# MACHAKOS UNIVERSITY

**University Examinations for 2019/2020Academic Year**

**SCHOOL OF ENGINEERING AND TECHNOLOGY**

**DEPARTMENT OF ELECTRICAL AND ELECTRONICS ENGINEERING**

**THIRD YEAR SECOND SEMESTER EXAMINATION FOR**

**BACHELOR OF SCIENCE IN ELECTRICAL AND ELECTRONICS ENGINEERING**

**EEE 309: ANALOGUE ELECTRONICS II**

**DATE: 25/11/2020** **TIME: 8.30-10.30 AM**

**INSTRUCTIONS**

***Answer Question One and Any Other Two Questions***

**QUESTION ONE (30 MARKS)**.

a) Determine the open circuit impedance matrix of the two-port network shown in Fig.Q1(a).

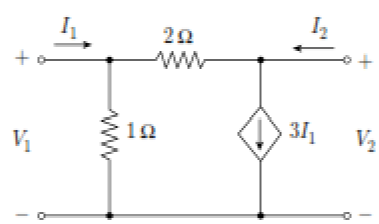



Fig.Q1(a).

(5 marks)

b) An NMOS transistor has parameters $V_{TN} = 0.4$ V. $k_n' = 100\ \mu A/V^2$, and $\lambda = 0.02\ V^{-1}$.

i. Determine the width-to-length ratio W / L such that $g_m = 0.5$ Ma/V at $I_{DQ} = 0.5$ mA when biased in the saturation region.

ii. Calculate the required value of $V_{GSQ}$.

iii. Repeat part (i) and (ii) for $I_{DQ} = 0.15$ mA. (8 marks)

c) A transistor used in common emitter configuration has the following set of h parameters when d.c. operating point is $V_{CE} = 5$ V and $I_C = 1$ mA. $H_{ie} = 1700\ \Omega$ ; $h_{re} = 1.3 \times 10^{-4}$ ; $h_{fe} = 38$ ; $h_{oe} = 6 \times 10^{-6}$ siemens and a.c load as seen by the transistor is $= r_L = 2\ K\Omega$. Determine:

i. Input impedance;

ii. Current gain;

iii. Voltage gain. (6 marks)

d) Consider a non-inverting amplifier with $R_1 = 6.8\ k\Omega$, $R_2 = 47\ k\Omega$ and an op-amp with $A_{OL} = 2 \times 10^4$.

i. What is the closed-loop gain?

ii. Determine the percent difference between the actual gain and the ideal gain.

(4 marks)

e) An inverting amplifier has closed-loop voltage gain of -25. The op-amp used has a low-frequency, open-loop gain of $2 \times 10^4$ and has a unity-gain bandwidth of $10^6$ Hz .

i. What is the 3dB frequency $f_{3\text{-dB}}$ of the op-amp and the 3 dB frequency $f_{3\text{-dB}}$ of the closed-loop amplifier?

ii. Using the results of part (i), what is the magnitude of the voltage gain for the open-loop and closed-loop amplifiers at $f = 0.25\ f_{3\text{-dB}}$ and at $f = 5f_{3\text{-Db}}$ (7 marks)

## QUESTION TWO (20 MARKS)

a) i What is the Barkhausen criterion?

ii. Describe the two conditions for sustained oscillation. (6 marks)

b) Determine the output impedance for the given network with the following Parameters

$C_S = 10\ \mu F$ , $C_E = 20\ \mu F$ , $C_C = 1 \mu F$ , $R_S = 1\ k\Omega$,

$R_1 = 40\ k\Omega$, $R_2 = 10\ k\Omega$, $R_E = 2\ k\Omega$, $R_C = 4\ k\Omega$,

$R_L = 2.2\ k\Omega$, $\beta = 100$, $r_o = \infty\ \Omega$ and $V_{CC} = 20$ V (14 marks)

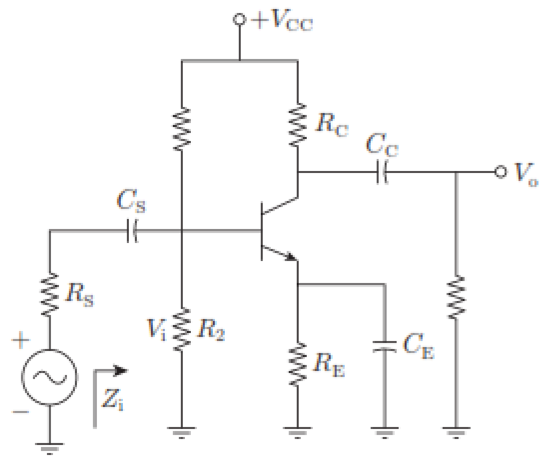



Fig.Q3 (b)

