ISSN(Online): 2320-9801
ISSN (Print): 2320-9798

International Journal of Innovative Research in Computer and Communication Engineering

(An ISO 3297: 2007 Certified Organization)

Vol. 4, Issue 8, August 2016

Features and Principles of OFDM: A Brief Study

G.Banupriya[1], D.Thilagavathi[2]

M. Phil Scholar, Department of Computer Science, NGM College, Pollachi, India[1]

Asst. Professor, Department of Computer Science, NGM College, Pollachi, India[2]

ABSTRACT: Orthogonal frequency division multiplexing (OFDM) is a special case of multicarrier transmission where a single DataStream is transmitted over a number of lower rate subcarriers. This new standard is the first one to use OFDM in packet-based communications. In wireless communication, concept of parallel transmission of symbols is used to achieve high throughput and better transmission quality. Orthogonal Frequency Division Multiplexing (OFDM) is one of the techniques for parallel transmission. The idea of OFDM is to split the total transmission bandwidth into a number of orthogonal subcarriers in order to transmit the symbols using these subcarriers in parallel. In this paper we will discuss the basics of OFDM techniques, the principles and features of OFDM in this era, its benefits and losses and also some of its application.

KEYWORDS: Orthogonal Frequency Division Multiplexing (OFDM), BER, ISI, PAPR, DVB, DAB.

I. INTRODUCTION

With the increase of communications technology, the demand for higher data rate services such as multimedia, voice and data over both wired and wireless links is also increased. New modulation schemes are required to transfer the large amount of data which existing techniques cannot support .These techniques must be able to provide high data rate, allowable Bit Error Rate (BER) and maximum delay. Orthogonal Frequency Division Multiplexing (OFDM) is one of them. OFDM has been used for Digital Audio Broadcasting (DAB) and Digital Video Broadcasting (DVB) in Europe and for Asymmetric Digital Subscriber Line (ADSL) high data rate wired links. OFDM has also been standardized as the physical layer for the wireless networking standard, "HIPERLAN2" in Europe and as the IEEE 802.11a, standard in the US, promising raw data rates of between 6 and 54Mbps.Orthogonal Frequency Division Multiplexing (OFDM) is a digital transmission Method developed to meet the increasing demand for higher data rates in communications which can be used in both wired and wireless environments [5]. To send data securely between two nodes, the system must encrypt the data or systematically scramble information so that it cannot be read without knowing the coding key[7].

II. RELATED WORK

Acosta, Guillermo explain about a large number of low data rate carriers to construct a composite high data rate communication system [1]. Bernhard Kaehs explain about the Crest Factor in DVB-T (OFDM) Transmitter Systems and its Influence on the Dimensioning of Power Components [2]. C.R. Nassar stated about the capacity by adapting the data rate per subcarrier according to SNR of that particular subcarrier [3].ETSI explain about the evolution beyond FM radio broadcasting providing interference free transmission [4].G. Fay explain about an Orthogonal Frequency Division Multiplexing (OFDM) is a digital transmission Method developed to meet the increasing demand for higher data rates in communications which can be used in both wired and wireless environments [5]. G. Hill., et al. stated about Orthogonal Frequency Division Multiplexing (OFDM) is a digital transmission Method developed to meet the increasing demand for higher data rates in communications which can be used in both wired and wireless environments [6]. G.Banupriya, J.Thilagavathi, stated about An Evaluation On Security In Wireless Data Networks [7], Jeon, W.G., et al. explain about an equalization technique for orthogonal frequency-division multiplexing systems in time-variant multipath channels [8]. Litwin., et al. explain about the basic principle of OFDM is to split a high-rate data stream into a number of lower rate streams that are transmitted simultaneously over a number of subcarriers[9]. From URL

ISSN(Online): 2320-9801
ISSN (Print): 2320-9798

International Journal of Innovative Research in Computer and Communication Engineering

(An ISO 3297: 2007 Certified Organization)

Vol. 4, Issue 8, August 2016

http://www.dsplog.com/2007/12/3/minimum-frequency spacing for-having-orthogonal-sinusoidal explain about the Minimum frequency spacing for having orthogonal sinusoidal [10]. Ramjee Prasad stated about an OFDM is similar to FDMA in that the multiple user access is achieved by subdividing the available bandwidth into multiple channels that are then allocated to users [11]. Ramjee Prasad stated about an OFDM towards fixed and mobile broadband wireless Access [12]. R.V. Nee and R. Prasad, explain about the OFDM transmitters low cost is the ability to implement the mapping of bits to unique carriers via the use of IFFT [13].

