/μs
- Low Noise: 1.3uVp-p (0.01~10Hz)
- Low Power Consumption: 180μA /op amp
- Overload Recovery Time:2us
- Low Supply Voltage: +2.5 V to +5.5 V
- No External Capacitors Required
- Extended Temperature: -40°C to +125°C

## Application

- Temperature Sensors
- Medical/Industrial Instrumentation
- Pressure Sensors
- Battery-Powered Instrumentation
- Active Filtering
- Weight Scale Sensor
- Strain Gage Amplifiers
- Power Converter/Inverter

## Description

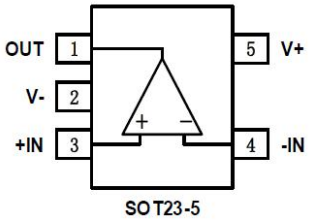
The CBM8538, CBM8539 series of CMOS operational amplifiers use auto-zero techniques to simultan-eously provide very low offset voltage (5μV max) and near-zero drift over time and temperature. This family of amplifiers has ultralow noise, offset and power.

This miniature, high-precision operational amplifiers offer high input impedance and rail-to-rail input and rail-to-rail output swing. With high gain-bandwidth product of 1.6MHz and slew rate of 0.7V/μs.

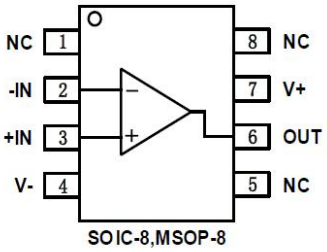
Single or dual supplies as low as +2.5V(±1.25V) and up to +5.5V (±2.75V) may be used.

The CBM8538/CBM8539 are specified for the extended industrial and automotive temperature range (-40°C to 125°C). The CBM8538 single amplifier is available in 5-lead SOT23, 8-lead MSOP and 8-lead SOIC packages, The CBM8539 dual amplifier is available in 8-lead SOIC and 8-lead MSOP narrow surface mount packages.

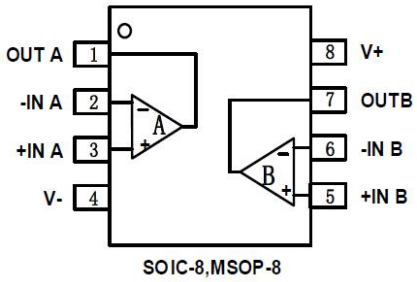
## PIN CONFIGURATIONS




SOT23-5




SOIC-8,MSOP-8




SOIC-8,MSOP-8

NC = No Connect

## ABSOLUTE MAXIMUM RATINGS (1)

- Supply Voltage, V+ to V-.....7.0V
- Input Terminals, Voltage (2) ..... – 0.5 to (V+) + 0.5V
  Current (2)..... ±10mA
- Temperature ..... −65°C to +150°C
- Operating Temperature ..... −40°C to +125°C
- Junction Temperature.....150°C
- Package Thermal Resistance @ $T_A$= +25°C
- SOT23-5, SOT23-6.....200°C/W
- MSOP-8, SOIC-8 ..... 150°C/W
- SOIC-14, TSSOP-14.....100°C/W
- Lead Temperature (Soldering, 10s) .....260°C
  ESD Susceptibility
- HBM .....5000V
- MM .....400V

1. Stresses above these ratings may cause permanent damage. Exposure to absolute maximum conditions for extended periods may degrade device reliability. These are stress ratings only, and functional operation of the device at these or any other conditions beyond those specified is not implied.
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.

## ESD SENSITIVITY CAUTION

ESD damage can range from subtle performance degradation to complete device failure. Precision integrated circuits may be more susceptible to damage because very small parametric changes could cause the device not to meet its published specifications. could cause the device not to meet its published specifications.

## ELECTRICAL CHARACTERISTICS

Boldface limits apply over the specified temperature range, $T_A$ = –40°C to +125°C.
(At $T_A$ = +25°C, $V_s$=5V, $R_L$ = 10kΩ connected to $V_S$/2, and $V_{OUT}$ = $V_S$/2, unless otherwise noted.)

