# 1MHz, 35uA, Single/Dual/Quad Rail-to-Rail Input and Output CMOS Operational Amplifier

## Features

- Rail-to-Rail Input and Output
- Unit Gain Stable
- Supply Voltage Range: 2.2V to 5.5V
- Thermal Shutdown Protection Circuitry
- Low Input Offset Voltage
  0.9mV typical
- Gain Bandwidth Product: 1.0MHz
- Slew Rate: 0.7V/us
- Micro Power
  35uA/Amplifier Typical Supply Current
- Small Packaging:
  Available in Green SOT/SOP/DFN Package

## Applications

- Active Filters
- Photodiode Amplifier
- Piezoelectric Sensors
- Test Equipment
- Medical Instrumentation
- Audio Output
- Portable Systems
- Smoke Detectors
- Notebook PC
- Mobile Communication
- Sensor Interface
- Battery Equipment
- DSP Interface
- ASIC Input
- A/D Output Amplifier

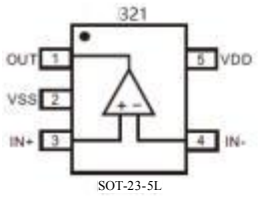
## Descriptions

The 321,358,324 families of products are single/dual/quad rail-to-rail input and output operational amplifier offering low cost and high performance. They have a wide input common-mode voltage range and output voltage swing, running at single supply voltage from 2.2V to 5.5V.

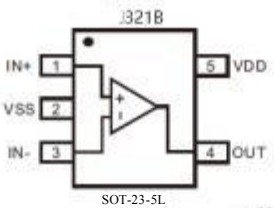
The op-amps provide 1MHz bandwidth at a low current consumption of 35uA per amplifier, offering excellent overall performance. The op-amps exhibit low noise and distortion, low offset and high output current capability, making this device an excellent choice for sensor interface, active filter, low voltage or battery operated systems.

The 321,358,324 families of products are offered in Green SOT/SOP/DFN packages ,and are specified over the extended -4 ℃ to +125 ℃ temperature range.

