National Semiconductor

December 1999

LMV101/102/105/110
Fixed-Gain Amplifiers

General Description

The LMV101/102/105/110 fixed-gain amplifier family integrates a rail-to-rail op amp, two internal gain-setting resistors and a V⁺/2 bias circuit into one ultra tiny package, SC70-5 or SOT23-5. Fixed inverting gains of −1, −2, −5, and −10 are available.

The core op amp in this series is an LMV321, which provides rail-to-rail output swing, excellent speed-power ratio, 1MHz bandwidth, and 1V/µs of slew rate with low supply current.

The LMV101/102/105/110 family reduces external component count. It is the most cost effective solution for applications where low voltage operation, low power consumption, space savings, and reliable performance are needed. It enables the design of small portable electronic devices, and allows the designer to place the device closer to the signal source to reduce noise pickup and increase signal integrity.

Features

(For 5V Supply, Typical Unless Otherwise Noted)
■ Fixed inverting gain available   −1,−2,−5,−10
■ DC gain accuracy @2.7V supply
  — LMV101/102/105   2% (typ)
  — LMV110   6% (typ)
■ Space saving packages   SC70-5 & SOT23-5
■ Industrial temperature range   −40˚C to +85˚C
■ Low supply current   130µA
■ Rail-to-Rail output swing
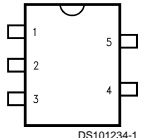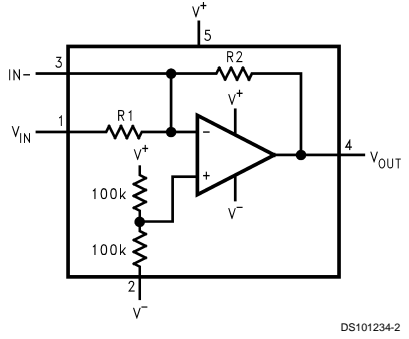■ Guaranteed 2.7V and 5V performance

Applications

■ General purpose portable devices
■ Mobile communications
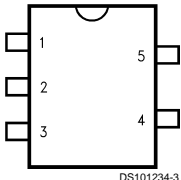■ Battery powered electronics
■ Active filters
■ Microphone preamplifiers

Typical Application

Phase Inverting AC Amplifier

DS101234-10

$$V_{OUT} = 0.5V_{CC} - V_{IN} (R_2/R_1)$$

LMV101/102/105/110
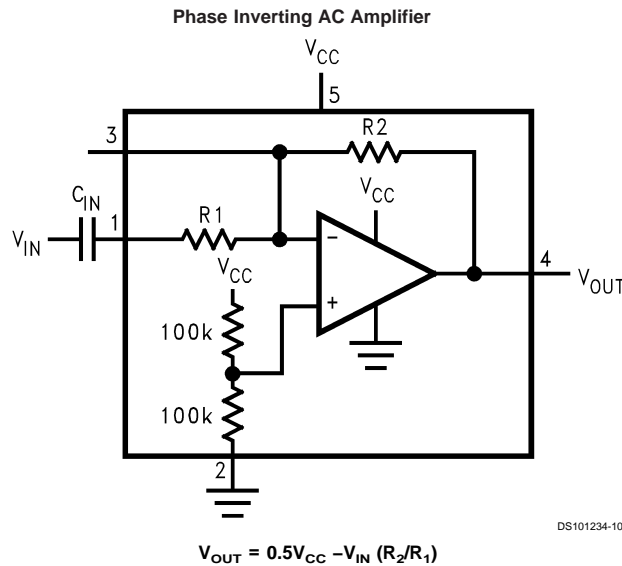
Connection Diagrams

DS101234-2

5-Pin SC70-5 (M7)

5-Pin SOT23-5 (M5)

