



# SGM321/SGM358/SGM324 1MHz, 60µA, Rail-to-Rail I/O CMOS Operational Amplifiers

## PRODUCT DESCRIPTION

The SGM321(single), SGM358(dual) and SGM324(quad) are rail-to-rail input and output voltage feedback amplifiers offering low cost. They have a wide input common-mode voltage range and output voltage swing, and take the minimum operating supply voltage down to 2.1V and the maximum recommended supply voltage is 5.5V. All are specified over the extended  $-40^{\circ}\text{C}$  to  $+85^{\circ}\text{C}$  temperature range.

The SGM321/358/324 provide 1MHz bandwidth at a low current consumption of 60µA per amplifier. Very low input bias currents of 10pA enable SGM321/358/324 to be used for integrators, photodiode amplifiers, and piezoelectric sensors. Rail-to-rail inputs and outputs are useful to designers buffering ASIC in single-supply systems.

Applications for the series amplifiers include safety monitoring, portable equipment, battery and power supply control, and signal conditioning and interfacing for transducers in very low power systems.

The SGM321 is available in SOT23-5 and SC70-5 packages. The SGM358 comes in SO-8, MSOP-8 and DIP-8 packages. The SGM324 is offered in SO-14 and TSSOP-14 packages.

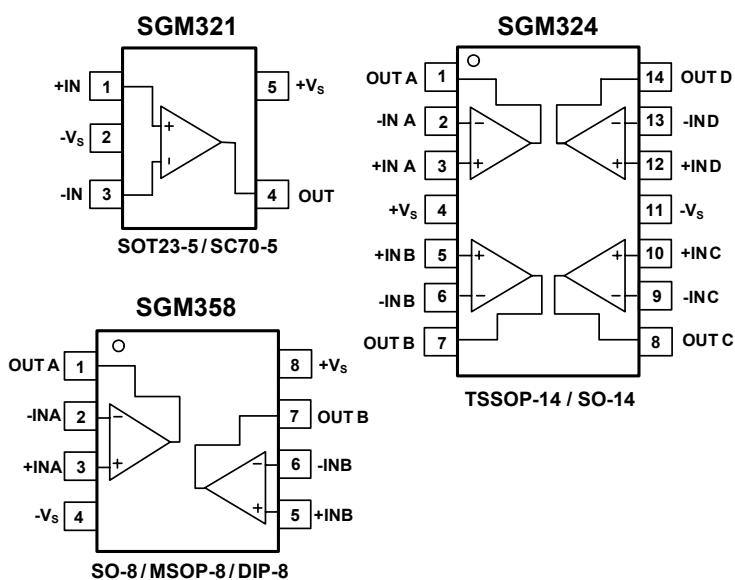
## APPLICATIONS

- ASIC Input or Output Amplifier
- Sensor Interface
- Piezo Electric Transducer Amplifier
- Medical Instrumentation
- Mobile Communication
- Audio Output
- Portable Systems
- Smoke Detectors
- Notebook PC
- PCMCIA Cards
- Battery –Powered Equipment
- DSP Interface

## FEATURES

- Low Cost
- Rail-to-Rail Input and Output  
0.8mV Typical  $V_{OS}$
- Unity Gain Stable
- Gain Bandwidth Product: 1MHz
- Very Low Input Bias Currents: 10pA
- Operates on 2.1V to 5.5V Supplies
- Input Voltage Range:  
 $-0.1\text{V}$  to  $+5.6\text{V}$  with  $V_S = 5.5\text{V}$
- Low Supply Current: 60µA/Amplifier
- Small Packaging  
SGM321 Available in SOT23-5 and SC70-5  
SGM358 Available in SO-8, MSOP-8 and DIP-8  
SGM324 Available in SO-14 and TSSOP-14

## PIN CONFIGURATIONS (Top View)



**PACKAGE/ORDERING INFORMATION**

MODEL	ORDER NUMBER	PACKAGE DESCRIPTION	PACKAGE OPTION	MARKING INFORMATION
SGM321	SGM321YC5/TR	SC70-5	Tape and Reel, 3000	321
	SGM321YN5/TR	SOT23-5	Tape and Reel, 3000	321
SGM358	SGM358YS/TR	SO-8	Tape and Reel, 2500	SGM358YS
	SGM358YMS/TR	MSOP-8	Tape and Reel, 3000	SGM358YMS
	SGM358YP	DIP-8	Tube, 50	SGM358YP
SGM324	SGM324YS14/TR	SO-14	Tape and Reel, 2500	SGM324YS14
	SGM324YTS14/TR	TSSOP-14	Tape and Reel, 3000	SGM324YTS14

Note: SC70-5 package is same as SOT-353 package.

**ABSOLUTE MAXIMUM RATINGS**

Supply Voltage, V+ to V-.....	7.5V	SOT23-5, $\theta_{JA}$ .....	190°C/W
Common-Mode Input Voltage ..... (-V <sub>S</sub> ) - 0.5V to (+V <sub>S</sub> ) + 0.5V		SO-8, $\theta_{JA}$ .....	125°C/W
Storage Temperature Range.....	-65°C to +150°C	MSOP-8, $\theta_{JA}$ .....	216°C/W
Junction Temperature.....	160°C	Lead Temperature Range (Soldering 10 sec).....	260°C
Operating Temperature Range.....	-45°C to +85°C	ESD Susceptibility	
Package Thermal Resistance @ T <sub>A</sub> = 25°C		HBM.....	4000V
SC70-5, $\theta_{JA}$ .....	333°C/W	MM.....	400V

**NOTE:**

Stresses above those listed under Absolute Maximum Ratings may cause permanent damage to the device. This is a stress rating only; functional operation of the device at these or any other conditions above those indicated in the operational section of this specification is not implied. Exposure to absolute maximum rating conditions for extended periods may affect device reliability.

