

## General Description

The EC5912 is wideband, low-noise, low-distortion operational amplifier, that offer rail-to-rail output and single-supply operation down to 2.2V. They draw 5.6mA of quiescent supply current, as well as low input voltage-noise density (13nV/√Hz) and low input current-noise density (400fA/√Hz). These features make the devices an ideal choice for applications that require low distortion and low noise. The EC5912 has output which swing rail-to-rail and their input common-mode voltage range includes ground and offer wide bandwidth to 200MHz (G=+1). They are specified over the extended industrial temperature range (-45°C ~ 125°C). The single EC5912 is available in space-saving, MSOP-8 and SOP-8 packages.

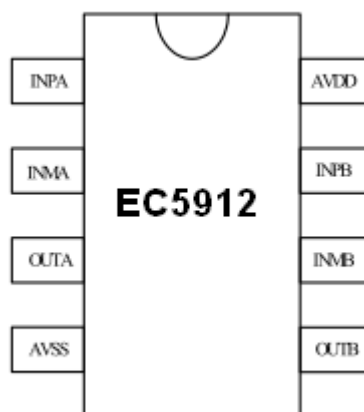
## Features

- Single-Supply Operation from +2.2V ~ +5.5V
- Rail-to-Rail Input / Output
- Gain-Bandwidth Product: 200MHz
- Low Input Bias Current: 10pA
- Low Offset Voltage: 1mV
- Quiescent Current: 5.6mA
- Available in MSOP-8 and SOP-8 Packages

## Applications

- Portable Equipment
- Mobile Communications
- Smoke Detector
- Sensor interface
- Medical Instrumentation
- Handheld Test Equipment
- imaging / video

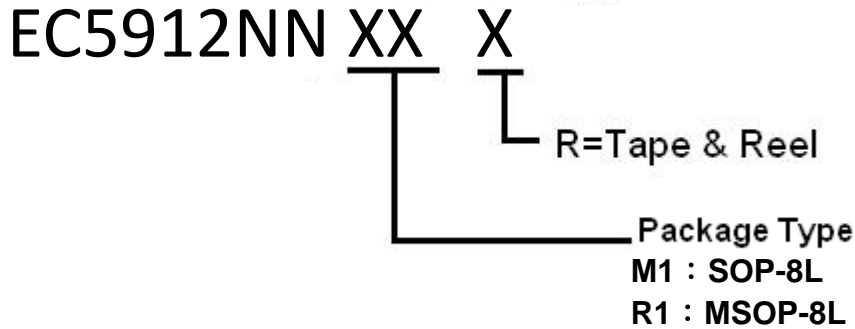
## Pin Configurations(Top View)



**Figure 1. Pin Assignment Diagram (MSOP-8 and SOP-8 Package)**



Ordering Information



Part Number	Package	Marking	Marking Information
EC5912NNR1R	MSOP-8L	5912 LLLL YYWW	1. LLLL : Last four Number of Lot No 2. YY : Year Code 3. WW : Week Code
EC5912NNM1R	SOP-8L	EC5912 LLLLL YYWWT	1. LLLLL : Last five Number of Lot No 2. YY : Year Code 3. WW : Week Code 4. T : Internal Tracking Code

Absolute Maximum Ratings

**Note:** Stress greater than those listed under Absolute Maximum Ratings may cause permanent damage to the device. This is a stress rating only and functional operation of the device at these or any other conditions outside those indicated in the operational sections of this specification are not implied. Exposure to absolute maximum rating conditions for extended periods may affect reliability.

Condition	Min	Max
Power Supply Voltage (V <sub>DD</sub> to V <sub>SS</sub> )	-0.5V	+7V
Analog Input Voltage (IN+ or IN-)	V <sub>SS</sub> -0.5V	V <sub>DD</sub> +0.5V
Operating Temperature Range	-40°C	+125°C
Junction Temperature	+150°C	
Storage Temperature Range	-65°C	+150°C
Lead Temperature (soldering, 10sec)	+300°C	
Package Thermal Resistance (T <sub>A</sub> =+25°C)		
MSOP-8, θ <sub>JA</sub>	210°C	
SOP-8, θ <sub>JA</sub>	130°C	



