LMV931,LMV932,LMV934

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

TEXAS INSTRUMENTS

Literature Number: SNOS993H

National Semiconductor

LMV931 Single/LMV932 Dual/ LMV934 Quad

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1.8V, RRIO Operational Amplifiers

General Description

The LMV931/LMV932/LMV934 are low voltage, low power operational amplifiers. LMV931/LMV932/LMV934 operate from +1.8V to +5.5V supply voltages and have rail-to-rail input and output. LMV931/LMV932/LMV934 input common mode voltage extends 200mV beyond the supplies which enables user enhanced functionality beyond the supply voltage range. The output can swing rail-to-rail unloaded and within 105mV from the rail with 600Ω load at 1.8V supply. The LMV931/LMV932/LMV934 are optimized to work at 1.8V which make them ideal for portable two-cell battery powered systems and single cell Li-Ion systems.

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

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

Features

(Typical 1.8V Supply Values; Unless Otherwise Noted)

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

Applications

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

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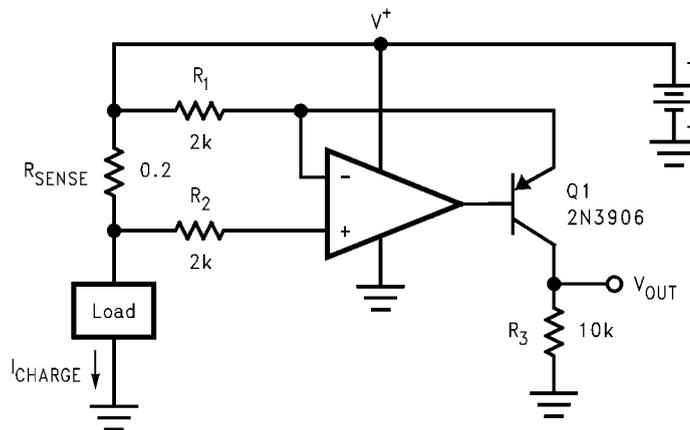
$$V_{OUT} = \frac{R_{SENSE} \cdot R_3}{R_1} \cdot I_{Charge} = 1\Omega \cdot I_{Charge}$$

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Absolute Maximum Ratings (*Note 1*)

If Military/Aerospace specified devices are required, please contact the National Semiconductor Sales Office/ Distributors for availability and specifications.

ESD Tolerance (*Note 2*)	
Machine Model	200V
Human Body Model	2000V
Supply Voltage (V+–V −)	6V
Differential Input Voltage	± Supply Voltage
Voltage at Input/Output Pins	V++0.3V, V- -0.3V
Storage Temperature Range	−65°C to 150°C
Junction Temperature (*Note 4*)	150°C

For soldering specifications:
see product folder at www.national.com and
www.national.com/ms/MS/MS-SOLDERING.pdf

Operating Ratings (*Note 1*)

Supply Voltage Range	1.8V to 5.5V
Temperature Range	−40°C to 125°C
Thermal Resistance (θ$_{JA}$)	
5-Pin SC70	414°C/W
5-Pin SOT23	265°C/W
8-Pin MSOP	235°C/W
8-Pin SOIC	175°C/W
14-Pin TSSOP	155°C/W
14-Pin SOIC	127°C/W

1.8V DC Electrical Characteristics

Unless otherwise specified, all limits guaranteed for T$_J$ = 25°C. V+ = 1.8V, V − = 0V, V$_{CM}$ = V+/2, V$_O$ = V+/2 and R$_L$ > 1 MΩ. **Boldface** limits apply at the temperature extremes. See (*Note 10*)

Symbol	Parameter	Condition		Min (*Note 6*)	Typ (*Note 5*)	Max (*Note 6*)	Units
V$_{OS}$	Input Offset Voltage	LMV931 (Single)			1	4 **6**	mV
		LMV932 (Dual) LMV934 (Quad)			1	5.5 **7.5**	mV
TCV$_{OS}$	Input Offset Voltage Average Drift				5.5		µV/°C
I$_B$	Input Bias Current				15	35 **50**	nA
I$_{OS}$	Input Offset Current				13	25 **40**	nA
I$_S$	Supply Current (per channel)				103	185 **205**	µA
CMRR	Common Mode Rejection Ratio	LMV931, 0 ≤ V$_{CM}$ ≤ 0.6V 1.4V ≤ V$_{CM}$ ≤ 1.8V (*Note 8*)		60 **55**	78		dB
		LMV932 and LMV934 0 ≤ V$_{CM}$ ≤ 0.6V 1.4V ≤ V$_{CM}$ ≤ 1.8V (*Note 8*)		55 **50**	76		
		−0.2V ≤ V$_{CM}$ ≤ 0V 1.8V ≤ V$_{CM}$ ≤ 2.0V		50	72		
PSRR	Power Supply Rejection Ratio	1.8V ≤ V+ ≤ 5V		75 **70**	100		dB
CMVR	Input Common-Mode Voltage Range	For CMRR Range ≥ 50dB	T$_A$ = 25°C	V− −0.2	−0.2 to 2.1	V+ +0.2	V
			T$_A$ −40°C to 85°C	V−		V+	
			T$_A$ = 125°C	V− +0.2		V+ −0.2	
A$_V$	Large Signal Voltage Gain LMV931 (Single)	R$_L$ = 600Ω to 0.9V, V$_O$ = 0.2V to 1.6V, V$_{CM}$ = 0.5V		77 **73**	101		dB
		R$_L$ = 2kΩ to 0.9V, V$_O$ = 0.2V to 1.6V, V$_{CM}$ = 0.5V		80 **75**	105		
	Large Signal Voltage Gain LMV932 (Dual) LMV934 (Quad)	R$_L$ = 600Ω to 0.9V, V$_O$ = 0.2V to 1.6V, V$_{CM}$ = 0.5V		75 **72**	90		dB
		R$_L$ = 2kΩ to 0.9V, V$_O$ = 0.2V to 1.6V, V$_{CM}$ = 0.5V		78 **75**	100		

Symbol	Parameter	Condition	Min (Note 6)	Typ (Note 5)	Max (Note 6)	Units
V_O	Output Swing	$R_L = 600\Omega$ to 0.9V $V_{IN} = \pm100mV$	1.65 **1.63**	1.72		V
				0.077	0.105 **0.120**	
		$R_L = 2k\Omega$ to 0.9V $V_{IN} = \pm100mV$	1.75 **1.74**	1.77		
				0.024	0.035 **0.04**	
I_O	Output Short Circuit Current (Note 3)	Sourcing, $V_O = 0V$ $V_{IN} = 100mV$	4 **3.3**	8		mA
		Sinking, $V_O = 1.8V$ $V_{IN} = -100mV$	7 **5**	9		

1.8V AC Electrical Characteristics

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

Symbol	Parameter	Conditions	Min (Note 6)	Typ (Note 5)	Max (Note 6)	Units
SR	Slew Rate	(Note 7)		0.35		V/µs
GBW	Gain-Bandwidth Product			1.4		MHz
Φ_m	Phase Margin			67		deg
G_m	Gain Margin			7		dB
e_n	Input-Referred Voltage Noise	f = 10 kHz, $V_{CM} = 0.5V$		60		$\frac{nV}{\sqrt{Hz}}$
i_n	Input-Referred Current Noise	f = 10 kHz		0.08		$\frac{pA}{\sqrt{Hz}}$
THD	Total Harmonic Distortion	f = 1kHz, $A_V = +1$ $R_L = 600\Omega$, $V_{IN} = 1\ V_{PP}$		0.023		%
	Amp-to-Amp Isolation	(Note 9)		123		dB

