Polyphase Filter to Denoise OFDM Signals

Irfan Ahmad Sheikh[1], Nirmaljeet Kaur Pannu[2]
[1]Research Scholar, [2]Head of Department
[12]Adesh Institute of Technology, Mohali, Punjab, India

Abstract- A spectrally efficient digital modulation mechanism in which multiple carriers are present that are mutually orthogonal to each other over particular time is known as Orthogonal Frequency Division Multiplexing (OFDM) system. Amongst traditional signals, there is a need to involve a guard band. However, in OFDM systems this is not required. Even though there is an overlap of the sidebands from each carrier, there is no interference involved within the signals that are received here since they are orthogonal with respect to each other. This research work is based on wireless channel to reduce bit error rate using space-time trellis codes. In this research work, the bit error rate is reduced over the wireless channels using space time trellis codes and poly-phase filters. The simulation of the proposed modal is performed in MATLAB and results show that bit error rate is reduced in the network.

Keywords- Signal Denoising, OFDM, Polyphase Filter

I. INTRODUCTION

Wireless communication can be defined as the process through which data is transmitted to two locations that are not connected to each other physically. For providing communications in the wireless technology, electromagnetic waves are utilized. On the basis of different applications in which this communication is being used, these waves travel in smaller distances. Several fixed, mobile as well as portable applications include such mode of communication. There are two-way radios, personal digital assistants (PDAs) and various other modes included here. Other components such as keyboards, radio receivers, headsets etc. are include within the radio wireless applications as well [1]. For providing communication, the light, sound, magnetic or electric fields are included within the wireless communication technology. However, in comparison to the above mentioned mediums, these modes of communication are used less. Orthogonal frequency-division multiplexing (OFDM): OFDM is the technology in which the digital data is encoded on multiple carrier frequencies. There are wireless and wired communications available within the wideband digital communications being performed. Thus, the OFDM systems have also begun to utilize these two modes. Multiple-input and multiple-output (MIMO) is defined as the technology in which the transmitter and receiver ends have multiple antennas [2]. In the systems that are attained from receiver's end, there are several copies provided for similar type of information signal. From more than two real or virtual communication channels, the transmission of these copies can be done. The basic work provided within diversity in the repetition or redundancy of data present in the networks. In the diversity method, the decisions are made by receiver and the transmitter also does not know about them. Further, for transmission of signal, several propagation paths are also available [3]. The occurrence of fading process within wireless channel can result in affecting the signal across particular propagation media. There is variation in fading as per the time, geographical location or radio frequency being used. The processing here is done in random manner. A fading channel is known to be the one in which there is communication as well as fading included. The fading might be caused in wireless systems either because of multipath propagation or because of shadowing from the obstacles [4]. A signal is a function of independent variables, for example, time, distance, position, temperature and pressure. A signal conveys information, and the objective of signal processing is to extract valuable information conveyed by the signal. Signal processing is concerned with the mathematical representation of the signal and the algorithmic operation did on it to extract the information available. The rapid development of science and engineering is a result of the significant advances in digital computer technology and integrated circuit fabrication [5]. The digital computers and associated digital hardware of three decades prior were relatively large and expensive and, as a consequence, their utilization was limited to broadly useful non-real-time (disconnected) scientific computations and business applications. Electric equipment is vigorously utilized as a part of almost every field. Analog to Digital Converters (ADC) and Digital to Analog Converters (DAC) are essential components for any variation of DSP in any field. These two converting interfaces are important to convert real world signals to take into account digital electronic equipment to get any analog signal and process it. Digital filters are a vital part of DSP. Truth to be told, their extraordinary performance is one of the key reasons that DSP has turned out to be so popular. Filters have two uses: signal separation and signal restoration. Signal separation is required when a signal has been contaminated with interference, noise, or different signals. There are five fundamental filter types (bandpass, notch, low-pass, high-pass, and all-pass). The number of possible bandpass response characteristics is infinite, yet they all share a similar fundamental form [6]. The curve present in the graphs of bandpass may be called an "ideal" bandpass response, with totally constant gain inside the passband, zero gain outside the passband, and an abrupt boundary between the two. A filter with effectively the opposite function of the bandpass is the band-reject or notch filter. Notch filters are utilized to remove an unwanted frequency from a signal, while affecting all other frequencies a little less. A third filter type is the low-pass. A low-pass filter passes low frequency signals, and rejects signals at frequencies over the filter's cutoff frequency. The opposite of the low-pass is the high-pass filter, which rejects signals below its cutoff frequency [7]. A high-pass filter can be made by rearranging the components. High-pass filters are utilized as a part of applications requiring the rejection of low-frequency signals. A FIR filter requires more computation time on the DSP and more memory. The DSP chip in this way needs to be all the more powerful. miniDSP products that support FIR filtering include the OpenDRC and the miniSHARC kit. A FIR filter is designed by finding the coefficients and filter order that meet certain specifications, which can be in the time-domain (e.g. a matched filter) and additionally the frequency domain (most regular).

