



# SGM8541/2/4

## 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, rail-to-rail input and output voltage feedback amplifiers. They have a wide input common mode voltage range and output voltage swing, and take the minimum operating supply voltage down to 2.1V. The maximum recommended supply voltage is 5.5V.

The SGM8541/2/4 provide 1.1MHz bandwidth at a low current consumption of 46 $\mu$ A per amplifier. Very low input bias currents of 0.5pA enable SGM8541/2/4 to be used for integrators, photodiode amplifiers, and piezoelectric sensors. Rail-to-rail input and output are useful to designers for buffering ASIC in single-supply systems.

Applications for these amplifiers include safety monitoring, portable equipment, battery and power supply control, and signal conditioning and interfacing for transducers in very low power systems.

The SGM8541 single is available in the Green SOT-23-5, SC70-5 and SOIC-8 packages. The SGM8542 dual comes in the Green SOIC-8, MSOP-8 and TSSOP-8 packages. The quad SGM8544 is offered in Green TSSOP-14 and SOIC-14 packages. They are specified over the extended industrial temperature range (-40 $^{\circ}$ C to +125 $^{\circ}$ C).

### FEATURES

- **Low Cost**
- **Rail-to-Rail Input and Output**  
**0.8mV Typical  $V_{OS}$**
- **Unity Gain Stable**
- **Gain-Bandwidth Product: 1.1MHz**
- **Very Low Input Bias Current: 0.5pA**
- **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**
- **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 Amplifier  
Sensor Interface  
Piezoelectric Transducer Amplifier  
Medical Instrumentation  
Mobile Communication  
Audio Output  
Portable Systems  
Smoke Detectors  
Mobile Telephone  
Notebook PC  
PCMCIA Cards  
Battery-Powered Equipment

**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	SGM8542XTS8G/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

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<sub>s</sub> to -V<sub>s</sub> .....6V  
 Input Common Mode Voltage ..... (-V<sub>s</sub>) - 0.3V to (+V<sub>s</sub>) + 0.3V  
 Storage Temperature Range ..... -65°C to +150°C  
 Junction Temperature .....+150°C  
 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  
 Lead Temperature (Soldering 10sec) .....+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 may cause permanent damage to the device. Functional operation of the device at these or any other conditions beyond those indicated in the operational section of the specification is not implied. Exposure to absolute maximum rating conditions for extended periods may affect reliability.

**ESD SENSITIVITY CAUTION**

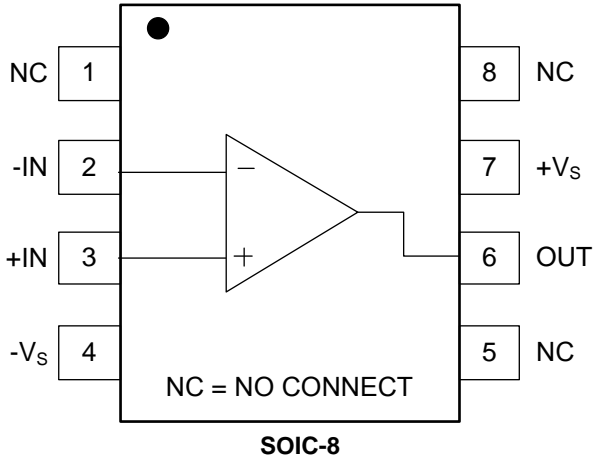
This integrated circuit can be damaged by ESD if you don't pay attention to ESD protection. SGMICRO recommends that all integrated circuits be handled with appropriate precautions. Failure to observe proper handling and installation procedures can cause damage. ESD damage can range from subtle performance degradation to complete device failure. Precision integrated circuits may be more susceptible to damage because very small parametric changes could cause the device not to meet its published specifications.

**DISCLAIMER**

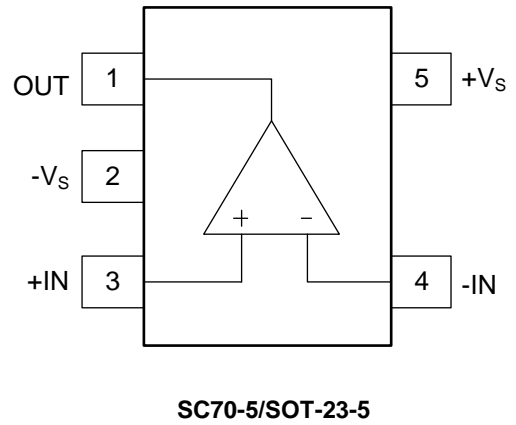
SG Micro Corp reserves the right to make any change in circuit design, specification or other related things if necessary without notice at any time.

PIN CONFIGURATIONS

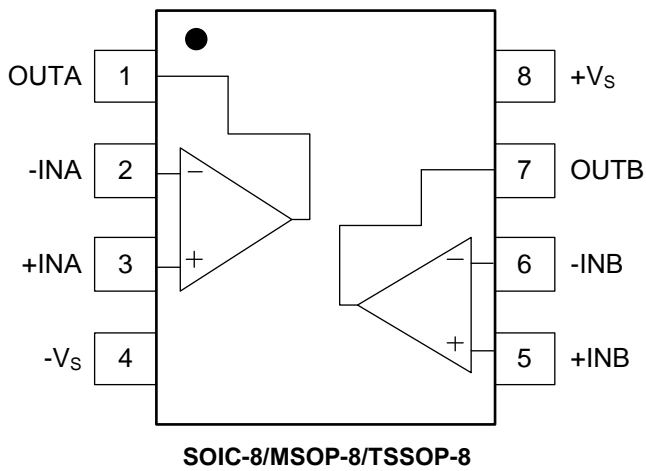
SGM8541 (TOP VIEW)



