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Research Article

Performance Comparison of Various Low Noise-High Speed Amplifier Topologies for GPS Applications

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Abstract

The low noise high speed amplifier is the key component in any receiver system. In receiver front-end, low noise amplifier plays an important role in GPS applications. This paper presents the comparison of various topologies of LNA depending on performance analysis. Cadence design suite is used for the analysis of various LNA topologies. A 0.18µm CMOS technology is used to design and analyse the LNA topologies. In this, two main LNA topologies namely single ended LNA and inductive source degenerated LNA are designed and by adding the vital features of both topologies, we designed LNA for better performance. All LNA's are analysed for GPS frequency of 1.57GHz. The LNAs are compared for performance analysis using several parameters like noise figure, S- parameters and gain. In this paper, we compared the topologies with circuit diagram and the parameters mainly noise figure.

Keywords: *LNA (Low Noise Amplifier), CMOS, GPS, Noise Figure.*

1. Introduction

As the market of wireless communication increasing rapidly, the designing of low noise amplifier becomes vital part on which whole receiver performance depends. In the radio frequency front end devices, the RF signals received from the antenna are fed to the low noise amplifier which amplifies the very weak signal received. Low noise amplifier must amplify so that the other components in the receiver like mixer do not degrade the signal by their noise. As the signal received at the low noise amplifier is possibly very weak so the LNA with extremely low noise figure is required. In addition, the LNA must exhibit a large gain to suppress noise from subsequent stages. Thus to satisfy these requirements, the LNA must be designed accordingly to fulfill the necessary conditions for better performance of receiver.

In this paper, we are using 0.18µm CMOS technology in cadence design suite to design LNA. We are designing LNA for GPS applications with frequency 1.57GHz. In this paper, we present three main topologies of LNA for performance comparison. In these three topologies, first is basic topology which is single ended LNA used mainly for cascading various LNAs in series in order to achieve the high gain. Second is inductive source degenerated LNA for low noise figure. As both high gain and low noise figure is essential, third is designed by taking the advantages of both topologies to get the better performance results. The LNAs are then simulated using spectre for doing S- parameter analysis and noise analysis. Again mainly gain analysis is also done to note different gains like voltage gain, power gain and current gain. After simulation, results are compared for performance analysis.

2. Single Ended LNA

A single ended LNA design for GPS frequency 1.57GHz is shown in figure 1. This LNA is commonly used in cascading to achieve high gain. Single ended LNA is having very simple structure with very few components. Due to fewer components, this LNA consumes very less die area.

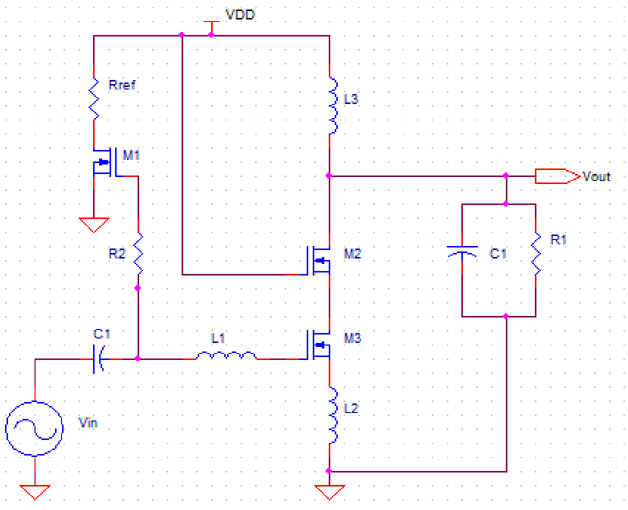

Figure 1: Single Ended LNA

As the input to LNA received from antenna is very weak, input voltage is 6µV with 50Ω input impedance. The

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values of components are taken using matching condition equation. By taking the values according to matching equations of input impedance and input frequency, LNA is simulated using cadence spectre. With supply of 1.3V at 1.57GHz, LNA is simulated for finding S- parameters, gain and noise figure.

After the simulation, the results are shown below as s-parameter response, noise response in which mainly focuses on noise figure. In s- parameter response, S_{11}, S_{12}, S_{21} and S_{22} are plotted. Here, S_{21} is forward gain, S_{12} is reverse gain, S_{11} and S_{22} are reflection coefficients. These are shown as follows in figure 2.

