Review of Development of Reconfigurable High Speed Filter Bank and OFDM

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Abstract **-Recent advances in wireless communication systems have increased the throughout over wireless channels. With the rapidly growing demand for data in wireless communications and the significant increase of the number of users, the radio frequency spectrum become one of the scarcest resources in the world. Motivated by the more and more crowed RF spectrum, optical wireless communications (OWC) has been identified as a promising candidate to complement conventional RF communication. Nowadays, low-complexity, high speed filter bank is an important concept for wireless communication applications such as spectrum sensing and channelization etc. In signal processing, a filter bank is an array of band pass filters that separates the input signal into multiple components, each one carrying a signal. In this paper, we discuss the review of the various filter banks and orthogonal frequency division multiplexing (OFDM) for wireless communication, discussed in previous paper by authors. Unipolar communications systems can transmit information using only real and positive signals. We consider flip OFDM is used to guarantee nonnegative signals in optical wireless communication (OWC) systems and flipped orthogonal frequency division multiplexing (Flip-OFDM) transmits the positive and negative parts of the signal over two consecutive OFDM. The fast filter bank is suitable for the design of filter banks due to its reduced complexity. The fast filter bank follows a tree structure and it can be decomposed into several stages.**

Keywords**: Orthogonal frequency division multiplexing (OFDM), fast filter bank, flip-OFDM, optical wireless communication.**

I. INTRODUCTION

Orthogonal frequency division multiplexing (OFDM)

Orthogonal Frequency Division Multiplexing (OFDM) is a multicarrier modulation technique. Multicarrier transmission is a method devised to deal with frequency selective channels. In frequency selective channels different frequencies experience disparate degrees of fading. The problem of variation in fading levels among different frequency components is especially aggravated for high data rate systems due to the fact that in a typical single carrier transmission the occupied bandwidth is inversely proportional to the symbol period. The basic principle of multicarrier transmission is to translate high rate serial data stream into several slower parallel streams such that the channel on each of slow parallel streams can be considered flat. Parallel streams are modulated on subcarriers. In addition to that, by making symbol period longer on parallel streams the effect of the delay spread of the multipath channel, namely inter-symbol interference (ISI), is greatly reduced. In multipath channels multiple copies of the transmitted signal with different delays, which depend on characteristics of the material from which the transmitted signal has been reflected, are received at the receiver. The delay spread of a channel is a measure of degree of multipath effect - it is equal to the difference between arrival times of the first and the last multipath components. Due to the fact the length of the symbol period of each parallel stream scales proportionally to the number of subcarriers used the percentage of overlap between two adjacent symbols due to delay spread and resulting from it inter-symbol interference (ISI) also decreases proportionally to the number of subcarriers. [9]

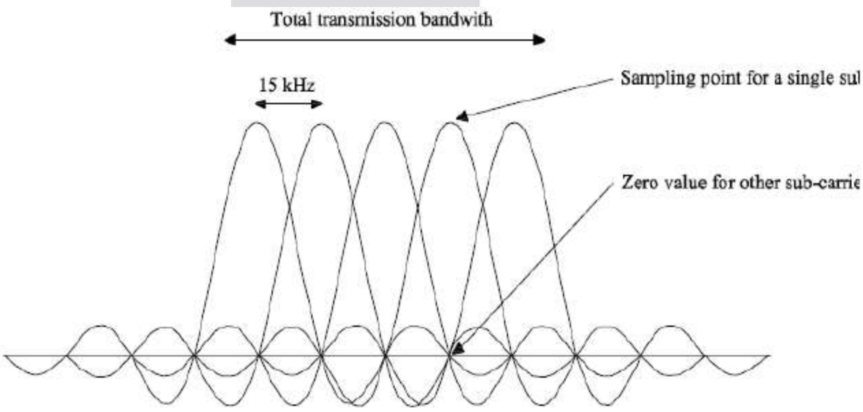

Figure 1.1: OFDM Spectrum [9]

Concept of Flip-Ofdm

In Flip-OFDM, positive and negative parts are extracted from the real bipolar OFDM symbol generated by preserving the Hermitian symmetry property of transmitted information symbols. Then the polarity of negative parts are inverted before transmission of both positive and negative parts in two consecutive OFDM symbols. Since the transmitted signal is always positive, Flip-OFDM is indeed an unipolar OFDM technique that can be used for unipolar communications

- Flip-OFDM is widely used to compensate dispersion effects in optical wireless communication.
- In OWC, intensity modulation with direct detection (IM/DD) technique is commonly used for data transmission.
- OWC is also used a concept of unipolar communication that is it works on only real and positive signal.[1]

Optical Wireless Communication

Optical wireless communications (OWC) is a form of optical communication in which unguided visible, infrared (IR), or ultraviolet light is used to carry a signal.Also known as Visible Light Communication.

