# LMV301

# Low Bias Current, 1.8V to 5V Single-Supply, Rail-to-Rail Operational Amplifier

The LMV301 CMOS operational amplifier can operate over a power supply range from 1.8 V to 5 V and has a quiescent current of less than 200 μA, maximum, making it ideal for portable battery−operated applications such as notebook computers, PDA's and medical equipment. Low input bias current and high input impedance make it highly tolerant of high source−impedance signal−sources such as photodiodes and pH probes. In addition, the LMV301's excellent rail−to−rail performance will enhance the signal−to−noise performance of any application together with an output stage capable of easily driving a 600 Ω resistive load and up to 1000 pF capacitive load.

## Features

- Single Supply Operation (or $\pm V_S/2$)
- $V_S$ from 1.8 V to 5 V
- Low Quiescent Current: 185 μA, Max with $V_S$ = 1.8 V
- Rail−to−Rail Output Swing
- Low Bias Current: 35 pA, max
- No Output Phase−Reversal when the Inputs are Overdriven
- These are Pb−Free Devices

## Typical Applications

- Portable Battery−Powered Instruments
- Notebook Computers and PDAs
- Cell Phones and Mobile Communication
- Digital Cameras
- Photodiode Amplifiers
- Transducer Amplifiers
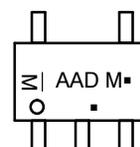- Medical Instrumentation
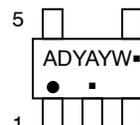- Consumer Products

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**http://onsemi.com**

**MARKING DIAGRAMS**



SC70−5
SQ SUFFIX
CASE 419A
STYLES 2, 3
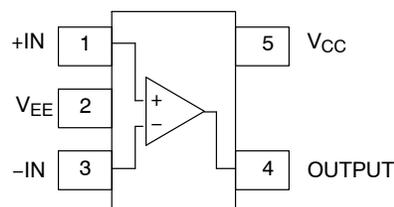


TSOP−5
CASE 483

| M | = Date Code |
| A | = Assembly Location |
| Y | = Year |
| W | = Work Week |
| ▪ | = Pb−Free Package |

(*Note: Microdot may be in either location)

*Date Code orientation and/or position may vary depending upon manufacturing location.

**PIN CONNECTION**



| +IN | 1 | | 5 | $V_{CC}$ |
| $V_{EE}$ | 2 | | | |
| −IN | 3 | | 4 | OUTPUT |

STYLE 3 PINOUT

## ORDERING INFORMATION

**December, 2011 − Rev. 2**

Publication Order Number:
**LMV301/D**

# LMV301

**MAXIMUM RATINGS**

| Symbol | Rating | Value | Unit |
|--------|--------|-------|------|
| $V_S$ | Power Supply (Operating Voltage Range $V_S$ = 1.8 V to 5.0 V) | 5.5 | V |
| $V_{IDR}$ | Input Differential Voltage | ±Supply Voltage | V |
| $V_{ICR}$ | Input Common Mode Voltage Range | −0.5 to (V+) + 0.5 | V |
| | Maximum Input Current | 10 | mA |
| $t_{So}$ | Output Short Circuit (Note 1) | Continuous | |
| $T_J$ | Maximum Junction Temperature (Operating Range −40°C to 85°C) | 150 | °C |
| $J_A$ | Thermal Resistance (5−Pin SC70−5) | 280 | °C/W |
| $T_{stg}$ | Storage Temperature | −65 to 150 | °C |
| | Mounting Temperature (Infrared or Convection (30 sec)) | 260 | |
| $V_{ESD}$ | ESD Tolerance<br>Machine Model<br>Human Body Model | 100<br>1500 | V |

Stresses exceeding Maximum Ratings may damage the device. Maximum Ratings are stress ratings only. Functional operation above the Recommended Operating Conditions is not implied. Extended exposure to stresses above the Recommended Operating Conditions may affect device reliability.

1. Continuous short−circuit to ground 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. Also, shorting output to V+ will adversely affect reliability; likewise shorting output to V− will adversely affect reliability.

# LMV301

**1.8 V DC ELECTRICAL CHARACTERISTICS** (Unless otherwise specified, all limits are guaranteed for $T_A$ = 25°C, $V_{CC}$ = 1.8 V, $R_L$ = 1 MΩ, $V_{EE}$ = 0 V, $V_O$ = $V_{CC}$/2)

| Parameter | Symbol | Condition | Min | Typ | Max | Unit |
|---|---|---|---|---|---|---|
| Input Offset Voltage | $V_{IO}$ | $T_A$ = −40°C to +85°C | | 1.7 | 9 | mV |
| Input Offset Voltage Average Drift | $T_C V_{IO}$ | $T_A$ = −40°C to +85°C | | 5 | | µV/°C |
| Input Bias Current (Note 2) | $I_B$ | | | 3 | 35 | pA |
| | | $T_A$ = −40°C to +85°C | | | 50 | |
| Common Mode Rejection Ratio | CMRR | 0 V ≤ $V_{CM}$ ≤ 0.9 V | 50 | 63 | | dB |
| Power Supply Rejection Ratio | PSRR | 1.8 V ≤ $V_{CC}$ ≤ 5 V, $V_O$ = 1 V, $V_{CM}$ = 1 V | 62 | 100 | | dB |
| Input Common−Mode Voltage Range | $V_{CM}$ | For CMRR ≥ 50 dB | 0 to 0.9 | −0.2 to 0.9 | | V |
| Large Signal Voltage Gain (Note 2) | $A_V$ | $R_L$ = 600Ω | 83 | 100 | | dB |
| | | $T_A$ = −40°C to +85°C | 80 | | | |
| | | $R_L$ = 2 kΩ | 83 | 100 | | |
| | | $T_A$ = −40°C to +85°C | 80 | | | |
| Output Swing | $V_{OH}$ | $R_L$ = 600 Ω to 0.9 V $T_A$ = −40°C to +85°C | 1.65 1.63 | | | V |
| | $V_{OL}$ | $R_L$ = 600 Ω to 0.9 V $T_A$ = −40°C to +85°C | | 75 | 100 120 | mV |
| | $V_{OH}$ | $R_L$ = 2 kΩ to 0.9 V $T_A$ = −40°C to +85°C | 1.5 1.4 | 1.76 | | V |
| | $V_{OL}$ | $R_L$ = 2 kΩ to 0.9 V $T_A$ = −40°C to +85°C | | 25 | 35 40 | mV |
| Output Short Circuit Current (Note 2) | $I_O$ | Sourcing = $V_O$ = 0 V Sinking = $V_O$ = 1.8 V | 10 20 | 60 160 | | mA |
| Supply Current | $I_{CC}$ | $T_A$ = −40°C to +85°C | | | 185 | µA |