2.7V DC Electrical Characteristics

Unless otherwise specified, all limits guaranteed for T_J = 25°C. V⁺ = 2.7V, V⁻ = 0V, V_{CM} = V⁺/2, V_O = V⁺/2 and R_L > 1 MΩ. **Boldface** limits apply at the temperature extremes. See (*Note 10*)

Symbol	Parameter	Condition		Min (*Note 6*)	Typ (*Note 5*)	Max (*Note 6*)	Units
V_{OS}	Input Offset Voltage	LMV931 (Single)			1	4 **6**	mV
		LMV932 (Dual) LMV934 (Quad)			1	5.5 **7.5**	mV
TCV_{OS}	Input Offset Voltage Average Drift				5.5		µV/°C
I_B	Input Bias Current				15	35 **50**	nA
I_{OS}	Input Offset Current				8	25 **40**	nA
I_S	Supply Current (per channel)				105	190 **210**	µA
CMRR	Common Mode Rejection Ratio	LMV931, 0 ≤ V_{CM} ≤ 1.5V 2.3V ≤ V_{CM} ≤ 2.7V (*Note 8*)		60 **55**	81		dB
		LMV932 and LMV934 0 ≤ V_{CM} ≤ 1.5V 2.3V ≤ V_{CM} ≤ 2.7V (*Note 8*)		55 **50**	80		
		−0.2V ≤ V_{CM} ≤ 0V 2.7V ≤ V_{CM} ≤ 2.9V		50	74		
PSRR	Power Supply Rejection Ratio	1.8V ≤ V⁺ ≤ 5V V_{CM} = 0.5V		75 **70**	100		dB
V_{CM}	Input Common-Mode Voltage Range	For CMRR Range ≥ 50dB	T_A = 25°C	V⁻ −0.2	−0.2 to 3.0	V⁺ +0.2	V
			T_A = −40°C to 85°C	V⁻		V⁺	
			T_A = 125°C	V⁻ +0.2		V⁺ −0.2	
A_V	Large Signal Voltage Gain LMV931 (Single)	R_L = 600Ω to 1.35V, V_O = 0.2V to 2.5V		87 **86**	104		dB
		R_L = 2kΩ to 1.35V, V_O = 0.2V to 2.5V		92 **91**	110		
	Large Signal Voltage Gain LMV932 (Dual) LMV934 (Quad)	R_L = 600Ω to 1.35V, V_O = 0.2V to 2.5V		78 **75**	90		dB
		R_L = 2kΩ to 1.35V, V_O = 0.2V to 2.5V		81 **78**	100		
V_O	Output Swing	R_L = 600Ω to 1.35V V_{IN} = ±100mV		2.55 **2.53**	2.62		V
					0.083	0.110 **0.130**	
		R_L = 2kΩ to 1.35V V_{IN} = ±100mV		2.65 **2.64**	2.675		
					0.025	0.04 **0.045**	
I_O	Output Short Circuit Current (*Note 3*)	Sourcing, V_O = 0V V_{IN} = 100mV		20 **15**	30		mA
		Sinking, V_O = 0V V_{IN} = −100mV		18 **12**	25		

2.7V AC Electrical Characteristics

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

Symbol	Parameter	Conditions	Min (*Note 6*)	Typ (*Note 5*)	Max (*Note 6*)	Units
SR	Slew Rate	(*Note 7*)		0.4		V/μs
GBW	Gain-Bandwidth Product			1.4		MHz
Φ_m	Phase Margin			70		deg
G_m	Gain Margin			7.5		dB
e_n	Input-Referred Voltage Noise	f = 10 kHz, V_{CM} = 0.5V		57		$\dfrac{nV}{\sqrt{Hz}}$
i_n	Input-Referred Current Noise	f = 10 kHz		0.08		$\dfrac{pA}{\sqrt{Hz}}$
THD	Total Harmonic Distortion	f = 1kHz, A_V = +1 R_L = 600Ω, V_{IN} = 1V_{PP}		0.022		%
	Amp-to-Amp Isolation	(*Note 9*)		123		dB

5V DC Electrical Characteristics

Unless otherwise specified, all limits guaranteed for T_J = 25°C. V+ = 5V, V− = 0V, V_{CM} = V+/2, V_O = V+/2 and R_L > 1 MΩ. **Boldface** limits apply at the temperature extremes. See (*Note 10*)

Symbol	Parameter	Condition		Min (*Note 6*)	Typ (*Note 5*)	Max (*Note 6*)	Units
V_{OS}	Input Offset Voltage	LMV931 (Single)			1	4 **6**	mV
		LMV932 (Dual) LMV934 (Quad)			1	5.5 **7.5**	mV
TCV_{OS}	Input Offset Voltage Average Drift				5.5		µV/°C
I_B	Input Bias Current				14	35 **50**	nA
I_{OS}	Input Offset Current				9	25 **40**	nA
I_S	Supply Current (per channel)				116	210 **230**	µA
CMRR	Common Mode Rejection Ratio	$0 \leq V_{CM} \leq 3.8V$ $4.6V \leq V_{CM} \leq 5.0V$ (*Note 8*)		60 **55**	86		dB
		$-0.2V \leq V_{CM} \leq 0V$ $5.0V \leq V_{CM} \leq 5.2V$		50	78		
PSRR	Power Supply Rejection Ratio	$1.8V \leq V+ \leq 5V$ $V_{CM} = 0.5V$		75 **70**	100		dB
CMVR	Input Common-Mode Voltage Range	For CMRR Range ≥ 50dB	$T_A = 25°C$	V− −0.2	−0.2 to 5.3	V+ +0.2	V
			$T_A = -40°C$ to 85°C	V−		V+	
			$T_A = 125°C$	V− +0.3		V+ −0.3	
A_V	Large Signal Voltage Gain LMV931 (Single)	R_L = 600Ω to 2.5V, V_O = 0.2V to 4.8V		88 **87**	102		dB
		R_L = 2kΩ to 2.5V, V_O = 0.2V to 4.8V		94 **93**	113		
	Large Signal Voltage Gain LMV932 (Dual) LMV934 (Quad)	R_L = 600Ω to 2.5V, V_O = 0.2V to 4.8V		81 **78**	90		dB
		R_L = 2kΩ to 2.5V, V_O = 0.2V to 4.8V		85 **82**	100		
V_O	Output Swing	R_L = 600Ω to 2.5V V_{IN} = ±100mV		4.855 4.835	4.890		V
					0.120	0.160 **0.180**	
		R_L = 2kΩ to 2.5V V_{IN} = ±100mV		4.945 **4.935**	4.967		
					0.037	0.065 **0.075**	
I_O	Output Short Circuit Current (*Note 3*)	LMV931, Sourcing, V_O = 0V V_{IN} = 100mV		80 **68**	100		mA
		Sinking, V_O = 5V V_{IN} = −100mV		58 **45**	65		

