4GHZ LOW NOISE AMPLIFIER FOR SATELLITE DOWNLINK COMMUNICATION

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This Report Is Submitted In Partial Fulfillment Of The Requirements For The Award Of Bachelor Of Degree Electronic Engineering (Telecommunication Electronic) With Honors

Faculty of Electronic Engineering & Computer Engineering
Universiti Teknikal Malaysia Melaka

JUNE 2014

UNIVERSITI TEKNIKAL MALAYSIA MELAKA

UNIVERSTI TEKNIKAL MALAYSIA MELAKA

FAKULTI KEJURUTERAAN ELEKTRONIK DAN KEJURUTERAAN KOMPUTER

BORANG PENGESAHAN STATUS LAPORAN

PROJEK SARJANA MUDA II

Tajuk Projek : 4GHZ LOW NOISE AMPLIFIER FOR SATELLITE DOWNLINK COMMUNICATION

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For the most beloved and supporting parents,

MD NOR BIN HJ ALIAS

ROPE'NGAH BINTI JANTAN

Dedicated, in thankful appreciation for the support, encouragement, love and understanding.

ACKNOWLEDGEMENT

Alhamdulillah, all praise to Allah SWT, God Almighty, Most Merciful for His guidance, blessing and by his will the project is successfully finished. A million thanks to my beloved family, who gives me encouragement and moral supported throughout the project. Without the encouragement and moral supported , the project will not be succeeded. Their trust and conviction towards me will always inspire me to become honestly in knowledge and never give up whatever happened towards especially during realization this final project. It is to them that I dedicate this work.

Generally, I personally gratitude to my supervisor; Dr Mohd Azlishah Bin Othman for His wide knowledge and critical thinking has helped me in a lot of way in completing this project. This project is done by his guidance and supervision and he has helped me understand the task at hand that has to be done.

I would like to extend my thankfulness to my fellow friends,classmates for never ending reminding me to always be confident and strive till the end during finishing this project. Last but not least,thank you for all the people who have helped me intentionally or unintentionally with my work and for their cooperation, support and encouragement.

ABSTRACT

Communication is the most important in our life through rapidly with technology.Since, there are many ways to communicate even through the world.Satellite is one of the part of communication that consist of uplink and downlink.This project will design for downlink satellite at C-Band indicate in microwave spectrum frequency with frequeny 4GHz.This Low Noise Amplifier (LNA) which is located at the front-end of the receiver(ground station). Low Noise Amplifier functioned to amplify the firsts amplication signal and to reduce the noise in the received signal.This will make it harder for the system to read the signal. The objective of this project is to design a LNA with operating frequency at 4GHz. The goal of noise figure(nf2) less than 1.3 dB and gain is over than 10 dB. GaAS FET transistor ATF-54143 from Avago Technology will be used as one of the part Low Noise Amplifier because it meet the specifications Avago Technology and able to used for satellite downlink communication. The simulation for this project will be using Advance Design System 2011. This LNA input and output match by using single stub technique and fabricated by using microstrip technology FR4 as a material. The design was successfully achieved with noise figure(nf2) 1.182dB and reasonable gain(S21) 11.112dB.

ABSTRAK

Komunikasi adalah yang paling penting dalam kehidupan kita seiring dengan kepesatan teknologi.Disebabkan itu , terdapat banyak cara untuk berkomunikasi walaupun dengan perhubungan diseluruh dunia.Satelite adalah salah satu sebahagian daripada komunikasi yang terdiri daripada 'uplink' dan 'downlink' yang terletak stesen bumi.Projek ini akan mereka bentuk untuk pautan turun satelit di C -Band menunjukkan dalam spektrum frekuensi gelombang mikro dengan 4GHz.Frekuesi Bunyi Rendah Amplifier (LNA) yang terletak di bahagian depan yang penerima (stesen tanah) . Fungsi utama LNA adalah untuk memberi isyarat pertama meluaskan dan mengurangkan bunyi dalam isyarat yang diterima. Objektif projek adalah untuk mereka bentuk LNA yang menggunakan frekuensi 4GHz dan angka bunyi yang disasarkan adalah kurang daripada 1.3 dB dan gandaan lebih besar daripada 10 dB. Transistor GaAS FET ATF - 54143 dari Avago Teknologi akan digunakan untuk mereka bentuk LNA kerana ia memenuhi spesifikasi dari Avago Teknologi untuk reka bentuk LNA bagi aplikasi satelit. Simulasi untuk projek ini akan menggunakan Rekabentuk Sistem Advance 2011 . Pada LNA input dan output perlawanan dengan menggunakan teknik puntung tunggal dan direka dengan menggunakan teknologi mikrostrip dan FR4. Reka bentuk itu berjaya mencapai angka hingar (nf2) 1.182dB dan gandaan (S21) 11.112dB .

