



SGM8210-1/SGM8210-2/SGM8210-4

High Voltage, Low Power, Low Noise, Rail-to-Rail I/O Operational Amplifiers

GENERAL DESCRIPTION

The SGM8210-1 (single), SGM8210-2 (dual) and SGM8210-4 (quad) are low power, low noise and high voltage operational amplifiers, which are suitable for battery-powered systems. These devices can operate from 3.3V to 24V single supply or from $\pm 1.65\text{V}$ to $\pm 12\text{V}$ dual power supplies, and consume only 50 μA quiescent current per amplifier. They also provide rail-to-rail input and output operation.

The SGM8210-1/2/4 provide low power, low bias current, low noise and wide bandwidth. These devices fit in small packages. The combination of the above features makes them appropriate for various applications.

The SGM8210-1 is available in Green SOT-23-5 and SC70-5 packages. The SGM8210-2 is available in Green SOIC-8, MSOP-8 and TDFN-2 $\times$ 3-8L packages. The SGM8210-4 is available in a Green SOIC-14 package. They are specified over the extended -40°C to +125°C temperature range.

FEATURES

- **Wide Supply Voltage Range:** 3.3V to 24V
- **Rail-to-Rail Input and Output**
- **Low Quiescent Current:** 50 μA /Amplifier (TYP)
- **Low Offset Voltage:** 1mV (MAX)
- **Low 0.1Hz to 10Hz Noise:** 3 $\mu\text{V}_{\text{P-P}}$
- **Input Voltage Noise Density:** 25nV/ $\sqrt{\text{Hz}}$ at 1kHz
- **CMRR:** 115dB (TYP)
- **PSRR:** 120dB (TYP)
- **Open-Loop Voltage Gain:** 120dB (TYP)
- **Slew Rate:** 0.3V/ μs
- **-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-2 $\times$ 3-8L Packages
 - SGM8210-4 Available in a Green SOIC-14 Package

APPLICATIONS

Power Managements
Telecom Equipment
Mobile Phones
Laptop Computers
Welding Devices
Battery Chargers

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

MARKING INFORMATION

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

SOT-23-5/SC70-5

YYY X X

Serial Number
 Date Code - Year
 Date Code - Month

SOIC-8/MSOP-8/SOIC-14

XXXXX

Vendor Code
 Date Code - Week
 Date Code - Year

TDFN-2×3-8L

YYY — Serial Number
 XXXX

Date Code - Week
 Date Code - Year

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, $+V_S$ to $-V_S$	26V
Signal Input Voltage Terminals $(-V_S) - 0.3V$ to $(+V_S) + 0.3V$	
Differential Input Voltage.....	$\pm 2V$
Signal Input Current Terminals.....	$\pm 10mA$
Output Short-Circuit Current.....	$\pm 40mA$
Junction Temperature.....	$+150^{\circ}C$
Storage Temperature Range.....	$-65^{\circ}C$ to $+150^{\circ}C$
Lead Temperature (Soldering, 10s).....	$+260^{\circ}C$
ESD Susceptibility	
HBM.....	8000V
MM.....	200V
CDM.....	1000V

RECOMMENDED OPERATING CONDITIONS

Input Voltage Range.....	3.3V to 24V
Operating Temperature Range.....	$-40^{\circ}C$ to $+125^{\circ}C$

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

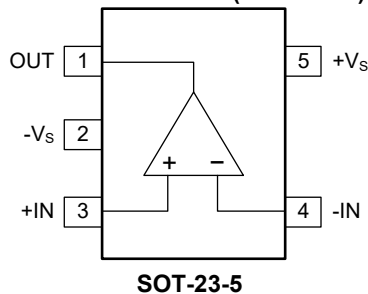
This integrated circuit can be damaged if ESD protections are not considered carefully. SGMICRO recommends that all integrated circuits be handled with appropriate precautions. Failure to observe proper handling and installation procedures can cause damage. ESD damage can range from subtle performance degradation to complete device failure. Precision integrated circuits may be more susceptible to damage because even small parametric changes could cause the device not to meet the published specifications.

DISCLAIMER

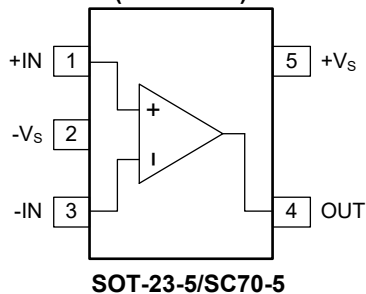
SG Micro Corp reserves the right to make any change in circuit design, or specifications without prior notice.

PIN CONFIGURATIONS

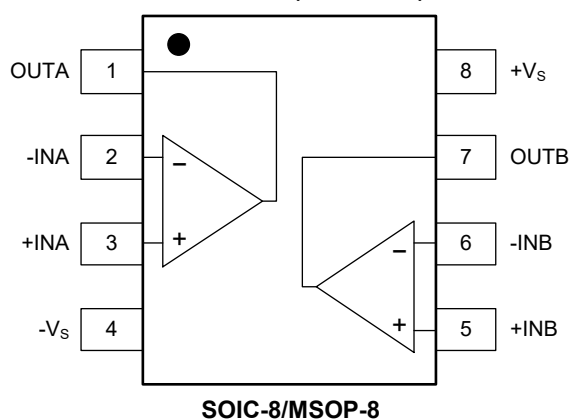
SGM8210-1AXN5G (TOP VIEW)



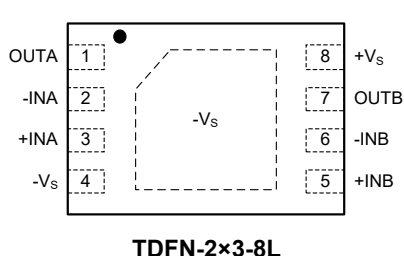
**SGM8210-1BXN5G/SGM8210-1XC5G
(TOP VIEW)**



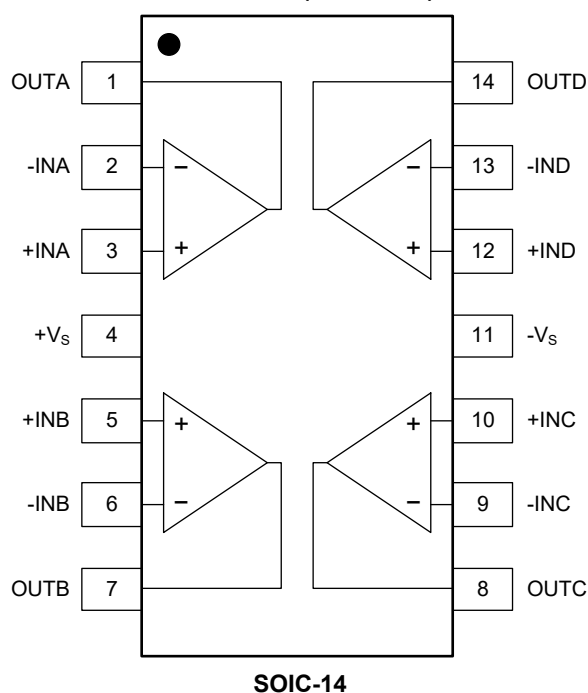
SGM8210-2 (TOP VIEW)



