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S Deepak Kumar, K Aravinda, K Akilesh, P Chandra Mohan, C S Govind Raj, K Harshitha and G Sai Sandeep

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VLSI IMPLEMENTATION OF MIMO-OFDM TRANSMITTER AND RECEIVER CHAIN

Mr. Deepak Kumar S Nadiger *, Dr Aravinda K,
Akilesh K, Chandra Mohan P, Govind Raj C S, K Harshitha, G Sai Sandeep
Dept. of Electronics and Communication Engineering
New Horizon College of Engineering, Bangalore, India
*sdeepaknadiger@gmail.com

Abstract: OFDM, is a modulation technique that divides the available spectrum into sub-carriers. OFDM when compared with Frequency-Division Multiple Access (FDMA), it uses the spectrum effectively by channel spacing, in this case channels are spaced close together and makes the carriers perpendicular to each other which prevents the interference between a closely spaced carrier channels. OFDM is principally used for its robustness in channel fading in the wireless environment. In order to make the system flexible for the design pre-requisites, we use reconfigurable architecture. FPGA is considered as one of the most efficient reconfigurable and reusable architecture. Following OFDM technique, for achieving maximum data rate, we can use MIMO systems. Interference between user to user may be observed by every user in MIMO, because data of many users transmitting over a common channel. In order to reduce the inter-user-interference, a zero-force precoding technique can be used at the transmitting end. Here, the information is being coded and is transmitted over the channel (MIMO), then the information received at receiver has comparatively less Bit Error Rate (BER). The main aim of our project is to design and implement a base band (BB) OFDM transmitter and receiver on a FPGA hardware. This process includes QPSK mapping module, scrambler, encoder, inter-leaver and cyclic prefix insertion modules. The design uses a 64-point FFT or IFFT as one of its main module. In addition to OFDM, we are using a zero-force-pre-coding technique in MIMO OFDM system which will be simulated using Xilinx 14.5 software and verify by using MATLAB 7.1.

KEYWORDS: OFDM, MIMO, FFT/IFFT, QPSK, BER.

I) INTRODUCTION:

With an exponential increase in the use of digital communication, the requirement for high-speed transmission of a data is increased. The telecom industry is facing a major problem in distributing a technology that is capable of supporting "n" number of services which are ranging from voice communication having a bit rate of few kilobits per second to a wireless multimedia of two megabits per second. We use OFDM to efficiently distribute services to mobile subscribers.

OFDM, a type of multi-carrier system where the data bits are encoded on various sub-carriers. Unlike a single carrier system, all the available frequencies are sent simultaneously at the same time. OFDM also offers a various several advantages over the single carrier system, such as improved immunity to multipath effects, simplex channel equalization, and also due time acquisition restrictions. This can also be done in the digital domain which allows the system to be implemented in ASIC and FPGA. OFDM possibly be implemented using a general-purpose microprocessor or microcontroller. Moreover, we need a memory and other peripheral chips to the operation to be performed, thus we require a larger area. The requirement of power and the time required for the processing of the processors is higher compared to the other possible options. FPGA is a best example for a VLSI circuit in which the customer provides the functions in a list of cables. To provide a good noise performance we can develop a efficient OFDM FPGA system.

To achieve high data speed without interference between users, we use MIMO system. To lower the error rate of a bit (BER) in these MIMO systems, a suitable and less complex precoding technique must be used. One of these techniques is the zero-force precoding technique, this technique is relatively simpler and straightforward comparing with other non-linear precoding techniques. This is a linear precoding technique depending on the obtaining of channel inversion for various multi-user systems, called block diagonalization. It is a matrix that calculates on the basis of a Single Value Decomposition (SVD) operation, effectively, it depends on the users dimension and total available users in each particular channel matrix.

II) LITERATURE REVIEW:

1) **SU HU et.al**: The main focus of the article is on the design of training sequences for efficient channel estimation in multi-carrier communications with multiple inputs and outputs of filter banks (MIMO-FBMC) using AM shifted quadrature (OQAM) modulation. MIMO-FBMC can be a promising technique to achieve high spectral efficiency and high strong quality over other dispersive channels because of its time frequency localization characteristic. In this article, the authors propose a new class of learning sequences, which are formed by concatenating two identical zones of zero correlation sequences in which the autocorrelation and the cross-correlation are zero in the time shift window around of the phased location.

