DESIGN, FABRICATE AND MEASUREMENT OF A LOW NOISE AMPLIFIER FOR WIMAX APPLICATIONS

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ABSTRACT

This report presents the progress done so far on the design simulation of Low Noise Amplifier (LNA). LNA is one of the important blocks in received RF path of a wireless communication system that is responsible for providing reasonable power gain and linearity, while not degrading the signal-to-noise ratio. So it is designed to provide low noise characteristics at high frequency as it signifies impact to the whole communication system. Usually, in RF amplifier, the signal being received by the antenna is usually very weak. So, amplifier will be used to amplify the signal. The problems occur when amplifying the signal where the transmitted noise also being amplified. To avoid this from happen, the LNA is designed so that the signal is transmitted without contributing too much noise. In WiMAX applications, receiver chain is designed with low noise in order to ensure reliable performance of the receiver. The purpose of this project is to study the characteristics of LNA, design and fabricate the LNA together with applying technical skills in solving problem according to the project requirement. The project begins with literature review on LNA and WiMAX and continues with the simulation using the ADS2004A software and after that, the circuit being transfer into layout and the fabrication purpose is done onto the FR4 board.

ABSTRAK

Laporan ini menerangkan tentang kemajuan projek untuk merekabentuk Penguat Hingar Rendah (LNA). LNA merupakan salah satu daripada blok yang penting dalam sistem Radio Frekuensi (RF) terutamanya dalam sistem perhubungan tanpa wayar yang berfungsi untuk menghasilkan gandaan kuasa yang bersesuaian dan mewujudkan kelinaran dalam sistem, di samping itu tidak mengurangkan nisbah isyarat kepada hingar (SNR). Jadi, LNA ini direka untuk menghasilkan ciri-ciri hingar rendah pada frekuensi yang tinggi sambil menunjukkan kesan ke atas sistem perhubungan tersebut. Kebiasaanya, dalam penguat RF, isyarat yang diterima oleh antena adalah sangat lemah. Jadi, penguat digunakan untuk menguatkan isyarat tersebut. Masalah timbul apabila isyarat dikuatkan kerana hingar yang dihantar bersama isyarat itu turut dikuatkan. Untuk mengelakkan keadaan ini, LNA direka supaya isyarat yang dihantar tidak mengandungi hingar yang tinggi. Dalam aplikasi WiMAX, blok-blok penerima dilengkapkan dengan LNA untuk memastikan sistem penerimaan itu berfungsi tanpa menerima hingar yang tinggi. Tujuan utama projek ini dilaksanakan adalah untuk mempelajari tentang ciri-ciri LNA, merekabentuk dan membina LNA serta mengaplikasikan kebolehan dalam bidang teknikal dalam menyelesaikan masalah mengikut keperluan projek. Projek ini bermula dengan kajian latar belakang LNA dan WiMAX dan diteruskan dengan simulasi menggunakan perisian ADS2004A dan seterusnya mengaplikasikan ke atas papan FR4 untuk tujuan fabrikasi.

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LIST OF ABBREVIATIONS

AP	-	Access Point
ADS2004A	-	Advanced Design System 2004 A
AGC	-	Automatic Gain Control
BJT	-	Bipolar Junction Transistor
CDMA	-	Collision Detection Multiple Access
DC	-	Direct Current
DSL	-	Direct Sequence Links
F	-	Noise Factor
GND	-	Ground
IF	-	Intermediate Frequency
IP		Intercept Point
ISP		Internet Service Provider
KVL		Kirchoff's Voltage Law
LNA		Low Noise Amplifier
LO		Local Oscillator
LOS		Line-of-sight
MAC		Media Access Controller
MIMO		Multiple Input Multiple Output
NF	-	Noise Figure
NLOS	-	Non-line-of-sight
Q-Point	-	Quiescent Point
QoS	-	Quality of Services
RF		Radio Frequency