**Electrical Characteristic**

( $V_{DD} = +5V$ ,  $V_{SS} = 0V$ ,  $V_{CM} = 0V$ ,  $V_{OUT} = V_{DD}/2$ ,  $R_L$  tied to  $V_{DD}/2$ ,  $SHDNB = V_{DD}$ ,  $T_A = -40^{\circ}C$  to  $+125^{\circ}C$ , unless otherwise noted. Typical values are at  $T_A = +25^{\circ}C$ .) (Notes 1,2)

Parameter	Symbol	Conditions	Min.	Typ.	Max.	Units
Supply-Voltage Range	$V_{DD}$	Guaranteed by the PSRR test	2.2	-	5.5	V
Quiescent Supply Current (per Amplifier)	$I_Q$	$V_{DD} = 5V$	-	7	8.4	mA
Input Offset Voltage	$V_{OS}$	$T_A = 25^{\circ}C$	-	$\pm 1$	-	mV
		$T_A = -40^{\circ}C \sim +85^{\circ}C$	-	$\pm 8$	-	
		$T_A = -40^{\circ}C \sim +125^{\circ}C$	-	-	$\pm 10$	
Input Offset Voltage Tempco	$\Delta V_{OS}/\Delta T$		-	$\pm 2$	-	$\mu V/^{\circ}C$
Input Bias Current	$I_B$	(Note 3)	-	$\pm 10$	$\pm 100$	pA
Input Offset Current	$I_{OS}$	(Note 3)	-	$\pm 10$	$\pm 100$	pA
Input Common-Mode Voltage Range	$V_{CM}$	Guaranteed by the $T_A = 25^{\circ}C$ CMRR test, $T_A = -40^{\circ}C \sim +125^{\circ}C$	-0.1	-	$V_{DD} + 0.1.5$	V
Common-Mode Rejection Ratio	CMRR	$V_{SS} - 0.1V \leq V_{CM} \leq V_{DD} + 0.1V$ $T_A = 25^{\circ}C$	-	75	-	dB
		$V_{SS} \leq V_{CM} \leq V_{DD}$ $T_A = 25^{\circ}C$	72	90	-	
		$V_{SS} - 0.1V \leq V_{CM} \leq V_{DD} + 0.1V$ $T_A = -40^{\circ}C \sim +125^{\circ}C$	-	68	-	
Power-Supply Rejection Ratio	PSRR	$V_{DD} = +2.2V$ to $+5.5V$	75	90	-	dB
Open-Loop Voltage Gain	$A_V$	$R_L = 10k\Omega$ to $V_{DD}/2$ $V_{OUT} = 100mV$ to $V_{DD} - 125mV$	90	100	-	dB
		$R_L = 1k\Omega$ to $V_{DD}/2$ $V_{OUT} = 200mV$ to $V_{DD} - 250mV$	80	95	-	
		$R_L = 500\Omega$ to $V_{DD}/2$ $V_{OUT} = 350mV$ to $V_{DD} - 500mV$	70	80	-	
Output Voltage Swing	$V_{OUT}$	$ V_{IN+} - V_{IN-}  \geq 10mV$ $V_{DD} - V_{OH}$	-	10	35	mV
		$R_L = 10k\Omega$ to $V_{DD}/2$ $V_{OL} - V_{SS}$	-	10	30	
		$ V_{IN+} - V_{IN-}  \geq 10mV$ $V_{DD} - V_{OH}$	-	80	50	
		$R_L = 1k\Omega$ to $V_{DD}/2$ $V_{OL} - V_{SS}$	-	30	50	
		$ V_{IN+} - V_{IN-}  \geq 10mV$ $V_{DD} - V_{OH}$	-	100	140	
		$R_L = 500\Omega$ to $V_{DD}/2$ $V_{OL} - V_{SS}$	-	100	140	
Output Short-Circuit Current	$I_{SC}$	Sinking or Sourcing	-	$\pm 60$	-	mA
Input Capacitance	$C_{IN}$			1.5		pF
Bandwidth	GBW	$A_V = +1V/V$	-	200	-	MHz
Slew Rate	SR	$A_V = +1V/V$	-	125	-	V/ $\mu s$