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CHAPTER I

INTRODUCTION

1.1 Project Background

There are one parts of communication in RF repeater known as satellite. A carrier begins at a transmit terminal with an effective isotropic radiated power, arrives at the satellite to be amplified by a transponder high-power amplifier (HPA), and then goes downlink to a receive terminal [1].At the earth station, the instrument consist of dish antenna at transmitter carries high frequency 6GHz meanwhile the receiver carries 4GHz of micro wave signals. Ground station can transmit and receive the signals while the others can only receive high directivity signals and a high gain antenna is necessary at the earth station due the loss and the transmission very high [2]. Meanwhile, it is important to have a low noise amplifier before the mixer stage at receiving end a parabolic dish antenna provides a high gain, thus amplifies the signal power. The uplink is affected by the satellite antenna and LNA noises, and the downlink is affected by the receive terminal antenna and LNA noises. The end-to-end noise-to-signal power ratio is additive in those of uplink.

Low Noise Amplifier is one of the RF Receiver links that functioned to amplify the received signal in front end receiver especially. Initially, Low Noise Amplifier is one of the key components used to dominate the sensitivity of the complete receiver. The received signal might be very weak and the Low Noise Amplifier used to amplify the signal without injects much noise from the Low Noise Amplifier itself. This LNA is usually placed close to the detection device (antenna) to reduce losses and to avoid degradable of the signal-to-noise ratio (SNR). A good Low Noise Amplifier adds as little noise as possible to the signal and has high gain. Since the satellite downlink receiver operating with frequency 4GHZ (received signal) is weak, the LNA design to provide major gain with minimum the noise that flow to the system and boost the antenna signal.

The selective transistor is necessary it to calculate the value of s-parameters before simulation done. The s-parameters use to match impedance for minimum noise figure because s-parameters use for high frequency circuit. At last but not least, this report will force designer to design complexity the schematic and layout of LNA. To design LNA some parameter highlighted includes noise , input output matching, stability, linearity and gain that which will affect the performance of the entire receiver.For this project, the LNA are design by using a ATF54143 transistor from Avago Technologies and simulated by using Advance Design System 2011 software by Agilent Technologies. This project will deals mostly with Low Noise Amplifier design, fabricating and testing the amplifier using Vector Network Analyzer.

1.2 Problem Statement

In satellite communication system,the earth station receiving antenna will connect to a Low Noise Amplifier due to the received signal is weak and the received signal is usually a little above background noise.In addition, the LNA boosts the antenna signal to compensate for the feedline losses going from the (outdoor) antenna to the (indoor) antenna.Generally,the RF performance of the Low Noise Amplifier is quite good as it able to achieve the reasonable gain and provides low noise figure.Due for the different biasing circuit,active biasing circuit does not offer

much advantage compare to the passive biasing circuit.The only improvement detected and recorded is the noise figure performance of the Low Noise Amplifier with active biasing circuit. The matching networks using microstrip stub element matching is easier to design, simple and cost savings compare to two other matching. By using high performance devices such as the ATF-54143, however, circuits designed on FR4 material can meet the customer‟s requirements for noise figure, gain and linearity. The biggest benefit to customers is the lower cost of the FR4 material. This is a critical concern for customers‟ main production.

1.3 Objective

There are several objectives during designing this Low Noise Amplifier. The objectives include:

1. To study the characteristic and the specification of low noise amplifier (LNA) for satellite communication at 4GHz.

2. To design and simulate a low noise amplifier by using Advance Design System 2011.

3. To fabricate a low noise amplifier by using microstrip technology.

1.4 Scope of Projects

The scope of project is explore varies topologies of low noise amplifier and identify the most suitable method to satisfy the design target. Scope of this project can be separated into three parts:

1. Simulation-It will be done by varied parameters using Advanced Design System (ADS) in order to get required results which are close to the theoretical results.

2. Fabricating-The fabrication of the Low Noise Amplifier, PCB laminate (e.g:FR4 board), components, etching facilities.

3. Test analysis-A test analysis is the last stage in this project. The performance of the designed amplifier circuit is verified on board using RF testing equipment such as the vector network analyzer and cable.

