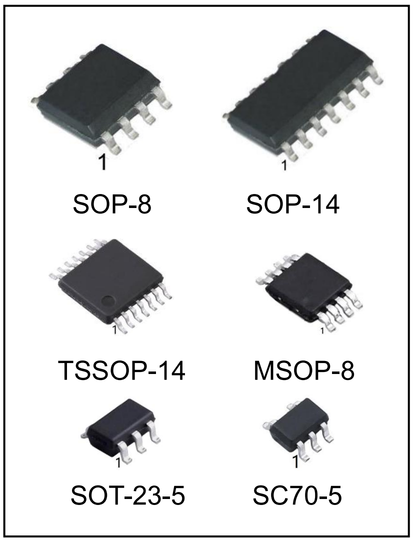
10MHz CMOS Rail-to-Rail IO Opamps

Features

- Single-Supply Operation from +2.1V ~ +5.5V
- Rail-to-Rail Input / Output
- Gain-Bandwidth Product: 10MHz (Typ.)
- Low Input Bias Current: 1pA (Typ.)
- Low Offset Voltage: 3.5mV (Max.)
- High Slew Rate: 9V/μs
- Settling Time to 0.1% with 2V Step: 0.3μs
- Low Noise : 8nV/ Hz @10kHz
- Quiescent Current: 1.1mA per Amplifier (Typ.)
- Operating Temperature: -40°C ~ +125°C
- Small Package:

AD8605 Available in SOT-23-5 and SC70-5 Packages
AD8606 Available in SOP-8 and MSOP-8 Packages
AD8608 Available in SOP-14 and TSSOP-14 Packages



Ordering Information

DEVICE	Package Type	MARKING	Packing	Packing Qty
AD8605M5/TR	SOT-23-5	8605,B3A,B3A#	REEL	3000pcs/reel
AD8605M7/TR	SC70-5(SOT-353)	8605,B3A,B3A#	REEL	3000pcs/reel
AD8606M/TR	SOP-8	AD8606,8606	REEL	2500pcs/reel
AD8606MM/TR	MSOP-8	8606,B6A,B6A#	REEL	3000pcs/reel
AD8608M/TR	SOP-14	AD8608,8608	REEL	2500pcs/reel
AD8608MT/TR	TSSOP-14	AD8608,8608	REEL	2500pcs/reel

Note: SOT-353 equal to SC70-5 Package Type

General Description

The AD860x have a high gain-bandwidth product of 10 MHz, a slew rate of 9V/μs, and a quiescent current of 1.1mA per amplifier at 5V. The AD860x are designed to provide optimal performance in low voltage and low noise systems. They provide rail-to-rail output swing into heavy loads. The input common mode voltage range includes ground, and the maximum input offset voltage is 3.5mV for AD860x. They are specified over the extended industrial temperature range (-40℃ to +125℃). The operating range is from 2.1V to 5.5V. The AD8605 single is available in Green SC70-5 and SOT-23-5 packages. The AD8606 dual is available in Green SOP-8 and MSOP-8 packages. The AD8608 Quad is available in Green SOP-14 and TSSOP-14 packages.

Applications

- Sensors
- Active Filters
- Cellular and Cordless Phones
- Laptops and PDAs
- Audio
- Handheld Test Equipment
- Battery-Powered Instrumentation
- A/D Converters

Pin Configuration

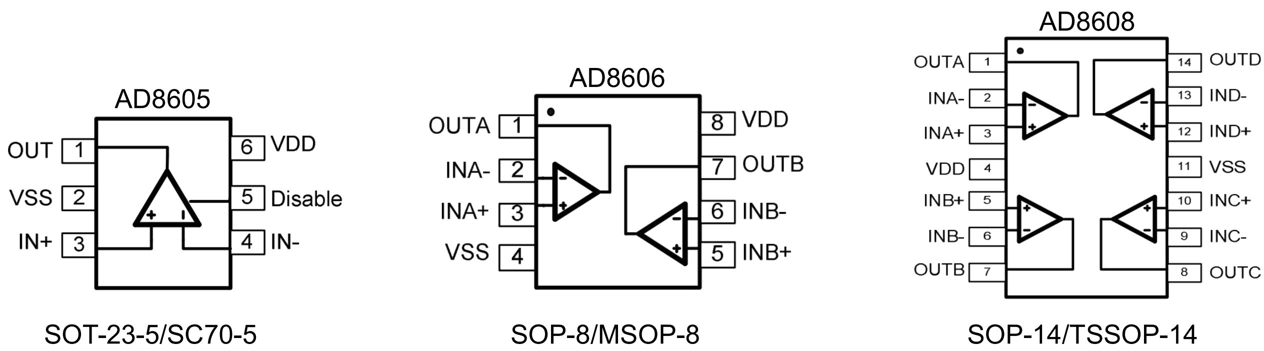


Figure 1. Pin Assignment Diagram

Absolute Maximum Ratings

Condition	Min	Max
Power Supply Voltage (V_{DD} to Vss)	-0.5V	+7.5V
Analog Input Voltage (IN+ or IN-)	Vss-0.5V	V_{DD}+0.5V
PDB Input Voltage	Vss-0.5V	+7V
Operating Temperature Range	-40°C	+125°C
Junction Temperature	-	+160°C
Storage Temperature Range	-55°C	+150°C
Lead Temperature (soldering, 10sec)	-	+245°C
Package Thermal Resistance (TA=+25℃)		
SOP-8, θ_{JA}	-	125°C/W
MSOP-8, θ_{JA}	-	216°C/W
SOT-23-5, θ_{JA}	-	190°C/W
SC70-5, θ_{JA}	-	333°C/W
ESD Susceptibility		
HBM	-	8KV
MM	-	400V

