



# SGM8541/SGM8542/SGM8544 1.1MHz, 46 $\mu$ A, Rail-to-Rail I/O, CMOS Operational Amplifiers

## GENERAL DESCRIPTION

The SGM8541 (single), SGM8542 (dual) and SGM8544 (quad) are low cost, voltage feedback amplifiers. These devices can operate from 2.1V to 5.5V single supply, while consuming only 46 $\mu$ A 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 SGM8541/2/4 appropriate for buffering ASIC.

The SGM8541/2/4 offer a gain-bandwidth product of 1.1MHz and an ultra-low input bias current of 0.5pA. They are well suited for piezoelectric sensors, integrators and photodiode amplifiers.

The SGM8541/2/4 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 SGM8541 is available in Green SOT-23-5, SC70-5 and SOIC-8 packages. The SGM8542 is available in Green SOIC-8, MSOP-8 and TSSOP-8 packages. The SGM8544 is available in Green TSSOP-14 and SOIC-14 packages. They are specified over the extended industrial temperature range (-40°C to +125°C).

## FEATURES

- **Low Cost**
- **Input Offset Voltage: 3.5mV (MAX)**
- **Ultra-Low Input Bias Current: 0.5pA**
- **Unity-Gain Stable**
- **Gain-Bandwidth Product: 1.1MHz**
- **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 Supply Current: 46 $\mu$ A/Amplifier**
- **-40°C to +125°C Operating Temperature Range**
- **Small Packaging:**  
**SGM8541 Available in Green SOIC-8, SC70-5 and SOT-23-5 Packages**  
**SGM8542 Available in Green SOIC-8, MSOP-8 and TSSOP-8 Packages**  
**SGM8544 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

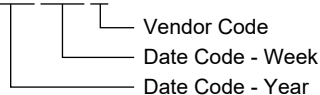
**PACKAGE/ORDERING INFORMATION**

MODEL	PACKAGE DESCRIPTION	SPECIFIED TEMPERATURE RANGE	ORDERING NUMBER	PACKAGE MARKING	PACKING OPTION
SGM8541	SC70-5	-40°C to +125°C	SGM8541XC5/TR	8541	Tape and Reel, 3000
	SOT-23-5	-40°C to +125°C	SGM8541XN5/TR	8541	Tape and Reel, 3000
	SOIC-8	-40°C to +125°C	SGM8541XS/TR	SGM8541XS XXXXX	Tape and Reel, 2500
SGM8542	SOIC-8	-40°C to +125°C	SGM8542XS/TR	SGM8542XS XXXXX	Tape and Reel, 4000
	MSOP-8	-40°C to +125°C	SGM8542XMS/TR	SGM8542 XMS XXXXX	Tape and Reel, 3000
	TSSOP-8	-40°C to +125°C	SGM8542XTS8/TR	SGM8542 XTS8 XXXXX	Tape and Reel, 4000
SGM8544	SOIC-14	-40°C to +125°C	SGM8544XS14/TR	SGM8544XS14 XXXXX	Tape and Reel, 2500
	TSSOP-14	-40°C to +125°C	SGM8544XTS14/TR	SGM8544 XTS14 XXXXX	Tape and Reel, 4000

**MARKING INFORMATION**

NOTE: XXXXX = Date Code and Vendor Code.

**XXXXX**



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> ..... 6V
- Input Common Mode Voltage Range  
..... (-V<sub>S</sub>) - 0.3V to (+V<sub>S</sub>) + 0.3V
- Package Thermal Resistance @ T<sub>A</sub> = +25°C
- SC70-5, θ<sub>JA</sub>..... 333°C/W
- SOT-23-5, θ<sub>JA</sub>..... 190°C/W
- SOIC-8, θ<sub>JA</sub>..... 125°C/W
- MSOP-8, θ<sub>JA</sub>..... 216°C/W
- TSSOP-8, θ<sub>JA</sub>..... 175°C/W
- Junction Temperature.....+150°C
- Storage Temperature Range.....-65°C to +150°C
- Lead Temperature (Soldering, 10s).....+260°C
- ESD Susceptibility
- HBM..... 4000V
- MM..... 400V

**RECOMMENDED OPERATING CONDITIONS**

- Operating Temperature Range.....-40°C to +125°C

**OVERSTRESS CAUTION**

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

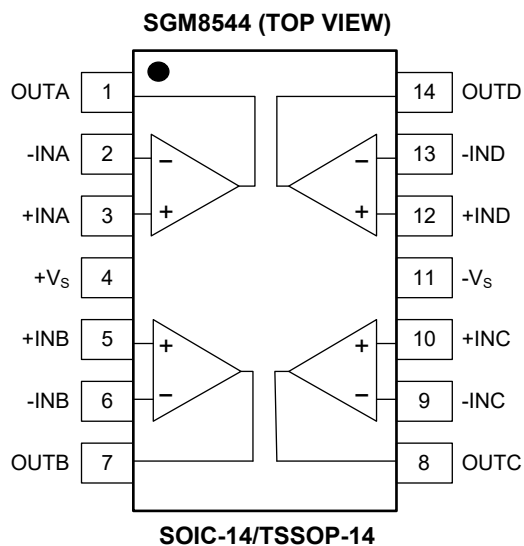
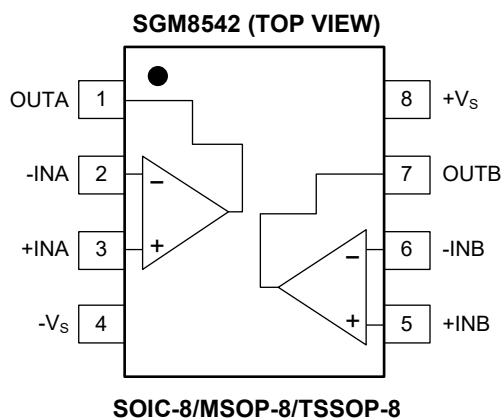
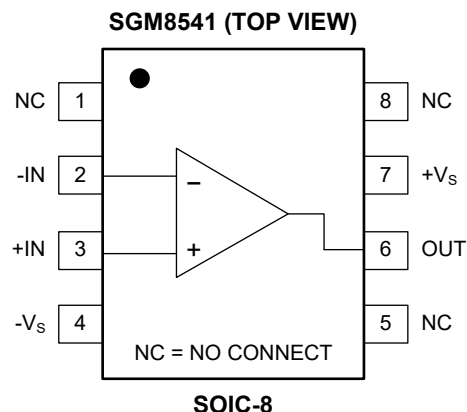
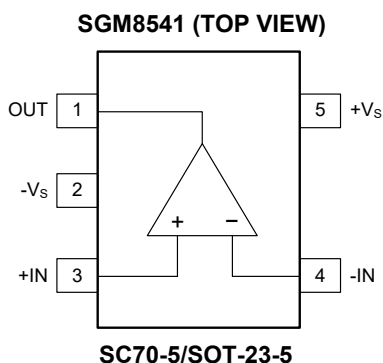
**ESD SENSITIVITY CAUTION**

