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Optimization of Bit Error Rate Using MIMO OFDM System

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Abstract *– The major challenging task in multiple input multiple output (MIMO) OFDM systems is to design a good channel estimation method with less computational complexity and lower value of bit error rate (BER). Here, a novel signal processing method based on combining the advantages of multi-scale property of wavelet transform (WT) with blind estimation capability of independent component analysis (ICA), called, a multi-scale ICA (MS-ICA) has been proposed to estimate the channel characteristics. The MS-ICA method can effectively identify the channel impulse response under unknown channel conditions i.e. blindly. Performance of the proposed MSICA method is evaluated by calculating the BER for different fading channels. As compared to other well known OFDM channel estimation methods the proposed MS-ICA method resulted in a lower value of BER, which indicates the superiority of the proposed method. The proposed ASP channel estimation method firstly utilizes the PN based correlation in the time-domain to obtain the auxiliary channel information.*

Keywords*: MIMO, OFDM, Channel estimation, Bit error rate,*

I. Introduction

Orthogonal frequency division multiplexing (OFDM) is an increasingly popular multicarrier modulation technique, mainly because of its ability to combat multipath effects in wireless communication systems. It has been implemented in several wire line and wireless high-speed data communications standards (ADSL [6], IEEE 802.11 [6], HiperLAN) and has been adopted by the European digital audio and video broadcasting standards (DAB and DVB). [6] Wireless communication system requires an effective communication technique which should combat the shortcomings produced by the high data rate and high bandwidth systems. The main problem with high data rate systems over a frequency selective fading channel is inter symbol interference (ISI), which can be easily eliminated by the use of spectral efficient orthogonal frequency division multiplexing (OFDM) [1]. The advantages of OFDM system makes it a way to important applications in third, fourth generation wireless communication systems, military, commercial applications, wireless LANs and WiMAX. [1]

Orthogonal frequency-division multiplexing (OFDM) is generally known as an effective technique for prime bit rate applications like digital audio broadcasting (DAB), digital video broadcasting (DVB), and digital high-definition television (HDTV) broadcasting, since it will stop intersymbol interference (ISI) by inserting a guard interval and may mitigate frequency selectivity of a multipath channel using a simple one-tap equalizer [2]. In an OFDM system, though the degree of channel variation over the sampling amount becomes smaller as data rates increase, the time variation of a fading channel over an OFDM block period causes a loss of sub channel orthogonality, resulting in an error floor that increases with the Doppler frequency. The performance degradation due to the interchannel interference (ICI) becomes significant as the carrier frequency, block size, and vehicle rate increase. The time-domain compensation technique, which can reduce the fading distortion in a flat (not frequency selective) Rayleigh fading channel by correcting gain and part distortions of the received time-domain signal using a pilot symbol, is proposed. In [2], the frequency domain equalization technique is proposed to catch up on the fading distortion with less noise improvement in an exceedingly flat Rayleigh fading channel. [2]

Orthogonal Frequency Division Multiplexing may be a style of signal modulation that divides a high data rate modulating stream placing them onto many slowly modulated narrowband close-spaced subcarriers and during this method is a smaller amount sensitive to frequency selective weakening. Orthogonal Frequency Division Multiplexing or OFDM is a modulation format that is being used for many of the latest wireless and telecommunications standards. OFDM has been adopted within the Wi-Fi arena wherever the standards like 802.11a, 802.11n, 802.11ac and more. It has also been chosen for the cellular telecommunications customary LTE / LTE-A, and additionally to the current it's been adopted by different standards such as WiMAX and many more.

