

# SGM8521 SGM8522 SGM8524

## 150KHz, 4.7µA, Rail-to-Rail I/O CMOS Operational Amplifier

### PRODUCT DESCRIPTION

The SGM8521 (single), SGM8522 (dual) and SGM8524 (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 +125°C temperature range.

The SGM8521/8522/8524 provide 150KHz bandwidth at a low current consumption of 4.7µA per amplifier. Very low input bias currents of 0.5pA, enable the SGM8521/8522/8524 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 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 the tiny SOT23-5 and SO-8 packages. The SGM8522 comes in the miniature SO-8 and MSOP-8 packages. The SGM8524 is offered in TSSOP-16 SO-16 and SO-14 packages.

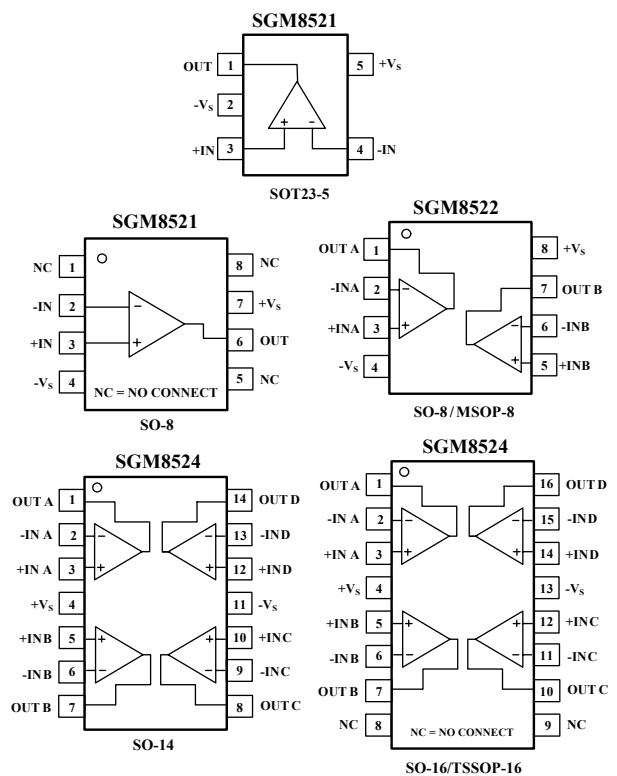
### APPLICATIONS

- ASIC Input or Output Amplifier
- Sensor Interface
- Piezo Electric Transducer Amplifier
- Medical Instrumentation
- Mobile Communication
- Audio Output
- Portable Systems
- Smoke Detectors
- Mobile Telephone
- Notebook PC
- PCMCIA cards
- Battery-Powered equipment

### FEATURES

- Low Cost
- Rail-to-Rail Input and Output  
0.8mV Typical  $V_{OS}$
- Unity Gain Stable
- Gain Bandwidth Product: 150KHz
- Very low input bias currents : 0.5pA
- Operates on 2.1 V to 5.5 V Supplies
- Input Voltage Range = - 0.1 V to +5.6 V with  $V_S = 5.5V$
- Low Supply Current: 4.7µA/Amplifier
- Small Packaging  
SGM8521 Available in SO-8 and SOT23-5  
SGM8522 Available in SO-8 and MSOP-8  
SGM8524 Available in SO-16, SO-14 and TSSOP-16

### PIN CONFIGURATIONS (Top View)



# ELECTRICAL CHARACTERISTICS : $V_S = +5V$

(At  $R_L = 500k\Omega$  connected to  $V_S/2$  and  $V_{OUT} = V_S/2$ , unless otherwise noted)

