

# SGM8531/SGM8532/SGM8534 500kHz, 18 $\mu$ A, Rail-to-Rail I/O, CMOS Operational Amplifiers

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## GENERAL DESCRIPTION

The SGM8531 (single), SGM8532 (dual) and SGM8534 (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 SGM8531/2/4 provide 500kHz bandwidth at a low current consumption of 18 $\mu$ A per amplifier. Very low input bias currents of 0.5pA enable the SGM8531/2/4 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 single SGM8531 is available in Green SOT-23-5 and SOIC-8 packages. The dual SGM8532 is available in Green SOIC-8 and MSOP-8 packages. The quad SGM8534 is available in Green SOIC-14 and TSSOP-14 packages. They are specified over the extended -40°C to +125°C temperature range.

## FEATURES

- **Low Cost**
- **Rail-to-Rail Input and Output**
- **Input Offset Voltage: 3.5mV (MAX)**
- **Unity Gain Stable**
- **Gain-Bandwidth Product: 500kHz**
- **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: 18 $\mu$ A/Amplifier**
- **Small Packaging:**
  - SGM8531 Available in Green SOIC-8 and SOT-23-5 Packages**
  - SGM8532 Available in Green SOIC-8 and MSOP-8 Packages**
  - SGM8534 Available in Green SOIC-14 and TSSOP-14 Packages**

## APPLICATIONS

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

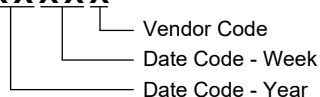
**PACKAGE/ORDERING INFORMATION**

MODEL	PACKAGE DESCRIPTION	SPECIFIED TEMPERATURE RANGE	ORDERING NUMBER	PACKAGE MARKING	PACKING OPTION
SGM8531	SOT-23-5	-40°C to +125°C	SGM8531XN5/TR	8531	Tape and Reel, 3000
	SOIC-8	-40°C to +125°C	SGM8531XS/TR	SGM8531XS XXXXX	Tape and Reel, 2500
SGM8532	SOIC-8	-40°C to +125°C	SGM8532XS/TR	SGM8532XS XXXXX	Tape and Reel, 2500
	MSOP-8	-40°C to +125°C	SGM8532XMS/TR	SGM8532 XMS XXXXX	Tape and Reel, 3000
SGM8534	SOIC-14	-40°C to +125°C	SGM8534XS14/TR	SGM8534XS14 XXXXX	Tape and Reel, 2500
	TSSOP-14	-40°C to +125°C	SGM8534XTS14/TR	SGM8534 XTS14 XXXXX	Tape and Reel, 3000

**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	
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
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
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**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.

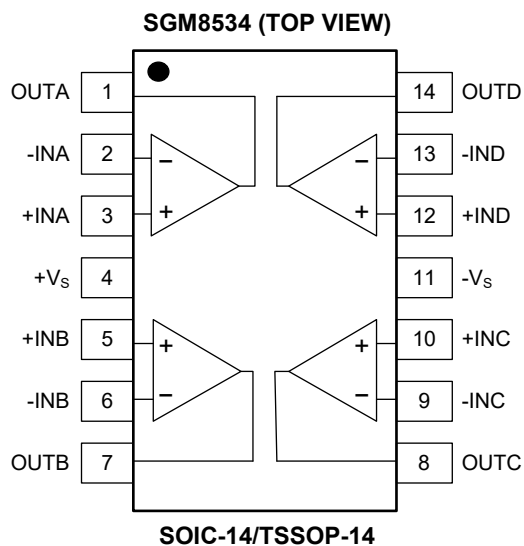
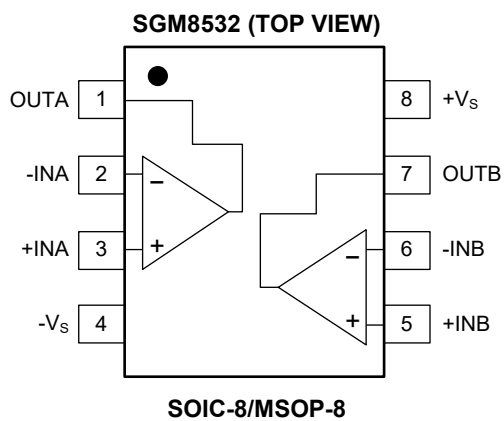
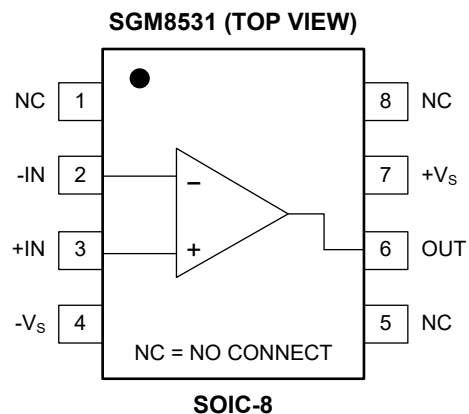
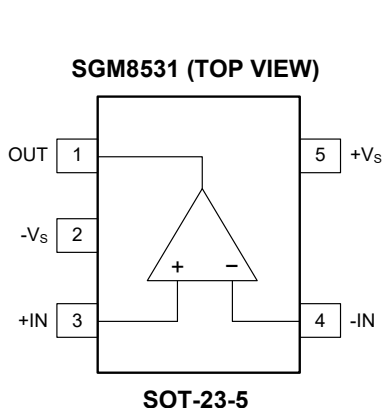
**ESD SENSITIVITY CAUTION**

This integrated circuit can be damaged 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, or specifications without prior notice.

