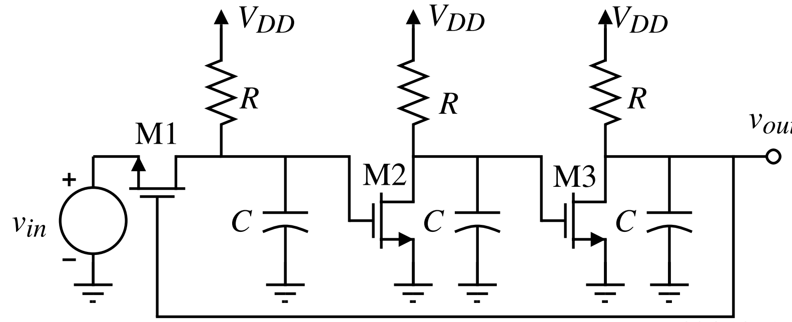
Homework Assignment No. 14 - Solution

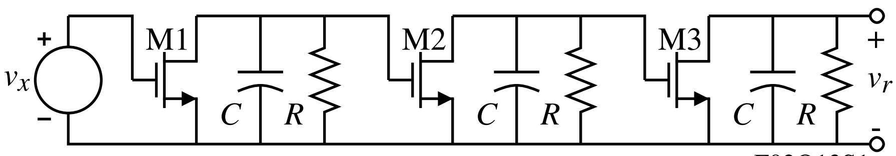
1.) Find the loop gain of the amplifier shown. Assume that g_m = 1mS and $r_{ds} = \infty$ for all MOSFETs and that R = 10kΩ and C = 100nF.



F02Q13P1B

Solution

Use the model shown to find the loop gain.



F02Q13S1

This circuit consists of three identical stages with each transfer function given as

$$A(s) = \frac{-g_m R}{sRC+1}$$

Therefore,

$$T(s) = -\frac{v_r}{v_x} = -\left(\frac{-g_m R}{sRC+1}\right)^3 = -\left(\frac{-10}{\frac{s}{10^3}+1}\right)^3 = \frac{1000}{\left(\frac{s}{10^3}+1\right)^3} \rightarrow \boxed{T(s) = \frac{1000}{\left(\frac{s}{10^3}+1\right)^3}}$$

2.) Problem 18.49 of the text.

(a) $T = A\beta = \frac{2\text{x}10^{14}\pi^2}{(s+2\text{x}10^3\pi)(s+2\text{x}10^5\pi)}\left(\frac{1}{5}\right)$ | Yes, it is a second-order system and will have some phase margin, although Φ_M may be vanishingly small.

(b) For $\omega >> 2\pi \text{ x } 10^5$, $|T(j\omega)| \approx \frac{4\text{x}10^{13}\pi^2}{\omega^2}$ and $|T(j\omega)| = 1$ for $\omega = 1.987\text{x}10^7 \ \frac{\text{rad}}{\text{s}}$

$\angle T(j1.987\text{x}10^7) = -\tan^{-1}\frac{1.987\text{x}10^7}{2000\pi} - \tan^{-1}\frac{1.987\text{x}10^7}{2\text{x}10^5\pi} = 178.2^\circ \rightarrow \Phi_M = 1.83^\circ$ | A very small phase margin.

3.) Problem 18.61 of the text.

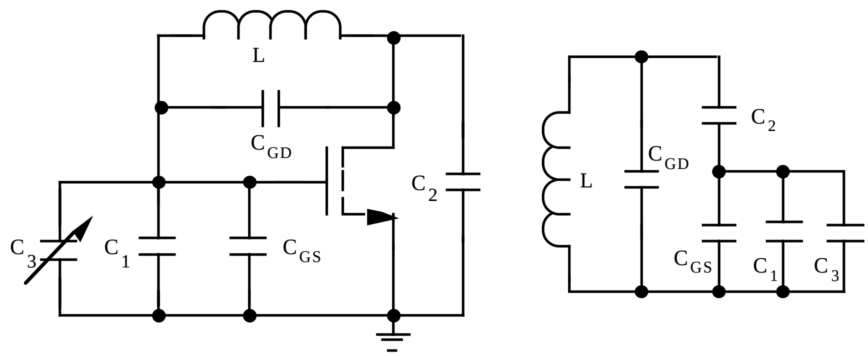
$$A_{V1} = \frac{\mathbf{V_{o1}}}{\mathbf{V_{o2}}} = -\frac{1}{sRC} \qquad \mathbf{V_{o2}} = \left(1+\frac{2R}{2R}\right)\mathbf{V_+} = 2\mathbf{V_+}$$

$(\mathbf{V_+} - \mathbf{V_{o1}})\frac{G}{2} + sC\mathbf{V_+} + (\mathbf{V_+} - \mathbf{V_{o2}})G_F = 0$ Combining these yields

$A_{V2} = \frac{\mathbf{V_{o2}}}{\mathbf{V_{o1}}} = \frac{G}{sC + \left(\frac{G}{2} - G_F\right)}$ and $T(s) = A_{V1}A_{V2} = \frac{1}{sRC\left(sRC + \frac{1}{2} - \frac{R}{R_F}\right)}$

$$\angle T(j\omega_o) = 0 \rightarrow R_F = 2R \quad \text{and} \quad |T(j\omega_o)| = 1 \rightarrow \omega_o = \frac{1}{RC}$$

4.) Problem 18.70 of the text.



$$C_{TC} = C_{GD} + \frac{1}{\frac{1}{C_2} + \frac{1}{C_1 + C_3 + C_{GS}}} = 4pF + \frac{1}{\frac{1}{50pF} + \frac{1}{50pF + 0 + 10pF}} = 31.27pF$$

$$f_o = \frac{1}{2\pi\sqrt{LC_{TC}}} = \frac{1}{2\pi\sqrt{(10^{-5}H)(31.27x10^{-12}F)}} = 9.00MHz$$

$$g_m r_o \geq \frac{C_1 + C_3 + C_{GS}}{C_2} = \frac{50pF + 0 + 10pF}{50pF} = 1.20 \quad \text{which is easily met.}$$

5.) Problem 12,123 of the text.