## GENERAL DESCRIPTION

The OPAx333 series of CMOS operational amplifiers use a proprietary auto-calibration technique to simultaneously provide very low offset voltage (±4uV,maximum)and near-zero drift over time and temperature. These miniature,high-precision,low quiescent current (13.5uA)amplifiers offer high impedance inputs that have a common-mode range 100 mV beyond the rails,and rail-to-rail output that swings within 50 mV of the rails.Single or dual supplies as low as 1.8 V(±0.9 V)and up to 5.5 V(+2.75 V)can be used.These devices are optimized for low voltage, single-supply operation.

The OPA333AIDBVR (single version)is available in the 5-pin SOT23, while the OPA2333AIDR-MS(dual version)is available in the 8-pin SOIC and packages.All versions are specified for operation from -25°℃to 85℃.

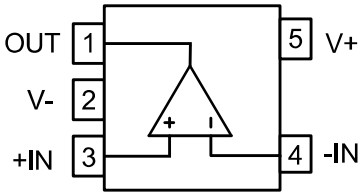
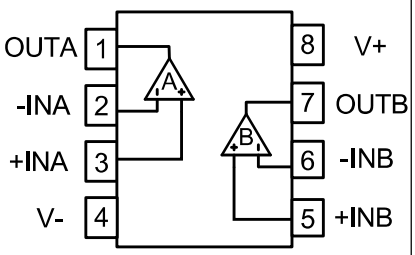
## FEATURES

- Input Offset Voltage:±1μV(Typ)
- Zero Drift:0.01μV/℃(Typ)
- 0.01Hz-10Hz Noise:1.5μVpp
- Quiescent Current:13.5μA
- High Open-Loop Gain:150dB
- Single or Dual Supply Operation
- Supply Voltage:1.8V to 5.5V
- Rail-to-Rail Input/Output
- Micro Size Packages:
  OPA333AIDBVR :SOT-23-5
  OPA2333AIDR :SOP-8

## TYPICALAPPLICATIONS

- Temperature Sensors
- Active Filtering
- Transducers
- Electronic Scales
- Temperature Measurements
- Medical Instrumentation
- Battery-Powered Instruments
- Handheld Test Equipment

## PACKAGE/ORDER INFORMATION

| Part Number | Op Temp(℃) | Package | Pin Configuration | Marking | QTY |
|---|---|---|---|---|---|
| OPA333AIDBVR | -25°C~85℃ | SOT23-5 |  |  | 3000 |
| OPA2333AIDR | -25°C~85℃ | SOP8 |  |  | 2500 |

## Pin Description

| PIN | | I/O | DESCRIPTION |
|---|---|---|---|
| NAME | SOT-23-5 | | |
| +IN | 3 | I | Positive(noninverting)input |
| -IN | 4 | I | Negative (inverting)input |
| NC | - | - | No Connection |
| OUT | 1 | O | Output |
| V+ | 5 | - | Positive (highest)power supply |
| V- | 2 | - | Negative (lowest)power supply |

| PIN | | I/O | DESCRIPTION |
|---|---|---|---|
| NAME | SOP-8 | | |
| +INA | 3 | I | Noninverting input,channel A |
| +INB | 5 | I | Noninverting input,channel B |
| -INA | 2 | I | Inverting input,channel A |
| -INB | 6 | I | Inverting input,channel B |
| OUTA | 1 | O | Output,channel A |
| OUTB | 7 | O | Output,channel B |
| V- | 4 | - | Negative (lowest)power supply |
| V+ | 8 | - | Positive(highest)power supply |

