SGMICRO

SGM8621/2/3/4
250μA, 3MHz, Rail-to-Rail I/O CMOS Operational Amplifiers

PRODUCT DESCRIPTION

The SGM8621(single), SGM8622(dual), SGM8623(single with shutdown) and SGM8624(quad) are low noise, low voltage, and low power operational amplifiers, that can be designed into a wide range of applications. The SGM8621/2/3/4 have a high gain-bandwidth product of 3MHz, a slew rate of 1.7V/μs, and a quiescent current of 250μA/amplifier at 5V. The SGM8623 has a power-down disable feature that reduces the supply current to 150nA.

The SGM8621/2/3/4 are designed to provide optimal performance in low voltage and low noise systems. They provide rail-to-rail output swing into heavy loads. The input common-mode voltage range includes ground, and the maximum input offset voltage is 3mV for SGM8621/2/3/4. They are specified over the extended industrial temperature range (−40℃ to +125℃). The operating range is from 2.5V to 5.5V.

The single version, SGM8621/8623, is available in SC70-5, SO-8 and SOT23-5(6) packages. The dual version SGM8622 is available in SO-8 and MSOP-8 packages. The quad version SGM8624 is available in SO-14 and TSSOP-14 packages.

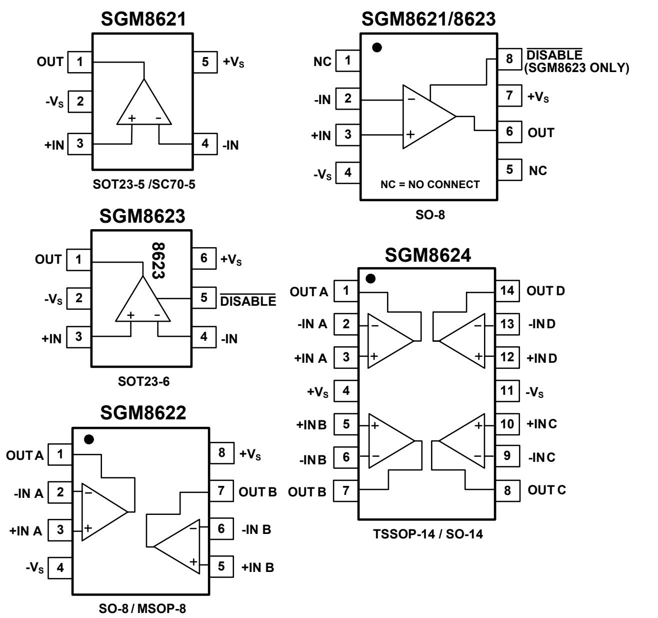
APPLICATIONS

Sensors
Audio
Active Filters
A/D Converters
Communications
Test Equipment
Cellular and Cordless Phones
Laptops and PDAs
Photodiode Amplification
Battery-Powered Instrumentation

FEATURES

- **Low Cost**
- **Rail-to-Rail Input and Output**
  0.7mV Typical V_{OS}
- **High Gain-Bandwidth Product: 3MHz**
- **High Slew Rate: 1.7V/μs**
- **Settling Time to 0.1% with 2V Step: 2.1μs**
- **Overload Recovery Time: 1μs**
- **Low Noise : 12nV/$\sqrt{Hz}$**
- **Operates on 2.5V to 5.5V Supplies**
- **Input Voltage Range = -0.1V to +5.6V with V_S = 5.5V**
- **Low Power**
  250μA/Amplifier Typical Supply Current
  SGM8623 150nA when Disabled
- **Small Packaging**
  SGM8621 Available in SC70-5, SOT23-5 and SO-8
  SGM8622 Available in MSOP-8 and SO-8
  SGM8623 Available in SOT23-6 and SO-8
  SGM8624 Available in TSSOP-14 and SO-14

PIN CONFIGURATIONS (Top View)



PACKAGE/ORDERING INFORMATION

MODEL	ORDER NUMBER	PACKAGE DESCRIPTION	PACKAGE OPTION	MARKING INFORMATION
SGM8621	SGM8621XC5/TR	SC70-5	Tape and Reel, 3000	8621
	SGM8621XN5/TR	SOT23-5	Tape and Reel, 3000	8621
	SGM8621XS/TR	SO-8	Tape and Reel, 2500	SGM8621XS
SGM8622	SGM8622XMS/TR	MSOP-8	Tape and Reel, 3000	SGM8622XMS
	SGM8622XS/TR	SO-8	Tape and Reel, 2500	SGM8622XS
SGM8623	SGM8623XN6/TR	SOT23-6	Tape and Reel, 3000	8623
	SGM8623XS/TR	SO-8	Tape and Reel, 2500	SGM8623XS
SGM8624	SGM8624XS14/TR	SO-14	Tape and Reel, 2500	SGM8624XS14
	SGM8624XTS14/TR	TSSOP-14	Tape and Reel, 3000	SGM8624XTS14

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

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℃
SC70-5, θ_{JA}.. 333℃/W
SOT23-5, θ_{JA}.. 190℃/W
SOT23-6, 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...1500V
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 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 T_A = +25℃, V_{CM} = Vs/2, R_L = 600Ω, unless otherwise noted.)

