West Virginia University LCSEE

EE 355L

Spring 2023

Section: 001

Date: 9/18/23

Lab 3: LTSpice Amplifiers

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Objective

The objective of this lab is to build fundamental amplifier circuits. The Three amplifier circuits to be built are: the inverting, non inverting and summing amplifier circuits. IC 741 is the "ideal" op amp component used for the circuits.

Procedure

Circuit 1: Simulate non inverting amplifier in LTSpice and implement on breadboard. The following parameters were used: Vdd+ = 5v , Vdd- = -5v, R_1= 2k Ω, R_2= 28k Ω,
V_{in} = 0.2sin(2π500t) v

Circuit 2: Vdd+ =Simulate inverting amplifier in LTSpice and implement on breadboard. The following parameters were used: Vdd+ = 5v , Vdd- = -5v, R_1= 1.5k Ω, R_2= 30k Ω,
V_{in} = 0.2sin(2π500t) v

Circuit 3: Using the input and output signals in diagrams 1 and 2 as a guide, design a summing amplifier to behave accordingly. The following circuit parameters were used: Vdd+ = 5v , Vdd- = -5v , V_1= 100 mV, V_2= ?, V_{out} = 1.6 v, R_1= 1.5k Ω, R_2= 15k Ω, R_f = 30k Ω, DC offset = 1v.

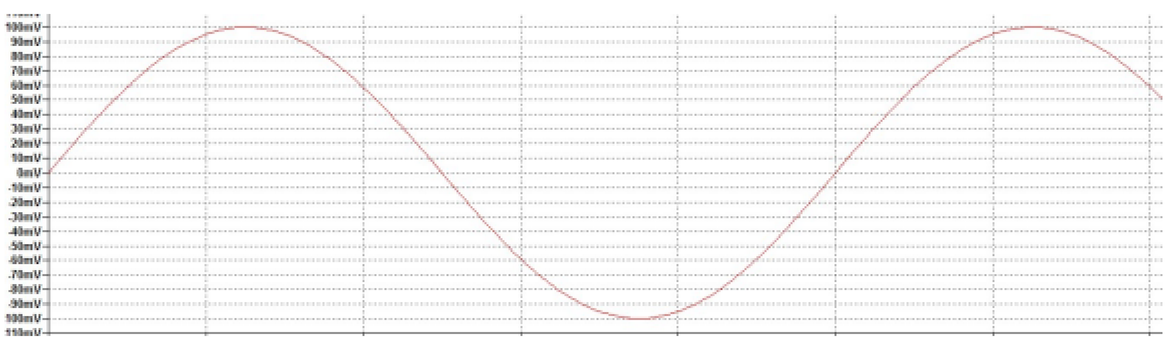


Diagram 1: Input Voltage graph

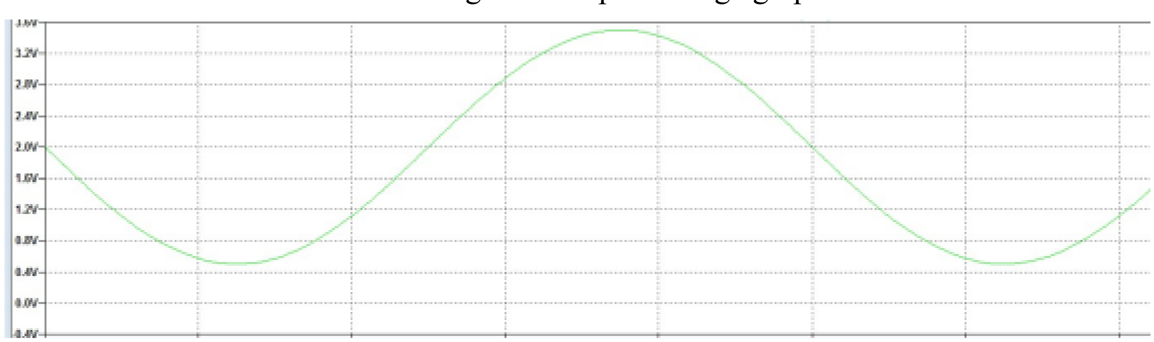


Diagram 1: Input Voltage graph

Calculation

Circuit 1: **Gain** for the circuit $1+(R_2/R_1) = 1+(28k\ /2k) = \mathbf{15}$
Circuit 2: **Gain** for the circuit $= -(R_2/R_1) = -(30k/1.5k) = \mathbf{-\ 20}$

Circuit 3: Calculation for V_2 using the following formula:

$$V_o=-((R_f\ /\ R_1)(V_1) + (R_f\ /\ R_2)(V_2)\ )$$

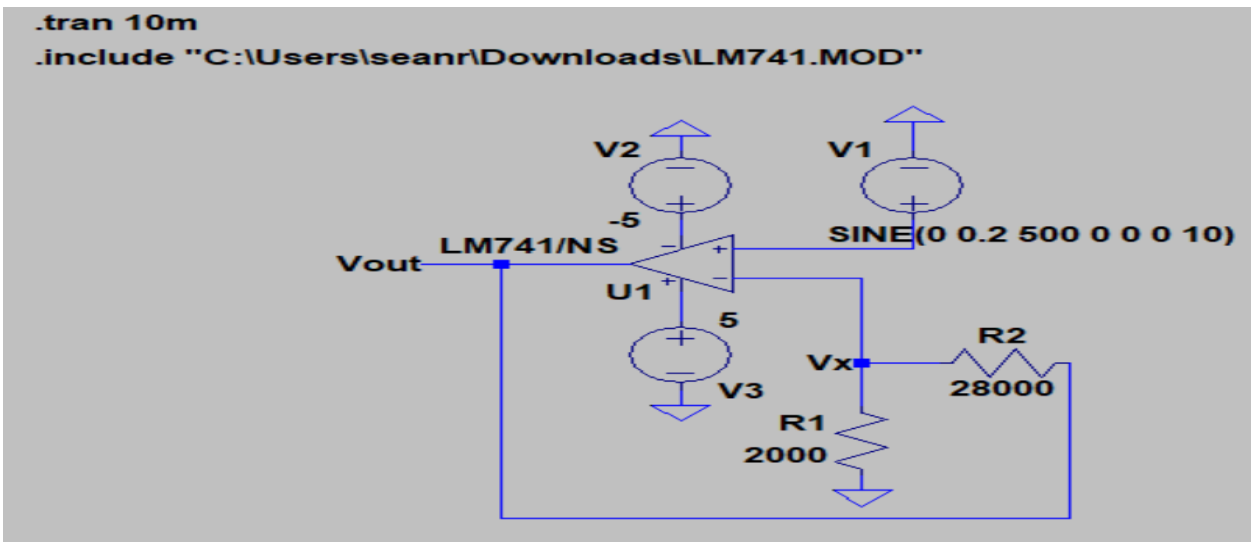
Plugging in values:

