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Improved Cyclic Prefix - Orthogonal Frequency Division Multiplexing System for Multipath Propagation

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***Abstract*— In this paper titled 'Improved CP-OFDM System for multipath propagation, we attempt to enhance the quality of 5G communication with Cyclic Prefix OFDM System. Various methods can be used to reduce the multipath effects observed in wireless communication. Multicarrier modulation for data transmission, also known as Orthogonal Frequency Division Multiplexing (OFDM) is a better technology to combatthe effect of Inter Symbol Interference (ISI). Primitive OFDM Systems were widely used in 4G communication. To achieve high transmission rate and speed requirements of 5G communication, multiple other alternative methods are being explored. Upon the performance analysis,CP-OFDM found to be a good candidate in terms of compatibility with multi-antenna technologies, high spectral efficiency and low implementation complexity.**

Keywords—OFDM, Cyclic Prefix, CP-OFDM, FFT, IFFT.

I. INTRODUCTION

CP – OFDM stands for Cyclic Prefix - Orthogonal Frequency Division Multiplexing and widely used for 5G communication. It involves the adding and removing of an entity called the 'Cyclic Prefix' during modulation and demodulation respectively.Inter Symbol Interference (ISI) in OFDM system can be reduced by using guard intervals of null value but that will disrupt the orthogonality of the subcarriers [1]. So, guard space filled with cyclic prefix is used, wherein the last few samples are added to the front of the signal.

OFDM copes better with severe channel conditions such as high attenuation, etc as compared to single carrier modulation techniques. OFDM adopts a different approach than single carrier modulation techniques. The data is transmitted in parallel across the various carriers within the overall OFDM signal. Since the signal is only split into a number of parallel "subcarriers", the overall data rate is that of the original stream, but that of each of the subcarriers is much lower, and the symbols are spaced further apart in time.

In this paper, CP-OFDM model was implemented using MATLAB tool. MATLAB Code has been used to simulate BER vs SNR curves and graphs for Power Spectral Density (PSD).

Section II discusses the OFDM technique and provides an insight into the working of OFDM. The concept of Cyclic Prefix covered in Section III explains the need for Cyclic Prefix and the process involved in generation of the Cyclic Prefix. Section IV consists of a detailed explanation of the working of a CP-OFDM system.

II. OFDM

A. *Evolution of OFDM*

FDM (Frequency Division Multiplexing) has been used in communication systems such as telephones from a long time. FDM involves the passing of more than one signal over a telephone line by dividing the channel into several subchannels [2]. Nonetheless, to forestall the covering of signs, the idea of guard bands was presented. Yet, it was seen that use of guard band brought about wasteful utilization of data transfer capacity. This prompted the advancement of OFDM (Orthogonal Frequency Division Multiplexing). OFDM is generally utilized in advanced TV, sound telecom and 4G correspondence organizations. One of the primary employments of OFDM was an advanced radio.

OFDM includes the passing of multiple signals over a channel that is isolated into a few subchannels. Unlike FDM, in OFDM the signals are transmitted over carrier frequencies that are all orthogonal to each other. Here, it is possible for the channels to be overlapping and it further increases the transmission rate [3].

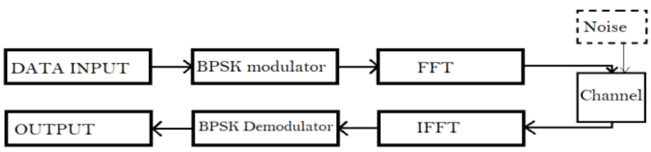

Fig 1. Block Diagram of OFDM

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B. Orthogonality in OFDM

The defining feature of OFDM is the orthogonality between the subcarriers. There is a mathematical relationship between the subcarriers i.e. each of them is linearly independent of one another [4]. The condition of linear independence is satisfied if the spacing between each of the subcarriers is 1/Ts wherein Ts is the Symbol Duration.

The orthogonality of the carriers implies that each carrier consists of an integer number of cycles over one symbol period. Because of this, the spectrum of each carrier will have a null at the center frequency of each of the other carriers in the system. Thus, there is no interference between the carriers which allows them to be spaced as close together as theoretically possible.

