SGM8240-1/SGM8240-2/SGM8240-4
High Voltage, Micro-Power, Rail-to-Rail I/O Operational Amplifiers

GENERAL DESCRIPTION

The SGM8240-1 (single), SGM8240-2 (dual) and SGM8240-4 (quad) are micro-power and high voltage operational amplifiers, which are suitable for battery-powered systems. These devices can operate from 2.7V to 24V single supply or from ±1.35V to ±12V dual power supplies, and consume only 2.8μA quiescent current per amplifier. They also provide rail-to-rail input and output operation.

The SGM8240-1/2/4 provide low power, low bias current and low noise. These devices fit in small packages. The combination of the above features makes them appropriate for various applications.

The SGM8240-1 is available in Green SOT-23-5 and SC70-5 packages. The SGM8240-2 is available in Green SOIC-8, MSOP-8 and TDFN-2×3-8L packages. The SGM8240-4 is available in a Green SOIC-14 package. They are specified from -40℃ to +125℃ temperature range.

FEATURES

- **Wide Supply Voltage Range: 2.7V to 24V**
- **Rail-to-Rail Input and Output**
- **Low Quiescent Current: 2.8μA/Amplifier (TYP)**
- **Low Offset Voltage: 0.4mV (TYP)**
- **Low 0.1Hz to 10Hz Noise: 3μV_{P-P}**
- **Input Voltage Noise Density: 100nV/$\sqrt{Hz}$ at 1kHz**
- **CMRR: 110dB (TYP)**
- **PSRR: 116dB (TYP)**
- **Open-Loop Voltage Gain: 120dB (TYP)**
- **Slew Rate: 0.05V/μs**
- **-40℃ to +125℃ Operating Temperature Range**
- **Small Packaging:**
  SGM8240-1 Available in Green SOT-23-5 and SC70-5 Packages
  SGM8240-2 Available in Green SOIC-8, MSOP-8 and TDFN-2×3-8L Packages
  SGM8240-4 Available in a Green SOIC-14 Package

APPLICATIONS

Battery-Powered Instrumentation
Portable Equipment
Handheld Test Equipment
Medical Instrumentation

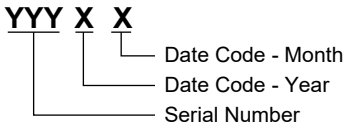
PACKAGE/ORDERING INFORMATION

MODEL	PACKAGE DESCRIPTION	SPECIFIED TEMPERATURE RANGE	ORDERING NUMBER	PACKAGE MARKING	PACKING OPTION
SGM8240-1	SC70-5	-40℃ to +125℃	SGM8240-1XC5G/TR	G88XX	Tape and Reel, 3000
	SOT-23-5	-40℃ to +125℃	SGM8240-1AXN5G/TR	G1CXX	Tape and Reel, 3000
	SOT-23-5	-40℃ to +125℃	SGM8240-1BXN5G/TR	G89XX	Tape and Reel, 3000
SGM8240-2	SOIC-8	-40℃ to +125℃	SGM8240-2XS8G/TR	SGM 82402XS8 XXXXX	Tape and Reel, 2500
	MSOP-8	-40℃ to +125℃	SGM8240-2XMS8G/TR	SGM82402 XMS8 XXXXX	Tape and Reel, 4000
	TDFN-2×3-8L	-40℃ to +125℃	SGM8240-2XTDC8G/TR	G8C XXXX	Tape and Reel, 3000
SGM8240-4	SOIC-14	-40℃ to +125℃	SGM8240-4XS14G/TR	SGM82404XS14 XXXXX	Tape and Reel, 2500

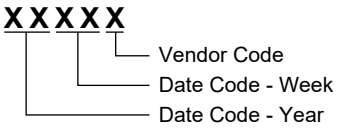
MARKING INFORMATION

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

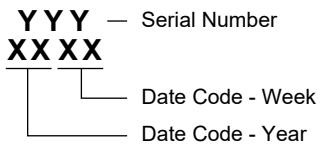
SC70-5/SOT-23-5



SOIC-8/MSOP-8/SOIC-14



TDFN-2×3-8L



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
Signal Input Current Terminals ..... ±10mA
Output Short-Circuit Current ..... ±20mA
Junction Temperature ..... +150℃
Storage Temperature Range ..... -65℃ to +150℃
Lead Temperature (Soldering, 10s) ..... +260℃
ESD Susceptibility
HBM 8000V
MM 200V
CDM 1000V

RECOMMENDED OPERATING CONDITIONS

Input Voltage Range ..... 2.7V to 24V
Operating Temperature Range ..... -40℃ to +125℃

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

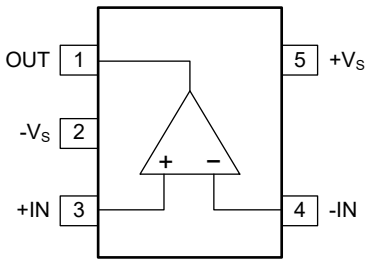
This integrated circuit can be damaged if ESD protections are not considered carefully. SGMICRO recommends that all integrated circuits be handled with appropriate precautions. Failure to observe proper handling and installation procedures can cause damage. ESD damage can range from subtle performance 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.

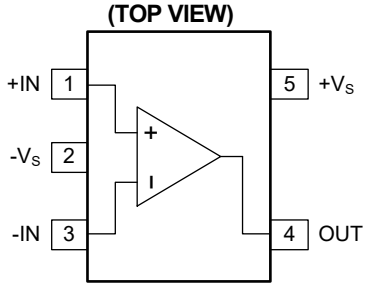
PIN CONFIGURATIONS

SGM8240-1AXN5G (TOP VIEW)



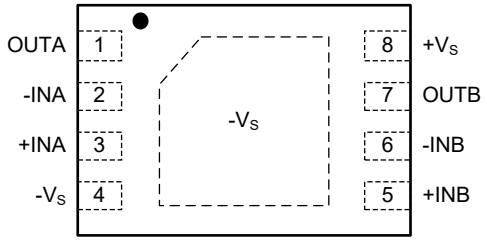
SOT-23-5

SGM8240-1BXN5G/SGM8240-1XC5G
(TOP VIEW)



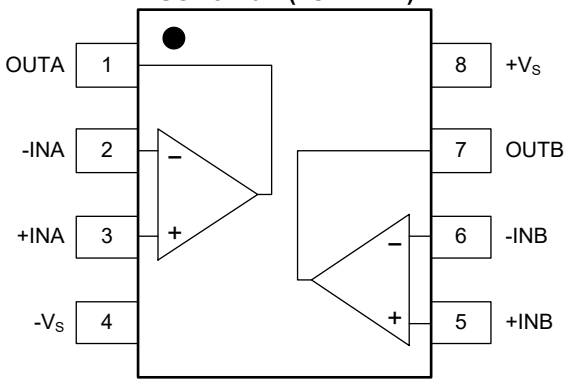
SOT-23-5/SC70-5

SGM8240-2 (TOP VIEW)



