



# SGM8210-1/SGM8210-2/SGM8210-4

## 3.3V to 24V, 1MHz, Low Noise, Rail-to-Rail I/O Operational Amplifiers

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### GENERAL DESCRIPTION

The SGM8210-1, SGM8210-2 and SGM8210-4 low power, wide power supply range operational amplifiers are designed for battery-powered applications. The amplifiers operate with a supply voltage from 3.3V ( $\pm 1.65V$ ) to 24V ( $\pm 12V$ ). High-performance, single-supply operation and rail-to-rail capability make the SGM8210-1/2/4 useful for a wide range of applications.

In addition of small packages, the SGM8210-1/2/4 operational amplifiers feature impressive bandwidth, low bias current and low noise relative to the low quiescent current.

The single SGM8210-1 is available in Green SOT-23-5 and SC70-5 packages. The dual SGM8210-2 is available in Green SOIC-8, MSOP-8 and TDFN-2x3-8L packages. The quad SGM8210-4 is available in Green SOIC-14 package. They are specified over the extended industrial temperature range ( $-40^{\circ}C$  to  $+125^{\circ}C$ ).

### FEATURES

- **Low 0.1Hz to 10Hz Noise:**  $3\mu V_{P-P}$
- **Wide Supply Voltage Range:** 3.3V to 24V
- **Low Power Consumption:** 50 $\mu A$ /Amplifier (TYP)
- **Low Offset Voltage:** 1mV (MAX)
- **Input Voltage Noise Density:** 25nV/ $\sqrt{Hz}$  at 1kHz
- **Slew Rate:** 0.3V/ $\mu s$
- **Rail-to-Rail Input and Output**
- **High DC Precision:**
  - CMRR:** 115dB
  - PSRR:** 120dB
  - A<sub>OL</sub>:** 120dB
- **-40°C to +125°C Operating Temperature Range**
- **Small Packaging:**
  - SGM8210-1 Available in Green SOT-23-5 and SC70-5 Packages**
  - SGM8210-2 Available in Green SOIC-8, MSOP-8 and TDFN-2x3-8L Packages**
  - SGM8210-4 Available in Green SOIC-14 Package**

### APPLICATIONS

Notebook Computers  
Battery Chargers  
Welding Equipment  
Power Management  
Cell Phones  
Telecom Equipment

**PACKAGE/ORDERING INFORMATION**

MODEL	PACKAGE DESCRIPTION	SPECIFIED TEMPERATURE RANGE	ORDERING NUMBER	PACKAGE MARKING	PACKING OPTION
SGM8210-1	SOT-23-5	-40°C to +125°C	SGM8210-1AXN5G/TR	G1BXX	Tape and Reel, 3000
	SOT-23-5	-40°C to +125°C	SGM8210-1BXN5G/TR	G8AXX	Tape and Reel, 3000
	SC70-5	-40°C to +125°C	SGM8210-1XC5G/TR	G87XX	Tape and Reel, 3000
SGM8210-2	SOIC-8	-40°C to +125°C	SGM8210-2XS8G/TR	SGM 82102XS8 XXXXX	Tape and Reel, 2500
	MSOP-8	-40°C to +125°C	SGM8210-2XMS8G/TR	SGM82102 XMS8 XXXXX	Tape and Reel, 4000
	TDFN-2×3-8L	-40°C to +125°C	SGM8210-2XTDC8G/TR	G8B XXXX	Tape and Reel, 3000
SGM8210-4	SOIC-14	-40°C to +125°C	SGM8210-4XS14G/TR	SGM82104XS14 XXXXX	Tape and Reel, 2500

NOTE: XX = Date Code. XXXX = Date Code. XXXXX = Date Code and Vendor Code.

Green (RoHS & HSF): SG Micro Corp defines "Green" to mean Pb-Free (RoHS compatible) and free of halogen substances. If you have additional comments or questions, please contact your SGMICRO representative directly.

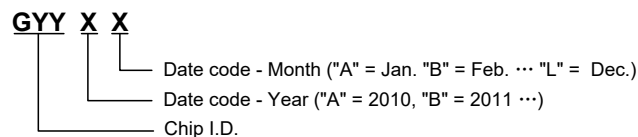
**ABSOLUTE MAXIMUM RATINGS**

Supply Voltage, +V<sub>S</sub> to -V<sub>S</sub>..... 26V  
 Signal Input Terminals, Voltage  
 ..... (-V<sub>S</sub>) - 0.3V to (+V<sub>S</sub>) + 0.3V  
 Differential Input Voltage..... ±2V  
 Signal Input Terminals, Current..... ±10mA  
 Output Short-Circuit Current..... ±40mA  
 Junction Temperature ..... +150°C  
 Storage Temperature Range..... -65°C to +150°C  
 Lead Temperature (Soldering, 10s) ..... +260°C  
 ESD Susceptibility  
 HBM..... 8000V  
 MM..... 200V  
 CDM ..... 1000V

**RECOMMENDED OPERATING CONDITIONS**

Input Voltage Range ..... 3.3V to 24V  
 Operating Temperature Range ..... -40°C to +125°C

**MARKING INFORMATION**



For example: G1BFA (2015, January)

**OVERSTRESS CAUTION**

Stresses beyond those listed may cause permanent damage to the device. Functional operation of the device at these or any other conditions beyond those indicated in the operational section of the specification is not implied. Exposure to absolute maximum rating conditions for extended periods may affect reliability.

**ESD SENSITIVITY CAUTION**

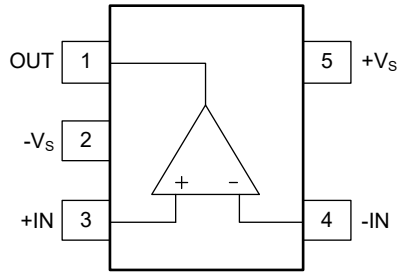
This integrated circuit can be damaged by ESD if you don't pay attention to ESD protection. SGMICRO recommends that all integrated circuits be handled with appropriate precautions. Failure to observe proper handling and installation procedures can cause damage. ESD damage can range from subtle performance 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, specification or other related things if necessary without notice at any time.

