1. An amplifier was designed using a bipolar transistor with $C_\mu = C_\pi = 5pF$, a $10\mu F$ coupling capacitors C_C and a $50\mu F$ bypass capacitor C_B. The resistances seen by these capacitors are $R_\mu = 10k\Omega$, $R_\pi = 1k\Omega$, $R_C = 1k\Omega$, $R_B = 100\Omega$, respectively. A $1k\Omega$ resistor is connected in parallel with C_B and the amplifier's midband gain is 1234.

   (a) Find the approximate low and high effective cut-off frequencies. (10 points)

   (b) Write an expression for the gain as a function of frecuency, valid for all frecuency bands. (10 pts)

(a)

$$\omega_\mu = \frac{1}{5pF \times 10k\Omega} = 2\times10^7 \text{ rps}$$

$$\omega_\pi = \frac{1}{5pF \times 10k\Omega} = 2\times10^8 \text{ rps}$$

} high freq poles

$$\omega_C = \frac{1}{10\mu F \times 1K\Omega} = 100 \text{ rps}$$

$$\omega_B = \frac{1}{50\mu F \times 100\Omega} = 200 \text{ rps}$$

} low freq. poles

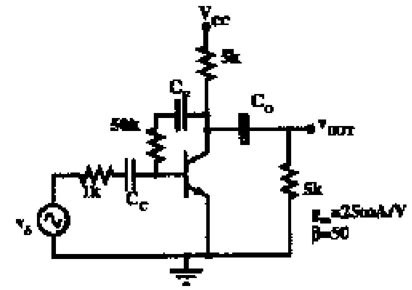
$$\omega_{ZB} = \text{zero due to bypass cap.} = \frac{1}{50\mu F \times 1K\Omega} = 20 \text{ rps}$$

(b)

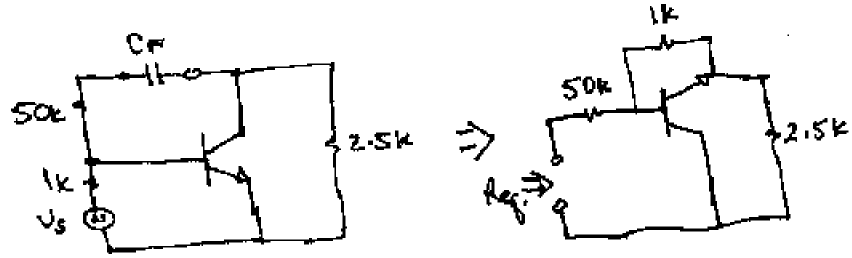
$$A_v = 1234 \frac{s+20}{s+200} \frac{s}{s+100} \frac{2\times10^7}{s+2\times10^7} \frac{2\times10^8}{s+2\times10^8}$$

where $s = j\omega$

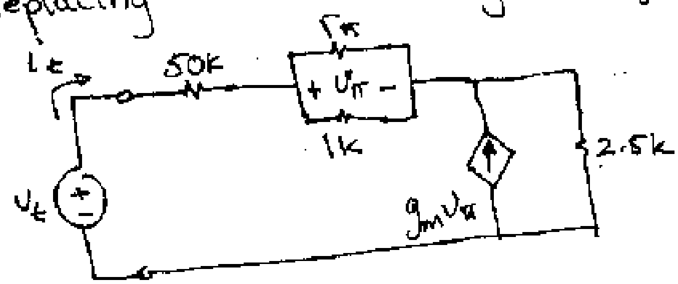
2. Use the *short-circuit time-constant* method to determine the resistance seen by C_F in the following amplifier. You should use the low-frecuency transistor model. (20 pts)



a.c. circuit :



Replacing the transistor by its equivalent circuit, we get



$$r_\pi = \frac{\beta}{g_m} = \frac{50}{25mA/V} = 2k\Omega$$

$$V_\pi = (1k \| 2k)\, i_t = 666.7\, i_t$$

KVL in outer loop:

$$V_t = 50k\, i_t + 666.7\, i_t + 2.5k\,(i_t + g_m V_\pi)$$

$$V_t = 53167\Omega \times i_t + 2.5k \times 25mV/A \times 666.7$$

$$V_t \cong 94.8k\Omega \times i_t$$

$$\boxed{R_{EQ} = 94.8k\Omega}$$

3. A power amplifier capable of providing up to 25 watts to a 50 Ohms load is needed. To reduce distortion, the amplifier's output voltage should never exceed 80% of the power supply voltage.

