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Development of Channel Estimation Scheme with Effective Pilot Scheme and MIMO-PSK Approach

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Abstract - The ever-increasing popularity of mobile devices and the success of social networking have brought data traffic to experience an exponential growth over the last decade. The growing need of higher data rates has motivated to move towards new methodologies that maximize spectral efficiency and throughput. OFDM is a multi carrier modulation scheme widely used in modern communication technology enables high speed data transmission rate with huge bandwidth efficiency in multipath channels. For OFDM systems utilizing coherent demodulation, perfect channel estimation is most essential in terms of low bit error rate. Unlike for systems with a single-transmit antenna, the channel estimation process for OFDM systems with multiple transmit antennas is bit complex.

In this work to concern BER a channel estimation scheme with effective pilot scheme is carried out for MIMO OFDM system using PSK modulation scheme. All the sub-carriers in an OFDM block are used as pilot tones, and the OFDM block is transmitted periodically. The implementation and simulation of proposed work has done in MATLAB. Simulation results show that the BER performance of the proposed system is identical with that of the effect of noise as compare to existing base one. The system is implemented for Multiple Input Multiple Output (MIMO) 2X2 and 4X4 antenna system, with Orthogonal Frequency Division Multiplexing (OFDM) modulation, it shows a better Bit Error Rate (BER) performance for proposed 2X2 MIMO system and 4X4 MIMO system than that of the respective existing base work.

Keywords - Pilot Scheme, Spatial Diversity,16-PSK, MIMO.

I. INTRODUCTION

With 3G networks gradually becoming the main stream and in some markets even being replaced by 4G networks, consumers' appetite for more bandwidth has never been bigger. Under this backdrop, any research work related to MIMO is expected to have a significant impact on the society in the immediate future. The importance of MIMO capacity is that it provides a theoretical limit capping network throughput for reliable transmission of information over MIMO channels. A simple MIMO system is illustrated in Fig. 1.1.

The multiple Input Multiple Output (MIMO) technology employs multiple transmit and receive antennas at either end of the wireless link to increase data rates or the reliability with which data is received. MIMO systems offer an efficient way of improving the performance of a wireless link through the exploitation of the spatial resource. MIMO equipped systems can also implement the discrete multitone technique Orthogonal Frequency Division Multiplexing (OFDM) which has the advantage of eliminating Inter-Symbol Interference (ISI), an effect prevalent at high data rates due to multipath propagation. The MIMO-OFDM technology is therefore poised to deliver the high data throughput and quality of service projected for future wireless systems.

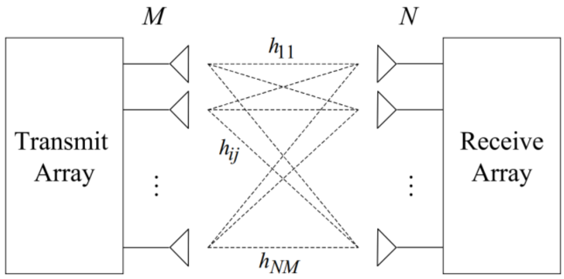

Figure 1.1 Block diagram of MIMO.

One technology that is poised to deliver the enhanced capabilities of the future systems is the Multiple Input Multiple Output1 (MIMO) system technology. Such systems promise to deliver high data throughput, and reliable detection, without additional bandwidth or transmission power. This is achieved through spatial multiplexing (when more data can be transmitted simultaneously from multiple antennas), diversity (sending coded bit sequences that allow for correct detection), as well as beamforming. Alternatively, methods that combine the spatial multiplexing and diversity advantages of MIMO transmission can be implemented, for example, the layered approach and joint optimization schemes. However, in order to realize the MIMO advantage, the elements of the antennas arrays at the transmitter and receiver must be adequately separated, where the minimum separation is typically considered to be on the order of a single wavelength.