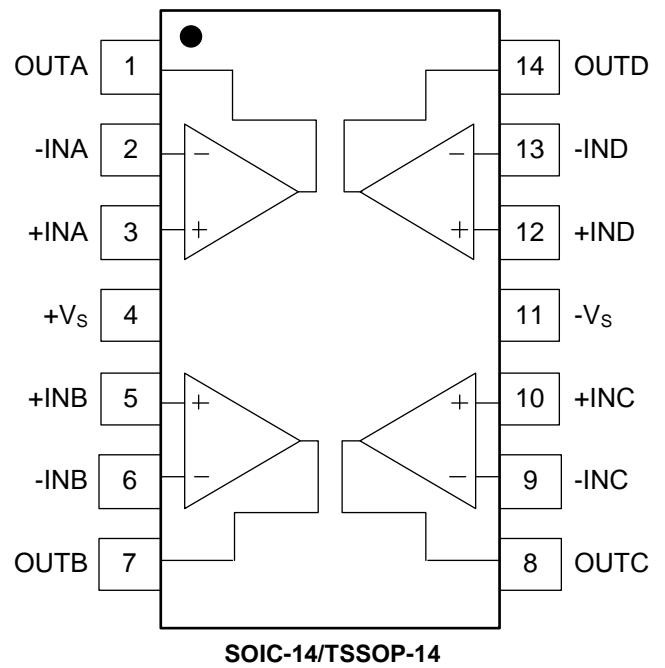
SGM8541 (TOP VIEW)



SGM8542 (TOP VIEW)



SGM8544 (TOP VIEW)



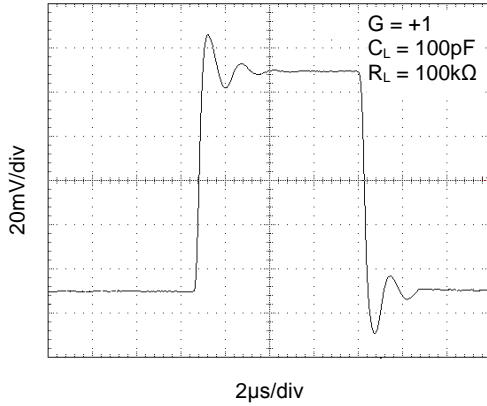
**ELECTRICAL CHARACTERISTICS**(At  $V_S = +5V$ ,  $R_L = 100k\Omega$  connected to  $V_S/2$  and  $V_{OUT} = V_S/2$ , unless otherwise noted.)

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	$A_{OL}$	$R_L = 5k\Omega, V_O = +0.1V$ to +4.9V	98	80	73	dB	MIN	
		$R_L = 100k\Omega, V_O = +0.035V$ 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		$V_{IN} \cdot Gain = V_S$	2.6			$\mu s$	TYP	
<b>NOISE PERFORMANCE</b>								
Voltage Noise Density	$e_n$	$f = 1kHz$	27			$nV/\sqrt{Hz}$	TYP	
		$f = 10kHz$	20			$nV/\sqrt{Hz}$	TYP	

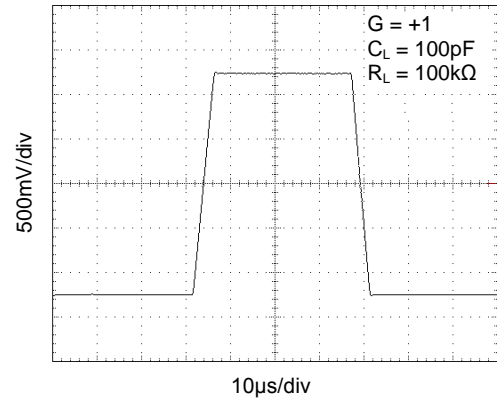
TYPICAL PERFORMANCE CHARACTERISTICS

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.

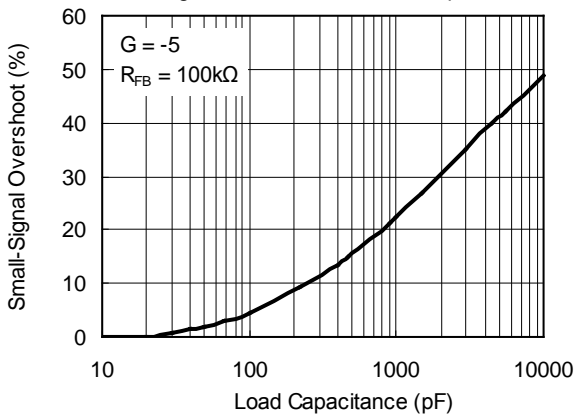
Small-Signal Step Response



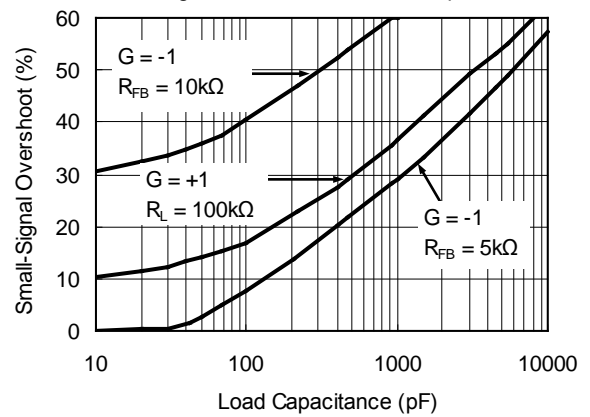
Large-Signal Step Response



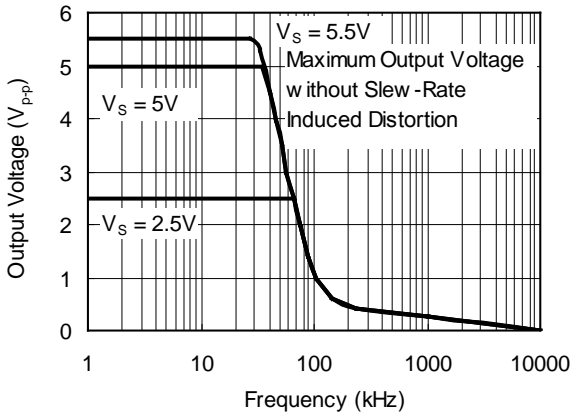
Small-Signal Overshoot vs. Load Capacitance



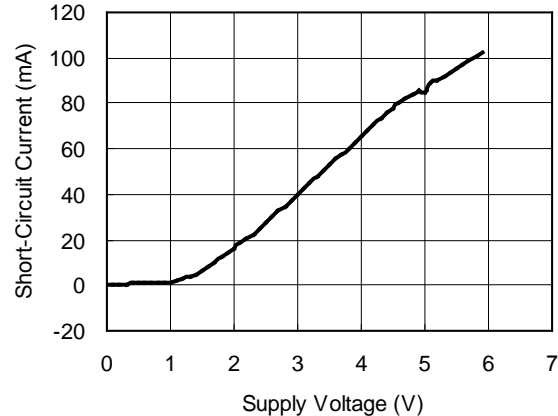
Small-Signal Overshoot vs. Load Capacitance