Note: Stress greater than those listed under Absolute Maximum Ratings may cause permanent damage to the device. This is a stress rating only and functional operation of the device at these or any other conditions outside those indicated in the operational sections of this specification are not implied. Exposure to absolute maximum rating conditions for extended periods may affect reliability.

Electrical Characteristics

(At Vs=5V, T_A = +25℃, V_{CM} = V_S/2, R_L = 600Ω, unless otherwise noted.)

PARAMETER	CONDITIONS	AD8605/6/8						
		TYP	MIN/MAX OVER TEMPERATURE					
		+25℃	+25℃	0℃ to 70℃	-40℃ to 85℃	-40℃ to 125℃	UNITS	MIN / MAX
INPUT CHARACTERISTICS								
Input Offset Voltage (V_{OS})		0.8	3.5	3.9	4.3	4.6	mV	MAX
Input Bias Current (I_B)		1					pA	TYP
Input Offset Current (I_{OS})		1					pA	TYP
Input Common Mode Voltage Range (V_{CM})	V_S = 5.5V	-0.1 to +5.6					V	TYP
Common Mode Rejection Ratio (CMRR)	V_S = 5.5V, V_{CM} = -0.1V to 4V	82	65	64	64	63	dB	MIN
	V_S = 5.5V, V_{CM} = -0.1V to 5.6V	75					dB	MIN
Open-Loop Voltage Gain (A_{OL})	R_L = 600Ω, V_O = 0.15V to 4.85V	90	80	76	75	68	dB	MIN
	R_L = 10kΩ, V_O = 0.05V to 4.95V	108					dB	MIN
Input Offset Voltage Drift ($\Delta V_{OS}/\Delta T$)		2.4					μV/℃	TYP
OUTPUT CHARACTERISTICS								
Output Voltage Swing from Rail	R_L = 600Ω	0.1					V	TYP
	R_L = 10kΩ	0.015					V	TYP
Output Current (I_{OUT})		70	55	45	42	38	mA	MIN
Closed-Loop Output Impedance	f = 100kHz, G = 1	7.5					Ω	TYP
POWER-DOWN DISABLE								
Turn-On Time		1.1					μs	TYP
Turn-Off Time		0.3					μs	TYP
DISABLE Voltage-Off			0.8				V	MAX
DISABLE Voltage-On			2				V	MIN
POWER SUPPLY								
Operating Voltage Range			2.1	2.1	2.1	2.1	V	MIN
			5.5	5.5	5.5	5.5	V	MAX
Power Supply Rejection Ratio (PSRR)	V_S = +2.5V to +5.5V	91	74	72	72	68	dB	MIN MAX
	V_{CM} = (-V_S) + 0.5V I_{OUT} = 0	1.1	1.5	1.65	1.7	1.85	Ma	MAX

Electrical Characteristics

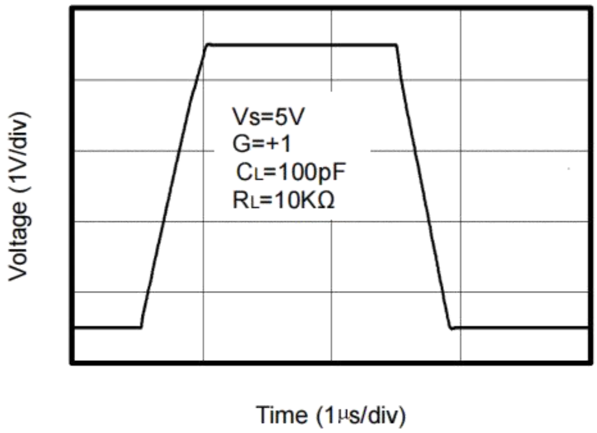
(At Vs=5V, TA = +25℃, VCM = VS/2, RL = 600Ω, unless otherwise noted.)

PARAMETER	CONDITIONS	AD8605/6/8						
		TYP	MIN/MAX OVER TEMPERATURE					
		+25℃	+25℃	0℃ to 70℃	-40℃ to 85℃	-40℃to 125℃	UNITS	MIN / MAX
DYNAMIC PERFORMANCE								
Gain-Bandwidth Product (GBP)	R_L = 10kΩ, C_L = 100pF	10					MHz	TYP
Phase Margin ($φ_O$)	R_L = 10kΩ, C_L = 100pF	51					Degrees	TYP
Full Power Bandwidth (BWP)	＜1% distortion, R_L = 600Ω	400					kHz	TYP
Slew Rate (SR)	G = +1, 2V Step, R_L = 10kΩ	9					V/μs	TYP
Settling Time to 0.1% (t_S)	G = +1, 2V Step, R_L = 600Ω	0.3					μs	TYP
Overload Recovery Time	V_{IN} ·Gain = VS, R_L = 600Ω	1.5					μs	TYP
NOISE PERFORMANCE								
Voltage Noise Density (e_n)	f = 1kHz	11.5					nV /Hz	TYP
	f = 10kHz	8					nV /Hz	TYP

