

ENHANCED ESTIMATION OF CHANNELS IN OFDM USING CYCLIC PREFIX AND TWO DIMENSIONAL PROLATE FUNCTION

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Abstract— The channel estimation in OFDM is necessary and to recover the accurate information from the received data .The OFDM will be next generation of wireless communication technology. As per users need OFDM has very high data rate and high speed mobile terminals. In addition to the fast fading channels, ICI and multipath fading may damage the data. Using two-dimensional prolate functions we can reduce the complexity in parameters calculation. If we compared with state –of-art approach the complexity is $O(N)^3$, the complexity using two-dimensional Prolate function is $O(N)^2$. These functions depend upon maximum delay and maximum Doppler frequency spread thus parameter calculation is reduced. Slepian sequences use the bandwidth, as the sharp pulses replace the regular rectangular pulses which cause spectral leakage and thus ICI.

The MATLAB simulations of BER Vs SNR using Cyclic Prefix and Unique Word with and without two-dimensional Prolate function is suggested in this paper. It will increase spectral efficiency with reduced calculations .The two-dimensional prolate replaces rectangular pulses by Slepian pulses which increases energy concentration and thus reduction in ICI caused by multipath fading.

Index Terms— OFDM, time –varying channel estimation, least square (LS), minimum mean square estimation (MMSE), cyclic prefix (CP), unique word (UW).

I. INTRODUCTION

OFDM has become very suitable modulation technique to transmit higher data transmission rates over the frequency-selective channels. The estimation of channels and equalization processes are simple over slow fading and time-varying channels. In the particular environment, the channel changes and variations for the individual OFDM symbol is negligible, which allows each subcarrier to be estimated effectively and compensated independently [1]. However, for broadband applications in high-mobility devices as well as migration to higher carrier frequencies it becomes necessary to

deal with fast time-varying channels. In this condition, it is observed that a single OFDM symbol experience channel variations and suffers from inter-carrier interference (ICI). Since the ICI greatly disturbs system working performance, the estimation of channel and compensation of the channel vary for each OFDM symbol is critical.

To deal with estimation of fast time-varying channels, various authors observed that variations of the channel impulse response during an OFDM symbol can be approximated by a first-degree polynomial. In addition proposes an iterative scheme that discards the ICI to pilots for the purpose of improving channel estimation. Under these situations, a basis expansion model (BEM) for the process of varying time of each type is important and proposed where the base weights are estimated with the information contents of the pilots of the current OFDM symbol. In a BEM is used together with Kalman filtering for estimating and tracking the channel's weights. Further, an approach depends on MMSE filter and pre-distortion is to be assumed in line-of-sight (LOS) conditions, having knowledge of accurate channel statistics.

By considering the current algorithms, the following factors can be highlighted [4]:

- The number of physical paths in real channels may be very high or infinite, as considered in several standards. In these conditions, approaches are not directly applicable.
- In a finite number of physical paths, the delay estimations shows extra computational complexity. In that case, system performance can be largely degraded by various inaccuracies in the path gains and delay estimation of the channel.
- However, mobile conditions cannot guarantee LOS. Besides, knowledge of accurate channel statistics implies that is hard to estimate and expensive signal processing, which makes this approach applicable only for particular conditions.
- As channel equalization is usually in the frequency domain (FD), and the channel variations are estimated in the time domain (TD). We know that current requirements dealing

with ICI require performing calculations and considerable number of Fourier transformations. And finally, there is a trade-off between performance factor and complexity of the channel.

Above factors lead to the conclusion that it is desirable to give an estimation algorithm that has the following important features:

- It must not be dependent of the number and delay-position of physical paths or their associated exact Doppler spectrum shapes.
- It must be able to working in FD, in order to provide the channel estimate directly in a suitable format for the channel equalizer.
- It must be provide better performance at manageable computational complexity

II. OFDM CHANNEL ESTIMATION TECHNIQUES

Previously different techniques are presented on Channel Estimation. These channel estimations were suggested in different channel characteristics such as fast time varying environment, largely dispersive channel, and using antenna arrays [6]. These techniques are shortly discussed below.

A. Pilot Method

The insertion of pilot symbol or tones with the specific pilot pattern arrangements used for channel estimation often called the pilot-aided channel estimation.

