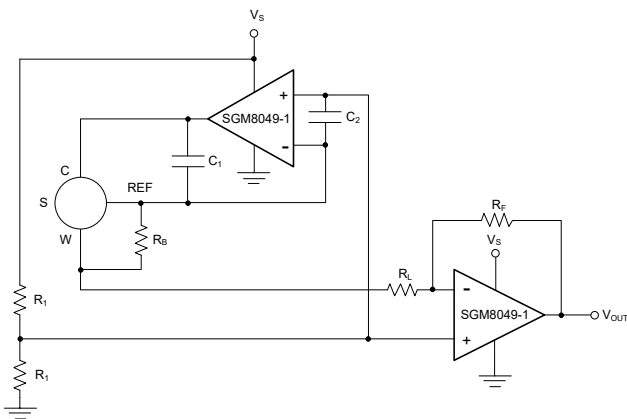


### GENERAL DESCRIPTION

The SGM8049-1, SGM8049-2 and SGM8049-4 micro power, low voltage operational amplifiers are designed for battery-powered applications. The amplifiers operate on a supply voltage as low as 1.8V ( $\pm 0.9V$ ). High-performance, single-supply operation with rail-to-rail capability makes the SGM8049-1/2/4 useful for a wide range of applications.

In addition of small packages, the SGM8049-1/2/4 feature impressive bandwidth, low bias current and low noise relative to the very low quiescent current.

The single SGM8049-1 is available in Green SC70-5, SOT-23-5 and TDFN-2 $\times$ 2-6L packages. The dual SGM8049-2 is available in Green SOT-23-8 and SOIC-8 packages. The quad SGM8049-4 is available in a Green TSSOP-14 package. They are specified over the extended  $-40^{\circ}C$  to  $+125^{\circ}C$  temperature range.



**Figure 1. SGM8049-1 in Portable Gas Meter Application**

### FEATURES

- **Low Noise:** 3.5 $\mu V_{PP}$  (0.1Hz to 10Hz)
- **Wide Supply Voltage Range:** 1.8V to 5.5V
- **Low Quiescent Current:** 2.5 $\mu A$ /Amplifier (TYP)
- **Low Offset Voltage:** 0.85mV (MAX)
- **DC Precision:**
  - CMRR:** 100dB
  - PSRR:** 2.5 $\mu V/V$
  - A<sub>OL</sub>:** 118dB
- **$-40^{\circ}C$  to  $+125^{\circ}C$  Operating Temperature Range**
- **Small Packaging:**
  - SGM8049-1 Available in Green SC70-5, SOT-23-5 and TDFN-2 $\times$ 2-6L Packages**
  - SGM8049-2 Available in Green SOT-23-8 and SOIC-8 Packages**
  - SGM8049-4 Available in a Green TSSOP-14 Package**

### APPLICATIONS

- Battery-Powered Instruments
- Portable Devices
- Wearable Devices
- Medical Instruments
- Handheld Test Equipment



**ABSOLUTE MAXIMUM RATINGS**

Supply Voltage, +V <sub>S</sub> to -V <sub>S</sub> .....	6V
Signal Input Terminals, Voltage .....	(-V <sub>S</sub> ) - 0.3V to (+V <sub>S</sub> ) + 0.3V
Signal Input Terminals, Current .....	$\pm$ 10mA
Output Short-Circuit Current .....	30mA
Junction Temperature .....	+150°C
Storage Temperature Range .....	-65°C to +150°C
Lead Temperature (Soldering, 10s) .....	+260°C
ESD Susceptibility	
HBM .....	6000V
MM .....	400V
CDM .....	1000V

**RECOMMENDED OPERATING CONDITIONS**

Input Voltage Range .....	1.8V to 5.5V
Operating Temperature Range .....	-40°C to +125°C

**OVERSTRESS CAUTION**

Stresses beyond those listed in Absolute Maximum Ratings may cause permanent damage to the device. Exposure to absolute maximum rating conditions for extended periods may affect reliability. Functional operation of the device at any conditions beyond those indicated in the Recommended Operating Conditions section is not implied.

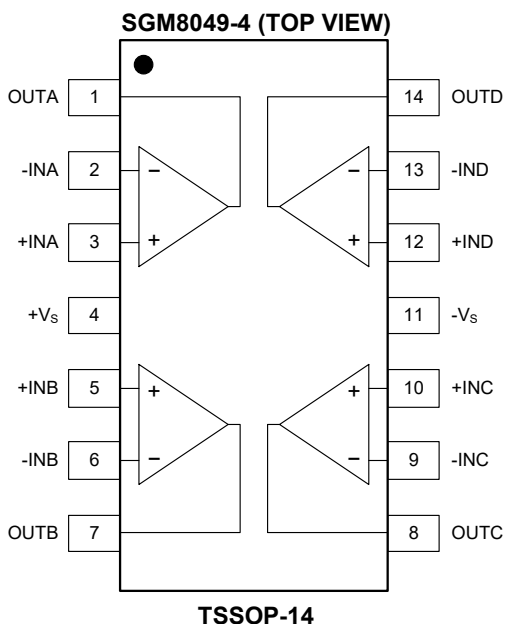
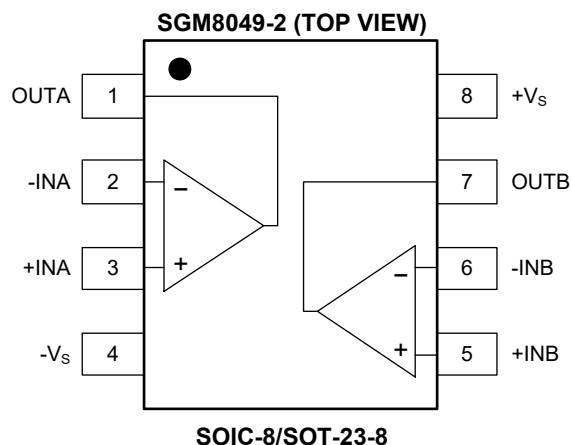
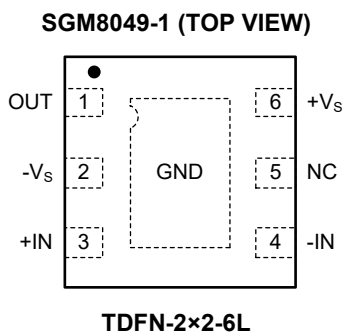
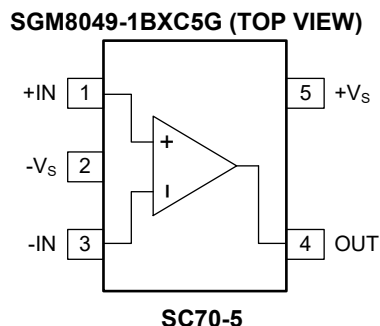
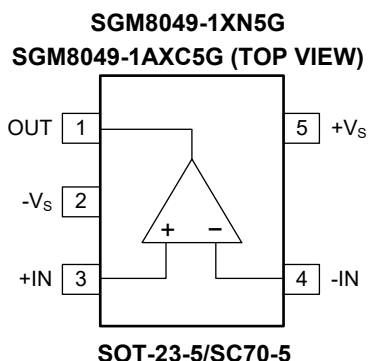
**ESD SENSITIVITY CAUTION**

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.

**DISCLAIMER**

SG Micro Corp reserves the right to make any change in circuit design, or specifications without prior notice.

