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Enhancement of the MIMO-OFDM Technologies

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Abstract: ***Multi input and multi output (MIMO) systems, which use several antennas at either the transmitter or the receiver or both, are able to provide a big capacity compared to systems that use single antenna. MIMO makes wireless communication work intelligently by gathering all information arriving from different branches at different times. By using multiplexing, the interference may happen, but MIMO use smart selections at the receiver to improve the equality of the signal. One of the applications of MIMO is orthogonal frequency division multiplexing (OFDM). OFDM technique is used for multiple access schemes and multiple-input multiple-output (MIMO) systems are applied to increase data rate. In this thesis we want to study the enhancement MIMO-OFDM technologies by using Matlab.***

Keywords: MIMO,-OFDM, MATLAB

1. Introduction

To begin with, this system is characterized by Fast Fourier Transforms at the Receiver (FFR). MIMO is an advanced technology for radio or RF communications used in various cellular, broadcast media and satellite applications, Wi-Fi, and LTE (third generation and fourth generation). Likewise, it is used in wireless data communication methods to enable increased link capacity and reliability across the frequency spectrum. It is enhanced in a number of ways, chiefly engineers putting more transmitter antennas at base stations. They do this in order to increase the rate of data upload/download even if the available spectrum band is limited. There are various aspects to the MIMO-OFDM combination. They assist in reducing multi-pathing, fading, high signal to noise ratios, coded modulation, improving spread spectrum solutions, and synchronization. According to Telatar, OFDM-MIMO assists in ensuring high data transmission speed up to 100Mbps in broadband internet connection [1]. One characteristic of OFDM is its ability to reduce the complexity of the receiver by converting a frequency selective channel into a series of flat channels. With regard to MIMO- OFDM, applications exist in wireless internet, cellular communication, and multimedia applications. However, for there to be effective communication, a corresponding increase in the number of Multiple Input Multiple Output receivers and transmitters has to be noted. This implies that if one installs several antennas at both the receiver and transmitter, the quality of wireless signals improves as the rate of data transmission increases. This is because MIMO is dependent on reflections seen by the receiver. There are several techniques used in MIMO-OFDM, one of which is the STC/MRC. Here, multiple independent data streams transferred simultaneously within one channel are spatially multiplexed. This means that in a MIMO wireless communication transmission, separately encoded data signals or streams are transmitted from each of the multiple transmitting antennas in a location. In short, an increase in the number of data streams leads to an increase in data output. The MIMO channel has multiple elements, one of which is the MN elements. The channel is actually a wireless link between the transmitter and receiver antennas, which are denoted as M transmits and N receive antennas. The MN elements represent the MIMO coefficients and the multiple transmit and receive antennas can be distributed between various users or lone users. When this distribution occurs across multiple users, it is termed as cooperative communications and distributed MIMO. In order to get flexibility in selecting temporal, spatial correlations and channel parameters, it is necessary for one to use statistical MIMO channel models [2]. The significance of the MIMO-OFDM system especially with regard to (STC/MRC) is seen in the improvement through various factors tied to speed and accuracy of data transmission. With regard to the MATLAB simulation for a MIMO OFDM communication system, one must be familiar with a number of things. The first is that information bits are clustered into packet or frame format before transmission to a receiver. Sometimes during this process, the packets received can get lost or riddled with errors due to EMI or noise interference. Any high PER (Packet Error Rate) calculated as erroneous received packets negatively affect communication. In a coded system, the PER depends on the ratio between the BE and the NSD (the Bit Energy and Noise Spectrum Density). With the MIMO-OFDM system, the FFT approach translates to an increase in the number of sub carriers. This means that there is better accuracy and higher rates of data transmission.