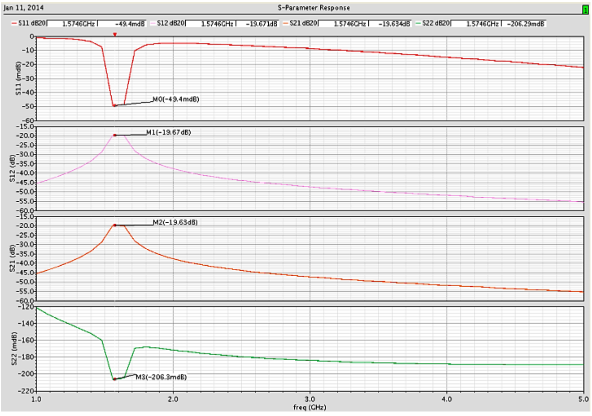

Figure 2: S- parameter Response

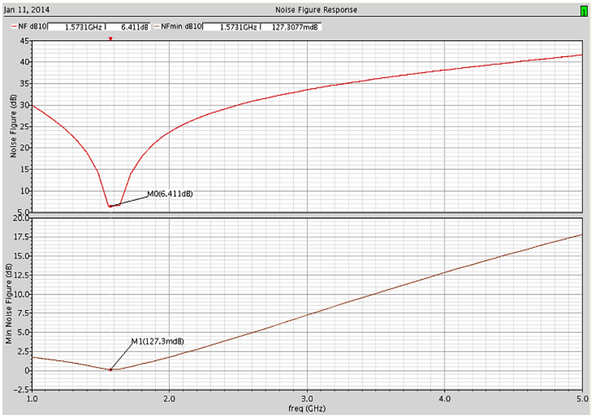

Figure 3: Noise Figure Response

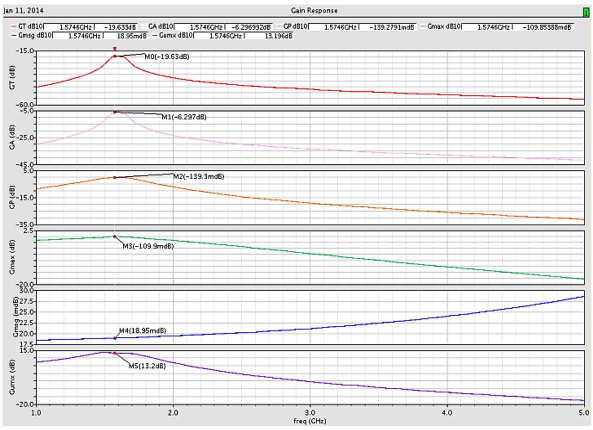

Figure 4: Gain Response

In noise response, noise figure and minimum noise figure are shown. In this mainly noise figure is considered as best for indicating noise which is shown in figure 3.

In gain response, various gains are represented as G_T (Transducer Gain), G_A (Available Gain), G_P (Power Gain), G_{max} (Maximum Power Gain), G_{msg} (Maximum Stable Power Gain), Gumx (Maximum Unilateral Power Gain) as shown in figure 4. From these three main responses shown, we can analyze the performance of LNA.

3. Inductive Source Degenerated LNA

Inductive source degenerated LNA for GPS applications at GPS frequency 1.57GHz is shown in figure 5. This LNA topology is mainly used to reduce the noise figure so that we could get the maximum SNR. Inductive source degenerated LNA is derived from single ended LNA to improve the noise figure. As we know that each component generates noise, but minimum noise figure is preferred to avoid the signal degradation.