Ordering Information

Package	Part number	Marking	DC Gain	R1	R2	Transport Media	NSC Drawing
SC70-5	LMV101M7	A38	−1	100k	100k	1k Units Tape and Reel	MAA05A
	LMV101M7X					3k Units Tape and Reel	
	LMV102M7	A39	−2	100k	200k	1k Units Tape and Reel	
	LMV102M7X					3k Units Tape and Reel	
	LMV105M7	A40	−5	50k	250k	1k Units Tape and Reel	
	LMV105M7X					3k Units Tape and Reel	
	LMV110M7	A41	−10	10k	100k	1k Units Tape and Reel	
	LMV110M7X					3k Units Tape and Reel	
SOT23-5	LMV101M5	A33A	−1	100k	100k	1k Units Tape and Reel	MA05B
	LMV101M5X					3k Units Tape and Reel	
	LMV102M5	A34A	−2	100k	200k	1k Units Tape and Reel	
	LMV102M5X					3k Units Tape and Reel	
	LMV105M5	A35A	−5	50k	250k	1k Units Tape and Reel	
	LMV105M5X					3k Units Tape and Reel	
	LMV110M5	A36A	−10	10k	100k	1k Units Tape and Reel	
	LMV110M5X					3k Units Tape and Reel	

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	1500V
Supply Voltage (V^+ - V^-)	5.5V
Output Short Circuit to V^+	(Note 3)
Output Short Circuit to V^-	(Note 4)
Mounting Temperature	
Infrared or Convection (20 sec)	235˚C

Storage Temperature Range	-65˚C to 150˚C
Junction Temperature (T_J, max) (Note 5)	150˚C

Operating Ratings (Note 1)

Supply Voltage	2.7V to 5.0V
Temperature Range	$-40˚C \leq T_J \leq 85˚C$
Thermal resistance (θ_{JA})	
5-pin SC70-5	478˚C/W
5-pin SOT23-5	265˚C/W

2.7V Electrical Characteristics

Unless otherwise specified, all limits guaranteed for T_J = 25˚C, V^+ = 2.7V, V^- = 0V, V_O = V^+/2 and R_L > 1MΩ. **Boldface** limits apply at the temperature extremes.

Symbol	Parameter	Conditions	Typ (Note 6)	Max (Note 7)	Units
V_O	Output Swing	R_L = 10kΩ to 1.35V	V^+−0.01	V^+−0.1	V min
			0.08	0.18	V max
I_S	Supply Current		80	170	µA max
	DC Gain Accuracy	LMV101, Gain = −1	2	**5**	%
		LMV102, Gain = −2	2	**5**	%
		LMV105, Gain = −5	2	**6**	%
		LMV110, Gain = −10	6	**12**	%
GBW	−3dB Bandwidth	LMV101, Gain = −1, R_L = 2kΩ, C_L = 100pF	1.6		MHz
		LMV102, Gain = −2, R_L = 2kΩ, C_L = 100pF	1.8		MHz
		LMV105, Gain = −5, R_L = 2kΩ, C_L = 100pF	0.8		MHz
		LMV110, Gain = −10, R_L = 2kΩ, C_L = 100pF	0.2		MHz

5V Electrical Characteristics

Unless otherwise specified, all limits guaranteed for T_J = 25˚C, V^+ = 5V, V^- = 0V, V_O = V^+/2 and R_L > 1MΩ. **Boldface** limits apply at the temperature extremes.

Symbol	Parameter	Conditions	Typ (Note 6)	Max (Note 7)	Units
V_O	Output Swing	R_L = 2kΩ to 2.5V	V^+−0.04	V^+−0.3 **V^+−0.4**	V min
			0.14	0.3 **0.4**	V max
		R_L = 10kΩ to 2.5V	V^+−0.01	V^+−0.1 **V^+−0.2**	V min
			0.1	0.18 **0.28**	V max
I_O	Output Current	Sourcing, V_O = 0V	60	5	mA min
		Sinking, V_O = 5V	160	10	mA min

LMV101/102/105/110

5V Electrical Characteristics (Continued)

Unless otherwise specified, all limits guaranteed for T_J = 25˚C, V^+ = 5V, V^- = 0V, V_O = V^+/2 and R_L > 1MΩ. **Boldface** limits apply at the temperature extremes.