**CAUTION**

This integrated circuit can be damaged by ESD if you don't pay attention to ESD protection. SGMICRO recommends that all integrated circuits be handled with appropriate precautions. Failure to observe proper handling and installation procedures can cause damage.

ESD damage can range from subtle performance degradation to complete device failure. Precision integrated circuits may be more susceptible to damage because very small parametric changes could cause the device not to meet its published specifications.

**ELECTRICAL CHARACTERISTICS:  $V_S = +5V$**

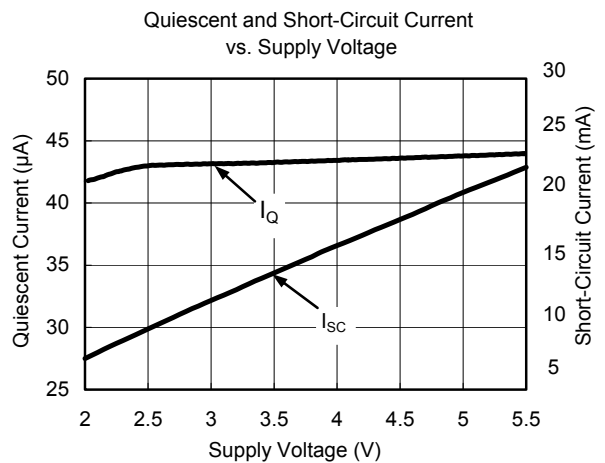
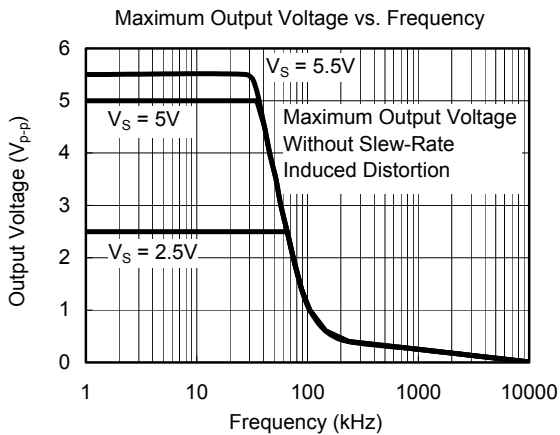
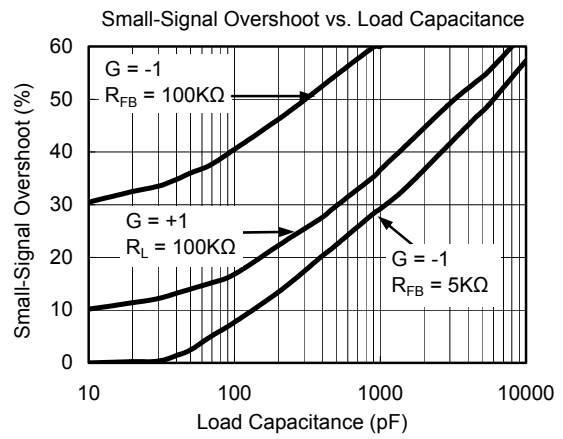
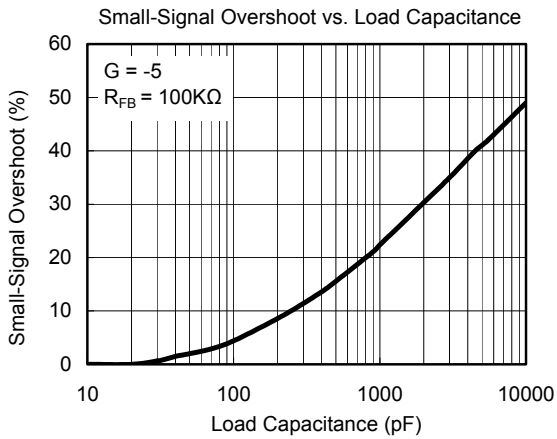
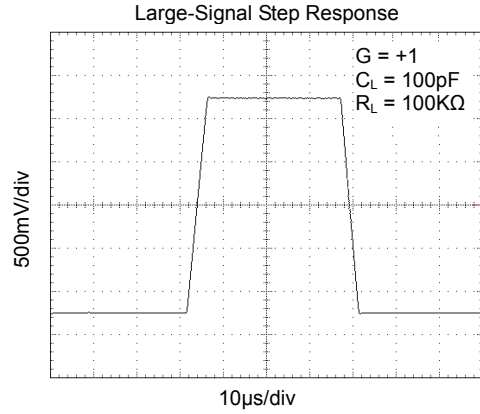
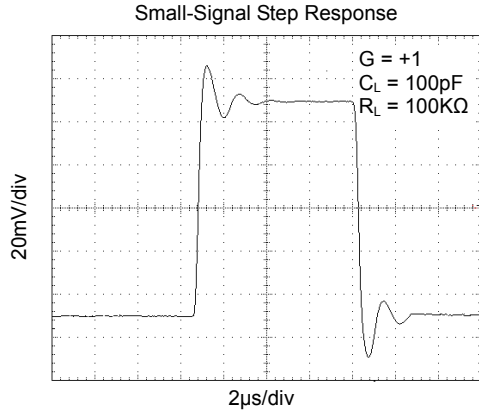
(At  $R_L = 100K\Omega$  connected to  $V_S/2$ , and  $V_{OUT} = V_S/2$ , unless otherwise noted.)

