LMV931, LMV932

Single and Dual Low Voltage, Rail-to-Rail Input and Output, Operational Amplifiers

The LMV931 Single and LMV932 Dual are CMOS low−voltage operational amplifiers which can operate on single−sided power supplies (1.8 V to 5.0 V) with rail−to−rail input and output swing. Both devices come in small state−of−the−art packages and require very low quiescent current making them ideal for battery−operated, portable applications such as notebook computers and hand−held instruments. Rail−to−Rail operation provides improved signal−to−noise performance plus the small packages allow for closer placement to signal sources thereby reducing noise pickup.

The single LMV931 is offered in space saving SC70−5 package. The dual LMV932 is in a Micro8. These small packages are very beneficial for crowded PCB's.

Features

- Performance Specified on Single−Sided Power Supply: 1.8, 2.7, and 5 V
- Small Packages:
  LMV931 in a SC−70
  LMV932 in a Micro8
- No Output Crossover Distortion
- Extended Industrial Temperature Range: −40°C to +125°C
- Low Quiescent Current 210 μA, max per channel
- No Output Phase−Reversal from Overdriven Input
- These are Pb−Free Devices

Typical Applications

- Notebook Computers, Portable Battery−Operated Instruments, PDA's
- Active Filters, Low−Side Current Monitoring

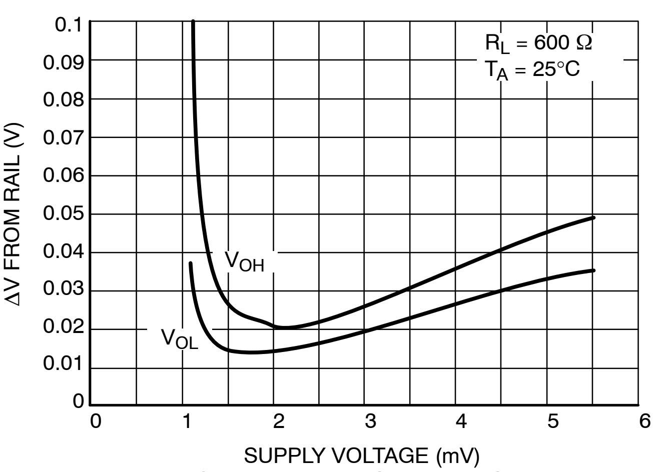

Figure 1. Output Voltage Swing vs. Supply Voltage

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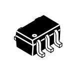
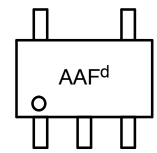
MARKING DIAGRAMS

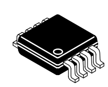
LMV931 (Single)



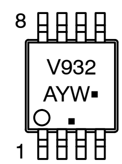
SC−70
CASE 419A



LMV932 (Dual)



Micro8™
CASE 846A



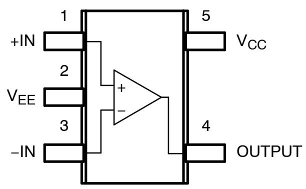
A = Assembly Location
Y = Year
W = Work Week
▪ = Pb−Free Package
(Note: Microdot may be in either location)

ORDERING INFORMATION

See detailed ordering and shipping information in the package dimensions section on page 16 of this data sheet.

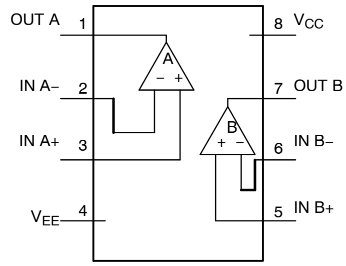
PIN CONNECTIONS

SC70−5



(Top View)

Micro8



(Top View)

MAXIMUM RATINGS

Symbol	Rating	Value	Unit
V_S	Supply Voltage (Operating Range V_S = 1.8 V to 5.5 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
θ_{JA}	Thermal Resistance: SC−70 Micro8	280 238	°C/W
T_{stg}	Storage Temperature	−65 to 150	°C
	Mounting Temperature (Infrared or Convection ≤ 30 sec)	260	°C

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.

ESD data available upon request.

1. Continuous short−circuit operation to ground 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. Shorting output to either V+ or V− will adversely affect reliability.

1.8 V DC ELECTRICAL CHARACTERISTICS Unless otherwise noted, all min/max limits are guaranteed for T_A = 25°C, V^+ = 1.8 V, V^- = 0 V, V_{CM} = V+/2, V_O = V^+/2 and R_L > 1 MΩ. Typical specifications represent the most likely parametric norm.

Parameter	Symbol	Condition	Min	Typ	Max	Unit
Input Offset Voltage	V_{IO}	LMV931 (Single) (−40°C to +125°C)		1	6	mV
		LMV932 (Dual) (−40°C to +125°C)		1	7.5	
Input Offset Voltage Average Drift	TCV_{IO}			5.5		μV/°C
Input Bias Current (Note 2)	I_B	−40°C to +125°C		< 1		nA
Input Offset Current (Note 2)	I_{IO}	−40°C to +125°C		< 1		nA
Supply Current (per Channel)	I_{CC}	In Active Mode		103	185	μA
		−40°C to +125°C			205	
Common Mode Rejection Ratio	CMRR	0 V ≤ V_{CM} ≤ 0.6 V, 1.4 V ≤ V_{CM} ≤ 1.8 V	50	70		dB
		− 40°C to +125°C	50			
		−0.2 V ≤ V_{CM} ≤ 0 V, 1.8 V ≤ V_{CM} ≤ 2 V	50	70		
Power Supply Rejection Ratio	PSRR	1.8 V ≤ V^+ ≤ 5 V, V_{CM} = 0.5 V	50	70		dB
		−40°C to +125°C	50			
Input Common−Mode Voltage Range	VCM	For CMRR ≥ 50 dB and T_A = 25°C	V^- − 0.2	−0.2 to 2.1	V^+ + 0.2	V
		For CMRR ≥ 50 dB and T_A = − 40°C to +85°C	V^-		V^+	
		For CMRR ≥ 50 dB and T_A = − 40°C to +125°C	V^- + 0.2		V^+ − 0.2	
Large Signal Voltage Gain LMV931 (Single) (Note 2)	A_V	R_L = 600 Ω to 0.9 V, V_O = 0.2 V to 1.6 V, V_{CM} = 0.5 V	77	101		dB
		−40°C to +125°C	73			
		R_L = 2 kΩ to 0.9V, V_O = 0.2 V to 1.6 V, V_{CM} = 0.5 V	80	105		
		−40°C to +125°C	75			
Large Signal Voltage Gain LMV932 (Dual) (Note 2)		R_L = 600 Ω to 0.9 V, V_O = 0.2 V to 1.6 V, V_{CM} = 0.5 V	75	90		
		−40°C to +125°C	72			
		R_L = 2 kΩ to 0.9 V, V_O = 0.2 V to 1.6 V,V_{CM} = 0.5 V	78	100		
		−40°C to +125°C	75			
Output Swing	V_{OH}	R_L = 600 Ω to 0.9V, V_{IN} = ±100 mV	1.65	1.72		V
		−40°C to +125°C	1.63			
	V_{OL}	R_L = 600 Ω to 0.9V, V_{IN} = ±100 mV		0.077	0.105	
		−40°C to +125°C			0.12	
	V_{OH}	R_L = 2 kΩ to 0.9V, V_{IN} = ±100 mV	1.75	1.77		
		−40°C to +125°C	1.74			
	V_{OL}	R_L = 2 kΩ to 0.9 V, V_{IN} = ±100 mV		0.24	0.035	
		−40°C to +125°C			0.04	
Output Short Circuit Current	I_O	Sourcing, Vo = 0 V, V_{IN} = +100 mV	4	8		mA
		−40°C to +125°C	3.3			
		Sinking, Vo = 1.8V, V_{IN} = −100 mV	7	9		
		−40°C to +125°C	5			

