SGM8651/2/4
SGM8653/5
50MHz, Rail-to-Rail Output CMOS Operational Amplifiers

PRODUCT 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.

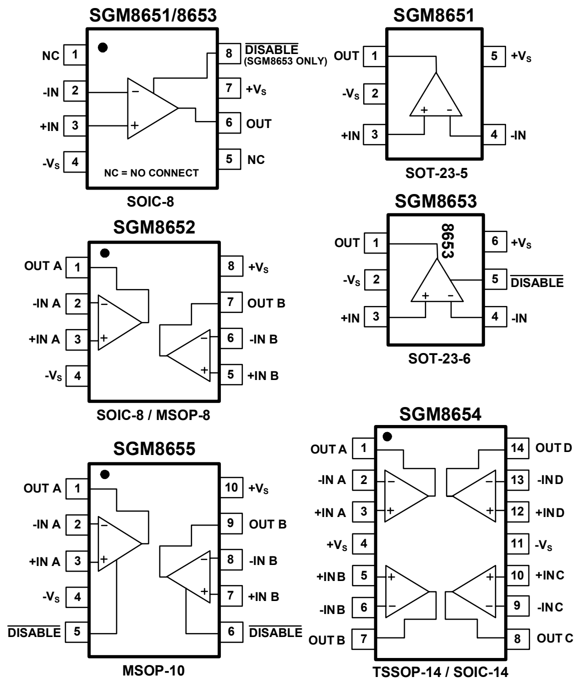
APPLICATIONS

Data Acquisition
Process Control
Audio Processing
Video Processing
Active Filters
Test Equipment
Cell Phone PA Control
Broadband Communications
A-to-D Driver
D-to-A Driver

FEATURES

- **Low Cost**
- **Rail-to-Rail Output**
  2mV Typical V_{OS}
- **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 Supplies**
- **Input Voltage Range = -0.2V to + 3.8V with V_S = 5V**
- **Low Power**
  2.3mA/Amplifier Typical Supply Current
  75μA/Amplifier when Disabled (SGM8653/5 Only)
- **Small Packaging**
  SGM8651 Available in SOT-23-5 and SOIC-8
  SGM8652 Available in MSOP-8 and SOIC-8
  SGM8653 Available in SOT-23-6 and SOIC-8
  SGM8654 Available in TSSOP-14 and SOIC-14
  SGM8655 Available in MSOP-10

PIN CONFIGURATIONS (Top View)



PACKAGE/ORDERING INFORMATION

MODEL	CHANNEL	ORDER NUMBER	PACKAGE DESCRIPTION	PACKAGE OPTION	MARKING INFORMATION
SGM8651	Single	SGM8651XN5/TR	SOT-23-5	Tape and Reel, 3000	8651
		SGM8651XS/TR	SOIC-8	Tape and Reel, 2500	SGM8651XS
SGM8652	Dual	SGM8652XMS/TR	MSOP-8	Tape and Reel, 3000	SGM8652XMS
		SGM8652XS/TR	SOIC-8	Tape and Reel, 2500	SGM8652XS
SGM8653	Single with Shutdown	SGM8653XN6/TR	SOT-23-6	Tape and Reel, 3000	8653
		SGM8653XS/TR	SOIC-8	Tape and Reel, 2500	SGM8653XS
SGM8654	Quad	SGM8654XS14/TR	SOIC-14	Tape and Reel, 2500	SGM8654XS14
		SGM8654XTS14/TR	TSSOP-14	Tape and Reel, 3000	SGM8654XTS14
SGM8655	Dual with Shutdown	SGM8655XMS/TR	MSOP-10	Tape and Reel, 3000	SGM8655XMS

ABSOLUTE MAXIMUM RATINGS

Supply Voltage, V+ to V- 7.5V
Common-Mode Input Voltage
……..……………..………………......($–V_S$) – 0.5 V to ($+V_S$) +0.5V
Storage Temperature Range.............................–65℃ to +150℃
Junction Temperature ....160℃
Operating Temperature Range......................... –55℃ to +150℃
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
Lead Temperature Range (Soldering 10 sec)................. 260℃
ESD Susceptibility
HBM..1000V
MM..400V

NOTE:
Stresses above those listed under Absolute Maximum Ratings may cause permanent damage to the device. This is a stress rating only; functional operation of the device at these or any other conditions above those indicated in the operational section of this specification is not implied. Exposure to absolute maximum rating conditions for extended periods may affect device reliability.

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.

SGMICRO reserves the right to make any change in circuit design, specification or other related things if necessary without notice at any time. Please contact SGMICRO sales office to get the last datasheet.

