ELE 504 Lab Report 1

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Introduction

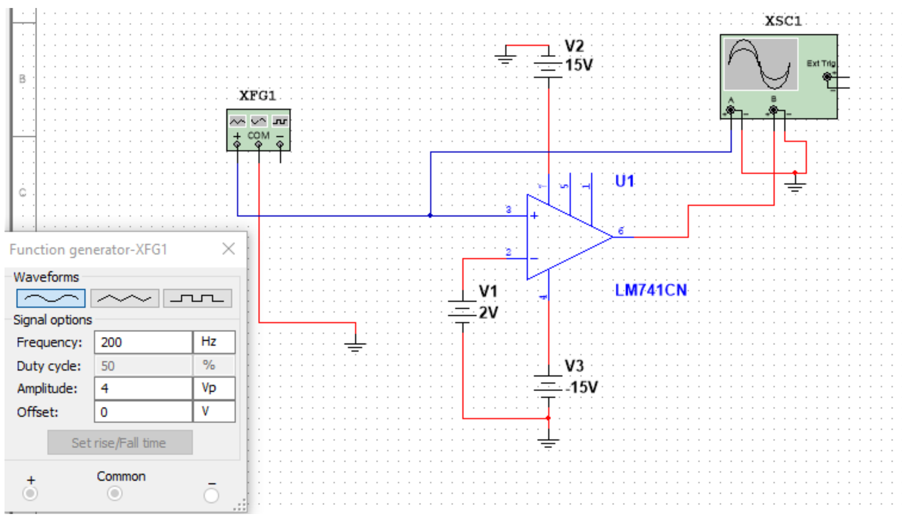
Operational Amplifiers are one of the most vital Integrated Circuits used in a wide range of technology and equipment around the world. An Op-Amp has the ability to amplify signals or voltage values, and isolate parts of a circuit and act as a buffer. This lab will take a look at the different functions that the Op-Amp can be used for and help gain a deeper understanding on how it functions and how the orientation of different parts of the circuit impacts the output of the Op-Amp.

Objective

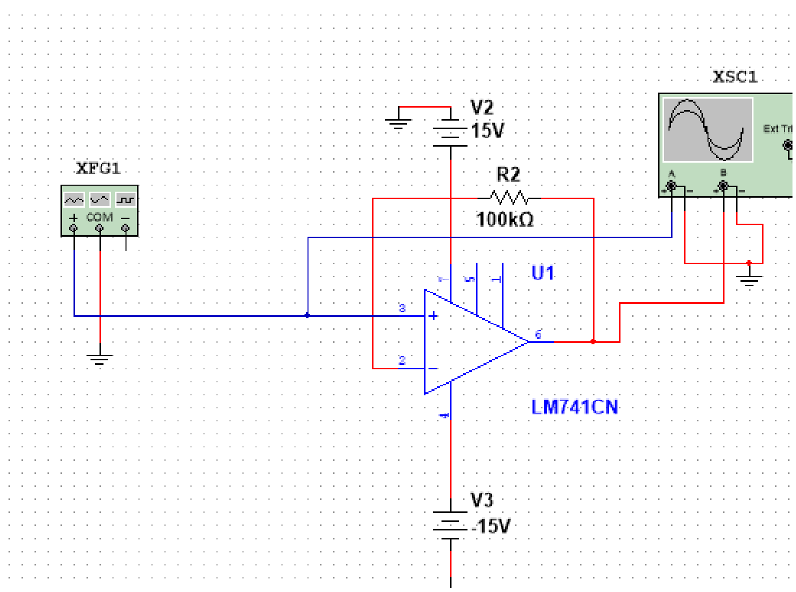
The objective of this lab is to build, simulate and understand the characteristics of several Operational Amplifier circuits such as the buffer, positive and negative feedback loops and open loop.