5V AC Electrical Characteristics

Unless otherwise specified, all limits guaranteed for T_J = 25°C. V+ = 5V, V− = 0V, V_{CM} = V+/2, V_O = 2.5V and R_L > 1 MΩ.
Boldface limits apply at the temperature extremes. See (*Note 10*)

Symbol	Parameter	Conditions	Min (*Note 6*)	Typ (*Note 5*)	Max (*Note 6*)	Units
SR	Slew Rate	(*Note 7*)		0.42		V/µs
GBW	Gain-Bandwidth Product			1.5		MHz
Φ_m	Phase Margin			71		deg
G_m	Gain Margin			8		dB
e_n	Input-Referred Voltage Noise	f = 10 kHz, V_{CM} = 1V		50		$\frac{nV}{\sqrt{Hz}}$
i_n	Input-Referred Current Noise	f = 10 kHz		0.08		$\frac{pA}{\sqrt{Hz}}$
THD	Total Harmonic Distortion	f = 1kHz, A_V = +1 R_L = 600Ω, V_O = 1V $_{PP}$		0.022		%
	Amp-to-Amp Isolation	(*Note 9*)		123		dB

Note 1: Absolute Maximum Ratings indicate limits beyond which damage to the device may occur. Operating Ratings indicate conditions for which the device is intended to be functional, but specific performance is not guaranteed. For guaranteed specifications and the test conditions, see the Electrical Characteristics.

Note 2: Human Body Model, applicable std. MIL-STD-883, Method 3015.7. Machine Model, applicable std. JESD22-A115-A (ESD MM std. of JEDEC) Field-Induced Charge-Device Model, applicable std. JESD22-C101-C (ESD FICDM std. of JEDEC).

Note 3: Applies to both single-supply and split-supply operation. Continuous short circuit operation at elevated ambient temperature can result in exceeding the maximum allowed junction temperature of 150°C. Output currents in excess of 45mA over long term may adversely affect reliability.

Note 4: The maximum power dissipation is a function of $T_{J(MAX)}$, θ_{JA} and T_A. The maximum allowable power dissipation at any ambient temperature is $P_D = (T_{J(MAX)} - T_A)/ \theta_{JA}$. All numbers apply for packages soldered directly onto a PC Board.

Note 5: Typical values represent the most likely parametric norm as determined at the time of characterization. Actual typical values may vary over time and will also depend on the application and configuration. The typical values are not tested and are not guaranteed on shipped production material.

**Note 6:** All limits are guaranteed by testing or statistical analysis.

Note 7: Connected as voltage follower with input step from V− to V+. Number specified is the slower of the positive and negative slew rates.

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

Note 9: Input referred, R_L = 100kΩ connected to V+/2. Each amp excited in turn with 1kHz to produce V_O = 3V_{PP} (For Supply Voltages <3V, V_O = V+).

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

Connection Diagrams

**5-Pin SC70-5/SOT23-5
(LMV931)**

Top View   200326ao
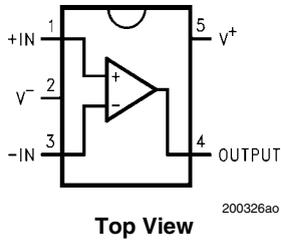
**8-Pin MSOP/SOIC
(LMV932)**

Top View   200326g12
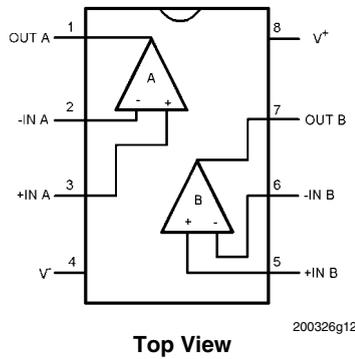
**14-Pin TSSOP/SOIC
(LMV934)**

Top View   200326g13
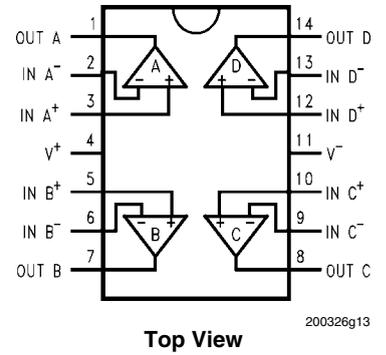
Ordering Information

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

Typical Performance Characteristics Unless otherwise specified, V$_S$ = +5V, single supply, T$_A$ = 25°C.

Supply Current vs. Supply Voltage (LMV931)
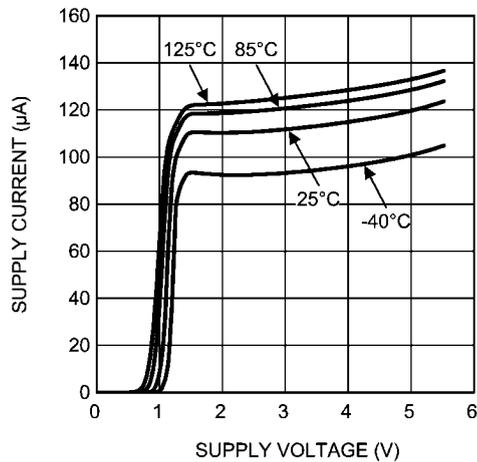
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Sourcing Current vs. Output Voltage
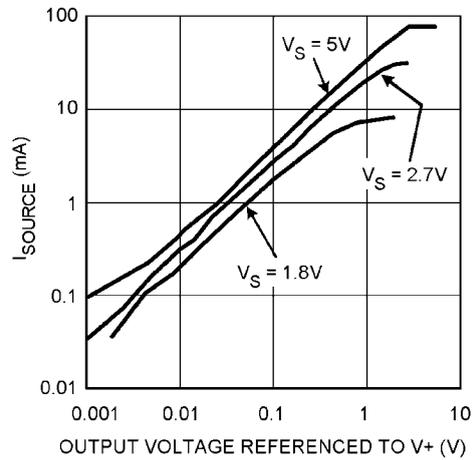
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Sinking Current vs. Output Voltage
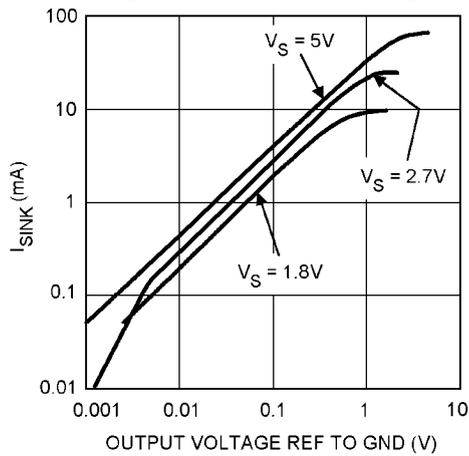
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Output Voltage Swing vs. Supply Voltage
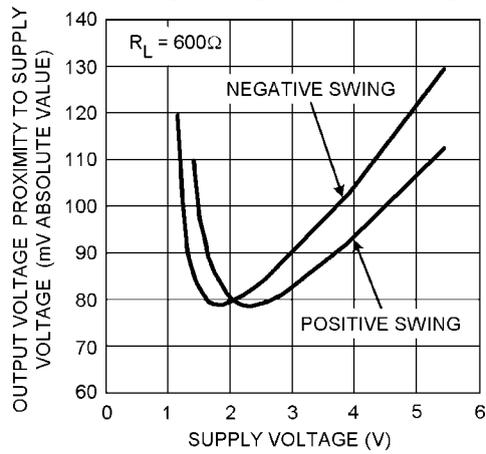
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Output Voltage Swing vs. Supply Voltage
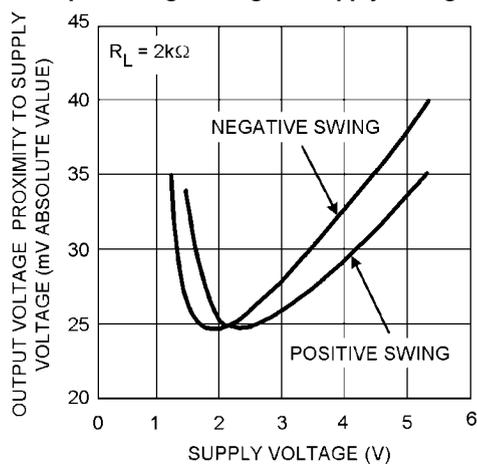
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Gain and Phase vs. Frequency

