

## FEATURES

- Single-Supply Operation from +2.1V ~ +5.5V
- Rail-to-Rail Input / Output
- Gain-Bandwidth Product: 6MHz (Typ.)
- Low Input Bias Current: 1pA (Typ.)
- Low Offset Voltage: 3.5mV (Max.)
- Quiescent Current: 470μA per Amplifier (Typ.)
- Operating Temperature: -40°C ~ +125°C
- Small Package:
- TPV8631 Available in SOT23-5, SOP-8 and SC70-5 Packages
- TPV8632 Available in SOP-8 and MSOP-8 Packages
- TPV8634 Available in SOP-14 and TSSOP-14 Packages
- TPV8634 Available in SOP-14 and TSSOP-14 Packages

## APPLICATIONS

- Sensors
- Active Filters
- Cellular and Cordless Phones
- Laptops and PDAs
- Audio
- Handheld Test Equipment
- Battery-Powered Instrumentation
- A/D Converters

## GENERAL DESCRIPTION

The TPV863X have a high gain-bandwidth product of 6MHz, a slew rate of 4.2V/μs, and a quiescent current of 470μA per amplifier at 5V. The TPV863X are designed to provide optimal performance in low voltage and low noise systems. They provide rail-to-rail output swing into heavy loads. The input common mode voltage range includes ground, and the maximum input offset voltage is 3.5mV for TPV863X. They are specified over the extended industrial temperature range (-40°C to +125°C). The operating range is from 2.1V to 5.5V. The TPV863X single is available in Green SC70-5, SOT23-5 and SOP-8 packages. The TPV863X dual is available in Green SOP-8 and MSOP-8 packages. The TPV863X Quad is available in Green SOP-14 and TSSOP-14 packages.

ORDERING NUMBER	TEMPRANGE	PACKAGE	TRANSPOT MEDIA, QUANTILY
TPV8631C5	-40°C~125°C	SC70-5	Tape and Reel,3000
TPV8631S5	-40°C~125°C	SOT23-5	Tape and Reel,3000
TPV8631S8	-40°C~125°C	SOP-8	Tape and Reel,4000
TPV8632S8	-40°C~125°C	SOP8	Tape and Reel,4000
TPV8632M8	-40°C~125°C	MSOP-8	Tape and Reel,3000
TPV8634S14	-40°C~125°C	SOP-14	Tape and Reel,2500
TPV8634M14	-40°C~125°C	TSSOP-14	Tape and Reel,3000

## PIN CONFIGURATIONS

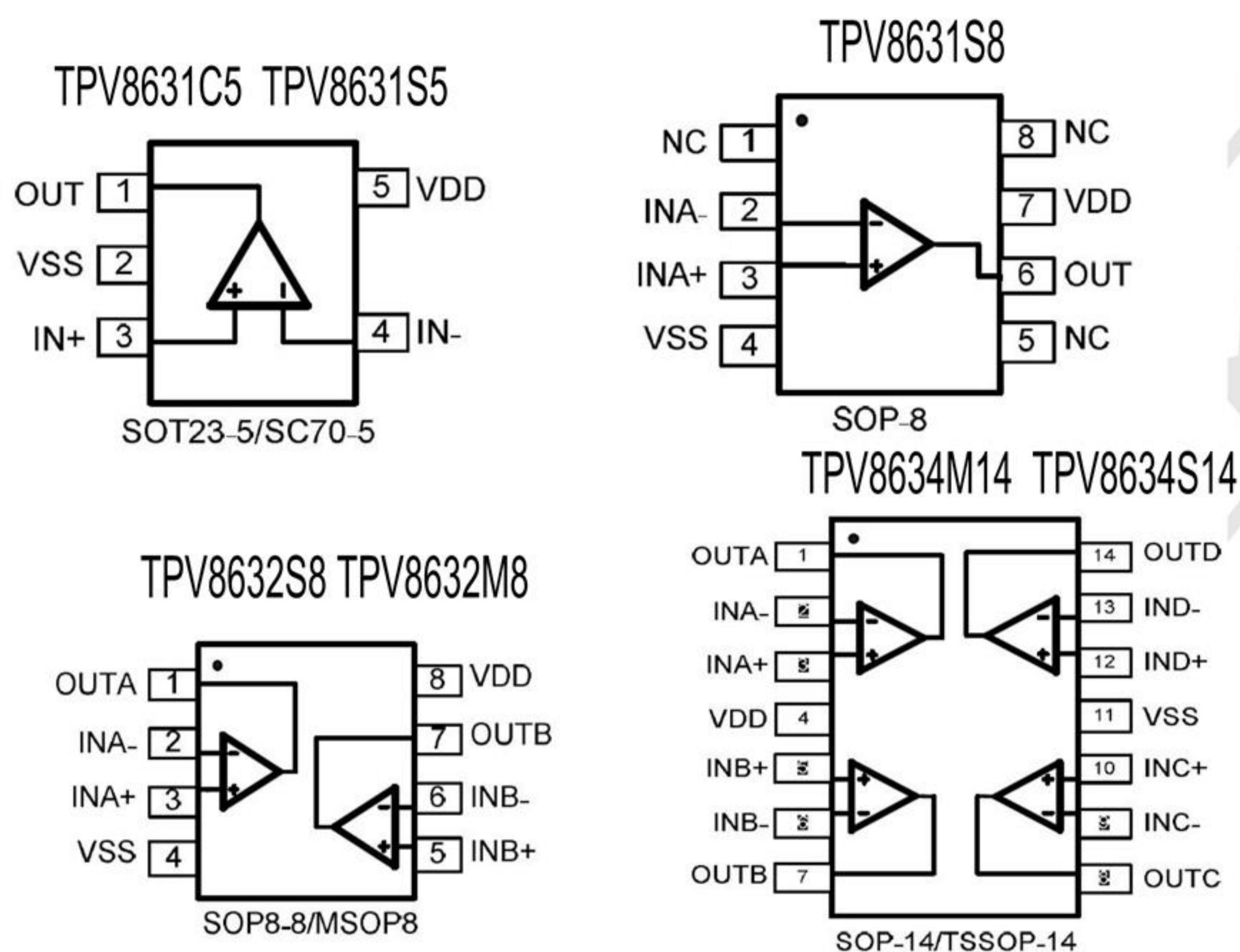


Figure 1. Pin Assignment Diagram

## Absolute Maximum Ratings

Condition	Min	Max
Power Supply Voltage ( $V_{DD}$ to $V_{SS}$ )	-0.5V	+7.5V
Analog Input Voltage (IN+ or IN-)	$V_{SS}-0.5V$	$V_{DD}+0.5V$
PDB Input Voltage	$V_{SS}-0.5V$	+7V
Operating Temperature Range	-40°C	+125°C
Junction Temperature	+160°C	
Storage Temperature Range	-55°C	+150°C
Lead Temperature (soldering, 10sec)	+260°C	
<b>Package Thermal Resistance (<math>T_A=+25^\circ\text{C}</math>)</b>		
SOP-8, $\theta_{JA}$	125°C/W	
MSOP-8, $\theta_{JA}$	216°C/W	
SOT23-5, $\theta_{JA}$	190°C/W	
SOT23-6, $\theta_{JA}$	190°C/W	
SC70-5, $\theta_{JA}$	333°C/W	
<b>ESD Susceptibility</b>		
HBM	8KV	
MM	400V	

**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.

**ELECTRICAL CHARACTERISTICS**

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

PARAMETER	CONDITIONS	TPV8631 TPV8632 TPV8634 Series							
		TYP	MIN/MAX OVER TEMPERATURE					UNITS	MIN /MAX
		+25°C	+25°C	0°C to 70°C	-40°C to 85°C	-40°C to 125°C			
<b>INPUT CHARACTERISTICS</b>									
Input Offset Voltage ( $V_{OS}$ )		0.8	3.5	3.9	4.3	4.6	mV	MAX	
Input Bias Current ( $I_B$ )		1					pA	TYP	
Input Offset Current ( $I_{OS}$ )	$V_S = 5.5V$	1					pA	TYP	
Input Common Mode Voltage Range ( $V_{CM}$ )		-0.1 to +5.6					V	TYP	
Common Mode Rejection Ratio (CMRR)	$V_S = 5.5V$ , $V_{CM} = -0.1V$ to $4V$	90	73	70	70	65	dB	MIN	
	$V_S = 5.5V$ , $V_{CM} = -0.1V$ to $5.6V$	83					dB	MIN	
Open-Loop Voltage Gain ( $A_{OL}$ )	$R_L = 600\Omega$ , $V_O = 0.15V$ to $4.85V$	97	90	87	86	79	dB	MIN	
	$R_L = 10k\Omega$ , $V_O = 0.05V$ to $4.95V$	108					dB	MIN	
Input Offset Voltage Drift ( $\Delta V_{OS}/\Delta T$ )		2.4					$\mu V/^\circ C$	TYP	
<b>OUTPUT CHARACTERISTICS</b>									
Output Voltage Swing from Rail	$R_L = 600\Omega$	0.1					V	TYP	
	$R_L = 10k\Omega$	0.015					V	TYP	
Output Current ( $I_{OUT}$ )		53	49	45	40	35	mA	MIN	
Closed-Loop Output Impedance	$f = 200kHz$ , $G = 1$	3					$\Omega$	TYP	
<b>POWER-DOWN DISABLE</b>									
Turn-On Time		4					$\mu s$	TYP	
Turn-Off Time		1.2					$\mu s$	TYP	
<b>POWER SUPPLY</b>									
Operating Voltage Range			2.1	2.1	2.1	2.1	V	MIN	
			5.5	5.5	5.5	5.5	V	MAX	
Power Supply Rejection Ratio (PSRR)	$V_S = +2.5V$ to $+5.5V$ $V_{CM} = (-V_S) + 0.5V$	91	74	72	72	68	dB	MIN	
Quiescent Current/Amplifier ( $I_Q$ )	$I_{OUT} = 0$	470	650	727	750	815	$\mu A$	MAX	

