SOLUTION

Habib University

Electrical Engineering Department

Dhanani School of Science & Engineering

Course	EE/CE – 211 – Basic Electronics
Semester	Spring 2024
Section	Section L2
Exam	Quiz – 4
Instructor	Dr. Ahmad Usman
Total Marks	10

Question – 1 (CLO 2, Points: 1.5 + 5 + 1.5 + 2)

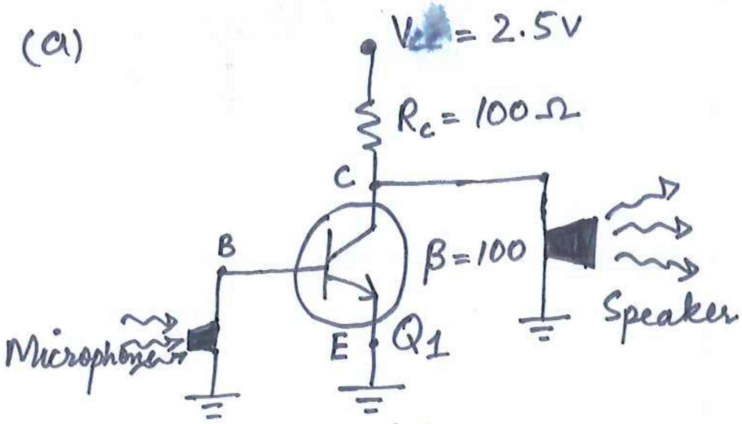
Consider an npn transistor-based amplifier circuit, biased in common emitter configuration, and having the following parameters: $V_{CC} = 2.5$ V, $I_S = 3\text{x}10^{-16}$ A, $R_C = 100\Omega$, $V_{BE} = 800$ mV, $\beta = 100$. The amplifier is having a microphone attached at the input (i.e., base terminal) and the amplified output is observed at the collector terminal.

a) Draw the circuit diagram of the amplifier circuit clearly representing each of the important components.
b) Calculate I_C, I_B, I_E, V_{CE}, g_m, and r_π.
c) Draw the equivalent small-signal model of the transistor. Assume no-early effect.
d) Assuming a 2 mV of input signal at the microphone, calculate the amplified signal voltage at the output.

***Bonus: (Points: 3)**

Does the input signal qualifies as a small-signal? Calculate the voltage swing at the output with respect to the Q-point of the circuit. Does the transistor remain in forward active region of operation or not? Use your calculations to justify your answer.

(a)



$V_{BE} = 0.8V$

Assuming $V_T = 26mV$

(b) $I_c = I_s \exp\left(\frac{V_{BE}}{V_T}\right)$

$\boxed{I_c = 6.918mA}$

$I_c = \beta I_B$

$\boxed{I_B = 69.187\,\mu A}$

$I_E = I_c + I_B$

$\boxed{I_E = 6.9871\,mA}$

$$V_{cc} - I_c R_c - V_{CE} = 0$$

$$\boxed{V_{CE} = 1.8082\ V}$$

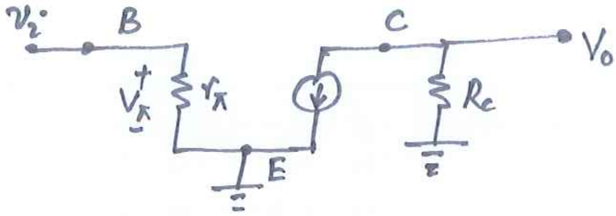
$$g_m = \frac{I_c}{V_T}$$

$$\boxed{g_m = 0.26607\ \Omega^{-1}}$$

$$r_\pi = \beta / g_m$$

$$\boxed{r_\pi = 375.831\ \Omega}$$

(c) Small-Signal Model



(d) $\Delta i_c = g_m \Delta v_{BE}$

$$\Delta v_{BE} = v_{in} = 2mV$$

$$\Delta i_c = 0.266 \times 2m = 0.532mA$$

$$\Delta v_o = (\Delta i_c) R_c = \boxed{53.2\ mV}$$

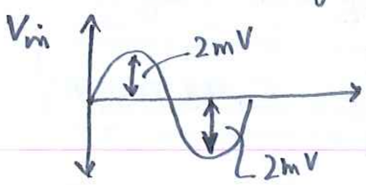
$$A_v = \frac{v_o}{v_{in}} = \frac{53.2m}{2m} = \boxed{26.6}$$

X ———————————— X

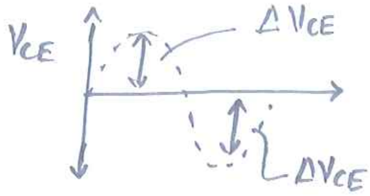
BONUS

$$\frac{v_{in}}{V_{cc}} = \frac{2m}{2.5} \times 100 = 0.08\% < 1\%$$

The input signal is less than 1% of Vcc. It qualifies as a small-signal.



Variation in i/p
$\Delta v_i = 2mV$



Variation on o/p
$\Delta V_{CE} = 0.532V$

This cause $V_{CE,Q}$ to varry.

$$V_{CE,Q(max)} = 1.8082 + 0.0532 = 1.8614V$$

$$V_{CE,Q(min)} = 1.8082 - 0.0532 = 1.7550V$$

For $V_{CE,(max)}$

$V_{BE} = 0.8V$ (Forward Bias)

$V_{CB} = 1.0614$ (Reverse Bias)

→ Transistor stays in "Forward Active Region".

For $V_{CE(min)}$

$V_{BE} = 0.8V$ (Forward Bias)

$V_{CB} = 0.9550$ (Reverse Bias)

→ Transistor stays in "Forward Active Region".