Non_Inverting_Voltage_Follower -- Overview

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Non-Inverting, Unity-Gain Amplifier

Objectives:

After performing this lab exercise, learner will be able to:

- Understand and comprehend working of opamp
- Design & build non-inverting amplifier of unity gain using opamp
- Establish relationship between input and output signal
- Practice working with measuring equipment and laboratory tools like digital oscilloscope, signal generator, multimeter and power supply
- Use digital oscilloscope to debug/analyze the circuit

Equipment:

To perform this lab experiment, learner will need:

- Digital Storage Oscilloscope (TBS1000B-Edu from Tektronix or any equivalent)
- Power Supply (2231A-30-3 Power Supply from Keithley or any equivalent power supply capable of supplying +/- 10V DC)
- Signal generator (AFG1000 from Tektronix or equivalent) for providing AC input to circuit
- Multimeter
- Electronic Components
  - Opamp 741 / TL082 or equivalent - as single IC or as part of any analog circuit kit (like ASLK board from TI)
  - Resistor (10K ohms)
- BNC cables
- Breadboard and connecting wires

Theory / Key Concepts:

Before performing this lab experiment, it is important to learn following concepts:

- An opamp is a high-gain differential amplifier with very high input impedance. Very high open-loop gain allow for creating amplifiers with stable gain using feedback.
- In a non-inverting amplifier, the input signal is applied to non-inverting pin of the opamp and there is no phase inversion between output and input.
- The amplification factor or gain can be controlled by external components - Resistor in feedback path R_f and input path R_i.
- Voltage gain of the non-inverting amplifier is given by:

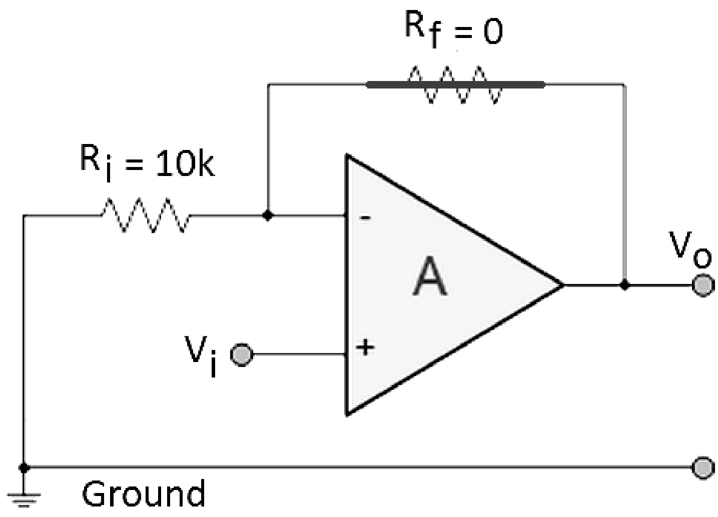
$$Gain = 1 + \frac{R_f}{R_i}$$

- While designing opamp circuits, one has to be careful about output saturation - if the gain or input signal is high enough to drive output beyond the supply voltages (V_{cc} and V_{ee}), the amplifier goes into saturation and output is limited to supply voltages.

Circuit Design:

Learner can use the theoretical design rules to calculate the circuit component values:

- For non-inverting amplifier, the gain depends on R_f and R_i. If R_f = 0 ohms, then gain becomes 1.
- So we will choose R_f = 0 ohms and R_i = 10k ohms as shown in the circuit below:



Non_Inverting_Voltage_Follower -- Procedures

Step 1

Check Your Understanding:

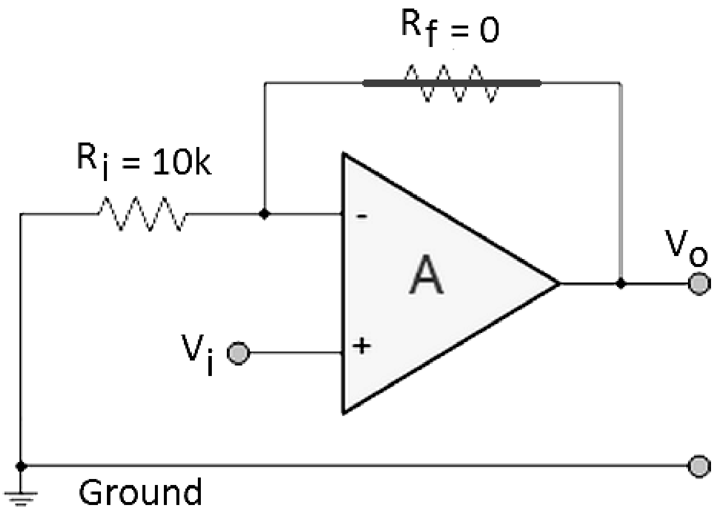
Before performing this lab experiment, learners can check their understanding of key concepts by answering these?

- For a non-inverting amplifier circuit, if R_f = 10K and R_i = 100K ohms, the phase shift between output and input will be:
  - 0 Degree
  - 90 Degree
  - 180 Degree
  - -90 Degree
- For a non-inverting amplifier circuit, if R_f = 10K and R_i = 100K ohms, what will be relation between amplitude of input and output signals?
  - input amplitude will be greater than output
  - both will have same input
  - output amplitude will be greater than input
  - it will depend on the opamp IC chosen
- What will be the effect on gain of a non-inverting voltage follower circuit, if R_i is doubled of its previous value?
  - Gain will be doubled
  - Gain will remain the same (no change)
  - Gain will be halved
  - Gain will be ¼ of previous gain

Step 2

Circuit diagram / Connection Details

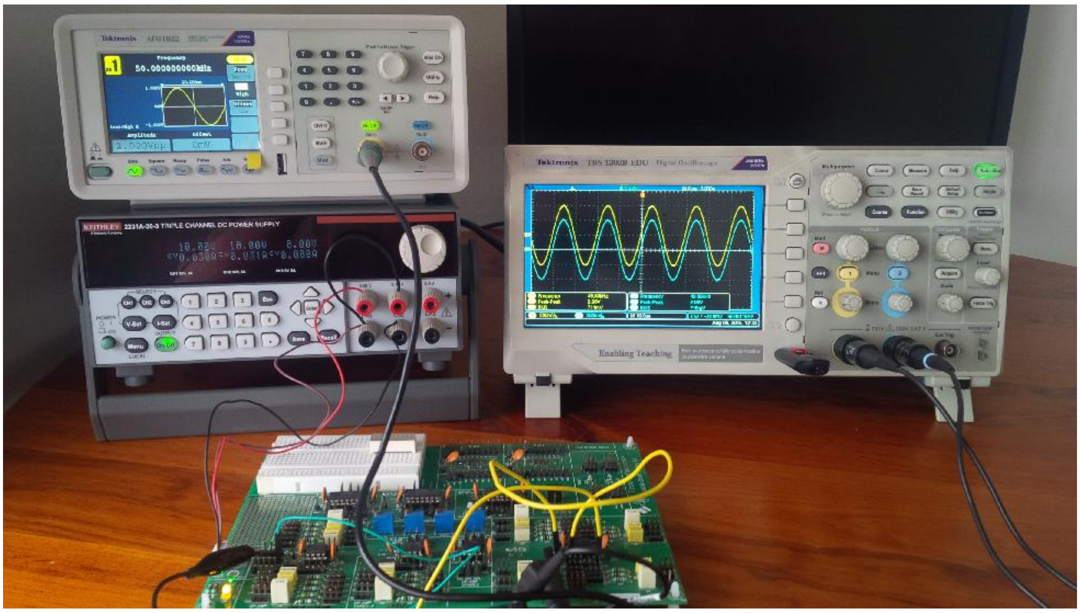
- Using the jumper / connecting wires prepare the circuit as shown below:



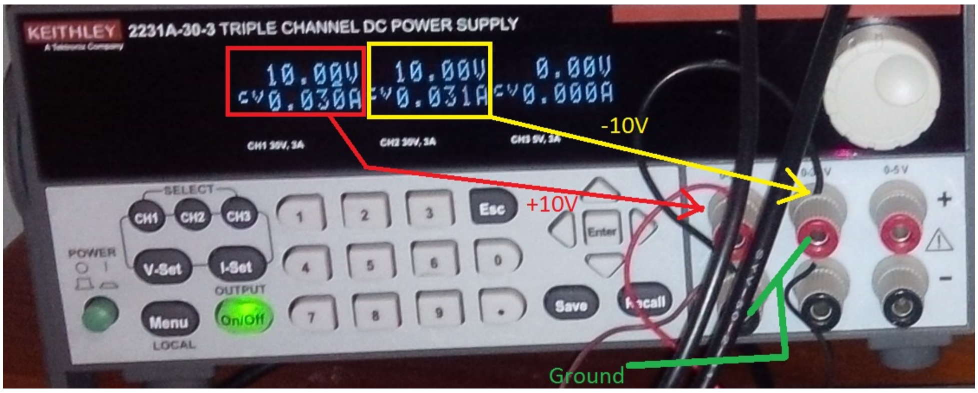
Step 3

Experiment Setup

- Make the arrangement as shown in figure below -



- Turn on the DC power supply, ensure that +/- 10V is applied to ASLK /Opamp circuit
  - You can use '2 channels' of 2231A DC power supply in independent mode and combine negative one channel with positive of other to be treated as common or ground point



- Use signal from AFG/signal generator to feed to opamp input
- Probe at input and output pins of the amplifier to view the signal on oscilloscope - View input on channel 1 and output on channel 2

Step 4

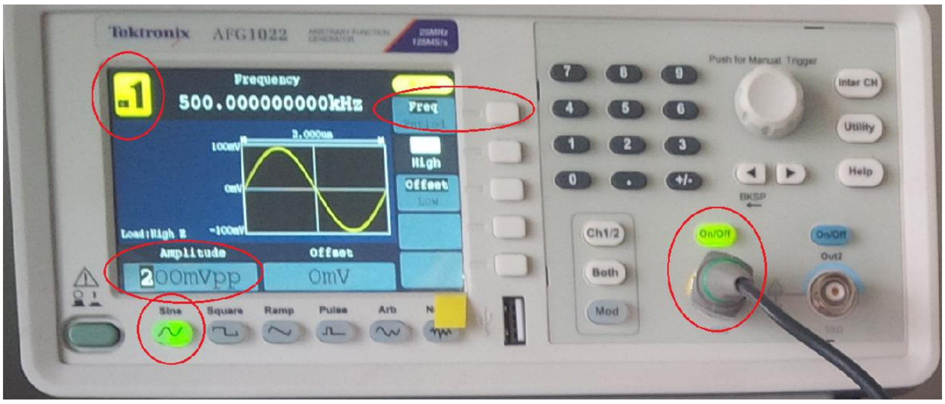
Make the Circuit Work

- Use signal from AFG/signal generator to feed to opamp input
- Set sinusoidal signal from channel 1 of the AFG
  - amplitude = 1 V_{pp}
  - frequency = 500 kHz
- Autoset the oscilloscope to see both input and output waveforms