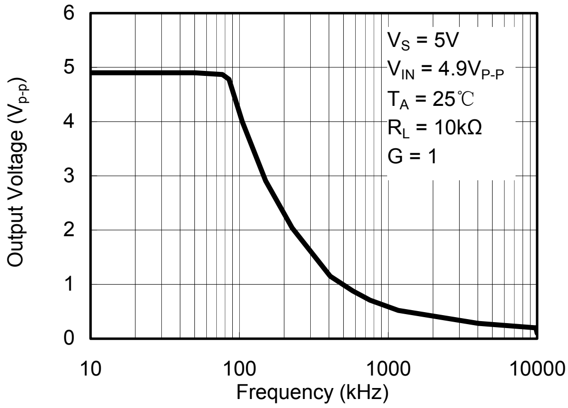
PARAMETER	CONDITIONS	SGM8621/2/3/4						
		TYP	MIN/MAX OVER TEMPERATURE					
		+25℃	+25℃	0℃ to 70℃	-40℃ to 85℃	-40℃ to 125℃	UNITS	MIN/ MAX
INPUT CHARACTERISTICS								
Input Offset Voltage (V_{OS})		0.7	3	3.1	3.3	3.5	mV	MAX
Input Bias Current (I_B)		1					pA	TYP
Input Offset Current (I_{OS})		1					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	90	75	74	73	73	dB	MIN
	V_S = 5.5V, V_{CM} = - 0.1V to 5.6V	92	66	65	65	64	dB	MIN
Open-Loop Voltage Gain (A_{OL})	R_L = 600Ω , Vo = 0.15V to 4.85V	100	92	90	89	78	dB	MIN
	R_L =10KΩ , Vo = 0.05V to 4.95V	110	100	99	98	82	dB	MIN
Input Offset Voltage Drift ($\Delta V_{OS}/\Delta_T$)		2.7					μV/℃	TYP
OUTPUT CHARACTERISTICS								
Output Voltage Swing from Rail	R_L = 600Ω	0.1					V	TYP
	R_L = 10KΩ	0.015					V	TYP
Output Current (I_{OUT})		48	45	42	40	30	mA	MIN
Closed-Loop Output Impedance	F = 100kHz, G = +1	2.6					Ω	TYP
POWER-DOWN DISABLE								
Turn-On Time		6.2					ns	TYP
Turn-Off Time		1.4					ns	TYP
$\overline{\text{DISABLE}}$ Voltage-Off			0.8				V	MAX
$\overline{\text{DISABLE}}$ Voltage-On			2				V	MIN
POWER SUPPLY								
Operating Voltage Range			2.5	2.5	2.5	2.5	V	MIN
			5.5	5.5	5.5	5.5	V	MAX
Power Supply Rejection Ratio (PSRR)	V_s = +2.5V to +5.5V							
	V_{CM} = ($-V_S$) + 0.5V	94	79	78	77	76	dB	MIN
Quiescent Current/ Amplifier (I_Q)	I_{OUT} = 0	250	300	345	350	380	μA	MAX
Supply Current when Disabled (SGM8623 only)		150					nA	MAX
DYNAMIC PERFORMANCE								
Gain-Bandwidth Product (GBP)	R_L = 10KΩ	3					MHz	TYP
Phase Margin (φ_O)		67					Degrees	TYP
Full Power Bandwidth (BW_P)	< 1% distortion, R_L = 600Ω	50					kHz	TYP
Slew Rate (SR)	G = +1, 2V Step, R_L = 10KΩ	1.7					V/μs	TYP
Settling Time to 0.1%(t_S)	G = +1, 2 V Step, R_L = 600Ω	2.1					μs	TYP
Overload Recovery Time	V_{IN} ·Gain = Vs, R_L = 600Ω	1					μs	TYP
NOISE PERFORMANCE								
Voltage Noise Density (e_n)	f = 1kHz	12					nV/ $\sqrt{Hz}$	TYP
Current Noise Density(i_n)	f = 1kHz	3					fA/ $\sqrt{Hz}$	TYP

Specifications subject to changes without notice.

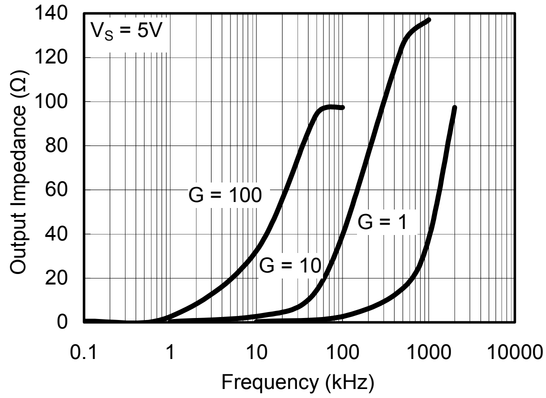
TYPICAL PERFORMANCE CHARACTERISTICS

(At T_A = +25℃, V_{CM} = Vs/2, R_L = 600Ω, unless otherwise noted.)

