SGM8968-1/SGM8968-2/SGM8968-4
1.6mA, 10MHz, High Precision, Rail-to-Rail I/O, Low Noise, CMOS Operational Amplifiers

GENERAL DESCRIPTION

The SGM8968-1/2/4 are a family of single, dual and quad rail-to-rail input and output operational amplifiers with 10MHz gain-bandwidth product and 20V/μs slew rate, while consuming only 1.6mA quiescent current per amplifier at 5V.

The SGM8968-1/2/4 feature a 50μV typical input offset, and the devices are optimized for low voltage operation from 1.8V to 5.5V.

The single SGM8968-1 is available in Green SOT-23-5 and SOIC-8 packages. The dual SGM8968-2 is available in Green SOIC-8 and MSOP-8 packages. The quad SGM8968-4 is available in Green SOIC-14 and TSSOP-14 packages. They are specified over the extended industrial temperature range (-40 ℃ to +125℃).

FEATURES

- **Rail-to-Rail Input and Output**
- **Input Offset Voltage: 50μV (TYP)**
- **High Gain-Bandwidth Product: 10MHz**
- **High Slew Rate: 20V/μs**
- **Settling Time to 0.1% with 2V Step: 280ns**
- **Overload Recovery Time: 100ns**
- **Low Noise: 8nV/$\sqrt{Hz}$ at 10kHz**
- **Supply Voltage Range: 1.8V to 5.5V**
- **Input Voltage Range: -0.1V to 5.6V with V_S = 5.5V**
- **Low Power:**
  Supply Current: 1.6mA/Amplifier (TYP)
- **-40℃ to +125℃ Operating Temperature Range**
- **Small Packaging:**
  SGM8968-1 Available in Green SOT-23-5 and SOIC-8 Packages
  SGM8968-2 Available in Green SOIC-8 and MSOP-8 Packages
  SGM8968-4 Available in Green SOIC-14 and TSSOP-14 Packages

APPLICATIONS

Sensor
Audio
Active Filter
A/D Converter
Communication
Test Equipment
Cellular and Cordless Phone
Laptop and PDA
Photodiode Amplification
Battery-Powered Instrumentation

PACKAGE/ORDERING INFORMATION

MODEL	PACKAGE DESCRIPTION	SPECIFIED TEMPERATURE RANGE	ORDERING NUMBER	PACKAGE MARKING	PACKING OPTION
SGM8968-1	SOT-23-5	-40℃ to +125℃	SGM8968-1XN5G/TR	MB6XX	Tape and Reel, 3000
	SOIC-8	-40℃ to +125℃	SGM8968-1XS8G/TR	SGM 89681XS8 XXXXX	Tape and Reel, 4000
SGM8968-2	SOIC-8	-40℃ to +125℃	SGM8968-2XS8G/TR	SGM 89682XS8 XXXXX	Tape and Reel, 4000
	MSOP-8	-40℃ to +125℃	SGM8968-2XMS8G/TR	SGM89682 XMS8 XXXXX	Tape and Reel, 4000
SGM8968-4	SOIC-14	-40℃ to +125℃	SGM8968-4XS14G/TR	SGM89684XS14 XXXXX	Tape and Reel, 2500
	TSSOP-14	-40℃ to +125℃	SGM8968-4XTS14G/TR	SGM89684 XTS14 XXXXX	Tape and Reel, 4000

MARKING INFORMATION

NOTE: XX = Date Code. XXXXX = Date Code, Trace Code and Vendor Code.

SOT-23-5

YYY X X
- X (second): Date Code - Week
- X (first): Date Code - Year
- YYY: Serial Number

SOIC-8/MSOP-8/SOIC-14/TSSOP-14

X X X X X
- X (last): Vendor Code
- X X (middle): Trace Code
- X (first): Date Code - Year

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 $-V_S$ 6V
Input Common Mode Voltage Range
.... $(-V_S)$ - 0.3V to $(+V_S)$ + 0.3V
Junction Temperature .... +150℃
Storage Temperature Range .... -65℃ to +150℃
Lead Temperature (Soldering, 10s) .... +260℃