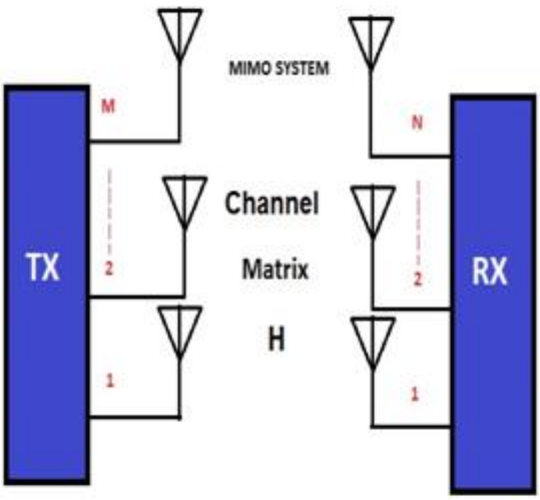

Figure 1: MIMO Antennas

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2. Simulation and Performance Analysis of OFDM-MIMO

An increasing the number of MIMO transmitters and receivers have a direct benefit to the rate of data download, upload, and transmission through multiple antennas; the transmission rate is boosted as is the quality of signals. MIMO uses STC/MRC techniques in which spatial multiplexes increase independent streams of data to be simultaneously transferred within one channel. This channel of bandwidth is known as a spectral channel. If the number of spatial data paths is increased, MIMO-OFDM can increase data throughput at an enhanced rate. In the MIMO system style, the input or output is a relation of the narrow band single user MIMO wireless link, and is modulated by the following notation Y= HX + n....1 [3]. In the OFDM-MIMO model, the MATLAB simulation shows that the time varying channel impulse response between j-th (j= 1.2......M) transmit antenna and the i-th (j= 1.2.....N) receive antenna is denoted as hi.j (t,T), while the composite channel response is shown by the M x N matrix H (τ,t) [4].

$$H(\tau,t) = \begin{bmatrix} H_{1,1}(\tau,t) & H_{1,2}(\tau,t) & H_{1,3}(\tau,t) \ldots & H_{1,N}(\tau,t) \\ H_{2,1}(\tau,t) & H_{2,2}(\tau,t) & H_{2,3}(\tau,t) \ldots & H_{2,N}(\tau,t) \\ H_{3,1}(\tau,t) & H_{3,2}(\tau,t) & H_{3,3}(\tau,t) \ldots & H_{3,N}(\tau,t) \\ \vdots & \vdots & \vdots & \vdots \\ H_{M,1}(\tau,t) & H_{M,2}(\tau,t) & H_{M,3}(\tau,t) \ldots & H_{M,N}(\tau,t) \end{bmatrix}$$

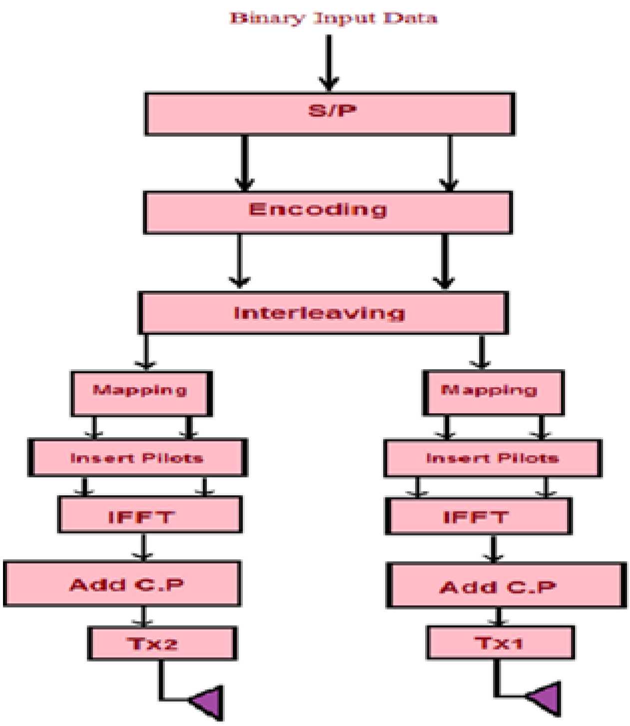

Figure 2: MIMO-OFDM transmitter system

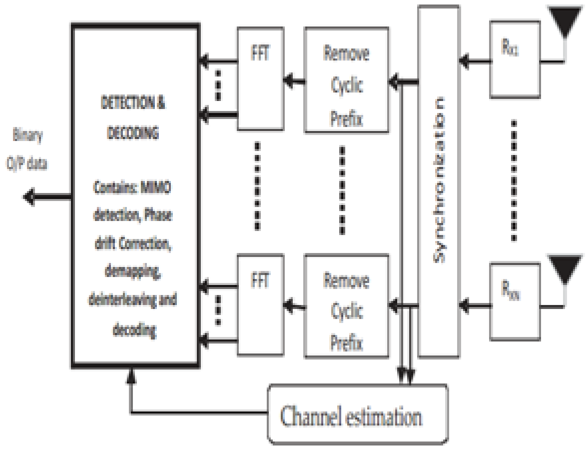

Figure 3: MIMO_OFDM receiver system [3]

3. Matlab Program of Magnitude of PBSK, QPSK and MIMO-OFDM Signal

The program below gives a plot of the real and proposed values of the magnitude of PBSK, QPSK and MIMO-OFDM signal, together with their distribution in relation to the placement of the values of Q and N within the relay network [5].

