## PRODUCT DESCRIPTION

The LMV321 (single), LMV358 (dual) and LMV324 (quad) are general purpose, low offset, high frequency response and micro power operational amplifiers .With an excellent bandwidth of 1MHz, a slew rate of 0.8 V/μs, and a quiescent current of 85μA per amplifier at 5V, the LMV321/358/324 family can be designed into a wide range of applications. The LMV321/358/324 op-amps are designed to provide optimal performance in low voltage and low power systems. The input common-mode voltage range includes ground, and the maximum input offset voltage are 3.0mV. These parts provide rail-to-rail output swing into heavy loads. The LMV321/358/324 family is specified for single or dual power supplies of +2.1V to +6.0V. All models are specified over the extended industrial temperature range of −40℃ to +125℃.

## FEATURES

- General Purpose 1.2 MHz Amplifiers, Low Cost
- High Slew Rate:0.8 V/μs
- Low Offset Voltage:3.0 mV Maximum
- Low Power:85 μA per Amplifier Supply Current
- Unit Gain Stable
- Rail-to-Rail Input and Output
- Operating Power Supply: +2.1 V to +6.0 V
- Operating Temperature Range: −40℃ to +125℃
- ESD Rating: HBM – 4kV, CDM – 2kV

## APPLICATIONS

- Smoke/Gas/Environment Sensors Audio
- Outputs
- Battery and Power Supply Control
- Portable Equipments and Mobile Devices
- Active Filters
- Sensor Interfaces
- Battery-Powered Instrumentation Medical
- instrumentation

### Pin Configuration

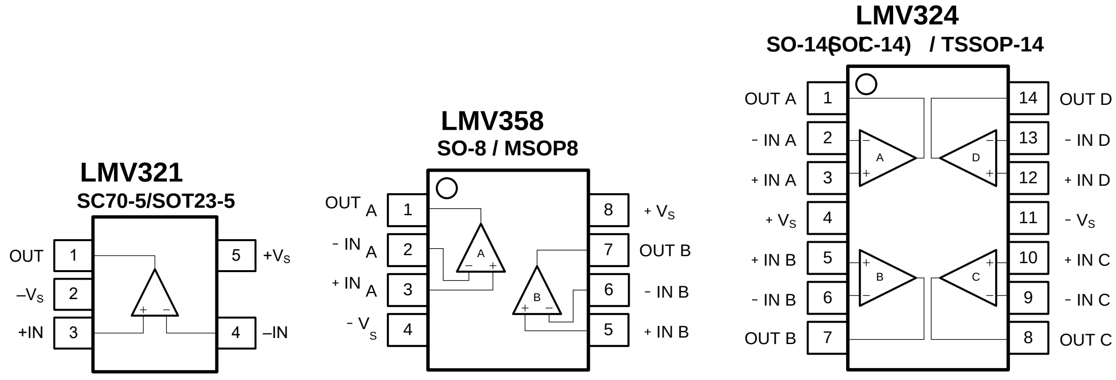



Figure 1. Pin Assignment Diagram

## ABSOLUTE MAXIMUM RATINGS

Supply Voltage, $+V_S$ to $-V_S$ ................................................7V
Input Common Mode Voltage Range
.................................................... $(-V_S)$ - 0.5V to $(+V_S)$ + 0.5V
Storage Temperature Range . ......... ............ ..-65℃ to +150℃

Junction Temperature ................................................+160℃
Lead Temperature (Soldering 10sec).........................+ 260℃

ESD Susceptibility
HBM.........................................................5000V

MM...............................................................................400V
CDM ...........................................................................2000V

## RECOMMENDED OPERATING CONDITIONS

Operating Temperature Range .....................-40℃ to +125℃

**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.

### Electrical Characteristics

| | | | | | | |
|---|---|---|---|---|---|---|
| *OUTPUT* | | | | | | |
| $V_{OH}$ | High output voltage swing | $R_L$ = 50 kΩ | $V_{S+}$–6 | $V_{S+}$–3 | | mV |
| | | $R_L$ = 2 kΩ | $V_{S+}$–100 | $V_{S+}$–65 | | |
| $V_{OL}$ | Low output voltage swing | $R_L$ = 50 kΩ | | $V_{S-}$+2 | $V_{S-}$+4 | mV |
| | | $R_L$ = 2 kΩ | | $V_{S-}$+43 | $V_{S-}$+65 | |
| $I_{SC}$ | Short-circuit current | Source current through 10Ω | | 40 | | mA |
| | | Sink current through 10Ω | | 50 | | |
| *POWER SUPPLY* | | | | | | |
| $V_S$ | Operating supply voltage | | 1.8 | | 5.5 | V |
| $I_Q$ | Quiescent current (per amplifier) | | | 85 | 120 | μA |
| | | $T_A$ = −40 to +125 ℃ | | | **150** | |
| *THERMAL CHARACTERISTICS* | | | | | | |
| $T_A$ | Operating temperature range | | –40 | | +125 | ℃ |