PARAMETER	CONDITIONS	SGM321/358/324				
		TYP	MIN/MAX OVER TEMPERATURE			
		+25°C	+25°C	-40°C to 85°C	UNITS	MIN/MAX
<b>INPUT CHARACTERISTICS</b>						
Input Offset Voltage ( $V_{OS}$ )		±0.8	±5	±5.6	mV	MAX
Input Bias Current ( $I_B$ )		10			pA	TYP
Input Offset Current ( $I_{OS}$ )		10			pA	TYP
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	70	62	62	dB	MIN
	$V_S = 5.5V, V_{CM} = -0.1V$ to 5.6V	68	56	55	dB	MIN
Open-Loop Voltage Gain ( $A_{OL}$ )	$R_L = 5K\Omega, V_o = 0.1V$ to 4.9V	80	70	70	dB	MIN
	$R_L = 100K\Omega, V_o = 0.035V$ to 4.965V	84	80	80	dB	MIN
Input Offset Voltage Drift ( $\Delta V_{OS}/\Delta T$ )		2.7			µV/°C	TYP
<b>OUTPUT CHARACTERISTICS</b>						
Output Voltage Swing from Rail	$R_L = 100K\Omega$	0.008			V	TYP
	$R_L = 10K\Omega$	0.08			V	TYP
Output Current ( $I_{OUT}$ )		23	20	18.8	mA	MIN
<b>POWER SUPPLY</b>						
Operating Voltage Range			2.1	2.5	V	MIN
			5.5	5.5	V	MAX
Power Supply Rejection Ratio (PSRR)	$V_S = +2.5V$ to + 5.5V $V_{CM} = (-V_S) + 0.5V$	82	60	58	dB	MIN
Quiescent Current / Amplifier ( $I_Q$ )	$I_{OUT} = 0$	60	80	86	µA	MAX
<b>DYNAMIC PERFORMANCE</b>						
Gain-Bandwidth Product (GBP)	$C_L = 100pF$	1			MHz	TYP
Slew Rate (SR)	$G = +1, 2V$ Output Step	0.52			V/µs	TYP
Settling Time to 0.1% ( $t_s$ )	$G = +1, 2V$ Output Step	5.3			µs	TYP
Overload Recovery Time	$V_{IN} \cdot Gain = V_S$	2.6			µs	TYP
<b>NOISE PERFORMANCE</b>						
Voltage Noise Density ( $e_n$ )	$f = 1kHz$	27			nV/√Hz	TYP
	$f = 10kHz$	20			nV/√Hz	TYP

Specifications subject to changes without notice.

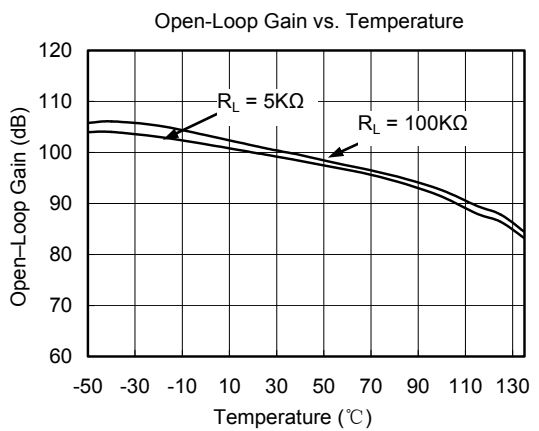
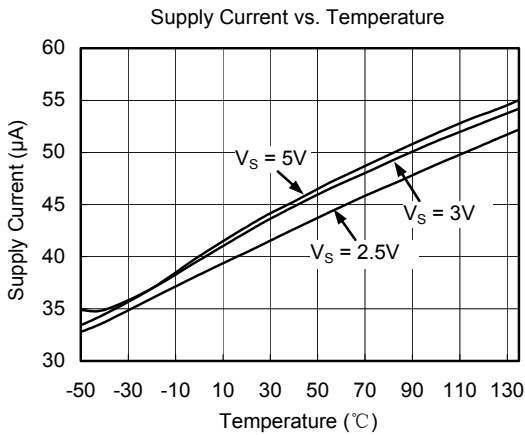
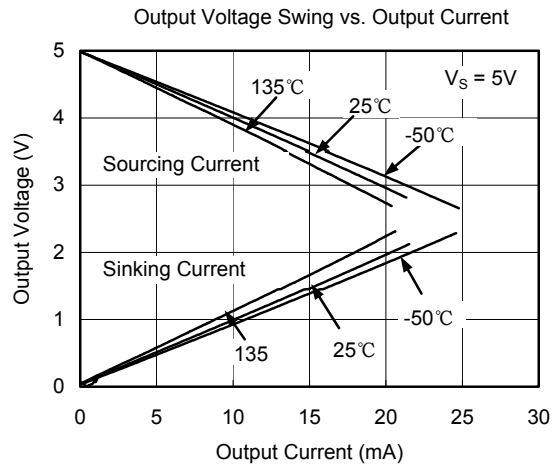
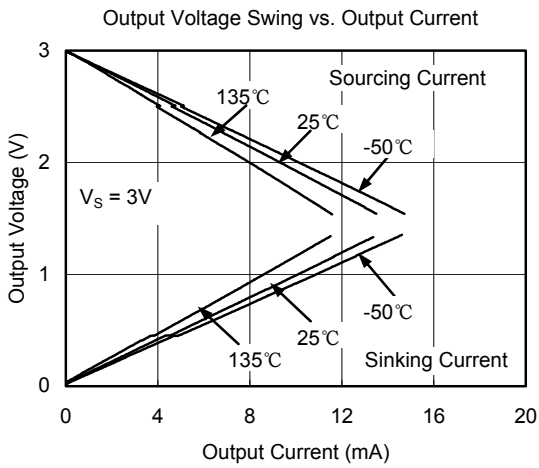
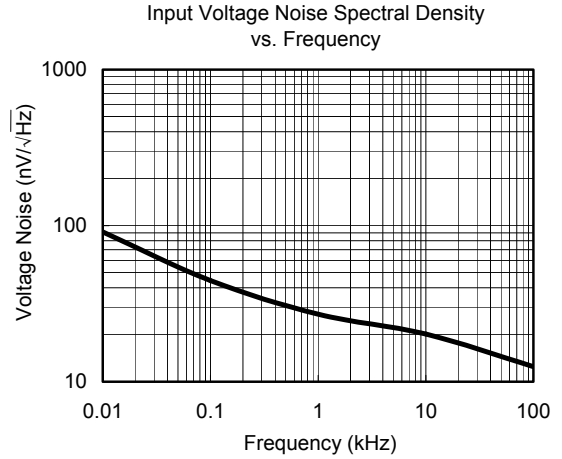
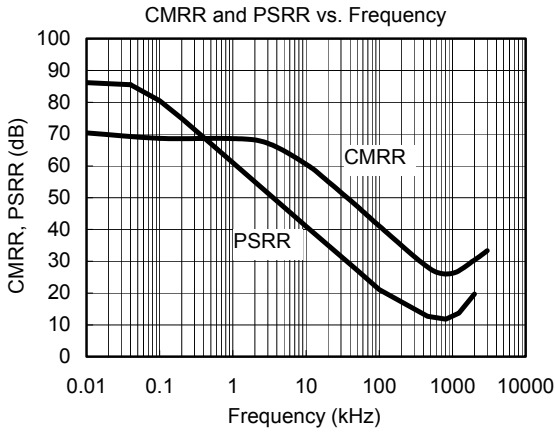
TYPICAL PERFORMANCE CHARACTERISTICS

