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# Performance Analysis of SCFDMA with PN Sequence using different modulation techniques

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***Abstract*— Earlier Orthogonal frequency-division multiplexing (OFDM) method had various disadvantages like sensitivity to Doppler shift and frequency synchronization problems. It had high peak to average power ratio (PAPR) and low power efficiency and required linear transmitter circuitry. The OFDM reduces inter Symbol interference (ISI) caused by the delay spread of wireless channels. Therefore, it is used in many wireless systems and is adopted by various standards. OFDM is similar to traditional frequency-division multiplexing (FDM) but differ in modulation and demodulation methods. The main function is to minimize the interference or crosstalk among the channels and symbols consisting of data streams. SCFDMA is more advanced than OFDM. The SCFDMA system using PN sequence the proposed part provides much better results than the traditional OFDM. Along with this, the equalizer like MMSE, zero forcing etc. can also be used. The PN sequences helped in reducing the BER and also promised reliable transmission. The equalizer is used for minimizing the error in the signal obtained at the output. By using the equalizer and the PN sequence, the results obtained are more efficient than the traditional method.**

***Index Terms*— CP, OFDM, PAPR, SCFDMA.**

## I. INTRODUCTION

OFDM is descriptor for orthogonal frequency division multiplexing method used to encode the data on multiple carrier frequencies. It is an effective technique used in many communication systems such as audio broadcasting, DSL, wireless networks etc. OFDM follows frequency division multiplication method which means that data travels in the form of multiple sub carriers on parallel channels [2]. These sub carrier signals are modulated using existing modulation schemes such as QAM and PSK i.e. Quadrature amplitude modulation and Phase shift keying respectively. But conventional modulation schemes used generate low symbol rate in the same bandwidth. SCFDMA is an alternative here. SCFDMA is abbreviated as single carrier frequency division multiple access scheme. It follows the same concept as used by the multiple access schemes like OFDM, TDMA and FDMA in which multiple users assigned with shared communication resource. SCFDM is same as that of OFDM scheme except an additional step called DFT processing step [1]. SCFDM is preferred over OFDM in the uplink communication because it produces low PAPR value which tends to improve power efficiency and also reduces the cost of the power amplifier. As Single Carrier Frequency Division Multiple Access transmits the data serially, therefore it provides low PAPR value as compared to the OFDM system. Its frequency offset is also less sensitive as compared to the traditional modulation technique. SCFDMA is more robust with respect to frequency selective fading. SCFDMA works same as that of OFDM but has an additional step of DFT mapper. In the SCFDMA, data mapper converts the data bits into modulation symbols. These symbols are converted into a block consisting of N symbols. These N symbols are converted into the frequency domain because N-point is used in time domain. Then the frequency mapped samples are converted into subsets of M subcarriers. M should be greater than N. SCFDMA has some useful properties which make them popular such as:

- Provides less PAPR value
- Low sensitivity to carrier frequency offset
- It allows the use of low-cost power amplifiers
-

Transmitter and receiver structure of SC-FDMA:

After representation of SCFDMA, there is N point DFT at the transmitter side and N point IDFT at the receiver side. DFT produce frequency domain symbols that will spread over the bandwidth. On the other side, IDFT produce time domain channel symbols.

In this paper, SCFDMA using PN sequence technique is proposed. Section II discusses the type of fading channels. In section III, some existing works related to proposed approach are discussed. Section IV deals with the methodology used to implement the desired work. Section V and Section VI discusses the problem formulation and proposed work respectively. Results are shown in section VII in which the traditional technique i.e. TFT-OFDM results are compared with proposed technique results and paper is concluded in section VIII.

## II. FADING CHANNELS

Fading is a problem that affects the signal while travelling over the channel. It can vary depending upon many factors such as time, radio frequency or geographical position. A fading channel is a type of communication channel that is generally affected by fading. Fading can be caused by multiple factors such as multipath propagation which causes multipath induced fading. In the same way, shadowing may lead to shadow fading. While travelling through media, a signal may follow multiple paths created by reflectors present in the environment which causes the transmitted signal to traverse [5]. Consequently, receiver can see each signal traversing a different path.

