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. The LMV301 comes in the space saving 5–pin SC–70 package with an industry–standard pinout, giving it both equivalent function and similar performance to competitive devices.

Features

- Single Supply Operation (or $\pm V_S/2$)
- V_S from 1.8 V to 5 V
- Low Quiescent Current: 185 μ A, Max with $V_S = 1.8 \text{ V}$
- Rail-to-Rail Output Swing
- Low Bias Current: 35 pA, max
- Space Saving SC70-5 Package
- 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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MARKING DIAGRAM

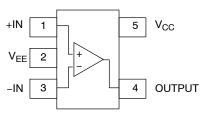


SC70-5 SQ SUFFIX CASE 419A STYLES 2, 3



d = Date Code
G or = = Pb-Free Package

PIN CONNECTION



STYLE 3 PINOUT

ORDERING INFORMATION

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

MAXIMUM RATINGS

Symbol	Rating	Value	Unit
Vs	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	
TJ	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 Machine Model Human Body Model	100 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.

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.

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 $M\Omega$, V_{EE} = 0 V, V_O = $V_{CC}/2$)

Parameter	Symbol	Condition	Min	Тур	Max	Unit
Input Offset Voltage	V _{IO}	$T_A = -40^{\circ}C \text{ to } +85^{\circ}C$		1.7	9	mV
Input Offset Voltage Average Drift	T_CV_{IO}	$T_A = -40^{\circ}C \text{ to } +85^{\circ}C$		5		μV/°C
Input Bias Current (Note 2)	I _B			3	35	pА
		$T_A = -40^{\circ}C \text{ to } +85^{\circ}C$			50	
Common Mode Rejection Ratio	CMRR	$0 \text{ V} \leq \text{V}_{\text{CM}} \leq 0.9 \text{ V}$	50	63		dB
Power Supply Rejection Ratio	PSRR	$1.8 \text{ V} \le \text{V}_{CC} \le 5 \text{ V},$ $\text{V}_{O} = 1 \text{ V}, \text{V}_{CM} = 1 \text{ V}$	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	$R_L = 600\Omega$	83	100		dB
		$T_A = -40^{\circ}C \text{ to } +85^{\circ}C$	80			
		$R_L = 2 k\Omega$	83	100		
		$T_A = -40^{\circ}C \text{ to } +85^{\circ}C$	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)	Io	Sourcing = $V_O = 0 V$ Sinking = $V_O = 1.8 V$	10 20	60 160		mA
Supply Current	I _{CC}	$T_A = -40^{\circ}C \text{ to } +85^{\circ}C$			185	μΑ

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 $M\Omega$, V_{EE} = 0 V , V_O = $V_{CC}/2$)

Parameter	Symbol	Condition	Min	Тур	Max	Unit
Slew Rate	S _R			1		V/μs
Gain Bandwidth Product	GBWP	C _L = 200 pF		1		MHz
Phase Margin	Θ_{m}			60		0
Gain Margin	G _m			10		dB
Input-Referred Voltage Noise	e _n	f = 50 kHz		50		nV/√ Hz
Total Harmonic Distortion	THD	$A_V = +1, V - 1 V_{PP},$ $R_L = 10 \text{ kW, f} = 1 \text{ kHz}$		0.01		%

2. Guaranteed by design and/or characterization.

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 $M\Omega$, V_{EE} = 0 V, V_O = $V_{CC}/2$)

