

## 250MHz CMOS Rail-to-Rail Output Opamps

### Features

- Single-Supply Operation from +2.5V ~ +5.5V
- Rail-to-Rail Output
- -3dB Bandwidth(G=+1): 250MHz (Typ)
- Low Input Bias Current: 1pA (Typ)
- Quiescent Current: 2.8mA/Amplifier (Typ)
- Operating Temperature: -40°C ~ +125°C
- Small Package:

AD8051 Available in SOT23-5 and SC70-5

Packages

AD8052 Available in SOP-8,MSOP-8 and DFN-8

Packages

AD8054 Available in SOP-14 and TSSOP-14

Packages



### Ordering Information

DEVICE	Package Type	MARKING	Packing	Packing Qty
AD8051M5/TR	SOT-23-5	8051	REEL	3000pcs/reel
AD8051M7/TR	SC70-5	8051	REEL	3000pcs/reel
AD8052M/TR	SOP-8	AD8052	REEL	2500pcs/reel
AD8052MM/TR	MSOP-8	8052	REEL	3000pcs/reel
AD8052DQ/TR	DFN-8 2*2	AD8052	REEL	3000pcs/reel
AD8054M/TR	SOP-14	AD8054	REEL	2500pcs/reel
AD8054MT/TR	TSSOP-14	AD8054	REEL	2500pcs/reel

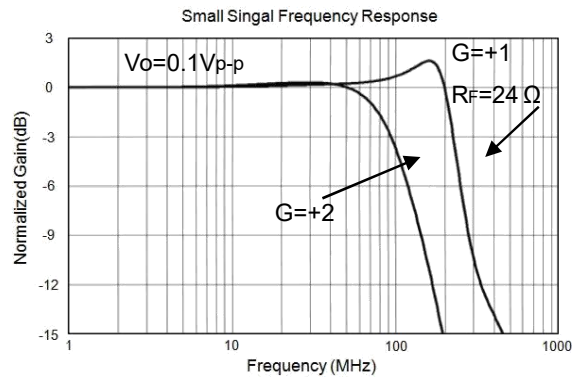
### General Description

The AD8051(single), AD8052(dual), AD8054(quad) are rail-to-rail output voltage feedback amplifiers offering ease of use and low cost. They have bandwidth and slew rate typically found in current feedback amplifiers. All have a wide input common-mode voltage range and output voltage swing, making them easy to use on single supplies as low as 2.5V. Despite being low cost, the AD805X series provide excellent overall performance. They offer wide bandwidth to 250MHz (G = +1) along with 0.1dB flatness out to 52MHz (G = +2) and offer a typical low power of 2.8mA/amplifier.

The AD805X series is low distortion and fast settling make it ideal for buffering high speed A/D or D/A converters. The AD8051 has a power-down disable feature that reduces the supply current to 50µA. These features make the AD8051/2 ideal for portable and battery-powered applications where size and power are critical. All are specified over the extended -40°C to +125°C temperature range.

## Applications

- Imaging
- Photodiode Preamp
- DVD/CD
- Filters
- Professional Video and Cameras
- Hand Sets
- Base Stations
- A-to-D Driver



## Pin Configuration

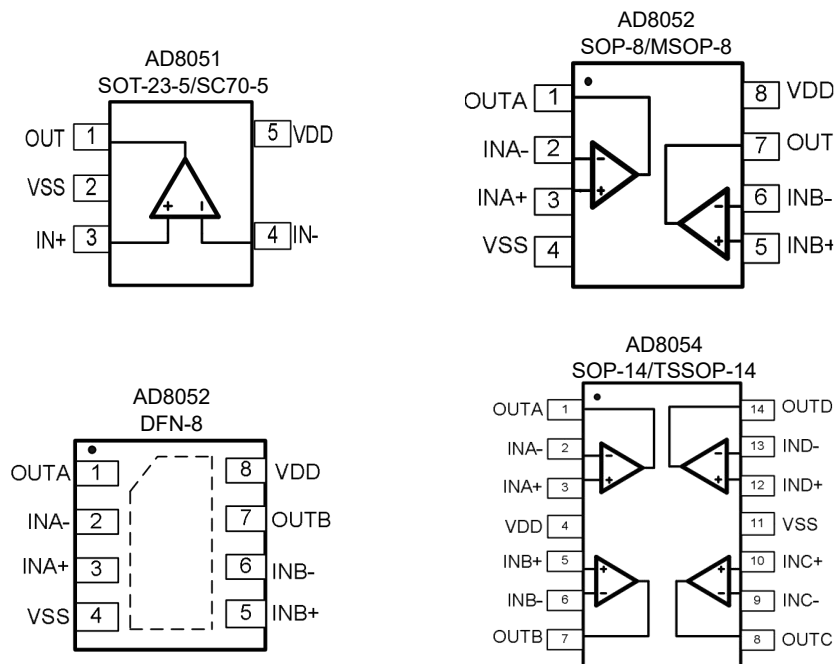


Figure 1. Pin Assignment Diagram

## Absolute Maximum Ratings

Condition	Min	Max
Power Supply Voltage (VDD to Vss)	-0.5V	+7.5V
Analog Input Voltage (IN+ or IN-)	Vss-0.5V	VDD+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°C)		
SOP-8, θJA	125°C/W	
MSOP-8, θJA	216°C/W	
SOT23-5, θJA	190°C/W	
SC70-5, θJA	333°C/W	
ESD Susceptibility		
HBM	6KV	
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 Performance Characteristics

( $G = +2$ ,  $R_F = 887\Omega$ ,  $R_G = 887\Omega$ , and  $R_L = 150\Omega$  connected to  $V_S/2$ , unless otherwise noted. Typical values are at  $T_A = +25^\circ\text{C}$ .)

