Noise and Interference Modelling for WLAN

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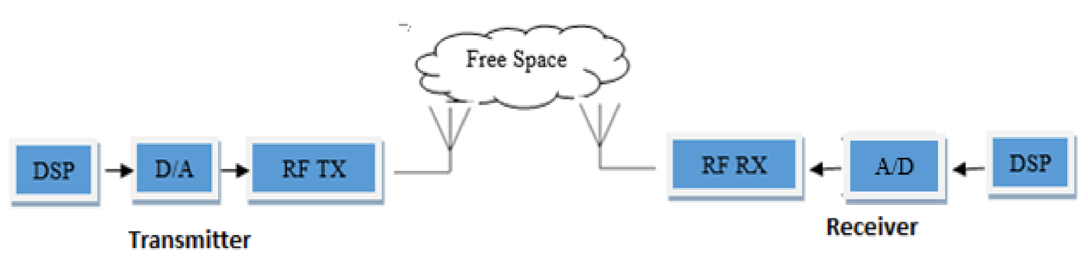
Introduction

Wireless communication systems are heavily being used in present days. These systems could be utilized in different type of communication applications that can be access by any person or any place in the world. These systems have to overcome different types of deficiencies in the channel, receiver, and transmitter.



This project will simulate different types of RF frontend architectures along with individual RF frontend components to estimate vigorous parameters to reduce noise, interference, distortion of the WLAN receiver, and design optimal Low Noise Amplifier (LNA) for this application.

LNA design have low sensitivity because it's transfer low power signal received from the antenna to the next stage with added power gain and minimum noise. The signal coming from the antenna is constantly varying, so the linearity of the LNA is critical. Some of the important characteristics, which is important for LNA in WLAN receivers, are input and output return loss, forward gain, VSWR, linearity, and power consumption. Matching plays a very important role in the design of LNA for maximum power transfer.

Methodology

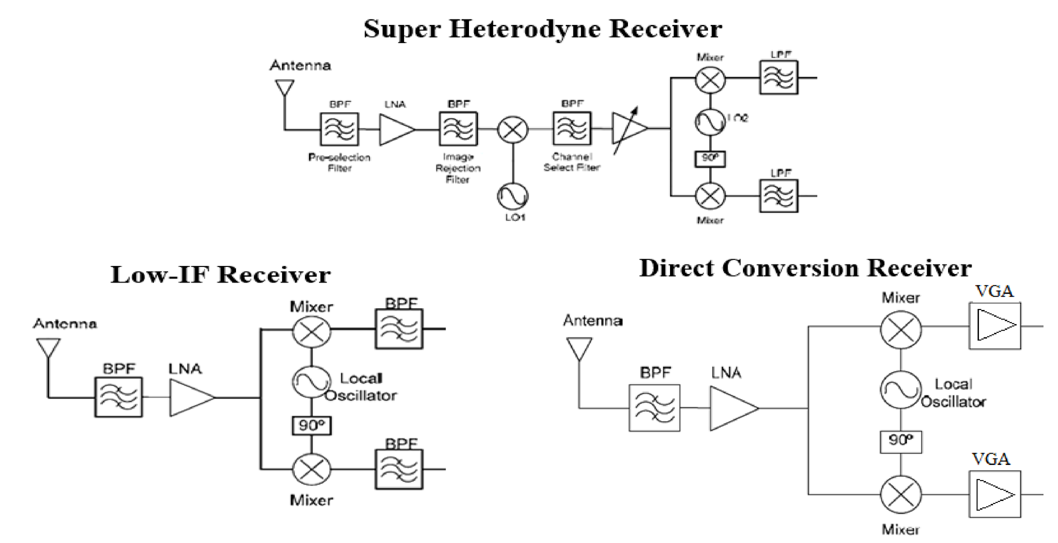
Model different type of receiver architectures in Matlab Simulink to analysis the noise, interference, and distortion due to the each components such as filter, LNA, Mixer, LO, and VGA. The noise will be measured at the frontend of the receiver and will keep all the other parts constant in the analyses since the interference is greater after the Mixer.

