Lab 2

ELECENG 2EJ4

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Part 1

1. (10 points)
   a. Based on the simulation data obtained in Step 1.2, what are the Vo,min, and Io of the current sink? Use the measurement data obtained in Step 1.10 to verify the Vo,min and Io.

Vo,min in Step 1.2 = -3V

Io in Step 1.2 = 0.000184804mA

Vo,min in Step 1.10 = -3V

Io in Step 1.10 = 0.0001990623mA

   b. Based on the simulation data obtained in Step 1.2 and the measurement data obtained in Step 1.10, what are the ranges of the simulated and measured output resistance Ro of the current sink for VCC larger than Vo,min?

Range of Ro for VCC larger than Vo,min in Step 1.2 = [7.50E+7Ω, 7.69E+7Ω]

Range of Ro for VCC larger than Vo,min in Step 1.10 = [-6.97E+6Ω, 9.54E+5Ω]

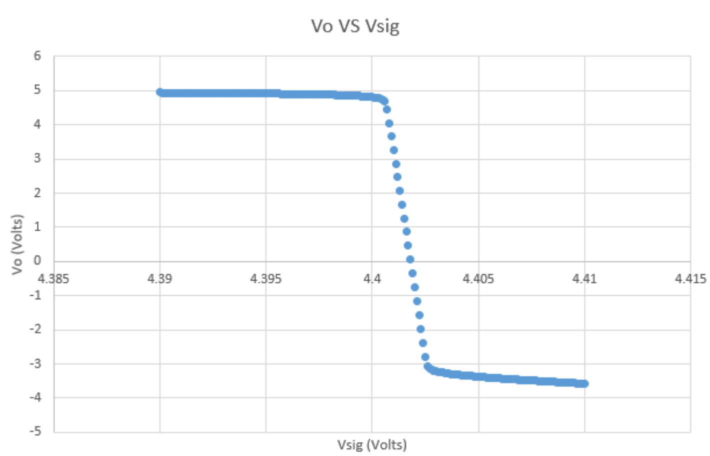
2. (10 Points) What are the values of Vo1 and Vo2 obtained in Step 1.5? Check the Q-points of Q2 under these two conditions and explain/justify the results obtained qualitatively.

Vo1 in Step 1.5 = 4.94V

Vo2 in Step 1.5 = -3.58V

Because the value of Vsig is outside of the range in V01 and V02, these values are close to the maximum and minimum output voltages.

3. (15 Points) Based on the simulation data obtained in Step 1.6:
   a. plot the simulated DC Vo vs. Vsig characteristics. Discuss/justify the simulated characteristics.



This graph is able to tell us when the circuit is able to work as an amplifier within a specific range of volts in Vsig and can also tell us the corresponding output voltage for a controlled output voltage in the amplifier.

b. For the circuit to work as an amplifier, find the DC input range for Vsig and the output voltage range for Vo.

Input range for Vsig = [4.4006V, 4.4028V]

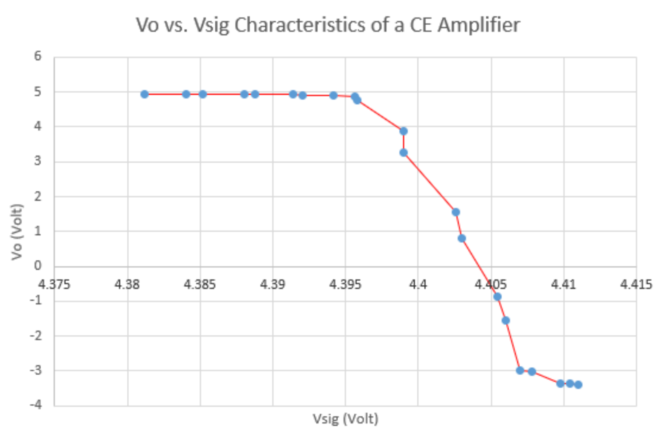
Output voltage for Vo = [4.675276V, -3.180605V]

c. Find the Vsig value and its corresponding collector current Ic2 that results in Vo ≈ 0 V.

Vsig = 4.40179999999997V

Vo = 0.05354082V

d. Based on the measurement data obtained in Step 1.16, plot the measured DC Vo vs. Vsig characteristics.



4. (10 Points)

a. Based on the simulation data obtained in Step 1.7, what are the magnitude (in dB) and phase of intrinsic voltage gain Avo at low frequency (i.e., 100 Hz) and the upper 3-dB frequency f3dB (i.e., the frequency at which the amplitude become $1\sqrt{2} = 0.707$ of its low-frequency value, or the phase changes 45°) of this CE amplifier?

The upper 3-dB frequency is about 14077Hz and 135.148 degrees and 2.0269dB.

b. Verify the voltage gain Avo using the measurement data obtained in Steps 1.18 and 1.19.

c. Increase the frequency of W1 to the upper 3-dB frequency f3dB obtained from the simulation, check the value of Avo, and see if it is about 0.707 of its low-frequency value obtained at 100 Hz. Provide WaveForms screenshots of your measurement results.

