Benha University
Faculty of Engineering at Shoubra
Electrical Engineering Department
Third Year (Communications)

Final Term Exam (Fall 2015)
Date: Monday (4/1/2016)
Subject: Electronic Circuits (A)
Duration: 4 hours

- **Significant equations sheet is attached.**
- **Answer all the following questions**
- **No. of questions : 5**
- **Total Mark: 90 Marks**

Model Answer

Questions:

Question (1) (12 Marks)

Choose the correct answer:

1- Which of the h-parameters corresponds to βr_e in a common-emitter configuration?
   a. h_{re} b. h_{fb} c. h_{fe} d. h_{ie}

2- The loaded voltage gain of an amplifier is always less than the no-load level.
   a. True b. False

3- A change in frequency by a factor of ________ is equivalent to 1 decade.
   a. 2 b. 10 c. 5 d. 20

4- By how much does the output signal vary for a class B power amplifier?
   a. 360° b. 180° c. between 180° and 360° d. Less than 180°

5- An oscillator differs from an amplifier because the oscillator
   a. has more gain b. requires no input signal c. requires no dc supply

6- A phase-shift oscillator has
   a. three RC circuits b. three LC circuits c. lead-lag circuit

Question (2) (20 Marks)

1- Differentiate between the audio, tuned and power amplifiers.

2- Sketch the approximate hybrid, hybrid π and r_e models for a common-emitter ***pnp*** transistor. Given r_b= 3Ω, r_π= 1.6kΩ, r_u= 20MΩ, C_u= 1pF, C_π= 5pF, β= 100, h_{oe}= 18 µS.

3- The feedback capacitance of an inverting amplifier is 10 pF. What is the Miller capacitance at the input and the output if the gain of the amplifier is 40dB?

4- Draw two different circuits for phase splitting to be used in class B power amplifier.

Question (3) (25 Marks)

1- For the small-signal amplifier circuit of Fig. 1,
   a. Determine r_e , Z_i.
   b. Derive an equation for A_v and calculate its value.
   c. Determine the lower and higher cut-off frequencies.
   d. Sketch the low-frequency and the high-frequency responses.
   e. Sketch the phase response.

2- For the power amplifier circuit of Fig. 2 and for an input of 10 V rms, calculate
   a. The input power
   b. The output power
   c. The power handled by each output transistor
   d. The circuit efficiency

