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Design and Simulation of Low Noise Amplifier at 15 GHz Using Advanced Design System (ADS)

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ABSTRACT
the first stage of each microwave receiver there is low noise amplifier (LNA) circuit, and this state has important rule in quality factor of the receiver. In this study, design and simulation of 15 GHz low noise amplifier (LNA) have been explored. This simulation has been performed by using the Agilent Advanced Design System (ADS) software. It also describes the design and simulation of a high frequency low noise amplifier, with high gain and low noise using MESFET for frequency 15GHz .A single stage LNA has successfully designed with 14.5 dB forward gain and 0.003dB noise figure in frequency of 15GHz.The NE76000 transistor was chosen for the design of the LNA due to its low noise figure, stability, and good gain at high frequency, good input and output impedance matching. Also the designed LNA should be working stably in frequency of 15GHz.

KEYWORD: *Low Noise Amplifier (LNA), Microwave Receiver, Impedance Matching, Noise Figure, Advanced design System, Stability, High Frequency*

I. INTRODUCTION
Designing amplifiers for a minimum noise figure then becomes simply a matter of setting the optimum condition for a particular transistor. Based on S parameters of the transistor and certain performance requirements, a systematic procedure is developed for the design of the LNA. The low noise amplifiers are key components in the receiving end of the communication system. in most of the microwave communication RF front end receivers, low noise amplifier(LNA) is the first block which amplifies the received RF signal from antenna and provides gain as high as possible which the lowest noise possible. The designed procedure is simulated and optimized using Advanced Design System (ADS).The operating frequency of the design is 15GHz.In LNA design, the most important factors are low noise, moderate gain, matching and stability [8].

II. EQUIVALENT CIRCUIT OF MICROWAVE MESFET
Most Microwave amplifiers today use Gallium Arsenide (GA AS) Field-Effect Transistor (FETs). They can presently be used at frequencies up to 100GHz in a wide variety of applications requiring low noise figure, broad band width and medium power capacity. Knowledge of the equivalent circuit of a MESFET is very useful for the device performance analysis (gain, noise …) in designing of microwave circuits [1] [2]. In this paper low noise GA AS MESFET NE76000 has been used for the design of LNA. The first step for the choice of transistor is to define the amplifier topology that best suits the design requirements. As this is a high frequency design, the parameters S, MAG (Maximum Available Gain), and Rollet factor (K). For the case of study, the chosen is the NE76000, which provides a low noise figure and high associated gain through K-band. Fig.1 shows the equivalent circuit of the transistor which has been recovered by NEC Company for frequency range of 1GHz to 26GHz. In this paper; the aim is to design and simulate a single state low noise amplifier circuit with high gain and low noise using Ga as FET for frequency of 15 GHz.

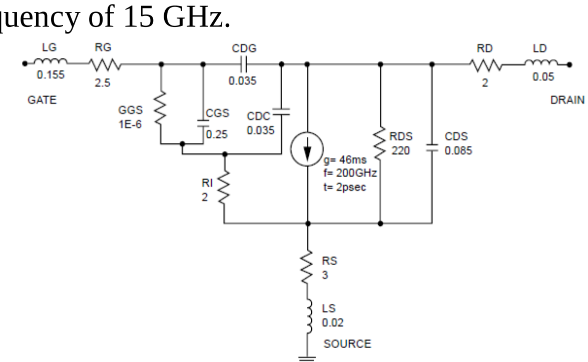

Fig.1 Equivalent Circuit of NE 76000 Transistor

III. DC BIASING

Table.1 LNA Requirements

Parameters	specification
Operating frequency	15GHz
Bias Point	Vd=3v,Ids=10mA
Technology	Ga As MESFET
Gain	>14.4
Noise Figure	<1

In order to design a low noise device, the transistor must be DC biased at an appropriate operating point. These depends of the application (low noise, high gain, high power), and the type of the transistor (FET, HFET, etc) [4].

