

# SGM321 SGM358 SGM324

## 1MHz, 60µA, Rail-to-Rail I/O CMOS Operational Amplifier

### 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 5.5 V. All are specified over the extended - 40°C to +85°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 PDIP-8 packages. The SGM324 is offered in SO-14, TSSOP-14, TSSOP-16 and SO-16 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

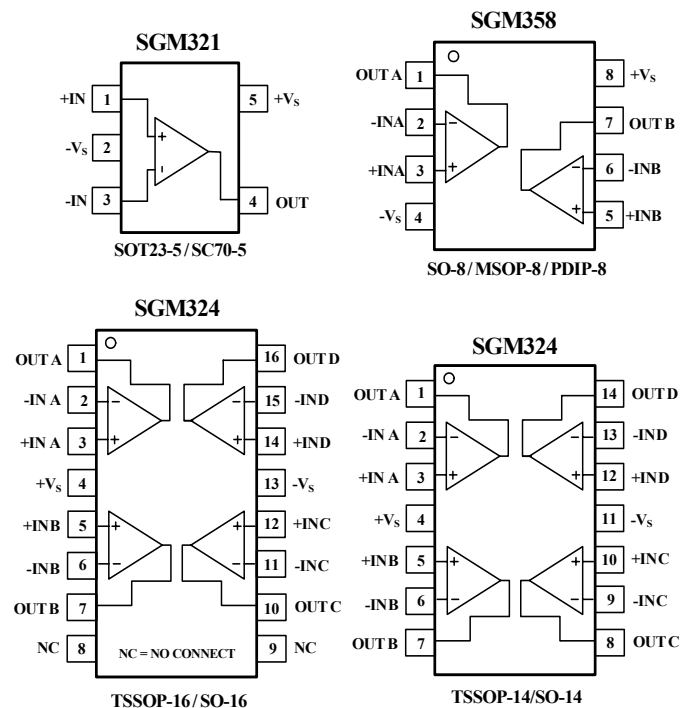
- Low Cost
- Rail-to-Rail Input and Output  
0.8mV Typical  $V_{os}$
- Unity Gain Stable
- Gain Bandwidth Product: 1MHz
- Very Low Input Bias Currents: 10pA
- Operates on 2.1 V to 5.5 V Supplies
- Input Voltage Range:  
- 0.1 V to +5.6 V with  $V_s = 5.5$  V
- Low Supply Current: 60µA/Amplifier
- Small Packaging

SGM321 Available in SOT23-5 and SC70-5

SGM358 Available in SO-8, MSOP-8 and PDIP-8

SGM324 Available in SO-14, SO-16, TSSOP-14 and TSSOP-16

### PIN CONFIGURATIONS (Top View)



# 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	CONDITION	SGM321/358/324					
		TYP	MIN/MAX OVER TEMPERATURE			UNITS	MIN/MAX
		+25°C	+25°C	-40°C to 85°C			
<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 4 V	70	62	62	dB	MIN	
	$V_S = 5.5V, V_{CM} = - 0.1V$ to 5.6 V	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			$\mu V/^\circ C$	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)	$V_S = +2.5 V$ to + 5.5 V $V_{CM} = (-V_S) + 0.5$	82	60	58	dB	MIN	
Quiescent Current / Amplifier ( $I_Q$ )	$I_{OUT} = 0$	60	80	86	$\mu A$	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			$V/\mu s$	TYP	
Settling Time to 0.1% ( $t_S$ )	$G = +1, 2 V$ Output Step	5.3			$\mu s$	TYP	
Overload Recovery Time	$V_{IN} \cdot Gain = V_S$	2.6			$\mu s$	TYP	
<b>NOISE PERFORMANCE</b>							
Voltage Noise Density ( $e_n$ )	$f = 1kHz$	27			$nV/\sqrt{Hz}$	TYP	
	$f = 10kHz$	20			$nV/\sqrt{Hz}$	TYP	

Specifications subject to change without notice.

## 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	PDIP-8	Tube, 50	SGM358YP
SGM324	SGM324YS/TR	SO-16	Tape and Reel, 2500	SGM324YS
	SGM324YTS/TR	TSSOP-16	Tape and Reel, 3000	SGM324YTS
	SGM324YS14/TR	SO-14	Tape and Reel, 2500	SGM324YS14
	SGM324YTS14/TR	TSSOP-14	Tape and Reel, 3000	SGM324YTS14

### ABSOLUTE MAXIMUM RATINGS

Supply Voltage, V+ to V- ..... 7.5 V  
 Common-Mode Input Voltage  
 ..... (-Vs) – 0.5 V to (+Vs) +0.5V  
 Storage Temperature Range ..... -65°C to +150°C  
 Junction Temperature ..... 160°C  
 Operating Temperature Range ..... -45°C to +85°C  
 Package Thermal Resistance @ T<sub>A</sub> = 25°C  
 SC70-5, θ<sub>JA</sub>..... 333°C/W  
 SOT23-5, θ<sub>JA</sub>..... 190°C/W  
 SO-8, θ<sub>JA</sub>..... 125°C/W  
 MSOP-8, θ<sub>JA</sub>..... 216°C/W  
 SO-16, θ<sub>JA</sub>..... 82°C/W  
 TSSOP-16, θ<sub>JA</sub>..... 105°C/W  
 Lead Temperature Range (Soldering 10 sec)  
 ..... 260°C  
 ESD Susceptibility  
 HBM..... 4000V  
 MM..... 400V

