A 2.4 GHZ MIMO WIRELESS TRANSCEIVER DESIGN

By

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DEDICATION

بِسْمِ ٱللَّهِ ٱلرَّحْمَٰنِ ٱلرَّحِيمِ

... رَبِّ أَوْزِعْنِيٓ أَنْ أَشْكُرَ نِعْمَتَكَ ٱلَّتِيٓ أَنْعَمْتَ
عَلَيَّ وَعَلَىٰ وَٰلِدَيَّ وَأَنْ أَعْمَلَ صَٰلِحًا تَرْضَىٰهُ وَأَصْلِحْ لِي فِي
ذُرِّيَّتِيٓ ۖ إِنِّي تُبْتُ إِلَيْكَ وَإِنِّي مِنَ ٱلْمُسْلِمِينَ سُورَةُ الأَحْقَافِ ١٥

Praise be to Allah, the most gracious and the most merciful. Without his blessing and guidance my accomplishments would never have been possible.

My father mohd Ibrahim and my mother yusra mohd for their patience and support for all these years

My fiancée who always light up for me.

My supervisor mohd fadzil ain.

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LIST OF ABBREVIATIONS

ADC	Analog to digital converter
ADS	advanced design system
AM	Amplitude modulation
ASK	Amplitude shift keying
BER	Bit error rate
BW	Band width
DAC	Digital to analog converter
DSP	Digital signal processing
FDM	Frequency division multiplexing
FFT	Fast furrier transform
FM	Frequency modulation
FSK	Frequency shift keying
GSM	Global system mobile
IFFT	Inverse furrier transform
ISI	Intersymbol interference
LAN	Local area network
LNA	Low noise amplifier
LO	Local oscillator
MDS	Minimum detectable signal
MIMO	Multi input multi output

OFDM	Orthogonal frequency division multiplexing
PA	Power amplifier
PCB	Printed circuit board
PSK	Phase shift keying
PWB	Printed wiring board
QPSK	Quadrature phase shift keying
RF	Radio frequency
SM	Spatial multiplexing
SSB	Single side band
SNR	Signal to noise ratio

REKABENTUK PEMANCARTERIMA TANPOA WAYAR 2.4GHz UNTUK SISTEM MIMO

ABSTRAK

Kombinasi antara MIMO dan modulasi kesukuan dianggap sebagai salah satu penyelesaian yang paling berkesan bagi memperbaiki kecekapan spektrum dan meningkatkan kadar data untuk sistem komonikasi tanpa wayar bagi generasi akan datang . Tujuan penyeldikan ini adalah untuk membangunkan satu pemancarterima tanpa wayar MIMO beroperasi pada 2.4GHz menggunakan teknik modulasi QPSK. Pembangunan pemancarterima dilaksanakan dengan membina dua bahagian penting yang berlainan dikenali sebagai pemancar dan penerima. Pemancar terdiri daripada penukar digital kepada analog, pemodulasi sukuan dan peguat kuasa. Rekabentuk ini akan tertumpu pada merekabentuk keupayaan yang optima bagi 2.4GHz pemancarterima tanpa wayar MIMO dimana keputusan yang dijangka akan diperolehi lalah dua fasa isyarat yang bebas yang mewakili isyarat I dan isyarat Q. Dua isyarat bebas ini lelah dijanakan dengan menggunakan perisian Matlab melalui pangjualan komputer selari yang akan diproses di dalam pemancar dan penerima. Pemancarterima telah dilaksanakan di dalam perkakasan dan setiap bahagian pemancarterima lelah diuji secara individu di mana ianya mempamerkan hubungan pancaranterima yang beroperasi pada 2.4GHz.

2.4GHz MIMO WIRELESS TRANSCEIVER DESIGN

ABSTRACT

The combination of multiple input multiple output (MIMO) and quadrature modulation is regarded as one of the most promising solutions for improving spectrum efficiency and enhancing data rate for next-generation wireless communication systems. The aim of this research is to develop a MIMO wireless transceiver operates at 2.4GHz using QPSK modulation technique. ADS software is used for the simulation and Orcad software is used for PCB fabrication. The transceiver development is implemented by building two separated main parts, the transmitter and the receiver. The transmitter consists of digital to analog converter, quadrature modulator and power amplifier. While the receiver consists of low noise amplifier, down converter, quadrature demodulator and analog to digital converter. This design is focused on the determination of optimum performance of 2.4GHz MIMO wireless transceiver where the expected results would be achieved as two independent phase signals represented as I signal and Q signal. These two independent signals are generated by Matlab through the computer parallel ports to be processed in transmitter and receiver. A power improvement is achieved for the proposed transmitter architecture. The receiver shows balanced quadrature signal output power. The transceiver which is implemented into the hardware exhibits a MIMO transceiving link operates at radio frequency thus reducing system complexity, size and price.

