Experiment 6
Operational Amplifiers-II

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Contents

1 Introduction

In this experiment, as students, we are expected to experiment with different kinds of Op-Amp circuits by completing the steps described in the sixth experiment laboratory manual. Throughout these steps, the some characteristics of Op-Amps and the behavior of the Op-Amp circuits are expected to be learned. The output versus input characteristics is observed by connecting the signal generator to the oscilloscope and the circuit. The non-ideal behavior of the components is compared with the ideal simulation plots. Also some measurements are expected to be finalized via manipulating the output. The results of the steps were recorded and plotted for further comments.

2 Experimental Results

In this section, the results of Experiment 6 are discussed. Before the experiment begins, necessary adjustments are made to the DC power supply. LM 741 operational amplifier integrated circuit is used in this experiment. Capacitors are placed to the power line in order to prevent unstable supply behavior by compansating the line for short time intevals.

2.1 Step 1

In this step, circuit shown in the Figure 1 is constructed.

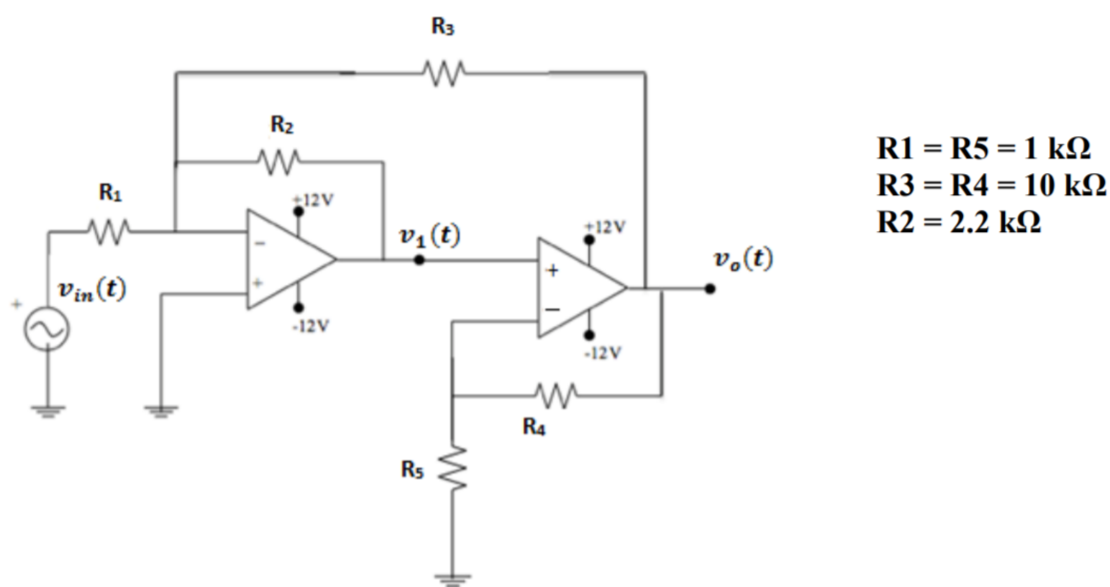

Figure 1: Circuit schematic for Step 1

2.1.1 a)

In the circuit given in Figure 1 , V_{in} is selected as $0.4sin(1000\pi)$ V. Then, V_{out} versus V_{in} characteristic is plotted and shown in Figure 2.

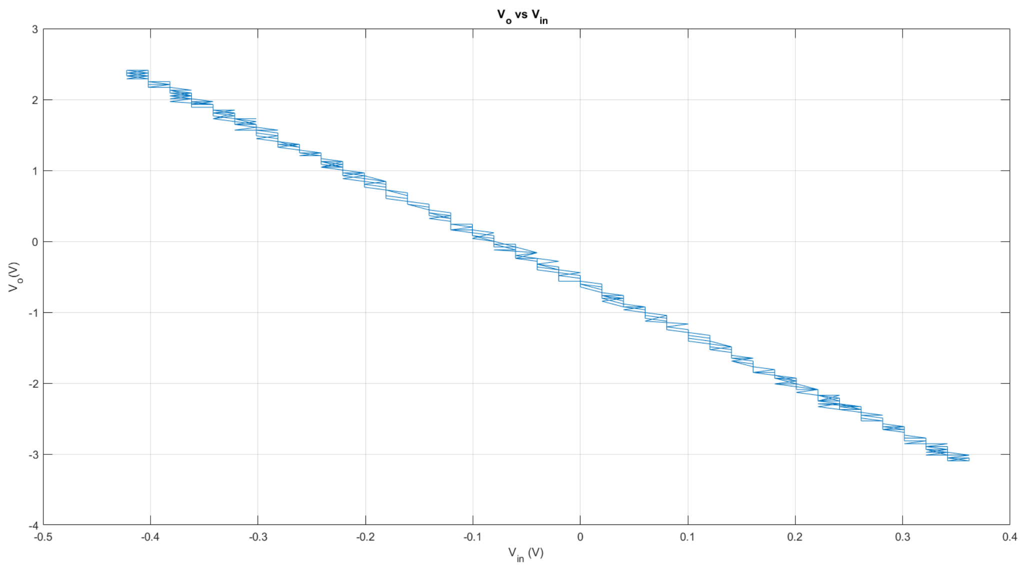

Figure 2: V_o vs V_{in}

The V_o , V_{in} waveforms are observed and plotted in MATLAB shown in Figure 3.

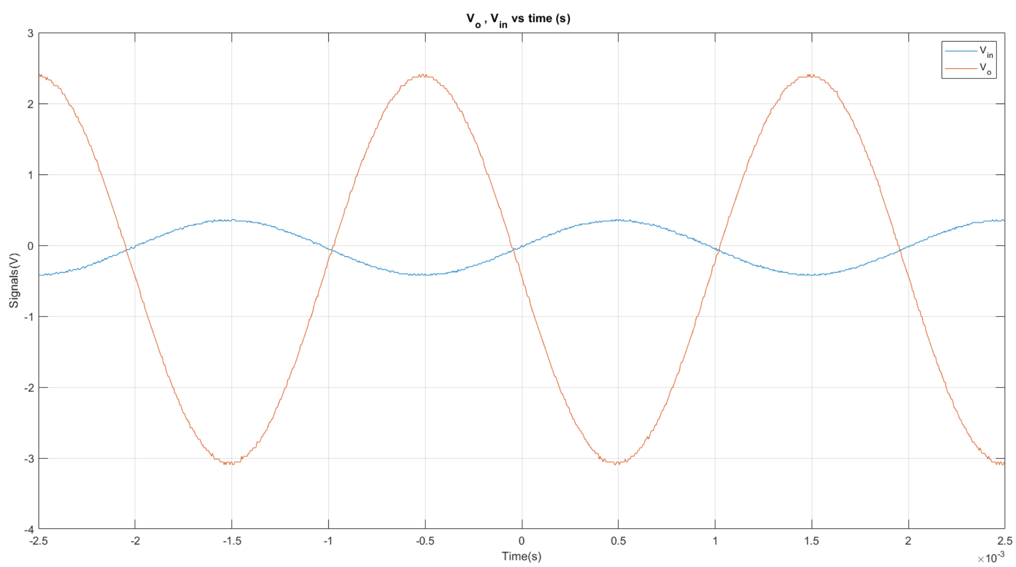

Figure 3: V_o , V_{in} vs time (s)

It can be said that , this circuit stays in linear region with this setup. The input signal is inverted and amplified.