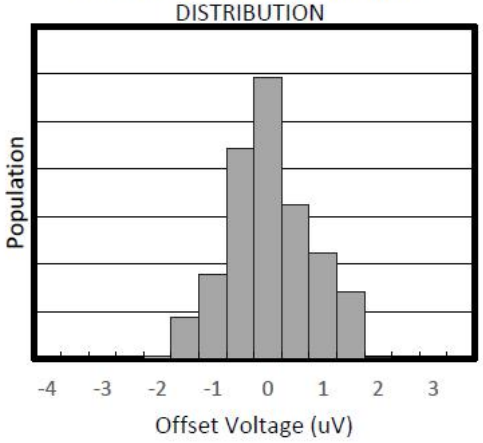
| PARAMETER | | CONDITION | CBM8538, CBM8539 | | | UNIT |
|---|---|---|---|---|---|---|
| | | | MIN | TYP | MAX | |
| **OFFSET VOLTAGE** | | | | | | |
| Input Offset Voltage | $V_{os}$ | $V_{CM}$ = Vs/2 | | 1 | 5 | μV |
| **VS Temperature** | **$dV_{os}/dT$** | | | **0.005** | **0.05** | **μV/°C** |
| **VS Power Supply** | **PSRR** | **VS = +2.5V to +5.5V, VCM = 0** | **110** | **130** | | **dB** |
| Channel Separation, dc | | | | 0.1 | | μV/V |
| **INPUT BIAS CURRENT** | | | | | | |
| Input Bias Current | $I_B$ | VCM = Vs/2 | | 50 | | pA |
| Input Offset Current | $I_{os}$ | | | 10 | | pA |
| **NOISE PERFORMANCE** | | | | | | |
| Input Voltage Noise | $e_n$p-p | f=0.01Hz to 10Hz | | 1.3 | | μVpp |
| Input Voltage Noise | $e_n$p-p | f=0.01Hz to 1Hz | | 0.4 | | μVpp |
| Input Voltage Noise Density | $e_n$ | f=1KHz | | 60 | | $nV\sqrt{Hz}$ |
| Input Current Noise Density | $i_n$ | f=10Hz | | 8 | | $fA\sqrt{Hz}$ |

| | | | | | | |
|---|---|---|---|---|---|---|
| **INPUT VOLTAGE RANGE** | | | | | | |
| Common-Mode Voltage Range | $V_{CM}$ | | (V-)-0.1 | | (V+)+0.1 | V |
| **Common-Mode Rejection Ratio** | **CMRR** | **(V–) – 0.1V < $V_{CM}$ < (V+)+ 0.1V** | **110** | **130** | | **dB** |
| **INPUT CAPACITANCE** | | | | | | |
| Differential | | | | 1 | | pF |
| Common-Mode | | | | 5 | | pF |
| **OPEN-LOOP GAIN** | | | | | | |
| **Open-Loop Voltage Gain** | **$A_{OL}$** | **RL=10KΩ, VO=0.3V to 4.7V, -40°C~125°C** | **110** | **130** | | **dB** |
| **DYNAMIC PERFORMANCE** | | | | | | |
| Slew Rate | SR | G=+1 | | 0.7 | | V/μs |
| Gain-Bandwidth Product | GBW | | | 1.6 | | MHz |
| Overload Recovery Time | | | | 2 | | us |
| **OUTPUT CHARACTERISTICS** | | | | | | |
| Output Voltage High | $V_{OH}$ | RL=100 KΩ to GND | 4.99 | 4.998 | | V |
| | | RL=10 KΩ to GND | 4.95 | 4.98 | | V |
| Output Voltage Low | $V_{OL}$ | RL=100 KΩ to V+ | | 1 | 10 | mV |
| | | RL=10 KΩ to V+ | | 10 | 30 | mV |
| Short-Circuit Current | $I_{SC}$ | | | 40 | | mA |
| **POWER SUOOLY** | | | | | | |
| Operating Voltage Range | | | 2.5 | | 5.5 | V |
| Quiescent Current/ Amplifier | $I_Q$ | | | 180 | 260 | uA |
| **SHUTDOWN** | | | | | | |
| $t_{OFF}$ | | | | 2 | | μs |
| $t_{ON}$ | | | | 150 | | μs |
| $V_L$ (shutdown) | | | 0 | | +0.8 | V |
| $V_H$ (amplifier is active) | | | 0.75(V+) | | V+ | V |
| Input Bias Current of Enable Pin | | | | 50 | | pA |
| $I_{QSD}$ | | | | 1 | 5 | uA |