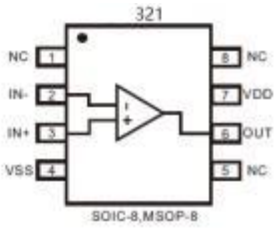
## Pin Configurations



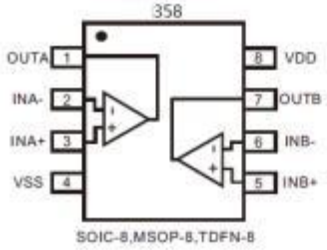
SOT-23-5L



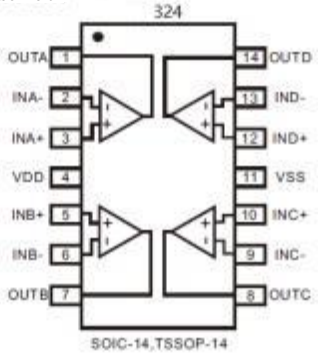
SOT-23-5L



SOIC-8,MSOP-8



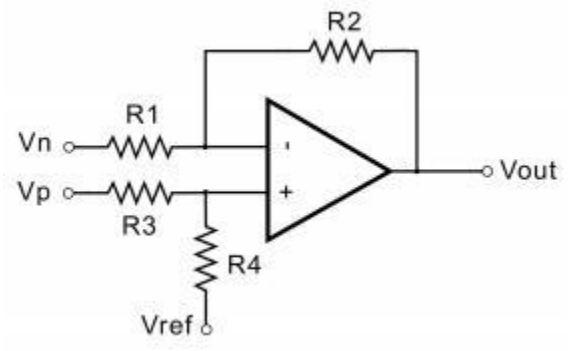
SOIC-8,MSOP-8,TDFN-8



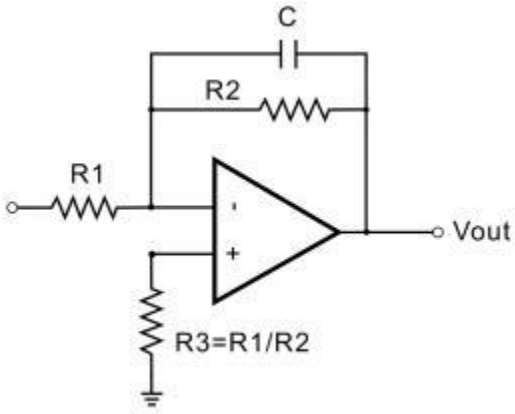
SOIC-14,TSSOP-14

Note: NC=No Connect

### Typical Application Circuit




**Difference Amplifier**




**Low Pass Active Filter**

## Ordering Information

| Order Part Number | Top Marking | Pb-Free | $T_A$ | Package | |
|---|---|---|---|---|---|
| LMV321 | XXXXX | Yes | -40 to +125°C | SOT-23-5L | Tape & Reel, 3000 |
| LMV321 | XXXXX | Yes | -40 to +125°C | SOT-23-5L | Tape & Reel, 3000 |
| LMV321 | XXXXX | Yes | -40 to +125°C | SOIC-8 | Tape & Reel, 4000 |
| LMV358 | XXXXX | Yes | -40 to +125°C | SOIC-8 | Tape & Reel, 4000 |
| LMV358 | XXXXX | Yes | -40 to +125°C | MSOP-8 | Tape & Reel, 4000 |
| LMV358 | XXXXX | Yes | -40 to +125°C | TDFN-8 | Tape & Reel, 5000 |
| LMV324 | XXXXX | Yes | -40 to +125°C | SOP-14 | Tape & Reel, 4000 |
| LMV324 | XXXXX | Yes | -40 to +125°C | TSSOP-14 | Tape & Reel, 4000 |

## Absolute Maximum Ratings

Stresses beyond those listed under "Absolute Maximum Rating" may cause permanent damage to the device. These are stress ratings only and functional operation of the device at these or any other condition beyond those indicated in the operational sections of the specifications is not implied. Exposure to absolute maxim rating conditions for extended periods may affect device reliability.

| Parameter | Rating | Unit |
|---|---|---|
| Supply Voltage, +VS to -VS | 6 | V |
| Common-Mode Input Voltage | -0.1 to 6.0 | V |
| Package Thermal Resistance (θJA) | 82 | °C/W |
| Junction Temperature Range | 160 | °C |
| Lead Temperature (***Soldering***, 10 sec.) | 260 | °C |
| Storage Temperature Range | -65 to 150 | °C |
| ESD HBM (Human Body Mode) | 8 | KV |
| ESD MM (Machine Mode) | 400 | V |
| Operating Temperature Range... | -40 to 125 | V |

## Recommend Operating Conditions

The Recommended Operating Conditions table defines the conditions for actual device operation to ensure optimal performance to the datasheet specifications. Do not recommend exceeding them or designing to Absolute Maximum Ratings.

| Parameter | Min. | Typ. | Max. | Unit |
|---|---|---|---|---|
| Supply Input Voltage | 2.2 | | 5.5 | V |
| Junction Temperature Range | -40 | | 125 | V |
| Ambient Temperature Range | -40 | | 85 | ℃ |

## Electrical Characteristics: VS = +5V

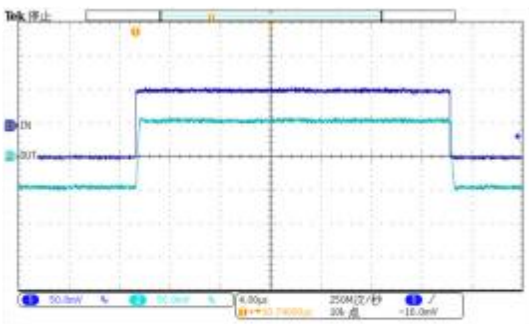
(At $V_S$ = 5V, $T_A$ = +25℃, $R_L$ = 100kΩ connected to $V_S$/2, unless otherwise noted)