### NOTES

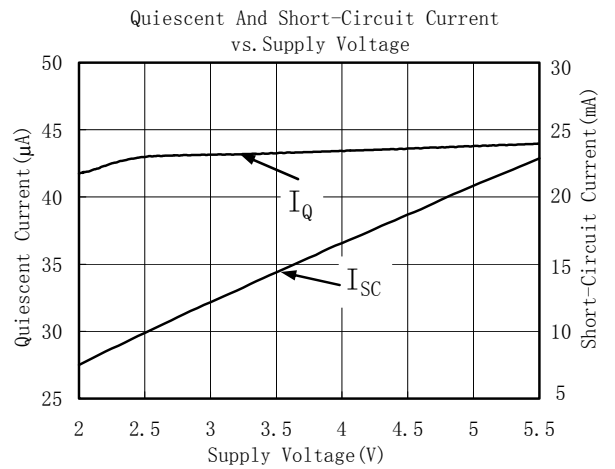
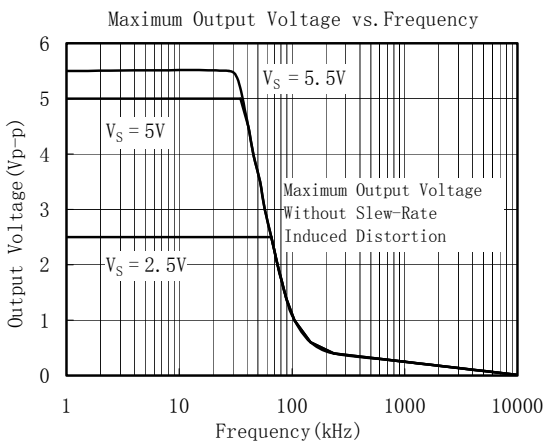
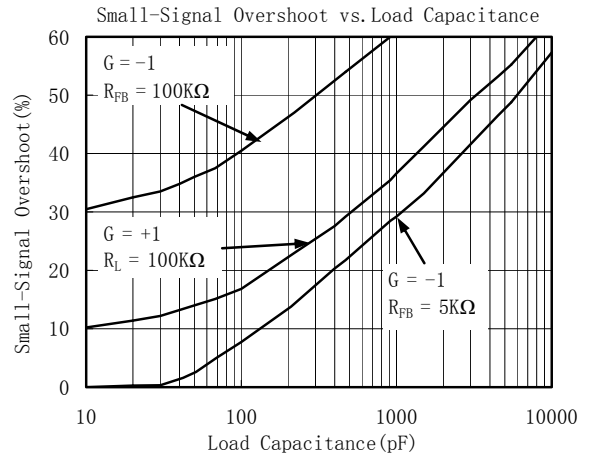
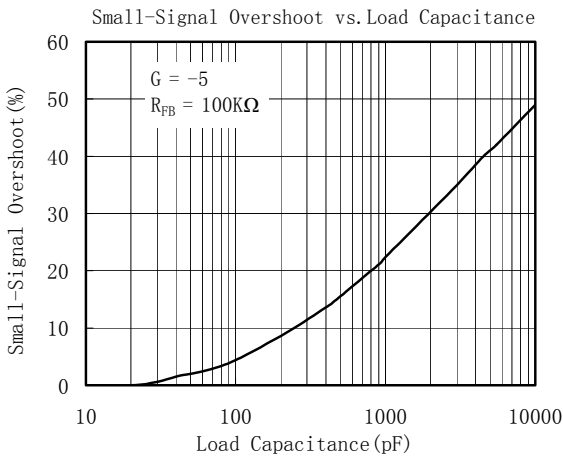
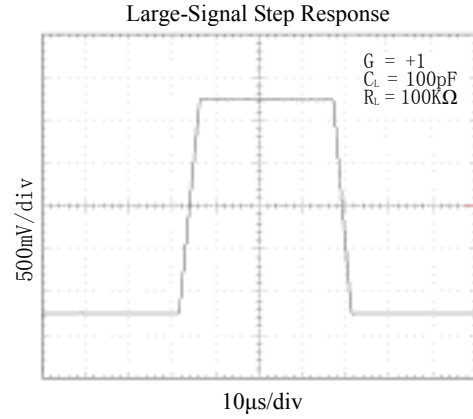
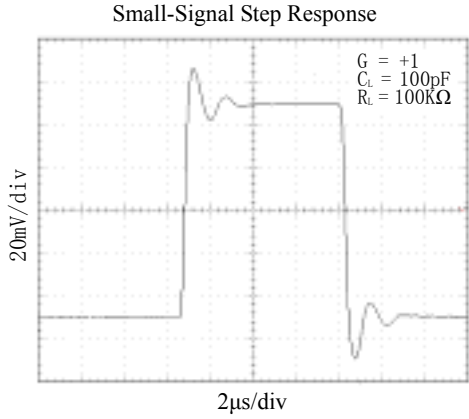
1. Stresses above those listed under Absolute Maximum Ratings may cause permanent damage to the device. This is a stress rating only; functional operation of the device at these or any other conditions above those indicated in the operational section of this specification is not implied. Exposure to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

### CAUTION

This integrated circuit can be damaged by ESD. Shengbang Micro-electronics 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.