This integrated circuit can be damaged 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**



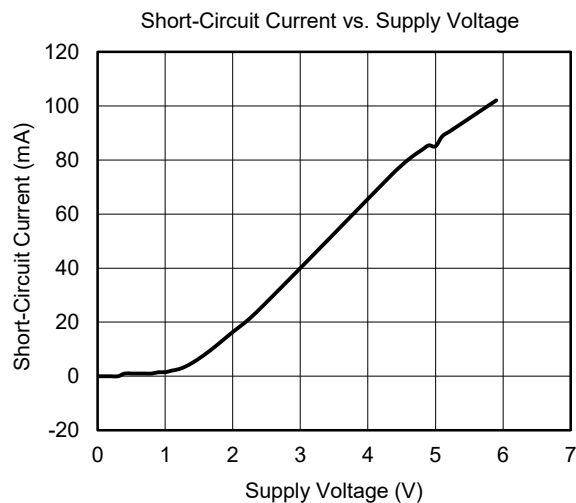
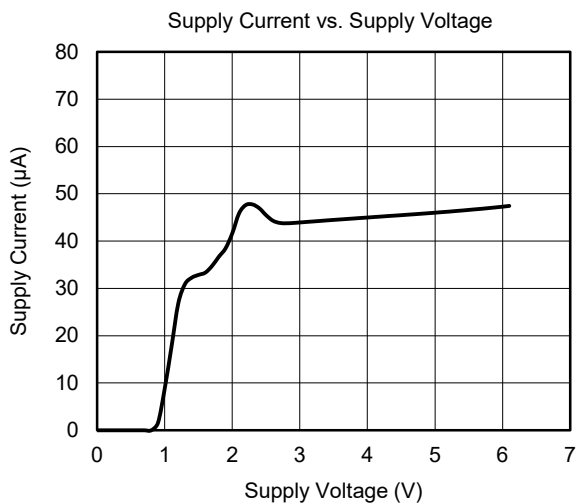
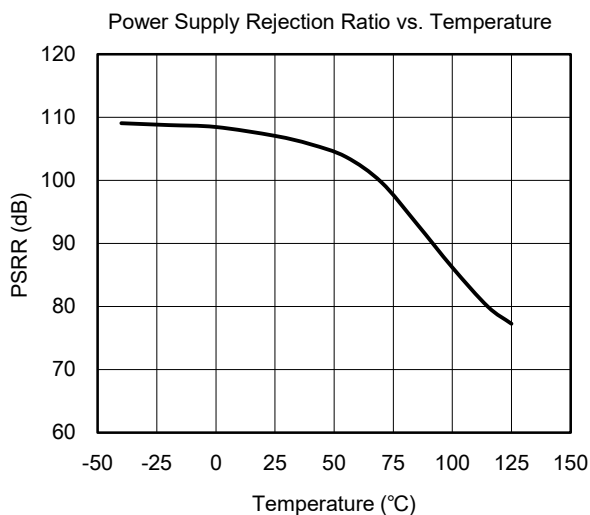
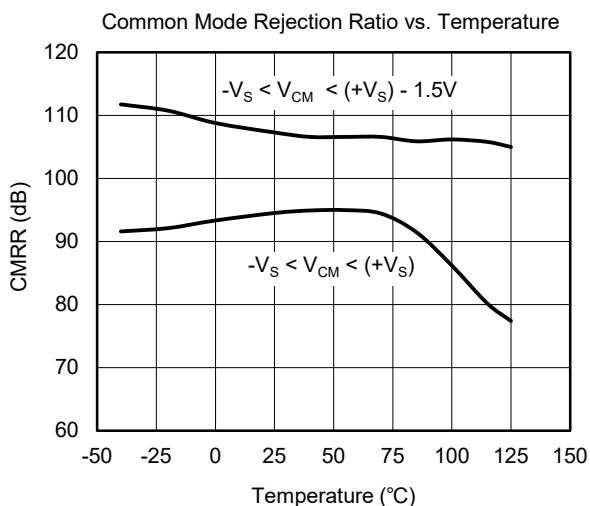
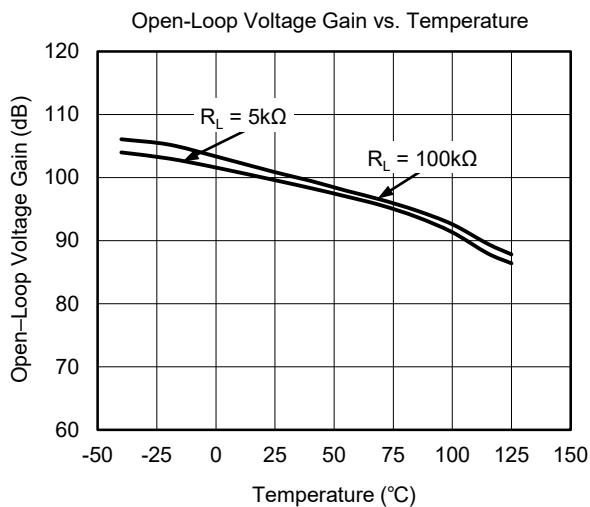
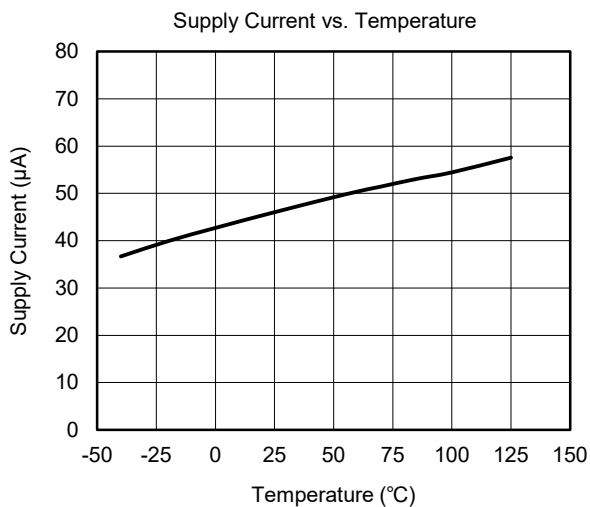
**ELECTRICAL CHARACTERISTICS**

