International Journal of Scientific Research & Engineering Trends
Volume 5, Issue 3, May-Jun-2019, ISSN (Online): 2395-566X

Performance of MIMO-OFDM based on integrated encoding transmitted using VLC and SS-SAMP based channel estimation for 5G networks

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***Abstract*-Orthogonal Frequency Division Multiplexing (OFDM) is a multiple carrier system. It can decrease the symbol rate thereby reducing the power consumption of the system. It can also able to increase the bandwidth and capacity of the channel which ultimately increases the speed of the system. The key idea is to implement MIMO-OFDM in VLC to get maximum data rate transmission and improve the performance. In the paper, STBC-SM had been proposed for high data rates and high spectral efficiencies has led to the development of spatial multiplexing systems, with SS-SAMP algorithm for channel estimation. BER, NMSE and PAPR parameters has been calculated for the performance evaluation of the proposed technique.**

***Key words*- OFDM, SS-SAMP, STBC-SM, VLC**

I. INTRODUCTION

In visible light communication (VLC), light-emitting diodes (LEDs) are used to illuminate and at the same time to transmit data using intensity modulation (the power of light). LEDs have a finite operating voltage scope and coverage, and the voltage-current characteristic shows nonlinear behavior [1]. VLC presents various isolated advantages such as economic, no license requirement, and secure. Ample researches have been done for different VLC applications particularly indoor high-speed wireless access.To achieve high-speed transmission in such a bandwidth-limited VLC system, advanced modulation formats have been employed for high spectral efficiency, for example carrier-less amplitude and phase [2]. Spatial modulation (SM), which is apotent MIMO solution, is altered for VLC systems to obtain higher spectral efficiencies than single-input single-output VLC systems.

Orthogonal frequency division multiplexing (OFDM) is also gaining heed for intensity modulation/direct detectionVLC systems because to its power efficiency and robustness to the intersymbol interference (ISI) [3]. For occasion, real time-domain signals are simply obtained by employing the conjugate symmetry property of the fast Fourier transformation (FFT), well known as the Hermitian symmetry. However, the innovation of the proposed systems stems from how they sort with the bipolar nature of the signals. One of the simple solutions to achieve positive signals is to connect a DC bias after the inverse FFT (IFFT) operation. The developed system is termed as DC biased optical OFDM [4]. There are several kinds of enhanced structures formed on the conventional algorithms. However, when the signal-to-noise ratio (SNR) is low, the mean square errors (MSE) of the timing offset prediction of these algorithms are vast. It is complicated to find the right timing point in Schmidl's and Minn's algorithm because of the large side-lobes of the timing metric results. Park's algorithm would come to the flaw that the magnitude of side-lobe is greater than main-lobe when the length of cyclic prefix (CP) is long [5].

II. LITERATURE SURVEY

Lin *et al.* [6] had proposed aim proved orthogonal frequency division multiplexing/offset quadrature amplitude modulation (OFDM/OQAM) strategy for visible light communications (VLC). The OFDM/OQAM VLC system had efficiently enhanced the data rate, and resisted multipath induced ISI and inters carrier interference.

Deng and Kavehrad [7], had demonstrated a software-defined real-time multiple input multiple output (MIMO) visible light communication system utilizing Single-Carrier Quadrature Amplitude Modulation. The system employed two self-sufficient phosphorescent white LED transmitters with 10 MHz bandwidth in the lack of blue filters, and two independent 150 MHz P-I-N photodiode optical receivers. The parameters measured and compared the constellation diagram, error vector magnitude (EVM) and bit error rate (BER) performance for single-carried M-QAM MIMO VLC employing spatial multiplexing and diversity.

Zhang *el al.* [8], presented an enhancedstrategy to improve the bit error rate (BER) for indoor visible light communication systems. The proposed strategy employed cascaded codes-based channel code and least square discrete Fourier transform (LS-DFT)-based channel prediction to improve the robustness of indoor optical wireless communication channel. The simulation results presented that a 3–5 dB signal noise rate (SNR) gain can be obtained when the BER is 10−3 below the forward error correction (FEC) limit for a 16-quadrature amplitude modulation (QAM).