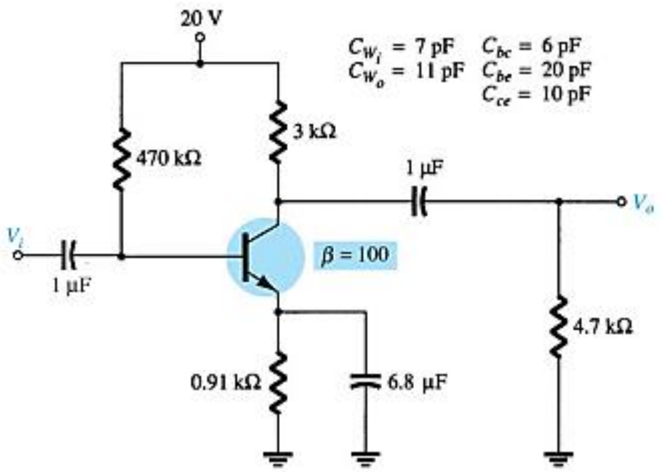


Fig. 1

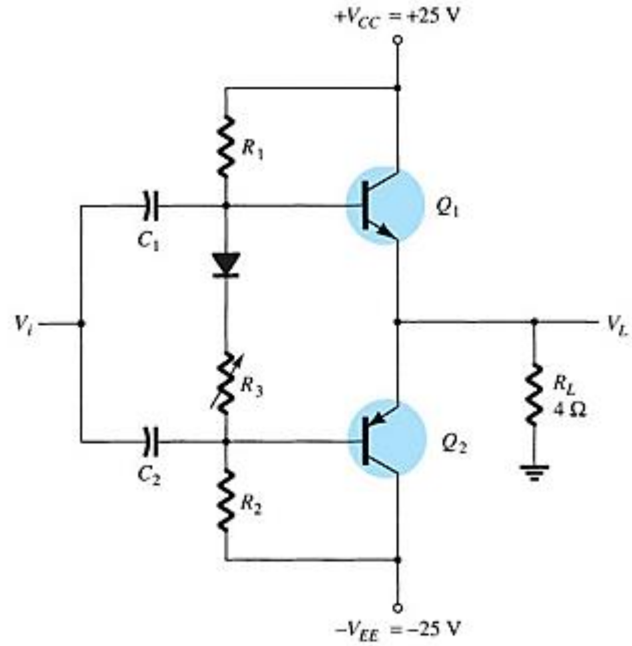


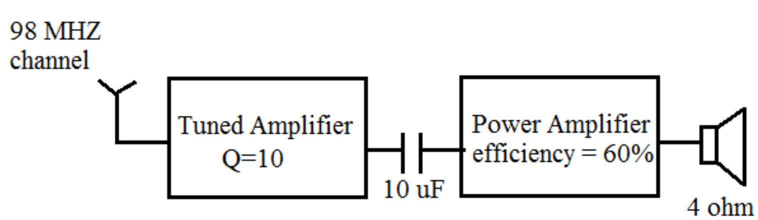
Fig. 2

<u>Question (4)   (13 Marks)</u>

1- For the voltage-divider biasing circuit, discuss the condition required to perform the approximate analysis.
2- Derive an equation for the Wien-bridge oscillation frequency and show how you can control its gain automatically.
3- Calculate the resonance frequency of a Hartley oscillator with the elements of the tank circuit as L_1= 1.5 mH, L_2=10 mH and C=470pF.
4- Draw the clamper bias circuit used in tuned amplifier and mention the purpose of its usage.

<u>Question (5)   (20 Marks)</u>

1- Design a BJT Audio Amplifier with following specifications:
   - The amplifier consists of two direct coupled stages with total gain of 57 dB.
   - It uses a capacitor to couple a microphone signal with internal resistance of 1kΩ and frequency band between 400 Hz and 3.4 KHz.
   - It drives an 8 Ω speaker through a coupling transformer of 1:3 turns ratio.
   - The speaker signal should be in-phase with the microphone one.
2- Design the following system:



Good Luck,
Dr. Ahmad El-Banna

Model Answer

Answers:

Q1:

Choices:

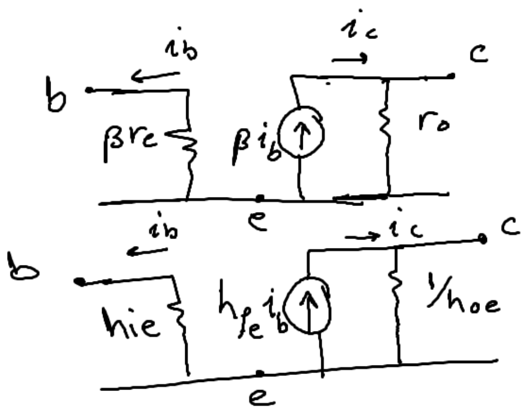
1	d
2	a
3	b
4	b
5	b
6	a

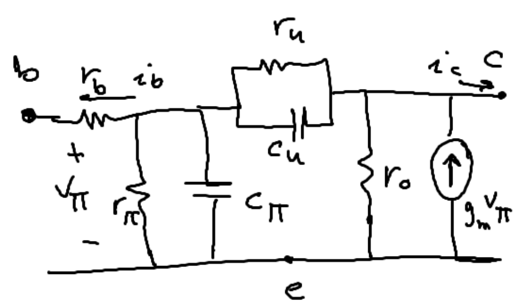
Q2:

1- Differentiate between the audio, tuned and power amplifiers.

Audio Amplifier	Tuned Amplifier	Power Amplifier
It's a small signal amplifier	Select and amplify certain frequencies	Provide suitable current to small loads such as speakers
Most feature is its linearity	Most feature is its quality factor	Most feature is its efficiency
Work with many biasing circuits	Work with negative bias or clamper bias circuit	Has 4 classes with different biasing includes zero level, slightly bias and half the supply bias.