## Electrical Characteristic

Parameter	Symbol	Conditions	Min.	Typ.	Max.	Units
Differential Phase error (NTSC)	DP	$G=2, R_L=150\Omega$	-	0.03	-	deg
Differential Gain error (NTSC)	DG	$G=2, R_L=150\Omega$	-	0.09	-	dB
Settling Time	$t_s$	To 0.01%, $V_{OUT} = 2V$ step $A_V = +1V/V$	-	52	-	ns
Capacitive-Load Stability	$C_{LOAD}$	No sustained oscillations $A_V = +1V/V$		200		pF
Input Voltage Noise Density	$e_n$	$f = 1kHz$	-	15	-	nV/ $\sqrt{Hz}$
		$f = 30kHz$	-	13	-	
Input Current Noise Density	$i_n$	$f = 1kHz$	-	400	-	fA/ $\sqrt{Hz}$
Total Harmonic Distortion plus Noise	THD+N	$f_C=5MHz, V_{OUT}=2Vp-p, G=+2$	-	-60	-	dB

Note 1: All devices are 100% production tested at  $T_A = +25^\circ C$ ; all specifications over the automotive temperature range is guaranteed by design, not production tested.

Note 2: Parameter is guaranteed by design.

Note 3: Peak-to-peak input noise voltage is defined as six times rms value of input noise voltage.

## APPLICATION INFORMATION

### Size

EC5912 series op amps are unity-gain stable and suitable for a wide range of general-purpose applications. The small footprints of the EC5912 series packages save space on printed circuit boards and enable the design of smaller electronic products.

### Power Supply Bypassing and Board Layout

EC5912 series operates from a single 2.5V to 5.5V supply or dual  $\pm 1.25\text{V}$  to  $\pm 2.75\text{V}$  supplies. For best performance, a  $0.1\mu\text{F}$  ceramic capacitor should be placed close to the  $V_{\text{DD}}$  pin in single supply operation. For dual supply operation, both  $V_{\text{DD}}$  and  $V_{\text{SS}}$  supplies should be bypassed to ground with separate  $0.1\mu\text{F}$  ceramic capacitors.

### Low Supply Current

The low supply current (7mA) of EC5912 series will help to maximize battery life. They are ideal for battery powered systems

### Operating Voltage

EC5912 series operate under wide input supply voltage (2.5V to 5.5V). In addition, all Temperature specifications apply from  $-40^{\circ}\text{C}$  to  $+125^{\circ}\text{C}$ . Most behavior remains unchanged throughout the full operating voltage range. These guarantees ensure operation throughout the single Li-Ion battery lifetime

### Rail-to-Rail Input

The input common-mode range of EC5912 series extends 100mV beyond the negative supply rail ( $V_{\text{SS}}-0.1\text{V}$  to  $V_{\text{DD}}-1.5\text{V}$ ). This is achieved by using complementary input stage. For normal operation, inputs should be limited to this range.

### Rail-to-Rail Output

Rail-to-Rail output swing provides maximum possible dynamic range at the output. This is particularly important when operating in low supply voltages. The output voltage of EC5912 series can typically swing to less than 10mV from supply rail in light resistive loads ( $>100\text{k}\Omega$ ), and 60mV of supply rail in moderate resistive loads (10k $\Omega$ ).

### Capacitive Load Tolerance

The EC5912 series can directly drive 200pF capacitive load in unity-gain without oscillation. Increasing the gain enhances the amplifier's ability to drive greater capacitive loads. In unity-gain configurations, the capacitive load drive can be improved by inserting an isolation resistor  $R_{\text{ISO}}$  in series with the capacitive load, as shown in Figure 1.

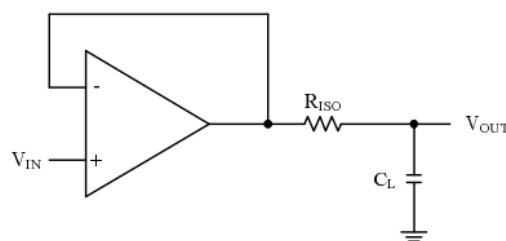


Figure 1. Indirectly Driving a Capacitive Load  
Using Isolation Resistor

The bigger the  $R_{ISO}$  resistor value, the more stable  $V_{OUT}$  will be. However, if there is a resistive load  $R_L$  in parallel with the capacitive load, a voltage divider (proportional to  $R_{ISO}/R_L$ ) is formed, this will result in a gain error. The circuit in Figure 2 is an improvement to the one in Figure 1.  $R_F$  provides the DC accuracy by feed-forward the  $V_{IN}$  to  $R_L$ .  $C_F$  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 the phase margin in the overall feedback loop. Capacitive drive can be increased by increasing the value of  $C_F$ . This in turn will slow down the pulse response.

