SGM721/2/3/4
970µA, 10MHz, Rail-to-Rail I/O CMOS Operational Amplifiers

PRODUCT DESCRIPTION

The SGM721 (single), SGM722 (dual), SGM723 (single with shutdown) and SGM724 (quad) are low noise, low voltage, and low power operational amplifiers, that can be designed into a wide range of applications. The SGM721/2/3/4 have a high gain-bandwidth product of 10MHz, a slew rate of 8.5V/µs, and a quiescent current of 0.97mA/amplifier at 5V. The SGM723 has a power-down disable feature that reduces the supply current to 0.16µA.

The SGM721/2/3/4 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 4mV for SGM721/2/3/4. They are specified over the extended industrial temperature range (-40°C to +125°C). The operating range is from 2.5V to 5.5V.

The single version, SGM721 is available in Green SC70-5, SOT-23-5 and SOIC-8 packages. SGM723 is available in Green SOT-23-6 and SOIC-8 packages. The dual version SGM722 is available in Green SOIC-8 and MSOP-8 packages. The quad version SGM724 is available in Green SOIC-14 and TSSOP-14 packages.

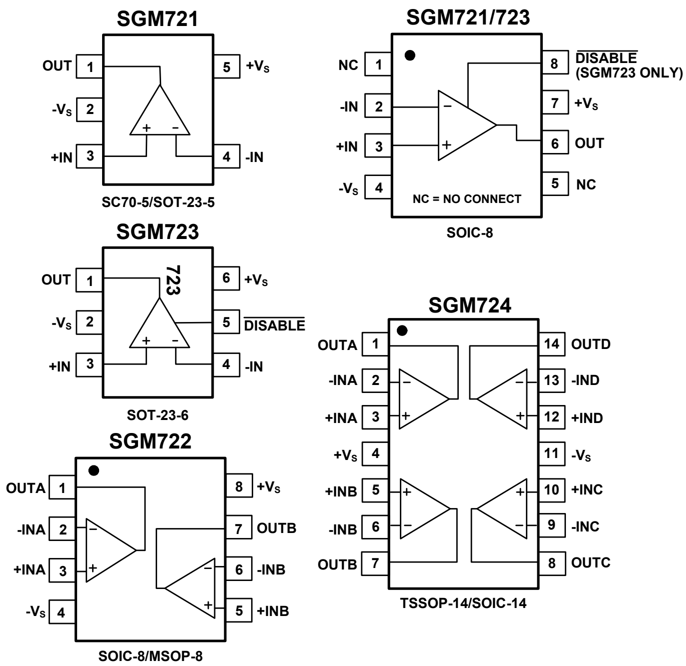
APPLICATIONS

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**
  1mV Typical V_{OS}
- **High Gain-Bandwidth Product: 10MHz**
- **High Slew Rate: 8.5V/µs**
- **Settling Time to 0.1% with 2V Step: 0.36µs**
- **Overload Recovery Time: 0.4µs**
- **Low Noise : 8nV/$\sqrt{Hz}$**
- **Supply Voltage Range: 2.5V to 5.5V**
- **Input Voltage Range: -0.1V to +5.6V with V_S = 5.5V**
- **Low Supply Current**
  0.97mA/Amplifier (TYP)
  0.16µA Shutdown Current for SGM723
- **Small Packaging**
  SGM721 Available in SC70-5, SOT-23-5 and SOIC-8
  SGM722 Available in MSOP-8 and SOIC-8
  SGM723 Available in SOT-23-6 and SOIC-8
  SGM724 Available in TSSOP-14 and SOIC-14

PIN CONFIGURATIONS (TOP VIEW)



PACKAGE/ORDERING INFORMATION

MODEL	ORDER NUMBER	PACKAGE DESCRIPTION	PACKAGE OPTION	MARKING INFORMATION
SGM721	SGM721XC5/TR	SC70-5	Tape and Reel, 3000	721
	SGM721XN5/TR	SOT-23-5	Tape and Reel, 3000	721
	SGM721XS/TR	SOIC-8	Tape and Reel, 2500	SGM721XS
SGM722	SGM722XMS/TR	MSOP-8	Tape and Reel, 3000	SGM722XMS
	SGM722XS/TR	SOIC-8	Tape and Reel, 2500	SGM722XS
SGM723	SGM723XN6/TR	SOT-23-6	Tape and Reel, 3000	723
	SGM723XS/TR	SOIC-8	Tape and Reel, 2500	SGM723XS
SGM724	SGM724XS14/TR	SOIC-14	Tape and Reel, 2500	SGM724XS14
	SGM724XTS14/TR	TSSOP-14	Tape and Reel, 3000	SGM724XTS14

ABSOLUTE MAXIMUM RATINGS

Supply Voltage, $+V_S$ to $-V_S$..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
SOT-23-5, θ_{JA}.. 190℃/W
SOT-23-6, θ_{JA}.. 190℃/W
SOIC-8, θ_{JA}..125℃/W
MSOP-8, θ_{JA}... 216℃/W
Lead Temperature (Soldering 10sec)................................260℃
ESD Susceptibility
HBM...1500V
MM...400V

NOTE:
Stresses beyond those listed under "Absolute Maximum Ratings" may cause permanent damage to the device. These are stress ratings only, and functional operation of the device at these or any other conditions beyond those indicated in the operational sections of the specifications 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.

SGMICRO reserves the right to make any change in circuit design, specification or other related things if necessary without notice at any time. Please contact SGMICRO sales office to get the latest datasheet.

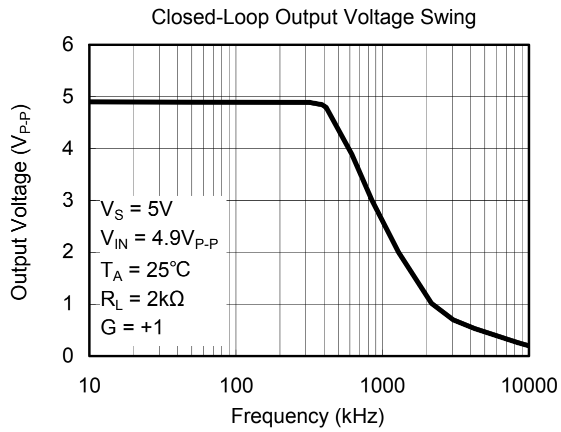
ELECTRICAL CHARACTERISTICS: V_S = +5V

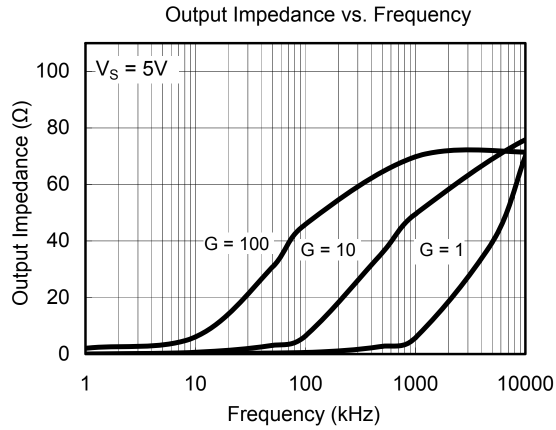
(At T_A = +25℃, V_{CM} = Vs/2, R_L = 600Ω, unless otherwise noted.)

