Benha University
Faculty of Engineering- Shoubra
Electrical Engineering Department
Third Year Computers

Final Exam-2 nd Semester
Date: 19-5-2014
Electronic Circuits(1) ECE 321c
Duration : 3 hours

- Answer all the following questions
- Illustrate your answers with sketches when necessary.
- The exam consists of two pages

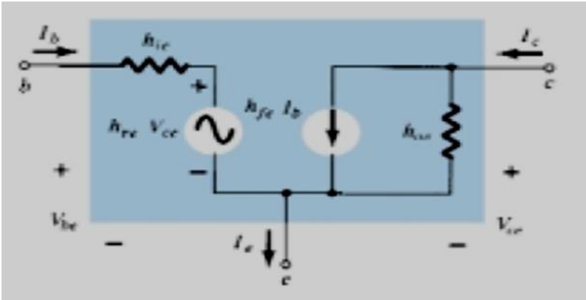
- No. of questions: 5
- Total marks: 80
- Examiner: Dr. Ibtesam Omer

Question 1 [20 Marks]

(a)Given h_{ie} = 2.4 kΩ, h_{fe} = 100, h_{re} = 4×10^{-4} and h_{oe} = 25 µS, sketch the:

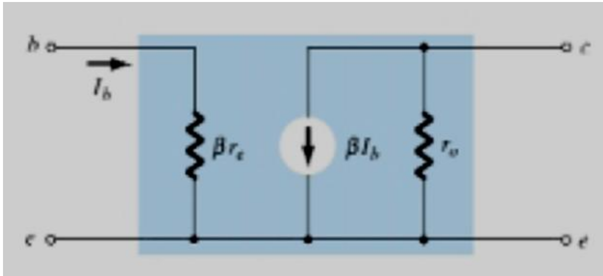
Ans:

(i) Common-emitter hybrid equivalent model.



h_{ie} = βr_e = 2.4 kΩ
h_{fe} = β = 100
h_{re} = 4×10^{-4}
h_{oe} = 25 µS

(ii) Common-emitter r_e equivalent model.



r_e = 2.4 kΩ /100 = 24 Ω
r_o = 1/ h_{oe} =1/ 25 µS = 40 kΩ

(b)For the common-base configuration of Figure 1, the emitter current is 3.2 mA and α is 0.99.
If the applied voltage is 48 mV and the load is 2.2 kΩ
Determine the following:

(a) r_e
(b) Z_i
(c) I_c
(d) V_o
(e) A_v
(f) I_b

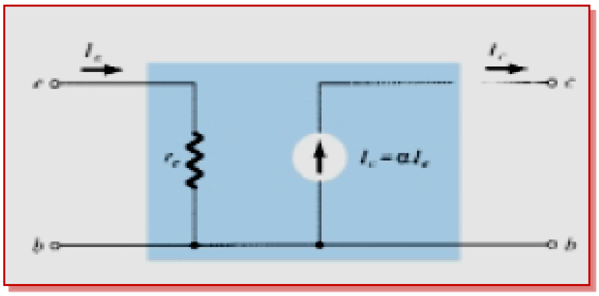


Figure (1) Common-base r_e equivalent circuit

Ans:

(a) $r_e = \frac{V_i}{I_i} = \frac{48mV}{3.2mA} = 15\Omega$

(b) $Z_i = r_e = 15\Omega$

(c) $I_c = \alpha I_e = (0.99)(3.2mA) = 3.168mA$

(d) $V_o = I_c R_L = (3.168mA)(2.2k\Omega)$
$= 6.97V$

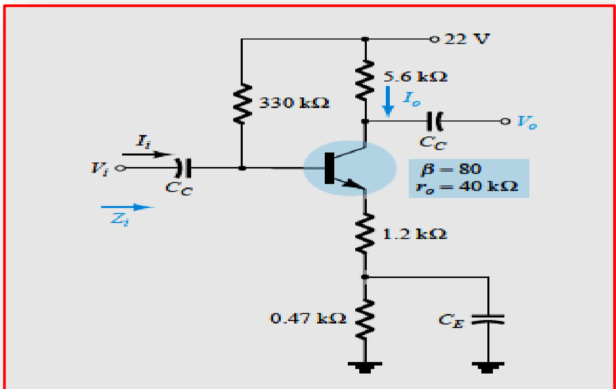
(e) $A_v = \frac{V_o}{V_i} = \frac{6.97V}{48mV} = 145.21$

(f) $I_b = (1-\alpha)I_e = (1-0.99)I_e = (0.01)(3.2mA)$
$= 32\mu A$

Question 2 [14 Marks]

(a)For the network of Figure2 at r_o = ∞ KΩ:

(a) Determine r_e.
(b) Find Z_i and Z_o.
(c) Calculate A_i and A_v.