**PIN CONFIGURATIONS**



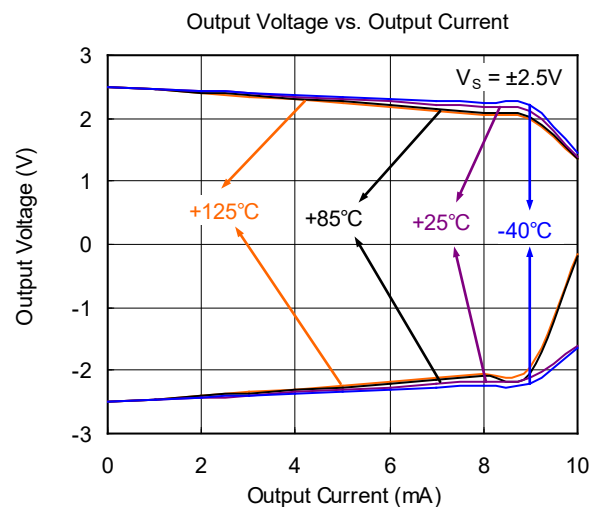
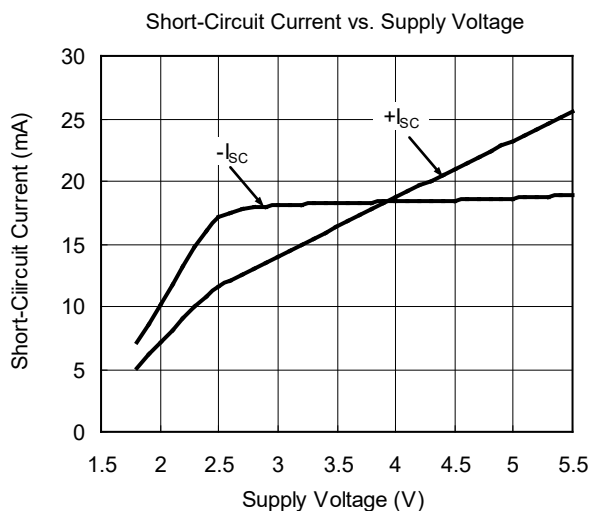
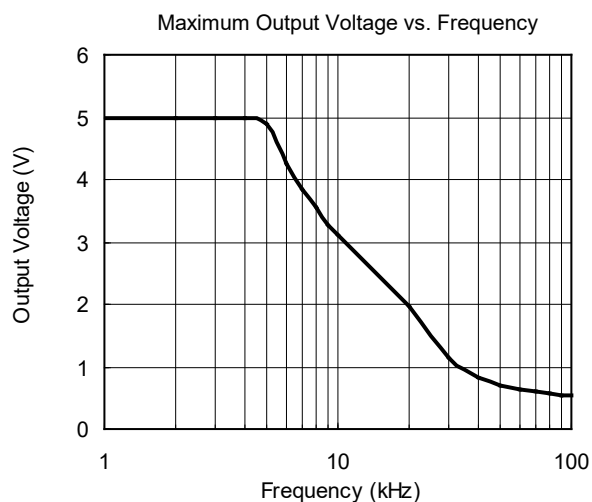
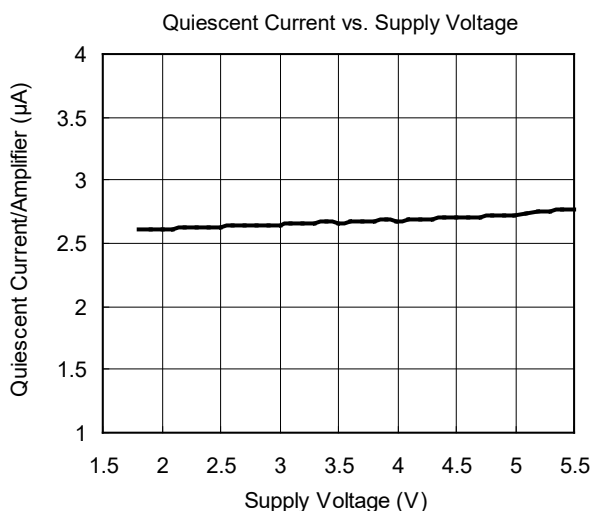
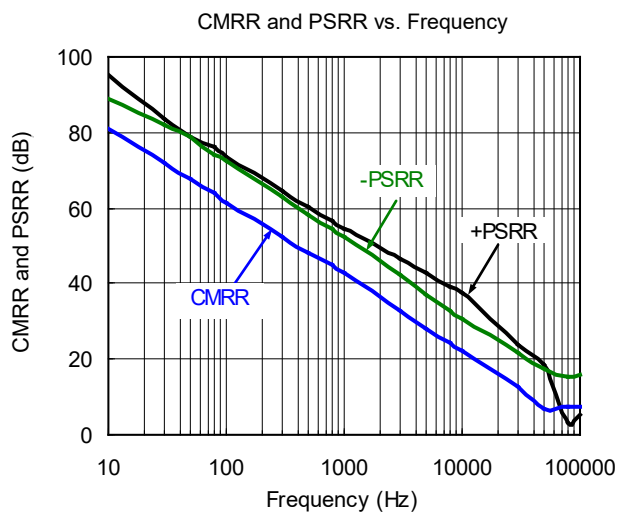
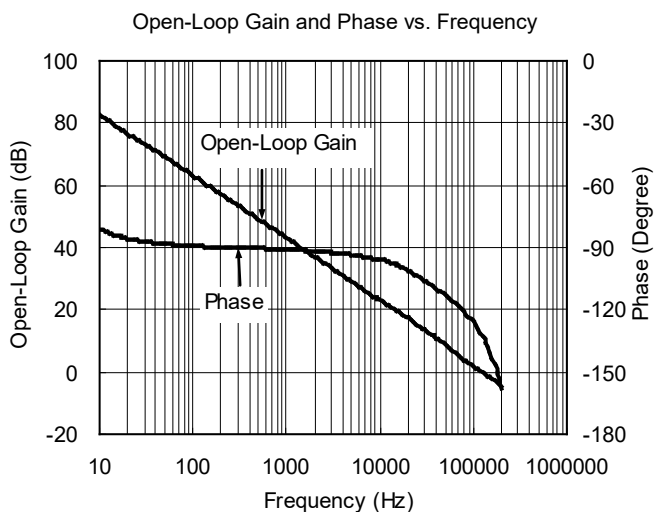
## ELECTRICAL CHARACTERISTICS

(At  $T_A = +25^\circ\text{C}$ ,  $V_S = 1.8\text{V}$  to  $5.5\text{V}$ ,  $R_L = 25\text{k}\Omega$  connected to  $V_S/2$  and  $V_{CM} < (+V_S) - 1.2\text{V}$ , unless otherwise noted.)