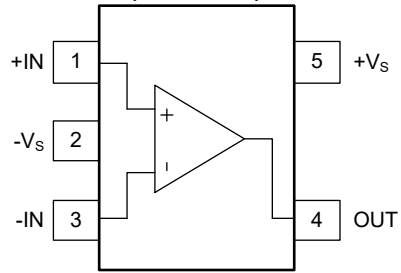
**PIN CONFIGURATIONS**

**SGM8210-1AXN5G (TOP VIEW)**



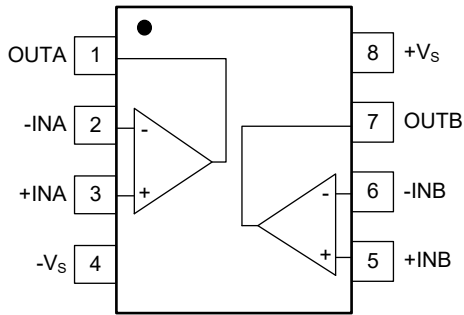
**SOT-23-5**

**SGM8210-1BXN5G/SGM8210-1XC5G  
(TOP VIEW)**



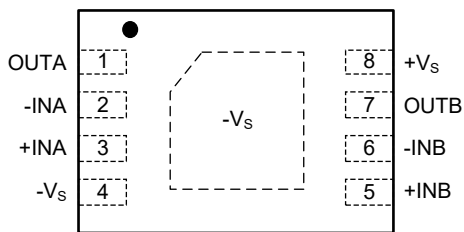
**SOT-23-5/SC70-5**

**SGM8210-2 (TOP VIEW)**



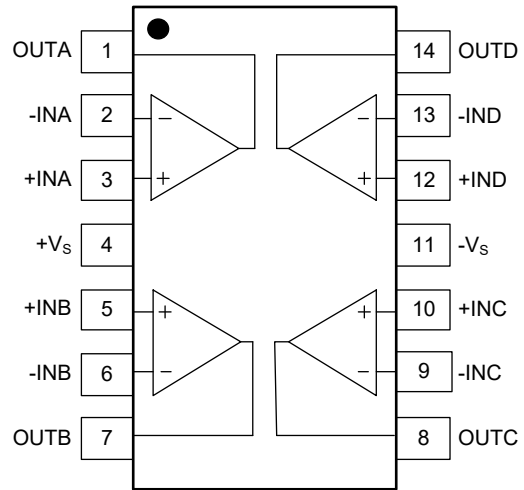
**SOIC-8/MSOP-8**

**SGM8210-2 (TOP VIEW)**



**TDFN-2x3-8L**

**SGM8210-4 (TOP VIEW)**



**SOIC-14**

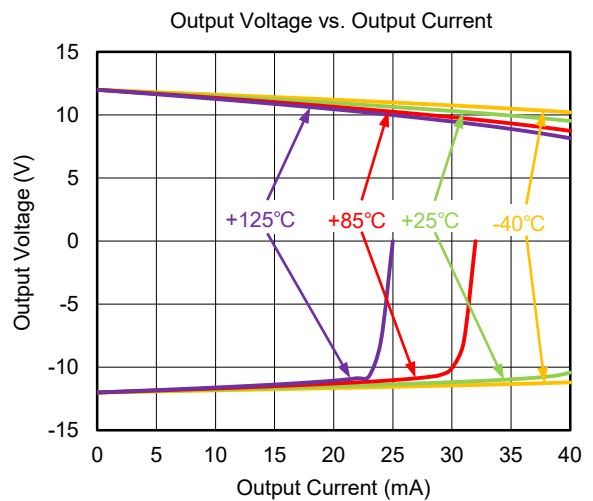
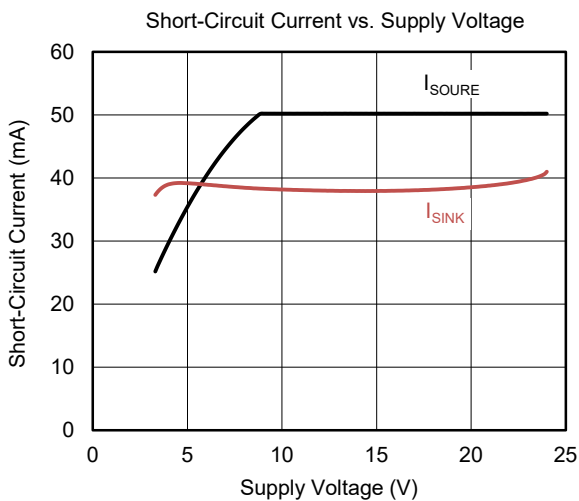
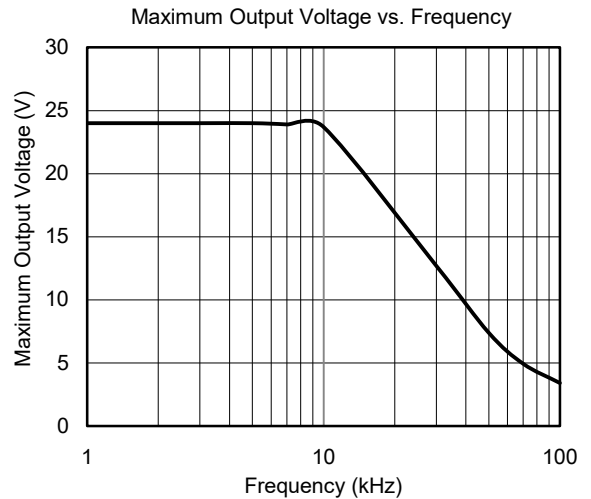
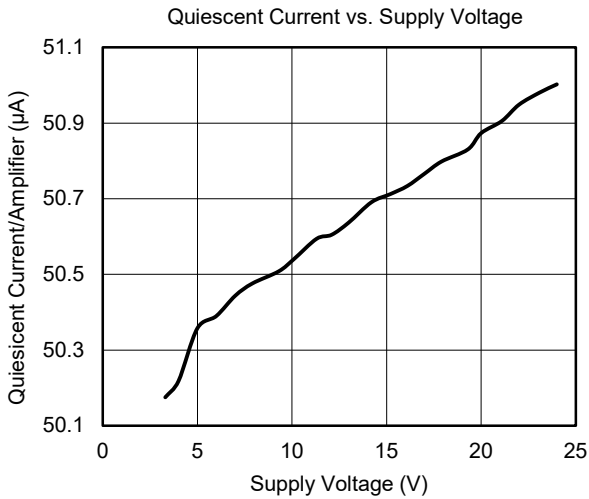
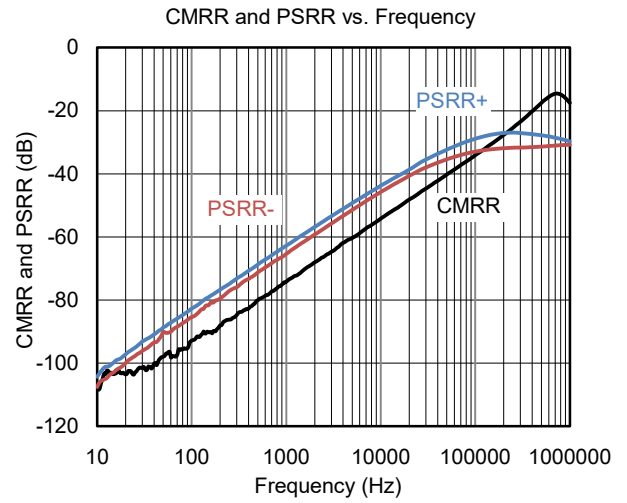
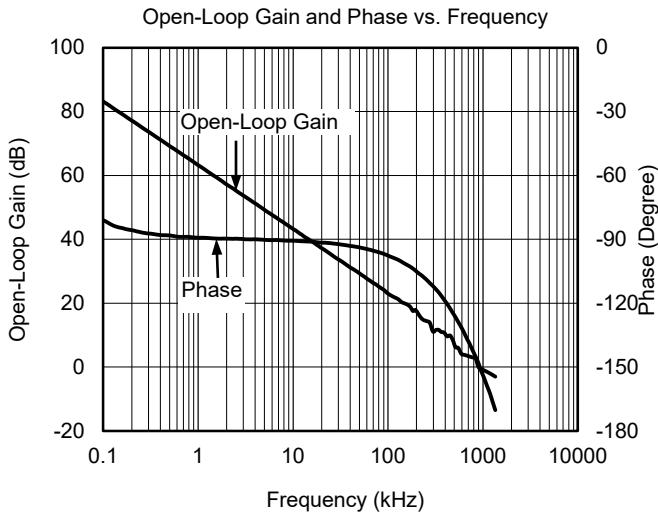
**ELECTRICAL CHARACTERISTICS**

(At  $T_A = +25^\circ\text{C}$ ,  $V_S = 3.3\text{V}$  to  $24\text{V}$ ,  $R_L = 10\text{k}\Omega$  connected to  $V_S/2$ , and  $V_{CM} < (+V_S) - 1\text{V}$ , Full =  $-40^\circ\text{C}$  to  $+125^\circ\text{C}$ , unless otherwise noted.)

