ECE 4300

Experiment \#: 8

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We declare that this lab submission is our own work, is not copied from any other person's work (published or unpublished) and has not assisted by others. And also, we confirm that we have read and understood

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	Student 1	Student 2
Name	Anna Behm	Amr Kabel
Student ID	202005872	202048096
Signature	Anna Behm	
Date	July 27, 2022	July 29, 2022

Memorial University of Newfoundland
Faculty of Engineering and Applied Science
Department of Electrical and Computer Engineering
ECE 4300 – Electronic Circuits I
Lab #8 – The Single-Stage Common-Emitter Amplifier

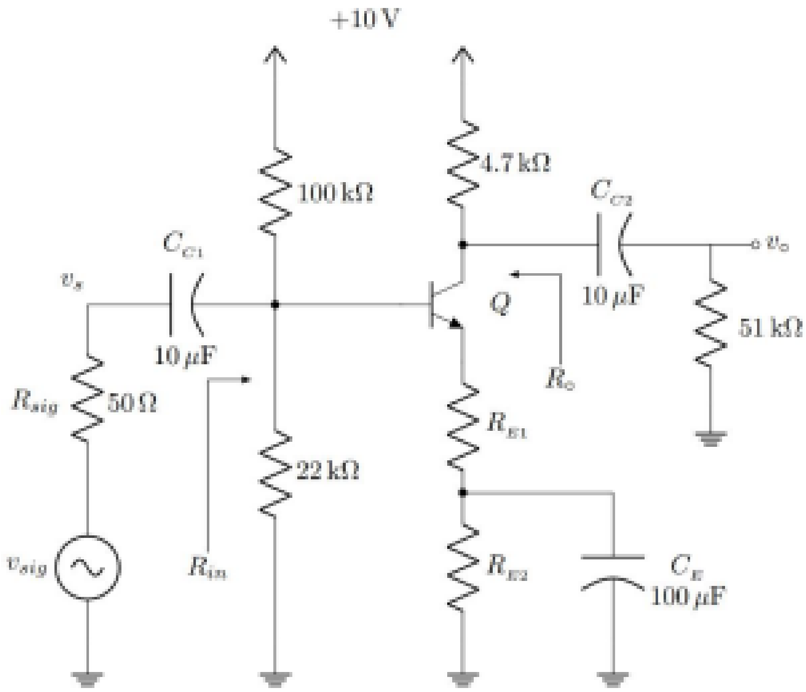


Figure 8.1: The CE Amplifier

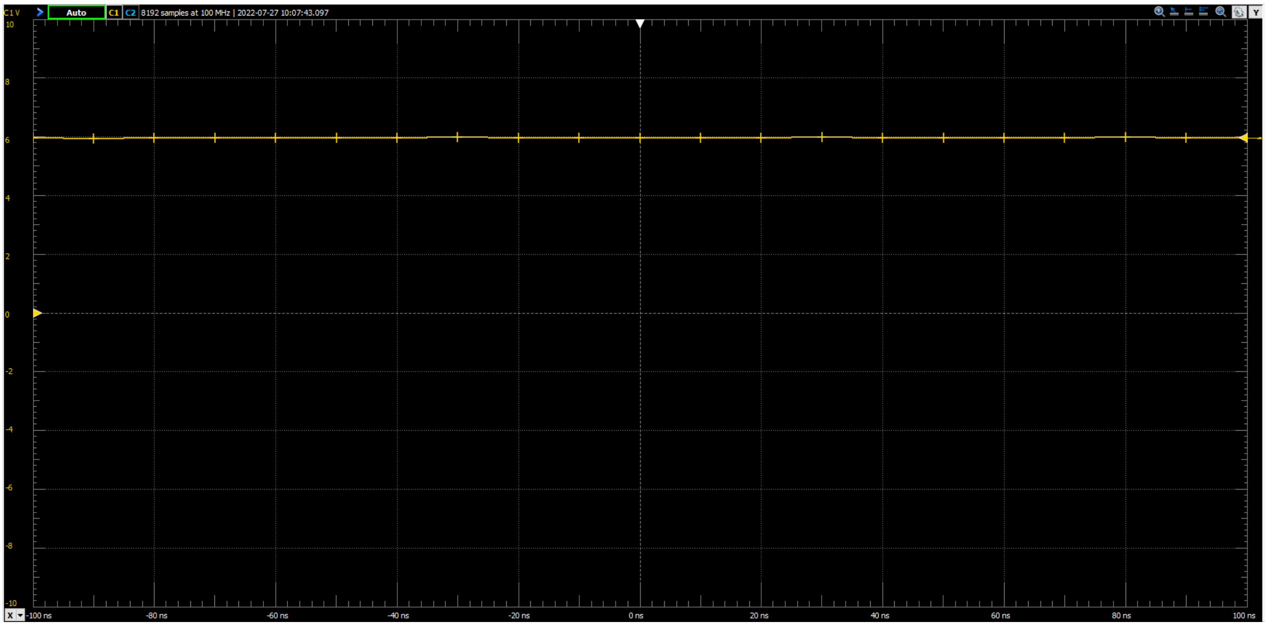
2. EXPERIMENT

2.1 Midband Frequency Operation of the Common Emitter (CE) Amplifier

2.1.1 The voltage divider bias circuit in Figure 1 was constructed using the 2N3904 BJT and values such as R_{E1} = 220 Ω and R_{E2} = 1 kΩ. It was ensured that the device operated in the active region.