## Functional Block Diagram

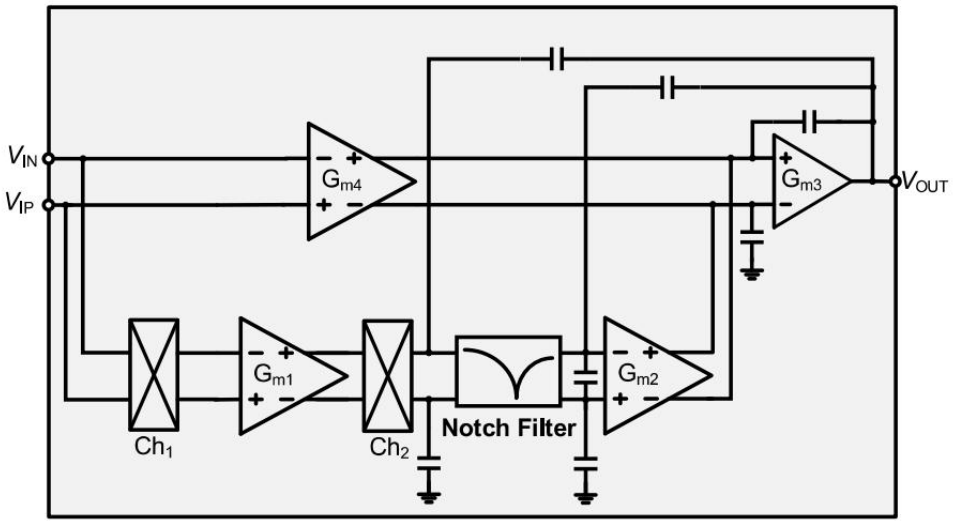



Figure 1. Typical Application

# SPECIFICATIONS

## Absolute Maximum Ratings(1)

| | MIN | MAX | UNIT |
|---|---|---|---|
| Supply Voltage | | 7 | V |
| Signal Input Terminals Voltage (2) | - 0.3 | (V+) + 0.3 | V |
| Signal Input Terminals Current (2) | -1 | 1 | mA |
| Output Short-Circuit(3) | Continuous | | mA |
| Junction Temperature, $T_J$ | | 150 | °C |
| Operating Temperature Range, $T_A$ | -25 | 85 | °C |
| Storage Temperature Range, Tstg | -35 | 150 | °C |

(1) Stresses beyond those listed under absolute maximum ratings may cause permanent damage to the device. These are stress ratings only, which do not imply functional operation of the device at these or any other conditions beyond those indicated under recommended operating conditions. Exposure to absolute-maximum-rated conditions for extended periods may affect device reliability.

(2) Input terminals are diode clamped to the power-supply rails. Input signals that can swing more than 0.3V beyond the supply rails should be current limited to 10mA or less.

(3) Short-circuit to ground, one amplifier per package.

## ESD Ratings

| | | VALUE | UNIT |
|---|---|---|---|
| $V_{(ESD)}$ Electrostatic discharge | Human body model (HBM) | ±4000 | V |
| | Charged-device model (CDM) | ±1000 | V |

## Recommended Operating Conditions

over operating free-air temperature range (unless otherwise noted)

| | | MIN | MAX | UNIT |
|---|---|---|---|---|
| Supply Voltage, $V_S$ | Single-supply | 1.8 | 5.5 | V |
| | Dual-supply | ±0.9 | ±2.75 | V |
| Specified temperature | | -25 | 125 | °C |

## ELECTRICAL CHARACTERISTICS

At $T_A$ = 25°C, $V_S$ = ±2.5V, $V_{IN}$=0V, unless otherwise noted.

