

# 36V, Precision Low-Noise Instrumentation Amplifier

## Features

- Low Offset Voltage: 50μV (Max.)
- Low Drift: 0.2μV/°C
- Low Input Bias Current: 2nA (Max.)
- Gain Bandwidth Product: 1.5MHz
- Slew Rate: 1.0V/μs
- Wide Supply Range: ±2.25V ~ ±18V
- Low Quiescent Current: 1.0mA
- Unity Gain Stable
- Input Over-Voltage Protection
- Extended Temperature Ranges  
From -40°C to +125°C
- Available as SOP8/MSOP8/DIP8

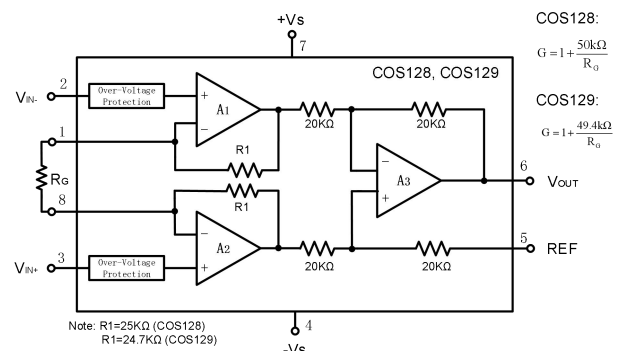
## Applications

- Medical Instrumentation
- RTD Sensor Amplifier
- Data Acquisition
- Thermocouple Amplifier
- Bridge Amplifier

## General Description

COS128 and COS129 are low-power, general purpose instrumentation amplifiers offering excellent accuracy. The versatile 3-op amp design and small size make these amplifiers ideal for a wide range of applications. A single external resistor sets any gain from 1 to 10,000.

COS128 and COS129 are laser-trimmed for very low offset voltage (50μV), drift (0.2μV/°C) and high common mode rejection. They operate with power supplies as low as ±2.25. The quiescent current is only 1.0mA, ideal for battery-operated systems. COS128/129 are available in 8-pin plastic SOP8, DIP8 and MSOP8 packages, specified for the -40 °C to +125 °C temperature range.

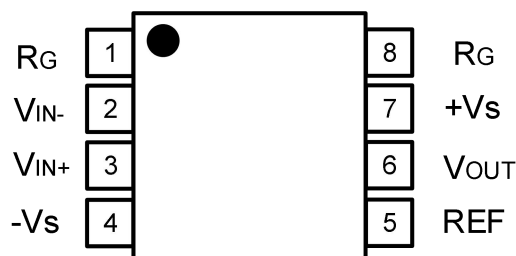


Block Diagram

Rev1.3  
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## 1. Pin Configuration and Functions



### Pin Functions

| Pin | Name      | I/O | Description                                                                        |
|-----|-----------|-----|------------------------------------------------------------------------------------|
| 1,8 | $R_G$     | -   | Gain setting pin. For gains greater than 1, place a gain resistor between pin1 & 8 |
| 2   | $V_{IN-}$ | I   | Negative input                                                                     |
| 3   | $V_{IN+}$ | I   | Positive input                                                                     |
| 4   | $-V_S$    | P   | Negative supply                                                                    |
| 5   | REF       | I   | Reference input. This Pin must be driven by low impedance or connected to ground   |
| 6   | $V_{OUT}$ | O   | Output                                                                             |
| 7   | $+V_S$    | P   | Positive supply                                                                    |

## 2. Product Specification

### 2.1 Absolute Maximum Ratings <sup>(1,2)</sup>

| Parameter                                      | Rating           | Units              |
|------------------------------------------------|------------------|--------------------|
| Power Supply: $+V_S$ to $-V_S$                 | 36               | V                  |
| Differential Input Voltage Range               | $\pm 36$         | V                  |
| Common Mode Input voltage Range <sup>(2)</sup> | $-V_S$ to $+V_S$ | V                  |
| Output Current                                 | 50               | mA                 |
| Storage Temperature Range                      | -65 to 150       | $^{\circ}\text{C}$ |
| Junction Temperature                           | 150              | $^{\circ}\text{C}$ |
| Operating Temperature Range                    | -40 to 125       | $^{\circ}\text{C}$ |
| ESD Susceptibility, HBM                        | 2000             | V                  |

(1) Stresses exceeding the absolute maximum ratings may damage the device. The device may not function or be operable above the recommended operating conditions and stressing the parts to these levels is not recommended. In addition, extended exposure to stresses above the recommended operating conditions may affect device reliability. The absolute maximum ratings are stress ratings only.

