

# LMV931 Single / LMV932 Dual / LMV934 Quad 1.8V, RRIO Operational Amplifiers

## General Description

The LMV931/LMV932/LMV934 are low voltage, low power operational amplifiers. LMV931/LMV932/LMV934 are guaranteed to operate from +1.8V to +5.0V supply voltages and have rail-to-rail input and output. LMV931/LMV932/LMV934 input common mode voltage extends 200mV beyond the supplies which enables user enhanced functionality beyond the supply voltage range. The output can swing rail-to-rail unloaded and within 105mV from the rail with 600Ω load at 1.8V supply. The LMV931/LMV932/LMV934 are optimized to work at 1.8V which make them ideal for portable two-cell battery powered systems and single cell Li-Ion systems.

LMV931/LMV932/LMV934 exhibit excellent speed-power ratio, achieving 1.4MHz gain bandwidth product at 1.8V supply voltage with very low supply current. The LMV931/LMV932/LMV934 are capable of driving a 600Ω load and up to 1000pF capacitive load with minimal ringing. LMV931/LMV932/LMV934 have a high DC gain of 101dB, making them suitable for low frequency applications.

The single LMV931 is offered in space saving SC70-5 and SOT23-5 packages. The dual LMV932 are in MSOP-8 and SOIC-8 packages and the quad LMV934 are in TSSOP-14 and SOIC-14 packages. These small packages are ideal solutions for area constrained PC boards and portable electronics such as cellular phones and PDAs.

## Features

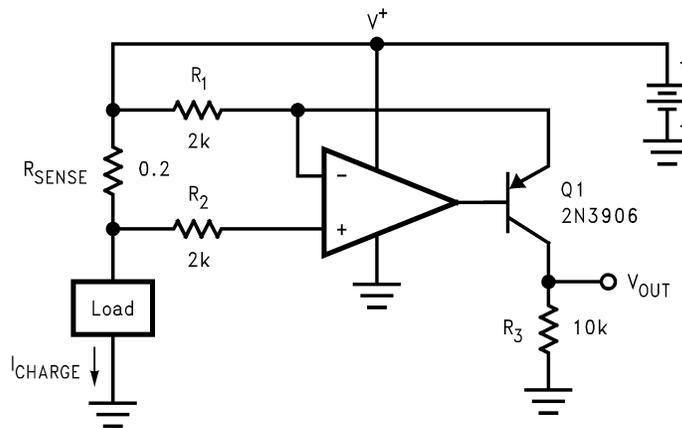
(Typical 1.8V Supply Values; Unless Otherwise Noted)

- Guaranteed 1.8V, 2.7V and 5V specifications
- Output swing
  - w/600Ω load 80mV from rail
  - w/2kΩ load 30mV from rail
- $V_{CM}$  200mV beyond rails
- Supply current (per channel) 100μA
- Gain bandwidth product 1.4MHz
- Maximum  $V_{OS}$  4.0mV
- Ultra tiny packages
- Temperature range -40°C to 125°C

## Applications

- Consumer communication
- Consumer computing
- PDAs
- Audio pre-amp
- Portable/battery-powered electronic equipment
- Supply current monitoring
- Battery monitoring

## Typical Application



$$V_{OUT} = \frac{R_{SENSE} \cdot R_3}{R_1} \cdot I_{CHARGE} = 1\Omega \cdot I_{CHARGE}$$

200326H0

**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                          | 200V             |
| Human Body Model                       | 2000V            |
| 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) |                  |
| Storage Temperature Range              | -65°C to 150°C   |
| Junction Temperature (Note 4)          | 150°C            |
| Mounting Temp.                         |                  |

Infrared or Convection (20 sec)

235°C

**Operating Ratings** (Note 1)

|                                      |                |
|--------------------------------------|----------------|
| Supply Voltage Range                 | 1.8V to 5.0V   |
| Temperature Range                    | -40°C to 125°C |
| Thermal Resistance ( $\theta_{JA}$ ) |                |
| SC70-5                               | 414°C/W        |
| SOT23-5                              | 265°C/W        |
| MSOP-8                               | 235°C/W        |
| SOIC-8                               | 175°C/W        |
| TSSOP-14                             | 155°C/W        |
| SOIC-14                              | 127°C/W        |

**1.8V DC Electrical Characteristics**

Unless otherwise specified, all limits guaranteed for  $T_J = 25^\circ\text{C}$ .  $V^+ = 1.8\text{V}$ ,  $V^- = 0\text{V}$ ,  $V_{CM} = V^+/2$ ,  $V_O = V^+/2$  and  $R_L > 1\text{M}\Omega$ . **Boldface** limits apply at the temperature extremes. See (Note 10)

| Symbol     | Parameter   | Condition   | Min<br>(Note 6)                                 | Typ<br>(Note 5) | Max<br>(Note 6)   | Units                        |   |
|------------|---|---|---|-----------------|-------------------|------------------------------|---|
| $V_{OS}$   | Input Offset Voltage  | LMV931 (Single)   |   | 1               | 4<br><b>6</b>     | mV                           |   |
|            |   | LMV932 (Dual)   |   | 1               | 5.5               | mV                           |   |
|            |   | LMV934 (Quad)   |   |                 | <b>7.5</b>        |                              |   |
| $TCV_{OS}$ | Input Offset Voltage Average Drift                          |   |   | 5.5             |                   | $\mu\text{V}/^\circ\text{C}$ |   |
| $I_B$      | Input Bias Current  |   |   | 15              | 35<br><b>50</b>   | nA                           |   |
| $I_{OS}$   | Input Offset Current  |   |   | 13              | 25<br><b>40</b>   | nA                           |   |
| $I_S$      | Supply Current (per channel)                                |   |   | 103             | 185<br><b>205</b> | $\mu\text{A}$                |   |
| CMRR       | Common Mode Rejection Ratio                                 | LMV931, $0 \leq V_{CM} \leq 0.6\text{V}$  | 60  | 78              |                   | dB                           |   |
|            |   | $1.4\text{V} \leq V_{CM} \leq 1.8\text{V}$ (Note 8)   | <b>55</b>                                       |                 |                   |                              |   |
|            |   | LMV932 and LMV934<br>$0 \leq V_{CM} \leq 0.6\text{V}$   | 55  | 76              |                   |                              |   |
|            |   | $1.4\text{V} \leq V_{CM} \leq 1.8\text{V}$ (Note 8)   | <b>50</b>                                       |                 |                   |                              |   |
|            |   | $-0.2\text{V} \leq V_{CM} \leq 0\text{V}$   | 50  | 72              |                   |                              |   |
|            |   | $1.8\text{V} \leq V_{CM} \leq 2.0\text{V}$  |   |                 |                   |                              |   |
| PSRR       | Power Supply Rejection Ratio                                | $1.8\text{V} \leq V^+ \leq 5\text{V}$   | 75<br><b>70</b>                                 | 100             |                   | dB                           |   |
| CMVR       | Input Common-Mode Voltage Range                             | For CMRR Range $\geq 50\text{dB}$   | $T_A = 25^\circ\text{C}$                        | $V^- - 0.2$     | -0.2 to 2.1       | $V^+ + 0.2$                  | V |
|            |   |   | $T_A = -40^\circ\text{C}$ to $85^\circ\text{C}$ | $V^-$           |                   | $V^+$                        |   |
|            |   |   | $T_A = 125^\circ\text{C}$                       | $V^- + 0.2$     |                   | $V^+ - 0.2$                  |   |
| $A_V$      | Large Signal Voltage Gain<br>LMV931 (Single)                | $R_L = 600\Omega$ to $0.9\text{V}$ ,<br>$V_O = 0.2\text{V}$ to $1.6\text{V}$ , $V_{CM} = 0.5\text{V}$       | 77<br><b>73</b>                                 | 101             |                   | dB                           |   |
|            |   | $R_L = 2\text{k}\Omega$ to $0.9\text{V}$ ,<br>$V_O = 0.2\text{V}$ to $1.6\text{V}$ , $V_{CM} = 0.5\text{V}$ | 80<br><b>75</b>                                 | 105             |                   |                              |   |
|            | Large Signal Voltage Gain<br>LMV932 (Dual)<br>LMV934 (Quad) | $R_L = 600\Omega$ to $0.9\text{V}$ ,<br>$V_O = 0.2\text{V}$ to $1.6\text{V}$ , $V_{CM} = 0.5\text{V}$       | 75<br><b>72</b>                                 | 90              |                   | dB                           |   |
|            |   | $R_L = 2\text{k}\Omega$ to $0.9\text{V}$ ,<br>$V_O = 0.2\text{V}$ to $1.6\text{V}$ , $V_{CM} = 0.5\text{V}$ | 78<br><b>75</b>                                 | 100             |                   |                              |   |

## 1.8V DC Electrical Characteristics (Continued)

Unless otherwise specified, all limits guaranteed for  $T_J = 25^\circ\text{C}$ .  $V^+ = 1.8\text{V}$ ,  $V^- = 0\text{V}$ ,  $V_{\text{CM}} = V^+/2$ ,  $V_O = V^+/2$  and  $R_L > 1\text{M}\Omega$ . **Boldface** limits apply at the temperature extremes. See (Note 10)

| Symbol | Parameter                    | Condition  | Min<br>(Note 6) | Typ<br>(Note 5) | Max<br>(Note 6)       | Units |
|--------|------------------------------|--|-----------------|-----------------|-----------------------|-------|
| $V_O$  | Output Swing                 | $R_L = 600\Omega$ to $0.9\text{V}$<br>$V_{\text{IN}} = \pm 100\text{mV}$       | 1.65            | 1.72            |                       | V     |
|        |                              |  | <b>1.63</b>     | 0.077           | 0.105<br><b>0.120</b> |       |
|        |                              | $R_L = 2\text{k}\Omega$ to $0.9\text{V}$<br>$V_{\text{IN}} = \pm 100\text{mV}$ | 1.75            | 1.77            |                       |       |
|        |                              |  | <b>1.74</b>     | 0.024           | 0.035<br><b>0.04</b>  |       |
| $I_O$  | Output Short Circuit Current | Sourcing, $V_O = 0\text{V}$<br>$V_{\text{IN}} = 100\text{mV}$                  | 4               | 8               |                       | mA    |
|        |                              | Sinking, $V_O = 1.8\text{V}$<br>$V_{\text{IN}} = -100\text{mV}$                | <b>3.3</b>      | 7               | 9                     |       |
|        |                              |  | <b>5</b>        |                 |                       |       |

