LMV921/LMV922/LMV924 Single, Dual and Quad 1.8V, 1MHz, Low Power Operational Amplifiers with Rail-To-Rail Input and Output

Check for Samples: LMV921, LMV922, LMV924

FEATURES

- **(Typical 1.8V Supply Values; Unless Otherwise Noted)**
- **Ensured 1.8V, 2.7V and 5V Specifications**
- **Rail-to-Rail Input & Output Swing**
- **w/600Ω Load 100 mV from Rail**
- **w/2kΩ Load 30 mV from Rail**
- **V_{CM} 300mV Beyond Rails**
- **Supply Current 145µA/amplifier**
- **Gain Bandwidth Product 1MHz**
- **LMV921 Maximum V_{OS} 6mV**
- **90dB Gain w/600Ω Load**
- **LMV921 Available in Ultra Tiny, SC70-5 Package**
- **LMV922 Available in VSSOP-8 Package**
- **LMV924 Available in TSSOP-14 Package**

APPLICATIONS

- **Cordless/Cellular Phones**
- **Laptops**
- **PDAs**
- **PCMCIA**
- **Portable/Battery-Powered Electronic Equipment**
- **Supply Current Monitoring**
- **Battery Monitoring**

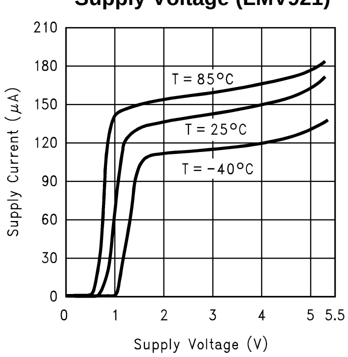
DESCRIPTION

The LMV921 Single/LMV922 Dual/LMV924 Quad are ensured to operate from +1.8V to +5.0V supply voltages and have rail-to-rail input and output. This rail-to-rail operation enables the user to make full use of the entire supply voltage range. The input common mode voltage range extends 300mV beyond the supplies and the output can swing rail-to-rail unloaded and within 100mV from the rail with 600Ω load at 1.8V supply. The LMV921/LMV922/LMV924 are optimized to work at 1.8V which make them ideal for portable two-cell battery-powered systems and single cell Li-Ion systems.

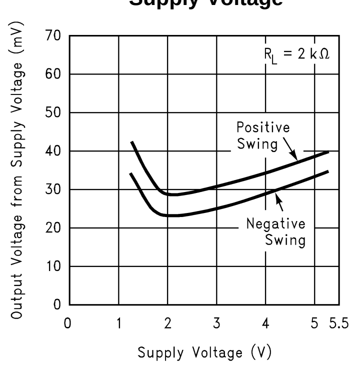
The LMV921/LMV922/LMV924 exhibit excellent speed-power ratio, achieving 1MHz gain bandwidth product at 1.8V supply voltage with very low supply current. The LMV921/LMV922/LMV924 are capable of driving 600Ω load and up to 1000pF capacitive load with minimal ringing. The LMV921/LMV922/LMV924's high DC gain of 100dB makes them suitable for low frequency applications.

The LMV921 (Single) is offered in a space saving SC70–5 and SOT-23–5 packages. The SC70–5 package is only 2.0X2.1X1.0mm. These small packages are ideal solutions for area constrained PC boards and portable electronics such as cellphones and PDAs.

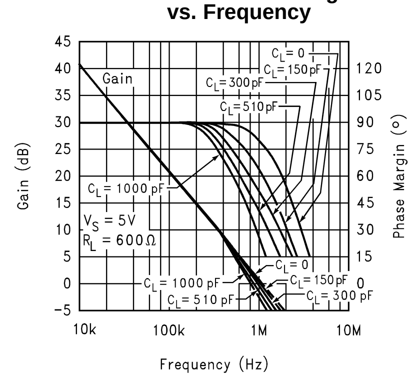
Supply Current vs. Supply Voltage (LMV921)



Output Voltage Swing vs. Supply Voltage



Gain and Phase Margin vs. Frequency



These devices have limited built-in ESD protection. The leads should be shorted together or the device placed in conductive foam during storage or handling to prevent electrostatic damage to the MOS gates.

ABSOLUTE MAXIMUM RATINGS[1][2]

ESD Tolerance[3]	Machine Model	100V
	Human Body Model	2000V
Differential Input Voltage		± Supply Voltage
Supply Voltage (V^+–V^-)		5.5V
Output Short Circuit to V^+[4]		
Output Short Circuit to V^-[4]		
Storage Temperature Range		−65°C to 150°C
Junction Temperature[5]		150°C
Mounting Temp.	Infrared or Convection (20 sec)	235°C

(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 ensured. For ensured specifications and the test conditions, see the Electrical Characteristics.
(2) If Military/Aerospace specified devices are required, please contact the TI Sales Office/ Distributors for availability and specifications.
(3) Human body model, 1.5 kΩ in series with 100pF. Machine model, 200Ω in series with 100 pF.
(4) 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.
(5) 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 into a PC board.

OPERATING RATINGS[1]

Supply Voltage			1.5V to 5.0V
Temperature Range			$-40°C \le T_J \le 85°C$
Thermal Resistance (θ_{JA})	Ultra Tiny SC70-5 Package	5-Pin Surface Mount	440 °C/W
	Tiny SOT-23-5 Package	5-Pin Surface Mount	265 °C/W
	VSSOP Package	8-Pin Surface Mount	235°C/W
	TSSOP Package	14-Pin Surface Mount	155°C/W
	SOIC Package	8-Pin Surface Mount	175°C/W
		14-Pin Surface Mount	127°C/W

(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 ensured. For ensured specifications and the test conditions, see the Electrical Characteristics.

1.8V DC ELECTRICAL CHARACTERISTICS

Unless otherwise specified, all limits specified 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.

Symbol	Parameter	Condition	Typ[1]	Limits[2]	Units
V_{OS}	Input Offset Voltage	LMV921 (Single)	−1.8	6 **8**	mV max
		LMV922 (Dual) LMV924 (Quad)	−1.8	8 **9.5**	mV max
TCV_{OS}	Input Offset Voltage Average Drift		1		µV/°C
I_B	Input Bias Current		12	35 **50**	nA max
I_{OS}	Input Offset Current		2	25 **40**	nA max
I_S	Supply Current	LMV921 (Single)	145	185 **205**	µA max
		LMV922 (Dual)	330	400 **550**	
		LMV924 (Quad)	560	700 **850**	
CMRR	Common Mode Rejection Ratio	0 ≤ V_{CM} ≤ 0.6V	82	62 **60**	dB min
		−0.2V ≤ V_{CM} ≤ 0V 1.8V ≤ V_{CM} ≤ 2.0V	74	50	
PSRR	Power Supply Rejection Ratio	1.8V ≤ V^+ ≤ 5V, V_{CM} = 0.5V	78	67 **62**	dB min
V_{CM}	Input Common-Mode Voltage Range	For CMRR ≥ 50dB	-0.3	-0.2 **0**	V min
			2.15	2.0 **1.8**	V max
A_V	Large Signal Voltage Gain LMV921 (Single)	R_L = 600Ω to 0.9V, V_O = 0.2V to 1.6V, V_{CM} = 0.5V	91	77 **73**	dB min
		R_L = 2kΩ to 0.9V, V_O = 0.2V to 1.6V, V_{CM} = 0.5V	95	80 **75**	
	Large Signal Voltage Gain LMV922 (Dual) LMV924 (Quad)	R_L = 600Ω to 0.9V, V_O = 0.2V to 1.6V, V_{CM} = 0.5V	79	65 **61**	dB min
		R_L = 2kΩ to 0.9V, V_O = 0.2V to 1.6V, V_{CM} = 0.5V	83	68 **63**	
V_O	Output Swing	R_L = 600Ω to 0.9V V_{IN} = ± 100mV	1.7	1.65 **1.63**	V min
			0.075	0.090 **0.105**	V max
		R_L = 2kΩ to 0.9V V_{IN} = ± 100mV	1.77	1.75 **1.74**	V min
			0.025	0.035 **0.040**	V max
I_O	Output Short Circuit Current	Sourcing, V_O = 0V V_{IN} = 100mV	6	4 **3.3**	mA min
		Sinking, V_O = 1.8V V_{IN} = −100mV	10	7 **5**	mA min

(1) Typical Values represent the most likely parametric norm.
(2) All limits are specified by testing or statistical analysis.

1.8V AC ELECTRICAL CHARACTERISTICS

Unless otherwise specified, all limits specified 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.

