

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: 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, MSOP-8, TSSOP-8 and DFN2*2-8 Packages
 - GS8723 Available in SOT23-6 Package
 - GS8724 Available in SOP-14 and TSSOP-14 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 supply current of GS8723 is less than 0.5μA in power-down mode. 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, MSOP-8, TSSOP-8 and DFN2*2-8 packages. The GS8723 single is available in Green SOT23-6 package. 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

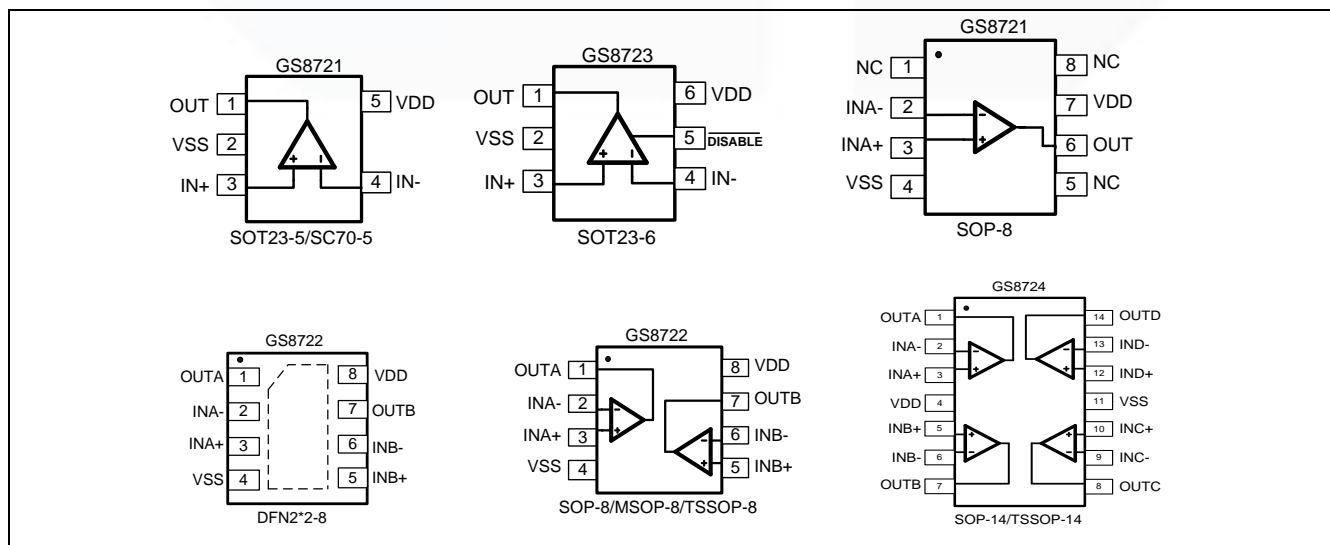


Figure 1. Pin Assignment Diagram

Absolute Maximum Ratings

Condition	Min	Max
Power Supply Voltage (V _{DD} to V _{SS})	-0.5V	+7.5V
Analog Input Voltage (IN+ or IN-)	V _{SS} -0.5V	V _{DD} +0.5V
PDB Input Voltage	V _{SS} -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°C	
Package Thermal Resistance (TA=+25°C)		
SOT23-5, θ _{JA}	190°C/W	
SOT23-6, θ _{JA}	190°C/W	
SC70-5, θ _{JA}	333°C/W	
SOP-8, θ _{JA}	125°C/W	
MSOP-8, θ _{JA}	216°C/W	
TSSOP-8, θ _{JA}	170°C/W	
SOP-14, θ _{JA}	120°C/W	
TSSOP-14, θ _{JA}	180°C/W	
ESD Susceptibility		
HBM	8KV	
MM	400V	

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	Single	GS8721-CR	SC70-5	Tape and Reel,3000	721/8721
		GS8721-TR	SOT23-5	Tape and Reel,3000	721/8721
		GS8721-SR	SOP-8	Tape and Reel,4000	GS8721
GS8723	Single	GS8723-TR	SOT23-6	Tape and Reel,3000	GS8723
GS8722	Dual	GS8722-SR	SOP-8	Tape and Reel,4000	GS8722
		GS8722-MR	MSOP-8	Tape and Reel,3000	GS8722
		GS8722-TR	TSSOP-8	Tape and Reel,3000	GS8722
		GS8722-FR	DFN2*2-8	Tape and Reel,3000	GS8722
GS8724	Quad	GS8724-TR	TSSOP-14	Tape and Reel,3000	GS8724
		GS8724-SR	SOP-14	Tape and Reel,2500	GS8724

Electrical Characteristics

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

PARAMETER	SYMBOL	CONDITIONS	GS8721/2/3/4			
INPUT CHARACTERISTICS			TYP	MIN	MAX	UNITS
Input Offset Voltage	V _{OS}		0.8	-5	5	mV
Input Bias Current	I _B		1			pA
Input Offset Current	I _{OS}		1			pA
Common-Mode Voltage Range	V _{CM}	V _S =5.5V	-0.1 to +5.6			V
Common-Mode Rejection Ratio	CMRR	V _S = 5.5V, V _{CM} = -0.1V to 4V	82	65		dB
		V _S = 5.5V, V _{CM} = -0.1V to 5.6V	75			
Open-Loop Voltage Gain	A _{OL}	R _L = 600Ω, V _O = 0.15V to 4.85V	90	80		dB
		R _L = 10KΩ, V _O = 0.05V to 4.95V	108			
Input Offset Voltage Drift	ΔV _{OS} /ΔT		2.4			μV/°C
OUTPUT CHARACTERISTICS						
Output Voltage Swing from Rail		R _L = 600Ω	0.1			V
		R _L = 10kΩ	0.015			V
Output Current			70	55		mA
Closed-Loop Output Impedance		f = 100kHz, G = 1	7.5			Ω
POWER-DOWN DISABLE						
Turn-On Time			1.1			μs
Turn-Off Time			0.3			μs
DISABLE Voltage-Off					0.8	V
DISABLE Voltage-On				2		V
POWER SUPPLY						
Operating Voltage Range				2.1	5.5	V
Power Supply Rejection Ratio	PSRR	VS = +3.3V to +30V, VCM = +0.5V	91	74		dB
Quiescent Current /Amplifier	I _Q		1.1		1.5	mA
Supply current when Disabled (GS8723 only)			0.5		8	μA