SGM8210-2 (TOP VIEW)



SGM8210-4 (TOP VIEW)



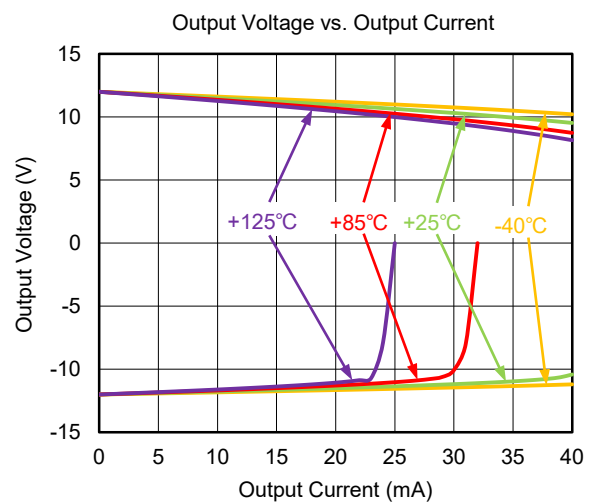
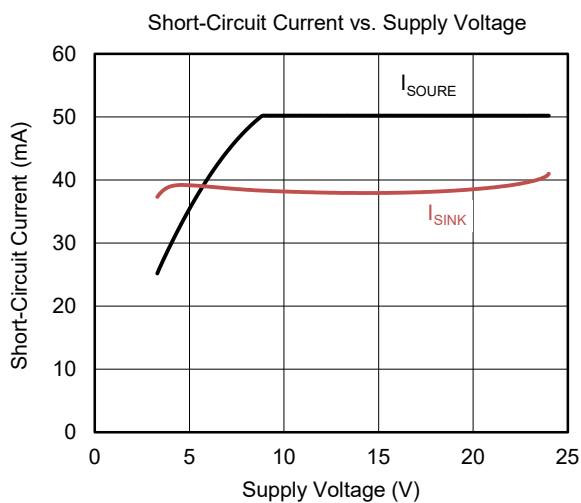
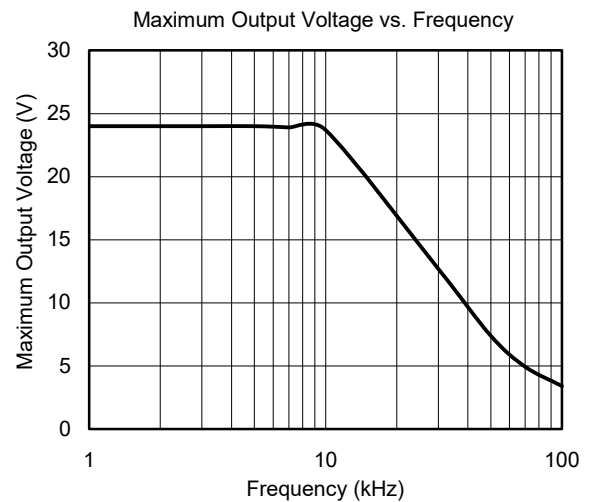
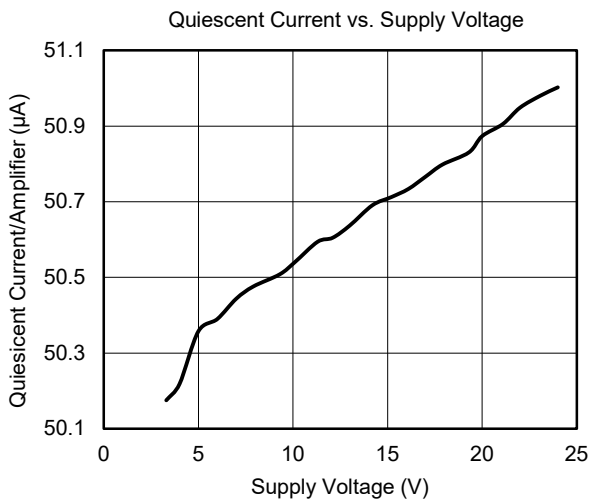
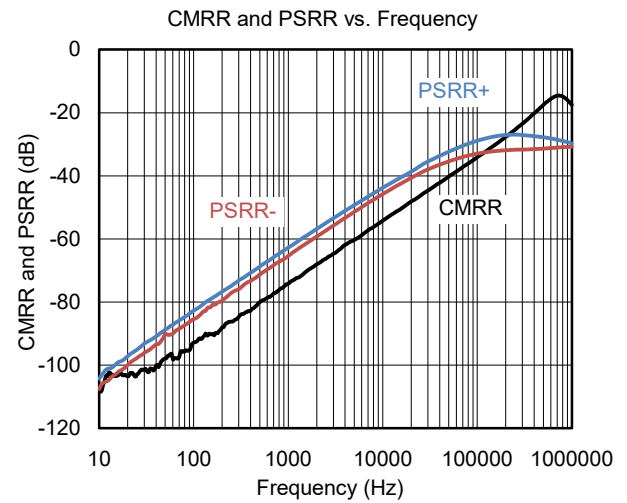
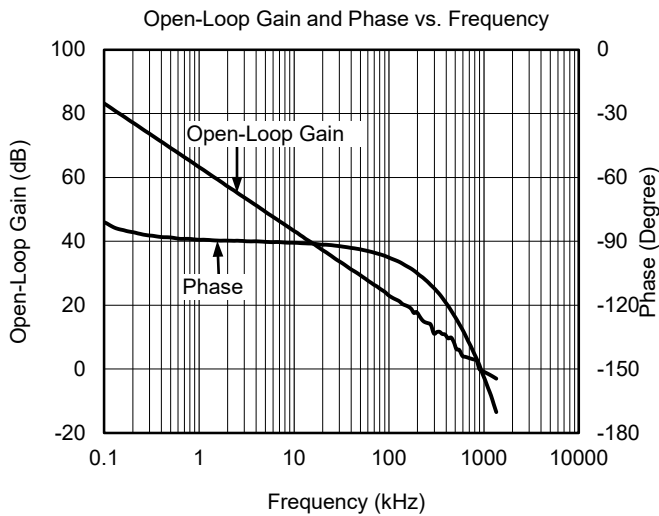
ELECTRICAL CHARACTERISTICS