Circuit Screenshots

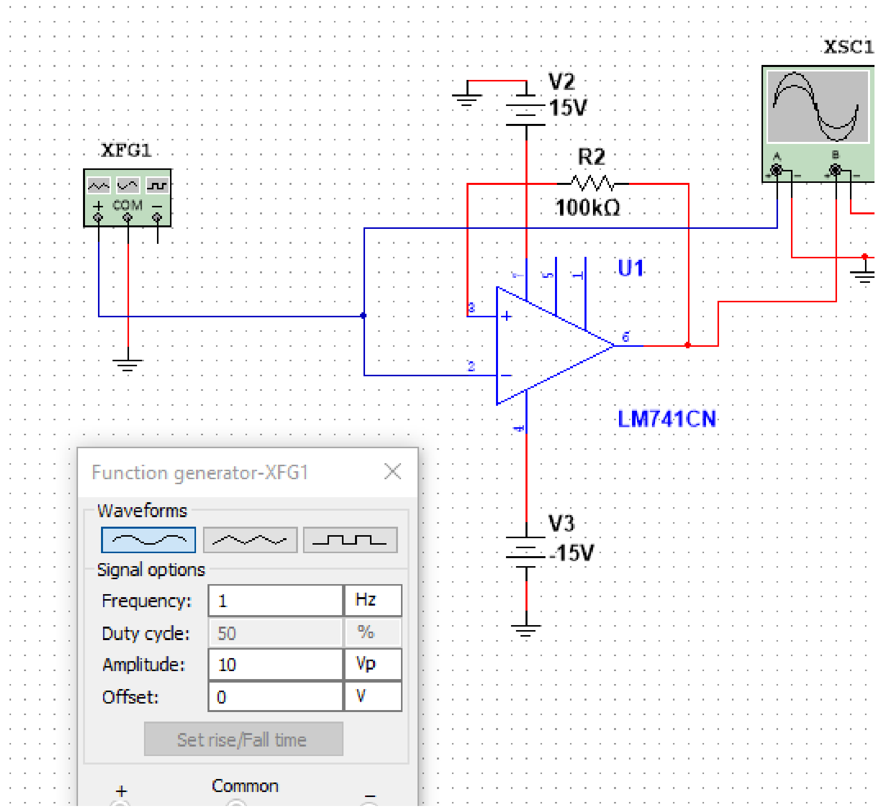
<u>Part 1</u>



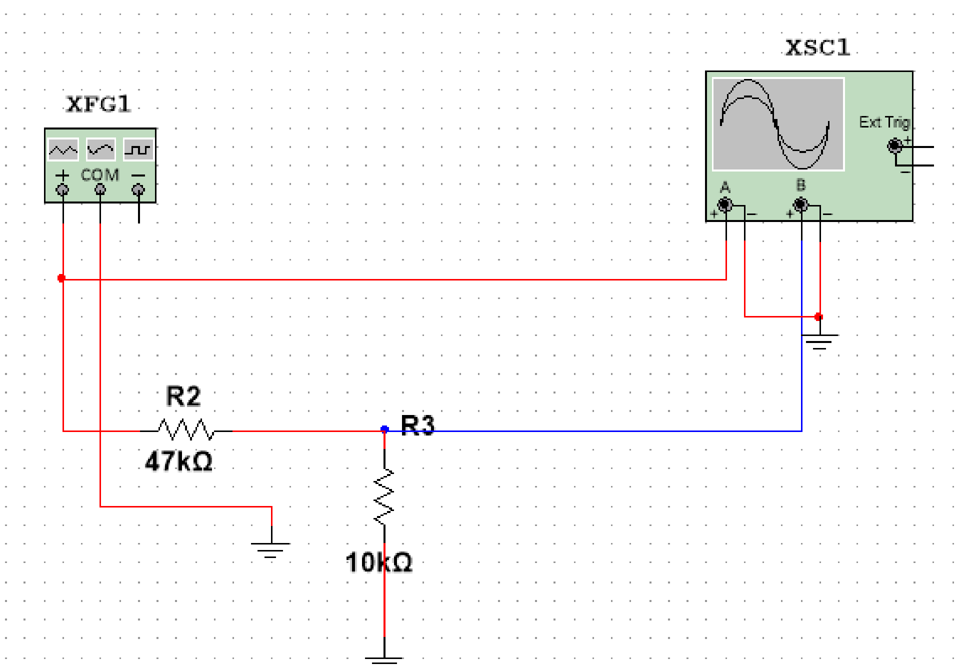
<u>Part 2a</u>



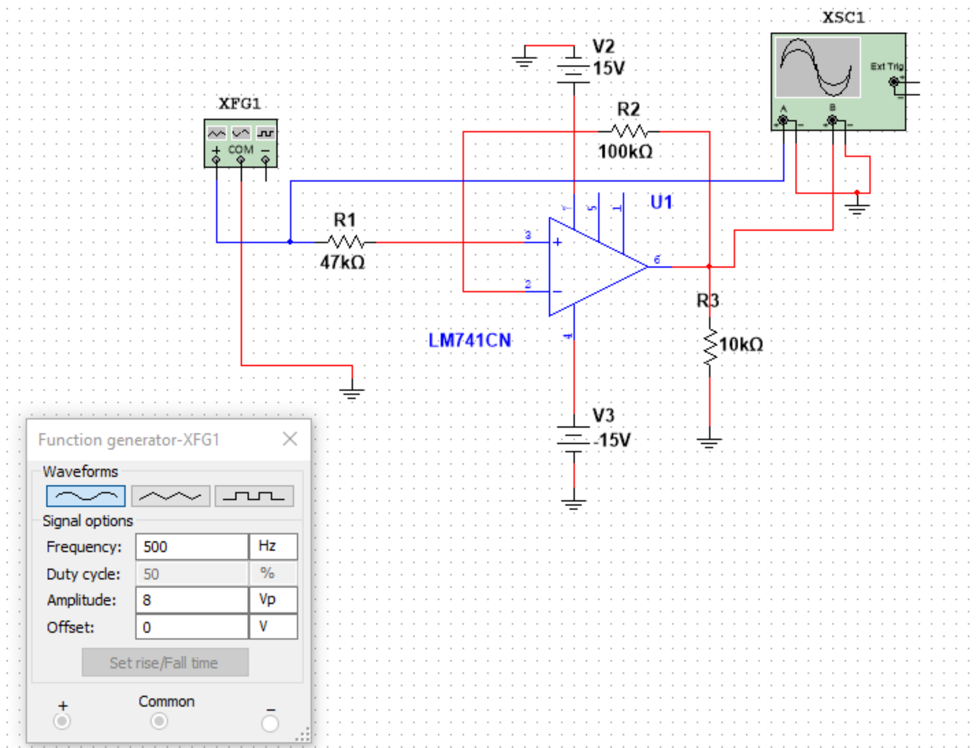
Part 2b