2.1.1.1 Comparison with the simulation results

The simulation is run in preliminary work according to the circuit shown in Figure 4.

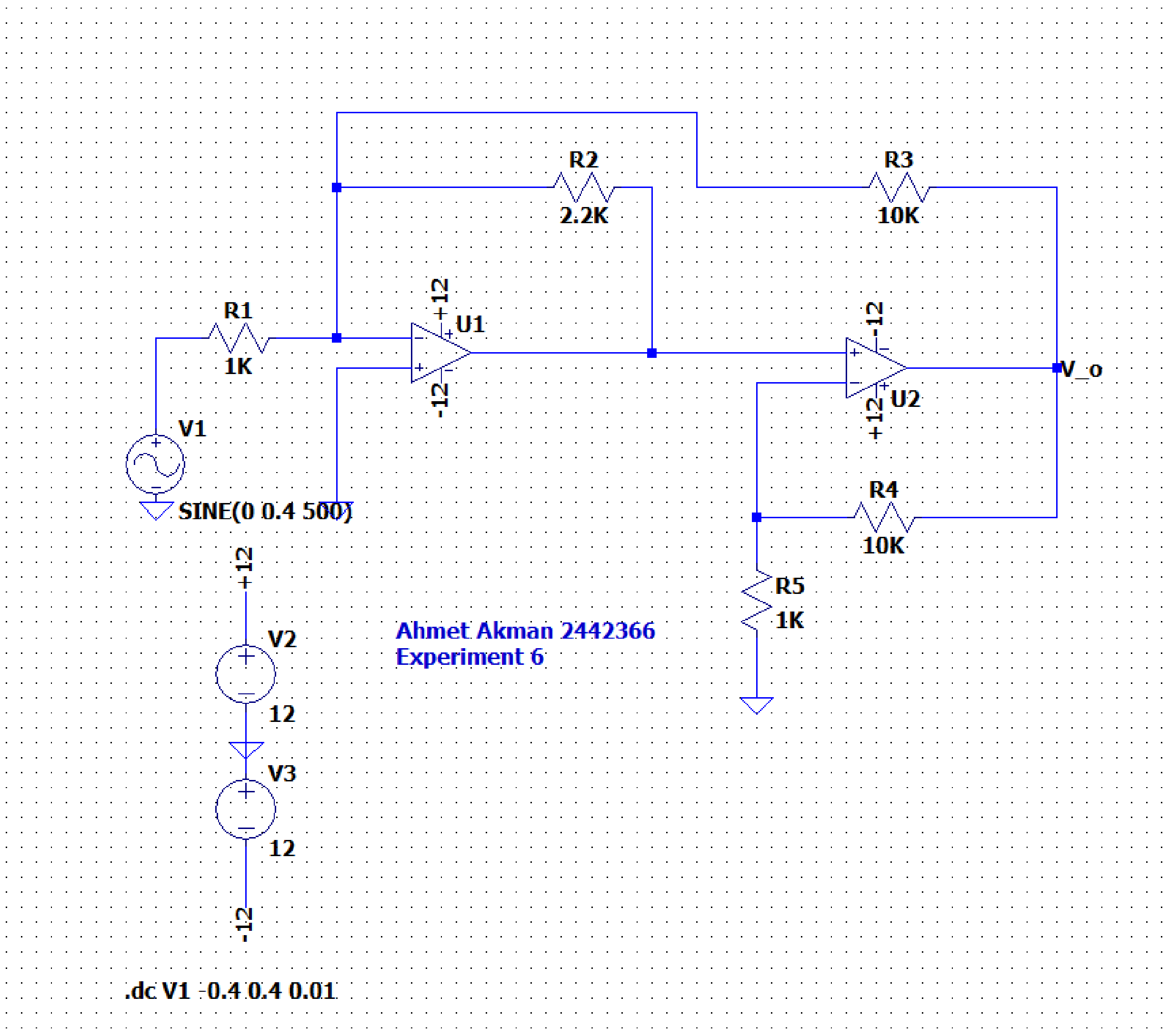

Figure 4: LTSpice schematic for the simulation 1a

Then the plot given in Figure 5 is obtained.

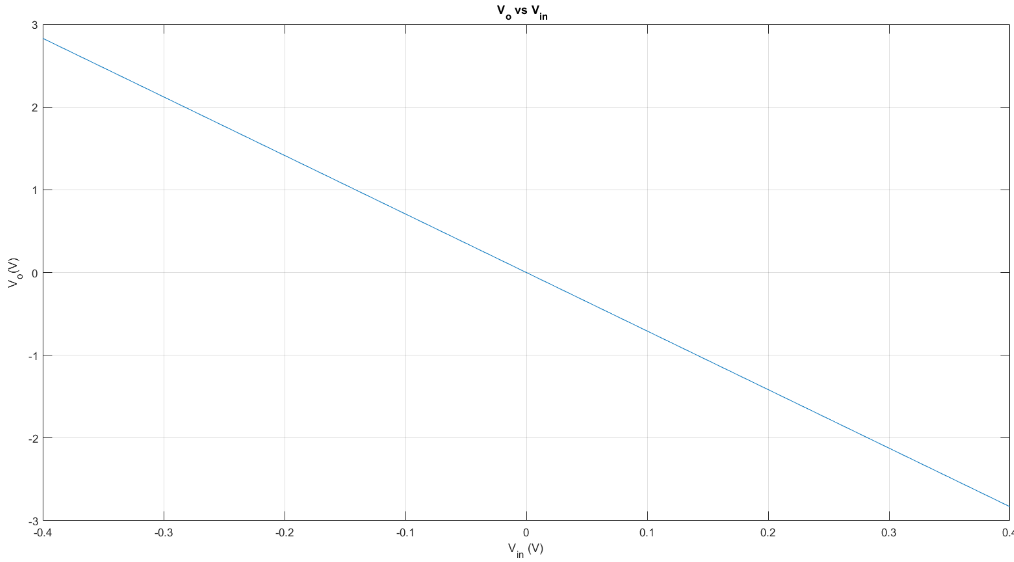

Figure 5: V_o vs V_{in}

So, it can be concluded that the therotical result obtained in preliminary work is quite consistent with the simulation and real world data. The expression relating V_o and V_in is;

$$V_{in} = V_o(\frac{-1}{10} + \frac{-5}{121})$$

There is a little offset of signal in the real plot. This is predicted to be stemmed from the non-ideality of either the LM741 component or the power line of the power supply.

2.1.2 b)

In the circuit given in Figure 1 , V_{in} is kept as $0.4sin(1000\pi)$ V. Then $R3$ is removed from the circuit. The V_{out} versus V_{in} characteristic is plotted and shown in Figure 6.