The circuit is designed to meet the chosen biasing, considering that very high values of resistance naturally add more noise to the system, and very low resistance increase the power consumption of the system. Accounts both source and load mismatch. Thus from [6],can be separate effective gain factors for the input (source) matching network, the transistor itself and the output (load) matching network as follow.

Vd (drain voltage) =3V and Ids (drain-Source current) =10mA.This biasing point is obtained by using a Vg (gate voltage) range from -0.6 to 3 V [5].

A. Single Stage Amplifier

A single stage amplifier microwave transistor amplifier can be modeled by the circuit in Fig.2, where a matching network is used both sides of the transistor to transform the input and output impedance Z0 to the source and load impedance Zs and ZL. The most useful gain definition for amplifier design is the transducer power gain, which accounts both source and load mismatch. Thus from[6], can be defined separate effective gain factors for the input (source) matching network, the transistor itself and output (load) matching network

As follow:

$$G_s^{'} = \frac{1-|\Gamma_S|^2}{|1-\Gamma_{IN}\Gamma_S|^2} \quad (1)$$

$$G_L = \frac{1-|\Gamma_L|^2}{|1-S_{22}\Gamma_L|^2} \quad (2)$$

Then the overall transducer gain is GT=G_S'GoGL. The effective gains from GS and GL are due to the impedance matching of the transistor to the impedance Z0.

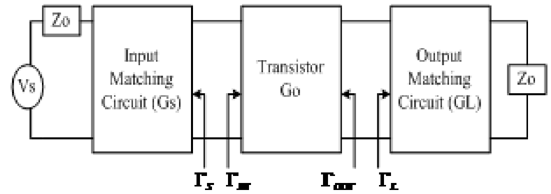

Fig.2 the General Transistor Amplifier Circuit

B. Stability Consideration

The stability of an amplifier, or its resistance to oscillate, is a very important consideration in a design and can be determined from the S parameters, the matching networks, and the terminations. In the circuit, oscillations are possible when either the input or output port presents a negative resistance. This occurs when Γ_{IN} >1 or Γ_{OUT} >1.These because of Γ_{IN} and Γ_{OUT} depend on the source and load matching networks. While, the stability of the amplifier depends on Γ_S and Γ_L as presented by the matching networks, when starting on any amplifier design it is very important to spend time checking on the stability of the device chosen, otherwise the amplifier may well turn into an oscillator. The main way of determining the stability of a device is to calculate the Rollett's stability factor(K), which is calculate using a set of S-parameters for the device at the frequency of operation. Alternatively, it can be shown that amplifier will be unconditionally stable if the following necessary and sufficient conditions are met [7].

$$K = \frac{1-|S_{11}|^2 - |S_{22}|^2 + |\Delta_S|^2}{2|S_{21}.S_{12}|} > 1 \quad (3)$$

$|\Delta| < 1$

K=1.393

C. Matching Network Design

The need for matching network arises because amplifiers, in order to deliver maximum power to a load, or to perform in a certain desired way, must be properly terminated at both the input and output port. Several types of matching network are available, however factors likes complexity, bandwidth, implementation and adjustability need to be considered in the matching network seletion. The amplifier could be matched for a variety of conditions such as low noise applications, unilateral case and bilateral case. The impedance matching networks can be designed either mathematically or graphically.

IV. NOISE FIGURES SIMULATION RESULT

The minimum noise figure is needed in order to achieve the maximum gain.Fig.3 Show the minimum noise figure plot. The Lowest Fm in 0.004 dB obtained at frequency 15GHz.

