RESEARCH ARTICLE OPEN ACCESS

Comparitive Study of Modfet Based Low Noise Amplifier Design In The Bandwidth Of 6 Ghz

V.J.K.Kishor Sonti *, Sundari.G **
*(Associate Professor, Department of ECE,Sathyabama University, Chennai
Email: jayakrishna_adc@yahoo.com)
** (Professor, Department of ECE, Sathyabama University, Chennai)

ABSTRACT:
Low noise amplifier is vital in the design of receivers at microwave frequencies. In this paper , the performance of HEMT Low noise amplifier is analyzed at 2.4 GHz within a bandwidth of 6 GHz, FR4 substrate is chosen and Noise figure , Gain are considered as the performance parameters for the comparison. C4 based model obtained by parametric analysis is compared with various other designs in the 6 GHz bandwidth. It is observed that the noise figure and gain values of C4 based design are 0.263 dB and 15.317 dB, which are better when compared with other models.The simulation is carried out using ADS software and performance parameter variation with respect to frequency was studied. The layout of the design is obtained using ADS momentum.

Keywords: GaAs, LNA, Microstirp, FR4 substrate, Noise Figure, Gain

---

Date of Submission: 07-11-2017 Date of acceptance: 22-11-2017

I. INTRODUCTION

Research on the high speed devices in electronics has become resurgent with the upcoming challenges thrown by integrated circuit technology. This has also paved the way for future high speed radio communication systems. Noise Analysis in the high speed devices has been the topic of interest since last two decades; many researchers have attempted toexplore the noise behavior of the devices. Several models were proposedto analyze the noise in the devices under different constraints orlimitations. There are different approaches that were adopted to do thisanalysis in a more systematic manner and some of them includeequivalent circuit method, device simulation, noise models, and lumped, distributed models when it comes to applications.

Theconcept of noise is random and extends to wide range of applicationsunder constraints of different frequencies and different topologies inelectronic systems, in particular to communication systems.Noise has been a limiting factor for the performance of the many electronic systems. With advent of new technologies like Very Large Scale Integrated Circuit Design (VLSI), newer heights of development have been achieved in the design of electronic systems. Packaging density has posed serious problems to the basic functionality of the design, particularly due to scaling of the devices. This devicesizing has become a rudimentary aspect of the VLSI circuit designing.

II. MODFET AND LOW NOISE AMPLIFIER

MODFET refers to Modulation-Doped Field-Effect Transistor (MODFET). Due to higher gain, estimated device noise is greater for the MODFET than MESFET. Shorter channel lengths of MODFET’s also contribute to higher noise current. Parasitic contribution and channel noise is greater for MODFET structure. The cross section of a basic MODFET is illustrated in Fig. 1.

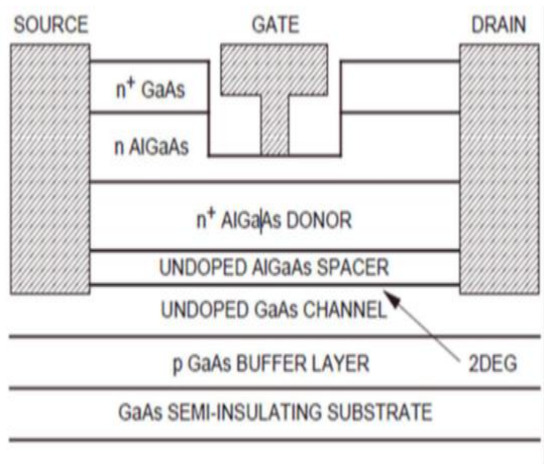

Fig. 1. AlGaAs/GaAs MODFET's basic Structure [3]

The electrons transits in the vertical direction are collected by 2DEG layer and the concentration of two dimensional electron gas is controlled by the applied gate voltage. The buffer layer here is the GaAs layer over the substrate so as to isolate defects from the substrate. This develops a smooth surface upon which active layers of the transistor are considered. Further substrate conduction is inhibited by the superlattice structure of this PMODFET. At this heterojunction there exists two electron accumulation peaks. One is related to the 2DEG and the second is the interface trap occupancy. These hetero interface traps conquer the free electrons in the donor layer; an electron accumulation peak is formed at this junction. Design of Low noise amplifier using these MODFET's is one of the interesting areas of research from last few decades [7 and 8].

Low noise amplifier fundamentally suppresses the noise signal intensity and amplifies the required signal in a particular range of frequency of operation [4 and 5]. LNA provides modest gain at Radio Frequency and a low noise figure in RF front end applications. LNA is a vital component in the receiving section of any communication system. The main aim of LNA is to receive the input signal, which is in generally very feeble and to amplify this signal besides upholding minimized noise levels. The performance metrics of this RF front end subsystem are typically, Gain and Noise Figure.