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



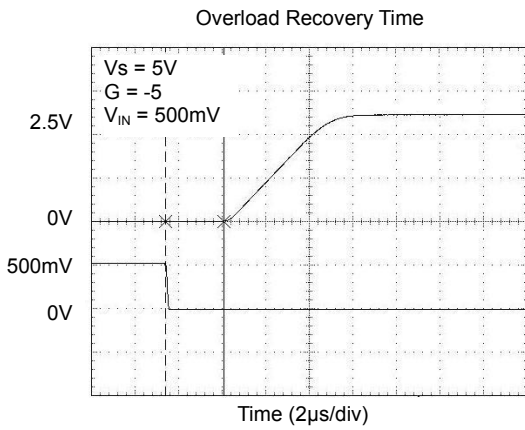
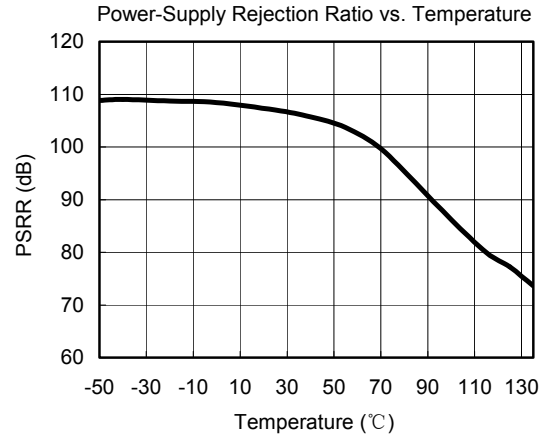
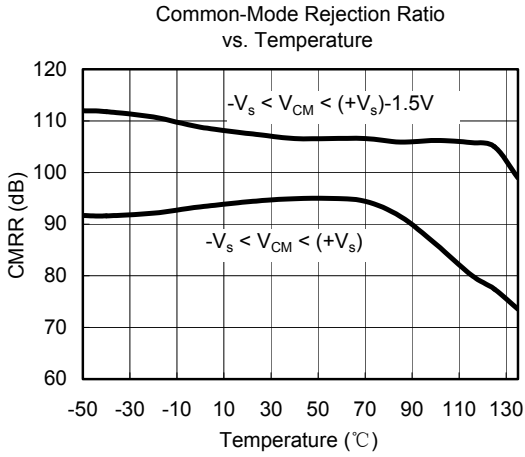
**TYPICAL PERFORMANCE CHARACTERISTICS**

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



**TYPICAL PERFORMANCE CHARACTERISTICS**

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



**APPLICATION NOTES**

**Driving Capacitive Loads**

The SGM3XX can directly drive 250pF in unity-gain without oscillation. The unity-gain follower (buffer) is the most sensitive configuration to capacitive loading. Direct capacitive loading reduces the phase margin of amplifiers and this results in ringing or even oscillation. Applications that require greater capacitive drive capability should use an isolation resistor between the output and the capacitive load like the circuit in Figure 1. The isolation resistor  $R_{ISO}$  and the load capacitor  $C_L$  form a zero to increase stability. The bigger the  $R_{ISO}$  resistor value, the more stable  $V_{OUT}$  will be. Note that this method results in a loss of gain accuracy because  $R_{ISO}$  forms a voltage divider with the  $R_{LOAD}$ .

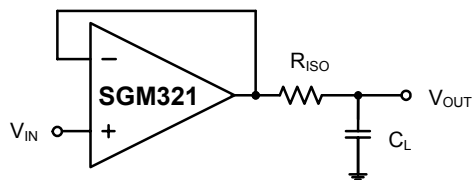


Figure 1. Indirectly Driving Heavy Capacitive Load

An improvement circuit is shown in Figure 2. It provides DC accuracy as well as AC stability.  $R_F$  provides the DC accuracy by connecting the inverting signal with the output.  $C_F$  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 phase margin in the overall feedback loop.

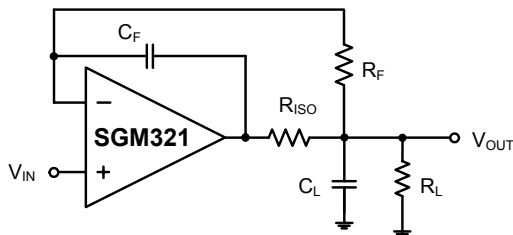


Figure 2. Indirectly Driving Heavy Capacitive Load with DC Accuracy

For no-buffer configuration, there are two others ways to increase the phase margin: (a) by increasing the amplifier's gain or (b) by placing a capacitor in parallel with the feedback resistor to counteract the parasitic capacitance associated with inverting node.