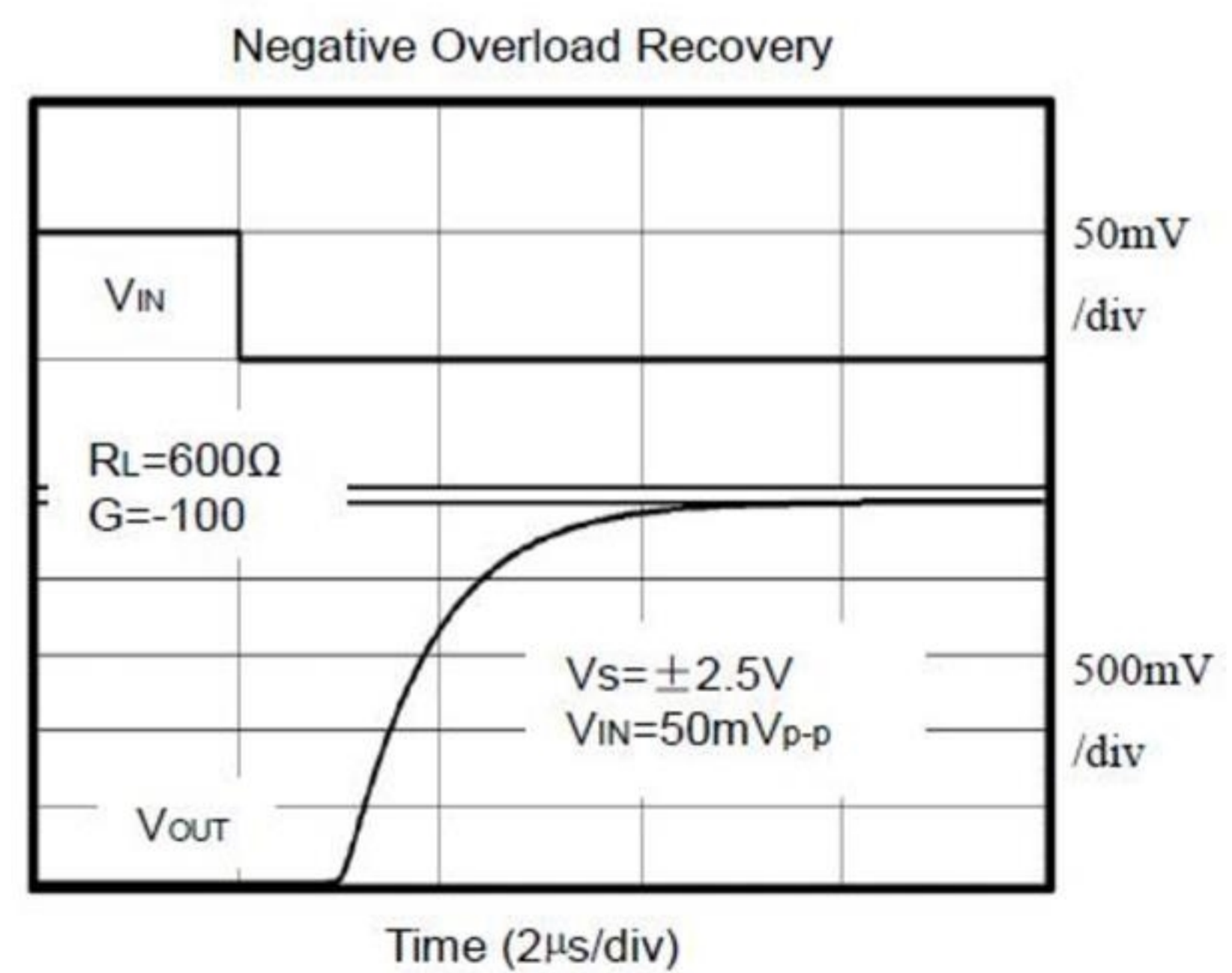
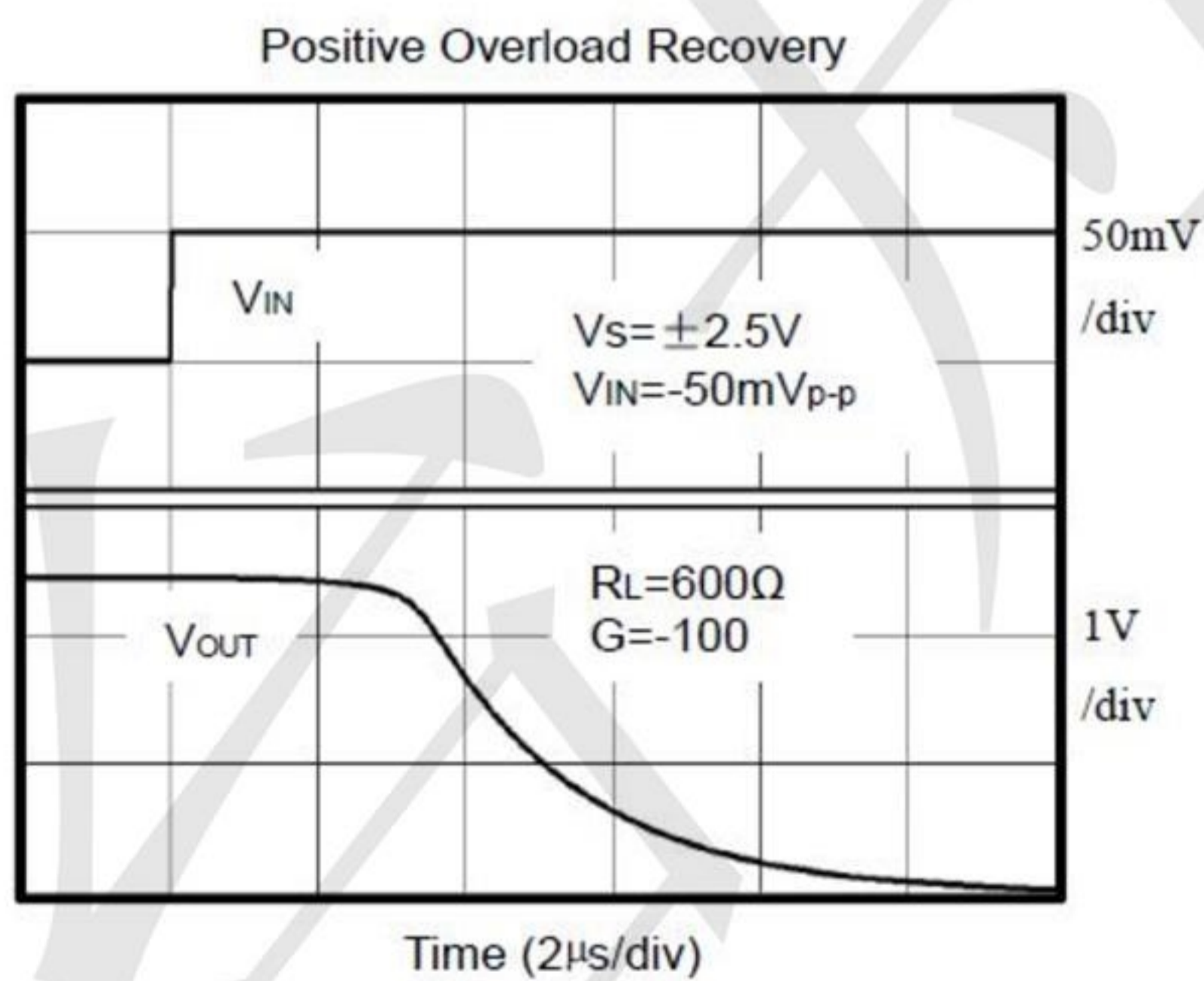
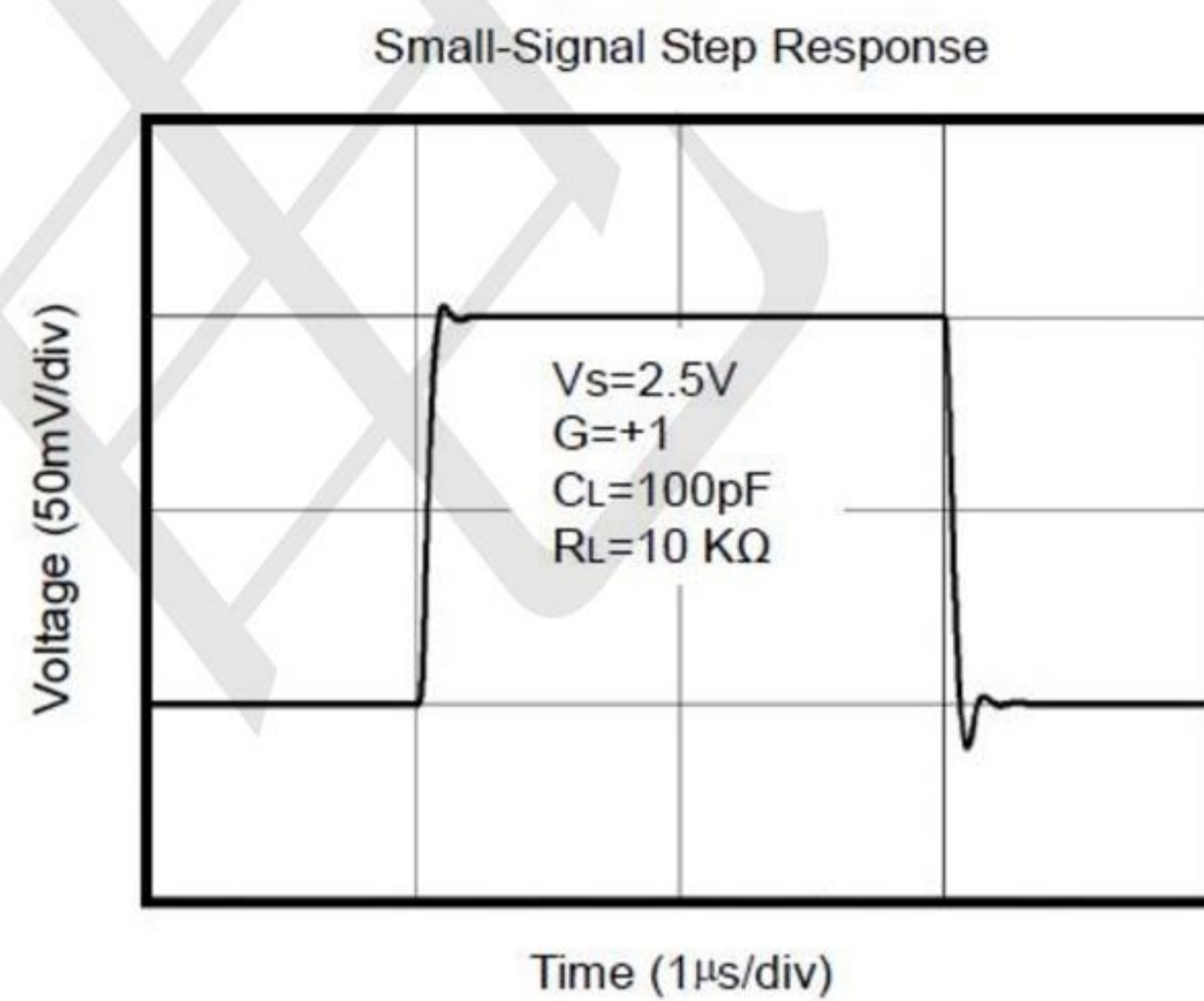
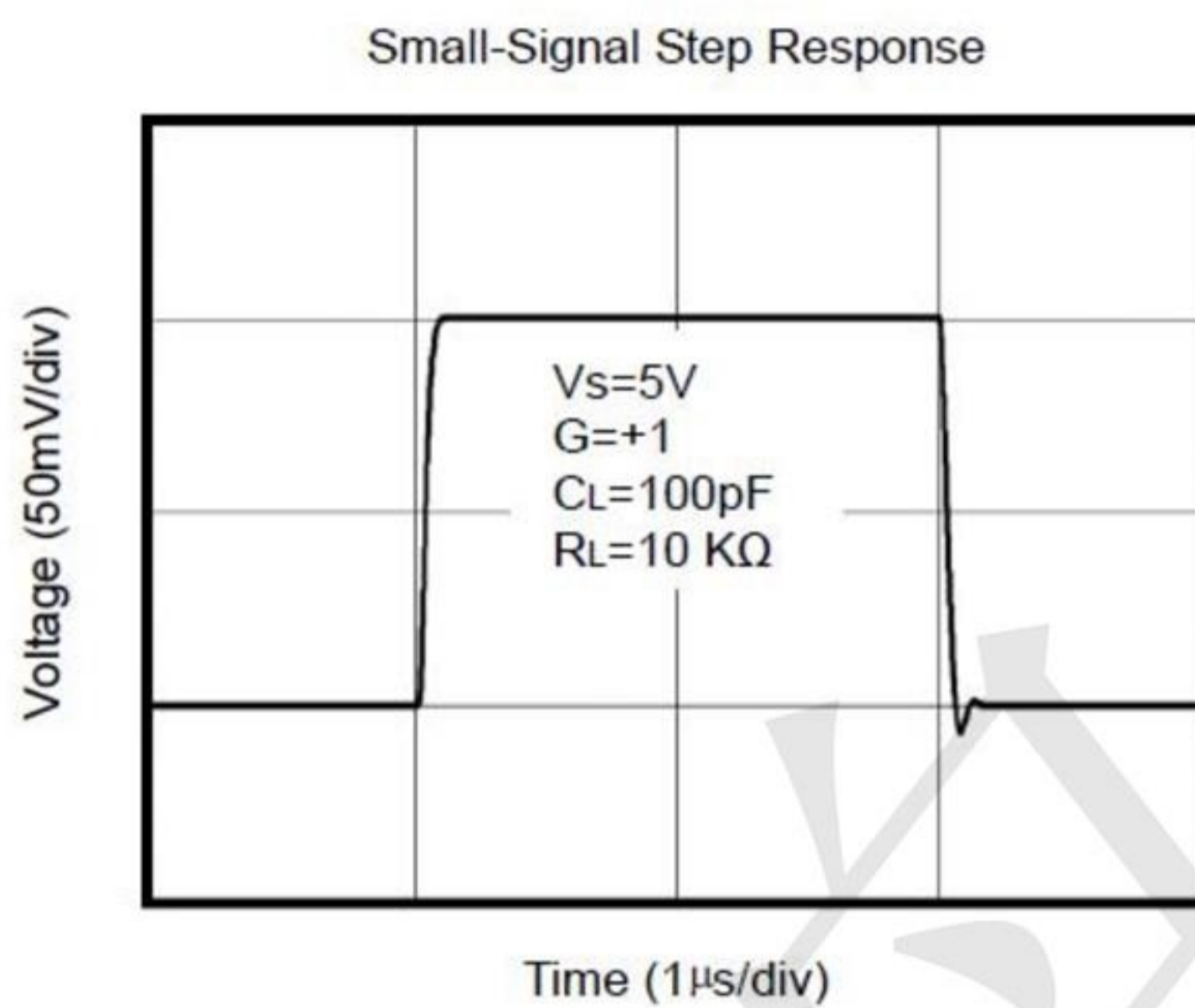
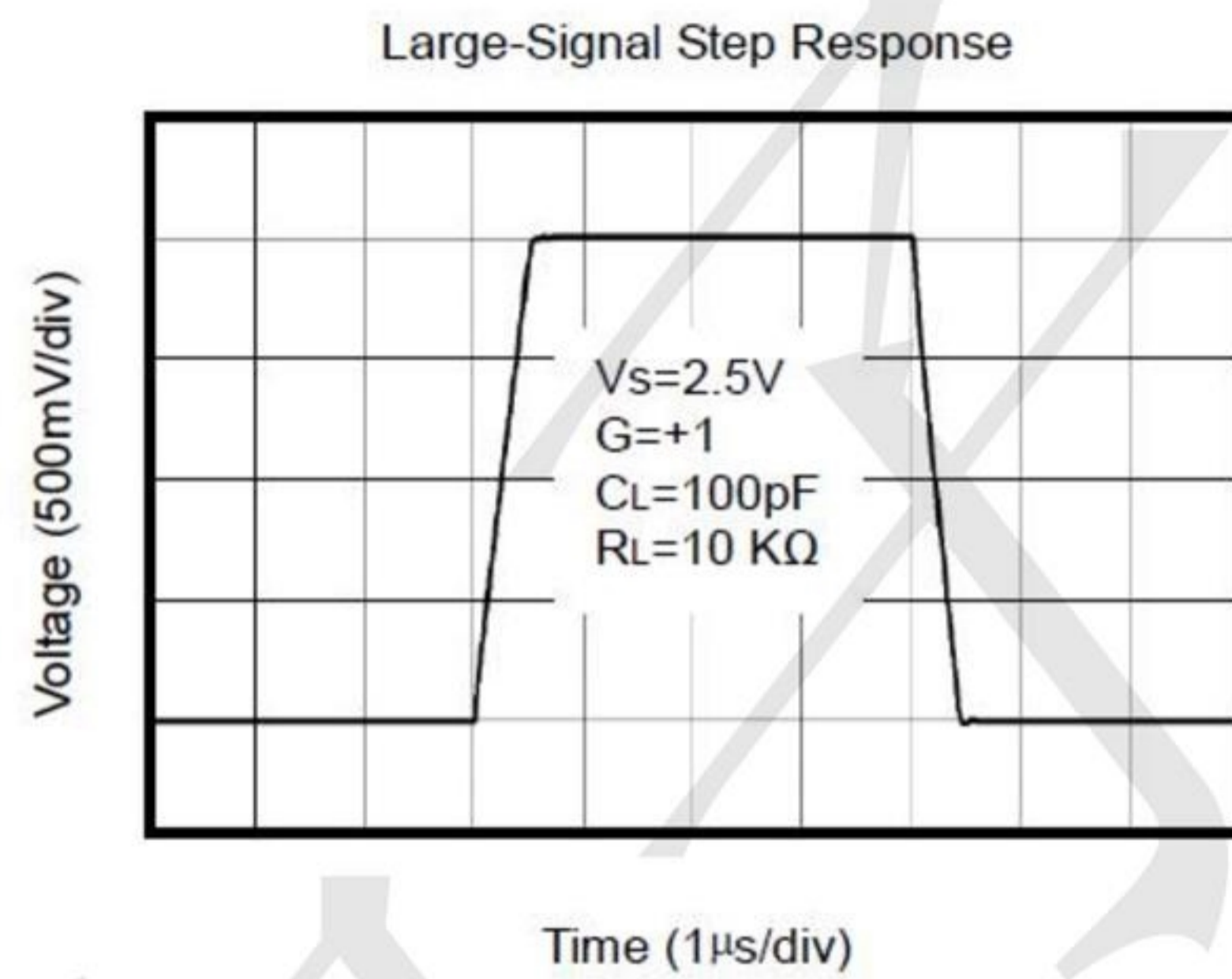
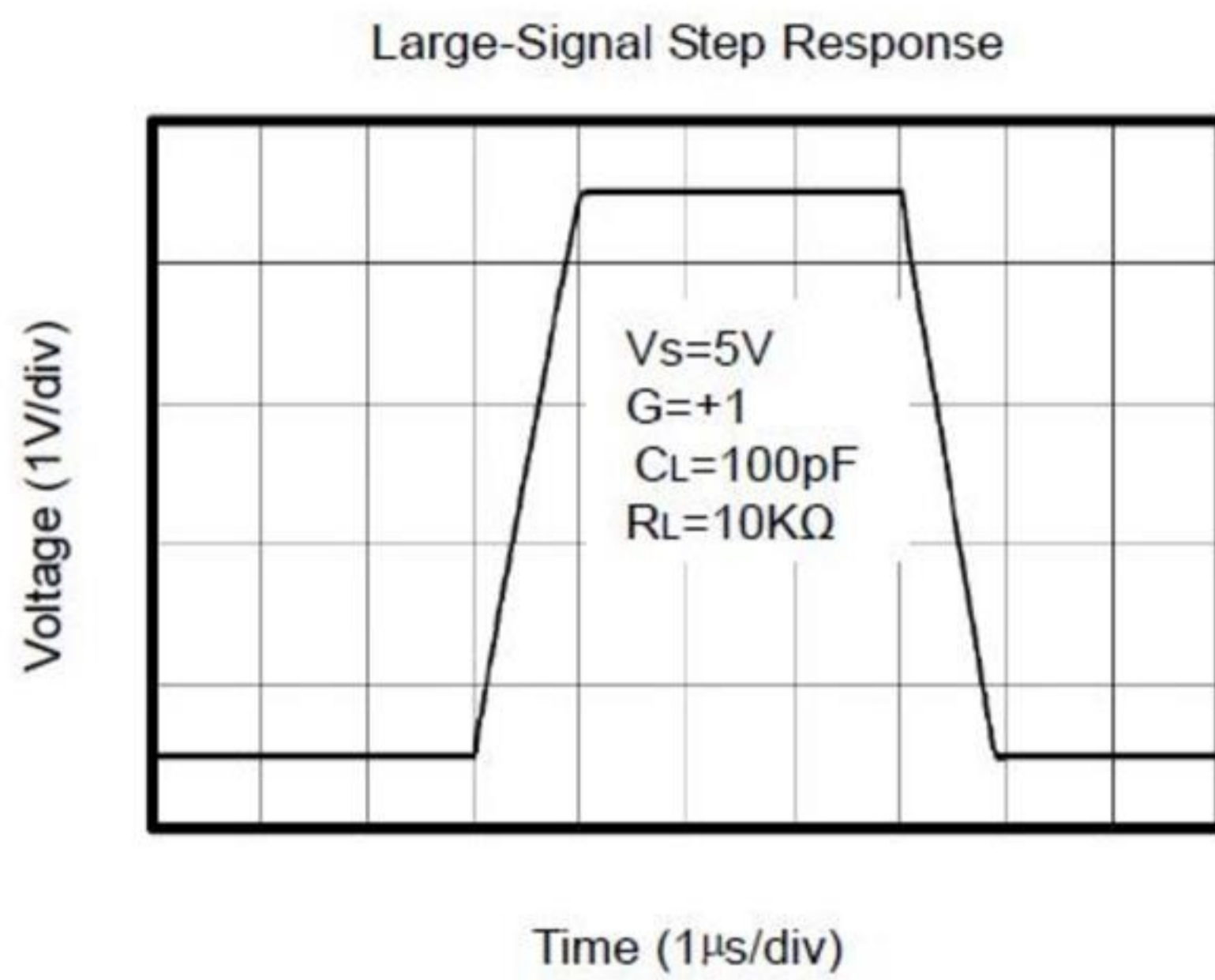
## Electrical Characteristics