Multipath propagation, despite being essential for MIMO transmission, results in Inter-Symbol Interference (ISI). Inter-symbol interference here refers to the phenomena where symbols that have been transmitted previously arrive via a longer, non-direct path at the same time as the symbols arriving currently via the direct path. Orthogonal Frequency Division Multiplexing (OFDM) is a digital modulation technique that solves the ISI problem. The use of multiple antennas with OFDM (MIMO-OFDM) therefore represents a robust technology for high data rate communications systems. However, in order to benefit from the opportunities presented by the new technology, industry will have to accept higher complexity and accuracy in the implementation; otherwise the accumulated implementation losses may significantly degrade the system performance

II. CHANNEL ESTIMATION

Channel estimation is required in wireless communication to counter the effects of channel on the signal. A defining characteristic of the wireless channel are the variations of the channel strength over time and over frequency. The variations can be roughly divided into two types:

1. Large-scale fading, due to path loss of signal as a function of distance and shadowing by large objects such as buildings and hills.

2. Small-scale fading, due to the constructive and destructive interference of the multiple signal paths between the transmitter and receiver.

To counter these effects various techniques are adopted at the receiver side. Mathematical models are used to predict the general behaviour of the channel in concern. Some important channel models are:

1. Rayleigh channel: For this model to be used it is required that there be many scatterers present, which means that Rayleigh fading can be a useful model in heavily built-up city centers where there is no line of sight between the transmitter and receiver and many buildings and other objects attenuate, reflect, refract and diffract the signal.

2. Rician channel: Rician channel is a transmission channel that may have a line-of-sight component and several scattered of multipath components.

3. Nakagami channel: The sum of multiple independent and identically distributed Rayleigh-fading signals have Nakagami distributed signal amplitude. This is particularly relevant to model interference from multiple sources in a cellular system.

Some popular techniques used at the receiver to detect the symbols sent through the channel are:

1. Detection by LSE (Least Square Error)

2. MMSE (Minimum Mean Square Error)

MIMO technology has attracted attention in wireless communications. MIMO systems have various advantages over SISO systems:

1. Significant increases in data transmission without additional bandwidth or transmit power. It achieves this by higher spectral efficiency (more bits per second per hertz of bandwidth) and link reliability or diversity (reduced fading).

2. No need to alter the common air interface while upgrading.

3. By various coding techniques, depth and duration of fades are reduced.

Channel estimation is a basic essential for the MIMO-OFDM framework, which is a center innovation for the fourth generation mobile correspondence framework (4G) and past 4G. It secures the required direct data ahead of time with the point of influencing the steering to code of the transmitter more productive to influence the beneficiary to identify flags all the more successfully. In this manner, the precision of channel estimation is the most basic in the worries that decide the general execution of a MIMO-OFDM framework. Figure 2.1 demonstrates the fundamental model of channel estimation in MIMO OFDM framework.

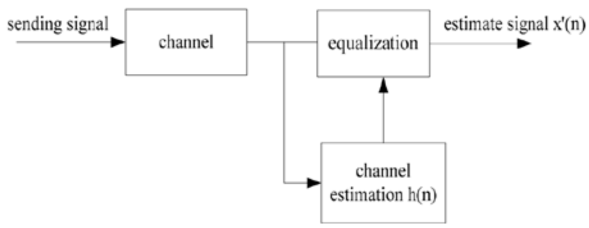

Figure 2.1 Basic channel estimation scheme.

III. PROPOSED METHODOLOGY

To design ubiquitous, high-quality, high-speed mobile multimedia transmission, various new technologies are constantly being applied to mobile communication systems. OFDM is one of the most promising core technologies in new generation of wireless mobile communication system to achieve high performance and reliability a channel estimation scheme with effective pilot scheme and MIMO-PSK Approach has proposed in this work to design and simulate proposed system in MATLAB. Block representation of proposed system has shown in figure 3.1. OFDM signals can be demodulated either coherently or differentially coherent manners. The most important advantage of differential demodulation is not requiring channel information, and the receiver is relatively simple. However, compared with coherent demodulation, system performance will be degraded from 3 to 4 dB. The pilot channel estimation methods are based on the pilot channel and pilot symbol used in this work.

