SGM321/SGM358/SGM324 1MHz, 60μA, Rail-to-Rail I/O CMOS Operational Amplifiers

GENERAL DESCRIPTION

The SGM321 (single), SGM358 (dual) and SGM324 (quad) are low cost, voltage feedback amplifiers. These devices can operate from 2.1V to 5.5V single supply, and consume only 60μA quiescent current per amplifier. They provide rail-to-rail input with a wide input common mode voltage range and rail-to-rail output voltage swing. This feature makes SGM321/358/324 appropriate for buffering ASIC.

The SGM321/358/324 offer a gain-bandwidth product of 1MHz and an ultra-low input bias current of 10pA. They are well suited for piezoelectric sensors, integrators and photodiode amplifiers.

The SGM321/358/324 are designed into a wide range of applications, such as battery-powered instrumentation, safety monitoring, portable systems, and transducer interface circuits in low power systems.

The SGM321 is available in Green SOT-23-5 and SC70-5 packages. The SGM358 is available in Green SOIC-8, MSOP-8 and DIP-8 packages. The SGM324 is available in Green TSSOP-14 and SOIC-14 packages. They are specified over the extended industrial temperature range (-40℃ to +85℃).

FEATURES

- **Low Cost**
- **Input Offset Voltage: 5mV (MAX)**
- **Ultra-Low Input Bias Current: 10pA (TYP)**
- **Unity-Gain Stable**
- **Gain-Bandwidth Product: 1MHz**
- **Rail-to-Rail Input and Output**
- **Supply Voltage Range: 2.1V to 5.5V**
- **Input Voltage Range:**
  -0.1V to 5.6V with V_S = 5.5V
- **Low Quiescent Current: 60μA/Amplifier (TYP)**
- **-40℃ to +85℃ Operating Temperature Range**
- **Small Packaging:**
  SGM321 Available in Green SOT-23-5 and SC70-5 Packages
  SGM358 Available in Green SOIC-8, MSOP-8 and DIP-8 Packages
  SGM324 Available in Green SOIC-14 and TSSOP-14 Packages

APPLICATIONS

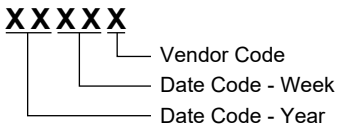
ASIC Input or Output Amplifiers
Piezoelectric Transducer Amplifiers
Battery-Powered Equipment
Portable Equipment
Sensor Interfaces
Medical Instrumentation
Mobile Communications
Audio Outputs
Smoke Detectors
Mobile Telephones
Notebook PCs
PCMCIA Cards

PACKAGE/ORDERING INFORMATION

MODEL	PACKAGE DESCRIPTION	SPECIFIED TEMPERATURE RANGE	ORDERING NUMBER	PACKAGE MARKING	PACKING OPTION
SGM321	SC70-5	-40℃ to +85℃	SGM321YC5/TR	321	Tape and Reel, 3000
	SOT-23-5	-40℃ to +85℃	SGM321YN5/TR	321	Tape and Reel, 3000
	SOT-23-5	-40℃ to +85℃	SGM321BYN5/TR	321B	Tape and Reel, 3000
SGM358	SOIC-8	-40℃ to +85℃	SGM358YS/TR	SGM358YS XXXXX	Tape and Reel, 4000
	MSOP-8	-40℃ to +85℃	SGM358YMS/TR	SGM358 YMS XXXXX	Tape and Reel, 3000
	DIP-8	-40℃ to +85℃	SGM358YP	SGM358YP XXXXX	20 Tube (1000pcs)
SGM324	SOIC-14	-40℃ to +85℃	SGM324YS14/TR	SGM324YS14 XXXXX	Tape and Reel, 2500
	TSSOP-14	-40℃ to +85℃	SGM324YTS14/TR	SGM324 YTS14 XXXXX	Tape and Reel, 3000

MARKING INFORMATION

NOTE: 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, $+V_S$ to $-V_S$ 6V
Input Common Mode Voltage Range
..... $(-V_S)$ - 0.3V to $(+V_S)$ + 0.3V
Package Thermal Resistance @ T_A = +25℃
SC70-5, θ_{JA} ..... 333℃/W
SOT-23-5, θ_{JA} ..... 190℃/W
SOIC-8, θ_{JA} ..... 125℃/W
MSOP-8, θ_{JA} ..... 216℃/W
Junction Temperature ..... +150℃
Storage Temperature Range ..... -65℃ to +150℃
Lead Temperature (Soldering, 10s) ..... +260℃
ESD Susceptibility
HBM 4000V
MM 400V

RECOMMENDED OPERATING CONDITIONS

Operating Temperature Range ..... -40℃ to +85℃

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

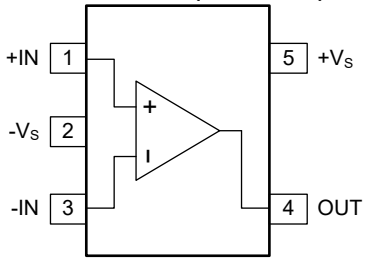
This integrated circuit can be damaged if ESD protections are not considered carefully. SGMICRO recommends that all integrated circuits be handled with appropriate precautions. Failure to observe proper handling and installation procedures can cause damage. ESD damage can range from subtle performance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

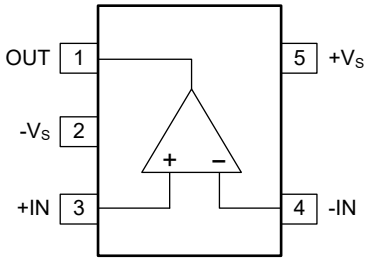
PIN CONFIGURATIONS

SGM321YN5/
SGM321YC5 (TOP VIEW)



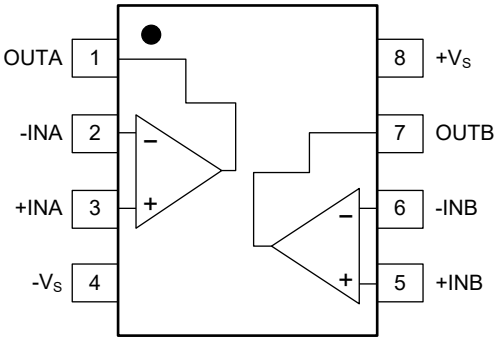
SOT-23-5/SC70-5

SGM321BYN5 (TOP VIEW)



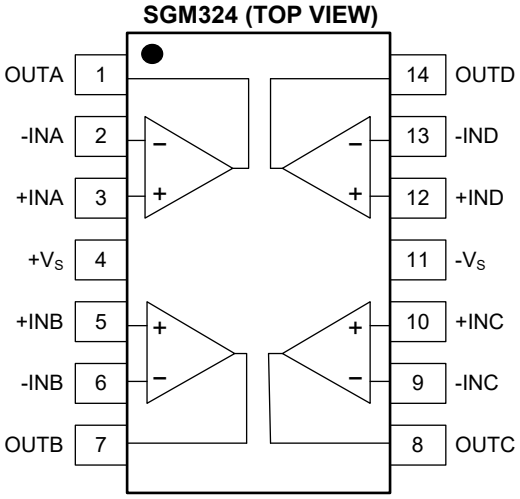
SOT-23-5

SGM358 (TOP VIEW)



