A 2x2 MIMO Communication System using NI USRP module in LabVIEW platform

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***Abstract*— Multiple-Input Multiple-Output (MIMO) can be referred to as the communication channel created with multiple transmitter antenna and multiple receiver antenna to improve the communication performance like data rate, spectral efficiency, and power utilization. In this paper we are using the advantages of MIMO communication systems and National Instruments Laboratory Virtual Instrument Engineering Workbench (NI LabVIEW) platform to efficiently demonstrate the working of a 2*2 MIMO communication system using National Instruments Universal Software Radio Pheripheral (NI USRP) in LabVIEW platform with vertical antennas of 900 MHz – 1.9GHz.**

Keywords—MIMO, USRP, NI USRP.

I. INTRODUCTION

Multiple-Input Multiple-Output (MIMO) can be referred to as the communication channel created with multiple transmitter antenna and multiple receiver antenna to improve the communication performance like data rate, spectral efficiency, and power utilization [1]. The MIMO Wireless Communication systems have become an integral part of the most forthcoming commercial and next generation wireless data communication systems.

The National Instruments (NI), Universal Software Radio Peripheral (USRP) is computer-hosted RF transceivers used for development and exploration of Software-Defined Radio (SDR).[2] NI USRP transceivers can transmit and receive radio-frequency signals in a several bands and can be used for applications in communications education and research. Paired with NI LabVIEW software, NI USRP transceivers provide affordable solution that offers access to real-world signals to enable interactive development and a hands-on approach to teaching [3].

NI USRP hardware and LabVIEW software offer flexibility, functionality, and affordability to deliver an ideal software-defined radio prototyping platform for educational laboratories and physical layer communications research. LabVIEW, running on a Gigabit Ethernet-connected host computer, provides the signal processing engine for the modulation and demodulation of signals streaming to and from NI USRP hardware. Toolkits extend LabVIEW software offer functional blocks for many common analog and digital modulation techniques and signal processing algorithms optimized for real-world radio signals [4].

In this project we are trying to use the advantages of MIMO communication systems and NI LabVIEW platform to efficiently demonstrate the working of a MIMO communication system using NI USRP in LabVIEW platform [5].

An SDR is a communications platform that uses software for implementing digital communications algorithms. In our course, we will utilize the National Instruments (NI) Universal Software Radio Peripheral (USRP) as the SDR to demonstrate the practical challenges of wireless communications.[6] The USRP product is a flexible computer-hosted hardware platform for software radios. "Radio in which some or all of the physical layer functions are software defined is known as SDR. It refers to the technology wherein software modules running on a generic hardware platform are used to implement radio functions.[7] By combining the NI USRP hardware with LabVIEW software you can create a flexible and functional SDR platform for rapid prototyping of wireless signals including physical layer design, record and playback, signal intelligence, algorithm validation, and more.[8]

1.1 *OBJECTIVES*

The main aim of this project is to design multiple input transmitter using independent non – directive antennas, creating transmit and receive diversity along with spatial multiplexing using Alamouti block coding and measure the system performance using various parameters like SNR, BER and probability of error.

II METHODOLOGY

The system explorers the MIMO communication system with two transmit and two receive antennas i.e. 2x2 MIMO systems. A random PN sequence input data is fed to QAM for symbol mapping with Alamouti block source coding technique for error correction at the receiver. The channel equalized scatter plot at the receiver is compared with the transmitter to evaluate the performance of the communication system [9].

