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Study of OFDM System for Application of Wireless Communication

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Abstract: ***OFDM is Orthogonal Frequency Division Multiplexing. This multiplexing technique use for many of the latest wireless and telecommunication standards. OFDM split wideband signal into narrowband signal for transmission. The transmission of these individual narrow band signal are executed with orthogonal carriers utilize this approach achieving high data rate transmission without ISI and high spectral efficiency requirement for wireless communication. In this paper discuss basic system of OFDM is gaining a wide spread popularity within the wireless transmission. The research paper focus on basic principle of OFDM and also discuss OFDM based UWB approach. finally the paper provide a number of wireless application where OFDM used and its advantages and disadvantages.***

Keywords: OFDM, Inter Carrier Interface (ICI), Inter Symbol Interface(ISI), Peak Average Power Ratio (PAPR), Carrier Frequency Offset(CFO),Cyclic Prefix(CP), Bit Error Rate(BER)

1. Introduction

Emerging technologies such as WiFi and WiMAX are profoundly changing the landscape of wireless broadband. As we evolve into future generation wireless network, a primary challenge is the support of high data rate, integrated multimedia type traffic over a unified platform[1]. Due to its inherent advantages in high speed communication orthogonal frequency division multiplexing (OFDM) has modem choice for number of high profile wireless system e.g. DVB-T, WiFi, WiMAX, and Ultra-Wideband[2]. Due to the high data rate transmission and the ability to against frequency selective fading orthogonal frequency division multiplexing is promising technique in the current broadband wireless communication system. OFDM technology is split a high rate data stream that are transmitted simultaneously over number of subcarrier [3].

A OFDM is a broadband multicarrier modulation method that offer superior performance and benefits over older more traditional single carrier modulation method because it is better fit with today high speed data requirement and operation in the UHF and microwave spectrum[4]. In wireless high speed communication technologies suffer some common problem such as attenuation, multipath fading, delay spread, self jamming, etc[5]. OFDM gain popularity for avoided this type problem used modulation technique which is provide such a high data rate in the emerging application of wireless communication [6]. It is provide higher data rate transmission capacity with high spectral efficiency, multipath delay speed tolerance, immunity to frequency selective fading channels, and power efficiency for high speed such as 4G and 5G mobile communication technology. OFDM transmit data in parallel by modulating a set of orthogonal subcarrier. The subcarrier in the OFDM system are orthogonal to each other and this orthogonality condition enables the subcarrier to be closely spaced and overlap without Inter Carrier Interface (ICI). Although, FDMA,TDMA,CDMA are the well-known multiplexing techniques used in wireless communication system over a number of year , the overall problems encountered in these techniques includes Inter Symbol Interface (ISI) resulted from time dispersion, multipath fading, less spectral efficiency and the requirement of larger transmitting power for high bit rate[3]. OFDM is a very power full modulation techniques which is capable of achieving high data rate transmission without ISI and Inter Carrier Interface. OFDM is made more efficient by the use of IFFT and its inverse FFT techniques to implement modulation and demodulation function respectively. The OFDM based wireless communication system design includes the design of OFDM transmitter, and OFDM receiver.

OFDM signal spectrum shown in figure(1), OFDM technique is successfully used in several narrow-band system such as the IEEE 802.11a and g are provide features such as frequency efficiency and robustness to multipath effects. Multiband OFDM (MB-OFDM) is the major UWB system from the IEEE.802.15.3a activity that uses OFDM modulation in the UWB spectrum[6].

The rest of this paper is organized as follows: section II provides the basic principle of OFDM system, section III OFDM based UWB approach, section IV application of OFDM and also discuss advantages and disadvantages of OFDM, finally, section V concludes the paper by giving future research direction.

