STATISTICAL ANALYSIS FOR FRONT END RF RECEIVER DESIGN

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This book is dedicated to my parents, family members and friends.

Last but not least, to my lovely supervisor and all the UTeM lecturers.

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ABSTRACT

Direct conversion receivers are increasingly popular for use in mobile terminals. This is due to advantages over other architectures such as heterodyne receivers in terms of cost, electrical current and physical size. In this paper, a 5.8 GHz direct conversion receiver is presented. RF receiver parameters presented in calculation and simulation such as gain, noise figure, intermodulation distortion (IMD), and gain compression. Advance Design System (ADS) software used to simulate all the parameter need to complete and stabilize the system. The receiver achieve a noise figure of 1.802 dB, an intermodulation distortion of -116.631 dBm, a gain of 52.605 dB, and P1 dB gain compression of -13.113 dBm.

ABSTRAK

Penerima-penerima pertukaran langsung adalah semakin popular digunakan untuk terminal bergerak. Ini kerana kelebihan reka bentuk penerima pertukaran langsung berbanding penerima heterodin dalam bentuk harga, arus elektrik dan saiz fizikal. Dalam kertas ini, 5.8 GHz penerima pertukaran langsung dibentangkan. Parameter penerima RF dibentangkan dalam bentuk pengiraan dan simulasi seperti gandaan, hingar, intermodulasi (IMD), dan gandaan mampatan. Perisian Advance Design System (ADS) digunakan untuk simulasi semua parameter yang diperlukan untuk melengkapkan serta menstabilkan system. Penerima mencapai hingar dalam 1.802 dB, intermodulasi (IMD) sebanyak -116.631 dBm, gandaan sebanyak 52.602 dB, dan gandaan mampatan sebanyak -13.113 dBm.

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CHAPTER 1

INTRODUCTION

1.1 Project Background

Telecommunication is the extension of communication over a distance. The elements of a telecommunication system are a transmitter, a medium and possibly a channel imposed upon the medium and a receiver. The transmitter is a device that transforms or encodes the message into a physical phenomenon, the signal. The receiver has a decoding mechanism capable of recovering the message within certain limits of signal degradation. In telecommunication, antenna is the best example to describe this system. Antenna is designed to transmit or receive a signal/radio wave. In this report, it discussed more about receiver. RF front end is a generic term for everything in a receiver that sits between the antenna and the intermediate frequency (IF) stage. Usually, the receiver circuit is combining with the transmitter circuit where it called transceiver. There are many type of front end receiver in the transceiver today. There are direct conversion receiver, directly amplifying receiver,

reflectional receiver, homodyne detection, low IF receiver, tuned radio frequency receiver, and superheterodyne receiver. To design a good front end receiver circuit, some of specifications must be taken. The front end receiver must be good image rejection, lower complexity and fewer components. Because of that a suitable architecture of the receiver must be consider to design this front end receiver circuit.[1].

The direct conversion principle has been well known as a demodulation method, especially for an AM signal, under the name of ‘‘synchrodyne” or “homodyne”[2]. An example of such efficient receiver architecture is a direct conversion receiver as presented in [3]. The main feature of direct conversion receivers is the down-conversion of the radio signal to baseband without any use of intermediate frequencies.

The 802.11a wireless local-area-network (WLAN) system, which uses orthogonal frequency division multiplexing (OFDM) [4], offers different communication data rates (through 6 to 54 Mbps) in the 5-GHz band. The principle of OFDM is to split high-rate data streams into a number of lower rate streams that are transmitted simultaneously over a number of subcarriers. To implement an 802.11a WLAN receiver, a direct conversion receiver (DCR) is more suitable than a heterodyne receiver. A typical Direct Conversion Receiver (DCR) block diagram is shown in Figure 1.1.

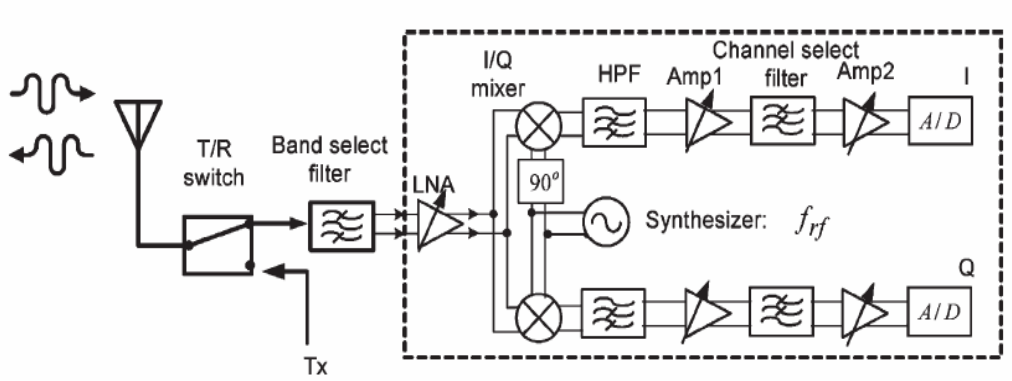

Figure 1.1: Example DCR block diagram

In this paper, a direct conversion receiver for 5.8 GHz (WLAN) system is presented, which is good image rejection, lower complexity, less component count and low noise figure.

1.2 Problem Statements

The major problems in this project are to choose suitable architecture for the receiver, optimize and design the suitable receiver for the specified requirement. The inefficient simulation technique in design tools is another challenge in getting accurate simulation result.

1.3 Objectives

The main objective in this project is to develop and optimize Front-End direct conversion receiver at 5.8 GHz.