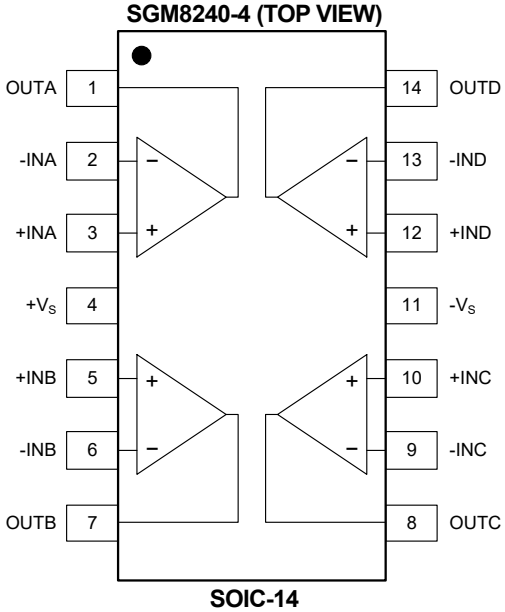
TDFN-2×3-8L

SGM8240-2 (TOP VIEW)



SOIC-8/MSOP-8

SGM8240-4 (TOP VIEW)



SOIC-14

ELECTRICAL CHARACTERISTICS

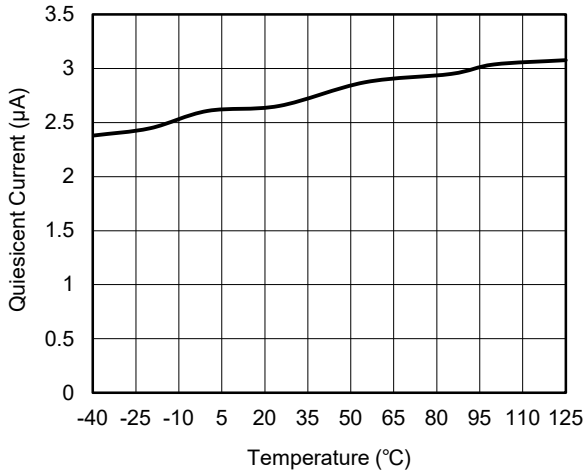
(V_S = 2.7V to 24V, V_{CM} < (+V_S) - 1V, and R_L = 25kΩ connected to V_S/2, Full = -40℃ to +125℃, typical values are at T_A = +25℃, unless otherwise noted.)

PARAMETER	SYMBOL	CONDITIONS	TEMP	MIN	TYP	MAX	UNITS
Input Characteristics							
Input Offset Voltage	V_{OS}		+25℃		0.4	1	mV
			Full			4.8	
Input Offset Voltage Drift	$\Delta V_{OS}/\Delta T$		+25℃		3		μV/℃
Input Bias Current	I_B	$V_{CM} = V_S/2$	+25℃		±5		pA
Input Offset Current	I_{OS}	$V_{CM} = V_S/2$	+25℃		±5		pA
Input Common Mode Voltage Range	V_{CM}		+25℃	(-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℃	96	110		dB
			Full	57			
Open-Loop Voltage Gain	A_{OL}	R_L = 25kΩ, (-V_S) + 0.2V < V_{OUT} < (+V_S) - 0.2V	+25℃	98	120		dB
			Full	60			
		R_L = 5kΩ, (-V_S) + 0.6V < V_{OUT} < (+V_S) - 0.6V	+25℃	94	110		
			Full	63			
Output Characteristics							
Output Voltage Swing from Rail	V_{OUT}	V_S = 24V, R_L = 25kΩ	+25℃		55	98	mV
			Full			130	
		V_S = 24V, R_L = 5kΩ	+25℃		230	345	
			Full			475	
Output Short-Circuit Current	I_{SC}		+25℃	±11	±20		mA
Power Supply							
Operating Voltage Range	V_S		+25℃	2.7		24	V
Quiescent Current/Amplifier	I_Q	I_{OUT} = 0mA	+25℃		2.8	4.2	μA
			Full			5.5	
Power Supply Rejection Ratio	PSRR		+25℃	97	116		dB
			Full	73			
Dynamic Performance (C_L = 30pF)							
Gain-Bandwidth Product	GBP		+25℃		100		kHz
Slew Rate	SR	G = +1	+25℃		0.05		V/μs
Overload Recovery Time		$V_{IN} \times G > V_S$	+25℃		40		μs
Noise							
Input Voltage Noise		f = 0.1Hz to 10Hz	+25℃		3		μV_{P-P}
Input Voltage Noise Density	e_n	f = 1kHz	+25℃		100		$nV/\sqrt{Hz}$
Input Current Noise Density	i_n	f = 1kHz	+25℃		3.5		$pA/\sqrt{Hz}$

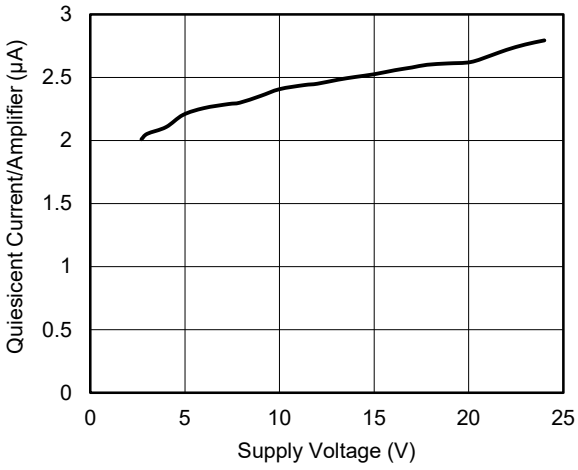
TYPICAL PERFORMANCE CHARACTERISTICS

At T_A = +25℃, V_S = 24V, R_L = 25kΩ, unless otherwise noted.