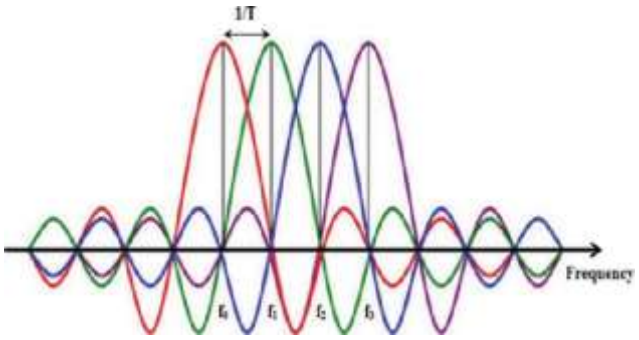

Figure 1: OFDM signal spectrum

2. Basic Principle of OFDM System

The basic principle of OFDM is to split a higher rate data stream into a number of lower rate streams that are

transmitted simultaneously in parallel over a number of subcarrier. In order to allow for high spectral efficiency in OFDM systems, the modulation scheme to be used and carrier power are controlled individually for each carrier. OFDM system block diagram shown in figure (2). OFDM is generated by choosing the spectrum required based on the input data (stream of bits), and modulation scheme to be used. All the subcarrier are carefully controlled in order to maintain the orthogonality condition between the carrier. Every sub-carrier OFDM system is assigned the same data during transmission.

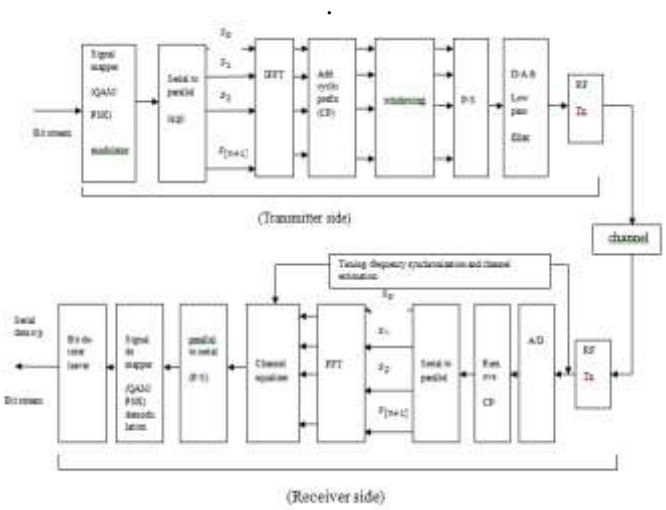

Figure 2: OFDM system block diagram

At the transmitter, the user information bit sequence is first subjected to channel encoding to reduce the probability of error at the receiver due to the channel effects. Usually convolution encoding is preferred. Then the bits are mapped to symbol. Usually, the bits are mapped into the symbol of different modulation scheme such as BPSK, QPSK, 8PSK, 16QAM, 64QAM, etc. this is so depending on the channel condition and the need of getting the best balance between the Bit Error Rate (BER) and frequency utilization. The input serial stream of data is then converted to parallel sets of data at the transmitter each set of data in OFDM system contains one symbol say Snfor every subcarrier. and IFFT is applied and the sequence is once again converted to serial format.

Guard time is provided between the OFDM symbol and the guard time is filled with the cyclic extension of the OFDM symbol. Windowing is applied to OFDM symbol to make the fall-off rate of the spectrum steeper. The resulting sequence is converted to an analog signal using a DAC and passed on to RF modulation stage. The resulting RF modulated signal is ,then transmitted to the receiver using the transmit antennas. Here, directional beam forming can be achieved using antenna array, which is allow for efficient spectrum reuse by providing spatial diversity. At the receiver, first RMF demodulation performed. Then, the signal is digitized using an ADC and timing and frequency synchronization are performed. Synchronization will be dealt with in the later sections. The guard time is removed from each OFDM symbol and the sequence is converted to parallel format and FFT is applied. The output is then serialized and symbol de-mapping is done to get back the coded back bit sequence. Channel decoding is, then, done to get the user sequence.

3. OFDM based UWB approach

In the indoor and home networking is unique, in that it simultaneously require high data rate (for multiple streams of digital video), very low cost (for broad consumer adoption), and very low power consumption (for embedding into battery-power handheld applications). With its enormous bandwidth, ultra-wideband (UWB) provides a promising solution to satisfying these requirements and becomes an attractive candidate for future wireless indoor networks[7].