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

PARAMETER	SYMBOL	CONDITIONS	SGM8541/2/4					
			TYP	MIN/MAX OVER TEMPERATURE			UNITS	MIN/MAX
			+25°C	+25°C	-40°C to +125°C			
<b>Input Characteristics</b>								
Input Offset Voltage	$V_{OS}$	$V_{CM} = V_S/2$	0.8	3.5		mV	MAX	
Input Bias Current	$I_B$		0.5			pA	TYP	
Input Offset Current	$I_{OS}$		0.5			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	87	71	69	dB	MIN	
		$V_S = 5.5V, V_{CM} = -0.1V$ to 5.6V	80	60	56			
Open-Loop Voltage Gain	$A_{OL}$	$R_L = 5k\Omega, V_{OUT} = 0.1V$ to 4.9V	98	80	73	dB	MIN	
		$R_L = 100k\Omega, V_{OUT} = 0.035V$ to 4.965V	105	85	74			
Input Offset Voltage Drift	$\Delta V_{OS}/\Delta T$		2.7			$\mu V/^\circ C$	TYP	
<b>Output Characteristics</b>								
Output Voltage Swing from Rail	$V_{OH}$	$R_L = 100k\Omega$	4.997	4.980	4.970	V	MIN	
	$V_{OL}$	$R_L = 100k\Omega$	5	20	30	mV	MAX	
	$V_{OH}$	$R_L = 10k\Omega$	4.992	4.970	4.960	V	MIN	
	$V_{OL}$	$R_L = 10k\Omega$	8	30	40	mV	MAX	
Output Current	$I_{SOURCE}$	$R_L = 10\Omega$ to $V_S/2$	85	60	45	mA	MIN	
	$I_{SINK}$		75	60	45			
<b>Power Supply</b>								
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, $V_{CM} = 0.5V$	87	70	64	dB	MIN	
Quiescent Current/Amplifier	$I_Q$		46	69	89	$\mu A$	MAX	
<b>Dynamic Performance (<math>C_L = 100pF</math>)</b>								
Gain-Bandwidth Product	GBP		1.1			MHz	TYP	
Slew Rate	SR	$G = +1, 2V$ Output Step	0.52			$V/\mu s$	TYP	
Settling Time to 0.1%	$t_s$	$G = +1, 2V$ Output Step	5.3			$\mu s$	TYP	
Overload Recovery Time		$V_{IN} \cdot G = V_S$	2.6			$\mu s$	TYP	
<b>Noise Performance</b>								
Input Voltage Noise Density	$e_n$	$f = 1kHz$	27			$nV/\sqrt{Hz}$	TYP	
		$f = 10kHz$	20			$nV/\sqrt{Hz}$	TYP	

