

## 150KHz CMOS Rail-to-Rail IO Opamp with RF Filter

### Features

- Single-Supply Operation from +2.1V ~ +5.5V
  - Rail-to-Rail Input / Output
  - Gain-Bandwidth Product: 150KHz (Typ)
  - Low Input Bias Current: 1pA (Typ)
  - Low Offset Voltage: 3.5mV (Max)
  - Quiescent Current: 5.5μA per Amplifier (Typ)
  - Operating Temperature: -40°C ~ +125°C
  - Embedded RF Anti-EMI Filter
  - Small Package:
- HGV2451 Available in SOT23-5 Package  
 HGV2452 Available in SOP-8 and MSOP-8 Packages  
 HGV2454 Available in SOP-14 and TSSOP-14 Packages



### Ordering Information

DEVICE	Package Type	MARKING	Packing	Packing Qty
HGV2451M5/TR	SOT-23-5	2451	REEL	3000pcs/box
HGV2452M/TR	SOP-8	V2452	REEL	2500pcs/reel
HGV2452MM/TR	MSOP-8	V2452	REEL	3000pcs/reel
HGV2454M/TR	SOP-14	HGV2454	REEL	2500pcs/reel
HGV2454MT/TR	TSSOP-14	V2454	REEL	2500pcs/reel

## General Description

The HGV245X family have a high gain-bandwidth product of 150KHz, a slew rate of 0.07V/ $\mu$ s, and a quiescent current of 5.5 $\mu$ A/amplifier at 5V. The HGV245X family is 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 HGV245X family. They are specified over the extended industrial temperature range (-40 $^{\circ}$ C to +125 $^{\circ}$ C). The operating range is from 2.1V to 5.5V. The HGV2451 single is available in Green SOT-23-5 packages The HGV2452 Dual is available in Green SOP-8 and MSOP-8 packages. The HGV2454 Quad is available in Green SOP-14 and TSSOP-14 packages.

## Applications

- ASIC Input or Output Amplifier
- Sensor Interface
- Medical Communication
- Smoke Detectors
- Audio Output
- Piezoelectric Transducer Amplifier
- Medical Instrumentation
- Portable Systems

## Pin Configuration

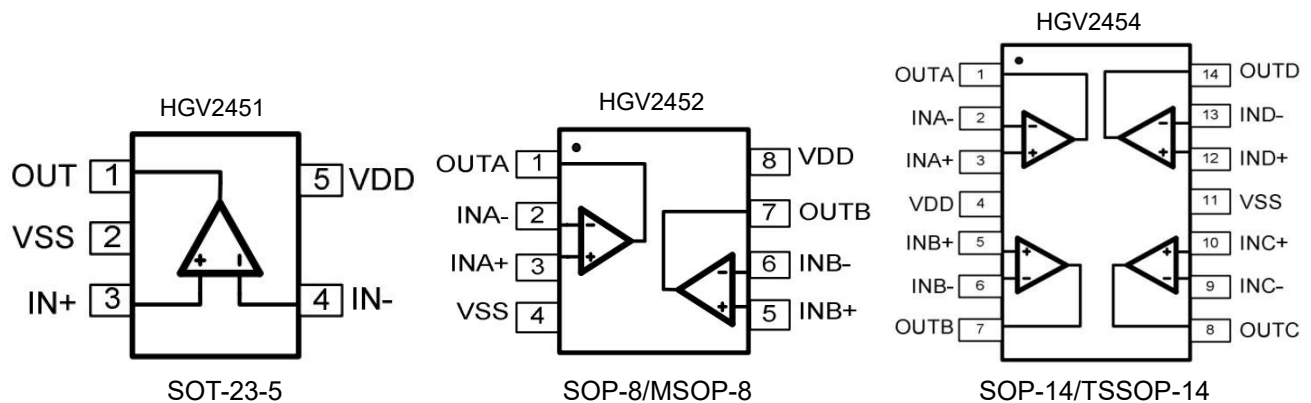


Figure 1. Pin Assignment Diagram

## 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 <sup>(1)</sup>	-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	
<b>ESD Susceptibility</b>		
HBM	6KV	
MM	300V	

**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.

**Note(1):** Operating temperature range: -40°C to +125°C. This product is designed for industrial grade applications. For automotive grade versions compliant with AEC-Q100, please conduct internal screening per the standard or contact our sales team for availability.

