High Voltage Low Power OPERATIONAL AMPLIFIERS

FEATURES

- **Input Offset Voltage：0.5mV (Typical)**
- **Low Supply Current：250μA/ch**
- **Supply Range：5V to 36V**
- **Gain Bandwidth：4MHz**
- **Slew rate: 2.3V/μs**
- **Rail-to-Rail Output**
- **Micro size Packages：**
  LM321：SOT23-5 SOP-8
  LM358：SOP-8 MSOP-8 TSSOP-8
  LM324：SOP-14 TSSOP-14

APPLICATIONS

- **Walkie-Talkie**
- **Battery Management Solution**
- **Transducer Amplifiers**
- **Multivibrators**
- **Summing Amplifiers**
- **Oscillators**

GENERAL DESCRIPTION

The LM321 (single), LM358 (dual) and LM324 (quad) are general purpose, low offset, high frequency response and low power operational amplifiers. With an excellent bandwidth of 4MHz, a slew rate of 2.3V/μs, and a quiescent current of 250μA per amplifier, the LM321/358/324 family can be designed into a wide range of applications.The input common-mode voltage range includes ground, These parts provide rail-to-rail output swing into heavy loads.

The LM321/358/324 families of operational amplifiers are specified at the full temperature range of -55°C to +125°C under single or dual power supplies of 5V to 36V.

TYPICAL APPLICATION

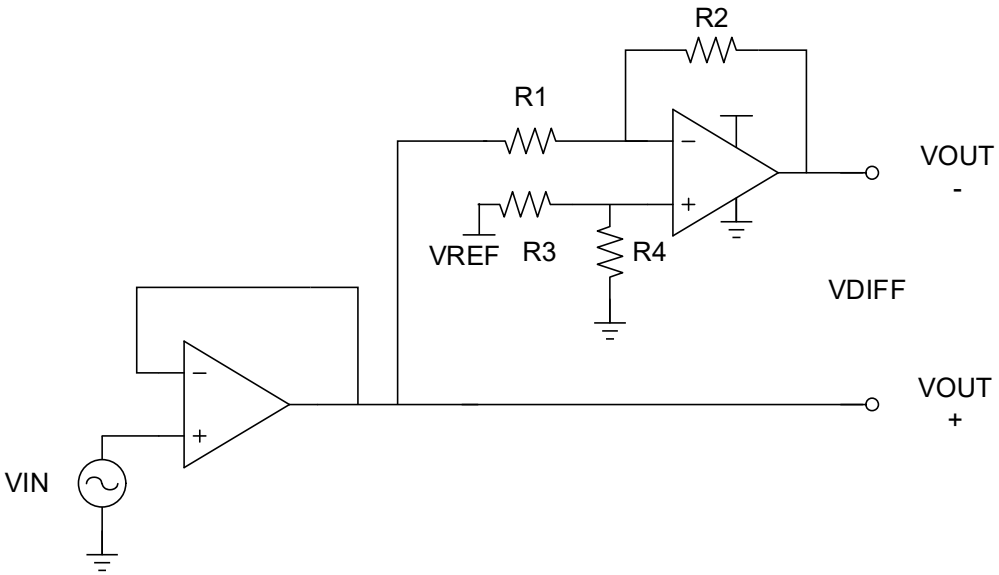


Figure 1. Typical Application

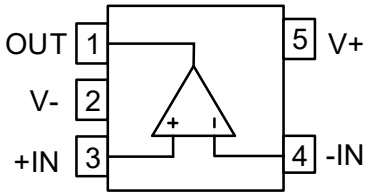
PACKAGE/ORDER INFORMATION

MODEL	Op Temp(°C)	ORDERING NUMBER	PACKAE DESCRIPTION
LM321	-55°C~125°C	LM321AC	SOT23-5
	-55°C~125°C	LM321AJ	SOIC-8 (SOP-8)
LM358	-55°C~125°C	LM358AJ	SOIC-8 (SOP-8)
	-55°C~125°C	LM358CK	MSOP-8
	-55°C~125°C	LM358CH	TSSOP-8
LM324	-55°C~125°C	LM324CJ	SOIC-14 (SOP-14)
	-55°C~125°C	LM324CG	TSSOP-14