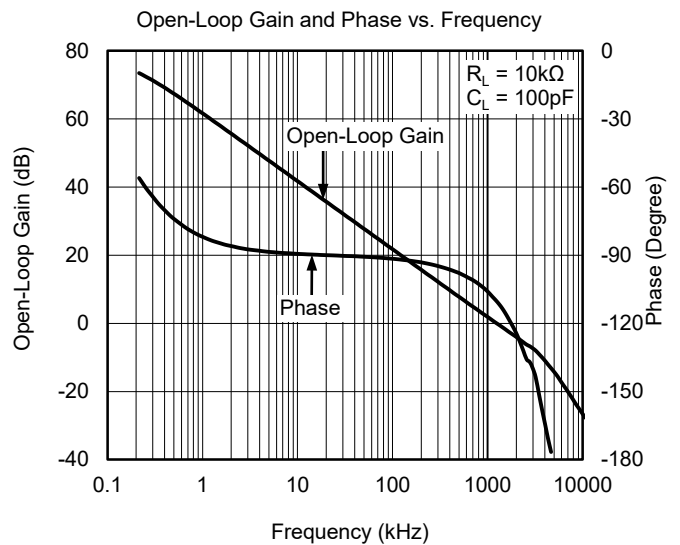
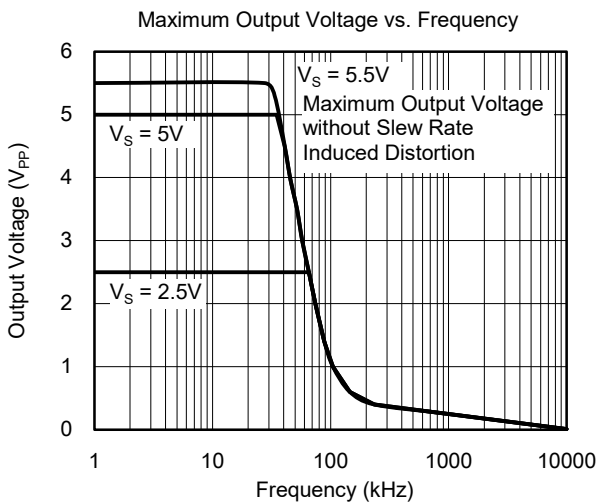
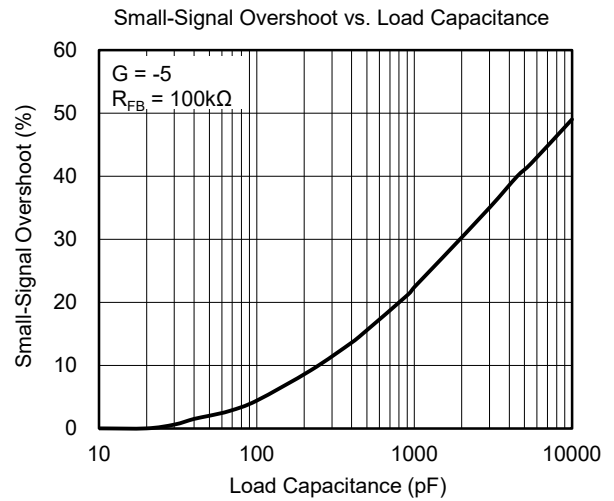
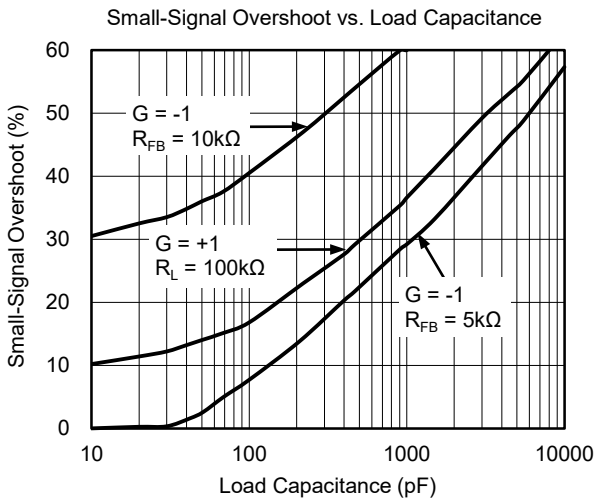
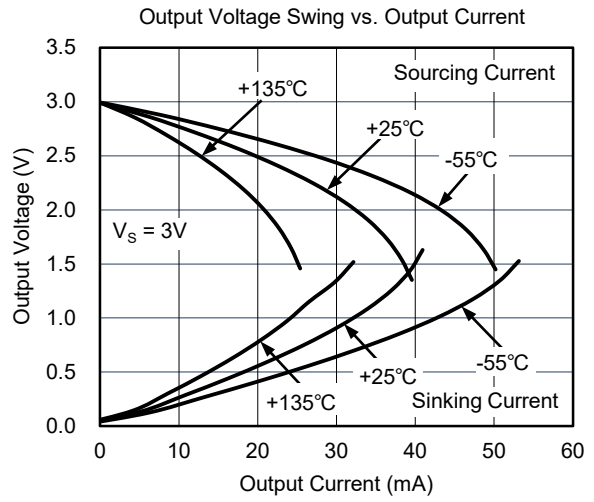
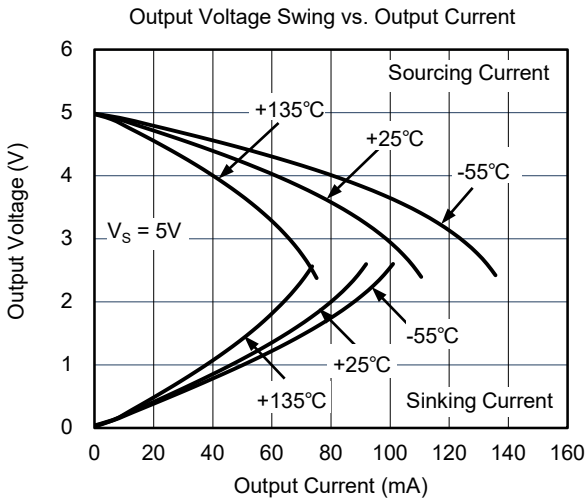
**TYPICAL PERFORMANCE CHARACTERISTICS**

At  $T_A = +25^\circ\text{C}$ ,  $V_S = 5\text{V}$ , and  $R_L = 100\text{k}\Omega$  connected to  $V_S/2$ , unless otherwise noted.



