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923 – 927

Performance Analysis of a signal by removing ICI using Kalman Filter for OFDM Channel

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Abstract- The OFDM communication is very much inspired from the channel frequencies over the network. In such network some kind of orthogonal distortion occur over the channel called Inter carrier Interference. Here we will improve the ICI using Kalman Filtering improved by using repetitive slot and correlated channel tap. The Kalman Filter is been improved by implementing the two stage kalman filter. In first stage the Kalman based statistical analysis is performed to estimate the PAPR and the respective Phase variated PAPR reduction is performed. In second stage the ICI reduction is performed by implementing the Kalman filter based carrirer offset values.
The proposed work of this paper is when data travel over some channel it suffers from the problem of interference. The interference results the high signal to noise ratio as well as high bit error rate. The proposed system will improved the signal by removing the different kind of impurities over the signal. These impurities includes the ICI, PAPR and the noise over the signal. The signal will be more effective than standard OFDM. So we needn't many pilot symbols in practice, still can ensure the algorithm performance and reduce the time- delay and complexity of this algorithm.

Keywords-- Inter Channel Interference, Kalaman Filter, ANN, MIMO, OFDM, PAPR techniques.

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I. INTRODUCTION

Orthogonal frequency division multiplexing (OFDM) is a multicarrier modulation MCM) technique which seems to be an attractive candidate for fourth generation (4G) wireless communication systems. OFDM offer high spectral efficiency, immune to the multipath delay, low inter-symbol interference (ISI), immunity to frequency selective fading and high power efficiency. Due to these merits OFDM is chosen as high data rate communication systems such as Digital Video Broadcasting (DVB) and based mobile worldwide interoperability for microwave access (mobile Wi-MAX). However OFDM system suffers from serious problem of high PAPR. In OFDM system output is superposition of multiple sub-carriers. In this case some instantaneous power output might increase greatly and become far higher than the mean power of system. To transmit signals with such high PAPR, it requires power amplifiers with very high power scope. These kinds of amplifiers are very expensive and have low efficiency-cost. If the peak power is too high, it could be out of the scope of the linear power amplifier. This gives rise to non-linear distortion which changes the superposition of the signal spectrum resulting in performance degradation. If no measure is taken to reduce the high PAPR, MIMO-OFDM system could face serious restriction for practical applications. PAPR can be described by its complementary cumulative distribution function (CCDF). In this probabilistic approach certain schemes have been proposed by researchers. These include clipping, coding and signal scrambling techniques. Under the heading of signal scrambling techniques there are two schemes included.

OFDM represents a different system design approach. It can be thought of as a combination of modulation and multiple-access schemes that segments a communications channel in such a way that many users can share it. Whereas TDMA segments are according to time and CDMA segments are according to spreading codes, OFDM segments are according to frequency. It is a technique that divides the spectrum into a number of equally spaced tones and carries a portion of a user's information on each tone. A tone can be thought of as a frequency, much in the same way that each key on a piano represents a unique frequency. OFDM can be viewed as a form of frequency division multiplexing (FDM), however, OFDM has an important special property that each tone is orthogonal with every other tone. FDM typically requires there to be frequency guard bands between the frequencies so that they do not interfere with each other. OFDM allows the spectrum of each tone to overlap, and because they are orthogonal, they do not interfere with each other. By allowing the tones to overlap, the overall amount of spectrum required is reduced.

OFDM is a modulation technique in that it enables user data to be modulated onto the tones. The information is modulated onto a tone by adjusting the tone's phase, amplitude, or both. In the most basic form, a tone may be present or disabled to indicate a one or zero bit of information; however, either phase shift keying (PSK) or quadrature amplitude modulation (QAM) is typically employed. An OFDM system takes a data stream and splits it into N parallel data streams, each at a rate 1/N of the original rate. Each stream is then mapped to a tone at a unique frequency and combined together using the inverse fast fourier transform (IFFT) to yield the time domain waveform to be transmitted.