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Gain and Phase vs. Frequency

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Gain and Phase vs. Frequency

200326g10

Gain and Phase vs. Frequency

200326g11

CMRR vs. Frequency
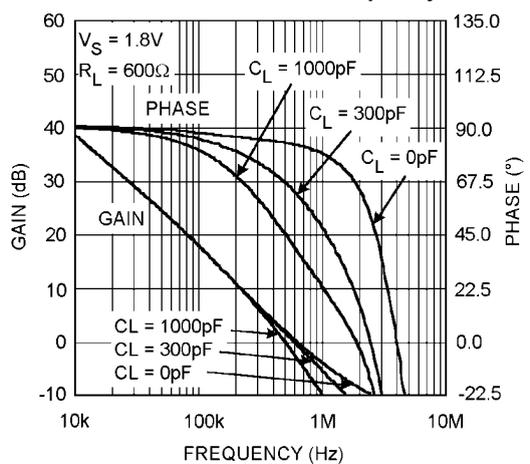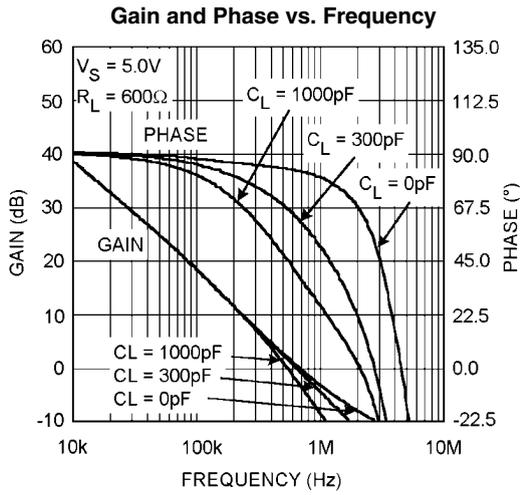
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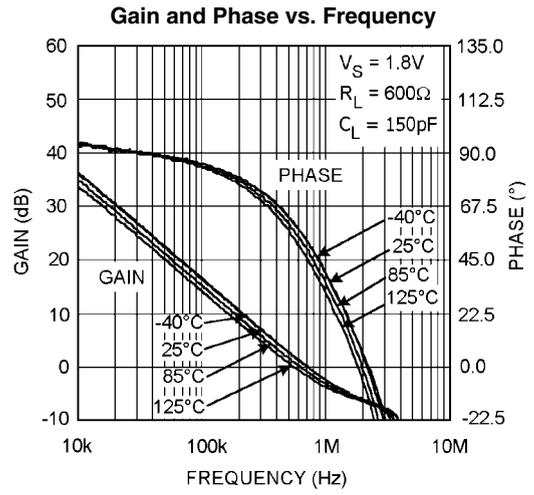
PSRR vs. Frequency
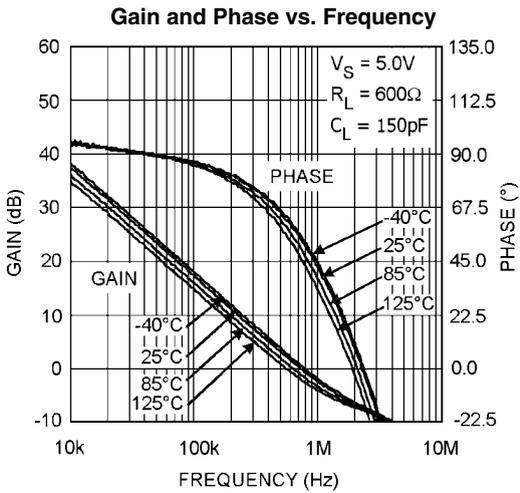

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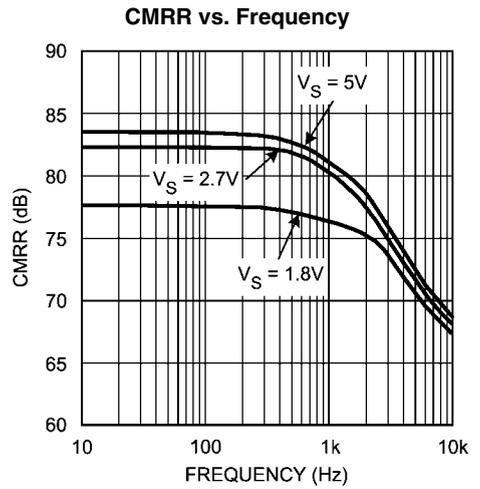
**Input Voltage Noise vs. Frequency**
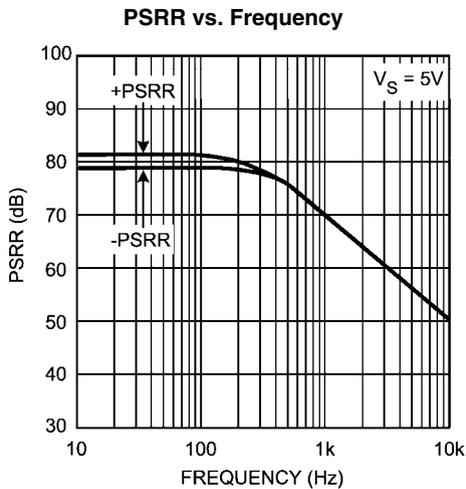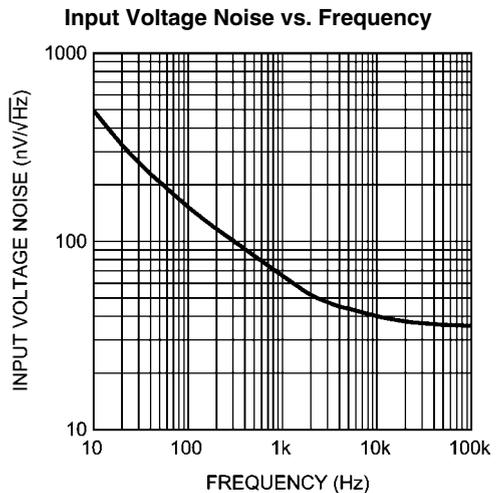

