Shunt-Series Feedback (Current Amplifier)

Approach:

1.) Find $g_{11F} = \left.\frac{i_{1F}}{v_{1F}}\right|_{i_{2F}=0}$ (input conductance of the feedback network with the output open circuited)

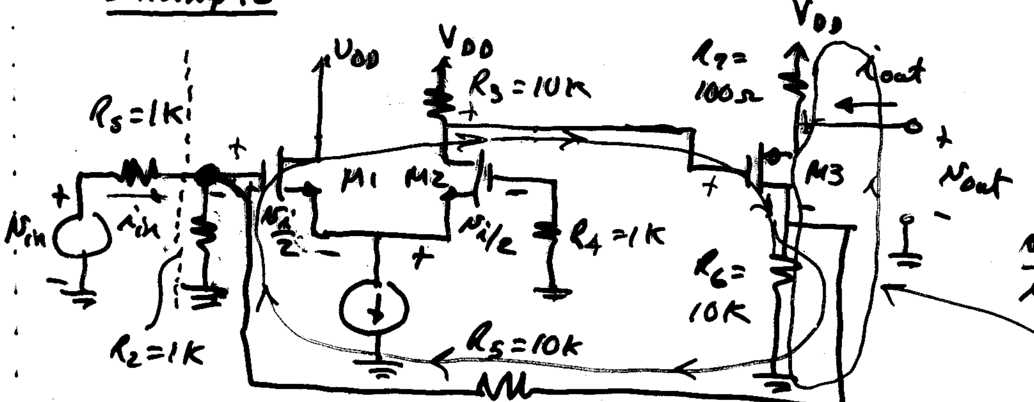
2.) Find $g_{22F} = \left.\frac{v_{2F}}{i_{2F}}\right|_{v_{1F}=0}$ (output resistance of the fb. ntwk. with the input short-circuited)

3.) Find $g_{12F} = \left.\frac{i_{1F}}{i_{2F}}\right|_{v_{1F}=0}$ = (current gain from the output to the input thru the fb. ntwk. with the input short-circuited)

4.) Find $A = \frac{i_2'}{i_1'}$

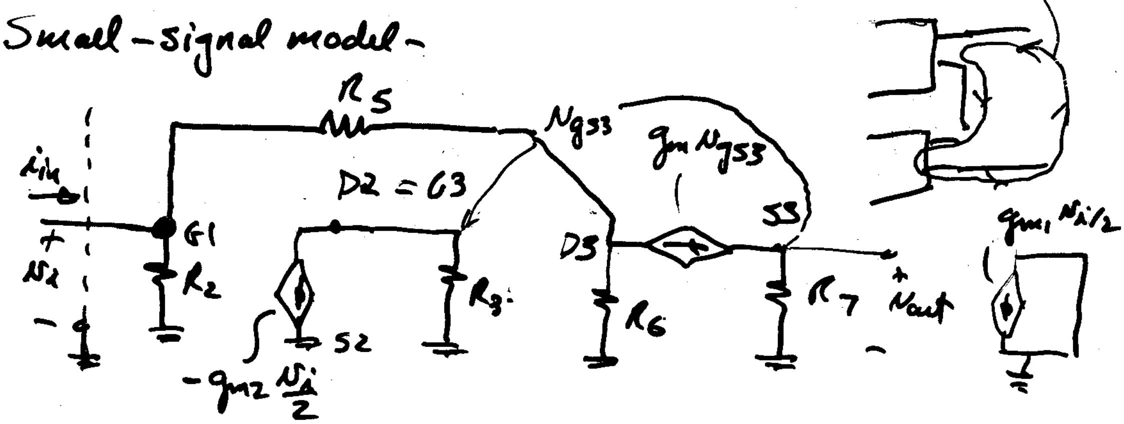
Continue to find A_F, R_{iF} and R_{oF}.