Symbol	Parameter	Conditions	Typ (1)	Units
SR	Slew Rate	See (2)	0.39	V/µs
GBW	Gain-Bandwidth Product		1	MHz
Φ_m	Phase Margin		60	Deg
G_m	Gain Margin		10	dB
e_n	Input-Referred Voltage Noise	f = 1 kHz, V_{CM} = 0.5V	45	$nV/\sqrt{Hz}$
i_n	Input-Referred Current Noise	f = 1 kHz	0.1	$pA/\sqrt{Hz}$
THD	Total Harmonic Distortion	f = 1kHz, A_V = +1 R_L = 600kΩ, V_{IN} = 1 V_{PP}	0.089	%
	Amp-to-Amp Isolation	See (3)	140	dB

(1) Typical Values represent the most likely parametric norm.
(2) V^+ = 5V. Connected as voltage follower with 5V step input. Number specified is the slower of the positive and negative slew rates.
(3) Input referred, V^+ = 5V and R_L = 100kΩ connected to 2.5V. Each amp excited in turn with 1kHz to produce V_O = $3V_{PP}$.

2.7V DC ELECTRICAL CHARACTERISTICS

Unless otherwise specified, all limits specified 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.

Symbol	Parameter	Condition	Typ (1)	Limits (2)	Units
V_{OS}	Input Offset Voltage	LMV921 (Single)	−1.6	6 **8**	mV max
		LMV922 (Dual) LMV924 (Quad)	−1.6	8 **9.5**	mV max
TCV_{OS}	Input Offset Voltage Average Drift		1		µV/°C
I_B	Input Bias Current		12	35 **50**	nA max
I_{OS}	Input Offset Current		2	25 **40**	nA max
I_S	Supply Current	LMV921 (Single)	147	190 **210**	uA max
		LMV922 (Dual)	380	450 **600**	
		LMV924 (Quad)	580	750 **900**	
CMRR	Common Mode Rejection Ratio	0V ≤ V_{CM} ≤ 1.5V	84	62 **60**	dB min
		−0.2V ≤ V_{CM} ≤ 0V 2.7V ≤ V_{CM} < 2.9V	73	50	
PSRR	Power Supply Rejection Ratio	1.8V ≤ V^+ ≤ 5V, V_{CM} = 0.5V	78	67 **62**	dB min
V_{CM}	Input Common-Mode Voltage Range	For CMRR ≥ 50dB	-0.3	-0.2 **0**	V min
			3.050	2.9 **2.7**	V max

(1) Typical Values represent the most likely parametric norm.
(2) All limits are specified by testing or statistical analysis.

2.7V DC ELECTRICAL CHARACTERISTICS (continued)

Unless otherwise specified, all limits specified 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.

Symbol	Parameter	Condition	Typ(1)	Limits(2)	Units
A_V	Large Signal Voltage Gain LMV921 (Single)	R_L = 600Ω to 1.35V, V_O = 0.2V to 2.5V	98	80 **75**	dB min
		R_L = 2kΩ to 1.35V, V_O = 0.2V to 2.5V	103	83 **77**	dB min
	Large Signal Voltage Gain LMV922 (Dual) LMV924 (Quad)	R_L = 600Ω to 1.35V, V_O = 0.2V to 2.5V	86	68 **63**	dB min
		R_L = 2kΩ to 1.35V, V_O = 0.2V to 2.5V	91	71 **65**	dB min
V_O	Output Swing	R_L = 600Ω to 1.35V V_{IN} = ± 100mV	2.62	2.550 **2.530**	V min
			0.075	0.095 **0.115**	V max
		R_L = 2kΩ to 1.35V V_{IN} = ± 100mV	2.675	2.650 **2.640**	V min
			0.025	0.040 **0.045**	V max
I_O	Output Short Circuit Current	Sourcing, V_O = 0V V_{IN} = 100mV	27	20 **15**	mA min
		Sinking, V_O = 2.7V V_{IN} = −100mV	28	22 **16**	mA min

2.7V AC ELECTRICAL CHARACTERISTICS

Unless otherwise specified, all limits specified 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.

Symbol	Parameter	Conditions	Typ(1)	Units
SR	Slew Rate	See(2)	0.41	V/µs
GBW	Gain-Bandwidth Product		1	MHz
Φ_m	Phase Margin		65	Deg.
G_m	Gain Margin		10	dB
e_n	Input-Referred Voltage Noise	f = 1 kHz, V_{CM} = 0.5V	45	nV/√Hz
i_n	Input-Referred Current Noise	f = 1 kHz	0.1	pA/ √Hz
THD	Total Harmonic Distortion	f = 1 kHz, A_V = +1 R_L = 600kΩ, V_{IN} = 1 V_{PP}	0.077	%
	Amp-to-Amp Isolation	See(3)	140	dB

(1) Typical Values represent the most likely parametric norm.
(2) V^+ = 5V. Connected as voltage follower with 5V step input. Number specified is the slower of the positive and negative slew rates.
(3) Input referred, V^+ = 5V and R_L = 100kΩ connected to 2.5V. Each amp excited in turn with 1kHz to produce V_O = $3V_{PP}$.

5V DC ELECTRICAL CHARACTERISTICS

Unless otherwise specified, all limits specified 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.

Symbol	Parameter	Condition	Typ[(1)]	Limits[(2)]	Units
V_{OS}	Input Offset Voltage	LMV921 (Single)	−1.5	6 **8**	mV max
		LMV922 (Dual) LMV924 (Quad)	−1.5	8 **9.5**	mV max
TCV_{OS}	Input Offset Voltage Average Drift		1		μV/°C
I_B	Input Bias Current		12	35 **50**	nA max
I_{OS}	Input Offset Current		2	25 **40**	nA max
I_S	Supply Current	LMV921 (Single)	160	210 **230**	μA max
		LMV922 (Dual)	400	500 **700**	
		LMV924 (Quad)	750	850 **980**	
CMRR	Common Mode Rejection Ratio	0V ≤ V_{CM} ≤ 3.8V	86	62 **61**	dB min
		−0.2V ≤ V_{CM} ≤ 0V 5.0V ≤ V_{CM} ≤ 5.2V	72	50	
PSRR	Power Supply Rejection Ratio	1.8V ≤ V^+ ≤ 5V V_{CM} = 0.5V	78	67 **62**	dB min
V_{CM}	Input Common-Mode Voltage Range	For CMRR ≥ 50dB	-0.3	-0.2 **0**	V min
			5.350	5.2 **5.0**	V max
A_V	Voltage Gain LMV921 (Single)	R_L = 600Ω to 2.5V V_O = 0.2V to 4.8V	104	86 **82**	dB min
		R_L = 2kΩ to 2.5V V_O = 0.2V to 4.8V	108	89 **85**	
	Voltage Gain LMV922 (Dual) LMV924 (Quad)	R_L = 600Ω to 2.5V V_O = 0.2V to 4.8V	90	72 68	dB min
		R_L = 2kΩ to 2.5V V_O = 0.2V to 4.8V	96	77 73	
V_O	Output Swing	R_L = 600Ω to 2.5V V_{IN} = ± 100mV	4.895	4.865 **4.840**	V min
			0.1	0.135 **0.160**	V max
		R_L = 2kΩ to 2.5V V_{IN} = ± 100mV	4.965	4.945 **4.935**	V min
			0.035	0.065 **0.075**	V max
I_O	Output Short Circuit Current	LMV921 Sourcing, V_O = 0V V_{IN} = 100mV	98	85 **68**	mA min
		LMV922, LMV924 Sourcing, V_O = 0V V_{IN} = 100mV	60	35	
		Sinking, V_O = 5V V_{IN} = −100mV	75	65 **45**	mA min

(1) Typical Values represent the most likely parametric norm.
(2) All limits are specified by testing or statistical analysis.

5V AC ELECTRICAL CHARACTERISTICS

Unless otherwise specified, all limits specified 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.

Symbol	Parameter	Conditions	Typ (1)	Units
SR	Slew Rate	See (2)	0.45	V/µs
GBW	Gain-Bandwidth Product		1	MHz
Φ_m	Phase Margin		70	Deg
G_m	Gain Margin		15	dB
e_n	Input-Referred Voltage Noise	f = 1 kHz, V_{CM} = 1V	45	$nV/\sqrt{Hz}$
i_n	Input-Referred Current Noise	f = 1 kHz	0.1	$pA/\sqrt{Hz}$
THD	Total Harmonic Distortion	f = 1 kHz, A_V = +1 R_L = 600Ω, V_O = 1 V_{PP}	0.069	%
	Amp-to-Amp Isolation	See (3)	140	dB

(1) Typical Values represent the most likely parametric norm.
(2) V^+ = 5V. Connected as voltage follower with 5V step input. Number specified is the slower of the positive and negative slew rates.
(3) Input referred, V^+ = 5V and R_L = 100kΩ connected to 2.5V. Each amp excited in turn with 1kHz to produce V_O = $3V_{PP}$.