Maximum Output Voltage vs. Frequency

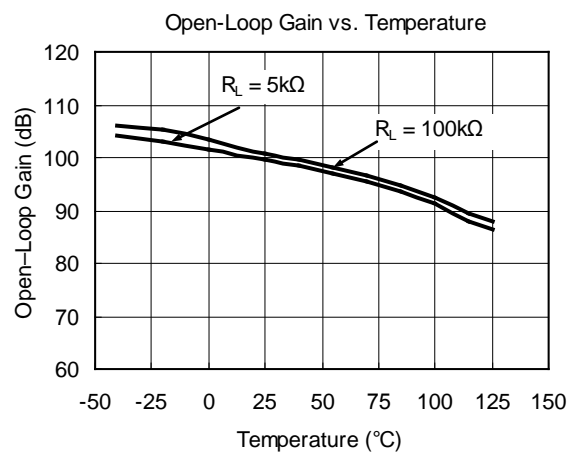
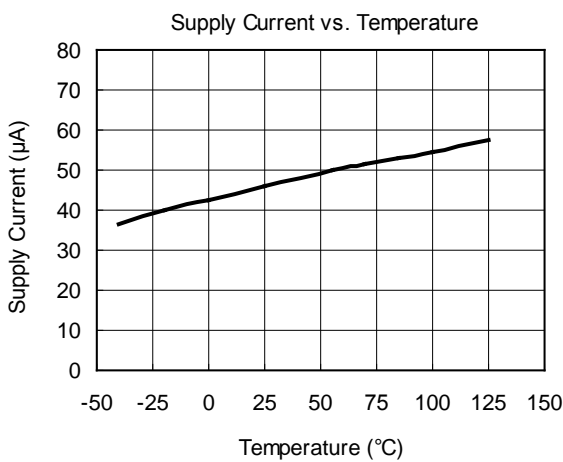
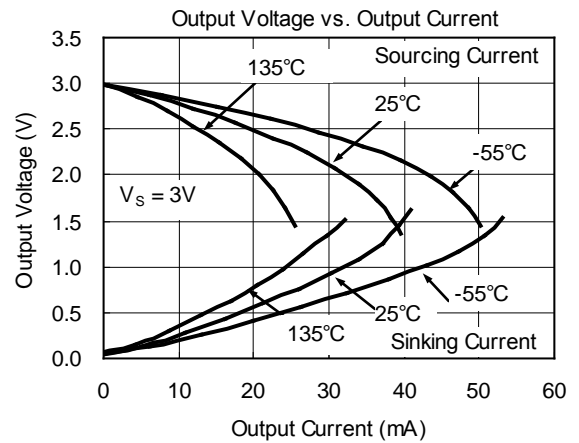
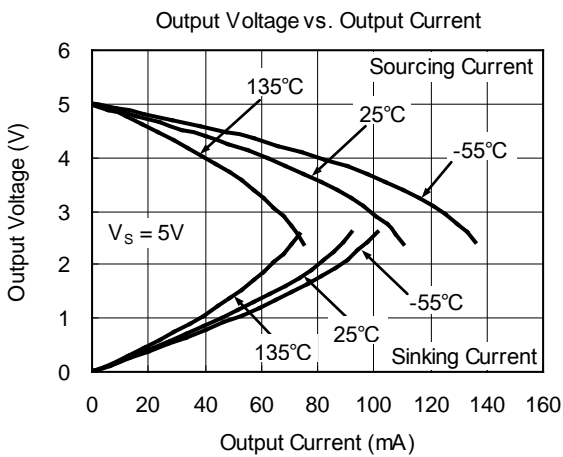
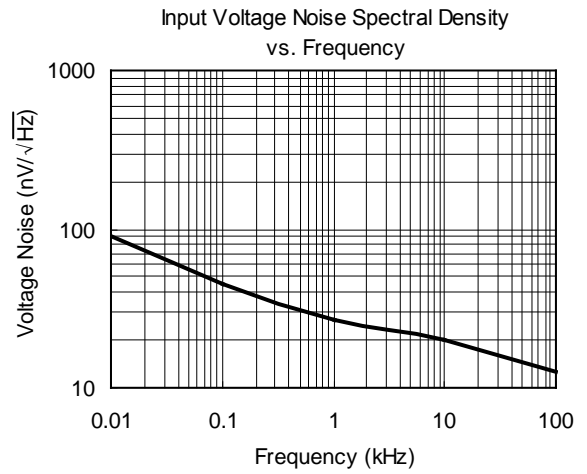
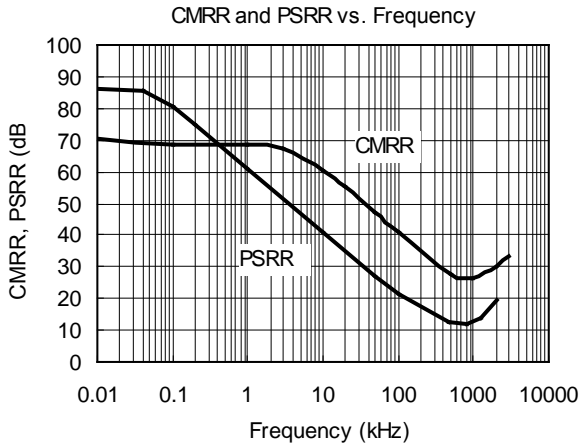