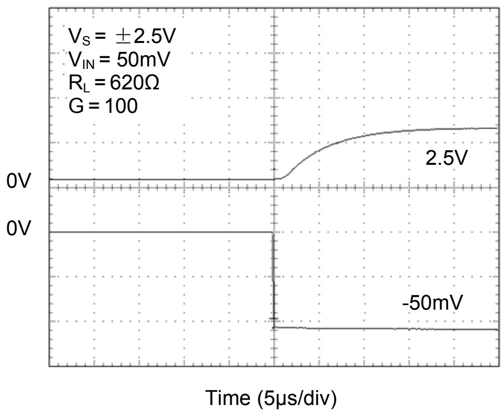
Closed-Loop Output Voltage Swing



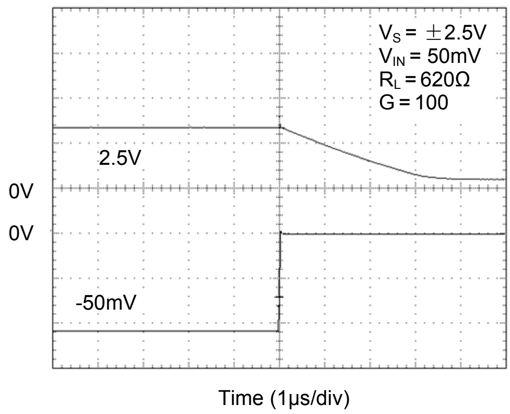
Output Impedance vs. Frequency



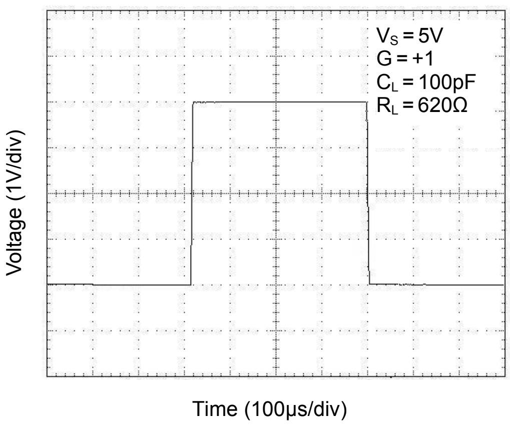
Positive Overload Recovery



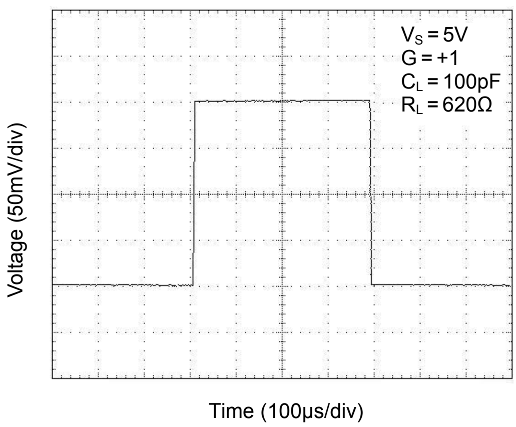
Negative Overload Recovery



Large-Signal Step Response



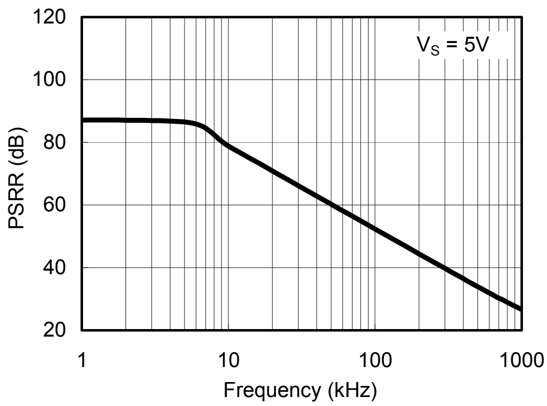
Small-Signal Step Response



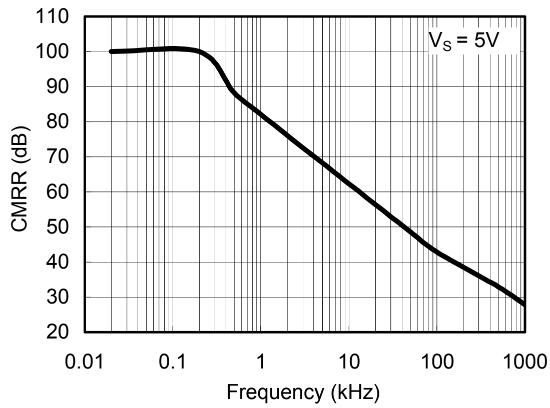
TYPICAL PERFORMANCE CHARACTERISTICS

(At T_A = +25℃, V_{CM} = Vs/2, R_L = 600Ω, unless otherwise noted.)