Parameter	Symbol	Condition	Min	Тур	Max	Unit
Input Offset Voltage	V _{IO}	$T_A = -40^{\circ}C$ to $+85^{\circ}C$		1.7	9	mV
Input Offset Voltage Average Drift	T_CV_{IO}	$T_A = -40^{\circ}C \text{ to } +85^{\circ}C$		5		μV/°C
Input Bias Current (Note 2)	Ι _Β			3	35	pА
		$T_A = -40^{\circ}\text{C to } +85^{\circ}\text{C}$			50	
Common Mode Rejection Ratio	CMRR	$0 \text{ V} \leq \text{V}_{\text{CM}} \leq 1.35 \text{ V}$	50	63		dB
Power Supply Rejection Ratio	PSRR	$1.8 \text{ V} \le \text{V}_{CC} \le 5 \text{ V},$ $\text{V}_{O} = 1 \text{ V}, \text{V}_{CM} = 1 \text{ V}$	62	100		dB
Input Common-Mode Voltage Range	V _{CM}	For CMRR ≥ 50 dB	0 to 1.35	-0.2 to1.35		٧
Large Signal Voltage Gain (Note 2)	A _V	R _L = 600 Ω	83	100		dB
		$T_A = -40^{\circ}C \text{ to } +85^{\circ}C$	80			
		$R_L = 2 k\Omega$	83	100		1
		$T_A = -40^{\circ}C \text{ to } +85^{\circ}C$	80			1
Output Swing	V _{OH}	$R_L = 600 \Omega \text{ to } 1.35 \text{ V}$ $T_A = -40^{\circ}\text{C to } +85^{\circ}\text{C}$	2.55 2.53	2.62		V
	V _{OL}	$R_L = 600 \Omega \text{ to } 1.35 \text{ V}$ $T_A = -40^{\circ}\text{C to } +85^{\circ}\text{C}$		78	100 280	mV
	V _{OH}	$R_L = 2 k\Omega \text{ to } 1.35 \text{ V}$ $T_A = -40^{\circ}\text{C to } +85^{\circ}\text{C}$	2.65 2.64	2.675		V
	V _{OL}	$R_L = 2 \text{ k}\Omega \text{ to } 1.35 \text{ V}$ $T_A = -40^{\circ}\text{C to } +85^{\circ}\text{C}$		75	100 110	mV
Output Short Circuit Current (Note 2)	Io	Sourcing = $V_O = 0$ V Sinking = $V_O = 2.7$ V	10 20	60 160		mA
Supply Current	Icc	$T_A = -40^{\circ}\text{C} \text{ to } +85^{\circ}\text{C}$			185	μΑ

 $\textbf{2.7 V AC ELECTRICAL CHARACTERISTICS} \ (\textbf{Unless otherwise specified, all limits are guaranteed for } T_{A} = 25^{\circ}\text{C}, \ V_{CC} = 2.7 \ \text{V}, \ \textbf{V}_{CC} = 2.7 \ \text{V}_{CC} = 2.7 \ \text{V}, \ \textbf{V}_{CC} = 2.7 \ \text{V}_{CC} = 2.7$

$$R_L$$
 = 1 $M\Omega$, V_{EE} = 0 V , V_O = $V_{CC}/2$)

Parameter	Symbol	Condition	Min	Тур	Max	Unit
Slew Rate	S _R			1		V/μs
Gain Bandwidth Product	GBWP	C _L = 200 pF		1		MHz
Phase Margin	Θ_{m}			60		٥
Gain Margin	G _m			10		dB
Input-Referred Voltage Noise	e _n	f = 50 kHz		50		nV/√Hz
Total Harmonic Distortion	THD	$A_V = +1, V - 1 V_{PP},$ $R_L = 10 \text{ kW, f} = 1 \text{ kHz}$		0.01		%

2. Guaranteed by design and/or characterization.

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 M Ω , V_{EE} = 0 V, V_O = $V_{CC}/2$)

Parameter	Symbol	Condition	Min	Тур	Max	Unit
Input Offset Voltage	V _{IO}	$T_A = -40^{\circ}C$ to $+85^{\circ}C$		1.7	9	mV
Input Offset Voltage Average Drift	T_CV_{IO}	$T_A = -40^{\circ}C \text{ to } +85^{\circ}C$		5		μV/°C
Input Bias Current (Note 2)	Ι _Β			3	35	pА
		$T_A = -40^{\circ}C \text{ to } +85^{\circ}C$			50	
Common Mode Rejection Ratio	CMRR	$0 \text{ V} \leq \text{V}_{\text{CM}} \leq 4 \text{ V}$	50	63		dB
Power Supply Rejection Ratio	PSRR	$1.8 \text{ V} \le \text{V}_{CC} \le 5 \text{ V},$ $\text{V}_{O} = 1 \text{ V}, \text{V}_{CM} = 1 \text{ V}$	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	$R_L = 600 \Omega$	83	100		dB
		$T_A = -40^{\circ}C \text{ to } +85^{\circ}C$	80			
		$R_L = 2 k\Omega$	83	100		
		$T_A = -40^{\circ}C \text{ to } +85^{\circ}C$	80			
Output Swing	V _{OH}	$R_L = 600 \Omega \text{ to } 2.5 \text{ V}$ $T_A = -40^{\circ}\text{C to } +85^{\circ}\text{C}$	4.850 4.840			V
	V _{OL}	$R_L = 600 \Omega \text{ to } 2.5 \text{ V}$ $T_A = -40^{\circ}\text{C to } +85^{\circ}\text{C}$			150 160	mV
	V _{OH}	$R_L = 2 \text{ k}\Omega \text{ to } 2.5 \text{ V}$ $T_A = -40^{\circ}\text{C to } +85^{\circ}\text{C}$	4.935 4.900			V
	V _{OL}	$R_L = 2 \text{ k}\Omega \text{ to } 2.5 \text{ V}$ $T_A = -40^{\circ}\text{C to } +85^{\circ}\text{C}$			65 75	mV
Output Short Circuit Current (Note 2)	lo	Sourcing = $V_O = 0 V$ Sinking = $V_O = 5 V$	10 10	60 160		mA
Supply Current	I _{CC}	$T_A = -40^{\circ}C$ to $+85^{\circ}C$			200	μΑ

