

### Features

- Single-Supply Operation from +1.8V ~ +5.5V
- Rail-to-Rail Input / Output
- Gain-Bandwidth Product: 1MHz (Typ)
- Low Input Bias Current: 5pA (Typ)
- Low Offset Voltage: 400μV (Max)
- Quiescent Current: 65μA per Amplifier (Typ)
- Embedded RF Anti-EMI Filter
- Operating Temperature: -40°C ~ +125°C
- Small Package:  
GS6011A/YA Available in SOT23-5 and SC70-5 Packages

### General Description

The GS6011A/YA have a high gain-bandwidth product of 1MHz, a slew rate of 0.7V/μs. and a quiescent current of 65μA/amplifier at 5V. The GS6011A/YA 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 400μV for GS6011A/YA. They are specified over the extended industrial temperature range (-40°C to +125°C). The operating range is from 1.8V to 5.5V. The GS6011A/YA is available in Green SC70-5 and SOT23-5 packages.

### Applications

- ASIC Input or Output Amplifier
- Sensor Interface
- Medical Communication
- Smoke Detectors
- Audio Output
- Piezoelectric Transducer Amplifier
- Medical Instrumentation
- Portable Systems

### Pin Configuration

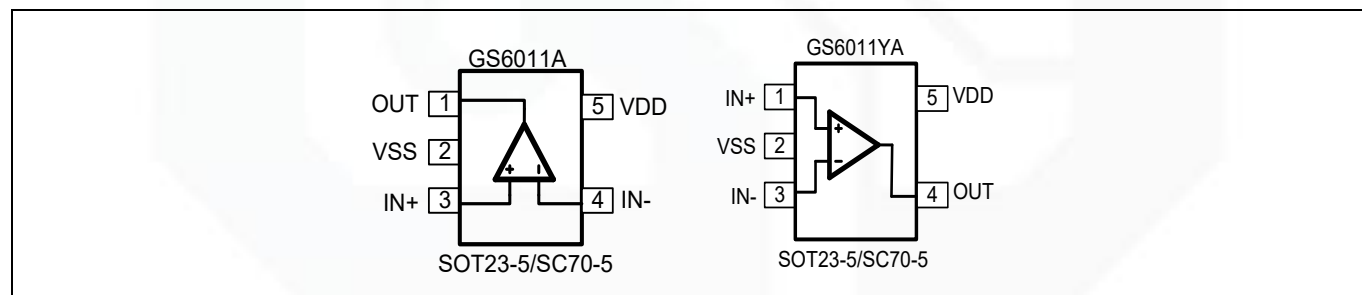


Figure 1. Pin Assignment Diagram

### Package/Ordering Information

MODEL	CHANNEL	ORDER NUMBER	PACKAGE	OPTION	MARKING
GS6011A/YA	Single	GS6011A-CR	SC70-5	Tape and Reel,3000	6011A
		GS6011A-TR	SOT23-5	Tape and Reel,3000	6011A
		GS6011YA-CR	SC70-5	Tape and Reel,3000	6011YA
		GS6011YA-TR	SOT23-5	Tape and Reel,3000	6011YA

## Absolute Maximum Ratings

Condition	Min	Max
Power Supply Voltage (V <sub>DD</sub> to V <sub>SS</sub> )	-0.5V	+8V
Analog Input Voltage (IN+ or IN-)	V <sub>SS</sub> -0.5V	V <sub>DD</sub> +0.5V
PDB Input Voltage	V <sub>SS</sub> -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)	+260°C	
Package Thermal Resistance (T <sub>A</sub> =+25°C)		
SOT23-5, θ <sub>JA</sub>	190°C/W	
SC70-5, θ <sub>JA</sub>	333°C/W	
ESD Susceptibility		
HBM	±7KV	
CDM	±2KV	
Latch up	±500mA	

**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

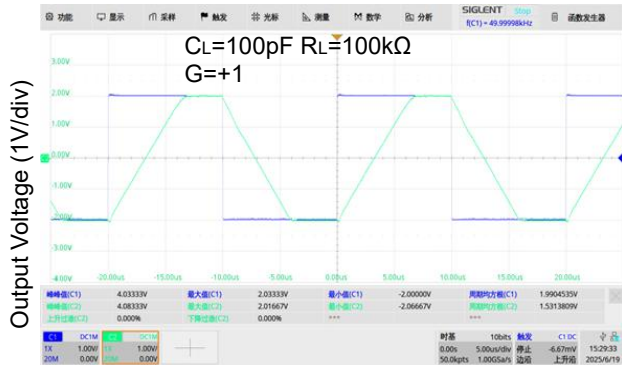
(At  $V_S = +5V$ ,  $R_L = 100k\Omega$  connected to  $V_S/2$ , and  $V_{OUT} = V_S/2$ ,  $T_A = 25^\circ C$ , unless otherwise noted.)