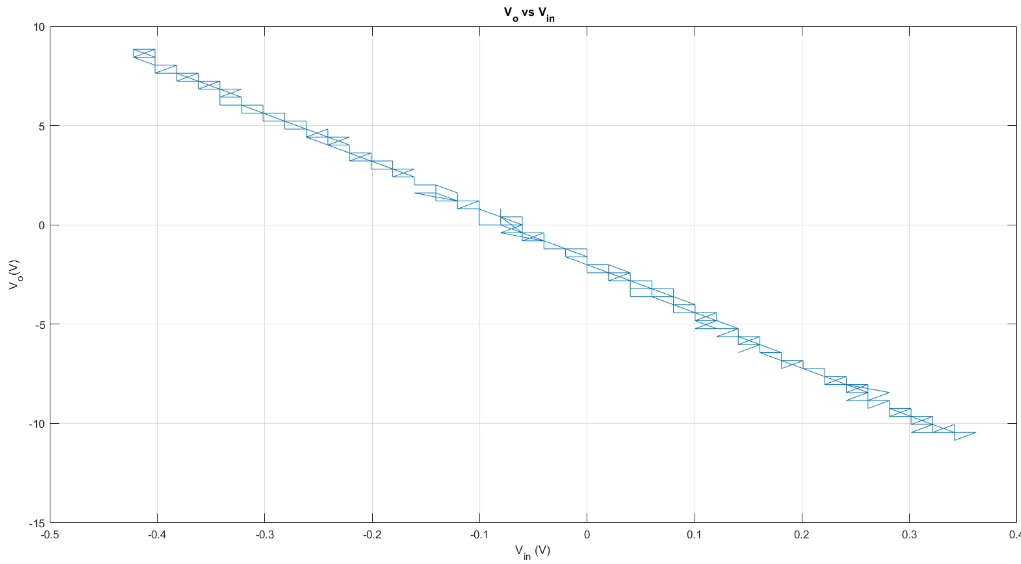

Figure 6: V_o vs V_{in}

The V_o , V_{in} waveforms are also observed and plotted in MATLAB shown in Figure 7.

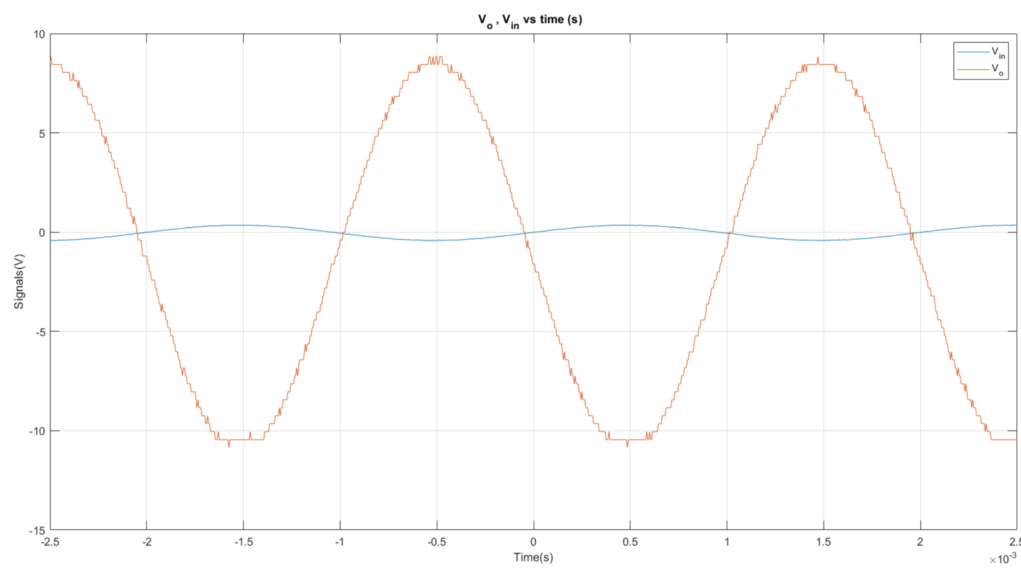

Figure 7: V_o , V_{in} vs time (s)

It can be stated that in this configuration the first opamp is not propageted with negative feedback from the V_o , so the signal is amplfied more.

2.1.2.1 Comparison with the simulation results

The simulation is run in preliminary work according to the circuit shown in Figure 4 by removing R3 connection. So the V_o vs V_{in} result is shown in Figure 8.

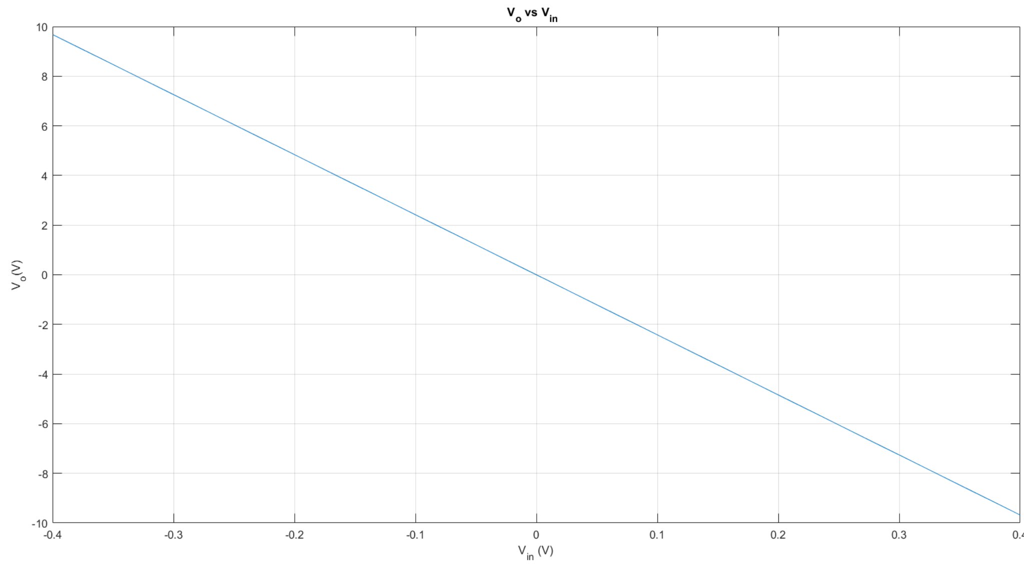

Figure 8: V_o vs V_{in}

It can be concluded that the laboratary results and simulation results are quite consistent. The relation found in preliminary work seem to be hold which is;

$$V_{in} = \frac{-5V_o}{121}$$

Also, there is a shift towards the negative side in laboratary plot. This is predicted to be sourced from the non-ideality of either the LM741 component or the power line of the power supply.

2.1.3 c)

The circuit setup is conserved in this section. The V_{in} is selected as $1sin(200\pi)$ V this time. V_o vs V_{in} is obtained as shown in Figure 9.