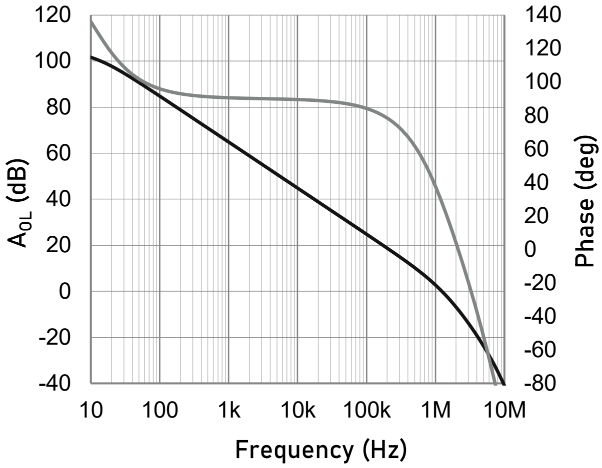
## Electrical Characteristics

***$V_S$ = 5.0V, $T_A$ = +25℃, $V_{CM}$ = $V_S$/2, $V_O$ = $V_S$/2, and $R_L$ = 10kΩ connected to $V_S$/2, unless otherwise noted. Boldface limits apply over the specified temperature range, $T_A$ = −40 to +125 ℃.***

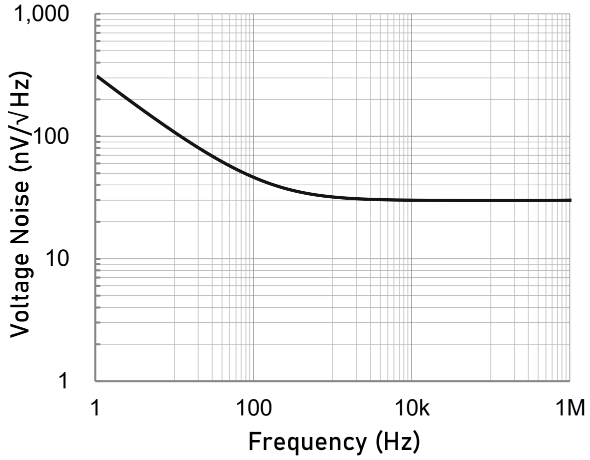
| Symbol | Parameter | Conditions | Min. | Typ. | Max. | Unit |
|---|---|---|---|---|---|---|
| *OFFSET VOLTAGE* | | | | | | |
| $V_{OS}$ | Input offset voltage | | | ±0.7 | ±3.0 | mV |
| $V_{OS}$ TC | Offset voltage drift | $T_A$ = −40 to +125 ℃ | | ±1 | 3.5 | μV/℃ |
| PSRR | Power supply rejection ratio | $V_S$ = 2.0 to 5.5 V, $V_{CM}$ < $V_{S+}$ − 2V | 80 | 110 | | dB |
| | | $T_A$ = −40 to +125 ℃ | 75 | | | |
| *INPUT BIAS CURRENT* | | | | | | |
| $I_B$ | Input bias current | | | 5 | 50 | pA |
| | | $T_A$ = +85 ℃ | | | 200 | |
| | | $T_A$ = +125 ℃ | | | 2000 | |
| $I_{OS}$ | Input offset current | | | 10 | 50 | pA |
| *NOISE* | | | | | | |
| $V_n$ | Input voltage noise | f = 0.1 to 10 Hz | | 6 | | $μV_{P-P}$ |
| $e_n$ | Input voltage noise density | f = 10 kHz | | 27 | | nV/√Hz |
| | | f = 1 kHz | | 30 | | |
| $I_n$ | Input current noise density | f = 1 kHz | | 5 | | fA/√Hz |
| *INPUT VOLTAGE* | | | | | | |
| $V_{CM}$ | Common-mode voltage range | | $V_{S-}$–0.1 | | $V_{S+}$+0.1 | V |
| CMRR | Common-mode rejection ratio | $V_S$ = 5.5 V, $V_{CM}$ = −0.1 to 5.6 V | 70 | 83 | | dB |
| | | $V_{CM}$ = 0 to 5.3 V, $T_A$ = −40 to +125 ℃ | 65 | | | |
| | | $V_S$ = 2.0 V, $V_{CM}$ = 0.1 to 2.1 V | 65 | 77 | | |
| | | $V_{CM}$ = 0 to 2.1 V, $T_A$ = −40 to +125 ℃ | 60 | | | |
| *INPUT IMPEDANCE* | | | | | | |
| $C_{IN}$ | Input capacitance | Differential | | 2.0 | | pF |
| | | Common mode | | 3.5 | | |
| *OPEN-LOOP GAIN* | | | | | | |
| $A_{VOL}$ | Open-loop voltage gain | $R_L$ = 25 kΩ, $V_O$ = 0.05 to 3.5 V | 90 | 105 | | dB |
| | | $T_A$ = −40 to +125 ℃ | 85 | | | |
| | | $R_L$ = 2 kΩ, $V_O$ = 0.15 to 3.5 V | 85 | 100 | | |
| | | $T_A$ = −40 to +125 ℃ | 80 | | | |
| *FREQUENCY RESPONSE* | | | | | | |
| GBW | Gain bandwidth product | | | 1.2 | | MHz |
| SR | Slew rate | G = +1, $C_L$ = 100 pF, $V_O$ = 1.5 to 3.5 V | | 1.0 | | V/μs |
| THD+N | Total harmonic distortion + noise | G = +1, f = 1 kHz, $V_O$ = 1 $V_{RMS}$ | | 0.003 | | % |
| $t_S$ | Settling time | To 0.1%, G = +1, 1V step | | 1.5 | | μs |
| | | To 0.01%, G = +1, 1V step | | 1.8 | | |
| $t_{OR}$ | Overload recovery time | To 0.1%, $V_{IN}$ * Gain > $V_S$ | | 2.5 | | μs |