TYPICAL PERFORMANCE CHARACTERISTICS

Unless otherwise specified, V_S = +5V, single supply, T_A = 25°C.
*For large signal pulse response in the unity gain follower configuration, the input is 5mV below the positive rail and 5mV above the negative rail at 25°C and 85°C. At −40°C, input is 10mV below the positive rail and 10mV above the negative rail.

Supply Current vs. Supply Voltage (LMV921)

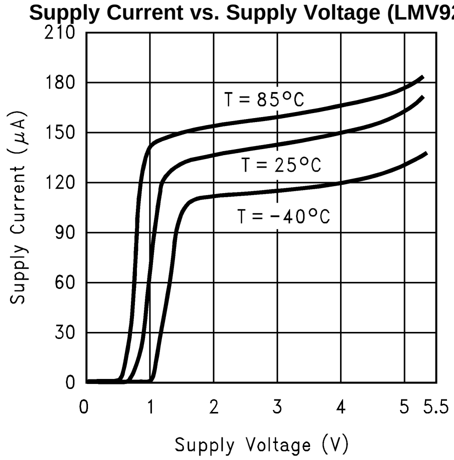


Figure 1.

Input Bias Current vs. V_{CM}

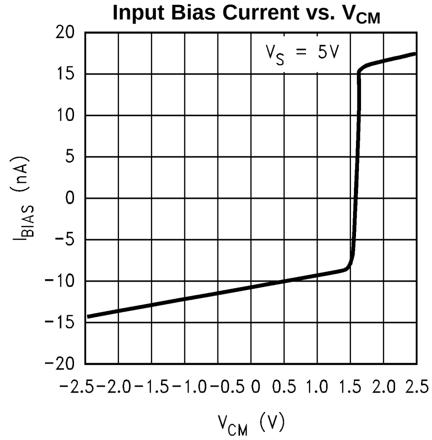


Figure 2.

Sourcing Current vs. Output Voltage

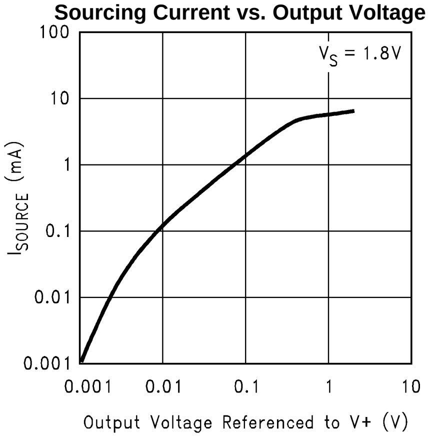


Figure 3.

Sourcing Current vs. Output Voltage

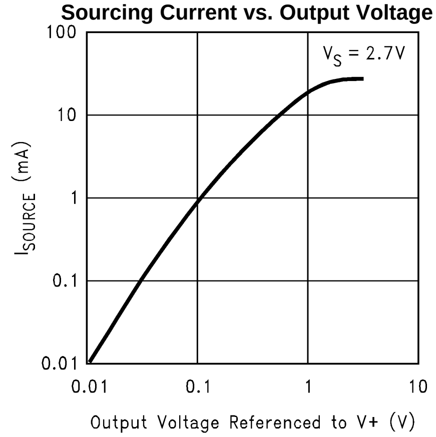


Figure 4.

Sourcing Current vs. Output Voltage

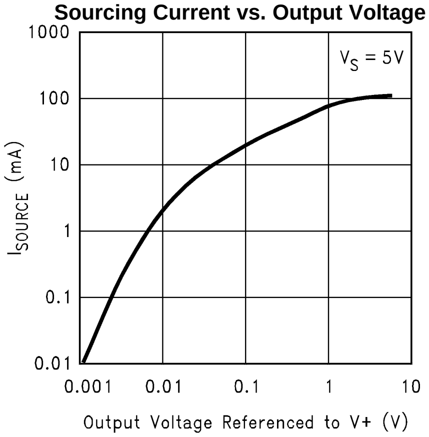


Figure 5.

Sinking Current vs. Output Voltage

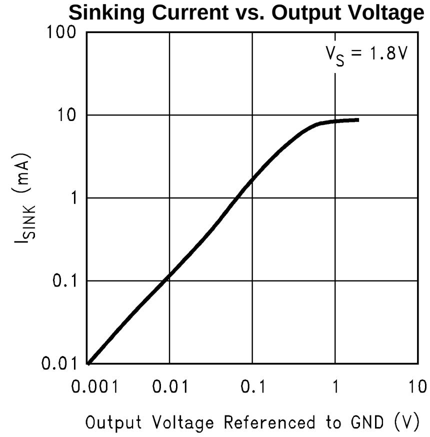


Figure 6.

TYPICAL PERFORMANCE CHARACTERISTICS (continued)

Unless otherwise specified, V_S = +5V, single supply, T_A = 25°C.

*For large signal pulse response in the unity gain follower configuration, the input is 5mV below the positive rail and 5mV above the negative rail at 25°C and 85°C. At −40°C, input is 10mV below the positive rail and 10mV above the negative rail.

Sinking Current vs. Output Voltage

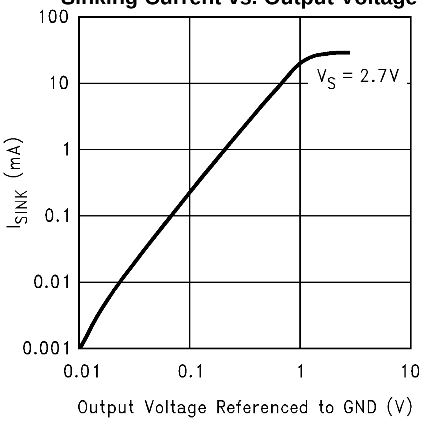


Figure 7.

Sinking Current vs. Output Voltage

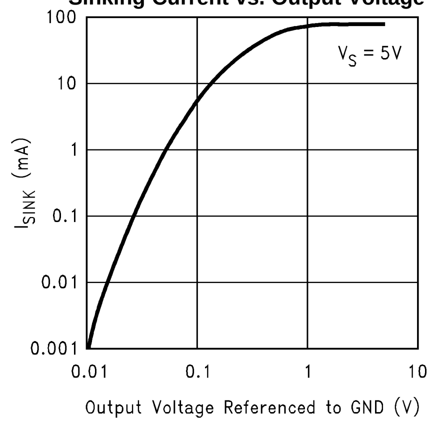


Figure 8.

Offset Voltage vs. Common Mode Voltage

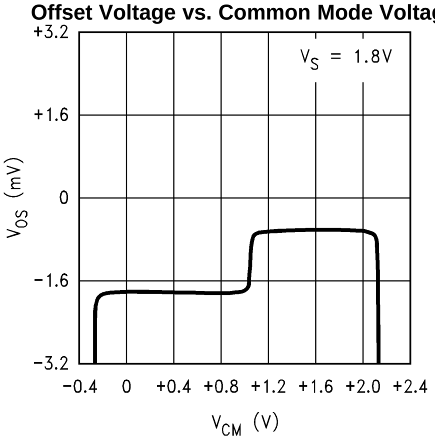


Figure 9.

Offset Voltage vs. Common Mode Voltage

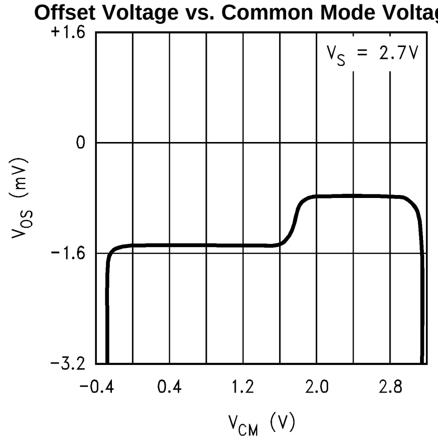


Figure 10.

Offset Voltage vs. Common Mode Voltage

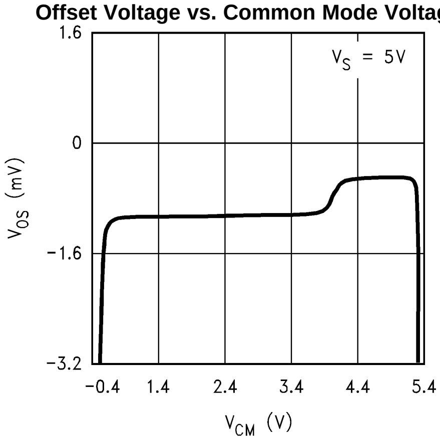


Figure 11.