As different design methodologies of LNA design exists, first the method of designing should be chosen. Some of these methods include the design using passive lumped elements for impedance matching, usage of distributed elements in the design etc. Nextimportant step is to choose the transistor model that is used in the design based on the specifications or requirements and the stability of the transistor should be calculated. Later the impedance matching networks should be designed. After these rudimentary steps, the DC simulation was carried out. The chosen workspace is ADS environment [1].

According to the theoretical observations, the typical value of noise figure for a LNA design should be less than 1.5dB, which is well in accordance with the values obtained here, except when Rg is a higher value, which indicates the influence of shot noise. An important conclusion can be drawn here is increasedvalue of gate resistance reduces the gain as it is the source of the shot noise, which is in accordance with the theoretical observations. In general, when transconductance (g_m) changes, there is a shift in gain drastically and also in noise figure values. As the noise influence is more at higher frequencies the main reason for this behavior is once again the shot noise, which is inherent within the device. Various technological constraints, regarding material properties and device technology must be properly examined to analyze the noise [9 and 6].

III. C4 MODEL OF HEMT LOW NOISE AMPLIFIER

An application is considered, namely LNA MODFET amplifier and influence of noise on the performance is analyzed.All the parameters influencing the noise on the device were taken into account in developing the better model of MODFET LNA design.By the extensive analysis of the effect of parasitic influence on the MODFET LNA, C4 based model was obtained. LNA design was carried out with a bandwidth of 6GHz and by using microstrip based design methodology. The substrate chosen is FR4 with the dielectric constant value of 4.6 and the design [11] is as shown in the Fig. 2.

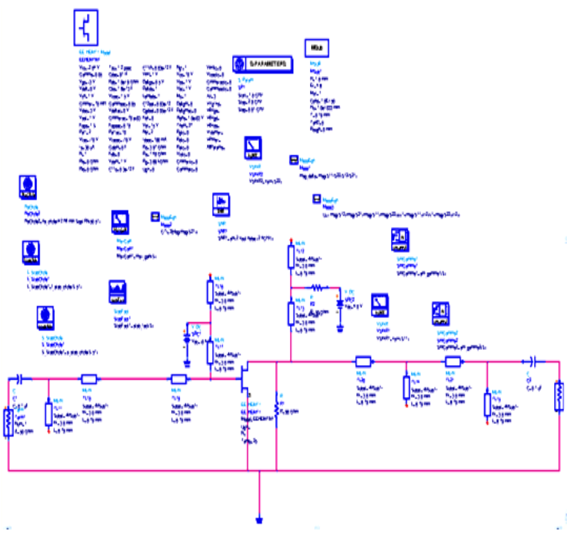

Fig.2.C4 based LNA with same Microstrip technology

MODFET LNA is designed using microstrip line methodology and the substrate chosen is FR4, where the dielectric constant value is 4.6. Noise bandwidth is 6 GHz and H =1.6mm, whereas W =3.00mm and L = 6.79 mm. The operating voltage is 3V dc. This is designed using C4 model obtained by the parametric analysis method and here same dimensions of microstrip lines are used throughout this design. The Impedance matching network consists of inductive and capacitive components with terminations of 50 ohms at input and output. The bandwidth of this design is considered as 6 GHz in accordance with the demands of the communication applications like Software Defined Radio.

IV. RESULTS

Various models are analyzed in performance along with the reference design values of the C4 based model.In AVAGO model the noise figure obtained is 0.863, gain is17.410 dB and the noise resistance is around 3.3[12]. In the case ofEE_MODFET these values are 4.2, 1.22 and 1.35 respectively [13]. When itcomes to the MODFET LNA using unequal microstrip lines at 2.4 GHz is concerned the values of noise figure increases to 1.262, whereas thegain drops to 3.5 and the noise resistance is observed to be 1.78k. In the case of MODFET LNA designed using equal microstrip concept thegain is increased to 9.27, noise figure obtained as 1.4 and the noiseresistance is observed to be of 3.9k.

In the C4 based proposed model at gate to source voltage of-3V and drain to source voltage of 4V the noise resistance is observed tobe of 27.8 ohm and the noise figure is obtained as 0.263, whereas thegain increases to 15.317.These results testify the fact that the C4 based model is betterwhen compared with the other models. Table 1 represents thecomprehensive statement of the performance of C4 based model withthe other models. Fig. 3 and Fig. 4 represents the variation of noise figure and gain with respect to the frequency and it also can be observed that the value of the noise figure obtained is 1.207 dB at 2.4 GHz; this is also noted that noise figure value increases with frequency, whereas the gain is observed to be 5.853 dB at 2.4 GHz.