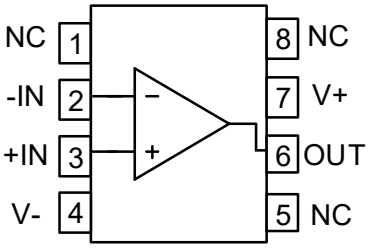
Pin Configuration and Functions (Top View)

Pin Description

SOT23-5



SOIC-8



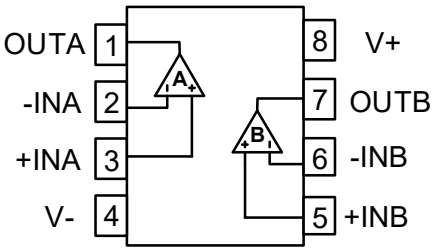
LM321

PIN			I/O	DESCRIPTION
NAME	SOT23-5	SOP-8		
+IN	1	3	I	Positive (noninverting) input
-IN	3	2	I	Negative (inverting) input
OUT	4	6	O	Output
V-	2	4	-	Positive (highest) power supply
V+	5	7	-	Negative (lowest) power supply

Pin Configuration and Functions (Top View)

Pin Description

SOIC-8/MSOP-8/TSSOP-8

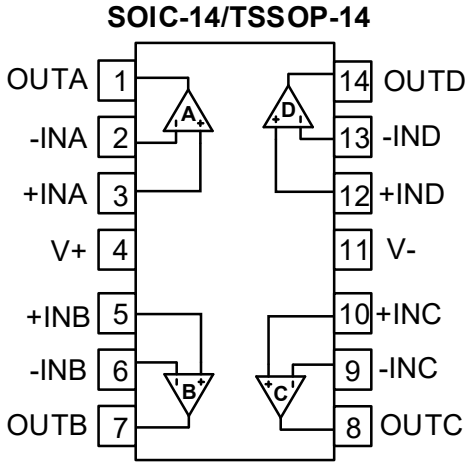


LM358

PIN		I/O	DESCRIPTION
NAME	Number		
+INA	3	I	Noninverting input, channel A
+INB	5	I	Noninverting input, channel B
-INA	2	I	Inverting input, channel A
-INB	6	I	Inverting input, channel B
OUTA	1	O	Output, channel A
OUTB	7	O	Output, channel B
V-	4	-	Negative (lowest) power supply
V+	8	-	Positive (highest) power supply

Pin Configuration and Functions (Top View)

Pin Description



LM324

PIN		I/O	DESCRIPTION
NAME	Number		
+INA	3	I	Noninverting input, channel A
+INB	5	I	Noninverting input, channel B
+INC	10	I	Noninverting input, channel C
+IND	12	I	Noninverting input, channel D
-INA	2	I	Inverting input, channel A
-INB	6	I	Inverting input, channel B
-INC	9	I	Inverting input, channel C
-IND	13	I	Inverting input, channel D
OUTA	1	O	Output, channel A
OUTB	7	O	Output, channel B
OUTC	8	O	Output, channel C
OUTD	14	O	Output, channel D
V-	4	-	Negative (lowest) power supply
V+	11	-	Positive (highest) power supply

SPECIFICATIONS

Absolute Maximum Ratings(1)

		MIN	MAX	UNIT
Voltage	Supply Voltage		40	V
	Signal Input Terminals Voltage(2)	(V-) - 0.5	(V+) + 0.5	V
	Signal Input Terminals Voltage(3)	(V-) - 0.5	(V+) + 0.5	V
Current	Signal Input Terminals Current(2)	-10	10	mA
	Signal output Terminals Current(3)	-200	200	mA
	Output Short-Circuit(4)	Continuous		
θ_{JA}	Operating Temperature Range	-55	125	°C
	Storage Temperature Range	-65	150	°C
	Junction Temperature	-40	150	°C

(1) Stresses above these ratings may cause permanent damage. Exposure to absolute maximum conditions for extended periods may degrade device reliability. These are stress ratings only, and functional operation of the device at these or any other conditions beyond those specified is not implied.

