Lab 3

ELECENG 2EJ4

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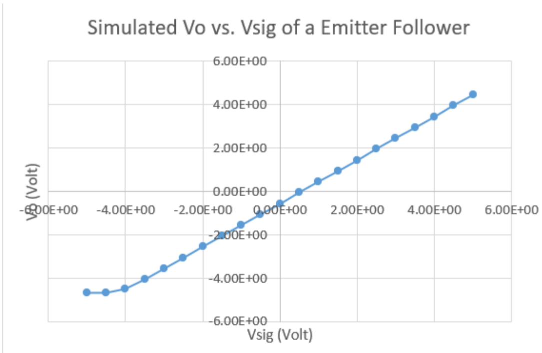
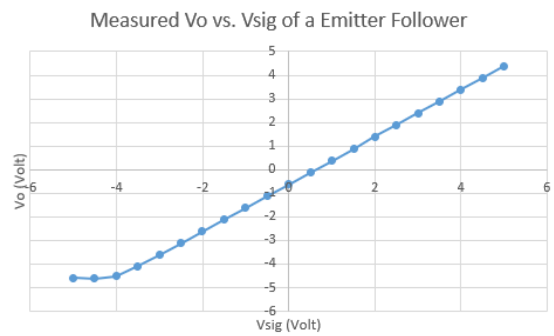
Part 1

1. (15 Points) Based on the simulation and measurement data obtained in Steps 1.2 and 1.6, (a) plot the simulated and measured V_o vs. V_{sig} characteristics and discuss/justify the characteristics. (b) To ensure the circuit work as a common-collector (CC) amplifier, find the DC input range for V_{sig} and the output voltage range for V_o. (c) Find the Vsig value that results in $V_o \approx 0$ V.





V_o vs. V_{sig} characteristics in Step 1.2 V_o vs. V_{sig} characteristics in Step 1.6

(a) In both simulated and measured graphs, the relationship between V_o and V_{sig} is mostly linear when neglecting the first 2 data entries, which shows us that there is a set pattern and steady relationship between V_o and V_{sig}. (b) In both graphs, the DC input range for V_{sig} is -4V to +5V and the output voltage range for V_o is about -4.5V to +4.5V. (c) The V_{sig} value that results in $V_o \approx 0$ V is 0.5V.

2. (10 Points) Based on the simulation and measurement data obtained in Steps 1.3 and 1.8, what are the simulated and measured intrinsic voltage gain A_{vo} at low frequency (i.e., 100 Hz) of this CC amplifier? Report its magnitude in dB and phase in degree.

In the simulated data from Step 1.3, the A_{vo} value at the low frequency point is 0 dB, however in the measured data from Step 1.8, the A_{vo} value at the low frequency point is 0.8 dB.

Part 2

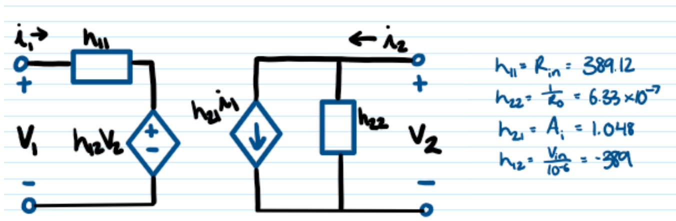
3. (15 Points) (a) Based on Section 8.2.3 in the textbook, derivate the relationship to express I_o as a function of I_{REF}. (b) Based on the simulation data obtained in Step 2.2, when $I_{REF}$is 0.1 mA, how is Io compared with I_{ERF}? When $I_{REF}$is 1 mA, how is Io compared with I_{ERF}? (c) Justify the observation between the theoretical prediction and the simulated result at I_{REF} is 0.1 mA and 1 mA, respectively.

(a) We can derivate a relationship of $I_o = I_{REF}$ to express I_o as a function of I_{REF}. (b) In our data, when I_{REF} is 1E-04A, I_o is 1.04E-04A which is $0.104I_{REF}$. When I_{REF} is 1E-03A, I_o is

9.75E-04A which is $0.975I_{REF}$. (c) Since the simulated values for I_o are very close to the values for I_{REF}, the theoretical prediction and simulated results almost the same.

4. (15 Points) (a) Based on the simulation data obtained in Step 2.5, what is the input impedance R_{in} looking from V_{in} toward the collector of Q1? What is the current gain A_i of the current mirror? (b) Based on the simulation data obtained in 2.6, what is the output impedance R_o of the current mirror looking into the collector of Q2? (c) Based on the information obtained in (1) and (2), draw the linear two-port network for the current mirror using its h-parameters.

(a) Based on the simulation data in Step 2.5, the input impedance R_{in} is about 389.12Ω and the current gain A_i is about 1.048. (b) Based on the simulation data in Step 2.6, the output impedance R_o is about 1.58E+06Ω. (c)



Part 3

5. (15 Points) (a) Based on the simulation data obtained in Step 3.2, what is the voltage gain A_d in dB for the differential-mode signal? (b) Did you observe any mismatch in Step 3.6? If yes, how much offset voltage did you apply at V_2? (c) Compare your simulated result with the measured result obtained in Step 3.8.

(a) based ont he simulation data from Step 3.2, the voltage gian A_d is about 70.07dB. (b) In Step 3.6, there was a little mismatch, so I applied an offset voltage of about 2.85E-3V at V_2. (c) In the meausred A_d in Step 3.8, the value of A_d was about 59.7dB, which is much lower than the simulated value of 70.07dB found in Step 3.2.

6. (10 Points) Estimate its upper 3-dB frequency f_H (i.e., the frequency at which the amplitude becomes $1\sqrt{2} = 0.707$ of its low-frequency value or the phase changes 45°).

The upper 3-dB frequency f_H would be about 29197.558Hz at -45.065° based on the data from Stpe 3.2.

7. (10 Points) Compare the upper 3-dB frequency f_{3dB} of this differential amplifier with a current mirror load with that of the differential amplifier using resistive loads obtained in Q8 of Lab 2. Why the differential amplifier with the current mirror load has a smaller f_{3dB}?

The upper 3-dB frequency f_{3dB} of the differential amplifier from lab 2 was 7781962Hz, which is greater than the differential amplifier from lab 3. This is due to the internal capacitive effects of the BJTs that were used in this lab.

8. (10 Points) What are the gain-bandwidth products (GBW) in Hz of the two differential amplifiers with the current mirror load and the resistive load, respectively

The GBW of the differential amplifier with the current mirror load from this lab is 3.57E+07Hz. The GBW of the differential amplifier with the resistive load from lab 2 is 1.34E+08 Hz.