2. Guaranteed by design and/or characterization.

1.8V AC ELECTRICAL CHARACTERISTICS Unless otherwise specified, all limits are guaranteed for T_A = 25°C, V+ = 1.8 V, V− = 0 V, V_{CM} = 2.0 V,Vo = V+/2 and R_L > 1 MΩ. Typical specifications represent the most likely parametric norm. Min/Max specifications are guaranteed by testing, characterization, or statistical analysis.

Parameter	Symbol	Condition	Min	Typ	Max	Unit
Slew Rate	SR	(Note 3)		0.35		V/μS
Gain Bandwidth Product	GBWP			1.4		MHz
Phase Margin	Θm			67		°
Gain Margin	Gm			7		dB
Input−Referred Voltage Noise	e_n	f = 50 kHz, V_{CM} = 0.5 V		60		nV/√Hz
Total Harmonic Distortion	THD	f = 1 kHz, A_V = +1, R_L = 600 Ω, V_O = 1 V_{PP}		0.023		%
Amplifier−to−Amplifier Isolation		(Note 4)		123		dB

3. Connected as voltage follower with input step from V− to V+. Number specified is the slower of the positive and negative slew rates.
4. Input referred, R_L = 100 kΩ connected to V+/2. Each amp excited in turn with 1 kHz to produce V_O = 3 V_{PP}. (For Supply Voltages < 3 V, V_O = V+).

2.7V DC ELECTRICAL CHARACTERISTICS Unless otherwise noted, all min/max limits are guaranteed for T_A = 25°C, V^+ = 2.7 V, V^- = 0 V, V_{CM} = V+/2, V_O = V^+/2 and R_L > 1 MΩ. Typical specifications represent the most likely parametric norm.

Parameter	Symbol	Condition	Min	Typ	Max	Unit
Input Offset Voltage	V_{IO}	LMV931 (Single) (−40°C to +125°C)		1	6	mV
		LMV932 (Dual) (−40°C to +125°C)		1	7.5	
Input Offset Voltage Average Drift	TCV_{IO}			5.5		μV/°C
Input Bias Current (Note 5)	I_B	−40°C to +125°C		< 1		nA
Input Offset Current (Note 5)	I_{IO}	−40°C to +125°C		< 1		nA
Supply Current (per Channel)	I_{CC}	In Active Mode		105	190	μA
		−40°C to +125°C			210	
Common Mode Rejection Ratio	CMRR	0 V ≤ V_{CM} ≤ 1.5 V, 2.3 V ≤ V_{CM} ≤ 2.7 V	50	70		dB
		−40°C to +125°C	50			
		−0.2 V ≤ V_{CM} ≤ 0 V, 2.7 V ≤ V_{CM} ≤ 2.9 V	50	70		
Power Supply Rejection Ratio	PSRR	1.8 V ≤ V^+ ≤ 5 V, V_{CM} = 0.5 V	50	70		dB
		−40°C to +125°C	50			
Input Common−Mode Voltage Range	VCM	For CMRR ≥ 50 dB and T_A = 25°C	V− − 0.2	−0.2 to 3.0	V+ + 0.2	V
		For CMRR ≥ 50 dB and T_A = −40°C to +85°C	V^-		V^+	
		For CMRR ≥ 50 dB and T_A = −40°C to +125°C	V− + 0.2		V^+ − 0.2	
Large Signal Voltage Gain LMV931 (Single) (Note 5)	A_V	R_L = 600 Ω to 1.35 V, V_O = 0.2 V to 2.5 V	87	104		dB
		−40°C to +125°C	86			
		R_L = 2 kΩ to 1.35 V, V_O = 0.2 V to 2.5 V	92	110		
		−40°C to +125°C	91			
Large Signal Voltage Gain LMV932 (Dual) (Note 5)	A_V	R_L = 600 Ω to 1.35 V, V_O = 0.2 V to 2.5 V	78	90		
		−40°C to +125°C	75			
		R_L= 2 kΩ to 1.35 V, V_O = 0.2 V to 2.5 V	81	100		
		−40°C to +125°C	78			
Output Swing	V_{OH}	R_L = 600 Ω to 1.35 V, V_{IN} = ±100 mV	2.55	2.62		V
		−40°C to +125°C	2.53			
	V_{OL}	R_L = 600 Ω to 1.35 V, V_{IN} = ±100 mV		0.083	0.11	
		−40°C to +125°C			0.13	
	V_{OH}	R_L = 2 kΩ to 1.35 V, V_{IN} = ±100 mV	2.65	2.675		
		−40°C to +125°C	2.64			
	V_{OL}	R_L = 2 kΩ to 1.35 V, V_{IN} = ±100 mV		0.025	0.04	
		−40°C to +125°C			0.045	
Output Short Circuit Current	I_O	Sourcing, Vo = 0 V, V_{IN} = ±100 mV	20	30		mA
		−40°C to +125°C	15			
		Sinking, Vo = 0 V, V_{IN} = −100 mV	18	25		
		−40°C to +125°C	12			

5. Guaranteed by design and/or characterization.

2.7V AC ELECTRICAL CHARACTERISTICS Unless otherwise specified, all limits are guaranteed for T_A = 25°C, V+ = 2.7 V, V− = 0 V, V_{CM} = 2.0V ,Vo = V+/2 and R_L > 1 MΩ. Typical specifications represent the most likely parametric norm. Min/Max specifications are guaranteed by testing, characterization, or statistical analysis.

Parameter	Symbol	Condition	Min	Typ	Max	Unit
Slew Rate	SR	(Note 6)		0.4		V/uS
Gain Bandwidth Product	GBWP			1.4		MHz
Phase Margin	¿m			70		°
Gain Margin	Gm			7.5		dB
Input−Referred Voltage Noise	e_n	f = 50 kHz, V_{CM} = 1.0 V		57		nV/√Hz
Total Harmonic Distortion	THD	f = 1 kHz, A_V = +1, R_L = 600 Ω, V_O = 1 V_{PP}		0.022		%
Amplifier−to−Amplifier Isolation		(Note 7)		123		dB

6. Connected as voltage follower with input step from V− to V+. Number specified is the slower of the positive and negative slew rates.
7. Input referred, R_L = 100 kΩ connected to V+/2. Each amp excited in turn with 1 kHz to produce V_O = 3 V_{PP}. (For Supply Voltages < 3 V, V_O = V+).

5V DC ELECTRICAL CHARACTERISTICS Unless otherwise noted, all min/max limits are guaranteed for T_A = 25°C, V^+ = 5 V, V^- = 0 V, V_{CM} = V+/2, V_O = V^+/2 and R_L > 1 MΩ. Typical specifications represent the most likely parametric norm.