(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.

(3) Output terminals are diode-clamped to the power-supply rails. Output signals that can swing more than 0.5V beyond the supply rails should be current-limited to ±200mA or less.

(4) Short-circuit to ground, one amplifier per package.

ESD Ratings

			VALUE	UNIT
$V_{(ESD)}$	Electrostatic discharge	Human-Body Model (HBM)	±2000	V
		Charged-Device Model (CDM)	±500	V
		Machine Model	100	V

Recommended Operating Conditions

		MIN	MAX	UNIT
Supply voltage， Vs= (V+) - (V-）	Single-supply	5	36	V
	Dual-supply	±2.5	±18	V

ELECTRICAL CHARACTERISTICS (V_S = ±15V)

At T_A = 25°C, V_{CM}=V_{OUT}= V_S /2, unless otherwise noted.

PARAMETER		CONDITIONS	MIN	TYP	MAX	UNIT
OFFSET VOLTAGE						
V_{OS}	Input Offset Voltage			0.5	2.5	mV
dV_{OS}/dT	Input Offset Voltage Average Drift	T_A = -55°C to 125°C		2		µV/°C
INPUT CURRENT						
I_B	Input Bias Current			60		pA
I_{OS}	Input Offset Current			40		pA
NOISE						
V_N	Input Voltage Noise	f=0.1Hz to 10Hz		6.5		μV_{PP}
e_n	Input Voltage Noise Density	f=1kHz		40		nV/√Hz
INPUT VOLTAGE						
V_{CM}	Common-Mode Voltage Range		V_{S-}		V_{S+} - 0.7	V
CMRR	Common-Mode Rejection Ratio			120		dB
FREQUENCY RESPONSE						
GBW	Gain-Bandwidth Product			4		MHz
SR	Slew Rate	G = +1, V_{IN}=10V Step		2.3	3	V/µs
t_S	Settling Time to 0.1%	G = +1, V_{IN}=10V Step		1		us
OUTPUT						
A_V	Open-Loop Voltage Gain	V_{OUT}=-7.5V to 7.5V R_L=10kΩ		120		dB
V_{OH}	High Output Voltage Swing	R_L=10kΩ			29.5	V
V_{OL}	Low Output Voltage Swing	R_L=10kΩ	0.01			V
I_{SC}	Output Short-Circuit Current	Source current		50	70	mA
		Sink current		50	70	mA

POWER SUPPLY						
PSRR	Power-Supply Rejection Ratio	V_S=5V to 30V	110	120		dB
V_S	Operating Voltage Range		5		36	V
I_Q	Quiescent Current/Amplifier	I_O=0A		250		μA

Detailed Description

Overview

The LM321/358/324 devices are a low power, unity-gain stable operational amplifier that operate in a single-supply voltage range of 5V to 36V (±2.5V to ±18V). A high supply voltage of 40V (absolute maximum) can permanently damage the amplifier. Rail-to-rail output wobbles significantly increase the dynamic range, especially in low-supply applications. Good layout practices require that a 0.1uF capacitor be used where it is tightly threaded through the power supply pin.

Phase Reversal Protection

The LM321/358/324 devices have internal phase-reversal protection. Many op amps exhibit phase reversal when the input is driven beyond the linear common-mode range. This condition is most often encountered in noninverting circuits when the input is driven beyond the specified common-mode voltage range, causing the output to reverse into the opposite rail. The input of the LM321/358/324 prevents phase reversal with excessive commonmode voltage. Instead, the appropriate rail limits the output voltage.