   (a) Design a Class-A amplifier to satisfy these requirements. You should determine (i) the power supply voltages, average current, maximum instantaneous current, and power; (ii) the transistor's required power rating, average collector current, maximum instantaneous collector current, and maximum collector-to-emitter voltage; (iii) the current source's current. (10 points)

   (b) Design a Class-B amplifier to satisfy these requirements. You should determine (i) the power supply voltages, peak ~~average~~ current, maximum instantaneous current, and power; (ii) the transistor's required power rating, average collector current, maximum instantaneous collector current, and maximum collector-to-emitter voltage. (10 points)

   (c) Determine the efficiency of the amplifiers designed in parts (a) and (b) when the output voltage is half of the maximum specified. (5 points)

(a) $P_{L\,max} = 25\,W$; $R_L = 50\Omega$ $\Rightarrow$ $V_{o\,peak} = \sqrt{2 P_{L\,max} R_L} = \sqrt{2(25w)(50\Omega)} = \boxed{50v}$

Since $V_{o\,peak} \le .8 V_{cc}$ it follows that $\boxed{V_{cc} = 62.5\,v}$

The current-source should be selected $\boxed{I_{EE} = \frac{62.5v}{50\Omega} = 1.25A}$

i. P.S. $\boxed{I_{AVG} = I_{EE} = 1.25A}$

max. current occurs when $v_o = V_{o\,peak} = 50v$; $i_{L\,peak} = 1A$

$I_{P.S.\,max} = 1A + 1.25A = i_{L\,peak} + I_{EE} = \boxed{2.25A = I_{PS\,max}}$

$P_{PS} = I_{EE} * 2V_{cc} = 2(62.5v)(1.25A) = \boxed{156.25\,w = P_{PS}}$

ii. transistor requirements

$P_D = \frac{1}{2} P_{PS}$

$\boxed{P_D = 78\tfrac{1}{8}\,W}$

$\boxed{i_{C\,AVG} = I_{EE} = 1.25A}$

$\boxed{i_{C\,max} = I_{PS\,max} = 2.25A}$

$\boxed{V_{CE\,max} = }$ $V_{cc} + V_{o\,peak} = 62.5v + 50v = \underline{112.5v}$

iii. $\boxed{I_{EE} = 1.25A}$

(b) <u>Class B</u>

$V_{cc} = 62.5\,v$ (see part a)

i.

$$i_{PS_{ave}} = \frac{i_{L\,peak}}{\pi} = \frac{50v/50\Omega}{\pi} \Rightarrow \boxed{i_{PS_{ave}} = 0.318\,A}$$

$$\boxed{i_{PS_{max}} = i_{L\,peak} = 1A}$$

$P_{PS} = 0\,w$ for $0v$ output

$= i_{PS_{ave}} \times V_{cc} \times 2 = 2(62.5V)(0.318A) \cong 40W$ (for a sinusoidal output of max. amplitude)

$= \boxed{40W}$

ii. Since $V_{o_{peak}} > \frac{2V_{cc}}{\pi} = \frac{2(62.5)}{\pi} = 40v$, we must find the transistor requirements based on a peak of $40v$

For $V_{o_{peak}} = 40v$, $P_L = \frac{(40v)^2}{2(50\Omega)} = 16w$; $P_{PS} = 2V_{cc}\, i_{PS_{AVE}}$

$$P_{PS} = 2(62.5v)\left(\frac{40v/50\Omega}{\pi}\right) = 31.83W$$

$$2P_D = P_{PS} - P_L = 31.83w - 16w = 15.83W$$

$$P_D = 15.83w/2 = \boxed{7.915\,w = P_D}$$

$$\boxed{i_{C_{ave}} = i_{PS_{ave}} = 0.318A} \quad \boxed{i_{C_{max}} = i_{L\,peak} = 1A}$$

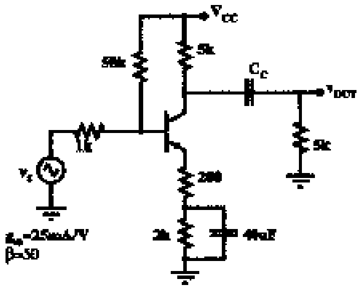
$$\boxed{V_{CE_{max}} = V_{cc} + V_{o_{peak}} = 112.5v}$$

(c)

$$\eta_{max\,classA} = \frac{25w}{156.25w} \times 100\% = \boxed{16\%}$$

$$\eta_{max\,class B} = \frac{25w}{40w} \times 100\% = \boxed{62.5\%}$$

4. For the following circuit,



$$r_\pi = \frac{50}{25mA/V} = 2K\Omega$$

assume that $C_\mu = 10pF$, $C_\pi = 50pF$ and $C_C = 10\mu F$. Find

(a) the low-frequency poles and zeros. (15 points)

[redacted]

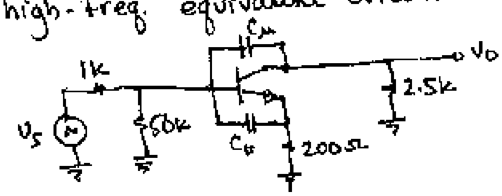
(b) the midband gain. (5 points)

(a) $\omega_{L_C} = \frac{1}{10\mu F \times 10K\Omega} = \boxed{10 rps}$; $\omega_{L_B} = \frac{1}{40\mu F \times R_{EQ_B}}$

$$R_{EQ_B} = 2k \,||\, \left[200 + \frac{r_\pi + R_B}{\beta+1}\right] = 2k \,||\, \left[200 + \frac{2k+980}{51}\right] = 229\Omega$$

$\omega_{L_B} = \frac{1}{40\mu F \times 229\Omega} = \boxed{109 rps}$; $\omega_{Z_B} = \frac{1}{40\mu F \times 2K\Omega} = \boxed{12.5 rps}$

(b) high-freq. equivalent circuit:



C_μ sees