**PIN CONFIGURATIONS**



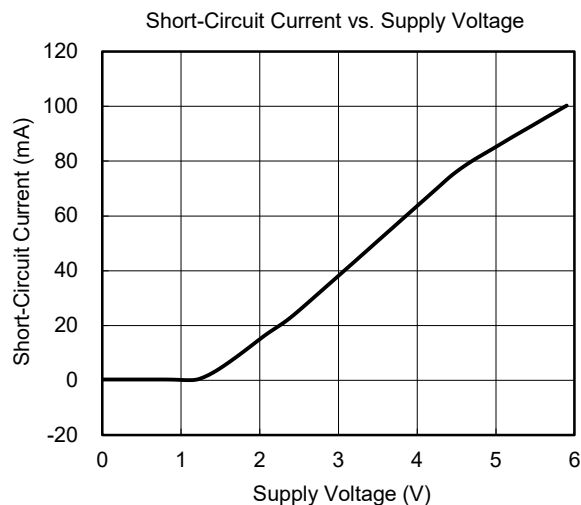
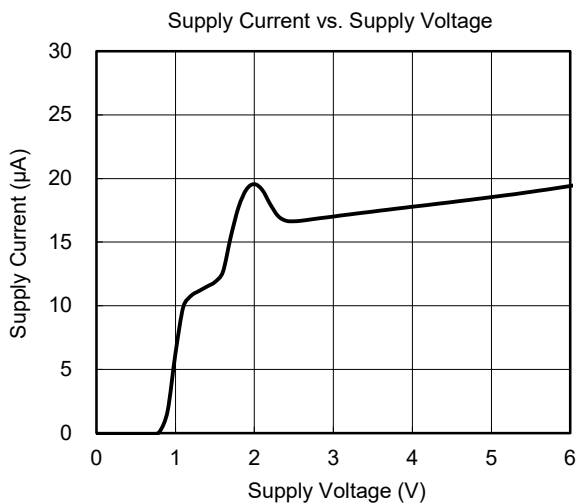
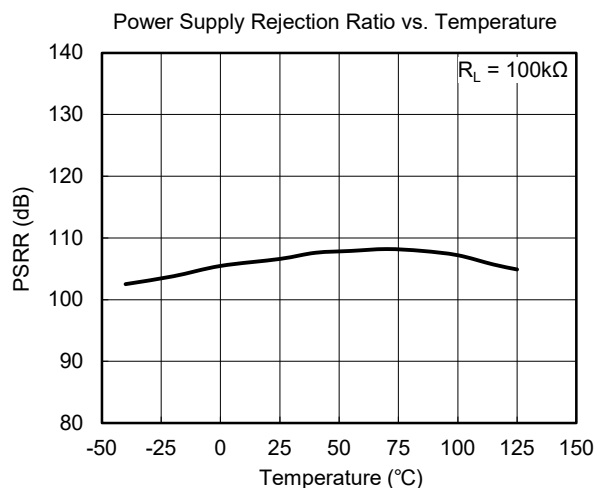
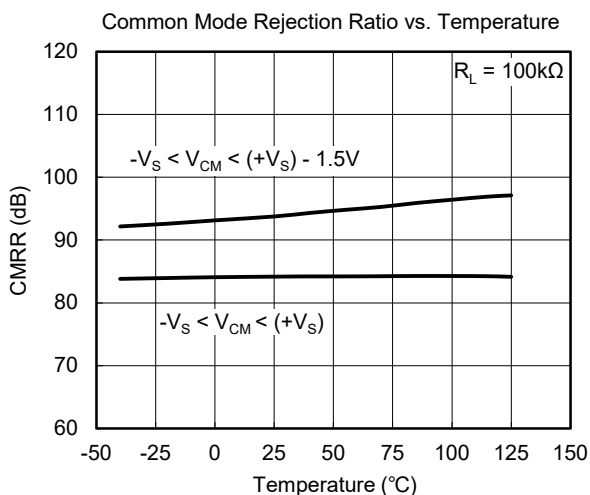
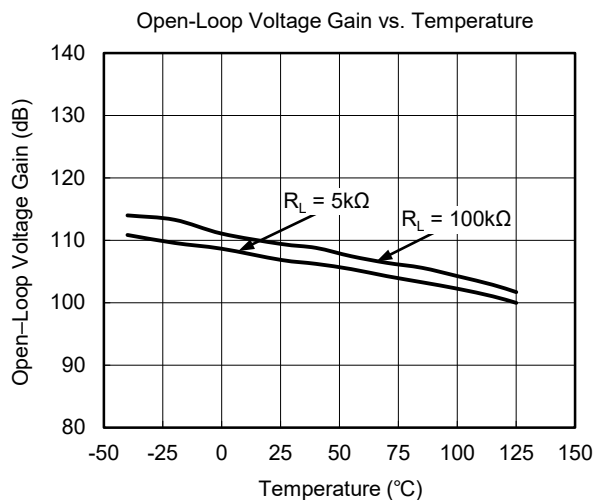
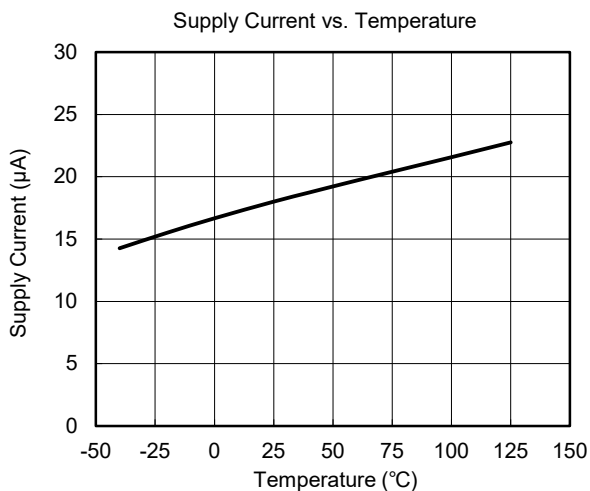
**ELECTRICAL CHARACTERISTICS**

(At  $V_S = 5V$ ,  $R_L = 200k\Omega$  connected to  $V_S/2$  and  $V_{OUT} = V_S/2$ , unless otherwise noted.)

PARAMETER	SYMBOL	CONDITIONS	SGM8531/2/4					
			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	5.4	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	88	71	68	dB	MIN	
		$V_S = 5.5V, V_{CM} = -0.1V$ to 5.6V	75	60	57			
Open-Loop Voltage Gain	$A_{OL}$	$R_L = 5k\Omega, V_{OUT} = 0.1V$ to 4.9V	104	86	81	dB	MIN	
		$R_L = 100k\Omega, V_{OUT} = 0.035V$ to 4.965V	110	90	86			
Input Offset Voltage Drift	$\Delta V_{OS}/\Delta T$		1.7			$\mu V/^\circ C$	TYP	
<b>OUTPUT CHARACTERISTICS</b>								
Output Voltage Swing	$V_{OH}$	$R_L = 100k\Omega$	4.997	4.980	4.970	V	MIN	
	$V_{OL}$	$R_L = 100k\Omega$	3	20	30	mV	MAX	
	$V_{OH}$	$R_L = 10k\Omega$	4.994	4.970	4.960	V	MIN	
	$V_{OL}$	$R_L = 10k\Omega$	6	30	40	mV	MAX	
Output Current	$I_{SOURCE}$	$R_L = 10\Omega$ to $V_S/2$	85	60	45	mA	MIN	
	$I_{SINK}$		76	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, $V_{CM} = 0.5V$	85	70	66	dB	MIN	
Quiescent Current/Amplifier	$I_Q$		18	33	39	$\mu A$	MAX	
<b>DYNAMIC PERFORMANCE (<math>C_L = 100pF</math>)</b>								
Gain-Bandwidth Product	GBP		500			kHz	TYP	
Slew Rate	SR	$G = +1, 2V$ Output Step	0.2			$V/\mu s$	TYP	
Settling Time to 0.1%	$t_s$	$G = +1, 2V$ Output Step	18			$\mu s$	TYP	
Overload Recovery Time		$V_{IN} \cdot G = V_S$	16			$\mu s$	TYP	
<b>NOISE PERFORMANCE</b>								
Input Voltage Noise Density	$e_n$	$f = 1kHz$	33			$nV/\sqrt{Hz}$	TYP	
		$f = 10kHz$	20			$nV/\sqrt{Hz}$	TYP	