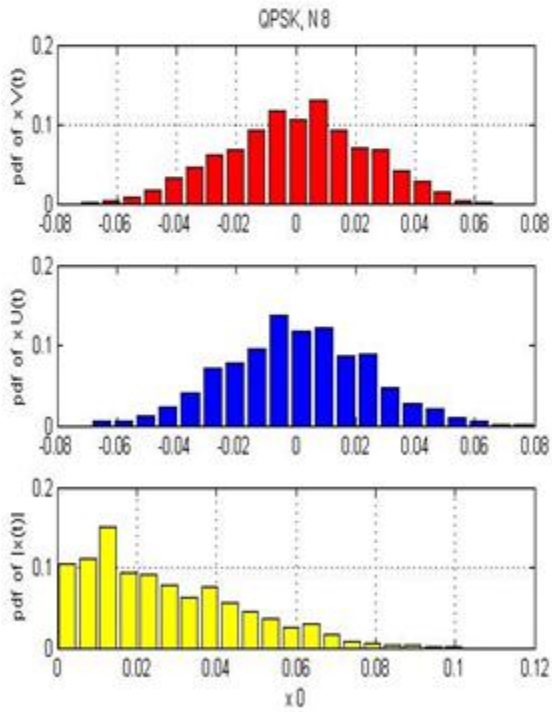

Figure 4: Magnitude distribution of OFDM QPSK N=8

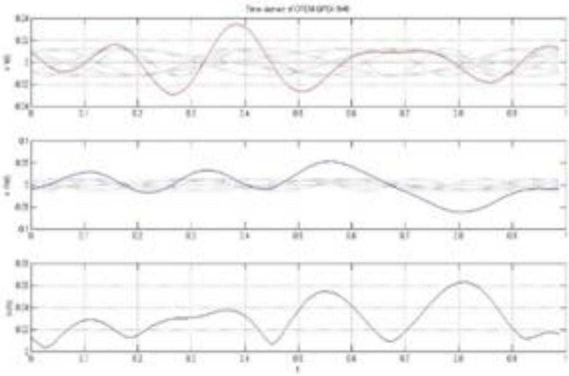

Figure 5: Time- domain of OFDM QPSK N=8

If we increase the number of fast Fourier transform of QPSK to 16, we will get the results shown in figures 6-9.

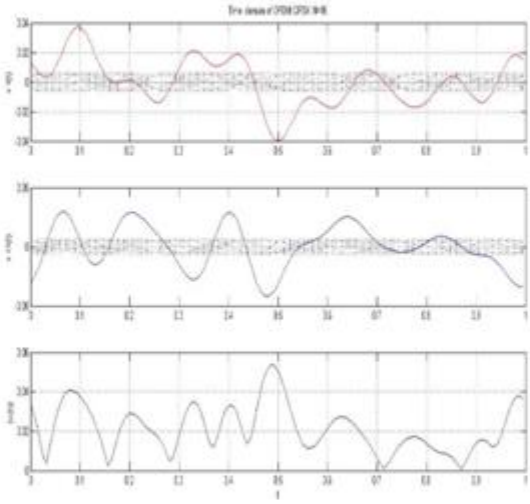

Figure 6: Time- domain of OFDM QPSK and N=16

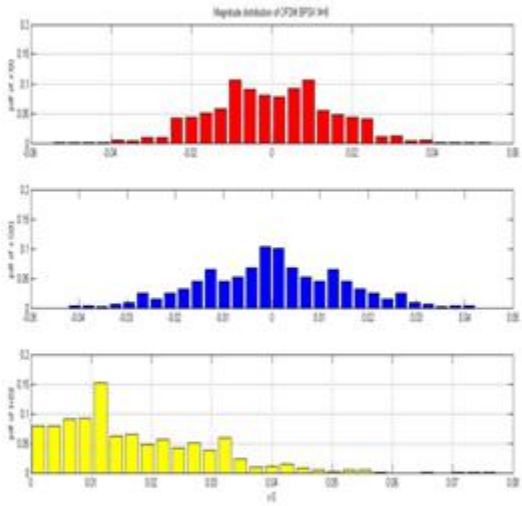

Figure 7: Magnitude distribution of OFDM BPSK and N=8.