Part 2

5. (15 Points) Based on the simulation data obtained in Step 2.2,

a. what are the voltages of Vo and VE, and Ic2 of Q2 when VCM = 0V

Vo = 4.24999047219929V

VE = -0.5253805V

Ic2 = 0.00009090927A

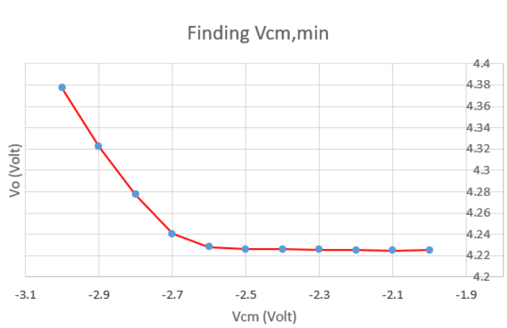
b. what is the input common-mode range (i.e., the voltage range of VCM to maintain the same out voltage), and

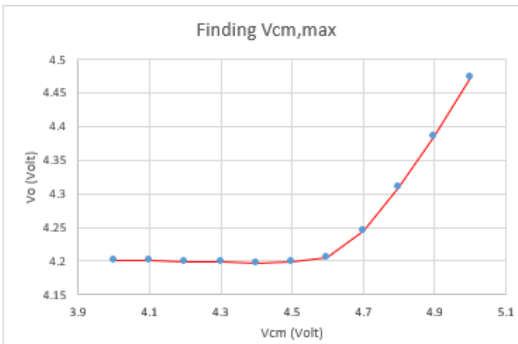
Range of Vcm where Vo is constant = [-2.6V, 4.6V]

c. what determines the upper and lower bounds of the input common-mode range?

Range is determined at -2.6V and 4.6V. When Vcm is higher than this range, Vo gradually increases and when Vcm is lower than this range, Vo gradually decreases. Inside the range Vo is stable.

d. Based on the measurement data obtained in Steps 2.7 and 2.8, verify the common-mode range by experimental data.





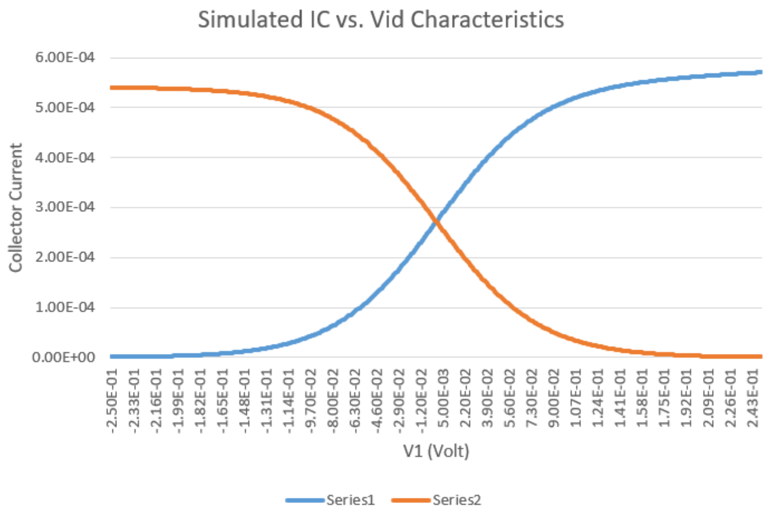
Based on the graphs in 2.7 and 2.8, we can tell that the Vcm,min is between -2.5 and -2.6 and that the Vcm,max is between 4.5 and 4.6.

6. (10 Points) Based on the simulated data obtained in Step 2.3, what is the low-frequency voltage gain Acm in dB for the common-mode signal?

Based on the simulated data, the low-frequency voltage gain Acm that was calculated in 2.3 is -86.8dB.

Part 3

7. (10 Points) Based on the simulation data obtained in Step 3.2 and the description in Section 9.2.3 Large-Signal Operation of the textbook,
    a. what is the input differential-mode range?



The input differential-mode range = [-0.102V, 0.102V].

    b. How do we determine the upper and lower bounds of the input differential-mode range?

The highest and lowest values occur when the voltage is -0.204V and 0.204V, so to ge the upper and lower bounds we simply divide these bounds by 2 to get -0.102V and 0.102V.

8. (10 Points)
    a. Based on the simulation data obtained in Step 3.3, what is the voltage gain Ad in dB for the differential-mode signal?

Based on the simulated data, the voltage gain Ad that was calculated in 3.3 is 19.63dB.

    b. Estimate its upper 3-dB frequency f3dB (i.e., the frequency at which the amplitude becomes 1√2 = 0.707 of its low-frequency value or the phase changes 45°) and calculate the gain-bandwidth product (GBW) in hertz (Hz).

The upper 3-dB frequency is about 7781962Hz and -44.897 degrees. The gain-bandwidth is 1.34E+08 Hz.

c. Compare the upper 3-dB frequency f3dB of this differential amplifier with that of the CE amplifier obtained in Q4.

This 3-dB frequency is greater than the value obtained in Q4.

d. Based on the measurement data obtained in Step 3.6, calculate the measured low-frequency differential voltage gain Ad in dB.

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9. (10 Points) Based on the simulation data, what is the common-mode rejection ratio (CMRR) of the amplifier in dB?

|Ad| / |Acm| = |19.63dB| / |-86.8dB| = 0.22615