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A Novel Approach for Design and Analysis of an Iterative Flip-OFDM receiver with Reduced PAPR

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Abstract:-As there is a tendency for the positive signals to get cancelled by their negative counterparts, the negative signals are strictly denied from being transmitted through wireless optical communication systems. In order to attenuate this problem and to ensure the denial of the negative signal propagation the Flip-Orthogonal Frequency Division Multiplexing (Flip-OFDM) splits the signal into positive and negative parts and transmits them separately in two non-overlapping paths. At the receiver end an Iterative-OFDM receiver is employed to reconstruct the data efficiently by subtracting the negative part from the positive part. The major problem of an Iterative Flip-OFDM system is Peak to Average Power Ratio (PAPR) which may limit the content boosting capabilities of Flip- OFDM signals. As a solution to this ever teasing problem in this paper we proposed a novel approach for design and analysis of an iterative Flip-OFDM receiver and to reduce the PAPR of Flip-OFDM signals using non-linear optimization approach. The proposed approach is implemented and simulated in MATLAB environment and the simulation results adjudged that the proposed approach is best in all aspects and outperforms all the existing approaches.

Keywords: DCO-OFDM, ACO-OFDM, PAM-DMT, OFDM, Iterative Receiver, PAPR and SLM

Introduction

Due to its enormous potential in providing rich spectrum resources and high communication security, an Optical Wireless Communication System (OWC)s has emerged as an attractive alternative for RF circuits and systems , especially in indoor scenarios. Also, the convergence of illumination and communication makes OWC to be one of the most important Eco technologies [1]. In a view to enable high data rates and assuage inter-symbol interference (ISI), the Orthogonal Frequency Division Multiplexing (OFDM) has been employed in OWC [2]–[4]. Since it is a common approach to employ intensity modulation and direct detection (IM/DD) in OWC systems, the transmitted signals must be of real and non-negative. Real temporal signals can be obtained by imposing Hermitian symmetry on the OFDM subcarriers.

On the other hand, OWC still possesses some drawbacks. One restriction is that the available optical transmit power is limited by eye safety standards [5-9]. And the issue of bipolarity in OFDM signals is attenuated with various sophisticated and expensive schemes such as direct current (DC) biased optical OFDM (DCO-OFDM) [10], asymmetrically clipped optical OFDM (ACOOFDM) [11] and pulse-amplitude-modulated discrete multitone (PAM-DMT) [12]. There is a price paid with these three schemes. DCO-OFDM adds a DC bias, which increases the power dissipation of the OFDM signal significantly. ACO-OFDM and PAM-DMT do not need DC bias, but each has only half the spectral efficiency of DCO-OFDM. The conventional Flip-OFDM receiver recovers the data by subtracting the negative signal block from the positive one [13]. Even though his method is simple and straightforward, but it increases the noise variance of the received symbols and reduces the performance of the OFDM receiver. A time-domain noise filtering technique was proposed in [14] and investigated in [15] to improve the performance of the Flip-OFDM, but the algorithm does not make full use of the signal structures. Hence in this context an iterative receiver is proposed for Flip-OFDM by fully exploiting the structures of the received signals. Simulations confirm that the proposed iterative receiver is superior to other receivers.

OFDM is an exceptional type of the multicarrier modulation technique that divides the entire frequency selective fading channel into many orthogonal narrow band flat fading channels in which a high bit rate data stream is transmitted in parallel over a number of low bit rate subcarriers there by substantially reducing the inter symbol interference [16] and improved spectral efficiency. However the conventional OFDM systems suffer from high PAPR, which necessitates a tight synchronization between the transmitter and receiver otherwise leads to Carrier Frequency Offset (CFO) errors. High peak values in OFDM system results from superposition of large number of statistically independent sub channels that can constructively sum up high peaks [17]. As number of carriers increases, PAPR also increases. The PAPR ratio is approximately equal to N, where N is the number of sub carriers. High PAPR ratio results in amplifier to work in large dynamic range which decreases the efficiency of power amplifier, DAC and ADC. Hence in order to overcome these hard striking problems in a Flip-OFDM based OWC systems, in this paper we proposed a novel approach for the design and analysis of an iterative Flip-OFDM scheme with relatively reduced PAPR using a modified Selective Mapping (SLM) scheme.

Proposed Work

In this work we proposed a novel approach for designing an iterative Flip-OFDM receiver. The proposed approach transmits the positive and negative signals on two consecutive OFDM sub frames. The DCO-OFDM approach is replaced with a nearly equal and more spectrally efficient iterative Flip-OFDM in OWC. As in conventional receiver for flip-OFDM, data is reconstructed by subtracting the negative signal block from the positive signal block. The schematic block overview of an iterative Flip-OFDM transmitter with N subcarriers is shown in Figure(1). To be certain that the time-domain signal is actually in IM/DD systems, the input data vector =[X(0) X(1) X(2) X(3)….X(N-1)]^T must be satisfy the Hermitian symmetry property, i.e.,

$$X(k) = X^*(N-k), k = 1,2,3, \ldots, \frac{N}{2} - 1$$

Be aware that X(0) and X(N/2) are on the whole set to zero considering the DC a part of OFDM signal is left unused in useful purposes. Hence, the time domain signal vector x=[x(0) x(1) x(2) x(3) ….x(N-1)] after inverse fast Fourier transform (IFFT) operation can be represented as

$$x(n) = \frac{1}{\sqrt{N}} \sum_{k=0}^{N-1} X(k) \exp\left(\frac{j2\pi kn}{N}\right)$$

$$x(n) = \frac{2}{\sqrt{N}} \sum_{k=0}^{\frac{N}{2}-1} Re\left[X(k) \exp\left(\frac{j2\pi kn}{N}\right)\right], \text{ n=0,1,2,….,N-1}$$

