

## High-Side Voltage Output, Zero-Drift Current Sense Amplifiers

### Features

- High-Side Measurement
- Wide Common-Mode Range:  
-0.3V to +25V
- Wide Power Supply Range:  
-2.7V to +25V
- Low Offset Voltage:  $\pm 50\mu\text{V}$  max
- Low Offset Drift:  $0.5\mu\text{V}/^\circ\text{C}$
- Low Gain Error: 2% max
- Low Gain Error Drift: 10 ppm/ $^\circ\text{C}$  max
- Rail-to-Rail Output
- Low Quiescent Current: 50 $\mu\text{A}$  typical
- Industrial Operation Range:  
-40 $^\circ\text{C}$  to 125 $^\circ\text{C}$
- Small Packaging: SOT23-5/MSOP8
- Choice of Gains:
  - 20V/V (COSINA180A1)
  - 50V/V (COSINA180A2)
  - 100V/V (COSINA180A3)
  - 200V/V (COSINA180A4)

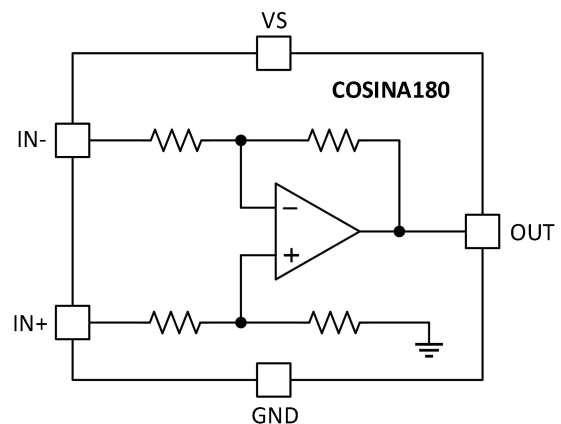
### Applications

- Current Sensing
- Battery Charging and Discharging
- Overcurrent Protection
- Motor Control

### General Description

The COSINA180 (single) and COSINA2180 (dual) are voltage output, current sense amplifiers (also called current shunt monitors) which can measure voltage across shunts at common-mode voltages from -0.3V to +25V, independent of supply voltage. The low offset of the zero-drift architecture enables current sensing across the shunt with maximum voltage drop as low as 10mV full-scale.

These devices can operate from a single +3.0V to +25 V power supply, drawing a typical 50 $\mu\text{A}$  of supply current, and are specified over the extended operating temperature range (-40 $^\circ\text{C}$  to +125 $^\circ\text{C}$ ). The COSINAx180 family are commonly used for over-current protection, precision-current measurement for system optimization or in closed-loop feedback circuits.



Simplified Schematic

Rev1.0  
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## 1. Pin Configuration and Functions

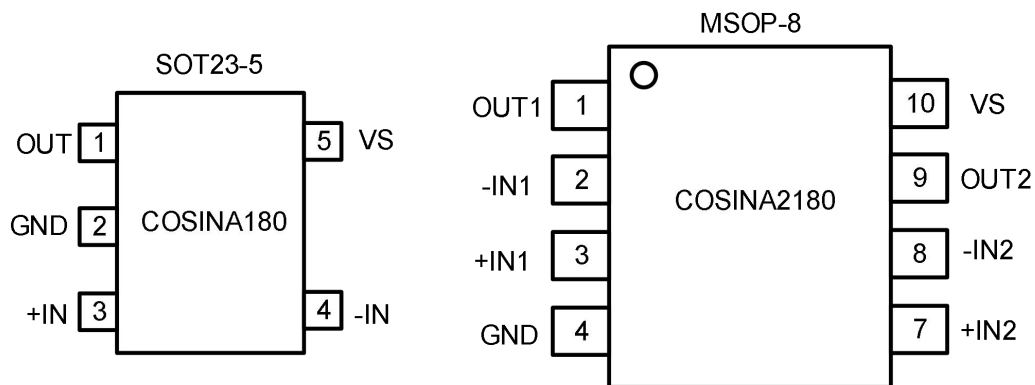


Figure 1 Pin Diagram

### Pin Description

Pin	Name	I/O	Description
1	OUT	Analog output	Output voltage
2	GND	Analog	Ground
3	+IN	Analog input	Connect to supply side of shunt resistor
4	-IN	Analog input	Connect to load side of shunt resistor
5	VS	Analog	Power supply, 2.7V to +25V