## Typical Performance characteristics

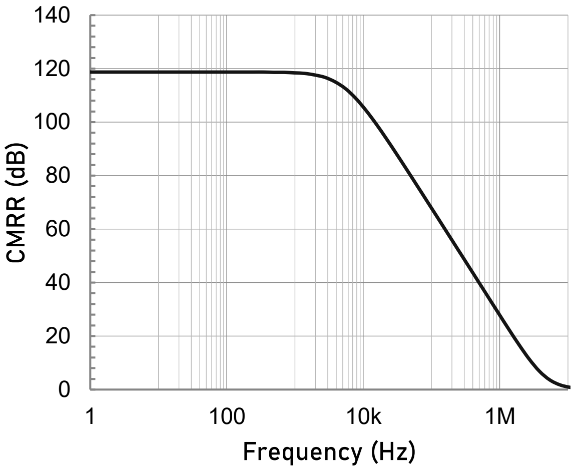
***At $T_A$ = +25℃, $V_{CM}$ = $V_S$/2, and $R_L$ = 10kΩ connected to $V_S$/2, unless otherwise noted.***



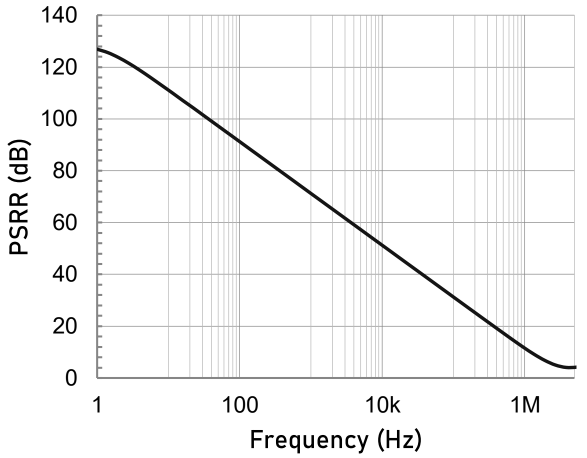

Open-loop Gain and Phase as a function of Frequency.



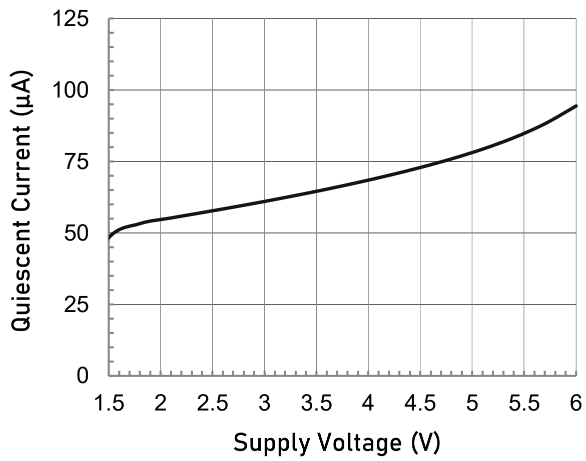

Input Voltage Noise Spectral Density as a function of Frequency.