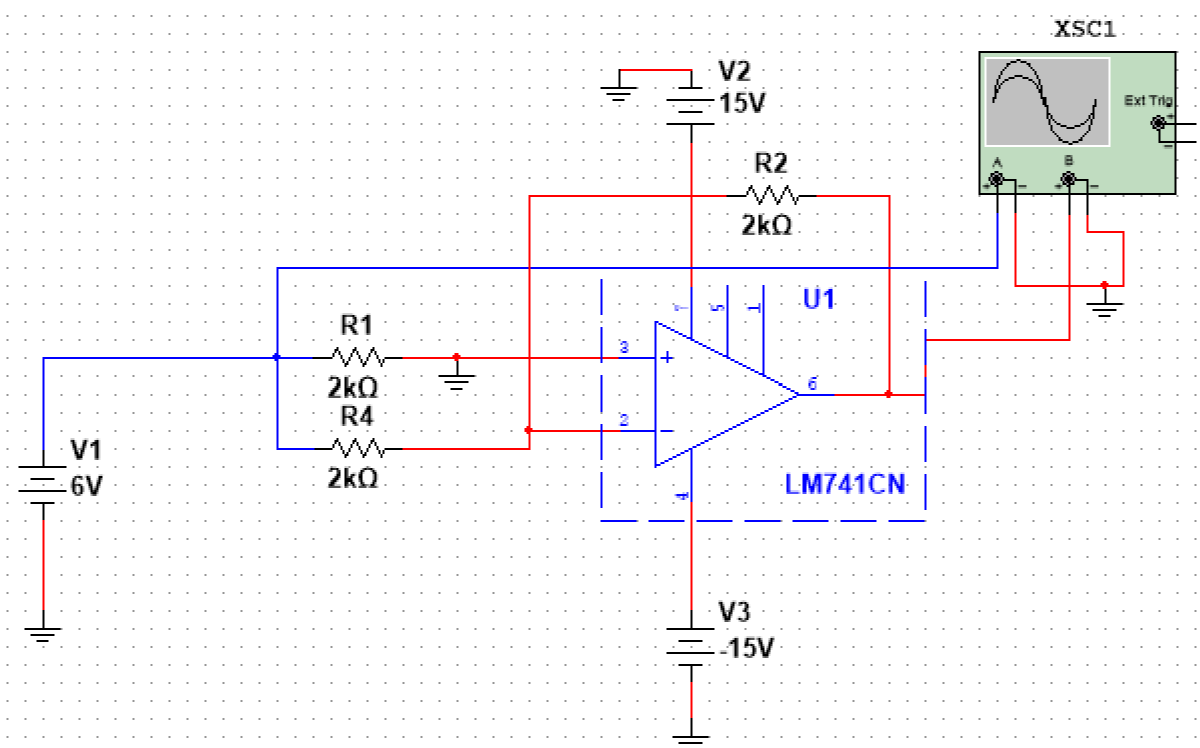
Part 3a



Part 3b



Part 4



Results and Tables

For all oscilloscope photos, the green waveform is the input and the yellow waveform is the output.