## 2. Ordering Information

Channel	Gain (V/V)	Model	Order Number	Package	Package Option	Marking
1	20	COSINA180A1	COSINA180A1	SOT23-5	Tape and Reel, 3000	C180A1
	50	COSINA180A2	COSINA180A2	SOT23-5	Tape and Reel, 3000	C180A2
	100	COSINA180A3	COSINA180A3	SOT23-5	Tape and Reel, 3000	C180A3
	200	COSINA180A4	COSINA2180A4	SOT23-5	Tape and Reel, 3000	C180A4
2	20	COSINA2180A1	COSINA2180A1	MSOP-8	Tape and Reel, 3000	COS2180A1
	50	COSINA2180A2	COSINA2180A2	MSOP-8	Tape and Reel, 3000	COS2180A2
	100	COSINA2180A3	COSINA2180A3	MSOP-8	Tape and Reel, 3000	COS2180A3
	200	COSINA2180A4	COSINA2180A4	MSOP-8	Tape and Reel, 3000	COS2180A4

### 3. Product Specification

#### 3.1 Absolute Maximum Ratings <sup>(1)</sup>

Parameter	Min	Max	Unit
Supply Voltage, $V_s$		+26	V
Differential Analog Inputs, $(V_{IN+}) - (V_{IN-})$	-26	+26	V
Common Mode Analog Inputs, $V_{IN+}, V_{IN-}$	GND-0.3	+26	V
Output Voltage, $V_{OUT}$	GND-0.3	$V_s+0.3$	V
Maximum Output Current, $I_{OUT}$		8	mA
Maximum Junction Temperature, $T_{J(max)}$		+150	V
Storage temperature, $T_{STG}$	-55	+150	°C

(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.

#### 3.2 Thermal Data

Parameter	Rating	Unit
Package Thermal Resistance, $R_{\theta JA}$ (Junction-to-Ambient)	190 (SOT23-5) 206 (MSOP8)	°C/W

#### 3.3 Recommended Operating Conditions

Parameter	Min.	Typ.	Max.	Unit
Common-mode Input Voltage, $V_{CM}$	-0.3	12	25	V
Supply Voltage, $V_s$	2.7	5	25	V
Operating Ambient Temperature, $T_A$	-40		+125	°C

### 3.4 Electrical Characteristics

(Typical values are tested at  $T_A=25^\circ\text{C}$ ,  $V_S=5\text{V}$ ,  $V_{IN+}=12\text{V}$ , and  $V_{SENSE}=V_{IN+} - V_{IN-}$ , unless otherwise noted)

Parameter	Symbol	Conditions	Min.	Typ.	Max.	Unit
<b>INPUT</b>						
Common-mode Input Range	$V_{CM}$	$V_{SENSE}=10\text{mV}$ $T_A = -40^\circ\text{C to } +125^\circ\text{C}$	-0.3		25	V
Common-mode Rejection Ratio	CMRR	$V_{IN+} = 0\text{V to } +25\text{V}$ , $V_{SENSE} = 0\text{mV}$	80	100		dB
Offset Voltage, RTI (input referred)	$V_{OS}$	$V_{SENSE} = 0\text{mV}$		$\pm 5$	$\pm 50$	$\mu\text{V}$
Vos Temperature Drift	$\Delta V_{OS}/\Delta T$	$V_{SENSE} = 0\text{mV}$ $T_A = -40^\circ\text{C to } +125^\circ\text{C}$		0.1	0.5	$\mu\text{V}/^\circ\text{C}$
Vos vs Power Supply Ratio	PSRR	$V_S = 3.0\text{V to } +25\text{V}$ , $V_{SENSE}=10\text{mV}$		$\pm 0.2$	$\pm 20$	$\mu\text{V/V}$
Input Bias Current	$I_{IB}$	$V_{SENSE} = 0\text{mV}$		12	30	$\mu\text{A}$
Input Offset Current	$I_{IO}$	$V_{SENSE} = 0\text{mV}$		$\pm 0.1$		$\mu\text{A}$
<b>OUTPUT</b>						
Gain	G	COSINA180A1		20		V/V
		COSINA180A2		50		
		COSINA180A3		100		
		COSINA180A4		200		
Gain Error	$E_G$	$V_{SENSE} = -5\text{mV to } 5\text{mV}$ $T_A = -40^\circ\text{C to } +125^\circ\text{C}$		$\pm 0.2$	$\pm 2$	%
Gain Error vs Temperature		$T_A = -40^\circ\text{C to } +125^\circ\text{C}$		3	20	ppm/ $^\circ\text{C}$
Non-linearity Error		$V_{SENSE} = -5\text{mV to } 5\text{mV}$		$\pm 0.01$		%
Maximum Capacitive Load	$C_L$	No sustained oscillation		0.5		nF
Swing to $V_S$ Power Supply Rail	$V_{OH}$	$R_{LOAD}=10\text{k}\Omega$ to GND $T_A = -40^\circ\text{C to } +125^\circ\text{C}$		$V_S-0.02$	$V_S-0.2$	V
Swing to GND	$V_{OL}$			$V_{GND}+0.002$	$V_{GND}+0.05$	V

