



## GENERAL DESCRIPTION

The SGM8651/3 (single), SGM8652/5 (dual) and SGM8654 (quad) are low cost, high precision, low noise, low distortion, CMOS voltage feedback amplifiers. These devices can operate from 2.5V to 5.5V single supply, and consume 2.3mA low quiescent current per amplifier. And, the supply current of SGM8653/5 is only 75 $\mu$ A per amplifier in power-down mode. So SGM8653/5 are suitable for battery-powered equipment and portable devices, which require low power dissipation. The SGM8651/2/3/4/5 provide a wide input common mode voltage range and rail-to-rail output voltage swing.

These devices are designed to provide optimal performance in all aspects. They exhibit a wide bandwidth of 50MHz. The short settling time and low distortion make the operational amplifiers appropriate for buffering high speed ADC and DAC.

The SGM8651 is available in Green SOT-23-5 and SOIC-8 packages. The SGM8652 is available in Green SOIC-8 and MSOP-8 packages. The SGM8653 is available in Green SOT-23-6 and SOIC-8 packages. The SGM8654 is available in Green SOIC-14 and TSSOP-14 packages. The SGM8655 is available in a Green MSOP-10 package. They are specified over the extended -40°C to +125°C temperature range.

## SGM8651/SGM8652/SGM8654 SGM8653/SGM8655 50MHz, Rail-to-Rail Output CMOS Operational Amplifiers

## FEATURES

- Input Offset Voltage: 2mV (TYP)
- Gain-Bandwidth Product: 50MHz
- High Slew Rate: 66V/ $\mu$ s
- Settling Time to 0.1% with 2V Step: 60ns
- Overload Recovery Time: 25ns
- Low Noise: 8.7nV/ $\sqrt{\text{Hz}}$
- Rail-to-Rail Output
- Supply Voltage Range: 2.5V to 5.5V
- Input Voltage Range: -0.2V to 3.8V with V<sub>S</sub> = 5V
- Low Supply Current:  
2.3mA/Amplifier (TYP)  
75 $\mu$ A/Amplifier Shutdown Current for SGM8653/5
- -40°C to +125°C Operating Temperature Range
- Small Packaging:  
SGM8651 Available in Green SOT-23-5 and SOIC-8 Packages  
SGM8652 Available in Green MSOP-8 and SOIC-8 Packages  
SGM8653 Available in Green SOT-23-6 and SOIC-8 Packages  
SGM8654 Available in Green SOIC-14 and TSSOP-14 Packages  
SGM8655 Available in a Green MSOP-10 Package

## APPLICATIONS

- Data Acquisition
- Process Control
- Audio Processing
- Video Processing
- Active Filter
- Test Equipment
- Cell Phone PA Control
- Broadband Communication
- ADC Driver
- DAC Driver

## PACKAGE/ORDERING INFORMATION

MODEL	PACKAGE DESCRIPTION	SPECIFIED TEMPERATURE RANGE	ORDERING NUMBER	PACKAGE MARKING	PACKING OPTION
SGM8651	SOT-23-5	-40°C to +125°C	SGM8651XN5/TR	8651	Tape and Reel, 3000
	SOIC-8	-40°C to +125°C	SGM8651XS/TR	SGM8651XS	Tape and Reel, 2500
SGM8652	MSOP-8	-40°C to +125°C	SGM8652XMS/TR	SGM8652XMS	Tape and Reel, 3000
	SOIC-8	-40°C to +125°C	SGM8652XS/TR	SGM8652XS	Tape and Reel, 2500
SGM8653	SOT-23-6	-40°C to +125°C	SGM8653XN6/TR	8653	Tape and Reel, 3000
	SOIC-8	-40°C to +125°C	SGM8653XS/TR	SGM8653XS	Tape and Reel, 2500
SGM8654	SOIC-14	-40°C to +125°C	SGM8654XS14/TR	SGM8654XS14	Tape and Reel, 2500
	TSSOP-14	-40°C to +125°C	SGM8654XTS14/TR	SGM8654XTS14	Tape and Reel, 3000
SGM8655	MSOP-10	-40°C to +125°C	SGM8655XMS/TR	SGM8655XMS	Tape and Reel, 3000

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 $-V_S$ .....	7.5V
Input Common Mode Voltage ..... ( $-V_S$ ) - 0.5V to ( $+V_S$ ) + 0.5V	
Package Thermal Resistance @ $T_A = +25^\circ C$	
SOT-23-5, $\theta_{JA}$ .....	190°C/W
SOT-23-6, $\theta_{JA}$ .....	190°C/W
SOIC-8, $\theta_{JA}$ .....	125°C/W
MSOP-8, $\theta_{JA}$ .....	216°C/W
MSOP-10, $\theta_{JA}$ .....	216°C/W
Junction Temperature .....	+160°C
Storage Temperature Range .....	-65°C to +150°C
Lead Temperature (Soldering, 10s) .....	+260°C
ESD Susceptibility	
HBM .....	1000V
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.

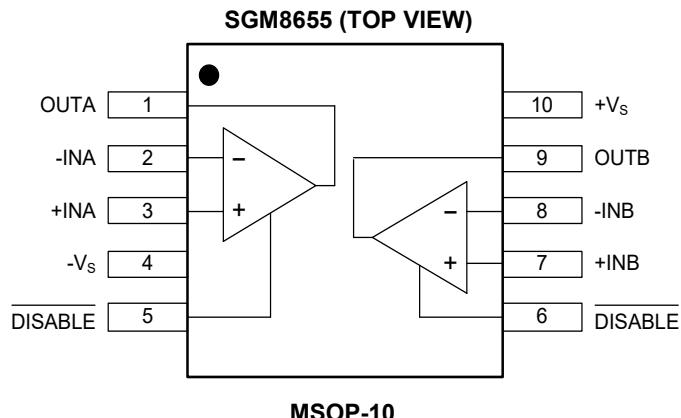
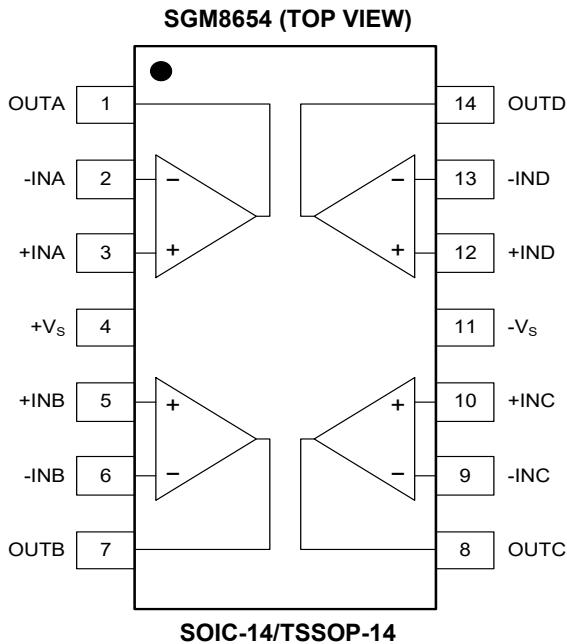
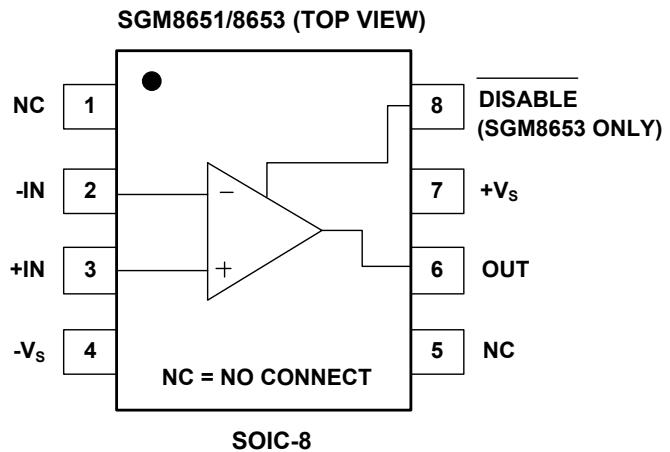
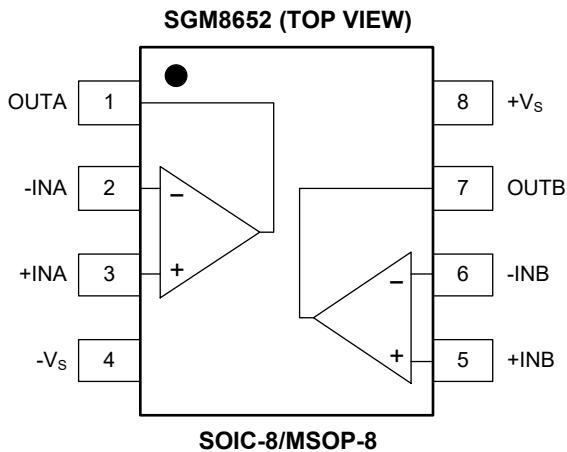
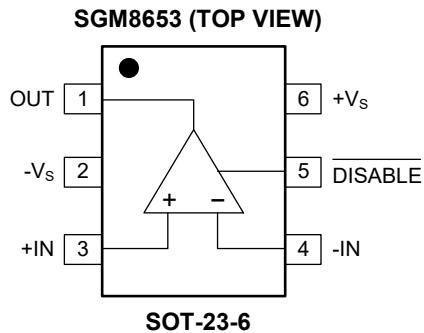
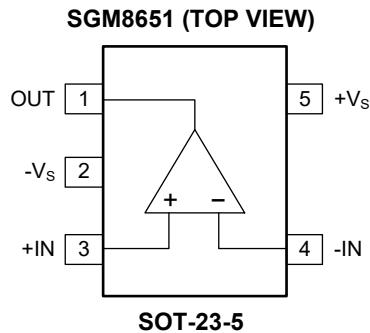
## ESD SENSITIVITY CAUTION