1.5 Thesis Outline

The thesis is divided to five chapters and covers covering the research works that have been through for Low Noise Amplifier circuit design.

1. Chapter 1 is introduces the concept of the project, which is a brief the introduction for the satellite and Low Noise Amplifier. Several objectives are made to achieve the designing LNA.

2. Chapter 2 briefs the literature review of the basic concepts in Low Noise Amplifier circuit design. All the overview of this chapter will describes the techniques and procedures for design by making a various type of research.

3. Chapter 3 describes the design and simulation process and method that will be used. The transistor GaAS FET ATF54143 selected and Advance Design System 2011 used to simulate the LNA to obtain low noise figure and reasonable high gain.

4. Chapter 4 will report the simulation and measurement. This chapter also includes discussion from simulation and measurement results.

5. Chapter 5 concludes the research works that have been carried and gives suggestion for future development of the research project.

CHAPTER II

LITERATURE REVIEW

This Chapter will review the basic concept during designing Low Noise Amplifier circuit. Research has been done study include:

1) Satellite Frequency Bands
2) Satellite Communication
3) Low Noise Amplifier
4) Transistor

2.1 Satellite Frequency Bands

Radio Frequency (RF) devices are designed to operate at radio frequencies bands with various types of spectrum frequency.For this project , Low Noise Amplifier operates at downlink at 4GHz indicated at C-bands.[3]. Satellite C-band usually transmits (uplink) around 6 GHz and receives(downlink) around 4 GHz[4].

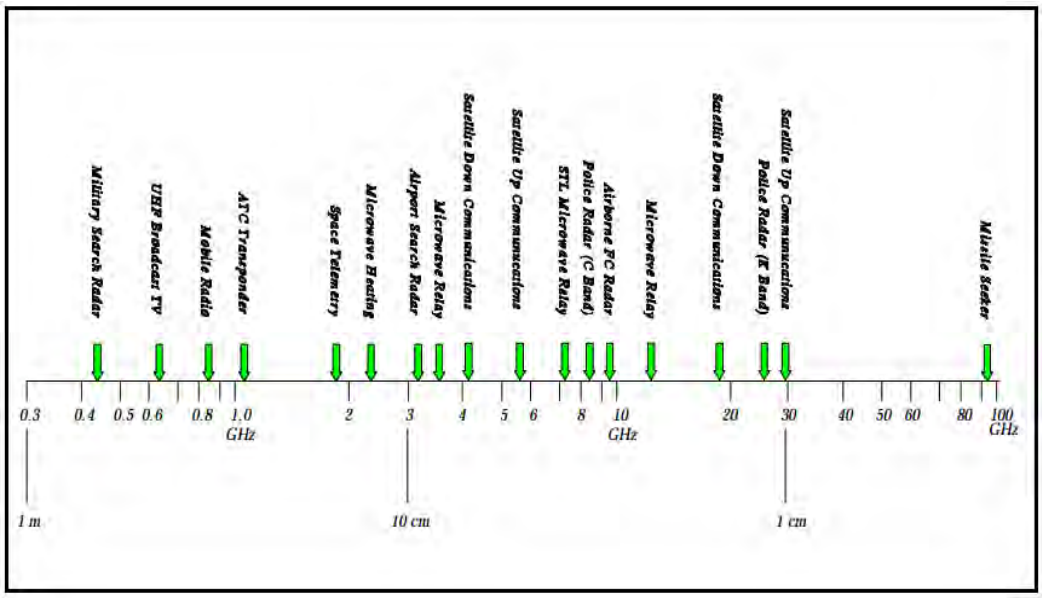

Figure 2.1: The microwave spectrum

From the microwave spectrum, C band was the first part of the spectrum to be applied extensively to satellite communications and still extensively used due to the low cost and wide availability of components and avaibility in heavy rain compare to high frequency satellite.The Table 2.1 shows the RF Band frequency in satellite applications.

Table 2.1: Bands available for fixed satellite services

RF Bands	Frequency(GHz)
L-Bands	1-2
C-Bands	4-6
Ku-Bands	12-18
Ka-Bands	26.5-40

2.2 Satellite Communication

S.Ekpo and D.George [3] in their journal have discussed of 4-8 GHz LNA Design for a Highly Adaptive Small Satellite Transponder Using InGaAS pHEMT Technology. Based on this journal, small satellite communication critical due to the noise level at the receiver. Thus, GaAs pHEMT consist of low noise and high gain in the frequency band 4-8GHz.A better design that delivers low noise performance, high gain and low power consumption for space mission. This LNA located in front receiver satellite successfully developed with high gain 17dB and 0.5dB of noise figure over the characterised bandwidth.