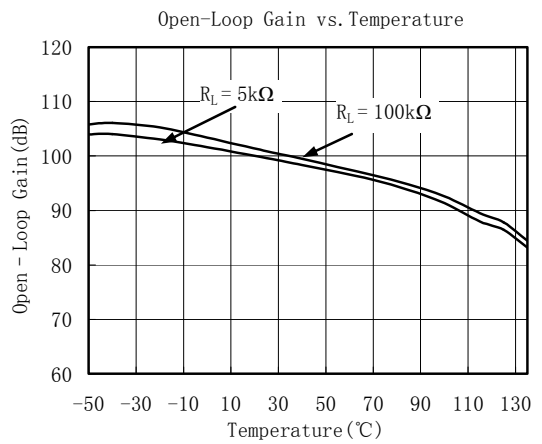
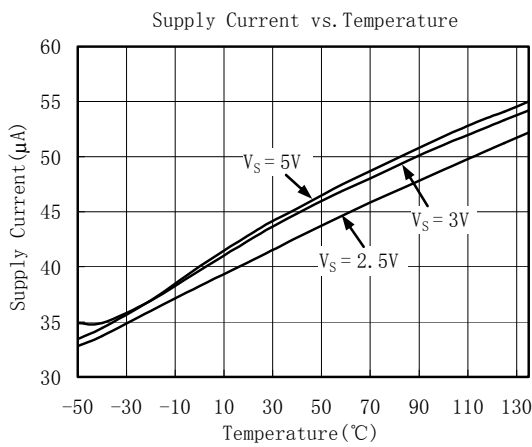
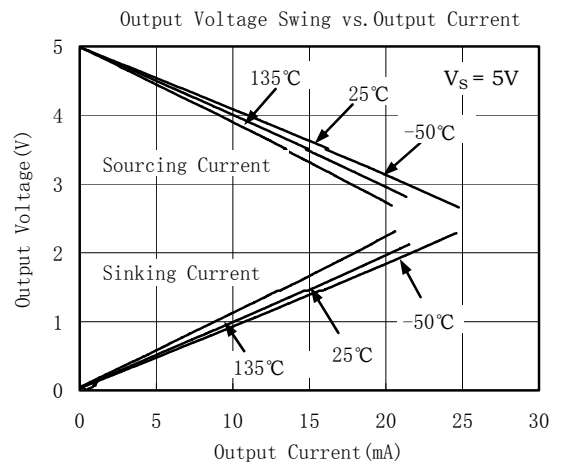
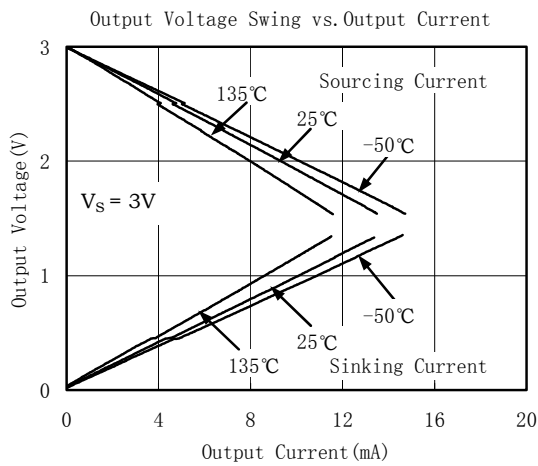
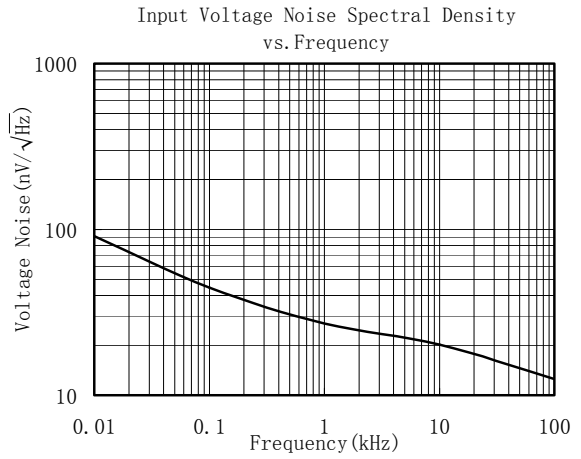
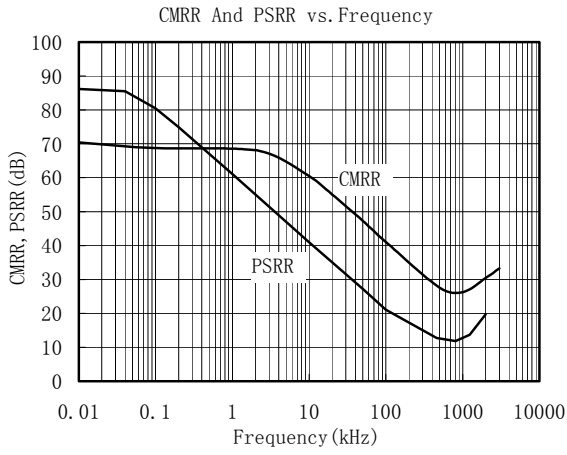
# TYPICAL PERFORMANCE CHARACTERISTICS

