

#### **Features**

Single-Supply Operation from +2.1V ~ +5.5V

· Rail-to-Rail Input / Output

Gain-Bandwidth Product: 11MHz (Typ)

Low Input Bias Current: 1pA (Typ)

Low Offset Voltage: 3.5mV (Max)

· High Slew Rate: 9V/µs

· Settling Time to 0.1% with 2V Step: 0.3μs

Low Noise : 8nV/√Hz @10kHz

Quiescent Current: 1.1mA per Amplifier (Typ)

Operating Temperature: -40°C ~ +125°C

· Small Package:

GS8721 Available in SOT23-5, SOP-8 and SC70-5

**Packages** 

GS8722 Available in SOP-8 and MSOP-8 and TSSOP-8

**Packages** 

GS8724 Available in SOP-14 and TSSOP-14 Packages

GS8721 Available in SOT23-6 and SC70-6 and SOP-8

**Packages** 

### **General Description**

The GS872X have a high gain-bandwidth product of 11MHz, a slew rate of 9V/µs, and a quiescent current of 1.1mA per amplifier at 5V. The GS872X 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 3.5mV for GS872X. They are specified over the extended industrial temperature range (-40°C to +125°C). The operating range is from 2.1V to 5.5V. The GS8721 single is available in Green SC70-5, SOT23-5 and SOP-8 packages. The GS8722 dual is available in Green SOP-8 and MSOP-8 and TSSOP-8 packages. The GS8724 Quad is available in Green SOP-14 and TSSOP-14 packages.

### **Applications**

- Sensors
- Active Filters
- · Cellular and Cordless Phones
- Laptops and PDAs

- Audio
- Handheld Test Equipment
- · Battery-Powered Instrumentation
- A/D Converters

### **Pin Configuration**

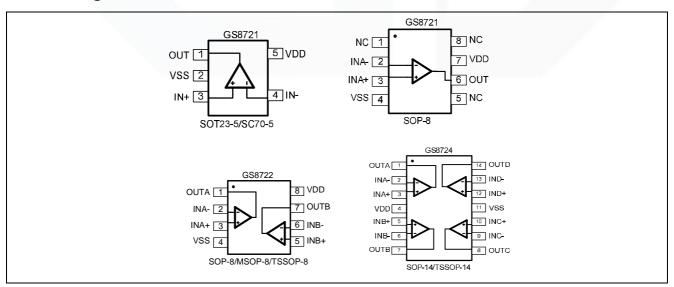


Figure 1. Pin Assignment Diagram





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### **Absolute Maximum Ratings**

Condition	Min	Max			
Power Supply Voltage (V <sub>DD</sub> to Vss)	-0.5V	+7.5V			
Analog Input Voltage (IN+ or IN-)	Vss-0.5V	V <sub>DD</sub> +0.5V			
PDB Input Voltage	Vss-0.5V	+7V			
Operating Temperature Range	-40°C	+125°C			
Junction Temperature	+160	)°C			
Storage Temperature Range	-55°C	+150°C			
Lead Temperature (soldering, 10sec)	+260	+260°C			
Package Thermal Resistance (TA=+25℃)					
SOP-8, θ <sub>JA</sub>	125°	C/W			
MSOP-8, θ <sub>JA</sub>	216°	C/W			
SOT23-5, θ <sub>JA</sub>	190°	C/W			
SOT23-6, θ <sub>JA</sub>	190°	C/W			
SC70-5, θ <sub>JA</sub>	333°	C/W			
ESD Susceptibility					
НВМ	8k	(V			
MM	400	OV			

**Note**: Stress greater than those listed under Absolute Maximum Ratings may cause permanent damage to the device. This is a stress rating only and functional operation of the device at these or any other conditions outside those indicated in the operational sections of this specification are not implied. Exposure to absolute maximum rating conditions for extended periods may affect reliability.