Two periodic signals satisfy the conditions for orthogonality or are orthogonal when the integral of their product, over one period, is equal to zero [5]. This condition holds good for certain sinusoids as illustrated in the equations below:

Continuous Time:

$$\int_0^T \cos(2\pi nft) * \cos(2\pi mft)dt = 0 \quad ; n \neq m \tag{1}$$

Discrete Time:

$$\sum_0^{N-1} \cos\left(\frac{2\pi kn}{N}\right) * \cos\left(\frac{2\pi km}{N}\right) = 0 \quad ; n \neq m \tag{2}$$

This requirement is met by the carriers of OFDM since they are sinusoids and because each one is a multiple of frequency and has an integer number of cycles in the fundamental period.

III. CYCLIC PREFIX

When adjacent symbols in a channel interfere with each other, they produce noise and because delay spread which affects the beginning of the next symbol [6]. To avoid this noise at the front of the symbol, the symbol is moved further away from the region of delay spread. A small amount of blank space is added between symbols to catch the delay spread. But blank spaces cannot be left in signals and this is not feasible for hardware which emits signals continuously. In order to solve this challenge, the symbol is slid over to start at the edge of the delay spread time. The guard space is then filled with a copy of the tail end of the symbol. The symbol is extended so it is 1.25 times as long. To do this, the back of the symbol is copied and glued to the front. The symbol source is continuous, so in reality only the starting phase is being adjusted and the symbol period is being made longer.

This procedure is called adding a cyclic prefix. Since the OFDM signal is a linear combination, the whole process is to be done only once to the OFDM signal, rather than repeating it with each and every sub-carrier.

In our paper, Cyclic Prefix length has been considered to be 7% of the OFDM Symbol Length [7].

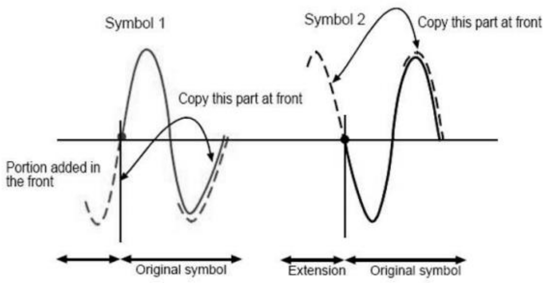

Fig 2. Cyclic Prefix

IV. CP – OFDM

In recent trends of communication in 5G, there is an observed necessity for higher speed data transmission which led to the development of systems based on OFDM such as CP – OFDM, PCC – OFDM, UFMC, SP – OFDM, F – OFDM etc. To implement the CP-OFDM system on MATLAB, the following parameters are being considered.

I. Size of OFDM symbol
ii. Length of IFFT and FFT
iii. Number of OFDM symbols to be simulated
iv. Size of alphabet used in modulation/demodulation
v. Constellation Phase Offset
vi. Number of Cyclic Prefix Samples (Length of Cyclic Prefix)

The size of OFDM symbol has been considered to be the same as the length of IFFT/FFT. Cyclic Prefix length is taken as 7% of the length of the OFDM Symbol. If OFDM symbol length is considered to be 256, length of the cyclic prefix will be 7% of 256 ≈ 16.

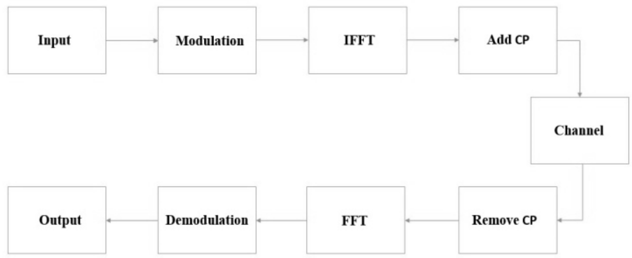

Fig 3. Block Diagram of CP-OFDM

Input is generated as a matrix of random integers, matrix row, column dimensions being size of OFDM symbol and number of symbols being simulated respectively. The modulation of the input symbols is performed using BPSK modulation technique. Modulation using BPSK which allows the modulated signal to be overlapped under the same spectral bandwidth through the use of multiplexing. The modulated signal is converted to parallel data to facilitate the Inverse Fast Fourier Transform (IFFT) operation. IFFT of the parallel data is computed wherein the length of IFFT symbol is the same as the OFDM symbol. The data is then converted back into serial format for addition of Cyclic Prefix. Depending on the length of Cyclic Prefix stipulated by the user, certain number of OFDM symbols from the backend portion of the signal are copied and glued to the front. Addition of the Cyclic Prefix completes the transmitter end of the CP-OFDM model.