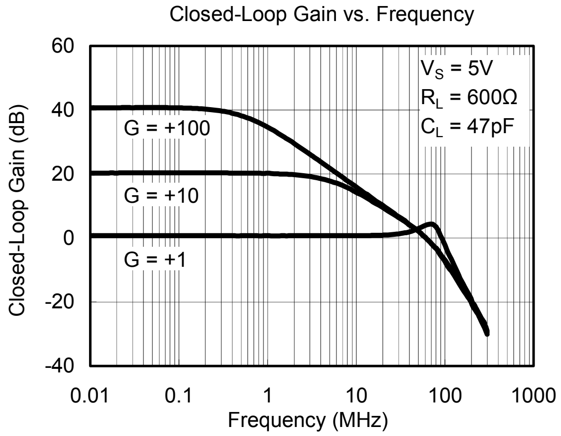
ELECTRICAL CHARACTERISTICS: V_S = +5V

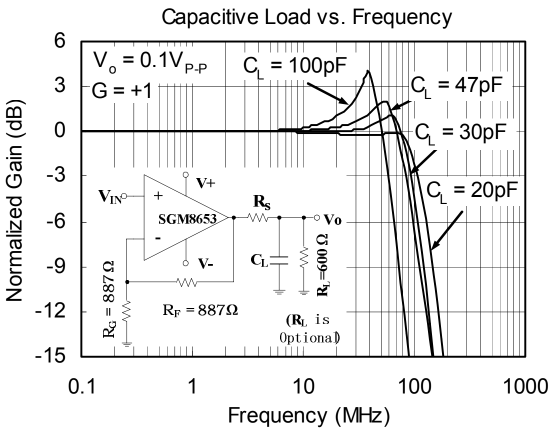
(At T_A = +25℃, R_L = 600Ω connected to Vs/2, unless otherwise noted.)

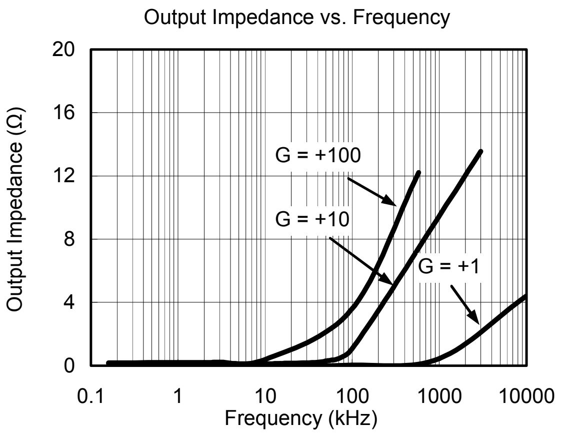
PARAMETER	CONDITIONS	SGM8651/2/3/4/5						
		TYP	MIN/MAX OVER TEMPERATURE					
		+25℃	+25℃	0℃ to 70℃	-40℃ to 85℃	-40℃to 125℃	UNITS	MIN/ MAX
DYNAMIC PERFORMANCE								
Gain-Bandwidth Product (GBP)	G = +10	50					MHz	TYP
Slew Rate	G = +1, 2V Output Step	66					V/μs	TYP
Settling Time to 0.1%	G = +1, 2V Output Step	60					ns	TYP
Overload Recovery Time	V_{IN}·G = +V_S	25					ns	TYP
NOISE PERFORMANCE								
Input Voltage Noise(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_O = 0.3V to 4.7V, R_L = 150Ω	80	75	74	74	73	dB	MIN
	V_O = 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)	ΔVs = + 2.7V to + 5.5V, V_{CM} = (-V_S) + 0.5	80	67	67	65	62	dB	MIN

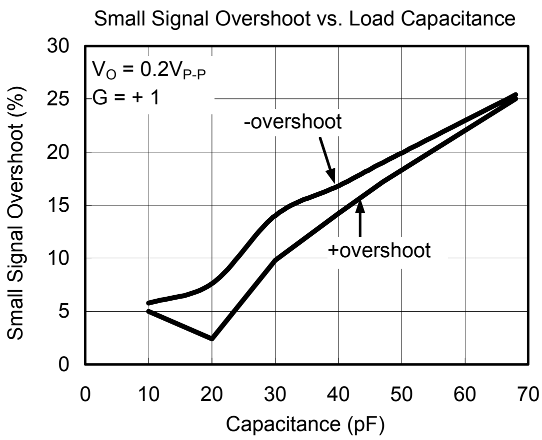
TYPICAL PERFORMANCE CHARACTERISTICS

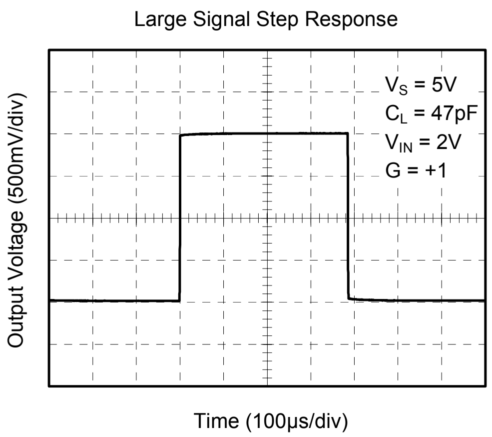
At T_A= +25℃, V_S = +5V, G = +2, R_F = 887Ω, R_G = 887Ω, C_L =47pF, and R_L= 600Ω, unless otherwise noted.