PARAMETER	SYMBOL	CONDITIONS				
			TYP	MAX	MIN	UNITS
INPUT CHARACTERISTICS						
Input Offset Voltage	V <sub>OS</sub>	V <sub>CM</sub> = 0V to (V <sub>S</sub> -1.2V)	50	400	-400	μV
Input Bias Current	I <sub>B</sub>		5			pA
Input Offset Current	I <sub>OS</sub>		1			pA
Common-Mode Voltage Range	V <sub>CM</sub>	V <sub>S</sub> = 5.5V	-0.1 to +5.6			V
Common-Mode Rejection Ratio	CMRR	V <sub>S</sub> = 5.5V, V <sub>CM</sub> = -0.1V to 4V	110		62	dB
		V <sub>S</sub> = 5.5V, V <sub>CM</sub> = -0.1V to 5.6V	78		56	
Open-Loop Voltage Gain	A <sub>OL</sub>	R <sub>L</sub> = 5kΩ, V <sub>O</sub> = +0.1V to +4.9V	80		70	dB
		R <sub>L</sub> = 10kΩ, V <sub>O</sub> = +0.1V to +4.9V	100		94	
Input Offset Voltage Drift	ΔV <sub>OS</sub> /ΔT		2.7			μV/°C
OUTPUT CHARACTERISTICS						
Output Voltage Swing from Rail	V <sub>OH</sub>	R <sub>L</sub> = 100kΩ	4.997			mV
	V <sub>OL</sub>	R <sub>L</sub> = 100kΩ	5	30		mV
	V <sub>OH</sub>	R <sub>L</sub> = 10kΩ	4.992			mV
	V <sub>OL</sub>	R <sub>L</sub> = 10kΩ	8	30		mV
Output Current	I <sub>SINK</sub>	R <sub>L</sub> = 10Ω to V <sub>S</sub> /2	60		40	mA
	I <sub>SOURCE</sub>		60		40	
POWER SUPPLY						
Operating Voltage Range					1.8	V
				5.5		V
Power Supply Rejection Ratio	PSRR	V <sub>S</sub> = +2V to +5V, V <sub>CM</sub> = +0.5V	95		60	dB
Quiescent Current / Amplifier	I <sub>Q</sub>		65			μA
DYNAMIC PERFORMANCE (CL = 100pF)						
Gain-Bandwidth Product	GBP		1			MHz
Slew Rate	SR	G = +1, 2V Output Step	0.7			V/μs
Settling Time to 0.1%	t <sub>s</sub>	G = +1, 2V Output Step	3.6			μs
Overload Recovery Time		V <sub>IN</sub> · Gain = V <sub>S</sub>	2.6			μs
NOISE PERFORMANCE						
Voltage Noise Density	e <sub>n</sub>	f = 1kHz	27			nV / √Hz
		f = 10kHz	20			nV / √Hz

## Typical Performance characteristics

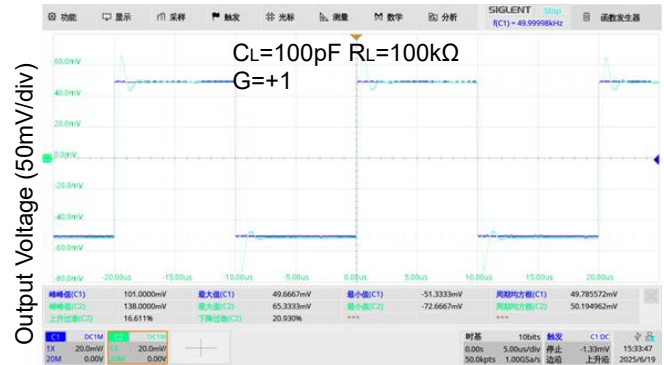
At  $T_A=+25^{\circ}\text{C}$ ,  $V_S=5\text{V}$ ,  $R_L=100\text{k}\Omega$  connected to  $V_S/2$  and  $V_{OUT}=V_S/2$ , unless otherwise noted.