| Parameter | Test Conditions | Min. | Typ. | Max. | Unit |
|---|---|---|---|---|---|
| **DYNAMIC PERFORMANCE** | | | | | |
| Gain-Bandwidth Product (GBP) | RL = 100kΩ | | 1.0 | | MHz |
| Slew Rate | 2Vpp Step, AV = 1 | | 0.7 | | V/us |
| Settling Time to 0.1% (Ts) | 0.2Vpp Step, AV = 1 | | 1 | | us |
| Overload Recovery Time | Gain=10X, VIN=250mVpp | | 6 | | us |
| **DC PERFORMANCE** | | | | | |
| Input Offset Voltage (VOS) | VCM = 2.5V | -1.5 | 0.9 | 1.5 | mV |
| Input Offset Voltage Drift | RL = 100kΩ, VOUT = 0.15V to | | | 5 | uV/deg |
| Large Signal Voltage Gain (AVO) | 4.85V | | 110 | | dB |
| **INPUT CHARACTERISTICS** | | | | | |
| Input Common Mode Voltage Range (VCM) | VCM = -0.1V to VCC +0.1V | -0.1 | | 5.6 | V |
| Common Mode Rejection Ratio (CMRR) | VCM = -0.1V to VCC+0.1V | | 100 | | dB |
| **OUTPUT CHARACTERISTICS** | | | | | |
| Output Voltage Swing from Rail | RL=100K | | 0.001 | | V |
| | RL=10K | | 0.01 | | V |
| Output Current (IOUT) | | | 30 | | mA |
| **POWER SUPPLY** | | | | | |
| Operating Voltage Range | IOUT = 0mA | 2.2 | | 5.5 | V |
| Quiescent Current (per Amplifier) | VS = 5V, | | 35 | | uA |
| Power Supply Rejection Ratio (PSRR) | VCM = (-VS) + 0.5V | | 85 | | dB |
| **NOISE/DISTORTION PERFORMANCE** | | | | | |
| Voltage Noise Density (en) | F=1kHz | | 50 | | nV/rtHz |
| | f=10kHz | | 45 | | nV/rtHz |
| Total Harmonic Distortion (THD) | 10kHz,G=+1,RL=100K | | 0.0007 | | % |

**Note 1**: Stresses listed as the above "Absolute Maximum Ratings" may cause permanent damage to the device. These are for stress ratings. Functional operation of the device at these or any other conditions beyond those indicated in the operational sections of the specifications is not implied. Exposure to absolute maximum rating conditions for extended periods may remain possibility to affect device reliability.

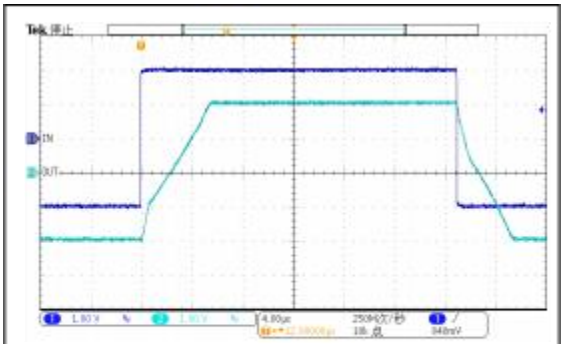
# Typical Performance Characteristics

**At TA = +25C, Vs=+-2.5V, RL = 100kΩ connected to GND, unless otherwise noted.**



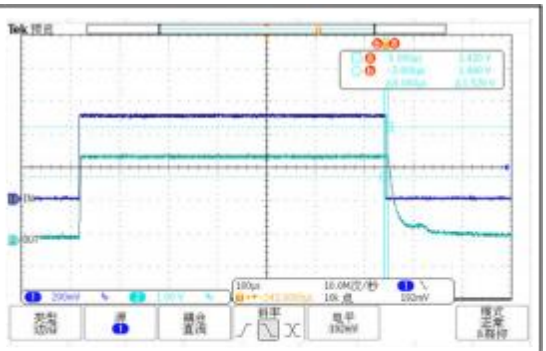
Small Signal Response

V+=2.5V,V-=-2.5V ，G=1, CL=100pF, RL=100kOhm to GND



Large Signal Response

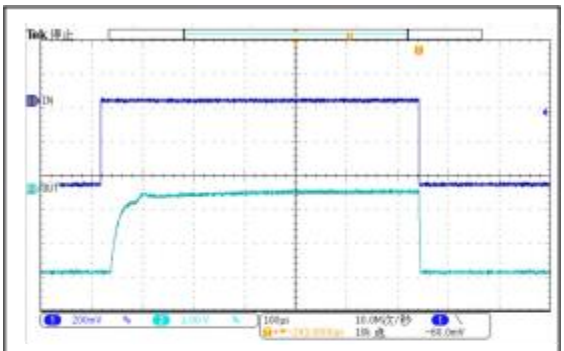
V+=2.5V,V-=-2.5V ，G=1, CL=100pF, RL=100kOhm to GND



