High-Side Current Sense Amplifier

Features

- Unipolar High-Side Measurement
- Single Resistor Gain Setting
- Independent Supply and Input Common Mode Voltages
- Wide Common-Mode Range: 3.5V to 40V
- Wide Power Supply Range: 3.5V to 25V
- Low Offset Voltage: ±50 μV max
- Low Offset Drift: 0.005 μV/°C
- Low Quiescent Current: 35 μA typical
- Industrial Operation Range: –40°C to 125°C
- Small Packaging: SOT23-5

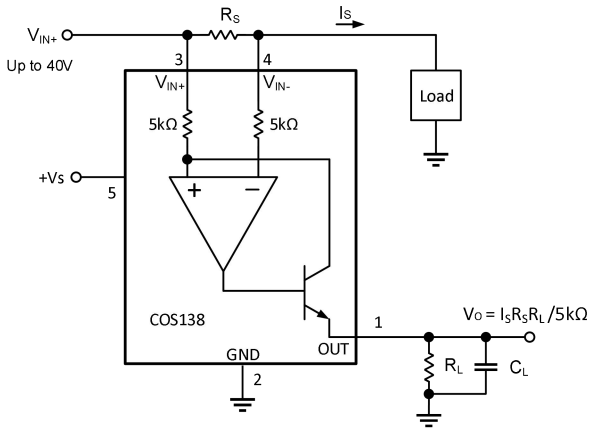
Applications

- Current Shunt Sensing
- Battery Charging and Discharging
- Over-current Protection
- Motor Control
- Power Management

General Description

The COSINA138 is a unipolar high-side current sense amplifier (also called current shunt monitor) which can measure voltage across shunts at common−mode voltages from 3.5V to 40V, 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.

The device can operate from a single 3.5V to 25V power supply, drawing a typical 35 μA of supply current, and are specified over the extended operating temperature range (–40°C to +125°C). The COSINA138 is commonly used for over-current protection, precision current measurement for system optimization or in closed-loop feedback circuits.



Simplified Schematic

1 Pin Configuration and Functions

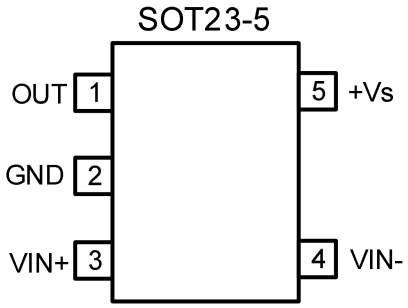


Figure 1 Pin Diagram

Pin Description

Pin	Name	I/O	Description
1	OUT	Analog Output	Current Output
2	GND	-	Ground
3	VIN+	Analog Input	Positive Input Voltage
4	VIN-	Analog Input	Negative Input Voltage
5	+VS	Analog	Power Supply, 3.5V to 25V

2 Product Specification

2.1 Absolute Maximum Ratings (1)

Parameter	Min	Max	Unit
Supply Voltage, Vs	-0.3	26	V
Differential Analog Inputs, $(V_{IN+}) - (V_{IN-})$	-26	2	V
Common Mode Analog Inputs, V_{IN+}, V_{IN-}	-0.3	41	V
Output Voltage, V_{OUT}	-0.3	26	V
Maximum Input Current into Any Pin, I_{IN}		10	mA
Maximum Junction Temperature, $T_{J(max)}$		+150	°C
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.

2.2 Thermal Data

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

2.3 Recommended Operating Conditions

Parameter	Min.	Typ.	Max.	Unit
Supply Voltage, +Vs	3.5	5	25	V
Full-scale Sense Voltage, $V_{SENSE} = (V_{IN+} - V_{IN-})$		50	500	mV
Common-mode Input Voltage, V_{CM}	3.5	12	40	V
Operating Ambient Temperature, T_A	-40	25	+125	°C

2.4 Electrical Characteristics

(Typical values are tested at T_A=25°C, +V_S=5V, V_{IN+}=12V, V_{SENSE}=V_{IN+} - V_{IN-}, and R_L=125kΩ, unless otherwise noted)