Electrical Characteristics

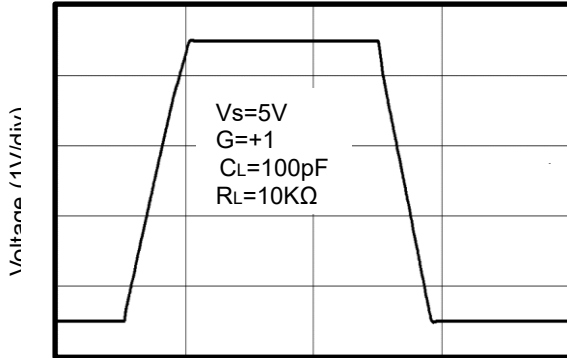
(At $V_S=5V$, $T_A = +25^{\circ}C$, $V_{CM} = V_S/2$, $R_L = 600\Omega$, unless otherwise noted.)

PARAMETER	SYMBOL	CONDITIONS	GS8721/2/3/4			
DYNAMIC PERFORMANCE			TYP	MIN	MAX	UNITS
Gain-Bandwidth Product	GBP	$R_L = 10k\Omega$, $CL = 100pF$	11			MHz
Phase Margin	ϕ_o	$R_L = 10k\Omega$, $CL = 100pF$	51			Degrees
Full Power Bandwidth	BWP	$< 1\%$ distortion, $R_L = 600\Omega$	400			kHz
Settling Time to 0.1%	t_s	$G = +1$, 2V Step, $R_L = 600\Omega$	0.3			μs
Slew Rate	SR	$G = +1$, 2V Step, $R_L = 10k\Omega$	9			V/ μs
Overload Recovery Time		$V_{IN} \cdot Gain = V_S$, $R_L = 600\Omega$	1.5			μs
NOISE PERFORMANCE						
Voltage Noise Density	e_n	$f = 1kHz$	11.5			nV / \sqrt{Hz}
		$f = 10kHz$	8			nV / \sqrt{Hz}

Typical Performance characteristics

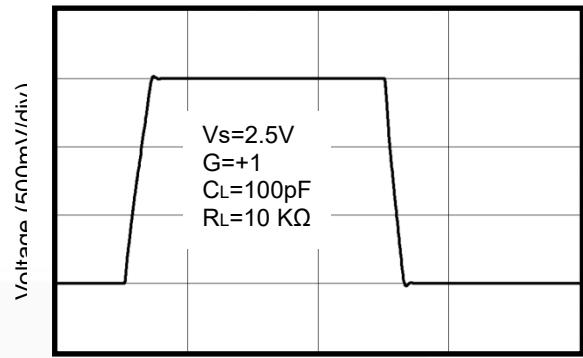
(At $V_s=5V$, $T_A = +25^\circ C$, $V_{CM} = V_s/2$, $R_L = 600\Omega$, unless otherwise noted.)

Large-Signal Step Response



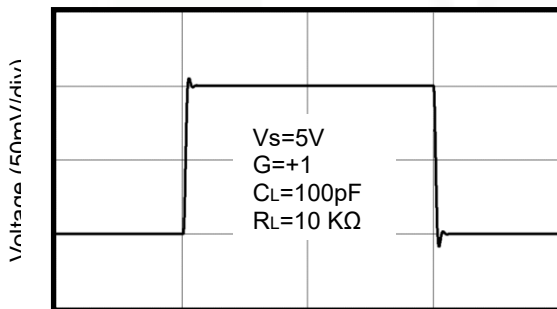
Time ($1\mu s/div$)

Large-Signal Step Response



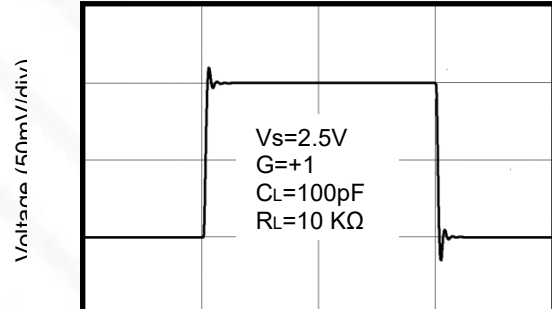
Time ($1\mu s/div$)

Small-Signal Step Response



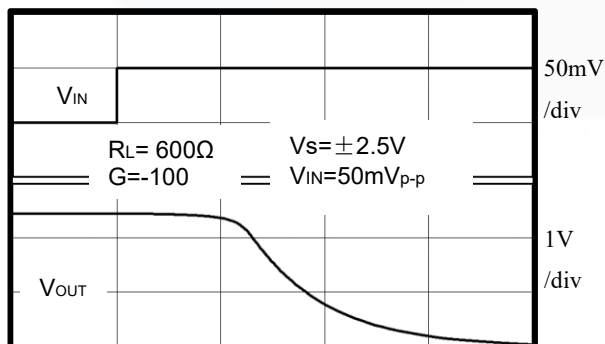
Time ($1\mu s/div$)