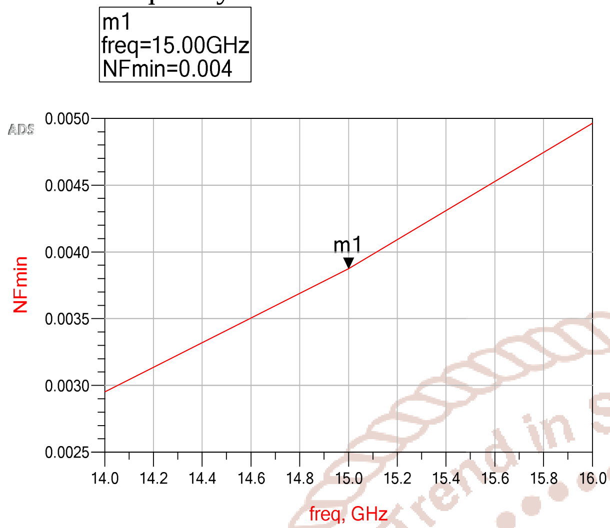

Fig.3 Minimum Noise Figure

V. EXPERIMENTAL RESULT

The designed LNA with matching network at 15GHz was obtained. The forward gain (S_{21}), isolation (S_{12}), S_{11} and S_{22} plot is shown in figures. The results shows that the $|S_{11}|<1$ and $|S_{22}|<1$ full fills the stability condition.

The highest forward gain (S_{21})is 14.49dB at 15GHz as shown in Fig.6.The design LNA also shows a good isolation when S_{12} value is below -50dB at 15GHz.

Also the stability factor, K=1.393 plot is shown in Fig.8.Thus the design LNA should be working stably in frequency of 15GHz.

