Generalization of Feedback Circuit Analysis

Let $\psi = h, g, y$ or z (parameters)

1.) Find ψ_{11F}
2.) Find ψ_{22F}
3.) Find $\psi_{12F} = B$
4.) Find A which has the input-output variables of $(\psi_{12})^{-1}$ incorporating the loading of ψ_{11F} and ψ_{22F}.
5.) $A_F = \dfrac{A}{1+AB}$
6.) $R_{inF} = \begin{cases} (R_s + \psi_{11T})(1+AB) & \text{if the input is series} \\ \dfrac{1}{(G_s + \psi_{11T})(1+AB)} & \text{if the input is shunt} \end{cases}$
7.) $R_{outF} = \begin{cases} \dfrac{1}{(G_L + \psi_{22T})(1+AB)} & \text{if the output is shunt} \\ (R_L + \psi_{22T})(1+AB) & \text{if the output is series} \end{cases}$

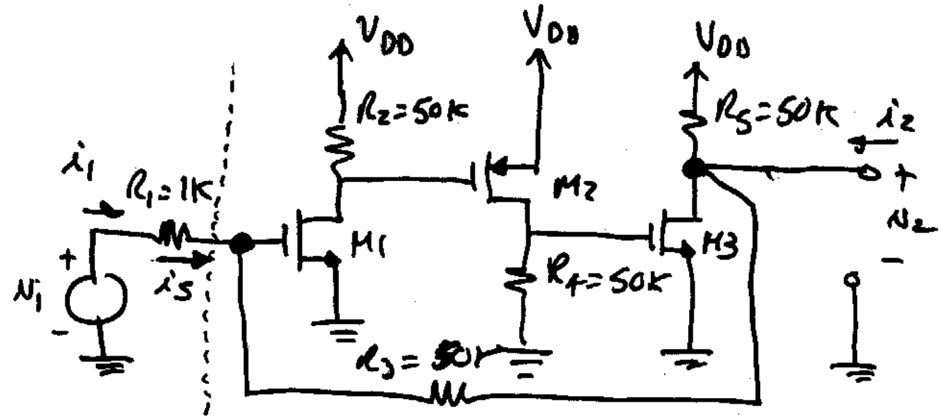
	Series-shunt	Shunt-shunt	Shunt-series	Series-series
Type of Amplifier	Voltage	Transresistance	Current	Transconductance
Two-Port Parameters	$v_1 = h_{11} i_1 + h_{12} v_2$ $i_2 = h_{21} i_1 + h_{22} v_2$	$i_1 = y_{11} v_1 + y_{12} v_2$ $i_2 = y_{21} v_1 + y_{22} v_2$	$i_1 = g_{11} v_1 + g_{12} i_2$ $v_2 = g_{21} v_1 + g_{22} i_2$	$v_1 = z_{11} i_1 + z_{12} i_2$ $v_2 = z_{21} i_1 + z_{22} i_2$
Units of A	$\dfrac{V_2}{V_1}$	$\dfrac{V_2}{I_1}$	$\dfrac{I_2}{I_1}$	$\dfrac{I_2}{V_1}$

Shunt-Shunt Neg. Feedback Example

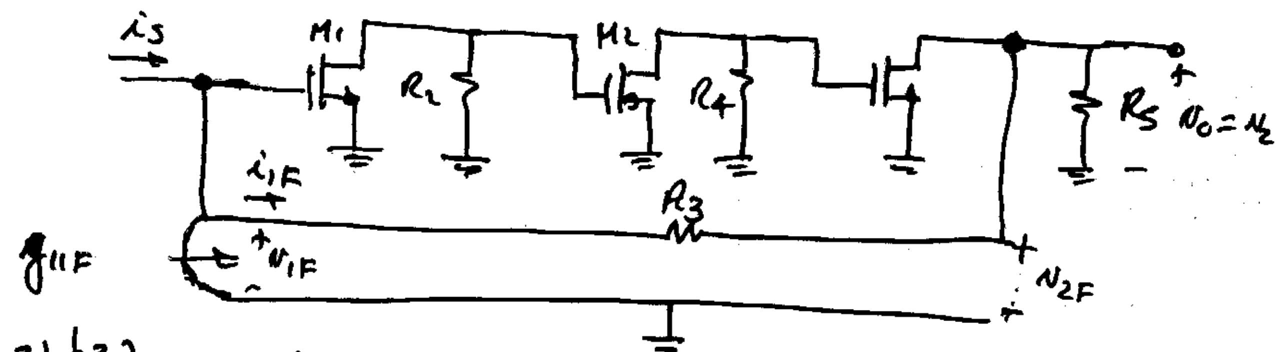
Y-parameters are the appropriate parameters