RECOMMENDED OPERATING CONDITIONS

Operating Temperature Range .... -40℃ to +125℃

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

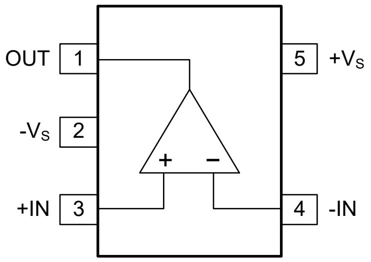
This integrated circuit can be damaged by ESD if you don't pay attention to ESD protection. SGMICRO recommends that all integrated circuits be handled with appropriate precautions. Failure to observe proper handling and installation procedures can cause damage. ESD damage can range from subtle performance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

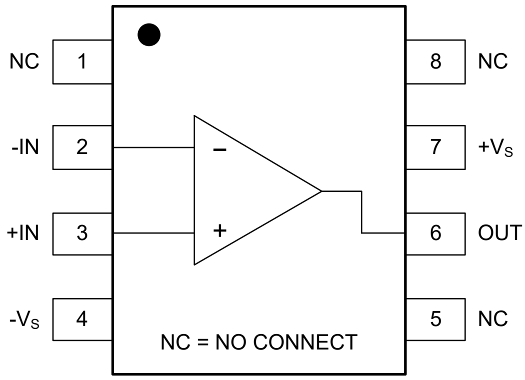
PIN CONFIGURATIONS

SGM8968-1 (TOP VIEW)



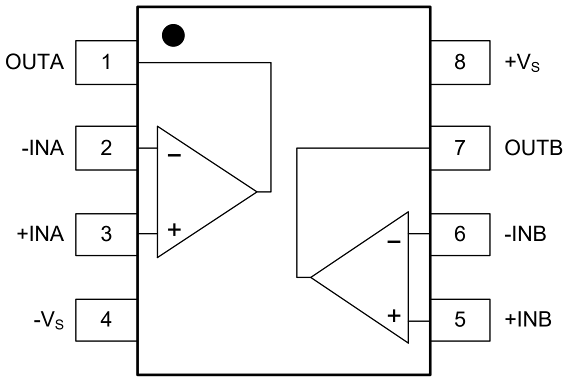
SOT-23-5

SGM8968-1 (TOP VIEW)



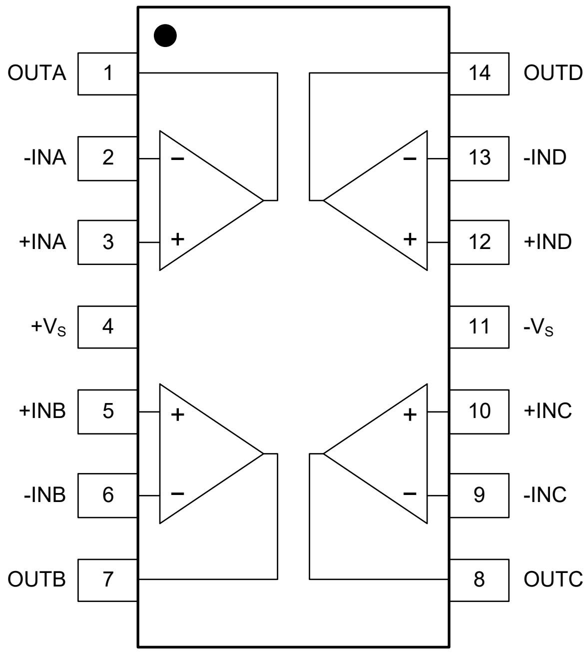
SOIC-8

SGM8968-2 (TOP VIEW)



SOIC-8/MSOP-8

SGM8968-4 (TOP VIEW)



SOIC-14/TSSOP-14

ELECTRICAL CHARACTERISTICS

(At T_A = +25℃, V_S = 1.8V to 5.5V or ±0.9V to ±2.75V, V_{CM} = V_S/2 and R_L = 10kΩ connected to V_S/2, unless otherwise noted.)

