

Low-Noise Rail-to-Rail Operational Amplifier

Features

- Bandwidth: 10MHz
- Input Voltage Range: -0.2V to +5.7V($V_s = 5.5V$)
- Low input bias current: $\pm 1.0pA$ (Typ.)
- Supply Voltage Range: +2.1V to +5.6V
- Operating temperature range: -40°C to +125°C
- Slew Rate: 8.5V/ μs
- Input Offset Voltage: $\pm 0.5mV$ (Typ.)

Applications

- Active Filters, Sensors and Audio
- A/D Converters
- The mobile communication
- Cellular and Cordless Phones

General Description

The LMV721 (single) /LMV722 (dual) /LMV724 (quad) are operational amplifiers, which are optimized for low voltage, low noise and low power operation. These devices can operate from 2.1V to 5.6V single supply, and consume low quiescent current.

The LMV721/2/4 feature a 4mV maximum input offset voltage. The minimum input common mode voltage is within 0.1V below the negative rail, and the output swing is rail-to-rail with heavy loads. They exhibit a high gain-bandwidth product of 10MHz and a slew rate of 8.5V/ μs .

These specifications make the operational amplifiers appropriate for various applications.

Reference News

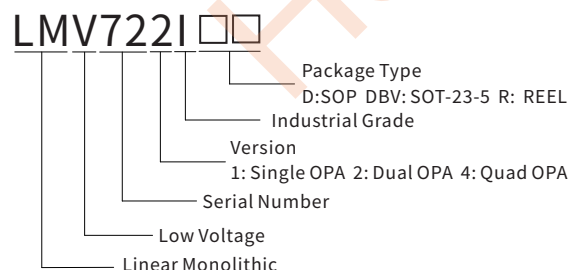
Marking:

LMV721IDBVR: V721A

LMV722IDR: R+O+LMV722+Date code

LMV724IDR: R+O+LMV724+Date code

Part Numbering



Ordering Information

Order Number	Package	Package Code	Unit Weight(g)	Reel(pcs)	Box(pcs)	Carton(pcs)	Delivery Mode	MSL
LMV721IDBVR	SOT-23-5	R1	0.0146	3000	30000	120000	7"	3
LMV722IDR	SOP-8	R3	0.077	4000	8000	80000	13"	3
LMV724IDR	SOP-14	R3	0.134	2500	5000	40000	13"	3

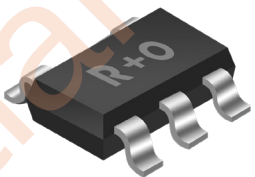
Supply Voltage

+2.1V ~ +5.6V

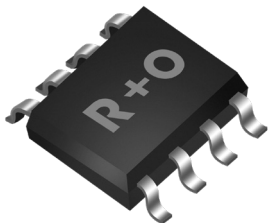
Offset Voltage

$\pm 0.5mV$

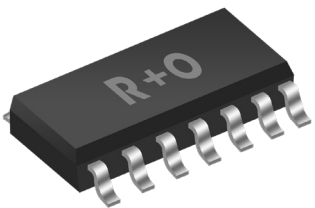
SOT-23-5



SOP-8

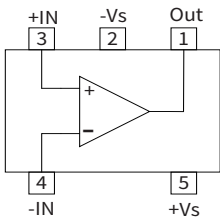


SOP-14

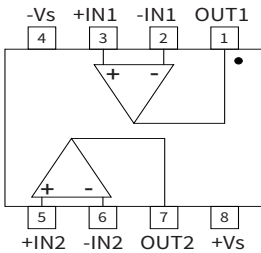


● Pin Configuration

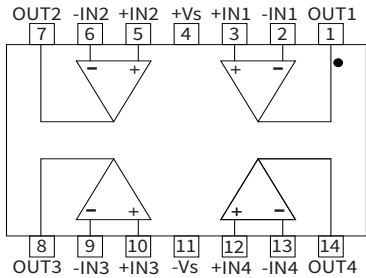
SOT-23-5



SOP-8



SOP-14



● Pin Description

Pin Name	Functional Description
OUT, OUT 1 to 4	Output of operational amplifier
IN-, IN 1- to IN 4-	Negative input of of operational amplifier
IN+, IN 1+ to IN 4+	Positive input of of operational amplifier
-Vs	Negative power supply
+Vs	Positive power supply

● Absolute Maximum Ratings (T_A = 25°C Unless otherwise specified)

Parameter	Symbol	Value	Unit
Supply Voltage, (+Vs)–(–Vs)	V _{CC}	7.0	V
Maximum Junction Temperature	T _J	150	°C
Input Voltage	V _{ICR}	(–Vs) – 0.5 to (+Vs) + 0.5	V
Operating Temperature Range	T _{OPR}	–45 to 85	°C
Storage Temperature Range	T _{STG}	–65 to 150	°C
Lead Temperature (Soldering, 10 sec)	T _L	260	°C

Stresses beyond those listed under Absolute Maximum Ratings may cause permanent damage to the device. Exposure to any Absolute Maximum Rating condition for extended periods may affect device reliability and lifetime. Electrostatic discharge can also cause damage to chips, so it is suggested to take some preventive measures for integrated circuits. Failure to follow proper handling and installation can also cause damage. Precision LMV722 and other devices are more vulnerable to damage than ordinary devices in the case of tiny electrostatic, and small parameter changes may make the whole circuit performance substandard.