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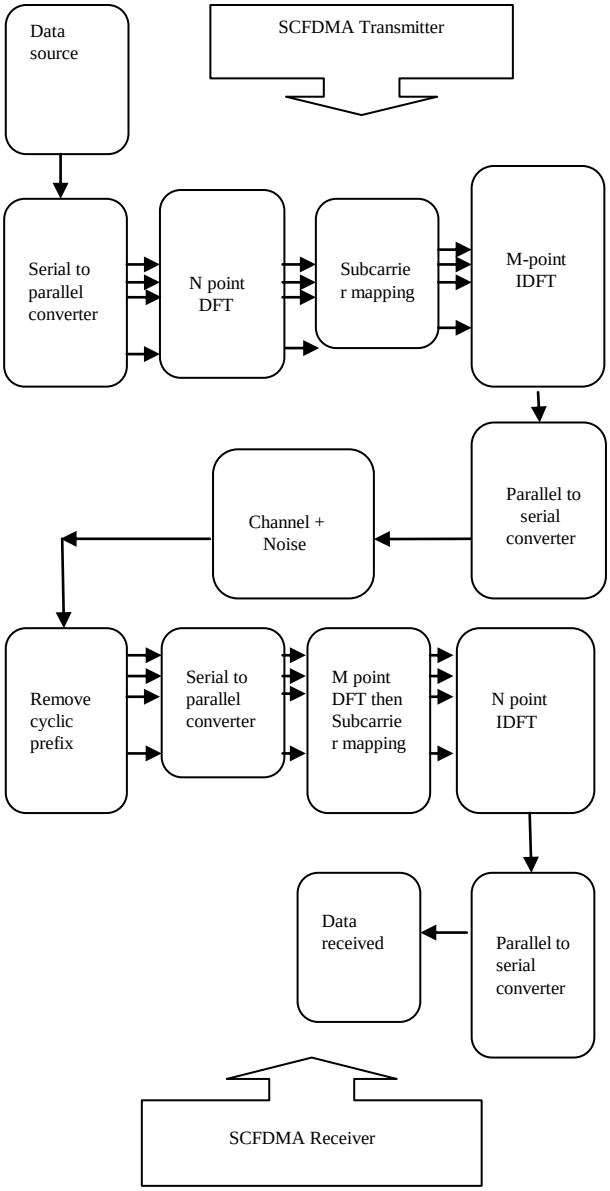


Figure 1 shows the basic block diagram of SCFDMA

In underwater acoustic communication, disturbances occurring due to water movement may lead to distortion which can be modeled using channel.

Depending on how rapidly the transmitted signal changes as compared to change of the channel, Fading can been divided into two types named as slow fading and fast fading.

**Slow fading**

In a slow fading channel, the channel variation rate is much slower than the rate of change of transmitted signal. The rate of change of channel may be assumed to be static over one or more timing intervals. In frequency domain, this specifies that Doppler spread of channel is much less than bandwidth of transmitted signal in the frequency domain. This type of fading occurs due to shadowing in which large building or hill can destroy the path between the transmitter and receiver.

**Fast fading**

Fast fading deals with rate of change of channel due to motion. In fast fading channel, rate of change of channel is faster than rate of change of transmitted signal.

**Selective Fading**

It occurs due to the fact that radio signal gets partially cancelled by itself. It is also referred as frequency selective fading. It happens in early evening or early morning because at that time environment conditions changes and various layers in the ionosphere may get separated or combined which causes fading to occur.

Selective fading is a type of fading which constantly changes due to the cyclic disturbance sweeping through the received audio. Thus as a result, carrier frequency of the signal will vary leading to change in the amplitude. The coherence bandwidth measures separation in frequency; thus two signals will experience uncorrelated fading.

**Fading Models**

There are different fading models available and different in terms of delay, gain and phase shift [5]. Some of them are:

- Nakagami fading
- Log normal shadow fading
- Rayleigh fading
- Rician fading
- Weibull fading

## III. RELATED WORK

Kumar Naresh et al. This paper presents uplink and downlink communication with the help of OFDMA and SCFDMA. LTE i.e. Long term evolution adopted SCDFMA and used for uplink communication. SCFDMA is also known as Discrete Fourier Transform spread OFDM. This paper has proposed a new technique named as Wavelet based SCFDMA to analyze Bit error rate performance. Evaluation is performed on several wavelets under different modulation schemes with AWGN channel. Thus results shows that by using wavelet transform BER is reduced and performance is better as compared to existing approach used in SCFDMA.

