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Efficient Time and Frequency Synchronization in MIMO-OFDM System using Median Filtering

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Abstract: **Time and frequency offset has a important aspect in OFDM based communication to maintain the orthogonality of the and control errors and interferences. In this paper we have investigated the time and frequency offset in MIMO-OFDM system and performance calculated as mean square error (MSE) for given values of signal to noise ratio (SNR). Time and frequency synchronization is achieved by using median filtering with the different values of FFT points in OFDM. During simulation it has been seen that the higher values of FFT gives better performance than lower values, but higher values added complexity in the system as well, so for optimum performance mid range of FFT is sufficient enough.**

Keywords: Time/Frequency Synchronization, Multiple Input Multiple Output (MIMO), OFDM, Bit Error Rate (BER), Inter Carrier Interference(ICI), Cyclic Prefix(CP), MSE, Single Input Single Output(SISO). Median Filtering, FFT.

I. INTRODUCTION

The need for higher data rates has been increasing rapidly in the new generation data transmission systems. The spectrum available is limited and in the multi-carrier system, OFDM, the spectrum is powerfully used. Still, the maximum realizable data rate is limited to a tight upper bound defined by the Shannon-Hartley theorem often referred to as the Shannon's channel capacity theorem. By the means of introduction of the multiple antenna transmission system, which uses spatial multiplexing, the edge is crossed and a incredibly high data rate can be achieved. In OFDM systems and hence in MIMO-OFDM systems the synchronization is a key issue. A small synchronization error would lead to the loss of orthogonality of the subcarriers and therefore the degradation of the system performance. Hence it is important to have a robust synchronization algorithm and to know its effect on the system performance.

The process of synchronization and channel estimation are related to each other. One process could be achieved based on the outcome of the other. As the channel impulse response is observed at the fine management output, it might be used for channel evaluation.

The advancement in wireless and mobile communication has led the researchers to design and implement transceiver with higher data rates using the bandwidth efficiently. The single carrier modulation scheme is not enough to meet the demands of high data rates and higher capacity. To achieve this goal, multicarrier networks such as Frequency Division Multiplexing (FDM) were utilized since 1950's but it was hard to implement those networks. This implementation complexity caused to limit their use for military applications [1] . In a multicarrier system, there are a number of carriers which carry the information in parallel manner. This system is less susceptible to noise and interference especially in wireless environment. Chang [2] was the first who introduced OFDM by further developing and utilizing the Frequency Division Multiplexing (FDM) in 1950.

Orthogonal Frequency Division Multiplexing is a digital Multi-carrier modulation scheme in which a large number of closely spaced orthogonal subcarriers are used to carry the data [3]. The data is divided into several parallel data sequence or channels, one for every subcarrier. Each sub-carrier is modulated with a conventional modulation scheme such as M-ary Phase Shift Keying (M-PSK) or Quadrature Amplitude Modulation (QAM) at a small symbol rate, maintaining all data rates alike to those in a straight single-carrier modulation scheme in the same bandwidth.

II. ARCHITECTURE OF OFDM

This section describes the Tx, Rx and other blocks of OFDM system [4]. The block diagram of OFDM transceiver is shown in the Figure 1.1.

Timing Offset Error

In OFDM, modulation and demodulation are accomplished using IFFT and FFT techniques which cause delay in the structure.