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



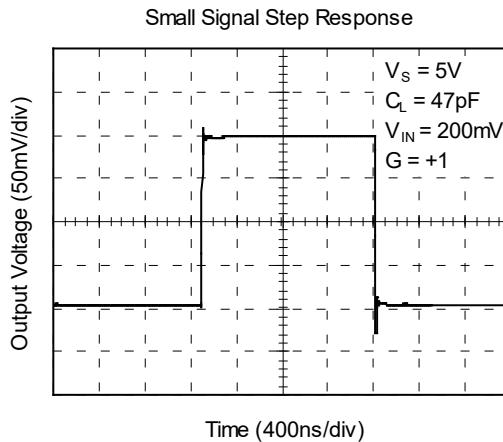
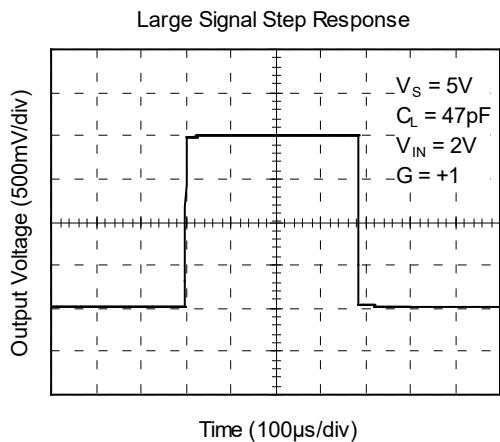
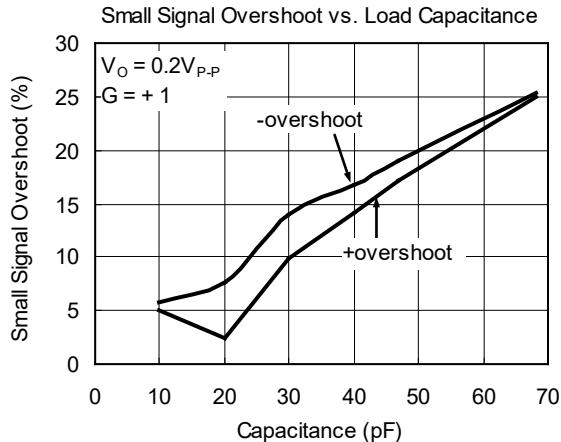
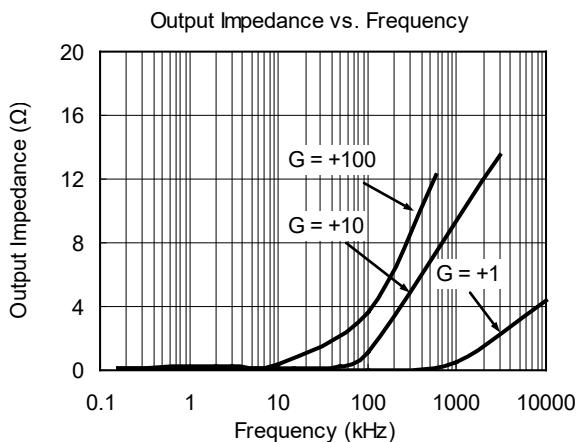
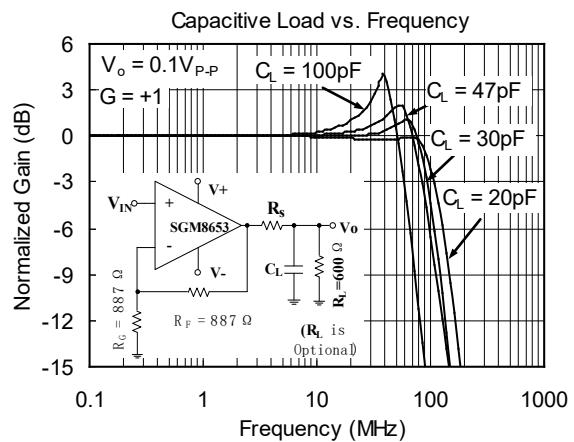
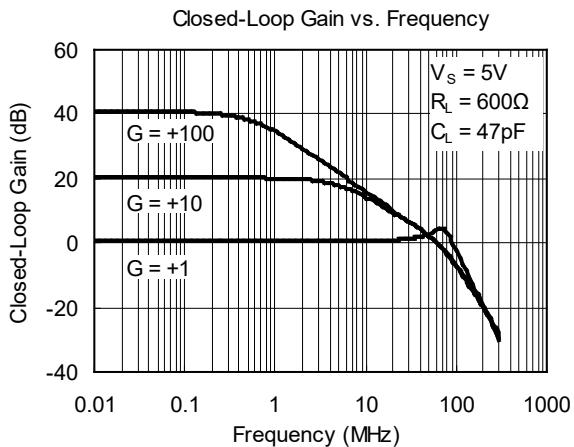
## ELECTRICAL CHARACTERISTICS

(At  $T_A = +25^\circ\text{C}$ ,  $V_S = 5\text{V}$ ,  $R_L = 600\Omega$  connected to  $V_S/2$ , unless otherwise noted.)