2) Irfan Y Khan et.al: These people demonstrated the performance of the adaptive uncoded modulation OFDM system using QAM and PSK techniques. To improvise the system further, the authors used convolutional encoding for OFDM system. For this type of system, the SNR is estimated at the level of the receiver and then transmitted for transmission via a feedback channel. The transmitter then estimates the SNR accordingly, selects the modulation scheme and its coding rate which keeps the BER constant. This can be achieved by implementing the superiority of adaptive modulation schemes over fixed modulation schemes**.**

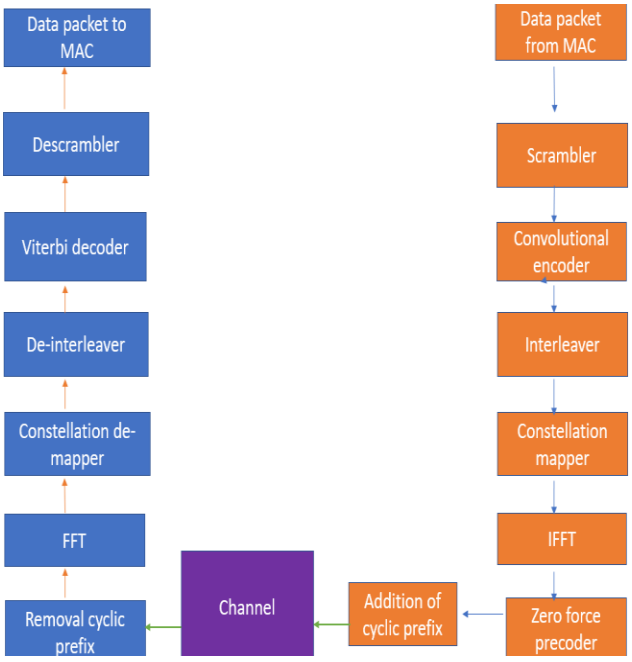
3) **Sanjana T et.al**: This article discusses the channel estimation and equalization techniques to maximize the OFDM system performance. These techniques are estimated using a Wiener filter and a frequency domain approach. The estimate of the previous channel gives a simple equalizer. Channel equalization techniques are used to support the one tap frequency domain equalization and LMS algorithm, on different channels; Additive White Gaussian Noise, Rayleigh and Rican channels. In simulation multichannel eye patterns are compared. From the observation, simulation that the Wiener filter provides a better estimate and the performance of OFDM is better on the AWGN channel when compared with the fading channels. The SER curves picturizes an steady upgrade of 6db in AWGN performance over the attenuation channels to reach 0.1 SER. Additionally, MSE performance shows rapid decay for the AWGN channel.

4) **Alessandro Tomasoni et.al**: In this article, the OFDM transmission scheme has been studied. The reason for implementing an adaptive transmission scheme which can be illustrated by differentiating its overall performance using a fixed transmission system.. The performance is increased by using a best algorithm technique called adaptive algorithm. In the switching parameter conditions,this technique uses the mean value of the instantaneous SIR. The result is obtained as improved performance with considerable BER performance.

Sunho Park et.al: Solving the pilot signal shortage in OFDM MIMO systems the authors have presented an updated decision-driven technique for channel estimation. Using soft symbols,the acquired decision of an itertaive IDD scheme (Iterative detection & decoding) to improve the standards of the channel estimate. Using software information from the decoders, the presented channel estimator chooses a good data tone, eliminates interference, and re-estimates the channels. The authors discuss the criterion for selecting the optimal data tone, which provides a basis for the accurate symbol decisions and channel correlation between pilot tones and data tones. MIMO-OFDM scenarios resulting from numerical simulations.