## 1.8V AC Electrical Characteristics

Unless otherwise specified, all limits guaranteed for  $T_J = 25^\circ\text{C}$ .  $V^+ = 1.8\text{V}$ ,  $V^- = 0\text{V}$ ,  $V_{\text{CM}} = V^+/2$ ,  $V_O = V^+/2$  and  $R_L > 1\text{M}\Omega$ . **Boldface** limits apply at the temperature extremes. See (Note 10)

| Symbol   | Parameter                    | Conditions  | Min<br>(Note 6) | Typ<br>(Note 5) | Max<br>(Note 6) | Units                                |
|----------|------------------------------|---|-----------------|-----------------|-----------------|--------------------------------------|
| SR       | Slew Rate                    | (Note 7)  |                 | 0.35            |                 | V/ $\mu\text{s}$                     |
| GBW      | Gain-Bandwidth Product       |   |                 | 1.4             |                 | MHz                                  |
| $\Phi_m$ | Phase Margin                 |   |                 | 67              |                 | deg                                  |
| $G_m$    | Gain Margin                  |   |                 | 7               |                 | dB                                   |
| $e_n$    | Input-Referred Voltage Noise | $f = 1\text{kHz}$ , $V_{\text{CM}} = 0.5\text{V}$   |                 | 60              |                 | $\frac{\text{nV}}{\sqrt{\text{Hz}}}$ |
| $i_n$    | Input-Referred Current Noise | $f = 1\text{kHz}$   |                 | 0.06            |                 | $\frac{\text{pA}}{\sqrt{\text{Hz}}}$ |
| THD      | Total Harmonic Distortion    | $f = 1\text{kHz}$ , $A_V = +1$<br>$R_L = 600\Omega$ , $V_{\text{IN}} = 1\text{V}_{\text{PP}}$ |                 | 0.023           |                 | %                                    |
|          | Amp-to-Amp Isolation         | (Note 9)  |                 | 123             |                 | dB                                   |

## 2.7V DC Electrical Characteristics

Unless otherwise specified, all limits guaranteed for  $T_J = 25^\circ\text{C}$ .  $V^+ = 2.7\text{V}$ ,  $V^- = 0\text{V}$ ,  $V_{\text{CM}} = V^+/2$ ,  $V_O = V^+/2$  and  $R_L > 1\text{M}\Omega$ . **Boldface** limits apply at the temperature extremes. See (Note 10)

| Symbol                   | Parameter                          | Condition       | Min<br>(Note 6) | Typ<br>(Note 5) | Max<br>(Note 6)   | Units                        |
|--------------------------|------------------------------------|-----------------|-----------------|-----------------|-------------------|------------------------------|
| $V_{\text{OS}}$          | Input Offset Voltage               | LMV931 (Single) |                 | 1               | 4<br><b>6</b>     | mV                           |
|                          |                                    | LMV932 (Dual)   |                 | 1               | 5.5               | mV                           |
|                          |                                    | LMV934 (Quad)   |                 |                 | <b>7.5</b>        |                              |
| $\text{TCV}_{\text{OS}}$ | Input Offset Voltage Average Drift |                 |                 | 5.5             |                   | $\mu\text{V}/^\circ\text{C}$ |
| $I_B$                    | Input Bias Current                 |                 |                 | 15              | 35<br><b>50</b>   | nA                           |
| $I_{\text{OS}}$          | Input Offset Current               |                 |                 | 8               | 25<br><b>40</b>   | nA                           |
| $I_S$                    | Supply Current (per channel)       |                 |                 | 105             | 190<br><b>210</b> | $\mu\text{A}$                |

## 2.7V DC Electrical Characteristics (Continued)

Unless otherwise specified, all limits guaranteed for  $T_J = 25^\circ\text{C}$ .  $V^+ = 2.7\text{V}$ ,  $V^- = 0\text{V}$ ,  $V_{\text{CM}} = V^+/2$ ,  $V_O = V^+/2$  and  $R_L > 1\text{M}\Omega$ . **Boldface** limits apply at the temperature extremes. See (Note 10)

| Symbol          | Parameter   | Condition  | Min<br>(Note 6)                                 | Typ<br>(Note 5)       | Max<br>(Note 6) | Units |             |
|-----------------|---|--|---|-----------------------|-----------------|-------|-------------|
| CMRR            | Common Mode Rejection Ratio                                 | LMV931, $0 \leq V_{\text{CM}} \leq 1.5\text{V}$<br>$2.3\text{V} \leq V_{\text{CM}} \leq 2.7\text{V}$ (Note 8)              | 60<br><b>55</b>                                 | 81                    |                 | dB    |             |
|                 |   | LMV932 and LMV934<br>$0 \leq V_{\text{CM}} \leq 1.5\text{V}$<br>$2.3\text{V} \leq V_{\text{CM}} \leq 2.7\text{V}$ (Note 8) | 55<br><b>50</b>                                 | 80                    |                 |       |             |
|                 |   | $-0.2\text{V} \leq V_{\text{CM}} \leq 0\text{V}$<br>$2.7\text{V} \leq V_{\text{CM}} \leq 2.9\text{V}$                      | 50  | 74                    |                 |       |             |
| PSRR            | Power Supply Rejection Ratio                                | $1.8\text{V} \leq V^+ \leq 5\text{V}$<br>$V_{\text{CM}} = 0.5\text{V}$   | 75<br><b>70</b>                                 | 100                   |                 | dB    |             |
| $V_{\text{CM}}$ | Input Common-Mode Voltage Range                             | For CMRR<br>Range $\geq 50\text{dB}$   | $T_A = 25^\circ\text{C}$                        | $-0.2$ to $3.0$       | $V^+ + 0.2$     | V     |             |
|                 |   |  | $T_A = -40^\circ\text{C}$ to $85^\circ\text{C}$ |                       | $V^-$           |       | $V^+$       |
|                 |   |  | $T_A = 125^\circ\text{C}$                       |                       | $V^- + 0.2$     |       | $V^+ - 0.2$ |
| $A_V$           | Large Signal Voltage Gain<br>LMV931 (Single)                | $R_L = 600\Omega$ to $1.35\text{V}$ ,<br>$V_O = 0.2\text{V}$ to $2.5\text{V}$  | 87<br><b>86</b>                                 | 104                   |                 | dB    |             |
|                 |   | $R_L = 2\text{k}\Omega$ to $1.35\text{V}$ ,<br>$V_O = 0.2\text{V}$ to $2.5\text{V}$  | 92<br><b>91</b>                                 | 110                   |                 |       |             |
|                 | Large Signal Voltage Gain<br>LMV932 (Dual)<br>LMV934 (Quad) | $R_L = 600\Omega$ to $1.35\text{V}$ ,<br>$V_O = 0.2\text{V}$ to $2.5\text{V}$  | 78<br><b>75</b>                                 | 90                    |                 | dB    |             |
|                 |   | $R_L = 2\text{k}\Omega$ to $1.35\text{V}$ ,<br>$V_O = 0.2\text{V}$ to $2.5\text{V}$  | 81<br><b>78</b>                                 | 100                   |                 |       |             |
| $V_O$           | Output Swing  | $R_L = 600\Omega$ to $1.35\text{V}$<br>$V_{\text{IN}} = \pm 100\text{mV}$  | 2.55<br><b>2.53</b>                             | 2.62                  |                 | V     |             |
|                 |   |  | 0.083   | 0.110<br><b>0.130</b> |                 |       |             |
|                 |   | $R_L = 2\text{k}\Omega$ to $1.35\text{V}$<br>$V_{\text{IN}} = \pm 100\text{mV}$  | 2.65<br><b>2.64</b>                             | 2.675                 |                 |       |             |
|                 |   |  | 0.025   | 0.04<br><b>0.045</b>  |                 |       |             |
| $I_O$           | Output Short Circuit Current                                | Sourcing, $V_O = 0\text{V}$<br>$V_{\text{IN}} = 100\text{mV}$  | 20<br><b>15</b>                                 | 30                    |                 | mA    |             |
|                 |   | Sinking, $V_O = 0\text{V}$<br>$V_{\text{IN}} = -100\text{mV}$  | 18<br><b>12</b>                                 | 25                    |                 |       |             |
|                 |   |  |   |                       |                 |       |             |

## 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. See (Note 10)

| Symbol   | Parameter                    | Conditions  | Min<br>(Note 6) | Typ<br>(Note 5) | Max<br>(Note 6) | Units                                |
|----------|------------------------------|---|-----------------|-----------------|-----------------|--------------------------------------|
| SR       | Slew Rate                    | (Note 7)  |                 | 0.4             |                 | V/ $\mu\text{s}$                     |
| GBW      | Gain-Bandwidth Product       |   |                 | 1.4             |                 | MHz                                  |
| $\Phi_m$ | Phase Margin                 |   |                 | 70              |                 | deg                                  |
| $G_m$    | Gain Margin                  |   |                 | 7.5             |                 | dB                                   |
| $e_n$    | Input-Referred Voltage Noise | $f = 1\text{kHz}$ , $V_{\text{CM}} = 0.5\text{V}$ |                 | 57              |                 | $\frac{\text{nV}}{\sqrt{\text{Hz}}}$ |
| $i_n$    | Input-Referred Current Noise | $f = 1\text{kHz}$                                 |                 | 0.082           |                 | $\frac{\text{pA}}{\sqrt{\text{Hz}}}$ |