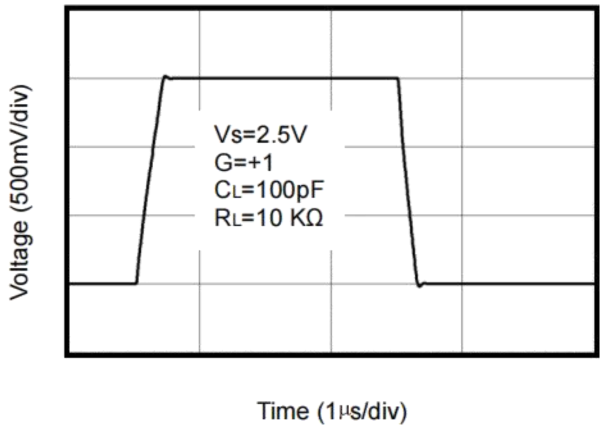
Typical Performance characteristics

(At V_S=5V, T_A = +25℃, V_{CM} = V_S/2, R_L = 600Ω, unless otherwise noted.)

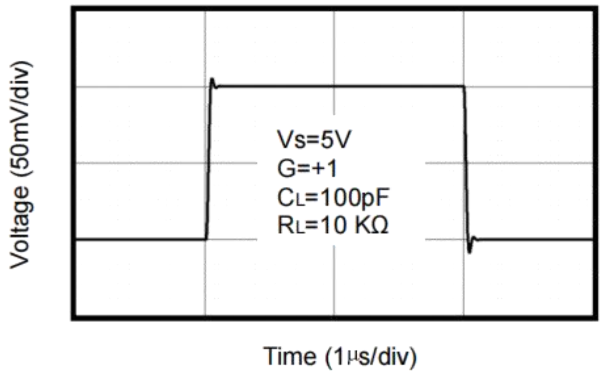
Large-Signal Step Response



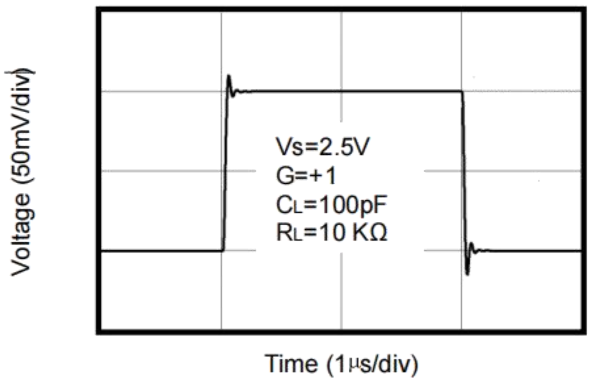
Large-Signal Step Response



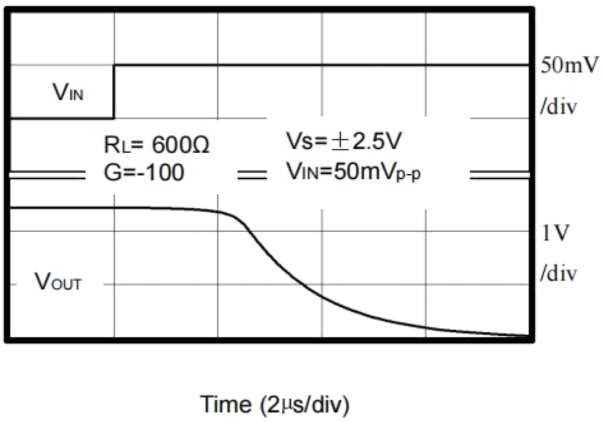
Small-Signal Step Response



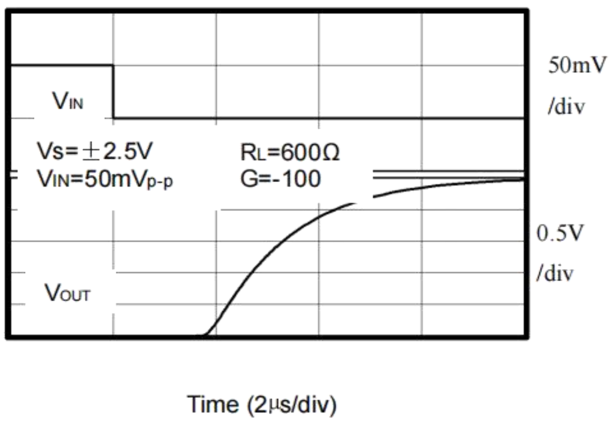
Small-Signal Step Response



Positive Overload Recovery



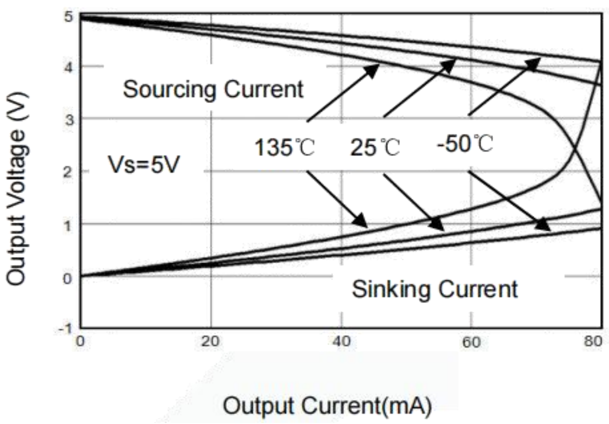
Negative Overload Recovery



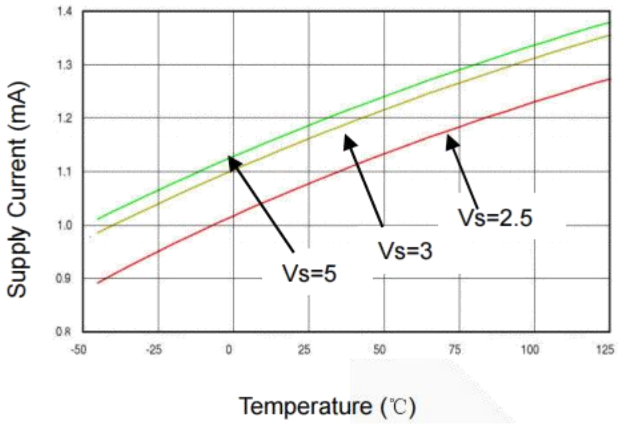
Typical Performance characteristics

(At Vs=5V, TA = +25°C, VCM = VS/2, RL = 600Ω, unless otherwise noted.)

