

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:
 - LPV321 Available in SOT23-5 Package
 - LPV358 Available in SOP-8 and MSOP-8 Packages
 - LPV324 Available in SOP-14 and TSSOP-14 Packages



Ordering Information

DEVICE	Package Type	MARKING	Packing	Packing Qty
LPV321M5/TR	SOT-23-5	A27A	REEL	3000pcs/box
LPV358M/TR	SOP-8	LPV358	REEL	2500pcs/reel
LPV358MM/TR	MSOP-8	P358	REEL	3000pcs/reel
LPV324M/TR	SOP-14	LPV324	REEL	2500pcs/reel
LPV324MT/TR	TSSOP-14	LPV324	REEL	2500pcs/reel

General Description

The LPV321/358/324 family have a high gain-bandwidth product of 150KHz, a slew rate of 0.07V/μs, and a quiescent current of 5.5μA/amplifier at 5V. The LPV321/358/324 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 LPV321/358/324 family. 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 LPV321 single is available in Green SOT-23-5 packages The LPV358 Dual is available in Green SOP-8 and MSOP-8 packages. The LPV324 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

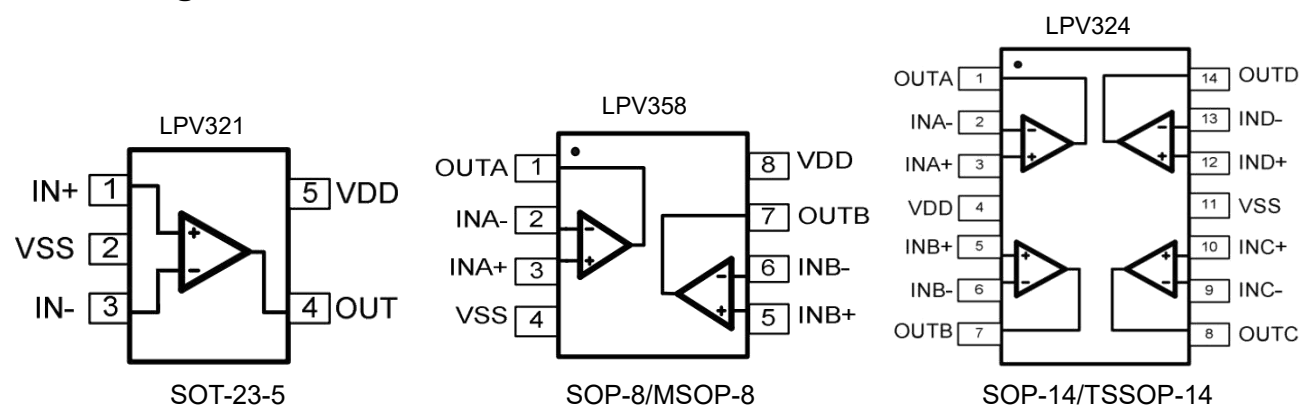


Figure 1. Pin Assignment Diagram

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 ⁽¹⁾	-40°C	+125°C
Junction Temperature	+160°C	
Storage Temperature Range	-55°C	+150°C
Lead Temperature (soldering, 10sec)	260°C	
Package Thermal Resistance (T _A =+25°C)		
SOP-8, θ _{JA}	125°C/W	
MSOP-8, θ _{JA}	216°C/W	
SOT23-5, θ _{JA}	190°C/W	
ESD Susceptibility		
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

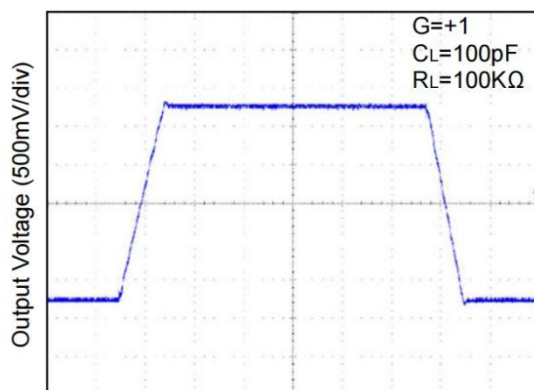
(At $V_S = +5V$, $R_L = 500k\Omega$ connected to $V_S/2$, and $V_{OUT} = V_S/2$, unless otherwise noted.)

