

LMV821 Single/ LMV822 Dual/ LMV824 Quad Low Voltage, Low Power, R-to-R Output, 5 MHz Op Amps

General Description

The LMV821/LMV822/LMV824 bring performance and economy to low voltage / low power systems. With a 5 MHz unity-gain frequency and a guaranteed 1.4 V/ μ s slew rate, the quiescent current is only 220 μ A/amplifier (2.7 V). They provide rail-to-rail (R-to-R) output swing into heavy loads (600 Ω Guaranteed). The input common-mode voltage range includes ground, and the maximum input offset voltage is 3.5mV (Guaranteed). They are also capable of comfortably driving large capacitive loads (refer to the application notes section).

The LMV821 (single) is available in the ultra tiny SC70-5 package, which is about half the size of the previous title holder, the SOT23-5.

Overall, the LMV821/LMV822/LMV824 (Single/Dual/Quad) are low voltage, low power, performance op amps, that can be designed into a wide range of applications, at an economical price.

Features

(For Typical, 5 V Supply Values; Unless Otherwise Noted)

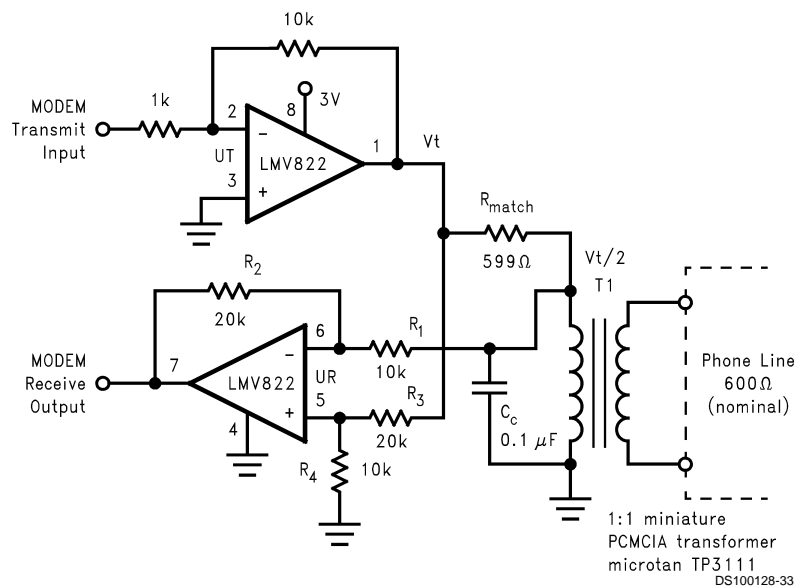
- Ultra Tiny, SC70-5 Package 2.0 x 2.0 x 1.0 mm

- Guaranteed 2.5 V, 2.7 V and 5 V Performance
- Maximum VOS 3.5 mV (Guaranteed)
- VOS Temp. Drift 1 μ V/ $^{\circ}$ C
- GBW product @ 2.7 V 5 MHz
- I_{Supply} @ 2.7 V 220 μ A/Amplifier
- Minimum SR 1.4 V/ μ s (Guaranteed)
- CMRR 90 dB
- PSRR 85 dB
- Rail-to-Rail (R-to-R) Output Swing
 - @600 Ω Load 160 mV from rail
 - @10 k Ω Load 55 mV from rail
- V_{CM} @ 5 V -0.3 V to 4.3 V
- Stable with High Capacitive Loads (Refer to Application Section)

Applications

- Cordless Phones
- Cellular Phones
- Laptops
- PDAs
- PCMCIA

Telephone-line Transceiver for a PCMCIA Modem Card



Absolute Maximum Ratings (Note 1)

If Military/Aerospace specified devices are required, please contact the National Semiconductor Sales Office/ Distributors for availability and specifications.

| | |
|--|------------------|
| ESD Tolerance (Note 2) | |
| Machine Model | 100V |
| Human Body Model | |
| LMV822/824 | 2000V |
| LMV821 | 1500V |
| Differential Input Voltage | ± Supply Voltage |
| Supply Voltage ($V^+ - V^-$) | 5.5V |
| Output Short Circuit to V^+ (Note 3) | |
| Output Short Circuit to V^- (Note 3) | |
| Soldering Information | |
| Infrared or Convection (20 sec) | 235°C |
| Storage Temperature Range | -65°C to 150°C |
| Junction Temperature (Note 4) | 150°C |

Operating Ratings (Note 1)

| | |
|--|-------------------------------|
| Supply Voltage | 2.5V to 5.5V |
| Temperature Range | |
| LMV821, LMV822, LMV824 | -40°C ≤ T _J ≤ 85°C |
| Thermal Resistance (θ _{JA}) | |
| Ultra Tiny SC70-5 Package | 440 °C/W |
| 5-Pin Surface Mount | |
| Tiny SOT23-5 Package 5-Pin Surface Mount | 265 °C/W |
| SO Package, 8-Pin Surface Mount | 190 °C/W |
| MSOP Package, 8-Pin Mini Surface Mount | 235 °C/W |
| SO Package, 14-Pin Surface Mount | 145 °C/W |
| TSSOP Package, 14-Pin | 155 °C/W |

2.7V DC Electrical Characteristics

Unless otherwise specified, all limits guaranteed for T_J = 25°C. V⁺ = 2.7V, V⁻ = 0V, V_{CM} = 1.0V, V_O = 1.35V and R_L > 1 MΩ. **Boldface** limits apply at the temperature extremes.

| Symbol | Parameter | Condition | Typ (Note 5) | LMV821/822/824 Limit (Note 6) | Units |
|-------------------|---------------------------------------|--|-----------------|----------------------------------|-----------|
| V _{OS} | Input Offset Voltage | | 1 | 3.5 4 | mV max |
| TCV _{OS} | Input Offset Voltage Average Drift | | 1 | | μV/°C |
| I _B | Input Bias Current | | 30 | 90 140 | nA max |
| I _{OS} | Input Offset Current | | 0.5 | 30 50 | nA max |
| CMRR | Common Mode Rejection Ratio | 0V ≤ V _{CM} ≤ 1.7V | 85 | 70 68 | dB min |
| +PSRR | Positive Power Supply Rejection Ratio | 1.7V ≤ V ⁺ ≤ 4V, V ⁻ = 1V, V _O = 0V, V _{CM} = 0V | 85 | 75 70 | dB min |
| -PSRR | Negative Power Supply Rejection Ratio | -1.0V ≤ V ⁻ ≤ -3.3V, V ⁺ = 1.7V, V _O = 0V, V _{CM} = 0V | 85 | 73 70 | dB min |
| V _{CM} | Input Common-Mode Voltage Range | For CMRR ≥ 50dB | -0.3 | -0.2 | V max |
| | | | 2.0 | 1.9 | V min |
| A _V | Large Signal Voltage Gain | Sourcing, R _L = 600Ω to 1.35V, V _O = 1.35V to 2.2V | 100 | 90 85 | dB min |
| | | Sinking, R _L = 600Ω to 1.35V, V _O = 1.35V to 0.5V | 90 | 85 80 | dB min |
| | | Sourcing, R _L = 2kΩ to 1.35V, V _O = 1.35V to 2.2V | 100 | 95 90 | dB min |
| | | Sinking, R _L = 2kΩ to 1.35, V _O = 1.35 to 0.5V | 95 | 90 85 | dB min |

2.7V DC Electrical Characteristics (Continued)

Unless otherwise specified, all limits guaranteed for $T_J = 25^\circ\text{C}$. $V^+ = 2.7\text{V}$, $V^- = 0\text{V}$, $V_{\text{CM}} = 1.0\text{V}$, $V_O = 1.35\text{V}$ and $R_L > 1\text{ M}\Omega$.

Boldface limits apply at the temperature extremes.

| Symbol | Parameter | Condition | Typ (Note 5) | LMV821/822/824 Limit (Note 6) | Units |
|--------|----------------|---|-----------------|----------------------------------|-----------|
| V_O | Output Swing | $V^+ = 2.7\text{V}$, $R_L = 600\Omega$ to 1.35V | 2.58 | 2.50 2.40 | V min |
| | | | 0.13 | 0.20 0.30 | V max |
| | | $V^+ = 2.7\text{V}$, $R_L = 2\text{k}\Omega$ to 1.35V | 2.66 | 2.60 2.50 | V min |
| | | | 0.08 | 0.120 0.200 | V max |
| I_O | Output Current | Sourcing, $V_O = 0\text{V}$ | 16 | 12 | mA min |
| | | Sinking, $V_O = 2.7\text{V}$ | 26 | 12 | mA min |
| I_S | Supply Current | LMV821 (Single) | 0.22 | 0.3 0.5 | mA max |
| | | LMV822 (Dual) | 0.45 | 0.6 0.8 | mA max |
| | | LMV824 (Quad) | 0.72 | 1.0 1.2 | mA max |
| | | | | | |

2.5V DC Electrical Characteristics

Unless otherwise specified, all limits guaranteed for $T_J = 25^\circ\text{C}$. $V^+ = 2.5\text{V}$, $V^- = 0\text{V}$, $V_{\text{CM}} = 1.0\text{V}$, $V_O = 1.25\text{V}$ and $R_L > 1\text{ M}\Omega$.

Boldface limits apply at the temperature extremes.

| Symbol | Parameter | Condition | Typ (Note 5) | LMV821/822/824 Limit (Note 6) | Units |
|-----------------|----------------------|---|-----------------|----------------------------------|-----------|
| V_{OS} | Input Offset Voltage | | 1 | 3.5 4 | mV max |
| V_O | Output Swing | $V^+ = 2.5\text{V}$, $R_L = 600\Omega$ to 1.25V | 2.37 | 2.30 2.20 | V min |
| | | | 0.13 | 0.20 0.30 | V max |
| | | $V^+ = 2.5\text{V}$, $R_L = 2\text{k}\Omega$ to 1.25V | 2.46 | 2.40 2.30 | V min |
| | | | 0.08 | 0.12 0.20 | V max |

2.7V AC Electrical Characteristics

Unless otherwise specified, all limits guaranteed for $T_J = 25^\circ\text{C}$. $V^+ = 2.7\text{V}$, $V^- = 0\text{V}$, $V_{\text{CM}} = 1.0\text{V}$, $V_O = 1.35\text{V}$ and $R_L > 1\text{ M}\Omega$.