For pilot based channel estimation of proposed MIMO OFDM system. A suitable pilot pattern needs to be considered first. Then, pilot-based channel estimation algorithm with low complexity is applied. Finally, a PSK demodulation method toward effective channel estimation is applied.

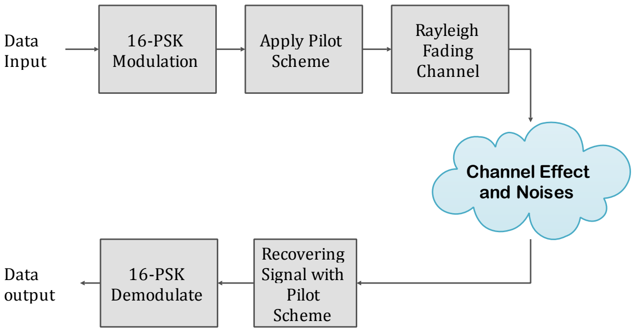

Figure 3.1 Block Diagram of Proposed systems.

The first one, block-type pilot channel estimation, is performed by inserting pilot tones into all subcarriers of OFDM symbols with a specific period in time.

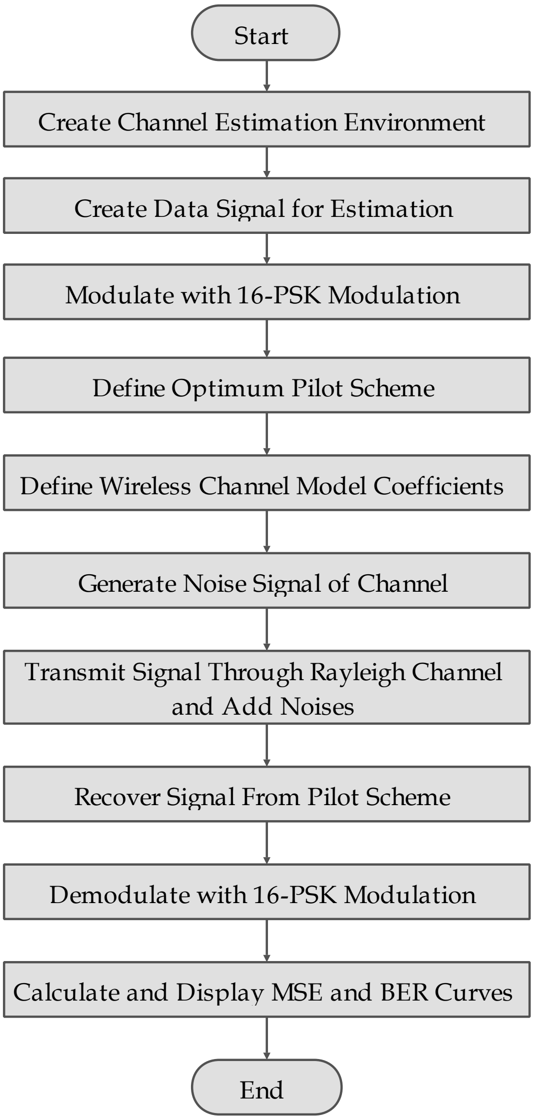

Figure 3.2 Implementation and Simulation Flow.

There are mainly three blocks are there in transmitter end of proposed system. First, 16-PSK modulation is applied on information signal. Second, pilot scheme is applied on modulated information signal for effective detection. Third, Rayleigh fading channel. Channel effect and noises are added in transmitting signal. At the receiver end a detection scheme is used to detect pilot symbols and recover signal. A 16-PSK demodulation is applied on received signal to obtain error free information signal.

The Process flow Implementation and Simulation of proposed system in Matlab environment has shown in figure 3.2.

