Integrated Radio Electronics

Laboratory 3: Down-conversion Mixer

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Introduction

In this laboratory you will verify your design of the mixer in hand in exercise 2. You will also learn to simulate mixers with GoldenGate.

It is very important that you have done hand in exercise 3 **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 'Mixer'
- 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. Put 1pF capacitors from analogLib in parallel to the load resistors.
- Put vdc sources to bias the RF and LO 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.
- Insert one vpulse source from analogLib between the vdc source and each LO input, one source should be turned backwards
  Properties:
  DC voltage=0
  Voltage 1=150m
  Voltage 2=-150m
  Rise time=50p
  Fall time=50p
  Pulse width=200p
  Period=500p
  Frequency name for 1/period= fLO
- Analysis -> Choose, the click on CR
  In the choosing analysis form:
  Fundamental Frequency: 2G
  Number of harmonics: 5
- Save the node voltages, using Outputs->To Be Saved, and clicking in the schematic
- Run the simulation
- Investigate the voltage waveforms at the different nodes
- Increase number of harmonics in the CR Analysis to 10
- Run the simulation
- Do you see any difference in the waveforms, in that case why?
- **A plot of the waveforms should be included in the lab report**
- Now insert a psin source between the RF inputs. Also connect two **noiseless** 25Ω resistors in series between the RF inputs. Connect the node between the resistors to the vdc source setting the common mode input bias voltage.
- The properties for the psin:
  Frequency name=RF
  Number of Frequencies=0
  Resistance=50
  Port Number=1
  DC Voltage=0
  Source type=sine
  Amplitude(dBm)=pRF
  Frequency=fRF

- Set the two design variables:
  pRF=-40
  fRF=1.8G
- Create two Golden Gate Probes (Outputs ->Golden Gate Probes)
  One voltage probe between the RF inputs called ‘input’
  One voltage probe between the IF outputs called ‘output’
- In the CR Analysis:
  Fundamental Frequency=200M
  Number of Harmonics=100
  Click the Specification Variable button, and choose Range from -60 to 8 step 4
  Create a performance: Voltage_Gain_dB=20*log10(output.v(1, 0, 0))-20*log10(input.v(9, 0, 0))
- Investigate the results (found under Golden Gate Results)
  A plot of Voltage_Gain_dB vs. pRF should be included in the lab report
  Locate the 1dB input referred compression point in the plot
- Set up an IP analysis:
  IP Rank=3
  Input Source: Select the Port at the RF input
  Output Probes= /output
  Input Freq1=1.791e9 (avoid to even numbers)
  Input Freq2=1.804e9
  Large Signal number of tones:1
  LO frequency=2.0e9
  No. of LO Harmonics=10
  LO Harm. Mixing Index=1
  Click the Diff button
- Run the simulation
- From the Golden Gate Results, plot the power sweep
  Note the values of IIP3 and OIP3
  The plot should be included in the lab report
- Now set up an SSNA analysis to find small signal gain and noise performance:
  No. of Tones=1
  Fundamental Freq. = 2.0e9
  Number of Harmonics=10
  Input Frequency (Hz) (Tone2)=fRF
  Input source: Select the port connected to the input
  Output Probe=/output
  Output Frequency Index (m, n)=(-1,1)
  Click the Specification Variable button:
  Variable Name=fRF
  Range From=1.5G Linear To=2.52G Step=51M
  Click the buttons: Compute Noise, SSB, Compute NCT and Spot Noise

- Run the simulation
- Plot voltage gain versus frequency
  This plot should be part of the lab report
- Plot noise figure vs. frequency
  This plot should be part of the lab report
- Investigate the NCT
  What is the dominating noise source?
- Try to simulate noise when the RF is close to the LO frequency (2GHz).
  What causes the increased noise figure? Hint: Check the NCT

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