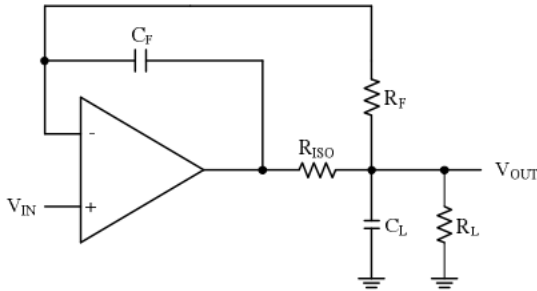


Figure 2. Indirectly Driving a Capacitive Load With DC Accuracy

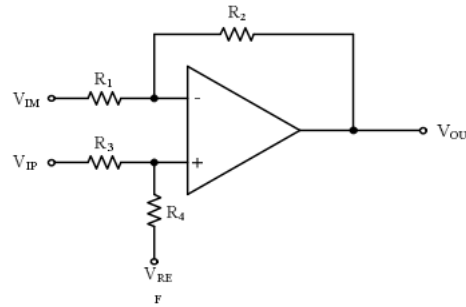


Figure 3. Differential Amplifier

### Differential amplifier

The differential amplifier allows the subtraction of two input voltages or cancellation of a signal common to the two inputs. It is useful as a computational amplifier in making a differential to single-end conversion or in rejecting a common mode signal. Figure 3 shows the differential amplifier using EC5912

$$V_{out} = \left( \frac{R_1 + R_2}{R_3 + R_4} \right) \frac{R_4}{R_1} V_2 - \frac{R_2}{R_1} V_1 + \left( \frac{R_1 + R_2}{R_3 + R_4} \right) \frac{R_3}{R_1} \frac{V^+}{2}$$

If the resistor ratios are equal (i.e.  $R_1 = R_3$  and  $R_2 = R_4$ ), then

$$V_{out} = \frac{R_2}{R_1} (V_2 - V_1) + \frac{V^+}{2}$$

### Instrumentation Amplifier

The input impedance of the previous differential amplifier is set by the resistors  $R_1$ ,  $R_2$ ,  $R_3$ , and  $R_4$ . To maintain the high input impedance, one can use a voltage follower in front of each input as shown in the following two instrumentation amplifiers.

### Three-Op-Amp Instrumentation Amplifier

The triple EC5912 can be used to build a three-op-amp instrumentation amplifier as shown in Figure 4. The amplifier in Figure 4 is a high input impedance differential amplifier with gain of  $R_2/R_1$ . The two differential voltage followers assure the high input impedance of the amplifier.

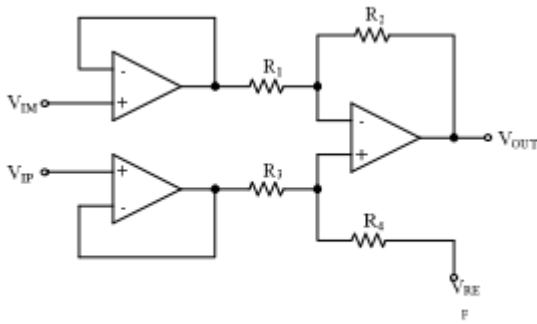


Figure 4. Three-Op-Amp Instrumentation Amplifier

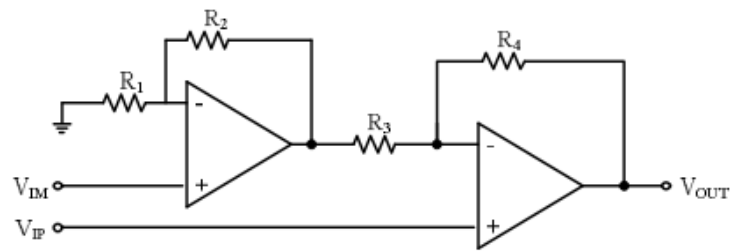


Figure 5. Two-Op-Amp Instrumentation Amplifier

### Two-Op-Amp Instrumentation Amplifier

EC5912 can also be used to make a high input impedance two-op-amp instrumentation amplifier as shown in Figure 5.

$$V_o = \left(1 + \frac{R_4}{R_3}\right)(V_2 - V_1)$$

Where  $R_1=R_3$  and  $R_2=R_4$ . If all resistors are equal, then  $V_o=2(V_2-V_1)$