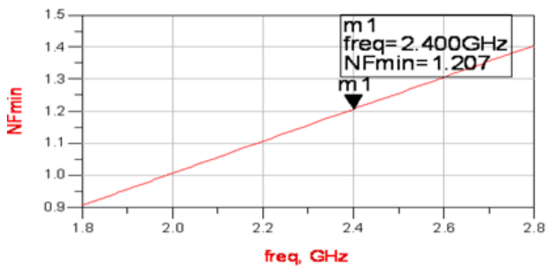

Fig. 3.NFminVs Frequency

TABLE 1. Comparative analysis of C4 based model with other models

1.	AVAGO model based design	0.863	17.410	3.326
2.	EE_MODFET model based design	4.269	1.223	1.35
3.	AVAGO Manual [4]	1.4	12	0.13
4.	C4 based model	0.263	15.317	27.832
5.	MODFET LNA using unequal microstrip	12.621	3.1	1.78k
6.	MODFET LNA using equal Microstrip	1.472	9.297	3.93k
7.	Ref 1 [2]	0.42	12	27.4
8.	Ref 2 [10]	0.7	15	-
9.	Ref 3 [14]	1.35	12	-

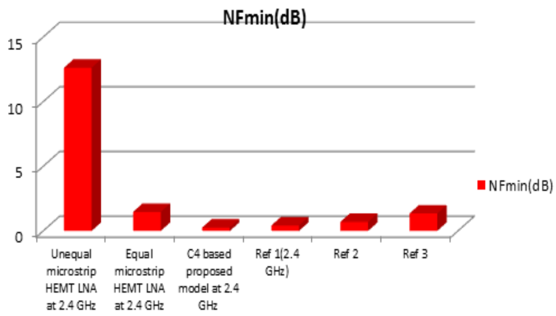

Fig. 4. Gain Vs Frequency

Fig.5 represents the noise figure comparison for different models and Fig. 6 represents the gain comparison. Fig. 7 represents the layout of the C4 design obtained using ADS momentum.

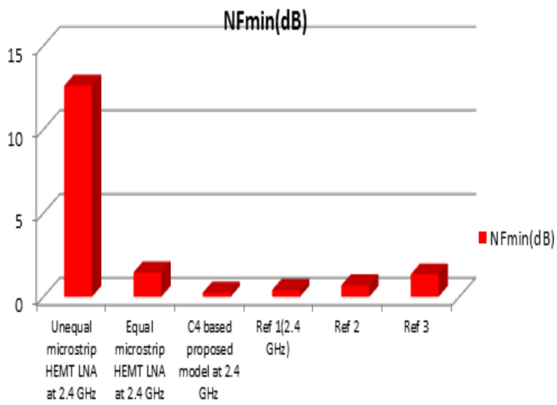

Fig. 5. Comparative analysis of NFmin

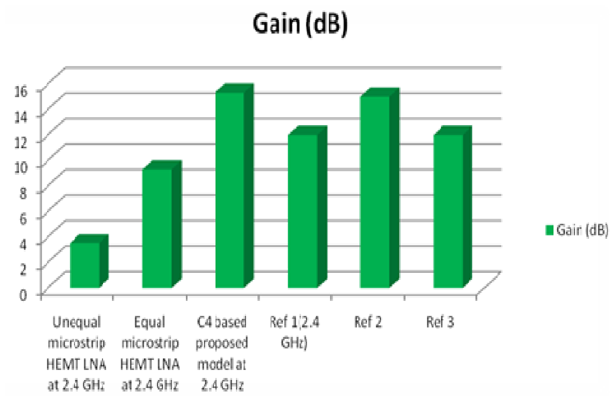

Fig. 6. Comparative analysis of Gain

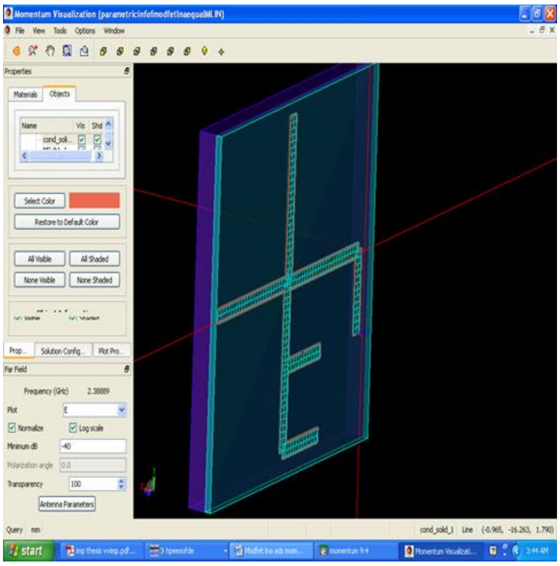

Fig.7. Layout of the C4 based model of AlGaAs MODFET LNA using ADS momentum

V. CONCLUSION AND FUTURESCOPE

The observations suggest that the influence of shot noise ispredominant at high frequencies, which is in accordance with the theory.C4 basedmodel performance is compared with other models, apart from this it is even observed from Fujitsu manual thatthe minimum noise figure is of 0.6 dB , gain is of 10.2 dB , where as inthe case of C4 based design0.263 dB and 15.317 dB respectively. C4 based design is better at 2.4 GHz when compared with other models and references, which makes it more suitable design for applications like SDR.