The concept of UWB was developed in early 1960s through research In time-domain electromagnetic, where were used to characterize the transient behavior of certain class microwave networks [8]. In the late 1960s, impulse measurement technique was applied to the design of wideband antenna element, leading to development of short-pulse radar communication systems. In 1973 The first UWB communication patent was awarded for short pulse receiver [9]. Through the late 1980s, UWB was referred to as baseband, carrier-free, or impulse technology.

The term ultra-wideband was coined in approximately 1989 by the U.S. Department of Defense. By 1989, UWB theory, techniques, and many implementation approaches had been developed for a wide range of application such as radar, communication, automobile collision avoidance, positioning systems, liquid-level sensing, and altimetry. However, much of the early work in the UWB field occurred in military or was funded by the U.S. government within classified programs. By the late 1990s, UWB technology had become more commercialized and its development had accelerated greatly.

A substantial change in UWB history occurred in February 2002, when the U.S. Federal Communication Commission (FCC) issued UWB ruling that provided the first radiation limitation for UWB transmission and permitted the operation of UWB device on an unlicensed basis [10]. According to FCC allocated 7.5 GHz spectrum from 3.1 GHz to 10.6 GHz for ultra-wideband (UWB) devices, band group spectrum shown in figure (3) basis on frequency. After this, the following years have seen significant increase in research activity in both industry and academic circles in the field of UWB systems for short range indoor communications [11].this ruling has helped to create new standard IEEE802.15.3a, that focus on developing high speed wireless communication system for personal area network.

The multi-hand OFDM system is an OFDM solution proposed for the UWB WAN (IEEE 802.15.3a) physical layer standard [6]. In that proposal, the whole available ultra wideband spectrum between 3.1-10.6 *GHz* is divided into several sub-bands with smaller bandwidth. The bandwidth of each sub-band is larger than 500 MHz in compliance with the FCC rules for UWB transmission [10]. Specifically, the proposal uses 528 MHz sub-bands

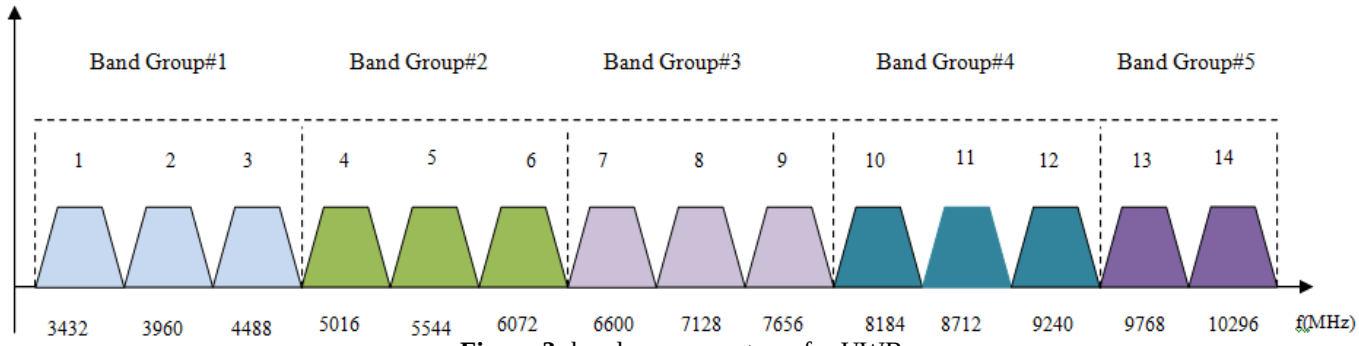

Figure 3: band group spectrum for UWB

The main difference between the multi-band OFDM system and other narrowband OFDM systems is the way that different sub-hands are used in the system. The transmission is not done continually on all sub-bands. Rather, it is time multiplexed between different bands in order to use a single hardware for communications over different sub-bands. The pattern in which the switching is done and the rate of switching has a large impact on the performance of the system.