Figure 1 for Part a

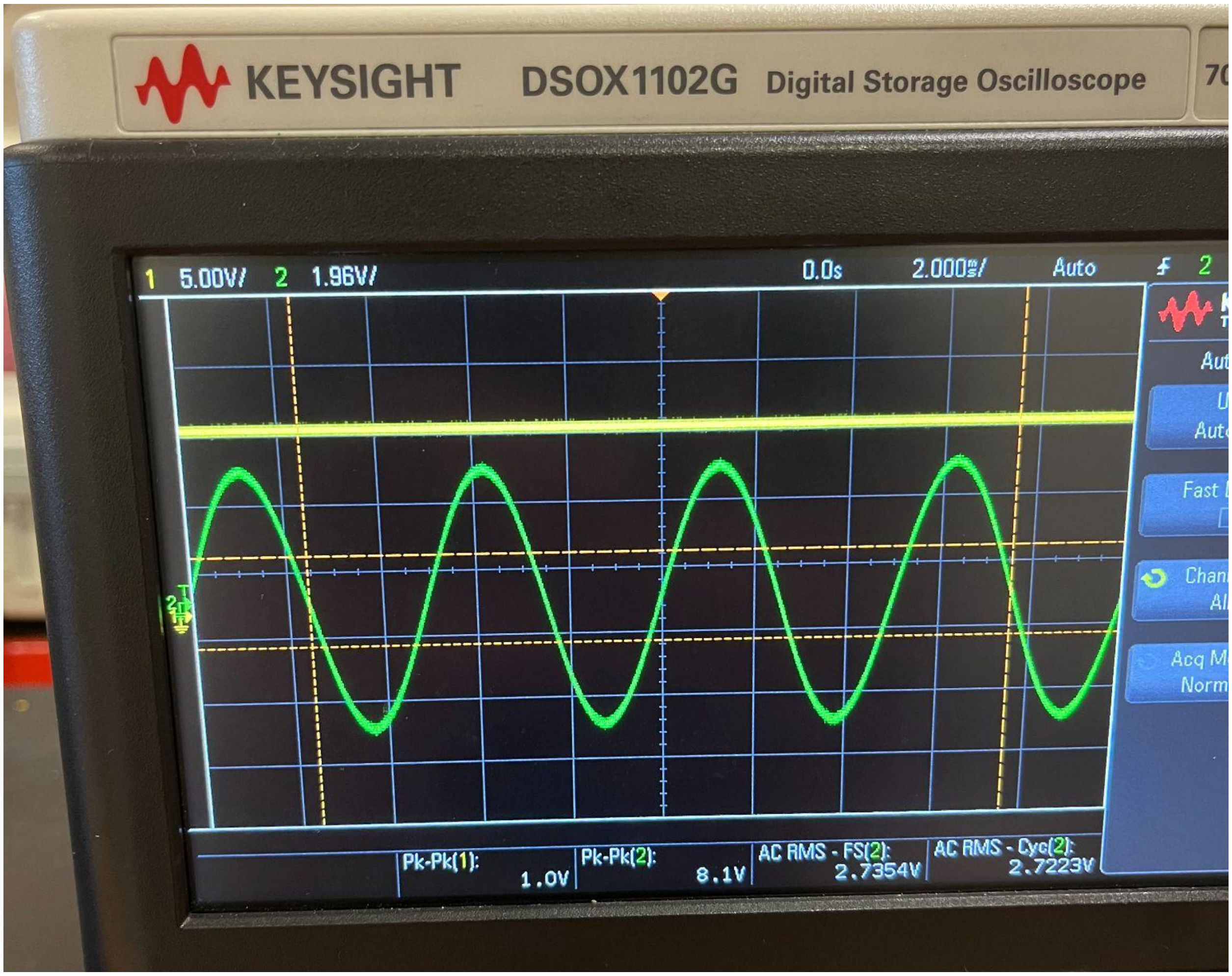


Table 1 for Part a

	Vo (Pre-Lab Analysis)	Vo (Pre-Lab Simulations)	Vo (In-Lab Measurement)
$V_I < V_{TH}$	−14V	−14.027V	15V
$V_I > V_{TH}$	14V	14.027V	15V