# Package/Ordering Information

MODEL	CHANNEL	ORDER NUMBER	PACKAGE DESCRIPTION	PACKAGE OPTION	MARKING INFORMATION
		GS8721-CR	SC70-5	Tape and Reel,3000	721
GS8721	Single	GS8721-TR	SOT23-5	Tape and Reel,3000	721
		GS8721-SR	SOP-8	Tape and Reel,4000	GS8721
		GS8722-SR	SOP-8	Tape and Reel,4000	GS8722
GS8722	Dual	GS8722-MR	MSOP-8	Tape and Reel,3000	GS8722
		GS8722-TR	TSSOP-8	Tape and Reel,3000	GS8722
000704	Overd	GS8724-TR	TSSOP-14	Tape and Reel,3000	GS8724
GS8724	Quad	GS8724-SR	SOP-14	Tape and Reel,2500	GS8724







### **Electrical Characteristics**

(At Vs=5V,  $T_A$  = +25  $^{\circ}\mathrm{C}$  ,  $V_{CM}$  = Vs/2,  $R_L$  = 600  $^{\Omega}$  , unless otherwise noted.)

		GS8721/2/4						
	CONDITIONS	TYP	MIN/MAX OVER TEMPERATURE					
PARAMETER	CONDITIONS	+25℃	+25℃	0℃ to 70℃	-40℃ to 85℃	-40 ℃ to	UNITS	MIN /
INPUT CHARACTERISTICS	1	•			N.		·	
Input Offset Voltage (Vos)		0.8	3.5	3.9	4.3	4.6	mV	MAX
Input Bias Current (I <sub>B</sub> )		1					pА	TYP
Input Offset Current (I <sub>OS</sub> )		1					pА	TYP
Input Common Mode Voltage Range (V <sub>CM</sub> )	V <sub>S</sub> = 5.5V	-0.1 to					V	TYP
	1	+5.6						
Common Mode Rejection Ratio (CMRR)	$V_S = 5.5V$ , $V_{CM} = -0.1V$ to 4V	82	65	64	64	63	dB	MIN
	$V_S = 5.5V$ , $V_{CM} = -0.1V$ to 5.6V	75					dB	MIN
Open-Loop Voltage Gain (A <sub>OL</sub> )	$R_L = 600\Omega, V_O = 0.15V \text{ to } 4.85V$	90	80	76	75	68	dB	MIN
	$R_L = 10k\Omega, V_O = 0.05V \text{ to } 4.95V$	108					dB	MIN
Input Offset Voltage Drift ( $\Delta V_{OS}/\Delta_T$ )		2.4					μV/°C	TYP
OUTPUT CHARACTERISTICS					1			
Output Voltage Swing from Rail	$R_L = 600\Omega$	0.1					V	TYP
	$R_L = 10k\Omega$	0.015					V	TYP
Output Current (I <sub>OUT</sub> )		70	55	45	42	38	mA	MIN
Closed-Loop Output Impedance	f = 100kHz, G = 1	7.5					Ω	TYP
POWER-DOWN DISABLE	1 1				1			
Turn-On Time		1.1					μs	TYP
Turn-Off Time		0.3					μs	TYP
DISABLE Voltage-Off			0.8				V	MAX
DISABLE Voltage-On			2				V	MIN
POWER SUPPLY				I.	1			
Operating Voltage Range			2.1	2.1	2.1	2.1	V	MIN
			5.5	5.5	5.5	5.5	V	MAX
Power Supply Rejection Ratio (PSRR)	$V_S = +2.5V \text{ to } +5.5V$							
	$V_{CM} = (-V_S) + 0.5V$							
Quiescent Current/Amplifier (IQ)	I <sub>OUT</sub> = 0	91	74	72	72	68	dB	MIN
		1.1	1.5	1.65	1.7	1.85	mA	MAX







### **Electrical Characteristics**

(At Vs=5V,  $T_A$  = +25  $^{\circ}\mathrm{C}$  ,  $V_{CM}$  = Vs/2,  $R_L$  = 600  $^{\Omega}$  , unless otherwise noted.)