PARAMETER	SYMBOL	CONDITIONS	MIN	TYP	MAX	UNITS
Input Characteristics						
Input Offset Voltage	V_{OS}			50		μV
Input Bias Current	I_B			5		pA
Input Offset Current	I_{OS}			5		pA
Input Common Mode Voltage Range	V_{CM}		$(-V_S) - 0.1$		$(+V_S) + 0.1$	V
Common Mode Rejection Ratio	CMRR	V_S = 5.5V, V_{CM} = -0.1V to 5.6V		100		dB
Open-Loop Voltage Gain	A_{OL}	R_L = 10kΩ , $(-V_S) + 0.15V < V_{OUT} < (+V_S) - 0.15V$		105		dB
Output Characteristics						
Output Voltage Swing from Rail		V_S = 5.5V, R_L = 10kΩ		8		mV
Output Current	I_{OUT}	V_S = 5.5V		70		mA
Power Supply						
Operating Voltage Range	V_S		1.8		5.5	V
Power Supply Rejection Ratio	PSRR	V_S = 1.8V to 5.5V, $V_{CM} = (-V_S) + 0.5V$		5		μV/V
Quiescent Current/Amplifier	I_Q	I_{OUT} = 0		1.6		mA
Dynamic Performance						
Gain-Bandwidth Product	GBP	V_S = 5V		10		MHz
Phase Margin	φ_O	V_S = 5V		60		°
Slew Rate	SR	V_S = 5V, G = +1, 2V output step		20		V/μs
Settling Time to 0.1%	t_S	V_S = 5V, G = +1, 2V output step		280		ns
Overload Recovery Time		V_S = 5V, $V_{IN} \times G = V_S$		100		ns
Total Harmonic Distortion + Noise	THD+N	V_{OUT} = 4V_{P-P}, G = +1, f = 10kHz, R_L = 10kΩ, BW = 22Hz to 80kHz		0.0005		%
Noise Performance						
Input Voltage Noise Density	e_n	f = 1kHz		18		nV/$\sqrt{Hz}$
		f = 10kHz		8		

APPLICATION NOTES

Rail-to-Rail Input

The input common mode voltage range of the SGM8968-1/2/4 extends 100mV beyond the supply rails for the full supply voltage range of 1.8V to 5.5V. Diodes between the inputs and the supply rails keep the input voltage from exceeding the rails.

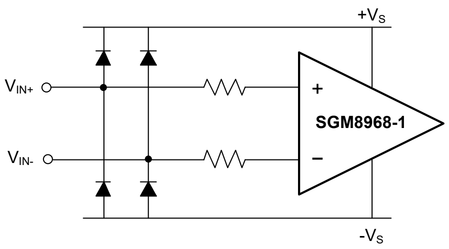


Figure 1. Equivalent Input Circuit

Input Protection

The SGM8968-1/2/4 family incorporates internal ESD protection circuits on all pins. For input and output pins, this protection primarily consists of current-steering diodes connected between the input and power supply pins. Therefore, as well as keeping the input voltage below the maximum rating, it is also important to limit the input current to less than 10mA. Figure 2 shows how a series input resistor can be added to the driven input to limit the input current. The added resistor contributes thermal noise at the amplifier input and the value must be kept to a minimum in noise-sensitive applications.

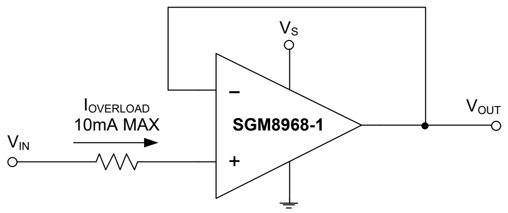


Figure 2. Input Current Protection

Rail-to-Rail Output

The minimum output voltage will be within millivolts of ground for single-supply operation where the load is referenced to ground ($-V_S$). With a 5.5V supply and the load tied to ground, the typical output swings from 0.008V to 5.492V.

Driving Capacitive Loads

The SGM8968-1/2/4 are unity-gain stable for capacitive load up to 1nF. Applications that require greater capacitive drive capability should use an isolation resistor between the output and the capacitive load (Figure 3). Note that this alternative results in a loss of gain accuracy because R_{ISO} forms a voltage divider with the R_{LOAD}.

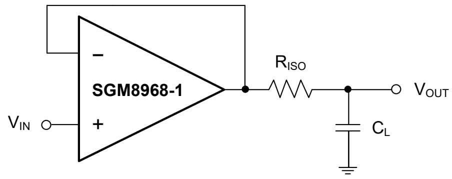


Figure 3. Using Isolation Resistor to Improve Stability when Driving Heavy Capacitive Load

Power Supply Bypassing and Layout

Power supply pins are actually inputs to the amplifiers. Care must be taken to provide the amplifiers with a clean, low noise DC voltage source.

Power supply bypassing is employed to provide a low impedance path to ground for noise and undesired signals at all frequencies. This cannot be achieved with a single capacitor type; but with a variety of capacitors in parallel, the bandwidth of power supply bypassing can be greatly extended. The bypass capacitors have two functions:

1. Provide a low impedance path for noise and undesired signals from the supply pins to ground.

2. Provide local stored charge for fast switching conditions and minimize the voltage drop at the supply pins during transients. This is typically achieved with large electrolytic capacitors.