Chen and Jiang [9], presented a new channel estimation (CE) algorithm for indoor downlink (DL) VLC systems, termed to as the adaptive statistical Bayesian minimum mean square error channel estimation (AS-BMMSE-CE). Varing statistic window (VSW) mechanism was developed for exploiting past channel information within a window of adaptively optimized size, such that the channel estimation performance can be significantly boosted. Thorough theoretical analysis was given and verified by extensive numerical results, demonstrating the superior performance of the proposed AS-BMMSE-CE scheme.

Damen *el al.* [10], considered multiple-input multiple-output (MIMO) visible light communication (VLC) systems. The physical layer of VLC system formed upon optical orthogonal frequency division multiplexing (O-OFDM). Repetition code (RC), spatial multiplexing (SMUX) and spatial modulation (SMUD) were used as MIMO techniques.

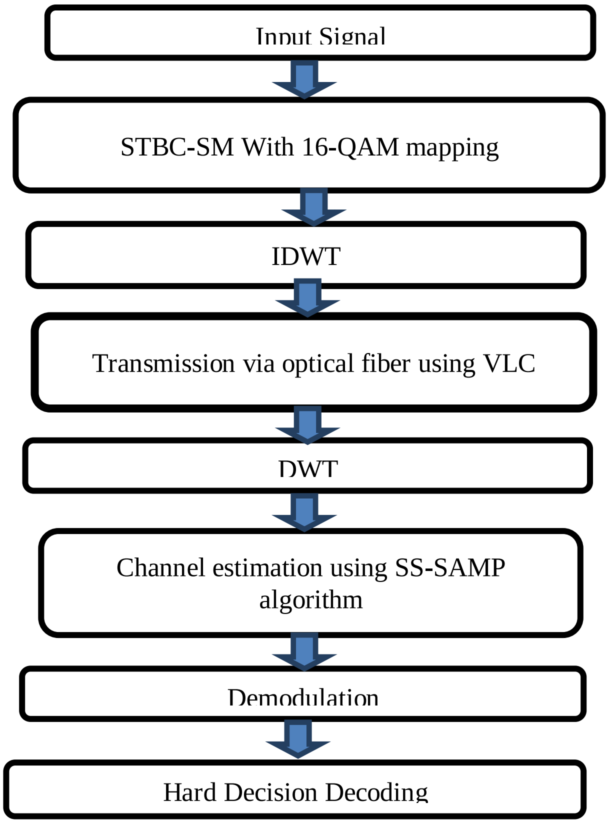

Figure 1 Flow diagram of proposed technique

III.RESEARCH METHODOLOGY

In this paper, integrated STBC-SM encoding has been proposed for high data rates and high spectral efficiencies to the development of spatial multiplexing systems, with SS-SAMP (self-aware step size sparsity matching.

1. System model- Let we have *M* -user synchronous uplink MIMO-OFDM system which are reqiped with two transmit antennas and the STBC-SM scheme at the transmitter and N (*N*=*M*) receive antennas at the receiver.

Let $s_i^{(N)} = \left[s_i^{(N)}(0).......s_i^{(k)}(N-1) \right]^T$ be the i^th^Block transmitted symbol of user *M*.In the STBC-SM strategy, both STBC symbols and the indices of the transmit antennas from which these symbols are transmitted, transfer information. We desire Alamouti's STBC, which transmits one symbol pcu, as the key STBC due toits superiority in terms of spectral efficiency and hard decision detection. In Alamouti's STBC, two well formatted information symbols ($x1$ and $x2$) drawn from 16-QAMconstellation are transmitted from two transmit antennas with multiple users in two symbol interims in an orthogonal manner by the codeword.