| PARAMETER | | CONDITIONS | MIN | TYP | MAX | UNIT |
|---|---|---|---|---|---|---|
| **OFFSET VOLTAGE** | | | | | | |
| $V_{OS}$ | Input Offset Voltage | | | ±1 | ±10 | μV |
| $dV_{OS}/dT$ | Input Offset Voltage Average Drift | $T_A$ = -25°C to 125°C | | 0.01 | | μV/℃ |
| **INPUT CURRENT** | | | | | | |
| $I_B$ | Input Bias Current | | | 1 | 20 | pA |
| | | $T_A$ = -25°C to 125°C | | | 180 | pA |
| $I_{OS}$ | Input Offset Current | | | 1 | 20 | pA |
| **NOISE** | | | | | | |
| $V_N$ | Input Voltage Noise | f=0.1Hz to 10Hz | | 1.5 | 2 | $\mu V_{PP}$ |
| | Input Voltage Noise PSD | f=1kHz | | 79.4 | | nV/√Hz |
| **INPUT VOLTAGE** | | | | | | |
| $V_{CM}$ | Common-Mode Voltage Range | | (VS-)-0.1 | | (VS+)+0.1 | V |
| CMRR | Common-Mode Rejection Ratio | $\Delta V_{IN}$=1V | 130 | 135 | | dB |
| **GAIN** | | | | | | |
| $A_V$ | Open-Loop Voltage Gain | $\Delta V_{OUT}$=1V | 140 | 150 | | dB |
| **FREQUENCY RESPONSE** | | | | | | |
| GBW | Gain-Bandwidth Product | | | 550 | | kHz |
| SR | Slew Rate | G = +1 , $V_{IN}$=4V Step | | 0.1 | | V/us |
| **OUTPUT** | | | | | | |
| $V_{OUT-SWING}$ | Output Swing from Rail | | | 0.32 | 0.5 | mV |
| $I_{SC}$ | Output Short-Circuit Current | | | 21 | | mA |
| $C_L$(1) | Capacitive Load Drive | G = +1 , $V_{IN}$=4V Step | | | 1 | nF |
| **POWER SUPPLY** | | | | | | |
| PSRR | Power-Supply Rejection Ratio | $\Delta V_S$=1V | | 135 | | dB |
| $V_S$ | Operating Voltage Range | $I_O$=0A | 1.8 | | 5.5 | V |
| $I_Q$ | Quiescent Current/Amplifier | OPA333AIDBVR | | 13.5 | | uA |
| | | OPA2333AIDR | | 25 | | uA |

(1) Capacitive load drive means that above a given maximum value, the output waveform will oscillate under the step response.

## TYPICAL CHARACTERISTICS

At TA = 25°C, $V_S$ = ±2.5V, $V_{IN}$=0V, unless otherwise noted.