PARAMETER	SYMBOL	CONDITIONS	TYP	MIN	MAX	UNITS
INPUT CHARACTERISTICS						
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 = 500kΩ, V _O = +0.1V to +4.9V	110	90		dB
		R _L = 100kΩ, V _O = +0.1V to +4.9V	108	88		
Input Offset Voltage Drift	ΔV _{OS} /ΔT		2			μV/°C
OUTPUT CHARACTERISTICS						
Output Voltage Swing from Rail	V _{OH}	R _L = 500kΩ	4.997	4.990		V
	V _{OL}	R _L = 500kΩ	3	10		mV
Output Current	I _{SOURCE}	R _L = 10Ω to V _S /2	58	40		mA
	I _{SINK}		58	40		
POWER SUPPLY						
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			μA
DYNAMIC PERFORMANCE						
Gain-Bandwidth Product	GBP		150			kHz
Slew Rate	SR	G = +1, 2V Output Step	0.07			V/μS
Settling Time to 0.1%	t _s	G = +1, 2V Output Step	30			μS
NOISE PERFORMANCE						
Voltage Noise Density	e _n	f = 1kHz	85			nV /√Hz
		f = 10kHz	44			nV /√Hz

Typical Performance characteristics

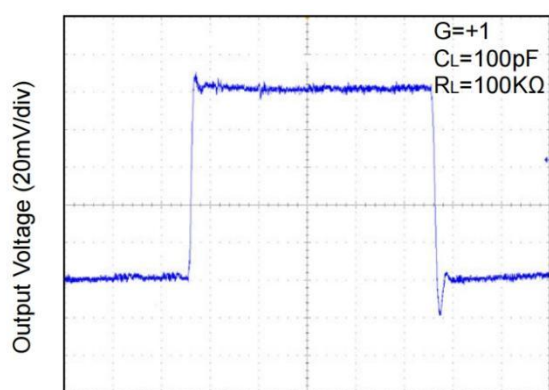
At $T_A=+25^{\circ}\text{C}$, $V_S=+5\text{V}$, and $R_L=500\text{K}\Omega$ connected to $V_S/2$, unless otherwise noted.

Large-Signal Step Response



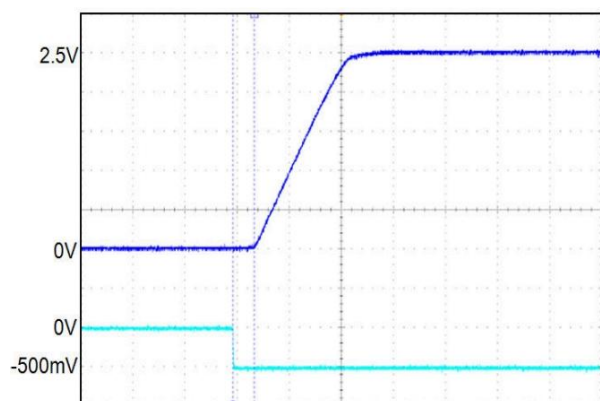
Time (40μs/div)

Small-Signal Step Response



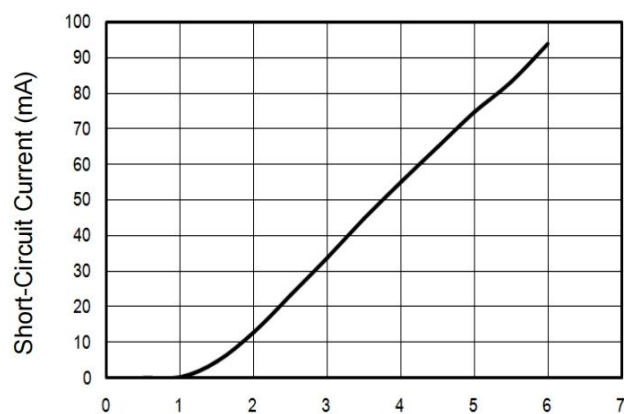
Time (20μs/div)

