ISSN (Online) 2278-1021
ISSN (Print) 2319-5940

International Journal of Advanced Research in Computer and Communication Engineering
Vol. 4, Issue 6, June 2015

A Novel Study on Optical Frequency Division Multiplexing System for Digital Broadcasting Standard

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Abstract: With the advancement in age and its growing demands, there has been rapid growth in the field of communications. Communication is one of the important aspects of life. For better transmission, even single-carrier waves are being replaced by multi-carriers. Multi-carrier systems like CDMA and OFDM are now a day's being implemented commonly. So, the main objective of this paper is to design and implement an OFDM System for digital broadcasting standard. In the OFDM system, orthogonally placed sub-carriers are used to carry the data from the transmitter end to the receiver end. In this paper we are focussing on learning the basics of an OFDM System. The purpose of this paper is to provide a simulation of the process involved in the generation and reception of an OFDM signal in a physical channel and to provide a description of each of the steps involved. For this purpose, we shall use one of the proposed OFDM signals of the Digital Broadcasting (DVB) standard for the European digital television service.

Keywords: OFDM System, Wireless Communication, QAM modulation, Demodulation etc.

I. INTRODUCTION

Communication is one of the important aspects of life. Previously various methods like sign languages were used for this purpose. With the advancement in age and its growing demands, there has been rapid growth in the field of communications. By the turn of 19th century, a great leap in the field of communication was observed. Signals, which were initially sent in analog domain, are being sent more and more in digital domain now [1].

Wireless communication is, by any measure the fastest growing segment of the communication industry. As such, it has captured the attention of the media and the imagination of the public. Wireless cellular phones and the LANs currently replace wired networks. Many new applications, including wireless sensor networks, automated highways and factories, smart homes and appliances and remote tele-medicines, are emerging from research ideas to connect systems [2].

The 1st Wireless networks were developed in the pre-industrial age. These systems transmit information over line-of-sight distances using smoke signals, torch signalling, flashing mirrors, signal flares or semaphore flags. These earlier communication networks were replaced first by the telegraph network and later by telephone. In 1895, a few decades after the telephone was invented, Marconi demonstrated the first radio transmission and thus the radio communication was born. Early radio systems transmitted analog signals, today most radio systems transmit digital signals [3].

Vision of wireless communication supporting information exchange between people or devices is the communication frontier of the next few decades and much of it already exist in some forms. This vision will allow multimedia communication from anywhere in the world using a small handheld device or laptop. In the home, these networks will enable a new class of intelligent electronic devices that can interact with each other and with the internet. Such homes can also help the elderly and disabled with assisted living, patients monitoring and emergency response. The current wireless systems includes cellular telephone systems, cordless phone, wireless LANs, wide area wireless data services, broadband wireless access, paging systems etc [4].

In the current and future mobile communications systems, data transmission at high bit rates is essential for many services such as video, high quality audio and mobile integrated service digital network. When the data is transmitted at high bit rates, over mobile radio channels, the channel impulse response can extend over many symbol periods, which leads to inter-symbol interference (ISI). Orthogonal Frequency Division Multiplexing (OFDM) is one of the promising candidates to mitigate the ISI. In an OFDM signal the bandwidth is divided into many narrow sub-channels which are transmitted in parallel. Each sub-channel is typically chosen narrow enough to eliminate delay spread [5].

The paper is ordered as follows. In section II, it represents related work with proposed system in OFDM System. In Section III, It defines basics of OFDM technique. In Section IV, It defines proposed OFDM System. Finally, conclusion is explained in Section V.