Symbol	Parameter	Conditions	Typ (Note 6)	Max (Note 7)	Units
I_S	Supply Current		130	250 **350**	µA max
	DC Gain Accuracy	LMV101, Gain = −1	3.5	**5**	%
		LMV102, Gain = −2	3.5	**5**	%
		LMV105, Gain = −5	3.5	**6**	%
		LMV110, Gain = −10	9.0	**12**	%
SR	Slew Rate	(Note 8)	1		V/µs
GBW	−3dB Bandwidth	LMV101, Gain = −1, R_L = 2kΩ, C_L = 100pF	1.6		MHz
		LMV102, Gain = −2, R_L = 2kΩ, C_L = 100pF	1.8		MHz
		LMV105, Gain = −5, R_L = 2kΩ, C_L = 100pF	0.8		MHz
		LMV110, Gain = −10, R_L = 2kΩ, C_L = 100pF	0.2		MHz

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, 1.5kΩ in series with 100pF. Machine model, 0Ω in series with 100pF.

Note 3: Shorting circuit output to V^+ will adversely affect reliability.

Note 4: Shorting circuit output to V^- will adversely affect reliability.

Note 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.

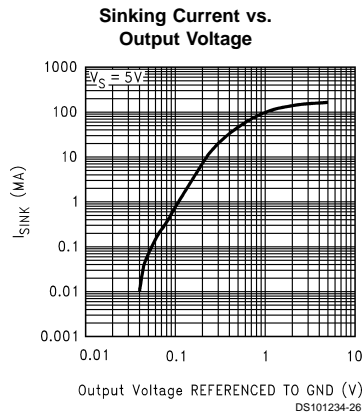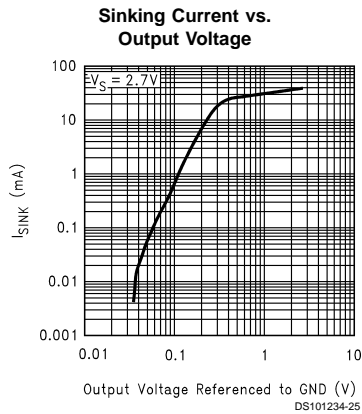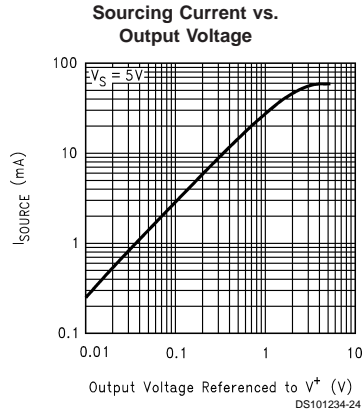**Note 6:** Typical Values represent the most likely parametric norm.

Note 7: All limits are guaranteed by testing or statistical analysis.

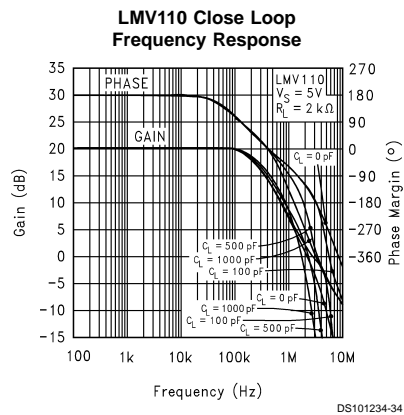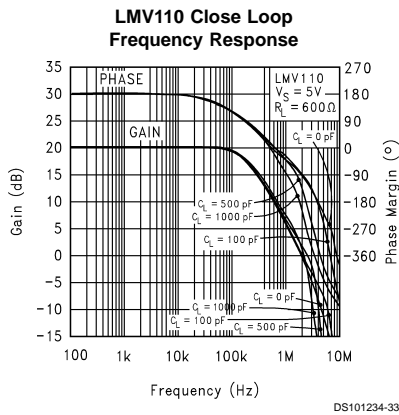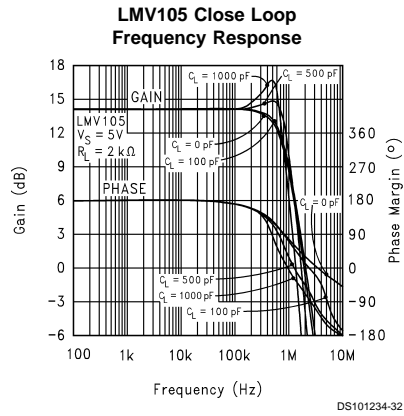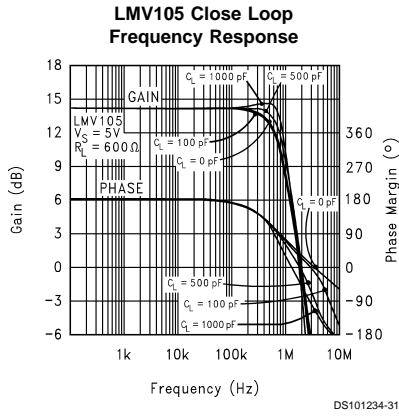**Note 8:** Number specified is the slower of the positive and negative slew rates.