Overload Recovery Time



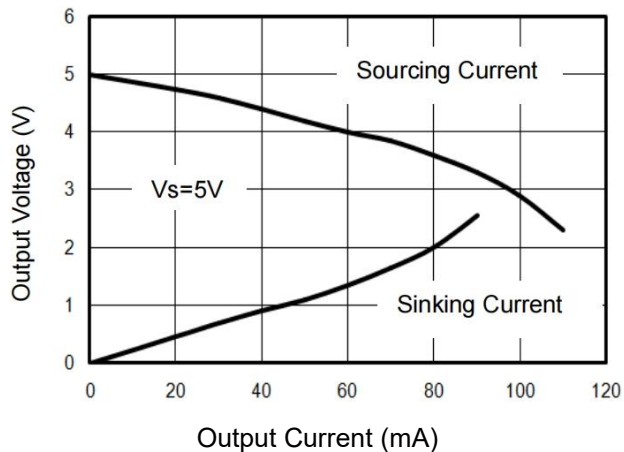
Time (20μs/div)

Short-Circuit Current vs. Supply Voltage

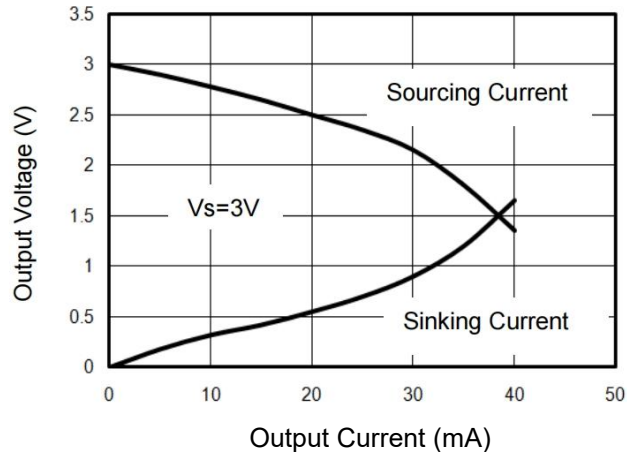


Supply Voltage (V)

Output Voltage vs. Output Current



Output Voltage vs. Output Current



Application Note

Size

LPV321/358/324 family series op amps are unity-gain stable and suitable for a wide range of general-purpose applications. The small footprints of the LPV321/358/324 family packages save space on printed circuit boards and enable the design of smaller electronic products.

Power Supply Bypassing and Board Layout

LPV321/358/324 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_{DD} pin in single supply operation. For dual supply operation, both V_{DD} and V_{SS} supplies should be bypassed to ground with separate $0.1\mu\text{F}$ ceramic capacitors.

Low Supply Current

The low supply current (typical $5.5\mu\text{A}$ per channel) of LPV321/358/324 family will help to maximize battery life. They are ideal for battery powered systems.

Operating Voltage

LPV321/358/324 family operates under wide input supply voltage (2.1V to 5.5V). In addition, all temperature specifications apply from -40°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 LPV321/358/324 family extends 100mV 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 LPV321/358/324 family can typically swing to less than 10mV from supply rail in light resistive loads ($>500\text{k}\Omega$), and 30mV of supply rail in moderate resistive loads ($100\text{k}\Omega$).

Capacitive Load Tolerance

The LPV321/358/324 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.

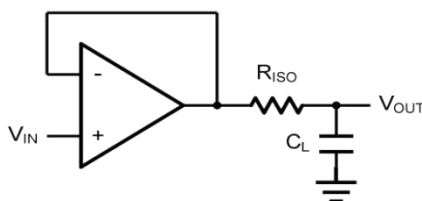


Figure 2. Indirectly Driving a Capacitive Load Using Isolation Resistor

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.

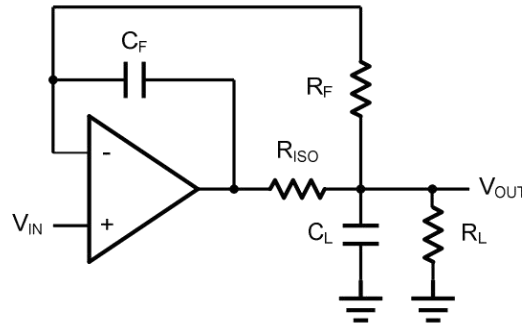


Figure 3. Indirectly Driving a Capacitive Load with DC Accuracy

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 LPV321/358/324 family.

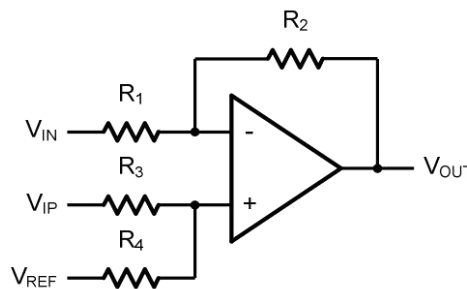


Figure 4. Differential Amplifier

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

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 -20dB/decade roll-off after its corner frequency $f_c = 1/(2\pi R_3 C_1)$.