PARAMETER	SYMBOL	CONDITIONS	TEMP	MIN	TYP	MAX	UNITS
<b>INPUT CHARACTERISTICS</b>							
Input Offset Voltage	$V_{OS}$		+25°C		0.4	1	mV
			Full			1.2	
Input Offset Voltage Drift	$\Delta V_{OS}/\Delta T$		+25°C		1		$\mu\text{V}/^\circ\text{C}$
Input Bias Current	$I_B$	$V_{CM} = V_S/2$	+25°C		$\pm 5$		pA
Input Offset Current	$I_{OS}$	$V_{CM} = V_S/2$	+25°C		$\pm 5$		pA
Input Common Mode Voltage Range	$V_{CM}$		+25°C	$(-V_S) - 0.1$		$(+V_S) + 0.1$	V
Common Mode Rejection Ratio	CMRR	$V_S = 24\text{V}$ , $(-V_S) < V_{CM} < (+V_S) - 1\text{V}$	+25°C	98	115		dB
			Full	92			
Open-Loop Voltage Gain	$A_{OL}$	$R_L = 10\text{k}\Omega$ , $(-V_S) + 0.2\text{V} < V_{OUT} < (+V_S) - 0.2\text{V}$	+25°C	102	120		dB
			Full	84			
		$R_L = 2\text{k}\Omega$ , $(-V_S) + 0.6\text{V} < V_{OUT} < (+V_S) - 0.6\text{V}$	+25°C	96	110		
			Full	65			
<b>OUTPUT CHARACTERISTICS</b>							
Output Voltage Swing from Rail	$V_{OUT}$	$V_S = 24\text{V}$ , $R_L = 10\text{k}\Omega$	+25°C		55	83	mV
			Full			110	
		$V_S = 24\text{V}$ , $R_L = 2\text{k}\Omega$	+25°C		270	380	
			Full			510	
Output Short-Circuit Current	$I_{SC}$		+25°C	$\pm 29$	$\pm 40$		mA
<b>POWER SUPPLY</b>							
Operating Voltage Range	$V_S$		+25°C	3.3		24	V
Quiescent Current/Amplifier	$I_Q$	$I_{OUT} = 0$	+25°C		50	72	$\mu\text{A}$
			Full			75	
Power Supply Rejection Ratio	PSRR		+25°C	104	120		dB
			Full	102			
<b>DYNAMIC PERFORMANCE (<math>C_{LOAD} = 30\text{pF}</math>)</b>							
Gain-Bandwidth Product	GBP		+25°C		1		MHz
Slew Rate	SR	$G = +1$	+25°C		0.3		$\text{V}/\mu\text{s}$
Overload Recovery Time		$V_{IN} \times G > V_S$	+25°C		3		$\mu\text{s}$
<b>NOISE</b>							
Input Voltage Noise		$f = 0.1\text{Hz}$ to $10\text{Hz}$	+25°C		3		$\mu\text{V}_{P-P}$
Input Voltage Noise Density	$e_n$	$f = 1\text{kHz}$	+25°C		25		$\text{nV}/\sqrt{\text{Hz}}$
Input Current Noise Density	$i_n$	$f = 1\text{kHz}$	+25°C		400		$\text{fA}/\sqrt{\text{Hz}}$

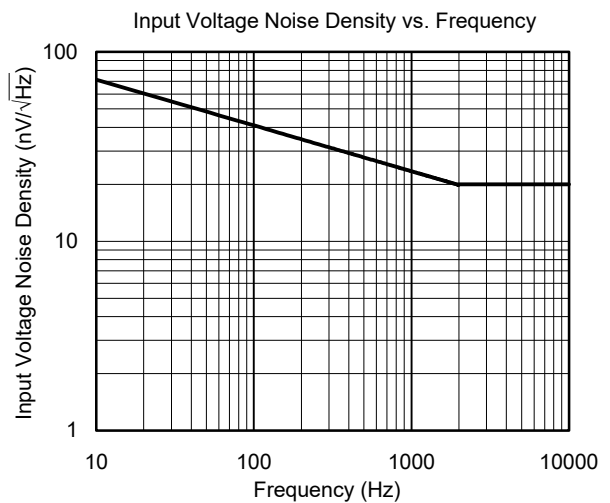
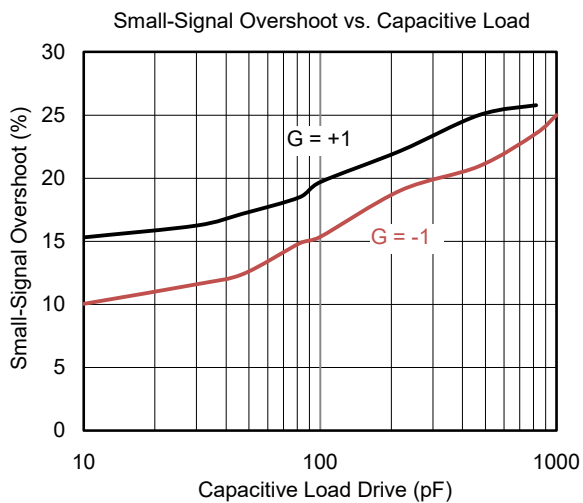
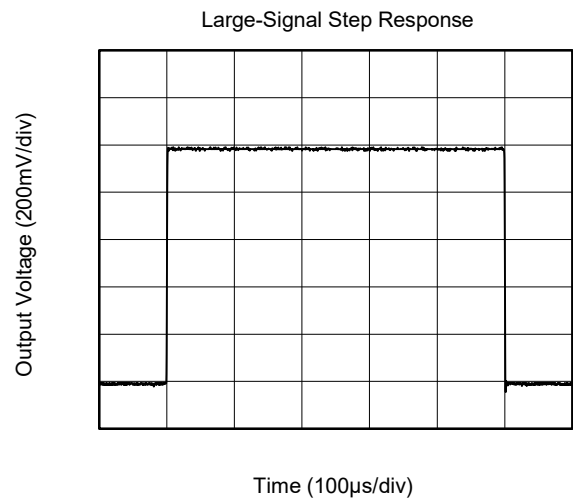
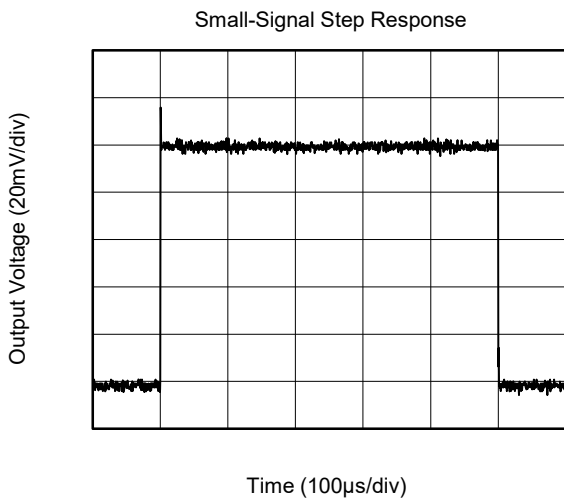
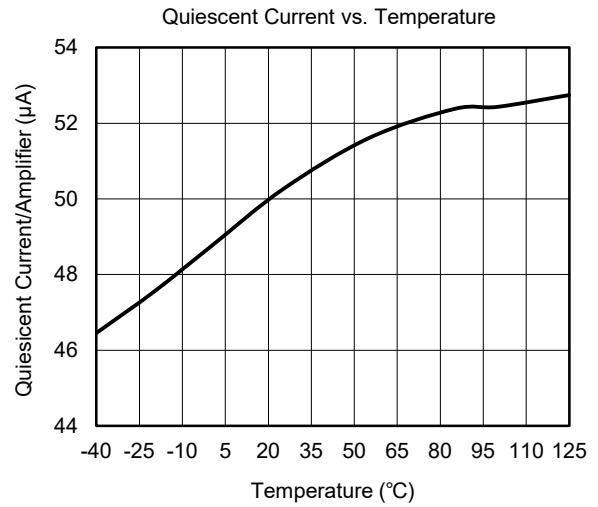
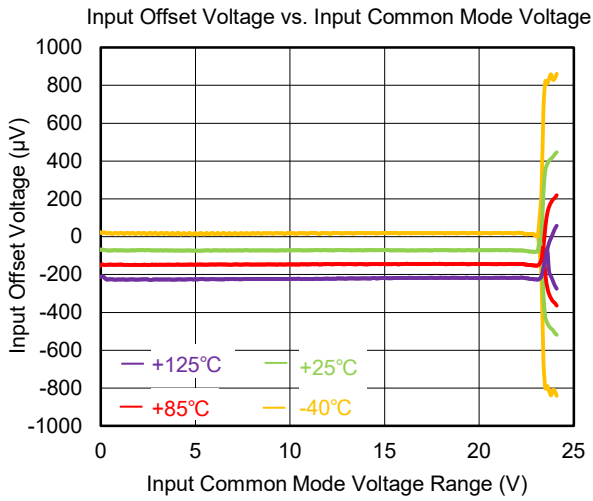
**TYPICAL PERFORMANCE CHARACTERISTICS**