Output Voltage Swing vs. Supply Voltage

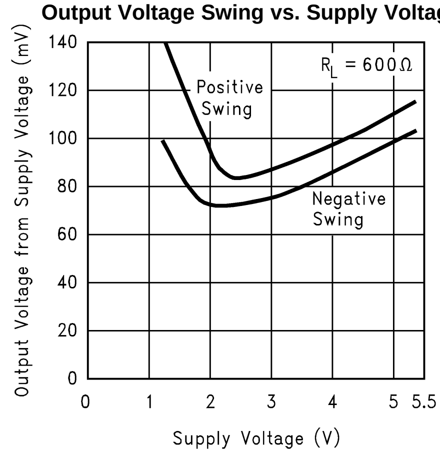


Figure 12.

TYPICAL PERFORMANCE CHARACTERISTICS (continued)

Unless otherwise specified, V_S = +5V, single supply, T_A = 25°C.

*For large signal pulse response in the unity gain follower configuration, the input is 5mV below the positive rail and 5mV above the negative rail at 25°C and 85°C. At −40°C, input is 10mV below the positive rail and 10mV above the negative rail.

Output Voltage Swing vs. Supply Voltage

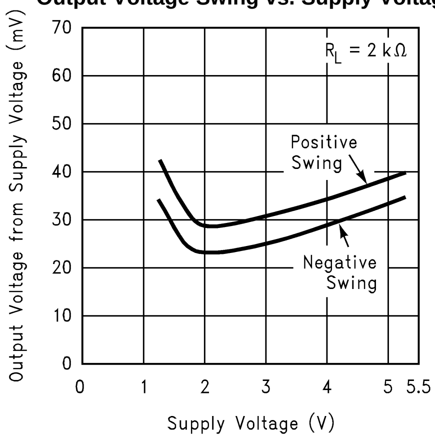


Figure 13.

Gain and Phase Margin vs. Frequency

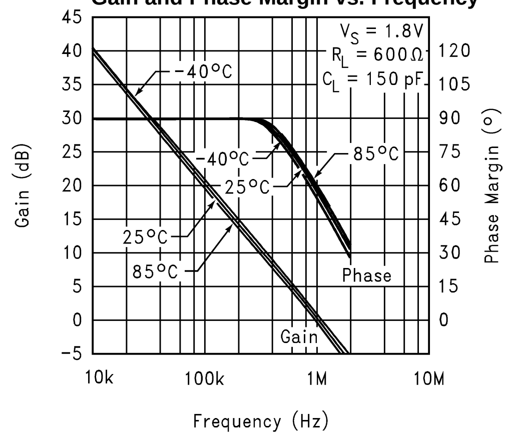


Figure 14.

Gain and Phase Margin vs. Frequency

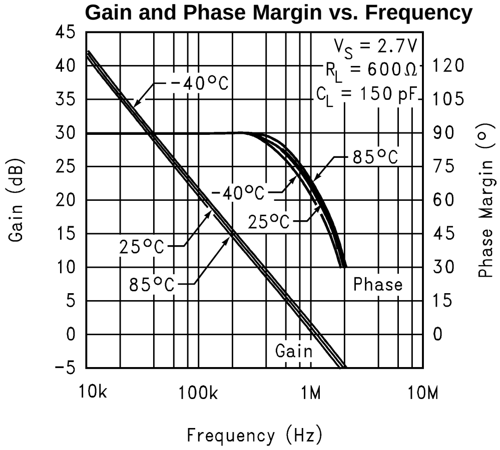


Figure 15.

Gain and Phase Margin vs. Frequency

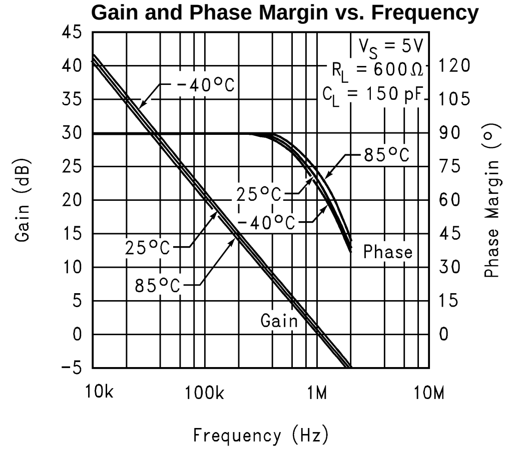


Figure 16.

Gain and Phase Margin vs. Frequency

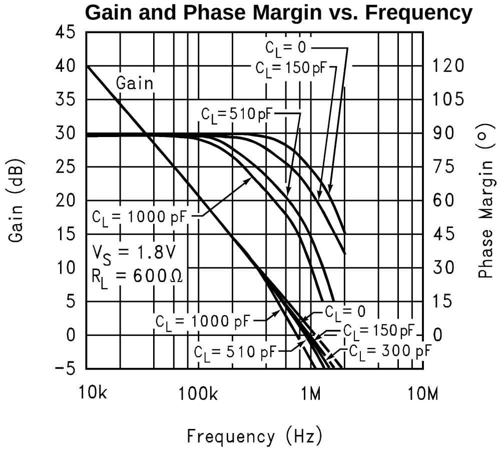


Figure 17.

Gain and Phase Margin vs. Frequency

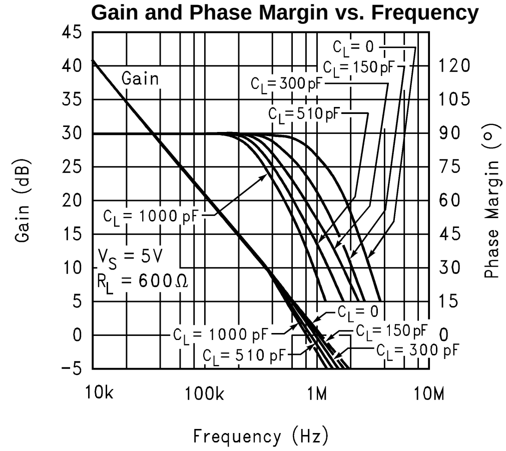


Figure 18.

TYPICAL PERFORMANCE CHARACTERISTICS (continued)

Unless otherwise specified, V_S = +5V, single supply, T_A = 25°C.

*For large signal pulse response in the unity gain follower configuration, the input is 5mV below the positive rail and 5mV above the negative rail at 25°C and 85°C. At −40°C, input is 10mV below the positive rail and 10mV above the negative rail.

CMRR vs. Frequency

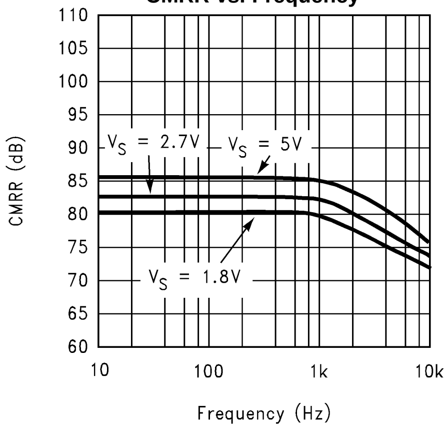


Figure 19.

PSRR vs. Frequency

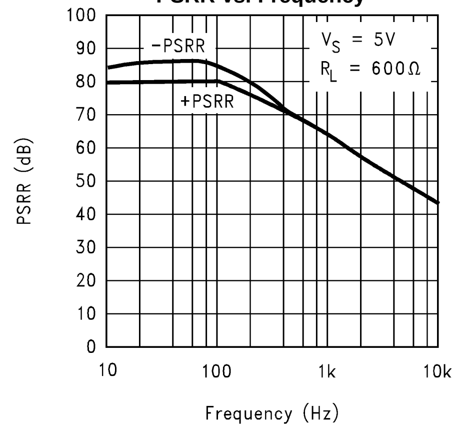


Figure 20.

Input Voltage Noise vs. Frequency

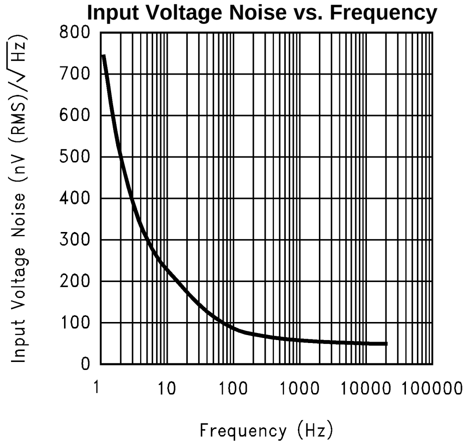


Figure 21.

Input Current Noise vs. Frequency

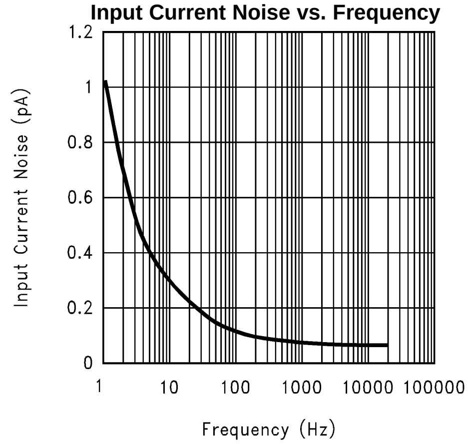


Figure 22.