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

PARAMETER	SYMBOL	CONDITIONS	TEMP	MIN	TYP	MAX	UNITS
Input Characteristics							
Input Offset Voltage	V _{OS}		+25°C		0.4	1	mV
			Full			1.2	
Input Offset Voltage Drift	ΔV _{OS} /ΔT		+25°C		1		μV/°C
Input Bias Current	I _B	V _{CM} = V _S /2	+25°C		±5		pA
Input Offset Current	I _{OS}	V _{CM} = V _S /2	+25°C		±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 = 24V, (-V _S) < V _{CM} < (+V _S) - 1V	+25°C	98	115		dB
			Full	92			
Open-Loop Voltage Gain	A _{OL}	R _L = 10kΩ, (-V _S) + 0.2V < V _{OUT} < (+V _S) - 0.2V	+25°C	102	120		dB
			Full	84			
		R _L = 2kΩ, (-V _S) + 0.6V < V _{OUT} < (+V _S) - 0.6V	+25°C	96	110		
			Full	65			
Output Characteristics							
Output Voltage Swing from Rail	V _{OUT}	V _S = 24V, R _L = 10kΩ	+25°C		55	83	mV
			Full			110	
		V _S = 24V, R _L = 2kΩ	+25°C		270	380	
			Full			510	
Output Short-Circuit Current	I _{SC}		+25°C	±29	±40		mA
Power Supply							
Operating Voltage Range	V _S		+25°C	3.3		24	V
Quiescent Current/Amplifier	I _Q	I _{OUT} = 0mA	+25°C		50	72	μA
			Full			75	
Power Supply Rejection Ratio	PSRR		+25°C	104	120		dB
			Full	102			
Dynamic Performance (C _{LOAD} = 30pF)							
Gain-Bandwidth Product	GBP		+25°C		1		MHz
Slew Rate	SR	G = +1	+25°C		0.3		V/μs
Overload Recovery Time		V _{IN} × G > V _S	+25°C		3		μs
Noise							
Input Voltage Noise		f = 0.1Hz to 10Hz	+25°C		3		μV _{P-P}
Input Voltage Noise Density	e _n	f = 1kHz	+25°C		25		nV/√Hz
Input Current Noise Density	i _n	f = 1kHz	+25°C		400		fA/√Hz

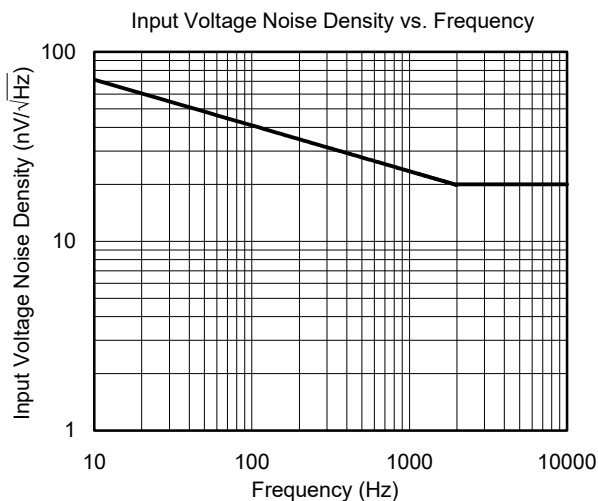
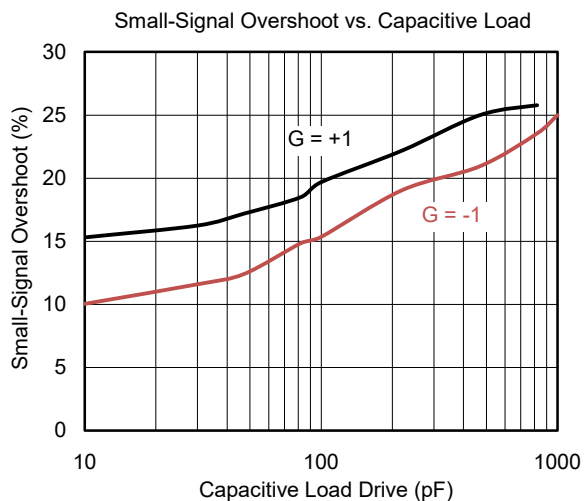
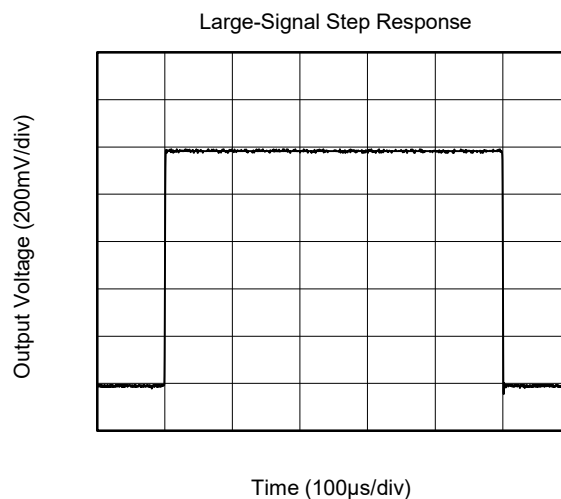
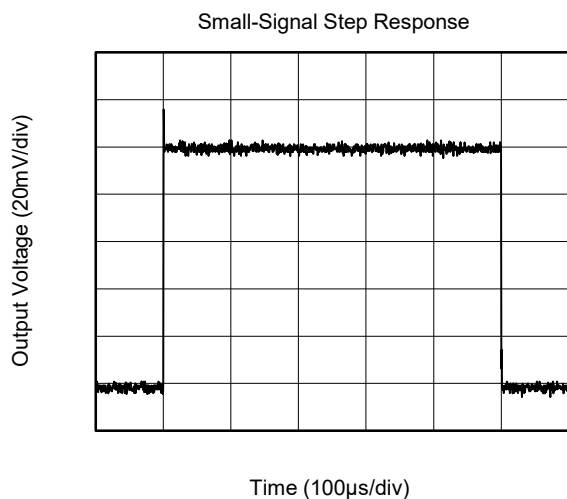
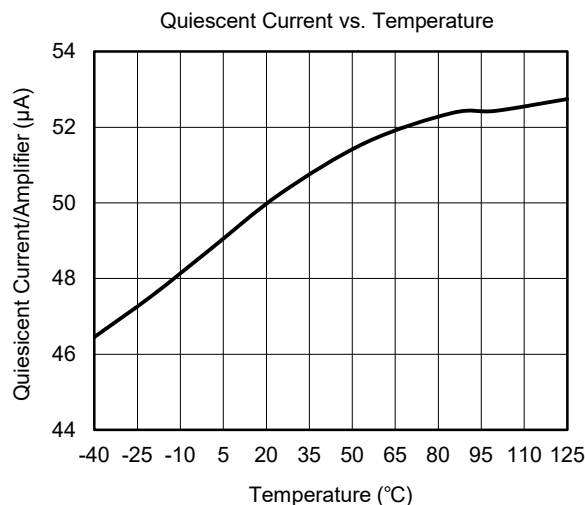
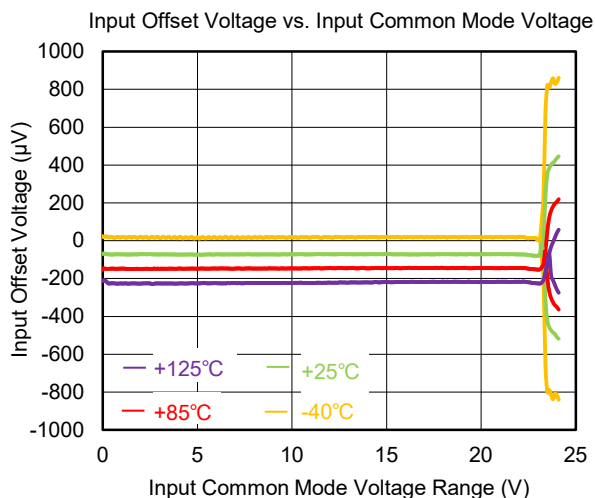
TYPICAL PERFORMANCE CHARACTERISTICS

