Statistical Analysis Approach to Reduce Inter Channel Interference by using Kalaman Filter in term of BER & SNR

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Abstract**—** *Many wireless networks have adapted the same communication approach. The OFDM communication is very much inspired from the channel frequencies over the network. In such a network some kind of orthogonal distortion occurs over the channel called Inter Carrier Interference. In this work, we are presenting the concept of mathematical model called Kalman filter to analyze the signal interference and to resolve the problem. In first phase the signal is analyzed for the disruption using Kalman filter and adaptive filter is implemented to reduce the ICI over the signal. The mathematical analysis is performed by using Extended Kalman filter. The result analysis has been performed with respect to BER and the SNR. A novel spatial Kalman filtering scheme is proposed as the second stage to successively cancel the ICI. Simulation results show the effectiveness of the proposed two-stage method and its robustness to channel estimation uncertainties that may arise in practical systems.*

Keywords**— *Decision-feedback equalization, digital communications receiver, frequency selective time-varying fading channel, interference suppression, iteration detection, Kalman filter.***

I. INTRODUCTION

Orthogonal frequency division multiplexing (OFDM) is a multicarrier modulation (MCM) technique which seems to be an attractive choice for fourth generation (4G) wireless communication systems. OFDM offers high spectral efficiency, immunity 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 in 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 may increase to a large extent and may become far higher than the mean power of the 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. If the peak power is too high, it could be out of the scope of the linear power amplifiers. This gives rise to nonlinear 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 in 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 we have included two schemes included [1],[2].

The OFDM has many advantages such as high bandwidth efficiency, robustness to the selective fading problem, use of small guard interval, and its ability to combat the ISI problem. So, simple channel equalization is needed instead of complex adaptive channel equalization. Apart from various advantages of OFDM, there are certain disadvantages also. The frequency offset of the sub-carriers and the high PAPR are the major drawbacks of OFDM [3].

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. BENEFITS OF OFDM

Orthogonal FDM's (OFDM) spread spectrum technique distributes the data over a large number of carriers that are spaced apart at precise frequencies. This spacing provides the "orthogonality" in this technique which prevents the demodulators from seeing frequencies other than their own. The major benefits of OFDM system are

- High spectral efficiency
- Resiliency to RF interference
- Lower multi-path distortion

OFDM is sometimes called multi-carrier or discrete multi-tone modulation. It is the modulation technique used for digital TV in Europe, Japan and Australia. The major uses of OFDM system are:

- Wireless Local Area Networks development is ongoing for wireless point-to-point and point-to-multipoint configurations using OFDM technology.
- In a supplement to the IEEE 802.11 standard, the IEEE 802.11 working group published IEEE 802.11a, which outlines the use of OFDM in the 5.8-GHz band.
- DAB - OFDM forms the basis for the Digital Audio Broadcasting (DAB) standard in the European market.

OFDM, or multitone modulation is presently used in a number of commercial wired and wireless applications. On the wired side, it is used or a variant of digital subscriber line (DSL). For wireless, OFDM is the basis for several television and radio broadcast applications, including the European digital broadcast television standard, as well as digital radio in North America. OFDM is also used in several fixed wireless systems and wireless local-area network (LAN) products. A system based on OFDM has been developed to deliver mobile broadband data service at data rates comparable to those of wired services, such as DSL and cable modems.

III. SYNCHRONIZATION IN OFDM SYSTEMS

When the modulated signal is received, it has propagated a distance which is unknown to the receiver. This means, that three parameters are all unknown; the phase of the carrier, the phase of the sample clock, and start time of the transmitted signal.

Synchronization has to be done before demodulation at OFDM receiver. It is a complex and extensive field, and is made possible by introducing a marker or synchronizing sequence at the transmitter. Here an overview of two synchronization problems; carrier frequency and symbol or time synchronization is given.

3.1 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

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

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

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

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]

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

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]

$$\left(f_c \pm f_i\right) \longrightarrow \left(1+\xi\right)\left(f_c \pm f_i\right)$$

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 below Equation can be written as

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

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

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

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.