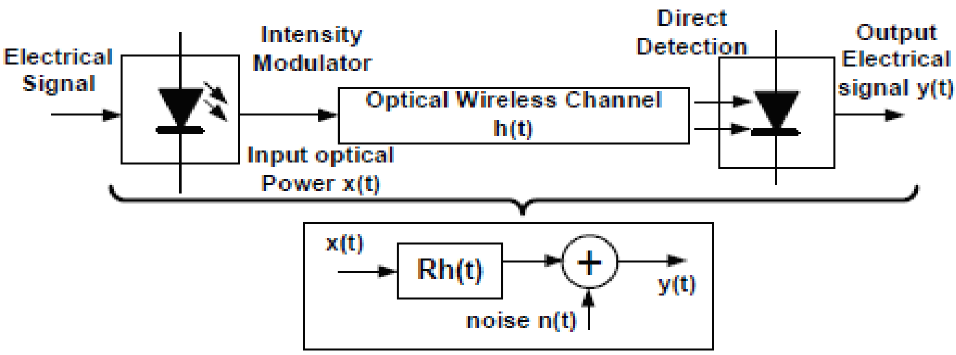

Figure 1.2: Equivalent model of Optical Wireless Channel

A block diagram of a typical IM/DD based optical wireless communication system is shown in Figure. 1.2 In most optical wireless applications, an infrared emitter is used as optical transmitter to generate optical signal x(t). This signal represents the intensity of the optical carrier transmitted over optical wireless channel. At the receiver, a photo detector collects the optical signal and converts it to an electrical current y(t). In general, the optical wireless link can be operated in two modes: directed and non-directed (or diffused). In directed optical wireless link, the contribution of the Line-of- Sight (LOS) is dominating and an additive white Gaussian noise channel model is appropriate. However, the AWGN assumption is no longer valid for diffused optical wireless channels, where no strong LOS is present. The optical wireless channel is modeled as a linear baseband system, as shown in Figure. 1.2 Given the channel impulse response and noise component h(t) and n(t), respectively, the received electrical signal can be given as,

$$y(t) = x(t) * h(t) + n(t).$$

Concept of Filter Bank

A multi-standard wireless receiver enables different air interfaces with the digital signal processing. Generally, filter bank is used to perform several operations for MSWRs. The filter bank must be dynamically reconfigurable to support multiple communication standards with different channel bandwidth and center frequency specifications. Various filter bank design approaches exist like DFTFB, DFTFB using CDM technique operation and widely used for various communication applications but they fails to provide nonuniform sub-band bandwidth and fixed center frequency for each sub-band. The fast filter bank, is a low complexity alternative to DFTFB and is suitable for applications requiring sharp transition bandwidth. However, the FFB has the drawbacks of uniform subband bandwidth. Several improvements in FFBs are suggested. In order to have fine control over subband bandwidth, a new approach of reconfigurable fast filter bank is designed by combining FFB and a variable digital filter. The RFFB provides fine control over the sub-band bandwidth on the desired bandwidth range. This makes RFFB suitable for multi communication standards with different channel bandwidth.

II. REVIEW OF LITERATURE

The study of many authors is discussed in this chapter on fast filter bank and orthogonal frequency division multiplexing (OFDM). Here are some of the views of the various papers referred by many authors for development of filter bank and ofdm.