II. LITERATURE REVIEW

Authors proposed the behaviour of DD-OFDM with different high order modulation formats from 4 QAM to 64 QAM. The impact of fiber nonlinearity for 4-QAM modulation format in long-haul WDM-OFDM transmission with direct detection is also investigated. Bit-

ISSN (Online) 2278-1021
ISSN (Print) 2319-5940

International Journal of Advanced Research in Computer and Communication Engineering
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rate up to a factor of 3 is increased without requesting more bandwidth or higher speed components. [6]

Due to rapid growth of internet traffic and capacity requirement applications, there is urgent need for optical fiber transmission technology. Authors approved Optical OFDM as a promising technology for future high-speed transmission because of its superior tolerance to

CD/PMD, high spectrum efficiency, and scalability to ever increasing data rates based on its subcarrier multiplexing technology. It presented a comprehensive survey that covers optical OFDM transmission & OFDM based elastic optical networking. OFDM principles including its mathematical formulation, the main building blocks, and related key functions were also introduced. [7]

Some proposed ADO-OFDM, a recently developed modulation scheme for IM/DD systems. Performance of ADO-OFDM is compared with ACO-OFDM and DCO-OFDM. The subcarriers in ADO-OFDM are modulated using ACO-OFDM and DCO-OFDM. Also the performance of the ADO-OFDM depends on a number of parameters including the proportion of power allocated to ACO-OFDM and DCO-OFDM, and constellations used on each component. [8]

Some presented a realistic performance analysis on IEEE 802.15.4g MR-OFDM multi-hop system in an environment with multi-PHY interference. Extensive cross-layer computer simulations are conducted to validate the accuracy of the system performance. We can do the Future work in this work in frequency-agile mechanisms such as frequency hopping operations. [9]

Some demonstrated Adapted and extended GMPLS in order to deploy a control plane for elastic/flexible optical networks with coherent optical OFDM transmission technology. The control plane protocol extensions involved in the main functional aspects have been presented and will be useful for future standardization. The integrated system in a control plane test bed emulating a 14-node Japan topology is evaluated in this paper. Different key performance indicators such as path setup latency for different assignment strategies are obtained. [10]

An ICA-based CE is presented to recover the OFDM signal in optical OFDM systems without using TSs. The ICA-based CEs are used to compensate the linear channel impairments in DDO-OFDM and PDM-CO-OFDM system. 3 types of ICA algorithms including MN, ML, MMI are applied for the purpose of channel equalization [11].

III. GENERAL DESRIPTION OF OFDM SYSTEM

Various multicarrier modulation techniques have been developed to meet the need for high speed communication. In this, CDMA and OFDM are mainly important. OFDM is a frequency division multiplexing (FDM) technique utilized as a digital multi carrier modulation method. A large number of closely spaced orthogonal sub carriers are used to send the data. The data is divided in to several parallel streams of channel. Each sub-carrier is modulated with a modulating technique such as QPSK at a low symbol rate, maintaining total data rate similar to single carrier modulation in the same bandwidth [12].

OFDM System

The development of OFDM system can be divided into three stages, these are – Frequency division multiplexing, multicarrier communication and orthogonal frequency division multiplexing.

Frequency Division Multiplexing:

Frequency division multiplexing is a form of multiplexing technique in which non-overlapping frequency channels are assigned to different signals. A gap is given between these channels known as guard band to ensure that the signals don't interfere each other.

Multicarrier Communication:

It is ineffective to transfer a high rate data stream through a channel, so the signal is split to give a number of signals over that frequency range. Each of these are modulated individually and transmitted. At the receiver, a demux is used to de-modulate the signals and these are then re-combined to obtain the desired signal.

Orthogonal Frequency Division Multiplexing:

OFDM is a type of multicarrier modulation which is best suited for transmission over a dispersive channel. The carriers are independent of one another that is they are orthogonal to each other. The orthogonality is achieved by placing the carriers exactly at the nulls in the modulation spectra of each other. The diagram of this OFDM spectrum is shown in figure 1 & 2. From the figure 2, it can be seen that one subscriber's peak point corresponds to the other subscriber's zero point, therefore when a subscriber is sampled at its peak, there is no interference from other subscribers as all other subscribers have zero crossings at that point. So the orthogonality property of OFDM is very important as it leads to the more efficient usage of spectral resources, which is limited in many communication media.