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.



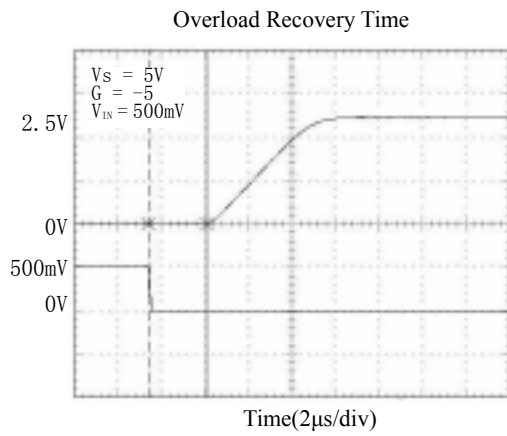
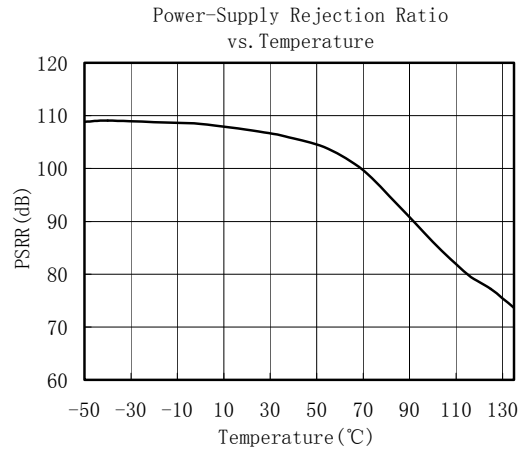
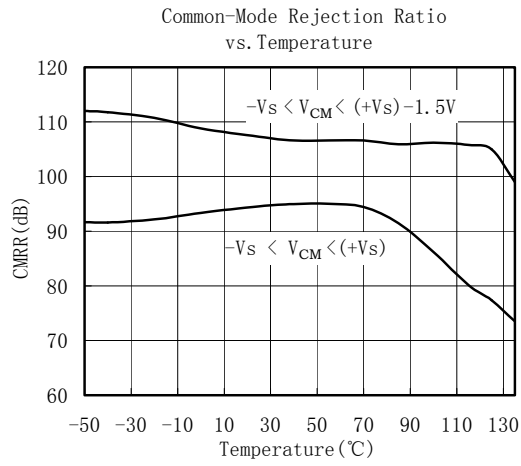
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# TYPICAL PERFORMANCE CHARACTERISTICS

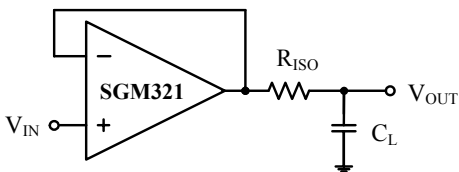
At  $T_A = +25^\circ\text{C}$ ,  $V_S = +5\text{V}$ , and  $R_L = 100\text{k}\Omega$  connected to  $V_S/2$ , unless otherwise noted.



# APPLICATION NOTES

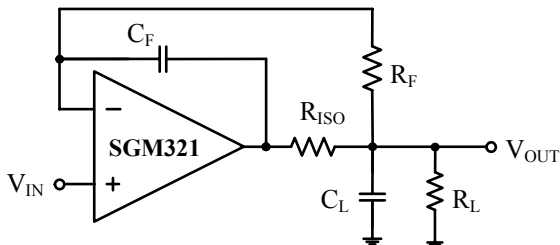
## Driving Capacitive Loads

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.