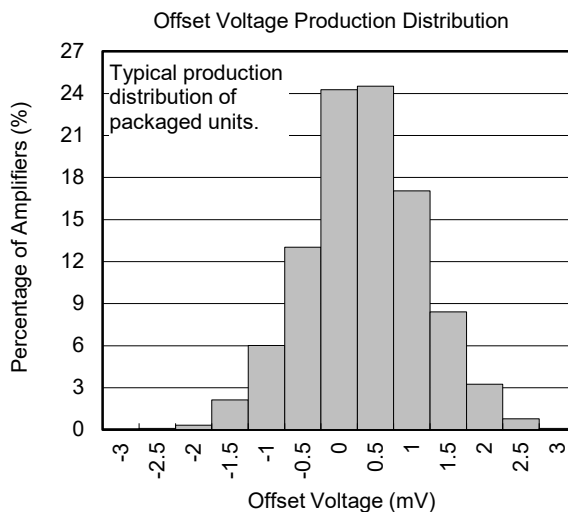
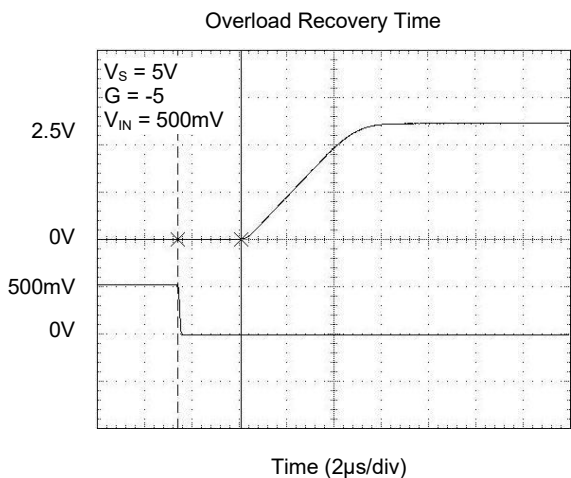
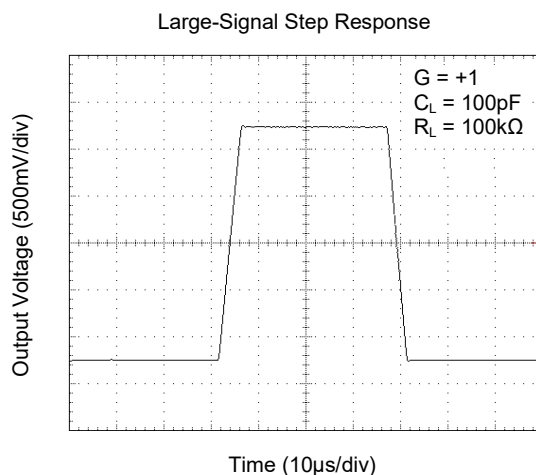
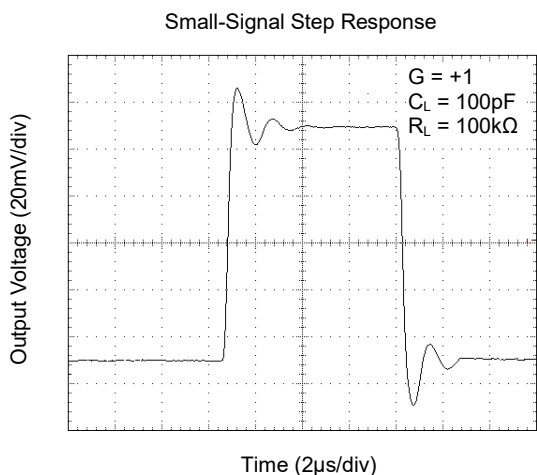
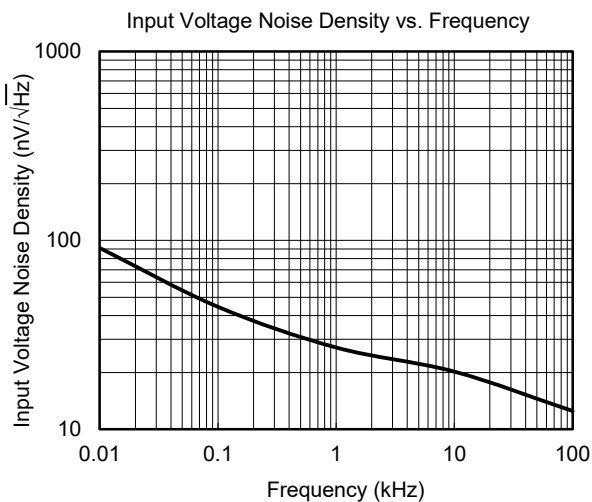
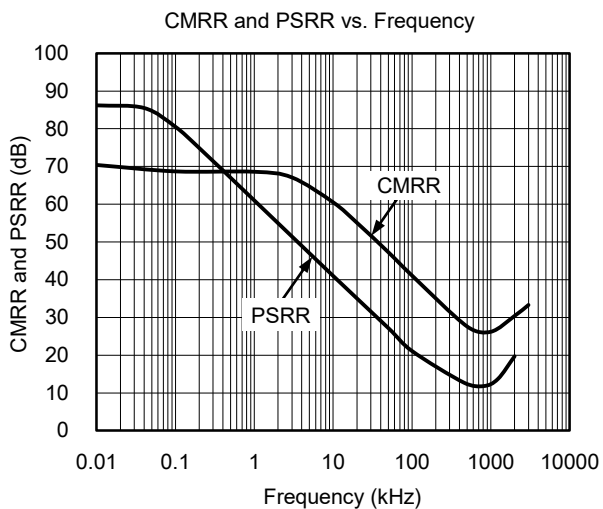
**TYPICAL PERFORMANCE CHARACTERISTICS (continued)**

At  $T_A = +25^\circ\text{C}$ ,  $V_S = 5\text{V}$ , and  $R_L = 100\text{k}\Omega$  connected to  $V_S/2$ , unless otherwise noted.



**TYPICAL PERFORMANCE CHARACTERISTICS (continued)**

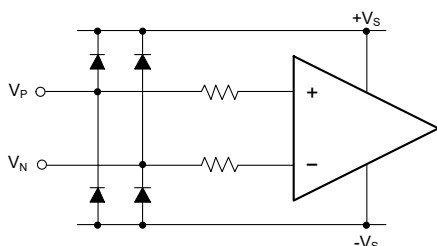
At  $T_A = +25^\circ\text{C}$ ,  $V_S = 5\text{V}$ , and  $R_L = 100\text{k}\Omega$  connected to  $V_S/2$ , unless otherwise noted.



**APPLICATION INFORMATION**

**Rail-to-Rail Input**

When SGM8541/2/4 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.



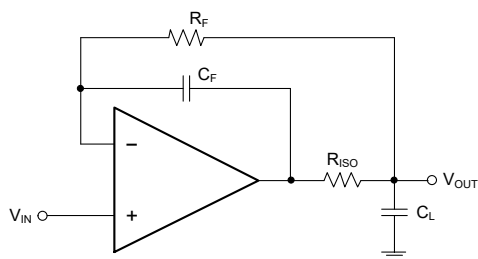
**Figure 1. Input Equivalent Circuit**

**Rail-to-Rail Output**

The SGM8541/2/4 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**

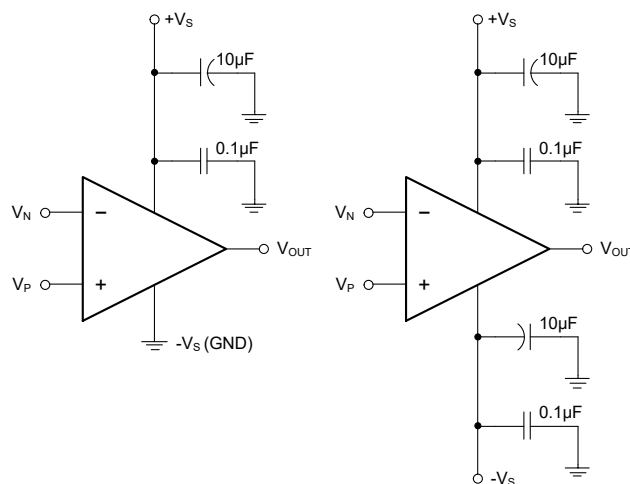
The SGM8541/2/4 are designed for unity-gain stable for capacitive load up to 250pF. If greater capacitive load must be driven in application, the circuit in Figure 2 can be used. In this circuit, the IR drop voltage generated by  $R_{ISO}$  is compensated by feedback loop.