Typical Applications

1 Voltage Follower

As shown in Figure 2, the voltage gain is 1. With this circuit, the output voltage V_{OUT} is configured to be equal to the input voltage V_{IN}. Due to the high input impedance and low output impedance, the circuit can also stabilize the output voltage, the output voltage expression is

$$V_{OUT}=V_{IN} \quad (1)$$

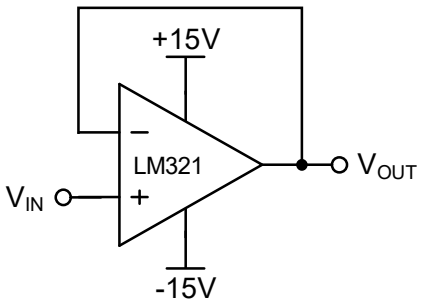


Figure 2. Voltage Follower

2 Inverting Proportional Amplifier

As shown in Figure 3, for a reverse-phase proportional amplifier, the input voltage V_{IN} is amplified by a voltage gain that depends on the ratio of R1 to R2. The output voltage V_{OUT} is inversely with the input voltage V_{IN}. The input impedance of the circuit is equal to R1, and the output voltage expression is

$$V_{OUT}=-\frac{R2}{R1}V_{IN} \quad (2)$$

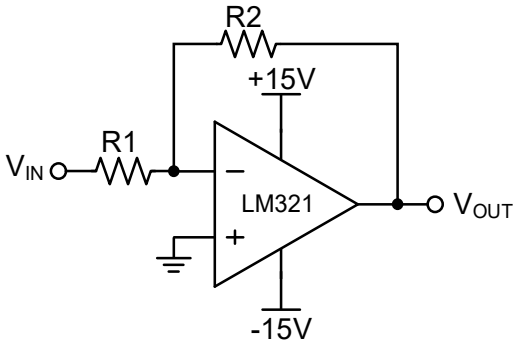


Figure 3. Inverting Proportional Amplifier

3 Noninverting Proportional Amplifier

As shown in Figure 4, for a noninverting amplifier, the input voltage V_{IN} is amplified by a voltage gain that depends on the ratio of R1 to R2. The output voltage V_{OUT} is in phase with the input voltage V_{IN}. In fact, this circuit has a high input impedance because its input side is the same as the input side of the operational amplifier. The output voltage expression is