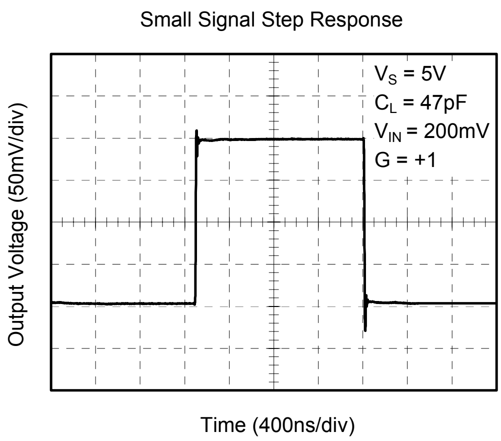








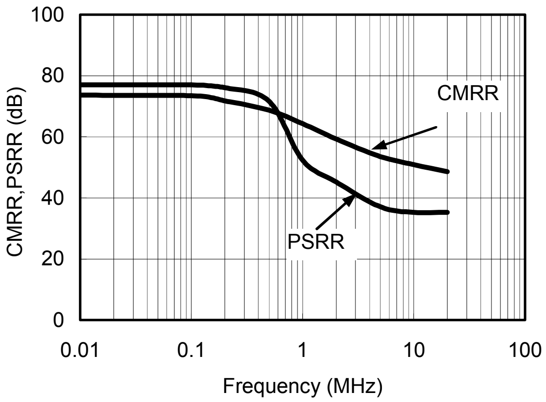




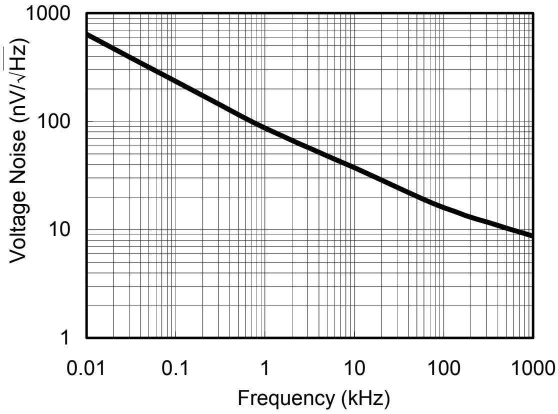
TYPICAL PERFORMANCE CHARACTERISTICS

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.

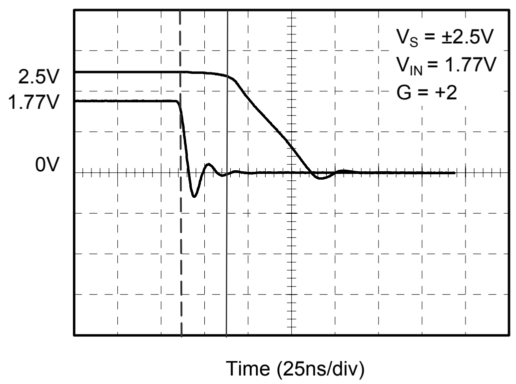
CMRR and PSRR vs. Frequency



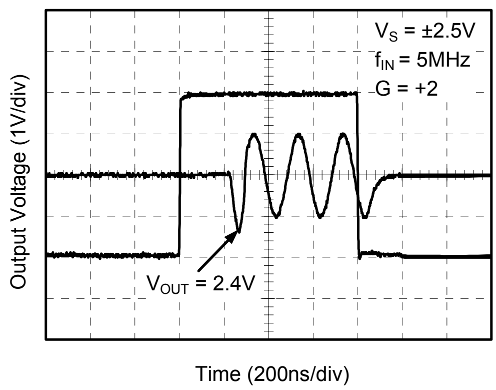
Input Voltage Noise Spectral Density vs. Frequency