Figure 2 for Part 2a

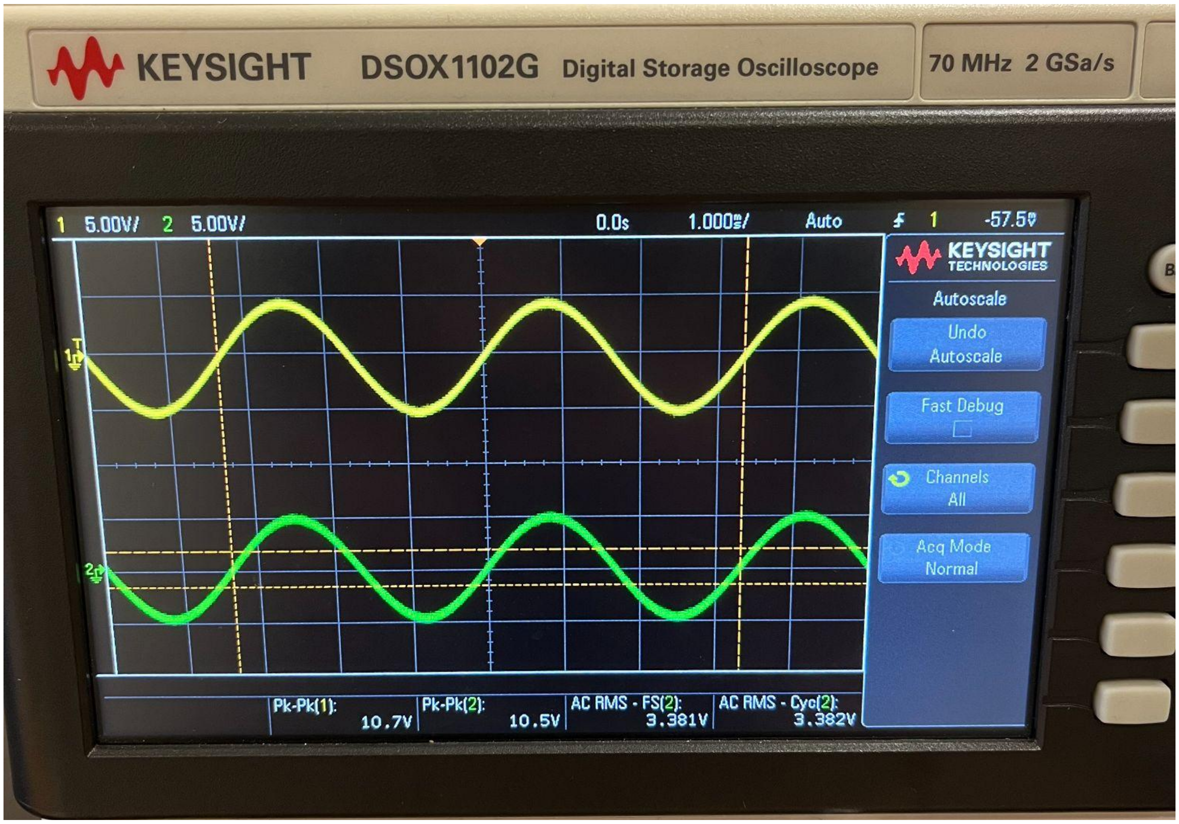
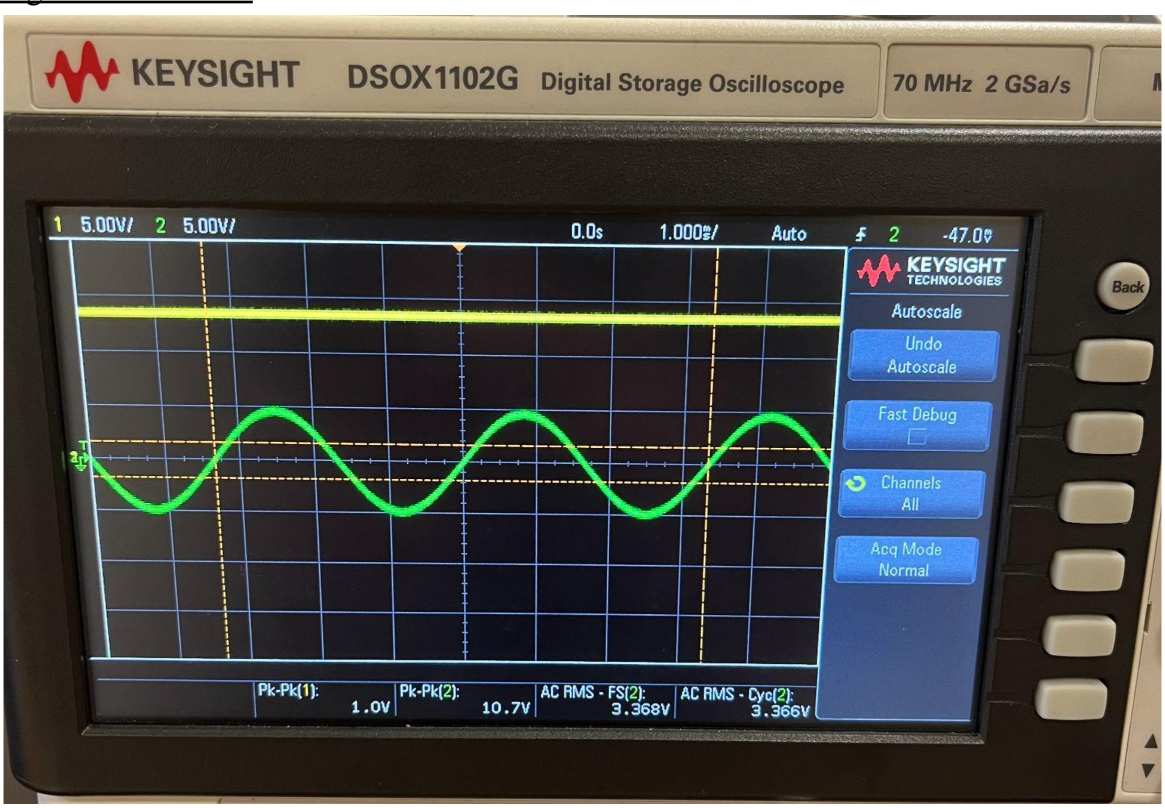


Figure 3 for Part 2b



The discrepancy between Figures 2 and 3 for part 2a and 2b respectively is caused because in part a, negative feedback exists whereas in part b, positive feedback exists so the output is set at the upper saturation value of 14V. The output values are exactly the same as the simulated and expected values from the pre-lab.