If we allow switching inside an OFDM symbol then we can design a near optimal OFDM system that offers high time resolution and provides full multipath diversity in multipath frequency selective fading channels. This system, which is called UWB-OFDM, was introduced in [13]. Since implementation of fast switching between bands leads to complexity levels that exceed the requirements of WPAN IEEE 802.15.3a devices, the switching in multi-hand OFDM proposal is done after transmitting a complete OFDM symbol in each hand. Different pattern of switching is chosen for different users (different piconets) such that the multi-user interference is minimized. Since the pulsed-OFDM system that is presented in this paper uses the same switching pattern as the baseline proposal we will not consider it in the reminder of the paper. Note that since consecutive OFDM symbols are sent in different sub-bands in the multi-band OFDM system, there is no inter-symbol interference (ISI) in the system. Without loss of generality we will therefore study the problem of transmitting a single OFDM symbol over multipath fading channels

4. Applications and Advantages vs Disadvantages

In this section discuss applications basis details on past year to current technology where OFDM principle are used and we have also summarized advantages and disadvantage of OFDM.

1) Application of OFDM

The idea of OFDM , was proposed in mid-1960,, used parallel data transmission and frequency division multiplexing(FDM)[14].

a) In the 1960s, the OFDM technique was used in several high frequency military system such as KINEPLEX, ANDEFT, and KATHRYN.
b) In 1971 , weinstein and Ebert applied the Discrete Fourier Transform(DFT) to parallel data transmission as part of modulation and demodulation process are FFT-based OFDM
c) In the 1980s, OFDM was studied for high –speed modems digital mobile communication, and high dencity recoding such as Trellies code is implemented and COFDM(1987).
d) In 1990s, OFDM was exploited for wideband data communication based are mobile radio FM channel and fix-wire-network such as High bit rate digital subscriber line(HDSL), Asymmetric digital subscriber line (ADSL) and very-high-speed digital subscriber line.
e) Digital audio broadcasting (DAB) (1995).
f) Digital video broadcasting (DvB) (1997).
g) High–definition television (HDTV) terrestrial broadcast
h) Wireless Lan
   - IEEE802.11a(U.S.A) (1999)
   - IEEE802.11g(U.S.A)(2002)

   Now OFDM technique has been adopted as the new European DAB standard, and HDTV standard.
i) OFDM/UWB (IEEE802.15.3a)(2004)
j) IEEE 802.16 broadband wireless access (2004)
k) IEEE802.20 mobile broadband wireless access(MBWA)
l) 4G mobile communication based LTE and LTE advanced
m) Candidate 5G technology

2) OFDM Advantages

a) **Immunity to selective fading** *:* One of the main advantages of OFDM is that is more resistant to frequency selective fading than signal carrier system because it divides the overall channel into multiple narrowband signals that are affected individually as flat fading sub-channel.
b) **Resilience to interference***:* Interference appearing on a channel may be bandwidth limited and in this way will not affect all the sub-channel. This means that not all the data is lost.
c) **Spectrum efficiency***:* Using closed- spaced overlapping sub-carrier, a significant OFDM advantage is that it makes efficient use of the available spectrum.
d) **Resilient to IS:** Another advantage of OFDM is that is very resilient to inter-symbol and inter-frame interference. This result from the low data rate on each of the subcarrier.
e) **Simpler channel equalization***:* An advantage of OFDM is that using multiple sub-channels the channel equalization becomes much simpler

3) Disadvantages

a) **High peak to average power ratio:** An OFDM signal has a noise like amplitude variation and has a relative large dynamic range, or peak to average power ratio.

This impacts the RF amplifier efficiency as the amplifier need to be linear accommadate the large amplitude variation and these factors mean the amplifier cannot operate with a high efficiency level.

b) **Sensitive carrier frequency offset and drift*:*** Another disadvantage of OFDM is that is sensitive to carrier frequency offset and drift. Signal carrier systems are less sensitive.

5. Conclusion

The paper has concluded that for high data rate wireless communication has been increasing dramatically over the last decade. OFDM, which is most effective emerging multicarrier modulation technology of this era, can solve this problem significantly. This work has provided a survey of OFDM principle and based on OFDM system UWB thing. This approach very use full for higher data rate wireless communication. Also study different area of application over past technologies to current technologies based on OFDM as well as UWB approach.

In this approach find major disadvantage such as high peak to average power ratio (PAPR) and carrier frequency offset (CFO). This disadvantage needs to addressed properly to allow further widespread use of OFDM.

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