This work can be extended to various other substrates of modulation doped field effect transistors that have different category of applications. The Indium Phosphide substrate based devices and their applications need to be analyzed. With the emerging challenges of technology, device level research is ever demanding. Although electromagnetic radiation due to microstrip lines can be avoided by the proper choice and covering of the substrate, still it will have its influence at very high frequencies, which can be taken as a separate study. Noise in the Digital circuits designed using these MODFET transistors can also be the potential area of research.

REFERENCES

[1] Agilent Technologies (2004), “ADS 2004A, program help and amplifier design guide”.

[2] FHX35LG HEMT LNA at 2.4 GHz : https://www.scribd.com/doc/92601551/LNA -Report

[3] Helmut Brech, Thomas Grave and Siegfried Selberherr (2000), “Development of Global Calibration for Accurate GaAs-PHEMT Simulation”, IEEE Transactions on Electron Devices,VOL.47,No.10.

[4] Long S., Design of Low Noise Amplifier (2007) , ECE145A/ECE218A 2007.

[5] MGA-665P8, GaAs Enhancement-Mode PHEMT, 0.5 – 6 GHz Low Noise Amplifier,www.avagotech.com.

[6] Romaninil P., M. Peronil, C. Lanzieril, A. Cetroniol, M. Caloril A. Passaseo, B. Poti, Chini,L. Mariucci, A. Di Gaspare, V. Teppati and V. Camarchia (2006), “ Very HighPerformanceGaN HEMT devices by Optimized Buffer and Field Plate Technology”,Proceedings of First European Microwave Integrated Circuits Conference, EuMA, Manchester, UK.

[7] S. AghnoutandN. Mas*oumi*, “Modeling of substrate noise impact on a single-ended cascode LNA in a lightly doped substrate (research note)”, IJE transactions a: basics vol. 23, no. 1 (january 2010) 23-28.

[8] S. Babaeisedaghat, g. Karimi and r. Banitalebi, “A low voltage full-band folded cascodeduwblna with feedback topology”, IJE transactions a: basics vol. 28, no. 1 (january 2015) 66-73.

[9] Sona P. Kumar, Anju Agrawal,1RishuChaujar, SnehaKabra,Mridula Gupta and R.S.Gupta (2007), “ 3-Dimensional Analytical Modeling and Simulation of Fully Depleted AlGaN/GaN Modulation Doped Field Effect Transistor ” , IEEE.

[10] Trang Thai, Low Noise Amplifier design for operating frequency of 4.2 GHz (2007), Dec 12.

[11] V.J.K.Kishor Sonti and V.Kannan, “Noise Analysis of Novel design of MODFET Low Noise Amplifier”, International Journal of Recent Technology and Engineering, ISSN: 2277-3878, Volume-2, Issue-2, PP [105-108], May 2013, IF:1.131, No.of Citations: 02

[12] V.J.K.Kishor Sonti and V.Kannan, Performance analysis of PHEMT Low Noise Amplifier design Based on RT Duroid Substrate”, European Journal of Scientific Research, ISSN 1450-216X ,Vol . 90, No.3/ pp[425-430] / November -2012, IF:0.493

[13] V.J.K.KishorSonti and V.Kannan,” Comparative analysis of HEMT LNA performance based on microstrip based design methodology”, ICTEEP 2012,International Conference on Trends in Electrical, Electronics and Power

Engineering, ISBN 978-93-82242-03-1, Paper ID: 12062,/ pp[92-96],/July 15-16, 2012 , Singapore, No.of Citations: 02

[14] Zhang Hualiang (2004), "The Design of Low Noise Amplifier Using ADS", 22nd December 22.Johnson J.B, (1928), Physical Review, Vol.32, 97.

International Journal of Engineering Research and Applications (IJERA) is **UGC approved** Journal with Sl. No. 4525, Journal no. 47088. Indexed in Cross Ref, Index Copernicus (ICV 80.82), NASA, Ads, Researcher Id Thomson Reuters, DOAJ.

V.J.K.Kishor Sonti Comparitive Study of Modfet Based Low Noise Amplifier Design In The Bandwidth Of 6 Ghz." International Journal of Engineering Research and Applications (IJERA) , vol. 7, no. 11, 2017, pp. 38-42.