PARAMETER	CONDITIONS	AD8051/52/54						
		TYP	MIN/MAX OVER TEMPERATURE					MIN/MAX
		+25°C	+25°C	0°C to 70°C	-40°C to 85°C	-40°C to 125°C	UNITS	
<b>DYNAMIC PERFORMANCE</b>								
-3dB Small Signal Bandwidth	$G = +1$ , $V_o = 0.1\text{V p-p}$ , $R_F = 24\Omega$ , $R_L = 150\Omega$	180					MHz	TYP
	$G = +1$ , $V_o = 0.1\text{V p-p}$ , $R_F = 24\Omega$ , $R_L = 1\text{k}\Omega$	250					MHz	TYP
	$G = +2$ , $V_o = 0.1\text{V p-p}$ , $R_L = 50\Omega$	55					MHz	TYP
	$G = +2$ , $V_o = 0.1\text{V p-p}$ , $R_L = 150\Omega$	93					MHz	TYP
	$G = +2$ , $V_o = 0.1\text{V p-p}$ , $R_L = 1\text{k}\Omega$	122					MHz	TYP
	$G = +2$ , $V_o = 0.1\text{V p-p}$ , $R_L = 10\text{k}\Omega$	130					MHz	TYP
Gain-Bandwidth Product	$G = +10$ , $R_L = 150\Omega$	115					MHz	TYP
	$G = +10$ , $R_L = 1\text{k}\Omega$	150					MHz	TYP
Bandwidth for 0.1dB Flatness	$G = +2$ , $V_o = 0.1\text{V p-p}$ , $R_L = 150\Omega$ , $R_F = 887\Omega$	52					MHz	TYP
Slew Rate	$G = +1$ , 2V Output Step	77/-151					V/ $\mu\text{s}$	TYP
	$G = +2$ , 2V Output Step	88/-119					V/ $\mu\text{s}$	TYP
	$G = +2$ , 4V Output Step	93/-131					V/ $\mu\text{s}$	TYP
Rise-and-Fall Time	$G = +2$ , $V_o = 0.2\text{V p-p}$ , 10% to 90%	4.5					ns	TYP
	$G = +2$ , $V_o = 2\text{V p-p}$ , 10% to 90%	18					ns	TYP
Settling Time to 0.1%	$G = +2$ , 2V Output Step	50					ns	TYP
Overload Recovery Time	$V_{IN} \cdot G = +V_S$	18					ns	TYP
<b>NOISE/DISTORTION PERFORMANCE</b>								
Input Voltage Noise	$f = 1\text{MHz}$	4.9					nV/Hz	TYP
Differential Gain Error (NTSC)	$G = +2$ , $R_L = 150\Omega$	0.03					%	TYP
Differential Phase Error (NTSC)	$G = +2$ , $R_L = 150\Omega$	0.08					degree	TYP
<b>DC PERFORMANCE</b>								
Input Offset Voltage (VOS)		$\pm 2$	$\pm 8$	$\pm 8.9$	$\pm 9.5$	$\pm 9.8$	mV	MAX
Input Offset Voltage Drift		2					$\mu\text{V}/^\circ\text{C}$	TYP
Input Bias Current (IB)		1					PA	TYP
Input offset Current (IOS)		2					PA	TYP
Open-Loop Gain (AOL)	$V_O = 0.3\text{V to } 4.7\text{V}$ , $R_L = 150\Omega$	80	75	74	74	73	dB	MIN
	$V_O = 0.2\text{V to } 4.8\text{V}$ , $R_L = 1\text{k}\Omega$	104	92	91	91	80	dB	MIN
<b>INPUT CHARACTERISTICS</b>								
Input Common-Mode Voltage Range (VCM)	$V_{CM} = -0.1\text{V to } +3.5\text{V}$	-0.2 to +3.8					V	TYP
Common-Mode Rejection Ratio (CMRR)		80	66	65	65	62	dB	MIN

## Electrical Performance Characteristics

( $G=+2$ ,  $R_F=887\Omega$ ,  $R_G=887\Omega$ , and  $R_L=150\Omega$  connected to  $V_S/2$ , unless otherwise noted. Typical values are at  $T_A=+25^\circ\text{C}$ .)

PARAMETER	CONDITIONS	AD8051/52/54						
		TYP	MIN/MAX OVER TEMPERATURE					MIN/ MAX
		+25 $^\circ\text{C}$	+25 $^\circ\text{C}$	0 $^\circ\text{C}$ to 70 $^\circ\text{C}$	-40 $^\circ\text{C}$ to 85 $^\circ\text{C}$	-40 $^\circ\text{C}$ to 125 $^\circ\text{C}$	UNITS	
<b>OUTPUT CHARACTERISTICS</b>								
Output Voltage Swing from Rail	$R_L = 150\Omega$	0.12					V	TYP
	$R_L = 1k\Omega$	0.03					V	TYP
Output Current		80	60				mA	MIN
Closed-Loop Output Impedance	$f < 100\text{kHz}$	0.08					$\Omega$	TYP
<b>POWER-DOWN DISABLE (AD8051/2 only)</b>								
Turn-On Time		236					ns	TYP
Turn-Off Time		52					ns	TYP
DISABLE Voltage-Off			0.8				V	MAX
DISABLE Voltage-On			2				V	MIN
<b>POWER SUPPLY</b>								
Operating Voltage Range			2.5	2.7	2.7	2.7	V	MIN
			5.5	5.5	5.5	5.5	V	MAX
Quiescent Current (per amplifier)		2.8	3.65				mA	MAX
Supply Current when Disabled per amplifier (AD8051/2 only)		50	70	85	100	137	$\mu\text{A}$	MAX
Power Supply Rejection Ratio (PSRR)	$\Delta V_S = +2.7\text{V to } +5.5\text{V}$ , $V_{CM} = (-V_S) + 0.5$	80	67	67	65	62	dB	MIN