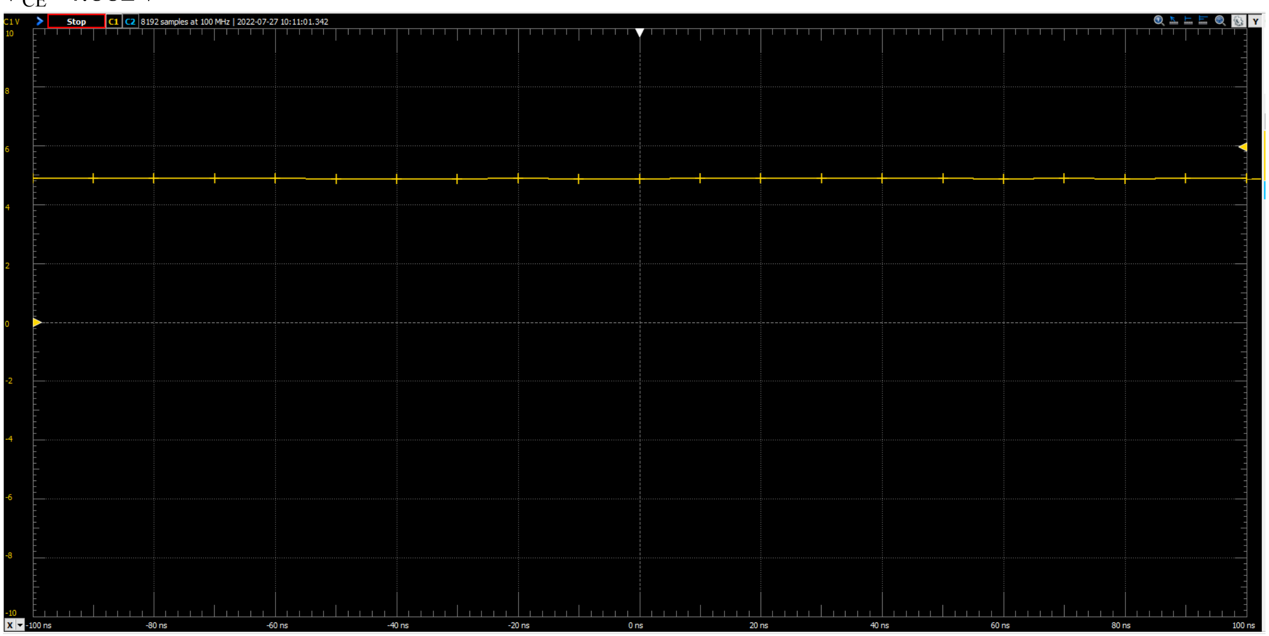
2.1.3 The bias conditions for the collector current I_C and the collector to emitter voltage V_{CE} were measured and recorded.

V_C =5.956V



$I_C = (10- 5.956)/ 4.7k = 0.00086043A = 8.6043*10^{-4}$

V_{CE}=4.882V



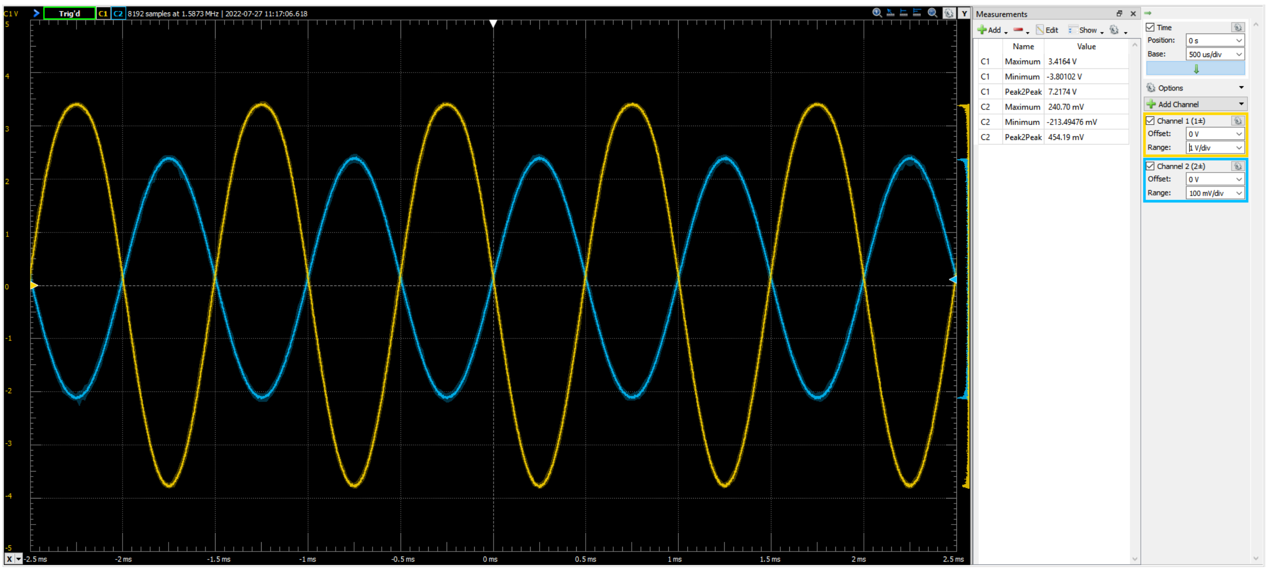
2.1.4 The circuit found in Figure 1 was then completed with values such as C_{C1} = 10 μF, C_E = 100 μF and C_{C2} = 10 μF. The waveform used from the signal generator was that of v_s = 160 mV peak-peak, and 1 kHz sinusoidal voltage, while ensuring that the output remained constant.