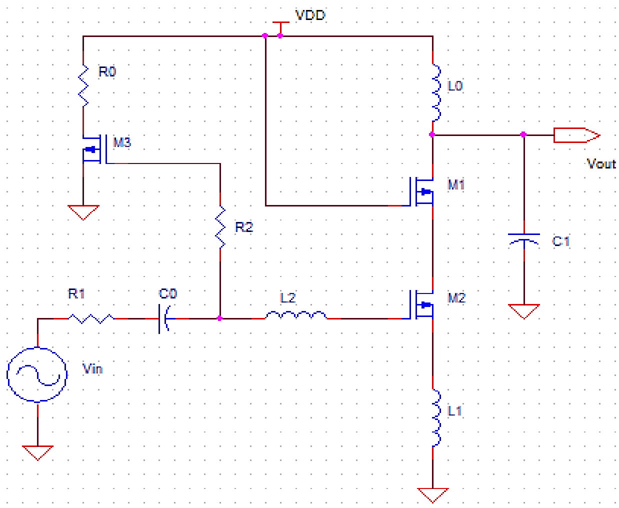

Figure 5: Inductive source degenerated LNA

The simulation results for inductive source degenerated LNA are shown as follows indicating S-parameter response, noise response and gain response in figure 6, figure 7 and figure 8 respectively.

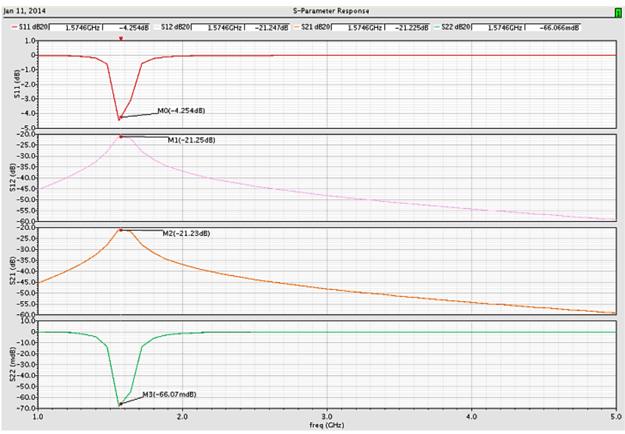

Figure 6: S-parameter Response

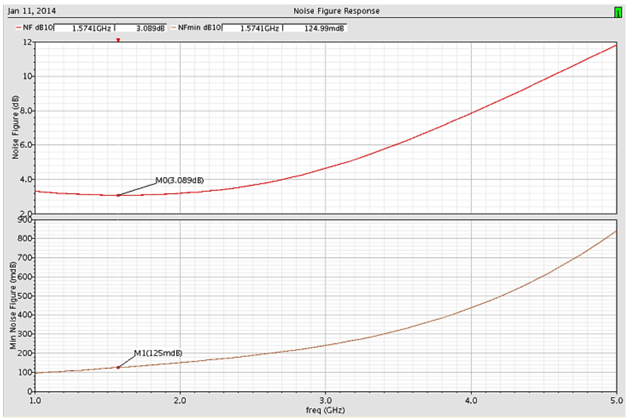

Figure 7: Noise Figure Response

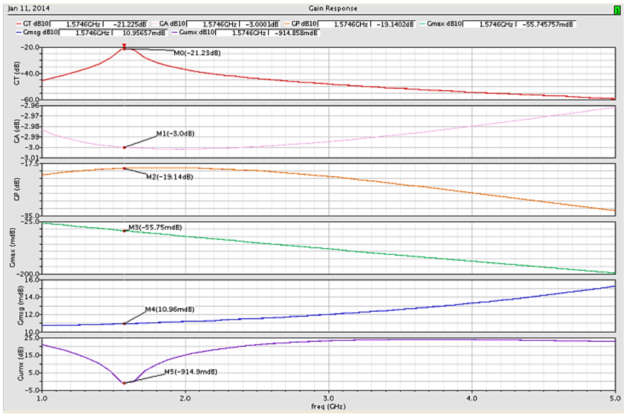

Figure 8: Gain Response

4. Single Ended Inductive Source Degenerated LNA

Single ended inductive source degenerated LNA topology is the combination of the topologies discussed above. This topology for GPS frequency 1.57GHz is shown in figure 9. By this topology of LNA, we have included the main features of both topologies namely high gain and low noise figure. So in order to get effective performance, we have combined both topologies to get maximum benefits. This topology seems to be proved in performance issues to get maximum efficiency and high gain.