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Input Current Noise vs. Frequency
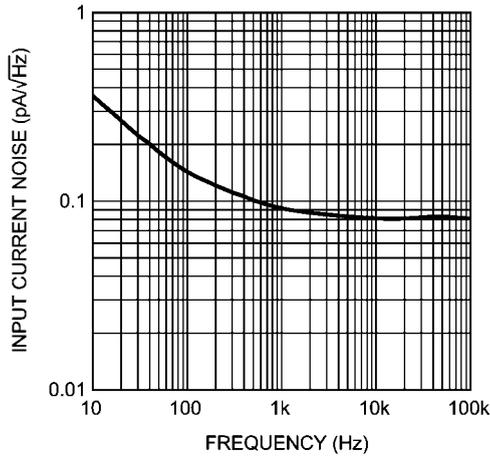

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THD vs. Frequency
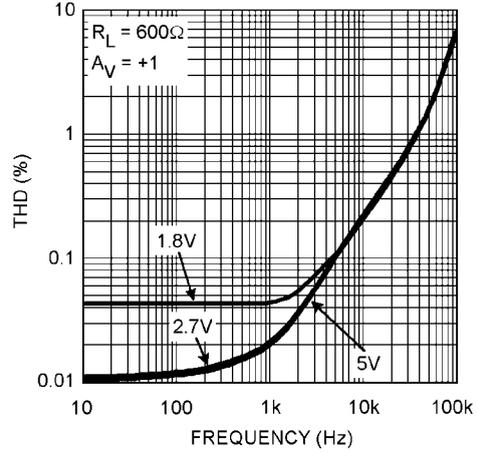
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THD vs. Frequency
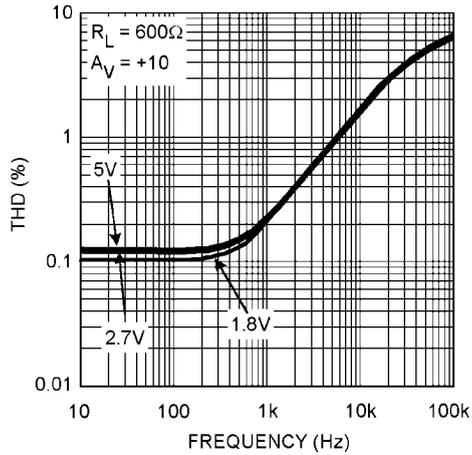

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Slew Rate vs. Supply Voltage
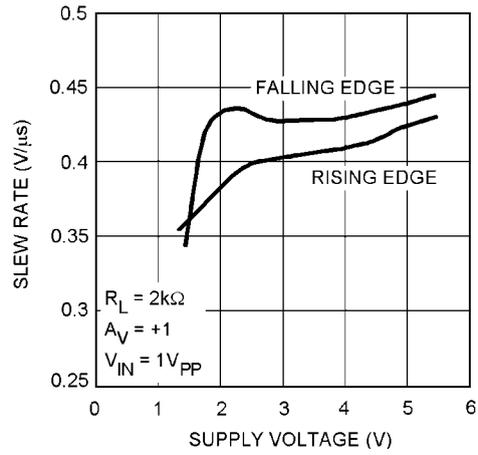

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Small Signal Non-Inverting Response
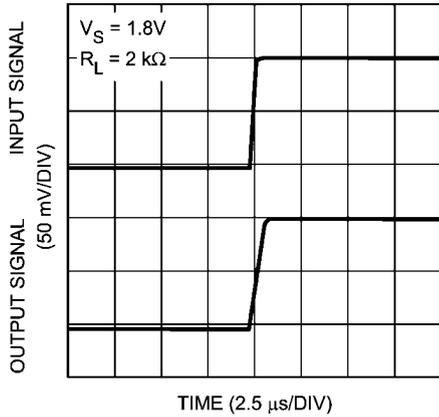

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Small Signal Non-Inverting Response
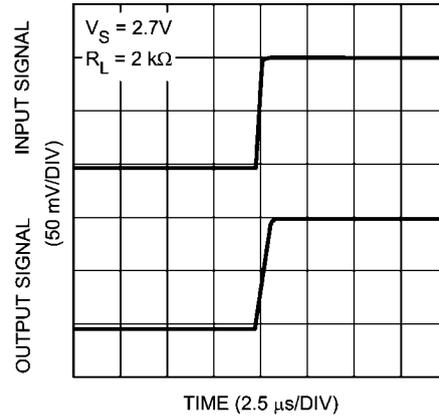
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Small Signal Non-Inverting Response

TIME (2.5 µs/DIV)
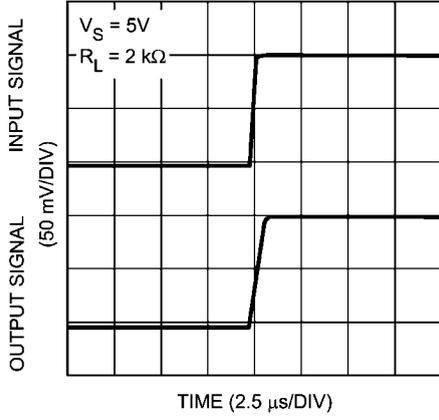
20032672

Large Signal Non-Inverting Response

TIME (10 µs/div)
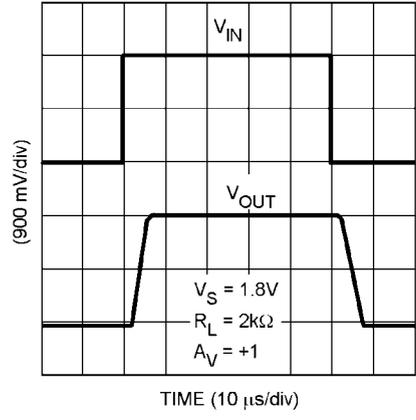
20032673

Large Signal Non-Inverting Response

TIME (10 µs/DIV)
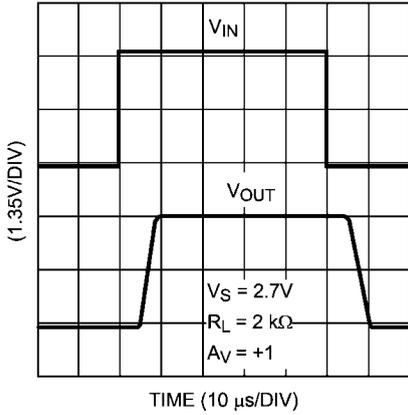
20032674

Large Signal Non-Inverting Response

TIME (10 µs/div)
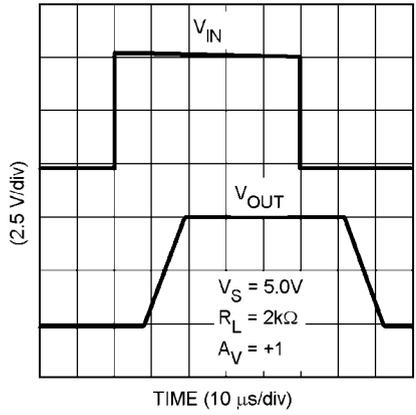
20032675

### Short Circuit Current vs. Temperature (Sinking)
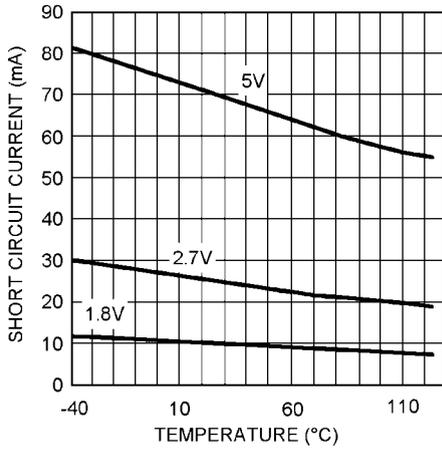
20032676

Short Circuit Current vs. Temperature (Sourcing)