II. LITERATURE REVIEW

Hen-Geul Yeh, et.al (2016) presented that for OFDM systems, coding gain as well as diversity gain are provided along with ensuring that bandwidth efficiency is not minimized by using Space-time trellis code (STTC) techniques. In order to enhance BER within the frequency selective mobile fading channels, three STTC-based OFDM systems are presented in this paper [8]. In comparison to existing STTC-WH-ST-OFDM and STTC-ST-OFDM systems, the proposed STTC-WH-STCC-OFDM system proves to be better as per the simulation results. The compatibility of all three systems is good with respect to OFDM systems and they are also simple to implement. For multiuser OFDM systems, these algorithms serve as baseband building blocks.

Neethu V, et.al (2017) proposed a novel technique in order to enhance the overall performance of OFDM systems [9]. The trellis coded orbital angular momentum- quadrature amplitude modulation (OAM-QAM) and enhanced time frequency multiplexing techniques (eTFM) are integrated in order to generate a novel approach. The mapping of trellis coded data to the OAM-QAM constellation points is done and by utilizing viterbi decoder, this data is identified. By ensuring that the bandwidth is not expanded, the coding gain is enhanced here. In comparison to traditional approaches, there is minimization of BER value due to the increase in Euclidean distance. Thus, there is enhancement in performance of results achieved through proposed technique.

Houshou Chen, et.al (2018) proposed a novel algorithm in order to minimize the peak-to-average power ratio (PAPR) within OFDM signals [10]. Within the least trellis of block codes, partial transmit sequence (PTS) is executed here. In order to select the transmitted OFDM signal that has least PAPR, a linear code that includes good minimal trellis is applied. Through correct of error, the side information is then transmitted. As per the simulations performed and results achieved it is seen that the complexity is minimized along with minimization of PAPR through the application of proposed technique.

Samet Yıldız, et.al (2016) proposed an enhancement maximum-likelihood decoding method in order isolate each of the transmitted signals at the relevant receiver [11]. Here, at the transmitter, a multiplexer is used and at the receiver, a de-multiplexer is used. Enhanced frame error rate (FER) performance is achieved by applying STTC-OFDM as per the experiments conducted. In order to aggregate the system such that the proposed as well as existing methodologies can contrast, the Doppler impact is included here. Enhancements in simulation results show that the proposed mechanism is better in comparison to other already existing approaches.

Ryota Yoshizawa et.al (2016) proposed a novel constellation design in which at the receiver end, the controlling bits as well as information bits can be separated perfectly [12]. The trellis-based constraint that is generated through a bank of memories is used to control the bits. Further, for the proposed system, a novel constellation design is appropriate. For the coded OFDM systems, a simple implementation that includes soft-in soft-out (SISO) decoder is generated here. The performance of proposed system is analyzed in terms of several performance parameters. Further, the practical advantage of this approach in high spectral efficiency system is seen through the comparisons made amongst proposed and several existing approaches.

Funmilayo B. Offiong, et.al (2016) proposed a novel pilot-assisted method in this paper by which the peak-to-average-power-ratio has been minimized for which they utilized the optical orthogonal frequency division multiplexing systems in this paper. DCO-OFDM and ACO-OFDM are the two systems was studied in this paper, these are the time domain signals. They utilized the Gaussian and half-Gaussian distributions in their systems in order to obtain the better performance [13]. Due to the higher value of P and due to the minimization of PAPR, there is huge complexity. The better results have been provided by this method by which optical energy per bit to noise power spectral thickness ratio has been minimized. They performed various experiments and comparisons on the basis of various parameters and concluded that proposed method has better performance as compared to other methods.