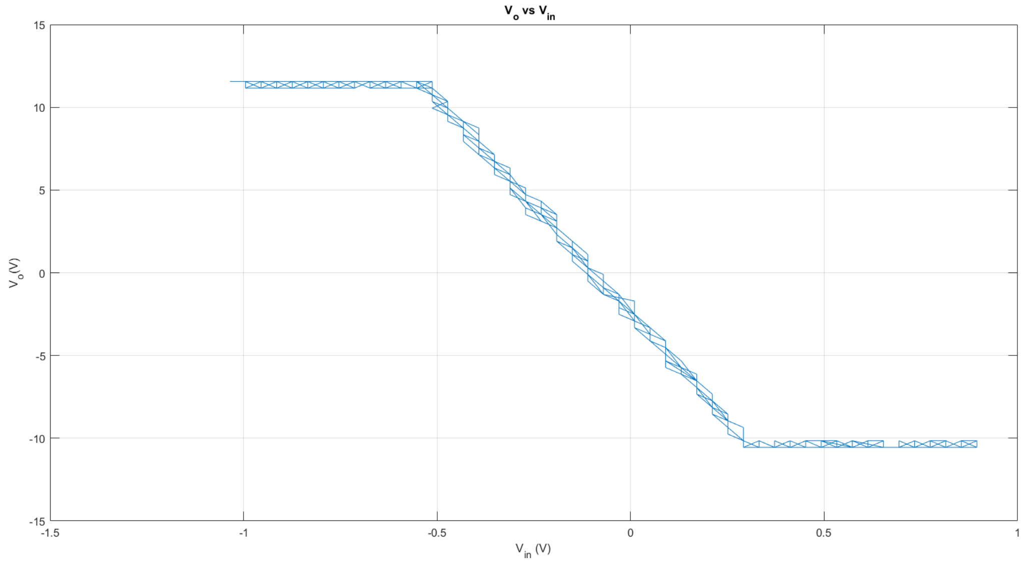

Figure 9: V_o vs V_{in}

The waveforms V_0 and V_{in} are observed and plotted in time domain is given in Figure 10.

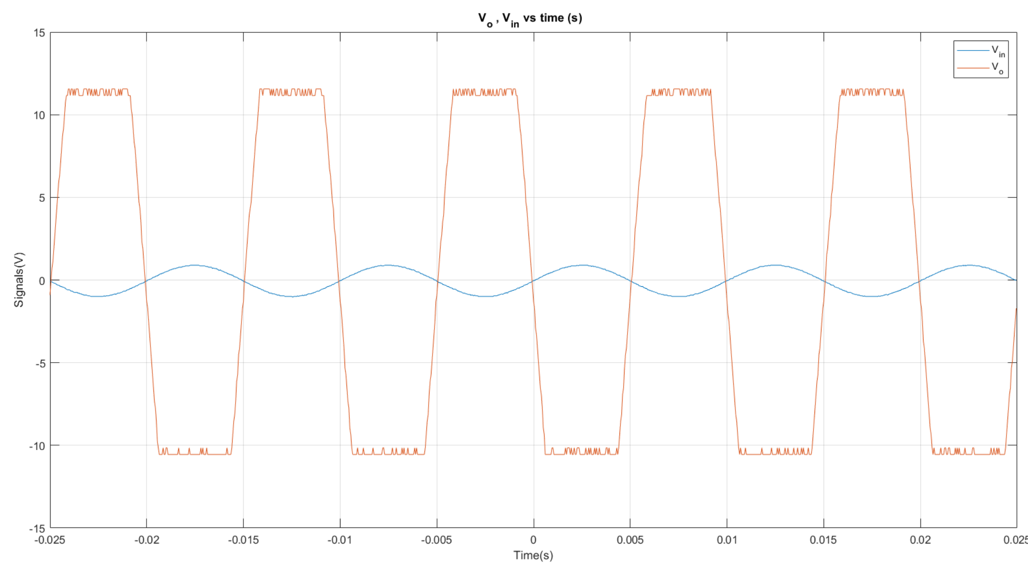

Figure 10: V_o , V_{in} vs time (s)

As a result it can be stated that, when the signal amplitude increases the opamp(s) may not stay at their linear region can be saturated. This circuit setup in principle always inverts the signal and inverts it.