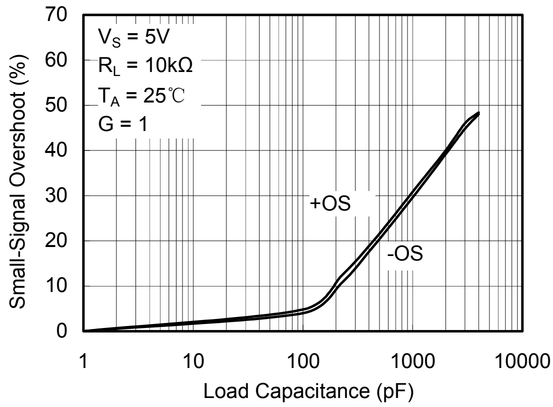
PSRR vs. Frequency



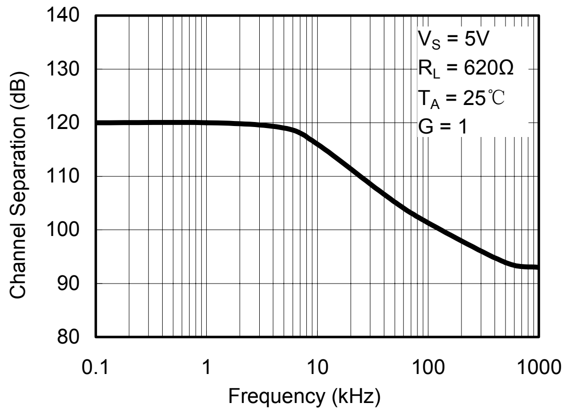
CMRR vs. Frequency



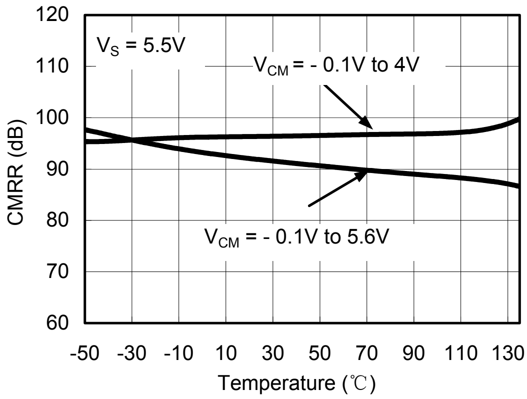
Small-Signal Overshoot vs. Load Capacitance



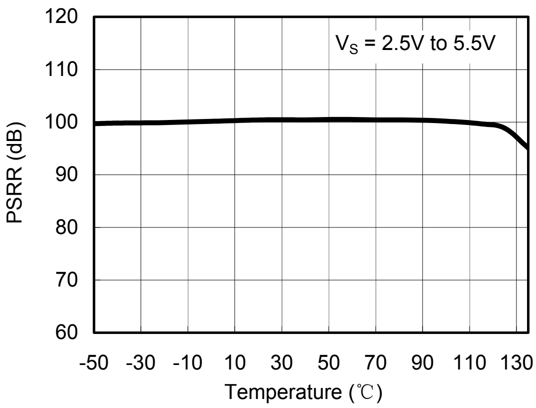
Channel Separation vs. Frequency



CMRR vs. Temperature



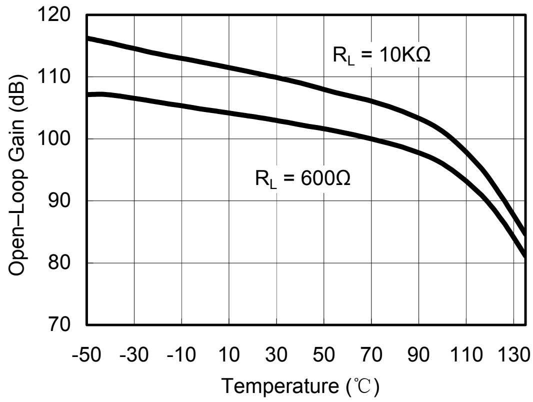
PSRR vs. Temperature



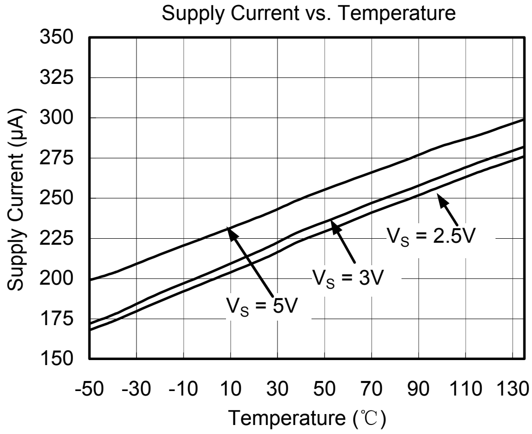
TYPICAL PERFORMANCE CHARACTERISTICS

(At T_A = +25℃,V_{CM} = Vs/2, R_L = 600Ω, unless otherwise noted.)