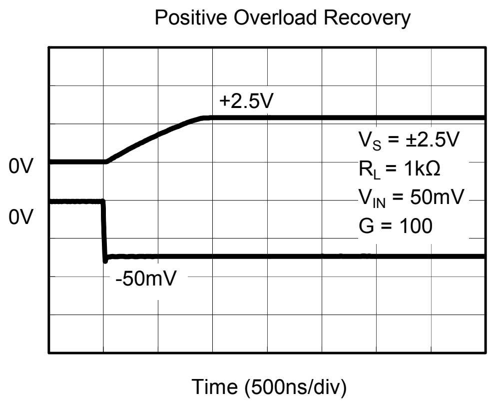
PARAMETER	CONDITIONS	SGM721/2/3/4 TYP	MIN/MAX OVER TEMPERATURE					
		+25℃	+25℃	0℃ to 70℃	-40℃ to 85℃	-40℃ to 125℃	UNITS	MIN/ MAX
INPUT CHARACTERISTICS								
Input Offset Voltage (V_{OS})		1	4	4.5	4.75	5	mV	MAX
Input Bias Current (I_B)		1					pA	TYP
Input Offset Current (I_{OS})		1					pA	TYP
Input 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	75	74	73	72.5	dB	MIN
	V_S = 5.5V, V_{CM} = - 0.1V to 5.6V	86	64	64	63	62	dB	MIN
Open-Loop Voltage Gain (A_{OL})	R_L = 600Ω ,Vo = 0.15V to 4.85V	90	84	81	80	72	dB	MIN
	R_L = 10kΩ ,Vo = 0.05V to 4.95V	100	95	90	88	77	dB	MIN
Input Offset Voltage Drift ($\Delta V_{OS}/\Delta_T$)		2.1					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})		57	53	52	50	45	mA	MIN
Closed-Loop Output Impedance	f = 1MHz, G = +1	5.7					Ω	TYP
POWER-DOWN DISABLE								
Turn-On Time		2.2					μs	TYP
Turn-Off Time		0.8					μs	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	100	73	72	71	70	dB	MIN
Quiescent Current/Amplifier (I_Q)	I_{OUT} = 0	0.97	1.13	1.25	1.28	1.38	mA	MAX
Supply Current when Disabled (SGM723 only)		0.16	1				μA	MAX
DYNAMIC PERFORMANCE								
Gain-Bandwidth Product (GBP)		10					MHz	TYP
Phase Margin (φ_O)		63.5					degrees	TYP
Full Power Bandwidth (BW_P)	< 1% distortion	400					kHz	TYP
Slew Rate (SR)	G = +1, 2V output step	8.5					V/μs	TYP
Settling Time to 0.1% (t_S)	G = +1, 2V output step	0.36					μs	TYP
Overload Recovery Time	V_{IN} ·Gain = Vs	0.4					μs	TYP
NOISE PERFORMANCE								
Voltage Noise Density (e_n)	f = 1kHz	8					nV/ $\sqrt{Hz}$	TYP
	f = 10kHz	6.4					nV/ $\sqrt{Hz}$	TYP
Current Noise Density (i_n)	f = 1kHz	10					fA/ $\sqrt{Hz}$	TYP

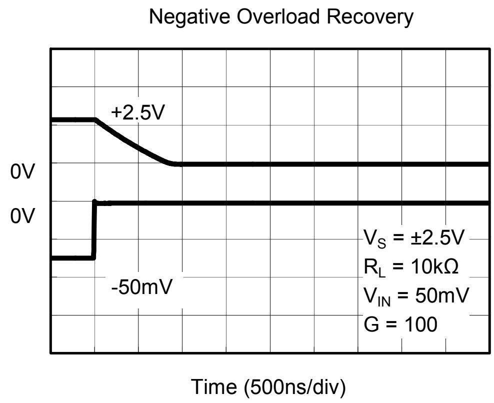
TYPICAL PERFORMANCE CHARACTERISTICS

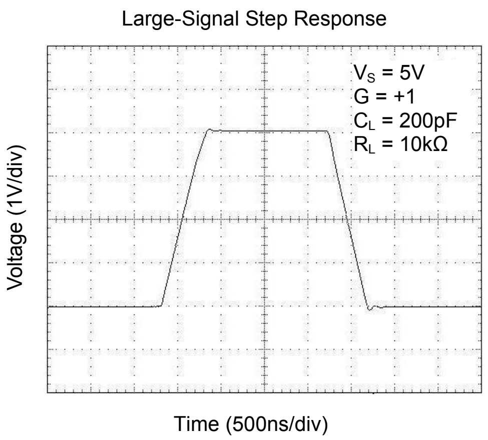
At T_A = +25°C, V_{CM} = Vs/2, R_L = 600Ω, unless otherwise noted.

