EE526 Project
LC VCO

1. Design the LC VCO in Fig. 1 to give an oscillation frequency of 1Ghz around the middle of the VCO tuning range.
    a. Use Vdd=1.8V, Rs=4ohms, Iss=400uA. For Iss, you can use an ideal current source; there is no need to use a current mirror.
    b. You can form the varactor by using a regular NMOS transistor. You tie both the drain and source together to form one terminal of the varactor ; the gate is the other terminal. You can tie the body of the NMOS varactor to the drain/source terminals (we are assuming that the varactor is available on a separate substrate). The characteristics for a varactor of size W=50u, L=10u is shown in Fig. 2 (C_{GS} vs V_{GS}). The C_{GS} is in pF and V_{GS} in volts. Remember that the varactor capacitance depends on the area (W*L) of the transistor.
    c. Your common-mode output voltage, Vo,cm, should be between 0.45V to 0.65V. (See Fig. 3 on how to find Vo,cm from your waveform).
    d. Your VCO should have a tuning range from 0.6V to Vdd for Vcont. It should give a frequency of 1Ghz near the middle of the tuning range.
    e. As a start, you can assume Lopt=12nH and varactor size of W=50u, L=10u. You can then fine tune them to get the desired results.
    f. When running your transient simulation, use a 'Stop time' of 1000/BR and 'Maximum timestep' of 0.1/BR, where bitrate (BR) = 1Gbit/s. (Note that when we specify an expression in spice, we need to enclose them in {} brackets).
    g. Note that although you can measure the frequency by first measuring the period using the LTspice cursors and taking the inverse, an alternate way is by using FFT. To do FFT, zoom in on the steady-state portion of the waveform (showing at least 10 cycles of oscillation), right click on the waveform, choose 'view', 'FFT', select 'Use current zoom extent', and click 'ok'. This will show you the FFT, i.e. spectrum, of the waveform. The highest peak of the spectrum represents the fundamental frequency of your waveform.
2. Specify the values for Lopt, $W/L_{1,2}$, and the size of the varactors (M3, M4) for your design.
3. Include a plot of Vo1 at 1Ghz (zoom in on the waveform *near the simulation end* so that we see only around 5 cycles of oscillations). Specify the Vcont to obtain this frequency and the Vo,cm.
4. Include a print-out of the schematic and netlist in your report.
5. Find the VCO frequency for different values of Vcont between 0.6V to Vdd. Get at least 6 data points (3 below 1Ghz, 3 above). Plot the VCO frequency vs. Vcont (you can plot by hand or use Excel or some other software). Include this plot in your report.

** Reminder: Don't forget to change the prefix of the MOSFETs in your circuit, as mentioned in part4 of "Getting started LTspice.txt".

