

# 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  $\mu\text{A}$ , 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  $\Omega$  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  $\mu\text{A}$ , Max with  $V_S = 1.8 \text{ V}$
- 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



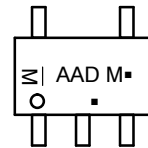
ON Semiconductor®

<http://onsemi.com>

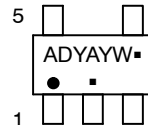
### MARKING DIAGRAMS



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



TSOP-5  
CASE 483

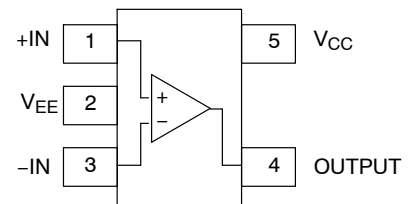


M = Date Code  
A = Assembly Location  
Y = Year  
W = Work Week  
▪ = Pb-Free Package

(\*Note: Microdot may be in either location)

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

### PIN CONNECTION



STYLE 3 PINOUT

### ORDERING INFORMATION

See detailed ordering and shipping information in the dimensions section on page 11 of this data sheet.

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## MAXIMUM RATINGS

Symbol	Rating	Value	Unit
V <sub>S</sub>	Power Supply (Operating Voltage Range V <sub>S</sub> = 1.8 V to 5.0 V)	5.5	V
V <sub>IDR</sub>	Input Differential Voltage	±Supply Voltage	V
V <sub>ICR</sub>	Input Common Mode Voltage Range	-0.5 to (V <sub>+</sub> ) + 0.5	V
	Maximum Input Current	10	mA
t <sub>SO</sub>	Output Short Circuit (Note 1)	Continuous	
T <sub>J</sub>	Maximum Junction Temperature (Operating Range -40°C to 85°C)	150	°C
J <sub>A</sub>	Thermal Resistance (5-Pin SC70-5)	280	°C/W
T <sub>stg</sub>	Storage Temperature	-65 to 150	°C
	Mounting Temperature (Infrared or Convection (30 sec))	260	
V <sub>ESD</sub>	ESD Tolerance	100 1500	V
	Machine Model		
	Human Body Model		

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<sub>+</sub> will adversely affect reliability; likewise shorting output to V<sub>-</sub> will adversely affect reliability.

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

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

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

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

2. Guaranteed by design and/or characterization.

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

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

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

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

2. Guaranteed by design and/or characterization.

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

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

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

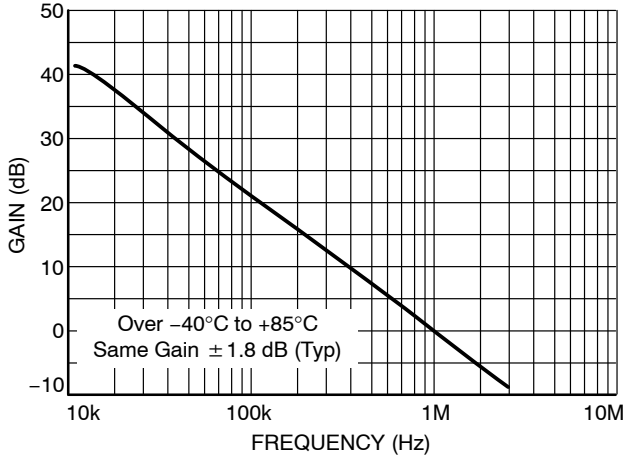
Parameter	Symbol	Condition	Min	Typ	Max	Unit
Slew Rate	$S_R$			1		$\text{V}/\mu\text{s}$
Gain Bandwidth Product	GBWP	$C_L = 200\text{ pF}$		1		MHz
Phase Margin	$\Theta_m$			60		$^\circ$
Gain Margin	$G_m$			10		dB
Input-Referred Voltage Noise	$e_n$	$f = 50\text{ kHz}$		50		$\text{nV}/\sqrt{\text{Hz}}$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

2. Guaranteed by design and/or characterization.

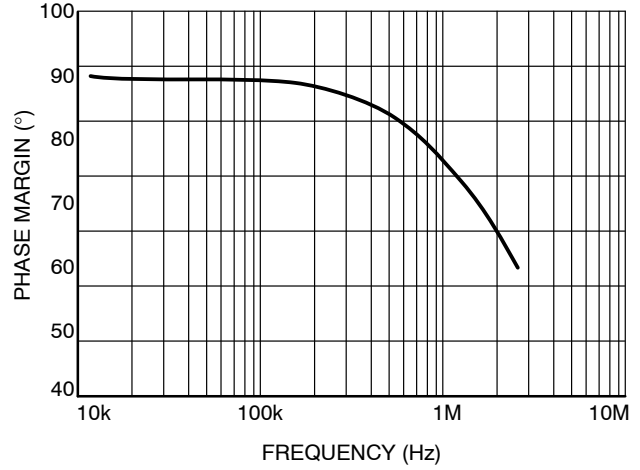
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## TYPICAL CHARACTERISTICS