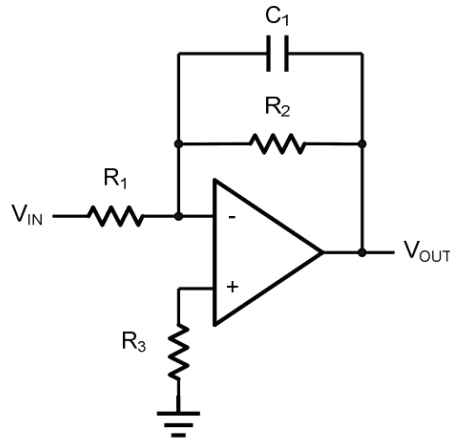


Figure 5. Low Pass Active Filter

Instrumentation Amplifier

The triple LPV321/358/324 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.

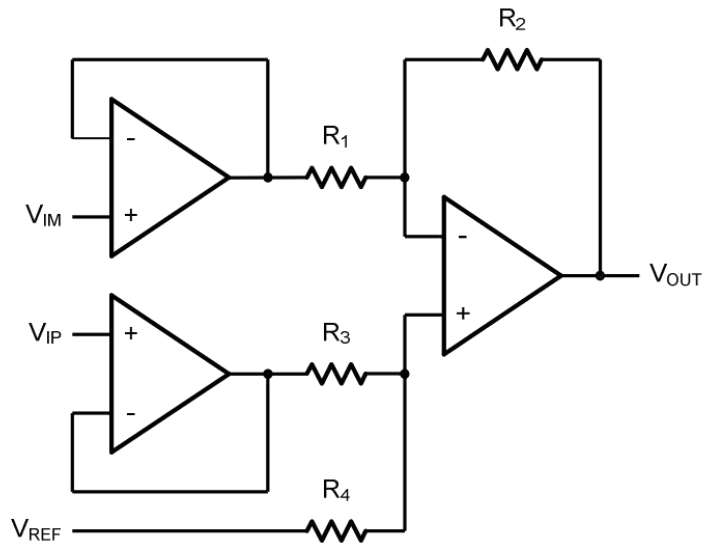
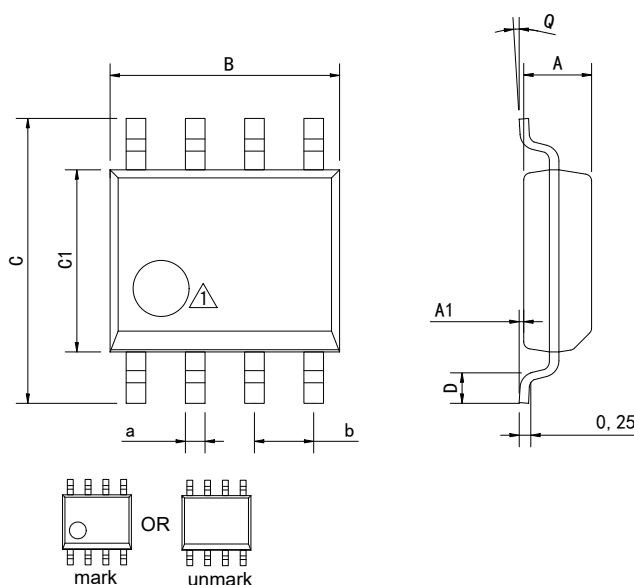