CHAPTER ONE

INTRODUCTION

1.1 Background

Communication is the process of exchanging information by various means such as verbal, nonverbal, print and electronic media. People communicate in order to express their thoughts, ideas and feelings to others and the tendency for communication is inherent to all human beings.

Multiple input multiple output (MIMO) is based on the multi carrier communications technique. The idea of multi carrier communication is to divide the total signal bandwidth into number of sub carriers and information is transmitted on each of the sub carriers.

Unlike the conventional single carrier communication scheme in which spectrum of carrier is non-overlapping and band pass filtering is used to extract the frequency of interest, in MIMO the frequency spacing between sub carriers is selected such that the subcarriers are mathematically orthogonal to each other. The spectra of subcarriers overlap each other but individual subcarrier can be extracted by baseband processing. This overlapping property makes MIMO more spectral efficient than the conventional single carrier communication scheme.

1.2 Motivation

The goal of future fourth-generation (4G) systems is to achieve high data rate communications and to get continuous funding of services across a multiplicity of wireless systems and networks, from internal to external, and from private to public network infrastructure (Luciano et al,2006)(Foschini,1996).

Higher data rates allow the proliferation of multi-media applications which include voice, data, pictures, and video over communication networks (Foschini et al, 1998). MIMO is a technical modulation for multi carrier communication systems and is a promising technique for 4G systems because it has less quick impact to inter symbol interference introduced in multi path environment (Pan et al, 2006).

An adaptive antenna array deployed at the receiver can enhance the signal integrity in an interference environment. If the desired signal and the interfering signals are located at different spatial locations, an antenna array can act as a spatial filter which separates the desired signal from the interfering signal. In the cellular environment, using an adaptive antenna can reduce the co-channel interference from other users within its own cell and the neighboring cells, thus increasing system capacity. Due to its advantages, an adaptive antenna array is likely to be an integral part of the 4G systems.

The application of adaptive algorithms in the antenna array for the single -carrier systems has been studied extensively. However, the RF front-end of the MIMO is an independent subsystem therefore it is necessary to be designed to fulfill MIMO requirements.

1.3 Objectives

The present research is aimed to achieve the following objectives:

1. To design a transceiver for multiple input multiple output wireless system employing Quadrature Phase Shift Keying (QPSK) digital modulation technique which can operate at 2.4GHZ.

2. To interface the transceiver with the Field Programmable Gate Array (FPGA) MIMO system.

1.4 Thesis outline

The thesis is organized as follows:

Chapter 1 gives the basic introduction to the thesis including the objectives.

Chapter 2 provides a detailed review of the previous studies on MIMO systems in an organized manner and presents its fundamentals and the basic terminology.

Chapter 3 provides the necessary information to understand the MIMO radio hardware and for the sake of completeness, involving the circuit simulation, PCB layout measurements and analysis.

Chapter 4 presents a detailed discussion on the simulation methodology and the results obtained from the current research.

Chapter 5 concludes the dissertation by summarizing the results and briefly presenting some suggestions for future work.

CHAPTER TWO

LITERATURE REVIEW

2.1 Introduction

Communication equipment design is typically a high complex action (Rappapot, 2001). The telecommunication diligence is technologically dynamic which both new and surviving technologies constantly demand for. This chapter sets fourth some basic information on an MIMO communication system in general. Emphasis is placed on communication passage base and wireless spread spectrum design issues. The most important issue in designing a large communication network is that it must supply authentic service for 10 to 20 years or more to ensure economic property (Sedra, 1998). If we look at the present scenario and the predictable future of telecommunication industry the degree of technological change and market limiting present both troubles and chances (Sarperi et al, 2006).

The troubles are in the real possibility of equipment devolution. As with computers, the communication manufacturer is going through a rapid development of usable equipment. The chances may involve providing with the new communications parties the relieved environment is producing. Although the design of the communication elements within single projects may not involve system judgment and large scale concepts, it is important that the individual designers be aware of possible alterations in communication network equipment and structure produced by either of the above troubles and chances.

2.2 Theory of communication systems

Communication network equipment can be separated into two different families: analog and digital (Hara et al, 1997). Analog technology expresses data as different electronic signal of changing frequency or amplitude that are added to carrier waves of an afforded frequency. Broadcast and phone transmission has conventionally used analog technology. Digital draws electronic technology that gives store and presses data in terms of two states: positive and none positive. Positive is shown in logic 1 and none positive by logic 0. Thus data carried or stored with digital technology is shown as a string of 0’s and 1’s. Each of these state digits is referred to as a binary digit or bit in short. A string of bits that computer can address one by one as a group is byte. Figure 2.1 shows the basis of all electronic communication, the essential components are:

- Transmitter
- Receiver
- Communication channel

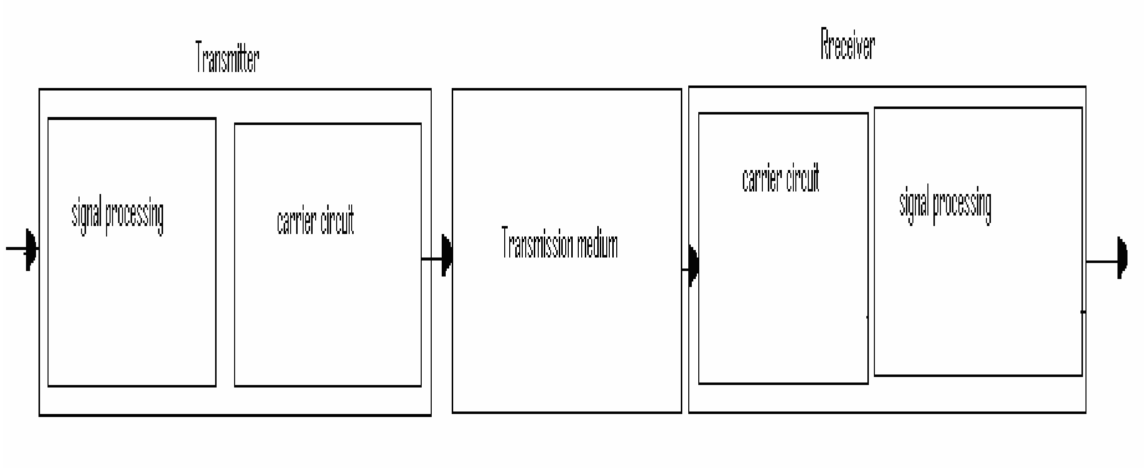

Figure 2.1: basic element of communication system

Data or intelligence signal generated by human is inserted to the transmitter which is then carried over to the communication channel. The message is received by the receiver and communicated to another human. Along the way, noise is added to the message in the communication channel or medium. Noise is a general term that refers to any disturbance *that takes down* the transmitted data.

2.2.1 Transmitter

The first transmitter was invented by Guglielmo Marconi spark transmitter with antenna at his home in Bologna, Italy, in December 1894 (Zeng, 1999). The spark transmitter, the only known system at that time, became the subject of intensive development.

Direct conversion architecture support several desirable features such as reduced power consumption and reduced hardware complexity and size (Hilborn et al. 1994). These features made the direct conversion transmitter became popular for many applications. A successful direct conversion transmitter must therefore have a linearizer, control over quadrature modulator errors, and adaptation of both linearizer and control over quadrature modulator errors to maintain acceptable system performance. These requirements establish the design goals of the direct conversion transmitter.

2.2.1.1 Quadrature Signal linearization

It is well known that the execution of MIMO-OFDM (Orthogonal Frequency Division Multiplexing) systems is cruelly affected by the non linearity of the power amplifier and the IQ imbalances of the vector modulators in the transmitter. With the low power and low cost front-end architectures using direct conversion MIMO-OFDM is pondered as the most promising transmission technique to support future applications (Ashtiani et al.1998) (McPherson,2001).Since both the power amplifier and quadrature modulator features alteration with temperature, biasing, and frequency, both the predistorter and quadrature modulator correction must adapt to maintain acceptable performance quality.

Saleh and Cox, (1983); Bateman et al. (1988) revealed that a number of linearization techniques have been studied such as Cartesian feedback, feedforward, LINC, and predistortion (PD). Predistortion is the most generally used technique for linearizing an amplifier and quadrature modulation. This technique consists of a nonlinear process placed between the input signal and the amplifier (Namiki, 1983) (Nojima and Konno, 1985).

Cavers et al. (1991) presented a satisfactory technique at the transmitter in a more effective asymmetric version that the quadrature modulator could result in inter modulation end products even for nominally constant envelope modulation. More extensively, it could reduce or remove the advantages of linearizing predistorters.

Stapleton and Costescu (1992) indicated that leakage of transmitted power into the adjacent channel is quandrantically dependent on predistorter mis adjustment and that assessment of this neighbouring channel power could supply the required feedback in an adaptive predistorter system.

Cavesrs and liao (1993) improved adaptive compensation technique for the quadrature modulator at the transmitter which could decrease or cut out the benefits of linearizing predistorters and could result in intermodulatoin results even for nominally constant envelope modulation.

Hilborn et al. (1994) declared that the out-of-band power of direct conversion transmitter is a quadratic function of both the power amplifier's nonlinearities and the quadrature modulators imperfections. Furthermore, they deduced that the predistorter and quadrature modulator compensator circuits approached in roughly three seconds, and a betterment of about 20 dB in adjacent channel power was reduced.