Simulink functional blocks will be identified with in the receiver to create robust models to complete the analysis. Simulated 802.11 RF signal will be sent through the receiver to measure noise, interference, distortion effect.

The system will display input and output RF signal with the noise, interference, and nonlinearity due to each model. It is well known that LNA of the receiver will have nonlinear effect and there will be interference after Mixer of the WLAN receiver architecture.

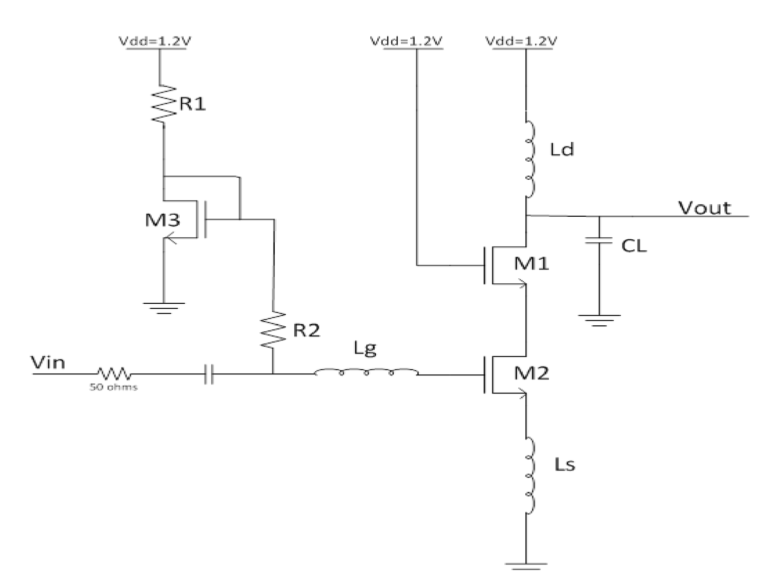
Methodology

Following receiver architectures below will be utilized to analyze this behavior.



Designing a LNA is a logical procedure and the components have to be tuned carefully to meet the required specification. The designing a Cascode amplifier was chosen since it provides good isolation, high gain, and linearity.

Following is the schematic of the Cascode amplifier



LNA design methodology starts with choosing the quality factor by the following equation

$$Q = \frac{1}{C_{gs} * R_S * \omega}$$

One has to keep in mind that as the size of the transistor increases, the quality factor decreases. The width of the transistor can be calculated using the following equation.

$$W_{M1} = \frac{3}{2 * Cox * L * Q * Rs * \omega_0}$$

The g_m of the transistor.

$$g_m = \sqrt{2 * \mu_n * Cox * \left(\frac{W}{L}\right) * Id}$$

Using the value of gm, the unity gain frequency can be determined which will lead us to estimate the Noise figure of our design.

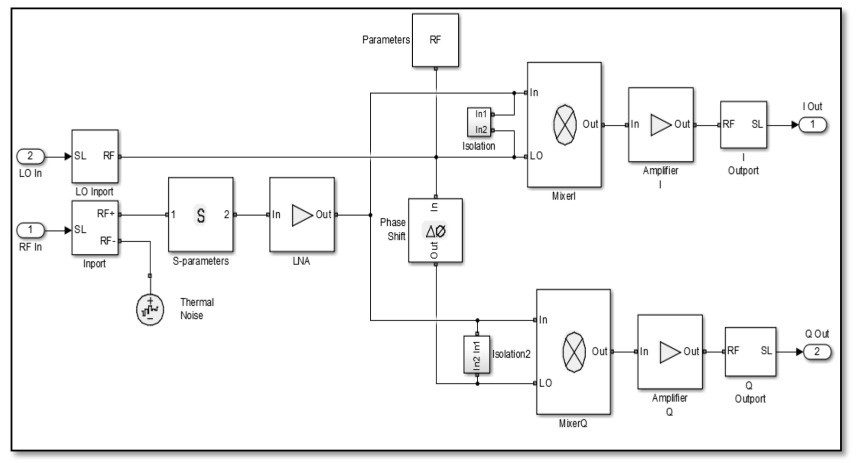
$$NF_{min} \approx 1 + 2.4\frac{\gamma}{\alpha}\left(\frac{\omega_0}{\omega_T}\right) \geq 1 + 1.62\left(\frac{\omega_0}{\omega_T}\right)$$

It is very critical to note that as the drain current increases, ω_T increases, which leads to decrease in Noise figure.

