# Features

- **Single-Supply Operation from +2.1V ~ +5.5V**
- **Rail-to-Rail Input / Output**
- **Gain-Bandwidth Product: 1MHz (Typ)**
- **Low Input Bias Current: 1pA (Typ)**
- **Low Offset Voltage: 3.5mV (Max)**
- **Quiescent Current: 40µA per Amplifier (Typ)**
- **Operating Temperature: -40°C ~ +125°C**
- **Embedded RF Anti-EMI Filter**

# Applications

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

# Pin Configuration
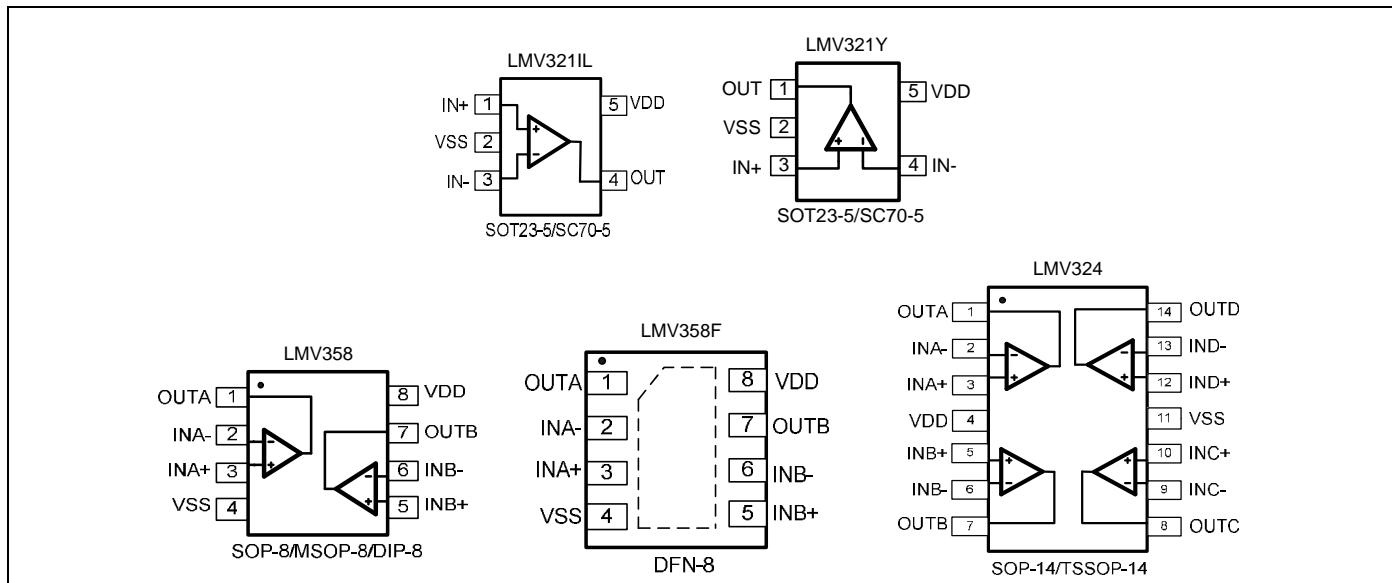


Figure 1. Pin Assignment Diagram

# Absolute Maximum Ratings

| Condition | Min | Max |
|---|---|---|
| Power Supply Voltage ($V_{DD}$ to Vss) | -0.5V | +7.5V |
| Analog Input Voltage (IN+ or IN-) | Vss-0.5V | $V_{DD}$+0.5V |
| PDB Input Voltage | Vss-0.5V | +7V |
| Operating Temperature Range | -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℃)** | | |
| SOP-8, $\theta_{JA}$ | 125°C/W | |
| MSOP-8, $\theta_{JA}$ | 216°C/W | |
| SOT23-5, $\theta_{JA}$ | 190°C/W | |
| SC70-5, $\theta_{JA}$ | 333°C/W | |
| **ESD Susceptibility** | | |
| HBM | 6KV | |
| MM | 300V | |

# Package/Ordering Information

| MODEL | CHANNEL | ORDER NUMBER | PACKAGE DESCRIPTION | PACKAGE OPTION | MARKING INFORMATION |
|---|---|---|---|---|---|
| LMV321 | Single | LMV321IL | SC70-5 | Tape and Reei,3000 | 321 |
| | | LMV321IL | SOT23-5 | Tape and Reei,3000 | 321 |
| | | LMV321Y | SC70-5 | Tape and Reei,3000 | 321Y |
| | | LMV321Y | SOT23-5 | Tape and Reei,3000 | 321Y |
| LMV358 | Dual | LMV358B | SOP-8 | Tape and Reei,4000 | LMV358 |
| | | LMV358C | MSOP-8 | Tape and Reei,3000 | LMV358 |
| | | LMV358D | DIP-8 | 20Tube(1000pcs) | LMV358 |
| | | LMV358F | DFN-8 | Tape and Reei,3000 | LMV358 |
| LMV324 | Quad | LMV324T | TSSOP-14 | Tape and Reei,3000 | LMV324 |
| | | LMV324S | SOP-14 | Tape and Reei,2500 | LMV324 |

# Electrical Characteristics

(At $V_S = +5V$, $R_L = 100k\Omega$ connected to $V_S/2$, and $V_{OUT} = V_S/2$, unless otherwise noted.)