**1.8 V AC ELECTRICAL CHARACTERISTICS** (Unless otherwise specified, all limits are guaranteed for $T_A$ = 25°C, $V_{CC}$ = 1.8 V, $R_L$ = 1 MΩ, $V_{EE}$ = 0 V, $V_O$ = $V_{CC}$/2)

| Parameter | Symbol | Condition | Min | Typ | Max | Unit |
|---|---|---|---|---|---|---|
| Slew Rate | $S_R$ | | | 1 | | V/µs |
| Gain Bandwidth Product | GBWP | $C_L$ = 200 pF | | 1 | | MHz |
| Phase Margin | $\Theta_m$ | | | 60 | | ° |
| Gain Margin | $G_m$ | | | 10 | | dB |
| Input−Referred Voltage Noise | $e_n$ | f = 50 kHz | | 50 | | nV/$\sqrt{Hz}$ |
| Total Harmonic Distortion | THD | $A_V$ = +1, V − 1 $V_{PP}$, $R_L$ = 10 kW, f = 1 kHz | | 0.01 | | % |

2. Guaranteed by design and/or characterization.

# LMV301

**2.7 V DC ELECTRICAL CHARACTERISTICS** (Unless otherwise specified, all limits are guaranteed for $T_A$ = 25°C, $V_{CC}$ = 2.7 V, $R_L$ = 1 MΩ, $V_{EE}$ = 0 V, $V_O$ = $V_{CC}$/2)

| Parameter | Symbol | Condition | Min | Typ | Max | Unit |
|---|---|---|---|---|---|---|
| Input Offset Voltage | $V_{IO}$ | $T_A$ = −40°C to +85°C | | 1.7 | 9 | mV |
| Input Offset Voltage Average Drift | $T_CV_{IO}$ | $T_A$ = −40°C to +85°C | | 5 | | μV/°C |
| Input Bias Current (Note 2) | $I_B$ | | | 3 | 35 | pA |
| | | $T_A$ = −40°C to +85°C | | | 50 | |
| Common Mode Rejection Ratio | CMRR | 0 V ≤ $V_{CM}$ ≤ 1.35 V | 50 | 63 | | dB |
| Power Supply Rejection Ratio | PSRR | 1.8 V ≤ $V_{CC}$ ≤ 5 V, $V_O$ = 1 V, $V_{CM}$ = 1 V | 62 | 100 | | dB |
| Input Common−Mode Voltage Range | $V_{CM}$ | For CMRR ≥ 50 dB | 0 to 1.35 | −0.2 to1.35 | | V |
| Large Signal Voltage Gain (Note 2) | $A_V$ | $R_L$ = 600 Ω | 83 | 100 | | dB |
| | | $T_A$ = −40°C to +85°C | 80 | | | |
| | | $R_L$ = 2 kΩ | 83 | 100 | | |
| | | $T_A$ = −40°C to +85°C | 80 | | | |
| Output Swing | $V_{OH}$ | $R_L$ = 600 Ω to 1.35 V $T_A$ = −40°C to +85°C | 2.55 2.53 | 2.62 | | V |
| | $V_{OL}$ | $R_L$ = 600 Ω to 1.35 V $T_A$ = −40°C to +85°C | | 78 | 100 280 | mV |
| | $V_{OH}$ | $R_L$ = 2 kΩ to 1.35 V $T_A$ = −40°C to +85°C | 2.65 2.64 | 2.675 | | V |
| | $V_{OL}$ | $R_L$ = 2 kΩ to 1.35 V $T_A$ = −40°C to +85°C | | 75 | 100 110 | mV |
| Output Short Circuit Current (Note 2) | $I_O$ | Sourcing = $V_O$ = 0  V Sinking = $V_O$ = 2.7 V | 10 20 | 60 160 | | mA |
| Supply Current | $I_{CC}$ | $T_A$ = −40°C to +85°C | | | 185 | μA |

**2.7 V AC ELECTRICAL CHARACTERISTICS** (Unless otherwise specified, all limits are guaranteed for $T_A$ = 25°C, $V_{CC}$ = 2.7 V, $R_L$ = 1 MΩ, $V_{EE}$ = 0 V, $V_O$ = $V_{CC}$/2)

| Parameter | Symbol | Condition | Min | Typ | Max | Unit |
|---|---|---|---|---|---|---|
| Slew Rate | $S_R$ | | | 1 | | V/μs |
| Gain Bandwidth Product | GBWP | $C_L$ = 200 pF | | 1 | | MHz |
| Phase Margin | $\Theta_m$ | | | 60 | | ° |
| Gain Margin | $G_m$ | | | 10 | | dB |
| Input−Referred Voltage Noise | $e_n$ | f = 50 kHz | | 50 | | nV/√Hz |
| Total Harmonic Distortion | THD | $A_V$ = +1, V − 1 $V_{PP}$, $R_L$ = 10 kW, f = 1 kHz | | 0.01 | | % |

2. Guaranteed by design and/or characterization.

# LMV301

**5.0 V DC ELECTRICAL CHARACTERISTICS** (Unless otherwise specified, all limits are guaranteed for $T_A$ = 25°C, $V_{CC}$ = 5.0 V, $R_L$ = 1 MΩ, $V_{EE}$ = 0 V, $V_O$ = $V_{CC}$/2)

| Parameter | Symbol | Condition | Min | Typ | Max | Unit |
|---|---|---|---|---|---|---|
| Input Offset Voltage | $V_{IO}$ | $T_A$ = −40°C to +85°C | | 1.7 | 9 | mV |
| Input Offset Voltage Average Drift | $T_C V_{IO}$ | $T_A$ = −40°C to +85°C | | 5 | | µV/°C |
| Input Bias Current (Note 2) | $I_B$ | | | 3 | 35 | pA |
| | | $T_A$ = −40°C to +85°C | | | 50 | |
| Common Mode Rejection Ratio | CMRR | 0 V ≤ $V_{CM}$ ≤ 4 V | 50 | 63 | | dB |
| Power Supply Rejection Ratio | PSRR | 1.8 V ≤ $V_{CC}$ ≤ 5 V, $V_O$ = 1 V, $V_{CM}$ = 1 V | 62 | 100 | | dB |
| Input Common−Mode Voltage Range | $V_{CM}$ | For CMRR ≥ 50 dB | 0 to 4 | −0.2 to 4.2 | | V |
| Large Signal Voltage Gain (Note 2) | $A_V$ | $R_L$ = 600 Ω | 83 | 100 | | dB |
| | | $T_A$ = −40°C to +85°C | 80 | | | |
| | | $R_L$ = 2 kΩ | 83 | 100 | | |
| | | $T_A$ = −40°C to +85°C | 80 | | | |
| Output Swing | $V_{OH}$ | $R_L$ = 600 Ω to 2.5 V $T_A$ = −40°C to +85°C | 4.850 4.840 | | | V |
| | $V_{OL}$ | $R_L$ = 600 Ω to 2.5 V $T_A$ = −40°C to +85°C | | | 150 160 | mV |
| | $V_{OH}$ | $R_L$ = 2 kΩ to 2.5 V $T_A$ = −40°C to +85°C | 4.935 4.900 | | | V |
| | $V_{OL}$ | $R_L$ = 2 kΩ to 2.5 V $T_A$ = −40°C to +85°C | | | 65 75 | mV |
| Output Short Circuit Current (Note 2) | $I_O$ | Sourcing = $V_O$ = 0 V Sinking = $V_O$ = 5 V | 10 10 | 60 160 | | mA |
| Supply Current | $I_{CC}$ | $T_A$ = −40°C to +85°C | | | 200 | µA |