## Typical Performance characteristics

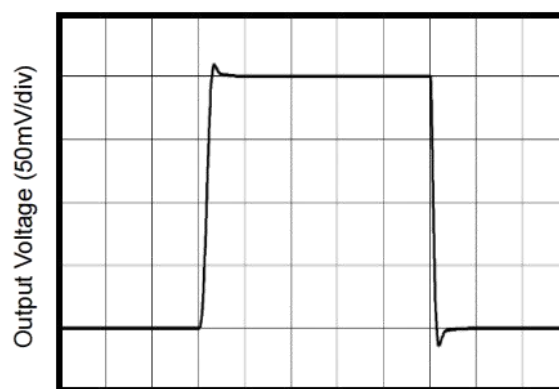
( $V_s=+5V$ ,  $G=+2$ ,  $R_F=887\Omega$ ,  $R_G=887\Omega$ , and  $R_L=150\Omega$  connected to  $V_s/2$ , Typical values are at  $T_A=+25^\circ\text{C}$ .)

Non-Inverting Large-Signal Step Response



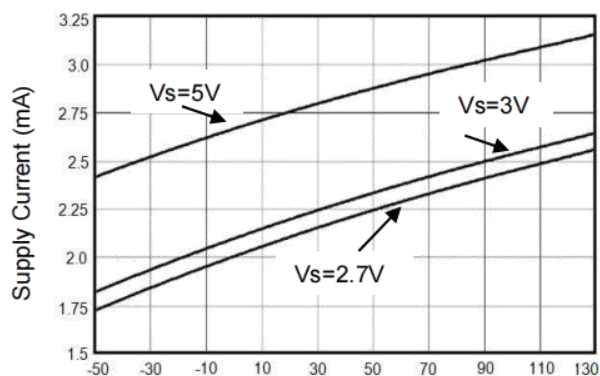
Time (50ns/div)

Non-Inverting Small-Signal Step Response



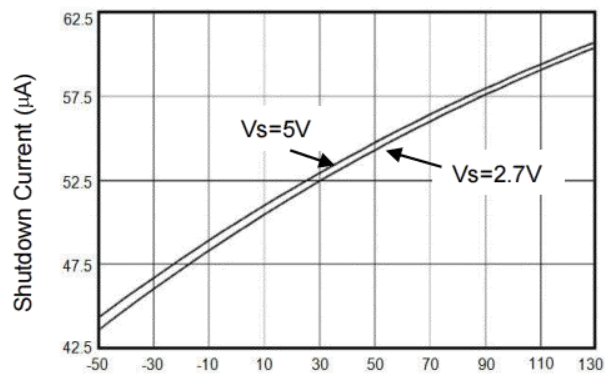
Time (50ns/div)

Supply Current vs. Temperature



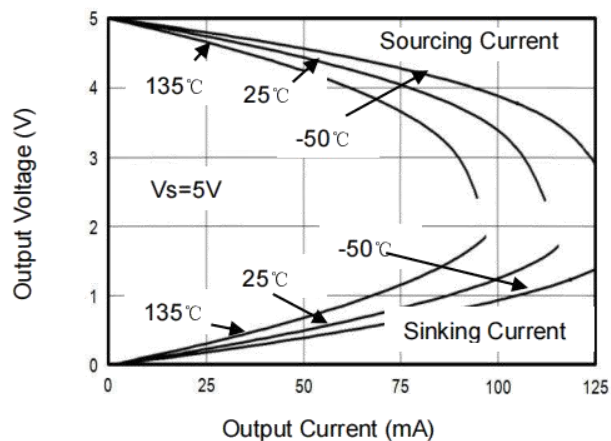
Temperature ( $^\circ\text{C}$ )

Shutdown Current vs. Temperature



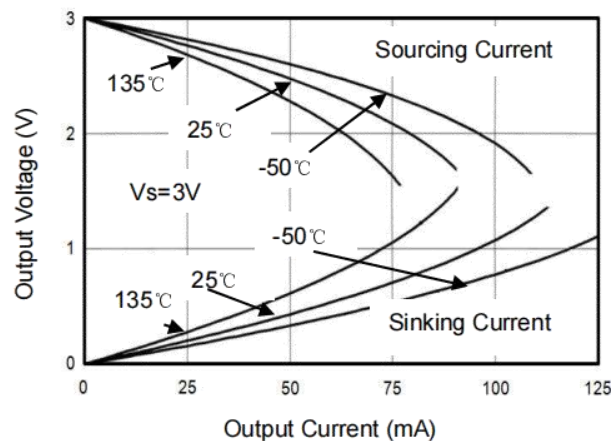
Temperature ( $^\circ\text{C}$ )

Output Voltage Swing vs. Output Current



Output Current (mA)