At  $T_A = +25^\circ\text{C}$ ,  $V_S = 24\text{V}$ ,  $R_L = 10\text{k}\Omega$ , unless otherwise noted.



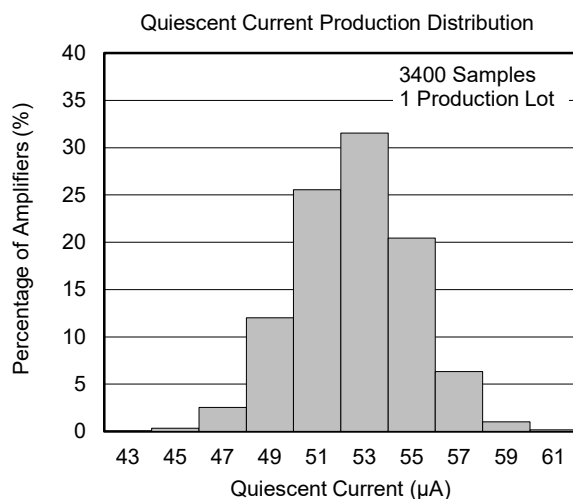
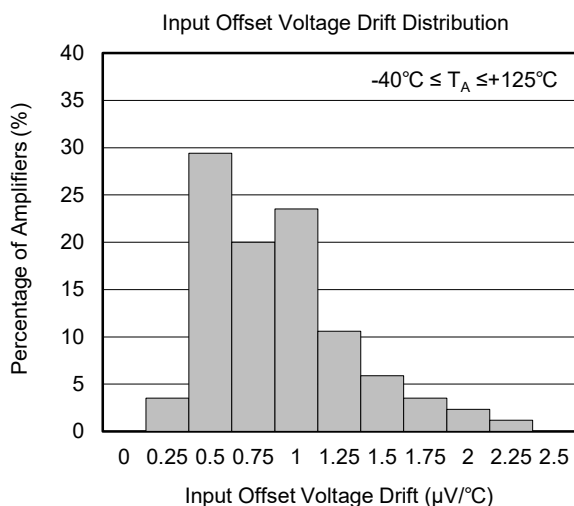
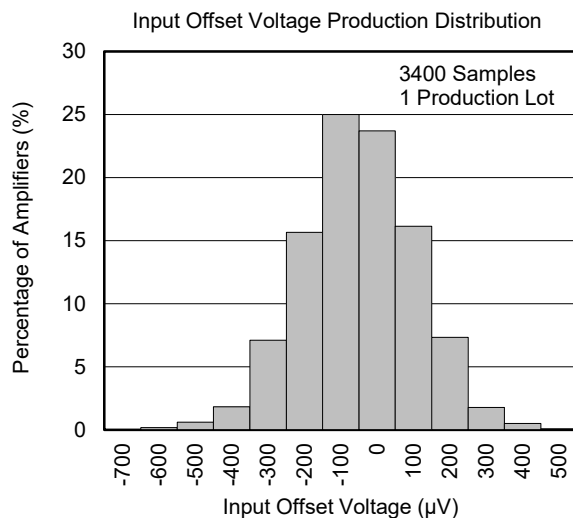
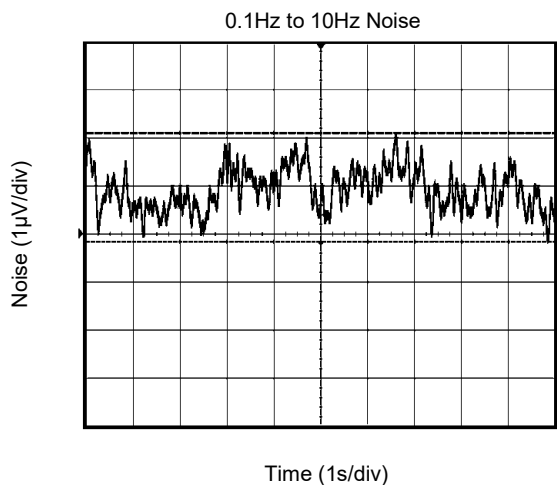
**TYPICAL PERFORMANCE CHARACTERISTICS (continued)**

At  $T_A = +25^\circ\text{C}$ ,  $V_S = 24\text{V}$ ,  $R_L = 10\text{k}\Omega$ , unless otherwise noted.



**TYPICAL PERFORMANCE CHARACTERISTICS (continued)**

At  $T_A = +25^\circ\text{C}$ ,  $V_S = 24\text{V}$ ,  $R_L = 10\text{k}\Omega$ , unless otherwise noted.



