Name: Key

Student No: ______________________

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Electronics II - Fall 1999 - Third Exam (b) - Prof. Manuel Toledo

EACH PROBLEM IS 25 POINTS
BE CLEAR AND WELL ORGANIZED OR LOOSE POINTS

1. A 3-pole feedback amplifier has a dc gain of 10^4. All three open-loop poles are located at $f = 1MHz$. Find the maximum feedback β for which the amplifier is stable.

   You may find the following two formulas useful:

   - the number of decades between frequencies f_1 and f_2 is $n = |log\frac{f_2}{f_1}|$
   - the phase at frequency f_2 due to a pole at f_1 is $-tan^{-1}(\frac{f_2}{f_1})$.

Let f_2 be the freq. at which total phase $= -180^\circ$

Since each pole contributes -60° at f_2,

$$-60^\circ = -\tan^{-1}\left(\frac{f_2}{1MHz}\right)$$

$$f_2 = 1.73 MHz$$

At this freq.

$$|A(f = 1.73MHz)| = \left|\frac{10^4}{\left(j\frac{1.73MHz}{1MHz} + 1\right)^3}\right| = \frac{10^4}{\left(\sqrt{1.73^2 + 1^2}\right)^3} = 1253.3$$

Since we want this to become 0dB

$$\frac{1}{\beta} = 1253.3$$

and

$$\boxed{\beta \cong 8 \times 10^{-4}}$$

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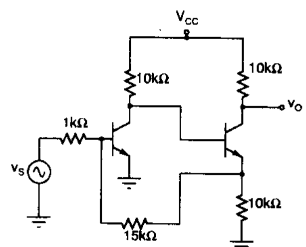
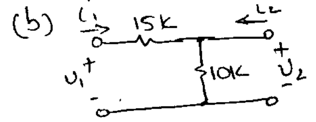
2. For the circuit shown below, the transistor's $\beta = 50$, $r_\pi = 2k\Omega$, $r_b = 0$ and $r_o = \infty$. Find
   (a) type of feedback
   (b) feedback network's β
   (c) current gain of the amplifier without feedback, but taking into account the loading due to the feedback network
   (d) current gain of feedback amplifier (do **not** approximate to $1/\beta$)



(a) current-shunt

(b)



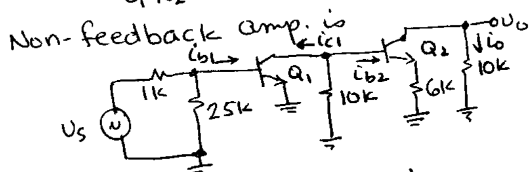
$$g_{12} = \left.\frac{i_1}{i_2}\right|_{v_1=0} = \frac{-10K}{10K+15K}$$

$$= -10/25$$

Since $i_o = -i_2 \Rightarrow \boxed{\beta = -g_{12} = 10/25}$

(c) $g_{11} = \left.\frac{i_1}{v_1}\right|_{i_2=0} = 1/25K\Omega$; $g_{22} = \left.\frac{v_2}{i_2}\right|_{v_1=0} = 10K // 15K = 6K\Omega$

Non-feedback amp.:



$i_o = -\beta i_{b2} \Rightarrow \frac{i_o}{i_{b2}} = -50$

$$\frac{i_{b2}}{i_{c1}} = -\frac{10K}{10K+2K+51\times 6K} = -10/318$$

$$\frac{i_{c1}}{i_{b1}} = \beta = 50 \quad ; \quad \frac{i_{b1}}{i_s} = \frac{25K}{2K+25K} = 25/27$$

$$A_i = i_o/i_s = \frac{i_o}{i_{b2}}\frac{i_{b2}}{i_{c1}}\frac{i_{c1}}{i_{b1}}\frac{i_{b1}}{i_s} = (-50)\left(\frac{-10}{318}\right)(50)\left(\frac{25}{27}\right) = \boxed{72.8 = A_i}$$

(d) $$A_{if} = \frac{A_i}{1+\beta A_i} = \frac{72.8}{1+\frac{10}{25}(72.8)} = \boxed{2.42 = A_{if}}$$

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3. For a shunt feedback amplifier, $R_{if} = 110\Omega$, $R_{of} = 26k\Omega$, $A_f = 20$, and $\omega_{L,f} = 10rad/s$. For the associated non-feedback amplifier, $R_o = 2k\Omega$ and $\omega_H = 10^4 rad/s$.