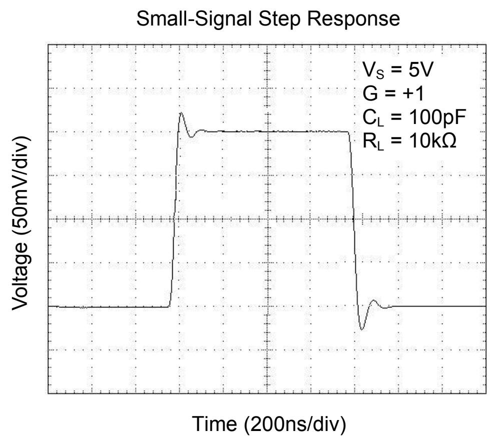








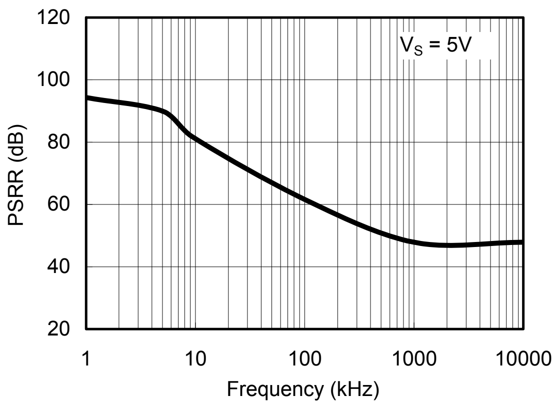




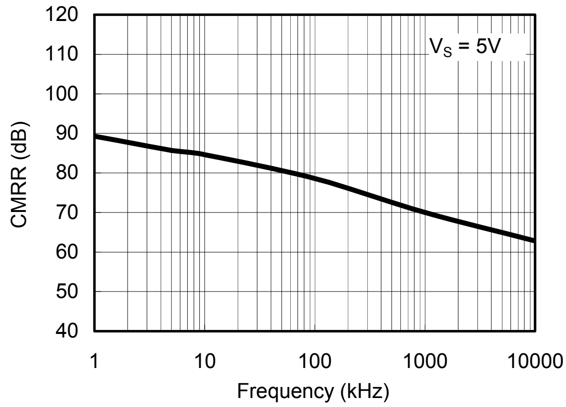
TYPICAL PERFORMANCE CHARACTERISTICS

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

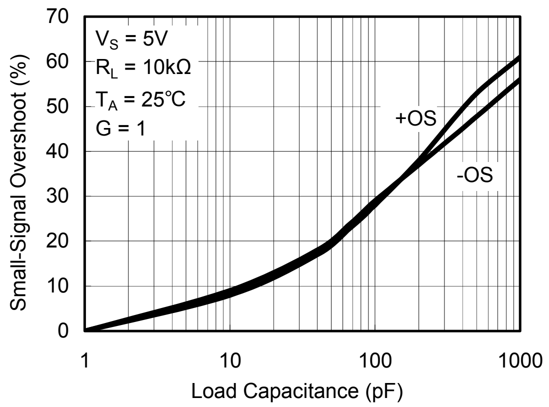
PSRR vs. Frequency



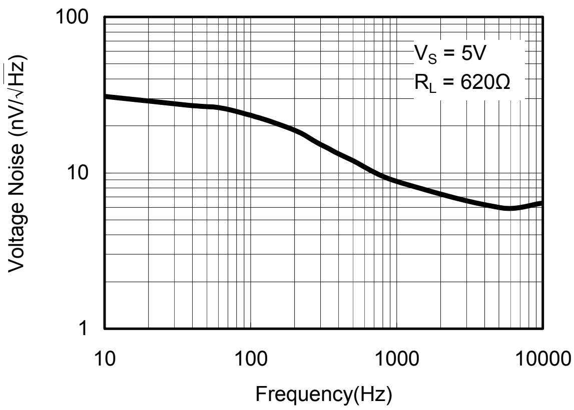
CMRR vs. Frequency



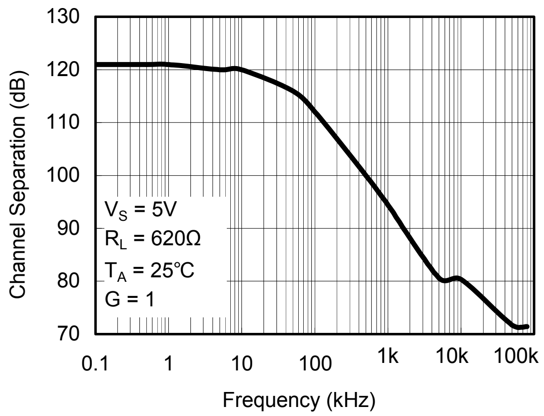
Small-Signal Overshoot vs. Load Capacitance



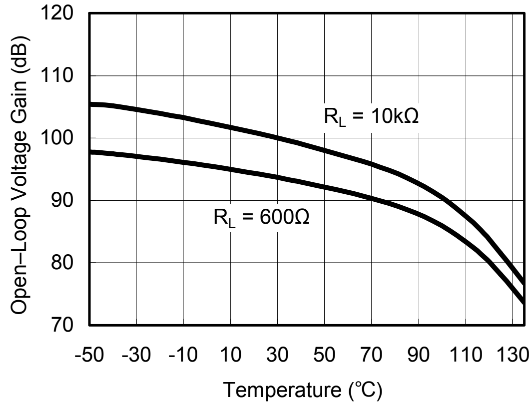
Input Voltage Noise Spectral Density vs. Frequency



Channel Separation vs. Frequency

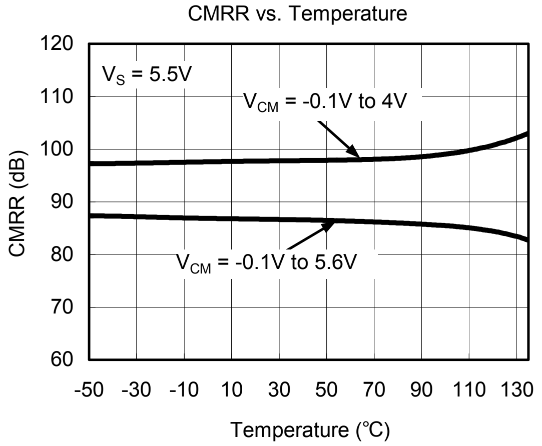


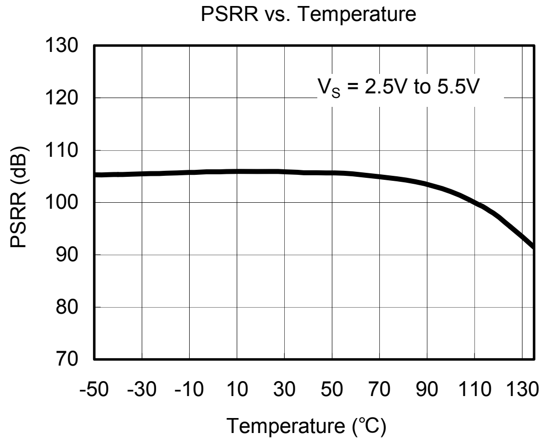
Open-Loop Voltage Gain vs. Temperature

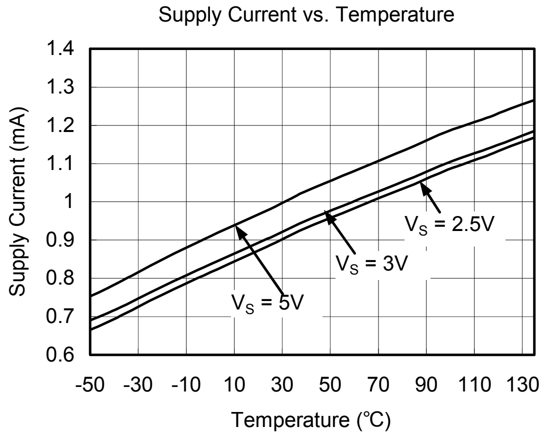


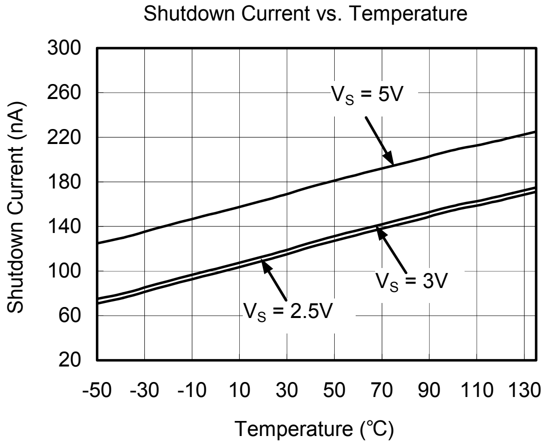
TYPICAL PERFORMANCE CHARACTERISTICS

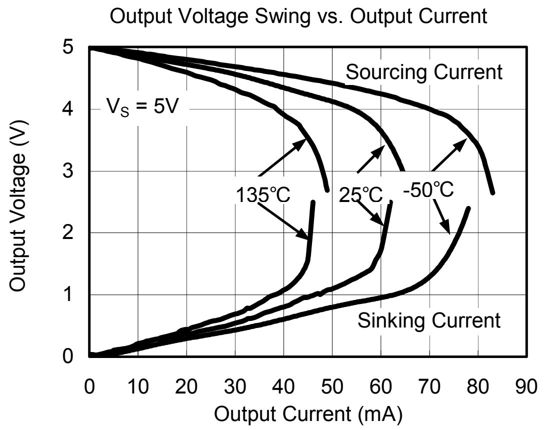
At T_A = +25℃, V_{CM} = Vs/2, R_L = 600Ω, unless otherwise noted.