20032677

12
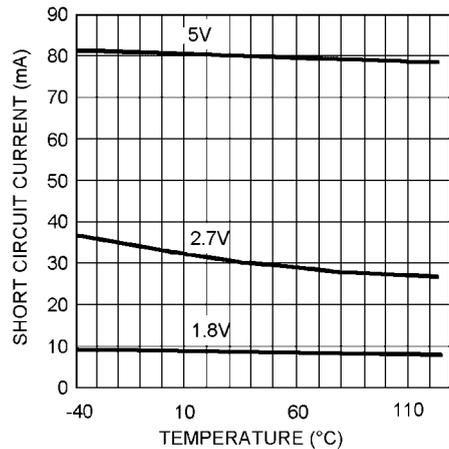
Offset Voltage vs. Common Mode Range
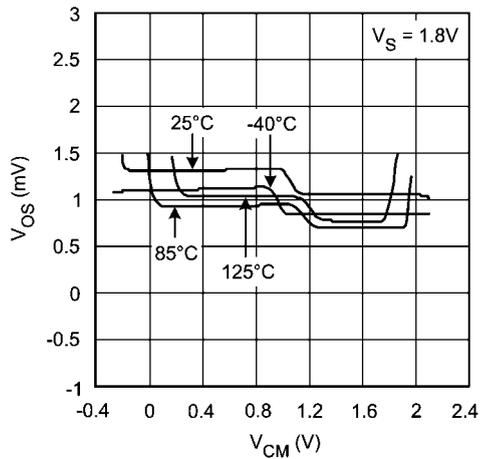
20032636

Offset Voltage vs. Common Mode Range
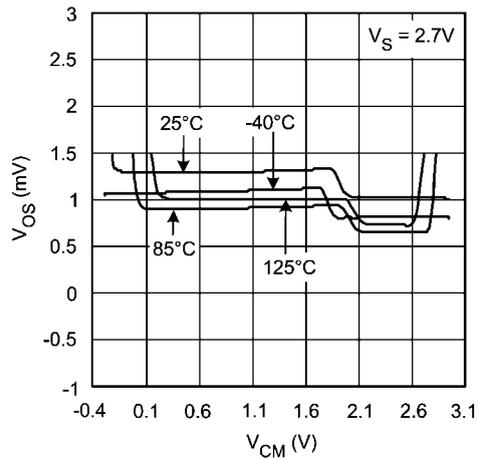
20032637

**Offset Voltage vs. Common Mode Range**
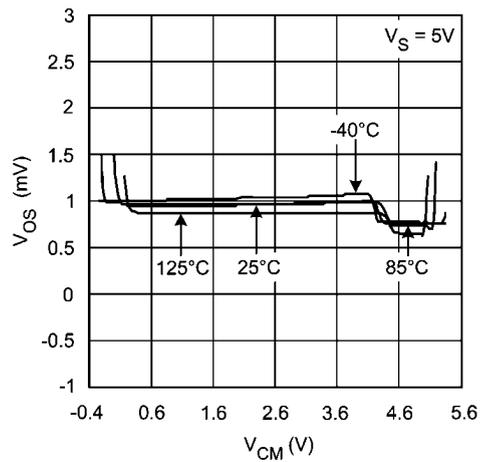
20032638

Application Note

INPUT AND OUTPUT STAGE

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

This V_{OS} crossover point can create problems for both DC and AC coupled signals if proper care is not taken. Large input signals that include the V_{OS} crossover point will cause distortion in the output signal. One way to avoid such distortion is to keep the signal away from the crossover. For example, in a unity gain buffer configuration and with V_S = 5V, a 5V peak-to-peak signal will contain input-crossover distortion while a 3V peak-to-peak signal centered at 1.5V will not contain input-crossover distortion as it avoids the crossover point. Another way to avoid large signal distortion is to use a gain of −1 circuit which avoids any voltage excursions at the input terminals of the amplifier. In that circuit, the common mode DC voltage can be set at a level away from the V_{OS} cross-over point. For small signals, this transition in V_{OS} shows up as a V_{CM} de-

pendent spurious signal in series with the input signal and can effectively degrade small signal parameters such as gain and common mode rejection ratio. To resolve this problem, the small signal should be placed such that it avoids the V_{OS} crossover point. In addition to the rail-to-rail performance, the output stage can provide enough output current to drive 600Ω loads. Because of the high current capability, care should be taken not to exceed the 150°C maximum junction temperature specification.

INPUT BIAS CURRENT CONSIDERATION

The LMV931/LMV932/LMV934 family has a complementary bipolar input stage. The typical input bias current (I_B) is 15nA. The input bias current can develop a significant offset voltage. This offset is primarily due to I_B flowing through the negative feedback resistor, R_F. For example, if I_B is 50nA and R_F is 100kΩ, then an offset voltage of 5mV will develop (V_{OS} = I_B x R_F). Using a compensation resistor (R_C), as shown in *Figure 1*, cancels this effect. But the input offset current (I_{OS}) will still contribute to an offset voltage in the same manner.
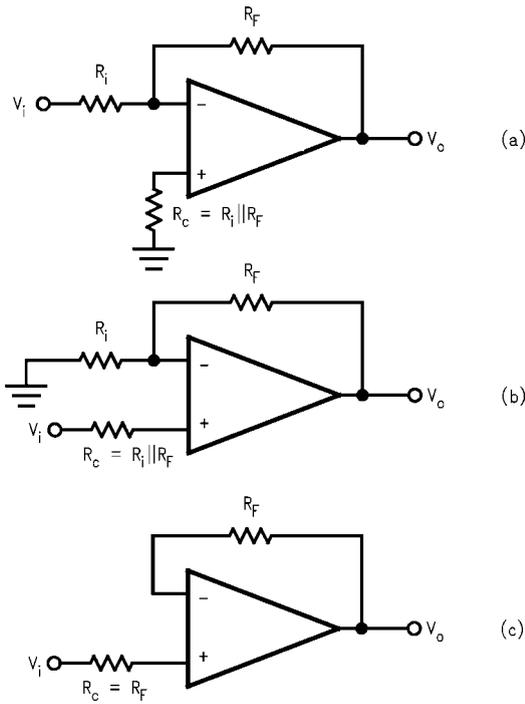
FIGURE 1. Canceling the Offset Voltage due to Input Bias
Current