Output Voltage vs. Output Current

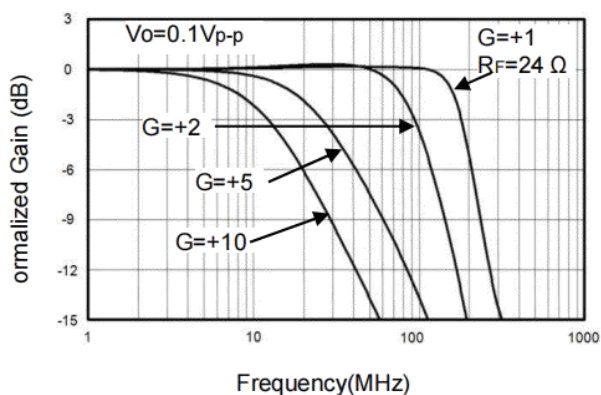


Output Current (mA)

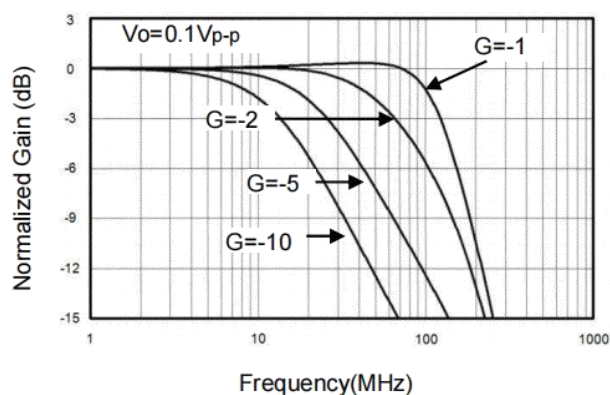
## Typical Performance characteristics

(( $V_s=+5V$ ,  $G=+2$ ,  $R_F=887\Omega$ ,  $R_G=887\Omega$ , and  $R_L=150\Omega$  connected to  $V_s/2$ , Typical values are at  $T_A=+25^\circ C$ .)

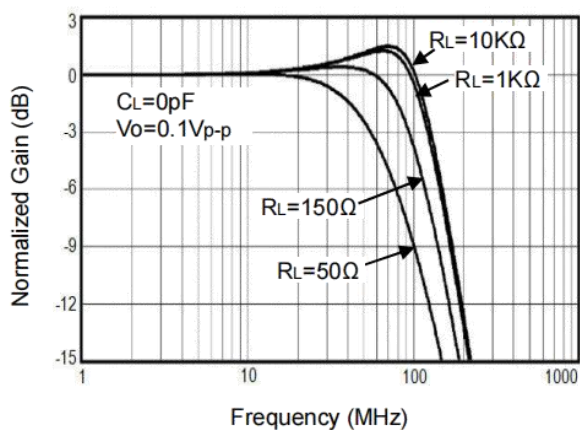
Non-Inverting Small Signal Frequency Response



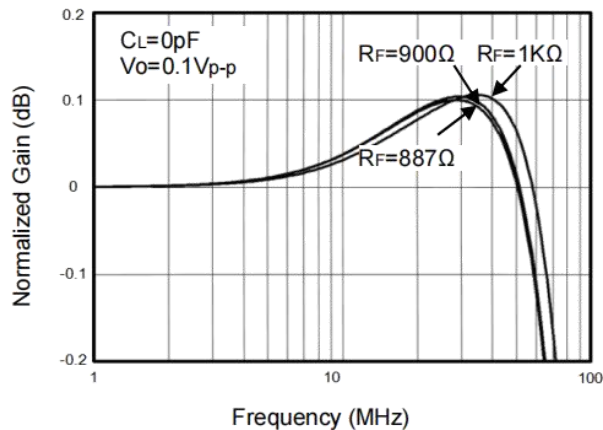
Inverting Small Signal Frequency Response



