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IMPLEMENTATION OF CHANNEL ESTIMATION AND MODULATION TECHNIQUE FOR MIMO SYSTEM

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Abstract: Future wireless communication system has to be designed to integrate features such as high data rates, high quality of service and multimedia in the existing communication framework. Increased demand in wireless communication system has led to demand for higher network capacity and performance. Higher bandwidth, optimized modulation offers practically limited potential to increase the spectral efficiency. Hence MIMO systems utilizes space multiplex by using array of antenna's for enhancing the efficiency at particular utilized bandwidth. MIMO use multiple inputs multiple outputs from single channel. These systems defined by spectral diversity and spatial multiplexing. The aim of this paper is to design and implement of channel estimation method and modulation technique for MIMO system. The design specifications are obtained using MATLAB. The RTL coding is carried for the design to be implemented on Xilinx FPGA.

Keywords: MIMO, FPGA, Space multiplex, RTL.

I. INTRODUCTION

MIMO describes the ways to send data from multiple users on the same frequency/time channel using multiple antennas at the transmitter and receiver end. A transmitter/receiver system uses multiple antennas not only for transmitting data between corresponding antennas but also between adjacent antennas. The data is received in the form of MIMO Channel Matrix. A top-level MIMO system is shown in Fig.1 MIMO system is used in many applications like WiMax, WiFi, WLANs, and many more signal processing applications.

MIMO system are scrambler/descrambler, RS encoder/decoder, convolution encoder/decoder, puncturing/de-puncturing, inter leaver/de-inter leaver, modulator/ demodulator, diversity or space time encoder/decoder and channel estimation. This paper aims at design and implementation of a simple and most efficient channel estimation method and a good modulation technique for increasing the channel capacity, bandwidth, increasing bit rates and eliminates inter symbol interference. There are well-known training-based channel estimation methods are; least square (LS), Minimum Mean Square Estimation (MMSE), Least mean square (LMS), Recursive Least Square (RLS). In this paper the main focus is on simple LS algorithm, which is simple to analyse and efficient. The comparison of LS is not performed. The main aim is to reduce the computational complexity of channel estimation using LS algorithm and implementing 2x2 MIMO system using QPSK modulation technique.

II. LITERARTURE SURVEY

A. CHANNEL ESTIMATION AND QPSK

The in-phase and the quadrature phase components are very important component in QPSK. Yantao Qiao, et all, has made a research on an iterative algorithm of least square channel estimation in MIMO OFDM systems. The main objective of this paper is an iterative channel estimation algorithm for MIMO OFDM is proposed. Sarod Yatawatta, et.

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proposed a solution for minimizing the energy spent on during the channel estimation when subjected to known error and delay when timing symbols are transmitted. The minimization of energy is carried by reducing the hardware, also by using a low rank equalization at the receiver. Benoit Le Saux, et.al, proposed a MIMO system with OFDM has greater potential like reduction in inter-symbol interference, decrease in fading, increase in bandwidth, and increase in data rates. The performance of MIMO system degrades due to inaccurate channel estimation over frequency selective fast-varying channels.

B. CS-BASED CHANNEL ESTIMATION

Riza Abdolee,et.al proposed a method to reduce the computational complexity of channel estimation algorithm for MIMO-OFDM. Channel estimation is highly intensive which suffer from high computational complexity. Solution for highly efficient channel estimation and simplified computational complexity is stated. Deseada Bellido, et.al, proposed LS channel estimation algorithm for MIMO-OFDM. This evaluation has been made using pilot design rules that guarantee a bounded error level for the estimation. This method is used for estimation of the channel matrix. Markus Myllyla, et.al, proposed method for performance evaluation of 2 FPGA implementation of a LMMSE based detector for radio channels. The recently introduced principle and methodology of compressed sensing (CS) allows the efficient reconstruction of sparse signals from a very limited number of measurements (samples).

III. PROPOSED SYSTEM

The frequency shift keying is the most important digital modulation technique, and it is also known as FSK. A signal has the amplitude, frequency, and phase as properties. Every signal has these three properties. To increase any one of the signal properties we can go for the modulation process. These are the important advantages of the modulation process. If we modulate the amplitude of the input binary signal according to the carrier signal called as amplitude shift keying.

