Development of Reconfigurable High Speed Filter Bank for Wireless Receiver

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Abstract- 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 reconfigurable high speed filter bank, the bandwidth and center frequency of sub-bands can be varied with high frequency resolution. This is achieved with an improved Modified frequency transformation-based variable digital filter (MFTVDF). This low-pass MFT-VDF offers unabridged control over the cutoff frequency on a wide frequency range. The work deals with the interfacing of MFT-VDF with orthogonal frequency division multiplexing (OFDM) wireless application. In thiss dissertation, orthogonal frequency division multiplexing (OFDM) is used which is a combination of modulation & multiplexing. It is multi-carrier high data transmission scheme which supports 4G and has tremendous scope in the field of wireless communication. Unipolar communications systems can transmit information using only real and positive signals called as Flip-OFDM technique it is originally designed for optical communication to obtain error free transmission of data signal. Using MFT-VDF filter bank in OFDM side lobes in the signals are removed and achieved error free output and the design example shows that the RFFB is easy to design and offers substantial savings in gate counts over other filter banks.

Keywords- Orthogonal frequency division multiplexing (OFDM), reconfigurable filter bank, flip-OFDM, variable digital filter (VDF).

I. INTRODUCTION

Orthogonal Frequency Division Multiplexing (OFDM)

In a single carrier communication system, the symbol period must be much greater than the delay time in order to avoid inter-symbol interference (ISI). OFDM (Orthogonal Frequency Division Multiplexing) is a multicarrier digital communication scheme to solve both issues. In orthogonal frequency division multiplexing communication model the sub carrier used are orthogonal to each other. The orthogonally helps in employing the overlapping between the sub carriers in the respective frequency domain. The accuracy of communication model is based on how effective the bandwidth is used and this is technically termed as spectral efficiency or bandwidth efficiency, the acquired bandwidth efficiency is free of Inter carrier interference and the absence of Inter carrier interference is mainly because of usage of orthogonally in orthogonal frequency division multiplexing [10].

To overcome this problem, orthogonal frequency division multiplexing (OFDM), which is now widely used as multi-carrier modulation in both wire line and wireless communications, is employed since OFDM provides a good protection against ISI. OFDM is not only used in RF wireless technology, but is also increasingly used in OWC wireless technology. For data transmissions with IM/DD, OFDM signals must be real and non-negative, namely unipolar, whereas transmitted signals of traditional OFDM are bipolar. There are a techniques to make OFDM signals unipolar. In this paper we are going to transmit the signal through a novel OFDM technique named as Flip-OFDM.

Concept of Flip-OFDM

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. [9]

Review of Filter Bank

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. The discrete Fourier transform filter bank is a modulated filter bank that consists of a low-pass prototype filter followed by DFT 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. An improved DFTFB using coefficient decimation method (CDM) allows changing sub-band bandwidths using a fixed-coefficient filter but it fails to have fine control over sub-band bandwidth because the decimation factor in the CDM is restricted to be integers. Also, center frequency of sub-bands in CDM-DFTFB is fixed. The fast filter bank, is a low complexity alternative to DFTFB and is suitable for applications requiring sharp transition bandwidth. [5] However, the FFB has the drawbacks of uniform subband bandwidth. Several improvements in FFBs are suggested, particularly multi resolution FFB in also has only coarse control over sub-band bandwidth by changing the filter bank resolution. [2] 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. A VDF that offers wide cutoff frequency range is desired. The reconfigurable FFB (RFFB) is designed by replacing fixed-coefficient low-pass subfilter in the first stage of FFB with the MFT-VDF. The subfilters in RFFB have higher order than FFB that can be reduced by varying the subfilters TBW. The RFFB provides fine control over the sub-band bandwidth on the desired bandwidth range. [4] This makes RFFB suitable for multi communication standards with different channel bandwidth. [3]

Review of Variable digital filter (VDF)

VDF is a filter whose frequency specifications such as cutoff frequency, *fc*, phase delay or group delay can be controlled through a small number of parameters with minimum overhead on complexity. For the RFFB, a linear phase VDF that offers unabridged control over *fc* on a wide frequency range is desired. A number of linear phase VDF designs are available in literature. [1] A programmable filter cannot provide an efficient solution due to the large memory and reconfiguration time required. CDM-VDF in fails to provide unabridged control over *fc* on a wide frequency range. Farrow structure based VDFs have higher gate count complexity compared to frequency transformation-based VDFs when *fc* needs to be varied over a wide frequency range. Hence, we shall concentrate on frequency transformation-based VDFs [8].