## 2.7V AC Electrical Characteristics (Continued)

Unless otherwise specified, all limits guaranteed for  $T_J = 25^\circ\text{C}$ .  $V^+ = 2.7\text{V}$ ,  $V^- = 0\text{V}$ ,  $V_{CM} = 1.0\text{V}$ ,  $V_O = 1.35\text{V}$  and  $R_L > 1\text{M}\Omega$ . **Boldface** limits apply at the temperature extremes. See (Note 10)

| Symbol | Parameter                 | Conditions   | Min<br>(Note 6) | Typ<br>(Note 5) | Max<br>(Note 6) | Units |
|--------|---------------------------|--|-----------------|-----------------|-----------------|-------|
| THD    | Total Harmonic Distortion | $f = 1\text{kHz}$ , $A_V = +1$<br>$R_L = 600\text{k}\Omega$ , $V_{IN} = 1V_{PP}$ |                 | 0.022           |                 | %     |
|        | Amp-to-Amp Isolation      | (Note 9)   |                 | 123             |                 | dB    |

## 5V DC Electrical Characteristics

Unless otherwise specified, all limits guaranteed for  $T_J = 25^\circ\text{C}$ .  $V^+ = 5\text{V}$ ,  $V^- = 0\text{V}$ ,  $V_{CM} = V^+/2$ ,  $V_O = V^+/2$  and  $R_L > 1\text{M}\Omega$ . **Boldface** limits apply at the temperature extremes. See (Note 10)

| Symbol     | Parameter   | Condition   | Min<br>(Note 6)                                 | Typ<br>(Note 5) | Max<br>(Note 6)       | Units                        |   |
|------------|---|---|---|-----------------|-----------------------|------------------------------|---|
| $V_{OS}$   | Input Offset Voltage  | LMV931 (Single)   |   | 1               | 4<br><b>6</b>         | mV                           |   |
|            |   | LMV932 (Dual)<br>LMV934 (Quad)  |   | 1               | 5.5<br><b>7.5</b>     | mV                           |   |
| $TCV_{OS}$ | Input Offset Voltage Average Drift                          |   |   | 5.5             |                       | $\mu\text{V}/^\circ\text{C}$ |   |
| $I_B$      | Input Bias Current  |   |   | 14              | 35<br><b>50</b>       | nA                           |   |
| $I_{OS}$   | Input Offset Current  |   |   | 9               | 25<br><b>40</b>       | nA                           |   |
| $I_S$      | Supply Current (per channel)                                |   |   | 116             | 210<br><b>230</b>     | $\mu\text{A}$                |   |
| CMRR       | Common Mode Rejection Ratio                                 | $0 \leq V_{CM} \leq 3.8\text{V}$  | 60  | 86              |                       | dB                           |   |
|            |   | $4.6\text{V} \leq V_{CM} \leq 5.0\text{V}$ (Note 8)                                     | <b>55</b>                                       |                 |                       |                              |   |
|            |   | $-0.2\text{V} \leq V_{CM} \leq 0\text{V}$<br>$5.0\text{V} \leq V_{CM} \leq 5.2\text{V}$ | 50  | 78              |                       |                              |   |
| PSRR       | Power Supply Rejection Ratio                                | $1.8\text{V} \leq V^+ \leq 5\text{V}$<br>$V_{CM} = 0.5\text{V}$                         | 75<br>70  | 100             |                       | dB                           |   |
| CMVR       | Input Common-Mode Voltage Range                             | For CMRR Range $\geq 50\text{dB}$   | $T_A = 25^\circ\text{C}$                        | $V^- - 0.2$     | $-0.2$ to $5.3$       | $V^+ + 0.2$                  | V |
|            |   |   | $T_A = -40^\circ\text{C}$ to $85^\circ\text{C}$ | $V^-$           |                       | $V^+$                        |   |
|            |   |   | $T_A = 125^\circ\text{C}$                       | $V^- + 0.3$     |                       | $V^+ - 0.3$                  |   |
| $A_V$      | Large Signal Voltage Gain<br>LMV931 (Single)                | $R_L = 600\Omega$ to $2.5\text{V}$ ,<br>$V_O = 0.2\text{V}$ to $4.8\text{V}$            | 88<br><b>87</b>                                 | 102             |                       | dB                           |   |
|            |   | $R_L = 2\text{k}\Omega$ to $2.5\text{V}$ ,<br>$V_O = 0.2\text{V}$ to $4.8\text{V}$      | 94<br><b>93</b>                                 | 113             |                       |                              |   |
|            | Large Signal Voltage Gain<br>LMV932 (Dual)<br>LMV934 (Quad) | $R_L = 600\Omega$ to $2.5\text{V}$ ,<br>$V_O = 0.2\text{V}$ to $4.8\text{V}$            | 81<br><b>78</b>                                 | 90              |                       | dB                           |   |
|            |   | $R_L = 2\text{k}\Omega$ to $2.5\text{V}$ ,<br>$V_O = 0.2\text{V}$ to $4.8\text{V}$      | 85<br><b>82</b>                                 | 100             |                       |                              |   |
| $V_O$      | Output Swing  | $R_L = 600\Omega$ to $2.5\text{V}$<br>$V_{IN} = \pm 100\text{mV}$                       | 4.855<br>4.835                                  | 4.890           |                       | V                            |   |
|            |   |   |   | 0.120           | 0.160<br><b>0.180</b> |                              |   |
|            |   | $R_L = 2\text{k}\Omega$ to $2.5\text{V}$<br>$V_{IN} = \pm 100\text{mV}$                 | 4.945<br><b>4.935</b>                           | 4.967           |                       |                              |   |
|            |   |   |   | 0.037           | 0.065<br><b>0.075</b> |                              |   |

## 5V DC Electrical Characteristics (Continued)

Unless otherwise specified, all limits guaranteed for  $T_J = 25^\circ\text{C}$ .  $V^+ = 5\text{V}$ ,  $V^- = 0\text{V}$ ,  $V_{\text{CM}} = V^+/2$ ,  $V_O = V^+/2$  and  $R_L > 1\text{M}\Omega$ . **Boldface** limits apply at the temperature extremes. See (Note 10)

| Symbol | Parameter                    | Condition                           | Min<br>(Note 6) | Typ<br>(Note 5) | Max<br>(Note 6) | Units |
|--------|------------------------------|-------------------------------------|-----------------|-----------------|-----------------|-------|
| $I_O$  | Output Short Circuit Current | LMV931, Sourcing, $V_O = 0\text{V}$ | 80              | 100             |                 | mA    |
|        |                              | $V_{\text{IN}} = 100\text{mV}$      | <b>68</b>       |                 |                 |       |
|        |                              | Sinking, $V_O = 5\text{V}$          | 58              | 65              |                 |       |
|        |                              | $V_{\text{IN}} = -100\text{mV}$     | <b>45</b>       |                 |                 |       |

## 5V AC Electrical Characteristics

Unless otherwise specified, all limits guaranteed for  $T_J = 25^\circ\text{C}$ .  $V^+ = 5\text{V}$ ,  $V^- = 0\text{V}$ ,  $V_{\text{CM}} = V^+/2$ ,  $V_O = 2.5\text{V}$  and  $R_L > 1\text{M}\Omega$ . **Boldface** limits apply at the temperature extremes. See (Note 10)

| Symbol   | Parameter                    | Conditions  | Min<br>(Note 6) | Typ<br>(Note 5) | Max<br>(Note 6) | Units                                |
|----------|------------------------------|---|-----------------|-----------------|-----------------|--------------------------------------|
| SR       | Slew Rate                    | (Note 7)  |                 | 0.42            |                 | V/ $\mu\text{s}$                     |
| GBW      | Gain-Bandwidth Product       |   |                 | 1.5             |                 | MHz                                  |
| $\Phi_m$ | Phase Margin                 |   |                 | 71              |                 | deg                                  |
| $G_m$    | Gain Margin                  |   |                 | 8               |                 | dB                                   |
| $e_n$    | Input-Referred Voltage Noise | $f = 1\text{kHz}$ , $V_{\text{CM}} = 1\text{V}$                                     |                 | 50              |                 | $\frac{\text{nV}}{\sqrt{\text{Hz}}}$ |
| $i_n$    | Input-Referred Current Noise | $f = 1\text{kHz}$   |                 | 0.07            |                 | $\frac{\text{pA}}{\sqrt{\text{Hz}}}$ |
| THD      | Total Harmonic Distortion    | $f = 1\text{kHz}$ , $A_V = +1$<br>$R_L = 600\Omega$ , $V_O = 1\text{V}_{\text{PP}}$ |                 | 0.022           |                 | %                                    |
|          | Amp-to-Amp Isolation         | (Note 9)  |                 | 123             |                 | dB                                   |

**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  $100\text{pF}$ . Machine model,  $200\Omega$  in series with  $100\text{pF}$ .

**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  $150^\circ\text{C}$ . Output currents in excess of  $45\text{mA}$  over long term may adversely affect reliability.

**Note 4:** The maximum power dissipation is a function of  $T_{\text{J(MAX)}}$ ,  $\theta_{\text{JA}}$ , and  $T_{\text{A}}$ . The maximum allowable power dissipation at any ambient temperature is  $P_D = (T_{\text{J(MAX)}} - T_{\text{A}}) / \theta_{\text{JA}}$ . 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  $5\text{V}$  step input. Number specified is the slower of the positive and negative slew rates.