2.2.1.2 Transmitter types

The schematic of quadrature transmitter architecture is shown in figure 2.2. In quadrature transmitter architectures, I/Q parts of the signal modulated individually and then summed can be sorted out granting to the modulator effectuation as follows:

- Superheterodyne (two steps conversion)
- Direct conversion (homodyne)

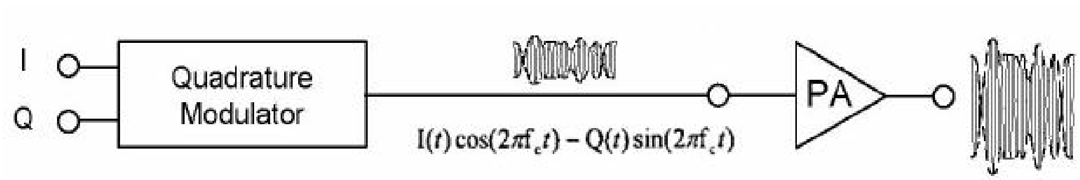

Figure 2.2: Quadrature transmitter architecture.

2.2.1.2.1 Superheterodyne transmitter

Signal is modulated at an IF and then converted to the transmit relative frequency by a mixer's. An IF filter is needed to eliminate the local oscillator harmonics after the modulation. An RF filter is required at the mixer output to move out the undesirable sideband (Peng et al, 2006). Super-heterodyne transmitter basic block diagram is shown in figure 2.3.

Advantages of super heterodyne transmitter are, the power amplifier output spectrum is distant from LO frequencies, I/Q modulator works at IF and Possible gain control can be employed at IF

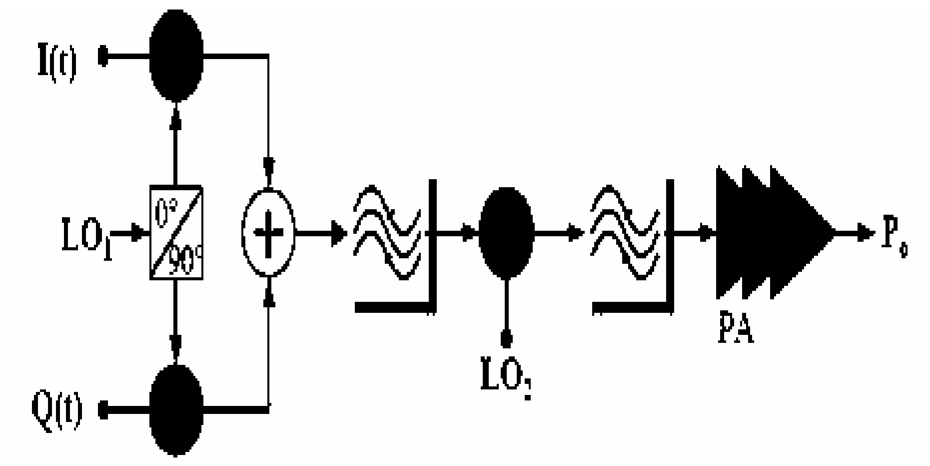

Figure 2.3: Superheterodyne transmitter

However, it has disadvantages such as significant amount of circuitry and low integration level requires a power amplifier with good linearity and Multimode implementation is difficult.

2.2.1.2.2 Direct conversion transmitter (homodyne)

Baseband signal is directly modulated to RF. RF filter may be required to suppress the noise floor in the receiver band, for instance in case of global system mobile (GSM) application (Wen Hu Zhao, 2005). Schematic of the direct conversion transmitter is shown in figure 2.4.

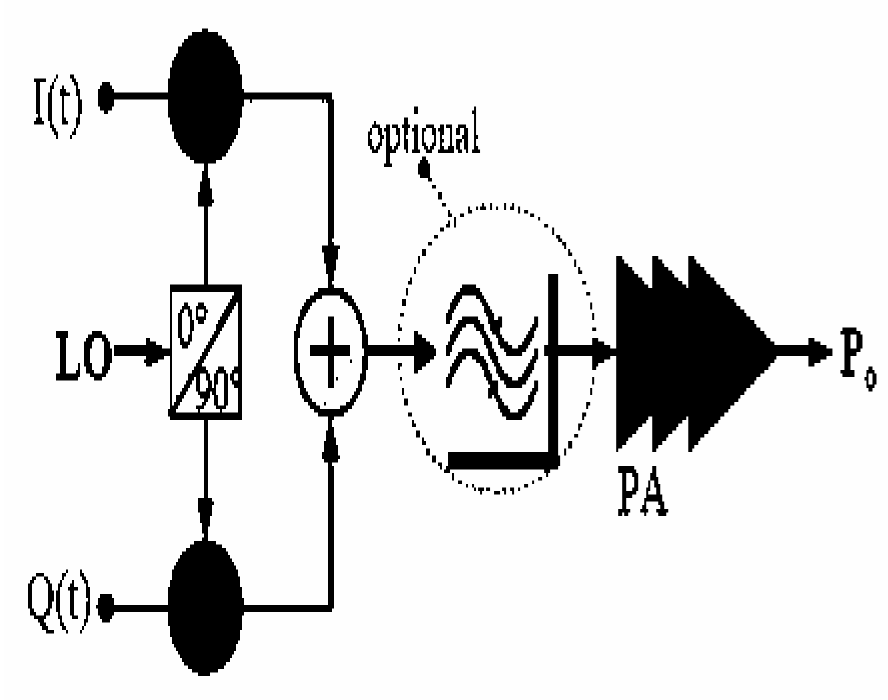

Figure 2.4: Direct conversion transmitter

2.2.2 Receiver

A superheterodyne receiver counterpart was first established and introduced in1918 by Armstrong (Lessing, 1969). The origins of the direct conversion receiver (DCR) date back to the first half of last century when a single down-conversion receiver was first described by F.M. Colebrook in 1924 (Colebrook,1924) and the term homodyne was applied.

