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

GENERAL DESCRIPTION

The SGM8651/2/3/4/5 are high precision, low noise, low distortion, rail-to-rail output CMOS voltage feedback operational amplifiers offering ease of use and low cost. They have a wide input common mode voltage range and output voltage swing, running at single-supply voltage from 2.5V to 5.5V.

Despite being low cost, the SGM8651/2/3/4/5 provide excellent overall performance. They offer wide gain-bandwidth product to 50MHz and a typical low power of 2.3mA/amplifier.

The SGM8651/2/3/4/5's low distortion and fast settling make them ideal for buffering high speed A/D or D/A converters. The SGM8653/5 has a power-down disable feature that reduces the supply current to 75μA/amplifier. These features make the SGM8653/5 ideal for portable and battery-powered applications where size and power are critical. All are specified over the extended -40℃ to +125℃ temperature range.

FEATURES

- **Rail-to-Rail Output**
- **Input Offset Voltage: 2mV (TYP)**
- **Gain-Bandwidth Product: 50MHz**
- **High Slew Rate: 66V/μs**
- **Settling Time to 0.1% with 2V Step: 60ns**
- **Overload Recovery Time: 25ns**
- **Low Noise: 8.7nV/$\sqrt{Hz}$**
- **Operates on 2.5V to 5.5V Supply**
- **Input Voltage Range: -0.2V to 3.8V with V_S = 5V**
- **Low Supply Current:**
  2.3mA/Amplifier (TYP)
  75μA/Amplifier Shutdown Current for SGM8653/5
- **-40℃ to +125℃ 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 TSSOP-14 and SOIC-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
A-to-D Driver
D-to-A Driver

PACKAGE/ORDERING INFORMATION

MODEL	PACKAGE DESCRIPTION	SPECIFIED TEMPERATURE RANGE	ORDERING NUMBER	PACKAGE MARKING	PACKING OPTION
SGM8651	SOT-23-5	-40℃ to +125℃	SGM8651XN5/TR	8651	Tape and Reel, 3000
	SOIC-8	-40℃ to +125℃	SGM8651XS/TR	SGM8651XS	Tape and Reel, 2500
SGM8652	MSOP-8	-40℃ to +125℃	SGM8652XMS/TR	SGM8652XMS	Tape and Reel, 3000
	SOIC-8	-40℃ to +125℃	SGM8652XS/TR	SGM8652XS	Tape and Reel, 2500
SGM8653	SOT-23-6	-40℃ to +125℃	SGM8653XN6/TR	8653	Tape and Reel, 3000
	SOIC-8	-40℃ to +125℃	SGM8653XS/TR	SGM8653XS	Tape and Reel, 2500
SGM8654	SOIC-14	-40℃ to +125℃	SGM8654XS14/TR	SGM8654XS14	Tape and Reel, 2500
	TSSOP-14	-40℃ to +125℃	SGM8654XTS14/TR	SGM8654XTS14	Tape and Reel, 3000
SGM8655	MSOP-10	-40℃ to +125℃	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℃
SOT-23-5, θ_{JA} ..... 190℃/W
SOT-23-6, θ_{JA} ..... 190℃/W
SOIC-8, θ_{JA} ..... 125℃/W
MSOP-8, θ_{JA} ..... 216℃/W
MSOP-10, θ_{JA} ..... 216℃/W
Operating Temperature Range ..... -55℃ to +150℃
Junction Temperature ..... +160℃
Storage Temperature Range ..... -65℃ to +150℃
Lead Temperature (Soldering, 10s) ..... +260℃
ESD Susceptibility
HBM 1000V
MM 400V

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

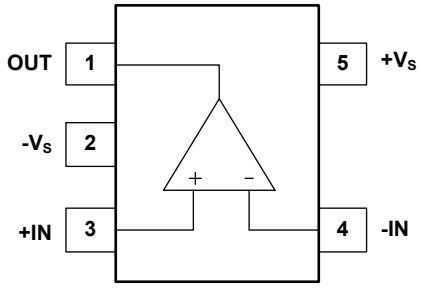
This integrated circuit can be damaged by ESD if you don't pay attention to ESD protection. SGMICRO recommends that all integrated circuits be handled with appropriate precautions. Failure to observe proper handling and installation procedures can cause damage. ESD damage can range from subtle performance 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.

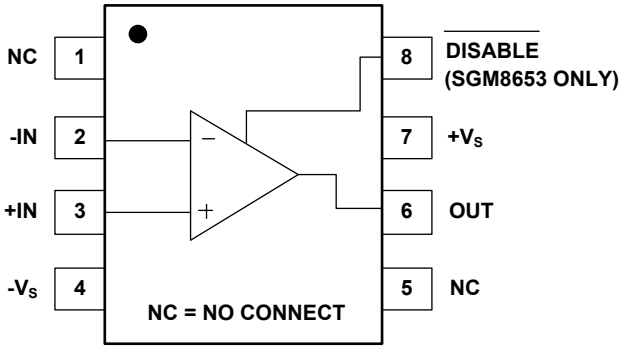
PIN CONFIGURATIONS

SGM8651 (TOP VIEW)



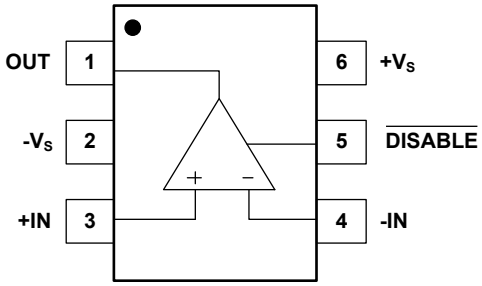
SOT-23-5

SGM8651/8653 (TOP VIEW)



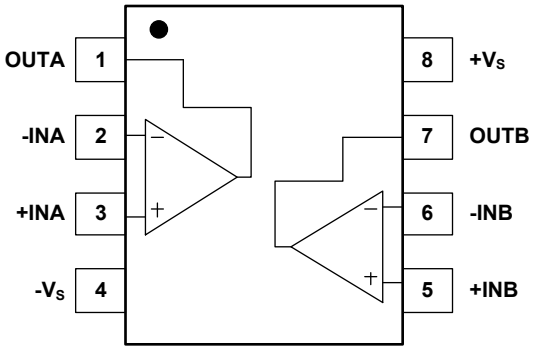
SOIC-8

SGM8653 (TOP VIEW)