FREQUENCY RESPONSE						
Bandwidth	BW	A1 device, C <sub>LOAD</sub> =10pF		67		kHz
		A2 device, C <sub>LOAD</sub> =10pF		42		
		A3 device, C <sub>LOAD</sub> =10pF		30		
		A4 device, C <sub>LOAD</sub> =10pF		14		
Slew Rate	SR			0.55		V/μs
NOISE						
Input Referred Voltage Noise	e <sub>n</sub>	f=1kHz		45		nV/ √Hz
POWER SUPPLY						
Operating Voltage Range	V <sub>s</sub>		2.7	-	25	V
Quiescent Current	I <sub>Q</sub>	COSINA180		50	100	μA
		COSINA2180		100	200	μA

## 4. Application Information

The COSINA180, COSINA2180 current-sense amplifiers provide the fully differential input necessary to get accurate shunt connections, while also providing a built-in gain network with precision difficult to obtain with external resistors. The COSINAx180 series of devices can be configured for both low-side and high-side current sensing. While at times the application requires low-side sensing, only high-side sensing can detect a short from the positive supply line to ground. Furthermore, high-side sensing avoids adding resistance to the ground path of the load being measured. The application below focus primarily on high-side current sensing.

Figure 2 shows the basic connections of the COSINA180. The device amplify the voltage developed across a current-sensing resistor as current flows through the resistor to the load or ground. When the input signal increases, the output voltage at the OUT pin increases. For the best measurement accuracy, connect the input pins (IN+ and IN-) as close as possible to the shunt resistor to minimize any resistance in series with the shunt resistor.

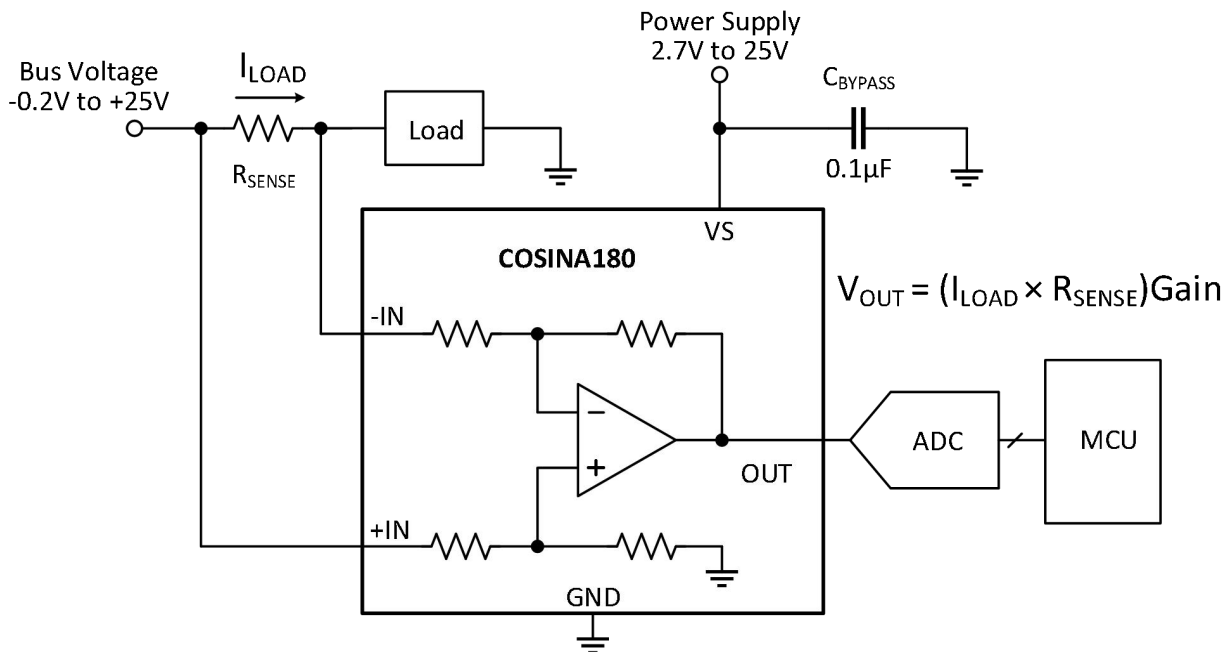


Figure 2 Typical Application Schematic

The desired accuracy of the current measurement determines the current-sensing resistor precision and value. The larger the resistor value, the more accurate the measurement possible, but a large resistor value also results in greater power loss. Therefore, using current-sense resistors larger than a few ohms is generally not recommended.