**Power-Supply Bypassing and Layout**

The SGM3XX family operates from either a single +2.5V to +5.5V supply or dual ±1.25V to ±2.75V supplies. For single-supply operation, bypass the power supply  $V_{DD}$  with a 0.1µF ceramic capacitor which should be placed close to the  $V_{DD}$  pin. For dual-supply operation, both the  $V_{DD}$  and the  $V_{SS}$  supplies should be bypassed to ground with separate 0.1µF ceramic capacitors. 2.2µF tantalum capacitor can be added for better performance.

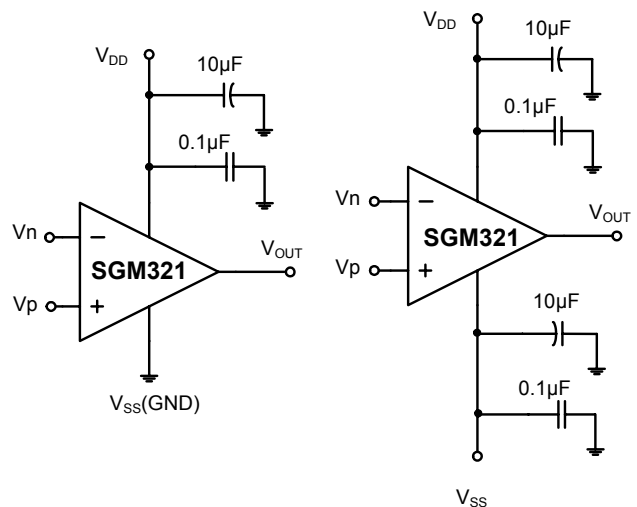


Figure 3. Amplifier with Bypass Capacitors

## TYPICAL APPLICATION CIRCUITS

### Differential Amplifier

The circuit shown in Figure 4 performs the difference function. If the resistors ratios are equal ( $R_4 / R_3 = R_2 / R_1$ ), then  $V_{OUT} = (V_p - V_n) \times R_2 / R_1 + V_{REF}$ .

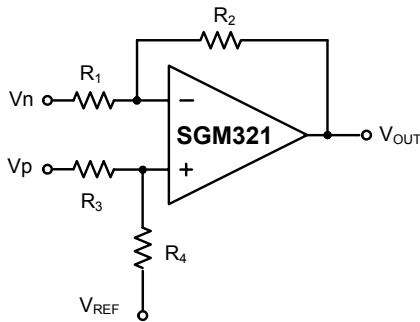


Figure 4. Differential Amplifier

### Instrumentation Amplifier

The circuit in Figure 5 performs the same function as that in Figure 4 but with the high input impedance.

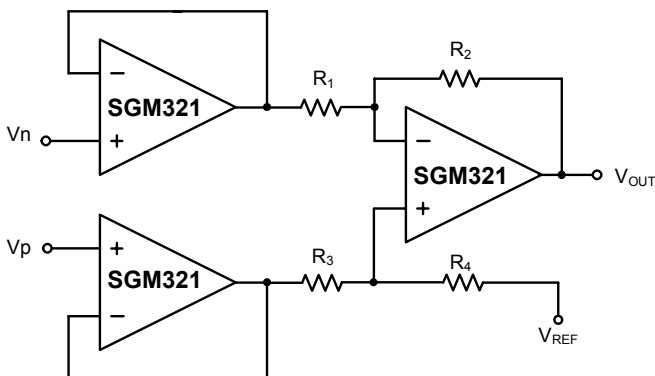


Figure 5. Instrumentation Amplifier

### Low Pass Active Filter

The low pass filter shown in Figure 6 has a DC gain of  $(-R_2 / R_1)$  and the  $-3\text{dB}$  corner frequency is  $1/2\pi R_2 C$ . Make sure the filter is within the bandwidth of the amplifier. The Large values of feedback resistors can couple with parasitic capacitance and cause undesired effects such as ringing or oscillation in high-speed amplifiers. Keep resistors value as low as possible and consistent with output loading consideration.

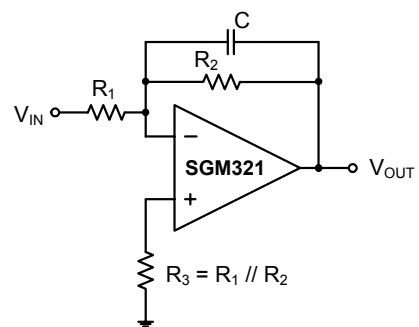
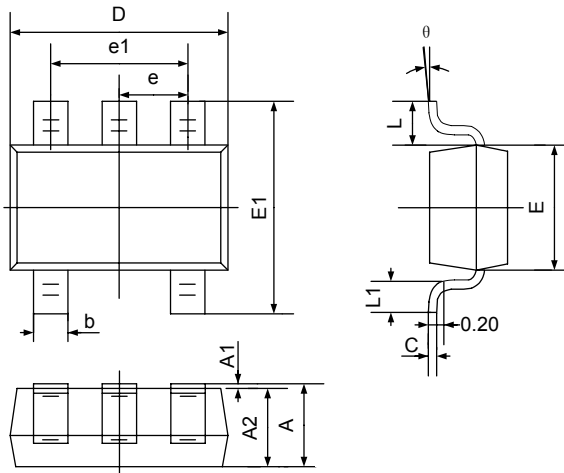