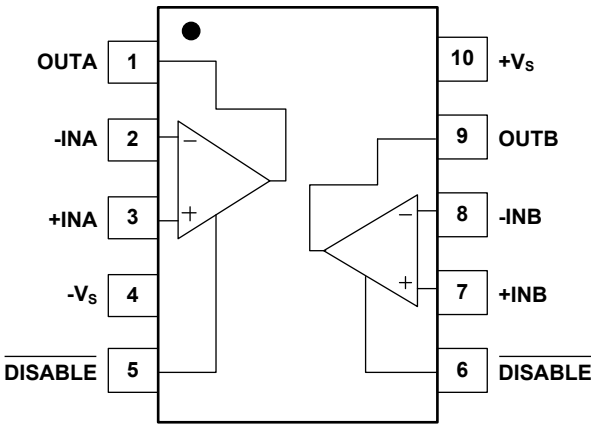
SOT-23-6

SGM8652 (TOP VIEW)



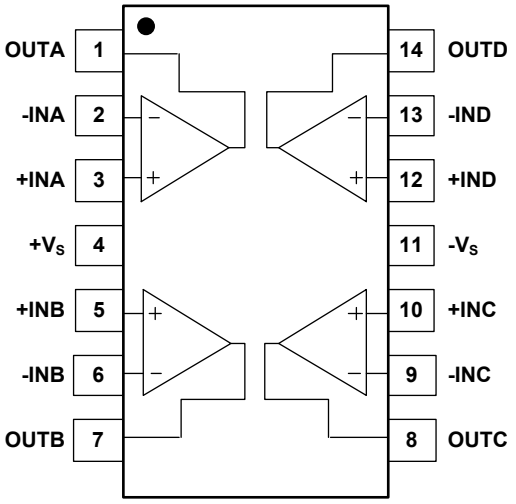
SOIC-8/MSOP-8

SGM8653 (TOP VIEW)



MSOP-10

SGM8654 (TOP VIEW)



TSSOP-14/SOIC-14

ELECTRICAL CHARACTERISTICS

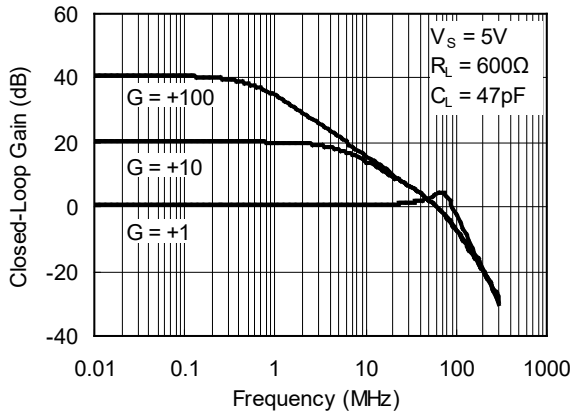
(At T_A = +25℃, V_S = 5V, R_L = 600Ω connected to V_S/2, unless otherwise noted.)

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

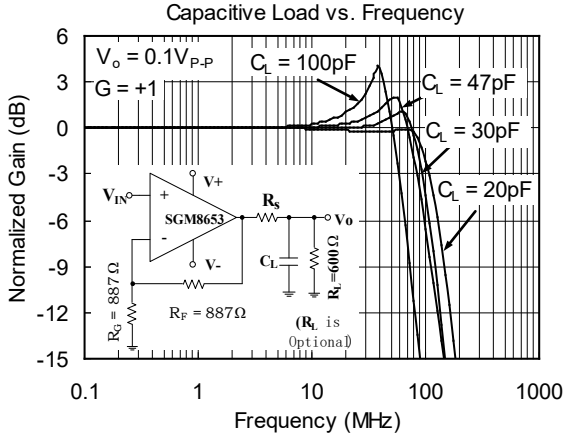
TYPICAL PERFORMANCE CHARACTERISTICS

At T_A= +25℃, V_S = 5V, G = +2, R_F = 887Ω, R_G = 887Ω, C_L = 47pF, and R_L= 600Ω, unless otherwise noted.

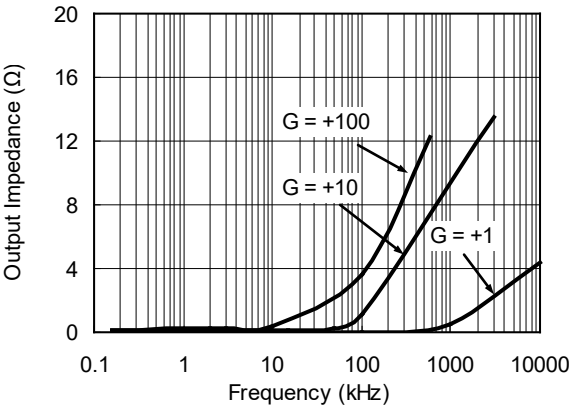
Closed-Loop Gain vs. Frequency



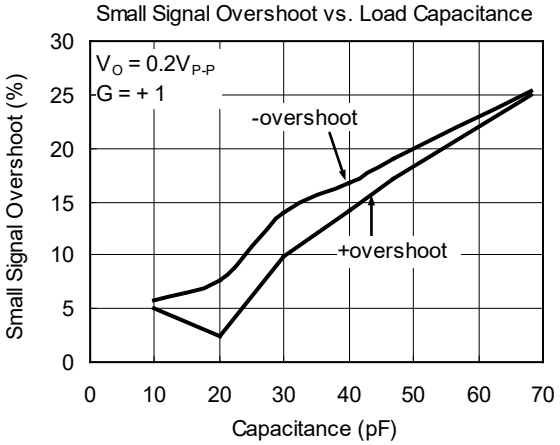
Capacitive Load vs. Frequency



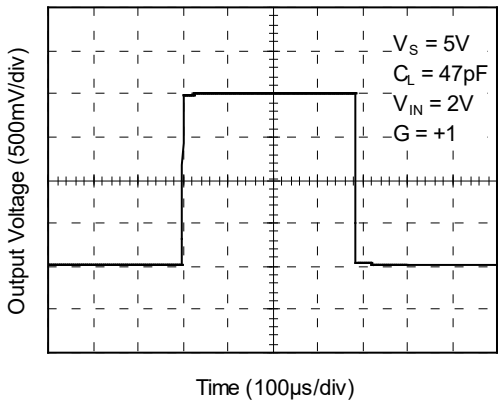
Output Impedance vs. Frequency



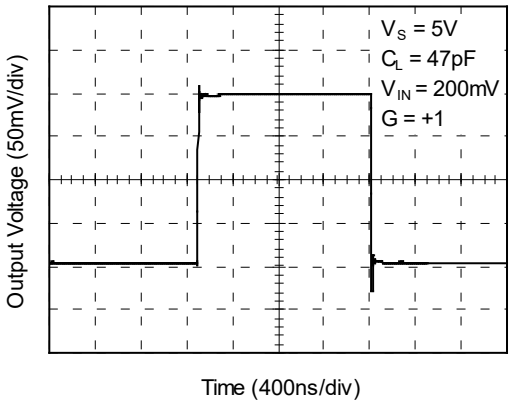
Small Signal Overshoot vs. Load Capacitance