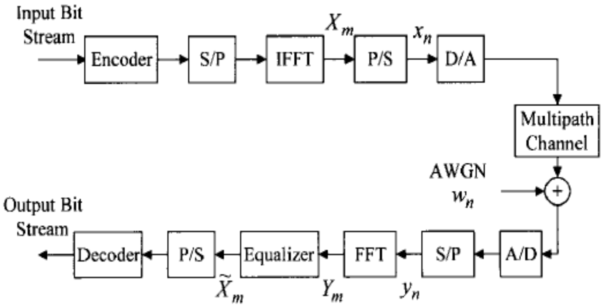

Fig. 1 A baseband block diagram for an OFDM system

OFDM is a style of multicarrier modulation. AN OFDM signal consists of variety of closely spaced modulated carriers. When modulation of any form - voice, data, etc. is applied to a carrier, then aspect bands detached either side. It's necessary for a receiver to be able to receive the whole signal to be able to successfully demodulate the data. As a result when signals are transmitted near each other they need to be spaced so the receiver will separate them using a filter and there must be a guard band between them. This is not the case with OFDM. Although the sidebands from every carrier overlap, they will still be received while not the interference that might be expected because they are orthogonal to each another. This is achieved by having the carrier spacing equal to the reciprocal of the symbol period.

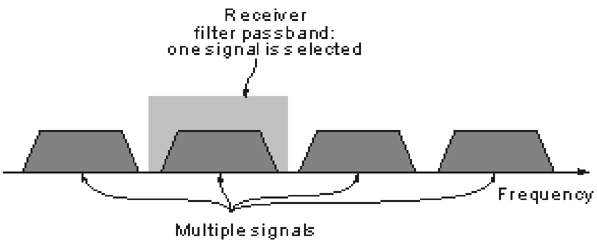

Fig. 2 Traditional view of receiving signals carrying modulation

To see how OFDM works, it is necessary to look at the receiver. This acts as a bank of demodulators, translating every carrier right down to DC. The ensuing signal is integrated over the symbol period to regenerate the data from that carrier. The same demodulator additionally demodulates the opposite carriers. because the carrier spacing capable the reciprocal of the symbol period means that they will have a whole number of cycles in the symbol period and their contribution can total to zero - in different words there's no interference contribution.

One requirement of the OFDM transmitting and receiving systems is that they must be linear. Any non-linearity can cause interference between the carriers as a result of inter-modulation distortion. This will introduce unwanted signals that would cause interference and impair the orthogonality of the transmission.

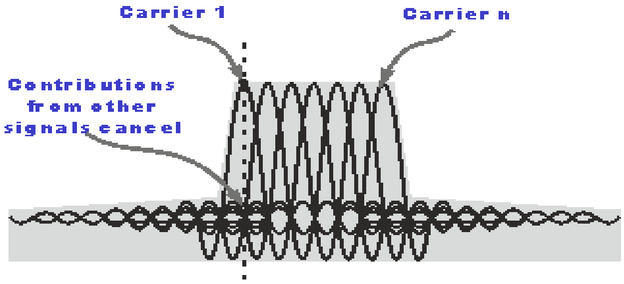

Fig. 3 OFDM Spectrum

II. Spatial Modulation (SM)

Unlike conventional MIMO schemes, SM exploits multiple transmit antennas in a way that only a single RF chain is required. Fig. 4 shows the underlying concept of SM. During the signaling period, the bits to be transmitted are divided into two blocks. The first block is encoded using a conventional signal constellation diagram such as QAM. Provided that the number of antennas is a power two and each antenna is allocated a unique binary index, the second block of bits is used for the selection of the single transmitting antenna. The transmitting antenna possesses the binary index which corresponds to the second block of bits. Well known advantages of SM are the avoidance of Inter-Antenna Synchronization (IAS) at the transmitter and ICI at the receiver [16]. In addition, the detection at the receiver is performed using a low-complexity (single stream) ML detector [104], which jointly detects the conventional constellation point and the index of the transmitting antenna. Note, that even though SM employs a single stream detector, it is able to achieve a multiplexing gain..

II.1. SM-MIMO-OFDM system with SLM as BER technique

The system level block diagram of SM-MIMO-OFDM system using SLM as BER reduction technique is shown in Figure 4.