III. WHAT IS OFDM?

A loss of sub channel orthogonality due to time-variant multipath channels in orthogonal frequency division multiplexing (OFDM) systems leads to inter-channel interference (ICI) which increases the error floor in proportion to the Doppler frequency. A simple frequency-domain equalization technique which can compensate for the effect of ICI in a multipath fading channel is proposed. In this technique, the equalization of the received OFDM signal is achieved by using the assumption that the channel impulse response (CIR) varies in a linear fashion during a block period and by compensating for the ICI terms that significantly affect the bit-error rate (BER) performance.[6] A multicarrier system, such as FDM (Frequency Division Multiplexing), divides the total available bandwidth in the spectrum into sub-bands for multiple carriers to transmit in parallel.[13] It combines a large number of low data rate carriers to construct a composite high data rate communication system. Orthogonality gives the carriers a valid reason to be closely spaced with overlapping without ICI. [1]

IV. WHY OFDM?

- High spectral efficiency –provides more data services.
- Resiliency to RF interference –good performance in unregulated and regulated frequency bands.
- Lower multi-path distortion –works in complex indoor environments as well as at speed in vehicles.[11]

V. THE PRINCIPLE OF OFDM

Orthogonal Frequency Division Multiplexing (OFDM) is a multicarrier transmission technique, which divides the bandwidth into many carriers; each one is modulated by a low rate data stream. In term of multiple access technique, OFDM is similar to FDMA in that the multiple user access is achieved by subdividing the available bandwidth into multiple channels that are then allocated to users [10]. However, OFDM uses the spectrum much more efficiently by spacing the channels much closer together. This is achieved by making all the carriers orthogonal to one another, preventing interference between the closely spaced carriers. The figure shows the difference between the conventional non-overlapping multicarrier technique and overlapping multicarrier modulation technique. As shown in figure1, by using the overlapping multicarrier modulation technique, we save almost 50% of bandwidth. To realize the overlapping multicarrier technique, however we need to reduce crosstalk between subcarriers, which means that we want orthogonality between the different modulated carriers.

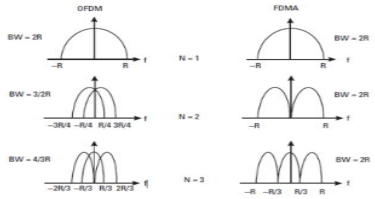

Figure 1: Concept of OFDM Signal: Orthogonal Multicarrier Technique Vs Conventional Multicarrier Technique [11]

ISSN(Online): 2320-9801
ISSN (Print): 2320-9798

International Journal of Innovative Research in Computer and Communication Engineering

(An ISO 3297: 2007 Certified Organization)

Vol. 4, Issue 8, August 2016

VI. FEATURES OF OFDM

The main features of a practical OFDM system are as follows:

- Some processing is done on the source data, such as coding for correcting errors, interleaving and mapping of bits onto symbols. An example of mapping used is QAM.
- The symbols are modulated onto orthogonal sub-carriers. This is done by using IFFT.
- Orthogonality is maintained during channel transmission. This can be achieved by adding a cyclic prefix to the OFDM frame to be sent. The cyclic prefix consists of the L last samples of the frame, which are copied and placed in the beginning of the frame. It must be longer than the channel impulse response.
- Synchronization: cyclic prefix can be used to detect the start of each frame. This is done by using the fact that the L first and last samples are the same and therefore correlated.
- Demodulation of the received signal by using FFT.
- Channel equalization: the channel can be estimated either by using a training sequence or sending known so-called pilot symbols at predefined sub-carriers.
- Decoding and de-interleaving. [1]

