



# SGM8521/2/4 150kHz, 5.5 $\mu$ A, Rail-to-Rail I/O, CMOS Operational Amplifiers

## GENERAL DESCRIPTION

The SGM8521 (single), SGM8522 (dual) and SGM8524 (quad) are low cost, rail-to-rail input and output voltage feedback amplifiers. They have a wide input common mode voltage range and output voltage swing, and take the minimum operating supply voltage down to 2.1V. The maximum recommended supply voltage is 5.5V. All are specified over the extended -40°C to +125°C temperature range.

The SGM8521/2/4 provide 150kHz bandwidth at a low current consumption of 5.5 $\mu$ A per amplifier. Very low input bias currents enable the SGM8521/2/4 to be used for integrators, photodiode amplifiers, and piezoelectric sensors. Rail-to-rail input and output are useful to designers for buffering ASIC in single-supply systems.

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

The SGM8521 is available in Green SOT-23-5 and SOIC-8 packages. The SGM8522 is available in Green SOIC-8 and MSOP-8 packages. The SGM8524 is available in Green SOIC-14 and TSSOP-14 packages.

## FEATURES

- **Low Cost**
- **Rail-to-Rail Input and Output**
- **Input Offset Voltage: 3.5mV (MAX)**
- **Unity Gain Stable**
- **Gain-Bandwidth Product: 150kHz**
- **Supply Voltage Range: 2.1V to 5.5V**
- **Input Voltage Range:**  
-0.1V to +5.6V with  $V_S = 5.5V$
- **Low Supply Current: 5.5 $\mu$ A/Amplifier**
- **Small Packaging**  
**SGM8521 Available in Green SOIC-8 and SOT-23-5 Packages**  
**SGM8522 Available in Green SOIC-8 and MSOP-8 Packages**  
**SGM8524 Available in Green SOIC-14 and TSSOP-14 Packages**

## APPLICATIONS

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

**PACKAGE/ORDERING INFORMATION**

MODEL	PACKAGE DESCRIPTION	SPECIFIED TEMPERATURE RANGE	ORDERING NUMBER	PACKAGE MARKING	PACKING OPTION
SGM8521	SOT-23-5	-40°C to +125°C	SGM8521XN5/TR	8521	Tape and Reel, 3000
	SOIC-8	-40°C to +125°C	SGM8521XS/TR	SGM8521XS XXXXX	Tape and Reel, 2500
SGM8522	SOIC-8	-40°C to +125°C	SGM8522XS/TR	SGM8522XS XXXXX	Tape and Reel, 2500
	MSOP-8	-40°C to +125°C	SGM8522XMS/TR	SGM8522 XMS XXXXX	Tape and Reel, 3000
SGM8524	SOIC-14	-40°C to +125°C	SGM8524XS14/TR	SGM8524XS14 XXXXX	Tape and Reel, 2500
	TSSOP-14	-40°C to +125°C	SGM8524XTS14/TR	SGM8524 XTS14 XXXXX	Tape and Reel, 3000

NOTE: XXXXX = Date Code and Vendor Code.

Green (RoHS & HSF): SG Micro Corp defines "Green" to mean Pb-Free (RoHS compatible) and free of halogen substances. If you have additional comments or questions, please contact your SGMICRO representative directly.

**ABSOLUTE MAXIMUM RATINGS**

Supply Voltage, +V<sub>S</sub> to -V<sub>S</sub> ..... 6V  
 Input Common Mode Voltage Range  
 ..... (-V<sub>S</sub>) - 0.3V to (+V<sub>S</sub>) + 0.3V  
 Package Thermal Resistance @ T<sub>A</sub> = +25°C  
 SOT-23-5, θ<sub>JA</sub> ..... 190°C/W  
 SOIC-8, θ<sub>JA</sub> ..... 125°C/W  
 MSOP-8, θ<sub>JA</sub> ..... 216°C/W  
 Storage Temperature Range ..... -65°C to +150°C  
 Junction Temperature ..... +150°C  
 Lead Temperature (Soldering 10sec) ..... +260°C  
 ESD Susceptibility  
 HBM ..... 4000V  
 MM ..... 400V

**RECOMMENDED OPERATING CONDITIONS**

Operating Temperature Range ..... -40°C to +125°C

**OVERSTRESS CAUTION**

Stresses beyond those listed may cause permanent damage to the device. Functional operation of the device at these or any other conditions beyond those indicated in the operational section of the specification is not implied. Exposure to absolute maximum rating conditions for extended periods may affect reliability.

**ESD SENSITIVITY CAUTION**

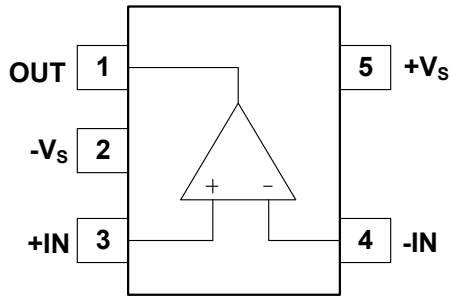
This integrated circuit can be damaged by ESD if you don't pay attention to ESD protection. SGMICRO recommends that all integrated circuits be handled with appropriate precautions. Failure to observe proper handling and installation procedures can cause damage. ESD damage can range from subtle performance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

**DISCLAIMER**

SG Micro Corp reserves the right to make any change in circuit design, specification or other related things if necessary without notice at any time.

