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Effect of Cyclic Prefix on OFDM System

Rashmi Mishra, Baibaswata Mohapatra, Nitin Naiyar

Abstract: ***Orthogonal Frequency Division Multiplexing (OFDM), because of its resistance to multipath fading, has attracted increasing interest in recent years as a suitable modulation scheme for commercial high-speed broadband wireless communication systems. OFDM can provide large data rates. Orthogonal frequency division multiplexing (OFDM) is one of the Multi-Carrier Modulation (MCM) techniques that transmit signals through multiple carriers. These carriers (subcarriers) have different frequencies and they are orthogonal to each other. There are different parameters which alters the performance of OFDM system. This thesis analyzes OFDM system and the effect of cyclic prefix and length of cyclic prefix on OFDM system. Besides, compare the performance of the system with and without cyclic prefix and with different RSF(Repeated Symbol Fraction).BER performance of the OFDM system is carried out with emphasis on the cyclic prefix and RSF. The simulation results show how a tradeoff is needed between reduction in multi-path effects and Transmission efficiency.***

Index Terms: ***BER, RSF, ISI.***

I. INTRODUCTION

In an OFDM scheme a large number of sub channels or sub-carriers are used to transmit digital data. Each sub-channel is orthogonal to every other. They are closely spaced and narrow band. The separation of the sub-channels is as minimal as possible to obtain high spectral efficiency. OFDM is being used because of its capability to handle with multipath interference at the receiver. The basic principle of OFDM is to split a high-rate data stream into a number of lower

rate streams that are transmitted simultaneously over a number of subcarriers. The relative amount of dispersion in time caused by multipath delay spread is decreased because the symbol duration increases for lower rate parallel subcarriers. The other problem to solve is the Inter Symbol Interference (ISI), which is eliminated almost completely by introducing a guard time in every OFDM symbol. This means that in the guard time, the OFDM symbol is cyclically extended to avoid Inter Carrier Interference (ICI). An OFDM signal is a sum of subcarriers that are individually modulated by using phase shift keying (PSK) or quadrature amplitude modulation (QAM) or any modulation scheme.

II. OFDM SYSTEM

The basic model of OFDM system is shown below. First the data is converted to several parallel stream. Then each stream is modulated by different subcarriers. The modulation schemes can be BPSK, QPSK, QAM etc. These modulated signals are processed by IFFT block. Then the cyclic prefix is added to the signals. The cyclic prefix, which is transmitted during the guard interval, consists of the end of the OFDM symbol copied into the guard interval, and the guard interval is transmitted followed by the OFDM symbol. The reason that the guard interval consists of a copy of the end of the OFDM symbol is so that the receiver will integrate over an integer number of sinusoid cycles for each of the multi-paths when it performs OFDM demodulation with the FFT. OFDM has excellent robustness in multi-path environments. Cyclic prefix preserves orthogonality between sub carriers. Cyclic prefix allows the receiver to capture multipath energy more efficiently. Then the signals are converted to serial form and transmitted through transmitter.

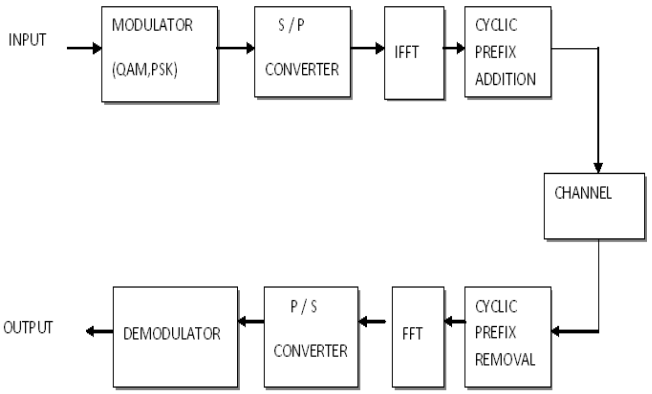

Figure1: FFT OFDM

At the receiver the reverse process is performed. The serial data is received which is converted to parallel form. Then cyclic prefix is removed. After removal of cyclic prefix, Fast Fourier Transform is performed. Then the signals are demodulated to get the original data.

III. PARAMETERS

BER(Bit Error Rate): Bit error rate is a key parameter that is used in assessing systems that transmit digital data from one location to another. BER is applicable to radio data links, Ethernet, as well as fiber optic data systems. When data is transmitted over a data link, there is a possibility of errors being introduced into the system.

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* Correspondence Author
Miss Rashmi Mishra*, M.Tech Student, Department of Electronics and Telecommunication Department, Rungta College of Engineering and Technology, Bhilai, (C.G.) India.
Dr. Baibaswata Mohapatra, Associate Professor, Department of Electronics and Telecommunication, Rungta College of Engineering and Technology, Bhilai, (C.G.) India.
Mr. Nitin Naiyar Associate Professor, Department of Electronics and Telecommunication, Rungta College of Engineering and Technology, Bhilai, (C.G.) India.