Boldface limits apply at the temperature extremes.

| Symbol | Parameter | Conditions | Typ (Note 5) | LMV821/822/824 Limit (Note 6) | Units |
|----------|-----------------------------|--|-----------------|----------------------------------|--------------------------------------|
| SR | Slew Rate | (Note 7) | 1.5 | | V/ μs |
| GBW | Gain-Bandwidth Product | | 5 | | MHz |
| Φ_m | Phase Margin | | 61 | | Deg. |
| G_m | Gain Margin | | 10 | | dB |
| | Amp-to-Amp Isolation | (Note 8) | 135 | | dB |
| e_n | Input-Related Voltage Noise | $f = 1\text{ kHz}$, $V_{\text{CM}} = 1\text{V}$ | 28 | | $\frac{\text{nV}}{\sqrt{\text{Hz}}}$ |

2.7V AC Electrical Characteristics (Continued)

Unless otherwise specified, all limits guaranteed for $T_J = 25^\circ\text{C}$. $V^+ = 2.7\text{V}$, $V^- = 0\text{V}$, $V_{\text{CM}} = 1.0\text{V}$, $V_O = 1.35\text{V}$ and $R_L > 1\text{ M}\Omega$. **Boldface** limits apply at the temperature extremes.

| Symbol | Parameter | Conditions | Typ (Note 5) | LMV821/822/824 Limit (Note 6) | Units |
|--------|------------------------------|---|-----------------|----------------------------------|--------------------------------------|
| i_n | Input-Referred Current Noise | $f = 1\text{ kHz}$ | 0.1 | | $\frac{\text{pA}}{\sqrt{\text{Hz}}}$ |
| THD | Total Harmonic Distortion | $f = 1\text{ kHz}$, $A_V = -2$, $R_L = 10\text{ k}\Omega$, $V_O = 4.1\text{ V}_{\text{PP}}$ | 0.01 | | % |

5V DC Electrical Characteristics

Unless otherwise specified, all limits guaranteed for $T_J = 25^\circ\text{C}$. $V^+ = 5\text{V}$, $V^- = 0\text{V}$, $V_{\text{CM}} = 2.0\text{V}$, $V_O = 2.5\text{V}$ and $R_L > 1\text{ M}\Omega$. **Boldface** limits apply at the temperature extremes.

| Symbol | Parameter | Condition | Typ (Note 5) | LMV821/822/824 Limit (Note 6) | Units |
|--------------------------|---------------------------------------|---|-----------------|----------------------------------|------------------------------|
| V_{OS} | Input Offset Voltage | | 1 | 3.5 4.0 | mV max |
| TCV_{OS} | Input Offset Voltage Average Drift | | 1 | | $\mu\text{V}/^\circ\text{C}$ |
| I_B | Input Bias Current | | 40 | 100 150 | nA max |
| I_{OS} | Input Offset Current | | 0.5 | 30 50 | nA max |
| CMRR | Common Mode Rejection Ratio | $0\text{V} \leq V_{\text{CM}} \leq 4.0\text{V}$ | 90 | 72 70 | dB min |
| +PSRR | Positive Power Supply Rejection Ratio | $1.7\text{V} \leq V^+ \leq 4\text{V}$, $V^- = 1\text{V}$, $V_O = 0\text{V}$, $V_{\text{CM}} = 0\text{V}$ | 85 | 75 70 | dB min |
| -PSRR | Negative Power Supply Rejection Ratio | $-1.0\text{V} \leq V^- \leq -3.3\text{V}$, $V^+ = 1.7\text{V}$, $V_O = 0\text{V}$, $V_{\text{CM}} = 0\text{V}$ | 85 | 73 70 | dB min |
| V_{CM} | Input Common-Mode Voltage Range | For CMRR $\geq 50\text{dB}$ | -0.3 4.3 | -0.2 4.2 | V max V min |
| A_V | Large Signal Voltage Gain | Sourcing, $R_L = 600\Omega$ to 2.5V , $V_O = 2.5$ to 4.5V | 105 | 95 90 | dB min |
| | | Sinking, $R_L = 600\Omega$ to 2.5V , $V_O = 2.5$ to 0.5V | 105 | 95 90 | dB min |
| | | Sourcing, $R_L = 2\text{k}\Omega$ to 2.5V , $V_O = 2.5$ to 4.5V | 105 | 95 90 | dB min |
| | | Sinking, $R_L = 2\text{k}\Omega$ to 2.5 , $V_O = 2.5$ to 0.5V | 105 | 95 90 | dB min |
| V_O | Output Swing | $V^+ = 5\text{V}$, $R_L = 600\Omega$ to 2.5V | 4.84 | 4.75 4.70 | V min |
| | | | 0.17 | 0.250 .30 | V max |
| | | $V^+ = 5\text{V}$, $R_L = 2\text{k}\Omega$ to 2.5V | 4.90 | 4.85 4.80 | V min |
| | | | 0.10 | 0.15 0.20 | V max |

5V DC Electrical Characteristics (Continued)

Unless otherwise specified, all limits guaranteed for $T_J = 25^\circ\text{C}$. $V^+ = 5\text{V}$, $V^- = 0\text{V}$, $V_{CM} = 2.0\text{V}$, $V_O = 2.5\text{V}$ and $R_L > 1\text{ M}\Omega$.

Boldface limits apply at the temperature extremes.

| Symbol | Parameter | Condition | Typ (Note 5) | LMV821/822/824 Limit (Note 6) | Units |
|--------|----------------|-----------------------------|-----------------|----------------------------------|-----------|
| I_O | Output Current | Sourcing, $V_O = 0\text{V}$ | 45 | 20 15 | mA min |
| | | Sinking, $V_O = 5\text{V}$ | 40 | 20 15 | mA min |
| I_S | Supply Current | LMV821 (Single) | 0.30 | 0.4 0.6 | mA max |
| | | LMV822 (Dual) | 0.5 | 0.7 0.9 | mA max |
| | | LMV824 (Quad) | 1.0 | 1.3 1.5 | mA max |
| | | | | | |

5V AC Electrical Characteristics

Unless otherwise specified, all limits guaranteed for $T_J = 25^\circ\text{C}$. $V^+ = 5\text{V}$, $V^- = 0\text{V}$, $V_{CM} = 2\text{V}$, $V_O = 2.5\text{V}$ and $R_L > 1\text{ M}\Omega$.

Boldface limits apply at the temperature extremes.

| Symbol | Parameter | Conditions | Typ (Note 5) | LMV821/822/824 Limit (Note 6) | Units |
|----------|------------------------------|--|-----------------|----------------------------------|--------------------------------------|
| SR | Slew Rate | (Note 7) | 2.0 | 1.4 | V/ μs min |
| GBW | Gain-Bandwidth Product | | 5.6 | | MHz |
| Φ_m | Phase Margin | | 67 | | Deg. |
| G_m | Gain Margin | | 15 | | dB |
| | Amp-to-Amp Isolation | (Note 8) | 135 | | dB |
| e_n | Input-Related Voltage Noise | $f = 1\text{ kHz}$, $V_{CM} = 1\text{V}$ | 24 | | $\frac{\text{nV}}{\sqrt{\text{Hz}}}$ |
| i_n | Input-Referred Current Noise | $f = 1\text{ kHz}$ | 0.25 | | $\frac{\text{pA}}{\sqrt{\text{Hz}}}$ |
| THD | Total Harmonic Distortion | $f = 1\text{ kHz}$, $A_V = -2$, $R_L = 10\text{ k}\Omega$, $V_O = 4.1\text{ V}_{PP}$ | 0.01 | | % |

Note 1: Absolute Maximum Ratings indicate limits beyond which damage to the device may occur. Operating Ratings indicate conditions for which the device is intended to be functional, but specific performance is not guaranteed. For guaranteed specifications and the test conditions, see the Electrical Characteristics.

Note 2: Human body model, $1.5\text{ k}\Omega$ in series with 100 pF . Machine model, 200Ω in series with 100 pF .

Note 3: Applies to both single-supply and split-supply operation. Continuous short circuit operation at elevated ambient temperature can result in exceeding the maximum allowed junction temperature of 150°C . Output currents in excess of 45 mA over long term may adversely affect reliability.

Note 4: The maximum power dissipation is a function of $T_{J(max)}$, θ_{JA} , and T_A . The maximum allowable power dissipation at any ambient temperature is $P_D = (T_{J(max)} - T_A) / \theta_{JA}$. All numbers apply for packages soldered directly into a PC board.

Note 5: Typical Values represent the most likely parametric norm.

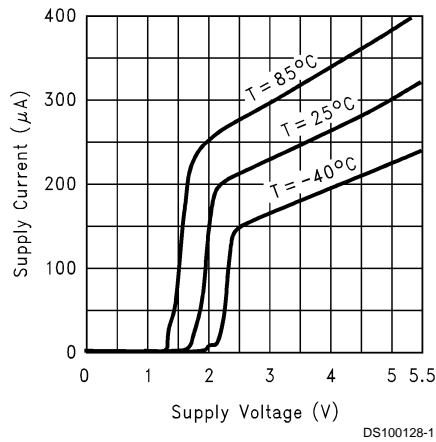
Note 6: All limits are guaranteed by testing or statistical analysis.

Note 7: $V^+ = 5\text{V}$. Connected as voltage follower with 3V step input. Number specified is the slower of the positive and negative slew rates.

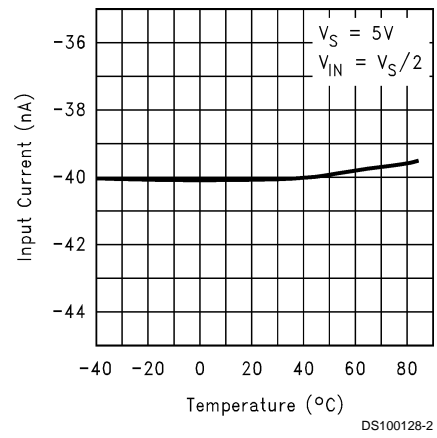
Note 8: Input referred, $V^+ = 5\text{V}$ and $R_L = 100\text{ k}\Omega$ connected to 2.5V . Each amp excited in turn with 1 kHz to produce $V_O = 3\text{ V}_{PP}$.

Typical Performance Characteristics Unless otherwise specified, $V_S = +5V$, single supply, $T_A = 25^\circ C$.

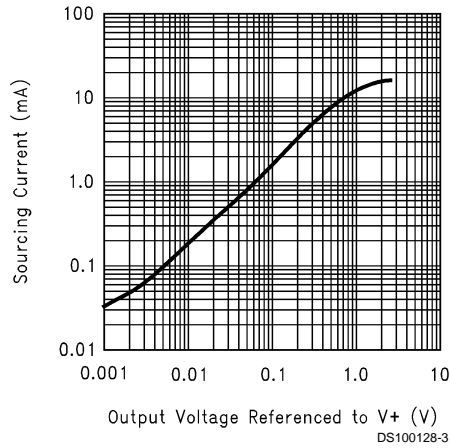
Supply Current vs. Supply Voltage (LMV821)



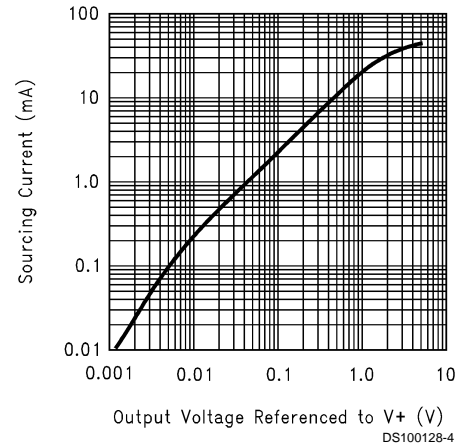
Input Current vs. Temperature



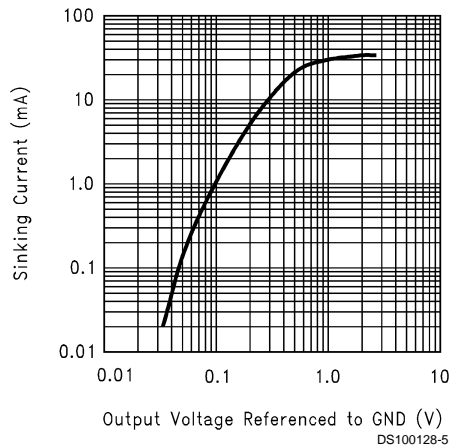
Sourcing Current vs. Output Voltage ($V_S = 2.7V$)