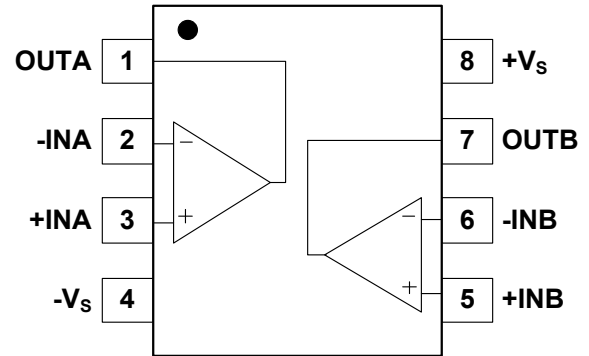
PIN CONFIGURATIONS

SGM8521 (TOP VIEW)



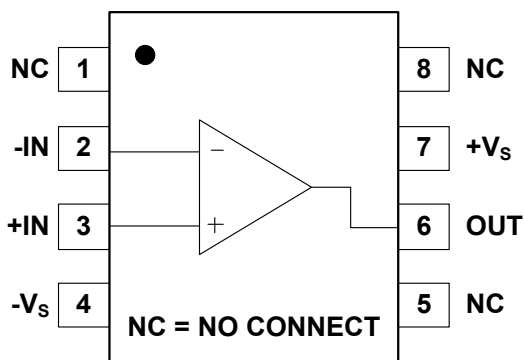
SOT-23-5

SGM8522 (TOP VIEW)



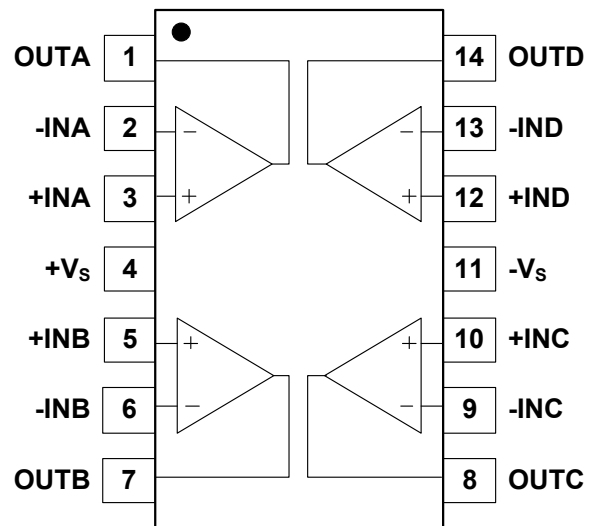
SOIC-8/MSOP-8

SGM8521 (TOP VIEW)



SOIC-8

SGM8524 (TOP VIEW)



TSSOP-14/SOIC-14

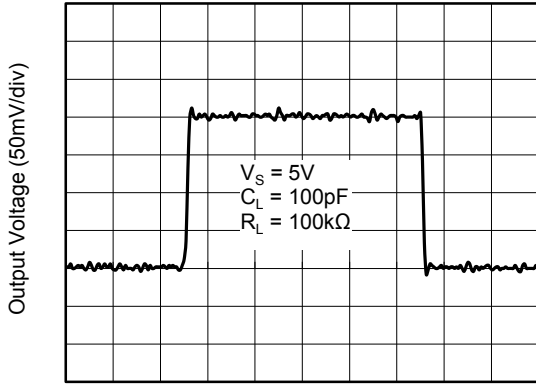
**ELECTRICAL CHARACTERISTICS**(At  $T_A = +25^\circ\text{C}$ ,  $V_S = 5\text{V}$ ,  $R_L = 500\text{k}\Omega$  connected to  $V_S/2$  and  $V_{OUT} = V_S/2$ , unless otherwise noted.)

PARAMETER	SYMBOL	CONDITIONS	MIN	TYP	MAX	UNITS
Input Offset Voltage	$V_{OS}$			1	3.5	mV
Input Bias Current	$I_B$			3		pA
Input Offset Current	$I_{OS}$			3		pA
Input Offset Voltage Drift	$\Delta V_{OS}/\Delta T$			2		$\mu\text{V}/^\circ\text{C}$
Quiescent Current/Amplifier	$I_Q$			5.5		$\mu\text{A}$
Open-Loop Voltage Gain	$A_{OL}$	$V_O = 0.015\text{V}$ to $4.985\text{V}$ , $R_L = 500\text{k}\Omega$	90	110		dB
		$V_O = 0.1\text{V}$ to $4.9\text{V}$ , $R_L = 100\text{k}\Omega$	88	108		
Common Mode Rejection Ratio	CMRR	$V_S = 5.5\text{V}$ , $-0.1\text{V} < V_{CM} < 5.6\text{V}$	60	87		dB
		$V_S = 5.5\text{V}$ , $-0.1\text{V} < V_{CM} < 4\text{V}$	70	114		
Power Supply Rejection Ratio	PSRR	$V_S = 2.5\text{V}$ to $5.5\text{V}$ , $V_{CM} = 0.5\text{V}$	65	94		dB
Output Current	$I_{SOURCE}$	$R_L = 10\Omega$ to $V_S/2$	61	87		mA
	$I_{SINK}$		60	76		
Output Voltage Swing	$V_{OH}$		4.990	4.997		V
	$V_{OL}$			0.005	0.010	
Gain-Bandwidth Product	GBP			150		kHz
Slew Rate	SR	$R_L = 100\text{k}\Omega$		0.05		$\text{V}/\mu\text{s}$
Voltage Noise Density	$e_n$	$f = 1\text{kHz}$		85		$\text{nV}/\sqrt{\text{Hz}}$
		$f = 10\text{kHz}$		44		

**TYPICAL PERFORMANCE CHARACTERISTICS**

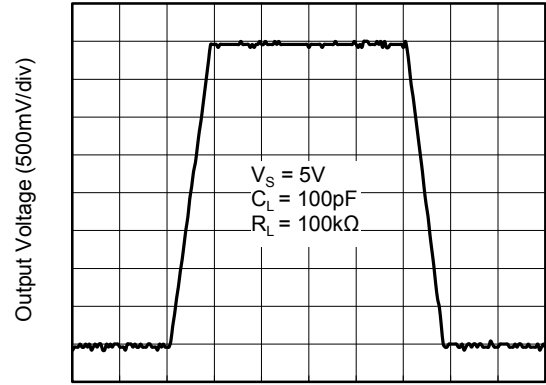
At  $T_A = +25^\circ\text{C}$ ,  $V_S = 5\text{V}$  and  $R_L = 500\text{k}\Omega$  connected to  $V_S/2$ , unless otherwise noted.

