PROMINENT PUBLICATION HOUSE

A survey of ISI & PAPR reduction techniques in OFDM

[1]Ms.Swarnita Gorakshnath Kale,[2] Prof.Manoj Kumar
[1]Student, SVCET,Rajuri,Pune
[2]Head of E & TC Department
[1]Email: kalesg@amrutpoly.in
[2]Email: manoj1985.111@gmail.com

ABSTRACT:-
Orthogonal frequency-division multiplexing (OFDM) effectively mitigates inter symbol interference (ISI) caused by the delay unfold of wireless channels. The rise within the range of wireless devices and also the demand for higher information rates places an increasing demand on information measure. This necessitates the requirement for communication systems with redoubled turnout and capability. Multiple input multiple output orthogonal frequency division multiplexing (MIMO-OFDM) is a way to satisfy this would like. OFDM is employed in several wireless communication devices and offers high spectral potency and resilience to multipath channel effects. Therefore, it's been utilized in several wireless systems and adopted by varied standards. During this paper, we tend to gift a comprehensive survey on OFDM for wireless communications techniques for receiver planning as references. In telecommunications, orthogonal frequency- division multiplexing (OFDM) is a method of encoding digital data on multiple carrier frequencies. OFDM has developed into a popular scheme for wideband digital communication, used in applications such as digital television and audio broadcasting, DSL internet access, wireless networks, power line networks, and 4G mobile communications. The main advantage of OFDM over single-carrier schemes is its ability to cope with severe channel conditions (for example, attenuation of high frequencies in a long copper wire, narrowband interference and frequency-selective fading due to multipath) without complex equalization filters. Channel equalization is simplified because OFDM may be viewed as using many slowly modulated narrowband signals rather than one rapidly modulated wideband signal. The low symbol rate makes the use of a guard interval between symbols affordable, making it possible to eliminate inter symbol interference (ISI) and use echoes and time-spreading (in analog television visible as ghosting and blurring, respectively) to achieve a diversity gain, i.e. a signal-to- noise ratio improvement.

Keywords- Channel estimation, frequency-offset estimation, inter carrier interference (ICI), multicarrier (MC), multiple input–multiple-output (MIMO) orthogonal frequency-division multiplexing (OFDM), peak-to-average power reduction, and time offset estimation

I. INTRODUCTION

The ever-increasing demand for terribly high rate wireless knowledge transmission necessitates technologies that build use of the offered magnetism resource within the most intelligent method. Key objectives area unit spectrum potency (bits per second per Hertz), hardiness against multipath propagation, range, power consumption and implementation complexness. These objectives area unit usually conflicting, thus techniques and implementations area unit wanted which provide the most effective doable trade off between them. The net revolution has created the requirement for wireless technologies which will deliver knowledge at high speeds in a very spectrally economical manner. However, supporting such high knowledge rates with decent hardiness to radio channel impairments needs careful choice of modulation techniques. Currently, the foremost appropriate alternative seems to be OFDM (Orthogonal Frequency Division Multiplexing) [15]. One in all the most reasons to use OFDM is to extend the hardiness against frequency selective attenuation or narrowband interference. in a very single carrier system, one fade or interferer will cause the whole link to fail, however in a very multicarrier system, solely a little share of the subcarriers is going to be affected. Error correction committal to writing will then be wont to correct for the few inaccurate subcarriers. The idea of victimization parallel knowledge transmission and frequency division multiplexing was revealed within the mid-1960s. OFDM may be a special case of multi-carrier modulation. Multi-carrier modulation is that the idea of rending a proof into variety of signals, modulating every of those new signals to many frequency channels, and mixing the info received on the multiple channels at the receiver. In OFDM, the multiple frequency channels, referred to as sub-carriers, area unit orthogonal to every alternative. Orthogonal frequency division multiplexing (OFDM) may be a multicarrier multiplexing technique, wherever knowledge is transmitted through many parallel frequency sub channels at a lower rate. It’s been popularly standardized in several wireless applications like Digital Video Broadcasting (DVB), Digital Audio Broadcasting (DAB), High Performance Wireless native space Network (HIPERLAN), IEEE 802.11 (Wi-Fi), and IEEE 802.16 (WiMAX). It’s conjointly been used for wired applications as within the Asynchronous Digital connexons (ADSL) and power-line communications. OFDM requires very accurate frequency synchronization between the receiver and the transmitter; with frequency deviation the sub-carriers will no longer be orthogonal, causing inter- carrier interference (ICI).