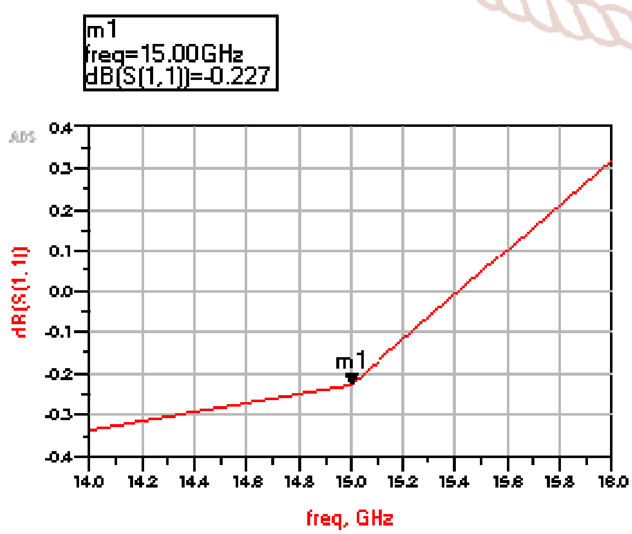

Fig.4 S11 Parameter Plot

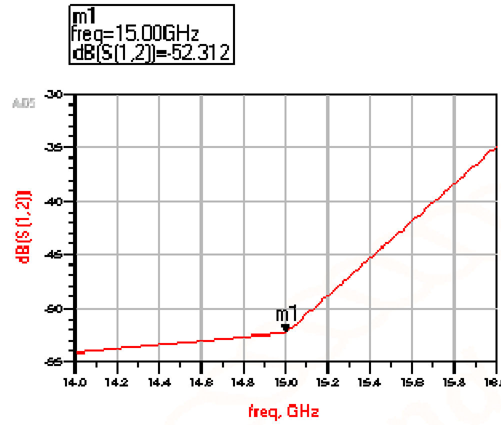

Fig.5 S12 Parameter Plot

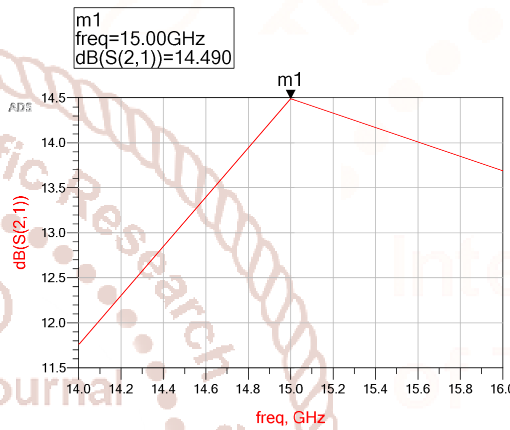

Fig.6 S21 Parameter Plot

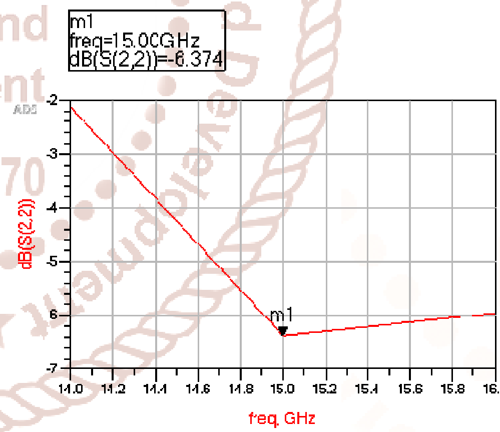

Fig.7 S22 Parameter Plot

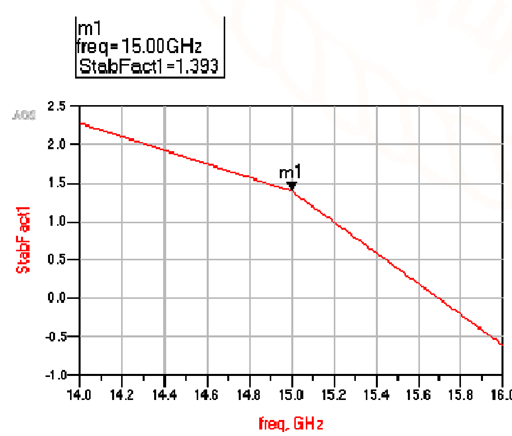

Fig.8 Stability Factor K Plot

VI. CONCLUSION

In this paper, LNA at 15 GHz for microwave receiver system have been designed and simulated. It is observed that the forward gain and noise figure of these designs is almost 14.49 dB and 0.004 dB respectively in 15GHz.This simulation result have good assent with desired demand.

VII. REFERENCES

1. C.A BAL anis, Antenna Theory: Analysis and design, Harper and Row N. Y., 1982.
2. K. Miyauchi, “Millimeter-Wave Communication, “in Infrared and millimeter waves, vol. 9, K. J. Button, ED, Academic pres, N. Y., 1983.
3. Exclusive North America Agent for NEC RF, Microwave &optoelectronic semiconductors CEL California Eastern Laboratories-Headquarters-4590 Parick Heny Drive, Santa clora, CA 95054-1817-www.CEL.com.
4. Microwave Engineering-David M-Pozar. John Wiley &Sons. INC-New York. Chichester. Weinheim. Brisbane-Singapore. Toronto.
5. Agilent Technologies (2000).”Application No to 1190-Low Noise Amplifier for 900MHz using the Agilent ATF-34143.Low Noise PHEMT”.USA: Agilent Technologies 1-8.
6. D.M Pozar (2000). ”Microwave RF Wireless System”, United State of America: John Wiley and sons Inc 77797, 205-207.
7. Microwave Transistor Amplifier Analysis and Design Guillermo Gonzalez, Ph.D.1984 by Prentice-Hall, Inc Englewood Cliffs, New Jersey 07632.
8. Mohd. Zinol Abidin Abd Aziz (2004),”Low Noise Amplifier Circuit Design for 5GHz to 6GHz”, Proceeding of the 2004 IEEE-0-7083-8671-X/04/-RF and microwave conference, October 5-6, Subang, Selangor, Malasia. 81300skudia, Johor, Malaysia will be deleted from the biography.