APPLICATION NOTES (continued)

Good quality ceramic chip capacitors should be used and always kept as close as possible to the amplifier package. A parallel combination of a 0.1μF ceramic and a 10μF electrolytic covers a wide range of rejection for unwanted noise. The 10μF capacitor is less critical for high frequency bypassing, and in most cases, one per supply line is sufficient. The values of capacitors are circuit-dependent and should be determined by the system's requirements.

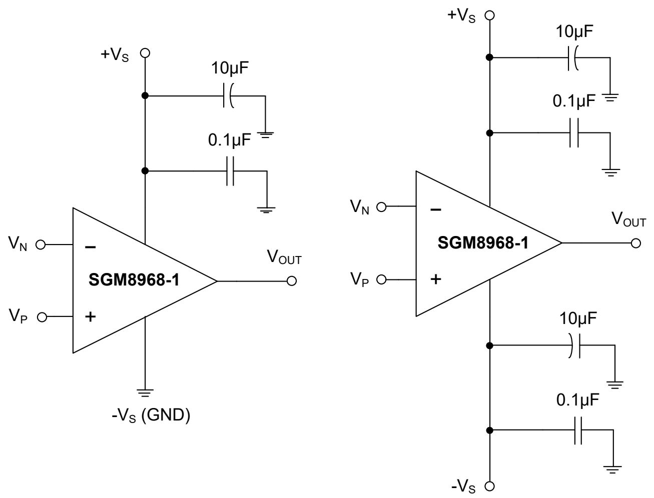


Figure 4. Amplifier with Bypass Capacitors

Grounding

Separate grounding for analog and digital portions of circuitry is one of the simplest and most effective methods of noise suppression. One or more layers on multilayer PCBs are usually devoted to ground planes.

A ground plane helps distribute heat and reduces EMI noise pickup. Make sure to physically separate digital and analog grounds, paying attention to the flow of the ground current.

Input-to-Output Coupling

To minimize capacitive coupling, run the input traces as far away from the supply or output traces as possible. If these traces cannot be kept separate, crossing the sensitive trace perpendicular is much better as opposed to in parallel with the noisy trace. This helps reduce unwanted positive feedback.

TYPICAL APPLICATION CIRCUITS

Difference Amplifier

The circuit shown in Figure 5 performs the difference function. If the resistor ratios are equal ($R_4/R_3 = R_2/R_1$), then $V_{OUT} = (V_P - V_N) \times R_2/R_1 + V_{REF}$.

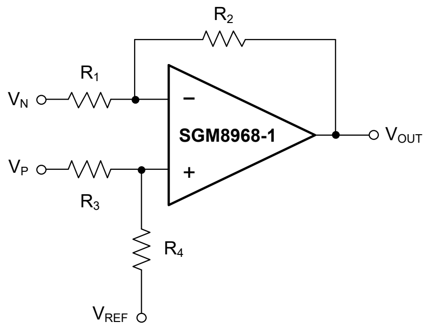


Figure 5. Difference Amplifier

High Input Impedance Difference Amplifier

The circuit in Figure 6 performs the same function as that in Figure 5 but with a high input impedance.

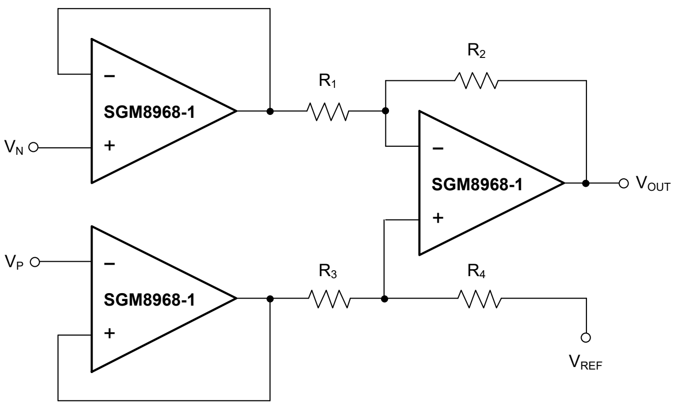


Figure 6. High Input Impedance Difference Amplifier

Active Low-Pass Filter

The low-pass filter shown in Figure 7 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.