The OFDM channel estimation can be done by following pilot methods:

1. Block pilot type
2. Comb pilot type

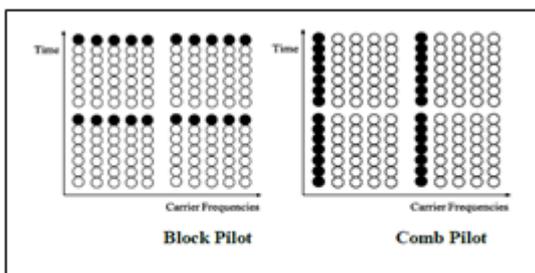


Fig2.1Block pilot type Fig2.2 Comb pilot type

B. Block Pilot Type

In block pilot type method, generally pilot tones are added in all subcarriers of an OFDM symbols periodically. This type is comfortable for slow-fading channels where channel characteristics are assumed stationary or stable during individual OFDM data block. In block type method [2], pilot

tones channels can be estimated by using LMMSE based estimation, and observed that channel remain the same for the whole block. So in block type channel estimation, we start with estimation of the channel, and then use the same estimation within the entire block.

C. Comb Pilot Type

The comb pilot type method, pilot tones are added in each individual OFDM data blocks. The channel is estimated in all OFDM symbols. The concept is to introduce some of the subcarriers as pilot carriers in each OFDM symbol. Comb pilot type tone estimation method [2], is introduced for equalization when the channel changes even in individual OFDM block. The comb pilot type channel estimation contains the algorithms to estimate the channel at definite pilot frequencies and to interpolate the channel. For a fast fading channel, the characteristics of a radio channel are varying within an individual OFDM block. Therefore, transfer function of the channel should be estimated in each OFDM symbol of a data block.

The blind channel technique of estimation is introduced in paper. This method achieves accurate channel estimation and provides fast convergence with insensitivity and inaccuracies to overestimates of the true channel order. However, the blind channel technique is limited to slow time varying channels and has more complexity at the receiver. Also Pilot-aided algorithm [4] for the estimation of fast time-varying channels in OFDM transmission.

Generally, channel estimation is performed in the frequency domain, which is to exploit the structure of the channel response optimizes the pilot group most of the computations offline resulting in high performance.

A discrete prolate spheroidal basis expansion model (DPSBEM) is important to describe the time-varying channel [5]. A non-random training sequence is arithmetically superimposed at low power in the sequence of information at the transmitter before modulation and transmission .Therefore, there is no loss in data transmission rate compared to that time-multiplexed (TM) training sequence. In this estimator, the unknown information sequence acts as interference generating in a poor signal-to-noise-and-interference ratio (SNIR) for channel estimation. Then providing a data-dependent superimposed training sequence, for equalization effects of the information sequence at the receiver on channel estimation which are unknown.

In this paper [7] sending out pilots with random phases in this way to “spread out” the sparse taps in the impulse response over the uniformly down sampled measurements at the receiver ADC and thereby impulse response can still be recovered by sparse equalization. This is helpful for good resolution channel estimation with low speed ADCs,

Combination of least squares or a minimum normal channel slope estimation and the detection of the channel paths [8] sets any channel path power equal zero once the corresponding power estimate is lesser than a given threshold. The algorithm exploits the large channel correlations between the cyclic prefix and OFDM symbol. These maximum correlations reasons provide the superiority of ICI mitigation

with cyclic prefixes compared to channel estimation slope with adjacent OFDM symbols, which may needs at least twice the number of pilot symbols.

III. ASSOCIATED PROBLEMS WITH TRADITIONAL METHOD

3.1 channel estimation techniques

Generally in time domain and frequency domain finding the channel transfer function becomes very difficult as for various subcarriers it goes different. Therefore it becomes essential then to find unique and versatile method that works properly better on all the subcarriers for estimation. The pilot based method is more suitable than block coding and is widely used. MMSE (minimum mean square error) provides accurate results but more complexity as more calculations, whereas LS (Least Square) estimator gives less accurate results comparatively and lesser calculations[5]. In this paper, we focused on simpler estimator.

3.2 (DPSS) Discrete Prolate Spheroidal Sequences

Without training sequences or pilots, blind channel estimation requires longer data records and larger complexity [3]. This method takes various previous data blocks for channel estimation. This shows slow convergence time and any possible mis-convergence and this is disadvantage.. In this paper superimposed training-based sequences are used where the training sequence is transmitted at low power concurrently superimposed on the information sequences.

(DPSS) Discrete Prolate spheroidal sequences can be considered as discrete time, finite length sequences whose Discrete Time Fourier Transformation (DTFT) is concentrated within a given band. Therefore having N- sub bands in OFDM with bandwidth W, DPSS function captures all the energy in any sample vector from uniformly sampled analog signal and DPSS with OFDM can also cancel the strong narrowband interferences.

3.3 BEM (Basis Expansion Model)

Especially BEM is used in a mobile environment where strong reflection creates multipath signals. It is used where the autoregressive model fails as it relies upon the previous

receptions for channel estimation [4]. BEM utilizes time domain estimation compared to frequency domain thus minimizes the errors. BEM uses doubly- selective channel estimation which is carried out before FFT. BEM is also used in frequency domain channel estimation using Slepian sequences. Typically, Slepian sequences utilized to find the channel correlation in time.