		GS8721/2/4							
0.00.445750	CONDITIONS	TYP		MIN/MAX OVER TEMPERATURE					
PARAMETER	CONDITIONS	.25%	+25℃	0℃ to	0℃ to -40℃ to		LINUTO	MIN/	
		+25℃		<b>70℃</b>	85℃	125℃	UNITS	MAX	
DYNAMIC PERFORMANCE									
Gain-Bandwidth Product (GBP)	$R_L = 10k\Omega$ , $C_L = 100pF$	11					MHz	TYP	
Phase Margin (φ <sub>0</sub> )	$R_L = 10k\Omega$ , $C_L = 100pF$	51					Degrees	TYP	
Full Power Bandwidth (BWP)	$<$ 1% distortion, R <sub>L</sub> = 600 $\Omega$	400					kHz	TYP	
Slew Rate (SR)	$G = +1$ , 2V Step, $R_L = 10k\Omega$	9					V/µs	TYP	
Settling Time to 0.1% (t <sub>S</sub> )	$G = +1$ , 2V Step, $R_L = 600\Omega$	0.3					μs	TYP	
Overload Recovery Time	$V_{IN}$ ·Gain = VS, $R_L = 600\Omega$	1.5					μs	TYP	
NOISE PERFORMANCE									
Voltage Noise Density (e <sub>n</sub> )	f = 1kHz	11.5					$nV/\sqrt{Hz}$	TYP	
	f = 10kHz	8				1	$nV/\sqrt{Hz}$	TYP	





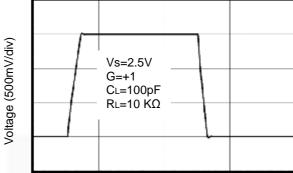
Voltage (1V/div)

### **Typical Performance characteristics**

(At Vs=5V, TA = +25°C, VcM = Vs/2, RL = 600 $\Omega$ , unless otherwise noted.)

# Large-Signal Step Response Vs=5V G=+1 C<sub>L</sub>=100pF $RL=10K\Omega$

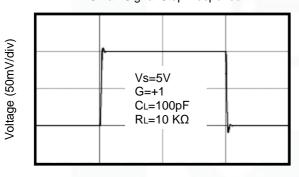




Large-Signal Step Response

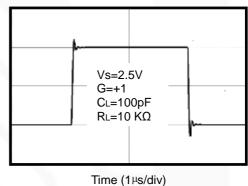
Time (1µs/div)

Small-Signal Step Response

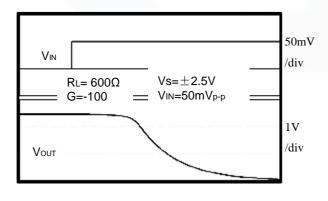


Time (1µs/div)

Small-Signal Step Response

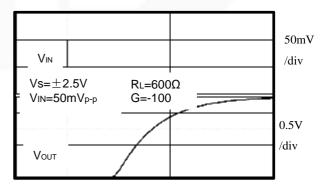


Positive Overload Recovery



Time (2µs/div)

**Negative Overload Recovery** 



Time (2µs/div)

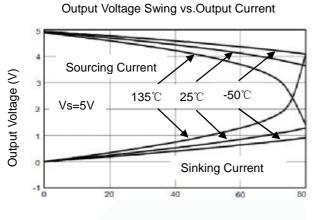


Voltage (50mV/div)

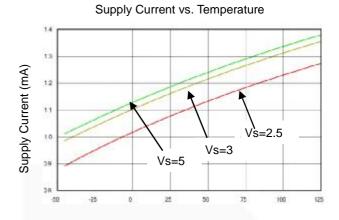


### **Typical Performance characteristics**

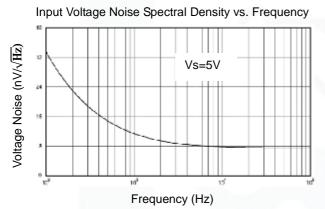
(At Vs=5V, TA = +25°C, VcM = Vs/2, RL = 600 $\Omega$ , unless otherwise noted.)

