EEE 202 Circuit Theory Lab 1
Melih Kutay Yagdereli 22002795
Section 1

Part 1 Software Implementation

Introduction:

The main purpose of this experiment is to practice time-domain analysis and frequency-domain analyses firstly on basic RL circuit than on basic OPAMP circuits. For this purpose firstly basic passive elements are used in the circuit like resistor and inductor circuit and on the second part with the OPAMP, basic inverting amplifier and integrator circuit is implemented and their outputs are investigated with different analysis.

Analysis:
At Part 1 step 1 voltage divider circuit with two resistors is implemented. For R3 3 ohm and for R4 15oh resistors are selected. For the Input voltage 14V peak to peak 5 KHz sinusoidal wave is used. The results came as expected in the simulation

Voltage Divider eq:

$$V_{Out} = V_{Input} \cdot \frac{R4}{R4+R3} \quad \text{(eq.1.1)}$$

$$7 \cdot \frac{15}{15+3} = 5.83\, V \quad \text{(eq. 1.2)}$$

At step 2 by changing the resistor to inductor we create a simple high pass filter since the inductor shows little reactance for the low frequencies they pass through on the output side we observe the high frequency signals. This can be shown with the simple eq

$$X = jwL\, \Omega \quad \text{(eq. 2.1)}$$

$$V_{Out} = V_{Input} \cdot \frac{jwL}{\sqrt{R3^2 + jwL^2}}\ \text{V} \quad \text{(eq. 2.2)}$$

$$V(t)_{Out} = I(t) \cdot jwL\ \text{V} \quad \text{(eq. 2.3)}$$

As the eq. 2.3 shows high frequency, increases the w thus the Vout increases and from the eq. 2.2 we can see that as the frequency increases the Vout approaches the Vinput values. This result is expected as the inductor keeps most of the high frequencies in the output and sends the low frequencies to the ground. These equations are tested with three different frequencies in the experiment with 10 KHz, 100 Khz, and 500 KHz.

At part 2 instead of manually changing and observing all the different frequencies in the time domain we use the frequency-domain analysis to show how the circuit is responding to all different frequencies within a given range.

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In part 3, firstly a simple inverting amplifier circuit is implemented. By using KVL at the minus input and assuming the opamp in linear region ($V_+ = V_-$) we can reach the gain equations.

$$V_{Out} = V_{Input} \cdot - \frac{R2}{R1} \text{ (eq. 3.1)}$$

$$V_{out} = 1V \cdot - 4 = 4\,V \text{ (eq. 3.2)}$$

$$H = \frac{V_{out}}{V_{input}} = - \frac{R2}{R1} \text{ (eq. 3.3)}$$

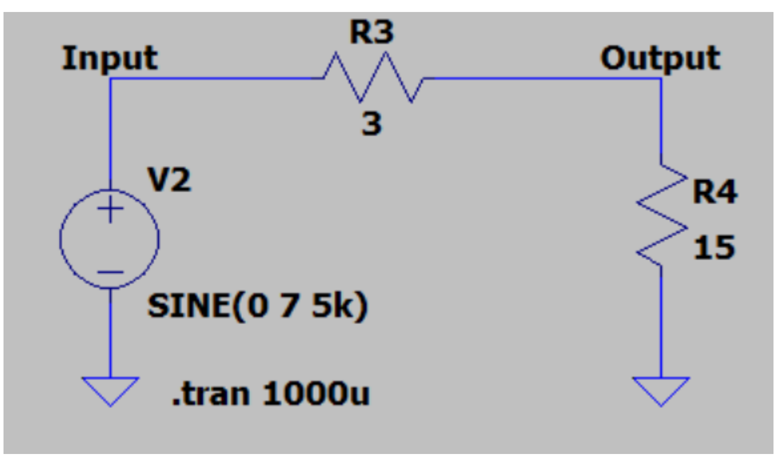
By choosing the ratio 4 for the R1 and R2 we expect a -4 times of the input voltage in the output as shown in the eq. 3.3. We use the time-domain analysis since we are interested in voltage gain and there is no motivation to observe frequency response. In step 5 after the ratio 7 the opamp clearly becomes saturated and we observe cutted cap shape in the output wave. Since after saturation the opamp just gives the maximum voltage amplitude it can deliver.

In step 6 by replacing R2 with a capacitor we create an integrator OPAMP. We can show this by using KVL at the minus input similar to the previous one. But this time the capacitor adds a differential part. And creates this equation:

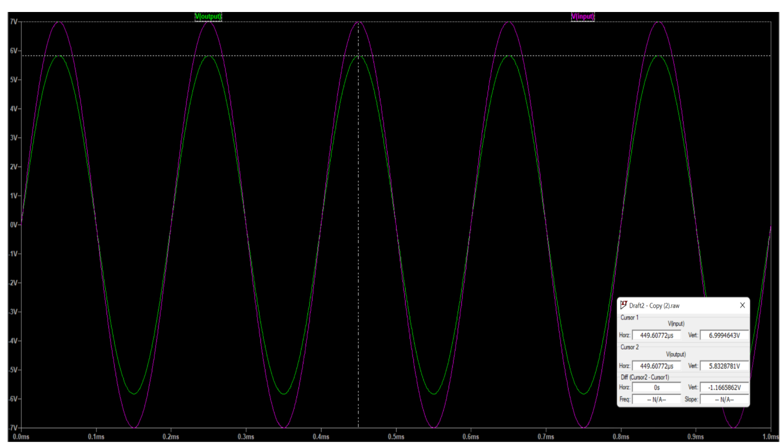
$$V_{Out} = - \frac{1}{R1C} \int_0^t V_{input} dt \text{ (eq. 4.1)}$$

As seen in the eq. 4.1 the capacitor integrates the input signal so when we supply a square wave it creates a ramp function in the output.