Guard interval for elimination of intersymbol interference One key principle of OFDM is that since low symbol rate modulation schemes (i.e., where the symbols are relatively long compared to the channel time characteristics) suffer less from inter symbol interference caused by multipath propagation, it is advantageous to transmit a number of low- rate streams in parallel instead of a single high-rate stream. Since the duration of each symbol is long, it is feasible to insert a guard interval between the OFDM symbols, thus eliminating the inter symbol interference.

The guard interval also eliminates the need for a pulse- shaping filter, and it reduces the sensitivity to time synchronization problems. A simple example: If one sends a million symbols per second using conventional single- carrier modulation over a wireless channel, then the duration of each symbol would be one microsecond or less. This imposes severe constraints on synchronization and necessitates the removal of multipath interference. If the same million symbols per second are spread among one thousand sub-channels, the duration of each symbol can be longer by a factor of a thousand (i.e., one millisecond) for orthogonality with approximately the same bandwidth. Assume that a guard interval of 1/8 of the symbol length is inserted between each symbol. Inter symbol interference can be avoided if the multipath time-spreading (the time between the reception of the first and the last echo) is shorter than the guard interval (i.e., 125 microseconds). This corresponds to a maximum difference of 37.5 kilometers between the lengths of the paths. The cyclic prefix, which is transmitted during the guard interval, consists of the end of the OFDM symbol copied into the guard interval, and the guard interval is transmitted followed by the OFDM symbol. The reason that the guard interval consists of a copy of the end of the OFDM symbol is so that the receiver will integrate over an integer number of sinusoid cycles for each of the multipath when it performs OFDM demodulation with the FFT.

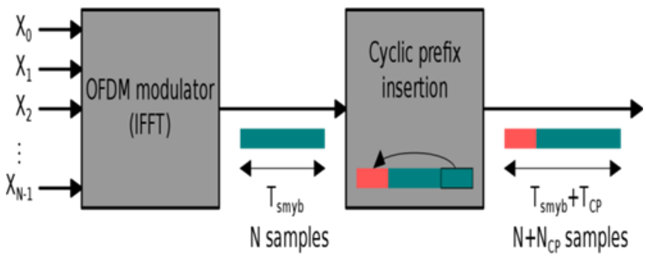

Fig.1 Guard interval for elimination of inter symbol interference

OFDM is used in:

- Digital Audio Broadcasting (DAB)
- Digital television DVB-T/T2 (terrestrial),
- DVB-H (handheld), DMB-T/H, DVB-C2 (cable)
- Wireless LAN IEEE 802.11a, IEEE 802.11g, IEEE 802.11n, IEEE 802.11ac, and IEEE 802.11ad
- WiMAX
- Li-Fi
- ADSL (G.dmt/ITU G.992.1)
- The LTE and LTE Advanced 4G mobile phone standards
- Modern narrow and broadband power line communications

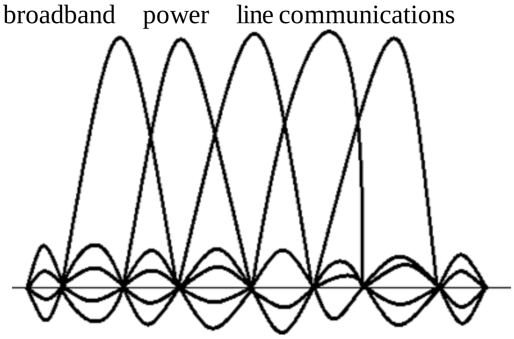

Fig.2 OFDM Spectrum

II Inter Symbol Interference

Inter-Symbol Interference Reduction by Orthogonal Frequency Division Multiplexing

In the digital signal transmission, we use digital pulse which is rectangular and assume that the transmission channel is linear and distortions. Much, the canals cause a limited bandwidth, and hence transmitted pulses tend to be “spread” during transmission. This pulse spreading or dispersion causes overlap of pulses into adjacent time slots as indicated in image. The signal overlaps may result in an error at the recipient. This phenomenon of pulse overlaps and the consequent difficulty of discriminating between symbols at the receiver is termed ISI [3].