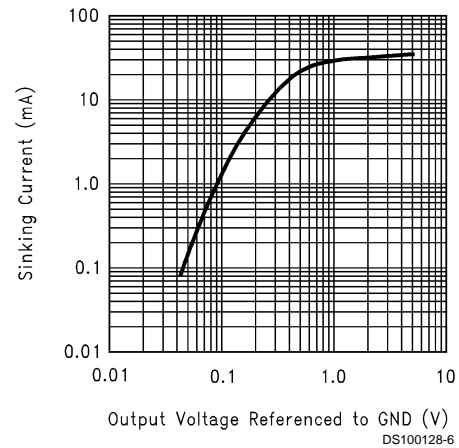
Sourcing Current vs. Output Voltage ($V_S = 5V$)



Sinking Current vs. Output Voltage ($V_S = 2.7V$)



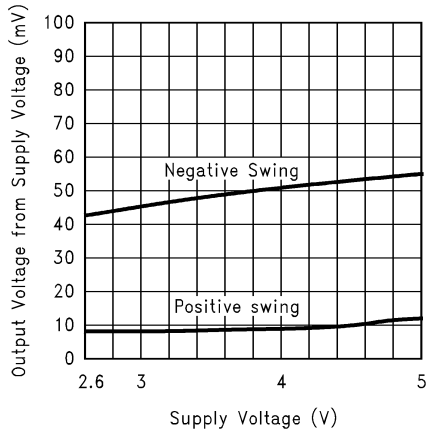
Sinking Current vs. Output Voltage ($V_S = 5V$)



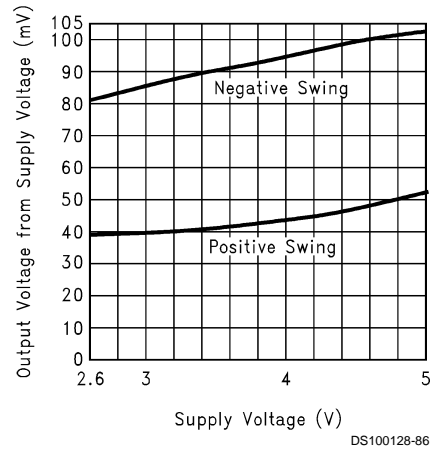
Typical Performance Characteristics

Unless otherwise specified, $V_S = +5V$, single supply, $T_A = 25^\circ C$. (Continued)

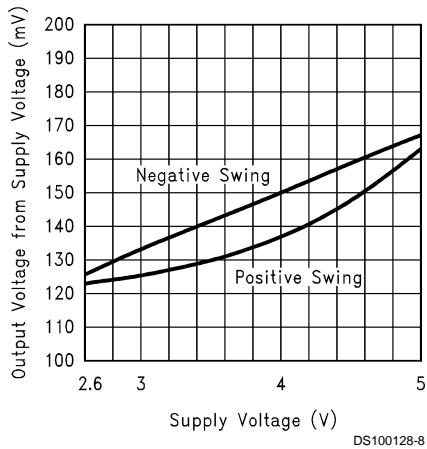
Output Voltage Swing vs. Supply Voltage ($R_L = 10k\Omega$)



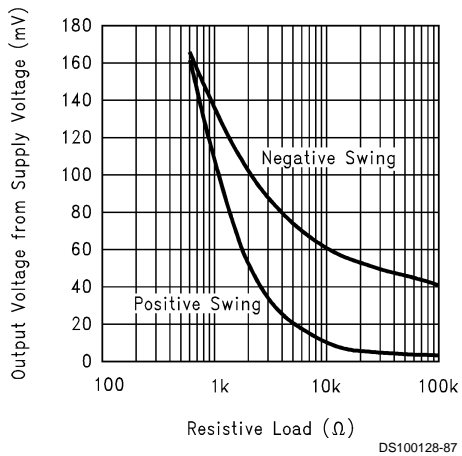
Output Voltage Swing vs. Supply Voltage ($R_L = 2k\Omega$)



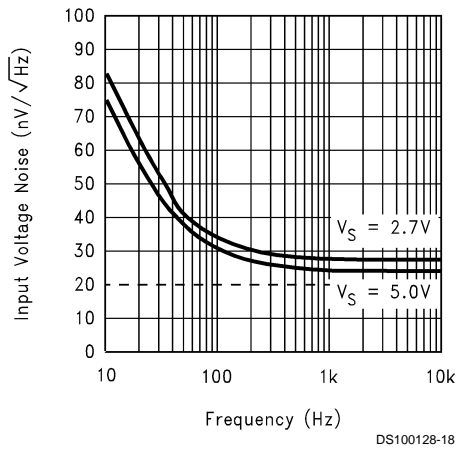
Output Voltage Swing vs. Supply Voltage ($R_L = 600\Omega$)



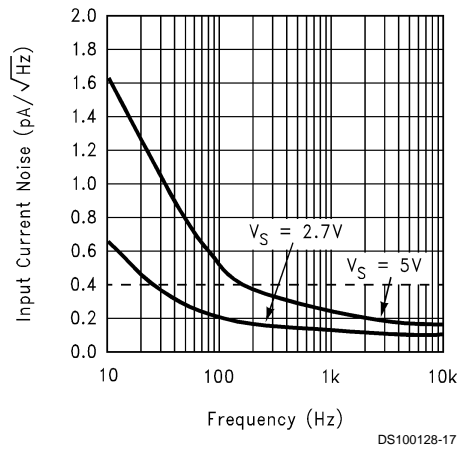
Output Voltage Swing vs. Load Resistance



Input Voltage Noise vs. Frequency

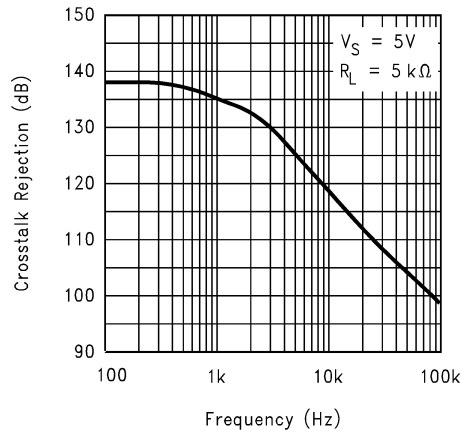


Input Current Noise vs. Frequency

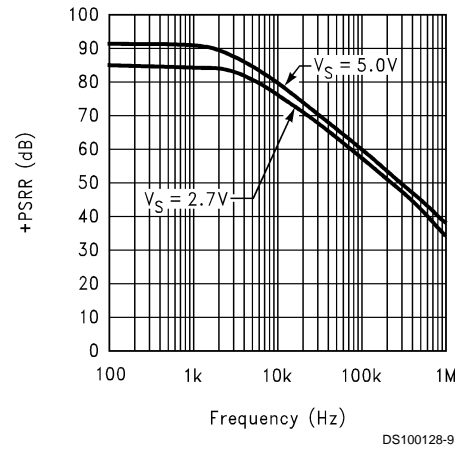


Typical Performance Characteristics Unless otherwise specified, $V_S = +5V$, single supply, $T_A = 25^\circ C$. (Continued)

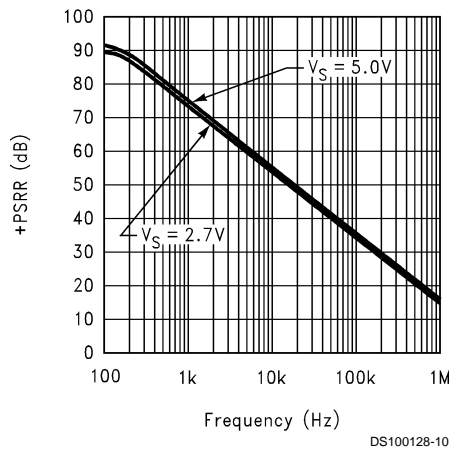
Crosstalk Rejection vs. Frequency



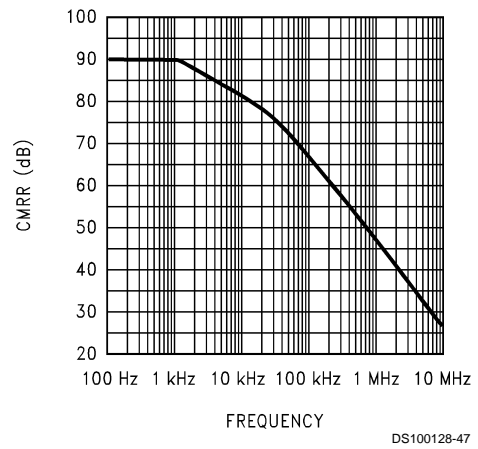
+PSRR vs. Frequency



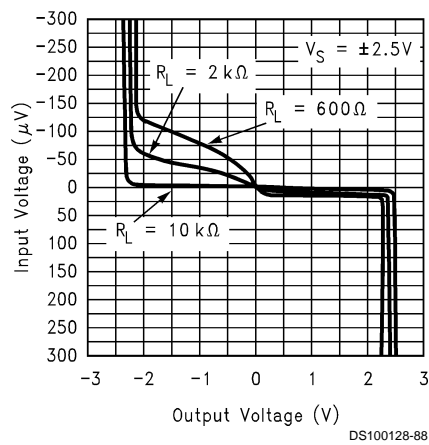
-PSRR vs. Frequency



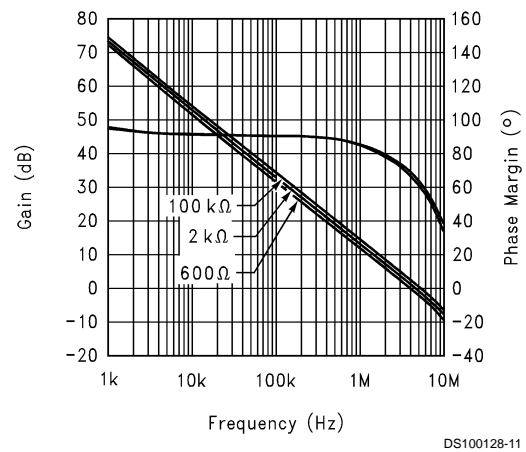
CMRR vs. Frequency



Input Voltage vs. Output Voltage



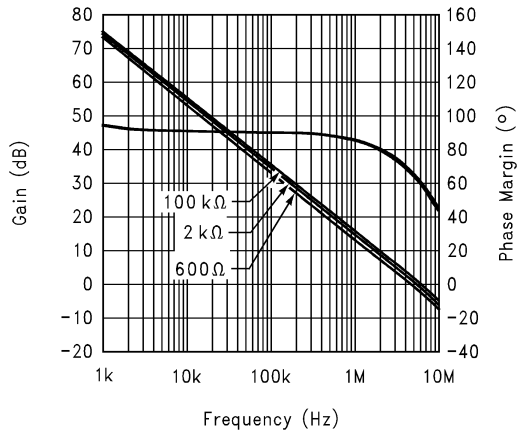
Gain and Phase Margin vs. Frequency
($R_L = 100k\Omega, 2k\Omega, 600\Omega$) 2.7V



