2.4 GHz Ultra-Low Power Receiver Front-End

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Abstract
This project focuses on the design of an ultra-low power receiver front-end potentially for biomedical wireless sensor systems with the following major characteristics: low noise, high gain, and high center frequency of the receiver is 2.4 GHz, which is also adopted to Bluetooth application.

Motivations

Low Noise Amplifier (LNA)
We use current-reuse topology for LNA as the following figure. Current-reuse lowers the power consumption and achieves noise matching with the source degeneration of each stage. Multiple stages provides a sufficient voltage gain, but the current-reuse cause poor linearity. To improve linearity effectively, a large current is provided. Therefore, we make the size of M₂ and M₃ up to 175 μm/2.18 μm.

Down Conversion Mixer
Two multiple-gated NMOS transistors with different aspect ratios are applied to improve the linearity of the mixer under such extreme bias conditions. Adopting folded-cascode lowers the voltage headroom to ensure that the transistors operate in saturation region. Using differential pair of M₆ and M₇ can lower the affect of noise. A 2.4 GHz input signal and a 2.39 GHz carrier signal from LO are applied to the mixer. After mixing the 2.4 GHz signal and the 2.39 GHz LO, there will be a 0.01 GHz intermediate signal (IF).

Simulation
Cadence Spectre is the software that we used in this project. S-parameter, periodic steady state (PSS), and DC analyses are used to simulate the following parameters: input return lost (S₁₁), output return lost (S₂₂), voltage gain (S₂₁), stability factor (kₙ), noise figure (NF), and P₁dB (linearity). The results are shown in the following figures.

"Result of the simulation"

Conclusion
After simulation, we obtain much better results of S₁₁ and S₂₂ than we expected. The circuit is unconditionally stable with kₙ = 2.3. Due to the addition of the capacitor C, which is in parallel with Cgs for better input matching, the voltage gain is slightly decreased.

"Result of the simulation"