Small-Signal Step Response



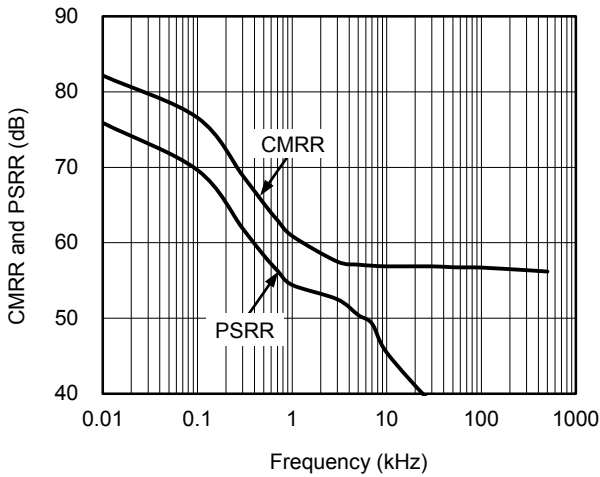
Time (50μs/div)

Large-Signal Step Response

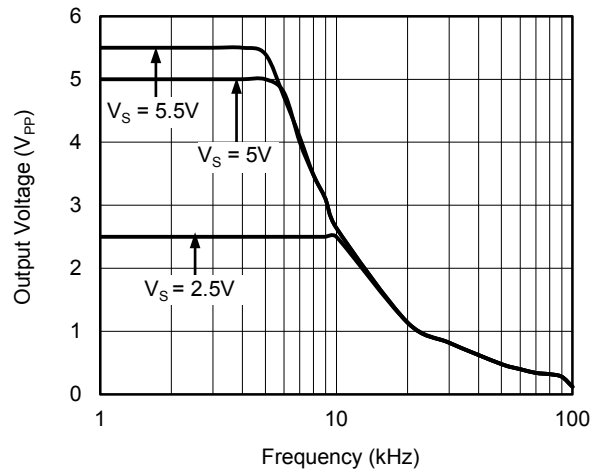


Time (100μs/div)

