SGM8521/2/4
150kHz, 4.7μA, Rail-to-Rail I/O CMOS Operational Amplifiers

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 5.5V. All are specified over the extended -40℃ to +125℃ temperature range.

The SGM8521/2/4 provide 150kHz bandwidth at a low current consumption of 4.7μA per amplifier. Very low input bias currents of 0.5pA enable the SGM8521/2/4 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-14 and SO-14 packages.

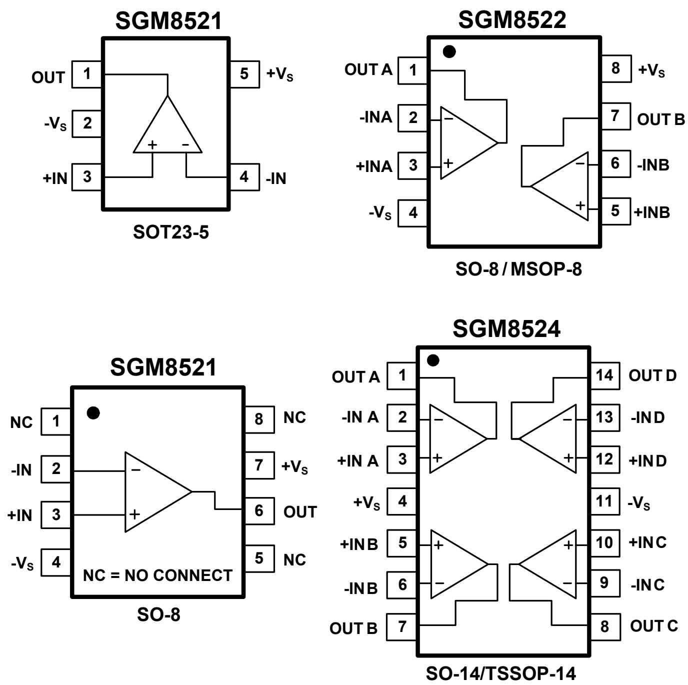
APPLICATIONS

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 2.1V to 5.5V Supplies**
- **Input Voltage Range = -0.1V to +5.6V 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-14 and TSSOP-14

PIN CONFIGURATIONS (Top View)



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	SGM8524XS14/TR	SO-14	Tape and Reel, 2500	SGM8524XS14
	SGM8524XTS14/TR	TSSOP-14	Tape and Reel, 3000	SGM8524XTS14

ABSOLUTE MAXIMUM RATINGS

Supply Voltage, V+ to V- 7.5V
Common-Mode Input Voltage
.... $(-V_S)$ - 0.5V to $(+V_S)$ + 0.5V
Storage Temperature Range..........................–65℃ to +150℃
Junction Temperature ....160℃
Operating Temperature Range..........................–55℃ to +150℃
Package Thermal Resistance @ T_A = 25℃
SOT23-5, θ_{JA}... 190℃/W
SO-8, θ_{JA}..125℃/W
MSOP-8, θ_{JA}... 216℃/W
Lead Temperature Range (Soldering 10 sec)..................260℃
ESD Susceptibility
HBM..4000V
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 = 500KΩ connected to Vs/2 and V_{OUT} = Vs/2, unless otherwise noted.)

