EE6320 Project 2: Mixer Design

In this project, you are asked to design a fully-differential double-balanced Gilbert-cell mixer with I and Q outputs to be used in a direct-conversion receiver, that meets or exceeds the specifications given below. The basic circuit topology should be the active gilbert cell mixer discussed in class. However, you can modify it with circuit techniques to improve its performance, as long as you support it with analytical and simulation results. The baseband (BB) should have at least a 1-pole response as per the below specifications. Use the TSMC 0.18 μm CMOS process parameters supplied to you through the class website. There are two sections in this project:

(a) In this portion of the project, design the mixer for the following specs:

- f_{LO} range is 3.4 to 3.6 GHz
- RF BW of desired signal = 20 MHz (i.e. Baseband BW = 10MHz). This means that f_{RF} occupies the spectrum f_{LO} ± 10MHz for a given f_{LO}. Maximum 3dB droop allowed at +10MHz at BB.
- In your simulations, set $f_{RF} = f_{LO} + 10$ MHz so that baseband sinusoidal outputs are at 10MHz.
- $V_{DD} = 1.8V$
- Mixer conversion gain > 15dB
- SSB NF ≤ 9dB (Integrate BB output of mixer from 1 kHz to 10 MHz)
- IIP2 ≥ +40dBm; use two tones at 3500 MHz and 3501 MHz and apply a systematic mismatch of 0.1% between all devices (active or passive) in the two differential halves
- IIP3 ≥ -5dBm; use two tones at 3500 MHz and 3501 MHz
- Minimise power consumption
- Try to maintain the input capacitance of the mixer to be lower than the total fixed capacitance at the LNA output in project 1. If it turns out to be larger, you may need to change the LNA drain inductor for section (b) below. If it is smaller, you can add a fixed ideal capacitance to set the resonance at LNA output to the original value.

(b) Now, combine the mixer from (a) above with the LNA you designed in Project 1. Determine the overall Gain, NF and IIP3 and compare your results to hand calculations.

Note 1: No ideal inductors are allowed! Add a resistor in parallel with each of the inductors in your circuit (if any) so that it has a Q of 15 at 3.5 GHz. All capacitors can be assumed to be ideal.

Note 2: It is expected that the IM2 and IM3 curves be well-behaved with normal linear behaviour at low power levels and gain compression at high powers. Some gain-expansion is ok (say ~1dB), but too much is not good. Make sure your IM2 and IM3 curves do not have any unexpected non-linearities at lower power levels. Choose the extrapolation point carefully.

Note 3: Include and discuss the expected characteristics of the LO waveform in your report