5.0 V AC ELECTRICAL CHARACTERISTICS (Unless otherwise specified, all limits are guaranteed for $T_A = 25$ °C, $V_{CC} = 5.0$ V,

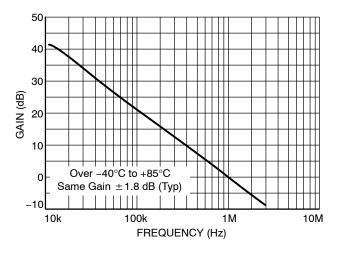
$$R_L$$
 = 1 $M\Omega$, V_{EE} = 0 V , V_O = $V_{CC}/2$)

Parameter	Symbol	Condition	Min	Тур	Max	Unit
Slew Rate	S _R			1		V/μs
Gain Bandwidth Product	GBWP	C _L = 200 pF		1		MHz
Phase Margin	Θ_{m}			60		0
Gain Margin	G _m			10		dB
Input-Referred Voltage Noise	e _n	f = 50 kHz		50		nV/√Hz
Total Harmonic Distortion	THD	$A_V = +1, V - 1 V_{PP},$ $R_L = 10 \text{ kW, f} = 1 \text{ kHz}$		0.01		%

2. Guaranteed by design and/or characterization.

TYPICAL CHARACTERISTICS

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



100 90 80 80 70 40 10k 100k 1M 10M FREQUENCY (Hz)

Figure 1. Open Loop Frequency Response (R_L = 2 k Ω , T_A = 25°C, V_S = 5 V)

100

90

80

70

60

50

40

30

20

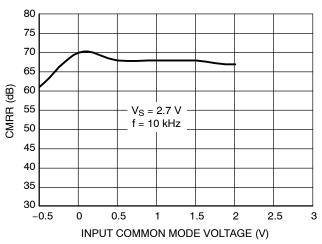
10

10

CMRR (dB)

100 1k 10k 100k

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



 $\begin{aligned} & \text{FREQUENCY (Hz)} \\ \textbf{Figure 3. CMRR vs. Frequency} \\ & \textbf{(R}_{L} = 5 \text{ k}\Omega, \text{ V}_{S} = 5 \text{ V)} \end{aligned}$

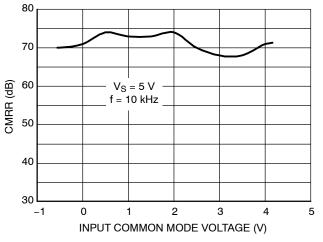


Figure 4. CMRR vs. Input Common Mode Voltage

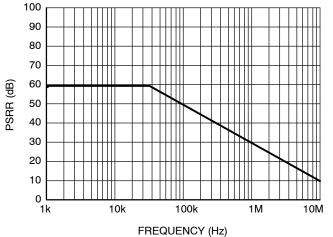
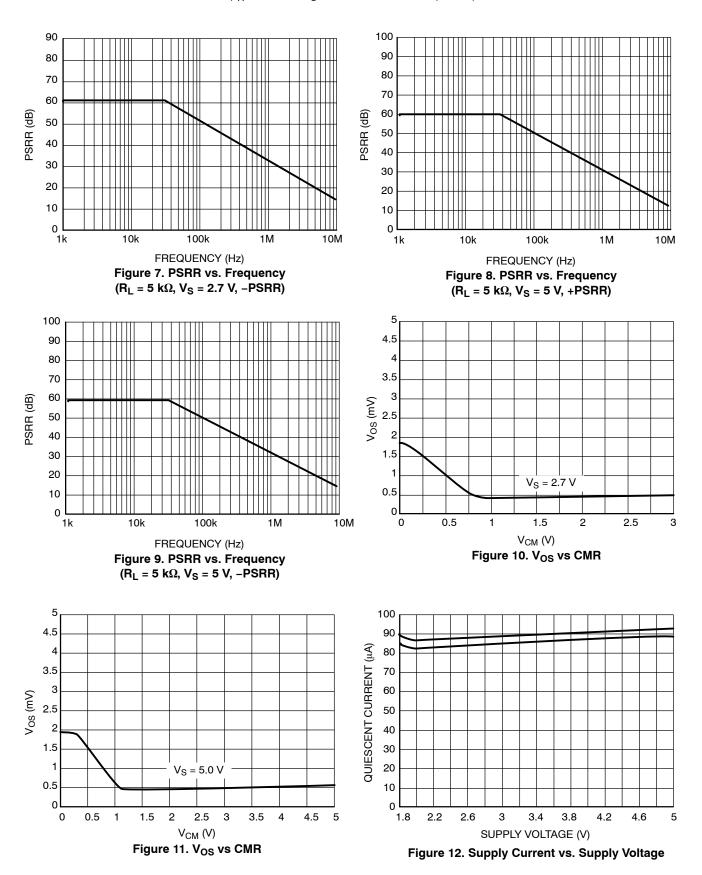