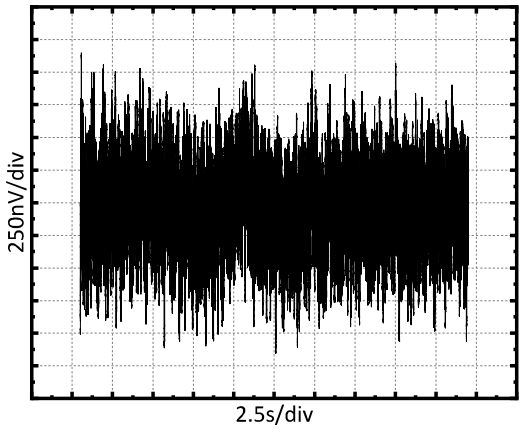



**Figure 2. 0.1Hz-10Hz Noise**

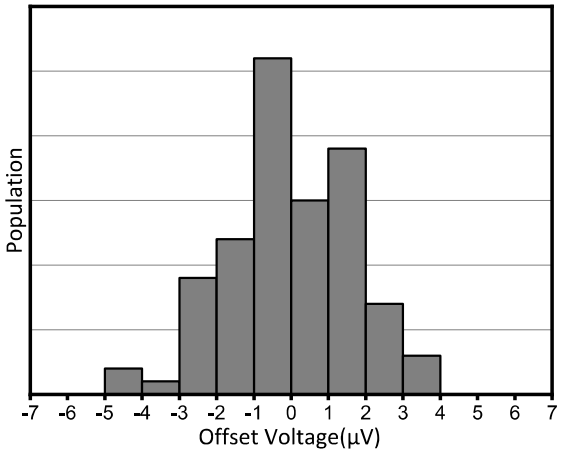



**Figure 3. Offset Voltage Production Distribution**

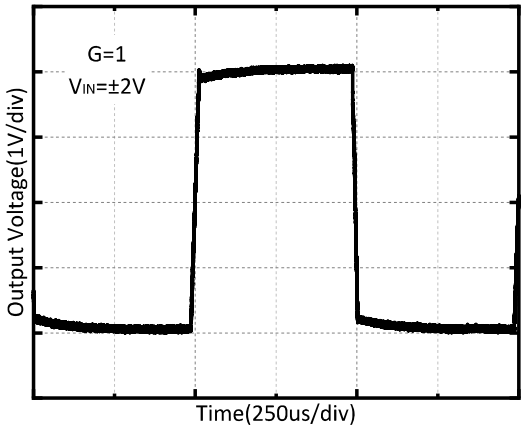



**Figure 4. Large-Signal Step Response**

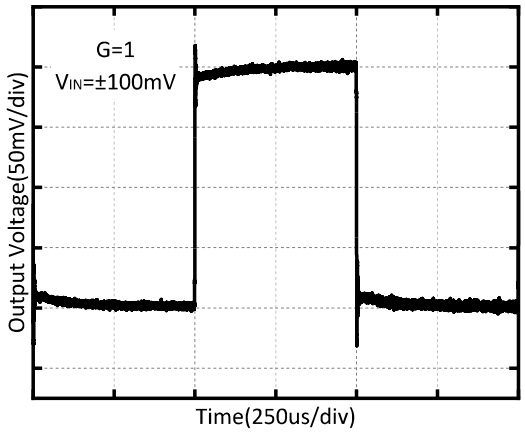



**Figure 5. Small -Signal Step Response**

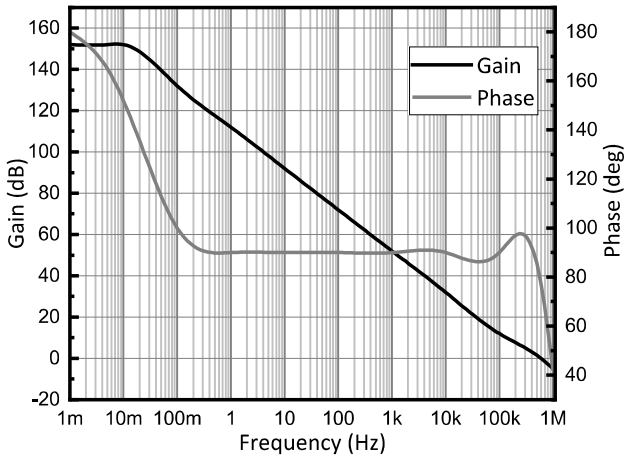



**Figure 6. Open-Loop Gain and Phase vs Frequency**

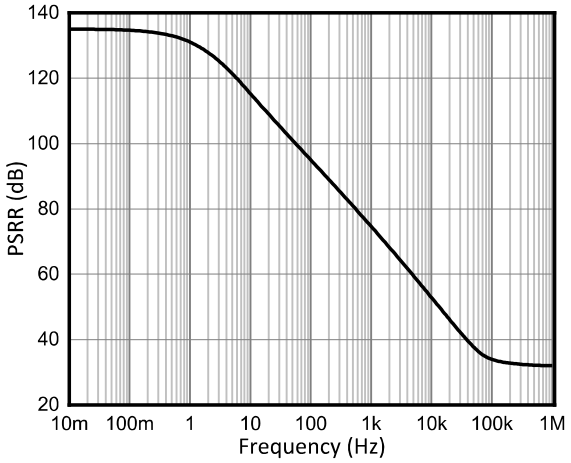



**Figure 7. PSRR vs Frequency**

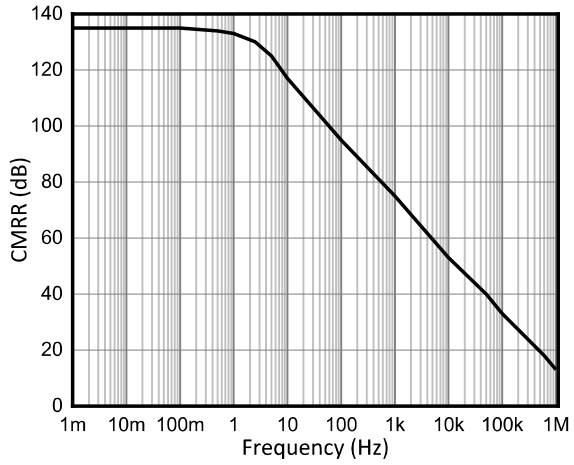



**Figure 8. CMRR vs Frequency**

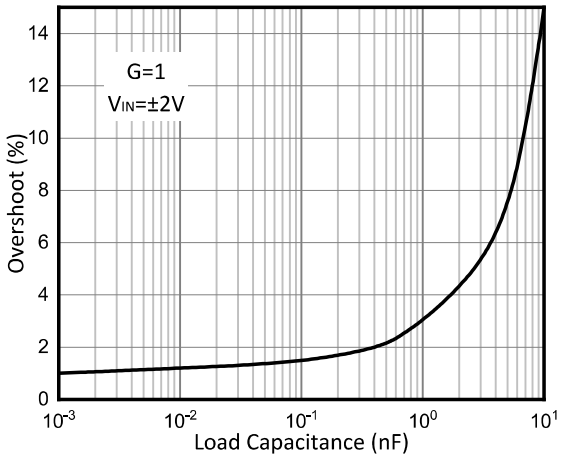



**Figure 9. Large-Signal Overshoot vs Load Capacitance**

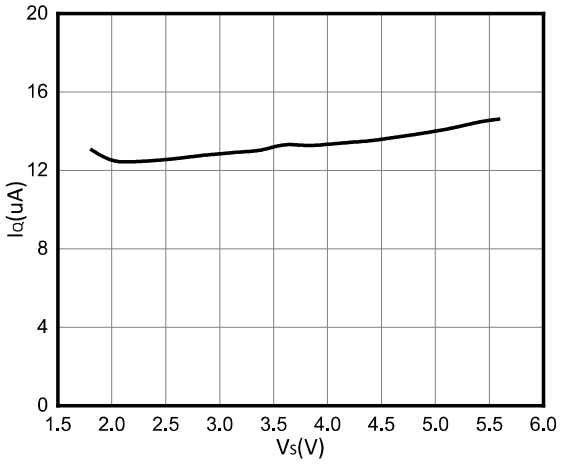