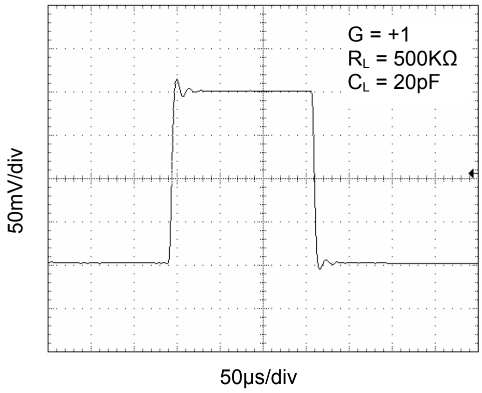
PARAMETER	SYMBOL	CONDITIONS	SGM8521/2/4			
			TYP	MIN/MAX OVER TEMPERATURE		
			+25℃	+25℃	UNITS	MIN/ MAX
INPUT CHARACTERISTICS						
Input Offset Voltage	V_{OS}		±0.8	±3.5	mV	MAX
Input Bias Current	I_B		0.5		pA	TYP
Input Offset Current	I_{OS}		0.5		pA	TYP
Common-Mode Voltage Range	V_{CM}	V_S = 5.5V	-0.1 to +5.6		V	TYP
Common-Mode Rejection Ratio	CMRR	V_S = 5.5V, V_{CM} = -0.1V to 4V	91	72	dB	MIN
		V_S = 5.5V, V_{CM} = -0.1V to 5.6V	83	63	dB	MIN
Open-Loop Voltage Gain	A_{OL}	R_L = 100KΩ ,Vo = 0.1V to 4.9V	100	84	dB	MIN
		R_L =500KΩ ,Vo = 0.015V to 4.965V	104	90	dB	MIN
Input Offset Voltage Drift	$\Delta V_{OS}/\Delta_T$		1.7		μV/℃	TYP
OUTPUT CHARACTERISTICS						
Output Voltage Swing from Rail		R_L = 500KΩ	0.005		V	MAX
Output Current	I_{OUT}		22		mA	MIN
POWER SUPPLY						
Operating Voltage Range				2.1	V	MIN
				5.5	V	MAX
Power Supply Rejection Ratio	PSRR	V_S = +2.5V to + 5.5V				
		V_{CM} = (-V_S) + 0.5	91		dB	MIN
Quiescent Current / Amplifier	I_Q	I_{OUT} = 0	4.7		μA	MAX
DYNAMIC PERFORMANCE		C_L = 100pF				
Gain-Bandwidth Product	GBP		150		kHz	TYP
Slew Rate	SR	G = +1 , 2V Output Step	0.04		V/μs	TYP
Settling Time to 0.1%	t_S	G = +1, 2V Output Step	32		μs	TYP
NOISE PERFORMANCE						
Voltage Noise Density	e_n	f = 1kHz	40		nV/$\sqrt{Hz}$	TYP
		f = 10kHz	12		nV/$\sqrt{Hz}$	TYP

Specifications subject to change without notice.

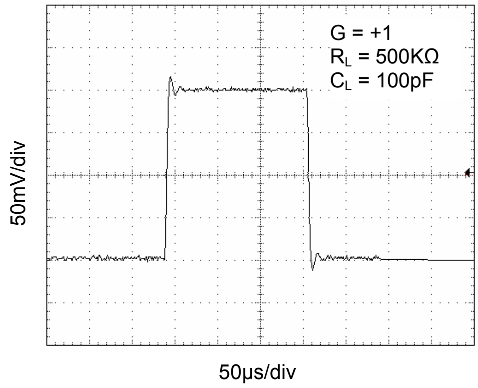
TYPICAL PERFORMANCE CHARACTERISTICS

At T_A= +25℃, V_S = +5V, and R_L=500KΩ connected to Vs/2, unless otherwise noted.