SOIC-8/MSOP-8/DIP-8

SGM324 (TOP VIEW)



TSSOP-14/SOIC-14

ELECTRICAL CHARACTERISTICS

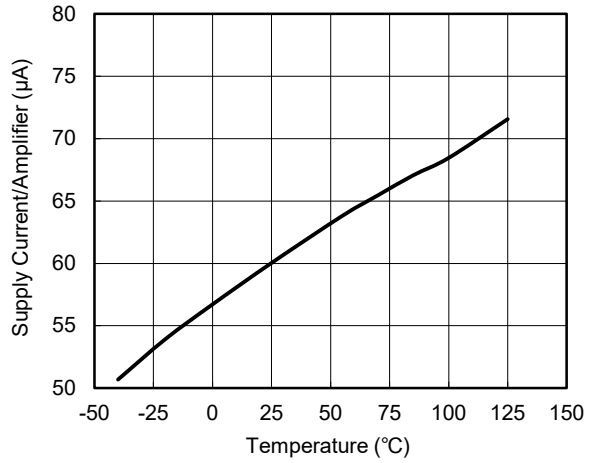
(At V_S = 5V, R_L = 100kΩ connected to V_S/2, and V_{OUT} = V_S/2, unless otherwise noted.)

PARAMETER	SYMBOL	CONDITIONS	SGM321/358/324				
			TYP	MIN/MAX OVER TEMPERATURE			
			+25℃	+25℃	-40℃ to +85℃	UNITS	MIN/MAX
Input Characteristics							
Input Offset Voltage	V_{OS}	V_{CM} = V_S/2	0.8	5	5.6	mV	MAX
Input Bias Current	I_B		10			pA	TYP
Input Offset Current	I_{OS}		10			pA	TYP
Input Common Mode Voltage Range	V_{CM}	V_S = 5.5V	-0.1 to 5.6			V	TYP
Common Mode Rejection Ratio	CMRR	V_S = 5.5V, V_{CM} = -0.1V to 4V	70	62	62	dB	MIN
		V_S = 5.5V, V_{CM} = -0.1V to 5.6V	68	56	55		
Open-Loop Voltage Gain	A_{OL}	R_L = 5kΩ, V_{OUT} = 0.1V to 4.9V	80	70	70	dB	MIN
		R_L = 100kΩ, V_{OUT} = 0.035V to 4.965V	84	80	80		
Input Offset Voltage Drift	$\Delta V_{OS}/\Delta T$		2.7			μV/℃	TYP
Output Characteristics							
Output Voltage Swing from Rail	V_{OH}	R_L = 100kΩ	4.997	4.980	4.970	V	MIN
	V_{OL}	R_L = 100kΩ	5	20	30	mV	MAX
	V_{OH}	R_L = 10kΩ	4.992	4.970	4.960	V	MIN
	V_{OL}	R_L = 10kΩ	8	30	40	mV	MAX
Output Current	I_{SOURCE}	R_L = 10Ω to V_S/2	84	60	45	mA	MIN
	I_{SINK}		75	60	45		
Power Supply							
Operating Voltage Range				2.1	2.5	V	MIN
				5.5	5.5	V	MAX
Power Supply Rejection Ratio	PSRR	V_S = 2.5V to 5.5V, V_{CM} = 0.5V	82	60	58	dB	MIN
Quiescent Current/Amplifier	I_Q		60	80	86	μA	MAX
Dynamic Performance (C_L = 100pF)							
Gain-Bandwidth Product	GBP		1			MHz	TYP
Slew Rate	SR	G = +1, 2V output step	0.52			V/μs	TYP
Settling Time to 0.1%	t_S	G = +1, 2V output step	5.3			μs	TYP
Overload Recovery Time		V_{IN} ·G = V_S	2.6			μs	TYP
Noise Performance							
Input Voltage Noise Density	e_n	f = 1kHz	27			$nV/\sqrt{Hz}$	TYP
		f = 10kHz	20			$nV/\sqrt{Hz}$	TYP

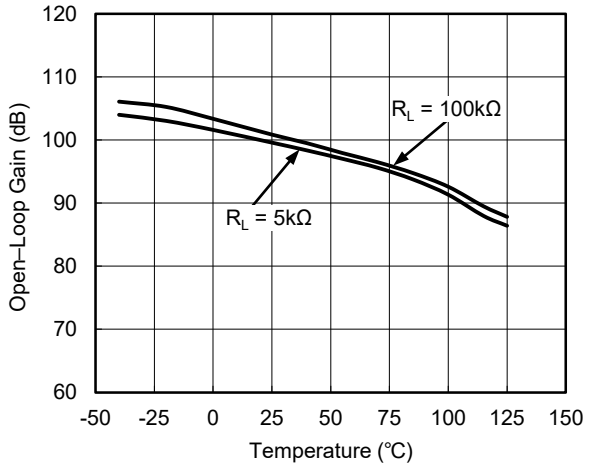
TYPICAL PERFORMANCE CHARACTERISTICS

At T_A = +25℃, V_S = 5V, and R_L = 100kΩ connected to V_S/2, unless otherwise noted.