Large Signal Transient Response



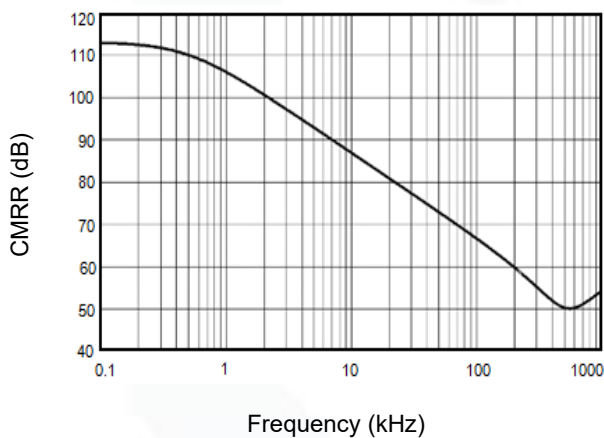
Time(5μs/div)

Small Signal Transient Response

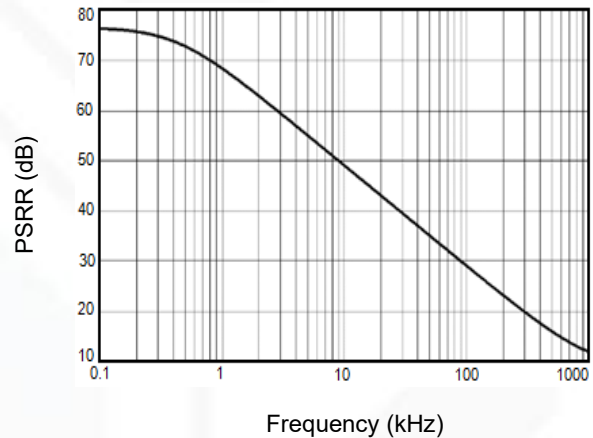


Time(5μs/div)

CMRR vs. Frequency



PSRR vs. Frequency

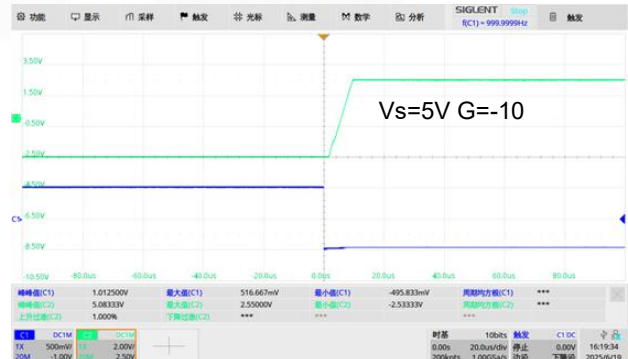


Overload Recovery Time



Time(20μs/div)

