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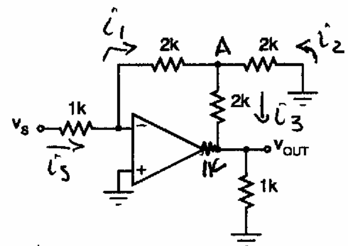
Electronics II - INEL 4202 - SPRING 2002 - Exam 2A - Prof. Manuel Toledo
THERE ARE FOUR PROBLEMS - WORK CLEARLY OR LOOSE POINTS

1. Find $A_v = v_{out}/v_S$ for the amplifier shown below. Assume that the opamp is ideal. (30 points)



$$V_{out} = V_A - i_3(2k)$$

$$V_A = -i_1(2k) = -2k\left(\frac{V_S}{1k}\right) = -2V_S$$

$$i_2 = \frac{V_A}{2k} = -\frac{V_S}{1k} \quad ; \quad i_3 = i_1 + i_2 = \frac{2V_S}{1k}$$

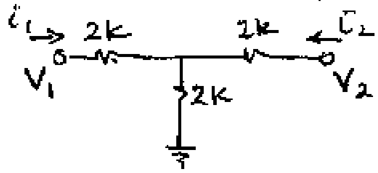
$$\therefore \quad V_{out} = -2V_S - \frac{2V_S}{1k}(2k) = -6V_S$$

$$\boxed{A_v = V_{out}/V_S = -6\ V/V}$$

2. The opamp in problem 1 has an input resistance (between the + and - terminals) $r_d = 10k\Omega$, open-loop voltage gain $A_{OL} = 10^4 V/V$, and zero output resistance. Use feedback theory to determine the voltage gain v_{out}/v_S. (50 points)

shunt-shunt feedback

feedback network

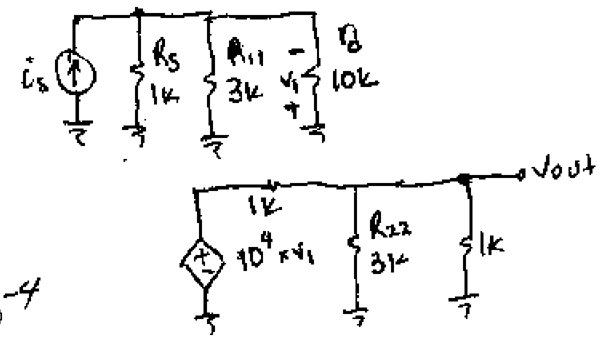


$R_{11} = 3K$

$R_{22} = 3K$

$\beta = -\frac{1}{3k}\frac{1}{2} = -\frac{1}{6K} = -1.67\times10^{-4}$

Non-feedback amp.



$$R_M = \frac{v_o}{i_s} = \frac{3k\|1k}{1k + 3k\|1k}\, 10^4\, (-10K)\, \frac{3k\|1k}{10k + 3k\|1k}$$

$$= (0.47)(-10^8)(0.07) = -3.3\,M\Omega$$

$$R_{Mf} = \frac{-3.3M\Omega}{1 + (-3.3M\Omega)(-1/6K\Omega)} = -5989\,\Omega = \frac{v_o}{i_s}$$

$$A_v = \frac{v_o}{v_s} = \frac{v_o}{i_s R_s} = \frac{R_{Mf}}{R_s} = \frac{-5989\Omega}{1000\Omega} = \boxed{-5.989\, V/V}$$

3. An amplifier with d.c. gain $A_0 = 10^4$ and poles at $10Hz$ and $1000Hz$ is used in a feedback configuration. Find the d.c. feedback gain A_f if the phase margin is $\phi_m = 45°$. (20 points)

$\phi_m = 45°$; $\therefore$ $L(1000Hz) = 0$ dB $= 1$ V/V $= A\beta$

Assuming voltage-voltage

at 1000 Hz $A = 80\text{dB} - 2(20\text{dB}) - 3\text{dB}$

$= 37$ dB $= 70.8$ V/V

(↑ or 40 dB = 100 if 3dB are neglected)

$\therefore \beta = \frac{1}{70.8} = 0.014$

Then $A_f = \frac{A_0}{1+\beta A_0} = \frac{10^4}{1 + 10^4/70.8}$

$A_f = 70.3$ V/V or

then $\beta = \frac{1}{100}$

$A_f = \frac{10^4}{1+10^4/100} = \frac{10^4}{1+10^2} = \frac{10^4}{101}$

$= 99$

↑ o.k. too