THD vs. Frequency

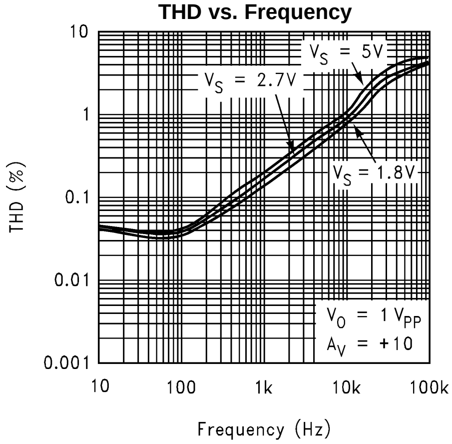


Figure 23.

THD vs. Frequency

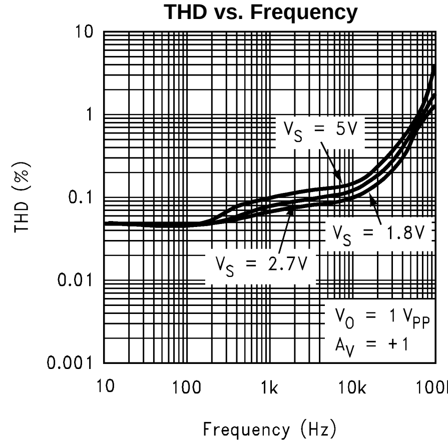


Figure 24.

TYPICAL PERFORMANCE CHARACTERISTICS (continued)

Unless otherwise specified, V_S = +5V, single supply, T_A = 25°C.

*For large signal pulse response in the unity gain follower configuration, the input is 5mV below the positive rail and 5mV above the negative rail at 25°C and 85°C. At −40°C, input is 10mV below the positive rail and 10mV above the negative rail.

Slew Rate vs. Supply Voltage

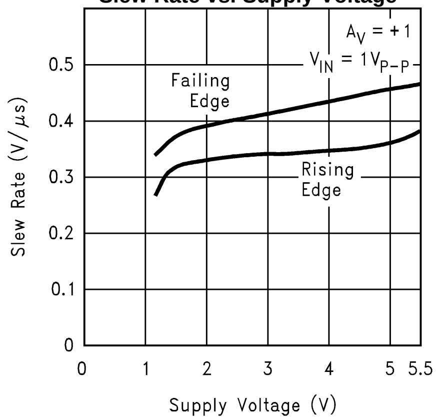


Figure 25.

Small Signal Non-Inverting Response

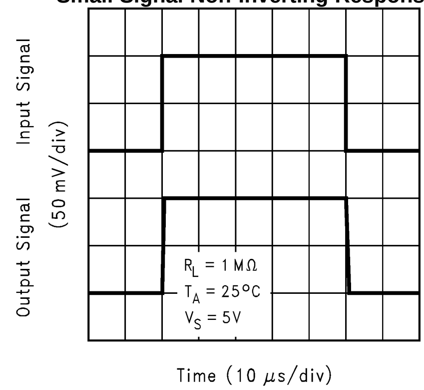


Figure 26.

Small Signal Non-Inverting Response

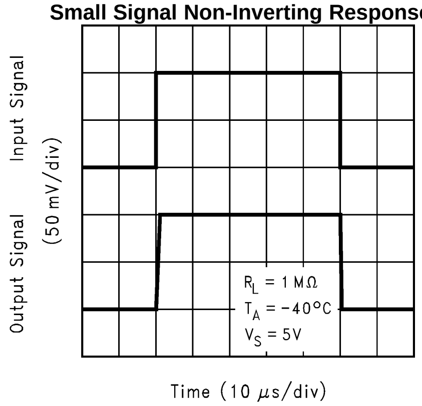


Figure 27.

Small Signal Non-Inverting Response

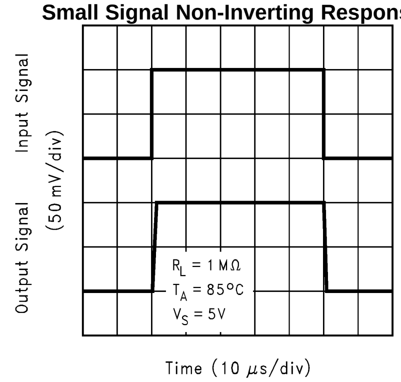


Figure 28.

Small Signal Inverting Response

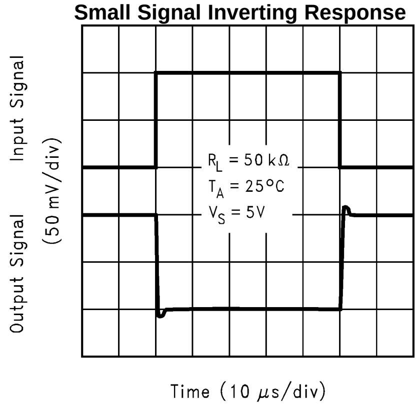


Figure 29.

Small Signal Inverting Response

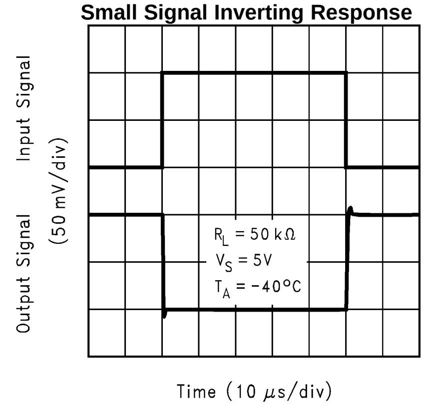


Figure 30.

TYPICAL PERFORMANCE CHARACTERISTICS (continued)

Unless otherwise specified, V_S = +5V, single supply, T_A = 25°C.

*For large signal pulse response in the unity gain follower configuration, the input is 5mV below the positive rail and 5mV above the negative rail at 25°C and 85°C. At −40°C, input is 10mV below the positive rail and 10mV above the negative rail.

Small Signal Inverting Response

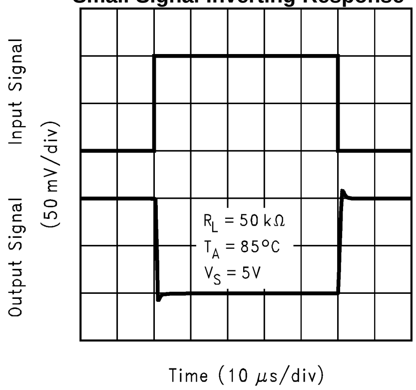


Figure 31.

Small Signal Non-Inverting Response

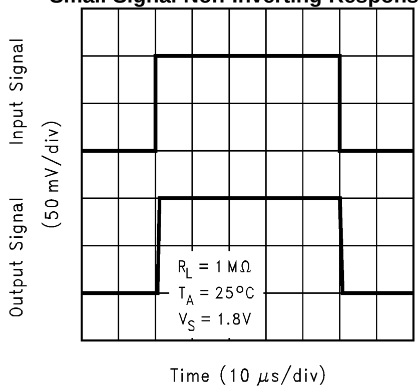


Figure 32.

Small Signal Non-Inverting Response

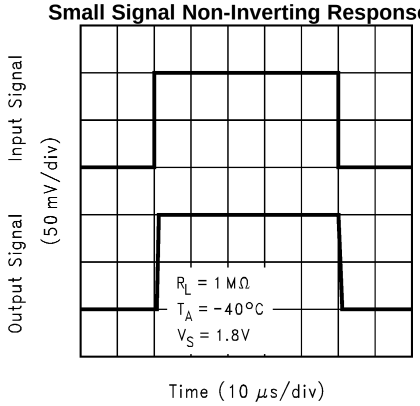


Figure 33.

Small Signal Non-Inverting Response

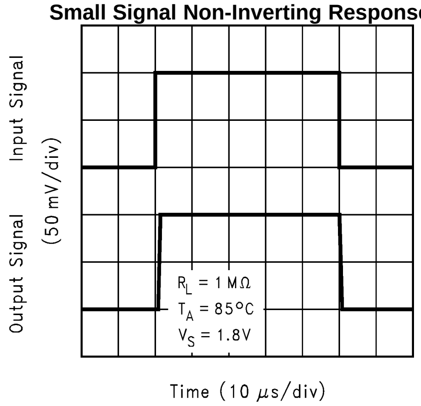


Figure 34.