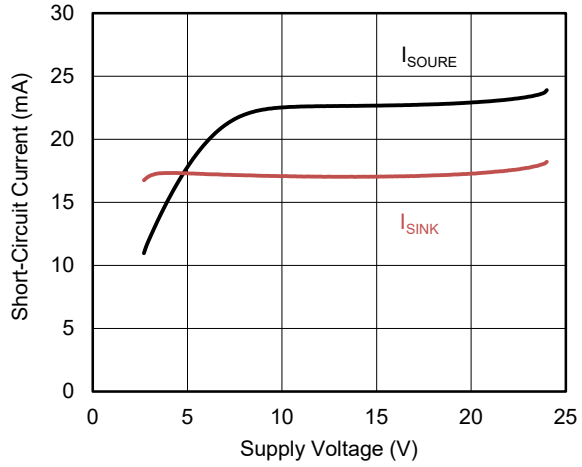
Quiescent Current vs. Temperature



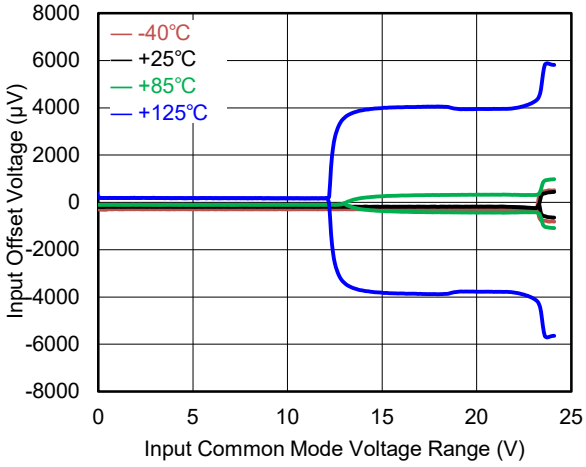
Quiescent Current vs. Supply Voltage



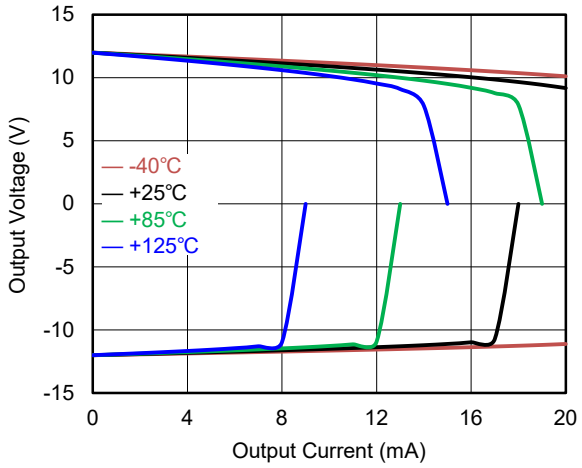
Short-Circuit Current vs. Supply Voltage



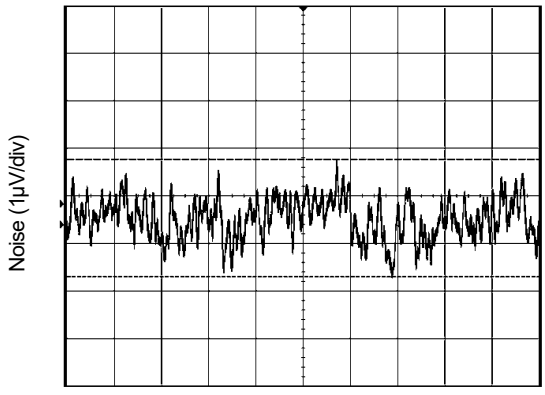
Input Offset Voltage vs. Input Common Mode Voltage



Output Voltage vs. Output Current



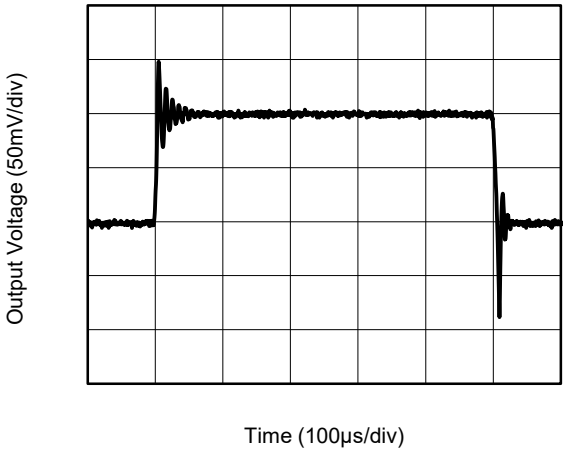
0.1Hz to 10Hz Noise



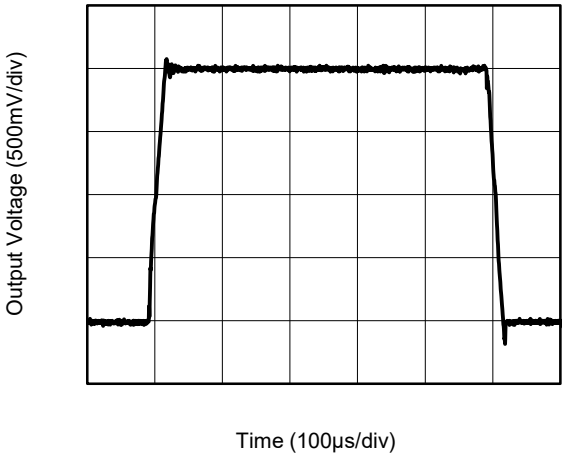
TYPICAL PERFORMANCE CHARACTERISTICS (continued)

At T_A = +25℃, V_S = 24V, R_L = 25kΩ, unless otherwise noted.