PARAMETER	Symbol	CONDITION	SGM8521/8522/8524							
			TYP	MIN/MAX OVER TEMPERATURE					UNITS	MIN/MAX
			+25°C	+25°C	0°C to 70°C	-40°C to +85°C	-40°C to +125°C			
<b>INPUT CHARACTERISTICS</b>										
Input Offset Voltage	$V_{OS}$		±0.8	±3.5					mV	MAX
Input Bias Current	$I_B$		0.5						pA	TYP
Input Offset Current	$I_{OS}$		0.5						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	91	72					dB	MIN
		$V_S = 5.5V, V_{CM} = -0.1V$ to 5.6 V	83	63					dB	MIN
Open-Loop Voltage Gain	$A_{OL}$	$R_L = 100K\Omega, V_o = 0.1V$ to 4.9V	100	84					dB	MIN
		$R_L = 500K\Omega, V_o = 0.015V$ to 4.965V	104	90					dB	MIN
Input Offset Voltage Drift	$\Delta V_{OS}/\Delta T$		1.7						$\mu V/^\circ C$	TYP
<b>OUTPUT CHARACTERISTICS</b>										
Output Voltage Swing from Rail		$R_L = 500K\Omega$	0.005						V	MAX
Output Current	$I_{OUT}$		22						mA	MIN
Short-Circuit Current	$I_{SC}$								mA	TYP
<b>POWER SUPPLY</b>										
Operating Voltage Range				2.1					V	MIN
				5.5					V	MAX
Power Supply Rejection Ratio	PSRR	$V_S = +2.5 V$ to + 5.5 V $V_{CM} = (-V_S) + 0.5$	91						dB	MIN
Quiescent Current / Amplifier	$I_Q$	$I_{OUT} = 0$	4.7						$\mu A$	MAX
<b>DYNAMIC PERFORMANCE</b>										
Gain-Bandwidth Product	GBP	$C_L = 100pF$	150						KHz	TYP
Slew Rate	SR	$G = +1, 2V$ Output Step	0.04						$V/\mu s$	TYP
Settling Time to 0.1%	$t_s$	$G = +1, 2 V$ Output Step	32						$\mu s$	TYP
Overload Recovery Time		$V_{IN} \cdot Gain = V_S$							$\mu s$	TYP
<b>NOISE PERFORMANCE</b>										
Voltage Noise Density	$e_n$	$f = 1kHz$ $f = 10kHz$	40						$nV/\sqrt{Hz}$	TYP
			12						$nV/\sqrt{Hz}$	TYP

Specifications subject to change without notice.

## PACKAGE/ORDERING INFORMATION

MODEL	ORDER NUMBER	PACKAGE DESCRIPTION	PACKAGE OPTION	MARKING INFORMATION
SGM8521	SGM8521XN5/TR	SOT23-5	Tape and Reel, 3000	8521
	SGM8521XS/TR	SO-8	Tape and Reel, 2500	SGM8521XS
SGM8522	SGM8522XS/TR	SO-8	Tape and Reel, 2500	SGM8522XS
	SGM8522XMS/TR	MSOP-8	Tape and Reel, 3000	SGM8522XMS
SGM8524	SGM8524XS/TR	SO-16	Tape and Reel, 2500	SGM8524XS
	SGM8524XS14	SO-14	Tube	SGM8524XS14
	SGM8524XTS/TR	TSSOP-16	Tape and Reel, 3000	SGM8524XTS

### 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 ..... -55°C to +150°C  
 Package Thermal Resistance @ T<sub>A</sub> = 25°C  
 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.

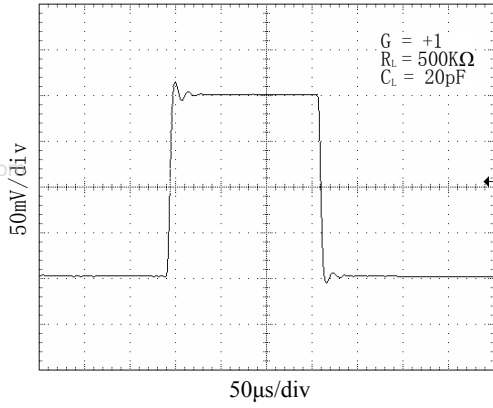
### CAUTION

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.