Parameter	Symbol	Condition	Min	Typ	Max	Unit
Input Offset Voltage	V_{IO}	LMV931 (Single) (−40°C to +125°C)		1	6	mV
		LMV932 (Dual) (−40°C to +125°C)		1	7.5	
Input Offset Voltage Average Drift	TCV_{IO}			5.5		μV/°C
Input Bias Current (Note 8)	I_B	−40°C to +125°C		< 1		nA
Input Offset Current (Note 8)	I_{IO}	−40°C to +125°C		< 1		nA
Supply Current (per Channel)	I_{CC}	In Active Mode		116	210	μA
		−40°C to +125°C			230	
Common−Mode Rejection Ratio	CMRR	0 V ≤ V_{CM} ≤ 3.8 V, 4.6 V ≤ V_{CM} ≤ 5.0 V	50	70		dB
		−40°C to +125°C	50			
		−0.2 V ≤ V_{CM} ≤ 0 V, 5.0 V ≤ V_{CM} ≤ 5. 2V	50	70		
Power Supply Rejection Ratio	PSRR	1.8 V ≤ V^+ ≤ 5 V, V_{CM} = 0.5 V	50	70		dB
		−40°C to +125°C	50			
Input Common−Mode Voltage Range	VCM	For CMRR ≥ 50 dB and T_A = 25°C	V^- − 0.2	−0.2 to 5.3	V^+ + 0.2	V
		For CMRR ≥ 50 dB and T_A = −40°C to +85°C	V^-		V^+	
		For CMRR ≥ 50 dB and T_A = −40°C to +125°C	V^- + 0.3		V^+ − 0.3	
Large Signal Voltage Gain LMV931 (Single) (Note 8)	A_V	R_L = 600 Ω to 2.5 V, V_O = 0.2 V to 4.8 V	88	102		dB
		−40°C to +125°C	87			
		R_L = 2 kΩ to 2.5 V, V_O = 0.2 V to 4.8 V	94	113		
		−40°C to +125°C	93			
Large Signal Voltage Gain LMV932 (Dual) (Note 8)	A_V	R_L = 600 Ω to 2.5 V, V_O = 0.2 V to 4.8 V	81	90		
		−40°C to +125°C	78			
		R_L = 2 kΩ to 2.5 V, V_O = 0.2 V to 4.8 V	85	100		
		−40°C to +125°C	82			
Output Swing	V_{OH}	R_L = 600 Ω to 2.5 V, V_{IN} = ±100 mV	4.855	4.89		V
		−40°C to +125°C	4.835			
	V_{OL}	R_L = 600 Ω to 2.5 V, V_{IN} = ±100 mV		0.12	0.16	
		−40°C to +125°C			0.18	
	V_{OH}	R_L = 2 kΩ to 2.5 V, V_{IN} = ±100 mV	4.945	4.967		
		−40°C to +125°C	4.935			
	V_{OL}	R_L = 2 kΩ to 2.5 V, V_{IN} = ±100 mV		0.037	0.065	
		−40°C to +125°C			0.075	
Output Short−Circuit Current	I_O	Sourcing, Vo = 0 V, V_{IN} = +100 mV	80	100		mA
		−40°C to +125°C	68			
		Sinking, Vo = 5 V, V_{IN} = −100 mV	58	65		
		−40°C to +125°C	45			

8. Guaranteed by design and/or characterization.

5V AC ELECTRICAL CHARACTERISTICS Unless otherwise specified, all limits are guaranteed for T_A = 25°C, V+ = 5 V, V− = 0 V, V_{CM} = 2.0 V,Vo = V+/2 and R_L > 1 MΩ. Typical specifications represent the most likely parametric norm.

Parameter	Symbol	Condition	Min	Typ	Max	Unit
Slew Rate	SR	(Note 9)		0.48		V/uS
Gain Bandwidth Product	GBWP			1.5		MHz
Phase Margin	Θm			65		°
Gain Margin	Gm			8		dB
Input−Referred Voltage Noise	e_n	f = 50 kHz, V_{CM} = 2 V		50		$nV/\sqrt{Hz}$
Total Harmonic Distortion	THD	f = 1 kHz, A_V = +1, R_L = 600 Ω, V_O = 1 V_{PP}		0.022		%
Amplifier−to−Amplifier Isolation		(Note 10)		123		dB

9. Connected as voltage follower with input step from V− to V+. Number specified is the slower of the positive and negative slew rates.
10. Input referred, R_L = 100 kΩ connected to V+/2. Each amp excited in turn with 1 kHz to produce V_O = 3 V_{PP}. (For Supply Voltages < 3 V, V_O = V+).

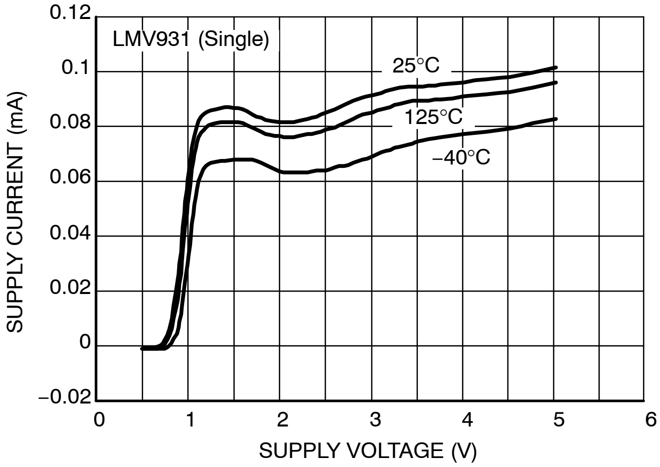


Figure 2. Supply Current vs. Supply Voltage

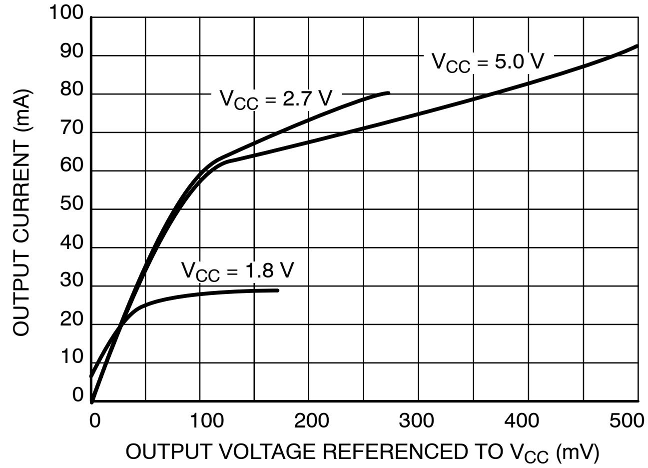


Figure 3. Sourcing Current vs. Output Voltage (T_A = 25°C)

