Based on Pseudo-Pilot Channel Estimation Performance Analysis of OFDM System

Akshay Rana, Rosy Dhiman, Mamta Arora

***Abstract:** The demand of Orthogonal Frequency Division Multiplexing (OFDM) has been increased from last few decades in wireless communication system. Channel estimation is the essential problem in OFDM system. Channel response can be obtained by employing pilot in payload symbols. In this paper we are estimating channel in OFDM system using pseudo-pilot inplace of pilot symbol. We are showing that the performance of proposed method is AWGN fading channel is better then the performance of pseudo-pilot in Rayleigh channel. In OFDM technique we are using time domain so signal in the series so we cannot used more signal it can use proposed channel estimation to estimate the channel impulse response using pseudo-pilot. The modulation technique used is QAM.*

***Index Terms:** Channel estimation, Orthogonal frequency division multiplexing (OFDM), Pseudo-Pilot, interlesver, MIMO*

I. INTRODUCTION

The fundamental concept of OFDM is always to divide high data rate streams into parallel, lower rate streams transmitted over a amount of orthogonal subcarriers. Each subcarrier is orthogonal to the others and it carries a percentage of the transmitted information. Hence, OFDM is different from the commonly used Frequency Division Multiplexing (FDM). OFDM is a special case of multicarrier modulation (MCM) that divides a communication channel spectrum into a number of equally spaced frequency bands, a modulation or multiplexing technique. A main reason for using OFDM is always to increase robustness against frequency selective channels and narrowband interference. In single carrier systems, one fade or interferer could cause a whole connect to fail, in multicarrier systems merely a small percentage of the subcarriers will soon be affected [1], [2]. OFDM design was proposed to overcome Inter Carrier Interference (ICI), with the Discrete Fourier Transform (DFT) ensuring subcarrier orthogonality, using the Fast Fourier Transform (FFT) algorithm. However, a high level of side lobes of the FFT rectangular window results in a high level of interferences and lower level of performance in the event of multipath fading. A guard interval was proposed to overcome the delay spread of the channel problem by inserting a cyclic prefix (CP), this calls for bandwidth and power and so reduces the spectral efficiency of the transmitted signal [1],[2].

Revised Version Manuscript Received on April 16, 2017.

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A pseudo pilot based OFDM design was proposed to overcome the limitations of the traditional OFDM design with pilot, where in the OFDM system the pilot is replaced by the pseudo-pilot for channel estimation, which gives a higher suppression of overhead issue in OFDM system during channel estimation. Thus, in OFDM system to overcome overhead issue there is no importance of the pilot, unless there in place of pilot, pseudo-pilot are used. In conventional OFDM systems, signals overlap in the frequency domain only, where using pseudo-pilot in OFDM systems, signals overlap in both the frequency and time domains but there is no impact of overlap during channel estimation process. The use of pseudo-pilot in OFDM systems reduces both overhead and complexity.

Channel estimation could be the evaluation of the effect of the wireless channel on the received signal. In order to mitigate hostile channel effects on the received signal, precise channel estimation must provide information for further processing of the received signal. Channel estimation may be categorized as non-data-aided and data-aided. Non-data-aided or blind channel estimators obtain the channel response from the statistics of the received signals. No specialized reference (or training signal) is necessary and the transmission efficiency is retained. However, without precise familiarity with the transmitted signals, a large number of data must certainly be collected in order to obtain reliable estimation. Data-aided channel estimators require known reference (training) signals to be transmitted, thus occupying bandwidth. Rapid and accurate channel estimation can be achieved by comparing the received signal with reference signals. A sufficient number of such reference signals must certainly be inserted according to the level of channel variation, namely coherence time and coherence bandwidth of the channel under estimation [7]. Other research has been carried out to assess and compare the training-based channel estimation algorithms performance for OFDM systems using either FFT or DWT, where pilot symbols are sent periodically [7],[8]. The periodically training sequence necessitates wasteful transmission, which reduces the spectral efficiency. To overcome this, improved Data- Aided (DA) based channel estimation has been proposed to overcome this problem [9],[10],[11].

In this paper we designed and implemented an OFDM system in MATLAB and BER performance was evaluated for AWGN and Rayleigh transmission channel with pseudo-pilot assisted system for channel estimation in OFDM system. The design consists of fundamental signal processing block such as QAM symbol mapping, modulator, interleavers and OFDM signal generator i.e.