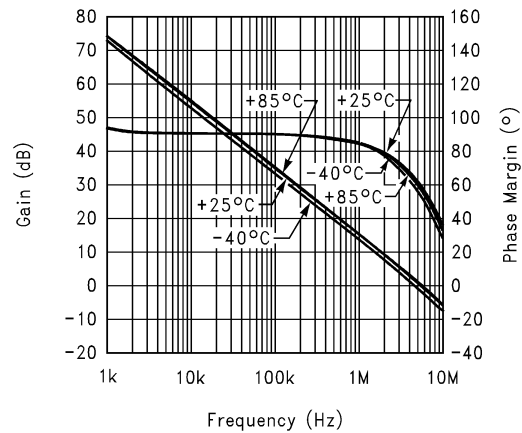
Typical Performance Characteristics

Unless otherwise specified, $V_S = +5V$, single supply,
 $T_A = 25^\circ C$. (Continued)

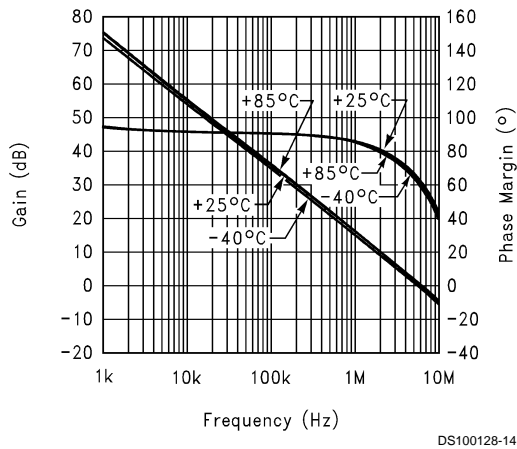
Gain and Phase Margin vs. Frequency
 $(R_L = 100k\Omega, 2k\Omega, 600\Omega) 5V$



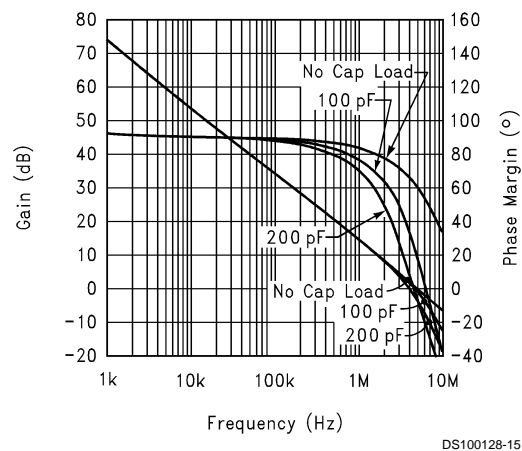
Gain and Phase Margin vs. Frequency
 $(Temp. = 25, -40, 85^\circ C, R_L = 10k\Omega) 2.7V$



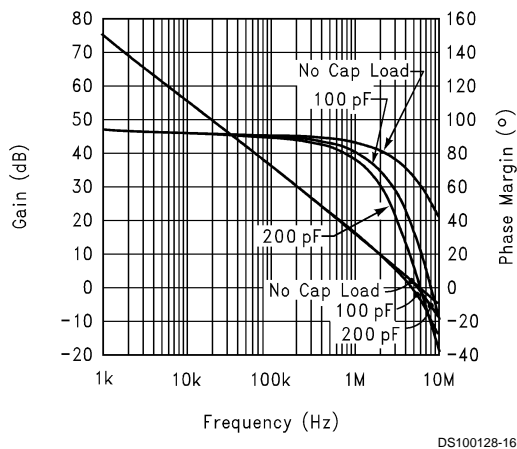
Gain and Phase Margin vs. Frequency
 $(Temp. = 25, -40, 85^\circ C, R_L = 10k\Omega) 5V$



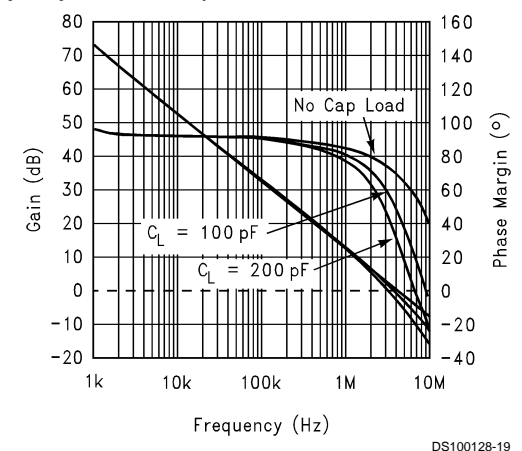
Gain and Phase Margin vs. Frequency
 $(C_L = 100pF, 200pF, 0pF, R_L = 10k\Omega) 2.7V$



Gain and Phase Margin vs. Frequency
 $(C_L = 100pF, 200pF, 0pF, R_L = 10k\Omega) 5V$

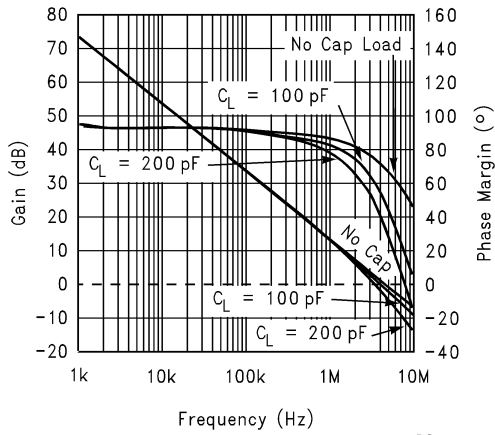


Gain and Phase Margin vs. Frequency $(C_L = 100pF, 200pF, 0pF, R_L = 600\Omega) 2.7V$

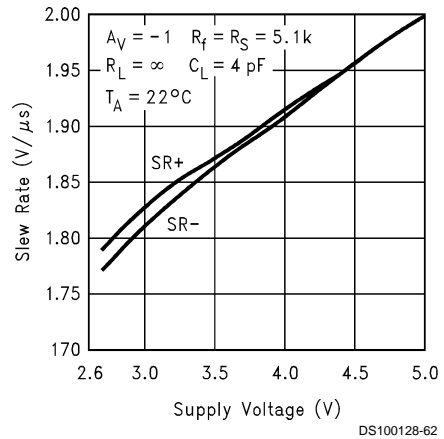


Typical Performance Characteristics Unless otherwise specified, $V_S = +5V$, single supply, $T_A = 25^\circ C$. (Continued)

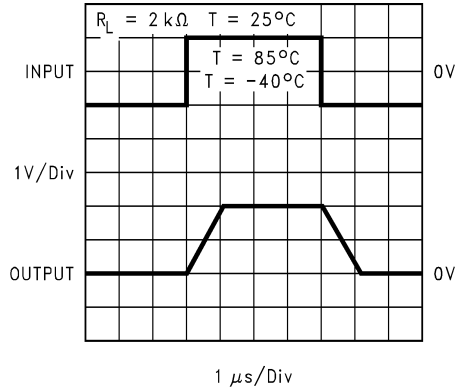
Gain and Phase Margin vs. Frequency
($C_L = 100pF, 200pF, 0pF$ $R_L = 600\Omega$) 5V



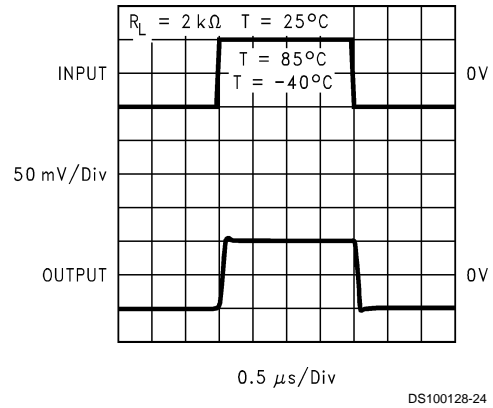
Slew Rate vs. Supply Voltage



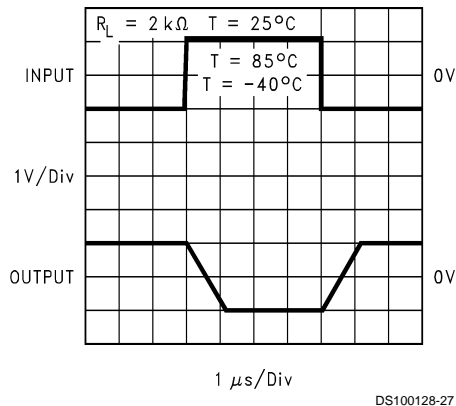
Non-Inverting Large Signal Pulse Response



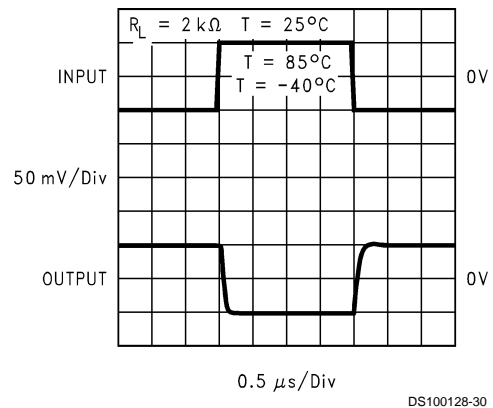
Non-Inverting Small Signal Pulse Response



Inverting Large Signal Pulse Response



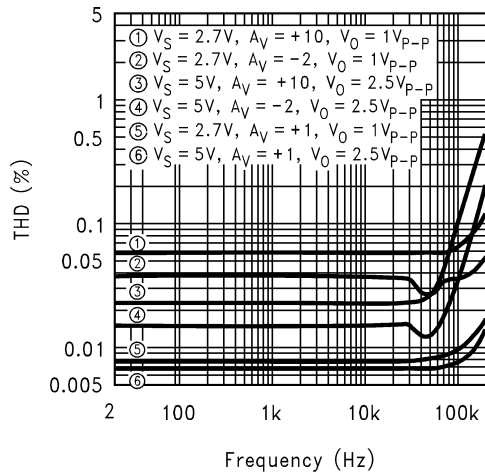
Inverting Small Signal Pulse Response



Typical Performance Characteristics

Unless otherwise specified, $V_S = +5V$, single supply,
 $T_A = 25^\circ C$. (Continued)

THD vs. Frequency



APPLICATION NOTE

This application note is divided into two sections: design considerations and Application Circuits.

1.0 Design Considerations

This section covers the following design considerations:

1. Frequency and Phase Response Considerations
2. Unity-Gain Pulse Response Considerations
3. Input Bias Current Considerations

1.1 Frequency and Phase Response Considerations

The relationship between open-loop frequency response and open-loop phase response determines the closed-loop stability performance (negative feedback). The open-loop phase response causes the feedback signal to shift towards becoming positive feedback, thus becoming unstable. The further the output phase angle is from the input phase angle, the more stable the negative feedback will operate. Phase Margin (ϕ_m) specifies this output-to-input phase relationship at the unity-gain crossover point. Zero degrees of phase-margin means that the input and output are completely in phase with each other and will sustain oscillation at the unity-gain frequency.