(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.

## 2.2 Thermal Data

| Parameter                  | Rating                                 | Unit |
|----------------------------|----------------------------------------|------|
| Package Thermal Resistance | 206 (MSOP8)<br>155 (SOP8)<br>46 (DIP8) | °C/W |

## 2.3 Recommended Operating Conditions

| Parameter                       | Rating                       | Unit |
|---------------------------------|------------------------------|------|
| DC Supply Voltage               | $\pm 2.5V \sim \pm 18V$      | V    |
| Input common-mode voltage range | $-V_S + 1.9 \sim +V_S - 1.2$ | V    |
| Operating ambient temperature   | -40 to +125                  | °C   |

## 2.4 Electrical Characteristics

( $+V_S = +15V$ ,  $-V_S = -15V$ ,  $T_A = +25^\circ C$ ,  $R_L = 10k\Omega$ , unless otherwise noted)

| Parameter                    | Symbol                   | Conditions                            | Min          | Typ       | Max          | Unit             |
|------------------------------|--------------------------|---------------------------------------|--------------|-----------|--------------|------------------|
| <b>Input Characteristics</b> |                          |                                       |              |           |              |                  |
| Input Offset Voltage         | $V_{OS}$                 | COS128U/129U                          |              | $\pm 10$  | $\pm 50$     | $\mu V$          |
|                              |                          | COS128UA/129UA                        |              | $\pm 25$  | $\pm 125$    | $\mu V$          |
|                              |                          | COS128C/129C                          |              | $\pm 50$  | $\pm 250$    | $\mu V$          |
| Input Offset Voltage Drift   | $\Delta V_{OS}/\Delta T$ | -40 to 125°C                          |              | 0.2       | 0.7          | $\mu V/^\circ C$ |
| Input Bias Current           | $I_B$                    |                                       |              | $\pm 0.5$ | $\pm 2$      | nA               |
| Input Offset Current         | $I_{OS}$                 |                                       |              | $\pm 0.2$ | $\pm 1$      | nA               |
| Common-Mode Voltage Range    | $V_{CM}$                 |                                       | $-V_S + 1.9$ |           | $+V_S - 1.2$ | V                |
| Common-Mode Rejection Ratio  | CMRR                     |                                       | 120          | 125       |              | dB               |
| Open-Loop Voltage Gain       | AOL                      | $R_L \geq 2k\Omega$ , $V_O = \pm 10V$ | 100          | 120       |              | dB               |

| <b>Output Characteristics</b> |           |                                                 |            |          |            |                        |
|-------------------------------|-----------|-------------------------------------------------|------------|----------|------------|------------------------|
| Output Voltage High           | $V_{OH}$  |                                                 |            |          | $+V_S-1.1$ | V                      |
| Output Voltage Low            | $V_{OL}$  |                                                 | $-V_S+1.1$ |          |            | V                      |
| Output Current                | $I_{OUT}$ | $V_{DROPOUT} < 1.2\text{ V}$                    |            | $\pm 10$ |            | mA                     |
| Short-Circuit Current         | $I_{SC}$  |                                                 |            | $\pm 24$ |            | mA                     |
| <b>Power Supply</b>           |           |                                                 |            |          |            |                        |
| Operating Voltage Range       |           |                                                 | $\pm 2.25$ |          | $\pm 18$   | V                      |
| Power Supply Rejection Ratio  | PSRR      |                                                 | 110        | 120      |            | dB                     |
| Quiescent Current / Amplifier | $I_Q$     |                                                 |            | 1.0      | 1.3        | mA                     |
| <b>Dynamic Performance</b>    |           |                                                 |            |          |            |                        |
| Gain Bandwidth Product        | GBWP      | $C_L=100\text{pF}, R_L=10\text{k}\Omega$        |            | 1.5      |            | MHz                    |
| Slew Rate                     | SR        | $C_L=100\text{pF}, R_L=10\text{k}\Omega, A_v=1$ |            | 1.0      |            | V/ $\mu\text{s}$       |
| <b>Noise Performance</b>      |           |                                                 |            |          |            |                        |
| Voltage Noise Density         | $e_n$     | $f=1\text{kHz}$                                 |            | 8.0      |            | nV/ $\sqrt{\text{Hz}}$ |

## 3.0 Application Notes

### 3.1 Overview

The COS128/129 instrumentation amplifiers are differential amplifier that has been outfitted with input protection circuit and input buffer amplifiers, which eliminate the need for input impedance matching and make the amplifier particularly suitable for use in measurement and test equipment. Additional characteristics of the COS128/129 include a very low DC offset, low drift, low noise, very high open-loop gain, very high common-mode rejection ratio, and very high input impedance.