Typical Performance Characteristics (Unless otherwise specified, V_S = +5V, single supply, T_A = 25˚C.)

Supply Current vs. Supply Voltage

DS101234-22
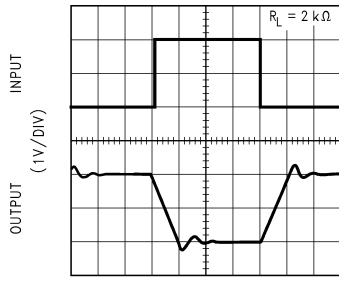
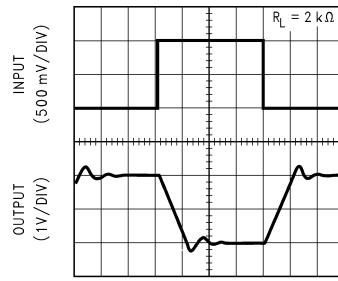Sourcing Current vs. Output Voltage

DS101234-23

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4

Typical Performance Characteristics (Unless otherwise specified, V_S = +5V, single supply, T_A = 25˚C.) (Continued)

Sourcing Current vs. Output Voltage

DS101234-24

Sinking Current vs. Output Voltage

DS101234-25

Sinking Current vs. Output Voltage

DS101234-26

Output Voltage Swing vs. Supply Voltage

DS101234-21

LMV101 Close Loop Frequency Response

DS101234-27

LMV101 Close Loop Frequency Response

DS101234-28

Typical Performance Characteristics (Unless otherwise specified, V_S = +5V, single supply, T_A = 25˚C.) (Continued)

LMV102 Close Loop Frequency Response

DS101234-29

LMV102 Close Loop Frequency Response

DS101234-30

LMV105 Close Loop Frequency Response

DS101234-31

LMV105 Close Loop Frequency Response

DS101234-32

LMV110 Close Loop Frequency Response

DS101234-33

LMV110 Close Loop Frequency Response

DS101234-34
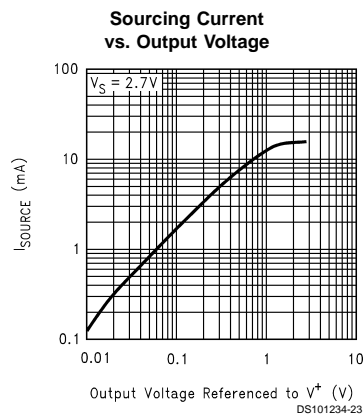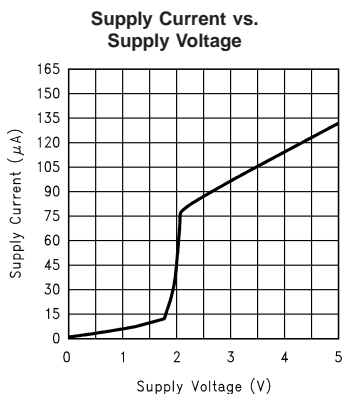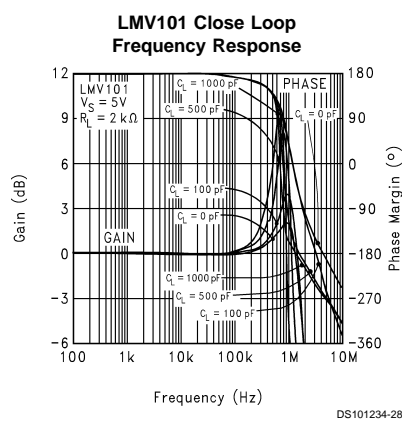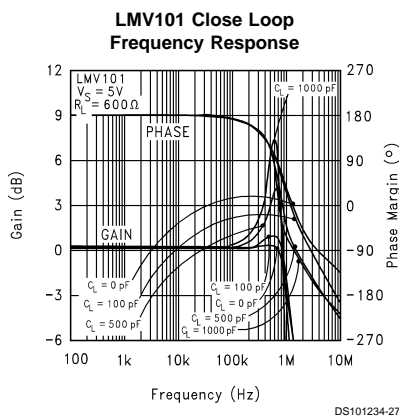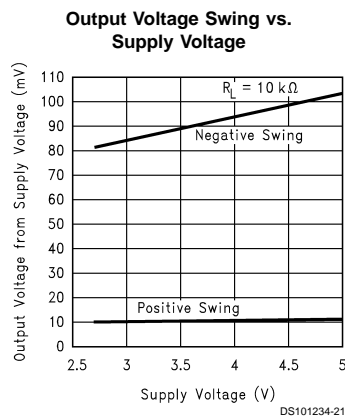
# Typical Performance Characteristics (Unless otherwise specified, V_S = +5V, single supply, T_A = 25˚C.) (Continued)