II CHANNEL MODELING IN MIMO SYSTEM

In wireless communication especially in MIMO system the channel modeling is the key area and needs great effort. The main objective of MIMO technology is to increase capacity which is depending on decorrelation properties between antennas and the full rankness of the channel matrix. To fully understand channel behaviour and then we extract formula which represents the channel and to determine the impact of the propagation parameters on the capacity of the channel.

Good channel modeling clearly put the following points:

It is exactly put the capacity of outdoor and indoor MIMO channel.

Identifies the important parameters governing capacity.

Put very simplify conditions to get full rank.

In MIMO systems, a transmitter sends multiple streams by multiple transmit antennas. The transmit streams go through a matrix channel which consists of multiple paths between multiple transmit antennas at the transmitter and multiple receive antennas at the receiver. Then, the receiver gets the received signal vectors by the multiple receive antennas and decodes the received signal vectors into the original information. Here MIMO system model:

$$Y = HX + G \qquad (1)$$

Where **Y** and X are receive and transmit vectors, H and G are the channel matrix and noise vector, respectively.

A 3×3 channel matrix is given by:

$$H = \begin{pmatrix} h_{11} & h_{12} & h_{13} \\ h_{21} & h_{22} & h_{23} \\ h_{31} & h_{32} & h_{33} \end{pmatrix}$$

III OFDM SYSTEM MODEL :

A baseband OFDM signal can be represented by [1]

$$b(t) = \sum_{i=1}^{N-1} A_i \cos(\omega_i t + \phi_i)$$

Where A_i is the amplitude, $w_i = 2\pi f_i$ is the angular frequency, ϕ_i is the phase of the i^{th} sub-carrier, and N is the number of sub-carriers. According to the modulation technique to be used, either A or ϕ is determined by the data. Now, the baseband OFDM signal b(t) is modulated next, onto a RF carrier with frequency f_c :

$$s(t) = 2b(t)\cos\omega_c t$$
$$= 2\sum_{i=o}^{N-1} A_i \cos(\omega_i t + \phi_i)\cos\omega_c$$
$$= \sum_{i=0}^{N-1} A_i \left\{\cos\left[(\omega_c + \omega_i)t + \phi_i\right] + \cos\left[(\omega_c - \omega_i)t - \phi_i\right]\right\}$$

where $w_c = 2\pi fc$, and we assume the phase of the carrier to be zero for simplicity. Since a single side band transmission is enough to carry the information in Ai or ϕ_i , it is assumed that the upper sideband is used, and therefore the transmitted signal can be represented as

$$s(t) = \sum_{i=0}^{N-1} A_i \cos\left[(\omega_c + \omega_i)t + \phi_i\right]$$

In this section the theoretical analysis of the effects of frequency errors is presented. The maximum Doppler shift occurs when the two mobile nodes move toward each other, given by [6]

ISSN: 2321-8169
923 – 927

$$f_d = \frac{vf_c}{c}$$

Where v is the relative speed of the two nodes, f_c is the carrier frequency and c is the speed of light (3 X 10^8 ms) .An OFDM signal consists of numerous sub-carriers with different frequencies. The amount of Doppler shift affecting the i_{th} sub-carrier is given by [7]

$$(f_c \pm f_i) \longrightarrow$$

$$(1+\xi)(f_c \pm f_i)$$

where ξ is the percentage of the change in frequency and is determined by

$$\xi = \frac{f_d}{f} = \frac{v}{c}\cos\theta$$

The right-hand side of Equation 3.5 can be written as

$$(1+\xi)(f_c \pm f_i) = (1+\xi)f_c \pm (1+\xi)f_i$$

Which demonstrates that the Doppler frequency shift affects the carrier frequency and the sub-carrier frequencies by the same percentage ξ . The Doppler shift of the carrier frequency can be calculated as

$$f_{dc} = \frac{vf_c}{c}\cos\theta$$

and the Doppler shift of the sub-carrier frequencies as

$$f_{di} = \frac{vf_i}{c}\cos\theta$$

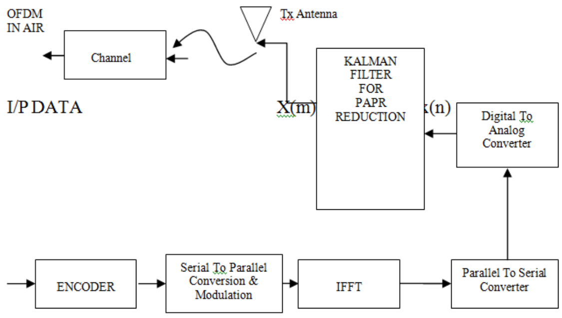
By using Equation again, the transmitted OFDM signal with Doppler shift can be written as