The AC tables show ϕ_m for a no load condition. But ϕ_m changes with load. The Gain and Phase margin vs Frequency plots in the curve section can be used to graphically determine the ϕ_m for various loaded conditions. To do this, examine the phase angle portion of the plot, find the phase margin point at the unity-gain frequency, and determine how far this point is from zero degree of phase-margin. The larger the phase-margin, the more stable the circuit operation.

The bandwidth is also affected by load. The graphs of Figure 1 and Figure 2 provide a quick look at how various loads affect the ϕ_m and the bandwidth of the LMV821/822/824 family. These graphs show capacitive loads reducing both ϕ_m and bandwidth, while resistive loads reduce the bandwidth but increase the ϕ_m . Notice how a 600 Ω resistor can be added in parallel with 220 picofarads capacitance, to increase the ϕ_m 20°(approx.), but at the price of about a 100 kHz of bandwidth.

Overall, the LMV821/822/824 family provides good stability for loaded condition.

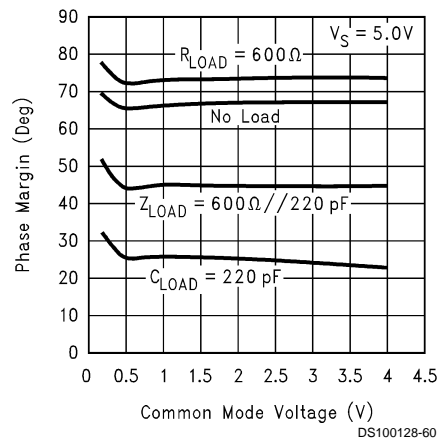


FIGURE 1. Phase Margin vs Common Mode Voltage for Various Loads

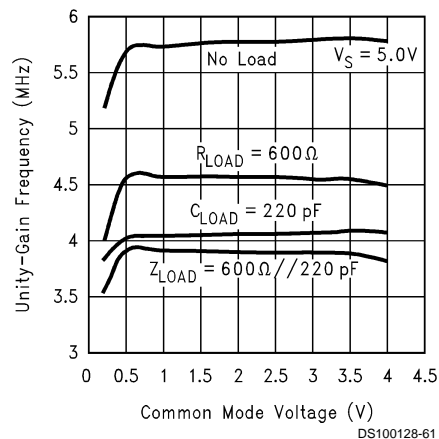


FIGURE 2. Unity-Gain Frequency vs Common Mode Voltage for Various Loads

1.2 Unity Gain Pulse Response Considerations

A pull-up resistor is well suited for increasing unity-gain, pulse response stability. For example, a 600 Ω pull-up resistor reduces the overshoot voltage by about 50%, when driving a 220 pF load. *Figure 3* shows how to implement the pull-up resistor for more pulse response stability.

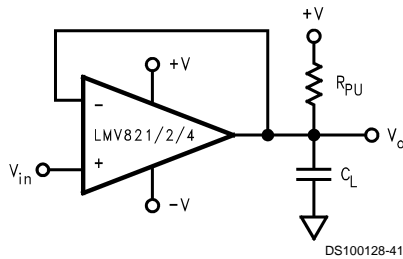


FIGURE 3. Using a Pull-up Resistor at the Output for Stabilizing Capacitive Loads

Higher capacitances can be driven by decreasing the value of the pull-up resistor, but its value shouldn't be reduced beyond the sinking capability of the part. An alternate approach is to use an isolation resistor as illustrated in *Figure 4*.

Figure 5 shows the resulting pulse response from a LMV824, while driving a 10,000pF load through a 20 Ω isolation resistor.

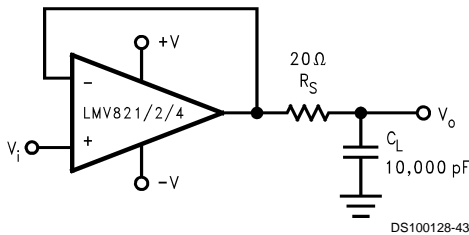


FIGURE 4. Using an Isolation Resistor to Drive Heavy Capacitive Loads

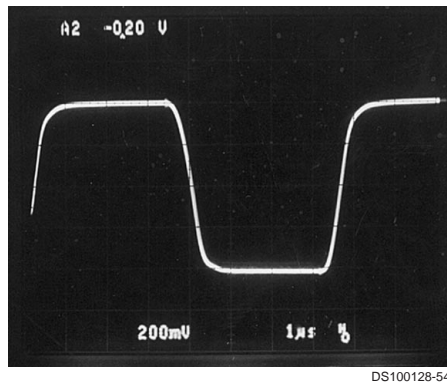


FIGURE 5. Pulse Response per Figure 4

1.3 Input Bias Current Consideration

Input bias current (I_B) can develop a somewhat significant offset voltage. This offset is primarily due to I_B flowing through the negative feedback resistor, R_F . For example, if I_B is 90nA (max room) and R_F is 100 k Ω , then an offset of 9 mV will be developed ($V_{OS} = I_B \times R_F$). Using a compensation resistor (R_C), as shown in *Figure 6*, cancels out this affect. But the

input offset current (I_{OS}) will still contribute to an offset voltage in the same manner - typically 0.05 mV at room temp.

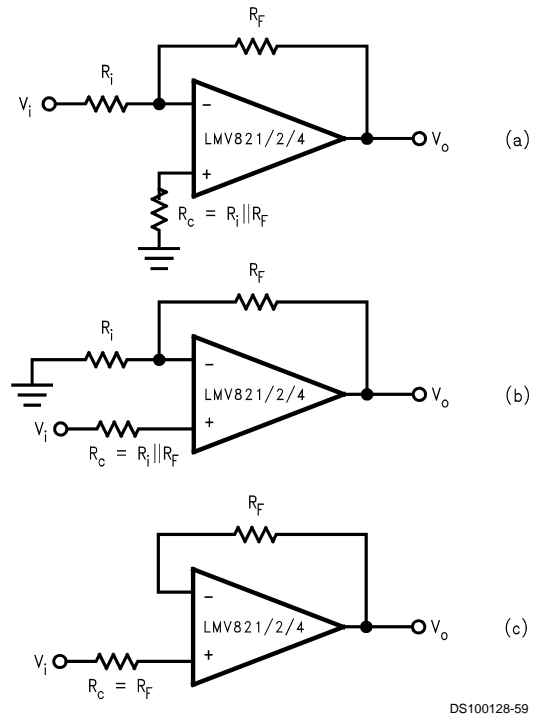


FIGURE 6. Canceling the Voltage Offset Effect of Input Bias Current

2.0 APPLICATION CIRCUITS

This section covers the following application circuits:

1. Telephone-Line Transceiver
2. "Simple" Mixer (Amplitude Modulator)
3. Dual Amplifier Active Filters (DAAFs)
 - a. Low-Pass Filter (LPF)
 - b. High-Pass Filter (HPF)
5. Tri-level Voltage Detector

2.1 Telephone-Line Transceiver

The telephone-line transceiver of *Figure 7* provides a full-duplexed connection through a PCMCIA, miniature transformer. The differential configuration of receiver portion (UR), cancels reception from the transmitter portion (UT). Note that the input signals for the differential configuration of UR, are the transmit voltage (V_t) and $V_t/2$. This is because R_{match} is chosen to match the coupled telephone-line impedance; therefore dividing V_t by two (assuming $R_1 \gg R_{match}$). The differential configuration of UR has its resistors chosen to cancel the V_t and $V_t/2$ inputs according to the following equation:

$$V_O = V_T \left(\frac{R_4}{R_3 + R_4} \right) \left(1 + \frac{R_2}{R_1} \right) - \frac{V_T}{2} \left(\frac{R_2}{R_1} \right) = V_T \frac{1}{3} (3) - \frac{V_T}{2} (2) = 0$$

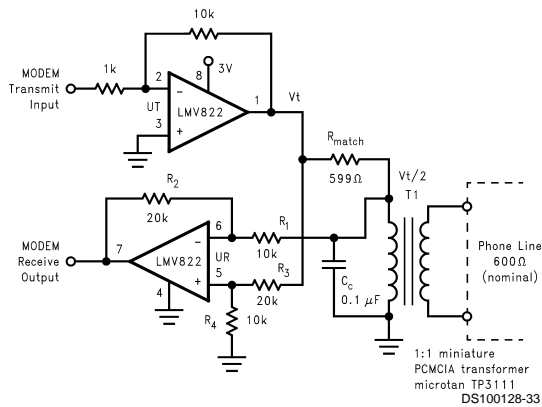


FIGURE 7. Telephone-line Transceiver for a PCMCIA Modem Card

Note that C_r is included for canceling out the inadequacies of the lossy, miniature transformer. Refer to application note AN-397 for detailed explanation.

2.2“Simple” Mixer (Amplitude Modulator)

The mixer of Figure 8 is simple and provides a unique form of amplitude modulation. V_i is the modulation frequency (F_M), while a +3V square-wave at the gate of Q1, induces a carrier frequency (F_C). Q1 switches (toggles) U1 between inverting and non-inverting unity gain configurations. Offsetting a sine wave above ground at V_i results in the oscilloscope photo of Figure 9.

The simple mixer can be applied to applications that utilize the Doppler Effect to measure the velocity of an object. The difference frequency is one of its output frequency components. This difference frequency magnitude ($F_M - F_C$) is the key factor for determining an object's velocity per the Doppler Effect. If a signal is transmitted to a moving object, the reflected frequency will be a different frequency. This difference in transmit and receive frequency is directly proportional to an object's velocity.

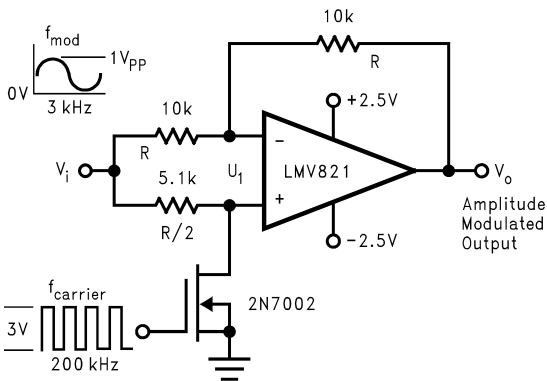


FIGURE 8. Amplitude Modulator Circuit

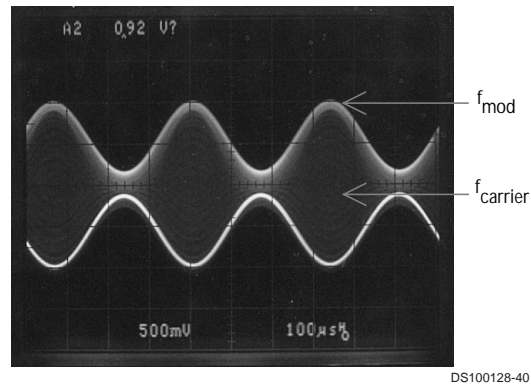


FIGURE 9. Output signal per the Circuit of Figure 8

2.4 Dual Amplifier Active Filters (DAAFs)

The LMV822/24 bring economy and performance to DAAFs. The low-pass and the high-pass filters of Figure 10 and Figure 11 (respectively), offer one key feature: excellent sensitivity performance. Good sensitivity is when deviations in component values cause relatively small deviations in a filter's parameter such as cutoff frequency (F_c). Single amplifier active filters like the Sallen-Key provide relatively poor sensitivity performance that sometimes cause problems for high production runs; their parameters are much more likely to deviate out of specification than a DAAF would. The DAAFs of Figure 10 and Figure 11 are well suited for high volume production.

