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Low Noise Amplifier Design for Wide-band Wireless Receivers in Frequency Range S-Band

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Abstract: *In this work, we have presented a design technique for the low-noise amplifier of wide-bandwireless receivers in frequency range 2 to 4 GHz (S-Band). We have utilized ADS software in order to analyze the design method. In the first part, we have described the design of low noise amplifier for wide-band based on lumped element by utilizing ATF-10136 amplifier technology in ADS software. In the second part, we have designed low noise amplifier for the frequency range 2 to 4GHz wide-band based on microstrip matching network. The simulation results indicate the excellence of microstrip matching network in comparison to lumped element matching network in this work.*
Keywords: *Low Noise Amplifier; Noise Figure; Stability; matching Network; ADS.*

I. Introduction

A low noise amplifier is one of the most important blocks of the front-end of any sensitive RF receiver setup [1].

The S band is the part of the microwave band of the electromagnetic spectrum that has been defined for radio waves with frequencies range from 2 to 4 GHz, crossing the conventional boundary between UHF and SHF at 3.0 GHz. The S band is utilized by surface ship radar, weather radar, and some communications satellites.

II. Circuit Design

A low noise amplifier (LNA) is a part in the receiver path of a wireless system. The main objective of the LNA is to achieve large gain and low noise figure. This objective should be achieved at the input of the LNA a general impedance of 50 ohm is considered [2].

Our wide-band low noise amplifier (WLNA) amplifies signals in frequency range for 2 to 4GHz. The weak radio signals from cosmic sources like the sun are received using a feed horn of a 4.5m parabolic dish The L-band pyramidal horn has a single polarization. The required specifications of the WLNA following the feed are gain (S21) > 10 dB, Noise Figure (NF) < 1dB. An LNA design presents a challenge because of a simultaneous requirement of high gain, low noise figure and perfect input and output matching. The S-parameters of the device, the matching networks, and the terminations are all utilized to evaluate stability [3].

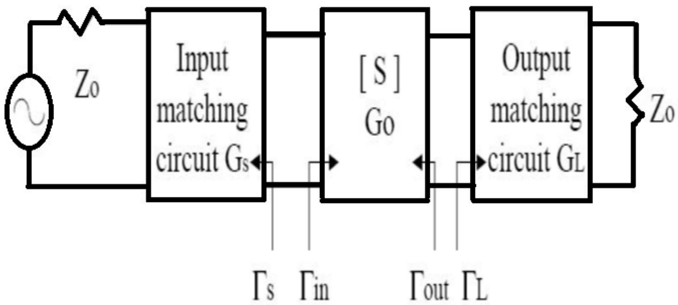


Figure1.block diagram of a microwave amplifier.

$$\Gamma_{in} = S_{11} + \frac{S_{12}S_{21}\Gamma_L}{1 - S_{22}\Gamma_L} \qquad (1)$$

$$\Gamma_{out} = S_{22} + \frac{S_{12}S_{21}\Gamma_s}{1 - S_{11}\Gamma_s} \qquad (2)$$

According to the figure1, Γ_S must be the conjugate match reflection coefficient (S11) < -10 dBand stability factor (K) >1. The characteristic impedance of the circuit is 50 ohm [1]. Furthermore, gain must be (S21) >10 dB and Noise Figure (NF) < 1dB. Similarly, Γ_L should be the conjugate match of the output impedance of the transistor [4].

A two-port network is considered to be unconditionally stable at a given frequency if the real part of Z_{IN} and Z_{OUT} are greater than zero for all passive load and source impedance. The stability can be defined using the stability criteria[5,6].

$$K = \frac{1 - |S_{11}|^2 - |S_{22}|^2 + |\Delta|^2}{2|S_{12}S_{21}|^2} \qquad (3)$$

$$\Delta = S_{11}S_{22} - S_{12}S_{21} \qquad (4)$$

For unconditional stability at a particular frequency $K > 1$ and $\Delta < 1$ where Δ is defined in the K-factor and K is the stability factor [5, 7, 8].

III. Design For Wide-Band LNA With Lumped Matching Network

Flat gain, low noise figure over wide-band (2GHz to 4 GHz) based on lumped elements has been designed, illustrating in figures 2[1].