2.1.5 A graph was plotted using v_o and v_s. The peak to peak values of such variables were determined and voltage gain was calculated.

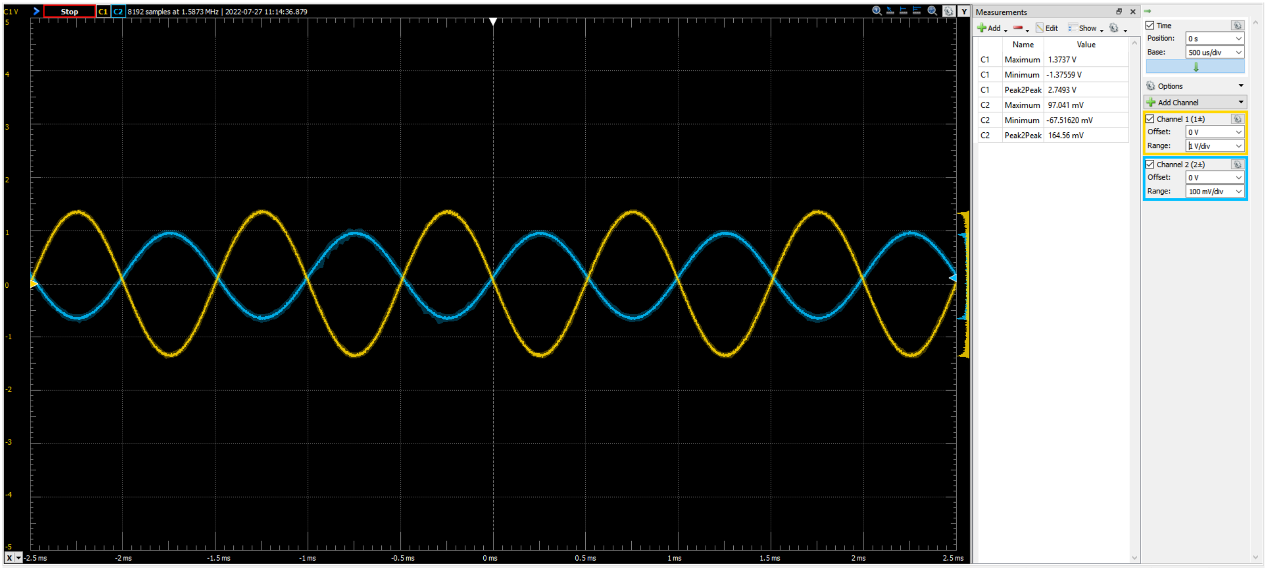
Peak to Peak value V_o = 2.7493V

Peak to Peak value V_s = 1.6456V

Voltage Gain = v_o/v_s= 2.7493V/164.56mV= 16.706V



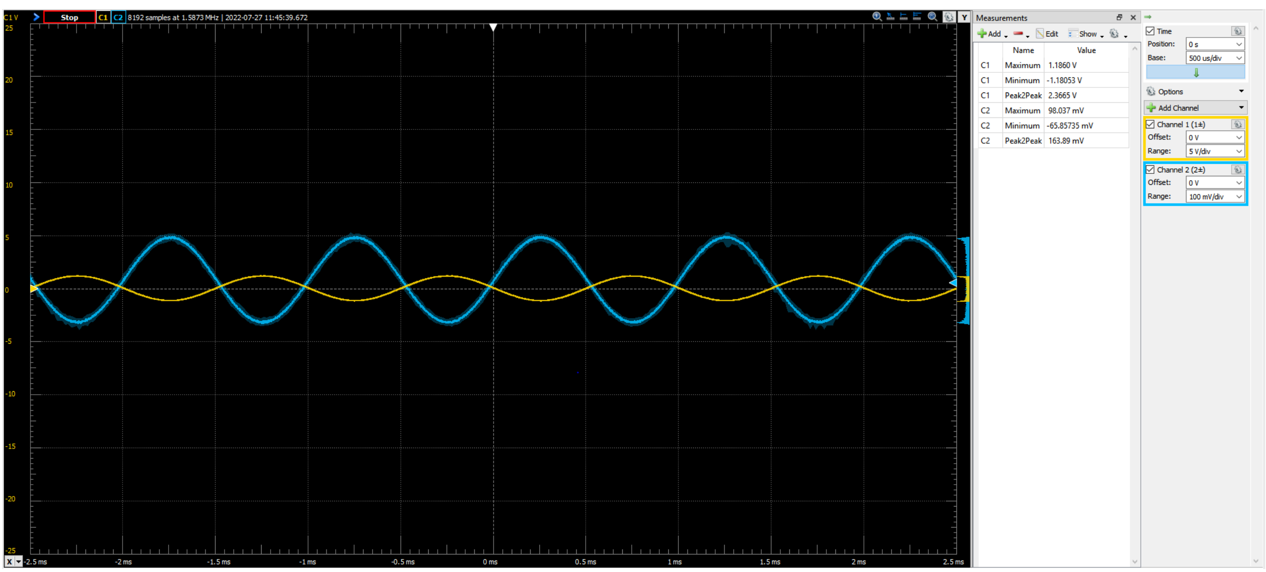
2.1.6 The performance of the amplifier circuit was observed through the output voltage vo as the input