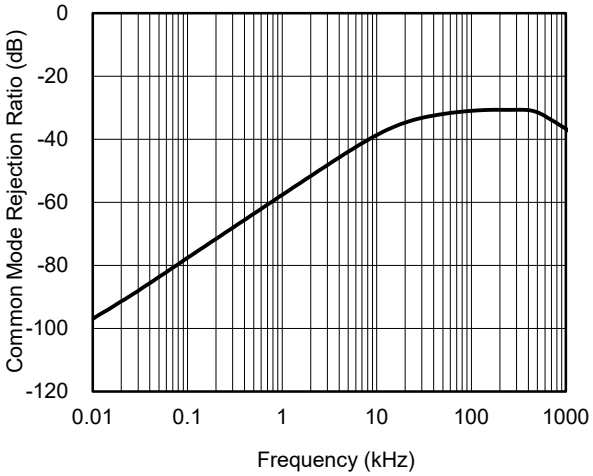
Small-Signal Step Response



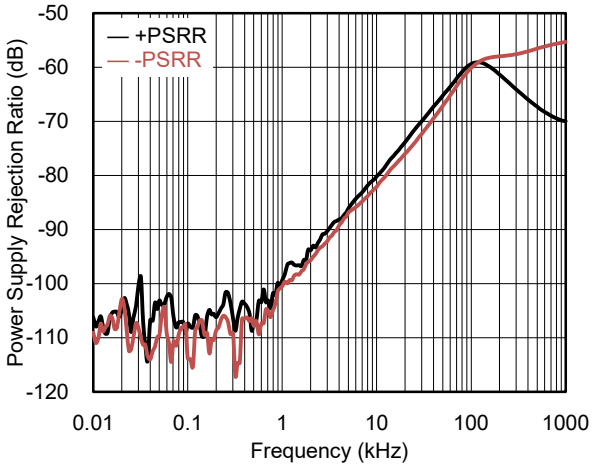
Large-Signal Step Response



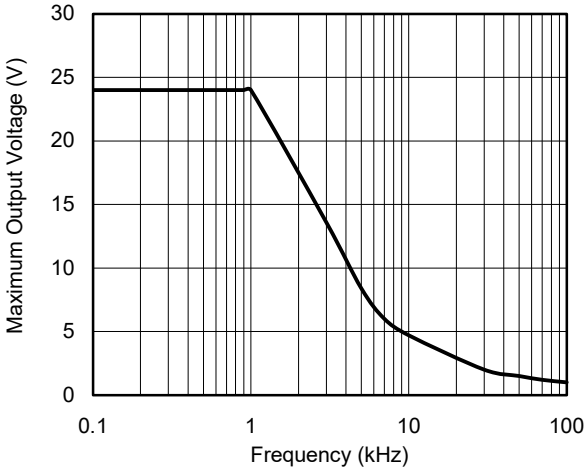
CMRR vs. Frequency



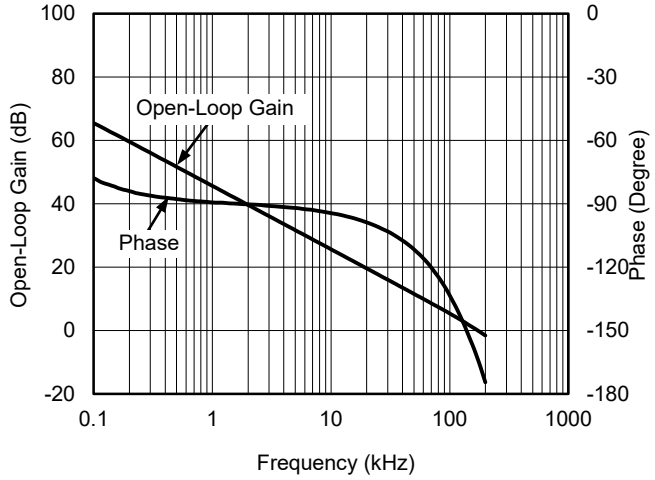
PSRR vs. Frequency



Maximum Output Voltage vs. Frequency



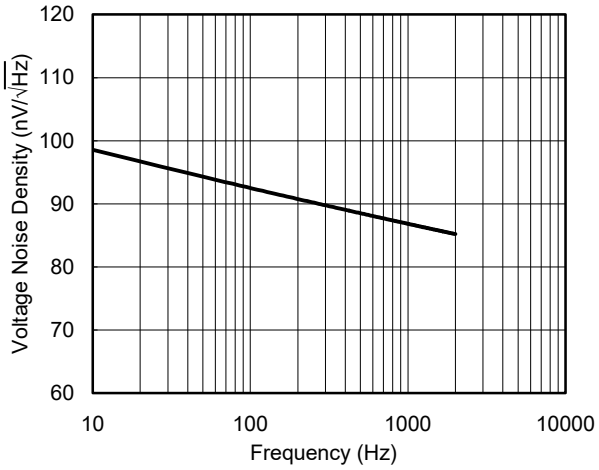
Open-Loop Gain and Phase vs. Frequency



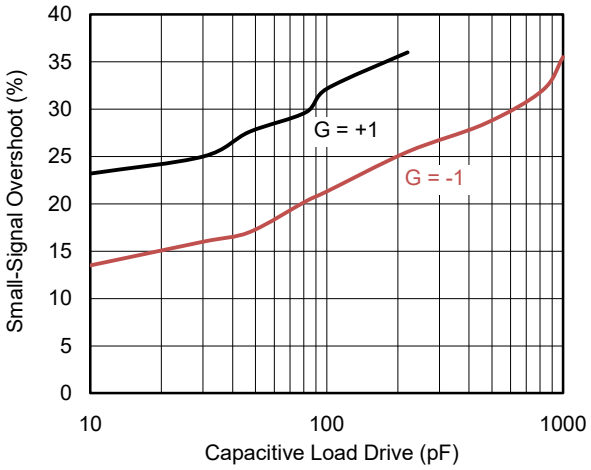
TYPICAL PERFORMANCE CHARACTERISTICS (continued)

At T_A = +25℃, V_S = 24V, R_L = 25kΩ, unless otherwise noted.

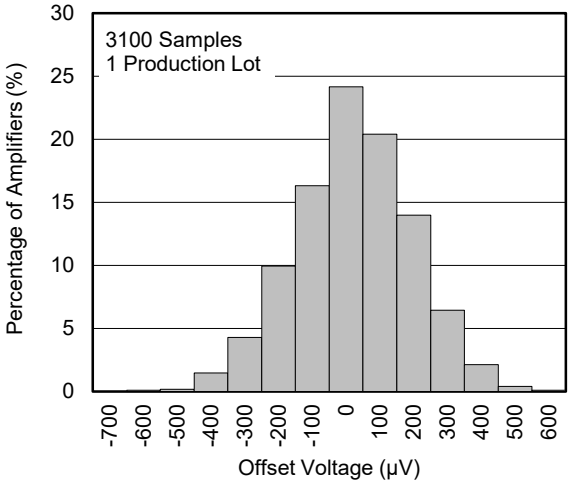
Voltage Noise Density vs. Frequency



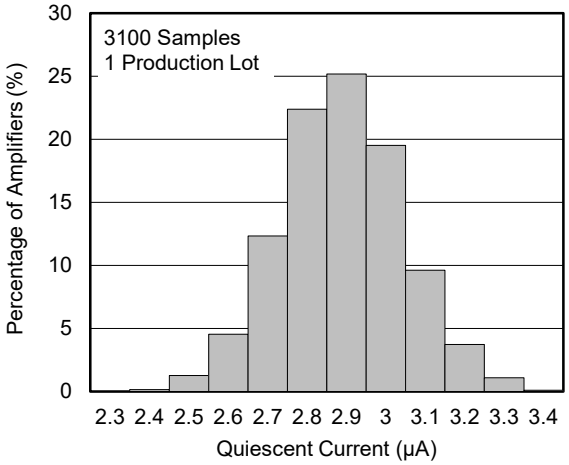
Small-Signal Overshoot vs. Capacitive Load