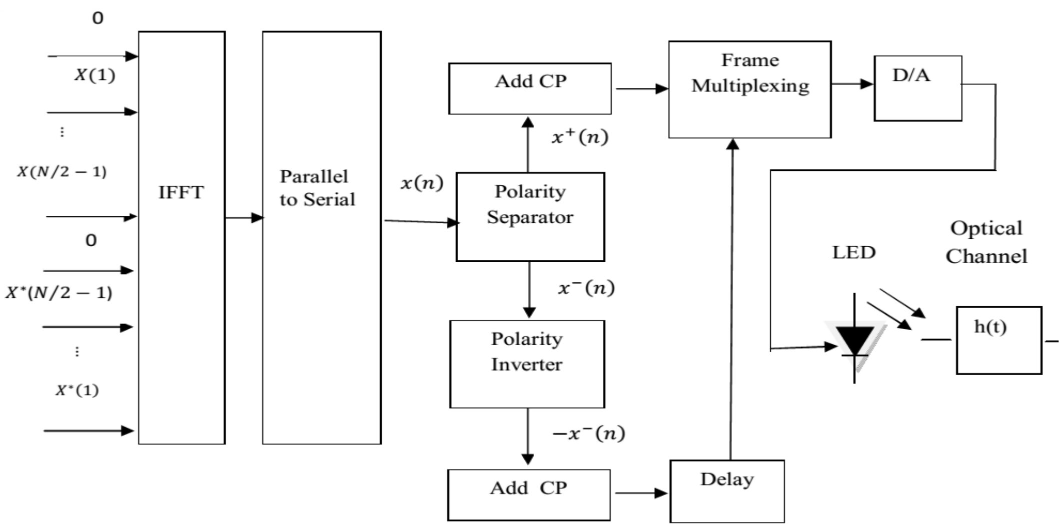

Figure1. Schematic block overview of the Proposed Iterative Flip-OFDM receiver.

The signal x(n) ,is real and bipolar valued, can be decomposed as

$$x(n) = x^+(n) + x^-(n)$$

Here, the positive part and the negative part are defined as

$$x^+(n) = \begin{pmatrix} x(n), x(n) \geq 0 \\ 0, \ x(n) < 0 \end{pmatrix}$$

$$x^-(n) = \begin{pmatrix} x(n), x(n) < 0 \\ 0, \ x(n) \geq 0 \end{pmatrix}$$

To assure a nonnegative time-domain signal, the two component

$$x^+ = [x^+(0), x^+(1), x^+(2), \ldots, x^+(N-1)]^T \text{ and}$$

$$x^- = [x^-(0), x^-(1), x^-(2), \ldots, x^-(N-1)]^T$$

are individually transmitted over two successive OFDM sub frames.

Assuming the channel impulse response vector $h = [h(0), h(1), h(2), h(3), \dots \dots h(N-1)]^T$ is constant over two consecutive OFDM sub frames, the received signal vectors in the frequency domain are given by

$$Y^+ = HX^+ + Z^+$$
$$Y^- = HX^- + Z^-$$

Where H=diag($W_N h$)

$$X^+ = W_N x^+$$
$$X^- = W_N x^-$$

W_N is the NXN Discrete Fourier Transform(DFT) matrix Z^+ and Z^- ~N(0,$\sigma^2 l$) represent the noise vectors of the two sub frames, respectively. The conventional receiver is easy and effortless, but it does not absolutely utilize the structures of the received signals.. Within the following, a new receiver is proposed through commencing the connection between the received signals Y^+, Y^- and the input signal x can e expressed as

$$|x| = S(X)x \; ; |x| = S(X)W_N^H H,$$

where S(X)=diag{sign(x)}

S(X)=diag{sign(W_N^Hx)}

$$\begin{bmatrix} Y^+ \\ Y^- \end{bmatrix} = \frac{1}{2}\begin{bmatrix} H + HW_N S(X) W_N^H \\ HW_N S(X) W_N^H - H \end{bmatrix} X + \begin{bmatrix} Z^+ \\ Z^- \end{bmatrix}$$

the zero-forcing (ZF) estimator is used to reconstruct the information back because of its low complexity and straight forwardness.

$$G(X) = \frac{1}{2}\begin{bmatrix} H + HW_N S(X) W_N^H \\ HW_N S(X) W_N^H - H \end{bmatrix}$$