Parameter	Symbol	Conditions	Min.	Typ.	Max.	Unit
INPUT						
Common-mode Rejection Ratio	CMRR	V_{SENSE} = 50mV	70	100		dB
Offset Voltage (input referred)	V_{OS}	V_{SENSE} = 0mV		±5	±50	μV
Vos Temperature Drift	$\Delta V_{OS}/\Delta T$	V_{SENSE} = 0mV, T_A = -40°C to +125°C		0.1	0.5	μV/°C
Vos vs Power Supply Ratio	PSRR	V_{SENSE} = 50mV, V_S = 3.5V to +25V		±0.1	±10	μV/V
Input Bias Current	I_{IB}			2		μA

OUTPUT						
Transconductance	gm	V_{SENSE} = 10mV to 150mV T_A = -40°C to +125°C	195	200	205	μA/V
Transconductance Drift	Δgm/ΔT	T_A = -40°C to +125°C		10		nA/°C
Non-linearity Error	NLE	V_{SENSE} = 10mV to 150mV		±0.01	±0.1	%
Total Output Error	TOE	V_{SENSE} = 100mV		±0.5	±2	%
Output Impedance	Z_L			1||5		GΩ || pF
Swing to Power Supply Rail	V_{OH}	R_L=125kΩ to GND T_A = -40°C to +125°C		Vs-0.8	Vs-1.0	V
Swing to Common-mode Volt	V_{OCM}			V_{CM}-0.5	V_{CM}-0.8	V
FREQUENCY RESPONSE						
Bandwidth	BW	R_L=5kΩ		300		kHz
		R_L=125kΩ		90		
Turn-on Time	ts			100		μs
NOISE						
Output Current Noise Density	i_n			20		pA/√Hz
POWER SUPPLY						
Operating Voltage Range	Vs		3.5	-	25	V
Quiescent Current	I_Q	V_{SENSE} = 0V, I_O = 0 mA,		35	80	μA
		T_A = -40°C to +125°C			100	μA

3 Application Information

Figure 2 shows the basic connections of the COSINA138. The device converts a differential input voltage to a current output. This current is converted back to a voltage with an external load resistor that sets any gain from 1 to over 100. The complete transfer function for the current measurement amplifier in this application is:

$$\text{Voltage Gain} = V_O/V_{SENSE} = R_L/5k\Omega \quad (1)$$

$$V_O=I_SR_SR_L/5k\Omega \quad (2)$$

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

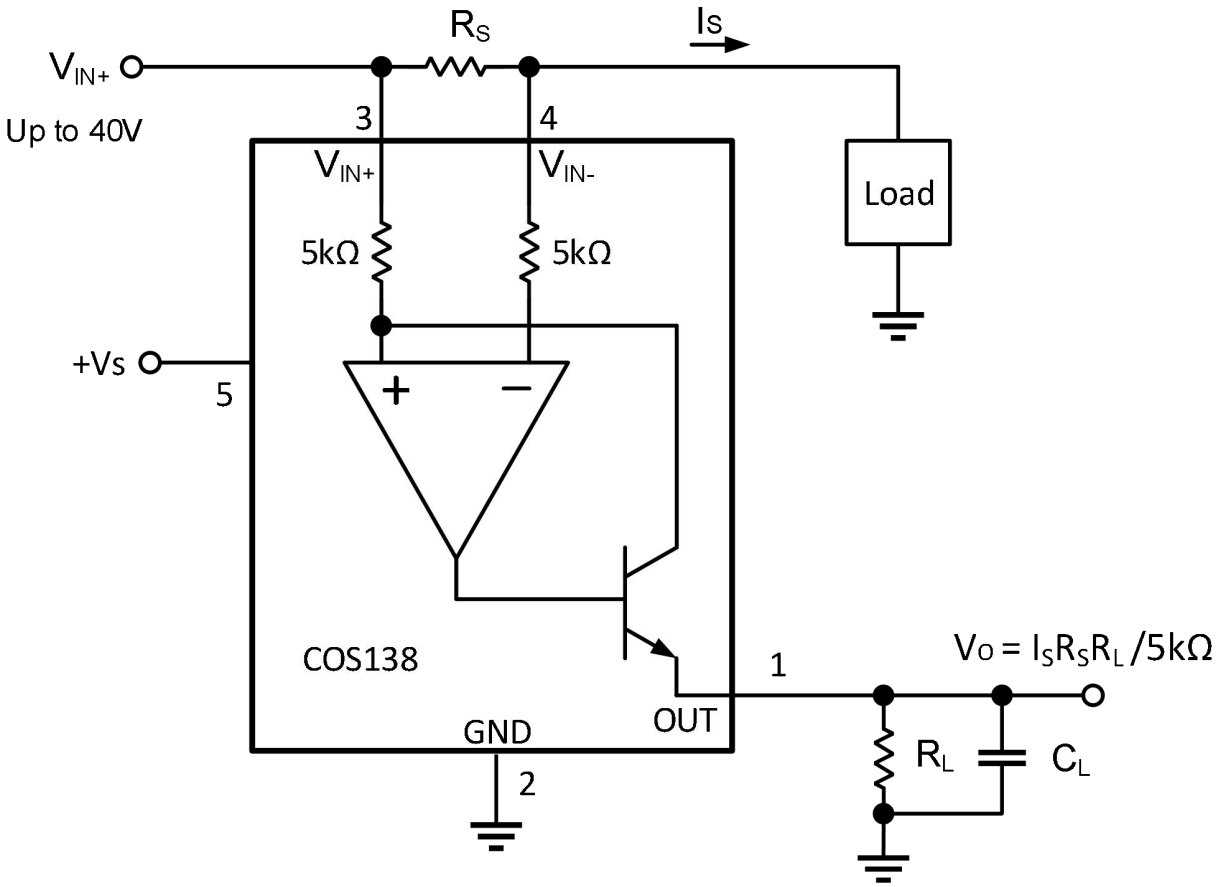


Figure 2 Typical Application Schematic

Table 3.1 Required Values of Gain Resistors

Desired Voltage Gain (V/V)	COSINA138: Gain=R_L/5 kΩ	
	Exact R_L(Ω)	Nearest 1% R_L(Ω)
1	5k	4.99k
2	10k	10k
5	25k	24.9k
10	50k	49.9k
20	100k	100k
50	250k	249k
100	500k	499k

The maximum differential input voltage for accurate measurements is 0.5V, which produces a 100-μA output current. A differential input voltage of up to 2V will not cause damage. Differential measurements (pins 3 and 4) must be unipolar with a more-positive voltage applied to pin 3. If a more-negative voltage is applied to pin 3, the output current, IO, will be zero, but it will not cause damage.

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. A capacitor (e.g. C_L=100nF) can be added to the output as shown in Figure 2 to filter the noise and ripple. This will not cause instability. The cut off frequency can be calculated based on:

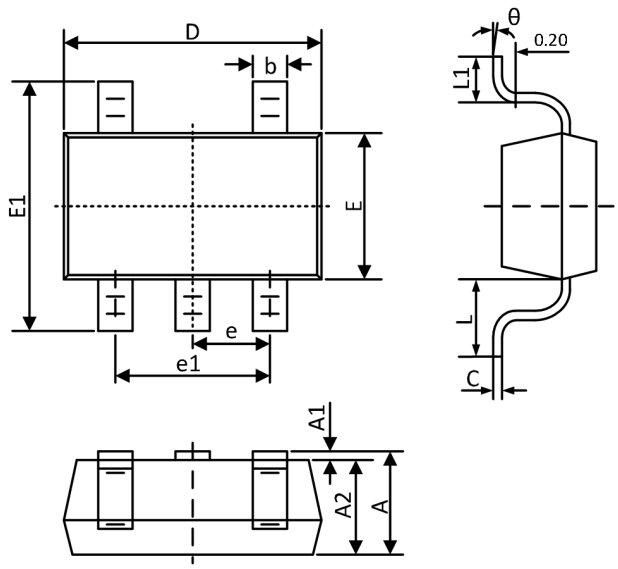
$$f_{-3dB} = 1/(2\pi R_L C_L) \quad (3)$$

The input circuitry of the COSINA138 can accurately measure beyond the power-supply voltage, Vs. For example, the Vs power supply can be 5 V, whereas the load power-supply voltage can be as high as 40V. However, the output voltage range of the OUT pin is limited by the voltages on the power-supply pin. Note also that the COSINAx138 can withstand the full input signal range up to 40V 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.

4 Package Information

4.1 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
θ	0°	8°	0°	8°

5 Package and Ordering Information

Model	Order Number	Package	Package Option	Marking
COSINA138	COSINA138	SOT23-5	Tape and Reel, 3000	COS138