Matric No.: | Section:

Name:

الجامعة الإسلامية العالمية ماليزيا

INTERNATIONAL ISLAMIC UNIVERSITY MALAYSIA

يونيبرسيتي إسلام انتارابغسا مليسيا

KULLIYYAH OF ENGINEERING

MIDTERM EXAMINATION
SEMESTER II, 2022/2023 SESSION

Programme	: **Engineering**	Level of Study	: **UG 2**
Time	: **8:00 pm - 10:00 pm**	Date	: **19/04/2023**
Duration	: **2 Hrs**		
Course Code	: **EECE 2313**	Section(s)	: **1**
Course Title	: **Electronic Circuits**		

This Question Paper Consists of **5 (Five)** Pages (Including Cover Page) with **4 (Four)** Questions.

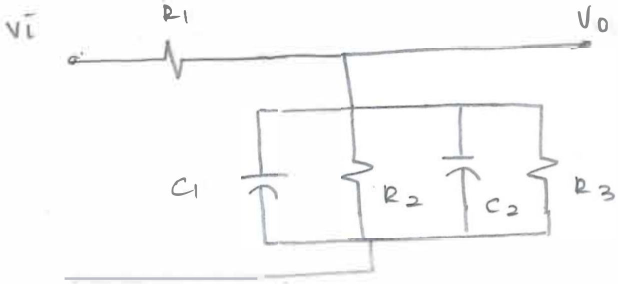
INSTRUCTION(S) TO CANDIDATES

- 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, no additional page will provid.
- Write your answer using pen, however you can use pencil for drawing the figure.

Q1 (6)	Q2 (7)	Q3 (8)	Q4 (4)	Total (25)

Question 1 [6 marks]

Consider the circuit shown in the **Fig. 1**, derive the expression (step by step) for the voltage transfer function, . Find the time constant and corner frequency of the circuit. **(6 marks)**



$$T(s) = \frac{Z_p}{Z_s + Z_p} \qquad C_3 = C_1 + C_2$$

$$Z_p = \left(R_2 \,\|\, R_3 \,\|\, \frac{1}{sC_3} \right)$$

$$Z_p = \left(\frac{1}{R_2} + \frac{1}{R_3} + sC_3 \right)^{-1}$$

$$Z_p = \left(\frac{R_3 + R_2 + sC_3R_2R_3}{R_2R_3} \right)^{-1}$$

$$Z_p = \frac{R_2R_3}{R_2 + R_3 + sC_3R_2R_3}$$

$$Z_s = R_1$$

$$Z_p + Z_s = R_1 + \frac{R_2R_3}{(R_2 + R_3 + sC_3R_2R_3)}$$

$$Z_p + Z_s = \frac{R_1(R_2 + R_3 + sC_3R_2R_3) + R_2R_3}{(R_2 + R_3 + sC_3R_2R_3)}$$

$$Z_p + Z_s = \frac{(R_1R_2 + R_1R_3 + R_2R_3) + sC_3R_1R_2R_3}{(R_2 + R_3 + sC_3R_2R_3)}$$

$$T(s) = \frac{Z_p}{Z_p + Z_s} = \frac{R_2R_3}{(R_1R_2 + R_1R_3 + R_2R_3) + sC_3R_1R_2R_3}$$

$$T(s) = \frac{R_2R_3}{(R_1R_2 + R_1R_3 + R_2R_3)} \cdot \frac{1}{\left(1 + \frac{sC_3R_1R_2R_3}{R_1R_2 + R_1R_3 + R_2R_3}\right)}$$

$$T(s) = k \cdot \frac{1}{1 + s\tau}$$

$$k = \frac{R_2R_3}{R_1R_2 + R_1R_3 + R_2R_3} \; ; \quad \tau = C_3 \left(\frac{R_1R_2R_3}{R_1R_2 + R_1R_3 + R_2R_3} \right)$$

$$f = \frac{1}{2\pi\tau} = \frac{1}{2\pi C_3 \left(\frac{R_1R_2R_3}{R_1R_2 + R_1R_3 + R_2R_3} \right)}$$

Question 2 [7 marks]

Plot the Bode magnitude and phase for the following transfer function.

$$T(s) = \frac{10^3(s+10)}{s(s+100)}$$

and determine the magnitude and phase at angular frequency (50 rad/sec.)

