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# Design of 2.4 GHz Low Noise Amplifiers for Wireless Communication System

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## ABSTRACT

Low noise amplifiers (LNAs) play a key role in radio receiver performance. A LNA is an electronic amplifier that amplifies a very low power signal without significantly degrading its signal-to-noise ratio. An amplifier will increase the power of both signal and the noise present at is input. Low noise amplifiers are designed to minimize the additional noise. Designers minimize the additional noise by considering trade-offs that include impedance matching, choosing the amplifier technology and selecting biasing conditions. Performance of different design is compared with respective noise figure, gain, input and output reflection coefficient. Advanced design system (ADS) tool was used for design and simulation of LNA.

**Keywords:** Low noise amplifier (LNA), noise figure, gain, input and output reflection coefficients, ADS.

## I. INTRODUCTION

A Low-noise amplifier (LNA) is an electronic amplifier that amplifies a very low- power signal without significantly degrading its signal to noise ratio. LNA is the first part in RF receiving system. The three stages of LNA are: the input matching circuit, the amplifier, and the output matching circuit. The simultaneous requirements of LNA design are high gain, minimum noise figure, stability, good input and output matching. Low-noise amplifier is being used in many applications such as RF communication systems, Wireless LAN, Cordless phone, cellular telephone, Bluetooth etc. Advanced Design System (ADS) tool is used for design and simulation and each design is tuned to get the optimum value for noise figure, gain, stability and input reflection coefficient. The ADS software has high strong capability in microwave circuit design and simulation analysis. A typical block diagram of LNA is shown in figure.1

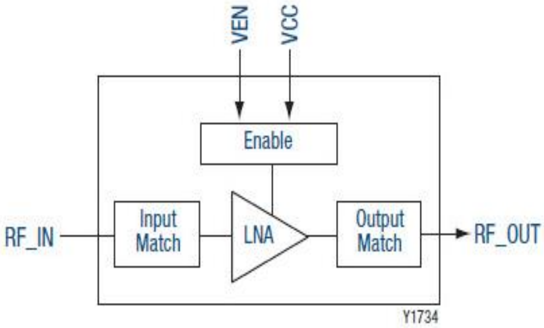


**Figure 1.** Block Diagram of LNA

## II. METHODS AND MATERIAL

### Design of LNA Parameters

In design of LNA, design specification should be made properly. The various parameters that influence the design of LNA are discussed in detail below.

### A. Transistor:

In this paper, the Low-noise amplifier is designed with GaAs FET transistor. Gallium arsenide is preferred over silicon due to its high performance at microwave frequencies. The features of this transistor are low noise and high electron mobility.

### B. Q-Point Selection:

The operating point of a device is known as Q-point, which is the steady-state operating condition of an active device without applying any input signal. Here, at first a suitable Q-point needs to be found for correct biasing of the transistor throughout the entire bandwidth.

### C. Noise Figure:

The noise figure is one of the important factors which determine the efficiency of the particular LNA. It can also say that, the ratio between SNR at input to the SNR at output, and is expressed in decibels. The decision on which LNA is suitable for a particular application is typically decided based on its noise figure.

$$NF = 10 \log \frac{SNR\ in}{SNR\ out} \text{ in (dB)}$$

where,

NF= Noise figure

SNR in= Signal to Noise ratio at the input of the circuit or system

SNR out= Signal to Noise ratio of the circuit or system at output

### D. Biasing:

It is to feed the amplifying devices with electrical power to activate them and make them capable to amplify signal. It is a DC pre-shift of voltage and current from the zero condition. The amplifier after biasing is able to receive signal to be amplified at its input. Biasing is done so that the circuit will make the device to stay at desired operating point. Biasing is necessary DC voltage required for any active device to operate.

### E. Gain:

With a low noise figure, an LNA must have high gain in order to process signal into post-circuit. If an LNA doesn't have high gain, then the signal will be affected by noise in the LNA circuit itself; the signal may become quite attenuated, so the LNA's high gain is an important parameter. The gain of an LNA varies with the operating frequency.

### F. Stability:

Stability test is one of the most important tasks to verify whether the amplifier is stabled or not .Due to improper stability, an RF circuit approaches to be oscillated.

$$K = \frac{1 - |S_{11}|^2 - |S_{22}|^2 + |\Delta|^2}{2|S_{12}||S_{21}|} > 1$$

$$\Delta = |S_{11}||S_{22}| - |S_{12}||S_{21}|$$

If K>1 and |Δ|<1 then the amplifier is stabled throughout the selected frequency band and bias conditions. An amplifier can be stabilized by introducing a shun conductance or a series resistance either at input port or output port. But a resistive element at the input side causes additional noises to the amplifier. In such cases the stabilization can be done by introducing inductors in emitter or source side, as the inductors are noiseless devices.