3.2 Carrier Synchronization in OFDM System using Kalaman Filter

Due to the carrier frequency difference Δf of the transmitter and receiver, each received sample at time t has an unknown phase factor given as $e^{j2\pi\Delta ft}$. Carrier frequency offset in OFDM system causes the loss of orthogonality of the sub-carriers (ICI), reduction of signal amplitude (the sinc function is shifted and no longer sampled at the peak), and degrades the performance of the system. Thus, the unknown phase factor must be estimated and compensated for each sample before the FFT process.

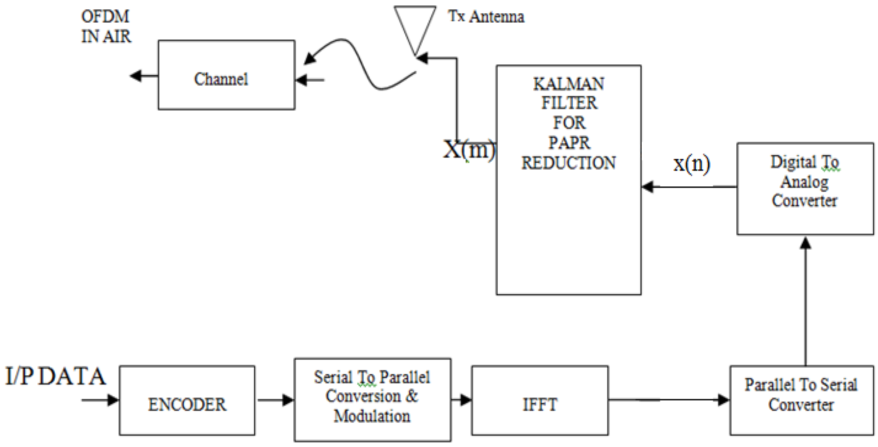

FIGURE 1: Block Diagram of OFDM Transmitter

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 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.

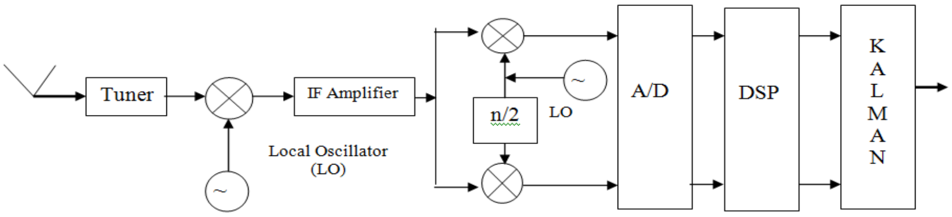

FIGURE. 2: Block Diagram of OFDM Receiver

IV. 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.

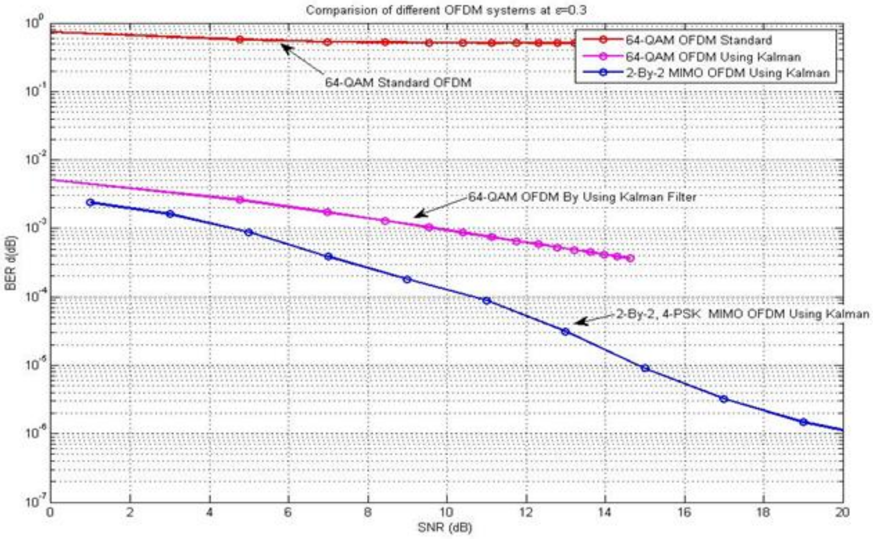

FIGURE 3: Comparison graph of OFDM Techniques

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 include the ICI, PAPR and the noise over the signal. The signal will be more effective than standard OFDM.