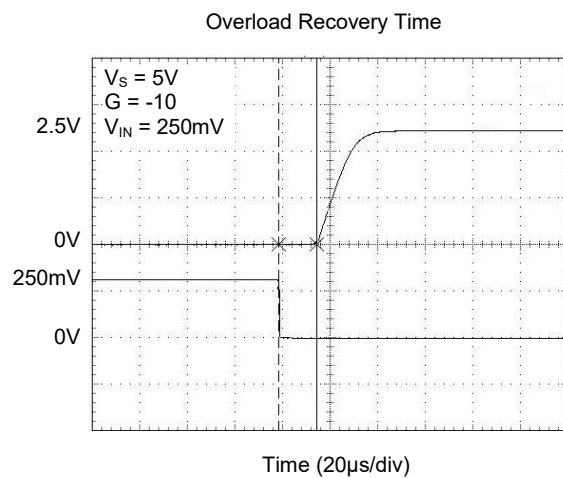
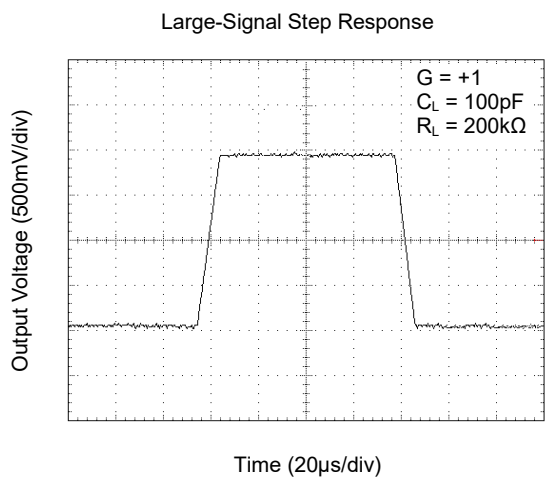
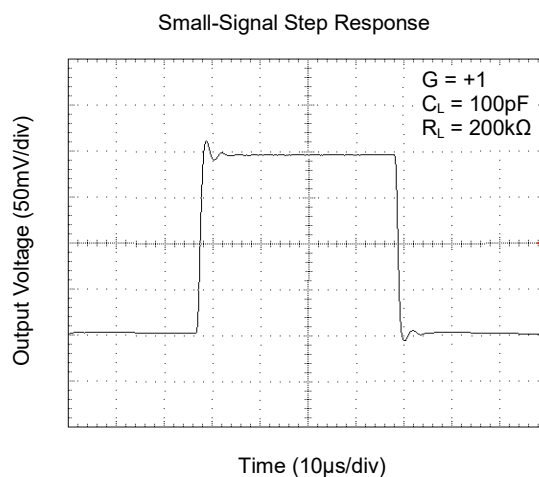
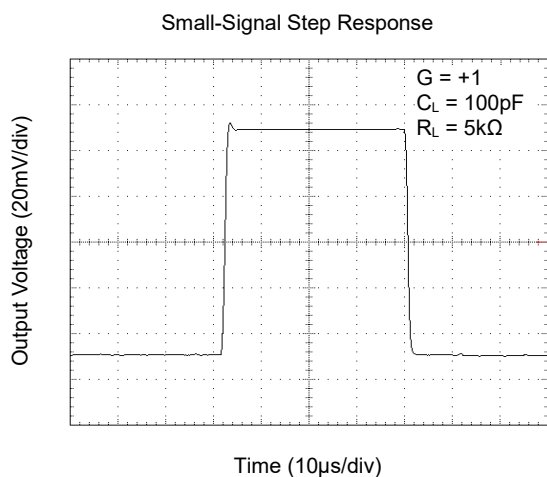
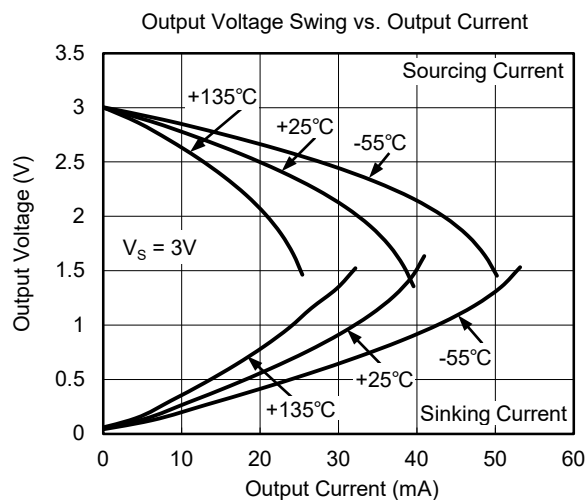
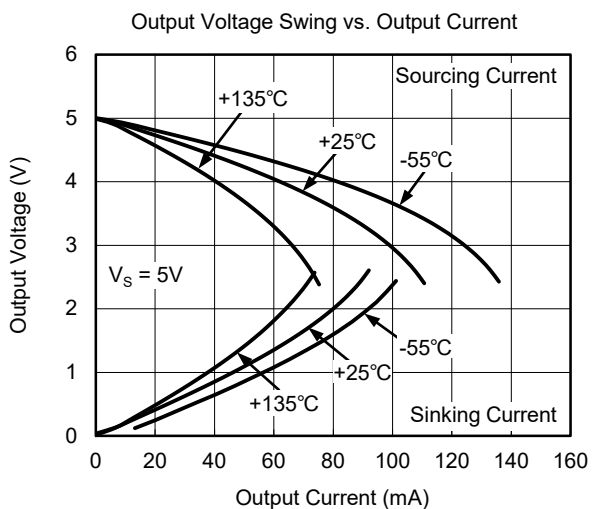
**TYPICAL PERFORMANCE CHARACTERISTICS**

At  $T_A = +25^\circ\text{C}$ ,  $V_S = 5\text{V}$  and  $R_L = 200\text{k}\Omega$  connected to  $V_S/2$ , unless otherwise noted.