**Inverting Large Signal Pulse Response
LMV101**

DS101234-35

**Inverting Large Signal Pulse Response
LMV102**

DS101234-37

**Inverting Large Signal Pulse Response
LMV105**
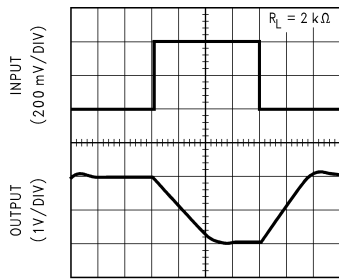
DS101234-39

**Inverting Large Signal Pulse Response
LMV110**
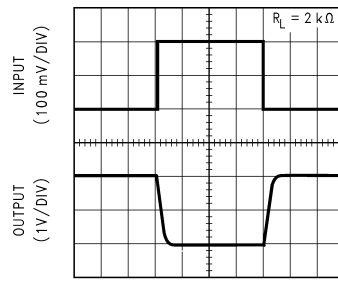
DS101234-41

**Inverting Small Signal Pulse Response
LMV101**
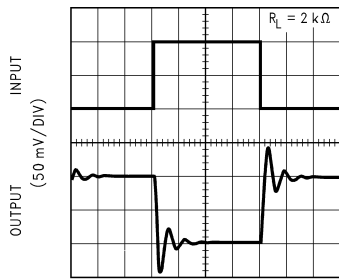
DS101234-36

**Inverting Small Signal Pulse Response
LMV102**
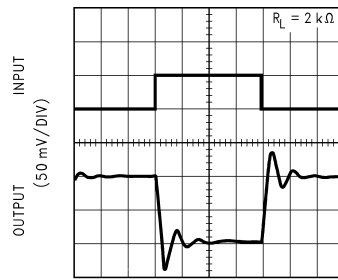
DS101234-38

Typical Performance Characteristics (Unless otherwise specified, V_S = +5V, single supply, T_A = 25˚C.) (Continued)

Inverting Small Signal Pulse Response LMV105

DS101234-40

Inverting Small Signal Pulse Response LMV110

DS101234-42
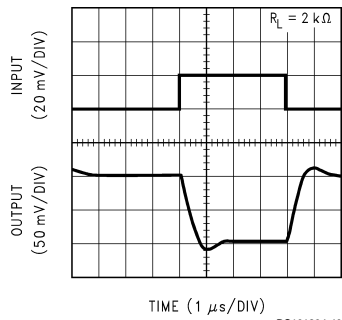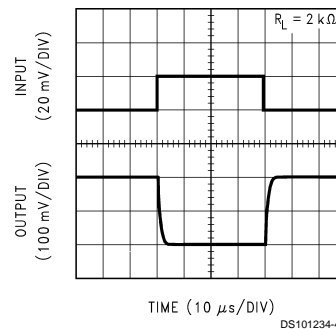
Slew Rate vs. Supply Voltage

DS101234-43
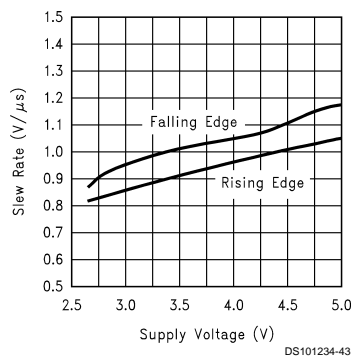
Application Notes

The LMV101/102/105/110 integrates a rail-to-rail op amp, two internal gain-setting resistors and a $V^+/2$ bias circuit into one ultra tiny package, SC70-5 or SOT23-5. With its small footprint and reduced component count for gain stage, it enables the design of smaller portable electronic products, such as cellular phones, pagers, PDAs, PCMCIA cards, etc. In addition, the integration solution minimizes printed circuit board stray capacitance, and reduces the complexity of circuit design.