Simple process to construct the circuit. Zero amplitude variations. Supports a high data rate. Low probability of error. High SNR (signal to noise ratio). More noise immunity than the ASK. Error-free reception can be possible with FSK Useful in high-frequency radio transmissions. Preferable in high-frequency communications.

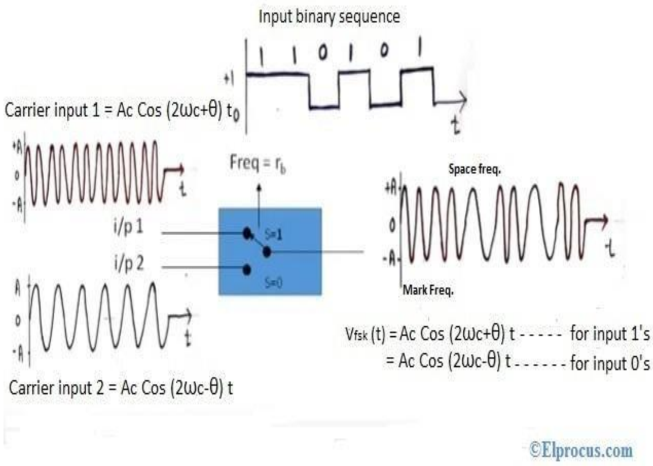

Fig.3. FSK Signal

ADVANTAGE:

- Simple process to construct the circuit. Zero amplitude variations. Supports a high data rate.
- Low probability of error. High SNR (signal to noise ratio). More noise immunity than the ASK.
- Error-free reception can be possible with FSK Useful in high-frequency radio transmissions. Preferable in high-frequency communications.

COMPONENTS:

- MATLAB
- Xilinx

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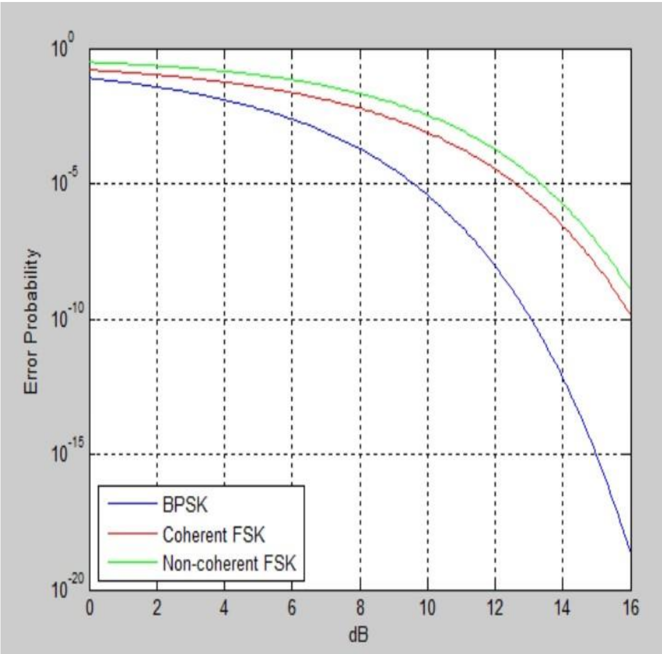
3.1. COMPARE FSK and PSK

FSK	PSK
More Bandwidth as compared.	Less to moderate Bandwidth.
Better Noise immunity.	Better Noise immunity.
Synchronizat ion is not required.	Synchronizat ion is essential.

COMPARE PSK and FSK GRAPH



IV. CHANNEL ESTIMATION IN OFDM SYATEM

The basic OFDM system block diagram under the assumption of frequency domain.
The binary information is being generated from uniformly distributed random integers with equal probability of either 0 or 1.
dk is converted from serial bit stream to parallel and mapped according to the modulation in the block of constellation mapper. The BPSK/QPSK symbols are then superimposed on orthogonal subcarriers using IDFT.

