Electronics2 1st Spring16 Dr.Hani Jamleh

University of Jordan
Electrical Engineering Department
Engineering School

[redacted]

Monday, March 14, 2016 Time: 3:00 to 4:00 (60 min)

Question	Q1	Q2	Q3	Q4	Total
Total Points	3	4	5	8	20
Student's Score	3	~~1.5~~ 2	4	6.5	15.5

Answer all the following 4 Questions clearly, fill in the blank your final answer, show details on the same sheet. Don't forget to label all plots and use the correct units per answer.

Question 1: [3-points]

The parameters of the transistor in the circuit in Figure Q.1 are $\beta = 100$, $V_A = 100\ V$, and $V_T = 0.026V$.

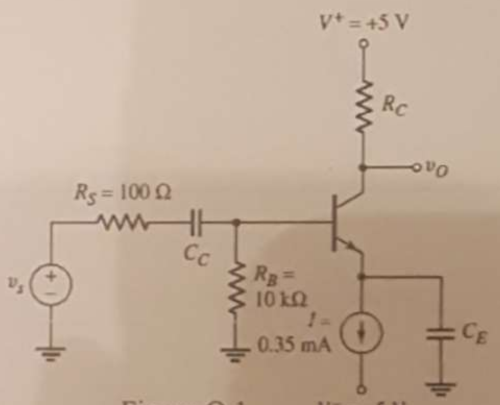


Figure Q.1

(a) Find the DC voltage at V_B

$V_B =$	$-0.0346\ v$

$I_{EQ} = 0.35 mA$

$I_{\beta Q} = 3.4\cancel{7}\cancel{10}\ \mu A$

$I_{CQ} = 0.34 mA$

$v_B = -I_{BQ} R_B$

$= -0.346$

$I_E = (1+\beta) I_{BQ}$

(b) Find the DC voltage at V_E

$V_E =$	$-0.7346\ v$

$v_{BE} = 0.7 = v_B - v_E$

$v_E = v_B - 0.7 = -0.7346$

(c) Find R_C such that $V_{CEQ} = 3.5V$.

$R_C =$	$6.44\ k\Omega$

$V_{CE} = V_C - V_E = 3.5$

$V_C = 3.5 + V_E = 2.765 v$

$$R_C = \frac{5 - 2.765}{0.347 \times 10^{-3}}$$

$= 6.44\ k\Omega$

Question 2: [4-points]

For the network of Figure Q.2 , determine:

$r_\pi =$ 910 Ω

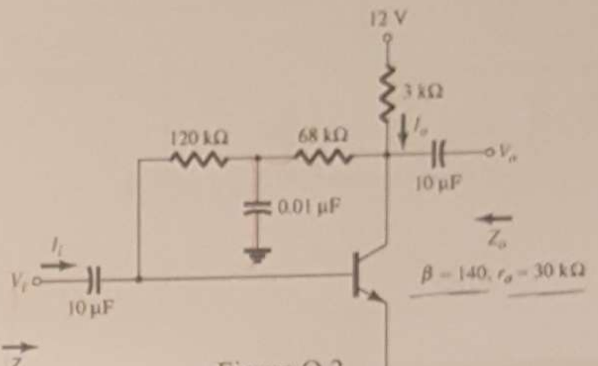


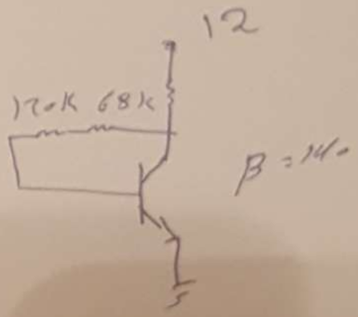
Figure Q.2

DC

$$r_\pi \equiv \frac{\beta V_T}{I_{Ca}} \ 0.5 \ (= 910$$

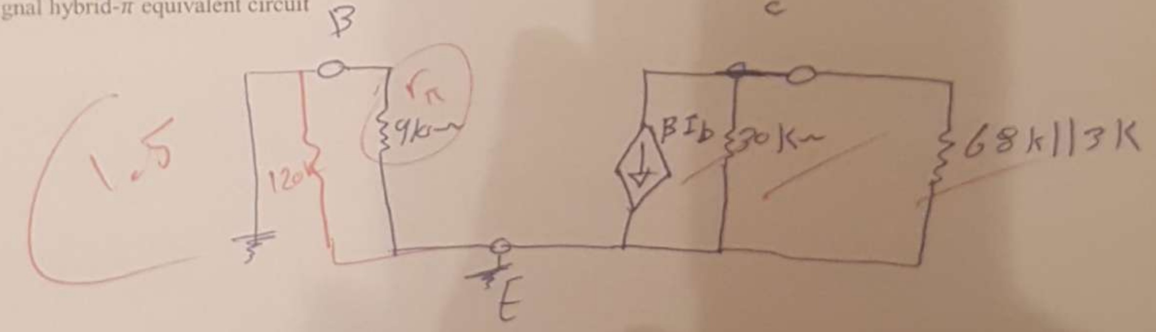
$$12 = I_c R_c$$

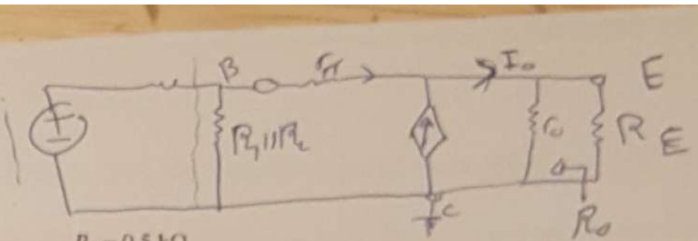
$$I_{ca} = \frac{12}{3K} = \cancel{4} \ 4mA$$



Draw the small signal hybrid-π equivalent circuit in the box below.

Small signal hybrid-π equivalent circuit





Question 3: [5-points]

Consider the small signal model of amplifier circuit in Figure Q.3.
It has $I_{CQ} = 0.5mA$.
The transistor parameters are $\beta = 80$ and $V_A = 80V$.
Let $V_{BE(on)} = 0.7V$

- **To get full credit, you need to show all your work!**

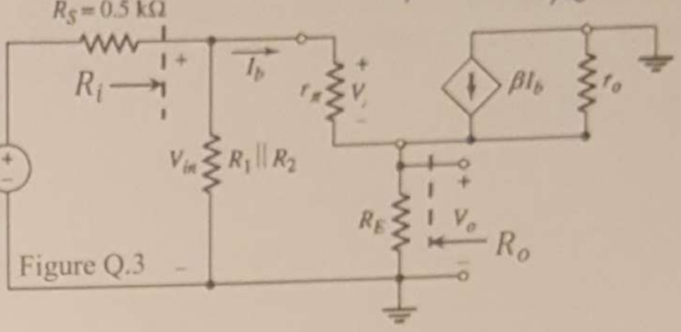


Figure Q.3

In steps, show how you derive the formula for the following:

1 a)

$$\boxed{R_i = R_1 \| R_2 \| \left[r_\pi + (1+\beta)(r_o \| R_E) \right]}$$

$$R_i \equiv R_1 \| R_2 \| R_{ib}$$

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

$$I_o = I_b(1+\beta)$$

1 b)

$$\boxed{R_o = (R_E \| r_o) \| \frac{R_{ib}}{(1+\beta)}}$$

~~For~~ source => S/C

$$(R_E \| r_o) \cancel{(1+\beta)} \| \frac{r_\pi \| R_1 \| R_2}{(1+\beta)}$$

1 c)

$$\boxed{A_{v_s} = \frac{V_o}{V_s} = \quad =}$$

$$\frac{R_1 \| R_2 \| R_{ib}}{\cancel{R_s + R_1 \| R_2 \| R_{ib}} \; r_\pi + R_1 \| R_2 \| R_{ib}} \cdot \frac{R_1 \| R_2 \| R_{ib}}{R_s + R_1 \| R_2 \| R_i}$$

$$V_o \equiv (r_o \| R_E)(1+\beta)$$

$$V_s \equiv \frac{R_1 \| R_2 \| R_i}{R_s + R_1 \| R_2 \| R_i}$$

1 d) Briefly describe the meaning of "inverse resistance reflection rule"?

when look back into the ckt there is a factor $(1+\beta)$ we ~~should~~ should put in our calculation due to 3the dependant source

Question 4: [8-points] For the circuit in Figure Q.4, the transistor parameters are $\boxed{\beta = 100}$ and $\boxed{V_A = \infty V}$

To achieve the maximum undistorted swing in the output voltage, we need the total instantaneous C–E voltage to remain in the range $\boxed{1 \le V_{CE} \le 8V}$ and the minimum collector current is to be $\boxed{i_C(min) = 0.1mA.}$