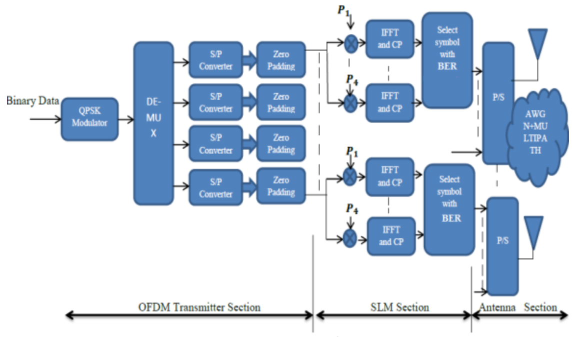

Figure 4: Designed block diagram of SM-MIMO-OFDM system transmitter with SLM.

It consists of three major sections; OFDM transmitter section, SLM section and Antenna section. This system uses SLM at the transmitter side. On each branch of MIMO-OFDM system SLM is inserted so that the data block is further divided into 4 branches. After the multiplication of data on each branch by the rotation factor Pm, IFFT is applied to obtain OFDM symbol. Then the symbol having the minimum PAPR is selected and transmitted. Figure 5 shows Block diagram of SM-MIMO-OFDM system receiver.

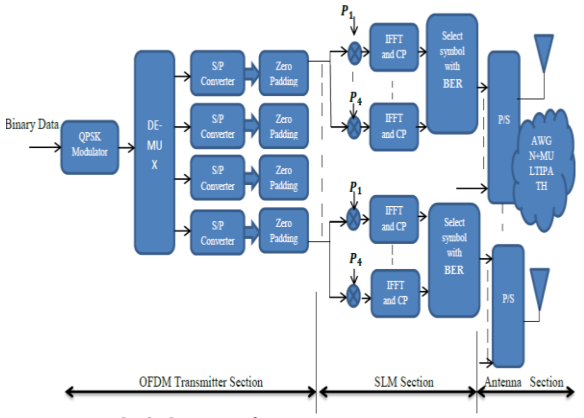

Figure 5: Block diagram of SM-MIMO-OFDM system receiver.

III. Proposed Methodology

The methodology used and tools to analysis of result in this dissertation. Auxiliary information based subspace pursuit algorithm is also discussed in this section.

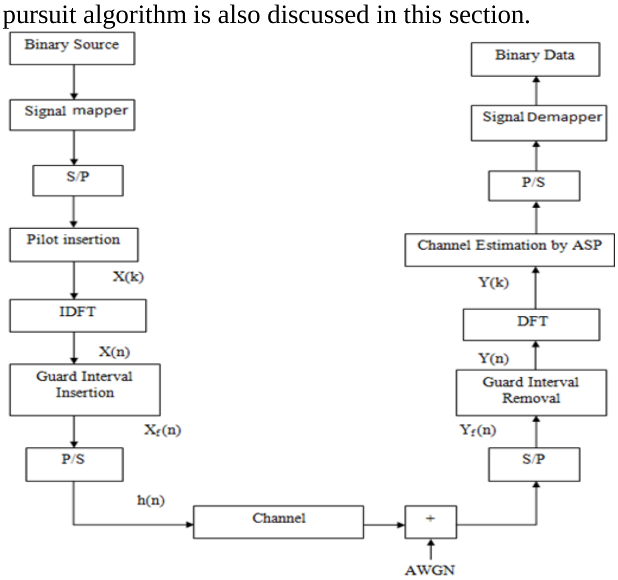

Fig. 6 Proposed flow diagrams

Implementation for Orthogonal Frequency Division Multiplexing (OFDM) system has been carried out in this chapter. It includes implementation of base band OFDM system. Design of OFDM signals, the number of subcarriers N, the bandwidth of each subcarrier 1/NT, the bandwidth of the system, and the length of the cyclic prefix are all important parameters in the design of an OFDM system.