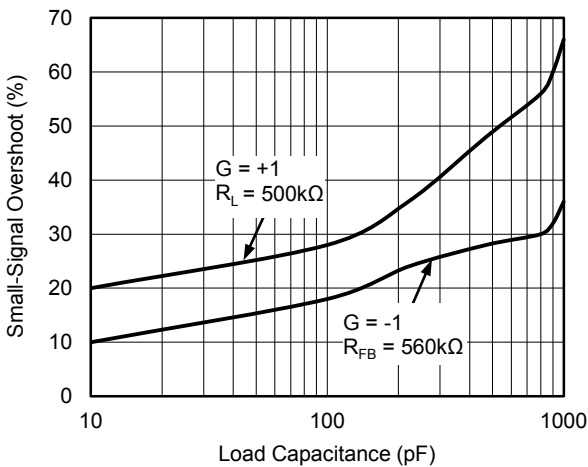
CMRR and PSRR vs. Frequency



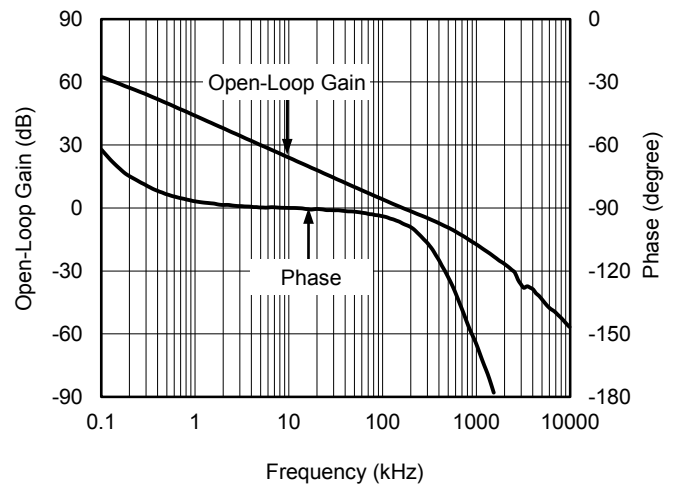
Maximum Output Voltage vs. Frequency



Small-Signal Overshoot vs. Capacitive Load

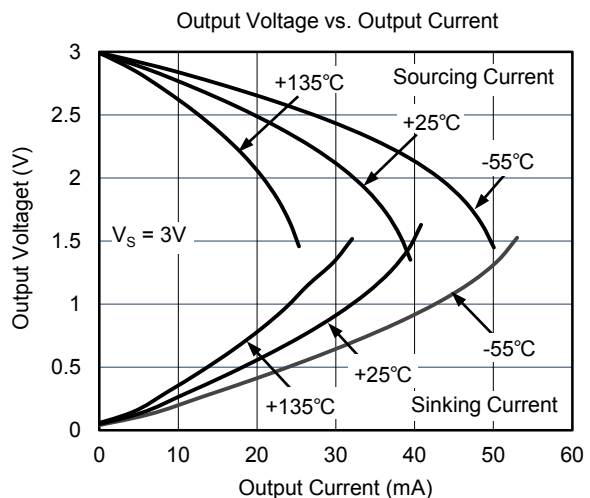
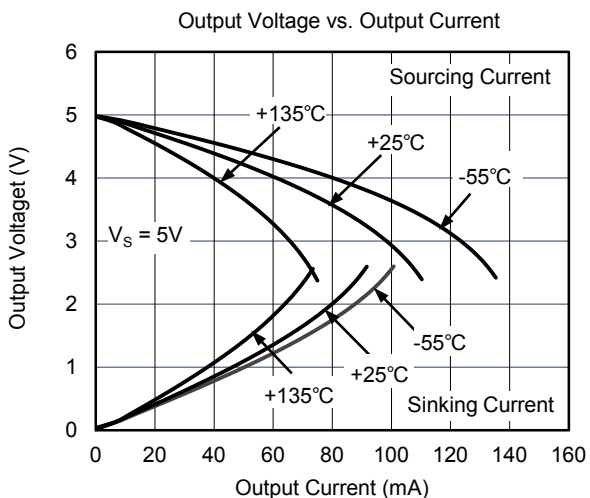
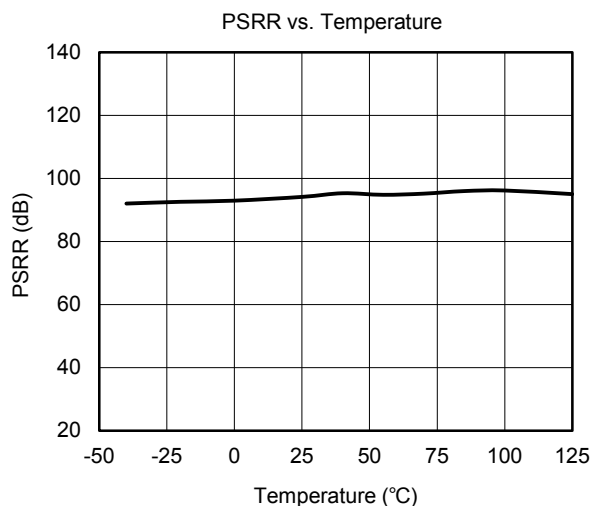
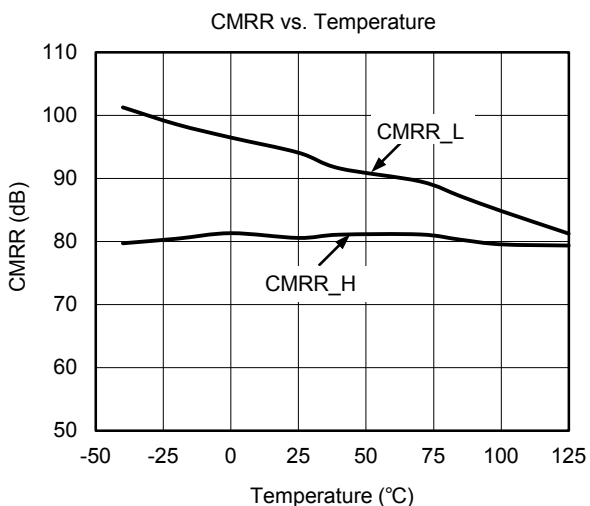
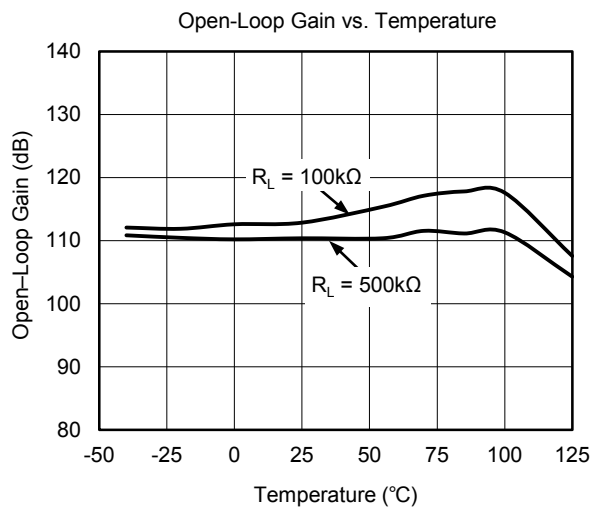
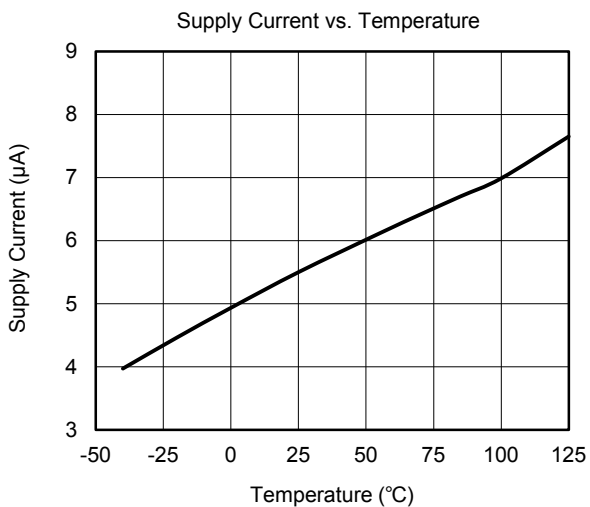