Tucker (1947) constructed an additional development, which first coined the term synchrodyne, for a receiver which was designed as a precision demodulator for measurement equipment rather than a radio.

Tucker in (1954) reports the various single down-conversion receivers published at the time and clarifies the difference between the homodyne (sometimes referred to as coherent detector) and the synchrodyne receivers. The homodyne receiver obtains the LO directly (from the transmitter, for example), whereas the synchrodyne receiver synchronizes a free-running LO to the incoming carrier.

Over the last decade or so, the drive of the wireless market and enabling monolithic integration technology has triggered research activities on direct conversion receivers. These direct conversion receivers integrated with the remaining analog and digital sections of the transceiver, have the potential to reach the "one-chip radio" goals. Moreover, it favors multi-mode, multi-standard applications and thereby constitutes another step towards software radio.

The present section refers to several recent publications (Abid, 1995) (Razavi, 1998) which provide a thorough survey and insight, and display renewed interest in direct conversion receivers. Overcoming some of the problems associated with the traditional superheterodyne and being more prone to integration, DCR has however an array of inherent challenges. After a brief description of alternative and well-established receiver architectures, this article presents the direct conversion reception technique and highlights some of the system level issues associated with DCR.

2.2.2.1 Quadrature signals imbalance

In MIMO-OFDM receiver systems gain and phase imbalance between I and Q channels is another source of impairment. The sources of this type of imbalance are usually the demodulator, amplifiers, mixer, analog to digital converter and the filters in each of the I and Q channels. A gain imbalance result in a constellation with an oval shape and a phase imbalance transforms the two-level signal into a multi-level signal, depending on the amount of imbalance.

Jian Lin and Tsui (2004) suggested an adaptive scheme to correct the IQ imbalances at the far-away transmitter as well as the receiver. Based on their model, an Adaptive IQ imbalance improvement approach was obtained which implemented frequency domain adaptive equalization. The approximation could result rapid converge on the order of microseconds to rectify both constant and frequency dependent IQ imbalances and to correct for transmitter IQ imbalance.

Tsui and Jian Lin (2004) introduced novel IQ imbalance correction approximation which implemented frequency domain adaptive equalization. The approximation could rectify both constant and frequency dependent IQ imbalances. It had a good appearance even under degraded channel correction.

Tarighat, and Sayed (2005) studied the outcome of IQ imbalances on MIMO-OFDM systems, and a structure for fighting such deformities through digital signal processing was developed. An input–output relation governing MIMO OFDM systems was obtained. The structure was used to model receiver algorithms with compensation for IQ imbalances.

Kamata et al. (2005) announced a new extended channel matrix involving the effect of IQ imbalance. It was verified by the personal computer simulation that the proposed compensation method could reduce the inter-sub carrier and inter-stream interferences.

Oostveen et al. (2006) introduced an iterative algorithm for IQ imbalance compensation in a packet-based MIMO-OFDM system with a preamble in a frequency selective fading channel. The approach was based on iteratively estimating, in baseband at the receiver, the receiver IQ imbalance, channel frequency response, transmitter IQ imbalance and transmitted data.

2.2.2.2 Receiver types

Various architectures of receivers have been proposed in literature, but most popular architectures among them are described as follows:

2.2.2.2.1 Super heterodyne Receiver

Super-heterodyne architecture was invented by Armstrong in 1917 and is the most widely used architecture in wireless transceivers so far. It is dual conversion architecture in which, at the first stage RF is down-converted to IF and then in second stage, from IF to baseband signal (Qizheng, 2006). The block diagram of super-heterodyne receiver architecture is shown in Figure 2.5.