III. RESEARCH METHODOLOGY

In order to mitigate ICI, the 2x1 STCC-OFDM systems are developed which are majorly inspired from the 2-path transmission mechanism of CC-OFDM schem. There is backward compatibility of most of the existing OFDM systems with that of STCC-OFDM system. Through the selection of either time division multiplexing (TDM), frequency division multiplexing (FDM) or code division multiplexing (CDM), the multiplexing (MUX) circuit is applied at transmitter and de-multiplexing (DEMUX) circuit at the receiver. Through these steps, the STCC-OFDM systems are designed.

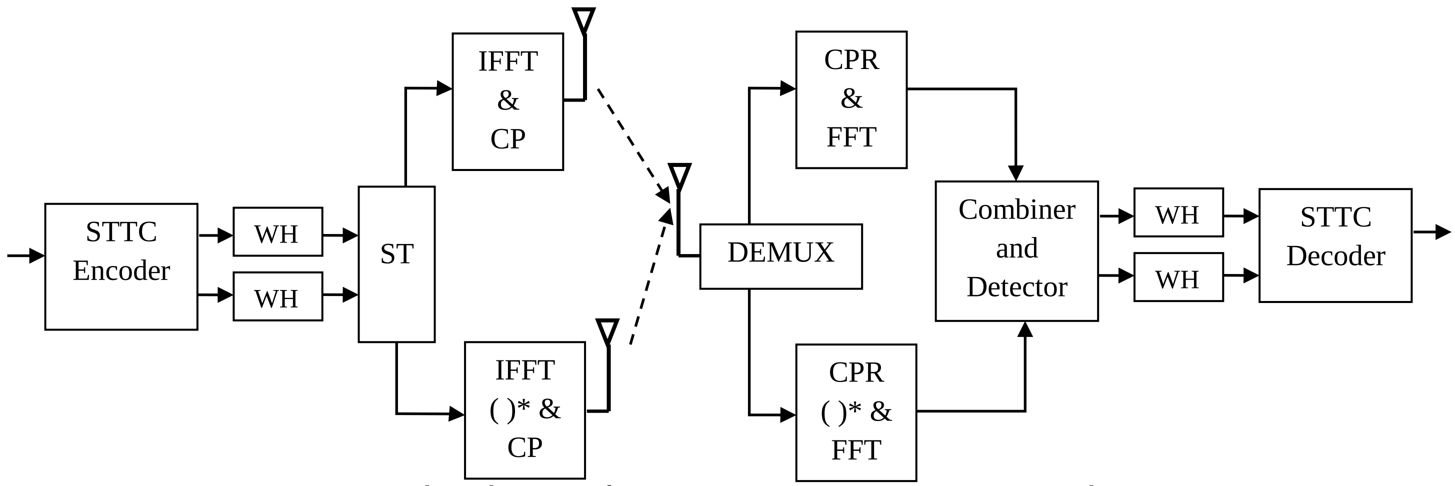

Fig.1: The architecture of a 2x1 STTC-WH-STCC-OFDM System with WHT pre-coders and CC scheme for mitigating ICI

A novel architecture is shown in figure 1.1 above. Here, a novel STTC-WH-STCC-OFDM system is presented by integrating STTC-WH-ST-OFDM and the STCC-OFDM system. At the transmitters end, multiplexing (MUX) circuit is added and at receivers end, de-multiplexing (DEMUX) circuit is added. A high transmission diversity gain is provided amongst the subcarriers present in OFDM block by the pre-coder WHT. However, within the two blocks, the conjugate data copies are transmitted externally with the help of two-path transmission method. It is also possible to extend the MISO model to MIMO architecture here.