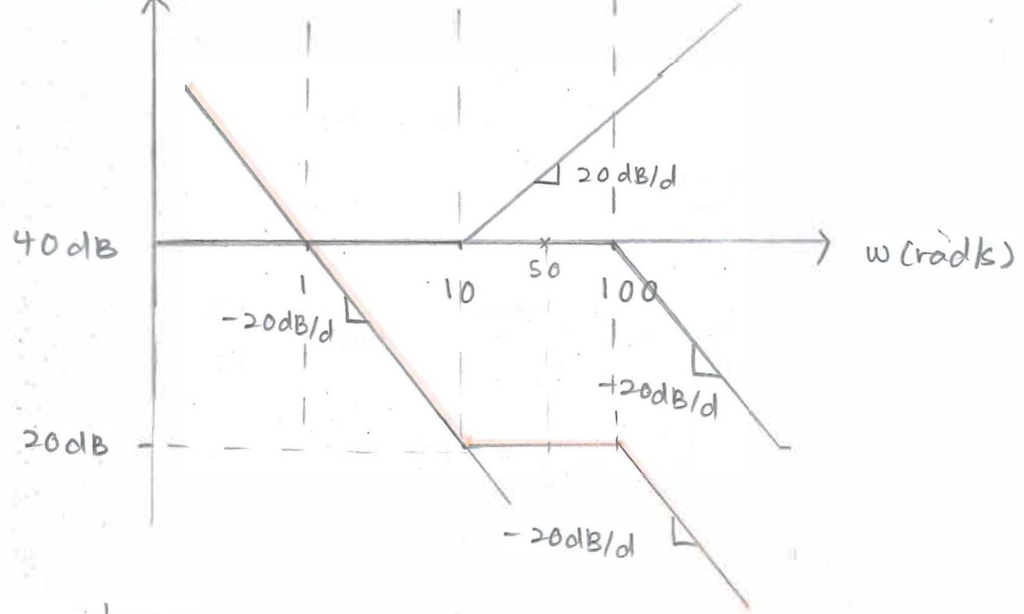
$$T(s) = \frac{10^3(10)}{(100)} \cdot \frac{(1+\frac{s}{10})}{s(1+\frac{s}{100})} = 100 \frac{(1+\frac{s}{10})}{s(1+\frac{s}{100})}$$

