SOLUTION

Habib University

Electrical Engineering Department

Dhanani School of Science & Engineering

Course	EE – 211 – Basic Electronics
Semester	Fall 2022
Section	Section L2
Exam	Quiz – 3a
Instructor	Dr. Ahmad Usman
Total Marks	10

<u>Question – 1</u> (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, $R_C = 100$, $V_{BE} = 800$ 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.

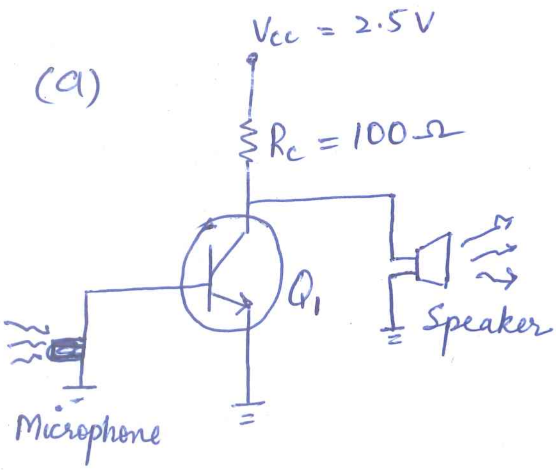
a) Draw the circuit diagram of the amplifier circuit clearly representing each of the important components.
b) Calculate I_C, I_B, I_E, V_{CE}, g_m, and r_π.
c) Draw the equivalent small-signal model of the transistor. Assume no-early effect.
d) Assuming a 2 mV of input signal at the microphone, calculate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

Assuming $\boxed{V_T \approx 26\,mV}$

(a)



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

$\boxed{I_c = 6.918\,mV}$

$I_B = \frac{I_c}{\beta}$

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

$\boxed{I_E = I_c + I_B = 6.9871\,mA}$

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

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

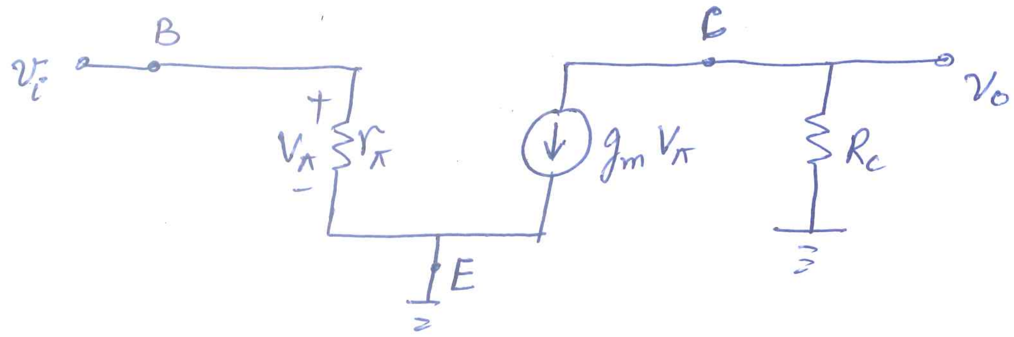
$g_m = \frac{I_c}{V_T}$

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

$r_\pi = \beta / g_m$

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

(C) Small Signal Model



(d)

$$\Delta i_c = g_m \Delta V_{BE}$$

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

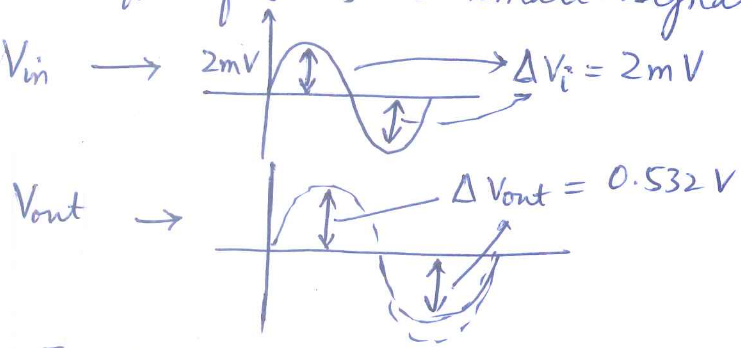
$$\Delta i_c = 0.266 \times 2m = \boxed{0.532 \, mA}$$

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

The voltage amplified by a factor of 26.6.

BONUS

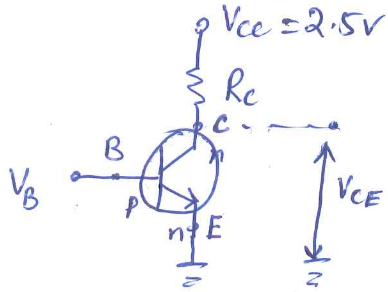
The input signal is less than 1% of the V_{cc}.
It qualifies as a small-signal.



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

$V_{CE(max)} = 2.3402 V$

$V_{CE(min)} = 1.2762 V$



FOR $V_{CE(max)}$

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

$V_{CB} = 1.5 V$ (Reverse Bias)

FOR $V_{CE(min)}$

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

$V_{CB} = 0.4762V$ (Reverse Bias)

→ The tranistor remains in forward active region and behaves as an amplifier.

