Matric No.: | | Section: |

Name: |

الجامعة الإسلامية العالمية ماليزيا

INTERNATIONAL ISLAMIC UNIVERSITY MALAYSIA

يونيۏرسيتي اسلام انتارابڠسا مليسيا

KULLIYYAH OF ENGINEERING

MIDTERM EXAMINATION
SEMESTER I, 2023/2024 SESSION

MODEL ANSWER

Programme	: **BEEE**	Level of Study	: **UG 2**
Time	: **8:00 pm - 10:00 pm**	Date	: **22/11/2023**
Duration	: **2 Hrs.**		
Course Code	: **EECE 2313**	Section(s)	: **1-3**
Course Title	: **Electronic Circuits**		

This Question Paper Consists of **6 (Six)** Printing Pages (Including Cover Page) with **3 (Three)** Questions.

INSTRUCTION(S) TO CANDIDATES

- Total mark of this examination is **25**.
- This examination is worth **25%** of the total course assessment.
- Answer **ALL QUESTIONS.**
- Marks assigned to each problem are listed in the margins.
- Write your answer on the question paper only, no additional page will provided.
- Write your answer using a pen, however, you can use a pencil for drawing the figure.

Q1	Q2	Q3	Total
8	6	11	25

Question 1 [8 marks]

(a) Derive the voltage transfer function step by step for the *RC*-circuit shown in **Fig. 1 (a)** as standard format. **(3 marks)**

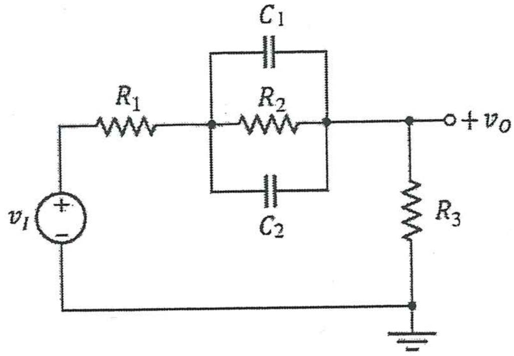
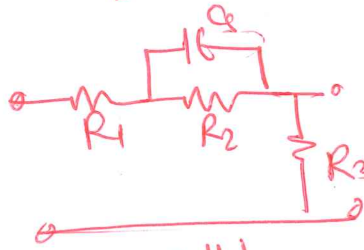


Fig. 1(a)

$C_s = C_1 + C_2$



$Z_2 = R_2 \| \frac{1}{sC_s} = \frac{R_2 / sC_s}{R_2 + 1/sC_s} = \frac{R_2}{1 + sC_sR_2}$

$Z_s = R_1 + \frac{R_2}{1+sC_sR_2}$

$Z_s + Z_p = R_1 + \frac{R_2}{1+sC_sR_2} + R_3 = \frac{(R_1+R_2+R_3) + (R_1+R_2)sC_sR_2}{1+sC_sR_2}$

$T(s) = \frac{Z_p}{Z_s+Z_p} = \frac{R_3(1+sC_sR_2)}{R_1+R_2+R_3 + s(R_1+R_2)R_3C_s}$

$= \frac{R_3}{R_1+R_2+R_3} \cdot \frac{1+sC_sR_2}{1+\frac{s(R_1+R_2)R_3C_s}{R_1+R_2+R_3}}$

$= K \cdot \frac{1+s\tau_1}{1+s\tau_2}$ $\quad \tau_1 = C_sR_2 \leftarrow$

$\tau_2 = C_s (R_1+R_2) \| R_3 \leftarrow$

(b) Assume that the circuit components of **Fig. 1(a)** are $R_1 = 1.0\ \text{k}\Omega$, $R_2 = 5.0\ \text{k}\Omega$, $R_2 = 2.5\text{k}\Omega$, $C_1 = 5.0$ pF, and $C_2 = 15.0$ pF respectively. **(3 marks)**

- *i.* Determine the -3dB corner frequency for the circuit
- *ii.* Determine the magnitude of the transfer function at -3dB corner frequency
- *iii.* Determine the phase of the transfer function at -3dB corner frequency

(i) $f_1 = \frac{1}{2\pi\tau_1} = \frac{1}{2\pi \times 20p \times 5K} = 1.59\ \text{MHz}$.