| PARAMETER | SYMBOL | CONDITIONS | LMV321/324/358 | | | | |
|---|---|---|---|---|---|---|---|
| | | | TYP | MIN/MAX OVER TEMPERATURE | | | |
| | | | +25℃ | +25℃ | -40℃ to +85℃ | UNITS | MIN/MAX |
| **INPUT CHARACTERISTICS** | | | | | | | |
| Input Offset Voltage | $V_{OS}$ | $V_{CM} = V_S/2$ | 0.4 | 3.5 | 5.6 | mV | MAX |
| Input Bias Current | $I_B$ | | 1 | | | pA | TYP |
| Input Offset Current | $I_{OS}$ | | 1 | | | pA | TYP |
| Common-Mode Voltage Range | $V_{CM}$ | $V_S = 5.5V$ | -0.1 to +5.6 | | | V | TYP |
| Common-Mode Rejection Ratio | CMRR | $V_S = 5.5V$, $V_{CM} = -0.1V$ to 4V | 70 | 62 | 62 | dB | MIN |
| | | $V_S = 5.5V$, $V_{CM} = -0.1V$ to 5.6V | 68 | 56 | 55 | | |
| Open-Loop Voltage Gain | $A_{OL}$ | $R_L = 5k\Omega$, $V_O = +0.1V$ to +4.9V | 80 | 70 | 70 | dB | MIN |
| | | $R_L = 10k\Omega$, $V_O = +0.1V$ to +4.9V | 100 | 94 | 85 | | |
| Input Offset Voltage Drift | $\Delta V_{OS}/\Delta_T$ | | 2.7 | | | µV/℃ | TYP |
| **OUTPUT CHARACTERISTICS** | | | | | | | |
| Output Voltage Swing from Rail | $V_{OH}$ | $R_L = 100k\Omega$ | 4.997 | 4.990 | 4.980 | V | MIN |
| | $V_{OL}$ | $R_L = 100k\Omega$ | 3 | 10 | 20 | mV | MAX |
| | $V_{OH}$ | $R_L = 10k\Omega$ | 4.992 | 4.970 | 4.960 | V | MIN |
| | $V_{OL}$ | $R_L = 10k\Omega$ | 8 | 30 | 40 | mV | MAX |
| Output Current | $I_{SOURCE}$ | $R_L = 10\Omega$ to $V_S/2$ | 84 | 60 | 45 | mA | MIN |
| | $I_{SINK}$ | | 75 | 60 | 45 | | |
| **POWER SUPPLY** | | | | | | | |
| Operating Voltage Range | | | | 2.1 | 2.5 | V | MIN |
| | | | | 5.5 | 5.5 | V | MAX |
| Power Supply Rejection Ratio | PSRR | $V_S = +2.5V$ to +5.5V, $V_{CM} = +0.5V$ | 82 | 60 | 58 | dB | MIN |
| Quiescent Current / Amplifier | $I_Q$ | | 40 | | | µA | TYP |
| **DYNAMIC PERFORMANCE (CL = 100pF)** | | | | | | | |
| Gain-Bandwidth Product | GBP | | 1 | | | MHz | TYP |
| Slew Rate | SR | G = +1, 2V Output Step | 0.6 | | | V/µs | TYP |
| Settling Time to 0.1% | $t_S$ | G = +1, 2V Output Step | 5 | | | µs | TYP |
| Overload Recovery Time | | $V_{IN} \cdot Gain = V_S$ | 2.6 | | | µs | TYP |
| **NOISE PERFORMANCE** | | | | | | | |
| Voltage Noise Density | $e_n$ | f = 1kHz | 27 | | | $nV/\sqrt{Hz}$ | TYP |
| | | f = 10kHz | 20 | | | $nV/\sqrt{Hz}$ | TYP |

## Typical Performance characteristics

At $T_A$=+25$^o$C, $V_S$=+5V, and $R_L$=100KΩ connected to $V_S$/2, unless otherwise noted.

Large-Signal Step Response

G=+1
$C_L$=100pF
$R_L$=100KΩ

Output Voltage (500mV/div)

Time (4µs/div)

Small-Signal Step Response

G=+1
$C_L$=100pF
$R_L$=100KΩ

Output Voltage (20mV/div)

Time (2µs/div)
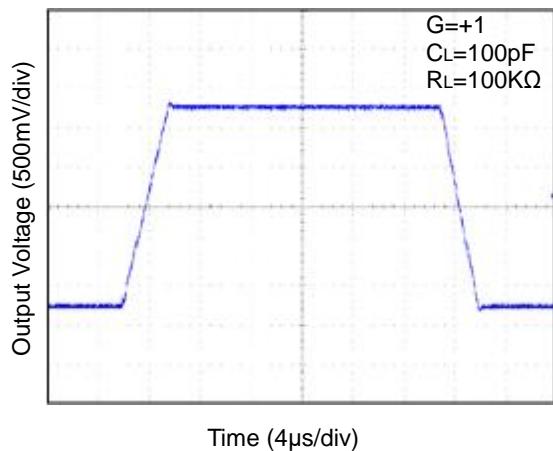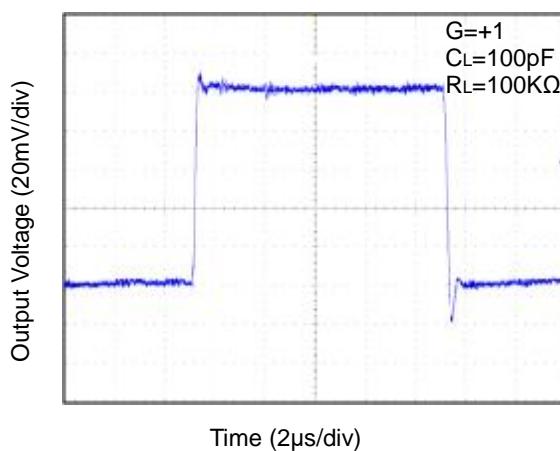
Supply Current vs. Supply Voltage