2- Sketch the approximate hybrid, hybrid π and r_e models for a common-emitter ***pnp*** transistor. Given $r_b = 3\Omega$, $r_\pi = 1.6k\Omega$, $r_u = 20M\Omega$, $C_u = 1pF$, $C_\pi = 5pF$, $\beta = 100$, $h_{oe} = 18\ \mu S$.





find unknown values using conversion formulas such as:

$g_m = 1/r_e$

$r_o = 1/h_{oe}$

$r_\pi = \beta r_e = h_{ie}$

$\beta i_b = g_m V_\pi$

3- The feedback capacitance of an inverting amplifier is 10 pF. What is the Miller capacitance at the input and the output if the gain of the amplifier is 40dB?

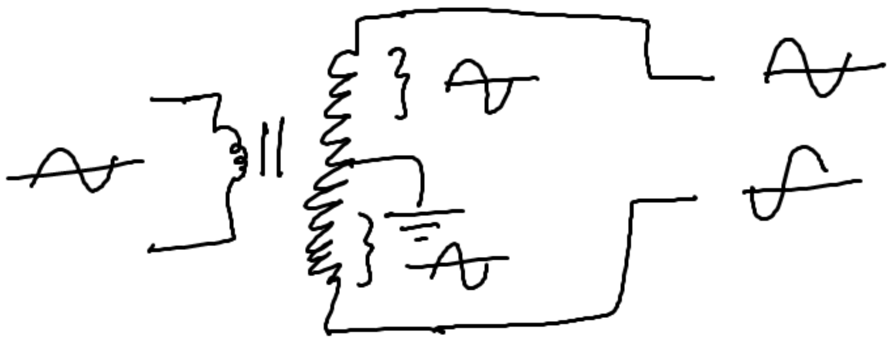
Use the miller formulas :

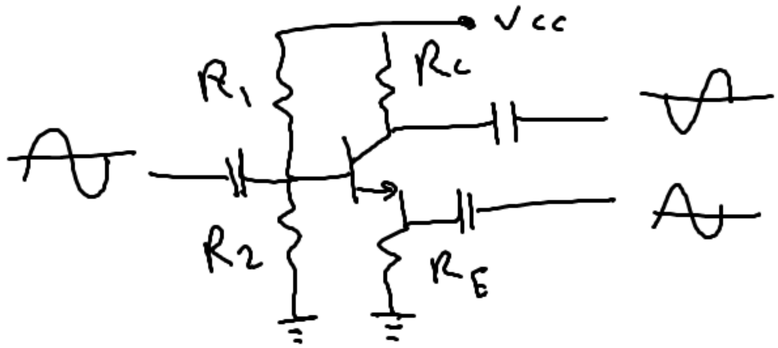
Av= -10^(AdB/-20) = -10^(40/-20)

$C_{MI} = (1-A_v)\ C_f = (1-A_v) * 10*10\text{^}-12$ F

$C_{Mo} = (1-1/A_v)\ C_{f\ \sim} = 10*10\text{^}-12 \sim = 10$ pF

4- Draw two different circuits for phase splitting to be used in class B power amplifier.





Q3:

1- For the small-signal amplifier circuit of Fig. 1,

$$r_e = \frac{26mV}{I_E}$$

$$I_E = \beta\left(\frac{20-0.7}{470k + 0.91\beta K}\right) = 3.4mA$$

$$\therefore r_e = 7.5\Omega$$

$$Z_i = R_B \parallel \beta r_e = 755.6\Omega$$

$$A_v = \frac{-R_C \parallel R_L}{r_e} = \frac{v_o}{v_i}$$

$$= -242.5$$

$$f_{LS} = \frac{1}{2\pi R_i C_s} = 210\,Hz$$

$\hookrightarrow R_B \parallel \beta r_e$

$$f_{LC} = \frac{1}{2\pi (R_o + R_L) C_c} = 20.6\,Hz$$

$\hookrightarrow R_C \parallel r_o$

$$f_{LE} = \frac{1}{2\pi R_e C_E} = 30.69\,Hz$$

$\hookrightarrow R_E \parallel \left(\frac{R_B}{\beta} + r_e\right)$

$$f_{Hi} = \frac{1}{2\pi R_{Thi} C_i} = 141.6\,KHz$$

$C_i \hookrightarrow C_{wi} + C_{be} + (1 - A_v) C_{bc}$

$R_{Thi} \hookrightarrow R_S \parallel R_B \parallel \beta r_e$

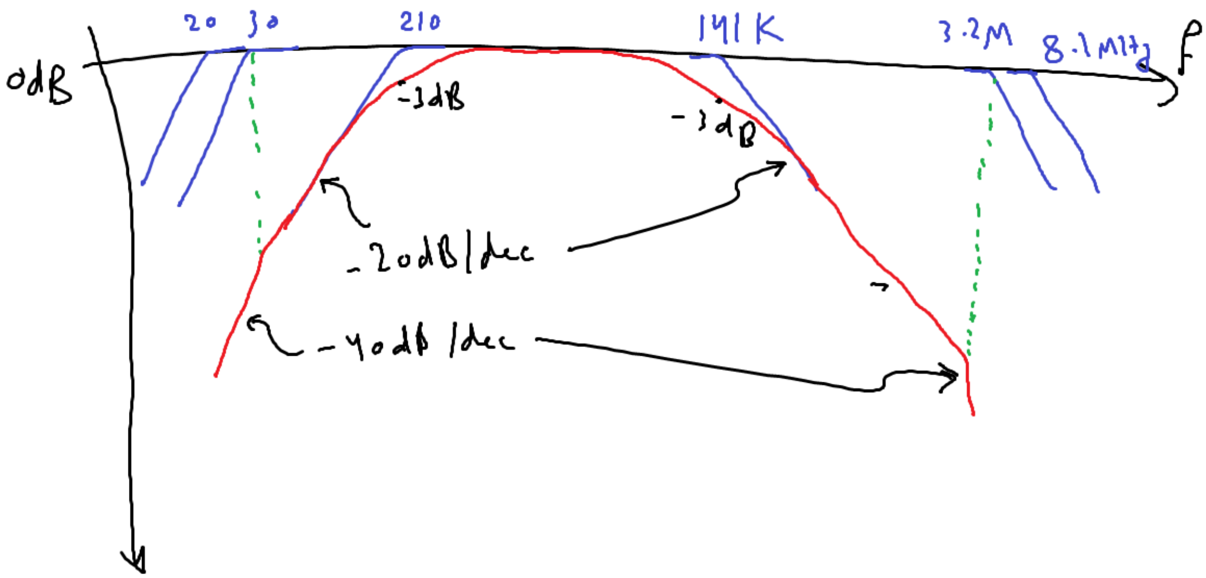
$$f_{Ho} = \frac{1}{2\pi R_{Tho} C_o} = 3.2\,MHz$$

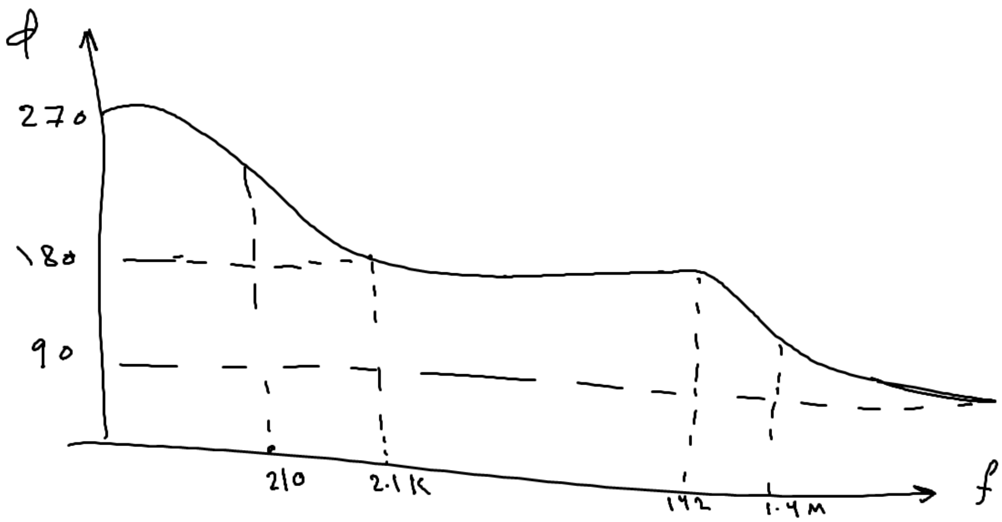
$C_o \hookrightarrow C_{wo} + C_{ce} + C_{bc}$