$$s(t) = \sum_{i=0}^{N-1} A_i \cos\left[(1+\xi)(\omega_c+\omega_i)t+\phi_i\right]$$
$$= \sum_{i=0}^{N-1}\left\{A_i\cos\left[(1+\xi)\omega_i t+\phi_i\right]\cos\left[(1+\xi)\omega_c t\right] - A_i\sin\left[(1+\xi)\omega_i t+\phi_i\right]\sin\left[(1+\xi)\omega_c t\right]\right\}$$

In Equation, A_i cos [(1+ξ) w_i t + ϕ_i] can be thought of as the envelope of the carrier, cos [(1+ξ) w_c t] , which helps to demonstrate that the Doppler shift affects the envelope and the carrier frequency by the same percentage The Doppler shift also affects the symbol rate and the time synchronization.

Design Of An OFDM System :

The design of an OFDM system requires a trade-off between various parameters as like in all communication system design. Usually, the input parameters to the design are the bit rate, available bandwidth and the maximum delay spread introduced by the channel. The design involves calculation of symbol duration, guard time, number of sub-carriers and the modulation and coding schemes among others.



Block Diagram of OFDM Transmitter

Fig. 1 Block Diagram of OFDM Transmitter

Bandwidth

Occupied bandwidth is of course directly related to the data rate to transmit. However, the question is, what is the minimum bandwidth to take in order to obtain enough diversity and avoid the loss off the entire signal in frequency selective fading environments. On the other hand much bandwidth means also much transmitting power. There is a tradeoff between bandwidth and transmitted power.

Channel simulations and field test trials find that optimal bandwidth. In DAB, for example, a bandwidth of 1,5 MHz is a good compromise for the type of propagation conditions that apply.

Guard Time and Symbol Duration :

The tradeoff of guard interval is to set it large enough to avoid inter symbol interference depending on the memory of channel and transmitter position spacing in a single frequency network. On the other hand, we want it to be as

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923 – 927

small as possible as it carries no information and can be seen as a spoil of bandwidth.

In wireless systems, a guard interval of 25% of symbol period is often met and seems to be a good compromise. That is the value taken for DAB, it allows a maximum distance of about 80 kilometers between transmitters.

As said previously, the guard time is made longer than the maximum delay spread introduced by the channel. But the guard time cannot be made very large since no information bits are transmitted during the guard time. As a rule of thumb, the guard time should be atleast 2-4 times the root-mean-squared delay spread.

The symbol duration must be fixed in such a way that the overhead associated with the guard time is minimal. This can be achieved by making the symbol duration much longer than the guard time. However large symbol duration means more number of sub-carriers and thus causes implementation complexities and increased peak-to-average power problems. Thus a practical design choice for the symbol duration is around 5-6 times the guard time.

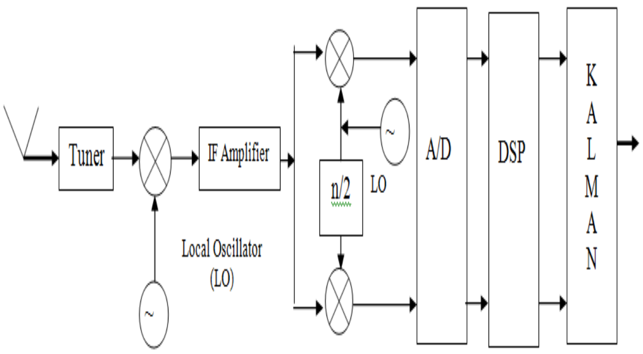

Fig. 2 Block Diagram of OFDM Receiver

IV. KALMAN FILTER

Kalman filter is basically designed as a generalized solution to the common problem. It is about to estimate the state of discrete time controlled process by using the basic concept of differential equations. The basic equation followed by Kalman Filter is given as Indeed the final estimation algorithm