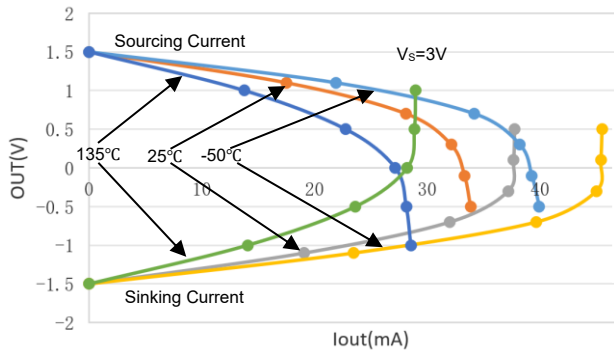
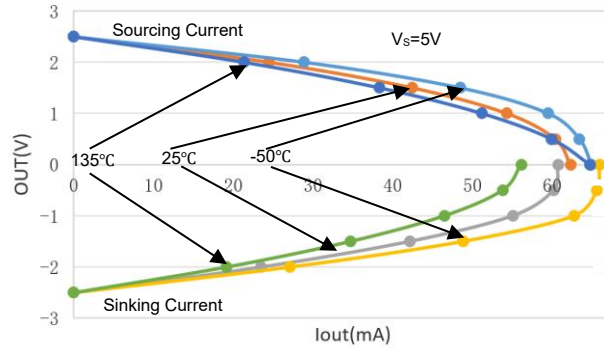
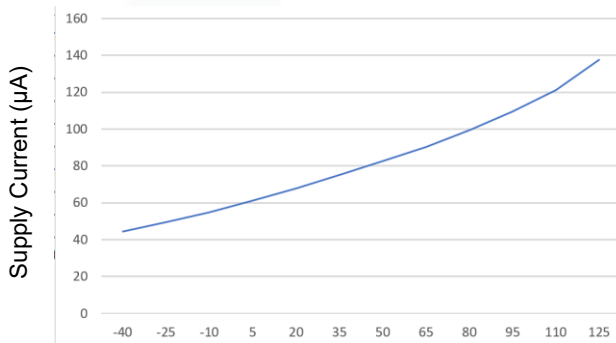
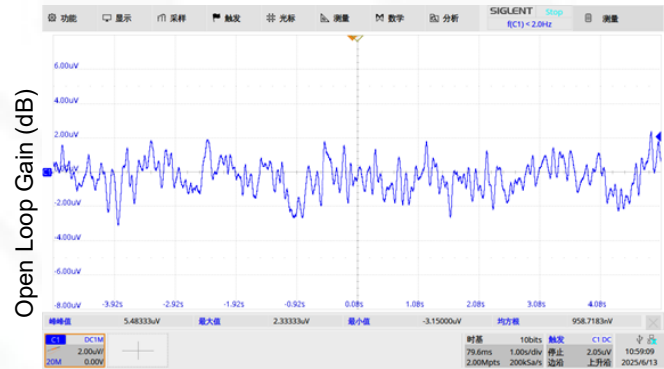
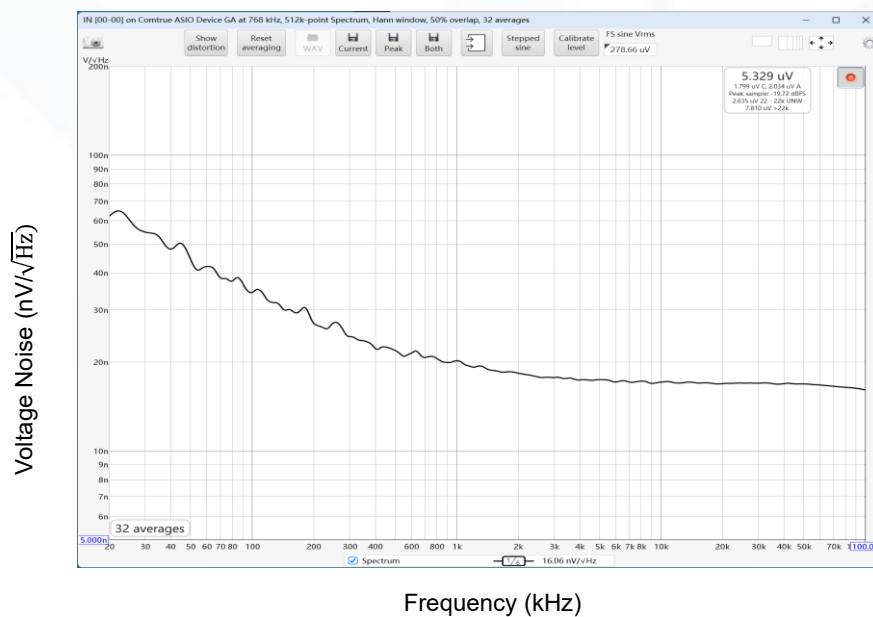
Overload Recovery Time



Time(20μs/div)

## Typical Performance characteristics

At  $T_A=+25^{\circ}\text{C}$ ,  $R_L=100\text{K}\Omega$  connected to  $V_S/2$  and  $V_{OUT}=V_S/2$ , unless otherwise noted.