Supply Current (uA)
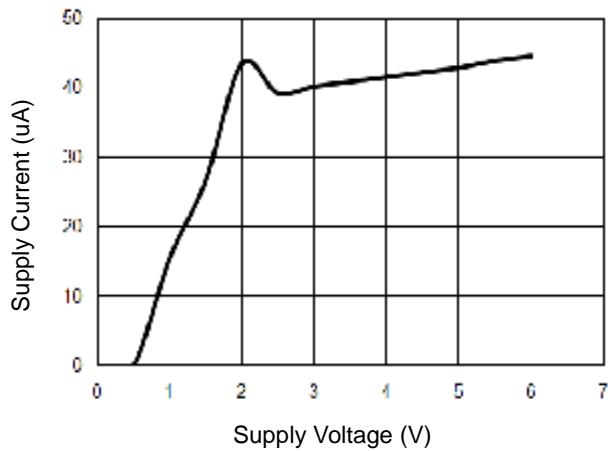
Supply Voltage (V)

Short-Circuit Current vs. Supply Voltage
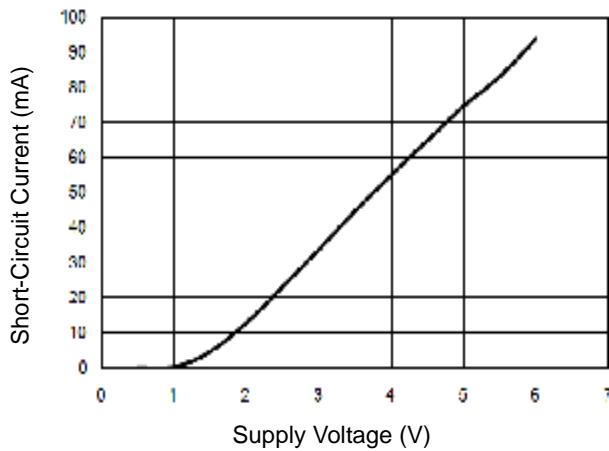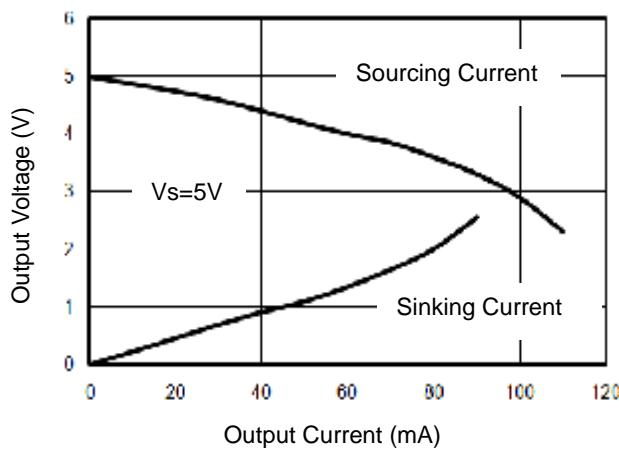
Short-Circuit Current (mA)

Supply Voltage (V)

Output Voltage vs. Output Current

Output Voltage (V)

Sourcing Current

Vs=5V

Sinking Current

Output Current (mA)

Output Voltage vs. Output Current

Output Voltage (V)

Sourcing Current

Vs=3V

Sinking Current

Output Current (mA)
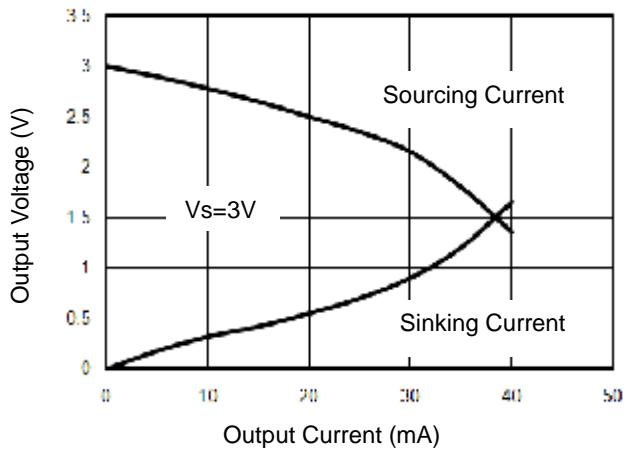
# Typical Performance characteristics

At $T_A$=+25$^o$C, $V_S$=+5V, and $R_L$=100KΩ connected to $V_S$/2, unless otherwise noted.