PARAMETER	CONDITIONS	SGM8651/2/3/4/5						
		TYP	MIN/MAX OVER TEMPERATURE					
		+25°C	+25°C	0°C to +70°C	-40°C to +85°C	-40°C to +125°C	UNITS	MIN/MAX
<b>Dynamic Performance</b>								
Gain-Bandwidth Product (GBP)	$G = +10$	50					MHz	TYP
Slew Rate	$G = +1$ , 2V Output step	66					V/ $\mu\text{s}$	TYP
Settling Time to 0.1%	$G = +1$ , 2V Output step	60					ns	TYP
Overload Recovery Time	$V_{IN} \cdot G = +V_S$	25					ns	TYP
<b>Noise Performance</b>								
Input Voltage Noise Density ( $e_n$ )	$f = 100\text{kHz}$ $f = 1\text{MHz}$	16 8.7					nV/ $\sqrt{\text{Hz}}$ nV/ $\sqrt{\text{Hz}}$	TYP TYP
<b>DC Performance</b>								
Input Offset Voltage ( $V_{OS}$ )		$\pm 2$	$\pm 8$	$\pm 8.9$	$\pm 9.5$	$\pm 9.8$	mV	MAX
Input Offset Voltage Drift		4.5					$\mu\text{V}/^\circ\text{C}$	TYP
Input Bias Current ( $I_B$ )		6					pA	TYP
Input Offset Current ( $I_{OS}$ )		2					pA	TYP
Open-Loop Gain ( $A_{OL}$ )	$V_{OUT} = 0.3\text{V to } 4.7\text{V}, R_L = 150\Omega$ $V_{OUT} = 0.2\text{V to } 4.8\text{V}, R_L = 1\text{k}\Omega$	80 104	75 92	74 91	74 91	73 80	dB	MIN MIN
<b>Input Characteristics</b>								
Input Common Mode Voltage Range ( $V_{CM}$ )		-0.2 to 3.8					V	TYP
Common Mode Rejection Ratio(CMRR)	$V_{CM} = -0.1\text{V to } 3.5\text{V}$	80	66	65	65	62	dB	MIN
<b>Output Characteristics</b>								
Output Voltage Swing from Rail	$R_L = 150\Omega$	0.12					V	TYP
	$R_L = 1\text{k}\Omega$	0.03					V	TYP
Output Current		127	100	96	89	82	mA	MIN
Closed-Loop Output Impedance	$f < 100\text{kHz}, G = +1$	0.08					$\Omega$	TYP
<b>Power-Down Disable</b> (SGM8653/5 Only)								
Turn-On Time		220					ns	TYP
Turn-Off Time		150					ns	TYP
DISABLE Voltage-Off		0.8					V	MAX
DISABLE Voltage-On		2					V	MIN
<b>Power Supply</b>								
Operating Voltage Range			2.5 5.5	2.7 5.5	2.7 5.5	2.7 5.5	V	MIN MAX
Quiescent Current/Amplifier		2.3	2.9	3.4	3.8	4	mA	MAX
Supply Current/Amplifier when Disabled (SGM8653/5 Only)		75	120	127	130	137	$\mu\text{A}$	MAX
Power Supply Rejection Ratio (PSRR)	$\Delta V_S = 2.7\text{V to } 5.5\text{V}$ , $V_{CM} = (-V_S) + 0.5\text{V}$	80	67	67	65	62	dB	MIN

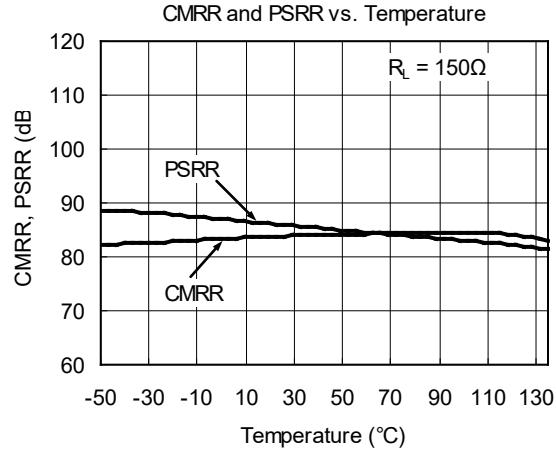
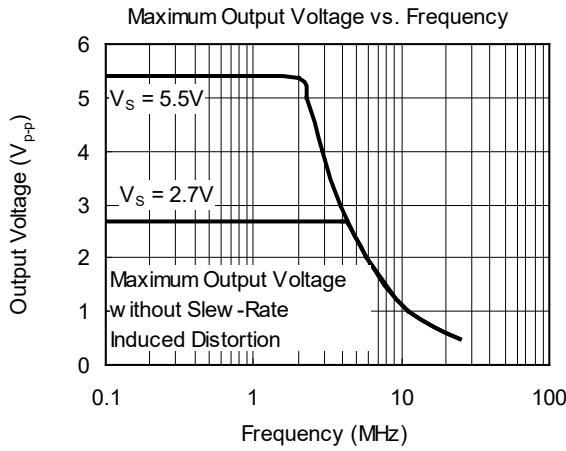
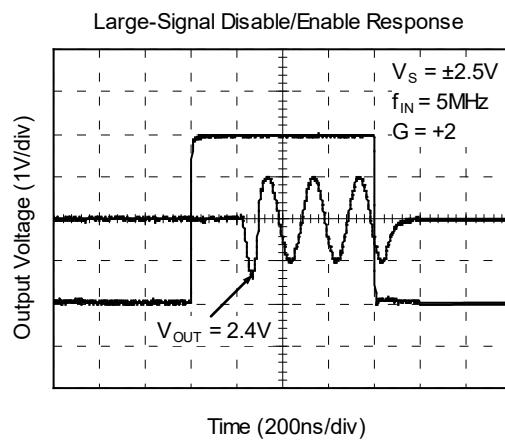
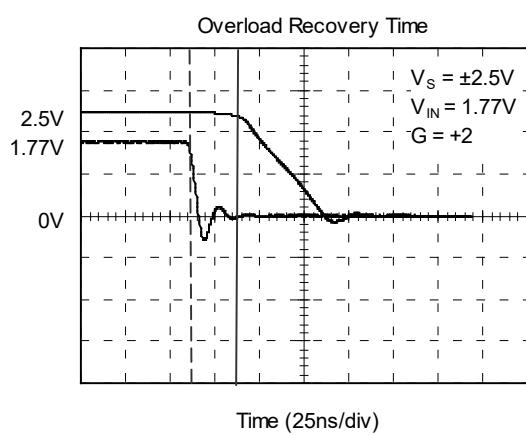
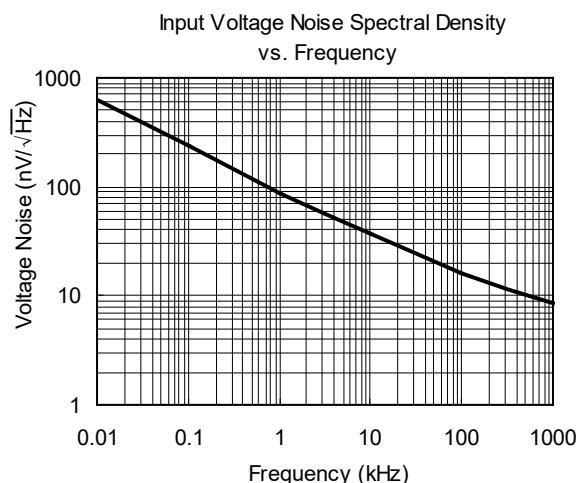
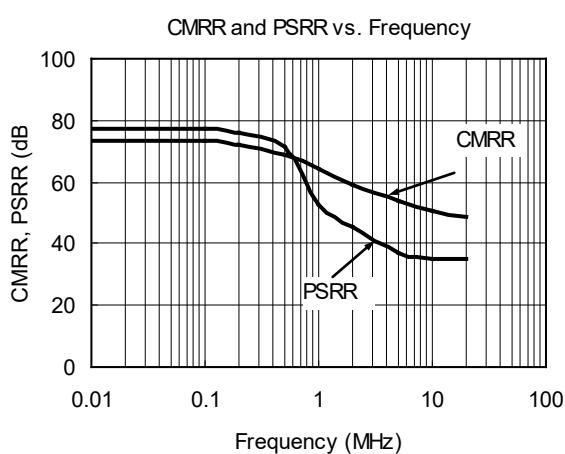
## TYPICAL PERFORMANCE CHARACTERISTICS