If this is so, the integrity of the system may be compromised. As a result, it is necessary to assess the performance of the system, and BER provides an ideal way in which this can be achieved. BER assesses the full end to end performance of a system including the transmitter, receiver and the medium between the two. BER is defined as the rate at which errors occur in a transmission system.

In simple form,

$$\text{BER} = \frac{\text{Number of bits in error}}{\text{Total number of bits sent}}$$

There are different parameters which alters the performance of OFDM system. Few of them are modulation scheme used, number of subcarriers used, coding schemes RSF, CP etc.

If TSymbol is the OFDM symbol time, TGuard represents the guard interval and TS is the effective symbol time then we can express the TSymbol as

$$T_{Symbol} = T_{Guard} + T_S$$

and $T_{Guard} = G \times T_S$

Where G is the Repeated Symbol Fraction (RSF).

IV. SIMULATION RESULTS

The performance of OFDM system has been investigated by means of computer simulation. Matlab as a software tool has been used. The results presented show the BER performance as a function of the signal to noise ratio. OFDM model was first simulated with and without using the cyclic prefix. Cyclic Prefix is used to reduce the effect of ISI due to the multi-path delay. Figure2 shows the performance of the OFDM system with the use of cyclic prefix and without using cyclic prefix The graph shows that performance of the system is better with the cyclic prefix. As SNR increases the performance of the system, without cyclic prefix degrades.

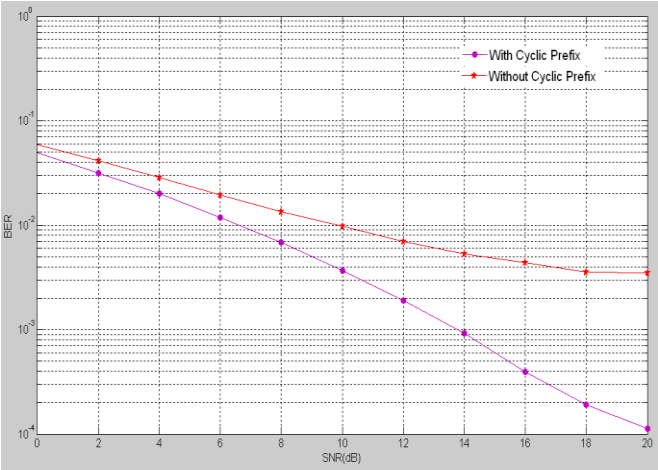

Figure2: BER performance of OFDM system with and without cyclic prefix

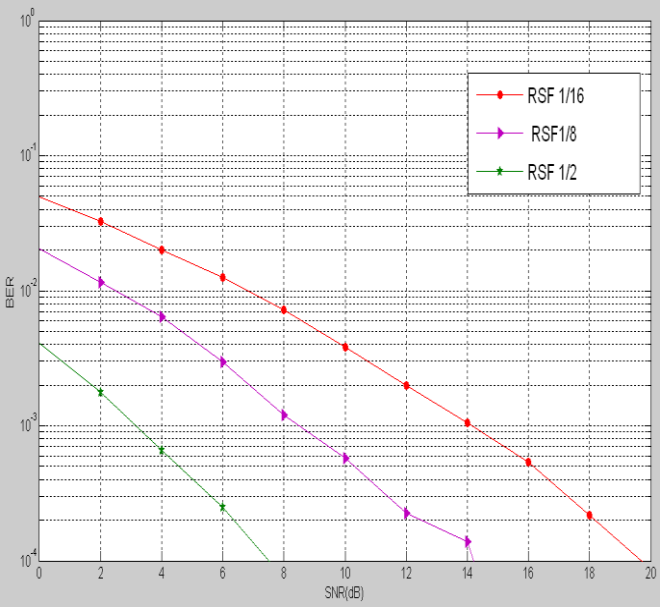

Figure3: BER Performance of OFDM system for different values of RSF

As cyclic prefix is nothing but a copy of last few samples of the OFDM symbol. So we can vary its length. RSF can also be defined in terms of length of the symbol and CP. For example for a symbol length of 256 bits acting as input to the CP block, with RSF= 1/8, the output should be 288 bits (as 1/8 th of 256 are appended). The simulation is carried out for different values of RSF.

Figure3 shows the performance of the OFDM system for RSF= 1/2, 1/8 and 1/64.The figure shows the system with RSF= 1/2, can tolerate the SNR from 3-6.The performance is poor with RSF=1/64.

Cyclic prefix is more, then the information content in one symbol would be less. So here also the trade off is needed between the transmission efficiency and the ISI effect. A moderate value of RSF=1/8, can be used, which gives a moderate values of BER and is transmission efficient.

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AUTHOR PROFILE

Ms. Rashmi Mishra is an M. Tech student in Rungta College of and Technology (RCET), Bhilai.She has received her B.E. degree from the RCET in year 2010.

Dr. Baibaswata Mohapatra is Associate Professor in Rungta College of Engineering and Technology Bhilai. He has received his Phd from National Institute of Technology Allahabad.

Mr NItin Naiyar is Assistant Professor in Rungta College of Engineering and Technology Bhilai. He has received his B.E> degree from Bhilai Institute of Technology, Bhilai and M.Tech degree from GSITS, Indore.

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