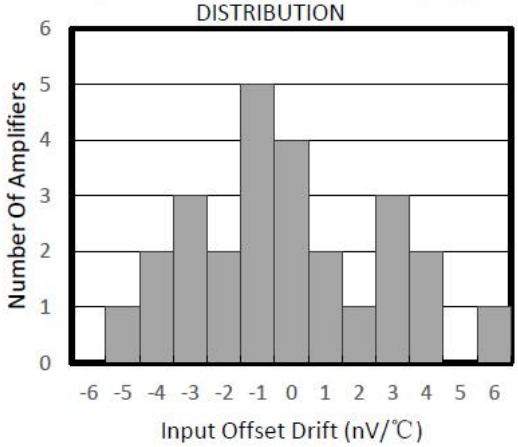
## TYPICAL CHARACTERISTICS

At $T_A$ = +25℃, Vs=5V, $R_L$ = 10kΩ connected to $V_S/2$, $V_{OUT}$ = $V_S/2$, unless otherwise noted.

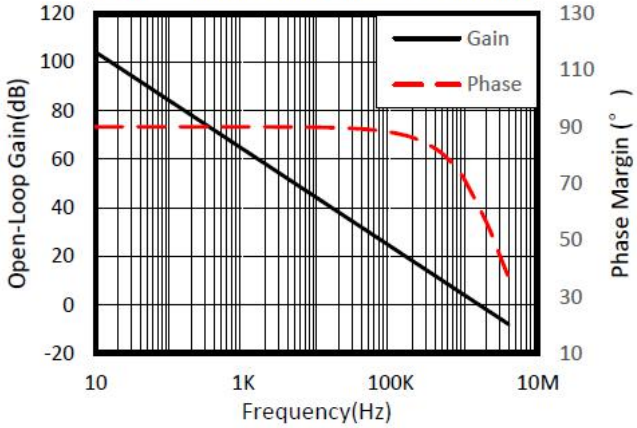
OFFSET VOLTAGE PRODUCTION DISTRIBUTION



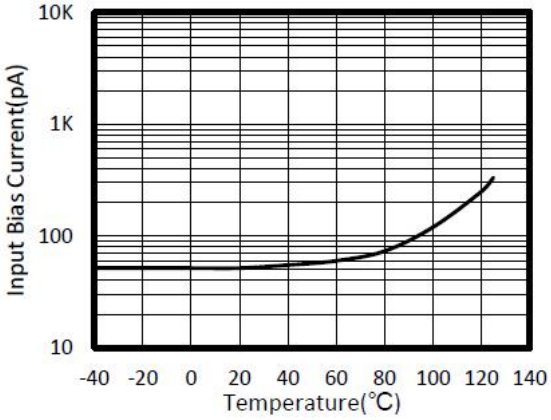

OFFSET VOLTAGE DRIFT PRODUCTION DISTRIBUTION



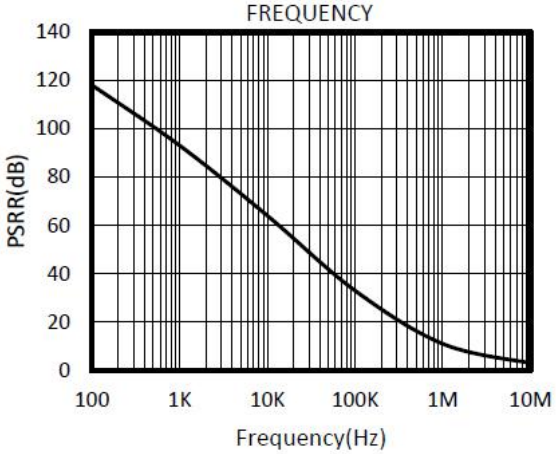