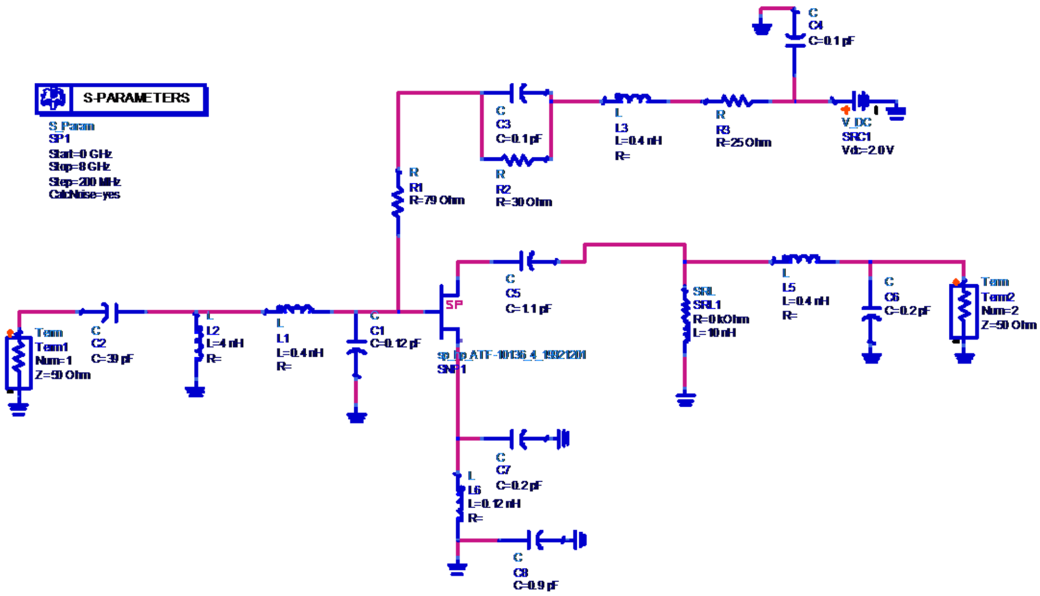
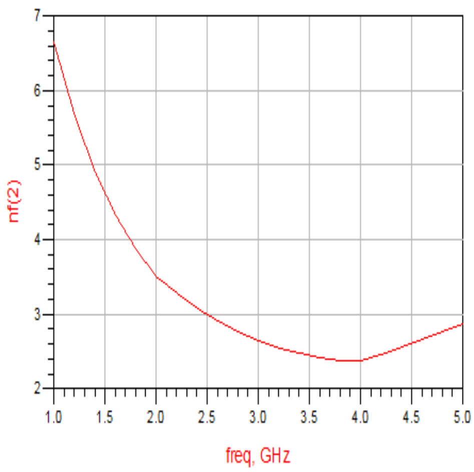


Figure2.Flat gain, low noise wide-band (2GHz to 4 GHz) circuit based on lumped elements [1].



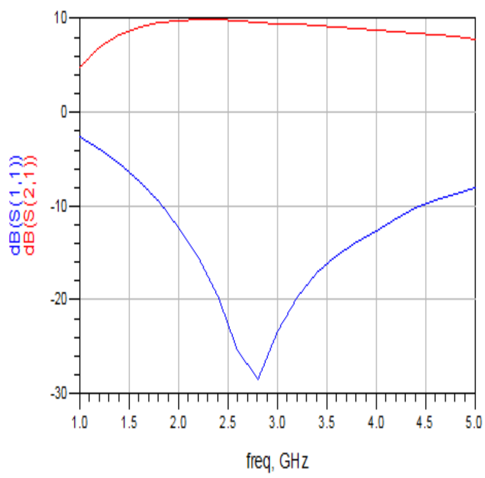


Figure3.The simulated noise figure (NF) by ADS [1] Figur4. Simulated gain (S21) and input return loss(S11)across Table UWB frequency band of the LNA using ADS [1].

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According to figure 3 and 4, minimum noise figure is 2.4 dB in 4 GHz frequency and maximum gain is 10 dB in 2.5 GHz frequency. Furthermore,noise figure (NF) has been illustrated in table1.