The ZF matrix can be obtained as

$$T_{ZF}(X) = [G^H(X)G(X)]^{-1}G^H(X)$$

Then the estimated input data of X is given by

$$\tilde{X} = T_{ZF}(X)\begin{bmatrix} Y^+ \\ Y^- \end{bmatrix}$$

The matrix $T_{ZF}(X)$ is dependent on the information vector X, an iterative receiver can hence be proposed as

$$\hat{X}^{(i)} = \begin{Bmatrix} dec\left[[H^{-1}Y^+ - H^{-1}Y^{-1}]\right], i = 0 \\ dec\{T_{ZF}\left(\hat{X}^{(i-1)}\begin{bmatrix} Y^+ \\ Y^- \end{bmatrix}\right\}, i = 1, \dots K \end{Bmatrix}$$

Where ‘i’ is the record of iteration, ‘K’ is the most extreme number of iterations. Especially in line-of-sight channels. This response can be derived as

$$h(n) = c\delta(n)$$

Where ‘c’ is a constant, $\delta(n)$ is the Dirac delta function. Here

$$\tilde{x}_{LOS}(n) = \frac{1}{2}\{1 + sgn[x(n)]\}y^+(n) + \frac{1}{2}\{sgn[x(n)] - 1\}y^-(n)$$

The conventional receiver incorporate a single fast Fourier transform (FFT) operation, it has a complexity of O(N log N). In the proposed iterative receiver, the computational complexity is related to the channel attributes. In non-line-of-sight (NLOS) channels, the iterative receiver has relatively a low computational complexity per iteration because of the matrix inversion of the ZF estimator. In LOS channels, the complexity of the iterative receiver is O(NlogN) per iteration due to the fact that matrix inversion is eliminated.

Conventional selective mapping (SLM) is a method for PAPR reduction in which B statistically independent alternative OFDM symbols are generated from the same OFDM symbol. These alternative OFDM symbols are generated by multiplying the N modulated data symbols with B different phase vectors component wise and then input to the B IFFT blocks of block size N. Finally an alternative OFDM symbol which has lowest PAPR is selected and then transmitted. In general the PAPR of a OFDM signal is defined as the ratio of the maximum instantaneous power to its average power.

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$$PAPR[x(t)] = \frac{\underset{0 \leq t \leq NT}{max}[|x(t)|^2]}{P_{av}}$$

In the next part of this work, we focused on reducing the PAPR to as smaller value as possible compared to the conventional approaches using a modified Selective Mapping(SLM) with clipping process.Figure1 shows the proposed method that is modified selective mapping with clipping. High peaks are being clipped here to remove PAPR problem by replacing the peak by average value. This concept of clipping of OFDM signal can also be applicable to selective mapping for clipping the signal that have more high peak to average power ratio and least probability of finding OFDM symbols. This proposed method will clip the signal whose value is greater than 5db or 4db it can be set to an arbitrary value depending upon the requirement of application. The proposed method to limit the PAPR value let the high power can handle PAPR value of 5db or 4 db by this method we can use that information with little bit-error –rate. By the property of selective mapping SLM selector selects the signal whose value is less then 4db or 5db and clip the high PAPR value signal.

Results and Discussions

In this section, the software simulations are performed to verify the bit error rate (BER) performance of the proposed iterative receiver. The number of subcarriers is 64, the length of cyclic prefix (CP) is 16, and 16-QAM is used for constellation mapping. For comparison, the BER curves corresponding to the noise filtering receiver and the case in where the sign matrices are perfectly known (“lower bound”) are also plotted.

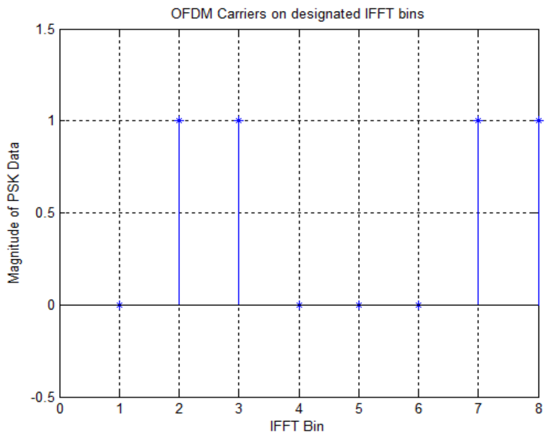

Figure 2. Iterative OFDM carriers on designated IFFT bins.

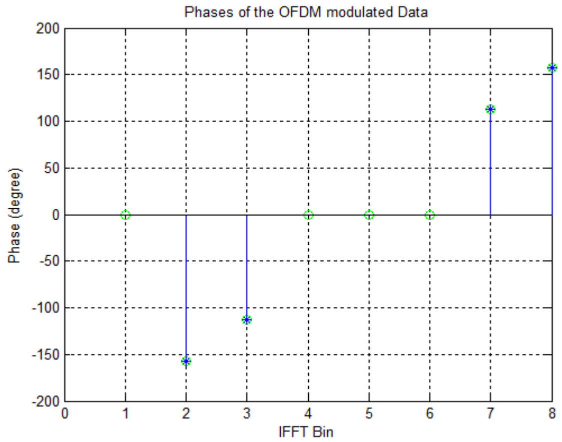

Figure 3. Phase of the iterative OFDM modulated Data.