$f_2 = \frac{1}{2\pi\tau_2} = \frac{1}{2\pi \times 20p \times 1.7647K} = 4.509\ \text{MHz}$

$\tau_1 = (C_1 + C_2) R_2 = (5+15)_p \times 5K = 20p \times 5K$

$= (C_1+C_2)[(R_1+R_2) \| 2.5K]$

$\tau_2 = 20\text{pF} \times 1.7647K$

$\frac{\tau_1}{\tau_2} = \frac{5K}{1.7647K} = 2.83$

$K = \frac{R_3}{R_1+R_2+R_3} = \frac{2.5}{8.5} = 0.29$

(ii) $T|_{\tau_1} = 0.29 \times \frac{1+j1}{1+j2.83}$

$T|_{\tau_2} = 0.29 \times \frac{1+j2.83}{1+j1}$

(c) The transfer function of an RC-circuit is represented as, **(2 marks)**

$$T(j\omega) = 5.0 + j10.72$$

Represent the transfer function in,

- *i.* Exponential form
- *ii.* Polar form

Polar $= \sqrt{5^2 + 10.72^2} \angle \tan^{-1} \frac{10.72}{5}$

$= 11.828 \angle 64.99^\circ$

Exponential $T = 11.828\, e^{j64.99}$

Question 2 [6 marks]

(a) Plot the Bode magnitude and phase for the following transfer function. **(4 marks)**

$$T(s) = \frac{10^{-2}(s+30)\,(s+50)}{s\,(s+60)}$$

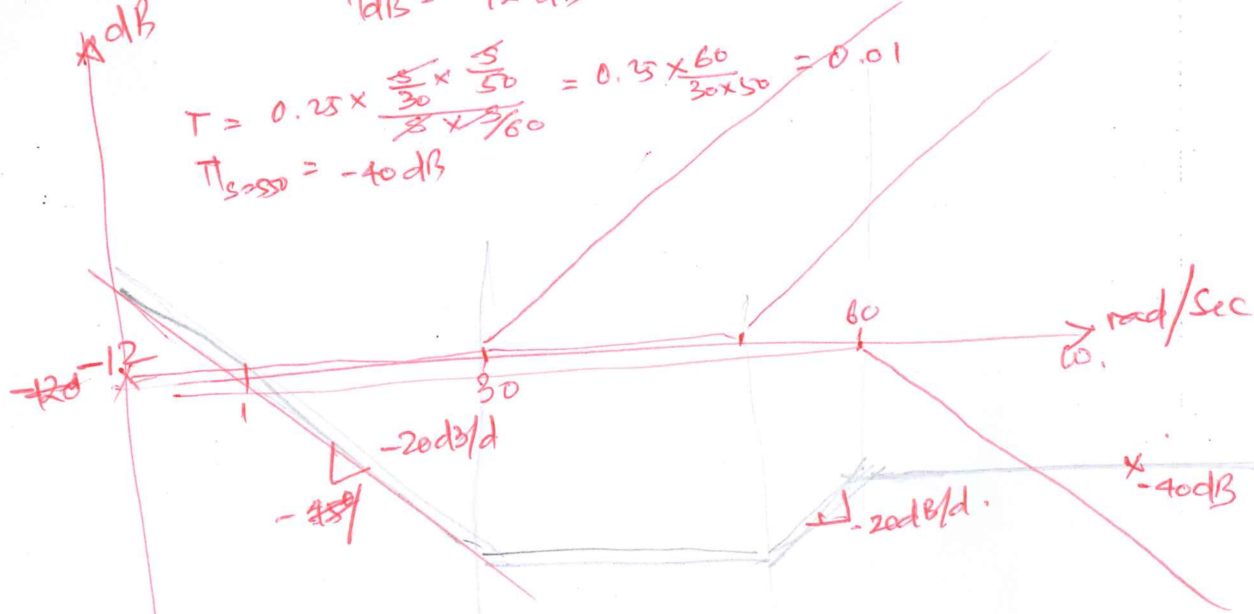
(b) Determine the magnitude and phase from the plot at angular frequency, $s = 550$ rad/sec **(2 marks)**