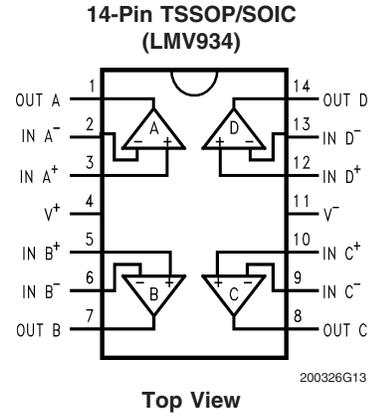
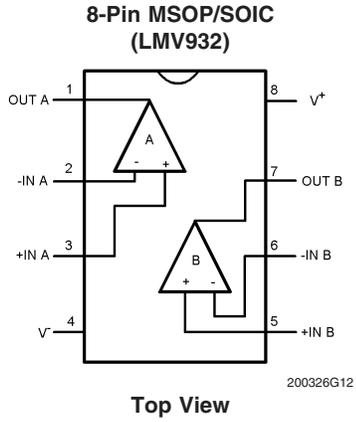
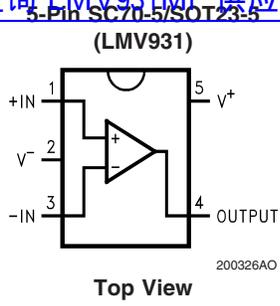
**Note 8:** For guaranteed temperature ranges, see Input Common-Mode Voltage Range specifications.

**Note 9:** Input referred,  $V^+ = 5\text{V}$  and  $R_L = 100\text{k}\Omega$  connected to  $2.5\text{V}$ . Each amp excited in turn with  $1\text{kHz}$  to produce  $V_O = 3V_{\text{PP}}$ .

**Note 10:** Electrical Table values apply only for factory testing conditions at the temperature indicated. Factory testing conditions result in very limited self-heating of the device such that  $T_J = T_A$ . No guarantee of parametric performance is indicated in the electrical tables under conditions of internal self-heating where  $T_J > T_A$ . See Applications section for information of temperature derating of the device. Absolute Maximum Ratings indicated junction temperature limits beyond which the device may be permanently degraded, either mechanically or electrically.

## Connection Diagrams

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## Ordering Information

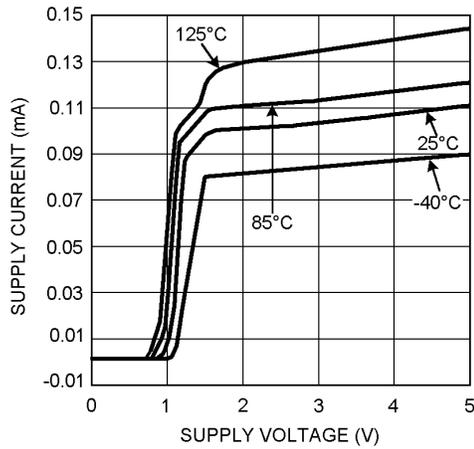
| Package      | Part Number | Packaging Marking | Transport Media          | NSC Drawing |
|--------------|-------------|-------------------|--------------------------|-------------|
| 5-Pin SC70   | LMV931MG    | A74               | 1k Units Tape and Reel   | MAA05A      |
|              | LMV931MGX   |                   | 3k Units Tape and Reel   |             |
| 5-Pin SOT23  | LMV931MF    | A79A              | 1k Units Tape and Reel   | MF05A       |
|              | LMV931MFX   |                   | 3k Units Tape and Reel   |             |
| 8-Pin MSOP   | LMV932MM    | A86A              | 1k Units Tape and Reel   | MUA08A      |
|              | LMV932MMX   |                   | 3.5k Units Tape and Reel |             |
| 8-Pin SOIC   | LMV932MA    | LMV932MA          | Rails                    | M08A        |
|              | LMV932MAX   |                   | 2.5k Units Tape and Reel |             |
| 14-Pin TSSOP | LMV934MT    | LMV934MT          | Rails                    | MTC14       |
|              | LMV934MTX   |                   | 2.5k Units Tape and Reel |             |
| 14-Pin SOIC  | LMV934MA    | LMV934MA          | Rails                    | M14A        |
|              | LMV934MAX   |                   | 2.5k Units Tape and Reel |             |

# Typical Performance Characteristics

Unless otherwise specified,  $V_S = +5V$ , single supply,

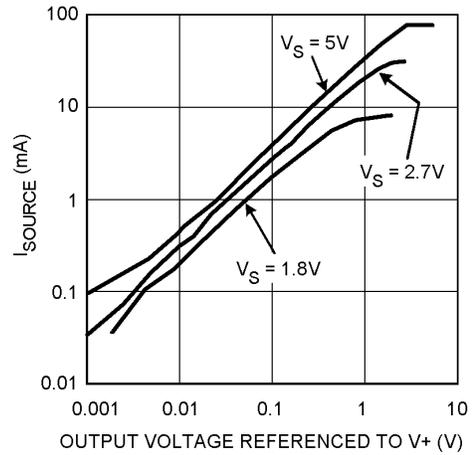
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Supply Current vs. Supply Voltage (LMV931)



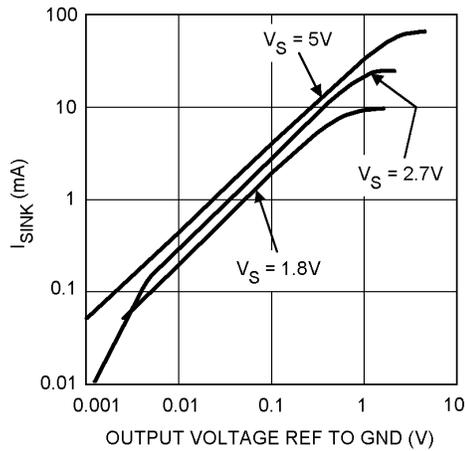
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Sourcing Current vs. Output Voltage



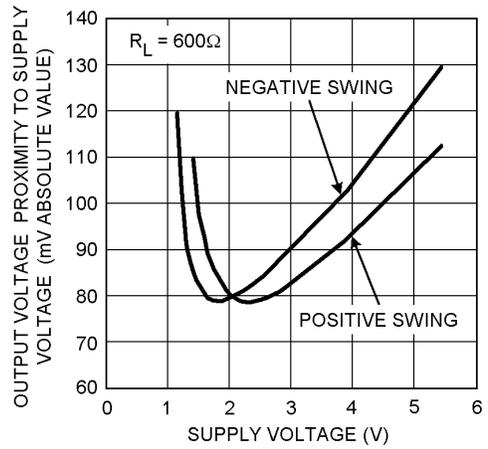
20032625

Sinking Current vs. Output Voltage



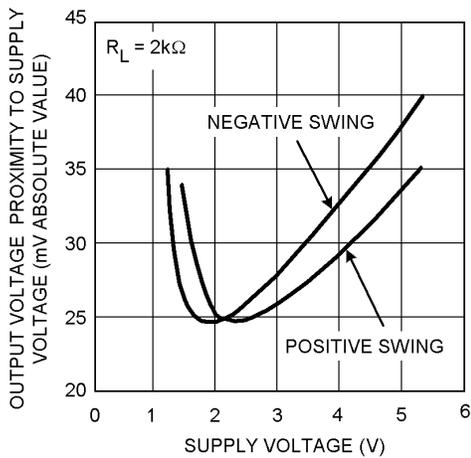
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Output Voltage Swing vs. Supply Voltage



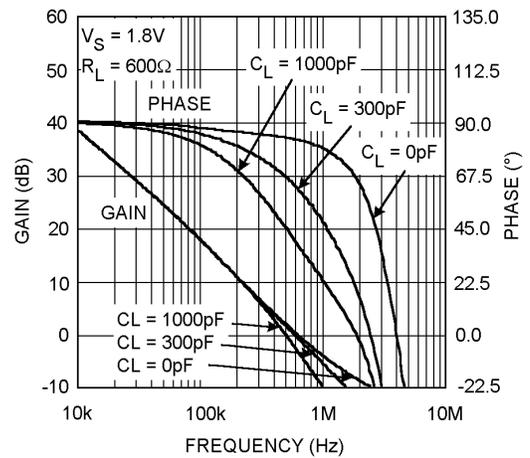
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Output Voltage Swing vs. Supply Voltage