$$y_{11F} = \left.\frac{i_{1F}}{v_{1F}}\right|_{v_{2F}=0} \qquad y_{22F} = \left.\frac{i_{2F}}{v_{2F}}\right|_{v_{1F}=0} \qquad y_{12F} = \beta = \left.\frac{i_{1F}}{v_{2F}}\right|_{v_{1F}=0}$$

$A\left(\frac{V}{A}\right)$



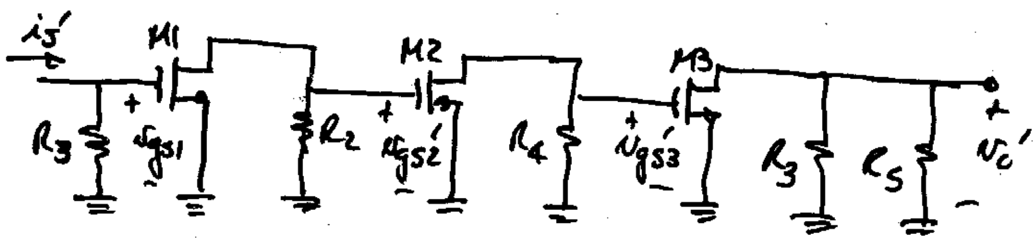
Find $\frac{v_2}{v_1}$, $\frac{v_1}{i_1}$, and $\frac{v_2}{i_2}$ if $g_{m1} = g_{m2} = g_{m3} = 0.2\,mA/V$ & $r_{ds} = \infty$



1.), 2.) & 3.) $y_{11F} = \frac{1}{R_3}$

$$y_{12F} = \left.\frac{i_{1F}}{v_{2F}}\right|_{v_{1F}=0} = \frac{-1}{R_3} \qquad y_{22F} = \frac{1}{R_3}$$

4)



$$\frac{v_o'}{i_S'} = \left(\frac{v_o'}{v_{gs3}'}\right)\left(\frac{v_{gs3}'}{v_{gs2}'}\right)\left(\frac{v_{gs2}'}{v_{gs1}'}\right)\left(\frac{v_{gs1}'}{i_S'}\right)$$

$$= \left(-g_{m3} R_3 \| R_5\right)\left(-g_{m2} R_4\right)\left(-g_{m1} R_2\right)\left(\frac{1}{R_3}\right)$$

Example - Cont'd

5.) $A = \frac{v_o'}{i_s'} = (-0.2\times 25)(-0.2\times 50)(-0.2\times 50)\left(\frac{1}{50k}\right) = -25M\Omega$

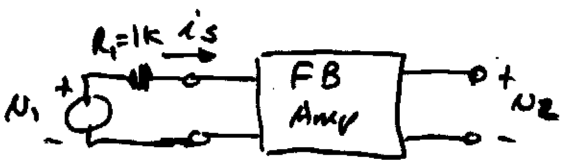
$A_F = \frac{v_2}{i_s} = \frac{A}{1+AB} = \frac{-25M\Omega}{1+(-25M\Omega)\left(\frac{-1}{50k}\right)} = \frac{-25M\Omega}{1+500} = -49.9k\Omega$

6.) $R_{inF} = \frac{1}{(G_s+y_{11T})(1+AB)} = \frac{1}{\left(0+\frac{1}{50k}\right)(501)} = 99.8\Omega$

$\frac{v_1}{i_1} = R_{in} = R_1 + R_{inF} = 1k + 0.0998k = \underline{1.0998k\Omega} \approx 1099\Omega$

7.) $R_{outF} = \frac{1}{(G_L+y_{22T})(1+AB)} = \frac{1}{\left(\frac{1}{R_5}+\frac{1}{R_3}\right)(1+AB)} = \frac{R_3||R_5}{1+AB} = \frac{25k}{501} = \underline{49.9\Omega}$