At  $T_A = +25^\circ\text{C}$ ,  $V_S = 5\text{V}$ ,  $G = +2$ ,  $R_F = 887\Omega$ ,  $R_G = 887\Omega$ ,  $C_L = 47\text{pF}$ , and  $R_L = 600\Omega$ , unless otherwise noted.



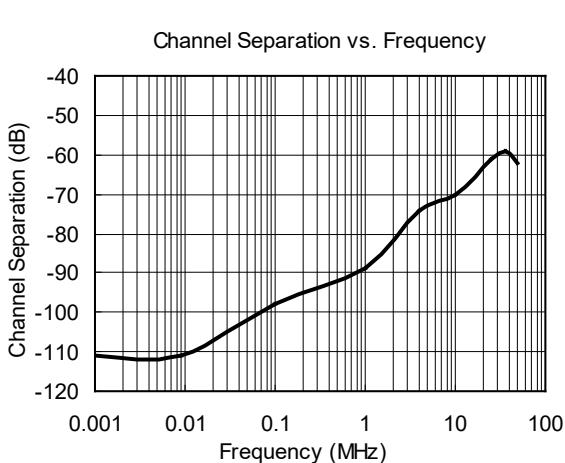
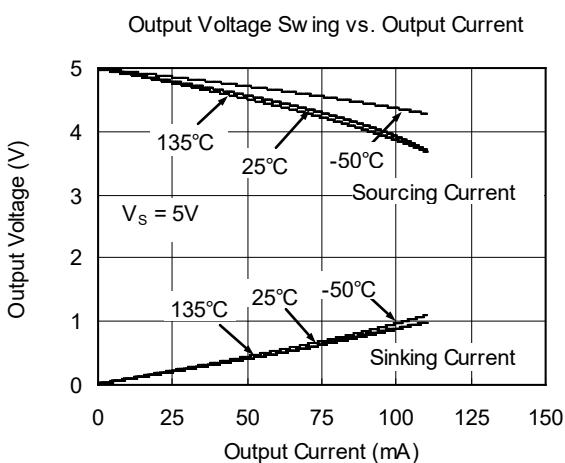
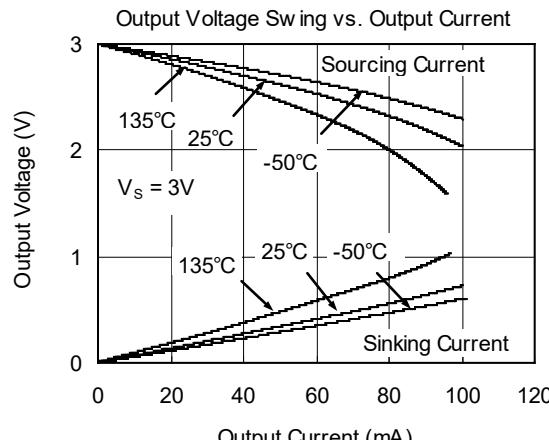
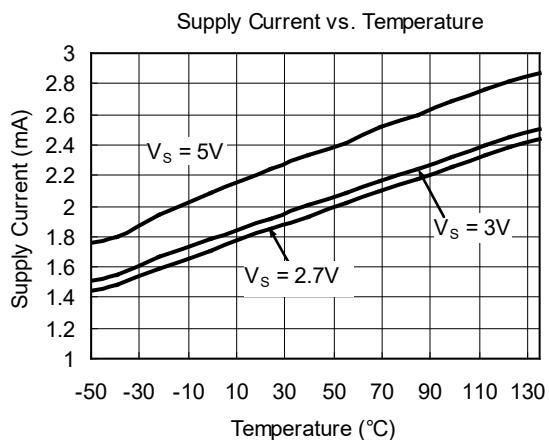
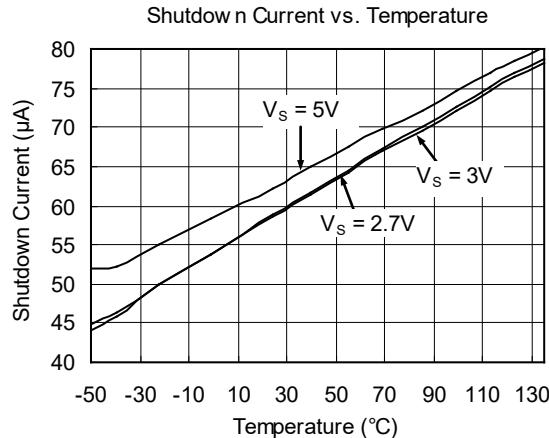
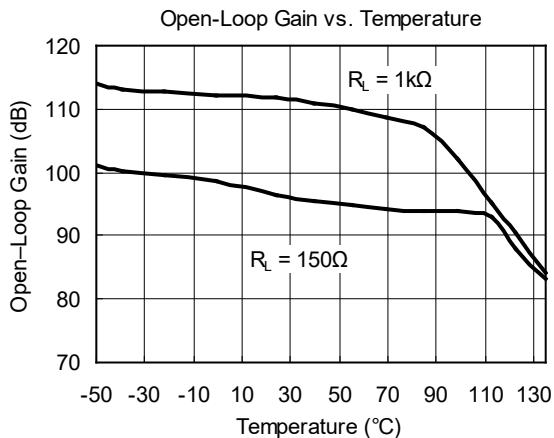
## TYPICAL PERFORMANCE CHARACTERISTICS (continued)

At  $T_A = +25^\circ\text{C}$ ,  $V_S = 5\text{V}$ ,  $G = +2$ ,  $R_F = 887\Omega$ ,  $R_G = 887\Omega$ ,  $C_L = 47\text{pF}$ , and  $R_L = 600\Omega$ , unless otherwise noted.



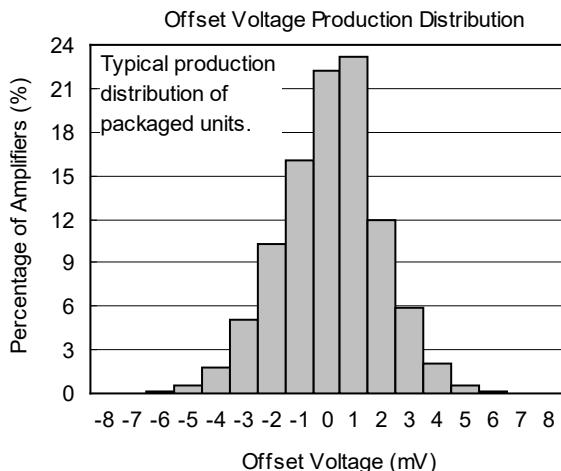
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## **TYPICAL PERFORMANCE CHARACTERISTICS (continued)**

At  $T_A = +25^\circ\text{C}$ ,  $V_S = 5\text{V}$ ,  $G = +2$ ,  $R_F = 887\Omega$ ,  $R_G = 887\Omega$ ,  $R_L = 150\Omega$  connected to  $V_S/2$ , unless otherwise noted.