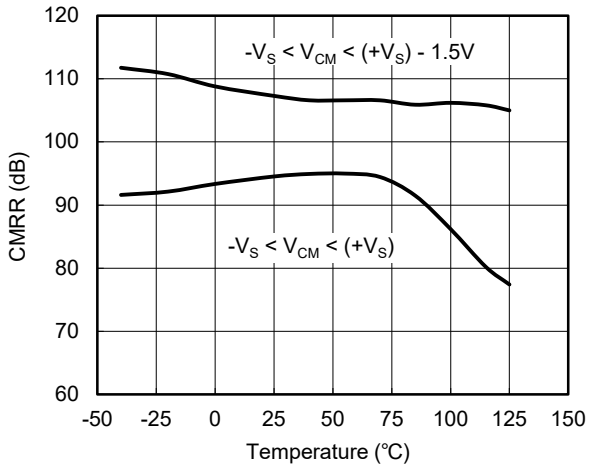
Supply Current vs. Temperature



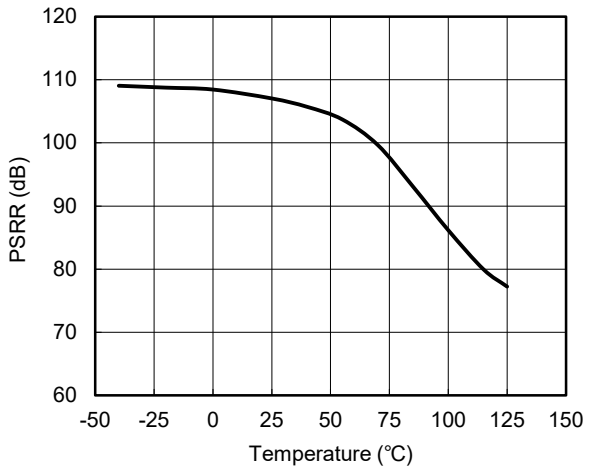
Open-Loop Gain vs. Temperature



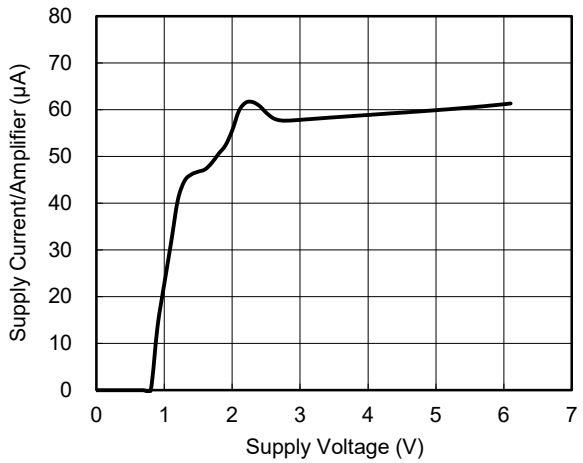
Common Mode Rejection Ratio vs. Temperature



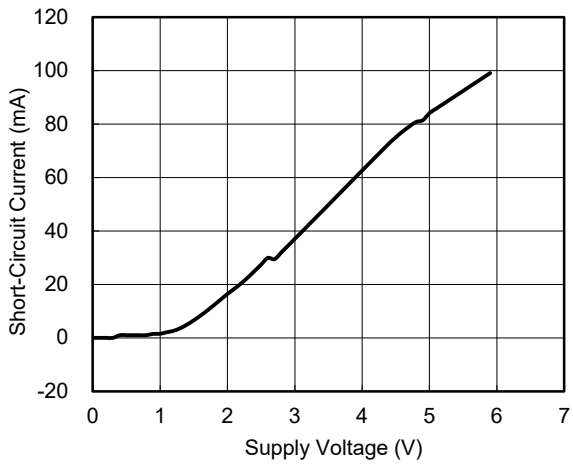
Power Supply Rejection Ratio vs. Temperature



Supply Current vs. Supply Voltage



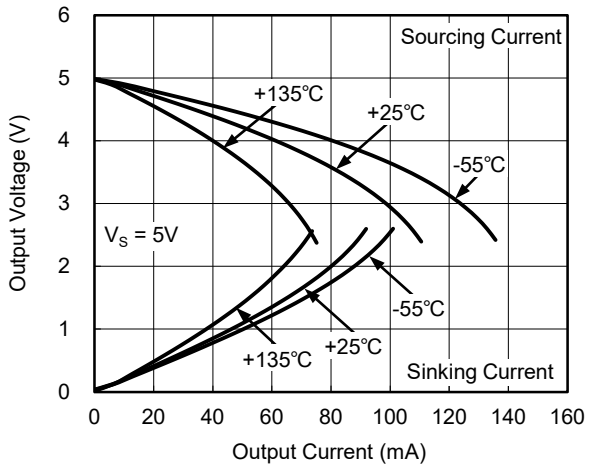
Short-Circuit Current vs. Supply Voltage



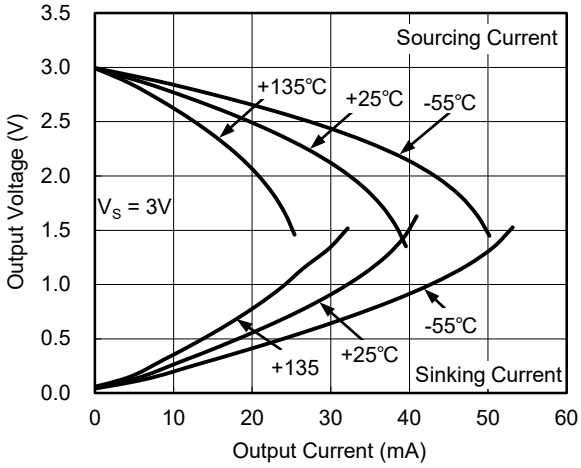
TYPICAL PERFORMANCE CHARACTERISTICS (continued)

At T_A = +25℃, V_S = 5V, and R_L = 100kΩ connected to V_S/2, unless otherwise noted.