II. PROBLEM IDENTIFICATION

Previous system is more complex gives low spectral efficiency. Conventional OFDM system is used for bipolar communication. In previous existing filter bank are more complex i.e. CDM-FB. In this the gate counts are more. In this system we use flip-OFDM for unipolar communication. It is used for a high speed data transfer. We reduce parameters in filter bank using MATLAB Simulink platform. In our system we reduce complexity using following technique In this paper. In wireless communication, we transfer the data without loss i.e. packet loss etc. We used this system in high data rate communication.

III. DESIGN AND IMPLEMENTATION

Actual System

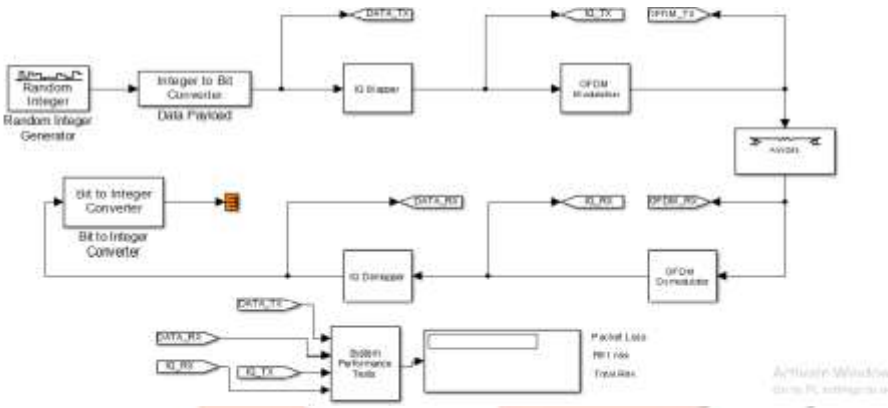

Figure3.1: Design of OFDM system model in MATLAB Simulink

Figure.3.1 shows the design of block diagram of flip-OFDM system interface with the RFFB filter bank at the transmitter section in MATLAB Simulink.

OFDM Transmitter Blocks

In the modulator block of OFDM in transmitter section the flip-OFDM is work. 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.

- Random Integer Generator Generate random uniformly distributed integers in the range [0, M-1], where M is the M-ary number.
- Integer to Bit Convertor block maps each integer in the input vector to a group of bits in the output vector. The block maps each integer value to a group of M-bits, using the selection of the output bit order to determine the most significant bit. The resulting output vector length is M times the input vector length. Block inputs must be integer values in the range [-2^ (M-1), 2^ (M-1)-1] when they are treated as signed and [0, 2^M-1] when they are treated as unsigned. Fox fixed-point inputs, the stored integer value is used.
- IQ-Mapper, the symbol mapper consists of a QAM modulator. The input 2-bit stream fed to the modulator divides it into two 2-bit symbols called I and Q (imaginary and quadrature). In QAM there are four phases, each 2-bit symbol is assigned to a phase, which are of 90 degrees difference between them. [11].
- OFDM Modulation, at the OFDM modulator we interface the Fast Filter Bank using the filter bank coefficient that is already coded in MATLAB. We invoked this filter coefficient represented by 'F' symbol in coding. There are many numer of filter coefficient but we used the seven filter coefficient diagonal matrix or confession matrix and classes, actual values. Read data values specified in time series, matrix, or structure format from the MATLAB workspace, model workspace, or mask workspace. MATLAB time series format may be used for any data type, complexity, or fixed dimensions. To load data for a bus signal, use a MATLAB structure that matches the bus hierarchy and specify time series for each leaf signal. For matrix formats, each row of the matrix has a time stamp in the first column and a vector containing the corresponding data sample in the subsequent columns. Then we interface the filter bank to the multiport selector using data type, Force all inputs to have the exact same data type. At the modulator we used the flip OFDM modulation, in this technique we connect the multiport selector lines divides in two frames i.e. real and imaginary frames or positive and negative frames. In the modulator block of OFDM in transmitter section the flip-OFDM is work. 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. [6]