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

PARAMETER	CONDITIONS	TPV8631 TPV8632 TPV8634 Series							
		TYP	MIN/MAX OVER TEMPERATURE					UNITS	MIN /MAX
		+25°C	+25°C	0°C to 70°C	-40°C to 85°C	-40°C to 125°C			
<b>DYNAMIC PERFORMANCE</b>									
Gain-Bandwidth Product (GBP)	$R_L = 10k\Omega$ , $C_L = 100pF$	6					MHz	TYP	
Phase Margin ( $\phi_o$ )	$R_L = 10k\Omega$ , $C_L = 100pF$	53					Degrees	TYP	
Full Power Bandwidth (BWP)	< 1% distortion, $R_L = 600\Omega$	250					kHz	TYP	
Slew Rate (SR)	$G = +1$ , 2V Step, $R_L = 10k\Omega$	4.2					V/ $\mu s$	TYP	
Settling Time to 0.1% ( $t_s$ )	$G = +1$ , 2V Step, $R_L = 600\Omega$	0.4					$\mu s$	TYP	
Overload Recovery Time	$V_{IN} \cdot Gain = V_S$ , $R_L = 600\Omega$	2.5					$\mu s$	TYP	
<b>NOISE PERFORMANCE</b>									
Voltage Noise Density ( $e_n$ )	$f = 1kHz$	13					$nV\sqrt{Hz}$	TYP	
	$f = 10kHz$	9.5					$nV\sqrt{Hz}$	TYP	

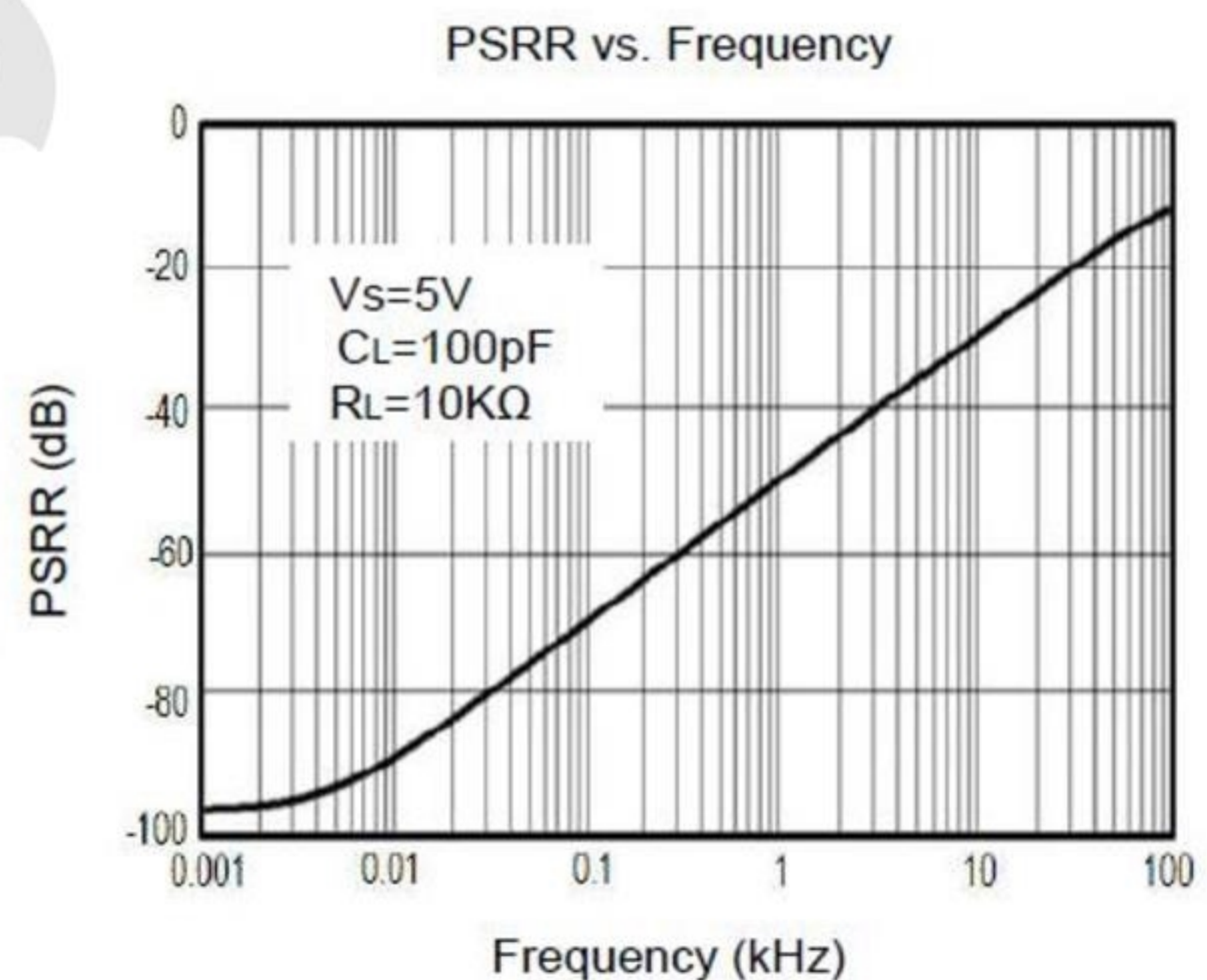
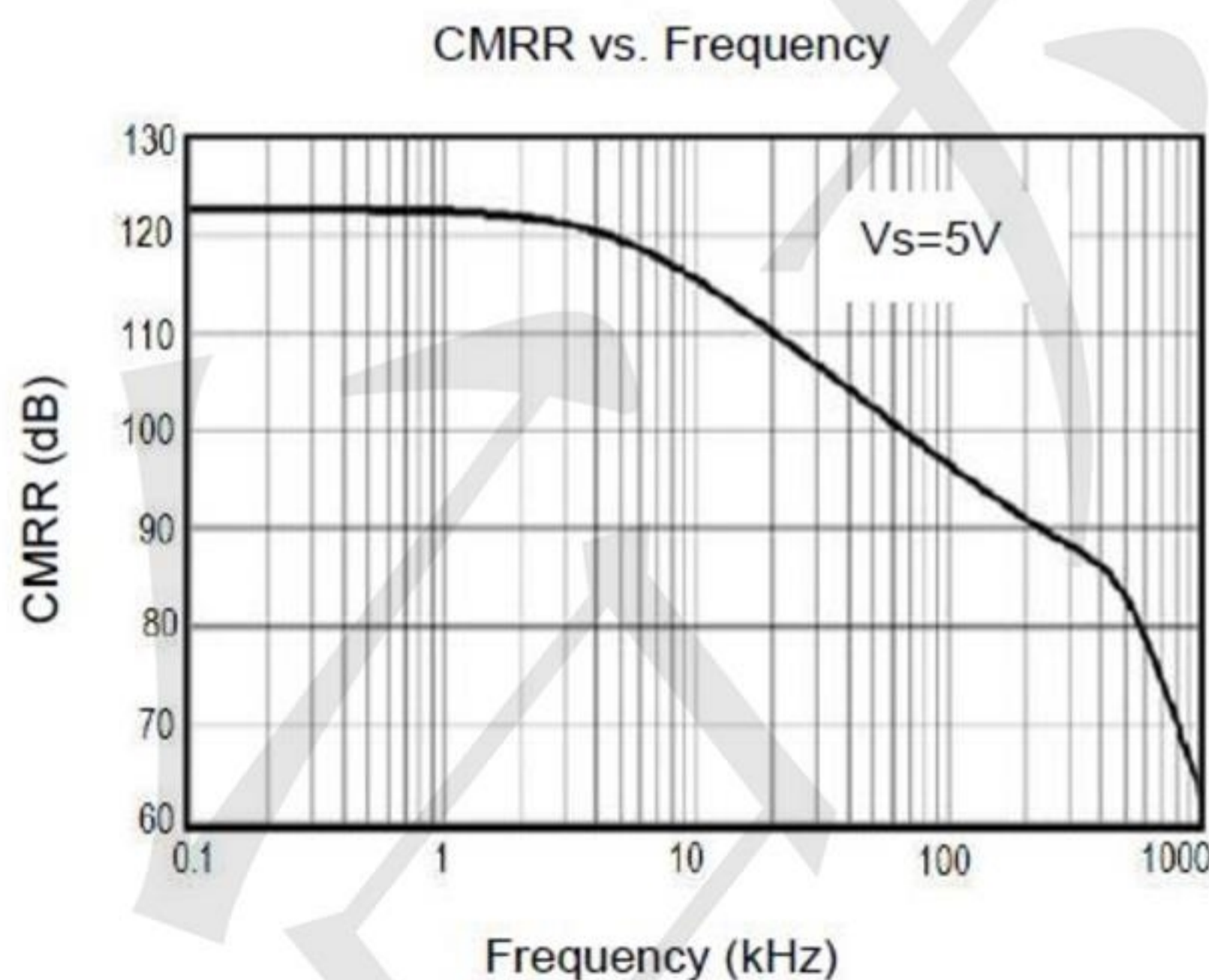
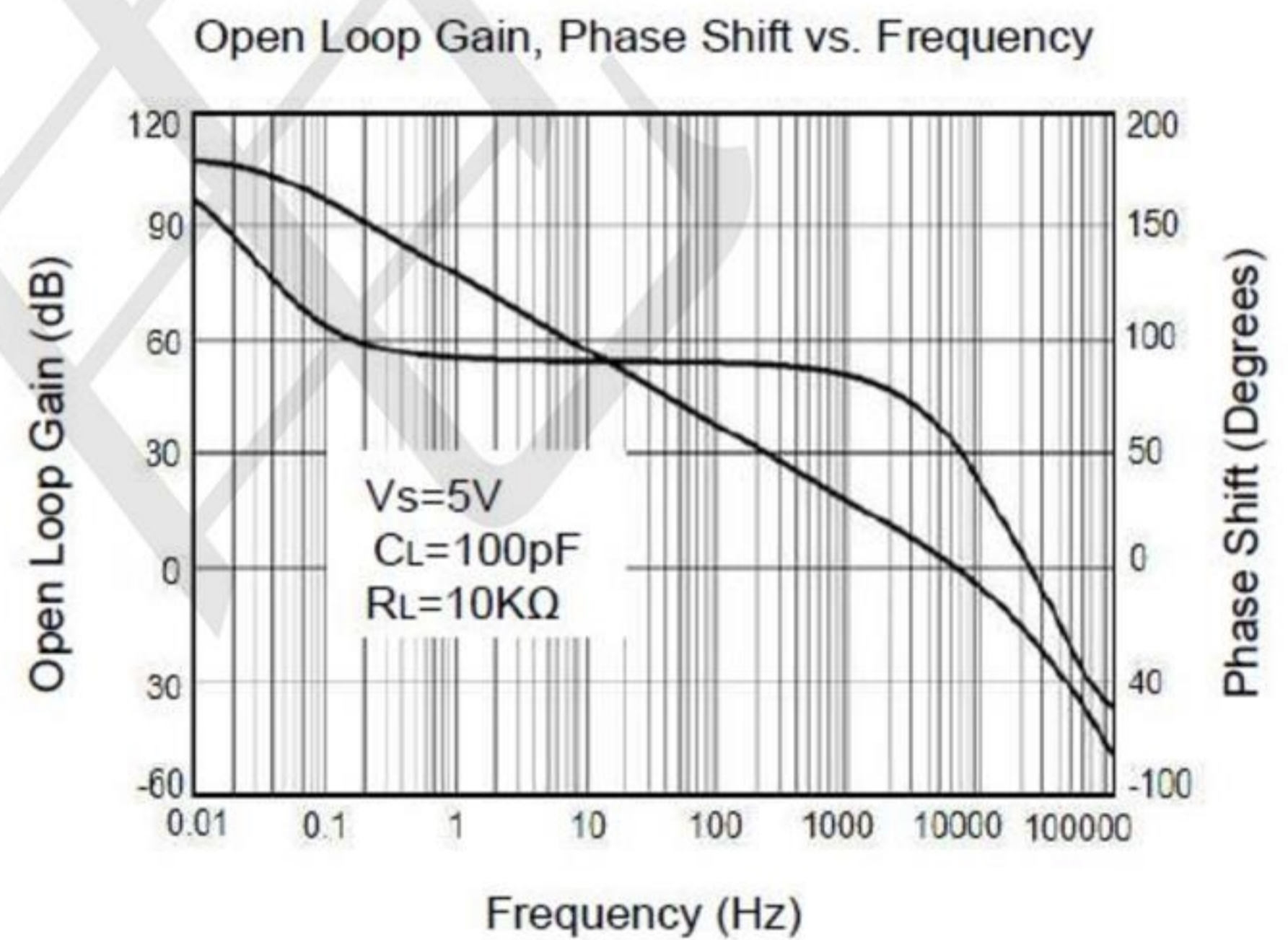
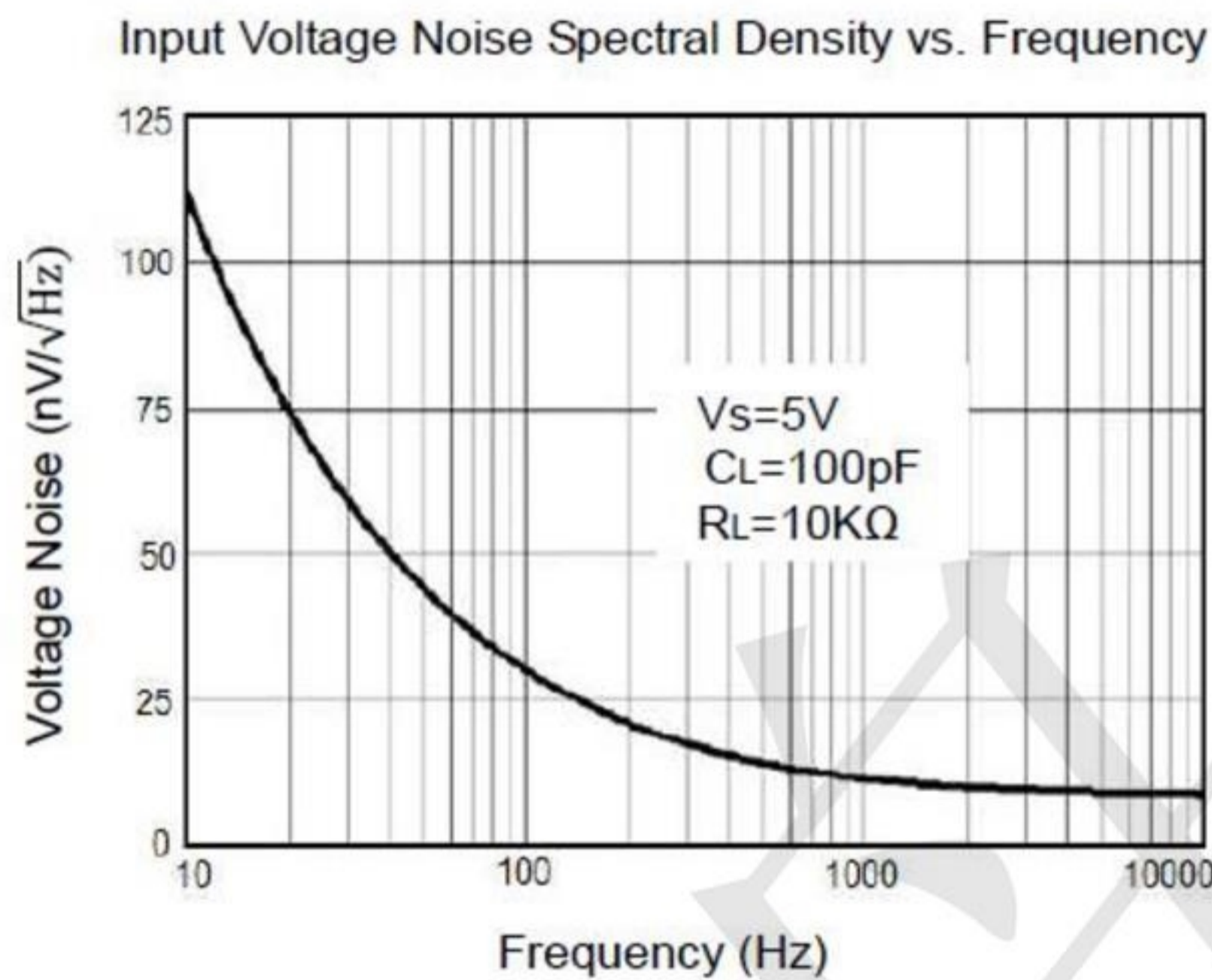
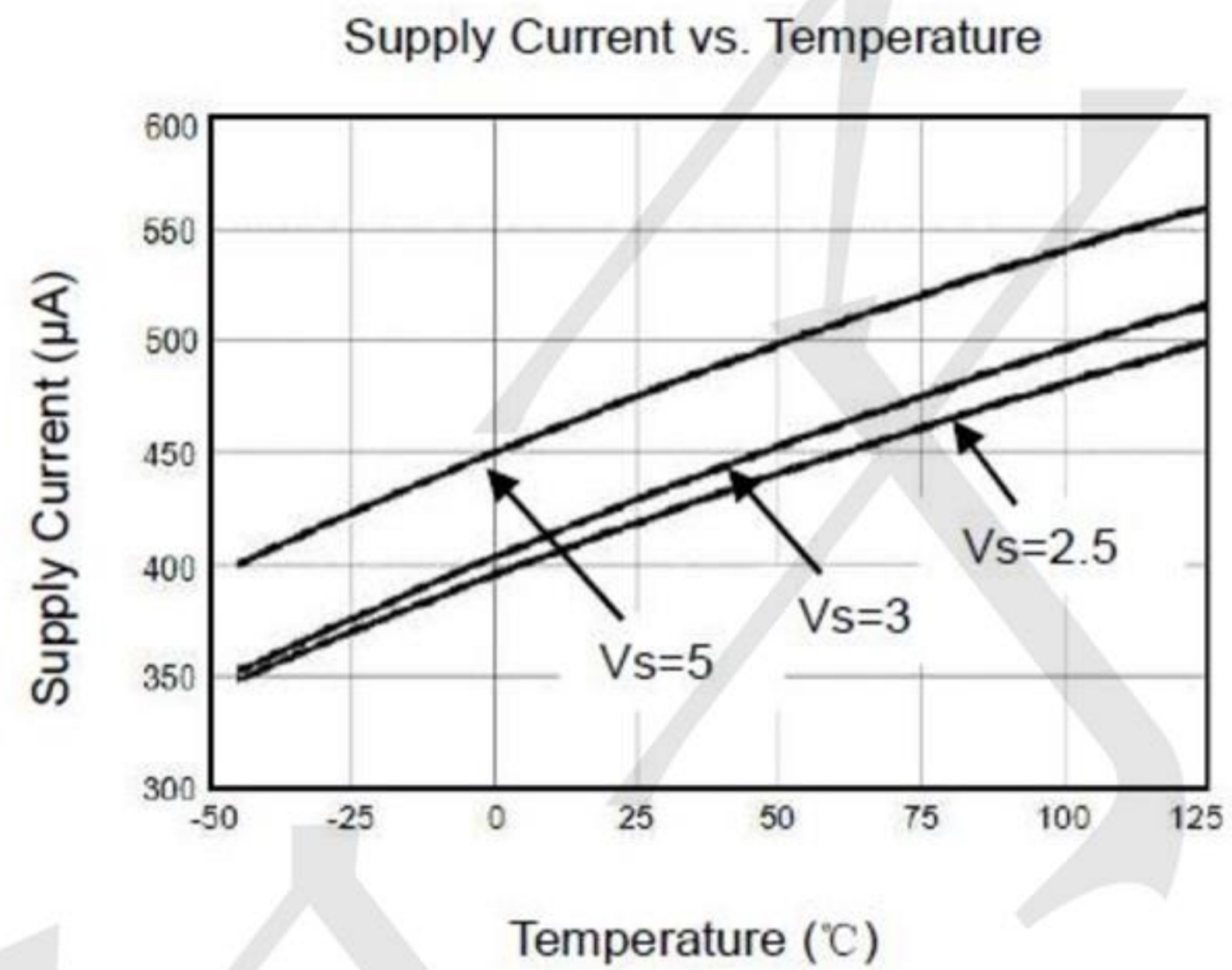
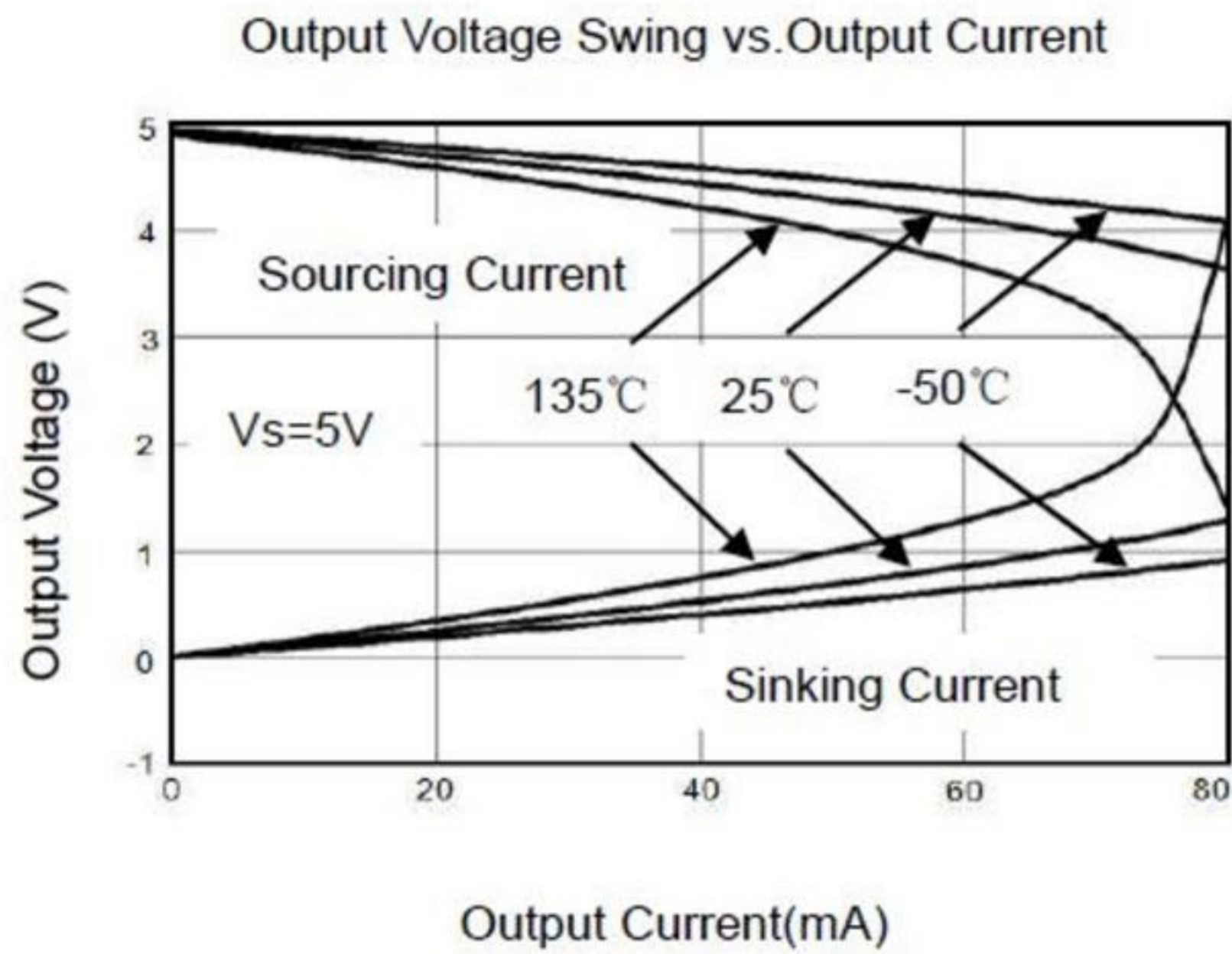
## Typical Performance characteristics