**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**

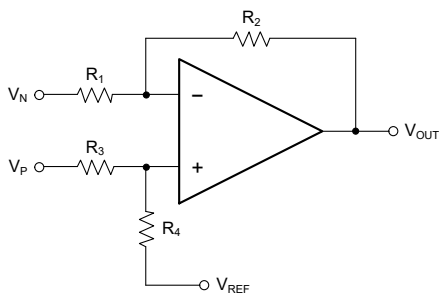


**APPLICATION INFORMATION (continued)**

**Typical Application Circuits**

**Difference Amplifier**

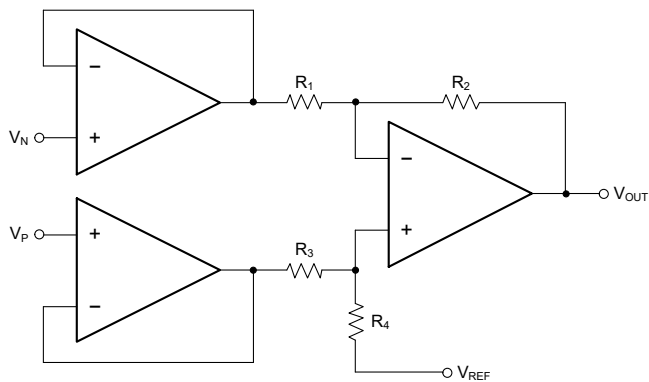
The circuit in Figure 4 is a design example of classical difference amplifier. If  $R_4/R_3 = R_2/R_1$ , then  $V_{OUT} = (V_P - V_N) \times R_2/R_1 + V_{REF}$ .



**Figure 4. Difference Amplifier**

**High Input Impedance Difference Amplifier**

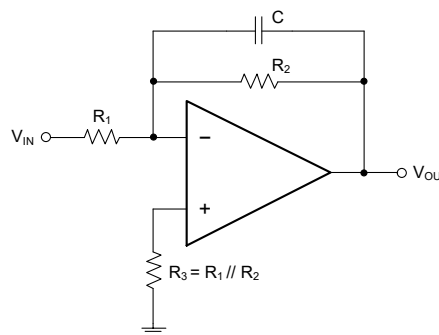
The circuit in Figure 5 is a design example of high input impedance difference amplifier, the added amplifiers at the input are used to increase the input impedance and eliminate drawback of low input impedance in Figure 4.



**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**

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## **REVISION HISTORY**

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

<b>NOVEMBER 2018 – REV.C.3 to REV.C.4</b>	<b>Page</b>
Added Open-Loop Gain and Phase vs. Frequency .....	6
<hr/>	
<b>JANUARY 2018 – REV.C.2 to REV.C.3</b>	<b>Page</b>
Changed Packing Option .....	2
<hr/>	
<b>JULY 2014 – REV.C.1 to REV.C.2</b>	<b>Page</b>
Added TSSOP-8 package for SGM8542 .....	1, 2, 13, 16
<hr/>	
<b>JANUARY 2013 – REV.C to REV.C.1</b>	<b>Page</b>
Added Tape and Reel Information .....	15, 16

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PACKAGE OUTLINE DIMENSIONS

SOT-23-5



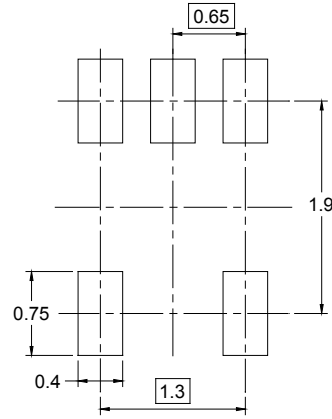
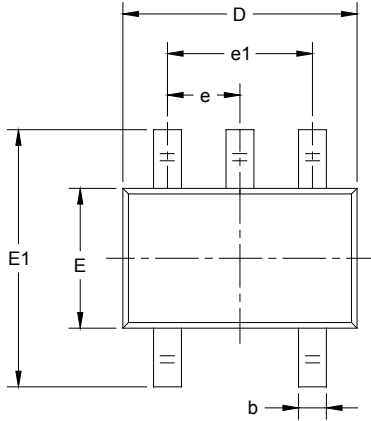
RECOMMENDED LAND PATTERN (Unit: mm)



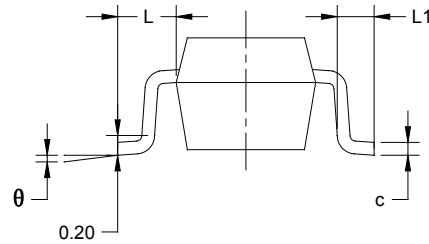
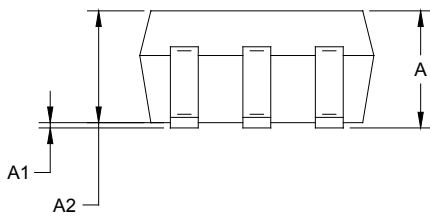
Symbol	Dimensions In Millimeters		Dimensions In Inches	
	MIN	MAX	MIN	MAX
A	1.050	1.250	0.041	0.049
A1	0.000	0.100	0.000	0.004
A2	1.050	1.150	0.041	0.045
b	0.300	0.500	0.012	0.020
c	0.100	0.200	0.004	0.008
D	2.820	3.020	0.111	0.119
E	1.500	1.700	0.059	0.067
E1	2.650	2.950	0.104	0.116
e	0.950 BSC		0.037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