$R_{Tho} \hookrightarrow R_C \parallel R_L$

$$f_\beta = \frac{1}{2\pi h_{femid} r_e (C_{be} + C_{bc})} = 81\,MHz$$

$$f_T = h_{femid} f_\beta = 808.7\,MHz$$





2- For the power amplifier circuit of Fig. 2 and for an input of 10 V rms, calculate

$V_{ip} = \sqrt{2}\, V_{irms} = 10\sqrt{2} = 14.14\ V_p$

$V_{L(p)} = V_{ip} = 14.14$

$P_{oac} = \frac{V_L^2}{2R_L} = 25\ W \longrightarrow (b)$

$I_{Lp} = \frac{V_{L(p)}}{R_L} = 3.535\ A$

$I_{dc} = \frac{2}{\pi} I_{L(p)} = 2.25\ A$

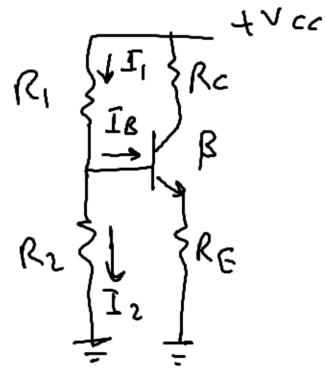
$\therefore P_i = V_{cc} I_{dc} = 56.28\ W \longrightarrow (a)$

$$P_Q = \frac{P_{2Q}}{2} = \frac{P_i - P_o}{2} = 15.6\,W \rightarrow (c)$$

$$\%\eta = \frac{P_o}{P_i} \times 100\,\% = \frac{V_L^2/2R_L}{V_{cc} * \frac{3}{\pi} V_L/R_L} = 44.4\,\% \rightarrow (d)$$

Q4:

1- For the voltage-divider biasing circuit, discuss the condition required to perform the approximate analysis.



$$\boxed{\beta R_E > 10 R_2}$$

I_B should be much smaller than I_2

i.e. $I_1 \simeq I_2$

To do so the resistances should follow

βR_E much large than R_2

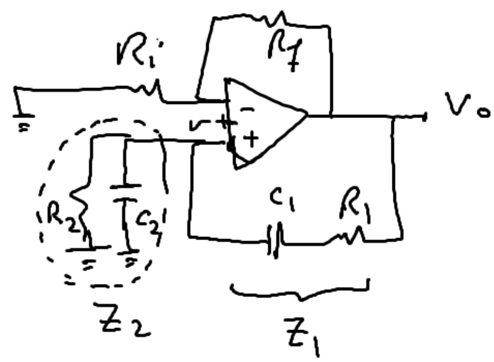
or $\beta R_E > 10 R_2$

2- Derive an equation for the Wien-bridge oscillation frequency and show how you can control its gain automatically.

$$Z_1 = R_1 - j/wc_1$$

$$Z_2 = R_2 \,//\, -j/wc_2 = \frac{R_2 * -j/wc_2}{R_2 - j/wc_2}$$

$$= \frac{R_2}{j\,wR_2c_2 + 1}$$



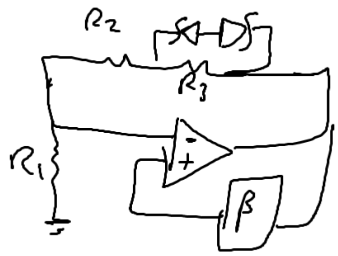
$$\beta = \frac{V^+}{V_o} = \frac{R_2}{(R_1 + R_2 + R_2\frac{c_2}{c_1}) + j\,(wR_1R_2c_2 - 1/wc_1)}$$

img Term $= 0$ $\therefore$ $w_o R_1 R_2 c_2 - 1/wc_1 = 0 \Rightarrow w_o = \frac{1}{\sqrt{R_1R_2c_1c_2}}$

$\therefore f_o = 1/2\pi\sqrt{R_1R_2C_1C_2}$ @ $R_1 = R_2$, $C_1 = C_2$ $\therefore f_o = 1/2\pi RC$ #

AGC in wien bridge

by: (1) use two Zener back to back in the feed back path as shown



(2) use FET circit.