## Electrical Characteristics

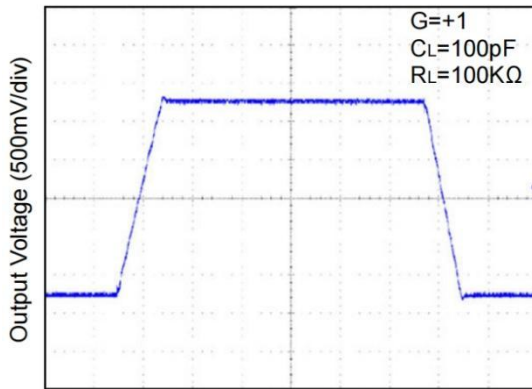
(At  $V_S = +5V$ ,  $R_L = 500k\Omega$  connected to  $V_S/2$ , and  $V_{OUT} = V_S/2$ , unless otherwise noted.)

PARAMETER	SYMBOL	CONDITIONS	TYP	MIN	MAX	UNITS
<b>INPUT CHARACTERISTICS</b>						
Input Offset Voltage	$V_{OS}$	$V_{CM} = V_S/2$	0.4		3.5	mV
Input Bias Current	$I_B$		1			pA
Input Offset Current	$I_{OS}$		1			pA
Common-Mode Voltage Range	$V_{CM}$	$V_S = 5.5V$	-0.1 to +5.6			V
Common-Mode Rejection Ratio	CMRR	$V_S = 5.5V$ , $V_{CM} = -0.1V$ to $4V$	114	70		dB
		$V_S = 5.5V$ , $V_{CM} = -0.1V$ to $5.6V$	87	60		
Open-Loop Voltage Gain	$A_{OL}$	$R_L = 500k\Omega$ , $V_O = +0.1V$ to $+4.9V$	110	90		dB
		$R_L = 100k\Omega$ , $V_O = +0.1V$ to $+4.9V$	108	88		
Input Offset Voltage Drift	$\Delta V_{OS}/\Delta T$		2			$\mu V/^\circ C$
<b>OUTPUT CHARACTERISTICS</b>						
Output Voltage Swing from Rail	$V_{OH}$	$R_L = 500k\Omega$	4.997	4.990		V
	$V_{OL}$	$R_L = 500k\Omega$	3	10		mV
Output Current	$I_{SOURCE}$	$R_L = 10\Omega$ to $V_S/2$	58	40		mA
	$I_{SINK}$		58	40		
<b>POWER SUPPLY</b>						
Operating Voltage Range				2.1	5.5	V
Power Supply Rejection Ratio	PSRR	$V_S = +2.5V$ to $+5.5V$ , $V_{CM} = +0.5V$	94	65		dB
Quiescent Current / Amplifier	$I_Q$		5.5			$\mu A$
<b>DYNAMIC PERFORMANCE</b>						
Gain-Bandwidth Product	GBP		150			kHz
Slew Rate	SR	$G = +1$ , 2V Output Step	0.07			V/ $\mu S$
Settling Time to 0.1%	$t_s$	$G = +1$ , 2V Output Step	30			$\mu S$
<b>NOISE PERFORMANCE</b>						
Voltage Noise Density	$e_n$	$f = 1kHz$	85			$nV/\sqrt{Hz}$
		$f = 10kHz$	44			$nV/\sqrt{Hz}$

## Typical Performance characteristics

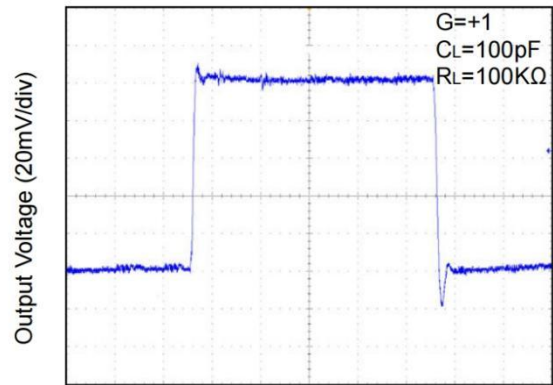
At  $T_A=+25^{\circ}\text{C}$ ,  $V_S=+5\text{V}$ , and  $R_L=500\text{K}\Omega$  connected to  $V_S/2$ , unless otherwise noted.