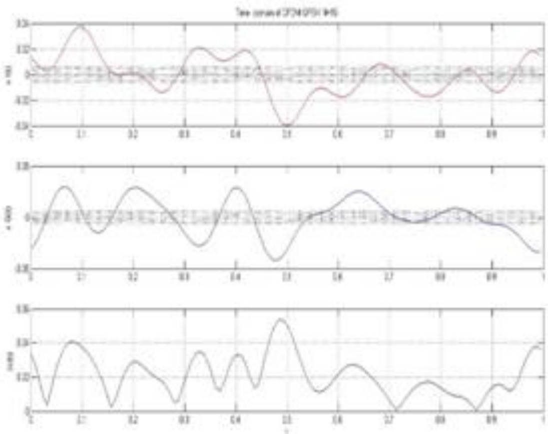

Figure 8: Time-domain of OFDM QPSK and N=16.

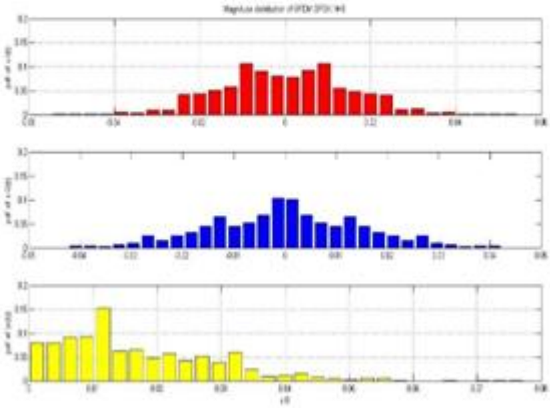

Figure 9: Magnitude distribution of OFDMBPSK and N=8.

4. Results of the Matlab Program of PBSK and QPSK over Additive White Gaussian Noise (AWGN) Channel

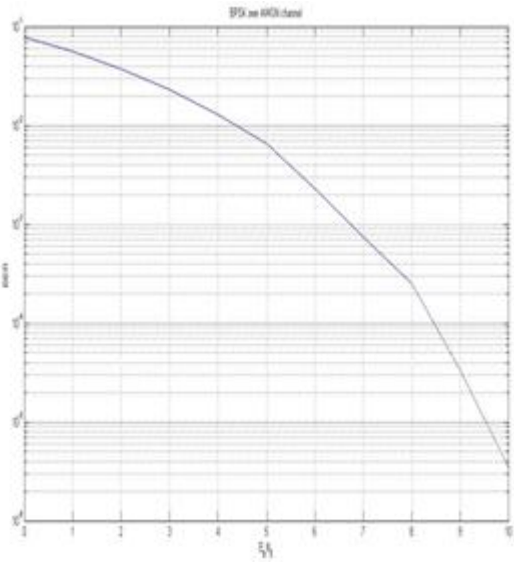

Figure 10: BPSK over AWGN channel

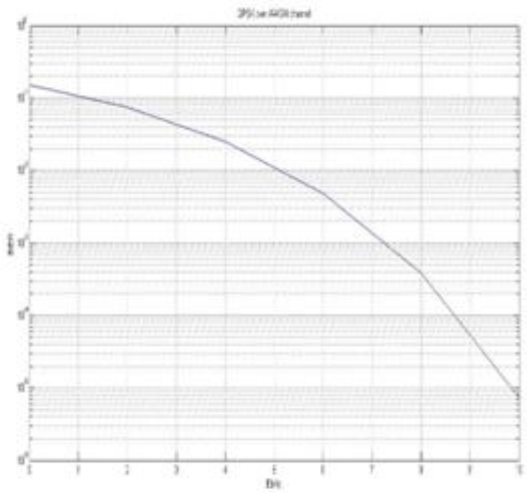

Figure 11: QPSK over AWGN channel

5. Comparison of the Capacity of MIMO and Proposed MIMO-OFDM

Using the MATLAB program code below, we can now calculate the grid capacity if the proposed MIMO-OFDM signal with the introduction of variations in the value of the Signal-to-Noise ratio and when the CSI of the transmitted signal has not been determined. The channel capacity can thence be determined through a variation in the number of antennas and the Signal-to-Noise ratio with variation in the values of N:

The Results of Comparison the Capacity of MIMO and Proposed MIMO-OFDM

When comparing figures 18 and 19, we can see that the capacity is about 17 bps when the number of transmitters and receivers equal three, but it becomes about 32 bps when the number of transmitters and receivers doubled.As shown in the graph in figure 19, one can clearly see that the capacity increases when the number of (NT, NR) increase. For example, capacity is about 11bpswhen (NR=NT=2) and become about 23when the number of antennas doubled.

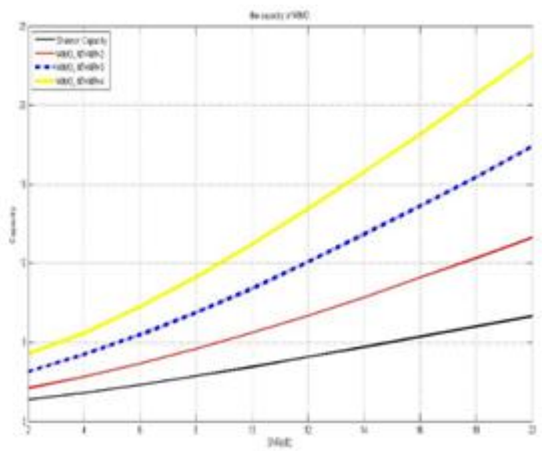

Figure 12: Comparison MIMO with different types of transmitters and receivers

Table 1: Comparison of different antennas system

Type	Tx antenna	Rx antenna	Data rates	Capacity	Coverage
SISO	single	single	less	less	less
MIMO	multiple	multiple	greater	greater	greater

6. Signal Transmit Comparison between MIMO and OFDM System

OFDM Generation

The amplitude and the phase of the carrier are calculated based on typical BPSK, QPSK, or QAM modulation schemes. The spectrum required is reconverted to the time domain using inverse Fourier Transform. IFFT does the transformation very efficiently by ensuring the carrier signals are orthogonally produced. The sinusoidal components which are orthogonal are represented by its amplitude and the phase. An IFFT converts several complex data points into the domain signal of similar amount of points [6]. Every statistic is called a bin. We can generate OFDM by changing the phase and amplitude for every bin. After we set the phase and amplitude, we perform IFFT. The figure below shows that the basic OFDM transmitter and receiver [7].

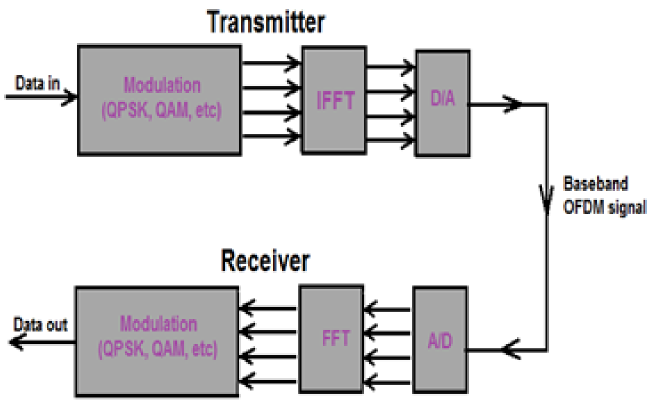

Figure 13: The transmitter and receiver of OFDM

The OFDM system is modeled using Matlab so as to allow the parameters of the system be varied and tested. The aim of simulation is to measure the performance and to allow for configurations to be tested. The multipath holdup extend, channel sound, climax power extract and time synchronization error are the four main criteria used to assess OFDM performance [8]. Figure 22 shows the OFDM symbol generation.