OPEN-LOOP GAIN AND PHASE vs FREQUENCY



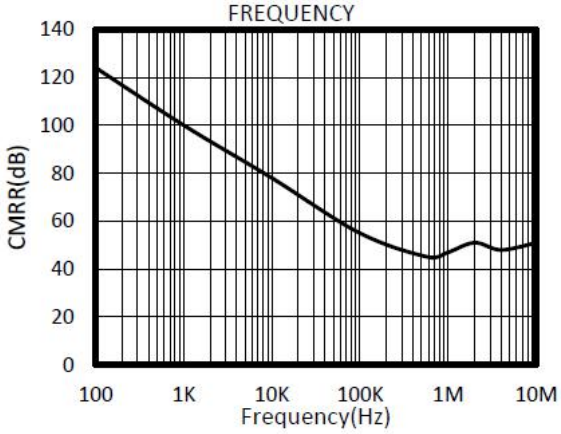

INPUT BIAS CURRENT vs TEMPERATURE




POWER-SUPPLY REJECTION RATIO vs FREQUENCY

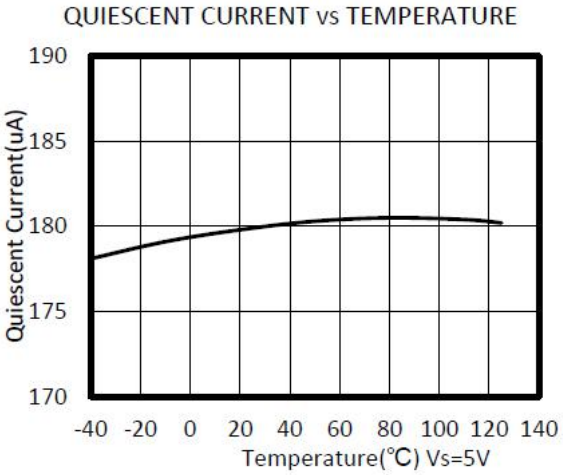


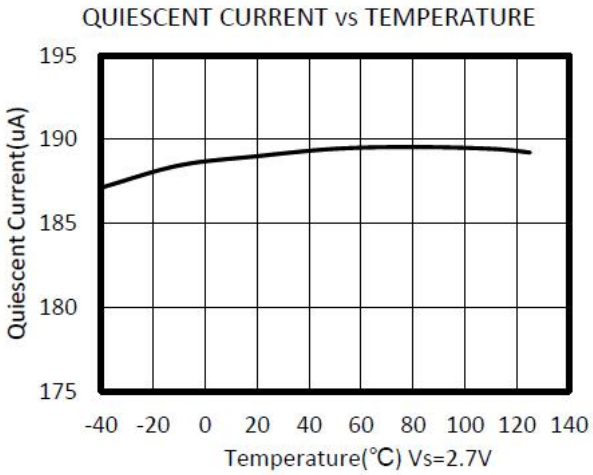

COMMON-MODE REJECTION RATIO vs FREQUENCY

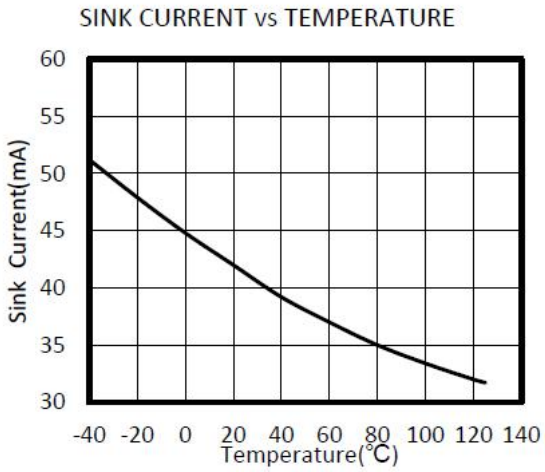


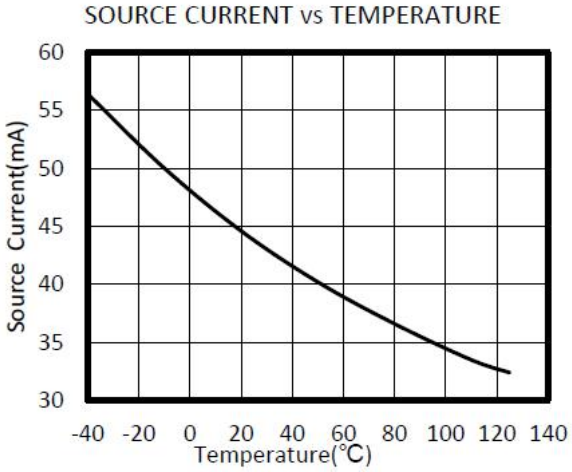
## TYPICAL CHARACTERISTICS

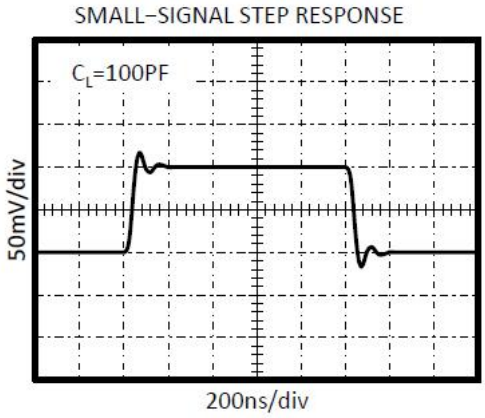