SOLUTION

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Course	EE – 211 – Basic Electronics
Semester	Fall 2022
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Exam	Quiz – 3b
Instructor	Dr. Ahmad Usman
Total Marks	10

Question – 1 (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, $I_S = 3\times10^{-16}$ A, $R_C = 75$, $V_{BE} = 700$ mV, $\beta = 150$. 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.

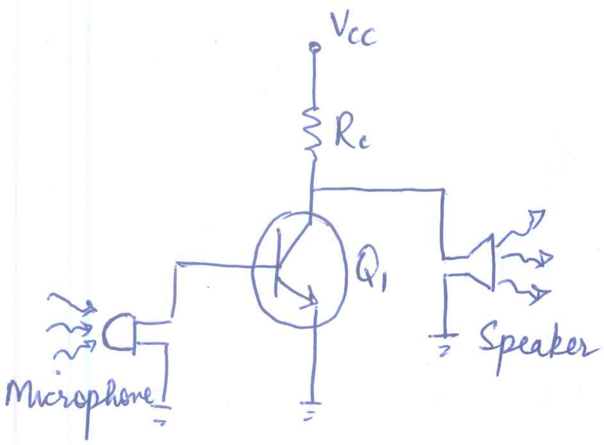
c) Draw the equivalent small-signal model of the transistor. Assume no-early effect.

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)



(b) Assuming $\boxed{V_T = 26\,mV}$

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

$$\boxed{I_c = 0.1478\ mA}$$

$$\boxed{I_B = I_c/\beta = 0.985\ \mu A}$$

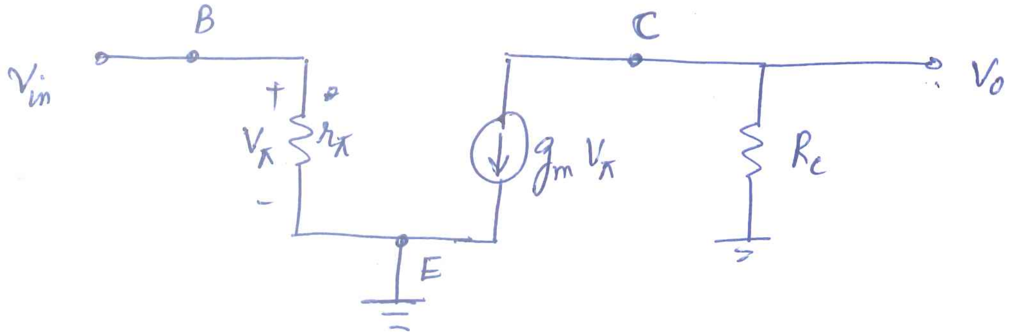
$$\boxed{I_E = I_c + I_B = 1.48718\ mA}$$

$$\boxed{V_{CE} = V_{cc} - I_c R_c = 2.4889\ V}$$

$$\boxed{g_m = \frac{I_c}{V_T} = 0.00568\ \Omega^{-1}}$$

$$\boxed{r_\pi = \beta/g_m = 26.387\ K\Omega}$$

(c)



(d)

$$\Delta i_c = g_m \Delta V_{BE}$$

$$= (0.0568)(2m)$$

$$\Delta i_c = \boxed{0.1136 \text{ mA}}$$

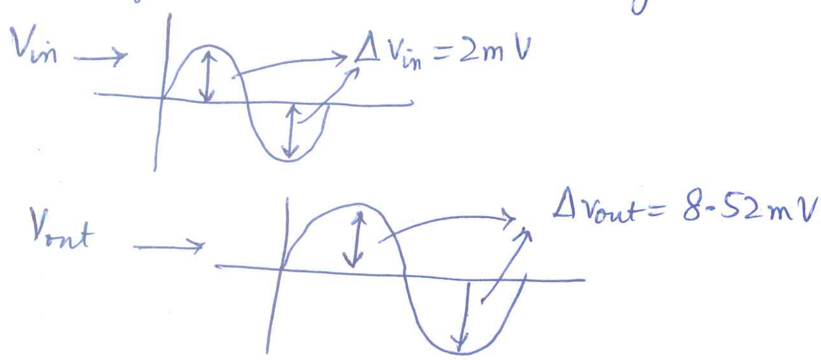
$$\Delta V_{out} = (\Delta i_c) R_c$$

$$= \boxed{8.52 \text{ mV}}$$

The voltage is amplified by a factor of 4.26

BONUS

- The input is less than 1% of the V_{cc}. It qualifies as a small signal



$$\boxed{V_{CE,Q} = 2.4889 V}$$

$$\boxed{V_{CE(max)} = 2.49742 V}$$

$$\boxed{V_{CE(min)} = 2.4803 V}$$

FOR $V_{CE(max)}$

$V_{BE} = 700$ mV (Forward Bias)

$V_{CB} = 1.7974$ (Reverse Bias)

For $V_{CE(min)}$

$V_{BE} = 700$ mV (Forward Bias)

$V_{CB} = 1.7803$ (Reverse Bias)

→ The transistor remains in forward active region and behaves as an ~~amplifier~~ amplifier.