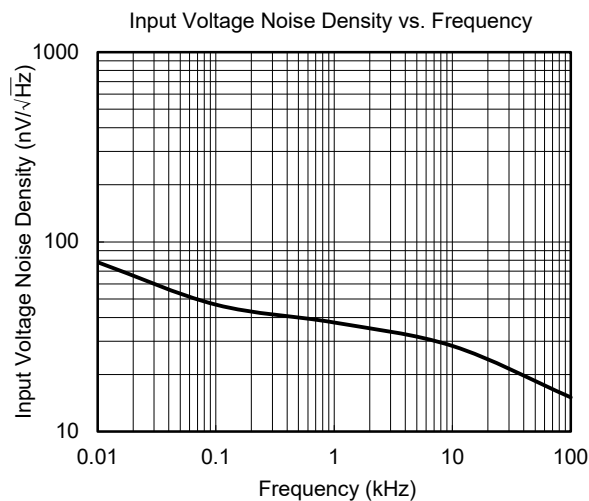
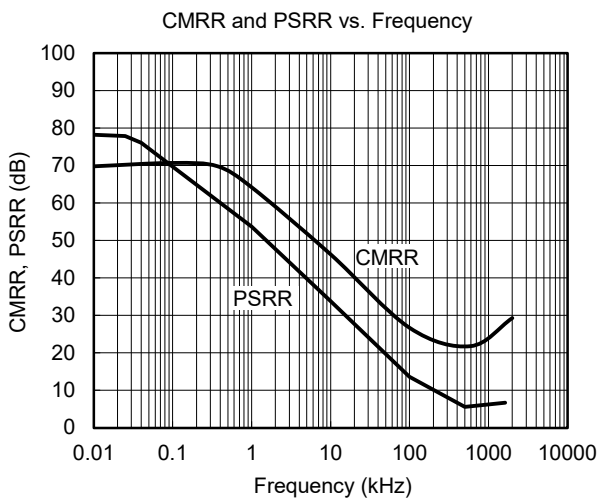
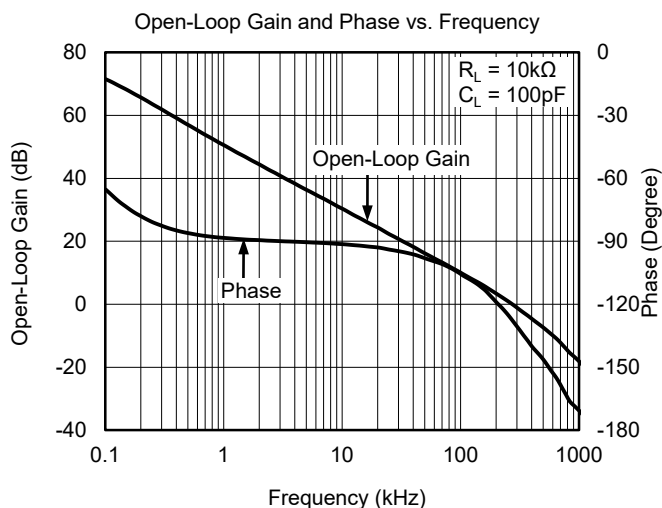
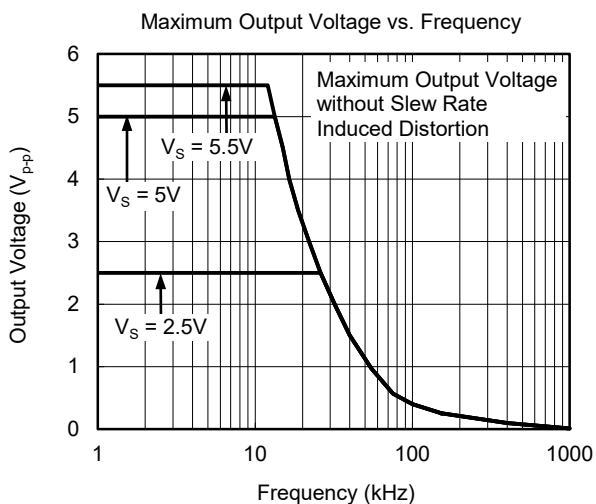
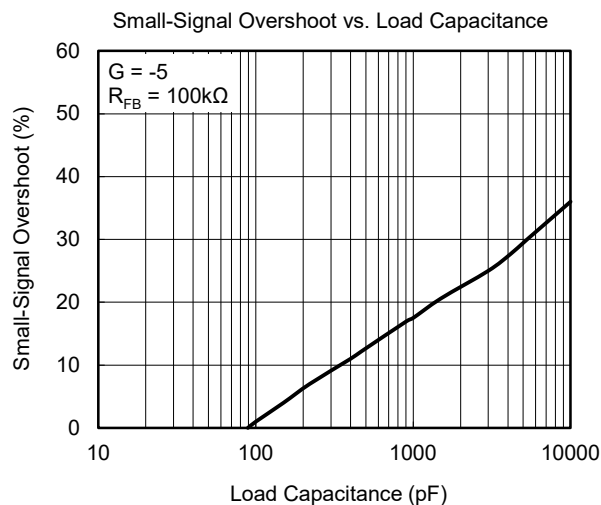
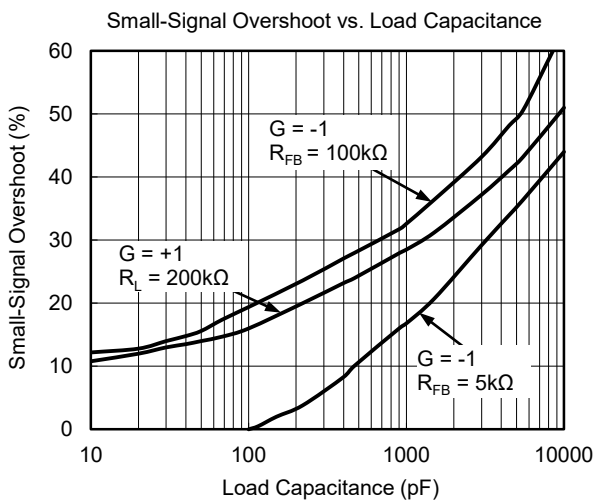
**TYPICAL PERFORMANCE CHARACTERISTICS (continued)**

At  $T_A = +25^\circ\text{C}$ ,  $V_S = 5\text{V}$  and  $R_L = 200\text{k}\Omega$  connected to  $V_S/2$ , unless otherwise noted.