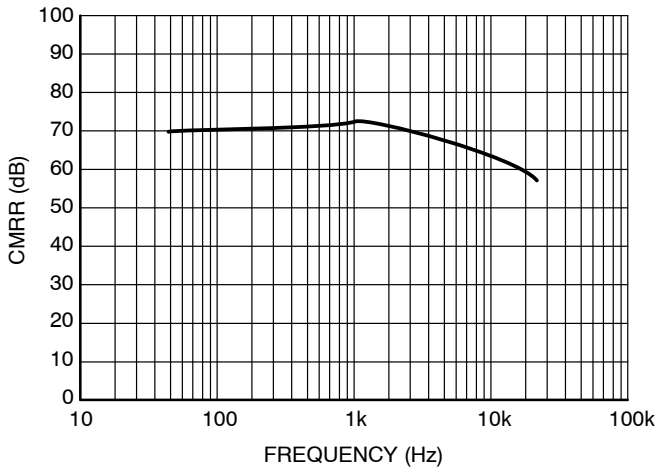
( $T_A = 25^\circ\text{C}$  and  $V_S = 5\text{ V}$  unless otherwise specified)



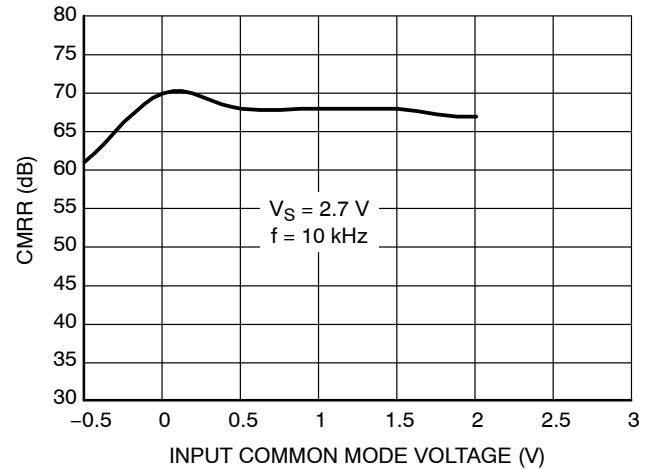
**Figure 1. Open Loop Frequency Response**  
( $R_L = 2\text{ k}\Omega$ ,  $T_A = 25^\circ\text{C}$ ,  $V_S = 5\text{ V}$ )



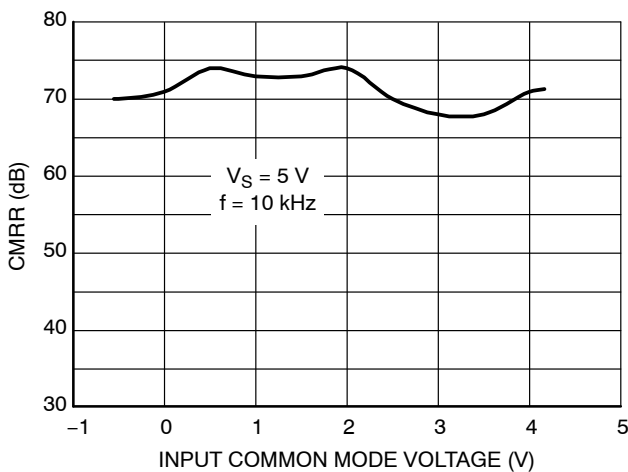
**Figure 2. Open Loop Phase Margin**  
( $R_L = 2\text{ k}\Omega$ ,  $T_A = 25^\circ\text{C}$ )



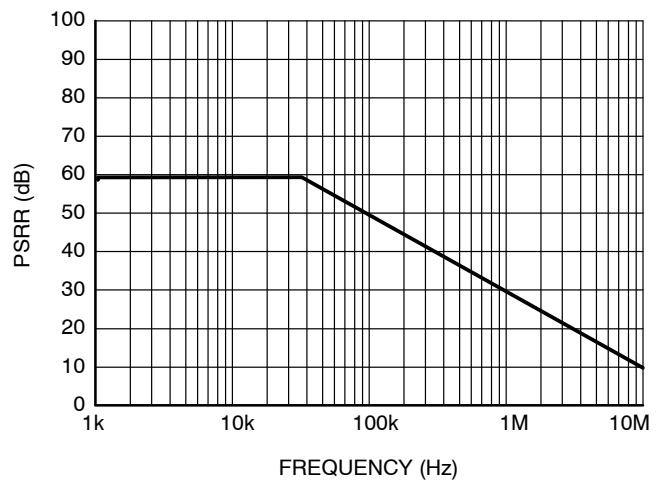
**Figure 3. CMRR vs. Frequency**  
( $R_L = 5\text{ k}\Omega$ ,  $V_S = 5\text{ V}$ )