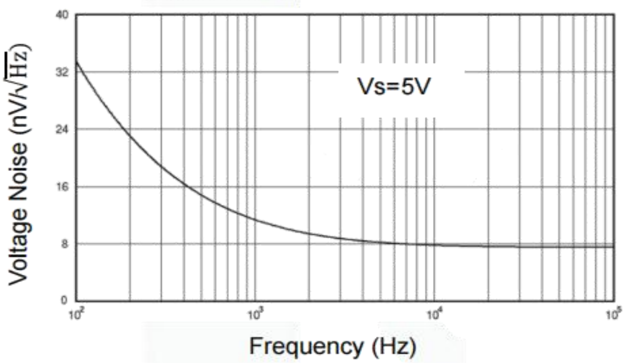
Output Voltage Swing vs.Output Current



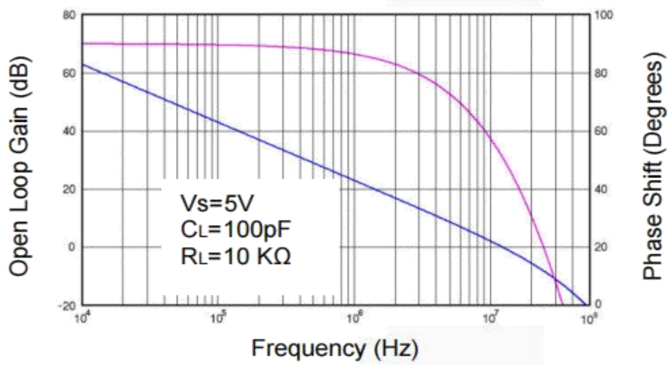
Supply Current vs. Temperature



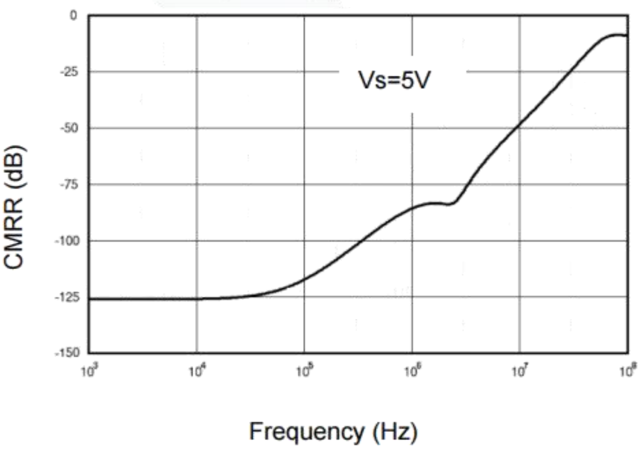
Input Voltage Noise Spectral Density vs. Frequency



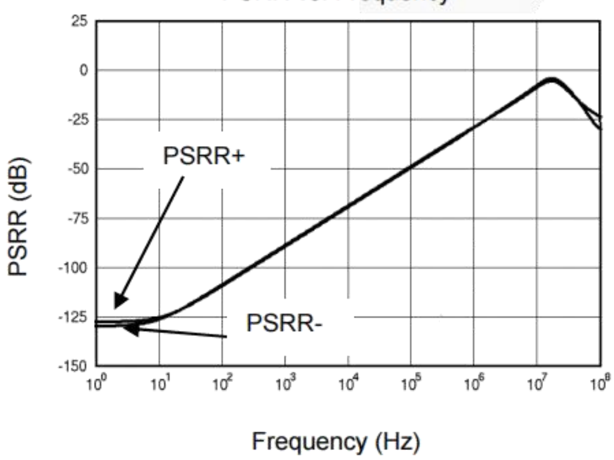
Open Loop Gain, Phase Shift vs. Frequency



CMRR vs. Frequency



PSRR vs. Frequency



Application Note

Size

AD860x series op amps are unity-gain stable and suitable for a wide range of general-purpose applications. The small footprints of the AD860x series packages save space on printed circuit boards and enable the design of smaller electronic products.