2.2 Step 2

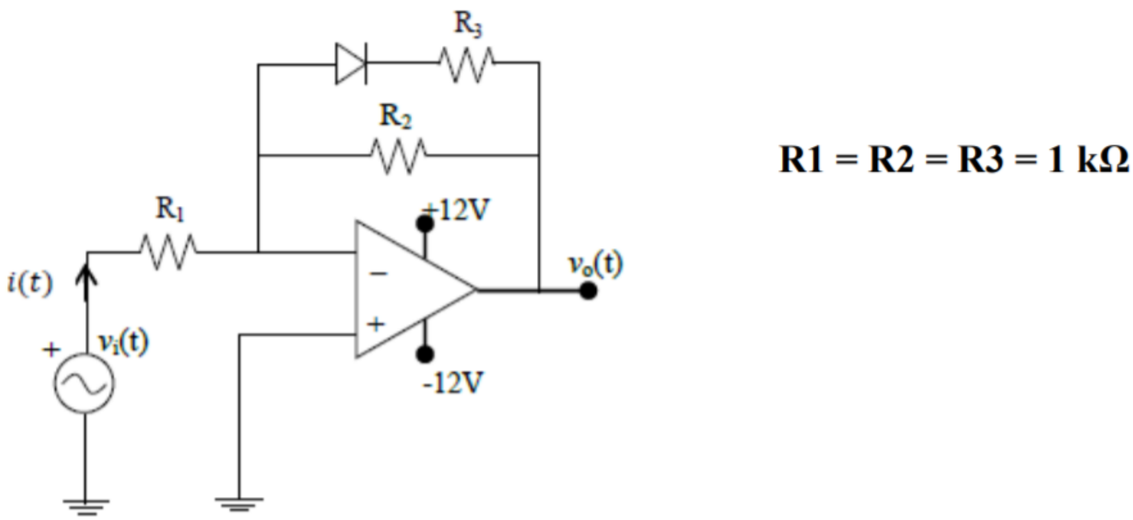

Figure 11: Circuit schematic for Step 2

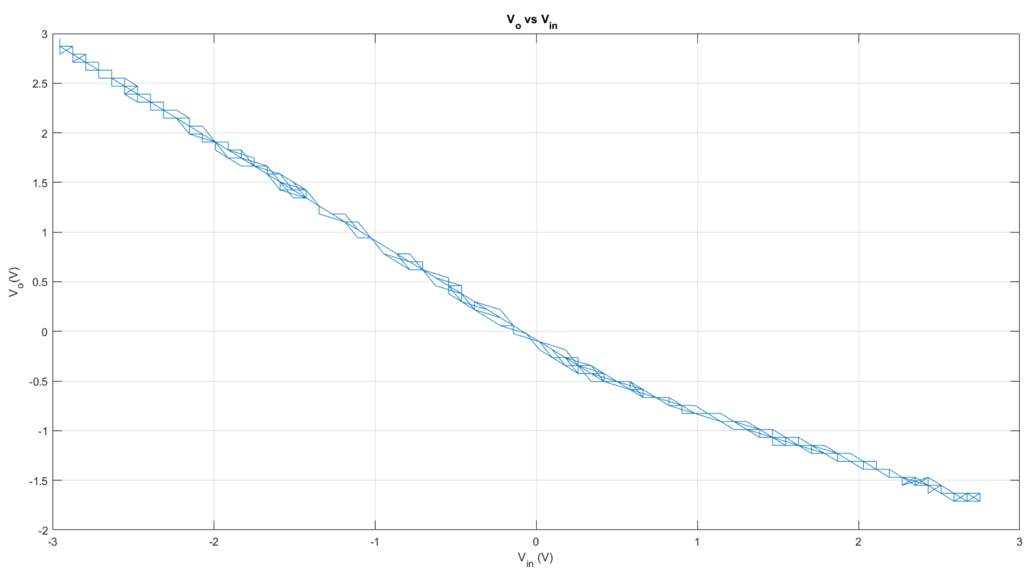

Figure 12: V_o vs V_{in}

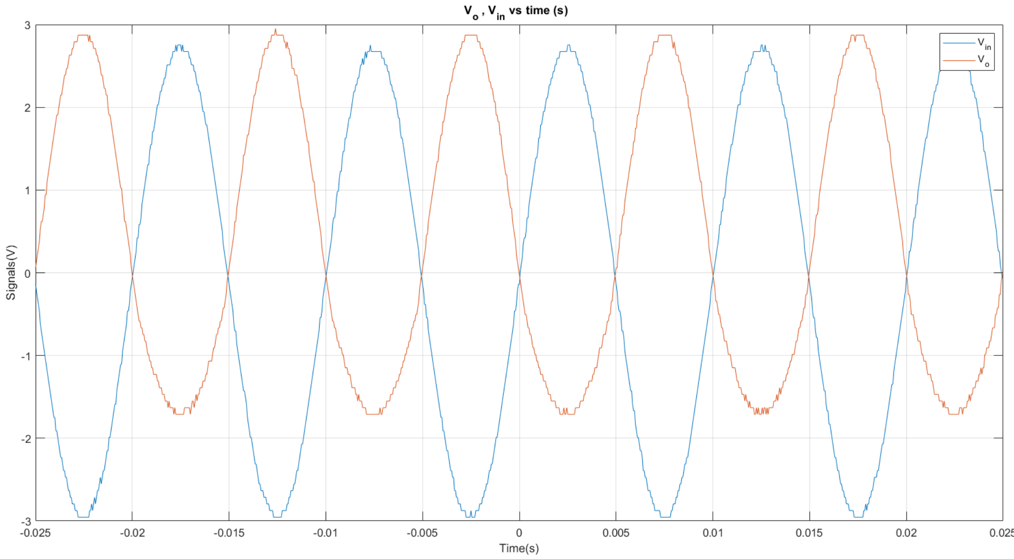

Figure 13: V_o , V_{in} vs time (s)

