Name:_____________________________________

Matric No:_______________Section:_____

الجامعة الإسلامية العالمية ماليزيا

INTERNATIONAL ISLAMIC UNIVERSITY MALAYSIA

MID-TERM EXAMINATION
SEMESTER II, 2017/2018 SESSION
KULLIYYAH OF ENGINEERING

MODEL ANSWER

Programme	: ENGINEERING	Level of Study	: UG 2
Time	: 5:15 pm-7:15 pm	Date	: 05/04/2018
Duration	: 2 Hours		
Course Code	: EECE 2313/ ECE 2133	Section(s)	: 1, 2
Course Title	: **Electronic Circuits**		

This Question Paper consists of **Five (5)** Printed Pages (Including Cover and a blank page) with **Three (3)** Questions.

INSTRUCTION(S) TO CANDIDATES

DO NOT OPEN UNTIL YOU ARE ASKED TO DO SO

- **Use only pen for writing answer.**
- **Do not use your own sheet.**
- A total mark of this examination is **60**.
- This examination is worth **30%** of the total assessment.
- For drawing you may use pencil
- Answer **ALL THREE(3)** questions.
- **Answer on the question paper.**

Any form of cheating or attempt to cheat is a serious offence which may lead to dismissal.

	Question 1	Question 2	Question 3	Total Marks
Marks	20	20	20	60
Marks Obtained				

Q.1 [20 marks]

(a) Consider the circuit as shown in **Fig. 1(a)**, derive the expression (step by step) for the voltage transfer function $T(s) = v_o(s)/v_i(s)$. Find the corner frequency of the circuit if R_s = 3 kΩ, R_p = 9 kΩ and C_{p1} = 8 nF and C_{p2} = 8 nF . **(6+2 marks)**

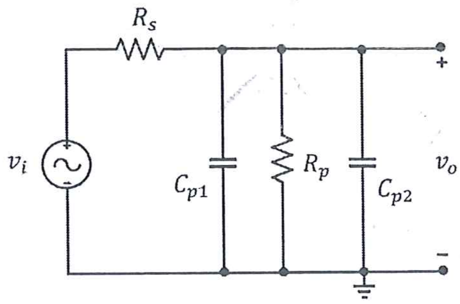


Fig. 1(a)

$C_p = C_{p1} + C_{p2}$

$Z_p = R_p \| \left(\frac{1}{sC_p}\right)$

$= \frac{R_p \times \frac{1}{sC_p}}{R_p + \frac{1}{sC_p}} = \frac{R_p}{1 + sR_pC_p}$

$Z_p + Z_s = \frac{R_p}{1 + sR_pC_p} + R_s = \frac{(R_p + R_s) + sC_pR_pR_s}{1 + sR_pC_p}$

$\therefore T(s) = \frac{V_o(s)}{V_i(s)} = \frac{Z_p}{Z_s + Z_p} = \frac{R_p/(1+sC_pR_p)}{\frac{(R_p+R_s) + sC_pR_pR_s}{(1+sC_pR_p)}} = \frac{R_p}{R_p + R_s + sC_pR_pR_s}$