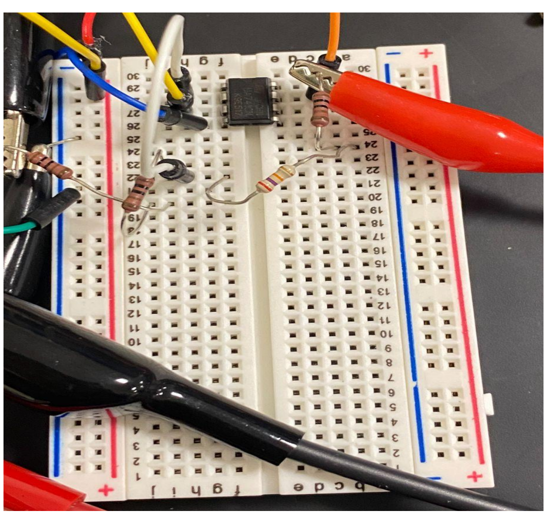
$$1.6=-((30k/\ 1.5k)(0.1) + (30k\ /\ 1.5k)(V_2)\ )$$

Solving for V_2:

$$\mathbf{V_2=-1.8v}$$

Circuit Diagram(s)and Breadboard Implementation





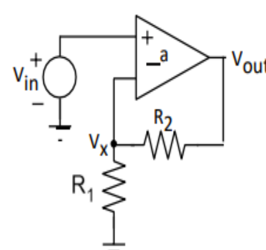
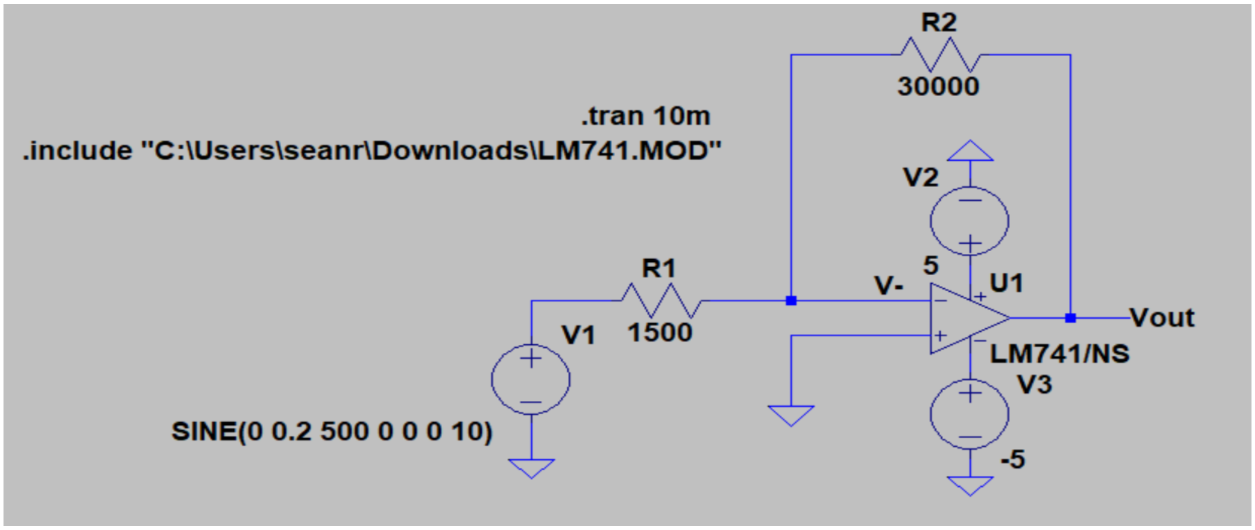


Figure 1: Non- Inverting Amplifier

where:
$R_1 = 2\ k\Omega$
$R_2 = 28\ k\Omega$
$V_{in} = 0.2\ Sin(2\pi 500t)\ V$

Figures 1: Non-Inverting Amplifier (circuit 1)



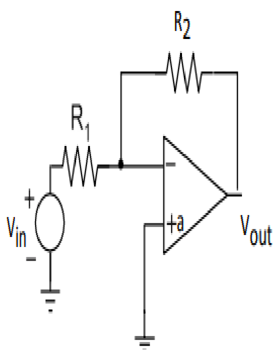


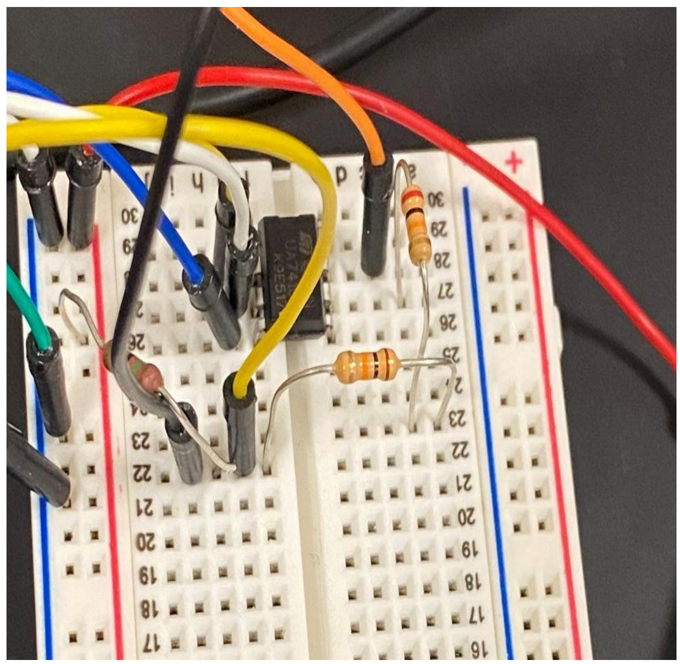
Figure 2: Inverting Amplifier

where:

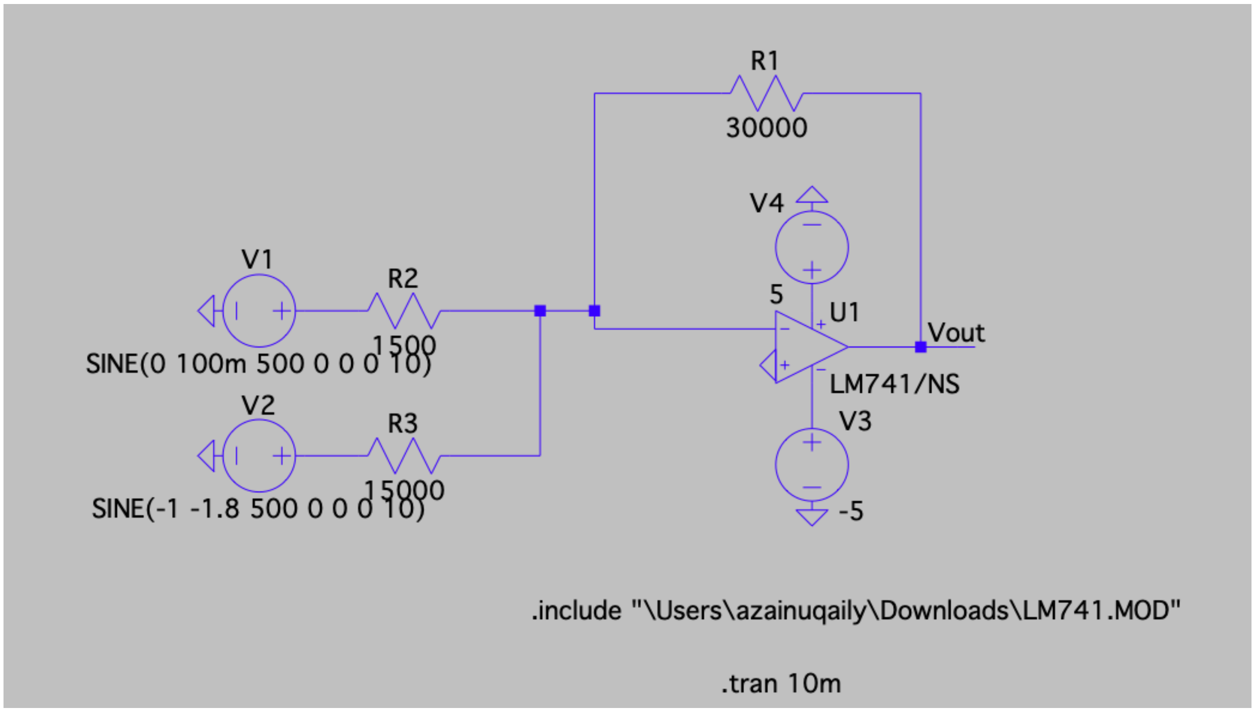
R_1= 1.5 kΩ

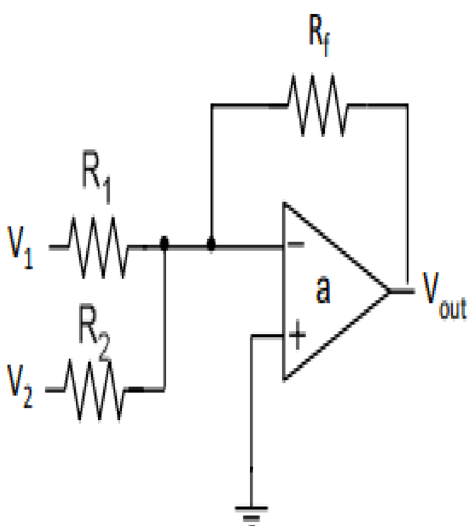
R_2= 30 kΩ

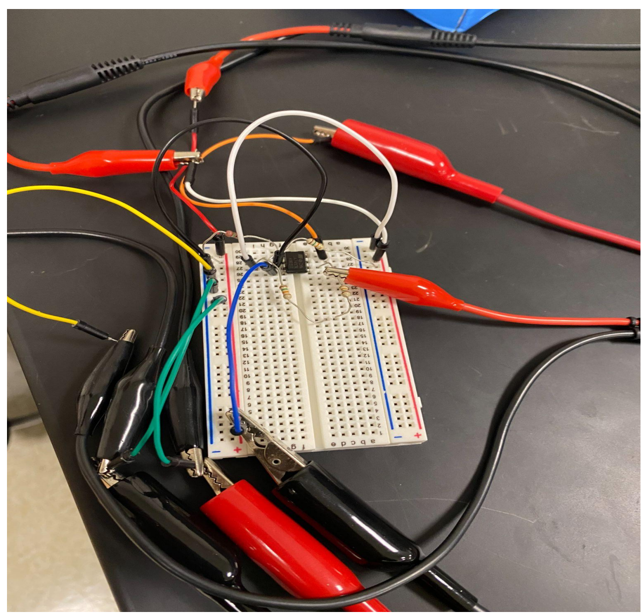
V_{in} = 0.2 Sin(2π500t) V



Figures 2: Inverting Amplifier (circuit 2)