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



**Typical Performance characteristics**

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



## Application Note

### Size

TPV863X series op amps are unity-gain stable and suitable for a wide range of general-purpose applications. The small footprints of the TPV863X series packages save space on printed circuit boards and enable the design of smaller electronic products.

### Power Supply Bypassing and Board Layout

TPV863X series operates from a single 2.1V to 5.5V supply or dual  $\pm 1.05V$  to  $\pm 2.75V$  supplies. For best performance, a  $0.1\mu F$  ceramic capacitor should be placed close to the  $V_{DD}$  pin in single supply operation. For dual supply operation, both  $V_{DD}$  and  $V_{SS}$  supplies should be bypassed to ground with separate  $0.1\mu F$  ceramic capacitors.

### Low Supply Current

The low supply current (typical 470uA per channel) of TP863X series will help to maximize battery life. They are ideal for battery powered systems

### Operating Voltage

TPV863X series operate under wide input supply voltage (2.1V to 5.5V). In addition, all temperature specifications apply from  $-40^{\circ}C$  to  $+125^{\circ}C$ . 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 TPV863X series extends 100mV beyond the supply rails ( $V_{SS}-0.1V$  to  $V_{DD}+0.1V$ ). 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 TPV863X series can typically swing to less than 2mV from supply rail in light resistive loads ( $>100k\Omega$ ), and 60mV of supply rail in moderate resistive loads ( $10k\Omega$ ).

**Capacitive Load Tolerance**

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The TPV863X family is optimized for bandwidth and speed, not for driving capacitive loads. Output capacitance will create a pole in the amplifier's feedback path, leading to excessive peaking and potential oscillation. If dealing with load capacitance is a requirement of the application, the two strategies to consider are (1) using a small resistor in series with the amplifier's output and the load capacitance and (2) reducing the bandwidth of the amplifier's feedback loop by increasing the overall noise gain. Figure 2. shows a unity gain follower using the series resistor strategy. The resistor isolates the output from the capacitance and, more importantly, creates a zero in the feedback path that compensates for the pole created by the output capacitance.

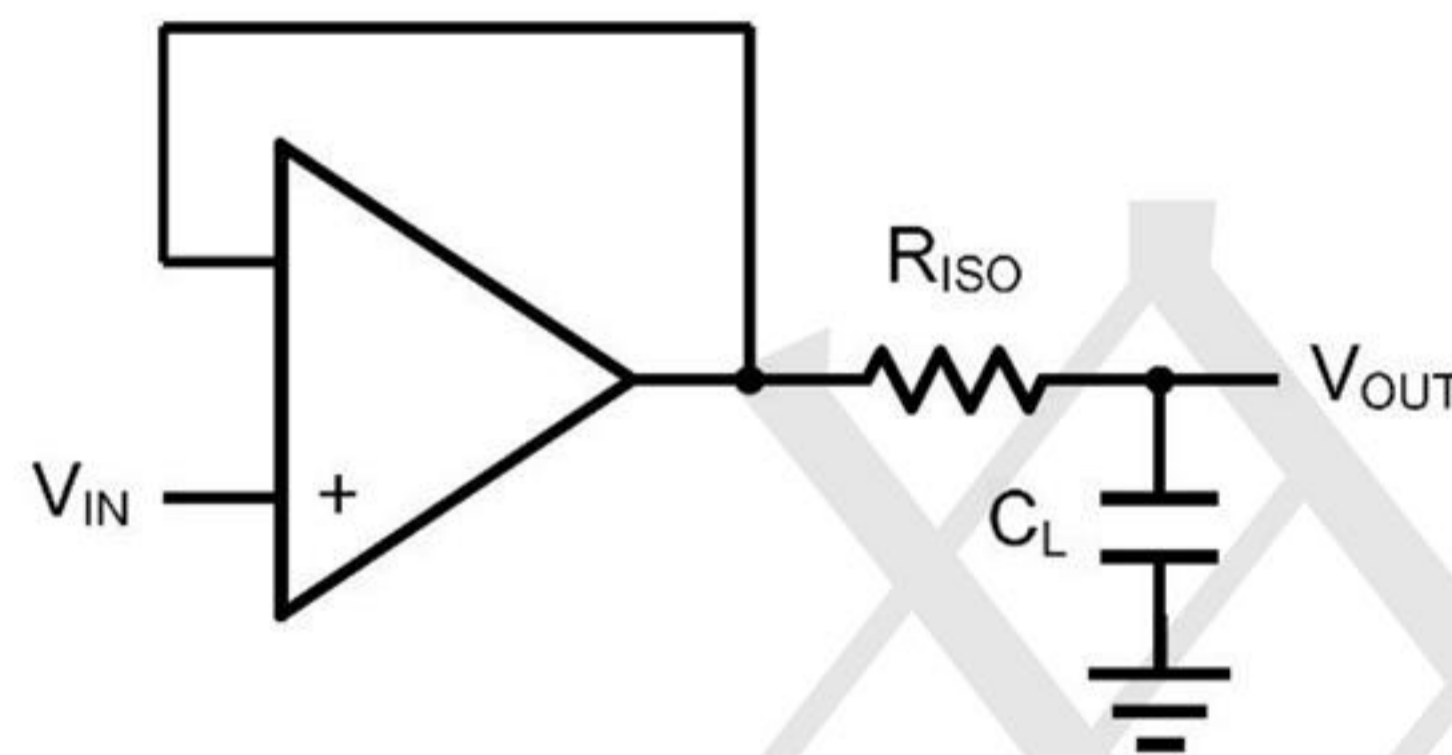


Figure 2. Indirectly Driving a Capacitive Load Using Isolation Resistor

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 3 is an improvement to the one in Figure 2.  $R_F$  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.