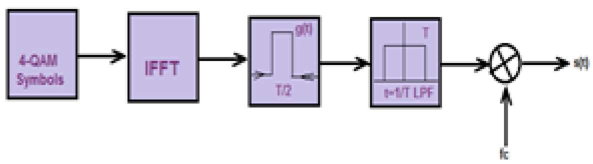

Figure 14: Generation OF OFDM

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In an OFDM transmission, when the number of Fast Fourier Transform is 4096 and the number of symbols is 1705, the zeros will be 2391, which are added to the signal information to center the spectrum. To produce a continuous-time signal, we need to apply transmit a filter, g (t), to complex signal carriers. In addition, to avoid aliasing, we need to apply a Butterworth Filter off on order 13 and cut-off the frequency of approximately 1/T. The results of Matlab program shows that the time response of signal after IFFT and in s(t).

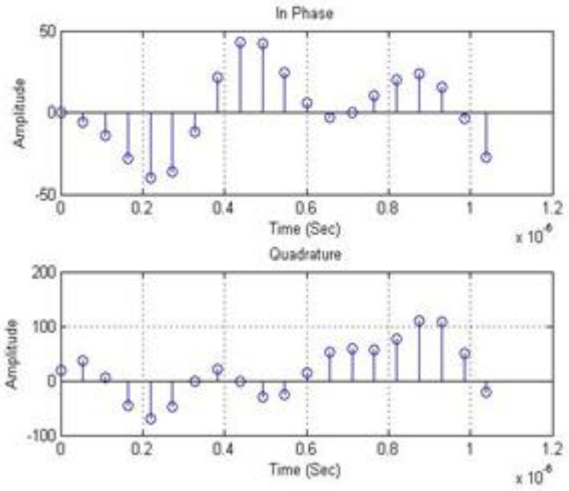

Figure 15: Time response of signal after IFFT

The preceding program shows the time response after IFFT. The result to the following matlab program shows the time response at s(t) point:

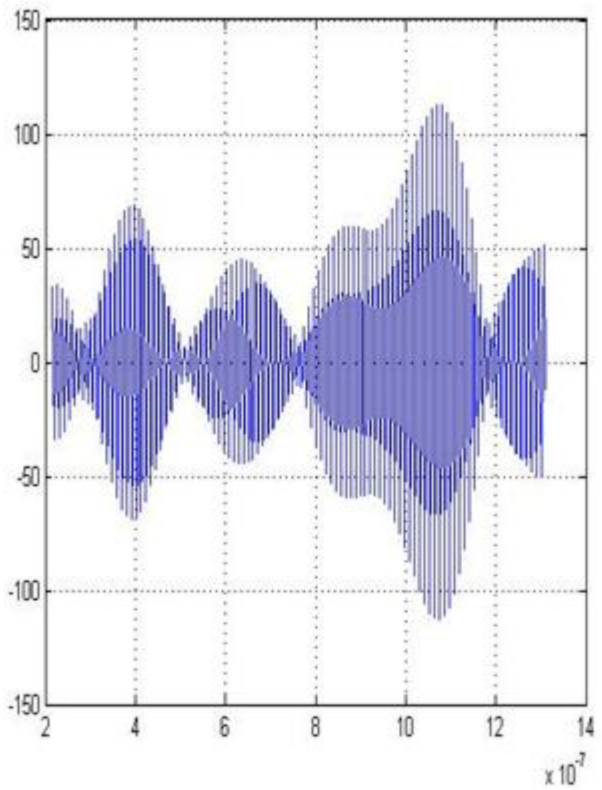

Figure 16: The time response at s (t) point

OFDM Reception

OFDM reception design is open in that there are only principles of transmission. A basic receiver follows the inverse of a transmission process. A receiving end is similar to the sending end only that they offer differing services [9]. The cause of the slight differences between transmitted and received signals is the delay produced by demodulation filters. Demodulation involves conversion of data signal into a mode that the receiver will understand. Figure 25 shows the basic design to the receiver which represents the inverse of transmission [6].