$$X = (X_1 + X_2) = \begin{pmatrix} s_1 & s_2 \\ -s_2^* & s_1^* \end{pmatrix} \quad (2)$$

where vertically and horizontal correspond to the transmit antennas and the symbol time, respectively. For the STBC-SM strategy we increase the matrix in (2) to the antenna domain. STBC-SM with four transmit antennas for a MIMO system with four transmit antennas can be presented as under:

$$X = (X_{11} + X_{12}) = \begin{pmatrix} s_1 & s_2 & 0 & 0 \\ -s_2^* & s_1^* & 0 & 0 \end{pmatrix}, \begin{pmatrix} 0 & 0 & s_1 & s_2 \\ 0 & 0 & -s_2^* & s_1^* \end{pmatrix} \quad (3)$$

$$X = (X_{21} + X_{22}) = \begin{pmatrix} 0 & s_1 & s_2 & 0 \\ 0 & -s_2^* & s_1^* & 0 \end{pmatrix}, \begin{pmatrix} s_2 & 0 & 0 & s_1 \\ s_1^* & 0 & 0 & -s_2^* \end{pmatrix} \quad (4)$$

where S_i, i = 1, 2 are called the STBC-SM codebooks each containing two STBC-SM code words S_{ij}, j = 1, 2 which do not interfere to each other. A wavelet transform has been used, which is a wave-like oscillation with amplitude that starts at zero, increases, and then descends back to zero. Wavelets can be clubbed, using a "reverse, shift, multiply and integrate" technique known as convolution, with portions of desired signal to extract information from the undesired signal. It has the tendency to recognize frequency component, simultaneously with their locations in time, and it is capable of providing the time and frequency information simultaneously. Wavelet transform use orthogonal wavelet as key functions to

International Journal of Scientific Research & Engineering Trends
Volume 5, Issue 3, May-Jun-2019, ISSN (Online): 2395-566X

process data in spite of sinusoids orthogonal wave. A family of wavelets can be built from a function $\phi(x)$ sometimes known as a mother wavelet which is limited in a finite interval. Daughter wavelets $\phi_a, b(x)$ are then formed by translation *(b)* and contraction *(a)*. An individual wavelet can be defined as shown in (5).

$$\phi^{a,b}(x) = |a|^{-1/2}\,\phi\left(\frac{x-b}{a}\right) \quad (5)$$

Wavelet transform of the signal $X(t)\phi^{a,b}$ can be define asshown in (6),

$$z_{\varphi}(f)(b,a) = \frac{1}{\sqrt{a}}\int_{-\infty}^{\infty} f(t)\phi\left(\frac{t-b}{a}\right)dt \quad (6)$$

IDWT presents the key point of the multicarrier transmitter in which the orthogonal wavelet modulation is executed, while the DWT performs the demodulator at the receiver for the inverse operation of IDWT stage. The main and the important difference between the conventional OFDM and DWT multicarrier system is the dispatching of the cyclic prefix blocks in the transmitter or in the receiver parts. By not considering the cyclic prefix, the accessible bandwidth would be more efficiently used, and hence high data rate can be achieved.

2. VLC transmission- Multiple LED units are established in a single room for illumination and set to transmit information for multiple users at the mean time. Here, we consider N_t LED units at transmitting end and Nrusers each with a single PD, where we have $N_t \geq N_r$. The transmitted $N_r \times 1$ data vector d is firstly preceded into an $N_t \times 1$ transmitted vector x. Since intensity modulation is employed at the transmitter, the transmitted vector has to be real-valued and non-negative, and DC bias is needed for each LED unit.