At $T_A$ = +25℃, Vs=5V, $R_L$ = 10kΩ connected to $V_S/2$, $V_{OUT}$ = $V_S/2$, unless otherwise noted.

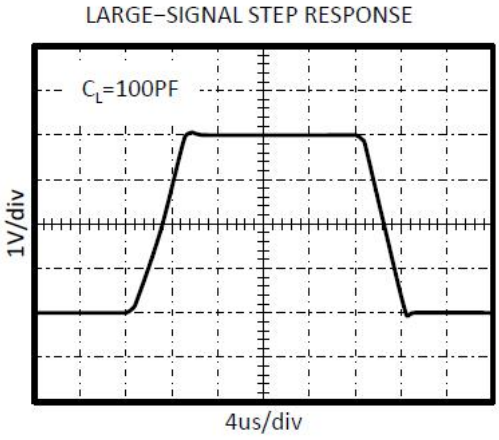


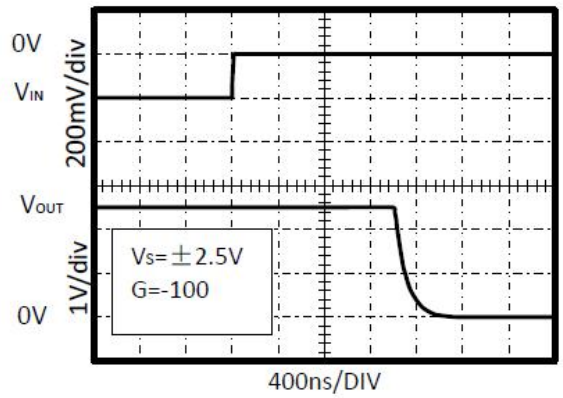



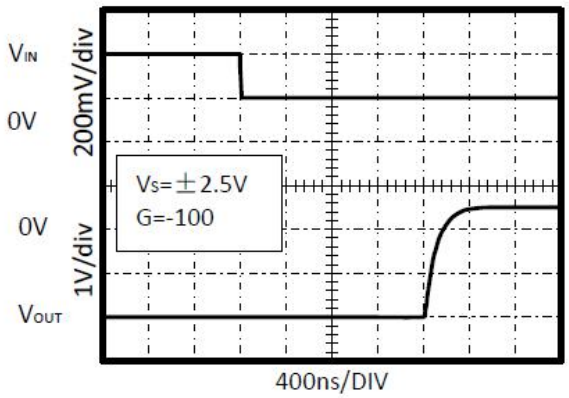
## TYPICAL CHARACTERISTICS

At $T_A$ = +25℃, Vs=5V, $R_L$ = 10kΩ connected to $V_S/2$, $V_{OUT}$ = $V_S/2$, unless otherwise noted