Large-Signal Step Response



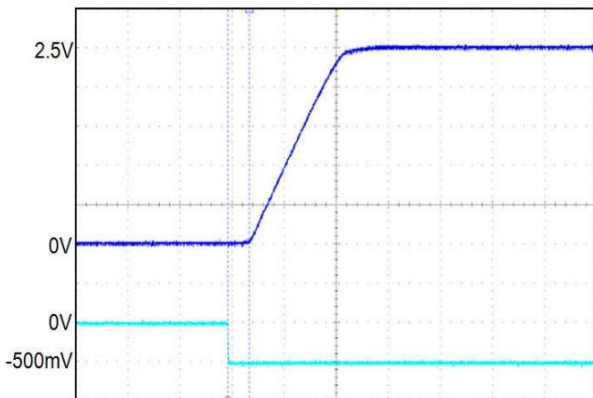
Time (40 $\mu\text{s}$ /div)

Small-Signal Step Response



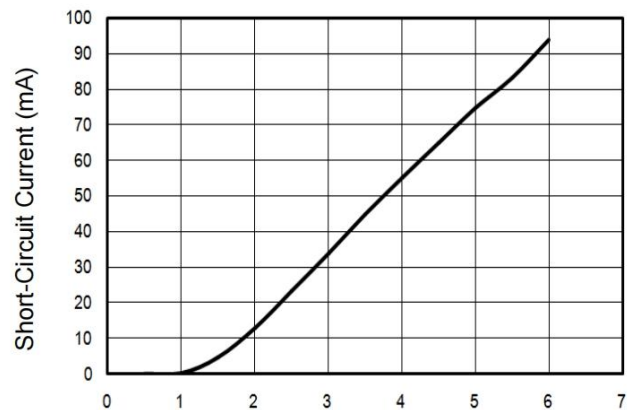
Time (20 $\mu\text{s}$ /div)

Overload Recovery Time



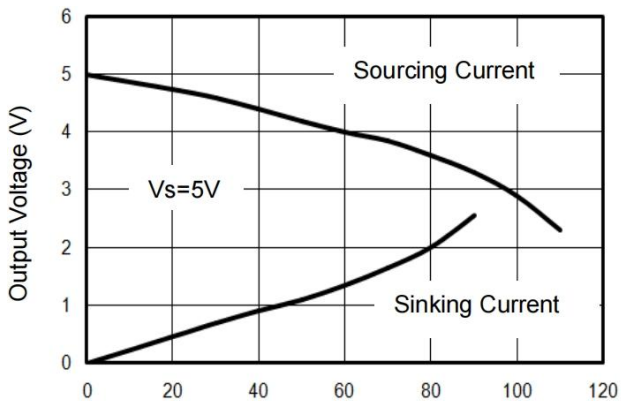
Time (20 $\mu\text{s}$ /div)

Short-Circuit Current vs. Supply Voltage



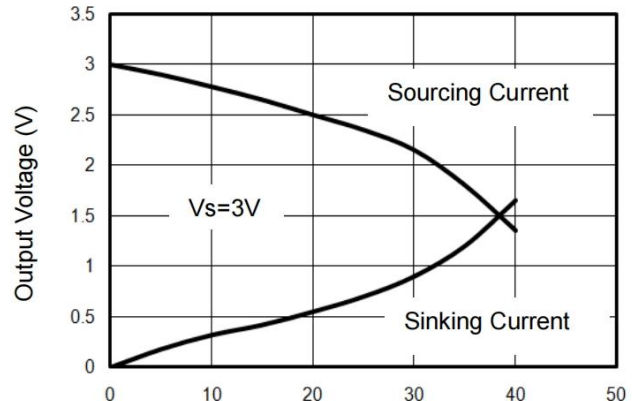
Supply Voltage (V)

Output Voltage vs. Output Current



Output Current (mA)

Output Voltage vs. Output Current



Output Current (mA)

## Application Note

### Size

HGV245X family series op amps are unity-gain stable and suitable for a wide range of general-purpose applications. The small footprints of the HGV245X family packages save space on printed circuit boards and enable the design of smaller electronic products.

### Power Supply Bypassing and Board Layout

HGV245X family series operates from a single 2.1V to 5.5V supply or dual  $\pm 1.05\text{V}$  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 (typical  $5.5\mu\text{A}$  per channel) of HGV245X family will help to maximize battery life. They are ideal for battery powered systems.