Open-Loop Gain and Phase vs. Frequency



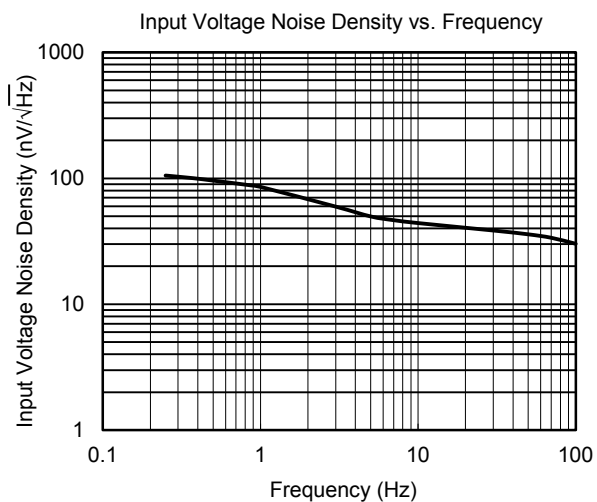
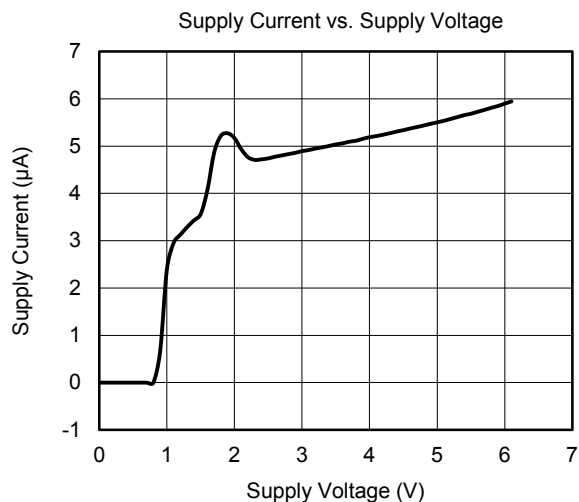
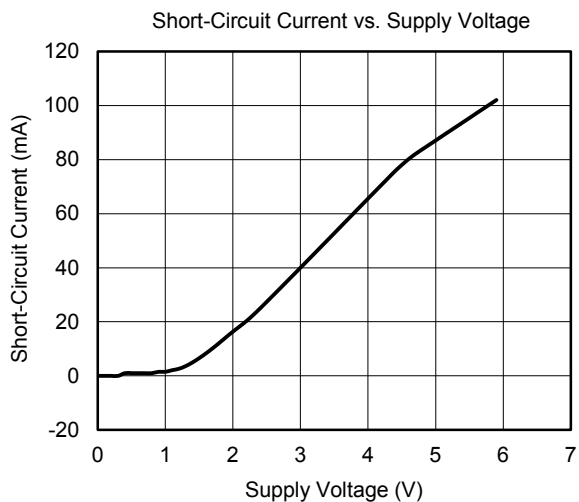
**TYPICAL PERFORMANCE CHARACTERISTICS (continued)**

At  $T_A = +25^\circ\text{C}$ ,  $V_S = 5\text{V}$  and  $R_L = 500\text{k}\Omega$  connected to  $V_S/2$ , unless otherwise noted.



**TYPICAL PERFORMANCE CHARACTERISTICS (continued)**

At  $T_A = +25^\circ\text{C}$ ,  $V_S = 5\text{V}$  and  $R_L = 500\text{k}\Omega$  connected to  $V_S/2$ , unless otherwise noted.



SGM8521/2/4

APPLICATION NOTES

Driving Capacitive Loads

The SGM8521/2/4 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 result in ringing or even oscillation. Applications that require greater capacitive driving 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  $R_{LOAD}$ .

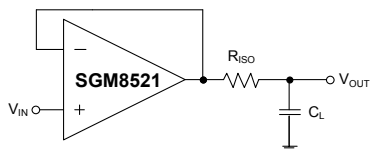


Figure 1. Indirectly Driving Heavy Capacitive Load

An improved 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.

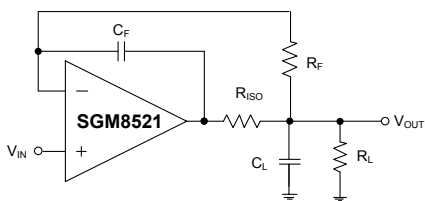


Figure 2. Indirectly Driving Heavy Capacitive Load with DC Accuracy

For non-buffer configuration, there are two other 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 SGM8521/2/4 family operates from either a single 2.1V to 5.5V supply or dual  $\pm 1.05V$  to  $\pm 2.75V$  supplies. For single-supply operation, bypass the power supply  $+V_S$  with a 0.1μF ceramic capacitor which should be placed close to the  $+V_S$  pin. For dual-supply operation, both the  $+V_S$  and the  $-V_S$  supplies should be bypassed to ground with separate 0.1μF ceramic capacitors. 2.2μF tantalum capacitor can be added for better performance.