Rahul Ohlan et al. This paper presents a recent trend in the field of LTE systems which is based on the OFDM with cyclic prefix and SCFDMA.OFDM basically used for downlink communication whereas SCFDMA is used for uplink communication. SCFDMA provides lower PAPR as compared to OFDM. This paper presents some historical techniques that had been used and also discusses survey results.

Anurag Pandey et al. paper mainly focuses on the OFDM system used in wireless communication due to its better data rate and low bandwidth. Simulation has been performed to show the results of signals over different faded channels and to obtain optimum Bit Error Rate. This paper focuses on the performance of the OFDM system on the basis of different modulation schemes and Rayleigh fading channels.

Mukesh Kumar Mishra et al. This paper presents Nakagami-m fading channels effect on OFDM system and effected value of BER through the characteristics of function based approach of this fading channel. BER value is expressed in terms of confluent hyper geometric functions known as higher transcendental function. As a result, paper concludes that BER performance may degrade depending on the number of channel taps as well as on the increasing value of Nakagami-m fading parameters.

## IV. METHODOLOGY

As problems are discussed in previous section a new approach is proposed for work in which the methodology is divided into two parts. One is from transmitter side and other is from receiver side.

**Transmitter Side:**

1. Initially a number of data sets will be generated.
2. SNR value of the signal is to be generated in this step.
3. After generating SNR, signal is generated carrying the information, which is to be transmitted for communication between the transmitter and the receiver.
4. On that generated signal different types of modulation techniques are applied and the technique which is best among them is chosen for the modulation of signal.

**Block diagram**

Transmitter Block:

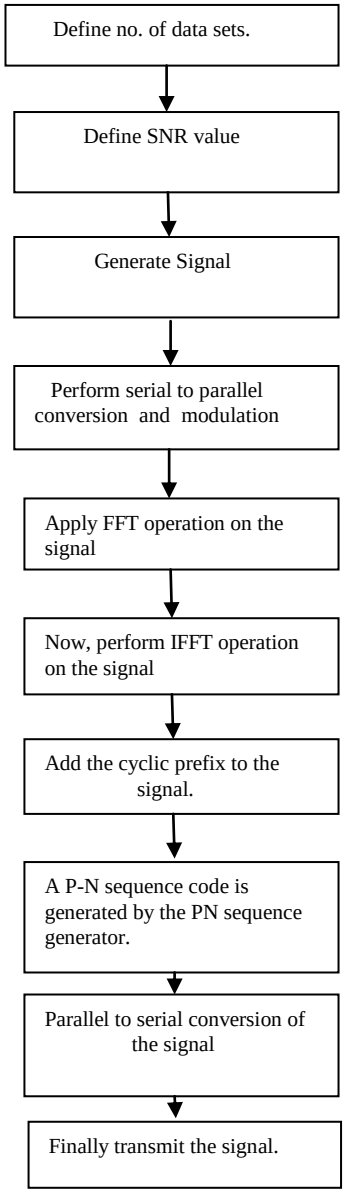


Figure 2 Block diagram of proposed technique at transmitter side

5. After modulation on the signal is performed, FFT operation is applied on that signal.
6. After applying FFT operation on the signal, next step is to apply IFFT operation on the received signal.
7. Now, cyclic prefix is added to the received IFFT Signal, as cyclic prefix is generally used in conjunction with modulation in order to retain sinusoid properties in multipath channels.
8. Now, parallel to serial conversion of the signal is done, so that the multiple data is transmitted at a time and also the speed is more.
9. After adding the cyclic prefix, a PN –sequence code is generated, by a PN-sequence code generator.
10. Finally this signal is transmitted from the transmitter.