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Inverse Fast Fourier Transform (IFFT) in the transmitter side and in receiver side used FFT with channel. estimator and detector corresponding inverse operations is carried out. Following this introduction the remaining part of the paper is Organized as follows. Section 2 provides brief overview of the system model design of OFDM system and channel estimation. This section explains the concept and introduces the OFDM system standard and channel estimation. In Section 3, the proposed system model and simulation of the system using MATLAB is presented. Then, simulation results have been discussed in Section 3 also. Finally, Section 4 provides the conclusions.

II. SYSTEM MODEL DESIGN

A. OFDM Model

OFDM concept is derived from the fact that the high bit rate data in parallel bit stream is transmitted over large number sub-carriers, every one of sub-carrier have a different frequency and these carriers are orthogonal to each other. OFDM converts frequency selective fading channel into N flat fading channels where N is the number of sub-carriers. Figure1 is shown, the block diagram of OFDM system.

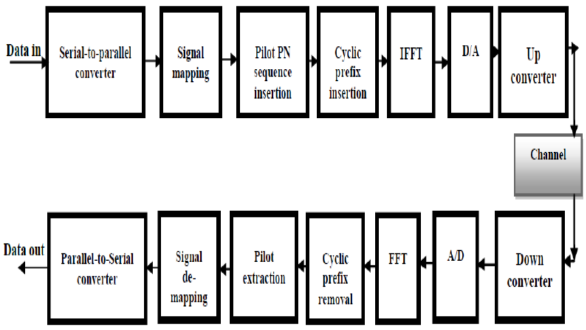

Fig.1. Block Diagram of OFDM system

However, far more unique merits of OFDM allow it to be widely utilized in wireless applications and standards. The important blocks used in OFDM model are described in brief as following:

Signal Modulation and Channel Coding:

In the OFDM system numbers of bits carried out based on which signal mapping or modulation scheme should be used and the sort of channel coding. Then, an appropriate mixture of modulation and coding techniques can be selected to match the input data rate to the OFDM symbols and, at once, satisfying the bit-error rate requirements. Usually BPSK/QPSK/QAM is preferred modulation techniques alongside convolutional coding and Viterbi decoding [12]. In OFDM system using digital modulation scheme such as BPSK, QPSK or QAM, firstly random data bits are mapped to data symbols

FFT and IFFT Block:

The Fast Fourier Transform is a very efficient mathematical method for calculating DFT. It can be easily implemented in integrated circuits at fairly low cost. The implementation of OFDM system is reduced due to the advancement in digital signal processing technology. The main block of of OFDM is only IFFT/FFT but the complexity [15] of performing an FFT is determined by the size of the FFT.DFT require N2 complex multiplications and N*(N-1) complex additions whereas utilization of FFT algorithm reduces the number of computations to the order of N/2*log2 (N) complex multiplications and N*log2 (N) additions. Moreover FFT algorithm works efficiently when N is a power of 2, therefore the number of sub-carriers is generally kept as power of 2. IFFT/FFT operation ensures that sub-carriers do not interfere each other. IFFT is employed at the transmitter to obtain enough time domain examples of the multicarrier signal.

Guard Time/ Cyclic Prefix:

Synchronization between the start and end of the transmitted OFDM symbol period is vital during demodulation otherwise ISI will occur. In addition, we likewise have ICI whenever we have a loss in orthogonality between sub-carriers. To be able to overcome the problem of multipath fading environment and hence inter symbol interference ISI [14], it is common practice in OFDM technology to incorporate guard interval between OFDM symbols. The guard interval is formed by a cyclic continuation of the signal so the info in the guard interval is really within the OFDM symbol. Guard interval makes the machine robust against multipath delay spread. The guard interval is really added by taking the copy of the last portion of the OFDM symbol and placing it at the start of the symbol. As a principle, the guard time must certainly be at the least 2-4 times the RMS delay spread of the multi-path channel.

Interleaving:

An interleaver permutes symbols in accordance with a mapping. A corresponding deinterleaver uses the inverse mapping to displace the initial sequence of symbols. Interleaving and deinterleaving can be ideal for reducing errors caused by burst errors in a communication system. A convolutional interleaver contains some shift registers, each with a fixed delay. Interleaving is often found in digital wireless communications to boost the performance of forward error correcting (FEC) codes [13]. As a result of random nature of mobile channels errors mostly occur in bursts if the number of errors within a rule word exceeds the error-correcting code's capability, then it fails to recoup the initial code word. Interleaving solves this dilemma by shuffling source symbols across several code words, thereby creating a more uniform distribution of errors. Therefore, interleaving is widely employed for burst error-correction.