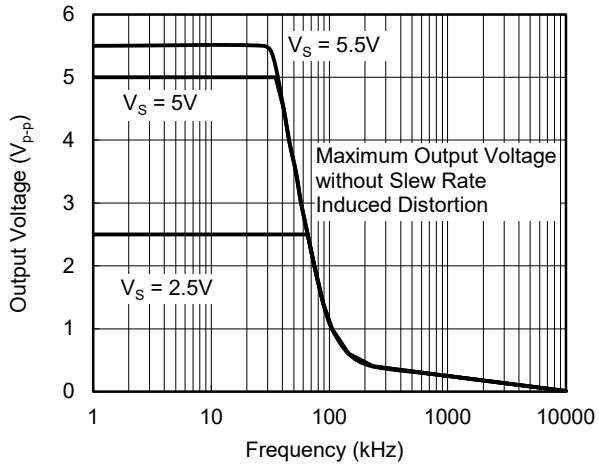
Output Voltage Swing vs. Output Current



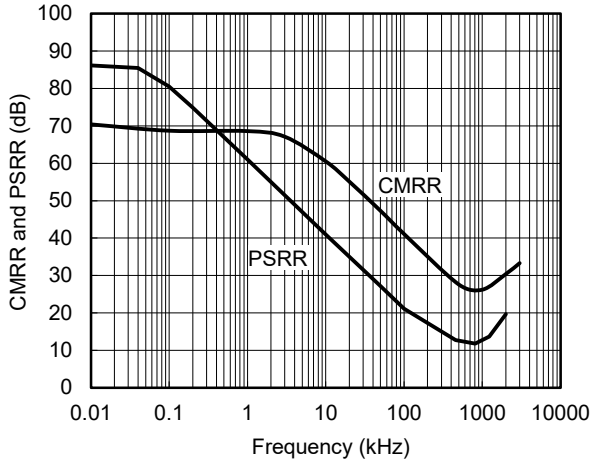
Output Voltage Swing vs. Output Current



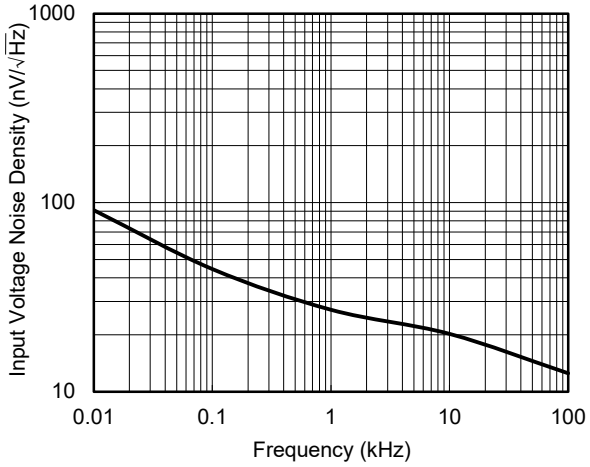
Maximum Output Voltage vs. Frequency



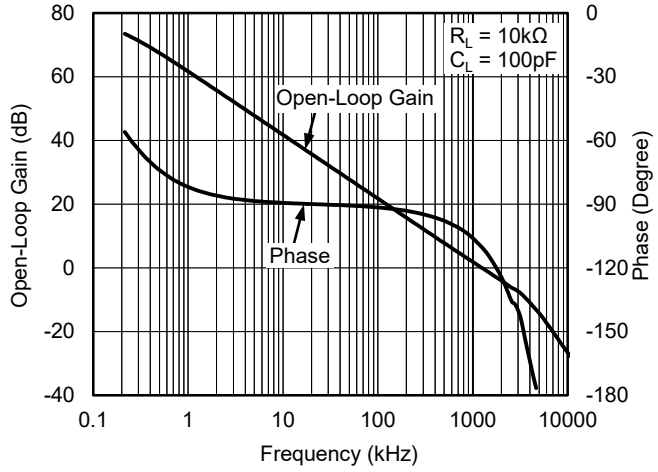
CMRR and PSRR vs. Frequency



Input Voltage Noise Density vs. Frequency



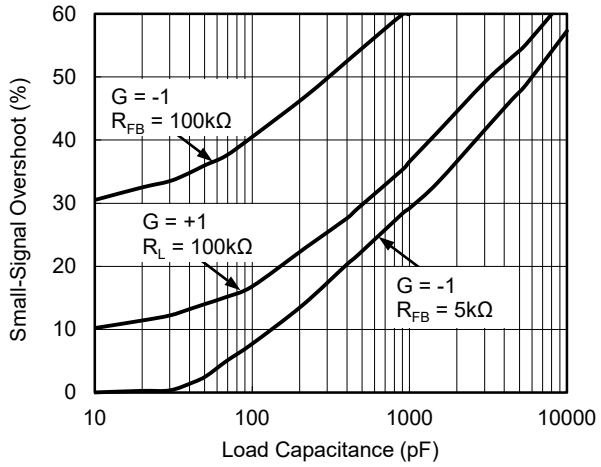
Open-Loop Gain and Phase vs. Frequency



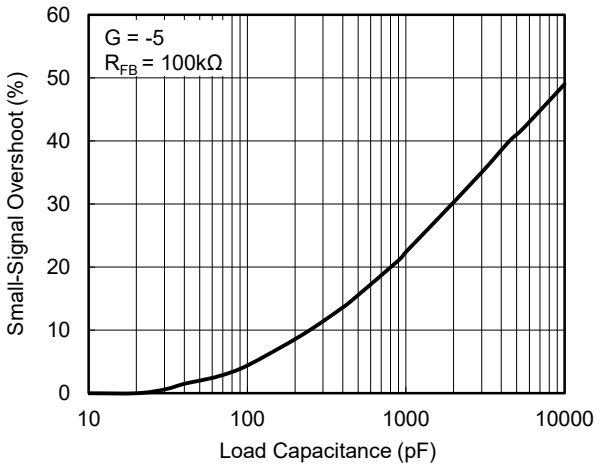
TYPICAL PERFORMANCE CHARACTERISTICS (continued)

At T_A = +25℃, V_S = 5V, and R_L = 100kΩ connected to V_S/2, unless otherwise noted.

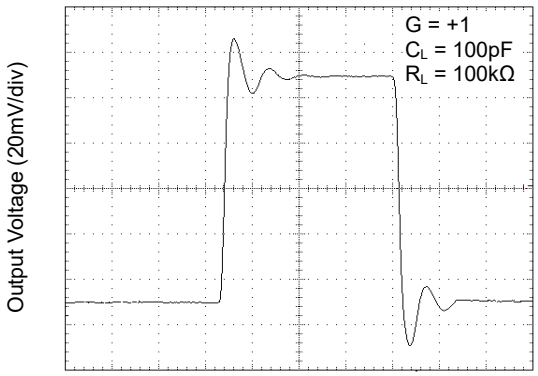
Small-Signal Overshoot vs. Load Capacitance



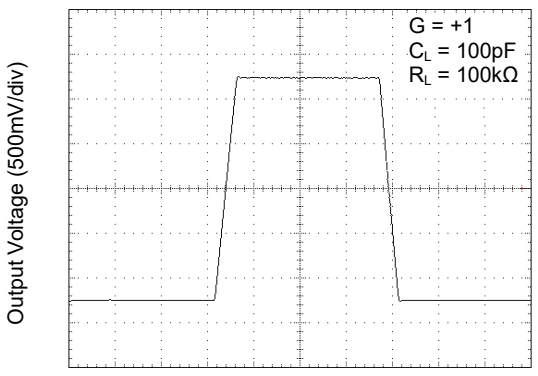
Small-Signal Overshoot vs. Load Capacitance



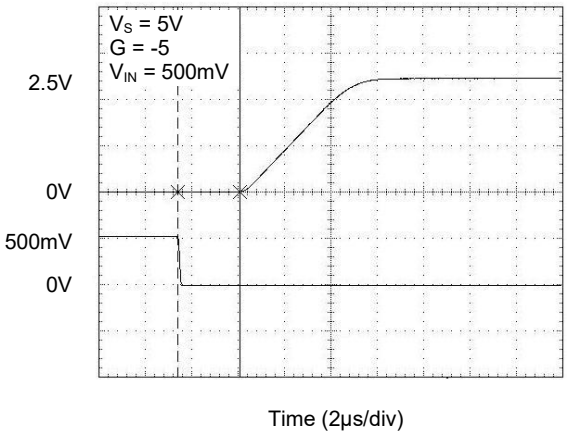
Small-Signal Step Response



Large-Signal Step Response



Overload Recovery Time



APPLICATION INFORMATION

Rail-to-Rail Input

When SGM321/SGM358/SGM324 work at the power supply between 2.1V and 5.5V, the input common mode voltage range is from ($-V_S$) - 0.1V to ($+V_S$) + 0.1V. In Figure 1, the ESD diodes between the inputs and the power supply rails will clamp the input voltage not to exceed the rails.

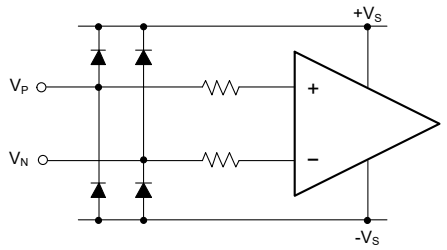


Figure 1. Input Equivalent Circuit

Rail-to-Rail Output

The SGM321/SGM358/SGM324 support rail-to-rail output operation. In single power supply application, for example, when $+V_S$ = 5V, $-V_S$ = GND, 100kΩ load resistor is tied from OUT pin to V_S/2, the typical output swing range is from 0.005V to 4.997V.