**APPLICATION INFORMATION**

The SGM8210-1/2/4 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 110dB 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 amplifier. These parasitic RC combinations can affect the stability of the overall system. A feedback capacitor may be required to ensure stability and limit overshoot or gain peaking.

Good layout practice mandates the use of a 0.1µF bypass capacitor placed closely across the supply pins.

**Operating Voltage**

SGM8210-1/2/4 operational amplifiers are fully specified and tested from 3.3V to 24V ( $\pm 1.65V$  to  $\pm 12V$ ).

**Input Common Mode Voltage Range**

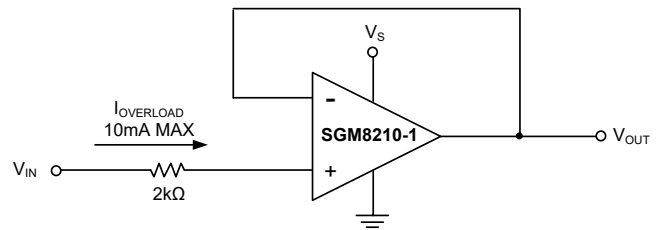
The input common mode voltage range of the SGM8210-1/2/4 typically extends 100mV beyond each supply rail. This rail-to-rail input is achieved by using a complementary input stage. CMRR is specified from the negative rail to 1V below the positive rail. Between  $(-V_S) - 0.1V$  and  $(+V_S) + 0.1V$ , the amplifier operates with lower CMRR because of the transition region of the input stage.

**Noise**

Although low power amplifiers frequently have high wideband noise, the SGM8210-1/2/4 offer excellent noise performance. Resistors should be chosen carefully because the SGM8210-1/2/4 have only  $3\mu V_{P-P}$  of 0.1Hz to 10Hz noise, and  $25nV/\sqrt{Hz}$  of wideband noise; otherwise, they can become the dominant source of noise.

**Protecting Inputs from Over-Voltage**

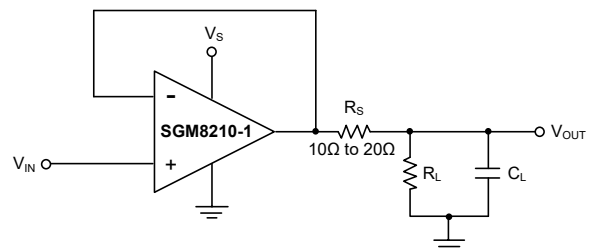
Normally, input currents are 5pA. However, a large voltage input (greater than 500mV beyond the supply rails) can cause excessive current to flow in or out of the input pins. Therefore, as well as keeping the input voltage below the maximum rating, it is also important to limit the input current to less than 10mA. This limit is easily accomplished with an input voltage resistor, as shown in Figure 1.



**Figure 1. Input Current Protection for Voltages Exceeding the Supply Voltage**

**Capacitive Load and Stability**

Followed 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 2. 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.



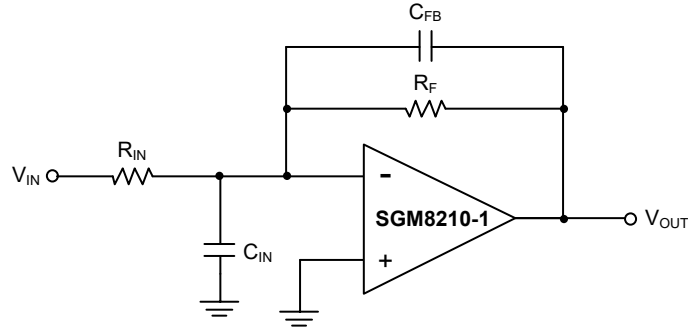
**Figure 2. Series Resistor in Unity-Gain Buffer Configuration Improves Capacitive Load Drive**



**APPLICATION INFORMATION (continued)**

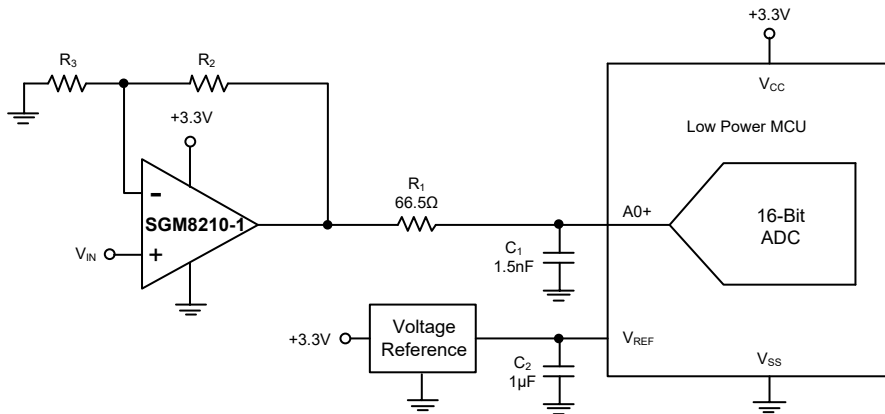
In unity-gain inverting configuration, phase margin can be reduced by the reaction between the capacitance at the operational amplifier input and the gain setting resistors. Best performance is achieved by using smaller valued resistors. However, when large valued resistors cannot be avoided, a small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

capacitor,  $C_{FB}$ , can be inserted in the feedback, as shown in Figure 3. 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.

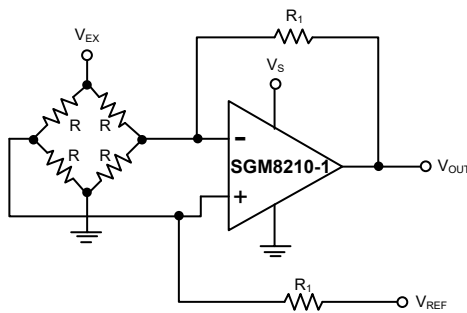


**Figure 3. Improving Stability for Large  $R_F$  and  $R_{IN}$**

Figure 4 through Figure 8 illustrate some low power application examples.