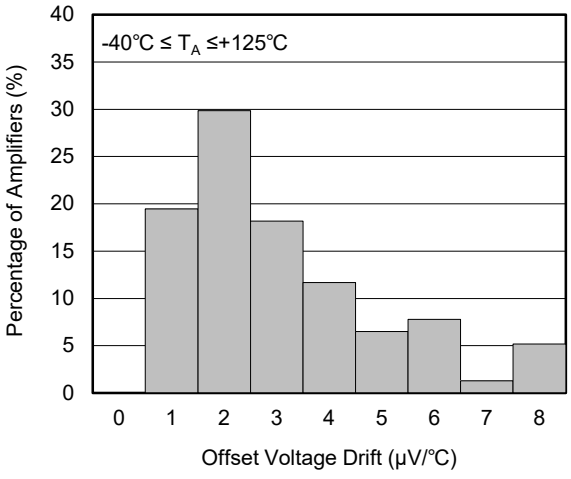
Offset Voltage Production Distribution



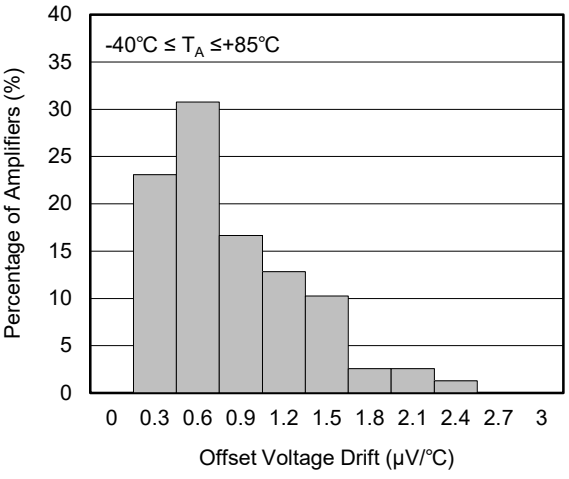
Quiescent Current Production Distribution



Offset Voltage Drift Distribution



Offset Voltage Drift Distribution



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 0.1μF capacitor is required to be placed as close as possible to the power supply pin.

Operating Voltage

SGM8240-1/2/4 are typically tested or specified in the power supply range from 2.7V to 24V (or ±1.35V to ±12V).

Input Common Mode Voltage Range

For the common mode voltage at the inputs of SGM8240-1/2/4, it is operated from ($-V_S$) - 0.1V to ($+V_S$) + 0.1V. 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 ($+V_S$) - 1V. Between ($-V_S$) - 0.1V and ($+V_S$) + 0.1V, the CMRR of the device in this region is lower since this is the transition region for the input structure of the SGM8240-1/2/4.

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.

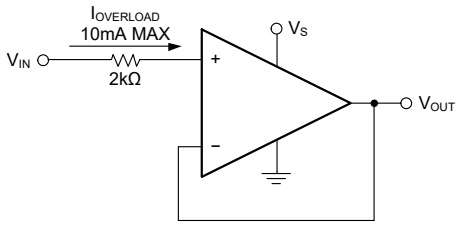


Figure 1. Protection for Input Current when Supply Voltage is Exceeded

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 10Ω to 20Ω 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.

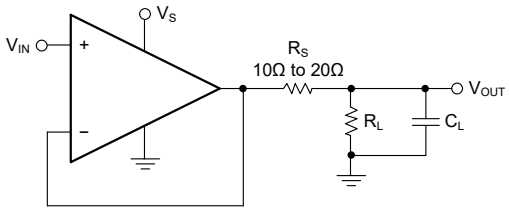


Figure 2. Capacitive Load Drive Improved by Series Resistor in Unity-Gain Buffer Configuration

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.

APPLICATION INFORMATION (continued)

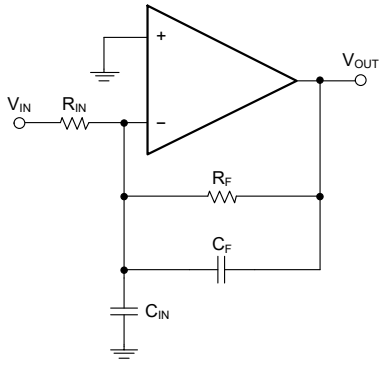


Figure 3. Enhancing the Stability of Large R_F and R_{IN}

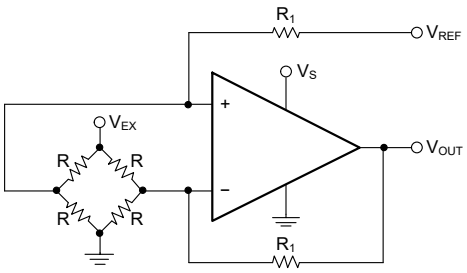
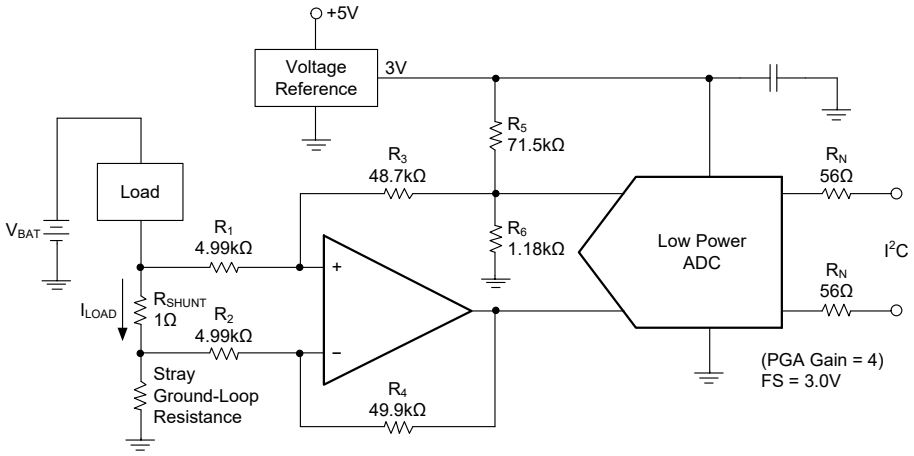


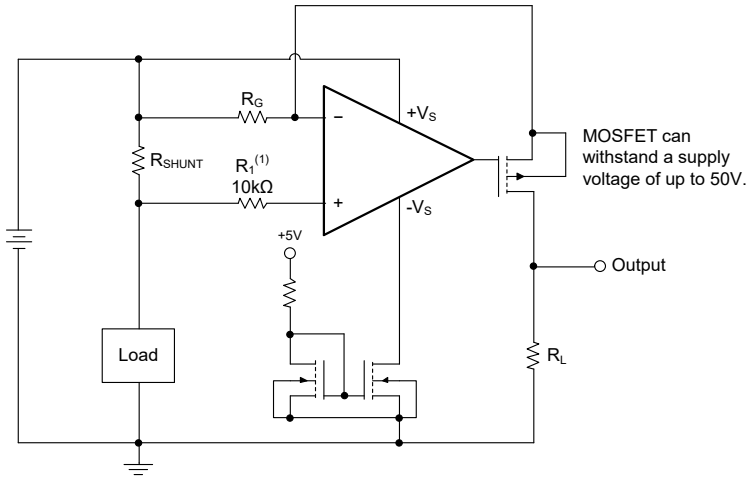
Figure 4. Bridge Amplifier Using a Single Operational Amplifier



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

Figure 5. Low-side Current Shunt Monitor

APPLICATION INFORMATION (continued)



NOTE: 1. Current-limit resistor.

