"Quiz 12":

IEEE SSCS/CAS Atlanta Chapter Meeting

6:30pm - Refreshments

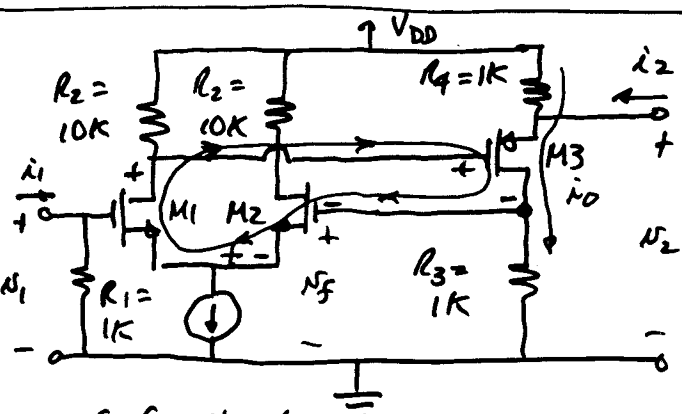
7:00pm - "Fundamental Property of MOS Transistors and Its Circuits Implications" - Dr. Eric Vittoz, Swiss Institute of Technology, Lausanne

ECE Auditorium

Quiz 11 - Solution

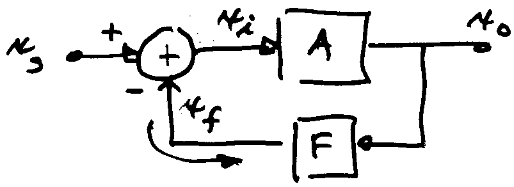
$g_m = 1mA/V$ and $r_{ds} = \infty$

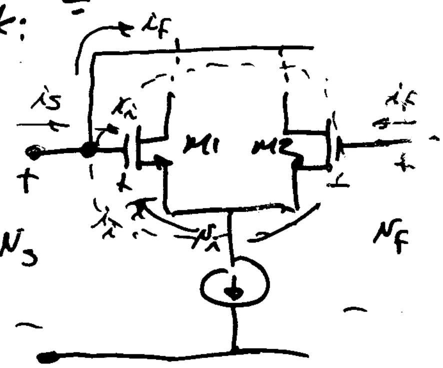
Find $\frac{v_2}{v_1}$, $\frac{v_1}{i_1}$ & $\frac{v_2}{i_2}$



Solution

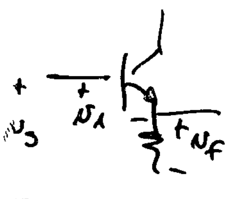
Identification of type of feedback:

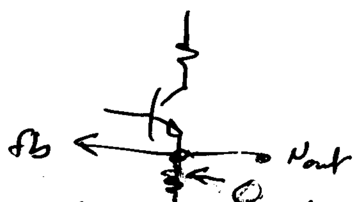




$v_i = v_s - v_f$ → $v_i = v_s - v_f$

→ $i_i = i_s - i_f$



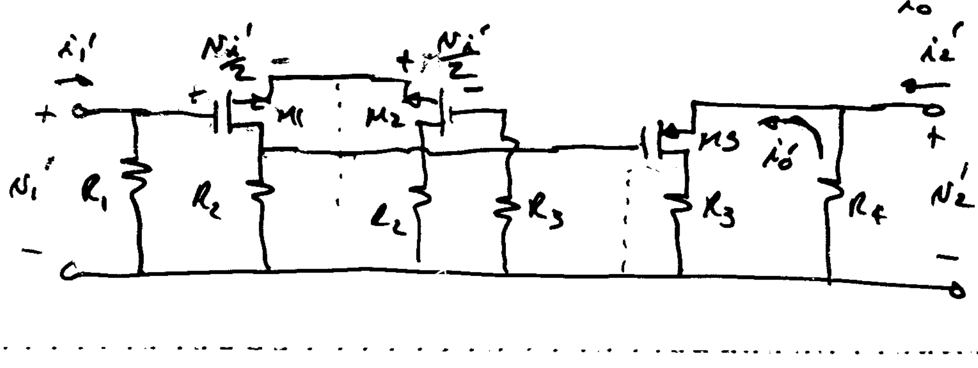


A units are $\frac{A}{V}$

F units are $\frac{V}{A}$

$F = \frac{v_f}{i_o} = 1K = R_3$

Redraw the circuit as open-loop:



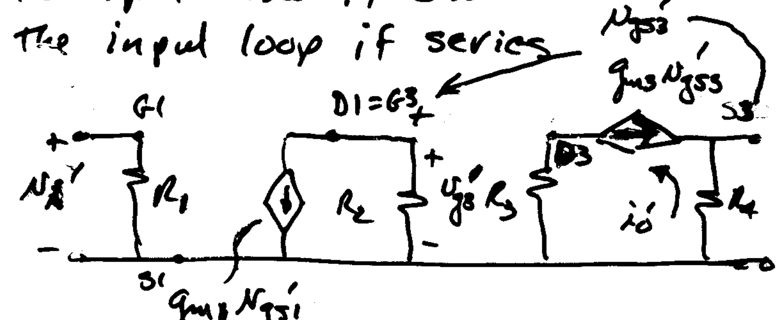
Rules for opening the loop (and finding the loading of the F network on the A network):

1.) Looking back into the F circuit from the input:
Short the output node if shunt (make $v_{out}=0$)
Open the output loop if series (make $i_o=0$)

2.) Looking back into the F ckt. from the output:
Short the input node if shunt
Open the input loop if series

$A = \frac{i_o'}{v_s'}$:

$v_s' = 2v_i'$



$$\frac{i_o'}{v_s'} = \left(\frac{i_o'}{v_{gs3}'}\right)\left(\frac{v_{gs3}'}{v_{g3}'}\right)\left(\frac{v_{g3}'}{v_i'}\right)\left(\frac{v_i'}{v_s'}\right) = (-g_{m3})$$

$$v_{gs3}' = v_{g3}' - v_{s3}' = v_{g3}' - (g_{m3}R_4 v_{gs3}')$$

$$v_{gs3}'(1+g_{m3}R_4) = v_{g3}'$$

$$A = \frac{i_o'}{v_s'} = (-g_{m3})\left(\frac{1}{1+g_{m3}R_4}\right)(-g_{m1}R_2)\left(\frac{1}{2}\right) = 2.5mS$$

$$\therefore A_F = \frac{i_o}{v_s} = \frac{A}{1+AF} = \frac{2.5mS}{1+(2.5)(1)} = 0.714mS$$

$$\frac{v_2}{v_1} = \frac{v_2}{v_s} = \left(\frac{i_o}{v_s}\right)(R_4) = -0.714 V/V$$

R_1 is not influenced by feedback so

$$\frac{v_1}{i_1} = R_i(1+AF)||R_1 = \infty||R_1 = 1K\Omega$$

$$R_o = R_4 + \frac{1}{g_{m3}} = 1k + 1k = 2K \rightarrow R_{oF} = 2k\Omega(3.5) = 7K\Omega$$

$$R_{out} = \frac{v_2}{i_2} = (R_{oF}-R_4)||R_4 = 6K||1K = 857\Omega$$