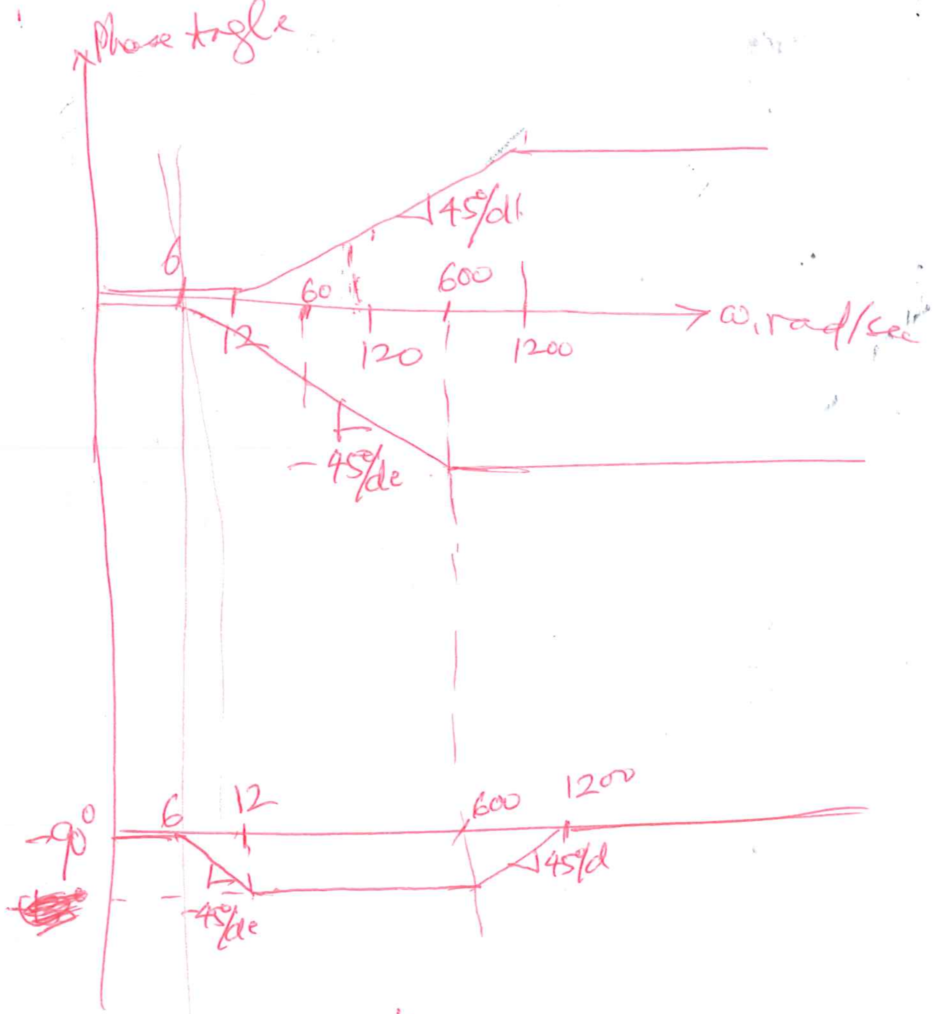
$= \frac{R_p}{R_p + R_s} \cdot \frac{1}{1 + s\frac{R_pR_s}{R_p+R_s}C_p} = \frac{R_p}{R_p + R_s} \cdot \frac{1}{1 + s\tau_p}$

$\tau = R_p \| R_s \times C_p = (3 \| 9)_k (8+8)_{nF}$

$= 2.5_k \times 16nF = 3.6 \times 10^{-5}$ sec $= 36\mu s$.

$\therefore f_c = \frac{1}{2\pi\tau} = 4.424$ KHz. ←

Phase.



$$\theta = -90^\circ + \tan^{-1}\frac{\omega}{120} - \tan^{-1}\frac{\omega}{60}$$