## APPLICATION INFORMATION

### Rail-to-Rail Output

The SGM8651/2/3/4/5 support rail-to-rail output operation. In single power supply application, for example, when  $+V_S = 5V$ ,  $-V_S = GND$ ,  $1k\Omega$  load resistor is tied from OUT pin to  $V_S/2$ , the typical output swing range is from 0.03V to 4.97V.

### Driving Capacitive Loads

The SGM8651/2/3/4/5 are designed for driving the 47pF capacitive load with unity-gain stable. If greater capacitive load must be driven in application, the circuit in Figure 1 can be used. In this circuit, the IR drop voltage generated by  $R_{ISO}$  is compensated by feedback loop.

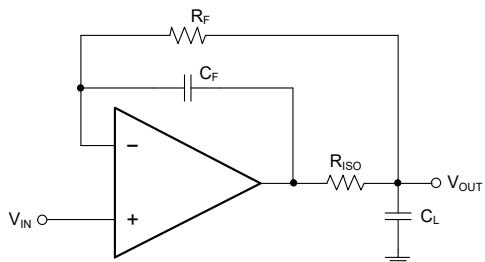


Figure 1. Circuit to Drive Heavy Capacitive Load

### 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,  $10\mu F$  ceramic capacitor paralleled with  $0.1\mu F$  or  $0.01\mu F$  ceramic capacitor is used in Figure 2. The ceramic capacitors should be placed as close as possible to  $+V_S$  and  $-V_S$  power supply pins.

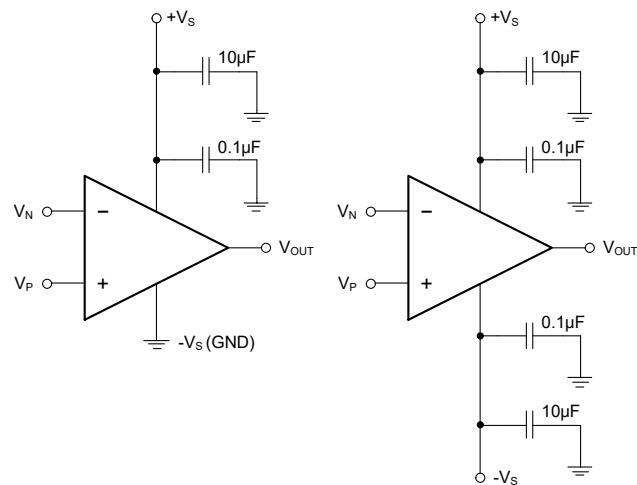


Figure 2. Amplifier Power Supply Bypassing

### Grounding

In low speed application, one node grounding technique is the simplest and most effective method to eliminate the noise generated by grounding. In high speed application, the general method to eliminate noise is to use a complete ground plane technique, and the whole ground plane will help distribute heat and reduce EMI noise pickup.

### Reduce Input-to-Output Coupling

To reduce the input-to-output coupling, the input traces must be placed as far away from the power supply or output traces as possible. The sensitive trace must not be placed in parallel with the noisy trace in same layer. They must be placed perpendicularly in different layers to reduce the crosstalk. These PCB layout techniques will help to reduce unwanted positive feedback and noise.

## APPLICATION INFORMATION (continued)

### Typical Application Circuits

#### Difference Amplifier

The circuit in Figure 3 is a design example of classical difference amplifier. If  $R_4/R_3 = R_2/R_1$ , then  $V_{OUT} = (V_P - V_N) \times R_2/R_1 + V_{REF}$ .

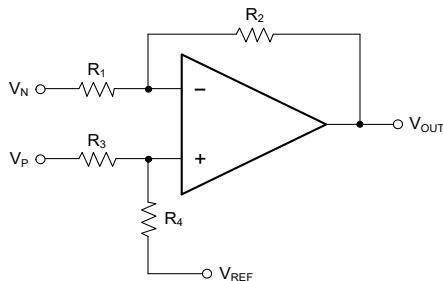


Figure 3. Difference Amplifier

#### High Input Impedance Difference Amplifier

The circuit in Figure 4 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 3.

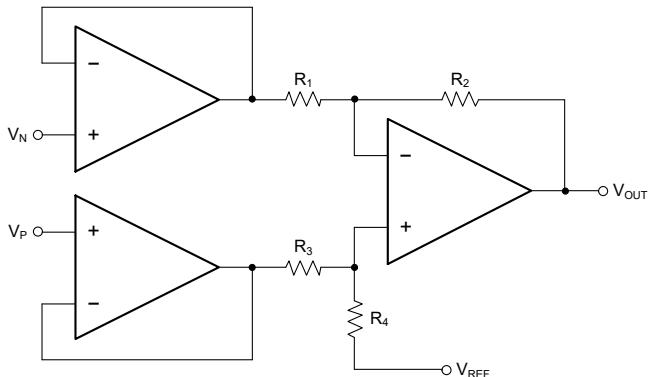


Figure 4. High Input Impedance Difference Amplifier

#### Active Low-Pass Filter

The circuit in Figure 5 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, and the resistor values must be selected as low as possible to reduce ringing or oscillation generated by the parasitic parameters in PCB layout.

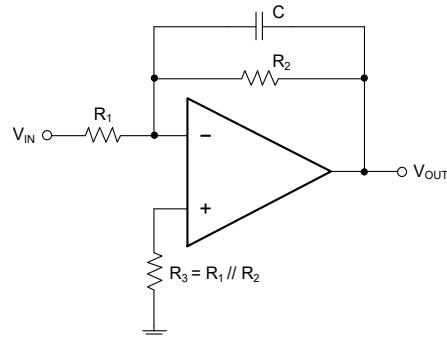


Figure 5. Active Low-Pass Filter

#### Driving Video

The SGM8651/2/3/4/5 can be used in video applications as shown in Figure 6.

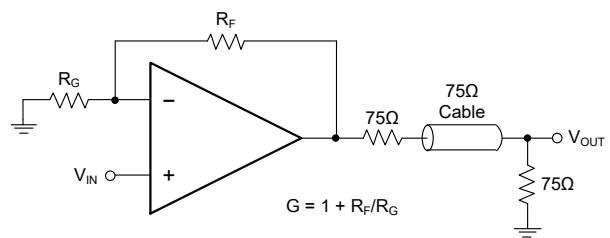


Figure 6. Typical Video Driving

## **REVISION HISTORY**

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

<b>JANUARY 2013 – REV.C.1 to REV.C.2</b>	<b>Page</b>
Updated Package Outline Dimensions section .....	12 ~ 18
Updated Tape and Reel Information section.....	19 ~ 20

