ISSN (Print) : 2320 – 3765
ISSN (Online): 2278 – 8875

International Journal of Advanced Research in Electrical, Electronics and Instrumentation Engineering

(An ISO 3297: 2007 Certified Organization)

Vol. 5, Issue 5, May 2016

A Study of Design and Development of an Efficient MIMO Communication System

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ABSTRACT: Wireless communication is based on radio signals. Traditionally, wireless applications were voice-centric and demanded only moderate data rates, while most high-rate applications such as file transfer or video streaming were wired applications. In recent years, however, there has been a shift to wireless multimedia applications, which is reflected in the convergence of digital wireless networks and the Internet. Recently MIMO techniques also makes use of smart antenna technology also. In this paper, a brief review about the design of communication channels using FPGA – VHDL environment is presented, which will be very useful to design the communication channels in the software environment.

KEYWORDS: Communication, Channel, FPGA, VHDL, Tx, Rx, SISO, MIMO

I.INTRODUCTION

Multiple Input Multiple Output (MIMO) Communication System is a new and emerging technology and is expected to play a very important role in 4G wireless systems. FPGA prototyping of MIMO provides an accelerated and repeatable test environment in a laboratory setting [1]. MIMO systems have evolved rapidly as a generic technology of communication in 4G wireless systems [2]. MIMO technology makes use of multiple antennas both at the transmitter section and at the receiver section to make excellent utilization of the available bandwidth and to reduce the effects of fading and signal loss. This technique also helps to increase the number of bits transmitted i.e. bitrate. Most recently MIMO systems are also used in wired power line communications for 3-wire installations. The prototyping of MIMO systems by using FPGA's or ASIC's provides an alternative testing environment for MIMO systems [3] as the practical realization and testing of MIMO technology is complex and costly. MIMO-OFDM is used in LTE [4]. Field Programmable Gate Arrays (FPGA) are integrated circuits which can be configured by the user or developer by using any hardware description languages (HDL) such as VHDL or Verilog. FPGA's provide a hardware testbed using which the testing and evaluation of many logic networks or circuits or systems can be done [1, 3].

FPGA's consists of large number of logic gates and memory blocks (RAM blocks) to implement complex digital computations. An important challenge for the MIMO technology would be the design of the transmitter and receiver sections which involves complex algorithms at both sections [5, 7]. The design and testing part can be simplified by designing the circuits using hardware description languages (HDL) and Integrated Software Environment (ISE) which provides accurate simulations of the design. In order to provide a hardware testbed for the MIMO systems, the designs can be synthesized into FPGA's. This type of prototyping of the MIMO system will provide an excellent testbed under which testing of MIMO can be done and also important parameters such as delay in communication, bit error rate, SNR etc., can be determined. Thus this type of prototyping of MIMO on an FPGA is also a convenient method to check the suitability of alternate algorithms and evaluating hardware tradeoff's. This prototyping provides verification of physical layer design ideas and makes the designing more economical [6].

FPGA's can also be used to implement a communication system directly as the complexity of baseband communications are high and there is always a need to do reprogramming due to changes in evolving standards. Multiple-input multiple-output (MIMO), is a radio frequency wireless communication technology that uses multiple antennas at the transmitter and receiver, is being used in many of the new and upcoming wireless techniques such as LTE, HSPA+ etc. MIMO is used in these technologies as this technique can provide excellent spectral efficiency and

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an improved link capacity over conventional single antenna techniques. MIMO performs three main functions of spatial multiplexing, spatial diversity and smart antennas.

II. MIMO SYSTEM MODEL

The figure below shows general MIMO scenarios with M transmit antennas and N receive antennas. The transmitter section and receiver section can be seen along with a multipath channel. Figure 1: General Outline of MIMO system As shown in the figure 1 an MIMO system can have M transmit and N receive antennas where the N transmitting antennas might send same signal or different signal to the receiver. Generally N and M are equal and sometimes different. The channel is generally wireless.

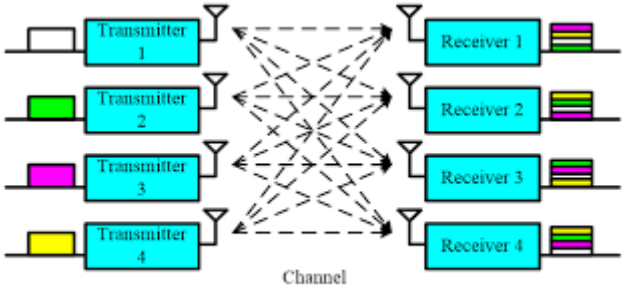

Fig 1: Block diagram of a MIMO system

As can be seen from the figure there are direct path transmission existing between the transmitters and receivers along with many multipath transmissions. The receiver will receive the signal and it decodes the signal accordingly, i.e, the first receive antenna will receive multiple signals through the multipath but it must detect only the signal sent from first transmitter, the same applies to another receivers.

Features of MIMO:

Some of the important features of the MIMO are listed below and it is these features that enable the MIMO with excellent spectral efficiency and higher bit rates.