Short-Circuit Current vs. Supply Voltage



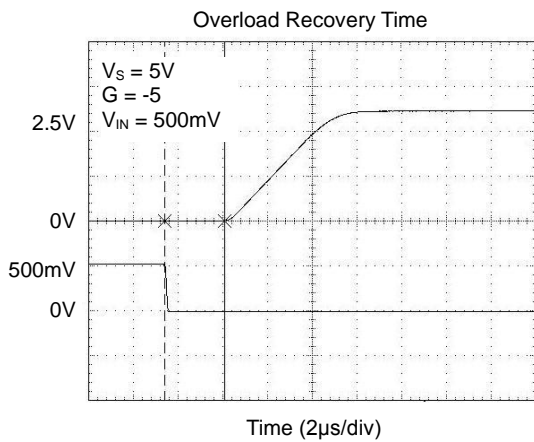
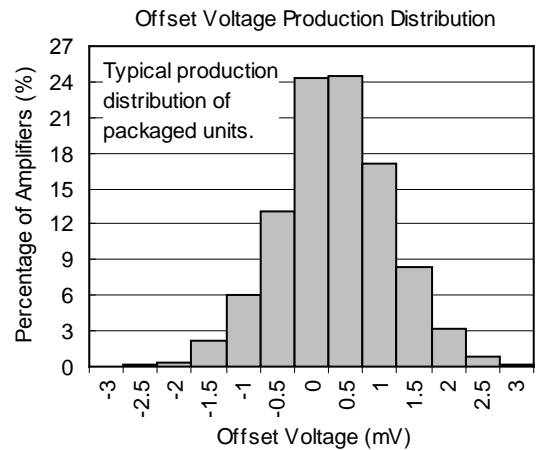
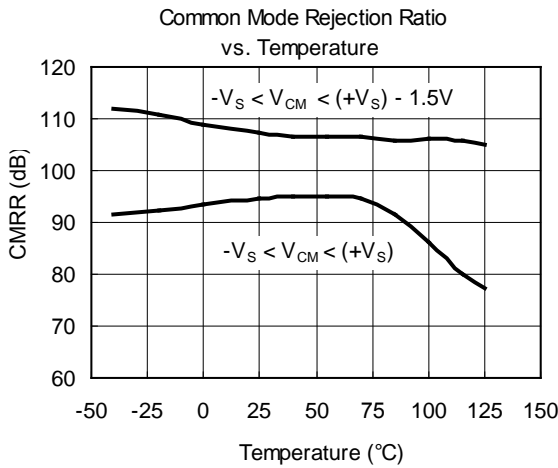
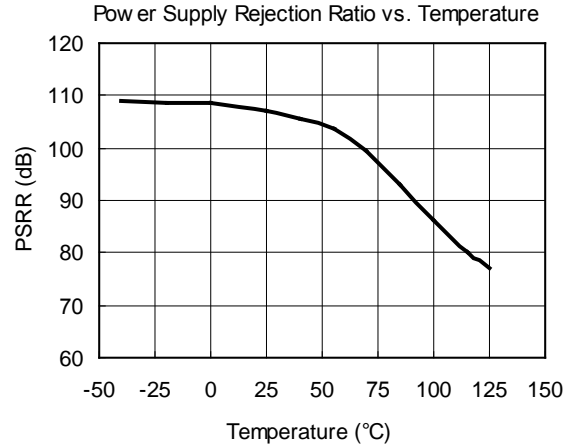
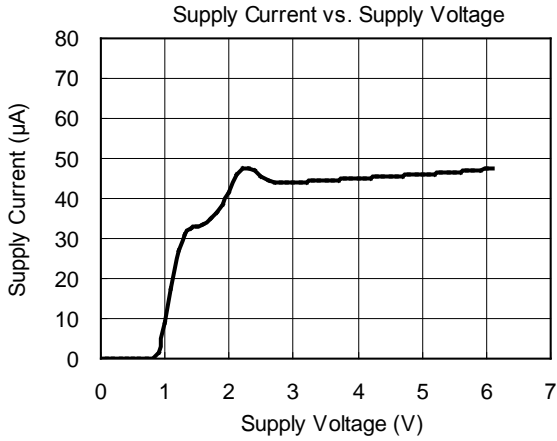
**TYPICAL PERFORMANCE CHARACTERISTICS (continued)**

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 NOTES

Driving Capacitive Loads

The SGM8541/2/4 can directly drive 250pF in unity-gain without oscillation. The unity-gain follower (buffer) is the most sensitive configuration to capacitive loading. Direct capacitive loading reduces the phase margin of amplifiers and this results in ringing or even oscillation. Applications that require greater capacitive driving capability should use an isolation resistor between the output and the capacitive load like the circuit in Figure 1. The isolation resistor  $R_{ISO}$  and the load capacitor  $C_L$  form a zero to increase stability. The bigger the  $R_{ISO}$  resistor value, the more stable  $V_{OUT}$  will be. Note that this method results in a loss of gain accuracy because  $R_{ISO}$  forms a voltage divider with the  $R_{LOAD}$ .

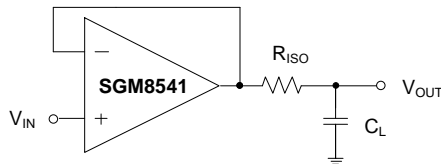


Figure 1. Indirectly Driving Heavy Capacitive Load

An improved circuit is shown in Figure 2. It provides DC accuracy as well as AC stability.  $R_F$  provides the DC accuracy by connecting the inverting signal with the output.  $C_F$  and  $R_{ISO}$  serve to counteract the loss of phase margin by feeding the high frequency component of the output signal back to the amplifier's inverting input, thereby preserving phase margin in the overall feedback loop.

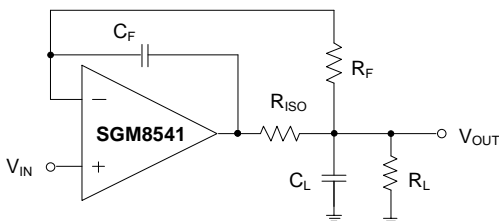


Figure 2. Indirectly Driving Heavy Capacitive Load with DC Accuracy

For non-buffer configuration, there are two other ways to increase the phase margin: (a) by increasing the amplifier's gain or (b) by placing a capacitor in parallel with the feedback resistor to counteract the parasitic capacitance associated with inverting node.

Power-Supply Bypassing and Layout

The SGM8541/2/4 family operates from either a single +2.1V to +5.5V supply or dual  $\pm 1.05V$  to  $\pm 2.75V$  supplies. For single-supply operation, bypass the power supply  $+V_S$  with a 0.1µF ceramic capacitor which should be placed close to the  $+V_S$  pin. For dual-supply operation, both the  $+V_S$  and the  $-V_S$  supplies should be bypassed to ground with separate 0.1µF ceramic capacitors. 2.2µF tantalum capacitor can be added for better performance.

