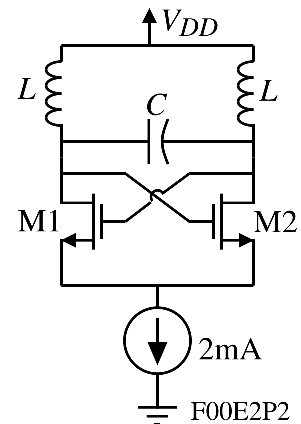
Homework Assignment No. 6

This homework assignment is due in class on Friday, June 27, 2003.

Problem 1 - (10 points)

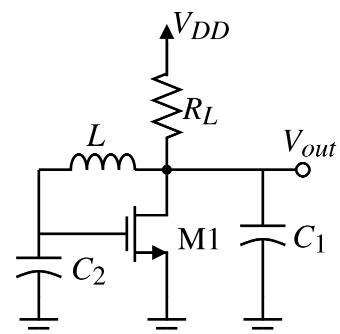
An LC oscillator is shown. The value of the inductors, L, are 5nH and the capacitor, C, is 5pF. If the Q of each inductor is 5, find (a.) the frequency of oscillation, (b.) the value of negative resistance that should be available from the cross-coupled, source-coupled pair (M1 and M2) for oscillation and (c.) design the W/L ratios of M1 and M2 to realize this negative resistance.



F00E2P2

Problem 2 - (10 points)

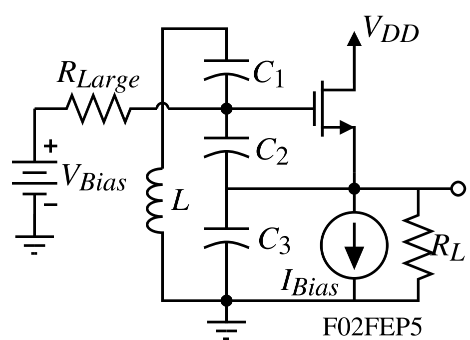
An LC oscillator is shown. Find an expression for the frequency of oscillation and the value of g_mR_L necessary for oscillation. Assume that the output resistance of the FET, r_{ds}, can be neglected.



F99E2P4

Problem 3 – (10 points)

A Clapp oscillator which is a version of the Colpitt's oscillator is shown. Find an expression for the frequency of oscillation and the value of g_mR_L necessary for oscillation. Assume that the output resistance of the FET, r_{ds}, and R_{Large} can be neglected (approach infinity).



F02FEP5

Problem 4 – (50 points maximum)

The objective of this problem is to use passive LC tank and negative feedback circuit to design an LC oscillator that meets the GSM specification. At first, show the condition that the ideal circuit oscillates at $\omega_{osc} = \frac{1}{\sqrt{LC}}$ and find quality factor, Q. The transistors should be modeled with the standard small-signal model using g_m and r_{ds} or r_{out} in this part of the problem. Second, use SPICE to obtain a transient simulation. Third, simulate the oscillator that replaces the ideal inductor with the lumped inductor model shown, and use the program referenced below [1] to layout the inductor. Use the model parameters given in [2] for this problem.

Fig.1. Ideal LC VCO

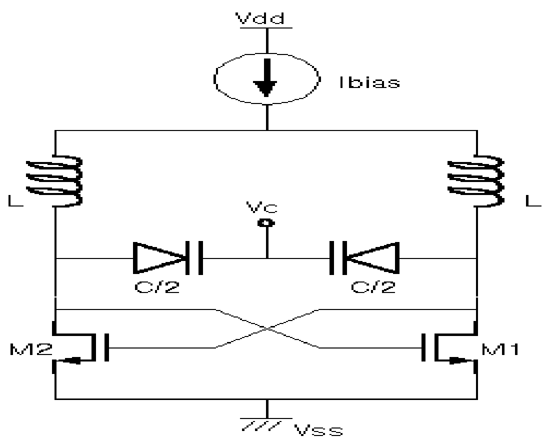
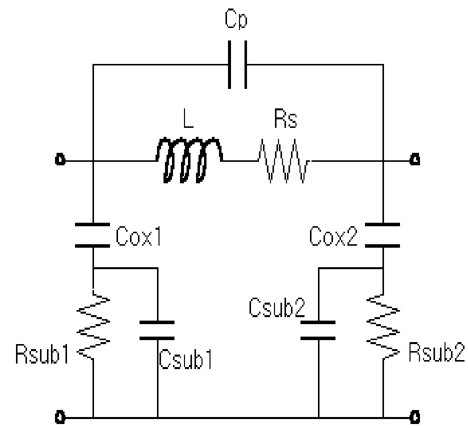


Fig.2. Lumped Inductor Model



GSM specifications:

Frequency range = 935 ~ 960MHz v_c = 0.75 ~ 1.75V

Switching time = 800µsec V_{DD} = 2.5V

Technology parameter:

Metal sheet resistance = 35 mΩ/sq.

Substrate layer resistivity = 0.015 Ω-cm

Metal to substrate capacitance = 5.91 aF/µm^2

Metal to metal capacitance = 98.0 aF/µm

C_{sub}, R_{sub}, C_p can be ignored

The score on this problem is calculated by you, the student, as follows:

$$\text{SCORE} = 15*\text{Min}[g_m r_{out}, 1] + 10*\left[\frac{\text{Frequency Range}}{25\text{MHz}}, 1\right] + 15*\left[\frac{90{,}000\mu\text{m}^2}{\text{Inductor Area in } \mu\text{m}^2}, 1\right] + 10*\left[\frac{1\text{mA}}{\text{Supply Current}}, 1\right]$$

All entries in the above formula must be from simulation. $g_m r_{out}$ are the transistor small signal values determined from simulation. The "inductor area" is a rectangle that encloses the inductor.

References

1.) Web site: www-smirc.stanford.edu/spiralcalc.html

2.) Hspice technology file: ftp://ftp.mosis.org/pub/mosis/vendors/tsmc-025/t17b-params.txt