2.2.1 Comparison with the simulation results

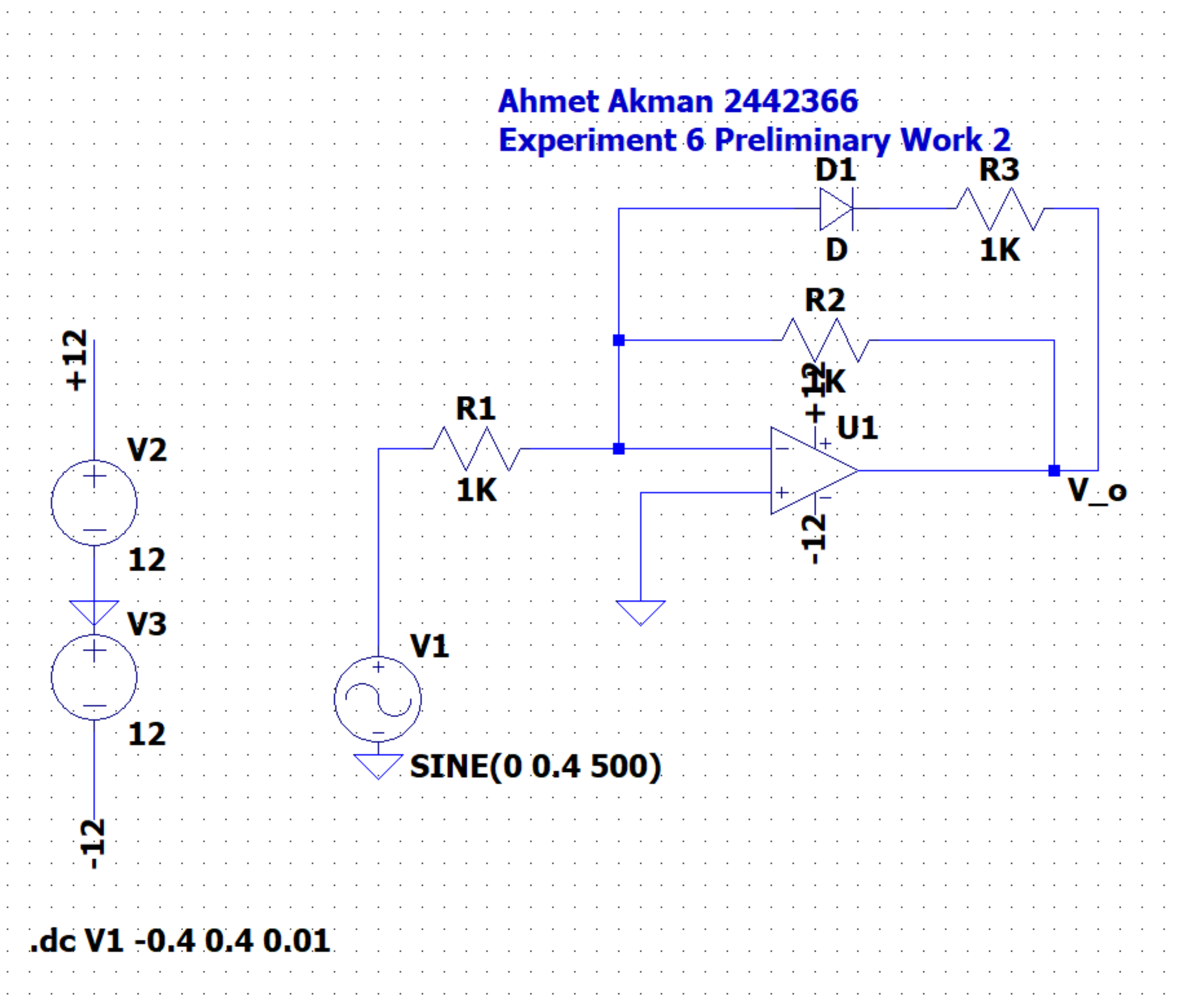

Figure 14: LTSpice schematic for the simulation 2

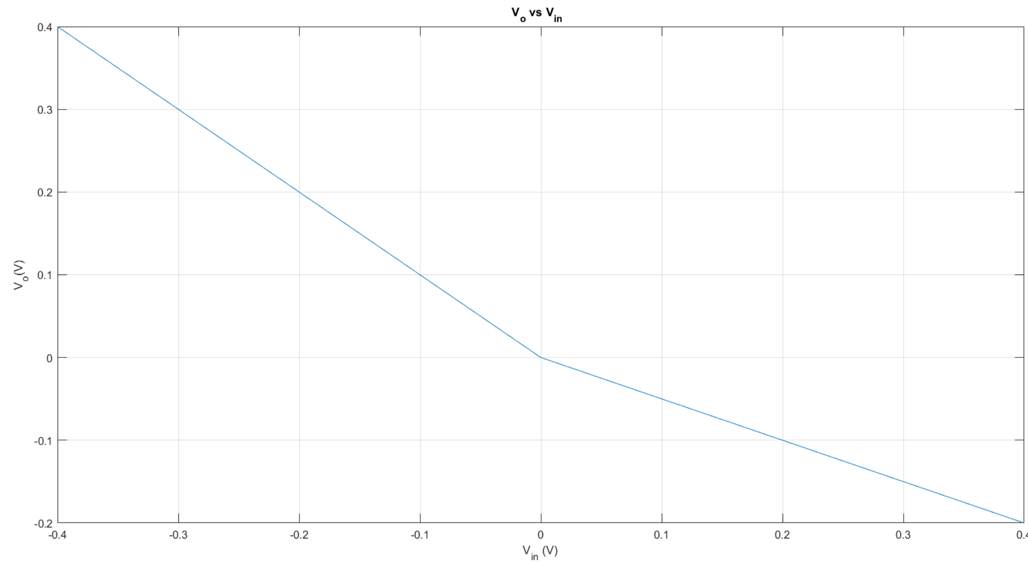

Figure 15: V_o vs V_{in}

2.3 Step 3

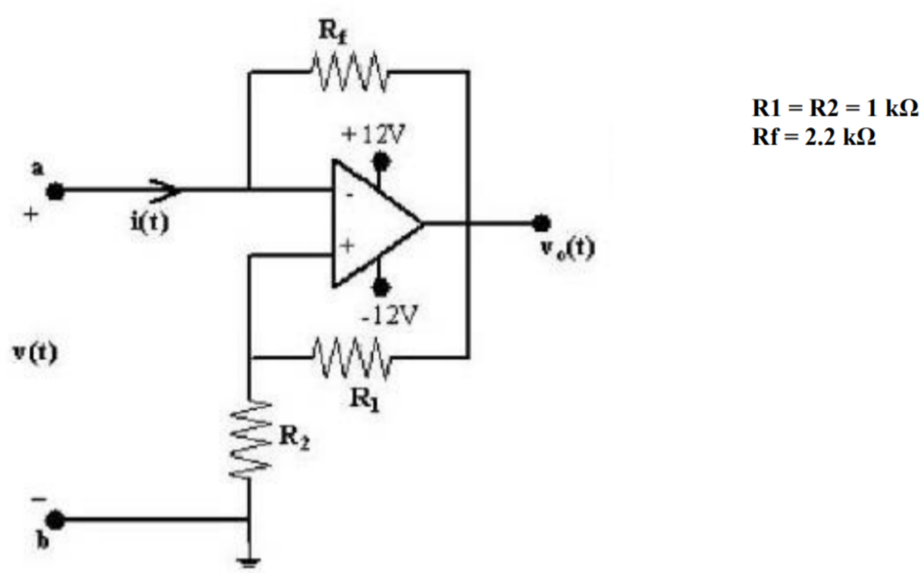

Figure 16: Circuit schematic for Step 3

2.3.1 a)

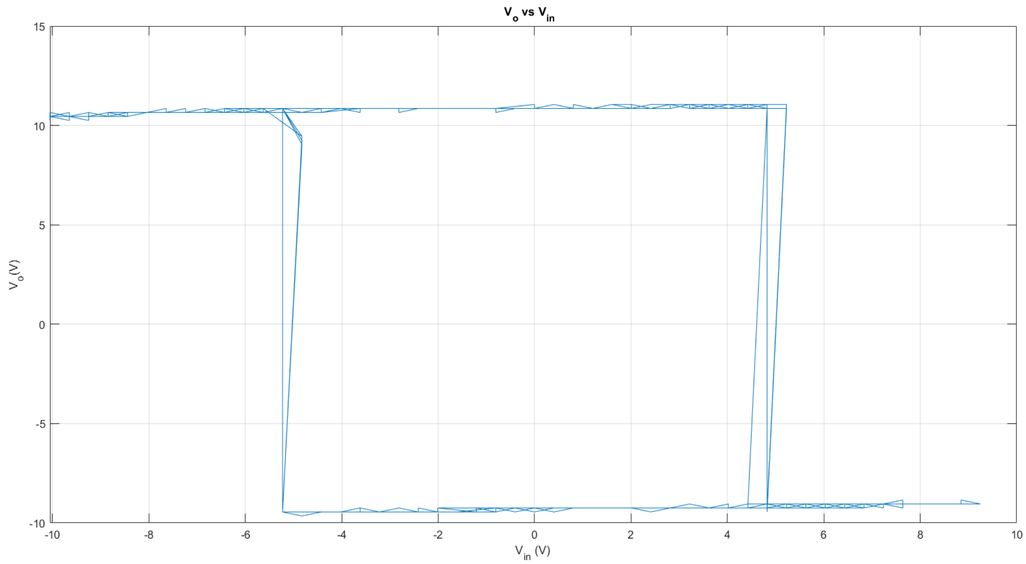

Figure 17: V_o vs V_{in}

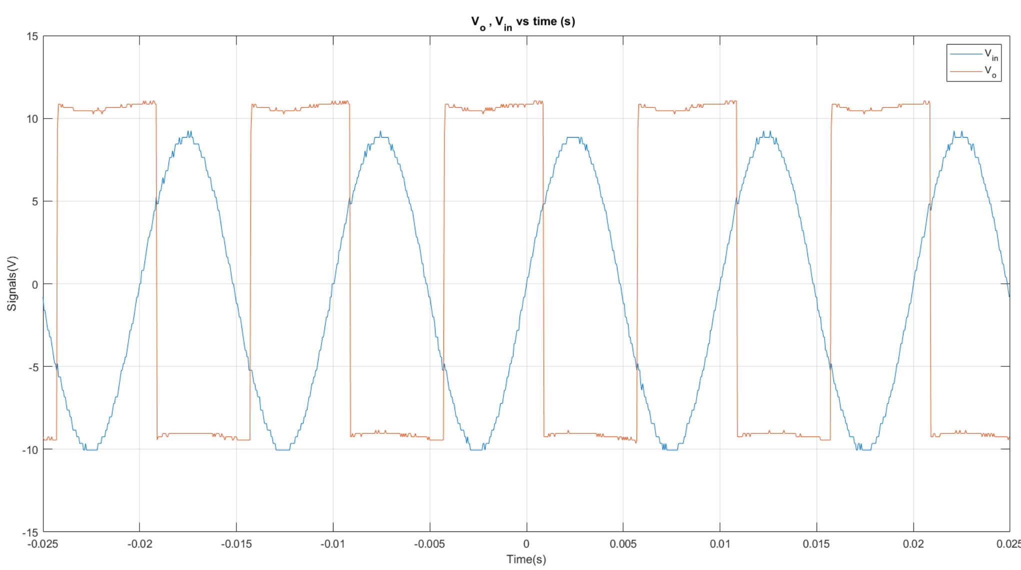

Figure 18: V_o , V_{in} vs time (s)

2.3.2 b)

