VE311 Electronic Circuit Homework 3

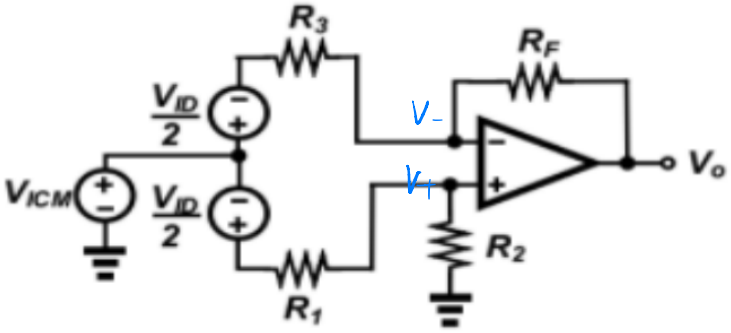
Due: **June 9th**

Note:

1) Please use A4 size paper or page.
2) Please clearly state out your final result for each question.
3) Please attach the screenshot of Pspice simulation result if necessary.

Question 1. Op-amp Circuit

The following figure shows a single op-amp differential amp circuit. The output voltage of the differential amplifier can be written in terms of V_{ICM} and V_{ID} as: $V_O = A_d \cdot V_{ID} + A_{CM} \cdot V_{ICM}$.Assuming the op-amp is ideal, find A_d and A_{CM} for $R_1 = 10k\Omega, R_2 = 10k\Omega, R_3 = 20k\Omega, R_F = 10k\Omega$.



$$V_- = V_+ = \left(V_{ICM} + \frac{V_{ID}}{2}\right) \cdot \frac{R_2}{R_1 + R_2} = \frac{1}{2} V_{ICM} + \frac{1}{4} V_{ID}$$

$$\frac{V_{ICM} - \frac{V_{ID}}{2} - V_-}{R_3} = \frac{V_- - V_o}{R_f} \Rightarrow V_{ICM} - \frac{V_{ID}}{2} - V_- = 2V_- - 2V_o$$

$$V_o = \frac{3}{2} V_- + \frac{1}{4} V_{ID} - \frac{1}{2} V_{ICM} = \frac{1}{4} V_{ICM} + \frac{5}{8} V_{ID}$$

$$\Downarrow$$

$$A_{CM} = \frac{1}{4} \quad A_D = \frac{5}{8}$$

For the following questions, use the SPICE model below

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.model Qbreakn NPN IS=5e-16 BF=200 VAF=200
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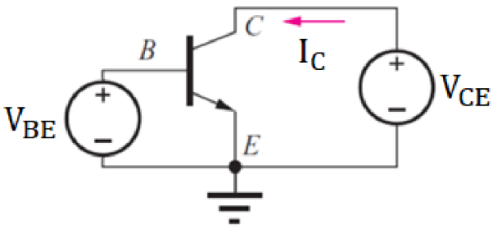
Question 2. BJT Forward-Active I-V Characteristics

For a npn BJT circuit as below:

(a) When $V_{BE} = 0.5V$ and $V_{CE} = 1V$, calculate gm and r_o.

(b) In Pspice, when $V_{CE} = 1V$, plot I_C versus V_{BE} (from 0 to 1V). Find out the slope at $V_{BE} = 0.5V$ and compare it with the gm value calculated in (a).

(c) In Pspice, when $V_{BE} = 0.5V$, plot I_C versus V_{CE} (from 0 to 2V). Find out the inverse of the slope at $V_{CE} = 1V$ and compare it with the r_o value calculated in (a).



(a) $I_C = 1.13 \times 10^{-7} A$

$gm = 4346 \times 10^{-6}$

$r_o = 1.77 \times 10^{9}\ \Omega$

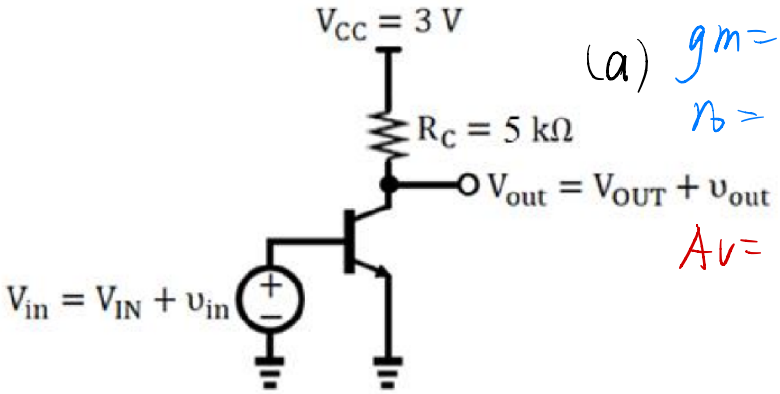
Question 3. BJT Common-Emitter Amplifier

For a npn BJT circuit as below:

(a) When $V_{IN} = 0.4V$, considering the Early Effect, calculate the small-signal voltage gain ($A_v = \frac{v_{out}}{v_{in}}$).

(b) In Pspice, plot V_{OUT} versus V_{IN} (from 0 to 1V). Find out the slope at $V_{IN} = 0.4V$ and compare it with the voltage gain calculated in (a).

(c) In Pspice, when $V_{in} = 0.4 + 0.001 \cdot \sin(2\pi 100 \cdot time)V$, plot V_{out} and V_{in} versus time (from 0 to 0.1 second). Find out $|A_v| = |\frac{v_{out}}{v_{in}}|$ and compare it with the absolute value of voltage gain calculated in (a)



$I_C = 2.4 \times 10^{-9} A$

(a) $gm = 9.23 \times 10^{-8}$

$r_o = 8.33 \times 10^{10}\ \Omega$

$A_V = -4.6 \times 10^{-4}$