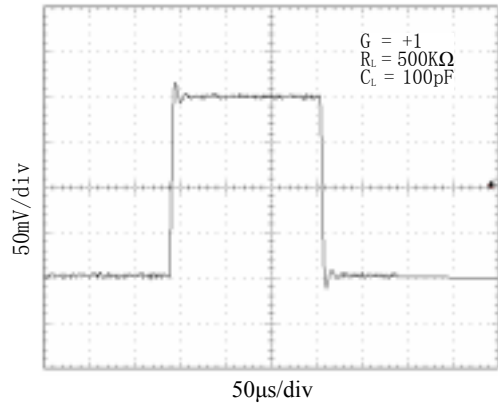
# TYPICAL PERFORMANCE CHARACTERISTICS

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

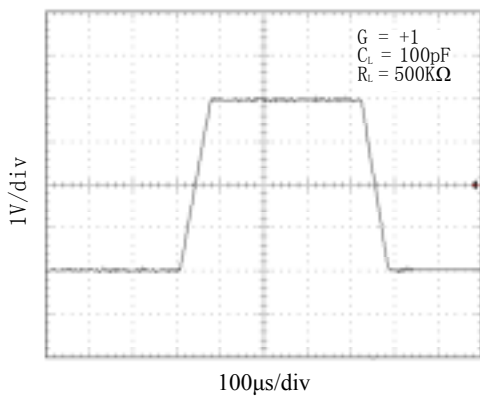
Small-Signal Step Response



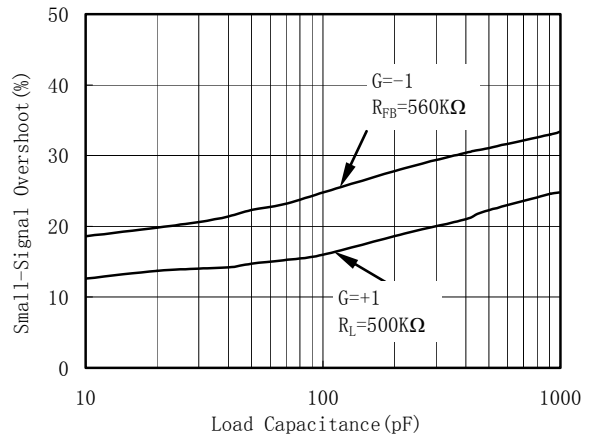
Small-Signal Step Response



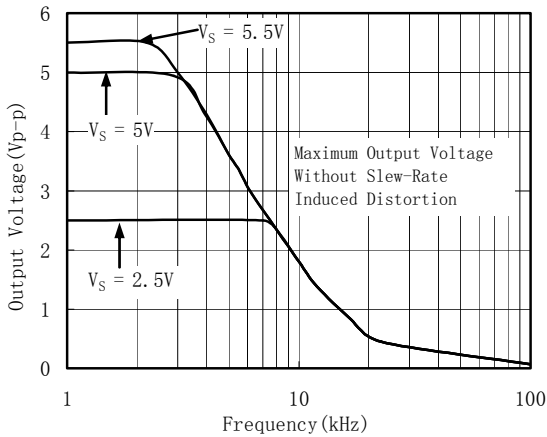
Large-Signal Step Response



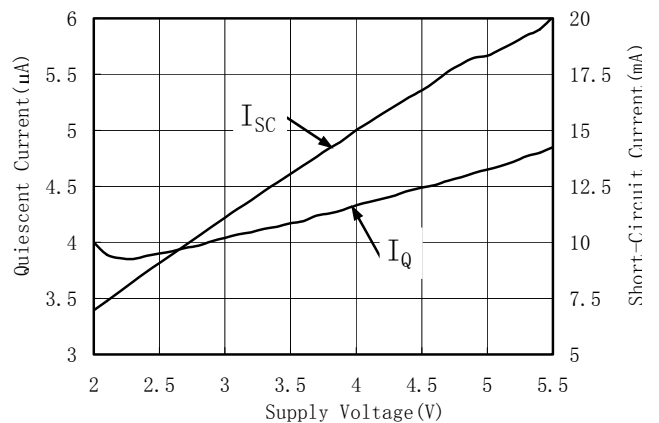
Small-Signal Overshoot vs. Load Capacitance