The paper byHai Huyen Dam at.al," Variable Digital Filter With Group Delay Flatness Specification or Phase Constraints". In this paper author proposed the design of finite-impulse response variable digital filters (VDFs) with variable cutoff frequency or variable fractional delay. This proposed technique design of VDFs with minimum integral squared error and constraints on the maximum error deviation in conjunction with flatness group delay specification or phase constraints. [1].The paper by K. G. Smitha at.al, "A Multi-Resolution Fast Filter Bank for Spectrum Sensing in Military Radio Receivers ". In this paper author designed a multi-resolution filter bank (MRFB)-based on the fast filter bank design for multiple resolution spectrum sensing in military radio receivers.The proposed method overcomes the constraint of fixed sensing resolution in spectrum. Our proposed method is having a gate count reduction over DFTFB based spectrum Sensor, [2].The paper by, Sumit J. Darak, at.al, "Low-Complexity Reconfigurable Fast Filter Bank for Multi-Standard Wireless Receivers". This paper presented by author a multi-standard wireless receiver (MSWR) enables different air interfaces to be implemented on a single generic hardware platform by replacing conventional analog signal processing with the digital signal processing. This brief presents a low-complexity reconfigurable fast filter bank (RFFB) for wireless communication applications such as spectrum sensing and channelization. The proposed low-pass MFT-VDF offers unabridged control over the cutoff frequency on a wide frequency range, [4].The paper by, S. Krishna Kumar "Area Efficient Reconfigurable Fast Filter Bank for Multi-Standard Wireless Receivers "this brief presented by author a reconfigurable fast filter bank (RFFB) with less gate counts for wireless communication applications such as spectrum sensing and channelization. RFFB offers fine control over sub band bandwidth without any reimplementation. This is accomplished with an improved modified frequency transformation-based variable digital filter. An area efficient RFFB with a MFT-VDF which allows fine control over the sub band bandwidth is designed with lower order sub filters i.e. lesser gate counts in sub filters when compared to other filter bank approaches, [5].The paper by, MichalLitwin "Orthogonal Frequency Division Multiplexing (OFDM) Transceiver" This project implemented by author an Orthogonal Frequency Division Multiplexing (OFDM) transceiver. The deliverable of the project is real-time processing MATLAB Simulink model of an OFDM transceiver implementation of a complete digital communication system based on most commonly used in wireless technology modulation scheme - Orthogonal Frequency Division Multiplexing. The orthogonally between overlapping subcarriers which is at the core of OFDM modulation requires a perfect synchronization, [10].The paper by, Nirmal Fernando, Yi Hong, EmanueleViterbo "Flip-OFDM for Unipolar Communication Systems" Unipolar communications systems can transmit information using only real and positive signals. Unipolar OFDM techniques enable to efficiently compensate frequency selective distortion in the unipolar communication systems.. In this paper, author first compare Flip-OFDM and ACO-OFDM, and show that both techniques have the same performance but different complexities (Flip-OFDM offers 50% saving). We then propose a new detection scheme, which enables to reduce the noise at the Flip-OFDM receiver by almost 3dB, [12]

III. SYSTEM DESCRIPTION AND MODEL

This model shows the OFDM system with transmitter and receiver section. The cyclic prefix acts as the guard interval and the reverse of transmission is accomplished at receiver end.

Generalized System of Ofdm

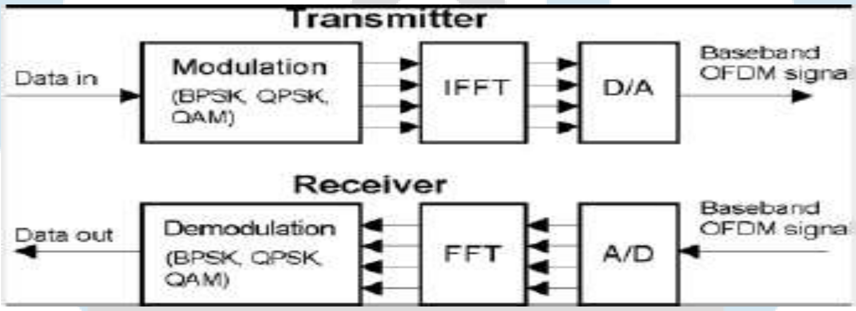

Figure: 3.1, Basic diagram of OFDM

Figure: 3.1 shows the basic block diagram of the OFDM system with transmitter and receiver section. The orthogonal frequency division multiplexing block diagram is illustrated as follows in figure 3.1. The input random signal data rate streams (high) are converted into data rate streams (low). The important aspect in the OFDM block diagram is the modulation technique which modulates the low data rate streams in parallel way and this parallel stream given input to the IFFT block which transforms the frequency data to time data before it reaches the channel. Adding the cyclic prefix acts as the guard interval and the reverse of transmission is accomplished at receiver end. [12]

The description of each block of the generalized block diagram are as follows,

To implement the OFDM transmission scheme, the message signal must first be digitally modulated. The carrier is then split into lower-frequency sub-carriers that are orthogonal to one another. An OFDM signal can be constructed using anyone of the following digital modulation techniques namely BPSK, QPSK, QAM etc. The data (D) has to be first converted from serial stream into parallel stream depending on the number of sub-carriers (N). Since we assumed that there are N subcarriers allowed for the OFDM transmission, we name the subcarriers from 0 to N-1.

Modulation is the technique by which the signal wave is transformed in order to send it over the communication channel in order to minimize the effect of noise. In an OFDM system, the high data rate information is divided into small packets of data which are placed orthogonal to each other. [14] Conceptually, the Fourier transform is used to convert the signals from time domain to frequency domain and the inverse Fourier transform is used to convert the signal back from the frequency domain to the time domain. If the signal is discrete in time that is sampled, one uses the discrete Fourier transform to convert them to the discrete frequency form DFT, and vice versa, the inverse discrete transform IDFT is used to back convert the discrete frequency form into the discrete time form. [14] Then Serial to Parallel convertor: Now, the Serial to Parallel converter takes the serial stream of input bits and outputs N parallel streams (indexed from 0 to N-1). These parallel streams are individually converted into the required digital modulation format (BPSK, QPSK, QAM etc..,). Finally, the resultant output from the N parallel arms are summed up together to produce the OFDM signal. Guard Interval Insertion (GII) is done in order to avoid ISI. At last, demodulation is the technique by which the original data is recovered from the modulated signal which is received at the receiver end.