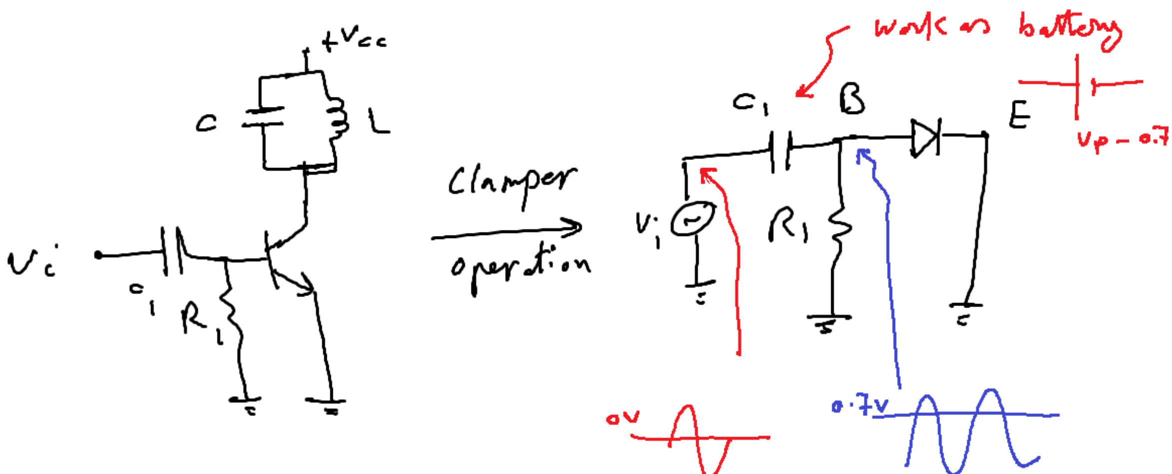
3- Calculate the resonance frequency of a Hartley oscillator with the elements of the tank circuit as L_1= 1.5 mH, L_2=10 mH and C=470pF.

$$f = \frac{1}{2\pi\sqrt{L_T C}}$$

$$L_T = L_1 + L_2 = 1.5 + 10 = 11.5 \text{ mH}$$

$$\therefore f = \frac{1}{2\pi\sqrt{11.5\times10^{-3}\times470\times10^{-12}}} = 68.457 \text{ KHz}$$

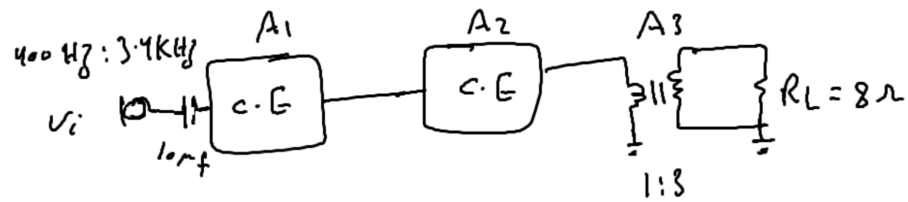
4- Draw the clamper bias circuit used in tuned amplifier and mention the purpose of its usage.



clamper bias removes the need of −ve bias at the transistor base.