Simulations:



Picture 1: The Voltage Divider



Picture 2: Simulation of the Volatge Divider

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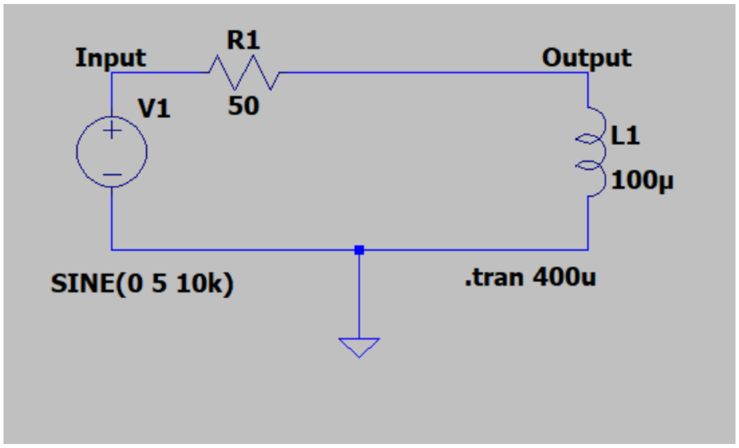
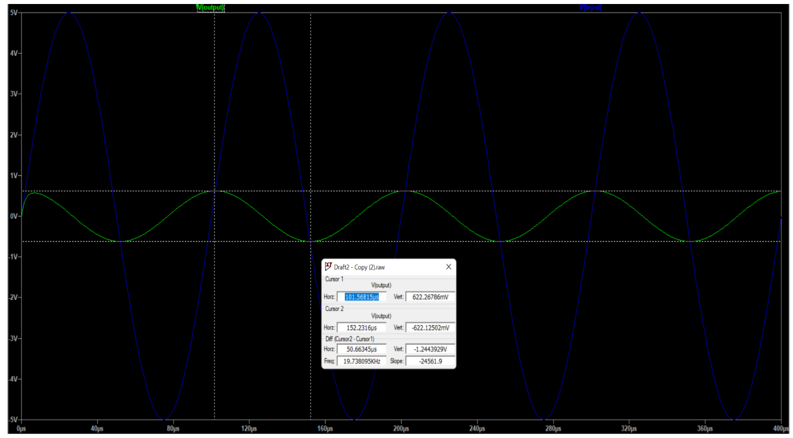
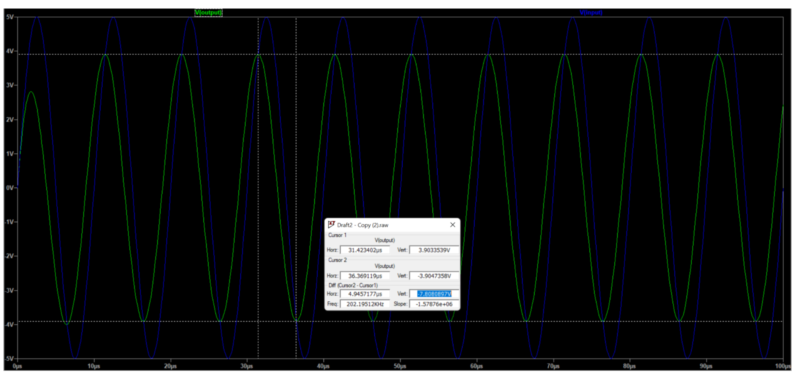