The core op amp of this family is National's LMV321.

1.0 Supply Bypassing

The application circuits in this datasheet do not show the power supply connections and the associated bypass capacitors for simplification. When the circuits are built, it is always required to have bypass capacitors. Ceramic disc capacitors (0.1µF) or solid tantalum (1µF) with short leads, and located close to the IC are usually necessary to prevent interstage coupling through the power supply internal impedance. Inadequate bypassing will manifest itself by a low frequency oscillation or by high frequency instabilities. Sometimes, a 10µF (or larger) capacitor is used to absorb low frequency variations and a smaller 0.1µF disc is paralleled across it to prevent any high frequency feedback through the power supply lines.

2.0 Input Voltage Range

The input voltage should be within the supply rails. The ESD protection circuitry at the input of the device includes a diode between the input pin and the negative supply pin. Driving the input more than 0.6V (at 25˚C) beyond the negative supply will turn on the diode and cause signal distortions. For applications that require sensing voltages beyond the negative rail, use the LMV111 with external gain setting resistors.

# Application Notes (Continued)

3.0 Capacitive Load Tolerance

The LMV101/102/105/110 can directly drive 200pF capacitive load with Vs = 5V at −1 gain configuration without oscillation. Direct capacitive loading reduces the phase margin of amplifiers. The combination of the amplifier's output impedance and the capacitive load induces phase lag. This results in either an underdamped pulse or oscillation. To drive a heavier capacitive load, a resistive isolation can be used as shown in *Figure 1*.
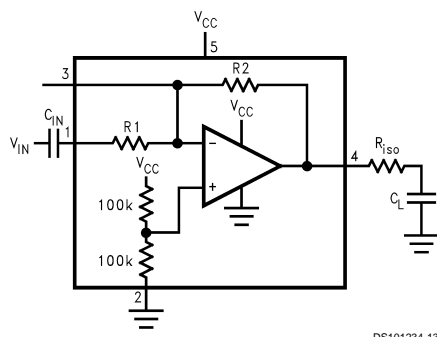
DS101234-13

FIGURE 1. Resistive Isolation of a Heavy Capacitive Load

The isolation resistor R_{iso} and the C_L form a pole to increase stability by adding more phase margin to the overall system. The desired performance depends on the value of R_{iso}. The bigger the R_{iso} resistor value, the more stable V_{OUT} will be. *Figure 2* is an output waveform of *Figure 1* using 100Ω for R_{iso} and 1000pF for C_L.
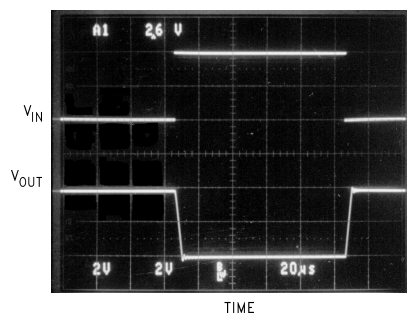
DS101234-12

FIGURE 2. Pulse Response of LMV101 in *Figure 1*

4.0 Phase Inverting AC Amplifier

A single supply phase inverting AC amplifier can be easily built with the LMV101/102/105/110 series (*Figure 3*). The output voltage is biased at mid-supply, and AC input signal is amplified by (R_2/R_1). Capacitor C_{IN} acts as an input AC coupling capacitor to block DC potentials. A capacitor of 0.1μF or

larger can be used. The output can swing rail-to-rail. To avoid output distortion, the peak-to-peak amplitude of the input AC signal should be less than $V_{CC}(R_1/R_2)$.
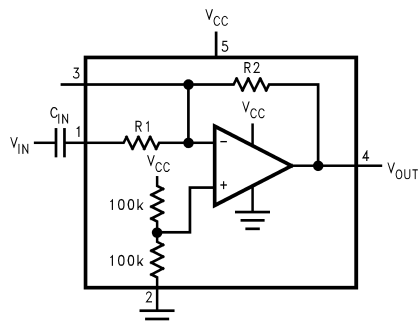
DS101234-10