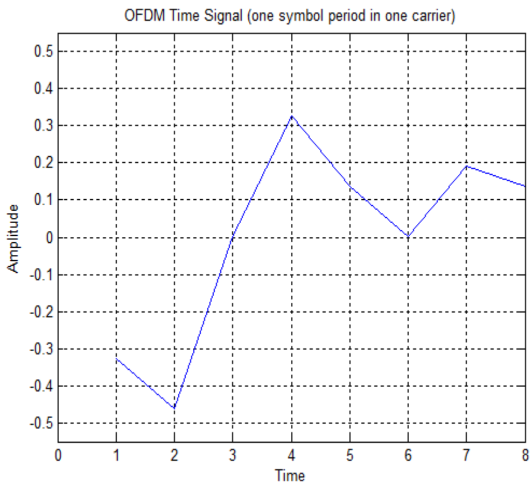

Figure 4. Iterative OFDM time signal.

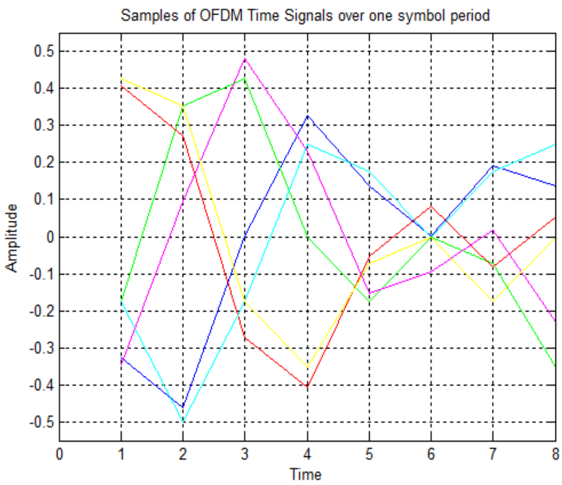

Figure 5. Samples of the OFDM Time Signals over one symbol period.

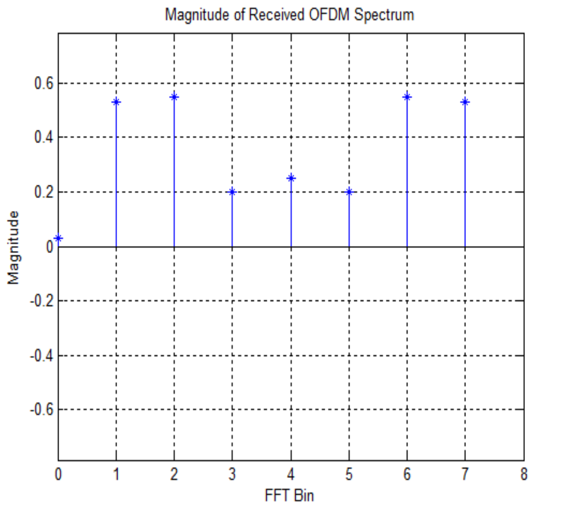

Figure 6. Magnitude of the Iterative Received OFDM Spectrum.

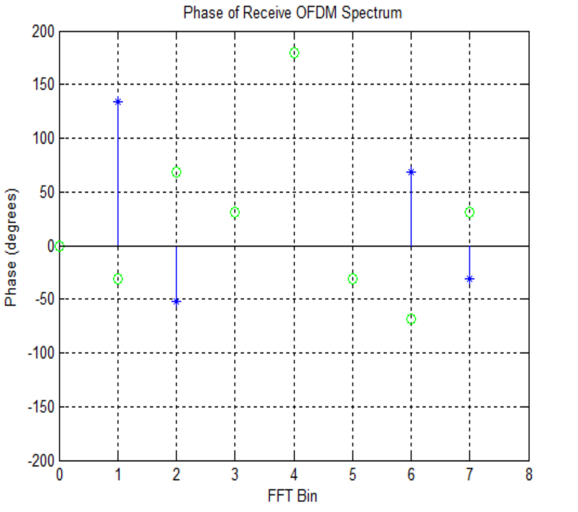

Figure 7. Magnitude of the Iterative Received OFDM Spectrum.

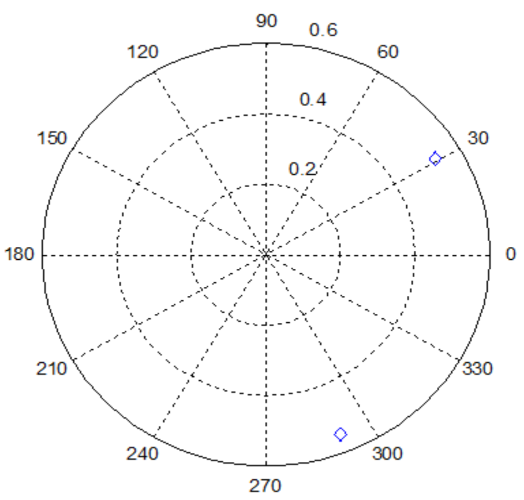

Figure 8. Polar plot of the received phases in the iterative Flip-OFDM.