**Figure 10. Quiescent Current vs Supply Voltage**

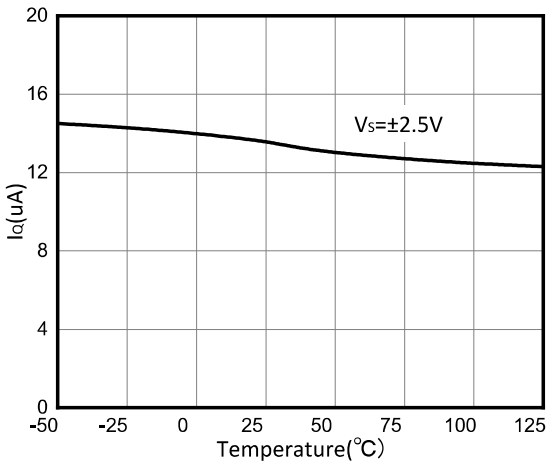



**Figure 11. Quiescent Current vs Temperature**

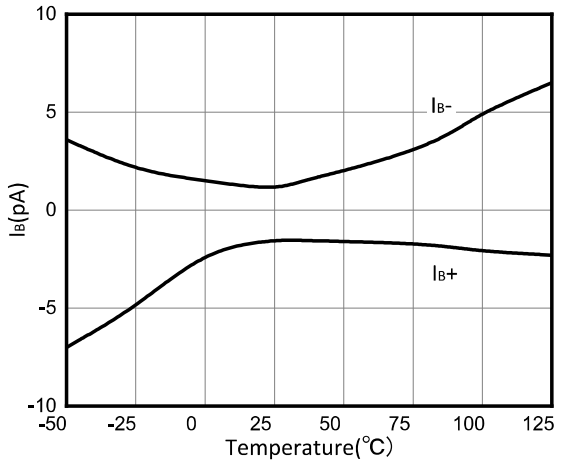



**Figure 12. Input Bias Current vs Temperature**

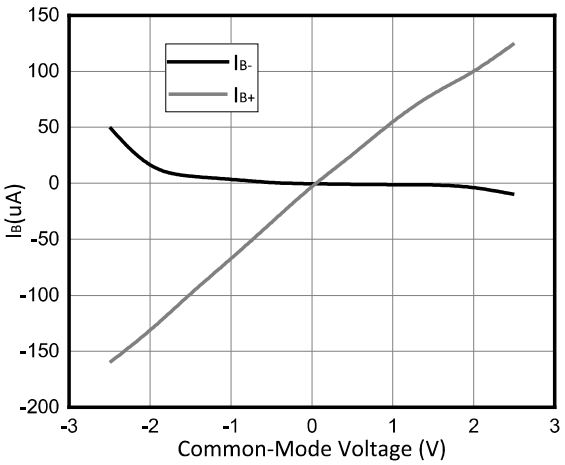



**Figure 13. Input Bias Current vs Common-Mode Voltage**

# Detailed Description

## Overview

The OPAx333 is a family of Zero-Drift, low-power, rail-to-rail input and output operational amplifiers. These devices operate from 1.8 V to 5.5 V, are unity-gain stable, and are suitable for a wide range of general-purpose applications. The Zero-Drift architecture provides ultra low offset voltage and near-zero offset voltage drift.