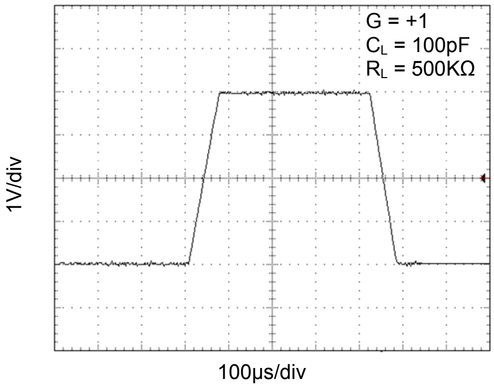
Small-Signal Step Response



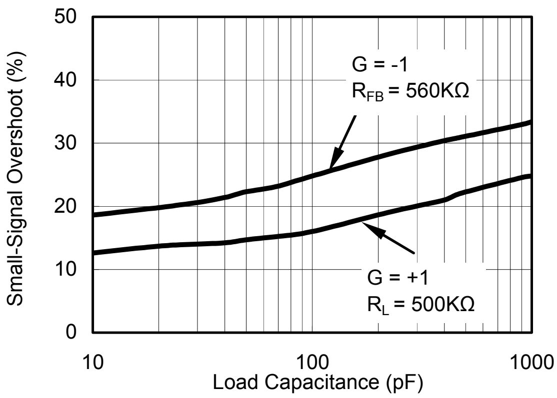
Small-Signal Step Response



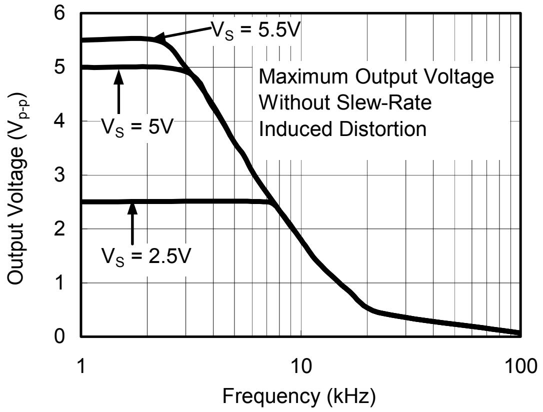
Large-Signal Step Response



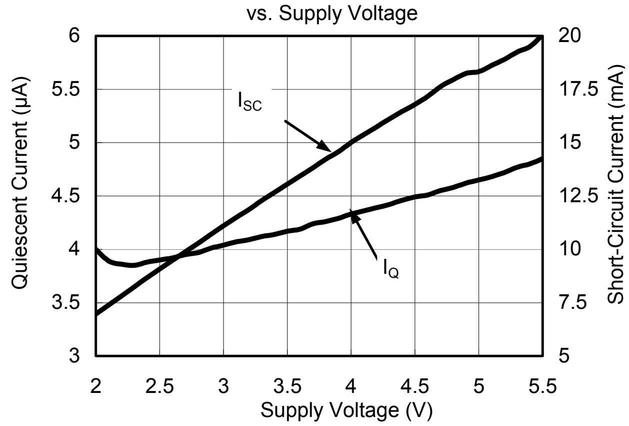
Small-Signal Overshoot vs. Load Capacitance



Maximum Output Voltage vs. Frequency

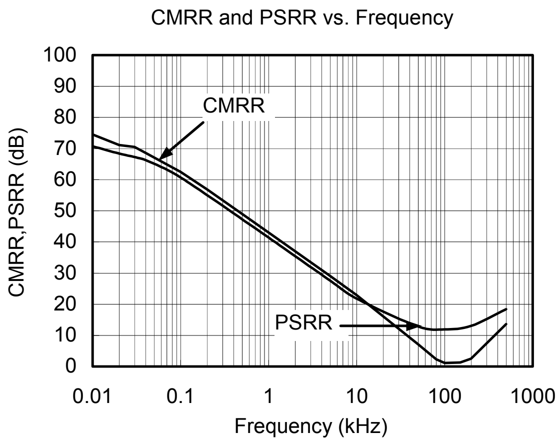


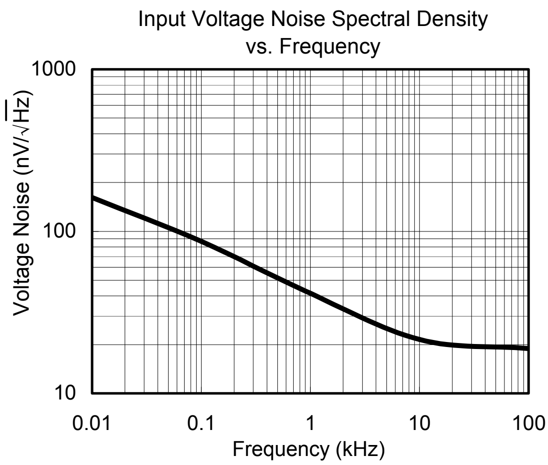
Quiescent and Short-Circuit Current vs. Supply Voltage