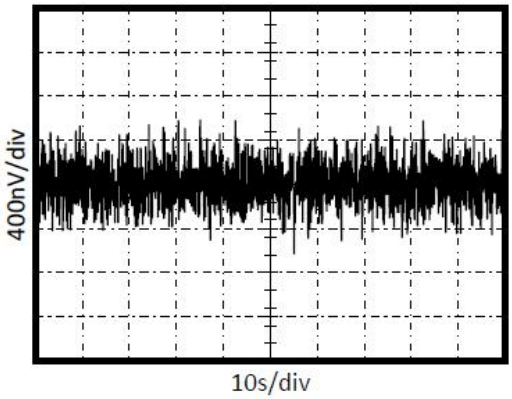
POSITIVE OVERVOLTAGE RECOVERY



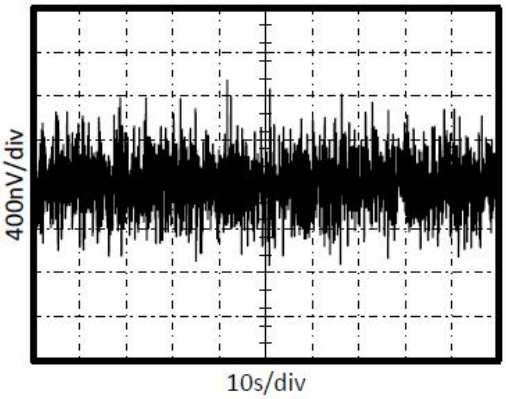

NEGATIVE OVERVOLTAGE RECOVERY



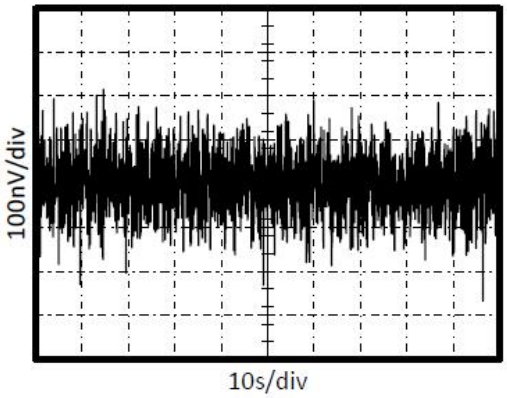

0.01Hz TO 10Hz NOISE AT Vs=5V



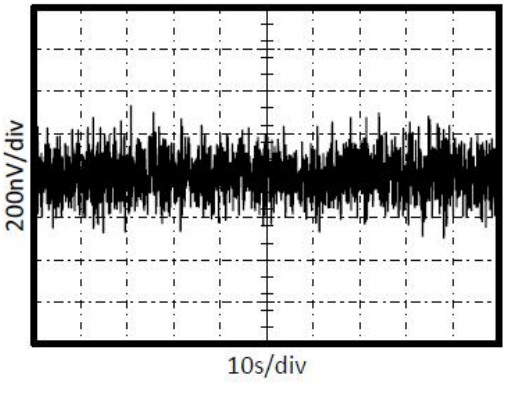

0.01Hz TO 10Hz NOISE AT Vs=2.7V




0.01Hz TO 1Hz NOISE AT Vs=5V




0.01Hz TO 1Hz NOISE AT Vs=2.7V



# APPLICATION NOTES

The CBM8538, CBM8539 series op amps are unity-gain stable and free from unexpected output phase reversal. They use auto-zeroing techniques to provide low offset voltage and very low drift over time and temperature.

Good layout practice mandates use of a 0.1μF capacitor placed closely across the supply pins.

For lowest offset voltage and precision performance, circuit layout and mechanical conditions should be optimized. Avoid temperature gradients that create thermoelectric (Seebeck) effects in thermocouple junctions formed from connecting dissimilar conductors. These thermally-generated potentials can be made to cancel by assuring that they are equal on both input terminals.

- Use low thermoelectric-coefficient connections (avoid dissimilar metals).
- Thermally isolate components from power supplies or other heat-sources.
- Shield op amp and input circuitry from air currents, such as cooling fans.

Following these guidelines will reduce the likelihood of junctions being at different temperatures, which can cause thermoelectric voltages of 0.1μV/°C or higher, depending on materials used.

## OPERATING VOLTAGE

The CBM8538, CBM8539 series op amps operate over a power-supply range of +2.5V to +5.5V (±1.25V to ±2.75V). Supply voltages higher than 7V (absolute maximum) can permanently damage the amplifier. Parameters that vary over supply voltage or temperature are shown in the Typical Charact-eristics section of this data sheet.

## LAYOUT GUIDELINES

Attention to good layout practices is always recommended. Keep traces short. When possible, use a PCB ground plane with surface-mount components placed as close to the device pins as possible. Place a 0.1μF capacitor closely across the supply pins. These guidelines should be applied throughout the analog circuit to improve performance and provide benefits such as reducing the EMI (electromagnetic-interference) susceptibility.