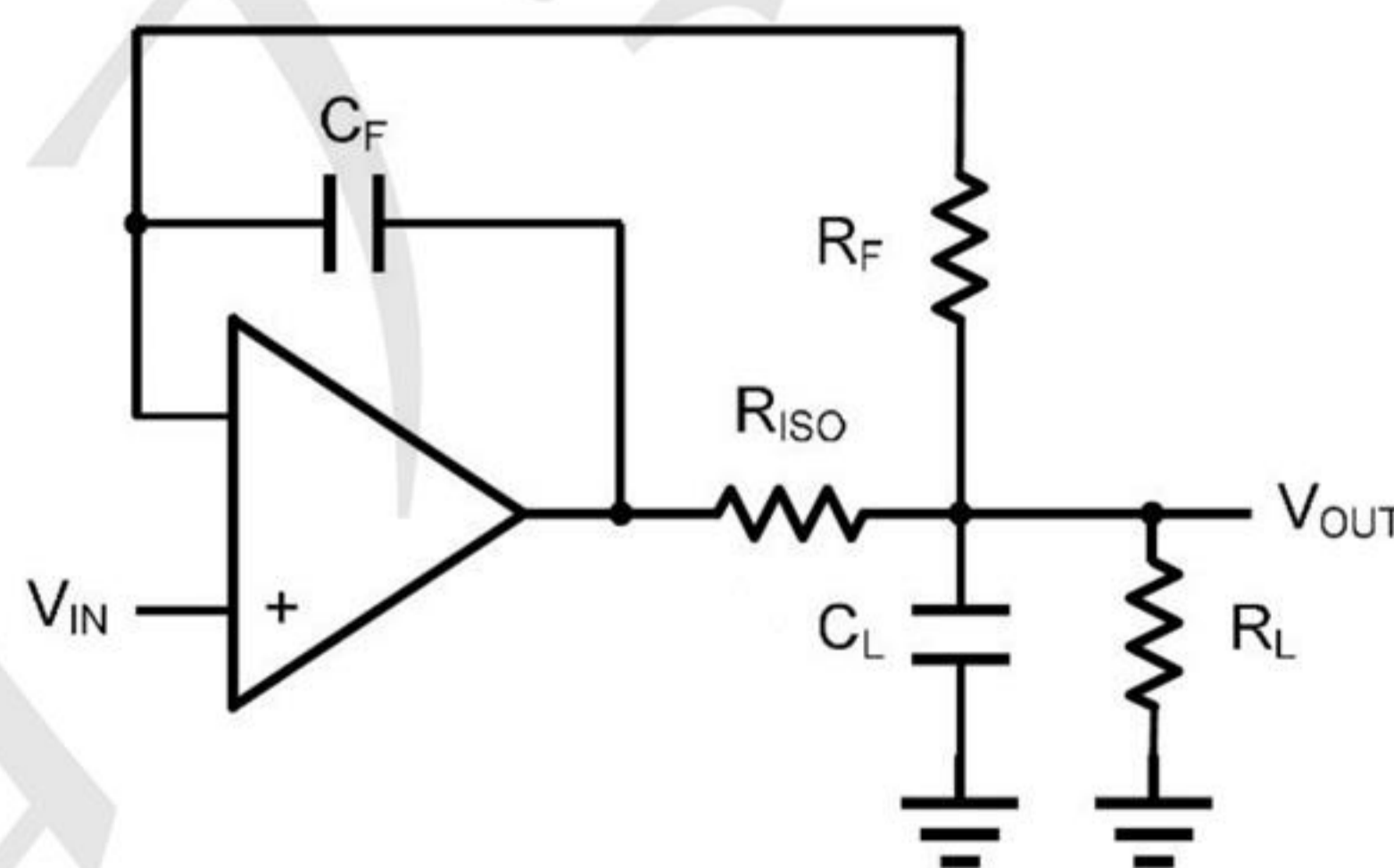


Figure 3. Indirectly Driving a Capacitive Load with DC Accuracy



## Typical Application Circuits

### Differential amplifier

The differential amplifier allows the subtraction of two input voltages or cancellation of a signal common 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 4. shown the differential amplifier using TPV8632X

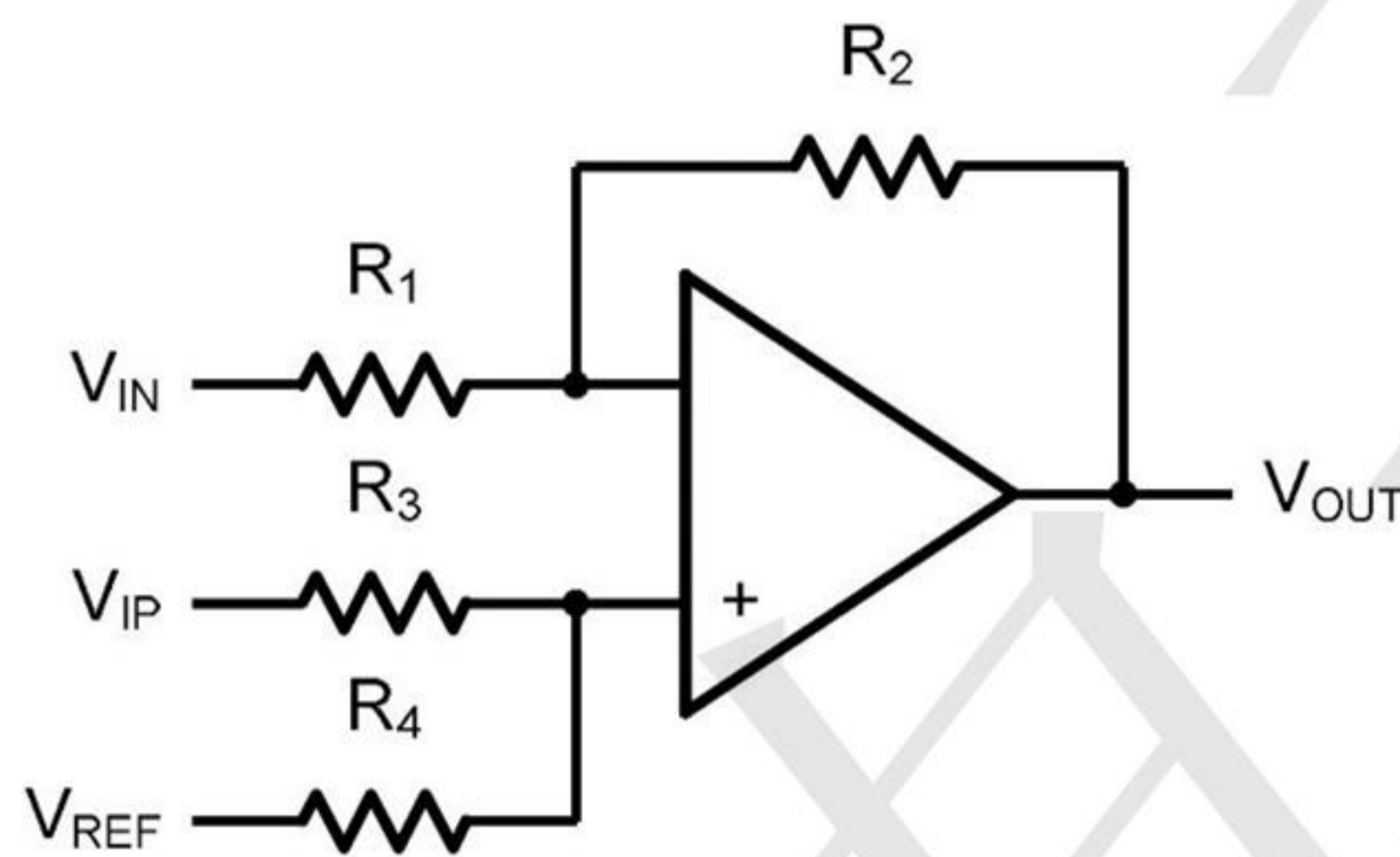


Figure 4. Differential Amplifier

$$V_{OUT} = \left( \frac{R_1 + R_2}{R_3 + R_4} \right) \frac{R_4}{R_1} V_{IN} - \frac{R_2}{R_1} V_{IP} + \left( \frac{R_1 + R_2}{R_3 + R_4} \right) \frac{R_3}{R_1} V_{REF}$$

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

$$V_{OUT} = \frac{R_2}{R_1} (V_{IP} - V_{IN}) + V_{REF}$$

**Low Pass Active Filter**

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The low pass active filter is shown in Figure 5. The DC gain is defined by  $-R_2/R_1$ . The filter has a -20dB/decade roll-off after its corner frequency  $f_c=1/(2\pi R_3C_1)$ .

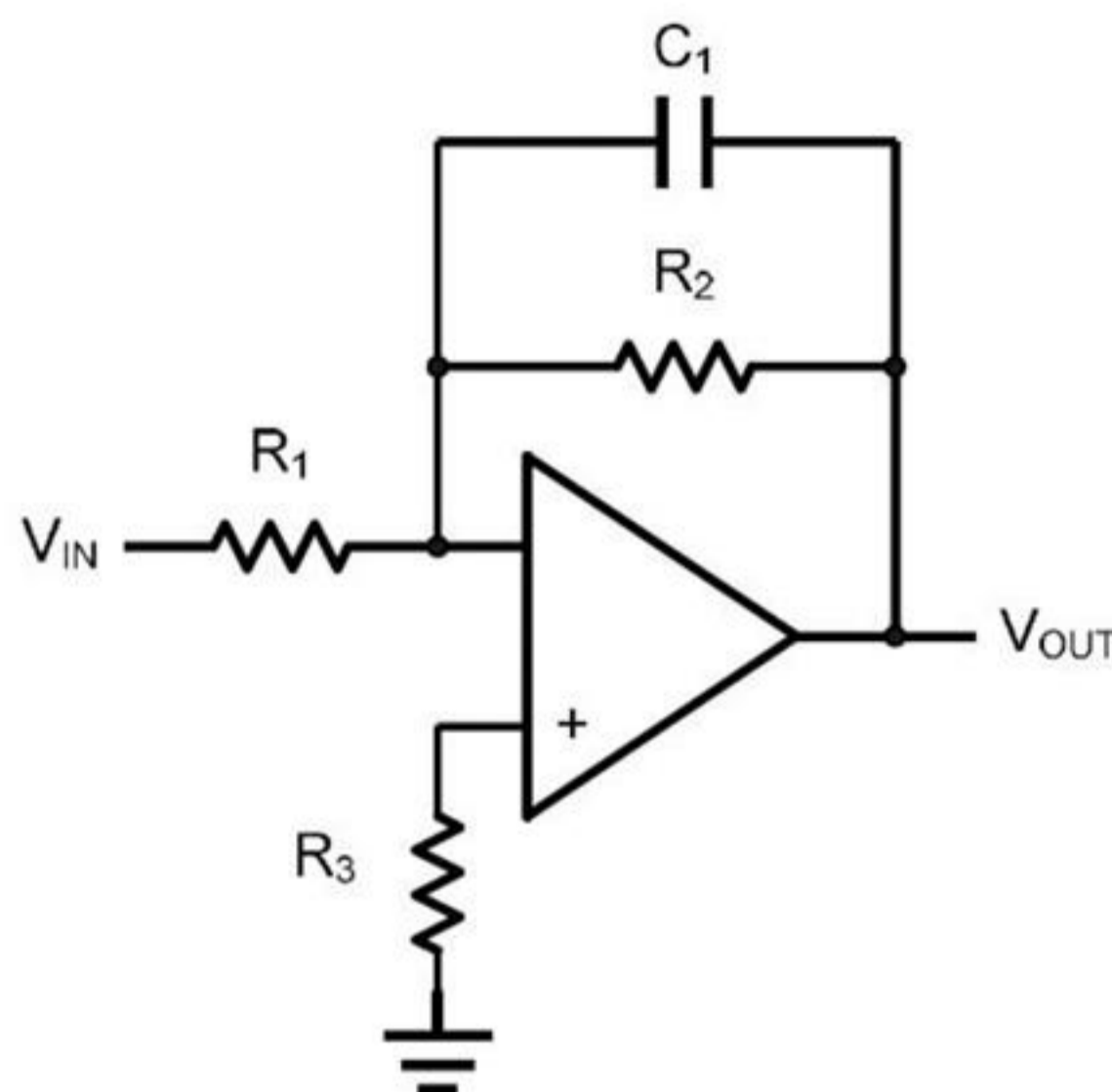


Figure 5. Low Pass Active Filter

**Instrumentation Amplifier**

The triple TP8632X can be used to build a three-op-amp instrumentation amplifier as shown in Figure 6. The amplifier in Figure 6 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.

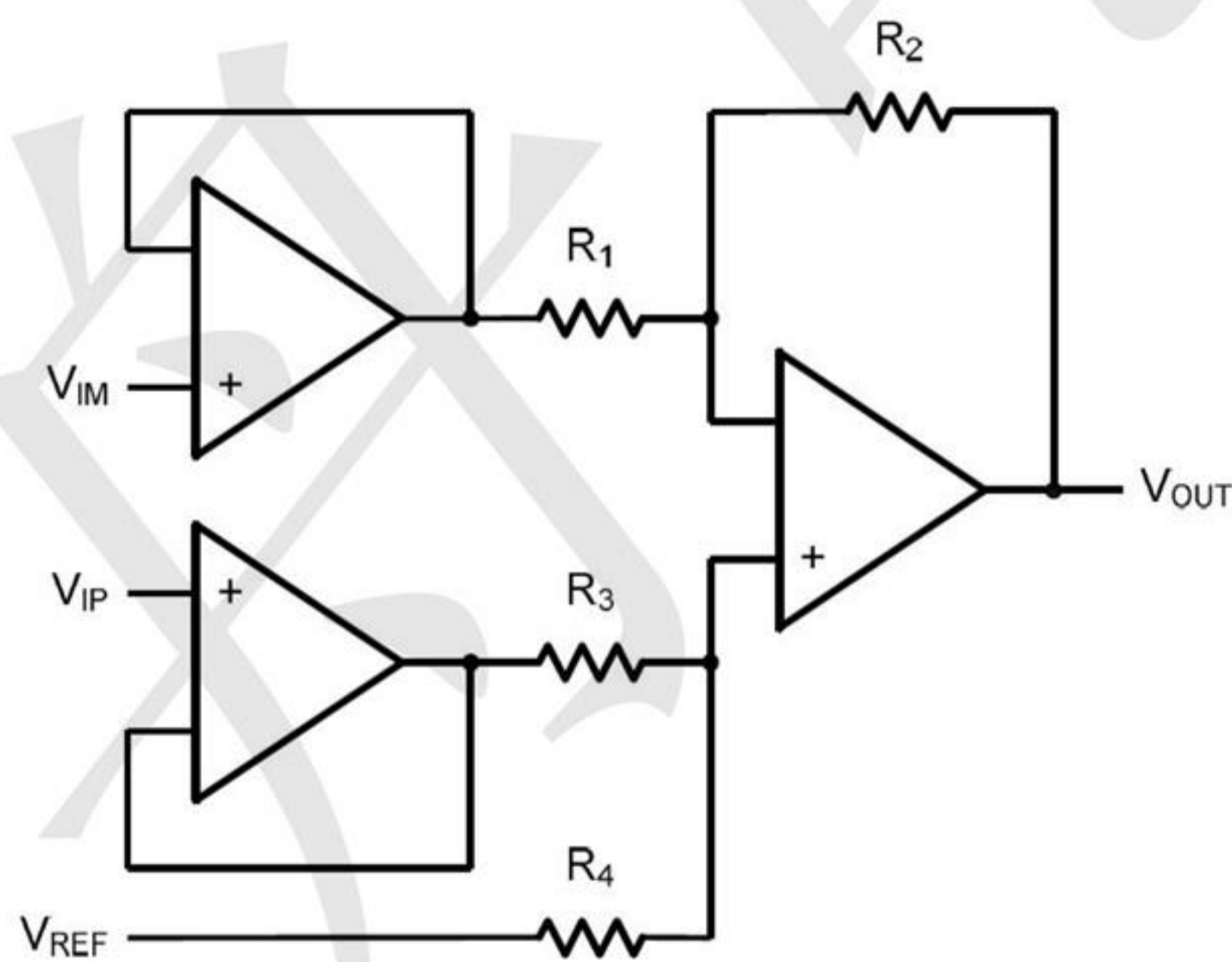
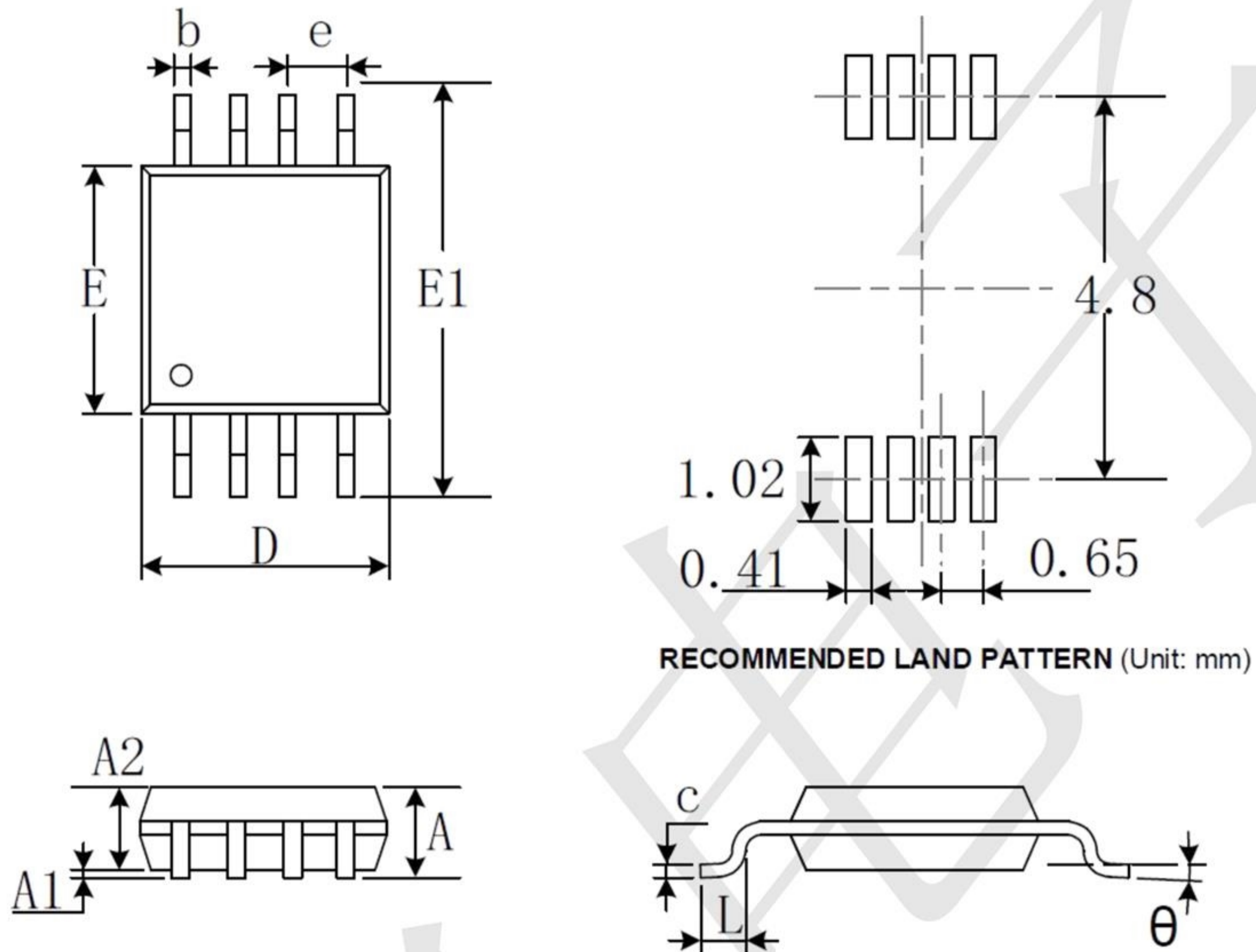