### Single-Supply Inverting Amplifier

The inverting amplifier is shown in Figure 6. The capacitor  $C_1$  is used to block the DC signal going into the AC signal source  $V_{IN}$ . The value of  $R_1$  and  $C_1$  set the cut-off frequency to  $f_c=1/(2\pi R_1 C_1)$ . The DC gain is defined by  $V_{OUT}=-\left(R_2/R_1\right)V_{IN}$

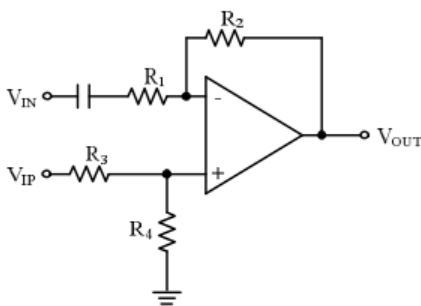


Figure 6. Single Supply Inverting Amplifier

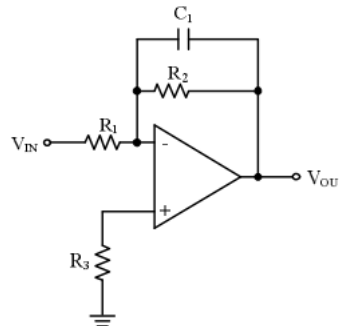


Figure 7. Low Pass Active Filter

### Sallen-Key 2nd Order Active Low-Pass Filter

EC4912 can be used to form a 2nd order Sallen-Key active low-pass filter as shown in Figure 8. The transfer function from  $V_{IN}$  to  $V_{OUT}$  is given by

$$\frac{V_{OUT}(S)}{V_{in}} = \frac{\frac{1}{C_1 C_2 R_1 R_2} A_{LP}}{S^2 + S \left( \frac{1}{C_1 R_1} + \frac{1}{C_1 R_2} + \frac{1}{C_2 R_2} \frac{A_{LP}}{C_2 R_2} \right) + \frac{1}{C_1 C_2 R_1 R_2}}$$

Where the DC gain is defined by  $A_{LP}=1+R_3/R_4$ , and the corner frequency is given by

$$\omega C = \sqrt{\frac{1}{C_1 C_2 R_1 R_2}}$$

The pole quality factor is given by

$$\frac{\omega C}{Q} = \frac{1}{C_1 R_1} + \frac{1}{C_1 R_2} + \frac{1}{C_2 R_2} - \frac{A_{LP}}{C_2 R_2}$$

Let  $R_1=R_2=R$  and  $C_1=C_2=C$ , the corner frequency and the pole quality factor can be simplified as below

$$\omega_C = \frac{1}{CR}$$

And  $Q=2-R_3/R_4$

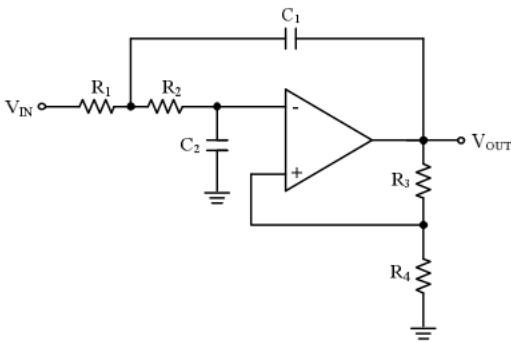


Figure 8. Sallen-Key 2<sup>nd</sup> Order Active Low-Pass Filter

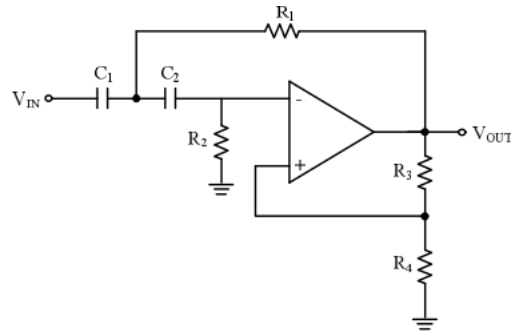


Figure 9. Sallen-Key 2<sup>nd</sup> Order Active High-Pass Filter

### Sallen-Key 2nd Order high-Pass Active Filter

The 2<sup>nd</sup> order Sallen-key high-pass filter can be built by simply interchanging those frequency selective components  $R_1$ ,  $R_2$ ,  $C_1$ , and  $C_2$  as shown in Figure 9.