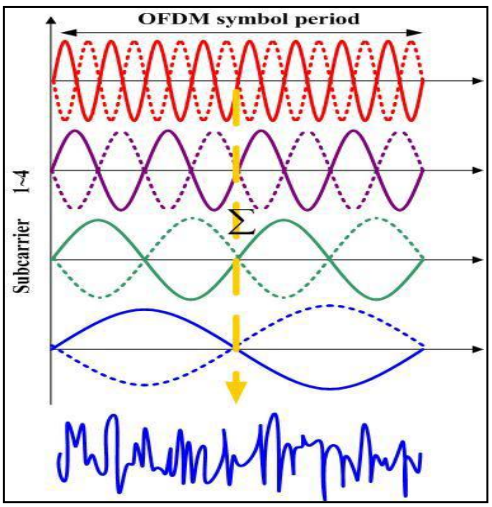

Figure 1: OFDM Spectrum in Time Domain [12]

DOI 10.17148/IJARCCE.2015.4672

ISSN (Online) 2278-1021
ISSN (Print) 2319-5940

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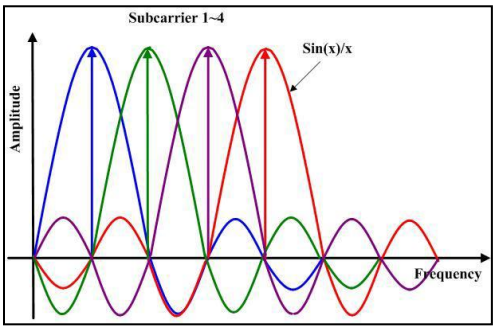

Figure 2: OFDM Spectrum in Frequency Domain [12]

O-OFDM System:

After the great success of OFDM in wireless and broadband access networks, it is now being used in optical transmission as well. Optical OFDM (O-OFDM) can be used in a range of optical communication systems including single-mode fiber (SMF), multimode fiber (MMF), plastic optical fiber (POF), and optical wireless communication systems (OWC). Based on the signal synthesis method, the O-OFDM can be divided into two types- FFT based approach, optical approach and on the basis of signal detection types- direct detection and coherent detection.

A. FFT based approach:

Here, the OFDM subcarriers are generated in the digital domain using IFFT. The FFT-based O-OFDM transmitter is composed of a RF OFDM transmitter and a RF-to-optical up-converter, while the receiver is composed of an optical-to-RF down-converter, and a RF OFDM receiver.

B. Optical approach:

Here, an optical OFDM signal is directly generated in the optical domain through modulation of multiple optical subcarriers, without the electrical IFFT processing. The main advantage of the optical approach is that electronics of ADC/DAC are eliminated.

C. Direct detection:

IT is realized by sending the optical carrier along with the OFDM baseband, so that direct detection with a single photodiode can be used at the receiver to convert the optical field back into electrical domain.

D. *Coherent detection*:

It is also referred to as coherent demodulation. It is a technique of phase locking to the carrier wave to improve detection [12].

Advantages of OFDM

There are many advantages of OFDM. Some of these are -

- OFDM divides the high-speed data stream into multiple low-data-rate subcarriers and then transmit them, thereby increasing the symbol duration and reducing the ISI, thus making OFDM, a good candidate for future high-speed communication systems.
- Smooth upgrading from low-speed transmission to high-speed transmission is possible in OFDM without major changes in system design.
- OFDM gives high spectrum efficiency and capacity.
- Energy-efficient operation is possible with OFDM through adaptive modulation and dynamically switching on/off specific subcarriers according to customer bandwidth requirements and channel conditions.