Receiver Block:

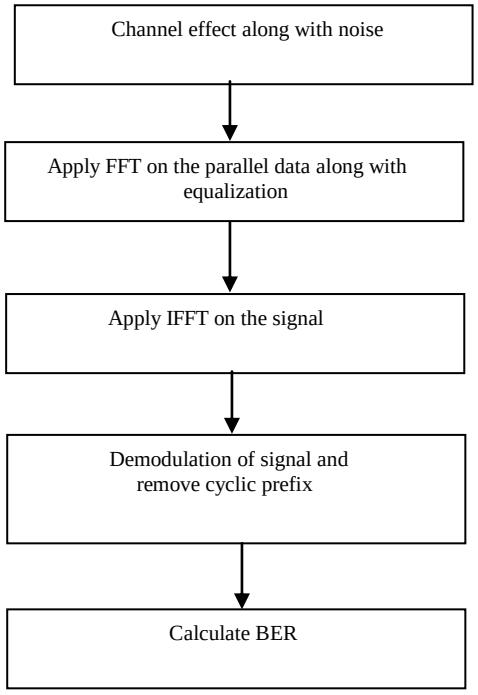


Figure 3 Block diagram of proposed technique at Receiver side

**RECEIVER SIDE:**

1. On receiver side, generate a channel effect along with the ratio of noise.
2. Then perform FFT and equalization on the signal.
3. Apply IFFT operation on the signal.
4. Perform demodulation on the signal.
5. Remove cyclic prefix from the received signal.
6. Now compare the transmitted signal with the received signal and calculate the error in the signal.

## V. PROBLEM FORMULATION

Orthogonal frequency-division multiplexing (OFDM) diminishes the effect of inter-symbol interference (ISI). Therefore, it is used in many wireless systems and adopted by various standards. OFDM is much similar to traditional

frequency-division multiplexing (FDM) in many ways. They can only be differentiated on the basis of modulation and demodulation methods. The main function is to minimize the interference or crosstalk among the channels and symbols consisting of data streams. Less significance is placed on perfecting the channels. Still some of the problems exist, like High peak to average power ratio having amplitude variations which resembles noise like appearance. Also OFDM has low RF amplifier efficiency. The basic reason is that it accommodates the large amplitude variations. These factors leads amplifier to operate with a low efficiency level and its sensitivity to carrier offset and drift also increases. Single carrier systems are less sensitive as compared OFDM.

## VI. PROPOSED SYSTEM

The traditional OFDM technique suffers from various problems such as frequency synchronization. It is highly sensitive to Doppler shift. Also it has high peak to average power ratio (PAPR), requiring linear transmitter circuitry, which leads to low power efficiency. Further, there is loss of efficiency caused by cyclic/guard interval. To overcome these limitations, it was advised to use various coding algorithms like PN sequence codes which improves efficiency or other multiple access technique.

By introducing the PN sequence code with the OFDM system the modified part gives much better results than the traditional OFDM. Along with this the equalizer like MMSE, zero forcing etc. can also be used. The PN sequences helped reducing the BER and also promised reliable transmission. The equalizer are used for the minimizing the error in the signal that is obtained at the output. By using the equalizer and the PN sequence the results obtained are more efficient than the traditional method.

Objectives:

- To replace the traditional OFDM technique in reduction of BER
- To Introduce the encoding approach in proposed communication system to enhance the performance of the system
- To introduce the PN sequence and equalizer to improve the performance of the OFDM system.
- Calculation of performance parameters of proposed work and analysis
- Design and develop the work in the software name MATLAB

## VII. SIMULATION AND RESULTS

To implement SCFDMA, we used information stream of 4096 bits having block size of 512 bits. The cyclic prefix of length 52 for each subcarrier is used. The n-point FFT and IFFT is used at the transmitter and receiver where n denotes the size of block. The PN sequence generator generates 8-bit random sequence. The signal is processed using generated PN sequence and different modulation techniques such as BPSK, QPSK and QAM-16. The modulated 4512 bit data stream is transmitted serially to implement SCFDMA. The value of m-factor for nakagami-m channel is 0.5 and omega equal to 2 is used. For simulation, 16 randomly selected values are picked and shown on the graph.