$20 \log(100) = 40\text{dB}$ ✱

$$|T(s)|_{\omega=50} = 100 \frac{(\frac{5}{10})}{5(1)} = 10$$

$20 \log(10) = 20\text{dB}$ ✱

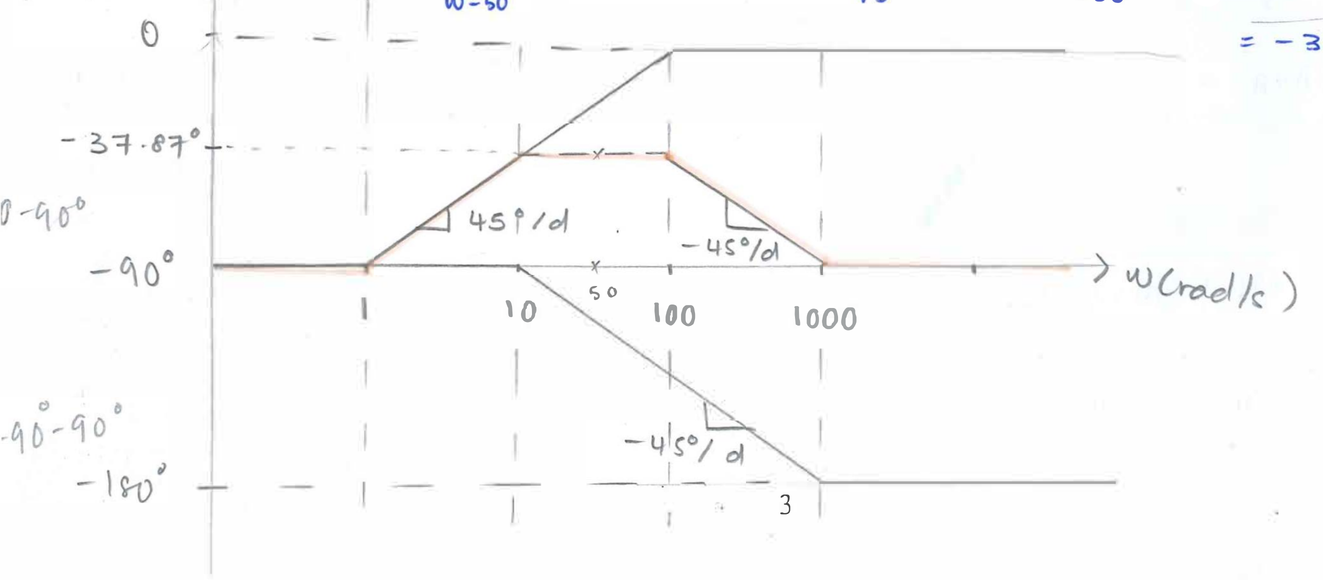
|T(s)|, dB



degree

$$\theta_{\omega=50} = -90^\circ + \tan^{-1}\frac{50}{10} - \tan^{-1}\frac{50}{100} = -37.875^\circ$$ ✱

$= -37.87^\circ$



Question 3 [8 marks]

The common ~~drain~~ source amplifier is shown in **Fig. 3** The MOSFET has AC small-signal hybrid-π parameters, $g_m = 2$ mA/V.

(**a**) Design the amplifier circuit for the lower corner frequency of 50 Hz and upper cornerfrequency of 50KHz **(3 marks)**

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

(**c**) Write the low frequency voltage gain expression considering Cc and $C_{C2} = \infty$. **(2 marks)**

$R_i = R_g = (R_1 \| R_2) = 99.8166k\Omega$

$(R_D \| R_L) = 3.204k\Omega$

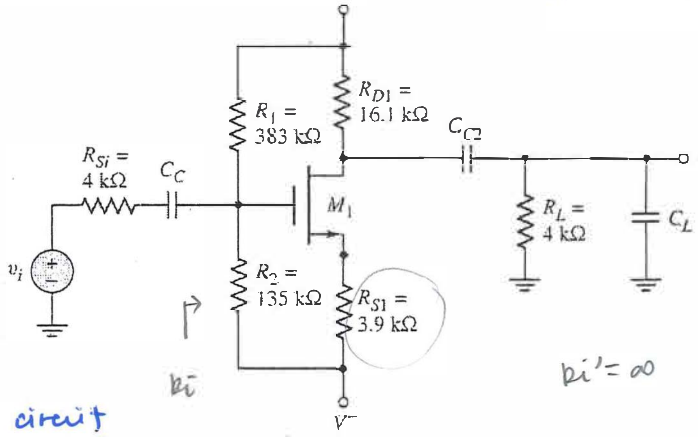
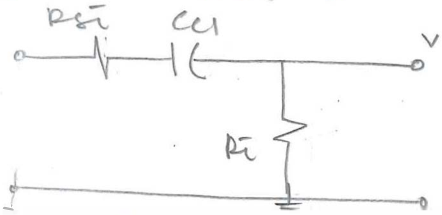


Fig. 3

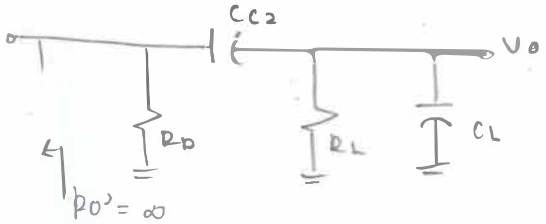
(a) input eq. circuit



$$f_{L1} = \frac{1}{2\pi C_{C1}[R_{si} + R_i]} = 50Hz$$

$$C_{C1} = \frac{1}{2\pi(50)(4k + 99.8166k)} = 3.066\times10^{-8}F = 30.66nF$$

output eq. circuit.



