Homework Assignment No. 7

This homework assignment is due in class on Monday, July 7, 2003.

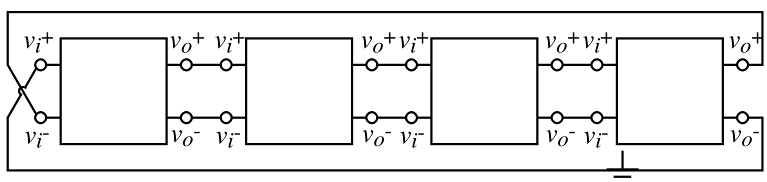
Problem 1 - (10 points)

A four-stage ring oscillator used as the VCO in a PLL is shown. Assume that M1 and M2 are matched and M3 and M4 are matched. Also assume that

$$g_m = \sqrt{2K'\frac{W}{L}I_D} \qquad \text{where } K'_N = 100\mu\text{A/V}^2 \text{ and } K'_P = 50\mu\text{A/V}^2$$

and that $r_{ds} = \infty$. The parasitic capacitors to ground at the outputs are 0.1pF each.

(a.) If I =2mA, find the frequency of oscillation in Hertz. (b.) Find the W/L ratio of M1 (M2) necessary for oscillation when I =2mA. (c.) If the current I is used to vary the frequency, express the relationship between ω_{osc} and I. In otherwords, find $\omega_{osc} = f(I)$.



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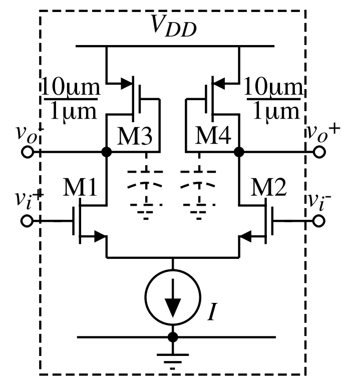
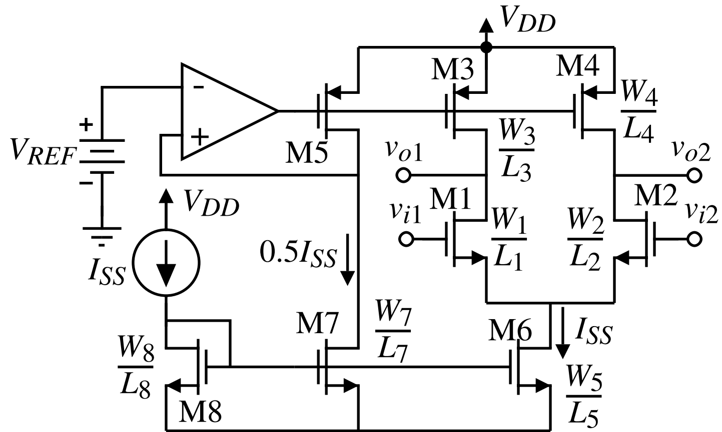


Problem 2 – (10 points)

How does the oscillation frequency depend on I_{SS} for a ring oscillator using the stage shown? Express your answer in terms of V_{DD}, V_{REF}, I_{SS}, the simple large signal model parameters of the MOSFETs (K', V_T, λ) and the W/L values of the MOSFETs.



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Problem 3 – (10 points)

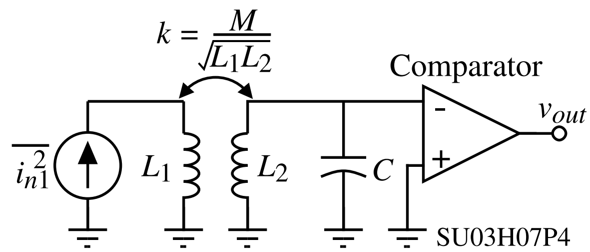
In every practical oscillator, the LC tank is not the only source of phase shift. Hence, the actual oscillation frequency may differ somewhat from the resonant frequency of the tank. Using the time-varying model, explain why the oscillators's phase noise can degrade if such off-frequency oscillations occur.

Problem 4 – (10 points)

Assume that the steady-state output amplitude of the following oscillator is 1V. Calculate the phase noise in dBc/Hz at an offset of 100kHz from the carrier from the signal coming out of the ideal comparator. Assume that L_1 = 25nH, L_2 = 100nH, M = 10nH, and C = 100pF. Further assume that the noise current is

$$\overline{i_{n1}^2} = 4kTG_{eff}\Delta f$$

where G_{eff} = 50Ω. The temperature of the circuit is 300°K.



Problem 5 – (10 points)

Find an expression for the value of R_n if k = 0.1 that will cancel the losses in the LC tank shown below. If f_{osc} = 1.8GHz, L = 4nH, $C_{total} = kC/(1+k)$ = 2pF and Q_L = 5 find the numerical value of R_n. What advantages or disadvantages would this LC oscillator have over the conventional LC oscillator?