signal vs was varied. The peak signal voltage was noted when distortion began to occur in the output signal. In this example, distortion occurred around Vs= 225mV amplitude.



2.1.7 The input resistance, R_{in}, of the amplifier was then calculated through Vox and Vo, while Rx is equivalent to 2.2 kΩ.

Vox = 2.3665V

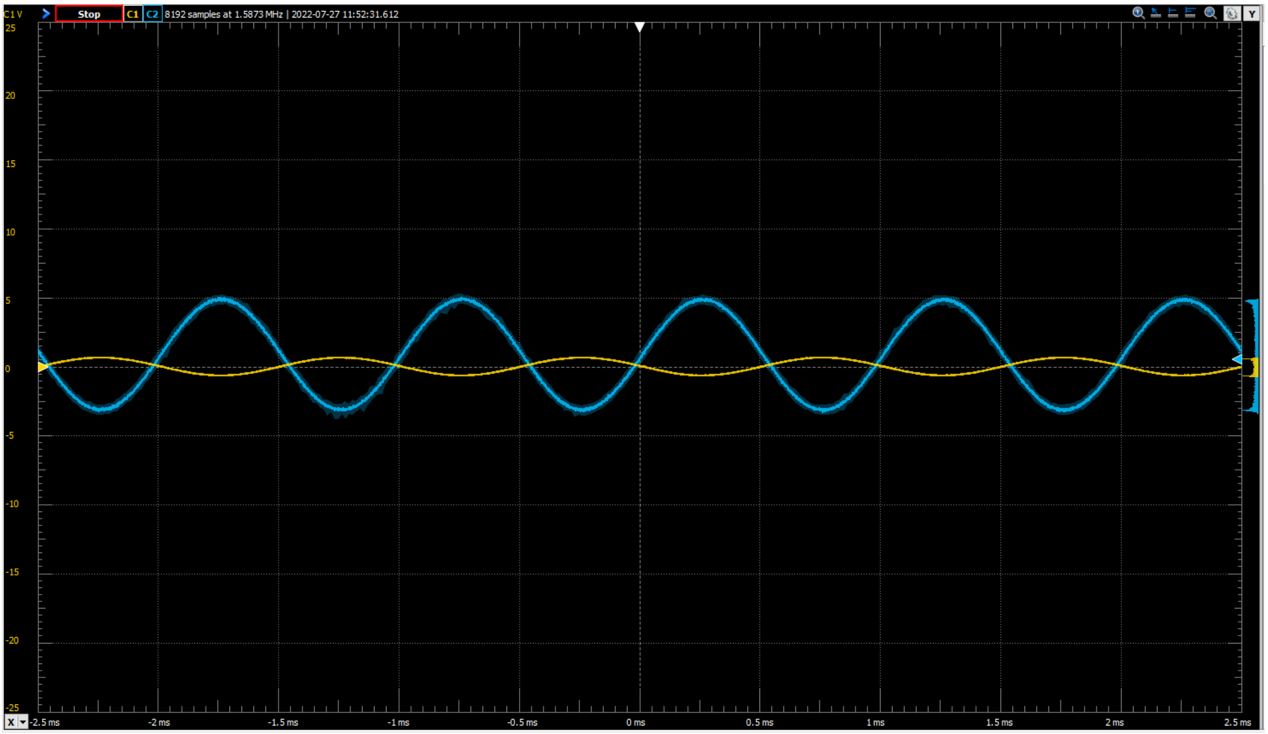
Rin = vox* Rx / (vo-vox) = 2.3665*2.2k/(2.7493-2.3665) = 13600.5747126 = 13.6kΩ