PARAMETER	SYMBOL	CONDITIONS	MIN	TYP	MAX	UNITS
<b>Input Characteristics</b>						
Input Offset Voltage	$V_{OS}$	$V_S = 5\text{V}$		0.2	0.85	mV
		$-40^\circ\text{C} \leq T_A \leq +125^\circ\text{C}$			1	
Input Bias Current	$I_B$	$V_S = 5\text{V}$ , $V_{CM} \leq V_S/2$		$\pm 1$		pA
Input Offset Current	$I_{OS}$	$V_S = 5\text{V}$		$\pm 1$		pA
Input Common Mode Voltage Range	$V_{CM}$		$(-V_S) - 0.1$		$(+V_S) + 0.1$	V
Common Mode Rejection Ratio	CMRR	$-V_S < V_{CM} < (+V_S) - 1.2\text{V}$	81	100		dB
		$-40^\circ\text{C} \leq T_A \leq +85^\circ\text{C}$	80			
		$-40^\circ\text{C} \leq T_A \leq +125^\circ\text{C}$	75			
Open-Loop Voltage Gain	$A_{OL}$	$V_S = 5\text{V}$ , $R_L = 25\text{k}\Omega$ , $100\text{mV} < V_{OUT} < (+V_S) - 100\text{mV}$	100	118		dB
		$-40^\circ\text{C} \leq T_A \leq +125^\circ\text{C}$	98			
		$V_S = 5\text{V}$ , $R_L = 5\text{k}\Omega$ , $500\text{mV} < V_{OUT} < (+V_S) - 500\text{mV}$	100	116		
		$-40^\circ\text{C} \leq T_A \leq +125^\circ\text{C}$	98			
Input Offset Voltage Drift	$\Delta V_{OS}/\Delta T$	$-40^\circ\text{C} \leq T_A \leq +85^\circ\text{C}$		0.5		$\mu\text{V}/^\circ\text{C}$
		$-40^\circ\text{C} \leq T_A \leq +125^\circ\text{C}$		0.6		
<b>Output Characteristics</b>						
Output Voltage Swing from Rail		$R_L = 25\text{k}\Omega$		5	14	mV
		$-40^\circ\text{C} \leq T_A \leq +125^\circ\text{C}$			15.5	
		$R_L = 5\text{k}\Omega$		25	40	
		$-40^\circ\text{C} \leq T_A \leq +125^\circ\text{C}$			46	
Output Short-Circuit Current	$I_{SC}$	$V_S = 5\text{V}$		20		mA
<b>Power Supply</b>						
Operating Voltage Range	$V_S$		1.8		5.5	V
Quiescent Current/Amplifier	$I_Q$	$V_S = 5.5\text{V}$ , $I_{OUT} = 0\text{mA}$		2.5	4.2	$\mu\text{A}$
		$-40^\circ\text{C} \leq T_A \leq +125^\circ\text{C}$			6.5	
Power Supply Rejection Ratio	PSRR	$V_S = 1.8\text{V}$ to $5.5\text{V}$ , $V_{CM} = 0.6\text{V}$		2.5	12	$\mu\text{V}/\text{V}$
		$-40^\circ\text{C} \leq T_A \leq +125^\circ\text{C}$			14	
<b>Dynamic Performance (<math>C_{LOAD} = 30\text{pF}</math>)</b>						
Gain-Bandwidth Product	GBP			120		kHz
Slew Rate	SR	$G = +1$		0.08		$\text{V}/\mu\text{s}$
Overload Recovery Time		$V_{IN} \times G > V_S$		25		$\mu\text{s}$
Turn-On Time	$t_{ON}$			0.2		ms
<b>Noise</b>						
Input Voltage Noise		$f = 0.1\text{Hz}$ to $10\text{Hz}$		3.5		$\mu\text{V}_{PP}$
Input Voltage Noise Density	$e_n$	$f = 1\text{kHz}$		75		$\text{nV}/\sqrt{\text{Hz}}$
Input Current Noise Density	$i_n$	$f = 1\text{kHz}$		0.2		$\text{pA}/\sqrt{\text{Hz}}$

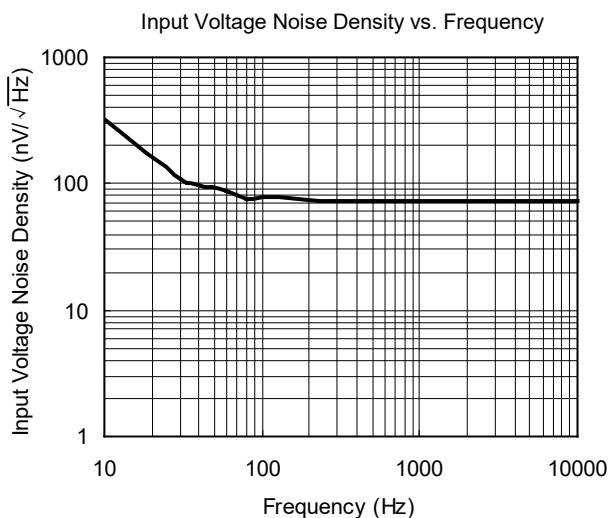
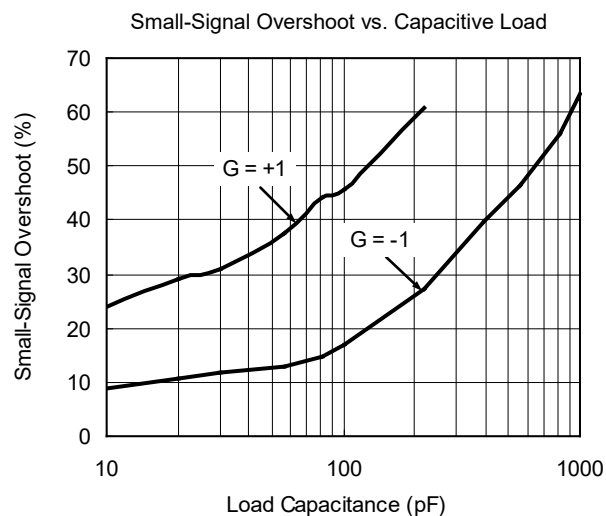
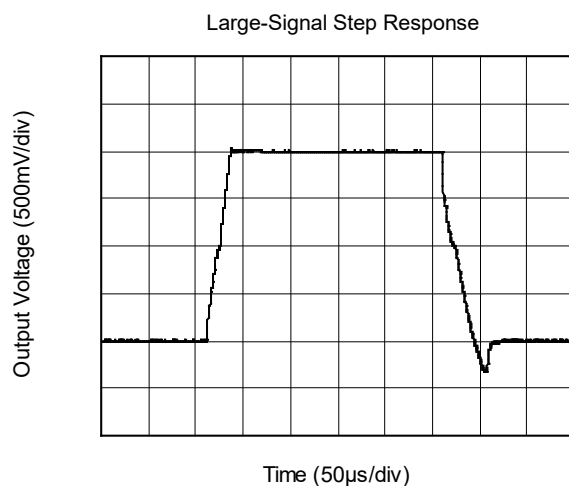
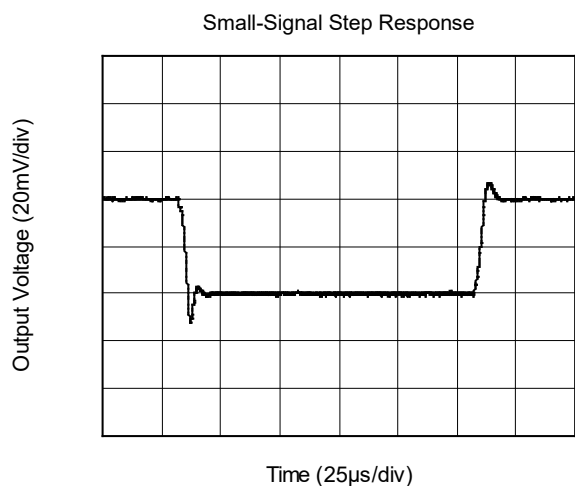
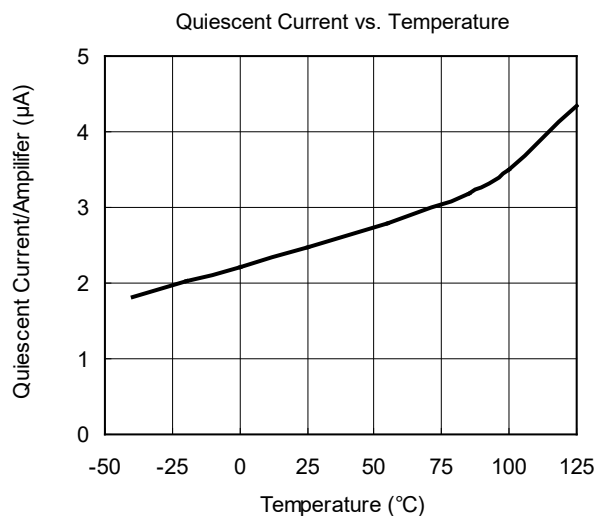
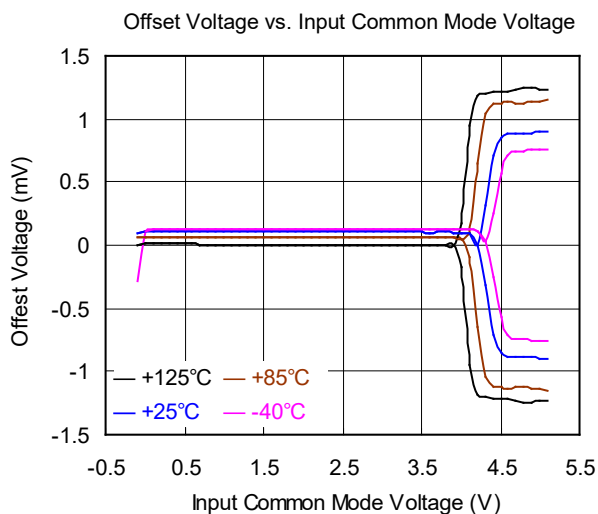
**TYPICAL PERFORMANCE CHARACTERISTICS**