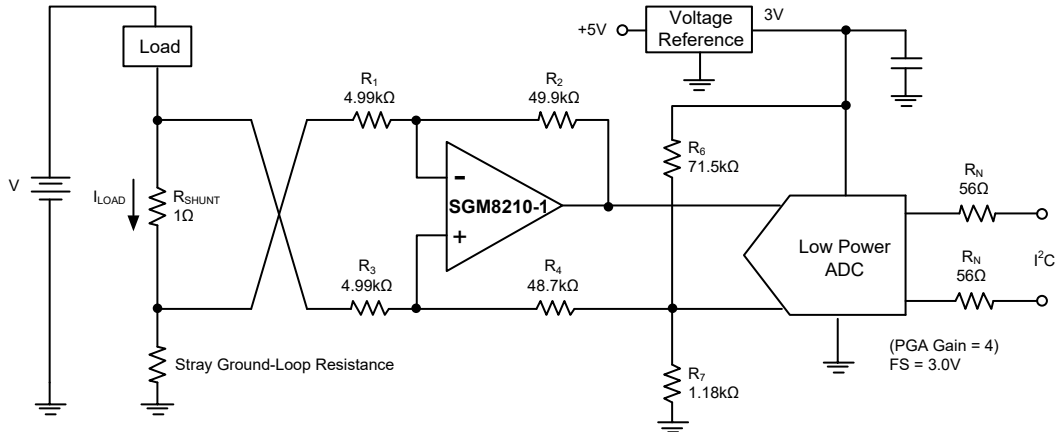


**Figure 4. Unipolar Signal Chain Configuration**



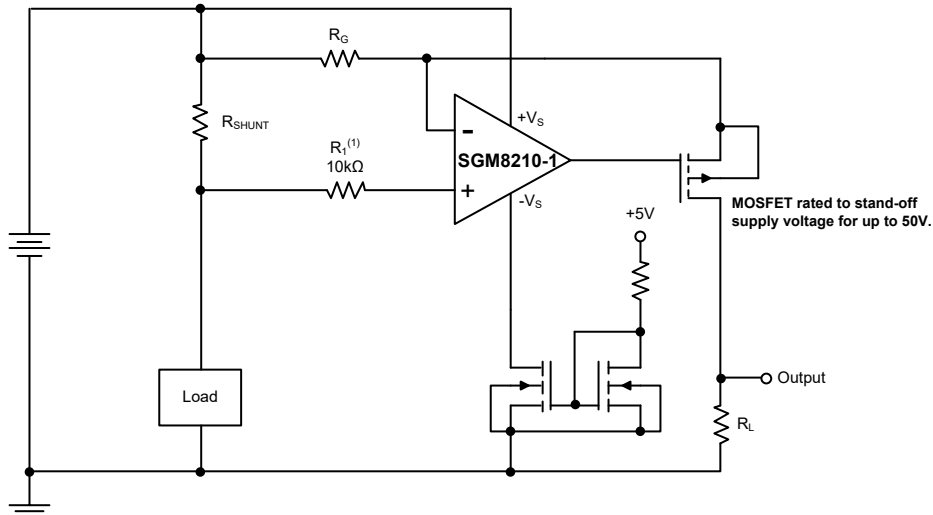
**Figure 5. Bridge Amplifier Configuration**

**APPLICATION INFORMATION (continued)**



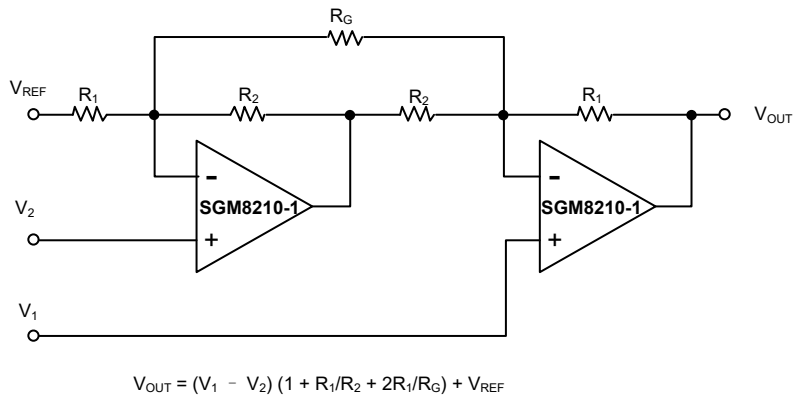
NOTE: 1% resistors provide adequate common mode rejection at small ground-loop errors.

**Figure 6. Low-side Current Shunt Monitor**



NOTE: 1. Current-limiting resistor.

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



**Figure 8. Two Opamp Low Power Instrumentation Amplifier**

## **REVISION HISTORY**

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

### **MARCH 2018 – REV.A to REV.A.1**

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Added Differential Input Voltage range ..... 2

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### **Changes from Original (DECEMBER 2016) to REV.A**

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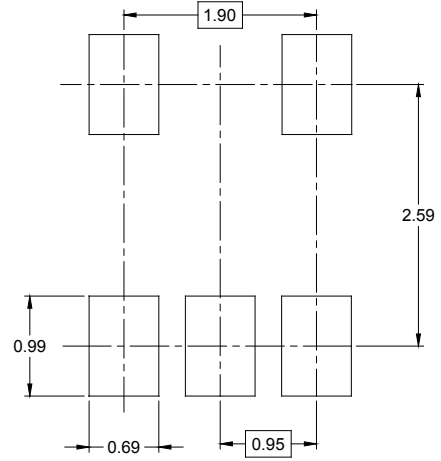
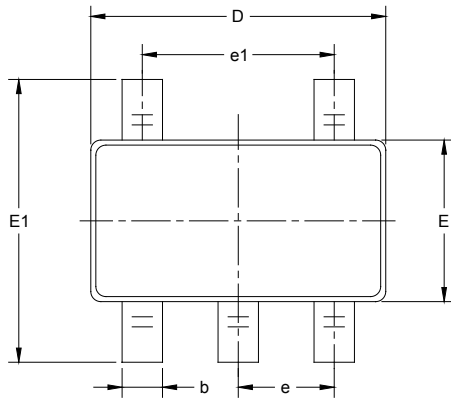
Changed from product preview to production data..... All

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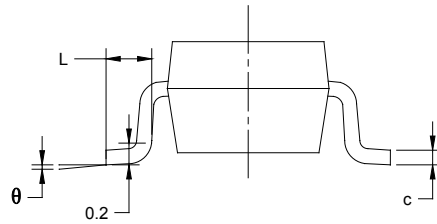
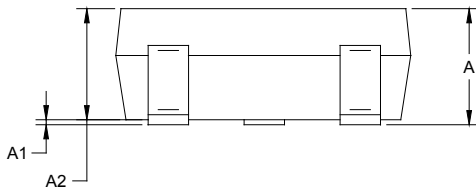
# PACKAGE INFORMATION

## PACKAGE OUTLINE DIMENSIONS

### SOT-23-5



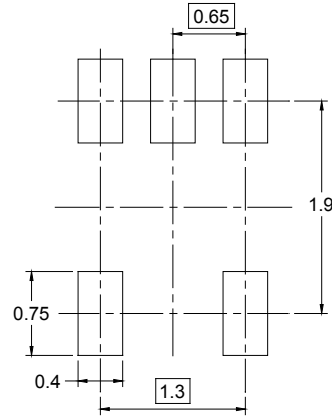
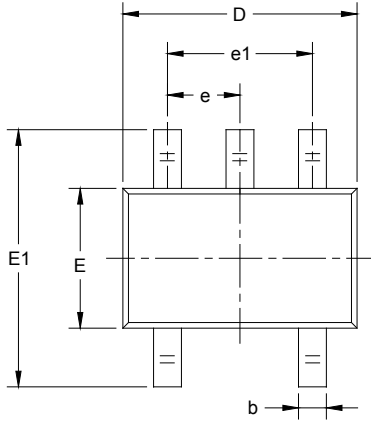
RECOMMENDED LAND PATTERN (Unit: mm)