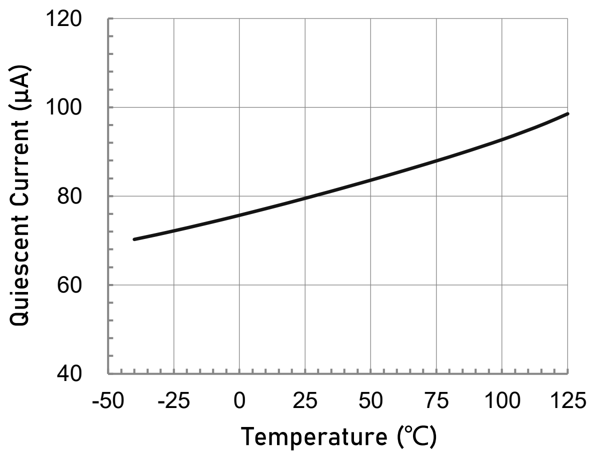

Common-mode Rejection Ratio as a function of Frequency.




Power Supply Rejection Ratio as a function of Frequency.



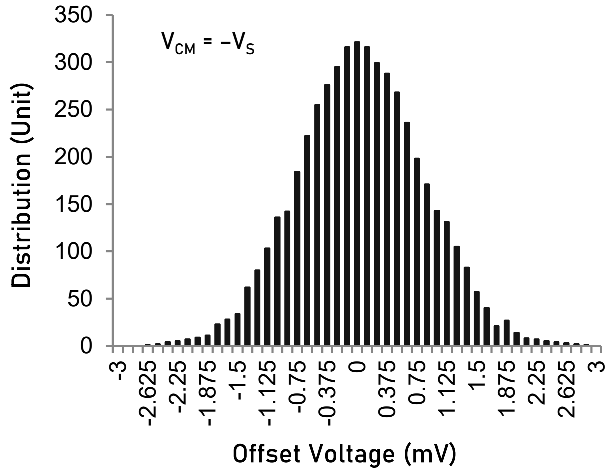

Quiescent Current as a function of Supply Voltage.



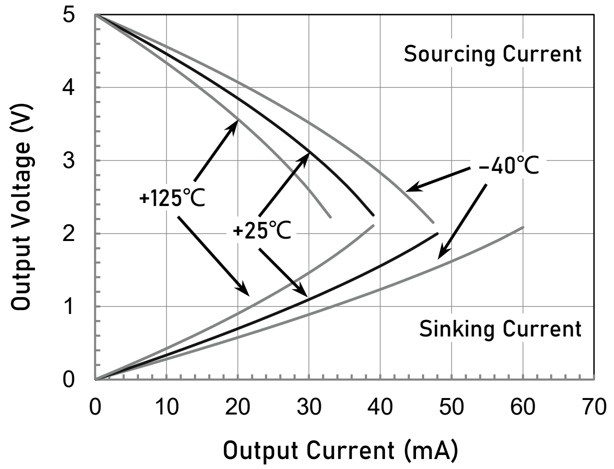

Quiescent Current as a function of Temperature.

## Typical Performance characteristics

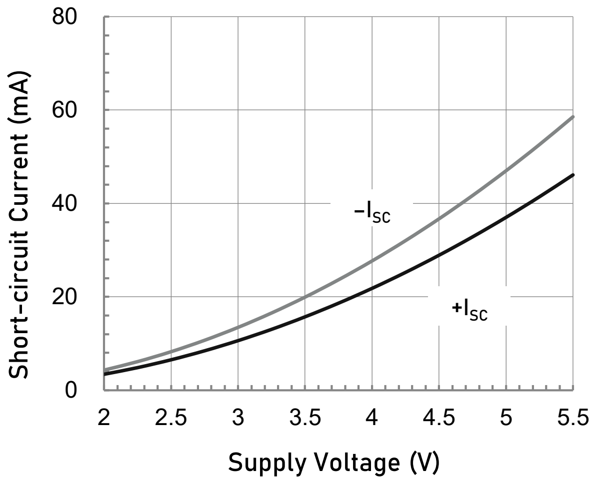
***At $T_A$ = +25℃, $V_{CM}$ = $V_S$/2, and $R_L$ = 10kΩ connected to $V_S$/2, unless otherwise noted.***



