Name: ______________________________

Student No: ______________________________

Electrical and Computer Engineering Department
University of Puerto Rico - Mayaguez, P.R.
Electronics II - Spring 1999 - Final Exam - Prof. Manuel Toledo

1. For the oscilator circuit shown below, the two transistors have $g_m = 1.6mA/V$. Each part below is 5 points.

   (a) Draw a diagram of the phase shift network.

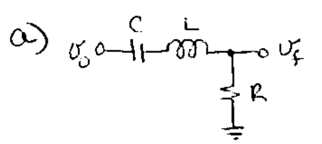
   (b) Find $\beta(s) = \frac{v_i}{v_o}$ from the diagram drawn in part (a).

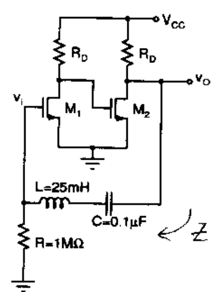
   (c) Determine the loop gain, $A(s)\beta(s)$. HINT: THE GAIN WILL DEPEND ON THE PHASE SHIFT NETWORK.

   (d) Apply the Barkhausen Criterion to find the frequency of oscillation.

   (e) Find the minimum value of R_D that would satisfy the Barkhausen Criterion.

a)





b) $$\frac{v_f}{v_o} = \frac{R}{R + sL + \frac{1}{sC}} = \beta(s)$$

$$\boxed{\beta(s) = \frac{sCR}{s^2CL + sCR + 1}}$$

c) $A_{v_1} = -g_m R_D$; $A_{v_2} = -g_m R_D \| Z \Rightarrow A_v = g_m^2 R_D^2 \frac{Z}{Z + R_D}$

$$Z = sL + \frac{1}{sC} + R = \frac{s^2LC + sCR + 1}{sC}$$

$$\therefore \quad A_v = g_m^2 R_D^2 \frac{s^2LC + sCR + 1}{s^2LC + sCR + 1 + sCR_D} = g_m^2 R_D^2 \frac{s^2LC + sCR + 1}{s^2LC + sC(R + R_D) + 1}$$

Using $\beta(s)$ from (b)

$$\boxed{A_v\beta = g_m^2 R_D^2 \frac{sCR}{s^2LC + sC(R + R_D) + 1}}$$

d) Real part of denominator must vanish $\Rightarrow -\omega^2LC + 1 = 0$

$$\therefore \boxed{\omega = \frac{1}{\sqrt{LC}}}$$

e) Using ω from (d) and $A\beta$ from c

$$g_m^2 R_D^2 R / R + R_D = g_m^2 R_D (R_D \| R) \geq 1 \Rightarrow \text{Solving for } R_D \text{ gives } \boxed{R_D \geq 624\,\Omega}$$

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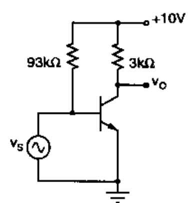
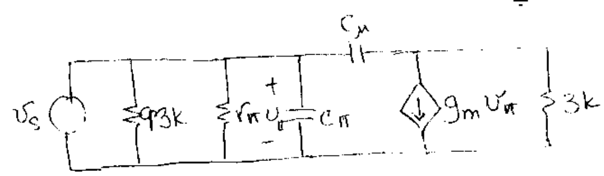
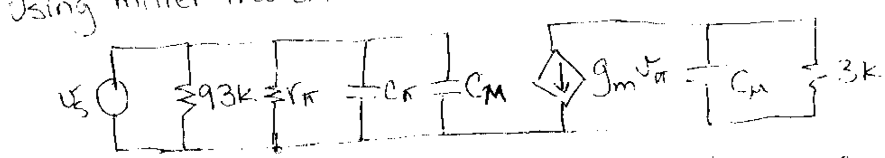
3. Determine the high cutoff angular frequency, w_H, for the following circuit. The input voltage source is ideal. HINT: YOU DON'T NEED β TO ANSWER THE QUESTION. DRAW THE AC EQUIVALENT CIRCUIT WITH THE TRANSISTOR REPLACED WITH ITS MODEL AND THINK. (25 points)





Using miller theorem



Since there is no resistor in series with v_s, C_π & C_μ can be charged instantly and do not affect the frequency response. Thus

$$\omega_H = \frac{1}{3k\, C_\mu}$$

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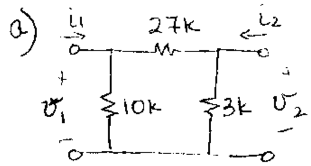
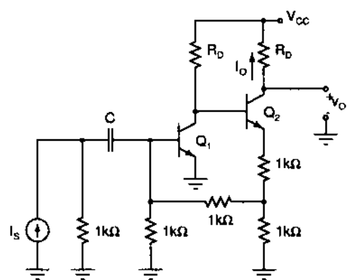
4. The sketch shown below is a diagram of a feedback amplifier. HINT: FEEDBACK TYPE IS CURRENT-SHUNT.
   (a) Draw a diagram of the feedback network. (5 points)
   (b) Find the feedback's network β. (5 points)
   (c) Estimate an approximate value of the feedback amplifier's gain. HINT: ASSUME THAT THE NON-FEEDBACK AMPLIFIER GAIN IS VERY LARGE. (5 points)
   (d) Draw a diagram of the non-feedback amplifier, including the loading effects of the feedback network. Include numeric values for the resistors. Do not replace the transistors by their model. (10 points)

a)





b) $\beta = g_{12} = \left.\frac{i_1}{i_2}\right|_{v_1=0}$

Short v_1, then

$i_1 = -i_2 \frac{1k}{1k+1k} = -0.5 i_2$

$\therefore$ $\boxed{\beta = -0.5}$ (the minus sign makes the feedback negative)

c) $\boxed{A_f \simeq \frac{1}{\beta} = +2}$

d) To draw the diagram, we must find g_{11} and g_{22}

$g_{11} = \left.\frac{i_1}{v_1}\right|_{i_2=0} = \frac{1}{1k} + \frac{1}{2k} = 0.0015$

$= 1/666\Omega$

$g_{22} = \left.\frac{v_2}{i_2}\right|_{v_1=0} = 1k \| 1k$

$= 500\Omega$