In proposed system flow diagram we consider number of sub-carriers Data, which is scrambled to remove sensitive data from the input signal. Scrambled data is encoded and mapped by data mapper block. The pilots are inserted into data sub-carriers at regular intervals. To avoid the inter symbol interference (ISI) due to multipath delay spread. After performing N-point Inverse fast Fourier transform, the symbols are transmitted. At the receiver side, the received data are passed to fast Fourier transform block. Then, the received symbols are extracted by channel estimator which estimates the channel frequency response and delay spread parameters.

The OFDM system based on pilot channel estimation is given in Figure 5. The binary information is first grouped and mapped according to the modulation in signal mapper. After inserting pilots to all sub-carriers with a specific period or uniformly between the information data sequence, IDFT block is used to transform the data sequence into time domain signal with the equation 4.8.

$$x(n) = IDFT\{X(k)\} \qquad n = 0, 1, 2 \ldots, N-1$$
$$= \sum_{k=0}^{N-1} X(k)\, e^{j(2\pi kn/N)} \ldots\ldots\ldots (4)$$

Where N is the DFT length

In the guard interval insertion block, guard time is chosen to be larger than expected delay spread and guard interval is inserted to prevent inter-symbol interference. This guard time includes the cyclically extended part of OFDM symbol in order to eliminate inter-carrier interference (ICI). The resultant OFDM symbol is given in equation 5.

$$Ex_f(n) = X(N+n), \qquad n = -N_g, -N_g+1, \ldots\ldots, -1$$
$$= x(n), \qquad n = 0, 1, \ldots\ldots N-1 \ldots\ldots.(5)$$

Where Ng is the length of the guard interval.

IV. Results

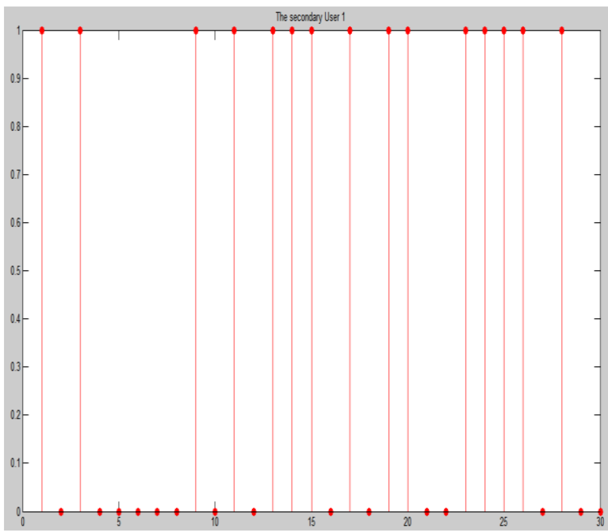

Fig.7 User 1 initialization

Fig.7 shows the user initialization for MIMO system. In MIMO system K no. of user is present in which one specific user 1 should be initialized by selection user process in which a significant user 1 is used for processing data.

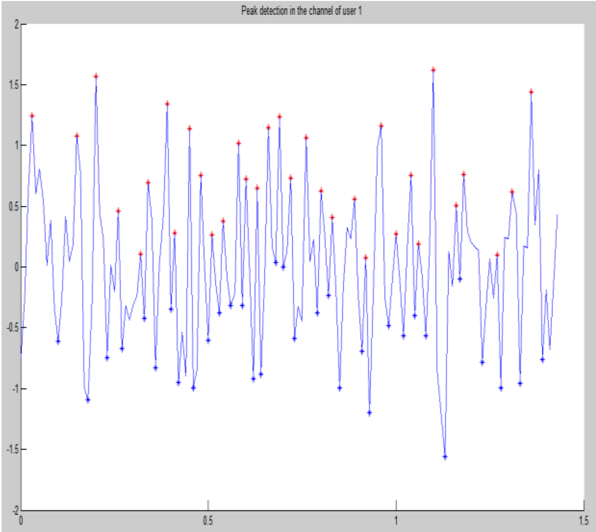

Fig.8 Data peak validation by user1

Fig.8 demonstrates the data peak validation by user 1. The above graph shows the peak validation process point of the specific user which shows the data peak validation point by user 1.