**Vout VS Iout**

**Vout VS Iout**

**Supply Current vs. Temperature**

**Open Loop Gain, Phase Shift vs. Frequency**

**Temperature ( $^{\circ}\text{C}$ )**
**Frequency (kHz)**
**Input Voltage Noise Spectral Density vs. Frequency**


## Application Note

### Size

GS6011A/YA series op amps are unity-gain stable and suitable for a wide range of general-purpose applications. The small footprints of the GS6011A/YA packages save space on printed circuit boards and enable the design of smaller electronic products.

### Power Supply Bypassing and Board Layout

GS6011A/YA series operates from a single 1.8V to 5.5V supply or dual  $\pm 0.9V$  to  $\pm 2.75V$  supplies. For best performance, a  $0.1\mu F$  ceramic capacitor should be placed close to the  $V_{DD}$  pin in single supply operation. For dual supply operation, both  $V_{DD}$  and  $V_{SS}$  supplies should be bypassed to ground with separate  $0.1\mu F$  ceramic capacitors.

### Low Supply Current

The low supply current (typical  $65\mu A$  per channel) of GS6011A/YA will help to maximize battery life. They are ideal for battery powered systems.

### Operating Voltage

GS6011A/YA operates under wide input supply voltage (1.8V to 5.5V). In addition, all temperature specifications apply from  $-40^\circ C$  to  $+125^\circ C$ . 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 GS6011A/YA extends  $100mV$  beyond the supply rails ( $V_{SS}-0.1V$  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 GS6011A/YA can typically swing to less than  $10mV$  from supply rail in light resistive loads ( $>100k\Omega$ ), and  $30mV$  of supply rail in moderate resistive loads ( $10k\Omega$ ).

### Capacitive Load Tolerance

The GS6011A/YA 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.

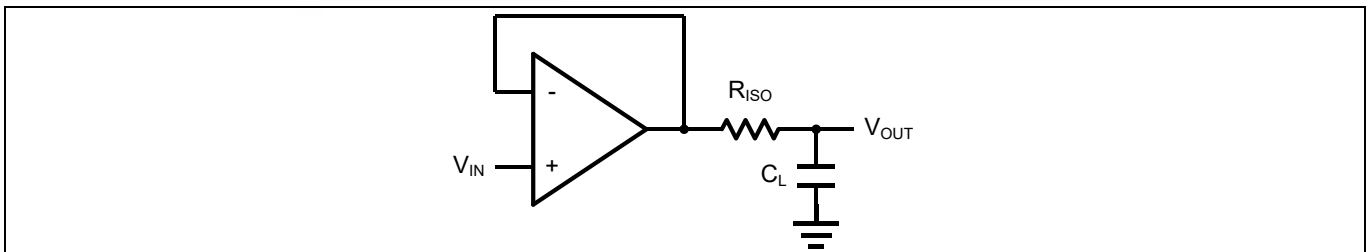


Figure 2 Indirectly Driving a Capacitive Load Using Isolation Resistor

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.

