AC coupled (HPF) non-inverting amplifier circuit

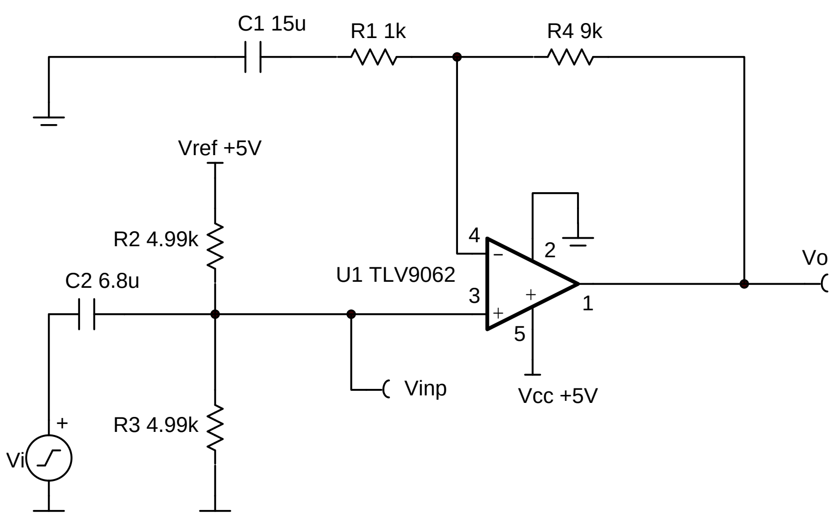
Design Goals

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

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

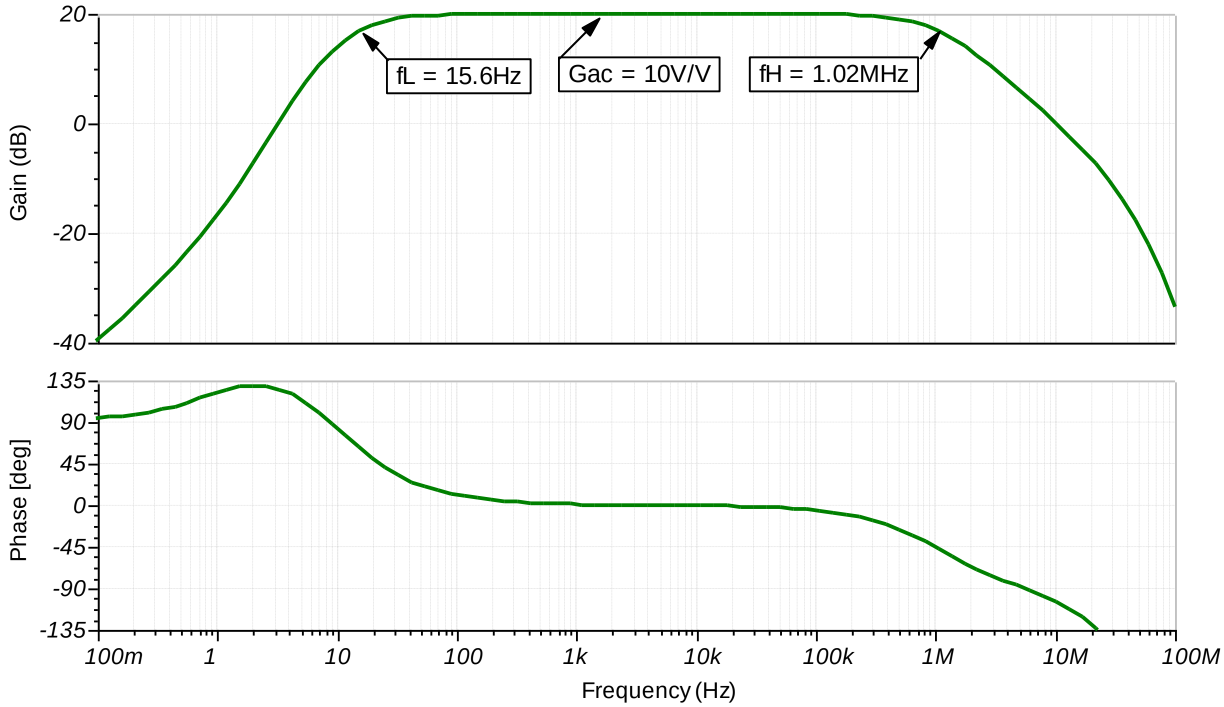
1. The voltage at V_{inp} sets the input common-mode voltage.
2. R_2 and R_3 load the input signal for AC frequencies.
3. Use low feedback resistance for low noise.
4. Set the output range based on linear output swing (see A_{ol} specification of op amp).
5. The circuit has two real poles that determine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