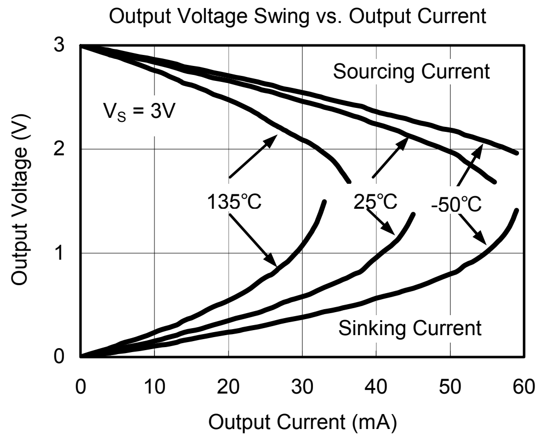






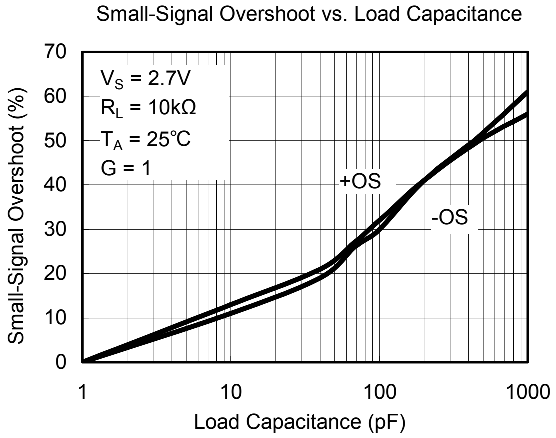


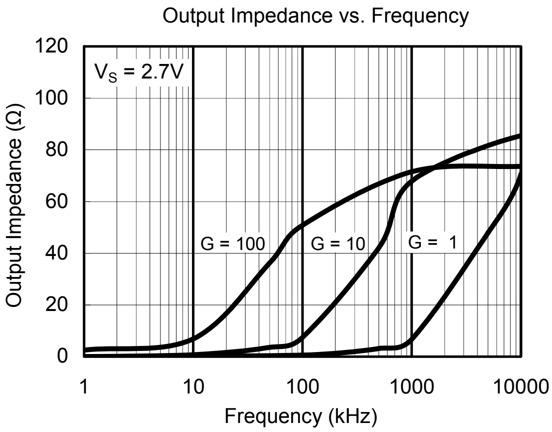


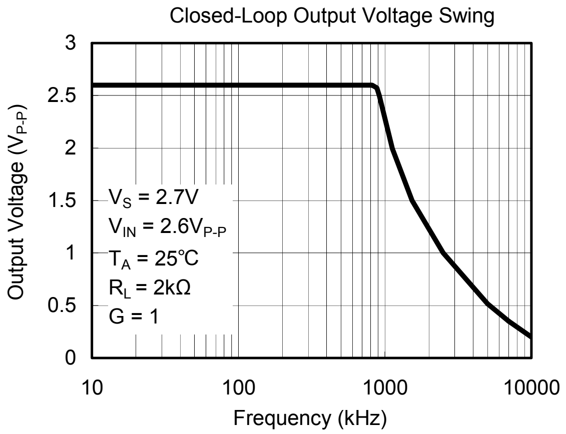


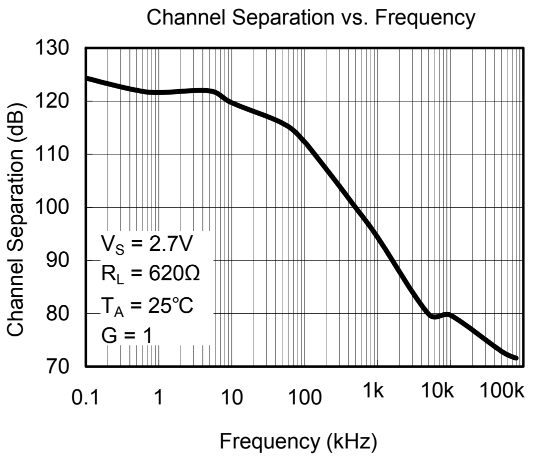
TYPICAL PERFORMANCE CHARACTERISTICS

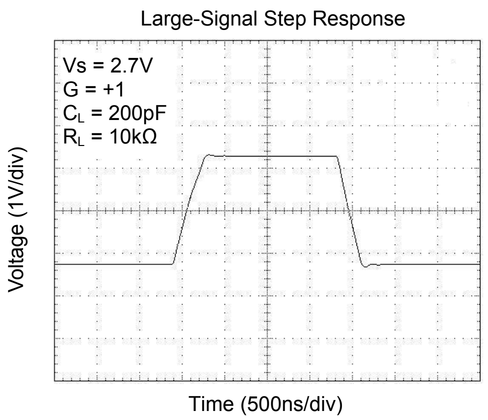
At T_A = +25℃, V_{CM} = Vs/2, R_L = 600Ω, unless otherwise noted.

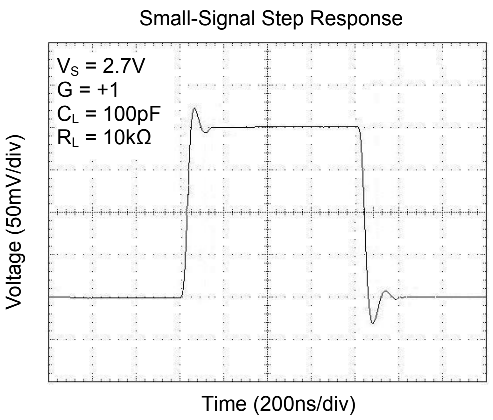






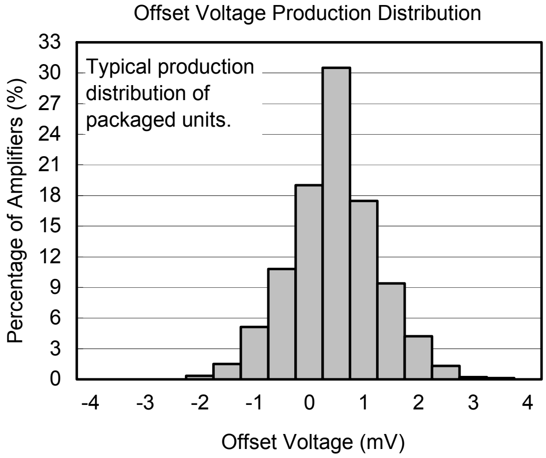






TYPICAL PERFORMANCE CHARACTERISTICS

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



APPLICATION NOTES

Driving Capacitive Loads

The SGM721/2/3/4 can directly drive 4700pF 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 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}.