## Functional Block Diagram

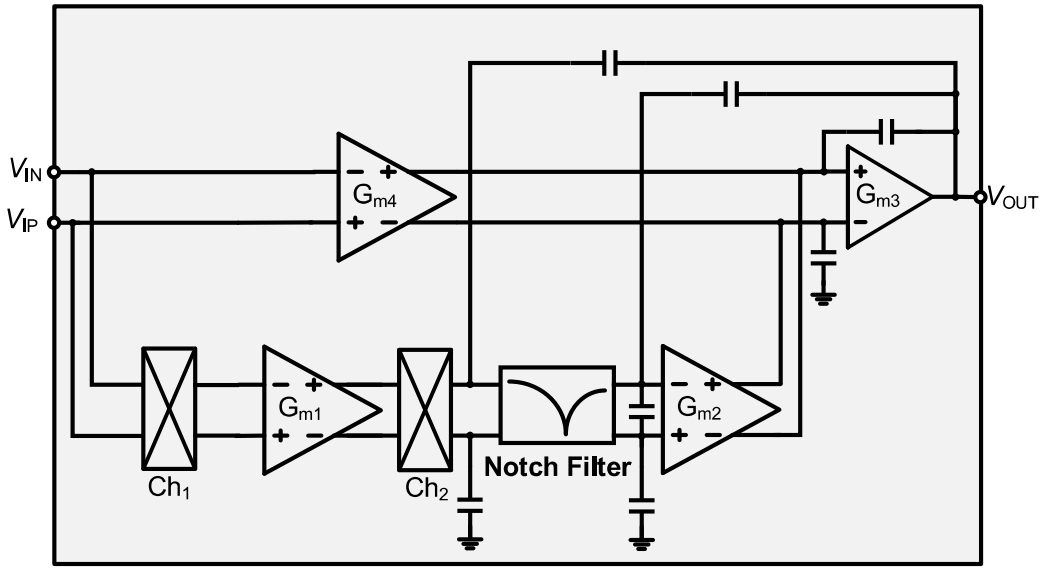



**Figure 14. OPAx333 Functional Block Diagram**

## Feature Description

The OPAx333 are unity-gain stable and free from unexpected output phase reversal. These devices use a proprietary auto-calibration technique to provide low offset voltage and very low drift over time and temperature. For lowest offset voltage and precision performance, optimize circuit layout and mechanical conditions. Avoid temperature gradients that create thermoelectric (Seebeck) effects in the thermocouple junctions formed from connecting dissimilar conductors. Cancel these thermally-generated potentials by assuring they are equal on both input terminals. Other layout and design considerations include:

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

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

## Input Voltage

The OPAx333 input common-mode voltage range extends 0.1 V beyond the supply rails. The OPAx333 is designed to cover the full range without the troublesome transition region found in some other rail-to-rail amplifiers.

## Device Functional Modes

The OPAx333 device has a single functional mode. The device is powered on as long as the power supply voltage is between 1.8 V (±0.9 V) and 5.5 V (±2.75 V).

# Application and Implementation

## Application Information

The OPAx333 family is a unity-gain stable, precision operational amplifier with very low offset voltage drift; these devices are also free from output phase reversal. Applications with noisy or high-impedance power supplies require decoupling capacitors close to the device power-supply pins. In most cases, 0.1-µF capacitors are adequate.