Figure 6. High-side Current Measurement

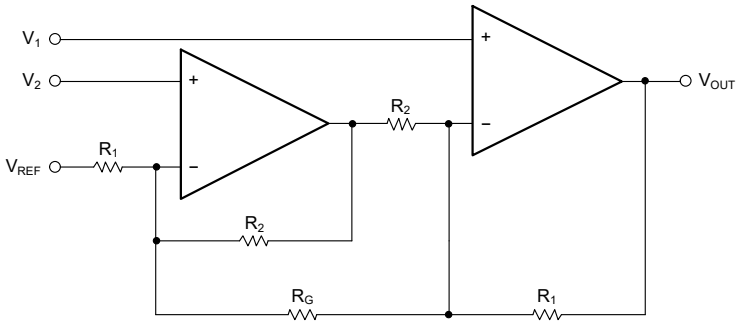


Figure 7. Low Power Instrumentation Amplifier Consisting of Two Operational Amplifiers

REVISION HISTORY

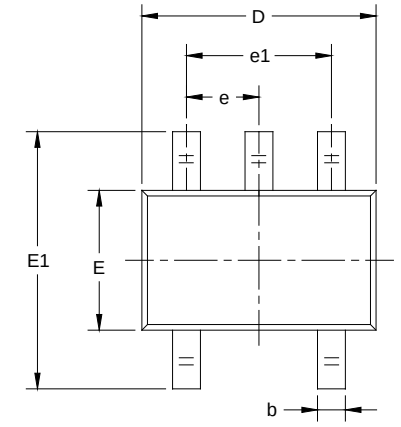
NOTE: Page numbers for previous revisions may differ from page numbers in the current version.

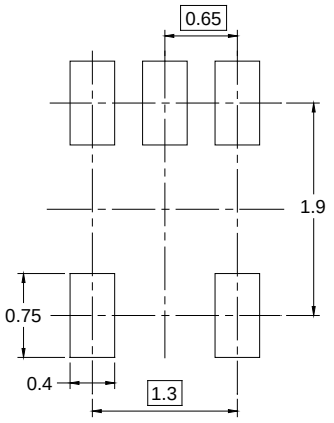
AUGUST 2023 – REV.A to REV.A.1	Page
Updated Typical Performance Characteristics section	7
Updated Package Outline Dimensions section	13

Changes from Original (DECEMBER 2016) to REV.A	Page
Changed from product preview to production data	All

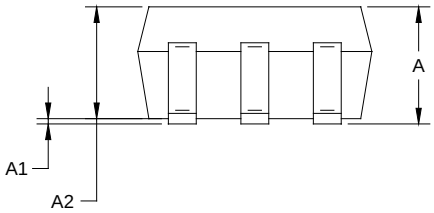
PACKAGE OUTLINE DIMENSIONS

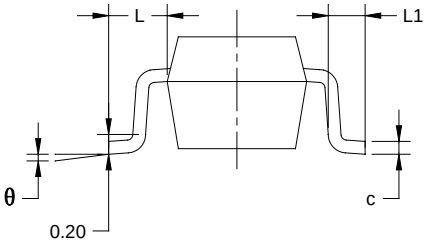
SC70-5





RECOMMENDED LAND PATTERN (Unit: mm)



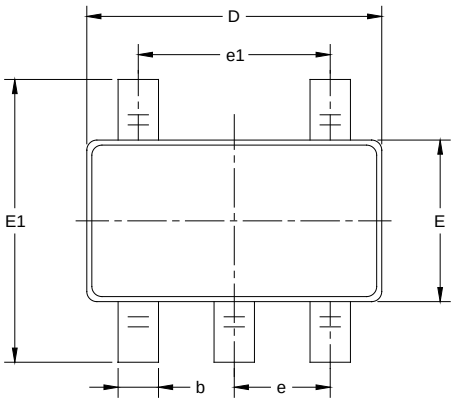


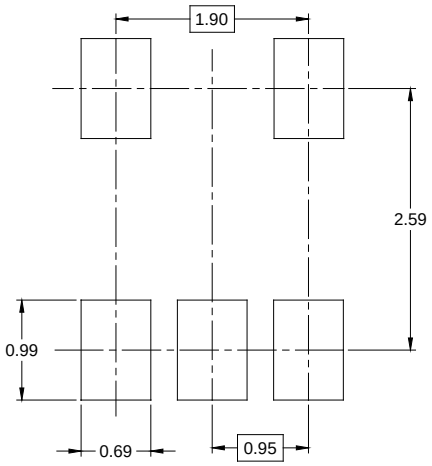
Symbol	Dimensions In Millimeters		Dimensions In Inches	
	MIN	MAX	MIN	MAX
A	0.800	1.100	0.031	0.043
A1	0.000	0.100	0.000	0.004
A2	0.800	1.000	0.031	0.039
b	0.150	0.350	0.006	0.014
c	0.080	0.220	0.003	0.009
D	2.000	2.200	0.079	0.087
E	1.150	1.350	0.045	0.053
E1	2.150	2.450	0.085	0.096
e	0.65 TYP		0.026 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 mode flash or protrusion.
2. This drawing is subject to change without notice.

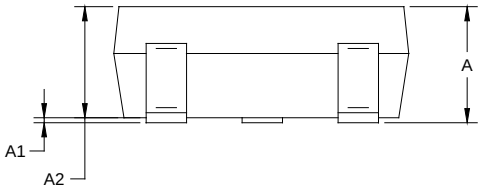
PACKAGE OUTLINE DIMENSIONS

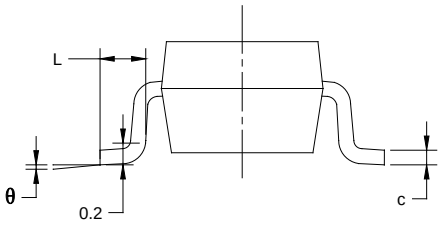
SOT-23-5





RECOMMENDED LAND PATTERN (Unit: mm)



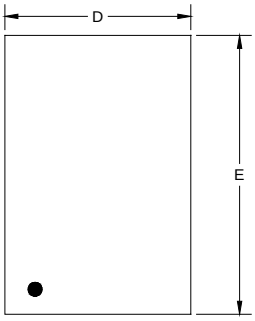


Symbol	Dimensions In Millimeters		Dimensions In Inches	
	MIN	MAX	MIN	MAX
A	1.050	1.250	0.041	0.049
A1	0.000	0.100	0.000	0.004
A2	1.050	1.150	0.041	0.045
b	0.300	0.500	0.012	0.020
c	0.100	0.200	0.004	0.008
D	2.820	3.020	0.111	0.119
E	1.500	1.700	0.059	0.067
E1	2.650	2.950	0.104	0.116
e	0.950 BSC		0.037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

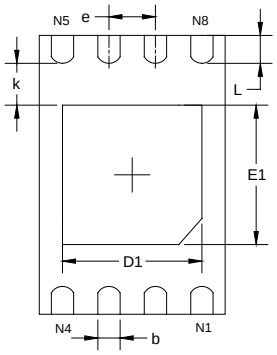
NOTES:
1. Body dimensions do not include mode flash or protrusion.
2. This drawing is subject to change without notice.