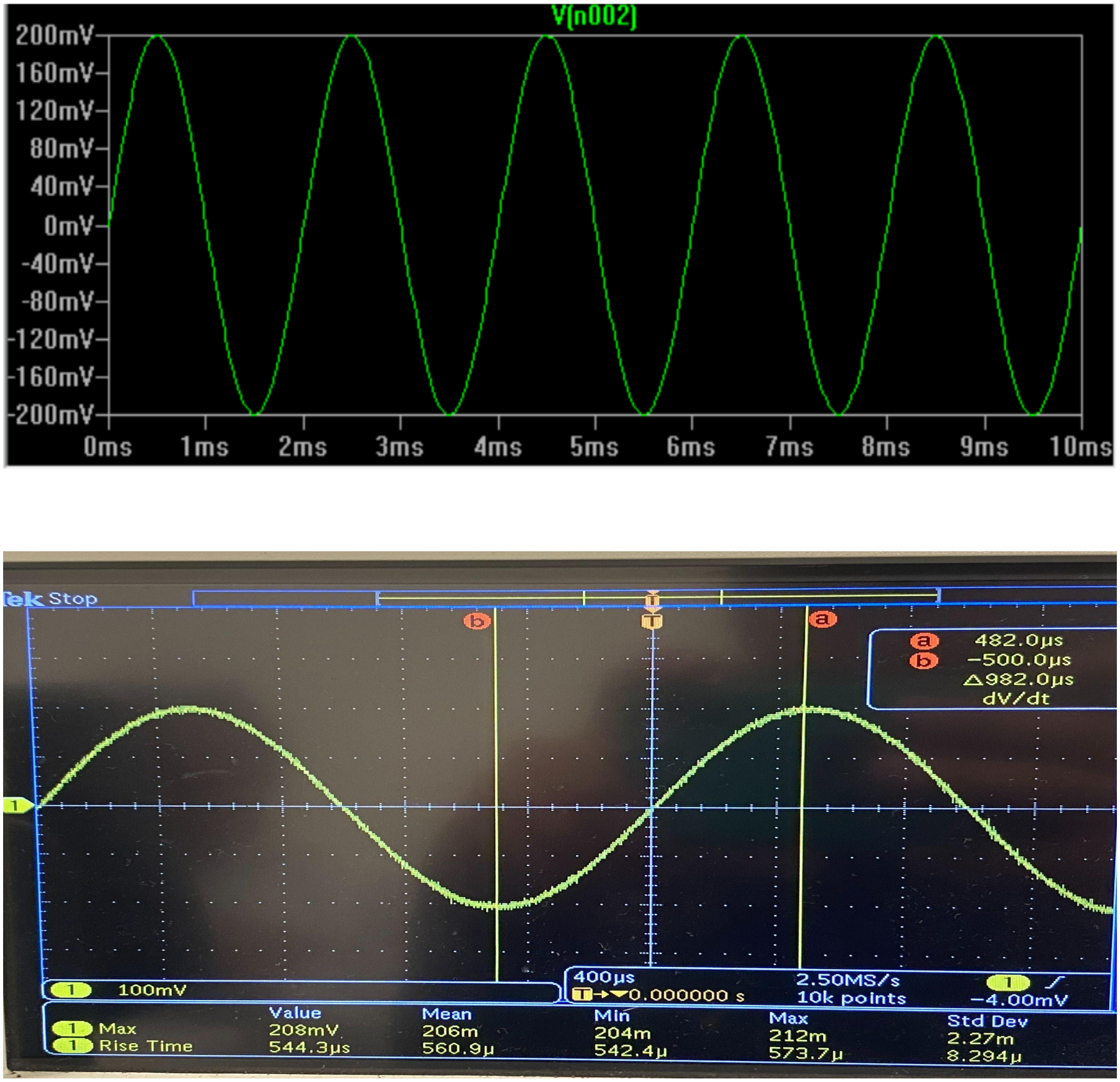




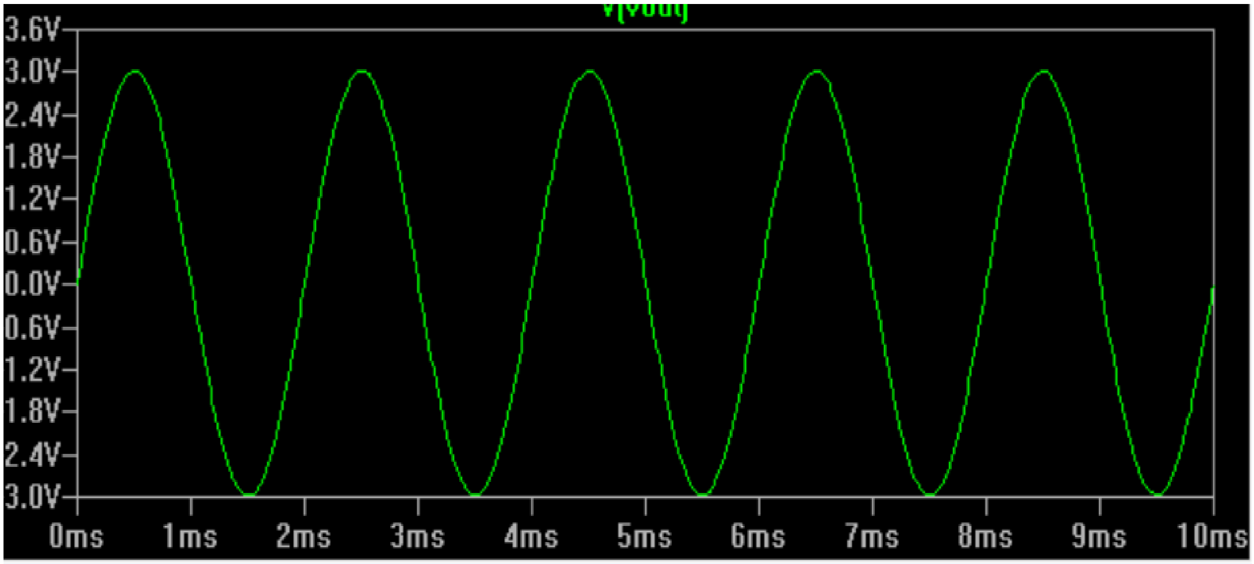


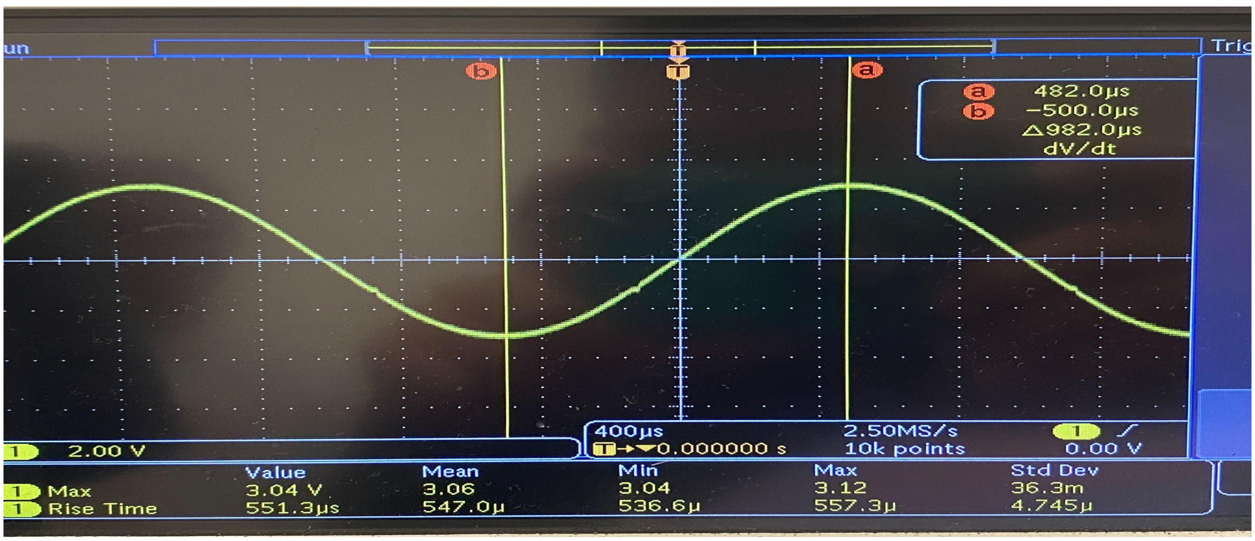
Figures 3: Summing Amplifier (circuit 3)