VII. BASIC OF OFDM

The OFDM signal generated by the system in Figure 2 & 3 is at baseband; in order to generate a radio frequency (RF) signal at the desired transmit frequency filtering and mixing is required. OFDM allows for a high spectral efficiency as the carrier power and modulation scheme can be individually controlled for each carrier. However in broadcast systems these are fixed due to the one-way communication. The basic principle of OFDM is to split a high-rate data stream into a number of lower rate streams that are transmitted simultaneously over a number of subcarriers. [8]

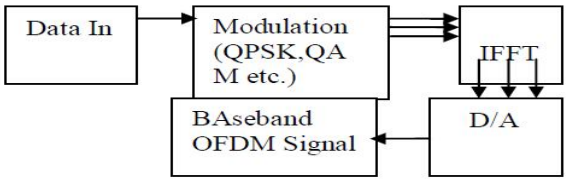

FIGURE 2: TRANSMITTER

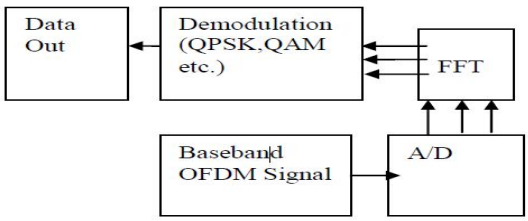

FIGURE: 3 RECEIVERS

VIII. OFDM PARAMETERS AND CHARACTERISTICS

The number of carriers in an OFDM system is not only limited by the available spectral bandwidth, but also by the IFFT size (the relationship is described by: number of carriers < ((ifft – size)/2 - 2), which is determined by the complexity of the system [10]. The more complex (also more costly) the OFDM system is, the higher IFFT size it has; thus a higher number of carriers can be used, and higher data transmission rate achieved. The choice of M-PSK modulation varies the data rate and Bit Error Rate (BER). The higher order of PSK leads to larger symbol size, thus less number of symbols needed to be transmitted, and higher data rate is achieved. But this results in a higher BER since the range of 0-360 degrees of phases will be divided into more sub-regions, and the smaller size of sub-regions is

ISSN(Online): 2320-9801
ISSN (Print): 2320-9798

International Journal of Innovative Research in Computer and Communication Engineering

(An ISO 3297: 2007 Certified Organization)

Vol. 4, Issue 8, August 2016

required, thereby received phases have higher chances to be decoded incorrectly. OFDM signals have high peak-to-average ratio, therefore it has a relatively high tolerance of peak power clipping due to transmission limitations.

IX. ORTHOGONALITY

The main aspect in OFDM is maintaining orthogonality of the carriers. If the integral the product of two signals is zero over a time period, then these two signals are said to be orthogonal to each other.

$$\int_0^T \cos(2\pi nf0t)\cos(2\pi mf0t)dt=0 \ (n\neq m) \quad (1)$$

Two sinusoids with frequencies that are integer multiples of a common frequency can satisfy this criterion. Therefore, orthogonality is defined by: Where n and m are two unequal integers; f_o is the fundamental frequency; T is the period over which the integration is taken. For OFDM, T is one symbol period and f o set to 1/T for optimal effectiveness [9].

X. PROS AND CONS OF OFDM

The advantages and disadvantages listed below are further discussed in the Characteristics and principles of operation section below, [2]

Pros of OFDM:

- High spectral efficiency as compared to other double sideband modulation schemes, spread spectrum, etc.,
- Can easily adapt to severe channel conditions without complex time-domain equalization.
- Robust against narrow-band co-channel interference.
- Robust against inter symbol interference (ISI) and fading caused by multipath propagation.
- Efficient implementation using fast Fourier transforms (FFT).
- Low sensitivity to time synchronization errors.
- Tuned sub-channel receiver filters are not required (unlike conventional FDM).
- Facilitates single frequency networks (SFNs) (i.e. transmitter macro diversity).