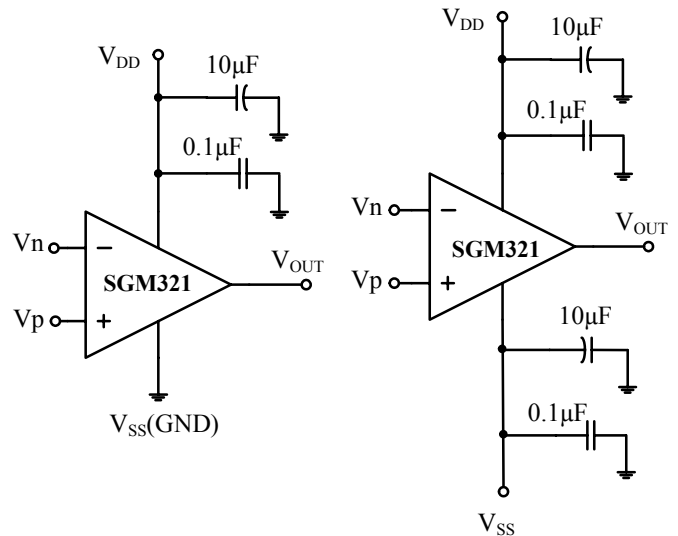


**Figure 2. Indirectly Driving Heavy Capacitive Load with DC Accuracy**

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  $\pm 1.25V$  to  $\pm 2.75V$  supplies. For single-supply operation, bypass the power supply  $V_{DD}$  with a  $0.1\mu F$  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  $0.1\mu F$  ceramic capacitors.  $2.2\mu F$  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  $V_{OUT} = (V_p - V_n) \times R_2 / R_1 + V_{ref}$ .

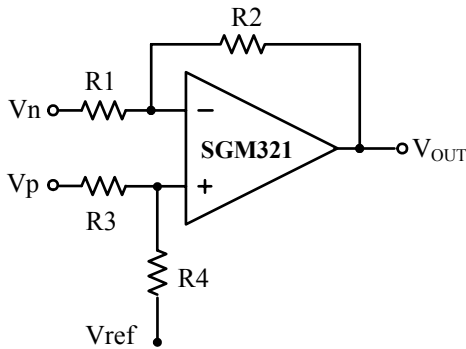


Figure 4. Differential Amplifier

## Instrumentation Amplifier

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

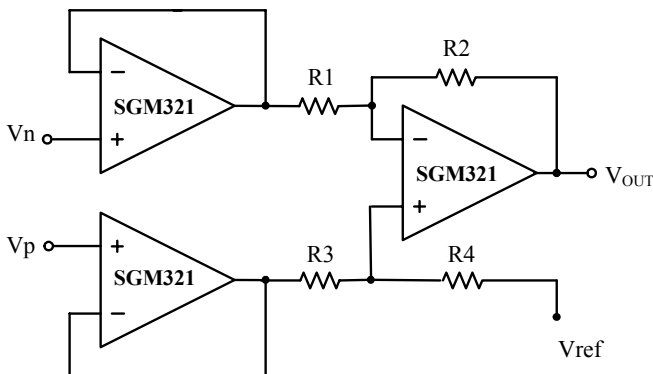


Figure 5. Instrumentation Amplifier

## 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.

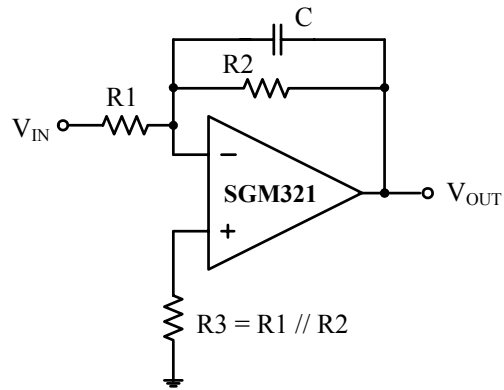
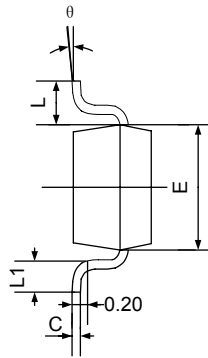
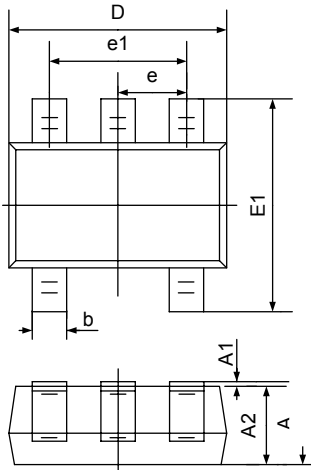