P.Raj Kumar [4], in this report have discuss and design of L-Band Low Noise Amplifier by using the ATF34143 GaAS HEMT's.In His project, a discretely 2-stage L-band low noise amplifier designed with center frequency 1.25GHz.Next,GaAS HEMT's offers low noise figure opposite to MESFET's and silicon FET's.This biasing sections by using radial stubs matching with tapered line. This LNA successfully developed with high gain 20dB and noise figure 0.17dB.

Curtis L.Mayberry. [5] in his journal 6GHz Low Noise Amplifier Design for C band application lies in the IEEE. This band suitable for satellite communications. This LNA design by using transistor pHEMT GaAS FET and operate at 6GHz.This amplifier need a high gain to effectively amplify the small signals received and to reduce noise. This amplifier successfully design and fabricated by using Duroid RO30006 with reasonable gain 13.1dB and noise figure 0.81dB.

2.3 Low Noise Amplifier

There are parts at RF front receiver known as Low Noise Amplifier where it interchanged part in the microwave system. This Low Noise Amplifier will produce a minimum noise figure also major gain for entire system. From the Figure 2.2, it is showed the block diagram of the RF receiver that has been simplified for easier to understand. Usually, RF filter will filtering the received signals from antenna at front receiver.

After that, RF filter then act with the LNA and this is where LNA function to amplify the signal before sent to the mixer. The signal with a local-oscillator (LO) and band pass filter [6] will combine by the mixer. Mixer used to amplify small signal or generate large signal. The signal will demodulate by demodulator, and then it will apply to ADC. The affected the performance of LNA especially at receiver are the case sensitivity for noise parameters [6].

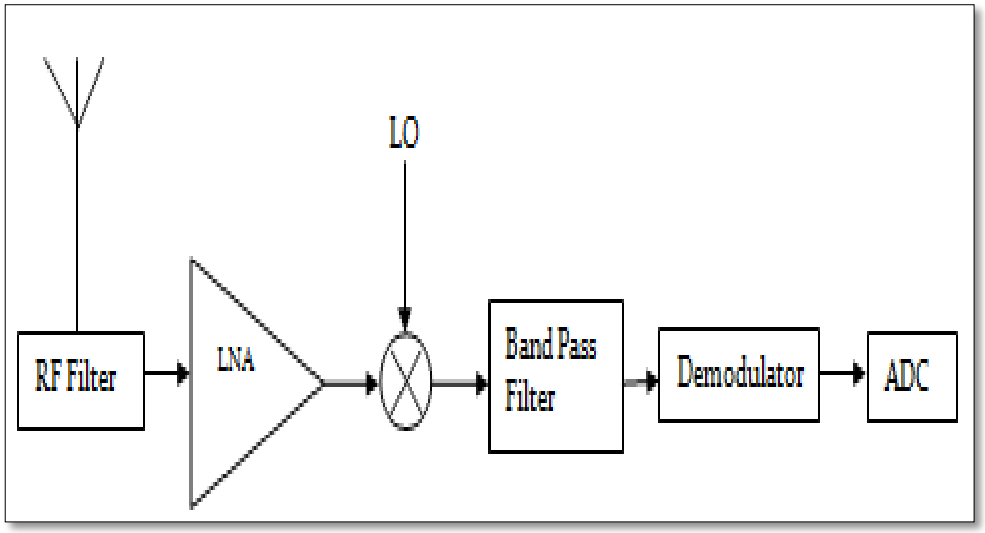

Figure 2.2: Basic block diagram of RF

Low Noise Amplifier merges a low noise figure, reasonable gain and stability without oscillation entire useful frequency range. The Low Noise Amplifier always operates in Class A amplifier, typically at 15-20% of its maximum useful current [7].Class A is characterized by a bias point does not shift. The smallest signal that can be received by a receiver defines the receiver sensitivity. For large signal levels, the LNA amplifies the extremely low power levels. The Low Noise Amplifier design presents a substantial challenge because of its simultaneous requirement for high gain, low noise figure, good input and output matching and unconditionally stability at the lowest possible current draw from the amplifier [8].