Analog Engineer's Circuit

AC Coupled (HPF) Non-Inverting Amplifier Circuit

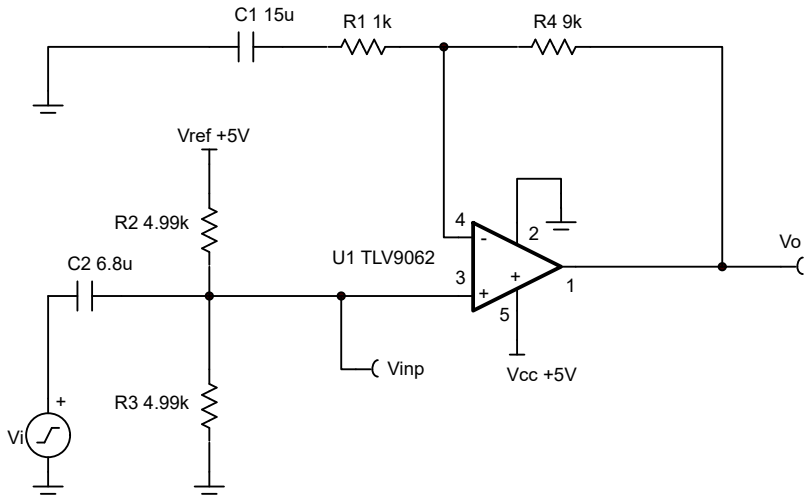
Design Goals

Input		Output		Supply		
V_{iMin}	V_{iMax}	V_{oMin}	V_{oMax}	V_{cc}	V_{ee}	V_{ref}
–240 mV	240 mV	0.1 V	4.9 V	5 V	0 V	5 V

Lower Cutoff Freq. (f_L)	Upper Cutoff Freq. (f_H)	AC Gain (G_{ac})
16 Hz	≥ 1 MHz	10 V/V

Design Description

This circuit amplifies an AC signal, and shifts the output signal so that it is centered at one-half the power supply voltage. Note that the input signal has zero DC offset so it swings above and below ground. The key benefit of this circuit is that it accepts signals which swing below ground even though the amplifier does not have a negative power supply.



Design Notes

1. The voltage at V_{inp} sets the input common-mode voltage.
2. R_2 and R_3 load the input signal for AC frequencies.
3. Use low feedback resistance for low noise.
4. Set the output range based on linear output swing (see A_{ol} specification of op amp).
5. The circuit has two real poles that determine the high-pass filter –3 dB frequency. Set them both to $f_L/1.557$ to achieve –3 dB at the lower cutoff frequency (f_L).

Design Steps

1. Select R_1 and R_4 to set the AC voltage gain.

$$R_1 = 1 \quad \text{k}\Omega \text{ (Standard Value)}$$

$$R_4 = R_1 \times (G_{ac} - 1) = 1 \quad \text{k}\Omega \times \left(10\frac{V}{V} - 1\right) = 9\text{k}\Omega \text{ (Standard Value)}$$

2. Select R_2 and R_3 to set the DC output voltage (V_{DC}) to 2.5 V, or mid–supply.

$$R_3 = 4.99\text{k}\Omega \text{ (Standard Value)}$$

$$R_2 = \frac{R_3 \times V_{ref}}{V_{DC}} - R_3 = \frac{4.99\text{k}\Omega \times 5\text{V}}{2.5\text{V}} - 4.99\text{k}\Omega = 4.99\text{k}\Omega$$

3. Select C_1 based on f_L and R_1.

$$f_L = 16\text{Hz}$$

$$C_1 = \frac{1}{2 \times \pi \times R_1 \times \left(\frac{f_L}{1.557}\right)} = \frac{1}{2 \times \pi \times 1 \quad \text{k}\Omega \times 10.3\text{Hz}} = 15.5\mu\text{F} \approx 15\mu\text{F} \text{ (Standard Value)}$$

4. Select C_2 based on f_L, R_2, and R_3.

$$R_{div} = \frac{R_2 \times R_3}{R_2 + R_3} = \frac{4.99\text{k}\Omega \times 4.99\text{k}\Omega}{4.99\text{k}\Omega + 4.99\text{k}\Omega} = 2.495\text{k}\Omega$$

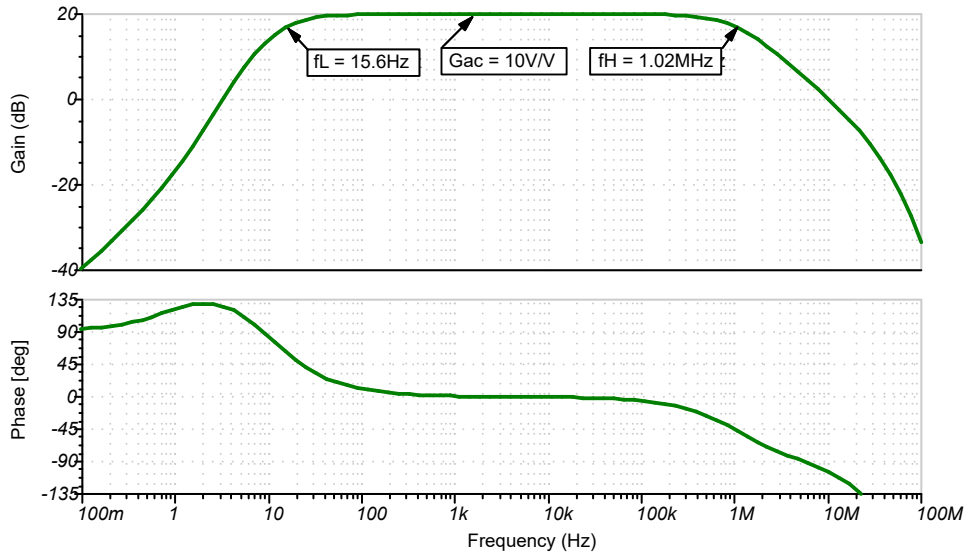
$$C_2 = \frac{1}{2 \times \pi \times R_{div} \times \left(\frac{f_L}{1.557}\right)} = \frac{1}{2 \times \pi \times 2.495\text{k}\Omega \times 10.3\text{Hz}} = 6.4\mu\text{F} \rightarrow 6.8\mu\text{F}\left(\text{StandardValue}\right)$$