● **Electrical Characteristics** ($V_S = 5V$, $R_L = 10k\Omega$, $V_{ICR} = V_S/2$, $V_{OUT} = V_S/2$, $T_A = 25^\circ C$, unless otherwise)

Parameter	Symbol	Conditions	Min.	Typ.	Max.	Unit
AC Specifications						
Gain-Bandwidth Product	GBW	$T_A = 25^\circ C$	--	10	--	MHz
Full-Power Bandwidth	BW_P	<1% distortion	--	400	--	KHz
Phase Margin	PM	$T_A = 25^\circ C$	--	62	--	Deg
Gain Margin	GM	$T_A = 25^\circ C$	--	-9	--	dB
Slew Rate	SR	$G = +1.2V$ Output Step	--	8.5	--	V/ μs
Input Voltage Noise Density	e_N	$f = 10kHz$	--	6.5	--	nV/ $\sqrt{Hz}$
DC Characteristics						
Input Offset Voltage	V_{OS}	$V_{CM} = V_S/2$	-2.5	± 0.5	2.5	mV
Input Bias Current	I_B	--	--	± 1	± 10	pA
Input Offset Current	I_{OS}	--	--	± 1	± 10	pA
Open-Loop Voltage Gain	A_{OL}	$R_L = 10K\Omega$, $V_{OUT} = +0.05V$ to $4.95V$	86	95	--	dB
Power Supply Rejection Ratio	PSRR	$V_S = 2.5V$ to $5.5V$, $V_{CM} = (-V_S) + 0.5V$	75	85	--	dB
Quiescent Current	I_Q	--	--	1.1	1.4	mA
Input Characteristics						
Common-mode Input Voltage Range	V_{CMR}	$V_S = 5.5V$	-0.1	--	5.6	V
Common Mode Rejection Ratio	CMRR	$V_S = 5.5V$, $V_{CM} = -0.1$ to $5.6V$	65	75	--	dB
Output Characteristics						
Output Current	I_O	$R_L = 10\Omega$, $V_O = V_S/2$	52	67	--	mA
Output Voltage Swing from Rail	V_{OH}	$R_L = 2k\Omega$	--	50	--	mV

Typical Applications

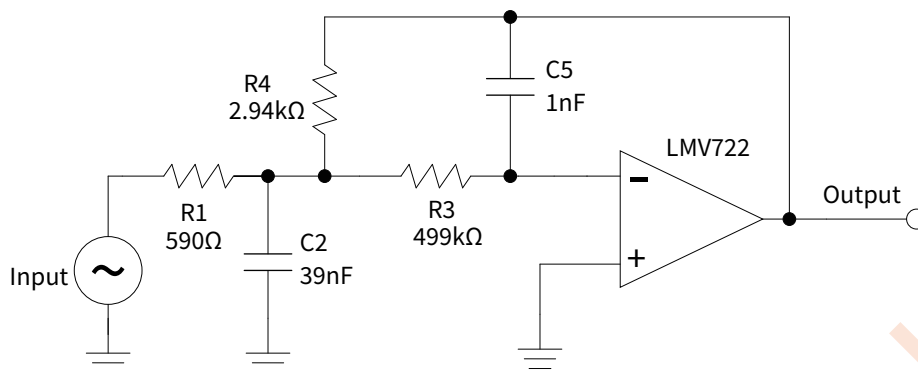


Figure 1.25-kHz Low-Pass Filter

Typical Performance Characteristics ($V_s = 5V$, $R_L = 100k\Omega$ connected to $V_s/2$, $T_A = 25^\circ C$)