Q5:

1- The design of the BJT Audio Amplifier :



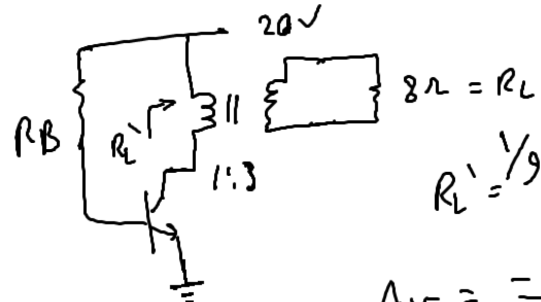
$A_{ToT} = 57\ dB = A_1 + A_2 + A_3$

$$A = 10^{57/20} = 707 = A_1 A_2 A_3 \text{ (absolute)}$$

$A_3 = 3$, let $A_2 = 10$ $\therefore A_1 = 23.5$

use two fixed bias C.E stages, each has phase shift of π as follows

stage #2



$R_L' = 1/9\ R_L = 8/9$

$$A_v = \frac{-R_L'}{r_e} = -10$$

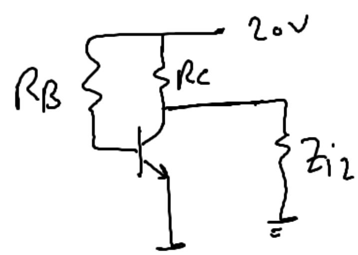
$\therefore \frac{8/9}{r_e} = 10$ $\therefore r_e = 8/90\ \Omega$

$\therefore I_E = \frac{26mV}{8/90} = ✓\ mA$, let $\beta = 100$ $\therefore I_B = \frac{I_E}{101} = \frac{20V - 0.7}{R_B}$

$\therefore R_B = ✓✓\ \Omega$

$Z_{i2} = R_B // \beta r_e \simeq 80/9\ \Omega$

stage #1



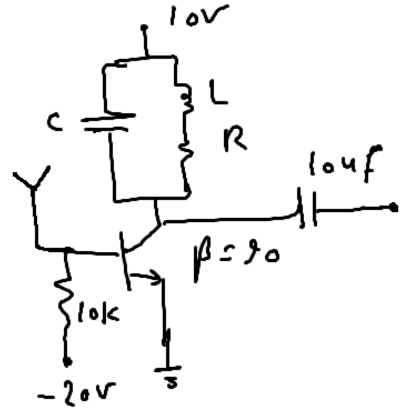
$A_v = -23.5 = \frac{-R_L // R_c}{r_e}$, $R_L = Z_{i2}$, let $R_c = 1K\Omega$

$\therefore 23.5 = \frac{(80/9) // (1K)}{r_e}$ $\therefore r_e = ✓$, $I_E = \frac{26mV}{r_e}$

let $\beta = 100$ $\therefore I_B = \frac{I_E}{101}$ $\therefore R_B = \frac{20V - 0.7}{I_B} = ✓✓\Omega$

2- The design of the receiver system:

for the Tuned Amp:



$$f_0 = 98\,KHz = \frac{1}{2\pi\sqrt{LC}}$$

$$Q = 10 = \frac{X_L}{R}$$

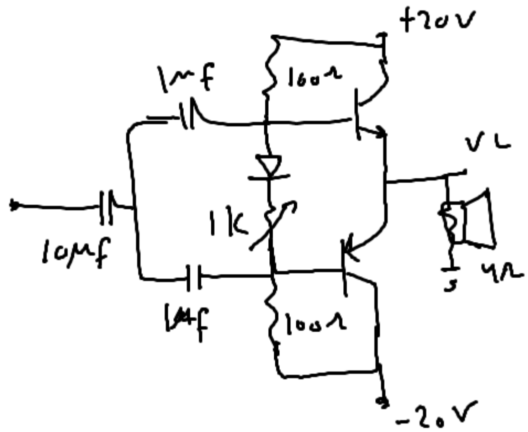
let L = 1 mH

$$\therefore C = \frac{(2\pi f_0)^2}{L} = \checkmark F$$

$$\therefore R = \frac{2\pi f_0 L}{10} = \checkmark\checkmark\ \Omega$$

for the Power Amplifier:

use class B Amp



$$\%\eta = 60\% = \frac{\pi}{4}\,\frac{V_L(P)}{V_{cc}} * 100\%$$

let $\pm V_{cc} = \pm 20V$

$$\therefore \frac{4 * 0.6}{3.14} = \frac{V_L}{V_{cc}} \qquad \therefore V_L = \checkmark V$$

$$\therefore I_L = \frac{V_L}{R_L} = \frac{V_L}{4\Omega} = \checkmark A$$

∴ use transistors with max current < I_L