



钜地半导体  
Tudi Semiconductor

## Product Specification

TUDI-TLV6001/6002/6004

low-power, rail-to-rail input/output, 1MHz operational  
amplifier for cost-sensitive

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**semiconductor device  
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- Design
- research and development
- production
- and sales



## Features

- Precision amplifier for cost-sensitive systems
- Low static current: 75 $\mu$ A/channel
- Supply voltage range: 1.8 to 5.5V
- Rail-to-rail input and output
- Gain bandwidth: 1MHz
- Low input bias current: 1pA
- offset voltage: 0.75mV
- Unit gain stable
- Operating temperature range: -40°C to 125°

## Description

The TLV600x series of single-channel, dual-channel, and quad-channel operational amplifiers are specifically designed general-purpose applications. These devices feature rail-to-rail input and output (RRIO) swing, low static current (typical value: 75 $\mu$ A, high bandwidth (1MHz), and low noise (28 nV/Hz at 1KHz), making them highly attractive for applications requiring a good balance between cost and performance, such as consumer electronics products, smoke detectors, and white goods. The TLV600x features low input bias current (typical value:  $\pm 1$ .pA), making it suitable for applications with source impedances as high as megaohms.

The TLV600x incorporates a robust and durable design for use by circuit designers. The device is unity gain stable under capacitive loads up to 150pF and integrates RF/EMI suppression filters with no phase inversion indriven conditions and high electrostatic discharge (ESD) protection (4kV human body model (HBM)).

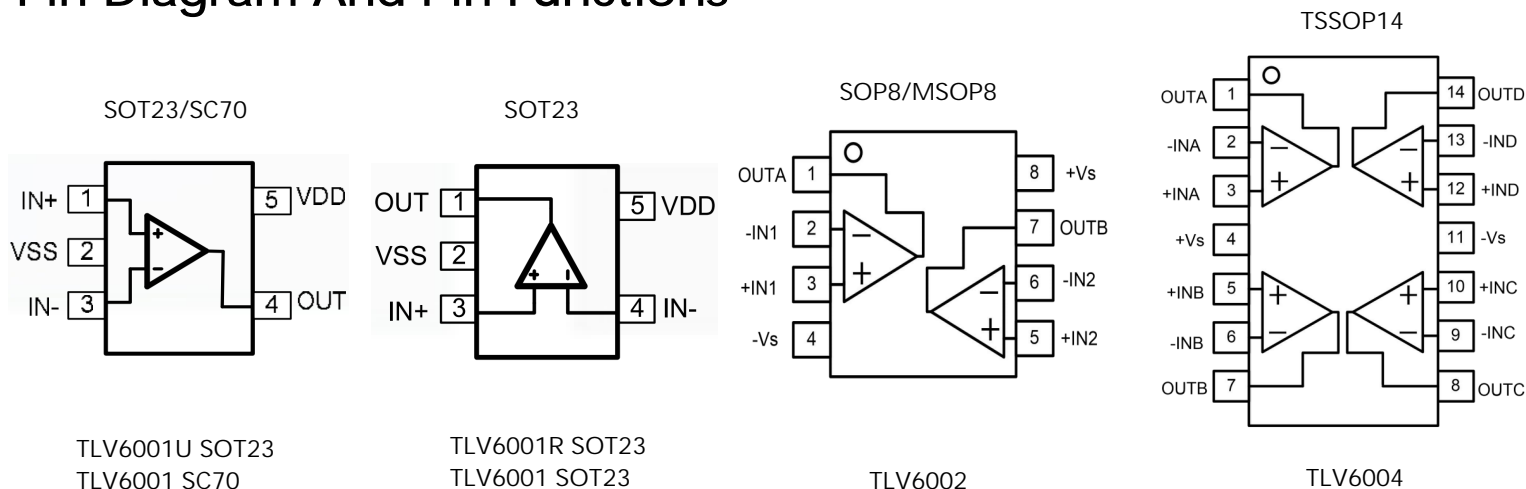
These devices are optimized for low-voltage operation at .8V ( $\pm 0.9$ V) to 5.5V ( $\pm 2.75$ V) and are rated to operate over the temperature range of -4°C to 125°C.