### Operating Voltage

HGV245X family operates under wide input supply voltage (2.1V to 5.5V). In addition, all temperature specifications apply from  $-40\text{ }^{\circ}\text{C}$  to  $+125\text{ }^{\circ}\text{C}$ . 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

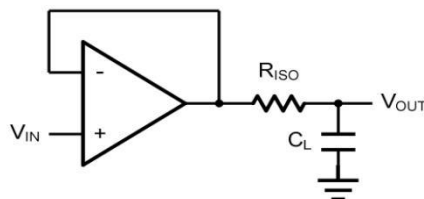
The input common-mode range of HGV245X family extends  $100\text{mV}$  beyond the supply rails ( $V_{\text{SS}}-0.1\text{V}$  to  $V_{\text{DD}}+0.1\text{V}$ ). This is achieved by using complementary input stage. For normal operation, inputs should be limited to this range.

### 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 HGV245X family can typically swing to less than  $10\text{mV}$  from supply rail in light resistive loads ( $>500\text{k}\Omega$ ), and  $30\text{mV}$  of supply rail in moderate resistive loads ( $100\text{k}\Omega$ ).

### Capacitive Load Tolerance

The HGV245X 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.

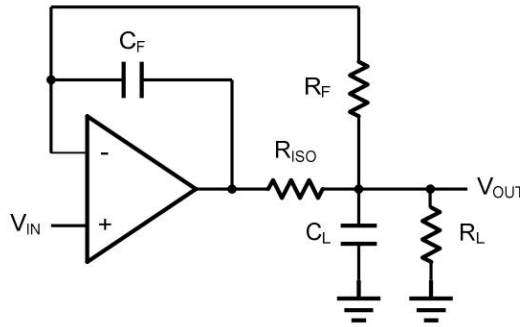


Figure 3. Indirectly Driving a Capacitive Load with DC Accuracy

## Typical Application Circuits

### Differential amplifier

The differential amplifier allows the subtraction of two input voltages or cancellation of a signal common 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 4. shown the differential amplifier using HGV245X family.

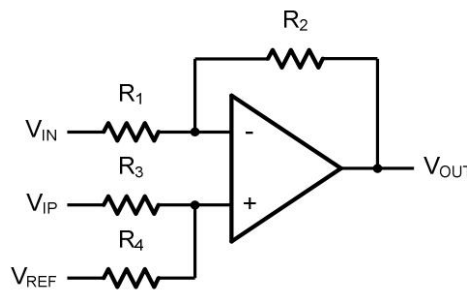


Figure 4. Differential Amplifier

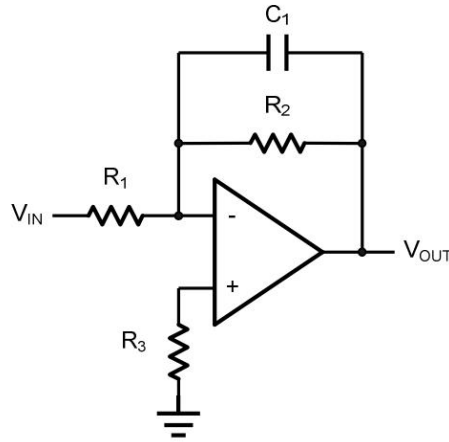
$$V_{OUT} = \left( \frac{R_1 + R_2}{R_3 + R_4} \right) \frac{R_4}{R_1} V_{IN} - \frac{R_2}{R_1} V_{IP} + \left( \frac{R_1 + R_2}{R_3 + R_4} \right) \frac{R_3}{R_1} V_{REF}$$

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**

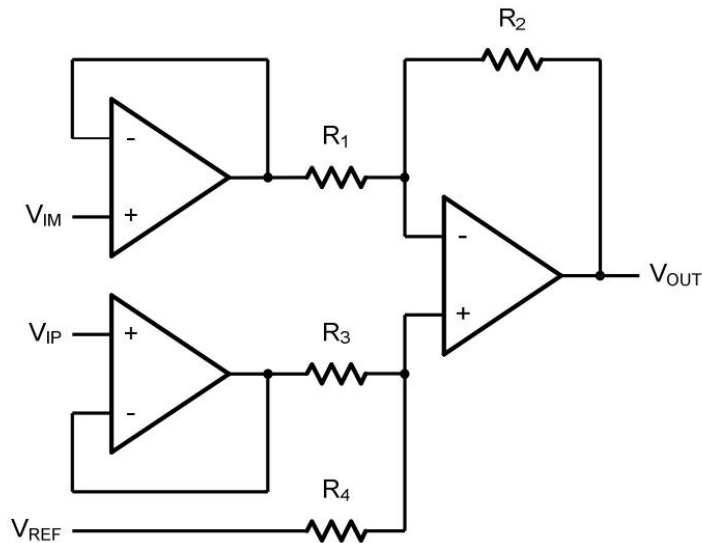
The low pass active filter is shown in Figure 5. The DC gain is defined by  $-R_2/R_1$ . The filter has a  $-20\text{dB/decade}$  roll-off after its corner frequency  $f_c=1/(2\pi R_3 C_1)$ .