S.No	Title of the paper	Author	Year of published	Outcomes	Drawbacks
01.	Training sequence design for efficient channel estimation in MIMO-FBMC systems	SU HU	2017	Efficient channel estimation using ZCZ. Achieves high spectrum efficiency.	Channel has to be orthogonal
02.	To improve perform-ance of OFDM systems using optimize coding techniques	Irfan Y Khan	2014	Bit error rate of OFDM is analysed using convolutional and BCH coding.	Only adaptive modulation is taken. Constant bit rate has to be maintained
03.	Comparison of channel estimation and equalisation techniques for OFDM systems	Sanjana T	2014	Channel equalization techniques use LMS algorithm. Wiener filter provides a better performance .	Problems in adaptive equaliser creates errors in output.
04.	Iterative channel estimation using virtual pilot signals for MIMO-OFDm systems	Sunho Park	2015	MIMO systems has very high reliability. Quality of channel is estimated is exactly by using IDD decoding scheme	Pilot signals are not the same as original signal which creates some calculation errors.

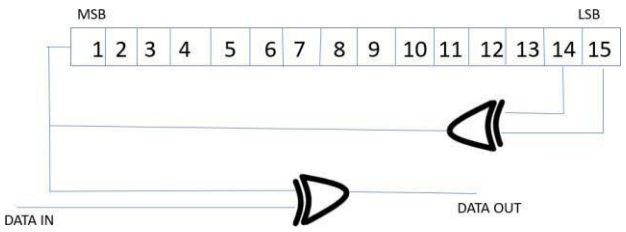
III) PROPOSED DESIGN:



Block diagram MIMO OFDM

SCRAMBLER:

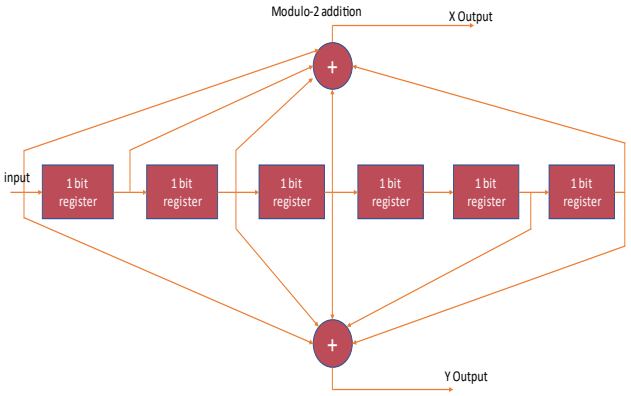
Scrambler is a device that can be used at the receiver end in order to transpose or inverts the input signals. In worst cases, it also encodes the message at the centre to perform a message conversion. In order to debug back to the original message, a descrambler device can be used. By adding the components at the input makes it difficult to extract the same at the receiver end.



CONVOLUTION ENCODER:

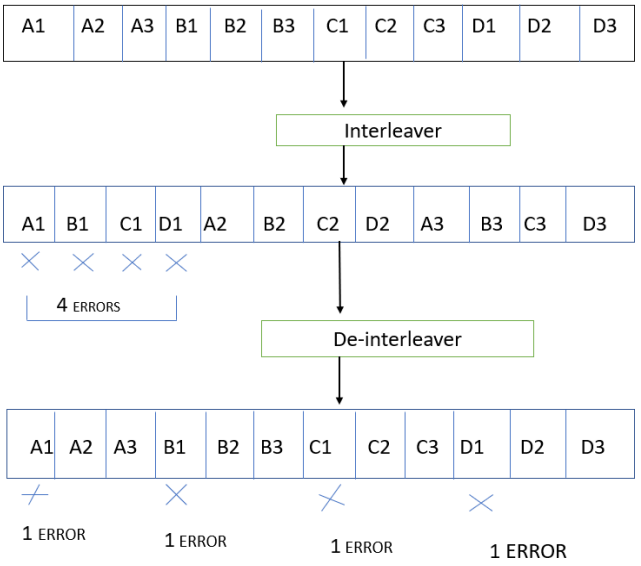
Convolution coding technique can be used to encode as well as decode never-ending sequence of bits. One of the essential concepts behind convolution is to overlap two signals to make the opposite phase. Because of the convolution technique, the binary bit sequence can be convolved by performing few binary operations on them.