## Applications

- Industrial and consumer electronics products
- Portable devices
- Portable blood glucose meter systems
- Smoke detectors
- White goods
- Mobile power



## Pin Diagram And Pin Functions



Name	Description	Note
+Vs	Positive power supply	A bypass capacitor of 0.1 $\mu$ F as close to the part as possible should be placed between power supply pins or between supply pins and ground.
-Vs	Negative power supply or ground	If it is not connected to ground, bypass it with a capacitor of 0.1 $\mu$ F as close to the part as possible
-IN	Negative input	Inverting input of the amplifier. Voltage range of this pin can go from -Vs-0.3V to +Vs-1V.
+IN	Positive input	Non-inverting input of the amplifier. This pin has the same voltage range as -IN.
OUT	Output	The output voltage range extends to within millivolts of each supply rail.
NC	No connection	

## Product Specification

### Recommended Operating Conditions

Parameter	Rating	Unit
DC Supply Voltage	1.8V ~ 5.5V	V
Input common-mode voltage range	-Vs ~ +Vs	V
Operating ambient temperature	- 40°C to 125°C	



## Electrical Characteristics

(+Vs=+5V,-Vs=0,VeM=Vs/2,TA=+25°C,RL=10kQto Vs/2,unless otherwise noted)

Parameter	Symbol	Conditions	Min	Typ	Max	Unit
Input Characteristics						
Input Offset Voltage	Vos			1.0	5.0	mV
Input Offset Voltage Drift	$\Delta V_{os}/\Delta T$	-40 to 125°C		5		$\mu V/^{\circ}C$
Input Bias Current	IB			2.5		pA
Input Offset Current	Ios			2.5		pA
Common-Mode Voltage Range	VcM	Vs=5.5V	-0.1		4.5	V
Common-Mode Rejection Ratio	CMRR	VCM=0.1V to 4.5V		125		dB
Open-Loop Voltage Gain	AOL	Vo=0.2V to 4.5V		120		dB
Output Characteristics						
Output Voltage Swing from Rail		RL=100k $\Omega$		1		mV
		RL=10k $\Omega$		10		mV
		RL=2k $\Omega$		40		mV
Short-Circuit Current	IsR	Sourcing		45		mA
	IsK	Sinking		50		mA
Power Supply						
Operating Voltage Range			1.8		5.5	V
Power Supply Rejection Ratio	PSRR	Vs=+1.8V to +5.5V	80	100		dB
Quiescent Current /Amplifier	IQ			85		$\mu A$
Dynamic Performance						
Gain Bandwidth Product	GBWP	G=+1		1.5		MHz
Slew Rate	SR	G=+1,2V Output Step		1		V/ $\mu s$
Noise Performance						
Voltage Noise Density	en	f=1kHz		28		nV/ $\sqrt{Hz}$





### Absolute Maximum Ratings

Parameter	Rating	Units
Power Supply: +Vs to -Vs	6.0	V
Input Voltage	-Vs -0.5V to +Vs+0.5V	V
Input Current(2)	10	mA
Storage Temperature Range	-65 to 150	°C
Junction Temperature	150	°C
Operating Temperature Range	-40 to 125	°C
ESD Susceptibility,HBM	2000	V

(1) Stresses exceeding the absolute maximum ratings may damage the device. The device may not function or be operable above the recommended operating conditions and stressing the parts to these levels is not recommended. In addition, extended exposure to stresses above the recommended operating conditions may affect device reliability. The absolute maximum ratings are stress ratings only.

(2) Input terminals are diode-clamped to the power-supply rails. Input signals that can swing more than 0.5V beyond the supply rails should be current-limited to 10mA or less.

## Application Notes

### Driving Capacitive Loads

Driving large capacitive loads can cause stability problems for voltage feedback op amps. As the load capacitance increases, the feedback loop's phase margin decreases, and the closed loop bandwidth is reduced. This produces gain peaking in the frequency response, with overshoot and ringing in the step response. A unity gain buffer ( $G = +1$ ) is the most sensitive to capacitive loads, but all gains show the same general behavior.