Positive Overload Recovery

V+=2.5V, V-=-2.5V, CL=100pF, RL=100kOhm to GND

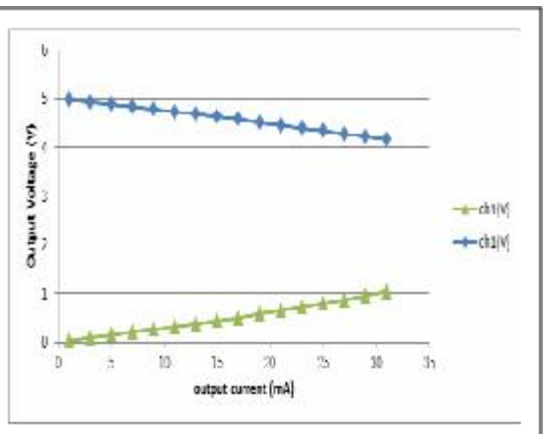
G=100



Negative Overload Recovery

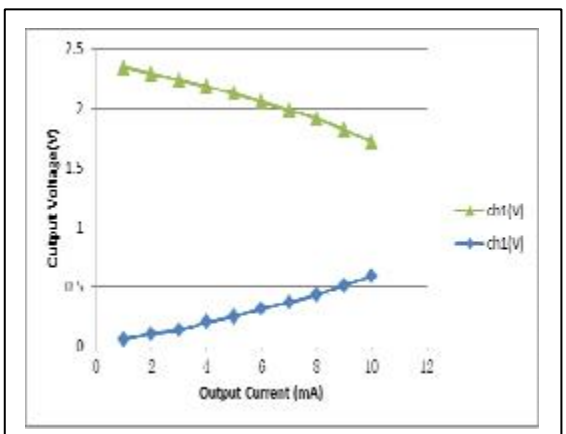
V+=2.5V, V-=-2.5V, CL=100pF, RL=100kOhm to GND,