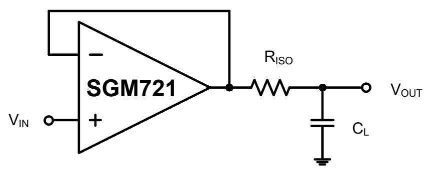


Figure 1. Indirectly Driving Heavy Capacitive Load

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.

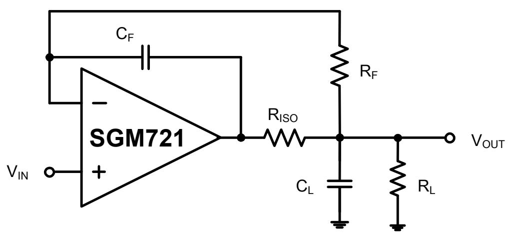


Figure 2. Indirectly Driving Heavy Capacitive Load with DC Accuracy

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 SGM721/2/3/4 operate 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 $+V_S$ 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.

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).

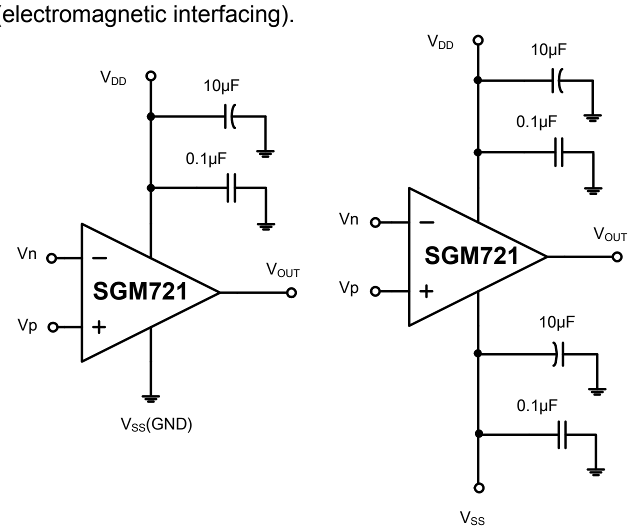


Figure 3. Amplifier with Bypass Capacitors

Grounding

A ground plane layer is important for SGM72x 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 resistor ratios are equal ($R_4/R_3 = R_2/R_1$), then $V_{OUT} = (V_P - V_n) \times R_2/R_1 + V_{REF}$.

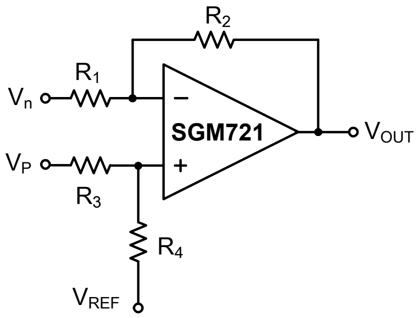


Figure 4. Differential Amplifier

Instrumentation Amplifier

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

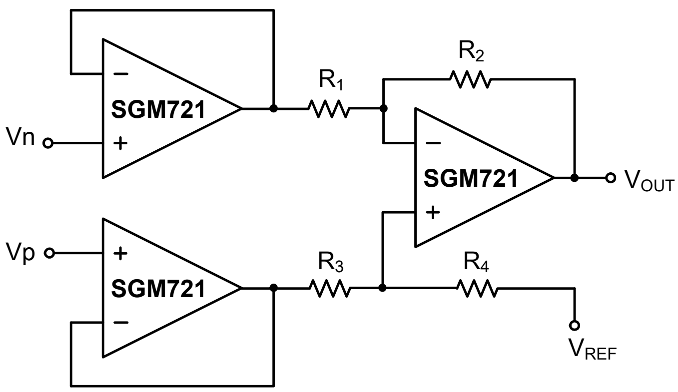


Figure 5. Instrumentation Amplifier

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 bandwidth 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 resistor values as low as possible and consistent with output loading consideration.

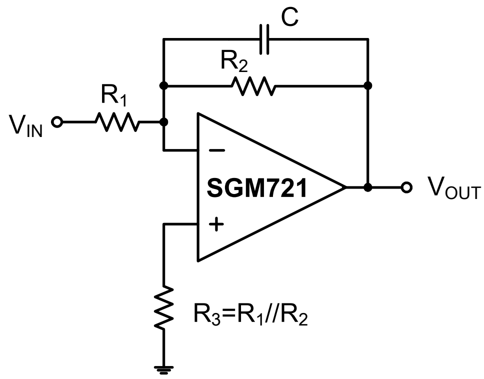
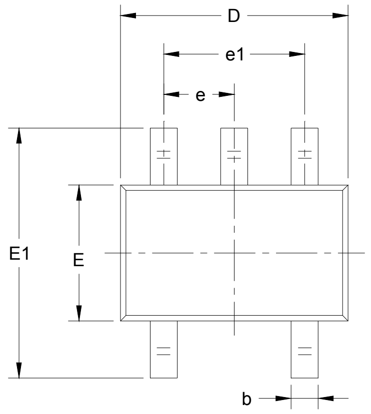
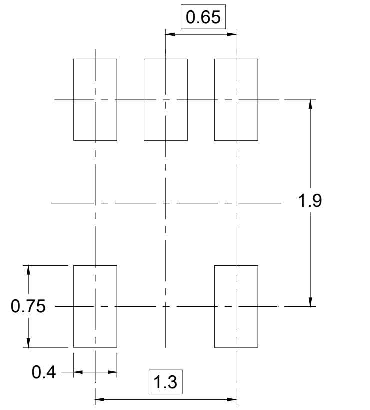


Figure 6. Low Pass Active Filter

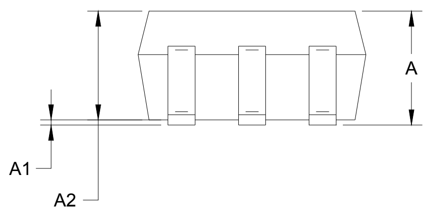
PACKAGE OUTLINE DIMENSIONS

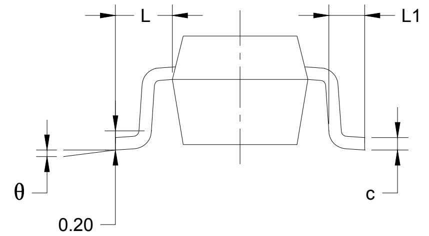
SC70-5





RECOMMENDED LAND PATTERN (Unit: mm)