- Interfacing of Filter Bank- in the OFDM, we interface the filter bank at modulator block in transmitter section. What is used of this filter bank in OFDM are as follows:

Orthogonal frequency division multiplexing (OFDM) is the current dominant technology for broadband multicarrier communications. Orthogonally of subcarrier signals, which enables the generation of transmit signal through an inverse fast Fourier transform (IFFT). Closely spaced orthogonal subcarriers partition the available bandwidth into narrow sub bands. Simplified carrier and symbol synchronization due to the special structure of OFDM symbols. However, in certain applications like wireless data communication and in the uplink of multiuser. Multicarrier systems, Where a subset of subcarriers is allocated to each user, OFDM may be an undesirable solution. In this blog post series, we look at some of the shortcomings of OFDM and conclude that Filter Bank could be a more effective solution in certain situations. Formulate equations that both apply to Filter Bank and OFDM. In OFDM, the main problem comes from the side lobes of each subcarrier,

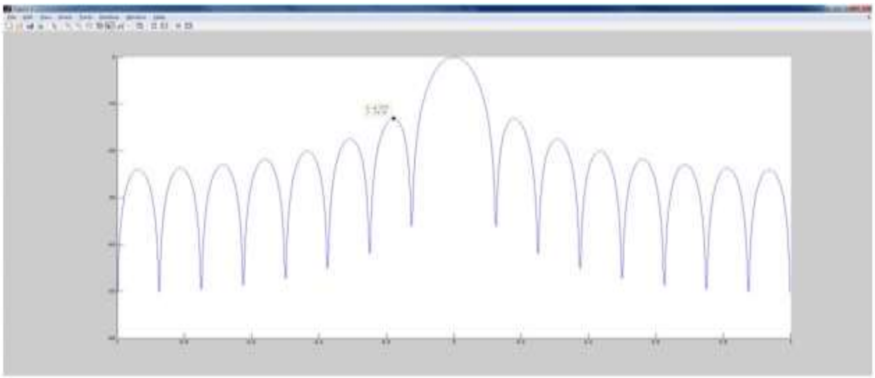

Figure: 3.2: side lobes of each carrier

The figure.3.2 above illustrates the frequency response of a subcarrier in an OFDM symbol. The first side lobe is only 13 dB lower than the main lobe. This frequency response is created by the filters associated with the synthesized subcarrier signals at the transmitter and the analyzed subcarrier signals at the receiver. The difference between OFDM and Filter Bank using OFDM lies in the choice of filter. Since each subcarrier needs to be filtered by this filter bank in OFDM, we can modify the transmitter block diagram accordingly as shown in figure: (3.3),

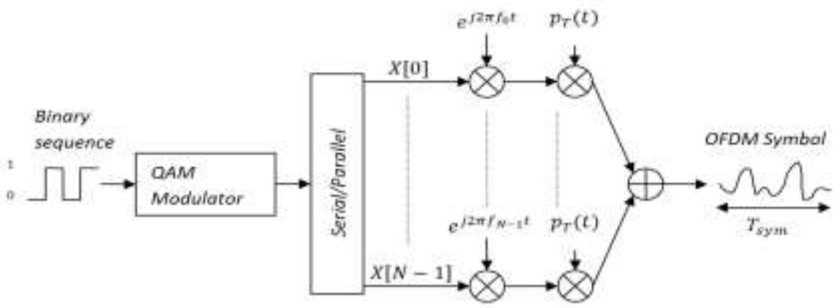

Figure3.3: modify the filter bank coefficient at transmitter

Since the above diagram and mathematical equation shows how to eliminate the side lobes in transmitted signal using filtering and data is transmitted without any loss. This digital data bits are transmitted using optical wireless channel i.e. AWGN channel. In most OWC systems, an infrared emitter is used as optical transmitter to generate optical signal x (t). At the receiver, a photo detector collects optical signal and converts it into electrical current y (t).