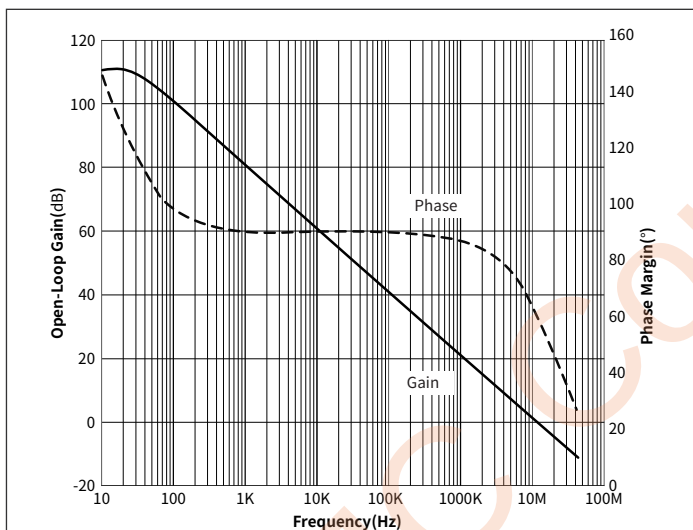


Fig.2 Open-Loop Gain and Phase vs Frequency

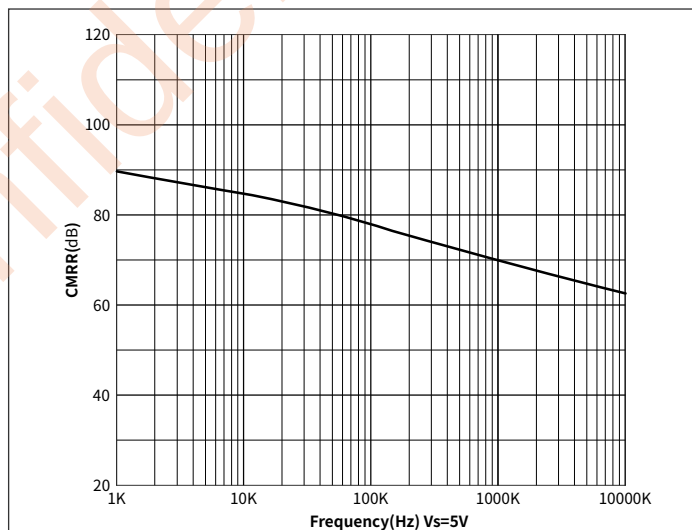


Fig.3 Common-Mode Rejection Ratio vs Frequency

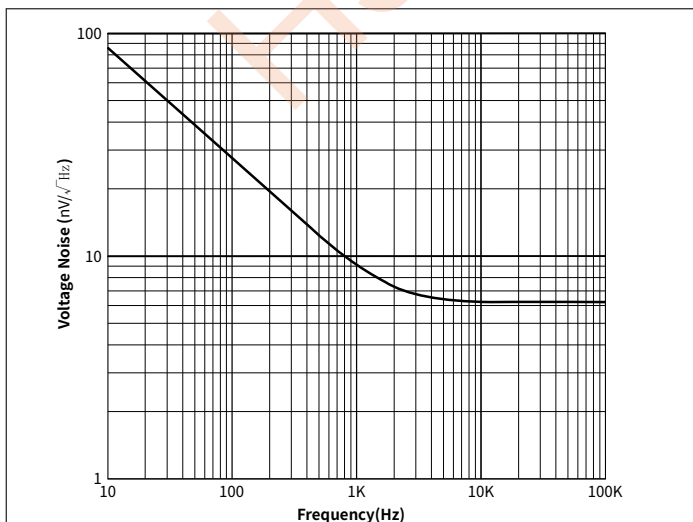


Fig.4 Input Voltage Noise Spectral Density vs Frequency

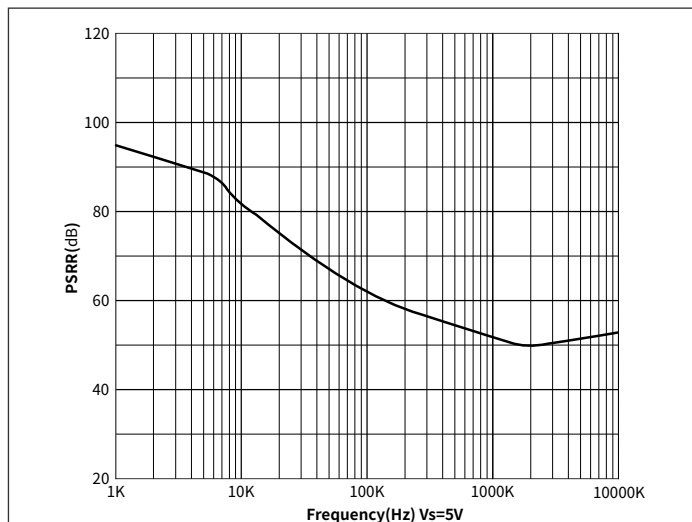


Fig.5 Power-Supply Rejection Ratio vs Frequency

● **Typical Performance Characteristics** ($V_S = 5V$, $R_L = 100k\Omega$ connected to $V_S/2$, $T_A = 25^\circ C$)