$$= -90^\circ + 39.80 - 59.036^\circ = -109.23^\circ$$

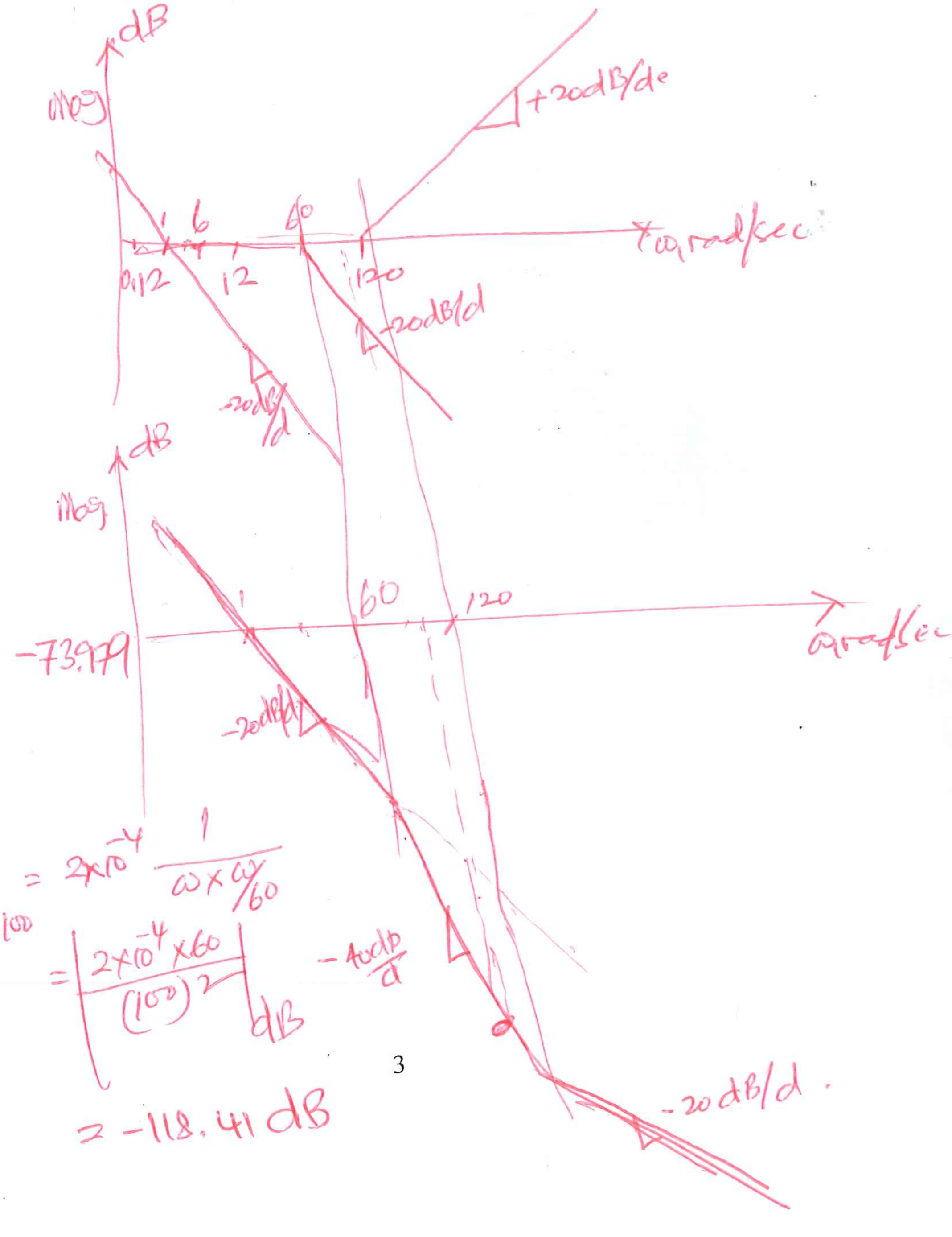
(b) Draw the Bode plot (magnitude and phase) of the following transfer function. **(8 marks)**

$$T(s) = \frac{10^{-4}(s+120)}{s(s+60)}$$

(c) Determine the magnitude and phase at $s = 100$ rad/sec, using the solution from the graph of the question Q1.(b). **(4 marks)**

$$T(S) = \frac{10^{-4} \times 120\left(1+\frac{s}{120}\right)}{s \times 60\left[1+\frac{s}{60}\right]} = 2\times10^{-4} \times \frac{1+s/120}{s(1+s/60)}$$

$$T_1\big|_{dB} = 20\log_{10}(2\times10^{-4}) = -73.979\text{ dB}.$$



$$|T(s)|_{\omega=100} = 2\times10^{-4}\,\frac{1}{\omega\times\frac{\omega}{60}}$$

$$= \left|\frac{2\times10^{-4}\times60}{(100)^2}\right|_{dB}$$

$$= -118.41\text{ dB}$$

Q.2 [20 marks]

A common source amplifier is shown in **Fig. 2**, with the following circuit component values R_{si} = 10kΩ, R_G = 40kΩ, R_S = 5kΩ, R_D = 10kΩ, R_L = 6 kΩ, C_C = 3.2nF and C_L = 1nF. The MOSFET has a small - signal parameters, g_m = 40 mA/V and $r_o = \infty$.