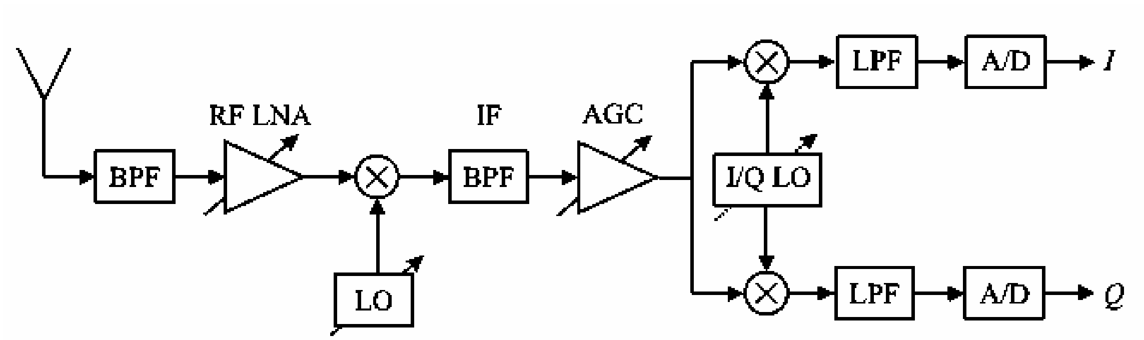

Figure 2.5: Super heterodyne Receiver

From the incoming RF signal preselecting filter removes out of band signal energy as well as partially reject image band signals. It is then amplified by LNA to suppress the contribution of noise from the succeeding stages. Image Reject filter attenuates the signals at image band frequencies coming from LNA. Mixer-I down converts the signal coming out of the IR filter from RF frequency to IF frequency with the output of a Local Oscillator. The channel selection is normally achieved through IF filter: It is a band pass filter to allow the IF band of interest and other band is rejected. This filter is critical in determining the sensitivity and selectivity of a receiver. Since channel selection is done at IF, the LO requires an external tank for good phase noise performance. In case of phases or frequency modulation, down conversion to the baseband requires both in-phase (I) and quadrature (Q) components of the signal. The second down conversion of IF signal divide it into, I and Q components for digital signal processing. The low pass filter acts as a channel reject filter along with jobs of anti-aliasing functionality.

2.2.2.2.2 Direct Conversion Receiver (Homodyne)

A simple way to reduce the number of components in the receiver and alleviate the problem of receiver complexity is to avoid the use of intermediate frequency stage and use complex or quadrature down conversion of the desired channel signal from RF directly to baseband. Complete elimination of the IF stage results in highly simplified structure where most of the channel selectivity and amplification are implemented at baseband. On one hand, since most of the signal processing tasks takes place at low frequencies, the power consumption is minimized. On the other hand, very low noise operation is called for in all the remaining analog components since the amplification provided by the RF stage is only moderate (Mohajer et al, 2007). Homodyne Direct-Conversion Receiver is shown in figure 2. 6.

For a satisfactory receiver performance, some compensation of the DC offsets is needed. The DC offset compensation is rather difficult to implement without compromising with the receiver RF performance. Another analog RF related problem is that higher linearity is required for the components because in a direct-conversion receiver, second-order.

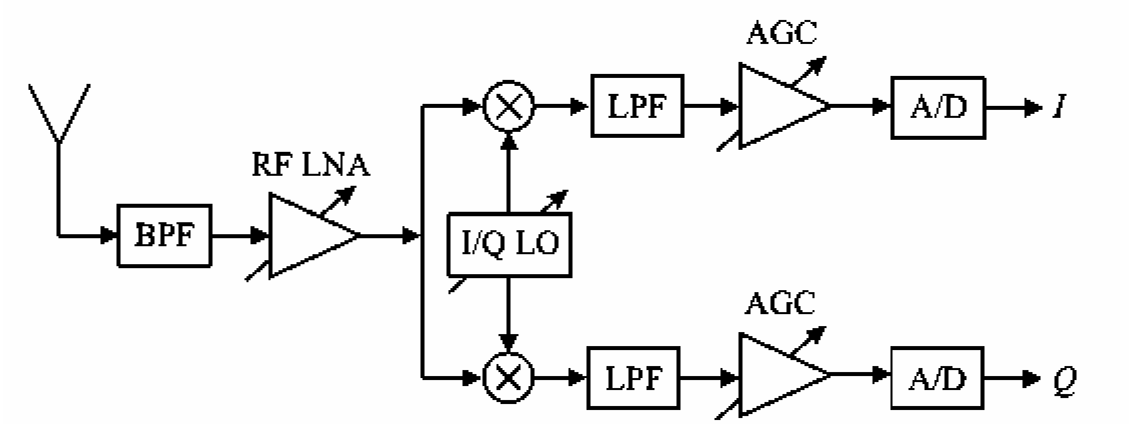

Figure 2.6: Direct-Conversion Receiver

Inter modulation products may fall in the signal band, in super heterodynes, the weaker third-order inter modulation products set the linearity requirements. These problems have limited the use of direct-conversion principle in practical systems earlier, but nowadays this approach is widely utilized in mobile terminals.

2.2.2.2.3 Low-IF Receiver

In Low-IF receiver architecture all the RF signals are translated to low-IF frequency which is then down-converted to BB signal in digital domain. Low-IF architecture comprises the advantages of both heterodyne and homodyne receivers. The block diagram of Low-IF receiver architecture is shown in Figure2.7.

After pre selection filtering and amplification, all the RF channels are quadrature mixed and down converted to low IF containing both wanted and unwanted signals. The IF frequency is just one or two channels bandwidth away from DC, which is just enough to overcome DC offset problems.