.

PROMINENT PUBLICATION HOUSE

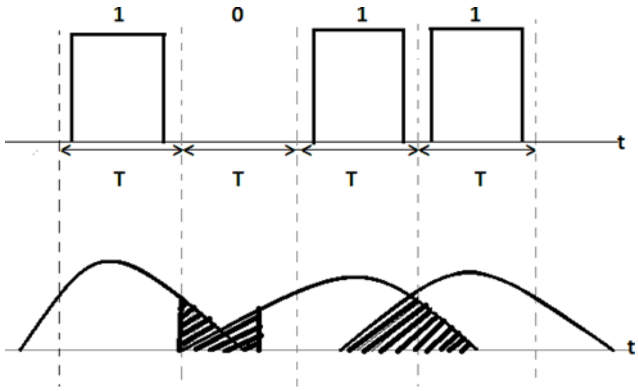

Fig. 3 Inter symbol Interference in digital Transmission

Effect of Inter Symbol Interference

In the absence of ISI and noise, the transmitted bit can be decoded correctly at the recipient [13]. The presence of ISI will introduce errors in the finish at the receiver output. Hence, the recipient can cause an error in determining whether it has received a logic 1 or logic 0.

Protection Against ISI

ISI can be treated effectively in OFDM system by using the 4-QAM technique. ISI effect can be reduced by interesting a

guard interval (cyclic prefix). The cyclic prefix or guard interval is a periodic extension of the final section of an OFDM symbol that is appended to the forepart of the symbol in the transmitter, and is removed at the receiver before demodulation [13]. The cyclic prefix has two significant benefits-

1. The cyclic prefix acts as a guard interval. It eliminates the inter-symbol interference from the previous symbol.
2. It acts as a repetition of the end of the symbol thus allowing the liner convolution of a frequency-selective multipath channel to be modeled as circular convolution which in turn may be transformed to the frequency domain using a discrete Fourier Transform. This approach allows for simple frequency – domain processing such as channel estimation and equalization.

guard interval (cyclic prefix). The cyclic prefix or guard interval is a periodic extension of the final section of an OFDM symbol that is appended to the forepart of the symbol in the transmitter, and is removed at the receiver before demodulation [13]. The cyclic prefix has two significant benefits-

3. The cyclic prefix acts as a guard interval. It eliminates the inter-symbol interference from the previous symbol.
4. It acts as a repetition of the end of the symbol thus allowing the liner convolution of a frequency-selective multipath channel to be modeled as circular convolution which in turn may be transformed to the frequency domain using a discrete Fourier Transform. This approach allows for simple frequency – domain processing such as channel estimation and equalization.

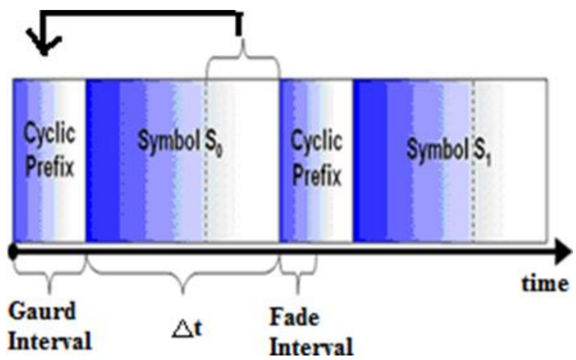

Fig.4 Cyclic Prefix

III MIMO-OFDM

The main motivation for using OFDM in a MIMO channel is the fact that OFDM modulation turns a frequency- selective MIMO channel into a set of parallel frequency-at MIMO channels. This renders multi-channel equalization particularly simple, since for each OFDM-tone only a constant matrix has to be inverted