We suppose the autocorrelation matrices of channel Rh are perfectly known at the BS. Compares the MSE performance of different estimators at the Rician channel condition. As can be seen, LS estimator possesses the worst performance among all methods tested. BEM-LS and LMMSE have the similar estimation performance. And our proposed BEM-EM performs better than these data-aided estimators. In addition, there is an error floor in high SNR region. The reason is that the strong LOS components in the Rician channel model are intensely affected by Doppler frequency shift.

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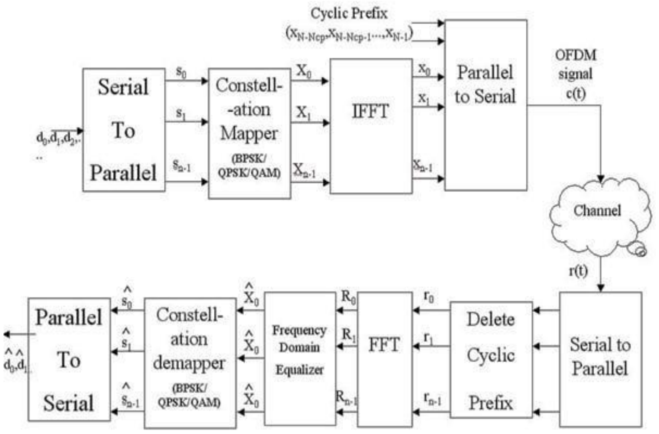

Fig.4. OFDM System

where, *S(n)* is the BPSK/QPSK symbols and N is the length IDFT. After the IFFT block, cyclic prefix of length D, which is considered to be greater than the impulse response of the channel, it is used to combat inter-symbol interference and intercarrier interference (ICI).

The OFDM signal is the constructed by applying the symbol along with CP to parallel to serial converter. It is then transmitted on channel.

V. FSK MODULATION

Now we will see how the FSK modulated wave can be demodulated at the receiver side. Demodulation is defined as reconstructing the original signal from the modulated signal. This demodulation can be possible in two ways.

5.1. Coherent FSK detection

The only difference between the coherent and non-coherent way of detection is the phase of the carrier signal. If the carrier signal we are using at the transmitter side and receiver side are in the same phase while demodulation process i.e. called a coherent way of detection and it is also known as synchronous detection. If the carrier signals which we are using at transmitter and receiver side are not in the same phase then such modulation process known as Non-coherent detection. Another name for this detection is Asynchronous detection.

5.2. Non-Coherent FSK Detection

In this synchronous FSK detection, the modulated wave got affected by noise while reaching the receiver. So, this noise can be eliminated from using the bandpass filter (BPF). Here at multiplier stage, the noisy FSK modulated signal is multiplied with the carrier signal from the local oscillator device. Then the resultant signal passes from the BPF. Here this bandpass filter is assigned to cut off frequency which is equal to the binary input signal frequency. So the same frequencies can be allowed to the decision device. Here this decision device gives 0 and 1 for space and mark frequencies of the FSK modulated waveforms.

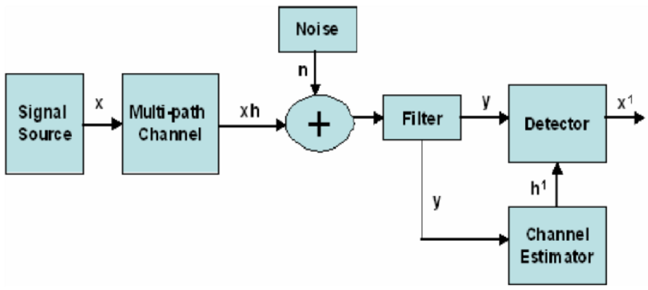

Fig. 5.2. FSK modulation

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VI. FSK DEMODULATION

The modulated FSK signal is forwarded from the bandpass filter 1 and 2 with cut off frequencies equals to space and mark frequencies. So, the unwanted signal components can be eliminated from the BPF. And the modified FSK signals are applied as input to the two envelop detectors. This envelope detector is a circuit having a diode (D). Based upon the input to the envelope detector it delivers the output signal. This envelope detector used in the amplitude demodulation process.