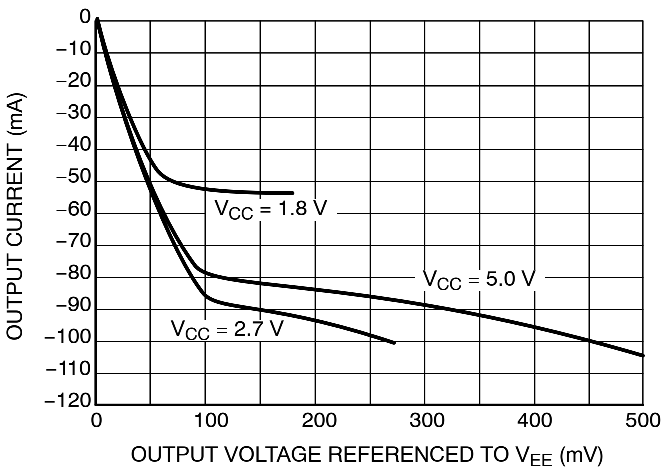


Figure 4. Sinking Current vs. Output Voltage (T_A = 25°C)

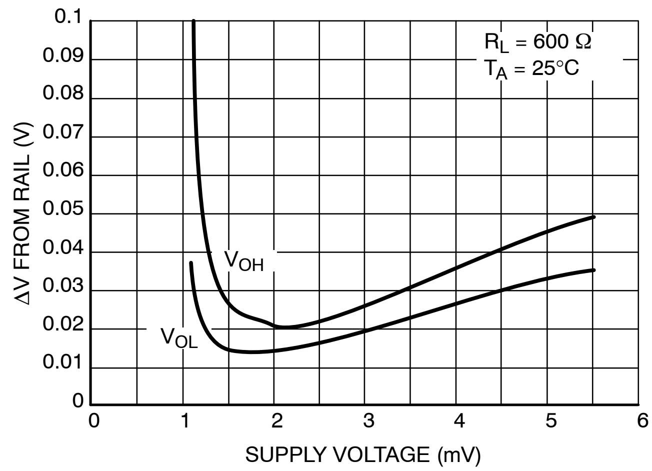


Figure 5. Output Voltage Swing vs. Supply Voltage

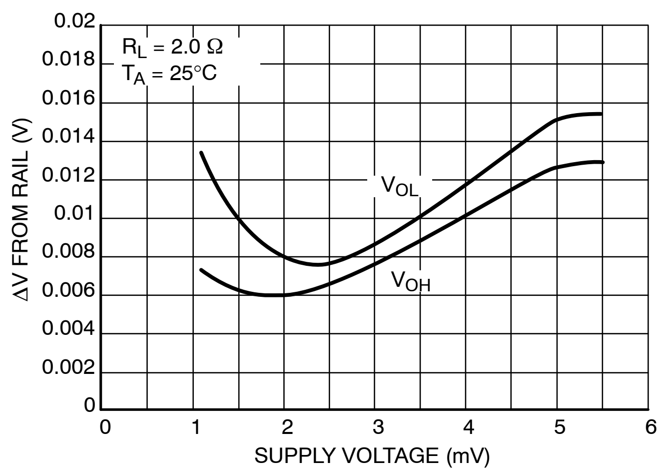


Figure 6. Output Voltage vs. Supply Voltage

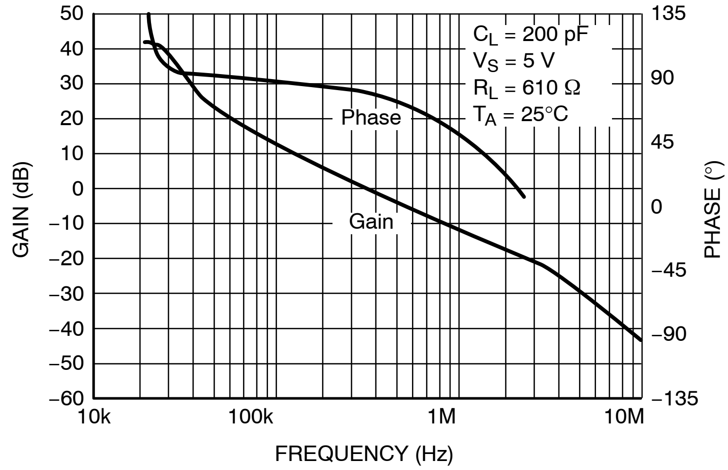


Figure 7. Gain and Phase vs. Frequency

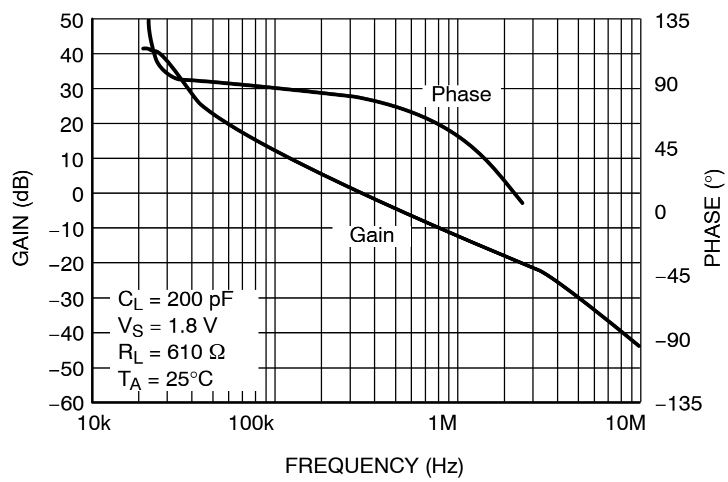


Figure 8. Gain and Phase vs. Frequency

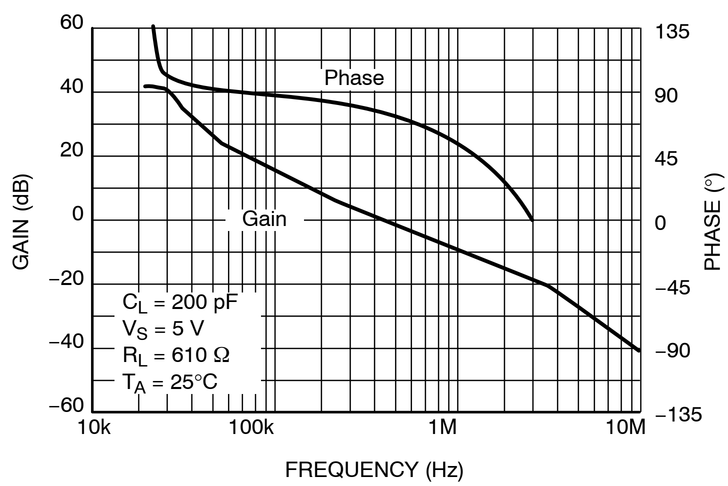