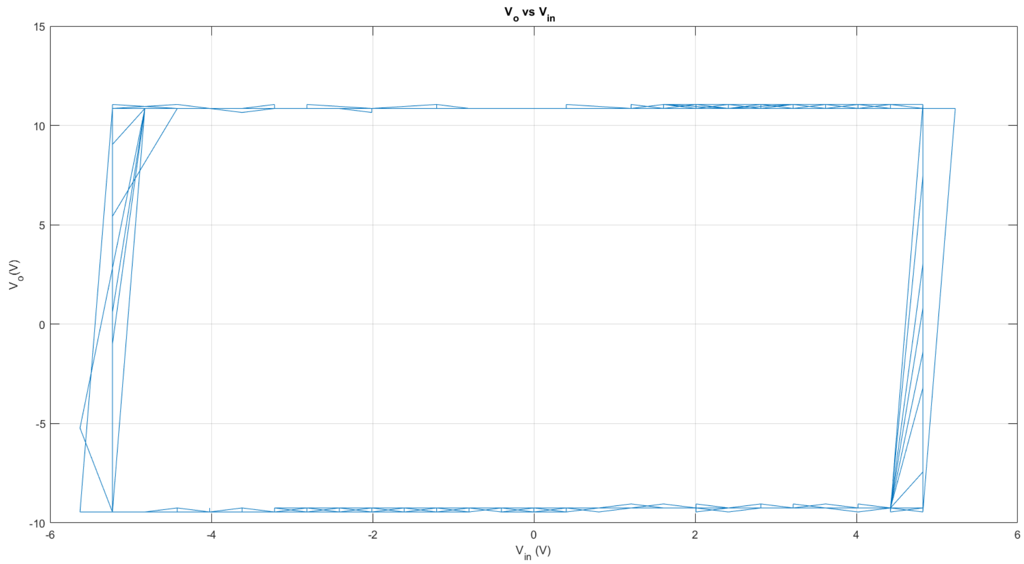

Figure 19: V_o vs V_{in}

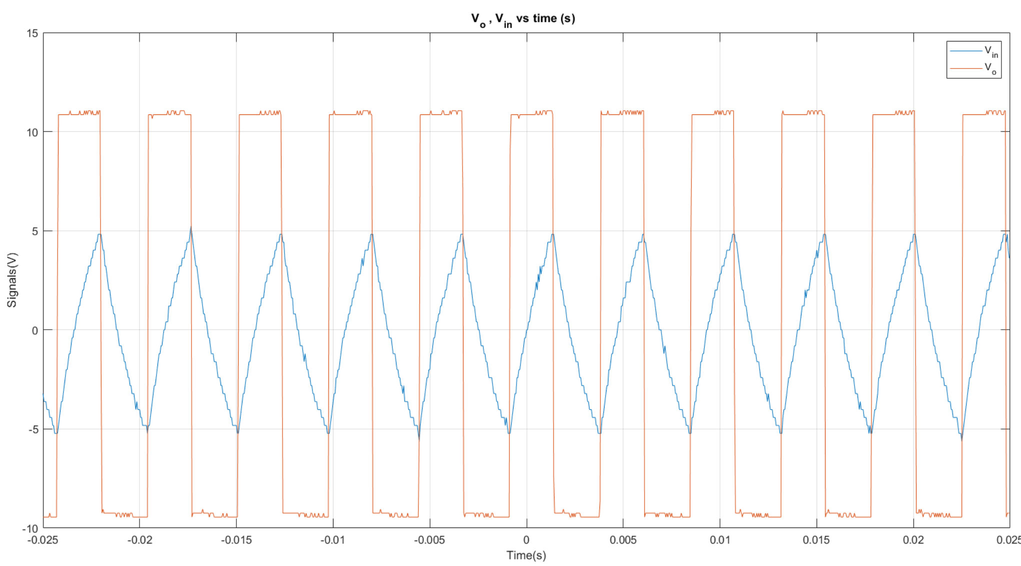

Figure 20: V_o , V_{in} vs time (s)

2.3.3 c)

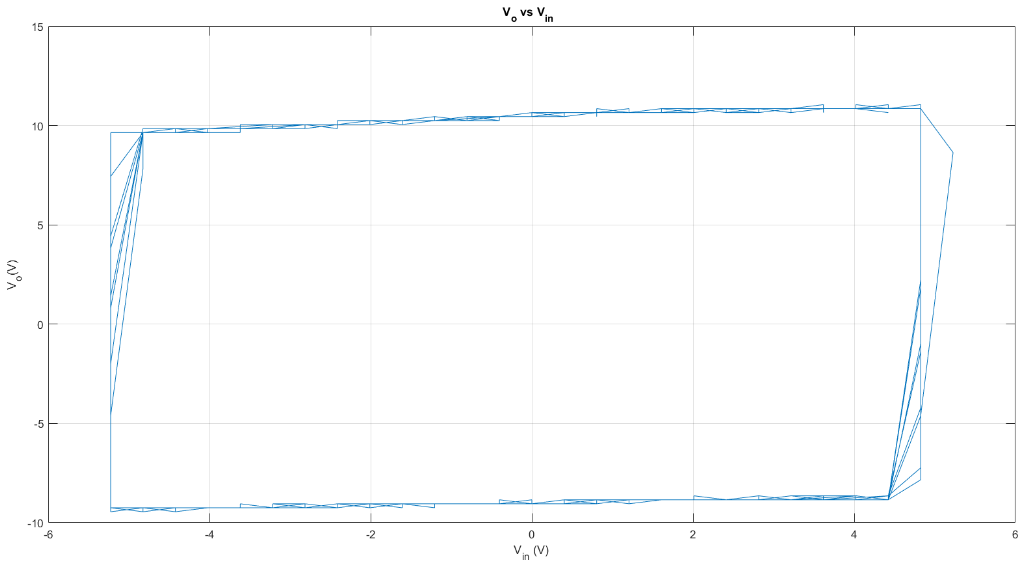

Figure 21: V_o vs V_{in}

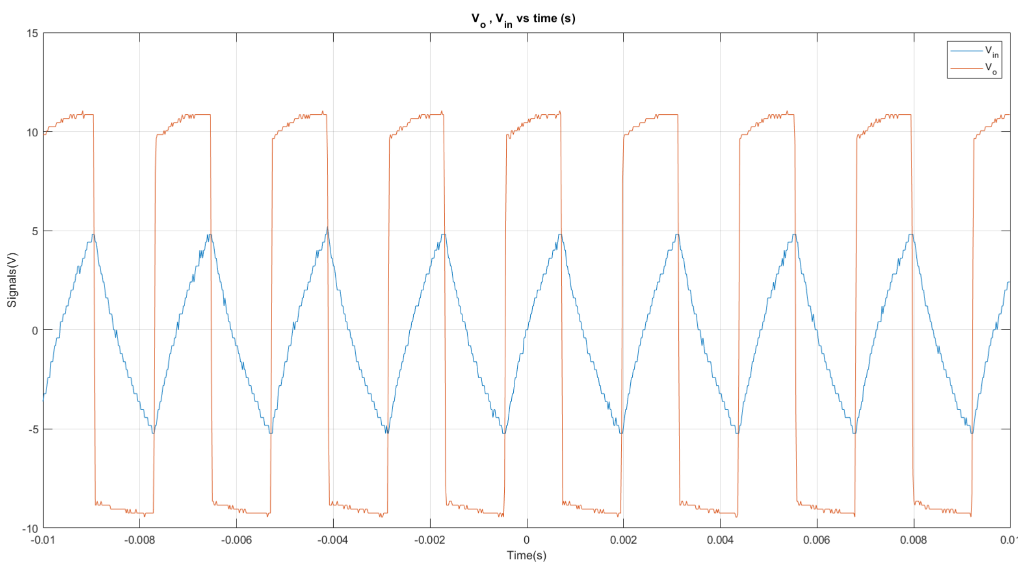

Figure 22: V_o , V_{in} vs time (s)

2.3.4 d)