**Figure 4. CMRR vs. Input Common Mode Voltage**



**Figure 5. CMRR vs. Input Common Mode Voltage**

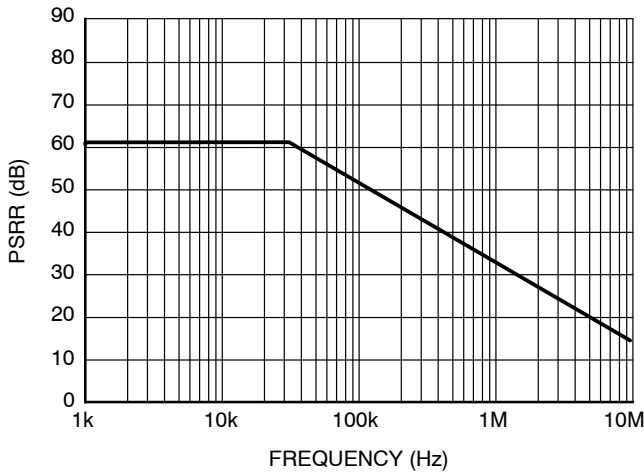


**Figure 6. PSRR vs. Frequency**  
( $R_L = 5\text{ k}\Omega$ ,  $V_S = 2.7\text{ V}$ , +PSRR)

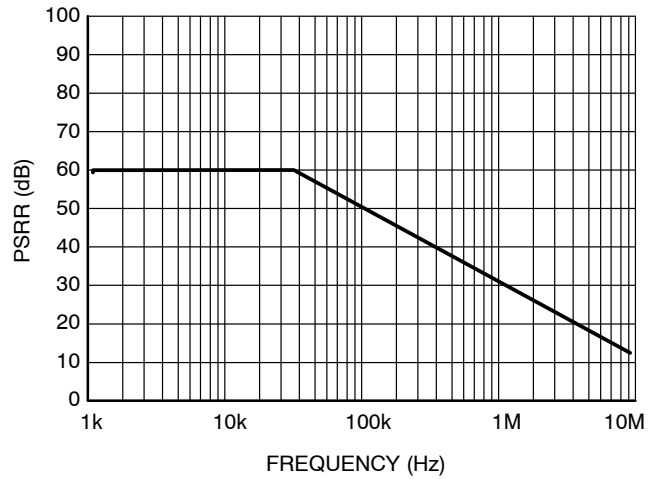
# LMV301

## TYPICAL CHARACTERISTICS

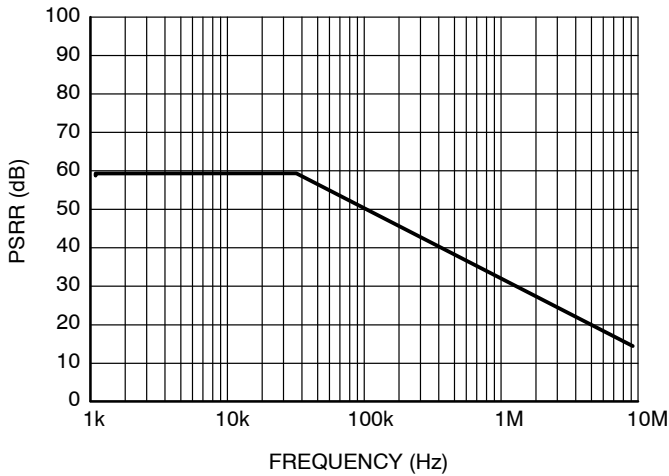
( $T_A = 25^\circ\text{C}$  and  $V_S = 5\text{ V}$  unless otherwise specified)



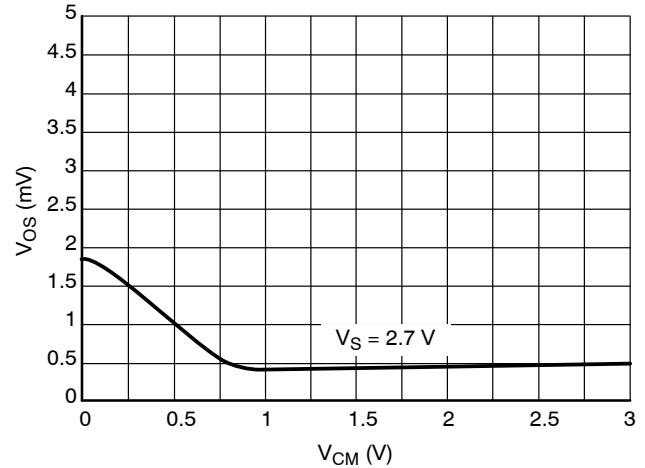
**Figure 7. PSRR vs. Frequency**  
( $R_L = 5\text{ k}\Omega$ ,  $V_S = 2.7\text{ V}$ ,  $-\text{PSRR}$ )