Power Supply Bypassing and Board Layout

AD860x series operates from a single 2.1V to 5.5V supply or dual ±1.05V to ±2.75V supplies. For best performance, a 0.1μF ceramic capacitor should be placed close to the V_{DD} pin in single supply operation. For dual supply operation, both V_{DD} and VSS supplies should be bypassed to ground with separate 0.1μF ceramic capacitors.

Low Supply Current

The low supply current (typical 1.1mA per channel) of AD860x series will help to maximize battery life . They are ideal for battery powered systems

Operating Voltage

AD860x series operate under wide input supply voltage (2.1V to 5.5V). In addition, all temperature specifications apply from -40°C to +125°C. Most behavior remains unchanged throughout the full operating voltage range. These guarantees ensure operation throughout the single Li-Ion battery lifetime

Rail-to-Rail Input

The input common-mode range of AD860x series extends 100mV beyond the supply rails (VSS-0.1V to V_{DD}+0.1V). This is achieved by using complementary input stage. For normal operation, inputs should be limited to this range.

Rail-to-Rail Output

Rail-to-Rail output swing provides maximum possible dynamic range at the output. This is particularly important when operating in low supply voltages. The output voltage of AD860x series can typically swing to less than 2mV from supply rail in light resistive loads (>100kΩ), and 15mV of supply rail in moderate resistive loads (10kΩ).

Capacitive Load Tolerance

The AD860x family is optimized for bandwidth and speed, not for driving capacitive loads. Output capacitance will create apole in the amplifier’s feedback path, leading to excessive peaking and potential oscillation. If dealing with load capacitance is a requirement of the application, the two strategies to consider are (1) using a small resistor in series with the amplifier’s output and the load capacitance and (2) reducing the bandwidth of the amplifier’s feedback loop by increasing the overall noise gain. Figure 2. shows a unity gain follower using the series resistor strategy. The resistor isolates the output from the capacitance and, more importantly, creates a zero in the feedback path that compensates for the pole created by the output capacitance.

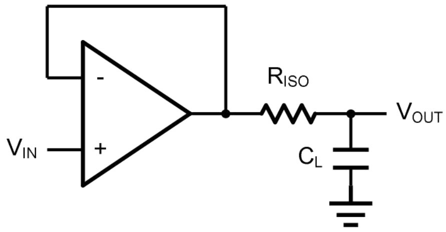


Figure 2. Indirectly Driving a Capacitive Load Using Isolation Resistor

The bigger the RISO resistor value, the more stable VOUT will be. However, if there is a resistive load RL in parallel with the capacitive load, a voltage divider (proportional to RISO/RL) is formed, this will result in a gain error.

The circuit in Figure 3 is an improvement to the one in Figure 2. RF provides the DC accuracy by feed-forward the VIN to RL. CF and RISO serve to counteract the loss of phase margin by feeding the high frequency component of the output signal back to the amplifier’s inverting input, thereby preserving the phase margin in the overall feedback loop. Capacitive drive can be increased by increasing the value of CF. This in turn will slow down the pulse response.

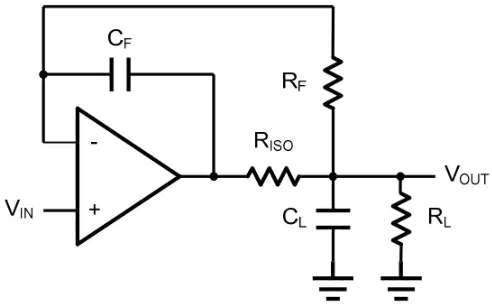


Figure 3. Indirectly Driving a Capacitive Load with DC Accuracy

Typical Application Circuits

Differential amplifier

The differential amplifier allows the subtraction of two input voltages or cancellation of a signal common the two inputs. It is useful as a computational amplifier in making a differential to single-end conversion or in rejecting a common mode signal. Figure 4. shown the differential amplifier using AD860x.

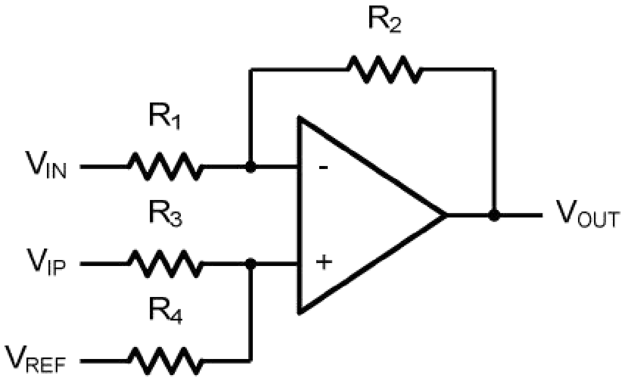


Figure 4. Differential Amplifier

$$V_{OUT} = (\frac{R_1+R_2}{R_3+R_4})\frac{R_4}{R_1}V_{IN} - \frac{R2}{R1}V_{IP} + (\frac{R_1+R_2}{R_3+R_4})\frac{R_3}{R_1}V_{REF}$$

If the resistor ratios are equal (i.e. R1=R3 and R2=R4), then

$$V_{OUT} = \frac{R_2}{R_1}(V_{IP} - V_{IN}) + V_{REF}$$

Low Pass Active Filter

The low pass active filter is shown in Figure 5. The DC gain is defined by –R2/R1. The filter has a -20dB/decade roll-off after its corner frequency ƒC=1/(2πR3C1).