Design Steps

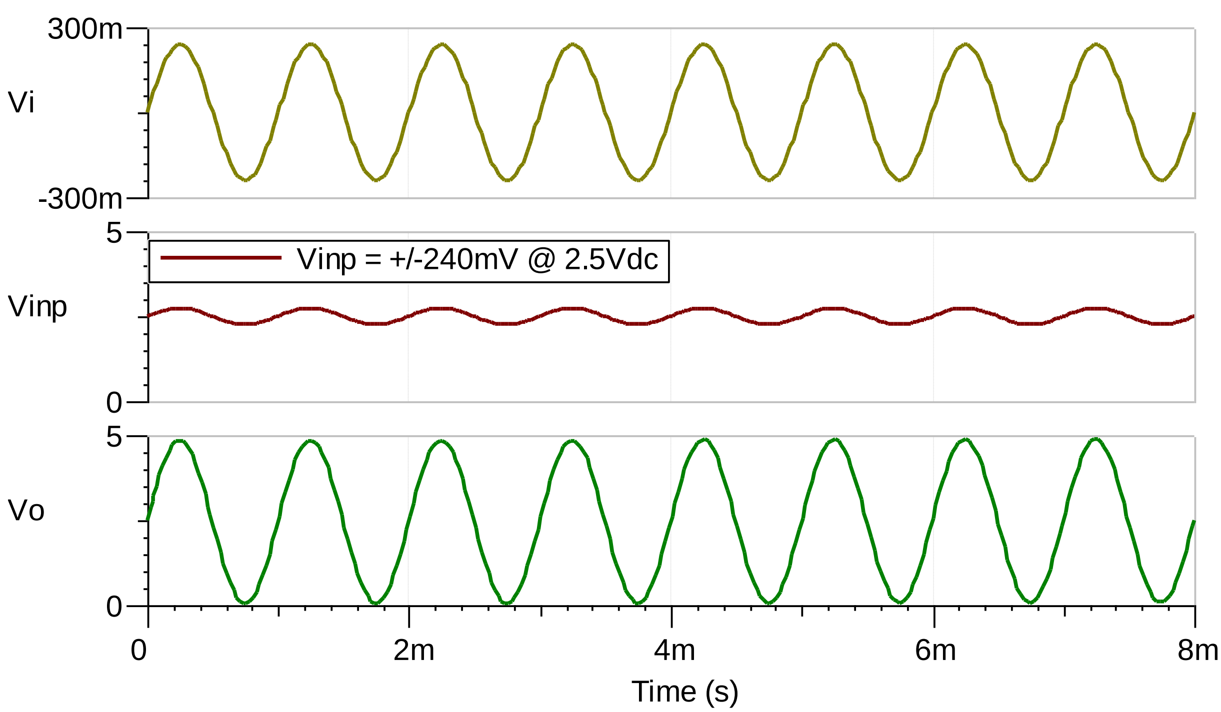
1. Select R_1 and R_4 to set the AC voltage gain.
   $$R_1 = 1\ \ k\Omega \text{ (Standard Value)}$$
   $$R_4 = R_1 \times (G_{ac} - 1) = 1\ \ k\Omega \times (10\tfrac{V}{V} - 1) = 9k\Omega \text{ (Standard Value)}$$
2. Select R_2 and R_3 to set the DC output voltage (V_{DC}) to 2.5V, or mid–supply.
   $$R_3 = 4.99k\Omega \text{ (Standard Value)}$$
   $$R_2 = \frac{R_3 \times V_{ref}}{V_{DC}} - R_3 = \frac{4.99k\Omega \times 5V}{2.5V} - 4.99k\Omega = 4.99k\Omega$$
3. Select C_1 based on f_L and R_1.
   $$f_L = 16Hz$$
   $$C_1 = \frac{1}{2 \times \pi \times R_1 \times \left(\frac{f_L}{1.557}\right)} = \frac{1}{2 \times \pi \times 1\ \ k\Omega \times 10.3Hz} = 15.5\mu F \approx 15\mu F \text{ (Standard Value)}$$
4. Select C_2 based on f_L, R_2, and R_3.
   $$R_{div} = \frac{R_2 \times R_3}{R_2 + R_3} = \frac{4.99k\Omega \times 4.99k\Omega}{4.99k\Omega + 4.99k\Omega} = 2.495k\Omega$$
   $$C_2 = \frac{1}{2 \times \pi \times R_{div} \times \left(\frac{f_L}{1.557}\right)} = \frac{1}{2 \times \pi \times 2.495k\Omega \times 10.3Hz} = 6.4\mu F \rightarrow 6.8\mu F\text{(StandardValue)}$$
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).
   $$f_H = \frac{\text{GBW of TLV9062}}{G_{ac}} = \frac{10MHz}{10\frac{V}{V}} = 1\ \ MHz$$

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, www.ti.com/tool/tipd185.

Design Featured Op Amp

TLV9062	
V_{cc}	1.8V to 5.5V
V_{inCM}	Rail-to-rail
V_{out}	Rail-to-rail
V_{os}	300µV
I_q	538µA
I_b	0.5pA
UGBW	10MHz
SR	6.5V/µs
#Channels	1, 2, 4
www.ti.com/product/tlv9062	

Design Alternate Op Amp

OPA192	
V_{cc}	4.5V to 36V
V_{inCM}	Rail-to-rail
V_{out}	Rail-to-rail
V_{os}	5µV
I_q	1mA/Ch
I_b	5pA
UGBW	10MHz
SR	20V/µs
#Channels	1, 2, 4
www.ti.com/product/opa192	

Revision History

Revision	Date	Change
A	January 2019	Downscale the title and changed title role to 'Amplifiers'. Added link to circuit cookbook landing page.