Table1.The noise figure of figure2

Frequency	2 GHz	3 GHz	4 GHz
Noise Figure	3.51 dB	2.6 dB	2.37 dB

IV. Design for Wide-Band Lna with Microstrip Matching Network

The design have performed based on ATF-10136 GaAs MESFET high frequency transistor for maximum achievable gain and a noise figure low along with input and output reflection coefficients below –10dB. The biasing network is based on a radial stub, an inductor and capacitor as shown in Figure 5. The design performances are illustrated in Figure6.

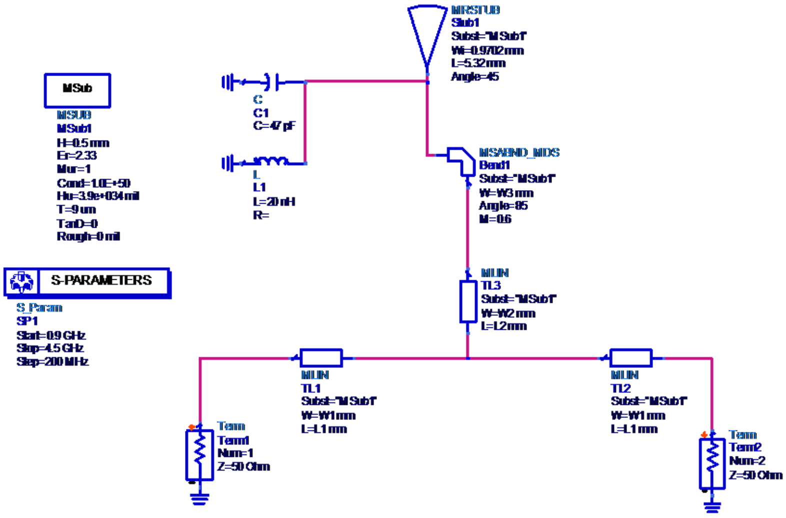

Figure5. ADS schematic diagram of biasing circuit.

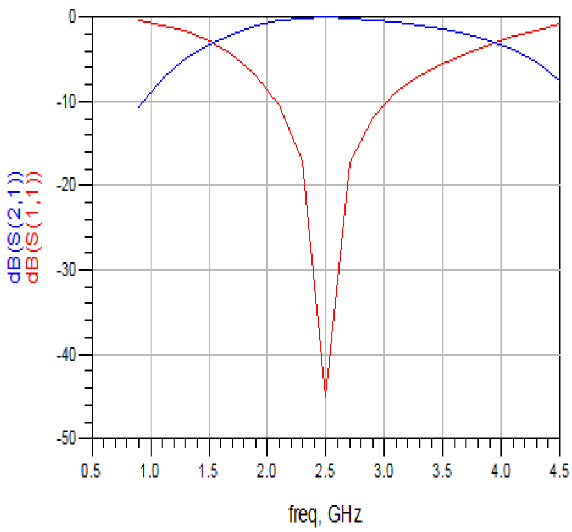

Figure6. Biasing network performance.

The complete LNA circuit diagram including the incorporated microstrip matching and biasing networks is shown in Figure7. Figures 8, 9 and 10 illustrate respectively the obtained input reflection coefficients and gain,Unconditional stability graph and the noise figure.