20032650

Gain and Phase vs. Frequency

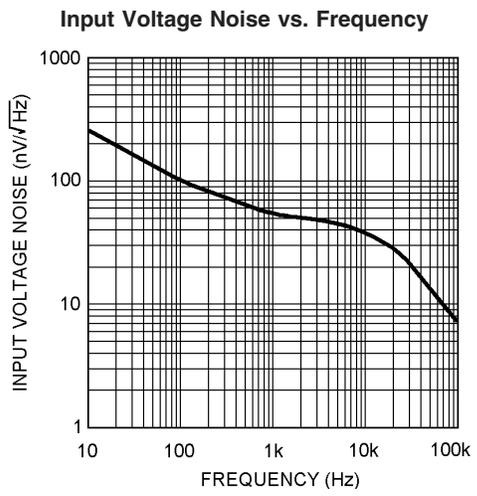
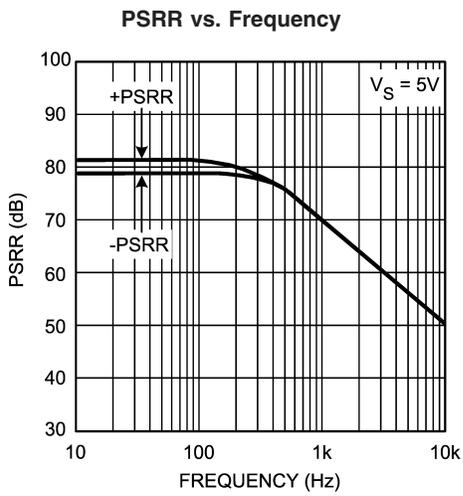
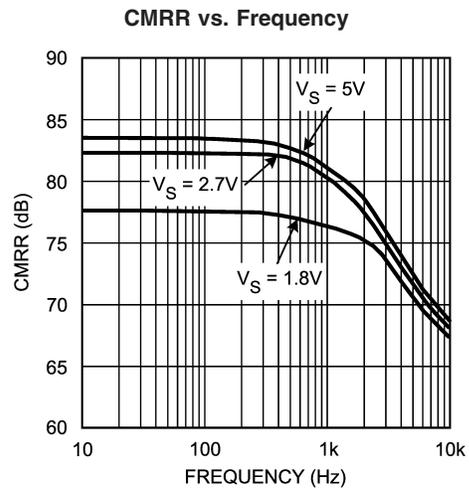
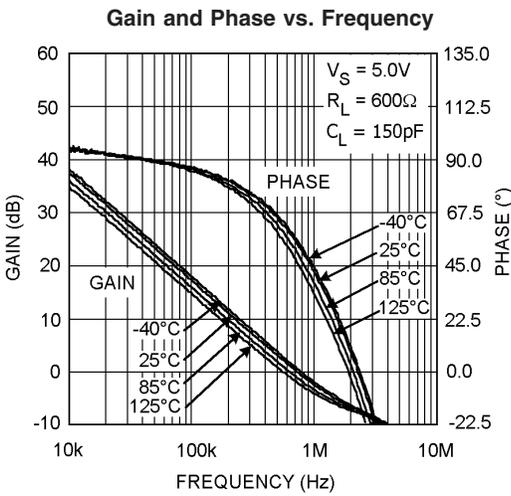
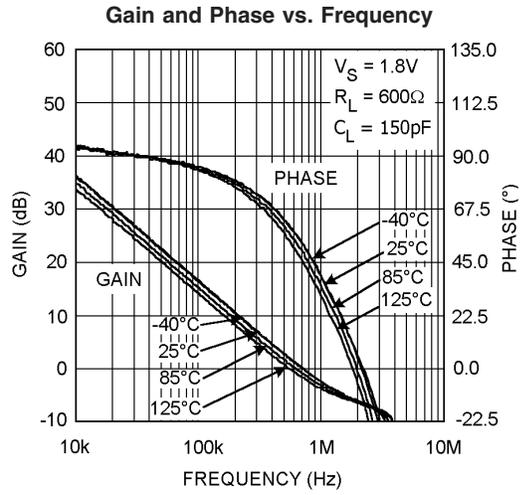
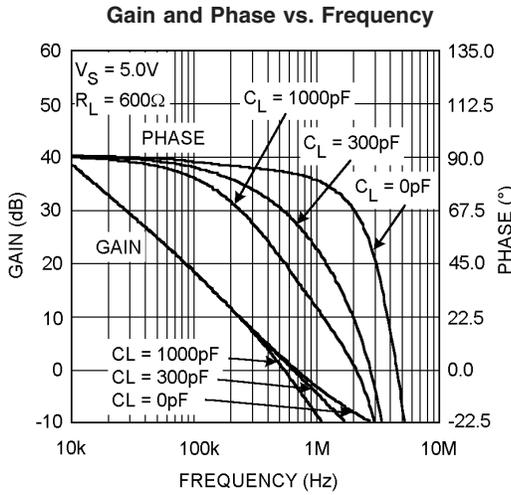


20032668

# Typical Performance Characteristics

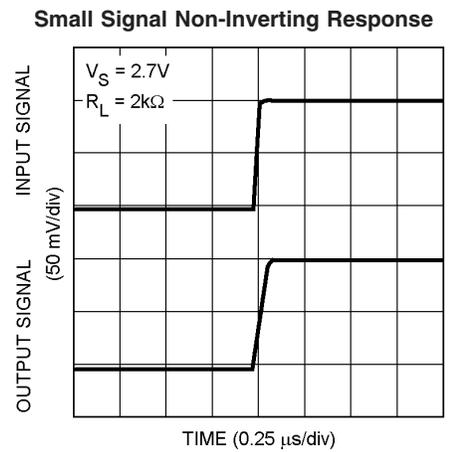
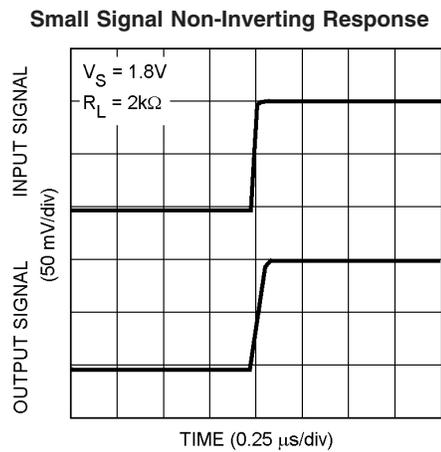
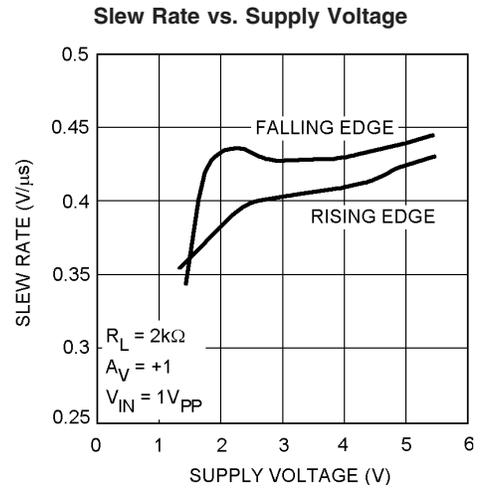
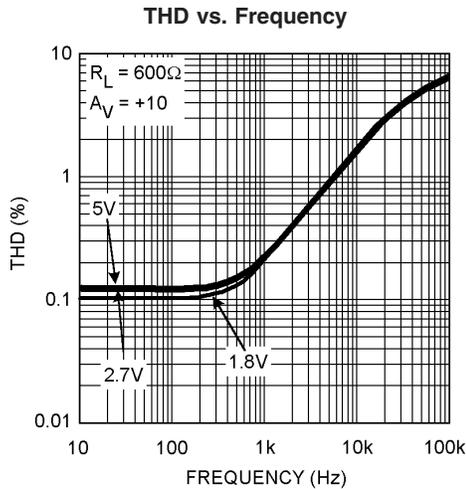
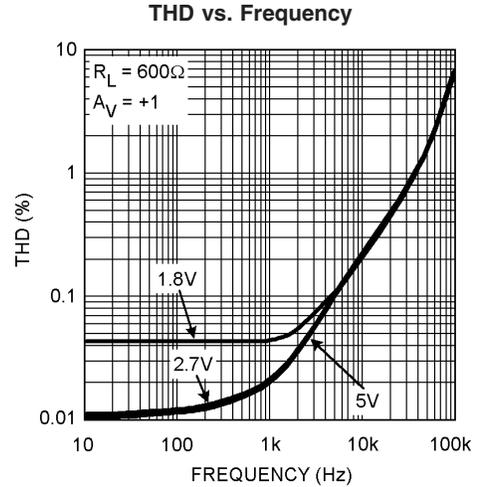
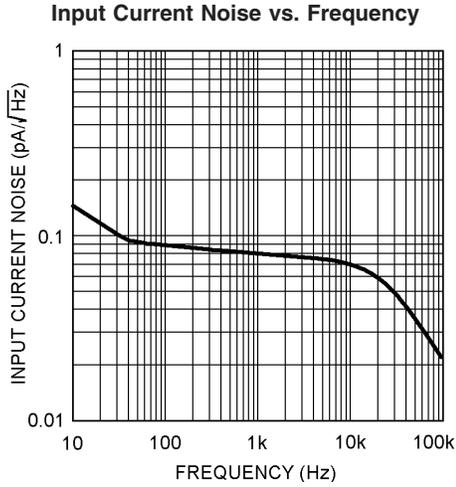
Unless otherwise specified,  $V_S = +5V$ , single supply,

$T_A$  查询“LMV934MF”供应商



# Typical Performance Characteristics

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

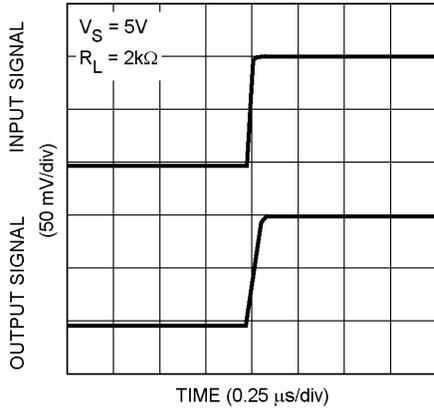


# Typical Performance Characteristics

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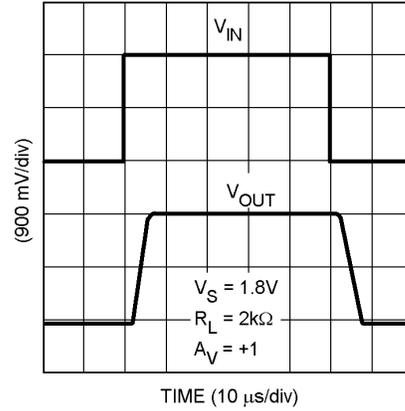
$T_A = 25^\circ C$  [查询"LMV934MF"供应商](#)

Small Signal Non-Inverting Response



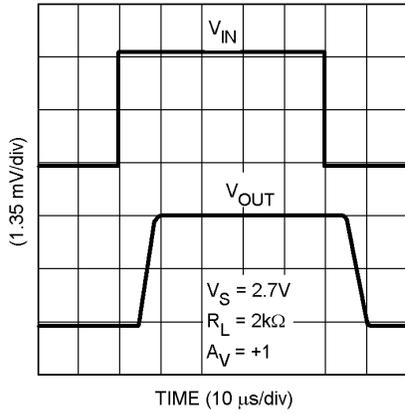
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Large Signal Non-Inverting Response