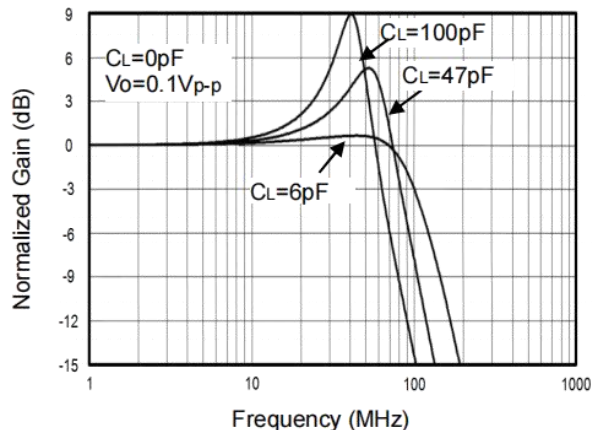
Frequency Response For Various  $R_L$



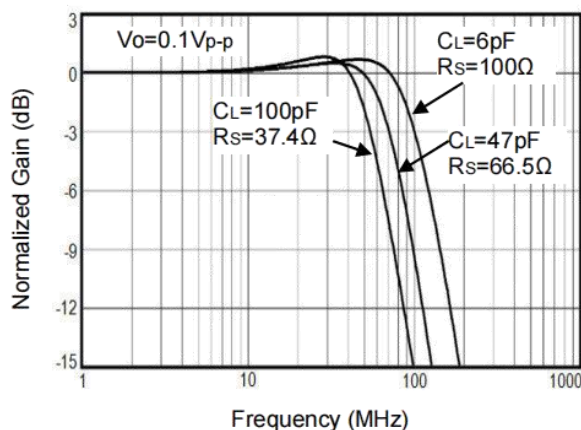
0.1dB Gain Flatness For Various  $R_F$



Frequency Response For Various  $C_L$



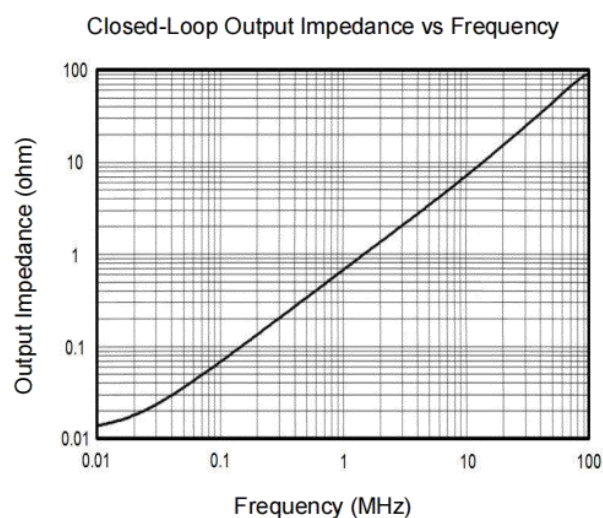
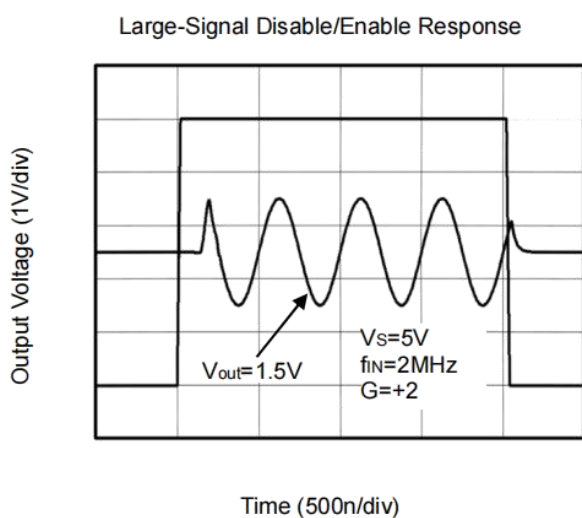
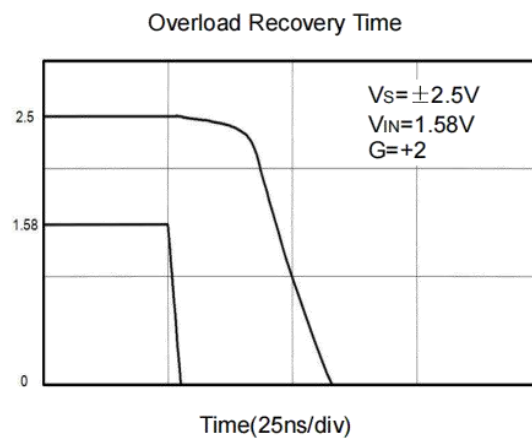
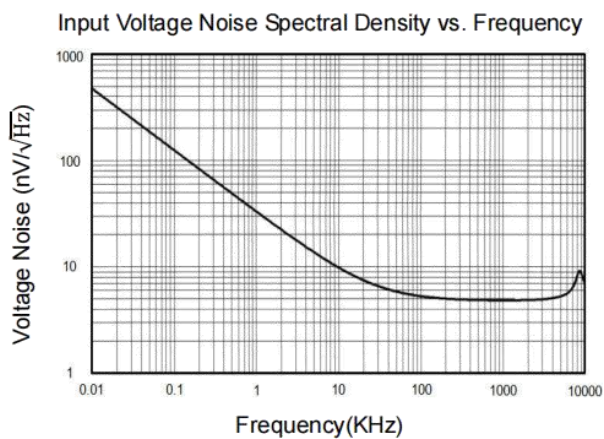
Frequency Response vs. Capacitive Load





## Typical Performance characteristics

( $V_S=+5V$ ,  $G=+2$ ,  $R_F=887\Omega$ ,  $R_G=887\Omega$ , and  $R_L=150\Omega$  connected to  $V_S/2$ , Typical values are at  $T_A=+25^\circ\text{C}$ .)





## Application Note

### Driving Capacitive Loads

AD805X series op amps are unity-gain stable and suitable for a wide range of general-purpose applications. The small footprints of the AD805X series packages save space on printed circuit boards and enable the design of smaller electronic products.

### Power Supply Bypassing and Board Layout

AD805X series operates from a single 2.5V to 5.5V supply or dual  $\pm 1.25\text{V}$  to  $\pm 2.75\text{V}$  supplies. For best performance, a  $0.1\mu\text{F}$  ceramic capacitor should be placed close to the  $V_{\text{DD}}$  pin in single supply operation. For dual supply operation, both  $V_{\text{DD}}$  and  $V_{\text{SS}}$  supplies should be bypassed to ground with separate  $0.1\mu\text{F}$  ceramic capacitors.

### Low Supply Current

The low supply current (typical 2.8mA per channel) of AD805X series will help to maximize battery life. They are ideal for battery powered systems.

### Operating Voltage

AD805X series operate under wide input supply voltage (2.5V to 5.5V). In addition, all temperature specifications apply from

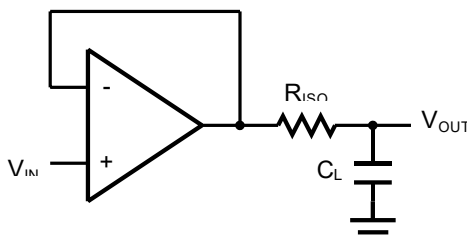
$-40^{\circ}\text{C}$  to  $+125^{\circ}\text{C}$ . Most behavior remains unchanged throughout the full operating voltage range. These guarantees ensure operation throughout the single Li-Ion battery lifetime.