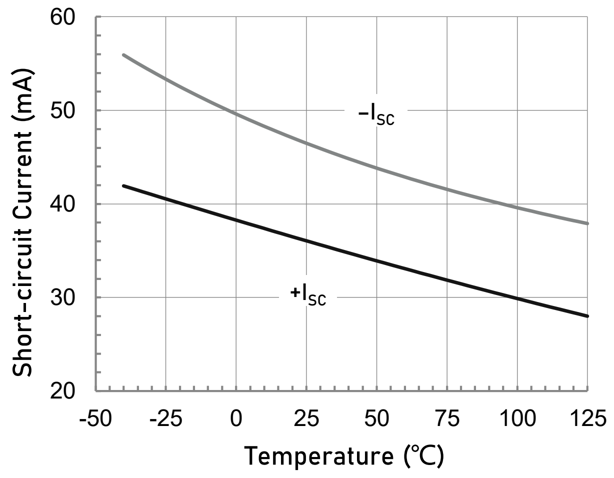

Offset Voltage Production Distribution



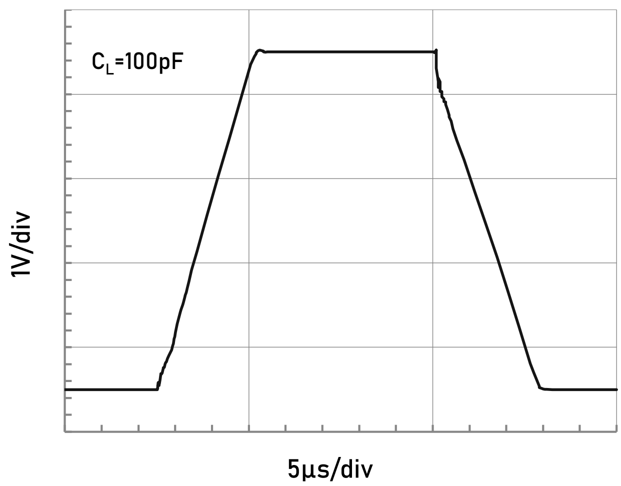

Output Voltage Swing as a function of Output Current.



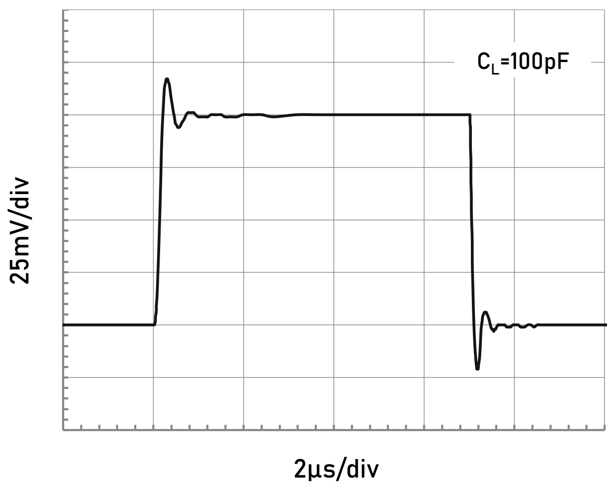

Short-circuit Current as a function of Supply Voltage.




Short-circuit Current as a function of Temperature.




Large Signal Step Response.




Small Signal Step Response.

## Application Note

### Size

LMV3XX family series op amps are unity-gain stable and suitable for a wide range of general-purpose applications. Thesmall footprints of the LMV3XX family packages save space on printed circuit boards and enable the design of smaller electronic products.

### Power Supply Bypassing and Board Layout

LMV3XX family series operates from a single 2.1V to 6.0V supply or dual ±1.0V to ±3V supplies. For best performance, a 0.1μF 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 0.1μF ceramic capacitors.

### Low Supply Current

The low supply current (typical 85μA per channel) of LMV3XX family will help to maximize battery life. They are ideal for battery powered systems.

### Operating Voltage

LMV3XX family operates under wide input supply voltage (2.1V to 6V). In addition, all temperature specifications apply from -40 °C to +125 °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 LMV3XX family extends 100mV beyond the supply rails ($V_{SS}$-0.1V to $V_{DD}$+0.1V). 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 LMV3XX family can typically swing to less than 10mV from supply rail in light resistive loads (>100kΩ), and 60mV of supply rail in moderate resistive loads (10kΩ).

### Capacitive Load Tolerance

The LMV3XX 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.

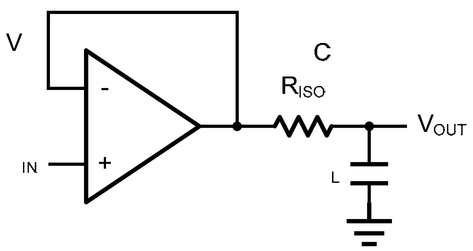



Figure 2 Indirectly Driving a Capacitive Load Using Isolation Resistor

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.