Small-Signal Step Response



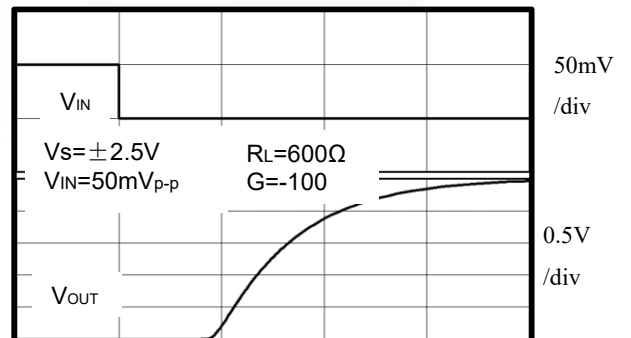
Time ($1\mu s/div$)

Positive Overload Recovery



Time ($2\mu s/div$)

Negative Overload Recovery

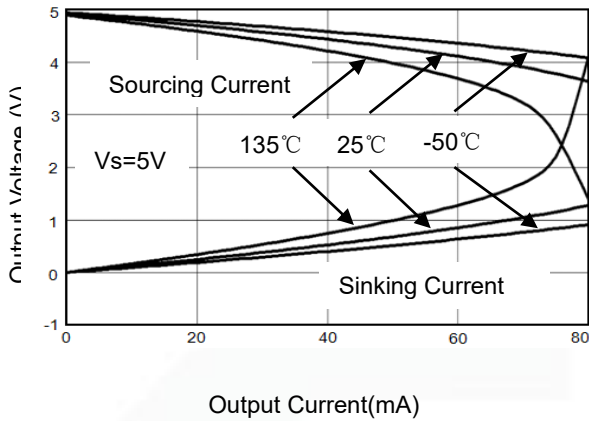


Time ($2\mu s/div$)

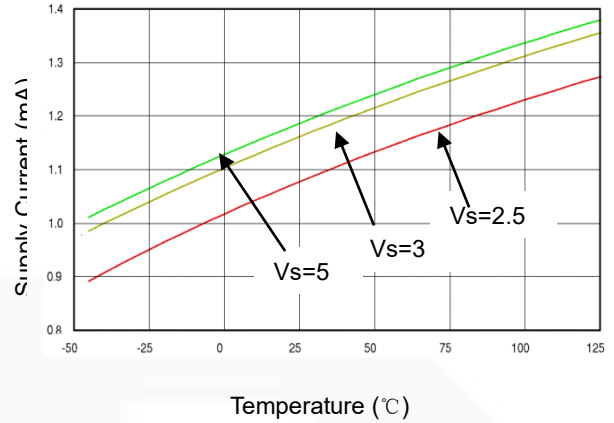
Typical Performance characteristics

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

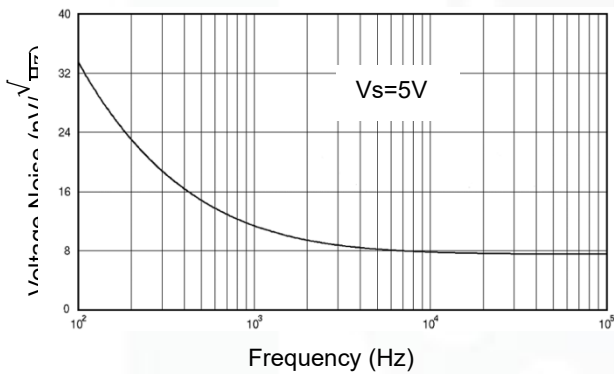
Output Voltage Swing vs. Output Current



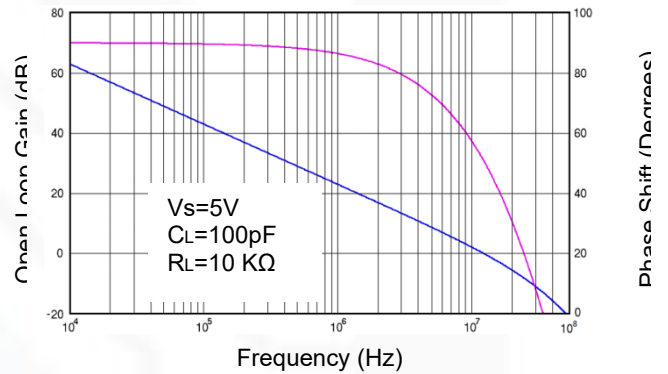
Supply Current vs. Temperature



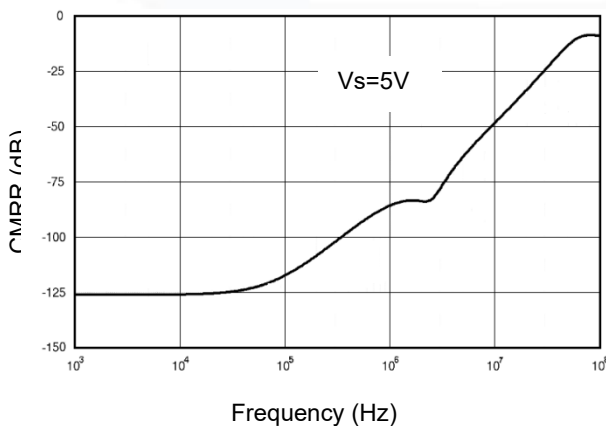
Input Voltage Noise Spectral Density vs. Frequency



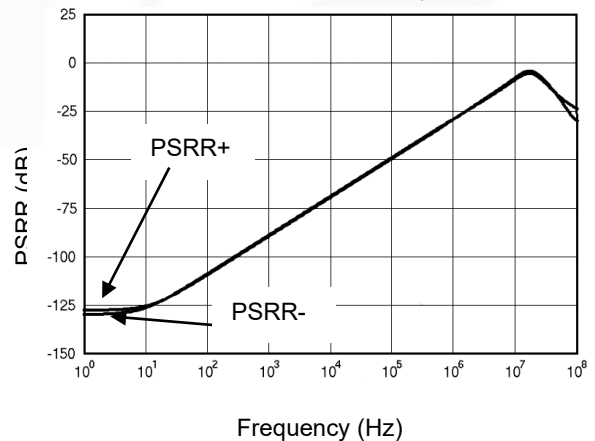
Open Loop Gain, Phase Shift vs. Frequency



CMRR vs. Frequency



PSRR vs. Frequency



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 $\pm 1.05\text{V}$ to $\pm 2.75\text{V}$ supplies. For best performance, a $0.1\mu\text{F}$ 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 $0.1\mu\text{F}$ 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. The supply current of GS8723 is less than $0.5\mu\text{A}$ in power-down mode.