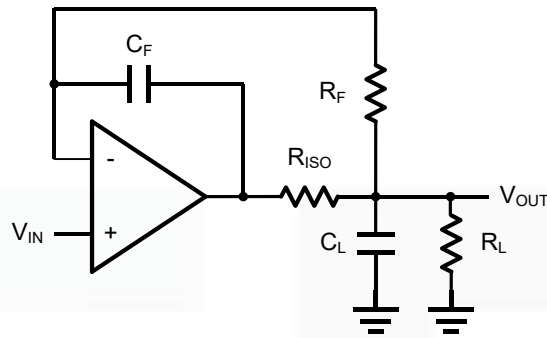


Figure 3. Indirectly Driving a Capacitive Load with DC Accuracy

## 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. shown the differential amplifier using GS6011A/YA.

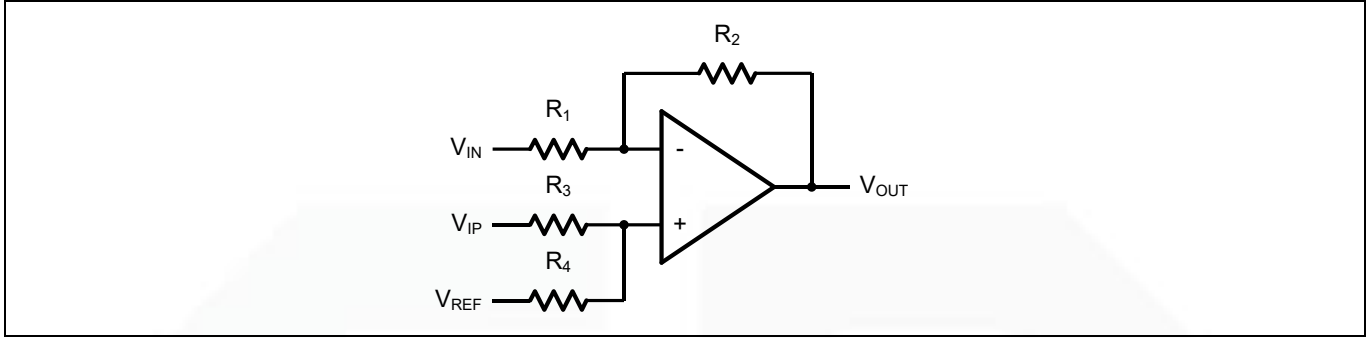


Figure 4. Differential Amplifier

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

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  $f_c = 1/(2\pi R_3 C_1)$ .

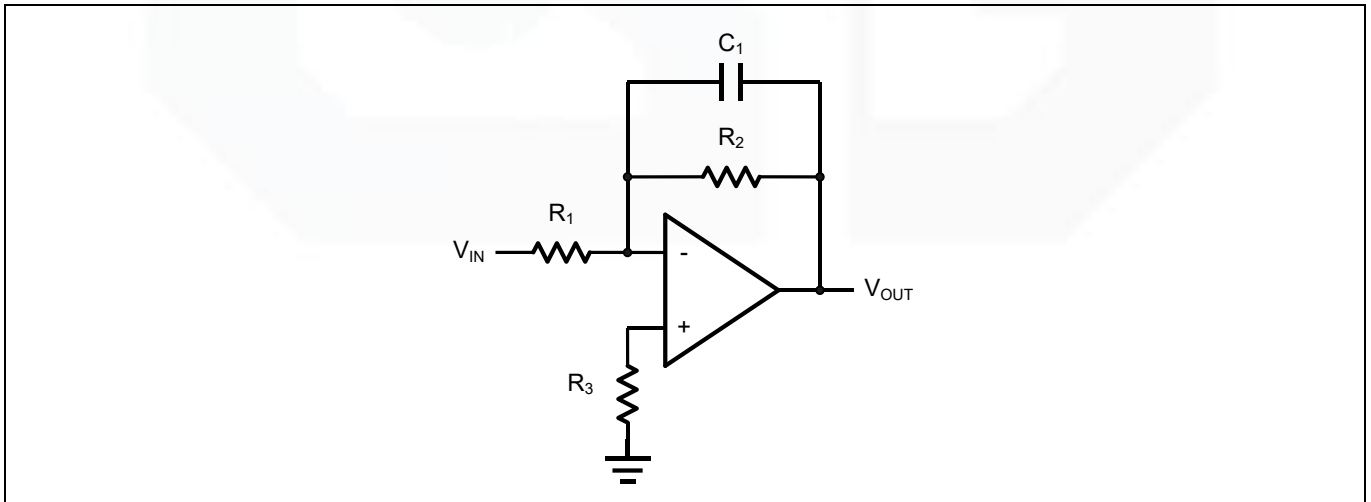


Figure 5. Low Pass Active Filter



### Instrumentation Amplifier

The triple GS6011A/YA 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  $R_2/R_1$ . The two differential voltage followers assure the high input impedance of the amplifier.