When driving large capacitive loads with these op amps (e.g.,  $> 100$  pF when  $G = +1$ ), a small series resistor at the output ( $R_{iso}$  in Figure 1) improves the feedback loop's phase margin (stability) by making the output load resistive at higher frequencies. It does not, however, improve the bandwidth. To select  $R_{iso}$ , check the frequency response peaking (or step response overshoot) on the bench. If the response is reasonable, you do not need  $R_{iso}$ . Otherwise, start  $R_{iso}$  at 1k $\Omega$  and modify its value until the response is reasonable.

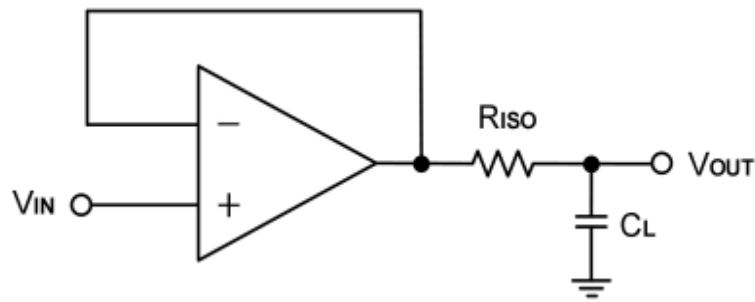


Figure 1. Indirectly Driving Heavy Capacitive Load

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.

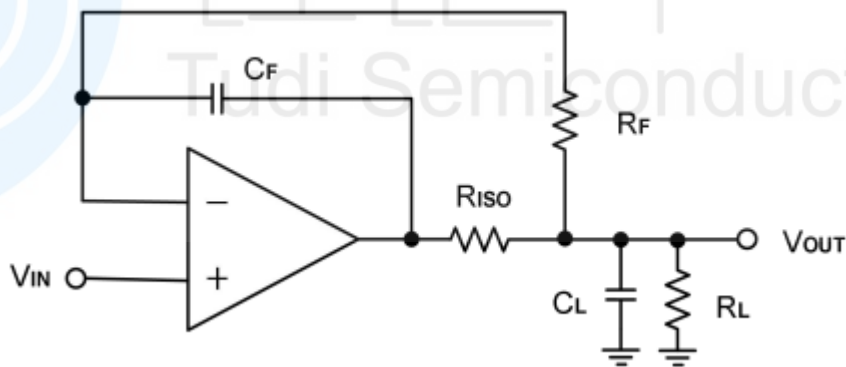


Figure 2. Indirectly Driving Heavy Capacitive Load with DC Accuracy

For non-inverting 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, as shown in Figure 3.

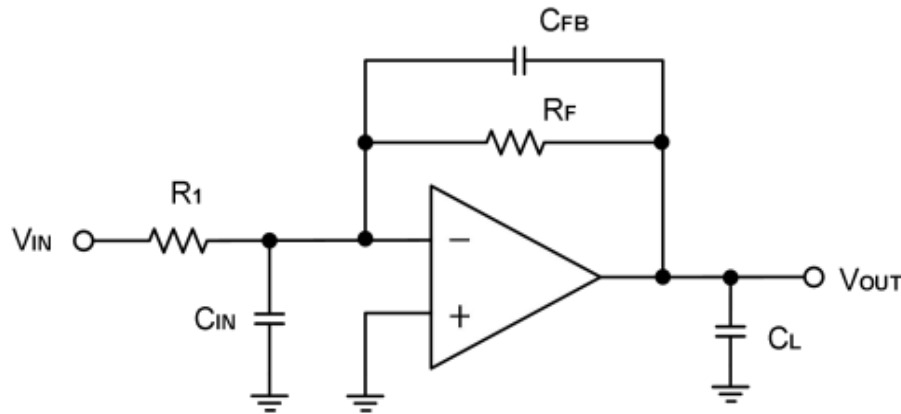


Figure 3. Adding a Feedback Capacitor in the Non-inverting Configuration

### Power-Supply Bypassing and Layout

The TLV6001/6002/6004 operates from a single +1.8V to +5.5V supply or dual  $\pm 1.05\text{V}$  to  $\pm 2.75\text{V}$  supplies.