**QUESTION THREE (20 MARKS)**

a) Calculate the operating frequency and feedback fraction for Hartely oscillator shown in Fig.Q3(a). The mutual inductance between the coils is M= 20mH. (5 marks)

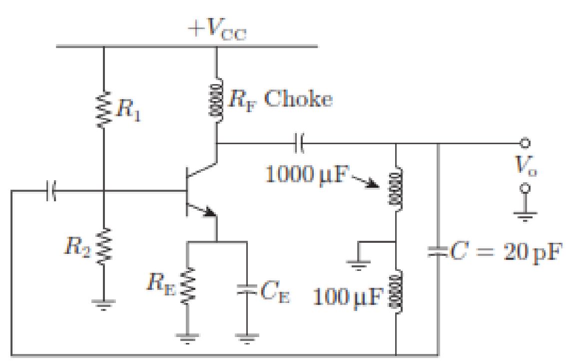



Fig.Q3(a)

Gate

b) For the network shown in Fig.Q3 (b) with the parameters $R_S$ = 1 kΩ, $R_1$ = 40 kΩ, $R_2$ = 10 kΩ, $R_E$ = 2 kΩ, $R_C$ = 4 kΩ, $R_L$ = 2.2 kΩ, $C_S$ = 10 μF, $C_C$ = 1 μF , $C_E$ = 20 μF, β = 100 , $r_o = \infty\Omega$, $V_{CC}$ = 20 V with the addition of $C_{be}$ = 35 pF, $C_{bc}$ = 4 pF, $C_{be}$ = 1 pF, $C_{wi}$ =6 pF ,and $C_{wo}$ = 8 pF.

Determine $f_{Hi}$ and $f_{Ho}$. (15 marks)

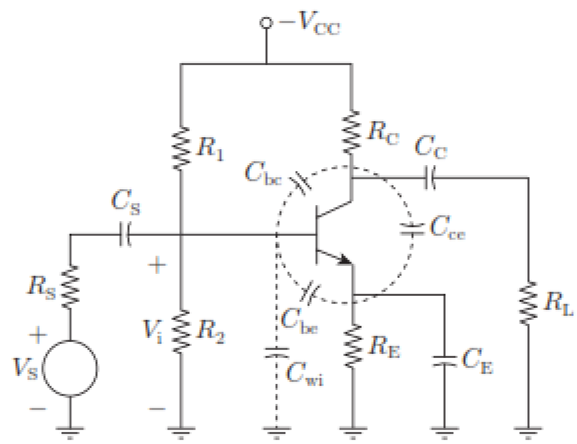



Fig.Q3 (b)

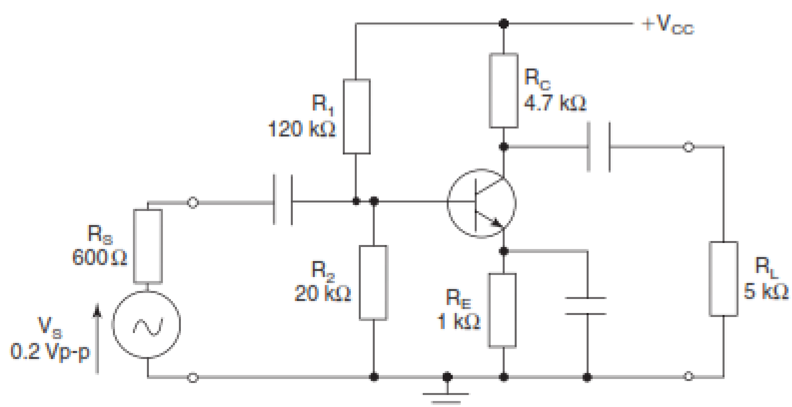
## QUESTION FOUR (20 MARKS)

a) The transistor used in the circuit of Fig.Q4 (a) has the the following h-parameters: $h_{ie}$ = 2 kΩ; $h_{oe}$ = 60 μS; $h_{fe}$ = 100. Calculate

i. the amplifier current gain;

ii. the actual power delivered to the external load;

iii. The turns ratio required for a matching transformer in order to maximize the power delivered to the load. (10 marks)




FigQ4(a)

b) The parameters of the transistor in the circuit in Fig.Q4 (b) are β = 150 and $V_A = \infty$ .

i. Determine $R_1$ and $R_2$ to obtain a bias-stable circuit with the Q-point in the center of the load line.

ii. Determine the small-signal voltage gain $A_v = v_o/v_s$. (10 marks)

