Name: MODEL ANSWER

Matric No:______________Section:_____

الجامعة الإسلامية العالمية ماليزيا

INTERNATIONAL ISLAMIC UNIVERSITY MALAYSIA

MID-TERM EXAMINATION
SEMESTER I, 2013/2014 SESSION
KULLIYYAH OF ENGINEERING

Programme	: ENGINEERING	Level of Study	: UG 2
Time	: 8:00 pm-10:00 pm	Date	: 06/11/2013
Duration	: 2 Hours		
Course Code	: ECE 2133	Section(s)	: 1 & 2
Course Title	: **Electronic Circuits**		

This Question Paper consists of **Eight (8)** 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 shown in **Fig. 1(a)**, derive the expression (step by step) for the voltage transfer function $T(s) = {}^{v_o(s)}\!/_{v_i(s)}$ and find the time constant and the corner frequency. **(8 marks)**

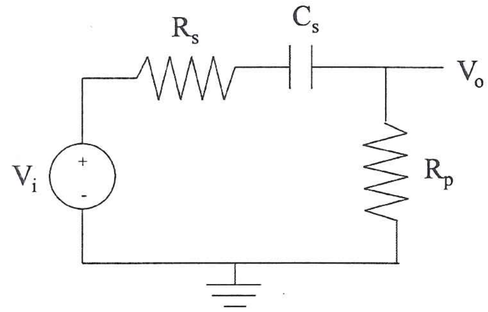


Fig. 1(a)

$$T(s) = \frac{v_o(s)}{v_i(s)} = \frac{R_p}{R_p + R_s + \frac{1}{sC_s}} = \frac{R_p\, sC_s}{1 + (R_p+R_s)\, sC_s}$$

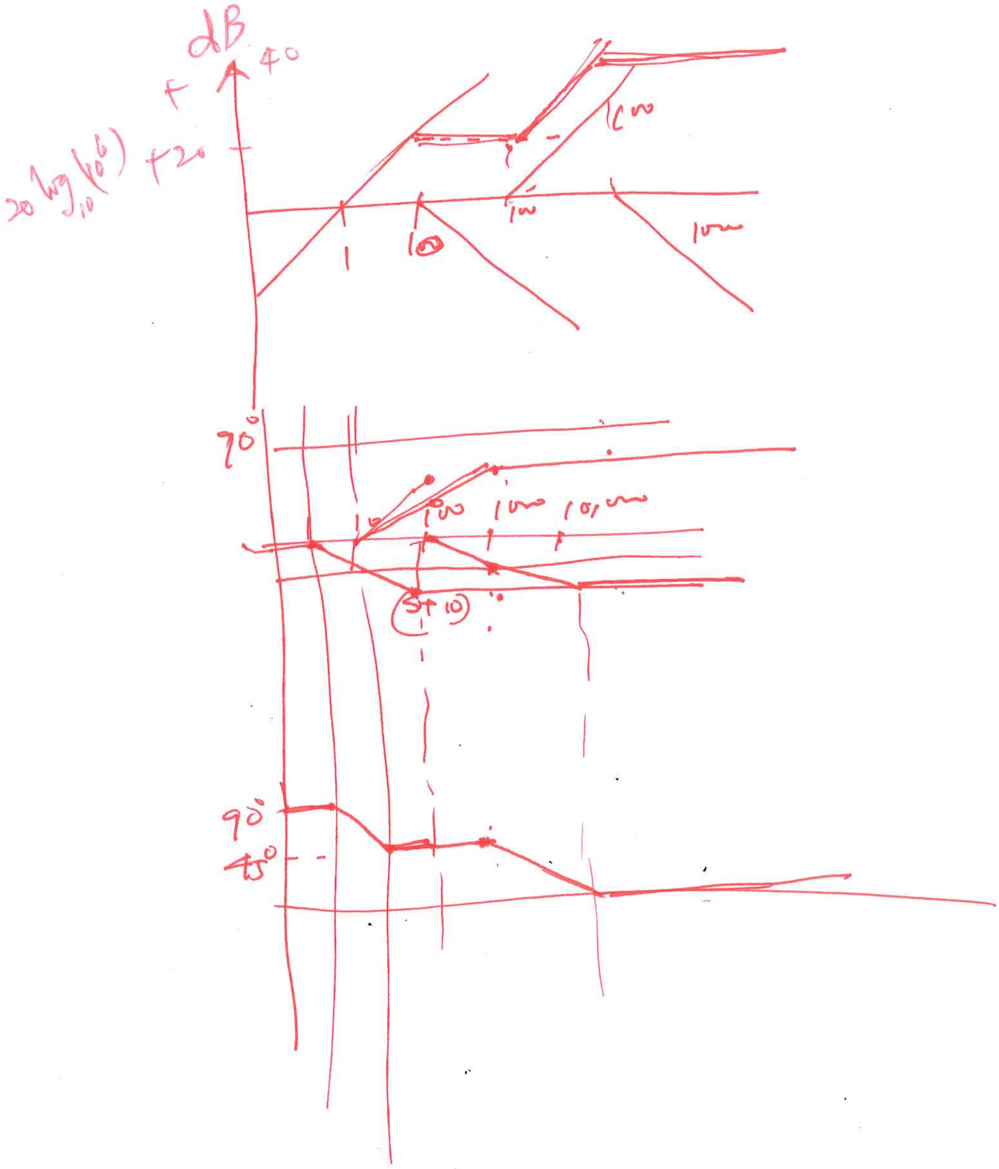
$$= \frac{R_p}{R_p+R_s} \cdot \frac{s(R_p+R_s)C_s}{1+s(R_p+R_s)C_s} = K \cdot \frac{s\tau_s}{1+s\tau_s}$$