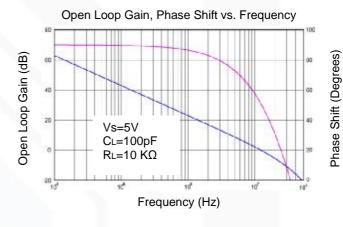


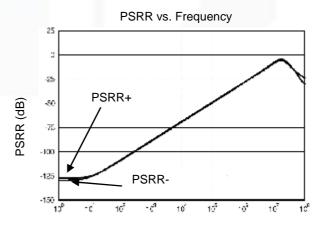




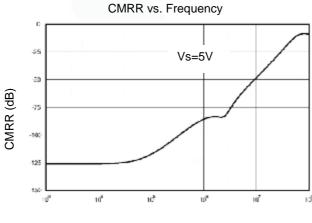
Temperature (°C)







Frequency (Hz)



Frequency (Hz)

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### **Application Note**

#### Size

GS872X series op amps are unity-gain stable and suitable for a wide range of general-purpose applications. The small footprints of the GS872X series packages save space on printed circuit boards and enable the design of smaller electronic products.

#### Power Supply Bypassing and Board Layout

GS872X series operates from a single 2.1V to 5.5V supply or dual  $\pm 1.05$ V to  $\pm 2.75$ V supplies. For best performance, a  $0.1\mu$ F ceramic capacitor should be placed close to the  $V_{DD}$  pin in single supply operation. For dual supply operation, both  $V_{DD}$  and  $V_{SS}$  supplies should be bypassed to ground with separate  $0.1\mu$ F ceramic capacitors.

#### Low Supply Current

The low supply current (typical 1.1mA per channel) of GS872X series will help to maximize battery life. They are ideal for battery powered systems.

#### **Operating Voltage**

GS872X series operate under wide input supply voltage (2.1V to 5.5V). In addition, all temperature specifications apply from -40 °C to +125 °C. Most behavior remains unchanged throughout the full operating voltage range. These guarantees ensure operation throughout the single Li-lon battery lifetime.

#### Rail-to-Rail Input

The input common-mode range of GS872X series extends 100mV beyond the supply rails ( $V_{SS}$ -0.1V to  $V_{DD}$ +0.1V). This is achieved by using complementary input stage. For normal operation, inputs should be limited to this range.

#### Rail-to-Rail Output

Rail-to-Rail output swing provides maximum possible dynamic range at the output. This is particularly important when operating in low supply voltages. The output voltage of GS872X series can typically swing to less than 2mV from supply rail in light resistive loads (>100k $\Omega$ ), and 15mV of supply rail in moderate resistive loads (10k $\Omega$ ).

#### Capacitive Load Tolerance

The GS872X family is optimized for bandwidth and speed, not for driving capacitive loads. Output capacitance will create a pole in the amplifier's feedback path, leading to excessive peaking and potential oscillation. If dealing with load capacitance is a requirement of the application, the two strategies to consider are (1) using a small resistor in series with the amplifier's output and the load capacitance and (2) reducing the bandwidth of the amplifier's feedback loop by increasing the overall noise gain. Figure 2. shows a unity gain follower using the series resistor strategy. The resistor isolates the output from the capacitance and, more importantly, creates a zero in the feedback path that compensates for the pole created by the output capacitance.

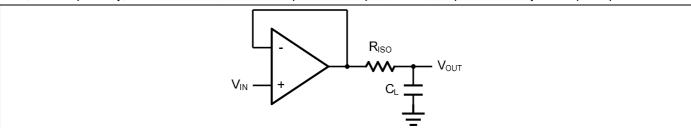


Figure 2. Indirectly Driving a Capacitive Load Using Isolation Resistor







The bigger the  $R_{ISO}$  resistor value, the more stable  $V_{OUT}$  will be. However, if there is a resistive load  $R_L$  in parallel with the capacitive load, a voltage divider (proportional to  $R_{ISO}/R_L$ ) is formed, this will result in a gain error.

The circuit in Figure 3 is an improvement to the one in Figure 2.  $R_F$  provides the DC accuracy by feed-forward the  $V_{IN}$  to  $R_L$ .  $C_F$  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 the phase margin in the overall feedback loop. Capacitive drive can be increased by increasing the value of  $C_F$ . This in turn will slow down the pulse response.