Figure 6. Low Pass Active Filter



# PACKAGE OUTLINE DIMENSIONS

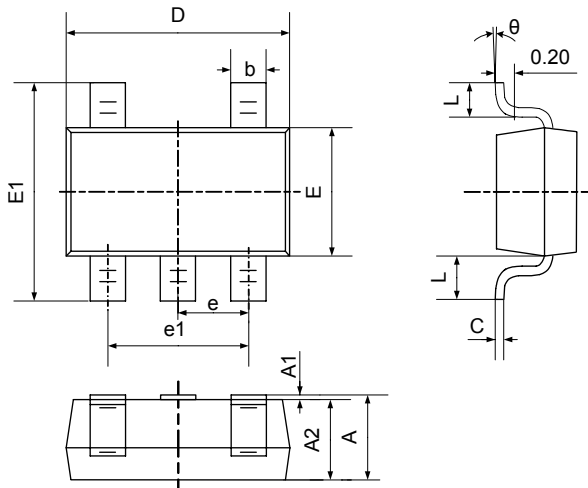
## SC70-5



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
$\theta$	0°	8°	0°	8°

# PACKAGE OUTLINE DIMENSIONS

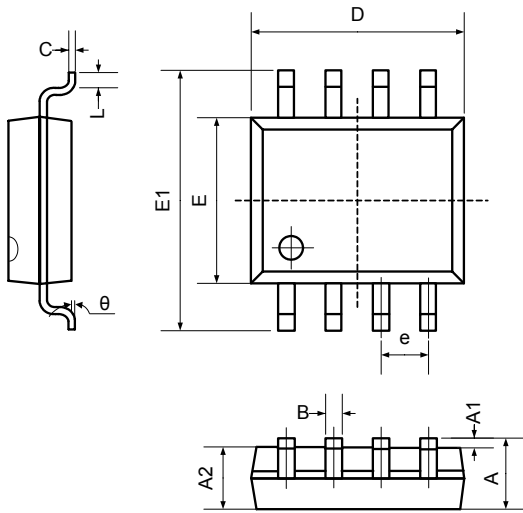
## SOT23-5



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
theta	0°	8°	0°	8°

# PACKAGE OUTLINE DIMENSIONS

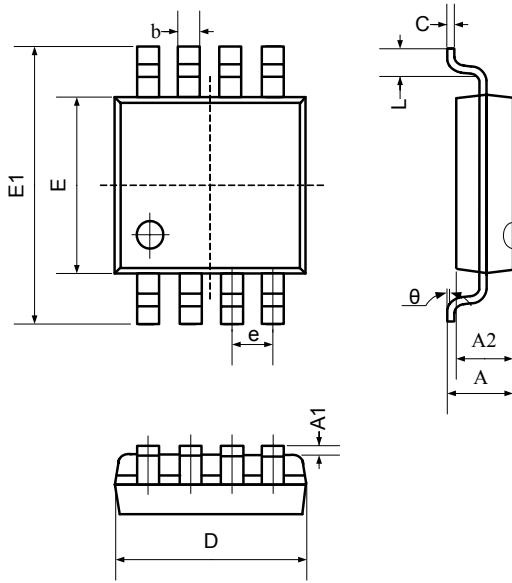
## SO-8



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

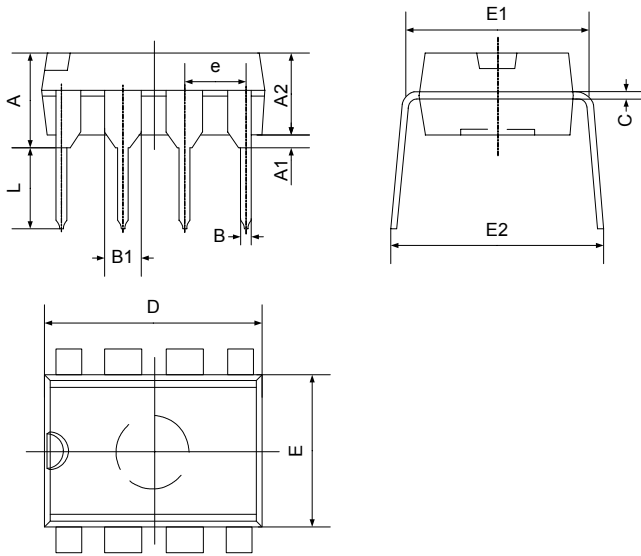
## MSOP-8



Symbol	Dimensions In Millimeters		Dimensions In Inches	
	Min	Max	Min	Max
A	0.800	1.200	0.031	0.047
A1	0.000	0.200	0.000	0.008
A2	0.760	0.970	0.030	0.038
b	0.30 TYP		0.012 TYP	
c	0.15 TYP		0.006 TYP	
D	2.900	3.100	0.114	0.122
e	0.65 TYP		0.026 TYP	
E	2.900	3.100	0.114	0.122
E1	4.700	5.100	0.185	0.201
L	0.410	0.650	0.016	0.026
theta	0°		6°	

# PACKAGE OUTLINE DIMENSIONS

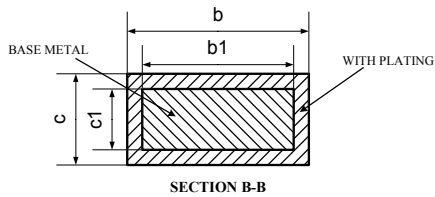
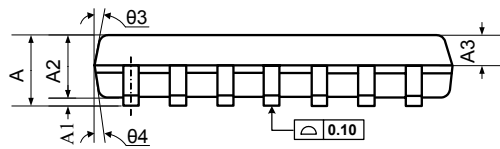
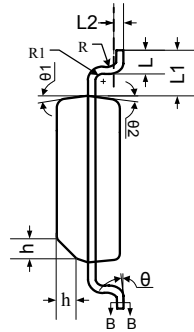
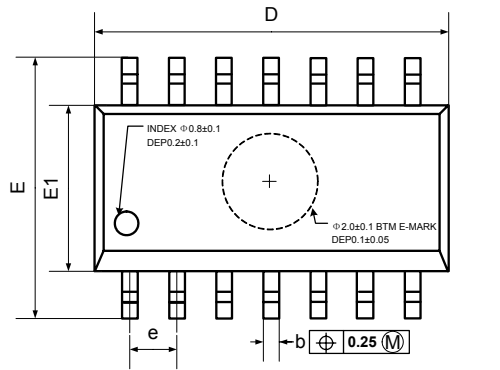
## PDIP-8