**5.0 V AC ELECTRICAL CHARACTERISTICS** (Unless otherwise specified, all limits are guaranteed for $T_A$ = 25°C, $V_{CC}$ = 5.0 V, $R_L$ = 1 MΩ, $V_{EE}$ = 0 V, $V_O$ = $V_{CC}$/2)

| Parameter | Symbol | Condition | Min | Typ | Max | Unit |
|---|---|---|---|---|---|---|
| Slew Rate | $S_R$ | | | 1 | | V/µs |
| Gain Bandwidth Product | GBWP | $C_L$ = 200 pF | | 1 | | MHz |
| Phase Margin | $\Theta_m$ | | | 60 | | ° |
| Gain Margin | $G_m$ | | | 10 | | dB |
| Input−Referred Voltage Noise | $e_n$ | f = 50 kHz | | 50 | | nV/√Hz |
| Total Harmonic Distortion | THD | $A_V$ = +1, V − 1 $V_{PP}$, $R_L$ = 10 kW, f = 1 kHz | | 0.01 | | % |

2. Guaranteed by design and/or characterization.

# LMV301

## TYPICAL CHARACTERISTICS

($T_A$ = 25°C and $V_S$ = 5 V unless otherwise specified)

Over −40°C to +85°C
Same Gain ± 1.8 dB (Typ)
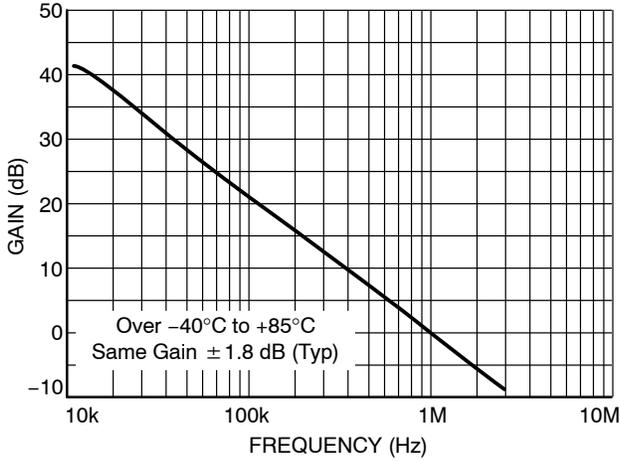
**Figure 1. Open Loop Frequency Response**
**($R_L$ = 2 kΩ, $T_A$ = 25°C, $V_S$ = 5 V)**
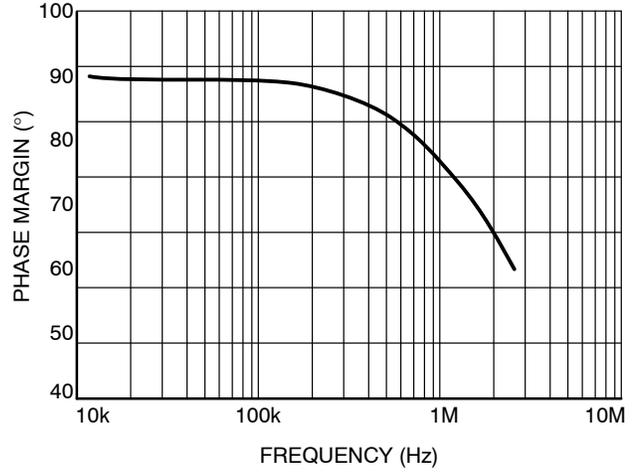
**Figure 2. Open Loop Phase Margin**
**($R_L$ = 2 kΩ, $T_A$ = 25°C)**
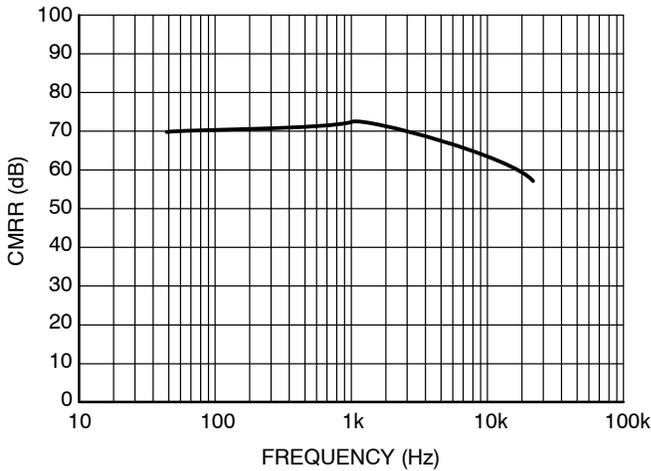
**Figure 3. CMRR vs. Frequency**
**($R_L$ = 5 kΩ, $V_S$ = 5 V)**
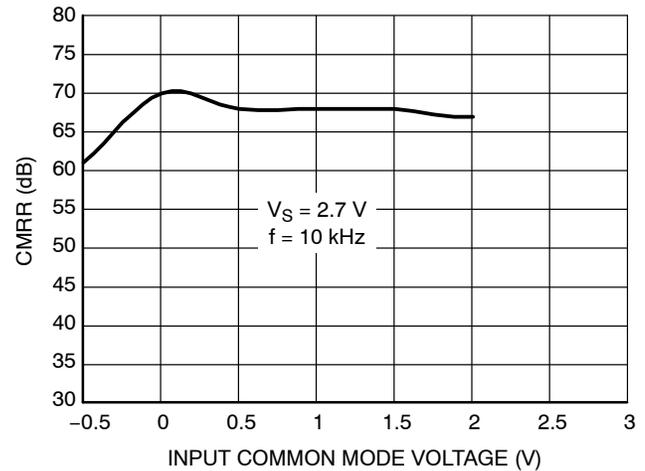
$V_S$ = 2.7 V
f = 10 kHz