Results & Discussion (LT Spice Simulation and Oscilloscope)

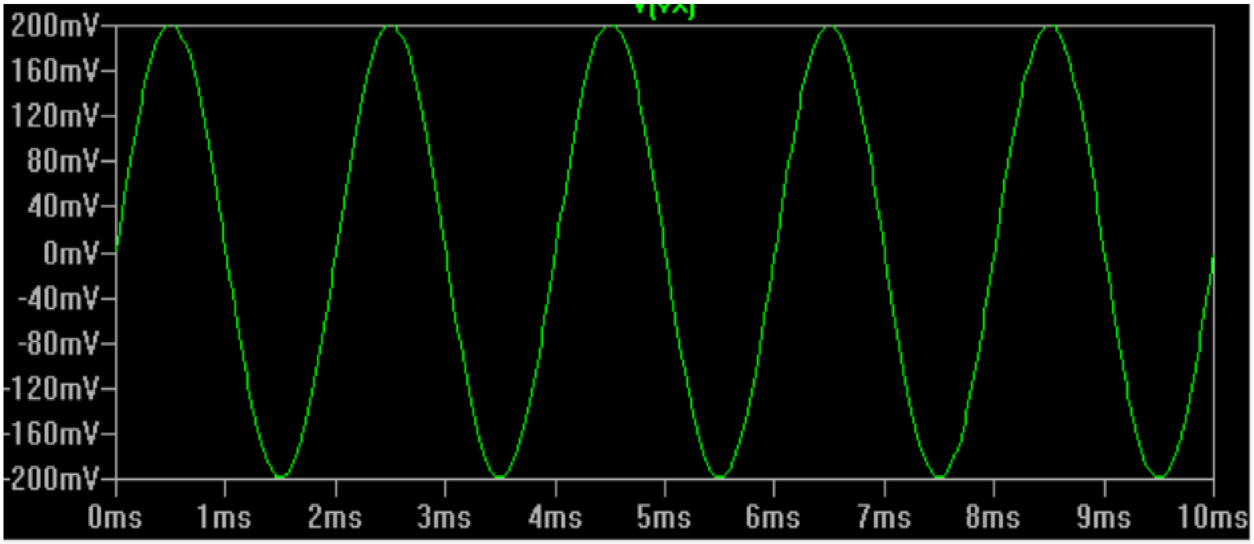


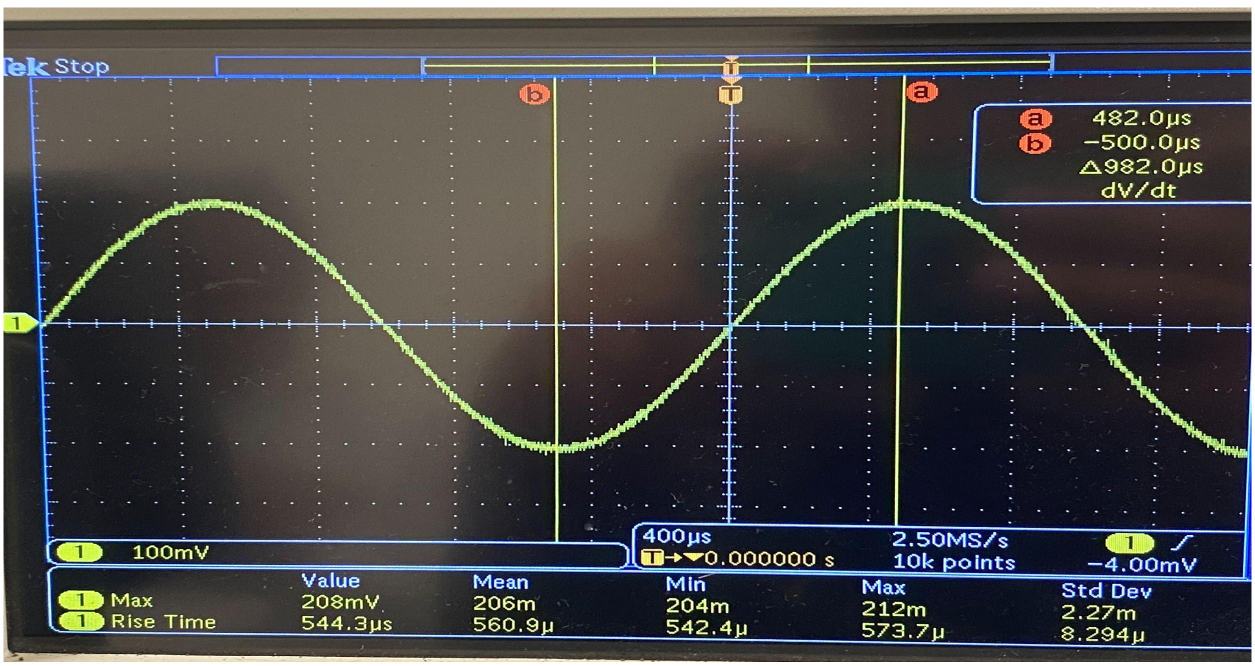
Figures 4a: (Non-Inverting) Input vs Time