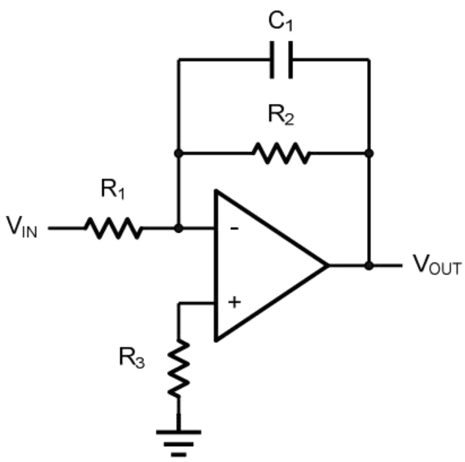


Figure 5. Low Pass Active Filter

Instrumentation Amplifier

The triple AD860x can be used to build a three-op-amp instrumentation amplifier as shown in Figure 6. The amplifier in Figure 6 is a high input impedance differential amplifier with gain of R2/R1. The two differential voltage followers assure the high input impedance of the amplifier.

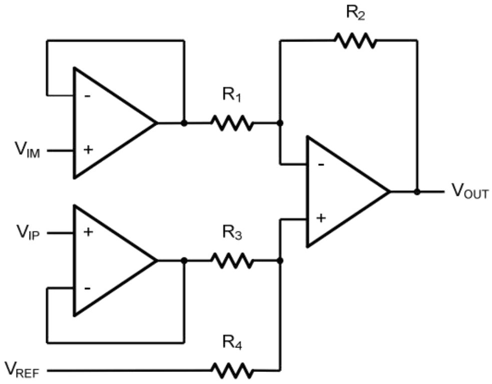
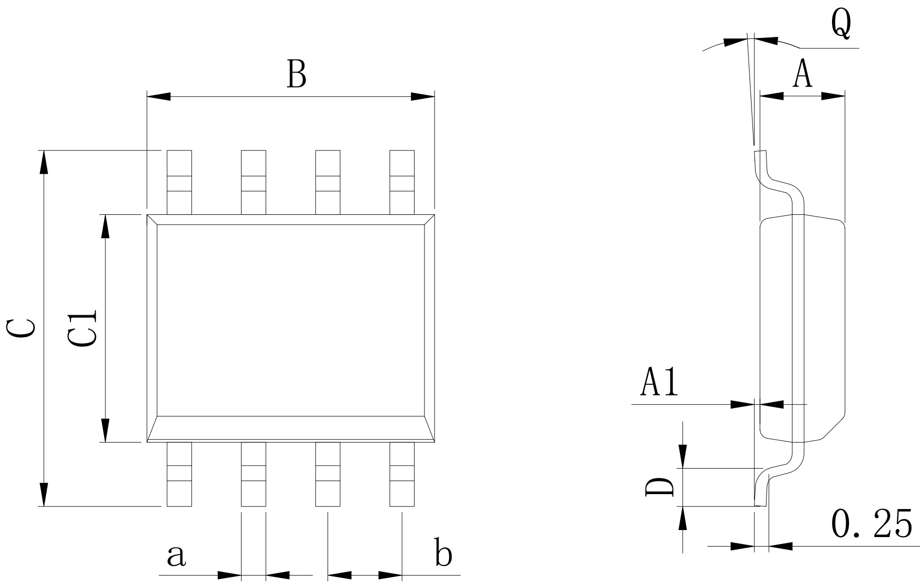