### 3.2 Application Information

COS128/129 measure small differential voltage with high common-mode voltage developed between the noninverting and inverting input. The ability to set the reference pin to adjust the functionality of the output signal offers additional flexibility that is practical for multiple configurations.

Figure 3.1 shows the basic connections required for operation of the COS128/129. Applications with noisy or high impedance power supplies may require decoupling capacitors close to the device pins as shown. This must be a low-impedance connection to assure good common-mode rejection. A resistance of 8Ω in series with the REF pin will cause a typical device to degrade to approximately 80dB CMR.

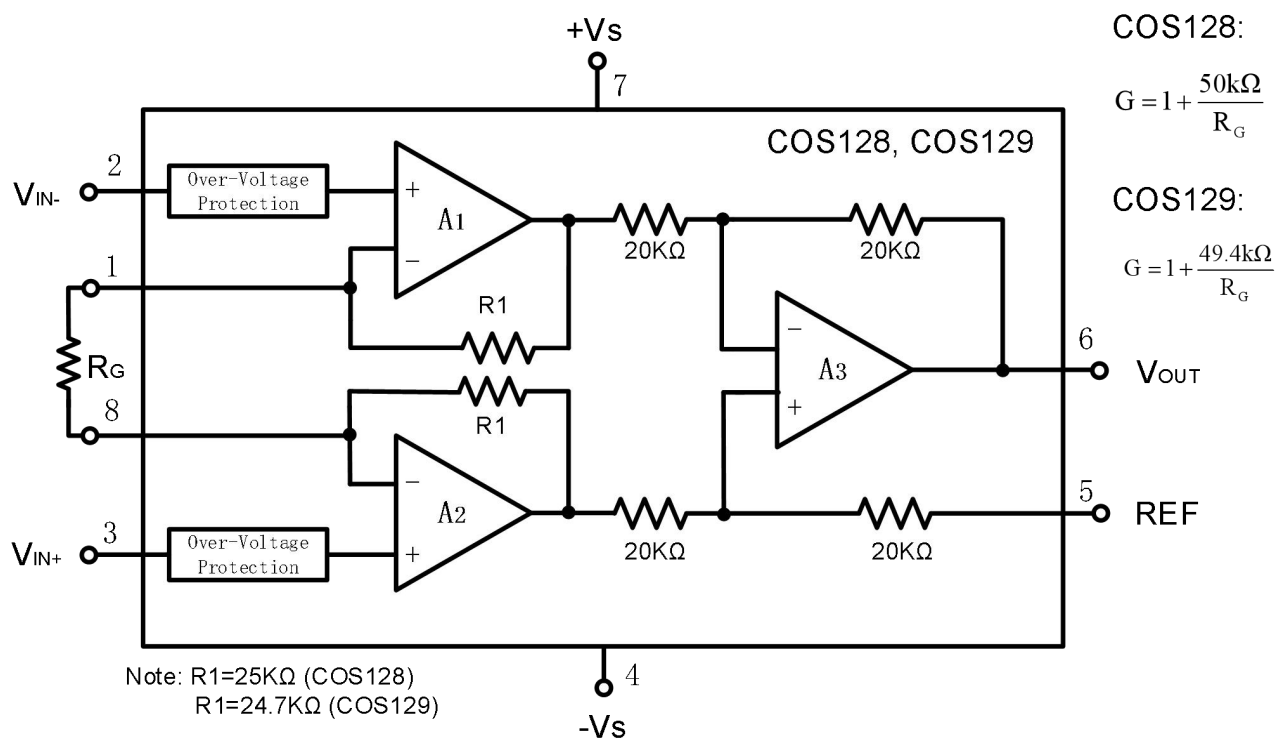


Figure 3.1 Functional Block Diagram

Gain is set by connecting a single external resistor,  $R_G$ , between pins 1 and 8:

$$\begin{aligned}
 G &= 1 + 2 \cdot R1 / R_G \\
 &= 1 + 50 \text{ k}\Omega / R_G && \text{for COS128} \\
 &= 1 + 49.4 \text{ k}\Omega / R_G && \text{for COS129}
 \end{aligned}$$