Model of Reconfigurable Filter Bank

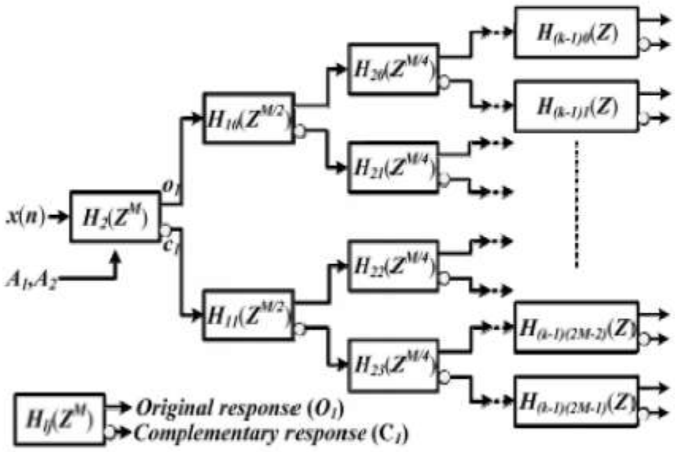

Figure 3.2: Reconfigurable fast filter bank [3]

Figure (3.2) shows that the low-pass VDF in the first stage is designed using modified second-order frequency transformation with transfer function *H*2*(Z)* in the form given by (3.2).The range over which cutoff frequency of *H*2*(Z)* can be varied is decided by parameters *A*1 and *A*2, while the order of the prototype filter of *H2(Z)* is decided by its TBW, pass-band ripple, and stop-band attenuation specifications. Expanding *D(Z)* in (3.1), we have the eq.(3.2):

$$D(Z) = A_0 Z^{-2} + A_1 Z^{-1}\left(\frac{1+Z^{-2}}{2}\right) + A_2\left(\frac{1+Z^{-2}}{2}\right)^2. \qquad (3.1)$$

From the constraints given by eq., we have A0 = 1 − A1 − A2. Substituting A0 into (3.1) and simplifying, we obtain given eq. (3.2):

$$D(Z) = A_1\left[\left(\frac{Z^{-1}+Z^{-3}}{2}\right) - Z^{-2}\right] + Z^{-2} - A_2\left[Z^{-2} - \left(\frac{1+Z^{-2}}{2}\right)^2\right]. \qquad (3.2)$$

In this way, only two multipliers are needed instead of three multipliers, to implement D(Z). A1 is fixed to unity. In the MFT-VDF, we have relaxed the constraint that A1 = 1 so that H2(Z) allows a much wider cutoff frequency range.[5] RFFB offers fine control over center frequency of fixed bandwidth sub-bands as shown in figure. All sub-bands in multiband responses O1 and C1 are individually extracted using sub filters in remaining (k − 1) stages [9].

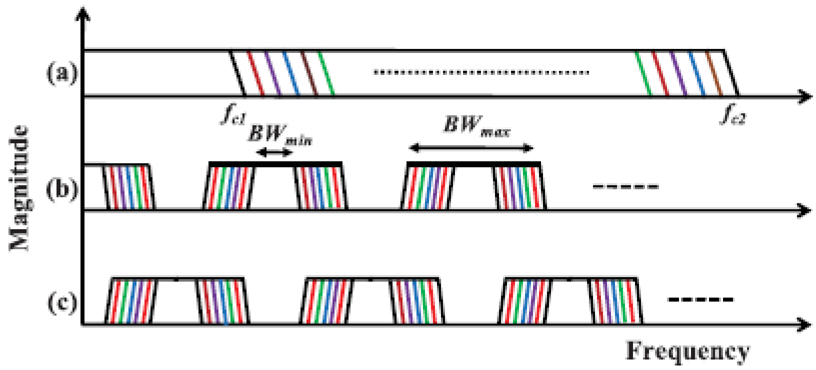

Figure.3.3: Frequency response of first stage a) Response of VDF, b) Original response O1, c) Complementary response C1

IV. CONCLUSION

An OFDM system and filter bank is successfully simulated using MATLAB in this project. All major components of an OFDM system are cover. This has demonstrated the basic concept and feasibility of OFDM and filter bank which was thoroughly described and explained in this report.In conclusion, OFDM is a very promising technology, and practical adaptive rate algorithm serves well to improve performance. In this paper we have proposed a spectrum sensing technique based on reconfigurable filter bank, which can have variable sensing resolutions and can adapt to different sensing bandwidths by software reconfiguration.

Using this having a gate count reduction and power reduction of over other filter bank. In futuremay be we can improve the system model in the field of wireless communication. Also since this system is used for wireless application, i.e. 3G communication.

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