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 $+125^\circ\text{C}$. Most behavior remains unchanged throughout the full operating voltage range. These guarantees ensure operation throughout the single Li-Ion battery lifetime.

Rail-to-Rail Input

The input common-mode range of GS872X series extends 100mV beyond the supply rails ($V_{\text{SS}}-0.1\text{V}$ to $V_{\text{DD}}+0.1\text{V}$). 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 ($>100\text{k}\Omega$), and 15mV of supply rail in moderate resistive loads ($10\text{k}\Omega$).

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.

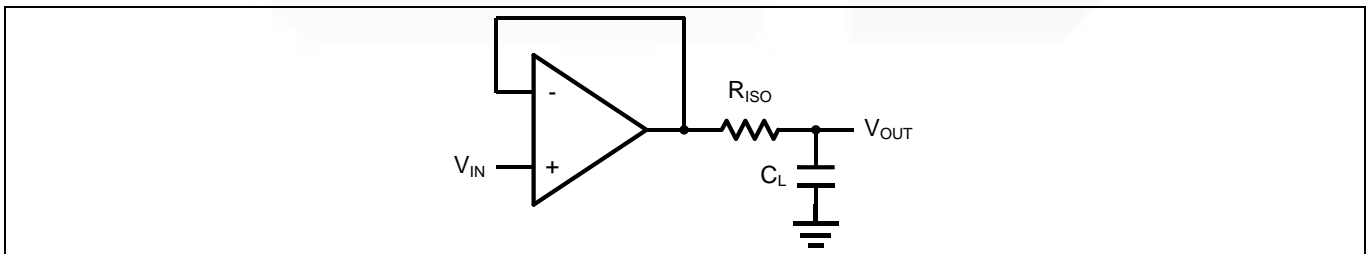


Figure 2. Indirectly Driving a Capacitive Load Using Isolation Resistor

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.

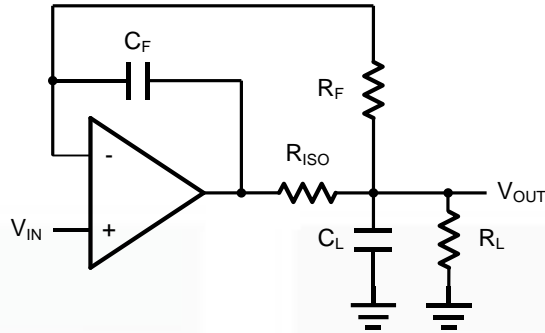


Figure 3. Indirectly Driving a Capacitive Load with DC Accuracy

Typical Application Circuits

Differential amplifier

The differential amplifier allows the subtraction of two input voltages or cancellation of a signal common to 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. shows the differential amplifier using GS872X.

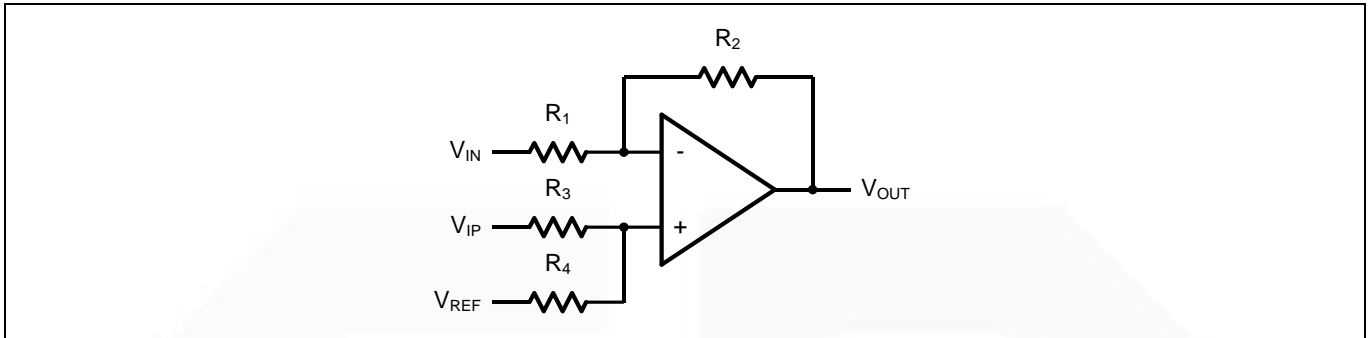


Figure 4. Differential Amplifier

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

If the resistor ratios are equal (i.e. $R_1=R_3$ and $R_2=R_4$), then

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

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 $f_c=1/(2\pi R_3 C_1)$.