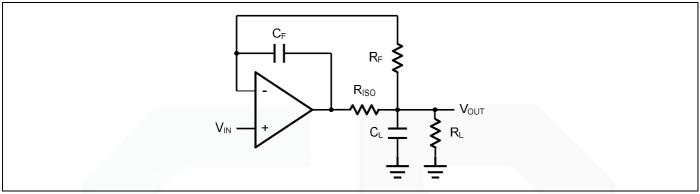


Figure 3. Indirectly Driving a Capacitive Load with DC Accuracy







### **Typical Application Circuits**

#### Differential amplifier

The differential amplifier allows the subtraction of two input voltages or cancellation of a signal common the two inputs. It is useful as a computational amplifier in making a differential to single-end conversion or in rejecting a common mode signal. Figure 4. shown the differential amplifier using GS872X.

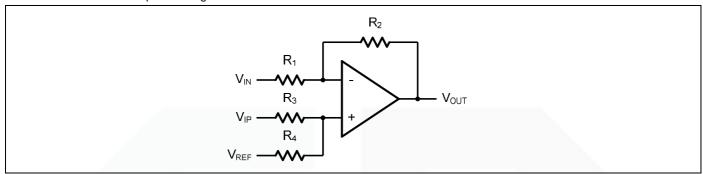


Figure 4. Differential Amplifier

$$V_{\text{OUT}} = (\frac{R_1 + R_2}{R_2 + R_4}) \frac{R_4}{R_1} V_{\text{IN}} - \frac{R_2}{R_1} V_{\text{IP}} + (\frac{R_1 + R_2}{R_2 + R_4}) \frac{R_3}{R_1} V_{\text{REF}}$$

If the resistor ratios are equal (i.e. R<sub>1</sub>=R<sub>3</sub> and R<sub>2</sub>=R<sub>4</sub>), then

$$V_{\text{OUT}} = \frac{R_2}{R_1} (V_{\text{IP}} - V_{\text{IN}}) + V_{\text{REF}}$$

#### Low Pass Active Filter

The low pass active filter is shown in Figure 5. The DC gain is defined by  $-R_2/R_1$ . The filter has a -20dB/decade roll-off after its corner frequency  $f_C=1/(2\pi R_3C_1)$ .

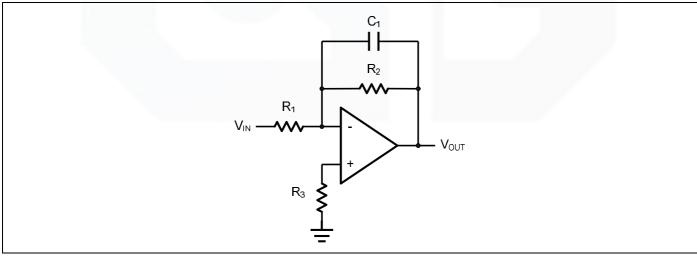


Figure 5. Low Pass Active Filter





### **Instrumentation Amplifier**

The triple GS872X can be used to build a three-op-amp instrumentation amplifier as shown in Figure 6. The amplifier in Figure 6 is a high input impedance differential amplifier with gain of  $R_2/R_1$ . The two differential voltage followers assure the high input impedance of the amplifier.

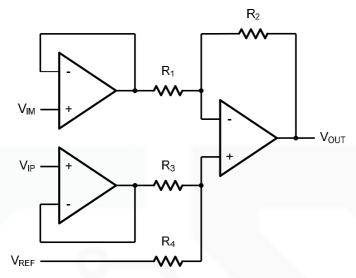


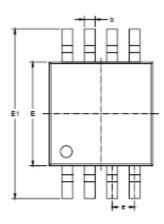
Figure 6. Instrument Amplifier

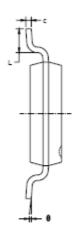


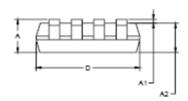


# Package Information

### MSOP-8

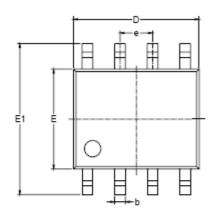


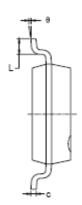


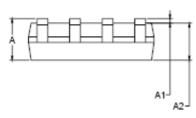


Symbol	Dimen In Milli		Dimensions In Inches		
	MIN	MAX	MIN	MAX	
A	0.820	1.100	0.032	0.043	
A1	0.020	0.150	0.001	0.008	
A2	0.750	0.950	0.030	0.037	
b	0.250	0.380	0.010	0.015	
С	0.090	0.230	0.004	0.009	
D	2.900	3.100	0.114	0.122	
E	2.900	3.100	0.114	0.122	
E1	4.750	5.050	0.187	0.199	
e	0.650	BSC	0.026	BSC	
L	0.400	0.800	0.016	0.031	
θ	0° 6°		0°	6°	