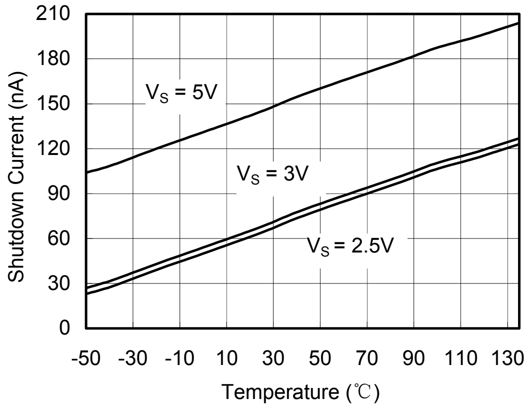
Open-Loop Gain vs. Temperature



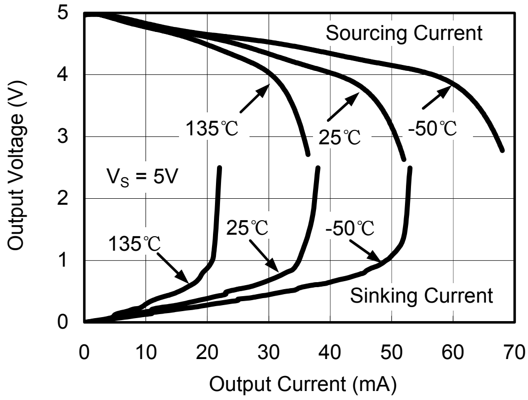
Supply Current vs. Temperature



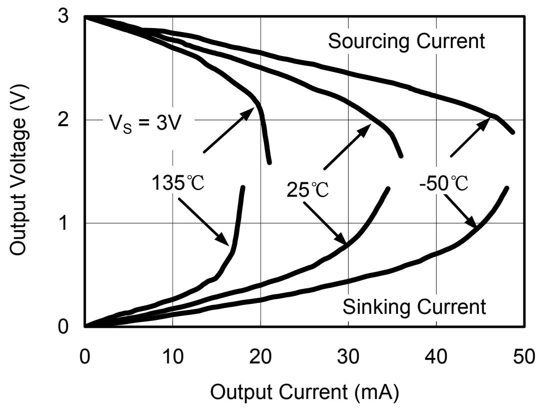
Shutdown Current vs. Temperature



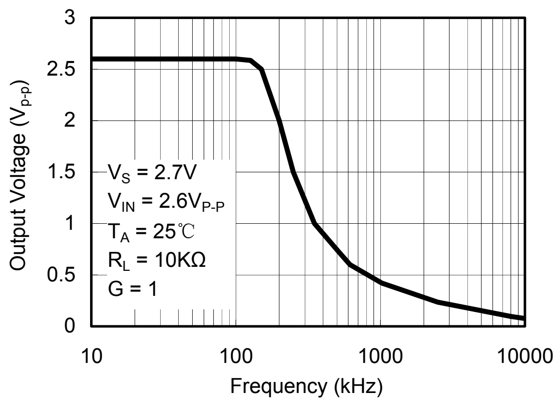
Output Voltage Swing vs. Output Current



Output Voltage Swing vs. Output Current

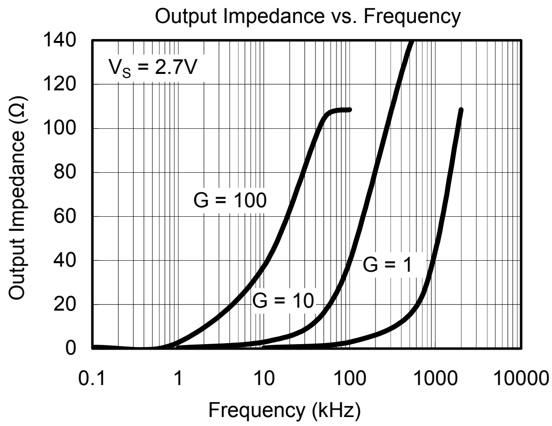


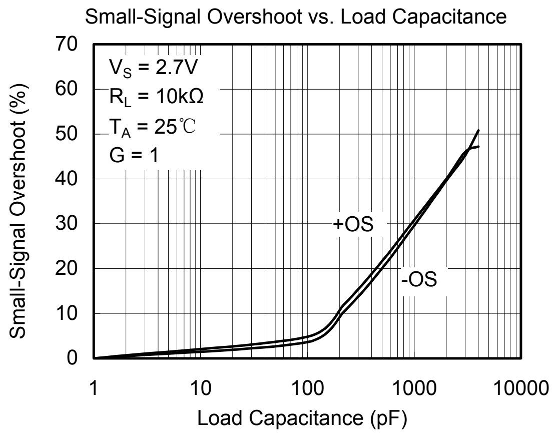
Closed-Loop Output Voltage Swing

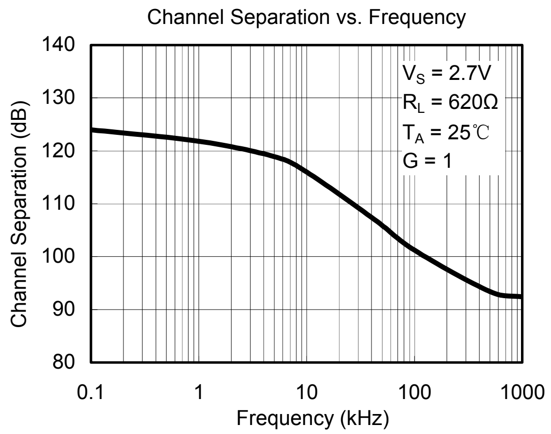


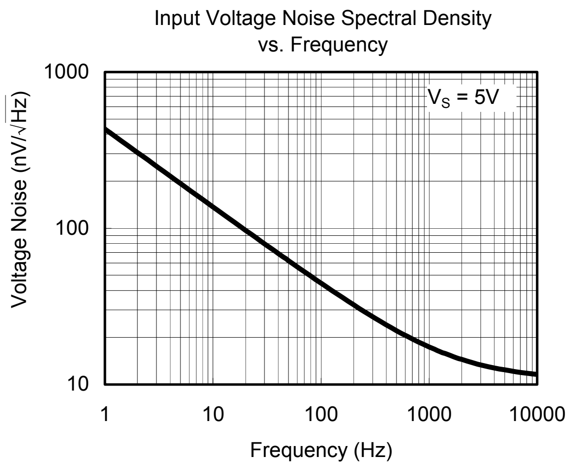
TYPICAL PERFORMANCE CHARACTERISTICS

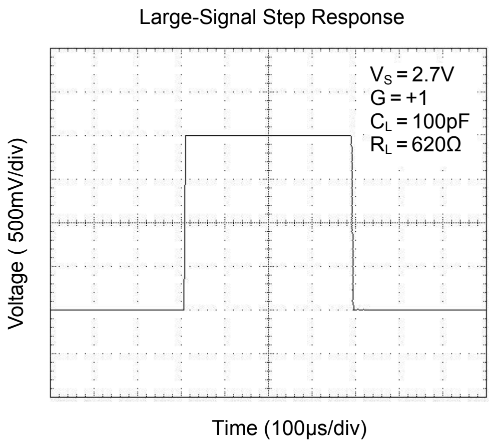
(At T_A = +25℃, V_{CM} = Vs/2, R_L = 600Ω, unless otherwise noted.)

