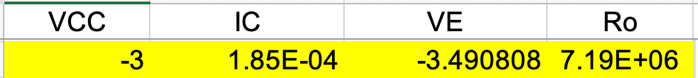
3EJ4 Lab2

Name: Rui Qiu

Student Id: 400318681

*Part1:*

**Q1. (10 Points)** (1) 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*. (2) 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*?

(1): , the Vo,min = -3V and Io = 1.85\*10^-4 A.

Chart, line chart

Description automatically generatedThe verified result from the Step 1.10.

(2):

Simulated result ranges of Ro: 7.19E+06 to 7.69E+07 ohm.

Experimental result ranges of Ro: 6.05E+06 to 3.24E+06 ohm. ???

**Q2. (10 Points)** What are the values of *Vo*1 and *Vo*2 obtained in Step 1.5? Check the *Q*-points of *Q*2 under these two conditions and explain/justify the results obtained qualitatively.

*Vo*1 = 4.94029V *Vo*2 = -3.57892V

Table

Description automatically generated with medium confidence

Explain/justify:

**Q3. (15 Points)** Based on the simulation data obtained in Step 1.6, (1) plot the simulated DC *Vo* vs. *Vsig* characteristics. Discuss/justify the simulated characteristics. (2) For the circuit to work as an amplifier, find the DC input range for *Vsig* and the output voltage range for *Vo*. (3) Find the *Vsig* value and its corresponding collector current *IC*2 that results in *Vo* ≈ 0 V. (4) Based on the measurement data obtained in Step 1.16, plot the measured DC *Vo* vs. *Vsig* characteristics.

(1):

Discuss/justify:

(2): For the circuit to work as an amplifier, the DC input range for Vsig is 4.4001 to 4.4029, and the output voltage range for Vo is 4.79871 to -3.203413

(3): Vsig = 4.4018V and Ic = -0.000184882, when *Vo* ≈ 0 V.

(4):

Chart, line chart

Description automatically generated

**Q4. (10 Points)** (1) 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 *f*3dB (i.e., the frequency at which the amplitude become 1 2 = 0.707 of its low-frequency value, or the phase changes 45°) of this CE amplifier? (2) Verify the voltage gain *Avo* using the measurement data obtained in Steps 1.18 and 1.19. (3) Increase the frequency of W1 to the upper 3-dB frequency *f*3dB 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.

(1): The magnitude (in dB) and phase of intrinsic voltage gain *Avo* at low frequency (i.e., 100 Hz) is, 72.14662238dB and 179.5968243deg. The upper 3-dB frequency f3dB = 9128.428949Hz.

(2): Text

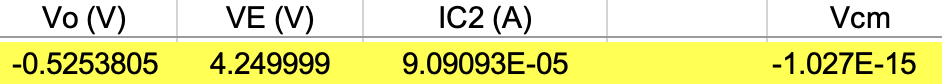
Description automatically generated It is close enough to the simulation result.

(3):

*Part2:*

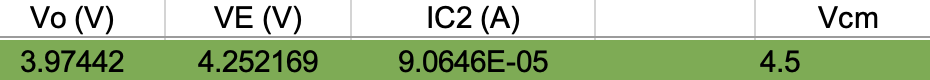
**Q5. (15 Points)** Based on the simulation data obtained in Step 2.2, (1) what are the voltages of *Vo* and *VE*, and *IC*2 of *Q*2 when *VCM* = 0V, (2) what is the input common-mode range (i.e., the voltage range of *VCM* to maintain the same out voltage), and (3) what determines the upper and lower bounds of the input common-mode range? (4) Based on the measurement data obtained in Steps 2.7 and 2.8, verify the common-mode range by experimental data.

(1): Vo = -0.5253805, VE = 4.249999, Ic2 = 9.09093\*10^-5 when Vcm = 0V.



(2): The input common-mode range of Vcm to stay constant is -2.5V to 4.5V.





Chart

Description automatically generated

(3): what determines the upper and lower bounds of the input common-mode range?

(4): Steps 2.7:

Chart

Description automatically generated

Steps 2.8:

Chart, line chart

Description automatically generated

Both data confirmed the range of Vcm.

**Q6. (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?

The gain Acm is -86.90dB.

*Part3:*

**Q7. (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, (1) what is the input differential-mode range? (2) How do we determine the upper and lower bounds of the input differential-mode range?

(1): T=25mV, 2/T=12.5mV, The differential-mode range is from -12.5mV to 12.5mV.

(2): Once the

**Q8. (10 Points)** (1) Based on the simulation data obtained in Step 3.3, what is the voltage gain *Ad* in dB for the differential-mode signal? (2) Estimate its upper 3-dB frequency *f*3dB (i.e., the frequency at which the amplitude becomes 1/sqrt(2) = 0.707 of its low-frequency value or the phase changes 45°) and calculate the gain-bandwidth product (GBW) in hertz (Hz). (3) Compare the upper 3-dB frequency *f*3dB of this differential amplifier with that of the CE amplifier obtained in Q4. (4) Based on the measurement data obtained in Step 3.6, calculate the measured low-frequency differential voltage gain *Ad* in dB.

(1): The voltage gain Ad is 19.63dB.

(2): The upper 3-dB frequency is 5655555.22514252Hz. The calculated gain-bandwidth product (GBW) is shown in excel file by multiplying the frequency and gain.

(3): The upper 3-dB frequency is f3dB = 9128.428949Hz from question (4).

(4): The measured low-frequency differential voltage gain Ad is 21.8dB.

**Q9. (10 Points)** Based on the simulation data, what is the common-mode rejection ratio (CMRR) of the amplifier in dB?

The common mode gain is -86.90dB.

The differential mode gain is 19.63dB.

The common-mode rejection ratio (CMRR) is |19.63dB|/|-86.90dB| = 0.2258918297 ≈ 0.2359