OPTIMIZATION OF 5.8 GHz FRONT END RECEIVERS FOR WiMAX APPLICATION

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Special dedication to my late father, Mustaffa Bin Nawawi and my mother, Mazanah Binti Jaafar.

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ABSTRACT

This report explores how to design the Low Noise Amplifier that was used in the front end receiver for the WiMAX application. This report also explains the fundamental knowledge in designing the Low Noise Amplifier. The fundamental objective of this project is to design and optimize the 5.8 GHz front end receiver. However, the main focus of this project is the designing and optimization of the Low Noise Amplifier. All the basic parameter and fundamental theory are described in detail. The result of the design will be revealed and discussed.

ABSTRAK

Laporan ini mengkaji kaedah untuk mereka-bentuk penguat rendah hingar untuk pengunaan aplikasi WiMAX. Laporan ini turut menerangkan pengetahuan asas di dalam kaedah mereka-bentuk penguat rendah hingar. Objektif asas kajian ini adalah untuk mereka – bentuk penguat rendah hingar dan mengoptima penerima bahagian depan radio frekuensi. Walau bagaimanapun, laporan ini memfokus pada bahagian mereka-bentuk penguat rendah hingar. Segala parameter dan teori asas diterangkan secara mendalam. Hasil projek ini akan didedahkan serta dibincangkan di akhir laporan ini.

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LIST OF ABBREVIATIONS

WiFi	-	Wireless Fidelity
WiMAX	-	Worldwide Interoperability Microwave Access
RF	-	Radio frequency
LNA	-	Low Noise Amplifier
DC	-	Direct current
QoS	-	Quality of Services
VSWR	-	Voltage Standing Wave Ratio
ADS	-	Advance Design System

CHAPTER 1

INTRODUCTION

Chapter one is focusing on the project background, project's objectives, problem's statements, scope of work, methodology and organization of thesis.

1.1 Project Introduction

Wireless connectivity is very common on these days. The most popular wireless connectivity for today is Wireless Fidelity (WiFi). WiFi is using the 802.11b and 802.11g standard which is operated at 2.4GHz. However, this 2.4GHz channel is quite congested. These channel are not only been used for Wifi but also for Bluetooth, WPAN-CSS (Wireless Personal Area Network using Chirp Spread Spectrum technique) and ZigBee.

However, there are new standard that has been introduced by IEEE which is the 802.16d and 802.16e. These standards are basically known as WiMax. WiMax are operating at channel of 3.5GHz and 5.8GHz. The 3.5GHz spectrum is a licensed spectrum and the 5.8GHz spectrum is the unlicensed spectrum.

Front end receiver is the first part of equipment in receiving signal. Basically front end receiver consists of antenna, Low Noise Amplifier (LNA), Radio Frequency (RF) amplifier, Power Divider and Band Pass Filter. LNA is an integrated component of most RF systems. In order to sustain a good signal reception, the total gain of the system should be in big number while the noise figure should be as low as it could be.

In order to get the best signal, the parameter in the LNA and the RF amplifier can be manipulate. Theoretically, by improving the gain of the system, the noise figure also will be increased. The only solution is to find the optimum system in terms of great gain and minimum noise.

1.2 Objective

The main purpose of this report are to document the learning process involved in the design and optimize theoretically of LNA that been used in 5.8 GHz operating frequency for the WiMAX application.

The objectives of this LNA design are to understand the concept of WiMAX communication and RF amplifier system, to know the different between narrow band amplifier and broadband amplifier, to design a Low Noise Amplifier that can operate in WiMAX frequency that is 5.8 GHz and finally the design will be simulated by using simulation software such as Advance System Designer.