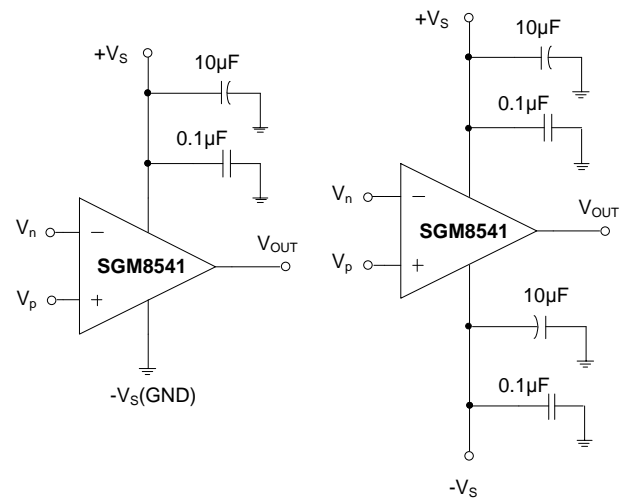


Figure 3. Amplifier with Bypass Capacitors



**TYPICAL APPLICATION CIRCUITS**

**Differential Amplifier**

The circuit shown in Figure 4 performs the difference function. If the resistor ratios are equal to  $(R_4/R_3 = R_2/R_1)$ , then  $V_{OUT} = (V_p - V_n) \times R_2/R_1 + V_{REF}$ .

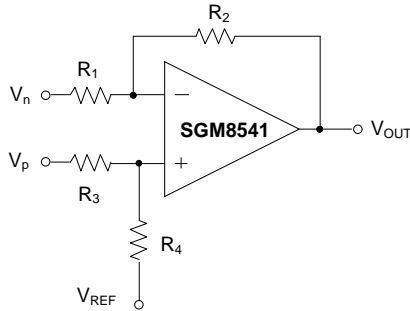


Figure 4. Differential Amplifier

**Instrumentation Amplifier**

The circuit in Figure 5 performs the same function as that in Figure 4 but with a high input impedance.

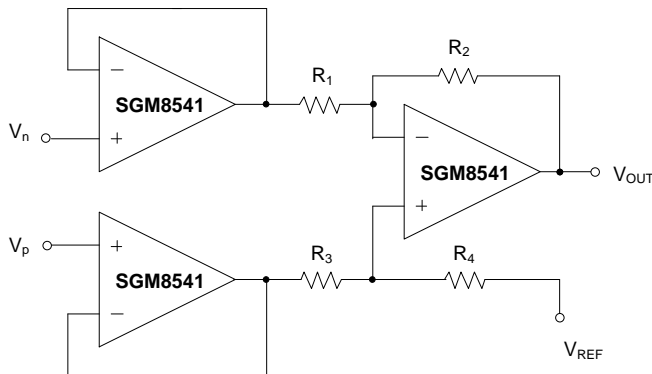


Figure 5. Instrumentation Amplifier

**Low-Pass Active Filter**

The low-pass filter shown in Figure 6 has a DC gain of  $(-R_2/R_1)$  and the -3dB corner frequency is  $1/2\pi R_2 C$ . Make sure the filter bandwidth is within the bandwidth of the amplifier. The large values of feedback resistors can couple with parasitic capacitance and cause undesired effects such as ringing or oscillation in high-speed amplifiers. Keep resistor values as low as possible and consistent with output loading consideration.

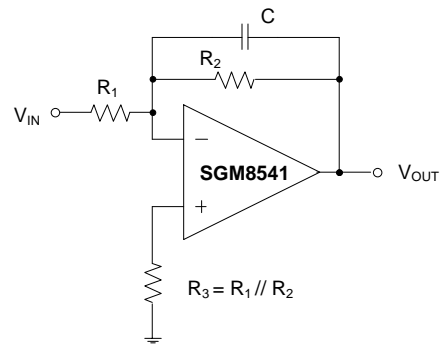
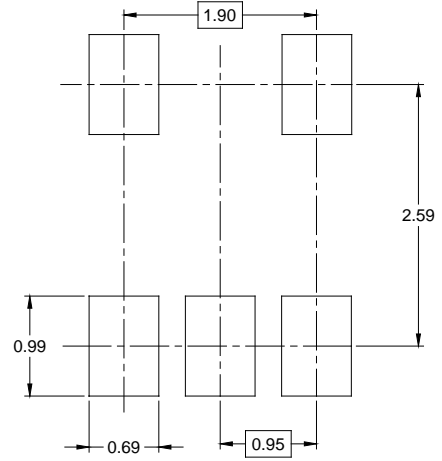
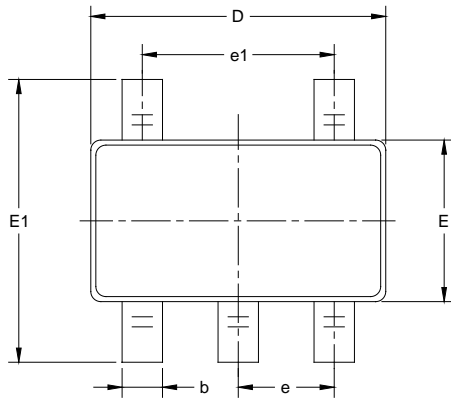


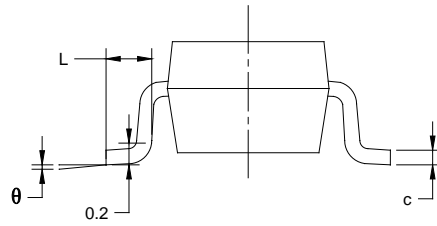
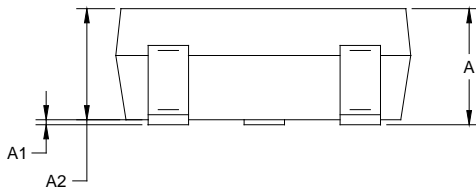
Figure 6. Low-Pass Active Filter

PACKAGE OUTLINE DIMENSIONS

SOT-23-5



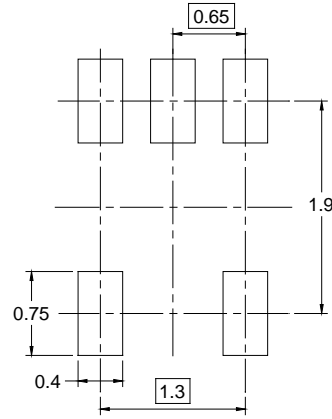
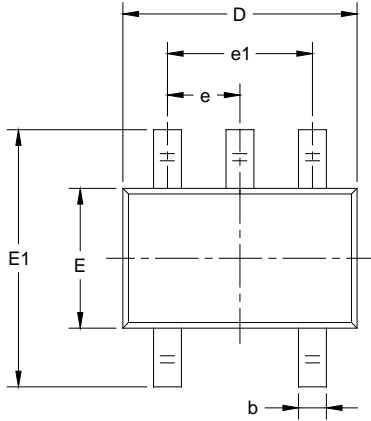
RECOMMENDED LAND PATTERN (Unit: mm)