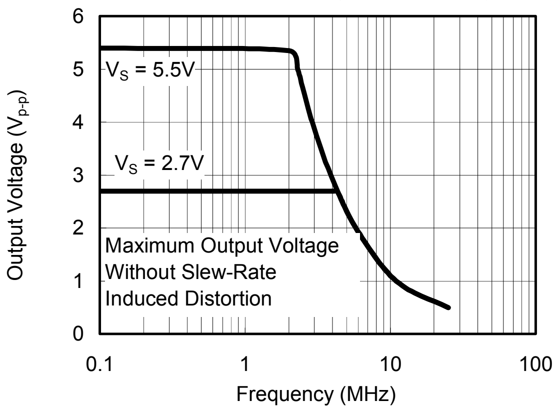
Overload Recovery Time



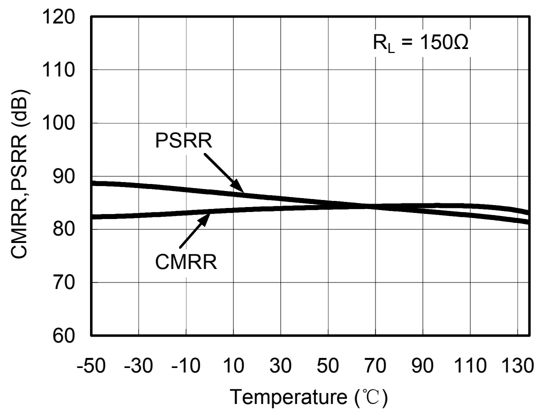
Large-Signal Disable/Enable Response



Maximum Output Voltage vs. Frequency

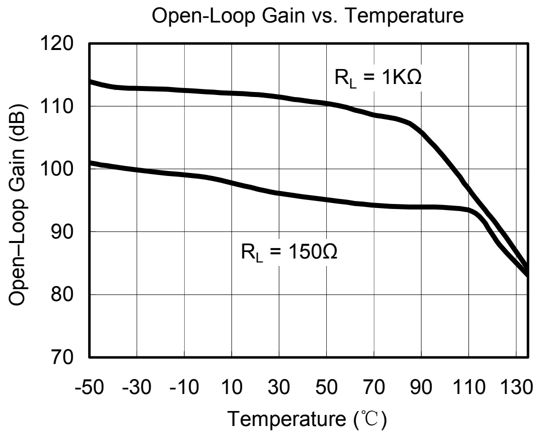


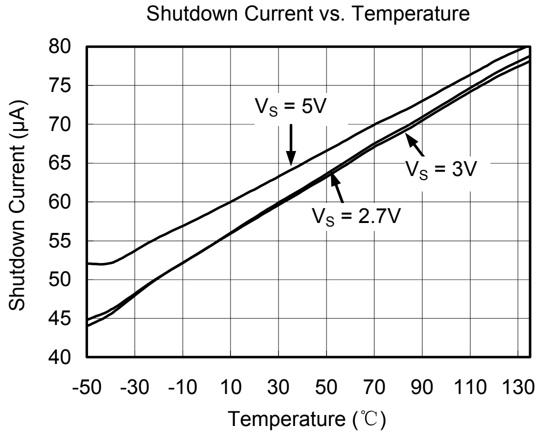
CMRR and PSRR vs. Temperature

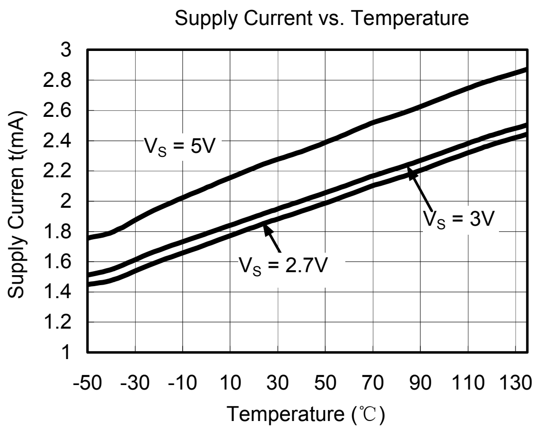


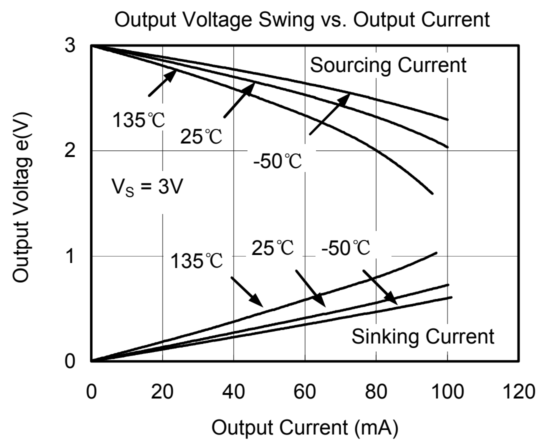
TYPICAL PERFORMANCE CHARACTERISTICS

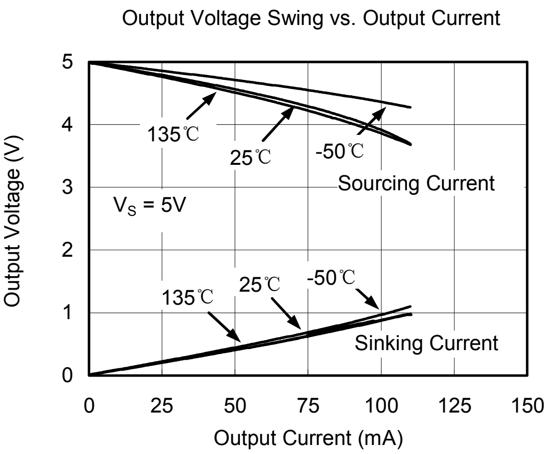
At T_A= +25℃, V_S = +5V, G = +2, R_F = 887Ω, R_G = 887Ω, R_L = 150Ω connected to Vs/2, unless otherwise noted.

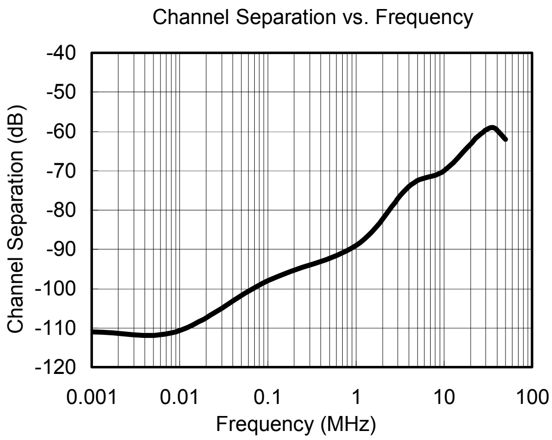






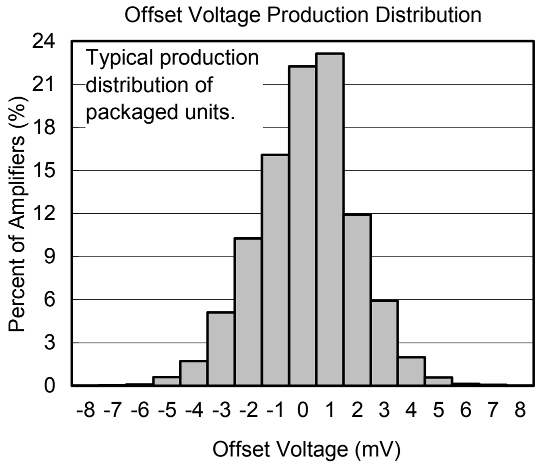






TYPICAL PERFORMANCE CHARACTERISTICS

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.