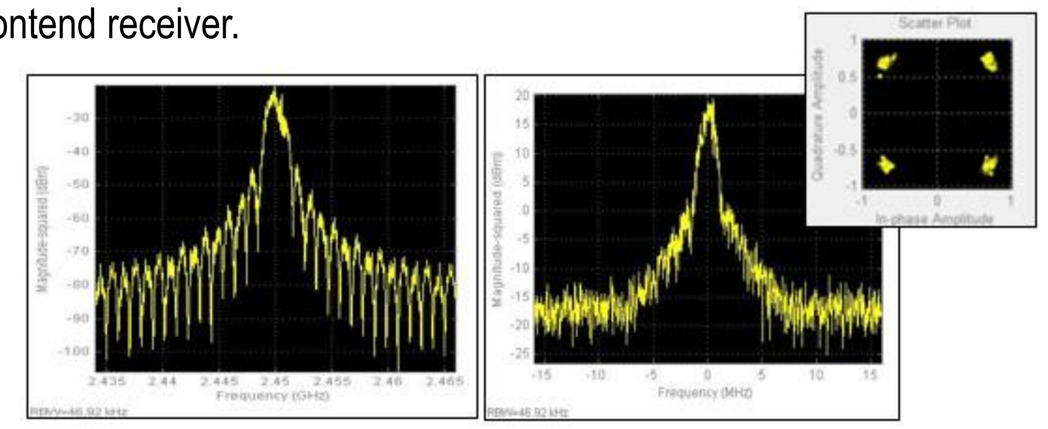
The size of the transistor has to be increased in order to increase the current (I_d). This will lead to higher power consumption. Thus, it will have to tradeoff I_d with Noise figure.

Results

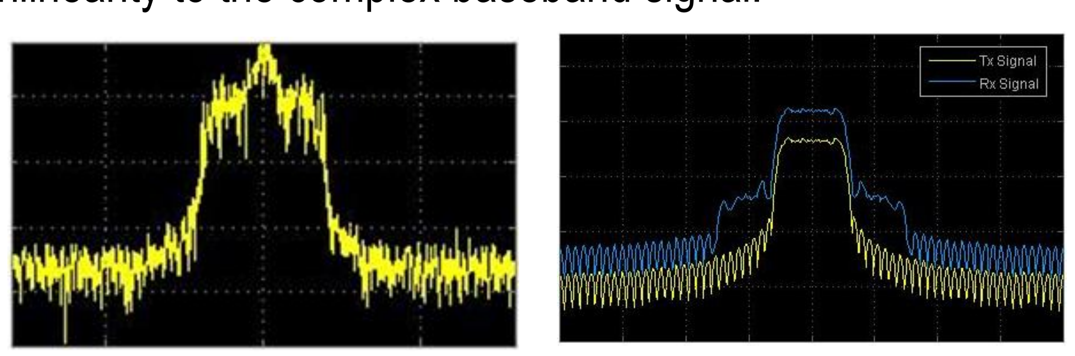
The model below is constructed by using SimRF library components. This will convert Simulink data into RF signal for both incoming RF signal and oscillating signal. The RF signal will go through a band pass SAW filter and LNA before entering into Mixer/LO to perform the down conversion. During this stage, the RF signal will be split into in phase and quadrature components. Next, the RF signal get amplified using variable gain amplifier and the signal will convert to Simulink data for further analysis.