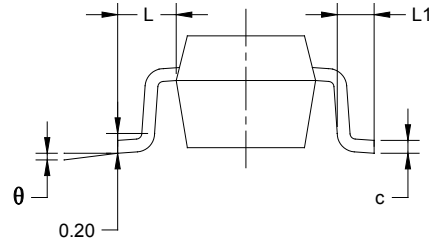
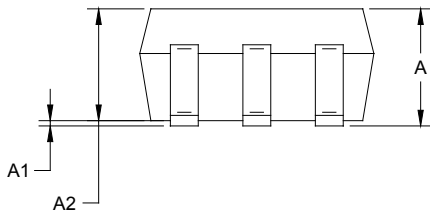
Symbol	Dimensions In Millimeters		Dimensions In Inches	
	MIN	MAX	MIN	MAX
A	1.050	1.250	0.041	0.049
A1	0.000	0.100	0.000	0.004
A2	1.050	1.150	0.041	0.045
b	0.300	0.500	0.012	0.020
c	0.100	0.200	0.004	0.008
D	2.820	3.020	0.111	0.119
E	1.500	1.700	0.059	0.067
E1	2.650	2.950	0.104	0.116
e	0.950 BSC		0.037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

SC70-5



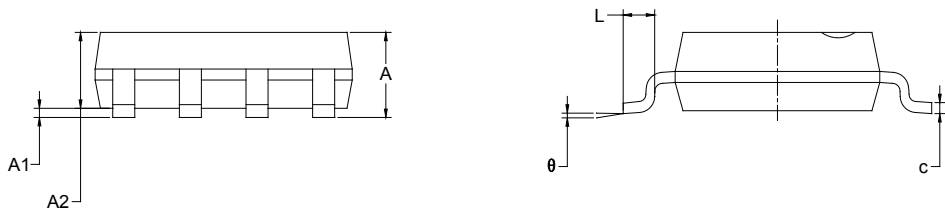
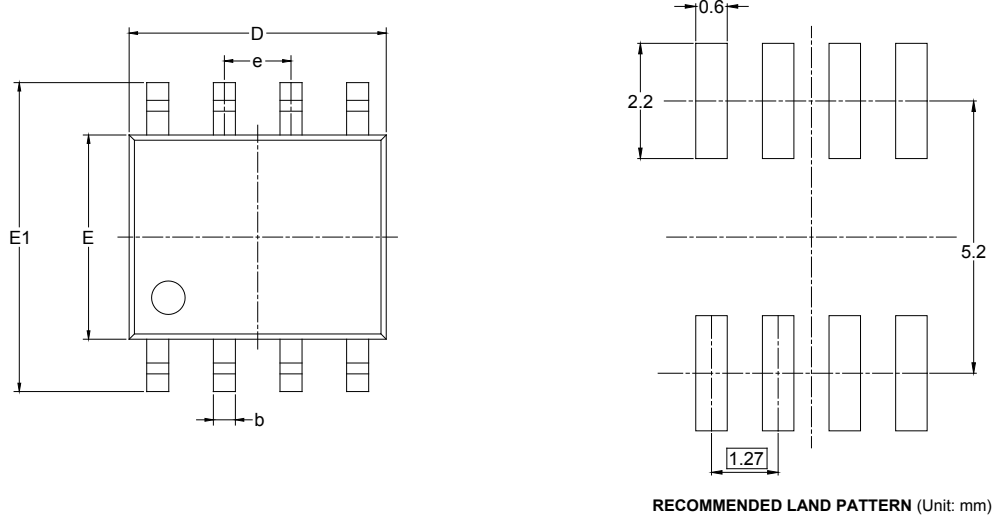
RECOMMENDED LAND PATTERN (Unit: mm)



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

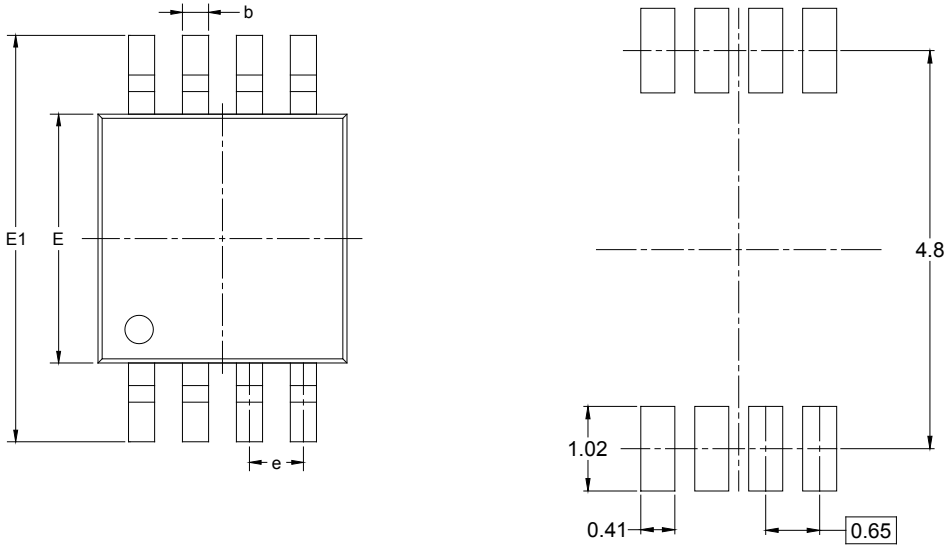
SOIC-8



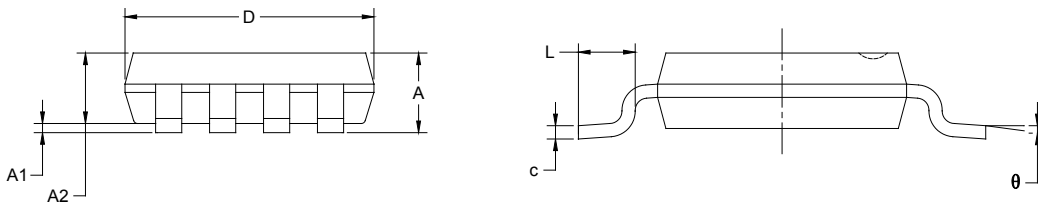
Symbol	Dimensions In Millimeters		Dimensions In Inches	
	MIN	MAX	MIN	MAX
A	1.350	1.750	0.053	0.069
A1	0.100	0.250	0.004	0.010
A2	1.350	1.550	0.053	0.061
b	0.330	0.510	0.013	0.020
c	0.170	0.250	0.006	0.010
D	4.700	5.100	0.185	0.200
E	3.800	4.000	0.150	0.157
E1	5.800	6.200	0.228	0.244
e	1.27 BSC		0.050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

PACKAGE OUTLINE DIMENSIONS

MSOP-8



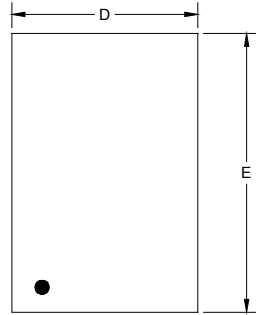
RECOMMENDED LAND PATTERN (Unit: mm)



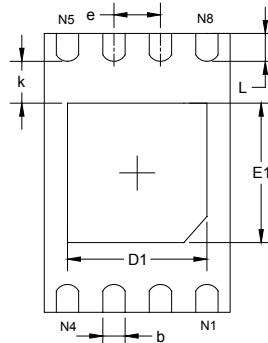
Symbol	Dimensions In Millimeters		Dimensions In Inches	
	MIN	MAX	MIN	MAX
A	0.820	1.100	0.032	0.043
A1	0.020	0.150	0.001	0.006
A2	0.750	0.950	0.030	0.037
b	0.250	0.380	0.010	0.015
c	0.090	0.230	0.004	0.009
D	2.900	3.100	0.114	0.122
E	2.900	3.100	0.114	0.122
E1	4.750	5.050	0.187	0.199
e	0.650 BSC		0.026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