The coded as well as WH transformed symbol vectors those are (d_1', d_2') and $(-d_1'^*, -d_2'^*)$ are forwarded to the two parallel branches at time slots 1 and 2. IFFT is performed within the upper branch as well as IFFT and conjugate operations ( )* are performed together in lower branch. In order to demodulate the received signal from Tx1, an FFT is employed by upper branch at the receiver baseband [15]. However, a conjugate operator is applied initially and then an FFT is applied for demodulating the received signal from Tx2 at the lower branch. In order to process the upper as well as lower branches separately, the DEMUX is utilized here. At time slots 1 and 2, and Tx1 and Tx2, the four signal vectors that are received are given below:

$$y_{111}' = FFT\left[\square_{11} * \left(IFFT(d_1')\right)\right] = H_{11} d_1' \qquad \ldots(1)$$

$$y_{121}' = FFT\{\left[\square_{12} * \left(IFFT(d_2')\right)^*\right]^*\} = H_{12} d_2' \qquad \ldots(2)$$

$$y_{112}' = FFT\left[\square_{11} * \left(IFFT(-d_2'^*)\right)\right] = -H_{11} d_2'^* \qquad \ldots(3)$$

$$y_{122}' = FFT\{\left[\square_{12} * \left(IFFT(d_1'^*)\right)^*\right]^*\} = H_{12} d_1'^* \qquad \ldots(4)$$

Further, hard decision variables are achieved through the assumption that across two consecutive time slots, fading is constant and these variables are shown below as:

$$\overline{d_1} = \Psi^{-1} H_{11}^* y_{111}' + H_{12}^* y_{122}'^* = \Psi^{-1}\Psi(|H_{11}|^2 + |H_{12}|^2) d_1 \qquad \ldots(5)$$

$$\overline{d_2} = -\Psi^{-1} H_{11} y_{112}'^* + H_{12} y_{121}' = \Psi^{-1}\Psi(|H_{11}|^2 + |H_{12}|^2) d_2 \qquad \ldots(6)$$

Here, the hard detected signal vector is represented by $\bar{d}_j, j = 1,2$. Through the receiver antenna Rx1 this signal is obtained and then through Tx antenna j it is transmitted. With the help of CC, the channel impact to subcarriers is compensated after the IWHT and coherent combiner and detector. For novel STTC-WHSTCC-OFDM system, the new deconder algorithms are generated through equations (5) and (6). Thus, by concerning on each subcarrier, the hard-detected signal vectors enter the ML decoding algorithm.

$$\hat{\hat{b}} = arg_Q \min\left(\sum_{k=0}^{N-1}\left|\bar{d}_1^k - Q_{11k}\right|^2 + \sum_{k=0}^{N-1}\left|\bar{d}_2^k - Q_{12k}\right|^2\right) \qquad \ldots(7)$$

Here, the kth element of hard detection vector is denoted by $\bar{d}_1^k$. With respect to the receiver antenna Rx1 and the transmit antenna Tx "j", this hard detection vector is represented as $\overline{d_j}, j = 1,2$. Using two decision vectors which are $\overline{d_1}$ and $\overline{d_2}$ and including all possible code words that are Q_{11k} and Q_{12k} respectively, the two squared Euclidean distances are calculated separately [15]. Equation (7) shows the computation of final soft detected data bit vector that is denoted by $\hat{\hat{b}}$. The STTC, pre-coder WHT, and conjugate cancellation are combined with each other in this mechanism and it is seen that there is enhancement in the performance of BER in terms of MUX and DEMUX operations at Tx and Rx, respectively, in comparison to other previously studied approaches.

IV. EXPERIMENTAL RESULTS

Filtering is a very common factor required within the radio communication systems as there is lot of noise present within them. For removing this noise from the electromagnetic signals, an effective filtering algorithm is applied.