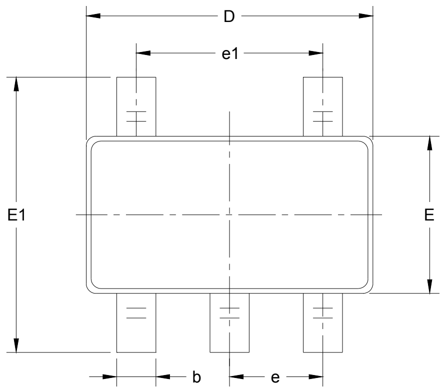


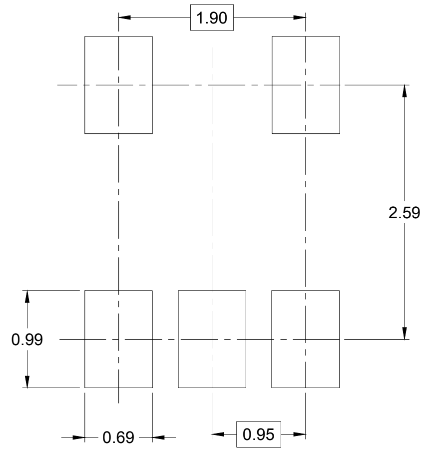


Symbol	Dimensions In Millimeters		Dimensions In Inches	
	MIN	MAX	MIN	MAX
A	0.900	1.100	0.035	0.043
A1	0.000	0.100	0.000	0.004
A2	0.900	1.000	0.035	0.039
b	0.150	0.350	0.006	0.014
c	0.080	0.150	0.003	0.006
D	2.000	2.200	0.079	0.087
E	1.150	1.350	0.045	0.053
E1	2.150	2.450	0.085	0.096
e	0.65 TYP		0.026 TYP	
e1	1.300 BSC		0.051 BSC	
L	0.525 REF		0.021 REF	
L1	0.260	0.460	0.010	0.018
θ	0°	8°	0°	8°

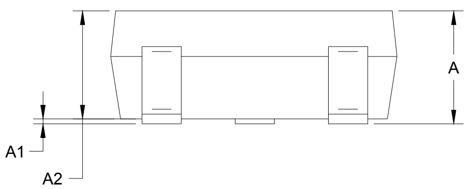
PACKAGE OUTLINE DIMENSIONS

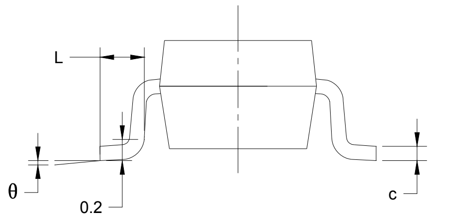
SOT-23-5





RECOMMENDED LAND PATTERN (Unit: mm)

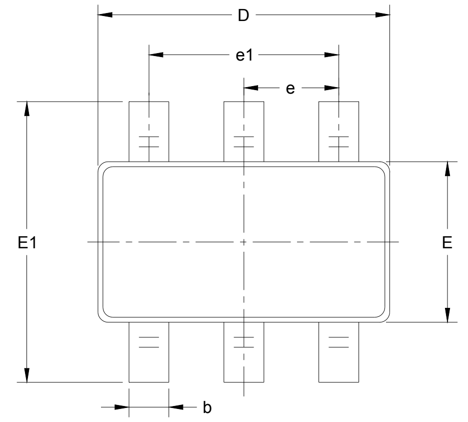


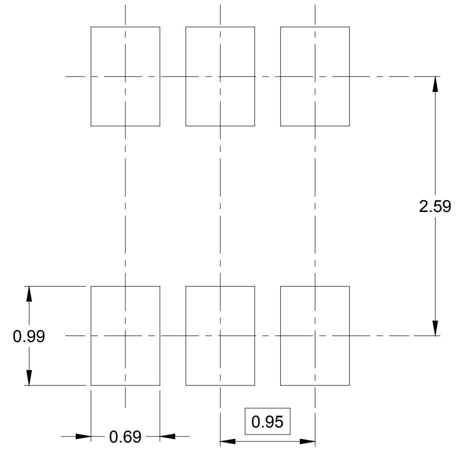


Symbol	Dimensions In Millimeters		Dimensions In Inches	
	MIN	MAX	MIN	MAX
A	1.050	1.250	0.041	0.049
A1	0.000	0.100	0.000	0.004
A2	1.050	1.150	0.041	0.045
b	0.300	0.500	0.012	0.020
c	0.100	0.200	0.004	0.008
D	2.820	3.020	0.111	0.119
E	1.500	1.700	0.059	0.067
E1	2.650	2.950	0.104	0.116
e	0.950 BSC		0.037 BSC	
e1	1.900 BSC		0.075 BSC	
L	0.300	0.600	0.012	0.024
θ	0°	8°	0°	8°

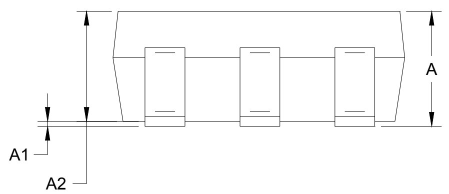
PACKAGE OUTLINE DIMENSIONS

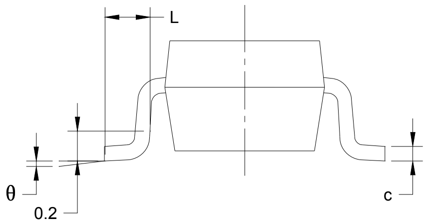
SOT-23-6





RECOMMENDED LAND PATTERN (Unit: mm)

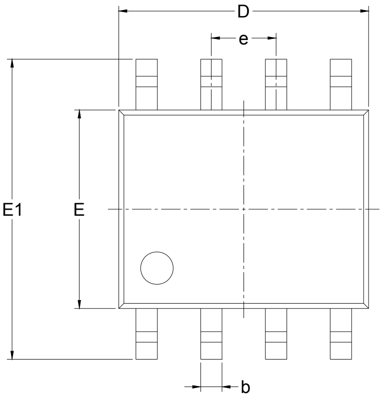


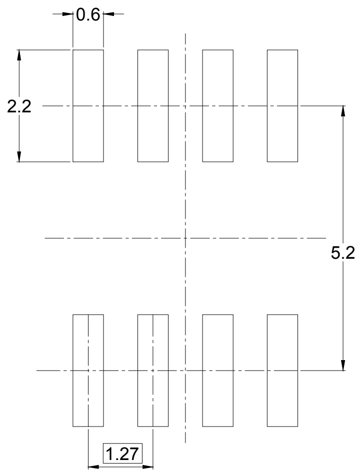


Symbol	Dimensions In Millimeters		Dimensions In Inches	
	MIN	MAX	MIN	MAX
A	1.050	1.250	0.041	0.049
A1	0.000	0.100	0.000	0.004
A2	1.050	1.150	0.041	0.045
b	0.300	0.500	0.012	0.020
c	0.100	0.200	0.004	0.008
D	2.820	3.020	0.111	0.119
E	1.500	1.700	0.059	0.067
E1	2.650	2.950	0.104	0.116
e	0.950 BSC		0.037 BSC	
e1	1.900 BSC		0.075 BSC	
L	0.300	0.600	0.012	0.024
θ	0°	8°	0°	8°