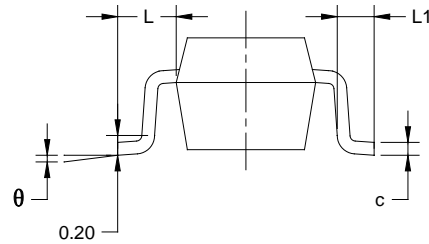
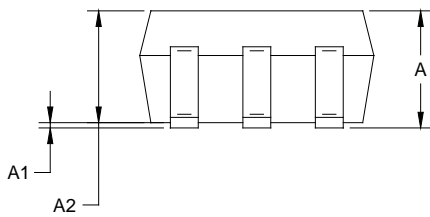
Symbol	Dimensions In Millimeters		Dimensions In Inches	
	MIN	MAX	MIN	MAX
A	1.050	1.250	0.041	0.049
A1	0.000	0.100	0.000	0.004
A2	1.050	1.150	0.041	0.045
b	0.300	0.500	0.012	0.020
c	0.100	0.200	0.004	0.008
D	2.820	3.020	0.111	0.119
E	1.500	1.700	0.059	0.067
E1	2.650	2.950	0.104	0.116
e	0.950 BSC		0.037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

PACKAGE OUTLINE DIMENSIONS

SC70-5



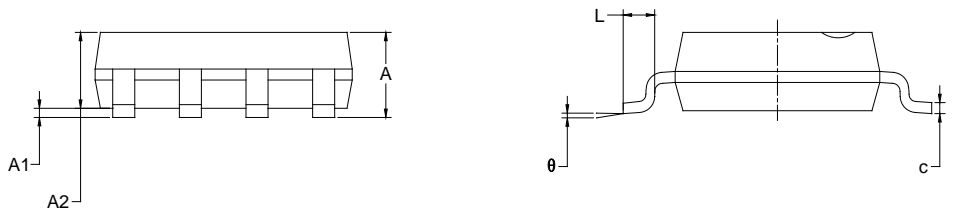
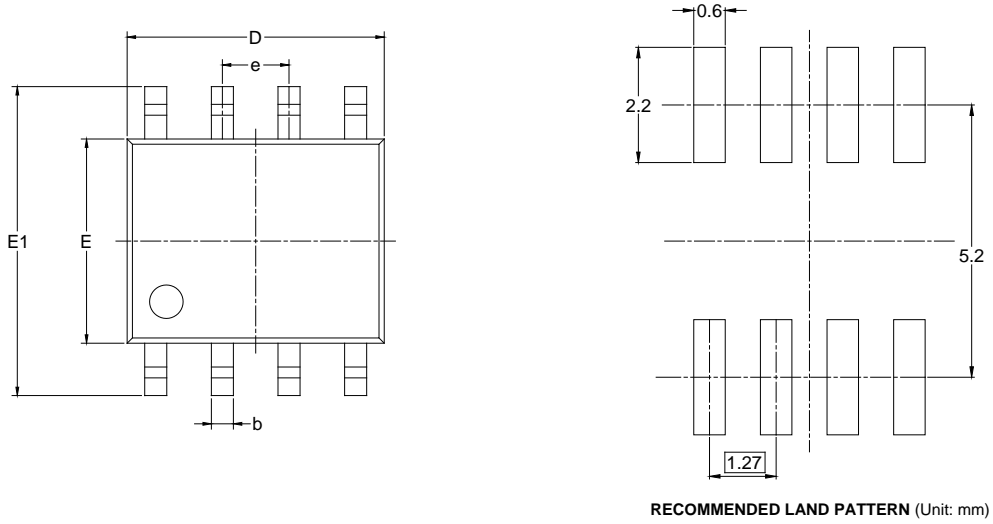
RECOMMENDED LAND PATTERN (Unit: mm)



Symbol	Dimensions In Millimeters		Dimensions In Inches	
	MIN	MAX	MIN	MAX
A	0.900	1.100	0.035	0.043
A1	0.000	0.100	0.000	0.004
A2	0.900	1.000	0.035	0.039
b	0.150	0.350	0.006	0.014
c	0.080	0.150	0.003	0.006
D	2.000	2.200	0.079	0.087
E	1.150	1.350	0.045	0.053
E1	2.150	2.450	0.085	0.096
e	0.65 TYP		0.026 TYP	
e1	1.300 BSC		0.051 BSC	
L	0.525 REF		0.021 REF	
L1	0.260	0.460	0.010	0.018
$\theta$	0°	8°	0°	8°