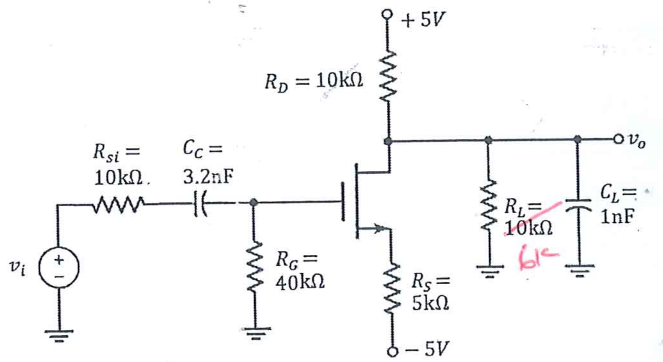


Fig. 2

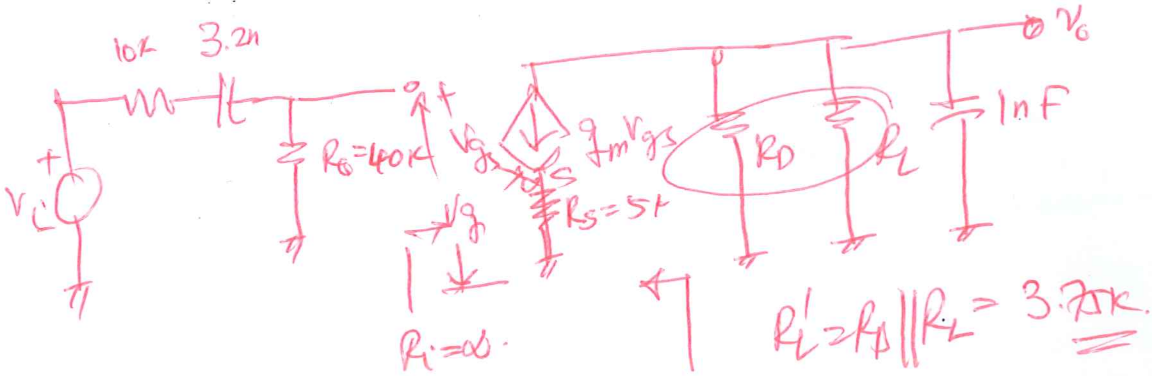
(i) Draw the small signal equivalent circuit diagram of the circuit. **(3 marks)**

(ii) Evaluate the midband voltage gain, $A_v = \frac{v_o}{v_i}$ of the amplifier in dB scale. **(7 marks)**

(iii) Determine the lower corner frequency, f_L (3 dB frequency) due to C_C. **(4 marks)**

(iv) Determine the higher corner frequency f_H. **(4 marks)**

(v) What is the bandwidth of the amplifier? **(2 marks)**



$R_L' = R_D || R_L = 3.75k$

$R_o = \infty$

(iii) $\tau_L = (R_{si} + R_G) C_C$

$= (10+40)k \times 3.2nF$

$= 160 \mu S$

$f_L = \frac{1}{2\pi \tau_L} = 994.7 Hz$

$\tau_H = R_L' || C_L$

$= 3.75 \mu S$

$f_H = \frac{1}{2\pi \tau_H} = 42.44 kHz$

$BW = f_H - f_L = 41.445 kHz$

$$A_{V_A} = -\frac{g_m V_{gs} R_L'}{(V_{gs} + g_m V_{gs} R_s)} = \frac{v_o}{v_g}$$

$$= \frac{-g_m R_L'}{(1 + g_m R_s)} = \frac{-40_m \times 3.75K}{1 + 40_m \times 5K}$$

$$= -0.746$$

$$A_V = A_{V_A} \times \frac{R_g}{R_{si} + R_g}$$

$$= -0.746 \times \frac{40}{10+50} = -0.597$$

$$A_V\big|_{dB} = 20 \log 0.597 = \underline{-4.48\ dB}$$

Q.3 [20 marks]