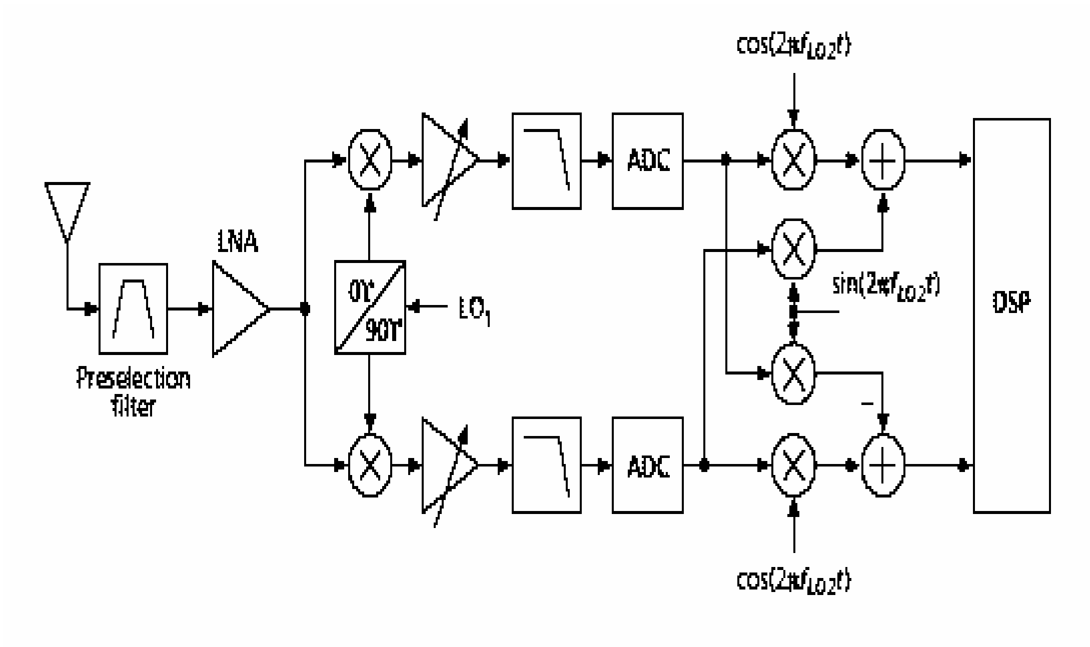

Figure 2.7: Low-IF Receiver

It is then amplified and filtered before sampled by ADC. Since the ADC samples have both wanted and unwanted signals, there will be higher demand on ADC dynamic range requirements. The ac-coupled signal path to ADC eliminates the need of DC offset compensation circuitry. The sampled digital data are fed to image reject mixer which is implemented in digital domain (Chung-Yun et al, 2002).

2.2.2.2.4 Wideband IF receiver

Wideband-IF receiver is dual conversion architecture in which data is down converted from RF to IF in the 1st stage, and in the 2nd stage it is from IF to Baseband. The block diagram of Wideband-IF receiver architecture is shown in Figure 2.8.

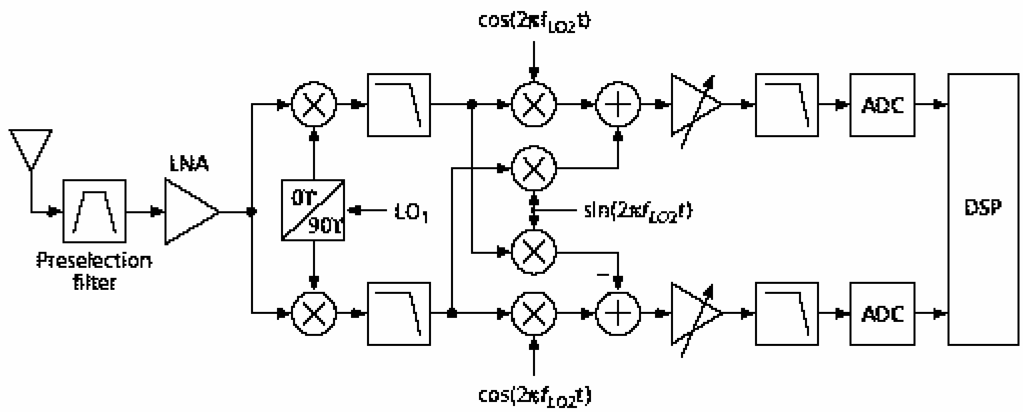

Figure 2.8: Wideband IF receiver

In this architecture all the RF channels are complex mixed and down converted to fix IF after pre selection filtering and amplification. In second stage an Image Reject (IR) mixer does complex mixing and translate IF to BB using a tunable channel select frequency synthesizer. All the image frequencies are canceled by IR mixer. If the IF is chosen high enough, additional image rejection may be obtained from the RF front-end pre selection filter. Channel selection is performed at baseband by using programmable integrated channel select filter. Since LO-1 is fixed, frequency synthesizer generated by crystal controlled oscillator good phase noise performance is obtained. Channel tuning is achieved by using programmable frequency synthesizer at IF (Richter et al, 2003).

