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Channel Analysis in OFDM Systems

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***Abstract*— Orthogonal frequency division multiplexing (OFDM) Technique has received a lot of interest in mobile communication research. For wideband mobile communication system, the radio channel is usually frequency selective and time variant. In OFDM system, the channel transfer function of radio channel appears in both frequency and time domains. Therefore, a estimation of channel is necessary for demodulation of OFDM signal. Channel estimation methods for OFDM system based on pilot aided. In this thesis we investigate and compare different pilot based channel estimation schemes for OFDM systems. The channel estimation can be performed by either inserting pilot tones into all subcarriers of OFDM symbols with a specific period or inserting pilot tones into each OFDM symbol. In this present study, major type of pilot arrangement such as 1. Block type 2. Comb type. Both type of pilot arrangement have been focused employing least square error (LSE) and Minimum mean square error (MMSE) channel estimators. Block type pilot subcarrier is suitable for slow fading radio channels. Comb type pilot subcarrier is suitable for fast fading radio channels. Also com type pilot arrangement is sensitive to frequency selective when compare to block type pilot arrangement. Channel estimation algorithm based on comb type pilot is dividing into pilot signal estimation and channel interpolation. Symbol error rate performance of OFDM systems for both type pilot subcarriers are presented in this thesis.**

Index Terms*— *OFDM, Channel Estimation, Block Type, Comb Type.

I. INTRODUCTION

Radio transmission has allowed people to communicate without any physical connection for more than hundred years. When Marconi managed to demonstrate a technique for wireless telegraphy, more than a century ago, it was a major breakthrough and the start of a completely new industry. May be one could not call it a mobile wireless system, but there was no wire! Today, the progress in the semiconductor technology has made it possible, not to forgot affordable, for millions of people to communicate on the move all around the world.

The Mobile Communication Systems are often categorized as different generations depending on the services offered. The first generation comprises the analog frequency division multiple access (FDMA) systems such as the NMT and AMPS (Advanced Mobile Phone Services). The second generation consists of the first digital mobile communication systems such as the time division multiple access (TDMA) based GSM (Global System for Mobile Communication), D-AMPS (Digital AMPS), PDC and code division multiple access (CDMA) based systems such as IS-95. These systems mainly offer speech communication, but also data communication limited to rather low transmission rates. The third generation started operations on 1st October 2002 in Japan.

During the past few years, there has been an explosion in wireless technology. This growth has opened a new dimension to future wireless communications whose ultimate goal is to provide universal personal and multimedia communication without regard to mobility or location with high data rates. To achieve such an objective, the next generation personal communication networks will need to be support a wide range of services which will include high quality voice, data, facsimile, still pictures and streaming video. These future services are likely to include applications which require high transmission rates of several Megabits per seconds (Mbps).

In the current and future mobile communications systems, data transmission at high bit rates is essential for many services such as video, high quality audio and mobile integrated service digital network. When the data is transmitted at high bit rates, over mobile radio channels, the channel impulse response can extend over many symbol periods, which lead to inter symbol interference (ISI). Orthogonal Frequency Division Multiplexing (OFDM) is one of the promising candidates to mitigate the ISI. In an OFDM signal the bandwidth is divided into many narrow sub channels which are transmitted in parallel. Each sub channel is typically chosen narrow enough to eliminate the effect of delay spread. By combining OFDM with Turbo Coding and antenna diversity, the link budget and dispersive-fading limitations of the cellular mobile radio environment can be overcome and the effects of co-channel interference can be reduced.

II. LITERATURE REVIEW

The first OFDM scheme was proposed by Chang in 1966 for dispersive fading channels, which has also undergone a dramatic evolution due to the efforts. Recently OFDM was selected as the high performance local area network transmission technique. A method to reduce the ISI is to increase the number of subcarriers by reducing the bandwidth of each sub channel while keeping the total bandwidth constant .The ISI can instead be eliminated by adding a guard interval at the cost of power loss and bandwidth expansion. These OFDM systems have been employed in military applications since the 1960's, for example by Bello, Zimmerman others. The employment of discrete Fourier transform (DFT) to replace the banks of sinusoidal generators and the demodulators was suggested by Weinstein and Ebert

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in 1971, which significantly reduces the implementation complexity of OFDM modems. Hirosaki suggested an equalization algorithm in order to suppress both inter symbol and inter subcarrier interference caused by the channel impulse response or timing and frequency errors. Simplified model implementations were studied by Peled in 1980. Cimini and Kelet published analytical and early seminal experimental results on the performance of OFDM modems in mobile communication channels.

Most recent advances in OFDM transmission were presented in the impressive state of art collection of works edited by Fazel and Fettweis. OFDM transmission over mobile Communications channels can alleviate the problem of multipath propagation. Recent research efforts have focused on solving a set of inherent difficulties regarding OFDM, namely peak-Tomean power ratio, time and frequency synchronization, and on mitigating the effects of the frequency selective fading channels.