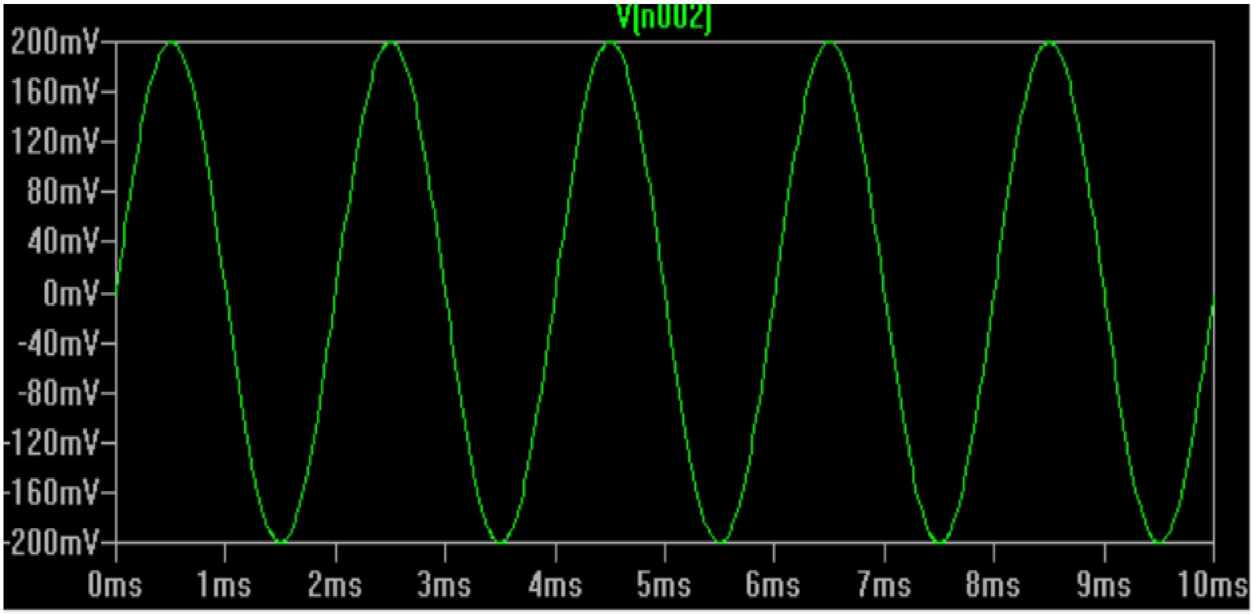


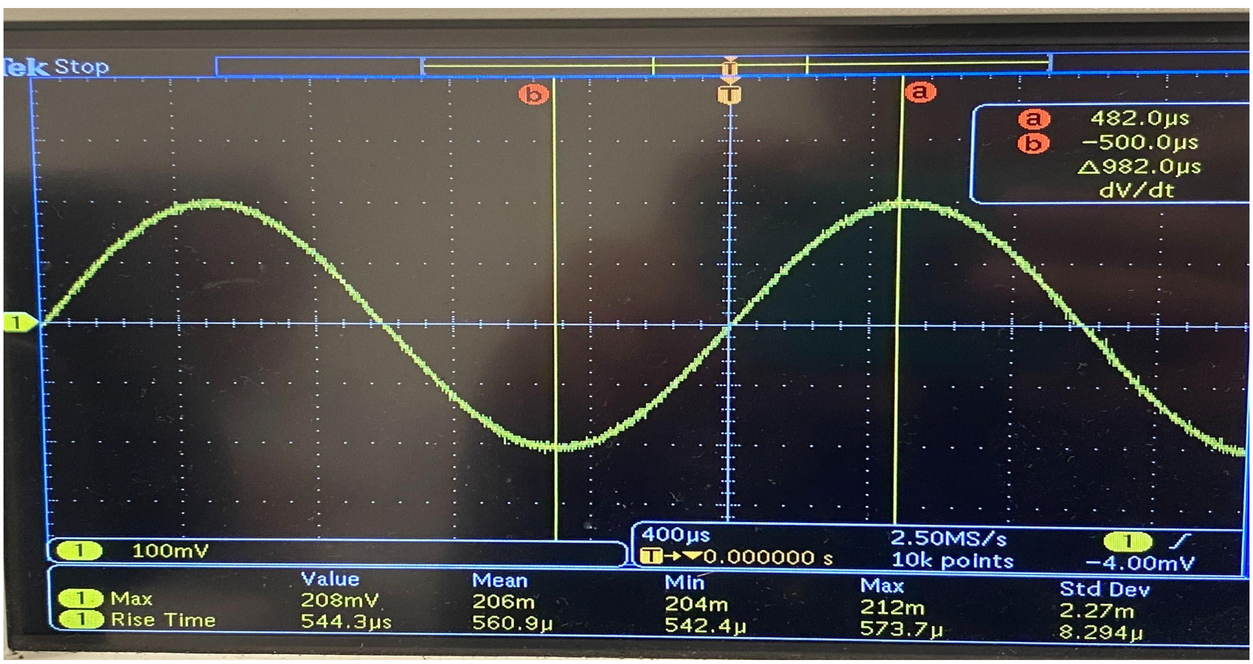
Figures 4b: (Non-Inverting) Output vs Time