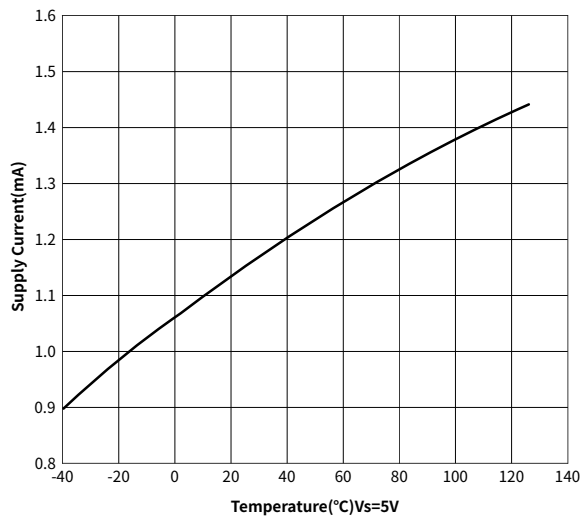


Fig.6 Quiescent Current vs Temperature

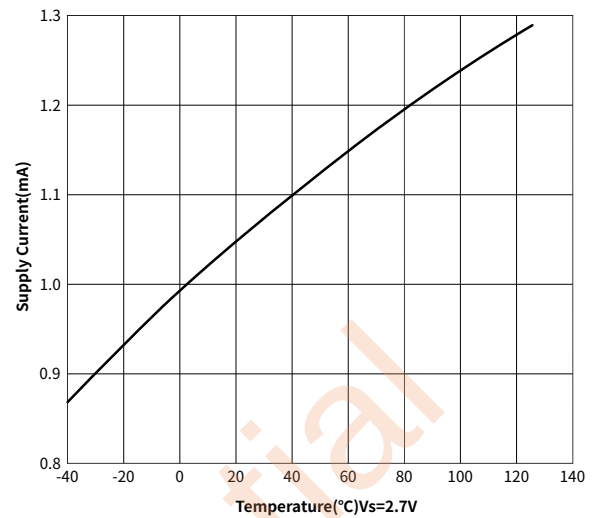


Fig.7 Quiescent Current vs Temperature

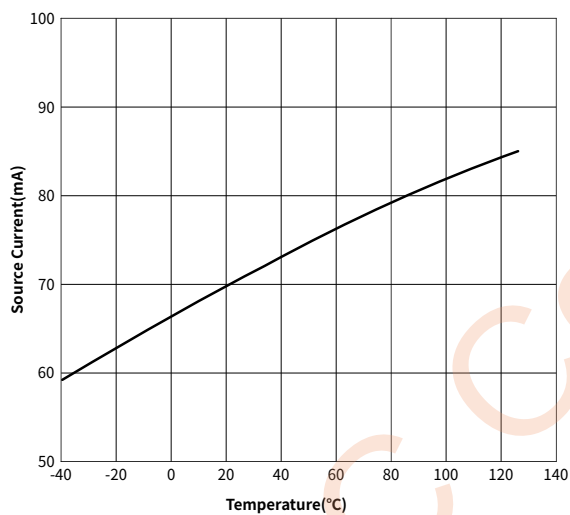


Fig.8 Source Current vs Temperature

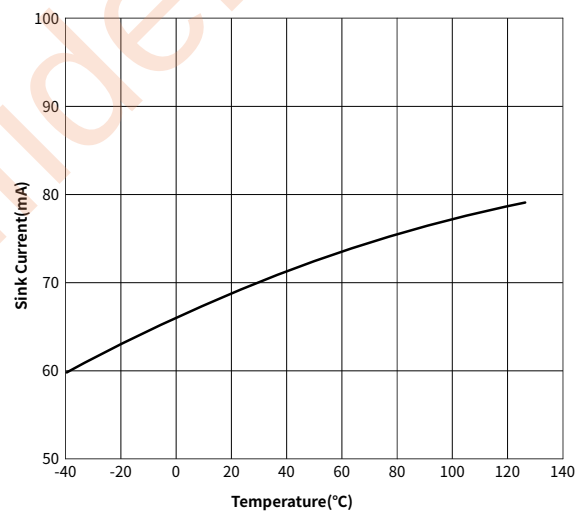


Fig.9 Sink Current vs Temperature