Figure 6. Instrument Amplifier

**Package Information**

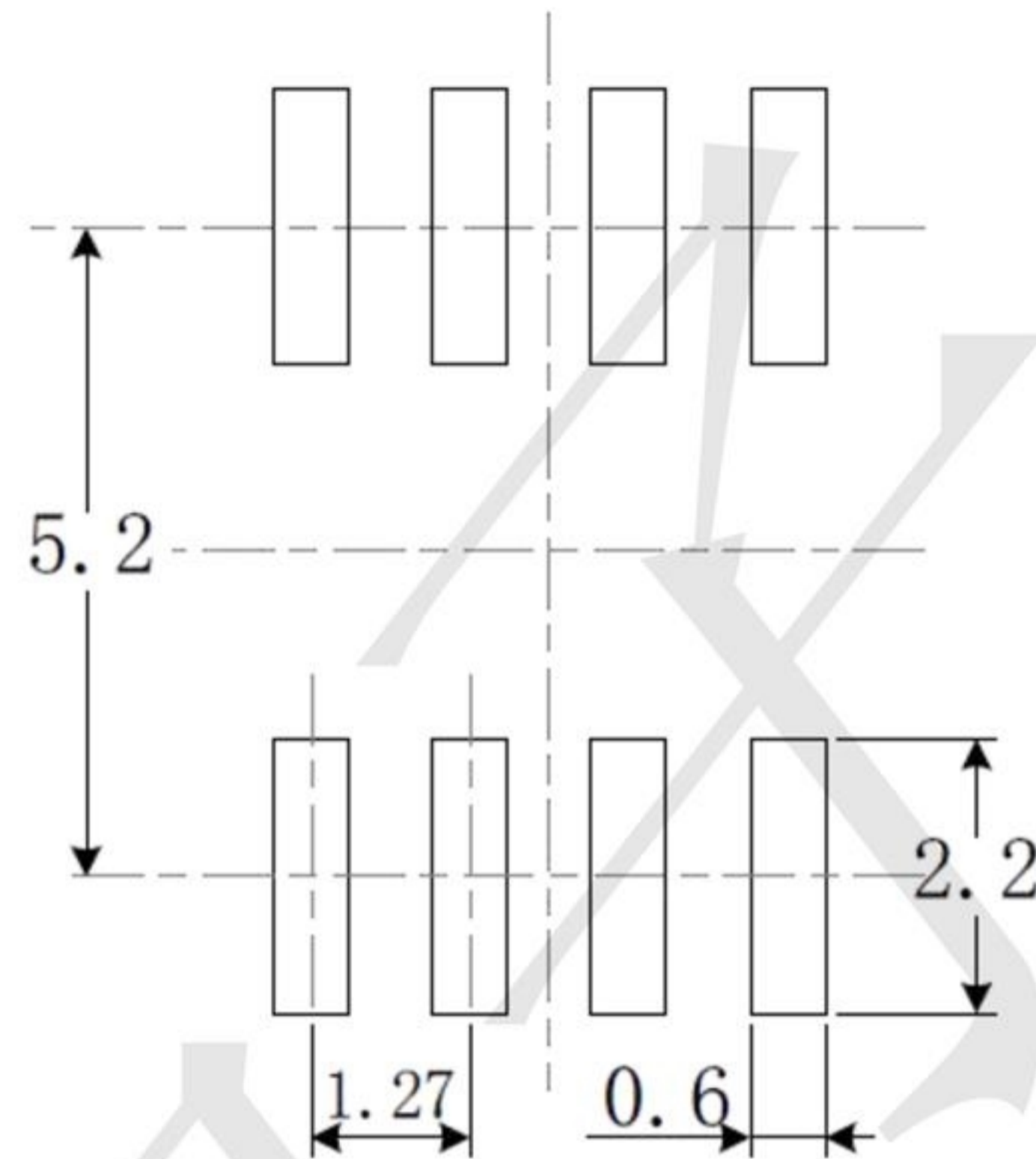
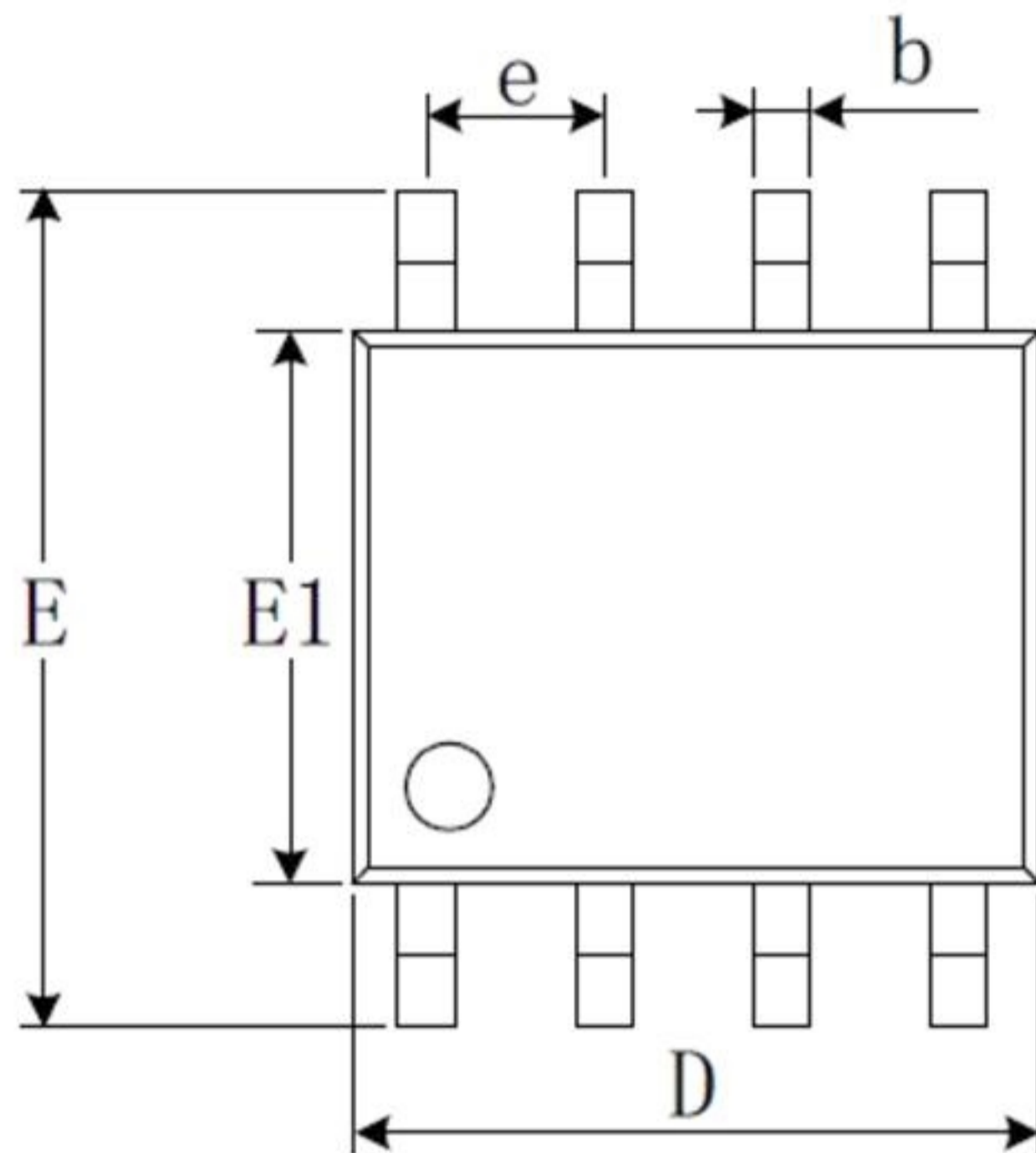
**MSOP-8**



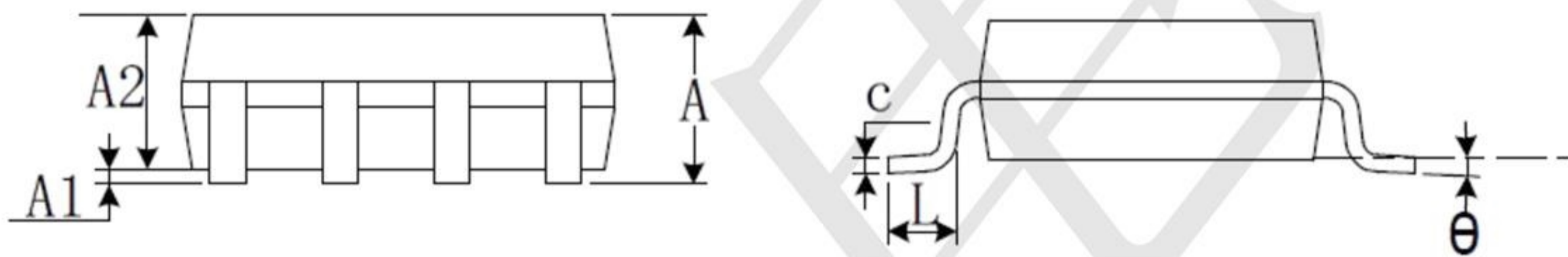
Symbol	Dimensions In Millimeters		Dimensions Inches	
	Min	Max	Min	Max
A	0.820	1.100	0.032	0.043
A1	0.020	0.150	0.001	0.006
A2	0.750	0.950	0.030	0.037
b	0.250	0.380	0.010	0.015
c	0.090	0.230	0.004	0.009
D	2.900	3.100	0.114	0.122
E	2.900	3.100	0.114	0.122
E1	4.750	5.050	0.187	0.199
e	0.650 BSC		0.026 BSC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