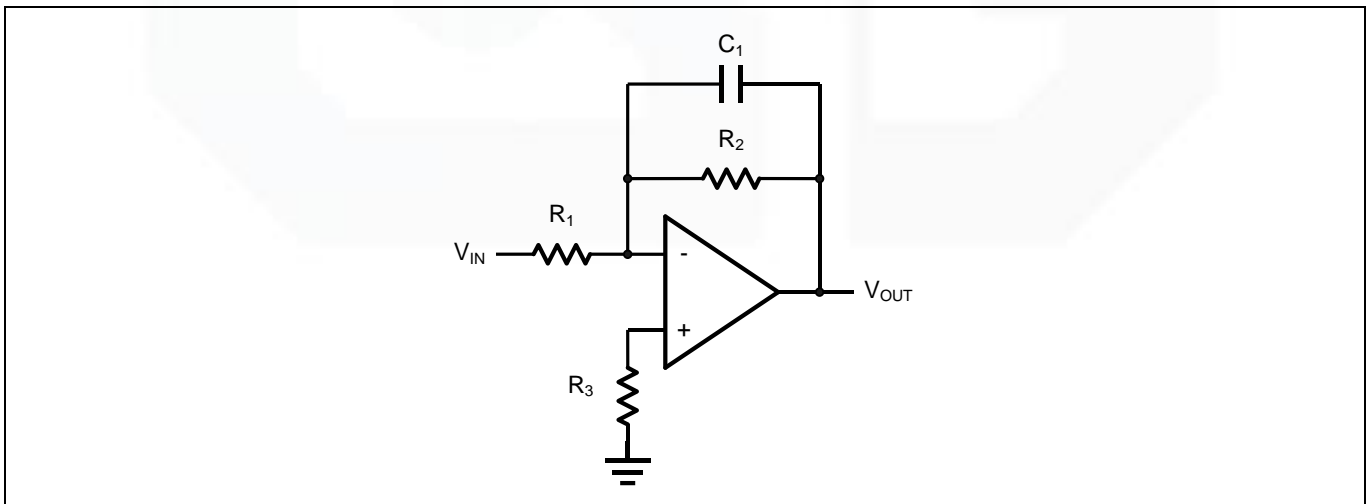


Figure 5. Low Pass Active Filter

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.

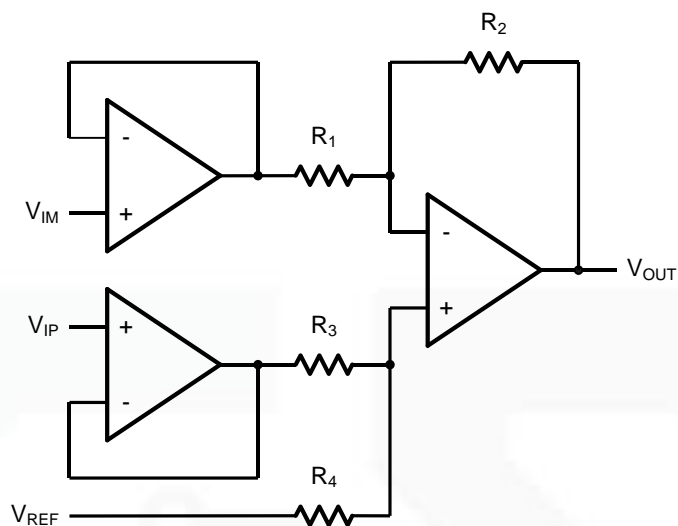
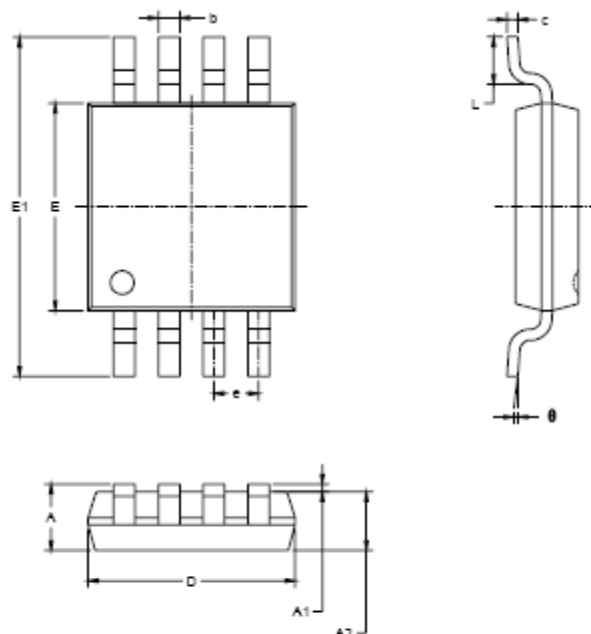