in a MIMO-OFDM system with N subcarriers (or tones) the individual data streams are passed through OFDM modulators which perform an IFFT on blocks of length N followed by a parallel-to-serial conversion. A cyclic prefix (CP) of length Lcp L containing a copy of the last Lcp samples of the parallel-to-serial converted output of the N-point IFFT is then prepended. The resulting OFDM symbols of length N + Lcp are launched simultaneously from the individual transmit antennas. The CP is essentially a guard interval which serves to eliminate interference between OFDM symbols and turns linear convolution into circular convolution such that the channel is diagonalized by the FFT. In the receiver the individual signals are passed through OFDM demodulators which discard the CP and then perform an N-point FFT. The outputs of the OFDM demodulators are finally separated and decoded. For a more detailed discussion of the basic principles of OFDM the interested reader is referred to [6]. The assumption of the length of the CP being greater or equal than the length of the discrete-time baseband channel impulse response (i.e. Lcp) guarantees that the frequency-selective MIMO fading channel indeed decouples into a set of parallel frequency-at MIMO fading channels. Organizing the transmitted data symbols into frequency vectors

$$C_k = \left[c_k^{(0)} \; c_k^{(1)} \; c_k^{(M_T-1)} \right] \quad (k = 0,1,\ldots\ldots,N-1)$$

…..(1)

with C^i_k denoting the data symbol transmitted from the i^{th} antenna on the k^{th} tone, the reconstructed data vector for the k^{th} tone is given by

$$r_k = H\left(e^{j\frac{2\pi k}{N}}\right) c_k + n_k$$

(k=0,1,…….N-1) …..(2)

where nk is complex-valued circularly symmetric additive white Gaussian noise satisfying

IV Pulse Shaping Techniques for Efficient PAPR Reduction in OFDM System

Orthogonal Frequency Division Multiplexing is a multicarrier modulation technique that divides the available spectrum into subcarriers. Each subcarrier is orthogonal to each other [9]. The transmitter model which is used in our proposed pulse shaping technique is shown in Fig.

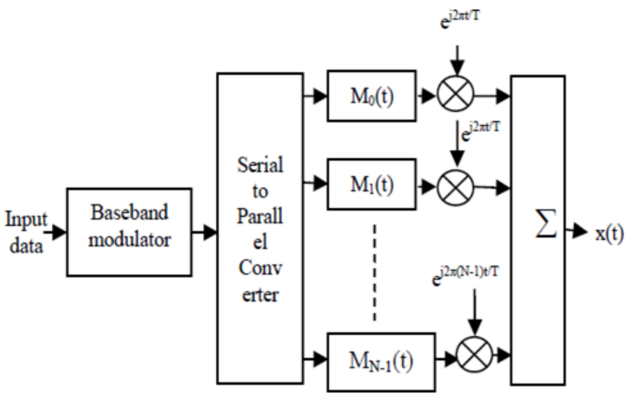

Fig.5 OFDM transmitter Model Using Pulse Shaping

The above figure illustrates the transmitter block diagram of OFDM system with N sub-carrier using pulse shaping technique. Here the incoming data is first modulated in baseband modulator using a bandwidth efficient modulation. The baseband modulated stream, with data rate1/Ts is then split into N parallel streams. Each stream is shaped by a time waveform (pulse shaping waveform) and transmitted over a given subcarrier [10]. However, only one IFFT is used in the transmitter section. Thus, the

$$x(t) = \sum_{k=0}^{N-1} X_p(k) M_k(t) e^{j2\pi k\frac{t}{T}} \qquad where\; pT \le t \le (p+1)T.$$

OFDM transmitted signal can be expressed as

A. Peak-to-Average Power Ratio of OFDM System

One of the major drawbacks of OFDM system is high PAPR which can be defined as the maximum power occurring in the OFDM transmission to the average power of the OFDM transmission [14]. Mathematical representation has been given below

$$PAPR = \frac{P_{peak}}{P_{average}} = \frac{\max |\, x_N(t) \,|^2}{E[|\, x_N(t) \,|^2]}. \quad \text{---------------------(4)}$$

Where, P_{peak} = Peak power of the OFDM system, $P_{average}$ = average power of the OFDM system and

E [⋅] is the expectation operator. Assuming uncorrelated symbols within each OFDM block, the maximum PAPR is obtained as

$$PAPR = \frac{1}{N}\max_{0<=t<=T}\left(\sum_{k=0}^{N-1} | a_k(t) |\right)^2.$$

This is a function of the number of subcarriers N and the pulse shape used at each subcarrier. With large number of subcarriers, the maximum of the PAPR occurs with very low probability.