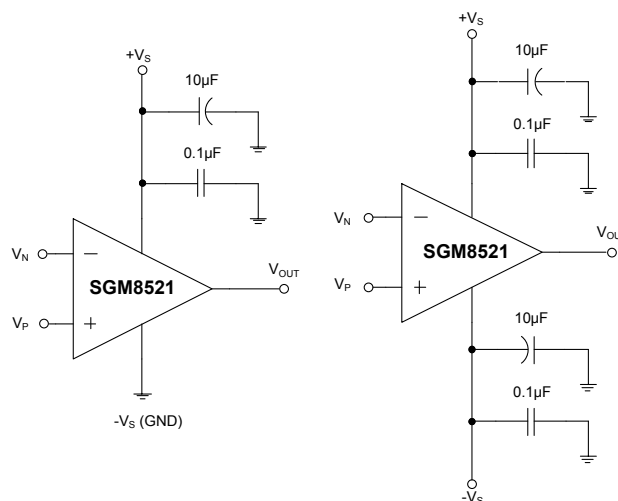


Figure 3. Amplifier with Bypass Capacitors



**APPLICATION NOTES (continued)**

**Differential Amplifier**

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

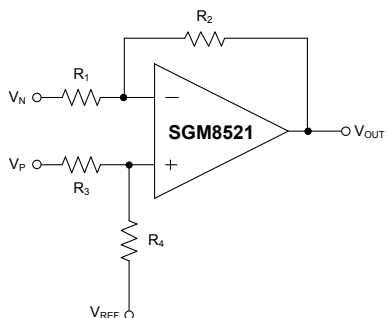


Figure 4. Differential Amplifier

**Instrumentation Amplifier**

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

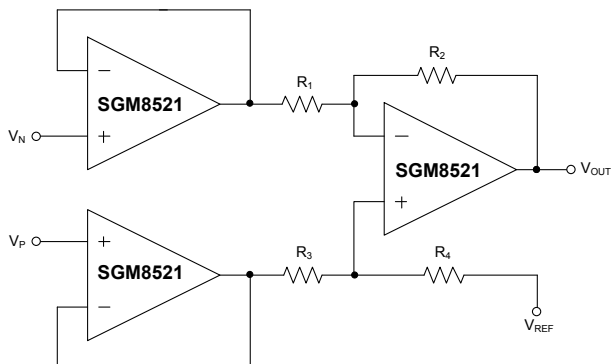


Figure 5. Instrumentation Amplifier

**Active Low-Pass 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 bandwidth is within the bandwidth of the amplifier. Feedback resistors with large values can couple with parasitic capacitance and cause undesired effects such as ringing or oscillation in high-speed amplifiers. Keep resistor values as low as possible and consistent with output loading consideration.

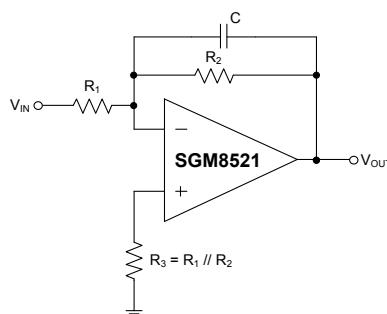
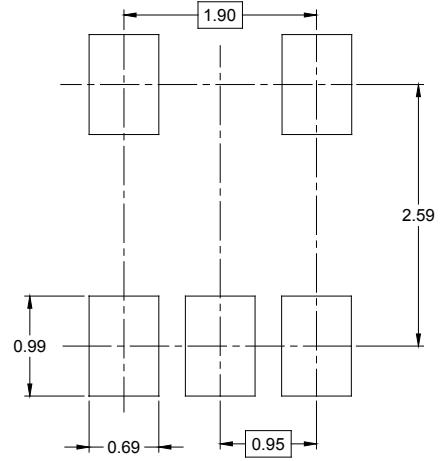


Figure 6. Active Low-Pass Filter

PACKAGE OUTLINE DIMENSIONS

SOT-23-5



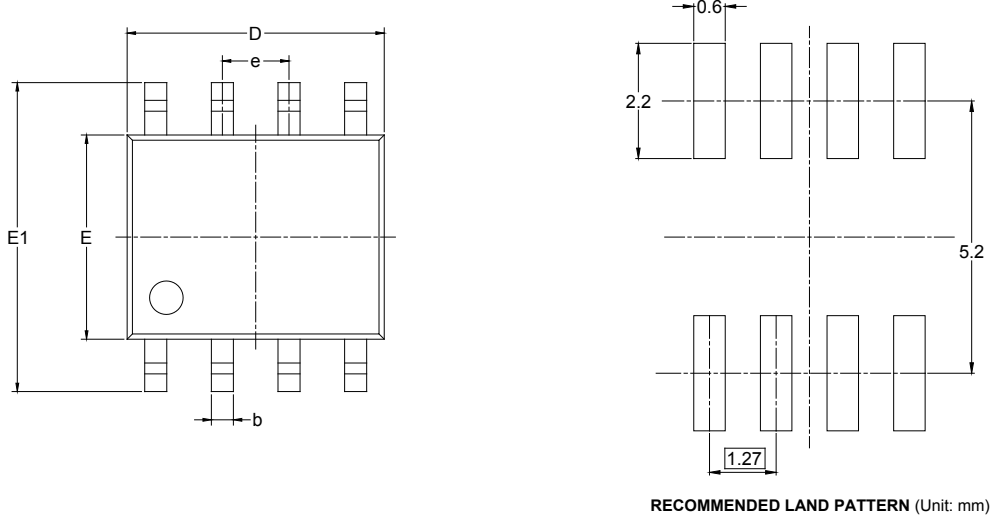
RECOMMENDED LAND PATTERN (Unit: mm)