PACKAGE OUTLINE DIMENSIONS

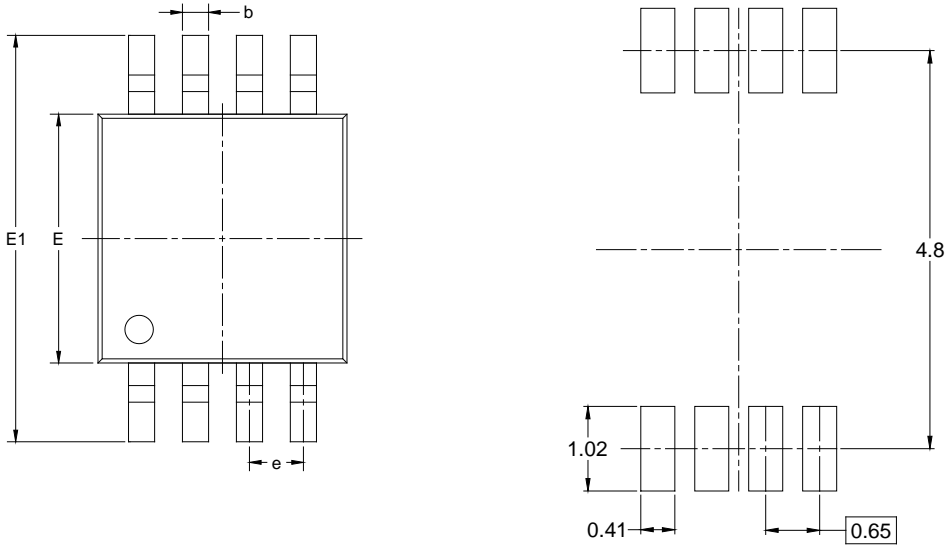
SOIC-8



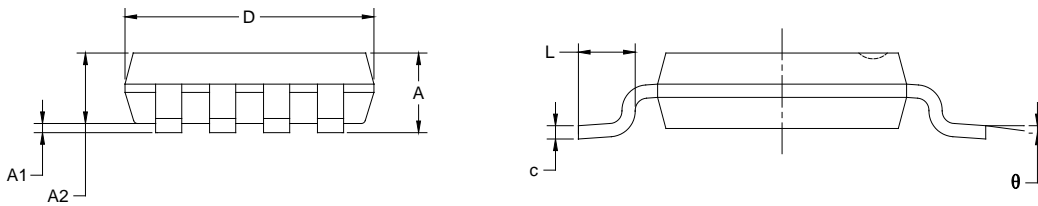
Symbol	Dimensions In Millimeters		Dimensions In Inches	
	MIN	MAX	MIN	MAX
A	1.350	1.750	0.053	0.069
A1	0.100	0.250	0.004	0.010
A2	1.350	1.550	0.053	0.061
b	0.330	0.510	0.013	0.020
c	0.170	0.250	0.006	0.010
D	4.700	5.100	0.185	0.200
E	3.800	4.000	0.150	0.157
E1	5.800	6.200	0.228	0.244
e	1.27 BSC		0.050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

PACKAGE OUTLINE DIMENSIONS

MSOP-8



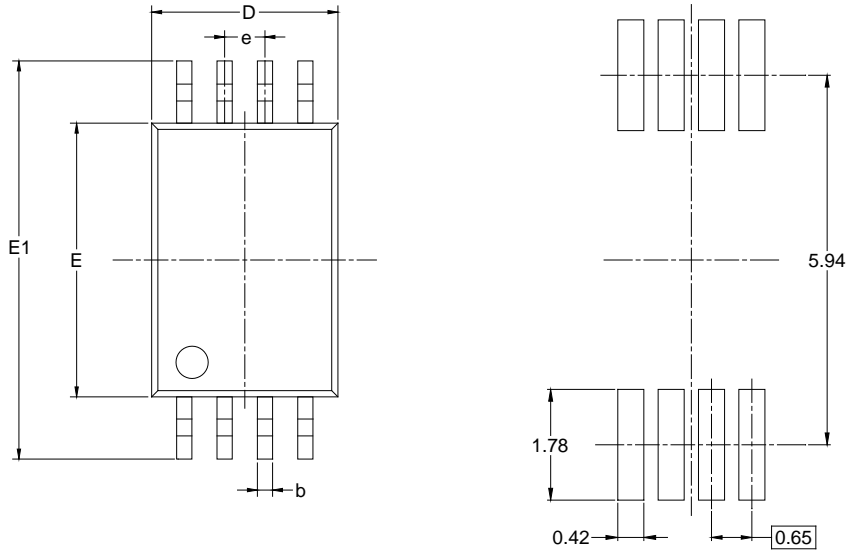
RECOMMENDED LAND PATTERN (Unit: mm)



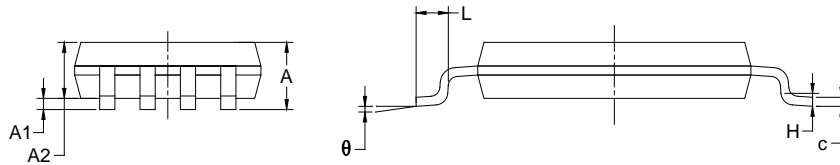
Symbol	Dimensions In Millimeters		Dimensions In Inches	
	MIN	MAX	MIN	MAX
A	0.820	1.100	0.032	0.043
A1	0.020	0.150	0.001	0.006
A2	0.750	0.950	0.030	0.037
b	0.250	0.380	0.010	0.015
c	0.090	0.230	0.004	0.009
D	2.900	3.100	0.114	0.122
E	2.900	3.100	0.114	0.122
E1	4.750	5.050	0.187	0.199
e	0.650 BSC		0.026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

PACKAGE OUTLINE DIMENSIONS

TSSOP-8



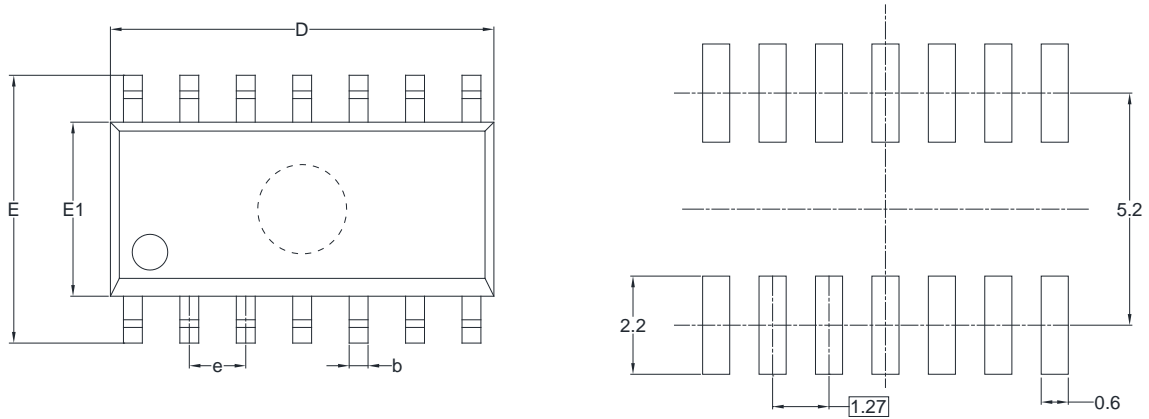
RECOMMENDED LAND PATTERN (Unit: mm)