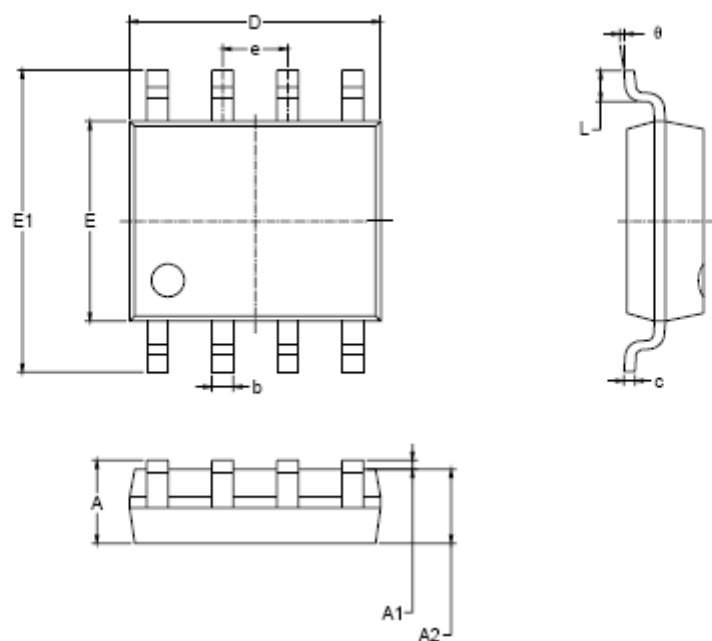
Figure 6. Instrument Amplifier

Package Information

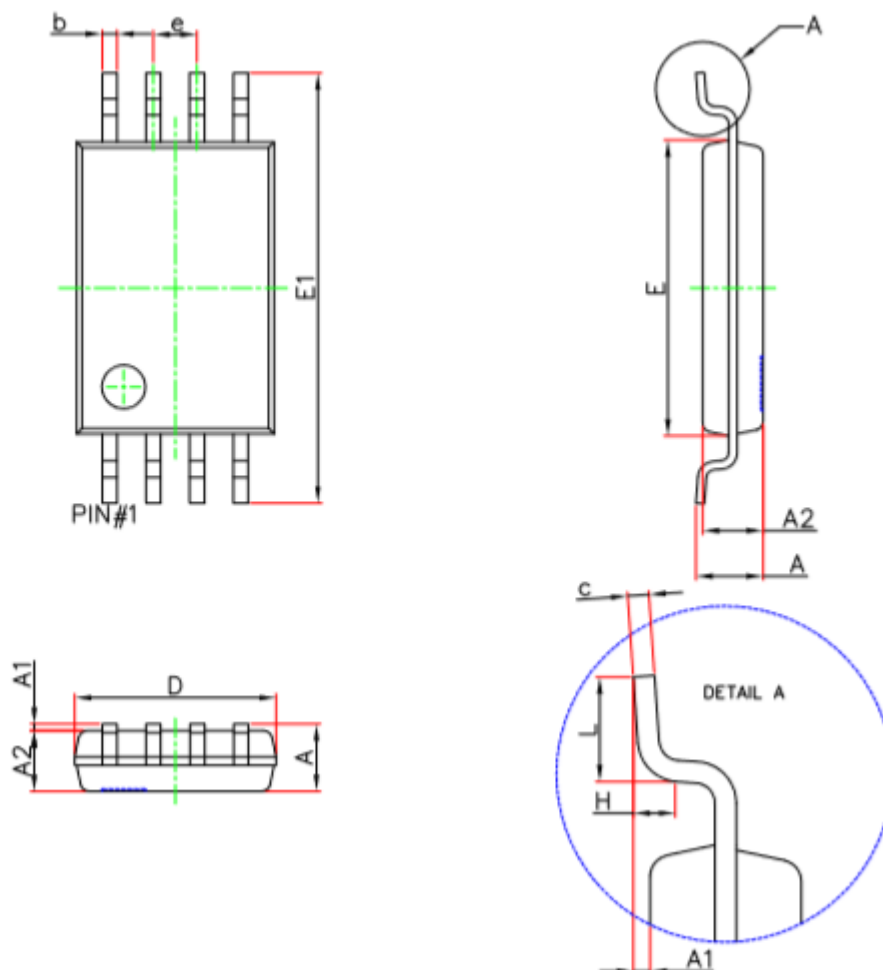
MSOP-8



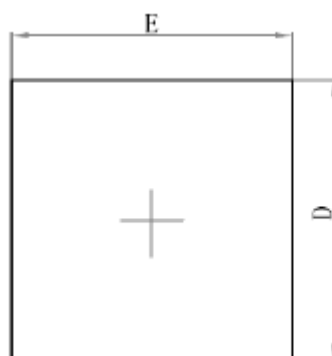
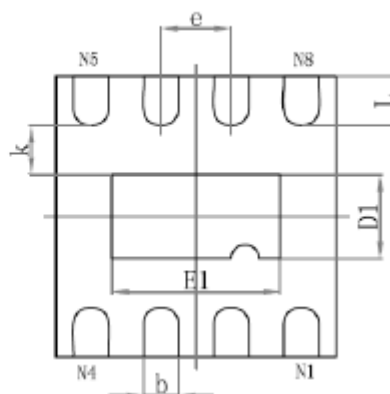
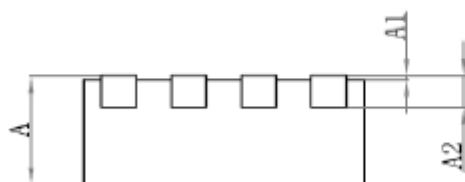
Symbol	Dimensions In Millimeters		Dimensions In Inches	
	MIN	MAX	MIN	MAX
A	0.820	1.100	0.032	0.043
A1	0.020	0.150	0.001	0.008
A2	0.750	0.950	0.030	0.037
b	0.250	0.380	0.010	0.015
c	0.090	0.230	0.004	0.009
D	2.900	3.100	0.114	0.122
E	2.900	3.100	0.114	0.122
E1	4.750	5.050	0.187	0.199
e	0.650 BSC		0.026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

SOP-8


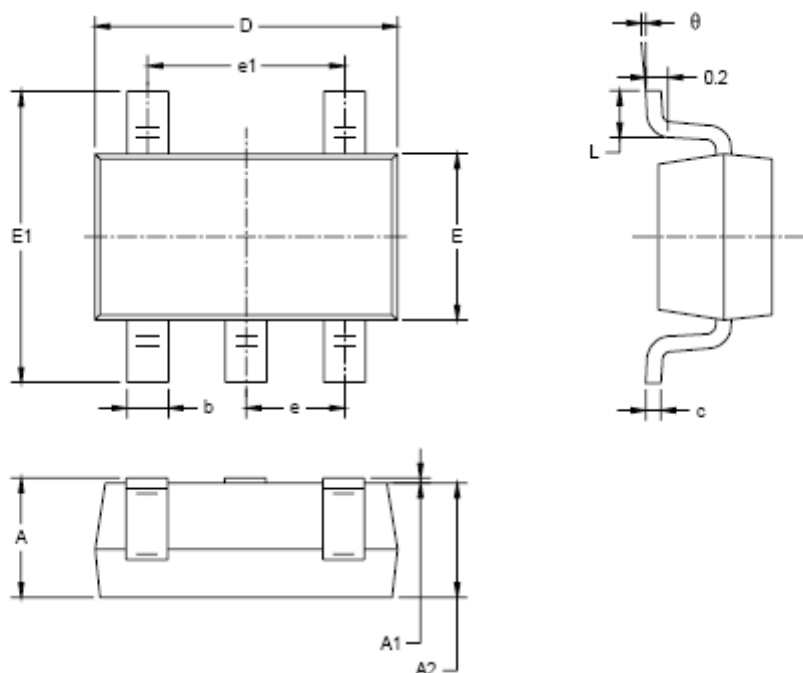
Symbol	Dimensions In Millimeters		Dimensions In Inches	
	MIN	MAX	MIN	MAX
A	1.350	1.750	0.053	0.069
A1	0.100	0.250	0.004	0.010
A2	1.350	1.550	0.053	0.061
b	0.330	0.510	0.013	0.020
c	0.170	0.250	0.006	0.010
D	4.700	5.100	0.185	0.200
E	3.800	4.000	0.150	0.157
E1	5.800	6.200	0.228	0.244
e	1.27 BSC		0.050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