BEM gives time varying channels and by taking channel Impulse response and Fourier transform we can characterize the channel perfectly and accurately [7]. This model provides us estimation of fast time varying process by estimating some of its other slow time varying parameters.

BEM assumes that length of pilot block should be longer than the number of BEM coefficient to be estimated. At the receiver side the extended Kalman filter is used for data detection. Perfect and accurate estimation are possible with lower complexity by finding the frequency correlation of the channel. This type gives better results using BEM considering the channel as a combination of complex exponential function.

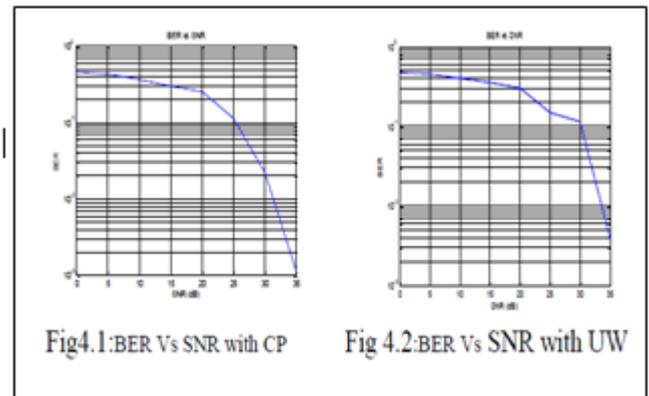
The project objectives are mentioned below.

- Analysis of OFDM with CP
- Addition of a linear minimum mean-squared error (LMMSE) estimator at receiver side of OFDM
- Providing low complexity channel estimation algorithm using two dimensional prolate functions.
- Plotting BER graphs and mentioning the less complex products

IV. REQUIRED AND PROPOSED METHOD

Using CP in channel estimation means the receiver has no idea about the cyclic extension, whereas using unique word means the receiver has knowledge of the transmitted extension [8].

The BER vs SNR graph of both the techniques is shown in Figure 4.1 and Figure 4.2



PROJECT MODULE

The Figure 4.3 shows the block diagram of orthogonal frequency division multiplexing. The block diagram gives detailed information about the OFDM data transmission. Here the high data rate obtained with modulating data on subcarriers [7]. Pilots are added which provide channel estimation. And to avoid ICI guard (CP/UW) is inserted. Because of the multipath fading, fast fading, highly mobile equipment, the channel changes within the symbol. Thus it is necessary to estimate the channel characteristics.

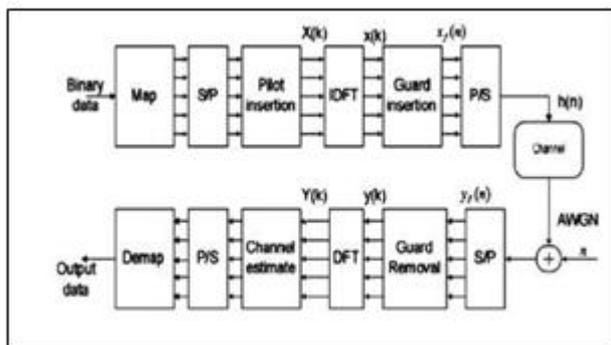


Fig.4.3 OFDM basic block diagram

In this paper replacing the channel estimation by State of Art approach where the complexity is $O(N)^3$, a two Dimensional Prolate function is used which reduces the Complexity to $O(N)^2$. This technique depends only upon maximum delay spread and maximum Doppler spread. This technique is independent of particular channel scattering function. Basis expansion model (BEM) is used for channel estimation. In this paper we have used the LS method as it is less complex than MMSE.

To equalize the effect of inter symbol along with the Prolate function we have also used the Slepian pulses which are highly bandwidths limited. Thus can estimate the channel perfectly using chirp as pilot and using Doppler frequency shift and actual time delays. Discrete spheroidal sequences are pulses having highly concentrated in the bandwidth. Thus use of DPSS provides spectral efficiency.

In this paper we are generally using the discrete prolate spheroidal sequences to reduce the no. Of calculations also to reduce the bandwidth requirement thus comparison with rectangular pulses with DPSS.

V. CONCLUSION

An enhanced OFDM channel estimation based on Basis Expansion Model using Slepian sequences for time varying OFDM systems is proposed. It can be shown that with less number of SNR requirement, LS performs better as compare to the MMSE. To reduce the complexity Slepian Basis expansion model is used for estimation of fast as well as slow time varying channel. Also the comparison study between LS and MMSE estimation techniques with and without prolate function is proposed. By using sharp discrete Slepian pulses replacing rectangular pulse we can extract all the information from uniformly spaced samples and effectively use the bandwidth

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