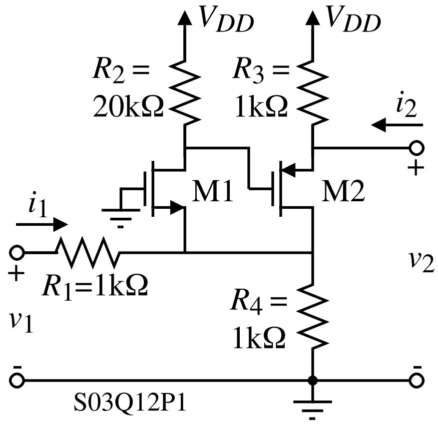
QUIZ NO. 12-SOLUTION

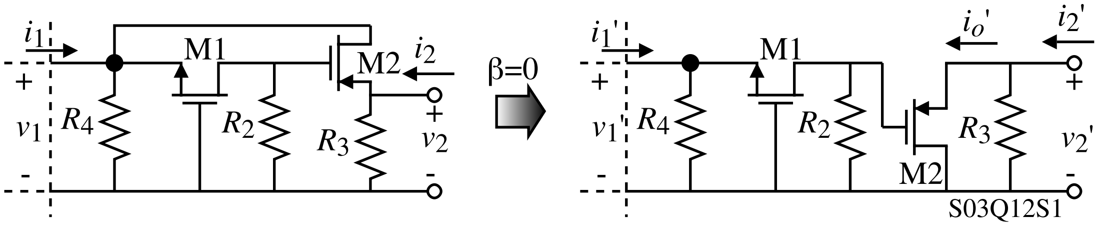
(Average Score = 5.7/10 of those taking this quiz.)

A feedback amplifier is shown. Use the methods of feedback analysis to find the numerical values of v_2/v_1, v_1/i_1, and v_2/i_2. Assume that all transistors are matched and that g_m= 1mS, and $r_{ds} = \infty$.

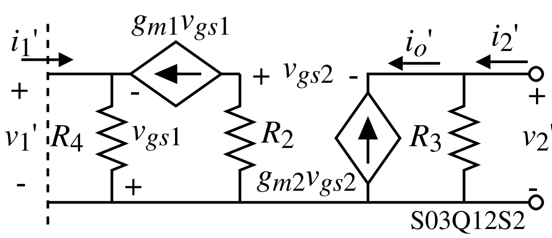


Solution

The feedback circuit is shunt-series. You should know by now not to include R_1 in the feedback circuit. The simplified transistor circuit and the open-loop equivalent is shown below. It is easy to see that $\beta = i_{1F}/i_{2F}\ (v_{1F}=0) = -1$.



The small-signal, open-loop circuit is,



$$A = \frac{i_o'}{i_1'} = \left(\frac{i_o'}{v_{gs2}'}\right)\left(\frac{v_{gs2}'}{v_{g2}'}\right)\left(\frac{v_{g2}'}{v_{gs1}'}\right)\left(\frac{v_{gs1}'}{i_1'}\right)$$

$$v_{gs2}' = v_{g2}' - v_{s2}' = v_{g2}' - g_{m2}R_3\, v_{gs2}'$$

$$\therefore \quad v_{gs2}'(1+ g_{m2}R_3) = v_{g2}'$$

Also, $i_1' + \dfrac{v_{gs1}'}{R_4} + g_{m1}v_{gs1}' = 0 \qquad \Rightarrow \qquad i_1' = -\left(\dfrac{1}{R_4} + g_{m1}\right) v_{gs1}'$

$$\therefore \ A = \frac{i_o'}{i_1'} = (-g_{m2})\left(\frac{1}{1+g_{m2}R_3}\right)(-g_{m1}R_2)\left(\frac{-1}{\frac{1}{R_4}+g_{m1}}\right) = (\text{-1mS})(0.5)(\text{-20})(\text{-0.5k}\Omega) = \text{-5 A/A}$$

Now, $\dfrac{i_o}{i_1} = \dfrac{-5}{1+(-1)(-5)} = -\dfrac{5}{6}$ A/A

$R_{in}(\beta=0) = R_4 \| (1/g_{m1}) = 0.5\text{k}\Omega$, $R_{inF} = \dfrac{0.5\text{k}\Omega}{1+5} = \dfrac{1}{12}\text{k}\Omega = 83.33\Omega \qquad \dfrac{v_1}{i_1} = \underline{\underline{1083.33\Omega}}$

$$\frac{v_2}{v_1} = \frac{i_o}{i_1}\left(\frac{-R3}{(v_1/i_1)}\right) = -\frac{5}{6}\,\frac{-1000}{1083.33} = \frac{10}{13} = \underline{\underline{0.7692 \text{ V/V}}}$$

$R_o(\beta=0) = R_3 + (1/g_{m2}) = 2\text{k}\Omega, \qquad R_{oF} = 2\text{k}\Omega(1+5) = 12\text{k}\Omega$

$$\frac{v_2}{i_2} = (12\text{k}\Omega - 1\text{k}\Omega)\|1\text{k}\Omega = 11\text{k}\Omega\|1\text{k}\Omega = \frac{11}{12}\text{k}\Omega = \underline{\underline{916.67\Omega}}$$