Typical Applications

HIGH SIDE CURRENT SENSING

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

$$V_{OUT} = \frac{R_{SENSE} \cdot R_3}{R_1} \cdot I_{Charge} = 1\,\Omega \cdot I_{Charge}$$
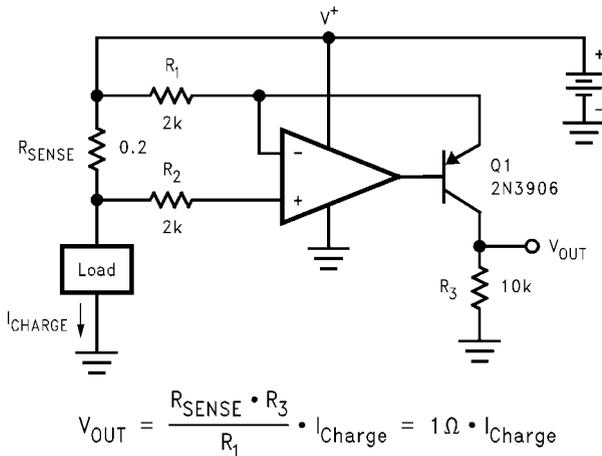
FIGURE 2. High Side Current Sensing

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

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

In *Figure 3* the circuit is referenced to ground, while in *Figure
4* the circuit is biased to the positive supply. These configu-
rations implement the half wave rectifier since the LMV931/
LMV932/LMV934 can not respond to one-half of the incoming
waveform. It can not respond to one-half of the incoming be-
cause the amplifier can not swing the output beyond either
rail therefore the output disengages during this half cycle.
During the other half cycle, however, the amplifier achieves a
half wave that can have a peak equal to the total supply volt-
age. R_I should be large enough not to load the LMV931/
LMV932/LMV934.
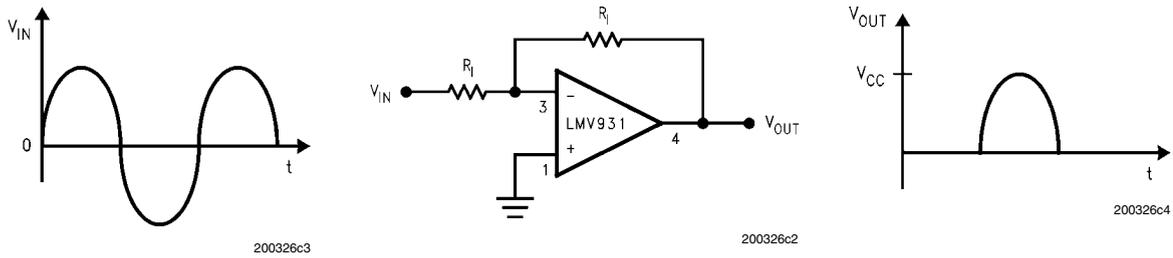
FIGURE 3. Half-Wave Rectifier with Rail-To-Ground Output Swing Referenced to Ground
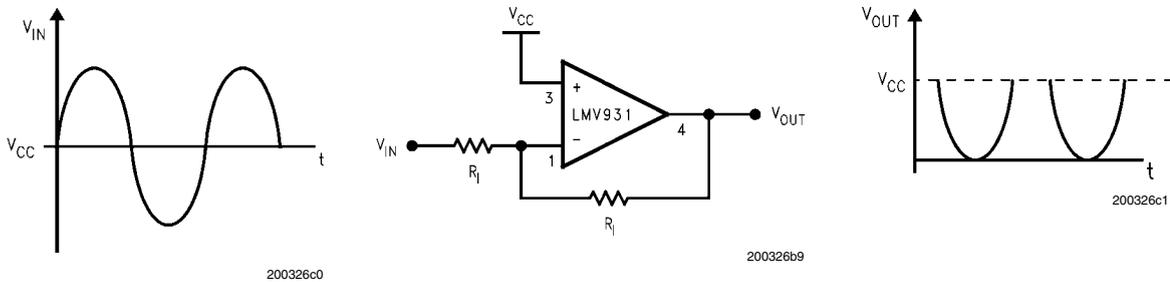
FIGURE 4. Half-Wave Rectifier with Negative-Going Output Referenced to V_{CC}

INSTRUMENTATION AMPLIFIER WITH RAIL-TO-RAIL INPUT AND OUTPUT

Some manufactures make a non-"rail-to-rail"-op amp rail-to-rail by using a resistive divider on the inputs. The resistors divide the input voltage to get a rail-to-rail input range. The problem with this method is that it also divides the signal, so in order to get the obtained gain, the amplifier must have a higher closed loop gain. This raises the noise and drift by the internal gain factor and lowers the input impedance. Any mismatch in these precision resistors reduces the CMRR as well. The LMV931/LMV932/LMV934 is rail-to-rail and therefore doesn't have these disadvantages.

Using three of the LMV931/LMV932/LMV934 amplifiers, an instrumentation amplifier with rail-to-rail inputs and outputs can be made as shown in Figure 5.

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

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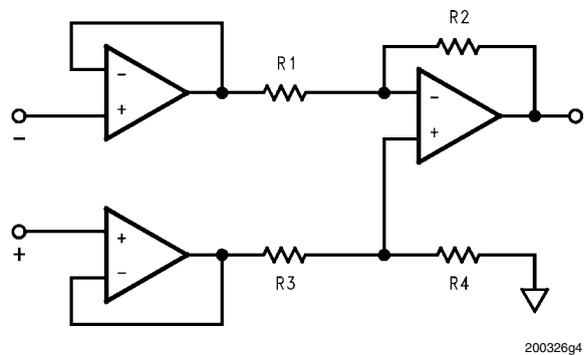

FIGURE 5. Rail-to-rail Instrumentation Amplifier

Simplified Schematic

200326a9

Physical Dimensions inches (millimeters) unless otherwise noted

SYMM ℄

2±0.1　　A

0.65

3　2　1

PIN 1 INDEX AREA

B

1.8-2.4　　1.25±0.1

4　5

5X 0.15-0.30

1.3

⊕ | 0.1 Ⓜ | C | BⓈ | AⓈ

SYMM ℄

(0.65)

(1.9)

(5X 0.75)

(5X 0.4)

(1.3)

LAND PATTERN RECOMMENDATION

0.8-1.1　　(0.9)

0.1 C

C

SEATING PLANE　　0-0.1

DIMENSIONS ARE IN MILLIMETERS
DIMENSIONS IN ( ) FOR REFENRENCE ONLY

R0.025 MIN TYP

R0.025 MIN TYP

GAGE PLANE

0.2

0°-5° TYP

0.1-0.2 TYP

5X 0.4±0.05

(0.515 TYP)

MAA05A (Rev D)

5-Pin SC70
NS Package Number MAA05A

A　.115±.003 [2.92±0.07]

.075 [1.91]

5　4

B

.112±.006 [2.84±0.15]　　.063±.003 [1.6±0.07]

1　2　3

2X .0375 [0.953]

(.075) [1.91]

PKG SYMM ℄

(.102) [2.59]

(5X .039) [0.99]

(5X .027) [0.69]

(2X .0375) [0.953]

LAND PATTERN RECOMMENDATION

.038-.047 [0.97-1.19]　　(.040) [1.02]

.004 [0.1] C

5X .0158±.0038 [0.4±0.096]

.002-.006 [0.05-0.15] TYP

⊕ | .008 [0.2] Ⓜ | C | AⓈ | BⓈ

R.004 MIN TYP [0.1]

R.004 MIN TYP [0.1]

.0060 +.0015 -.0010 TYP [0.152 +0.038 -0.025]

.008 [0.2] GAGE PLANE

C

SEATING PLANE

0°-8° TYP

(.025) [0.635]