$$V_{OUT}=(1+\frac{R2}{R1})V_{IN} \quad (3)$$

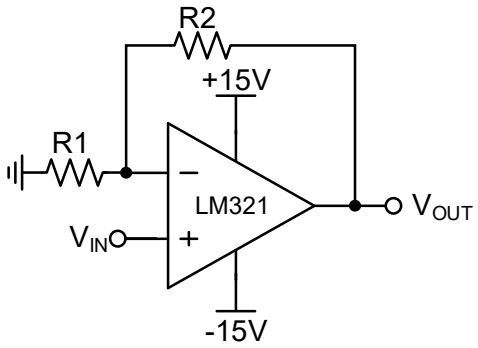


Figure 4. Noninverting Proportional Amplifier

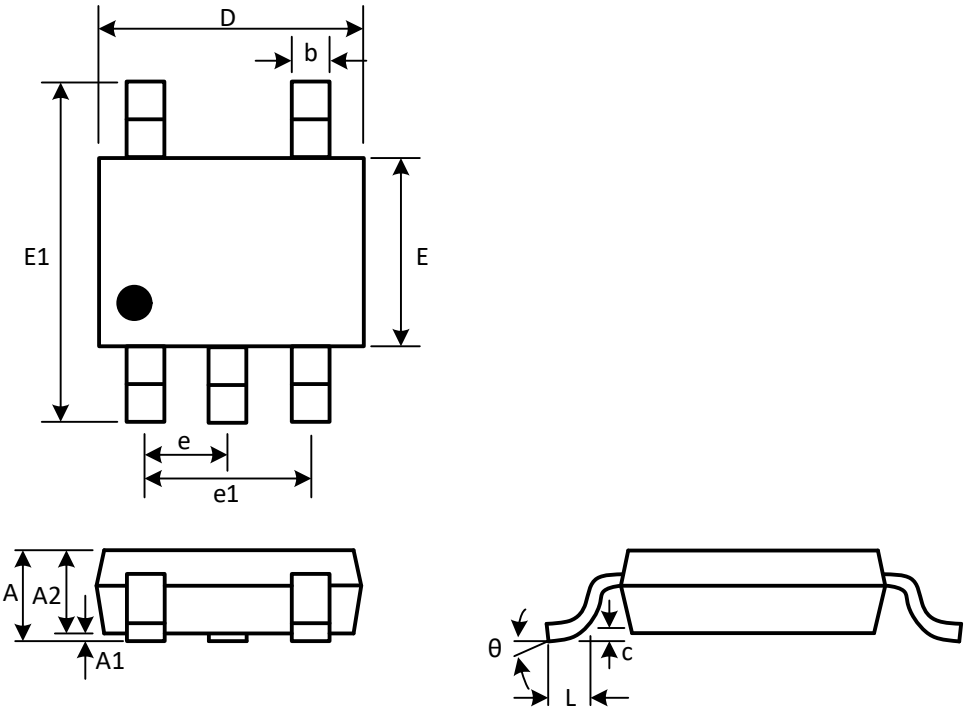
Layout Guidelines

Attention to good layout practices is always recommended. Keep traces short. When possible, use a PCB ground plane with surface-mount components placed as close to the device pins as possible. Place a 0.1uF capacitor closely across the supply pins.

These guidelines should be applied throughout the analog circuit to improve performance and provide benefits such as reducing the EMI susceptibility.

PACKAGE DESCRIPTION

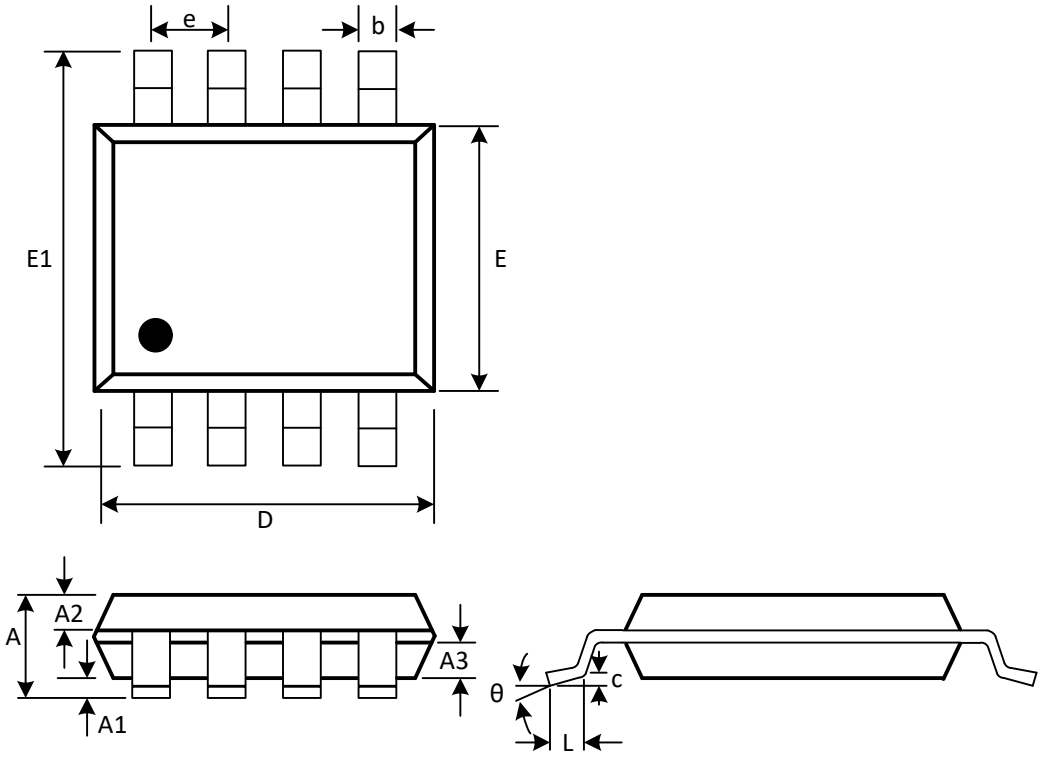
SOT23-5



(Unit: mm)