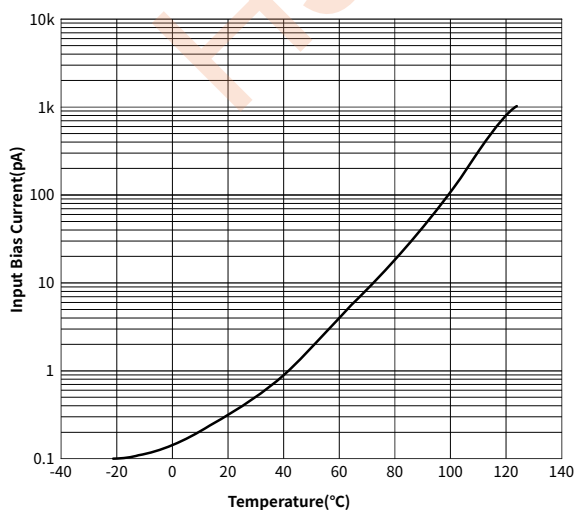


Fig.10 Input Bias Current vs Temperature

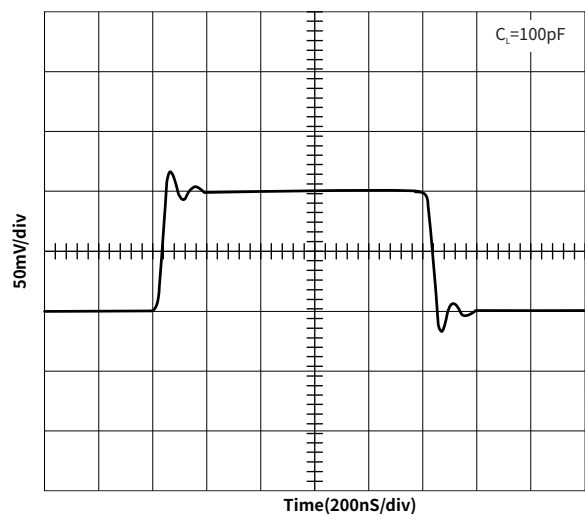
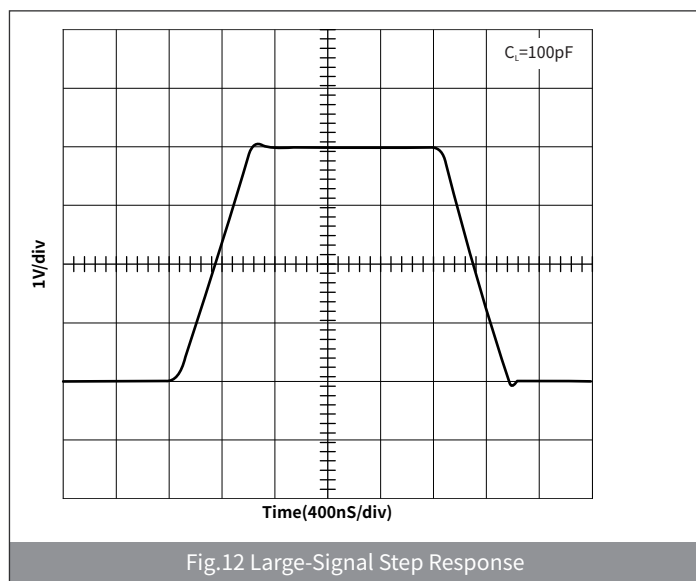
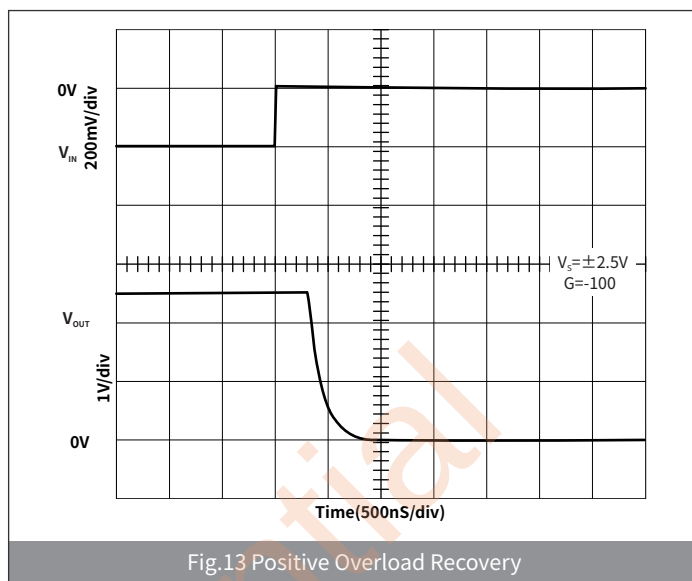
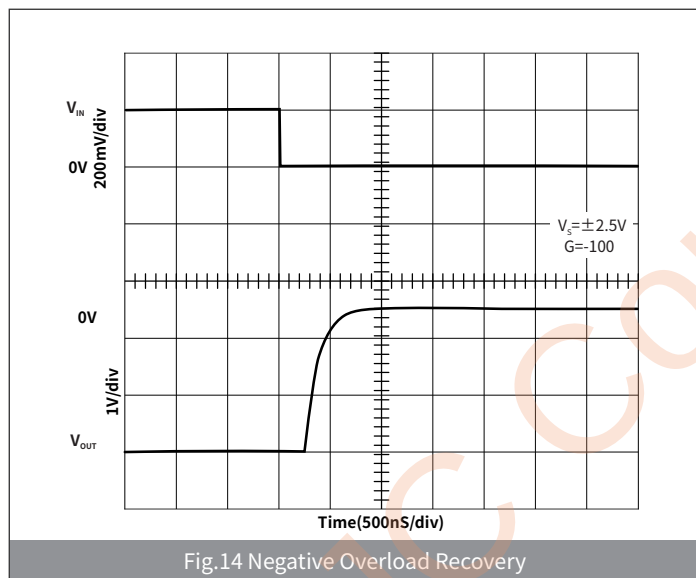
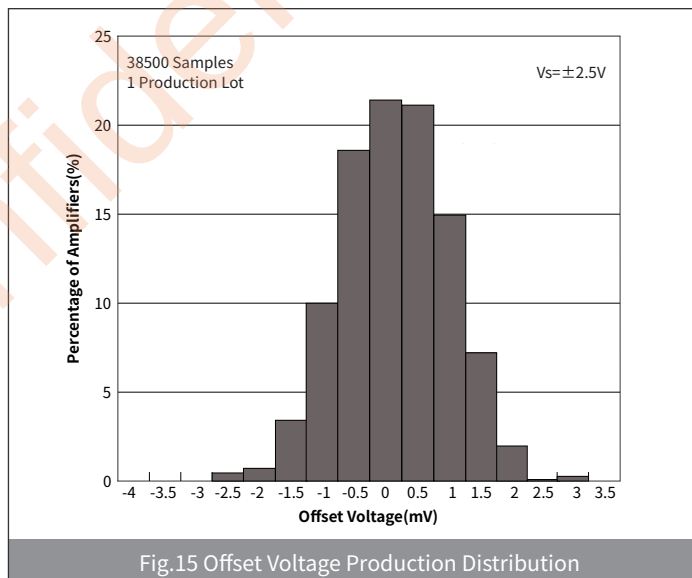


