Integrated Radio Electronics

Laboratory 2: Voltage Controlled Oscillator

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Introduction

In this laboratory you will verify your design of the low noise amplifier in hand in exercise 2. You will also learn to simulate phase noise with GoldenGate.

It is very important that you have done hand in exercise 2 **before** attending the laboratory!

Getting started

```
cd rfic2010
inittde ana2009
icfb &
```

Create Library and Schematic

First a schematic view must be created:

- Create a schematic cellview in the RFIC_Labs library, call it 'VCO'
- Draw the schematic according to the hand in assignment, and put in all component values you have calculated. Use transistor N_12_HSL130E from library umc130mmrf. Use ideal inductors 'ind' from analogLib. The Q value of the inductor can be set by putting a resistor in parallel (or in series) with the inductor.
- Put vdc sources to bias the inputs

Simulations

- Run a DC analysis and check if the bias points agree with your calculations. If the deviation is large, modify the schematic until you get the right bias currents and voltages.
  Hint 1: You can view the DC voltages and operating points using Results->Print or Results->Annotate, try both.
  Hint 2: Use options in the Choose analysis form, type DC in the Outfile prefix. This makes DC analysis results accessible to other analyses.
- Put an oscillator probe between the two differential output terminals.
  Outputs -> 'GoldenGate Probes' brings up the Virtual Probe Editor
  Tick the oscillator button
  Call the probe 'output'
  Select and click the two nodes in the schematic
  Click the Add button
  Save the changes using Design->Check and Save.
- Double click the DC analysis to bring up its form
  Click the Stability button
  Click the Eigenvalue Computation button
- Run the simulation
- In Golden Gate Results, DC
  Click the Stability button, then click Table
  Is the circuit stable or unstable?
  If unstable what is the oscillation frequency predicted?
- Analysis -> Choose, the click on CR
  In the choosing analysis form:
  Fundamental Frequency: Enter the value found in the DC analysis
  Oscillator Analysis = ticked
- Run the simulation
- Investigate the results (found under Golden Gate Results)
  A plot of the spectrum of output.v should be included in the lab report
- Also investigate the voltage waveform
- Now make a control voltage sweep:
  Set the DC voltage at the control input to a variable
  Check and Save
  Variables -> Copy From Cellview
  Set the variable to 600 mV
  In the CR Analysis, click the Specification Variable button
  Select the variable you just created
  From=0 To=1.2 Linear Step=0.05
  Run the simulation

- In the Golden Gate Results, tick Osc. Freq and Plot
- Is the tuning range as expected?
- If not tune the size of the varactors and/or the inductors and/or add additional capacitors until the frequency is as expected.
- **A plot of the tuning characteristic should be included in the lab report**
- Now phase noise should be simulated:
  In the CR analysis, unclick the Specification Variable, and click the Compute Noise
  Select the probe called /output
  Range From=10k To=10M Log Steps Pts/dec=10
  If not already clicked, click Compute NCT, this will allow you to see contributions from different noise sources
- Run the simulation
- Check the results in Golden Gate Results. Click Noise and select Tone (1 0 0), the fundamental Click plot
- Try to change the number of harmonics in the CR analysis and see if the result changes
  To get an accurate result the number of harmonics should be increase until the result does not change any more. How many harmonics are needed depends on the circuit. If it generates square wave like voltages and currents many harmonics are needed.
- **A plot of phase noise should be included in the lab report**
- Check also the amplitude noise. Is it as large as the phase noise?
- Check the contributions of different noise sources:
  In the Golden Gate Results (CR), click Post Process and choose NCT, then click Plot
  You get three windows, look at the one called PM at the end (Phase Modulation)
- What noise sources dominate at low offset frequencies?
- What dominates at high?
- Is the oscillator good? Can it be improved?
- If you have time: Try a noise filter and inductive source degeneration of the current source
- Now enable click the Specification Variable in the CR Analysis form
- Run the simulation
- Study the NCT for the phase noise at 1MHz offset versus control voltage
  Hint: Don't simulate the noise in a full range, just at a single offset frequency of 1MHz
  You can also increase the step size in the control voltage sweep.

The lab report should contain all the plots indicated. It should also contain comments about the results and about what is seen in the plots.

Additional assignment:
The SpectreRF simulator is very well known and used by many companies. Repeat the simulations above. Instructions can be found in the lab manual from 2009, although for an older version of the simulator still valid in most parts.

Getting started with SpectreRF: See instructions for Laboration 1