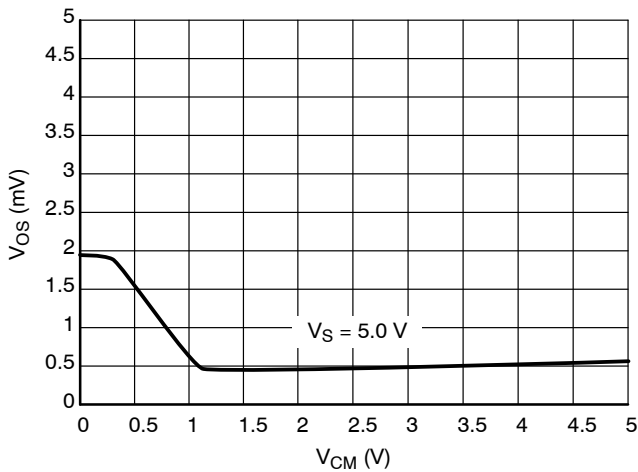
**Figure 8. PSRR vs. Frequency**  
( $R_L = 5\text{ k}\Omega$ ,  $V_S = 5\text{ V}$ ,  $+\text{PSRR}$ )



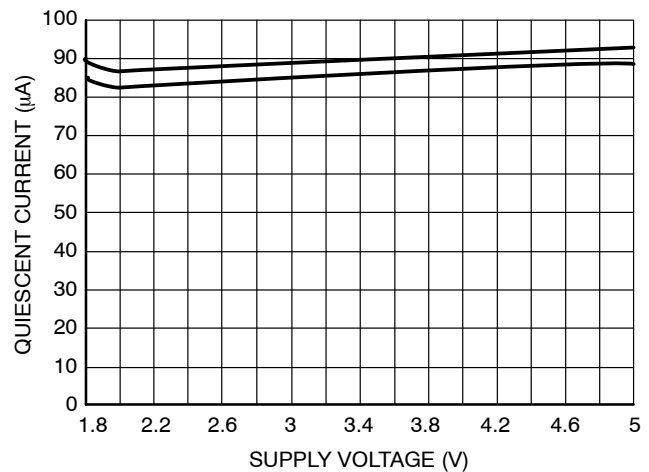
**Figure 9. PSRR vs. Frequency**  
( $R_L = 5\text{ k}\Omega$ ,  $V_S = 5\text{ V}$ ,  $-\text{PSRR}$ )



**Figure 10.  $V_{OS}$  vs. CMR**



**Figure 11.  $V_{OS}$  vs. CMR**



**Figure 12. Supply Current vs. Supply Voltage**

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## TYPICAL CHARACTERISTICS

( $T_A = 25^\circ\text{C}$  and  $V_S = 5\text{ V}$  unless otherwise specified)

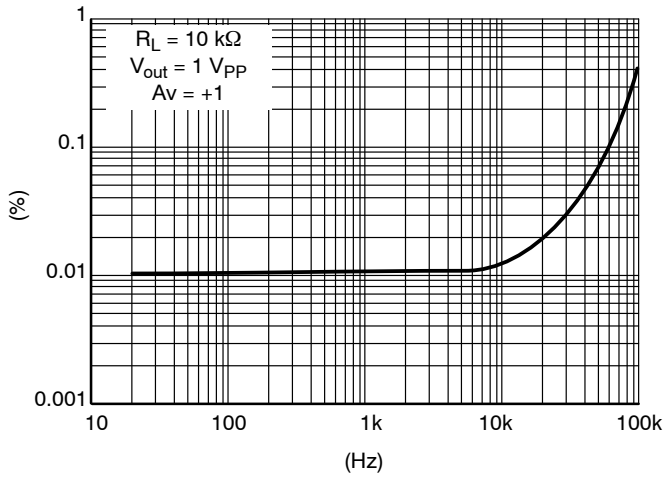


Figure 13. THD+N vs Frequency

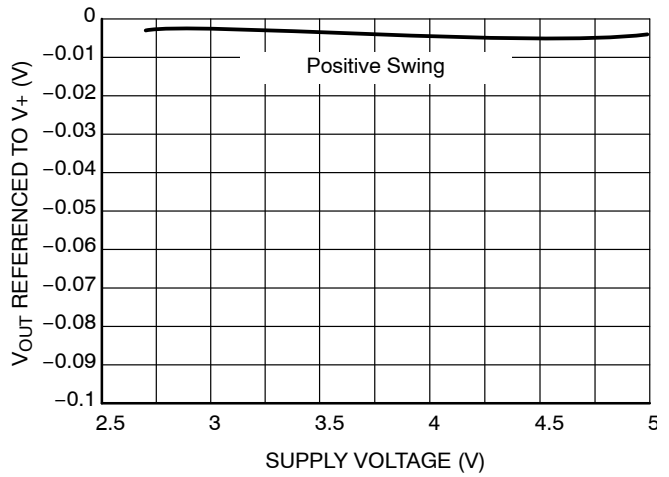


Figure 14. Output Voltage Swing vs Supply Voltage ( $R_L = 10\text{ k}$ )