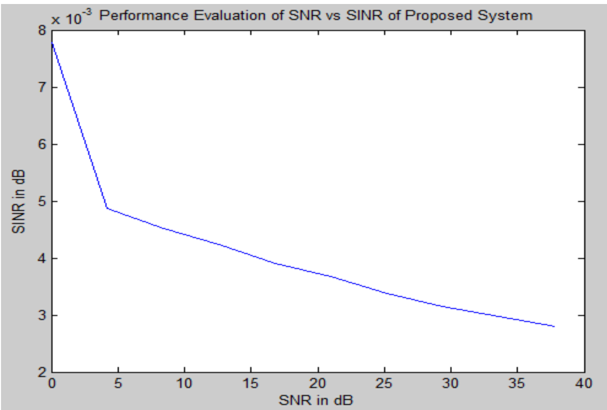

Fig. 9 Performance evaluation of SNR versus SINR proposed system

Result is analyzed for the state administration of radio, film and television-8 (SARFT-8) channel and ITU-VB channel.

The Complexity Order of A-SP for SARFT-8 channel 1.539269e+01

The Complexity Order of A-SP for ITU-VB channel 1.584223e+01

The Complexity Order of SP 1.471766e+01

In figure 9 the evaluation of proposed system performance is shown in which we can see the quantity of used the theoretical upper bounds on channels capacity or rate of transfer of information versus the level of a desired signal to the level of background noise.

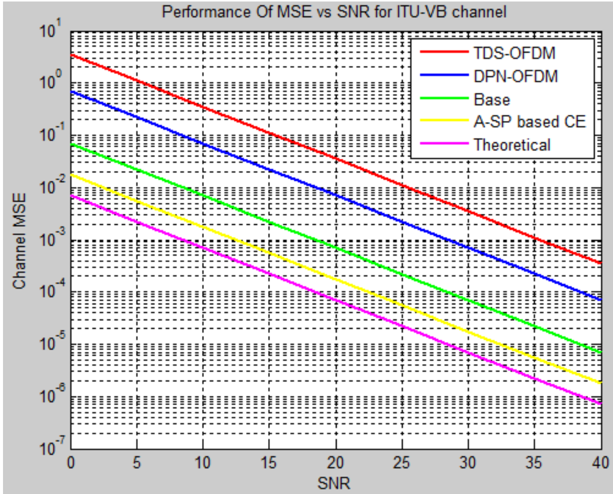

Fig.10: Performance of MSE vs. SNR for ITU-VB channel

In figure 10 we can see the graphical representation of the performance analysis of mean square error to the signal to noise ratio. The result of performance analysis of channel MSE vs. SNR for ITU-VB channel in which four parameters consider for analysis TDS-OFDM, DPN-OFDM, and A-SP based Channel estimation and theoretical output compression for ITU-VB channel. Here comparison is done with conventional OFDM techniques such as DPN-OFDM, TDS-OFDM. The value of SNR is taken in db (decibel).

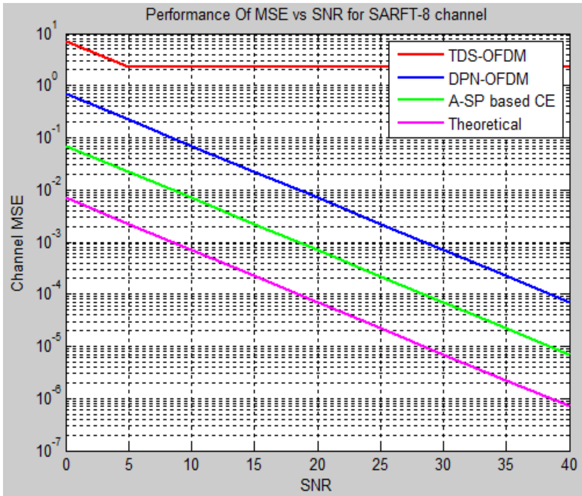

Fig.11: Performance of MSE vs SNR for SARFT-8 channel

In figure 11 we can see the graphical representation of the performance analysis of mean square error to the signal to noise ratio. The result of performance analysis of channel MSE vs. SNR for SARFT-8 channel in which four parameters consider for analysis TDS-OFDM, DPN-OFDM, and A-SP based Channel estimation and theoretical output compression for SARFT-8 channel.