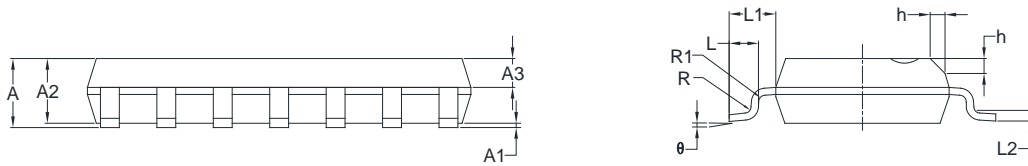
Symbol	Dimensions In Millimeters		Dimensions In Inches	
	MIN	MAX	MIN	MAX
A		1.100		0.043
A1	0.050	0.150	0.002	0.006
A2	0.800	1.000	0.031	0.039
b	0.190	0.300	0.007	0.012
c	0.090	0.200	0.004	0.008
D	2.900	3.100	0.114	0.122
E	4.300	4.500	0.169	0.177
E1	6.250	6.550	0.246	0.258
e	0.650 BSC		0.026 BSC	
L	0.500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

PACKAGE OUTLINE DIMENSIONS

SOIC-14



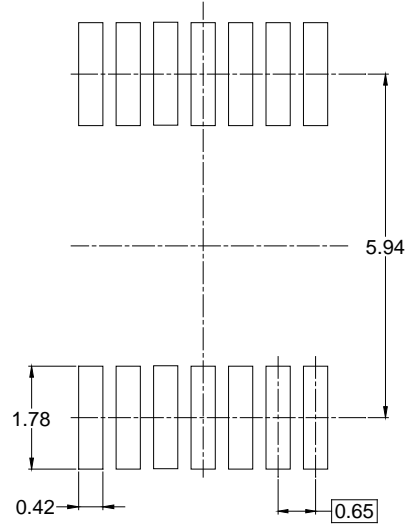
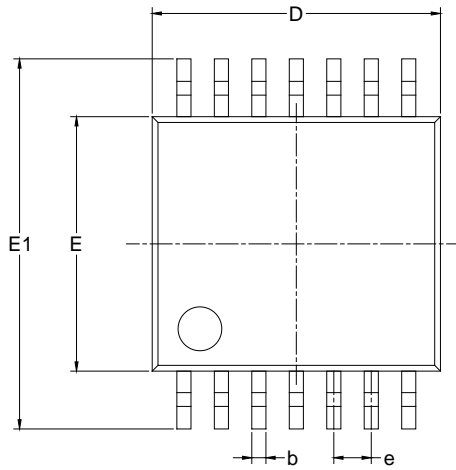
RECOMMENDED LAND PATTERN (Unit: mm)



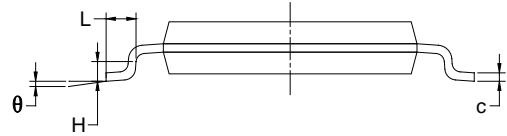
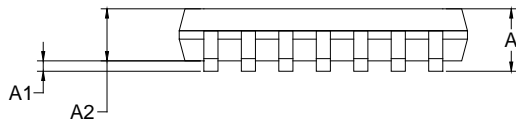
Symbol	Dimensions In Millimeters		Dimensions In Inches	
	MIN	MAX	MIN	MAX
A	1.35	1.75	0.053	0.069
A1	0.10	0.25	0.004	0.010
A2	1.25	1.65	0.049	0.065
A3	0.55	0.75	0.022	0.030
b	0.36	0.49	0.014	0.019
D	8.53	8.73	0.336	0.344
E	5.80	6.20	0.228	0.244
E1	3.80	4.00	0.150	0.157
e	1.27 BSC		0.050 BSC	
L	0.45	0.80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

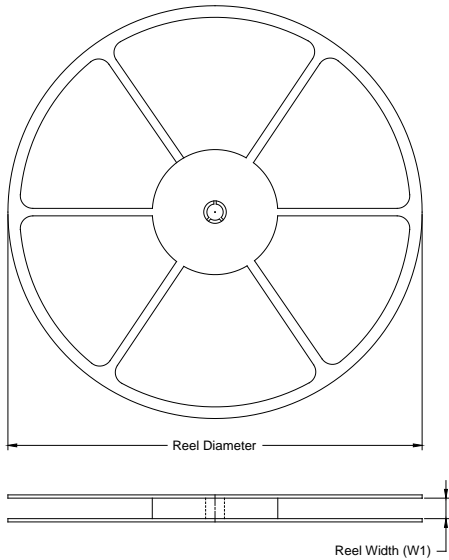


Symbol	Dimensions In Millimeters		Dimensions In Inches	
	MIN	MAX	MIN	MAX
A		1.200		0.047
A1	0.050	0.150	0.002	0.006
A2	0.800	1.050	0.031	0.041
b	0.190	0.300	0.007	0.012
c	0.090	0.200	0.004	0.008
D	4.860	5.100	0.191	0.201
E	4.300	4.500	0.169	0.177
E1	6.250	6.550	0.246	0.258
e	0.650 BSC		0.026 BSC	
L	0.500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

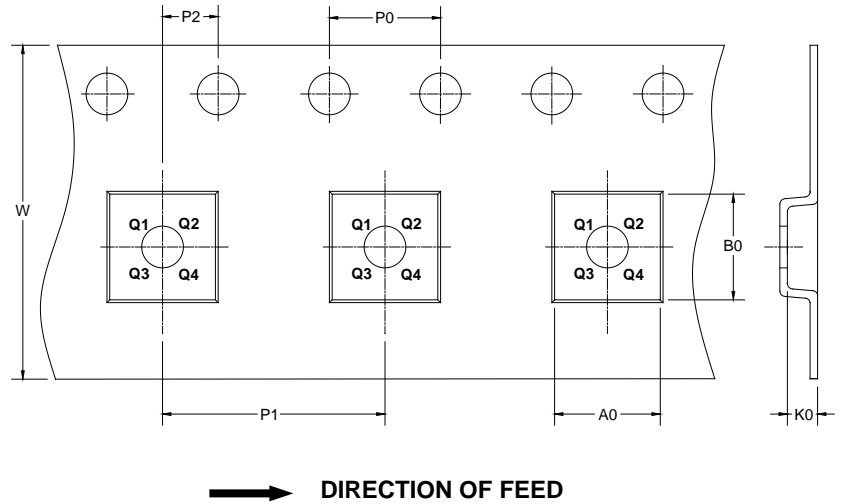


## TAPE AND REEL INFORMATION

### 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

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