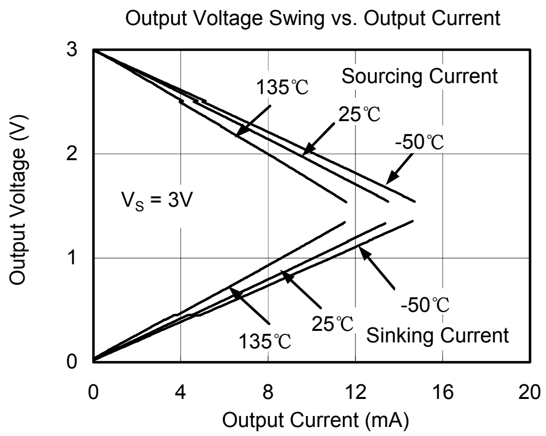


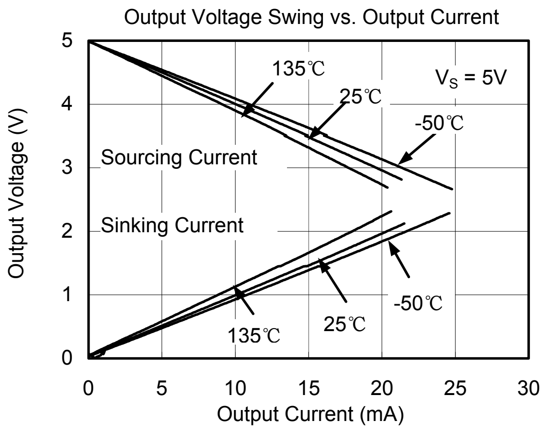
TYPICAL PERFORMANCE CHARACTERISTICS

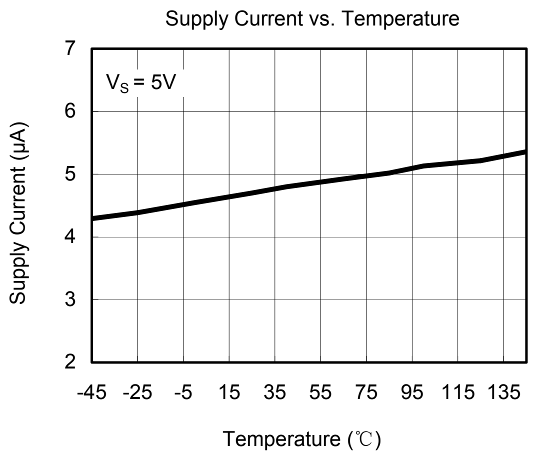
At T_A= +25℃, V_S = +5V, and R_L=500kΩ connected to Vs/2, unless otherwise noted.











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}.

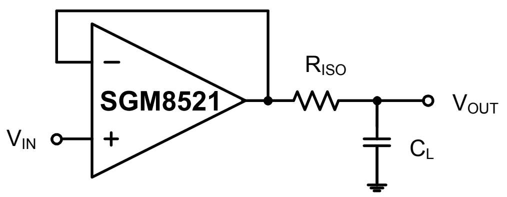


Figure 1. Indirectly Driving Heavy Capacitive Load

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.

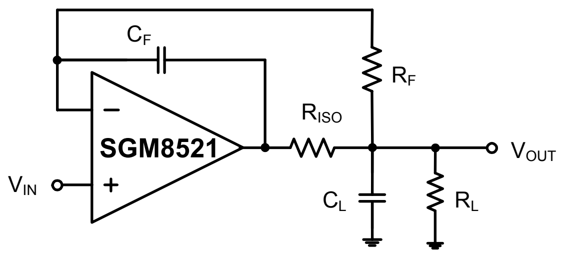


Figure 2. Indirectly Driving Heavy Capacitive Load with DC Accuracy

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 ±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.