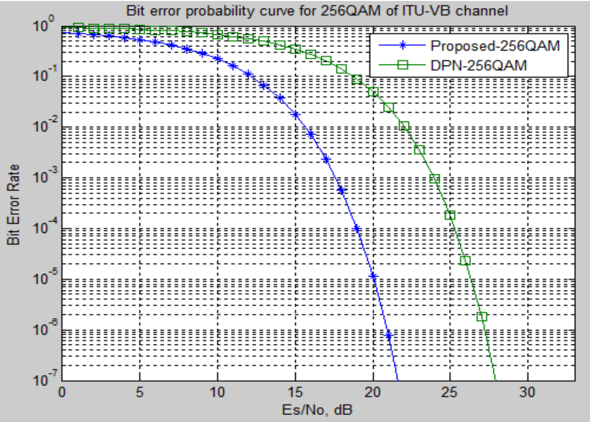

Fig.12: Bit error probability curve for 256QAM of ITU-VB channel

In figure 12 we can see the graphical representation of the Bit error probability curve for 256-QAM. The bit error probability curve analysis for ITU-VB channel for 256 QAM in which three parameters consider for analysis Proposed 256 QAM, DPN-256 QAM, and TDS-256 QAM based compression for ITU-VB channel. In figure 6.5 we can see the graphical representation of the Bit error probability curve for 16-QAM. The bit error probability curve analysis for ITU-VB channel for 16 QAM in which three parameters consider for analysis Proposed 256 QAM, DPN-256 QAM, and TDS-256 QAM based compression for ITU-VB channel.

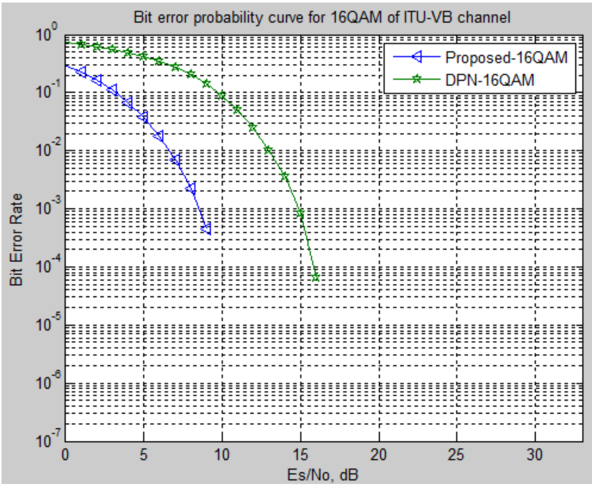

Fig. 13: Bit error probability curve for 16QAM of ITU-VB channel

In figure 13 we can see the graphical representation of the Bit error probability curve for 16-QAM. The bit error probability curve analysis for ITU-VB channel for 16 QAM in which three parameters consider for analysis Proposed 256 QAM, DPN-256 QAM, and TDS-256 QAM based compression for ITU-VB channel.

V. Conclusion

Present day wireless communication systems require a high data rate wireless access, for which the prerequisite is larger bandwidth. Obviously, to mitigate the inter symbol interference (ISI) caused by the multipath fading of high data rate communication system is orthogonal frequency division multiplexing (OFDM). In this proposed work water-filling and Langrange algorithms are used for the estimates the channel characteristics. As compared to other well known OFDM channel estimation methods the proposed water-filling and langrange method resulted in a lower value of BER, which indicates the superiority of the proposed method. For using subspace pursuit optimized channel and changing modulation technique achieves best signal quality. The positive results presented in this work would inspire more work to further investigate and appreciate the potential advantage of enhanced channel estimation techniques in the artificial neural network..

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