SOP-8



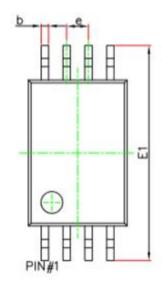


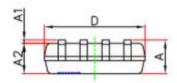


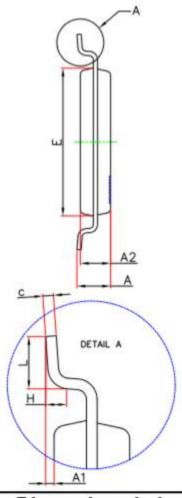
Symbol		nsions imeters	Dimensions In Inches		
,	MIN	MAX	MIN	MAX	
A	1.350	1.750	0.053	0.069	
A1	0.100	0.250	0.004	0.010	
A2	1.350	1.550	0.053	0.061	
b	0.330	0.510	0.013	0.020	
С	0.170	0.250	0.006	0.010	
D	4.700	5.100	0.185	0.200	
E	3.800	4.000	0.150	0.157	
E1	5.800	6.200	0.228	0.244	
e	1.27	1.27 BSC	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



TSSOP-8





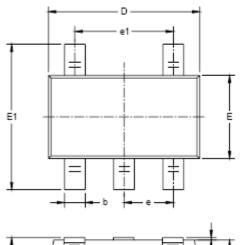


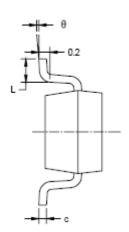
Cumbal	Dimensions In	n Millimeters	Dimensions In Inches			
Symbol	Min.	Max.	Min.	Max.		
D	4.900	5.100	0.193	0.201		
E	4.300	4.500	0.169	0.177		
b	0.190	0.300	0.007	0.012		
С	0.090	0.200	0.004	0.008		
E1	6.250	6.550	0.246	0.258		
Α	5 <del></del> 0	1.200	_	0.047		
A2	0.800	1.000	0.031	0.039		
A1	0.050	0.150	0.002	0.006		
е	0.65 (	BSC)	0.026 (BSC)			
L	0.500	0.700	0.020	0.028		
Н	0.25(TYP)		0.01(TYP)			
θ	1°	7°	1°	7°		

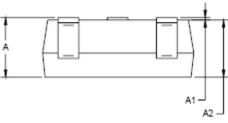




SOT23-5



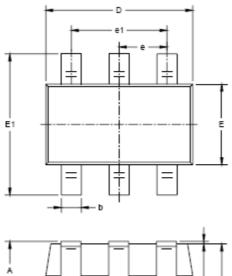


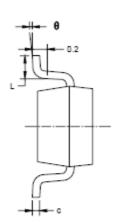


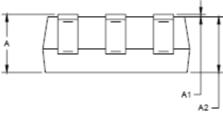
Symbol		nsions imeters	Dimensions In Inches		
-,	MIN	MAX	MIN	MAX	
Α	1.050	1.250	0.041	0.049	
A1	0.000	0.100	0.000	0.004	
A2	1.050	1.150	0.041	0.045	
b	0.300	0.500	0.012	0.020	
С	0.100	0.200	0.004	0.008	
D	2.820	3.020	0.111	0.119	
E	1.500	1.700	0.059	0.067	
E1	2.650	2.950	0.104	0.116	
е	0.950	BSC	0.037	BSC	
e1	1.900	1.900 BSC		BSC	
L	0.300	0.600	0.012	0.024	
е	0°	8°	0°	8°	