### Rail-to-Rail 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 AD805X series can typically swing to less than 8mV from supply rail in light resistive loads ( $>1\text{k}\Omega$ ), and 30mV of supply rail in moderate resistive loads ( $150\Omega$ ).

### Capacitive Load Tolerance

The AD805X family is optimized for bandwidth and speed, not for driving capacitive loads. Output capacitance will create a pole 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  $R_{ISO}$  resistor value, the more stable  $V_{OUT}$  will be. However, if there is a resistive load  $R_L$  in parallel with the capacitive load, a voltage divider (proportional to  $R_{ISO}/R_L$ ) is formed, this will result in a gain error.

The circuit in Figure 3 is an improvement to the one in Figure 2.  $R_F$  provides the DC accuracy by feed-forward the  $V_{IN}$  to  $R_L$ .  $C_F$  and  $R_{ISO}$  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  $C_F$ . This in turn will slow down the pulse response.

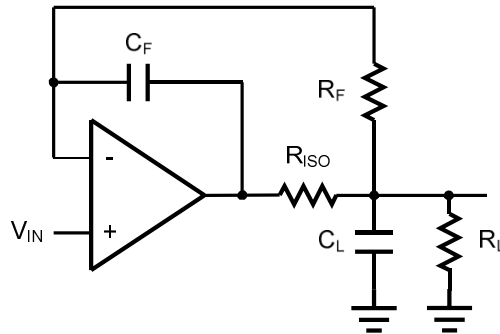


Figure 3. Indirectly Driving a Capacitive Load with DC Accuracy

## Typical Application Circuits

### Differential amplifier

The differential amplifier allows the subtraction of two input voltages or cancellation of a signal common to 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. shows the differential amplifier using AD805X.

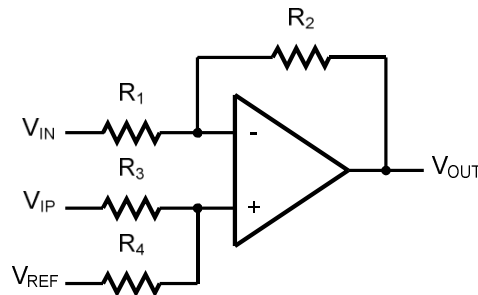


Figure 4. Differential Amplifier

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

If the resistor ratios are equal (i.e.  $R_1 = R_3$  and  $R_2 = R_4$ ), 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  $-R_2/R_1$ . The filter has a -20dB/decade roll-off after its corner frequency  $f_C=1/(2\pi R_3 C_1)$ .

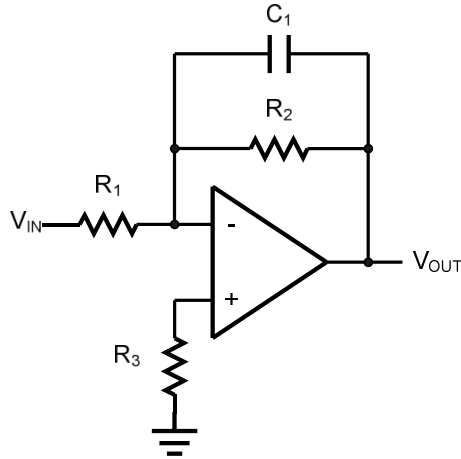


Figure 5. Low Pass Active Filter

## Driving Video

The AD805X can be used in video applications like in Figure 6.

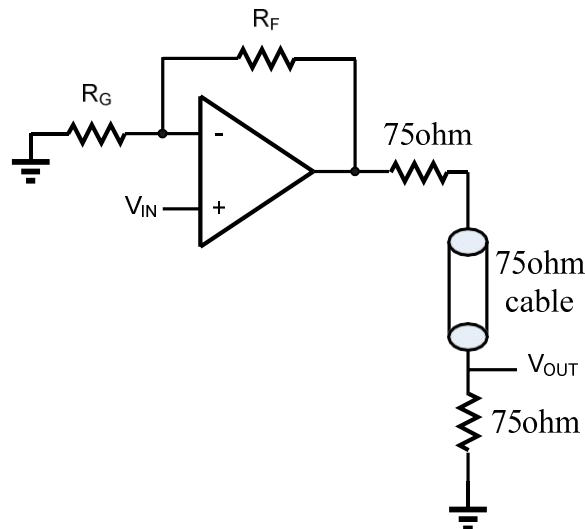
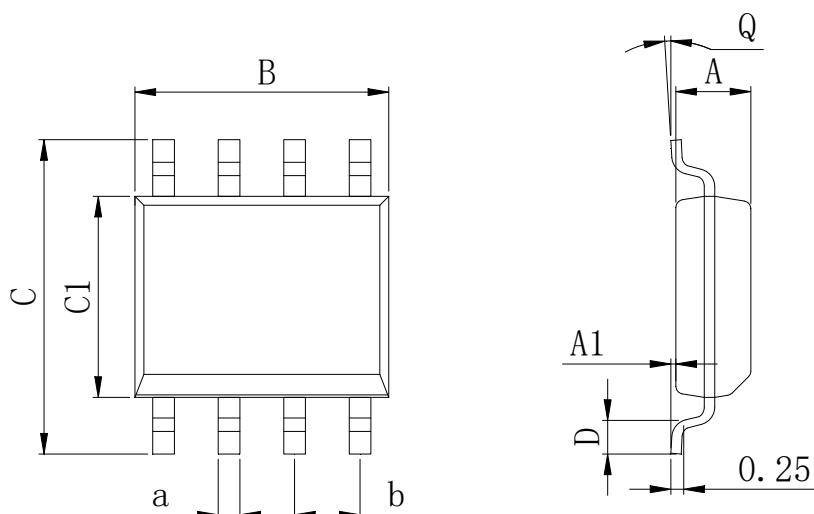