Figure 6. Instrument Amplifier

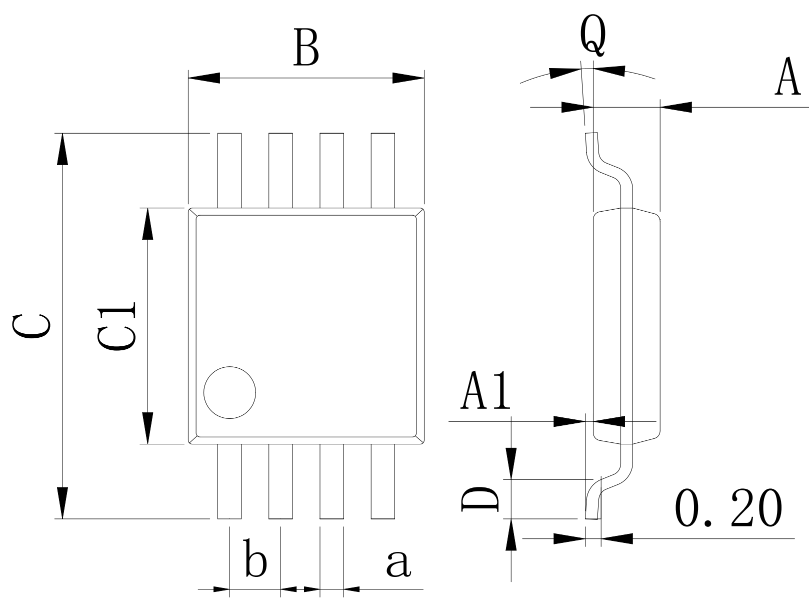
Physical Dimensions

SOP-8



Dimensions In Millimeters(SOP-8)									
Symbol:	A	A1	B	C	C1	D	Q	a	b
Min:	1.35	0.05	4.90	5.80	3.80	0.40	0°	0.35	1.27 BSC
Max:	1.55	0.20	5.10	6.20	4.00	0.80	8°	0.45	

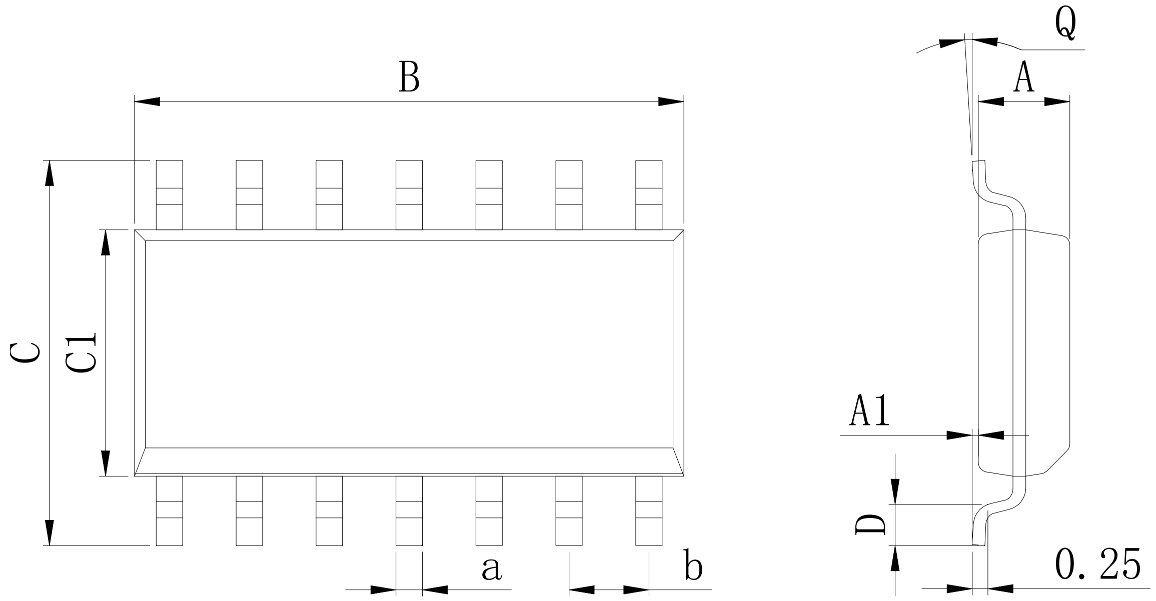
MSOP-8



Dimensions In Millimeters(MSOP-8)									
Symbol:	A	A1	B	C	C1	D	Q	a	b
Min:	0.80	0.05	2.90	4.75	2.90	0.35	0°	0.25	0.65 BSC
Max:	0.90	0.20	3.10	5.05	3.10	0.75	8°	0.35	

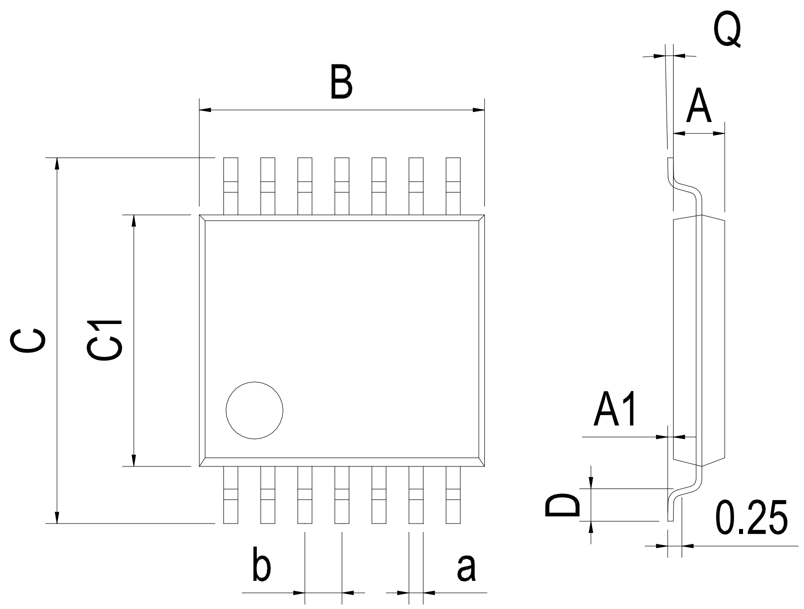
Physical Dimensions

SOP-14



Dimensions In Millimeters(SOP-14)									
Symbol:	A	A1	B	C	C1	D	Q	a	b
Min:	1.35	0.05	8.55	5.80	3.80	0.40	0°	0.35	1.27 BSC
Max:	1.55	0.20	8.75	6.20	4.00	0.80	8°	0.45	