**Figure 4. CMRR vs. Input Common Mode**
**Voltage**
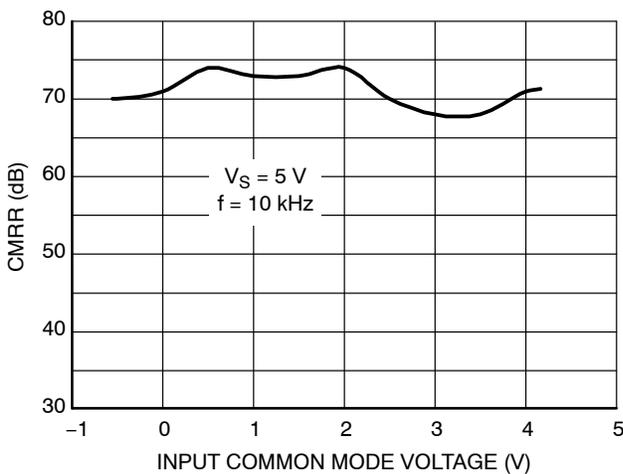
$V_S$ = 5 V
f = 10 kHz

**Figure 5. CMRR vs. Input Common Mode**
**Voltage**
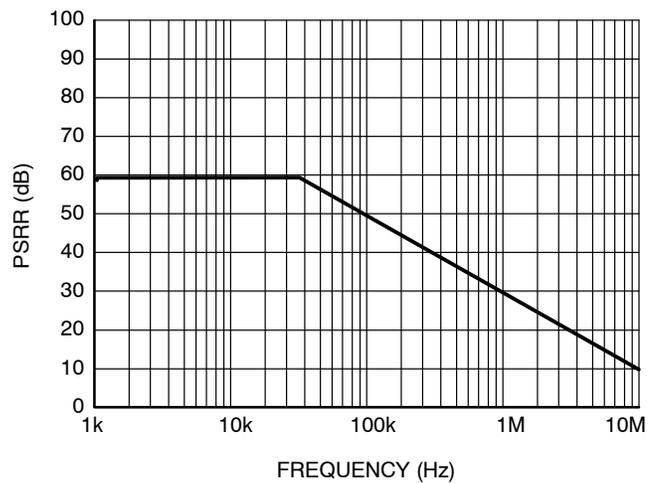
**Figure 6. PSRR vs. Frequency**
**($R_L$ = 5 kΩ, $V_S$ = 2.7 V, +PSRR)**

# LMV301

## TYPICAL CHARACTERISTICS

($T_A$ = 25°C and $V_S$ = 5 V unless otherwise specified)
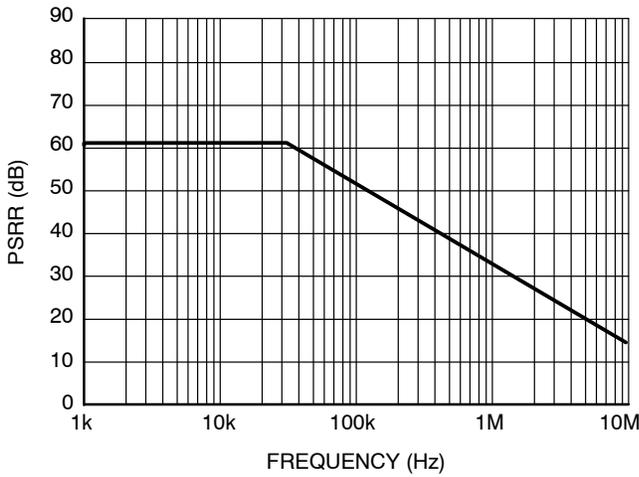
**Figure 7. PSRR vs. Frequency**
**($R_L$ = 5 kΩ, $V_S$ = 2.7 V, −PSRR)**
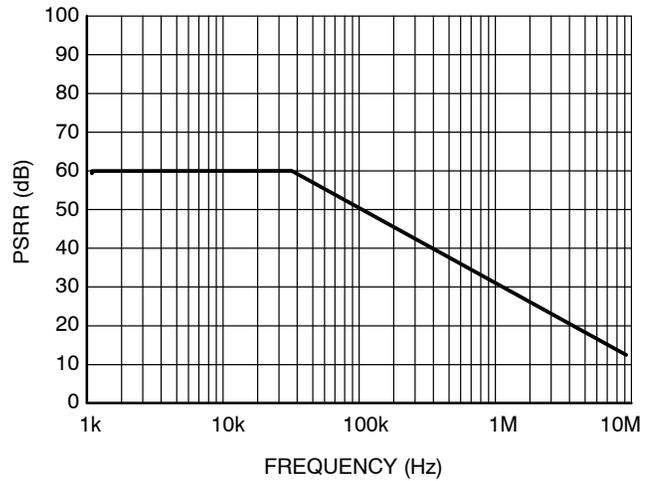
**Figure 8. PSRR vs. Frequency**
**($R_L$ = 5 kΩ, $V_S$ = 5 V, +PSRR)**
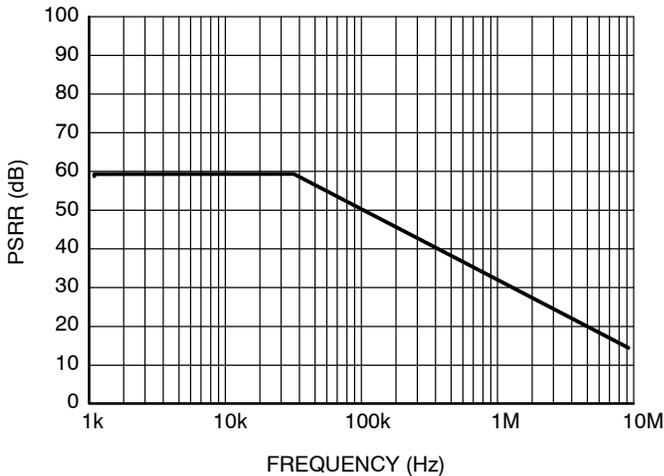
**Figure 9. PSRR vs. Frequency**
**($R_L$ = 5 kΩ, $V_S$ = 5 V, −PSRR)**
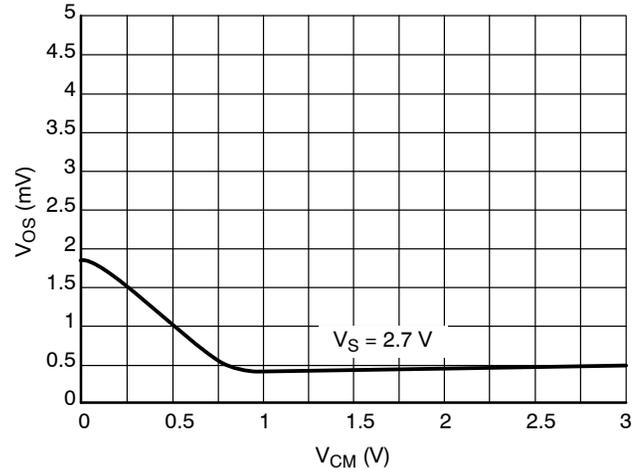
**Figure 10. $V_{OS}$ vs CMR**
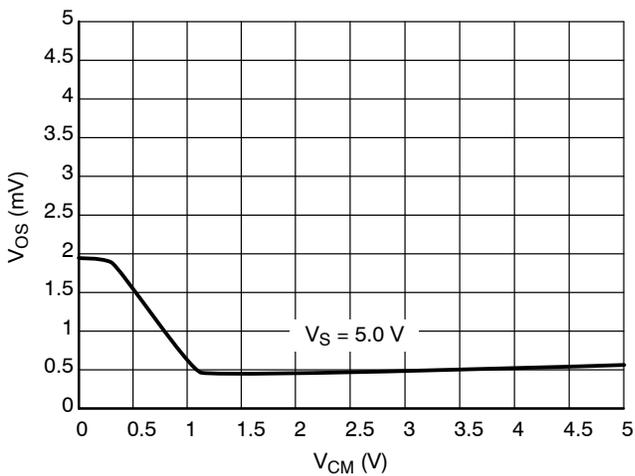
**Figure 11. $V_{OS}$ vs CMR**
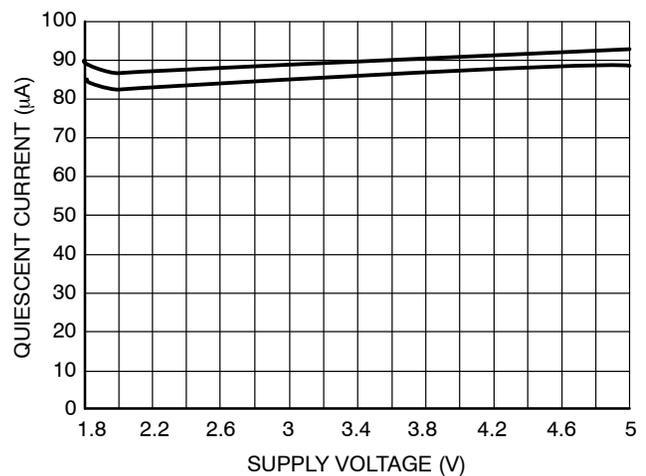
**Figure 12. Supply Current vs. Supply Voltage**