Fig.11 Small-Signal Step Response

● Typical Performance Characteristics ($V_S = 5V$, $R_L = 100k\Omega$ connected to $V_S/2$, $T_A = 25^\circ C$)



● Application Information

Phase Reversal Protection

The LMV721/LMV722/LMV724 family has internal phase-reversal protection. Many op amps exhibit phase reversal when the input is driven beyond the linear common-mode range. This condition is most often encountered in noninverting circuits when the input is driven beyond the specified common-mode voltage range, causing the output to reverse into the opposite rail. The input of the LMV721/LMV722/LMV724 prevents phase reversal with excessive common-mode voltage. Instead, the appropriate rail limits the output voltage. This performance is shown in figure 16.

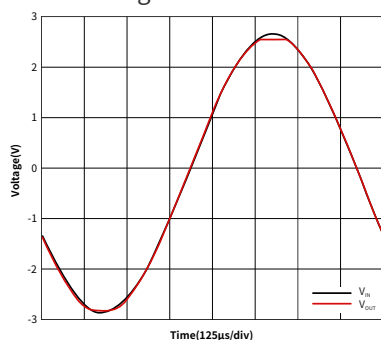


Figure 16. Output Waveform Devoid of Phase Reversal During an Input Overdrive Condition

EMI Rejection Ratio (EMIRR)

The electromagnetic interference (EMI) rejection ratio, or EMIRR, describes the EMI immunity of operational amplifiers. An adverse effect that is common to many operational amplifiers is a change in the offset voltage as a result of RF signal rectification. An operational amplifier that is more efficient at rejecting this change in offset as a result of EMI has a higher EMIRR and is quantified by a decibel value. Measuring EMIRR can be performed in many ways, but this document provides the EMIRR IN+, which specifically describes the EMIRR noninverting input pin of the operational amplifier.

In general, only the noninverting input is tested for EMIRR for the following three reasons:

- Operational amplifier input pins are known to be the most sensitive to EMI, and typically rectify RF signals better than the supply or output pins.
- The noninverting and inverting operational amplifier inputs have symmetrical physical layouts and exhibit nearly matching EMIRR performance.

EMIRR is easier to measure on noninverting pins than on other pins because the noninverting input pin can be isolated on a printed-circuit-board (PCB). This isolation allows the RF signal to be applied directly to the noninverting input pin with no complex interactions from other components or connecting PCB traces.

The EMIRR IN+ of the LMV721/LMV722/LMV724 is plotted versus frequency in Figure 17. If available, any dual and quad operational amplifier device versions have approximately identical EMIRR IN+ performance. The LMV721/LMV722/LMV724 unity-gain bandwidth is 10MHz. EMIRR performance below this frequency denotes interfering signals that fall within the operational amplifier bandwidth.

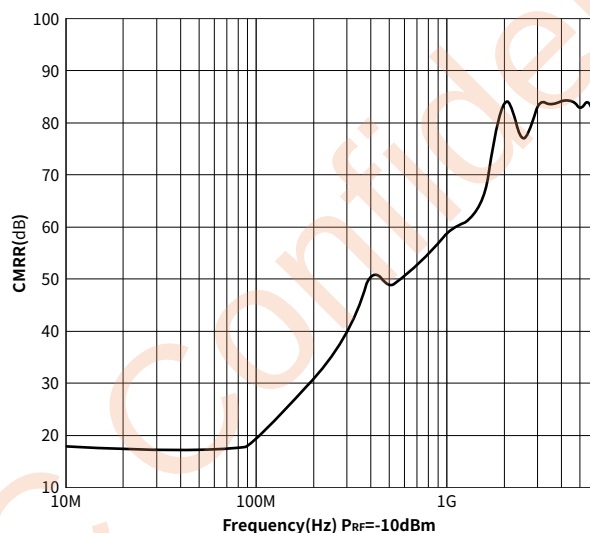


Figure 17. LMV721/LMV722/LMV724 EMIRR vs Frequency

EMIRR IN+ Test Configuration

Figure 18 shows the circuit configuration for testing the EMIRR IN+. RF source is connected to the operational amplifier noninverting input pin using a transmission line. The operational amplifier is configured in a unity-gain buffer topology with the output connected to a low-pass filter (LPF) and a digital multimeter (DMM). A large impedance mismatch at the operational amplifier input causes a voltage reflection; however, this effect is characterized and accounted for when determining the EMIRR IN+. The resulting dc offset voltage is sampled and measured by the multimeter. The LPF isolates the multimeter from residual RF signals that can interfere with multimeter accuracy.