For single-supply operation, bypass the power supply +Vs with a  $0.1\ \mu\text{F}$  ceramic capacitor which should be placed close to the +Vs pin. For dual-supply operation, both the +Vs and the -Vs supplies should be bypassed to ground with separate  $0.1\ \mu\text{F}$  ceramic capacitors.  $2.2\ \mu\text{F}$  tantalum capacitor can be added for better performance.

The length of the current path is directly proportional to the magnitude of parasitic inductances and thus the high frequency impedance of the path. High speed currents in an inductive ground return create an unwanted voltage noise. Broad ground plane areas will reduce the parasitic inductance. Thus a ground plane layer is important for high speed circuit design.

### Typical Application Circuits

#### Differential Amplifier

The circuit shown in Figure 4 performs the differential function. If the resistors ratios are equal ( $R_4/R_3 = R_2/R_1$ ), then  $V_{OUT} = (V_{IP} - V_{IN}) \times R_2/R_1 + V_{REF}$ .

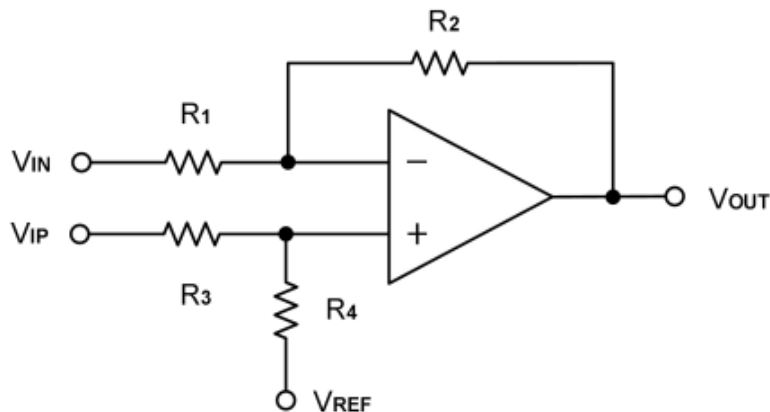


Figure 4. Differential Amplifier

### Low Pass Active Filter

When receiving low-level signals, limiting the bandwidth of the incoming signals into the system is often required. The simplest way to establish this limited bandwidth is to place an RC filter at the noninverting terminal of the amplifier. If even more attenuation is needed, a multiple pole filter is required. The Sallen-Key filter can be used for this task, as Figure 5. For best results, the amplifier should have a bandwidth that is 8 to 10 times the filter frequency bandwidth. Failure to follow this guideline can result in reduction of phase margin. 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.