G=100



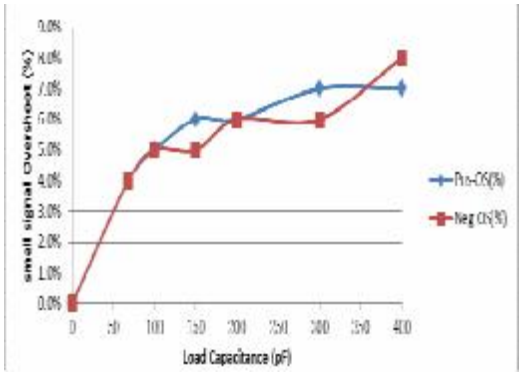

Output Voltage Swing vs Output Current

V+=2.5V, V-=-2.5V, CL=100pF, RL=100kOhm to GND



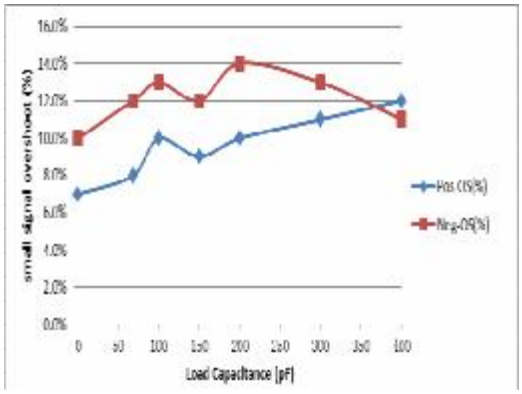

Output Voltage Swing vs Output Current

V+=1.2V, V-=-1.2V, CL=100pF, RL=100kOhm to GND



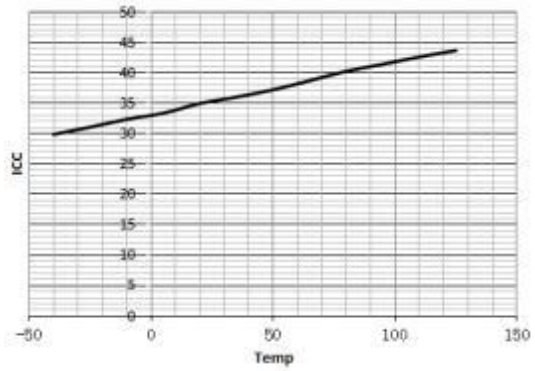

Overshoot (OS) vs Load Capacitance

V+=2.5V ,V-=-2.5V, RL=100kOhm to GND



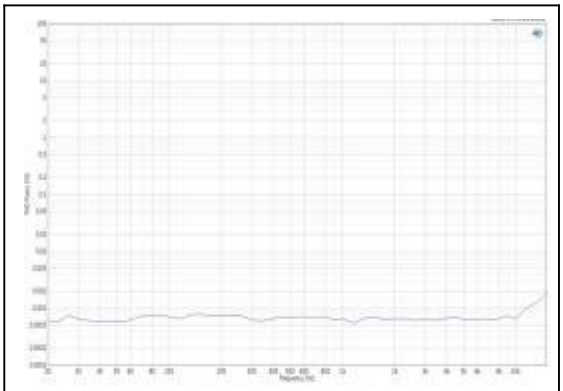

Overshoot (OS) vs Load Capacitance

V+=1.2V ,V-=-1.2V, RL=100kOhm to GND




ICC vs Temp

V+=2.5V ,V-=-2.5V, CL=100pf RL=100kOhm to GND



THD vs Frequency

V+=2.5V ,V-=-2.5V, Vin=1Vpp, CL=100pf RL=100kOhm to GND

## Power Supply Layout and Bypass

The 321,358,324 OPA's power supply pin (VDD for single-supply) should have a local bypass capacitor (i.e., 0.01μF to 0.1μF) within 2mm for good high frequency performance. It can also use a bulk capacitor (i.e., 1μF or larger) within 100mm to provide large, slow currents. This bulk capacitor can be shared with other analog parts. Ground layout improves performance by decreasing the amount of stray capacitance and noise at the OPA's inputs and outputs. To decrease stray capacitance, minimize PC board lengths and resistor leads, and place external components as close to the op amps' pins as possible.

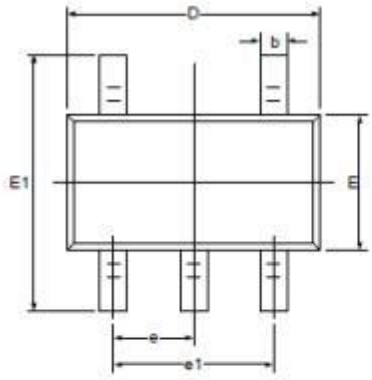
## Proper Board Layout

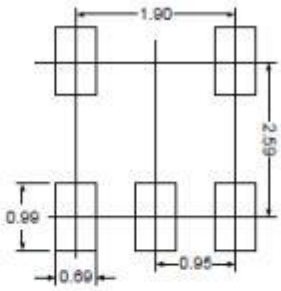
To ensure optimum performance at the PCB level, care must be taken in the design of the board layout. To avoid leakage currents, the surface of the board should be kept clean and free of moisture. Coating the surface creates a barrier to moisture accumulation and helps reduce parasitic resistance on the board. Keeping supply traces short and properly bypassing the power supplies minimizes power supply disturbances due to output current variation, such as when driving an ac signal into a heavy load. Bypass capacitors should be connected as closely as possible to the device supply pins. Stray capacitances are a concern at the outputs and the inputs of the amplifier. It is recommended that signal traces be kept at least 5mm from supply lines to minimize coupling.

A variation in temperature across the PCB can cause a mismatch in the feedback voltages at solder joints and other points where dissimilar metals are in contact, resulting in thermal voltage errors. To minimize these thermocouple effects, orient resistors so heat sources warm both ends equally. Input signal paths should contain matching numbers and types of components, where possible to match the number and type of thermocouple junctions. For example, dummy components such as zero value resistors can be used to match real resistors in the opposite input path. Matching components should be located in close proximity and should be oriented in the same manner. Ensure leads are of equal length so that thermal conduction is in equilibrium. Keep heat sources on the PCB as far away from amplifier input circuitry as is practical.