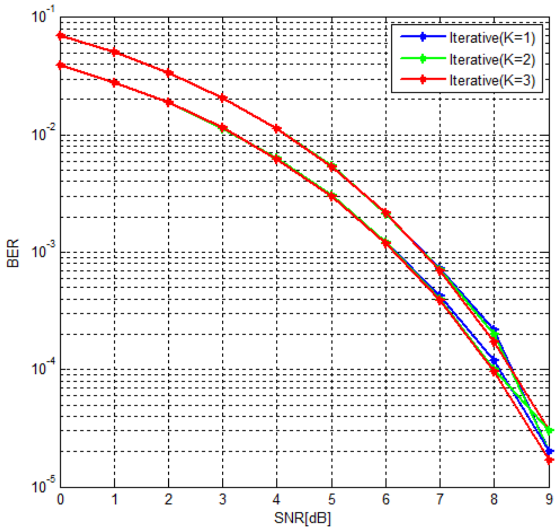

Figure 9. SNR versus Bit Error Rate comparison for various number of iterations.

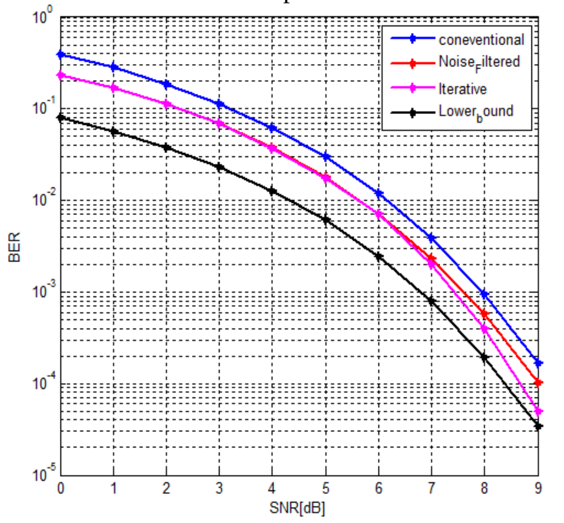

Figure 10. SNR versus Bit Error Rate comparison for various LOS channels.

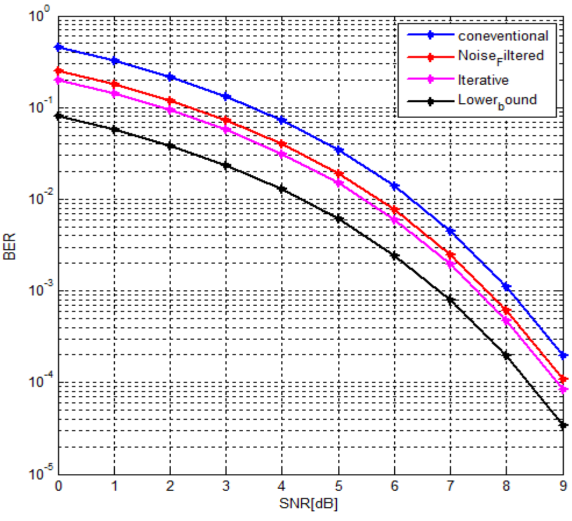

Figure 11. SNR versus Bit Error Rate comparison for various NLOS channels.

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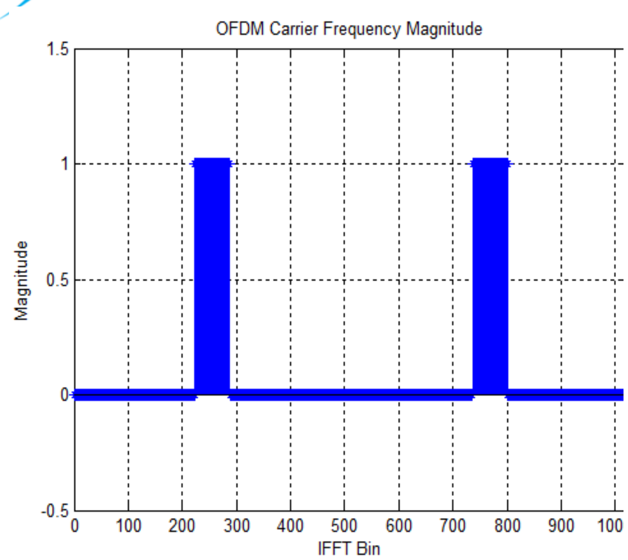

Figure 12. OFDM Carrier Signal Strength

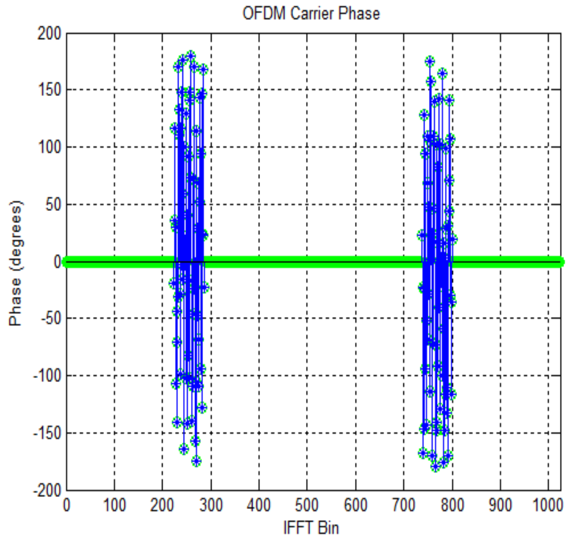

Figure 13. OFDM Carrier signal Phase.