$9 = I_c R_c + V_{CE} + I_E R$

a) Write down the **DC Load Line** Equation:

1

$$I_{CQ} = \frac{9}{R_c + R_E} - \frac{V_{CEQ}}{R_c + R_E}$$

b) Write down the **ac Load Line** Equation:

1

$$i_c = \frac{-V_{ce}}{R_L \| R_c}$$

c) To achieve the maximum undistorted swing in the output, find the following:

$\Delta I_C =$ 1.2 mA

1

$\Delta V_{CE} =$ 1.257 V

$I_{CQ} =$ 1.3 mA

$V_{CEQ} =$ 4.5

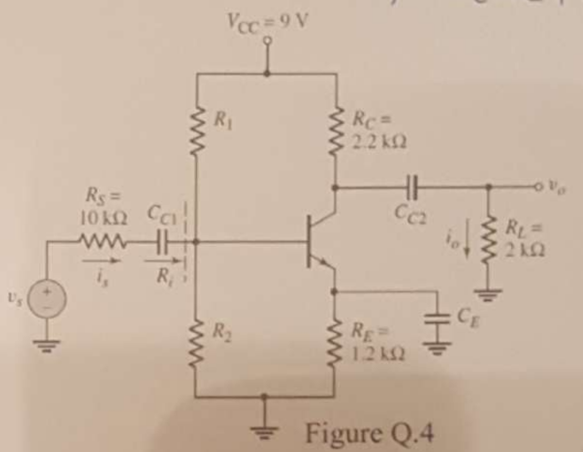
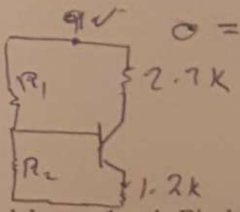


Figure Q.4



$0 = i_c (R_c \| R_L) + V_{ce}$

d) If the required $R_{TH} = 0.1(100+1)R_E$, suppose you found $I_{CQ} = 1mA$. Find R_1 and R_2

2

$R_{TH} =$ 12.12 KΩ $= \frac{R_1 R_2}{R_1 + R_2}$, $\frac{50.9 R_2}{50.9 + R_2} = \frac{12.12K}{1}$

$R_1 =$ 50.9 KΩ

$R_2 =$ 15.9 KΩ

$50.9 R_2 = 617.9m +$

$38.78 R_2 = 617.9m$ $12.12k R_2$

$$V_{th} = 2.14V \equiv \underbrace{\frac{R_1 R_2}{R_1 + R_2}}_{12.12K} \cdot 9 \frac{1}{R_1} \Rightarrow R_1 = 50.9 K\Omega$$

0.5

e) Give two reasons, why we need to use the ac load line to design a BJT amplifier?

① it controls the gain & ~~to~~ ② to make sure ~~to~~ that the signal not distorted

1

f) How the DC load line is affected by increasing the resistor value R_1?

no affect

Power Unit

$9 = I_c R_c + V_{CE} + I_E R_E$ Extra Page

$I_c \approx I_E$

$9 - V_{CE} = I_c (R_c + R_E)$

$$I_{CQ} = \frac{9}{R_c + R_E} - \frac{V_{CE}}{R_c + R_E}$$

$0 = i_c (R_L || R_c) + V_{ce}$

$$i_c = \frac{-V_{ce}}{R_L || R_c}$$

$\Delta I_c = I_{CQ} - I_c(min)$

$\Delta i_c = $ slope ΔV_{ce}

$\Delta V_{CE} = V_{CEQ} - V_{CE}(min)$

$V_{th} = I_B R_{th} + 0.7 + I_E R_E$

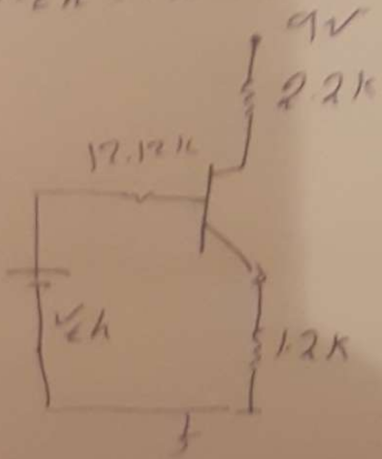
$I_{CQ} = 1mA$

$I_{BQ} = 10 \mu A$

$V_{th} = 2.1412$

DC

$R_{th} = 12.12\ k\Omega$



$\boxed{V_{CEQ} = 4.5\ V}$

$\boxed{I_{CQ} = 1.3\ mA}$