1.4 Scopes

The scope of the research work comprises as follows:

a) RF components such as low noise amplifier, RF amplifier, power divider and filter is selected to fulfill RF receiver architecture.

b) RF budgets such as gain, noise figure and IP3 are calculated and analyzed according to designed RF components.

c) The selected direct conversion receiver is then modeled in the ADS2005A software based on designed components. The DCR model is simulated for system characteristic and performance analysis.

1.5 Methodology

The method includes:

a) RF components for the receiver are chosen. RF budgets for the RF receiver design are calculated according to the parameters of the selected components in data sheet.

b) The RF receiver is modeled by using ADS2005A software. The RF receiver models are then simulated for system characteristic such as gain compression and third input intercept point (IIP3). This followed by system performance analyses according to IEEE802.11a standard[4] where the effects of RF distortions on the system performance are analyzed.

1.6 Expected Outputs

At the end of this project, the front-end direct conversion receiver is expected to be successfully developed for WLAN application. As the final result, front-end receiver will obtain the good sensitivity, gain, maximum receiver strength, low noise figure, IIP3, P-1dB and Dynamic Range.

1.7 Conclusion

In this project, a direct conversion RF front-end receiver for 5.8 GHz (WLAN) system will be presented, which is good image rejection, low power consumption, lower complexity, less component count and low noise figure and satisfy the IEEE 802.11a standard.

1.8 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 receiver. 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 describe in this chapter.

The fourth chapter is about the project progress focusing on the result of the simulation. All the data that were obtain during this semester 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

2.1 Literature Review

This chapter develops some basic principles used in the analysis and design of Front End Receiver. The most important design considerations in front End Receiver are Gain, Noise Figure, Sensitivity, and IMD (Intermodulation Distortion). To ensure the designed circuit fulfills performance requirement and could be install as a practical component in the future, one of the popular standard followed by the market product, which is developed by Institute of Electrical and Electronic Engineering (IEEE), is taken as the major requirement that design circuit should achieve.

2.2 INTRODUCTION TO WIRELESS LAN (WLAN)

Wireless technology has been available for a long time and it is only until recent few years that wireless LAN (WLAN) becomes popular. WLAN has continued to grow at incredible rate. Due to the convenience, availability, and cost of wireless hardware, there is an explosive growth in WLAN deployment and manufacture of WLAN hardware. It is therefore necessary to have organizations such as FCC, IEEE, the Wi-Fi Alliance and WLANA to remove barrier of operations between solutions.[5]

A wireless LAN is a data transmission system designed to provide location-independent network access between computing devices by using radio waves rather than a cable infrastructure. In the corporate enterprise, wireless LANs are usually implemented as the final link between the existing wired network and a group of client computers, giving these users wireless access to the full resources and services of the corporate network across a building or campus setting. The widespread acceptance of WLANs depends on industry standardization to ensure product compatibility and reliability among the various manufacturers. Table 2.1 shows the comparison between WLAN and Bluetooth.[5]

Table 2.1 : Comparison between WLAN and Bluetooth

	Bluetooth	WLAN
Standard	802.15	802.11a
Frequency (GHz)	2.45	5
Speed (Mbps)	0.75	54
Range	10m	50m
Advantages	Low cost	Speed
Disadvantages	Range	Cost

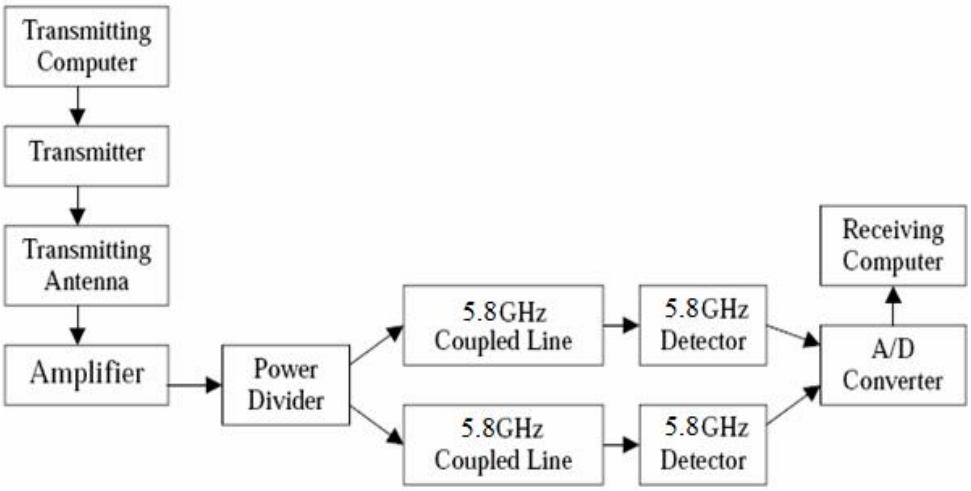

Figure 2.1: Block Diagram WLAN system

2.3 ADVANTAGES OF WLAN

What are the concrete benefits of WLAN over wired networks? While the most obvious is mobility, there are advantages also in building and maintaining a wireless network. Let us look at the benefits more closely:

a) Mobility - Mobility is a significant advantage of WLANs. User can access shared resources without looking for a place to plug in, anywhere in the organization. A wireless network allows users to be truly mobile as long as the mobile terminal is under the network coverage area.

b) Range of Coverage - The distance over which RF and IR waves can communicate depends on product design (including transmitted power and receiver design) and the propagation path, especially in indoor environments. Interactions with typical building objects, such as walls, metal, and even people, can affect the propagation of energy, and thus also the range and