APPLICATION NOTES

Driving Capacitive Loads

The SGM865x 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 drive 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}.

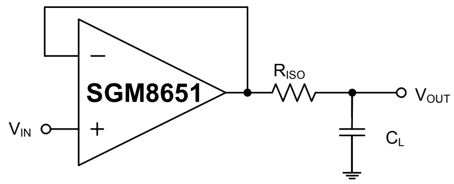


Figure 1. Indirectly Driving Heavy Capacitive Load

An improvement 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.

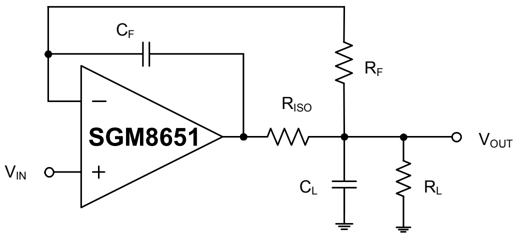


Figure 2. Indirectly Driving Heavy Capacitive Load with DC Accuracy

For no-buffer configuration, there are two others 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 SGM865x 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_{DD} with a 0.1μF ceramic capacitor which should be placed close to the V_{DD} pin. For dual-supply operation, both the V_{DD} and the V_{SS} 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 op amp'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 big current loop area small to minimize the EMI (electromagnetic interfacing).

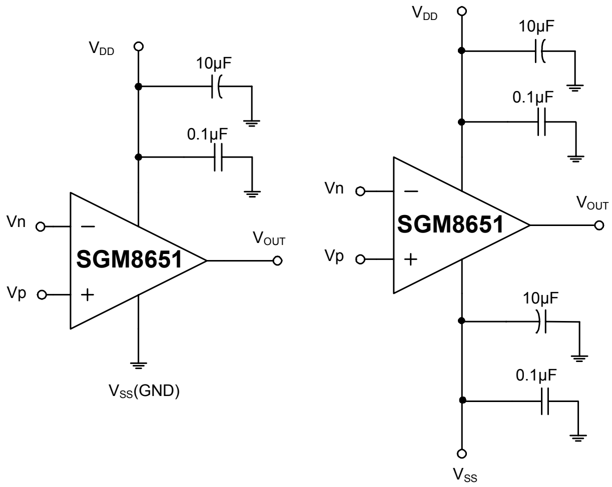


Figure 3. Amplifier with Bypass Capacitors

Grounding

A ground plane layer is important for high speed circuit design. The length of the current path speed currents 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 parallel. This helps reduce unwanted positive feedback.

TYPICAL APPLICATION CIRCUITS

Differential Amplifier

The circuit shown in Figure 4 performs the difference function. If the resistors ratios are equal (R_4 / R_3 = R_2 / R_1), then
V_{OUT} = (Vp – Vn) × R_2 / R_1 + V_{REF}.

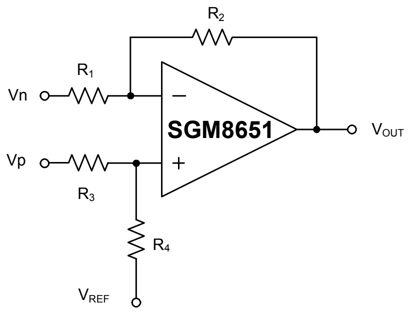


Figure 4. Differential Amplifier

Instrumentation Amplifier

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

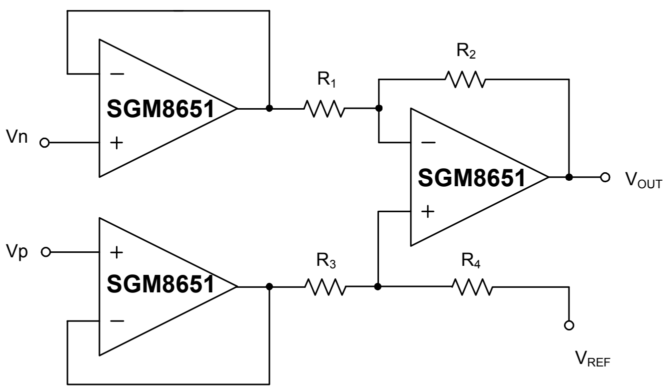


Figure 5. Instrumentation Amplifier

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 1/2πR_2C. Make sure the filter 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 resistors value as low as possible and consistent with output loading consideration.