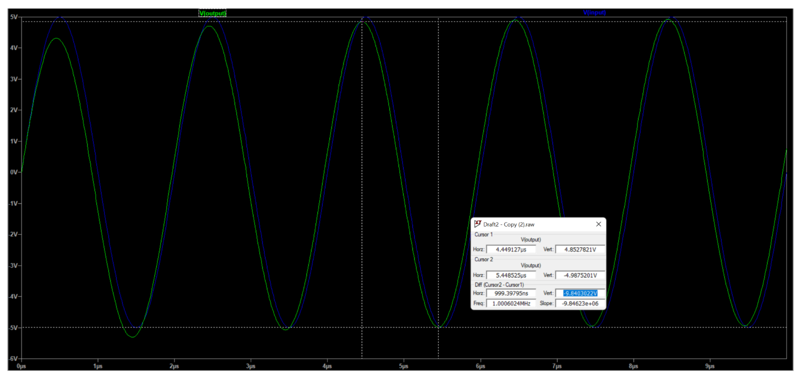
Picture 3:High Pass Filter



Picture 4: 10 KHz Output



Picture 5: 100 KHz Output



Picture 6: 500 KHz Output

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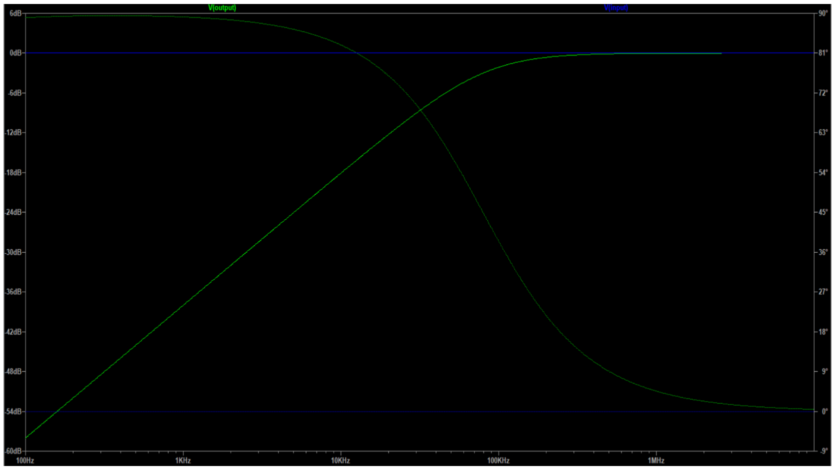
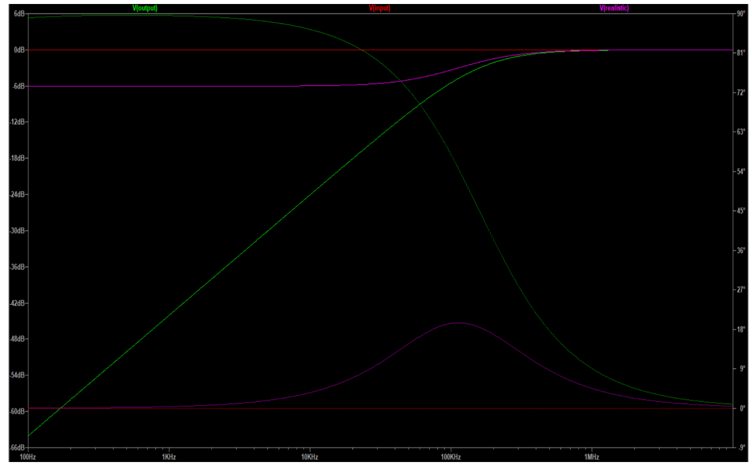
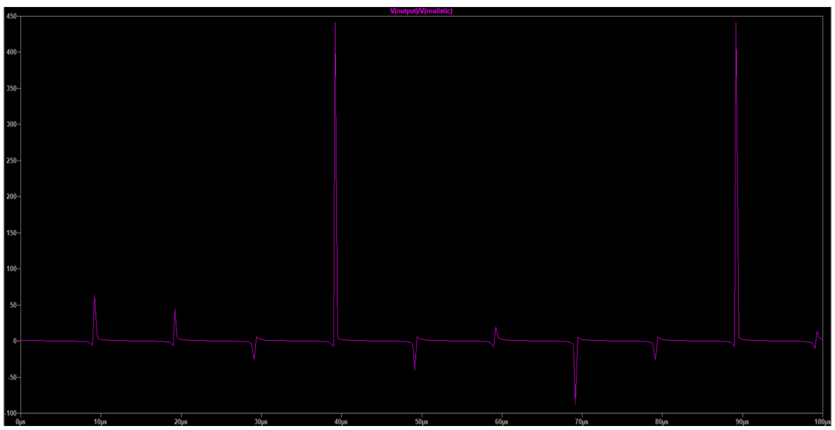


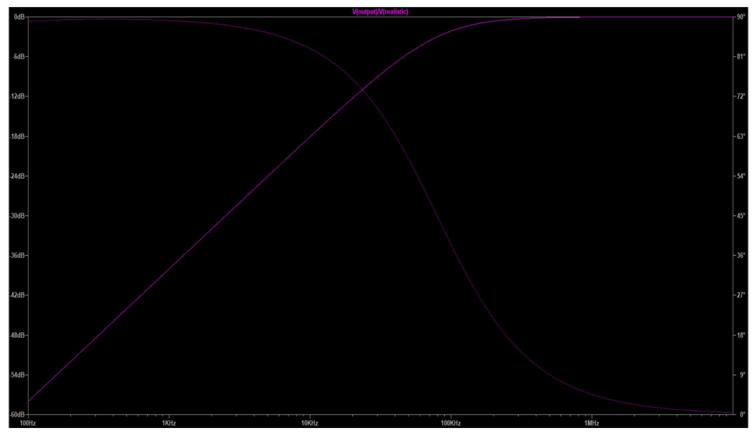
Picture 6: AC Analysis Results



Picture 7: AC Analysis Results with realistic model



Picture 8: AC Analysis Results with realistic model in transient analysis



Picture 9: AC Analysis Results with realistic model in AC analysis

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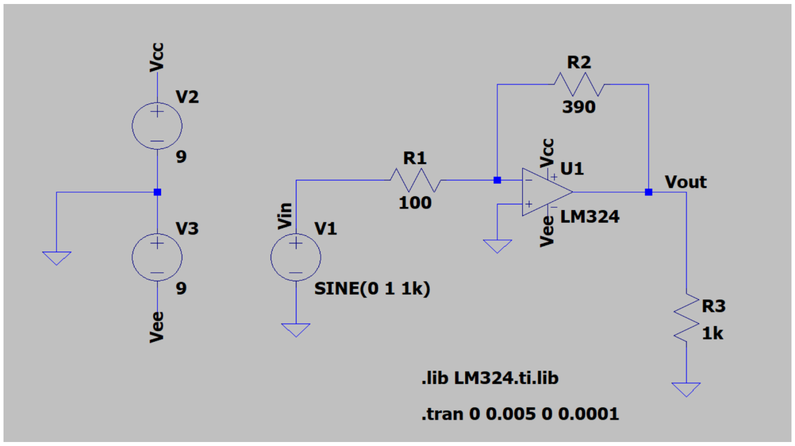
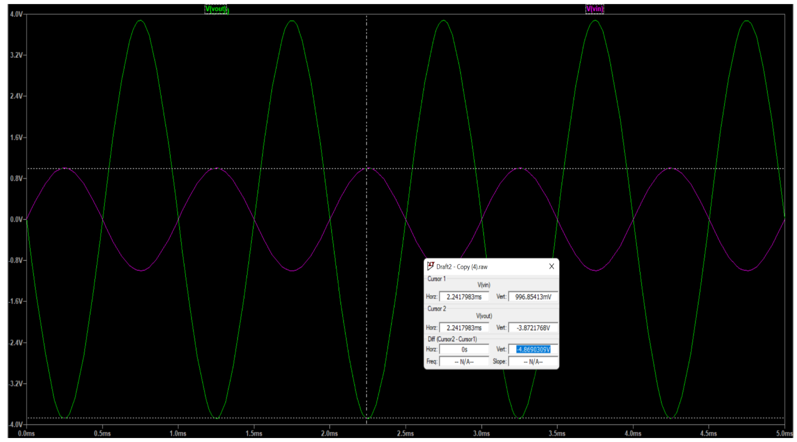
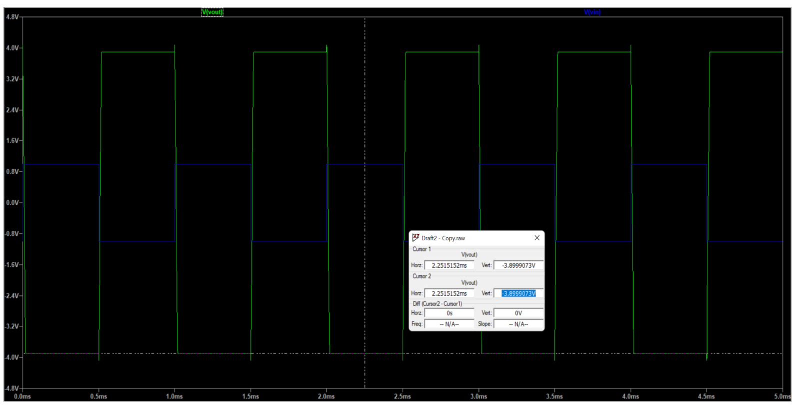