Being a memory-based system, it suggests that the output is always dependent on the previous encoded bit which had stored within the memory.



INTERLEAVER:

An inter-leaver, it is the hardware device generally utilized in conjunction with error correcting codes. The incoming data into the inter-leaver is split into two permutations. The primary permutation ensures that the adjacent bits are mapped onto carriers that don't seem to be adjacent. The second permutation makes sure that the coded bits that are adjacent are mapped onto the bits that are more or lower than it within the constellation. This is often done to form sure that the error bits are distributed equally throughout the message.

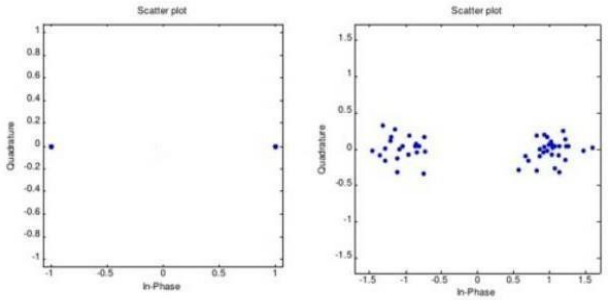


DATA MAPPING (QPSK):

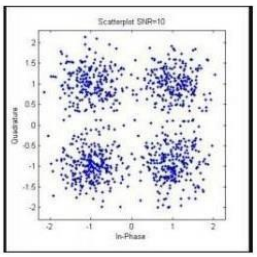
The bit interleaved data are then passed to the constellation mapper, where depending upon its size the information was modulated using the subsequent four different modulation

schemes: BPSK, Gray-Mapped QPSK. In Quadrature phase shift keying (QPSK) sine and cosine are considered as one of the base functions for modulation. Modulation will be attained by changing the phase of the premise functions that depends upon the message symbols. In QPSKM, one symbol contains two bits.

BPSK

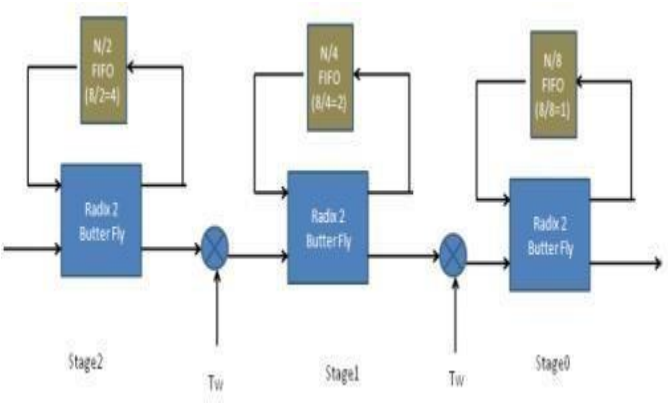


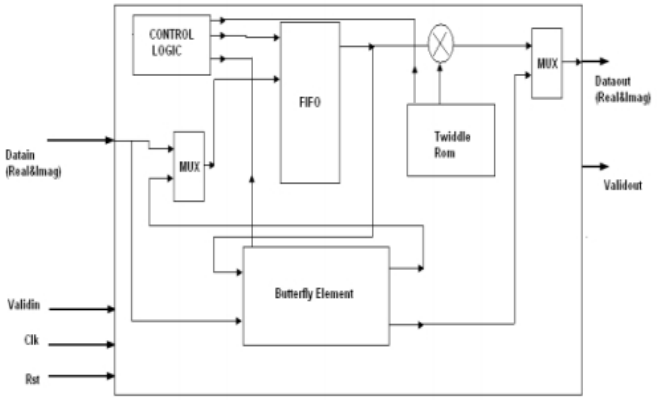
QPSK



IFFT MODULE:

Inverse Fast Fourier Transform basically involves in the formation of OFDM signals. The purpose of IFFT is, to convert the frequency domain signal which is received from the input to the time domain as the output. It gives an easier way to modulate data onto subcarriers. Here 64- point IFFT is used to get the OFDM output. With the help of Fourier transforms we can elimate individual multipliers which are needed for transmission and receiving the signals.