Small Signal Inverting Response

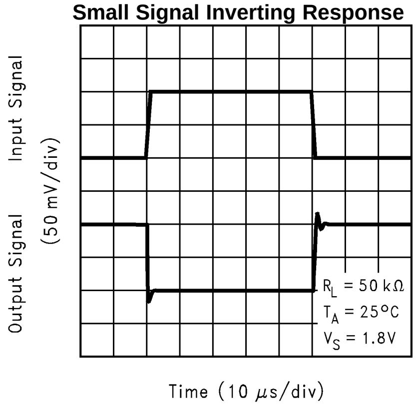


Figure 35.

Small Signal Inverting Response

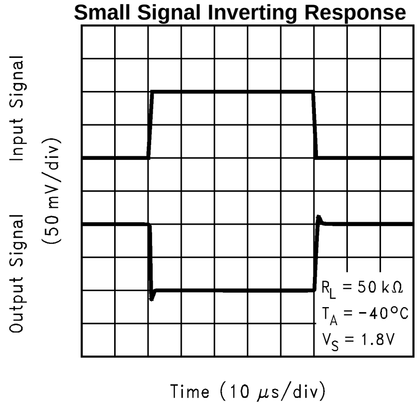


Figure 36.

TYPICAL PERFORMANCE CHARACTERISTICS (continued)

Unless otherwise specified, V_S = +5V, single supply, T_A = 25°C.

*For large signal pulse response in the unity gain follower configuration, the input is 5mV below the positive rail and 5mV above the negative rail at 25°C and 85°C. At −40°C, input is 10mV below the positive rail and 10mV above the negative rail.

Small Signal Inverting Response

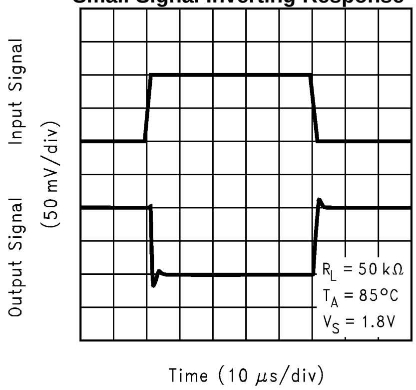


Figure 37.

***Large Signal Non-Inverting Response**

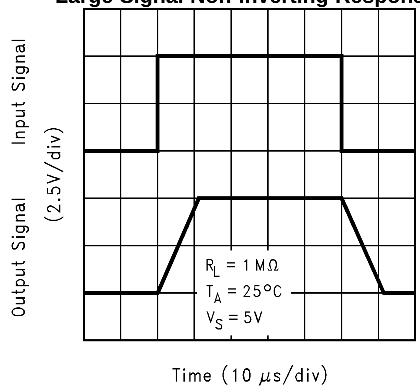


Figure 38.

***Large Signal Non-Inverting Response**

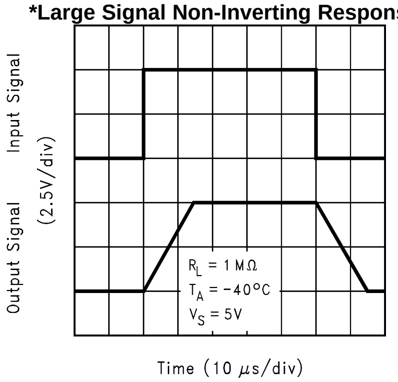


Figure 39.

***Large Signal Non-Inverting Response**

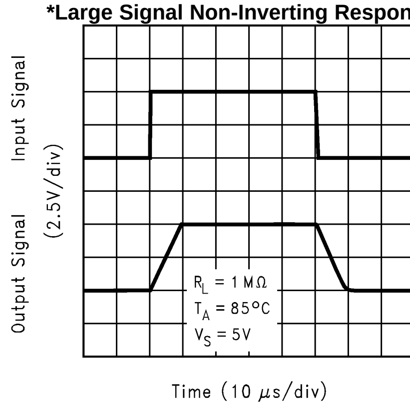


Figure 40.

***Large Signal Inverting Response**

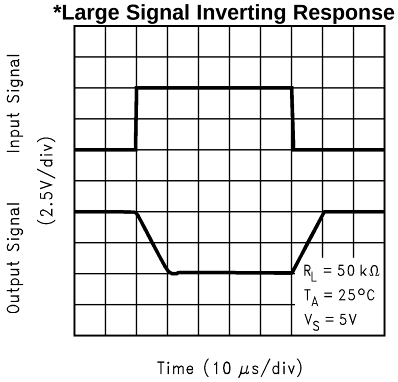


Figure 41.

***Large Signal Inverting Response**

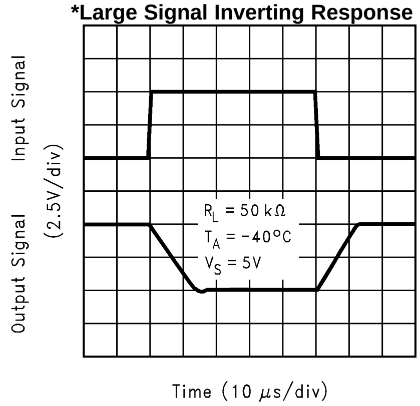


Figure 42.

TYPICAL PERFORMANCE CHARACTERISTICS (continued)

Unless otherwise specified, V_S = +5V, single supply, T_A = 25°C.

*For large signal pulse response in the unity gain follower configuration, the input is 5mV below the positive rail and 5mV above the negative rail at 25°C and 85°C. At −40°C, input is 10mV below the positive rail and 10mV above the negative rail.

***Large Signal Inverting Response**

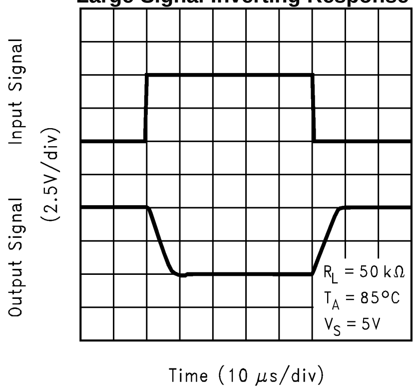


Figure 43.

***Large Signal Non-Inverting Response**

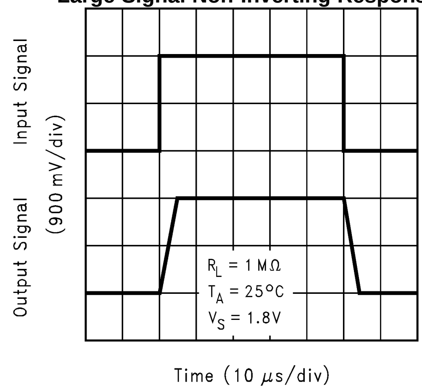


Figure 44.

***Large Signal Non-Inverting Response**

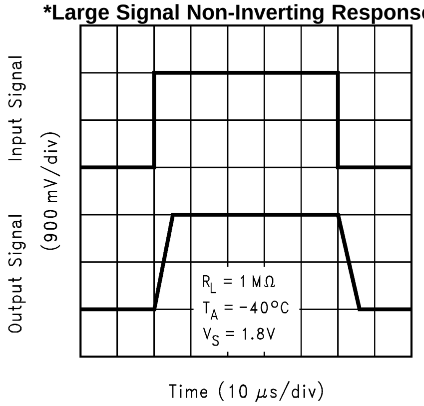


Figure 45.

***Large Signal Inverting Response**

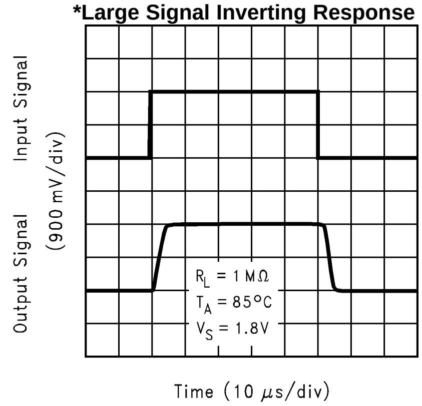


Figure 46.

***Large Signal Inverting Response**

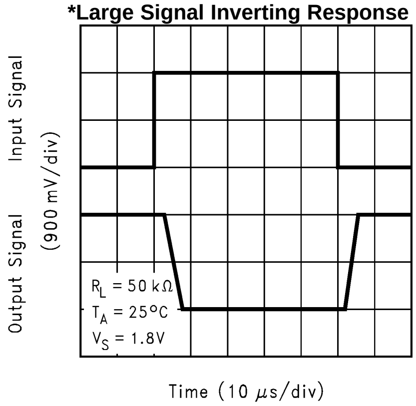


Figure 47.