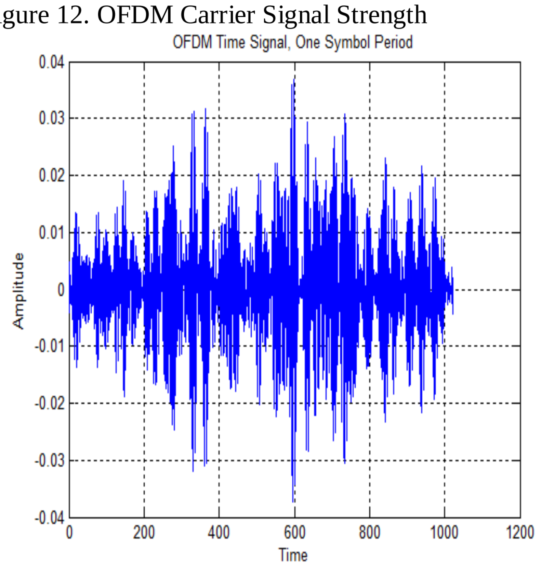

Figure 14. Temporal OFDM signal.

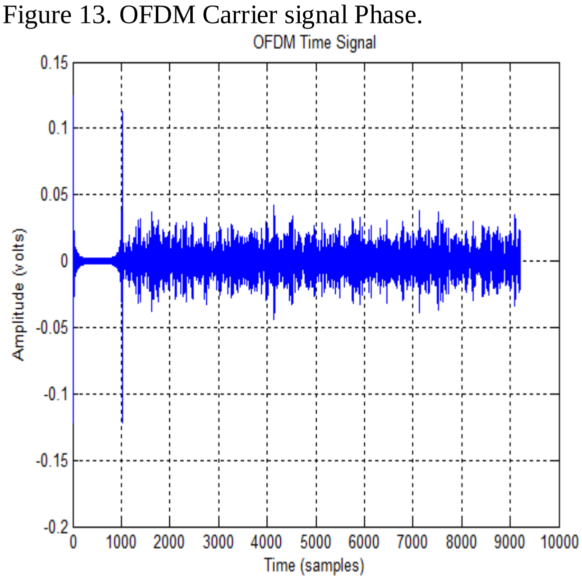

Figure 15. Envelope of the Temporal OFDM signal.

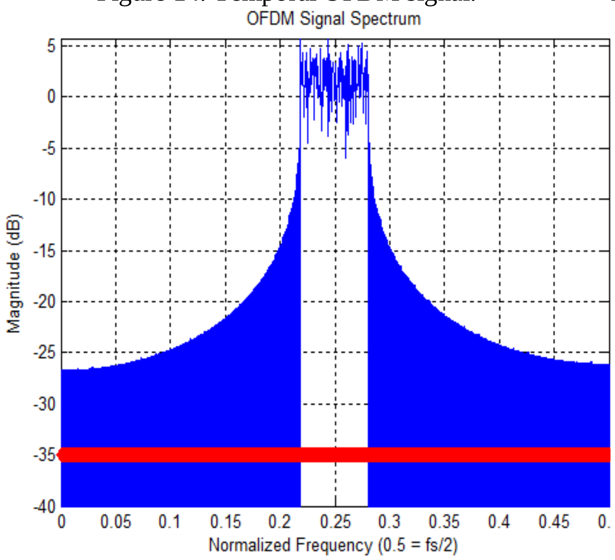

Figure 16. Frequency spectrum of the OFDM signal.

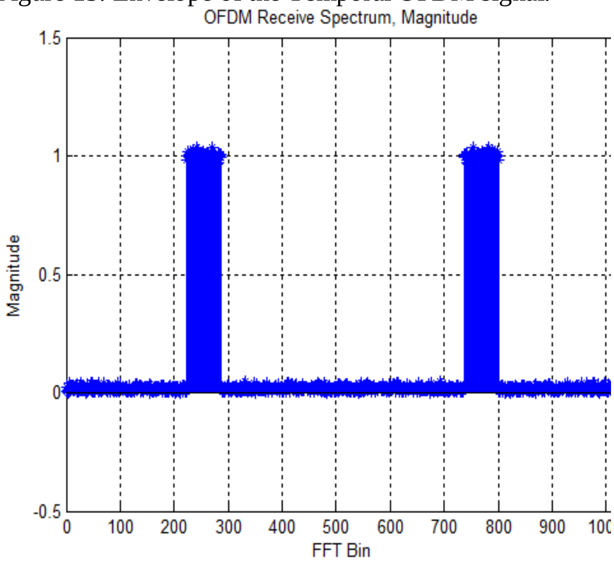

Figure 17. Received OFDM signal Amplitude Spectrum.