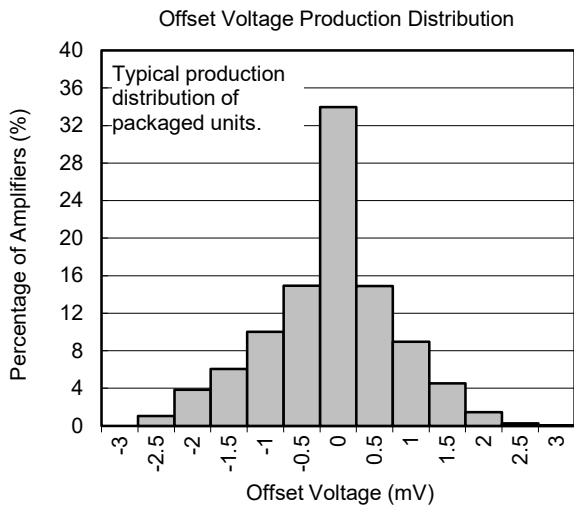
**TYPICAL PERFORMANCE CHARACTERISTICS (continued)**

At  $T_A = +25^\circ\text{C}$ ,  $V_S = 5\text{V}$  and  $R_L = 200\text{k}\Omega$  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  $R_L = 200\text{k}\Omega$  connected to  $V_S/2$ , unless otherwise noted.

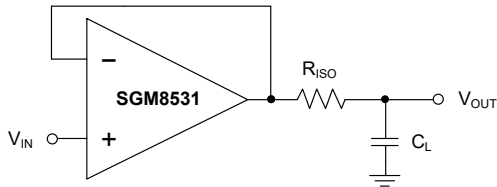




**APPLICATION NOTES**

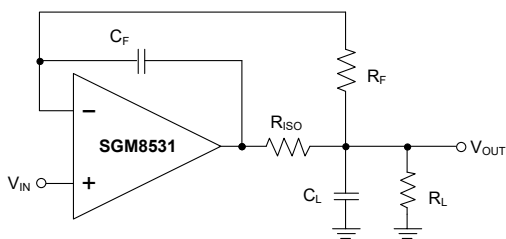
**Driving Capacitive Loads**

The SGM8531/2/4 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 input 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.

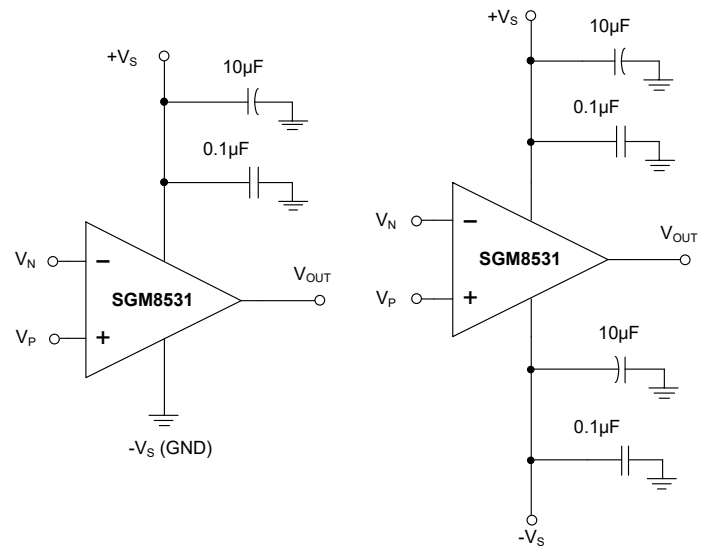


**Figure 2. Indirectly Driving Heavy Capacitive Load with DC Accuracy**

For non-buffer configuration, there are two other ways to increase the phase margin: (a) by increasing the amplifier's closed-loop 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 SGM8531/2/4 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.

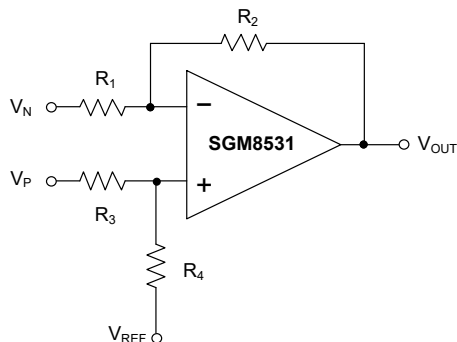


**Figure 3. Amplifier with Bypass Capacitors**

**TYPICAL APPLICATION CIRCUITS**

**Differential Amplifier**

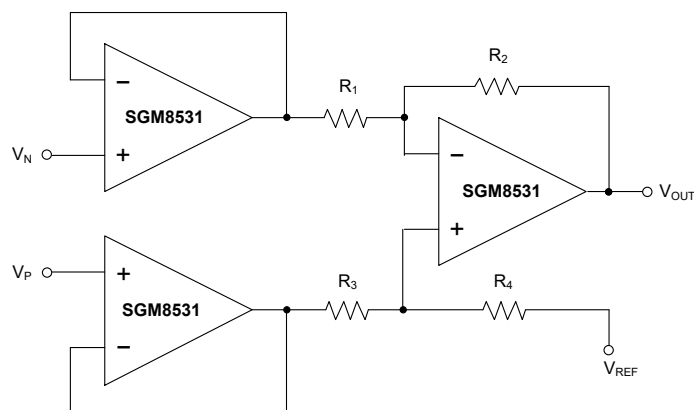
The circuit shown in Figure 4 performs the difference function. If the resistor ratios are equal ( $R_4/R_3 = R_2/R_1$ ), then  $V_{OUT} = (V_P - V_N) \times R_2/R_1 + V_{REF}$ .



**Figure 4. Differential Amplifier**

**Instrumentation Amplifier**

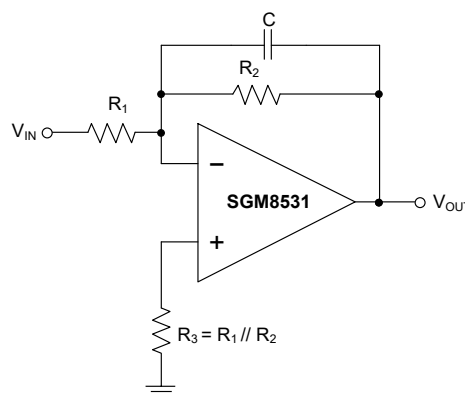
The circuit in Figure 5 performs the same function as that in Figure 4 but with a high input impedance.