# LMV301

## TYPICAL CHARACTERISTICS

($T_A$ = 25°C and $V_S$ = 5 V unless otherwise specified)
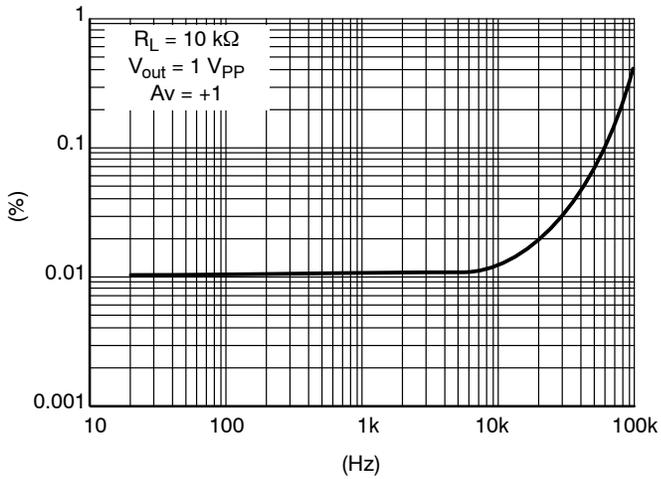


**Figure 13. THD+N vs Frequency**
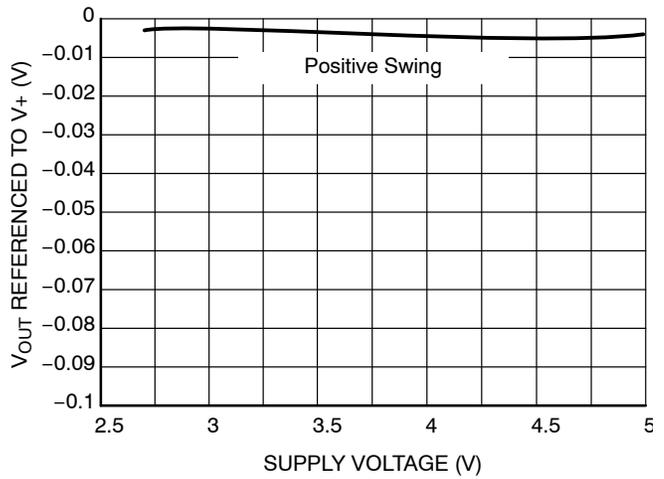


**Figure 14. Output Voltage Swing vs Supply
Voltage ($R_L$ = 10k)**
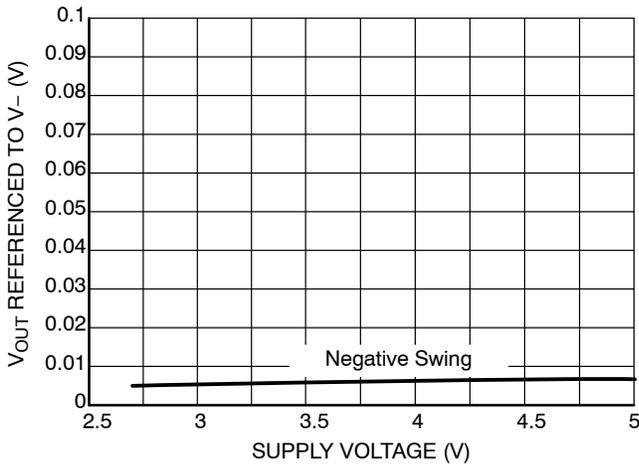


**Figure 15. Output Voltage Swing vs Supply
Voltage ($R_L$ = 10k)**
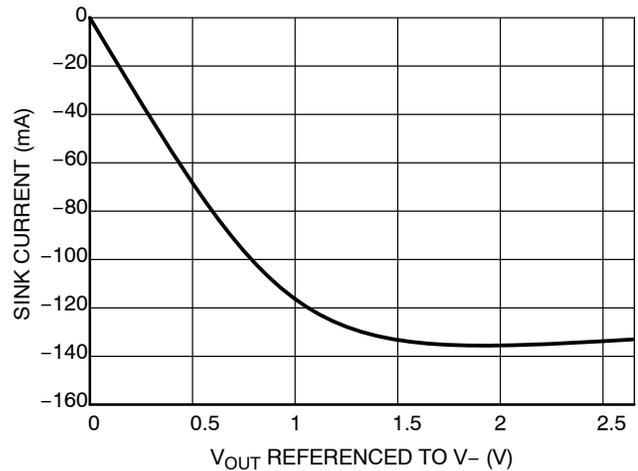


**Figure 16. Sink Current vs. Output Voltage
$V_S$ = 2.7 V**
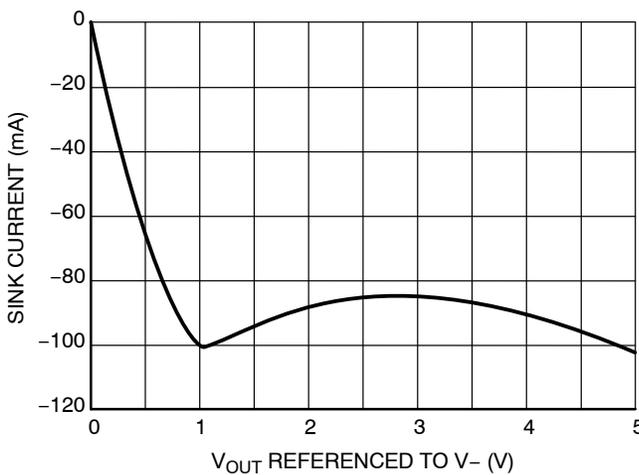


**Figure 17. Sink Current vs. Output Voltage
$V_S$ = 5.0 V**
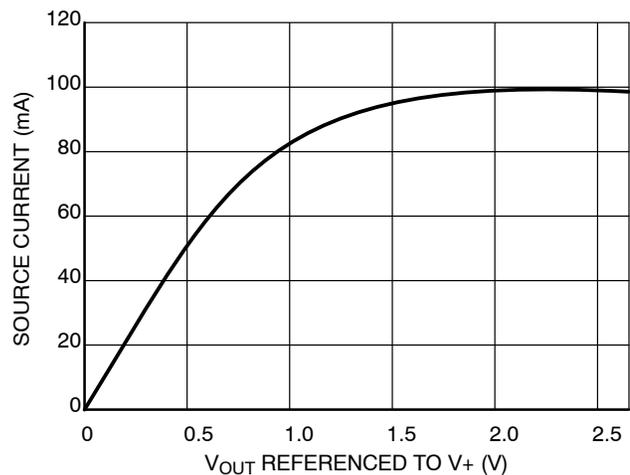


**Figure 18. Source Current vs. Output Voltage
$V_S$ = 2.7 V**