Figure 5. CMRR vs. Input Common Mode Voltage

Figure 6. PSRR vs. Frequency (R_L = 5 k Ω , V_S = 2.7 V, +PSRR)

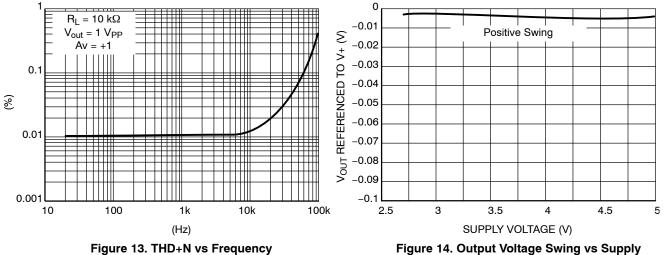
TYPICAL CHARACTERISTICS

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



TYPICAL CHARACTERISTICS

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





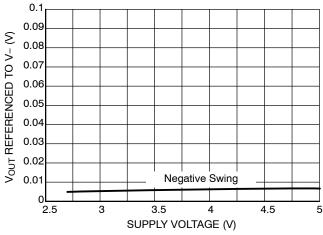


Figure 15. Output Voltage Swing vs Supply Voltage (R_L = 10k)

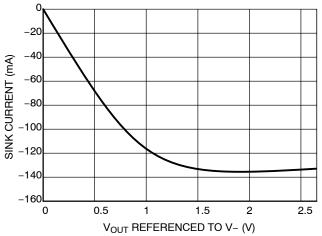


Figure 16. Sink Current vs. Output Voltage $V_S = 2.7 V$

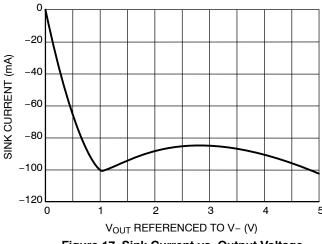


Figure 17. Sink Current vs. Output Voltage $V_S = 5.0 V$

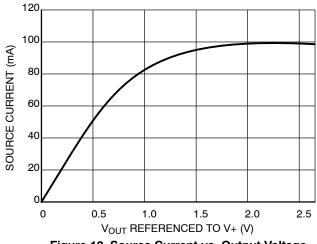


Figure 18. Source Current vs. Output Voltage $V_{S} = 2.7 V$

TYPICAL CHARACTERISTICS

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

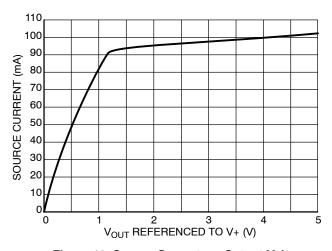


Figure 19. Source Current vs. Output Voltage $V_S = 5.0 \text{ V}$

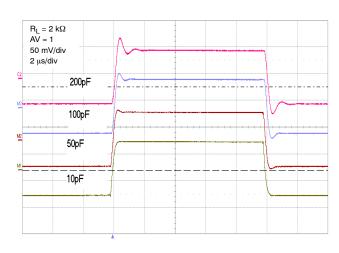


Figure 20. Settling Time vs. Capacitive Load

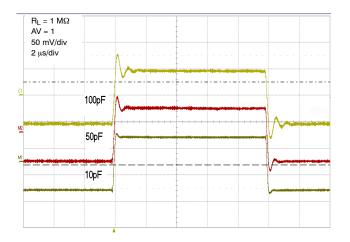


Figure 21. Settling Time vs. Capacitive Load

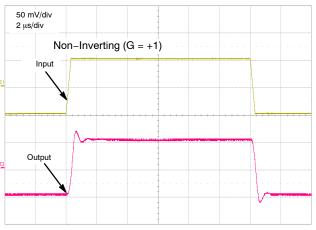


Figure 22. Step Response – Small Signal

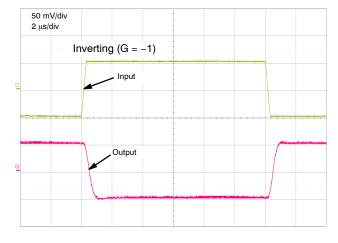


Figure 23. Step Response - Small Signal

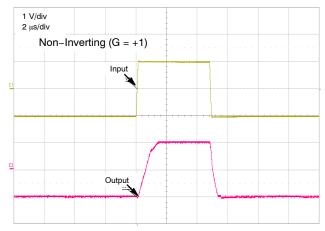


Figure 24. Step Response - Large Signal

TYPICAL CHARACTERISTICS

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

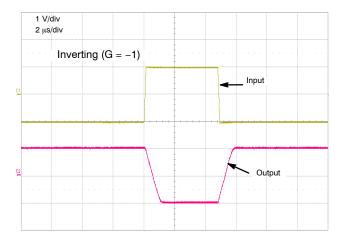


Figure 25. Step Response – Large Signal

APPLICATIONS

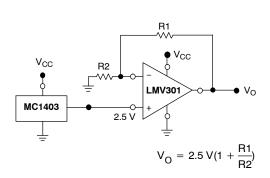


Figure 26. Voltage Reference

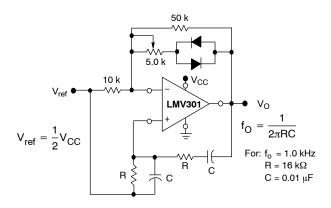