   (a) Find the non-feedback amplifier R_i, A and ω_L.

   (b) What's the feedback's network β?

   (c) Changing a resistor from $10k\Omega$ to $11k\Omega$ changes A_f from 20 to 21. Determine the value of A when the resistor is $11k\Omega$. (HINT: Use sensitivity analysis.)

(a) We can find D from R_{of}/R_o (notice that, since $R_{of} > R_o$, we know that the amp. is current-shunt)

$$D = \frac{26k\Omega}{2k\Omega} = 13$$

Thus,

$$\boxed{A = A_f D = 20(13) = 260}$$

$$\boxed{R_i = D R_{if} = 13(110\Omega) = 1.43k\Omega}$$

$$\omega_L = D\omega_{L,f} = 13(10\,rad/sec) = \boxed{130\,rad/sec}$$

(b) $D = 1 + \beta A = 13 = 1 + \beta(260)$

$$\beta = \frac{13-1}{260} = \boxed{\frac{12}{260}} = \frac{6}{130} = \frac{3}{65} = 0.046$$

(c) $S_R^{A_f} = \frac{S_R^A}{D} \rightarrow S_R^A = D S_R^{A_f} = (13)\frac{\Delta A_f/A_f}{\Delta R/R} = 13\frac{1/20}{1k/10k} = 6.5$

$$\therefore 6.5 = \frac{\Delta A/A}{\Delta R/R} \rightarrow \frac{\Delta A}{A} = 6.5\frac{1k}{10k} = .650$$

$$\Delta A = .65(260) = 169$$

and ~~xxx~~ $A = 260 + 169 = \boxed{429}$ when $R = 11K$

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4. A feedback amplifier displays a transresistance gain $R_{Mf} = 10^5\Omega$, $R_{if} = 10\Omega$ and $R_{of} = 10\Omega$. The feedback type is voltage-shunt with $\beta = 0.9 \times 10^{-5}$.

   (a) Determine the current and voltage gains of the feedback amplifier.

   (b) Find the transresistance gain R_M, input resistance R_i and output resistance R_o of the non-feedback amplifier.

   (c) Determine the current and voltage gains of the non-feedback amplifier.

(a) $\underline{A_{if}} = \frac{i_o}{i_s} = \frac{v_o/R_{of}}{i_s} = \frac{v_o}{i_s}\frac{1}{R_{of}} = R_{Mf}\frac{1}{R_{of}} = \frac{10^5\Omega}{10\Omega} = \boxed{10^4}$

$\underline{A_{vf}} = \frac{v_o}{v_s} = \frac{v_o}{i_s R_{if}} = \frac{1}{R_{if}} R_{Mf} = \frac{10^5\Omega}{10\Omega} = \boxed{10^4}$

(b) From table,

$R_{Mf} = R_M/D = R_M/1+\beta R_M$

$R_{MF} + \beta R_M R_{Mf} = R_M$

$R_{MF} = (1-\beta R_{MF})R_M$

$R_M = \frac{R_{MF}}{1-\beta R_{MF}} = \frac{10^5}{1-(.9\times10^{-5})(10^5)} = \frac{10^5}{.1} = \boxed{10^6}$

$D = 1 + (.9\times10^{-5})(10^6)$
$= 10$

$\therefore$ $R_{if} = R_i/D$; $R_i = D R_{if} = \boxed{100\Omega}$

$R_{of} = R_o/D$; $R_o = D R_{of} = \boxed{100\Omega}$

(c) $A_i = \frac{i_o}{i_s} = \frac{v_o/R_o}{i_s} = \frac{R_M}{R_o} = \frac{10^6}{100} = \boxed{10^4}$

$A_v = \frac{v_o}{v_s} = \frac{v_o}{i_s R_i} = \frac{R_M}{R_i} = \boxed{10^4}$