Ans:

(a) $I_B = \dfrac{V_{CC} - V_{BE}}{R_B + (\beta+1)R_E}$

$= \dfrac{22V - 0.7V}{330k\Omega + (81)(1.2k\Omega + 0.47k\Omega)} = \dfrac{21.3V}{465.27k\Omega}$

$= 45.78\mu A$

$I_E = (\beta+1)I_B = (81)(45.78\mu A) = 3.71mA$

$r_e = \dfrac{26mV}{I_E} = \dfrac{26mV}{3.71mA} = \underline{7\Omega}$

(b) $r_o < 10(R_C + R_E)$

$\therefore Z_b = \beta r_e + \left[\dfrac{(\beta+1) + R_C/r_o}{1 + (R_C+R_E)/r_o}\right]R_E$

$= (80)(7\Omega) + \left[\dfrac{(81) + 5.6k\Omega/40k\Omega}{1 + 6.8k\Omega/40k\Omega}\right]1.2k\Omega$

$= 560\Omega + \left[\dfrac{81 + 0.14}{1 + 0.17}\right]1.2k\Omega$

(note that $(\beta+1) = 81 >> R_C/r_o = 0.14$)

$= 560\Omega + [81.14/1.17]\,1.2k\Omega = 560\Omega + 83.22$

$= \underline{83.78k\Omega}$

$Z_i = R_B \| Z_b = 330k\Omega \| 83.78k\Omega = \underline{66.82k\Omega}$

$A_v = \dfrac{-\dfrac{\beta R_C}{Z_b}\left(1 + \dfrac{r_e}{r_o}\right) + \dfrac{R_C}{r_o}}{1 + \dfrac{R_C}{r_o}}$

$= \dfrac{-\dfrac{(80)(5.6k\Omega)}{83.78k\Omega}\left(1 + \dfrac{7\Omega}{40k\Omega}\right) + \dfrac{5.6k\Omega}{40k\Omega}}{1 + 5.6k\Omega/40k\Omega}$

$= \dfrac{-(5.35) + 0.14}{1 + 0.14}$

$= \underline{-4.57}$

(c) $A_i = -A_v \dfrac{Z_i}{R_C} = -(-4.57)(66.82k\Omega)/5.6k\Omega$

$= \underline{54.53}$

(b)What is the expected amplification of a BJT transistor amplifier if the dc supply is set to zero volts?

Ans:

If the dc supply is set to zero volts the amplification will be zero.

Question 3 [18 Marks]

(a)Determine the voltage gain the power gain, and the efficiency of the class A power amplifier in figure 3. Assume $\beta_{ac(Q1)} = \beta_{ac(Q2)} = 200$ and $\beta_{ac(Q3)} = 50$. Express the power gain as a decibel power gain.