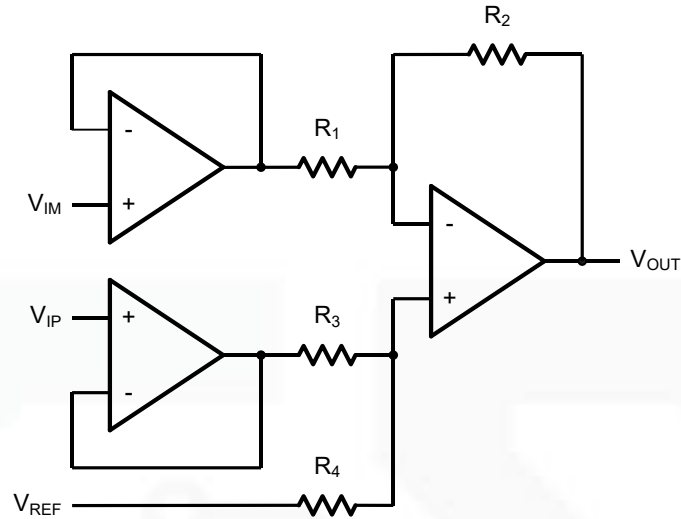
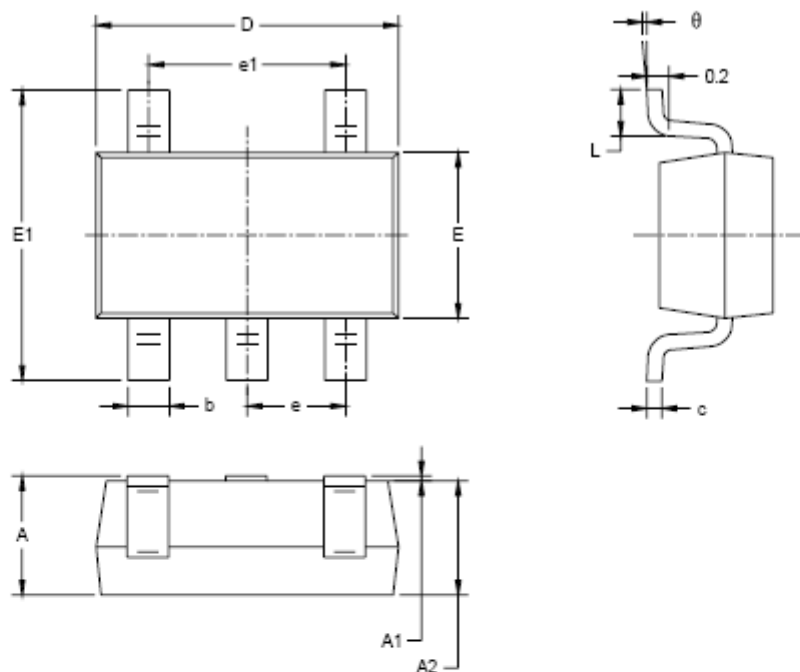


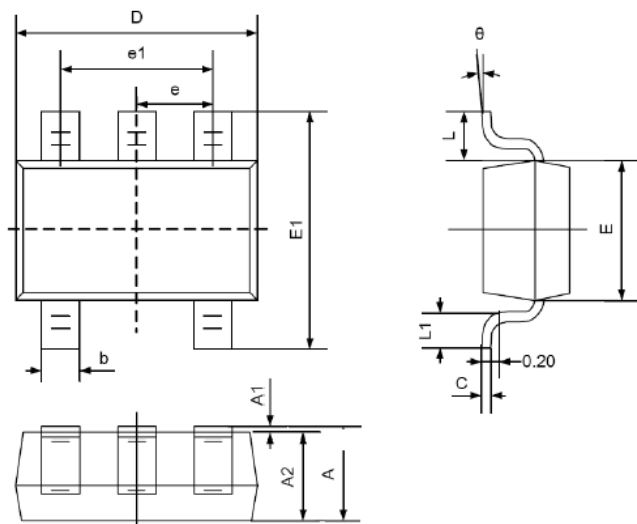
Figure 6. Instrument Amplifier

## Package Information

### SOT23-5



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	0.500	0.012	0.020
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	0.950 BSC		0.037 BSC	
e1	1.900 BSC		0.075 BSC	
L	0.300	0.600	0.012	0.024
θ	0°	8°	0°	8°

**SC70-5**


Symbol	Dimensions In Millimeters		Dimensions In Inches	
	Min	Max	Min	Max
A	0.900	1.100	0.035	0.043
A1	0.000	0.100	0.000	0.004
A2	0.900	1.000	0.035	0.039
b	0.150	0.350	0.006	0.014
C	0.080	0.150	0.003	0.006
D	2.000	2.200	0.079	0.087
E	1.150	1.350	0.045	0.053
E1	2.150	2.450	0.085	0.096
e	0.650TYP		0.026TYP	
e1	1.200	1.400	0.047	0.055
L	0.525REF		0.021REF	
L1	0.260	0.460	0.010	0.018
θ	0°	8°	0°	8°