Figure 9. Gain and Phase vs. Frequency

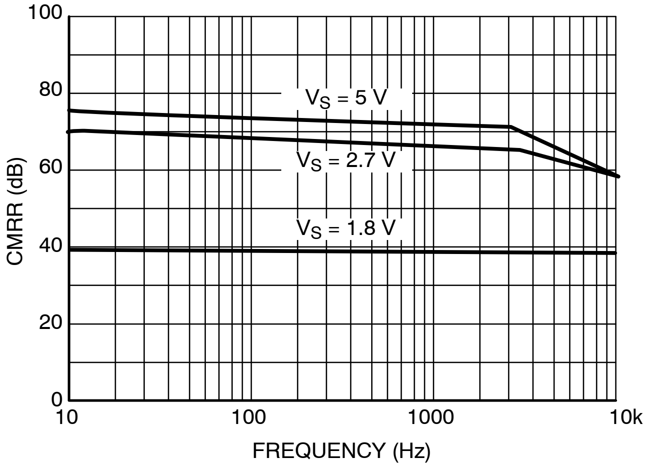


Figure 10. CMRR vs. Frequency

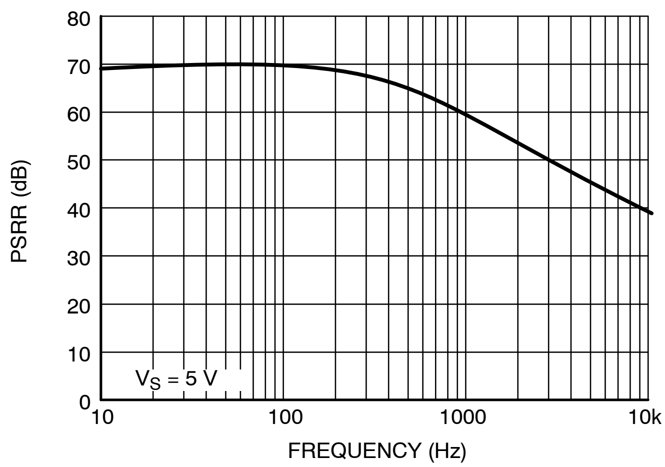


Figure 11. PSRR vs. Frequency

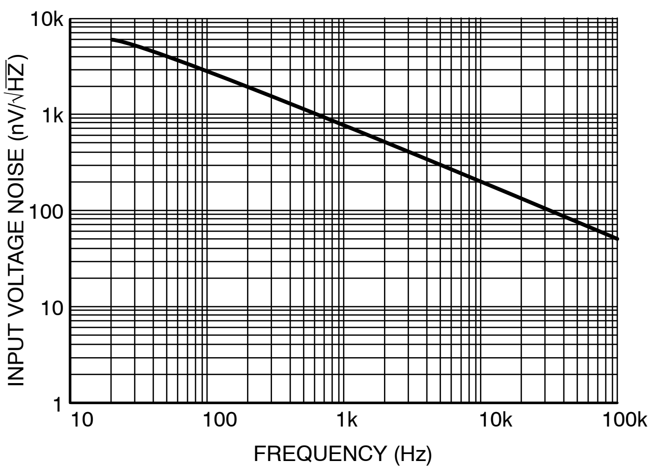


Figure 12. Input Voltage Noise vs. Frequency

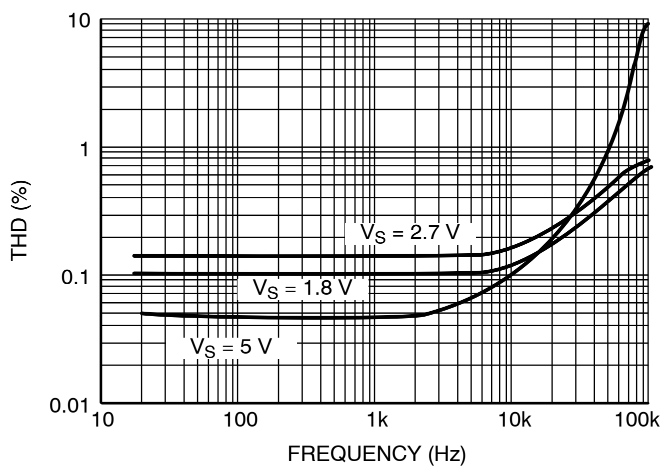


Figure 13. THD vs. Frequency

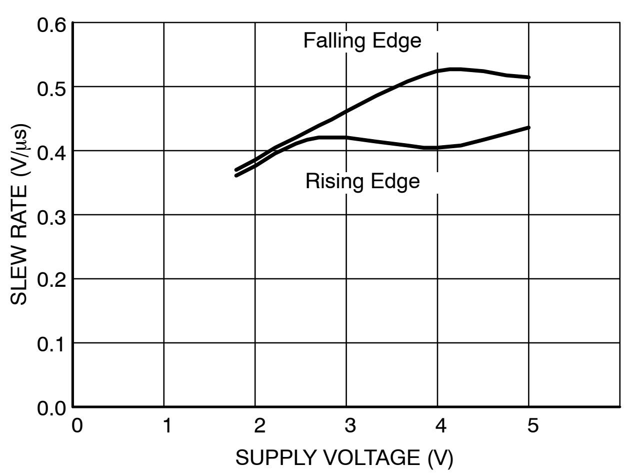
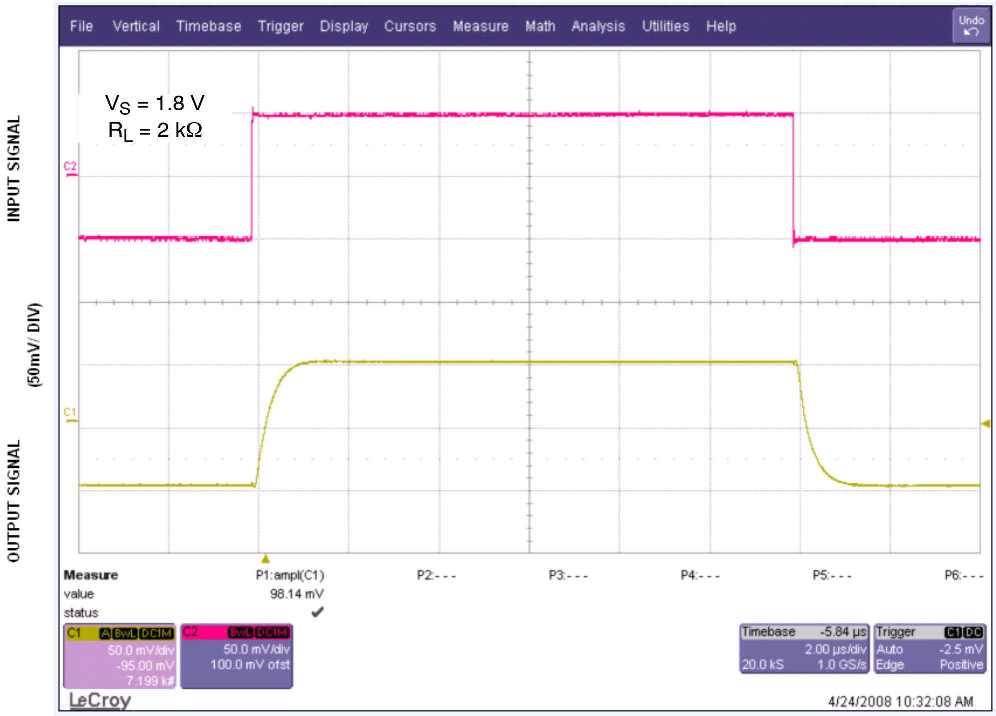
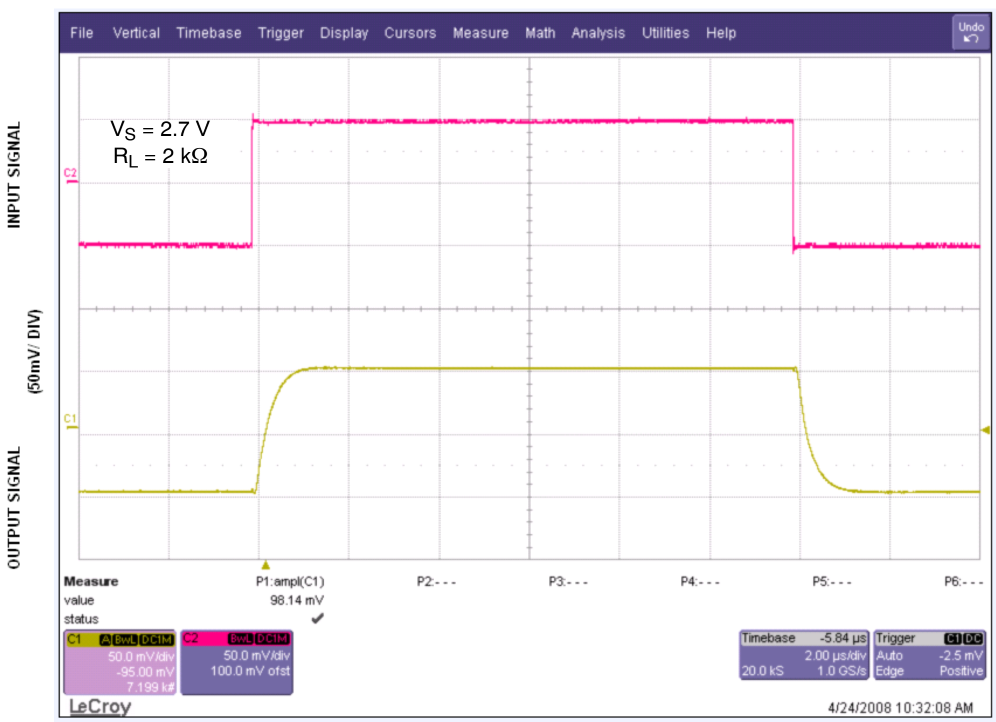