Channel estimation and equalization is an essential problem in OFDM system design. Basic task of equalizer is to compensate the influences of the channel. This compensation requires, however, than an estimate of the channel response is available. Often the channel frequency response or impulse response is derived from training sequence or pilot symbols, but it is also possible to use non pilot aided approaches like blind equalizer algorithms. Channel estimation is one of the fundamental issues of OFDM system design, without it non coherent detection has to be used, which incurs performance loss of almost 3-4 dB compared to coherent detection. If coherent OFDM system is adopted, channel estimation becomes a requirement and usually pilot tones are used for channel estimation. A popular class of coherent demodulation for a wide class of digital modulation schemes has been proposed by Moher and Lodge, and is known as Pilot Symbol Assisted Modulation, PSAM. The main idea of PSAM channel estimation is to multiplex known data streams with unknown data. Conventionally the receiver firstly obtains tentative channel estimates at the positions of the pilot symbols by means of remodulation and then compute final channel estimates by means of interpolation. Aghamohammadi et al. and Cavers [16] were among the first analysing and optimizing PSAM given different interpolation filters. The main disadvantage of this scheme is the slight increase of the bandwidth. One class of such pilot arrangements have been analysed. There are some other techniques, proposed for channel estimation and calculation of channel transfer function in OFDM systems. For example, the use of correlation based estimators working in the time domain and channel estimation using singular value decomposition. It's basically based on pilot symbols but in order to reduce its complexity,

Statistical properties of the channel are used in a different way. Basically the structure of OFDM allows a channel estimator to use both time and frequency correlations, but particularly it is too complex. They analysed a class of block oriented channel estimators for OFDM, where only the frequency correlation of the channel is used in estimation. Whatever, their level of performance, they suggested that they may be improved with the addition of second filter using the time correlation.

They proposed a channel estimation algorithm based polynomial approximations of the channel parameters both in time and frequency domains. This method exploits both the time and frequency correlations of the channel parameters. Use of the pilot symbols for channel estimation is basically an overhead of the system, and it is desirable to keep the number of pilot symbols to a minimum. Julia proposed a very good approach for OFDM symbol synchronization in which synchronization (correction of frequency offsets) is achieved simply by using pilot carriers already inserted for channel estimation, so no extra burden is added in the system for the correction of frequency offsets.

It has been shown that the number of pilot symbols for a desired bit error rate and Doppler frequency is highly dependent on the pilot patterns used, so by choosing a suitable pilot pattern we can reduce the number of pilot symbols, but still retaining the same performance. Most common pilot patterns used in literature are block and comb pilot Arrangements. Comb patterns perform much better than block patterns in fast varying environments.

III. OBJECTIVES

In this work, channel estimation in OFDM systems is investigated. The main objective of this thesis is to investigate the performance of channel estimation in OFDM systems and study different patterns of pilot symbols which already have been proposed in literature.

The main objectives of this thesis are:

(a) Investigate the effectiveness of Orthogonal Frequency Division Multiplexing (OFDM) as a modulation technique for wireless radio applications. Main factors affecting the performance of an OFDM system are multipath delay spread and channel noise.

(b) In pilot assisted channel estimation, we study different pilot arrangements, and investigate how to select a suitable pilot pattern for wireless OFDM transmission.

(c) To compare the estimation technique like least square error estimation (LS) and minimum mean square error channel estimation (MMSE).

(d) To proposed a modified MMSE technique and compare the MMSE estimation with modified MMSE in term of BER and MSE. The performance of OFDM is assessed using computer simulations performed using Matlab.

IV. RESULTS AND CONCLUSIONS

An OFDM system is modelled using MATLAB to allow various parameters of the system to be varied and tested. The aim of doing the simulations is to measure the performance of OFDM system under different channel conditions, and to allow for different OFDM configurations to be tested.

In comparison between block and comb type pilot arrangement, block type of pilot arrangement is suitable to use for slow fading channel where channel impulse response is not changing very fast. So that the channel estimated, in one block of OFDM symbols through pilot carriers can be used in next block for recovery the data which are degraded by the channel.

Comb type pilot arrangement is suitable to use for fast fading channel where the channel impulse response is changing very fast even if one OFDM block. So comb type of pilot arrangement can't be used in this case. We used both data and pilot carriers in one block of OFDM symbols. Pilot carriers are used to estimate the channel impulse response. The estimated channel can be used to get back the data sent by transmitter certainly with some error.

In our simulation of com type pilot arrangement we used 2048 number of carriers in one OFDM block. In which one fourth are used for pilot carriers and rest are of data carriers. We calculated BER and MSE for different SNR conditions for different modulation. We also have compared performance of LSE, MSE and modified MMSE with different modulation. MMSE estimation is better that LSE estimator in low SNRs where at high SNRs performance of LSE estimator approaches to MMSE estimator. Modified MMSE estimation given better performance than MMSE estimation. We also used interpolation techniques for channel estimation. It is found that higher order interpolation technique (spline) is giving better performance than lower order interpolation technique (linear). In simulation we have also calculated MSE for estimation of channel with number of pilot arrangement. MSE decreases when number of pilots increase. But we have to limit the number pilots when mean square error comes constant.

V. FUTURE SCOPE OF THE WORK

Following are the areas of future study which should be considered for further research work.

1. Implementation of other interpolation techniques for channel estimation:
2. In this work we have considered only one type interpolation techniques. We can extend this work for other interpolation techniques such as second order, low-pass etc.
3. Feasibility study of Multiple Input Multiple Output (MIMO) OFDM systems:
4. In this study we have discussed about Single Input Single Output (SISO) OFDM systems. MIMO OFDM can be implemented using multiple transmitting and receiving antennas which is an interesting work of future.

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