

# 36V, Precision Low-Noise Instrumentation Amplifiers

## 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

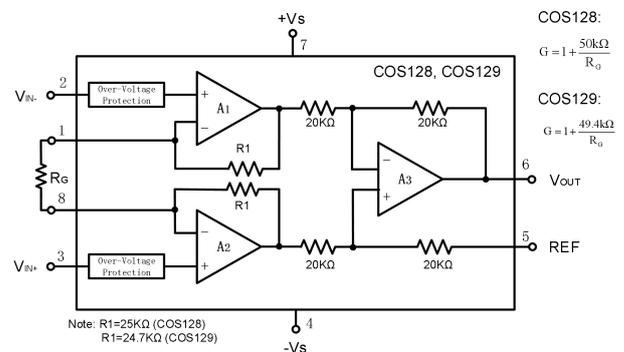
## Applications

- 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.



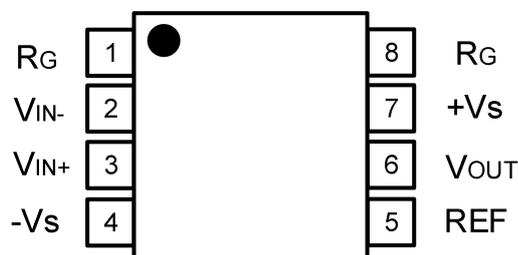
Block Diagram

Rev1.4

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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, $R_{\theta JA}$ (Junction-to-ambient)	206 (MSOP8) 155 (SOP8) 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	1.0	$\mu V/^\circ C$
Input Bias Current	$I_B$			$\pm 2$	$\pm 10$	nA
Input Offset Current	$I_{OS}$			$\pm 1$	$\pm 10$	nA
Common-Mode Voltage Range	$V_{CM}$		$-V_S+1.9$		$+V_S-1.2$	V
Common-Mode Rejection Ratio	CMRR	G=100		125		dB

<b>Gain Characteristics</b>						
Gain Range	GR		1		10000	V/V
Gain Equation		COS128	$1 + 50 \text{ k}\Omega/R_G$			V/V
		COS129	$1 + 49.4 \text{ k}\Omega/R_G$			
Gain Error	GE				$\pm 2$	%
<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			120		dB
Quiescent Current / Amplifier	$I_Q$			1.0	1.5	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/ $\mu$ 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.

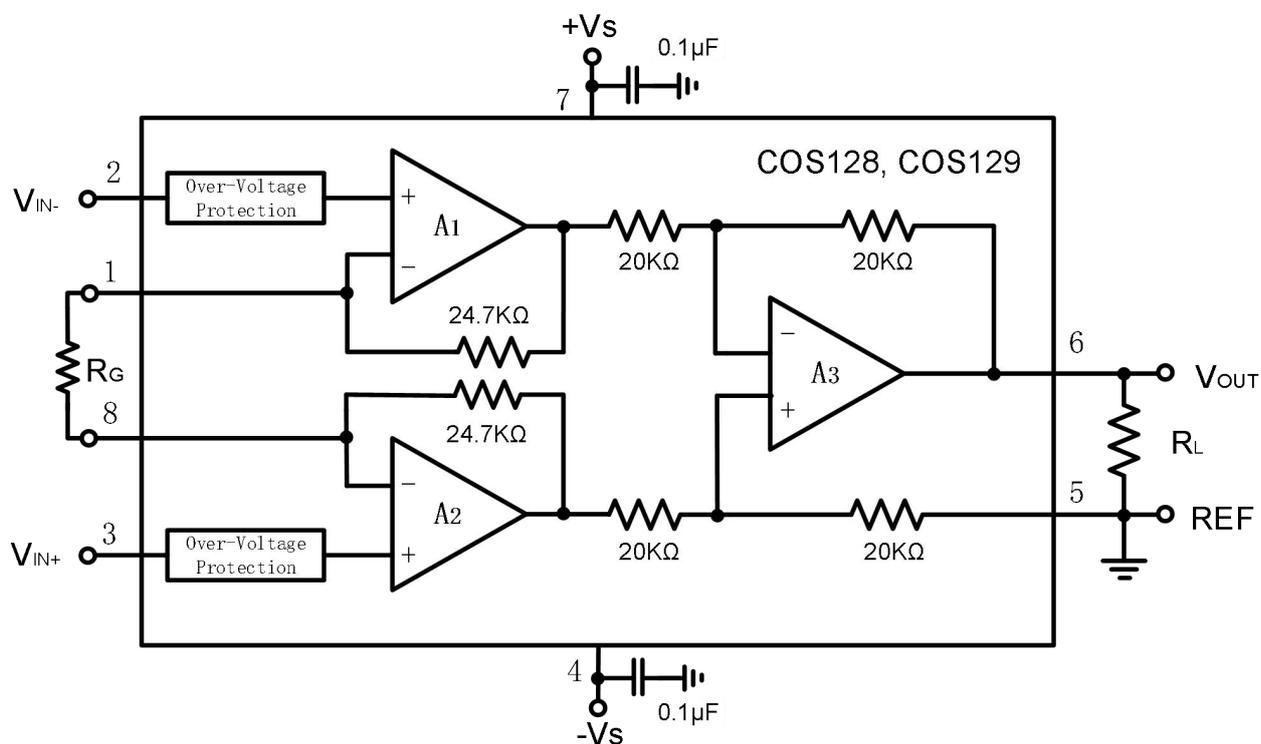


Figure 3.1 Functional Block Diagram and Basic Connections

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. REF pin 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. The voltage gain is set by connecting a single external resistor, R<sub>G</sub>, between pins 1 and 8:

$$\begin{aligned}
 G &= 1 + 2 \cdot R_1 / R_G \\
 &= 1 + 50 \text{ k}\Omega / R_G && \text{for COS128} \\
 &= 1 + 49.4 \text{ k}\Omega / R_G && \text{for COS129}
 \end{aligned}$$