Large Signal Step Response



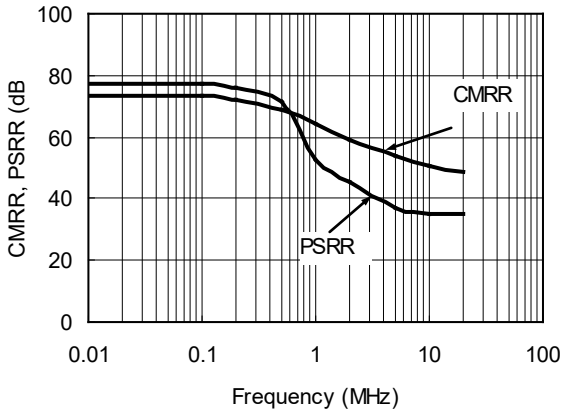
Small Signal Step Response



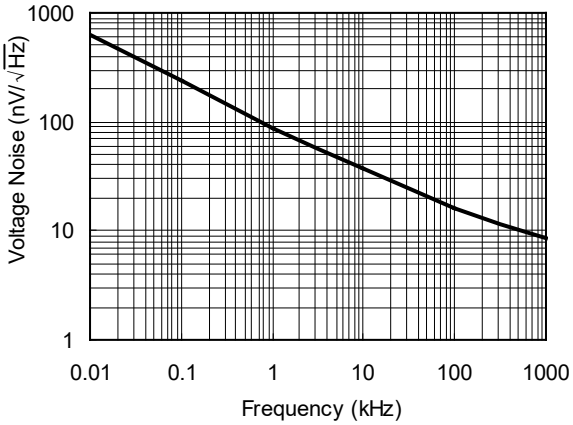
TYPICAL PERFORMANCE CHARACTERISTICS (continued)

At T_A= +25℃, V_S = 5V, G = +2, R_F = 887Ω, R_G = 887Ω, C_L = 47pF, and R_L= 600Ω, unless otherwise noted.

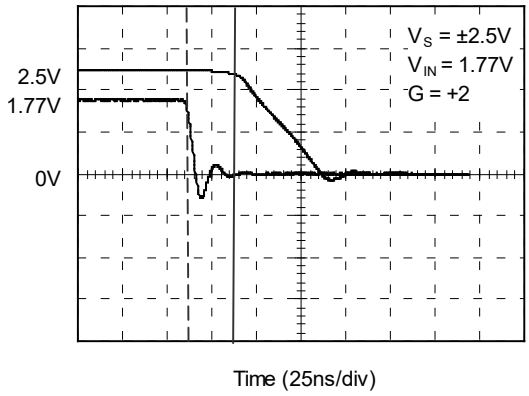
CMRR and PSRR vs. Frequency



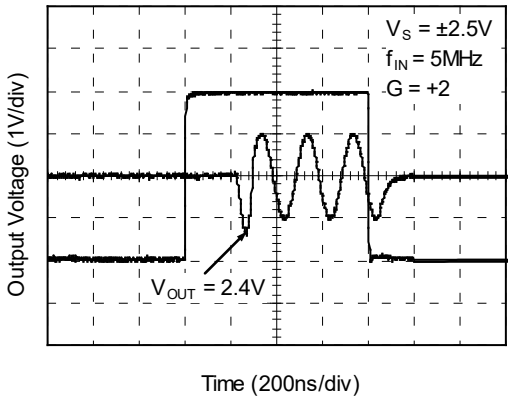
Input Voltage Noise Spectral Density vs. Frequency



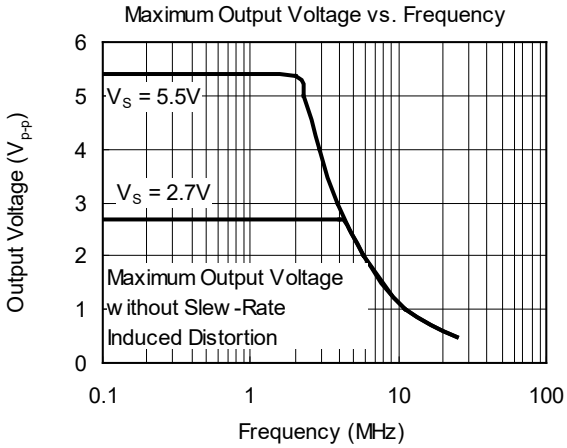
Overload Recovery Time



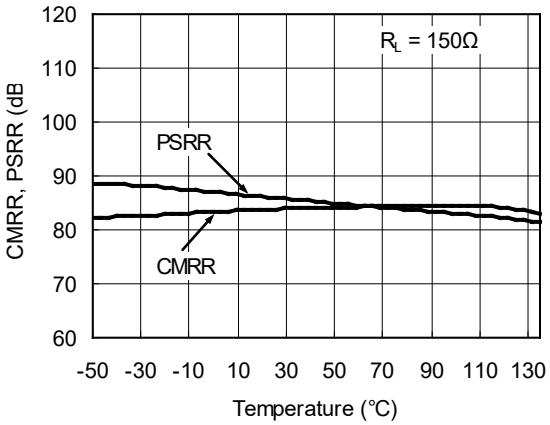
Large-Signal Disable/Enable Response



Maximum Output Voltage vs. Frequency



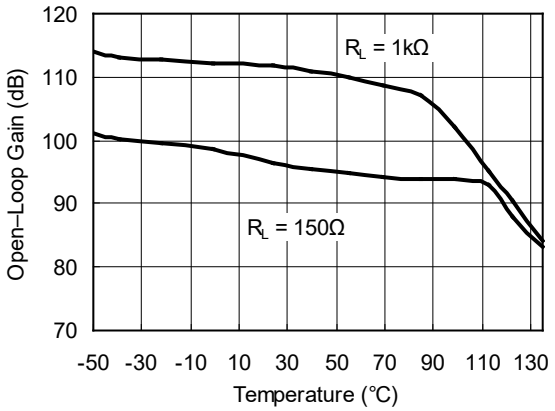
CMRR and PSRR vs. Temperature



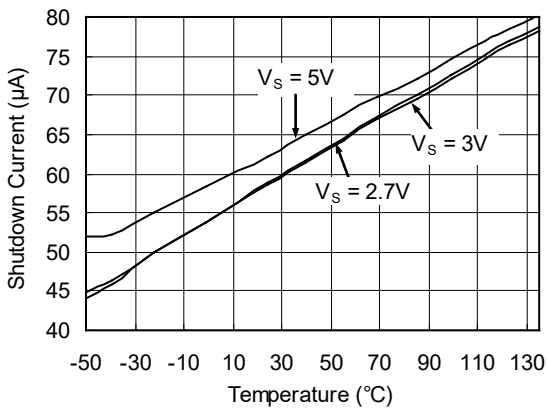
TYPICAL PERFORMANCE CHARACTERISTICS (continued)

At T_A= +25℃, V_S = 5V, G = +2, R_F = 887Ω, R_G = 887Ω, R_L = 150Ω connected to Vs/2, unless otherwise noted.