Symbol	Min	Max
A	1.050	1.250
A1	0.000	0.100
A2	1.050	1.150
b	0.300	0.500
c	0.100	0.200
D	2.820	3.020
e	0.950(BSC)	
e1	1.800	2.000
E	1.500	1.700
E1	2.650	2.950
L	0.300	0.600
θ	0°	8°

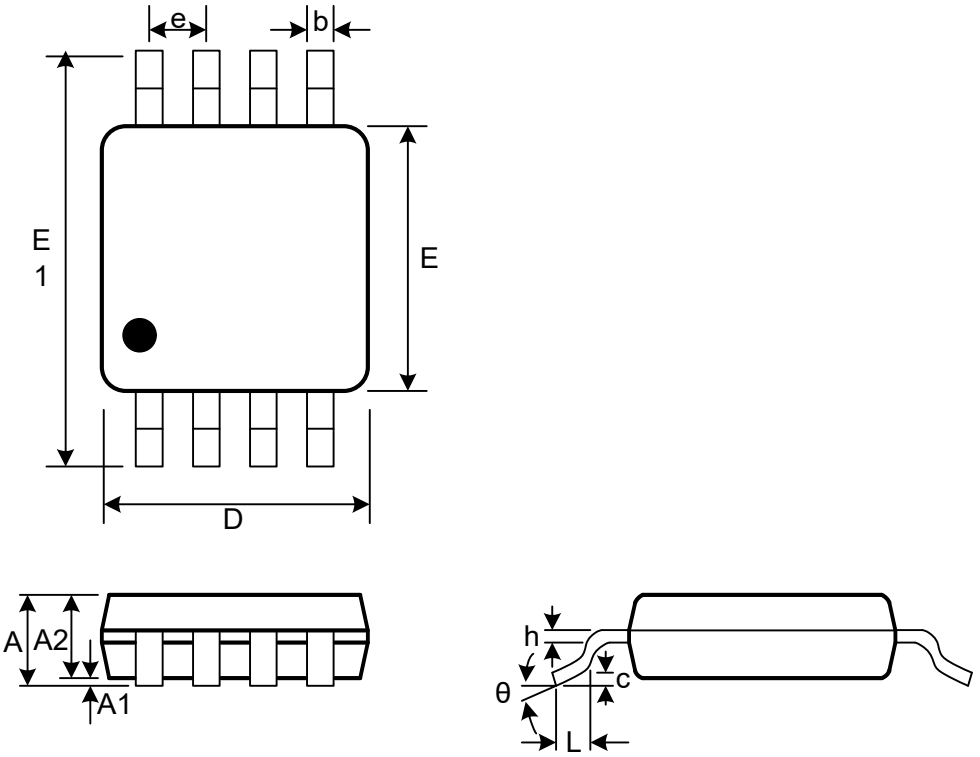
SOP-8



(Unit: mm)

Symbol	Min	Max
A	1.300	1.600
A1	0.050	0.200
A2	0.550	0.650
A3	0.550	0.650
b	0.356	0.456
c	0.203	0.233
D	4.800	5.000
e	1.270(BSC)	
E	3.800	4.000
E1	5.800	6.200
L	0.400	0.800
θ	0°	8°