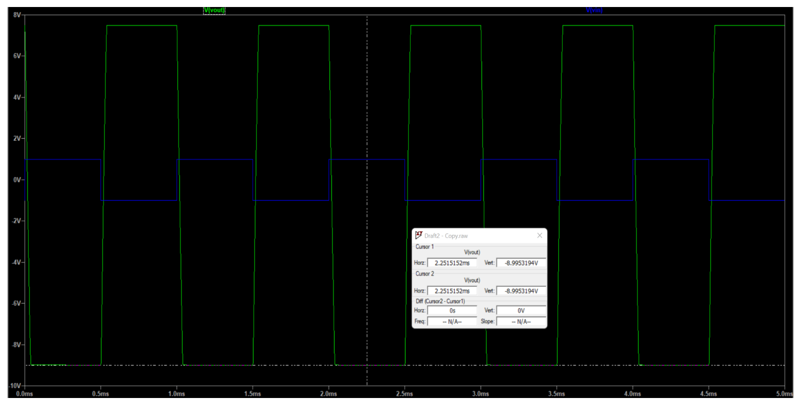
Picture 10: Inverting Amplifier Circuit



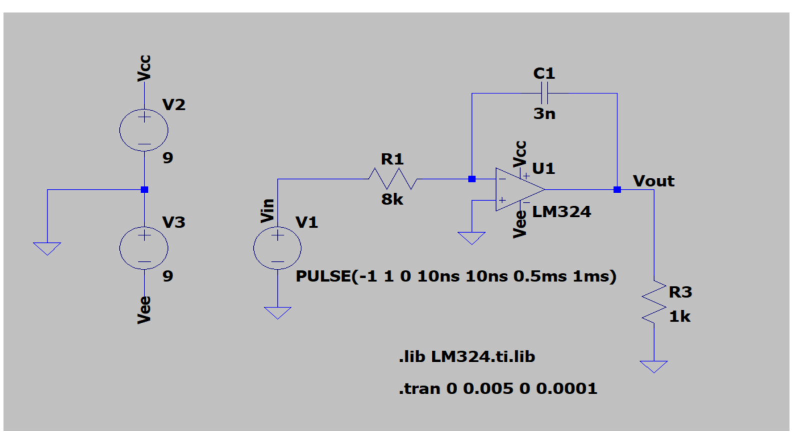
Picture 11: The results for 100 ohm /390 ohm



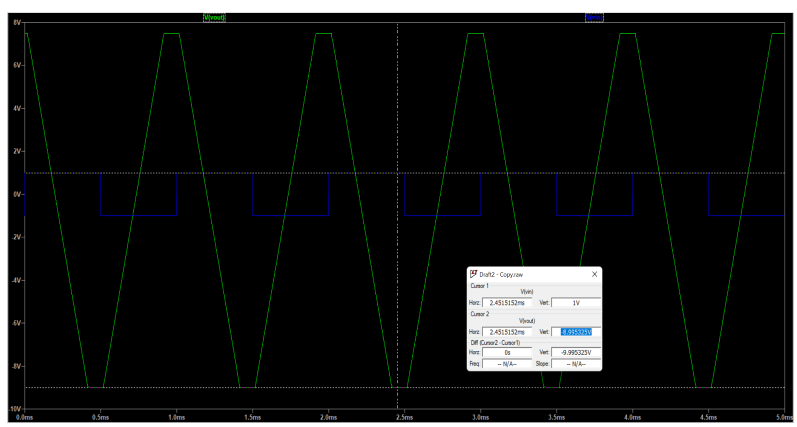
Picture 12: The results for 100 ohm /390 ohm with square wave input