2.1.8 The output resistance, R_o of the amplifier was calculated with Rx = 3.9 kΩ.

Vox = 1.3323V

Ro = (vo-vox) Rx / vox = (2.7493- 1.3323)*3900/ 1.3323 = 4147.93965323 = 4.14kΩ

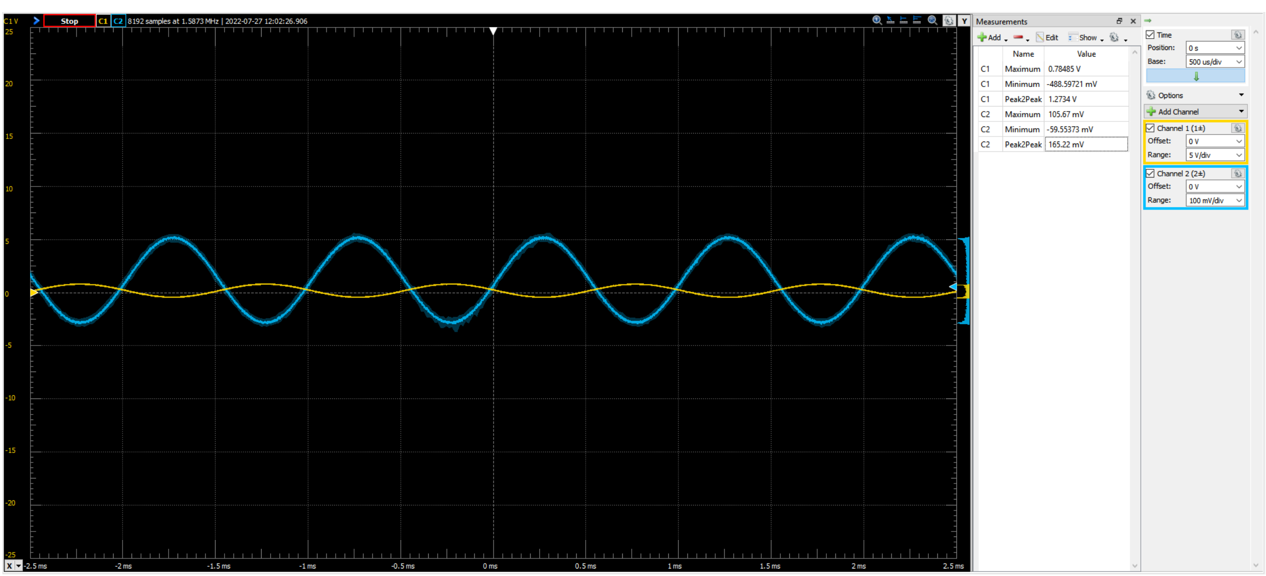


2.1.9 The steps 2.1.4 to 2.1.8 were repeated for values of R_{E1} = 560 Ω, R_{E2} = 1 kΩ and R_L = ∞.

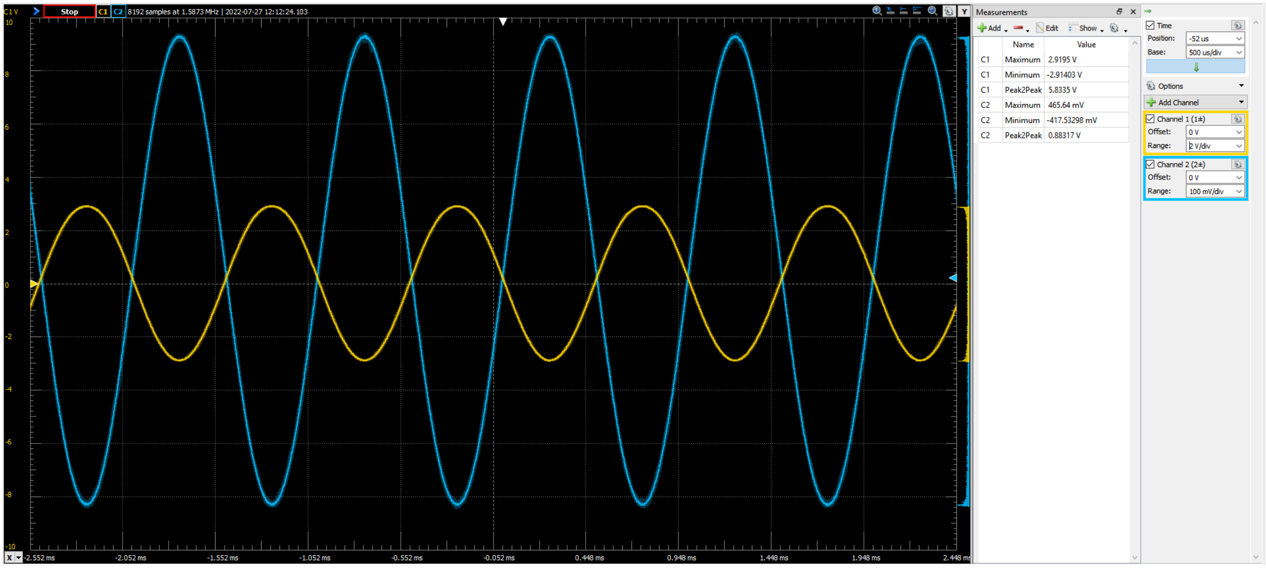
Pk-Pk Vo = 1.2734V

Pk-Pk Vs = 165.22mV

Vo/Vs = 1.2734/0.16522 = 7.70729935843

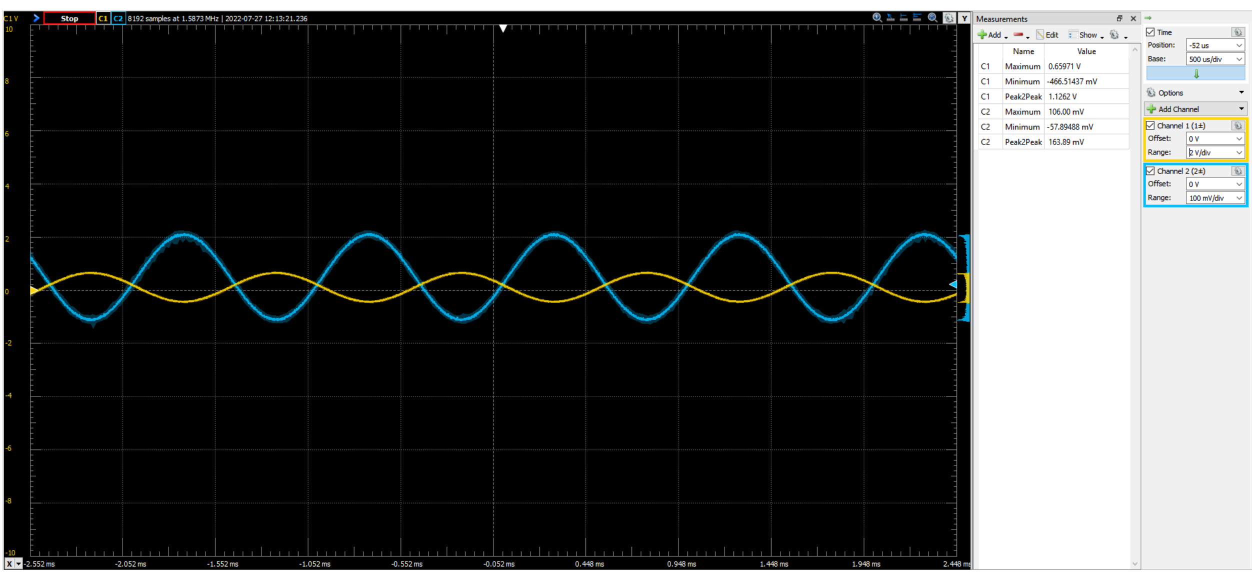


Distortion occurs at Vs= 440mV amplitude.



Vox = 1.1262V

Rin = vox* Rx / (vo-vox) = 1.1262*2200/(1.2734-1.1262) = 16831.7934783 = 16.831kΩ



Vox = 0.603V