SOT23-6



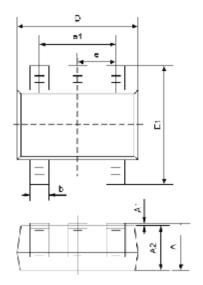


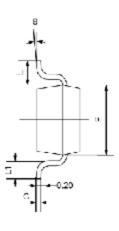


Symbol		nsions meters	Dimensions In Inches		
,	MIN	MAX	MIN	MAX	
Α	1.050	1.250	0.041	0.049	
A1	0.000	0.100	0.000	0.004	
A2	1.050	1.150	0.041	0.045	
b	0.300	0.500	0.012	0.020	
С	0.100	0.200	0.004	800.0	
D	2.820	3.020	0.111	0.119	
E	1.500	1.700	0.059	0.067	
E1	2.650	2.950	0.104	0.116	
e	0.950	BSC	0.037 BSC		
e1	1.900	1.900 BSC		BSC	
L	0.300	0.600	0.012	0.024	
θ	0°	8°	0°	8°	



#### SC70-5



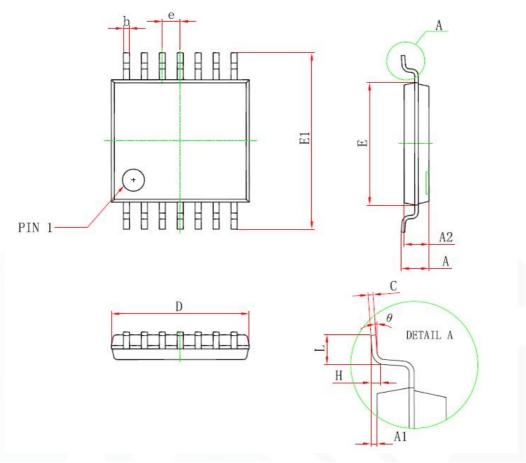


	Dimensions		Dimens	sions
Symbol	In Millir	In Millimeters Min Max		es
	Min			Max
A	0.900	1.100	0.035	0.043
A1	0.000	0.100	0.000	0.004
A2	0.900	1.000	0.035	0.039
b	0.150	0.350	0.006	0.014
С	0.080	0.150	0.003	0.006
D	2.000	2.200	0.079	0.087
E	1.150	1.350	0.045	0.053
E1	2.150	2.450	0.085	0.096
e	0.650T	ΥP	0.026T	ΥP
e1	1.200	1.400	0.047	0.055
L	0.525R	0.525REF		EF
L1	0.260	0.460	0.010	0.018
Ð	0.	8°	0°	8°





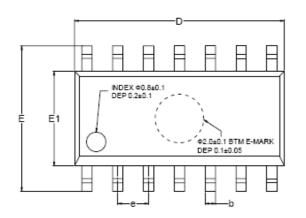
### TSSOP-14

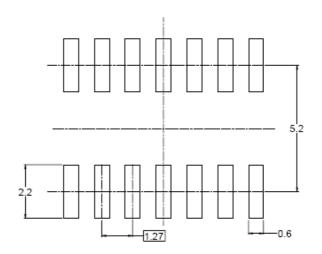


	Dimensions I	n Millimeters	Dimensions In Inche		
Symbol	Min	Max	Min	Max	
D	4.900	5. 100	0.193	0.201	
Е	4.300	4.500	0.169	0.177	
b	0.190	0.300	0.007	0.012	
c	0.090	0.200	0.004	0.008	
E1	6. 250	6.550	0.246	0.258	
A		1.200		0.047	
A2	0.800	1.000	0.031	0.039	
A1	0.050	0.150	0.002	0.006	
e	0.65	(BSC)	0.026 (BSC)		
L	0.500	0.700	0.020	0.028	
Н	0.25(	0.25(TYP)		TYP)	
θ	1°	7°	1°	7°	

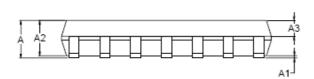


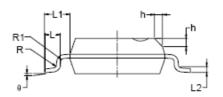
#### SOP-14





RECOMMENDED LAND PATTERN (Unit: mm)





C.mah.al	Dimen	Dimensions In Millimeters			Dimensions In Inches		
Symbol	MIN	MOD	MAX	MIN	MOD	MAX	
Α	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	
е		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°	

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