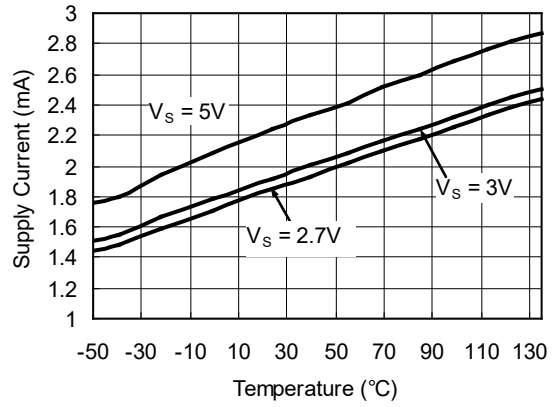
Open-Loop Gain vs. Temperature



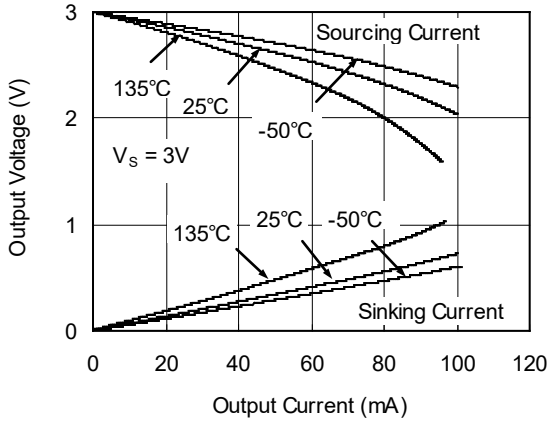
Shutdown Current vs. Temperature



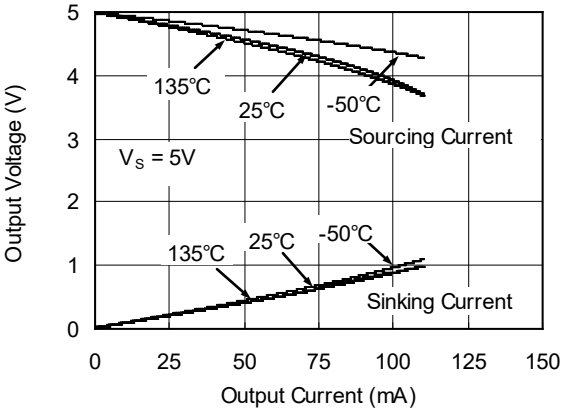
Supply Current vs. Temperature



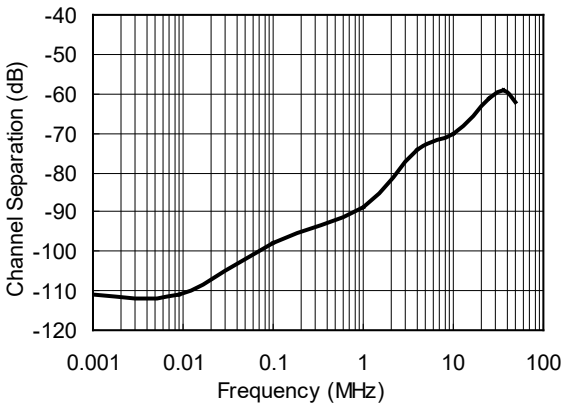
Output Voltage Swing vs. Output Current



Output Voltage Swing vs. Output Current

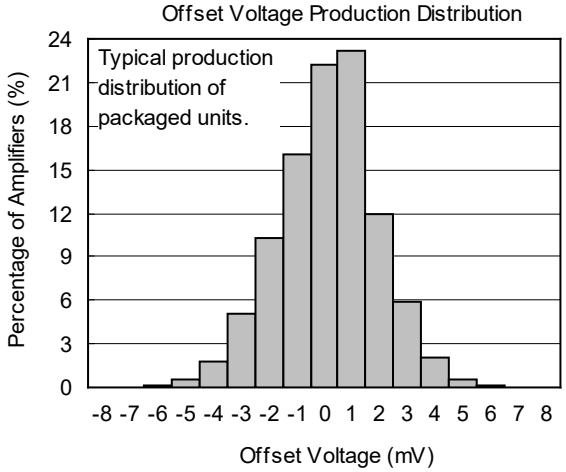


Channel Separation vs. Frequency



TYPICAL PERFORMANCE CHARACTERISTICS (continued)

At T_A= +25℃, V_S = 5V, G = +2, R_F = 887Ω, R_G = 887Ω, R_L = 150Ω connected to V_S/2, unless otherwise noted.



APPLICATION NOTES

Driving Capacitive Loads

The SGM8651/2/3/4/5 can directly drive 47pF 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}.

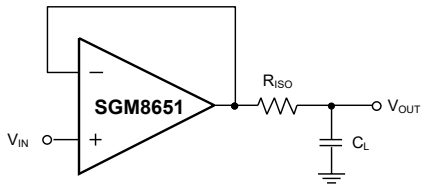


Figure 1. Indirectly Driving Heavy Capacitive Load

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.

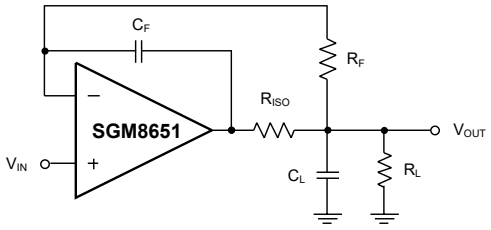


Figure 2. Indirectly Driving Heavy Capacitive Load with DC Accuracy

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 SGM8651/2/3/4/5 family operates from either a single 2.7V to 5.5V supply or dual ±1.35V to ±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.