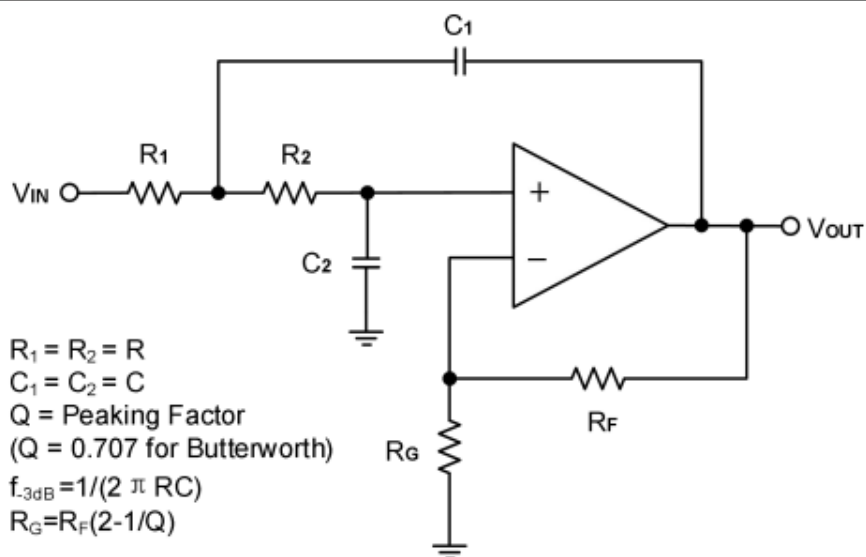
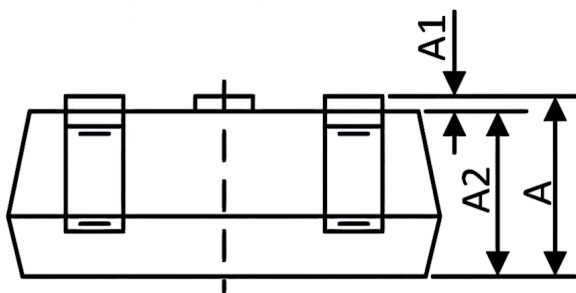
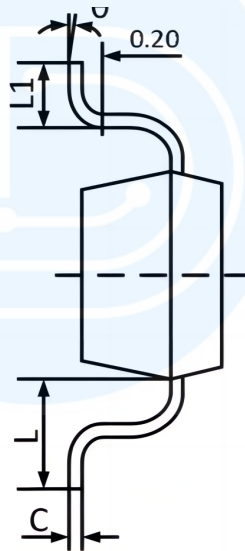
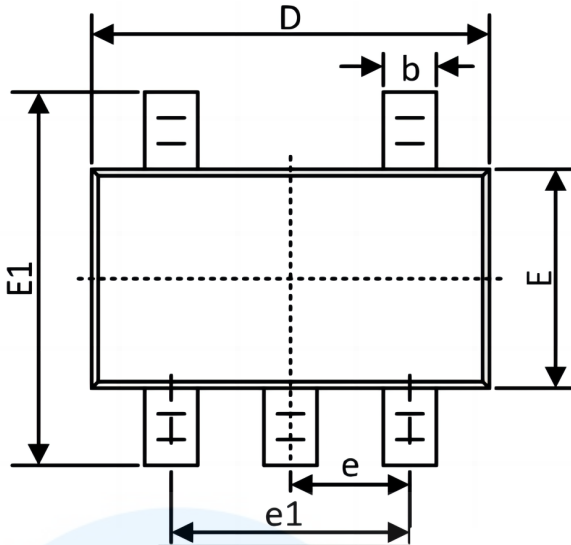


Figure 5. Two-Pole Low-Pass Sallen-Key Active Filter





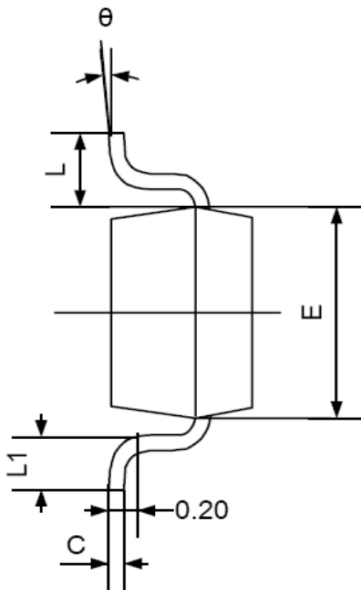
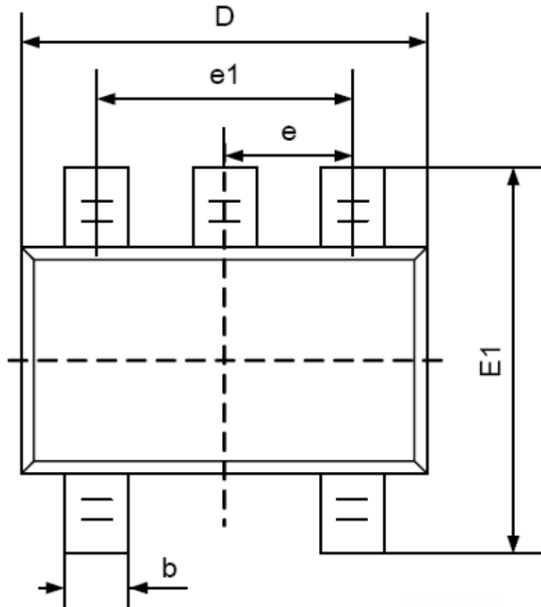
Package SOT23-5