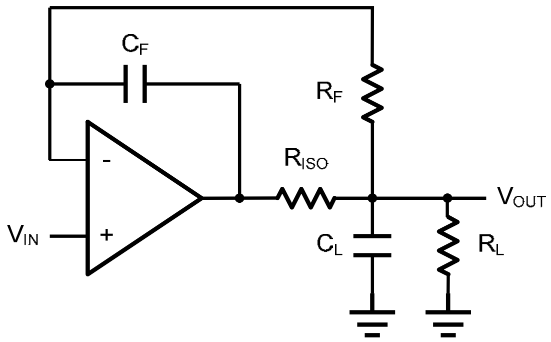



Figure 3. Indirectly Driving a Capacitive Load with DC Accuracy

### Instrumentation Amplifier

The triple LMV3XX 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.

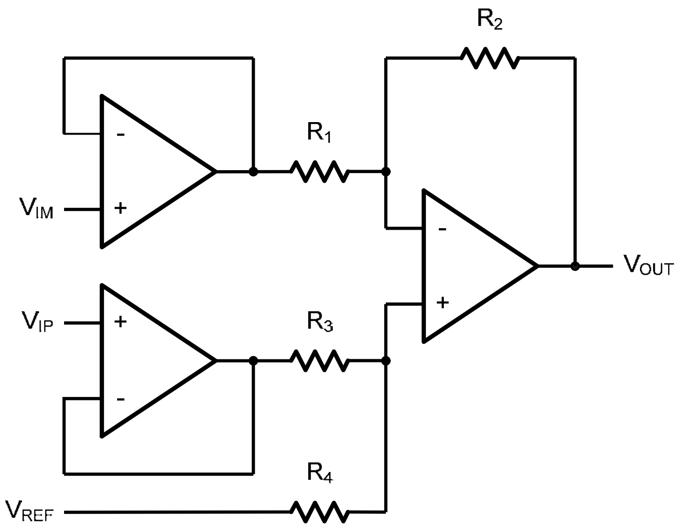



Figure 6. Instrument Amplifier

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# 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 LMV3XX family.

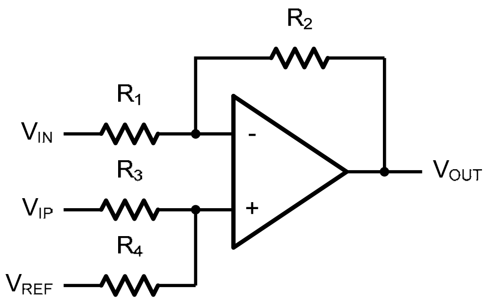



Figure 4. Differential Amplifier

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

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 $f_C=1/(2\pi R_3C_1)$.

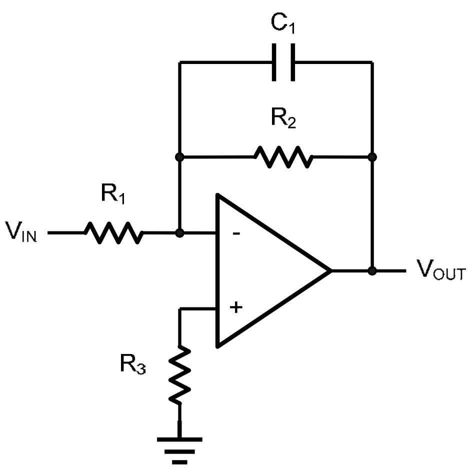
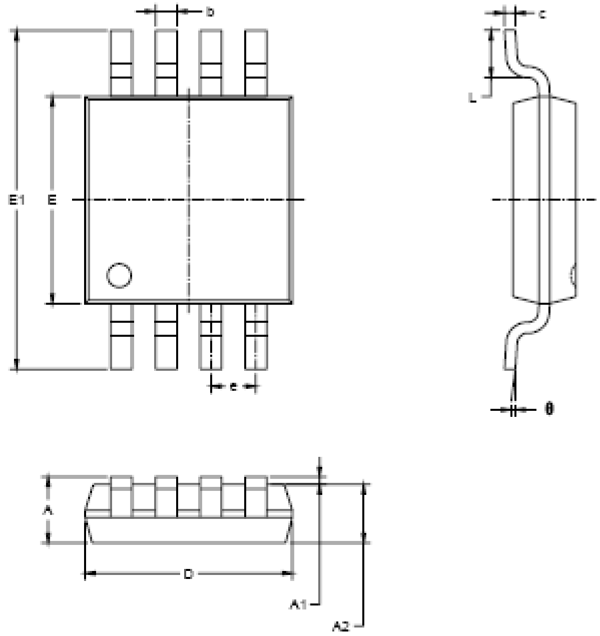