5. The upper cutoff frequency (f_H) is set by the non-inverting gain of this circuit and the gain bandwidth (GBW) of the device (TLV9062).

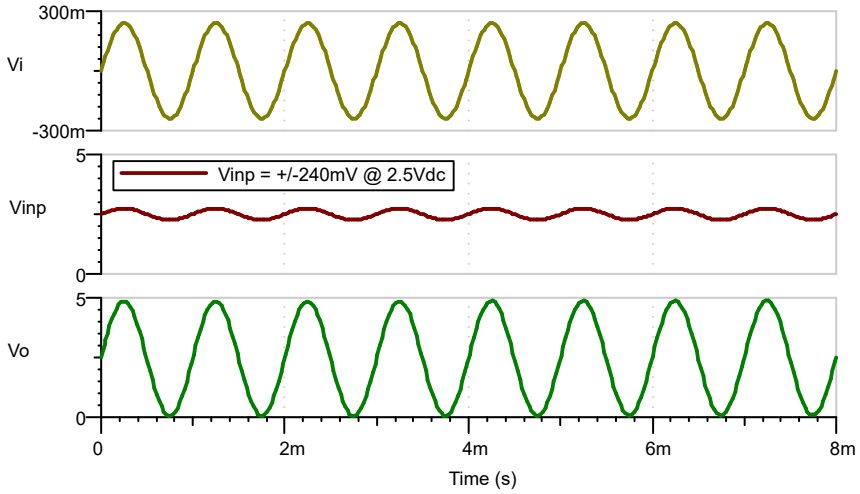
$$f_H = \frac{\text{GBW of TLV9062}}{G_{ac}} = \frac{10\text{MHz}}{10\frac{V}{V}} = 1 \quad \text{MHz}$$

Design Simulations

AC Simulation Results



Transient Simulation Results



Design References

See *Analog Engineer's Circuit Cookbooks* for TI's comprehensive circuit library.

See circuit SPICE simulation file SBOC505.

See TIPD185.

Design Featured Op Amp

TLV9062	
V_{cc}	1.8 V to 5.5 V
V_{inCM}	Rail-to-rail
V_{out}	Rail-to-rail
V_{os}	300 µV
I_q	538 µA
I_b	0.5 pA
UGBW	10 MHz
SR	6.5 V/µs
#Channels	1, 2, and 4
TLV9062	

Design Alternate Op Amp

OPA192	
V_{cc}	4.5 V to 36 V
V_{inCM}	Rail-to-rail
V_{out}	Rail-to-rail
V_{os}	5 µV
I_q	1 mA/Ch
I_b	5 pA
UGBW	10 MHz
SR	20 V/µs
#Channels	1, 2, and 4
OPA192	

Revision History

NOTE: Page numbers for previous revisions may differ from page numbers in the current version.

Changes from August 2, 2017 to February 1, 2019	Page
• Downscale the title and changed title role to 'Amplifiers'. Added link to circuit cookbook landing page	1

IMPORTANT NOTICE AND DISCLAIMER

TI PROVIDES TECHNICAL AND RELIABILITY DATA (INCLUDING DATA SHEETS), DESIGN RESOURCES (INCLUDING REFERENCE DESIGNS), APPLICATION OR OTHER DESIGN ADVICE, WEB TOOLS, SAFETY INFORMATION, AND OTHER RESOURCES “AS IS” AND WITH ALL FAULTS, AND DISCLAIMS ALL WARRANTIES, EXPRESS AND IMPLIED, INCLUDING WITHOUT LIMITATION ANY IMPLIED WARRANTIES OF MERCHANTABILITY, FITNESS FOR A PARTICULAR PURPOSE OR NON-INFRINGEMENT OF THIRD PARTY INTELLECTUAL PROPERTY RIGHTS.

These resources are intended for skilled developers designing with TI products. You are solely responsible for (1) selecting the appropriate TI products for your application, (2) designing, validating and testing your application, and (3) ensuring your application meets applicable standards, and any other safety, security, regulatory or other requirements.

These resources are subject to change without notice. TI grants you permission to use these resources only for development of an application that uses the TI products described in the resource. Other reproduction and display of these resources is prohibited. No license is granted to any other TI intellectual property right or to any third party intellectual property right. TI disclaims responsibility for, and you will fully indemnify TI and its representatives against, any claims, damages, costs, losses, and liabilities arising out of your use of these resources.

TI’s products are provided subject to TI’s Terms of Sale or other applicable terms available either on ti.com or provided in conjunction with such TI products. TI’s provision of these resources does not expand or otherwise alter TI’s applicable warranties or warranty disclaimers for TI products.

TI objects to and rejects any additional or different terms you may have proposed.

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