$\frac{v_2}{i_2} = R_{outF} = \underline{49.9\Omega}$

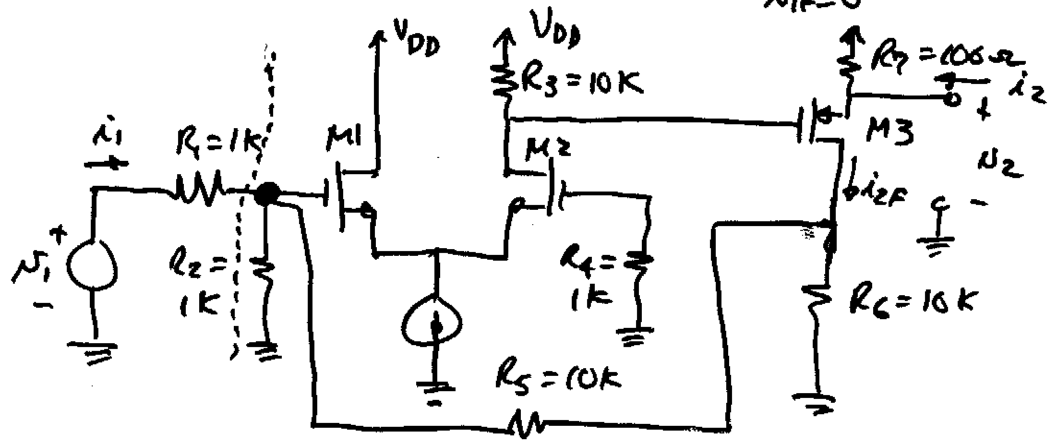


$\frac{v_2}{v_1} = \left(\frac{v_2}{i_s}\right)\left(\frac{i_s}{v_1}\right) = A\frac{1}{R_{in}} = \frac{-49.9K}{1099\Omega} = \underline{-45.4\ V/V}$

Shunt-Series Fb. Example - Current Amplifier

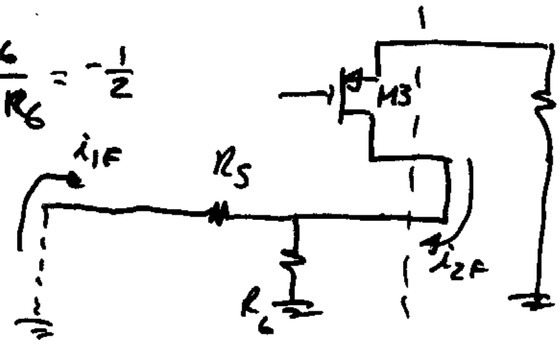
g - parameters

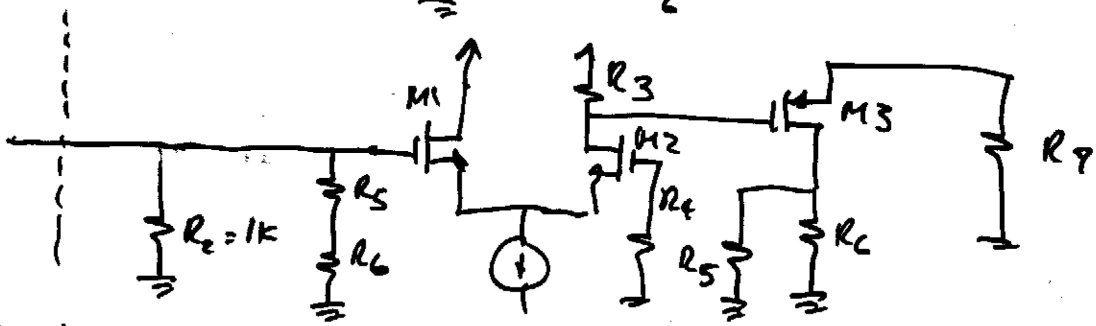
$g_{11F} = \frac{i_{1F}}{v_{1F}}\Big|_{i_{2F}=0}$, $g_{22F} = \frac{v_{2F}}{i_{2F}}\Big|_{v_{1F}=0}$, $g_{12F} = \frac{i_{1F}}{i_{2F}}\Big|_{v_{1F}=0}$ $\left(A \leftarrow \frac{A}{A}\right)$



Find $\frac{v_2}{v_1}$, $\frac{v_1}{i_1}$, and $\frac{v_2}{i_2}$ if $g_{m1}=g_{m2}=g_{m3}=1mS$ and $r_{ds}=\infty$.

1.) $g_{12F} = \frac{i_{1F}}{i_{2F}}\Big|_{v_{1F}} = \frac{-R_6}{R_5+R_6} = -\frac{1}{2}$





To be continued