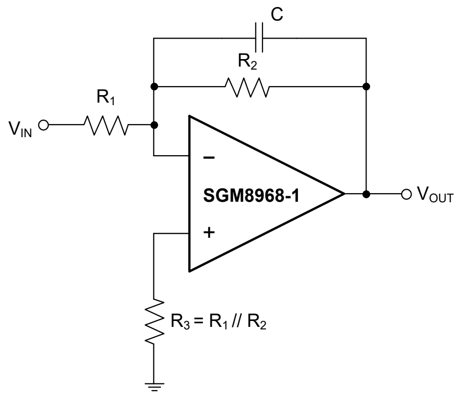
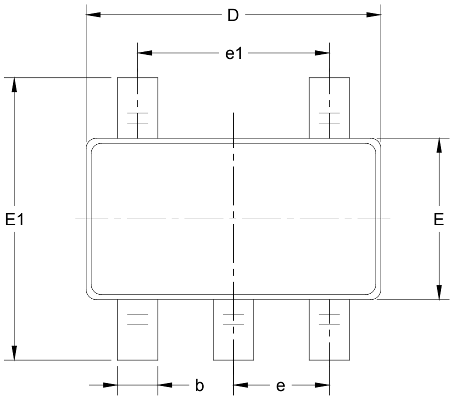
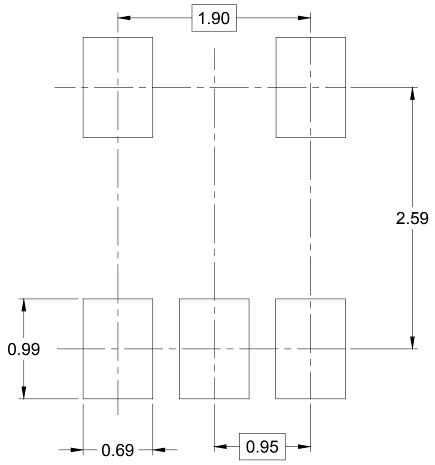


Figure 7. Active Low-Pass Filter

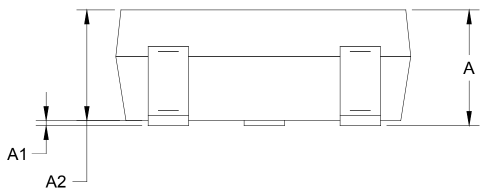
PACKAGE OUTLINE DIMENSIONS

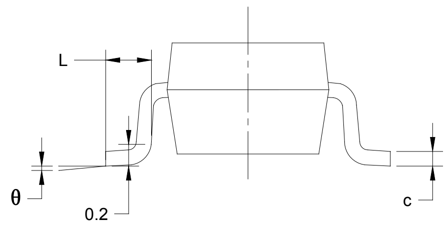
SOT-23-5





RECOMMENDED LAND PATTERN (Unit: mm)

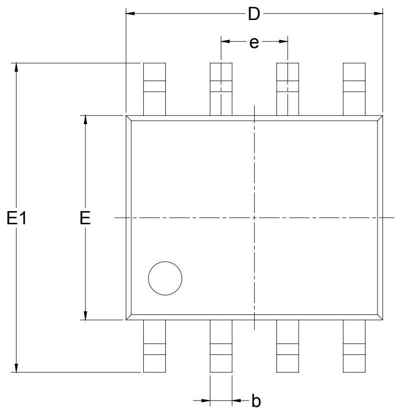


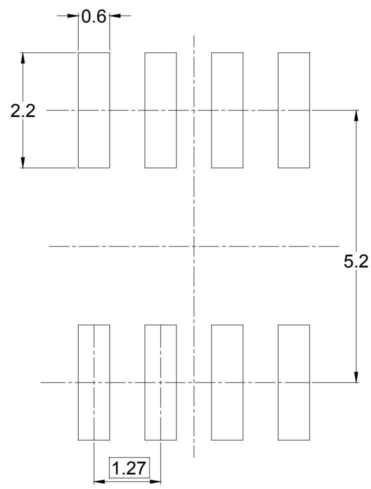


Symbol	Dimensions In Millimeters		Dimensions In Inches	
	MIN	**MAX**	**MIN**	**MAX**
A	1.050	1.250	0.041	0.049
A1	0.000	0.100	0.000	0.004
A2	1.050	1.150	0.041	0.045
b	0.300	0.500	0.012	0.020
c	0.100	0.200	0.004	0.008
D	2.820	3.020	0.111	0.119
E	1.500	1.700	0.059	0.067
E1	2.650	2.950	0.104	0.116
e	0.950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