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The Cyclic Prefix appended signal is then passed through an Additive White Gaussian Noise (AWGN) Channel after which the appended cyclic prefix portion of the signal is removed. The signal is then converted from serial to parallel format to compute the Fast Fourier Transform (FFT). The signal is then demodulated using BPSK demodulator baseband. Finally, Bit Error Ratio (BER) and Power Spectral Density are computed and plotted.

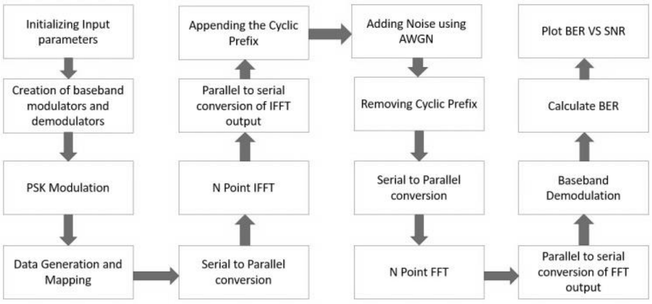

Fig 4. Operational blocks for CP-OFDM

V. RESULTS

A. The BER vs SNR graph as well as the Power Spectral Density graph have been plotted as shown below. The input data was successfully transmitted via the AWGN channel without the effect of inter-symbol interference. It was observed that the demodulated output at the receiver side was identical to the input data transmitted, proving that the overall transfer of data is successful.

B. Figures and Tables

S. No	SNR vs BER	
	SNR	***BER***
1.	0	0.0786
2.	2	0.0376
3.	4	0.0124
4.	6	0.0024
5.	8	0.0002
6.	10	0
7.	12	0

Table 1. SNR vs BER values for 10000 OFDM symbols

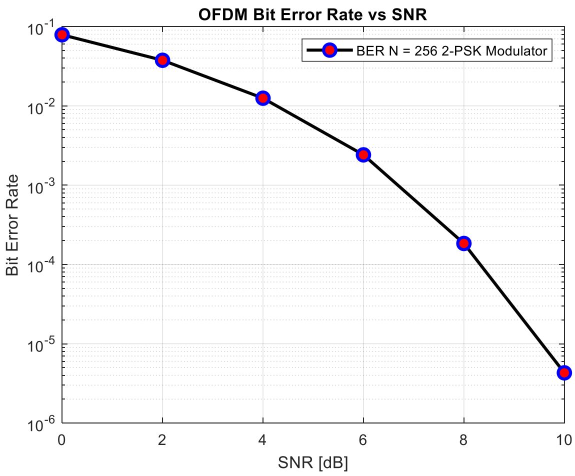

Fig 5. BER vs SNR plot

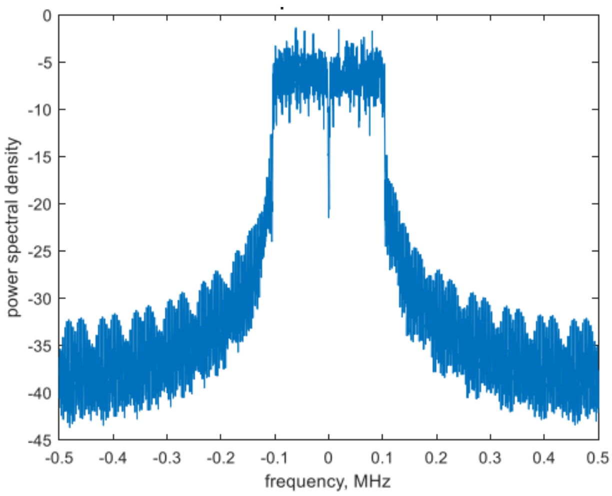

Fig 6. Power Spectral Density

	Modulator Baseband	***Demodulator Baseband***
Type	'PSK Modulator'	'PSK Demodulator'
M	2	2
Phase Offset	90	90
Constellation	[-0.4481 + 0.8940i 0.4481 - 0.8940i]	[-0.4481 + 0.8940i 0.4481 - 0.8940i]
Symbol Order	'Binary'	'Binary'
Symbol Mapping	[0 1]	[0 1]
Input Type	'Integer'	'Integer'