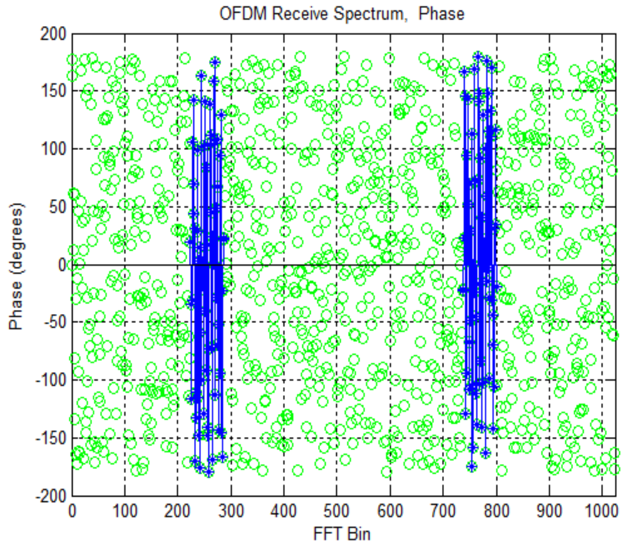

Figure 18. Received OFDM signal Phase Spectrum.

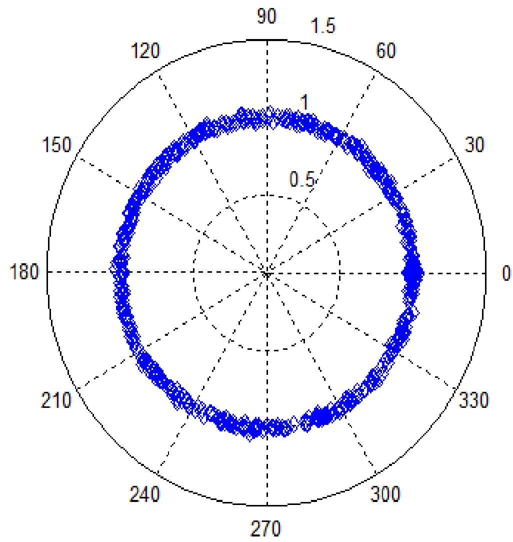

Figure 19. Received OFDM signal phases after PAPR reduction.

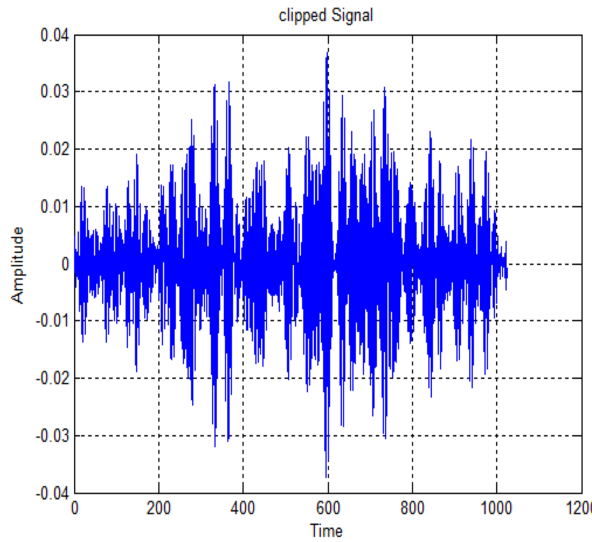

Figure 20. Clipped OFDM Signal.

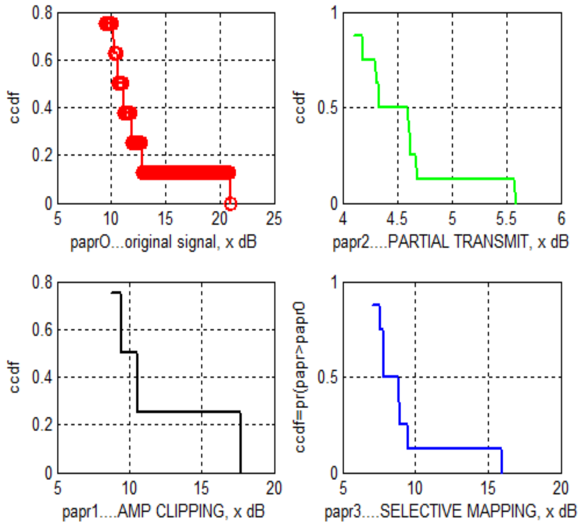

Figure 21. Performance comparison of the proposed PAPR reduction technique with the existing techniques.