**Figure 5. Low Pass Active Filter**

**Instrumentation Amplifier**

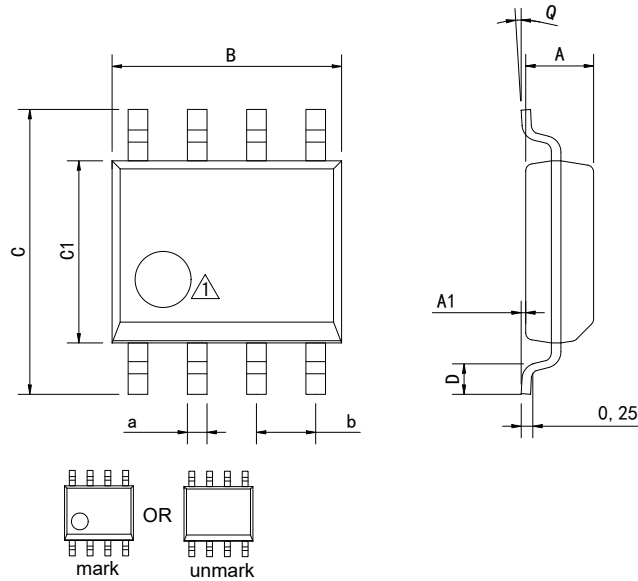
The triple HGV245X family can be used to build a three-op-amp instrumentation amplifier as shown in Figure 6. The amplifier in Figure 6 is a high input impedance differential amplifier with gain of  $R_2/R_1$ . The two differential voltage followers assure the high input impedance of the amplifier.




**Figure 6. Instrument Amplifier**

## Physical Dimensions

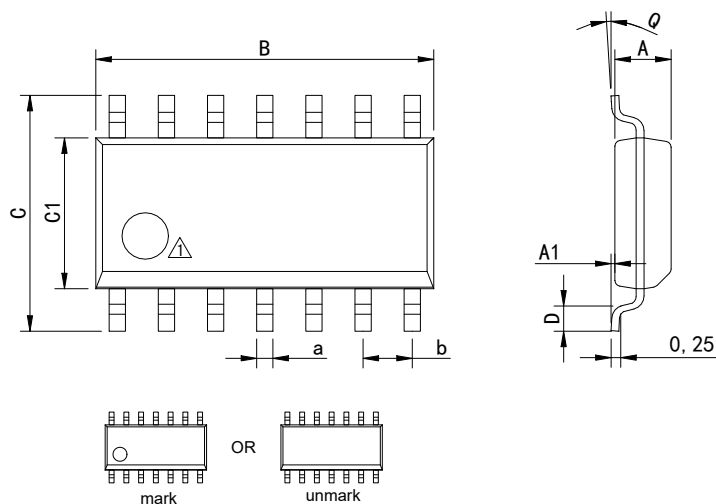
### SOP-8




 Package top mark may be in lower left corner or unmark

Dimensions In Millimeters(SOP-8)									
Symbol:	A	A1	B	C	C1	D	Q	a	b
Min:	1.35	0.05	4.90	5.80	3.80	0.40	0°	0.35	1.27 BSC
Max:	1.55	0.20	5.10	6.20	4.00	0.80	8°	0.45	