$$\tau_s = (R_p + R_p)C_s \qquad f = \frac{1}{2\pi\tau_s} = \frac{1}{2\pi(R_p+R_s)}$$

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

(12 marks)

$$T(s) = \frac{10^6 s(s+100)}{(s+10)(s+1000)}$$



Q.2 [20 marks]

(a) Draw the small signal equivalent circuit diagram of the circuit shown in **Fig. 2(a)** and find the followings: **(10 marks)**

(i) the input resistance R_i,

(ii) the midband voltage gain $A_v = \frac{v_o}{v_s}$ of the amplifier, and

(iii) the lower corner frequency due to C_C.

Given that $R_s = 0.5\ k\Omega$, $R_1 = 330\ k\Omega$, $R_2 = 85\ k\Omega$, $R_C = 4\ k\Omega$, $R_E = 1.5\ k\Omega$, $C_C = 1\ \mu F$. The transistor has small-signal hybrid-π parameters, $r_\pi = 3\ k\Omega$, $g_m = 40mA/V$ and $r_o = \infty$.

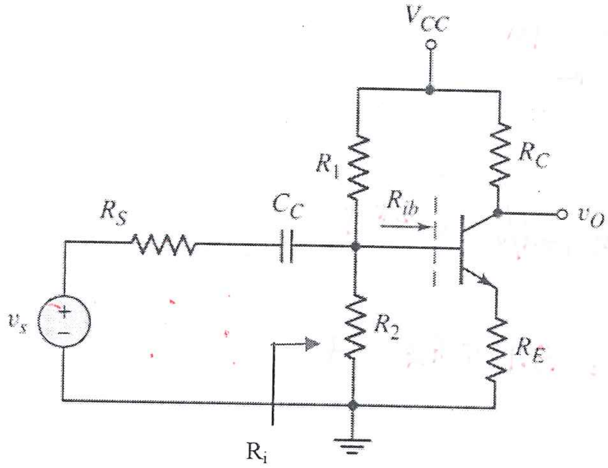


Fig. 2(a)