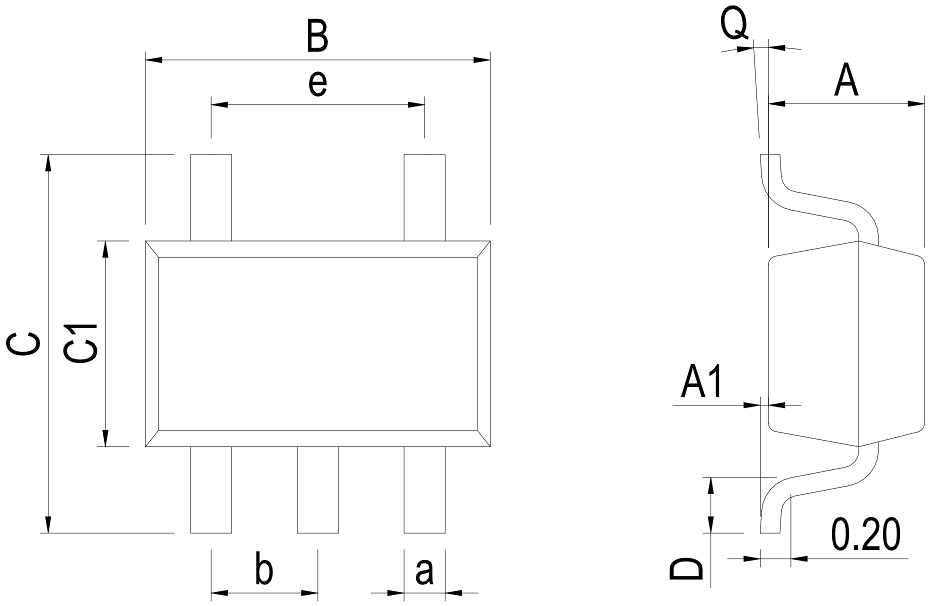
TSSOP-14



Dimensions In Millimeters(TSSOP-14)									
Symbol:	A	A1	B	C	C1	D	Q	a	b
Min:	0.85	0.05	4.90	6.20	4.30	0.40	0°	0.20	0.65 BSC
Max:	0.95	0.20	5.10	6.60	4.50	0.80	8°	0.25	

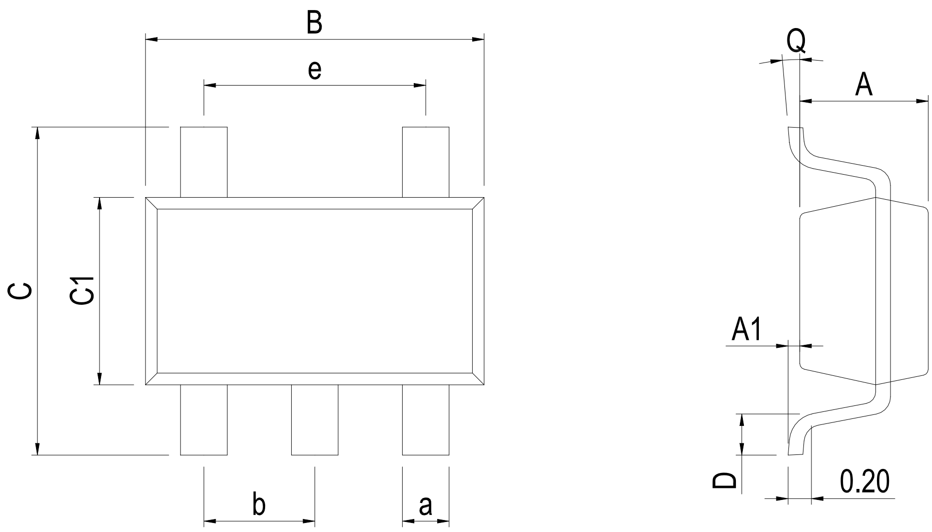
Physical Dimensions

SOT-23-5



Dimensions In Millimeters(SOT-23-5)										
Symbol:	A	A1	B	C	C1	D	Q	a	b	e
Min:	1.05	0.00	2.82	2.65	1.50	0.30	0°	0.30	0.95 BSC	1.90 BSC
Max:	1.15	0.15	3.02	2.95	1.70	0.60	8°	0.40		

SC70-5



Dimensions In Millimeters(SC70-5)										
Symbol:	A	A1	B	C	C1	D	Q	a	b	e
Min:	0.90	0.00	2.00	2.15	1.15	0.26	0°	0.15	0.65	1.30 BSC
Max:	1.00	0.15	2.20	2.45	1.35	0.46	8°	0.35	BSC	

Revision History

DATE	REVISION	PAGE
2016-7-8	New	1-16
2023-10-31	Update encapsulation type， Update Lead Temperature、Update SC70-5 Physical Dimensions	1、3、14
2024-8-22	Add a model marking name	1

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