Figure 14. Slew Rate vs. Supply Voltage



TIME (2µs/div)

Figure 15. Small Signal Noninverting Response



TIME (2µs/div)

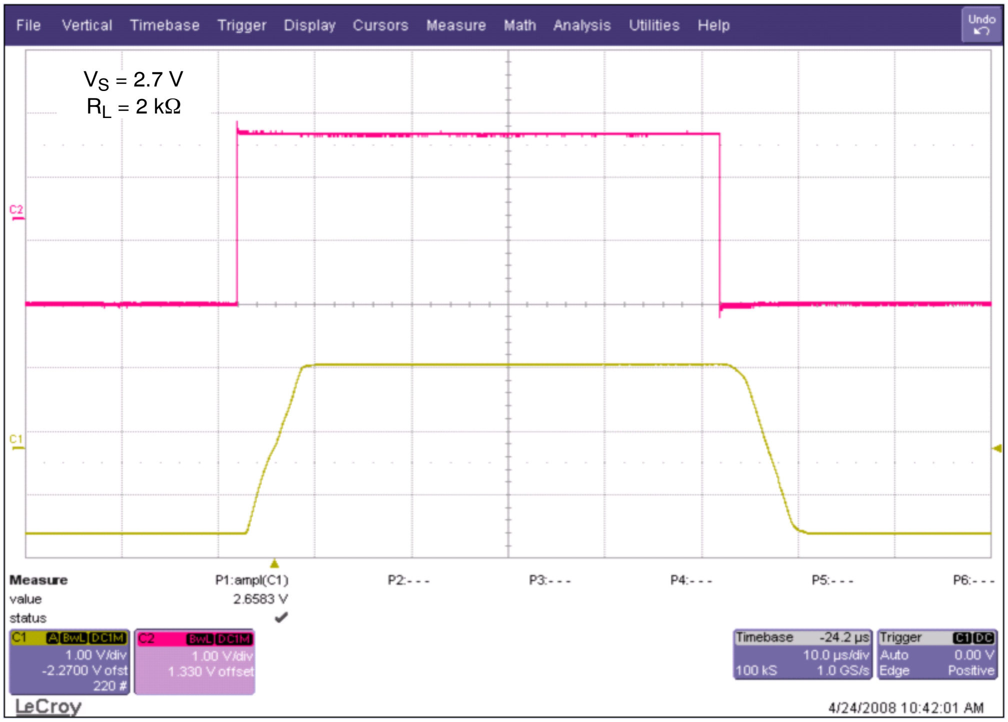
Figure 16. Small Signal Noninverting Response

TIME (2μs/div)

Figure 17. Small Signal Noninverting Response

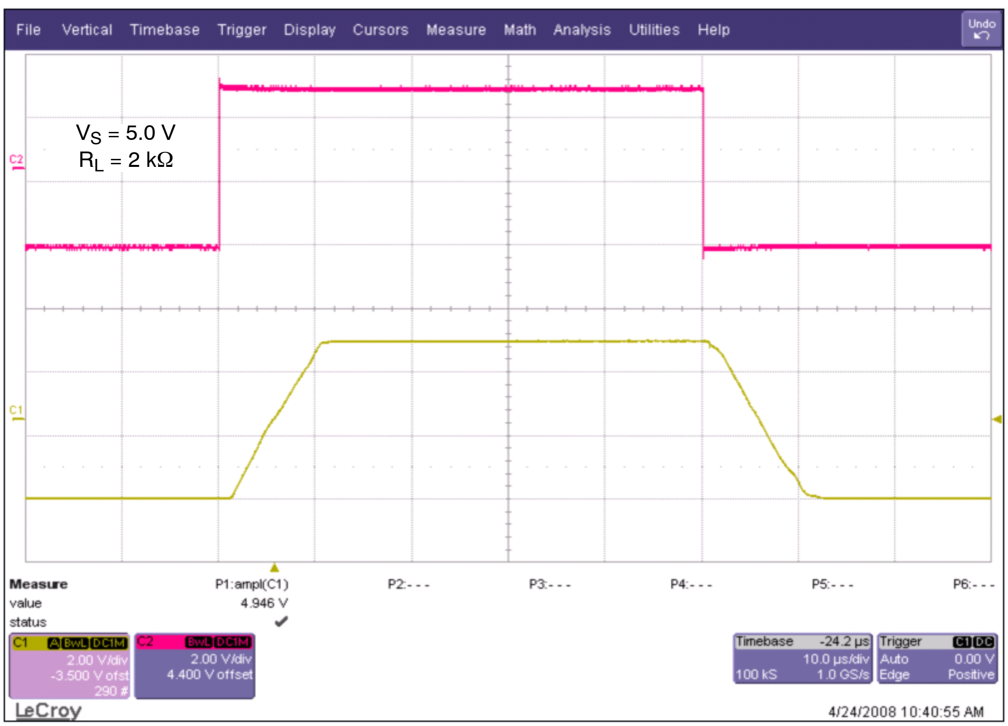
TIME (2μs/div)

Figure 18. Large Signal Noninverting Response



TIME (2µs/div)