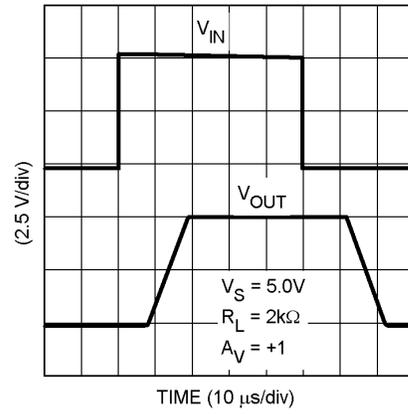
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Large Signal Non-Inverting Response



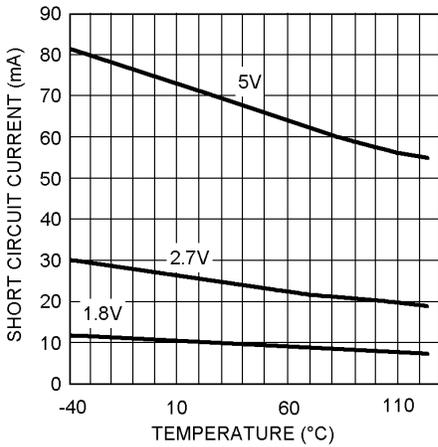
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Large Signal Non-Inverting Response



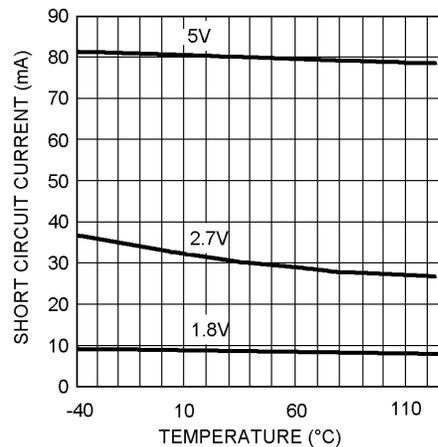
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Short Circuit Current vs. Temperature (Sinking)



20032676

Short Circuit Current vs. Temperature (Sourcing)



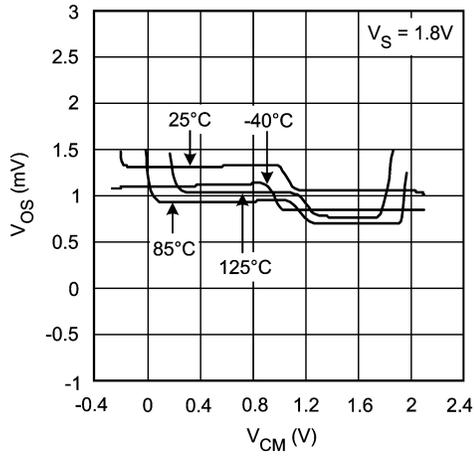
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# Typical Performance Characteristics

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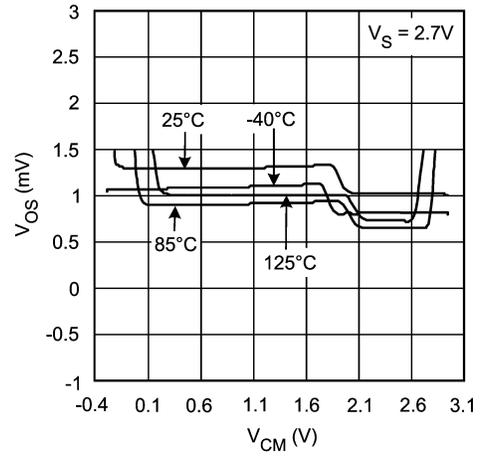
LMV931 (For Single)

Offset Voltage vs. Common Mode Range



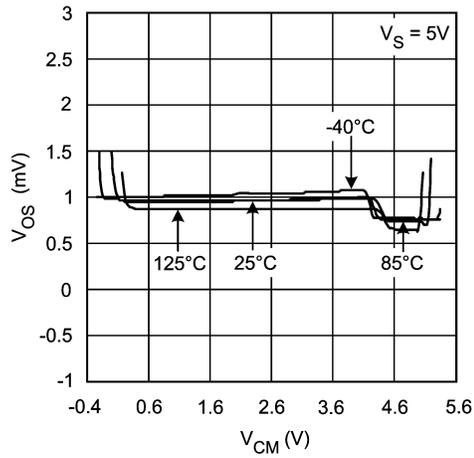
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Offset Voltage vs. Common Mode Range



20032637

Offset Voltage vs. Common Mode Range



20032638

## Application Note

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### 1.0 INPUT AND OUTPUT STAGE

The rail-to-rail input stage of this family provides more flexibility for the designer. The LMV931/LMV932/LMV934 use a complimentary PNP and NPN input stage in which the PNP stage senses common mode voltage near  $V^-$  and the NPN stage senses common mode voltage near  $V^+$ . The transition from the PNP stage to NPN stage occurs 1V below  $V^+$ . Since both input stages have their own offset voltage, the offset of the amplifier becomes a function of the input common mode voltage and has a crossover point at 1V below  $V^+$ .

This  $V_{OS}$  crossover point can create problems for both DC and AC coupled signals if proper care is not taken. Large input signals that include the  $V_{OS}$  crossover point will cause distortion in the output signal. One way to avoid such distortion is to keep the signal away from the crossover. For example, in a unity gain buffer configuration and with  $V_S = 5V$ , a 5V peak-to-peak signal will contain input-crossover distortion while a 3V peak-to-peak signal centered at 1.5V will not contain input-crossover distortion as it avoids the crossover point. Another way to avoid large signal distortion is to use a gain of  $-1$  circuit which avoids any voltage excursions at the input terminals of the amplifier. In that circuit, the common mode DC voltage can be set at a level away from the  $V_{OS}$  cross-over point. For small signals, this transition in  $V_{OS}$  shows up as a  $V_{CM}$  dependent spurious signal in series with the input signal and can effectively degrade small signal parameters such as gain and common mode rejection ratio. To resolve this problem, the small signal should be placed such that it avoids the  $V_{OS}$  cross-over point. In addition to the rail-to-rail performance, the output stage can provide enough output current to drive 600Ω loads. Because of the high current capability, care should be taken not to exceed the 150°C maximum junction temperature specification.

### 2.0 INPUT BIAS CURRENT CONSIDERATION

The LMV931/LMV932/LMV934 family has a complementary bipolar input stage. The typical input bias current ( $I_B$ ) is 15nA. The input bias current can develop a 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 50nA and  $R_F$  is 100kΩ, then an offset voltage of 5mV will develop ( $V_{OS} = I_B \times R_F$ ). Using a compensation resistor ( $R_C$ ), as shown in Figure 1, cancels this effect. But the input offset current ( $I_{OS}$ ) will still contribute to an offset voltage in the same manner.

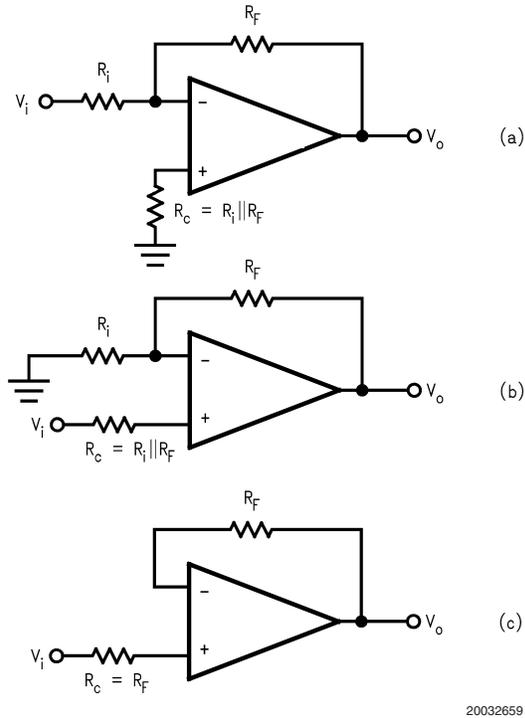


FIGURE 1. Canceling the Offset Voltage due to Input Bias Current

## Typical Applications

### 3.0 HIGH SIDE CURRENT SENSING

The high side current sensing circuit (Figure 2) is commonly used in a battery charger to monitor charging current to prevent over charging. A sense resistor  $R_{SENSE}$  is connected to the battery directly. This system requires an op amp with rail-to-rail input. The LMV931/LMV932/LMV934 are ideal for this application because its common mode input range goes up to the rail.

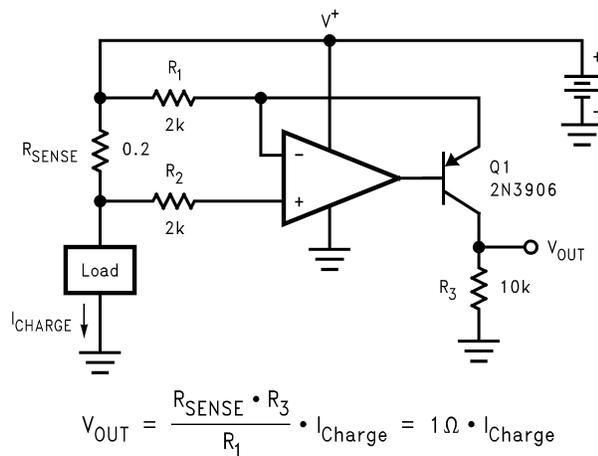


FIGURE 2. High Side Current Sensing

## Typical Applications (Continued)

### 4.0 HALF-WAVE RECTIFIER WITH RAIL-TO-GROUND OUTPUT SWING

Since the LMV931/LMV932/LMV934 input common mode range includes both positive and negative supply rails and the output can also swing to either supply, achieving half-wave rectifier functions in either direction is an easy task. All that is needed are two external resistors; there is no need for diodes or matched resistors. The half wave rectifier can have either positive or negative going outputs, depending on the way the circuit is arranged.