Maximum Output Voltage vs. Frequency

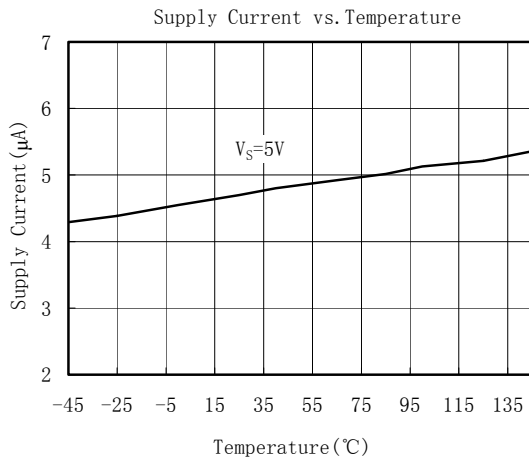
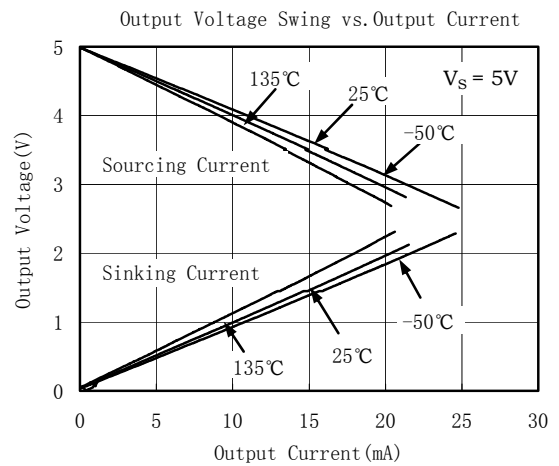
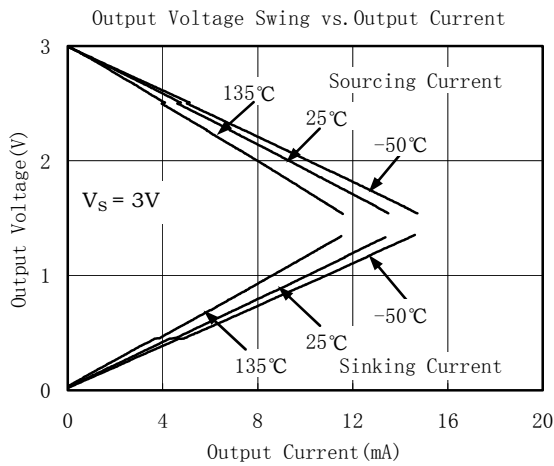
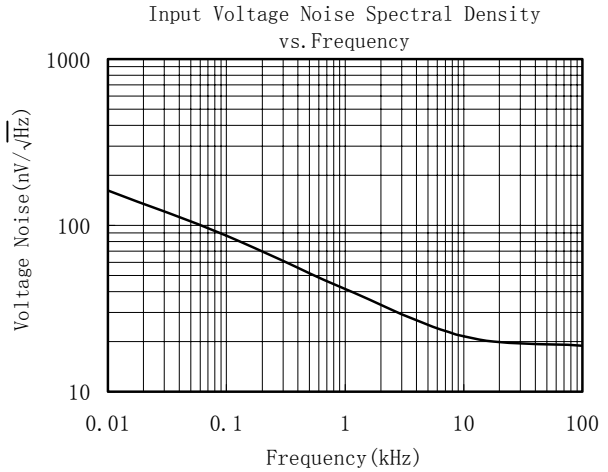
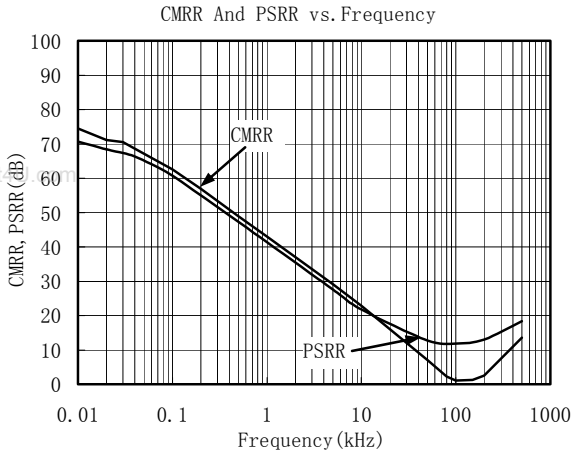


Quiescent And Short-Circuit Current vs. Supply Voltage



# 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.



# APPLICATION NOTES

## Driving Capacitive Loads

The SGM852X 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  $R_{LOAD}$ .