Figure 6. Low Pass Active Filter



PACKAGE OUTLINE DIMENSIONS

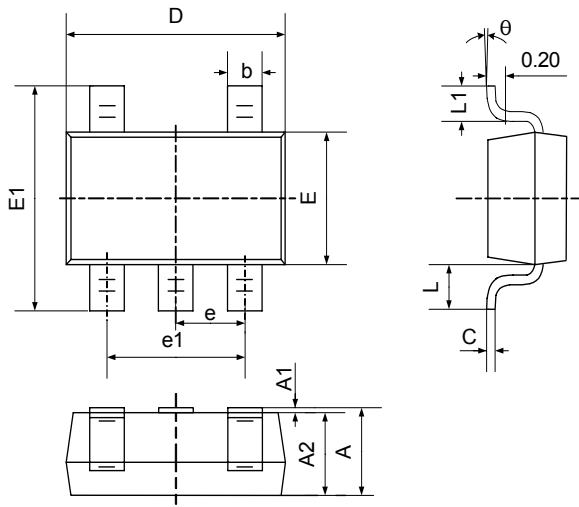
SC70-5 / SOT-353



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°	

PACKAGE OUTLINE DIMENSIONS

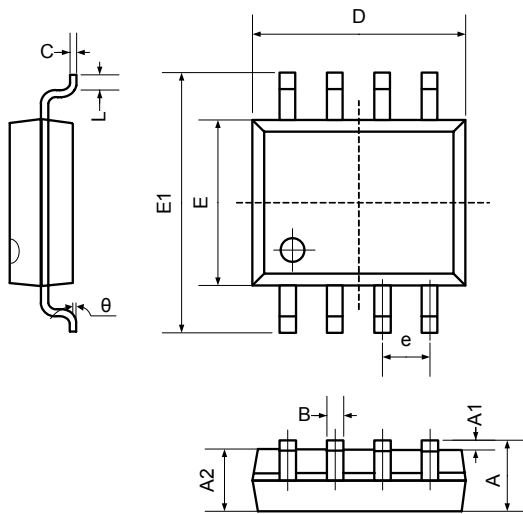
SOT23-5



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	0.400	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°

PACKAGE OUTLINE DIMENSIONS

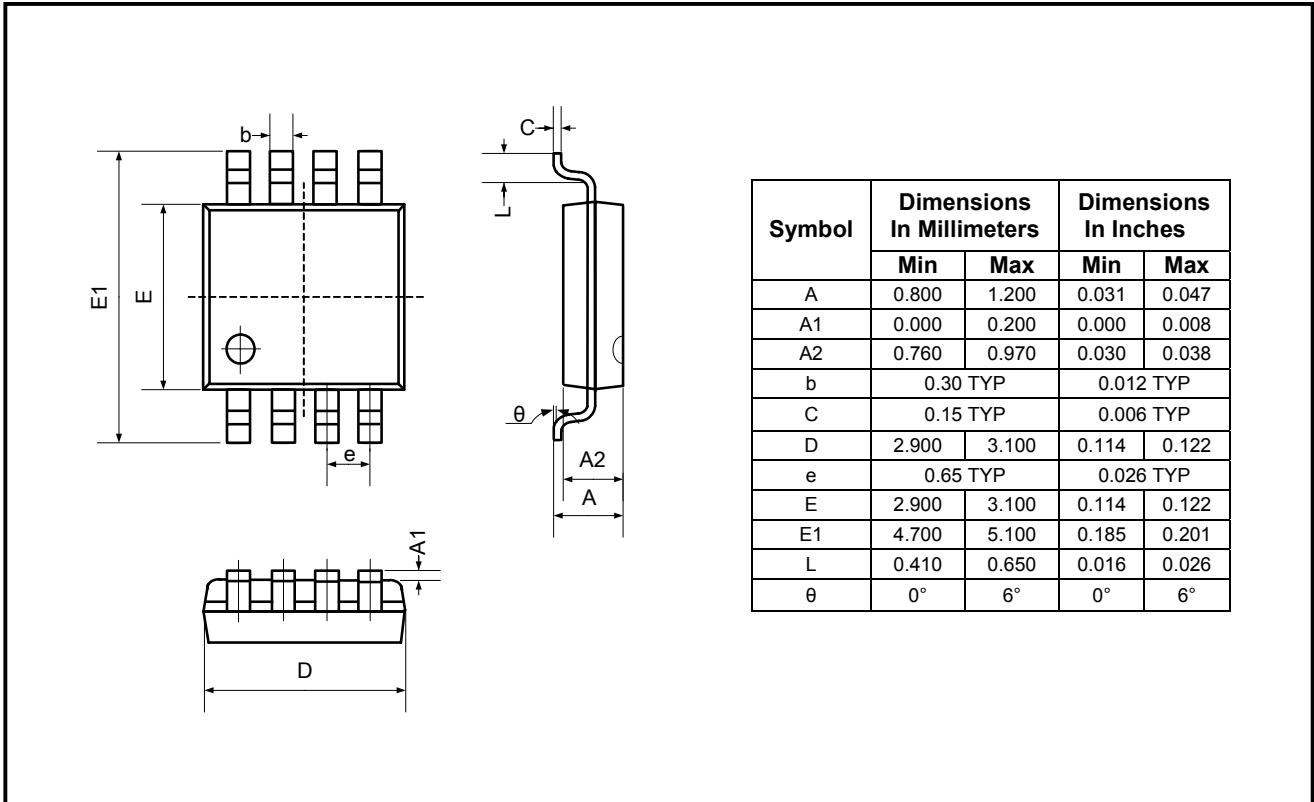
SO-8



Symbol	Dimensions In Millimeters		Dimensions In Inches	
	Min	Max	Min	Max
A	1.350	1.750	0.053	0.069
A1	0.100	0.250	0.004	0.010
A2	1.350	1.550	0.053	0.061
B	0.330	0.510	0.013	0.020
C	0.190	0.250	0.007	0.010
D	4.780	5.000	0.188	0.197
E	3.800	4.000	0.150	0.157
E1	5.800	6.300	0.228	0.248
e	1.270TYP		0.050TYP	
L	0.400	1.270	0.016	0.050
theta	0°	8°	0°	8°