At  $T_A = +25^\circ\text{C}$ ,  $V_S = 5\text{V}$  and  $R_L = 25\text{k}\Omega$  connected to  $V_S/2$ , unless otherwise noted.



**TYPICAL PERFORMANCE CHARACTERISTICS (continued)**

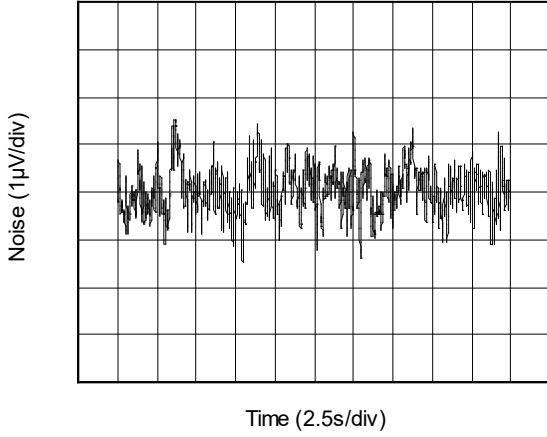
At  $T_A = +25^\circ\text{C}$ ,  $V_S = 5\text{V}$  and  $R_L = 25\text{k}\Omega$  connected to  $V_S/2$ , unless otherwise noted.



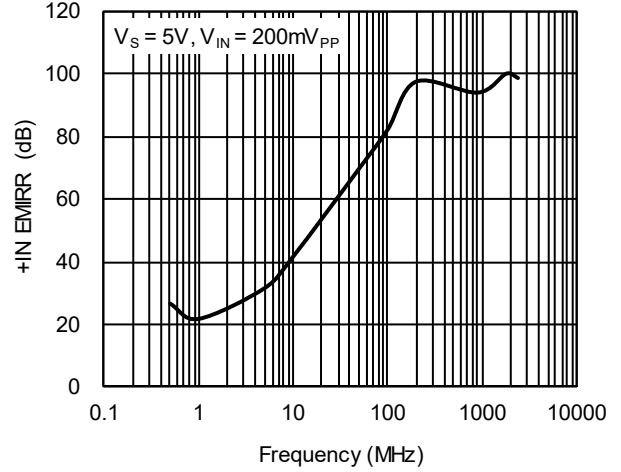
**TYPICAL PERFORMANCE CHARACTERISTICS (continued)**

At  $T_A = +25^\circ\text{C}$ ,  $V_S = 5\text{V}$  and  $R_L = 25\text{k}\Omega$  connected to  $V_S/2$ , unless otherwise noted.

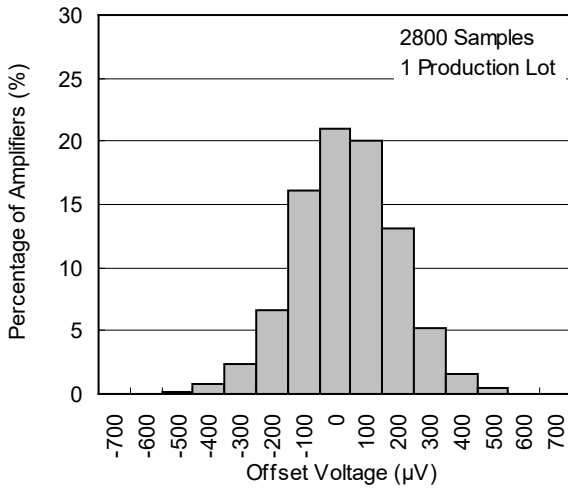
0.1Hz to 10Hz Noise



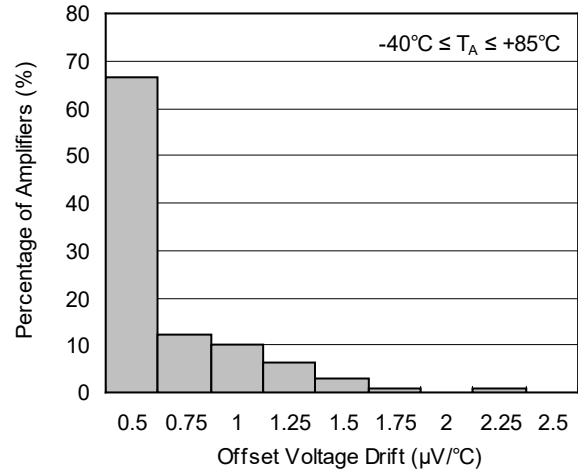
+IN EMIRR vs. Frequency



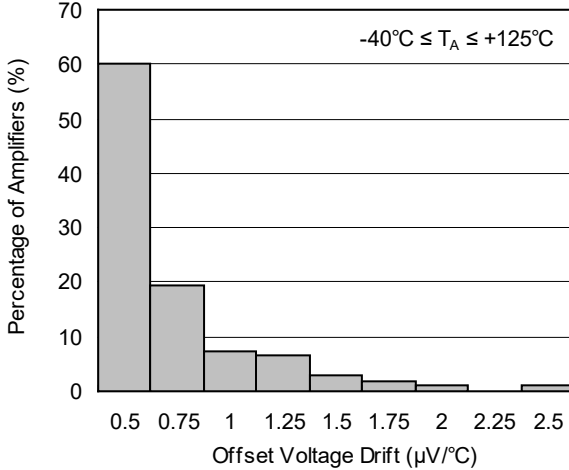
Offset Voltage Production Distribution



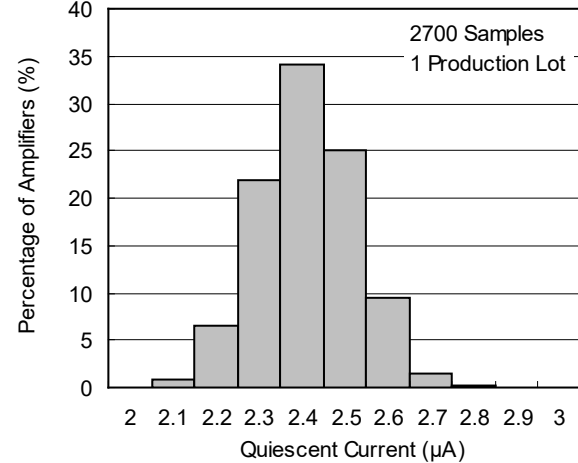
Offset Voltage Drift Distribution



Offset Voltage Drift Distribution



Quiescent Current Production Distribution





## APPLICATION INFORMATION

The SGM8049-1/2/4 operational amplifiers minimize power consumption without compromising bandwidth or noise. Typical values of power supply rejection ratio (PSRR), common mode rejection ratio (CMRR), and open-loop gain ( $A_{OL}$ ) are 100dB or better.