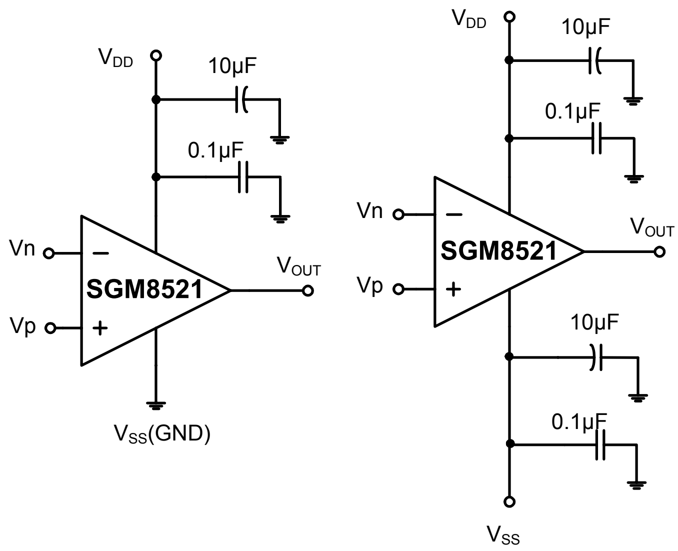


Figure 3. Amplifier with Bypass Capacitors

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} = (Vp – Vn) × R_2 / R_1 + V_{REF}.

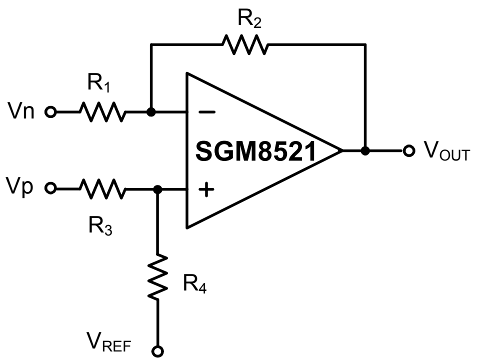


Figure 4. Differential Amplifier

Instrumentation Amplifier

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

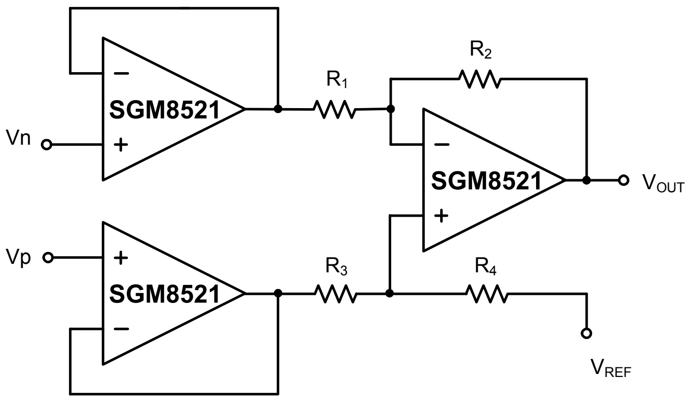


Figure 5. Instrumentation Amplifier

Low Pass Active Filter

The low pass filter shown in Figure 6 has a DC gain of (- R_2 / R_1) and the –3dB corner frequency is $1/2\pi R_2C$. 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.

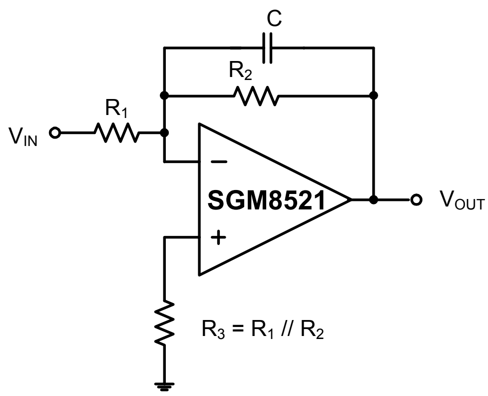
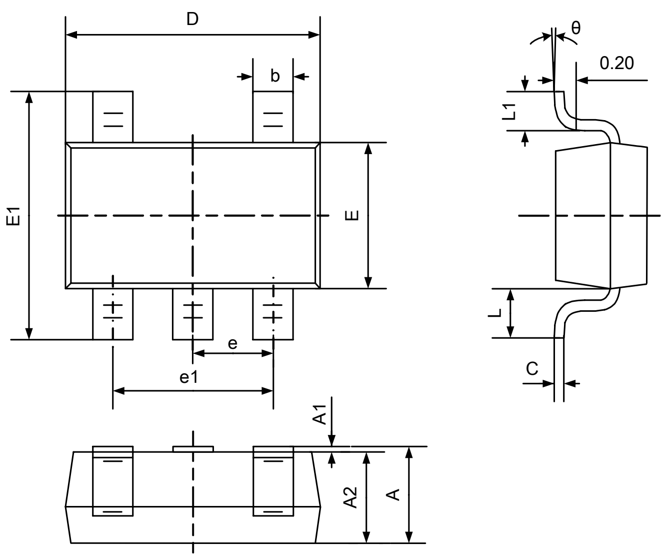