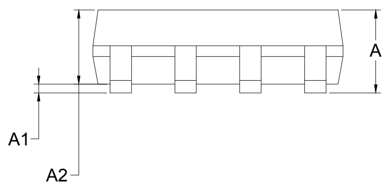
PACKAGE OUTLINE DIMENSIONS

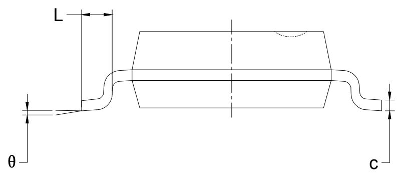
SOIC-8





RECOMMENDED LAND PATTERN (Unit: mm)

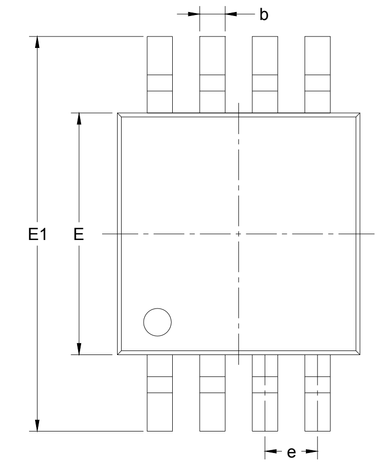


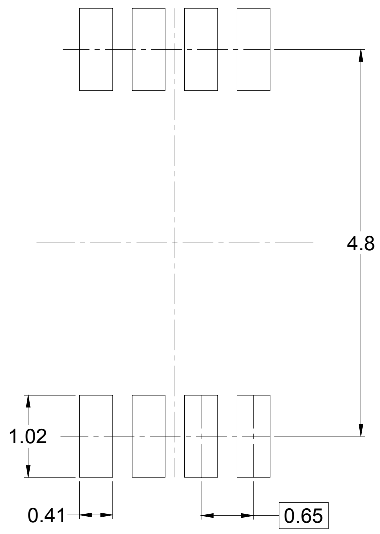


Symbol	Dimensions In Millimeters		Dimensions In Inches	
	MIN	MAX	MIN	MAX
A	1.350	1.750	0.053	0.069
A1	0.100	0.250	0.004	0.010
A2	1.350	1.550	0.053	0.061
b	0.330	0.510	0.013	0.020
c	0.170	0.250	0.006	0.010
D	4.700	5.100	0.185	0.200
E	3.800	4.000	0.150	0.157
E1	5.800	6.200	0.228	0.244
e	1.27 BSC		0.050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

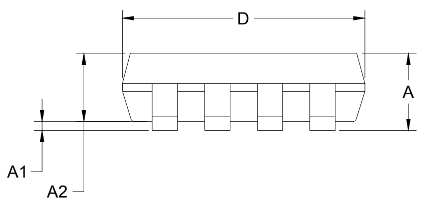
PACKAGE OUTLINE DIMENSIONS

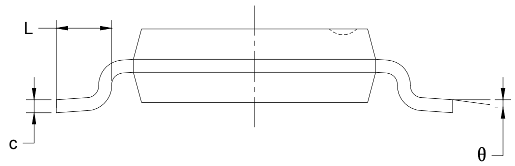
MSOP-8





RECOMMENDED LAND PATTERN (Unit: mm)

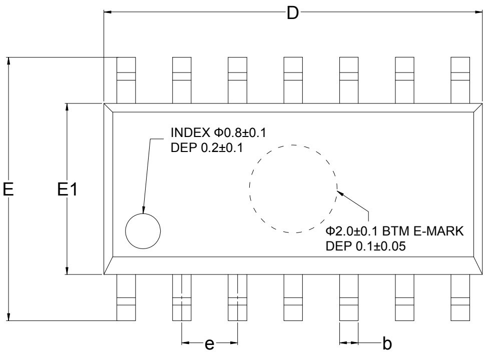


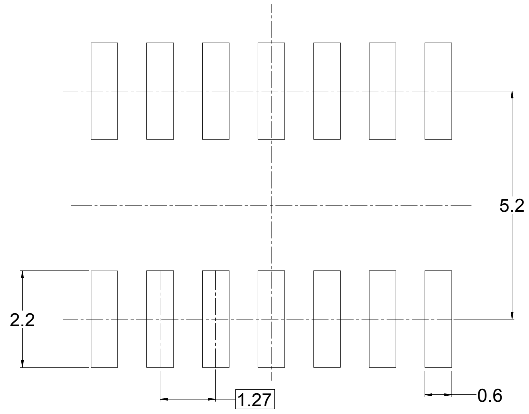


Symbol	Dimensions In Millimeters		Dimensions In Inches	
	MIN	MAX	MIN	MAX
A	0.820	1.100	0.032	0.043
A1	0.020	0.150	0.001	0.006
A2	0.750	0.950	0.030	0.037
b	0.250	0.380	0.010	0.015
c	0.090	0.230	0.004	0.009
D	2.900	3.100	0.114	0.122
E	2.900	3.100	0.114	0.122
E1	4.750	5.050	0.187	0.199
e	0.650 BSC		0.026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

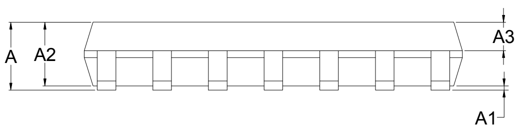
PACKAGE OUTLINE DIMENSIONS

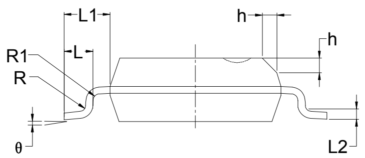
SOIC-14





RECOMMENDED LAND PATTERN (Unit: mm)