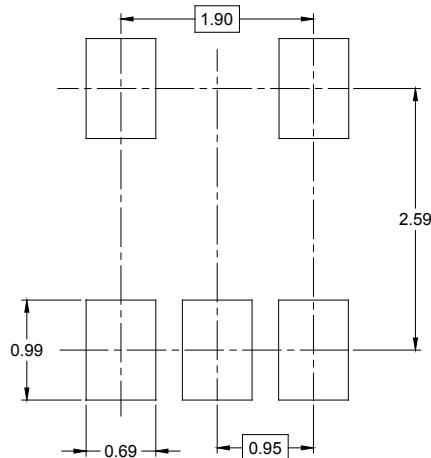
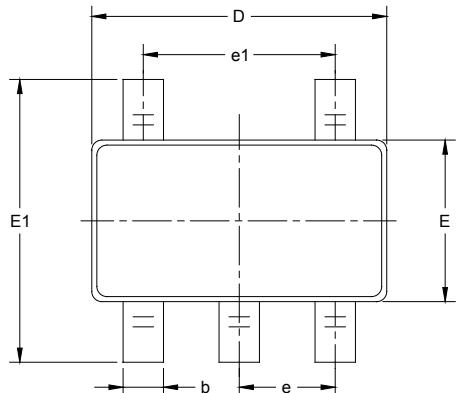
  

<b>APRIL 2009 – REV.C to REV.C.1</b>	<b>Page</b>
Changed from 16 pin to 14 pin.....	All

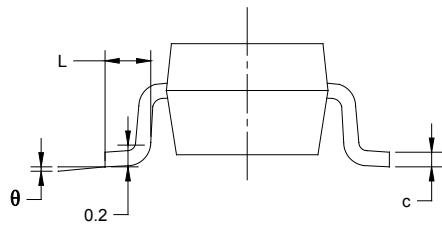
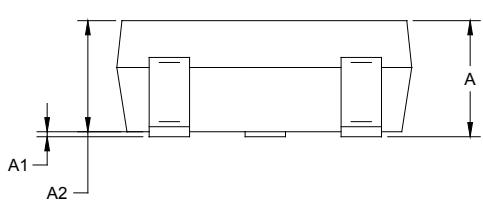
## PACKAGE INFORMATION

### PACKAGE OUTLINE DIMENSIONS

**SOT-23-5**



RECOMMENDED LAND PATTERN (Unit: mm)

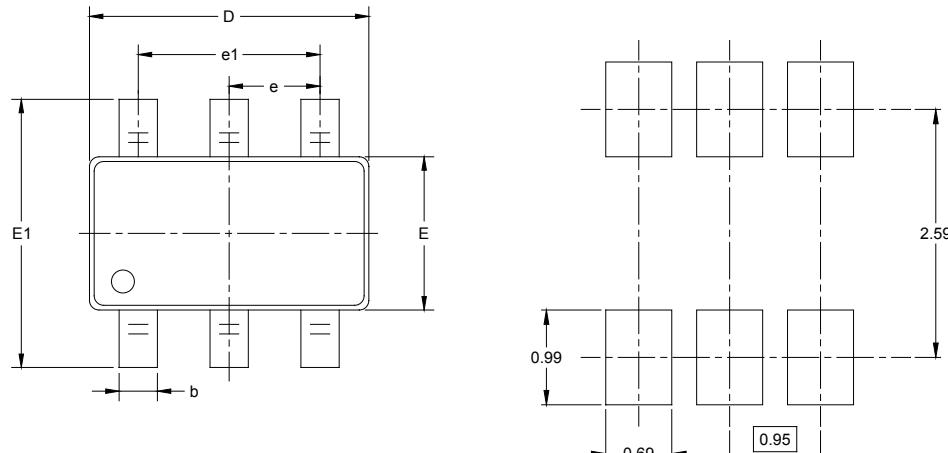


Symbol	Dimensions In Millimeters		Dimensions In Inches	
	MIN	MAX	MIN	MAX
A	1.050	1.250	0.041	0.049
A1	0.000	0.100	0.000	0.004
A2	1.050	1.150	0.041	0.045
b	0.300	0.500	0.012	0.020
c	0.100	0.200	0.004	0.008
D	2.820	3.020	0.111	0.119
E	1.500	1.700	0.059	0.067
E1	2.650	2.950	0.104	0.116
e	0.950 BSC		0.037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

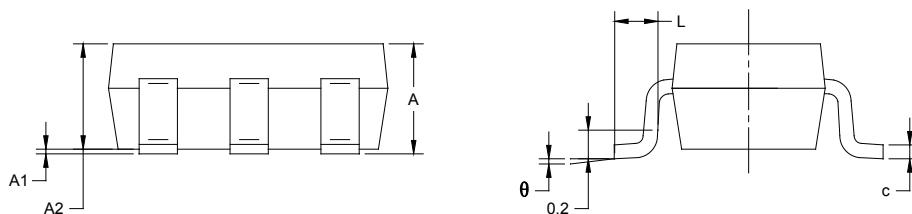
## PACKAGE INFORMATION

### PACKAGE OUTLINE DIMENSIONS

**SOT-23-6**



RECOMMENDED LAND PATTERN (Unit: mm)

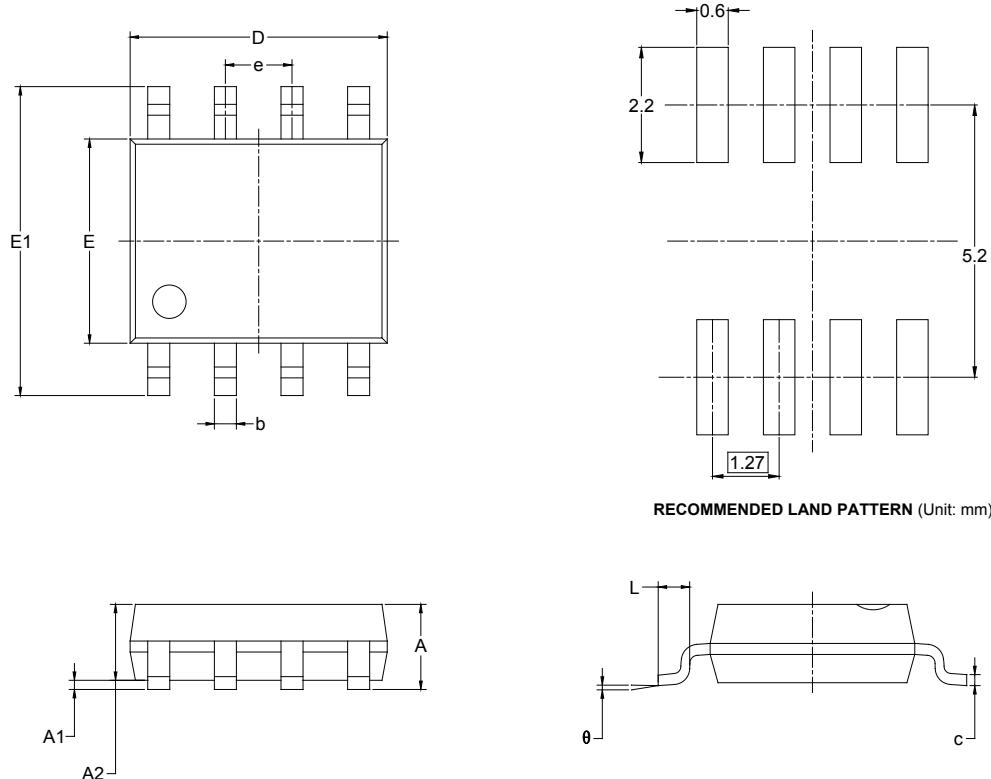


Symbol	Dimensions In Millimeters		Dimensions In Inches	
	MIN	MAX	MIN	MAX
A	1.050	1.250	0.041	0.049
A1	0.000	0.100	0.000	0.004
A2	1.050	1.150	0.041	0.045
b	0.300	0.500	0.012	0.020
c	0.100	0.200	0.004	0.008
D	2.820	3.020	0.111	0.119
E	1.500	1.700	0.059	0.067
E1	2.650	2.950	0.104	0.116
e	0.950 BSC		0.037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