### Overload Recovery Time

Vs=5V
G=-5
$V_{IN}$=500mV

Time (2μs/div)
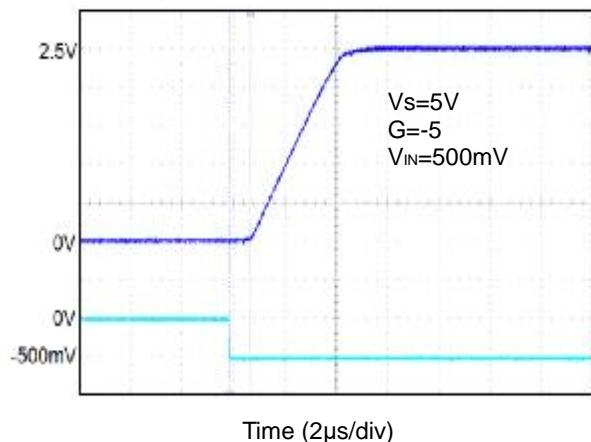
### Supply Current vs. Temperature
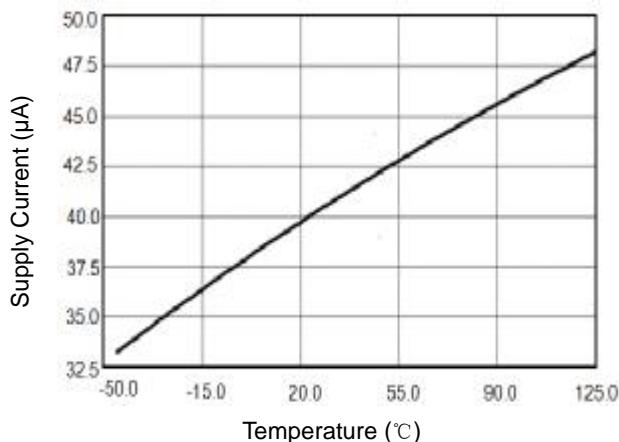
### Input Voltage Noise Spectral Density vs. Frequency
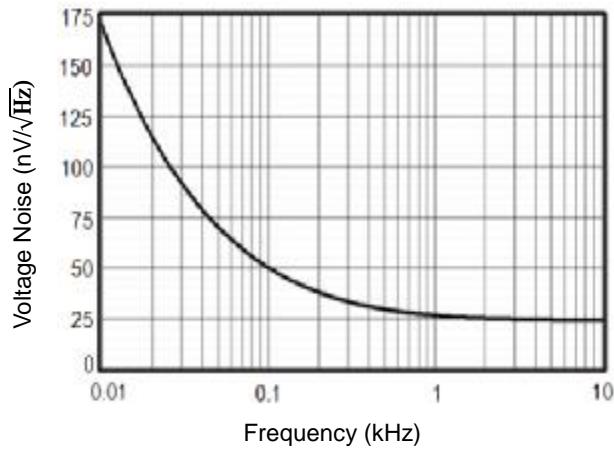
### Open Loop Gain, Phase Shift vs. Frequency at +5V
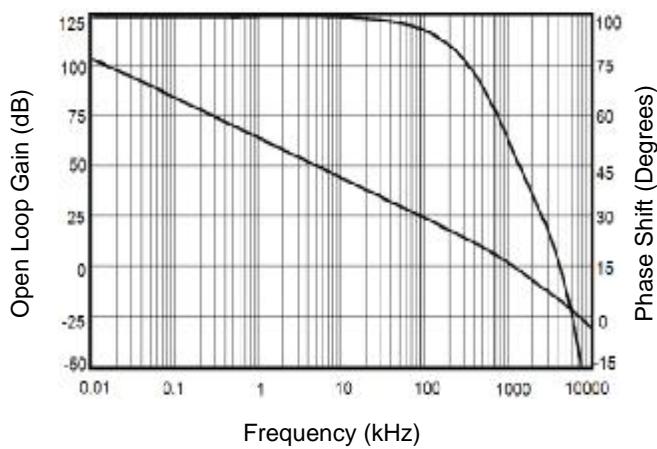
### CMRR vs. Frequency
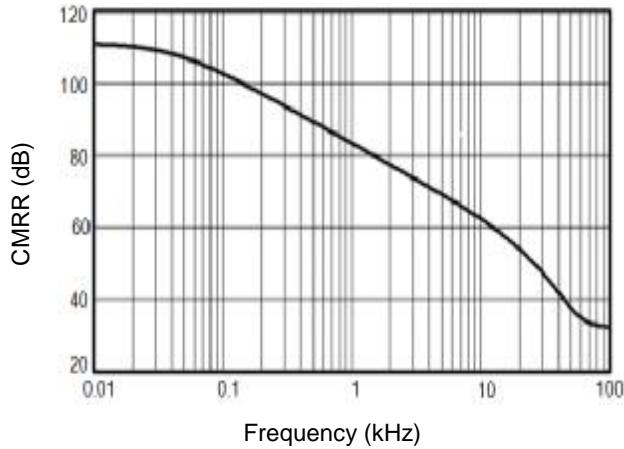
### PSRR vs. Frequency
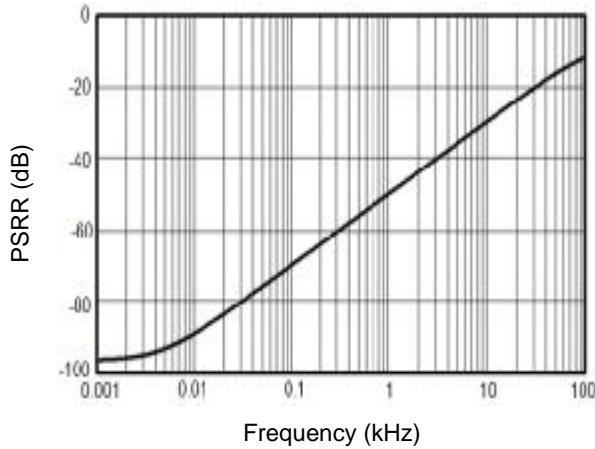
The bigger the $R_{ISO}$ resistor value, the more stable $V_{OUT}$ will be. However, if there is a resistive load $R_L$ in parallel with the capacitive load, a voltage divider (proportional to $R_{ISO}/R_L$) is formed, this will result in a gain error.