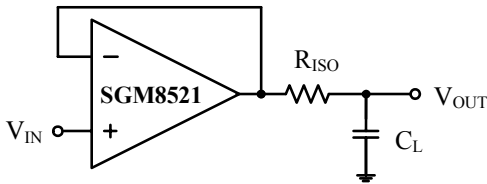


Figure 1. Indirectly Driving Heavy Capacitive Load

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.

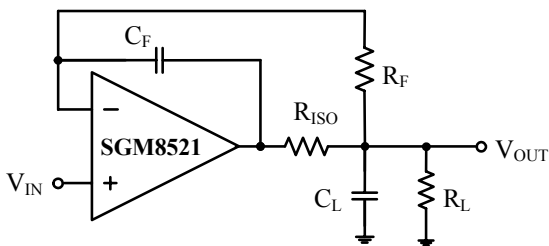


Figure 2. Indirectly Driving Heavy Capacitive Load with DC Accuracy

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 SGM852X 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.

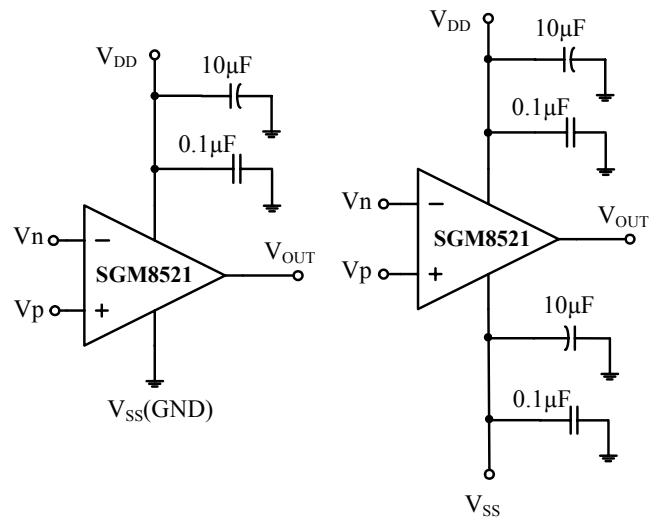


Figure 3. Amplifier with Bypass Capacitors

# Typical Application Circuits

## Differential Amplifier

The circuit shown in Figure 4 performs the difference function. If the resistors ratios are equal ( $R4 / R3 = R2 / R1$ ), then  $V_{OUT} = (Vp - Vn) \times R2 / R1 + Vref$ .

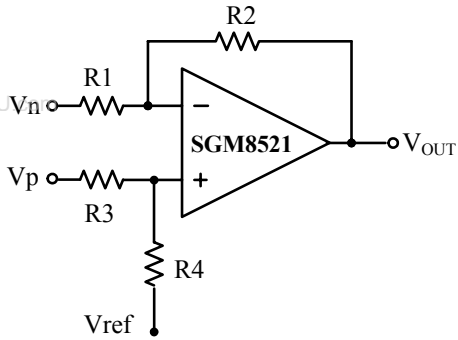


Figure 4. Differential Amplifier

## Instrumentation Amplifier

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

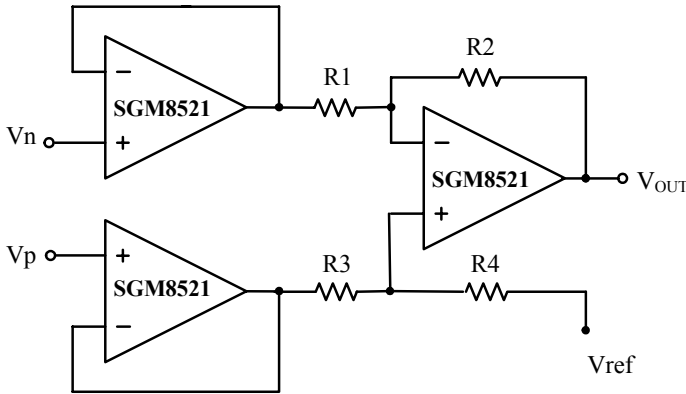


Figure 5. Instrumentation Amplifier

## Low Pass Active Filter

The low pass filter shown in Figure 6 has a DC gain of ( $-R2 / R1$ ) and the  $-3\text{dB}$  corner frequency is  $1/2\pi R2C$ . 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.