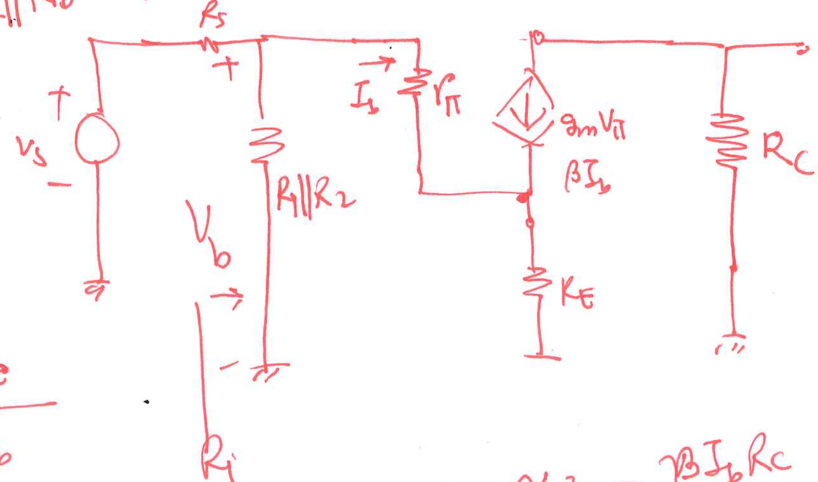
$\beta = r_\pi \times g_m$

$= 3 \times 40 = 120$

$R_{ib} = r_\pi + (1+\beta) R_E$

$= 3 + (1+120)1.5 = 184.5$

$R_i = R_1 || R_2 || R_{ib} = 49.468\ k\Omega$



$\therefore A_v = \frac{v_o}{v_b}$

$= - \frac{\beta I_b R_e}{R_{ib} I_b}$

$= - \frac{\beta \times R_c}{R_{ib}}$ $= - \frac{120 \times 4}{49.468}$

$= - \cancel{9.703}$ -2.60

$v_o = - \beta I_b R_c$

$V_b = (r_\pi + (1+\beta) R_E) I_b$

$= R_{ib} I_b$

$$A_{V\alpha} = A_{VA} \times \frac{R_i}{R_i + R_s} = \overset{-2.6}{-\cancel{9.703}} \times \frac{49.468}{49.468 + 0.5}$$

$$= -\cancel{9.606} \quad -2.57$$

(ii) $\tau = R_{eq} C_c$

$= (0.5 + 49.468)k \quad 1M$

$= 49.968\, ms$

$\therefore \omega = \frac{1}{\tau} = 20.0128 \ rad/s = 2\pi f$

$\therefore \quad f = \frac{\omega}{2\pi} = 3.185 \ Hz$

(b) Draw the small signal equivalent circuit diagram of the circuit shown in **Fig. 2(b)** and find the followings: **(10 marks)**

(i) the midband voltage gain $A_v = \frac{v_o}{v_i}$,

(ii) the output resistance R_o of the amplifier, and

(iii) the corner frequency due to $C_L = 4$ pF assumed that $C_C \rightarrow \infty$.

Given that $R_{si} = 2$ kΩ, $R_1 = 180$ kΩ, $R_2 = 330$ kΩ, $R_s = 1.0$ kΩ, $R_L = 10$ KΩ. The transistor parameters are $g_m = 0.65$ mA/V and $r_o = 100$ kΩ.

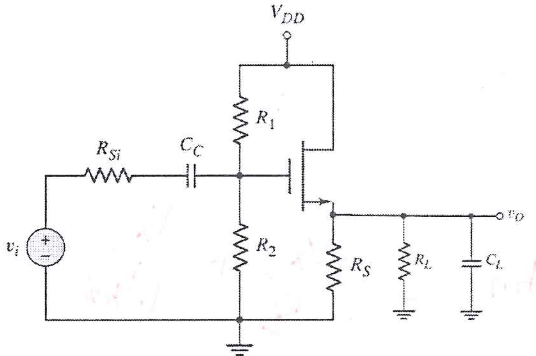
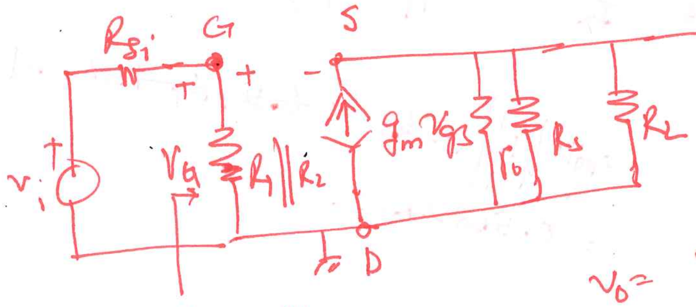


Fig. 2(b)



$v_o = g_m v_{gs} R_L'$ $(R_L' = R_s || R_L || r_o)$

$R_i = R_1 || R_G$

$V_G = v_{gs} + v_o$
$= v_{gs} + g_m v_{gs} R_L'$
$= (1 + g_m R_L') v_{gs}$.