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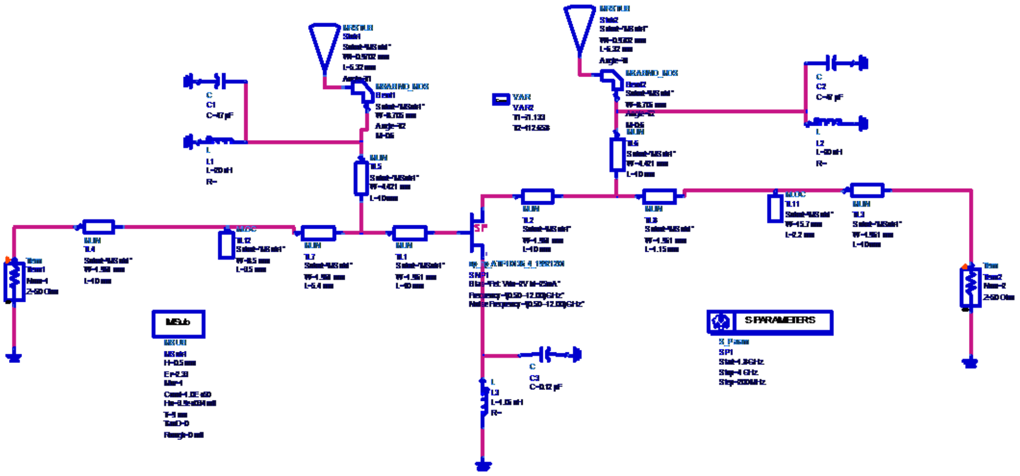
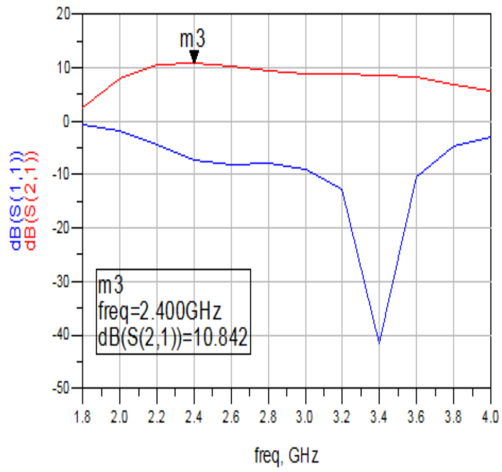


Figure7.The complete LNA circuit diagram including the microstrip matching and biasing networks.



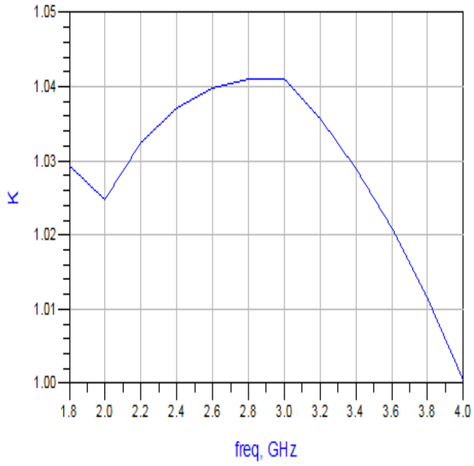


Figure 8.Simulated result of Input reflection coefficient and gain.Figure9. Unconditional stability graph.

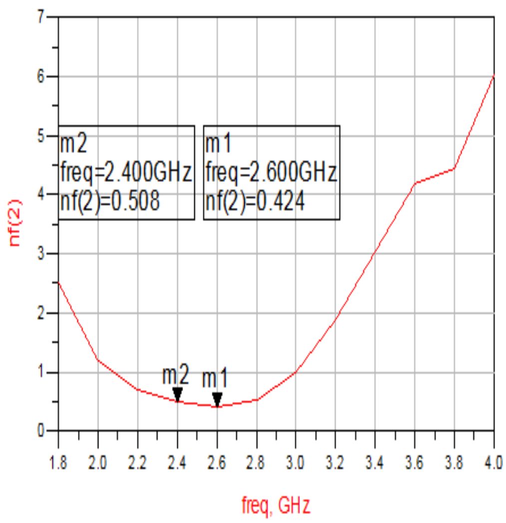


Figure10. Simulated result of noise figure

According to figure 8 and 10, minimum noise figure is 0.424 dB in 2.6 GHz frequency and maximum gain is 10.84 dB in 2.4 GHz frequency. Furthermore, noise figure has been illustrated in table2.

Table2.The noise figure of figure7.

Frequency	2 GHz	3 GHz	4 GHz
Noise Figure	1.2 dB	0.99 dB	6.02 dB

V. Conclusion

In this paper,we present wide-band LNA from 2GHz to 4GHz in a commercial GaAs MOSFET ATF-10136 based on lumped elements and microstrip matching network .The simulations results on based lumped elements and microstrip matching network are shown in figure3,4,8,9and10. Inductor and capacitor at the drain output of the transistor helps for the unconditional stability. The simulations results indicatethat in frequency range 2 to 4 GHz (S-band frequency)microstrip matching has higher performance in noise figure in comparison to the lumped elements matching.

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