Commonly used gains and resistor values are shown in Table 3.1.

| <b>Desired Gain<br/>G(V/V)</b> | <b>COS128: <math>G=1 + 50 \text{ k}\Omega/R_G</math></b> |                                                | <b>COS129: <math>G=1 + 49.4 \text{ k}\Omega/R_G</math></b> |                                                |
|--------------------------------|----------------------------------------------------------|------------------------------------------------|------------------------------------------------------------|------------------------------------------------|
|                                | <b><math>R_G(\Omega)</math></b>                          | <b>Nearest<br/>1% <math>R_G(\Omega)</math></b> | <b><math>R_G(\Omega)</math></b>                            | <b>Nearest<br/>1% <math>R_G(\Omega)</math></b> |
| 1                              | NC                                                       | NC                                             | NC                                                         | NC                                             |
| 2                              | 50k                                                      | 49.9k                                          | 49.4k                                                      | 49.9k                                          |
| 5                              | 12.5k                                                    | 12.4k                                          | 12.35k                                                     | 12.4k                                          |
| 10                             | 5.556k                                                   | 5.62k                                          | 5489                                                       | 5.49k                                          |
| 20                             | 2.632k                                                   | 2.61k                                          | 2600                                                       | 2.61k                                          |
| 50                             | 1.02k                                                    | 1.02k                                          | 1008                                                       | 1k                                             |
| 100                            | 505.1                                                    | 511                                            | 499                                                        | 499                                            |
| 200                            | 251.3                                                    | 249                                            | 248                                                        | 249                                            |
| 500                            | 100.2                                                    | 100                                            | 99                                                         | 100                                            |
| 1000                           | 50.05                                                    | 49.9                                           | 49.5                                                       | 49.9                                           |
| 2000                           | 25.01                                                    | 24.9                                           | 24.7                                                       | 24.9                                           |
| 5000                           | 10.00                                                    | 10                                             | 9.88                                                       | 9.76                                           |
| 10000                          | 5.001                                                    | 4.99                                           | 4.94                                                       | 4.87                                           |

Table 3.1 Required Values of Gain Resistors

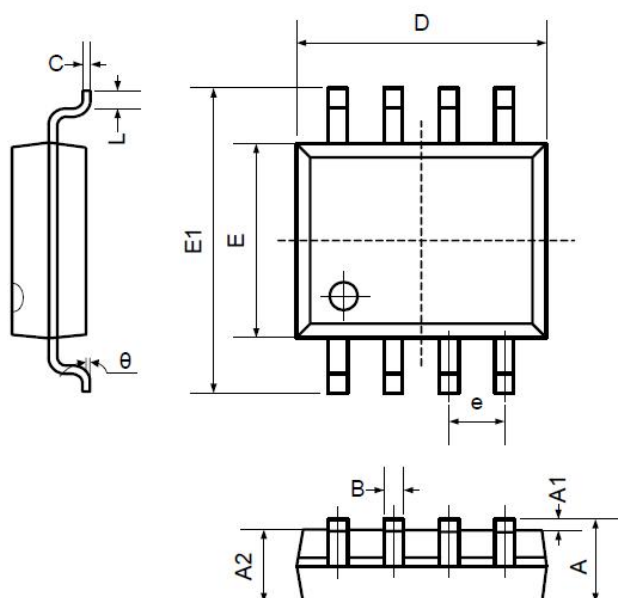
### 3.3 Power-Supply Bypassing and Layout

The COS128/129 operate from a single +4.5V to +36V supply or dual  $\pm 2.25\text{V}$  to  $\pm 18\text{V}$  supplies. For single-supply operation, bypass the power supply +Vs with a  $0.1\mu\text{F}$  ceramic capacitor which should be placed close to the +Vs pin. For dual-supply operation, both the +Vs and the -Vs supplies should be bypassed to ground with separate  $0.1\mu\text{F}$  ceramic capacitors.  $2.2\mu\text{F}$  tantalum capacitor can be added for better performance.