### SOP-14

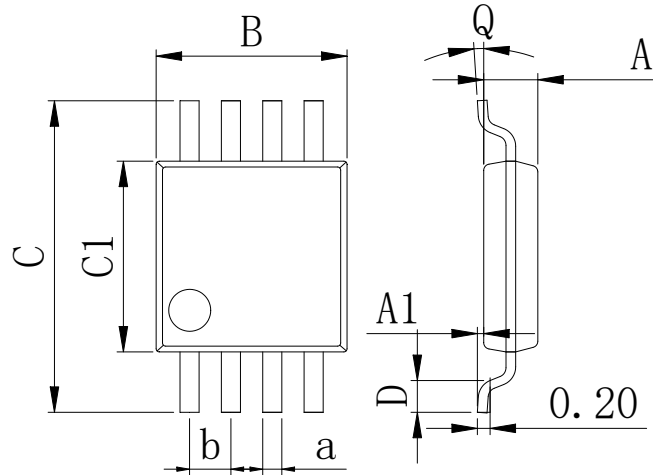


 Package top mark may be in lower left corner or unmark

Dimensions In Millimeters(SOP-14)									
Symbol:	A	A1	B	C	C1	D	Q	a	b
Min:	1.35	0.05	8.55	5.80	3.80	0.40	0°	0.35	1.27 BSC
Max:	1.55	0.20	8.75	6.20	4.00	0.80	8°	0.45	

## Physical Dimensions

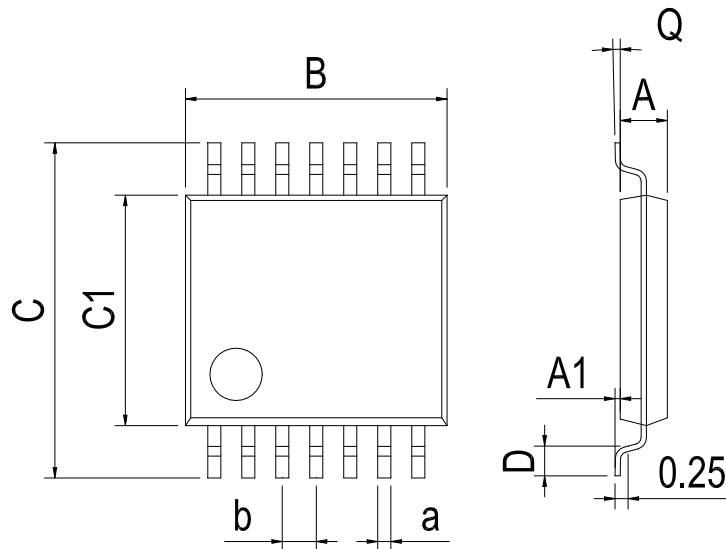
### MSOP-8



**Dimensions In Millimeters(MSOP-8)**

Symbol:	A	A1	B	C	C1	D	Q	a	b
Min:	0.80	0.05	2.90	4.75	2.90	0.35	0°	0.25	0.65 BSC
Max:	0.90	0.20	3.10	5.05	3.10	0.75	8°	0.35	

### TSSOP-14

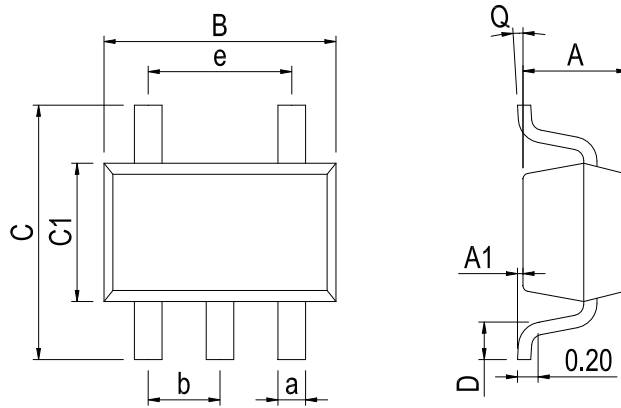


**Dimensions In Millimeters(TSSOP-14)**

Symbol:	A	A1	B	C	C1	D	Q	a	b
Min:	0.85	0.05	4.90	6.20	4.30	0.40	0°	0.20	0.65 BSC
Max:	0.95	0.20	5.10	6.60	4.50	0.80	8°	0.25	

**Physical Dimensions**

SOT-23-5



Dimensions In Millimeters(SOT-23-5)										
Symbol:	A	A1	B	C	C1	D	Q	a	b	e
Min:	1.00	0.00	2.82	2.65	1.50	0.30	0°	0.30	0.95 BSC	1.90 BSC
Max:	1.15	0.15	3.02	2.95	1.70	0.60	8°	0.50		

## Revision History

REVISION NUMBER	DATE	REVISION	PAGE
V1.0	2014-6	New	1-13
V1.1	2016-10	Update SOT-23-5 Physical dimension	11
V1.2	2024-10	Update Lead Temperature	3
V1.3	2025-12	Update important statements、 Update SOP-8 and SOP-14 Dimension drawing	9、 13

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