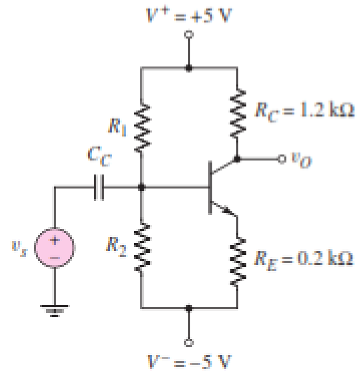



Fig.Q4 (b)

**QUESTION FIVE (20 MARKS)**

a) Calculate the efficiency of the amplifier circuit shown in Fig.Q5 (a). The input voltage applied is such that it produces a base-current of 10 mA peak, the transistor's base-emitter voltage is equal to 0.7V and β is equal to 40.

(12 marks)

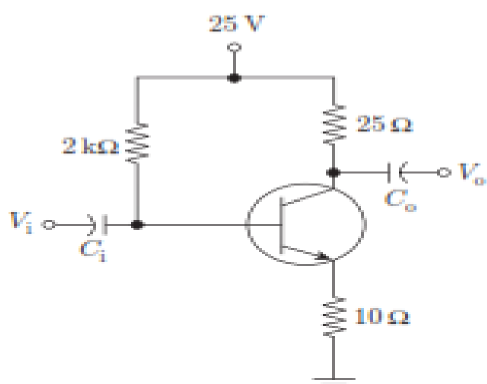
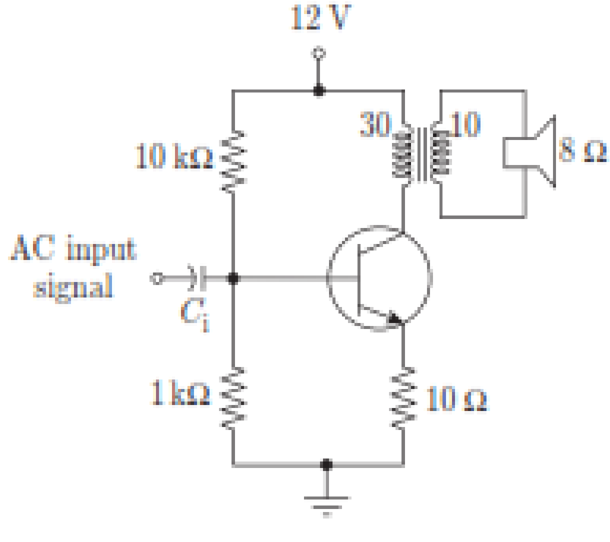


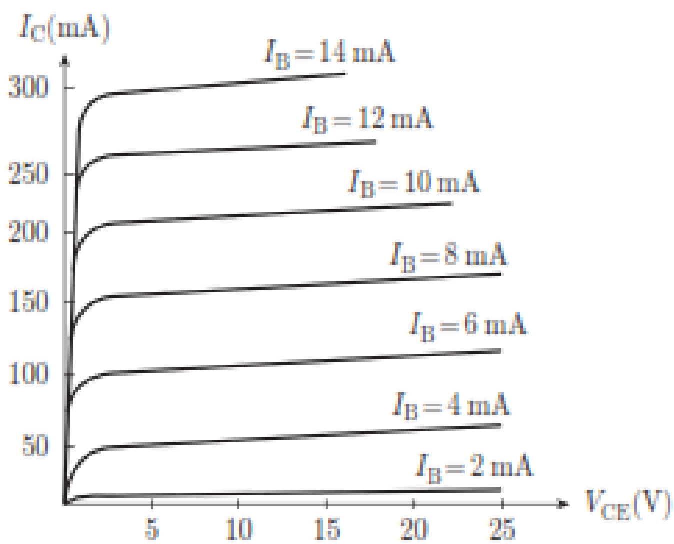

Fig.Q5 (a)

c) What is the AC power delivered to the speaker in the circuit shown in the Fig.Q5 (a)? The value of the quiescent base current is 8 mA and the input signal results in a peak-to-peak base current swing of 8 mA. The output characteristics of the transistor are shown in Fig.Q5 (b).

(8 marks)


12 V
10 kΩ
30
10
8 Ω
AC input signal
$C_i$
1 kΩ
10 Ω

(a)


$I_C$(mA)
$I_B = 14$ mA
$I_B = 12$ mA
$I_B = 10$ mA
$I_B = 8$ mA
$I_B = 6$ mA
$I_B = 4$ mA
$I_B = 2$ mA
300
250
200
150
100
50
5
10
15
20
25
$V_{CE}$(V)

(b)