# Typical Applications

## 1 Voltage Follower

As shown in Figure 15, the voltage gain is 1. With this circuit, the output voltage $V_{OUT}$ is configured to be equal to the input voltage $V_{IN}$. Due to the high input impedance and low output impedance, the circuit can also stabilize the output voltage, the output voltage expression is

$$V_{OUT}=V_{IN} \quad (1)$$

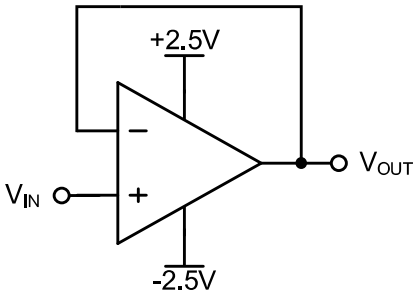



**Figure 15. Voltage Follower**

## 2 Inverting Proportional Amplifier

As shown in Figure 16, for a reverse-phase proportional amplifier, the input voltage $V_{IN}$ is amplified by a voltage gain that depends on the ratio of R1 to R2. The output voltage $V_{OUT}$ is inversely with the input voltage $V_{IN}$. The input impedance of the circuit is equal to R1, and the output voltage expression is

$$V_{OUT}=-\frac{R2}{R1}V_{IN} \quad (2)$$

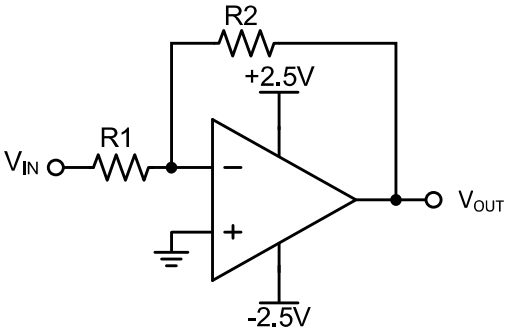



**Figure 16. Inverting Proportional Amplifier**

### 3 Noninverting Proportional Amplifier

As shown in Figure 17, for a noninverting amplifier, the input voltage $V_{IN}$ is amplified by a voltage gain that depends on the ratio of R1 to R2. The output voltage $V_{OUT}$ is in phase with the input voltage $V_{IN}$. In fact, this circuit has a high input impedance because its input side is the same as the input side of the operational amplifier. The output voltage expression is

(3)

$$V_{OUT}=(1+\frac{R2}{R1})V_{IN}$$

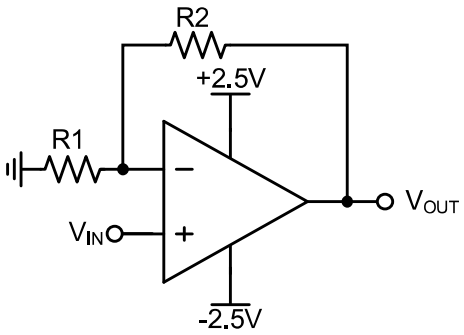
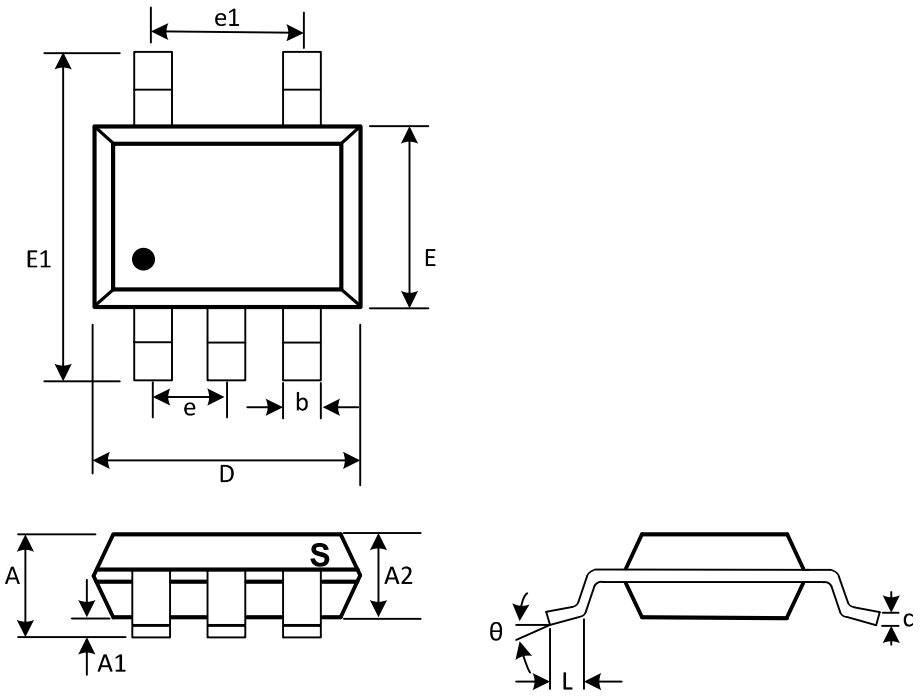