$\therefore A_{vA} = \frac{v_o}{V_G} = \frac{g_m v_{gs} R_L'}{(1+g_m R_L') v_{gs}}$

$= \frac{g_m R_L'}{1 + g_m R_L'} = 0.3696 = \cancel{0.372}$

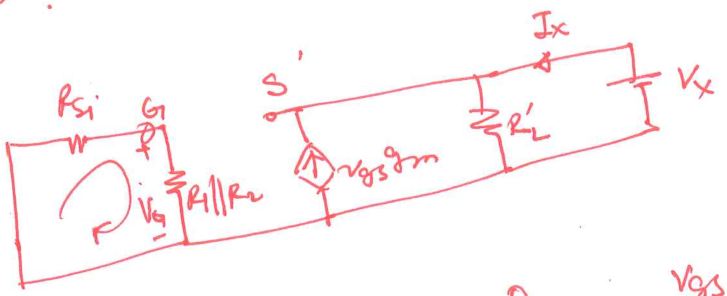
$g_m R_L' = 0.65 \times 10||1||100 = 0.586$

$\therefore A_v = A_{vA} \times \frac{R_i}{R_i + R_s} = \cancel{0.372}\ 0.3696 \times \frac{116.47}{116.47+2}$

$= \cancel{0.3657}$ V/V
$= 0.3633$ V/V

$R_i = 180||330 = 116.47$

$R_o = ?$



$V_G = v_{gs} + V_x = 0 \quad \therefore \; v_{gs} = -V_x$

$$I_x = \frac{V_x}{R_L'} - v_{gs} g_m$$

$$= \frac{V_x}{R_L'} + V_x g_m = \frac{V_x}{R_L'} + \frac{V_x}{(1/g_m)}$$

$$\frac{1}{g_m} = \frac{1}{0.65} = 1.538K$$

$$\therefore R_o = \frac{V_x}{I_x} = R_L' \| \left(\frac{1}{g_m}\right)$$

$$= 10 \| 10 \| 1 \| 1.538 = \cancel{0.5714\ K\Omega}$$

$$= 0.5682 K\Omega$$

iii) $\tau = R_{eq} \times C_L = 0.5682K \times 4p = 2.272\ nS.$

$$= \frac{1}{\tau} \qquad f_H = \frac{1}{2\pi\tau} = 70\ MHz$$

Q.3 [20 marks]

(a) Draw the simplified high frequency small-signal equivalent circuit diagram of the ac circuit shown in **Fig. 3(a)** and derive step by step short circuit current gain $A_i = I_c/I_b$. Then find the beta frequency f_β and cutoff frequency f_T and find the relation between gain and bandwidth. **(10 marks)**

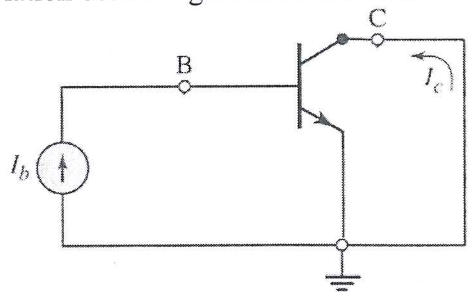
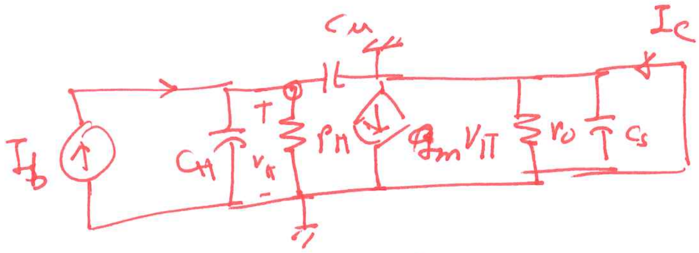


Fig. 3(a)



$$I_c = g_m v_\pi - \frac{v_\pi}{1/sC_\mu} = \left[g_m - sC_\mu\right] v_\pi$$

$$I_b = \frac{V_\pi}{1/sC_\pi} + \frac{V_\pi}{r_\pi} + \frac{V_\pi}{1/C_\mu}$$

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

$$\therefore \frac{I_c}{I_b} = \frac{r_\pi(g_m - sC_\mu)}{1 + r_\pi s(C_\mu + C_\pi)} \simeq \frac{r_\pi g_m}{1 + s r_\pi(C_\mu + C_\pi)} = \frac{\beta}{1 + r_\pi s(C_\mu + C_\pi)}$$