Figure 27. Wien Bridge Oscillator

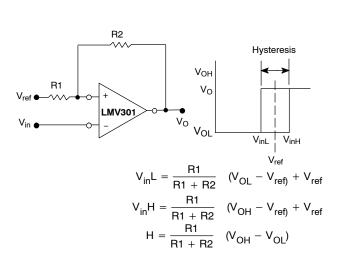
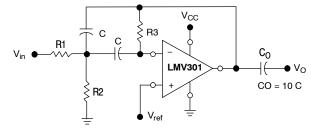


Figure 28. Comparator with Hysteresis



Given: f_0 = center frequency $A(f_0)$ = gain at center frequency

Choose value
$$f_o$$
, $\frac{C}{Q}$
Then: $R3 = \frac{Q}{\pi f_O C}$
$$R1 = \frac{R3}{2 \text{ A(f}_O)}$$

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

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

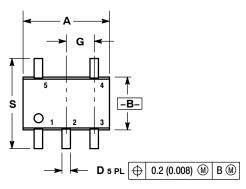
ORDERING INFORMATION

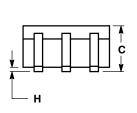
Device	Pinout Style	Marking	Package	Shipping [†]
LMV301SQ3T2G	Style 3	AAD	SC70-5 (Pb-Free)	3000 / Tape & Reel

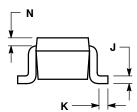
[†]For information on tape and reel specifications, including part orientation and tape sizes, please refer to our Tape and Reel Packaging Specifications Brochure, BRD8011/D.

PACKAGE DIMENSIONS

SC70-5 **SQ SUFFIX** CASE 419A-02 **ISSUE J**







NOTES:

- 1. DIMENSIONING AND TOLERANCING PER ANSI Y14.5M, 1982. 2. CONTROLLING DIMENSION: INCH.
- 419A-01 OBSOLETE. NEW STANDARD 419A-02. 3.
- DIMENSIONS A AND B DO NOT INCLUDE MOLD FLASH, PROTRUSIONS, OR GATE BURRS

	INC	HES	MILLIN	IETERS
DIM	MIN	MAX	MIN	MAX
Α	0.071	0.087	1.80	2.20
В	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	0.026 BSC		BSC
Н		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:

PIN 1. ANODE 2. EMITTE

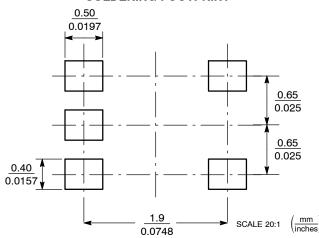
4. COLLECTOR 5. CATHODE

STYLE 3: PIN 1. ANODE 1 2. N/C

EMITTER BASE

3. ANODE 2 4. CATHODE 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.

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