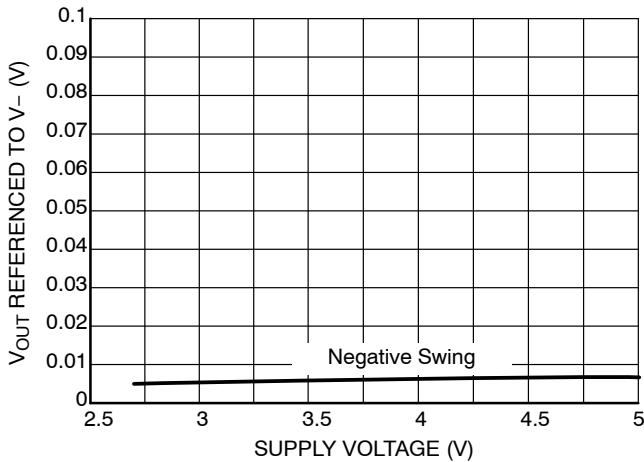


Figure 15. Output Voltage Swing vs Supply Voltage ( $R_L = 10\text{ k}$ )

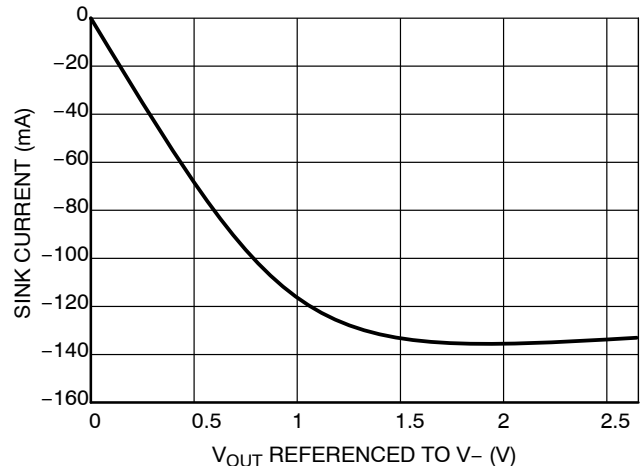


Figure 16. Sink Current vs. Output Voltage  $V_S = 2.7\text{ V}$

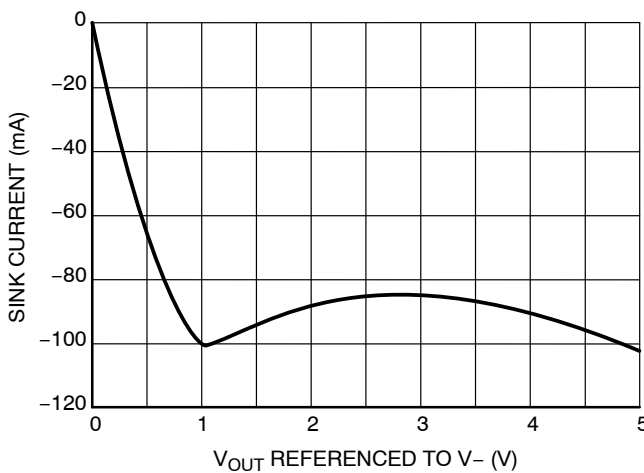


Figure 17. Sink Current vs. Output Voltage  $V_S = 5.0\text{ V}$

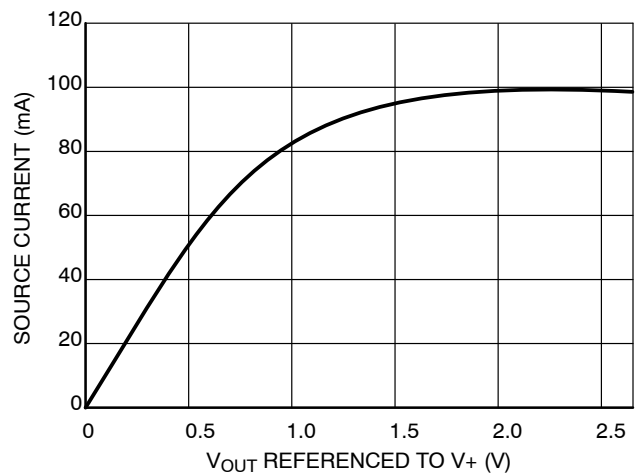


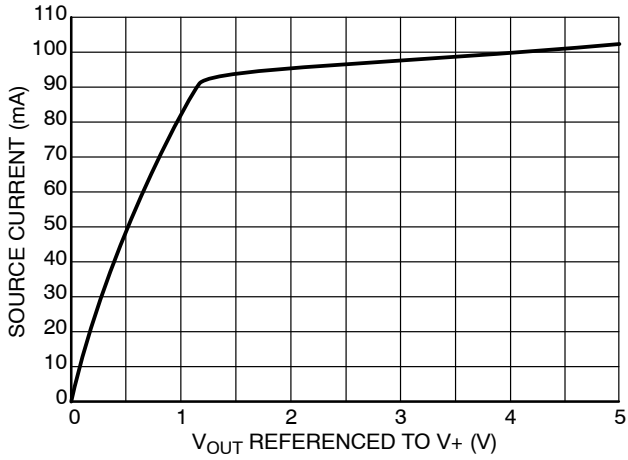
Figure 18. Source Current vs. Output Voltage  $V_S = 2.7\text{ V}$