PACKAGE OUTLINE DIMENSIONS

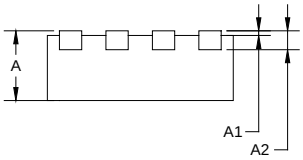
TDFN-2×3-8L



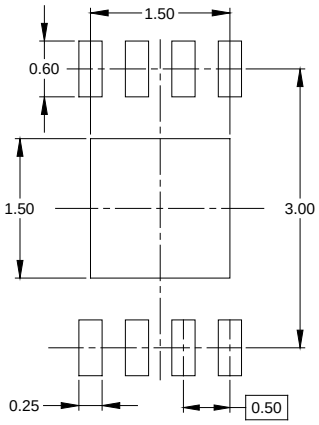
TOP VIEW



BOTTOM VIEW



SIDE VIEW



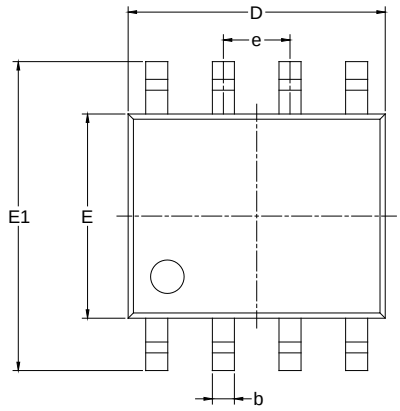
RECOMMENDED LAND PATTERN (Unit: mm)

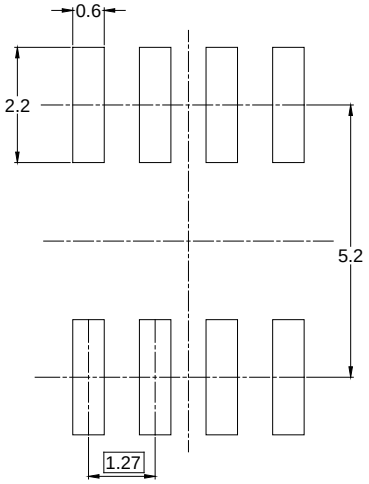
Symbol	Dimensions In Millimeters		Dimensions In Inches	
	MIN	MAX	MIN	MAX
A	0.700	0.800	0.028	0.031
A1	0.000	0.050	0.000	0.002
A2	0.203 REF		0.008 REF	
D	1.924	2.076	0.076	0.082
D1	1.400	1.600	0.055	0.063
E	2.924	3.076	0.115	0.121
E1	1.400	1.600	0.055	0.063
k	0.200 MIN		0.008 MIN	
b	0.200	0.300	0.008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

NOTE: This drawing is subject to change without notice.

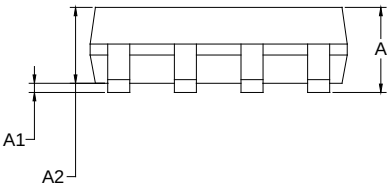
PACKAGE OUTLINE DIMENSIONS

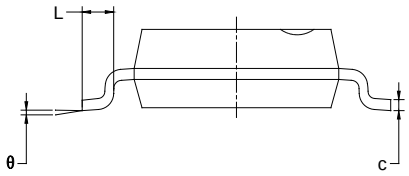
SOIC-8





RECOMMENDED LAND PATTERN (Unit: mm)



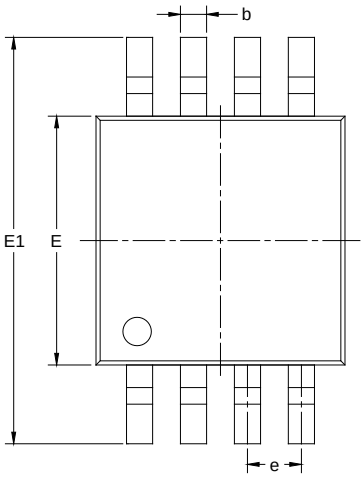


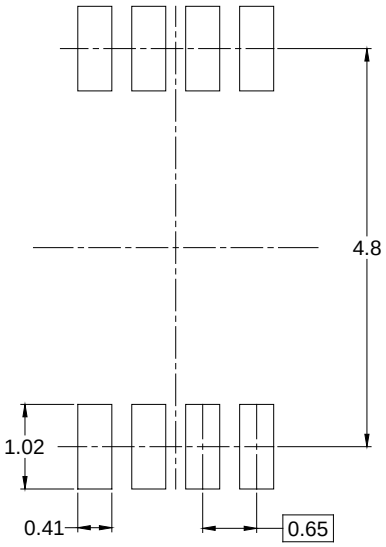
Symbol	Dimensions In Millimeters		Dimensions In Inches	
	MIN	MAX	MIN	MAX
A	1.350	1.750	0.053	0.069
A1	0.100	0.250	0.004	0.010
A2	1.350	1.550	0.053	0.061
b	0.330	0.510	0.013	0.020
c	0.170	0.250	0.006	0.010
D	4.700	5.100	0.185	0.200
E	3.800	4.000	0.150	0.157
E1	5.800	6.200	0.228	0.244
e	1.27 BSC		0.050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

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

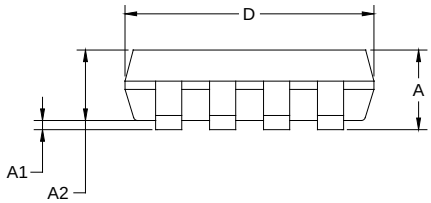
PACKAGE OUTLINE DIMENSIONS

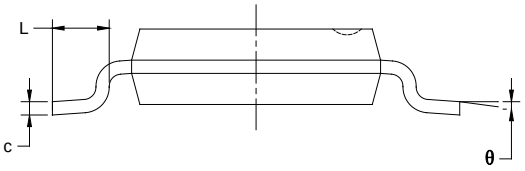
MSOP-8





RECOMMENDED LAND PATTERN (Unit: mm)