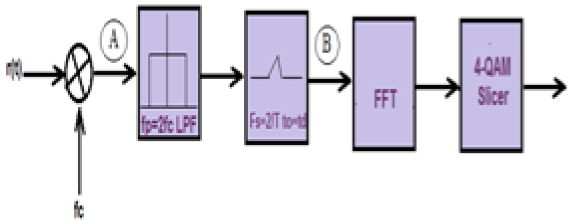

Figure 17: The basic design to the receiver

By using matlab, we can see the figure which represents the time response of signal at A point:

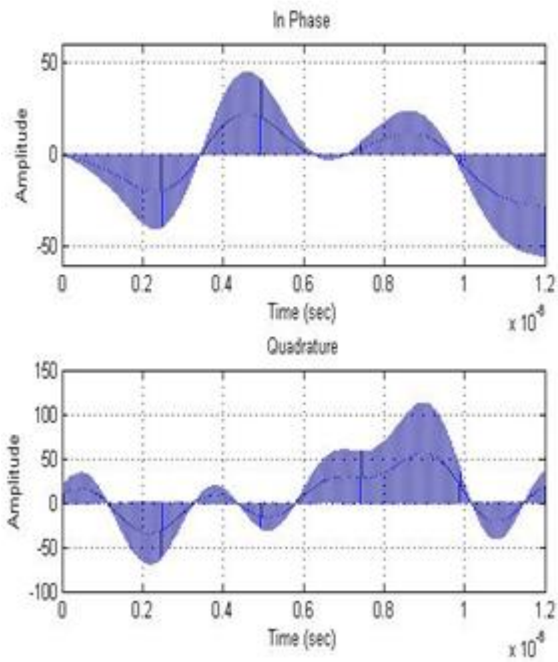

Figure 18: Time response of signal at A point

When we increase the number of IFFT to 8192, we can see the difference for the figures at the transmitter ann the receiver as shown in figures 27 and 28.

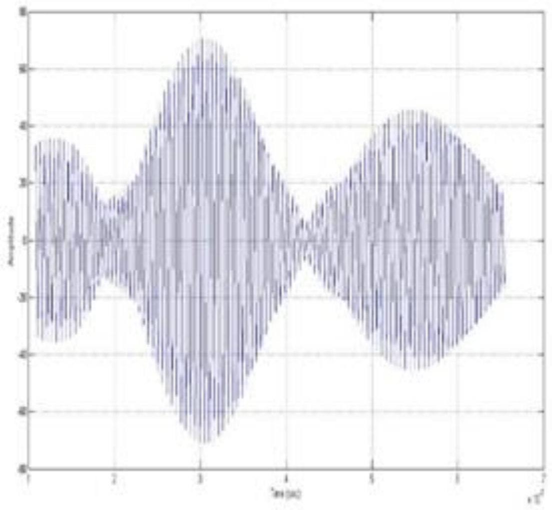

Figure 19: The time response at s (t) point

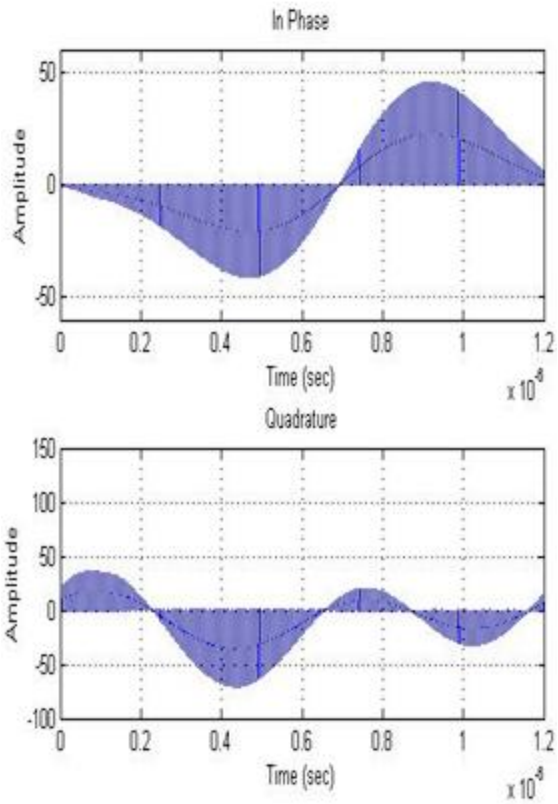

Figure 20: Time response of signal at A point

7. Conclusion

OFDM is a suitable technique in terms of modulation and demodulation for a high performance wireless telecommunication. It has many advantages; hence it has been adopted as DAB (Digital Audio Broadcasting) and for Terrestrial Digital Video Broadcasting (DVB). The technique has capabilities of reducing interference of data hence most of the networks in the recent market prefer using this system. Reduced interference enhances efficiency and that is what people need.

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