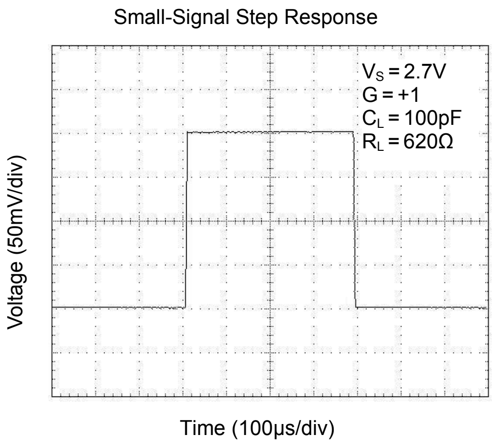






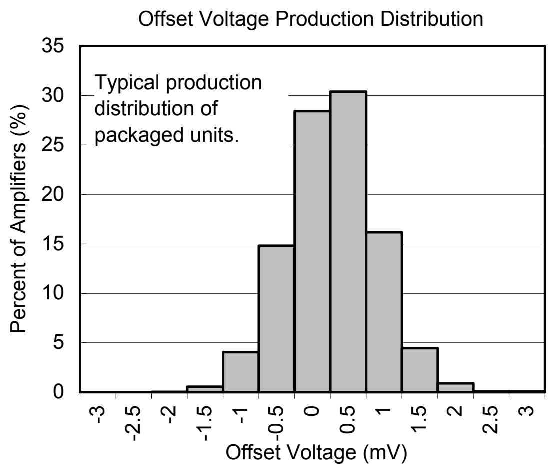






TYPICAL PERFORMANCE CHARACTERISTICS

(At T_A = +25℃, V_{CM} = Vs/2, R_L = 600Ω, unless otherwise noted.)



APPLICATION NOTES

Driving Capacitive Loads

The SGM862x can directly drive 1000pF 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}.

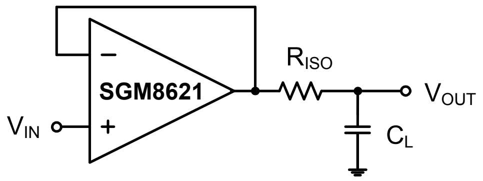


Figure 1. Indirectly Driving Heavy Capacitive Load

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.

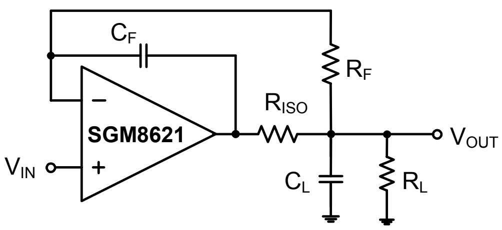


Figure 2. Indirectly Driving Heavy Capacitive Load with DC Accuracy

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 SGM862x 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.

Good PC board layout techniques optimize performance by decreasing the amount of stray capacitance at the op amp's inputs and output. To decrease stray capacitance, minimize trace lengths and widths by placing external components as close to the device as possible. Use surface-mount components whenever possible.

For the operational amplifier, soldering the part to the board directly is strongly recommended. Try to keep the high frequency big current loop area small to minimize the EMI (electromagnetic interfacing).

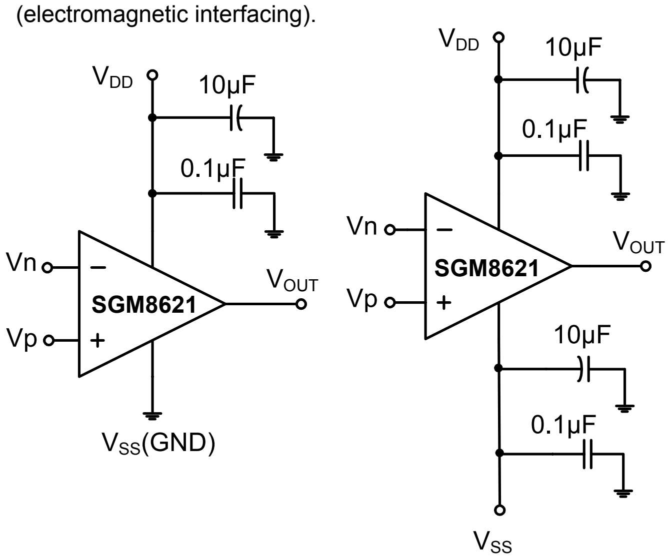


Figure 3. Amplifier with Bypass Capacitors

Grounding

A ground plane layer is important for SGM862x circuit design. The length of the current path speed currents in an inductive ground return will create an unwanted voltage noise. Broad ground plane areas will reduce the parasitic inductance.

Input-to-Output Coupling

To minimize capacitive coupling, the input and output signal traces should not be parallel. This helps reduce unwanted positive feedback.

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}.

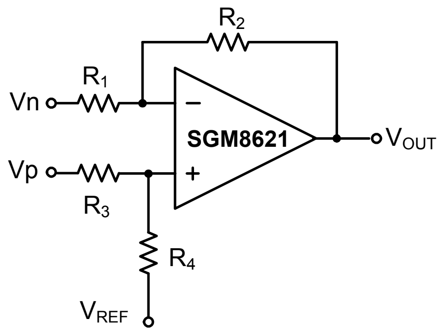


Figure 4. Differential Amplifier

Instrumentation Amplifier

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

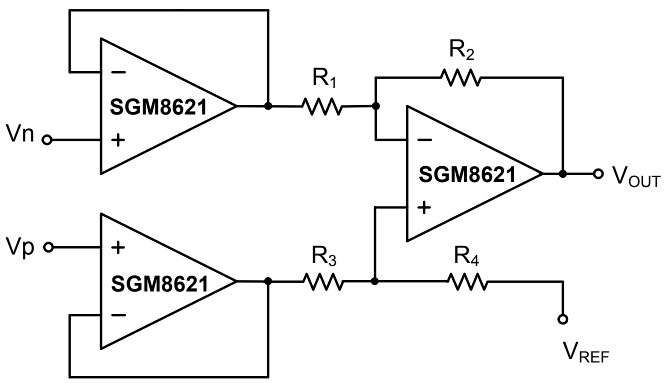


Figure 5. Instrumentation Amplifier

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.