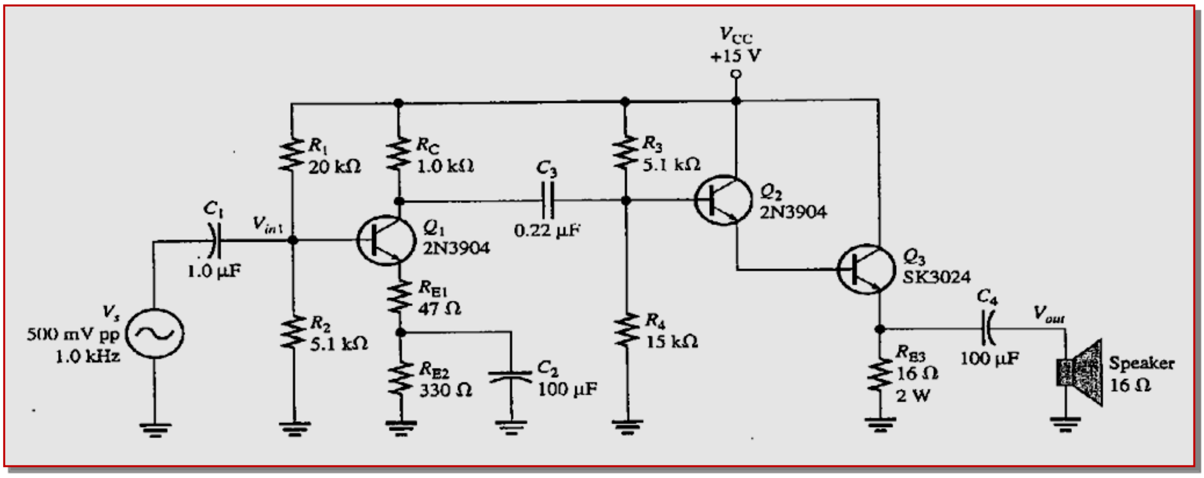


Figure (3) Class A Power Amplifier.

Ans:

$A_{v(tot)} = A_{v1} * A_{v2} * A_{v3}$

A_{v2}, A_{v3} is emitter follower so $A_{v2} = A_{v3} = 1$

After Ac Analysis

From common emitter configuration $A_{v1} = (-R_{c1})/(R_{E1}+r_{e(Q1)})$

First stage:

The ac collector resistance of the first stage is R_C in parallel with the input resistance to the second stage.

$$R_{c1} = R_C \| [R_3 \| R_4 \| \beta_{ac(Q2)}\beta_{ac(Q3)}(R_{E3} \| R_L)]$$
$$= 1.0\text{ k}\Omega \| [5.1\text{ k}\Omega \| 15\text{ k}\Omega \| (200)(50)(16\ \Omega \| 16\ \Omega)]$$
$$= 1.0\text{ k}\Omega \| (5.1\text{ k}\Omega \| 15\text{ k}\Omega \| 80\text{ k}\Omega) = 1.0\text{ k}\Omega \| 3.63\text{ k}\Omega = 784\ \Omega$$

The voltage gain of the first stage is the ac collector resistance, R_{c1}, divided by the ac emitter resistance, which is the sum of $R_{E1} + r'_{e(Q1)}$. The approximate value of $r'_{e(Q1)}$ is determined by first finding I_E.

$$V_B = \left(\frac{R_2 \| (\beta_{ac(Q1)}(R_{E1} + R_{E2})}{R_1 + R_2 \| (\beta_{ac(Q1)}(R_{E1} + R_{E2}))}\right)V_{CC}$$
$$= \left(\frac{5.1\text{ k}\Omega \| 200(377\ \Omega)}{20\text{ k}\Omega + 5.1\text{ k}\Omega \| 200(377\ \Omega)}\right)15\text{ V}$$
$$= \left(\frac{4.78\text{ k}\Omega}{20\text{ k}\Omega + 4.78\text{ k}\Omega}\right)15\text{ V} = 2.89\text{ V}$$
$$I_E = \frac{V_B - 0.7\text{ V}}{R_{E1} + R_{E2}} = \frac{2.89\text{ V} - 0.7\text{ V}}{377\ \Omega} = 5.81\text{ mA}$$
$$r'_{e(Q1)} = \frac{25\text{ mV}}{I_E} = \frac{25\text{ mV}}{5.81\text{ mA}} = 4.3\ \Omega$$

The voltage gain of the first stage with the loading of the second stage taken into account

$$A_{v1} = -\frac{R_{c1}}{R_{E1} + r'_{e(Q1)}} = -\frac{784\ \Omega}{47\ \Omega + 4.3\ \Omega} = -15.3$$

The negative sign is for inversion.

$R_{in\,(tot)} = R1 // R2 // \beta_{ac\,(Q1)} (r'_{e(Q1)} + R_{E1})$

$= 20\text{ k}\Omega // 5.1\text{ k}\Omega // 200(47\Omega + 4.3\Omega) = 2.9\text{k}\ \Omega$

$A_{v(tot)} = A_{v1} * A_{v2} * A_{v3} = -15.3$

$A_p = (A_{v\,(tot)})^2 (R_{in\,(tot)} / R_L) = 42{,}429$

dB= 10 Log A_p = 10 Log 42,429 = 46.23 dB

(b)List the capacitances that affect high frequency gain in BJT amplifier. Explain why the coupling capacitors do not have a significant effect on gain at sufficiently high signal frequencies.