FIGURE 3. Phase Inverting AC Amplifier

It is recommended that a small-valued capacitor be used across the feedback resistor (R_2) to eliminate stability problems, prevent peaking of the response, and limit the bandwidth of the circuit. This can also help to reduce high frequency noise and some other interference. (See *Figure 4*)
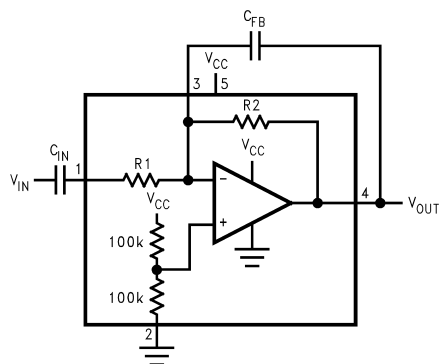
DS101234-11

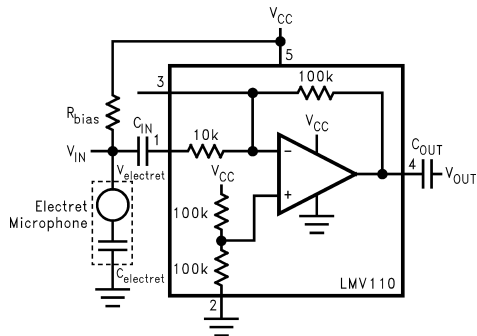**FIGURE 4.**

5.0 Microphone preamplifier

Most microphones have a low output voltage level. This output signal needs to be amplified so that it can feed the next stage with optimal level. *Figure 5* shows a microphone preamplifier circuit with the LMV110. This microphone preamplifier can provide 20dB gain. It can be implemented in PCs, PDAs, and mobile phones.

Input capacitor C_{IN} serves two important functions. First, it blocks any DC voltage from the previous stage to prevent the output from shifting to some unwanted DC level. This could cause the output to saturate when audio signal is applied at the input. Second, the C_{IN} and the 10k input resistor form a low pass filter to block any low frequency noise. The cut-off frequency of this low pass filter is given by,

$$f = \frac{1}{2\pi R_1 C_{IN}}$$

where R_1 = 10kΩ in LMV110. Output capacitor C_{OUT} is used to block the DC output from the next stage. R_{bias} is selected according to the microphone requirement.
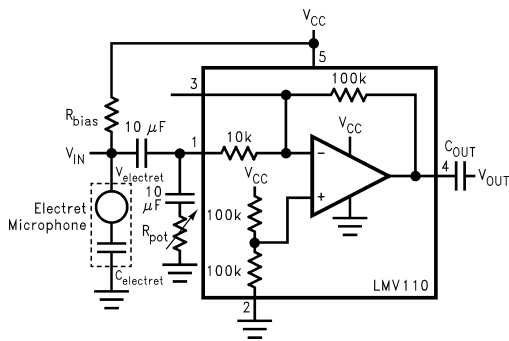
Physical Dimensions inches (millimeters) unless otherwise noted

2±0.1

C

SYMM C̸L

0.65

3   2   1

B

1.8−2.4

1.25±0.1

4   5

0.15−0.3 TYP

1.3

⊕ 0.1 Ⓜ A B Ⓢ C Ⓢ

SYMM C̸L

(0.65)

(1.9)

(0.75 TYP)

(0.4 TYP)

(1.3)

LAND PATTERN RECOMMENDATION

(0.9)