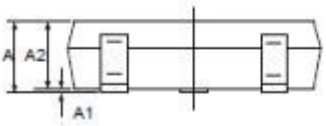
The use of a ground plane is highly recommended. A ground plane reduces EMI noise and also helps to maintain a constant temperature across the circuit board.

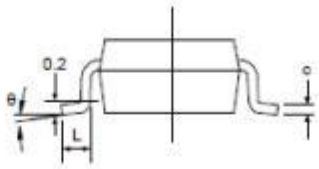
**Package Outline And Physical Dimensions: SOT-23-5L**



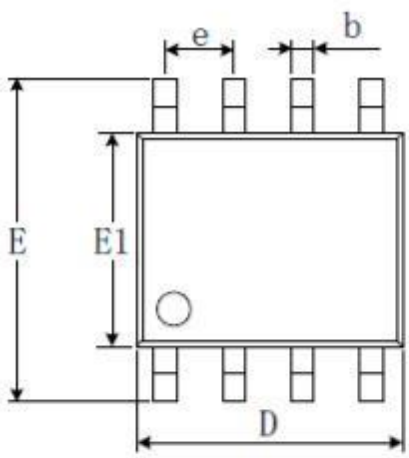

RECOMMENDED LAND PATTERN (Unit: mm)

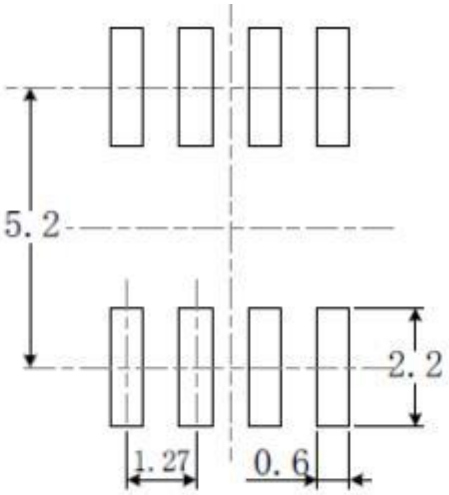


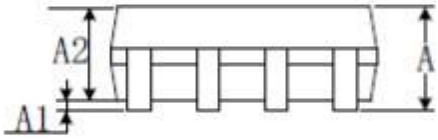

| Symbol | Dimensions In Millimeters | | Dimensions In Inches | |
|---|---|---|---|---|
| | Min | Max | Min | Max |
| A | 1.050 | 1.250 | 0.041 | 0.049 |
| A1 | 0.000 | 0.100 | 0.000 | 0.004 |
| A2 | 1.050 | 1.150 | 0.041 | 0.045 |
| b | 0.300 | 0.500 | 0.012 | 0.020 |
| c | 0.100 | 0.200 | 0.004 | 0.008 |
| 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 |
| θ | 0° | 8° | 0° | 8° |

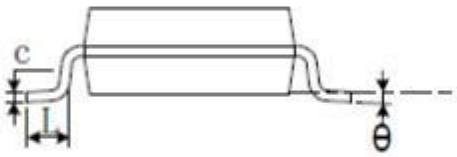
**Package Outline And Physical Dimensions: SOIC-8**



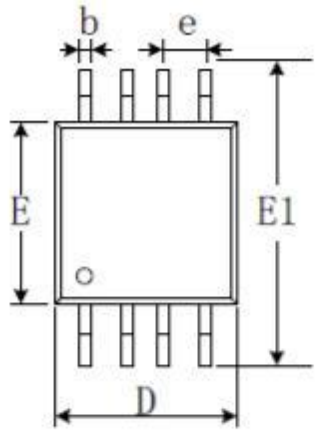

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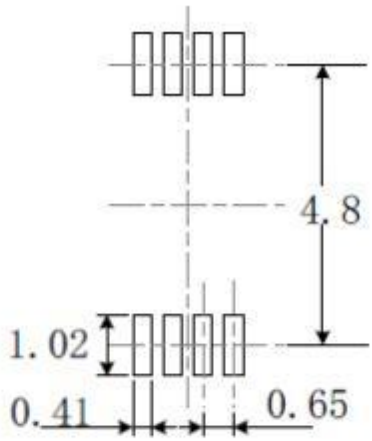