Figure 6. Low Pass Active Filter

PACKAGE OUTLINE DIMENSIONS

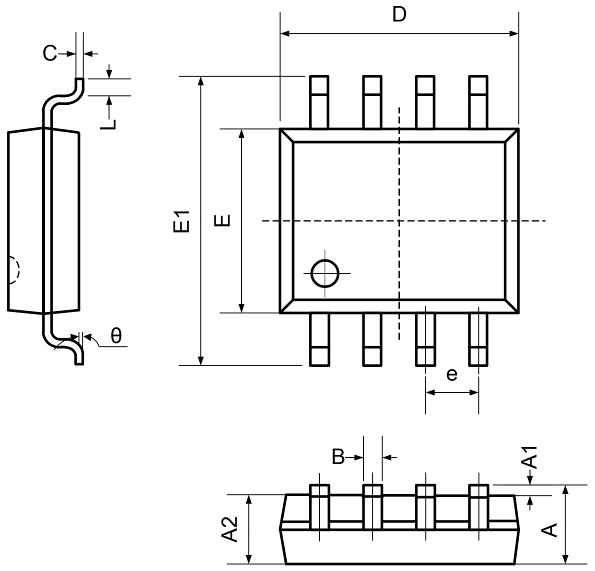
SOT23-5



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
θ	0°	8°	0°	8°

PACKAGE OUTLINE DIMENSIONS

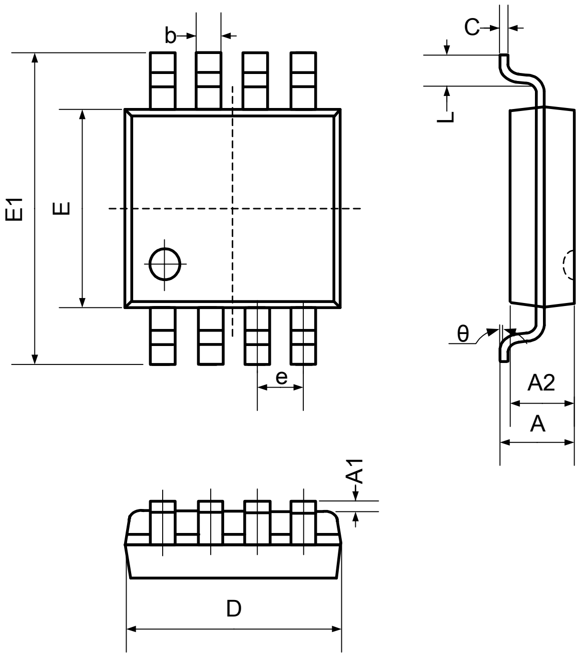
SO-8



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
θ	0°	8°	0°	8°

PACKAGE OUTLINE DIMENSIONS

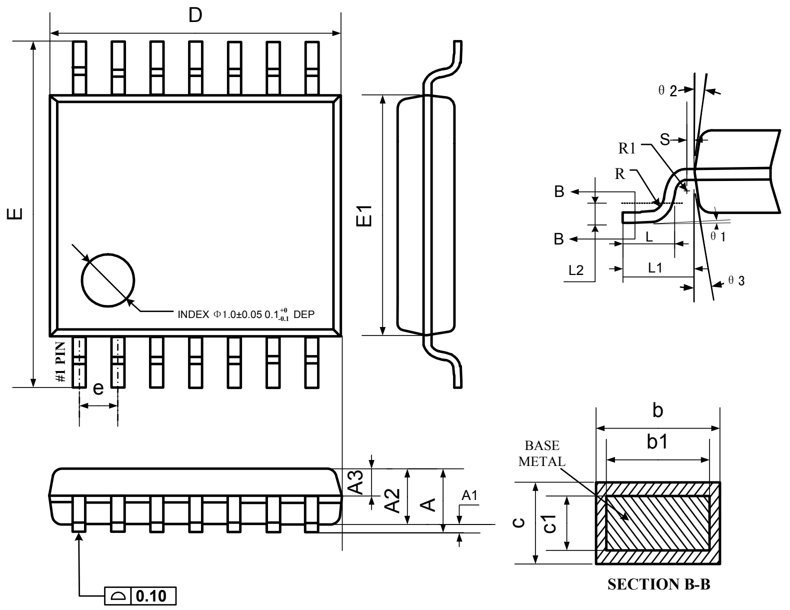
MSOP-8



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

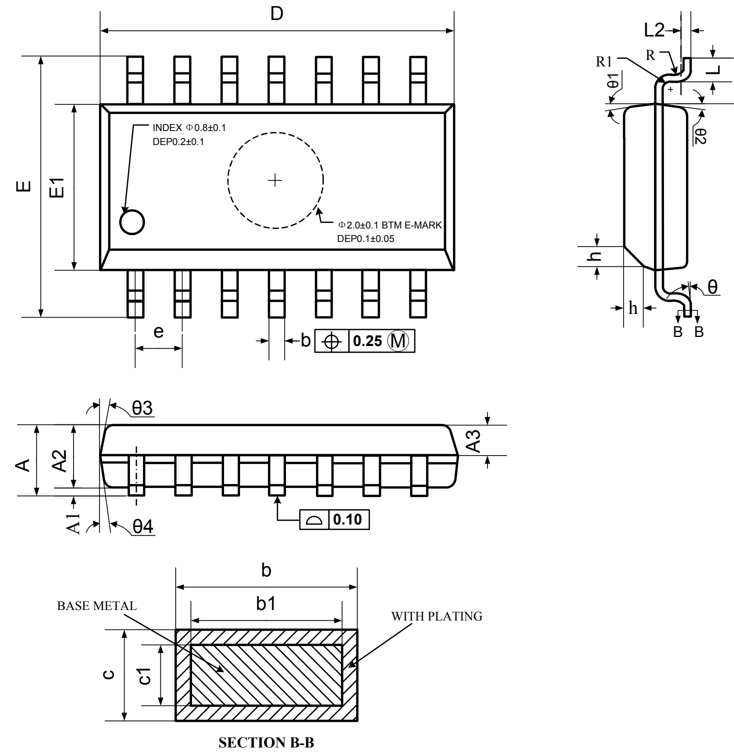
TSSOP-14



Symbol	Dimensions In Millimeters		
	MIN	NOM	MAX
A	—	—	1.20
A1	0.05	—	0.15
A2	0.90	1.00	1.05
A3	0.34	0.44	0.54
b	0.20	—	0.28
b1	0.20	0.22	0.24
c	0.10	—	0.19
c1	0.10	0.13	0.15
D	4.86	4.96	5.06
E	6.20	6.40	6.60
E1	4.30	4.40	4.50
e	0.65 BSC		
L	0.45	0.60	0.75
L1	1.00 REF		
L2	0.25 BSC		
R	0.09	—	—
R1	0.09	—	—
S	0.20	—	—
θ1	0°	—	8°
θ2	10°	12°	14°
θ3	10°	12°	14°

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
θ	0°		8°
θ1	6°	8°	10°
θ2	6°	8°	10°
θ3	5°	7°	9°
θ4	5°	7°	9°

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