Table 2. CP-OFDM Modulator and Demodulator Baseband Parameters

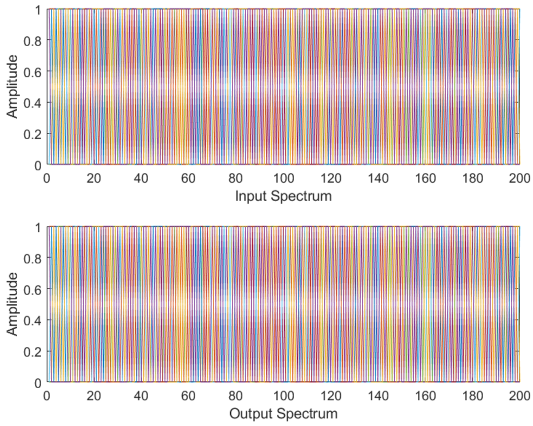

Fig 7. Input and Output Spectra for CP- OFDM where number of subcarriers are considered to be 200

VI. CONCLUSION

The cyclic prefix goes about as a support district where postponed data from the past image can get put away. It is a critical component to empower the OFDM to work with dependability and furthermore adds power to the OFDM signal. It empowers the presentation of the OFDM signal to be brought under conditions which have elevated levels of reflections and multipath engendering. This is finished by decreasing the Inter symbol interference (ISI).

With the improvement of cyclic prefix, OFDM has gotten reasonable to execute and has its applications going from modems, audio broadcasting to the next generation high speed wireless data communications to the cutting edge rapid remote information interchanges because of its proficient tweak conspire.

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REFERENCES

[1] N. Kaur and N. Kumar, "Review and analysis of Simulink based OFDM," 2017 3rd International Conference on Advances in Computing, Communication & Automation (ICACCA) (Fall), Dehradun, 2017

[2] S. Viswasom and D. Murali, "Effect of cyclic prefix reduction on OFDM-CDMA systems," 2013 Annual International Conference on Emerging Research Areas and 2013 International Conference on Microelectronics, Communications and Renewable Energy, Kanjirapally, 2013

[3] Xiurong Bao, "Matlab simulation and performance analysis of OFDM system," 2012 International Conference on Computer Science and Information Processing (CSIP), Xi'an, Shaanxi, 2012

[4] M. Batariere, K. Baum and T. P. Krauss, "Cyclic prefix length analysis for 4G OFDM systems," IEEE 60th Vehicular Technology Conference, 2004. VTC2004-Fall. 2004, Los Angeles, CA, 2004

[5] W. Henkel, G. Taubock, P. Odling, P. O. Borjesson and N. Petersson, "The cyclic prefix of OFDM/DMT - an analysis," 2002 International Zurich Seminar on Broadband Communications Access - Transmission - Networking (Cat. No.02TH8599), Zurich, Switzerland, 2002

[6] J. H. Manton, "Dissecting OFDM: the independent roles of the cyclic prefix and the IDFT operation," in IEEE Communications Letters, vol. 5, no. 12, pp. 474-476, Dec. 2001

[7] Ali Zaidi, Fredrik Athley, Jonas Medbo, Ulf Gustavsson, Giuseppe Durisi, Xiaoming Chen, “5G Physical Layer - Principles, Models and Technology Components”,2018.

[8] Cheol-Jin Park and Gi-Hong Im, "Efficient cyclic prefix reconstruction for coded OFDM systems," in IEEE Communications Letters, vol. 8, no. 5, pp. 274-276, May 2004

[9] O. D. Tören, E. Ayduslu, Y. Aydın and A. Özen, "A Novel Hybrid OFDM Technique for 5G," 2017 40th International Conference on Telecommunications and Signal Processing (TSP), Barcelona, 2017

[10] D Jagadeesh, “Simulation of Wireless Communication System using OFDM Principle.”