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

Table 3.1 Required Values of Gain Resistors

Desired Gain G(V/V)	COS128: G=1 + 50 kΩ/R <sub>G</sub>		COS129: G=1 + 49.4 kΩ/R <sub>G</sub>	
	R <sub>G</sub> (Ω)	Nearest 1% R <sub>G</sub> (Ω)	R <sub>G</sub> (Ω)	Nearest 1% R <sub>G</sub> (Ω)
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

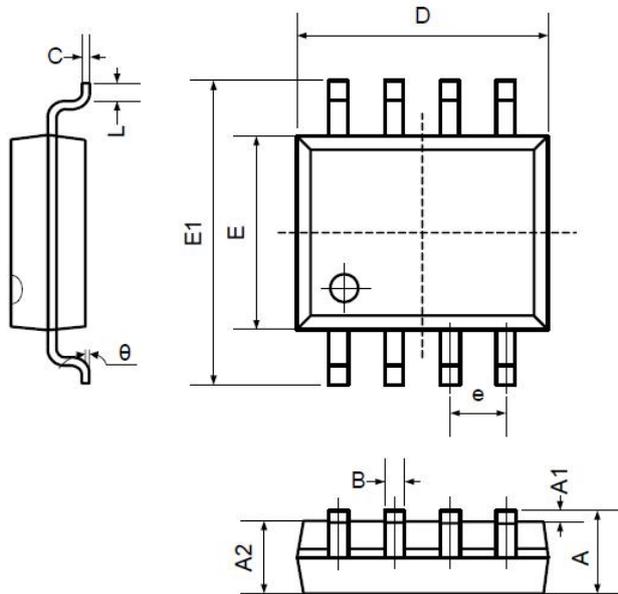
### 3.3 Power-Supply Bypassing and Layout

The COS128/129 operate from a single +4.5V to +36V supply or dual ±2.25V to ±18V supplies. For single-supply operation, bypass the power supply +Vs with a 0.1μF 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 0.1μF ceramic capacitors. 2.2μF 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.

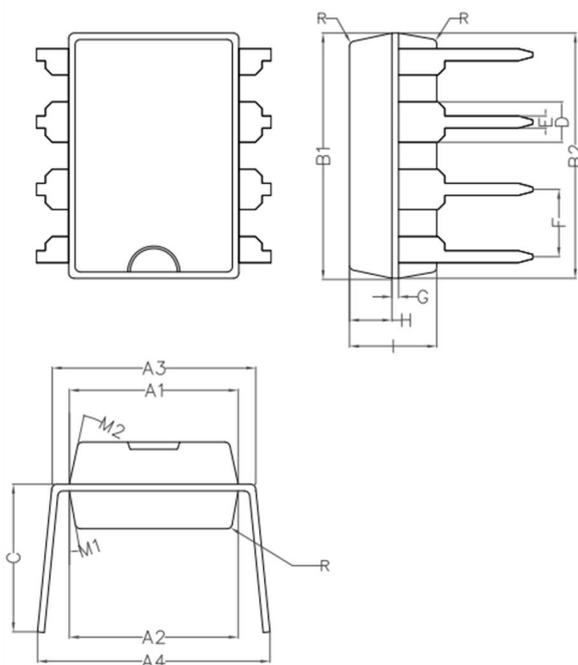
## 4. Package Information

### 4.1 SOP8 (Package Outline Dimensions)



Symbol	Dimensions In Millimeters		Dimensions 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. Package and 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

## 6. Related Parts

Part Number	Description
COS6042	24kHz, 0.5 $\mu$ A, Nano-Power Op Amps, 1.4V to 5.5V Supply
COS8042	160MHz, 5.5mA, High Speed Op Amps, 3V to 12V Supply
COS2172	10MHz, 1.2mA, RRIO Op Amps, 4.5 to 40V Supply
COS2333	350kHz, 18 $\mu$ A, Precision Op Amps, 1.8 to 5.5V Supply, Zero Drift, Vos<10 $\mu$ V
COS8552	1.5MHz, 55 $\mu$ A, Precision Op Amps, 1.8 to 5.5V Supply, Zero Drift, Vos<10 $\mu$ V
COS2388	9MHz, 570 $\mu$ A, Precision Op Amps, 1.8 to 5.5V Supply, Zero Drift, Vos<10 $\mu$ V
COS2227	10MHz, 1.3mA, Precision Op Amps, 4.5 to 36V Supply, Vos<50 $\mu$ V
COS2182	5MHz, 580 $\mu$ A, RRIO Precision Op Amps, 4.5 to 40V Supply, Vos<50 $\mu$ V
COS620	1.5MHz, 1.3mA, Instrumentation Amps, 4.5 to 36V Supply, Vos<50 $\mu$ V
COSINA333	150kHz, 65 $\mu$ A, Instrumentation Amps, 1.8 to 5.5V Supply, Vos<25 $\mu$ V