1. Spatial Multiplexing Spatial multiplexing is a technique where different transmitters transmit different information signals through different antennas. Thus when multiple antennas are used at the transmitting side, the bit rate is increased with an order equal to the number of transmit antennas over a single antenna system. This increases the spectral efficiency as the multiple transmissions happen over a bandwidth that was dedicated for a single antenna transceiver system. Thus higher bit rate communication is guaranteed by spatial multiplexing of MIMO.

2. Spatial Diversity: Space diversity or antenna diversity is the use of multiple spatially separated antennas to send and receive redundant information so that the fading effects of channel can be mitigated. MIMO can achieve exactly the same by transmitting redundant data through different antennas and receiving the same across the receivers thus reducing the error rates of the system as well as solving the problem of fading in a practical wireless environment.

3. Use of Smart Antennas: In addition to the above mentioned properties MIMO systems can make use of smart antennas with beam forming techniques to improve the signal to noise ratios of the communication systems. By careful use of smart antenna technology the co channel effects can also be mitigated.

III. ADVANTAGES OF A MIMO SYSTEM

The ever-growing demands for high-speed data and multimedia services are the driving forces behind the requirements for future wireless communication systems. The next generation of mobile communication, often referred to as 4G (Fourth Generation) networks are comprehensive IP solutions that deliver voice, data, and multimedia content to mobile users anytime and almost anywhere. LTE (Long Term Evolution) is a global 4G standard .Wireless communication is inherently limited by the available spectrum and impaired by path loss, interference and multi-path propagation. Hence, to meet the capacity needs for future wireless systems without increasing the required spectrum, accomplishment of implementation of advanced communication techniques is necessary. The intent of 4G technology is to converge high speed data application requirements and compete with other technologies. Different techniques i.e relaying, carrier aggregation, multiple input multiple output, and heterogeneous networks provide higher throughputs,

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low latency and enable LTE to become a Standard for Wireless broadband. Due to almost exponential increase in demand for high data rates it is expected that network will be occupied by more resource demanding applications. Therefore efficient scheduling of radio resources is required for better performance of LTE system.
MIMO (Multi-input multi-output) promises high bit rates, small error rates, reliability, increased channel capacity over rich scattering wireless channels without consuming extra bandwidth or transmit power when compared to conventional single antenna technologies.

IV. PROPOSED RESEARCH METHODOLOGY

The proposed MIMO system is shown in figure below

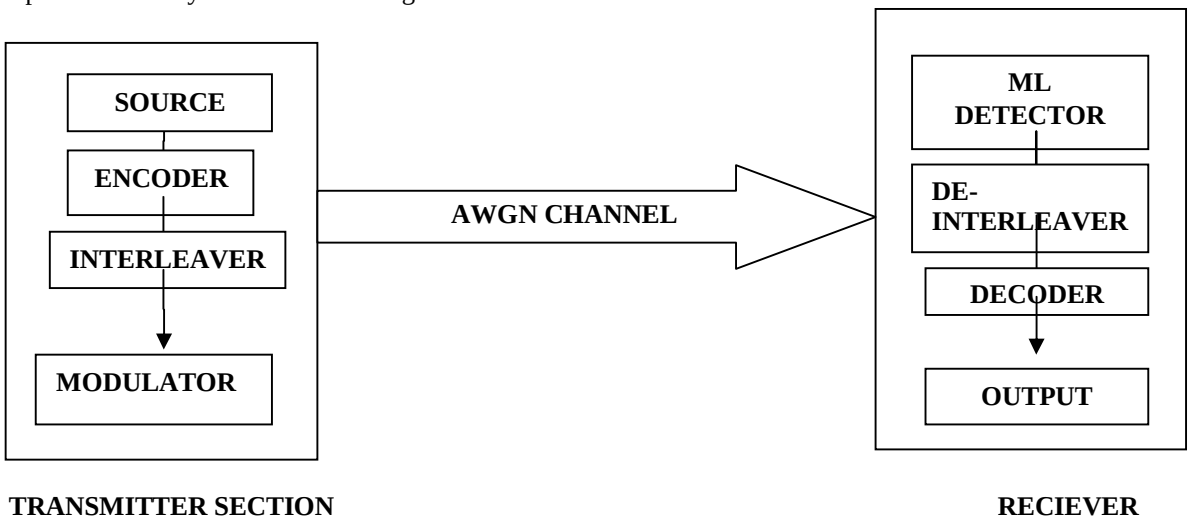

Fig 2: Block diagram of the proposed research methodology

The **transmitter** comprises of a source that generates the symbols as input and an encoder that performs encoding of the source symbols. The encoder is followed by an interleaver which is used for error correction during burst error scenarios in the channel. The interleaver is followed by a modulator that modulates the symbols and makes them suitable for transmission through a noisy channel.

The **channel** is realized through an Additive white Gaussian noise (AWGN) approximation model that mimics random noises which are experienced in real time communications.
The **receiver** section consists of a maximum likelihood detector which generates an optimal estimate of the transmitted symbols. The detector is followed by a de-interleaver that performs the inverse of interleaver and finally a decoder decodes the symbols. The decoded bit stream is subtracted from the original source inputs to obtain the outputs.