0.8−1.1

A

△ 0.1 A

SEATING PLANE

0−0.1

R0.025 MIN

R0.025 MIN

GAGE PLANE

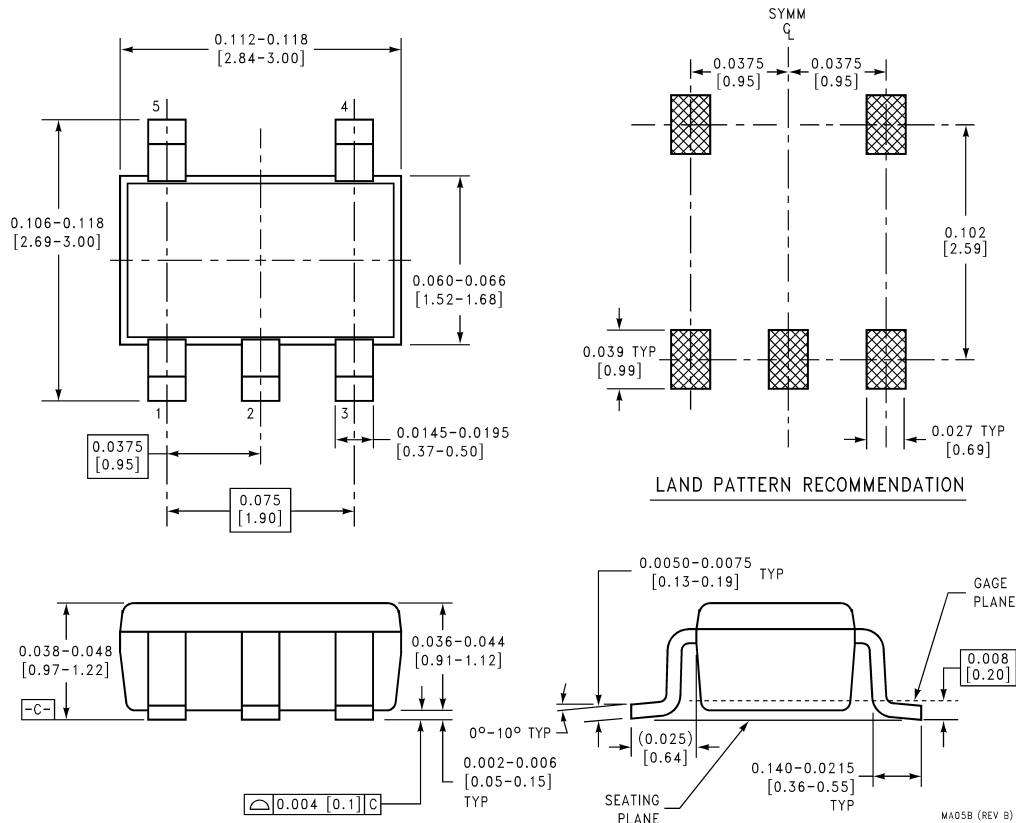0.2

0.1−0.20

0°−5° TYP

0.40±0.05

(0.515)

DIMENSIONS ARE IN MILLIMETERS

MAA05A (REV B)

5-Pin SC70-5 Tape and Reel
Order Numbers LMV101M7, LMV101M7X, LMV102M7, LMV102M7X,
LMV105M7, LMV105M7X, LMV110M7 or LMV110M7X
NS Package Number MAA05A

Physical Dimensions inches (millimeters) unless otherwise noted

SYMM
$\mathcal{CL}$

0.0375 [0.95]   0.0375 [0.95]

0.112-0.118
[2.84-3.00]

5   4

0.106-0.118
[2.69-3.00]

0.060-0.066
[1.52-1.68]

0.102
[2.59]

0.039 TYP
[0.99]

1   2   3

0.0375
[0.95]

0.0145-0.0195
[0.37-0.50]

0.027 TYP
[0.69]

0.075
[1.90]

LAND PATTERN RECOMMENDATION

0.0050-0.0075
[0.13-0.19] TYP

GAGE
PLANE

0.038-0.048
[0.97-1.22]

0.036-0.044
[0.91-1.12]

0.008
[0.20]

-C-

0°-10° TYP

(0.025)
[0.64]

0.140-0.0215
[0.36-0.55]
TYP

0.002-0.006
[0.05-0.15]
TYP

0.004 [0.1] C

SEATING
PLANE

MA05B (REV B)

5-Pin SOT23-5 Tape and Reel
Order Numbers LMV101M5, LMV101M5X, LMV102M5, LMV102M5X,
LMV105M5, LMV105M5X, LMV110M5 or LMV110M5X
NS Package Number MA05B