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.
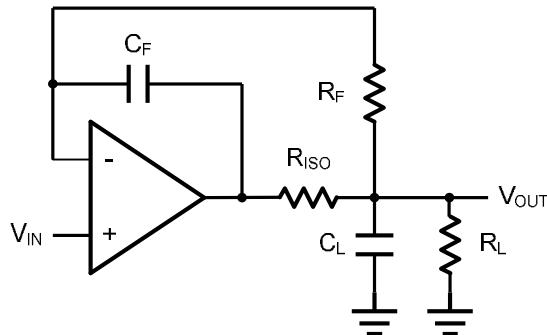


Figure 3. Indirectly Driving a Capacitive Load with DC Accuracy

# Typical Application Circuits

## Differential amplifier

The differential amplifier allows the subtraction of two input voltages or cancellation of a signal common 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 LMV321/324/358 family.
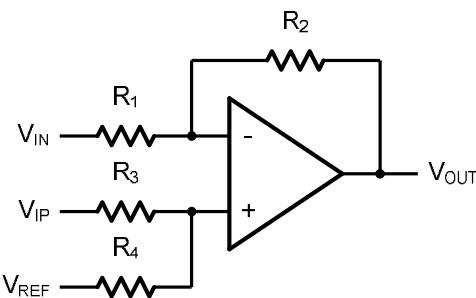
Figure 4. Differential Amplifier

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

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 $f_C = 1/(2\pi R_3 C_1)$.
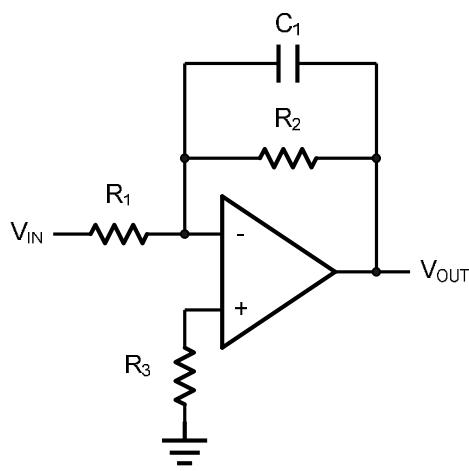
Figure 5. Low Pass Active Filter

## Instrumentation Amplifier

The triple LMV321/324/358 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 R2/R1. The two differential voltage followers assure the high input impedance of the amplifier.
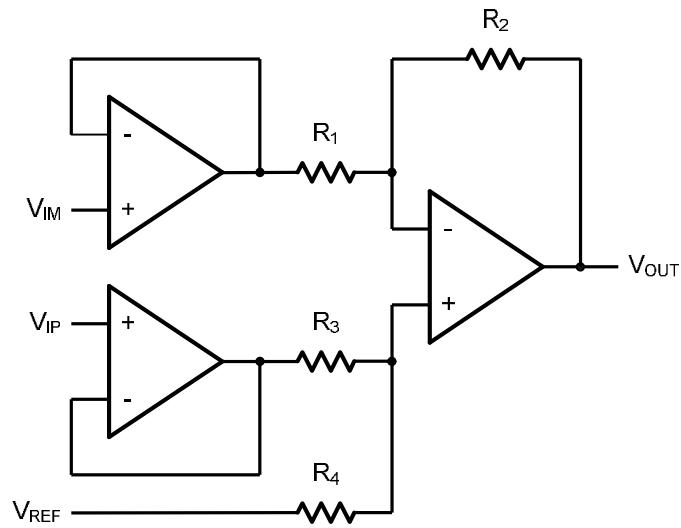
Figure 6. Instrument Amplifier

.

# Package Information

**MSOP-8**
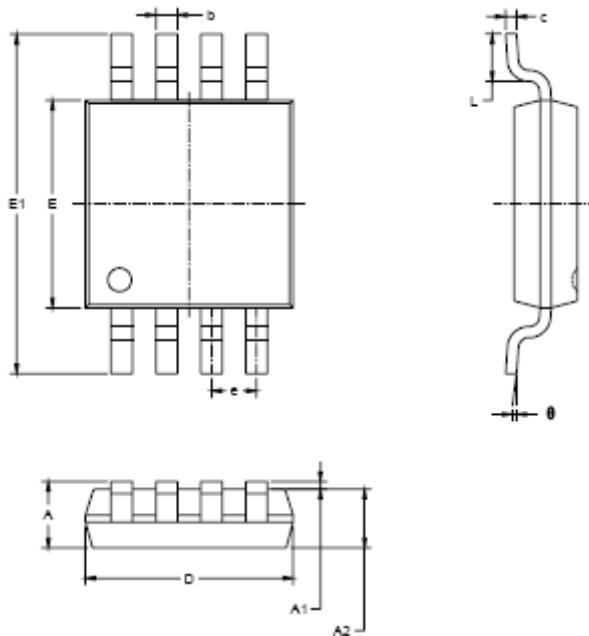
| Symbol | Dimensions In Millimeters | | Dimensions In Inches | |
|---|---|---|---|---|
| | MIN | MAX | MIN | MAX |
| A | 0.820 | 1.100 | 0.032 | 0.043 |
| A1 | 0.020 | 0.150 | 0.001 | 0.006 |
| A2 | 0.750 | 0.950 | 0.030 | 0.037 |
| b | 0.250 | 0.380 | 0.010 | 0.015 |
| c | 0.090 | 0.230 | 0.004 | 0.009 |
| D | 2.900 | 3.100 | 0.114 | 0.122 |
| E | 2.900 | 3.100 | 0.114 | 0.122 |
| E1 | 4.750 | 5.050 | 0.187 | 0.199 |
| e | 0.650 BSC | | 0.026 BSC | |
| L | 0.400 | 0.800 | 0.016 | 0.031 |
| θ | 0° | 6° | 0° | 6° |