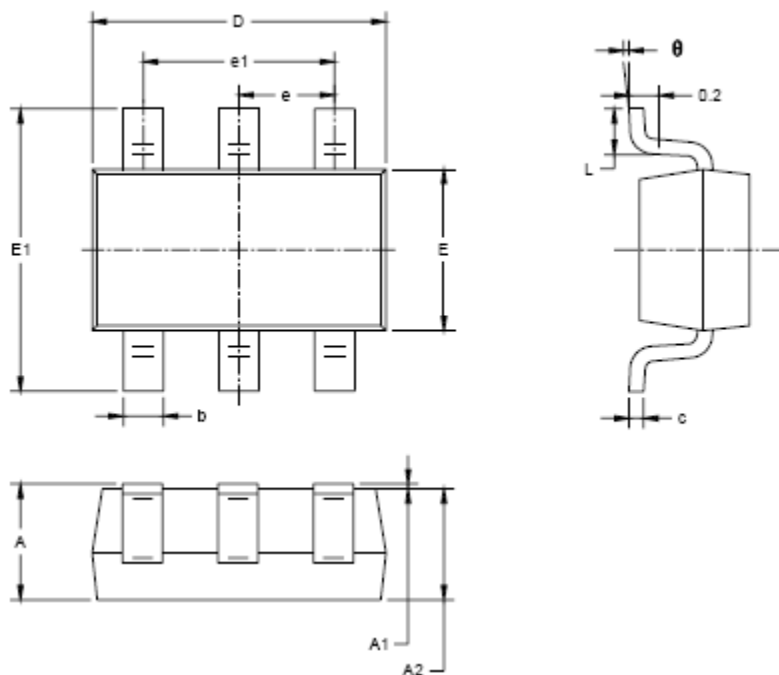
Symbol	Dimensions In Millimeters		Dimensions In Inches	
	Min.	Max.	Min.	Max.
D	4.900	5.100	0.193	0.201
E	4.300	4.500	0.169	0.177
b	0.190	0.300	0.007	0.012
c	0.090	0.200	0.004	0.008
E1	6.250	6.550	0.246	0.258
A	—	1.200	—	0.047
A2	0.800	1.000	0.031	0.039
A1	0.050	0.150	0.002	0.006
e	0.65 (BSC)		0.026 (BSC)	
L	0.500	0.700	0.020	0.028
H	0.25(TYP)		0.01(TYP)	
θ	1°	7°	1°	7°

DFN2*2-8

Top View

Bottom View

Side View

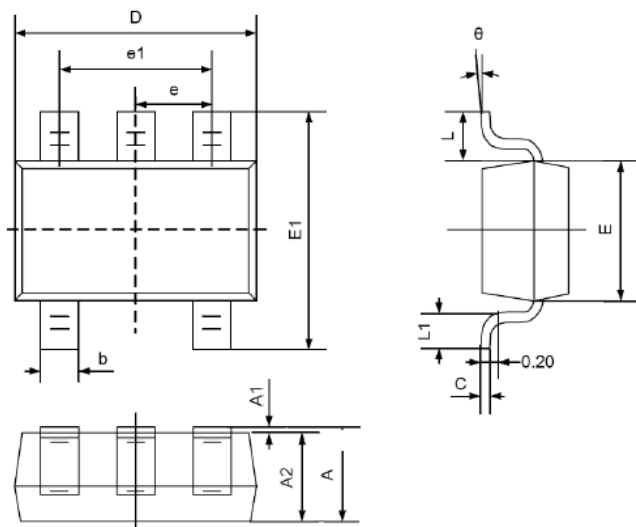
Symbol	Dimensions In Millimeters			Dimensions In Inches		
	Min	Nom	Max	Min	Nom	Max
A	0.80	0.85	0.9	0.031	0.033	0.035
A1	0.00	0.02	0.05	0.000	0.001	0.002
A2	0.153	0.203	0.253	0.006	0.008	0.010
b	0.18	0.24	0.30	0.007	0.009	0.012
D	1.9	2.0	2.1	0.075	0.079	0.083
E	1.9	2.0	2.1	0.075	0.079	0.083
D1	0.5	0.6	0.7	0.020	0.024	0.028
E1	1.1	1.2	1.3	0.043	0.047	0.051
e		0.50			0.20	
k	0.2			0.008		
L	0.25	0.35	0.45	0.010	0.014	0.018