Driving Capacitive Loads

The SGM321/SGM358/SGM324 are designed for driving the 250pF capacitive load with unity-gain stable. If greater capacitive load must be driven in application, the circuit in Figure 2 can be used. In this circuit, the IR drop voltage generated by R_{ISO} is compensated by feedback loop.

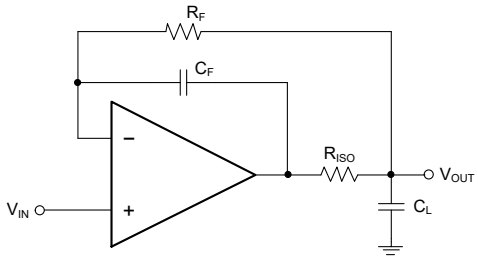


Figure 2. Circuit to Drive Heavy Capacitive Load

Power Supply Decoupling and Layout

A clean and low noise power supply is very important in amplifier circuit design, besides of input signal noise, the power supply is one of important source of noise to the amplifiers through $+V_S$ and $-V_S$ pins. Power supply bypassing is an effective method to clear up the noise at power supply, and the low impedance path to ground of decoupling capacitor will bypass the noise to GND. In application, 10μF ceramic capacitor paralleled with 0.1μF or 0.01μF ceramic capacitor is used in Figure 3. The ceramic capacitors should be placed as close as possible to $+V_S$ and $-V_S$ power supply pins.

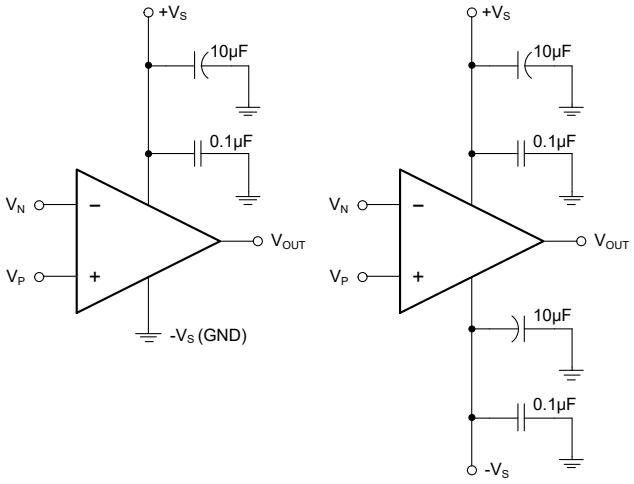


Figure 3. Amplifier Power Supply Bypassing

APPLICATION INFORMATION (continued)

Typical Application Circuits

Difference Amplifier

The circuit in Figure 4 is a design example of classical difference amplifier. If $R_4/R_3 = R_2/R_1$, then $V_{OUT} = (V_P - V_N) \times R_2/R_1 + V_{REF}$.

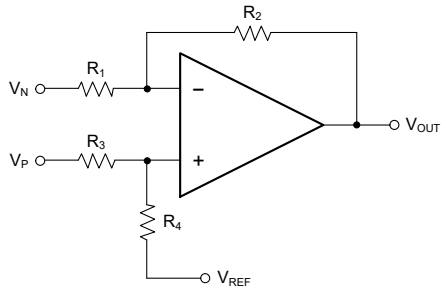


Figure 4. Difference Amplifier

High Input Impedance Difference Amplifier

The circuit in Figure 5 is a design example of high input impedance difference amplifier, the added amplifiers at the input are used to increase the input impedance and eliminate drawback of low input impedance in Figure 4.

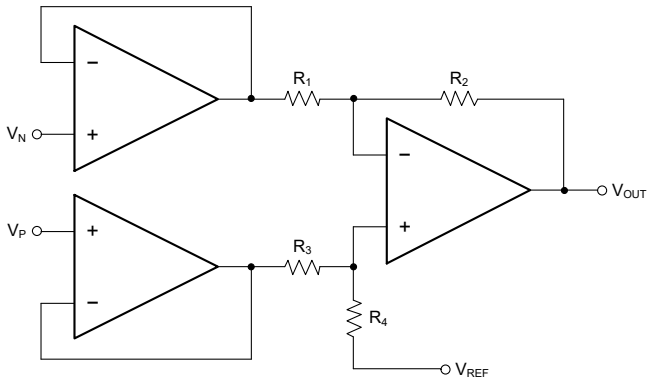


Figure 5. High Input Impedance Difference Amplifier

Active Low-Pass Filter

The circuit in Figure 6 is a design example of active low-pass filter, the DC gain is equal to $-R_2/R_1$ and the -3dB corner frequency is equal to $1/2\pi R_2 C$. In this design, the filter bandwidth must be less than the bandwidth of the amplifier, the resistor values must be selected as low as possible to reduce ringing or oscillation generated by the parasitic parameters in PCB layout.

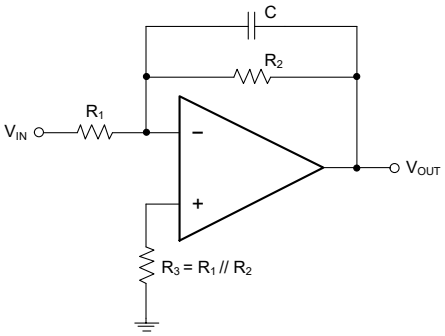


Figure 6. Active Low-Pass Filter

REVISION HISTORY

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

JULY 2023 – REV.E.2 to REV.E.3	Page
Updated Package Outline Dimensions section	12

APRIL 2019 – REV.E.1 to REV.E.2	Page
Added Open-Loop Gain and Phase vs. Frequency	6

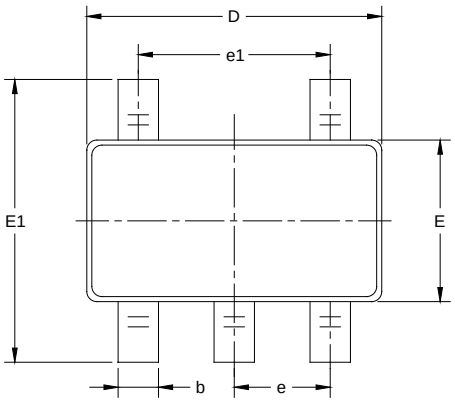
MARCH 2017 – REV.E to REV.E.1	Page
Updated Package/Ordering Information section	2

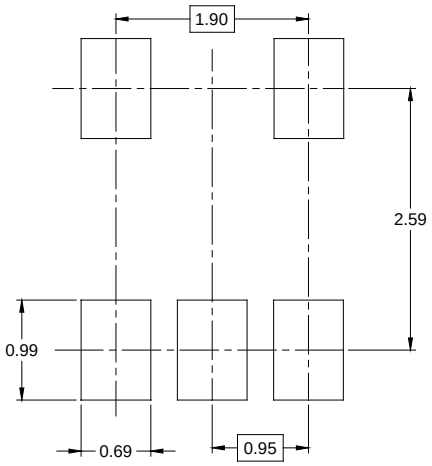
NOVEMBER 2015 – REV.D.4 to REV.E	Page
Updated Packing Option of DIP-8	2
Updated SOIC-14 and TSSOP-14 packages	14, 15