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
$\theta$	0°	8°	0°	8°

PACKAGE OUTLINE DIMENSIONS

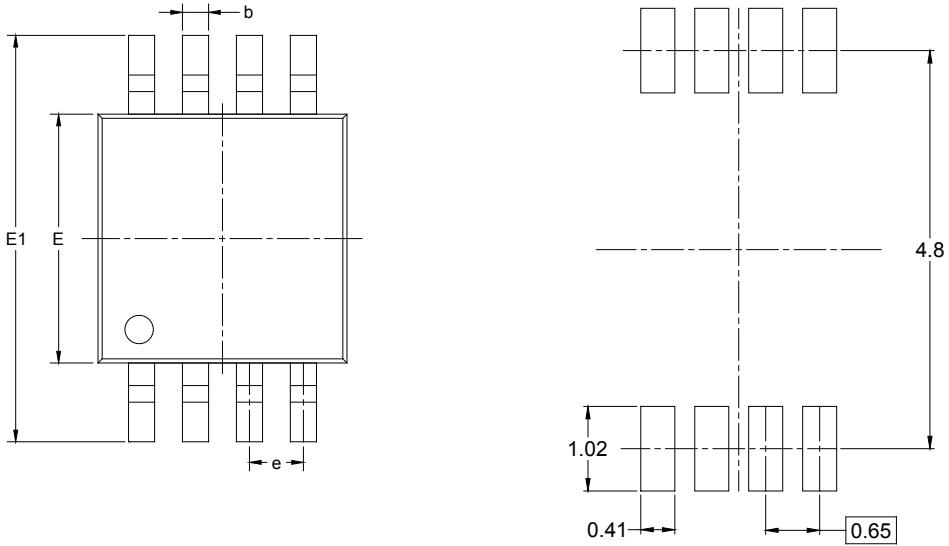
SOIC-8



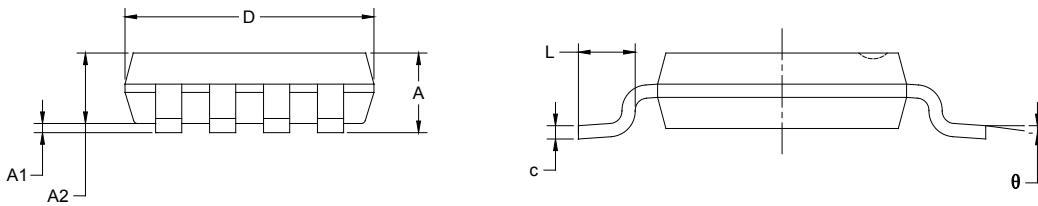
Symbol	Dimensions In Millimeters		Dimensions In Inches	
	MIN	MAX	MIN	MAX
A	1.350	1.750	0.053	0.069
A1	0.100	0.250	0.004	0.010
A2	1.350	1.550	0.053	0.061
b	0.330	0.510	0.013	0.020
c	0.170	0.250	0.006	0.010
D	4.700	5.100	0.185	0.200
E	3.800	4.000	0.150	0.157
E1	5.800	6.200	0.228	0.244
e	1.27 BSC		0.050 BSC	
L	0.400	1.270	0.016	0.050
$\theta$	0°	8°	0°	8°

PACKAGE OUTLINE DIMENSIONS

MSOP-8



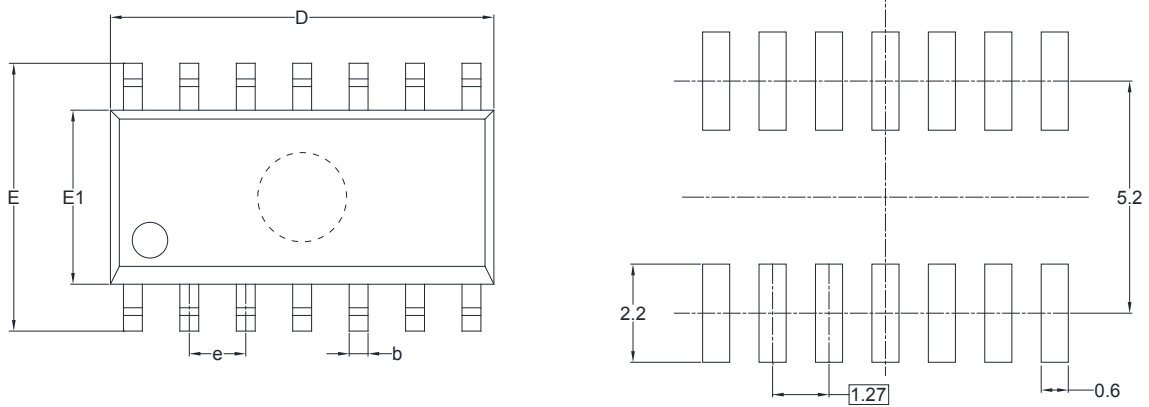
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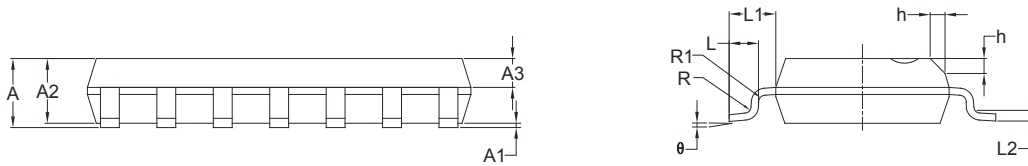
Symbol	Dimensions In Millimeters		Dimensions In Inches	
	MIN	MAX	MIN	MAX
A	0.820	1.100	0.032	0.043
A1	0.020	0.150	0.001	0.006
A2	0.750	0.950	0.030	0.037
b	0.250	0.380	0.010	0.015
c	0.090	0.230	0.004	0.009
D	2.900	3.100	0.114	0.122
E	2.900	3.100	0.114	0.122
E1	4.750	5.050	0.187	0.199
e	0.650 BSC		0.026 BSC	
L	0.400	0.800	0.016	0.031
θ	0°	6°	0°	6°

PACKAGE OUTLINE DIMENSIONS

SOIC-14



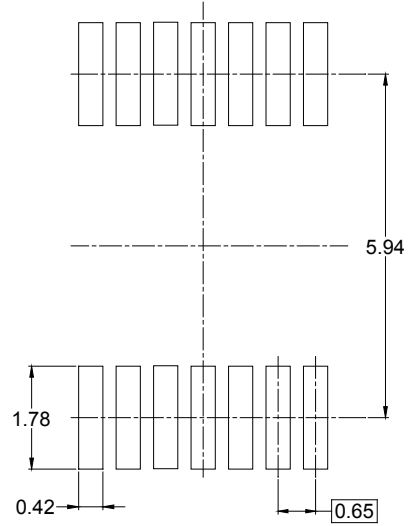
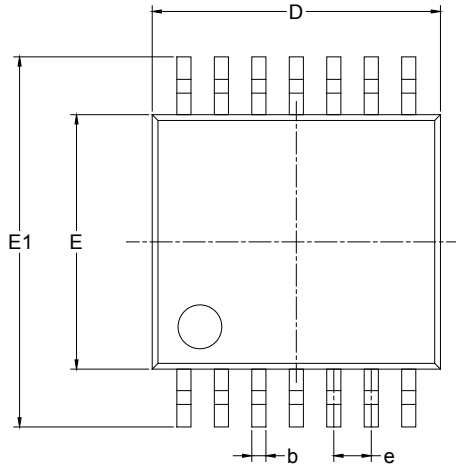
RECOMMENDED LAND PATTERN (Unit: mm)