SMT	-	Surface Mounted
SNR	-	Signal to Noise Ratio
VoIP	-	Voice over Internet Protocol
WiMAX	-	Worldwide Interoperability for Microwave Access
Wireless MAN	-	Wireless Metropolitan Area Network
WLAN	-	Wireless Local Area Network

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CHAPTER I

INTRODUCTION

1.1 Introduction

The request on the technology usage had increased day by day. Nowadays, the technology mostly in communications area has become tremendously expanded with a more sophisticated and even smaller which is easy to carry. The introduction to the wireless communication networks have contributes to the ease of human being where all the data can be obtained only at the tip of the fingers. The field of Radio Frequency (RF) design is a growing one as a result of increased demand for wireless products [1]. A microwave amplifier is one of RF system that becomes the most important part and extremely advanced with the involvement of microwave active and passive circuits.

WiMAX is the Worldwide Interoperability for Microwave Access is an example of the wireless communication system. WiMAX is a telecommunications technology aimed at providing wireless data over long distances in a variety of ways, from point-to-point links to full mobile cellular type access [2]. WiMAX applications require low-noise amplifiers with high gain and low noise figures and that operate under low DC power [3]. Low Noise Amplifier (LNA) is one of the important parts in receiver part whereas it helps to reduce the noise being transmitted especially in today's world

where RF circuit design is currently enjoying the revolution, and largely unanticipated, explosive growth in wireless telecommunications.

An RF front end circuit is usually includes the LNA, a mixer and a local oscillator. The LNA is implemented in RF circuit in order to obtain the received signal with minimum transmitted noise. LNA is the first block in the RF receiver and it is responsible for providing reasonable power gain and linearity while not degrading the signal-to-noise ratio (SNR). Generally, communication systems transfer information from a source to destination through a combination of transmitter and receiver. So if there is appear to have noise in the communication systems, the data being transferred will have losses or may be the signal being attenuated. Noise reduces the sensitivity of amplifier as it could overwhelm the required electrical signal.

Basically, amplifier design over a broad frequency range is a matter of properly designing the reactively matched circuit, traveling wave circuit, cascade single stage distributed amplifier, feedback circuit or loss matched circuit in order to compensate for the variations of frequency [4]. To select an appropriate amplifier, first the noise parameter for a particular application is understand and then the amplifier is determined either it is indeed low noise. In order to have a good performance of LNA, it must achieve the required gain and provides low noise figure. As for the different biasing circuit, active biasing does not offer much advantage over the passive biasing circuit.

This report provides background information and describes the tools used to build the LNA. As well, it explains the design methodology of the LNA and provides and explains simulation results and the tested result. The layout process is discussed in this paper. Finally, recommendations for others working on similar projects and for possible future work are provided.

1.2 Objectives

The main purpose of this project is to design the Low Noise Amplifier (LNA) that can operate under the operating frequency of WiMAX which is at 2.3 GHz. As the function of WiMAX which is to transfer wireless data over long distances range, so it promises users to deliver the best service with minimum disturbance or noise. LNA is an essential part of wireless LAN transceivers and as their demand increases, the requirements for better performance also increase. Some pressing issues in the design of narrowband LNA include the linearity of the amplifier, noise added to the system by the amplifier and the quality of integrated inductors [1].

The objectives of the projects include the study on the characteristics of LNA and understand the way it operates and function in the receiver. Once the study is understood and the characteristics of the LNA are distinguished, the design process is started. The design process involved the use of Advanced Design System 2004A (ADS2004A) software. The LNA is designed with the appearance of active and passive circuit where the involvement of the use of lumped elements for the dc bias circuit while the output and input matching circuit is designed using the passive circuit.

By taking care the noise figure and the gain of the designated LNA, the LNA circuit is adjusted until the desired noise figure and gain is suitable to be used under the operating frequency of WiMAX. Next, the objective of this project also involved of producing the hardware of the LNA circuit after the simulation is satisfied. The designated LNA is transferred and fabricated into the FR4 board. Then, the circuit is tested to check the functionability of the circuit designed. The design will use transistor BFP620 manufactured by Infineon Technologies Semiconductor.

