Project 2

ECE 5/413 – RF IC Design

1 Problem Statement

Mixer Design: After the LNA design, your manager chooses to entrust you with the 28GHz downconversion mixer design for the upcoming project. Typically an LO synthesizer with tunable frequency is used to cover the entire 26.5-29.5 GHz band with a fixed IF frequency. Here, we assume fixed LO and RF freqeuncies for simplicity. The Mixer should meet the following specifications in the 90nm CMOS technology:

Table 1: Mixer design specifications.

Parameter	**Value**
Technology	90nm CMOS
Supply voltage, V_{DD}	1.2V
f_{RF}	28 GHz
f_{IF}	**2 GHz**
Conversion Gain (G_c)	$> 6dB$
SSB NF	$< 28dB$
IIP_3	$> 0dBm$
On-chip load (low pass filter)	$100fF$
FoM	Maximize

- Ideal inductors are not allowed in the final design. Use the scalable inductor model provided on the server. The models are usually extracted using an electromagnetic simulator.

2 Report

Submit your neatly typed report as a **PDF** file (*Lastname_ECEx13_Project2_Report.pdf*). The report will include:

- Neatly drawn schematics with transistor sizes, bias currents, inductors and their equivalent circuit.

- Copy the testbenches (/home/vsaxena/rficdesign/Mixer90nm) provided by the instructor. You also need to define the library $CDSHOME/tools/dfII/samples/artist/rfLib in your cds.lib file in the ECE513 directory.

- Simulation results of the main specification parameters at $25°C$ with 1.2 V supply. Follow the guidance from [1, 2] (with the values for f_{RF} and f_{IF} specified in this project). In your report, include the following simulations:

  - Demonstrate the downconversion operation of the mixer using transient simulation. You may use the calculator function "frequency' to estimate frequency of the IF output signal. You may want to observe the operation for several power levels for RF and LO inputs.
  - Voltage Conversion Gain versus the LO Signal Power (swept PSS with PAC)
  - Voltage Conversion Gain versus RF Frequency range of 26.5-29.5 GHz (PSS with swept PAC)
  - Port-to-Port Isolation between LO-to-RF, RF-to-IF, and LO-to-IF (PSS, Swept PAC and Swept PXF).
  - S-parameter analysis (PSS and PSP). Plot S_{21}, S_{31}, S_{23}, S_{31}, S_{13}.
  - Noise-Figure (PSS and Pnoise)
  - 1dB Compression, IIP3 and IIP2 (QPSS & QPAC).
- Show the overall Mixer design performance with the $FoM = \frac{G_c \cdot IIP_3 \cdot IS_{LO-RF} \cdot f}{(F_{SSB}-1) \cdot P_{DC} P_{LO}}$ in a neatly tabulated manner along with the conclusion.

You can download the Visio schematic symbols from the course website [3]. Provide relevant references in your report.

3 Academic Honesty

You are expected to come up with your original design schematics. No circuits can be shared or copied from other student(s).

4 Grading Scheme

Design choices and justification 30%

Functionality and performance 30%

Design characterization and presentation of results 30%

Report presentation and clarity 10%

References

[1] T. Johansson, "Gilbert mixer simulation using Cadence SpectreRF," RF IC Design 2018, Linkoping University [Online].

[2] Cadence SpectreRF Workshop: Mixer Design Using SpectreRF [Online].

[3] Visio Schematic Symbols. Available [Online].

[4] IEEE Transactions Template. Available [Online].