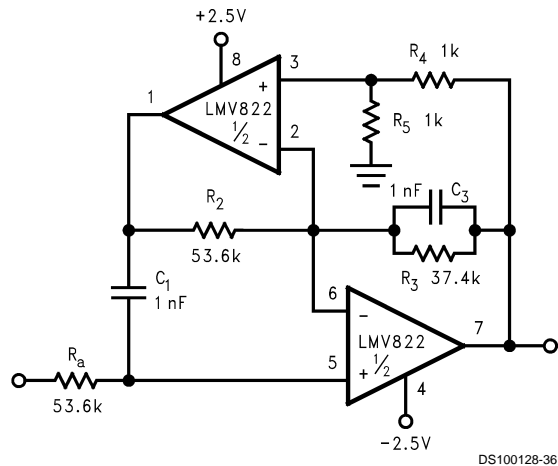
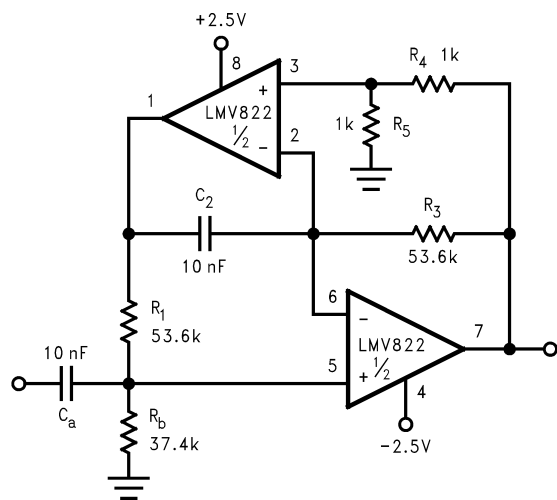


FIGURE 10. Dual Amplifier, 3 kHz Low-Pass Active Filter with a Butterworth Response and a Pass Band Gain of Times Two



DS100128-37

FIGURE 11. Dual Amplifier, 300 Hz High-Pass Active Filter with a Butterworth Response and a Pass Band Gain of Times Two

Table 1 provides sensitivity measurements for a 10 MΩ load condition. The left column shows the passive components for the 3 kHz low-pass DAAF. The third column shows the components for the 300 Hz high-pass DAAF. Their respective sensitivity measurements are shown to the right of each component column. Their values consists of the percent change in cutoff frequency (Fc) divided by the percent change in component value. The lower the sensitivity value, the better the performance.

Each resistor value was changed by about 10 percent, and this measured change was divided into the measured change in Fc. A positive or negative sign in front of the measured value, represents the direction Fc changes relative to components' direction of change. For example, a sensitivity value of negative 1.2, means that for a 1 percent increase in component value, Fc decreases by 1.2 percent. Note that this information provides insight on how to fine tune the cutoff frequency, if necessary. It should be also noted that R4 and R5 of each circuit also caused variations in the pass band gain. Increasing R4 by ten percent, increased the gain by 0.4 dB, while increasing R5 by ten percent, decreased the gain by 0.4 dB.

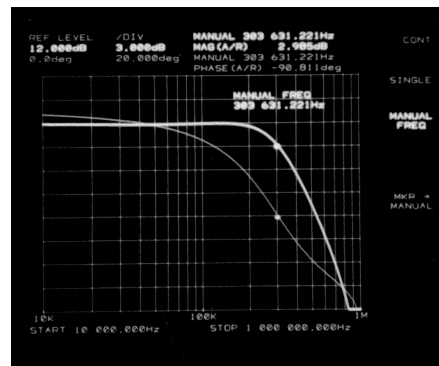
TABLE 1.

| Component (LPF) | Sensitivity (LPF) | Component (HPF) | Sensitivity (HPF) |
|-----------------|-------------------|-----------------|-------------------|
| Ra | -1.2 | Ca | -0.7 |
| C1 | -0.1 | Rb | -1.0 |
| R2 | -1.1 | R1 | +0.1 |
| R3 | +0.7 | C2 | -0.1 |
| C3 | -1.5 | R3 | +0.1 |
| R4 | -0.6 | R4 | -0.1 |
| R5 | +0.6 | R5 | +0.1 |

Active filters are also sensitive to an op amp's parameters -Gain and Bandwidth, in particular. The LMV822/24 provide a large gain and wide bandwidth. And DAAFs make excellent use of these feature specifications.

Single Amplifier versions require a large open-loop to closed-loop gain ratio - approximately 50 to 1, at the Fc of

the filter response. Figure 12 shows an impressive photograph of a network analyzer measurement (hp3577A). The measurement was taken from a 300kHz version of Figure 10. At 300 kHz, the open-loop to closed-loop gain ratio @ Fc is about 5 to 1. This is 10 times lower than the 50 to 1 "rule of thumb" for Single Amplifier Active Filters.



DS100128-92

FIGURE 12. 300 kHz, Low-Pass Filter, Butterworth Response as Measured by the HP3577A Network Analyzer

In addition to performance, DAAFs are relatively easy to design and implement. The design equations for the low-pass and high-pass DAAFs are shown below. The first two equations calculate the Fc and the circuit Quality Factor (Q) for the LPF (Figure 10). The second two equations calculate the Fc and Q for the HPF (Figure 11).

$$(LPF) \quad F_c = \frac{\sqrt{R_5}}{2\pi \sqrt{R_a} \cdot \sqrt{R_2} \cdot \sqrt{R_4} \cdot \sqrt{C_1} \cdot \sqrt{C_3}}$$

$$Q = 2\pi F_c \sqrt{C_1} \cdot \sqrt{C_3}$$

$$(HPF) \quad F_c = \frac{\sqrt{R_4}}{2\pi \sqrt{R_1} \cdot \sqrt{R_3} \cdot \sqrt{R_5} \cdot \sqrt{C_a} \cdot \sqrt{C_2}}$$

$$Q = 2\pi F_c \sqrt{C_a} \cdot \sqrt{C_2}$$

To simplify the design process, certain components are set equal to each other. Refer to Figure 10 and Figure 11. These equal component values help to simplify the design equations as follows:

$$(LPF) \quad R_a = R_2 = \frac{1}{2\pi F_c \sqrt{C_1} \cdot \sqrt{C_3}}$$

$$R_3 = \frac{Q}{2\pi F_c \sqrt{C_1} \cdot \sqrt{C_3}}$$

$$(HPF) \quad R_1 = R_3 = \frac{1}{2\pi F_c \sqrt{C_a} \cdot \sqrt{C_2}}$$

$$R_b = \frac{Q}{2\pi F_c \sqrt{C_a} \cdot \sqrt{C_2}}$$

To illustrate the design process/implementation, a 3 kHz, Butterworth response, low-pass filter DAAF (Figure 10) is designed as follows:

1. Choose $C_1 = C_3 = C = 1 \text{ nF}$
2. Choose $R_4 = R_5 = 1 \text{ k}\Omega$
3. Calculate R_a and R_2 for the desired Fc as follows:

$$\begin{aligned}
 R_a = R_2 &= \frac{1}{2\pi(F_C)C} \\
 &= \frac{1}{2\pi(3 \text{ kHz})1 \text{ nF}} \\
 &= 53.1 \text{ k}\Omega \\
 &\cong 53.6 \text{ k}\Omega \text{ (Practical Value)}
 \end{aligned}$$

4. Calculate R_3 for the desired Q. The desired Q for a Butterworth (Maximally Flat) response is 0.707 (45 degrees into the s-plane). R_3 calculates as follows:

$$\begin{aligned}
 R_3 &= \frac{Q}{2\pi(F_C)C} \\
 &= \frac{0.707}{2\pi(3 \text{ kHz})1 \text{ nF}} \\
 &= 37.5 \text{ k}\Omega \\
 &\cong 37.4 \text{ k}\Omega \text{ (Practical Value)}
 \end{aligned}$$

Notice that R_3 could also be calculated as 0.707 of R_a or R_2 . The circuit was implemented and its cutoff frequency measured. The cutoff frequency measured at 2.92 kHz.

The circuit also showed good repeatability. Ten different LMV822 samples were placed in the circuit. The corresponding change in the cutoff frequency was less than a percent.

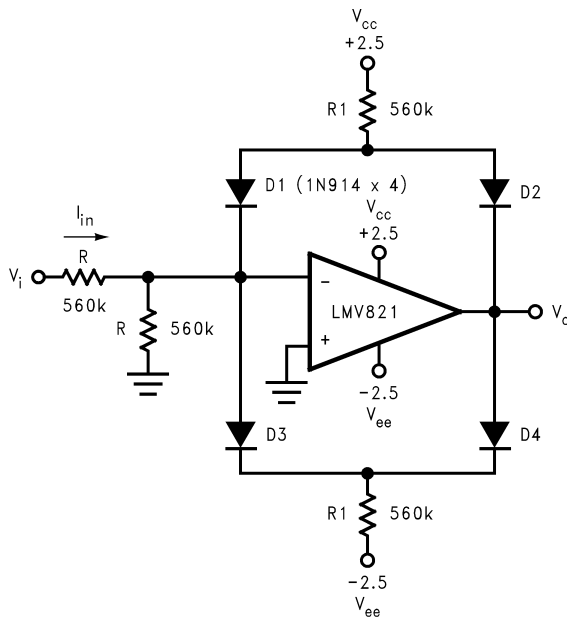


FIGURE 13. Tri-level Voltage Detector

2.5 Tri-level Voltage Detector

The tri-level voltage detector of Figure 13 provides a type of window comparator function. It detects three different input voltage ranges: Min-range, Mid-range, and Max-range. The output voltage (V_O) is at V_{CC} for the Min-range. V_O is clamped at GND for the Mid-range. For the Max-range, V_O is at V_{EE} . Figure 14 shows a V_O vs. V_I oscilloscope photo per the circuit of Figure 13.