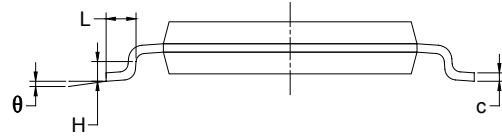
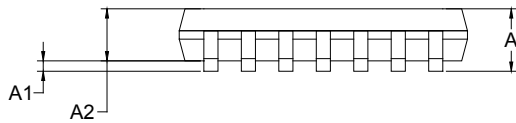
Symbol	Dimensions In Millimeters		Dimensions In Inches	
	MIN	MAX	MIN	MAX
A	1.35	1.75	0.053	0.069
A1	0.10	0.25	0.004	0.010
A2	1.25	1.65	0.049	0.065
A3	0.55	0.75	0.022	0.030
b	0.36	0.49	0.014	0.019
D	8.53	8.73	0.336	0.344
E	5.80	6.20	0.228	0.244
E1	3.80	4.00	0.150	0.157
e	1.27 BSC		0.050 BSC	
L	0.45	0.80	0.018	0.032
L1	1.04 REF		0.040 REF	
L2	0.25 BSC		0.01 BSC	
R	0.07		0.003	
R1	0.07		0.003	
h	0.30	0.50	0.012	0.020
θ	0°	8°	0°	8°

PACKAGE OUTLINE DIMENSIONS

TSSOP-14



RECOMMENDED LAND PATTERN (Unit: mm)

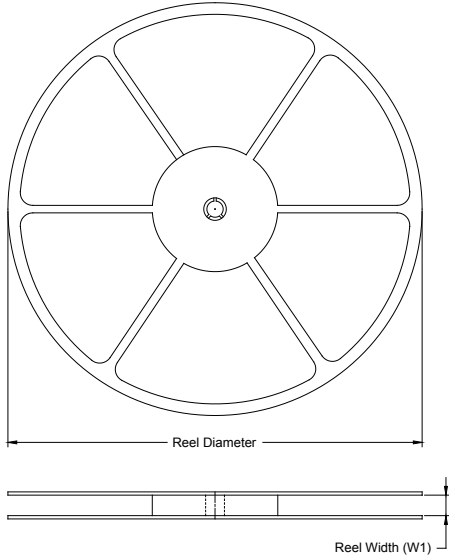


Symbol	Dimensions In Millimeters		Dimensions In Inches	
	MIN	MAX	MIN	MAX
A		1.200		0.047
A1	0.050	0.150	0.002	0.006
A2	0.800	1.050	0.031	0.041
b	0.190	0.300	0.007	0.012
c	0.090	0.200	0.004	0.008
D	4.860	5.100	0.191	0.201
E	4.300	4.500	0.169	0.177
E1	6.250	6.550	0.246	0.258
e	0.650 BSC		0.026 BSC	
L	0.500	0.700	0.02	0.028
H	0.25 TYP		0.01 TYP	
θ	1°	7°	1°	7°

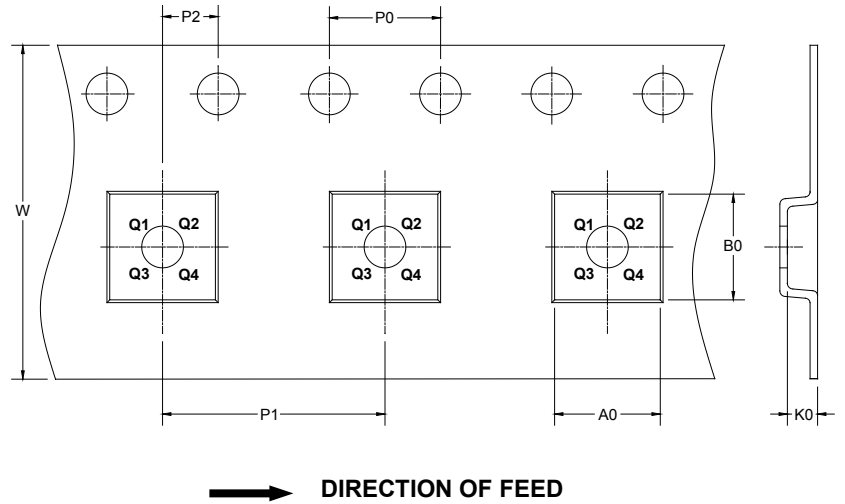
# PACKAGE INFORMATION

## TAPE AND REEL INFORMATION

### REEL DIMENSIONS



### TAPE DIMENSIONS



NOTE: The picture is only for reference. Please make the object as the standard.

### KEY PARAMETER LIST OF TAPE AND REEL

Package Type	Reel Diameter	Reel Width W1 (mm)	A0 (mm)	B0 (mm)	K0 (mm)	P0 (mm)	P1 (mm)	P2 (mm)	W (mm)	Pin1 Quadrant
SOT-23-5	7"	9.5	3.20	3.20	1.40	4.0	4.0	2.0	8.0	Q3
SOIC-8	13"	12.4	6.40	5.40	2.10	4.0	8.0	2.0	12.0	Q1
MSOP-8	13"	12.4	5.20	3.30	1.50	4.0	8.0	2.0	12.0	Q1
SOIC-14	13"	16.4	6.60	9.30	2.10	4.0	8.0	2.0	16.0	Q1
TSSOP-14	13"	12.4	6.95	5.60	1.20	4.0	8.0	2.0	12.0	Q1

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# PACKAGE INFORMATION

## CARTON BOX DIMENSIONS



NOTE: The picture is only for reference. Please make the object as the standard.

## KEY PARAMETER LIST OF CARTON BOX

Reel Type	Length (mm)	Width (mm)	Height (mm)	Pizza/Carton
7" (Option)	368	227	224	8
7"	442	410	224	18
13"	386	280	370	5

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