**Figure 17. Noninverting Proportional Amplifier**

## PACKAGE DESCRIPTION

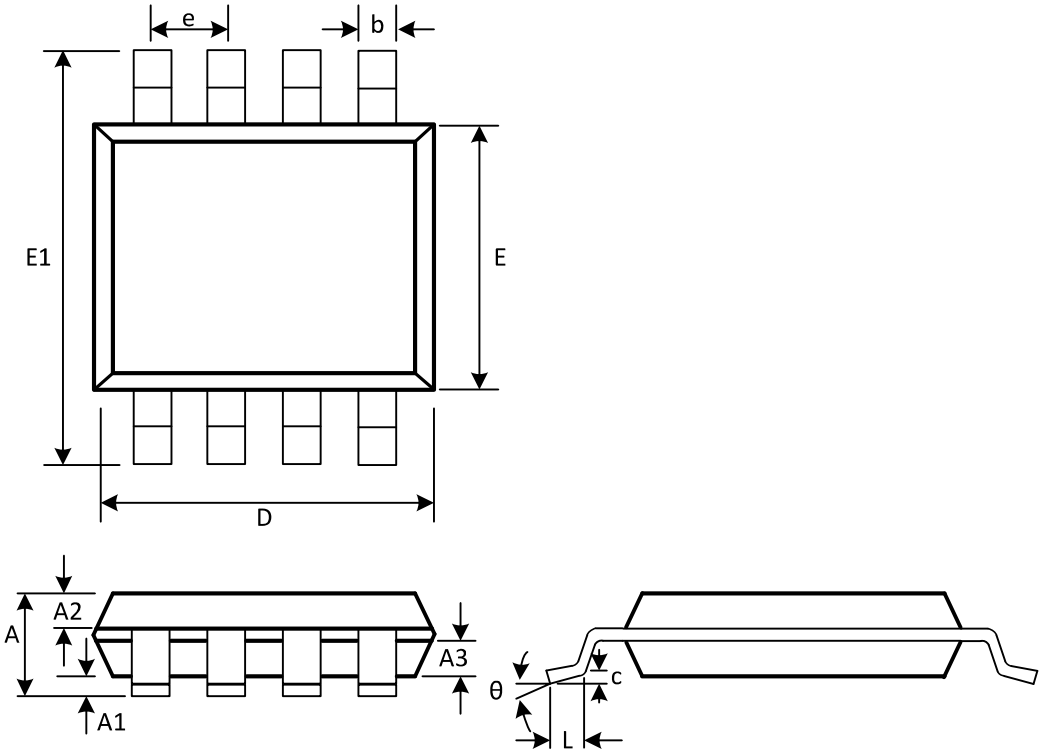
**SOT23-5**




(Unit: mm)

| Symbol | Min | Max |
|---|---|---|
| A | 1.05 | 1.25 |
| A1 | 0 | 0.1 |
| A2 | 1.05 | 1.15 |
| b | 0.3 | 0.5 |
| c | 0.1 | 0.2 |
| D | 2.82 | 3.02 |
| e | 0.95(BSC) | |
| e1 | 1.9(BSC) | |
| E | 1.5 | 1.7 |
| E1 | 2.65 | 2.95 |
| L | 0.3 | 0.6 |
| θ | 0° | 8° |

**SOP-8**




(Unit: mm)

| Symbol | Min | Max |
|---|---|---|
| A | 1.300 | 1.600 |
| A1 | 0.050 | 0.200 |
| A2 | 0.550 | 0.650 |
| A3 | 0.550 | 0.650 |
| b | 0.356 | 0.456 |
| c | 0.203 | 0.233 |
| D | 4.800 | 5.000 |
| e | 1.270(BSC) | |
| E | 3.800 | 4.000 |
| E1 | 5.800 | 6.200 |
| L | 0.400 | 0.800 |
| θ | 0° | 8° |