DIRECT CONVERSION RECEIVER FOR ACTIVE INTEGRATED ANTENNA

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To my parents and family, for their guidance, support, love and enthusiasm. Without these things this thesis could not have been possible.

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ABSTRACT

This thesis describes the design of a compact miniature and low cost microstrip dipole antenna integrated with 90^0 hybrid coupler, oscillator and diodes for direct conversion, or zero IF receiver. The frequency chosen is at 2.4 GHz, which is of particular interest for RFID application. In this receiver design, Agilent's ADS software using momentum simulation and circuit simulation is employed to analyze the entire structure. In the fabrication process, the proposed receiver element is printed on a FR4 substrate with a dielectric constant of 4.7, a thickness of 1.6 mm and a conductor loss of 0.019. Microstrip dipole antenna that is presented here has a wide bandwidth up to 24% bandwidth. The 90^0 hybrid coupler can act as a phase shifter to provide the necessary 90^0 characteristics to operate with I/Q signal for direct conversions. Two schottky diodes (HSMS 8101) are mounted onto each of two coupler's output port to act as a mixer. One kHz sinusoidal signal act as a baseband have been generated and modulated using signal generator. The demodulated signal is detected using direct conversion receiver circuit and the baseband signal at the output ports should be detected using oscilloscope.

ABSTRAK

Tesis ini menerangkan mengenai rekaan padat antena mikrostrip dipole digabungkan bersama 90^0 hybrid coupler, oscillator dan diod untuk penerima Direct .Conversion atau Zero-IF. Frekuensi yang digunakan adalah pada 2.4 GHz dimana ia banyak digunakan untuk aplikasi RF ID. Di dalam rekaan penerima ini, perisian Agilent ADS menggunakan simulasi momentum dan litar telah digunakan untuk menganalisa seluruh struktur litar. Antena microstrip dipole ini mempunyai lebarjalur sehingga 24 %. 90^0 hybrid coupler pula akan bertindak sebagai penganjak fasa, supaya mencapai ciri 90^0 untuk operasi bersama isyarat I/Q. Dua diod Schottky (HSMS 8101) dilekapkan bersama setiap pasangan port keluaran untuk bertindak sebagai pengadun. Satu pin daripada diod itu disambungkan pada hujung port keluaran dan satu pin lagi dibumikan di atas satah bumi. Satu kilohertz isyarat sinus bertindak sebagai isyarat baseband telah dijana dan dimodulat menggunakan penjana isyarat. Isyarat yang telah termodulat kemudian dikesan menggunakan litar penerima Direct Conversion dan isyarat baseband kemudiannya berjaya dikesan pada port keluaran menggunakan osiloskop.

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LIST OF ABBREVIATIONS

ADS	-	Advanced Design System
AIA	-	Active Integrated Antenna
BW	-	Bandwidth
CAD	-	Computer Aided Design
dB	-	Decibel
DCR	-	Direct Conversion Receiver
G	-	Gap
GHz	-	Giga Hertz
IF	-	Intermediate Frequency
kHz	-	Kilo Hertz
L	-	Length
LAN	-	Local Area Network
LO	-	Local Oscillator
MHz	-	Mega Hertz
Mm	-	Milimeter
^{o}C	-	Celcius
^{o}K	-	Kelvin
RF	-	Radio Frequency
VTO	-	Voltage Tuned Oscillator
W	-	Width
WCC	-	Wireless Communication Centre
Zo	-	Characteristic Impedance
εr	-	Material substrate
Λ	-	Wavelength
Ω	-	Ohm

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CHAPTER I

INTRODUCTION

1.1 Introduction

The wireless industry has experienced a significant growth in the past several years. In order to have smaller products with more features, lower power consumption, and shorter design cycles, the size and complexity of the RF section of the product must be reduced. To explain this impact on the RF section one must briefly examine radio receiver architecture [1].

There are several types of receiver architecture that have been implemented in the wireless industry. However, in this thesis, five types of receiver will be discussed in the next chapter. The these are Superheterodyne Receiver, Image-Reject Receiver, Low IF Single Conversion receiver, Wideband IF with Double Conversion and Direct Conversion Receiver.