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



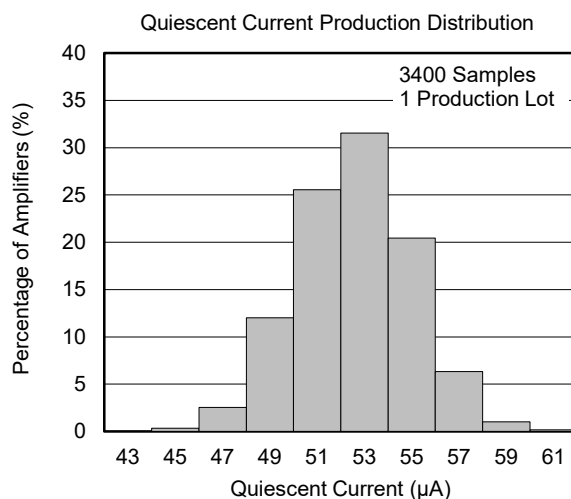
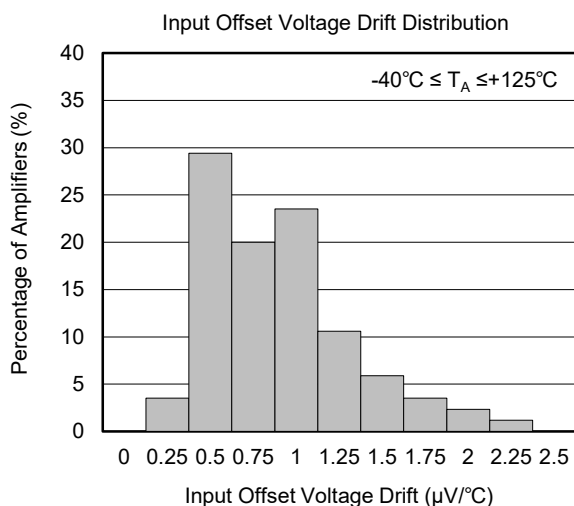
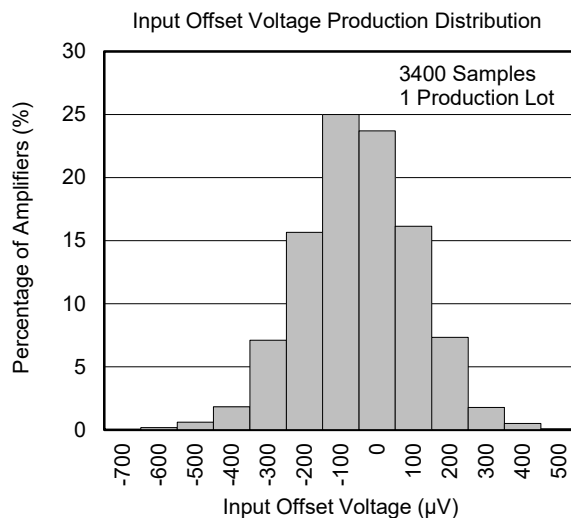
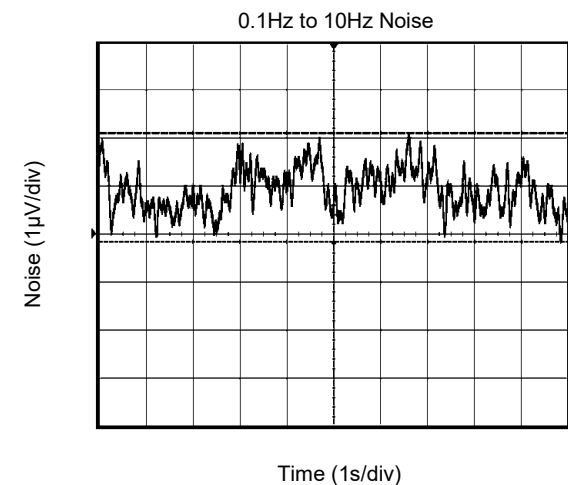
TYPICAL PERFORMANCE CHARACTERISTICS (continued)

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 performance of the signal bandwidth and the noise is not decreased though the power consumption is minimized. In addition, the common mode rejection ratio (CMRR), power supply rejection ratio (PSRR) and the open loop gain (A_{OL}) are greater than 110dB typically.

The system components should be selected carefully if users are desired to minimize the power consumption, which means that the large resistance should be taken into account. However, there are stray capacitances in any PCB board, which means that the large capacitance should be combined with these capacitors (RC delay) to affect the signal bandwidth and the stability of the feedback system. To avoid this issue, a feedback capacitor is required to enhance the stability and limit any gain peaking or overshoot.

Also, for decoupling, a 0.1 μ F capacitor is required to be placed as close as possible to the power supply pin.

Operating Voltage

SGM8210-1/2/4 are typically tested or specified in the power supply range from 3.3V to 24V (or ± 1.65 V to ± 12 V).

Input Common Mode Voltage Range

For the common mode voltage at the inputs of SGM8210-1/2/4, it is operated from $(-V_S) - 0.1$ V to $(+V_S) + 0.1$ V. The complementary structure at the input is applied for achieving the wide input common mode voltage range. The defined CMRR range is from $(-V_S)$ to $(+V_S) - 1$ V. Between $(-V_S) - 0.1$ V and $(+V_S) + 0.1$ V, the CMRR of the device in this region is lower since this is the transition region for the input structure of the SGM8210-1/2/4.

Noise

The performance of noise for SGM8210-1/2/4 is excellent. The resistors should be selected accordingly to prevent the thermal noise from being the dominant one, as the 0.1Hz to 10Hz noise for SGM8210-1/2/4 is just 3 μ V_{P-P}, and wideband noise is 25nV/ $\sqrt{\text{Hz}}$.

Input Over-Voltage Protection

The typical input biasing current is 5pA. However, if the input voltage level is 0.5V greater than the power supply rails of the operational amplifier, the current will be increased exponentially. Also, to keep the input voltage within the maximum allowed region, a resistor should be placed at the input of the amplifier to limit the input current within 10mA, which is shown in Figure 1.

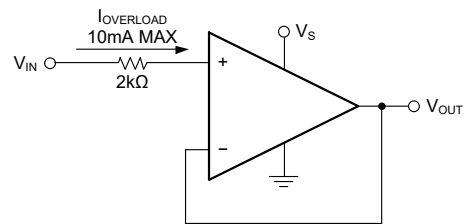


Figure 1. Protection for Input Current when Supply Voltage is Exceeded

Driving Capacitive Load with Stability

For unity-gain buffer application, the overshoot or gain peaking would be made if the load capacitance is greater than 30pF. To improve the ability of capacitive loading, one way is improving the voltage gain, and the other way is adding 10 Ω to 20 Ω isolated resistor at the output stage, which is shown in Figure 2. With this resistor, the ringing and gain peaking can be eliminated for light capacitive loading. However, if a resistive load is connected in parallel with the C_L , the output will be divided by the R_S and R_L . Generally, if the R_L is large, the influence is negligible.