B. Narrowband Pulse Shaping Techniques

The most commonly used narrowband pulses are Sine, Tukey window and Kaiser Window pulse. We have already derived the mathematical model of two narrowband pulses, Sine and Tukey window, in our previously published work. In this paper the different characteristics of those pulses have been analyzed and compared with the existing system. Here, another narrowband pulse, Kaiser window pulse, has been employed in the transmitter section of OFDM system for reducing the PAPR. The mathematical model of Kaiser window pulse is derived [14].

1) Kaiser Window Pulse

The subcarrier pulse shape which is tested in this section is created through the windowing of a rectangular pulse by the Kaiser window. The time domain Kaiser window shape will be examined and considered for comparisons with previously tested sine pulses. Because Kaiser Window produces similar time domain shapes to the sine pulse, more specific characteristics can be investigated to quantify the difference in performance with sine pulses for PAPR reduction. The following equations are formulated to the shape of the window according to beta which is an arbitrary real number

$$w[n] = \begin{cases} \dfrac{I_0[\pi\beta(1-[\frac{2n}{M}-1]^2)^{1/2}]}{I_0(\pi\beta)}, 0 \le n \le N. \\ 0, otherwise \end{cases}$$

$$for\beta = \begin{cases} 0.1102(A-8.7), \quad A > 50dB \\ 0.5842(\alpha-21)^{0.4} + 0.07886(A-21), \quad 21 \le A \le 50dB. \\ 0(rec\tan gular \quad window), \quad 0 \le A \le 21dB \end{cases}$$

Here, I0 is the zeroth order modified Bessel function of the first kind and M is an integer.

C. Broadband Pulse Shaping Techniques

Broadband pulse shapes are very flexible and can control the correlation between the OFDM block samples without destroying the orthogonality property between the subcarriers of the OFDM modulated signal. Some of broadband pulses named raised cosine and square root raised cosine pulses [14].

1) Raised Cosine Pulse

The raised cosine pulse has been designed such that its shape no longer adheres to rectangular shape with sharp transitions, but rather smoothed decaying transitions which were more practically achievable [14]. The investigation of pulse characteristics will begin with the following time domain equation.

The time domain raised cosine pulse will be used to compare with narrowband pulses.

$$p(t) = \mathrm{sinc}(2wt)\left(\frac{\cos(2\pi\alpha wt)}{1-(4\alpha wt)^2}\right) \quad where \quad T_b = \frac{1}{2w}.$$

2) Square Root Raised Cosine Pulse

The square root raise cosine pulse is a similar pulse that is based on the raised cosine pulse. The frequency response of the square root raised cosine pulse is achieved through the square root of the raised cosine magnitude response in the frequency domain. The equation that specifies the square root raise cosine time domain pulse can be defined by the following expression:

$$p(t)=\begin{cases}1-\alpha+4\dfrac{\alpha}{\pi}, & t=0\\ \dfrac{\alpha}{\sqrt{2}}\left[\left(1+\dfrac{2}{\pi}\right)\sin\left(\dfrac{\pi}{4\alpha}\right)+\left(1-\dfrac{2}{\pi}\right)\cos\left(\dfrac{\pi}{4\alpha}\right)\right], & t=\pm\dfrac{T}{4\alpha}\\ \left[\sin\left(\pi(1-\alpha)\dfrac{t}{T}\right)+4\alpha\dfrac{t}{T}\cos\left(\pi(1+\alpha)\dfrac{t}{T}\right)\right]\Big/\left[\pi\dfrac{t}{T}\left(1-\left(4\alpha\dfrac{t}{T}\right)^2\right)\right] & \\ & for\ \ all\ \ other\ \ t\end{cases} \quad ($$

V CONCLUSION

In this paper, we've in brief represented OFDM for wireless communications. We tend to begin with the essential principle of OFDM and techniques for Inter-Symbol Interference Reduction by Orthogonal Frequency Division Multiplexing, MIMO-OFDM, Pulse Shaping Techniques for Efficient PAPR Reduction in OFDM System.
We also discuss the narrowband & broadband pulse shaping techniques.