Ro = (vo-vox) Rx / vox = (1.2734- 0.0603)*2200/0.0603 = 44259.0381426 = 44.259kΩ

2.1.10 The results were as expected from the prelab results within experimental error. The graphs were sinusoidal in nature. As R_{E1} increases, the gain decreases, the input resistance increases, and the output resistance increases.

2.2 High Frequency Operation of the Common Emitter Amplifier

2.2.1 The circuit in Figure 8.1 was modified with RE1 = 560 Ω, and $C_{BP} = C_E = C_{C1} = C_{C2} =$ 1uF.

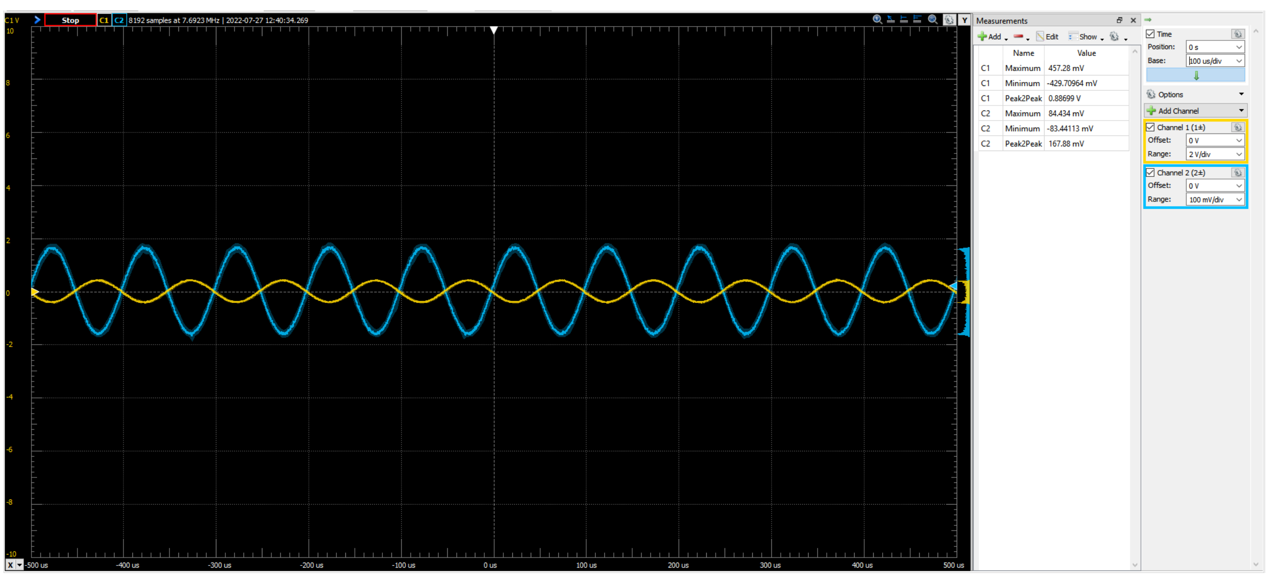
2.2.2 The AD2 signal generator was also modified to obtain v_s = 160 mV peak-peak, 10 kHz sinusoidal voltage.