Step 5

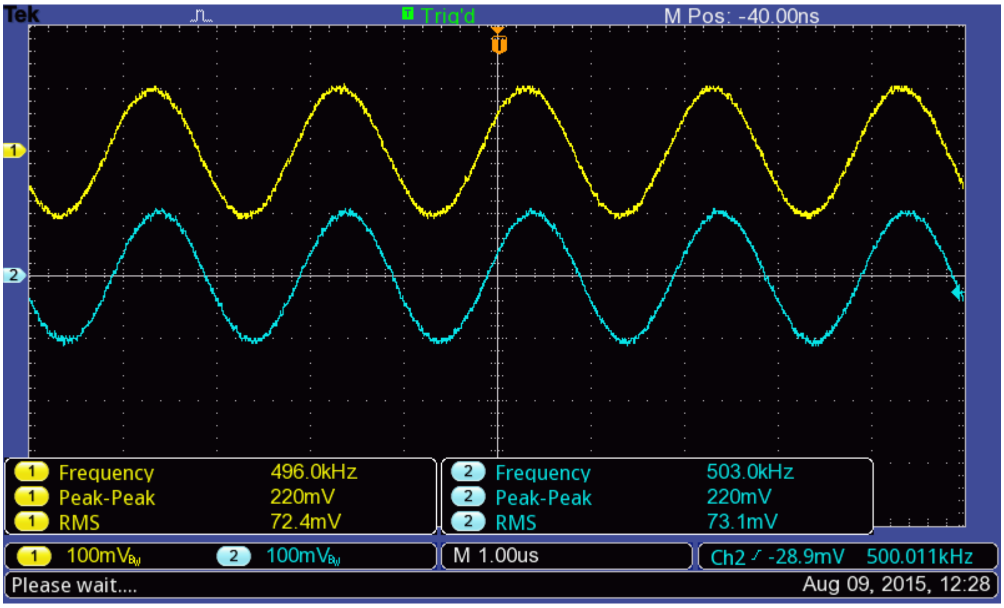
Taking the Measurements

- Set input
  - Sinusoidal, 1V peak-to-peak amplitude
  - 500kHz frequency
  - Continous mode (on AFG)
  - enable the channel 1 output on AFG



- Autoset the oscilloscope to optimally see both input and output signal
- Set up following measurements:
  - On Ch1 - V_{pp}, V_{rms}, Frequency

- On Ch2 - V_{pp}, V_{rms}
- Read the measurements in tabular format, for different input amplitude and (optionally) for another frequency. You can also capture screenshot for each measurement set.