Figure 6. Instrument Amplifier

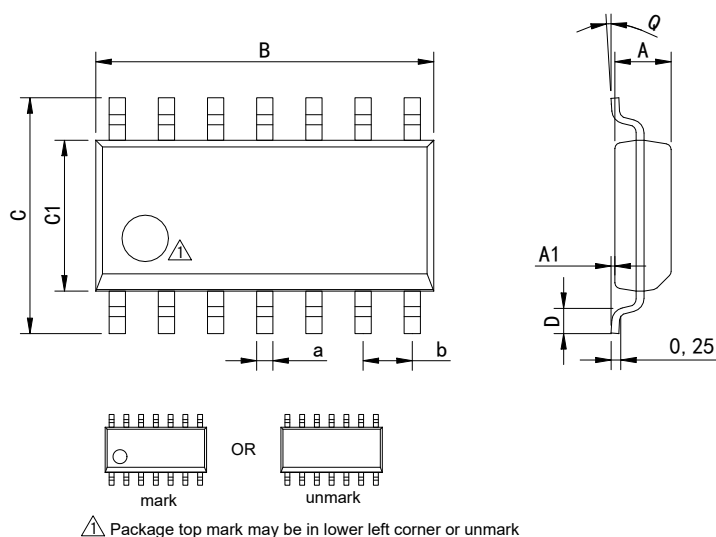
Physical Dimensions

SOP-8



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	

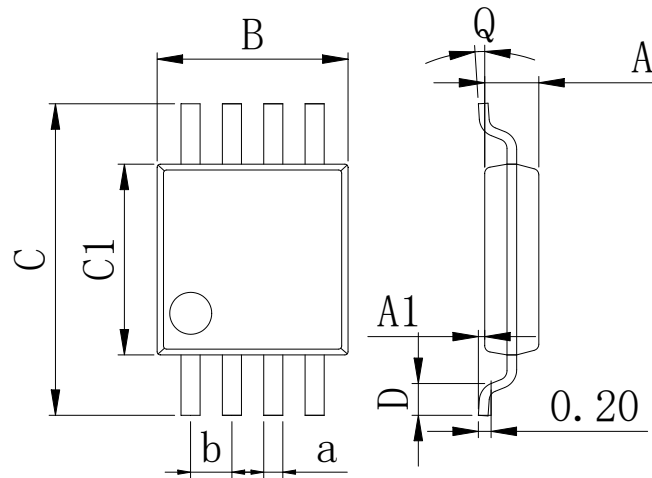
SOP-14



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

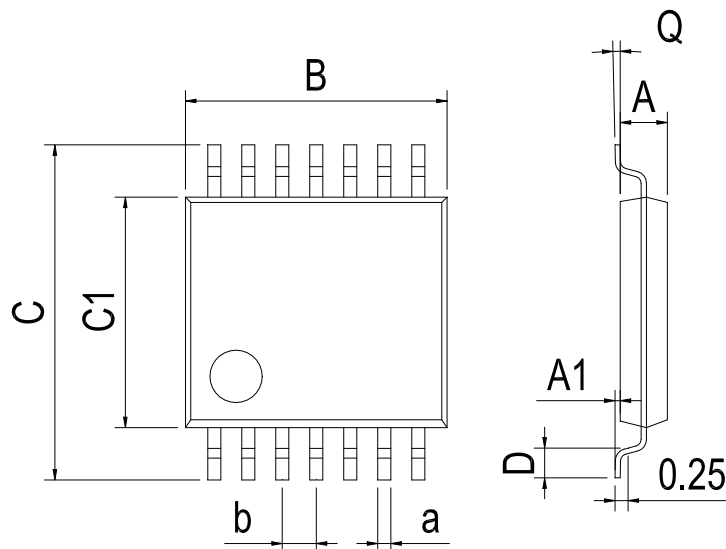
MSOP-8



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

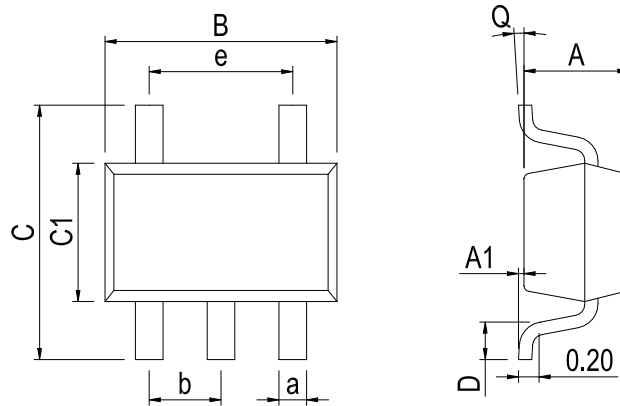


Dimensions In Millimeters(TSSOP-14)

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	2018-7	Document Reformatting	1-13
V1.2	2024-10	Update SOT-23-5 Physical dimension and Lead Temperature	11、 3
V1.3	2025-12	Update important statements、 Update SOP-8 and SOP-14 Dimension drawing	9、 13

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