V. IMPLEMENTATION REQUIREMENTS

Hardware: Artix Field Programmable Gate Arrays (FPGA) are developed by Xilinx. Artix FPGA's consume 50% lower power than the other FPGA's. The cost of artix FPGA's are also low compared to other family of FPGA's. The Artix family is designed to address the small form factor and low power performance requirements of battery powered portable ultrasound equipment, commercial digital camera lens control, and military avionics and communications equipment.
Software: Verify Logic (Verilog) is a Hardware Description Language a textual format for describing electronic circuits and systems. Applied to electronic design, Verilog is intended to be used for verification through simulation, for timing analysis, for test analysis (testability analysis and fault grading) and for logic synthesis.

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VI. APPLICATIONS OF MIMO

MIMO is combined with OFDMA and is used in IEEE 802.16e.MIMO-OFDM is used in IEEE 802.11n. Mobile radio telephone standards such as 3GPP and 3GPP2 make use of MIMO. In 3GPP, High Speed Packet Access Plus (HSPA+) and Long Term Evolution (LTE) standards utilize MIMO. MIMO technology is also used in non wireless applications such as home networking standard ITU-T G.9963. It is a power line communication system which uses MIMO to transmit multiple signals over multiple AC transmission wires. MIMO techniques are heavily exploited and integrated into many wireless standards like third-generation (3G) and fourth-generation (4G) wireless communication systems , IEEE 802.11n wireless local area network (WLAN) standard, IEEE 802.20 mobile broadband wireless access system and the 3GPP Long Term Evolution (LTE) of wideband CDMA (W-CDMA) .

REFERENCES

[1] S. P. Girija, K. Deergha Rao, "Smoothing term based noise correlation matrix construction for MIMO-OFDM wireless networks for impulse noise mitigation", Published in: TENCON 2015 - 2015 IEEE Region 10 Conference, Macao, China. 1-4 Nov. 2015, Pages 1 – 5, ISSN : 2159-3442, Print ISBN: 978-1-4799-8639-2, INSPEC Accession Number: 15717459

[2] Abhinav Ganesan, K. Pavan Srinath," Interference aligned space-time transmission with diversity for the 2 × 2 X-Network", Information Theory (ISIT), 2015 IEEE International Symposium on 14-19 June 2015,Hong Kong, Pages: 621 – 625, INSPEC Accession Number: 15506619

[3] AmirhosseinAlimohammad and SaeedFouladiFard, "FPGA-Based Bit Error Rate PerformanceMeasurement of Wireless Systems",*IEEE Transactions On Very Large Scale Integration (VLSI) systems*,ISSN No:1063-8210,volume 22, Issue: July 2014, Pages:1583-1592, Publication: 21 August 2014.

[4] Sparsh Mittal and Saket Gupta, "FPGA Implementation of MIMO System using Xilinx System Generator for Efficient Hardware/software co-design", *Software Engineering an international journal(SEIJ)"*,Volume 3, Publication:2013.

[5] Shreyakaushal ,Surabhisharma, "A 2×2 FPGA based Wrap tested for coloured image transmission in MIMO systems", *International journal of science and modern engineering*, Volume 1,Issue 6,ISSN:2319-6386, Publication:2013.

[6] Numan, M.W, Islam, M.T., Misran.N., "An efficient FPGA-based hardware implementation of MIMO wireless systems" *Communication Systems Networks and Digital Signal Processing conference* , ISBN: 978-1-4244-8858-2, pages: 152-156 Conference date:21-23 July 2010

[7] Alimohammad, S. F. Fard, and B. F. Cockburn, "FPGA-accelerated baseband design and verification of broadband MIMO wireless systems," in *Proc. IEEE 1st Int. Conf. Adv. Syst. Testing Validation*, Sep. 2009, pp. 135–140.

[8] Jan Meitzner, Robert Schober, Lutz Lampe, Wolf Gang.H.Gerstecker, Peter.A.Hoer, "Multiple antenna techniques for wireless communication-A comprehensive literature survey",*IEEE Communications survey and tutorials*, volume 11,pages 87-105, publication: 2009.

[9] Yu Heejung, Kyon Ghee song, KwhanghuynRyn "Design and FPGA implementation of MIMO-OFDM based WLAN system" *Vehicular technology conference VTC-2006 spring IEEE 63*, volume 3, pages 1333-1338, publication year: 2006

[10] Paulraj.A.J, Gore.D.A, Nabar.R.U, Bolcskei.H, " An overview of MIMO communications-a key to gigabit wireless", *Proceedings of the IEEE*, ISSN:0018-9219, volume:92, pages: 198-218,publication:08 November 2004.

[11] Murphy.P, Lou.F, Sabharwal.A, Frantz.J.P , "An FPGA based rapid prototyping platform for MIMO system", *Signal Systems and Computer Conference 2004, Record of the 37 Asilomar conference* , volume 1, pages:900-904, publication: 2003.