Picture 13: The results for 100 ohm / 12 KOhm with square wave input



Picture 14: Inverting Integrator Circuit



Picture 15: The Result of Inverting Integrator

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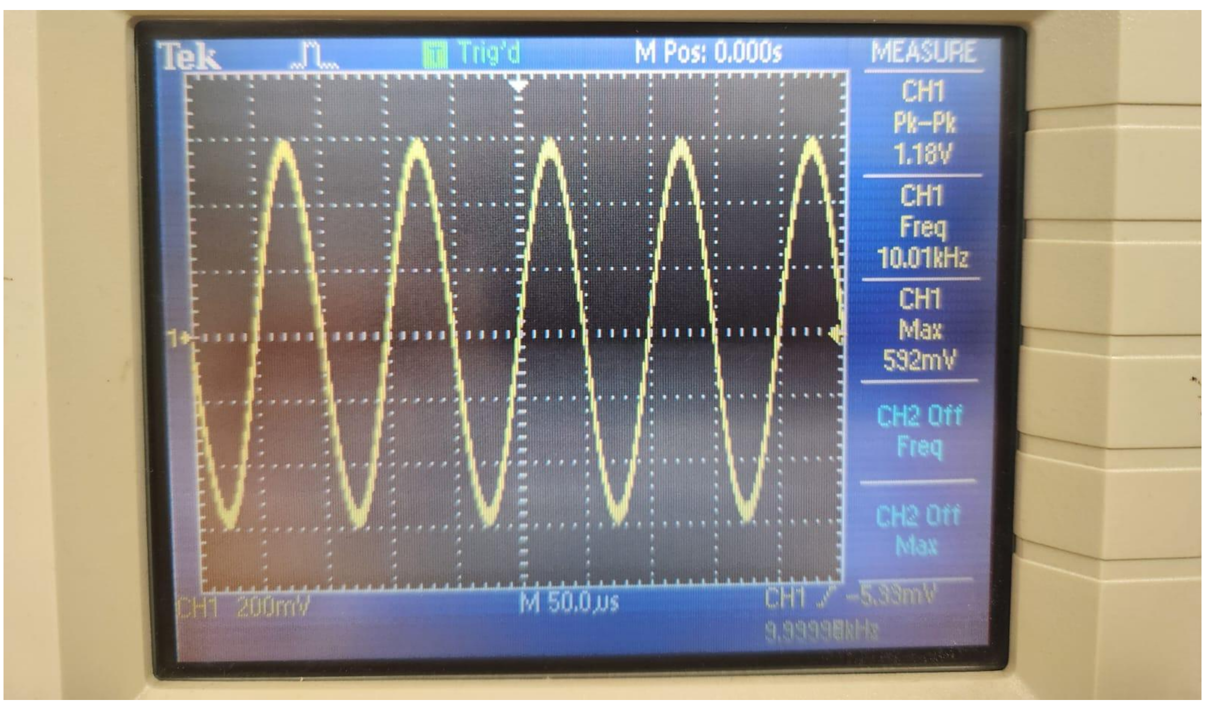
Frequency	Vinput	Voutput
10 KHz	10 Vpp	1.24 Vpp
100 Khz	10 Vpp	7.80 Vpp
500 Khz	10 Vpp	9.84 Vpp

Table 1:Results for High Pass Filter

R1/ R2	Vinput	Voutput
4	2 Vpp	7.99 Vpp
8	2 Vpp	15.48 Vpp
9	2 Vpp	16.42 Vpp
10	2 Vpp	16.42 Vpp

Table 2:Results for Inverting Amplifier

Part 2 HardwareImplementation



Picture 16:Results for 10 Khz in High Pass Filter

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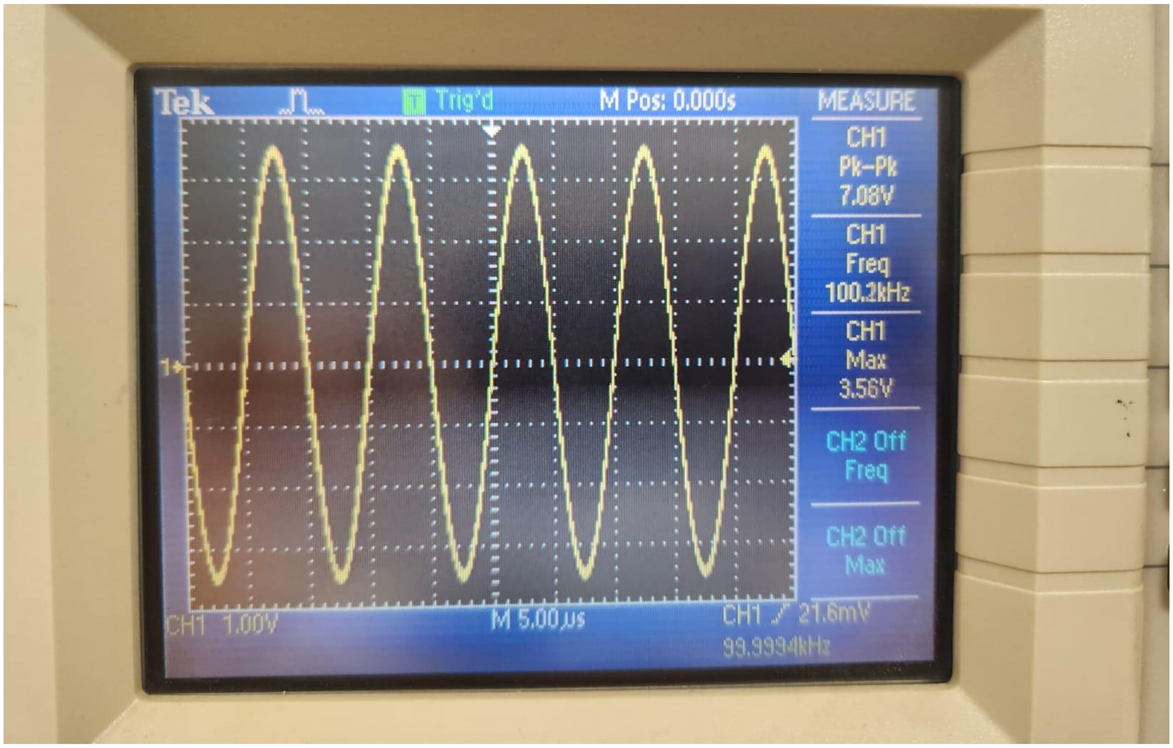
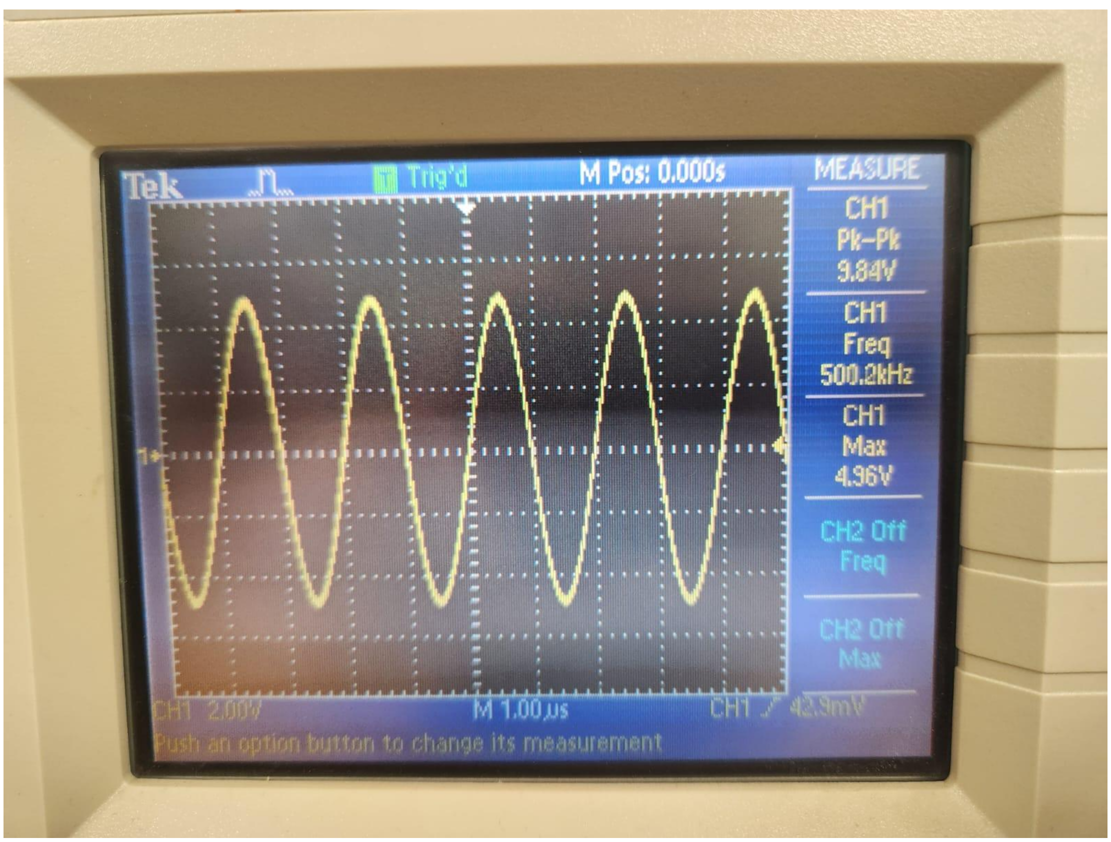