***Large Signal Inverting Response**

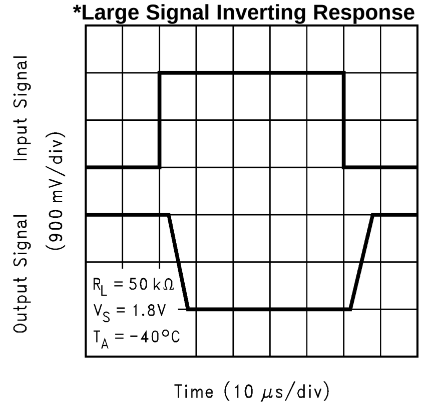


Figure 48.

TYPICAL PERFORMANCE CHARACTERISTICS (continued)

Unless otherwise specified, V_S = +5V, single supply, T_A = 25°C.

*For large signal pulse response in the unity gain follower configuration, the input is 5mV below the positive rail and 5mV above the negative rail at 25°C and 85°C. At −40°C, input is 10mV below the positive rail and 10mV above the negative rail.

***Large Signal Inverting Response**

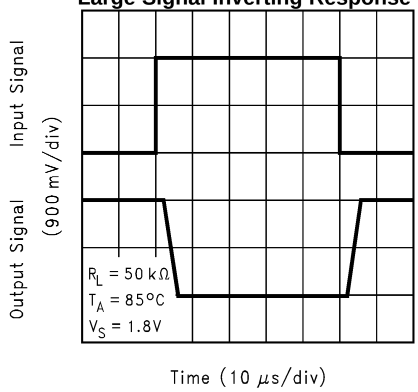


Figure 49.

Short Circuit Current vs.Temperature (sinking)

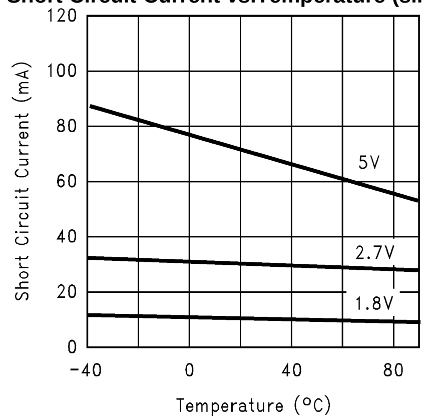


Figure 50.

Short Circuit Current vs. Temperature (sourcing)

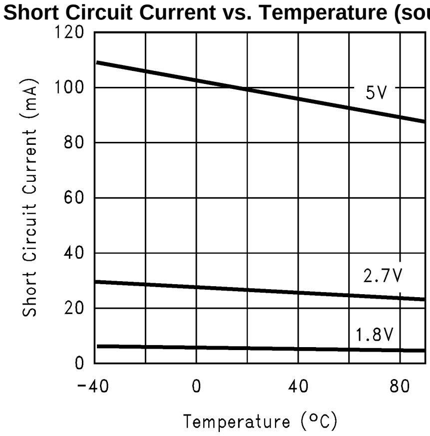


Figure 51.

APPLICATION NOTE

Unity Gain Pulse Response Considerations

The unity-gain follower is the most sensitive configuration to capacitive loading. The LMV921/LMV922/LMV924 family can directly drive 1nF in a unity-gain with minimal ringing. Direct capacitive loading reduces the phase margin of the amplifier. The combination of the amplifier's output impedance and the capacitive load induces phase lag. This results in either an underdamped pulse response or oscillation. The pulse response can be improved by adding a pull up resistor as shown in Figure 52

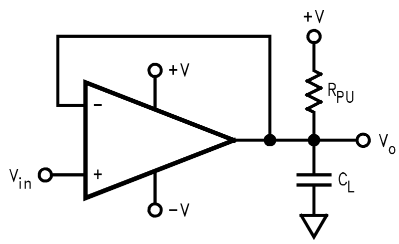


Figure 52. Using a Pull-Up Resistor at the Output for Stabilizing Capacitive Loads

Higher capacitances can be driven by decreasing the value of the pull-up resistor, but its value shouldn't be reduced beyond the sinking capability of the part. An alternate approach is to use an isolation resistor as illustrated in Figure 53.

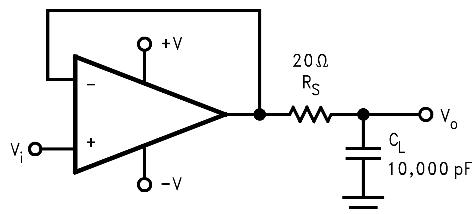


Figure 53. Using an Isolation Resistor to Drive Heavy Capacitive Loads

Input Bias Current Consideration

The LMV921/LMV922/LMV924 family has a bipolar input stage. The typical input bias current (I_B) is 12nA. 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 (max room) 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 54, cancels this affect. But the input offset current (I_{OS}) will still contribute to an offset voltage in the same manner.

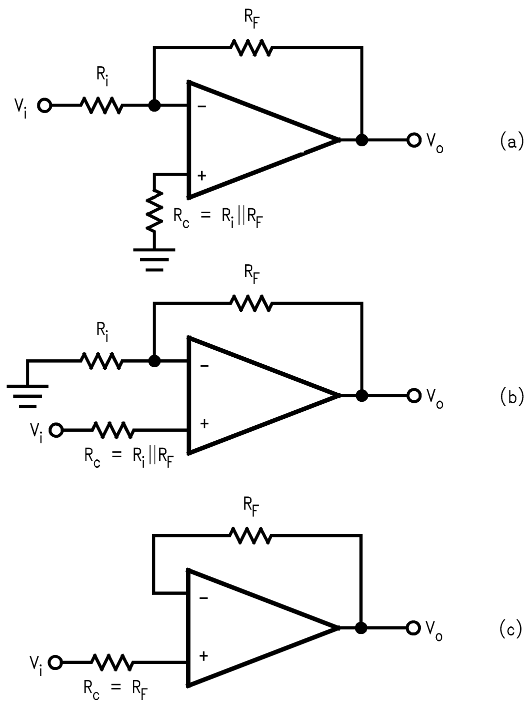


Figure 54. Canceling the Voltage Offset Effect of Input Bias Current

Operating Supply Voltage

The LMV921/LMV922/LMV924 family is ensured to operate from 1.8V to 5.0V. They will begin to function at power voltages as low as 1.2V at room temperature when unloaded. Start up voltage increases to 1.5V when the amplifier is fully loaded (600Ω to mid-supply). Below 1.2V the output voltage is not ensured to follow the input. Figure 55 below shows the output voltage vs. supply voltage with the LMV921/LMV922/LMV924 configured as a voltage follower at room temperature.

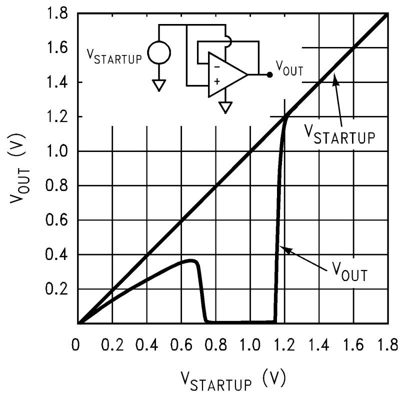


Figure 55. Output Voltage vs. Supply Voltage

Input and Output Stage

The rail-to-rail input stage of this family provides more flexibility for the designer. The LMV921/LMV922/LMV924 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^+ as shown in the V_{OS} vs. V_{CM} curves.

This V_{OS} crossover point can create problems for both DC and AC coupled signals if proper care is not taken. For large input signals that include the V_{OS} crossover point in their dynamic range, this 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} dependent 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.

Power-Supply Considerations

The LMV921/LMV922/LMV924 are ideally suited for use with most battery-powered systems. The LMV921/LMV922/LMV924 operate from a single +1.8V to +5.0V supply and consumes about 145µA of supply current per Amplifier. A high power supply rejection ratio of 78dB allows the amplifier to be powered directly off a decaying battery voltage extending battery life.

Table 1 lists a variety of typical battery types. Batteries have different voltage ratings; operating voltage is the battery voltage under nominal load. End-of-Life voltage is defined as the voltage at which 100% of the usable power of the battery is consumed. Table 1 also shows the typical operating time of the LMV921.

Distortion

The two main contributors of distortion in LMV921/LMV922/LMV924 family is:

1. Output crossover distortion occurs as the output transitions from sourcing current to sinking current.
2. Input crossover distortion occurs as the input switches from NPN to PNP transistor at the input stage.

To decrease crossover distortion:

1. Increase the load resistance. This lowers the output crossover distortion but has no effect on the input crossover distortion.
2. Operate from a single supply with the output always sourcing current.
3. Limit the input voltage swing for large signals between ground and one volt below the positive supply.
4. Operate in inverting configuration to eliminate common mode induced distortion.
5. Avoid small input signal around the input crossover region. The discontinuity in the offset voltage will effect the gain, CMRR and PSRR.