Its operation is as follows: V_I deviating from GND, causes the diode bridge to absorb I_{IN} to maintain a clamped condition ($V_O = 0V$). Eventually, I_{IN} reaches the bias limit of the diode bridge. When this limit is reached, the clamping effect stops and the op amp responds open loop. The design equation directly preceding Figure 14, shows how to determine the clamping range. The equation solves for the input voltage band on each side GND. The mid-range is twice this voltage band.

$$\Delta V = \frac{R}{R_1} (V_{CC} - V_{Diode})$$

DS100128-89

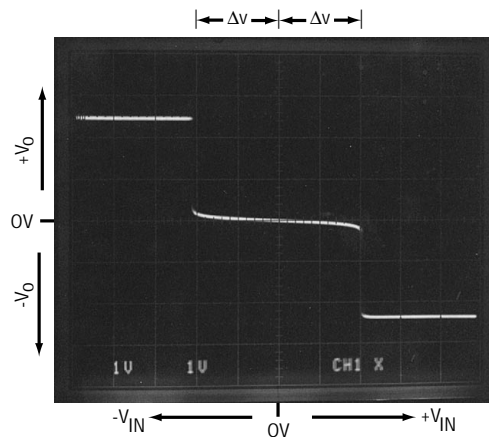
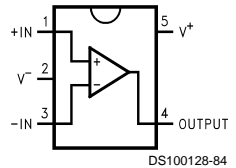


FIGURE 14. X, Y Oscilloscope Trace showing V_{OUT} vs V_{IN} per the Circuit of Figure 13

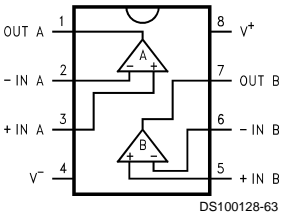
Connection Diagrams

5-Pin SC70-5/SOT23-5



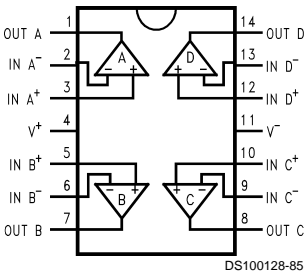
Top View

8-Pin SO/MSOP



Top View

14-Pin SO/TSSOP

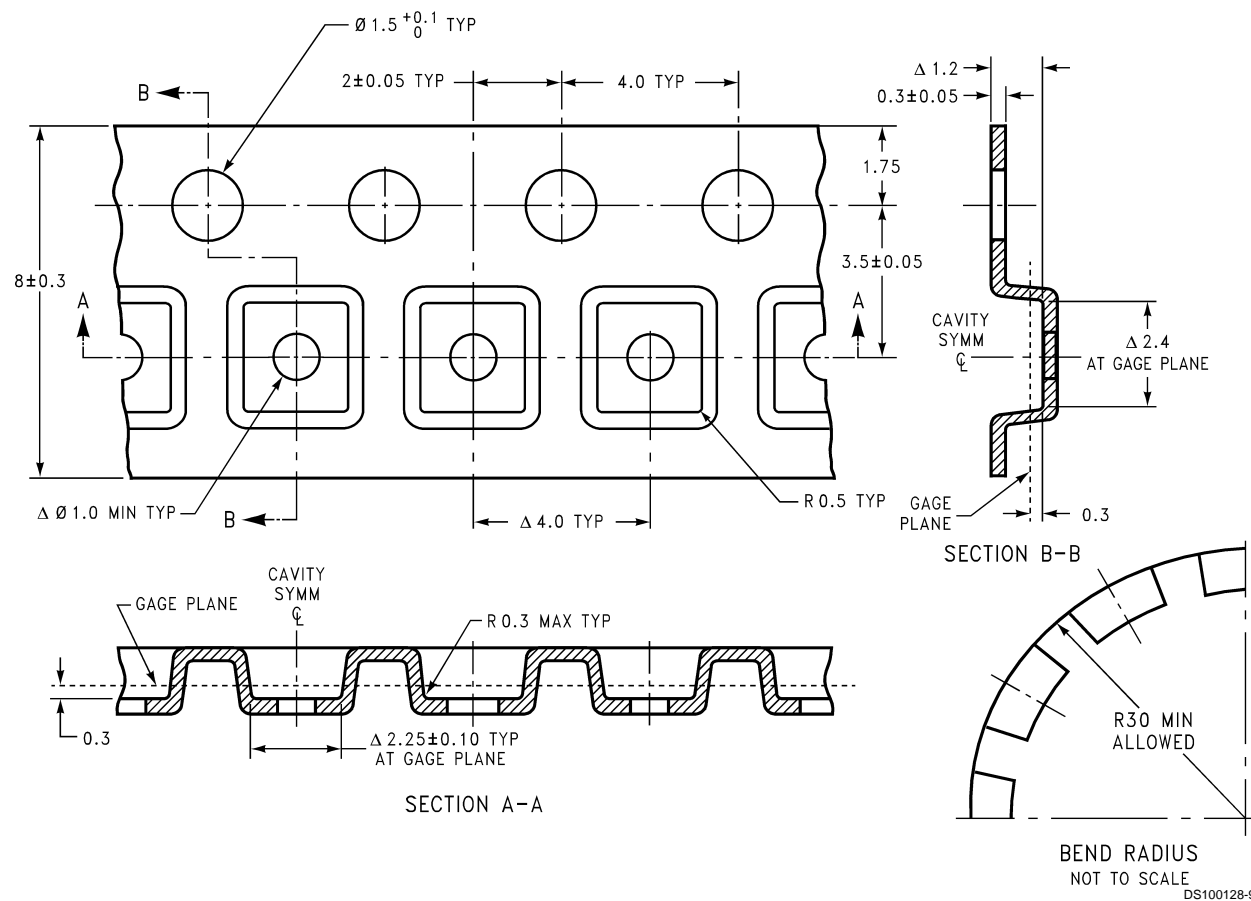


Top View

Ordering Information

| Package | Temperature Range | Packaging Marking | Transport Media | NSC Drawing |
|---------------|------------------------------|-------------------|--------------------------|-------------|
| | Industrial -40°C to +85°C | | | |
| 5-Pin SC-70-5 | LMV821M7 | A15 | 1k Units Tape and Reel | MAA05 |
| | LMV821M7X | A15 | 3k Units Tape and Reel | |
| 5-Pin SOT23-5 | LMV821M5 | A14 | 1k Units Tape and Reel | MA05B |
| | LMV821M5X | A14 | 3k Units Tape and Reel | |
| 8-Pin SO | LMV822M | LMV822M | Rails | M08A |
| | LMV822MX | LMV822M | 2.5k Units Tape and Reel | |
| 8-Pin MSOP | LMV822MM | LMV822 | 1k Units Tape and Reel | MUA08A |
| | LMV822MMX | LMV822 | 3.5k Units Tape and Reel | |
| 14-Pin SO | LMV824M | LMV824M | Rails | M14A |
| | LMV824MX | LMV824M | 2.5k Units Tape and Reel | |
| 14-Pin TSSOP | LMV824MT | LMV824MT | Rails | MTC14 |
| | LMV824MTX | LMV824MT | 2.5k Units Tape and Reel | |

SC70-5 Tape and Reel Specification

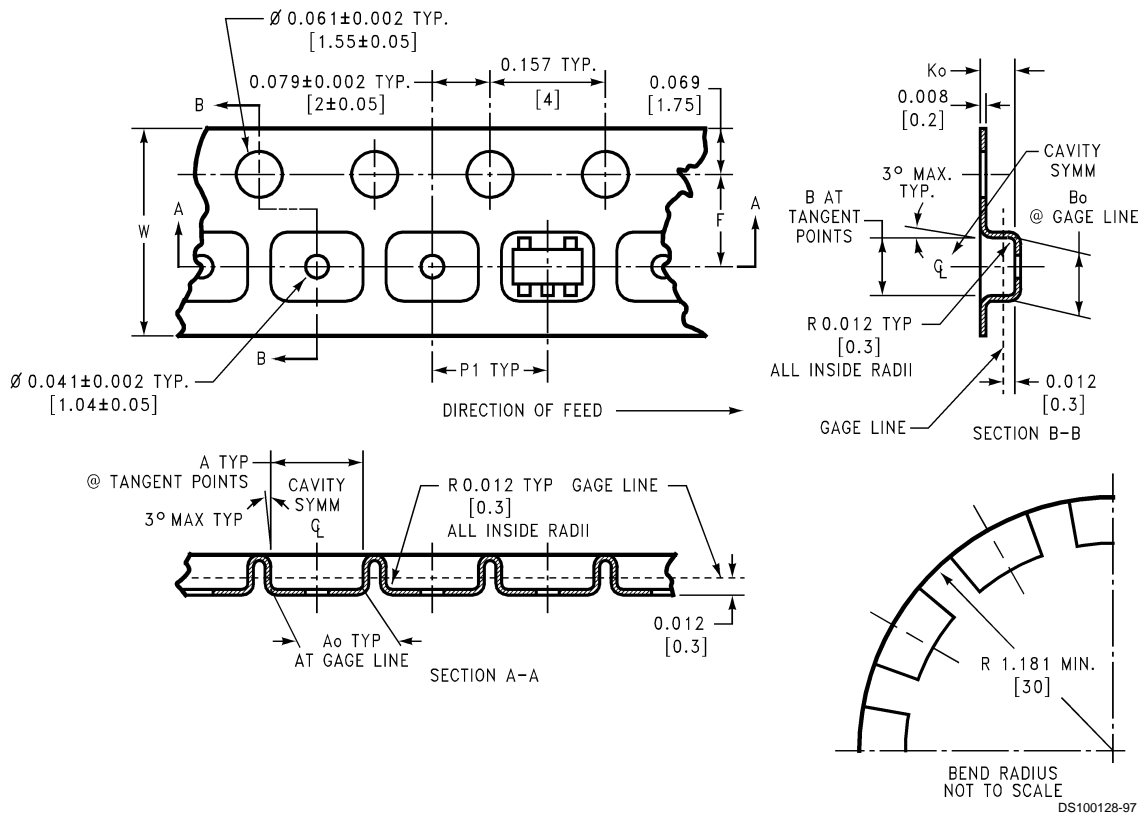


SOT-23-5 Tape and Reel Specification

Tape Format

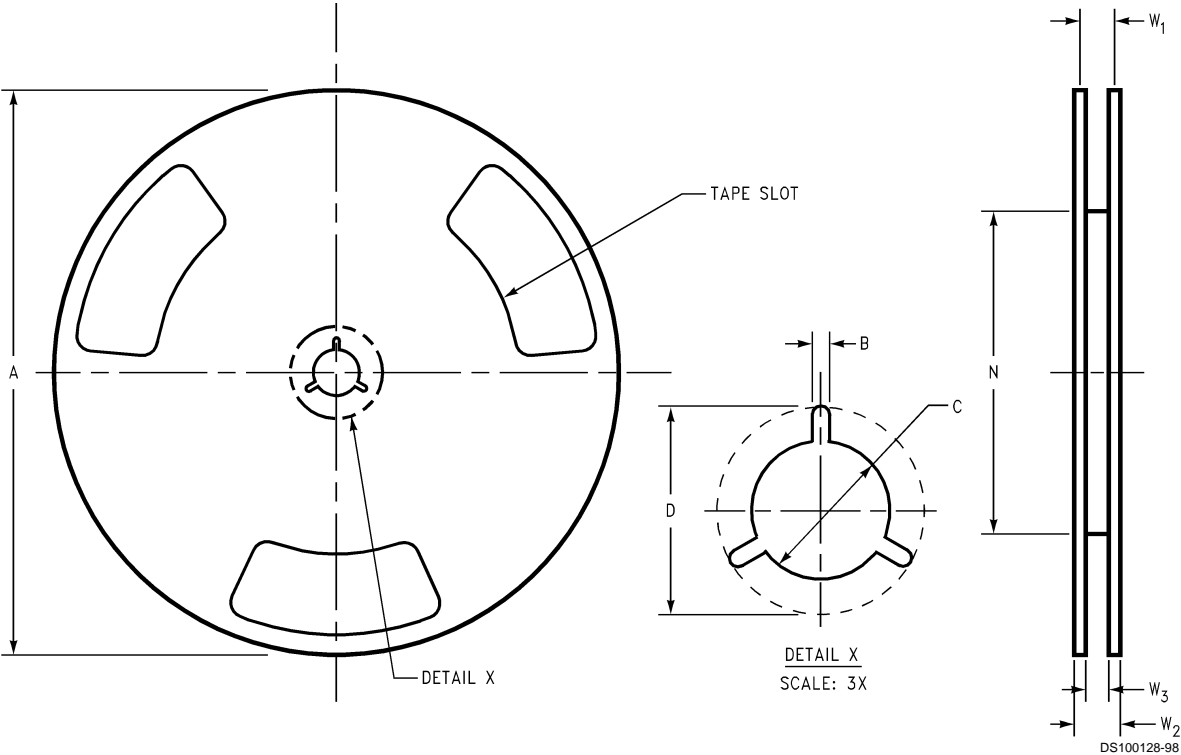
| Tape Section | # Cavities | Cavity Status | Cover Tape Status |
|-----------------------|------------|---------------|-------------------|
| Leader (Start End) | 0 (min) | Empty | Sealed |
| | 75 (min) | Empty | Sealed |
| Carrier | 3000 | Filled | Sealed |
| | 250 | Filled | Sealed |
| Trailer (Hub End) | 125 (min) | Empty | Sealed |
| | 0 (min) | Empty | Sealed |