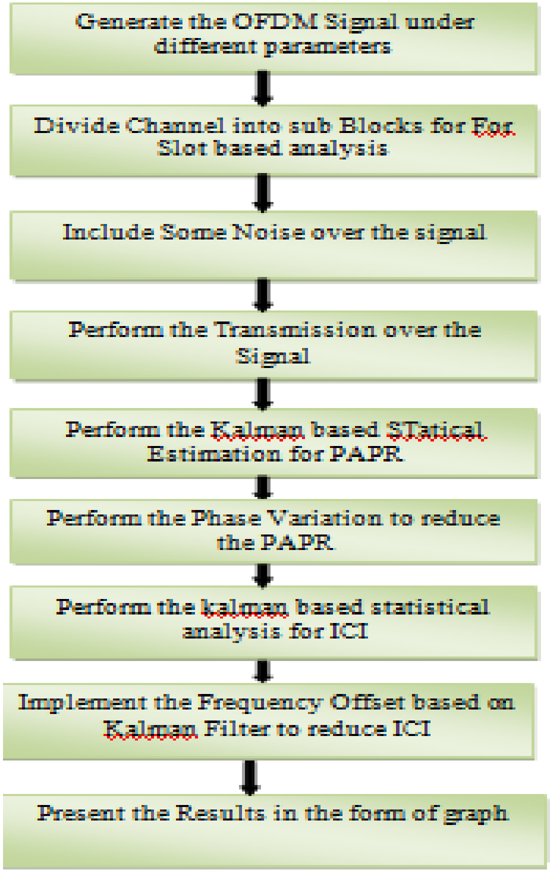

Fig. 3 Flow chart of Proposed Work

V. SIMULATION RESULTS

In this section, we verify the theory by simulation and we Test the performance of the iterative algorithm.

In figure, comparative analysis of PAPR reduction is shown using Kalman Filter. In this work we have implemented a two stage Kalman Filter. The first stage is about to reduce the PAPR. The results shows that the presented approach is more effective with less SNR over the signal.

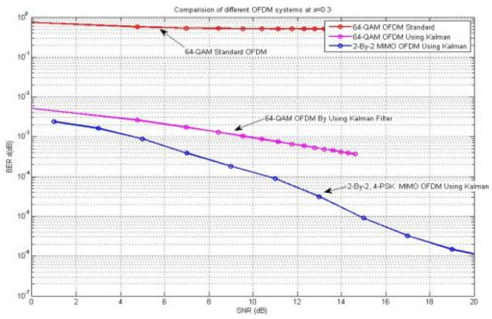

Fig. 4 Comparison graph of OFDM Techniques

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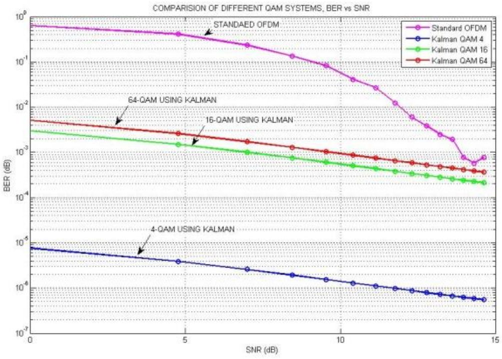

Fig. 5 Simulation Results of OFDM Technuques

VI. CONCLUSION

In this project, the performance of OFDM systems in the presence of frequency offset between the transmitter and the receiver has been studied in terms of the Carrier-to-Interference ratio (CIR) and the bit error rate (BER) performance. Inter-carrier interference (ICI), which results from the frequency offset, degrades the performance of the OFDM system.

One method is explored in this project for mitigation of the ICI i.e. ICI self-cancellation (SC). By using this method the BER is improved in comparison to simple OFDM system.

In this project, the simulations were performed in an AWGN channel. This model can be easily adapted to a flat-fading channel with perfect channel estimation. Performing simulations to investigate the performance of this ICI cancellation schemes in multipath fading channels without perfect channel information at the receiver can do further work.

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