Figure 19. Large Signal Noninverting Response



TIME (2µs/div)

Figure 20. Large Signal Noninverting Response

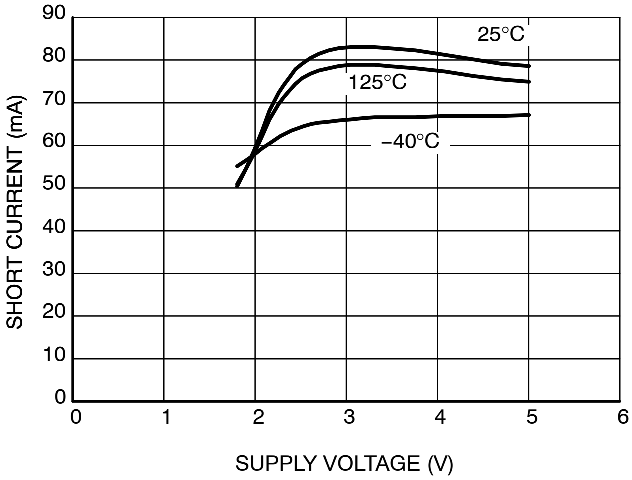


Figure 21. Short−Circuit vs. Supply Voltage (Sinking)

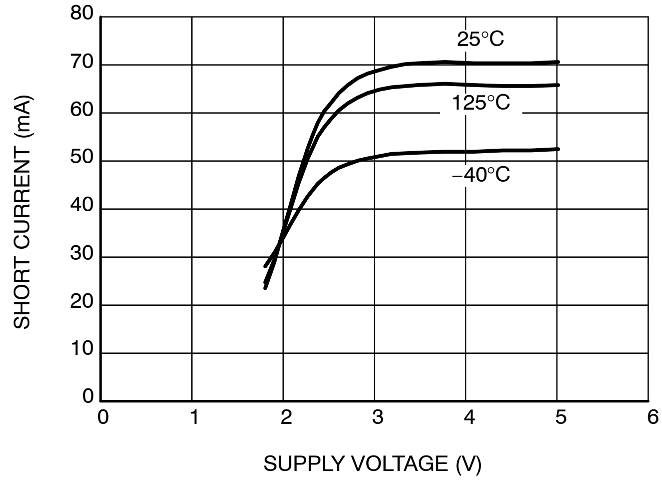


Figure 22. Short−Circuit vs. Supply Voltage (Sourcing)

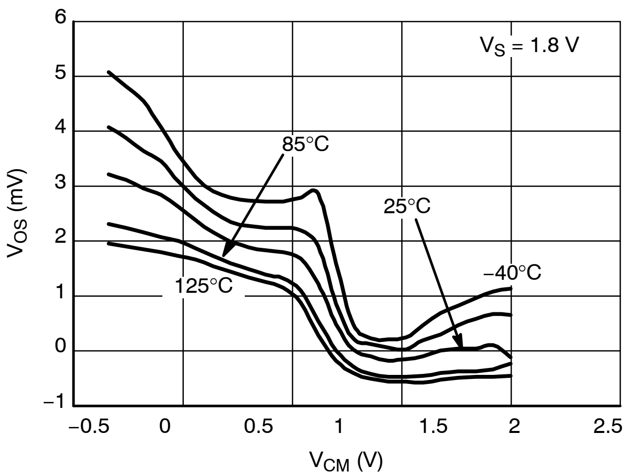


Figure 23. Offset Voltage vs. Common Mode Range V_{DD} 1.8 V

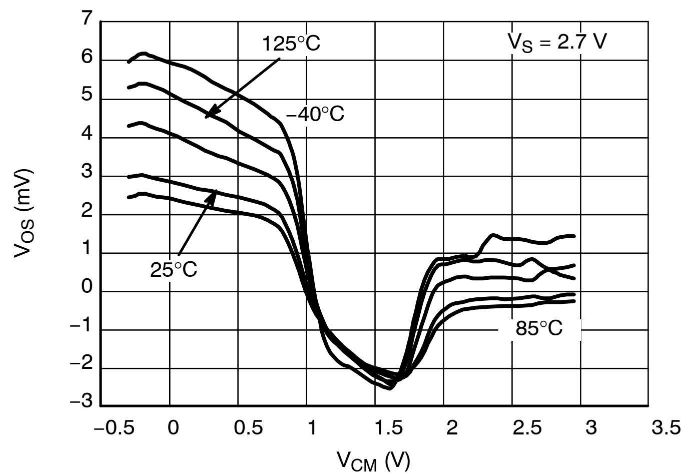


Figure 24. Offset Voltage vs. Common Mode Range V_{DD} 2.7 V

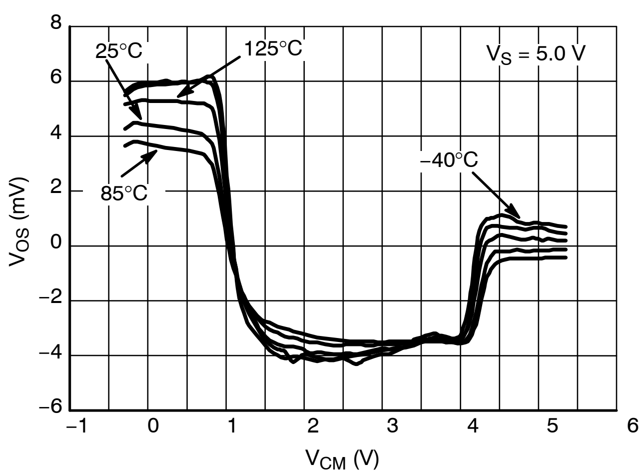
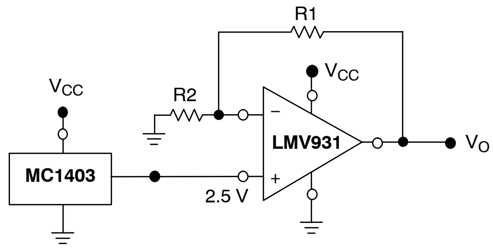


Figure 25. Offset Voltage vs. Common Mode Range V_{DD} 5.0 V

APPLICATION INFORMATION



$$V_O = 2.5\,V\left(1 + \frac{R1}{R2}\right)$$

Figure 26. Voltage Reference

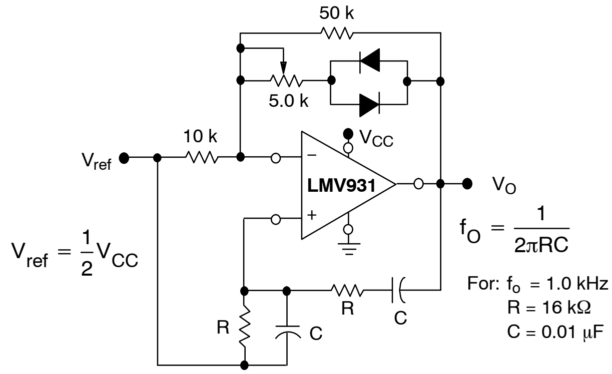
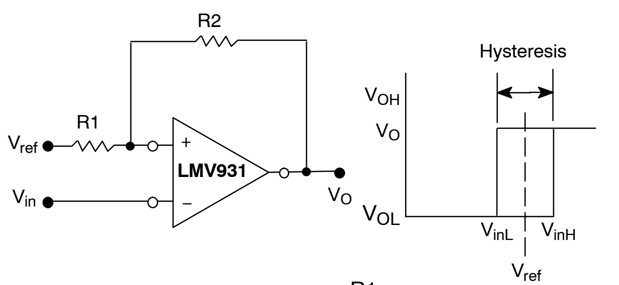