Good PC board layout techniques optimize performance by decreasing the amount of stray capacitance at the operational amplifier's inputs and output. To decrease stray capacitance, minimize trace lengths and widths by placing external components as close to the device as possible. Use surface-mount components whenever possible.

For the high speed operational amplifier, soldering the part to the board directly is strongly recommended. Try to keep the high frequency current loop area small to minimize the EMI (electromagnetic interference).

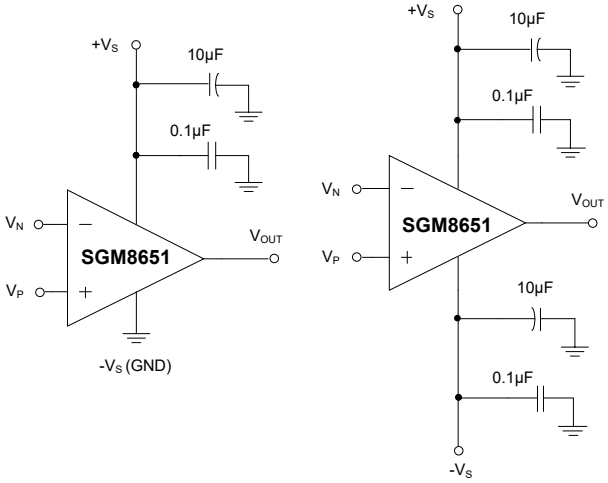


Figure 3. Amplifier with Bypass Capacitors

Grounding

A ground plane layer is important for high speed circuit design. The length of the current path in an inductive ground return will create an unwanted voltage noise. Broad ground plane areas will reduce the parasitic inductance.

Input-to-Output Coupling

To minimize capacitive coupling, the input and output signal traces should not be in parallel. This helps reduce unwanted positive feedback.

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 $V_{OUT} = (V_P - V_N) \times R_2/R_1 + V_{REF}$.

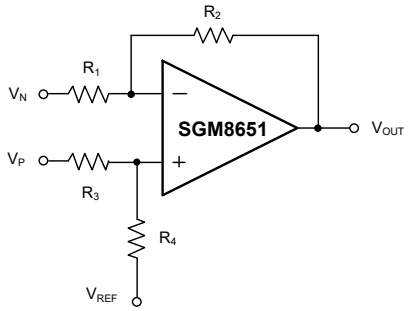


Figure 4. Differential Amplifier

Instrumentation Amplifier

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

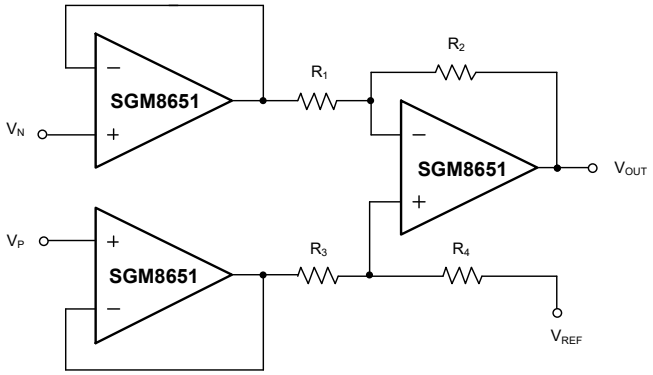


Figure 5. Instrumentation Amplifier

Active Low-Pass Filter

The low-pass filter shown in Figure 6 has a DC gain of $(-R_2/R_1)$ and the -3dB corner frequency is $1/2\pi R_2C$. 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.

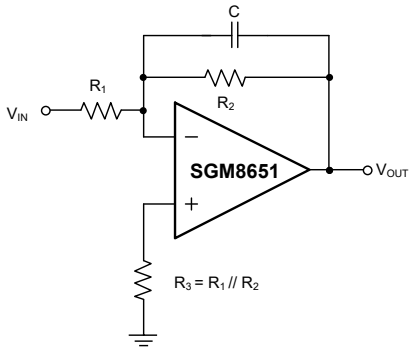


Figure 6. Active Low-Pass Filter

Driving Video

The SGM8651/2/3/4/5 can be used in video applications like in Figure 7.

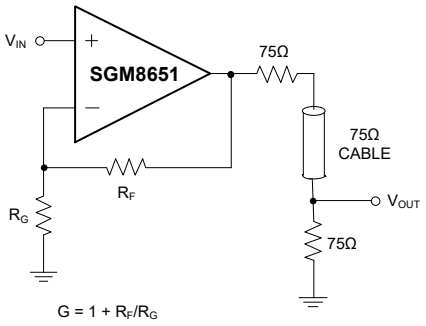


Figure 7. Typical Video Driving

REVISION HISTORY

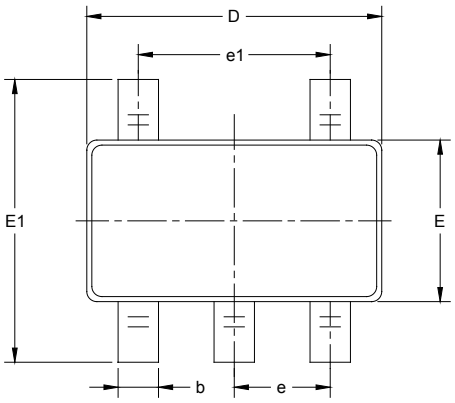
NOTE: Page numbers for previous revisions may differ from page numbers in the current version.

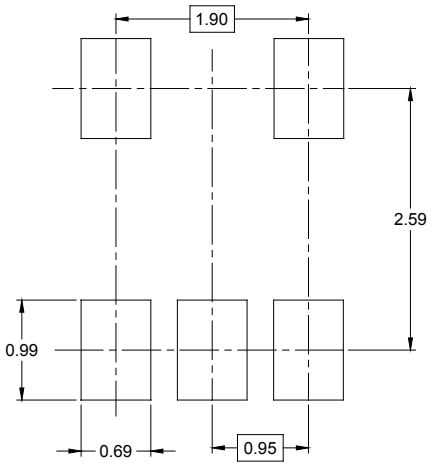
JANUARY 2013 – REV.C.1 to REV.C.2	Page
Changed Pin Configurations section	4