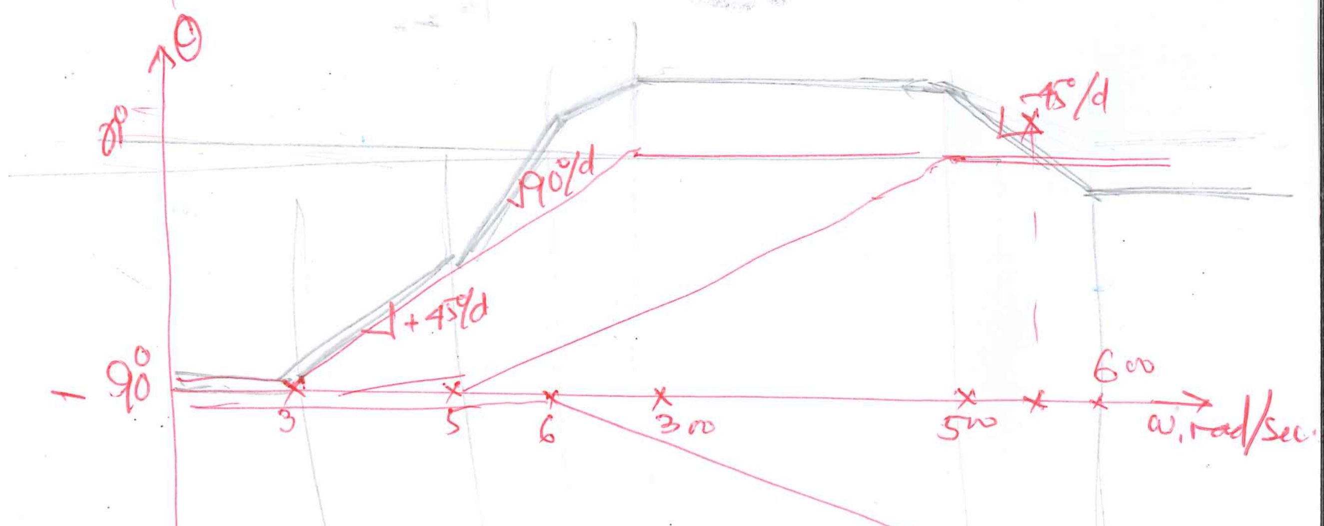
$T = 10^{-2} \times \frac{30 \times 50}{60} = 0.25$

$T|_{dB} = -12\ dB$

$T = 0.25 \times \frac{\frac{s}{30} \times \frac{s}{50}}{s \times s/60} = 0.25 \times \frac{60}{30 \times 50} = 0.01$

$T|_{s=550} = -40\ dB$





$\theta = -90^\circ + \tan^{-1}\frac{550}{30} + \tan^{-1}\frac{550}{50} - \tan^{-1}\frac{550}{60}$

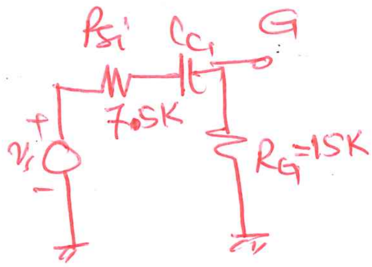
$= -90^\circ + 86.87^\circ + 84.80^\circ - 83.77^\circ = -2.1^\circ$

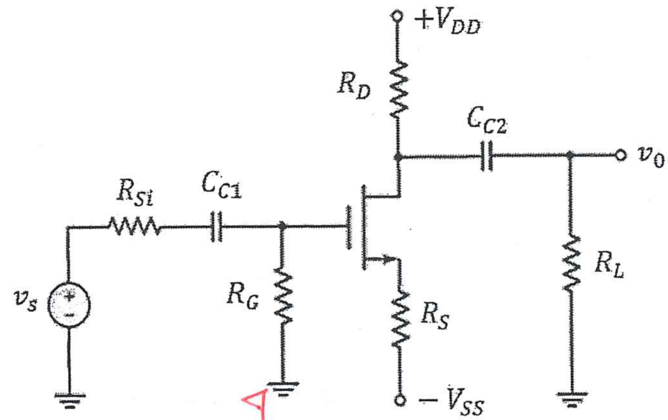
Question 3 [11 marks]

A common source audio amplifier is shown in **Fig. 3** with the following circuit component values, $R_{Si} = 7.5\ \text{k}\Omega$, $R_G = 15\ \text{k}\Omega$, $R_S = 1.0\ \text{k}\Omega$, $R_D = 5\ \text{k}\Omega$, $R_L = 5\ \text{k}\Omega$ and $C_{C1} = \infty$. The MOSFET has AC small-signal parameters, $g_m = 5.0$ mA/V, and $r_0 = \infty$.

(a) Design the amplifier circuit for the lower corner frequency 20 Hz. **(marks 2)**

(b) Draw the small-signal equivalent circuit and determine the maximum voltage gain of the designed amplifier in dB. **(marks 3)**





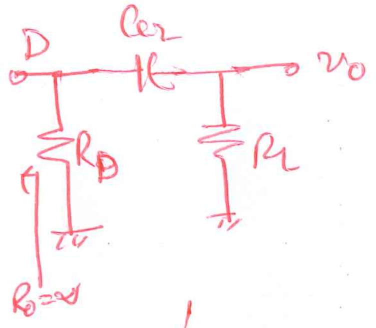


Fig. 3

$C_{C1} = \dfrac{1}{2\pi f(R_{Si} + R_G)}$ [$C_{C1} \neq \infty$]