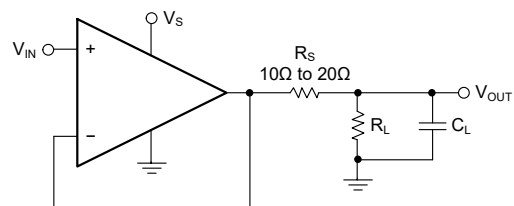


Figure 2. Capacitive Load Drive Improved by Series Resistor in Unity-Gain Buffer Configuration

APPLICATION INFORMATION (continued)

For the inverting unity-gain application, the phase margin of the loop gain can be decreased by reacting of the gain and feedback resistors and the parasitic capacitance which is at the negative input pin. For best performance, decreasing the R_F and R_{IN} should be taken into account. However, if users desire to use large feedback and gain resistors, placing a 4pF to 6pF capacitor in parallel with the R_F is a good choice for enhancing the stability of the feedback loop. Also, the gain peaking and the overshoot will be decreased accordingly. In Figure 3, C_{IN} indicates the parasitic capacitance for the operational amplifier and the PCB.

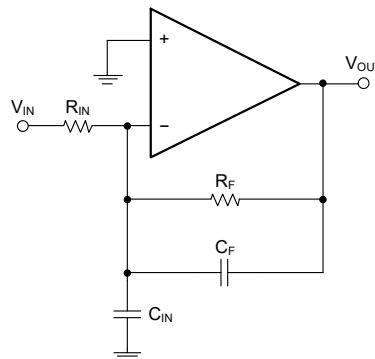


Figure 3. Enhancing the Stability of Large R_F and R_{IN}

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

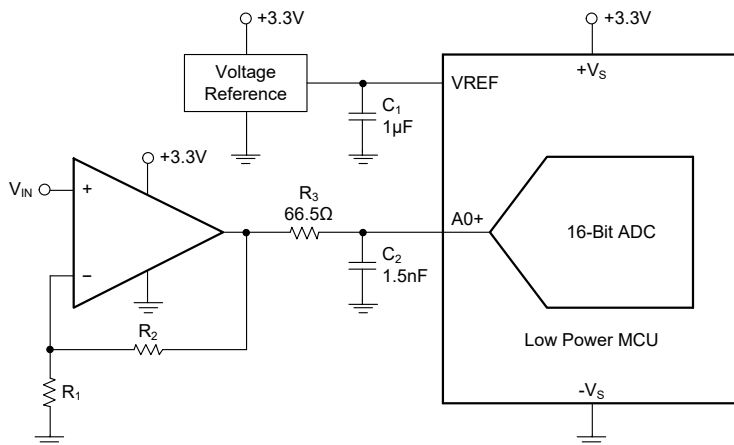


Figure 4. Single Amplifier Configurations for Driving Unipolar Precision ADC

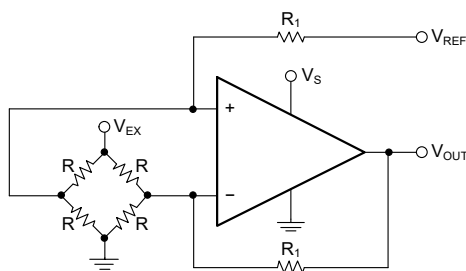
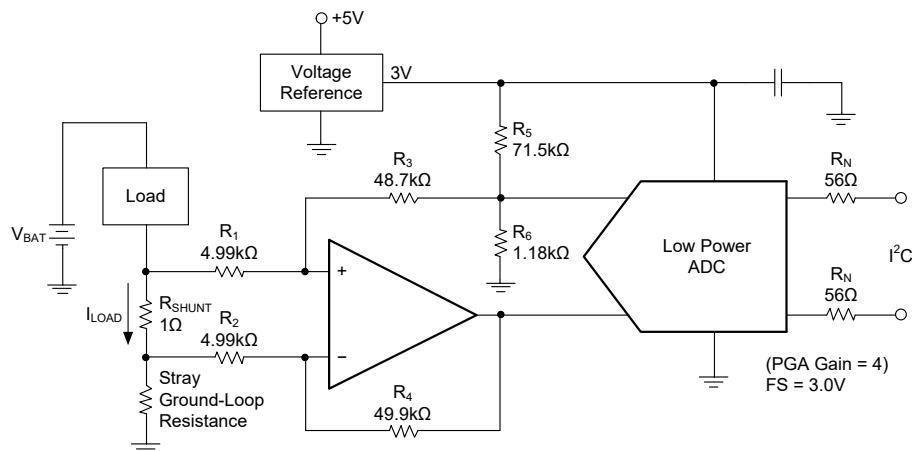


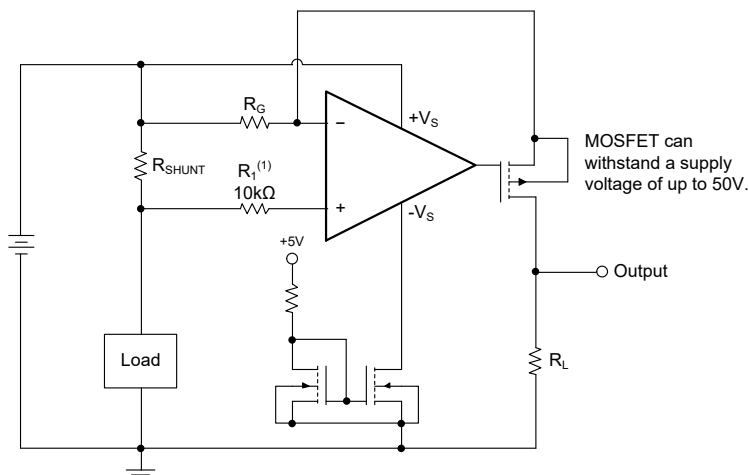
Figure 5. Bridge Amplifier Using a Single Operational Amplifier

APPLICATION INFORMATION (continued)



NOTE: 1% resistors can provide sufficient common mode rejection to reduce the adverse effects caused by small ground-loop errors.

Figure 6. Low-side Current Shunt Monitor



NOTE: 1. Current-limit resistor.

Figure 7. High-side Current Measurement

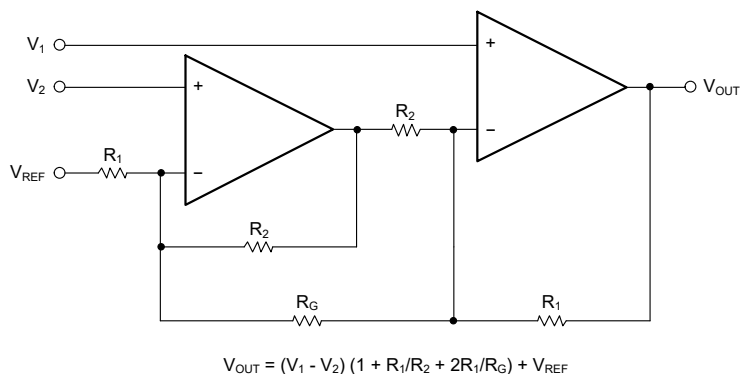


Figure 8. Low Power Instrumentation Amplifier Consisting of Two Operational Amplifiers