Cons of OFDM:

- Sensitive to Doppler shift.
- Sensitive to frequency synchronization problems.
- High peak-to-average-power ratio (PAPR), requiring linear transmitter circuitry, which suffers from poor power efficiency.
- Loss of efficiency caused by cyclic prefix/guard interval.

XI. SOME OTHER BENEFITS OF OFDM

- The beauty of OFDM lies in its simplicity. One trick of the trade that makes OFDM transmitters low cost is the ability to implement the mapping of bits to unique carriers via the use of IFFT [12].
- Unlike CDMA, OFDM receiver collects signal energy in frequency domain, thus it is able to protect energy loss at frequency domain.
- In a relatively slow time-varying channel, it is possible to significantly enhance the capacity by adapting the data rate per subcarrier according to SNR of that particular subcarrier [3].
- OFDM is more resistant to frequency-selective fading than single-carrier systems.
- The OFDM transmitter simplifies the channel effect, thus a simpler receiver structure is enough for recovering transmitted data. If we use coherent modulation schemes, then very simple channel estimation (and/or equalization) is needed, on the other hand, we need no channel estimator if differential modulation schemes are used.

ISSN(Online): 2320-9801
ISSN (Print): 2320-9798

International Journal of Innovative Research in Computer and Communication Engineering

(An ISO 3297: 2007 Certified Organization)

Vol. 4, Issue 8, August 2016

XII. OFDM APPLICATIONS

- OFDM technique is the most prominent technique of this era .Some of its applications is given below.
- DAB: DAB - OFDM forms the basis for the Digital Audio Broadcasting (DAB) standard in the European market [5]. Digital Audio Broadcasting (DAB) using OFDM has been standardized in Europe [4] and is the next step in evolution beyond FM radio broadcasting providing interference free transmission.
- HDTV
- Wireless LAN Networks
- 5.3.1 HIPERLAN/2
- IEEE 802.16 Broadband Wireless Access System.
- Wireless ATM transmission system
- IEEE 802.11a

REFERENCES

1. Acosta, Guillermo. “OFDM Simulation Using MATLAB” 2000.
2. Bernhard Kaehs, “The Crest Factor in DVB-T (OFDM) Transmitter Systems and its Influence on the Dimensioning of Power Components”.
3. C.R. Nassar et al., Multi-carrier Technologies for Wireless Communication, Kluwer Academic Publishers, Dordrecht, The Netherlands, 2002.
4. ETSI, "Radio Broadcast Systems: Digital Audio Broadcasting (DAB) to mobile, portable and fixed receivers," ETSI final draft ETS 300 401, Nov 1994.
5. G. Fay, "Wireless Data Networking," International Journal of Network Management, 8 March 1992, pp. 8-17.
6. G. Hill, M. Faulkner, and J. Singh, “Reducing the peak-to-average power ratio in OFDM by cyclically shifting partial transmit sequences”, Electronics Letters, vol.36, pp. 560-561, Mar 16 2000.
7. G.Banupriya, J.Thilagavathi, “An Evaluation On Security In Wireless Data Networks”, 3rd International Conference On Advances In Information Technology And Networking (ICATN ’16), FEB 11,2016
8. Jeon, W.G.; Chang, K.H.; Cho, Y.S. (1999). “An equalization technique for orthogonal frequency-division multiplexing systems in time-variant multipath channels”. IEEE Transactions on Communications. Page Number (27–32).
9. Litwin, Louis and Pugel, Michael. “The Principles of OFDM” 2001
10. Minimum frequency spacing for having orthogonal sinusoidal http:// www.dsplog.com /2007/12/3/ minimum-frequency spacing for-having-orthogonal-sinusoidal.
11. Ramjee Prasad, “OFDM for wireless communication system”, Artech House, 2004.
12. Ramjee Prasad, - “OFDM towards fixed and mobile broadband wireless Access”, Artech House, 2007.
13. R.V. Nee and R. Prasad, “ OFDM for Wireless Multimedia Communications”, Artech House Publishers, Norwood, MA, USA, 2000
14. Theory of Frequency Division Multiplexing: http://zone.ni.com/devzone/cda/ph/p/id/269.