Figure 5. Low Pass Active Filter

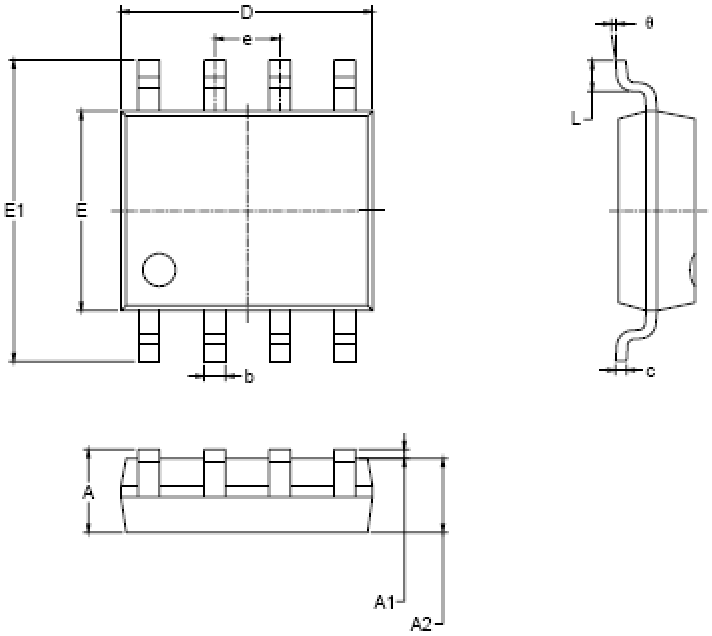
# Package Information

## MSOP-8



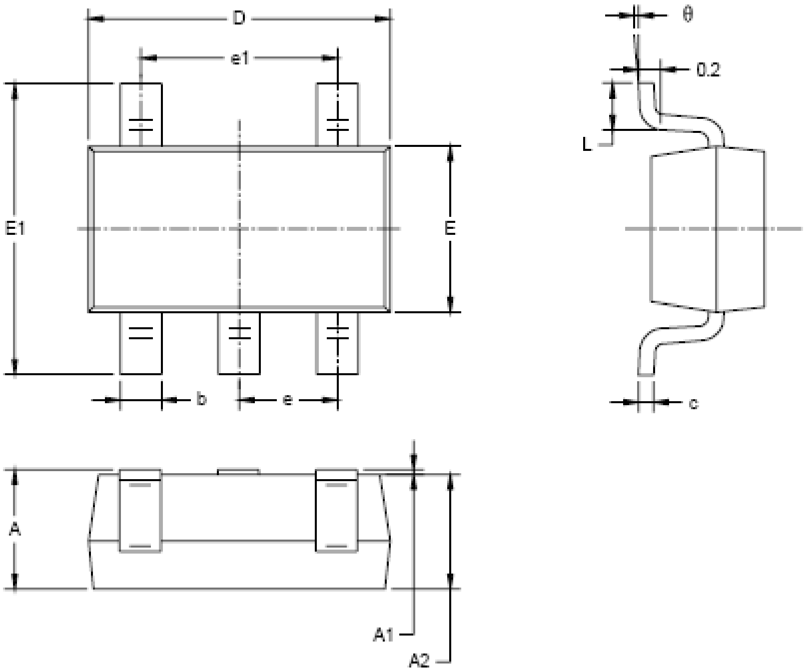

| Symbol | Dimensions In Millimeters | | Dimensions In Inches | |
|---|---|---|---|---|
| | MIN | MAX | MIN | MAX |
| A | 0.820 | 1.100 | 0.032 | 0.043 |
| A1 | 0.020 | 0.150 | 0.001 | 0.006 |
| A2 | 0.750 | 0.950 | 0.030 | 0.037 |
| b | 0.250 | 0.380 | 0.010 | 0.015 |
| c | 0.090 | 0.230 | 0.004 | 0.009 |
| 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**



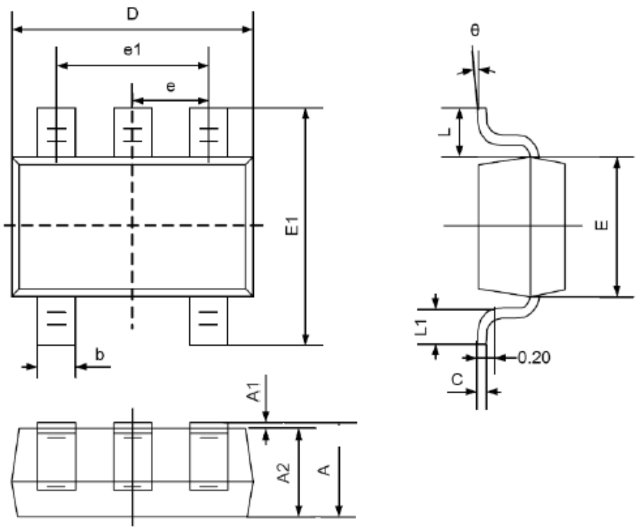

| Symbol | Dimensions In Millimeters | | Dimensions In Inches | |
|---|---|---|---|---|
| | MIN | MAX | MIN | MAX |
| A | 1.350 | 1.750 | 0.053 | 0.069 |
| A1 | 0.100 | 0.250 | 0.004 | 0.010 |
| A2 | 1.350 | 1.550 | 0.053 | 0.061 |
| b | 0.330 | 0.510 | 0.013 | 0.020 |
| c | 0.170 | 0.250 | 0.006 | 0.010 |
| 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° |