PACKAGE OUTLINE DIMENSIONS

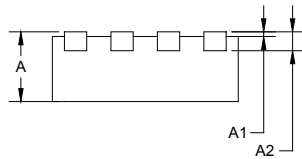
TDFN-2x3-8L



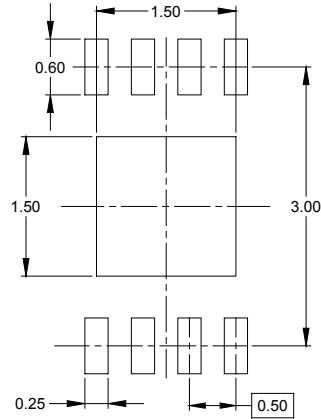
TOP VIEW



BOTTOM VIEW



SIDE VIEW



RECOMMENDED LAND PATTERN (Unit: mm)

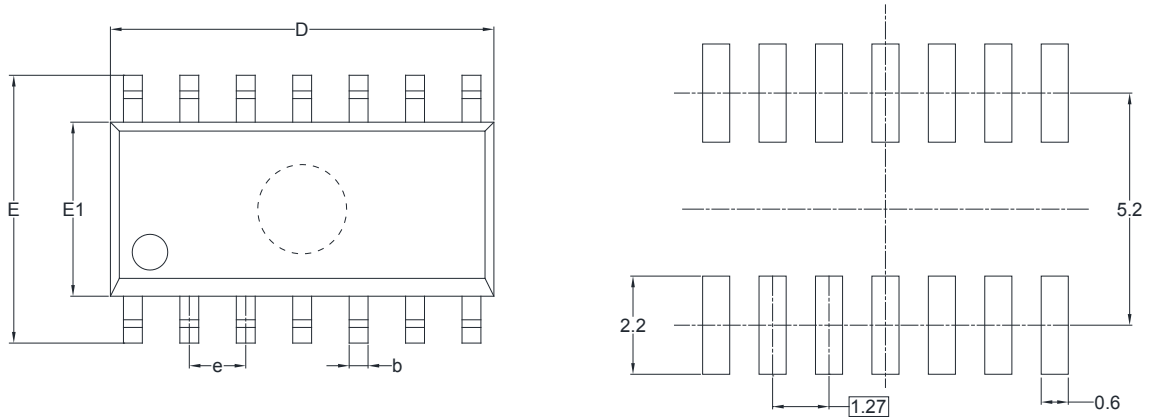
Symbol	Dimensions In Millimeters		Dimensions In Inches	
	MIN	MAX	MIN	MAX
A	0.700	0.800	0.028	0.031
A1	0.000	0.050	0.000	0.002
A2	0.203 REF		0.008 REF	
D	1.924	2.076	0.076	0.082
D1	1.400	1.600	0.055	0.063
E	2.924	3.076	0.115	0.121
E1	1.400	1.600	0.055	0.063
k	0.200 MIN		0.008 MIN	
b	0.200	0.300	0.008	0.012
e	0.500 TYP		0.020 TYP	
L	0.224	0.376	0.009	0.015



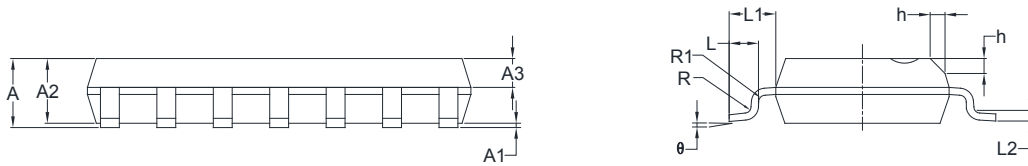
# PACKAGE INFORMATION

## PACKAGE OUTLINE DIMENSIONS

### SOIC-14



RECOMMENDED LAND PATTERN (Unit: mm)

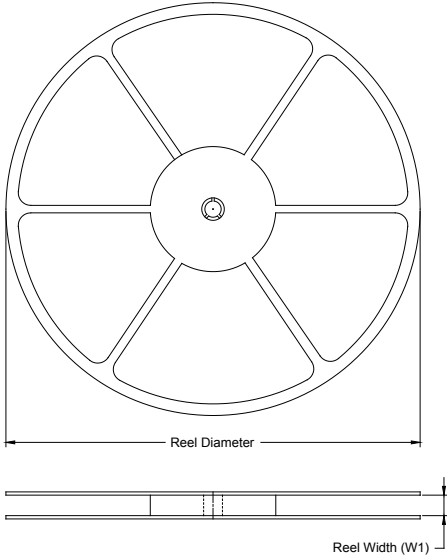


Symbol	Dimensions In Millimeters		Dimensions In Inches	
	MIN	MAX	MIN	MAX
A	1.35	1.75	0.053	0.069
A1	0.10	0.25	0.004	0.010
A2	1.25	1.65	0.049	0.065
A3	0.55	0.75	0.022	0.030
b	0.36	0.49	0.014	0.019
D	8.53	8.73	0.336	0.344
E	5.80	6.20	0.228	0.244
E1	3.80	4.00	0.150	0.157
e	1.27 BSC		0.050 BSC	
L	0.45	0.80	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°

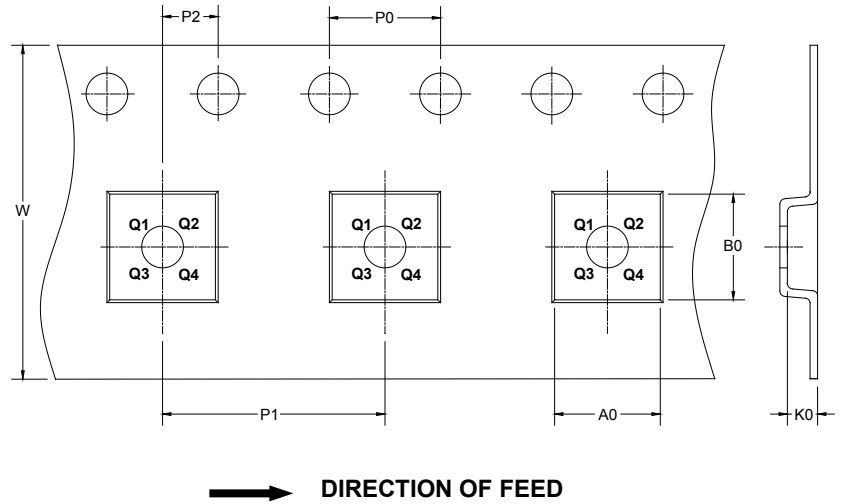
# PACKAGE INFORMATION

## 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
SOIC-8	13"	12.4	6.40	5.40	2.10	4.0	8.0	2.0	12.0	Q1
MSOP-8	13"	12.4	5.20	3.30	1.50	4.0	8.0	2.0	12.0	Q1
TDFN-2×3-8L	7"	9.5	2.30	3.30	1.10	4.0	4.0	2.0	8.0	Q2
SOIC-14	13"	16.4	6.60	9.30	2.10	4.0	8.0	2.0	16.0	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