APRIL 2009 – REV.C to REV.C.1	Page
Changed from 16 pin to 14 pin	All

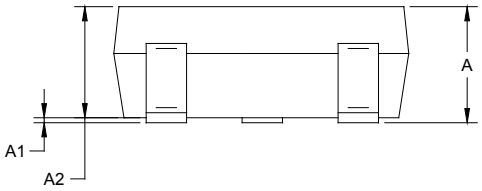
PACKAGE OUTLINE DIMENSIONS

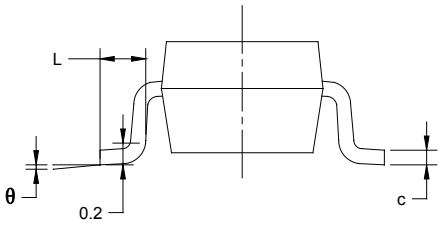
SOT-23-5





RECOMMENDED LAND PATTERN (Unit: mm)

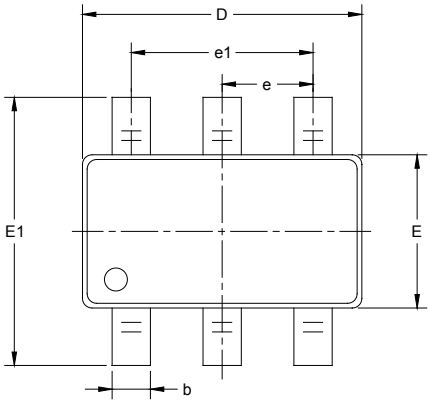


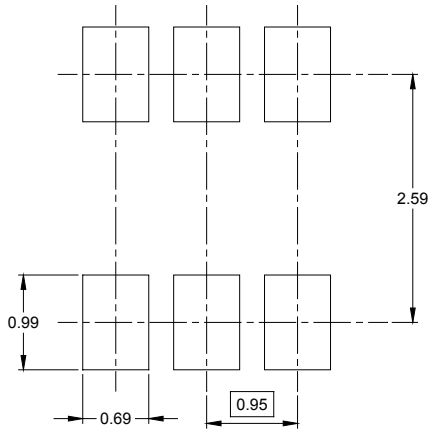


Symbol	Dimensions In Millimeters		Dimensions In Inches	
	MIN	MAX	MIN	MAX
A	1.050	1.250	0.041	0.049
A1	0.000	0.100	0.000	0.004
A2	1.050	1.150	0.041	0.045
b	0.300	0.500	0.012	0.020
c	0.100	0.200	0.004	0.008
D	2.820	3.020	0.111	0.119
E	1.500	1.700	0.059	0.067
E1	2.650	2.950	0.104	0.116
e	0.950 BSC		0.037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

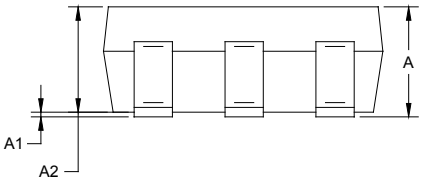
PACKAGE OUTLINE DIMENSIONS

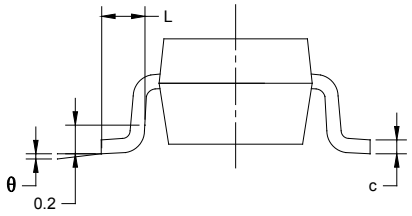
SOT-23-6





RECOMMENDED LAND PATTERN (Unit: mm)

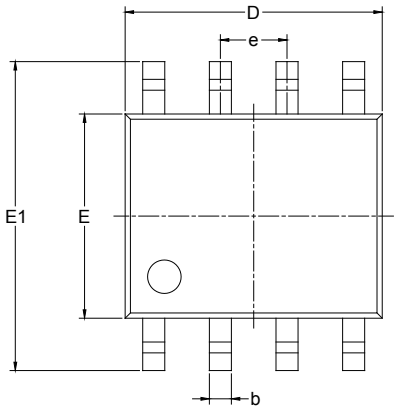


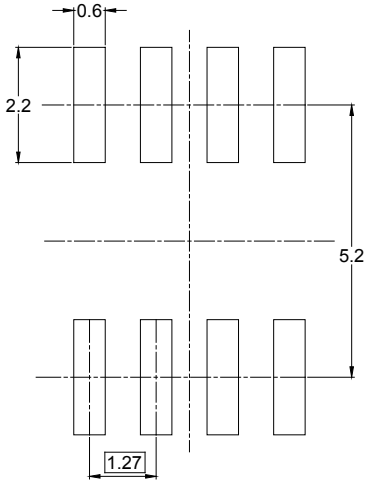


Symbol	Dimensions In Millimeters		Dimensions In Inches	
	MIN	MAX	MIN	MAX
A	1.050	1.250	0.041	0.049
A1	0.000	0.100	0.000	0.004
A2	1.050	1.150	0.041	0.045
b	0.300	0.500	0.012	0.020
c	0.100	0.200	0.004	0.008
D	2.820	3.020	0.111	0.119
E	1.500	1.700	0.059	0.067
E1	2.650	2.950	0.104	0.116
e	0.950 BSC		0.037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

PACKAGE OUTLINE DIMENSIONS

SOIC-8





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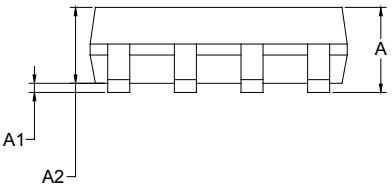
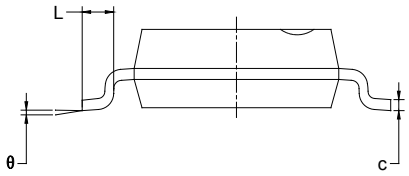
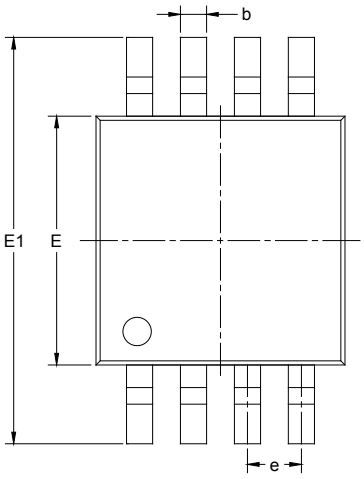


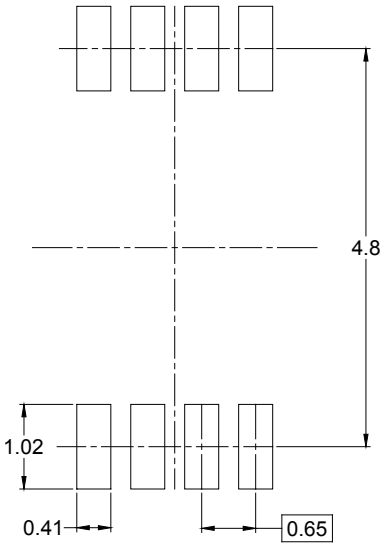


Symbol	Dimensions In Millimeters		Dimensions In Inches	
	MIN	MAX	MIN	MAX
A	1.350	1.750	0.053	0.069
A1	0.100	0.250	0.004	0.010
A2	1.350	1.550	0.053	0.061
b	0.330	0.510	0.013	0.020
c	0.170	0.250	0.006	0.010
D	4.700	5.100	0.185	0.200
E	3.800	4.000	0.150	0.157
E1	5.800	6.200	0.228	0.244
e	1.27 BSC		0.050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