1.3 Problem Statement

In general, the Low Noise Amplifier combines reasonable gain, good noise figure and also stability over entire useful range of frequency. Designing LNA will present challenges in obtaining high gain, low noise figure, good input and output matching, and the stability over certain range of frequency. There are certain criteria needs to be look upon during designing LNA. Those criteria are low supply voltage, low current consumption, high gain, high isolation and input return loss. Low Noise Amplifier usually implies RF/wireless applications thus the circuit needs to be small and cheap in order to be used widely. In order to achieve that, the matching networks can be changed to lump elements for space reduction and cost saving.

1.4 Scope of Work

The scope for this project is to develop and optimize theoretically the LNA and RF amplifier for the 5.8GHz front end receiver for WiMAX application. This project will only cover the theoretical analysis which involves the calculation of all the parameters. This project also will be simulated using simulation software in order to verify the theoretical results. The target of gain to be achieved is 30dB.

1.5 Methodology

The work progress of this project is divided into four main parts:

- Understanding the operation of front end receiver, Mathcad, and Advance System Designer software.
  In this part, all the literature review was done. The process included collection of internet journal, online tutorial and also material collection from printed material.

- Theoretical and statistical analysis of LNA using Mathcad.
  All the formula was formed in the software which then will be calculated using the software function itself.

- Simulation of designed amplifier circuit using Advance System Designer.

- Comparing the theoretical analysis and simulation result.

If problem occur, such as, the theoretical and simulation result doesn't match, the process will be repeated from simulation stage

1.6 Report Structure

This report was divided into five chapters. The first chapter is focusing on the introductions of the project. The introduction consist of the project brief introduction, objective of the project, the project statement, scope of work, project methodology and the report structure.

The second chapter is about the literature review. This chapter is focusing on the documentation of the theory that related in designing the Low Noise Amplifier. The reviews of previous case study are also included in this chapter.

The third chapter is mainly about the research methodology. All the progress and work flow are described in this chapter.

The fourth chapter is about the project progress focusing on the result of the simulation. All the data that were obtained will be documented in this chapter. The full project results are shown.

The final chapter is focusing on the discussion and conclusion of this report. These include the entire result and its justification. Some suggestion on improving this project also will be discussed.

CHAPTER 2

LITERATURE REVIEW

This chapter reviews some references from previous project, journal, article, books and data sheet. All these information was collected from the different sources such as library, internet, product manual and etc. The useful data will be discussed on the chapter.

2.1 Inroduction to WiMAX

WiMAX is actually the short form of Worldwide Interoperability Microwave Access. This term is agreed between several companies to be used in general. The actual name for this standard is IEEE 802.16. [1] This standard is a wireless digital communication system that is intended for metropolitan area that provides interoperable broadband wireless connectivity to every person in the metropolitan area. It provides up

to 50 kilometers of service area for fixed station, 5 to 15 kilometer for mobile station allowing user to get broadband connectivity without the need of direct line of sight to the base station. The WiMAX complaint system will provide a cost effective broadband access to user at home, in the office, in the areas under-served by wire-line Digital Subscriber Line (DSL) and cable services and even to users on the move equipped with portable devides such as laptop and personal digital assistance (PDA).

Table 2.1 Comparison between WiMAX and WLAN

Parameter	**WiMAX**	**WLAN**
Frequency Band	2 to 11 GHz	2.4 GHz
Range	31 miles	100 meters
Data Transfer Rate	70 Mbps	11 Mbps~55 Mbps
Number of user	Thousand	Dozens

The WiMAX standard relies upon a grant-request access protocol that does not allow data collision and therefore, uses the available bandwidth more efficiently. No collision means any loss of bandwidth due to data retransmission. All communication is coordinate by the base station. The main characteristic of the WiMAX standard include;

- Long range of service area – the service area of WiMAX standard can be up to 30 miles.
- Higher quality of services – the QoS of WiMAX is definitely higher compare to other standard due to no collision protocol.
- Wireless – WiMAX system is based on the wireless technology therefore the mobility of new technology can be implemented.