The length of the current path is directly proportional to the magnitude of parasitic inductances and thus the high frequency impedance of the path. High speed currents in an inductive ground return create an unwanted voltage noise. Broad ground plane areas will reduce the parasitic inductance. Thus a ground plane layer is important for high speed circuit design.

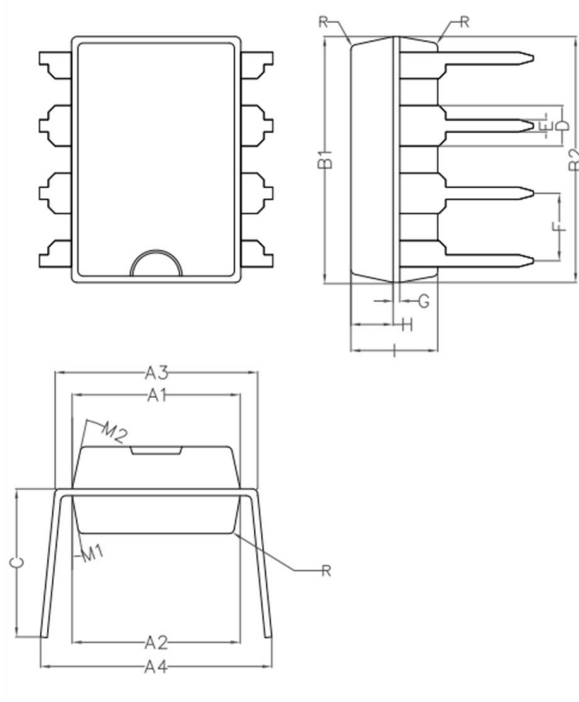
## 4. Package Information

### 4.1 SOP8 (Package Outline Dimensions)



| Symbol | Dimensions<br>In Millimeters |       | Dimensions<br>In 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      | 0.190                        | 0.250 | 0.007                   | 0.010 |
| D      | 4.780                        | 5.000 | 0.188                   | 0.197 |
| E      | 3.800                        | 4.000 | 0.150                   | 0.157 |
| E1     | 5.800                        | 6.300 | 0.228                   | 0.248 |
| e      | 1.270TYP                     |       | 0.050TYP                |       |
| L      | 0.400                        | 1.270 | 0.016                   | 0.050 |
| θ      | 0°                           | 8°    | 0°                      | 8°    |

### 4.2 DIP8 (Package Outline Dimensions)



| Symbol | Min  | Non  | Max  |
|--------|------|------|------|
| A1     | 6.28 | 6.33 | 6.38 |
| A2     | 6.33 | 6.38 | 6.43 |
| A3     | 7.52 | 7.62 | 7.72 |
| A4     | 7.80 | 8.40 | 9.00 |
| B1     | 9.15 | 9.20 | 9.25 |
| B2     | 9.20 | 9.25 | 9.30 |
| C      |      | 5.57 |      |
| D      |      | 1.52 |      |
| E      | 0.43 | 0.45 | 0.47 |
| F      |      | 2.54 |      |
| G      |      | 0.25 |      |
| H      | 1.54 | 1.59 | 1.64 |
| I      | 3.22 | 3.27 | 3.32 |
| R      |      | 0.20 |      |
| M1     | 9°   | 10°  | 11°  |
| M2     | 11°  | 12°  | 13°  |

## 5. Ordering Information

| Model  | Order Number | Package | Package Option      | Marking Information |
|--------|--------------|---------|---------------------|---------------------|
| COS128 | COS128U      | SOP-8   | Tape and Reel, 4000 | COS128              |
|        | COS128UA     | SOP-8   | Tape and Reel, 4000 | COS128              |
|        | COS128C      | SOP-8   | Tape and Reel, 4000 | COS128              |
|        | COS128P      | DIP-8   | Tube, 50            | COS128P             |
|        | COS128PA     | DIP-8   | Tube, 50            | COS128PA            |
| COS129 | COS129U      | SOP-8   | Tape and Reel, 4000 | COS129              |
|        | COS129UA     | SOP-8   | Tape and Reel, 4000 | COS129              |
|        | COS129C      | SOP-8   | Tape and Reel, 4000 | COS129              |
|        | COS129P      | DIP-8   | Tube, 50            | COS129P             |
|        | COS129PA     | DIP-8   | Tube, 50            | COS129PA            |