In *Figure 3* the circuit is referenced to ground, while in *Figure 4* the circuit is biased to the positive supply. These configurations implement the half wave rectifier since the LMV931/LMV932/LMV934 can not respond to one-half of the incoming waveform. It can not respond to one-half of the incoming because the amplifier can not swing the output beyond either rail therefore the output disengages during this half cycle. During the other half cycle, however, the amplifier achieves a half wave that can have a peak equal to the total supply voltage.  $R_1$  should be large enough not to load the LMV931/LMV932/LMV934.

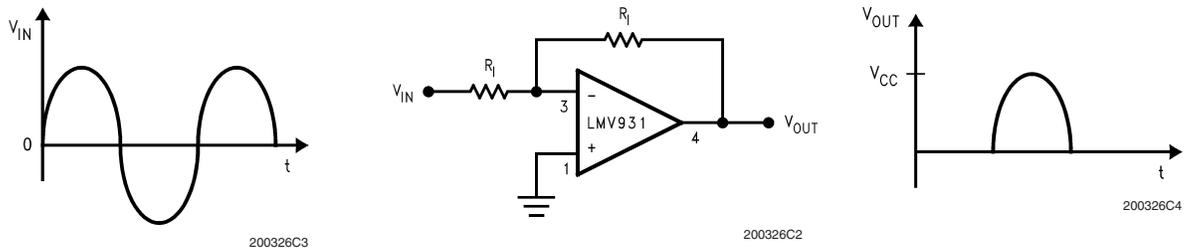


FIGURE 3. Half-Wave Rectifier with Rail-To-Ground Output Swing Referenced to Ground

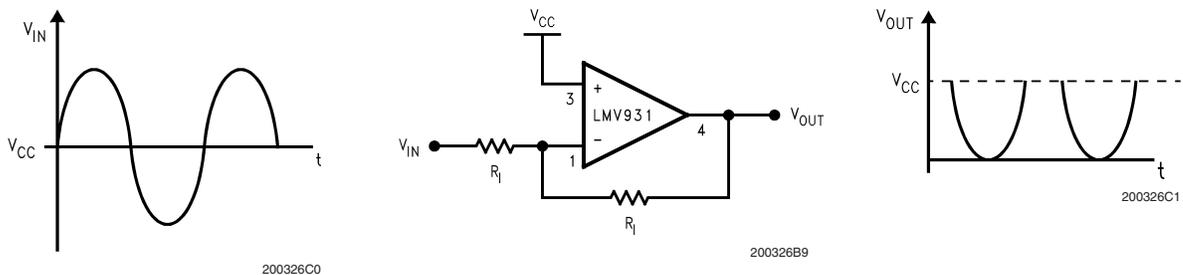


FIGURE 4. Half-Wave Rectifier with Negative-Going Output Referenced to  $V_{CC}$

### 5.0 INSTRUMENTATION AMPLIFIER WITH RAIL-TO-RAIL INPUT AND OUTPUT

Some manufactures make a non-“rail-to-rail”-op amp rail-to-rail by using a resistive divider on the inputs. The resistors divide the input voltage to get a rail-to-rail input range. The problem with this method is that it also divides the signal, so in order to get the obtained gain, the amplifier must have a higher closed loop gain. This raises the noise and drift by the internal gain factor and lowers the input impedance. Any mismatch in these precision resistors reduces the CMRR as well. The LMV981/LMV982 is rail-to-rail and therefore doesn't have these disadvantages.

Using three of the LMV981/LMV982 amplifiers, an instrumentation amplifier with rail-to-rail inputs and outputs can be made as shown in *Figure 5*.

In this example, amplifiers on the left side act as buffers to the differential stage. These buffers assure that the input impedance is very high and require no precision matched resistors in the input stage. They also assure that the difference amp is driven from a voltage source. This is necessary to maintain the CMRR set by the matching  $R_1$ - $R_2$  with  $R_3$ - $R_4$ . The gain is set by the ratio of  $R_2/R_1$  and  $R_3$  should equal  $R_1$  and  $R_4$  equal  $R_2$ . With both rail-to-rail input and output ranges, the input and output are only limited by the supply

voltages. Remember that even with rail-to-rail outputs, the output can not swing past the supplies so the combined common mode voltages plus the signal should not be greater than the supplies or limiting will occur. For additional applications, see National Semiconductor application notes AN-29, AN-31, AN-71, and AN-127.

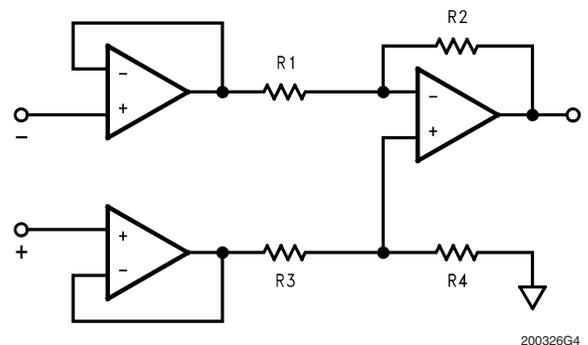
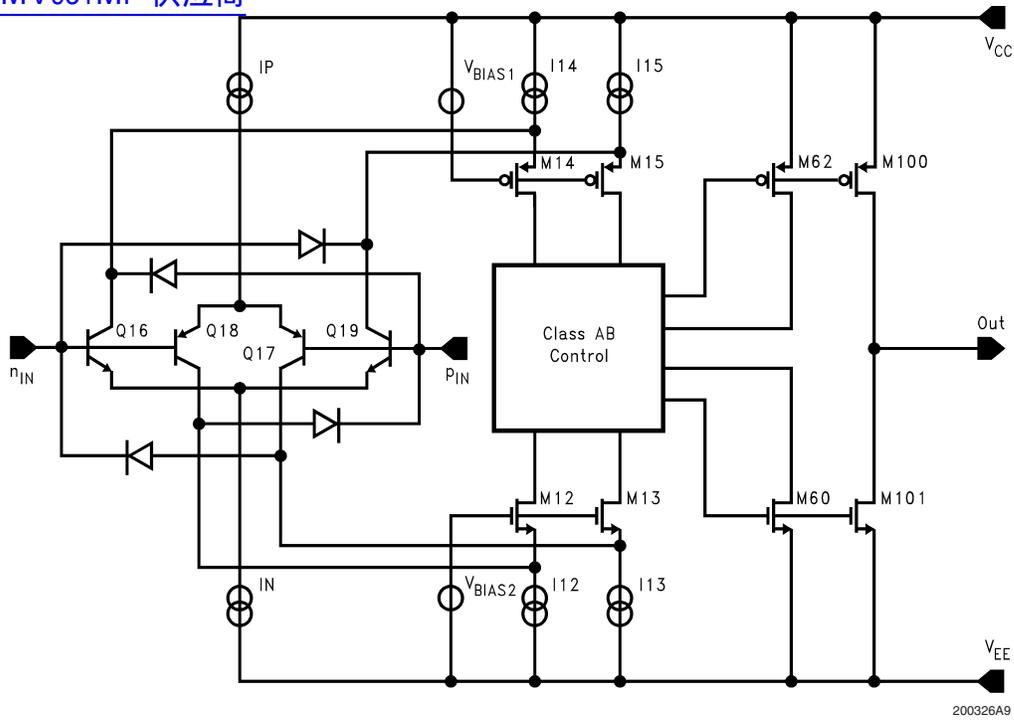


FIGURE 5. Rail-to-rail Instrumentation Amplifier

# Simplified Schematic

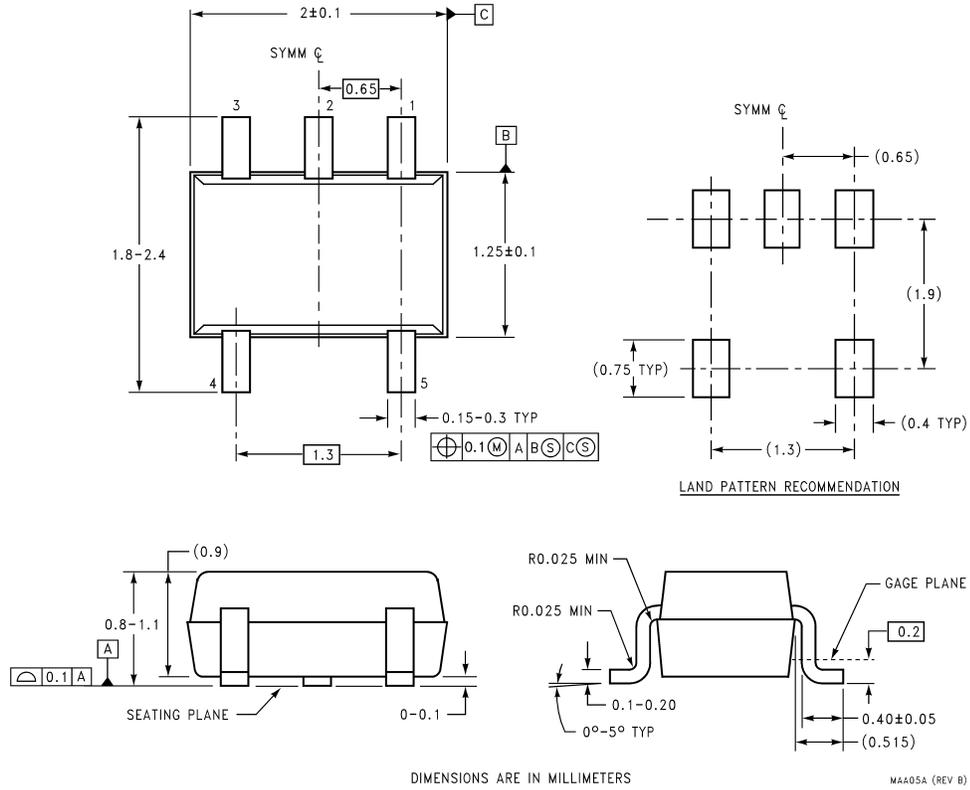
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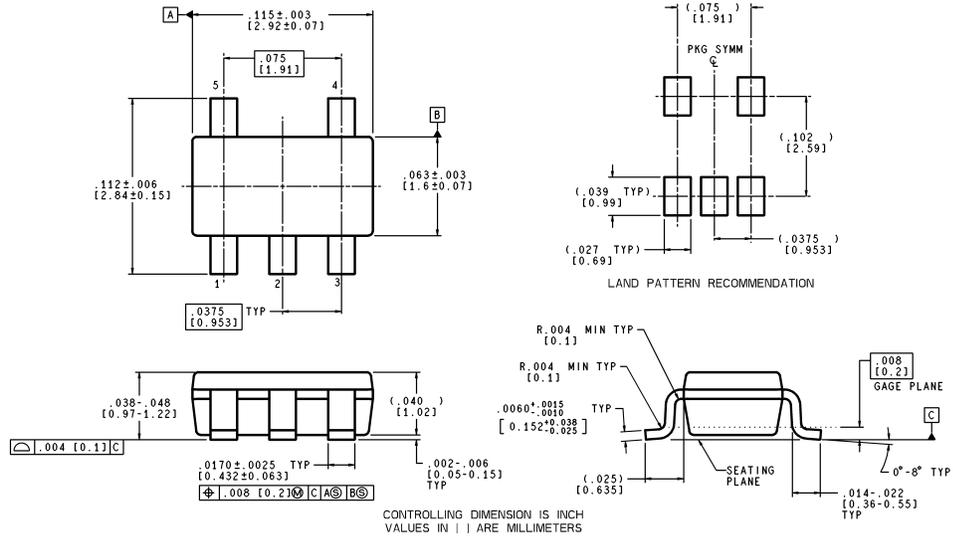
LMV931 Single / LMV932 Dual / LMV934 Quad