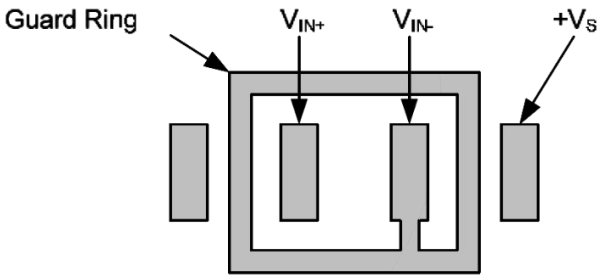
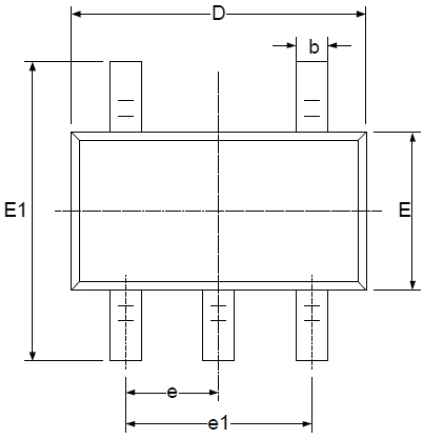
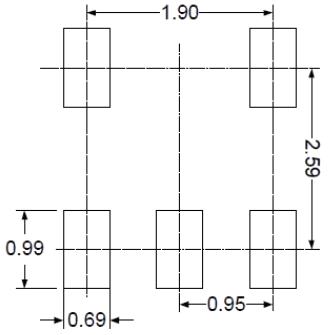



**Figure 1. The Layout of Guard Ring**

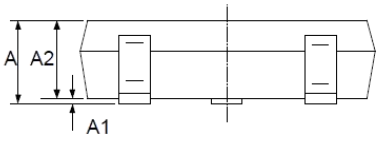
# PACKAGE OUTLINE DIMENSIONS

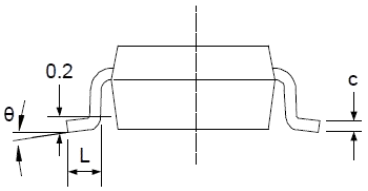
## SOT23-5



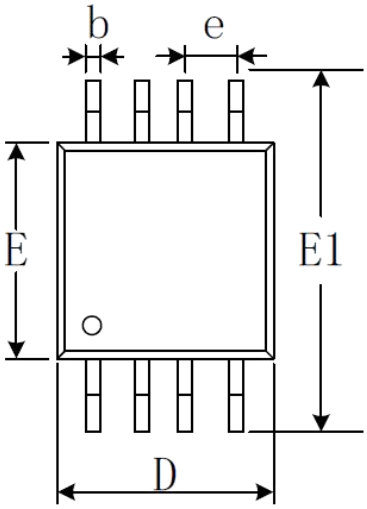

RECOMMENDED LAND PATTERN (Unit: mm)

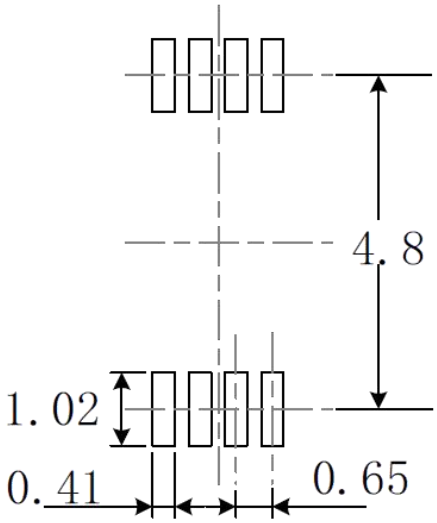


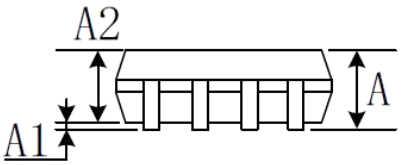

| Symbol | Dimensions In Millimeters | | Dimensions Inches | |
|---|---|---|---|---|
| | Min | Max | Min | Max |
| A | 1.050 | 1.250 | 0.041 | 0.049 |
| A1 | 0.000 | 0.100 | 0.000 | 0.004 |
| A2 | 1.050 | 1.150 | 0.041 | 0.045 |
| b | 0.300 | 0.500 | 0.012 | 0.020 |
| c | 0.100 | 0.200 | 0.004 | 0.008 |
| 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° |