# LMV301

($T_A$ = 25°C and $V_S$ = 5 V unless otherwise specified)
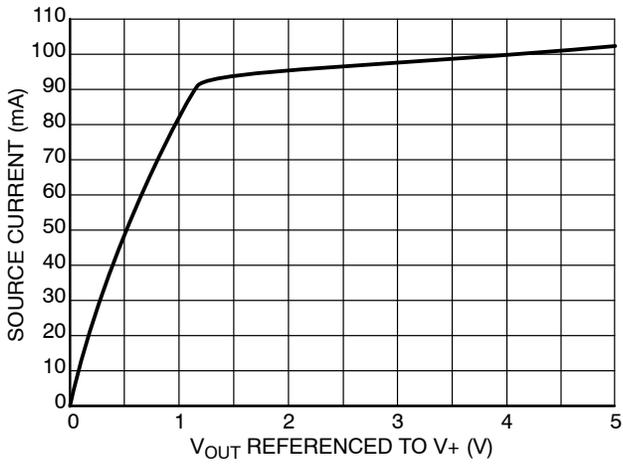


Figure 19. Source Current vs. Output Voltage
$V_S$ = 5.0 V
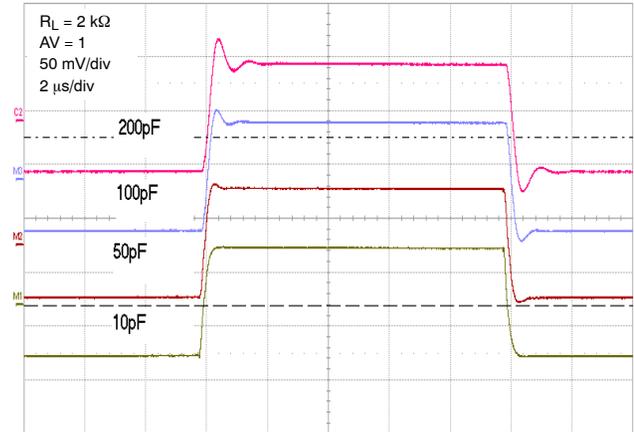


Figure 20. Settling Time vs. Capacitive Load
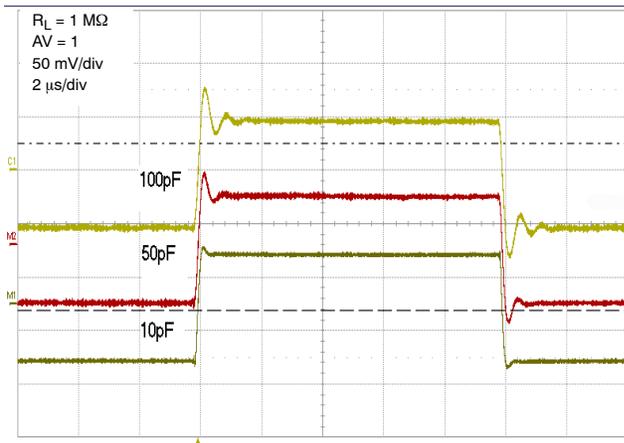


Figure 21. Settling Time vs. Capacitive Load
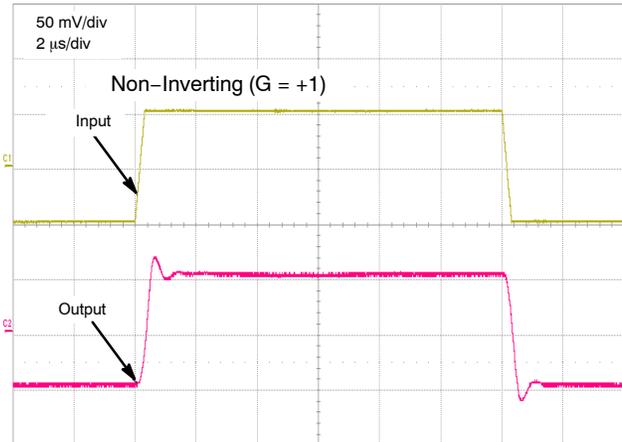


Figure 22. Step Response – Small Signal
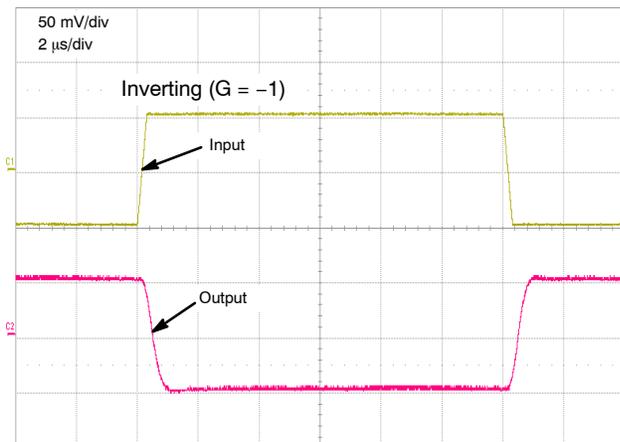


Figure 23. Step Response – Small Signal
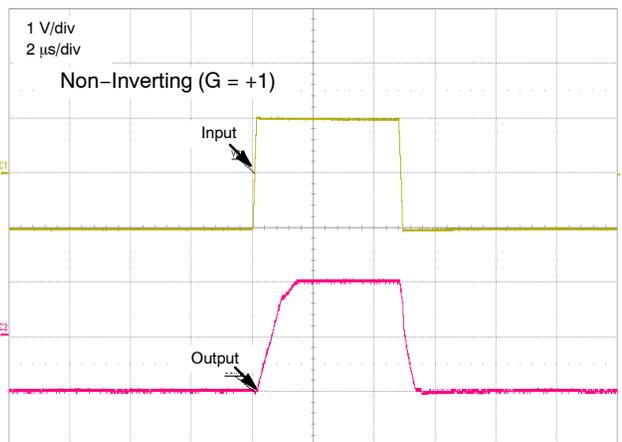


Figure 24. Step Response – Large Signal

# LMV301

## TYPICAL CHARACTERISTICS

($T_A$ = 25°C and $V_S$ = 5 V unless otherwise specified)