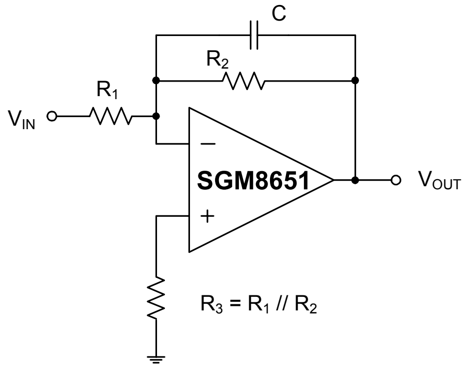
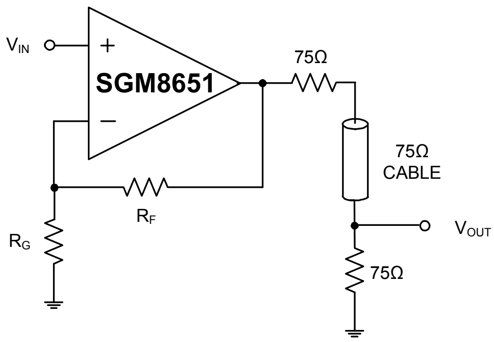


Figure 6. Low Pass Active Filter

Driving Video

The SGM865x can be used in video applications like in Figure 7.