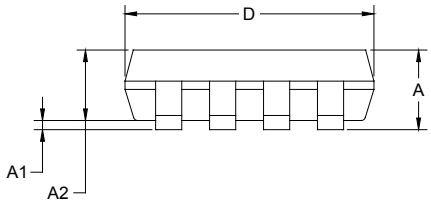
PACKAGE OUTLINE DIMENSIONS

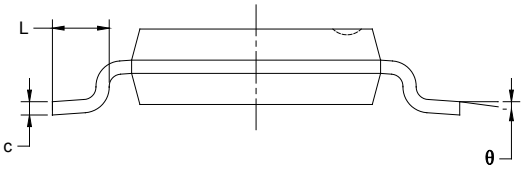
MSOP-8





RECOMMENDED LAND PATTERN (Unit: mm)

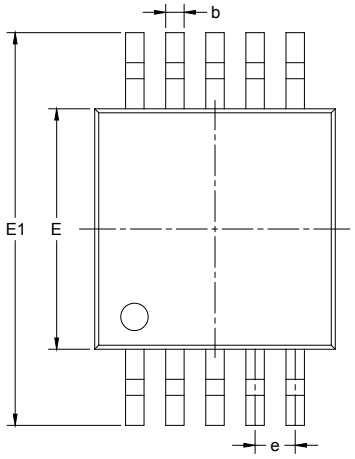


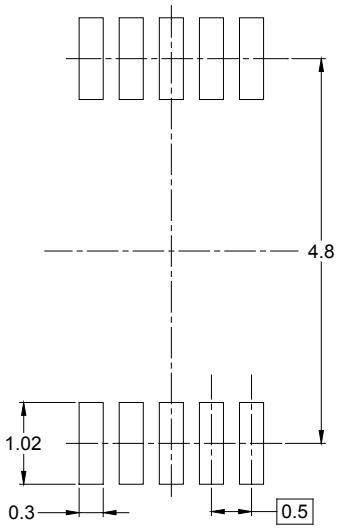


Symbol	Dimensions In Millimeters		Dimensions In Inches	
	MIN	MAX	MIN	MAX
A	0.820	1.100	0.032	0.043
A1	0.020	0.150	0.001	0.006
A2	0.750	0.950	0.030	0.037
b	0.250	0.380	0.010	0.015
c	0.090	0.230	0.004	0.009
D	2.900	3.100	0.114	0.122
E	2.900	3.100	0.114	0.122
E1	4.750	5.050	0.187	0.199
e	0.650 BSC		0.026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

PACKAGE OUTLINE DIMENSIONS

MSOP-10





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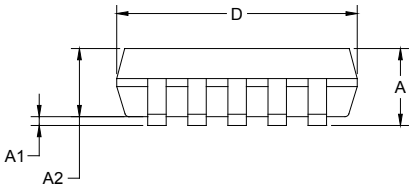
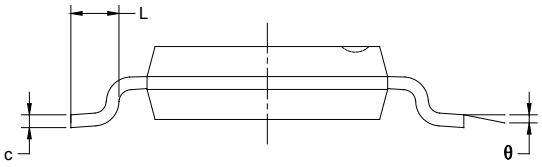
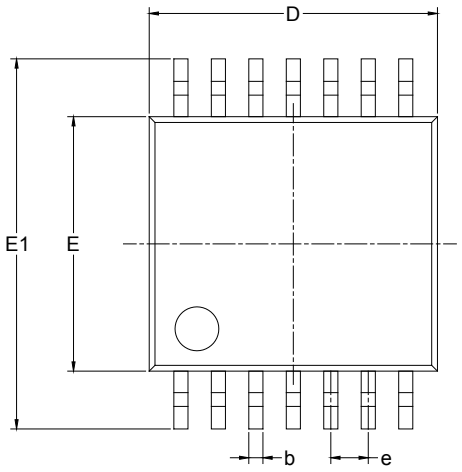


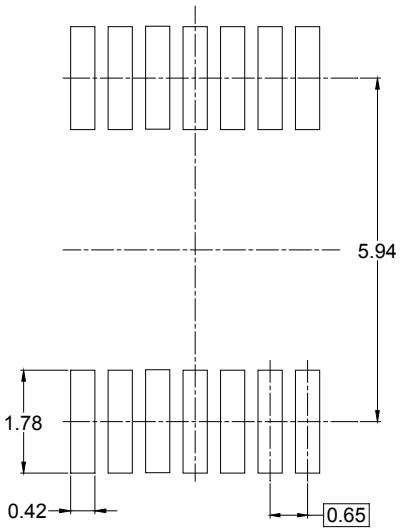


Symbol	Dimensions In Millimeters		Dimensions In Inches	
	MIN	MAX	MIN	MAX
A	0.820	1.100	0.032	0.043
A1	0.020	0.150	0.001	0.006
A2	0.750	0.950	0.030	0.037
b	0.180	0.280	0.007	0.011
c	0.090	0.230	0.004	0.009
D	2.900	3.100	0.114	0.122
E	2.900	3.100	0.114	0.122
E1	4.750	5.050	0.187	0.199
e	0.500 BSC		0.020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

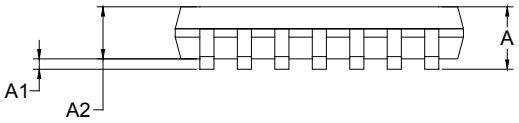
PACKAGE OUTLINE DIMENSIONS

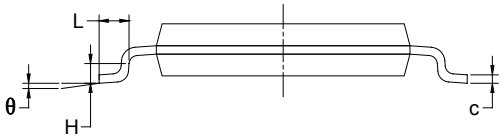
TSSOP-14





RECOMMENDED LAND PATTERN (Unit: mm)