.014-.022 [0.36-0.55] TYP

CONTROLLING DIMENSION IS INCH
VALUES IN [ ] ARE MILLIMETERS
DIMENSIONS IN ( ) FOR REFERENCE ONLY

MF05A (Rev D)

5-Pin SOT23
NS Package Number MF05A

.118±.004
[3±0.1]
NOT INCLUDING MOLD FLASH
.006[0.15] MAX PER END

.193±.006
[4.9±0.15]

.118±.004
[3±0.1]
NOT INCLUDING
MOLD FLASH

PIN 1 IDENT

6X .0256
[0.65]

(.189)
[4.8]

(8X .040)
[1.02]

(8X .016)
[0.41]

(6X .0256)
[0.65]

RECOMMENDED LAND PATTERN

.043 MAX
[1.09]

(.034)
[0.86]

.004 [0.1] A

.002-.006
[0.06-0.15]
TYP

8X .012 +.004
         -.002
[0.3 +0.10
     -0.05]

.002 [0.05] M B S C S

R.005 TYP
[0.13]

R.005 TYP
[0.13]

.007±.002 TYP
[0.18±0.05]

(.0375 TYP)
[0.953]

.021±.005
[0.53±0.12]
TYP

GAGE PLANE

.010
[0.25]

A

0°-6° TYP

SEATING PLANE

CONTROLLING DIMENSION IS INCH
VALUES IN [ ] ARE MILLIMETERS

MUA08A (Rev F)

8-Pin MSOP
NS Package Number MUA08A

4.9±0.1
[.193±.004]
NOT INCLUDING MOLD FLASH,
PROTRUSION OR GATE BURRS.
0.15[.006] MAX PER END

6±0.2
[.236±.008]

3.9±0.1
[.154±.004]
NOT INCLUDING
MOLD FLASH,
PROTRUSION
OR GATE BURRS

PIN 1 ID

8X (0.6)
[.02]

8X (2.2)
[.09]

(5.2)
[.20]

6X (1.27)
[.05]

RECOMMENDED LAND PATTERN

1.35-1.75
[.053-.069]
TYP

6X 1.27
[.050]

0.1[.004] C

C

(1.45)
[.057]

8X 0.35-0.51
[.0138-.0200]

0.10-0.25
[.004-.010]
TYP

0.25[.010] M C A S B S

45° X 0.25-0.50
[.010-.020]

R0.18±0.02
[.007±.0008]

R0.23±0.02
[.009±.0008]

0.25
[.010]
GAGE PLANE

0°-8°

TIE BAR

SEATING
PLANE

0.41-1.27
[.016-.050]

(1.04)
[.041]

0.190-0.248
[.0075-.0098]
TYP

CONTROLLING DIMENSION IS MILLIMETER
VALUES IN [ ] ARE INCHES
DIMENSIONS IN ( ) FOR REFERENCE ONLY

M08A (Rev M)

8-Pin SOIC
NS Package Number M08A

RECOMMENDED LAND PATTERN

DETAIL A
TYPICAL

DIMENSIONS ARE IN MILLIMETERS
DIMENSIONS IN ( ) FOR REFERENCE ONLY
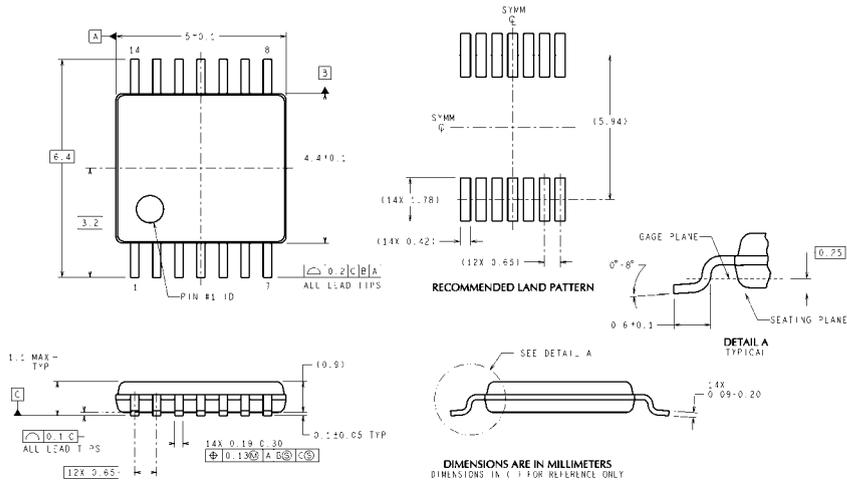
MTC14 (Rev D)

14-Pin TSSOP
NS Package Number MTC14
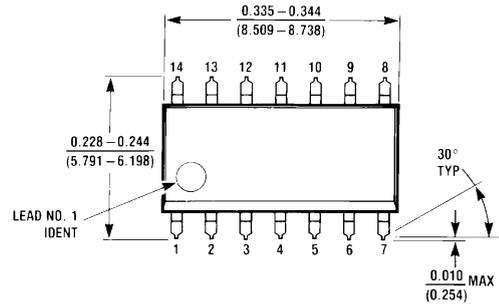
M14A (REV H)

14-Pin SOIC
NS Package Number M14A
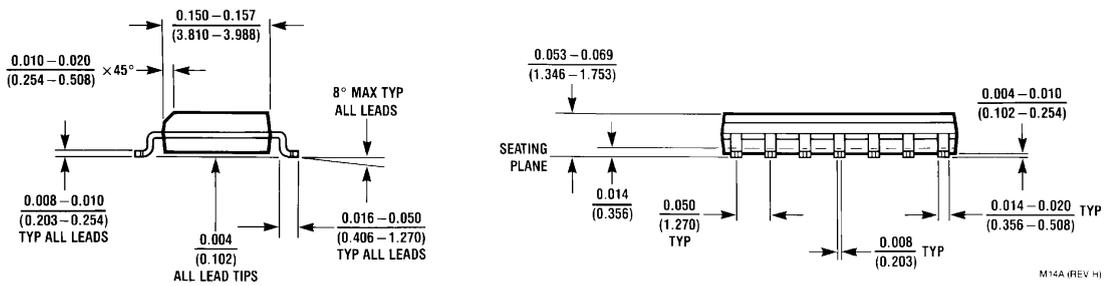
Notes

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Data Converters	www.national.com/adc	Samples	www.national.com/samples
Interface	www.national.com/interface	Eval Boards	www.national.com/evalboards
LVDS	www.national.com/lvds	Packaging	www.national.com/packaging
Power Management	www.national.com/power	Green Compliance	www.national.com/quality/green
Switching Regulators	www.national.com/switchers	Distributors	www.national.com/contacts
LDOs	www.national.com/ldo	Quality and Reliability	www.national.com/quality
LED Lighting	www.national.com/led	Feedback/Support	www.national.com/feedback
Voltage References	www.national.com/vref	Design Made Easy	www.national.com/easy
PowerWise® Solutions	www.national.com/powerwise	Applications & Markets	www.national.com/solutions
Serial Digital Interface (SDI)	www.national.com/sdi	Mil/Aero	www.national.com/milaero
Temperature Sensors	www.national.com/tempsensors	SolarMagic™	www.national.com/solarmagic
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Microcontrollers	microcontroller.ti.com	Video and Imaging	www.ti.com/video
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