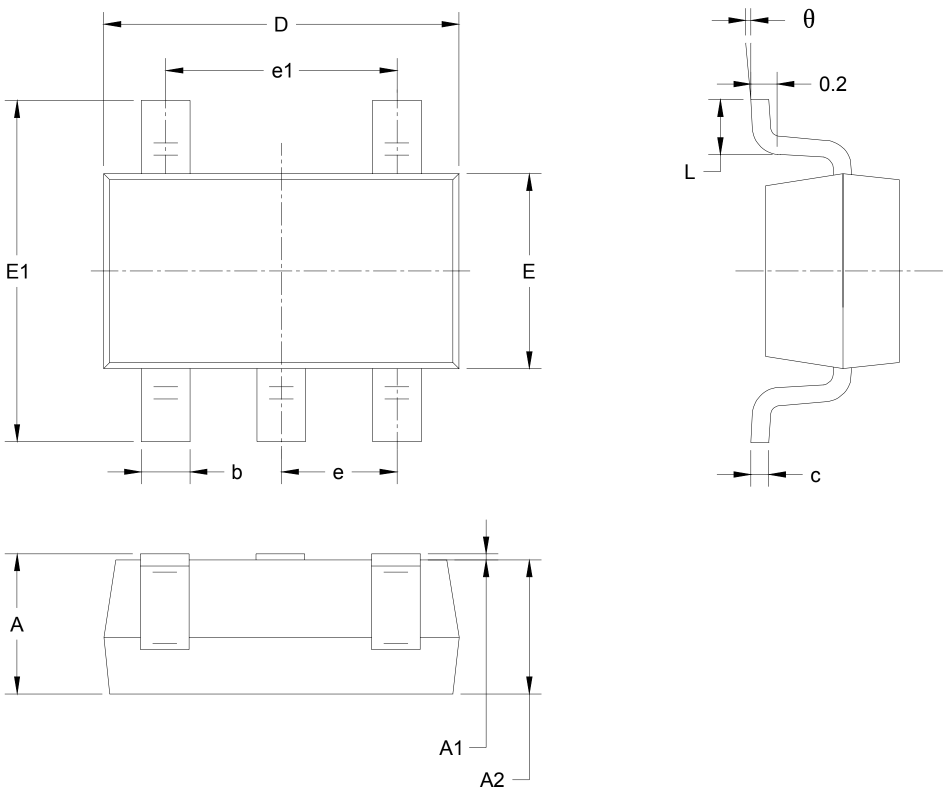


G = 1 + R_F / R_G

Figure 7. Typical Video Driving

PACKAGE OUTLINE DIMENSIONS

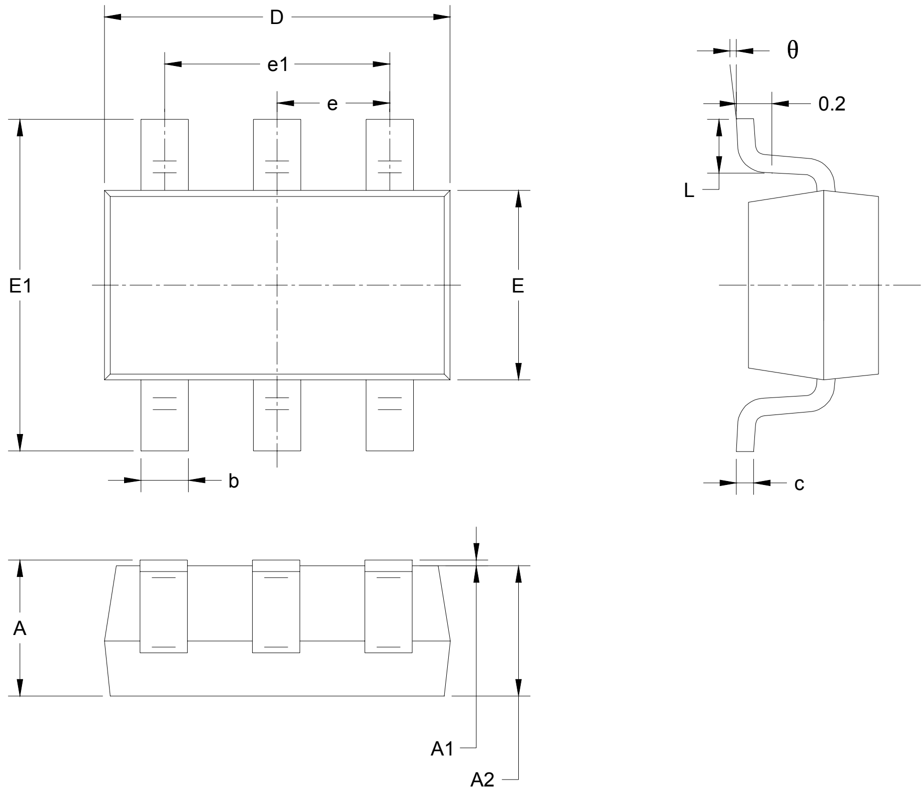
SOT-23-5



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

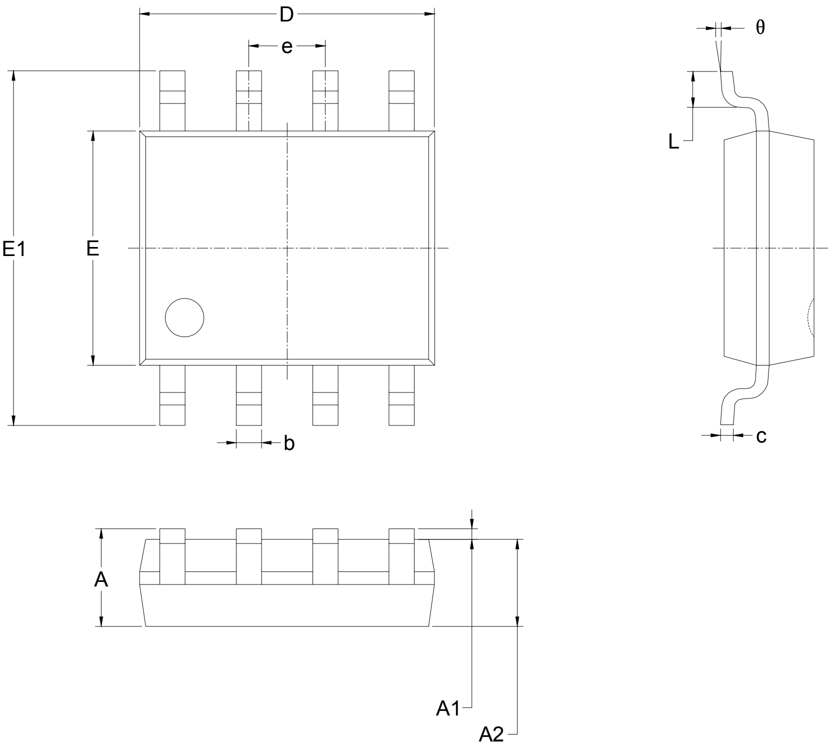
SOT-23-6



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

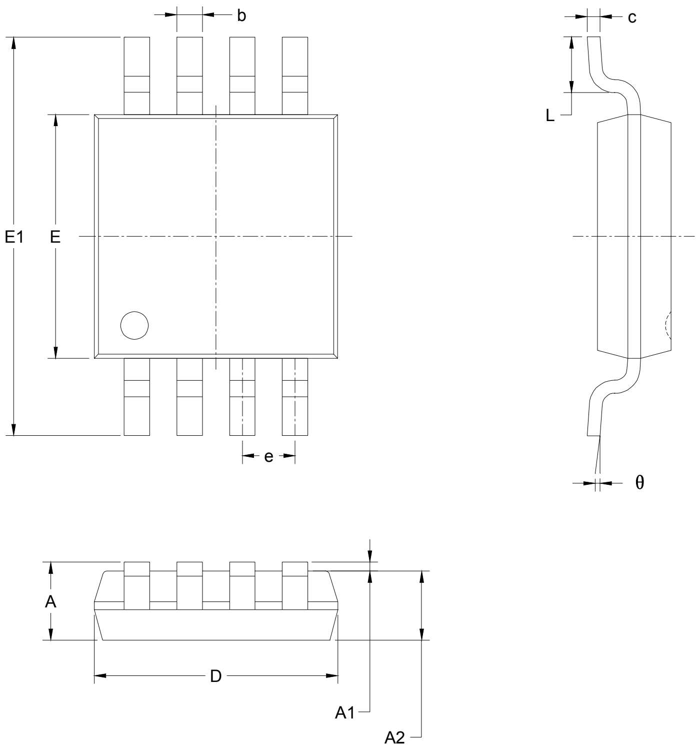
SOIC-8



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

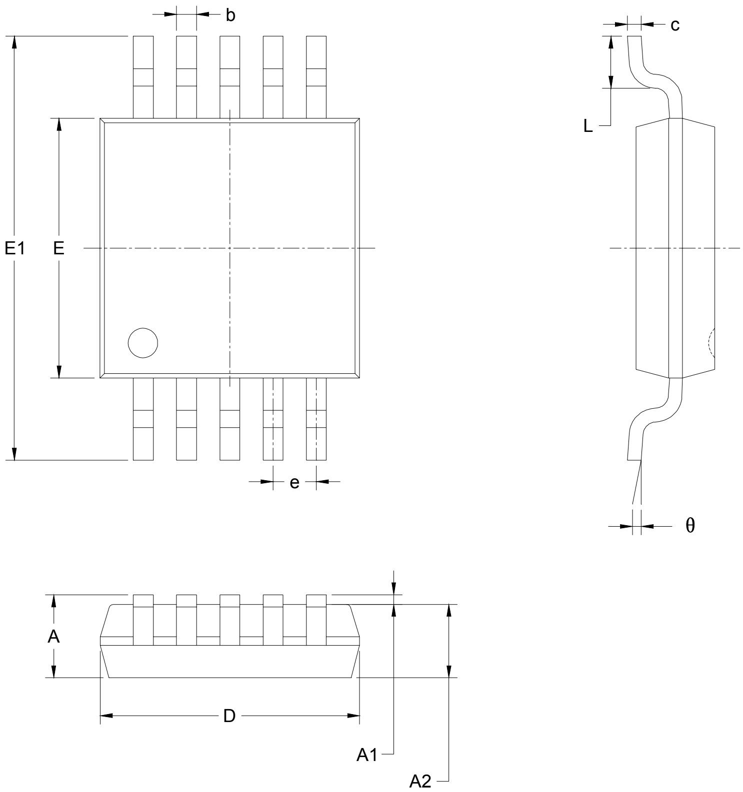
MSOP-8



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

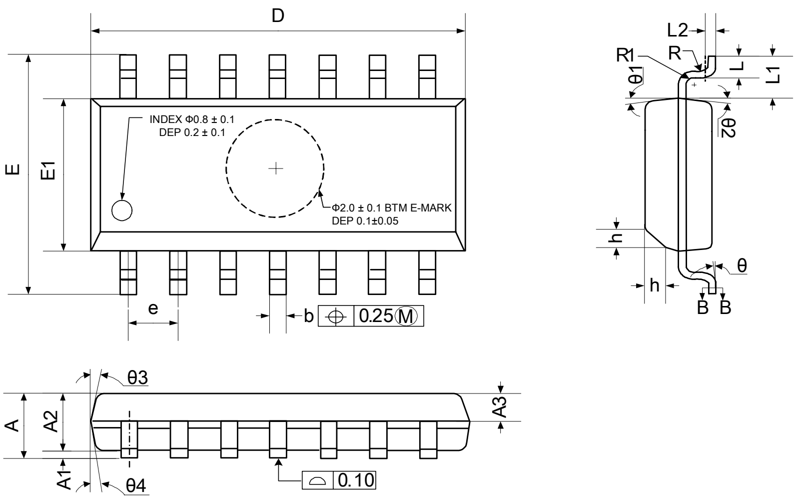