IV. SIMULATION OUTCOMES

The simulation of proposed model is done in MATLAB, the channel is designed as a Rayleigh channel and the simulation outcomes are shown on MATLAB GUI. From the results it can be analyzed that the proposed system with different spatial diversity i.e. multiple input multiple output (MIMO) enhances the estimation performance of system and reduces error. The MIMO-OFDM system for simulation is designed to form the scenario in which the number of transceiver antennas in the transmitter and receiver are set as NT = 2, NR = 2 and NT = 4, NR = 4, respectively.

It is analyzed by simulation that the BER bit error rate and SNR signal to noise ratio performance of received signal for deferent antenna configuration are different

In Figure 4.1 BER calculation of the proposed MIMO OFDM system with 4 Transmitting antennas and 2 receiving antennas are shown using PSK-16 modulation scheme. The BER vs SNR plot in dB.

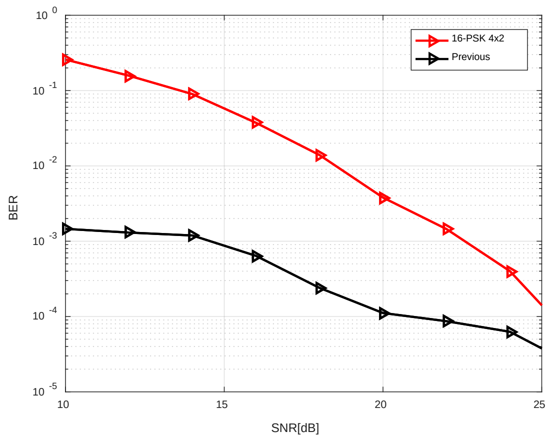

Figure 4.1 BER of the Proposed System with 4 Transmitting Antennas and 2 Receiving Antennas.

The mean squared error (MSE) calculation and plot of proposed model has shown in Figure 4.2 for 4 transmitting antennas and 2 receiving antennas. MSE represents procedure for error estimation based on square of errors the average squared difference of estimated error values used to evaluation of system performance.

Two different line color red and black shades in Fig. 4.1 shows the comparison of proposed work with previous work in terms of BER

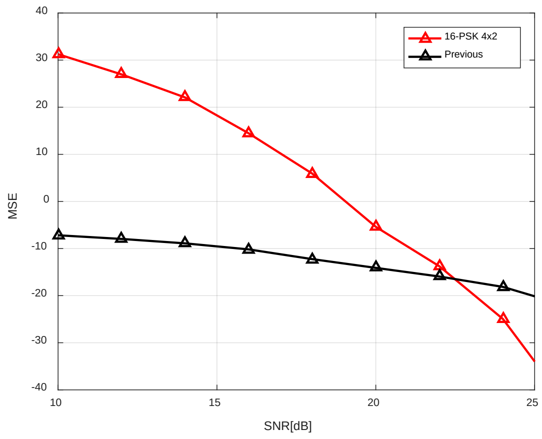

Figure 4.2 MSE of the Proposed System with 4 Transmitting Antennas and 2 Receiving Antennas.

Two different line color red and black shades in Fig. 4.2 shows the comparison of proposed work with previous work in terms of MSE.

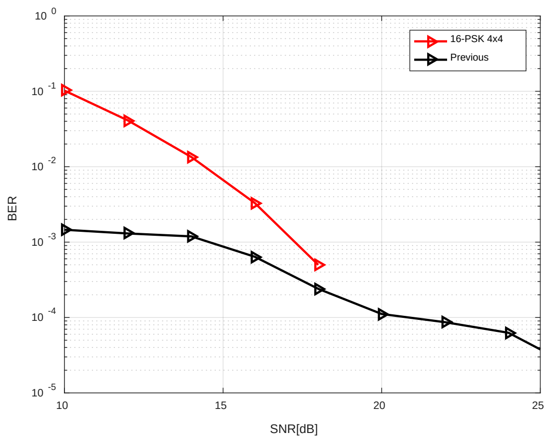

Figure 4.3 BER of the Proposed System with 4 Transmitting Antennas and 4 Receiving Antennas