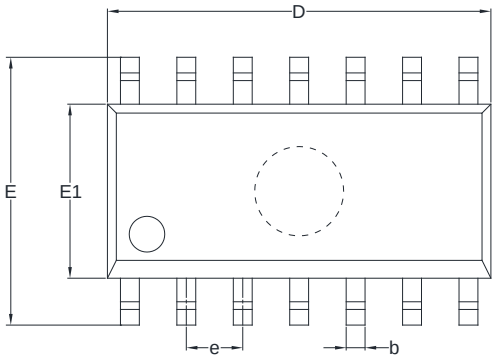


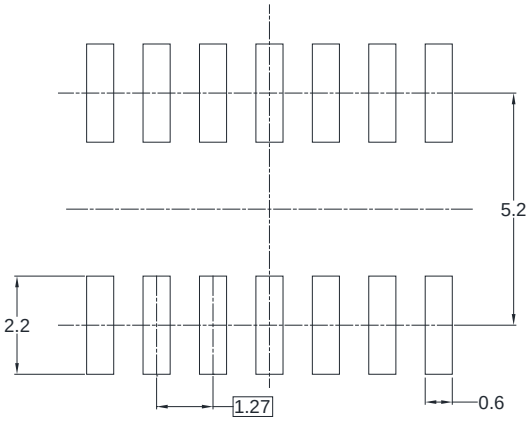
Symbol	Dimensions In Millimeters		Dimensions In Inches	
	MIN	MAX	MIN	MAX
A	0.820	1.100	0.032	0.043
A1	0.020	0.150	0.001	0.006
A2	0.750	0.950	0.030	0.037
b	0.250	0.380	0.010	0.015
c	0.090	0.230	0.004	0.009
D	2.900	3.100	0.114	0.122
E	2.900	3.100	0.114	0.122
E1	4.750	5.050	0.187	0.199
e	0.650 BSC		0.026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

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

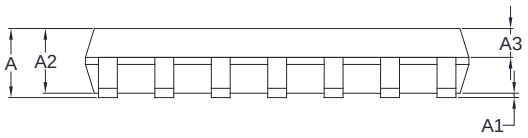
PACKAGE OUTLINE DIMENSIONS

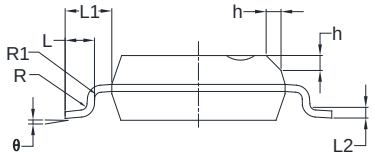
SOIC-14





RECOMMENDED LAND PATTERN (Unit: mm)



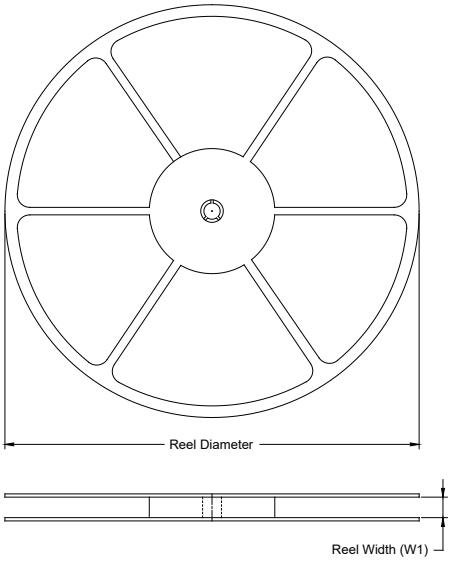


Symbol	Dimensions In Millimeters		Dimensions In Inches	
	MIN	MAX	MIN	MAX
A	1.35	1.75	0.053	0.069
A1	0.10	0.25	0.004	0.010
A2	1.25	1.65	0.049	0.065
A3	0.55	0.75	0.022	0.030
b	0.36	0.49	0.014	0.019
D	8.53	8.73	0.336	0.344
E	5.80	6.20	0.228	0.244
E1	3.80	4.00	0.150	0.157
e	1.27 BSC		0.050 BSC	
L	0.45	0.80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

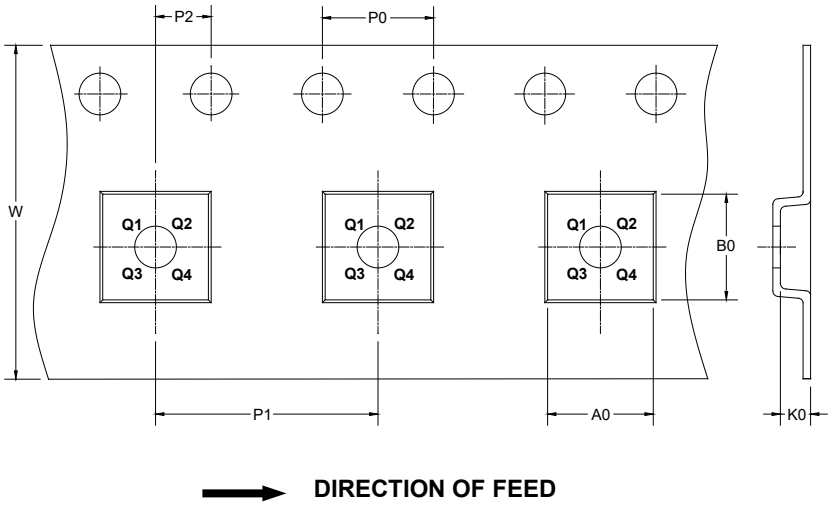
NOTES:
1. Body dimensions do not include mode flash or protrusion.
2. This drawing is subject to change without notice.

TAPE AND REEL INFORMATION

REEL DIMENSIONS



TAPE DIMENSIONS



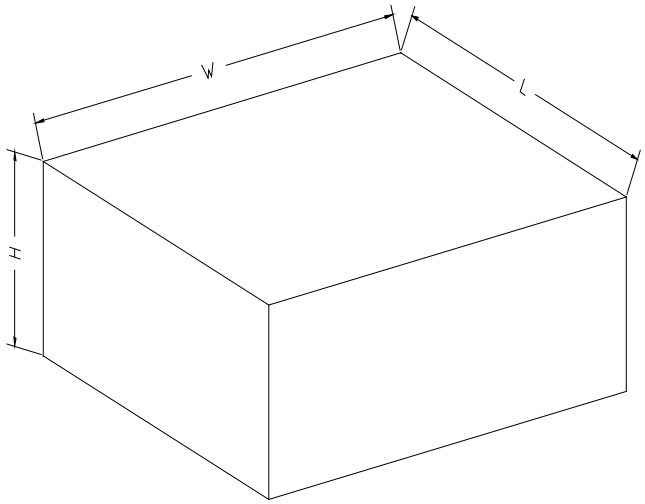
NOTE: The picture is only for reference. Please make the object as the standard.

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

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