When designing for ultra low power applications, choose system components carefully. To minimize current consumption, select large value resistors. Any resistors will react with stray capacitance in the circuit and the input capacitance of the operational amplifiers. These parasitic RC combinations can affect the stability of the overall system. A feedback capacitor may be required to assure stability and limit overshoot or gain peaking.

Good layout practice mandates the use of a 0.1 $\mu$ F bypass capacitor placed closely across the supply pins.

### Operating Voltage

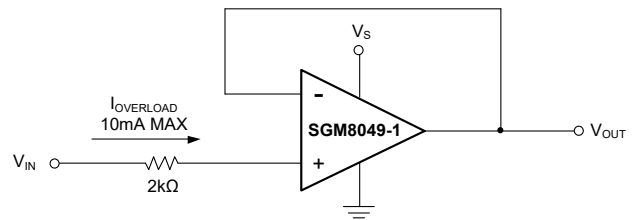
SGM8049-1/2/4 operational amplifiers are fully specified and tested from 1.8V to 5.5V or  $\pm 0.9V$  to  $\pm 2.75V$ .

### Input Common Mode Voltage Range

The input common mode voltage range of the SGM8049-1/2/4 is from  $(-V_S) - 0.1V$  to  $(+V_S) + 0.1V$ . This rail-to-rail input is achieved using a complementary input stage. CMRR is specified from the negative rail to 1.2V below the positive rail. Between  $(-V_S) - 0.1V$  to  $(+V_S) + 0.1V$ , the amplifier operates with higher offset voltage because of the transition region of the input stage.

### Protecting Inputs from Over-Voltage

Normally, input currents are 1pA. However, a large voltage input (greater than 500mV beyond the supply rails) can cause excessive current to flow in or out of the input pins. Therefore, as well as keeping the input voltage below the maximum rating, it is also important to limit the input current to less than 10mA. This limiting is easily accomplished with an input voltage resistor, as shown in Figure 2.



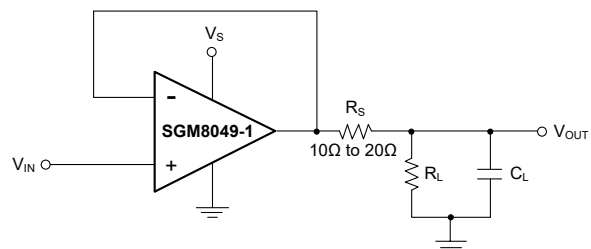
**Figure 2. Input Current Protection for Voltages Exceeding the Supply Voltage**

### Noise

Although micro-power amplifiers frequently have high wideband noise, the SGM8049-1/2/4 offer excellent noise performance. Resistors should be chosen carefully because the SGM8049-1/2/4 have only 3.5 $\mu$ V<sub>PP</sub> of 0.1Hz to 10Hz noise, and 75nV/ $\sqrt{\text{Hz}}$  of wideband noise; otherwise, they can become the dominant source of noise.

### Capacitive Load and Stability

Follow configurations with load capacitance in excess of 30pF can produce extra overshoot and ringing in the output signal. Increasing the gain enhances the ability of the amplifier to drive greater capacitive loads. In unity-gain configurations, capacitive load drive can be improved by inserting a small (10 $\Omega$  to 20 $\Omega$ ) resistor,  $R_S$ , in series with the output, as shown in Figure 3. This resistor significantly reduces ringing while maintaining direct current (DC) performance for purely capacitive loads. However, if there is a resistive load in parallel with the capacitive load, a voltage divider is created, introducing a DC error at the output and slightly reducing the output swing. The error introduced is proportional to the ratio  $R_S/R_L$ , and is generally negligible.

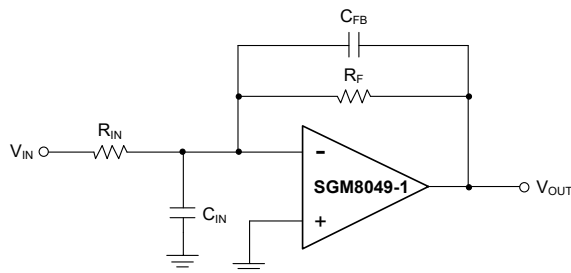


**Figure 3. Series Resistor in Unity-Gain Buffer Configuration Improves Capacitive Load Drive**

**APPLICATION INFORMATION (continued)**

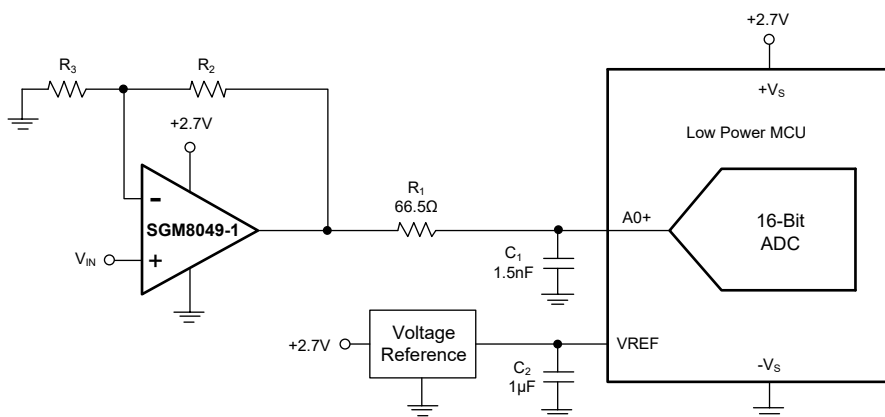
In unity-gain inverting configuration, phase margin can be reduced by the reaction between the capacitance at the operational amplifier input and the gain setting resistors. Best performance is achieved by using smaller valued resistors. However, when large valued resistors cannot be avoided, a small (4pF to 6pF)

capacitor,  $C_{FB}$ , can be inserted in the feedback, as shown in Figure 4. This configuration significantly reduces overshoot by compensating the effect of capacitance,  $C_{IN}$ , which includes the amplifier input capacitance and printed circuit board (PCB) parasitic capacitance.

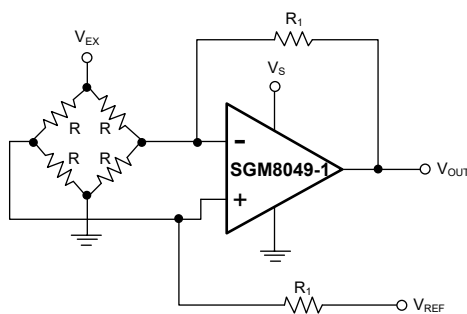


**Figure 4. Improving Stability for Large  $R_F$  and  $R_{IN}$**

Figure 5 through Figure 9 illustrate some low power application examples.