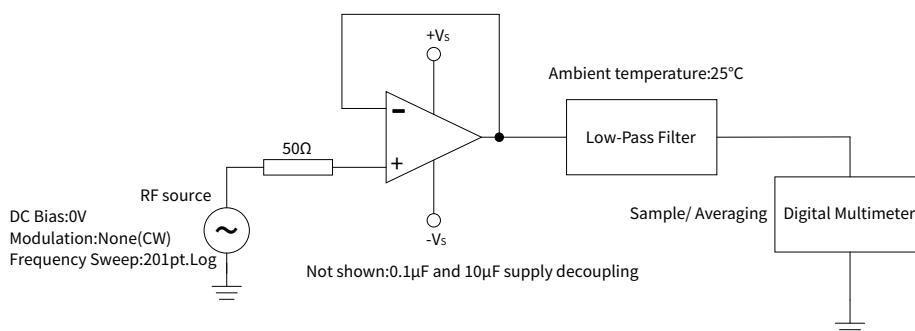


Figure 18. EMIRR IN+ Test Configuration Schematic

Application Note

The LMV721/LMV722/LMV724 are high precision, rail-to-rail operational amplifiers that can be run from a single-supply voltage 2.5V to 5.5V ($\pm 1.25V$ to $\pm 2.75V$). Supply voltages higher than 7V(absolute maximum) can permanently damage the amplifier. Rail-to-rail input and output swing significantly increases dynamic range, especially in low-supply applications. Good layout practice mandates use of a 0.1 μF capacitor place closely across the supply pins.

Design Requirements

Low-pass filters are commonly employed in signal processing applications to reduce noise and prevent aliasing. The LMV721/LMV722/LMV724 devices are ideally suited to construct high-speed, high-precision active filters. Figure 1 shows a second-order,

- Gain = 5 V/V (inverting gain)
- Low-pass cut off frequency = 25 kHz
- Second-order Chebyshev filter response with 3-dB gain peaking in the passband

Detailed Design Procedure

The infinite-gain multiple-feedback circuit for a low-pass network function is shown in Figure 1. Use Equation 1 to calculate the voltage transfer function:

$$\frac{V_{OUT}}{V_{IN}}(S) = \frac{-1/R_1 R_3 C_2 C_5}{S^2 + (S/C_2)(1/R_1 + 1/R_3 + 1/R_4) + 1/R_3 R_4 C_2 C_5}$$

This circuit produces a signal inversion. For this circuit, the gain at dc and the low-pass cut off frequency are calculated by Equation 2:

$$\text{Gain} = \frac{R_4}{R_1} \quad f_c = \frac{1}{2\pi} \sqrt{1/R_3 R_4 C_2 C_5}$$

Application Curve

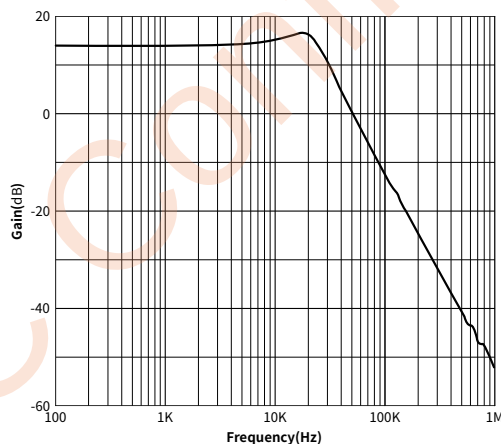


Figure 19. Low-Pass Filter Transfer Function

Layout Guidelines

Attention to good layout practices is always recommended. Keep traces short. When possible, use a PCB ground plane with surface-mount components placed as close to the device pins as possible. Place a 0.1 μF capacitor closely across the supply pins. These guidelines should be applied throughout the analog circuit to improve performance and provide benefits such as reducing the EMI susceptibility.

● Package Outline Dimensions (SOT-23-5)

Symbol	Dimensions			
	Millimeters		Inches	
	Min.	Max.	Min.	Max.
A	1.05	1.25	0.041	0.049
A1	0	0.13	0.000	0.005
A2	1.05	1.15	0.041	0.045
b	0.3	0.5	0.012	0.020
c	0.10	0.2	0.004	0.008
D	2.82	3.02	0.111	0.119
E	1.50	1.70	0.059	0.067
E1	2.65	2.95	0.104	0.116
e	0.95 BSC		0.037BSC	
e1	1.90 BSC		0.075 BSC	
L	0.3	0.60	0.012	0.024
θ	0	8°	0	8°