OFDM Receiver Section

Reconstruction and detection process at receiver is given Reconstruction and detection process at receiver. Cyclic prefixes associated with each OFDM sub frames are removed. Original signal can be reconstructed as – Here y_1 (k) and y_2 (k) represent time domain samples received in +ve and –ve sub frames. To detect transmitted QAM signal, FFT is used at receiver. [7] FFT can be applied in the digital signal processing of OFDM symbols since they can transform these symbols from time domain to frequency in the demodulator. Demodulate the input signal using the quadrature amplitude modulation method. This block accepts a scalar or column vector input signal. Map a vector of bits to a corresponding vector of integer values. M defines how many bits are mapped for each output integer. The input length must be an integer multiple of M.

IV. EXPERIMENTAL RESULT & DISCUSSION

Output 0f Filter Coefficient

Figure shows filter coefficients and selected diagonal matrix of required filter coefficients are as follows,

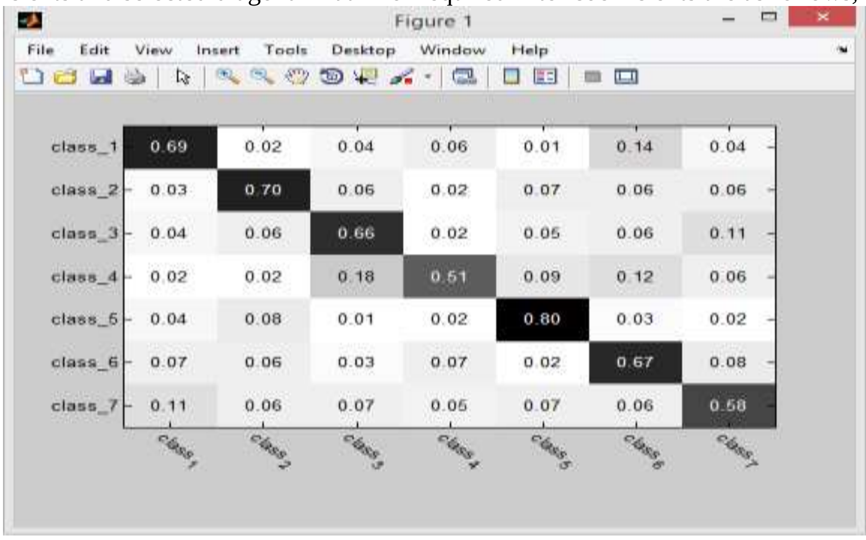

Figure 4.1: various filter coefficients in 7 classes

V. PERFORMANCE COMPARISON

Table 1.1: performance comparison

Parameters	Existing Methods			VDF
	CDM-DFTFB	RFFB	VDF in[11]	
Multipliers	461	191	327	210
Multiplexers	429	0	26	9
Adders	492	566	406	395
Total gate count	8,63,315	4,32,950	6,15,460	59234

This filter bank is designed in MATLAB Simulink for reduced the complexity, for this we reduced the parameters i.e. multiplier, multiplexer and gate counts as compared to the existing filter bank in various platform.

The graphical representation of this table 6.1 is as shown below,

VI. OUTPUT PERFORMANCE

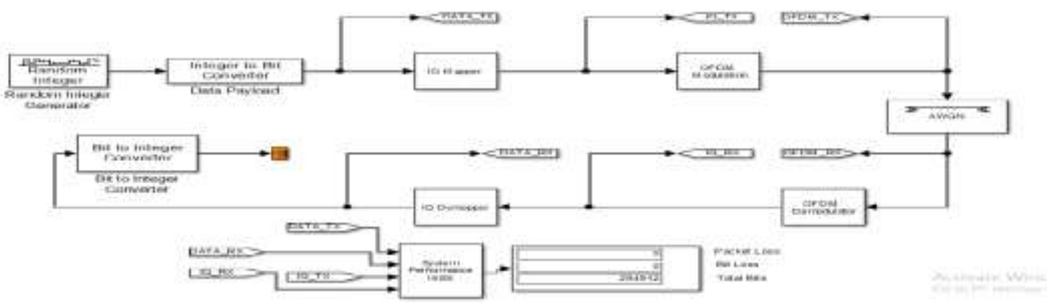

Figure 6.1: output of the OFDM system model

From the figure.6.3 shows the transmitted data signal is received at the output stage is without any loss i.e. packet loss and bit loss is zero.