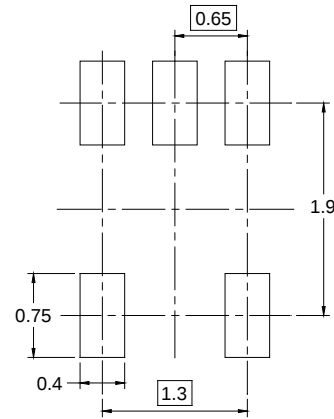
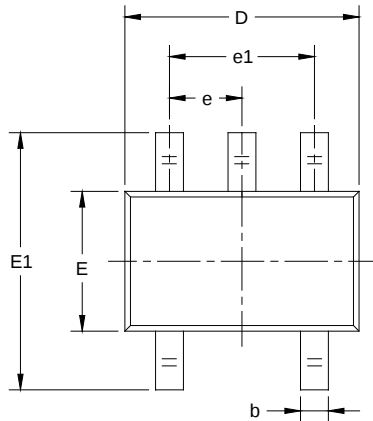
REVISION HISTORY

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

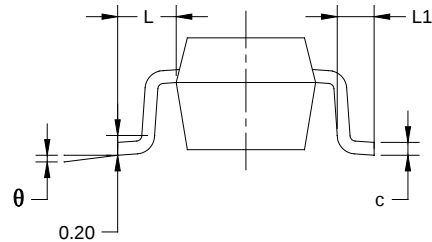
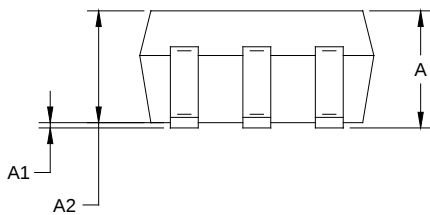
AUGUST 2023 – REV.A.1 to REV.A.2	Page
Updated Package Outline Dimensions section	13
MARCH 2018 – REV.A to REV.A.1	Page
Added Differential Input Voltage range	3
Changes from Original (DECEMBER 2016) to REV.A	Page
Changed from product preview to production data.....	All

PACKAGE OUTLINE DIMENSIONS

SC70-5



RECOMMENDED LAND PATTERN (Unit: mm)



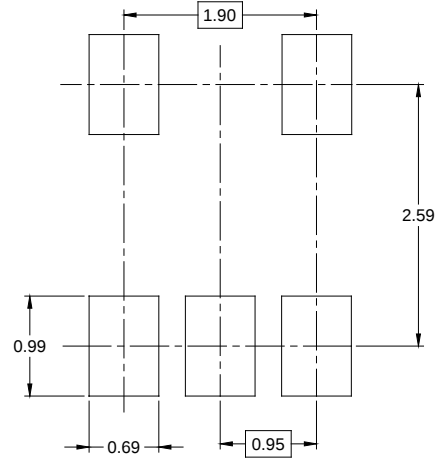
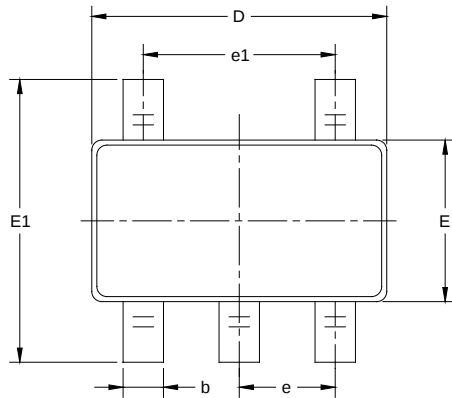
Symbol	Dimensions In Millimeters		Dimensions In Inches	
	MIN	MAX	MIN	MAX
A	0.800	1.100	0.031	0.043
A1	0.000	0.100	0.000	0.004
A2	0.800	1.000	0.031	0.039
b	0.150	0.350	0.006	0.014
c	0.080	0.220	0.003	0.009
D	2.000	2.200	0.079	0.087
E	1.150	1.350	0.045	0.053
E1	2.150	2.450	0.085	0.096
e	0.65 TYP		0.026 TYP	
e1	1.300 BSC		0.051 BSC	
L	0.525 REF		0.021 REF	
L1	0.260	0.460	0.010	0.018
θ	0°	8°	0°	8°

NOTES:

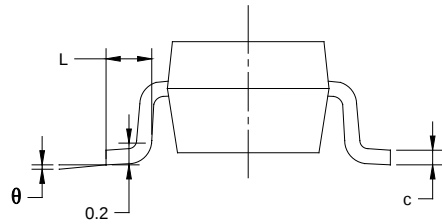
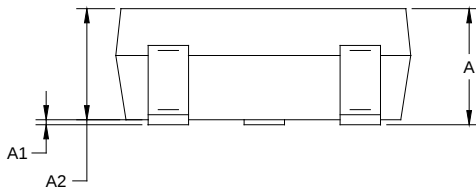
1. Body dimensions do not include mold flash or protrusion.
2. This drawing is subject to change without notice.

PACKAGE OUTLINE DIMENSIONS

SOT-23-5



RECOMMENDED LAND PATTERN (Unit: mm)



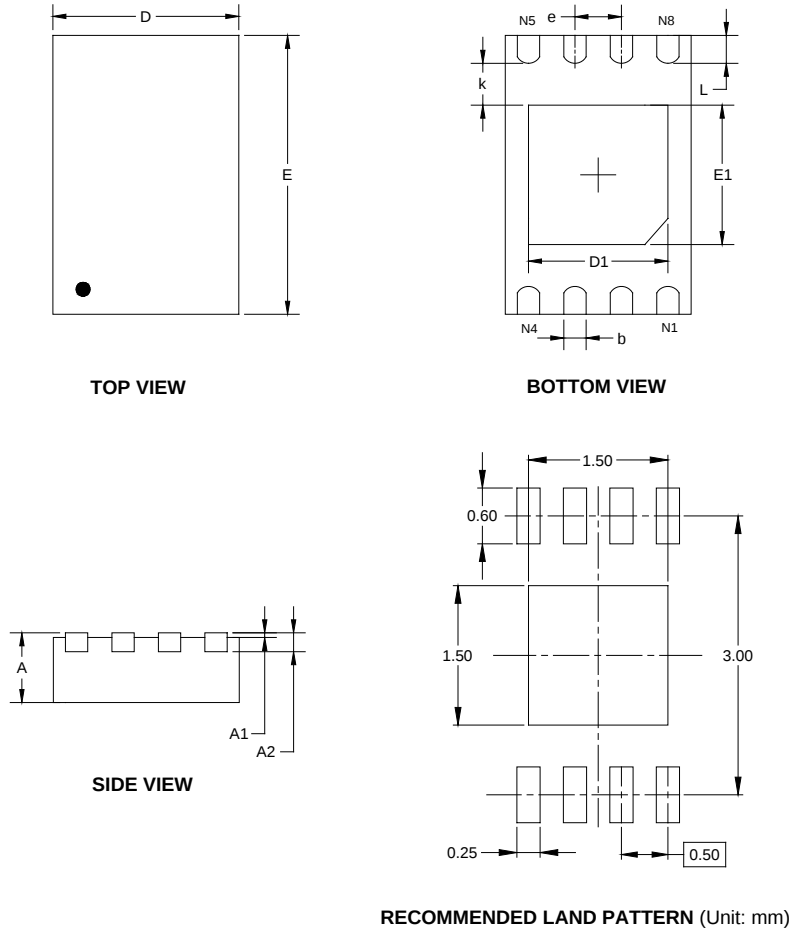
Symbol	Dimensions In Millimeters		Dimensions In Inches	
	MIN	MAX	MIN	MAX
A	1.050	1.250	0.041	0.049
A1	0.000	0.100	0.000	0.004
A2	1.050	1.150	0.041	0.045
b	0.300	0.500	0.012	0.020
c	0.100	0.200	0.004	0.008
D	2.820	3.020	0.111	0.119
E	1.500	1.700	0.059	0.067
E1	2.650	2.950	0.104	0.116
e	0.950 BSC		0.037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