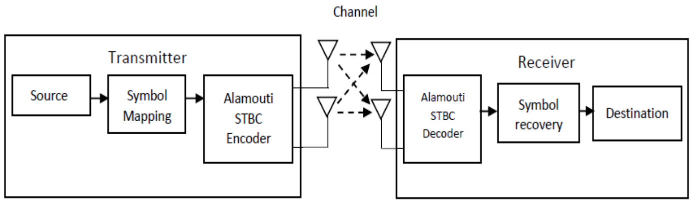

Figure 1: Generalized block diagram of Alamouti System Model

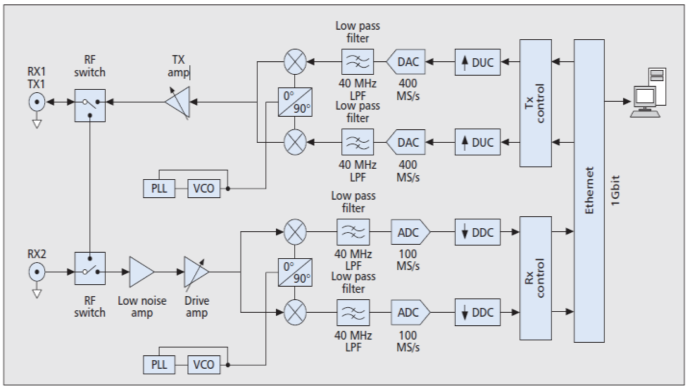

Figure 2: Block diagram of NI USRP module

Following a common software-defined radio architecture, NI USRP hardware implements a direct conversion analog front end with high-speed analog-to-digital converters (ADCs) and digital-to-analog converters (DACs) featuring a fixed-personality FPGA for the digital down conversion (DDC) and digital up conversion (DUC) steps. [10]

NI USRP is capable of receiving the signal when the received signal is mixed down from RF using a direct conversion receiver to baseband I/Q components. The digitized I/Q data follows parallel paths through a digital down-conversion process that mixes, filters, and decimates the input signal to a user-specified rate.[11] The down-converted samples are then passed to the host computer over a standard gigabit Ethernet connection. The NI USRP platform is capable of transmitting and receiving using two antennas, which implies that it is possible to implement a twin-antenna multiple-input multiple-output (MIMO) system using this platform [12] [13].

For transmission, baseband I/Q signal samples are synthesized by the host computer and fed to the USRP at a specified sample rate over Ethernet, USB or PCI express. The USRP hardware interpolates the incoming signal to a higher sampling rate using a digital up conversion (DUC) process and then converts the signal to analog with a digital-to-analog converter (DAC). The resulting analog signal is then mixed up to the specified carrier frequency.[14]

2.1 FLOW CHART

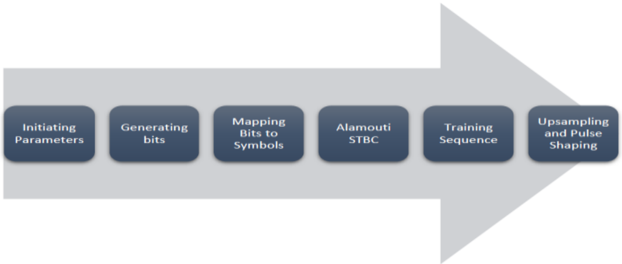

Figure 3. Model block diagram of Transmitter.

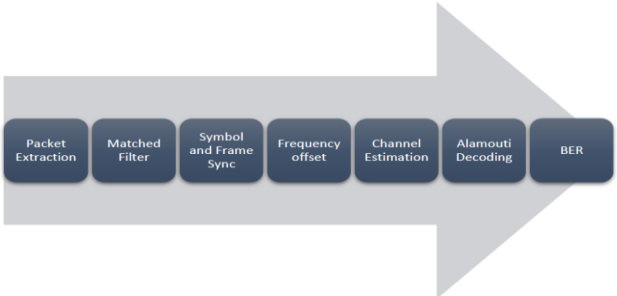

Figure 4. Model block diagram of Receiver block

III APPLICATIONS

- Communication system like Wi-Fi, WiMAX and Bluetooth.
- Mobile communication system like 4G, LTE and 5G systems.

IV ADVANTAGES

- MIMO communication system establishes a higher spectral efficiency by employing larger number of transmitter and receiver antennas.
- Efficient power utilization by using low power MIMO antennas thereby assisting for better battery life at user terminals.
- MIMO system provides spatial multiplexing mechanism which is much efficient when compared to conventional TDMA and FDMA techniques.
- MIMO communication system provides transmit and receive diversity by using precoders with Channel State Information (CSI) at the transmitter which provides constructive interference at the receiver.
- An elaborative platform like LabVIEW is used to simulate the MIMO communication system performance.
- To achieve higher data rates per user within a given cell.

V RESULTS AND DISCUSSIONS

This chapter gives the overall results and conclusion of the proposed system.

5.1 RESULTS

A SDR is designed and developed with multiple transmit and receive antenna, creating a MIMO environment using NI USRP in LabVIEW platform to achieve higher data rate, better spectral utilization, efficient power utilization. The modulation technique that we used is 4-QAM.