(a) Draw the simplified high-frequency model of a bipolar junction transistor (BJT) and mention the name of each parameter. **(2 marks)**

(b) Draw the simplified high-frequency small-signal short-circuit ($R_C = 0$) equivalent diagram of the circuit as shown in **Fig. 3(b)**, and determine the cutoff frequency f_T (step by step) for the transistor. **(14 marks)**

(c) Assume that a BJT has the parameters, $r_\pi = 1.5\text{k}\Omega$, $g_m = \frac{20\text{mA}}{\text{V}}$, $C_\pi = 20\text{pF}$ and $C_\mu = 12\text{pF}$, determine the f_β and f_T of the transistor. **(4 marks)**

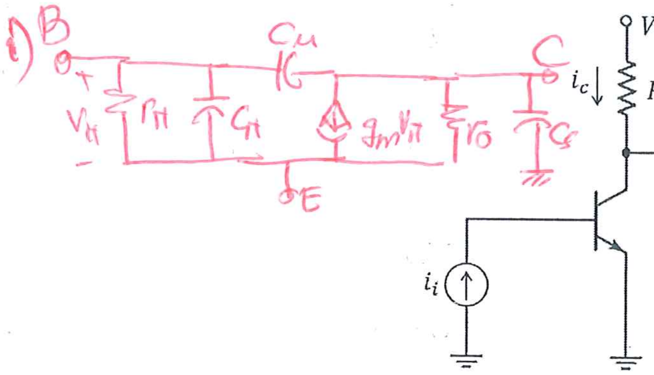
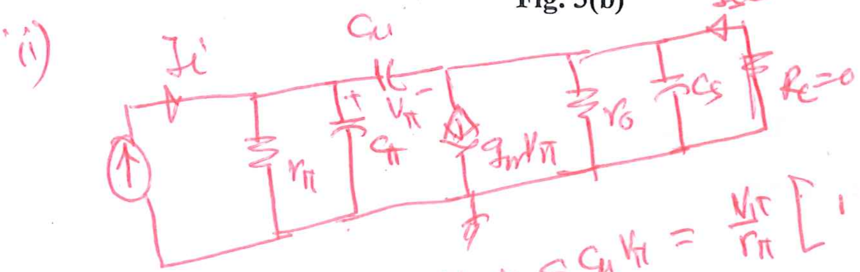


Fig. 3(b)



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

$I_c = I_o = g_m V_\pi - V_\pi s C_\mu$

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

$\simeq \frac{g_m r_\pi}{1 + s(C_\pi + C_\mu) r_\pi} = \frac{\beta}{1 + s r_\pi (C_\pi + C_\mu)}$ [$\because g_m r_\pi \gg \omega C_\mu r_\pi$ within freq of interest]

$|A_I| = 1 = \left|\frac{\beta}{1 + s r_\pi (C_\pi + C_\mu)}\right|$

$= \frac{\beta}{\sqrt{1 + [\omega_T r_\pi (C_\pi + C_\mu)]^2}} \simeq \frac{\beta}{\omega_T r_\pi (C_\pi + C_\mu)}$

$\therefore \omega_T = \frac{\beta}{r_\pi (C_\pi + C_\mu)} \Rightarrow f_T = \frac{\beta}{2\pi r_\pi (C_\pi + C_\mu)} = \beta f_\beta$

$\beta = g_m r_\pi$
$= 20 \times 1.5$
$= 30$

$$f_T = \frac{\beta}{2\pi r_\pi (C_\mu + C_\pi)}$$

$$= \frac{30}{2\pi \times 1.5K\ 32p} = 99.4718\,MHz \leftarrow$$

$$f_T = \beta f_\beta \Rightarrow f_\beta = \frac{f_T}{\beta} = 3.3157\ MHZ \leftarrow$$