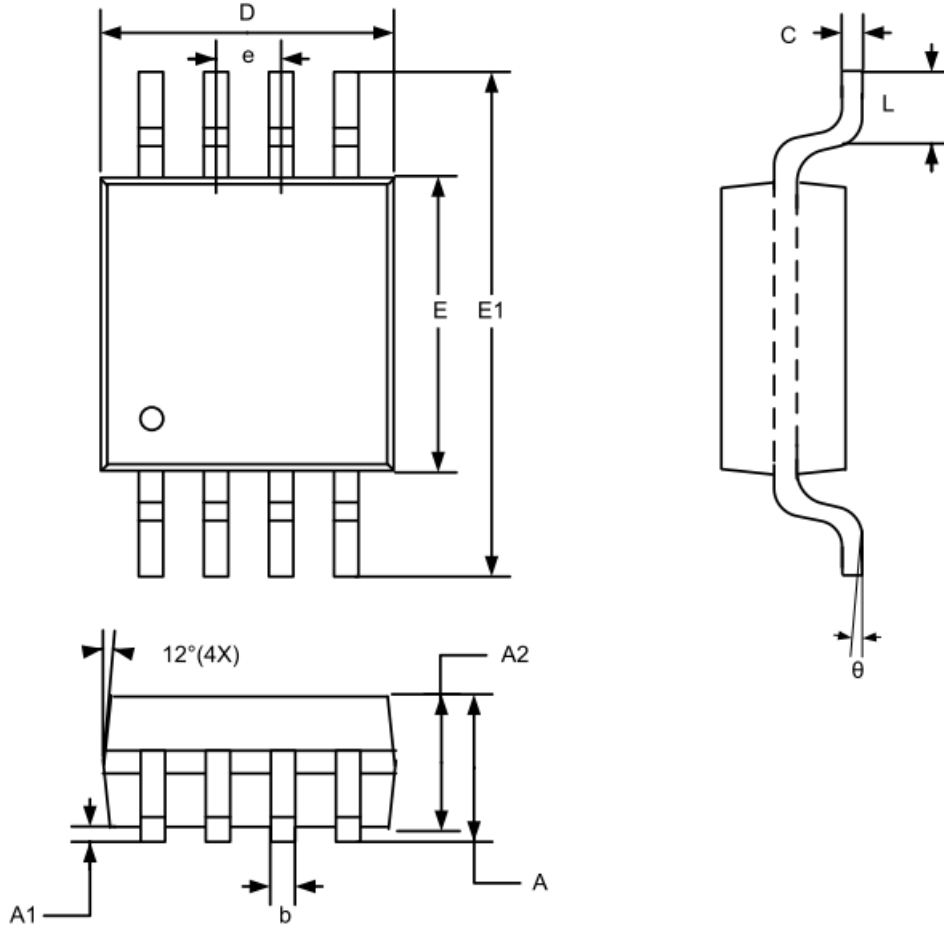
$$\frac{V_{OUT}}{V_{IN}}(S) = \frac{S^2 A_{HP}}{S^2 + S\left(\frac{1}{C_1 R_1} + \frac{1}{C_2 R_2} + \frac{1-A_{HP}}{C_1 R_1}\right) + \frac{1}{C_1 C_2 R_1 R_2}}$$

Where  $A_{HP}=1+R_3/R_4$



## Package Information

### MSOP-8



SYMBOLS	DIMENSIONS IN MILLIMETERS			DIMENSIONS IN INCHES		
	MIN	NOM	MAX	MIN	NOM	MAX
A	--	--	1.10	--	--	0.043
A1	0.05	--	0.15	0.002	--	0.006
A2	0.75	0.85	0.95	0.030	0.033	0.037
b	0.25	--	0.40	0.010	--	0.016
C	0.13	--	0.23	0.005	--	0.009
D	2.90	3.00	3.10	0.114	0.118	0.122
E	2.90	3.00	3.10	0.114	0.118	0.122
E1	4.90 BSC			0.193 BSC		
e	0.65 BSC			0.026 BSC		
L	--	--	0.55	--	--	0.022
Θ	0	--	7°	0	--	7°

Note:

1. Controlling Dimension: MM
2. Dimension D and E1 do not include Mold protrusion
3. Refer to Jedec standard MO187
4. Drawing is not to scale

SOP8