**Figure 5. Instrumentation Amplifier**

**Active Low-Pass Filter**

The low-pass filter shown in Figure 6 has a DC gain of  $(-R_2/R_1)$  and the  $-3\text{dB}$  corner frequency is  $1/2\pi R_2 C$ . Make sure the filter bandwidth is within the bandwidth of the amplifier. Feedback resistors with large values 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. 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.

### **NOVEMBER 2018 – REV.C.4 to REV.D**

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Added Open-Loop Gain and Phase vs. Frequency .....	7
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### **NOVEMBER 2012 – REV.C.3 to REV.C.4**

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Added SGM8534 .....	All
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### **DECEMBER 2011 – REV.C.2 to REV.C.3**

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Deleted SGM8534 .....	All
Changed Absolute Maximum Ratings section .....	2
Changed Electrical Characteristics section .....	3
Changed Typical Performance Characteristics section .....	5, 6
Changed Power Supply Bypassing and Layout section .....	7

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### **MAY 2011 – REV.C.1 to REV.C.2**

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Changed Caution section .....	2
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### **FEBRUARY 2009 – REV.C to REV.C.1**

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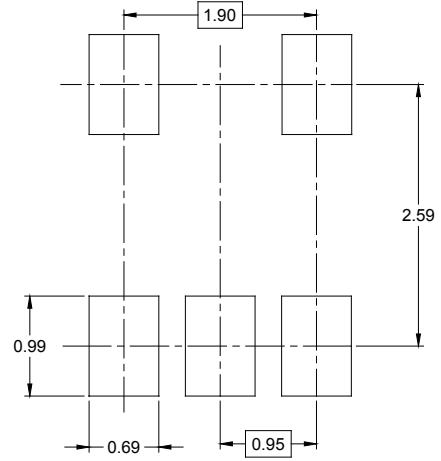
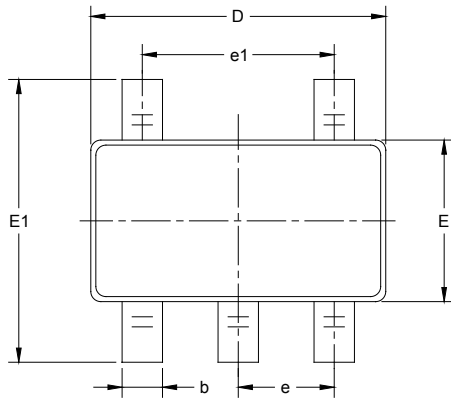
Deleted SOIC-16 and TSSOP-16 Packages .....	All
Changed SOIC-14 Package Option from Tube to Tape and Reel, 2500 .....	2
Changed TSSOP-14 Package Option from Tube to Tape and Reel, 3000 .....	2

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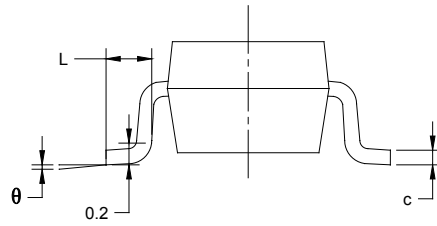
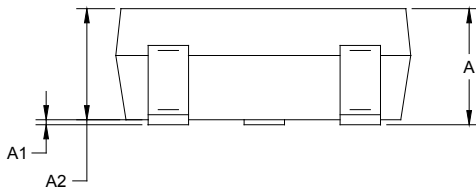
# PACKAGE INFORMATION

## PACKAGE OUTLINE DIMENSIONS

### SOT-23-5



RECOMMENDED LAND PATTERN (Unit: mm)

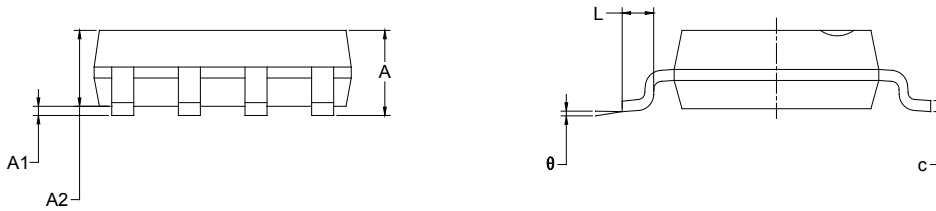
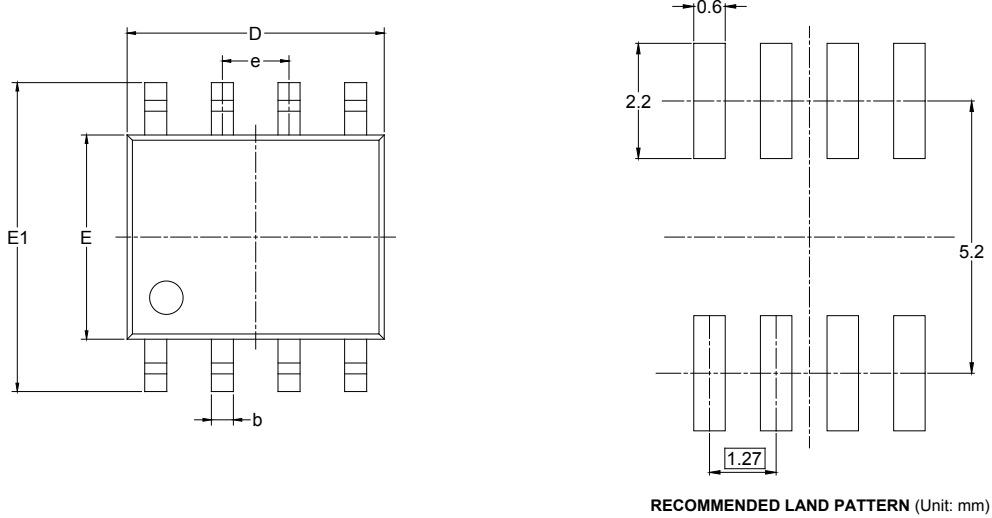


Symbol	Dimensions In Millimeters		Dimensions In Inches	
	MIN	MAX	MIN	MAX
A	1.050	1.250	0.041	0.049
A1	0.000	0.100	0.000	0.004
A2	1.050	1.150	0.041	0.045
b	0.300	0.500	0.012	0.020
c	0.100	0.200	0.004	0.008
D	2.820	3.020	0.111	0.119
E	1.500	1.700	0.059	0.067
E1	2.650	2.950	0.104	0.116
e	0.950 BSC		0.037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