Based upon its input it generates the signal and then it is forwarded to the threshold device. This threshold device gives the logic 1 and 0 for the different frequencies. This would be equal to the original binary input sequence. So, the FSK generation and detection can be done in this way. This process can be known for the frequency-shift keying modulation and demodulation experiment also. In this FSK experiment, FSK can be generated by the 555 timer IC and detection can be possible by 565IC which is known as a phase-locked loop (PLL).

The second method is the comb-type based channel estimation in which pilot symbols are transmitted on some of the sub carriers of each OFDM symbol. This method usually uses different interpolation schemes such as linear, low-pass, spline cubic, and time domain interpolation.

This paper aims to compare the performance of the pilot-based block type channel estimation by using Binary Phase Shift Keying (BPSK) modulation scheme in a slow fading channel. In Section II, the basic system model of OFDM is discussed. In Section III, the estimation of the slow fading channel is performed, based on block-type pilot arrangement. In Section IV, the simulation parameter sand results are discussed.

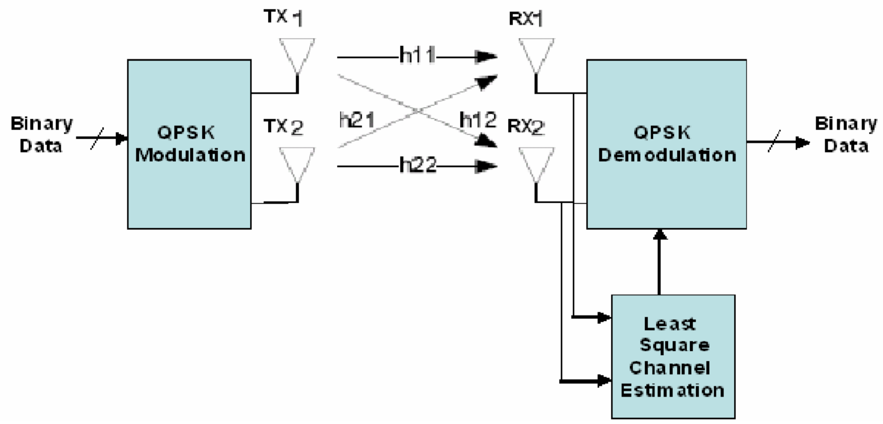

Fig.6.FSK Demodulation

FSK–frequency of carrier signal is varied to represent binary 1 or0 •peak amplitude & phase remain constant during each bit interval.

Demodulation: Demodulator must be able to determine which of two possible frequencies is present at a given time. Advantage: FSK is less susceptible to errors than ASK –receiver looks for specific frequency changes over a number of intervals, so voltage (noise) spikes can be ignored. Disadvantage: FSK spectrum is 2 x ASK spectrum •application: over voice lines, in high-freq. radio transmission, etc.

VII. RESULT

This section discusses the results of the simulation that were performed based on the information and mathematics discussed in the Section II & III respectively.

For the simulation of basic OFDM system, we used the following parameters.

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TABLE: SIMULATION PARAMETERS

Parameters	Specification
FFT size	64
No of used Subcarriers (Nst)	52
Cyclic Prefix (Ncn)	16
No. of OFDM symbols	100
Constellation	BPSK/QPSK
Channel Model	AWGN, FNS, Multipath
No of taps/multipath	8