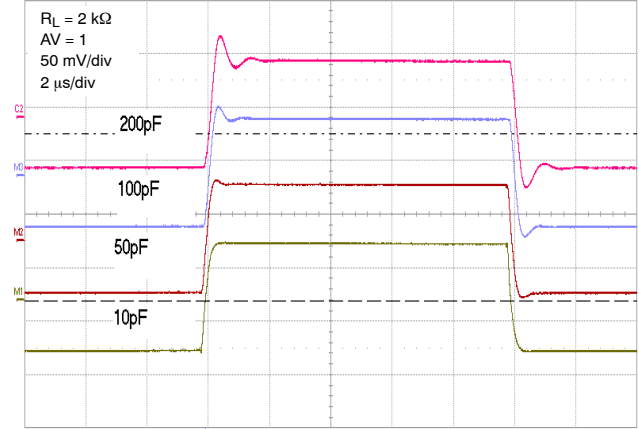
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## TYPICAL CHARACTERISTICS

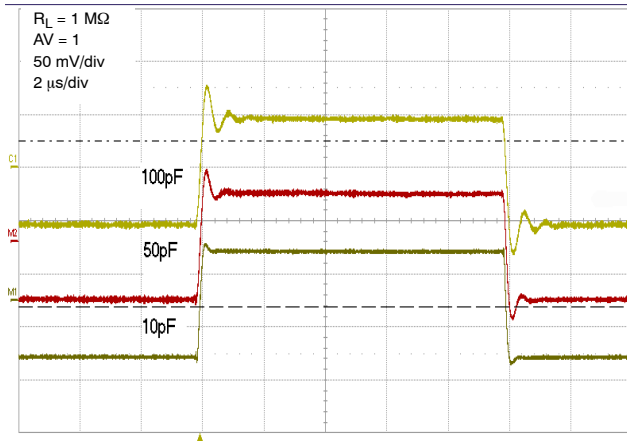
( $T_A = 25^\circ\text{C}$  and  $V_S = 5\text{ V}$  unless otherwise specified)



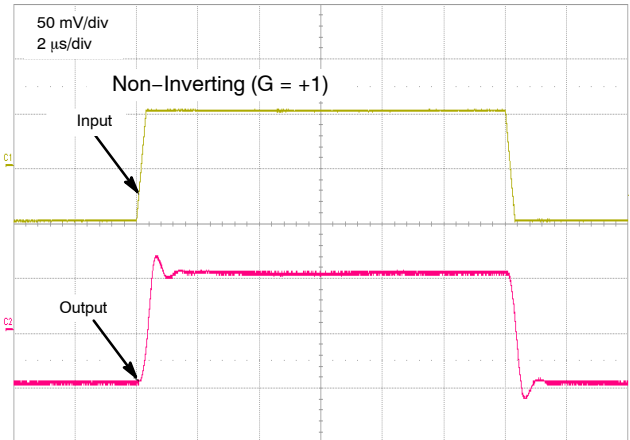
**Figure 19. Source Current vs. Output Voltage**  
 $V_S = 5.0\text{ V}$



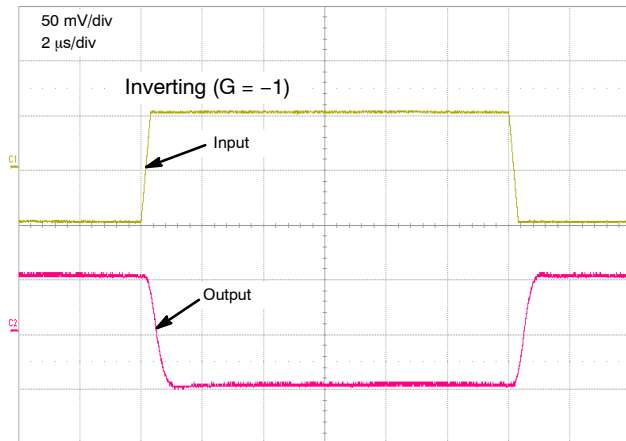
**Figure 20. Settling Time vs. Capacitive Load**