1 V/div
2 μs/div

Inverting (G = −1)

C1

Input

C2

Output
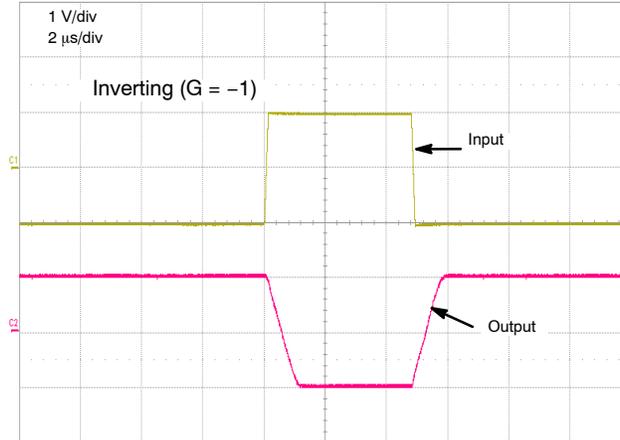
**Figure 25. Step Response − Large Signal**

## APPLICATIONS



$$V_O = 2.5\ V(1 + \frac{R1}{R2})$$
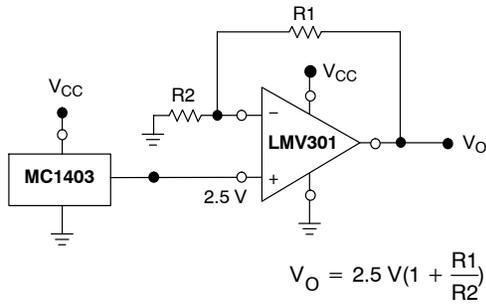
**Figure 26. Voltage Reference**



$$V_{ref} = \frac{1}{2}V_{CC}$$

$$f_O = \frac{1}{2\pi RC}$$

For: $f_o$ = 1.0 kHz
R = 16 kΩ
C = 0.01 μF
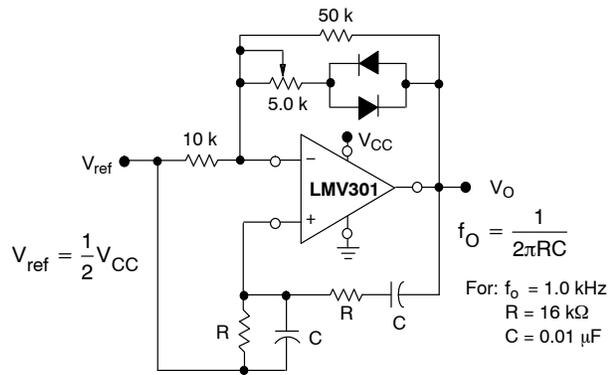
**Figure 27. Wien Bridge Oscillator**



$$V_{in}L = \frac{R1}{R1 + R2}\ (V_{OL} - V_{ref)} + V_{ref}$$

$$V_{in}H = \frac{R1}{R1 + R2}\ (V_{OH} - V_{ref)} + V_{ref}$$

$$H = \frac{R1}{R1 + R2}\ (V_{OH} - V_{OL})$$
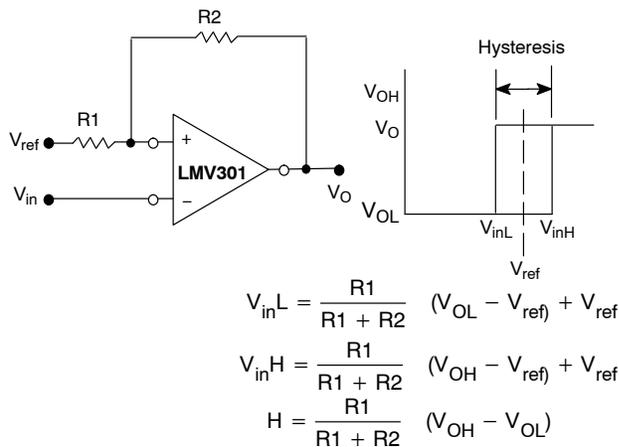
**Figure 28. Comparator with Hysteresis**
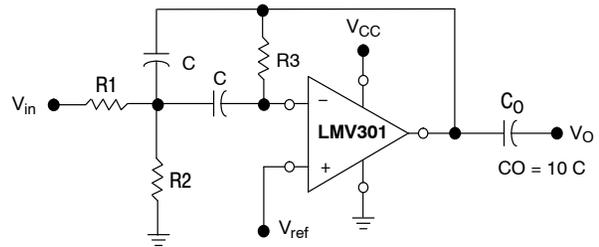


Given:  $f_o$  = center frequency
$A(f_o)$  = gain at center frequency

Choose value $f_o$, C

Then :    $R3 = \dfrac{Q}{\pi f_O\ C}$

$$R1 = \frac{R3}{2\ A(f_O)}$$

$$R2 = \frac{R1\ R3}{4Q^2\ R1\ -\ R3}$$

For less than 10% error from operational amplifier,
$((Q_O\ f_O)/BW) < 0.1$ where $f_o$ and BW are expressed in Hz.
If source impedance varies, filter may be preceded with
voltage follower buffer to stabilize filter parameters.

**Figure 29. Multiple Feedback Bandpass Filter**

### ORDERING INFORMATION

| Device | Pinout Style | Marking | Package | Shipping[†] |
|---|---|---|---|---|
| LMV301SQ3T2G | Style 3 | AAC | SC70–5 (Pb–Free) | 3000 / Tape & Reel |
| LMV301SN3T1G | Style 3 | ADY | TSOP–5 (Pb–Free) | 3000 / Tape & Reel |

†For information on tape and reel specifications, including part orientation and tape sizes, please refer to our Tape and Reel Packaging
 Specifications Brochure, BRD8011/D.