### G. Input and Output Matching Networks:

Matching networks is one of the important steps to design LNA. Impedance matching is used to minimize the reflections and obtain an acceptable amount of noise figure and maximum gain by making load impedance equal to the source impedance.

## III. RESULTS AND DISCUSSION

The design of LNA with and without biasing network and their simulation results are shown in below figures.

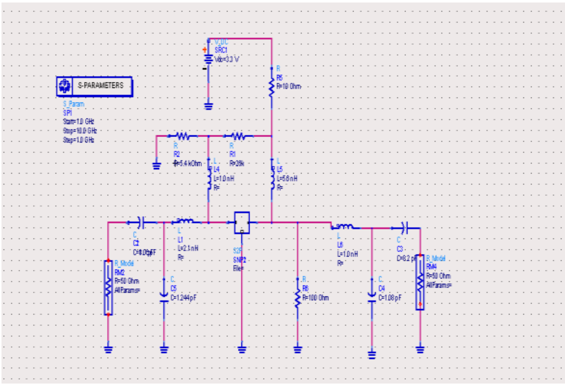

**Figure 2.** Circuit diagram of LNA with biasing

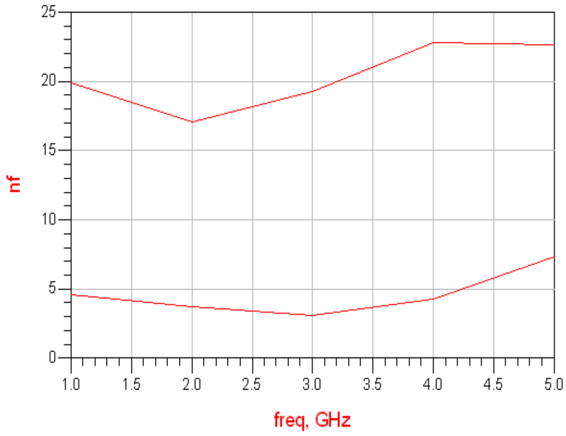


**Figure 3.** Simulation result of noise figure (NF)

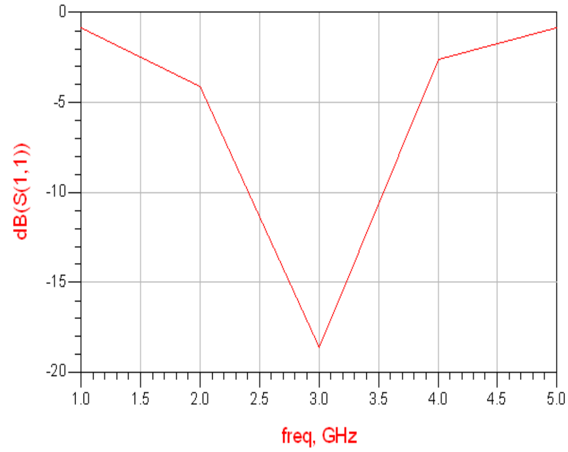


**Figure 4.** Simulation result of input reflection coefficient

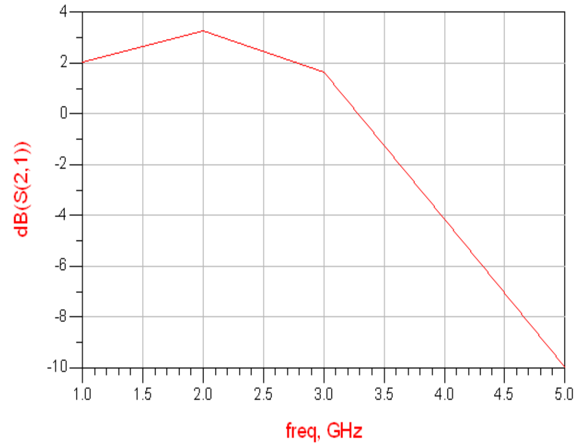


**Figure 5.** Simulation result of forward voltage gain

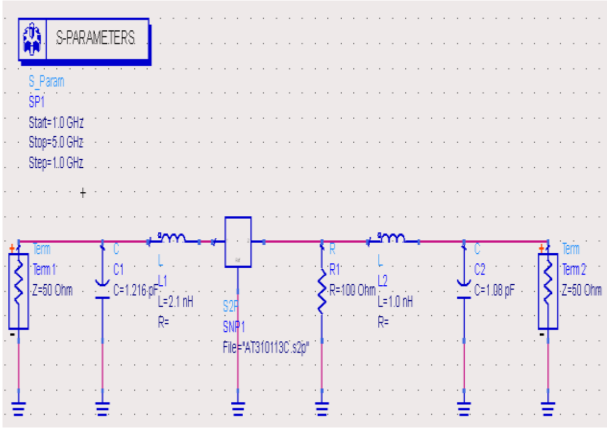


**Figure 6.** Circuit diagram of LNA without biasing

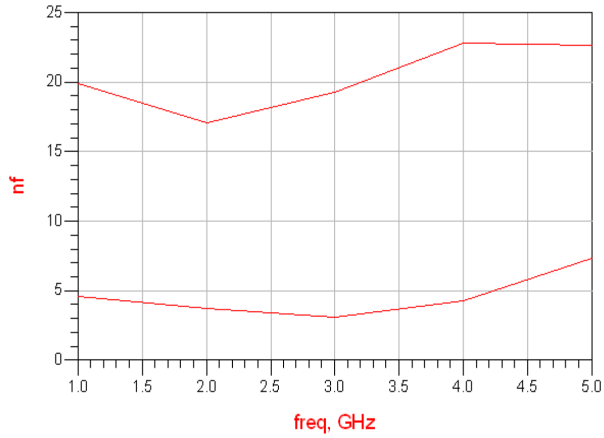