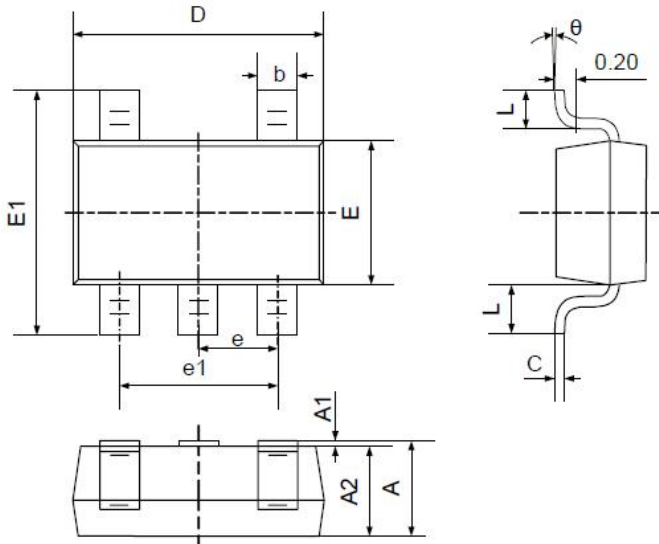
A typical non-zero-drift current shunt monitors typically require a full-scale range of 100 mV. The COSINAx180 zero-drift series gives equivalent accuracy at a full-scale range on the order of 10 mV. This accuracy reduces shunt dissipation by an order of magnitude with many additional benefits.

The input circuitry of the COSINAx180 can accurately measure beyond the power-supply voltage, V+. For example, the V+ power supply can be 5 V, whereas the load power-supply voltage can be as high as 25V. However, the output voltage range of the OUT pin is limited by the voltages on the power-supply pin. Note also that the COSINAx180 can withstand the full input signal range up to 25V at the input pins, regardless of whether the device has power applied or not.

A power-supply bypass capacitor of at least 0.1 µF is required for proper operation. Applications with noisy or high-impedance power supplies may require additional decoupling capacitors to reject power-supply noise. Connect bypass capacitors as close as possible to the device pins.

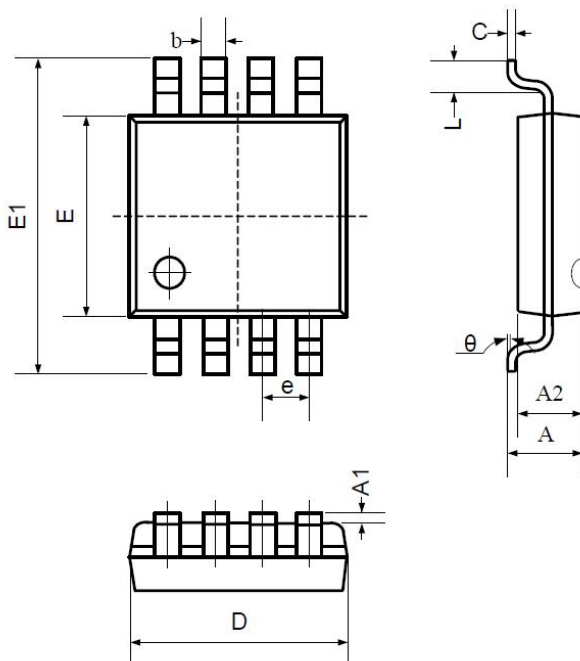
## 5. Package Information

### 5.1 SOT23-5 (Package Outline Dimensions)



Symbol	Dimensions In Millimeters		Dimensions In 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	0.400	0.012	0.016
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	0.950TYP		0.037TYP	
e1	1.800	2.000	0.071	0.079
L	0.700REF		0.028REF	
L1	0.300	0.600	0.012	0.024
$\theta$	0°	8°	0°	8°

### 5.2 MSOP8 (Package Outline Dimensions)



Symbol	Dimensions In Millimeters		Dimensions In Inches	
	Min	Max	Min	Max
A	0.800	1.200	0.031	0.047
A1	0.000	0.200	0.000	0.008
A2	0.760	0.970	0.030	0.038
b	0.30 TYP		0.012 TYP	
c	0.15 TYP		0.006 TYP	
D	2.900	3.100	0.114	0.122
e	0.65 TYP		0.026 TYP	
E	2.900	3.100	0.114	0.122
E1	4.700	5.100	0.185	0.201
L	0.410	0.650	0.016	0.026
$\theta$	0°	6°	0°	6°

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