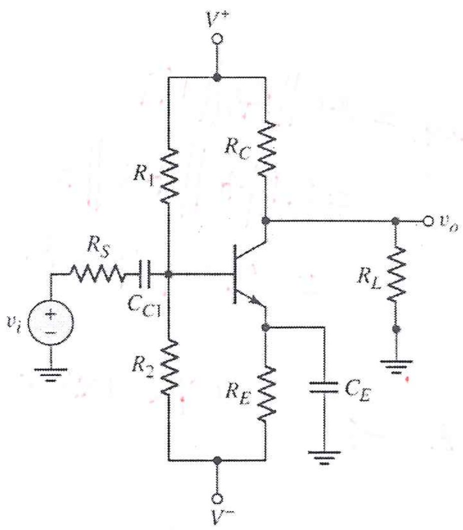
$$\tau = r_\pi(C_\mu + C_\pi) \qquad \therefore f_\beta = \frac{1}{2\pi\tau} = \frac{1}{\pi(C_\mu + C_\pi)}$$

$$1 = \frac{\beta}{\sqrt{1 + \left(r_\pi \omega_T (C_\mu + C_\pi)\right)^2}} \Rightarrow \omega_T = \frac{\beta}{r_\pi(C_\pi + C_\mu)} = \beta\omega_\beta$$

(b) The common emitter amplifier is shown in **Fig. 3(b)** and operated at high frequencies. Draw the simplified high-frequency small signal equivalent circuit diagram and

(i) find the Miller capacitance, and

(ii) determine the upper 3dB frequency (f_H) considering Miller capacitance and without considering Miller capacitance. **(10 marks)**

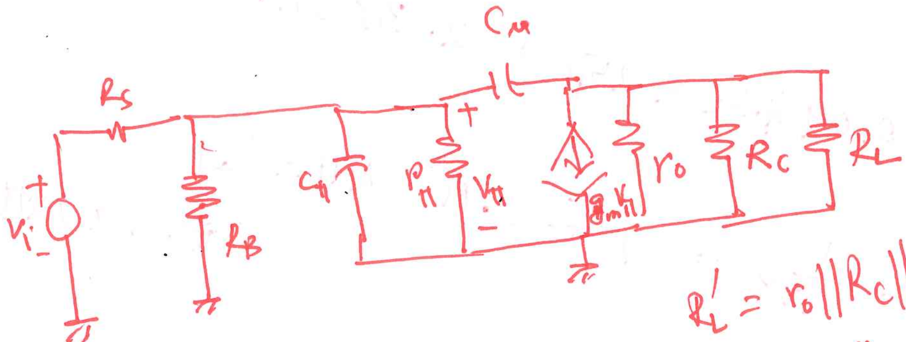


The circuit parameters are:

R_s=0.1kΩ, R_1= 40kΩ, R_2= 6.8 kΩ, R_E = 1.2 kΩ, R_C = 5 kΩ, R_L = 10 kΩ, C_C=∞μF and C_E= ∞ μF V^+= 5V, V^- = 5V.

The transistor parameters are :

r_π = 3 kΩ, g_m= 40 mA/V and r_o = 100 kΩ, C_π = 25 pF, and C_μ= 2 pF



$R_L' = r_o || R_C || R_L$

$= 100 || 5 || 10 = 3.226 k\Omega$

$A_{VA} = -g_m R_L'$

$= -40 \times 3.226 = -129.03$ V/A

(i) $C_M = (1 + A_{VA}) C_\mu$

$= (1 + 129.03) \times 2p =$

$= 260$ pF

i) $C_T = C_\pi + C_M$

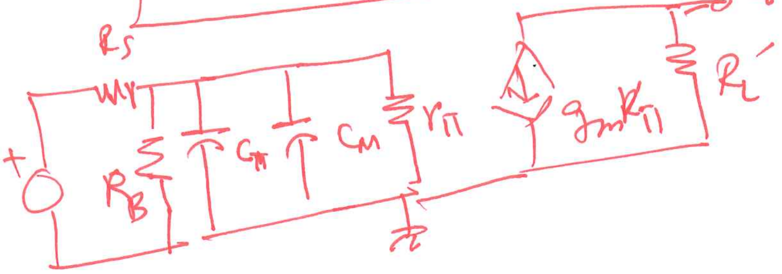
$= 25 + 260$

$= 285$ pF

$$\boxed{\begin{aligned} C_T &= C_\pi + C_\mu \\ &= 285pF \end{aligned}}$$

ii) $\tau_M = R_{eq} C_{eq}$

$= R_{eq} \cdot C_T$



ii)

$\tau_M = 0.0946k \times 285p$

$= 26.97nS.$

$R_{eq} = R_S || R_B || r_\pi$

$= 0.1 || 40 || 4.8 || 3$

$= 0.0946K.$

$f_{A_M} = \frac{1}{2\pi \tau_M} = 5.9 \text{ MHZ}$ ← with miller effect

$\tau = 0.0946k \times 25p = 2.365nS$

$f_H = \frac{1}{2\pi \tau} = 67.296 \text{ MHZ}$ ← with out miller effect.