Figure 6. Typical video driving

## Physical Dimensions

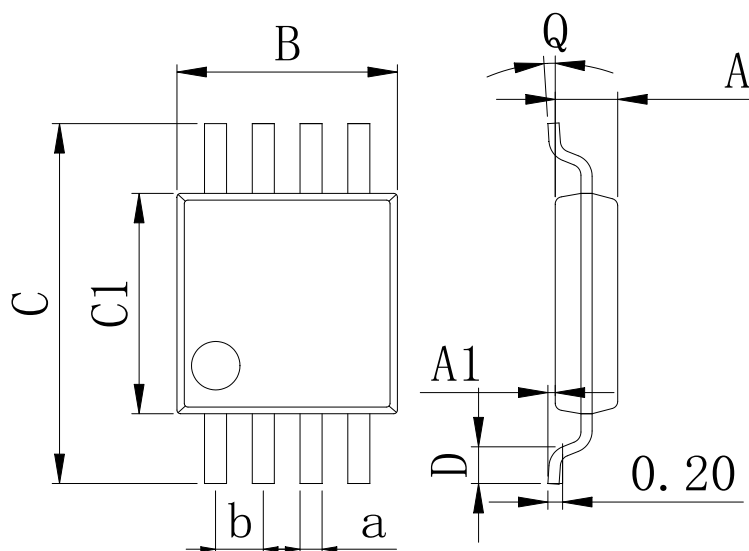
SOP-8



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

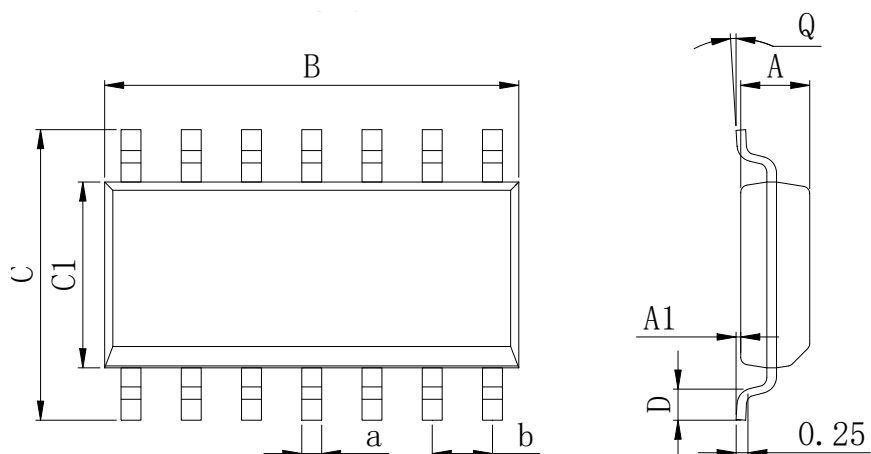


Dimensions In Millimeters(MSOP-8)

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

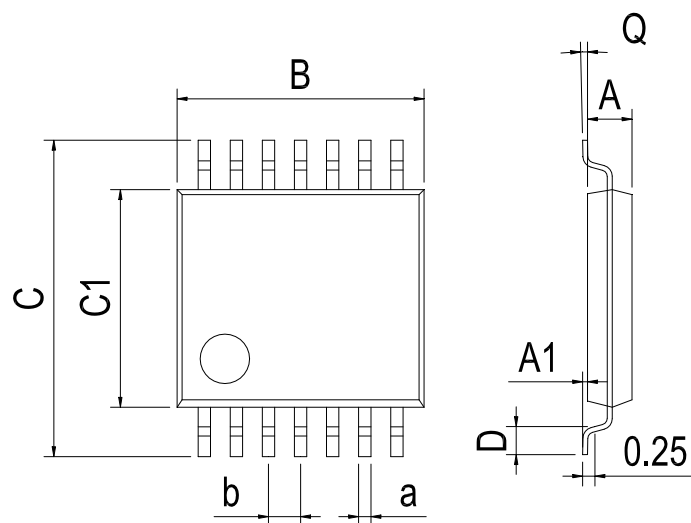
SOP-14



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

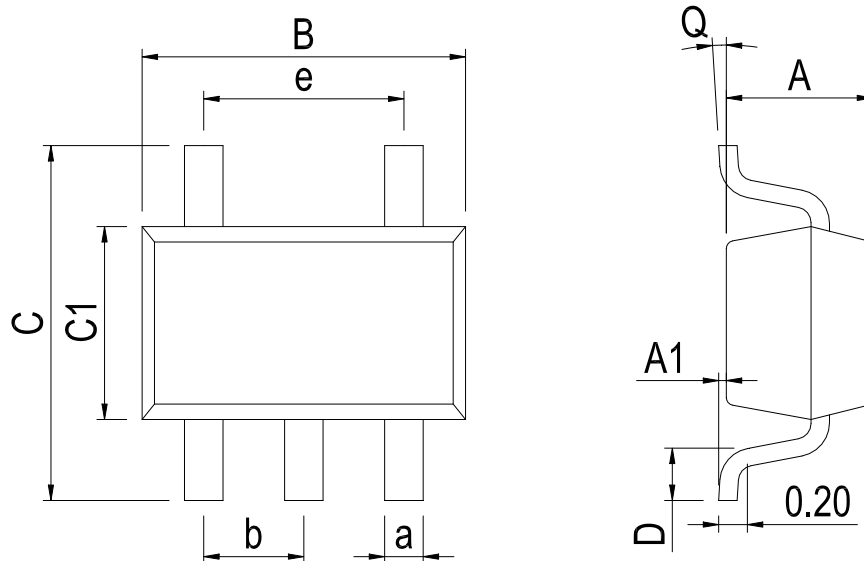


Dimensions In Millimeters(TSSOP-14)