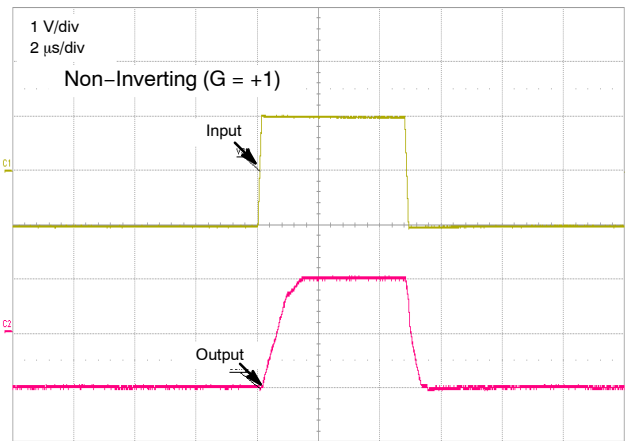
**Figure 21. Settling Time vs. Capacitive Load**



**Figure 22. Step Response – Small Signal**



**Figure 23. Step Response – Small Signal**



**Figure 24. Step Response – Large Signal**

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## TYPICAL CHARACTERISTICS

( $T_A = 25^\circ\text{C}$  and  $V_S = 5\text{ V}$  unless otherwise specified)

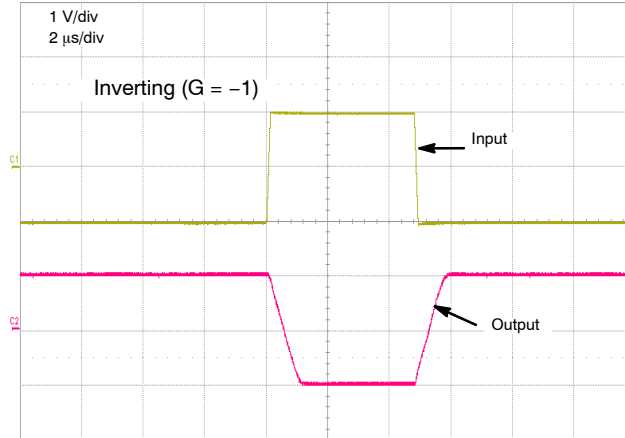


Figure 25. Step Response – Large Signal

# LMV301

## APPLICATIONS

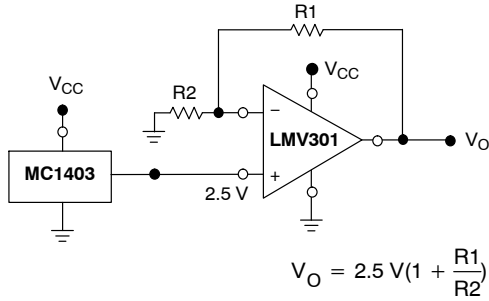


Figure 26. Voltage Reference

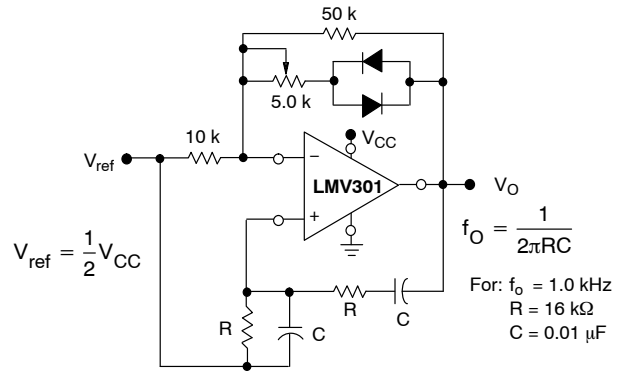


Figure 27. Wien Bridge Oscillator

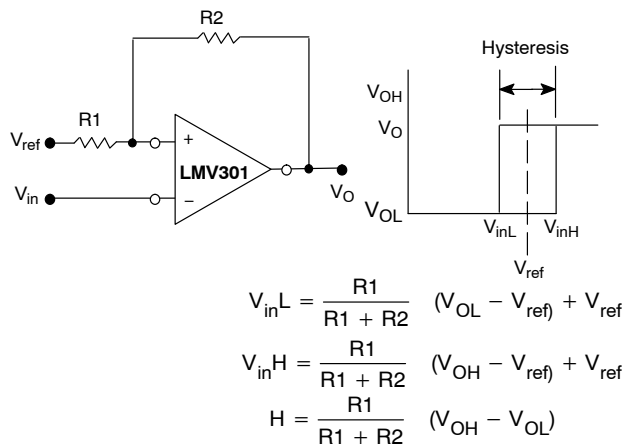
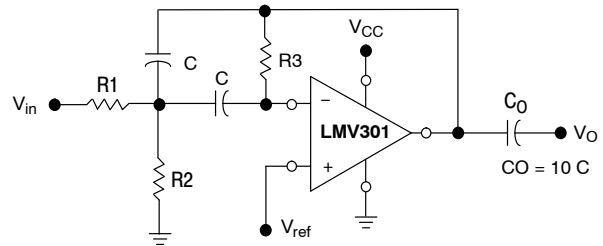