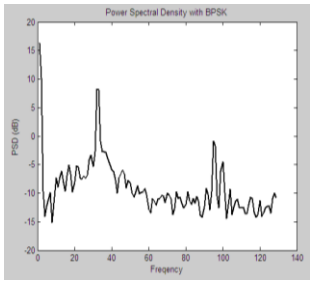


Figure 4

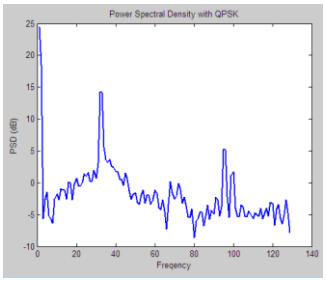


Figure 5

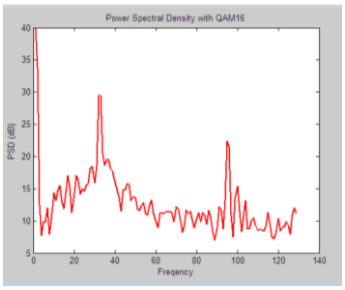


Figure 6

Figure 4, 5, 6 shows the graph which represents the Power Spectral Density Ratio of BPSK, QPSK and QAM-16.

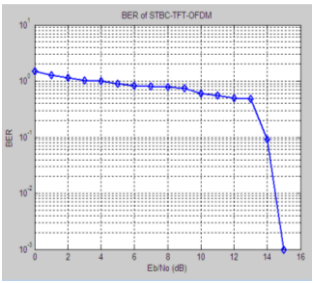


Figure 7

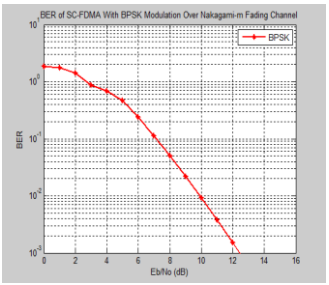


Figure 8

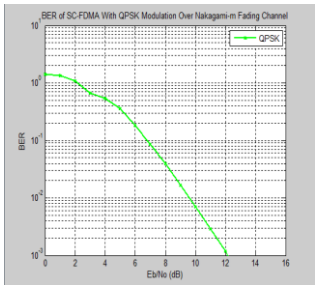


Figure 9

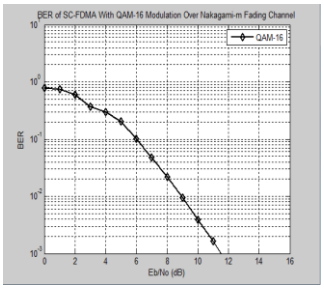


Figure 10

Figure 7, 8, 9, 10 represent the graph of BER i.e. Bit Error Rate of STBC-TFT-OFDM, BER of SC-FDMA with BPSK,QPSK and QAM modulation techniques respectively.

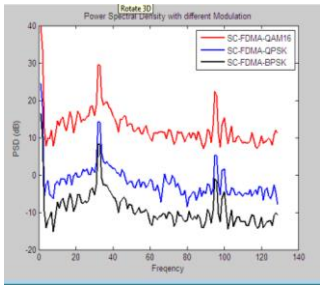


Figure 11

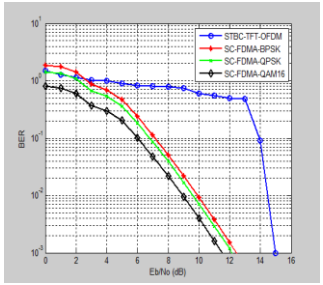


Figure 12

Figure 11 shows the graph which compares the PSNR of SC-FDMA signal w.r.t various modulation techniques like QAM, QPSK, and BPSK. The graph shows that the PSNR

value of SCFDMA (QAM) is efficient as compare to other modulation techniques. Figure 12 shows the comparison of BER of traditional OFDM with proposed SCFDMA system. Graph shows that the proposed system provides better BER results as compared to the existing system. Further, QAM qualifies as the best modulation technique among others.

## VIII. CONCLUSION AND FUTURE SCOPE

From results it is concluded that proposed method is best and efficient than the traditional method. There are a large number of techniques available in order to apply modulation on SC-FDMA signals. It is observed that the QAM 16 is the best approach to reduce the BER of the signal as compare to other modulation techniques.

As a future scope further enhancement can be done in this method by using trending technique for transmission of signal. Along with the SCFDMA technique, there can also be other techniques that can be used to produce quality retain signal at the receiving end. Furthermore, techniques can be developed that may simple in manipulation than the proposed technique.

## ACKNOWLEDGMENT

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