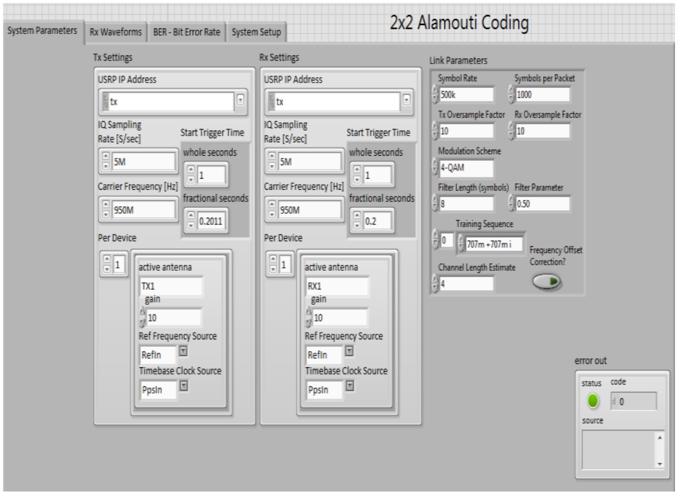

Figure 5. Snapshot of opening screen of LabVIEW software

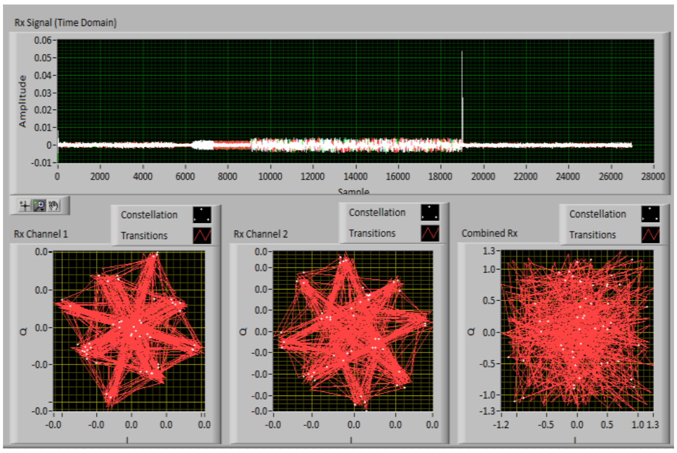

Figure 6.Snapshot of received signal for 4-QAM at 950MHz.

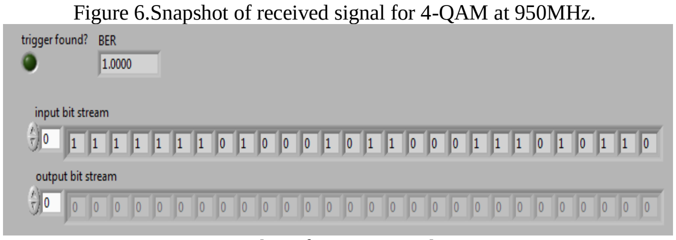

Figure 7. Snapshot of BER received at 950MHz.

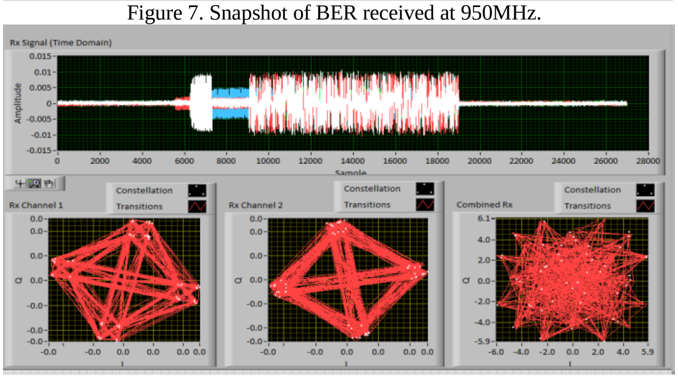

Figure 8. Snapshot of received signal for 4-QAM at 1.5GHz.

Figure 9. Snapshot of BER received at 1.5GHz.

The results in Figure 6 and Figure 8 shows the received signal constellations for the transmitted signals at 950MHz and 1.5GHz using 4-QAM, modulation technique. Figure 7 and Figure 9 shows the BER received at 950MHz and 1.5GHz using 4-QAM, modulation technique.

VI FUTURE SCOPE

This paper speaks about the implementation of MIMO communication system, further enhancement can be done by using precoders with Channel State Information (CSI), which is present apriori at the receiver for better QoS and spectral utilization. To meet the demand of the current mobile technology instead of using few antenna's, the number of antennas can be increased at the transmitter terminal to achieve the needed data rate.

VII CONCLUSION

The proposed 2*2 MIMO Alamouti source coded system was designed achieving both transmit and receive diversities which were verified using BER and scatter plots. Further the data were PN sequence generated with 4 QAM symbol mapping to meet the current wireless communication requirements. This system can be further enhanced by using more transmit and receive antennas resulting in better data rate/Hz.

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