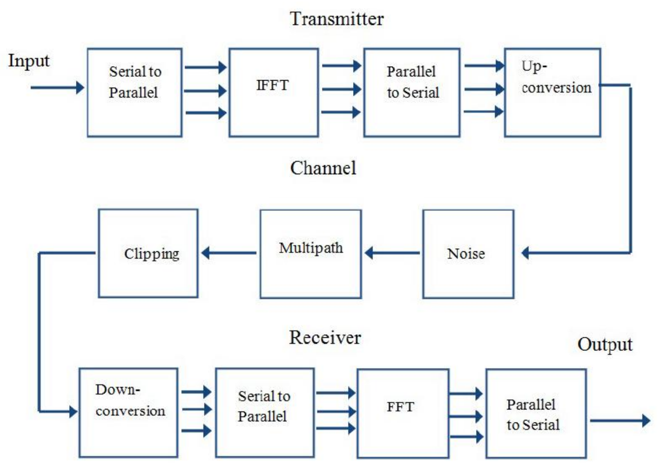

Figure 1.1: Structure of OFDM System

It is significant to discover the start of the OFDM symbol at the receiving end and the error in estimating the beginning of symbol causes the timing offset error. Therefore it is necessary to perform symbol time synchronization to accurately locate the start of the OFDM symbol. If this setback isn't corrected, it causes phase alternation in the constellation.

Carrier Frequency Offset

Carrier Frequency Offset is the amount of offset introduced by the mismatch in the frequency of transmitter and receiver local oscillator (LO), non-linear channels and Doppler shifts [11]. The type of carrier distortion introduced by the non-linearities of the channels is phase noise whereas CFO is the one produced by Doppler Shifts [9]. Synchronization of CFO correction is necessary to avoid loss of orthogonality in sub-carriers.

III. PROPOSED METHODOLOGY

In this section the block diagram of proposed approach has been illustrated which is shown in Fig. 3.1.

In MIMO-OFDM system the data sequence is generated from source of information and then this information is modulated to transmit on analog link in advance systems there is a addition of training sequence which makes system more robust against interference and errors. After this OFDM modulation is performed and signal is then transmitted over channel.

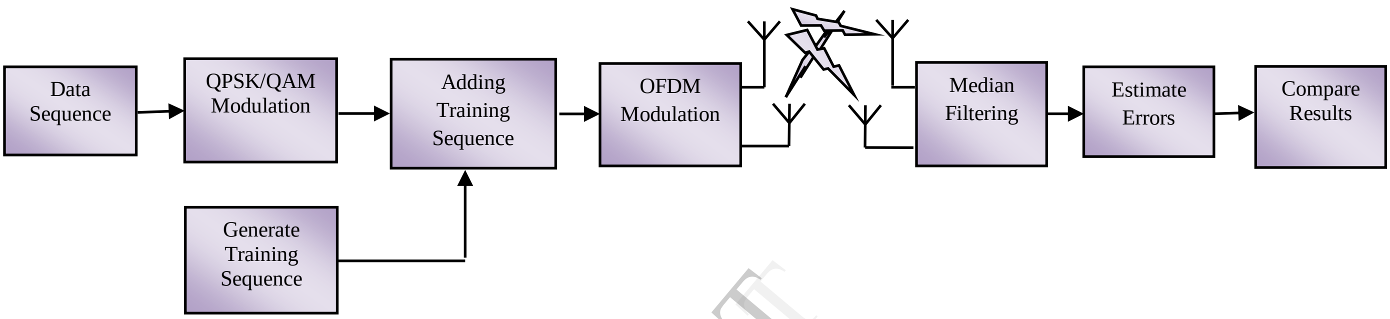

Fig. 3.1 Block Diagram of Time/Freq. Synchronization for MIMO-OFDM

During signal transmission through wireless channel, signal encountered with lots of noises and interferences, and signal is received with these unwanted signals. This causes the lower synchronization quality in time as well as in frequency offset. To reduce the effect of these signals median filtering will help a lot. After that estimation of errors will be done.

The execution of simulation procedure for time and frequency is visualized using flow chart shown in Fig. 3.2 and 3.3. In Fig. 3.2 flow chart of timing synchronization is shown. First step for simulation is to initialize the variables to create the practical like environment.

Now data signal is generated to transmit the data sequence to make signal more robust QPSK modulation is applied to signal and signal is passed through OFDM system and then MIMO channel architecture. The signal added with noises considering AWGN channel all these applied in timing synchronization after reception of noisy signal median filtering is applied to reduce the effect of noises and interferences. Then time synchronization algorithm is applied to the signal. After these estimation of errors are done and results are displayed.