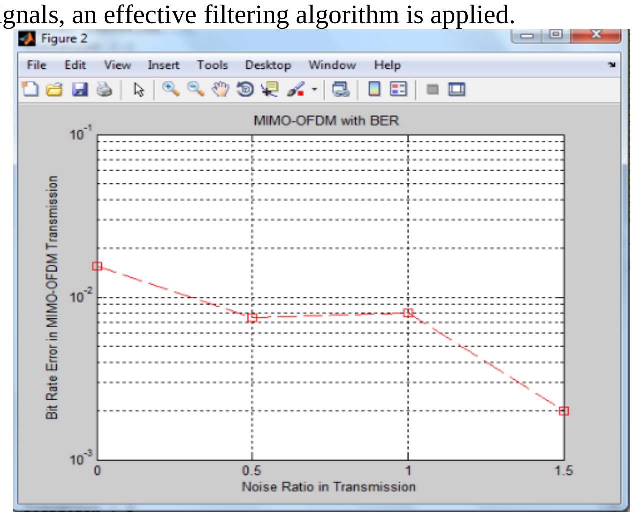

Fig.2: Bit error rate due to noise

As shown in figure 2, the noise ratio within the MIMO-OFDM systems, the red line depicts the noise ratio.

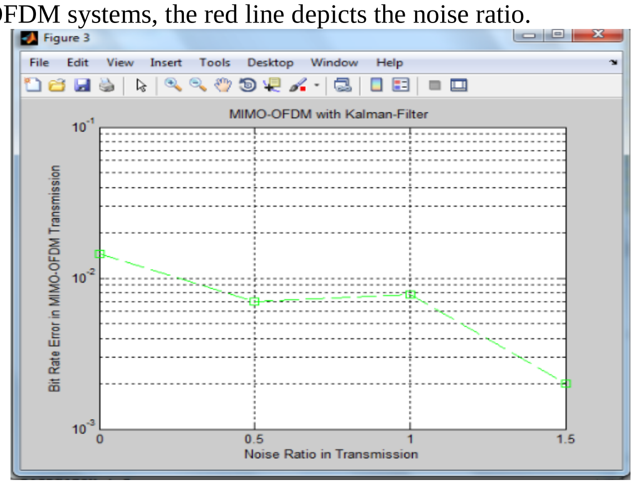

Fig.3: Noise ratio with POLY-PHASE filter

As shown in figure 3, the noise ratio is represented with the help of Poly-phase filter within the MIMO-OFDM systems.

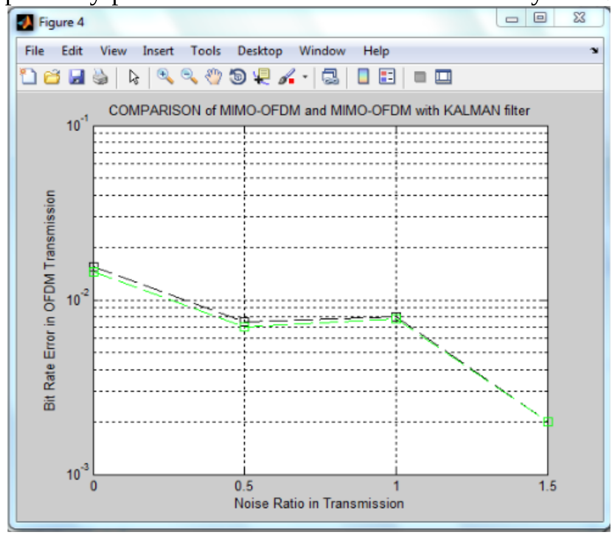

Fig.4: Comparison between MIMO-OFDM and with POLY-PHASE filter

As shown in figure 4, the noise ratio is represented with black line and green line shows noise ratio with the utilization of POLY-PHASE Filter. There is reduction in noise ration and bit error with the utilization of Poly-phase filter in comparison to the genuine MIMO-ODFM systems.

V. CONCLUSION

In this work, it is concluded A spectrally efficient digital modulation mechanism in which multiple carriers are present that are mutually orthogonal to each other over particular time is known as Orthogonal Frequency Division Multiplexing (OFDM) system. A sub-carrier is known as a carrier in which a pair of sine wave as well as cosine wave is involved. There are several closely spaced modulated carriers present within an OFDM signal. A propagation medium whose characterization is done through the wave phenomena is known as a mobile radio channel. The wireless fading channel has very high bit error rate. In this research work, the space-time trellis codes and poly phase filter is applied to reduce bit rate error. The simulation of proposed modal is implemented in MATLAB and results shows up to 20 percent improvement in the results.

VI. REFERENCES

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