PACKAGE OUTLINE DIMENSIONS

SOIC-8





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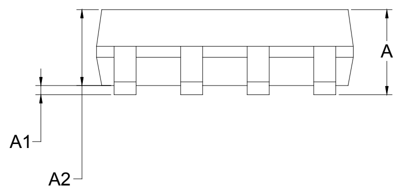
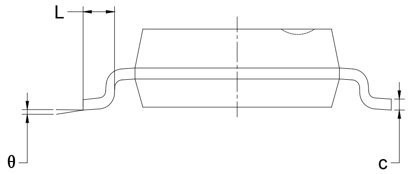
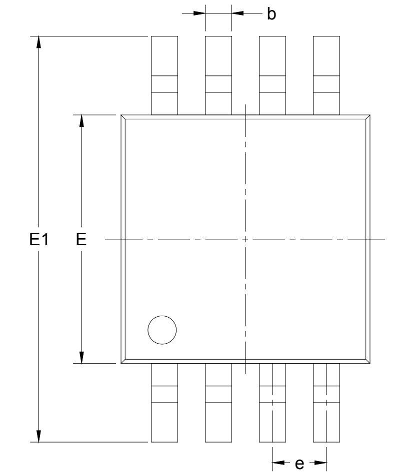


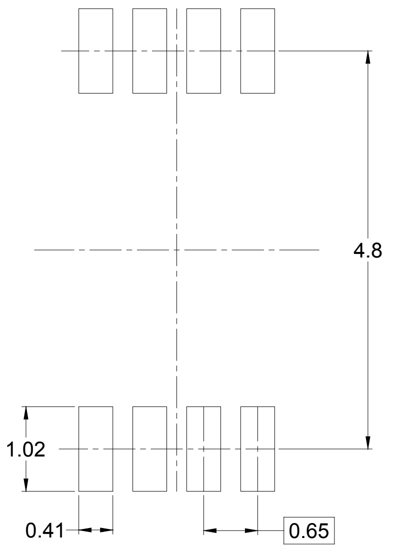


Symbol	Dimensions In Millimeters		Dimensions In Inches	
	MIN	**MAX**	**MIN**	**MAX**
A	1.350	1.750	0.053	0.069
A1	0.100	0.250	0.004	0.010
A2	1.350	1.550	0.053	0.061
b	0.330	0.510	0.013	0.020
c	0.170	0.250	0.006	0.010
D	4.700	5.100	0.185	0.200
E	3.800	4.000	0.150	0.157
E1	5.800	6.200	0.228	0.244
e	1.27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

PACKAGE OUTLINE DIMENSIONS

MSOP-8





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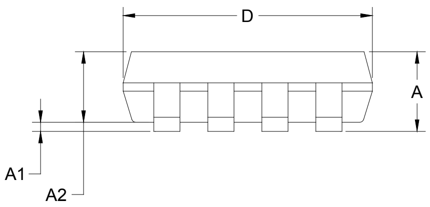
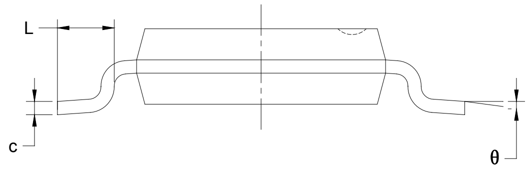
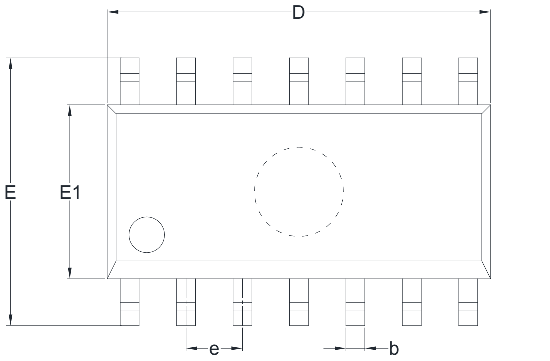