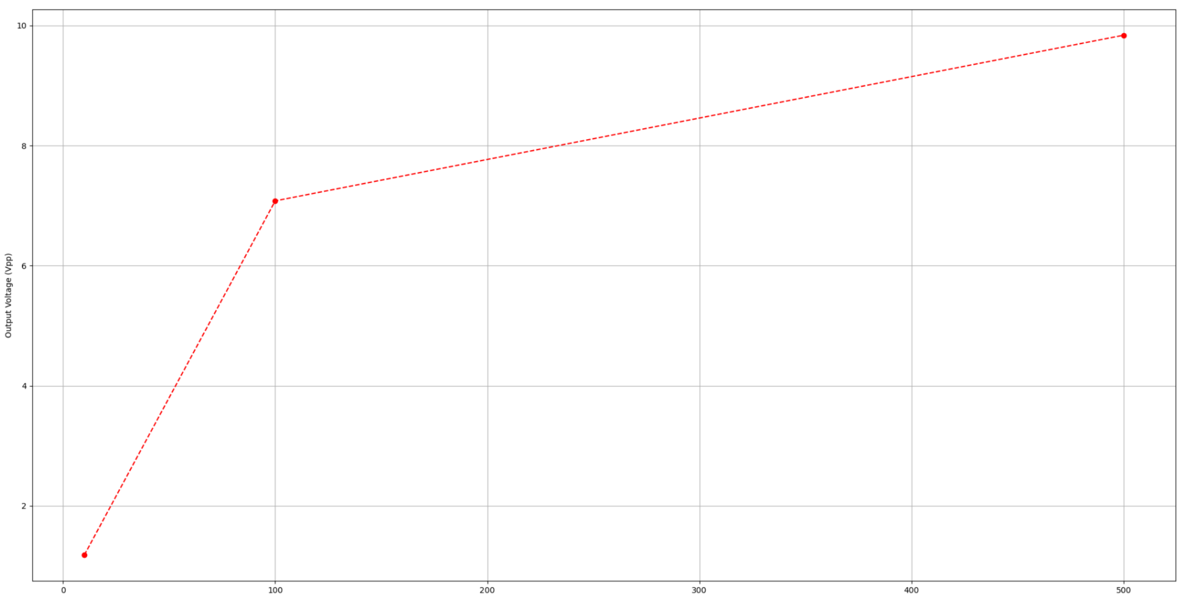
Picture 17: Results for 100 Khz in High Pass Filter