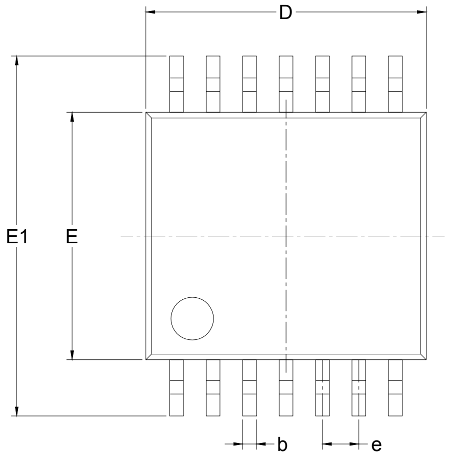


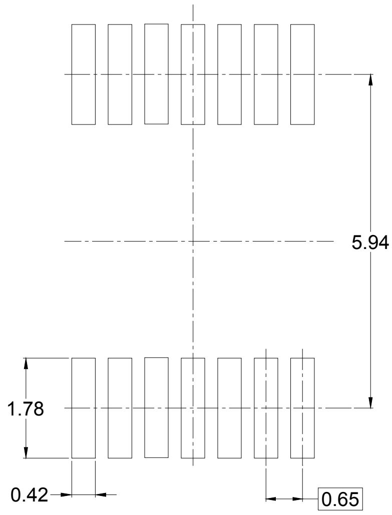


Symbol	Dimensions In Millimeters			Dimensions In Inches		
	MIN	MOD	MAX	MIN	MOD	MAX
A	1.35		1.75	0.053		0.069
A1	0.10		0.25	0.004		0.010
A2	1.25		1.65	0.049		0.065
A3	0.55		0.75	0.022		0.030
b	0.36		0.49	0.014		0.019
D	8.53		8.73	0.336		0.344
E	5.80		6.20	0.228		0.244
E1	3.80		4.00	0.150		0.157
e	1.27 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°

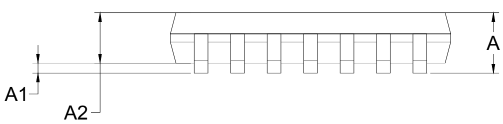
PACKAGE OUTLINE DIMENSIONS

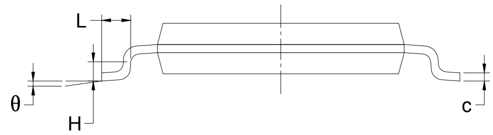
TSSOP-14





RECOMMENDED LAND PATTERN (Unit: mm)

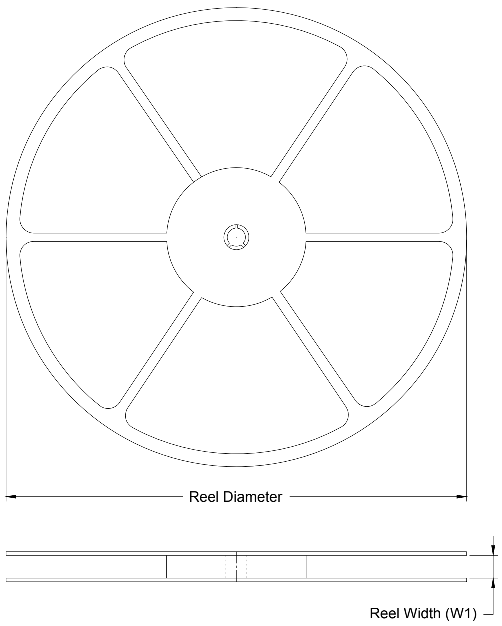




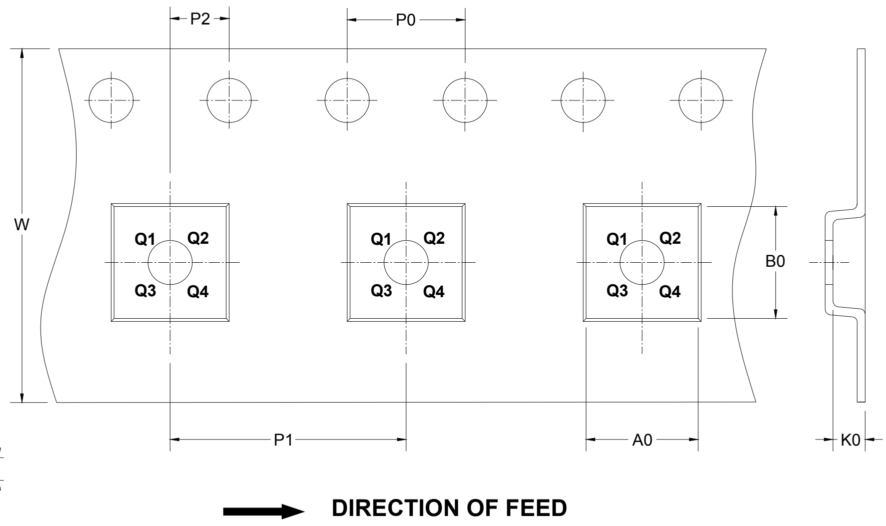
Symbol	Dimensions In Millimeters		Dimensions In Inches	
	MIN	MAX	MIN	MAX
A		1.100		0.043
A1	0.050	0.150	0.002	0.006
A2	0.800	1.000	0.031	0.039
b	0.190	0.300	0.007	0.012
c	0.090	0.200	0.004	0.008
D	4.900	5.100	0.193	0.201
E	4.300	4.500	0.169	0.177
E1	6.250	6.550	0.246	0.258
e	0.650 BSC		0.026 BSC	
L	0.500	0.700	0.02	0.028
H	0.25 TYP		0.01 TYP	
θ	1°	7°	1°	7°

TAPE AND REEL INFORMATION

REEL DIMENSIONS



TAPE DIMENSIONS

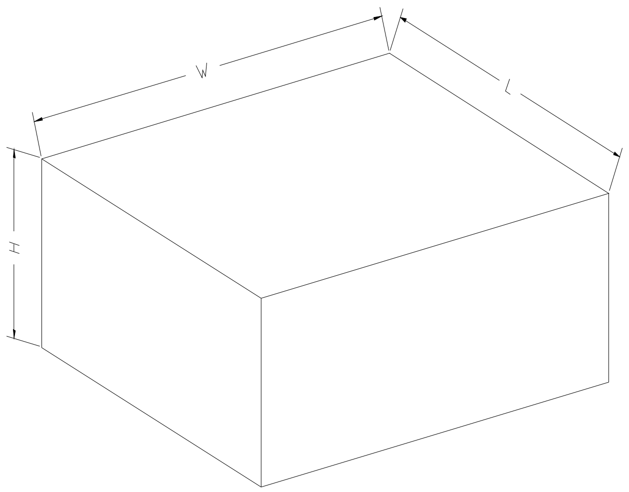


NOTE: The picture is only for reference. Please make the object as the standard.

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
SC70-5	7″	9.5	2.25	2.55	1.20	4.0	4.0	2.0	8.0	Q3
SOT-23-5	7″	9.5	3.17	3.23	1.37	4.0	4.0	2.0	8.0	Q3
SOT-23-6	7″	9.5	3.17	3.23	1.37	4.0	4.0	2.0	8.0	Q3
SOIC-8	13″	12.4	6.4	5.4	2.1	4.0	8.0	2.0	12.0	Q1
MSOP-8	13″	12.4	5.2	3.3	1.5	4.0	8.0	2.0	12.0	Q1
SOIC-14	13″	16.4	6.6	9.3	2.1	4.0	8.0	2.0	16.0	Q1
TSSOP-14	13″	12.4	6.95	5.6	1.2	4.0	8.0	2.0	12.0	Q1

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