JANUARY 2013 – REV.D.3 to REV.D.4	Page
Added Tape and Reel Information section	16, 17

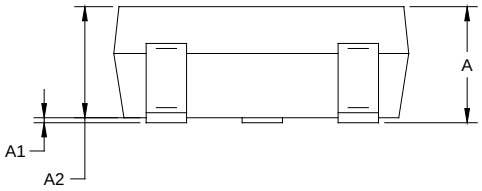
PACKAGE OUTLINE DIMENSIONS

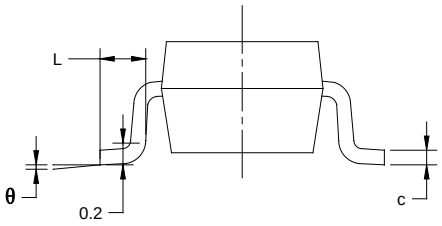
SOT-23-5





RECOMMENDED LAND PATTERN (Unit: mm)



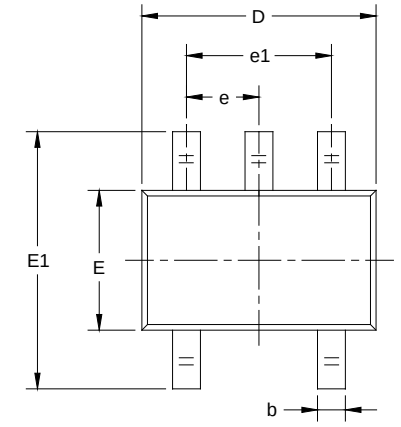


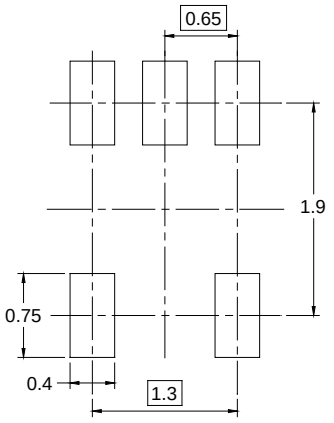
Symbol	Dimensions In Millimeters		Dimensions In Inches	
	MIN	MAX	MIN	MAX
A	1.050	1.250	0.041	0.049
A1	0.000	0.100	0.000	0.004
A2	1.050	1.150	0.041	0.045
b	0.300	0.500	0.012	0.020
c	0.100	0.200	0.004	0.008
D	2.820	3.020	0.111	0.119
E	1.500	1.700	0.059	0.067
E1	2.650	2.950	0.104	0.116
e	0.950 BSC		0.037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

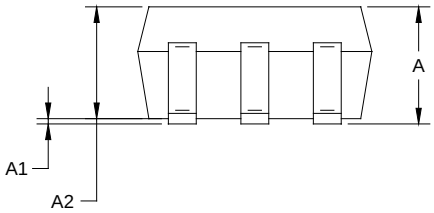
PACKAGE OUTLINE DIMENSIONS

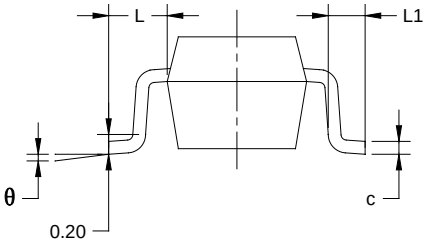
SC70-5





RECOMMENDED LAND PATTERN (Unit: mm)



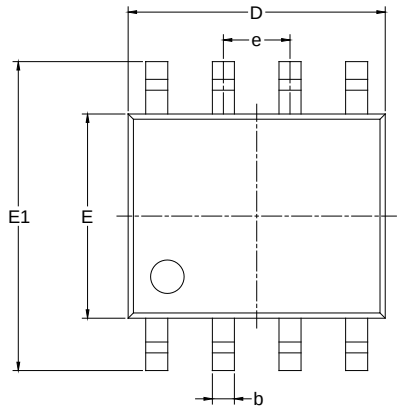


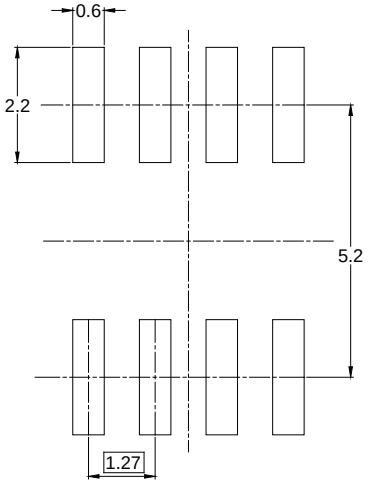
Symbol	Dimensions In Millimeters		Dimensions In Inches	
	MIN	MAX	MIN	MAX
A	0.800	1.100	0.031	0.043
A1	0.000	0.100	0.000	0.004
A2	0.800	1.000	0.031	0.039
b	0.150	0.350	0.006	0.014
c	0.080	0.220	0.003	0.009
D	2.000	2.200	0.079	0.087
E	1.150	1.350	0.045	0.053
E1	2.150	2.450	0.085	0.096
e	0.65 TYP		0.026 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.

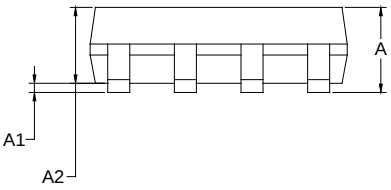
PACKAGE OUTLINE DIMENSIONS

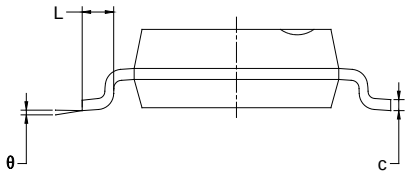
SOIC-8





RECOMMENDED LAND PATTERN (Unit: mm)



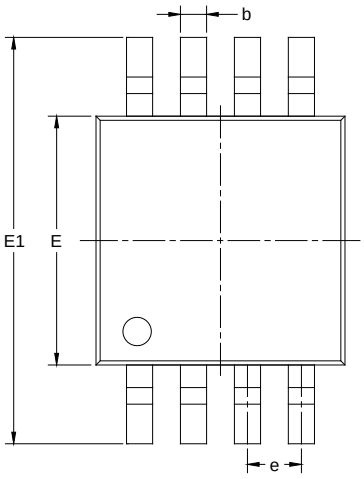


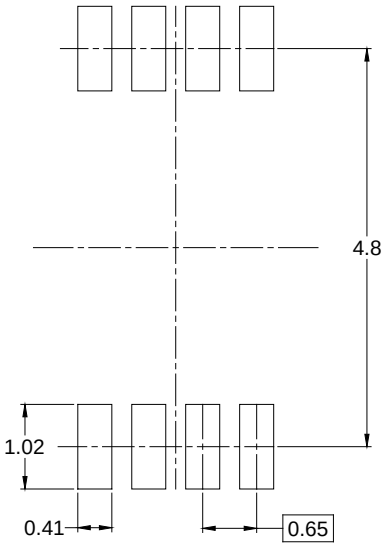
Symbol	Dimensions In Millimeters		Dimensions In Inches	
	MIN	MAX	MIN	MAX
A	1.350	1.750	0.053	0.069
A1	0.100	0.250	0.004	0.010
A2	1.350	1.550	0.053	0.061
b	0.330	0.510	0.013	0.020
c	0.170	0.250	0.006	0.010
D	4.700	5.100	0.185	0.200
E	3.800	4.000	0.150	0.157
E1	5.800	6.200	0.228	0.244
e	1.27 BSC		0.050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