SOP8

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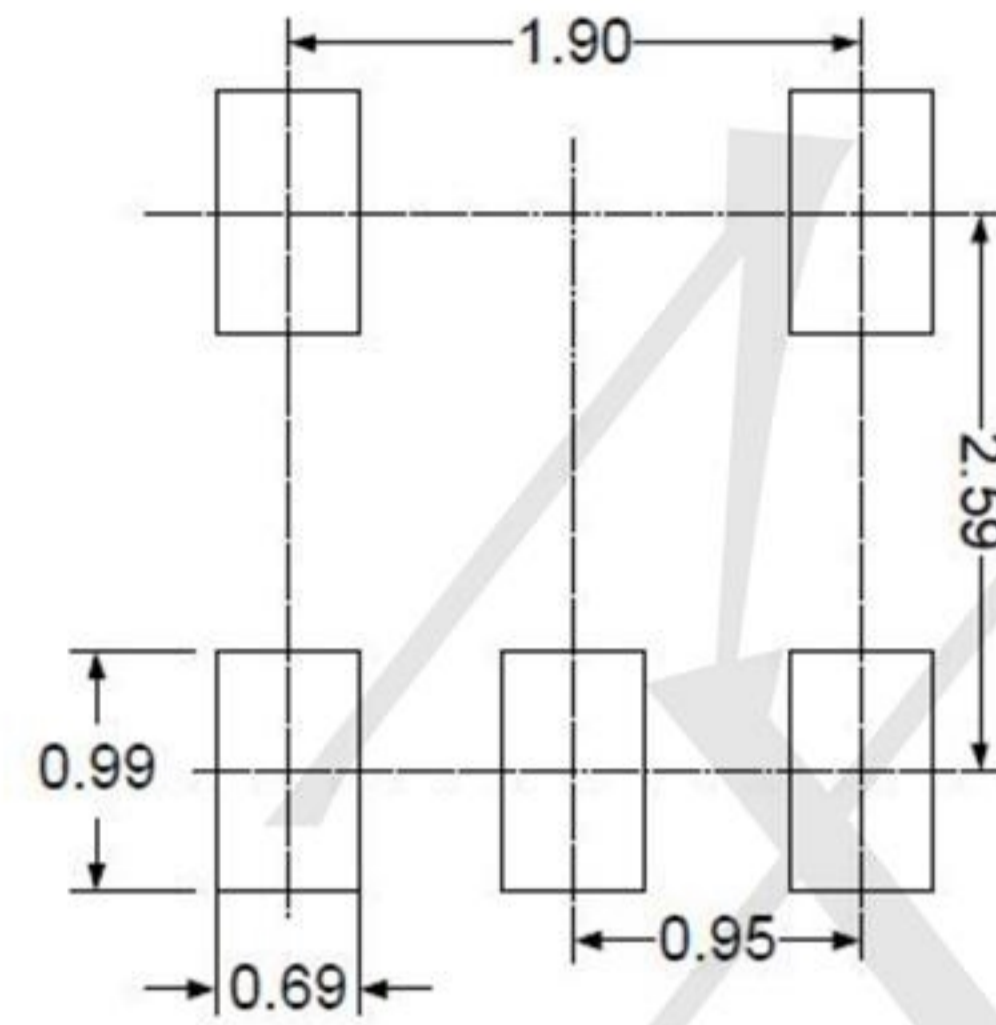
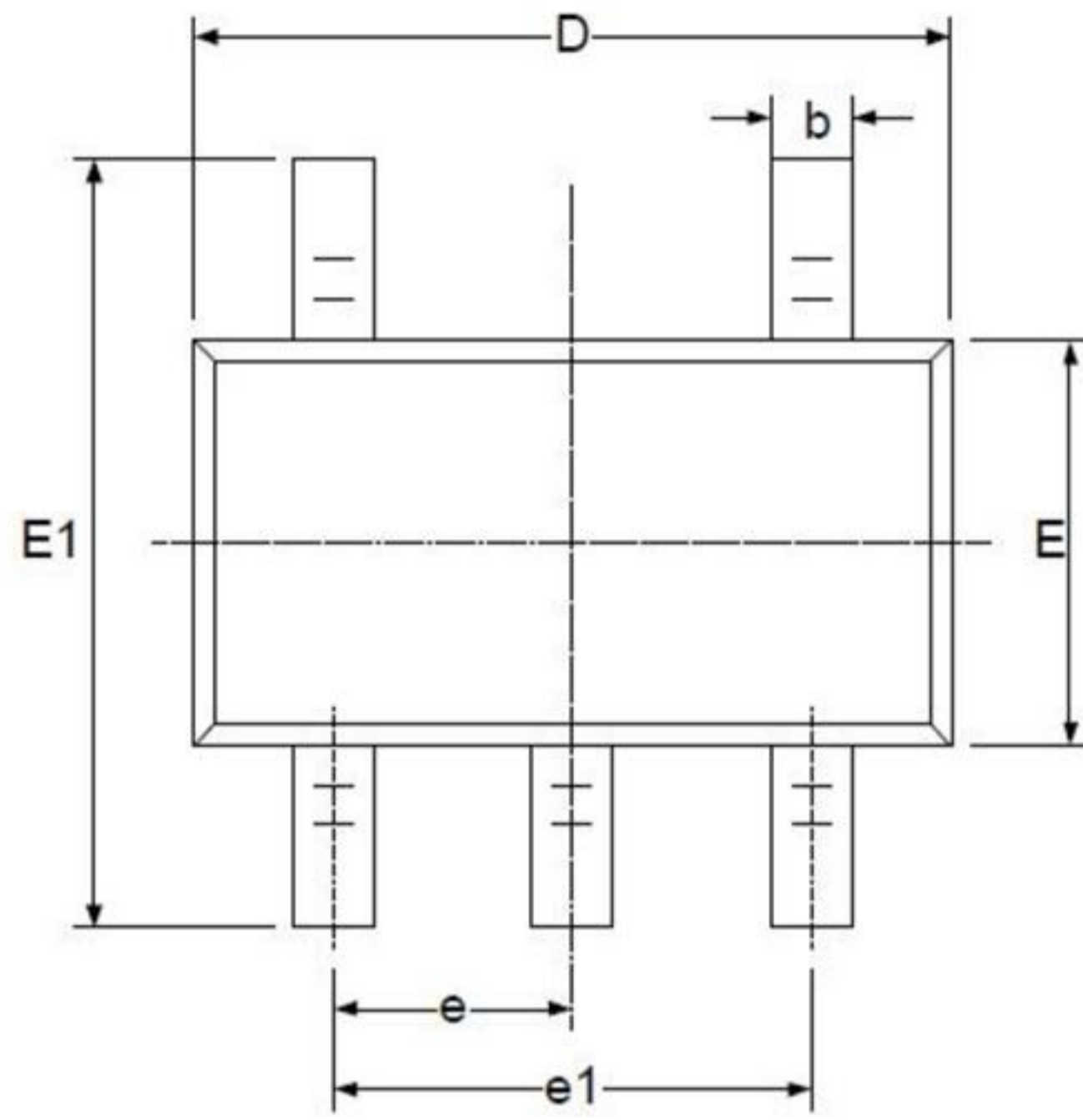


RECOMMENDED LAND PATTERN (Unit: mm)

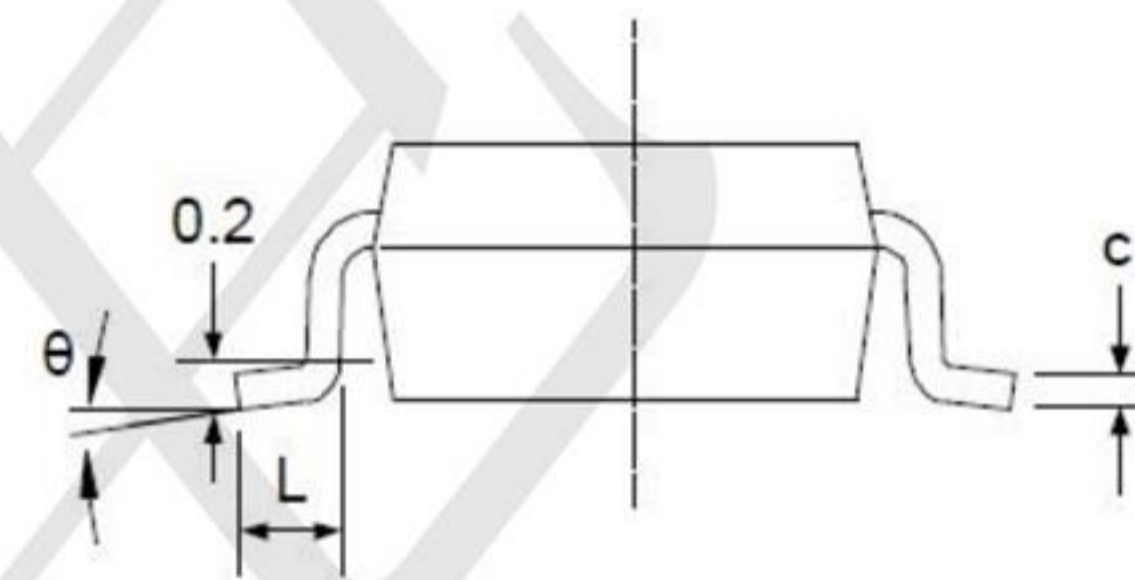
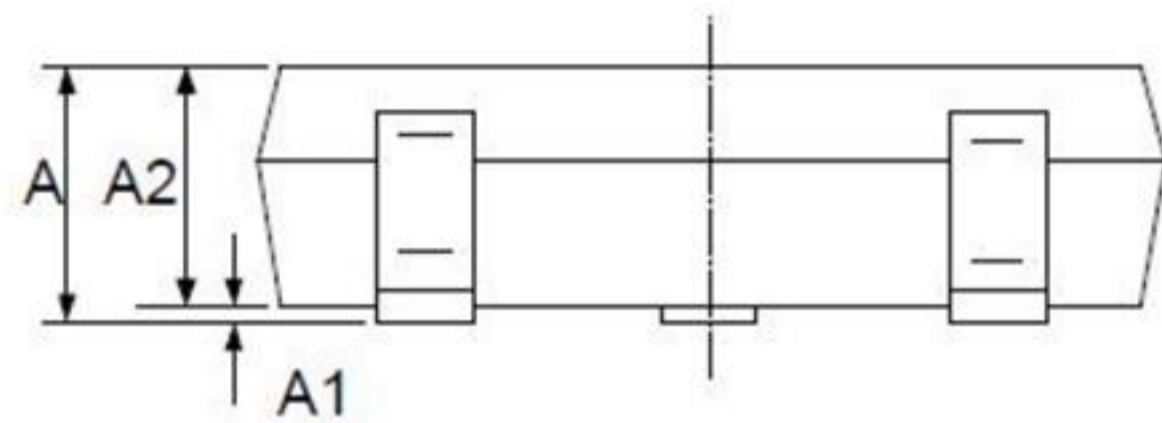


Symbol	Dimensions In Millimeters		Dimensions Inches	
	Min	Max	Min	Max
A	1.350	1.750	0.053	0.069
A1	0.100	0.250	0.004	0.010
A2	1.350	1.550	0.053	0.061
b	0.330	0.510	0.013	0.020
c	0.170	0.250	0.006	0.010
D	4.700	5.100	0.185	0.200
E	3.800	4.000	0.150	0.157
E1	5.800	6.200	0.228	0.244
e	1.270 BSC		0.050 BSC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

**SOT23-5**



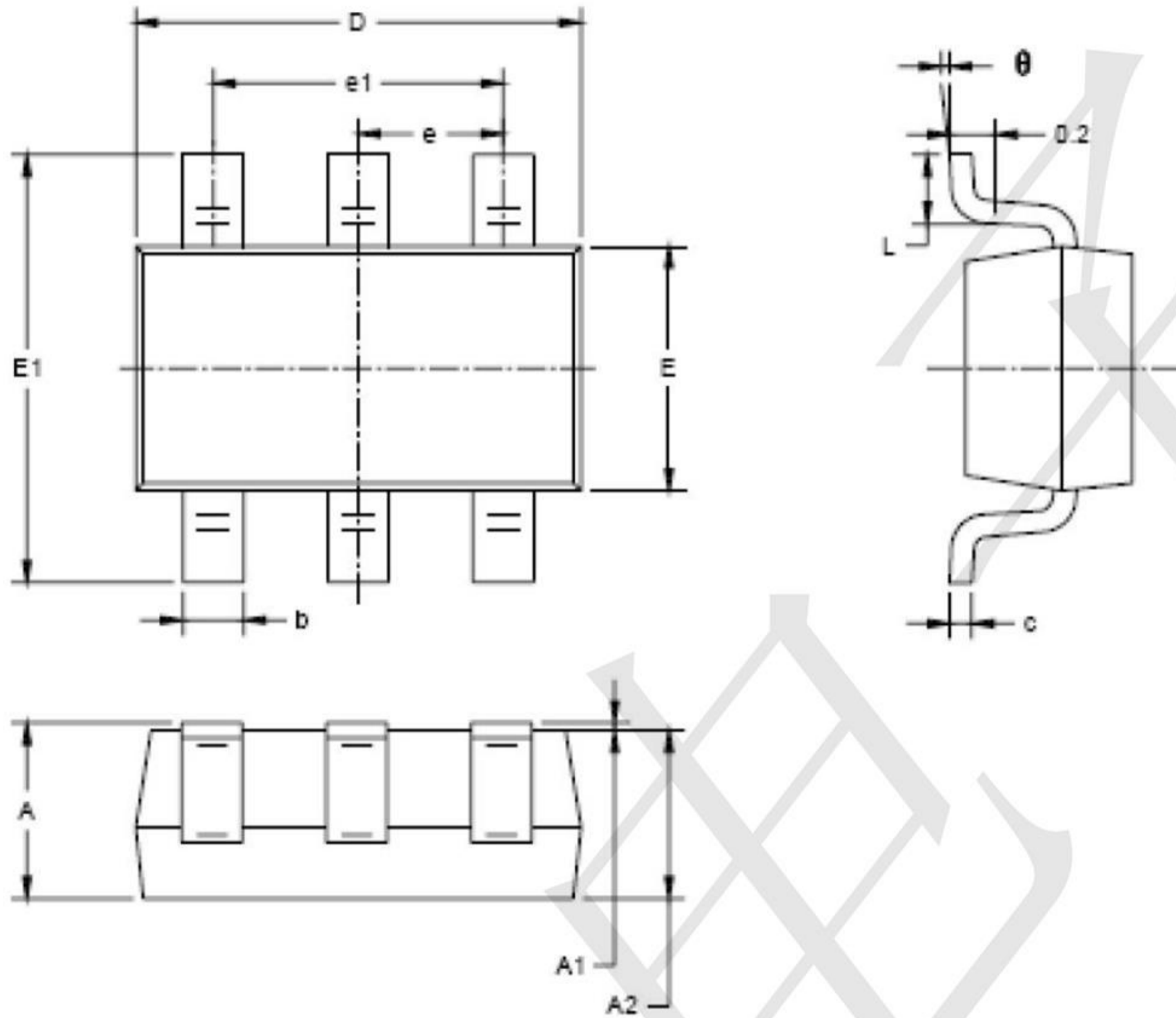
**RECOMMENDED LAND PATTERN (Unit: mm)**



Symbol	Dimensions In Millimeters		Dimensions 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	1.800	2.000	0.071	0.079
L	0.300	0.600	0.012	0.024
$\theta$	0°	8°	0°	8°

**SOT23-6**

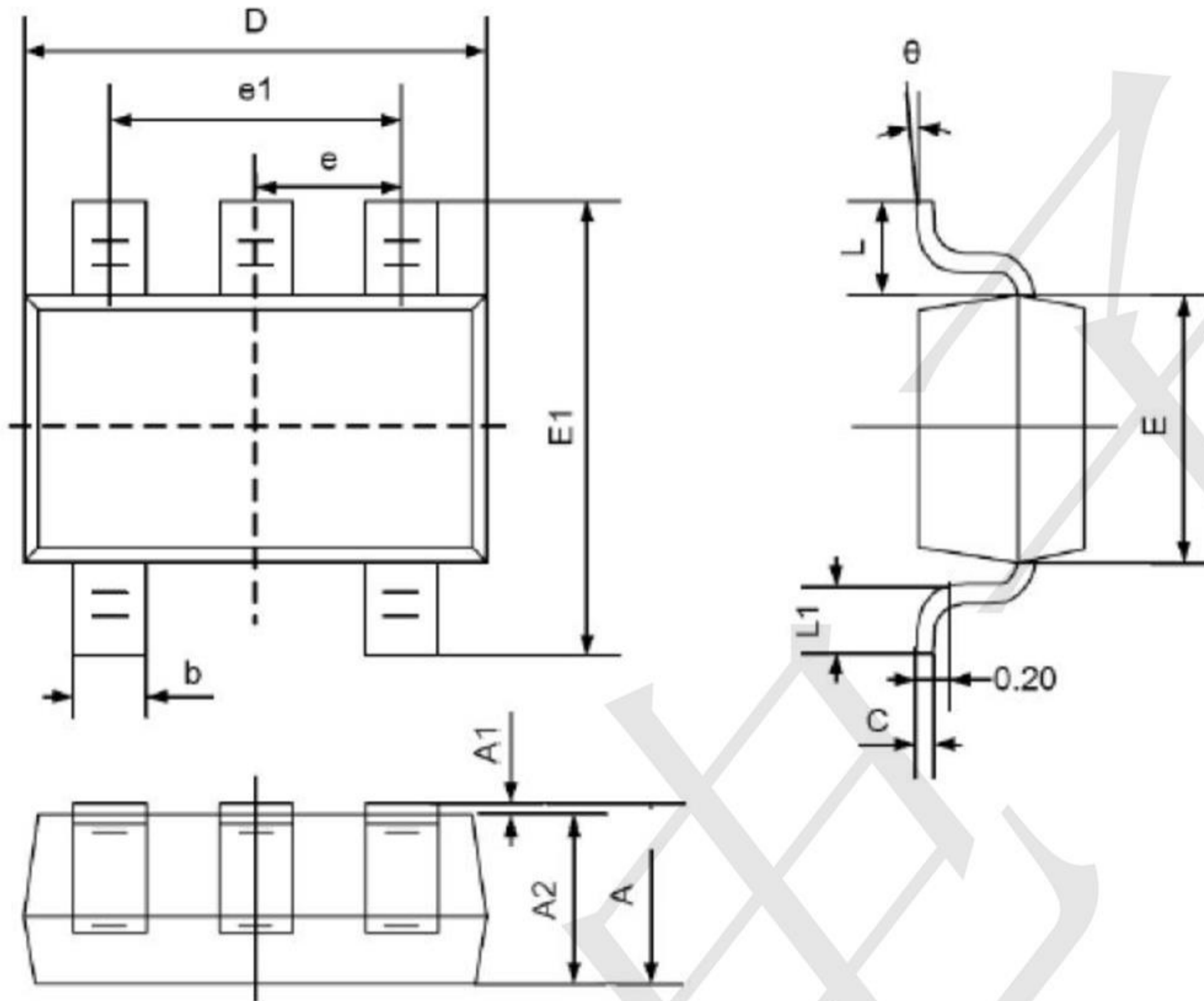
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Symbol	Dimensions In Millimeters		Dimensions Inches	
	Min	Max	Min	Max
A	1.050	1.250	0.041	0.049
A1	0.000	0.100	0.000	0.004
A2	1.050	1.150	0.041	0.045
b	0.300	0.500	0.012	0.020
c	0.100	0.200	0.004	0.008
D	2.820	3.020	0.111	0.119
E	1.500	1.700	0.059	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
theta	0°	8°	0°	8°