VII. GRAPHICAL REPRESENTATION

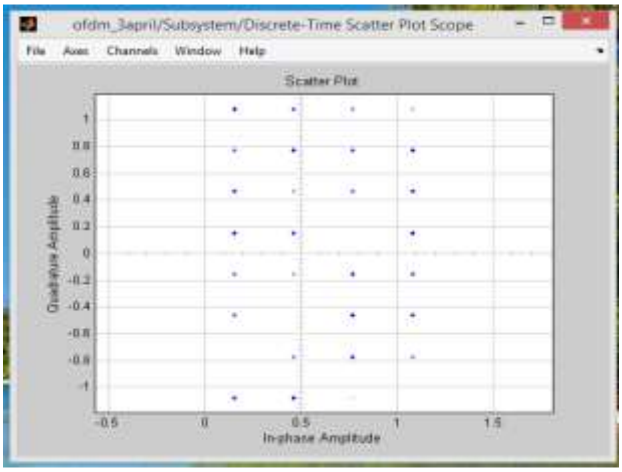

Figure7.1: Scatter Plot of Transmitted Data

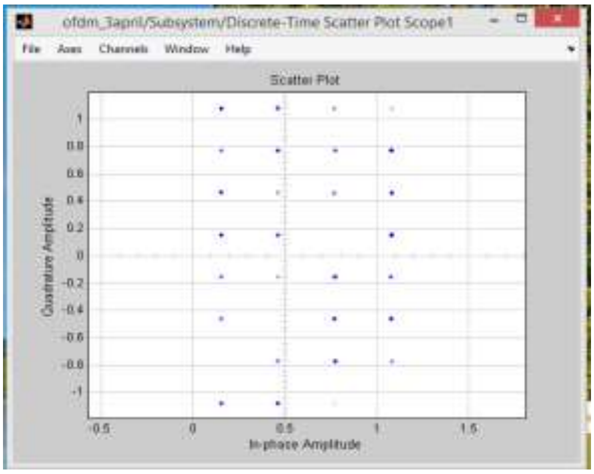

Figure7.2: Scatter Plot of received data

VIII. DISCUSSION

The result of our work is to transmit the data without any loss and it recovered fully at the receiver end of the ofdm system using filter bank in wireless communication. Using filter bank design in ofdm system side lobes of the signal are removed and no loss in signal. The RFFB provides high resolution control over sub-band bandwidth by varying parameters of filter. This makes the RFFB useful for the channelization or spectrum sensing scenario where channel bandwidth is fixed but their locations may vary dynamically. And we reduced the multiplier, multiplexer, adder and gate counts in filter bank using MFT-VDF technique using MATLAB simulation.

IX. ADVANTAGES, DISADVANTAGES AND APPLICATION

The OFDM system and filter bank has many advantages, the main advantages using filter bank in OFDM system the side lobes in transmitted signal is reduced and received data without any loss. It also has many advantages are as follows,

In OFDM technology is supports high data rate stream and transmitted simultaneously.

One of the main advantages of OFDM is that is more resistant to frequency selective fading than single carrier systems because it divides the overall channel into multiple narrowband signals that are affected individually as flat fading sub-channels. Another advantage of OFDM is that it is very resilient to inter-symbol and inter-frame interference. This results from the low data rate on each of the sub-channels. An OFDM is that using multiple sub-channels, the channel equalization becomes much simpler.

It has the only limitations is that to design wider BW and higher dynamic range system will have more challenges in achieving RF performance. Another disadvantage of OFDM is that is sensitive to carrier frequency offset and drift. Single carrier systems are less sensitive.

There are several applications are as follows,

DAB (Digital Audio Broadcaster), HDTV (High-definition Television), Wireless LAN, IEEE 802.16, IEEE 802.20, DSL, etc.

X. CONCLUSION

An OFDM system using 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 our work, OFDM application using flip-ofdm and filter bank i.e. the RFFB filter bank to reduce the side lobes in transmitted signal and reduced the complexity. Implementation result shows that the received data at receiver section are without loss in wireless communication. An RFFB using VDF's a MFT-VDF was presented in this brief. The RFFB allowed fine control of the sub-band bandwidths and their center frequencies. Rffb design using VDF's in MATLAB simulation achieved result is to reduce the parameter i.e. multiplier, multiplexer, adder and gate counts compared to the other filter banks.

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