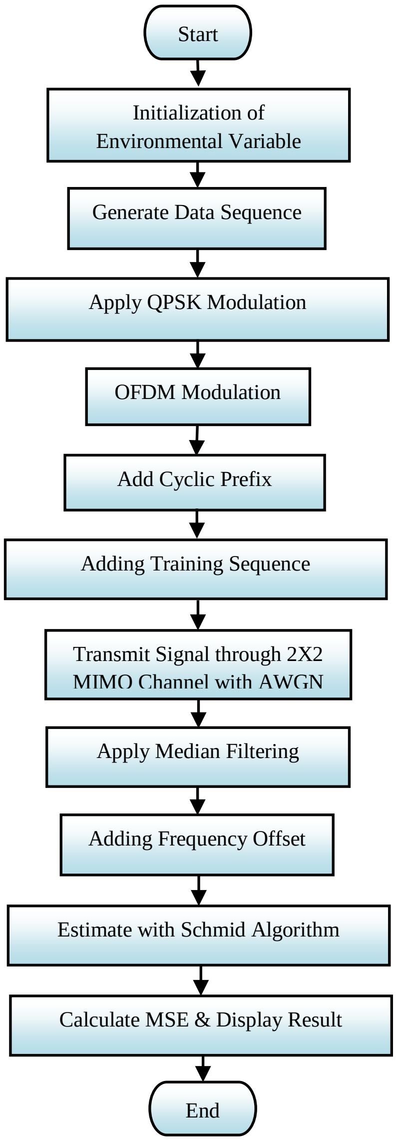

Fig. 3.2 Timing Synchronization in MIMO-OFDM

The signal added with noises considering AWGN channel all these applied in frequency synchronization after reception of noisy signal median filtering is applied to reduce the effect of noises and interferences. After these calculation of estimation of errors are done and results are displayed.

In Fig. 3.3 flow chart of frequency synchronization is shown. First step for simulation is to initialize the variables to create the practical like environment. Now data signal is generated to transmit the data sequence to make signal more robust QAM modulation is applied to signal and signal is passed through OFDM system and then MIMO channel architecture.

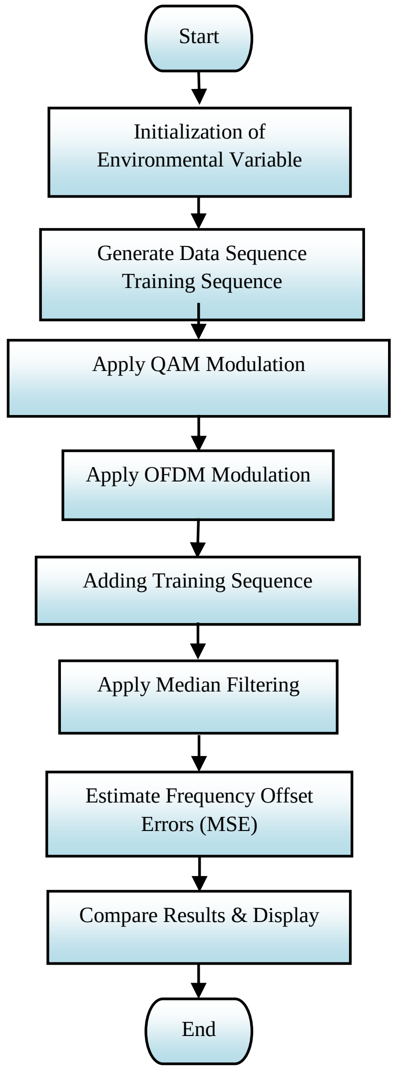

Fig.3.3 Frequency Synchronization in MIMO-OFDM

IV. SIMULATION RESULTS

Simulation results have been performed on MATLAB (R2010a) v7.10. The simulation environment created with help of parameters of the system. The system is simulated various times to get the average values of the results.

