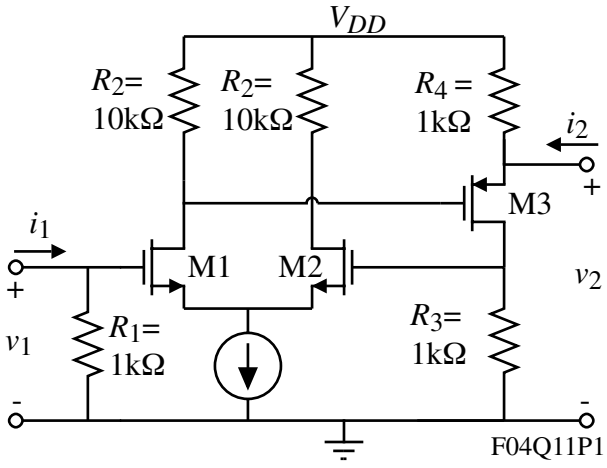
QUIZ NO. 11

(Average Score = 5.5/10 for those taking this quiz.)

The simplified schematic of a feedback amplifier is shown. Assume that all transistors are matched and g_m = 1mA/V and $r_{ds} = \infty$. Use the method of feedback analysis to find v_2/v_1, $R_{in} = v_1/i_1$, and $R_{out} = v_2/i_2$.

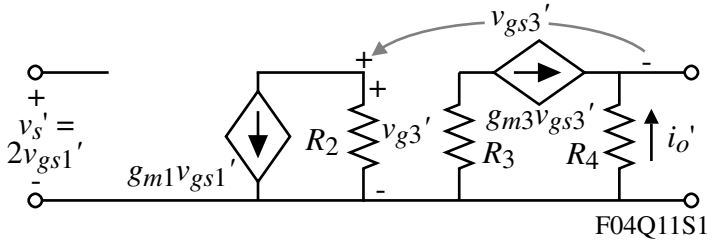


Solution

This feedback circuit is series-series. The units of A are A/V and the units of β are V/A.

$$F = z_{12f} = \frac{v_{1f}}{i_{2f}}\bigg|_{i_{1f}=0} = R_3 = 1\text{k}\Omega$$

The circuit for calculating the small-signal open-loop gain is,



$$A = \frac{i_o'}{v_s'} = \left(\frac{i_o'}{v_{gs3}'}\right)\left(\frac{v_{gs3}'}{v_{g3}'}\right)\left(\frac{v_{g3}'}{v_{gs1}'}\right)\left(\frac{v_{gs1}'}{v_s'}\right) = (-g_{m3})\left(\frac{1}{1+g_{m3}R_4}\right)(-g_{m1}R_2)\left(\frac{1}{2}\right)$$

$$A = \frac{i_o'}{v_s'} = (1\text{mS})(0.5)(5) = 2.5\text{mS} \;\rightarrow\; A_F = \frac{i_o}{v_s} = \frac{A}{1+AF} = \frac{2.5\text{mS}}{1+2.5\cdot 1} = 0.714\text{ mS}$$

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

R_1 is not influenced by feedback* so $\boxed{\frac{v_1}{i_1} = R_1 = 1\text{k}\Omega}$

$$R_o = R_4 + (1/g_{m3}) = 1\text{k}\Omega + 1\text{k}\Omega = 2\text{k}\Omega \;\rightarrow\qquad R_{oF} = 2\text{k}\Omega(1+2.5) = 7\text{k}\Omega$$

$$R_{out} = \frac{v_2}{i_2} = (R_{oF} - R_4)\|R_4 = 6\text{k}\Omega\|1\text{k}\Omega = 857\Omega \qquad \boxed{\frac{v_2}{i_2} = 875\Omega}$$

* The reason for this is that the input variable is v_s and the resistor, R_1, in parallel with v_s does not influence the circuit so the input resistance without feedback is ∞.