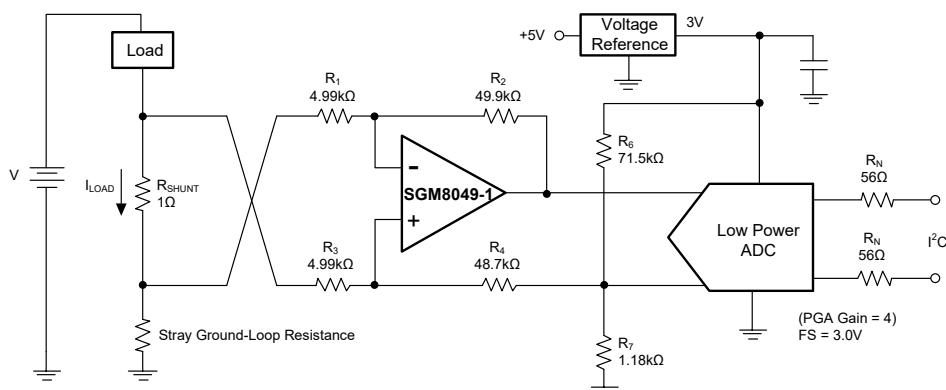


**Figure 5. Unipolar Signal Chain Configuration**



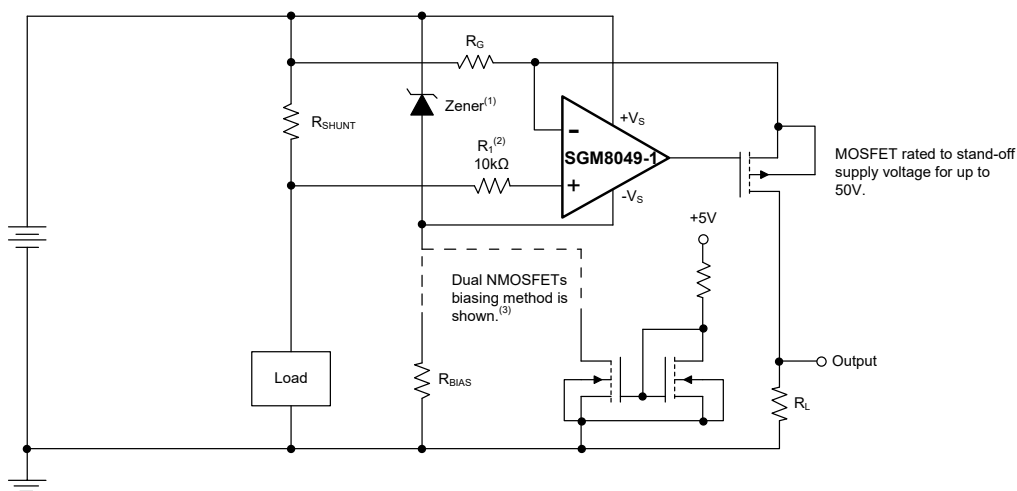
**Figure 6. Single Operational Amplifier Bridge Amplifier**

**APPLICATION INFORMATION (continued)**



NOTE: 1% resistors provide adequate common mode rejection at small ground-loop errors.

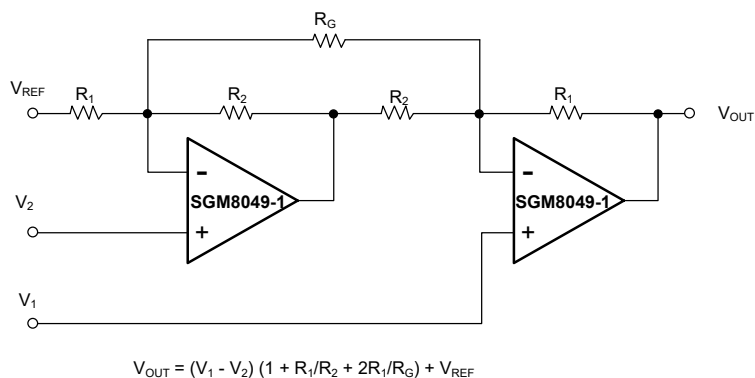
**Figure 7. Low-side Current Shunt Monitor**



NOTES:

1. Zener rated for operational amplifier supply capability (that is, 5.6V for SGM8049-1/2/4).
2. Current-limit resistor.
3. Choose Zener biasing resistor or dual NMOSFETs.

**Figure 8. High-side Current Measurement**



$$V_{OUT} = (V_1 - V_2) (1 + R_1/R_2 + 2R_1/R_G) + V_{REF}$$

**Figure 9. Two Operational Amplifiers Low Power Instrumentation Amplifier**

## REVISION HISTORY

NOTE: Page numbers for previous revisions may differ from page numbers in the current version.

<b>AUGUST 2017 – REV.A to REV.A.1</b>	<b>Page</b>
Added +IN EMIRR vs. Frequency.....	8

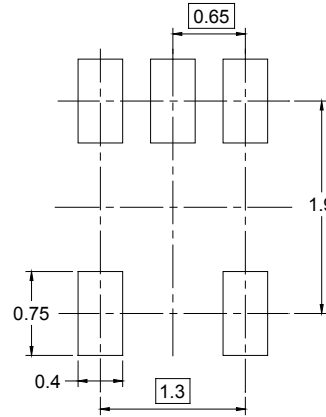
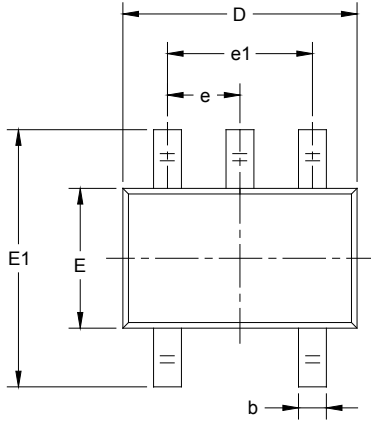
---

<b>Changes from Original (NOVEMBER 2015) to REV.A</b>	<b>Page</b>
Changed from product preview to production data.....	All

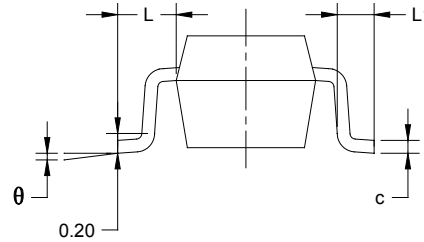
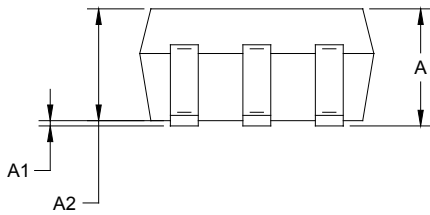
---

PACKAGE OUTLINE DIMENSIONS

SC70-5



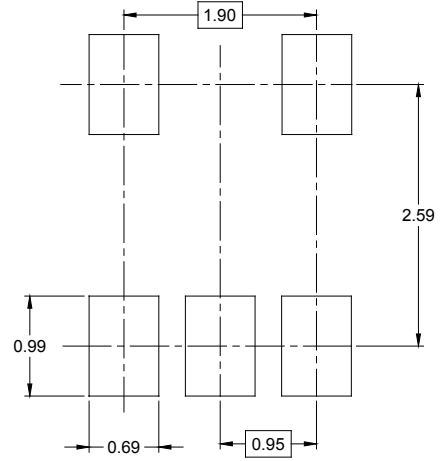
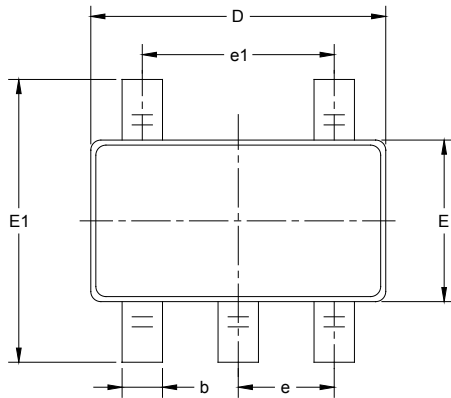
RECOMMENDED LAND PATTERN (Unit: mm)