Tape Dimensions



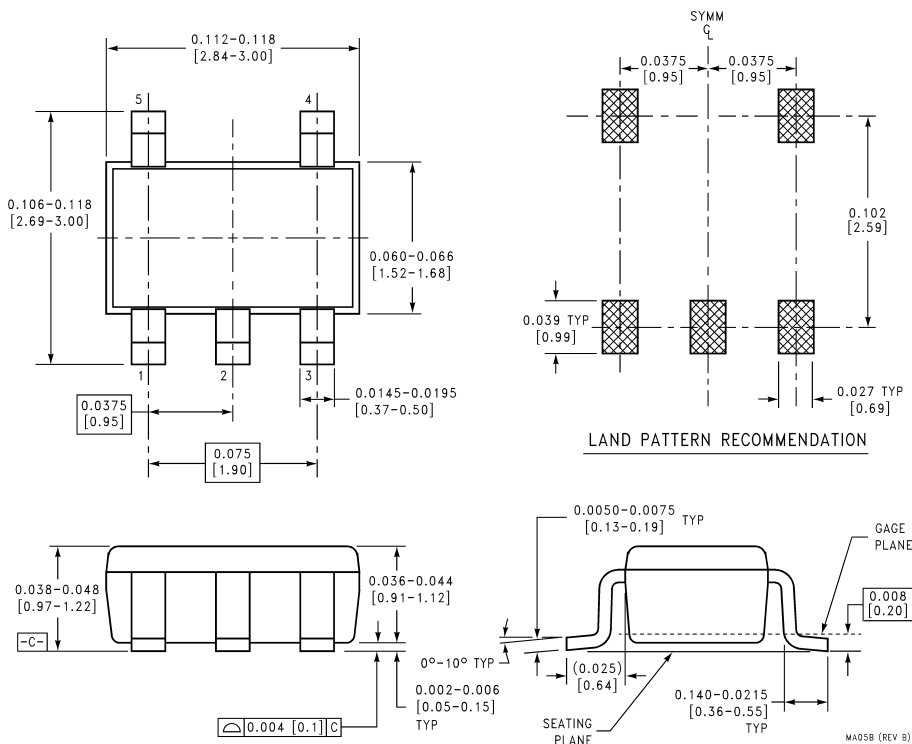
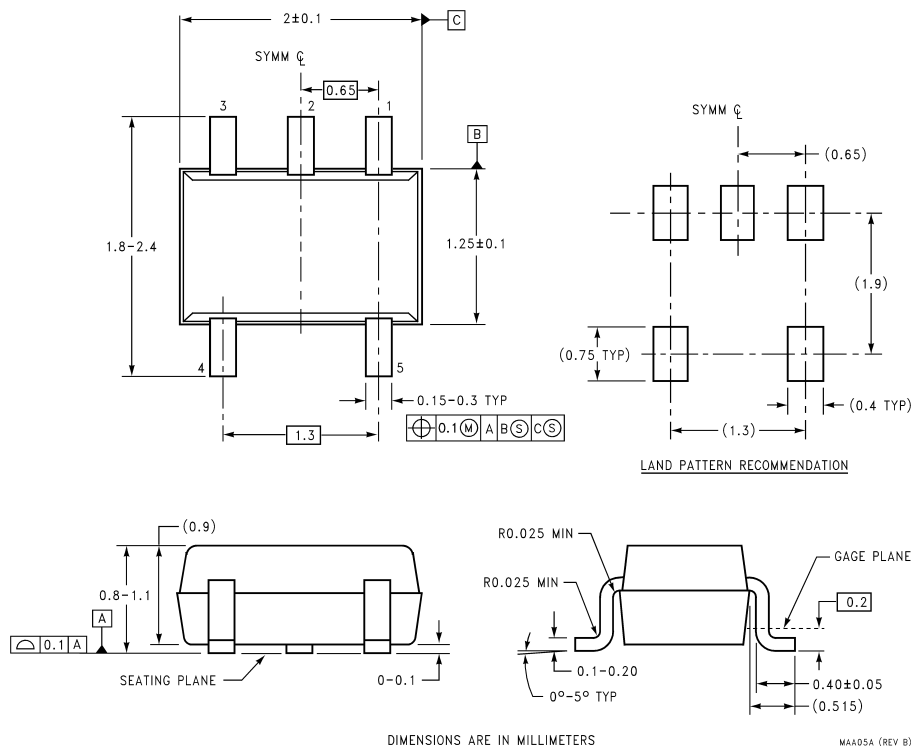
| | | | | | | | | |
|-----------|----------------|-----------------|----------------|----------------|-----------------------------|-----------------------------|--------------|--------------------------|
| 8 mm | 0.130 (3.3) | 0.124 (3.15) | 0.130 (3.3) | 0.126 (3.2) | 0.138 ±0.002 (3.5 ±0.05) | 0.055 ±0.004 (1.4 ±0.11) | 0.157 (4) | 0.315 ±0.012 (8 ±0.3) |
| Tape Size | DIM A | DIM Ao | DIM B | DIM Bo | DIM F | DIM Ko | DIM P1 | DIM W |

Reel Dimensions

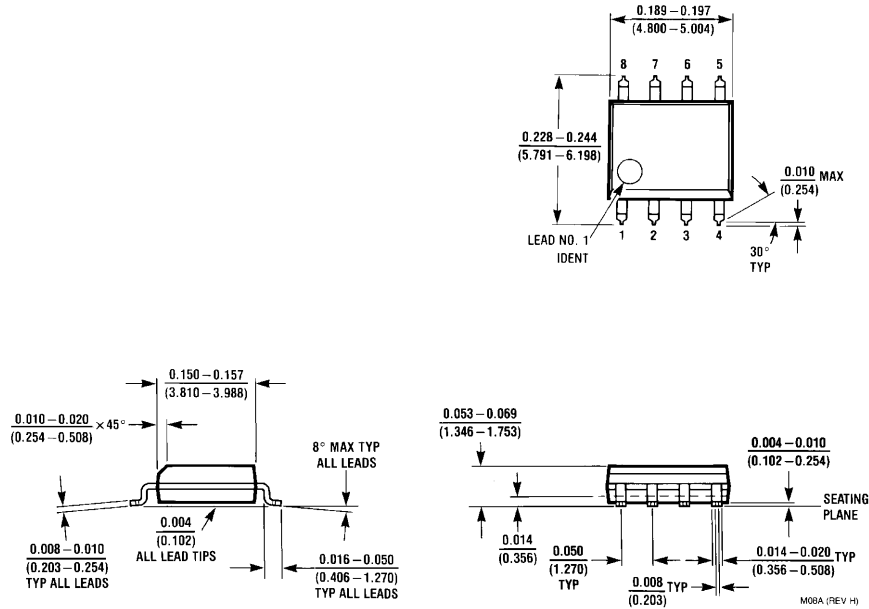


| | | | | | | | | |
|-----------|--------|-------|-------|-------|-------|----------------------|-------|------------------|
| 8 mm | 7.00 | 0.059 | 0.512 | 0.795 | 2.165 | 0.331 + 0.059/-0.000 | 0.567 | W1+ 0.078/-0.039 |
| | 330.00 | 1.50 | 13.00 | 20.20 | 55.00 | 8.40 + 1.50/-0.00 | 14.40 | W1 + 2.00/-1.00 |
| Tape Size | A | B | C | D | N | W1 | W2 | W3 |

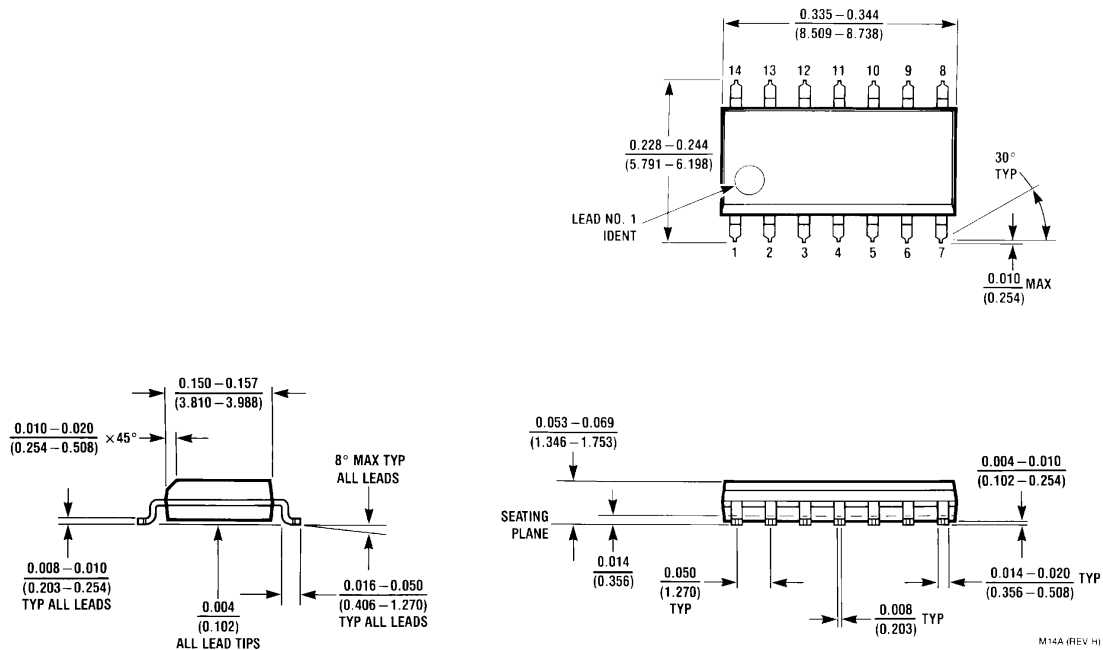
Physical Dimensions inches (millimeters) unless otherwise noted



Physical Dimensions inches (millimeters) unless otherwise noted (Continued)



8-Pin Small Outline
Order Number LMV822M or LMV822MX
NS Package Number M08A



14-Pin Small Outline
Order Number LMV824M or LMV824MX
NS Package Number M14A