**Physical Dimensions** inches (millimeters)

LMV931 Single / LMV932 Dual / LMV933 Quad



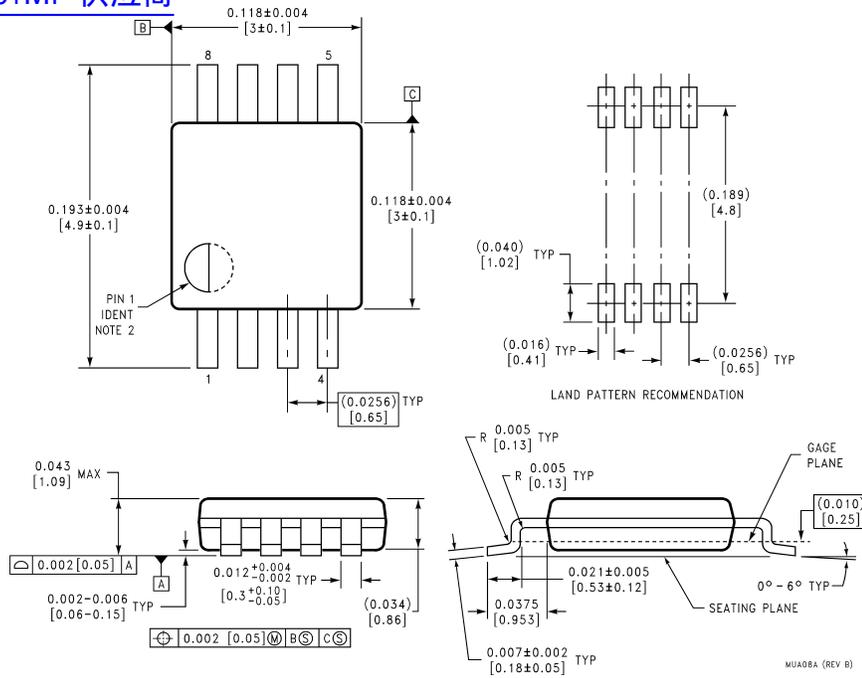
**5-Pin SC70**  
**NS Package Number MAA05A**



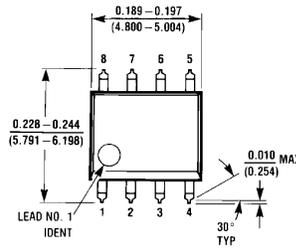
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**NS Package Number MF05A**

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

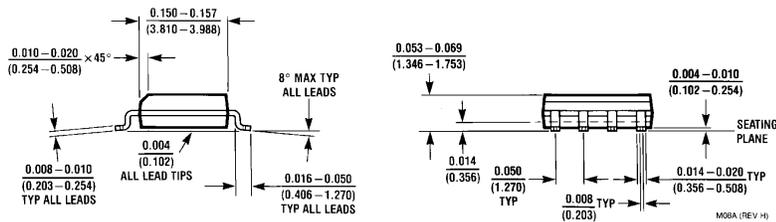
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**8-Pin MSOP**  
NS Package Number MUA08A

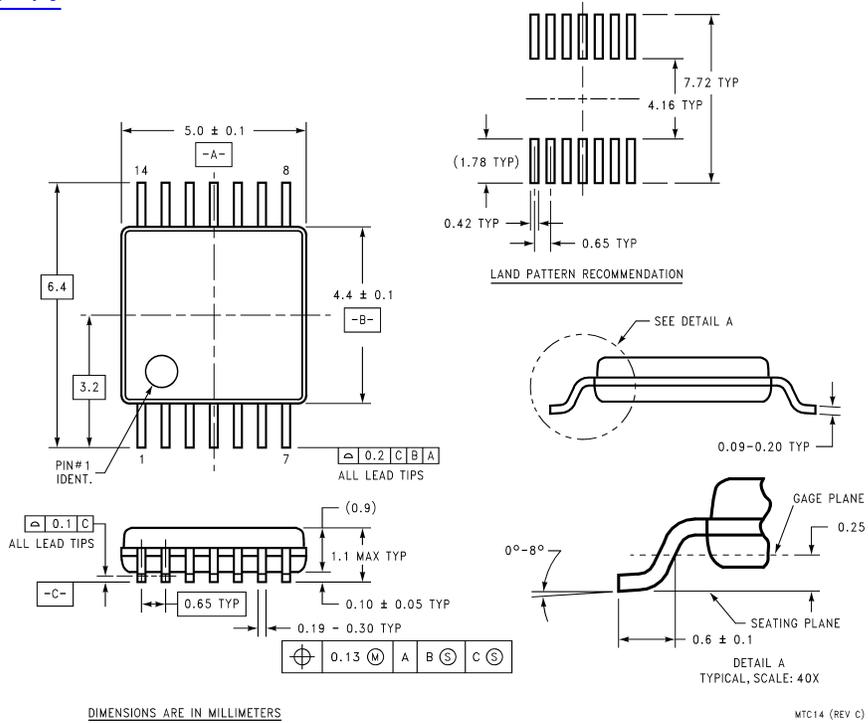


**8-Pin SOIC**  
NS Package Number M08A

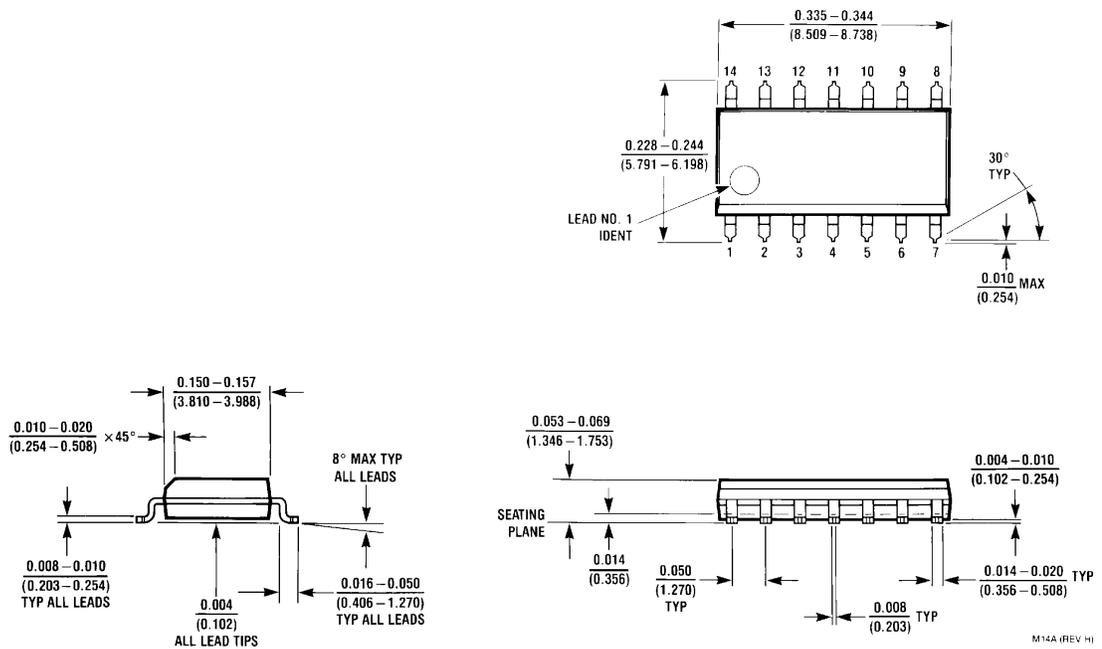


**Physical Dimensions** inches (millimeters) unless otherwise noted (Continued)

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**14-Pin TSSOP**  
NS Package Number MTC14



**14-Pin SOIC**  
NS Package Number M14A

## Notes

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## LIFE SUPPORT POLICY

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2. A critical component is any component of a life support device or system whose failure to perform can be reasonably expected to cause the failure of the life support device or system, or to affect its safety or effectiveness.



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