BJT: C_{be}, C_{bc}, and C_{ce}

Question 4 [12 Marks]

For the network shown in figure 4:

(a) **Determine the corner frequency.**
(b) **Determine the mathematical expression for the magnitude of the voltage gain.**
(c) **Determine the mathematical expression for the angle by which V_o leads V_i.**
(d) **Sketch the frequency response of Θ.**

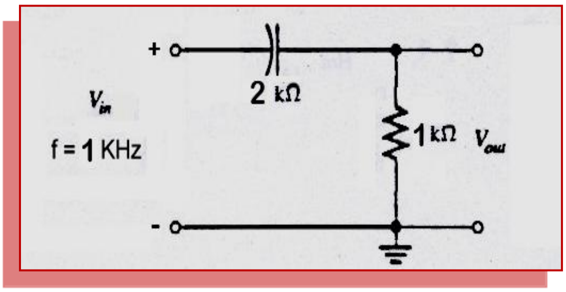


Figure (4) R-C combination that will define cut off frequency

Ans:

$$f_1 = \frac{1}{2\pi RC}$$

a)

$X_c = 1/2\pi fC = 2k\Omega$

C= 7.96 x10^{-8} farad

f_1=1/2 πRC =2 kHz

b)

If the gain equation is written as

$$A_v = \frac{V_o}{V_i} = \frac{R}{R - jX_C} = \frac{1}{1 - j(X_C/R)} = \frac{1}{1 - j(1/\omega CR)} = \frac{1}{1 - j(1/2\pi fCR)}$$

and using the frequency defined above,

$$A_v = \frac{1}{1 - j(f_1/f)}$$

In the magnitude and phase form,

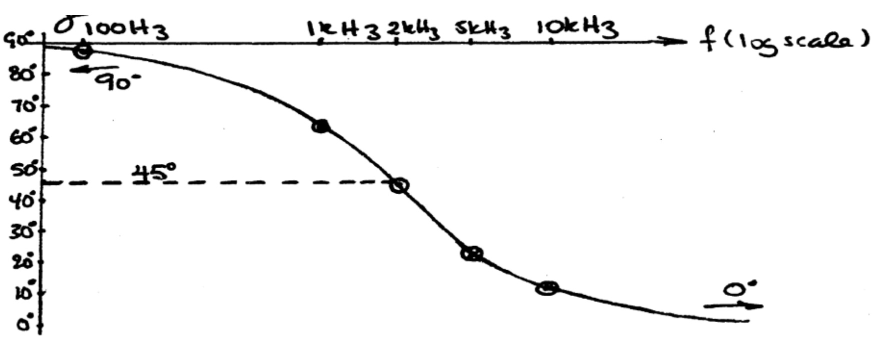
$$A_v = \frac{V_o}{V_i} = \underbrace{\frac{1}{\sqrt{1 + (f_1/f)^2}}}_{\text{magnitude of } A_v} \underbrace{\angle \tan^{-1}(f_1/f)}_{\text{phase} \angle \text{ by which } V_o \text{ leads } V_i}$$

c)

$$\theta = \tan^{-1}\frac{f_1}{f}$$

d)

f=100 Hz Θ=87.13°
f=1 kHz Θ=63.43°
f=2 kHz Θ=45°
f=5 kHz Θ=21.8°
f=10 kHz Θ=11.3°

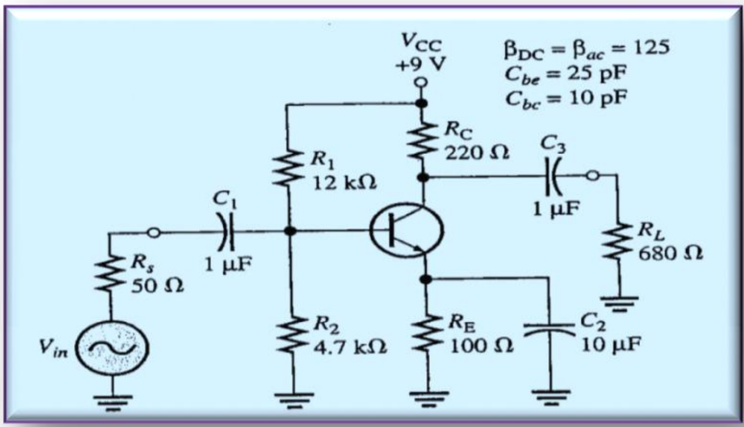


Question 5 [16 Marks]

For the BJT amplifier in figure 5:

(a)Determine the critical frequencies associated with the low frequency response.