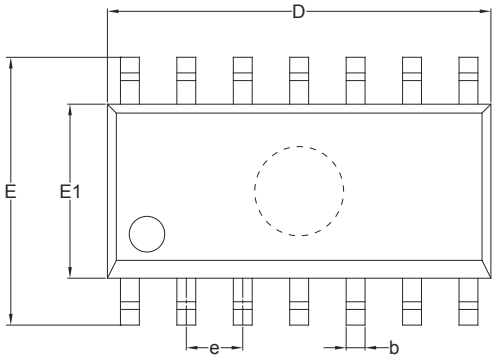


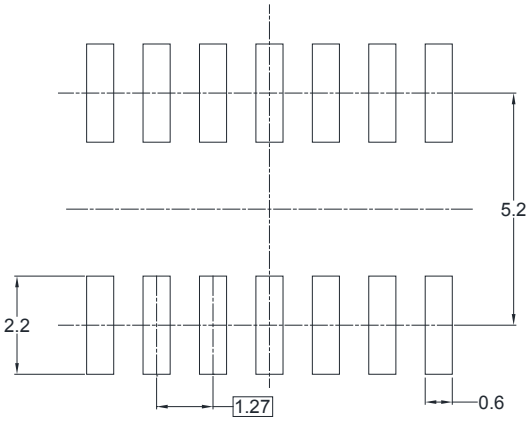


Symbol	Dimensions In Millimeters		Dimensions In Inches	
	MIN	MAX	MIN	MAX
A		1.200		0.047
A1	0.050	0.150	0.002	0.006
A2	0.800	1.050	0.031	0.041
b	0.190	0.300	0.007	0.012
c	0.090	0.200	0.004	0.008
D	4.860	5.100	0.191	0.201
E	4.300	4.500	0.169	0.177
E1	6.250	6.550	0.246	0.258
e	0.650 BSC		0.026 BSC	
L	0.500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

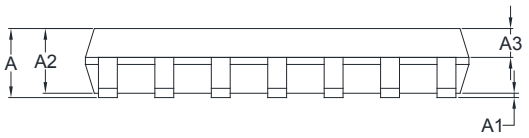
PACKAGE OUTLINE DIMENSIONS

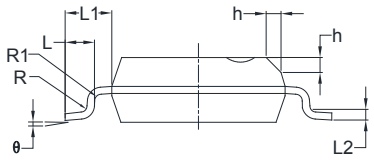
SOIC-14





RECOMMENDED LAND PATTERN (Unit: mm)

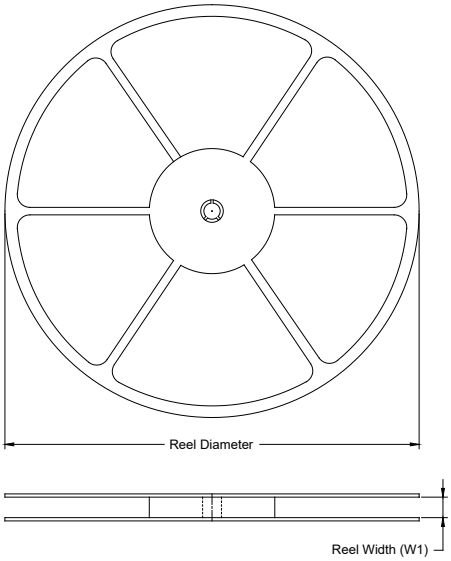




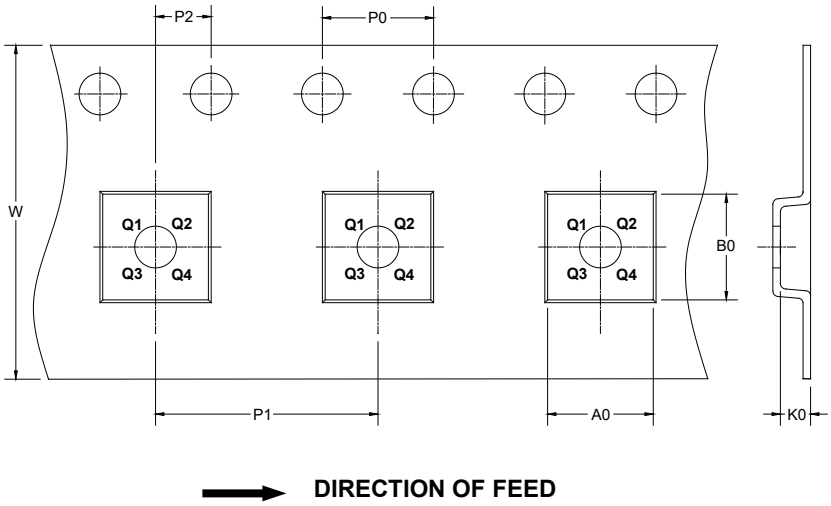
Symbol	Dimensions In Millimeters		Dimensions In Inches	
	MIN	MAX	MIN	MAX
A	1.35	1.75	0.053	0.069
A1	0.10	0.25	0.004	0.010
A2	1.25	1.65	0.049	0.065
A3	0.55	0.75	0.022	0.030
b	0.36	0.49	0.014	0.019
D	8.53	8.73	0.336	0.344
E	5.80	6.20	0.228	0.244
E1	3.80	4.00	0.150	0.157
e	1.27 BSC		0.050 BSC	
L	0.45	0.80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

TAPE AND REEL INFORMATION

REEL DIMENSIONS



TAPE DIMENSIONS



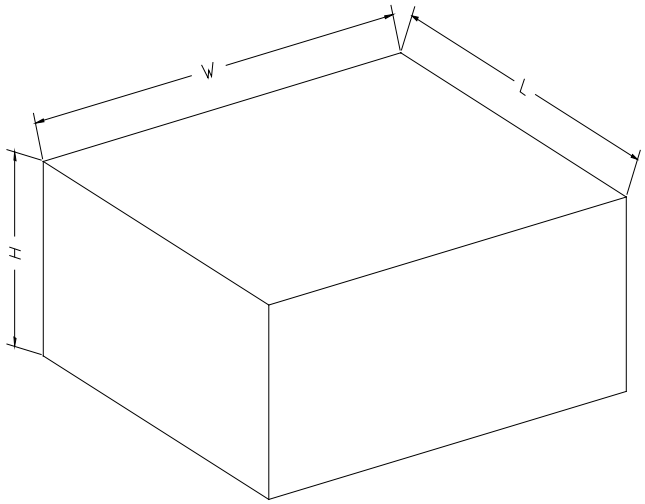
NOTE: The picture is only for reference. Please make the object as the standard.

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
TSSOP-14	13″	12.4	6.95	5.60	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

DD0001

CARTON BOX DIMENSIONS



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

KEY PARAMETER LIST OF CARTON BOX

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

DD0002