Table 1. LMV921 Characteristics with Typical Battery Systems.

Battery Type	Operating Voltage (V)	End-of-Life Voltage (V)	Capacity AA Size (mA - h)	LMV921 Operating time (Hours)
Alkaline	1.5	0.9	1000	6802
Lithium	2.7	2.0	1000	6802
Ni - Cad	1.2	0.9	375	2551
NMH	1.2	1.0	500	3401

TYPICAL APPLICATIONS

Half-wave Rectifier with Rail-To-Ground Output Swing

Since the LMV921 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 56 the circuit is referenced to ground, while in Figure 57 the circuit is biased to the positive supply. These configurations implement the half wave rectifier since the LMV921 can not respond to one-half of the incoming waveform. It can not respond to one-half of the incoming because 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 voltage. R_I should be large enough not to load the LMV921.

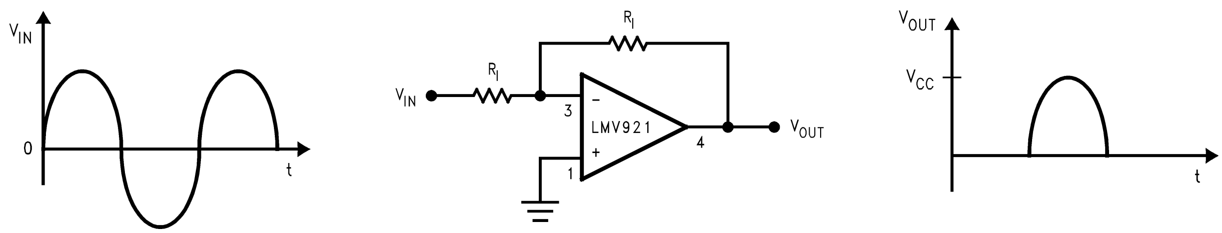


Figure 56. Half-Wave Rectifier with Rail-To-Ground Output Swing Referenced to Ground

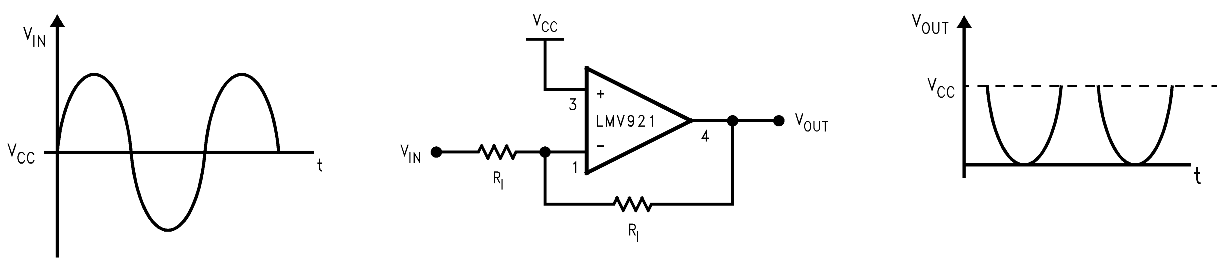


Figure 57. Half-Wave Rectifier with Negative-Going Output Referenced to V_{CC}

Instrumentation Amplifier with Rail-To-Rail Input and Output

Using three of the LMV924 Amplifiers, an instrumentation amplifier with rail-to-rail inputs and outputs can be made.

Some manufacturers use a precision voltage divider array of 5 resistors to divide the common mode 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 unity gain, the amplifier must be run at high loop gains. 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. Using the LMV924 eliminates all of these problems.

In this example, amplifiers A and B 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 TI application notes AN–29, AN–31, AN–71, and AN–127.

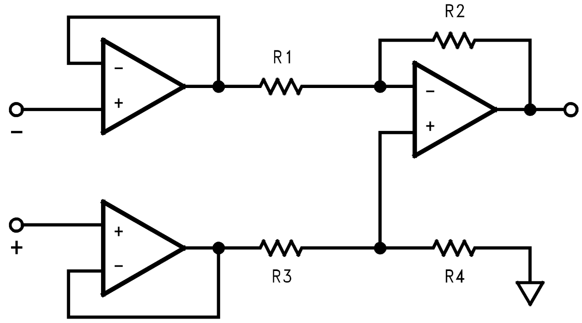
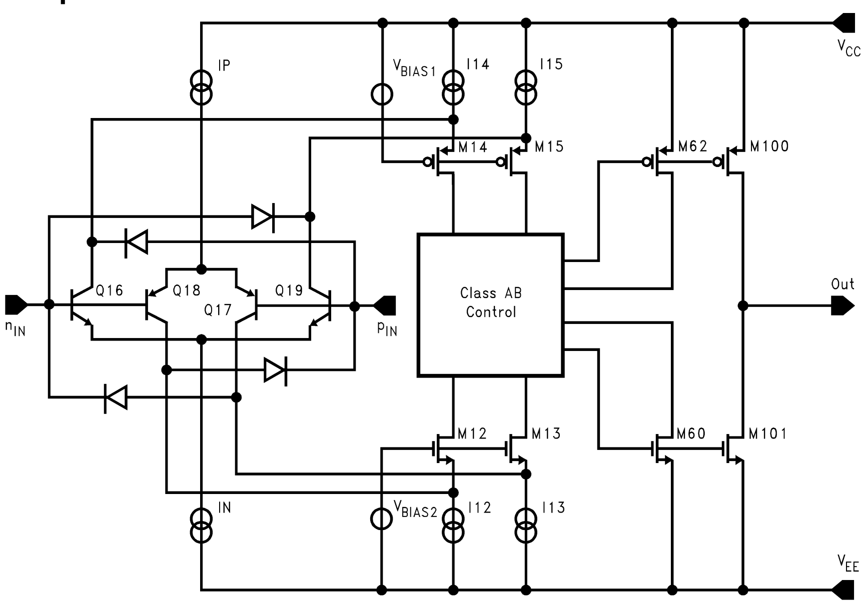


Figure 58. Rail-to-rail instrumentation amplifier

Simplified Schematic



Connection Diagrams

Top View

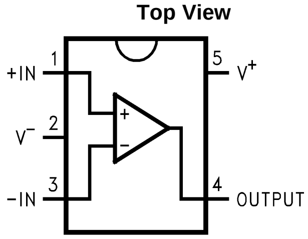


Figure 59. 5-Pin SC70-5/SOT-23-5 Package

Top View

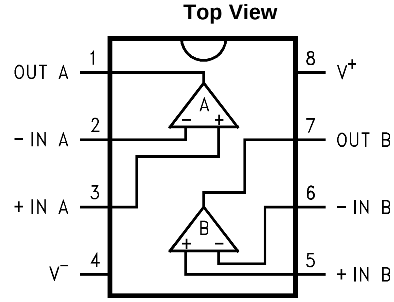


Figure 60. 8-Pin VSSOP/SOIC Package

Top View

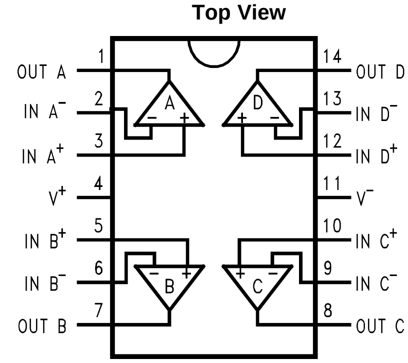


Figure 61. 14-Pin TSSOP/SOIC Package

REVISION HISTORY

Changes from Revision G (April 2013) to Revision H **Page**

- Changed layout of National Data Sheet to TI format 21

Products		**Applications**	
Audio	www.ti.com/audio	Automotive and Transportation	www.ti.com/automotive
Amplifiers	amplifier.ti.com	Communications and Telecom	www.ti.com/communications
Data Converters	dataconverter.ti.com	Computers and Peripherals	www.ti.com/computers
DLP® Products	www.dlp.com	Consumer Electronics	www.ti.com/consumer-apps
DSP	dsp.ti.com	Energy and Lighting	www.ti.com/energy
Clocks and Timers	www.ti.com/clocks	Industrial	www.ti.com/industrial
Interface	interface.ti.com	Medical	www.ti.com/medical
Logic	logic.ti.com	Security	www.ti.com/security
Power Mgmt	power.ti.com	Space, Avionics and Defense	www.ti.com/space-avionics-defense
Microcontrollers	microcontroller.ti.com	Video and Imaging	www.ti.com/video
RFID	www.ti-rfid.com		
OMAP Applications Processors	www.ti.com/omap	**TI E2E Community**	e2e.ti.com
Wireless Connectivity	www.ti.com/wirelessconnectivity		

Mailing Address: Texas Instruments, Post Office Box 655303, Dallas, Texas 75265