SOT23-5


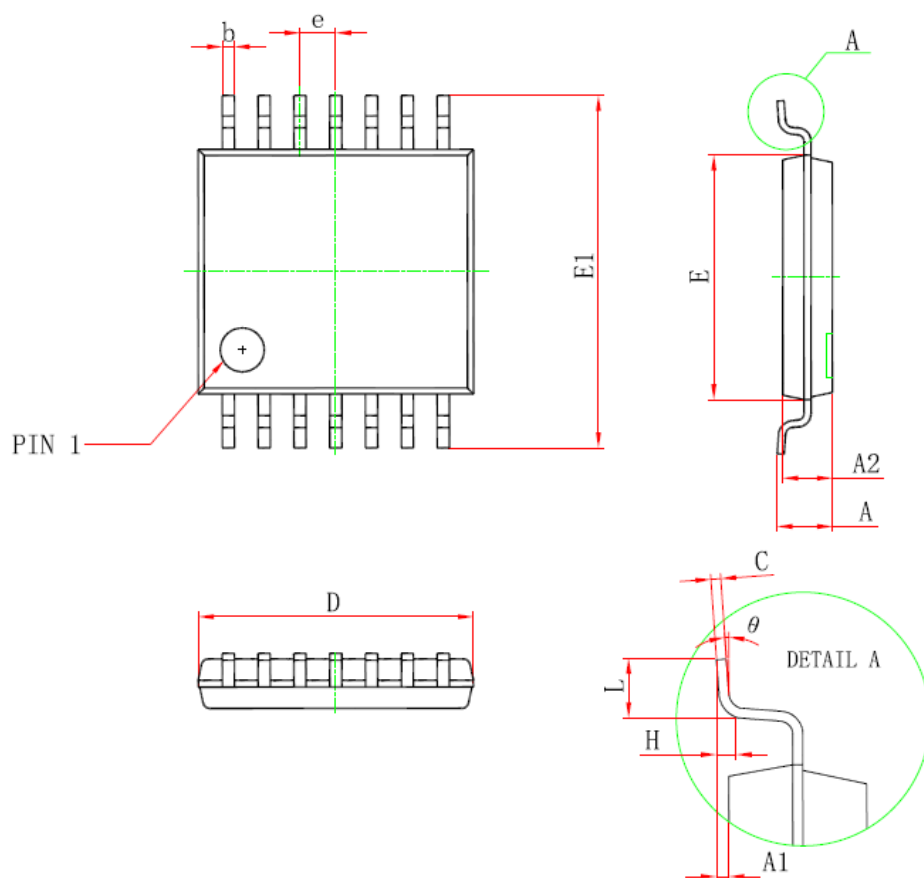
Symbol	Dimensions In Millimeters		Dimensions In Inches	
	MIN	MAX	MIN	MAX
A	1.050	1.250	0.041	0.049
A1	0.000	0.100	0.000	0.004
A2	1.050	1.150	0.041	0.045
b	0.300	0.500	0.012	0.020
c	0.100	0.200	0.004	0.008
D	2.820	3.020	0.111	0.119
E	1.500	1.700	0.059	0.067
E1	2.650	2.950	0.104	0.116
e	0.950 BSC		0.037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

SOT23-6


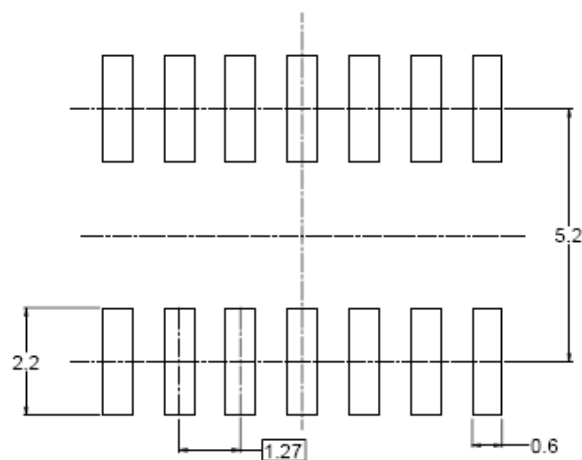
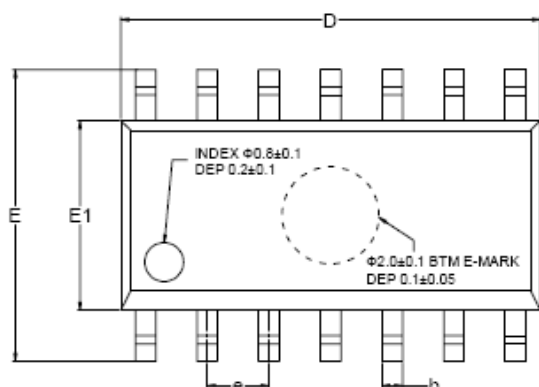
Symbol	Dimensions In Millimeters		Dimensions In Inches	
	MIN	MAX	MIN	MAX
A	1.050	1.250	0.041	0.049
A1	0.000	0.100	0.000	0.004
A2	1.050	1.150	0.041	0.046
b	0.300	0.500	0.012	0.020
c	0.100	0.200	0.004	0.008
D	2.820	3.020	0.111	0.119
E	1.500	1.700	0.059	0.067
E1	2.650	2.950	0.104	0.116
e	0.950 BSC		0.037 BSC	
e1	1.900 BSC		0.075 BSC	
L	0.300	0.600	0.012	0.024
θ	0°	8°	0°	8°

SC70-5


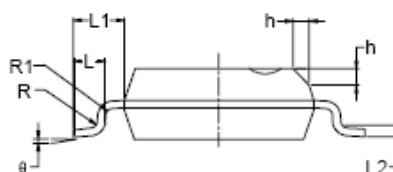
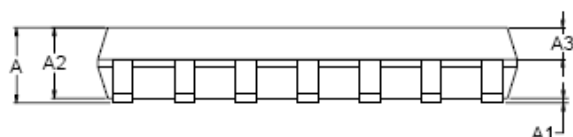
Symbol	Dimensions In Millimeters		Dimensions In Inches	
	Min	Max	Min	Max
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A1	0.000	0.100	0.000	0.004
A2	0.900	1.000	0.035	0.039
b	0.150	0.350	0.006	0.014
C	0.080	0.150	0.003	0.006
D	2.000	2.200	0.079	0.087
E	1.150	1.350	0.045	0.053
E1	2.150	2.450	0.085	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°



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		1.200		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
H	0.25(TYP)		0.01(TYP)	
θ	1°	7°	1°	7°

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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°