Time and frequency are two important aspects in any communication system that should be synchronized for the optimum performance of the communication system. Our simulation is concerned about the MIMO-OFDM system which is a very promising technology in the evolution if modern communication system. Our proposed approach says that when the synchronization of time or frequency is performed on MIMO-OFDM system we check the performance of the system by calculating the mean square error (MSE), because the nature of the channel in system is variable all the time which is not estimated once so for such scenarios we iterate simulation several times to consider possible changes in system and then we calculate the mean values of the calculated of the square of error that is called MSE. Then to enhance the performance of the system

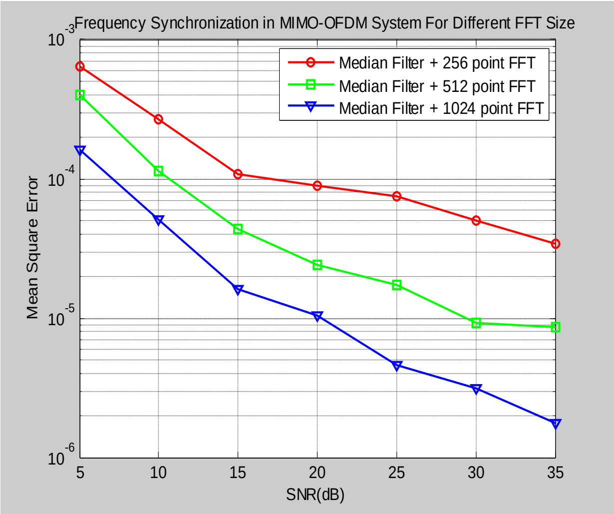

Fig. 5.1 Frequency Synchronization in MIMO-OFDM System with Median Filtering and variable FFT points.

During simulation we can see that the when we vary the FFT sizes the results also vary. And the performance of the system increases when FFT sizes increases, decreases when FFT size decreases. All the simulation performance has been shown in below figures.

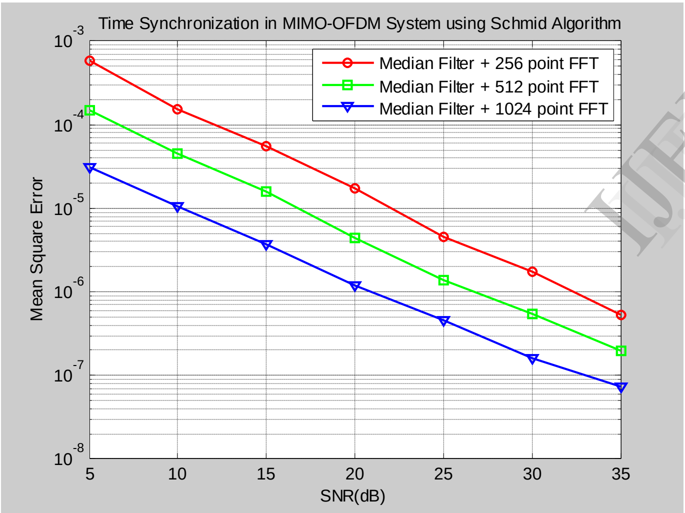

Fig. 5.2 Time Synchronization in MIMO-OFDM System with Median Filtering and variable FFT points.

In Fig. 5.1 frequency synchronization is in MIMO-OFDM system. As it is clear from the curves that when we apply median filtering in MIMO-OFDM system the frequency synchronization is better in addition with different FFT sizes and it is added advantage with median filtering which enhances the performance with increase in FFT sizes.

In deeper analysis context the more the FFT sizes, better the performance of the system. Further in time synchronization the proposed methodology also works in similar manner. In Fig. 5.2 Time synchronization in MIMO-OFDM system has been shown. The simulation results says that the proposed methodology work finer than in frequency synchronization. Increments in the FFT points drastically improve the performance of the time estimation in the OFDM system.

V. CONCLUSION & FUTURE SCOPES

This paper proposed a methodology which utilizes the median filtering before estimation of time or frequency offset in addition of training sequence which enhances the performance of MIMO-OFDM system . Here another parameter that is increase in the FFT make time/frequency synchronization more effective as shown in the simulation results. After comparison with existing methodologies, the proposed method not only has enhanced timing and frequency offset estimation, but also the time/frequency synchronization range is larger, that is important practical importance. In future of this technology improve with the improvement in technology and algorithms of estimation and channel characterisation architectures.

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