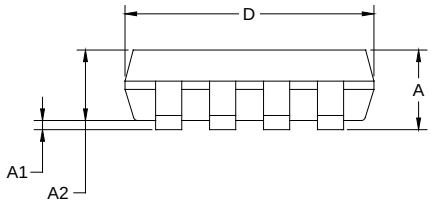
PACKAGE OUTLINE DIMENSIONS

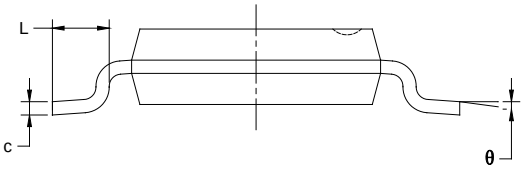
MSOP-8





RECOMMENDED LAND PATTERN (Unit: mm)



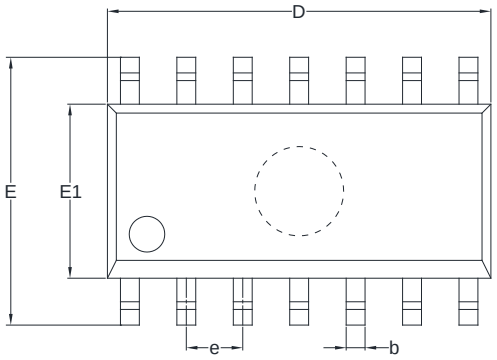


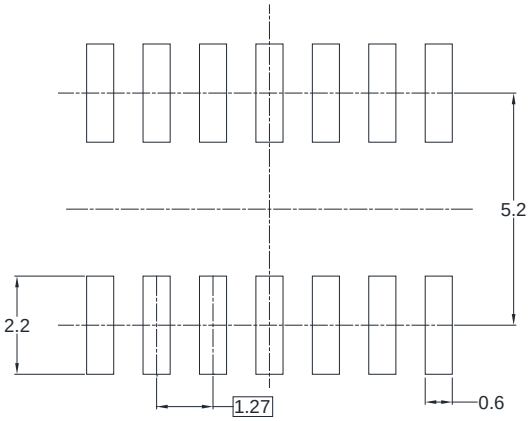
Symbol	Dimensions In Millimeters		Dimensions In Inches	
	MIN	MAX	MIN	MAX
A	0.820	1.100	0.032	0.043
A1	0.020	0.150	0.001	0.006
A2	0.750	0.950	0.030	0.037
b	0.250	0.380	0.010	0.015
c	0.090	0.230	0.004	0.009
D	2.900	3.100	0.114	0.122
E	2.900	3.100	0.114	0.122
E1	4.750	5.050	0.187	0.199
e	0.650 BSC		0.026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

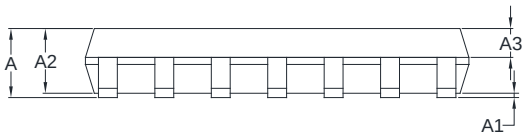
PACKAGE OUTLINE DIMENSIONS

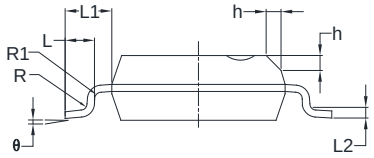
SOIC-14





RECOMMENDED LAND PATTERN (Unit: mm)



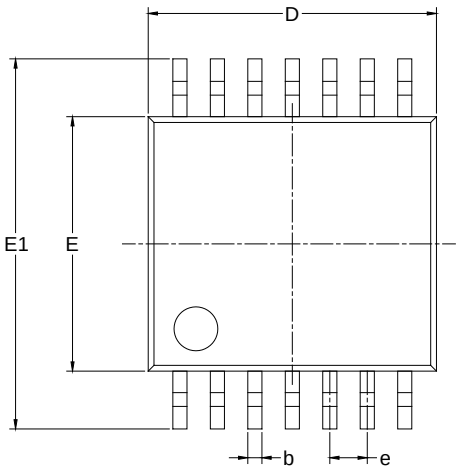


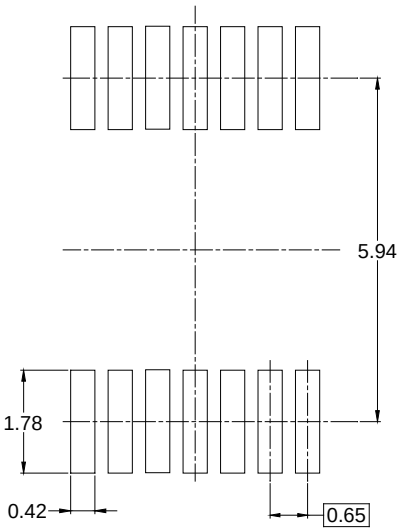
Symbol	Dimensions In Millimeters		Dimensions In Inches	
	MIN	MAX	MIN	MAX
A	1.35	1.75	0.053	0.069
A1	0.10	0.25	0.004	0.010
A2	1.25	1.65	0.049	0.065
A3	0.55	0.75	0.022	0.030
b	0.36	0.49	0.014	0.019
D	8.53	8.73	0.336	0.344
E	5.80	6.20	0.228	0.244
E1	3.80	4.00	0.150	0.157
e	1.27 BSC		0.050 BSC	
L	0.45	0.80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

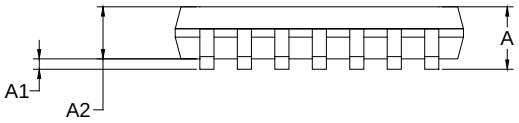
PACKAGE OUTLINE DIMENSIONS

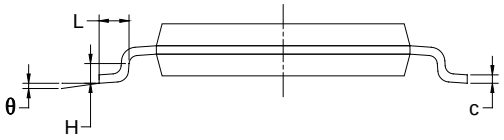
TSSOP-14





RECOMMENDED LAND PATTERN (Unit: mm)