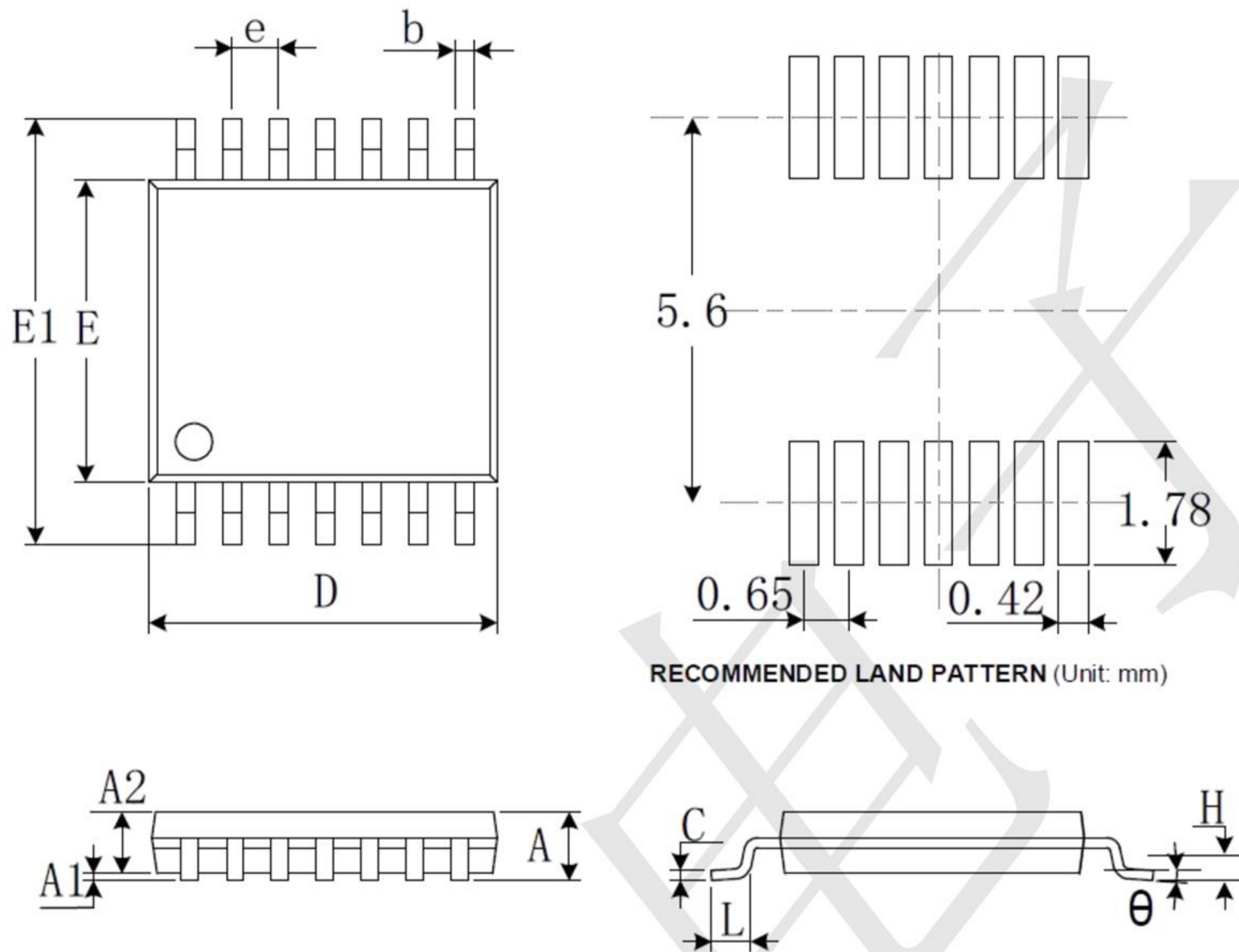
SC70-5

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Symbol	Dimensions In Millimeters		Dimensions Inches	
	Min	Max	Min	Max
A	0.900	1.100	0.035	0.043
A1	0.000	0.100	0.000	0.004
A2	0.900	1.000	0.035	0.039
b	0.150	0.350	0.006	0.014
C	0.080	0.150	0.003	0.006
D	2.000	2.200	0.079	0.087
E	1.150	1.350	0.045	0.053
E1	2.150	2.450	0.085	0.096
e	0.650 TYP		0.026TYP	
e1	1.200	1.400	0.047	0.055
L	0.525 REF		0.021 REF	
L1	0.260	0.460	0.010	0.018
θ	0°	8°	0°	8°

**TSSOP-14**

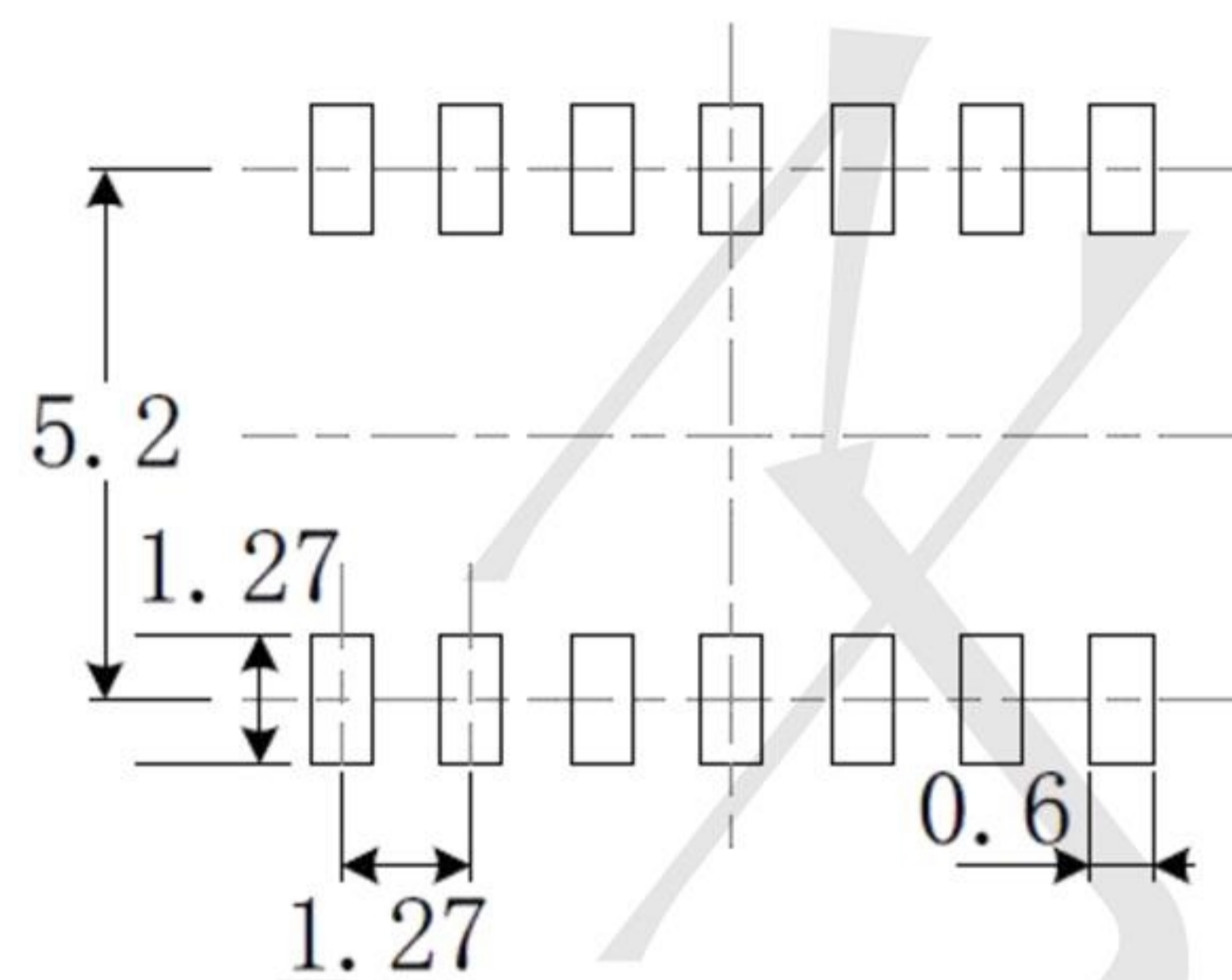
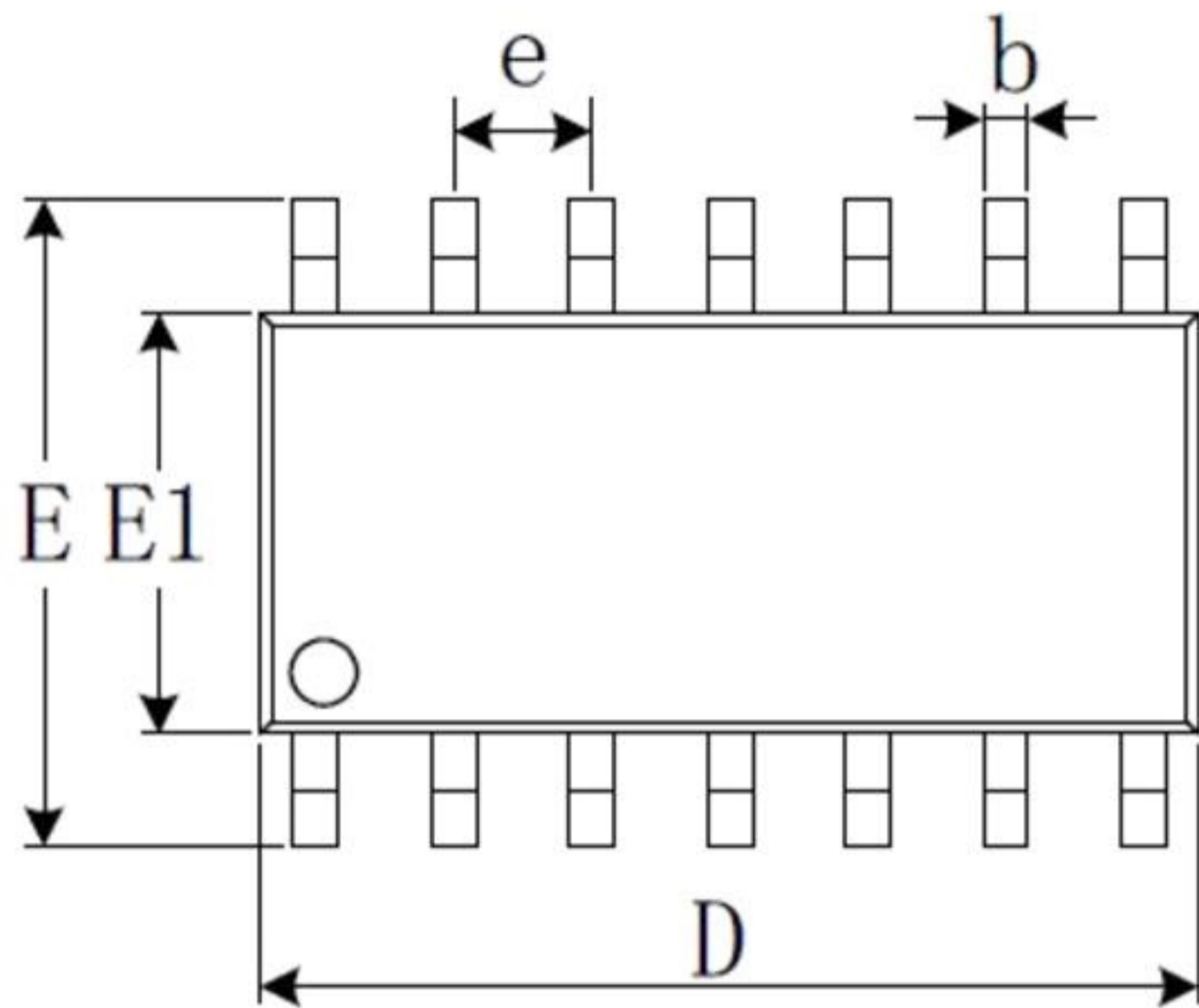


Symbol	Dimensions In Millimeters		Dimensions Inches	
	Min	Max	Min	Max
A		1.200		0.047
A1	0.050	0.150	0.002	0.006
A2	0.800	1.050	0.031	0.041
b	0.190	0.300	0.007	0.012
c	0.090	0.200	0.004	0.008
D	4.860	5.100	0.191	0.201
E	4.300	4.500	0.169	0.177
E1	6.250	6.550	0.246	0.258
e	0.650 BSC		0.026 BSC	
L	0.500	0.700	0.020	0.028
H	0.25 TYP		0.01 TYP	
θ	1°	7°	1°	7°

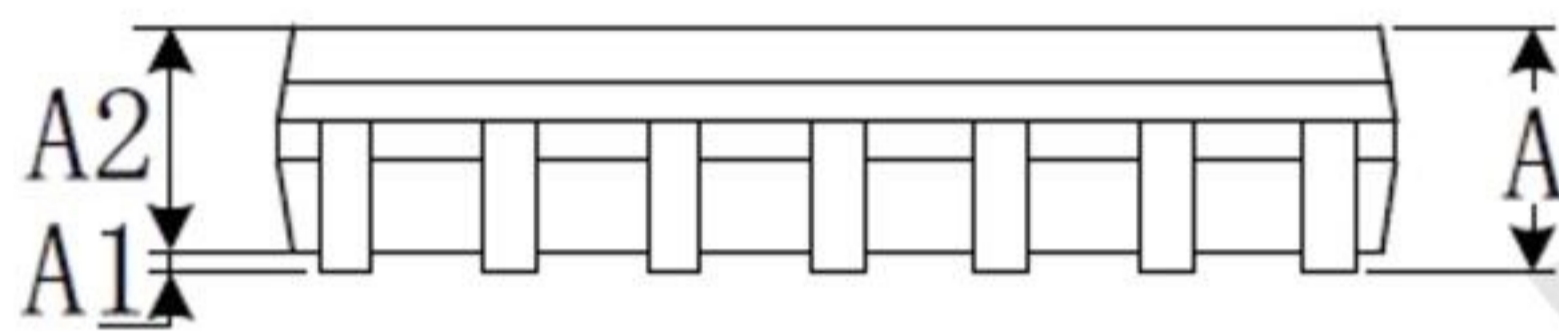


**SOIC-14(SOP14)**

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RECOMMENDED LAND PATTERN (Unit: mm)



Symbol	Dimensions In Millimeters		Dimensions 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	0.310	0.510	0.012	0.020
c	0.100	0.250	0.004	0.010
D	8.450	8.850	0.333	0.348
E	5.800	6.200	0.228	0.244
E1	3.800	4.000	0.150	0.157
e	1.270 BSC		0.050 BSC	
L	0.400	1.270	0.016	0.050
$\theta$	0°	8°	0°	8°