**SOP-8**
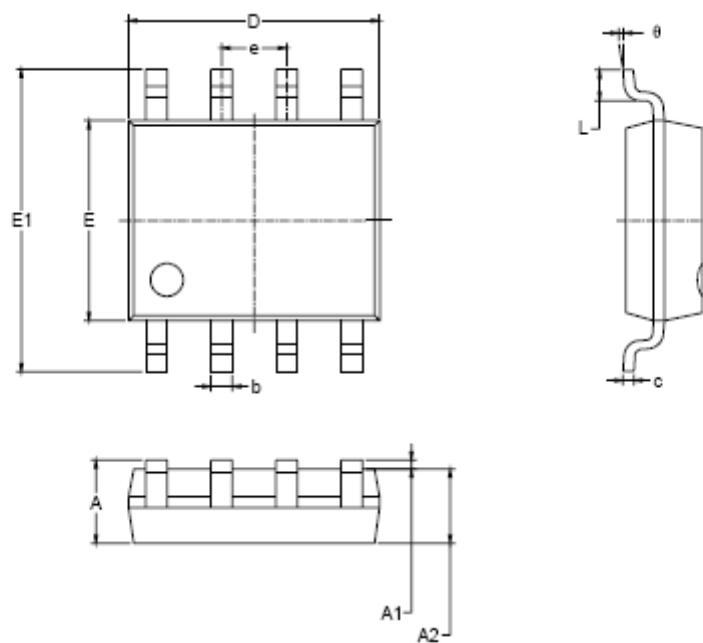


| Symbol | Dimensions In Millimeters | | Dimensions In Inches | |
|---|---|---|---|---|
| | MIN | MAX | MIN | MAX |
| A | 1.350 | 1.750 | 0.053 | 0.069 |
| A1 | 0.100 | 0.250 | 0.004 | 0.010 |
| A2 | 1.350 | 1.550 | 0.053 | 0.061 |
| b | 0.330 | 0.510 | 0.013 | 0.020 |
| c | 0.170 | 0.250 | 0.006 | 0.010 |
| D | 4.700 | 5.100 | 0.185 | 0.200 |
| E | 3.800 | 4.000 | 0.150 | 0.157 |
| E1 | 5.800 | 6.200 | 0.228 | 0.244 |
| e | 1.27 BSC | | 0.050 BSC | |
| L | 0.400 | 1.270 | 0.016 | 0.050 |
| θ | 0° | 8° | 0° | 8° |

**SOT23-5**
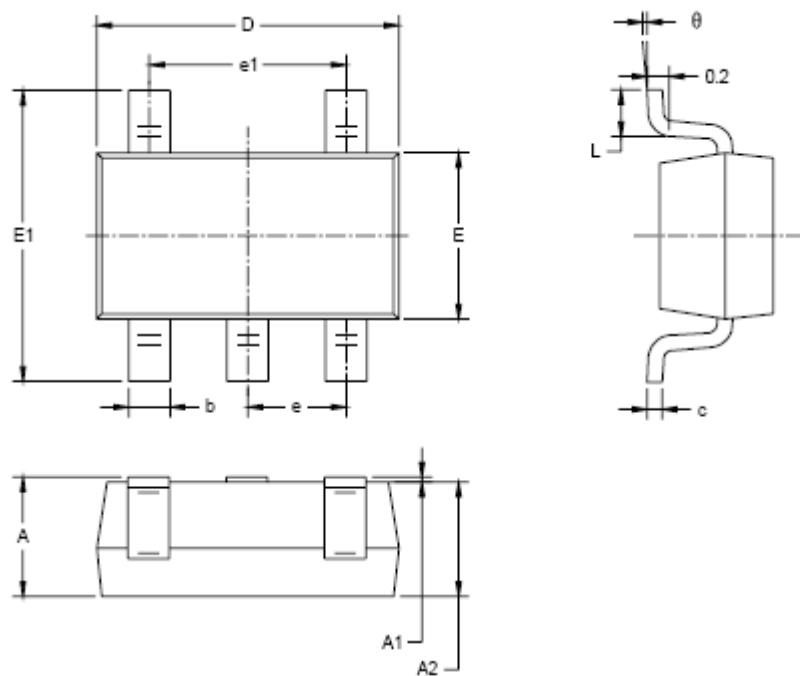
| Symbol | Dimensions In Millimeters | | Dimensions In Inches | |
|--------|------|------|------|------|
| | MIN | MAX | MIN | MAX |
| A | 1.050 | 1.250 | 0.041 | 0.049 |
| A1 | 0.000 | 0.100 | 0.000 | 0.004 |
| A2 | 1.050 | 1.150 | 0.041 | 0.045 |
| b | 0.300 | 0.500 | 0.012 | 0.020 |
| c | 0.100 | 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 | 1.900 BSC | | 0.075 BSC | |
| L | 0.300 | 0.600 | 0.012 | 0.024 |
| θ | 0° | 8° | 0° | 8° |