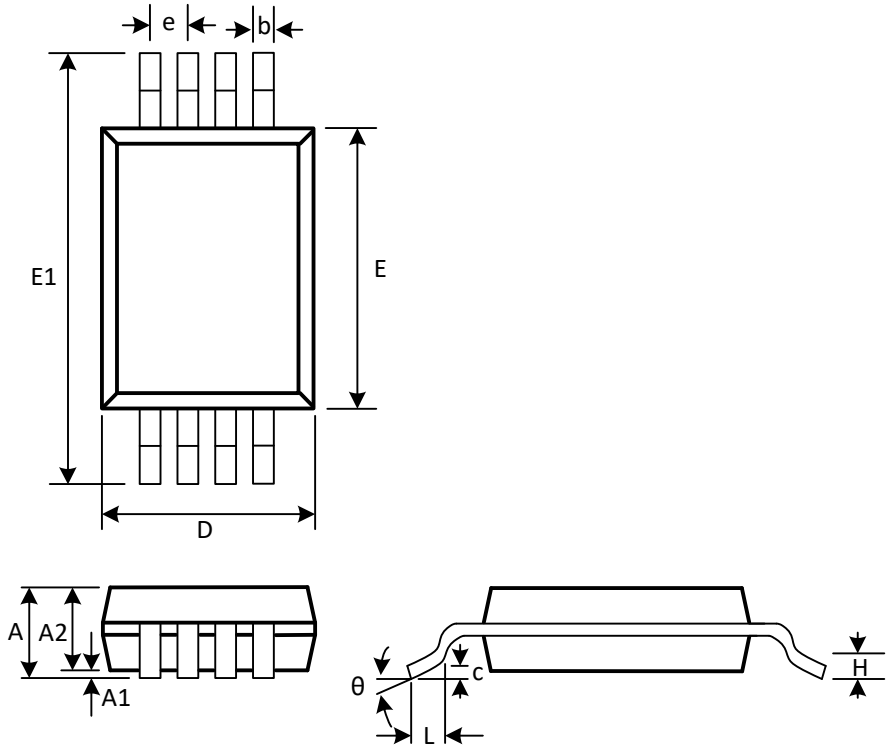
MSOP-8



(Unit: mm)

Symbol	Min	Max
A		1.100
A1	0.050	0.150
A2		0.950
b	0.250	0.380
c	0.250	
D	2.900	3.100
e	0.650(BSC)	
E	2.900	3.100
E1	4.750	5.050
h	0.130	0.230
L	0.400	0.700
θ	0°	8°

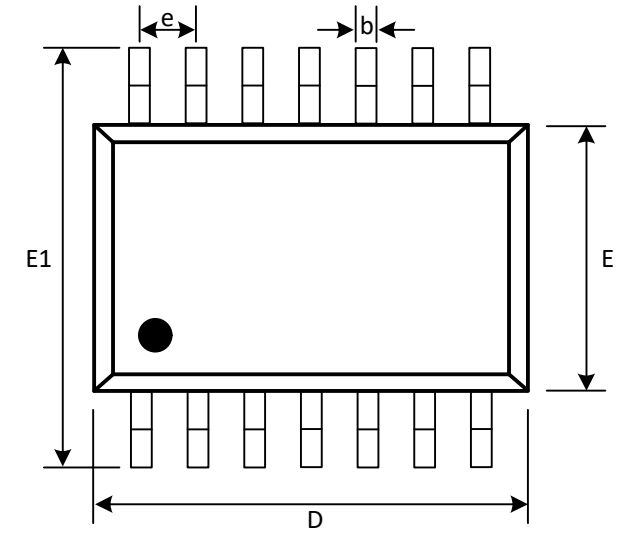
TSSOP-8

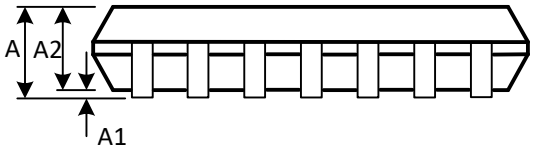


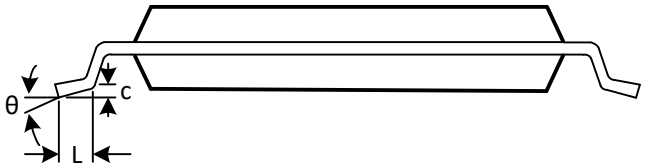
(Unit：mm)