Example

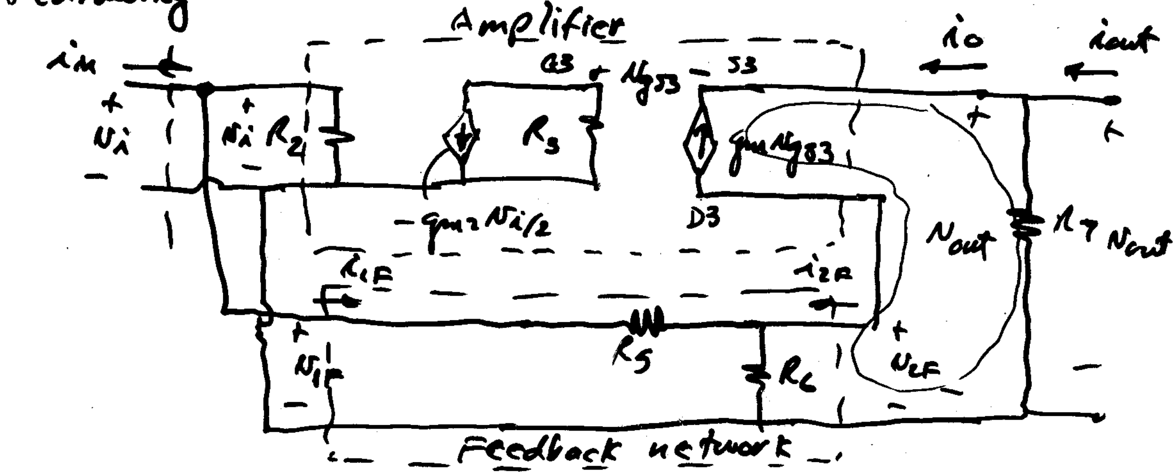


If $g_m = 1mS$ and $r_{ds} = \infty$ find $\frac{v_{out}}{v_{in}}$, $\frac{v_{in}}{i_{in}}$ & $\frac{v_{out}}{i_{out}}$

Small-signal model -



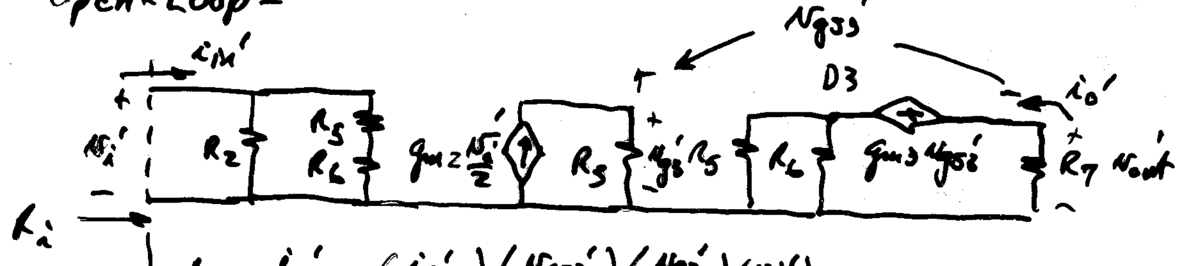
Redrawing -



$$g_{11F} = \frac{i_{1F}}{v_{1F}}\bigg|_{i_{2F}=0} = \frac{1}{R_5+R_6} \qquad g_{22F} = \frac{v_{2F}}{i_{2F}}\bigg|_{v_{1F}=0} = R_5 \| R_6$$

$$g_{12F} = \frac{i_{1F}}{i_{2F}}\bigg|_{v_{1F}=0} = \frac{i_{1F}}{i_o}\bigg|_{v_i=0} = -\frac{R_6}{R_5+R_6}$$

Open-Loop -



$$A = \frac{i_o'}{i_{in}'} = \left(\frac{i_o'}{v_{gs3}'}\right)\left(\frac{v_{gs3}'}{v_{g3}'}\right)\left(\frac{v_{g3}'}{v_i'}\right)\left(\frac{v_i'}{i_{in}'}\right)$$

$$= (-g_{m3})\left(\frac{1}{1+g_{m3}R_7}\right)\left(\frac{g_{m2}R_3}{2}\right)\left[R_3 \| (R_5+R_6)\right] = -4.329\,\frac{A}{A}$$

Back to closed loop -

$$\frac{i_o}{i_{in}} = \frac{A}{1+AF} = \frac{-4.329}{1+(4.329)(\frac{1}{2})} = -1.368\,\frac{A}{A}$$

$$R_{inF} = \frac{R_i}{1+AF} = \frac{R_2 \| (R_5+R_6)}{1+2.164} = \frac{952\,\Omega}{3.164} = 301\,\Omega$$

$$\frac{v_{in}}{i_{in}} = R_S + R_{inF} = 1K + 301\Omega = \underline{\underline{1301\,\Omega}}$$

$$\frac{v_{out}}{v_{in}} = \frac{-i_o R_7}{i_{in}(R_S+R_{inF})} = \left(\frac{i_o}{i_{in}}\right)\left(\frac{R_7}{[redacted]\ 1.301k}\right) = (-1.368)\left(\frac{100\,\Omega}{1301\,\Omega}\right)$$

$$\frac{v_{out}}{v_{in}} = \underline{\underline{-0.105\ V/V}} \qquad r_{out} = ?$$