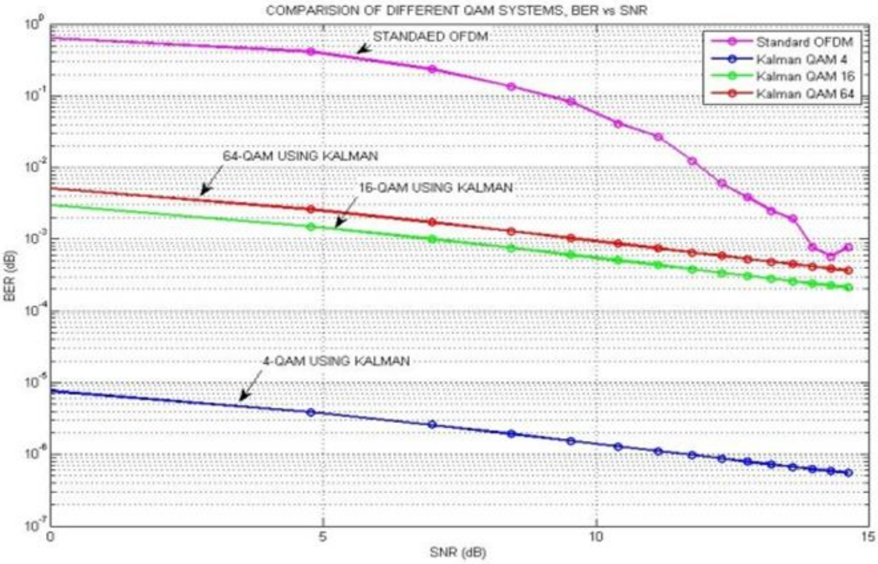

FIGURE 4: Simulation Results of OFDM Technuques

V. 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.

REFERENCES

[1] H. Hijazi and L. Ros, “ Time-varying channel complex gains estimation and ICI suppression in OFDM systems” in *IEEE GLOBAL COMMUNICATIONS Conf.*, Washington, USA, Nov. 2007.

[2] H. Hijazi and L. Ros, “ Polynomial estimation of time-varying multipath gains with intercarrier interference mitigation in OFDM systems” in *IEEE Trans. Vehic. Techno.*, vol. 57, no. 6, November 2008.

[3] A. R. S. Bahai and B. R. Saltzberg, *Multi-Carrier Dications: Theory and Applications of OFDM:* Kluwer Academic/Plenum, 1999.

[4] M. Hsieh and C. Wei, “Channel estimation for OFDM systems based on comb-type pilot arrangement in frequency selective fading channels” in *IEEE Trans. Consumer Electron.*, vol.44, no. 1, Feb. 1998.

[5] Z. Tang, R. C. Cannizzaro, G. Leus and P. Banelli, “Pilot-assisted timevarying channel estimation for OFDM systems” in *IEEE Trans. Signal Process.*, vol. 55, pp. 2226-2238, May 2007.

[6] S. Tomasin, A. Gorokhov, H. Yang and J.-P. Linnartz, “Iterative interference cancellation and channel estimation for mobile OFDM” in *IEEE Trans. Wireless Commun.*, vol. 4, no. 1, pp. 238-245, Jan. 2005.

[7] B. Yang, K. B. Letaief, R. S. Cheng and Z. Cao, “Channel estimation for OFDM transmisson in mutipath fading channels based on parametric channel modeling” in *IEEE Trans. Commun.*, vol. 49, no. 3, pp. 467-479, March 2001.

[8] E. Anderson and Z. Bai, *LAPACK User’s Guide: Third Edition,*SIAM, Philadelphia, 1999.

[9] Wikipedia contributors,“Linear regression”, Wikipedia, The Free Encyclopedia.

[10] K. E. Baddour and N. C. Beaulieu, “Autoregressive modeling for fading channel simulation” in *IEEE Trans. Wireless Commun.*, vol. 4, no. 4, pp. 1650-1662, July 2005.

[11] B. Anderson and J. B. Moore, *Optimal filtering,* Prentice-Hall, 1979.

[12] W. C. Jakes, Microwave Mobile Communications. Piscataway, NJ: IEEE Press, 1983.