Symbol	Min	Max
A		1.100
A1	0.050	0.150
A2	0.800	1.000
b	0.190	0.300
c	0.090	0.200
D	2.900	3.100
e	0.650(BSC)	
E	4.300	4.500
E1	6.250	6.550
H	0.250	
L	0.500	0.700
θ	1°	7°

SOIC-14(SOP-14)



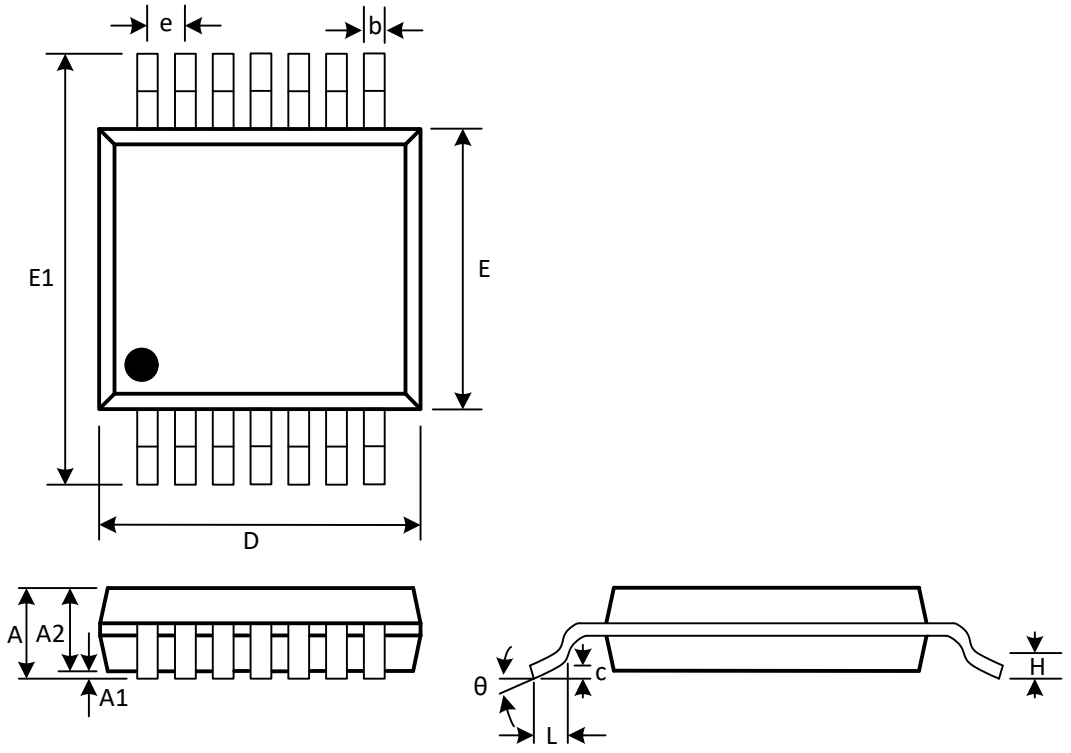




(Unit：mm)

Symbol	Min	Max
A	1.350	1.750
A1	0.100	0.250
A2	1.350	1.550
b	0.310	0.510
c	0.100	0.250
D	8.450	8.850
e	1.270(BSC)	
E	5.800	6.200
E1	3.800	4.000
L	0.400	1.270
θ	0°	8°

TSSOP-14



(Unit：mm)

Symbol	Min	Max
A		1.200
A1	0.050	0.150
A2	0.800	1.050
b	0.190	0.300
c	0.090	0.200
D	4.860	5.100
e	0.650(BSC)	
E	4.300	4.500
E1	6.250	6.550
L	0.500	0.700
	0.250(TYP)	
θ	1°	7°