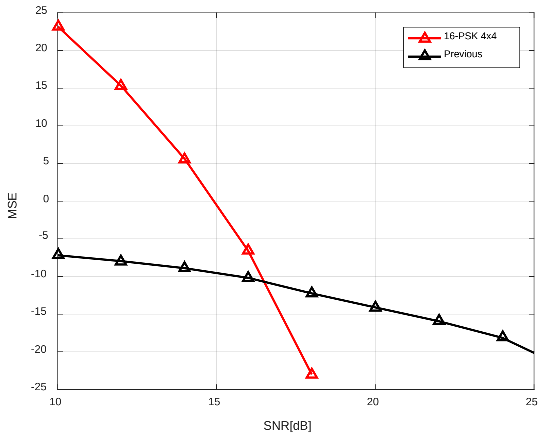

Figure 4.4 MSE of the Proposed System with 4 Transmitting Antennas and 4 Receiving Antennas.

Similarly to Figure 4.1 bit error rate BER for the proposed MIMO OFDM system with 4 Transmitting antennas and 4 receiving antennas are shown in Figure 4.3 using PSK-16 modulation scheme. The color shades in Fig. shows the comparative analysis of proposed work with corresponding previous work. Red line represents proposed work and black line represents previous work. The BER vs SNR plot in dB.

MSE calculation and representation for 4X4 transmitter and receiver antennas are shown in Figure 4.4. Comparison of proposed work with corresponding existing work is represented by two color shades red and black correspondingly.

The comparative analysis of proposed work and previous work are outlined in Table 1 Comparison of MSE (Previous and Our Work).

Table 1: Comparison of MSE (Previous and Our Work)

SNR	***Previous Work[1]***	***Our Work***	***Our Work***
		4x2	***4x4***
10	-7.1872	31.2562	23.20781
12	-7.9648	26.9614	15.28714
14	-8.9031	22.0661	5.584746
16	-10.1860	14.4561	-6.61942
18	-12.2495	5.9018	-23.0103
20	-14.1064	-5.3940	-
22	-15.9403	-13.7623	-
24	-18.1416	-24.9485	-
26	-22.1416	-43.0103	-

It very clear from table 5.1 that the proposed work have better MSE against previous work. To evaluate the performance of proposed work in terms of BER a comparative analysis of BER performance of proposed work with base work are outlined in below Table 2. Which is also seems better as compared to previous base work.

Table 2: Comparison of BER (Previous and Our Work)

SNR	***Previous Work[1]***	***Our Work***	***Our Work***
		4x2	***4x4***
10	1.46x10^{-3}	2.58x10^{-1}	1.02x10^{-1}
12	1.30x10^{-3}	1.58x10^{-1}	4.11x10^{-2}
14	1.19x10^{-3}	8.97x10^{-2}	1.35x10^{-2}
16	6.39x10^{-4}	3.74x10^{-2}	3.30x10^{-3}
18	2.40x10^{-4}	1.40x10^{-2}	5.00x10^{-4}
20	1.11x10^{-4}	3.80x10^{-3}	-
22	8.67x10^{-5}	1.45x10^{-3}	-
24	6.27x10^{-5}	4.00x10^{-4}	-
26	2.27x10^{-5}	5.00x10^{-5}	-

V. CONCLUSION AND FUTURE SCOPE

In this work implementation and simulation of channel estimation scheme with effective pilot scheme and MIMO-OFDM with PSK approach is proposed. Channel estimation of OFDM system based on pilot is represented in this work. This work first introduces the OFDM wireless communication technology and channel estimation in MIMO OFDM system. Then, the wireless multipath channel effect on the OFDM system is analyzed. After that, pilot-based channel estimation of OFDM with 16-PSK modulation scheme is implemented in MATLAB. The MATLAB simulation results show considerable improvement in BER performance for a MIMO- OFDM system. The incoming symbols are detected by receiver; as the estimation of channel is carried out at transmitter end itself thereby also reduce the receiver complexity. This technique is well suited for MIMO communication system. Multiple paths propagation happen because of the way that there is constantly atmospheric scattering and refraction or there is reflections from objects during signal propagation.

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