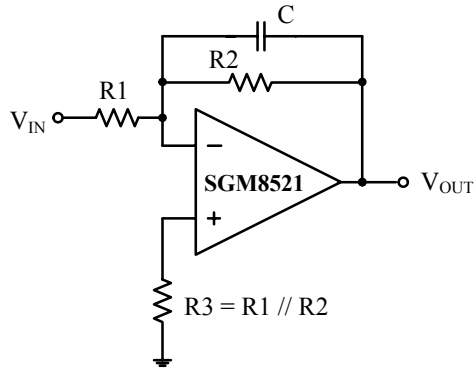
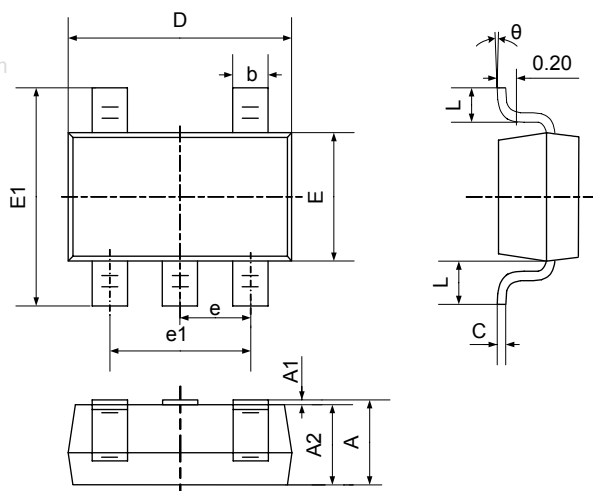


Figure 6. Low Pass Active Filter

# PACKAGE OUTLINE DIMENSIONS

## SOT23-5

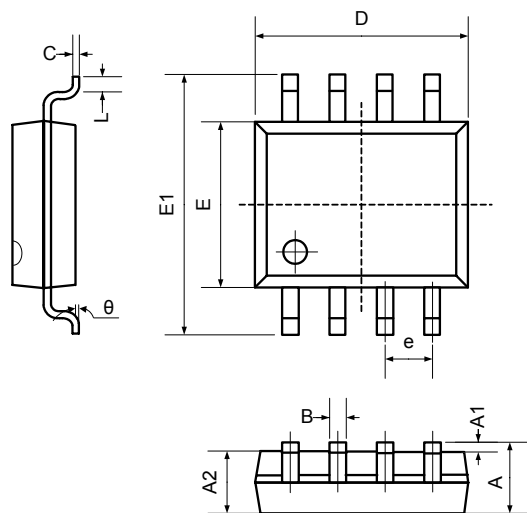


Symbol	Dimensions In Millimeters		Dimensions In Inches	
	Min	Max	Min	Max
A	1.050	1.250	0.041	0.049
A1	0.000	0.100	0.000	0.004
A2	1.050	1.150	0.041	0.045
b	0.300	0.400	0.012	0.016
c	0.100	0.200	0.004	0.008
D	2.820	3.020	0.111	0.119
E	1.500	1.700	0.059	0.067
E1	2.650	2.950	0.104	0.116
e	0.950TYP		0.037TYP	
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