SOFTWARE OUTPUT

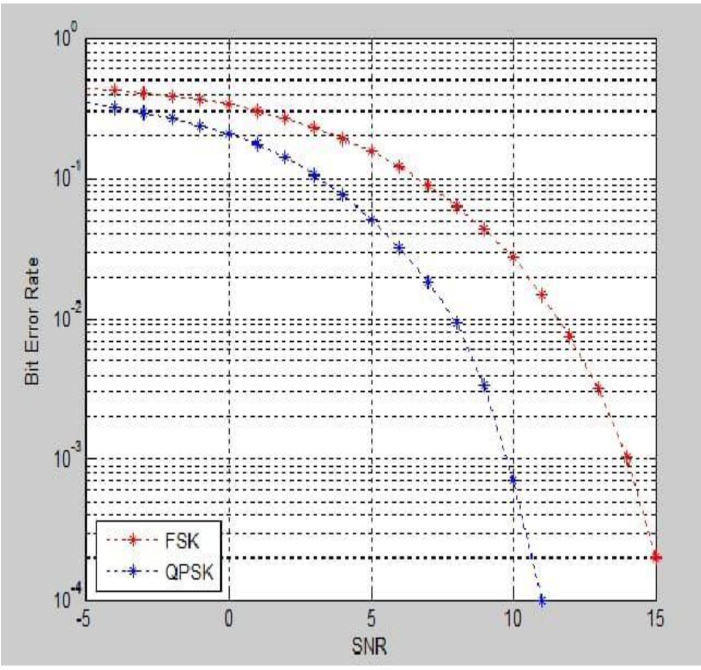

Fig. FSK Signal

VIII. CONCLUSION

The MIMO system design is simulated in MATLAB to arrive at the specifications. The RTL code is successfully simulated in Model Sim. The design synthesized and implemented on Virtex2Pro FPGA board and the results were validated using Logic Analyzer. The synthesis and timing is verified and the timing is met for both setup and hold in DC and PT. DFT is also carried without timing violation.

The operating frequency of the design is 13MHz obtained from Xilinx. The top design takes about 3999 number of slices out of 4928 slices i.e. in Virtex2Pro the device selected is 2vp7ff896 at speed grade of 6 with operating frequency 7.27MHz. The 2vp30ff896 is selected with a speed grade of 6, the slices are 1902 out of 13696 i.e. 13% resources usage and operating frequency is 13.388MHz and minimum period of 74.691ns. Timing verified is all met with positive slack with zero violations.

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REFERENCES

[1] Bernard Sklar "Digital Communications–Fundamentals and Application" Published by PEARSON Education. Year 2003.
[2] Bellido, Deseada, Entrambasaguas and Jose T. "MSE evaluation at reception end in MIMOOFDM systems using LS channel estimation", Waveform Divers ity and Design Conference, vol.1, pp. (174-177), 4-8 June,2007.
[3] Changchuan Yin, Jingyu Li, Xiaolin Hou and Guangxin Yue, "Pilot Aided LS Channel Estimation in MIMO-OFDM Systems" The 8th International Conference on Signal Processing, vol.3, pp. (16-20), 2006.
[4] Chia-Liang Lui, "Impacts of I/Q Imbalance on QPSK –OFDM-QAM Detection", IEEE Transactions on Consumer Electronics, vol. 44, no. 3, pp. (984-989), August, 1998.
[5] David Garrett, Linda Davis, Stephen ten Brink, Bertrand Hochwald and Geoff Knagge, "Silicon Complexity for Maximum Likelihood MIMO Detection Using Spherical Decoding",IEEE journal of Solid State Circuits, vol.39, no.9, pp. (1544-1552), September, 2004.
[6] G.Proakis, Masoud Salehi "Communication System Engineering", Second edition by John. Published by Pearson Education. 2002.
[7] Himanshu Bhatnagar – "Advanced ASIC Chip Synthesis Using Synopsys® Design Compiler™ Physical Compiler™ and PrimeTime®", Kluwer academic publishers, Second edition – 2002.
[8] Ian Griffiths "FPGA Implementation Of MIMO Wireless Communications System", University Of New Castle, Australia, 1st November, 2005.
[9] John G. Proakis, Dimitris G. Manolakis, "Digital Signal Processing Principles Algorithms and Applications", 4.
[10] Markus Myllyla, Markku Juntti, Matti Limingoja,Aaron Byman and Joseph,R. Cavallaro "Performance Evaluation of Two LMMSE Detectors in a MIMO-OFDM Hardware Testbed", Conf.on Signals, systems and Computers, Fortieth Asilomar Pacific Grove, pp. (1161-1165), Oct29Nov1 2006.