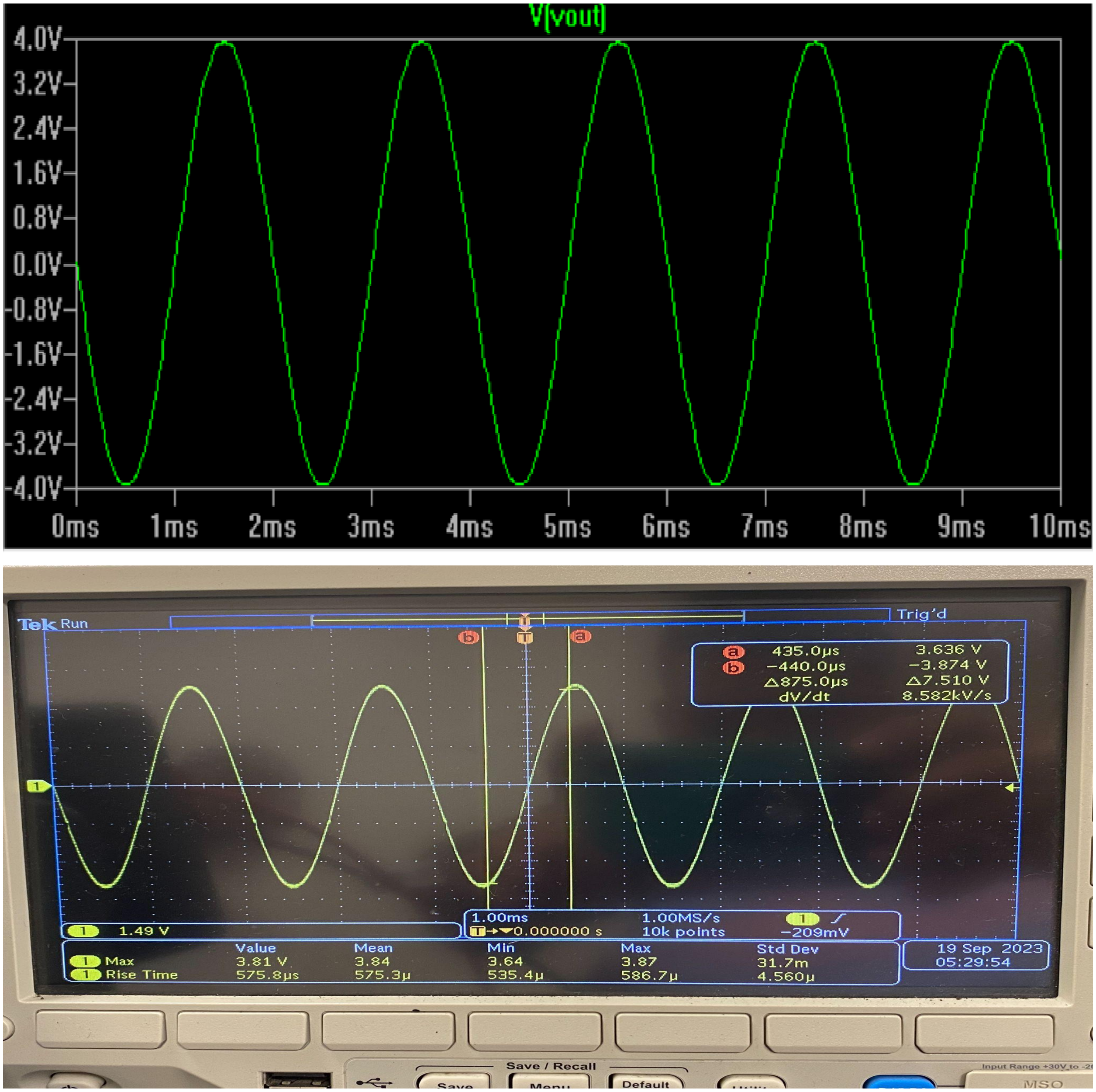


Figures 4c: (Non-Inverting) Vx vs Time

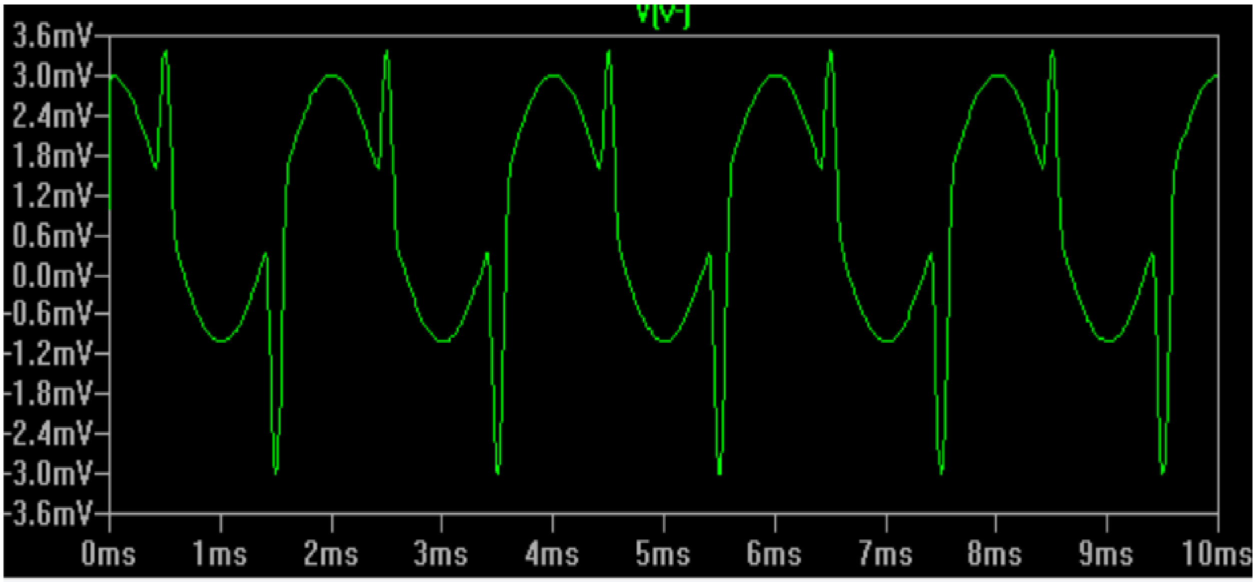




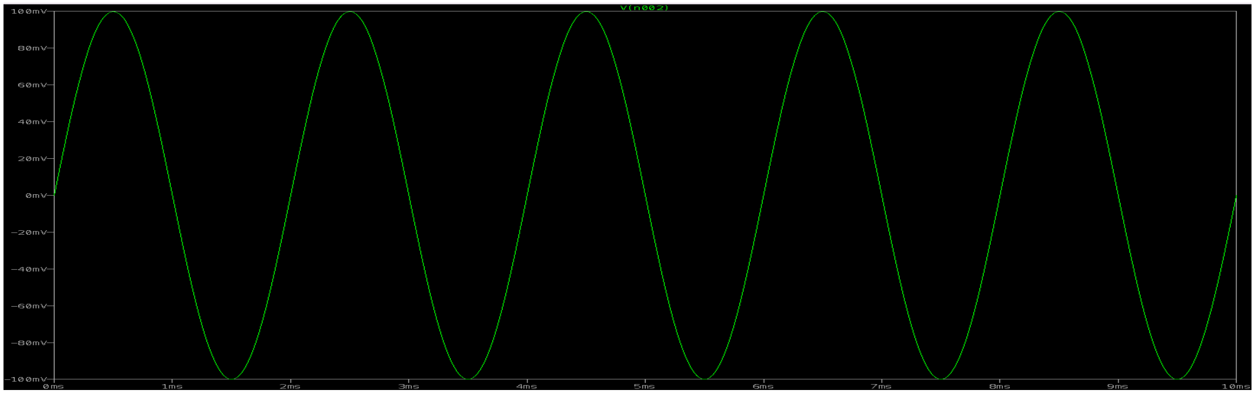
Figures 5a: (Inverting) Input vs Time



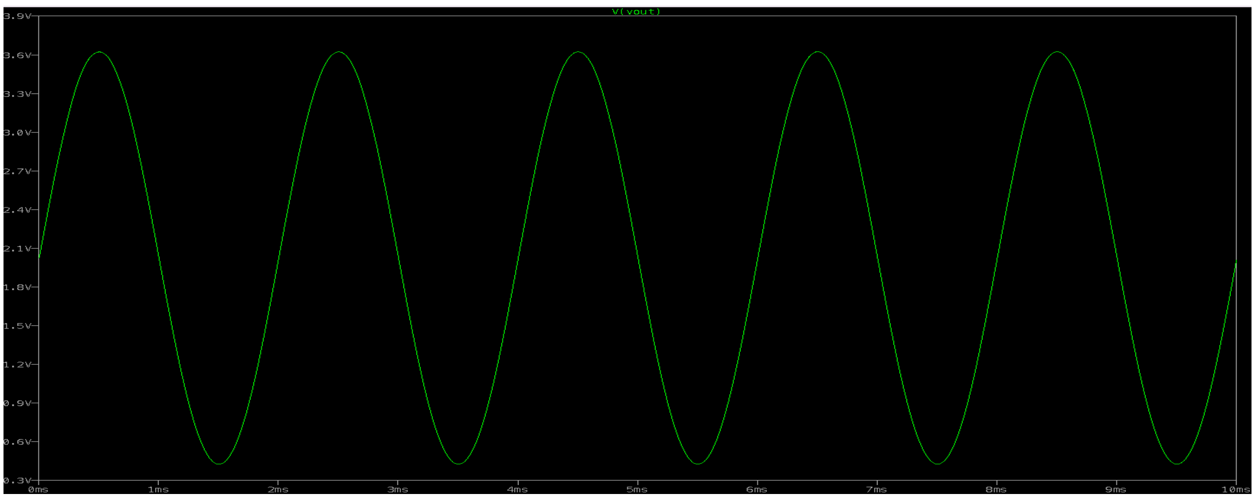
Figures 5b: (Inverting) Output vs Time



Figures 5c: (Inverting) V- vs Time (almost 0 as v+ is ground and v+ = v-)



Figures 6a: (Summing) Input vs Time



Figures 6b: (Summing) Output vs Time

Conclusion

What would happen to the gain if R2 is increased? Explain the reason behind the change.

Non Inverting: If R2 is increased the overall gain of the circuit is increased. Mathematically the gain is 1 plus R2/R1. Therefore when R2 is increased the overall gain is increased. Gain and R2 are proportional in this case.

Inverting: Similar to the non inverting case, increasing R2 will increase the gain. Another way to look at it is by seeing that the ratio between the two resistors increases causing the gain to increase.

Overall, this lab does a good job of solidifying our understanding of fundamental amplifier circuits: non-inverting, inverting and summing. Simulating and building these three circuits illustrated one very important aspect: theoretically our circuits seem perfect, however in practice these circuits are challenging to design and implement. One of the biggest challenges faced was working with imperfect components. In particular, the summing circuit was especially challenging to carefully calculate V_2, in order to produce the correct results. As observed in figure 6.B : oscilloscope reading of output voltage this did come to be 1.58 v which was very close to the calculated value of 1.8. Although our output had some uncertainties with phase shift, the summing amplifier circuit was able to “sum” two applied voltages.

Some other key conclusions to be drawn are the voltages Vx and V-. For the non-inverting amplifier, Vx is equal to V- as they have no resistance between them. Since V- equals V+ (ideal op amps have no voltage difference between terminals) Vx = V+. For the inverting amplifier it was proven that V- was approximately zero as V+ = 0v (grounded).