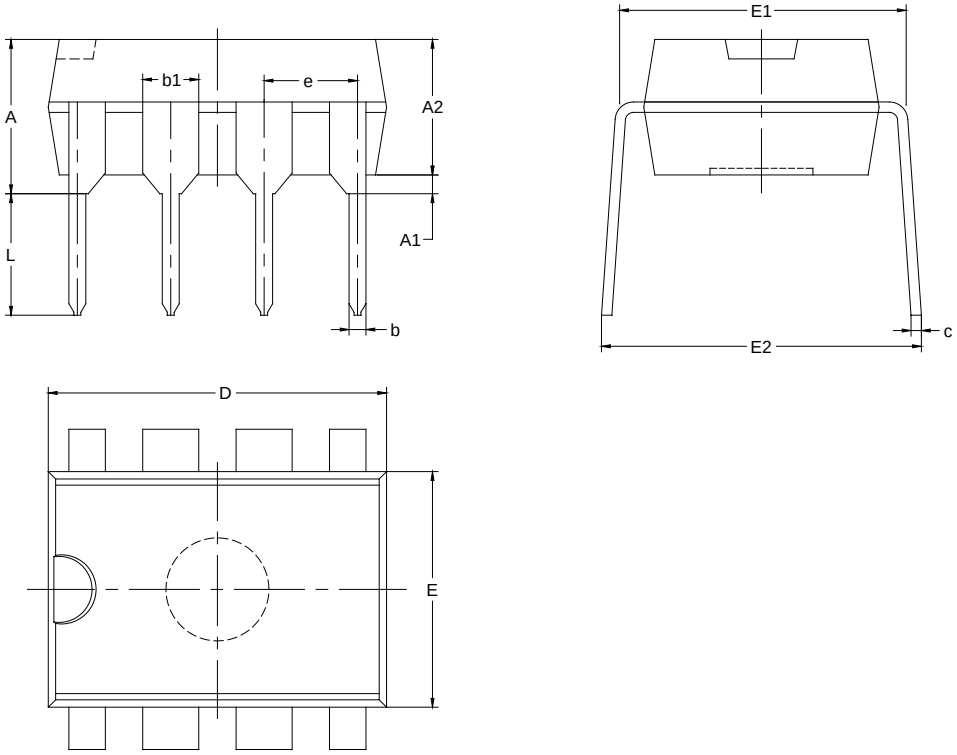


Symbol	Dimensions In Millimeters		Dimensions In Inches	
	MIN	MAX	MIN	MAX
A		1.200		0.047
A1	0.050	0.150	0.002	0.006
A2	0.800	1.050	0.031	0.041
b	0.190	0.300	0.007	0.012
c	0.090	0.200	0.004	0.008
D	4.860	5.100	0.191	0.201
E	4.300	4.500	0.169	0.177
E1	6.250	6.550	0.246	0.258
e	0.650 BSC		0.026 BSC	
L	0.500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

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

PACKAGE OUTLINE DIMENSIONS

DIP-8

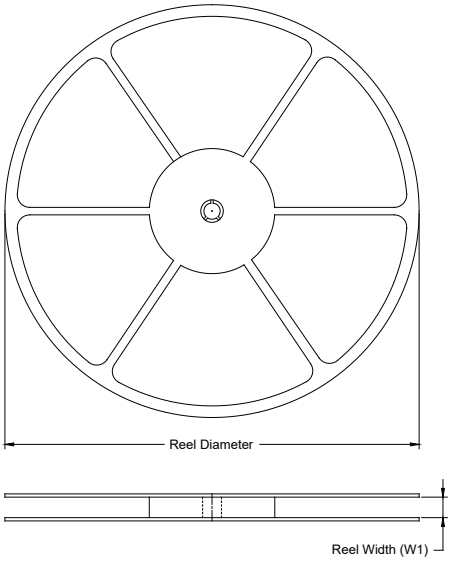


Symbol	Dimensions In Millimeters		Dimensions In Inches	
	MIN	MAX	MIN	MAX
A	3.710	4.310	0.146	0.170
A1	0.510		0.020	
A2	3.200	3.600	0.126	0.142
b	0.380	0.570	0.015	0.022
b1	1.524 BSC		0.060 BSC	
c	0.204	0.360	0.008	0.014
D	9.000	9.400	0.354	0.370
E	6.200	6.600	0.244	0.260
E1	7.320	7.920	0.288	0.312
e	2.540 BSC		0.100 BSC	
L	3.000	3.600	0.118	0.142
E2	8.400	9.000	0.331	0.354

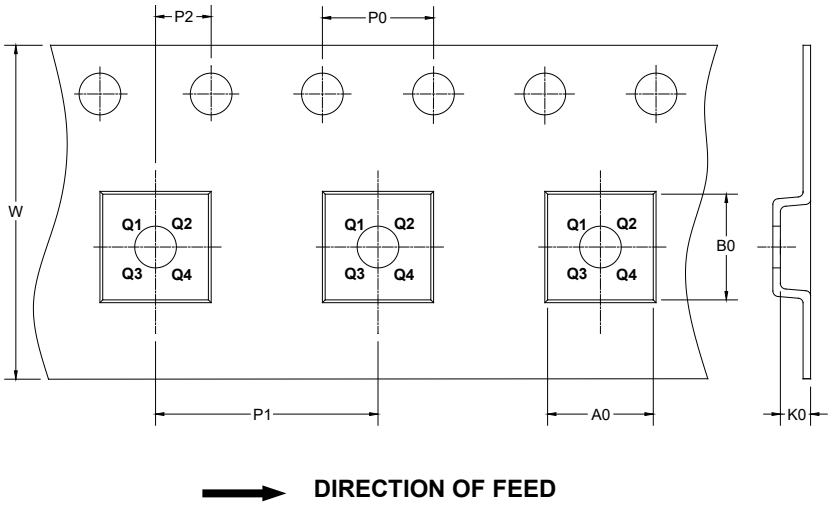
NOTES:
1. Body dimensions do not include mode flash or protrusion.
2. This drawing is subject to change without notice.

TAPE AND REEL INFORMATION

REEL DIMENSIONS



TAPE DIMENSIONS



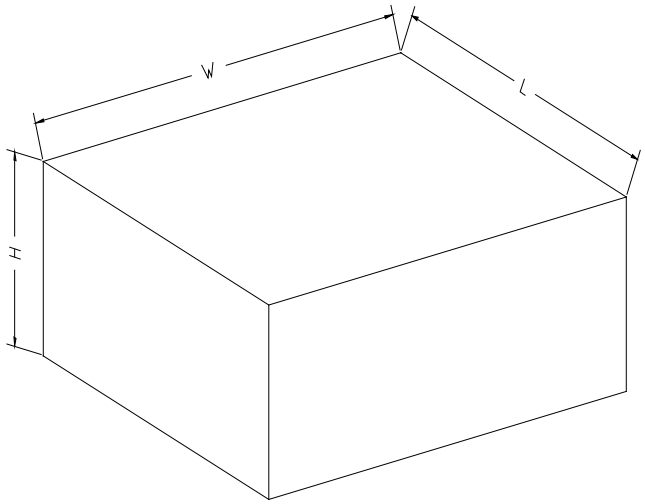
NOTE: The picture is only for reference. Please make the object as the standard.

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
SOT-23-5	7″	9.5	3.20	3.20	1.40	4.0	4.0	2.0	8.0	Q3
SC70-5	7″	9.5	2.40	2.50	1.20	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
SOIC-14	13″	16.4	6.60	9.30	2.10	4.0	8.0	2.0	16.0	Q1
TSSOP-14	13″	12.4	6.40	5.40	1.50	4.0	8.0	2.0	12.0	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