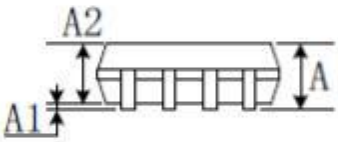

| Symbol | Dimensions In Millimeters | | Dimensions In Inches | |
|---|---|---|---|---|
| | Min | Max | Min | Max |
| A | 1.350 | 1.750 | 0.053 | 0.069 |
| A1 | 0.100 | 0.250 | 0.004 | 0.010 |
| A2 | 1.350 | 1.550 | 0.053 | 0.061 |
| b | 0.330 | 0.510 | 0.013 | 0.020 |
| c | 0.170 | 0.250 | 0.007 | 0.010 |
| D | 4.800 | 5.000 | 0.189 | 0.197 |
| e | 1.270(BSC) | | 0.050(BSC) | |
| E | 5.800 | 6.200 | 0.228 | 0.244 |
| E1 | 3.800 | 4.000 | 0.150 | 0.157 |
| L | 0.400 | 1.270 | 0.016 | 0.050 |
| θ | 0° | 8° | 0° | 8° |

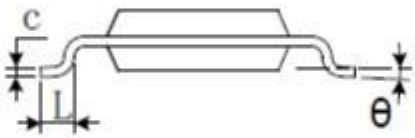
**Package Outline And Physical Dimensions: MSOP-8**



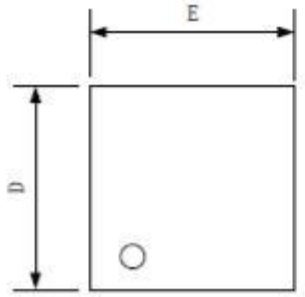

RECOMMENDED LAND PATTERN (Unit: mm)



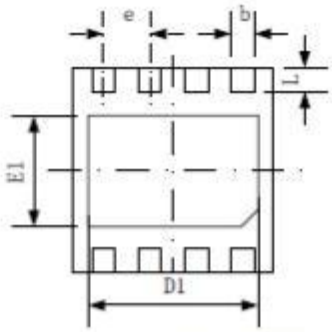




| Symbol | Dimensions In Millimeters | | Dimensions In Inches | |
|---|---|---|---|---|
| | Min | Max | Min | Max |
| A | 0.820 | 1.100 | 0.032 | 0.043 |
| A1 | 0.020 | 0.150 | 0.001 | 0.006 |
| A2 | 0.750 | 0.950 | 0.030 | 0.037 |
| b | 0.250 | 0.380 | 0.010 | 0.015 |
| c | 0.090 | 0.230 | 0.004 | 0.009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

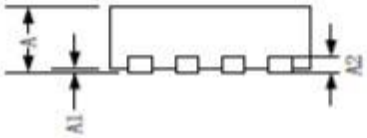
**Package Outline And Physical Dimensions: TDFN-8**