# PACKAGE INFORMATION

## PACKAGE OUTLINE DIMENSIONS

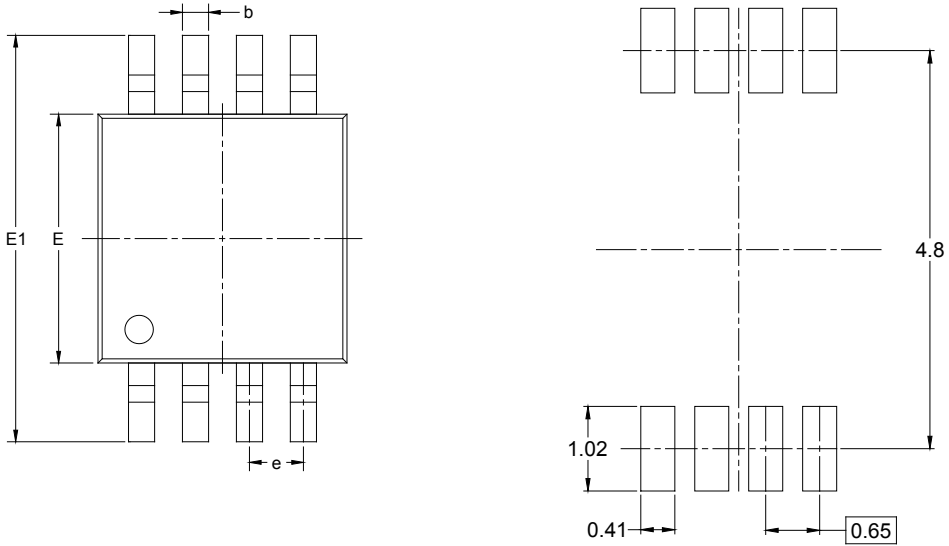
### SOIC-8



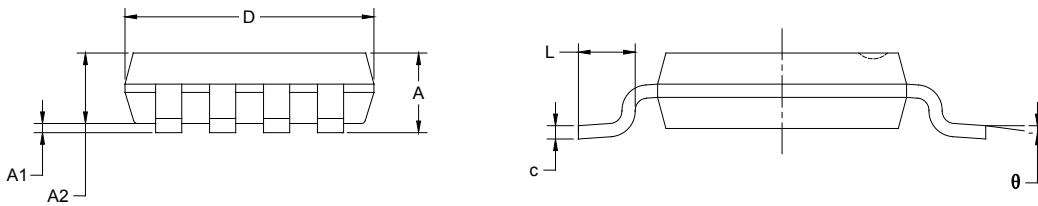
Symbol	Dimensions In Millimeters		Dimensions In Inches	
	MIN	MAX	MIN	MAX
A	1.350	1.750	0.053	0.069
A1	0.100	0.250	0.004	0.010
A2	1.350	1.550	0.053	0.061
b	0.330	0.510	0.013	0.020
c	0.170	0.250	0.006	0.010
D	4.700	5.100	0.185	0.200
E	3.800	4.000	0.150	0.157
E1	5.800	6.200	0.228	0.244
e	1.27 BSC		0.050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

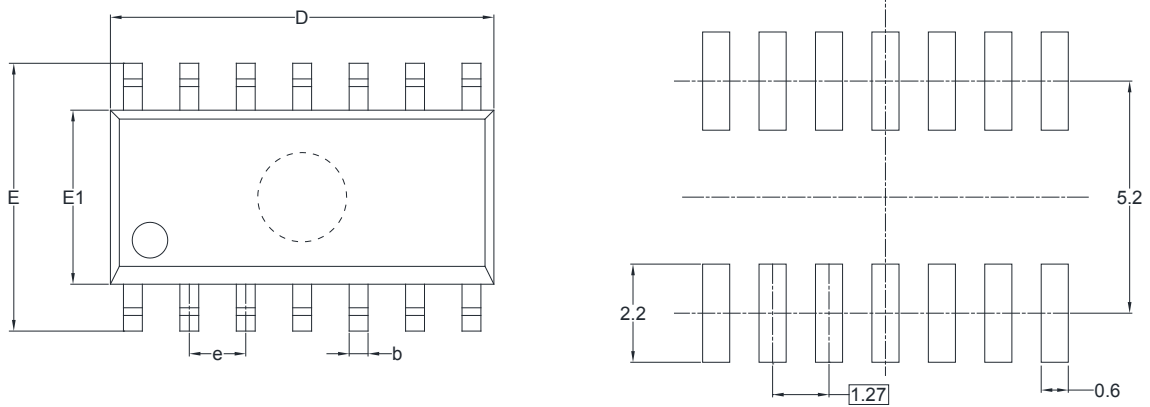


Symbol	Dimensions In Millimeters		Dimensions In Inches	
	MIN	MAX	MIN	MAX
A	0.820	1.100	0.032	0.043
A1	0.020	0.150	0.001	0.006
A2	0.750	0.950	0.030	0.037
b	0.250	0.380	0.010	0.015
c	0.090	0.230	0.004	0.009
D	2.900	3.100	0.114	0.122
E	2.900	3.100	0.114	0.122
E1	4.750	5.050	0.187	0.199
e	0.650 BSC		0.026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

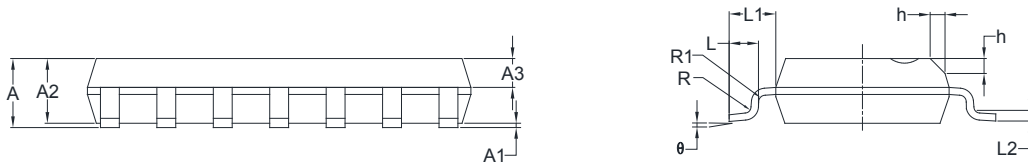
# PACKAGE INFORMATION

## PACKAGE OUTLINE DIMENSIONS

### SOIC-14



RECOMMENDED LAND PATTERN (Unit: mm)