MSOP-10



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

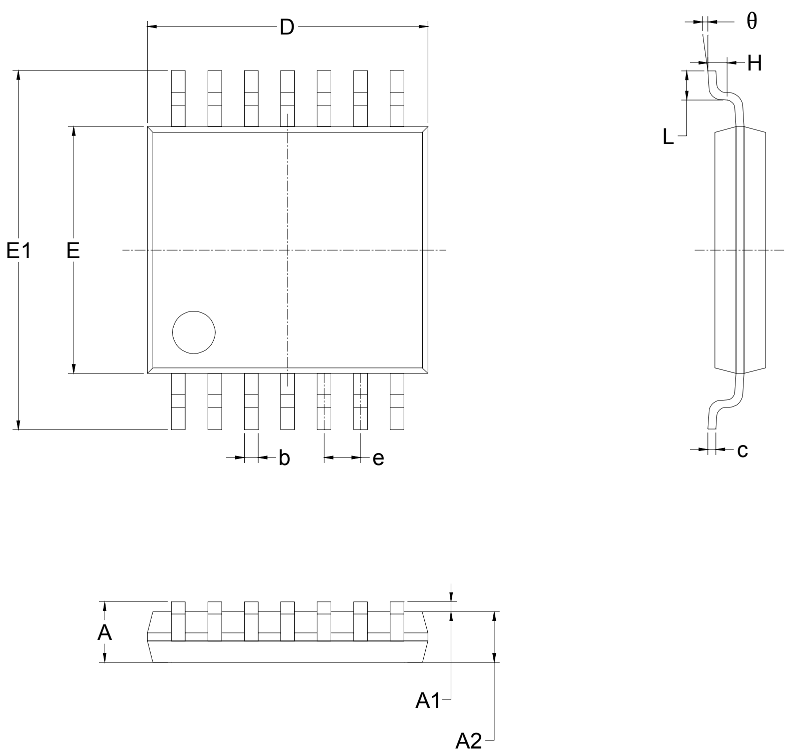
SOIC-14



Symbol	Dimensions In Millimeters			Dimensions In Inches		
	MIN	MOD	MAX	MIN	MOD	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
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°
θ1	6°	8°	10°	6°	8°	10°
θ2	6°	8°	10°	6°	8°	10°
θ3	5°	7°	9°	5°	7°	9°
θ4	5°	7°	9°	5°	7°	9°

PACKAGE OUTLINE DIMENSIONS

TSSOP-14



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	4.900	5.100	0.193	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°