IV. PROPOSED SYSTEM FOR BROADCASTING STANDARD

Orthogonal frequency division multiplexing (OFDM) is becoming the chosen modulation technique for wireless communications. OFDM can provide large data rates with sufficient robustness to radio channel impairments. In an OFDM scheme, a large number of orthogonal, overlapping, narrow band sub-channels or subcarriers, transmitted in parallel, divide the available transmission bandwidth. The separation of the subcarriers is theoretically minimal such that there is a very compact spectral utilization. The attraction of OFDM is mainly due to how the system handles the multipath interference at the receiver. Multipath generates two effects: frequency selective fading and inter-symbol interference (ISI). The "flatness" perceived by a narrow-band channel overcomes the former, and modulating at a very low symbol rate, which makes the symbols much longer than the channel impulse response, diminishes the latter. Using powerful error correcting codes together with time and frequency interleaving yields even more robustness against frequency selective fading and the insertion of an extra guard interval between consecutive OFDM symbols can reduce the effects of ISI even more. Thus, an equalizer in the receiver is not necessary.

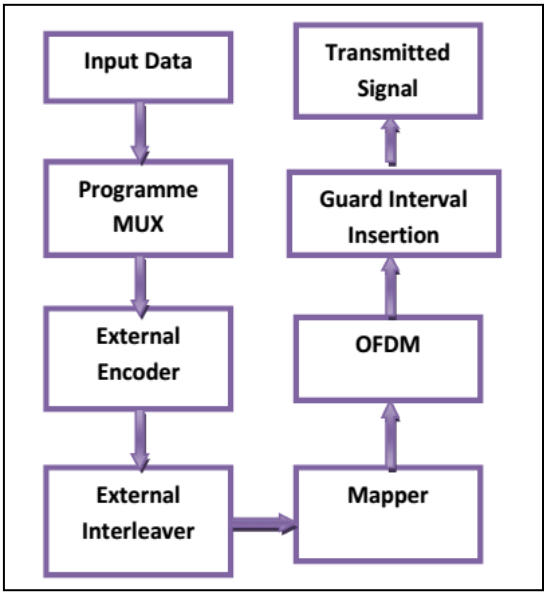

Figure 3: Digital Broadcasting Standard for OFDM

The OFDM system can be divided into three parts mainly, transmitter, channel and receiver. The block diagram of a typical OFDM transmitter and receiver is shown in figure 4 & 5.

The OFDM transmitter works as: The input serial data stream is first converted into many parallel data streams after passing through a serial – to – parallel converter. These parallel data streams are modulated onto

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ISSN (Print) 2319-5940

International Journal of Advanced Research in Computer and Communication Engineering
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the orthogonal subcarriers and changed to the time domain OFDM symbol by applying the IFFT.

The OFDM signal is then converted to analog signal by applying the digital-to-analog conversion (DAC) and filtered with low pass filter.

The baseband signal thus obtained can be up converted to an appropriate RF. At the receiver, the received signal is first down converted, sampled with an ADC and then the complex form OFDM signal is demodulated by applying the FFT. The demodulated signals go through a symbol decision module. Finally, the multiple data channels are converted back to a single data stream by applying the parallel – to – serial data converter.

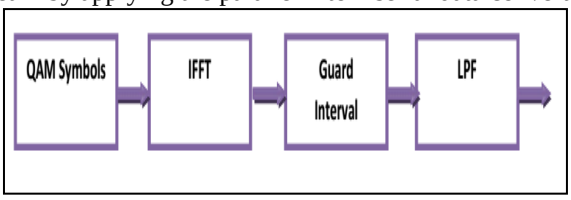

Figure 4: Generation of OFDM System

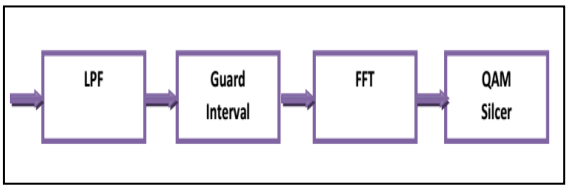

Figure 5: Reception of OFDM System

V. CONCLUSION

OFDM is a very attractive technique for multicarrier transmission and has become one of the standard choices for high – speed data transmission over a communication channel. So, it proposes a design of OFDM system for digital broadcasting standard. In this, the transmission and the reception model will be discussed in details along with their power spectral density estimation. For each step their time domain signal and also their frequency domain signal will be studied. All simulations will be done in Simulation tool.

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