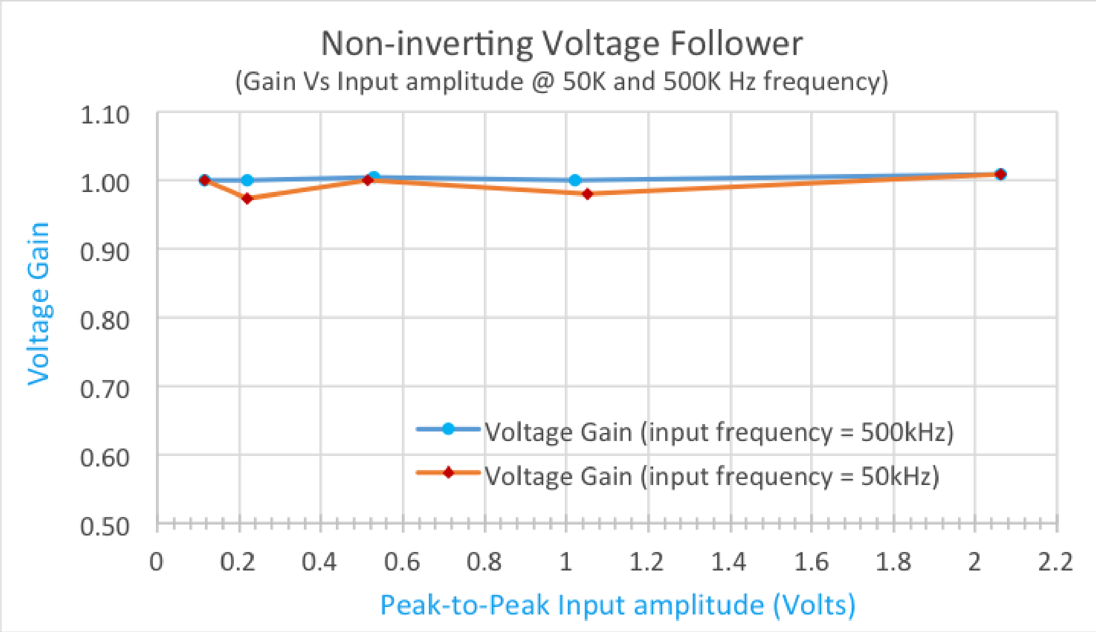
Step 6

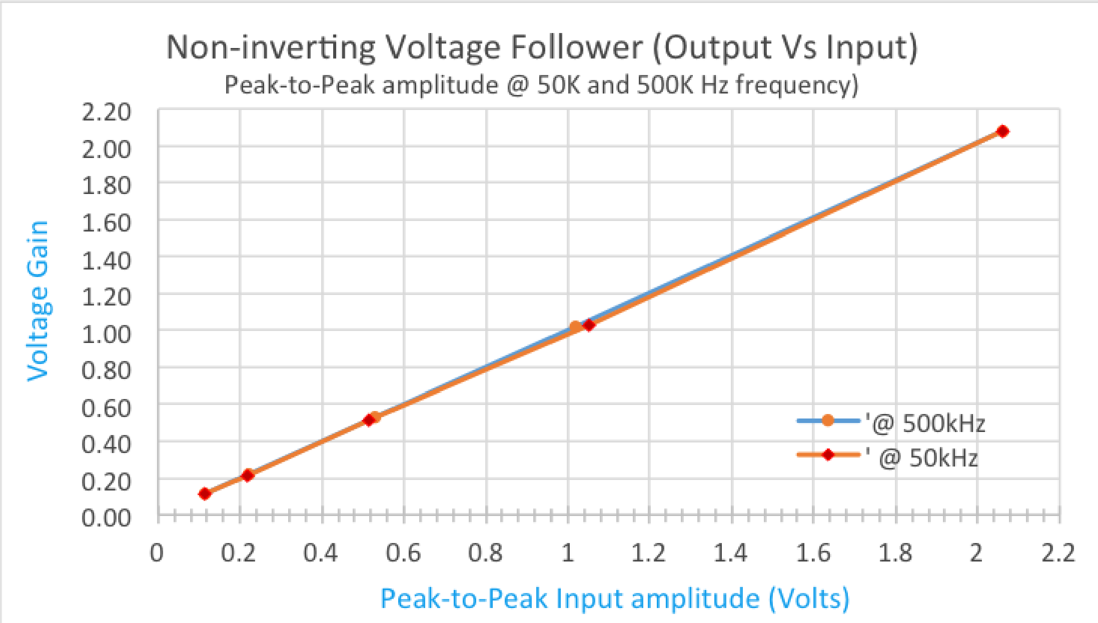
Analyzing the Result

- The observation table would look like this:

#	Frequency (Hz)	INPUT		OUTPUT		Voltage Gain	Voltage Gain (dB)
		Vpp (V)	Vrms (mV)	Vpp (V)	Vrms (mV)		
1	5,00,000	0.114	36.7	0.114	36.9	1.00	0.00
2	5,00,000	0.220	72.4	0.220	73.0	1.00	0.00
3	5,00,000	0.528	181	0.530	182.0	1.00	0.03
4	5,00,000	1.020	349	1.020	349.0	1.00	0.00
5	5,00,000	2.060	709	2.080	710.0	1.01	0.08
6	50,000	0.114	36.7	0.114	36.3	1.00	0.00
7	50,000	0.218	72.3	0.212	71.4	0.97	-0.24
8	50,000	0.516	179	0.516	178.0	1.00	0.00
9	50,000	1.050	360	1.030	359.0	0.98	-0.17
10	50,000	2.060	711	2.080	715.0	1.01	0.08

- The relationship between input and output can be summarized using graphs





Step 7

Conclusion

The analysis of the observation confirms that (As expected):

- The voltage gain is ~ 1 (as expected)
- The voltage gain remains constant for given voltage and frequency range
- The phase of input and output remains same - no phase inversion