Picture 18: Results for 500 Khz in High Pass Filter

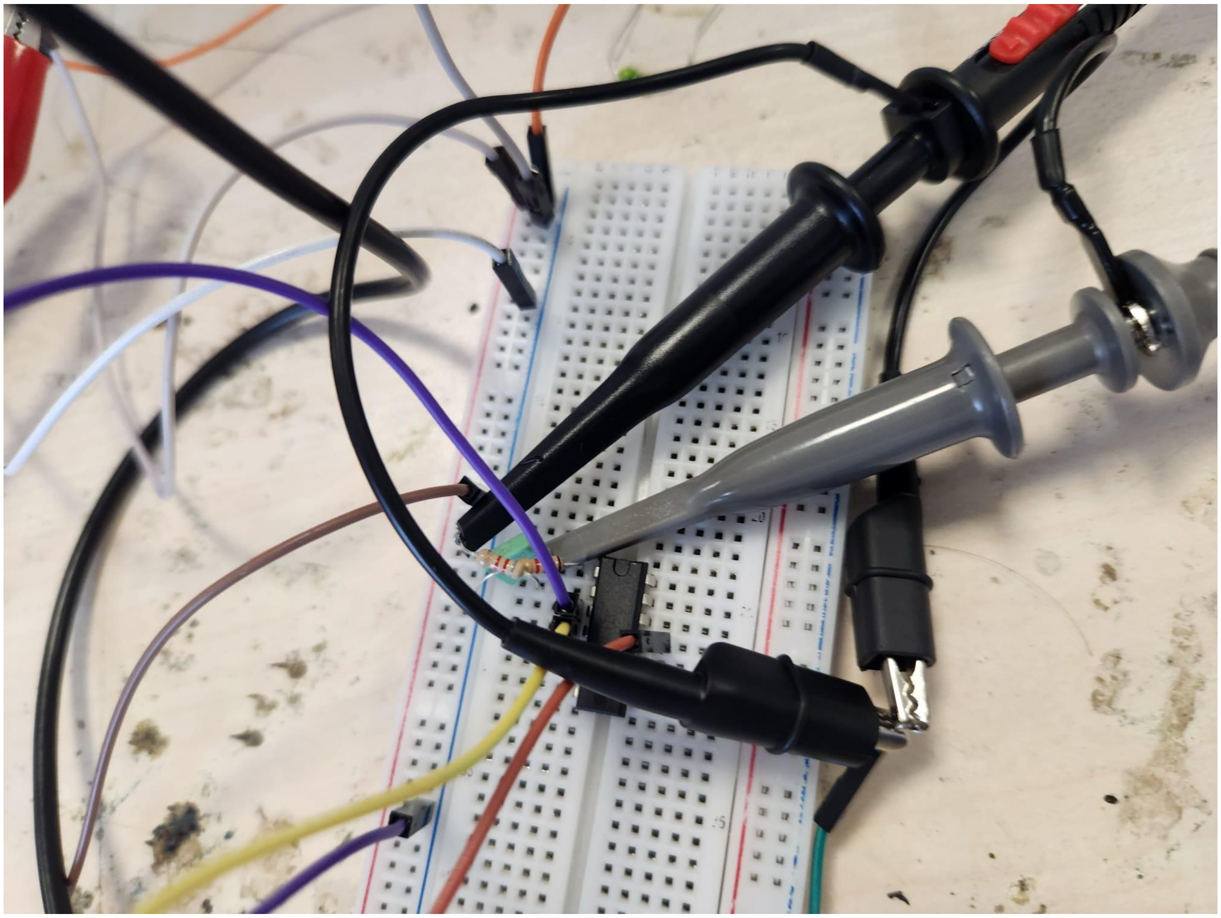
Frequency	Vinput	Voutput	%error (Compared to the simulation part)
10 KHz	10 Vpp	1.18 Vpp	%4.8
100 Khz	10 Vpp	7.08 Vpp	%9.2
500 Khz	10 Vpp	9.84 Vpp	%0

Table 3:Results for High Pass Filter in hardware



Picture 19: Rough plot of frequency response of High Pass Filter

The rough plot is came as expected in the simulation part. As the frequency increases it Voutput approaches the Vinput (0 dB gain line),500Khz is really close to the 0dB in 100khz it is around -2 -3dB gain and for the 10 Khz it is around -20 dB.