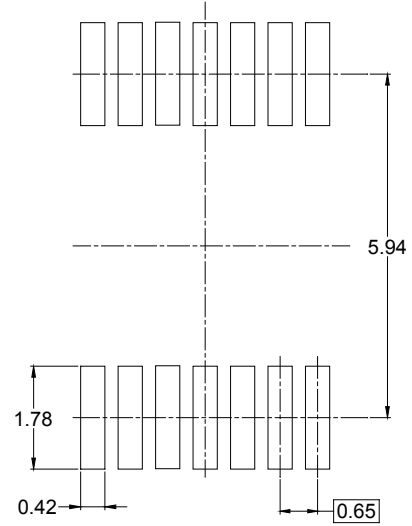
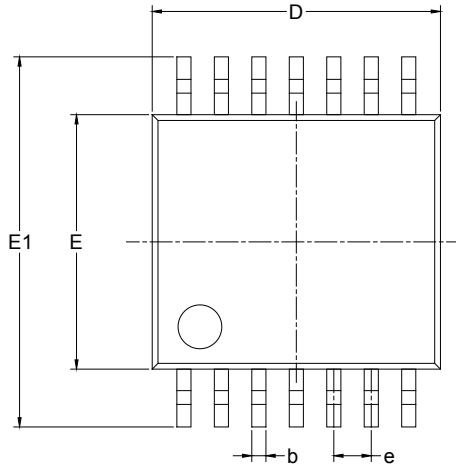


Symbol	Dimensions In Millimeters		Dimensions In Inches	
	MIN	MAX	MIN	MAX
A	1.35	1.75	0.053	0.069
A1	0.10	0.25	0.004	0.010
A2	1.25	1.65	0.049	0.065
A3	0.55	0.75	0.022	0.030
b	0.36	0.49	0.014	0.019
D	8.53	8.73	0.336	0.344
E	5.80	6.20	0.228	0.244
E1	3.80	4.00	0.150	0.157
e	1.27 BSC		0.050 BSC	
L	0.45	0.80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

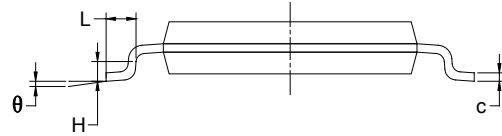
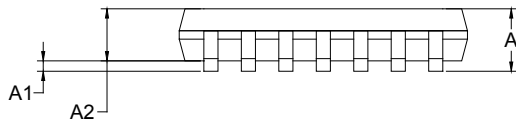
# PACKAGE INFORMATION

## PACKAGE OUTLINE DIMENSIONS

### TSSOP-14



RECOMMENDED LAND PATTERN (Unit: mm)



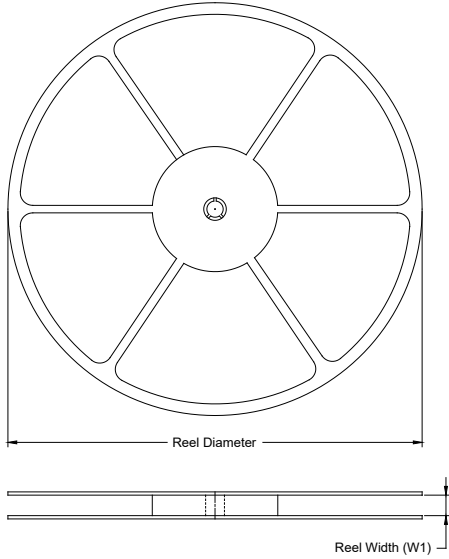
Symbol	Dimensions In Millimeters		Dimensions In Inches	
	MIN	MAX	MIN	MAX
A		1.200		0.047
A1	0.050	0.150	0.002	0.006
A2	0.800	1.050	0.031	0.041
b	0.190	0.300	0.007	0.012
c	0.090	0.200	0.004	0.008
D	4.860	5.100	0.191	0.201
E	4.300	4.500	0.169	0.177
E1	6.250	6.550	0.246	0.258
e	0.650 BSC		0.026 BSC	
L	0.500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



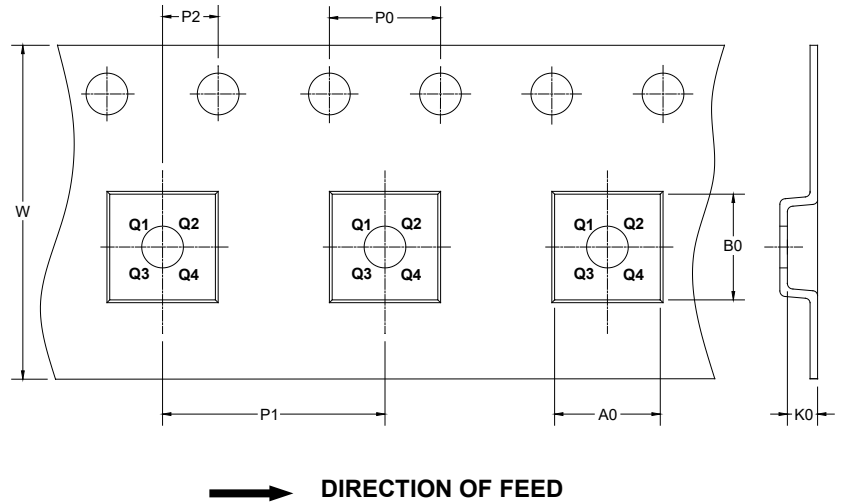
# PACKAGE INFORMATION

## TAPE AND REEL INFORMATION

### REEL DIMENSIONS



### TAPE DIMENSIONS



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

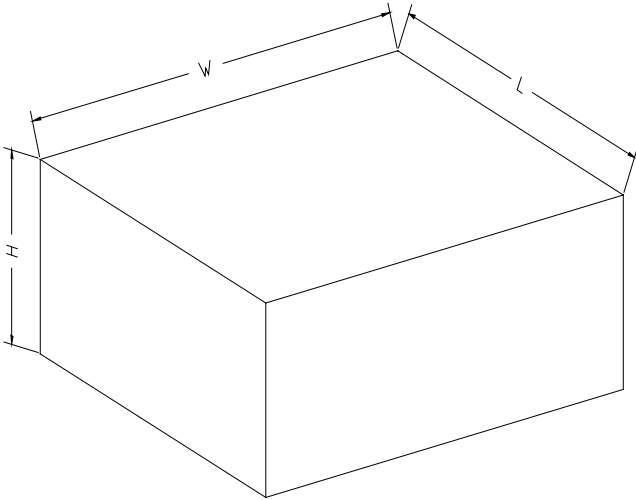
### KEY PARAMETER LIST OF TAPE AND REEL

Package Type	Reel Diameter	Reel Width W1 (mm)	A0 (mm)	B0 (mm)	K0 (mm)	P0 (mm)	P1 (mm)	P2 (mm)	W (mm)	Pin1 Quadrant
SOT-23-5	7"	9.5	3.20	3.20	1.40	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	6.95	5.60	1.20	4.0	8.0	2.0	12.0	Q1

D30001

# 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