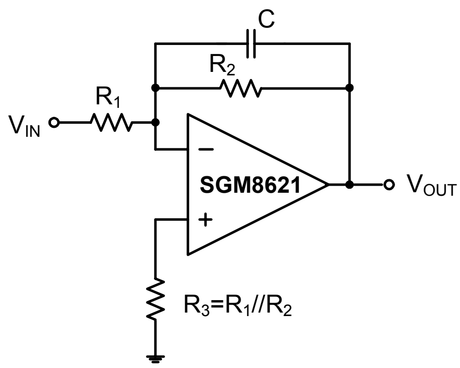
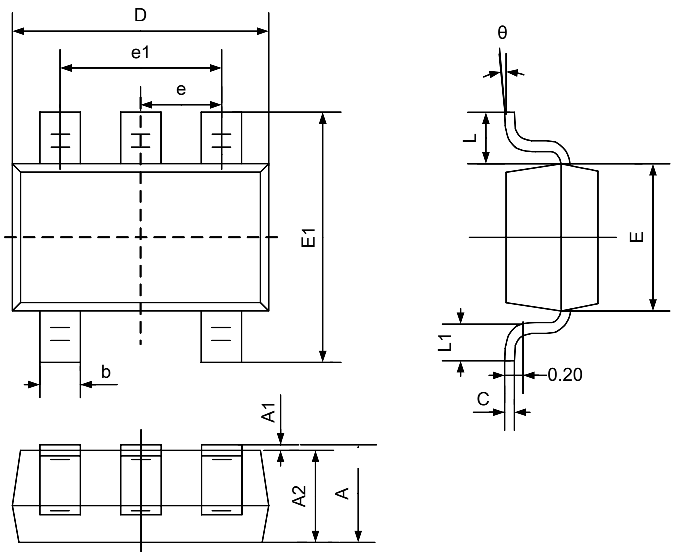