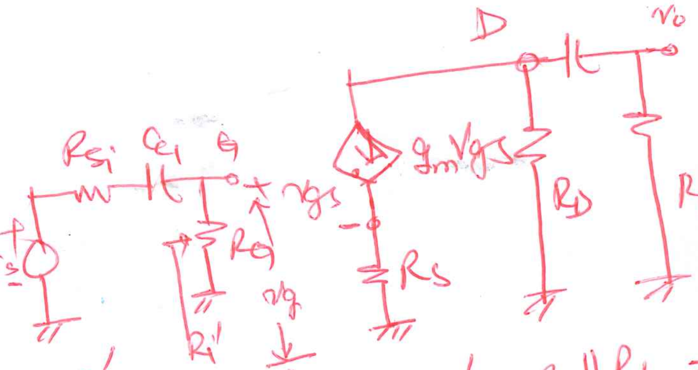
$= \dfrac{1}{2\pi \times 20[7.5 + 15]k}$

$= 0.3536\,\mu F$

$C_{C2} = \dfrac{1}{2\pi f(R_D + R_L)}$

$= \dfrac{1}{2\pi \times 20[5+5]k}$

$= 0.795\,\mu F$



$R_i' = R_G = 15K$

$R_L' = R_D \| R_L = 5 \| 5 = 2.5K$

$A_{VA} = \dfrac{-g_m V_{gs} R_L'}{V_{gs} + g_m V_{gs} R_S}$

$= \dfrac{-g_m R_L'}{1 + g_m R_S} = \dfrac{5m \times 2.5K}{1 + 5m \times 1K} = -\dfrac{12.5}{1+5} = -2.08$

$A_V = A_{VA} \times \dfrac{R_i'}{R_{Si} + R_G} = -2.08 \times \dfrac{15}{(7.5 + 15)} = -1.388$

$A_V|_{dB} = 20\log_{10}(1.388) = 2.853$ dB ←

(c) A short-circuit common-emitter amplifier small-signal equivalent circuit using a simplified BJT high-frequency model is shown in **Fig. 3(c)**.

i. Derive the high frequency short-circuit current gain expression stepwise and determine the f_β frequency. **(4 marks)**

ii. If the BJT small-signal parameters values are, $\beta_0 = 100, r_\pi = 750\Omega, r_o = 100\ k\Omega$, $C_\pi = 10pF$ and $C_\mu = 2pF$ determine the cut-off frequency of the transistor. **(2 marks)**

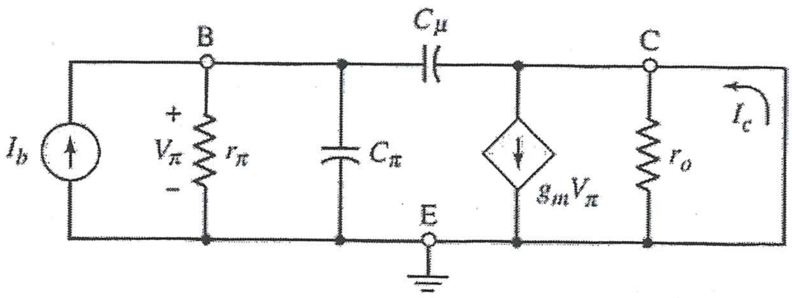


Fig. 3(c)

(i)

$$I_b = \frac{V_\pi}{r_\pi} + \frac{V_\pi}{1/sC_\pi} + \frac{V_\pi}{1/sC_\mu} = \frac{V_\pi}{r_\pi}\left[1 + s r_\pi (C_\pi + C_\mu)\right]$$

$$I_c = g_m V_\pi - V_\pi s C_\mu = V_\pi \left[g_m - sC_\mu\right]$$

$$\therefore A_I = \frac{I_c}{I_b} = \frac{V_\pi (g_m - sC_\mu)}{\frac{V_\pi}{r_\pi}\left[1 + s r_\pi (C_\mu + C_\pi)\right]} = \frac{g_m r_\pi - sC_\mu r_\pi}{1 + s r_\pi (C_\mu + C_\pi)}$$

$\because g_m r_\pi \gg sC_\mu r_\pi$

$$= \frac{g_m r_\pi}{1 + s r_\pi (C_\mu + C_\pi)} = \frac{\beta}{1 + s\tau_\beta} \qquad \therefore f_\beta = \frac{1}{2\pi\tau_\beta}$$

$$= \frac{\beta}{1 + s r_\pi (C_\mu + C_\pi)} \qquad = \frac{1}{2\pi r_\pi (C_\mu + C_\pi)}$$

ii)

$$f_\beta = \frac{1}{2\pi r_\pi (C_\mu + C_\pi)} = \frac{1}{2\pi\, 750\, (10 + 2)p} = 17.6838\,MHz$$

$$\therefore f_T = \beta f_\beta = 100 \times 17.6838 = \underline{1.768\ GHz}$$