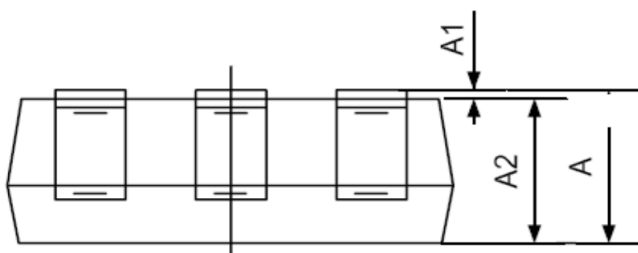
Symbol	Dimensions In Millimeters		Dimensions In Inches	
	MIN	MAX	MIN	MAX
A	1.050	1.250	0.041	0.049
A1	0.000	0.100	0.000	0.004
A2	1.050	1.150	0.041	0.045
b	0.300	0.400	0.012	0.016
C	0.100	0.200	0.004	0.008
D	2.820	3.020	0.111	0.119
E	1.500	1.700	0.059	0.067
E1	2.650	2.950	0.104	0.116
e	0.950TYP		0.037TYP	
e1	1.800	2.000	0.071	0.079
L	0.700REF		0.028REF	
L1	0.300	0.600	0.012	0.024
$\theta$	0°	8°	0°	8°



## Package SC70-5

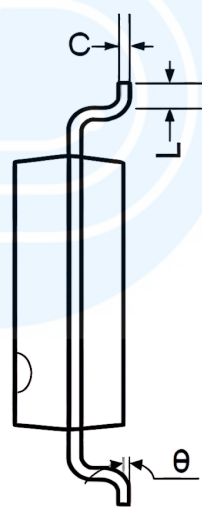
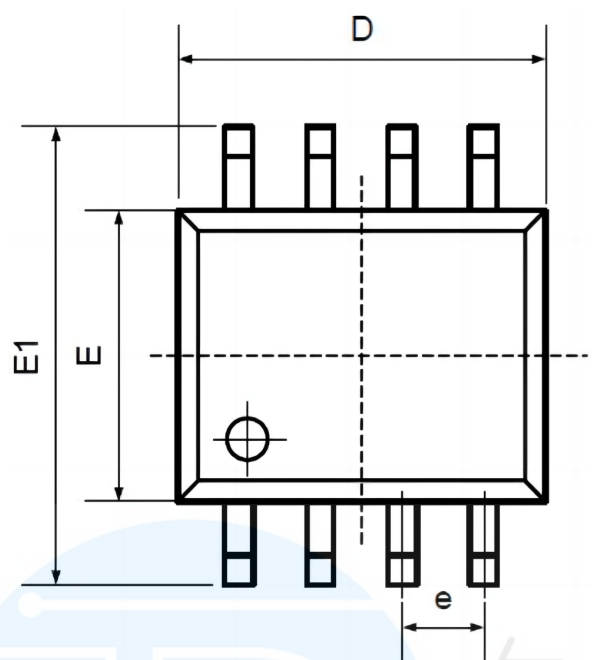


Symbol	DimensionsIn Millimeters		DimensionsIn Inches	
	Min	Max	Min	Max
A	0.600	1.100	0.035	0.043
A1	0.000	0.100	0.000	0.004
A2	0.600	1.000	0.035	0.039
b	0.150	0.350	0.006	0.014
C	0.080	0.150	0.003	0.006
D	2.000	2.200	0.079	0.087
E	1.150	1.350	0.045	0.053
E1	2.150	2.450	0.085	0.096
e	0.650TYP		0.026TYP	
e1	1.200	1.400	0.047	0.055
L	0.525REF		0.021REF	
L1	0.260	0.460	0.010	0.018
	0°	8°	0°	8°