In MIMO-OFDM technique with N subcarriers, the transmitted bit stream for the p[th] user is firstly mapped on to the complex-valued symbols $H_{p,k,}$, $K = 0,1,.........,N-1$ according to the selected constellations, like quadrature amplitude modulation (QAM).Since real-valued output is needed for intensity modulation, OFDM subcarriers should validate the Hermitian symmetry that $H_{p,k=H^*_{p,N-K},K=1,2,.....,N}$, $H_{p,0}$ and $H_{p,N/2}$ are set to zero. For each and every subcarrier, preceding is needed at the transmitter to abolish multi-user interference. Here we denote the preceding weights for $K^{th}(k = 0,1,..........., N-1)$ subcarrier as $\{D_{p,q,k,} 1 \leq p \leq N_r, 1 \leq q \leq N_t\}$. The preceding weights can be complex-valued since Hermitian symmetry constraint is foisted on the subcarriers to make sure the time-domain signals real-valued. By combining all the weighted symbols from N_r users at the q[th] LED unit, the frequency-domain signal can be expressed as:

$$X_{q,k} = \sum_{p=1}^{N_r} D_{p,q,k} D_{p,k}. \quad (7)$$

3. SS-SAMP algorithm for Channel estimation- Sparsity Adaptive Matching Pursuit (SAMP) is an innovative greedy pursuit algorithm for real compressed sensing applications. The most innovative feature of this algorithm is that it can blindly recover sparse signal without prior knowledge of sparsity, removing a common limitation of most of live greedy pursuit algorithms. The choice of step size is the main parameter which defines the performance of the proposed self-aware step size sparsity matching pursuit (SAMP) algorithm.

If the chosen step size is small, SAMP algorithm leads to better estimation accuracy but increases the computational complexity. On the other hand, if the step size is large, the computational complexity decreases but at the cost of low estimation accuracy. By making the algorithm self-aware with respect to step size, a better trade-off can be maintained between the estimation accuracy and computational complexity.

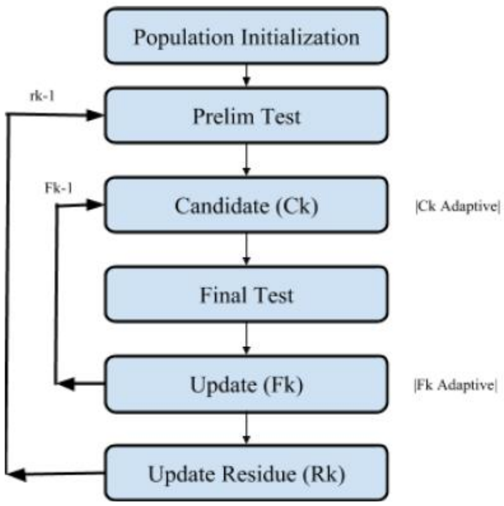

Figure2 flow diagram of SS-SAMP algorithm.

4. Decoded decisions- The throughput from the MMSE equalizer, non binary LDPC decoding as in is performed individually for each data stream. The decoder outputs the decoded information symbols and the upgraded posterior/extrinsic probability, which are employed in the next iteration of channel prediction and equalization. By the decoding process, if all the parity check conditions of one data stream are satisfied, the decoder states successful recovery of this data stream. Here, we assumed that all symbols of this data stream are defined without uncertainty. To employ feedback in channel prediction or MIMO detection, we require prediction of the unknown data and a measure of the uncertainty left in these predictions. Based on the processor round of decoding, the LDPC decoder outputs a posterior probability for each symbol, as well as assumption based on extrinsic information only. While the extrinsic knowledge is employed in the MIMO symbol recognition, a posterior probability is employed to enhance channel estimation. Next, we explore various feedback schemes for channel estimation.

IV. RESULTS AND DISCUSSION

1. BER (Bit Error Rate)- Multiple-input, multiple-output orthogonal frequency-division multiplexing (MIMO-OFDM) is the governing air interface for advanced wireless communications system. It combines multiple-input, multiple-output (MIMO) technology, which enhances capacity by transmitting various signals over multiple antennas, and orthogonal frequency-division multiplexing (OFDM), which split up a radio channel into sample number of closely spaced sub channels to offer more reliable communications at maximum speeds. The BER for the proposed technique is depicted as under in the figure 3.