Picture 20: The OPAMP circuit on the breadboard

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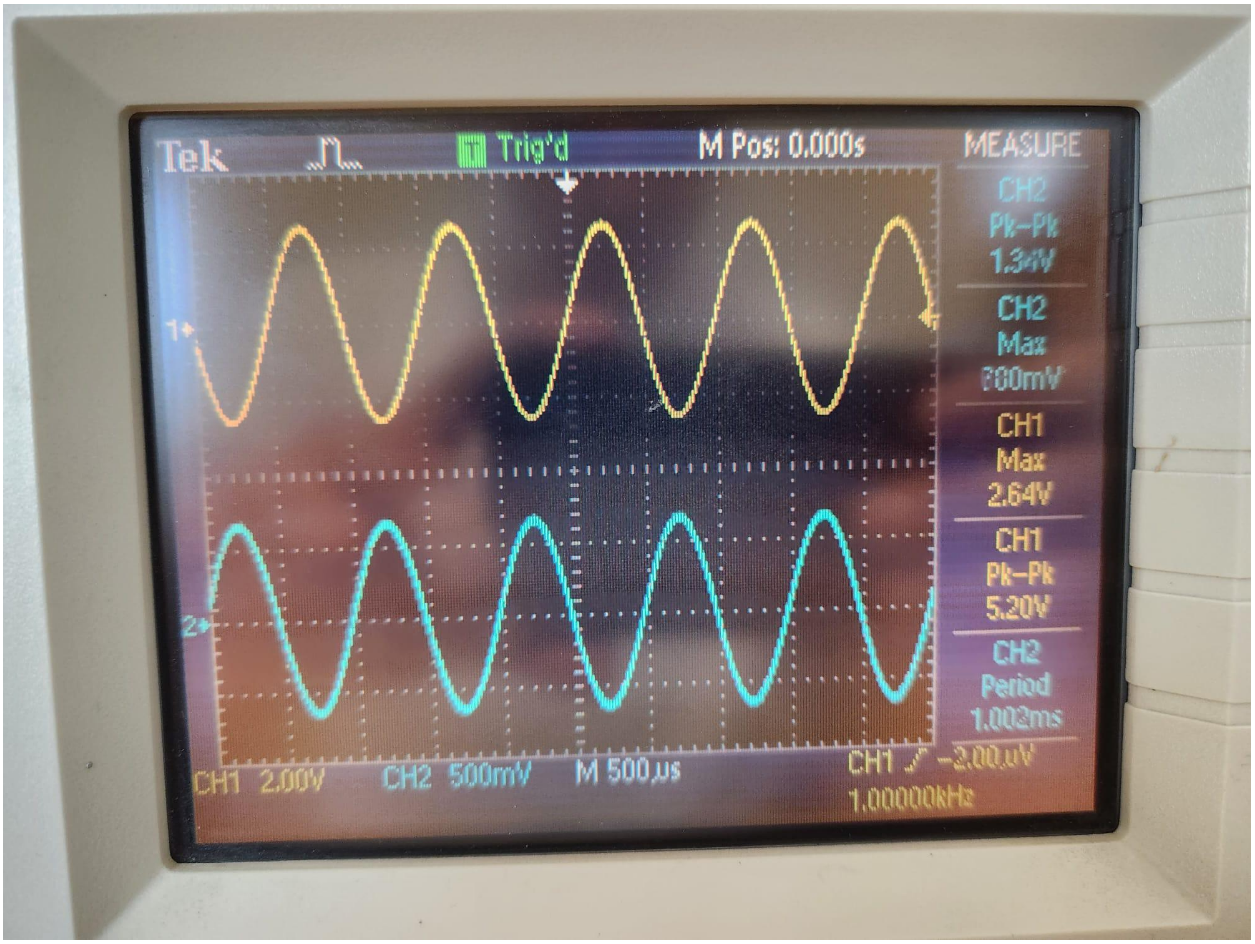
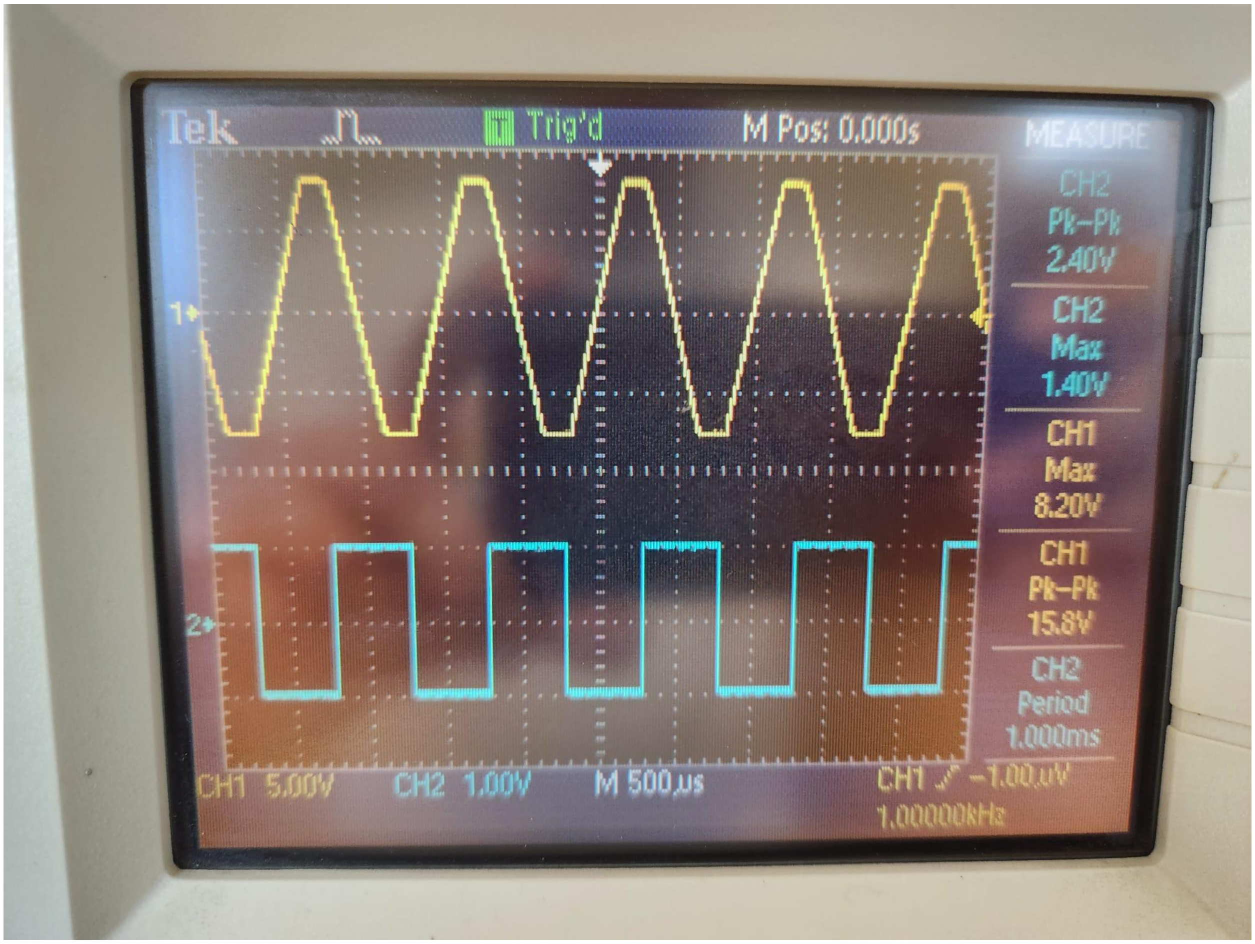


Picture 20: Inverting Amplifier Input and Output values

In this part there is only %0.49 error with the simulation which is well below the accepted error rate



Picture 21: Inverting Integrator Input and Output values

There is %3.6 error from the simulation values this is most probably because of the condition of the used capacitor and components inner resistances

Conclusion:
All of the results came within the %20 error percentage rate. There are small errors due to the components resistance like jumper cables, or breadboard. All of the results prove the equations given in the analysis part. There was only so little to solve or equate but it was a useful lab to practice basic operation in lt spice and components like oscilloscope and signal generator. This lab shows how RL circuits react to different frequencies and How OPAMPs react to different ratios of Resistances and how it can be used to create different shaped output waves from the input. There is nothing much to improve since it is a really basic and simple enough lab