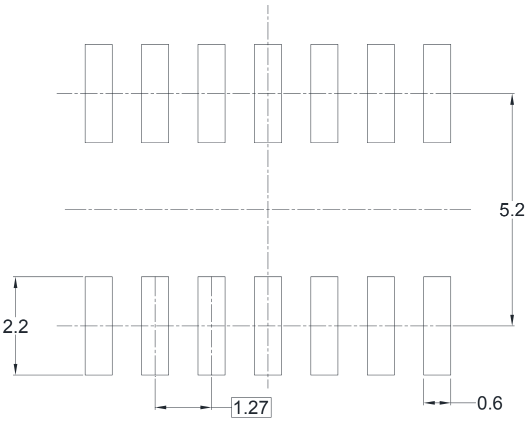


Symbol	Dimensions In Millimeters		Dimensions In Inches	
	MIN	MAX	MIN	MAX
A	0.820	1.100	0.032	0.043
A1	0.020	0.150	0.001	0.006
A2	0.750	0.950	0.030	0.037
b	0.250	0.380	0.010	0.015
c	0.090	0.230	0.004	0.009
D	2.900	3.100	0.114	0.122
E	2.900	3.100	0.114	0.122
E1	4.750	5.050	0.187	0.199
e	0.650 BSC		0.026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

PACKAGE OUTLINE DIMENSIONS

SOIC-14





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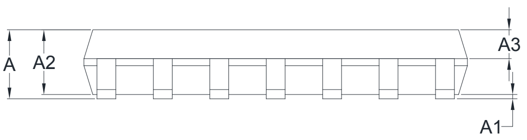
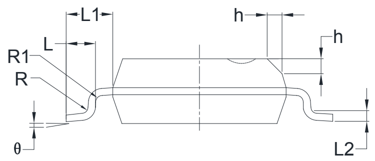
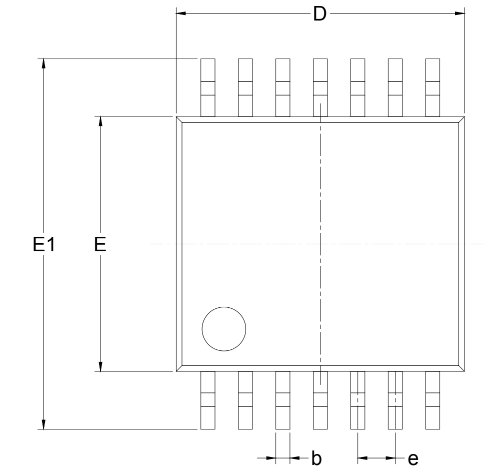


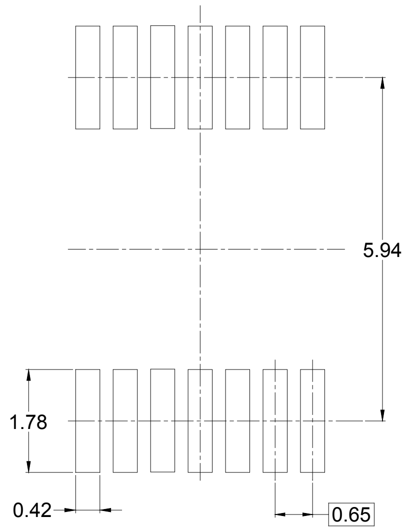


Symbol	Dimensions In Millimeters		Dimensions In Inches	
	MIN	**MAX**	**MIN**	**MAX**
A	1.35	1.75	0.053	0.069
A1	0.10	0.25	0.004	0.010
A2	1.25	1.65	0.049	0.065
A3	0.55	0.75	0.022	0.030
b	0.36	0.49	0.014	0.019
D	8.53	8.73	0.336	0.344
E	5.80	6.20	0.228	0.244
E1	3.80	4.00	0.150	0.157
e	1.27 BSC		0.050 BSC	
L	0.45	0.80	0.018	0.032
L1	1.04 REF		0.040 REF	
L2	0.25 BSC		0.01 BSC	
R	0.07		0.003	
R1	0.07		0.003	
h	0.30	0.50	0.012	0.020
θ	0°	8°	0°	8°