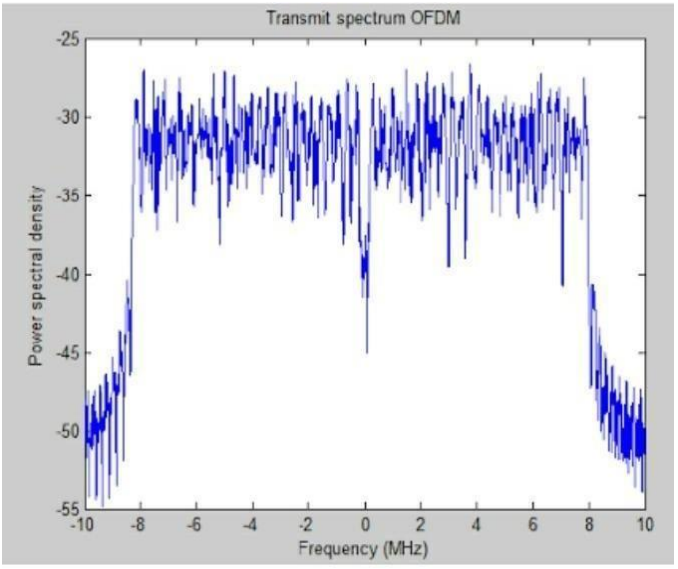


ZERO-FORCE PRE-CODER:

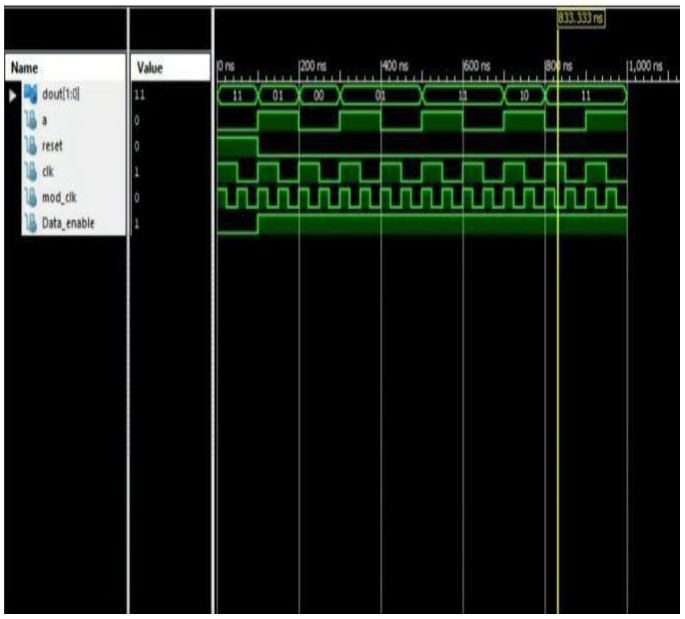
It basically means we are forcing a zero bit even before the coding technique actually starts. Zero-Force Pre-Coding technique is used to nullify the multi-user interference. Performance of Zero-Force Pre-Coder depends on CSI accuracy. Zero- Force technique can be achieved by improving signal to noise ratio and increasing the array spacing.

CYCLIC PREFIX:

When OFDM signal is transmitted, it enables the OFDM signal to work efficiently. To safeguard the signals from inter symbol interference, it acts as a guard interval or as a buffer region.



RESULTS:



OFDM OUTPUT

IV) CONCLUSION:

Transmitting different signals at a same time is known as Multiplexing. We have many multiplexing techniques like FDM, TDM, SDM. Here we opt to discuss about OFDM. When we transmit at once all the multiple signals, there is a high chance of interference . Inorder to reduce or eliminate the interference one efficient way is using OFDM. Here we use cyclic prefixing inorder to achieve circular convolution to reduce ISI effect. To reduce ISI ,use zero force precoding technique which is MIMO technique. Bit Error Rate can also be reduced .

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