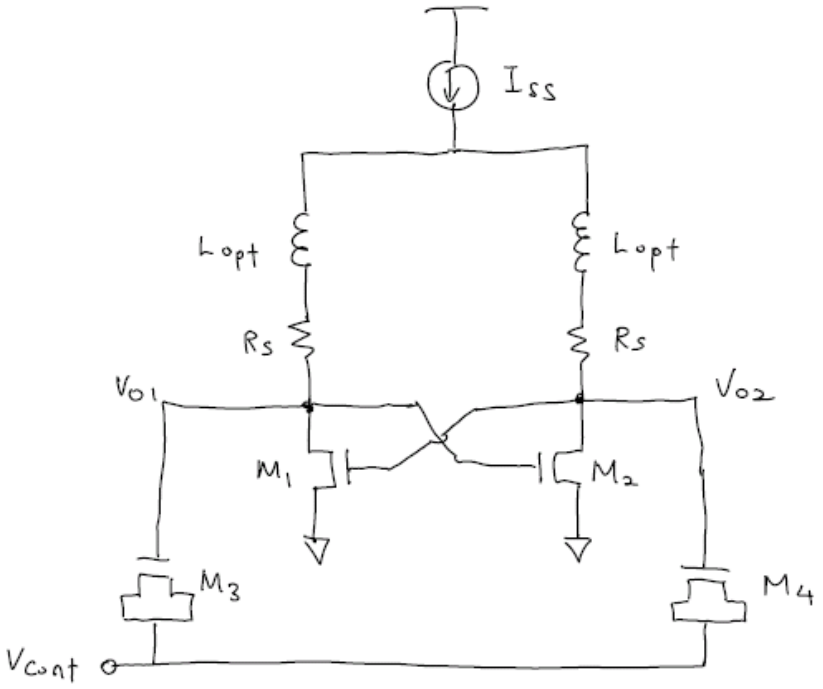

Fig.1 – LC VCO

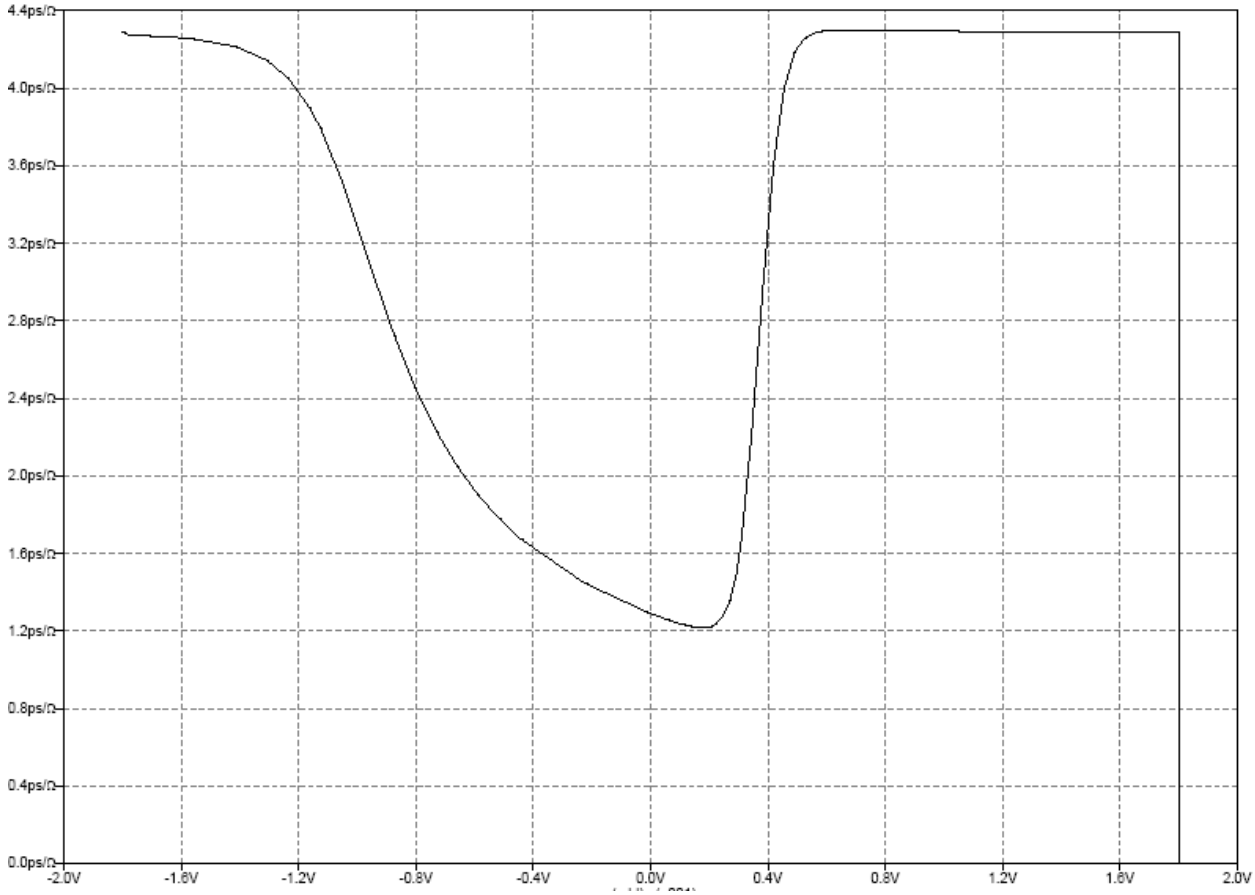

Fig.2 – Regular NMOS varactor characteristics C_{GS} (pF) vs V_{GS} (volts), size:W=50u, L=10u

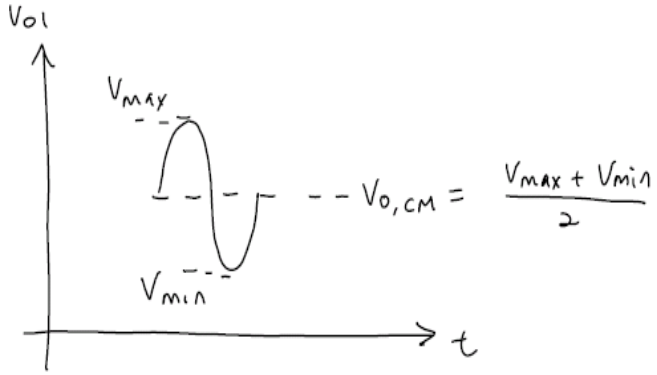

Fig.3 – How to determine Vo,cm