PACKAGE OUTLINE DIMENSIONS

TSSOP-14





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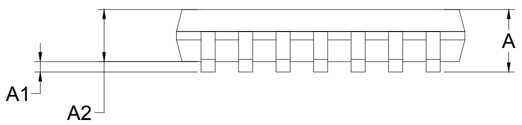
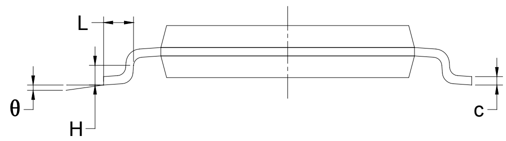
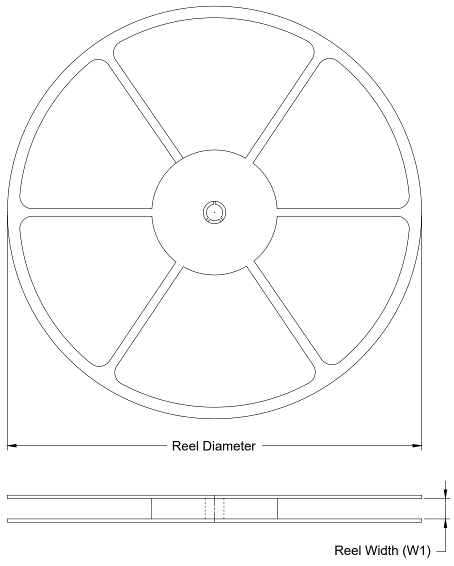




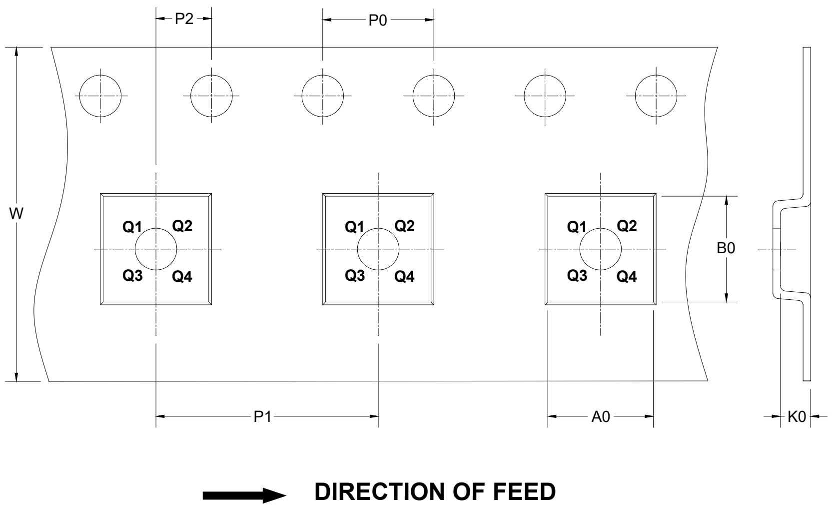
Symbol	Dimensions In Millimeters		Dimensions In Inches	
	MIN	MAX	MIN	MAX
A		1.200		0.047
A1	0.050	0.150	0.002	0.006
A2	0.800	1.050	0.031	0.041
b	0.190	0.300	0.007	0.012
c	0.090	0.200	0.004	0.008
D	4.860	5.100	0.191	0.201
E	4.300	4.500	0.169	0.177
E1	6.250	6.550	0.246	0.258
e	0.650 BSC		0.026 BSC	
L	0.500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

TAPE AND REEL INFORMATION

REEL DIMENSIONS



TAPE DIMENSIONS



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

KEY PARAMETER LIST OF TAPE AND REEL

Package Type	Reel Diameter	Reel Width W1 (mm)	A0 (mm)	B0 (mm)	K0 (mm)	P0 (mm)	P1 (mm)	P2 (mm)	W (mm)	Pin1 Quadrant
SOT-23-5	7″	9.5	3.20	3.20	1.40	4.0	4.0	2.0	8.0	Q3
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

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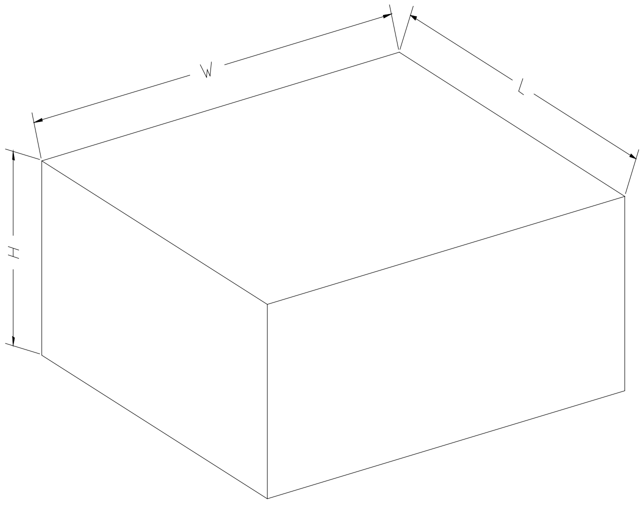
CARTON BOX DIMENSIONS



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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