Figure 6. Low Pass Active Filter

PACKAGE OUTLINE DIMENSIONS

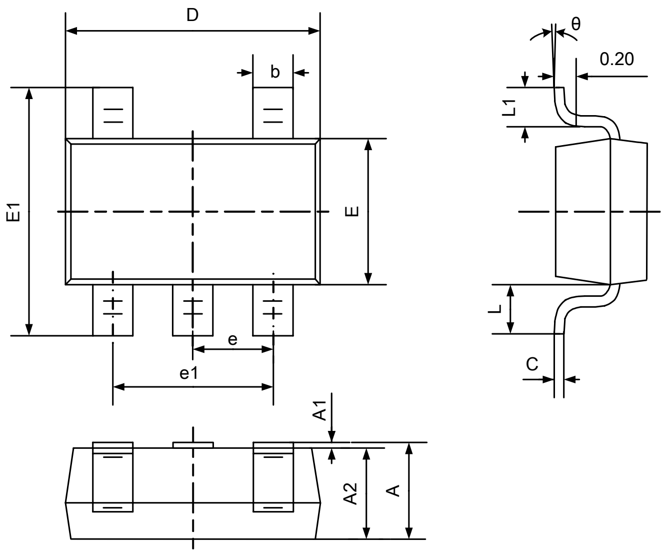
SC70-5 / SOT-353



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

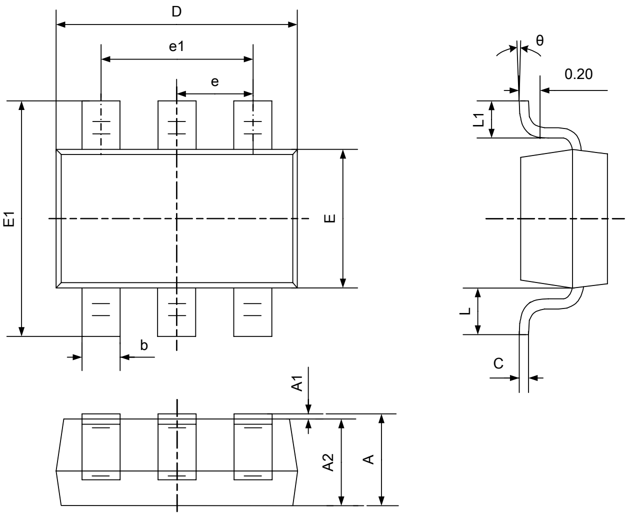
SOT23-5



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

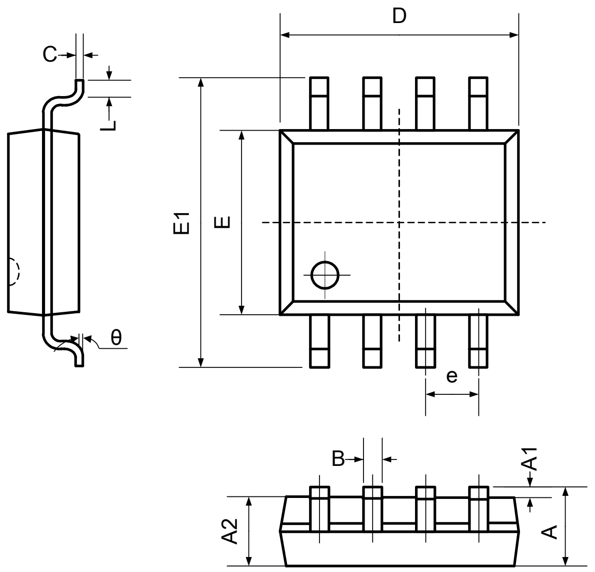
SOT23-6



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

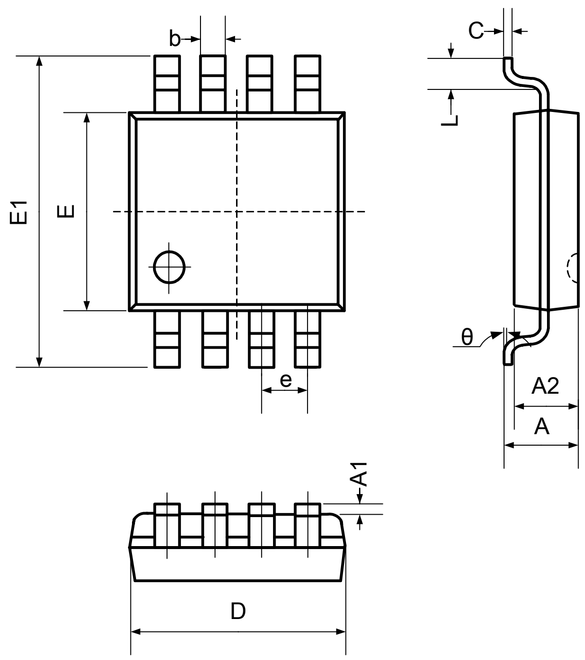
SO-8



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

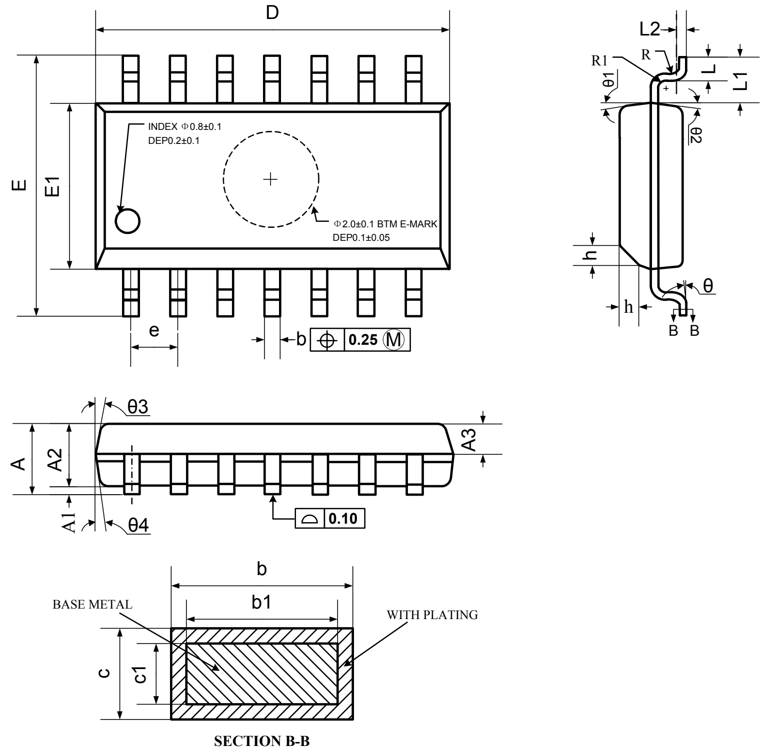
MSOP-8



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

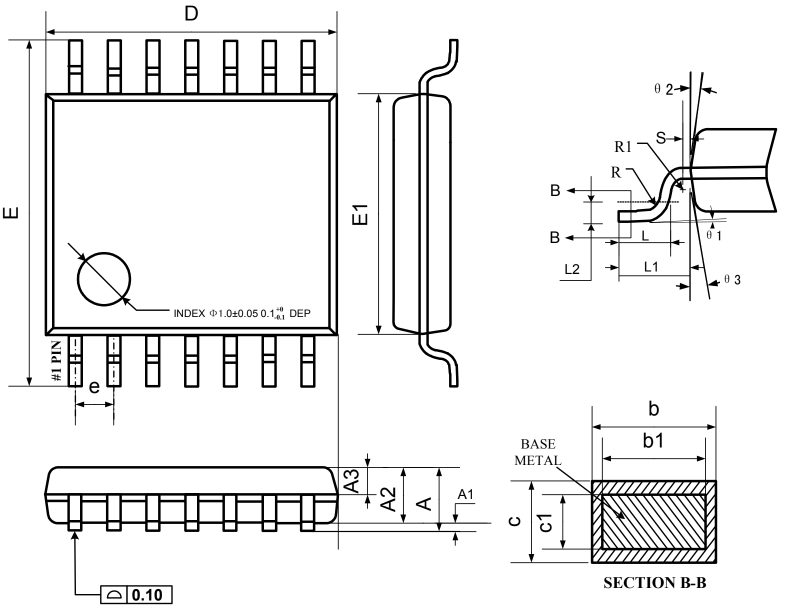
SO-14



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°

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°

04/2009 REV. B.1