Figure 4 for Part 3a

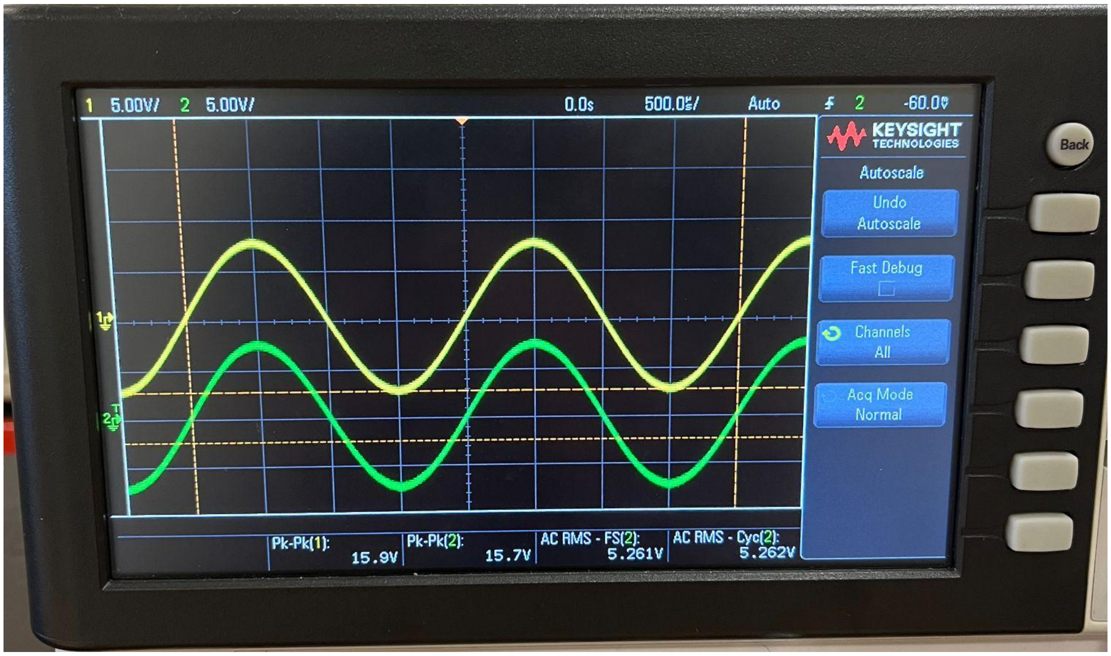


Figure 5 for Part 3b

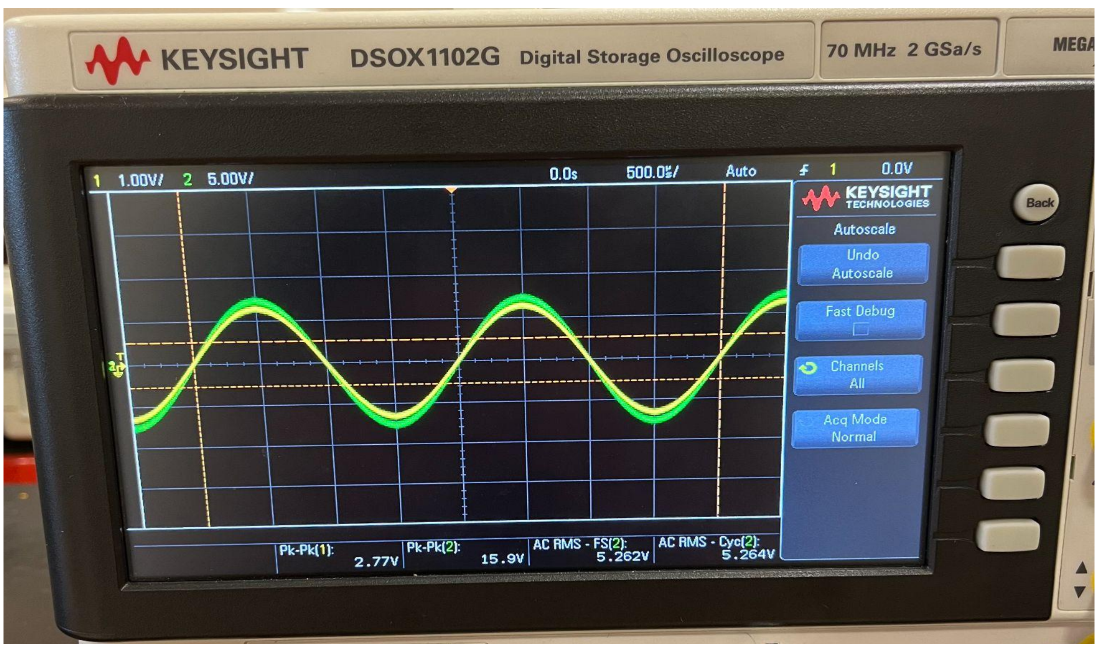


Table 2 for Part 3

	$Vi_{p\text{-}p}$ Measured	$Vo_{p\text{-}p}$ Measured	Gain ($Vo_{p\text{-}p}/Vi_{p\text{-}p}$) Derived from the measurement	Gain ($Vo_{p\text{-}p}/Vi_{p\text{-}p}$) From the Pre-Lab Analysis	Gain ($Vo_{p\text{-}p}/Vi_{p\text{-}p}$) From the Pre-Lab Simulation
Fig. 3a no Buffer	15.9V	2.77V	0.174	10/57	5.69
Fig. 3b with Buffer	15.7V	15.9V	1.0127	10/157	0.999

For the above table, there are discrepancies between the Gains. The pre-lab analysis is incorrect and the simulation Gain values are inverse to those derived from the measured values.

Table 3 for Part 4

	V_C	V_O (Pre-Lab Analysis)	V_O (Pre-Lab Simulations)	V_O Measured
Switch CLOSED	6V	−6V	−6V	−0.79mV
Switch OPEN	6V	6V	6V	5.209V

For Table 3, the voltage divider produced 5.3V instead of the desired 6V which is why the output voltage for open switch is 5.209V. In the closed switch scenario, when ground was connected to the positive terminal of the op-amp, this caused the voltage of our voltage divider to drop to 0.79mV. According to prelab analysis and simulations, the output voltage for the closed switch should be the negative of the input voltage which in this case was 0.79mV. The circuit behaved correctly outputting a voltage value negative of the input, it is just the wrong numerical value.

Conclusion

After conducting the experiment, several conclusions can be drawn from the results. Firstly, the open loop Op-Amp in **Part 1** did not function as expected, however the output voltage would have saturated at the saturation limits if it had worked. Secondly, the orientation of the feedback loop in **Part 2** had a big impact on the resulting output voltage. When the feedback loop was connected to the negative input terminal of the amplifier, it resulted in the amplifier acting as a buffer system where the voltage gain was very close to 1. However, when the feedback loop was connected to the positive input terminal, it resulted in the output voltage saturating at around 14V. Also, the practicality of the buffer Op-Amp was demonstrated in **Part 3**, where the buffer in Figure 3b prevented the voltage from dropping off at the output compared to the circuit in Figure 3a where a large voltage drop-off was observed. Lastly, we observed that the Op-Amp in **Part 4** acted as a polarity switch where the switch in the system resulted in the polarity of the output voltage being negative or positive while maintaining a voltage gain of 1. Overall, the experiment was pretty consistent with the pre lab and most of the results were observed as expected.