Channels:

Additive white Gaussian noise (AWGN): It is a channel model in which the only impairment to communication is a linear addition of wideband or white noise with a constant spectral density and a Gaussian distribution of amplitude. The model does not account for fading, frequency selectivity, interference, nonlinearity or dispersion.

In OFDM model firstly random data bits are mapped to data symbols using digital modulation scheme such as BPSK, QPSK or QAM. Then your serial data stream is changed into a fixed quantity of parallel data stream. Then, after adding pilot symbols, which are used for channel estimation or synchronization, IFFT operation is performed on each block of symbol which will be the OFDM signal. Then a proper period of Cyclic prefix or guard interval is appended to the OFDM signal, whose length is chosen to be larger compared to the maximum delay spread.

Of the channel in a way that ISI is taken care. Next the OFDM blocks are converted back once again to serial data [12], which will be transformed into analog domain using digital-to-analog converter (DAC) and finally with RF up-conversion sent out to the wireless channel. We assume perfect timing and carrier frequency synchronization at the receiver. Thus, the received signals after down conversion & analog-to-digital conversion (ADC) is transformed to parallel data and then following the cyclic prefix removal, FFT operation is done on each data block. After demodulation, the transmitted original bit stream is recovered. In broadband time-varying multipath fading channels, OFDM has a number of its challenging issues, such as peak-to-average-power ratio (PAPR) and carrier frequency offset (CFO).

B. Channel Estimation

Wireless channels are multipath fading channels, which in turn causes ISI (inter symbol interference). For every single path in wireless communication channel an unbiased path gain (or loss), independent path delay, and independent path phase shift will soon be there. The receiver should be supplied with the channel estimator which contain the information of channel impulse response (CIR). For the channel estimation the sequence of bits should be unique for every transmitter. MIMO is multiple input and multiple output system which uses multiple transmit and receive antennas communicating in same frequency band which increases the ability linearly of signals with the number minimum of transmit and receive antennas. An efficient MIMO OFDM system is quite definitely complex. OFDM uses a large bandwidth so as to provide the diversity on the subcarrier. The consequence of here is the carriers being lost in the noise [16].In order to improve performance of OFDM system under frequency selective channels; the channel estimation is necessary before demodulation of OFDM signals [17]. there are two different ways of arranging pilot tones in OFDM transmission: block-type pilot arrangement and comb-type pilot arrangement, as shown in figure 2.

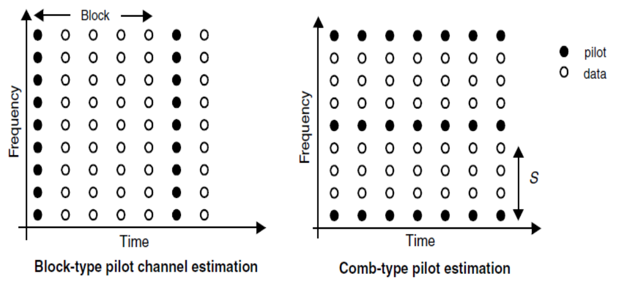

Fig.2. Pilot based Arrangement in Channel Estimation

The channel estimation is an activity of characterizing the effect of the transmission medium on the input signal. In OFDM system there are several techniques for channel estimation [16-18]. Among these techniques; the Block Type Pilot based channel estimation technique is more popular. The Block type Pilot based estimation techniques can use Least-Square (LS) method. The LS estimators have low complexity.

In block type pilot symbol assisted channel estimation, pilot symbols are sent periodically, where all sub channels are used as pilots. The estimation of the channel is completed by utilizing either Least Square (LS) or Minimum Mean Square (MMSE)[20],[21].The MMSE performs better than LS in terms of signal to noise ratio gain. Once the channel coefficient h is Gaussian and uncorrelated with channel noise which can be Additive White Gaussian Noise (AWGN), then LS channel estimate is given by [21].Considering that the comb type pilot arrangement is made beneath the assumption of fast fading channel, therefore an efficient interpolation technique is essential to estimate the channel at data carriers by utilizing channel response at pilot subcarriers.

III. PROPOSED SYSTEM MODEL AND SIMULATION

The Pseudo-pilot is a novel concept of channel estimation which is offers effectual and simple approach. The fundamental concept is to transmitted number of pseudo arbitrary symbol (PRS), engendered by bank of interleavers at the transmitter side [19]. Pseudo-pilot symbol generation for channel estimation in OFDM system shows in fig.4. At the transmitter side we employ a bank of pseudo-arbitrary symbol (PRS), payload symbol block rearranges in such a way at output of the interleavers at least one of the rearrangements contains a sub-block, where these sub-blocks are coinciding with a reference block. At receiver side these sub-block are kenned and thus they are designated as pseudo-pilot.