$$f_{L2} = \frac{1}{2\pi C_{C2}[R_D + R_L]} = 50Hz$$

$$C_{C2} = \frac{1}{2\pi(50)(16.1k + 4k)} = 1.584\times10^{-7}F = 0.1584\mu F$$

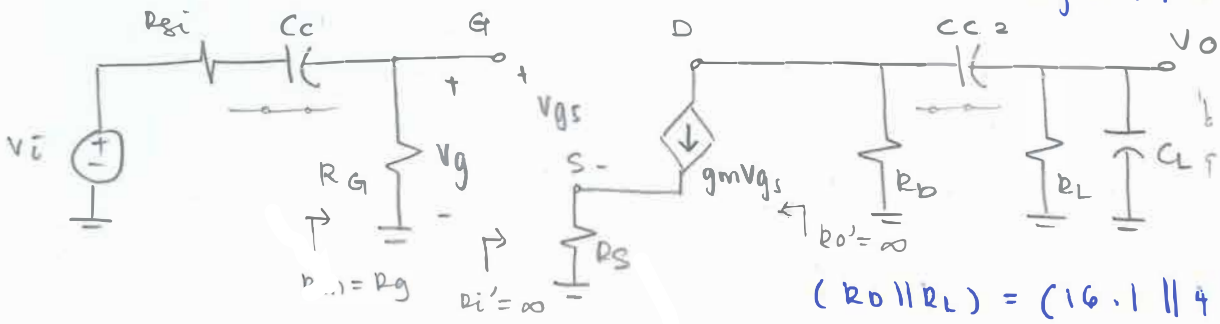
$$f_H = \frac{1}{2\pi C_L[R_D \| R_L]} = 50kHz$$

$$C_L = \frac{1}{2\pi(50k)(3.204)k} = 9.935\times10^{-10}F = 0.9935nF$$

3.(b) small-signal eq circuit :

$R_g = (R_1 \| R_2) = (383 \| 135)$

$R_g = 99.8166\,k\Omega$ ✱



$(R_D \| R_L) = (16.1 \| 4) = 3.204\,k\Omega$ ✱

<u>voltage gain</u> $= A_v = \dfrac{V_o}{V_i} = \dfrac{V_o}{V_g} \times \dfrac{V_g}{V_i}$

$A_{vA} = \dfrac{V_o}{V_g} = \dfrac{-g_m V_{gs} (R_D \| R_L)}{V_{gs} + g_m V_{gs} R_S} = \dfrac{-g_m (R_D \| R_L)}{1 + g_m R_S} \quad \dfrac{-2m(3.204k)}{1 + 2m(3.9k)} = -0.728$ ✱

$\dfrac{V_g}{V_i} = \dfrac{R_g}{R_g + R_{si}} = \dfrac{(R_1 \| R_2)}{(R_1 \| R_2) + R_{si}} = \dfrac{99.8166k}{(99.8166 + 4)k} = 0.96147$

$A_v = A_{vA} \times \dfrac{V_g}{V_i} = -0.728(0.96147) = -0.70$
(midband)

$20 \log (0.7) = -3.098\,dB$

current gain :

$A_I = \dfrac{I_o}{I_i} = \dfrac{V_o / R_L}{V_i / R_g + R_{si}} = \dfrac{V_o}{V_i} \times \dfrac{R_g + R_{si}}{R_L}$

$A_I = A_{vA} \times \dfrac{R_g}{R_g + R_{si}} \times \dfrac{R_g + R_{si}}{R_L} = A_{vA} \times \dfrac{R_g}{R_L}$

$A_I = -0.728 \times \dfrac{99.8166}{4} = -18.167$ ✱
(midband)

$20 \log (18.167) = 25.186\,dB$ ✱

3(c) low frequency voltage gain : C_c , $C_{C2} = \infty$ $\quad C_{C2} = \infty$

$A_v\big|_{low} = A_{vA} \times \dfrac{R_g}{R_g + R_{si} + \frac{1}{sC_c}}$

$C_c = 30.66\,nF$

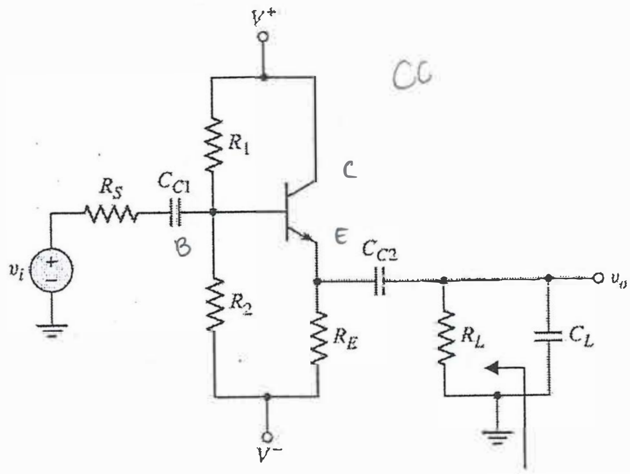
$A_v\big|_{low} = \dfrac{-g_m V_{gs} (R_D \| R_L)}{V_{gs} + g_m V_{gs} R_S} \times \dfrac{R_g}{R_g + R_{si} + \frac{1}{sC_c}}$