Symbol	Dimensions In Millimeters		Dimensions In Inches	
	Min	Max	Min	Max
A	3.710	4.310	0.146	0.170
A1	0.510		0.020	
A2	3.200	3.600	0.126	0.142
B	0.380	0.570	0.015	0.022
B1	1.524(BSC)		0.060(BSC)	
C	0.204	0.360	0.008	0.014
D	9.000	9.400	0.354	0.370
E	6.200	6.600	0.244	0.260
E1	7.320	7.920	0.288	0.312
e	2.540(BSC)		0.100(BSC)	
L	3.000	3.600	0.118	0.142
E2	8.400	9.000	0.331	0.354

# PACKAGE OUTLINE DIMENSIONS

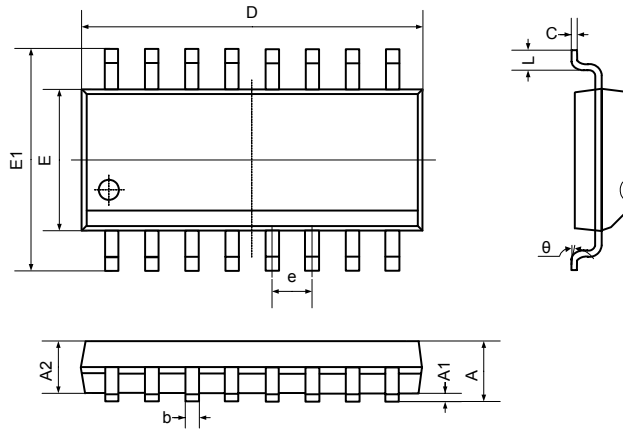
## SO-14



Symbol	Dimensions In Millimeters		
	MIN	NOM	MAX
A	1.35	1.60	1.75
A1	0.10	0.15	0.25
A2	1.25	1.45	1.65
A3	0.55	0.65	0.75
b	0.36		0.49
b1	0.35	0.40	0.45
c	0.16		0.25
c1	0.15	0.20	0.25
D	8.53	8.63	8.73
E	5.80	6.00	6.20
E1	3.80	3.90	4.00
e	1.27 BSC		
L	0.45	0.60	0.80
L1	1.04 REF		
L2	0.25 BSC		
R	0.07		
R1	0.07		
h	0.30	0.40	0.50
$\theta$	0°		8°
$\theta 1$	6°	8°	10°
$\theta 2$	6°	8°	10°
$\theta 3$	5°	7°	9°
$\theta 4$	5°	7°	9°