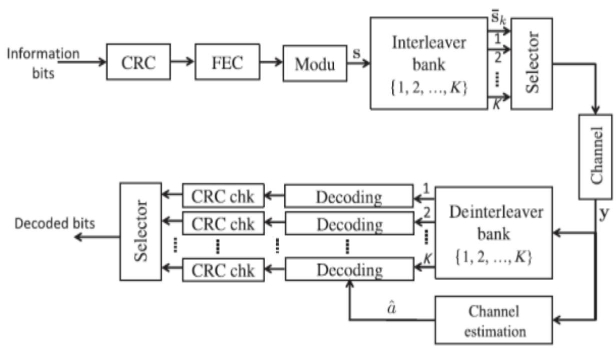

Fig.3. Pseudo-Pilot Generation

These PRS symbol then utilized for the purport of channel estimation. In estimation technique where pilot utilized for channel estimation and synchronization, superseded with pseudo-pilot symbol. It has been resulted that pseudo-pilot-availed systems can offer the same performance as pilot-availed systems at no cost of the pilot overhead [19]. In this paper we used MATLAB 2013ba software for simulation. For simulation design, it has been considered different channels.

The primary point of work is to give thought regarding the idea of pseudo-pilot direct estimation in OFDM framework, with equivalent likelihood data bits are produce with PRS. After it data bits nourished into 1/3 coded turbo encoder. Encoder delivered the 336 bits for each burst rate. At that point the coded bits were regulated into QAM and subcarrier separating is 15Kz. QAM image mapped with time area i.e. 16 schedule vacancy and 12 subcarrier. Each and every burst expecting 1Hz Doppler recurrence, created by channel freely. This help us to disregard the diversion from alternate issues incorporate non-perfect addition mistakes, pilot arrangement, channel time-recurrence selectivity. Direct model embraced in concentrate ease versatility machine sort (MTP) correspondence [22].

These stayed away from diversions will give indistinguishable effect on the execution whether we utilize pseudo-pilot or traditional pilot. Pseudo-pilot were isolated into two sections, first availability of asset piece filled by these parts. For leading estimation with pseudo-pilot we utilized the LS channel estimator.

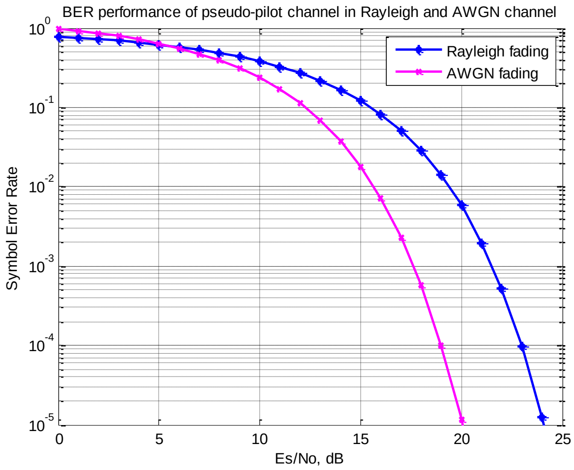

Fig.4. BER Performance of the OFDM system with pseudo-pilot in Rayleigh and AWGN channel

In the simulation transmitted bits are 10,000 bits per user and these bits has been detected by detector. A graph is plotted between different values of signal to noise ratio (SNR) E_b/N_o and different value of BER (bit error rate). For simulation purpose two different cases are chosen. In the case-1 we get result by employing simple pseudo-pilot in Rayleigh channel system and in other case we get results by employing pseudo-pilot for AWGN channels. Simulation comes about demonstrate that, BER execution for both the framework indistinguishable with equivalent number of pilot and pseudo-pilot.

IV. CONCLUSION

In this paper, we highlights the channel estimation technique based on pseudo-pilot symbols using LS algorithm. The channel estimation is the one of the fundamental issue of OFDM system design. The performance of technique is comparable on the bases of channel used for the transmission. Transmission of signal with different channel under goes with many effects such as reflection, refraction, multipath fading, noise and diffraction. When we compare channel estimation using pseudo-pilot symbols in Rayleigh channel and AWGN Channel we obtain the performance of pseudo-pilot in AWGN channel is better.

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