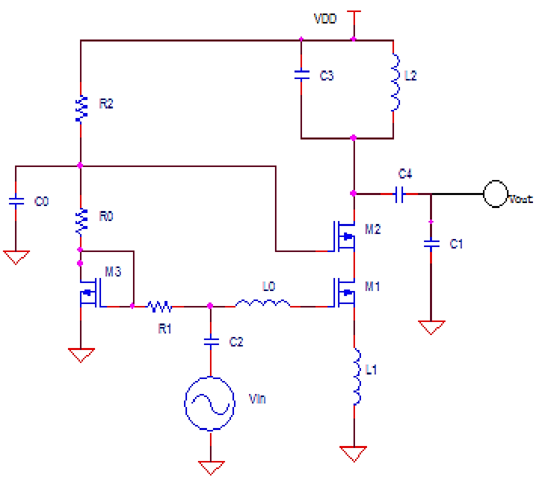

Figure 9: Single ended inductive source degenerated LNA

The S-parameter response, noise response and gain response of this LNA are shown in figure 10, figure 11 and figure 12 respectively.

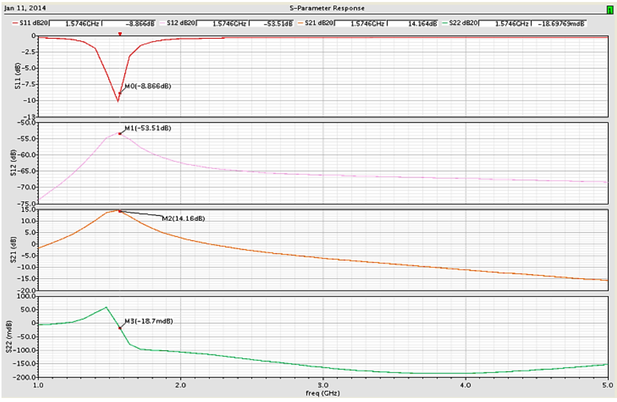

Figure 10: S-parameter Response

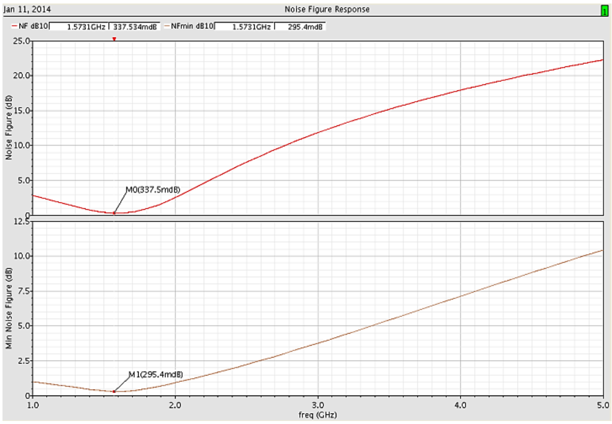

Figure 11: Noise Figure Response

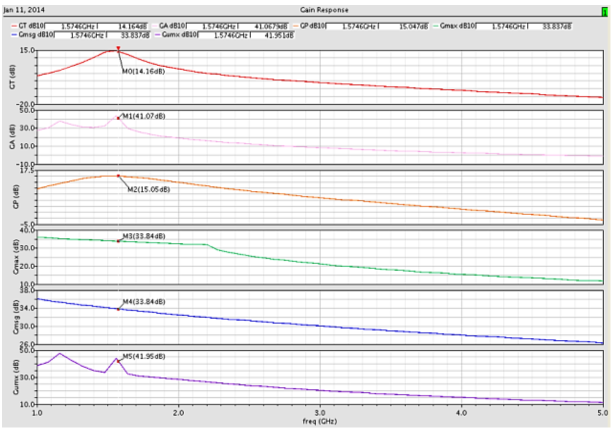

Figure 12: Gain Response

5. Performance Comparison

We have seen the simulation results for three LNA topologies designed for GPS frequency 1.57GHz. Cadence design suite is used to design these LNA's using 180nm technology. By comparing the simulation results, we analyzed three topologies and we can say that single ended inductive source degenerated LNA is best among all three topologies in all aspects like S-parameter, noise and gain. So, by performance wise comparing all the topologies, the single ended inductive source degenerated LNA seems to be superior in all.

Conclusion

In this paper, we have studied and compared various topologies of LNA like single ended LNA, inductive source degenerated LNA and single ended inductive source degenerated LNA. We have compared these topologies on performance comparison to various issues like s- parameters, noise figure and gain. Thus we have designed and analyzed these LNAs for GPS applications using cadence design suite.

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