1.3 Problem Statement

Today's technology has widely spread and new technology born without limits with tremendously variable specifications. WiMAX is one of the technologies being used today that related with the communication technology. The communication today has no border anymore no matter how far the communication is held. So, in this world without border, the information being sent should not have delayed, distorted or any disturbance that might affect the information that tried to be sent and delivered.

The LNA is designed to place it in an RF receiver to avoid from signal transmitted being received by the transmitter with high appearance of noise. LNA can help the amplified signal received by the RF receiver in the WiMAX applications with high signal-to-noise (SNR) ratio.

This project is developed in order to have the receiver to be as accurate as it can in receiving data. By combining both passive and active circuit, the receiver in WiMAX expects to have a better performance for a single-stage LNA design. Instead of low in costs, the designated LNA also will have a more compact circuit and easy to assemble in the receiver part. Furthermore, the use of microstrip in the receiver will make the receiver to have a better performance in receiving information instead of compact the circuit of the LNA on its own.

1.4 Scope of Work

The scope of the project can be divided into four parts which is the study of the characteristics of LNA, design and simulation of LNA using ADS2004A software, circuit fabrication, and test analysis and measurement. All the procedure taken is to make sure that the designated LNA achieved the theoretical results as close as it can be. The study of the characteristics of LNA is taken in order to understand and gain some knowledge on the LNA that is going to be designed. For example, some of the

characteristics of the LNA such as stability and linearity must be taken into considerations in order to obtain a better design for the LNA.

Second part is LNA design where the LNA is design in order to meet the specifications that were given in producing the LNA for WiMAX applications. This part involved of choosing the suitable transistor to obtain the best results of LNA design. All the characteristics, modeling and packages of the transistor are studied in order to have a transistor which has a better gain and high reliability. Besides that, the DC analysis is analyzed together with designing the biasing network and input output matching network.

In the next part, the simulation is done to obtain the best result before proceeding with the real design by using ADS2004A software. In this simulation process, the circuit is design and adjusted until the requirements are satisfied. The dc bias circuit together with the input and output matching is combined together to produce the matching result with required gain. The gain and noise figure is taken into attention and the circuit is adjusted so that the required gain and suitable noise figure is achieved as the specifications asked for.

The next part is about circuit's fabrication where the designated LNA will be designed and etch on the FR4 board. The fabrication process is done to apply the design towards the real design to test the simulated design on real time. This part is done after all the circuit designed in the ADS204A software is turned into the layout and being applied to the CorelDraw 12 software to convert it into the layout that can be exposed onto the FR4 board. Lastly, after fabrication process is done, the circuit is tested using the Signal Generator and Vector Network Analyzer in order to analyze the LNA.

1.5 Methodology

The process of performing the project begins with the literature review on the LNA and WiMAX. The process is done by finding the theory about both of it throughout the journals, articles and books that is related to the topic of the project. After the studying of the concept and some understanding is achieved, the process is continued with learning the software that going to be used in the simulation part for this project. Then, once the simulation has been learned, the process is continued with the simulation on finding the suitable design for bias circuit. Before proceeding with the simulation, some calculation is done to obtain the designed circuit for biasing circuit which is the value for suitable resistor to be used.

CHAPTER II

LITERATURE REVIEW

2.1 Wireless Communication System

Communication is very important in today's world in order to send and receive messages so that the idea between two parties or more will be done successfully. In the modern technologies that expand excitingly, there are many methods and mediums being used in order to transmit and receive the signal or information. One of the systems being used in communication process is wireless communication system. The system applied through this connection is without any transmission cable and the connection is based on the transmitted signal through the database that being set by the responsible person to the end user.

In the direct wireless communication mode, the participating wireless communication devices tune the receivers and transmitters to the same channel and communicate over that channel. The signal propagates through the medium by conversion into electromagnetic signals to the receiver with the help of another transducer into a desired form for a use by an end user. In the transmitter, it is usually includes the transducer and a transmission element which together convert the electrical