Figure 28. Comparator with Hysteresis



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

Choose value  $f_o, C$   
 Then:  $R3 = \frac{Q}{\pi f_o C}$   
 $R1 = \frac{R3}{2 A(f_o)}$   
 $R2 = \frac{R1 R3}{4Q^2 R1 - R3}$

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

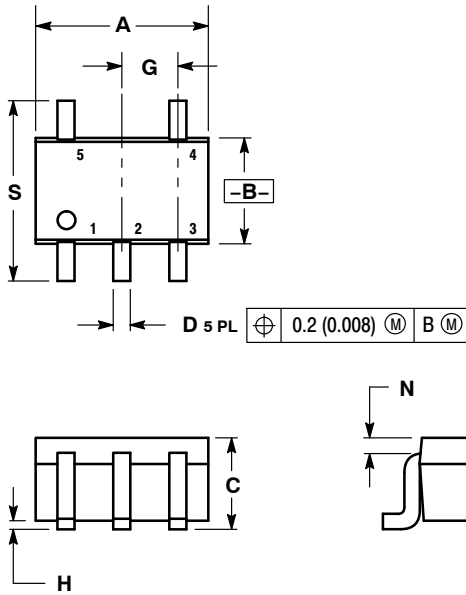
Device	Pinout Style	Marking	Package	Shipping <sup>†</sup>
LMV301SQ3T2G	Style 3	AAC	SC70-5 (Pb-Free)	3000 / Tape & Reel
LMV301SN3T1G	Style 3	ADY	TSOP-5 (Pb-Free)	3000 / Tape & Reel

<sup>†</sup>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

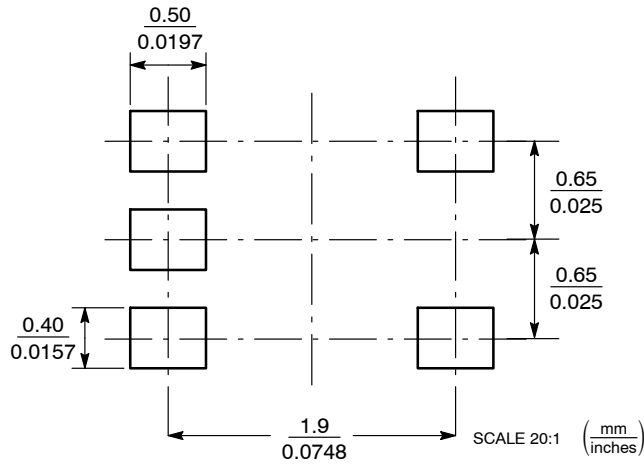
**STYLE 2:**

1. ANODE
2. EMITTER
3. BASE
4. COLLECTOR
5. CATHODE

**STYLE 3:**

1. ANODE 1
2. N/C
3. ANODE 2
4. CATHODE 2
5. CATHODE 1

### SOLDERING FOOTPRINT\*

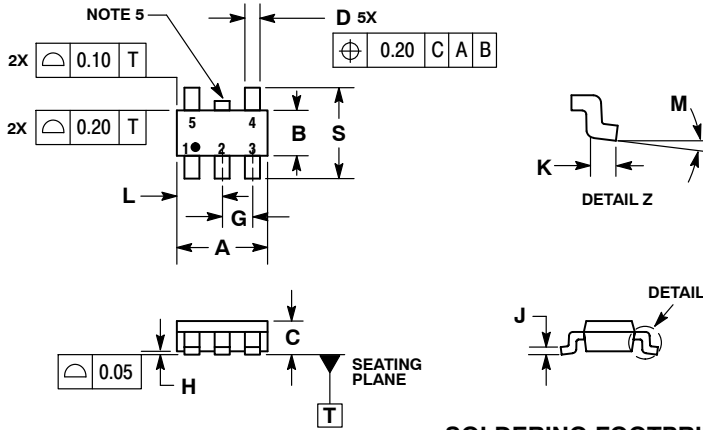


\*For additional information on our Pb-Free strategy and soldering details, please download the ON Semiconductor Soldering and Mounting Techniques Reference Manual, SOLDERRM/D.

# LMV301

## PACKAGE DIMENSIONS

TSOP-5  
CASE 483-02  
ISSUE H

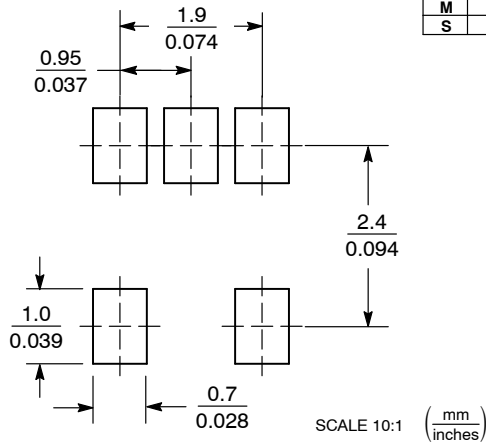


NOTES:

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\*



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

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