**TSSOP-14**
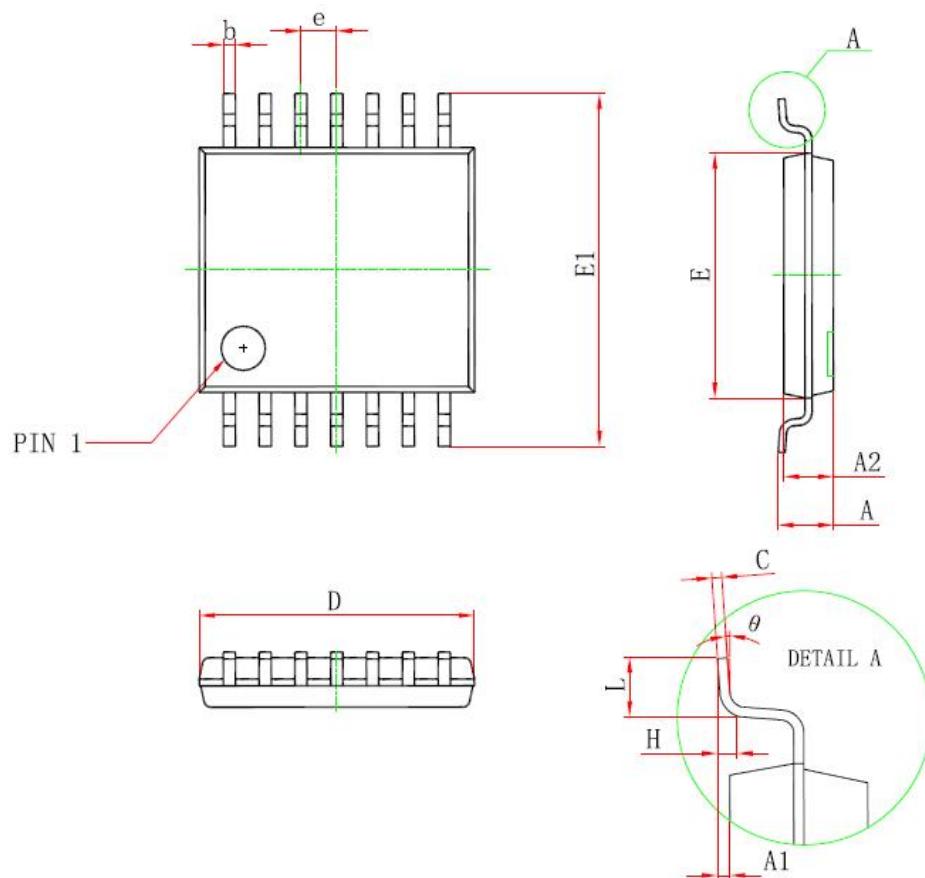
| Symbol | Dimensions In Millimeters | | Dimensions In Inches | |
|---|---|---|---|---|
| | Min | Max | Min | Max |
| D | 4.900 | 5.100 | 0.193 | 0.201 |
| E | 4.300 | 4.500 | 0.169 | 0.177 |
| b | 0.190 | 0.300 | 0.007 | 0.012 |
| c | 0.090 | 0.200 | 0.004 | 0.008 |
| E1 | 6.250 | 6.550 | 0.246 | 0.258 |
| A | | 1.200 | | 0.047 |
| A2 | 0.800 | 1.000 | 0.031 | 0.039 |
| A1 | 0.050 | 0.150 | 0.002 | 0.006 |
| e | 0.65 (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° |

## SC70-5
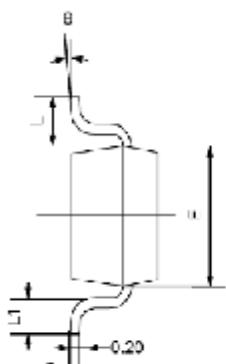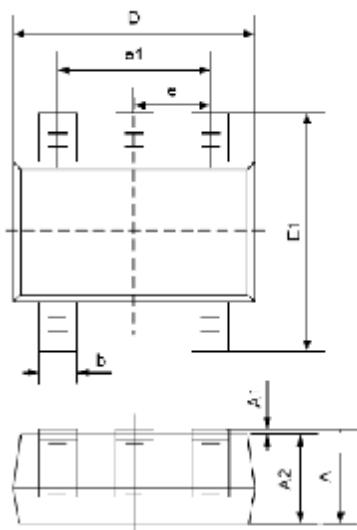


| Symbol | Dimensions In Millimeters | | Dimensions In Inches | |
|--------|------|------|------|------|
| | Min | Max | Min | Max |
| A | 0.900 | 1.100 | 0.035 | 0.043 |
| A1 | 0.000 | 0.100 | 0.000 | 0.004 |
| A2 | 0.900 | 1.000 | 0.035 | 0.039 |
| b | 0.150 | 0.350 | 0.006 | 0.014 |
| C | 0.080 | 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 |
| θ | 0° | 8° | 0° | 8° |