● Suggested Pad Layout

Symbol	Dimensions			
	Millimeters		Inches	
	Min.	Max.	Min.	Max.
X	0.85	0.85	0.033	0.033
Y	0.90	1.10	0.035	0.043
M	0.85	1.05	0.033	0.041
M1	1.80	2.0	0.071	0.079
N	2.3	2.5	0.091	0.098

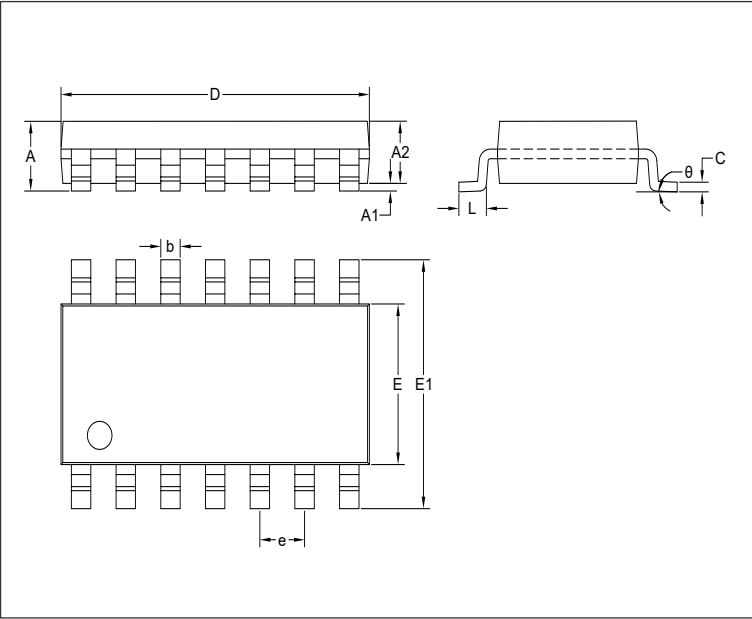
● Package Outline Dimensions (SOP-8)

Symbol	Dimensions			
	Millimeters		Inches	
	Min.	Max.	Min.	Max.
A	5.70	6.30	0.224	0.248
B	5.13MAX.		0.202MAX.	
C	4.72	5.12	0.186	0.201
E	1.80MAX.		0.071MAX.	
F	0.31	0.51	0.0122	0.020
F1	1.27TYP.		0.050TYP.	
G	3.75	4.15	0.148	0.163
H	1.35	1.65	0.053	0.065
H1	0.1	0.25	0.004	0.010
L	0.3	0.7	0.012	0.028
L1	0.21TYP.		0.008TYP.	
θ	-	8°	-	8°

● Suggested Pad Layout

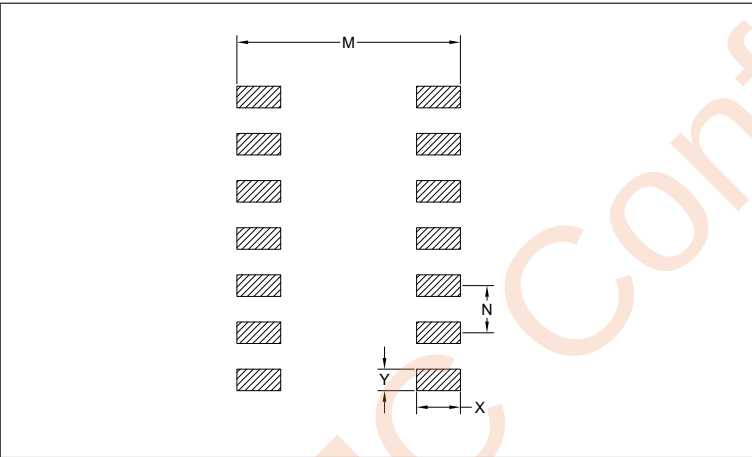
Symbol	Dimensions			
	Millimeters		Inches	
	Min.	Max.	Min.	Max.
a	2.90	3.10	0.114	0.122
J	5.10	5.30	0.201	0.209
K	1.17	1.37	0.046	0.054
X	2.10	2.30	0.083	0.091
X1	7.30	7.50	0.287	0.295
Y	0.50	0.70	0.020	0.028
Y1	3.71	3.91	0.146	0.154

● Package Outline Dimensions (SOP-14)



Symbol	Dimensions			
	Millimeters		Inches	
	Min.	Max.	Min.	Max.
A	1.35	1.75	0.053	0.069
A1	0.10	0.25	0.004	0.010
A2	1.35	1.55	0.053	0.061
b	0.33	0.51	0.013	0.020
c	0.17	0.25	0.007	0.010
D	8.36	8.76	0.329	0.345
E	3.80	4.00	0.150	0.157
E1	5.80	6.20	0.228	0.244
e	1.27BSC		0.050BSC	
L	0.40	1.27	0.016	0.050
θ	0°	8°	0°	8°

● Suggested Pad Layout



Symbol	Dimensions			
	Millimeters		Inches	
	Min.	Max.	Min.	Max.
X	-	1.18	-	0.046
Y	-	0.58	-	0.023
N	-	1.27	-	0.050
M	-	6.5	-	0.256