NOTES:

1. Body dimensions do not include mold flash or protrusion.
2. This drawing is subject to change without notice.

PACKAGE OUTLINE DIMENSIONS

TDFN-2x3-8L

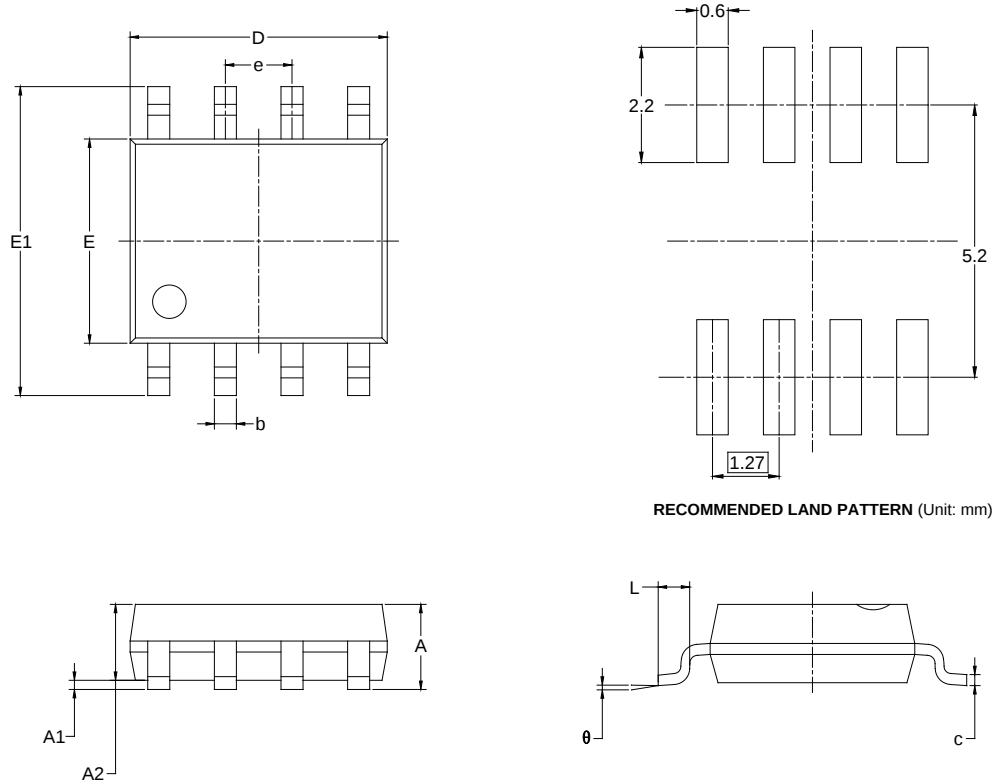


Symbol	Dimensions In Millimeters		Dimensions In Inches	
	MIN	MAX	MIN	MAX
A	0.700	0.800	0.028	0.031
A1	0.000	0.050	0.000	0.002
A2	0.203 REF		0.008 REF	
D	1.924	2.076	0.076	0.082
D1	1.400	1.600	0.055	0.063
E	2.924	3.076	0.115	0.121
E1	1.400	1.600	0.055	0.063
k	0.200 MIN		0.008 MIN	
b	0.200	0.300	0.008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

NOTE: This drawing is subject to change without notice.

PACKAGE OUTLINE DIMENSIONS

SOIC-8



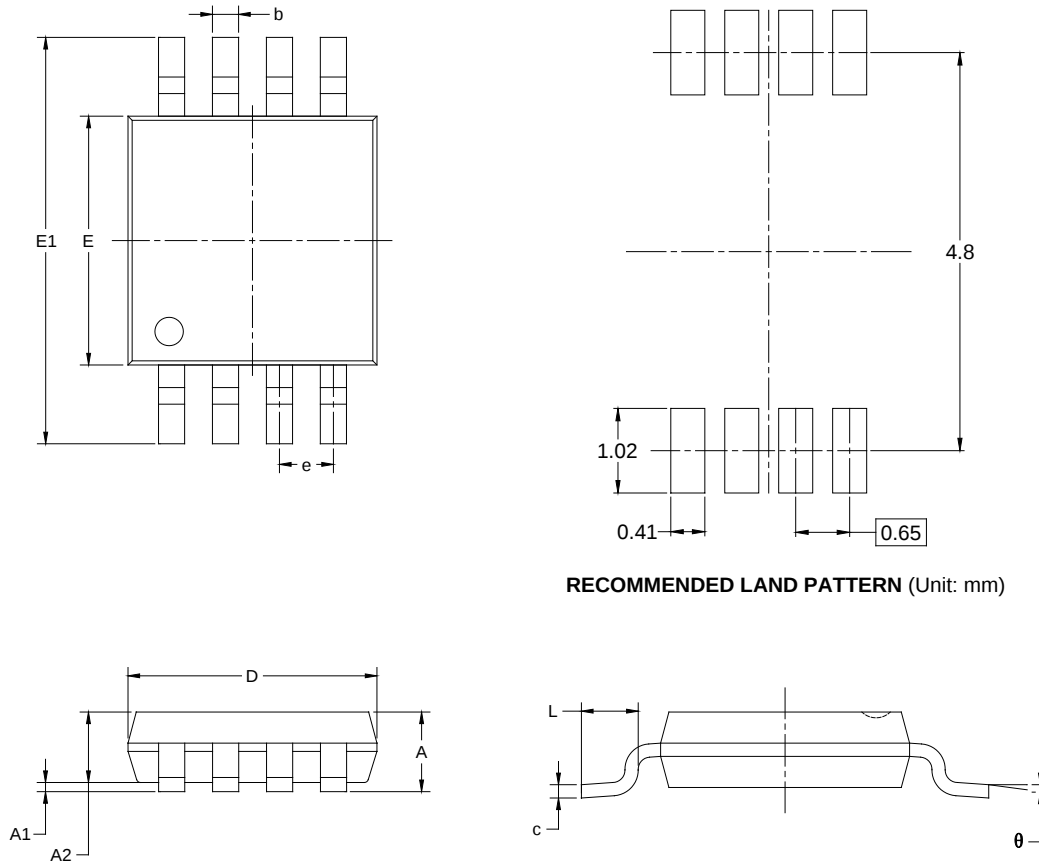
Symbol	Dimensions In Millimeters		Dimensions In Inches	
	MIN	MAX	MIN	MAX
A	1.350	1.750	0.053	0.069
A1	0.100	0.250	0.004	0.010
A2	1.350	1.550	0.053	0.061
b	0.330	0.510	0.013	0.020
c	0.170	0.250	0.006	0.010
D	4.700	5.100	0.185	0.200
E	3.800	4.000	0.150	0.157
E1	5.800	6.200	0.228	0.244
e	1.27 BSC		0.050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