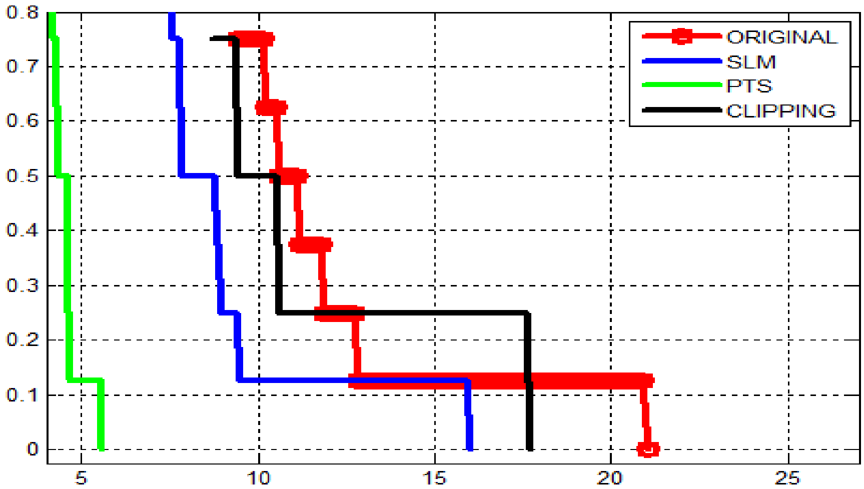

Figure 22. Overall Performance comparison of the proposed PAPR reduction technique with the others.

Conclusion

In this project we proposed an approach for design and analysis of an iterative Flip-OFDM receiver to counteract the issues of negative signal transmission through the OFDM channels in Optical Wireless Communications. And after that, inorder to attenuate the problem of the increased Peak to Average Power Power ratio in OFDM signal, we integrated a non-linear Selective Mapping (SLM) technique to reduce the PAPR value to an appreciable lower value. The proposed Algorithm is designed, coded, implemented and tested in the Matlab Environment successfully. The simulation results of the proposed approach adjudged that the proposed approach is best in all aspects and outperforms all the existing methods and techniques.

References

[1] J.-B. Wang, Q.-S. Hu, J. Wang, M. Chen, and J.-Y. Wang, "Tight bounds on channel capacity for dimmable visible light communications," Journal of Lightwave Technology, vol. 31, no. 23, pp. 3771–3779, Dec.2013.

[2] J. Armstrong, "OFDM for optical communications," Journal of Lightwave Technology, vol. 27, no. 3, pp. 189–204, Feb. 2009.

[3] D. J. Barros, S. K. Wilson, and J. M. Kahn, "Comparison of orthogonal frequency-division multiplexing and pulse-amplitude modulation in indoor optical wireless links," IEEE Transactions on Communications, vol. 60, no. 1, pp. 153–163, Jan. 2012.

[4] N. Huang, J.-B. Wang, J. Wang, C. Pan, H. Wang, and M. Chen, "Receiver design for PAM-DMT in indoor optical wireless links," IEEE Photonics Technology Letters, vol. 27, no. 2, pp. 161–164, Jan. 2015.

[5] Kahn J.M, Barry J.R. "Wireless infrared communications" Proc. of IEEE, Feb. 1997, pp. 265−298.

[6] Elgala. H., Mesleh. R., Haas. H. "Indoor broadcasting via white LEDs and OFDM" IEEE Trans. on Cons. Electron., Aug. 2009,pp.1127 −1134.

[7] Tanaka. Y., Komine. T., Haruyama S., Nakagawa M. "Indoor visible light data communication system utilizing white LED lights," IEICE Trans. on Comm.,Aug. 2003, E86 − B, pp.2440 −2454.

[8] Afgani M.Z., Haas H., Elgala H., Knipp D."Visible light communication using OFDM,"2nd Inter. Con. on TRIDENTCOM, Mar. 2006,Spain.

[9] Li X., Vucic J., Jungnickel V., Armstrong J. "On the capacity of intensity-modulated direct detection systems and the information rate of ACO-OFDM ACOOFDM for indoor optical wireless applications" IEEE Trans. Comm., Mar. 2002, pp. 799 −809.

[10] J. Armstrong and B. Schmidt, "Comparison of asymmetrically clipped optical OFDM and DC-biased optical OFDM in AWGN", IEEE Communications Letters, vol. 12, no. 5, pp. 343–345, May 2008.

[11] J. Armstrong and A. Lowery, "Power efficient optical OFDM," Electronics Letters, vol. 42, no. 6, pp. 370–372, Mar. 2006.

[12] S. C. J. Lee, S. Randel, F. Breyer, and A. M. Koonen, "PAM-DMT for intensity-modulated and direct-detection optical communication systems," IEEE Photonics Technology Letters, vol. 21, no. 23, pp. 1749–1751,Dec. 2009.

[13] N. Fernando, Y. Hong, and E. Viterbo, "Flip-OFDM for optical wireless communications," in Proc. 2011 IEEE Information Theory Workshop (ITW), 2011, pp. 5–9.

[14] N. Fernando, Y. Hong, and E. Viterbo, "Flip-OFDM for unipolar communication systems," IEEE Transactions on Communications, vol. 60, no. 12, pp. 3726–3733, Dec. 2012.

[15] D. Tsonev, S. Sinanovic, and H. Haas, "Novel unipolar orthogonal frequency division multiplexing (U-OFDM) for optical wireless," in Proc. 2012 IEEE 75th Vehicular Technology Conference (VTC Spring), pp. 1–5.

[16] J. Bingham, ìMulticarrier modulation for data : An idea whose time has comeî, IEEE communication Mag., pp.5-14, May 1990.

[17] Abdulla A. Adouda, ìPAPR Reduction of OFDM signal using Turbo coding and Selective Mappingî, Proceedings of 6th Nordic signal processing symposium-NORSIG2004.