TOP VIEW



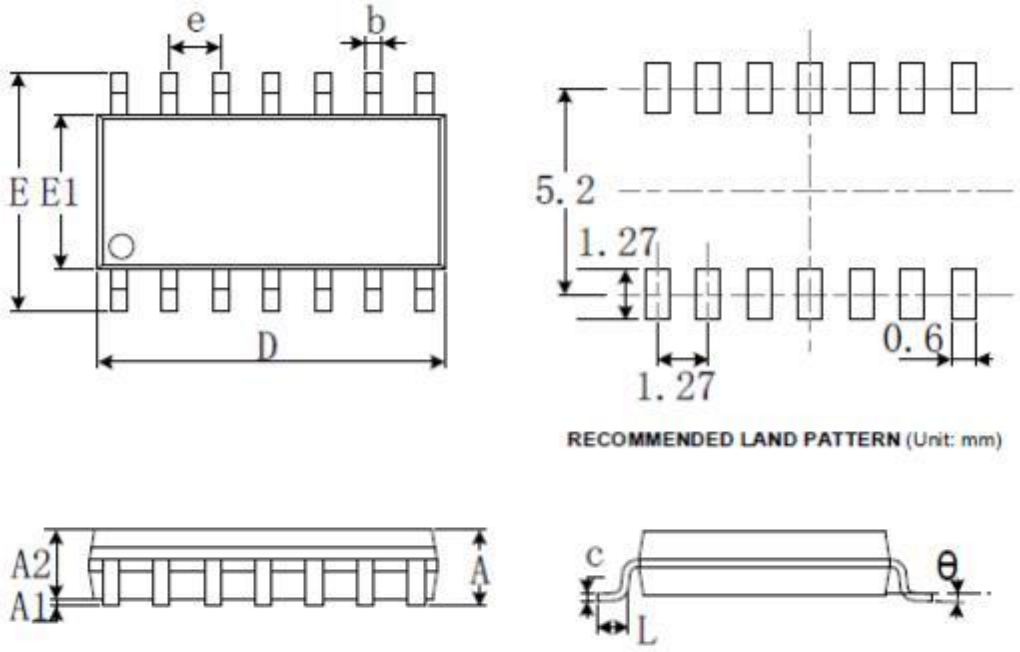

BOTTOM VIEW




SIDE VIEW

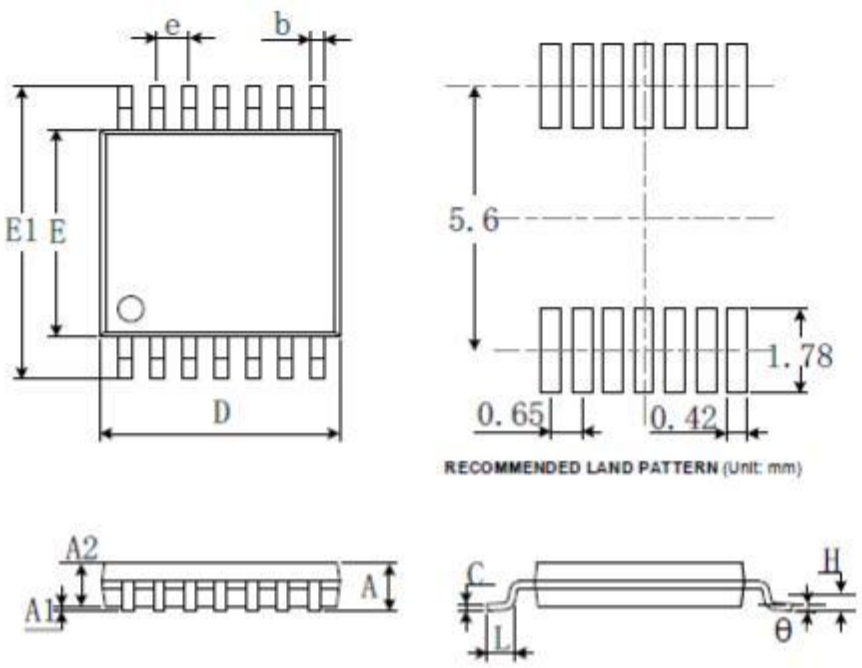
| Symbol | Dimensions In Millimeters | | Dimensions In Inches | |
|---|---|---|---|---|
| | Min | Max | Min | Max |
| A | 0.700 | 0.800 | 0.028 | 0.031 |
| A1 | 0.000 | 0.050 | 0.000 | 0.002 |
| A2 | 0.203 | | 0.008 | |
| b | 0.300 | 0.400 | 0.012 | 0.016 |
| D | 2.900 | 3.100 | 0.114 | 0.122 |
| D1 | 2.510 | 2.610 | 0.099 | 0.103 |
| E | 2.900 | 3.100 | 0.114 | 0.122 |
| E1 | 1.550 | 1.650 | 0.061 | 0.065 |
| e | 0.650 TYP | | 0.026 TYP | |
| L | 0.350 | 0.450 | 0.014 | 0.018 |

**Package Outline And Physical Dimensions: SOP-14**




| 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 | 0.310 | 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 | 1.270(BSC) | | 0.050(BSC) | |
| E | 5.800 | 6.200 | 0.228 | 0.244 |
| E1 | 3.800 | 4.000 | 0.150 | 0.157 |
| L | 0.400 | 1.270 | 0.016 | 0.050 |
| θ | 0° | 8° | 0° | 8° |

**Package Outline And Physical Dimensions: TSSOP-14**




| Symbol | Dimensions In Millimeters | | Dimensions In 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° |