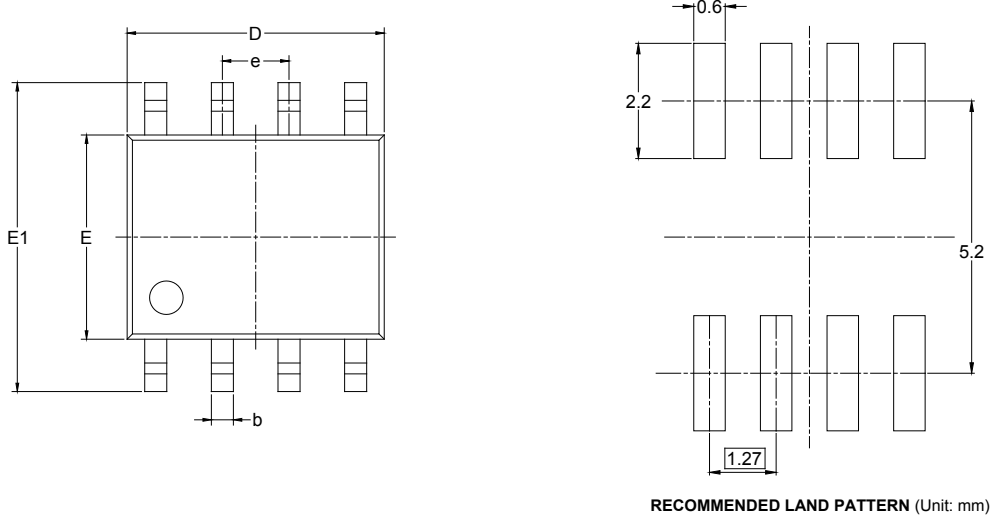
RECOMMENDED LAND PATTERN (Unit: mm)



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



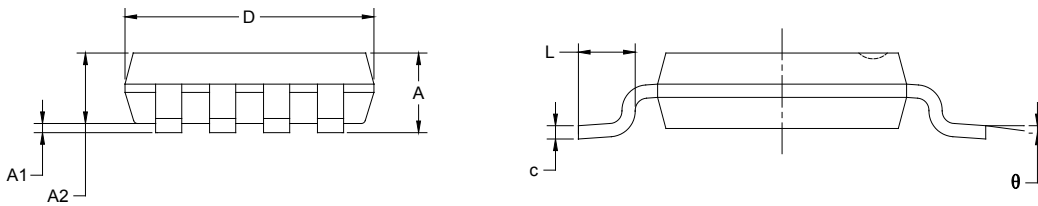
Symbol	Dimensions In Millimeters		Dimensions In Inches	
	MIN	MAX	MIN	MAX
A	1.350	1.750	0.053	0.069
A1	0.100	0.250	0.004	0.010
A2	1.350	1.550	0.053	0.061
b	0.330	0.510	0.013	0.020
c	0.170	0.250	0.006	0.010
D	4.700	5.100	0.185	0.200
E	3.800	4.000	0.150	0.157
E1	5.800	6.200	0.228	0.244
e	1.27 BSC		0.050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

PACKAGE OUTLINE DIMENSIONS

MSOP-8



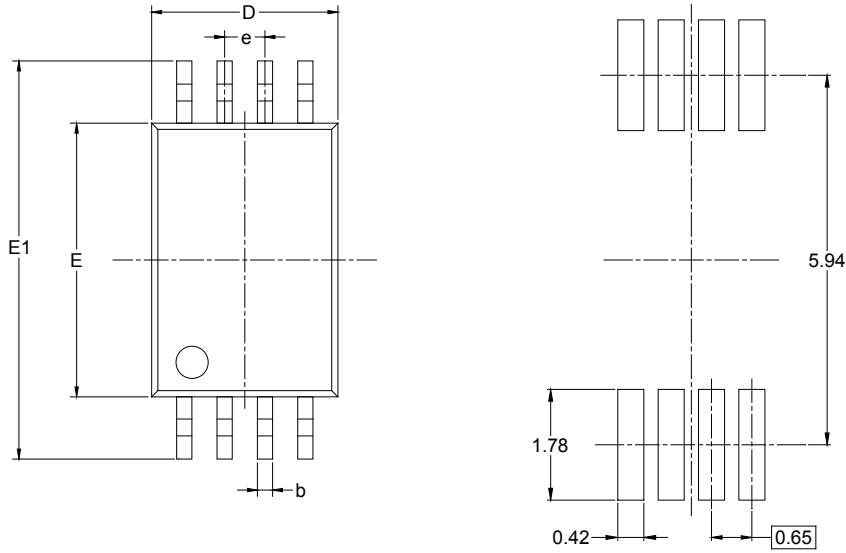
RECOMMENDED LAND PATTERN (Unit: mm)



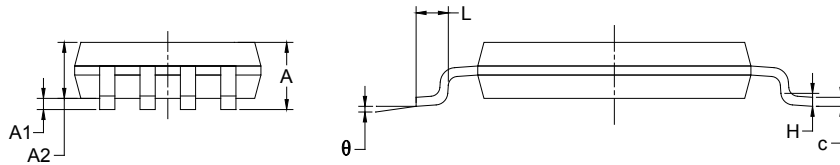
Symbol	Dimensions In Millimeters		Dimensions In Inches	
	MIN	MAX	MIN	MAX
A	0.820	1.100	0.032	0.043
A1	0.020	0.150	0.001	0.006
A2	0.750	0.950	0.030	0.037
b	0.250	0.380	0.010	0.015
c	0.090	0.230	0.004	0.009
D	2.900	3.100	0.114	0.122
E	2.900	3.100	0.114	0.122
E1	4.750	5.050	0.187	0.199
e	0.650 BSC		0.026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

PACKAGE OUTLINE DIMENSIONS

TSSOP-8



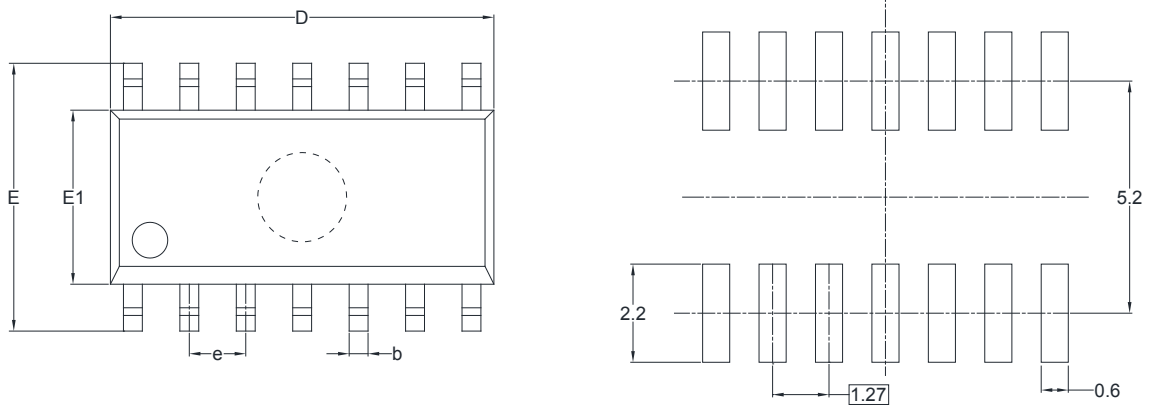
RECOMMENDED LAND PATTERN (Unit: mm)