**SOP-14**
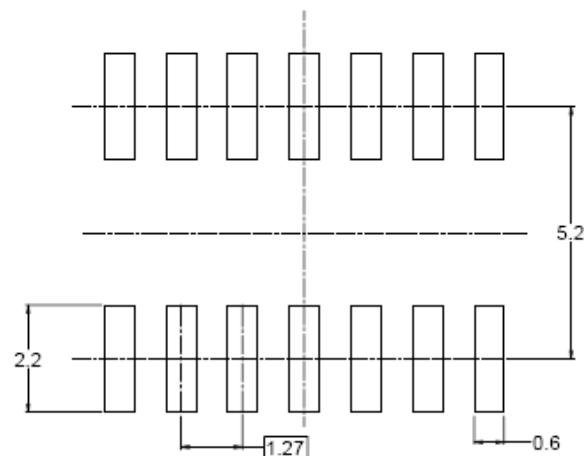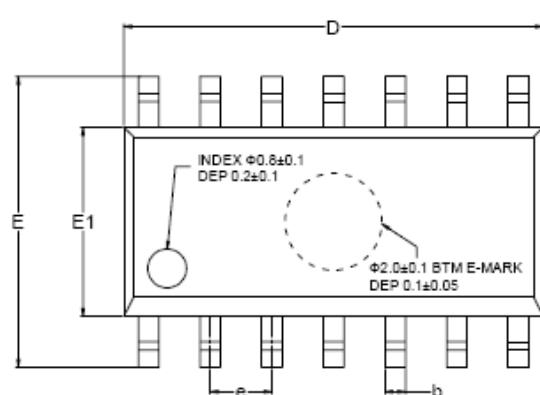


RECOMMENDED LAND PATTERN (Unit: mm)
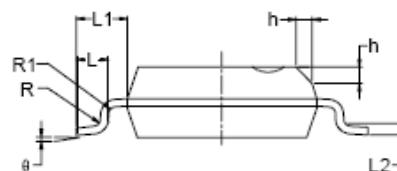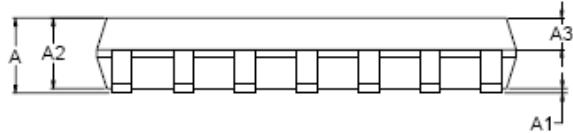


| Symbol | Dimensions In Millimeters | | | Dimensions In Inches | | |
|--------|-----|-----|-----|-----|-----|-----|
|        | MIN | MOD | MAX | MIN | MOD | MAX |
| A  | 1.35 |      | 1.75 | 0.053 |       | 0.069 |
| A1 | 0.10 |      | 0.25 | 0.004 |       | 0.010 |
| A2 | 1.25 |      | 1.65 | 0.049 |       | 0.065 |
| A3 | 0.55 |      | 0.75 | 0.022 |       | 0.030 |
| b  | 0.36 |      | 0.49 | 0.014 |       | 0.019 |
| D  | 8.53 |      | 8.73 | 0.336 |       | 0.344 |
| E  | 5.80 |      | 6.20 | 0.228 |       | 0.244 |
| E1 | 3.80 |      | 4.00 | 0.150 |       | 0.157 |
| e  |      | 1.27 BSC |  |       | 0.050 BSC |   |
| L  | 0.45 |      | 0.80 | 0.018 |       | 0.032 |
| L1 |      | 1.04 REF |  |       | 0.040 REF |   |
| L2 |      | 0.25 BSC |  |       | 0.01 BSC |    |
| R  | 0.07 |      |      | 0.003 |       |       |
| R1 | 0.07 |      |      | 0.003 |       |       |
| h  | 0.30 |      | 0.50 | 0.012 |       | 0.020 |
| θ  | 0° |        | 8°   | 0°    |       | 8°    |

**DFN-8**
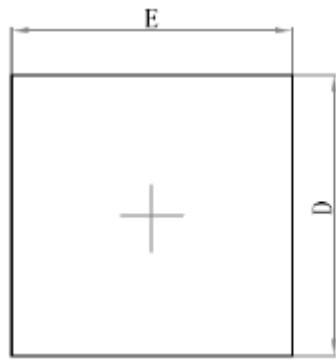


**Top View**
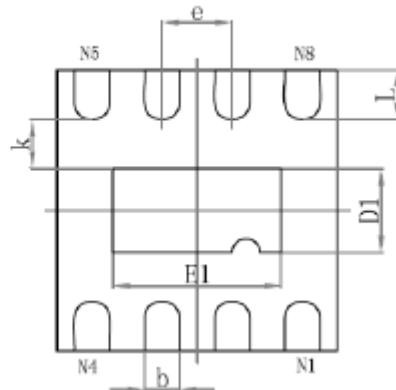


**Bottom View**
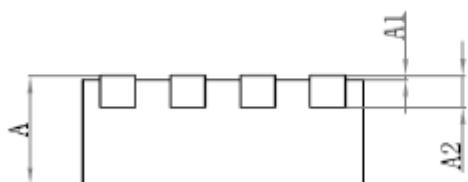


**Side View**

| Symbol | Dimensions In Millimeters | | | Dimensions In Inches | | |
|---|---|---|---|---|---|---|
| | Min | Nom | Max | Min | Nom | Max |
| A | 0.80 | 0.85 | 0.9 | 0.031 | 0.033 | 0.035 |
| A1 | 0.00 | 0.02 | 0.05 | 0.000 | 0.001 | 0.002 |
| A2 | 0.153 | 0.203 | 0.253 | 0.006 | 0.008 | 0.010 |
| b | 0.18 | 0.24 | 0.30 | 0.007 | 0.009 | 0.012 |
| D | 1.9 | 2.0 | 2.1 | 0.075 | 0.079 | 0.083 |
| E | 1.9 | 2.0 | 2.1 | 0.075 | 0.079 | 0.083 |
| D1 | 0.5 | 0.6 | 0.7 | 0.020 | 0.024 | 0.028 |
| E1 | 1.1 | 1.2 | 1.3 | 0.043 | 0.047 | 0.051 |
| e | | 0.50 | | | 0.20 | |
| k | 0.2 | | | 0.008 | | |
| L | 0.25 | 0.35 | 0.45 | 0.010 | 0.014 | 0.018 |