2.2.3 The values of v_o and v_s were measured once more, as well as the voltage gain.

Pk-Pk V_o= 0.88699V

Pk-Pk V_s= 167.88mV

Vo/Vs = 0.88699/0.16788=5.28347629259 = 5.28



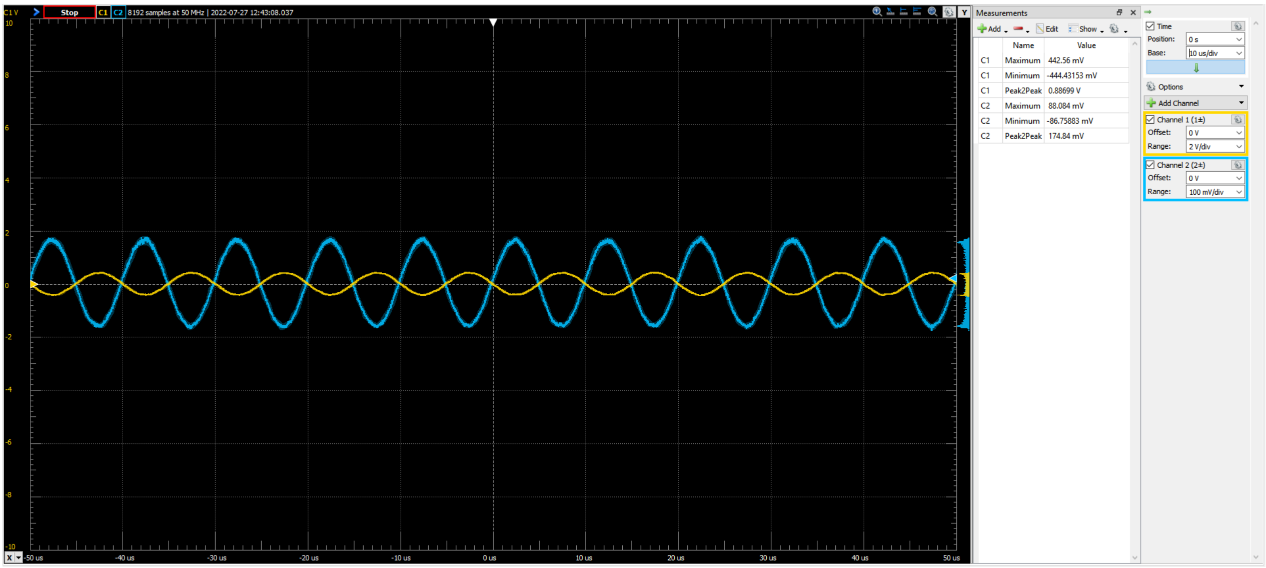
2.2.4 The function generator was raised to values of 100 kHz, and 1 MHz, while steps 2.2.2 and 2.2.3 were repeated.