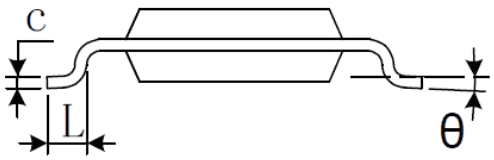
## MSOP-8



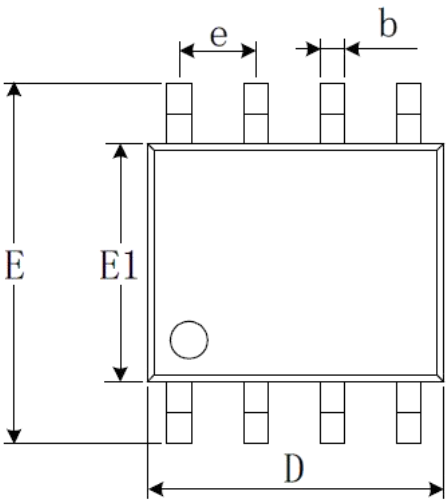

RECOMMENDED LAND PATTERN (Unit: mm)

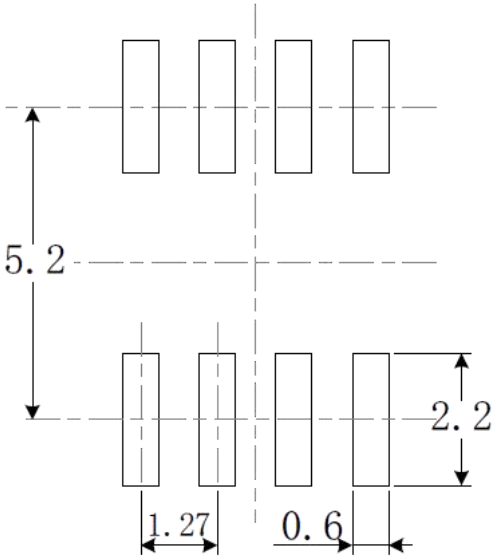


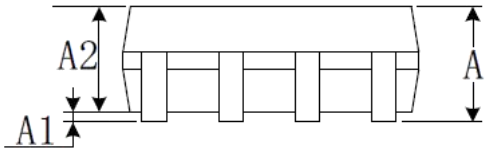

| Symbol | Dimensions In Millimeters | | Dimensions Inches | |
|---|---|---|---|---|
| | Min | Max | Min | Max |
| A | 0.820 | 1.100 | 0.032 | 0.043 |
| A1 | 0.020 | 0.150 | 0.001 | 0.006 |
| A2 | 0.750 | 0.950 | 0.030 | 0.037 |
| b | 0.250 | 0.380 | 0.010 | 0.015 |
| c | 0.090 | 0.230 | 0.004 | 0.009 |
| 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° |

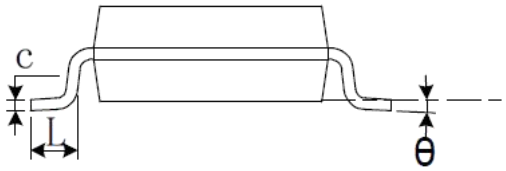
## SOIC-8(SOP8)




RECOMMENDED LAND PATTERN (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° |

## PACKAGE/ORDERING INFORMATION

| PRODUCT | ORDERING NUMBER | TEMPRANGE | PACKAGE | PAKEAGE MARKING | TRANSPOT MEDIA,QUANTILY |
|---|---|---|---|---|---|
| CBM8538 | CBM8538AST5 | -40℃~125℃ | SOT23-5 | 8538 | Reel,3000 |
| | CBM8538AS8 | -40℃~125℃ | SOIC-8(SOP8) | CBM8538 | Reel,2500 |
| | CBM8538AMS8 | -40℃~125℃ | MSOP-8 | CBM8538 | Reel,3000 |
| CBM8539 | CBM8539AS8 | -40℃~125℃ | SOIC-8(SOP8) | CBM8539 | Reel,2500 |
| | CBM8539AMS8 | -40℃~125℃ | MSOP-8 | CBM8539 | Reel,3000 |