# PACKAGE INFORMATION

## PACKAGE OUTLINE DIMENSIONS

### SOIC-8

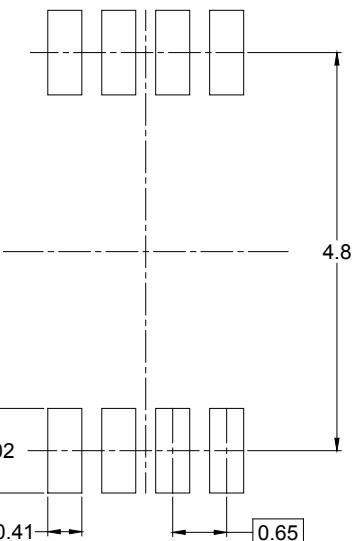
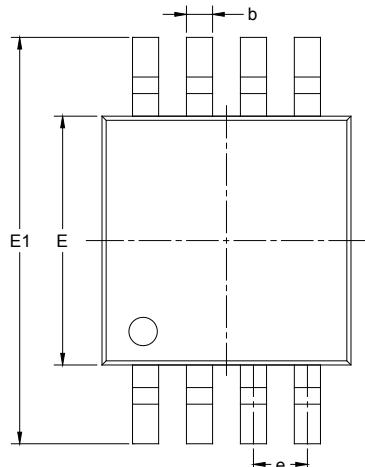


Symbol	Dimensions In Millimeters		Dimensions In Inches	
	MIN	MAX	MIN	MAX
A	1.350	1.750	0.053	0.069
A1	0.100	0.250	0.004	0.010
A2	1.350	1.550	0.053	0.061
b	0.330	0.510	0.013	0.020
c	0.170	0.250	0.006	0.010
D	4.700	5.100	0.185	0.200
E	3.800	4.000	0.150	0.157
E1	5.800	6.200	0.228	0.244
e	1.27 BSC		0.050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

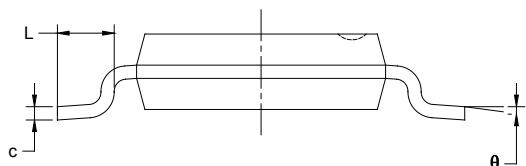
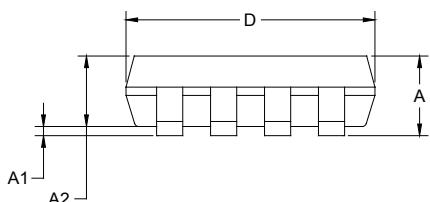
# PACKAGE INFORMATION

## PACKAGE OUTLINE DIMENSIONS

### MSOP-8



**RECOMMENDED LAND PATTERN** (Unit: mm)



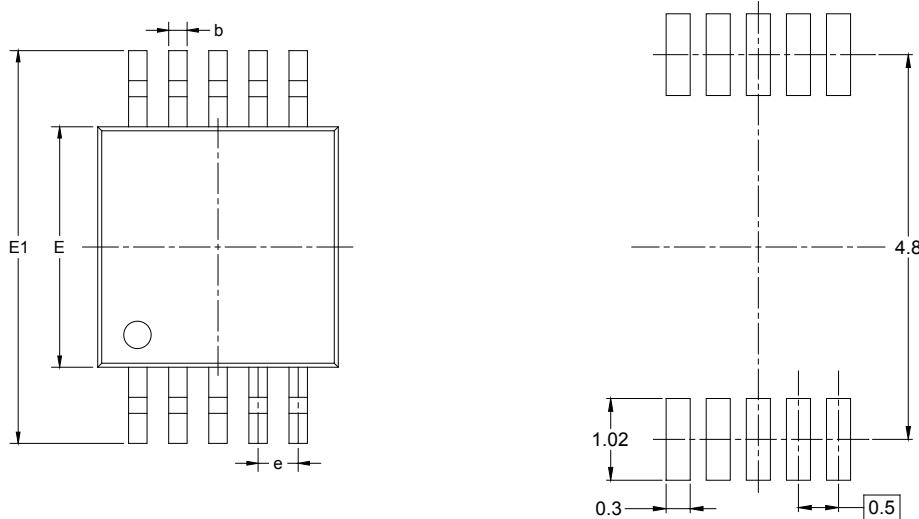
Symbol	Dimensions In Millimeters		Dimensions In Inches	
	MIN	MAX	MIN	MAX
A	0.820	1.100	0.032	0.043
A1	0.020	0.150	0.001	0.006
A2	0.750	0.950	0.030	0.037
b	0.250	0.380	0.010	0.015
c	0.090	0.230	0.004	0.009
D	2.900	3.100	0.114	0.122
E	2.900	3.100	0.114	0.122
E1	4.750	5.050	0.187	0.199
e	0.650 BSC		0.026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

## PACKAGE INFORMATION

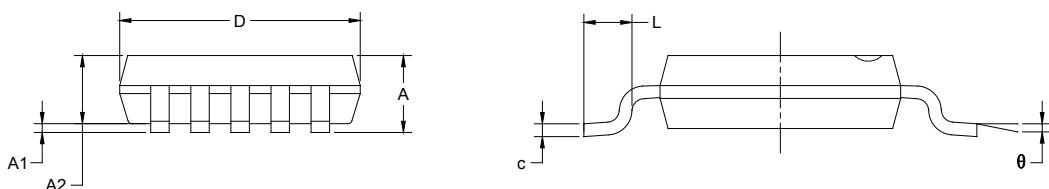
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### PACKAGE OUTLINE DIMENSIONS

#### MSOP-10



RECOMMENDED LAND PATTERN (Unit: mm)

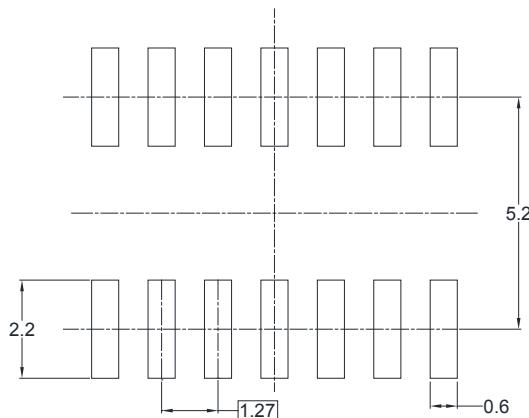
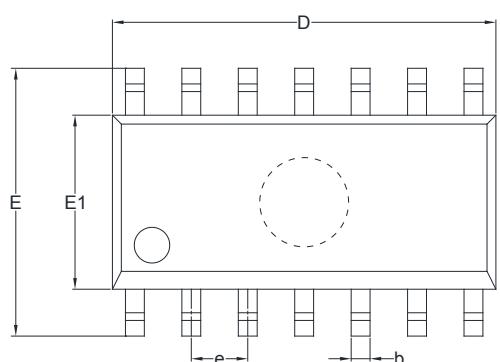


Symbol	Dimensions In Millimeters		Dimensions In Inches	
	MIN	MAX	MIN	MAX
A	0.820	1.100	0.032	0.043
A1	0.020	0.150	0.001	0.006
A2	0.750	0.950	0.030	0.037
b	0.180	0.280	0.007	0.011
c	0.090	0.230	0.004	0.009
D	2.900	3.100	0.114	0.122
E	2.900	3.100	0.114	0.122
E1	4.750	5.050	0.187	0.199
e	0.500 BSC		0.020 BSC	
L	0.400	0.800	0.016	0.031
θ	0°	6°	0°	6°

