Lab 4

ELECENG 2EJ4

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Part 1

1. (10 Points)

   a. Based on the simulation data obtained in Step 1.2, what is the low-frequency (i.e., f = 100 Hz) voltage gain in dB for the first-stage differential amplifier A_{d1}, the second-state CE amplifier A_{d2}, and the third stage CC amplifier A_{d3}, respectively for the differential-mode signal?

Low-frequency voltage gains:

$A_{d1} = 7.38$

$A_{d2} = 70.05$

$A_{d3} = 0.0$

   b. What is the overall voltage gain for the differential-mode signal?

Overall voltage gain is $A_d = 77.42$dB or 7432.9

   c. Which input (V_1 or V_2) is the non-inverting input of the operational amplifier?

V2 is the non-inverting input of the operational amplifier

   d. What is the upper 3-dB frequency f_H of the amplifier?

Upper 3-dB frequency f_H of the amplifier is 6195.54Hz when the phase is 135deg (45deg less than 180)

2. (5 Points) Compare the simulated differential-mode gain A_{d1} found in Q1 and the simulated gain A_d in the Q5 of Lab 3. What causes these two gains to be so different from each other for the same differential amplifier?

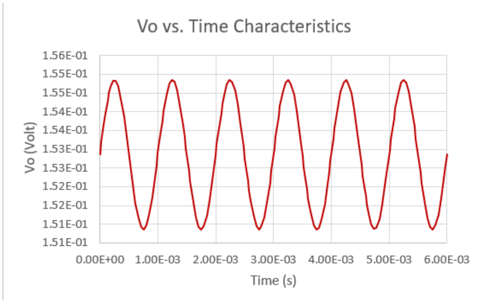
In lab 3 Q5, the simulated gain was 70.07dB, while the simulated differential-gain in this lab is 7.38, which is around a tenth of the value from the previous lab. This may be because of the fact that there are more BJTs which lowers the gain.

3. (5 Points) Based on the simulated results obtained in Steps 1.2 and1.3, what are the input resistance R_{in} and the output resistance R_o of the Op-Amp?

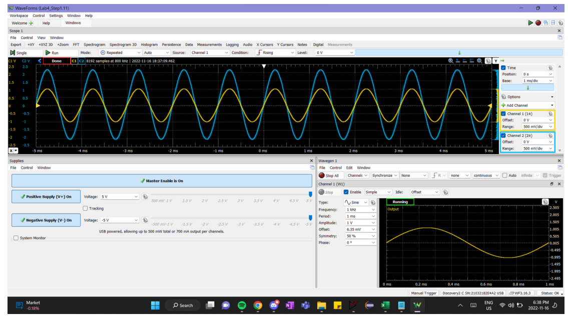
Based on the simulated results from 1.2 and 1.3, r_{in} is about 81760.2Ω and r_o is about 460.8Ω.

4. (10 Points)

   a. Based on the simulated and measured results from Steps 1.6 and 1.13, plot the simulated and measured output voltages V_o vs. time characteristics at 1 kHz.



1.6



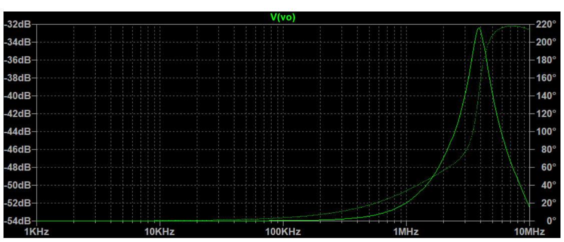
1.13

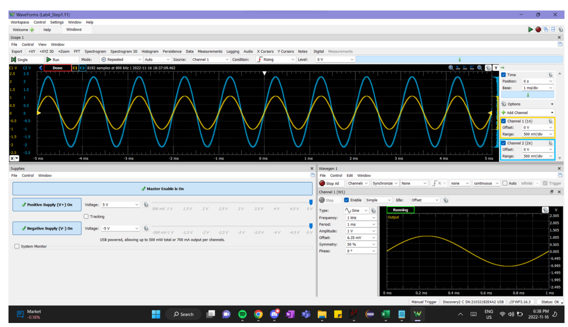
b. Calculate the simulated and measured peak-to-peak voltage V_{pp}, the AC amplitude V_p, and the dc voltage V_{dc} of V_o, and compare the simulation and measurement results.

The simulated results show a peak-to-peak voltage of 0.004V, an AC amplitude of 0.002V, and dc voltage of 0.155mV. The measured results show a peak-to-peak voltage of about 4V, an AC amplitude of about 2V, and dc voltage of about 2.1V. The peak-to-peak voltages and amplitudes for the simulated are about 1000 times less than the values of the measured, which may be because of the different AC voltage inputs.

5. (10 Points)

a. Based on the simulated and measured results from Steps 1.7 and 1.13, plot the simulated and measured voltage gain magnitude and phase vs. frequency characteristics. What is the low-frequency gain of this amplifier?





Low-frequency gain of the amplifier is 6.0dB or 2.0.

b. To operate this amplifier, what is its highest operating frequency to provide a constant gain as designed?

Highest operating frequency for constant gain is around 3926986.48Hz

6. (5 Points) What kind of feedback configurations (e.g., shunt-shunt) is it for the amplifier in Fig. 2?

Series-shunt feedback configuration is used for the amplifier.

7. (10 Points) Find the beta network and the feedback components β, R_{11}, and R_{22}, respectively.