**Figure 7.** Simulation result of noise figure(NF)

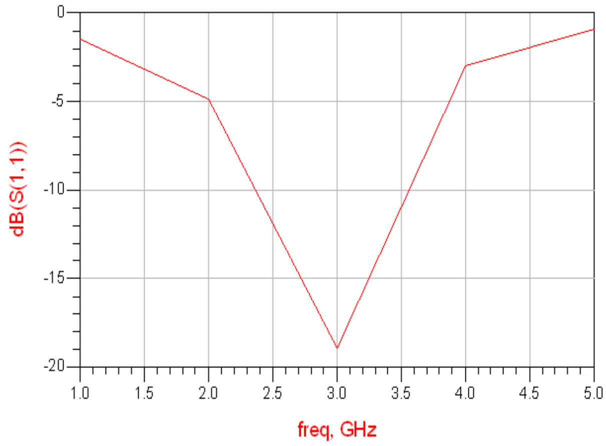


**Figure 8.** Simulation result of input reflection coefficient

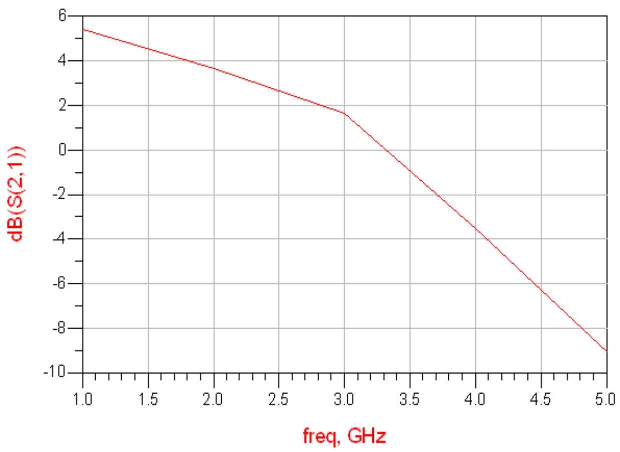


**Figure 9.** Simulation result of forward voltage gain

## IV. CONCLUSION

A low-noise amplifier has been designed at 2.4 GHz. Optimization was performed according to get the desired responses in all the designs. The simulation results for proposed low noise amplifier with biasing and without biasing is shown in above figures. The designed low noise amplifier with biasing provides a noise figure(NF) of 3.5 dB, input reflection coefficient($S_{11}$) of -9.4 dB and forward voltage gain($S_{21}$) of 2.6 dB and for LNA without biasing noise figure(NF) of 3.5 dB , input reflection coefficient($S_{11}$) of -10 dB and forward voltage gain($S_{21}$) of 3.1 dB are obtained for 2.4GHz frequency .

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