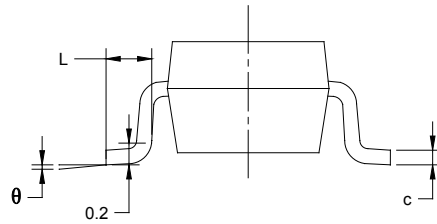
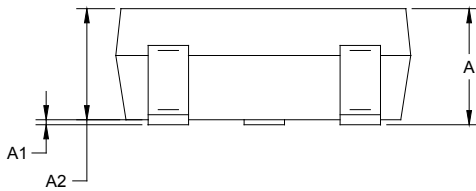
Symbol	Dimensions In Millimeters		Dimensions In Inches	
	MIN	MAX	MIN	MAX
A	0.900	1.100	0.035	0.043
A1	0.000	0.100	0.000	0.004
A2	0.900	1.000	0.035	0.039
b	0.150	0.350	0.006	0.014
c	0.080	0.150	0.003	0.006
D	2.000	2.200	0.079	0.087
E	1.150	1.350	0.045	0.053
E1	2.150	2.450	0.085	0.096
e	0.65 TYP		0.026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

PACKAGE OUTLINE DIMENSIONS

SOT-23-5



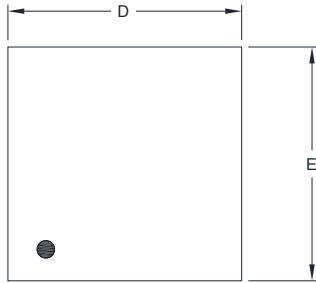
RECOMMENDED LAND PATTERN (Unit: mm)



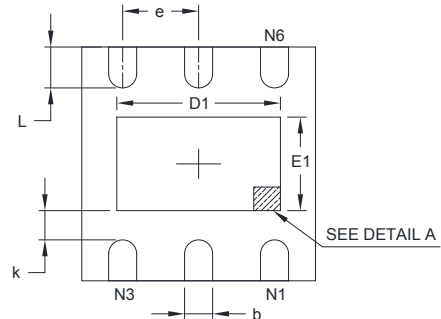
Symbol	Dimensions In Millimeters		Dimensions In Inches	
	MIN	MAX	MIN	MAX
A	1.050	1.250	0.041	0.049
A1	0.000	0.100	0.000	0.004
A2	1.050	1.150	0.041	0.045
b	0.300	0.500	0.012	0.020
c	0.100	0.200	0.004	0.008
D	2.820	3.020	0.111	0.119
E	1.500	1.700	0.059	0.067
E1	2.650	2.950	0.104	0.116
e	0.950 BSC		0.037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

PACKAGE OUTLINE DIMENSIONS

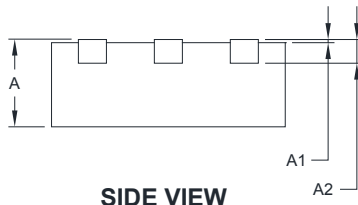
TDFN-2x2-6L



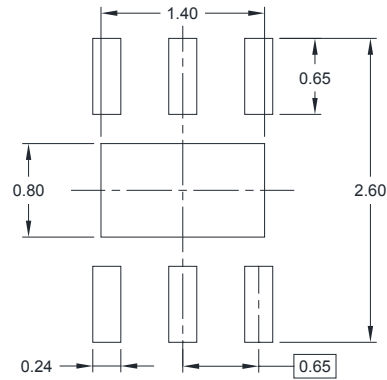
TOP VIEW



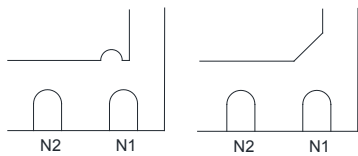
BOTTOM VIEW



SIDE VIEW



RECOMMENDED LAND PATTERN (Unit: mm)



DETAIL A

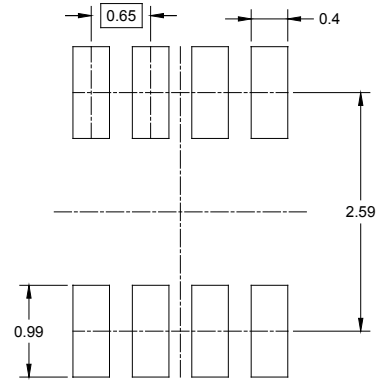
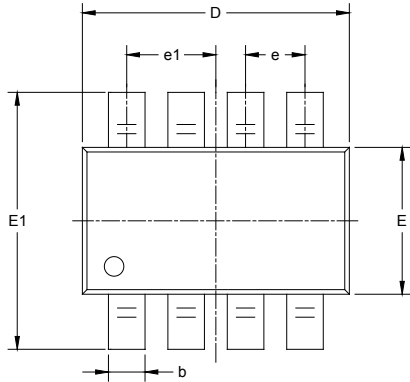
Pin #1 ID and Tie Bar Mark Options

NOTE: The configuration of the Pin #1 identifier is optional, but must be located within the zone indicated.

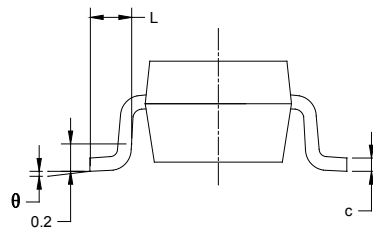
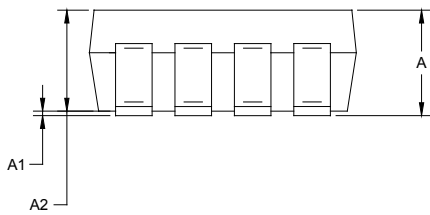
Symbol	Dimensions In Millimeters		Dimensions In Inches	
	MIN	MAX	MIN	MAX
A	0.700	0.800	0.028	0.031
A1	0.000	0.050	0.000	0.002
A2	0.203 REF		0.008 REF	
D	1.900	2.100	0.075	0.083
D1	1.100	1.450	0.043	0.057
E	1.900	2.100	0.075	0.083
E1	0.600	0.850	0.024	0.034
k	0.200 MIN		0.008 MIN	
b	0.180	0.300	0.007	0.012
e	0.650 TYP		0.026 TYP	
L	0.250	0.450	0.010	0.018

PACKAGE OUTLINE DIMENSIONS

SOT-23-8



RECOMMENDED LAND PATTERN (Unit: mm)

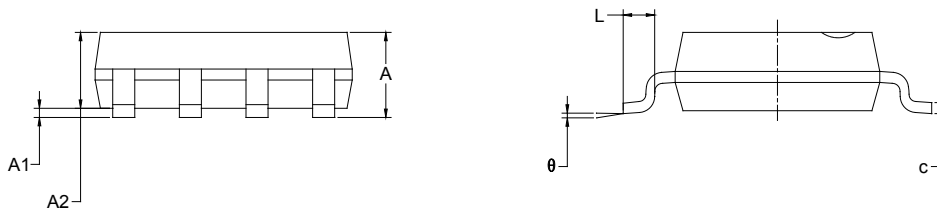
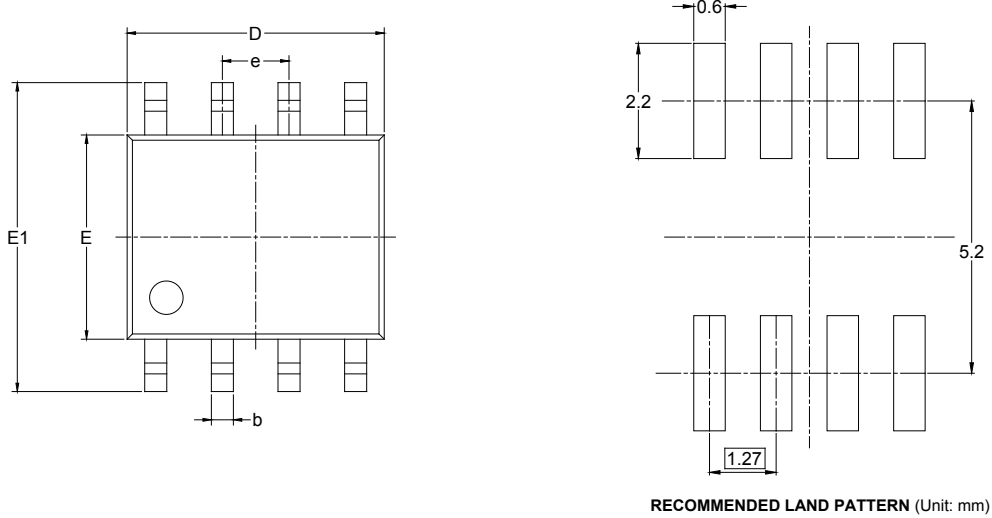