2.2 RF Front End Block Diagram

Direct conversion, also known as homodyne or zero-IF conversion, is a natural approach to convert an RF signal directly to baseband. A baseband signal has all the frequencies from 0 Hz to the highest frequency component with significant power. After the frequency it changed for transmission the higher frequency RF signal will have at least double what the baseband signal had initially. Alternately, one can think of choosing IF to be zero. The architecture of the proposed project;

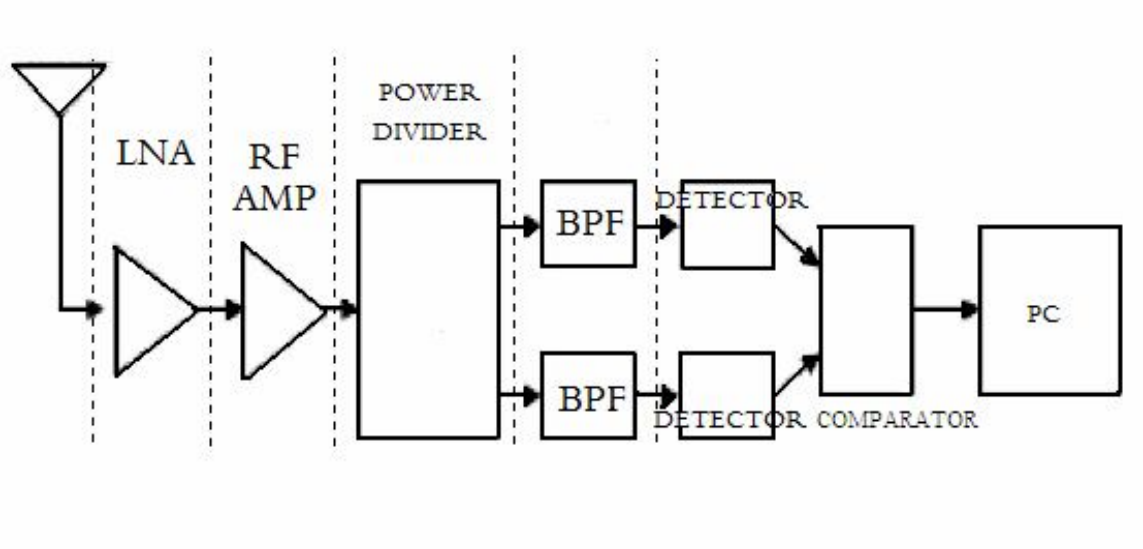

Figure 2.2.1 Front end receiver block diagram. [2]

In this project, the part that is being concerned is RF component part or specifically the low noise amplifier part. The low-noise amplifier (LNA) is a special type of electronic amplifier or amplifier used in the systems to amplify very weak signals captured by an antenna. The important things, the LNA deals with noise where LNA remove the noise even though not totally remove all the signal but it still an important part that dealing with noise. It just likes reducing the signal noise that came through antenna.

2.3 LNA Design

Microwave Transistor Amplifier is design using the scattered parameters (S parameter). Microwave amplifiers combine active elements with passive transmission line circuits to provide functions critical to microwave systems and instrument. The history of microwave amplifiers begins with electrons device using resonant or slow-wave structures to match wave velocity to electron beam velocity. [3]

The design techniques used for BJT and FET amplifiers employ the full range of concepts that have been developed in the study of microwave transmission lines, two-port network and Smith chart presentation. [4]

The development of S-parameter matrix concepts grew from the need to characterize active devices and amplifiers in a form that recognized the need for matched termination rather than short-or open circuit termination.

2.4 DC Biasing Technique

DC biasing is an important design consideration for proper operation of amplifiers [5]. The ideal biasing arrangement should select the proper quiescent point and hold the quiescent point constant over variation in the transistor parameter and temperature. This is due to large temperature changed in an active bias network. The DC and RF circuit should be isolated in order to make sure no RF signal will leak into the DC biasing circuit and the DC biasing circuit does not disturb the RF performance. In