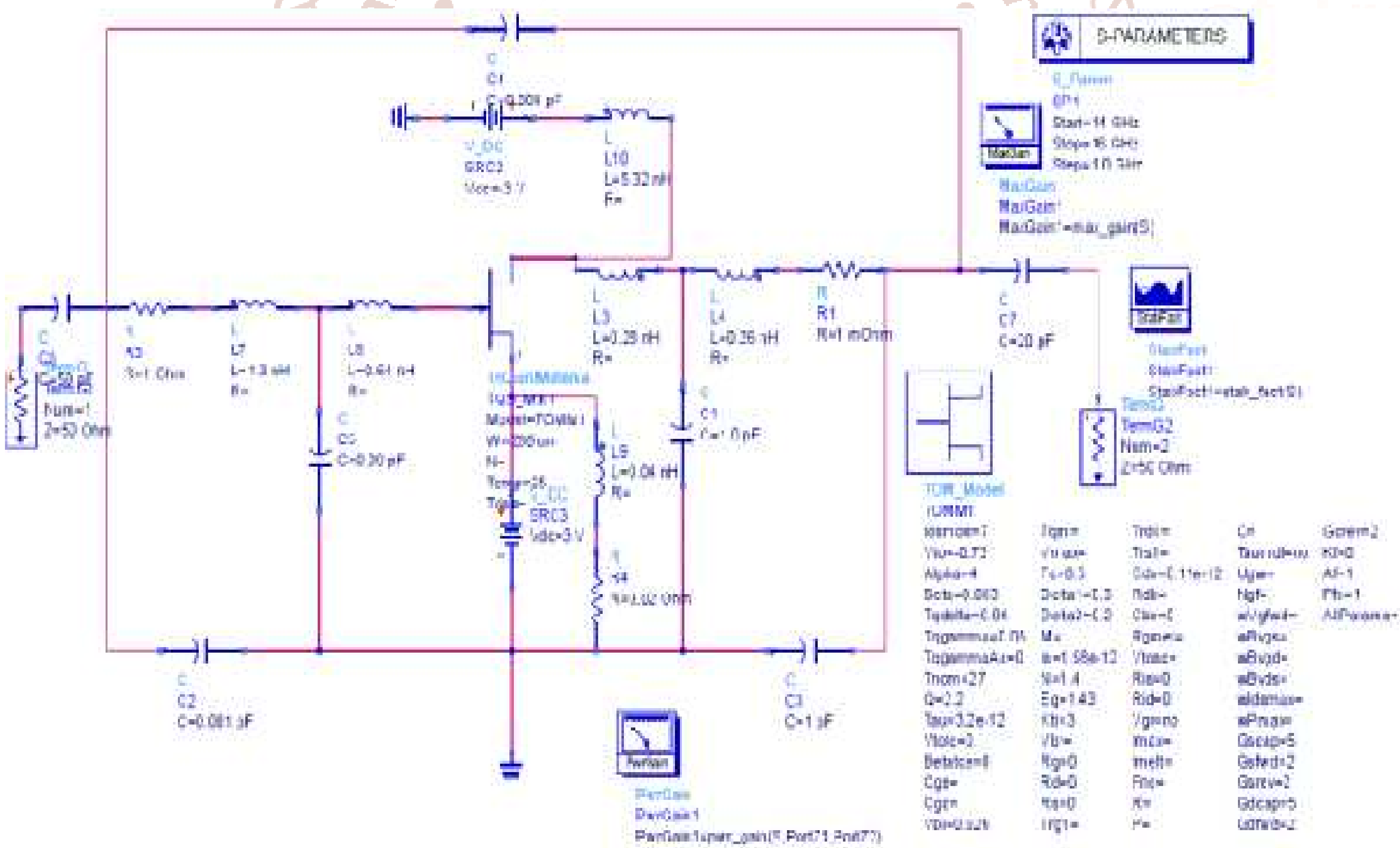

Fig.9 Input and Output Matching Network Of designed LNA