Superheterodyne receiver is the most widely used reception technique. However, it has several disadvantages that will be discussed later in the next chapter. The second type of receiver is Image Reject Receiver, which proposed is to remove image without the need of any post-LNA image-reject filtering. The third type of receiver is Low IF Single Conversion Receiver purpose is to protect the receiver from all the DC-related problems that pertain to DCR, while retaining the DCR's benefit of elimination of high Q IF filters. The fourth type of receiver is Wideband IF with Double Conversion is very similar to the superheterodyne configuration. The last type of receiver which is particularly topic of interest in this project is Direct Conversion Receiver (DCR) or Zero IF Receiver. This DCR is implemented to overcome the problem that occurred in superheterodyne receiver such as problem of image and complex circuitry.

Direct Conversion Receiver (DCR) can be implemented with Active Integrated Antenna (AIA). AIA is Active Integrated Antenna is used to classify a combined antenna and front end where the antenna and active device interact to produce the overall circuit's response. The implementation of DCR and AIA gives advantages such as simple circuitry, compact size and lower manufacturing cost. These make the DCR technique popular choice for implementation in majority of wireless products [2].

1.2 Objective

The objective of this project is to design and fabricate a compact and low cost Direct Conversion Receiver (DCR) at frequency 2.4 GHz.

1.3 Project Background

Most of radio receivers adopt superheterodyne technique, which can provide high selectivity and sensitivity. Superheterodyne receiver contains RF, IF and baseband stages. The system has many advantages such as good stability, high gain, low noise and flexibility for channel selection. However, superheterodyne receiver has some disadvantages such as high power consumption, complex circuitry and the existence of an image frequency signal. To overcome this problem, direct conversion or zero-IF detection has been proposed as alternative receiver architecture [2-4]. Zero IF or direct conversion detection is a kind of coherent detection method. A modulated signal is mixed with the unmodulated carrier to produce zero IF signal.

The output signal contains the baseband signal's amplitude and phase information [4]. This kind of receiver can eliminate the IF stage and the band pass and band reject filters, thereby reducing the circuit complexity.

A compact miniature direct conversion receiver constructed with microstrip dipole antenna, a local oscillator (LO), diodes mixer and hybrid coupler has been designed for this research. This design can be realized in an active integration antenna (AIA) [6-9]. AIA can be regarded as an active microwave circuit in which the output or input port is free space instead of a conventional 50Ω interface [10]. In this case, the antenna can provide certain circuit functions such as resonating, filtering, and duplexing, in addition to its original role as a radiating element. On the other hand, from an antenna designer's point-of-view, the AIA is an antenna that possesses built-in signal- and wave-processing capabilities such as mixing and amplification.

Miniature size, low cost and simple circuitry is the main advantages to implement this AIA design using direct conversion technique. 2.4 GHz frequency is chosen since it is within the license free frequency bands, Industrial, Scientific and Medical (ISM) bands [10]. In this thesis simulation and measurement results of DCR components and DCR itself will be discussed in this thesis.

1.4 Scope Of Project

The scope of this project describes the design of a compact miniature microstrip dipole antenna integrated with 90^0 hybrid coupler, oscillator and diodes for direct conversion, or zero IF receiver. The frequency chosen is at 2.4 GHz, which is of particular interest for RFID application. In this receiver design, Agilent's ADS software using momentum simulation and circuit simulation is employed to analyze the entire structure. DCR components which are dipole antenna and 90^0 hybrid coupler are needed to be design part by part. A suitable oscillator and mixer diodes selection should be done for DCR at 2.4 GHz. All of the DCR components are then being assembled and tested. This DCR should be able to detect baseband signal that has been transmitted throughout signal generator. A compact DCR are then fabricated in one board and again will be tested using signal generator.

1.5 Thesis Structure

The thesis is divided into five chapters and covers the research works that have been through for Direct Conversion Receiver design.

Chapter II reports the literature review of the basic concept of Direct Conversion Receiver and implementation with Active Integrated Antenna. Chapter III describes the design, simulation and fabrication process. Using Advanced Design System (ADS) software will do this process. The simulation and measurement results are reported in Chapter IV. This chapter also includes discussion from simulation and measurement results. Chapter V concludes the research work and gives suggestion for future development of the research project.

1.6 Summary

This chapter is an introduction for objective and research scope of the project. The research background and importance of the project also be explained. Besides, the thesis structure is highlighted. The research work performed will be reported in the following chapter.

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