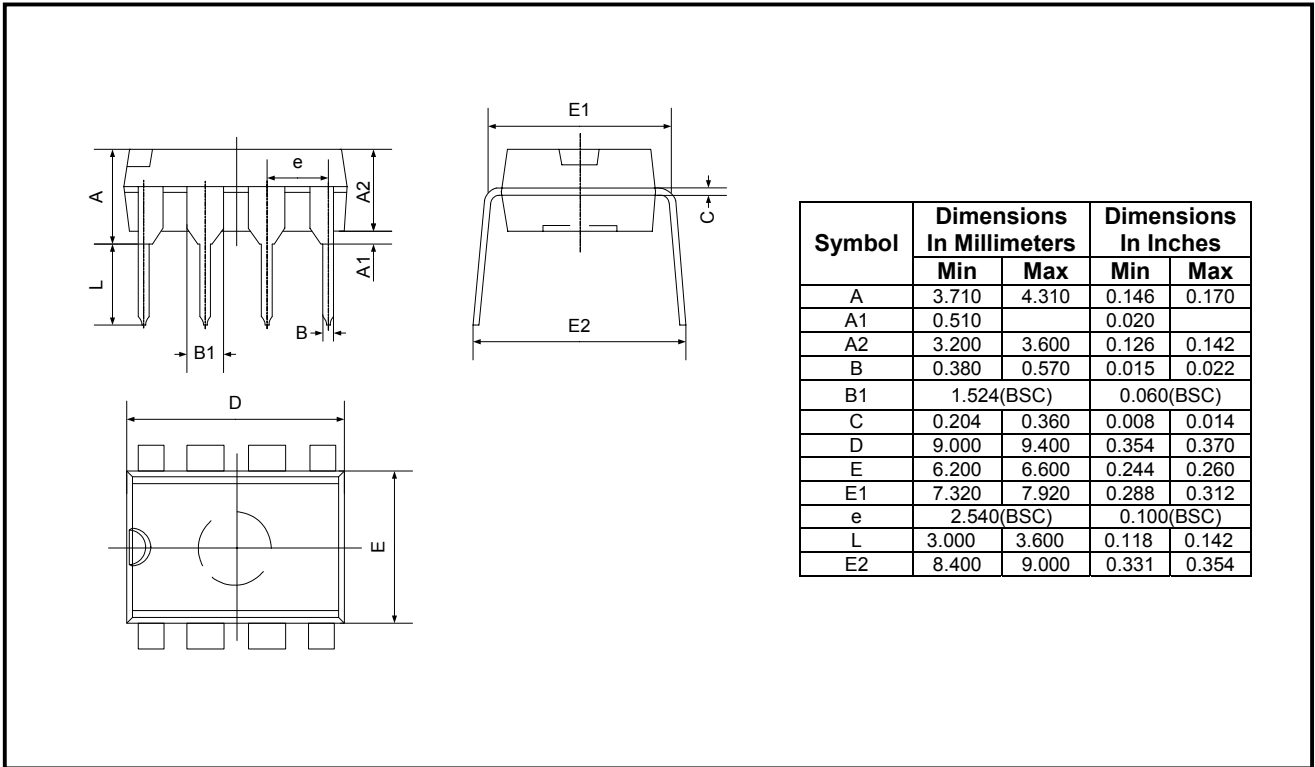
PACKAGE OUTLINE DIMENSIONS

MSOP-8



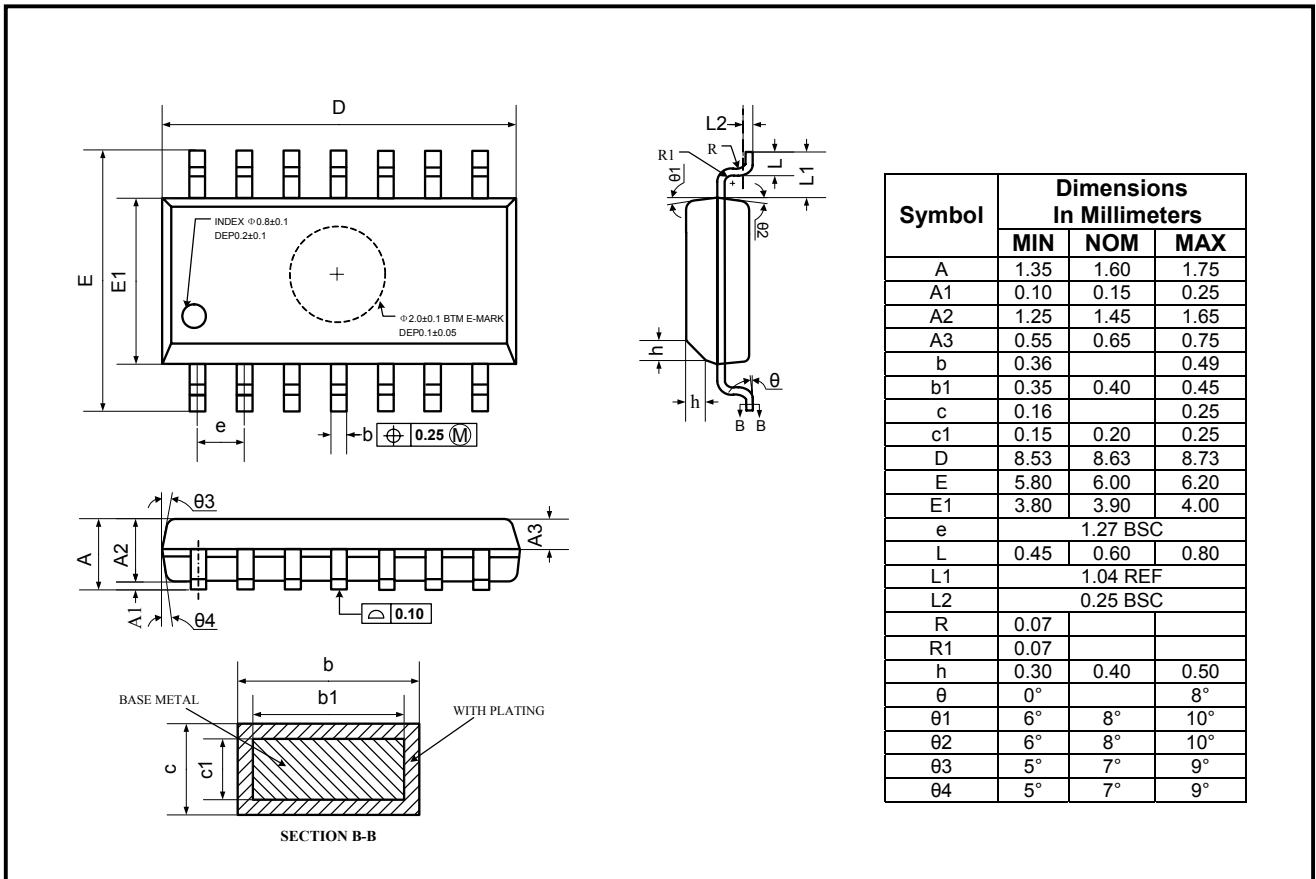
PACKAGE OUTLINE DIMENSIONS

DIP-8



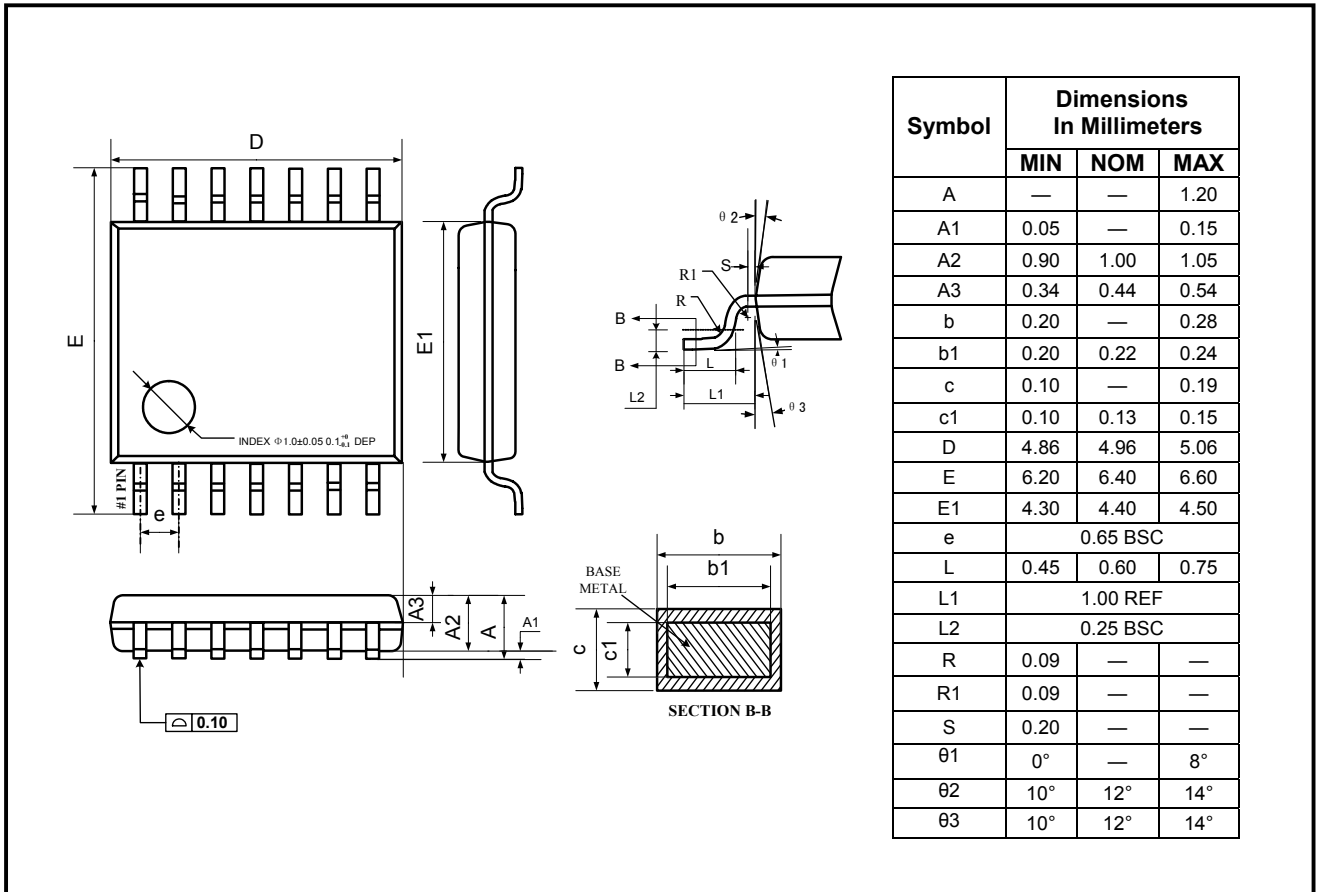
PACKAGE OUTLINE DIMENSIONS

SO-14



PACKAGE OUTLINE DIMENSIONS

TSSOP-14



03/2009 REV. D. 2

SGMICRO is dedicated to provide high quality and high performance analog IC products to customers. All SGMICRO products meet the highest industry standards with strict and comprehensive test and quality control systems to achieve world-class consistency and reliability.

For information regarding SGMICRO Corporation and its products, see [www.sg-micro.com](http://www.sg-micro.com)