2.4 Step 4

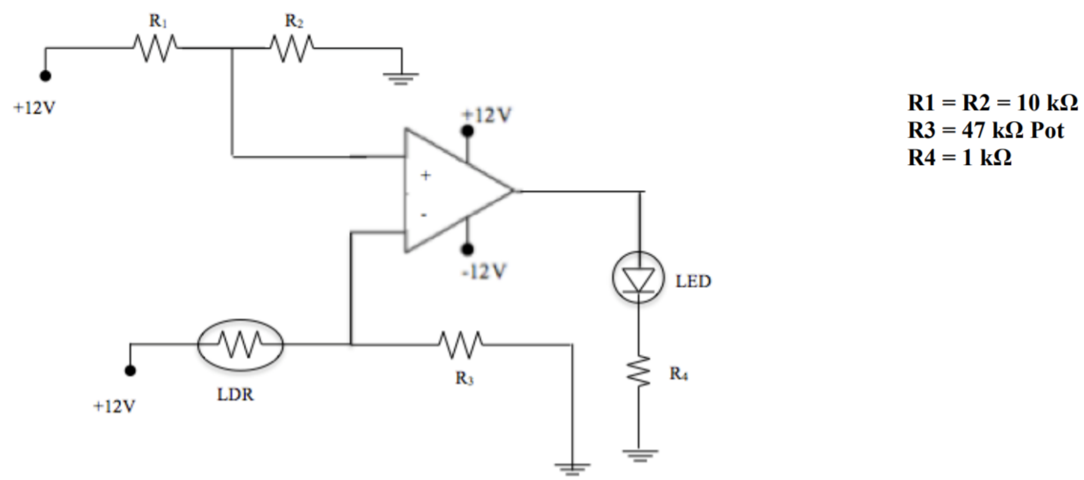

Figure 23: Circuit schematic for Step 4

2.4.1 a)

2.4.2 b)

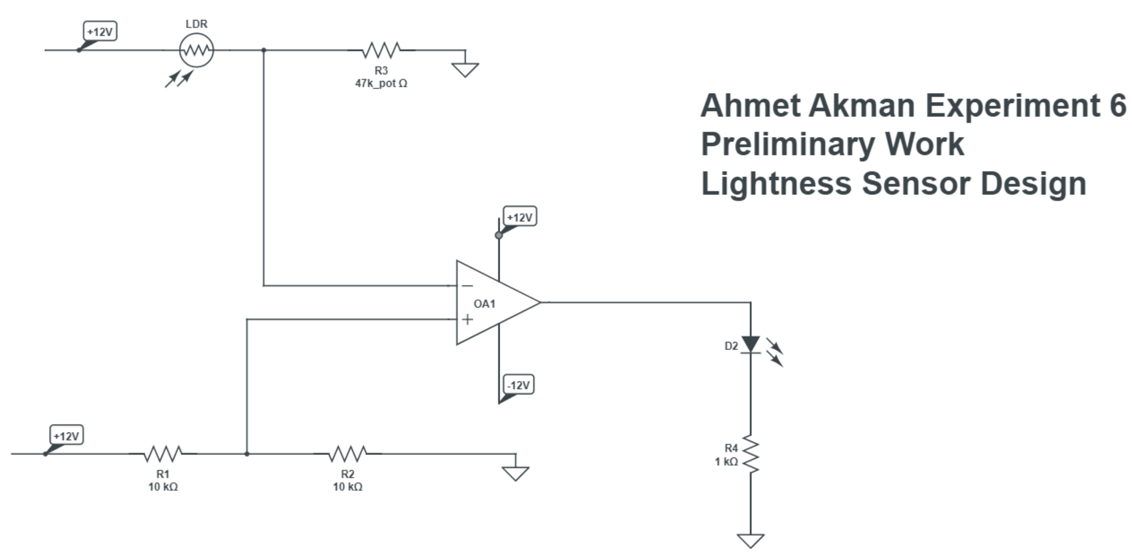

Figure 24: Lightness sensor circuit schematic for Step 4 part b

2.4.3 c)

2.5 5

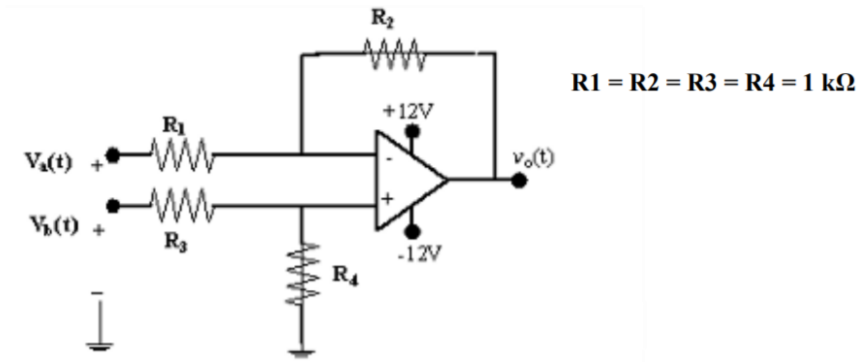

Figure 25: Difference amplifier circuit schematic for Step 5

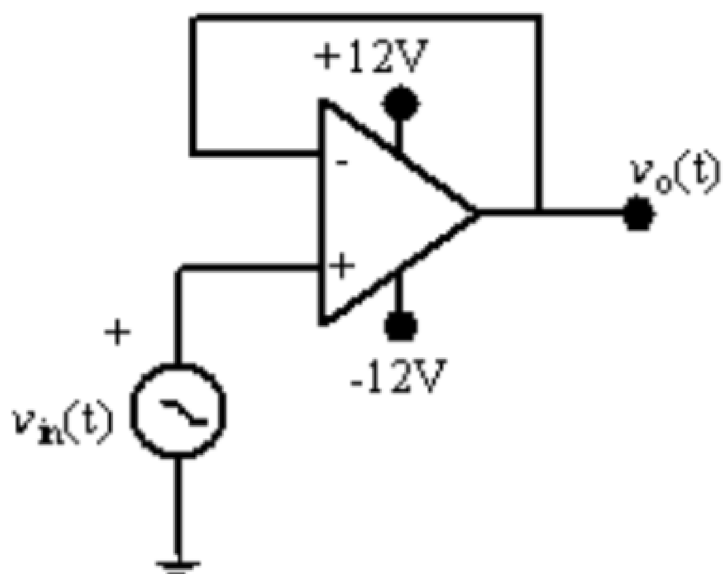

Figure 26: Buffer circuit schematic for Step 5

3 Conclusion

In conclusion, in experiment 5, "Operational Amplifiers," as students, we have learned how basic circuit setups of Op-Amps can be constructed. Preliminary laboratory work is done via simulations of the basic Op-Amp circuits in an LTSpice environment. As students, we have observed different characteristics of Op-Amp comparator, buffer, non-inverting, inverting, and summing configurations, and we have learned how voltage divider should be used when there is a load to the output terminal. To sum up,in this experiment, as students, we have experimented with how operates different kinds of operational amplifier circuits and how to work with voltage dividers.

Appendix I

Total time spent on/during:

- Pre-lab preparation: 6 hours (including the preliminary work and simulations)
- Experimental work: 2 hours (hours spent in lab)
- Report writing: 6 hours

Appendix II

The outputs of the simulations are fetched from LTSpice and plotted in MATLAB.