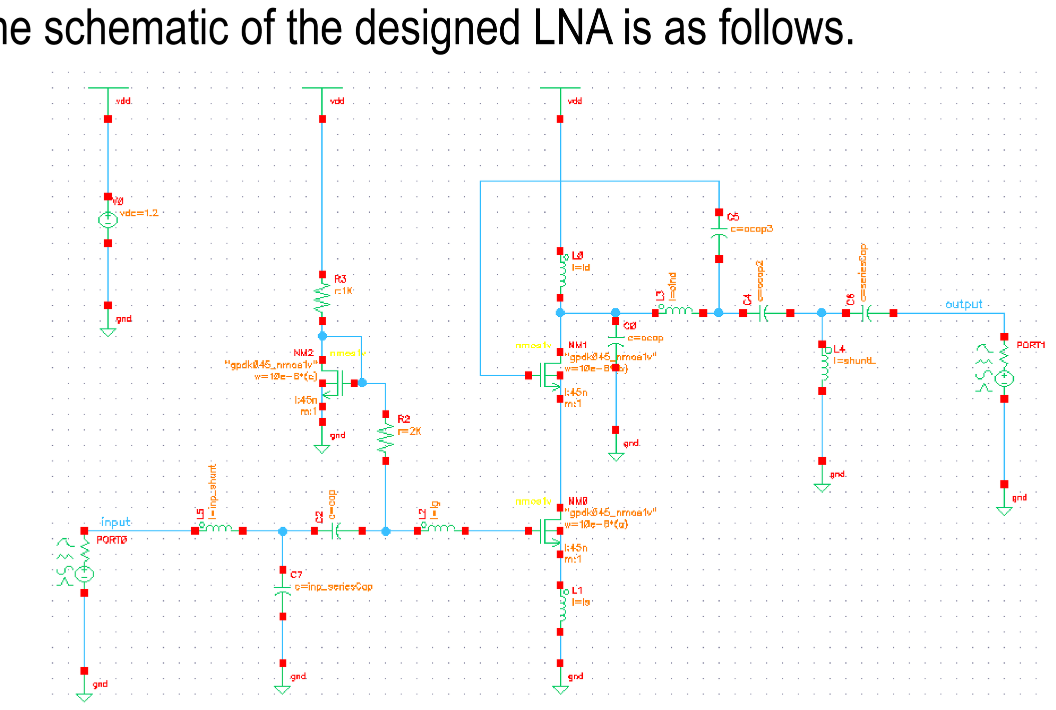
Optimized Simulink RF models to improve the performance of the frontend receiver.



The following results were obtained by adding memoryless nonlinearity to the complex baseband signal.

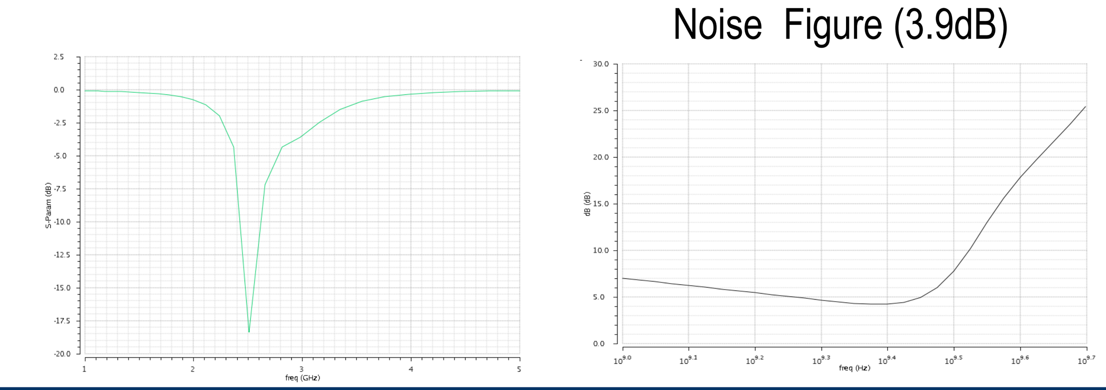


The schematic of the designed LNA is as follows.



S11 reflects the input matching of the LNA (input reflection coefficient). We were able to achieve approximately -18dB for return loss. The lumped T matching network at the input was carefully tuned to achieve this result.

Noise Figure (3.9dB)



Summary

This project is divided into two major sections. The first section was modeling different architectures of WLAN receivers to reduce noise, interference and distortion and then proposed a topology to design a Low noise amplifier by analyzing its performance. During this process, 2.4 GHz LNA was tuned to input and output matching network, so it will be stable and operate at the desired frequency

Key References

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