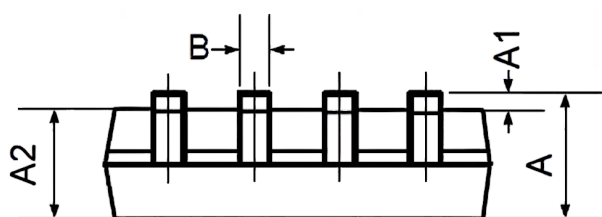




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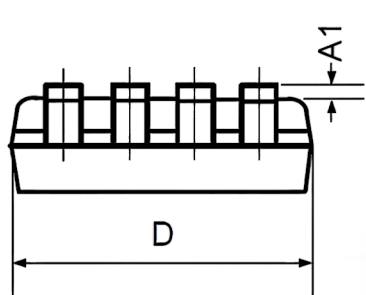
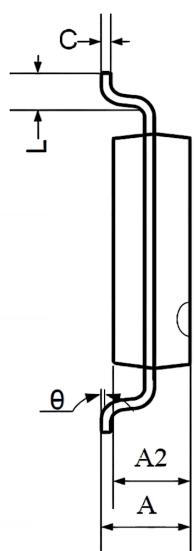
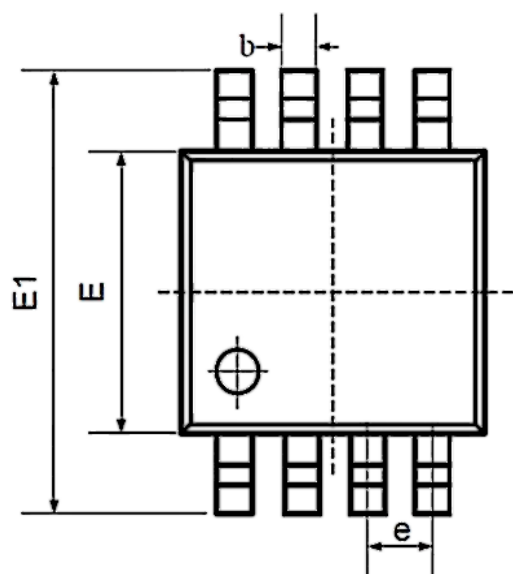


Symbol	Dimensions In Millimeters		Dimensions In Inches	
	Min	Max	Min	Max
A	1.350	1.750	0.053	0.069
A1	0.100	0.250	0.004	0.010
A2	1.350	1.550	0.053	0.061
B	0.330	0.510	0.013	0.020
C	0.190	0.250	0.007	0.010
D	4.780	5.000	0.188	0.197
E	3.800	4.000	0.150	0.157
E1	5.800	6.300	0.228	0.248
e	1.270TYP		0.050TYP	
L	0.400	1.270	0.016	0.050
$\theta$	0°	8°	0°	8°