Symbol	Dimensions In Millimeters		Dimensions In Inches	
	MIN	MAX	MIN	MAX
A	1.050	1.250	0.041	0.049
A1	0.000	0.100	0.000	0.004
A2	1.050	1.150	0.041	0.045
b	0.300	0.500	0.012	0.020
c	0.100	0.200	0.004	0.008
D	2.820	3.020	0.111	0.119
E	1.500	1.700	0.059	0.067
E1	2.650	2.950	0.104	0.116
e	0.650 BSC		0.026 BSC	
e1	0.975 BSC		0.038 BSC	
L	0.300	0.600	0.012	0.024
θ	0°	8°	0°	8°



PACKAGE OUTLINE DIMENSIONS

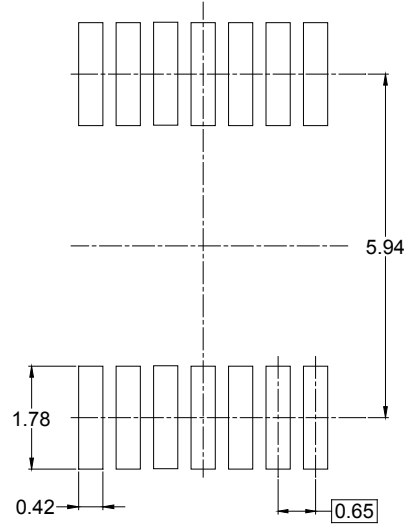
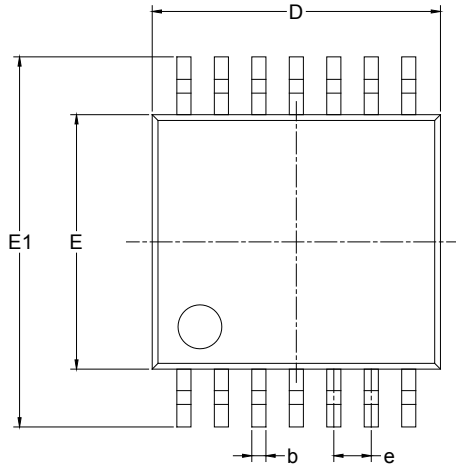
SOIC-8



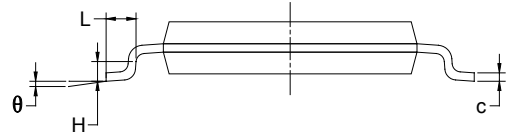
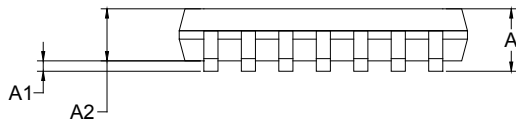
Symbol	Dimensions In Millimeters		Dimensions In Inches	
	MIN	MAX	MIN	MAX
A	1.350	1.750	0.053	0.069
A1	0.100	0.250	0.004	0.010
A2	1.350	1.550	0.053	0.061
b	0.330	0.510	0.013	0.020
c	0.170	0.250	0.006	0.010
D	4.700	5.100	0.185	0.200
E	3.800	4.000	0.150	0.157
E1	5.800	6.200	0.228	0.244
e	1.27 BSC		0.050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

PACKAGE OUTLINE DIMENSIONS

TSSOP-14



RECOMMENDED LAND PATTERN (Unit: mm)

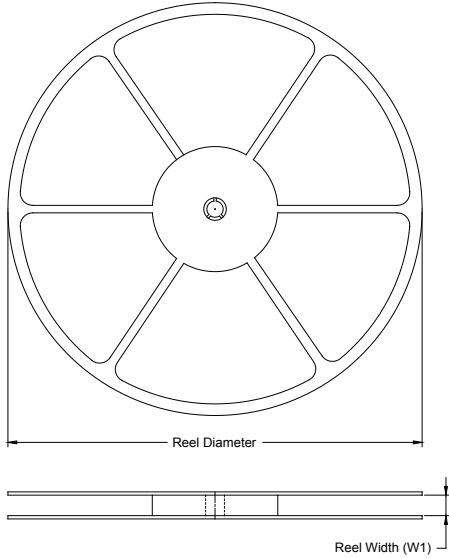


Symbol	Dimensions In Millimeters		Dimensions In Inches	
	MIN	MAX	MIN	MAX
A		1.200		0.047
A1	0.050	0.150	0.002	0.006
A2	0.800	1.050	0.031	0.041
b	0.190	0.300	0.007	0.012
c	0.090	0.200	0.004	0.008
D	4.860	5.100	0.191	0.201
E	4.300	4.500	0.169	0.177
E1	6.250	6.550	0.246	0.258
e	0.650 BSC		0.026 BSC	
L	0.500	0.700	0.02	0.028
H	0.25 TYP		0.01 TYP	
θ	1°	7°	1°	7°

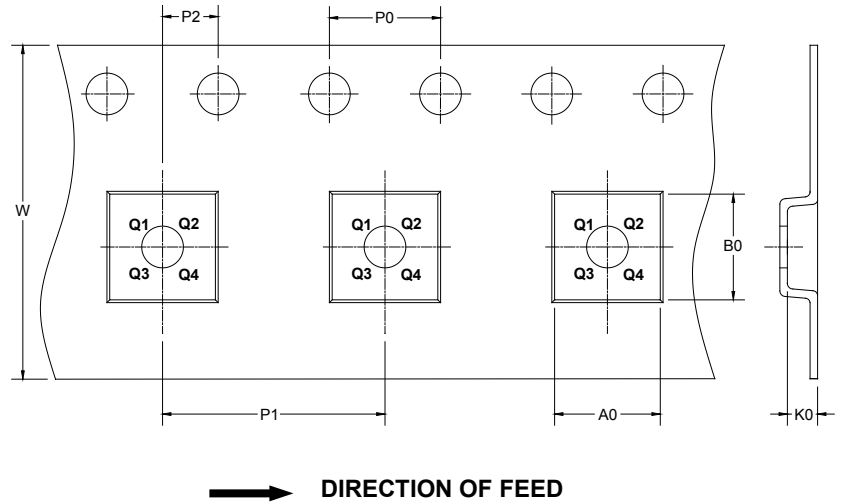
# PACKAGE INFORMATION

## 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	3.20	3.20	1.40	4.0	4.0	2.0	8.0	Q3
TDFN-2×2-6L	7"	9.5	2.30	2.30	1.10	4.0	4.0	2.0	8.0	Q1
SOT-23-8	7"	9.5	3.17	3.23	1.37	4.0	4.0	2.0	8.0	Q3
SOIC-8	13"	12.4	6.40	5.40	2.10	4.0	8.0	2.0	12.0	Q1
TSSOP-14	13"	12.4	6.95	5.60	1.20	4.0	8.0	2.0	12.0	Q1

D00001

# PACKAGE INFORMATION

## 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

DD0002