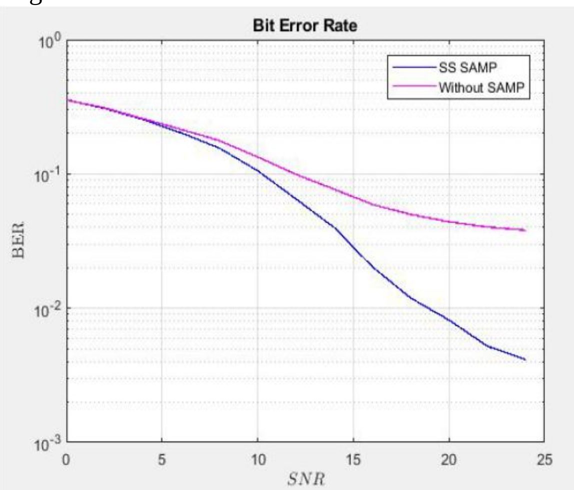

Figure 3 BER for SS-SAMP algorithm

In figure 3, BER can be noted has been reduced for SS-SAMP technique with the increase of SNR.

2. Normalized mean square error- Normalizing the RMSD offers comparison between datasets or models with distinct scales. Though there is no accordant means of normalization in the literature, common options are the mean or the range (defined as the difference between maximum value and the minimum value) of the measured data

$$NMSE = \frac{MSE}{Y_{max} - Y_{min}} \quad (8)$$

For the proposed technique NMSE has been depicted as under in figure 4.

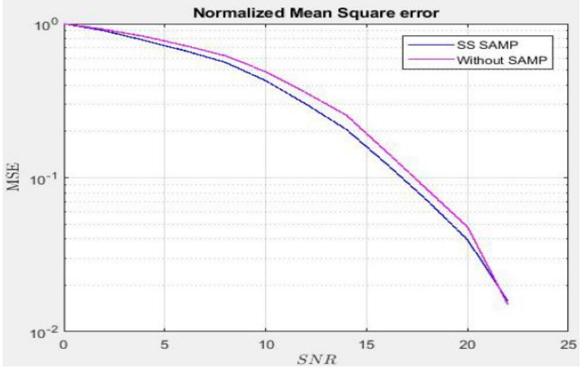

Figure 4 NMSE for SS-SAMP algorithm.

From the above graph it can be noted, that MSE has been declined with the increase in the SNR as compared general channel estimation in MIMO-OFDM.

3. Peak to Average Power Ratio- PAPR is the major drawback encountered in the MIMO-OFDM. The PAPR for the proposed technique has been depicted as under in the figure 5.

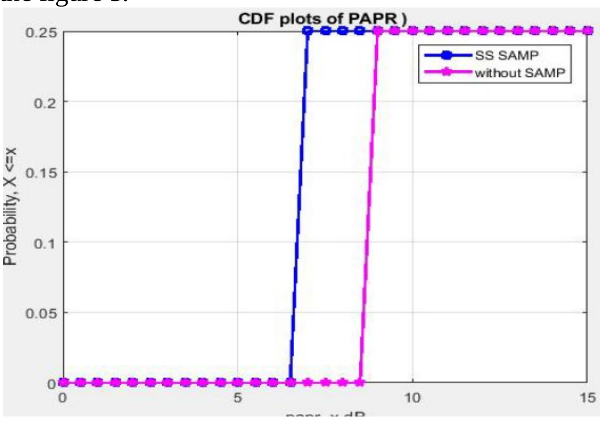

Figure 5 PAPR for SS-SAMP algorithm.

In the above figure, PAPR for the proposed channel estimation technique has been reduced to lower level as compared to the general form of the MIMO-OFDM technique

V. CONCLUSION

In the proposed implementation STBC-SM had been proposed for high data rates and high spectral efficiencies has led to the development of spatial multiplexing systems, with SS-SAMP algorithm for channel estimation. The results has been depicted in figure 3,4 and 5 for with SS-SAMP algorithm channel estimation and Without algorithm employment. It can be noted that from depicted graphs that SS-SAMP based system has shown better performance in terms of BER, Normalized MSE and PAPR.

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