a) 100kHz

Pk-Pk Vo= 0.85755V

Pk-Pk Vs= 168.87mV

Vo/Vs = 0.85755/0.16887= 5.07816663706 = 5.1

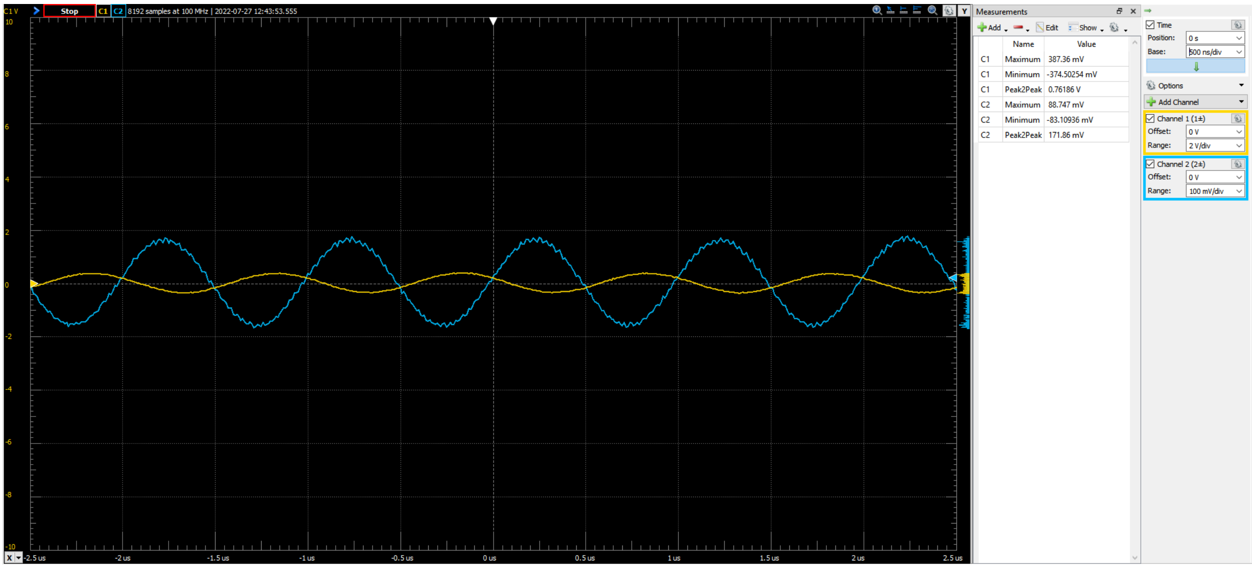


b) 1MHz

Pk-Pk Vo= 0.76186

Pk-Pk Vs= 171.86mV

Vo/Vs = 0.76186/0.17186= 4.43302688235 = 4.43



2.2.5 Through the calculations and experiment it was found that as the frequency increases, the gain decreases.

2.2.6 The results were as expected within experimental error. The graphs were sinusoidal in nature. As the frequency increases, the gain decreases.

3. CONCLUSIONS

3.1 The lab was successful. The results were as expected within experimental error. There were no problems encountered during this experiment. One better way to perform this experiment is to test the circuit for a larger range of resistances and frequencies.

3.2 The experimental results were as expected from the prelab results and from the theoretical model from the lectures and course textbook.

3.3 Through this laboratory experiment, the performance characteristics and frequency response of capacitor-coupled discrete common emitter amplifiers were examined. Vo, Vs, R_o, R_{in},V_c, I_C, and V_{ce}, among other values were all measured and calculated through the constructed circuit. The creation of simulations in PSpice (through the pre-laboratory assignment), as well as physical circuits ensured our understanding of capacitor-coupled discrete common emitter amplifiers. We were able to utilize many different technologies and softwares, including Analog Discovery 2 (AD2), voltage source providers, oscilloscopes, breadboards, and more.These skills are invaluable in the development of engineering students, as one obtains important knowledge that can be transferred to real world applications.

Measurement of Input Resistance and Output Resistance of Amplifier Circuits

The following procedures may be used to measure the input resistance, R_{in} and output resistance R_o of the amplifier.

Input Resistance, R_{in}

A.1 Measure v_o in Fig. A.1.
A.2 Connect a resistance, R_x in series with the source and amplifier input as shown in Fig. A.2. Adjust v_s to the same level as in step A.1 and measure v_{ox}. (R_x is an arbitrary resistance with a value usually of the same order of magnitude asthe input resistance to be measured). A.3 The input resistance is determined from the equation, $R_{in} = v_{ox} R_x / (v_o - v_{ox})$

Output Resistance, R_o

A.4 Measure v_o in Fig. A.3
A.5 Connect a resistance, R_x, at the output as shown in Fig. A.4. Adjust v_s to the same level as in step A.4 and measure v_{ox}. (R_x is an arbitrary resistance with a value usually of the same order of magnitude as the output resistance to be measured).
A.6 The output resistance can be determined from the equation, $R_o = (v_o - v_{ox}) R_x / v_{ox}$

Lab 8: APPENDIX B

ANNEX 1

Rubric – Lab 8

Total Mark		**100**

1. Pre-Lab (Note: 50% of the full prelab mark will be deducted if missing TA's signature in the final submission)		**30**
1.2	Simulation	
	Circuit diagram	2
1.2.1	Plots	5
1.2.2	Gain	3
1.2.3	Repeat for 2 different R_{E1}	14
1.2.4	Frequency response plot	6

2 Experiments		**60**
2.1 Midband Frequency Operation		**38**
2.1.3	Bias measurements	4
2.1.5	Plots and gain	7
2.1.6	Investigating distortion	2
2.1.7	Input resistance	3
2.1.8	Output resistance	3
2.1.9	Repeat previous steps for a different R_{E1}	15
2.1.10	Comparisons	4
2.2 High Frequency Operation		**22**
2.2.3	Plots and gain	7
2.2.4	Repeat previous steps for a high frequency	8
2.2.5	Explore the effect of frequency	3
2.2.6	Comparisons	4

3. Conclusion		**6**
3.1	Comment on lab procedure	2
3.2	Comment on simulation and theoretical values	2
3.3	Comments on learning outcomes	2
Report Quality		**4**

If simulation folder is not included, a penalty will be applied.