## Package MSOP8

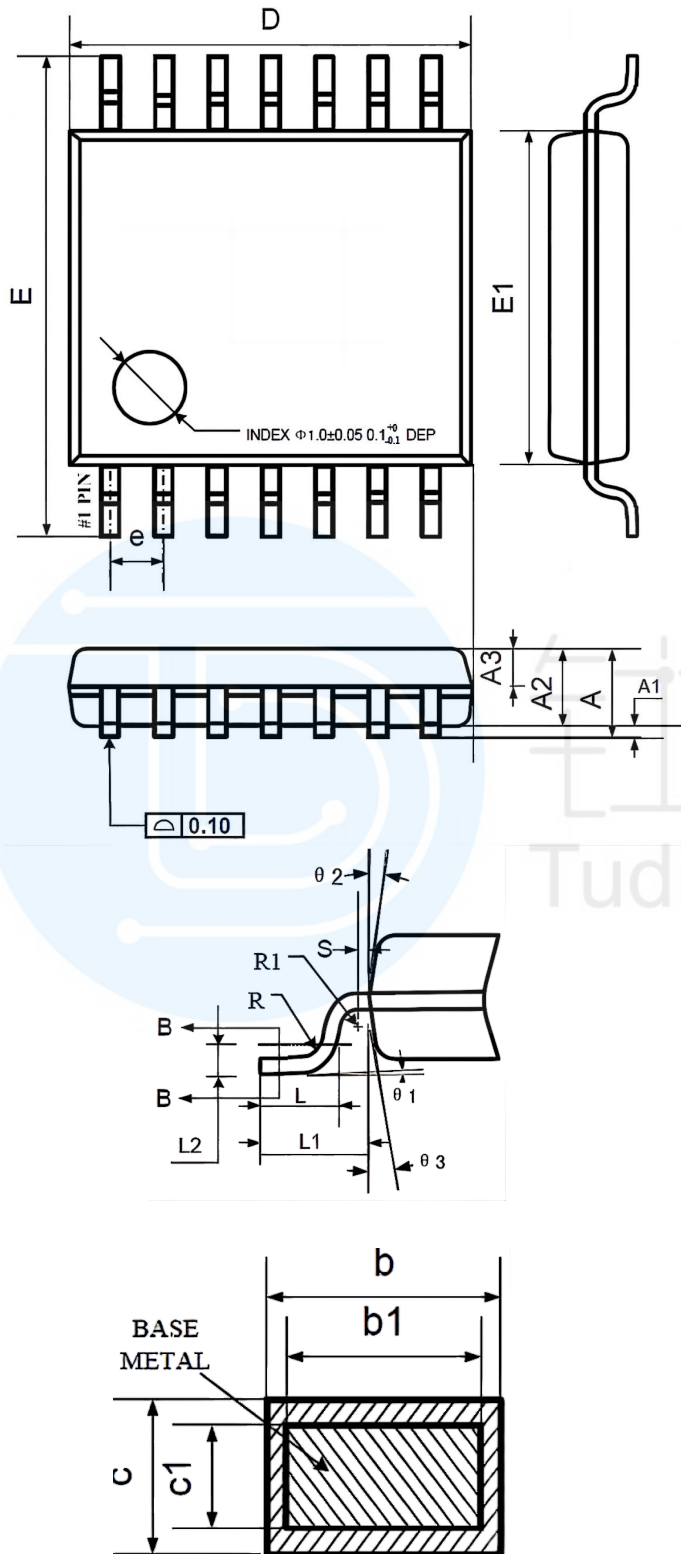


Symbol	Dimensions In Millimeters		Dimensions In Inches	
	Min	Max	Min	Max
A	0.800	1.200	0.031	0.047
A1	0.000	0.200	0.000	0.008
A2	0.760	0.970	0.030	0.038
b	0.30 TYP		0.012 TYP	
C	0.15 TYP		0.006 TYP	
D	2.900	3.100	0.114	0.122
e	0.65 TYP		0.026 TYP	
E	2.900	3.100	0.114	0.122
E1	4.700	5.100	0.185	0.201
L	0.410	0.650	0.016	0.026
θ	0°	6°	0°	6°





## Package TSSOP14



Symbol	Dimensions In Millimeters		
	MIN	NOM	MAX
A	—	—	1.20
A1	0.05	—	0.15
A2	0.90	1.00	1.05
A3	0.34	0.44	0.54
b	0.20	—	0.28
b1	0.20	0.22	0.24
C	0.10	—	0.19
c1	0.10	0.13	0.15
D	4.86	4.96	5.06
E	6.20	6.40	6.60
E1	4.30	4.40	4.50
e	0.65 BSC		
L	0.45	0.60	0.75
L1	1.00 REF		
L2	0.25 BSC		
R	0.09	—	—
R1	0.09	—	—
S	0.20	—	—
$\theta 1$	0°	—	8°
$\theta 2$	10°	12°	14°
$\theta 3$	10°	12°	14°



## Order information

Order Number	Package	Package Quantity	Marking On The park	Temperature
TLV6002IDGKR-TUDI	MSOP8	Tape,Reel,2500	14TV	-40 to 125
TLV6002IDR-TUDI	SOP8	Tape,Reel,2500	V6002	
TLV6002QDGKRQ1-TUDI	MSOP8	Tape,Reel,2500	1NX6	
TLV6002QDRQ1-TUDI	SOP8	Tape,Reel,2500	V6002Q	
TLV6001IDBVR-TUDI	SOT23-5	Tape,Reel,3000	14W2	
TLV6001IDCKR-TUDI	SC70-5	Tape,Reel,3000	13X	
TLV6001QDCKRQ1-TUDI	SC70-5	Tape,Reel,3000	1B1	
TLV6001RIDBVR-TUDI	SOT23-5	Tape,Reel,3000	16O2	
TLV6001UIDBVR-TUDI	SOT23-5	Tape,Reel,3000	16P2	
TLV6004IPWR-TUDI	TSSOP14	Tape,Reel,2500	TLV6004	



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