# LMV301

## PACKAGE DIMENSIONS

**SC−88A (SC−70−5/SOT−353)**
CASE 419A−02
ISSUE K
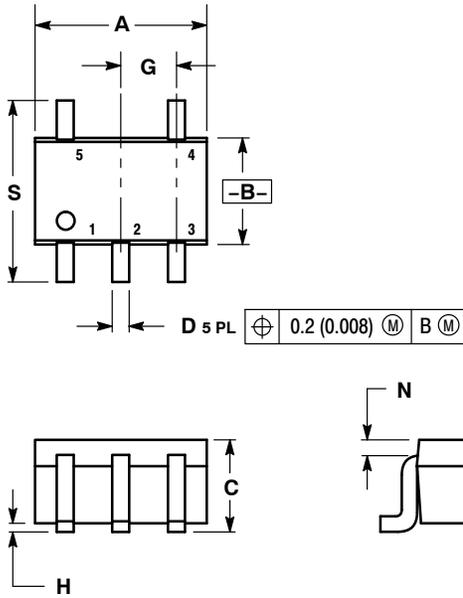
NOTES:
1. DIMENSIONING AND TOLERANCING PER ANSI Y14.5M, 1982.
2. CONTROLLING DIMENSION: INCH.
3. 419A−01 OBSOLETE. NEW STANDARD 419A−02.
4. DIMENSIONS A AND B DO NOT INCLUDE MOLD FLASH, PROTRUSIONS, OR GATE BURRS.

| DIM | INCHES | | MILLIMETERS | |
|-----|--------|--------|--------|--------|
|     | MIN | MAX | MIN | MAX |
| A | 0.071 | 0.087 | 1.80 | 2.20 |
| B | 0.045 | 0.053 | 1.15 | 1.35 |
| C | 0.031 | 0.043 | 0.80 | 1.10 |
| D | 0.004 | 0.012 | 0.10 | 0.30 |
| G | 0.026 BSC | | 0.65 BSC | |
| H | --- | 0.004 | --- | 0.10 |
| J | 0.004 | 0.010 | 0.10 | 0.25 |
| K | 0.004 | 0.012 | 0.10 | 0.30 |
| N | 0.008 REF | | 0.20 REF | |
| S | 0.079 | 0.087 | 2.00 | 2.20 |

D 5 PL ⊕ 0.2 (0.008) Ⓜ B Ⓜ

STYLE 2:
PIN 1. ANODE
2. EMITTER
3. BASE
4. COLLECTOR
5. CATHODE

STYLE 3:
PIN 1. ANODE 1
2. N/C
3. ANODE 2
4. CATHODE 2
5. CATHODE 1

## SOLDERING FOOTPRINT*
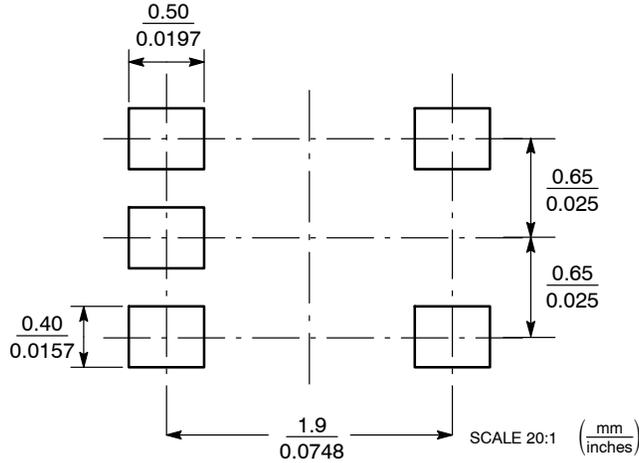
0.50 / 0.0197
0.65 / 0.025
0.65 / 0.025
0.40 / 0.0157
1.9 / 0.0748

SCALE 20:1  (mm / inches)

*For additional information on our Pb−Free strategy and soldering details, please download the ON Semiconductor Soldering and Mounting Techniques Reference Manual, SOLDERRM/D.

# LMV301

## PACKAGE DIMENSIONS

**TSOP–5**
CASE 483–02
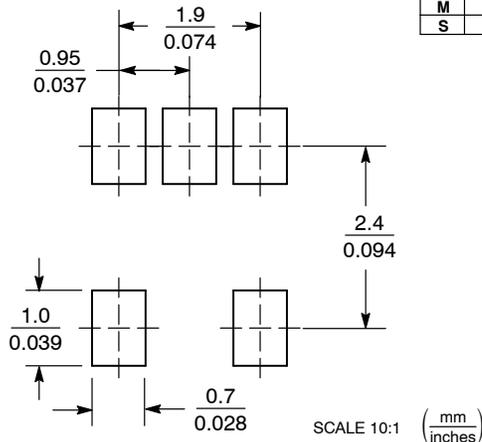ISSUE H



DETAIL Z

DETAIL Z

SEATING PLANE
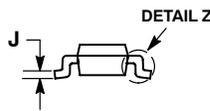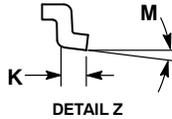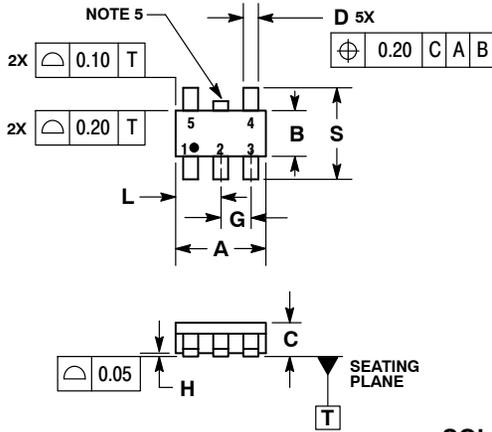
NOTES:
1. DIMENSIONING AND TOLERANCING PER ASME Y14.5M, 1994.
2. CONTROLLING DIMENSION: MILLIMETERS.
3. MAXIMUM LEAD THICKNESS INCLUDES LEAD FINISH THICKNESS. MINIMUM LEAD THICKNESS IS THE MINIMUM THICKNESS OF BASE MATERIAL.
4. DIMENSIONS A AND B DO NOT INCLUDE MOLD FLASH, PROTRUSIONS, OR GATE BURRS.
5. OPTIONAL CONSTRUCTION: AN ADDITIONAL TRIMMED LEAD IS ALLOWED IN THIS LOCATION. TRIMMED LEAD NOT TO EXTEND MORE THAN 0.2 FROM BODY.

| DIM | MILLIMETERS | |
| --- | --- | --- |
| | **MIN** | **MAX** |
| A | 3.00 BSC | |
| B | 1.50 BSC | |
| C | 0.90 | 1.10 |
| D | 0.25 | 0.50 |
| G | 0.95 BSC | |
| H | 0.01 | 0.10 |
| J | 0.10 | 0.26 |
| K | 0.20 | 0.60 |
| L | 1.25 | 1.55 |
| M | 0 ° | 10 ° |
| S | 2.50 | 3.00 |

### SOLDERING FOOTPRINT*



$\frac{1.9}{0.074}$

$\frac{0.95}{0.037}$

$\frac{2.4}{0.094}$

$\frac{1.0}{0.039}$

$\frac{0.7}{0.028}$

SCALE 10:1  $\left(\frac{mm}{inches}\right)$

*For additional information on our Pb–Free strategy and soldering details, please download the ON Semiconductor Soldering and Mounting Techniques Reference Manual, SOLDERRM/D.

**LMV301/D**