NOTES:

1. Body dimensions do not include mold flash or protrusion.
2. This drawing is subject to change without notice.

PACKAGE OUTLINE DIMENSIONS

MSOP-8



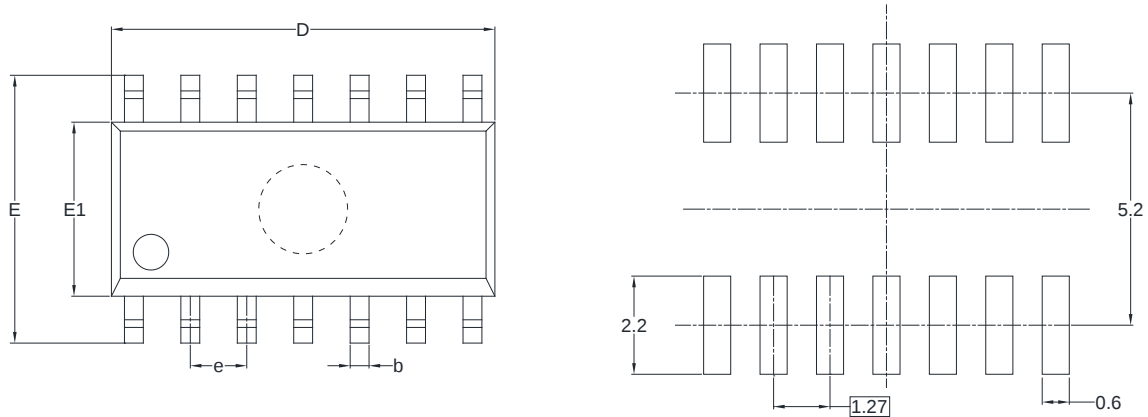
Symbol	Dimensions In Millimeters		Dimensions In Inches	
	MIN	MAX	MIN	MAX
A	0.820	1.100	0.032	0.043
A1	0.020	0.150	0.001	0.006
A2	0.750	0.950	0.030	0.037
b	0.250	0.380	0.010	0.015
c	0.090	0.230	0.004	0.009
D	2.900	3.100	0.114	0.122
E	2.900	3.100	0.114	0.122
E1	4.750	5.050	0.187	0.199
e	0.650 BSC		0.026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

NOTES:

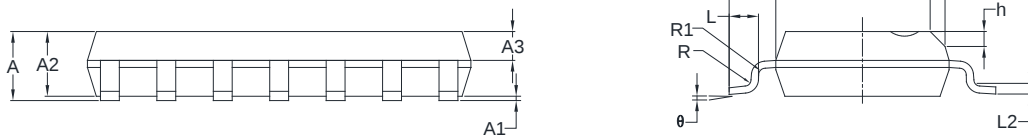
1. Body dimensions do not include mode flash or protrusion.
2. This drawing is subject to change without notice.

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°

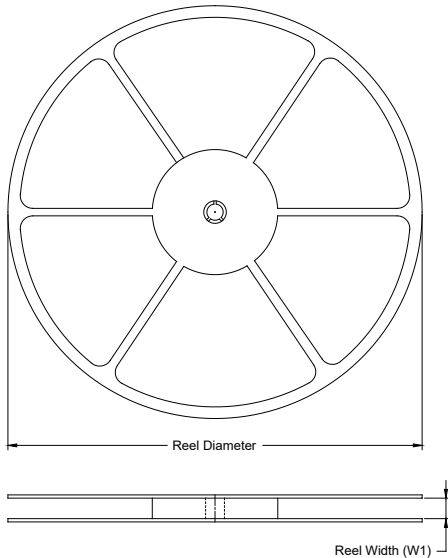
NOTES:

1. Body dimensions do not include mold flash or protrusion.
2. This drawing is subject to change without notice.

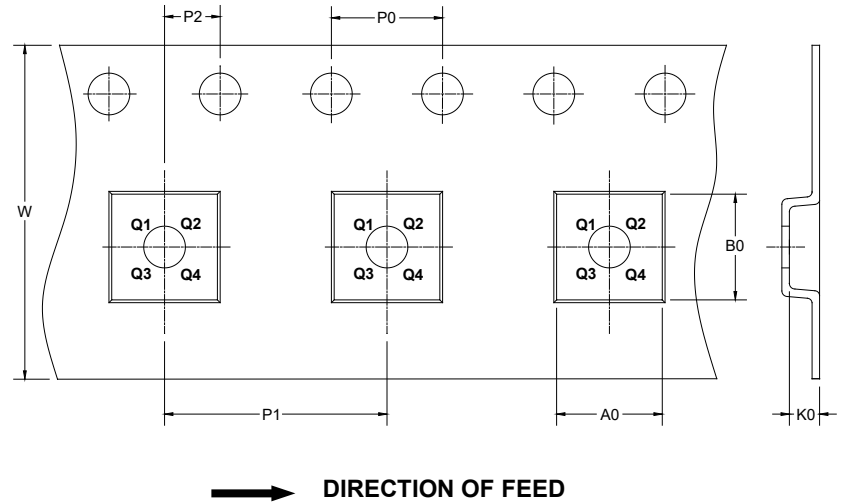
PACKAGE INFORMATION

TAPE AND REEL INFORMATION

REEL DIMENSIONS



TAPE DIMENSIONS



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

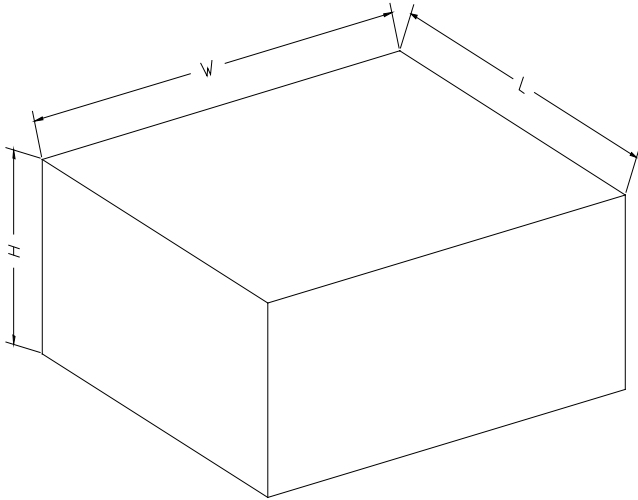
KEY PARAMETER LIST OF TAPE AND REEL

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	2.40	2.50	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-2×3-8L	7"	9.5	2.30	3.30	1.10	4.0	4.0	2.0	8.0	Q2
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
SOIC-14	13"	16.4	6.60	9.30	2.10	4.0	8.0	2.0	16.0	Q1

DD0001

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