REFERENCES

1.Neha pathak, OFDM simulation using MATLB, (IJERT) International Journal of Engineering Research & Technology, Vol. 1 Issue 6, August 2012

2.Mary Ann Ingram and Guillermo Acosta, Smart Antenna Research Laboratory using Matlab, 2000. [E-book] Available: toodoc ebook [Accessed Sep. 23, 2009].

3.Inter symbol Interference Reduction and Bit Error Rate Reduction in Wireless Channels Using Zero Forcing Equalizer Nisha Wadhwa1 , Savita Rangi2 , Dheeraj Rathee3 (Dept. of ECE, FET, Manav Rachna International University, INDIA)

4.Takashahi, T. Saba, "A novel symbol synchronization algorithm with reduced influence of ISI for OFDM systems",2001 Global Telecommunication Conference, Globcom‟01, IEEE, vol.1, pp.524-528, Nov.2001 USA.

5.Dukhyun Kim, Stuber, G.L., "Residual ISI cancellation for OFDM with applications to HDTV broadcasting", IEEE Journals on Communication, vol.16, pp.1590-1599, Oct. 1998

6.Principles of MIMO-OFDM Wireless Systems Helmut Bolcskei Communication Technology Laboratory Swiss Federal Institute of Technology (ETH) Sternwartstrasse 7, CH-8092 Zurich

7."An Investigation of Peak-to-Average Power Reduction in MIMO-OFDM Systems",Wang Yi Gu linfeng Blekinge Institute of Technology October 2009.

8.S. H. Muller, J. B. Huber, "A novel peak power reduction scheme for OFDM," The 8th IEEE International Symposium on Personal, Indoor and Mobile Radio Communications, Feb 1997.

9.Md. Abdullah Al Baki, Mohammad Zavid Parvez "PEAK TO AVERAGE POWER RATIO (PAPR) REDUCTION IN OFDM BASED RADIO SYSTEMS" Electrical Engineering Blekinge Institute of Technology, May 2010.

10. .Krongold, B. S. and D. L. Jones, "PAPR reduction in OFDM via active constellation extension," IEEE Trans. on Broadcasting, Vol. 49, 258–268, Sept. 2003.

11. Eonpyo Hong and Dongsoo Har, "Peak-to-Average Power Ratio Reduction in OFDM Systems Using All- Pass Filters", IEEE Transactions On Broadcasting, Vol. 56, No. 1, March 2010.
Residual ISI Cancellation for OFDM with Applications to HDTV Broadcasting Dukhyun Student Member, IEEE, and Gordon L. Stuber, Senior Member, IEEE

12. Inter-Symbol Interference Reduction by Orthogonal Frequency Division Multiplexing Kratika Rawat, B.Tech Scholar Department of Electronics & Communication Vivekananda Institute Of Technology-East Jaipur, Rajasthan, India & Communication

13. Employment of Pulse Shaping Techniques for Efficient PAPR Reduction in OFDM System Tangina Sultana and Shamim Ara Shawkat Institute of Information and Communication Technology (IICT).

14. Yang, James Ching-Nung (October 10, 2001). "What is OFDM and COFDM?". Shoufeng, Hualien 974, Taiwan:Department of Computer Science and Information Engineering National Dong Hwa University. Retrieved 2017-04-16.

15. J. Lorca, "Cyclic prefix overhead reduction for low- latency wireless communications in OFDM," in IEEE Vehicular Technology Conference (VTC Spring), 2015.

16. E. Guvenkaya, E. Bala, R. Yang and H. Arslan, "Time-asymmetric and subcarrier-specific pulse shaping in OFDM-based waveforms," IEEE Transactions on Vehicular Technology, vol. 64, pp. 5070-5082, 2015.

17. T. H. Pham, Techniques for multi-standard cognitive radios on FPGAs, PhD Thesis, 2015.