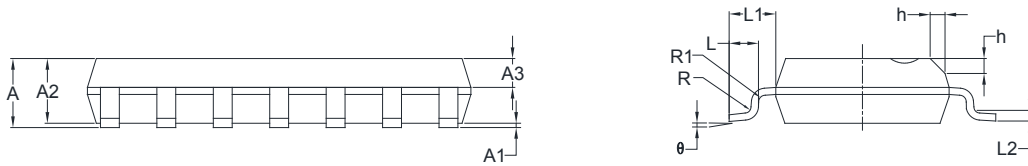
Symbol	Dimensions In Millimeters		Dimensions In Inches	
	MIN	MAX	MIN	MAX
A		1.100		0.043
A1	0.050	0.150	0.002	0.006
A2	0.800	1.000	0.031	0.039
b	0.190	0.300	0.007	0.012
c	0.090	0.200	0.004	0.008
D	2.900	3.100	0.114	0.122
E	4.300	4.500	0.169	0.177
E1	6.250	6.550	0.246	0.258
e	0.650 BSC		0.026 BSC	
L	0.500	0.700	0.02	0.028
H	0.25 TYP		0.01 TYP	
θ	1°	7°	1°	7°

PACKAGE OUTLINE DIMENSIONS

SOIC-14



RECOMMENDED LAND PATTERN (Unit: mm)

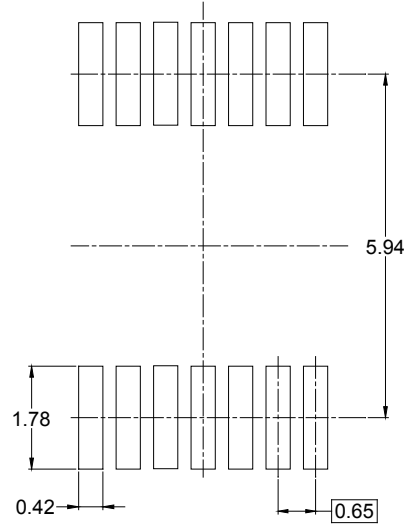
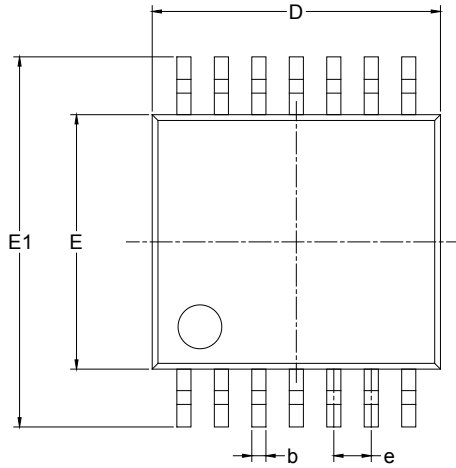


Symbol	Dimensions In Millimeters		Dimensions In Inches	
	MIN	MAX	MIN	MAX
A	1.35	1.75	0.053	0.069
A1	0.10	0.25	0.004	0.010
A2	1.25	1.65	0.049	0.065
A3	0.55	0.75	0.022	0.030
b	0.36	0.49	0.014	0.019
D	8.53	8.73	0.336	0.344
E	5.80	6.20	0.228	0.244
E1	3.80	4.00	0.150	0.157
e	1.27 BSC		0.050 BSC	
L	0.45	0.80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

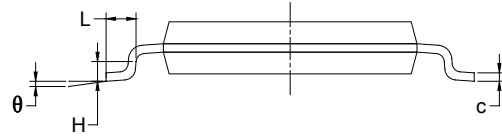
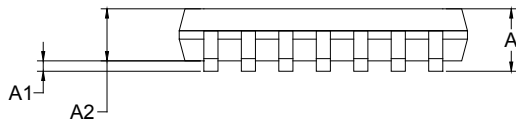


PACKAGE OUTLINE DIMENSIONS

TSSOP-14



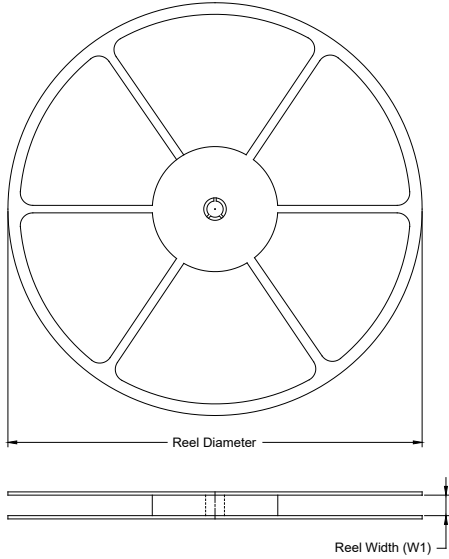
RECOMMENDED LAND PATTERN (Unit: mm)



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°

## 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	2.25	2.55	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
TSSOP-8	13"	12.4	6.76	3.30	1.80	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	6.95	5.60	1.20	4.0	8.0	2.0	12.0	Q1

D00001

# PACKAGE INFORMATION

## CARTON BOX DIMENSIONS



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

## KEY PARAMETER LIST OF CARTON BOX

Reel Type	Length (mm)	Width (mm)	Height (mm)	Pizza/Carton
7" (Option)	368	227	224	8
7"	442	410	224	18
13"	386	280	370	5

DD0002