**SOT23-5L**



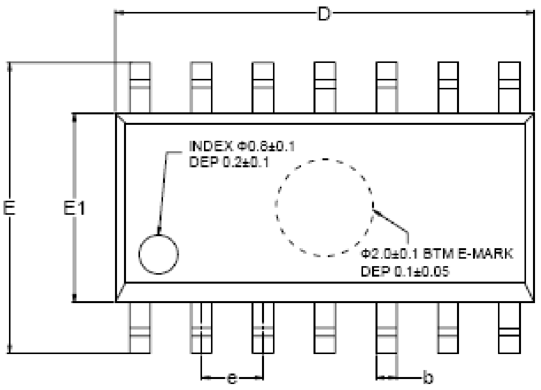

| Symbol | Dimensions In Millimeters | | Dimensions In Inches | |
|---|---|---|---|---|
| | MIN | MAX | MIN | MAX |
| A | 1.050 | 1.250 | 0.041 | 0.049 |
| A1 | 0.000 | 0.100 | 0.000 | 0.004 |
| A2 | 1.050 | 1.150 | 0.041 | 0.045 |
| b | 0.300 | 0.500 | 0.012 | 0.020 |
| c | 0.100 | 0.200 | 0.004 | 0.008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

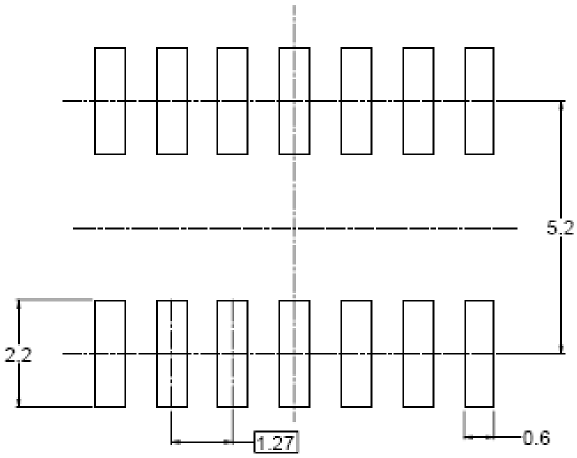
**SC70-5**



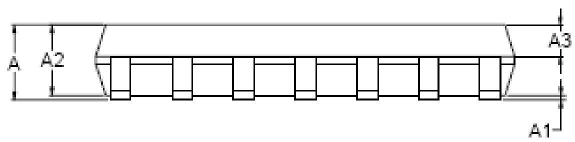

| Symbol | Dimensions In Millimeters | | Dimensions In Inches | |
|---|---|---|---|---|
| | Min | Max | Min | Max |
| A | 0.900 | 1.100 | 0.035 | 0.043 |
| A1 | 0.000 | 0.100 | 0.000 | 0.004 |
| A2 | 0.900 | 1.000 | 0.035 | 0.039 |
| b | 0.150 | 0.350 | 0.006 | 0.014 |
| C | 0.080 | 0.150 | 0.003 | 0.006 |
| 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° |

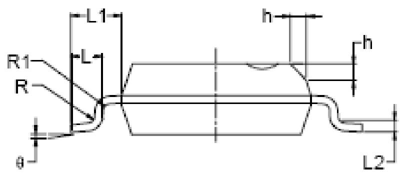
**SOP14(SOIC14)**




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° |

## Attention

■ Any and all HUA XUAN YANG ELECTRONICS products described or contained herein do not have specifications that can handle applications that require extremely high levels of reliability, such as life-support systems, aircraft's control systems, or other applications whose failure can be reasonably expected to result in serious physical and/or material damage. Consult with your HUA XUAN YANG ELECTRONICS representative nearest you before using any HUA XUAN YANG ELECTRONICS products described or contained herein in such applications.

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give rise to accidents or events that could endanger human lives, that could give rise to smoke or fire, or that could cause damage to other property. When designing equipment, adopt safety measures so that these kinds of accidents or events cannot occur. Such measures include but are not limited to protective circuits and error prevention circuits for safe design, redundant design, and structural design.

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