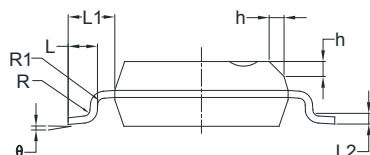
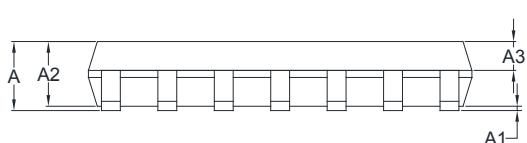
# PACKAGE INFORMATION

## PACKAGE OUTLINE DIMENSIONS

**SOIC-14**



RECOMMENDED LAND PATTERN (Unit: mm)

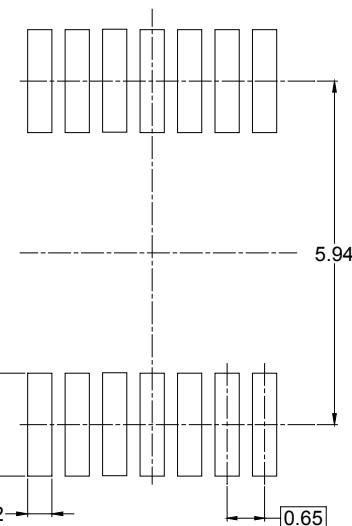
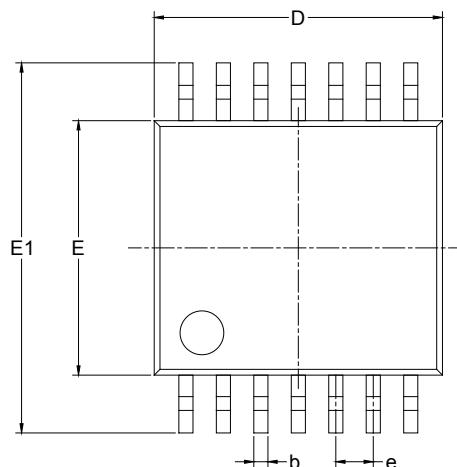


Symbol	Dimensions In Millimeters		Dimensions In Inches	
	MIN	MAX	MIN	MAX
A	1.35	1.75	0.053	0.069
A1	0.10	0.25	0.004	0.010
A2	1.25	1.65	0.049	0.065
A3	0.55	0.75	0.022	0.030
b	0.36	0.49	0.014	0.019
D	8.53	8.73	0.336	0.344
E	5.80	6.20	0.228	0.244
E1	3.80	4.00	0.150	0.157
e	1.27 BSC		0.050 BSC	
L	0.45	0.80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

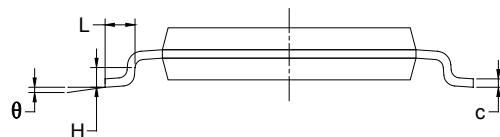
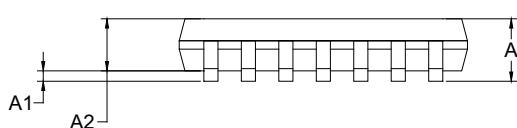
## PACKAGE INFORMATION

### PACKAGE OUTLINE DIMENSIONS

#### TSSOP-14



RECOMMENDED LAND PATTERN (Unit: mm)

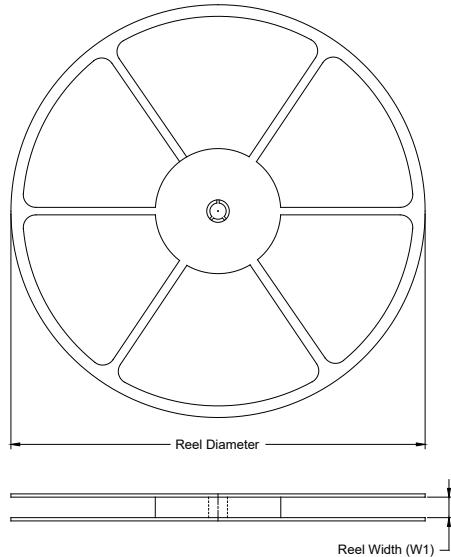


Symbol	Dimensions In Millimeters		Dimensions In Inches	
	MIN	MAX	MIN	MAX
A		1.200		0.047
A1	0.050	0.150	0.002	0.006
A2	0.800	1.050	0.031	0.041
b	0.190	0.300	0.007	0.012
c	0.090	0.200	0.004	0.008
D	4.860	5.100	0.191	0.201
E	4.300	4.500	0.169	0.177
E1	6.250	6.550	0.246	0.258
e	0.650 BSC		0.026 BSC	
L	0.500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

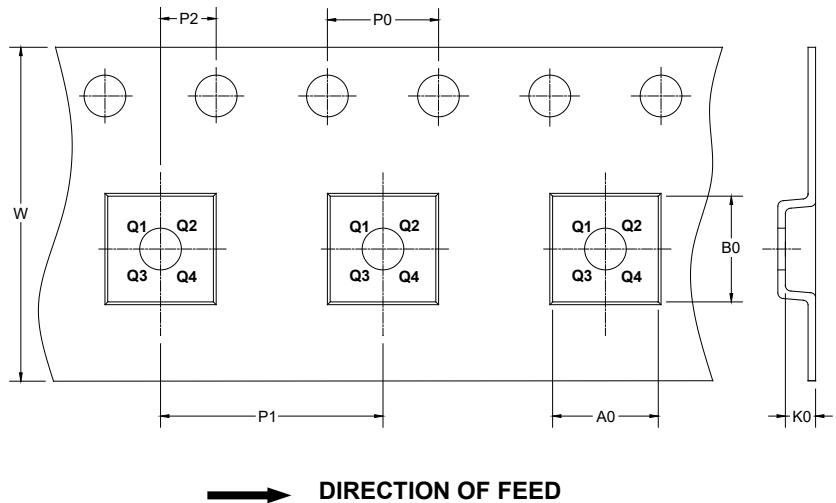
# PACKAGE INFORMATION

## TAPE AND REEL INFORMATION

### REEL DIMENSIONS



### TAPE DIMENSIONS



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

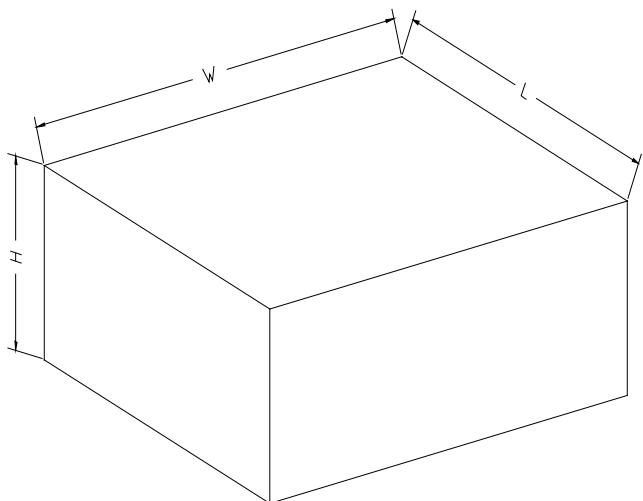
### KEY PARAMETER LIST OF TAPE AND REEL

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
SOT-23-6	7"	9.5	3.17	3.23	1.37	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
MSOP-10	13"	12.4	5.20	3.30	1.20	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

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## 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

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