(b)Which is the dominant critical frequency? Sketch the Bode Plot.



Ans:

(a)

Figure (5) Loaded BJT amplifier with capacitors that affect the low-frequency response

$$R_{IN(base)} = \beta_{DC} R_E = 12.5\ k\Omega$$

$$V_E = \left(\frac{R_2 \parallel R_{IN(base)}}{R_1 + R_2 \parallel R_{IN(base)}}\right) 9\ V - 0.7\ V = \left(\frac{4.7\ k\Omega \parallel 12.5\ k\Omega}{12\ k\Omega + 4.7\ k\Omega \parallel 12.5\ k\Omega}\right) 9\ V - 0.7\ V = 1.3\ V$$

$$I_E = \frac{V_E}{R_E} = \frac{1.3\ V}{100\ \Omega} = 13\ mA$$

$$r_e' = \frac{25\ mV}{13\ mA} = 1.92\ \Omega$$

$$R_{in(base)} = \beta_{ac} r_e' = (125)(1.92\ \Omega) = 240\ \Omega$$

$$R_{in} = 50\ \Omega + R_{in(base)} \parallel R_1 \parallel R_2 = 50\ \Omega + 240\ \Omega \parallel 12\ k\Omega \parallel 4.7\ k\Omega = 274\ \Omega$$

For the input network:

$$f_c = \frac{1}{2\pi R_{in} C_1} = \frac{1}{2\pi (274\ \Omega)(1\ \mu F)} = \mathbf{578\ Hz}$$

For the output network:

$$f_c = \frac{1}{2\pi (R_C + R_L) C_3} = \frac{1}{2\pi (900\ \Omega)(1\ \mu F)} = \mathbf{177\ Hz}$$

For the bypass network:

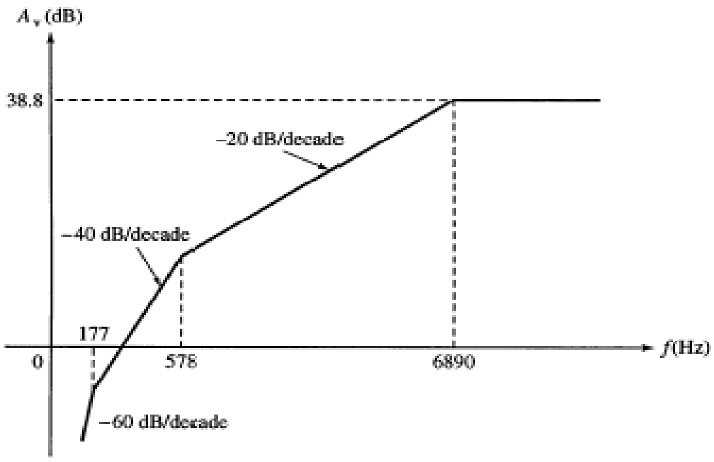
$$R_{TH} = R_1 \parallel R_2 \parallel R_s = 12\ k\Omega \parallel 4.7\ k\Omega \parallel 50\ \Omega \cong 49.3\ \Omega$$

$$f_c = \frac{1}{2\pi \left(r_e' + R_{TH}/\beta_{DC} \parallel R_E\right) C_2} = \frac{1}{2\pi (2.31\ \Omega)(10\ \mu F)} = \mathbf{6.89\ kHz}$$

$$A_v = \frac{R_C \parallel R_L}{r_e'} = \frac{220\ \Omega \parallel 680\ \Omega}{1.92\ \Omega} = 86.6$$

$$A_v(dB) = 20 \log(86.6) = 38.8\ dB$$

(b)The bypass network produces the dominant critical frequency. See the following figure



Good luck
Dr. Ibtesam Omer