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	

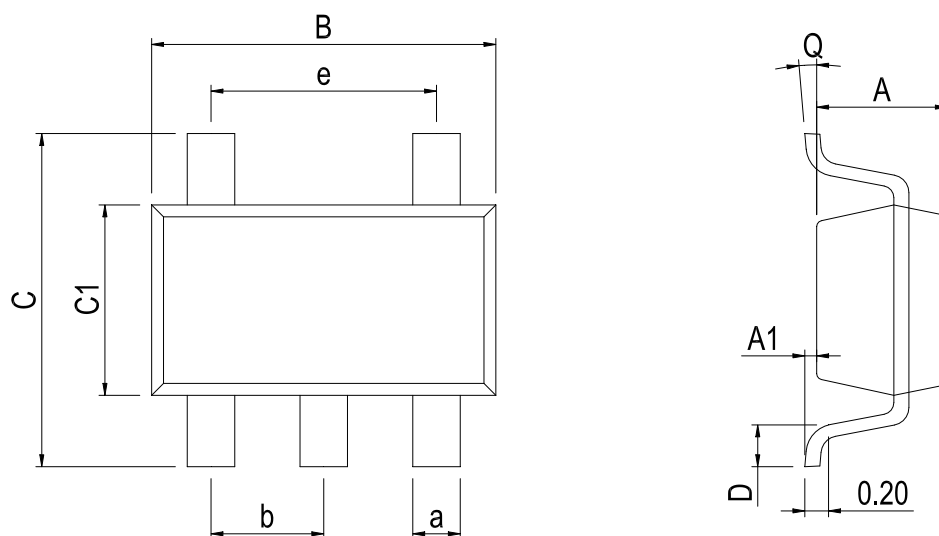
## Physical Dimensions

SOT-23-5



Dimensions In Millimeters(SOT23-5)										
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

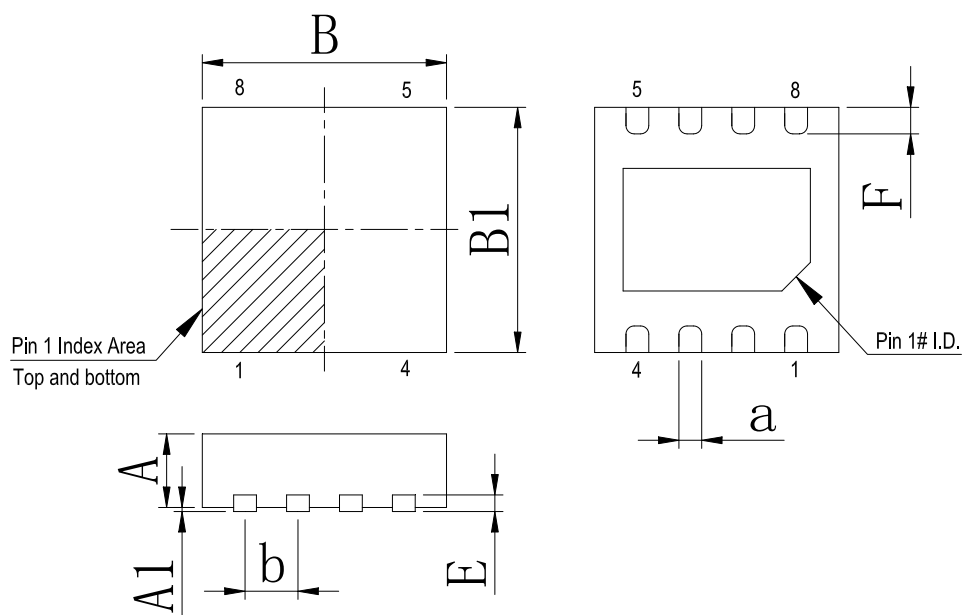


Dimensions In Millimeters(SC70-5)										
Symbol:	A	A1	B	C	C1	D	Q	a	b	e
Min:	0.90	0.00	2.00	2.15	1.15	0.26	0°	0.15	0.65 BSC	1.30 BSC
Max:	1.00	0.15	2.20	2.45	1.35	0.46	8°	0.35		



## Physical Dimensions

DFN-8 2\*2



Dimensions In Millimeters(DFN-8 2*2)								
Symbol:	A	A1	B	B1	E	F	a	b
Min:	0.85	0	1.90	1.90	0.15	0.25	0.18	0.50TYP
Max:	0.95	0.05	2.10	2.10	0.25	0.45	0.30	

## Revision History

DATE	REVISION	PAGE
2020-6-9	New	1-17
2023-10-30	Update Lead Temperature、Update encapsulation type、Update SC70-5 Physical Dimensions	3、 1、 14

**IMPORTANT STATEMENT:**

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