# PACKAGE OUTLINE DIMENSIONS

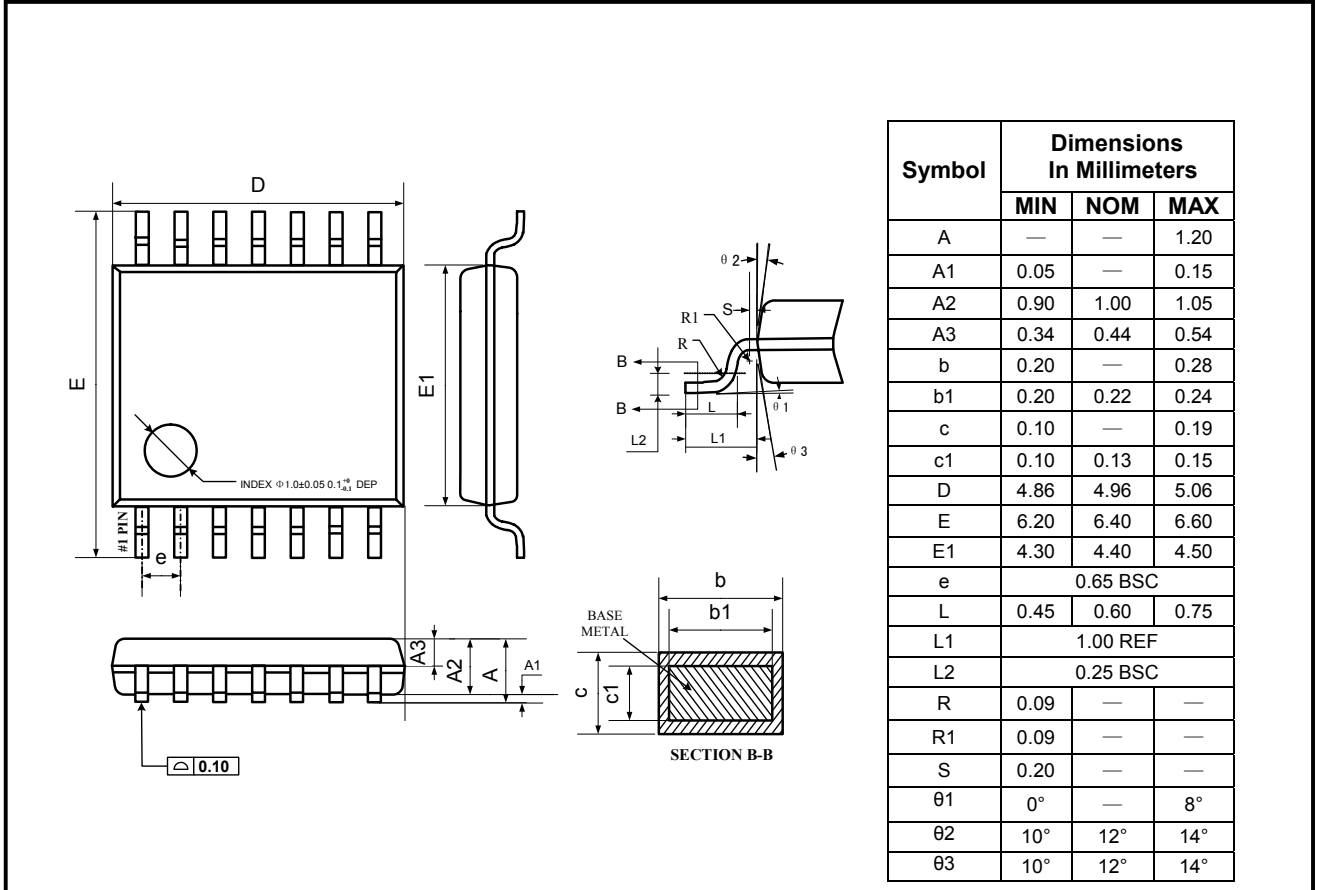
## SO-16



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	0.170	0.250	0.007	0.010
D	9.800	10.20	0.386	0.402
E	3.800	4.000	0.150	0.157
E1	5.800	6.200	0.228	0.244
e	1.270 (BSC)		0.050 (BSC)	
L	0.400	1.270	0.016	0.050
theta	0°	8°	0°	8°

# PACKAGE OUTLINE DIMENSIONS

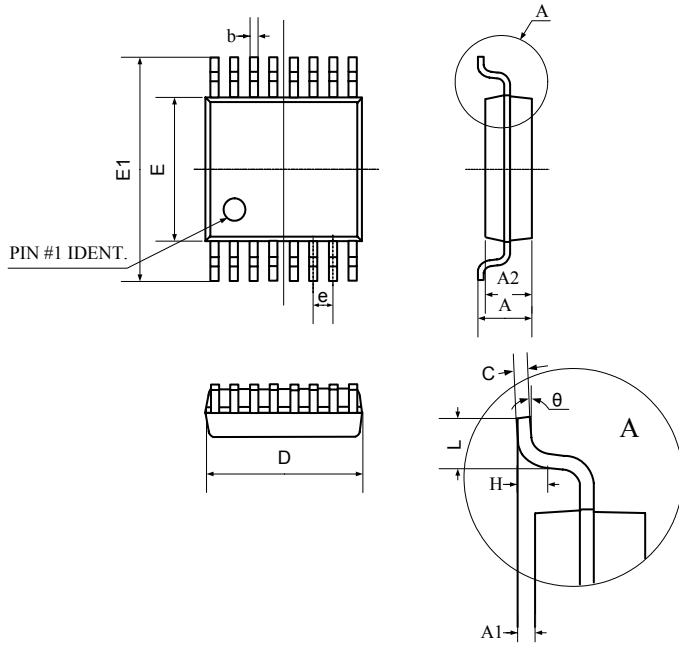
## TSSOP-14





# PACKAGE OUTLINE DIMENSIONS

## TSSOP-16



Symbol	Dimensions In Millimeters		Dimensions In Inches	
	Min	Max	Min	Max
D	4.900	5.100	0.193	0.201
E	4.300	4.500	0.169	0.177
b	0.190	0.300	0.007	0.012
c	0.090	0.200	0.004	0.008
E1	6.250	6.550	0.246	0.258
A		1.100		0.043
A2	0.800	1.000	0.031	0.039
A1	0.020	0.150	0.001	0.006
e	0.65 (BSC)		0.026 (BSC)	
L	0.500	0.700	0.020	0.028
H	0.25(TYP)		0.01(TYP)	
θ	1°	7°	1°	7°

## REVISION HISTORY

Location	Page
<b>11/06— Data Sheet changed from REV.A to REV.B</b>	
Changes to ABSOLUTE MAXIMUM RATINGS .....	3
<b>04/07— Data Sheet changed from REV.B to REV.C</b>	
Adds Output Voltage Swing from Rail test condition. ....	2
<b>06/07— Data Sheet changed from REV.C to REV. D</b>	
Adds SO-14 and TSSOP-14 Packages .....	.1, 3, 14, 16

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