2.2.3 Receiver Specification

Receiver Specification can be listed as shown below:

- Receiver sensitivity
- Receiver selectivity

2.2.3.1 Receiver sensitivity

The Minimum Detectable Signal (MDS) power Pi (min) at which a receiver can detect a signal while providing an adequate SNRo (min) at analog receiver output or BER at digital receiver output, for demodulation is called receiver sensitivity. The maximum BER dictates the minimum output SNR (SNRo (min)) necessary for satisfactory reproduction of the desired signal. The relation between SNR and BER is given by:

$$SNRo(dB) = (Eb / No)dB + (R / B)dB \qquad \textbf{(2 .1)}$$

where,

R - Bit rate

B - Channel Bandwidth

E_b - Energy per bit

SNR at the input, SNR_{in} is determined by input signal power (P_{in}) and noise floor (*NFloor*).

$$SNRin(dB) = Pin(dBm) - NFloor(dBm) \qquad \textbf{(2.2)}$$

$$NFloor = -174dBm/Hz + 10\log(B) \qquad \textbf{(2.3)}$$

After determining the minimum SNR required at the output of receiver from top level simulation, and knowing the SNR at the input, NF of the receiver can be determined.

$$NFRx(dB) = SNRin(dB) - SNRo(\min)(dB)$$

$$= Pin(dB) + 174(dBm/Hz) - 10\log(B) - (Eb/No)dB + (R/B)dB \qquad \textbf{(2.4)}$$

If $P_{in} = P_{i\,(min)}$, then sensitivity is given as,

$$Pin(\min)(dBm) - 174dBm/Hz + 10\log(B) + NFRx(dB) + SNR(\min)(dB) \qquad \textbf{(2.5)}$$

2.2.3.2 Receiver selectivity

The ability of a receiver to extract the desired signal in the presence of strong adjacent frequency interferers and channel blockers. Selectivity is determined by SSB phase noise, synthesizer spurs, IF selectivity, IF band width and co-channel rejection.

- Selectivity of the adjacent and alternate channels.
- Selectivity of interferences to inter modulation of third order.
- Blocking interferences selectivity.
- Selectivity is critical for good intermodulation performance.

2.2.3 Communication channel

The term channel, in communications, refers to the medium used to carry information from a transmitter to a receiver. Many types of channels are used in communication systems including wire conductors, fiber-optic, and free space.

2.2.3.1 Cables

A cable is one or more wires bound together, typically in a common protective jacket. The individual wires inside the jacket may be covered up or isolated. Combining cables may comprise both electrical wires. Electrical wire is usually copper due to its excellent conductivity, but aluminum is sometimes used since it costs less.

2.2.3.2 Fiber optic

An optical fiber is a glass or plastic fiber that takes light along its length. Fiber optics is a branch of applied science and engineering, concerned with the purpose and application program of optical fibers. Optical fibers are widely used in fiber optic communication, which allow transmission over longer distances and at higher data rates than other forms of communications. Fibers are used rather than metal wires because signals follow them with less loss, and they are resistant to electromagnetic disturbance. Optical fibers are also used to form sensors, and in a kind of other practical application. Light is kept in the core of the optical fiber by number of inner reflection. This causes the fiber to act as a waveguide (Udd, 1996).

2.2.3.3 Free space

In classical physics, free space is a term of electromagnetic theory, representing a theoretically perfect vacuum, and sometimes related to the vacuum of free space. Radio is the universal term used to any kind of electromagnetic spectrum data signal are convinced to electric and magnetic fields that spread through space over long distance (John et al, 2005).

Summary

In this chapter, the basic concept of several kinds of transmitters and receivers has been reviewed, describing the previous researches at each stage. The focus of the review was mainly on Direct Conversion Transmitter and Direct Conversion Receiver. Direct conversion transmitter power linearization techniques were reviewed. Furthermore, several quadrature signal imbalance methods were shown. In addition, the main idea of MIMO-OFDM concept is also being discussed.

CHAPTER THREE

MIMO WIRELESS TRANSCEIVER DESIGN

3.1 Introduction

This chapter deals with the design and fabrication procedure required for RF MIMO transceiver. The transceiver consists of the following four major parts:

1. Digital to analog converter
2. Analog to digital converter
3. Transmitter and
4. Receiver

The transmitter consists of two parts: the IQ modulator and the power amplifier .The receiver consists of two parts: the low noise amplifier and the demodulator. The design process flow can be illustrated by the flow chart as shown in Figure 3.1; the chart highlights the stages through which the transceiver has been developed.

3.2 Simulation and fabrication software

In the present study separate softwares were used for simulation and printed a circuit board (PCB) fabrication. For simulation part Agilent Advanced design system" ADS" was used and for PCB fabrication Orcad software was used.