$A_v\big|_{low} = \dfrac{-g_m (R_D \| R_L)}{1 + g_m R_S} \times \dfrac{R_g}{R_g + R_{si} + \frac{1}{sC_c}} = -0.728 \times \dfrac{99.8166}{99.8166 + 4 + \frac{1}{sC_c}}$

$A_v\big|_{low} = -0.728 \times \dfrac{99.8166}{103.8166 + \frac{1}{s(30.66n)}} = \dfrac{-72.67}{103.8166 + \frac{1}{s(30.66n)}}$

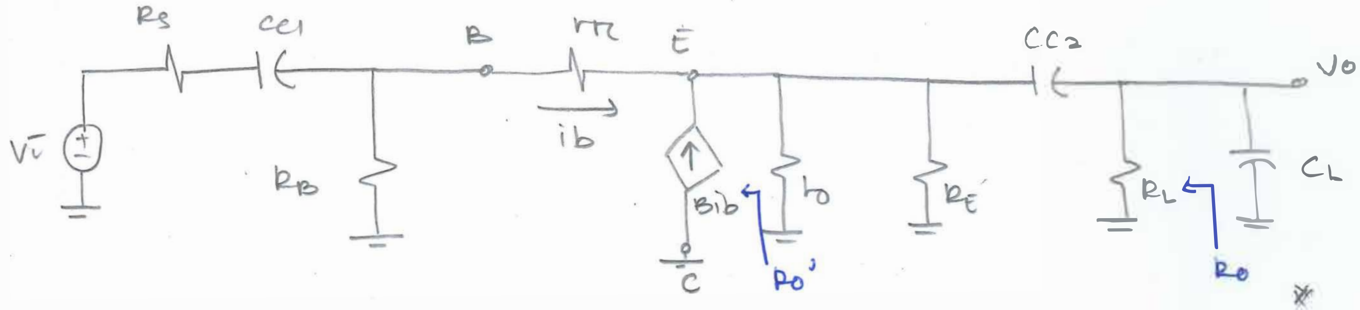
Question 4 [5 marks]

Step by step derive the output resistance Ro for midband frequency of the circuit shown in **Fig. 4** and also identy the type of the amplifier. **(4 marks)**

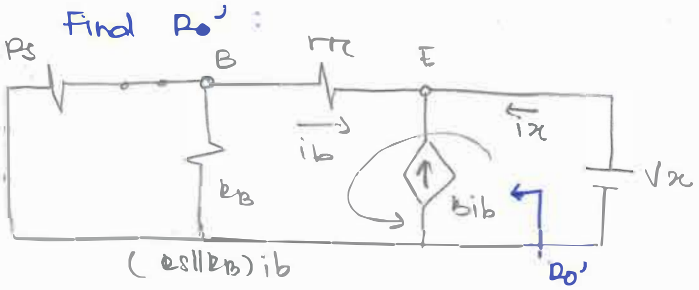


$R_B = (R_1 \| R_2)$

Fig. 4



Find R_o' :



$-V_x - r_\pi i_b - (R_s \| R_B) i_b = 0$

$V_x = -i_b (r_\pi + R_s \| R_B)$

$$R_o' = \frac{V_x}{i_x}$$

$V_x = -r_\pi i_b - (R_s \| R_B) i_b$
$- (i_b + \beta i_b)$

$i_x = -i_b (1 + \beta)$

$$R_o' = \frac{-i_b (r_\pi + (R_s \| R_B))}{-i_b (1 + \beta)}$$

$$R_o' = \frac{r_\pi + (R_s \| R_B)}{(1+\beta)}$$

$$R_o' = \frac{r_\pi + (R_s \| R_1 \| R_2)}{(1+\beta)}$$

$R_o = (R_L \| R_E \| r_o \| R_o')$

$$R_o = \left(R_L \| R_E \| r_o \| \frac{r_\pi + (R_s \| R_1 \| R_2)}{(1+\beta)}\right)$$

Type of amplifier : Common Collector Amplifier