Figure 27. Wien Bridge Oscillator

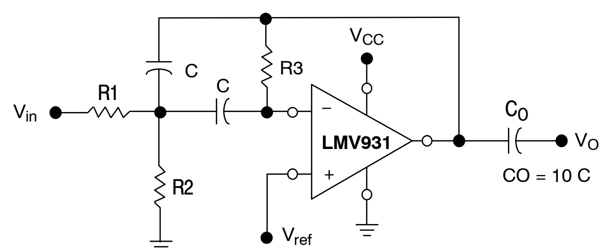


$$V_{in}L = \frac{R1}{R1 + R2}(V_{OL} - V_{ref}) + V_{ref}$$

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

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

Figure 28. Comparator with Hysteresis



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

Choose value f_o, C

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

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

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

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

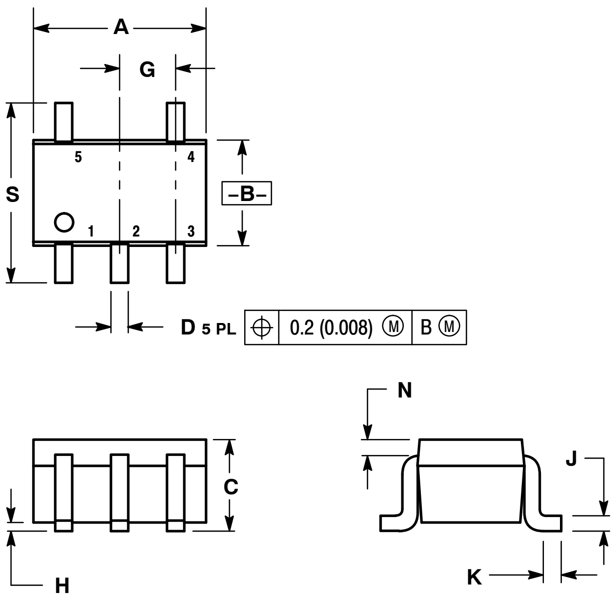
ORDERING INFORMATION

Order Number	Number of Channels	Number of Pins	Package Type	Shipping†
LMV931SQ3T2G	Single	5	SC70−5 (Pb−Free)	3000 / Tape & Reel
LMV932DMR2G*	Dual	8	Micro8 (Pb−Free)	4000 / 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.
*Consult Sales.

PACKAGE DIMENSIONS

SC−88A, SOT−353, SC−70
CASE 419A−02
ISSUE J

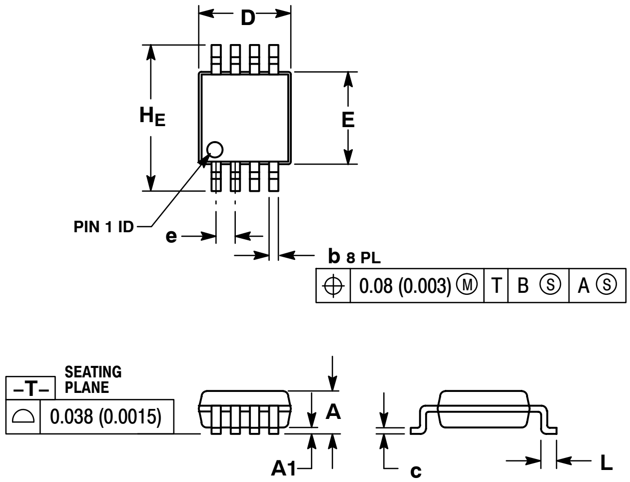


NOTES:
1. DIMENSIONING AND TOLERANCING PER ANSI Y14.5M, 1982.
2. CONTROLLING DIMENSION: INCH.
3. 419A−01 OBSOLETE. NEW STANDARD 419A−02.
4. DIMENSIONS A AND B DO NOT INCLUDE MOLD FLASH, PROTRUSIONS, OR GATE BURRS.

	INCHES		MILLIMETERS	
DIM	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

PACKAGE DIMENSIONS

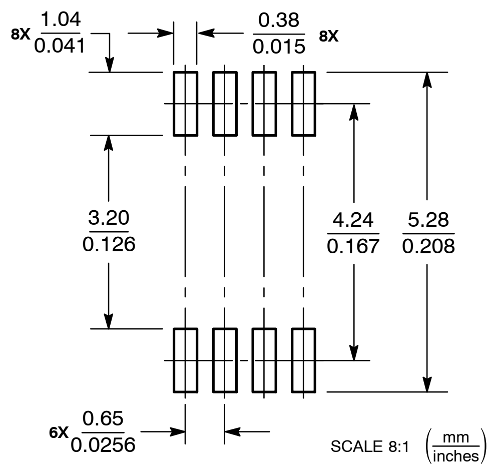
Micro8™
CASE 846A−02
ISSUE H



NOTES:
1. DIMENSIONING AND TOLERANCING PER ANSI Y14.5M, 1982.
2. CONTROLLING DIMENSION: MILLIMETER.
3. DIMENSION A DOES NOT INCLUDE MOLD FLASH, PROTRUSIONS OR GATE BURRS. MOLD FLASH, PROTRUSIONS OR GATE BURRS SHALL NOT EXCEED 0.15 (0.006) PER SIDE.
4. DIMENSION B DOES NOT INCLUDE INTERLEAD FLASH OR PROTRUSION. INTERLEAD FLASH OR PROTRUSION SHALL NOT EXCEED 0.25 (0.010) PER SIDE.
5. 846A−01 OBSOLETE, NEW STANDARD 846A−02.

	MILLIMETERS			INCHES		
DIM	MIN	NOM	MAX	MIN	NOM	MAX
A	−−	−−	1.10	−−	−−	0.043
A1	0.05	0.08	0.15	0.002	0.003	0.006
b	0.25	0.33	0.40	0.010	0.013	0.016
c	0.13	0.18	0.23	0.005	0.007	0.009
D	2.90	3.00	3.10	0.114	0.118	0.122
E	2.90	3.00	3.10	0.114	0.118	0.122
e	0.65 BSC			0.026 BSC		
L	0.40	0.55	0.70	0.016	0.021	0.028
H_E	4.75	4.90	5.05	0.187	0.193	0.199

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.

PUBLICATION ORDERING INFORMATION

LITERATURE FULFILLMENT:
Literature Distribution Center for ON Semiconductor
P.O. Box 5163, Denver, Colorado 80217 USA
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Fax: 303−675−2176 or 800−344−3867 Toll Free USA/Canada
Email: orderlit@onsemi.com

N. American Technical Support: 800−282−9855 Toll Free USA/Canada
Europe, Middle East and Africa Technical Support:
Phone: 421 33 790 2910
Japan Customer Focus Center
Phone: 81−3−5773−3850

ON Semiconductor Website: **www.onsemi.com**

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