$R_1 = R_2 = 100k\Omega$

$R_{11} = R_1 \,//\, R_2 = 50k\Omega$

$R_{22} = R_1 + R_2 = 200k\Omega$

$\beta = R_1 \div (R_1 + R_2) = 0.5$

8. (15 Points) Use the feedback theory and simulation results to find the voltage gain, the input resistance, and the output resistance of the amplifier, respectively.

$$R_o = \frac{1}{\frac{1}{1+\frac{vo}{vi}\beta} - \frac{1}{RL}} = \frac{1}{\frac{1}{1+(4596)(0.5)} - \frac{1}{240k}} = 0.2\Omega$$

$A_{vf} = Av/(1+Av\beta) = 4596/(1+(4596)(0.5)) = 2V/V$

$R_i = r_{i'f} - R$

Part 2

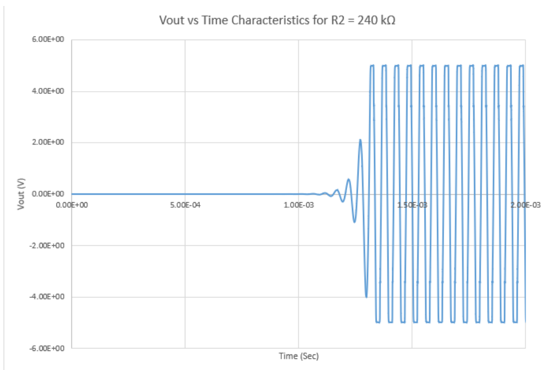
9. (15 Points) For the oscillator circuit in Fig. 9, find its loop gain L (s), the frequency for the zero loop phase, and R_2/R_1 for oscillation.

$R_2/R_1 = 240/100 = 2.4$

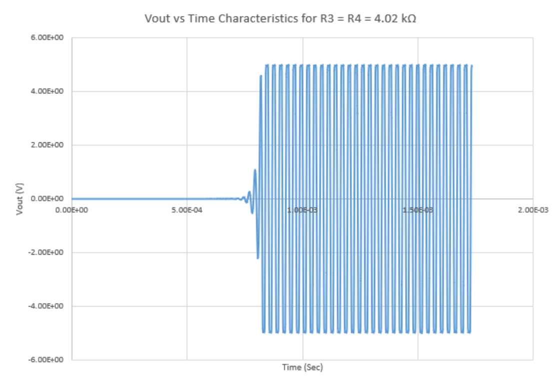
10. (5 Points) Based on the simulated results in Step 2.5, what are the settling times for R_2 = 220 kΩ, 240 kΩ, and 280 kΩ, respectively? What do you observe? Explain the observed trend.

The settling times for the resistors 220 kΩ, 240 kΩ, and 280 kΩ are 2.66ms, 1.315ms and 636us, respectively. As the resistance increases, the settling time is decreasing.

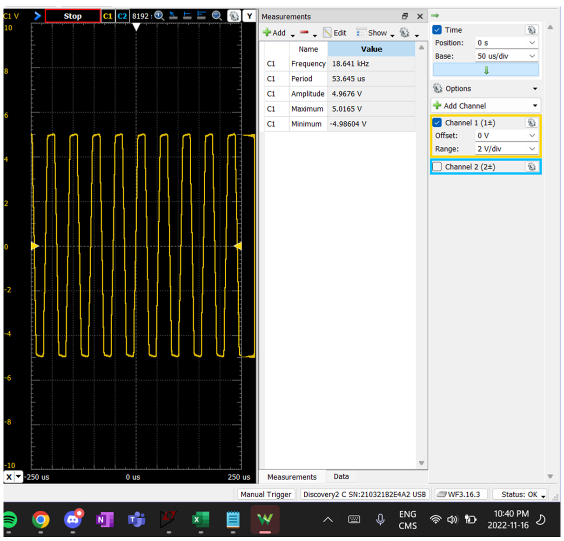
11. (10 Points)
    a. Based on the setup in Steps 2.4, 2.6, 2.9, and 2.10, plot the simulated and measured V_o.



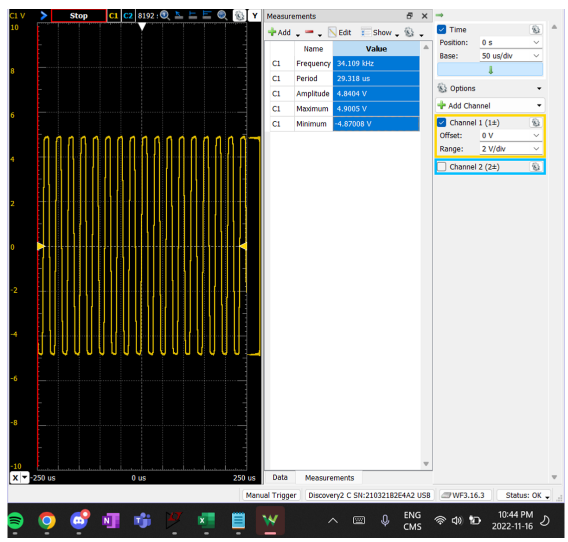
2.4



2.6



2.9



2.10

b. Calculate the simulated and measured oscillation frequencies in each case. Compare and discuss them with the results from the theory.

Oscillation frequencies:

2.4: about 20kHz

2.6: about 30kHz

2.9: 18.641kHz

2.10: 34.109kHz

2.9 to 2.10 is nearly doubled because the resistance was replaced and almost doubled.