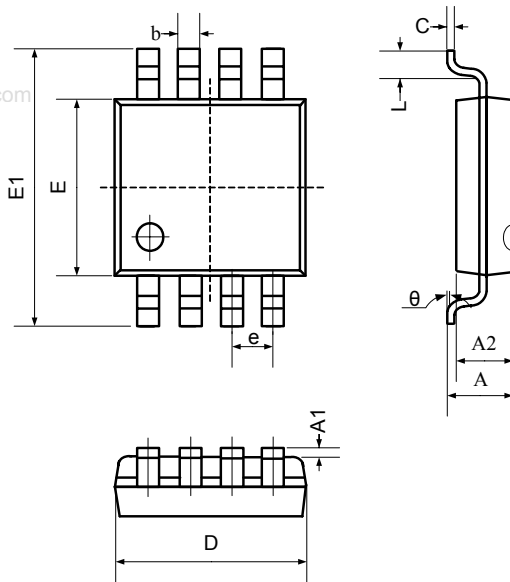
## SO-8



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

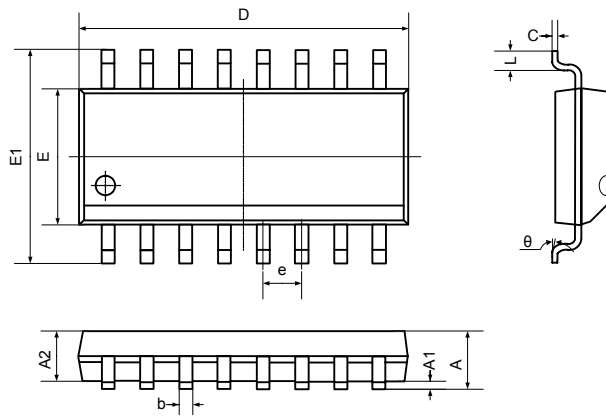
## MSOP-8



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
θ	0°	6°	0°	6°

# PACKAGE OUTLINE DIMENSIONS

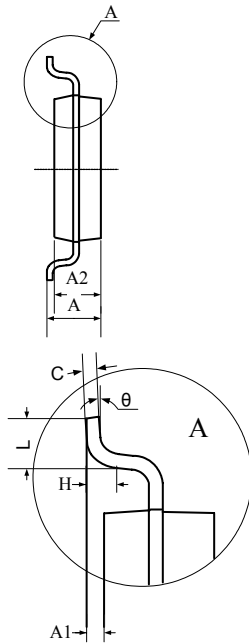
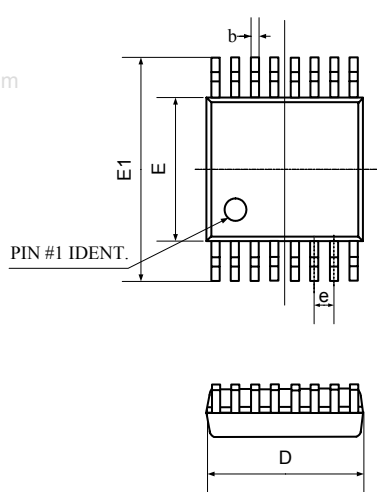
## SO-16



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
θ	0°	8°	0°	8°

# PACKAGE OUTLINE DIMENSIONS

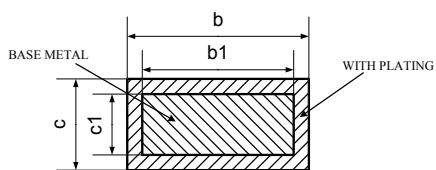
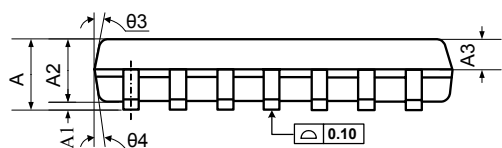
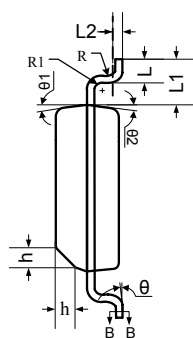
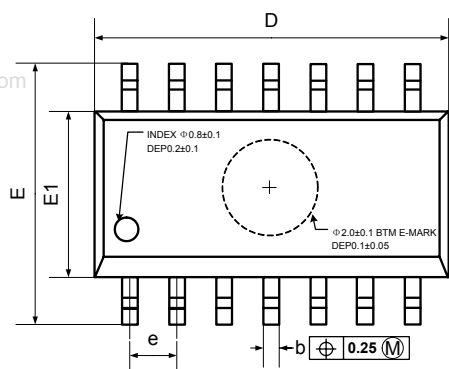
## TSSOP-16



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°

# PACKAGE OUTLINE DIMENSIONS

## SO-14



SECTION B-B

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°
theta1	6°	8°	10°
theta2	6°	8°	10°
theta3	5°	7°	9°
theta4	5°	7°	9°

# REVISION HISTORY

Location	Page
<b>11/06— Data Sheet changed from Preliminary to REV. A</b>	
Changes to ABSOLUTE MAXIMUM RATINGS .....	3
<b>11/06— Data Sheet changed from REV. A to REV. B</b>	
Adds SO-14 Package .....	1, 3

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